Zeller, D. and D. Pauly (Editors). 2007. *Reconstruction of Marine Fisheries Catches for Key Countries and Regions (1950-2005).* Fisheries Centre Research Reports, 15(2) 163 p.

ISSN 1198-6727

Fisheries Centre Research Reports

2007 Volume 15 Number 2

RECONSTRUCTION OF MARINE FISHERIES CATCHES FOR KEY COUNTRIES AND REGIONS (1950-2005)

Fisheries Centre, University of British Columbia, Canada

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Edited by
Dirk Zeller and Daniel Pauly

Fisheries Centre Research Reports 15(2)
163 pages © published 2007 by

The Fisheries Centre,
University of British Columbia

2202 Main Mall
Vancouver, B.C., Canada, V6T 1Z4

ISSN 1198-6727

Fisheries Centre Research Reports 15(2)
2007

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A Research Report from the Fisheries Centre at UBC

FISHERIES CENTRE RESEARCH REPORTS ARE ABSTRACTED IN THE FAO AQUATIC SCIENCES AND FISHERIES ABSTRACTS (ASFA)
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DIRECTOR'S FOREWORD

When, in 1998, I published a short paper providing "[A] rationale for reconstructing catch time series", I thought that the proposed concepts and methodology would need to be applied only to countries and regions (e.g., the Caribbean) not well covered in the global FAO database of fisheries landings.

Now, 10 years later, a rather different view of global fisheries statistics has emerged:

- IUU (i.e., Illegal, Unreported and Unregulated) fisheries catches, which are now perceived to be quite large, have moved to the centre stage in the consciousness of fisheries managers worldwide, and get regular coverage in the international media;

- Catch reconstructions performed for various countries throughout the world, many under the guidance of Dr. Dirk Zeller, this report's senior editor, show that the statistics supplied to FAO by many countries, large and small, underestimate their likely true catch (i.e., reported landings + IUU) by a factor of 2 or more.

While the illegal catches of industrial fisheries (which probably contribute most of the 'I' in IUU) are rather difficult to document, the mostly unreported catches of small-scale fisheries can be inferred from fisher number, and/or fish consumption data. Hence, catch reconstructions tend to boost catches from the small-scale sector, which is particularly neglected in the global FAO data set.

The neglect of small-scale fisheries has a strong effect on fisheries policy. Many countries, especially in the developing world, pay little attention to their small-scale fisheries, in the mistaken belief that they contribute little to their national economy and food security. Hence, these countries fail to devote resources to the study of these fisheries, and hence their catches remain un- or substantially under-reported to FAO, where they indeed appear to contribute little, thus perpetuating the problem.

The only way to get out of this vicious circle is to actually reconstruct national catches from independent data if possible, or by complementing the FAO data. This report presents both types of reconstructions. Also, two contributions are presented which disaggregate the catches of the ex-USSR and ex-Yugoslavia such that the republics that emerged from the dissolution of these multi-ethnic states are treated as if they had always existed (at least since 1950, when FAO's global statistical fisheries system began). This will enable one to treat, e.g., Russia, or Croatia, as any fisheries nations, i.e., building on fisheries catch data going back several decades, and allowing for analysis of long-term trends.

It may be useful to stress again that reconstructions of the sort presented here do not claim to provide 'true catches'. 'Truth' must remain elusive. But the catches presented in this report certainly represent an improvement over the present situation, and could thus be considered to move towards the 'likely true' catch levels. And often, this is all we can hope for: to improve on things.

Daniel Pauly,

Director, Fisheries Centre

CANADA'S ARCTIC MARINE FISH CATCHES[1]

Shawn Booth[a] and Paul Watts[b]

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ABSTRACT

Canada's arctic marine fisheries occur within FAO statistical areas 18 and 21. Although many of the communities in these areas rely on the sea, only commercial data have been part of the formal reporting procedure. Small-scale fisheries data, including subsistence fisheries, have not been formerly assessed, nor do they form part of the national and global reports. Here, we present reported and estimated catch data for the period 1950 to 2001 for the commercial and small-scale sectors, including catches that were formerly used for feeding sled-dog teams. During this period, it is estimated that small-scale marine fisheries were 27 times larger than the reported commercial catches suggest, and small-scale catches declined by 56 % overall. Excluding the sled-dog food component, the small-scale catches destined for human consumption increased from approximately 523 tonnes in 1950 to an average of nearly 1,200 tonnes in the 1970s, but declined to approximately 900 tonnes by the early 2000s. Arctic marine fisheries catches for the small-scale sector in terms of population (kg·person^{-1}·year^{-1}) reached an estimated peak of 268 kg in 1960 and were found to be 20.5 kg at the end of the study period.

INTRODUCTION

Canada's arctic fisheries occur within FAO statistical areas 18 and 21 (Figure 1). Fisheries and Oceans Canada (DFO) is Canada's federal agency responsible for fishery statistics, and it reports catch data for Canada, including the Central and Arctic region. The Central and Arctic region includes the coastal waters of the Yukon, the marine and inland waters of Nunavut, the Northwest Territories, Ontario and the prairie provinces of Alberta, Saskatchewan, Manitoba, while Quebec is its own separate region (DFO, 2006). However, existing reports allow for the estimation of the marine fish component of catches from arctic waters to be separated from the inland freshwater catches. The present study reports on marine fish catches taken by communities that fish the arctic waters of Canada (commercial and small-scale) for the period 1950-2001. One purpose of the study is to provide an estimate of marine fish catches to serve as a scientific baseline in the face of global warming, while both data and trends may also be of assistance in community and intercommunity development strategies. Although several studies and reports have been published previously, there has been no comprehensive review of potential historical catches, combining both small-scale catches with reported commercial catches, and there has been no expansion to cover the entire Canadian arctic.

Productivity in the marine waters of northern Canada is limited by low nutrient availability in the upper water layer caused by vertical stability, a lack of upwelling and the freeze/thaw cycle which dilutes available nutrients. In Hudson Bay, vertical stability is amplified by the large amount of freshwater inputs from various river sources. It is for these reasons that the commercial fishery potential has traditionally been considered to be low (Dunbar, 1970).

The Arctic Ocean region of Canada is characterized by small coastal communities with an extremely limited tax base and a high degree of dependence upon marine resources including mammals, as well as fish. The population is spread over a vast, often frozen coastline based in communities that are generally less developed than most others in Canada. Although the significance of subsistence fisheries has been recognized (Berkes 1990), this area has previously received little attention as a fishing culture, due in part to the small population and limited government services. The present study focuses on the marine fish catches of 56 northern communities (Appendix Table A1), which are thought to account for nearly the

[1] Cite as: Booth, S. and Watts, P.2007. Canada's arctic marine fish catches. p. 3-15. *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

entire human population in coastal arctic Canada. These communities are largely populated by Inuit, although some located on Hudson's Bay coast have large numbers of Algonkian, Athapaskan and Métis, as well as non-indigenous peoples. Most of these communities fall within FAO statistical area 18, but some on the east side of Baffin Island fall within FAO area 21 (Figure 1). The communities are linked by factors that include: cultural heritage, transportation routes, jurisdiction as well as ecological parameters thus providing opportunities for intercommunity coastal resource management, research and development. However, the distances involved and the cultural and jurisdictional diversity make strategic planning difficult.

Over the time period considered here, there has been a large change in the economics and infrastructure of these communities. Before the early 1950s, most Inuit were not living as much in fixed communities, but during the mid-1950s government based communities were established and the people adopted a less nomadic lifestyle. Dog-sled teams, the traditional mode of transportation, were replaced by the snowmobile starting in the early 1960s (Usher, 1972; 2002) and the subsistence economy, although still important, has become blended with a government, and market-based infrastructure. During the 1970s and 1980s there was an increasing tendency towards southern foods (Collings *et al.*, 1998) in part based upon the perception that many of the traditional foods were contaminated with toxins (Jensen *et al.*, 1997). There has also been a larger than 5-fold increase in the indigenous population of these communities, with an estimated growth from about 8,000 in 1950 to almost 44,000 in 2001.

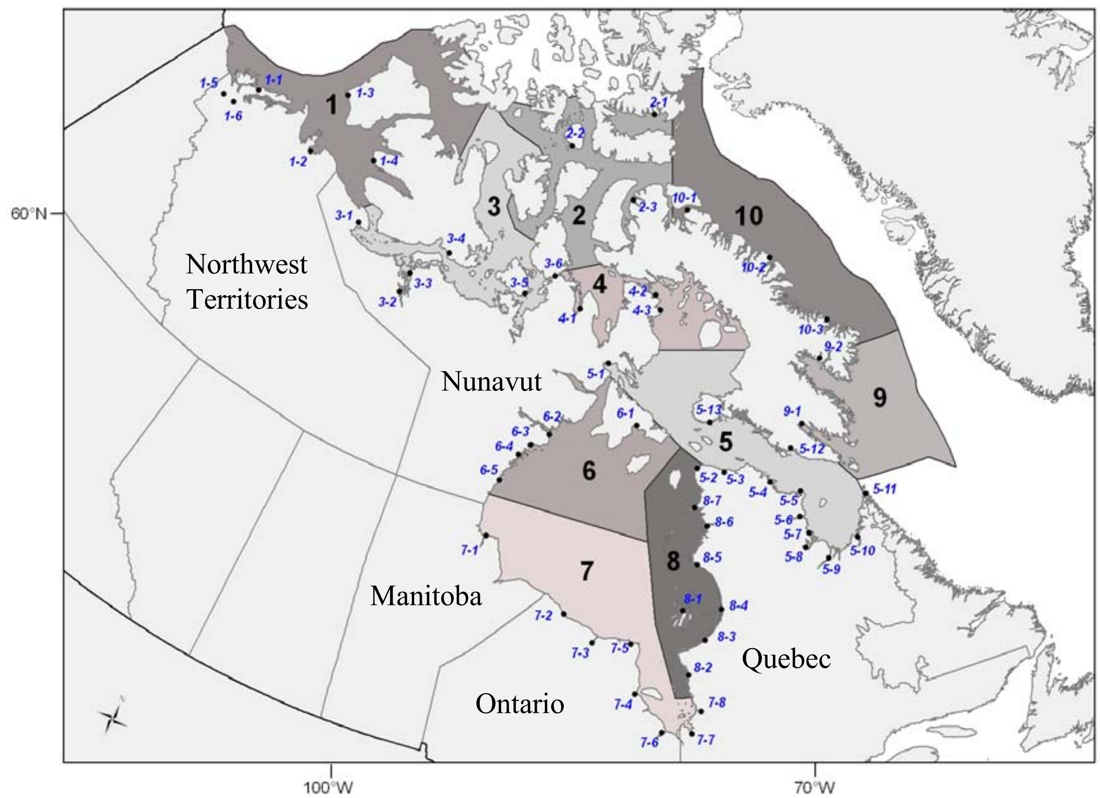

Figure 1: Map of Canada's arctic regions showing the territories and provinces as well as communities by regions (numbered; see Appendix Table A1 for community names).

MATERIALS AND METHODS

Estimates of commercial marine fish catches in round weight were taken from reports prepared by DFO, while small-scale catches were based on several reports detailing, by species, the number of fish taken. Numbers by taxon were converted to round weight as described below (see 'Small-scale fisheries data'). Since the small-scale reports did not cover the entire time period under consideration, catch data were transformed into per capita catch rates (by community) and combined with human population data to form the basis of the estimates for years when 'hard' data were not available. This method of interpolation between anchor points of hard data to estimate fishery catches has also been used elsewhere (Zeller *et al.*, 2006; Zeller *et al.*, 2007a).

Human population data

Population statistics for the 56 communities were taken from the Canada census undertaken every five years, and were adjusted to only represent the aboriginal population (Anonymous, 1954, 1963, 1973, 1977, 1978, 1983a, 1983b, 1996, 2001). Both the 1996 and 2001 census provide estimates of indigenous people's population by community, with most communities having greater than 90% of the population being self-identified as indigenous. Therefore, for communities that had this profile, this percentage was assumed to stay constant in time back to 1950, and is likely an underestimate for earlier periods. For communities in 1996 and 2001 that had less than 90% of the respondents identifying themselves as indigenous, the indigenous people's population was assumed to be 90% in 1950 and was then scaled linearly to the percentage presented in the 1996 census. Since the census data only provided 5-year snapshots of population numbers, a linear interpolation was done between census years. However, due to apparent erratic reporting during the early census years, the derived population numbers for each community were interpolated between the 1951 and 1971 estimates (Figure 2).

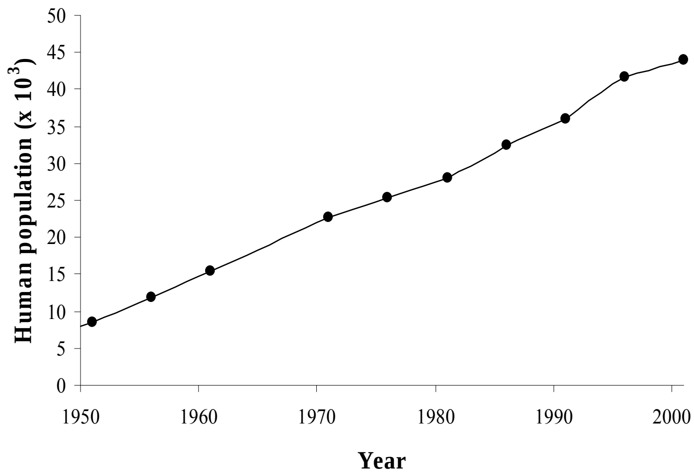

Figure 2: Estimated indigenous people's population (1950-2001) for the 56 coastal communities in Canada's arctic region

Commercial fisheries data

Studies reporting on the commercial catches of marine fishes taken in the Central and Arctic region have been reviewed by Crawford (1989) and Yaremchuk *et al.* (1989), as well as in a series of publications by Fisheries and Oceans Canada (DFO, 1991, 1992a, 1992b, 1993, 1994, 1995, 1996, 1997, 1999). Both Crawford (1989) and Yaremchuk *et al.* (1989) report on commercial catches taken from both marine and freshwater areas in the Northwest Territories and the two studies overlap in area and time. Crawford (1989) reports commercial data from the coastal arctic area including data from Rankin Inlet, Cambridge Bay, Pelly Bay (Kugaaruk), Iqaluit, Mackenzie Delta and other places combined, whereas Yaremchuk *et al.* (1989) describe commercial and test fisheries catches by community and location. Due to the greater detail given, only the work by Yaremchuk *et al.* (1989) was considered here. The data supplied in Yaremchuk *et al.* (1989) and the publications by Fisheries and Oceans Canada were geo-referenced using Google Earth, and capture locations were considered to be marine if they were located in ocean or estuarine areas.

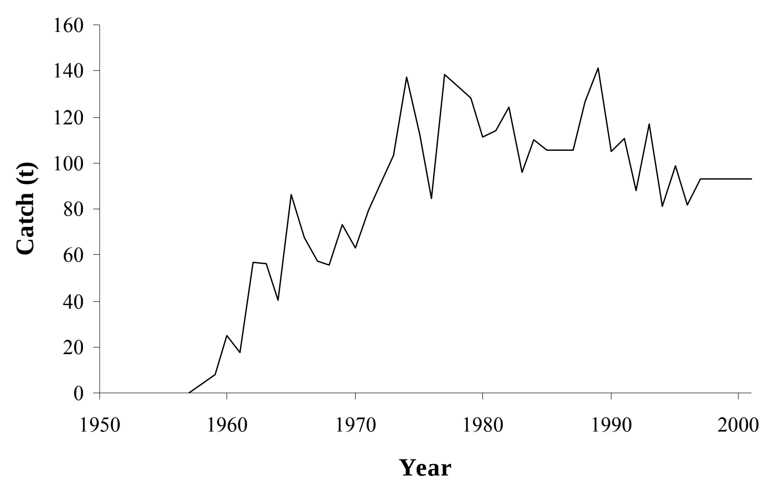

Figure 3: Commercial catches of marine fishes taken from marine waters in the Central and Arctic region from 1950-2001, as determined from national reports published by DFO.

Commercial fisheries in arctic marine waters started in the late 1950s, with the first commercial catches reported from Iqaluit in 1958, while commercial operations in Cambridge Bay, Killiniq and Whale Cove began in 1960 (Yaremchuk *et al.*, 1989). Between 1960 and 1996, 26 communities were determined to have commercial marine fisheries. For the period after 1996, the commercial data (Figure 3) represent a five-year average from the 1992-1996 Fisheries and Oceans Canada reports. Commercial fisheries in Canada's arctic tend to be distributed in space and time, following traditional practices, although some communities, e.g., Cambridge Bay, support yearly, seasonal fisheries (Kristofferson and Berkes, 2005).

Commercial data for the coastal communities located in Quebec and Ontario have not been estimated as it is assumed that the majority of commercial fisheries based in these provinces would be freshwater (Kierans, 2001). Test fisheries in FAO statistical area 21, primarily targeting turbot (*Reinhardtius hippoglossoides*) by large offshore trawlers (Anonymous, 2005), were not considered in this report.

Small-scale fisheries data

Although there are numerous definitions of small-scale fisheries, here we use the interpretation of the basic needs level as defined in the Nunavut Wildlife Harvest Study (NWHS; Priest and Usher, 2004). Although no explicit definition was given, it was acknowledged that it was the end use of fish that mattered. Thus, fish were considered to be part of the small-scale fishery if the fish were used in the fisher's community or entered into inter-settlement trade, but fish were not considered part of the small-scale fishery if the fish was for commercial sale. Therefore, we consider small-scale catches to be primarily subsistence in nature, including inter-community trading, but not those sold in the commercial market.

Small-scale catch data come from four studies. The earliest reported small-scale study used here was undertaken as a provision of the James Bay and Northern Quebec land claims agreement, and was meant to serve as a means to quantify guaranteed harvest levels to the indigenous inhabitants of the area (Anonymous, 1979), and it also estimated the caloric content of their diet. Data collected to estimate marine fish use were from the period 1974-1976.

Gamble (1988) reported on small-scale fisheries undertaken in the Keewatin region, for what was then the Northwest Territories (now part of Nunavut), for a four year period 1981-1986. However, only the data for the period 1982-1985 were used here, since data for other years were incomplete. Gamble (1988) reported on six coastal communities that were also a part of the NWHS (Priest and Usher, 2004). However, the data for Chesterfield Inlet, Coral Harbour and Whale Cove were not used, as their catches were judged to be exceedingly low, especially in comparison to the data reported in the NWHS. Data reported for Arviat, Rankin Inlet, and Repulse Bay were retained.

Two later studies, the ten year (1988-1997) Inuvialuit Harvest Study (IHS; Fabijian and Usher, 2003) and the five year (1996-2001) NWHS (Priest and Usher, 2004) also examined the basic needs level of the Inuit in the Inuvialuit Settlement region and in Nunavut as part of land claims agreements. Data collected in these reports were based on hunters' accounts of their monthly catch, with the term 'hunter' referring to hunters, fishers and collectors; for the remainder of the report we refer to 'fishers'. The data reported by fishers were converted into round weights using reported average weights and edible weight to round weight conversion factors (Appendix Table A2). Once converted into round weight, the data were transformed into per capita rates ($kg \cdot person^{-1} \cdot year^{-1}$) by taking the estimated total community harvest of that year and dividing it by the estimated human population for the community of that year. Thus, for each year and community represented in one of the four studies, a *per capita fish use rate* was determined, forming the best 'hard' data anchor points available.

The small-scale data collected in the original studies did not give locations of capture, and therefore the proportional commercial catch breakdown (marine vs. freshwater) was used to estimate the portion of reported small-scale catches taken in marine waters.

Human versus sled-dog use of fish resources

To account for changes in the life-style of the Inuit communities from the 1950s to the present, an additional anchor point was derived to account for the amount of fishery resources that were formerly used for feeding sled-dog teams. Sled-dogs formed the primary mode of transportation for Inuit into the late 1960s, early 1970s. However, the introduction of the snow-mobile in the 1960s led to a rapid decline in sled-dog teams, with their virtual disappearance as working dog-teams by the mid-1970s. Usher (2002) states that for 6 communities (Aklavik, Holman, Inuvik, Paulatuk, Sachs Harbour and Tuktoyaktuk) in the Inuvialuit Settlement Region the catch of marine and anadromous fish was approximately 4.3 times higher in the 1960s than compared to the annual mean harvest during the Inuvialuit study period (1988-1997), with the decline being largely due to the demise of the sled-dog teams. Therefore, the annual mean catch estimated during the Inuvialuit Harvest Study for the four coastal communities (Holman, Paulatuk, Sachs

Harbour and Tuktoyaktuk) were multiplied by 4.3 to derive estimated total catches for the year 1960. These 1960 catch estimates were converted into per capita use rates (kg·person^{-1}·year^{-1}) by dividing the catch estimates for each coastal community by the community's population for 1960. This allowed an average per capita use rate to be determined for 1960 which was, on average, 15.5 times higher compared to the average per capita use rate reported during the IHS (1988-1997).

Jessop (1974 in Usher, 2002) reported that in the 1960s, 75% of fish catches in the Mackenzie Delta were fed to sled-dog teams. Thus, the average per capita fish use determined for 1960 was split into a sled-dog feed component and a human consumption component using a 3:1 ratio. This resulted in the human component of per capita use rates to be approximately 3.9 times larger in 1960 than the rates estimated during the IHS period (1988-1997).

<u>Human use component</u>

For communities that were part of the IHS, the 1988-1997 estimated average per capita use rates for each community were multiplied by 3.9 to derive the human use component for the year 1960. The 1960 rates were linearly interpolated to the 1988 value (based on the 1988-1997 average), but were carried back unaltered from 1960 to 1950 (Figure 4). For communities that were not part of the IHS, the same method was used.

An average rate for the study period of the NWHS (1996-2001) was also determined for each community and the per capita use rates for 1960 were set at 3.9 times the 1996-2001 average, and linearly interpolated to the 1996 data point. The three communities of Arviat, Rankin Inlet and Repulse Bay, which form part of the NWHS (1996-2001) and Gamble's (1988) study (1981-1984) had their per capita use rates interpolated between two anchor points. For these three communities, the NWHS estimated mean per capita use rate for each community was multiplied by 3.9 to derive the human use component for the year 1960. The derived 1960 per capita use rates were linearly interpolated to the value estimated from Gamble (1988) for 1981. In turn, the value estimated for 1984 from Gamble (1988), was linearly interpolated to the estimated average value from the NWHS (e.g., Arviat, Figure 4).

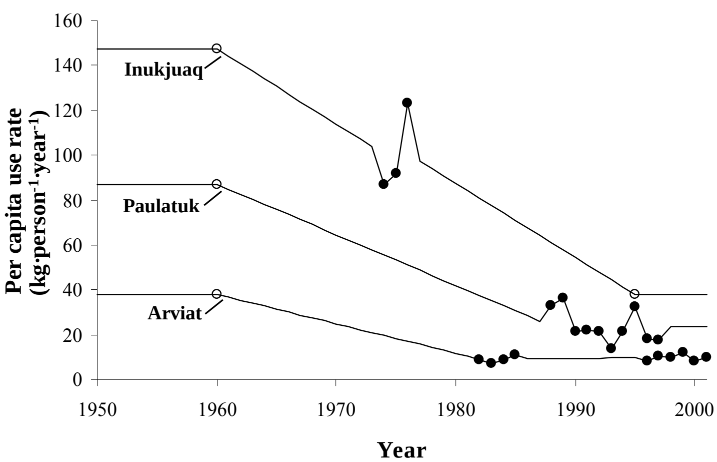

Figure 4: Representative examples of hard data anchor points (solid circles) for communities from small-scale studies, and the 1960 and 1995 (Inukjuaq, Quebec only) derived anchor points (open circles) for Inukjuaq (Anonymous, 1979); Paulatuk (Fabijian and Usher, 2003); and Arviat (Gamble, 1988; Priest and Usher, 2004).

Quebec communities had their per capita use rates scaled from the average estimated from 1974-1976 (Anonymous, 1979) to the per capita use rate determined for 1995, the median year reported from both the IHS and NWHS studies. The 1995 per capita use rate was considered to be 37.9 % of the 1974-1976 average (i.e., if the 1960 rates are 3.9 times the 1995 rate, then the 1995 value is 37.9% of the average estimated for 1974-1976). The 1960 rate was set to 3.9 times the 1995 per capita use rate. Since no other data were available for these communities, the estimated 1995 rate was carried forward to 2001 (e.g., Inukjuaq, Figure 4).

Twelve communities were not represented in any of the four previous studies (Appendix Table A1) and were thus entirely lacking data. For the nine mixed communities located around the southern portion of Hudson and James Bay a conservative estimate was used based on 10% of the average per capita use rate from Inukjuaq and Kuujarapik, the two nearest communities for which data were available. This very conservative assumption reflects the observation from a spatial land use study of these largely Cree communities, that suggested the majority of fishing occurred in freshwater (Berkes *et al.*, 1995). For the three other communities which are largely Inuit (Ivujivik, Puvirnituq and Umiujaq; Appendix Table A1, Figure 1), the average from Inukjuaq and Kuujarapik was applied unaltered.

<u>Sled-dog feed component</u>

The sled-dog feed component of per capita use rates were set at 3 times the derived 1960 human component of the per capita use rates (based on the reported 3:1 ratio; Usher, 2002), and were carried back unaltered to 1950. Going forward in time, the 1960 rate was scaled linearly to zero in 1975 for communities that are largely Inuit. Thus, we assume that 1974 was the last year that marine fish made up a significant part of sled-dog feed, since Usher (1972) states that by 1972 the transition from sled-dog teams to snowmobiles was virtually complete. For the mixed communities, along the southern portion of Hudson and James Bay, no sled-dog feed component was estimated.

RESULTS

Over the time period considered here, our estimated small-scale catches are approximately 27 times larger than reported commercial catches (Figure 5). Given that only commercial catches are reported by Canada to FAO, the global representation of Canada's arctic fisheries catches are substantially underestimated. Total catches may have doubled from 1950 to a peak in 1960 of approximately 4,000 tonnes before declining to catches of approximately 1,000 tonnes in the late 1990s. This overall decline is largely accounted for by the small-scale sector, and particularly by the sled-dog feed component. Although there has been a large human population increase, this has not translated into increased catches in the small-scale sector after 1960 due to the apparent changes in per capita fish use. Since 1975, catches have declined by approximately 21% in the small-scale sector and by approximately 17% in the commercial sector (Figure 5).

In the present study, small-scale per capita use rates were held constant for all communities from 1950 to 1960, and the overall average for all communities during this time period (1950-1960) was approximately 466 kg·person^{-1}·year^{-1}, or, with sled-dog feed component removed, 101

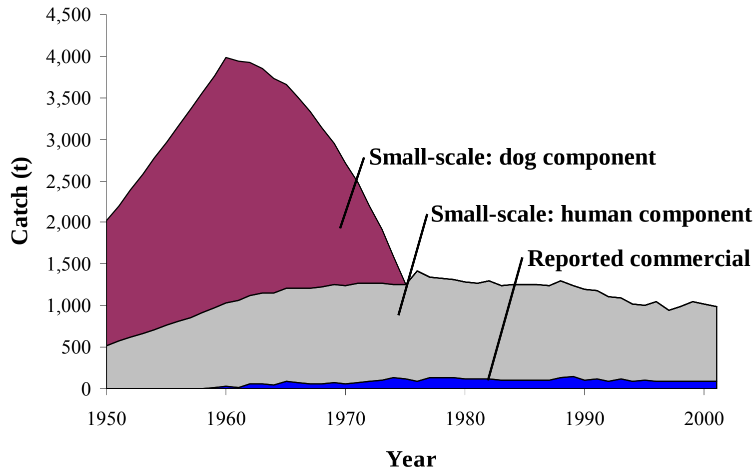

Figure 5: Canada's commercial and small-scale fishery catches in arctic marine waters, with catches for human and sled-dog use separated.

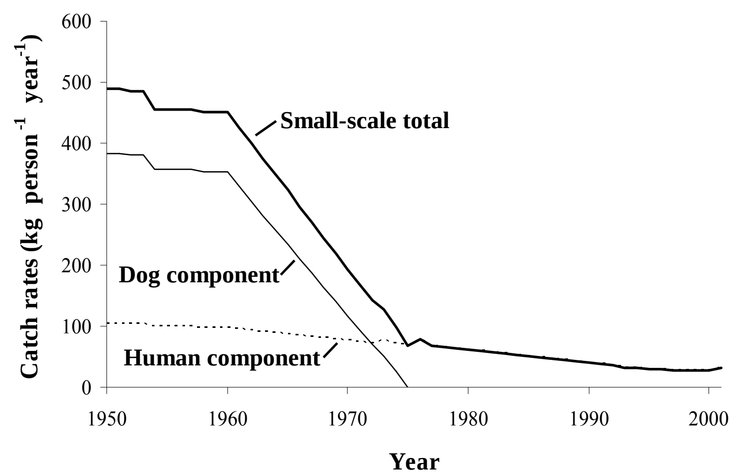

Figure 6: Per capita use rates of marine fish, averaged for all communities over the time period 1950-2001.

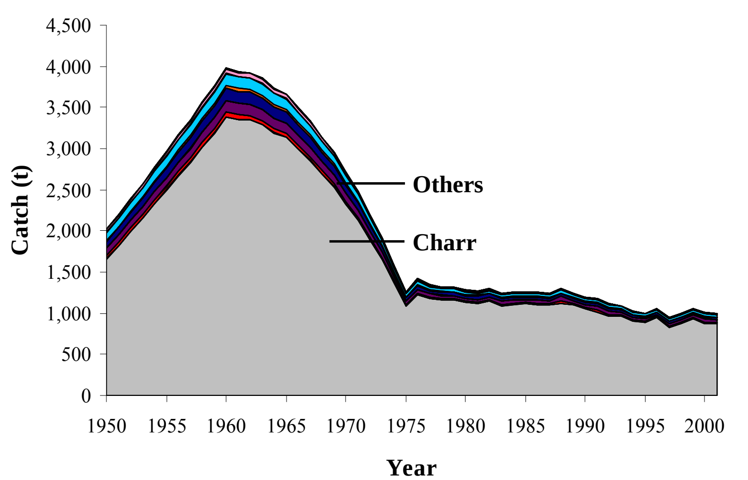

Figure 7: Estimated catches of marine fish in Arctic waters by common names (for species composition of 'others' and scientific names see Appendix Table A3).

kg·person^{-1}·year^{-1} as human use component. Thus, the increase noted from 1950 to 1960 only reflects the human population increase (and assumed concomitant increase in sled-dog teams). In 1975, the first year without the sled-dog feed component, the use rate fell to 68.1 kg·person^{-1}·year^{-1}, and has declined to 32.7 kg·person^{-1}·year^{-1} by 2001 (Figure 6; see Appendix Table A4 for data by region).

Taxonomic Breakdown

FAO, on behalf of Canada, only reports one taxonomic entity, charr (*Salvelinus alpinus*), over the entire time period, whereas here we report on catches of 17 taxonomic entities. Charr is clearly the dominant species accounting for an average of 86 % of total catches, whereas all other species combined account for 14% (Figure 7). However, of the 16 taxonomic entities reported, only 6 are reported for FAO area 21 (Appendix Table A3). It should also be noted that the family Gadidae comprises different species in different regions.

FAO Areas

Catches in FAO area 18 summed over the entire time period have been approximately 5 times larger than the Canadian catches in the arctic part of FAO area 21 (excluding Labrador; Figure 8). In 1950, the aboriginal population of the arctic communities in FAO area 21 made up approximately 5 per cent of the total arctic population, and catches within area 21 made up approximately 4.8% of total catches. By 2001 the aboriginal population accounted for approximately 14% of the arctic total, and catches matched to approximately 13.9 % of the total (Figure 8).

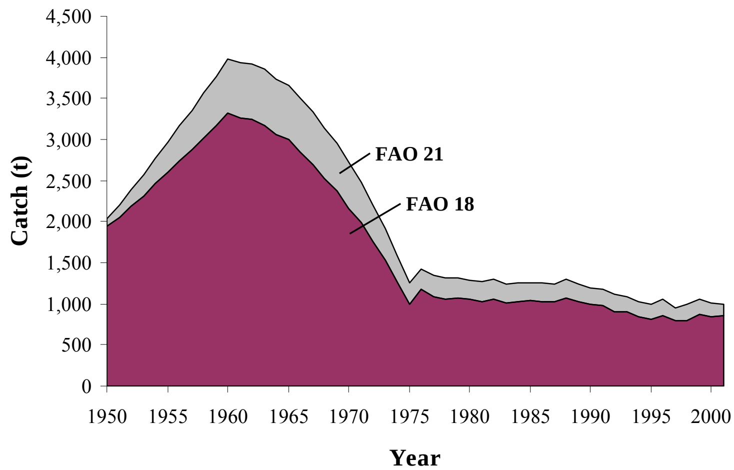

Figure 8: Total reconstructed catches taken in FAO statistical areas 18 and 21.

DISCUSSION

Here we present the first study to estimate the full extent of Canada's past marine fish catches in the Arctic. Although commercial catches are fairly well documented, there has been no such effort undertaken for the small-scale component, with previous studies documenting subsistence fisheries in Canada over relatively short time-spans (e.g., Gamble, 1988; Fabijian and Usher, 2003), and no expansion to consider the entire arctic has been done. The approach taken here provides estimates for years when there are no 'hard' data available. The development of community level fisheries self management systems (Berkes 1990) could potentially include periodic data collection with interpolations employed between survey periods, as suggested elsewhere (Zeller *et al.*, 2007a), thereby improving the inputs into public policy and decision making. The current work in terms of per capita use rates (kg·person^{-1}·year^{-1}) compares well with the study of Berkes (1990), who found an average use of 60 kg·person^{-1}·year^{-1} in his survey of subsistence fisheries in indigenous communities.

The small-scale component estimated here is 27 times larger than commercial catches and underlines the importance of the non-market economy. Changing the collected data from catch·fisher^{-1} to per capita marine fish use also reflects the importance of the non-market economy, since there are extended food sharing networks within and between communities (Collings *et al.*, 1998). Not formally considering estimates of small-scale catches can also lead to bias in national economic indicators (Zeller *et al.*, 2007b).

Global warming has already brought about some noticeable changes to the arctic environment, with the most prominent being the change in the extent and thickness of sea ice (Anonymous, 2003). Global warming will have direct effects on the biological productivity of the arctic and can also affect the livelihoods of the people, who often hunt for marine mammals at the ice edge. Strategies to adapt to this changing environment need to be considered both at the jurisdictional and local level. The change in sea ice conditions has also resulted in a shift of fauna associated with sea ice, with both the number of species and abundance of species being lower now than the 1970s (Melnikov *et al.*, 2002). Shifts in community structure have also been noticed in the northern Hudson Bay area, where the diet of nestling thick-billed murres (*Uria lomvia*) has changed as sea ice has decreased. Their diet has changed with a decrease in the amount of arctic cod (*Boreogadus saida*), sculpins (Cottidae) and eelpouts (Zoarcidae), and an increase in capelin (*Mallotus villosus*) and sandlance (*Ammodyte*s spp.) which are thought to be more typical of sub-arctic waters (Gaston *et al.*, 2003). There are also signs of other species appearing in the arctic, with Pacific salmon (*Oncorhynchus* spp.) showing up in the western arctic (Stephenson, 2006) and increased sightings of Killer whales (*Orcinus orca*) in Hudson Bay (Higdon *et al.*, 2006). The loss of sea ice has the potential to introduce new species into arctic areas, possibly creating a shift in community and ecosystem structure (e.g., Welch *et al.*, 1992; Mohammed, 2001).

The questions regarding how this changing ecosystem will affect the resource dependence and health of the peo0ple of the north will demand both local and jurisdictional attention and is exemplified by the region of Hudson Bay. Hudson Bay represents a major challenge in terms of global warming and related management systems since three provinces, a territory and the federal government have jurisdictional responsibility over these waters. The Bay also contains the only site in Canada where Algonkian, Athapaskan and Inuit people used the same area since pre-European contact, representing a unique cross cultural challenge.

The changes in the arctic ecosystem will affect the population living in the area, and it remains to be seen whether the anticipated and required changes will improve livelihoods. New ice conditions and new species may cause a challenge to these peoples in terms of meeting their basic need levels and ensuring food security. However, there have already been substantial changes in the diets of the people brought about by the introduction of foods imported from further south. Although country foods such as caribou and charr still play an important role in the mixed economy, the amount of country food on a per capita basis has declined, with the largest declines seen in the youngest generations (Blanchet *et al.*, 2000; Boult, 2004). The increased importance of southern foods, including foods rich in carbohydrates and sugars, has led to higher rates of obesity and obesity related diseases, such as type 2 diabetes (Young *et al.*, 2000). These changes in diet have largely occurred since the 1980s (Collings *et al.*, 1998).

The climate and the distances between arctic communities, together with underdeveloped infrastructure and economy, represent challenges. Mitigation of warming trends by the people living in this environment need to be considered in terms of resource management as a function of health, social accountability and cultural survival. Regardless of the roles adopted for local and jurisdictional organizations, the collection and use of fisheries and ecosystem data appears to be a growing priority.

Acknowledgements

This work forms part of the *Sea Around Us* project, funded by the Pew Charitable Trusts, Philadelphia, and located at the Fisheries Centre, University of British Columbia. We would like to thank D. Pauly and D. Zeller for their support and useful insights. We would also like to thank the Institute of Arctic Ecophysiology for providing access to a resource and report network on which this study was based. In particular we would like to thank the members of the Department of Fisheries and Oceans Canada who took personal time to assist: J. Mathias, M. Treble, P. Richard, J. Martin, and M. Dyck. We would also like to thank D. Malley for assistance in expanding the network of contacts.

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APPENDIX

Table A1: Coastal communities in Canada's arctic, their region and their associated community number used in Figure 1, separated by FAO statistical area; communities marked with an asterisk were missing fisheries data. Bathurst Inlet and Umingmaktok are reported as one community.

Community Name	Region	Community No.	Community Name	Region	Community No.
FAO statistical area 18			Kimmirut	5	12
Aklavik	1	5	Kugaruuk	4	1
Akulivik	8	7	Kugluktuk	3	1
Arctic Bay	2	3	Kuujuaq	5	9
Arviat	6	5	Kuujjuarapik	8	3
Attawapiskat*	7	4	Moosonee*	7	6
Aupaluk	5	7	Paulatuk	1	2
Bathurst Inlet	3	2	Peawanuck*	7	3
Cambridge Bay	3	4	Puvirnituq*	8	6
Cape Dorset	5	13	Quaqtaq	5	5
Chesterfield Inlet	6	2	Rankin Inlet	6	3
Chisasibi*	8	2	Repulse Bay	5	1
Churchill*	7	1	Resolute	2	2
Coral Harbour	6	1	Sachs Harbour	1	3
Eastmain*	7	8	Salluit	5	3
Fort Albany*	7	5	Sanikiluaq	8	1
Fort Severn*	7	2	Taloyoak	3	6
Gjoa Haven	3	5	Tasiujaq	5	8
Grise Fiord	2	1	Tuktoyaktuk	1	1
Hall Beach	4	3	Umiujaq*	8	4
Holman	1	4	Umingmaktok	3	3
Igloolik	4	2	Waskaganish*	7	7
Inukjuaq	8	5	Whale Cove	6	4
Inuvik	1	6	**FAO statistical area 21**		
Ivujivik*	5	2	Clyde River	10	2
Kangiqsualujjuaq	5	10	Iqaluit	9	1
Kangiqsujuaq	5	4	Pangnirtung	9	2
Kangirsuk	5	6	Pond Inlet	10	1
Killiniq	5	11	Qikiqtarjuaq	10	3

Table A2: Edible weights (kg) and edible to round weight conversion factors used to transform reported numbers of fish to round weight (kg). For scientific names see Appendix Table A3.

Common Name	Edible Weight (kg)	Source	Conversion Factor	Source
		Keewatin (Gamble, 1988)		
Arctic cod	0.225	Froese and Pauly (2007)	1.0000	n/a
Charr	2.500	Gamble (1988)	1.4375	Usher (2000)
Sculpins	0.175	Froese and Pauly (2007)	1.0000	n/a
		Inuvialuit (Fabijian and Usher, 2003)		
Arctic cisco	0.450		1.4444	Usher (2000)
Arctic cod	0.225	Froese and Pauly (2007)	1.0000	n/a
Broad whitefish	1.650	Usher (2000)	1.2121	Usher (2000)
Charr (Aklavik)	0.900	Usher (2000)	1.3846	Usher (2000)
Charr (Holman)	2.200	Usher (2000)	1.4194	Usher (2000)
Charr (Paulatuk)	2.300	Usher (2000)	1.4375	Usher (2000)
Charr (Sachs Harbour)	1.000	Usher (2000)	1.4286	Usher (2000)
Dolly varden	0.650	Usher (2000)	1.3846	Usher (2000)
Flounder	0.500	M. Treble, pers. comm.[a]	1.0000	n/a
Fourhorn sculpin	0.175	Froese and Pauly (2007)	1.0000	n/a
Inconnu	2.550	Usher (2000)	1.3333	Usher (2000)
Pacific herring	0.200	Usher (2000)	1.5000	Usher (2000)
Saffron cod	0.364	Fishbase	1.0000	n/a
		Nunavut (Priest and Usher, 2003)		
Charr	2.500	Gamble (1988)	1.4375	Usher (2000)
Arctic cisco	0.450	Usher (2000)	1.4444	Usher (2000)
Cod	0.872	Froese and Pauly (2007)	1.0000	n/a
Inconnu	2.550	Usher (2000)	1.3333	Usher (2000)
Least cisco	0.200	Froese and Pauly (2007)	1.0000	n/a
Sculpin	0.175	Froese and Pauly (,007)	1.0000	n/a
Turbot	1.400	Froese and Pauly (2007)	1.0000	n/a
		James Bay and Northern Quebec (Anonymous, 1979)		
Charr	4.500	Anon. (1979)	1.4375	Usher (2000)
Cod	2.500	Anon. (1979)	1.4375	Usher (2000)[b]
Salmon	8.500	Anon. (1979)	1.4375	Usher (2000)[b]
Sculpin	0.500	Anon. (1979)	1.2000	Usher (2000)[b]

[a] M. Treble, Fisheries and Oceans Canada, Winnipeg, MB, R3T 2N6, Canada. [b] Specific conversion factors were not available and the closest conversion factor in Usher (2000) was used.

Table A3: Common and scientific names for species reported in this study; common names marked with an asterisk are reported for FAO areas 18 and 21, all others are reported for FAO area 18.

Common Name	Taxonomic Name	Source
Arctic cod	*Boreogadus saida*	Gamble (1988)
Charr	*Salvelinus alpinus*	Gamble (1988)
Sculpins	Cottidae	Gamble (1988)
Arctic cisco	*Coregonus autumnalis*	Usher (2003)
Arctic cod	*Boreogadus saida*	Usher (2003)
Broad whitefish	*Coregonus nasus*	Usher (2003)
Dolly varden	*Salvelinus malma malma*	Usher (2003)
Charr	*Salvelinus alpinus*	Usher (2003)
Flounder	*Platichthys stellatus*	Usher (2003)
Fourhorn sculpin	*Triglopsis quadricornis*	Usher (2003)
Inconnu	*Stenodus leucichthys*	Usher (2003)
Pacific herring	*Clupea pallasi pallasi*	Usher (2003)
Saffron cod	*Eleginus gracilis*	Usher (2003)
Arctic cisco*	*Coregonus autumnalis*	Priest and Usher (2003)
Charr*	*Salvelinus alpinus*	Priest and Usher (2003)
Cod*	*Boreogadus saida* + *Gadus morhua* + *G. ogac*	Priest and Usher (2003)
Inconnu	*Stenodus leucichthys*	Priest and Usher (2003)
Least cisco*	*Coregonus sardinella*	Priest and Usher (2003)
Sculpin*	Cottidae	Priest and Usher (2003)
Turbot*	*Reinhardtius hippoglossoides*	Priest and Usher (2003)
Arctic charr	*Salvelinus alpinus*	Anonymous (1979)
Cod	*Boreogadus saida* + *Gadus morhua* + *Microgadus tomcod*	Anonymous (1979)
Salmon	*Salmo salar*	Anonymous (1979)
Sculpin	*Triglopsis quadricornis*	Anonymous (1979)

Table A4: Small-scale per capita use rates of marine fish determined for the 10 regions, divided into the amount used for sled-dog teams and for human use.

Region	Dog Component			Human Component			
	Min (Year)	Max (Year)	Mean (1950-1974)	Min (Year)	Max (Year)	2001	Mean (1950-2001)
1	10.4 (1974)	177.8 (1953)	115.5	15.0 (1997)	59.3 (1953)	19.0	35.8
2	7.3 (1974)	250.9 (1953)	101.5	8.1 (1998)	83.6 (1953)	9.4	27.9
3	32.6 (1974)	489.6 (1960)	352.5	32.7 (1998)	163.2 (1960)	106.6	109.8
4	23.9 (1974)	357.9 (1960)	257.7	15.7 (2000)	119.3 (1960)	27.3	79.3
5	31.5 (1974)	473.1 (1960)	340.7	40.5 (2000)	157.7 (1960)	40.6	102.9
6	17.2 (1974)	278.4 (1951)	192.1	13.6 (1997)	92.8 (1951)	17.0	54.6
7	n/a	n/a	n/a	2.1 (1995)	8.2 (1960)	2.1	5.4
8	43.1 (1974)	354.6 (1960)	257.6	41.7 (2000)	140.1 (1974)	44.0	83.4
9	32.5 (1974)	487.3 (1960)	350.9	33.5 (2001)	162.4 (1960)	33.5	108.1
10	22.3 (1974)	334.6 (1960)	240.9	17.9 (2000)	111.5 (1960)	18.1	74.2

MARINE FISH CATCHES IN NORTH SIBERIA (RUSSIA, FAO AREA 18)[1]

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ABSTRACT

The four Large Marine Ecosystems (Kara, Laptev, East Siberian and Chukchi Seas) that comprise Arctic Russia suffer from poor quality of fisheries data, and the FAO statistics for this area are too low to be credible. With the development of larger scale commercial fisheries in the region likely under global warming, it is imperative that past and current states of fisheries in the region are assessed, to provide a baseline with which to gauge any future development. Following an extensive online literature search, we were able to assemble a list of qualitative and quantitative descriptions of fisheries in the region (in particular catch statistics for anadromous *Coregonus* species from the 1980s to the early 1990s), from which we have generated time series of estimated catches for the region for the period from 1950 to 2004. We estimate that fisheries catches in the Kara Sea underwent a decline from around 15,000 tonnes in 1950 to an average of about 4,000 in the 1980s, and that they continue to decline, though at a lower rate. On the other hand, we had no basis for inferring a decline in the other three ecosystems. Instead, we estimated average catches in both the Laptev and East Siberian Seas to be around 4,000 tonnes·year^{-1}, and a catch of 100 tonnes·year^{-1} for the Russian section of the Chukchi Sea. We look forward to comments on these estimates, which, although tentative, are likely to be more accurate than the figures they are meant to replace.

INTRODUCTION

The Arctic, generally defined as the area within the 10°C summer isotherm, has about 4 million human inhabitants. FAO Fisheries Statistical Area 18, ranging from Novaya Zemlya in the east to the Hudson Bay in the west, is comprised of the Siberian coast (Russia), the Arctic coasts of Alaska (USA) and Canada, or about two-third of the entire Arctic region. FAO Area 18 is also an area with low fish catches and low fishery productivity. This is particularly the case along the Siberian coast, for which FAO reports catches which are too low to be credible (see www.fao.org), even considering the remoteness and harshness of the environment, which limits the development of fisheries. This may be due, in part, to Russia not joining FAO as a member until 2006. While the former USSR participated in the formation of the FAO, and had observer status, it never formally joined the organization.

This situation is likely to change under global warming, as the entire region is likely to become more accessible by sea, especially for fishing vessels. Hence, the development of fisheries in the region appears likely, if not inevitable. Thus, there is now an urgent need to establish a baseline against which future development can be assessed. Moreover, the assemblage of realistic historic fisheries catch time series for this part of the world will enable coverage of four Large Marine Ecosystems (LMEs), the Kara, Laptev, East Siberian and Chukchi Seas, for which hitherto, no reasonable fishery data have been available.

However, this report being a first attempt – at least in the English language – to establish a time series of fisheries catches for this part of the world, it must be stressed that it was written primarily as a starting point for our Russian and other colleagues with better data to work from (or against, as the case might be). We are under no illusion as to the quality of the data we present. We only believe that they are less wrong than what is available to date (mainly nothing), a theme to which we shall return in the Discussion.

An extensive online literature search was conducted, but yielded comparatively few sources of information on Russian Arctic fisheries in English, and even fewer in other languages that we master (French, German, Spanish and Japanese). Numerous references were found in which "fishing" by the indigenous peoples of Northern Siberia was mentioned (see also www.raipon.org), notably by anthropologists, but very few of

[1] Cite as: Pauly, D. and Swartz, W. 2007. Marine fish catches in North Siberia (Russia, FAO Area 18). p. 17-33. *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

them provided quantitative information. This is, regrettably, also the case with anthropologists working in warmer climes (Pauly 2006).

However, one source of data was found which proved to be extremely useful, the working papers of the International Northern Sea Route Programme (INSROP) conducted from 1993 to 1999. This project involved scientists from Norway, Russia, Japan and other countries, and explored the implications of possible operation of a regular shipping lane from Northern Europe to Japan and beyond - the legendary Northeast Passage – and its potential impact on the Siberian marine ecosystems (see www.fni.no/insrop/).

The project also studied the potential effect of a Northern Sea Route (NSR) on marine mammals (Wiig *et al.* 1996, Belikov *et al.* 1998, Thomassen *et al.* 1999), seabirds (Gavrilo *et al.* 1998) and invertebrates (Larsen *et al.* 1995). Significant in the present context, the project also included a volume devoted mainly to fisheries (Larsen *et al.* 1996), which we used extensively here, complemented by a smattering of heterogeneous sources.

The fisheries catch data in Larsen *et al.* (1996), also presented in the atlas of Brude *et al.* (1998), were obtained from the State Institute of Lake and River Fisheries (GOSNIORKH), then the relevant line agency in Russia. These data pertain almost exclusively to catches made with fixed and drifting gill nets, drag seines, trap nets and under-ice nets, which are all small-scale, artisanal gears. There is another management body, the National Administration for Fishery Enforcement, Resource Restoration, and Fishing Regulation (GLAVRYBVOD), which "regulates the industrial harvest of fish, marine mammals and plants in Russia's internal waters, on the continental shelf and in the two-hundred-mile Exclusive Economic Zone" (Newell 2004, p. xvi), but its relationship – if any – with GOSNIORKH is not clear.

The available data are highly fragmented and could be vastly improved by more complete information becoming available from present institutional arrangements and/or from colleagues working on these fisheries and with these institutions. Indeed, we sincerely hope that our Russian and other colleagues with first-hand knowledge of the Arctic will correct and improve our view of their fisheries and ecosystems, and the figures presented here.

In this report, the available fisheries data and our estimates are presented by Large Marine Ecosystems, from east to west, the Kara Sea, the Laptev Sea, the East Siberian Sea and the Chukchi Sea (Table 1).

Table 1. Oceanographic features of the Kara, Laptev, East Siberian and Chukchi Seas Large Marine Ecosystems relevant to their fisheries.

Property (Units)	Kara Sea	Laptev Sea	E. Siberian Sea	Chukchi Sea
Area (km²)	797,171	499,039	926,721	556,899
Mean depth (m)	127	578	1350	1004
Ice free shelf area (km²)	948,120	623,356	370,178	455,197*
Inshore fishing area (km²)	272,590	125,348	131,891	38,445*
Major river systems [from west to east]	Ob, Yenisei, Pyasina, Taimyrskaya	Khatanga, Lena, Yana	Indigirka, Kolyma	None
Primary production ($mgC \cdot m^{-2} \cdot day^{-1}$)	410	479	182	382

*ice free shelf and inshore fishing areas for the Chukchi Sea denote the areas that fall within the Russian Exclusive Economic Zone

THE FISHERIES OF THE KARA SEA

The Kara Sea is bounded to the west by the Novaya Zemlya islands and to the east by the Severnaya Zemlya islands (Figure 1). Its oceanography is complex (see e.g., Fetzer *et al.* 2002). Being adjacent to the Barents Sea, the Kara Sea benefits from the occasional intrusion of 'warm' water and the accompanying fauna, "as apparently occurred during 1919-1938, when a strong inflow of warm Atlantic water into the Kara Sea, Northern Russia, led to the eastward expansion of salmon" (Fleming and Jensen 2002).

However, except for these occasional strays, the fish fauna of the Kara Sea is as species-poor as the Laptev and East Siberian Seas further to the east (Table 2). Also, the bulk of the fisheries catches is contributed by the same group, which also accounts for the bulk of the catch in the Laptev and East Siberian seas, that is, fishes of the genus *Coregonus*, (Subfamiliy Coregoninae, Family Salmonidae; see www.fishbase.org), collectively known as 'whitefishes', or 'sig' in Russian. Larsen *et al.* (1996) wrote that catches of "eight species of [the genus *Coregonus*] have been recorded, from which 6 species make up 70 to 90 % of the total recorded landings from the area". Based on this, we will assume that the catches of fish other than coregonids in the Kara Sea constitute 20% of total catches.

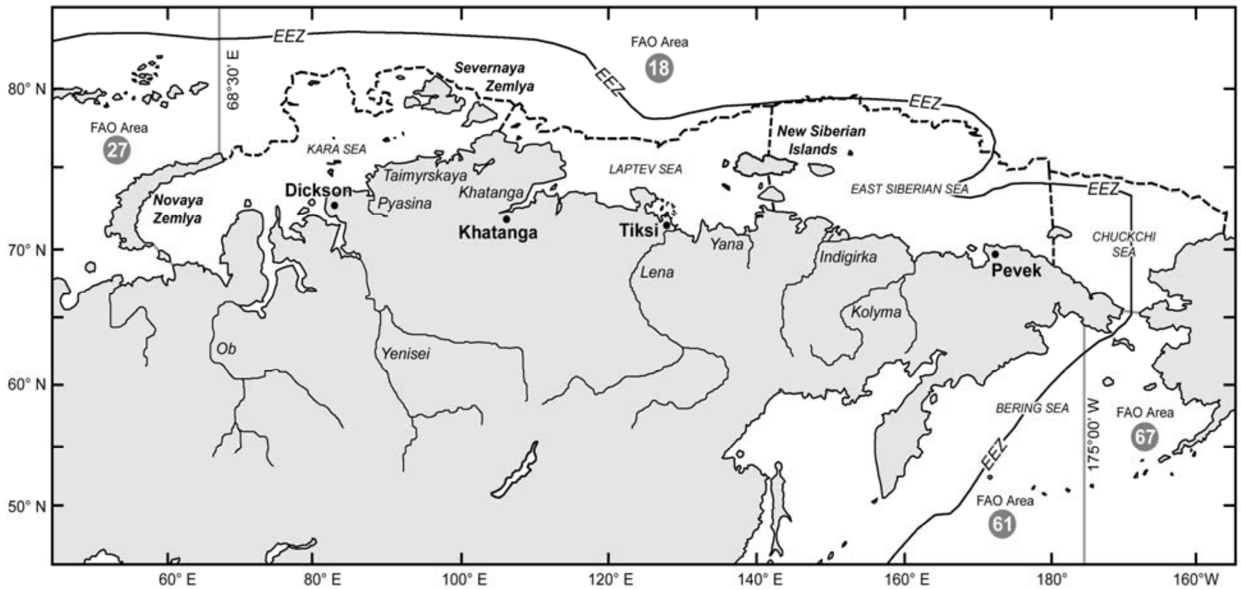

Figure 1. Map of Northern Siberia (Russian Federation), showing the extent of the Kara, Laptev, East Siberian and Chukchi Seas Large Marine Ecosystems, major rivers and their estuaries, and other features discussed in the text.

Coregonids are caught in the lower reaches of rivers, in the estuaries and in the surrounding coastal areas, notably in the giant estuaries of the rivers Ob and Yenisei. Slavin (1964) writes "the waters of the Ob are rich in fish. Up to 30,000 tons (66 millions lbs) are now landed there annually, including such rare species as white salmon and sturgeon."

Unfortunately, with the exception of *Coregonus muksun* for which scattered pre-1950 data exist, depicting elevated catches from the Yenisei River from 1934 to 1937 and from 1940 to 1943, the time series of catch data, from Larsen et al. (1996), based on reports from GOSNIORKH, cover only the years for 1980 to 1994 for the Ob Bay and 1989/1991 to 1994 for other tributaries. All four tributaries show a clear declining trend around a mean of 225 tonnes•year-1, which, extrapolated backward, would correspond to a coregonid catch of about 12,500 tonnes in 1950.

Moreover, Vilchek et al. (1996) writes that "The total catch in the Ob' in the late 1930s reached 34,140 tons or more, 22, 950 tons being from the lower reaches of the Ob'. By the mid-1940s the total catch in the Ob' basin was at a record level – 80, 400 tons; in the early 1950s it began to drop to 50, 000-55, 000 tons. Now the catches in the Ob' Gulf and the lower Ob' amount to only 150.8 and 374.5 tons, respectively. A similar picture can be observed in virtually all the rivers and seas of the Arctic".

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Acantholumpenus mackayi (Pighead prickleback)	√			√	North Pacific from Japan to the Okhotsk and Bering seas, and in Arctic Ocean. Some fisheries.
Acipenser baeri (Longnose Siberian sturgeon)	√	√	√		Anadromous. Found in Siberian rivers Ob, Irtysh, Yenisei, Lena, and Kolyma. Highly commercial.
Ammodytes hexapterus (Pacific sand lance)		√	√	√	Arctic and Pacific from Arctic Alaska to the Sea of Japan. Some commercial fisheries, sometimes targeted for fishmeal.
Anarrhichthys ocellatus (Wolf-eel)		√	√	√	In North Pacific from Sea of Okhotsk and Sea of Japan to the Aleutian chain and California. Minor commercial fisheries.
Anisarchus medius (Stout eelblenny)		√	√	√	North Pacific, Northwest Atlantic and Arctic. Some fisheries.
Arctogadus borisovi (East Siberian cod)		√	√	√	Arctic and North Atlantic including coasts of Siberia. Targeted for subsistence fisheries.
Arctogadus glacialis (Arctic cod)		√	√	√	Widely distributed in western part of Arctic basin. Minor commercial fisheries.
Artediellus scaber (Hamecon)	√			√	Southeastern part of Barents Sea to northern part of Bering Sea.
Aspidophoroides bartoni (Aleutian alligatorfish)				√	North Pacific and Arctic Ocean.
Bathymaster signatus (Searcher)		√	√	√	East Siberian Sea to eastern Kamchatka. From the Sea of Okhotsk to Washington, USA. Some fisheries.
Boreogadus saida (Polar cod)	√	√	√	√	Circumpolar in the Arctic. Highly commercial.
Careproctus reinhardti (Sea tadpole)	√	√			Kara and Laptev seas, Faroe-Shetland Channel to the Norwegian Sea, Spitsbergen, Murmansk and throughout Barents Sea.
Careproctus solidus		√			Laptev Sea.
Clupea pallasii (Pacific herring)	√	√	√	√	White Sea to Ob Bay in the Arctic and eastern Kamchatka to the Aleutian. Highly commercial.

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Coregonus autumnalis (Arctic cisco)	√ *	√ *	√ *	√	Russian name: **омуль**. Anadromous, in Barents Sea and coasts and rivers of Siberia. Some commercial fisheries.
Coregonus laurettae (Bering cisco)	√ *	√ *	√ *	√	Russian name: **беринговоморский омуль**. Anadromous. From Alaska to Chukotsk and Kamchatka regions of Siberia. Some subsistence fisheries.
Coregonus muksun (Muksun)	√	√	√		Russian name: **муксун**. Anadromous. Low-salinity portions of the Arctic Ocean. From Kara River to Kolyma River. Highly commercial.
Coregonus nasus (Broad whitefish)	√ *	√ *	√ *	√	Russian name: **Чир**. Anadromous. In the Arctic basin east of Pechora River. Targeted for commercial and recreational fisheries.
Coregonus pidschian (Humpback whitefish)	√	√	√	√	Russian name: **сиг-пыжьян**. Anadromous. Distribution ranges from Sweden to the western Bering Sea and the Sea of Okhotsk. Some commercial fisheries.
Coregonus sardinella (Sardine cisco)	√ *	√ *	√ *	√	Russian name: **ряпушка сибирская**. Anadromous. From Bering Sea to Kolyma and Kara Rivers. Some commercial fisheries.
Cyclopteropsis jordani (Smooth lumpfish)	√				Kara Sea to Baffin Island at Admiralty Inlet, Canada.
Eleginus gracilis (Saffron cod)				√	North Pacific from Yellow Sea to Alaska and from Cape Lisburne, Chukchi Sea to Dease Strait. Highly commercial.
Eleginus nawaga (Navaga)	√	√	√	√	White, Barents and Kara seas from Kola Bay to Ob Bay. Some commercial fisheries.
Eumesogrammus praecisus (Fourline snakeblenny)				√	Sea of Okhotsk, Bering Sea and Arctic Alaska in the North Pacific.
Eumicrotremus andriashevi (Pimpled lumpsucker)				√	Northeastern Chukchi Sea to eastern Bering Sea.
Eumicrotremus derjugini (Leatherfin lumpsucker)	√	√	√	√	Arctic Ocean, Barents Sea, Franz Josef Land, Spitsbergen, eastern Greenland, Kara, Laptev, Siberian and Chukchi seas and the Sea of Okhotsk.
Eumicrotremus orbis (Pacific spiny lumpsucker)				√	Chukchi Sea and Sea of Okhotsk to Muroran, Hokkaido (Japan), Amchitka Island in the Aleutian chain and Puget Sound, Washington, USA. Some fisheries.
Gymnelus andersoni	√	√			Spitsbergen, north, central and eastern parts of the Barents Sea off Nova Zemlya and in the Kara Sea; in the Shokalskii Straight and western part of the Laptev Sea.

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Gymnelus barsukovi		√	√	√	Western Laptev Sea to the Bering Strait; Canadian Arctic to Ungava Bay.
Gymnelus esipovi	√				Arctic Ocean.
Gymnelus hemifasciatus (Bigeye unernak)	√				Kara Sea east to Canada and in the Bering and Okhotsk seas.
Gymnelus platycephalus				√	Northern Bering Sea and Chukchi Sea.
Glymnocanthus pistilliger (Threaded sculpin)				√	Sea of Japan and the Sea of Okhotsk to the Chukchi Peninsula and Norton Sound, Alaska to Kiska Island in the Aleutian chain and southeastern Alaska. Some fisheries.
Gymnocanthus tricuspis (Arctic staghorn sculpin)	√	√	√	√	Eastern coasts of Greenland, Iceland, northern coast of Norway to White Sea and throughout Barents Sea to Spitsbergen and Novaya Zemlya.
Hemilepidotus papilio (Butterfly sculpin)				√	From Chukchi Sea in the Arctic to Sea of Okhotsk and the Aleutian in the North Pacific.
Hemilepidotus zapus (Longfin Irish lord)				√	Northern Kuril Islands, Bering Sea and Aleutian Islands, Alaska.
Hexagrammos stelleri (Whitespotted greenling)				√	Peter the Great Bay, Russia and the Sea of Japan to Cape Lisburne in the Chukchi Sea, Unimak Island in the Aleutian chain and Oregon, USA. Minor commercial and game fisheries.
Hippoglossoides robustus (Bering flounder)				√	Hokkaido, Japan and the Sea of Okhotsk north to northeast of Cape Lisburne, south to northwest of Akutan Island, Aleutian chain, Alaska.
Hippoglossoides stenolepis (Pacific halibut)				√	Hokkaido, Japan and the Sea of Okhotsk to the southern Chukchi Sea and Point Camalu, Baja California, Mexico. Highly commercial.
Icelus bicornis (Twohorn sculpin)	√	√	√	√	Greenland, Iceland, Jan Mayen, Spitsbergen, Barents and Kara seas, Bohuslän in Norway.
Icelus spatula (Spatulate sculpin)	√	√	√	√	Arctic Ocean to Ungava Bay, Gulf of St. Lawrence in Canada and Greenland; Kara Sea and southeastern part of Barents Sea. Some fisheries.
Lampetra camtschatica (Arctic lamprey)				√	Anadromous. Range from the Siberian coast to Anderson River in Canada. Some commercial fisheries.

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Leptagonus decagonus (Atlantic poacher)	√				Arctic Ocean to Grand Bank and Gulf of St. Lawrence, Canada in western Atlantic; Spitsbergen and Finmarken coasts in Norway to White Sea, Barents Sea and Kara Sea; also Iceland and Greenland, and Okhotsk and Bering Seas.
Leptoclinus maculatus (Daubed shanny)				√	Arctic Alaska to Sea of Okhotsk, northern Sea of Japan, Unalaska Island in the Aleutian chain and Puget Sound, Washington, USA.
Limanda aspera (Yellowfin sole)				√	Korea and the Sea of Japan to the Sea of Okhotsk, Bering Sea, and Barkley Sound, Canada. Highly commercial.
Liopsetta glacialis (Arctic flounder)	√	√	√	√	Barents and White Sea to the coasts of Siberia and the Bering Seas to Bristol Bay, Alaska and the northern Sea of Okhotsk. Minor commercial fisheries.
Liparis gibbus (Variegated snailfish)	√	√	√	√	Arctic, North Pacific and North Atlantic.
Lumpenus fabricii (Sledner eelblenny)	√	√	√	√	Circumpolar.
Lycenchelys kolthoffi	√	√	√		North of Novaya Zemlya and northern part of Kara Sea and in Greenland, Hudson Strait, north of Iceland, Faroe Islands, Svalbard and Laptev Sea.
Lycenchelys muraena	√				Norwegian Sea, Kara Sea and Northwest- and East Greenland.
Lycodes eudipleurostictus (Doubleline eelpout)	√	√	√	√	Arctic Alaska, Smith Sound, northwest Greenland, Kara Sea, Barents Sea, Spitsbergen, Norway, Iceland, northeast Greenland, and western Greenland.
Lycodes frigidus		√	√	√	Northern Laptev Sea, East Siberian and Chukchi seas.
Lycodes jugoricus (Shulupaoluk)	√	√	√	√	White Sea and southern parts of the Kara Sea; Laptev Sea, New Siberian Isles, Near mouth of the Kolyma River and near Herschel Island in the Beaufort Sea.
Lycodes mucosus (Saddled eelpout)				√	From Sea of Okhotsk to Arctic Canada.
Lycodes palearis (Wattled eelpout)				√	Point Hope, Alaska in the Chukchi Sea to Peter the Great Bay (Sea of Japan), Agattu Island (Aleutian chain) and Oregon, USA.
Lycodes pallidus (Pale eelpout)	√	√	√	√	Kara Sea, western part of Laptev Sea, Beaufort Sea and Arctic Canada.
Lycodes polaris (Canadian eelpout)	√	√	√	√	Nearly circumpolar along Arctic coasts of Asia and North America.

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Lycodes raridens (Marbled eelpout)				√	Sakhalin, Russia and the Okhotsk Sea to Bristol Bay and Alaskan Arctic.
Lycodes reticulates (Arctic eelpout)	√	√			West of Boothia Peninsula (Northwest Territories, Canada) and the northern parts of Kara and Laptev Seas.
Lycodes rossi (Threespot eelpout)	√	√	√	√	Kara Sea to Beaufort Sea.
Lycodes sagittarius (Archer eelpout)	√	√	√	√	Kara Sea to Beaufort Seas. May occur in the Barents Sea.
Lycodes seminudus (Longear eelpout)	√	√	√	√	Franklin Bay, North Western Territory and Alaska; also the Kara and Beaufort seas.
Lycodes turneri (Polar eelpout)	√			√	Arctic reaches of Canada to northern Gulf of Lawrence in Canada, Alaskan Arctic to the eastern Bering Sea.
Mallotus villosus (Capelin)	√	√	√	√	Circumpolar in the Arctic.
Megalocottus platycephalus (Belligerent sculpin)				√	North Pacific.
Myoxocephalus jaok (Plain sculpin)				√	Northern Sea of Japan to the Bering Sea and southeastern Alaska.
Myoxocephalus scorpius (Shorthorn sculpin)	√	√	√	√	Greenland, Jan Mayen Island, Iceland to Bay of Biscay; North and Baltic Seas, Spitsbergen and southern part of Barents Sea; throughout the Arctic Ocean.
Myoxocephalus stelleri (Steller's sculpin)				√	Northwest Pacific from northern Japan to the western Bering Sea.
Myoxocephalus verrucosus (Warty sculpin)		√	√	√	Laptev Sea and Chukchi Sea to the Kamchatka Gulf, Adak Island in the Aleutian chain and British Columbia, Canada.
Occella dodecaedron (Bering poacher)				√	Kotzebue Sound to the northern Sea of Japan, Sea of Okhotsk and Akun Island in the Aleutian chain and adjacent Arctic, including Gulf of Alaska.
Oncorhynchus gorbuscha (Pink salmon)				√	Anadromous. From Northwest Territories (Canada) to southern California, Bering and Okhotsk Seas. Highly commercial.

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Oncorhynchus keta (Chum salmon)		√	√	√	Anadromous. Korea, Japan, Okhotsk and Bering Sea, Arctic Alaska south to San Diego, California, USA. Highly commercial.
Oncorhynchus kisutch (Coho salmon)				√	Anadyr River in Russia south towards Hokkaido, and from Point Hope in Alaska southwards to Chamalu Bay in Baja California, Mexico. Highly commercial.
Oncorhynchus nerka (Sockeye salmon)				√	Anadromous. Northern Japan to Bering Sea and to Los Angeles, California, USA. Highly commercial.
Oncorhynchus tshawytscha (Chinook salmon)				√	Anadromous. Alaska to Ventura River, California, USA. Bering Sea and Sea of Okhotsk, Hokkaido; Coppermine River in the Arctic. Highly commercial.
Osmerus mordax (Arctic rainbow smelt)	√	√	√	√	Anadromous. North Korea and the Sea of Okhotsk, British Columbia, north to the Bering Sea and the Arctic. Also known from the White Sea. Some commercial fisheries.
Platichthys stellatus (Starry flounder)		√	√	√	Catadromous. Korea and southern Japan, the Bering Strait and Arctic Alaska to Northwest Territories, Canada; also southern California, USA. Commercial fisheries.
Pleuronectes quadrituberculatus (Alaska plaice)				√	Peter the Great Bay to Point Hope in the Chukchi Sea south to Unalaska Island and east to Kayak Island in southeast Alaska. Some commercial fisheries.
Podothecus acipenserinus (Sturgeon poacher)				√	Western Bering Sea south of Cape Navarin to Commander Islands, and Pacific Ocean to Sea of Okhotsk off southwestern Kamchatka and northern Kuril Islands; eastern Bering Sea and Aleutian Islands from Attu Island to northern California.
Pungitius pungitius (Ninespine stickleback)				√	Anadromous. Circumarctic. Some subsistence fisheries.
Reinhardtius hippoglossoides (Greenland halibut)				√	Sea of Japan off Honshu north to Shishmaref, Alaska in the Chukchi Sea, throughout the Aleutian Islands, to northern Baja California, Mexico. N.E. USA to Spitsbergen (Svalbard Islands) and the Barents Sea. Highly commercial.
Salvelinus alpinus (Charr)			√	√	Anadromous. Arctic. Minor commercial fisheries.
Salvelinus malma (Dolly varden)			√[**]	√	Anadromous. Distributed over a large area of the Arctic coast toward the south of the Bering Strait.[**] Some commercial fisheries.
Salvelinus taranetzi (Taranets)			√[**]	√[**]	Anadromous. Widely distributed in the eastern sector of the Arctic.[**]
Somniosus pacificus (Pacific sleeper shark)		√	√	√	Japan and along the Siberian coast to the Bering Sea, southern California (USA), and Baja California, Mexico.

Table 2. Marine fish species (English common names) occurrence in the Kara, Laptev (Lapt.), East Siberian (E.S.) and Chukchi Seas (Chuk.) Large Marine Ecosystems. Unless stated otherwise, all information based on FishBase (www.fishbase.org).

Species	Kara	Lapt.	E.S.	Chuk.	Comments
Theragra chalcogramma (Alaska pollock)				√	From Kivalina, Alaska, to the southern Sea of Japan and to Carmel, California, USA.
Triglopsis quadricornis (Fourhorn sculpin)		√	√	√	North Atlantic and Arctic. Some subsistence fisheries.
Ulcina olrikii (Arctic alligatorfish)	√	√	√	√	Arctic Ocean to Western Atlantic (Hudson Bay and Labrador, Canada, and Greenland). Also from Barents to Chukchi Sea and Anadyr Gulf.

*based on reported catches in Larsen *et al.* (1996). **based on Glubokowsky and Cheresenev (1981).

We thus have four independent sources of evidence that catches of coregonids in the estuaries and lower reaches of rivers of the Kara Sea were higher in the past.

1. Slavin (1964) wrote of a catch of 30,000 tonnes·year^{-1}, presumably pertaining to the late 1950s early 1960s, which is nearly ten time the catches in the 1980s;
2. The catch data of GOSNIORKH for *Coregonus muksun* for the lower Yenisei River, from 1934 to 1943 (360-780 tonnes·year^{-1}), which is about twice the mean catch for this species in the 1980s;
3. The backward extrapolation of the GOSNIORKH data, which yields catches estimate for 1950 three to four time higher than the mean catch for the 1980s (with consistent trends for Ob Bay, lower Yenisei, Pyasina and Taimyskaya rivers examined separately); and
4. The quote from Vilcheck *et al.* (1996), which suggests that pre-1950 catches would have been over hundred times the catches in the 1990s.

From this evidence, we can assume that (3) would lead to an estimate for 1950 that is both realistic and conservative, and which can thus serve as an anchor point for interpolation between 1950 and 1980 (for Ob Bay) and up to 1991 for the other three tributaries. Indeed, we believe such values represent an underestimate of the earlier fisheries catch in the region. Under the Soviet regime, Siberia, including its coastal regions, experienced a series of human population booms. First, via the dispatching of criminals and political prisoners to camps from 1929 onward, followed by German and other prisoners of war from 1942 onwards, and finally followed by the workers needed for massive industrialization projects in the region during the 1960s and 1970s. With the collapse of the Soviet Union and the loss of subsidies from the central government, Siberia experienced a large emigration of non-indigenous populations through the 1990s, with the total population of the Russian 'North' declining by more than 14 percent between 1989 and 2002 (Hill 2004). With such drastic changes in the local human population, the fisheries catch from 1950 to 1980 could easily have exceeded our estimates.

For the period from 1995 to 2004, after the year of last available data, we assumed, optimistically, a decline that proceeds at half the rate estimated for the earlier period.

Complementing the reported catches of coregonids, we added small catches to accommodate other species, for which we found the following observations:

"Until 1968 longnose Siberian sturgeon (*Acipenser baeri*) was caught in the Ob Bay and the lower Yenisei [R]iver. The annual yield in the 1960's was approximately 300 tons, until species became protected in Ob Bay in 1968. The sturgeon is presently caught in the lower Yenisei, with a catch of 31 tons recorded in 1994. For comparison, the catch of sturgeon in Yenisei was 398 tons in 1957, gradually falling to 56 tons in 1966. [...] The decrease in sturgeon catches is claimed to have arisen from a combination of several factors; construction of dams, pollution and overfishing. Today whitefish are more important than sturgeon in the fisheries in the Yenisei River and estuary" (Larsen *et al.* 1996).

The state of the sturgeon fisheries during the 1990s is also described as follows:

"Sturgeon resources during the last 10 years have been decreasing and are now in a critical state. The reasons for the reduction of Siberian sturgeon resources are: irrational commercial fishing; reduction in natural production as the result of hydro-electric construction (dams for the Novosibirsk and Bukhtarmin hydroelectric stations cut off 40% of the spawning habitats of sturgeon in the Ob River basin); and oil pollution in the lower flow of the Ob River" (Ministry of Natural Resources 1998).

Another fishery in the Kara Sea is an ice fishery for smelt (*Osmerus mordax*): "No data are available on the landings of smelt in the Yenisei River, but as much of the fish is caught for direct consumption by private persons (non-fishermen), the landings from this seasonal fishery would hardly appear in any statistics. However, in Ob Bay, the recorded catch of smelt has varied from 516 tons in 1989 to 28 tons in 1991" (Larsen *et al.* 1996).

Based on the above statements, we have estimated the historical catch of *A. baeri* in the Kara Sea to be 300 tonnes·year^{-1} from 1961 to 1967, 56 tonnes·year^{-1} following the closure of Ob Bay in 1968 and 31 tonnes·year^{-1} after 1994, the year of the last reported catch data. Furthermore, we estimated higher catches in the 1950s (500 tonnes·year^{-1}) to accommodate the reported catch from the Yenisei River in 1957. As for the catch estimates of *O. mordax*, in the absence of additional information, we took the mean of the two reported figures as our estimates for all years except 1989 and 1991 (Table 3).

Table 3. Catches (tonnes) from the Kara, Laptev, East Siberian and Chukchi Seas Large Marine Ecosystems (LME) from 1950 to 2004. Bold numbers denote reported catch; italics mark estimated catch; regular font numbers indicate reported catches limited to some rivers and estuaries (for coregonids, the reported catches were from: Ob Bay 1980-1994 except 1983, lower Yenisei 1990-1994, lower Pyasina 1989-1994, lower Taimyrskaya 1991 to 1994, Khatanga Bay 1981-1990, Lena 1981-1990, Yana 1982-1991, Indigirka 1981-1990, and Kolyma 1981-1990). Estimated coregonid catches for the Kara Sea were extrapolated linearly for each species and estuary/river back to the total catch of 12,500 tonnes in 1950 and for 1995 to 2004 using half the rate of decline used in the estimate of 1950 to 1980 (or up to 1991 for Yenisei, Pyasina and Taimyrskaya). For the Laptev and East Siberian Seas, coregonid catches were estimated as a mean of the first three years of the reported catches (for older estimates) or the last three years of the reported catches (for recent estimates). C.n = *Coregonus nasus*, C.a = *C. autumnalis*, C.m = *C. muksun*, C.s = *C. sardinella*, C.l = *C. lavaretus*, A.b = *Acipenser baeri*, O.m = *Osmerus mordax*, Oth = others.

Year	Kara Sea								Laptev Sea						E. Siberian Sea						Chuk. Sea
	C.n	C.a	C.m	C.s	C.l	A.b	O.m	Oth	C.n	C.a	C.m	C.s	C.l	Oth	C.n	C.a	C.m	C.s	C.l	Oth	Oth
1950	1073	1006	2284	6240	1897	500	272	1728	240	816	411	1184	205	857	216	356	53	805	262	508	100
1951	1052	985	2239	6136	1863	500	272	1683	240	816	411	1184	205	857	216	356	53	805	262	508	100
1952	1032	964	2194	6033	1830	500	272	1639	240	816	411	1184	205	857	216	356	53	805	262	508	100
1953	1011	943	2149	5930	1796	500	272	1594	240	816	411	1184	205	857	216	356	53	805	262	508	100
1954	991	922	2104	5827	1762	500	272	1549	240	816	411	1184	205	857	216	356	53	805	262	508	100
1955	971	901	2059	5724	1728	500	272	1505	240	816	411	1184	205	857	216	356	53	805	262	508	100
1956	950	880	2014	5621	1695	500	272	1460	240	816	411	1184	205	857	216	356	53	805	262	508	100
1957	930	858	1969	5518	1661	500	272	1415	240	816	411	1184	205	857	216	356	53	805	262	508	100
1958	909	837	1923	5415	1627	500	272	1370	240	816	411	1184	205	857	216	356	53	805	262	508	100
1959	889	816	1878	5312	1594	500	272	1326	240	816	411	1184	205	857	216	356	53	805	262	508	100
1960	869	795	1833	5209	1560	300	272	1481	240	816	411	1184	205	857	216	356	53	805	262	508	100
1961	848	774	1788	5106	1526	300	272	1436	240	816	411	1184	205	857	216	356	53	805	262	508	100
1962	828	753	1743	5003	1492	300	272	1392	240	816	411	1184	205	857	216	356	53	805	262	508	100
1963	807	731	1698	4900	1459	300	272	1347	240	816	411	1184	205	857	216	356	53	805	262	508	100
1964	787	710	1653	4797	1425	300	272	1302	240	816	411	1184	205	857	216	356	53	805	262	508	100
1965	766	689	1608	4694	1391	300	272	1258	240	816	411	1184	205	857	216	356	53	805	262	508	100
1966	746	668	1563	4591	1358	300	272	1213	240	816	411	1184	205	857	216	356	53	805	262	508	100
1967	726	647	1517	4488	1324	300	272	1168	240	816	411	1184	205	857	216	356	53	805	262	508	100
1968	705	626	1472	4385	1290	56	272	1368	240	816	411	1184	205	857	216	356	53	805	262	508	100
1969	685	604	1427	4282	1256	56	272	1323	240	816	411	1184	205	857	216	356	53	805	262	508	100
1970	664	583	1382	4179	1223	56	272	1278	240	816	411	1184	205	857	216	356	53	805	262	508	100
1971	644	562	1337	4076	1189	56	272	1234	240	816	411	1184	205	857	216	356	53	805	262	508	100
1972	624	541	1292	3973	1155	56	272	1189	240	816	411	1184	205	857	216	356	53	805	262	508	100
1973	603	520	1247	3870	1122	56	272	1144	240	816	411	1184	205	857	216	356	53	805	262	508	100
1974	583	499	1202	3767	1088	56	272	1099	240	816	411	1184	205	857	216	356	53	805	262	508	100
1975	562	478	1157	3663	1054	56	272	1055	240	816	411	1184	205	857	216	356	53	805	262	508	100
1976	542	456	1111	3560	1020	56	272	1010	240	816	411	1184	205	857	216	356	53	805	262	508	100
1977	521	435	1066	3457	987	56	272	965	240	816	411	1184	205	857	216	356	53	805	262	508	100
1978	501	414	1021	3354	953	56	272	921	240	816	411	1184	205	857	216	356	53	805	262	508	100

Table 3. Catches (tonnes) from the Kara, Laptev, East Siberian and Chukchi Seas Large Marine Ecosystems (LME) from 1950 to 2004. Bold numbers denote reported catch; italics mark estimated catch; regular font numbers indicate reported catches limited to some rivers and estuaries (for coregonids, the reported catches were from: Ob Bay 1980-1994 except 1983, lower Yenisei 1990-1994, lower Pyasina 1989-1994, lower Taimyrskaya 1991 to 1994, Khatanga Bay 1981-1990, Lena 1981-1990, Yana 1982-1991, Indigirka 1981-1990, and Kolyma 1981-1990). Estimated coregonid catches for the Kara Sea were extrapolated linearly for each species and estuary/river back to the total catch of 12,500 tonnes in 1950 and for 1995 to 2004 using half the rate of decline used in the estimate of 1950 to 1980 (or up to 1991 for Yenisei, Pyasina and Taimyrskaya). For the Laptev and East Siberian Seas, coregonid catches were estimated as a mean of the first three years of the reported catches (for older estimates) or the last three years of the reported catches (for recent estimates). C.n = *Coregonus nasus*, C.a = *C. autumnalis*, C.m = *C. muksun*, C.s = *C. sardinella*, C.l = *C. lavaretus*, A.b = *Acipenser baeri*, O.m = *Osmerus mordax*, Oth = others.

Year	Kara Sea								Laptev Sea						E. Siberian Sea						Chuk. Sea
	C.n	C.a	C.m	C.s	C.l	A.b	O.m	Oth	C.n	C.a	C.m	C.s	C.l	Oth	C.n	C.a	C.m	C.s	C.l	Oth	Oth
1979	*481*	*393*	*976*	*3251*	*919*	*56*	*272*	*876*	*240*	*816*	*411*	*1184*	*205*	*857*	*216*	*356*	*53*	*805*	*262*	*508*	*100*
1980	460	372	931	3148	886	*56*	*272*	*831*	*240*	*816*	*411*	*1184*	*205*	*857*	*216*	*356*	*53*	*805*	*262*	*508*	*100*
1981	296	351	950	1709	708	*56*	*272*	*475*	233	1019	257	1192	156	*857*	**185**	**314**	**42**	**765**	**368**	*502*	*100*
1982	249	329	803	1682	669	*56*	*272*	*418*	**233**	**632**	**467**	**1139**	**236**	*812*	**331**	**346**	**36**	**829**	**200**	*523*	*100*
1983	265	308	800	1652	632	*56*	*272*	*404*	**316**	**716**	**509**	**1274**	**235**	*915*	**133**	**409**	**82**	**821**	**217**	*499*	*100*
1984	295	287	765	1740	594	*56*	*272*	*408*	**151**	**910**	**392**	**1195**	**165**	*844*	**167**	**596**	**80**	**917**	**299**	*618*	*100*
1985	222	266	682	1478	557	*56*	*272*	*313*	**258**	**970**	**511**	**1421**	**212**	*1012*	**645**	**483**	**51**	**1020**	**280**	*744*	*100*
1986	244	245	632	1092	542	*56*	*272*	*223*	**172**	**877**	**487**	**1429**	**112**	*923*	**690**	**380**	**58**	**1431**	**785**	*1003*	*100*
1987	261	224	653	1365	482	*56*	*272*	*269*	**237**	**852**	**503**	**1240**	**185**	*905*	**425**	**318**	**104**	**1341**	**293**	*744*	*100*
1988	182	202	546	1058	439	*56*	*272*	*158*	**223**	**625**	**695**	**1145**	**195**	*865*	**339**	**247**	**76**	**1432**	**338**	*730*	*100*
1989	188	181	505	1288	407	*56*	**516**	*0*	**260**	**519**	**618**	**1107**	**188**	*808*	**505**	**122**	**122**	**1713**	**451**	*874*	*100*
1990	178	175	456	1285	408	*56*	*272*	*173*	**258**	**531**	**618**	**922**	**142**	*741*	**357**	**428**	**155**	**1729**	**289**	*887*	*100*
1991	**194**	**182**	**414**	**1131**	**344**	*56*	**28**	*369*	262	554	644	1021	213	*808*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1992	**139**	**147**	**411**	**771**	**334**	*56*	*272*	*32*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1993	**221**	**129**	**333**	**503**	**305**	*56*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1994	**197**	**70**	**302**	**564**	**301**	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1995	*186*	*60*	*282*	*512*	*284*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1996	*176*	*50*	*262*	*461*	*267*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1997	*166*	*41*	*243*	*409*	*250*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1998	*156*	*32*	*223*	*358*	*233*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
1999	*146*	*23*	*204*	*306*	*217*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
2000	*135*	*14*	*186*	*255*	*200*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
2001	*125*	*5*	*168*	*203*	*183*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
2002	*115*	*0*	*149*	*152*	*166*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
2003	*105*	*0*	*131*	*100*	*149*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*
2004	*97*	*0*	*113*	*54*	*132*	*31*	*272*	*0*	*256*	*557*	*644*	*1040*	*194*	*807*	*400*	*266*	*118*	*1625*	*359*	*830*	*100*

THE FISHERIES OF THE LAPTEV SEA

The Laptev Sea, bounded by the Severnaya Zemlya islands in the west and New Siberian Island and Kotelny Island in the east (Figure 1), is a mostly shallow water body with a complex oceanography (Kosobokova *et al.* 1998, Thiede *et al.* 1999). It is frozen nearly year round, with an extremely short summer, during which some parts of the water become ice-free as the coastal ice recedes, and into which the several large rivers discharge immense quantities of freshwater (Table 1). The fish fauna of the Laptev Sea is extremely impoverished, as it is remote from both the Barents Sea on the west and Bering Sea to the east (Figure 1, Table 2). According to an economic review of the Sakha Republic (Yakutia) by the Japan External Trade Organization (JETRO), there is no commercial marine fishery operating along the Republic's 5,000 km long coast facing the Laptev and East Siberia seas (Japan External Trade Organization 2004). For this same area, however, Isaev and Newell (p. 243 in Newell 2004) write that [small-scale] "fishing annually yields about 8,000 tons, mainly in the lower reaches of the Lena, Yana, Indigirka, and Kolyma Rivers". This catch estimate pertains to both the Laptev and East Siberian Seas, which we assume to be distributed equally, or 4,000 tonnes·year^{-1} for each LME, based on the similar size in their inshore fishing areas (to be described in a later section).

Coregonid species, again, form the bulk of the fishery in the Laptev Sea, but detailed records are available only from the lower reaches of the Lena and Yana rivers, and from Khatanga Bay for the years 1981 to 1991 (Larsen *et al.* 1996). These data, amounting to about 3,000 tonnes·year^{-1} on average, do not show any consistent trend unlike those from the Kara Sea. Thus, as evidence is lacking which would support any trend related estimation, the mean catch of the first three years with data (1980-1982) is extrapolated backward to 1950; similarly, the mean catch of the last three years is extrapolated forward from 1992 to 2004.

There is no information available on catches of any other species. Larsen *et al.* (1996), however, estimate a range of 10 to 30% of total catches being non-coregonid in Arctic Russia. We therefore applied the upper value of this range to both the Laptev and East Siberian seas as our estimated catches of other fish, which when combined with our estimates of coregonid catches brought our total catch close to the estimate of 4,000 tonnes·year^{-1} derived from Newell (2004; see Table 3).

THE FISHERIES OF THE EAST SIBERIAN SEA

The East Siberian Sea LME covers an area bounded by Kotelny Island in the west and Wrangel Island in the east. Like the Laptev Sea, it is remote from the Barents and Bering Seas and hence its fish fauna is species-poor (Table 2). A few large rivers, however, discharge into the East Siberian Sea, notably the Indigirka and Kolyma Rivers, and thus we find the familiar assemblage of coregonids being exploited by small-scale fisheries in the lower reaches and estuaries of these rivers.

According to Newell (2004, p. 43), rivers which discharge into Chaun Inlet, near Pevek (Figure 1), "have commercially valuable stocks of humpback salmon and dolly warden (*Salvelinus malma*)," that are threatened by overfishing.

The catch data used here are from GOSNIORKH as reported by Larsen *et al.* (1996), and the same assumptions were applied to their extrapolations as were applied for the Laptev Sea (Table 3). An estimate of 30% was assumed for catches of non-coregonid fish, yielding, for the 1980s, an annual average catch of 3,087 tonnes·year^{-1}, a figure conservative with regards to the estimate derived from Newell (2004; see above).

It should be noted here that unlike the catches in the Kara Sea which underwent a decline in fisheries catches, we can expect a more stable yield in the East Siberian Sea, and to some extent the Laptev Sea. This may likely be driven by a relatively larger proportion of indigenous inhabitants in the region, who are less inclined to emigrate following the collapse of regional industries (Larsen *et al.* 1996), and the lower levels of environmental degradation from the intensive industrialization of the regions (Newell 2004).

THE FISHERIES OF THE CHUKCHI SEA

The Chukchi Sea LME, being adjacent to the Bering Sea (Figure 1), includes a greater number of fish species than the East Siberian Sea, notably species which also occur in Arctic Alaska and the northern Pacific (Raymond 1988 in Larsen *et al.* 1996), for example the char, *Salvelinus alpinus* (Table 2). The "GOSNIORKH does not possess data on landings from areas east of the Kolyma river" (Brude *et al.* 1998), presumably because there are no large river systems feeding into the Chukchi Sea. However, the area has a number of smaller rivers rich in anadromous salmonids.

Given the absence of data, we estimated the catch from the Chukchi Sea as a 'Fermi solution' (von Baeyer 1993), i.e., by breaking down the problem at hand, and making informed guesses about each of the parts, whose errors are likely to cancel each other at the end.

The non-indigenous human population of the Chukotka Republic which borders the Chukchi Sea, is believe to be "rapidly dwindling in the whole region" (Newell 2004, p. 285), with about 17,000 indigenous people in total, comprising mostly Chukchi, Yukagirs, Yupik, Koryak and Even people (Newell 2004, p. 285). The overwhelming majority of this population appears to live in the southern parts of the Republic along the coast of the Bering Sea and the Sea of Okhotsk (Newell 2004, map 8.2, p. 308). For the purpose of this report, we shall assume that 5 percent of the total population (or about 1,000 inhabitants) occupy the coast of the Chukchi Sea, and that the following description of their lifestyle applies: "lacking money, coastal native people have again turned to the sea as source of food [...]. Most now survive exclusively on marine mammal meat, fish, and marine invertebrates [...]. Small surplus quantities of fish and meat [...] are sold to tourists, or traded [...]. Hunting at sea is once again becoming a prestigious calling in coastal cultures" (Newell 2004, p. 310). Therefore, if we assume that each of the 1,000 persons along the Chukchi Sea coast consumes 100 kg of fish·year^{-1} (a high value), a catch of 100 tonnes·year^{-1} would be required.

Alternatively, we could assume, in the absence of any evidence to the contrary, that annual catches along the Chukchi Sea coast are, on a per-area basis, 10% of those in the East Siberian Sea[1]. Such an estimate yields 2.3 kg·year^{-1}·km^{-2} of inshore fishing area. Given the size of inshore fishing area computed for the Chukchi Sea (Table 1), we computed 90 tonnes·year^{-1} as the likely catch for the region. This is close to the figure of 100 tonnes·year^{-1} estimated above, which we retained. This is also based on the concept that, as a "spontaneous number", it has the advantage of not suggesting a high precision (Albers and Albers 1983).

It is interesting to note that since the collapse of the Soviet Union, the region has attracted interest from the Alaskan sport fishing industry, and chartered trips have been organized targeting various Pacific salmon and Arctic char (Jenkins 1991) and their role in the local fisheries is expected to grow. We assume that the catches made by these fisheries easily fit into our estimate for the Chukchi Sea.

DISCUSSION

Figure (2) presents our estimated time series of catch, by species, for the entire North Siberian region, including the estimates for the catches of 'other fishes', based on Larsen *et al.* (1996) and other sources. These estimates are meant to provide an alternative to the official landings data reported by FAO on behalf of Russia, which are summarized in Table (4). These reported landings pertain to species usually caught by industrial trawlers, not likely to operate in any of the ecosystems reported upon here. These data are also incompatible with information provided in a report of the Ministry of Natural Resources (1998):

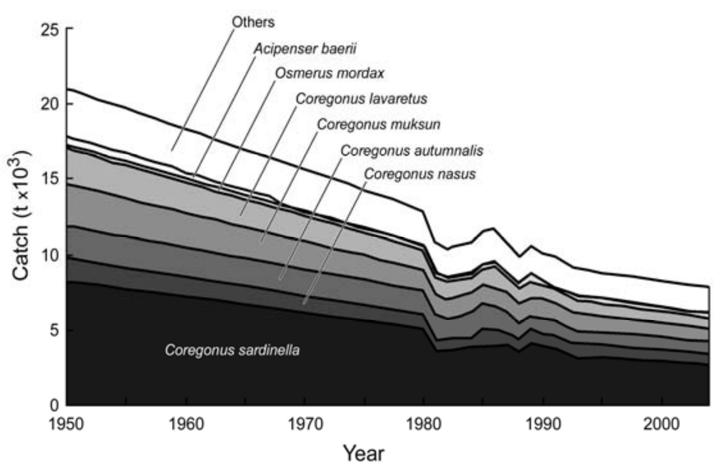

Figure 2. Estimated marine fisheries catch by species for the Russian Arctic Large Marine Ecosystems (Kara, Laptev, E. Siberian and the Russian section of the Chukchi Seas) from 1950 to 2004.

"Commercial fishing in the Kara and eastern Arctic seas is not viable. The largest amount of bioresources (mainly semi-migratory fish of the 'sig' family:

[1] The reference area used here is the 'inshore fishing area', previously used by Chuenpagdee *et al.* (2006) to compare fisheries yields by small-scale fisheries throughout the world, and which are defined as waters of up to 200 m in depth or up to 50 km from shore, whichever is nearest to the coastline.

muksun, pelyad, sig, ryapushka, and omul) are produced in the pre-mouth zones of the Ob and Yenisey Rivers. Along other areas of the coast, fish resources are small (Yakutia, Chukotka) and fishing is only for the subsistence needs of the local population."

Table (3) and Figure (2) are based on data and inference which are highly uncertain. However, the overall catch level may be within the correct range, as can be inferred by comparison with the catch data in Berg *et al.* (1949; E. Pakhomov, Earth & Ocean Sciences, UBC, pers. comm.). This is in contrast to the data presently available from the FAO, which reports landings 60 times lower than presented here (Table 4). Another concern is the distinction between marine, brackish-water and freshwater catches. We are almost certain that by relying heavily on the reported catches of anadromous coregonids in our estimates, we have included significant, and, for our purpose, unwanted freshwater catches (although we have omitted catches of *Coregonus peled*, an exclusively freshwater species, from our study). Nonetheless, we believe that such a potential overestimate in the catches of anadromous species is compensated for, at least in part, by unreported small-scale fisheries for marine species in larger estuaries such as that of Ob and Lena rivers or in areas such as Khatanga Bay. Indeed, it is more or less universal for small-scale subsistence fisheries to be overlooked in governments' statistical systems (Pauly 2006, Zeller *et al.* 2006, Zeller *et al.* 2007).

The region discussed here suffers to a substantial extent from various forms of industrial pollution, the result of decades of ruthless attempts to extract natural resources from the area without environmental safeguards (Gordeev *et al.* 2006, Newell 2004, Vilchek *et al.* 1996). Thus, it would be tempting to attribute the decline of fish catches observed during the period for which there is data solely to high levels of pollution, especially in the Kara Sea area. This is believed to be the case for the coregonid fisheries in the White Sea (Ministry of Natural Resources 1998), and generally for the Russian Arctic (Vilchek *et al.* 1996). Yet, massive demographic changes have also occurred during this period, as ethnic Russians that immigrated into the region during the Soviet era are leaving the area following the collapse of the Soviet regime. Those who remain are indigenous peoples, with few options but to (re-)turn to small-scale fishing and hunting.

Be that as it may, the present contribution was assembled essentially for the purpose of generating a straw man, which Russian and other colleagues interested in Arctic fisheries can now begin to shoot at.

Table 4. Official landings data reported by FAO for Area 18 on behalf of Russia and the former USSR, for the period 1950-2004.

Reported taxa	Year[a]				Total landings (t)
	1967	1968	1969	1970	
Greenland halibut	100	1,400	800	200	**2,500**
Roundnose grenadier	1,100	5,900	2,600	500	**10,100**
Miscellaneous marine fish	-	-	-	100	**100**
Total	**1,200**	**7,300**	**3,400**	**800**	**12,700[b]**

[a] Only the 4 years included here had non-zero landings. [b] This compares with 754,815 t in Table (3) for 1950-2004, i.e., 60 times more.

ACKNOWLEDGEMENTS

We thank C. Ragner of the Norwegian Institute for making available to us the reports which made this contribution possible. Our thanks also go to B. Campbell for the GIS work, and A. Atanacio for drawing the figures. A special thanks to E. Pakhomov, Earth & Ocean Sciences, UBC, for comments which, we hasten to add, do not make him responsible for any of the interpretations presented here. This work is a product of the *Sea Around Us* Project, funded by the Pew Charitable Trusts, Philadelphia.

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National conflict and fisheries: Reconstructing marine fisheries catches for Mozambique[1]

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Abstract

Mozambique is one of the poorest countries in the world; however, it is rich in marine resources. This study gives an overview of Mozambique's marine fishing history from the colonial period to the present, including how fishing was affected by the country's 16-year civil war. Since the 1950s, when the compilation of global fisheries data by FAO began, 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 strife. This study reconstructs small-scale catches, industrial catches, and discards, for the 1950-2004 period. Overall, small-scale catches may account for an average of 87% of Mozambique's national marine fisheries landings. Since 2000, the fishing sector as a whole has landed between 115,000 and 140,000 tonnes per year, which is 5.5 times greater than the statistics reported by FAO based on country reports. Though there is a large degree of uncertainty with this work, the assumptions made herein are better than the alternative, i.e., that the small-scale sector has no landings.

Introduction

To assess hunger and malnutrition by country, the United Nations Food and Agricultural 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 based on national statistical data supplied by its member countries. Therefore, the quality of the data depends on the capacity of statistical collection within these countries. The FAO data have been the basis of many influential global fisheries studies (e.g., Pauly *et al.*, 1998) but they are, in fact, incomplete (e.g., Zeller *et al.*, 2006; Zeller *et al.*, 2007). Furthermore, data reported by FAO do not distinguish between fisheries sub- sectors.

Small-scale, artisanal fishing 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). Instead, government focus and support is often directed toward industrial fishing, which provides foreign exchange (e.g., Renner, 1996; Cramer, 1995). This dichotomy is also reflected in reported data.

However, small-scale fisheries' role 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, one of the poorest countries in the world, the small-scale fishing sector is of historical and contemporary importance to rural livelihoods, though this case is not often made. Fishing in Mozambique obviously predates the colonial period but, for the present study, the fishing history is presented from the colonial period onward. Quantitatively, this study is limited to the period of global FAO reporting, i.e., from 1950 onwards.

[1] Cite as: Jacquet, J. L. and Zeller, D. 2007. National conflict and fisheries: Reconstructing marine fisheries catches for Mozambique. p. 35-47. *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

The colonial period: 16th century-1975

Mozambique has one of the longest coastlines of any African nation and a long history of fishing. When the Portuguese arrived in the 16th century, an estimated 10,000 people were living around the bay of Sofala and engaging primarily in trade, boat building, and fishing (Ehnmark and Wastberg, 1963). Where raising cattle was difficult, coastal populations caught fish with traps and cages and collected intertidal resources, such as oysters. In addition to subsistence use, fish was dried and traded inland and shellfish were sold in local markets (Anon., 1920; Foreign Office, 1920; Newitt, 1995; de Boer, 2000). Most of the finfish (primarily cod and canned sardines) eaten in urban centers during Portuguese colonial rule was, however, imported from Portugal and Angola (Nordic Fishery Project, 1985; Krantz *et al.*, 1986).

Until the 1960s, there was no local industrial fishing fleet in Mozambique, and trawling was prohibited under colonial law (Nordic Fishery Project, 1985). But, in the early 1960s, local Portuguese authorities recognized the export potential of a shrimp fishery (Anon., 1982) and in 1965, the trawling ban was overturned (Krantz *et al.*, 1986). A small industrial fleet was established in Mozambique, but was owned and operated by fishers from Portugal.

By the mid-1960s, the fishing industry began to expand. Large processing and freezing plants for shrimp, crabmeat, and fish canning were established at various locations along the coast. Ten of Portugal's largest fishing enterprises formed a corporation aiming to invest in the expansion of Mozambique's fishing industry. During the colonial epoch, most of the literature addresses only this development of industrialized fishing, though the government's *Missao de Bioceanologicia e Pescas se Moçambique* was working with FAO and the small-scale sector.

However, the small-scale sector is, for the most part, absent from the national fishing statistics presented by FAO. Yet, in the mid-1960s, there were more than 16,000 rural coastal fishers and coastal people consumed many varieties of fish and shellfish (Herrick *et al.*, 1969). The small-scale fishing sector would become of even greater importance when thousands of refugees fled to the coast during the era of conflict that followed independence (Kristiansen and Lopes, 1997).

Civil war: 1976-1992

In 1962, anti-colonial forces formed the Front for the Liberation of Mozambique (FRELIMO) and initiated an armed campaign against Portuguese colonialism. Mozambique did not gain independence, however, until 1975, after the 1974 coup in mainland Portugal, at which time FRELIMO established a one-party state aligned with the Soviet Union.

At independence in 1975, Mozambique was one of the world's poorest economies. Fishing infrastructure (including retailers) and the system of data collection were abandoned with the exodus of the Portuguese. The new government nationalized all industries, including the fishing boats, of which there were fewer than 100 (Nordic Fishery Project, 1985).

The political instability after independence led to a civil war fuelled by South Africa and lasting from 1977-1992, which destroyed much of the country's infrastructure and caused massive migrations of people. About 1.7 million refugees fled abroad. Four million people, about one-fourth of Mozambique's entire population, were internally displaced (Azevedo, 2002). The coastal cities of Angoche and Moma were attacked repeatedly but, generally, coastal areas experienced less fighting (Anon., 1982). Refugees migrated to the coast and islands and turned to fishing for survival (Kristiansen and Lopes, 1997). As the number of fishers increased, catch rates for coastal fishers declined (Lopes and Gervasio, 1999).

By the early 1980s, 80-90% of the population was dependent on subsistence agriculture and fishing for a large part of their livelihood. As late as 1985, the artisanal fishing fleet was still operating within a subsistence, rather than an industrial, market-based economy (Nordic Fishery Project, 1985). Trade of fish was made difficult due to the destruction of roads, landmines, and a shortage of salt, which prevented the preservation of fish for shipment inland (SEP, 1994).

To generate revenue, the government increased efforts to refurbish the industrial fishing sector. In August 1976, the government passed legislation designed to protect its inshore fishing grounds and to bring unrestricted offshore fishing under its control. The new law established a 12-mile nautical zone along the coast, and fishing there required a government license (Chingono, 1996).

Eager for foreign exchange, the new Mozambique government formed joint enterprises with private fishing interests in Japan, Spain, and Norway, and traded fishing rights for aid from the Soviet Union.

Through the 1980s, Norway supported most of the government-run industrial fishing (Instituto de Investigacao Pesqueira, 1995). By 1984, Mozambique's fishing grounds had not been fully surveyed (Avezedo, 2002). Yet, Norwegian advisors suggested increasing annual production of fish by 20,000 t by 1985 through the development of bottom trawling (Anon., 1982).

Soviet fishing vessels overexploited many of Mozambique's fishing grounds, including the rich resources of Sofala bank (Davidchick and Mahoney, 1979; Andersson, 1992). A joint Mozambique-Soviet fishing company was established in 1979 with the aim to supply fresh fish to the local domestic market and export shrimp for revenue. In the early 1980s, shrimp was, after cashews, the country's largest earner of foreign exchange (Anon., 1984).

Peace: 1992-present

In 1992, after 16 years of civil war, the government and the guerilla groups signed a cease-fire agreement. More than one million refugees who had fled abroad returned home to Mozambique. Though some refugees that fled to the coast of Mozambique during the war returned to their place of inland origin (SEP, 1994), many stayed.

Most of the landmines that impeded travel were removed once the civil war ended, but selling fish to inland markets remains difficult due to transport difficulties (Lopes *et al.*, 1996). The lack of education and, therefore, alternatives to fishing, is severe in rural areas (Azevedo, 2002). Fishers span the seven coastal provinces (Figure 1) and are some of the poorest people in Mozambique. Wooden, unmotorized canoes are the most common type of fishing vessel, and beach seining for small pelagic fish species is the most widespread gear type in the small-scale sector. Other traditional gears include line fishing, traps and cages, implying a high degree of sophistication (Gerdes, 1988). Some fishers have newer gear introduced in the 1980s, including gill nets, purse seines, longlines, and trolling equipment (Overballe *et al.*, 1987). Due to the lack of preservation techniques for fish, fishing effort is reduced during the rainy season (December through March), when sun drying is impossible.

In Mozambique, women also contribute to fisheries through processing and controlling retail of fish. Women and children also collect intertidal organisms, such as the mudcrab (*Syclla serrata*), the blue swimming crab (*Portunus pelagicus*), and many other species of bivalves, mollusks, and shellfish (de Boer and Longamane, 1996; de Boer *et al.*, 2000). This catch is eaten while the fish caught by men is sold. In Mozambique, "the role of women fishers is as hidden as it is crucial" (Wynter, 1990, p. 35). The catch from women and children, as well as most of the small-scale finfish catch, has been absent from national statistics until recently (IIP, 2003, 2004).

Figure 1: Mozambique, East Africa, with its maritime provinces and EEZ.

Mozambique's reports to FAO have systematically underreported actual catch due to their historic exclusion of small-scale fisheries catches (Charlier, 1994) and the lack of interest in this data expressed by FAO (Rudy van der Elst, ORI, pers. comm). Before independence, Portuguese data collectors focused entirely on the burgeoning industrial sector. This continued through independence and the civil war, as the industrial sector continued to grow (Nordic Fishery Project, 1985). After the war, government resources were understandably allocated to rebuilding basic infrastructure rather than resource monitoring.

However, the 2003 Marine Fisheries Regulation of Mozambique dedicated resources to improve monitoring of the small-scale fisheries sector, which is reflected in recent government reports (e.g., Afonso, 2006). In 2004, for instance, the national fisheries division made great advances and reported a catch of 57,747 t for the small-scale sector, an 800% increase from the landings reported in 2002. However, even this appears to be an underestimate; the 2004 data were derived from sampling 115 of the larger fishing centers, while 543 fishing centers (admittedly smaller) were not monitored at all. Local extrapolations were made for these 115 centers but not extended nationwide (N. Faucher, IDPPE, pers. comm.). Likewise, in 2003, only 19 percent of total fishing centers were monitored (Afonso, 2006).

Table 1. Mozambican fisher, collector and human populations, and ratio of total fishers (fishers & collectors) to total population with sources and estimates.

Year	Reported		Source	Estimated		Population ($x 10^6$)	Ratio
	fishers	collectors		Collectors[a]	Fishers & collectors		
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.

This situation of underreported catches is not unique to Mozambique or the Western Indian Ocean region as a whole (van der Elst *et al*., 2005, Chuenpadgee et al., 2006). The logic for reconstructing catches has been outlined previously (Pauly, 1998; Pauly and Zeller, 2003) and catches have been successfully reconstructed in other regions of the world (Zeller *et al*., 2006; Zeller *et al*., 2007). Here, we follow the basic concept and approach outlined by these studies to reconstruct historic fisheries catches for Mozambique. Catch data by sector is presented as a time series from 1950-2004.

Materials and Methods

Today, the government of Mozambique considers the fishing fleet in three sectors: industrial (boats larger than 20m), semi-industrial (10-18m) and artisanal (<12m and shore-based). The two latter categories, semi-industrial and artisanal, are combined under the heading ‘small-scale’. For the purposes of the present study, the industry is considered in two categories: small-scale and industrial. The small-scale sector also includes collectors and divers, hereafter referred to simply as collectors.

Small-scale sector

Using data from both published and gray literature sources as anchor points, time series data were reconstructed using interpolation and extrapolation. Hard data used to form these anchor points included fisher population data, national human census data, national reported catch data for 2003 and 2004, and estimates of catch per fisher.

Estimates of fisher populations were available for a number of years (Table 1). The estimates available for years prior to 1995 excluded collectors and divers. Therefore, we took the average proportion of the collectors to total fishers for 1995 and 2002 (45%), and applied this average proportion to estimate collector populations for the earlier years (Table 1).

Rather than interpolating fisher populations between the seven different years of fisher population data, the ratio of fishers to the entire Mozambique population was determined for these seven years and interpolated so that population trends in the fishing sector mirrored those of the country as a whole. For the time series data of the Mozambique national population, census data were used, with interpolation for the intervening periods. Multiplying these ratios by the overall Mozambique population provided estimated data on the number of fishers and collectors for 1950-2004 (Figure 2).

Reliable data on small-scale catches were not available. A few unpublished reports attempted to provide estimates for the small-scale fleet for certain years (e.g., Krantz *et al*., 1986; Charlier, 1994) and places (see Paula e Silva *et al.* 1993 and references therein for Maputo Bay). However, these studies did not present their methods for estimation, nor did they appear to include the collector component in catch estimates.

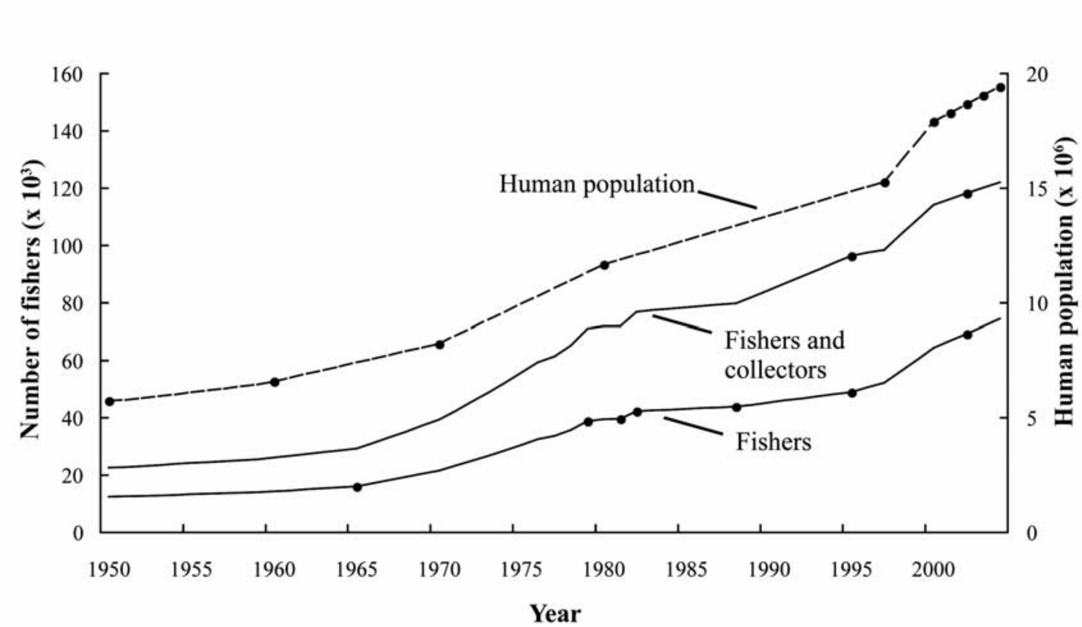

Figure 2: Number of fishers, number of fishers and collectors, and human population, 1950-2004. Reported data indicated by anchor points (•).

Therefore, the data that offered the least uncertainty were the 2003 and 2004 national catch data, which explicitly included estimated small-scale fisheries catches with a clearly described estimation method (IIP, 2003, 2004). The 2003 data included substantial coverage of three coastal provinces (Maputo, Sofala, and Zambezia) and 70% of two other coastal provinces (Nampula and Inhambane), but 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 knowledge was combined with the 2002 fisher census, which provided fisher populations by province (IDPPE, 2004), and it was determined that, overall, only approximately 62% of total number of fishers were included in the national statistics (Table 2).

Table 2. Number of fishers by province and the proportion of fishers represented in 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 [b]KPMG, 2006

Therefore, it was assumed that the reported catch for 2003 and 2004, of 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 total 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 $kg \cdot fisher^{-1} \cdot day^{-1}$ for 2003 and 2.09 $kg \cdot fisher^{-1} \cdot day^{-1}$ for 2004.

Anecdotal historical evidence suggests that, due to additional fishing pressure from refugees, catch rates have declined since the start of the civil war in 1975 (Dutton and Zolho, 1990; Lopes and Gervasio, 1999. A peer-reviewed study on the small-scale fishery of Inhaca Island (part of the province of Maputo; Figure 1) presented data from fisher interviews and suggested that catch rates on the island have declined from 29 $kg \cdot fisher^{-1} \cdot day^{-1}$ to 11 $kg \cdot fisher^{-1} \cdot day^{-1}$ over the last 30 years (de Boer *et al.*, 2001). This proportional decline of 38 percent was applied to the much lower 2003 national catch rate of 2.47 $kg \cdot fisher^{-1} \cdot day^{-1}$ (as approximated above) back to the start of the civil war in 1975 so that the catch rate declined from an assumed 6.44 $kg \cdot fisher^{-1} \cdot day^{-1}$ in 1975 to the adjusted rate of 2.47 $kg \cdot fisher^{-1} \cdot day^{-1}$ in 2003 (based on national statistics).

To remain conservative (and, without access to any earlier information), the catch rate was assumed constant (6.44 $kg \cdot fisher^{-1} \cdot day^{-1}$) from 1950-1974, prior to the war (Figure 3). These catch rates are conservative when compared to Zanzibar, Tanzania, where catch rates (including collectors) were estimated at 4.7 $kg \cdot fisher^{-1} \cdot day^{-1}$ (Jiddawi and Stanley, 1999). These derived annual catch rates were expanded to determine total small-scale catches using the fisher population time series.

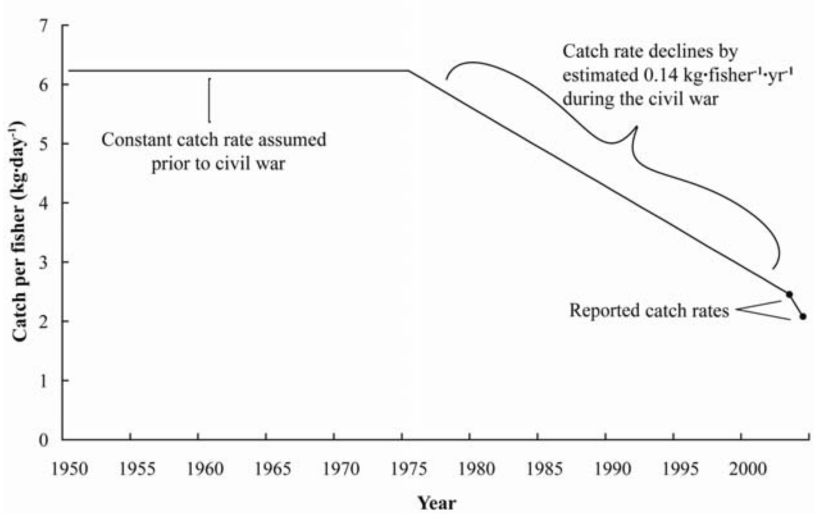

Figure 3. Catch per fisher, 1950-2004; catch rate declines with the start of the civil war in 1976.

Industrial sector

Landings

Historically, more resources have been allocated to monitoring and reporting the fisheries catch by the industrial sector. As a result, gray literature reports indicating industrial catch (Table 3) were accepted as reported. However, the accuracy is questionable as a number of years obviously contain rounded numbers. For years when data was unavailable, catch estimates were estimated using linear interpolation between adjacent periods, as no obvious correlation exists between industrial sector catch development and human population of Mozambique.

Table 3. Industrial sector catch estimates and sources, 1955-2003.

Year	Catch estimate (t)	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 meant a corresponding increase in by-catch (landed incidental catch) and discards (not landed). By-catch is likely underreported, while discards are entirely absent from the reported data series. Schultz (1997) found that, between 1993 and 1996, there was an annual by-catch between 21,000 and 29,000 t. In 1982, discards at sea in the shrimp industry were estimated at 15-20,000 t (Anon., 1982). This estimate is likely conservative, as Krantz *et al.* (1986) suggest that there was 40,000 t of incidental by-catch annually and that the vast majority of this was discarded at sea.

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

Year	Catch (t)[a]	Discards (t)[b]
1950	0	0
1960	400	674
1970	800	1,348
1980	11,700	19,718
1990	10,539	17,761
2000	11,195	18,867

[a]FAO FishStat;
[b]Based on 15,000 t of discards for the early 1980s (Anon., 1982), or a ratio of 1.69 t discarded per t of shrimp.

To estimate total discards, the conservative 1982 estimate of discards (15,000 t) was compared to the total shrimp catch that same year as reported by FAO (8,900 t). This ratio of discards to shrimp (1.69) was then applied to the time series of reported shrimp catch to produce a time series of discards (Table 4).

Results

The catch rate data combined with the fisher population data yielded the reconstructed time series of small-scale catch for 1950-2004, which is presented with reconstructions of industrial catch and discards for the same years (Figure 4, Table 5). The trend of production over time is consistent with the catch rate assumptions made for the small-scale sector and the use of the industrial sector for foreign exchange to finance the civil war; both the small-scale and the industrial sector's production peaked in the 1980s.

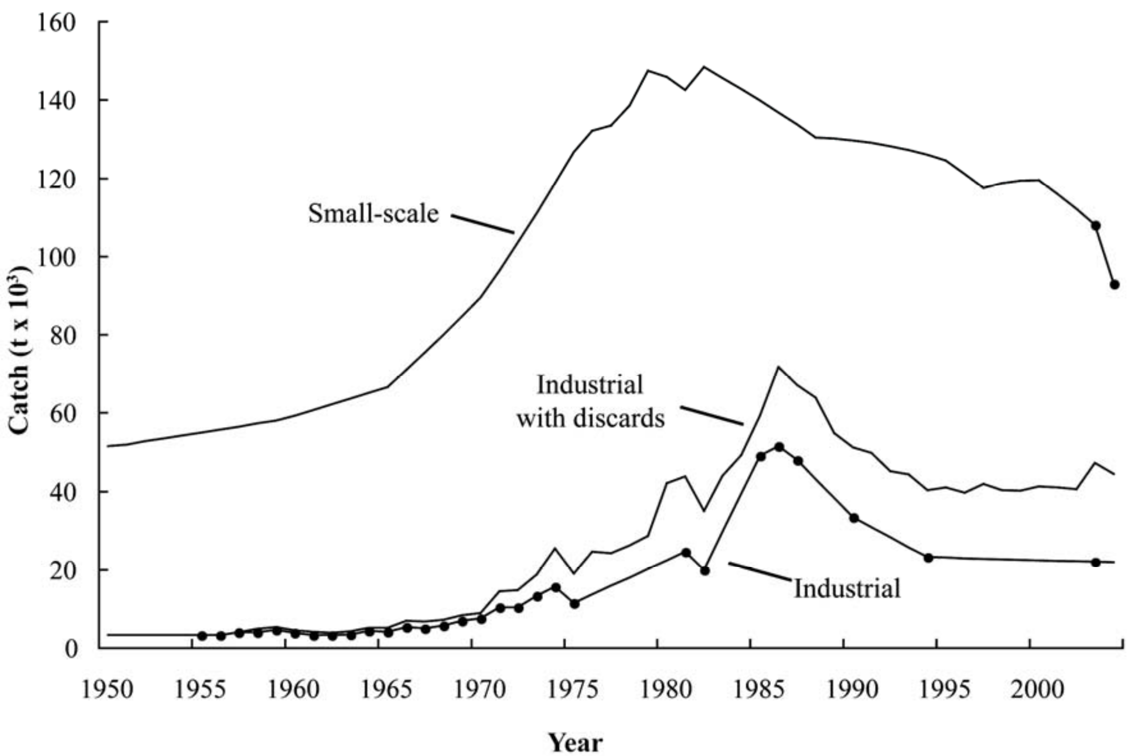

Figure 4. Catch reconstructions for the small-scale sector, industrial sector, and estimates of total industrial catch including discards, 1950-2004.

The time series data also show the magnitude of small-scale production. In terms of tonnage, the small-scale sector lands six times more than the industrial sector. Excluding freshwater catches, and assuming that the entire small-scale catch was consumed within Mozambique (and ignoring imports and exports of the industrial catch), the average per capita consumption over the 55-years was 9.6 $kg \cdot person^{-1} \cdot year^{-1}$. From 2000-2004, fish consumption is estimated between 4.8 and 6.7 $kg \cdot person^{-1} \cdot year^{-1}$.

The total reconstructed catch (small-scale and industrial combined) is presented for the same years and compared with the FAO reported data (Figure 5). The reconstructed catch is, overall, 550% larger than that reported by FAO. Since 2000, the FAO has reported catches between 24,000 and 32,000 t, while the present study suggests catches between 115,000 and 140,000 t for the same time period.

Discussion

Although there is a large degree of uncertainty associated with our estimates, total catch estimates for recent years of 115,000 to 140,000 $t \cdot year^{-1}$ are comparable to the estimate presented in the FAO country profile for Mozambique of 100,000 to 120,000 $t \cdot year^{-1}$ (Afonso, 2006), and used, e.g., in Chuenpagdee *et al.* (2006). However, our estimates diverge from those for earlier years. For instance, in 1990, Tembe (1991) estimated a catch of 102,000 t (without explicitly describing the methods) while our reconstruction yields 163,190 t for the same year. Nevertheless, our reconstructed data illustrates the most likely historical trends for Mozambique over the last 50 plus years. Furthermore, the postulations made here are likely closer to the truth than the alternative of assuming that no data means no catch.

Table 5. Time series of marine fisheries catches (t) for Mozambique by industrial sector, industrial discards, small-scale sector and total, 1950-2004.

Year	Industrial	Discards	Small-scale	Total
1950	3,300	0	51,627	54,927
1951	3,300	0	52,005	55,305
1952	3,300	0	52,760	56,060
1953	3,300	0	53,516	56,816
1954	3,300	0	54,272	57,572
1955	3,300	0	55,027	58,327
1956	3,300	0	55,783	59,083
1957	4,100	0	56,538	60,638
1958	4,100	843	57,294	61,394
1959	4,700	674	58,050	62,750
1960	3,900	674	59,309	63,209
1961	3,285	843	60,785	64,070
1962	3,256	674	62,262	65,518
1963	3,425	843	63,738	67,163
1964	4,428	674	65,214	69,642
1965	4,181	1,011	66,690	70,871
1966	5,347	1,685	71,007	76,354
1967	5,047	1,685	75,447	80,494
1968	5,707	1,517	80,010	85,717
1969	7,028	1,348	84,696	91,724
1970	7,634	1,348	89,505	97,139
1971	10,423	4,045	96,459	106,882
1972	10,413	4,382	103,671	114,084
1973	13,338	5,393	111,141	124,479
1974	15,655	9,842	118,869	134,524
1975	11,486	7,483	126,854	138,340
1976	13,680	10,954	132,182	145,862
1977	15,874	8,427	133,584	149,458
1978	18,068	8,089	138,643	156,711
1979	20,262	8,427	147,445	167,707
1980	22,456	19,718	145,907	168,363
1981	24,650	19,212	142,553	167,203
1982	20,000	15,000	148,465	168,465
1983	29,700	14,269	145,720	175,420
1984	39,400	9,854	142,871	182,271
1985	49,100	10,349	139,921	189,021
1986	51,610	20,220	136,875	188,485
1987	48,050	19,111	133,738	181,788
1988	43,179	20,785	130,512	173,691
1989	38,307	16,610	130,221	168,528
1990	33,436	17,761	129,754	163,190
1991	30,884	18,958	129,108	159,992
1992	28,333	16,883	128,277	156,609
1993	25,781	18,521	127,256	153,037
1994	23,229	17,055	126,042	149,271
1995	23,097	17,950	124,630	147,726
1996	22,964	16,775	121,182	144,147
1997	22,832	19,103	117,622	140,454
1998	22,699	17,596	118,847	141,546
1999	22,567	17,556	119,508	142,075
2000	22,434	18,867	119,613	142,047
2001	22,302	18,773	116,042	138,344
2002	22,169	18,392	112,224	134,394
2003	22,037	25,219	108,184	130,221
2004	21,905	22,575	93,140	115,045

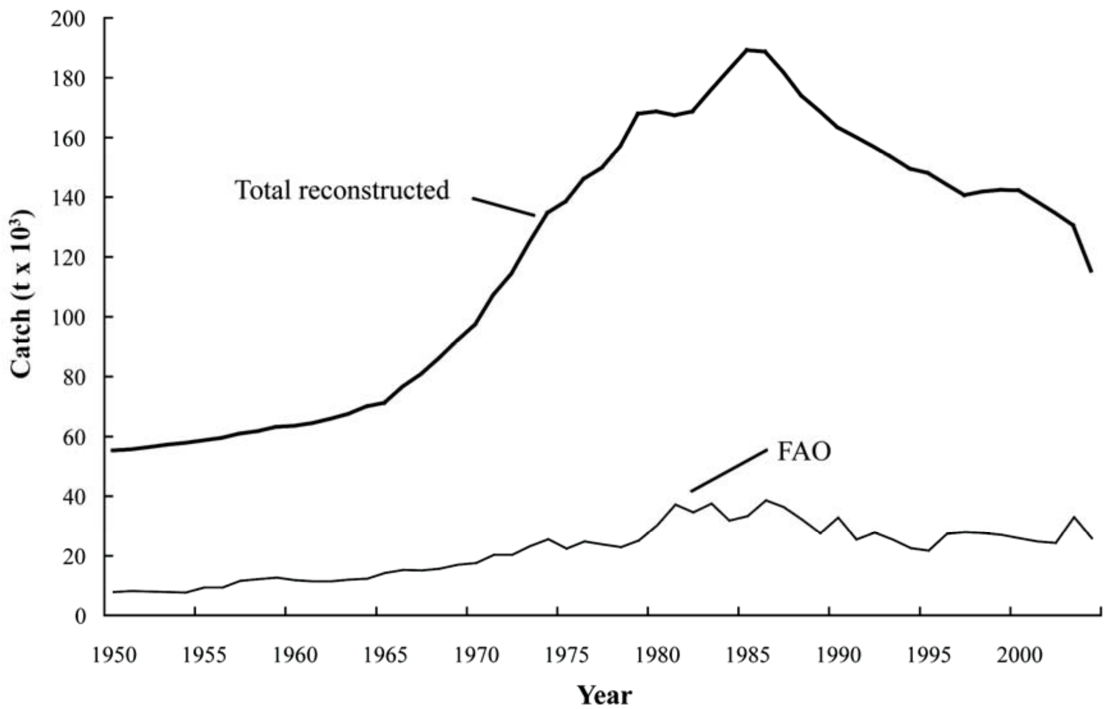

Figure 5. Total reconstructed catch (small-scale and industrial combined, excluding discards) compared with FAO reported catch, 1950-2004.

Summed for 1950-2004, reconstructed fisheries data suggested a 5.5-fold difference between reconstructed estimates and the statistics reported by FAO, itself based on country reports. These findings fall within the calculations van der Elst *et al.* (2005) made based on Ardill and Sanders (1991), which concluded that the level of non-reporting to the FAO was around 70% (a range of 22-96%) for artisanal fisheries the Western Indian Ocean.

Furthermore, these findings are consistent with findings by other catch reconstruction efforts. For America Samoa, for instance, catch reconstructions yielded a 17-fold difference (Zeller *et al.*, 2006), while for the Commonwealth of the Northern Mariana Islands catch reconstructions yielded a smaller, 2.2-fold difference (Zeller *et al.*, 2007). However, in both of these cases, maximum absolute catches were less than 800 t, which is very small compared to those of Mozambique, where maximum small-scale catch was nearly 150,000 t (in the late 1970s/early 1980s). The findings from Mozambique thus reinforce what Pauly and Zeller (2003) emphasize: there is a need to complement FAO data and incorporate previously ignored catches, even if these are based on approximations and assumptions.

Small-scale fisheries

Based on the small-scale catch estimates derived here, catches produced by this sector appear substantial and, on average, account for 87% of total marine catch. This is comparable to other African countries with large small-scale fleets, such as Ghana, where the small-scale sector produces at least 70% of total catch (Jacquet and Alder, 2006). The systematic underestimation of small-scale catches in Mozambique has been recognized repeatedly (e.g., Herrick *et al.*, 1969; Charlier, 1994; Gillet, 1995). Though other studies provide anecdotes and occasional catch estimates to emphasize the importance of the small-scale sector, the present study provides the first comprehensive countrywide small-scale catch estimates to quantitatively support these accounts from 1950 to the present.

Spence (1963) regarded fishing in Mozambique as "hardly deserving of the title 'industry'," though he recognized fishing as important for food and livelihoods for Mozambique's coastal population. It is likely that fishing was indeed important and even substantial—contributing, according to the present study estimates, roughly 64,000 t to the food supply in the early 1960s.

Even now, inshore resources are important to coastal people living marginal existences. Although the civil war has ended, Mozambique is still considered in the top 20 percent of poorest countries (UNDP, 2005). The vast majority of Mozambique's rural poor still lives on less than US$1 per day. Furthermore, Mozambican fishers and their households are the most disadvantaged of the rural poor[2]. The high level of poverty among fishers, combined with the reconstructed estimates, suggests that fish is a more important part of food security than was otherwise perceived. Previous per capita consumption estimates, based on poor data, were unreliable and vastly underestimated true consumption.

For example, the World Resources Institute reports annual per capita fish consumption as 3 kg for Mozambique but 8 kg for sub-Saharan Africa as a whole[3]. These numbers, however, seem a better indication of poor statistics than fish consumption rates. Using the reconstructed time series data, average countrywide per capita consumption over the 55-year period appears in the order of 9.6 $kg \cdot person^{-1} \cdot year^{-1}$. The national fisheries division of Mozambique estimates consumption at around 7.5 $kg \cdot person^{-1} \cdot year^{-1}$ for recent years (Afonso, 2006), while our estimates yield roughly 6 $kg \cdot person^{-1} \cdot year^{-1}$ since 2000. This suggests that the present reconstructed estimates might be conservative, or, more likely, that imports and freshwater catches (excluded by the present reconstruction) make up the remaining quantity. Either way, fish is a more important component to food security than is indicated by the FAO statistics.

Recently, improvements to monitoring the small-scale sector have been undertaken. Surprisingly, these data appear not to have been incorporated into the FAO FishStat database. In 2005, FishStat reported total marine captures at 78,129 t for 2003, which appeared to reflect the improvements in small-scale data collection. But in a later iteration of the database, the 2003 capture data had been changed and total marine captures were reported as 32,985 t.

Aside from lack of data, there is concern about the population growth in the fishing sector. The 2002 fisher census shows 69,359 canoe fishers along the coast, more than four times the fishers reported in 1965. Linked with population pressure is the decline in catch rates and other indications of overexploitation. Examination of historical shell middens also shows that mean shell size has decreased due to exploitation by collectors and that, in the past, piscivorous or omnivorous fishes, such as kingfishes, rays, grunts and snappers, were more abundant (de Boer *et al.*, 2001). Another regional study shows that on average, some species of fish (e.g., *Siganus sutor*) have gotten smaller (Kristiansen *et al.*, 1995).

The widespread use of very fine-meshed mosquito nets for beach seining is highly destructive. Mosquito nets capture high rates of juvenile fish that escape larger-meshed seine nets and, in Mozambique, have caused a reduction in catches (Lopes and Gervasio, 1999). Combined, population pressure and fishing practices suggest that 'Malthusian overfishing' (Pauly, 1997) is occurring in Mozambique. Though there is management in place to address some of these concerns, lack of human resources is but one of the barriers to proper enforcement. However, over the last ten years, due to political stabilization and the creation of an autonomous ministry for fisheries management, the number of areas under management and level of enforcement has increased significantly (Afonso, 2006).

Industrial fisheries

From the mid-1960s through the 1980s, the government of Mozambique encouraged industrial fishing for shrimp as a means to increase revenue through exchange earnings (see contributions in Pauly, 1992). Predictably, industrial catches peaked during this decade of technological innovation and financial need, as it did in many other countries around the world. While the trend for industrial catches is likely correct, the data presented are conservative estimates.

As shrimp fishing increased, so, too, did discards at sea. According to our results, aggregated from 1950-2004, the amount of total discards was estimated at 500,000 t. It should also be noted that the discards sampled in the 1982 study were comprised mostly of demersal species (65%) followed by small pelagics (35%) and sharks and rays (5%) (Anon., 1982), and many of the discarded species overlap with the species caught by small-scale fishers. These points are disconcerting in a country so reliant on small-scale fisheries for food security. Some attempts were made in the early 1990s to equip small-scale fishing vessels with motors so that they could recover some of the by-catch directly from the trawlers (SEP, 1994), but these efforts have had little effect.

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[2] International Fund for Agricultural Development (IFAD). Rural poverty in Mozambique. www.ruralpovertyportal.org/english/regions/africa/moz/index.htm [Accessed October 31, 2006].
[3] World Resources Institute (WRI). Costal and Marine Ecosystems-Mozambique. http://earthtrends.wri.org/pdf_library/country_profiles/wat_cou_508.pdf [Accessed November 11, 2006].

During the colonial period, sport fishing for gamefish such as marlins, particularly by South African tourists, was very popular (Herrick *et al.*, 1969), but historical data for these fisheries are not available. More recently, the government has begun collecting data for sport fishing, which increased drastically after the civil war ended, but there is little monitoring or control of this activity (Afonso, 2006). Neither were catch data available from the collection of ornamental fish, which has become prevalent in Mozambique since the moratorium on the collection of ornamental fish for commercial purposes ended in 2001 (Whittington *et al.*, 2000). Overall, while the value of these fisheries sectors may be substantial, the tonnage is likely low.

Similarly, the time series data presented do not include industrial catches by foreign vessels, such as Japanese, South African, French, Soviet, and Spanish fishing vessels, which fished the waters off Mozambique heavily in the early 1970s prior to the declaration of Exclusive Economic Zones (Chingono, 1996). Access agreements have subsequently been made. In 1994, there were 118 industrial fishing boats, only 48 of which were registered nationally (Gillett, 1995). However, the reported data are relatively small (e.g., 2,528 t from Romania in 1984)[4] and are often reported by the nations doing the fishing (vessel flag state) rather than Mozambique, as is the case with swordfishes and other Indo-Pacific billfishes (IOTC, 2006). Nor do the official data include fishing by pirate fishing vessels, which is thought to have occurred extensively since the 1970s in the largely unmonitored waters of Mozambique. Thus, the industrial catch estimates exclude sport fishing, ornamental fish collection, and a likely substantial amount of pirate fishing by foreign vessels.

The present study provides a historical look at the small-scale and industrial fishing sectors of Mozambique by reconstructing each sector's catches. The result is a reminder that the small-scale sector does not necessarily yield small catches. Furthermore, the small-scale sector supplies a high protein calorie source to poor rural populations. Yet, this sector has been largely ignored in the past, both in terms of statistics and management, in favor of the industrial sector, which generates foreign exchange earnings. But, as the small-scale sector directly competes with the industrial sector, which incidentally catches substantial amounts of small pelagic fishes, the two cannot be considered separately. Mozambique will have to decide how to balance foreign exchange and commerce with nutritional needs and rural livelihoods in the face of increasing pressure from global markets.

Acknowledgements

The authors acknowledge the Pew Charitable Trusts, Philadelphia, for funding the *Sea Around Us* Project, and WWF-US and WWF-International for their financial support of the present study. The authors thank R. van der Elst, Director of the Oceanographic Research Institute (ORI) in South Africa, for his comments on an earlier draft of this report. They also thank H. Fox, H. Motta, P. Afonso, and N. Faucher and their respective institutions (WWF, IIP, IDPPE) and M. Falco and R. Silva for help with data mining. Thank you also to J. Alder for help with the figures. Finally, thank you to D. Pauly for his insights regarding early results.

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PUTTING THE 'UNITED' IN THE UNITED REPUBLIC OF TANZANIA: RECONSTRUCTING MARINE FISHERIES CATCHES[1]

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ABSTRACT

This study reconstructs marine fisheries catches from 1950-2005 for the United Republic of Tanzania, comprised of mainland Tanganyika and several offshore islands, two of which make up the region of Zanzibar. For unknown reasons, Zanzibar's recorded fisheries data are absent from the marine fisheries landings reported by the United Nations Food and Agriculture Organization (FAO) on behalf of Tanzania. Furthermore, the mainland fisheries catches were likely at least one-third larger than those reported by the official data, due to incomplete country-wide expansion of locally sub-sampled catches. Since 2000, Tanzanian mainland fishers have likely caught around 70,000 tonnes annually, while Zanzibar catch estimates are around 25,000 tonnes per year. Overall, the United Republic of Tanzania has likely caught nearly 100,000 tonnes of marine fish per annum in recent years and total marine fisheries catches are likely 1.7 times greater than those presented by the FAO. These findings support broader research in the Western Indian Ocean that found historic FAO data to reflect about half of the real total catch in the region. These findings also call into question current understanding of fisheries stock exploitation in Tanzania and the recent decision by the Tanzanian government to commence export of marine finfish.

INTRODUCTION

Historical Perspective

Tanzania, located in East Africa, has a mainland coastline of approximately 800 km and three large offshore islands: Mafia, Pemba, and the island of Zanzibar, around which much inshore fishing is concentrated (Mngulwi, 2006). Pemba and the island of Zanzibar form the region of Zanzibar. In the past, the mainland (called Tanganyika) and Zanzibar were separate entities. Both Tanganyika and Zanzibar fell under German colonial control in 1886 and then to the British in 1920, after WWI. Tanganyika gained independence in 1961 and Zanzibar followed two years later. In 1964, the two countries merged as the United Republic of Tanzania (Figure 1).

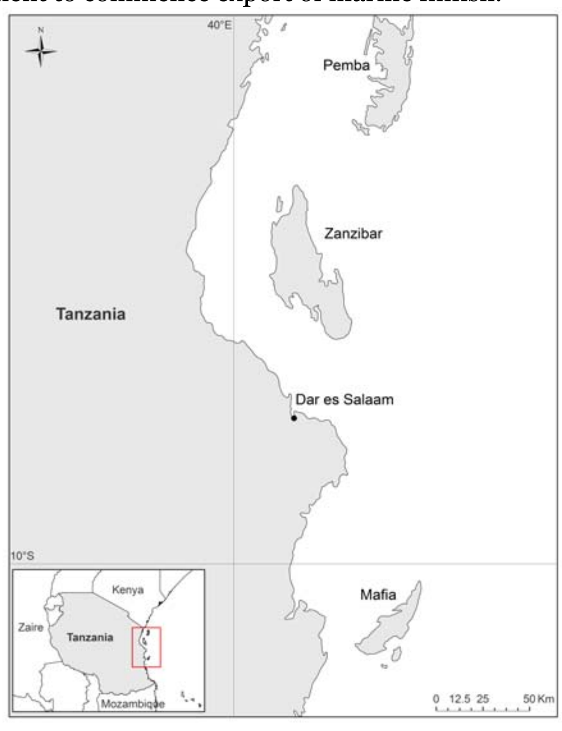

Figure 1: Tanzania, East Africa, and its three large offshore islands.

Lake Victoria has been the primary center of fishing, due partially to the fact that freshwater fishing is less capital intensive than marine fishing (Bagachwa *et al.*, 1994). Thus, most fisheries reports concentrate on freshwater catches (Anon., 1978). But subsistence marine fisheries have long provided protein for Tanzanian coastal and island communities (Anon., 1920).

Prior to independence, fishers fished for small pelagic

[1] Cite as: Jacquet, J.L. and Zeller, D. 2007. Putting the 'United' in the United Republic of Tanzania: Reconstructing marine fisheries catches. p. 49-60. *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

and demersal species using nets, traps, and hook and line. Women used a piece of sacking or a discarded *khanga* (printed cotton material worn as clothing) to catch prawns in the shallows (Wenban-Smith, 1965). Women and children also collected invertebrates. Fishing using ichthiotoxic plants and sea cucumbers was also common during the late 19th century (Stubbings, 1945). Wads of plants covered in the poison were thrown into estuaries where they stunned many fish that were then caught at the mouth of the river with a net. Legislation made fish poison illegal and, by the end of first half of the 20th century, the practice was less common (Alexander, 1964). The seafood trade in Tanzanian waters also has a long history. The export of fish and fisheries products from Zanzibar, for instance, dates back to the 13th century when Persians, Arabs, and Indians traded dried salted fish (particularly kingfish), shells, shark fins, and later, sea cucumber (Mgawe, 2005).

During the colonial period (1880s-1960s), sportfishing became increasingly common in Tanzanian waters (Hatchell, 1940). At independence, commercial fishing began with the introduction of the purse seine in the Zanzibar channel for small pelagics, i.e., sardines, scads, mackerel, and anchovies (Nhwani, 1981). After independence, the new Tanzanian government practiced an African socialist policy and, under this regime, implemented a ban on the export of marine finfish to protect food security (Anderson and Ngatunga, 2005), though the ban does not seem to apply to Zanzibar (Jiddawi, 2000).

Despite its nominally socialist policies, Tanzania allowed a large amount of foreign investment, including the introduction of shrimp trawling—a practice that, given the amount of wasted fish produced by trawling, seems ironic in light of the export ban on marine finfish. However, the export of shrimp was allowed and began to grow. In the mid 1960s, a Japanese company and the Tanzanian government formed a shrimp company, though the Japanese left in 1975 (Bwathondi and Mwaya, 1984) and the fleet was nationalized. With the rise of the shrimp fishery there was a great deal of bycatch, as much of 94 percent in the 1980s, though it is difficult to determine how much of this was retained and how much discarded (Nanyaro, 1984). It was reported that, in the 1980s and 1990s, the dumping of finfish discards was so great that it was polluting inshore waters. This waste was later addressed by improved enforcement and much of the bycatch is now sold onshore to local markets or processing facilities (Shao *et al.*, 2003).

A number of commercial cooperatives operated through the 1980s, including the Zanzibar Fishing Company (ZAFICO), the Bagamoyo Fishing Company (BAFICO), and the Tanzania Fishing Company (TAFICO) (Ngoile, 1982; Nanyaro, 1984). After trade liberalization began in 1985, a number of small-scale entrepreneurs as well as commercial and foreign trawlers became involved in the fishing sector and, in some cases, tripled fishing effort (Bakari and Andersson, 1999). In the 1980s, a market developed for the export of live aquaria fish (Mongi, 1991). In the early 1990s, Tanzania signed access agreements and allowed the EU to catch 7000 t of tuna annually (Mongi, 1991).

In the mid-1990s, tourism grew and so did demand for fresh fish and shellfish. On the mainland, the number of tourists increased from 82,000 in 1985 to 341,000 in 1996 (Coughanowr *et al.*, 1995; Bakari and Andersson, 1999), which was reflected in the Tanzanian lobster fishery. In 1968, there were 22 permits issued for fishing crustaceans (Anon., 1988). By 1987, there were 415 boats fishing lobster, which far exceeded the upper limits of the effort recommended for the fishery. In 1988, the lobster catch in Tanzania peaked. Since then, the average size of lobster has decreased (Bakari and Andersson, 1999).

In the 1990s, tourism also developed rapidly in Zanzibar. With the increase in tourism came an increase in demand for high-quality fresh fish. Tourist hotels offer good markets for fresh fish and prawns and hotel representatives now attend the fish auction in Kigomani, Zanzibar (Richmond, 1999). Tourism also increased demand for marine curios, such as shark jaws, shark teeth, and shells (Jiddawi, 2000; Shao *et al.*, 2003). Roughly 150 species of shells are collected by fishers for food or sold as curios (Jiddawi and Öhman, 2002). The most sought after shells by tourists are Horned Helmut shell, Triton trumpet shell, and Mauritian cowry. A shell survey done in the market in Dar es Salaam in 1998 found 112 species on sale with a total of 22,659 specimens. Seven years later, only 87 species were available on the market though there were 39,259 specimens. The number of Red Helmut shells (*Cypraecassis rufa*) in the market declined by 55 percent over the same time period (Sabel, 2005).

Tanzanian Small-scale Fisheries Today

In many ways, small-scale fisheries resemble those from a century ago. Small-scale fishing takes place almost exclusively in the nearshore waters of 40 m depth or less (UNEP, 2001) by means of outrigger canoes and dhow-type planked boats, mostly propelled by sails (Mngulwi, 2006). Dhows are still caulked with shark oil. Fishers use lines, traps, and nets to catch demersals, purse seines and scoop nets to catch small pelagics, and longlines, drift nets, gillnets, and shark nets to catch large pelagics. Like most small-scale fishing in the tropics, many species are caught and almost nothing is discarded. In Zanzibar, fishers from the villages exploit at least 61 families of fish (Jiddawi and Stanley, 1999).

Women and children still harvest shellfish, octopus, squid, crabs, sea cucumbers, and mollusks in the intertidal zone and mangrove areas using their hands, hooks, and natural and synthetic poisons (Semesi and Ngoile, 1993; Guard *et al.*, 2000; Silva, 2006). Women also beach seine for very small shrimp, which is quite profitable.

According to the 2005 fisheries frame survey, there are 29,754 fishers, 796 collectors, and 7190 boats on the Tanzanian mainland. No such survey has been conducted recently on Zanzibar, but it is estimated there are more than 23,000 fishers and collectors there (Jiddawi, 2000). There are more than 400 landing sites for the mainland and Zanzibar combined (Jiddawi and Muhando, 1990; Shao *et al.*, 2003). The majority of fish is eaten fresh though some is dried, smoked, fried, and/or salted (Tobey and Torell, 2006). Like other small-scale fisheries of East Africa (van der Elst, 2003), Tanzanian fisheries are subject to little management, and destructive (and illegal) fishing practices are common, such as use of herbicides, pesticides, beach seines and dynamite (Haule and Kiwia, 1999; Othman, 1999; Verheij *et al.*, 2004).

<u>Dynamite fishing</u>

The most discussed form of destructive fishing in Tanzania is dynamite, which was introduced in Tanzania in the early 1960s (Haule and Kiwia, 1999). Dynamite tends to be used during specific times of year (holidays and the beginning of the school year) when households need extra cash (Silva, 2006). Dynamite fishing had immediate negative consequences in Tanzania since it destroys the habitat upon which fisheries depend. Coral cover in Tanzania has greatly diminished and Kenyan and Tanzanian reefs are the most severely damaged in East Africa (Obura *et al.*, 2002). In East Africa as a whole, it is estimated that coral cover has decreased by half from 1997 to 2002 (Obura *et al.*, 2002).

In the late 1960s, the reef adjacent to Tanga in northern Tanzania was described as some of Tanzania's best. By 1987, an IUCN study showed the reef was extensively damaged. Fewer than 20 percent of the areas surveyed were covered in live coral. At Tanga, 12 percent of the 83 reef sites surveyed were completely destroyed by dynamite fishing (Guard *et al.*, 2000). Though enforcement existed, the two Tanga District Fisheries Officers were caught taking bribes from dynamite fishers (Horrill and Makoloweka, 1998).

Even after dynamite was made illegal, frequent dynamite blasting occurred despite public protests (Bryceson, 1981). In some villages, there were complaints of intimidation from dynamiters and cases of brutality (Horrill and Makoloweka, 1998). In just two months in 1996, 441 dynamite blasts were recorded at Mnazi Bay, Mtwara (Darwall *et al.*, 2000). In addition to the destruction of corals, the ease of use of dynamite also has the consequence of lost knowledge for future generations of fishers in terms of how to fish using traditional techniques (Darwall *et al.*, 2000).

As late as 2002, the elimination of dynamite was still the main priority in southern Tanzania (Darwall *et al.*, 2000) where dynamite fishing remained prolific along the coast (Bryceson, 1981; Andersson and Ngazi, 1995; Guard, 1999; Guard *et al.*, 2000). Today, dynamite use has greatly declined because the punishment for its use includes a much more substantial fine and a minimum of three years in jail (Horrill and Makoloweka, 1998; Guard *et al.*, 2000). In some areas, there are signs of recovery and coral cover is increasing, while sea urchin densities, a sign of disturbance, are decreasing (Verheij *et al.*, 2004).

Unfortunately, many young men who used dynamite turned to the illegal practice of coral mining, instead (Luhikula, 1998). Mining for coral for construction materials, particularly on Mafia Island, has also been highly damaging to fish and coral populations (Andersson and Ngazi, 1995; Dulvy *et al.*, 1995; Guard *et al.*, 2000). On mined sites, fish abundance was 42 percent lower and fish diversity 24 percent lower than on un-mined sites. On average, coral cover was reduced 70 percent (Dulvy *et al.*, 1995).

Data: Collection, Reporting, and Underreporting

According to official data in recent years, total reported fish catches in Tanzania are estimated between 300-400,000 t annually, of which marine catches account for only approximately 50,000 t (Mgawe, 2005). According to the national data, small-scale fisheries contribute more than 96 percent of total marine catches (Fisheries Division, 2005). However, the collection of accurate marine fisheries statistics has long been considered difficult or near impossible (Anon., 1988). Also, many records from the colonial era were also lost.

The newly independent government began the collection of fisheries statistics in Tanzania in the 1960s and chose several fishing villages to be monitored continually. Ideally, two recorders were stationed at each centre and recorded the weight and value by species of fish landed by every vessel. The monthly catches at each centre were meant to be extrapolated to the whole statistical area using a frame survey of the number of boats and gear types to obtain annual catch estimates (Nhwani, 1981).

During the 1970s, some improvements to data collection were made with the distribution of lists of species names and scales for each monitoring site (Nhwani, 1984). For instance, in 1975, the Government of Zanzibar ordered fish to be weighed so that fish would be sold by weight and consumers would receive fair prices (Othman, 1999) although weight was still visually estimated on Pemba until only recently (Othman, 1999). That same decade, the national government began decentralizing its power and one result was that there was little emphasis on monitoring fisheries in some regions (Nhwani, 1984).

In 1984, the Tanzanian national fisheries statistics office did not own even a simple calculator (Nhwani, 1984). That same year, due to financial constraints in the Zanzibar fisheries office, the number of beach recorders was reduced from 38 to 8 on Pemba and these 8 recorders returned to the visual estimation procedure (Othman, 1999). In 1988, collection methods improved as fish recorders were added to the Zanzibar Fisheries Department (Jiddawi and Muhando, 1990).

Industrial data are also likely underreported since collection relied on reports from the fisheries companies, which were inconsistent and, for foreign vessels, entirely unreported (Nhwani, 1981). Tuna, swordfish, sea cucumber, and prawn fisheries greatly misrepresent their catch (Anderson and Ngatunga, 2005). Jiddawi and Ohman (2002) point out that shark fin traders give a figure that is more than double what is reported officially. Middlemen, particularly those in the Pemba octopus fishery, also provide misinformation (Othman, 1999)

More recent data are also insufficient, which is disclosed in FAO reports (Mongi, 1991) and the data from the small-scale fishery are particularly inadequate (Guard *et al.*, 2000) as they omit the catch by collectors (often women and children) and often transfers at sea. Close analysis of FAO data reveals not only underreporting of Tanzanian data but also the omission entirely of Zanzibar from official statistics. This is likely due to the complexity of Tanzanian bureaucracy: Mainland Tanzania and Zanzibar each have autonomous institutional and legal structures for managing fisheries, and thus have separate systems of reporting. Additionally, Zanzibar Fisheries Division must account for catch statistics on the islands of Unguja and Pemba, which further complicates reporting. This research aims to give a time series estimate of national fisheries catches from 1950-2005 for both mainland Tanzania and Zanzibar.

Materials and Methods

Peer-reviewed publications on Tanzanian marine fisheries are rare - most reports center on Lake Victoria fisheries. The few reports that do exist are fairly recent.

Furthermore, because freshwater catches account for the majority of consumed fish nationwide, using consumption data to inform marine fisheries catch reconstructions was not possible. Though there may be anecdotes, there is often little scientific evidence to provide a view of fisheries 25 or more years ago. Jiddawi (2000) demonstrates this for Tanzania with a figure of fisheries publications through time: there were fewer than 5 fisheries research reports completed in 1900 while there were 120 reports written in 1990. Jiddawi and Stanley (1999), for instance, conducted the first comprehensive fisheries catches study in Zanzibar in the 1990s and provided "a first look at the relative status compared to other fisheries in the world."

Data for the present reconstructions were thus mostly obtained through gray literature and tables produced by the Fisheries Division and other local institutions in Tanzania (e.g., TAFIRI, TCMP, TRAFFIC, WWF). The majority of these reports did not elaborate on the methodology behind the data presented. Frontier (www.frontier.ac.uk), a non-profit organization from Britain, has done regional studies on small-scale fishing since 1989 but was, unfortunately, unwilling to share data.

Zanzibar

For Zanzibar, fisheries catches were available from 1982-2005, with the exception of 1989, which was interpolated. For 1980 and 1981, the data appeared to represent only the catch from the island of Unguja. For 1980, we had reliable data for the number of fishers on Unguja and Pemba: 5884 and 7058 respectively (Table 1). Using the 1980 reported catch for the island of Zanzibar (3965 t) divided by the number of fishers (5884) we obtained a catch per fisher of 0.67 $t \cdot year^{-1}$. We multiplied this catch rate by the 7058 fishers in Pemba to establish the Pemba catch: 4756 t for 1980. For 1981, we interpolated the number of fishers between frame surveys (1980 and 1985) and then repeated the steps used to determine the 1980 data to determine the 1981 catch data for Pemba, which gave us 6942 t for Pemba in 1981.

Aggregating the 1980 and 1981 data for the islands of Pemba and Zanzibar, we obtained catch estimates for Zanzibar as a whole from 1980-2005 for canoe fishers, but these did not include the catch by collectors. There were three years with reliable numbers of collectors on each island: 1980, 1985, 1989. We interpolated the number of collectors between these years to determine the number of collectors from 1980-1989 (Table 1).

Table 1. Number of fishers on the islands of Zanzibar and Pemba, and number of collectors on both islands combined (Zanzibar total), 1980-1989.

Year	No. of fishers (Zanzibar island)	No. of fishers (Pemba island)	Collectors (Zanzibar total)
1980	5,884[a]	7,058[a]	4,555[a]
1981	5,954	7,194	3,937
1982	6,024	7,330	3,319
1983	6,094	7,467	2,700
1984	6,164	7,603	2,082
1985	6,234[b]	7,739[b]	1,464[b]
1986	-	-	1,679
1987	-	-	1,894
1988	-	-	2,108
1989	-	-	2,323[c]

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

A study from Matemwe, Zanzibar estimated catch rates for collectors to be 4.0 kg·collector^{-1} (Jiddawi and Stanley, 1999). 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.). For the purposes of this study, we assumed the catch rates from Matemwe to represent the average catch for collectors, likely conservative because catch rates, at least anecdotally, have declined. Thus, we assumed a catch rate for collectors to be 4.0 kg·collector^{-1} and an effort of 20 days per month (240 days each year). 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 collected fish to caught fish in 1989 (23:100) and used this ratio to obtain a time series of collected fish from 1990-2005 based on a constant proportion to reported fisheries catches.

From 1950-1980, we had only two data points for fisheries catches: catch estimates for 1975 (12,500 t) and 1959 (8500 t), which was presumed not to include collectors. We thus interpolated fisheries data from 1976-1979 and 1960-1974. From 1950-1958, we extrapolated the catch backward based on the linearly increasing catches interpolated annually from 1959-1975 (an increase of 250 t annually). Based on the ratio of collected fish to caught fish in 1980 (33:100), we assumed this constant ratio and determined the collected catch from 1950-1979. We aggregated the fished and collected estimated catch for a time series of Zanzibar marine fisheries catches from 1950-2005.

Mainland Tanzania

For the Tanzanian mainland, we retained the estimated fisheries data reported by the FAO for the years 1950-1969, which were probably the best estimates we could obtain. In the absence of reliable number of fishers, consumption data, or catch rates for this time period, these data were likely 'estimates' given that they were round numbers in increments of hundreds.

For reasons mentioned above, the official marine catches for the Tanzania mainland from 1970-2005 that we obtained were likely underestimated. A new system of data collection practiced in Tanga (the northern-most province) and published in a peer-reviewed journal demonstrated catches were approximately 35 percent greater than previously believed (Verheij *et al.*, 2004). Based on this regional study, we increased the 1970-2005 time series of marine fisheries catches for the entire mainland Tanzania by 35 percent. This is considered conservative (Martin Guard, Eco2 Dive- Centre[2], pers. comm.), but there was no quantitative basis for adjusting the figures upwards.

Small-scale fishing accounts for at least 95 percent of the reported country data. Official reports show that small-scale fisheries produce almost half of shrimp (the primary industrial product) and that, overall, shrimp production is small according to data reported by FAO (1,200 t in the late 1980s to a peak of 2,800 t in 1998), particularly when compared to neighboring country of Mozambique (8,000-15,000 t since the 1980s). Thus, we have no way of gauging the degree to which industrial shrimp catches are underreported.

[2] Eco2, Ltd., PO Box 784, Mtwara, Tanzania, http://www.eco2.com/

But given that industrial catches make up less than 5 percent of reported data, the 35 percent increase in the data overall may account (minimally) for discards by the shrimp industry.

But this time series of fisheries catches for 1950-2005 (which included a 35 percent increase in reported catches for the last 35 years) did not include collector data. The only years for which we had estimates of collectors were 2001 and 2005, which, though they appear to be small (576 and 796 collectors respectively), were the result of recent mainland frame surveys and thus presumed to be reliable. We interpolated the number of collectors between 2001 and 2005. For years 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 1970-2000 (Table 2).

We then multiplied the number of collectors by the same catch and effort for collectors from Matemwe, Zanzibar (4.0 kg·collector^{-1} for 240 days·year^{-1}) to get a time series of collector catch. Because we had little information on the number of fishers and nothing on the number of collectors from 1950-1969, we took collector catch as a ratio to fishers catch (0.8:100 in 1970) and then used this ratio to determine conservative collecting estimates for 1950-1969 (57-260 t·year^{-1}). Then we aggregated collecting and fisher catches for total marine catch estimates for Tanzania mainland.

Finally, we aggregated the total catches (fishers and collectors) for Zanzibar and the Tanzania mainland to obtain an estimate of total catches for the United Republic of Tanzania from 1950-2005 (Table 3).

Table 2. 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) [e](Bagachwa et al., 1994) [f]1985-2005 (F. Sobo, Fisheries Division, pers. comm.) [g](Fisheries Division, 2002) [h](Fisheries Division, 2005)

RESULTS

Time series data is presented for the Tanzanian mainland and Zanzibar (Figure 2). Catch reconstructions for Zanzibar show that total marine catches over the last few decades range between 10-25,000 t. On the mainland, marine catches range from 36-77,000 t over the last 20 years or about three times those of Zanzibar. There is approximately the same number of fishers on the mainland as on Zanzibar (~20,000) and approximately the same number of landing sites (200); however mainland fishers are distributed over a much larger space, and they appear to access healthier resources. Thus, catch per fisher rates are much higher on the mainland, confirming that fishers in Zanzibar are worse off than those on the mainland. This point is further validated by a household survey of fishers, wherein 51 percent of respondents in Pemba, Zanzibar took three meals a day while 90 percent of fishers on Mafia island did (Tobey and Torell, 2006). However, mainland fisheries catches also appear to be declining in recent years. Anecdotes from the mainland also suggest that species composition for certain fisheries (e.g., the purse seine fishery in Tanga) have changed (Nhwani, 1981).

Table 3. Time series of marine fisheries catches (t) for Zanzibar fishers and collectors, mainland fishers and collectors, and the United Republic of Tanzania total, 1950-2005.

Year	Zanzibar catch (t)		Mainland Tanzania catch (t)		Total Catch (t)
	Fishers	Collectors	Fishers	Collectors	
1950	6,250	2,063	7,100	57	15,469
1951	6,500	2,145	7,100	57	15,802
1952	6,750	2,228	8,100	65	17,142
1953	7,000	2,310	13,400	107	22,817
1954	7,250	2,393	13,400	107	23,150
1955	7,500	2,475	14,100	113	24,188
1956	7,750	2,558	14,100	113	24,520
1957	8,000	2,640	14,100	113	24,853
1958	8,250	2,723	14,100	113	25,185
1959	8,500	2,805	14,000	112	25,417
1960	8,750	2,888	14,300	114	26,052
1961	9,000	2,970	16,600	133	28,703
1962	9,250	3,053	17,800	142	30,245
1963	9,500	3,135	12,500	100	25,235
1964	9,750	3,218	23,400	187	36,555
1965	10,000	3,300	22,800	182	36,282
1966	10,250	3,383	29,700	238	43,570
1967	10,500	3,465	30,000	240	44,205
1968	10,750	3,548	32,500	260	47,058
1969	11,000	3,630	27,500	220	42,350
1970	11,250	3,713	25,110	194	40,266
1971	11,500	3,795	29,565	236	45,096
1972	11,750	3,878	39,015	246	54,888
1973	12,000	3,960	32,400	236	48,596
1974	12,250	4,043	35,571	240	52,104
1975	12,500	4,125	69,039	245	85,909
1976	12,619	4,164	67,458	321	84,562
1977	12,738	4,203	63,443	289	80,673
1978	12,856	4,243	63,886	282	81,267
1979	12,975	4,282	45,692	233	63,182
1980	13,094	4,373	51,292	219	68,978
1981	16,466	3,779	52,533	380	73,158
1982	21,464	3,186	36,501	389	61,540
1983	17,902	2,592	45,195	274	65,963
1984	21,632	1,999	55,202	397	79,229
1985	15,205	1,405	57,843	328	74,782
1986	10,094	1,612	63,430	363	75,499
1987	16,648	1,818	52,778	367	71,611
1988	10,402	2,024	66,667	399	79,492
1989	9,627	2,230	67,827	400	80,083
1990	8,887	2,044	76,652	466	88,049
1991	7,999	1,840	73,363	471	83,673
1992	11,781	2,710	59,246	433	74,170
1993	9,409	2,164	49,525	433	61,531
1994	11,101	2,553	55,060	433	69,147
1995	9,789	2,251	68,949	398	81,387
1996	11,034	2,538	72,252	398	86,222
1997	9,966	2,292	72,284	398	84,941
1998	13,638	3,137	70,516	594	87,885
1999	14,444	3,322	67,500	594	85,860
2000	17,922	4,122	67,365	594	90,003
2001	20,542	4,725	71,462	553	97,281
2002	20,343	4,679	67,061	606	92,688
2003	20,861	4,798	66,515	659	92,832
2004	21,867	5,029	68,135	711	95,742
2005	23,185	5,333	67,500	764	96,782

The total reconstructed catch for the United Republic of Tanzania is presented for 1950-2005 along with the FAO data, which represent reported landings (Figure 3). Since 2000, the FAO has reported catches between 49,500 and 53,000 t, while the present study suggests catches between 90,000 and 97,500 t for the same time period. Overall, for the 1950-2005 period, the reconstructed catch is 1.7 times larger than that reported by FAO.

Discussion

As the seafood market globalizes and the coastal population of Tanzania continues to grow at high rates (as does the country's population as a whole), coastal fisheries resources have come under increasing pressure. But this is not always reflected in the official statistics.

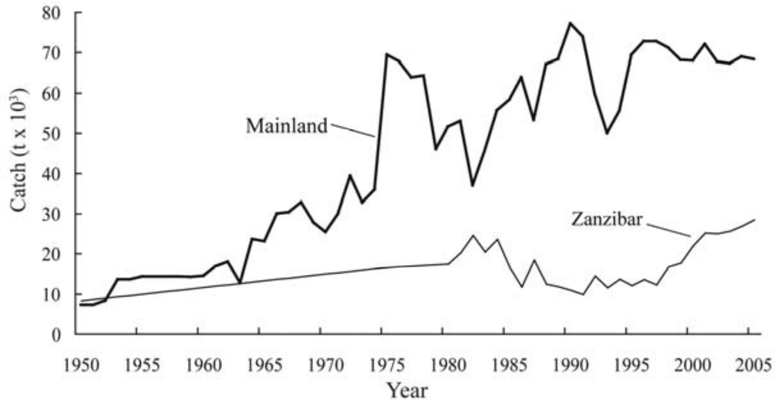

Figure 2. Marine fisheries catch reconstructions for the Tanzanian mainland and Zanzibar, 1950-2005.

Though there is a large degree of uncertainty with the present catch reconstructions, the assumptions made for this study are better than the alternative, i.e., the omission of Zanzibar from official reports and the chronic underreporting of mainland Tanzania catches. The result is that the reconstructed catches now incorporate Zanzibar into the overall marine fish catches statistics, they estimate catches by collectors on both the mainland and Zanzibar, and that they compensate for general underreporting on the Tanzania mainland. The finding that the reconstructed Tanzanian catches are 1.7 times larger than the catches presented by FAO over the 1950-2005 period supports the findings of van der Elst *et al.* (2005), which, based on calculations made for Africa's seven Western Indian Ocean countries, estimated that the FAO statistics reflect only half of the total real catch.

The present catch reconstruction also confirms reports of declining catch rates on the mainland (Silva, 2006). Historically, fishers in Tanzania were considered better off than farmers (Wenban-Smith, 1965), but this changed as catches became divided among more and more fishers (Shao *et al.*, 2003). Anecdotes and available fisheries data suggest that fishing grounds within range of the vessels were maximally exploited in the early 1980s (Ngoile, 1982). Catch per fisher also peaked in the early 1980s, though it could be that the high catches reported in the early 1980s were a result of improved statistics, such as those introduced in 1981 (Jiddawi and Muhando, 1990), and catch per fisher actually peaked earlier. On the mainland, catch per fisher in the mid-1990s was roughly 5 $t \cdot fisher^{-1} \cdot year^{-1}$, while in recent years, it has been around 3.5 $t \cdot fisher^{-1} \cdot year^{-1}$. Today, many mainland fishers are also farmers and own one to two hectares of land for farming when fishing is difficult (Shao *et al.*, 2003).

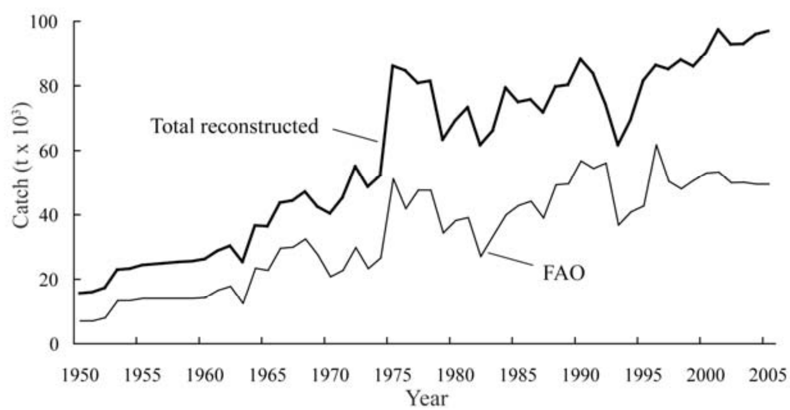

Figure 3. Total reconstructed marine fisheries catches for the United Republic of Tanzania compared to FAO reported catch, 1950-2005.

On Zanzibar, the population growth rate (~3.0 percent) is even higher than that of the mainland (~2.8 percent). Furthermore, there is almost an equal number of fishers on Zanzibar as the mainland (20,000) and they compete for resources in a much smaller coastal area. Though fisheries catches in Zanzibar in recent years are similar to those from the early 1980s, this catch is divided among almost double the number of fishers. Thus high catches in recent years are not a result of improved ecosystem health but rather due to much greater fishing pressure due to high population growth, lack of arable land, and the growth in tourism. In 1969, Zanzibar had a total of 80 landing sites. By 1990, there were nearly 200

(Jiddawi and Muhando, 1990). Today, catch rates per fisher are much lower in Zanzibar than on the mainland and range between 0.5 and 1 5 t·fisher^{-1}·year^{-1}, confirming that fishers in Zanzibar are among the poorest and most disadvantaged in Tanzanian society (Suleiman, 1999). Fishers in Zanzibar are also more heavily reliant on fish for protein than mainland fisheries, due to the shortage of arable land on the islands.

It is difficult to know how much fishing has deteriorated, though, due to the lack of emphasis on marine fisheries research. Jiddawi and Stanley (1999) provided the first "baseline observations, which can be followed over time." A late 1990s baseline will have obvious implications for marine management and/or ecosystem restoration. But poor data is no longer a good excuse for poor management, especially for nearshore finfisheries (Johannes, 1998).

Tanzania has enacted good fisheries legislation with calls for better data collection, though these efforts have been stymied due to lack of resources and likely the remoteness of fishing communities. The National Fisheries Sector Policy was adopted by the government in 1997 and stressed the need to understand the fisheries resource base and banned some destructive fishing practices, such as beach seining. However, they are still practiced (Othman, 1999; Verheij *et al.*, 2004; Mngulwi, 2006). Beach seining catches juveniles of many valuable species, such as snappers, scavengers and emperors (Nhwani, 1981).

Until just recently, fisheries management in Tanzania has almost entirely focused on the great lakes (Mngulwi, 2006). Assuming catches for freshwater systems do not suffer the same level of underreporting as marine fisheries, the present results show that marine catches account for 25-30 percent of total fisheries catches in Tanzania, rather than 10-15 percent as suggested by previous reports (Mgawe, 2005). This has obvious implications for the future of marine fisheries management, including national management efforts and foreign aid. Furthermore, this area of the Western Indian Ocean is more important than has otherwise been noted.

According to FAO statistics, the Western Indian Ocean represents 8 percent of the world's oceans but generates only 4 percent of reported landings (van der Elst *et al.*, 2005). As evidenced by this work and a similar study of Mozambique (Jacquet and Zeller, this volume), this discrepancy is a better indicator of underreporting of the small-scale sectors than of productivity. The marine fishing sector is a more important asset to food security and the magnitude of resource extraction much greater than was previously recognized. It may be true that collector catch estimates should be even larger than the ones generated here and that marine fish provides an even greater part of the coastal Tanzanians' diet.

On Zanzibar, collectors account for about 20 percent of the total catch while on the mainland the collector catch is less than one percent of total catch. Perhaps farming is much more productive on the mainland due to greater areas of arable land but perhaps the number of collectors is greatly underestimated. The number of reported collectors in the whole of Tanzania seems low in comparison with those reported for Mozambique (nearly 50,000) and further research should explore the extent and effort of collectors on the Tanzanian shore.

Though Malthusian overfishing - a combination of population growth and destructive fishing gear (Pauly, 2006) - is likely at work in Tanzania, increasingly global markets for seafood are also to blame. 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). Now, there is a recent government provision to lift the export ban on marine finfish and allow ten different groups of fish to be exported: tunas and kingfishes, carangids (jacks), parrotfish, and bluefish, red snapper, groupers, rock cod, rays and skates, soles, marlines, and catfishes (Mgawe, 2005).

The Fisheries Division believes that an export fishery would reduce local poverty (Anderson and Ngatunga, 2005). However, finfish provide an important protein source to coastal communities and account for about 60 percent of animal protein consumed (Shao *et al.*, 2003; Mngulwi, 2006). Furthermore, Anderson and Ngatunga (2005) point out that an export fishery would raise prices and reduce the supply to domestic markets and exacerbate hunger (Mgawe, 2000).

Furthermore, lessons from Lake Victoria's export fishery should be considered. At Lake Victoria, the export trade is dominated by a select few companies and fishers are price-takers (i.e., controlled by their credit relationship with large buyers) (Anderson and Ngatunga, 2005). Returns rarely go to fishers.

The impact of the global seafood market on fisheries, particularly those with weak management, is predictable. Foreign demand for crustaceans has caused the overfishing of lobsters and shrimp. The lobster catch peaked in the late 1980s and, since then, the average size of lobster has decreased (Bakari and Andersson, 1999; Jiddawi and Öhman, 2002). In just one decade, the CPUE for prawns declined from 610 kg·day^{-1} in 1990 to 307 kg·day^{-1} in 2001 (Mngulwi, 2006). The Asian market offers high prices for shark fins ($50·kg^{-1}) and, consequently, sharks are now heavily targeted (Jiddawi and Shehe, 1999) and overfished in many areas off Tanzania (Guard *et al.*, 2000).

This study indicates that the coastal population of Tanzania is exploiting fisheries resources to a degree that may be threatening their food security. Unless there is a way to ensure local fishers receive the benefits of an export fishery, there is no immediate reason to allow international markets to stimulate additional fishing effort, too.

Acknowledgements

The authors acknowledge the Pew Charitable Trusts, Philadelphia for funding the *Sea Around Us* Project, and the World Wildlife Fund (WWF) for their financial support of the present study. The authors also thank H. Fox, M. Guard, N. Jiddawi, H. Machano, M. Meddard, Y. Mgawe, S. Milledge, G. Mwamsojo, A. Ngusaru, J. Rubens, and F. Sobo.

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Reconstructing catches of marine commercial fisheries for Brazil[1]

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Abstract

A database of catches originating from marine commercial fisheries in Brazil was compiled at the state level based on data from national bulletins and previous work for the years 1950-2004. The degree of detail reported in the bulletins differed substantially among years. Three categories were identified: total catch per state (1950-1955), catch of large groups (fishes, crustaceans, molluscs, cetaceans, and chelonians) per state (1956-1961), catch of main taxa per state (1962-1975) and catch of all taxa per state (1976-2004). A simple estimation process was used to estimate missing values using data from the two closest years for which complete data were available. We assessed the estimation process using the 1969 data and found that estimated and observed values were very similar, with the exception of sardine in the State of Rio de Janeiro. National catches increased from 1950 to 1986, and declined thereafter to the current level of approximately 500,000 t. These catches were associated with 446 common names, which may include synonyms used in different states, as the correspondence between common and scientific names is still not well understood. Catches were almost equally distributed among regions (with lower values for northern Brazil) in the 1950s. With the development of industrial fisheries, the southern and southeastern regions started to dominate. After the collapse of sardine stocks, the distribution among regions seemed to be reverting towards homogeneity, but at levels 3.5 times higher than in the 1950s.

Introduction

The analysis of the 'health' of fisheries resources requires at least basic data such as catch and effort. Some countries do not keep an electronic historical record of such data either because they do not exist or because there is not enough interest in recovering historical data. In Brazil, only catch data are regularly collected, and effort information is available only for major resources such as sardine, lobster, and southern snapper. The low quality of catch statistics in Brazil has been long recognized (e.g., Paiva, 1997; Freire, 2005; Lucato, 2006). Nevertheless, this cannot serve as an excuse for not making official catch data from scattered documents more readily available.

Figure 1. Brazil and its coastal states: Amapá (AP), Pará (PA), Maranhão (MA), Piauí (PI), Ceará (CE), Rio Grande do Norte (RN), Paraíba (PB), Pernambuco (PE), Alagoas (AL), Sergipe (SE), Bahia (BA), Espírito Santo (ES), Rio de Janeiro (RJ), São Paulo (SP), Paraná (PR), Santa Catarina (SC), Rio Grande do Sul (RS).

The United Nations Food and Agriculture Organization (FAO) provides online access to catch data as supplied by its member countries (www.fao.org). However, these data are presented at a country level, and do not allow analyses at a more spatially detailed, e.g., state level. Considering the great length of the Brazilian coast (covering approximately 38 degrees of latitude, Figure 1), spatially detailed information is required, as the features of the marine environment and target species vary along the coast (Matsuura, 1995). Freire (2003) compiled catch data for the period from 1980 to 2000. Here, we extend the temporal

[1] Cite as: Freire, K.M.F. and Oliveira, T.L.S. 2007. Reconstructing catches of marine commercial fisheries for Brazil, p. 61-68 *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia, Vancouver [ISSN 1198-6727].

coverage of the electronic database backwards and forwards, covering the period from 1950 to 2004 in its entirety. Some important characteristics of local fisheries are also discussed.

Materials and Methods

A database of marine catches for Brazil was compiled for the period 1950-2004. Previously, catch data for 1980-2000 had been compiled by Freire (2003). For the remaining periods, a variety of source documents were used (see Table 1). The analysis was performed backwards in time. The values presented here refer only to landings[2], and originate from both artisanal and industrial fleets.

Table 1. Sources used to compile marine catch data from commercial fisheries (artisanal and industrial) in Brazil from 1950 to 2004.

YEAR	SOURCE	FORMAT	TYPE OF DATA[a]
1950-1955	IBGE (1957)	Paper	Total (M + F)
1956-1957	IBGE (1959)	Paper	Group (M+ F)
1958-1960	IBGE (1961)	Paper	Group (M + F)
1961	IBGE (1962)	Paper	Group (M + F)
1962	MA/SEP (1964)	Paper	Main taxa (M +F)
1963	MA/SEP (1965a)	Paper	Main taxa (M + F)
1964	Estimated	—	All taxa (M)
1965	Estimated	—	All taxa (M)
1966	MA/SEP (1967)	Paper	Main taxa (M + F)
1967	MA/ETEA (1968)	Paper	Main taxa (M + F)
1968	MA/ETEA (1969)	Paper	Main taxa (M + F)
1969	MA/ETEA (1969)	Paper	Main taxa (M + F)
1970	MA/EE (1971)	Paper	Main taxa (M + F)
1971	SUDEPE/IBGE (1973)	Paper	Main taxa (M + F)
1972	SUDEPE/IBGE (1975)	Paper	Main taxa (M + F)
1973	SUDEPE/IBGE (1976a)	Paper	Main taxa (M + F)
1974	SUDEPE/IBGE (1976b)	Paper	Main taxa (M + F)
1975	SUDEPE/IBGE (1976c)	Paper	Main taxa (M + F)
1976	SUDEPE/IBGE (1979a)	Paper	All taxa (M + F)
1977	SUDEPE/IBGE (1979b)	Paper	All taxa (M + F)
1978	SUDEPE (1980a)	Paper	All taxa (M + F)
1979	SUDEPE (1980b)	Paper	All taxa (M)
1980-2003	Freire (2003)	MS Access	All taxa (M)
2001	IBAMA (2003)	PDF	All taxa (M)
2002	IBAMA (2004)	PDF	All taxa (M)
2003	IBAMA (2004)	PDF	All taxa (M)
2004	IBAMA (2005)	PDF	All taxa (M)

[a] M = marine waters; F = Freshwater

2001-2004

Data were obtained from online PDF format bulletins made available by the Brazilian Institute for the Environment and Renewable Resources (IBAMA)[3] .

1980-2000

An existing electronic database was used for this period (Freire, 2003).

1979

From 1979 backwards, all data were entered manually, as no electronic versions were available. In 1979, values were presented by habitat, thus catches from marine waters were easily identifiable.

1976-1978

Catches from both marine and freshwater habitats were presented in the same source table, and were split between habitats for all taxa recorded in each state.

1962-1975

Catches from both habitats were presented in the same table but only for taxa that accounted for about 80% of total catch for each state. For this period, catches for the main taxa available in the bulletin were encoded manually (both for marine and freshwater habitats) and subtracted from the total catch for each group (fishes, crustaceans, molluscs, chelonians and cetaceans). The remaining catches were distributed among the non-mentioned taxa using the list available for 1976-1977. The distribution was based on the proportion observed of each taxon in 1976-1977 regardless of its habitat, which was adjusted every year as different taxa had catch values in each state each year. Thus, the procedure used was as follows:

The proportion of non-mentioned taxon j (taxon specific catches reported separately only for major taxa) of group g in year y:

[2] For simplicity's sake, they are still referred to as 'catches' in this document.
[3] Brazilian Institute for the Environment and Renewable Resources (IBAMA), accessible at www.ibama.gov.br.

$$P_{jgy} = \frac{(C_{jg76} + C_{jg77})}{\sum_{j=1}^{n}(C_{jg76} + C_{jg77})} \quad ...1)$$

where g represents the taxonomic group (fishes, crustaceans, molluscs, cetaceans, chelonians); C_{jgy} is the catch for non-mentioned taxon j of group g in year y, and is defined as:

$$C_{jgy} = (T_{gy} - S_{gy}) \times P_{jgy} \quad ...2)$$

where T_{gy} is the total reported catch for group g in year y; and S_{gy} is the sum of catches for all reported taxa i within group g in year y.

1956-1961

The procedure above was also used to estimate catches for 1956-1961, considering the total catch available per group for each state. However, proportions P_{jgy} were calculated based on the average catch data for the years 1962 and 1963.

1950-1955

For this period, total catch (one single number per year) was the only information available in the bulletins for each state and the proportion among groups was defined based on 1956 and 1957 values. The proportion among taxa was defined as presented for the period 1962-1975. This procedure was performed separately for each state.

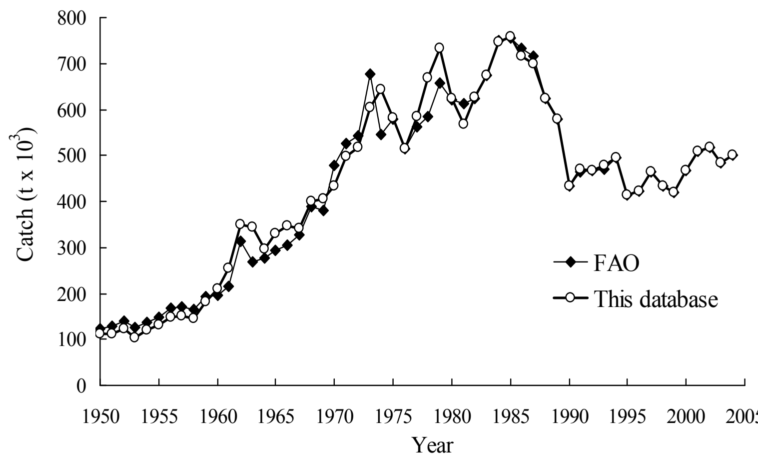

Figure 2. Catches originating from reported marine commercial fisheries in Brazil for the period 1950-2004, comparing FAO and present, reconstructed data.

RESULTS AND DISCUSSION

National and regional catches

The database compiled here indicates that marine catches from Brazil increased from 113,000 tonnes in 1950 to a maximum of 759,000 tonnes in 1985 (Figure 2). Subsequently, catches declined, but then have stabilized at approximately 500,000 tonnes. Data presented by FAO for Brazil indicate very similar trends (Figure 2). A previous analysis indicated that FAO data were higher than data from the national bulletins by about 100,000 tonnes for the period between 1988 and 2000 (Freire, 2003). Further analysis indicated that this discrepancy was due to the inclusion of 100,000 tonnes of 'marine fishes n.e.i.' (not elsewhere included; Freire, 2005). These 100,000 t were supposed to account for catches originating from recreational and subsistence fisheries, even though no basis for such an estimate could be found in local documents. The present re-analysis of the catch data for the same period indicated that this estimate was removed from official FAO data, which now matches the national bulletins for most of the years (Figure 2).

The present data strongly suggests that non-reported catches, e.g., subsistence and recreational, should be assessed and estimated for future inclusion in estimates of total marine catch for Brazil.

The trend in total catches is defined by the trend for fin-fishes, which represent 80-90% of total catches throughout the period. The trend for fishes is also similar to the crustaceans, increasing from 1950 to the early 1980s and decreasing thereafter (Figure 3a). The slight increase in the latest years appears mainly due to higher catches in Pará associated with an improving collection system of catch statistics. Note that catches of crustaceans were equivalent to 10-20% of fishes.

Molluscs were collected throughout the period, with an increasing trend (Figure 3b). Chelonians had the lowest catches amongst the groups with the highest volume caught between 1958 and 1983. After 1988, there was no record of chelonians, due to a complete catch ban imposed in 1986 (Marcovaldi and Marcovaldi, 1999). Nevertheless, it is known that they are caught incidentally by longliners and in gillnet lobster fisheries (e.g., Weidner and Arocha, 1999; Sales and Lima, 2002; Pinedo and Polacheck, 2004). For a discussion on catches of cetaceans, see below.

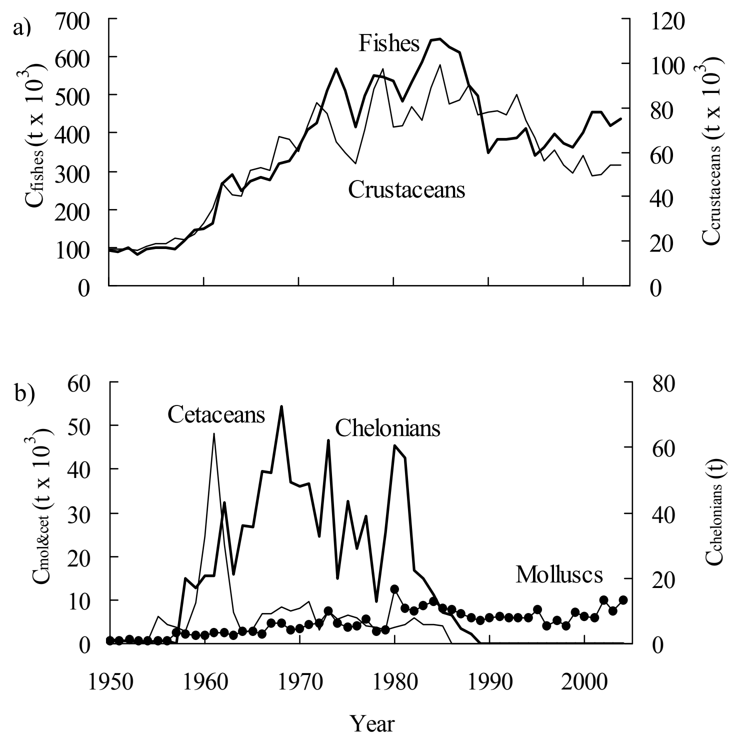

Figure 3:. Commercial marine fisheries catches in Brazil for the period 1950-2004: a) Fishes and crustaceans; b) Molluscs, cetaceans and chelonians.

From 1950 to the early 1960s, three out of four coastal geographic regions of Brazil contributed equally in terms of marine commercial catches (a fifth region is western Brazil and it pertains only to fresh waters, Figure 4). From the early 1960s onwards, when the first industrial fleets started to operate, the southern and southeastern regions alternated in dominating the catches of the country. This continued until 1980 when the southeast had the highest catches, dominated by sardine. After the collapse of sardine stocks in the early 1990s, the south dominated again. The northern and northeastern regions had a smooth increase in catches throughout the period analyzed. Currently, we notice that there is a trend back to the beginning of the period analyzed, with all regions contributing equally to total national catches (though at a level 3.5 times higher than in the early 1950s).

Assessing the estimation procedure

The estimation process was validated using 1969 data. Data were estimated for all taxa recorded in all years for all states. The estimated values were compared with observed data for the selected taxa for which observed data were available. The process was able to estimate well catch values for all taxa, except for 'sardinha' (sardine) in the state of Rio de Janeiro (Figure 5). When the sardine was eliminated from the analysis, the estimated values correlated very well with the observed data (r^2 = 0.96, Figure 5), with the intercept not being significantly different from zero, and the slope not being significantly different from unity. Thus, the estimation procedure used here appears adequate for all taxa, except for sardine, which represented 12% of total catch from Brazil in 1969. We estimated the 1969 catches for sardine using a regression for the period 1962-1971, but the estimated value increased only from 36,611 t to 36,893 t, a value far below the observed 48,664 t. Sardine is a small pelagic, and is closely affected by environmental oscillations. Thus, simple procedures such as those presented here fail to consider the effects of environmental fluctuations on catches. All estimated catches for sardine presented here as preliminary estimates can be replaced by better estimates for this taxon after

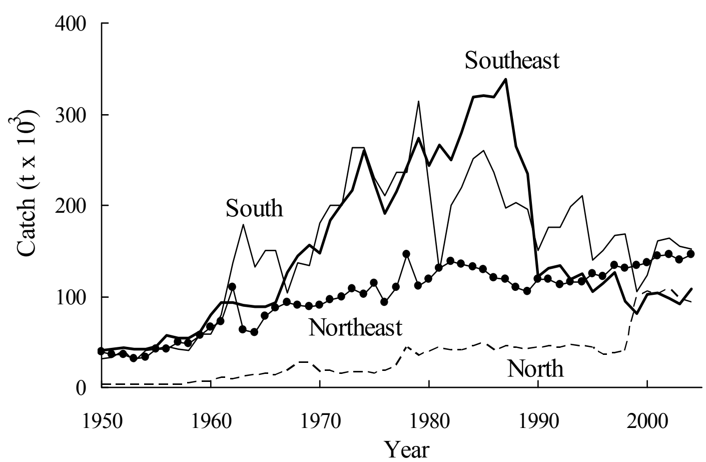

Figure 4. Commercial marine catches from the four coastal geographic regions of Brazil (1950-2004).

consulting local experts. One should point out that for the period between 1962 and 1977, sardine catches are referred to 'sardinha' (i.e., sardine) and 'sardinha verdadeira' (i.e., true sardine), with higher catches associated with 'sardinha' in some years and with 'sardinha verdadeira' in others. All analyses presented here were conducted with the combined catches for the two taxa, but excluding other sardine taxa.

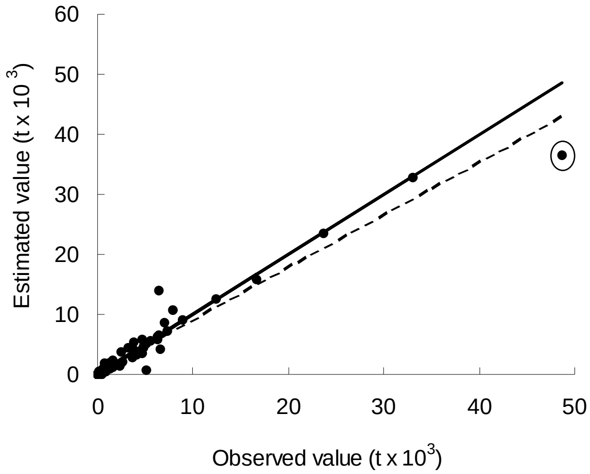

Figure 5. Estimated and observed marine commercial catches for the major taxa caught in 1969: dashed line includes sardine for the state of Rio de Janeiro, solid line excludes sardine for Rio de Janeiro.

Details for other taxa

The 'ghost crab' (*Ucides cordatus*), is distributed from the state of Amapá to Santa Catarina (Figure 1; Melo, 1996). It is an important resource for artisanal fishers and dealers in northern and northeastern Brazil, even though detailed information on catch, effort, and stock size are missing. Indeed, we noticed that the 'ghost crab' was not recorded as an individual entity in the 1980s and in the 1990s. The list of marine species available in the bulletins for these years indicated that records attributed to 'caranguejo' (i.e., 'crabs') were in fact 'ghost crab'. After 2000, 'ghost crab' appears in the bulletins only in the states of Rio de Janeiro, São Paulo, and Rio Grande do Norte. In the 1970s, the reporting situation is more confusing: in the 1979 and 1978 bulletins, 'ghost crab' was not present; in 1974-1977, 'ghost crab' appears together with another category called 'caranguejo (de mar)' (marine crab) but was reported as a freshwater species. In the early 1970s and in the 1960s, 'ghost crab' was not reported. In the 1950s, catches were not recorded at the taxon level. Any attempt to understand the dynamics of this fishery in Brazil is undermined by the way catch statistics are presented in national bulletins. Thus, the analysis presented for this species in GeoBrasil (2002) was restricted to 1998-1999, and thus missed important baselines. The analysis of catch data for northeastern Brazil presented in IBAMA (1994) was heterogeneous amongst all the states due to this data heterogeneity. Considering that *Ucides cordatus* is probably a keystone species in mangrove areas (e.g., Glaser and Diele, 2004), and its sale constitutes the main income for many households in northern Brazil (Glaser, 2003), more attention should be paid to correct data collection of catch statistics to allow for assessment of Brazilian stocks.

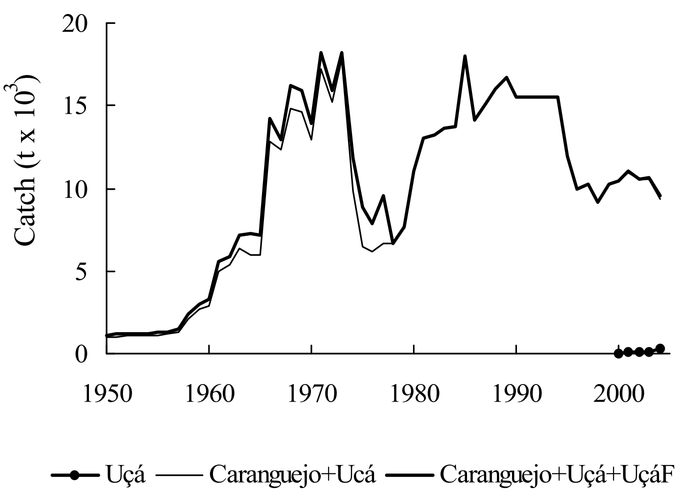

Figure 6. Catches of 'caranguejo-uçá' (*Ucides cordatus*) reported in national statistics, compiled here for all states combined; 'Caranguejo + uçá' indicates 'caranguejo' catches added to 'caranguejo-uçá' (both marine); and 'Caranguejo + uçá + uçáF' includes 'caranguejo-uçá' freshwater catches also.

Catches for 'ghost crab' as compiled here were low (Figure 6). When added to other marine 'caranguejo' data, catches were much higher, and indicated that there was an increase from 1,000 t in 1950 to about 18,000 t by 1973, followed by an apparent decrease from 1973 to 1978 before returning to the levels of the early 1970s. Another decline in apparent catches occurred from 1986 to 2004 (9,300 t in 2004). This apparent 23% decline in crab catches in the last few years is worrisome; however, we are not able to determine, based on the national bulletins, if all the catches presented in Figure 6 are associated only with *U. cordatus*.

Whale hunting is a very old activity in Brazil, going back to the 1660s. National statistics indicate that catches were very low in the early 1950s (Figure 7), when only humpback whales (*Megaptera novaeangliae*) were caught off the state of Paraíba in northeastern Brazil (Singarajah, 1985). In the early 1960s, catches increased as whalers s tarted to operate off the state of Rio de Janeiro in southeastern Brazil. This operation was very costly as whales were caught further offshore compared to the northeastern region. Whaling soon came to an end in southeastern Brazil and national catches dropped significantly. Mean individual weight of whales increased in the beginning of the period analyzed and decreased after the mid 1960s (Figure 7), when the comparatively smaller minke whale (*Balaenoptera acutorostrata*) was the main species targeted. Catches were zero from 1986 onwards. In 1987, the Brazilian government declared a complete ban on cetacean fisheries (Federal law no. 7643, December 18th, 1987).

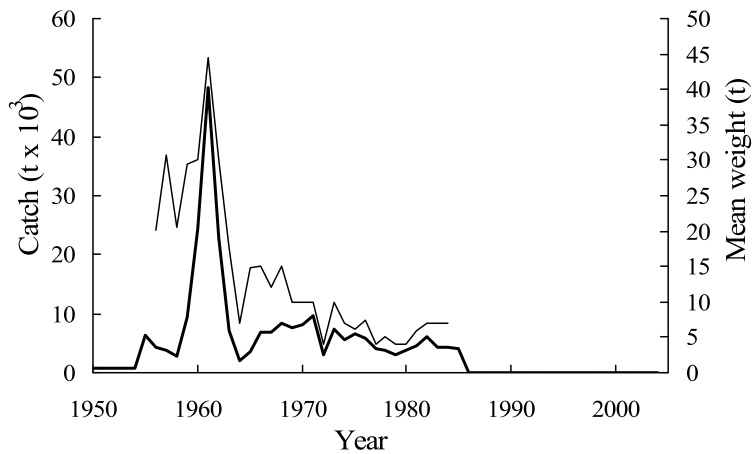

Figure 7. Whale catches in Brazilian waters from 1950 to 2004. The thin line indicates the mean individual weight of the whales caught.

Reported marine catches of molluscs were low compared to other groups, and encompassed 16 taxa. Catches for the main taxa are presented in Figure 8a. 'Marisco' (*Perna perna*) dominated the catches in the early years, and 'lula' (squid; Loliginidae and Ommastrephidae) in the end of the period. Catches of 'ostra' (oyster; *Crassostrea* spp.) and 'polvo' (octopus; *Octopus* spp. and *Eledone* spp.) increased slowly over the period analysed, while catches of 'sururu' (*Mytella* spp.) decreased. Important to note is that from 1970 to 1978, most of the catches were recorded as 'other molluscs'. Trends may be masked by changes and inconsistencies in reported taxon names as was observed for fishes.

Changes in taxon names

Catches are recorded using local common names. After correcting for different spelling of the same names, 446 taxa were recorded in this database. The correspondence between common name and scientific taxon remains to be resolved, although Freire (2005) has demonstrated a richness of common names for each taxon, with different names used in different states. Thus, a detailed comparison and standardization between common names and scientific taxon should be undertaken at state level.

We noticed that some taxon names were used interchangeably over time. This was observed for sardine and crabs as discussed above, but also for other marine taxa. In the state of Rio Grande do Sul, 'pescada real' was called 'pescada verdadeira' between 1968-1973. In northeastern Brazil, 'sarda' was used instead of 'serra' in 1974. In 1962-1963, 'atum' was called 'albacora'. These differences were not restricted to

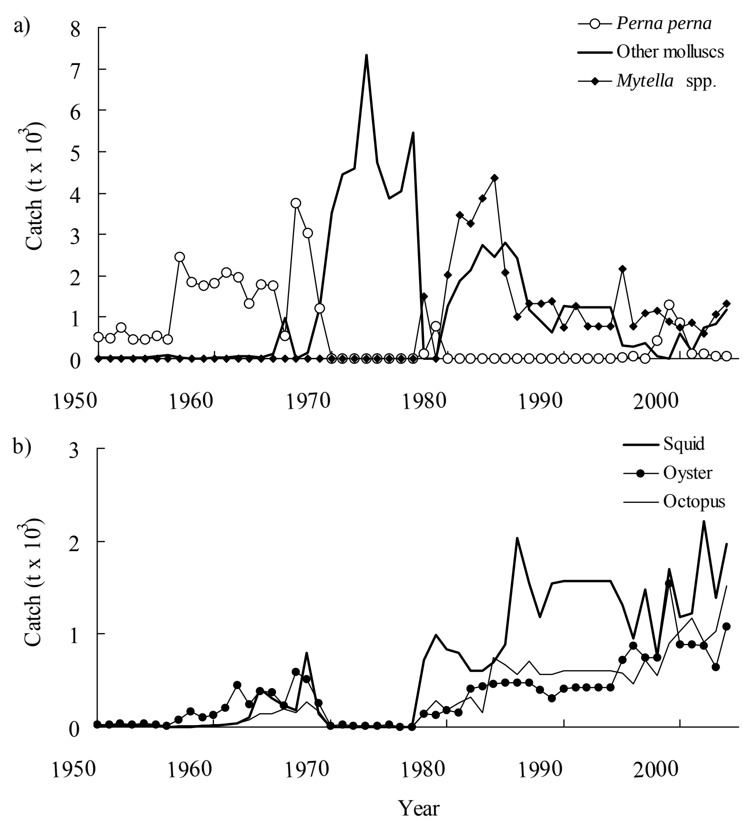

Figure 8. Commercial catches of molluscs in Brazilian marine waters (1950-2004): a) major taxa; b) minor taxa.

marine taxa. For example, 'piaba' was replaced by 'piau' from 1973 backwards. Reconstructions of historical catch time series as undertaken here help detect these and other changes.

FUTURE WORK

Each catch amount compiled in this database is associated with a common name of fish, crustacean, mollusc, cetacean or chelonian. For the first group, the correspondence between common and scientific name is not completely understood. We will establish this correspondence per state for each common name, based on the database compiled by Freire and Pauly (2005) and available from FishBase (www.fishbase.org).

Some states of Brazil have an independent system of collection of catch data, and these data have been encoded over the last few years. There are also bulletins produced by local institutions that report catch data for some states. Data from both sources will be compared with the data compiled here and values will be corrected if necessary.

In the process, we had to compile catch data from freshwater in order to be able to properly split catches from marine and fresh waters for the period 1950-1977. We intend to compile catch data originating from fresh waters from 1978 onwards to better understand how important fisheries are in each environment at a state level. We hope to convince national institutions to better account for historical catch series, using the database presented here as a foundation. This is particularly important now that we have seen some changes in the contribution of different regions to the catch in recent years.

ACKNOWLEDGEMENTS

We would like to thank J. Rodrigues, D. Rodrigues, and C. Primitivo for helping encode part of the data compiled here. The SINAGRI Library (Ministry of Agriculture) sent some of the bulletins used. S. Lucato reviewed an earlier version of this manuscript.

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A RECONSTRUCTION OF COLOMBIA'S MARINE FISHERIES CATCHES[1]

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ABSTRACT

Colombia has coasts on the Atlantic and Pacific Oceans, but its marine fisheries have been limited by the relatively small size of commercially important stocks. However, fishery resources have traditionally been exploited by coastal communities, and industrial fisheries have grown in recent years with the intensification of tuna fishing in both oceans. The management of Colombia's fisheries has been hampered by frequent administrative changes, which has notably led to the loss of parts of the official landings data. We reconstructed Colombia's fisheries catches in the Atlantic and Pacific Oceans for the period 1950-2005. We used secondary sources of information to estimate missing data, and estimated subsistence fishing and the unreported by-catches of the shrimp and tuna fisheries. Our results suggest that for the period 1950-2004, the marine fisheries catches of Colombia may have been more than 1.8 times higher then the landings reported by FAO on behalf of Colombia (1.4 times higher in the Colombian Pacific; 2.0 times higher in the Atlantic). The implications for management are discussed.

INTRODUCTION

Colombia has coasts on the Atlantic (Caribbean Sea) and Pacific Oceans (Figure 1), but its fisheries, although diverse, have been limited by the relatively small size of commercially important stocks (Prado and Drew 1999). Nonetheless, fishery resources historically have been an important part of the livelihood of human communities on both coasts (Squires and Riveros 1978, Pérez-Ramírez 1986, Prado and Drew 1999). Fisheries management in Colombia has been impaired by frequent transfers of management responsibilities between government agencies. In past years, the National Institute of Fisheries and Aquaculture (INPA) was responsible for the collection and analysis of fisheries statistics

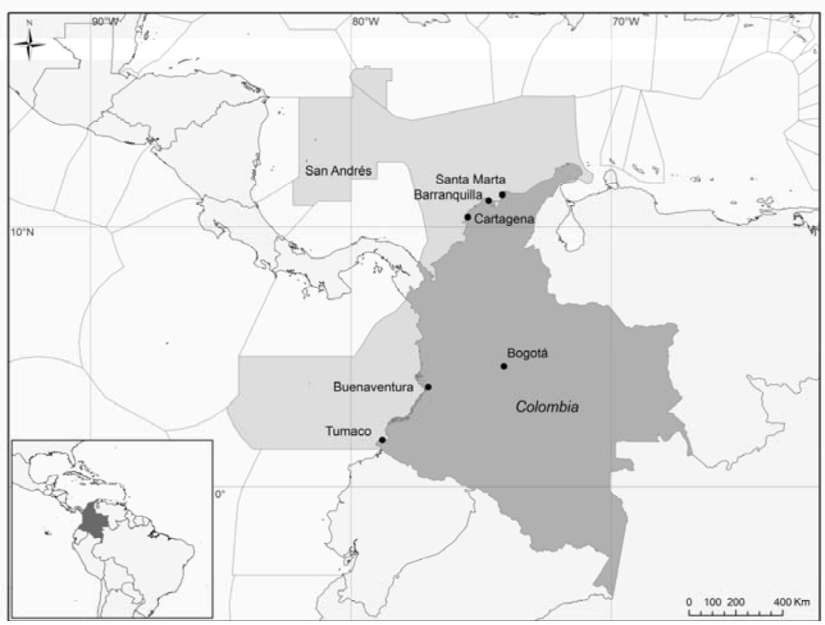

Figure 1. Colombia's EEZ and major ports in Atlantic and Pacific waters.

[1] Cite as: Wielgus, J., Caicedo-Herrera, D. and Zeller, D. 2007. Reconstruction of Colombia's marine fisheries catches. p. 69-79. *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

and the regulation of fishing activities from 1990 to 2003. With its closure, these responsibilities were assigned to the Colombian Institute of Rural Development (INCODER), a subsidiary agency of the Ministry of Agriculture and Rural Development.

Industrial fisheries

Industrial fishing (defined as boats larger than 15 m) in Colombia began with shallow-water shrimp trawling in the Pacific Ocean (for *Penaeus occidentalis*, *Xiphopenaeus riveti*, and *Trachypenaeus* spp.) in the late 1950s, and in the Caribbean Sea (for *Farfantopenaeus brasiliensis*, *F notialis, and F. schmitti*) in the mid-1960s (Gómez-Canchong *et al.* 2004). Shrimp was the most important contribution of the industrial fishery to total reported landings in both oceans until the mid-1980s, when overfishing began (Mora-Lara 1987, INDERENA 1988, Figure 2). Since then, tuna has been the most important component of industrial landings (Ministerio de Agricultura 1993, Beltrán-Turriago and Villaneda-Jiménez 2000; Figure 2). Tuna fishing takes place in EEZ waters of the Atlantic and Pacific with boats of less than 400 t capacity, and in international waters (for *Thunnus albacares* and *Katsuwonus pelamis*) with larger boats (Beltrán-Turriago and Villaneda-Jiménez 2000).

The industrial shrimp trawlers have remained virtually unchanged since they began operating in Colombia (Zúñiga-Clavijo *et al.* 2004, Rueda *et al.* 2004). Most trawlers have a capacity of 20-40 t (Barreto-Reyes *et al.* 2001). They are fuel-inefficient, and, as their gear is unselective, a large proportion of the by-catch is discarded, or is retained and marketed without being reported to the fisheries authorities (Duarte *et al.* 2006). Shrimp trawlers in the Caribbean are based in Barranquilla, Cartagena, and Santa Marta (Figure 1), but they fish along the entire coast (Giudicelli 1979). In the Pacific Ocean, there are shrimp trawlers in Buenaventura and Tumaco (Barreto 1986, Rueda *et al.* 2004, Figure 1). The Buenaventura trawlers operate along the entire Pacific coast, while the trawlers based in Tumaco operate only in the local waters (Barreto 1986, Mora-Lara 1986).

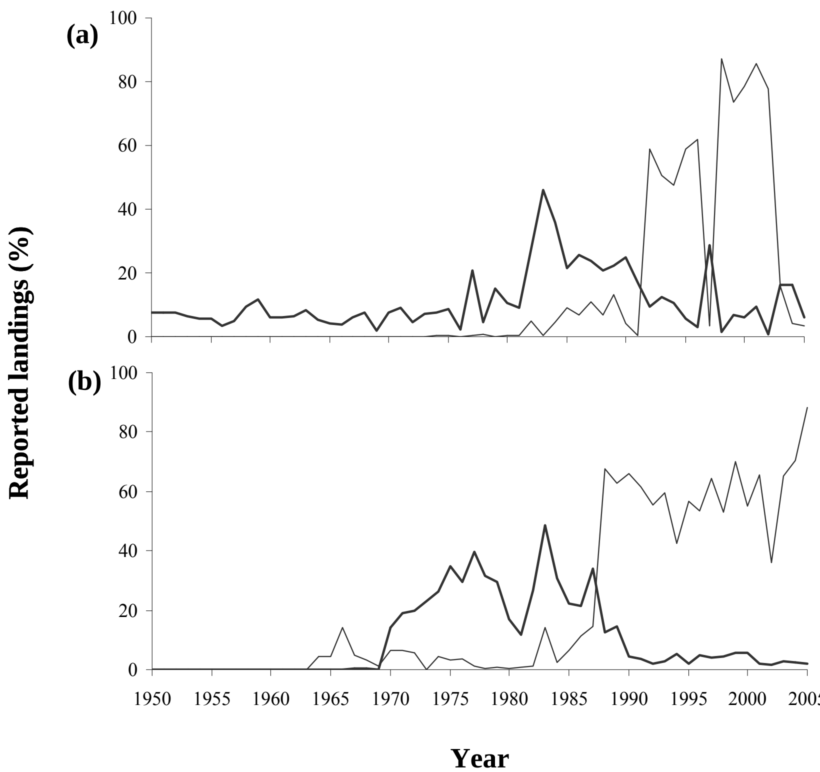

Figure 2. Percent contribution of shrimp (dark line) and tuna (light line) to total reported landings in Colombia's (a) Atlantic and (b) Pacific Oceans for 1950-2005. In years for which official data were not available, FAO landings statistics were used (see text for details).

In the Pacific, Colombia also has an industrial fishery for anchoveta (*Cetengraulis mysticetus*) and thread herring (*Opisthonema* spp.), which are used in fish-meal and fish-oil production (Beltrán-Turriago and Villaneda-Jiménez 2000). There are small industrial fisheries for spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*) off the San Andrés Archipelago in the Caribbean (Figure 1). Also, there is industrial fishing for fish of high value (e.g., snappers, groupers, sharks) in the Caribbean and Pacific Ocean. Most of the products of the industrial fisheries are exported (Beltrán-Turriago and Villaneda-Jiménez 2000).

Small-scale fisheries

Small-scale fisheries (nets cast from the shore and boats less than 15 m) target coastal resources in both oceans and supply a large part of the marine fish landed in Colombia (Magnusson *et al.* 1983, Mora-Lara 1987, Pereria-Velásquez 1993). There are approximately 14,000 small-scale fishers in the Caribbean, and approximately 15,000 in the Pacific coast (Beltrán-Turriago and Villaneda-Jiménez 2000). The most common fishing gears used by small-scale fisheries are cast nets, gill nets, surrounding nets, traps, and long lines (Beltrán-Turriago 2001). Surrounding nets are widely used by small-scale fishers to capture shrimp, and their mesh size is frequently below the legal limit (Friedemann and Arocha 1984, Mora-Lara 1986, 1987, Beltrán-Turriago 2001). These nets capture large numbers of immature shrimp and fish (Mora-Lara 1987). In 1986 (the last year for which data were available), 36% of the reported catch of *Penaeus occidentalis* landed in the port of Buenaventura was captured by the small-scale fishery using surrounding nets (Mora-Lara 1987). In the Tumaco area, shrimp fishing is done with artisanal trawl nets that are operated from motorized canoes. The small mesh size of these nets (1.0-2.5 cm) and their deployment in mangrove areas results in the incidental catch of large numbers of juvenile fish (Friedemann and Arocha 1984). Although small-scale fisheries supply the majority of the seafood that is consumed in Colombia, part of their product is purchased by the industrial sector and exported (Beltrán-Turriago, 2001).

Table 1. Number of taxa (common names) included in the marine landings statistics currently available from the Colombian fisheries management agency (INCODER).

Categories	1975-1990		1991-2005	
	Atlantic	Pacific	Atlantic	Pacific
Fishes	29	29	135	173
Crustaceans	4	4	13	21
Mollusks	4	4	1	10

Here we present a reconstruction of the Colombian Atlantic and Pacific fisheries catches for the years 1950-2005, which was conducted using the methodology in Zeller *et al.* (2006, 2007). First, we reconstruct the officially-reported landings and estimate the percent contribution of small-scale fisheries. We then estimate unreported catches, consisting of discarded and unreported by-catches of the shrimp industry, fish caught and consumed by fishers and their families (subsistence), and fish caught incidentally during tuna fishing. Finally, we compare the reconstructed total catch time series to the landings statistics reported by FAO (FAO Fishstat).

Materials and Methods

Officially-reported landings

Parts of Colombia's official landings data have been lost during the multiple changes in the fisheries management system; INCODER currently holds official landings data only for the years 1975-2005. This information consists of landings data for different number of taxa (by common names of species) for different years, as summarized in Table 1.

Official data for the years 1959-1965 and 1970-1974 were obtained from secondary sources (Ciardelli-Fadul 1968 and Mora-Lara 1986, respectively). These statistics consist of total landings for the Atlantic and Pacific Oceans, and are not disaggregated by taxa. For completing the reported landings time series, we assumed that the country's officially-reported landings

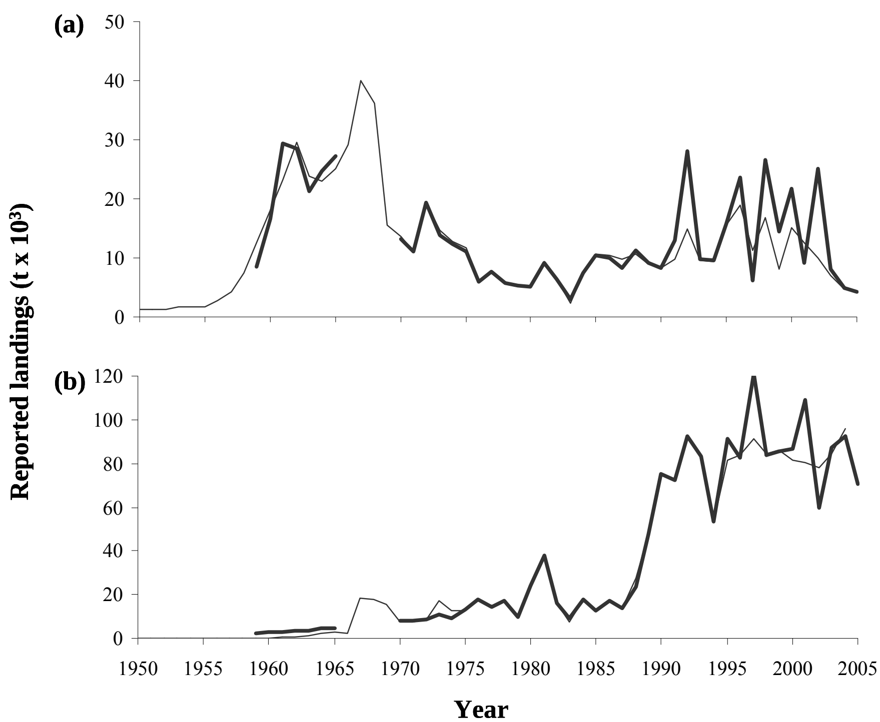

Figure 3. Reported landings statistics for Colombia in the (a) Atlantic and (b) Pacific Oceans for 1950-2005. Note differences in scale. Data obtained from the fisheries management agency (INCODER) or secondary sources are indicated by the dark line, and landings data from FAO are represented by the light line.

for missing years (1950-1958 and 1966-1969) could be represented by the data reported for those years by FAO on behalf of Colombia. This assumption was made because the officially-reported landings for the intervening years are similar to those reported by FAO (Figure 3).

Contribution of the small-scale sector

INCODER provided us with estimates of the percent contribution of the small-scale fisheries to total reported landings for 1999-2005. One additional estimate was found for each ocean in the literature (Table 2).

The percent contribution of small-scale fisheries for all other years was estimated using the following procedure. Tunas, clupeids, spiny lobster, and queen conch are fisheries that are targeted mainly by industrial fleets. We regressed the (arc-sine transformed) percent contribution of the small-scale sector for the known years (Table 2) against the catch of these fisheries, and obtained a significant inverse relationship (Atlantic: r^2=0.79, F=22.86, P<0.01; Pacific: r^2=0.78, F=20.77, P<0.01), The regression equations were used to estimate the percent contribution of the small-scale sector for the missing years in each ocean.

Table 2. Estimates of the percent contribution of the small-scale sector to total reported landings in Colombia.

Source	Area	Year	Contribution (%)
Duarte & García (2002)	Atlantic	1995	29.2
INCODER	Atlantic	1999	13.6
INCODER	Atlantic	2000	12.4
INCODER	Atlantic	2001	31.3
INCODER	Atlantic	2002	18.8
INCODER	Atlantic	2003	59.4
INCODER	Atlantic	2004	52.0
INCODER	Atlantic	2005	72.3
Mora-Lara (1986)	Pacific	1986	67.5
INCODER	Pacific	1999	6.5
INCODER	Pacific	2000	11.1
INCODER	Pacific	2001	5.3
INCODER	Pacific	2002	12.8
INCODER	Pacific	2003	4.8
INCODER	Pacific	2004	5.0
INCODER	Pacific	2005	2.4

Unreported by-catch and discards of the shrimp fisheries

Two studies in the Atlantic Ocean and two in the Pacific Ocean investigated the by-catch of the industrial shrimp fishery. In the Atlantic, INDERENA (1983) reported a mean retained by-catch/shrimp ratio of 2.59 for 3 trawlers during a typical 21-day fishing trip in the southern Caribbean, while the mean discards/shrimp ratio was 11.46. In a study of the shrimp-trawling fleet operating during 3 months in the central and northern Caribbean, Duarte *et al.* (2006) found a mean retained by-catch/shrimp ratio of 2.54 and a mean discards/shrimp ratio of 7.70. Because the Atlantic fleet fishes along the entire Caribbean coast, we averaged these estimates and obtained a mean retained by-catch/shrimp ratio of 2.57 and a mean discards/shrimp ratio of 9.58.

In the Pacific, Trujillo (1983) reported on the catches of shrimp trawlers in Tumaco over a 10-month period. He estimated a retained by-catch/shrimp ratio of 3.9 and a discards/shrimp ratio of 1.32. For a 21-day fishing trip of a boat based in Buenaventura, Barreto-Reyes *et al.* (2001) documented a retained by-catch/shrimp ratio of 2.13 and a discards/shrimp ratio of 0.80. The fishing fleet in Buenaventura is approximately 5 times larger than the Tumaco fleet (Mora-Lara 1986), and we used this weight to estimate mean rates of 2.43 for retained by-catch/shrimp and 0.89 for discards/shrimp.

In a study of the shrimp by-catches that were reported to the fishing authorities in Cartagena between 1974 and 1983, García (1985) found a by-catch/shrimp ratio of 0.15. This value was subtracted from the mean retained by-catch/shrimp ratios above, and the resulting rates and the mean discard/shrimp ratios were applied to shrimp landings to estimate the unreported retained by-catch and discards for each area. We are not aware of studies that have measured the by-catch of small-scale shrimp fisheries in Colombia. Because of the lack of selectivity of the fishing methods employed by these fisheries, we assumed that their by-catch rates (discards and unreported retained by-catch) were the same as those of the industrial shrimp fisheries.

Subsistence fishing

Rodas-López *et al.* (1994) found that small-scale fisheries in the Cartagena region sold only 59.5% of their catch. The remaining 40.5% was of low economic value and was retained for consumption by the fishers and their families (i.e., subsistence). During an exploratory study of fishery resources throughout the Colombian Caribbean, Manjarrés-Martínez *et al.* (2005a, b, c) reported that the percent contribution of commercially important fish to the total catch was 51.1%, 54.2%, and 65.5% in April, July, and October/November, respectively. The estimates of subsistence catch in Rodas-López *et al.* (1994) were based on data for November, so we used the ratio of the mean percent contribution of the catch of low commercial value (43.1%) to the percent contribution in October/November (34.5%) to estimate that the annual percentage of the total catch that is not sold by small-scale fishers is 50.6% (1.25 x 0.405). In 1986, 98% of the fish landed in the Caribbean, excluding tunas, was caught by the small-scale sector. This suggested that 49.6% of total catches (excluding tunas) was not reported in the Caribbean area. Thus, we adjusted the reported fish landings in the Caribbean (excluding tunas) by a factor of 1.98 (1/0.504) to account for subsistence fishing.

Tobón-López *et al.* (in press) studied the catch composition of small-scale fisheries in the central Pacific for an entire year. They found that 20 fish families contributed to 64% of the catch. From these 20 families, we added the contribution to total catch of the families that were classified by Tobón-López *et al.* (in press) as having low commercial but high subsistence value (Haemulidae and Sciaenidae), and those families containing species whose catch was not reported in the official statistics (Ophichthidae, Muraenidae, Labridae, Tetraodontidae, Synodontidae, Cirrhitidae, Scaridae, and Balistidae). We used FishBase (Froese and Pauly 2007) to identify the family of fish species that were reported by their (Spanish-language) common names. The contribution of the 10 families above to total catch was 29.1%. In 1989, 76.2% of the fish landed in the Pacific, excluding tunas and clupeids, was caught by the small-scale sector (Pereira-Velásquez 1993). This suggested that 22.2% of total catches (excluding tuna and clupeids) was not reported in the Pacific area. Thus, we adjusted the reported fish landings in the Pacific (excluding tuna and clupeids) by a factor of 1.29 (1/0.778) to account for subsistence fishing. We consider that this estimate may be conservative because Tobón *et al.* (in press) reported on only 20 fish families (the other families were grouped in a single category), and it is likely that other families include species that are not marketed, but are important for subsistence.

Discards from tuna fishing

During 4 trips aboard tuna fishing vessels with capacity <400 t in the Colombian Pacific, Lara (2004) reported that the discard/tuna ratio was 0.027 for casts directly on tuna schools and 0.056 for casts on floating objects. The mortality rate for the discarded fish was higher than 99%. Casts on tuna schools caught 1.59 as much tuna per hour as casts on floating objects, so we applied the weighted mean of discards/tuna (0.045) to tuna landings to estimate annual discards. We didn't find studies reporting discard rates for any region in the Caribbean, but the mean discard rate for tuna, bonito, and swordfish fisheries are 2.1 higher in the Atlantic than in the East-Central Pacific (Kelleher 2005), so we applied a discards/tuna ratio of 0.095 to the tuna landings in the Colombian Caribbean.

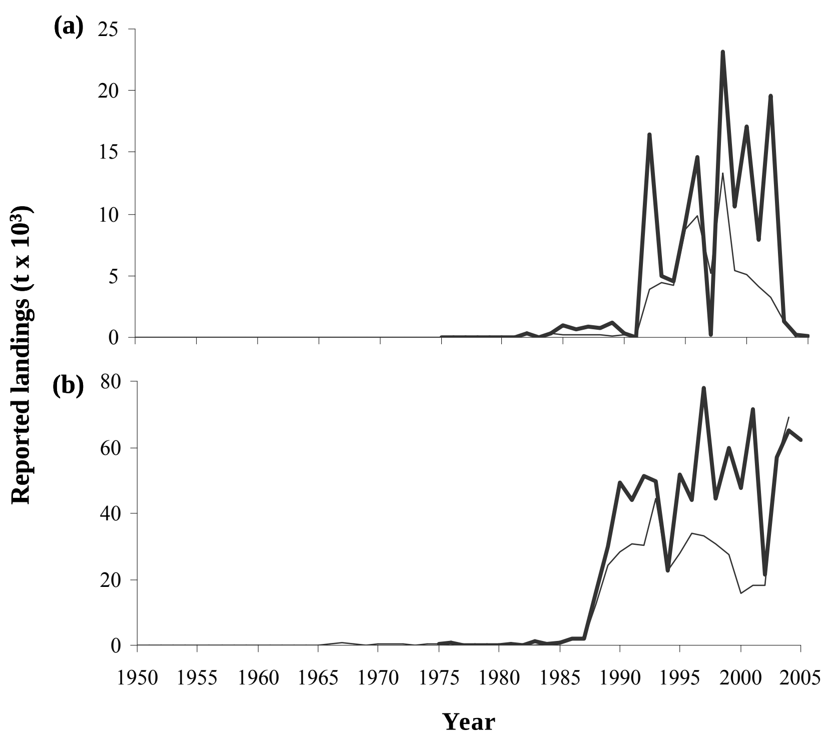

Figure 4. Officially-reported tuna landings (1950-2005, dark line) and tuna landings reported by FAO (1950-2004, light line) for the Colombian (a) Atlantic and (b) Pacific Oceans. Note differences in scale.

RESULTS

Differences in landings between the officially-reported data and those reported by FAO on behalf of the Colombian government have become more pronounced since the intensification of industrial tuna fishing (Figures 3 and 4).

In the Caribbean, differences in reported tuna landings between national sources and FAO statistics accounted for approximately 61% of the variation in the differences in total landings for 1991-2004 ($r^2=0.608$, $F=18.62$, $P<0.01$). In the Pacific Ocean, differences in reported tuna landings accounted for approximately 59% of the variation in the differences in total landings for 1988-2004 (r^2=0.591, F=21.67, P<0.01).

Before the intensification of tuna fishing, the small-scale sector contributed more than half of the total reported landings in the Caribbean and Pacific Oceans (Figure 5).

During years of low fishing by the industrial fleet, the small-scale sector still contributes substantially to the total catch (Figure 5). However, the industrial fleet has contributed with more than 80% of the catch during some recent years.

There are noticeable differences between the officially-reported landings and the reconstructed total catch estimates, and discrepancies were generally larger in the Atlantic than in the Pacific (Figures 6 and 7). The unreported by-catch and the discards from shrimp trawling were the largest components of unreported catch in both oceans, and they generally represented a larger proportion in the Atlantic than in the Pacific (Figure 7).

Our results suggest that for the period 1950-2004, fisheries catches in the Colombian Atlantic may have been 2.9 times higher than the reported landings presented by FAO on behalf of Colombia (Figure 8). In the Colombian Pacific, catches may have been 1.4 higher than the landings presented by FAO. For the country as a whole, total fisheries catches may have been more than 1.8 times higher than the landings reported by FAO (Figure 9).

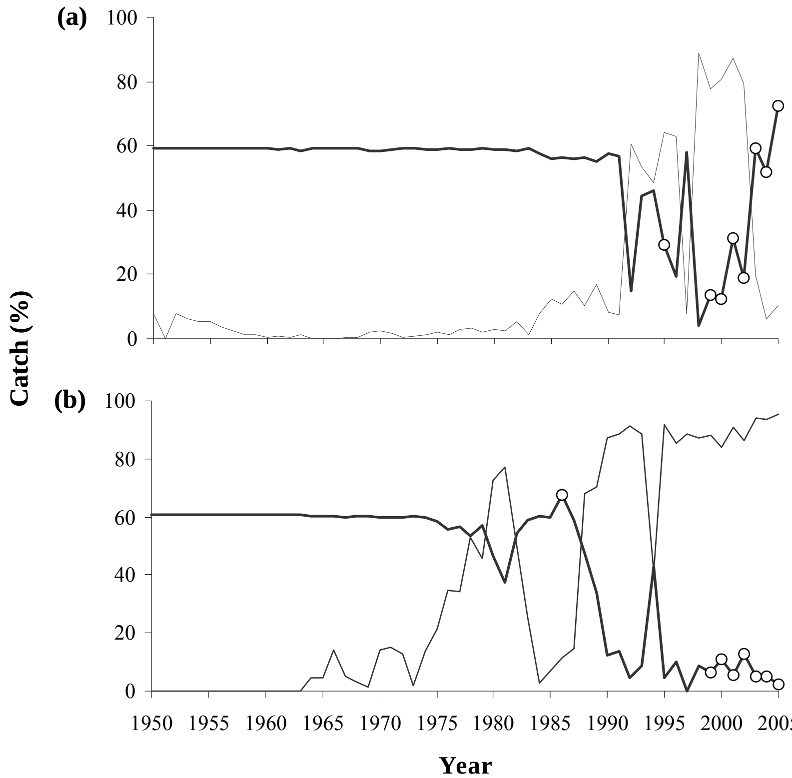

Figure 5. Percent contribution of small-scale fisheries (dark line) and tuna, clupeid, spiny lobster, and queen conch landings (light line) to total catches in the Colombian (a) Atlantic and (b) Pacific Oceans for 1950-2005. Open circles correspond to the values in Table 2. The remaining data points were estimated by using the regression equations of percent contribution vs. industrial landings (see text for details).

Discussion

Our catch reconstruction suggests that the retained, but unreported by-catch and the discards of the shrimp fisheries are the most important components of the unreported catches in the Colombian Atlantic and Pacific Oceans. The antiquated equipment used by the industrial fishery and the artisanal methods employed by the small-scale fishery are non-selective and result in unreported by-catches that are approximately 3 times larger than the shrimp catches in the Pacific Ocean, and 12 times larger than the shrimp catches in the Caribbean. These results are in agreement with FAO reports indicating that the mean discards/shrimp ratio of shrimp trawling in the Caribbean is 12.1, which is one of the highest discard rates of any fishery worldwide (Alverson *et al.* 1994). The lower contribution of discards to total catch in the Pacific may be associated with the higher number of commercially-important species in this area compared to the Caribbean (Table 1). The discard rate in the Colombian Pacific (0.89) is substantially lower than the rates reported for the industrial shrimp trawls in Ecuador and Perú (3.78 and 4.26, respectively, Kelleher 2005).

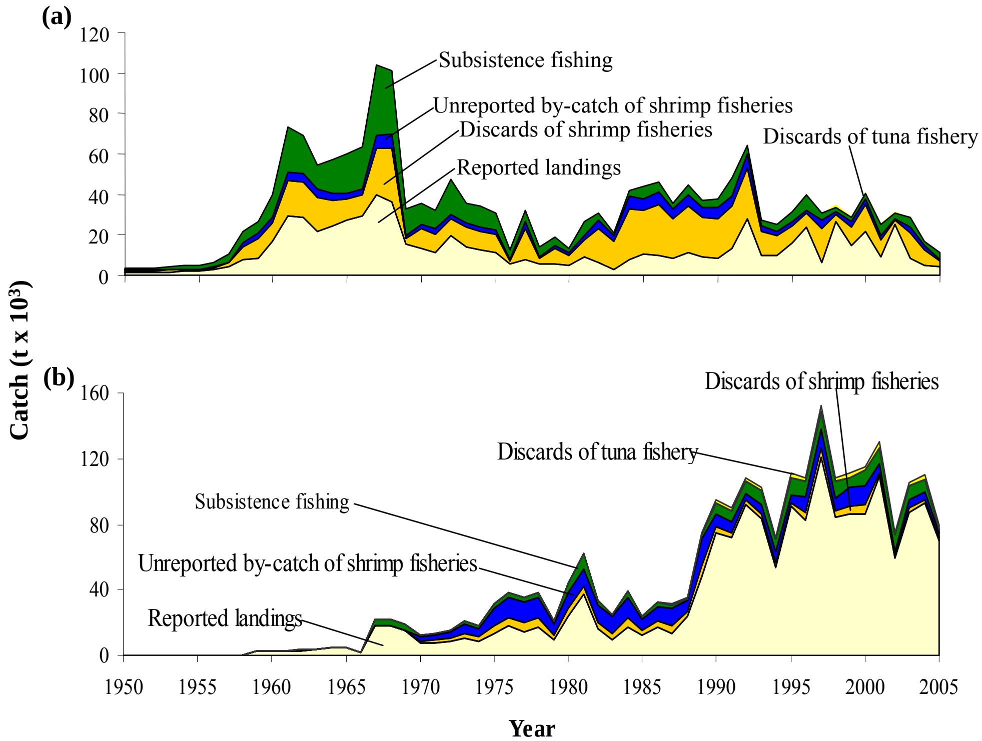

Figure 6. Reconstructed total catch estimates for the Colombian (a) Atlantic and (b) Pacific Oceans for 1950-2005. The reconstruction includes retained but unreported by-catch, discard, and subsistence components.

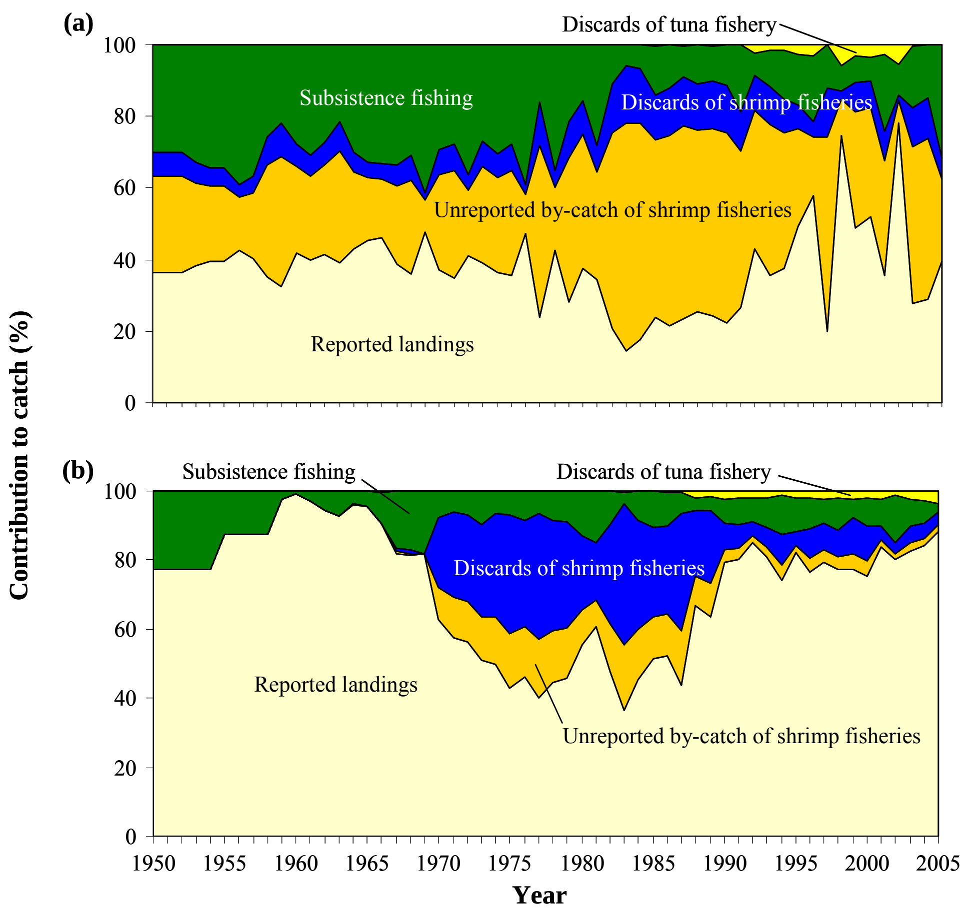

Figure 7. Percent contribution of the different catch components to the reconstructed total catch in the Colombian (a) Atlantic and (b) Pacific Oceans for 1950-2005.

Subsistence fishing is an important component of unreported fishing in the Colombian Atlantic and Pacific Oceans. Colombia has one of the highest numbers of internally-displaced people worldwide (between 2 to 3 million people according to UNHCR 2007), and food security is a critical issue in many areas of the country that have been affected by violence, including parts of the Caribbean and Pacific coasts. Fish is an important component of the diet of coastal communities, and during recent years, the number of people involved in artisanal fishing has increased as part of the displaced population seeks alternative means of sustenance and income (Beltrán-Turriago and Villaneda-Jiménez 2000).

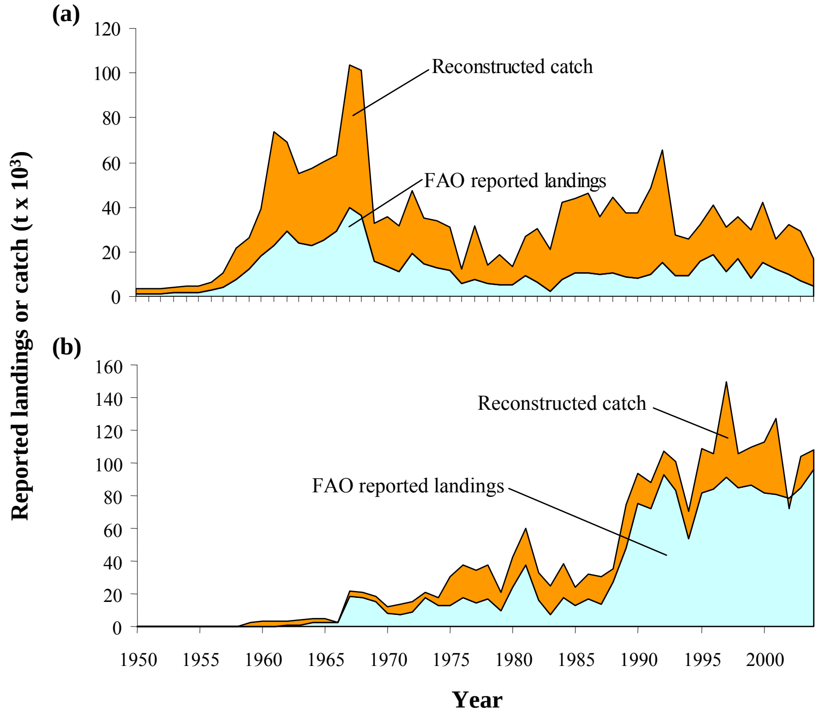

Figure 8. Reconstructed total catch estimates in the Colombian (a) Atlantic and (b) Pacific (b) Oceans, and reported landings data as presented by FAO on behalf of Colombia, for 1950-2004.

Difficulties with the collection of landings data have been pervasive in Colombia, and it likely that large fluctuations in landings between certain years are partly associated with unreliable landings data. Impediments to data collection in the country have been the result of the frequent transfer of management responsibilities between different agencies and the resulting changes in data collection procedures; the logistical difficulties involved in obtaining information from distant and geographically isolated communities; and the reduced number of staff of the fishery management agencies (Sáenz 1962; Ciardelli 1968; WCAFC 2000). These problems with data collection and management may help to explain the discrepancies between the official data held by INCODER and the data reported by FAO on behalf of Colombia. However, fluctuations in landings data are also likely associated with overfishing, as discussed above for the shrimp fisheries, and with environmental factors. In 1973 and 1983, for example, decreases in shrimp landings in the Pacific coincided with strong El Niño events (Mora-Lara 1987). Similarly, fluctuations in tuna catches in the Pacific during the 1980s and 1990s have been correlated with changes in sea-surface temperatures (Pedraza and Díaz-Ochoa 2006).

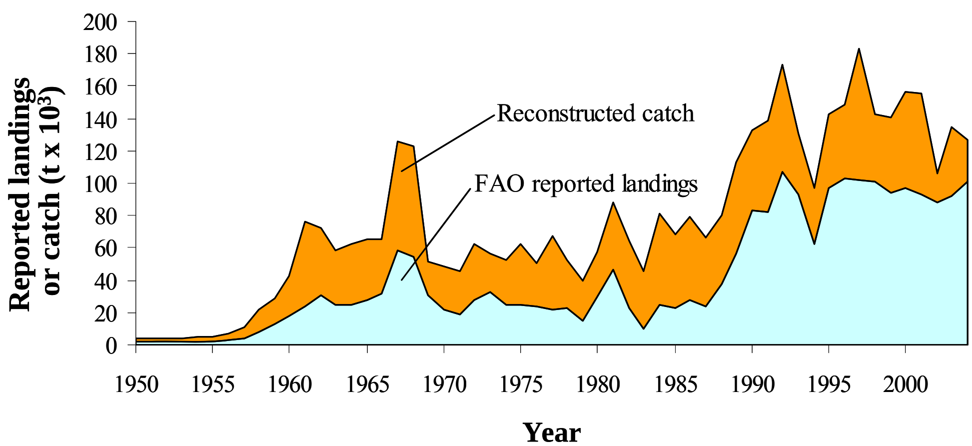

Figure 9. Reconstructed total catch estimates in Colombia (Atlantic and Pacific Oceans combined), and reported landings data as presented by FAO on behalf of Colombia, for 1950-2004.

In addition to the uncertainty in the reliability of the reported landings, our reconstruction may have underestimated total catches in Colombia because it did not include the following extractive activities which have been reported, but not quantified. Colombia has a limited ability to enforce fishing regulations (UNEP 2006), and the use of illegal fishing methods such as dynamite and fish poisons, which have a large impact on non-target species, has been observed in both coasts (Giudicelli 1979, Friedemann and Arocha 1984, Pérez-Ramírez 1986). Deficient enforcement has also resulted in recurrent illegal fishing by Honduran and Nicaraguan boats in the San Andrés Archipelago. Colombia has granted fishing rights to the United States in these waters[2], but United States vessels must provide records of their catches to the Colombian fisheries management authorities. However, we could not find any information indicating that these records have been provided.

Acknowledgements

We are indebted to Colombia's Minister of Agriculture and Rural Development, Andrés Felipe Arias-Leiva, for his interest in this research and his support in locating official fisheries data. We also thank the following people from the Ministry and INCODER-Bogotá: C.G. Barreto-Reyes, E. Bochno-Hernández, R. Campo-Soto, and L. Tobón-Torregloza. For assistance in finding fisheries reports we thank J. Altamar-López (Universidad del Magdalena), E. Arteaga (INVEMAR), M. Barros-Jiménez (Universidad de Concepción, Chile), M.I. Criales (CENSOR Project), N. Farias (Fundación Omacha), A. Giraldo (Universidad del Valle), G. Lara (Pontificia Universidad Javeriana), M. Prada (CORALINA), E. Taylor (CORALINA), A. Tobón-López (Fundación Natura), and J. Viaña-Tous (INCODER-Cartagena). We thank C. Close for extracting Colombian data from FAO FishStat and for producing the map of Colombia. We are grateful to D. Pauly for his support of this research. D. Pauly and S. Menzel provided helpful suggestions on the manuscript. This work forms part of the *Sea Around Us* Project, funded by the Pew Charitable Trusts, Philadelphia, and located at the Fisheries Centre, University of British Columbia.

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[2] The Vásquez-Saccio Treaty between Colombia and the United States was signed in 1972. Under this treaty, the United States gives up any claims over the islands of Quitasueño, Roncador, and Serrana and the surrounding waters, and Colombia grants it fishing rights, under certain conditions. The text of the treaty is available at www.armada.mil.co/tratados/tratcol-usa.doc.

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FISHERIES CATCH STATISTICS FOR MEXICO[1]

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ABSTRACT

This contribution presents a compilation of reported commercial catch statistics from Mexico, for the last five decades, extracted from statistical books published by agencies of the Mexican Federal Government. Statistics are reported by state, based on local common names. We annotated some aspects regarding the interpretation of catch data based on geographical distribution of the states, potential confusion with common names as well as potential misinterpretation when information is to be used as representative of the species distribution.

MEXICAN CATCH STATISTICS

Historically, catch statistics have been compiled by agencies of the Mexican Federal Government (Table 1). The basic process is as follows:

For the small-scale fisheries, catches are recorded at landing locations directly, or catch records are accumulated by 'mediators' who report catches to local fisheries officers. In both cases catch records are compiled and send to regional federal offices (mostly by State), before being send to the central office in Mexico City. The efficiency of this data collection process depends on region and state, and data transfer and 'preservation' levels differ, but have improved over time.

For industrials statistics, collection is easier in the sense that industrial operators have their own records as raw material; these catches are reported to local offices, and subsequently follow the same route as described above. In all cases the names of the taxa caught are local names, and names are conserved troughout the process.

Table 1: Federal governement sources of fisheries catch data for Mexico

Period	Source
1956 - 1958	Secretaria de Industria y Comercio, 1964. Dirección General de Pesca e Industrias Conexas. Estadísticas Pesqueras Concentradas, 1956 – 1961.
1959 – 1967	Secretaria de Industria y Comercio, 1966. Dirección General de Pesca e Industrias Conexas. Estadísticas Básicas de la Actividad Pesquera Nacional, 1959 – 1965.
1968 - 1970	Secretaria de Industria y Comercio, 1971. Dirección General de Regiones Pesqueras. Estadísticas Básicas de la Actividad Pesquera Nacional, 1968 – 1970.
1971 - 1975	Secretaría de Industria y Comercio, 1976. Dirección General de Plantación y Promoción Pesqueras. Departamento de Estadísticas Básicas. 1971 – 1975.
1976 - 1982	Anuarios Estadísticos de Pesca. Departamento de Pesca. Dirección General de Información y Estadística. One per year.
1983 - 1994	Anuarios Estadísticos de Pesca. Secretaría de Pesca. Dirección General de Información, Estadística y Documentación. One per year.
1995 - 2000	Anuarios Estadísticos de Pesca. Secretaría de Medio Ambiente, Recursos Naturales y Pesca. Dirección General de Política y Fomento Pesquero. One per year.
2001 – 2003	Anuarios Estadísticos de Pesca. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Comisión Nacional de Acuacultura y Pesca. One per year.

[1] Cite as: Arreguín-Sánchez, F. and Arcos-Huitrón, E. 2007. Fisheries catch statistics for Mexico. p. 81-103 *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Given the insitutional setup of data recording, catches are reported by each federal state (Figure 1), with concomittant aggregation of taxa to streamline reporting. This results, for example, in individual shrimp species being reported together as 'shrimp' (Spanish: camarón), which concentrate different species locally known as brown (café), white (blanco) etc. Complicating the taxonomic accounting is the fact that similar common names can relate to different species, and this may vary by state. For example, 'brown shrimp' as reported by the Pacific states is *Farfantepenaeus californiensis*, but in the Gulf of Mexico it is *Farfantepenaeus aztecus*. Similarly, the 'red snapper' is *Lutjanus peru* in the Pacific, and *Lutjanus campechanus* in the Gulf of Mexico. This problem needs correcting before these data can be used in a global setting. This requires transfer of commmon names to scientirfic entities (see Appendix 1).

The currently reported fisheries catches from 1956-2003, as reported here by state, illustrate the increase in reported catches over time, with peaks in time differing by coast. Catches taken along the Pacific coast have generally been higher than Gulf of Mexico catches (Figure 2a, b). Overall, Mexican catches peaked at over 1.2 x 10^{-6} t in the late 1980s, before declining to just under 1.0 x 10^{-6} t by early 2000 (Figure 2c). Breakdown of catch statistics by states are available from the authors and vis the *Sea Around Us* Project website (www.seaaroundus.org).

Figure 1. Coastal states of Mexico.

For species-specific catch distributions, special care must be taken with statistics from the states of Baja California and Baja California Sur, since some species occur only on the Pacific coast of the peninsula while others are only present within the Gulf of California. For example, this is the case for abalone, where *Haliotis fulgens* (blue abalone), *H. corrugate* (yellow), *H. cracherodii* (black), *H. rufescens* (red), *H. sorenseni* (chinese) and other *Haliotis* spp. only have a Pacific coast distribution, but are absent from the Gulf of California (Figure 3).

Specific issues relate also to the tuna fishery, which is important in terms of catch volume. The high mobility of fleets and catch area extending beyond the Exclusive Economic Zone (EEZ) of Mexico (Figure 4), result in catches being reported only for and by the home port of the vessel (not the area where catches were taken). Even when logbooks and scientific observers have specific spatial data on catch, global statistics refer mostly to the home ports.

The giant squid, *Dosidiscus gigas*, occurs in both the Gulf of California (except in the northern regions), and the Pacific coast of Baja California Sur (Figure 5). Since most catches are taken by small scale fisheries, statistics are recorded by landing site, which corresponds to the origin of the fleets. Catches for the state of Baja California Sur are not disaggregated by Gulf versus Pacific coast in the statistics.

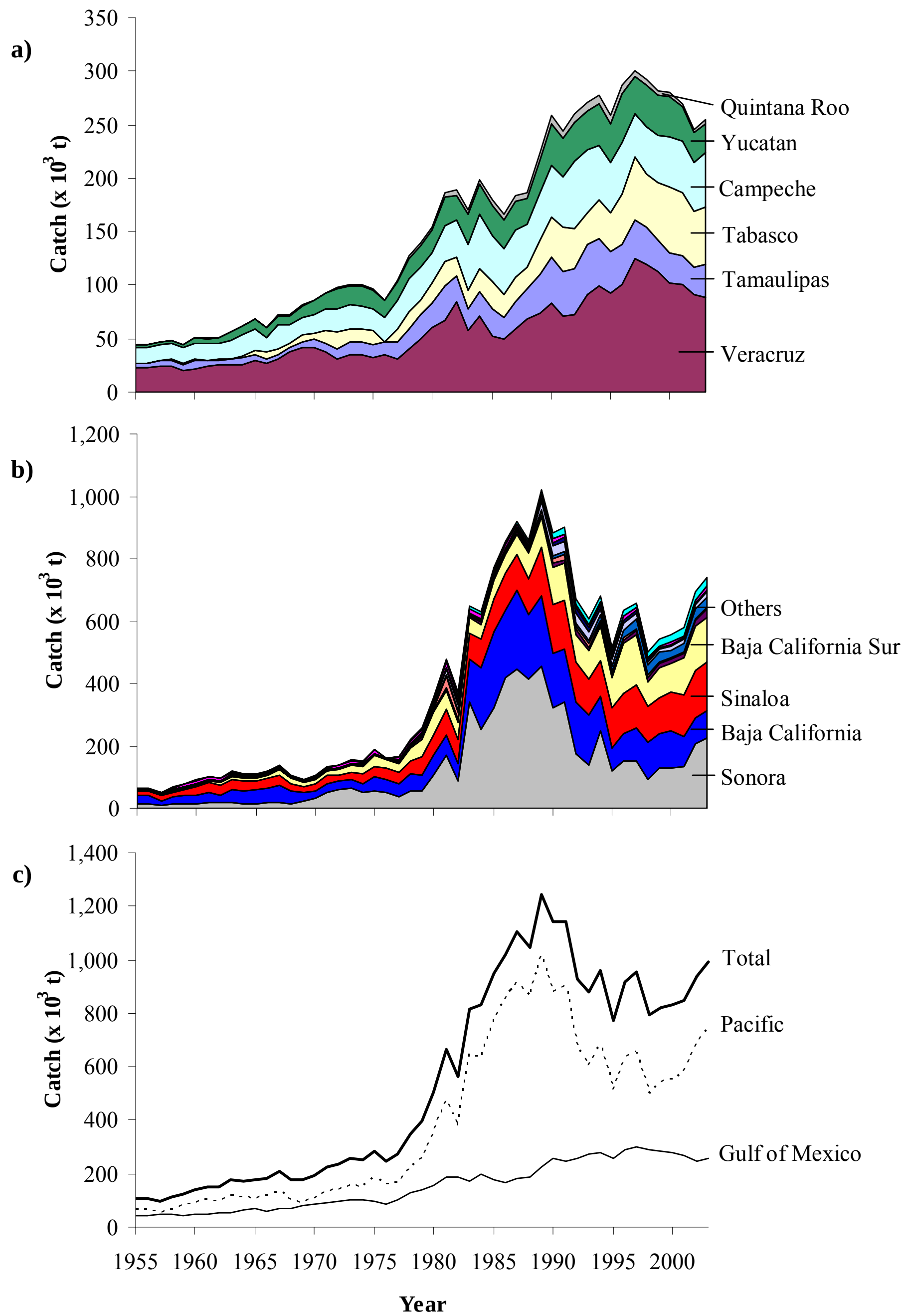

Figure 2. Catch time series for Mexico, by state, showing (a) Gulf of Mexico; (b) Pacific coast of Mexico; and (c) coastal and country-wide total catches.

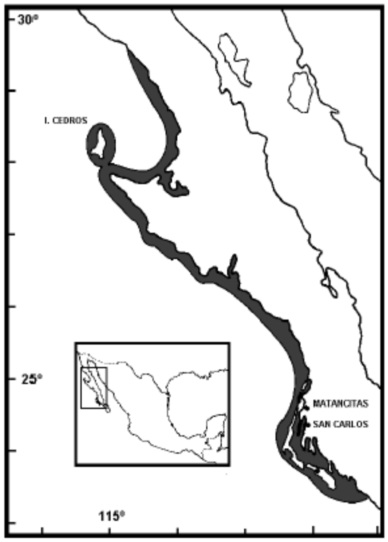

Figure 3. Distribution area of abalone species on the Pacific coast of the Peninsula of Baja California, Mexico (taken from Arreguín-Sánchez *et al.* 2006).

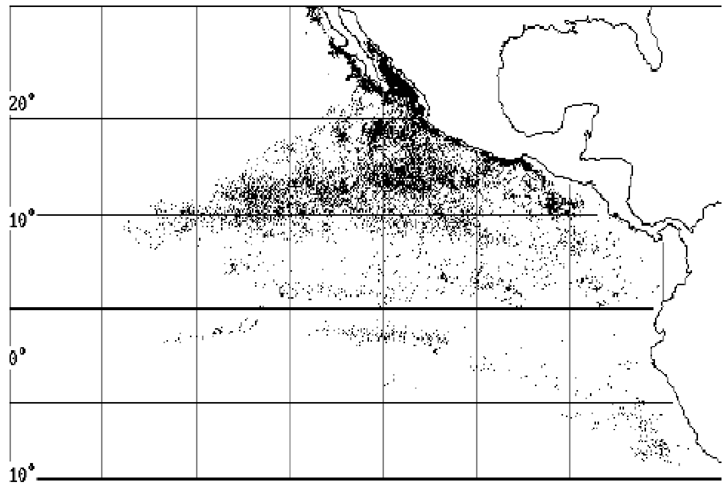

Figure 4. Catch locations for the Mexican tuna fleet, based on scientific observer programs. Records from the National Program for Tuna Use and Dolphin Conservation (taken from Arreguín-Sánchez *et al.* 2006).

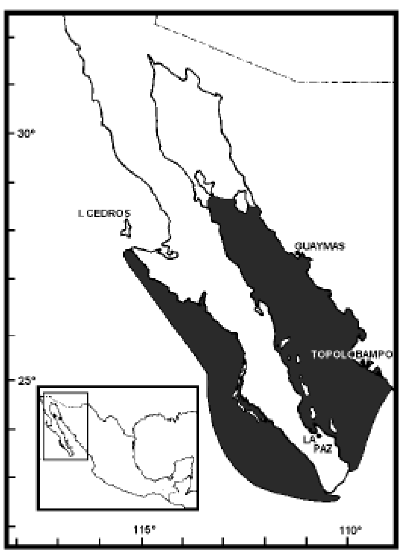

Figure 5. Giant squid records come from the whole distribution area which comprises the central Gulf of California and Pacific coast of the Peninsula of Baja California. This comprises the states of Sonora, northern Sinaloa, and both coasts of Baja California Sur (taken from Arreguín-Sánchez *et al.* 2006).

In order to spatially disaggregate these catches, we must turn to catch statistics at the local level (main landing sites). Currently, the Comisión Nacional de Acuacultura y Pesca (CONAPESCA) maintains a database with information from small-scale and industrial fleets, with detailed information by landing sites, for the last decade. Hernádez-Herrera and Ramírez-Rodríguez (2005) reviewed and validated localities around the Peninsula and the entire Gulf of California, to produce a better system to aggregate information. An Atlas of Fishing Localities for the Peninsula of Baja California and the Gulf of California is available (Ramírez-Rodríguez *et al.* 2006), which contains information for the last three years (Mauricio Ramírez-Rodríguez pers. comm., Centro Interdisciplinario de Ciencias Marinas del IPN, México, mramirr@ipn.mx). Additional details on the main fisheries in Mexico can be found in INP (2000, 2004), DOF (2004, 2006), and Arreguín-Sánchez *et al.* (2006). Note also that the present data do not include catches made, but not landed or reported, such as discards taken as part of shrimp trawl fisheries, and other IUU (Illegal, Unreported and Unregulated) catches. Therefore, estimating IUU catches would be a further, likley significant, improvement on the data presented here.

Acknowledgments

We thank colleagues from the Instituto Nacional de Pesca and the Comisión Nacional de Acuacultura y Pesca, who facilitated access to statistical books. We also thank SEMARNAT-CONACyT (contract: 1231), SAGARPA-CONACyT (contract: 12004), INCOFISH (contract 003739) and SPI-IPN (contract 20050686; 20060579; 20070767) for support. The senior author also thanks the National Polytechnic Institute for support through EDI and COFAA.

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APPENDIX

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
almeja	rangia americana, almeja gallito	Common rangia	*Rangia cuneata*	Mainly Veracruz & Campeche
	almeja de río	Brown rangia (5)	*Rangia flexuosa*	
	lucina tigre atlántica, almeja de mar	Atlantic tiger lucine	*Codakia orbicularis*	
	almeja de marjal	Carolina marsh clam	*Polymedosa caroliliana*	
	almeja de marjal triangular, de fango	Triangular marsh clam	*Polymesoda triangula*	
	arca auriculada	eared ark	*Anadara notabilis*	
	arca zebra	turkey wing	*Arca zebra*	
	berberecho del Atlántico	giant Atlantic cockle	*Dinocardium robustum*	
	almeja de mar, almejuela del sur	southern hard shell clam	*Mercenaria campechensis*	
anchoveta	anchoveta rabo amarillo	Atlantic anchoveta	*Cetengraulis edentulus*	Mainly Campeche & Yucatan
armado	armado	pigfish	*Orthopristis chrysoptera*	Campeche Bank (2)
atún	atún aleta amarilla	yellowfin tuna	*Thunnus albacares*	Mainly Veracruz
	atún aleta negra	blackfin tuna	*Thunnus atlanticus*	
	atún aleta azul	bluefin tuna	*Thunnus thynnus*	
	patudo , ojón	bigeye tuna	*Thunnus obesus*	
bagre	bagre	hardhead catfish	*Ariopsis felis*	Mainly Veracruz & Campeche
	bagre maya		*Ariopsis assimillis*	
	bagre prieto		*Cathorops melanopus*	
bandera	bagre bandera	gafttopsail	*Bagre marinus*	Mainly Veracruz & Campeche
barrilete	barrilete	skipjack tuna	*Katsuwonus pelamis*	

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
berrugata	zorra	nothern kingcroaker	*Menticirrhus saxatilis*	Only within the Gulf of Mexico
	gurrubata	gulf kingcroaker	*Menticirrhus littoralis*	
	rastreador	southern kingcroaker	*Menticirrhus americanus*	
besugo	pargo cunaro, pargo colorado	vermilion snapper	*Rhomboplites aurorubens*	Only within the Gulf of Mexico
bonito	bonito del Atlántico	Atlantic bonito	*Sarda sarda*	
	bacoreta	little tuny	*Euthynnus alletteratus*	
	melva	frigate tuna, frigate mackerel	*Auxis thazard*	
	melva	bullet tuna, bullet mackerel	*Auxis rochei*	
cabrilla	cabrilla	scamp	*Mycteroperca phenax*	
	cabrilla de roca	red hind	*Epinephelus guttatus*	
	cabrilla gato	tiger grouper	*Mycteroperca tigris*	
	cabrilla roja	coney	*Cephalopholis fulva*	
	payaso	rock hind	*Epinephelus adscensionis*	
calamar	calamar de aletas largas del Atlántico	Atlantic long-finned squid	*Loligo pealei*	
	calamar de dedal corto	brief thumbstall squid	*Lolliguncula brevis*	
camarón	camarón café	nothern brown shrim	*Farfantepenaeus aztecus*	
	camarón blanco	southern white shrim	*Litopenaeus setiferus*	
	camarón rosado	pink shrimp	*Farfantepenaeus duorarun*	
	camarón siete barbas del Golfo	Atlantic seabob	*Xiphopenaeus kroyeri*	
	camarón rojo	redspotter shrimp	*Farfantepenaeus brasiliensis*	
	camarón de roca	rock shrimp	*Sicyonia brevirostris*	
caracol	caracol rosado, de abanico, reina	pink conch, queen conch	*Strombus gigas*	Mainly Campeche
	caracol blanco, lanceta	cobo lechoso	*Strombus costatus*	

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
	caracol gigante, rojo, chacpel	Florida horse conch	*Pleuroploca gigantea*	
	caracol tomburro	west indian chank	*Turbinella angulatus*	
	caracol trompillo	Kiener's whelk	*Busycon carica*	
	caracol trompillo	lightning whelk	*Busycon contrarium*	
	caracol chivita, negro	west indian crown conch	*Melongena melongena*	
	caracol negro	common crown conch	*Melongena corona bispinosa*	
	caracol canelo	fighting conch	*Strombus pugilis*	
	caracol campechana, caracol tulipán	true tulip	*Fasciolaria tulipa*	
carito	carito lucio, peto	king mackerel	*Scomberomorus cavalla*	Only within the Gulf of Mexico
cazón	cazón de ley	Atlantic sharp-nosed shark	*Rhizoprionodon terraenovae*	
	cazón cabeza de pala, cornuda	bonnethead shark	*Sphyrna tiburo*	
	cazón perro, musola viuda	Narrowfin smooth-hound	*Mustelus norrisi*	
	cazón de playa, tiburón jaquetón	silky shark	*Carcharhinus falciformis*	
	cazón cangúey	blacknose shark	*Carcharhinus acronotus*	
	cazón espinoso	cuban dogfish	*Squalus cubensis*	
cherna mero)	cherna	jewfish	*Epinephelus itajara*	
	cherna boca amarilla, gallina	yellowmouth grouper	*Mycteroperca intersitialis*	
	cherna pinta	snowy grouper	*Epinephelus niveatus*	
chopa	chopa amarilla	yellow chub	*Kyphosus incisor*	Mainly Tabasco & Campeche
	chopa negra	Bermuda chub	*Kyphosus sectator*	
chucumite	chucumite	fat snook	*Centropomus parallelus*	Only within the Gulf of Mexico
cintilla (sable)	sable, yegua	Atlantic cutlassfish	*Trichiurus lepturus*	Only within the Gulf of Mexico
cojinuda	cojinuda	blue runner	*Caranx crysos*	Only within the Gulf of Mexico

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
	carbonera	bar jack	*Caranx ruber*	
coronado (jurel)	medregal coronado	greater amberjack	*Seriola dumerili*	Only in Yucatan & Quinta Roo
corvina	corvina pinta	sand seatrout	*Cynoscion nebulosus*	
	corvina de arena	spotted seatrout	*Cynoscion arenarius*	
	corvinón ocelado	reddrum	*Sciaenops ocellata*	
croca (ronco)	croca	spot	*Leiostomus xanthurus*	Only in Tamaulipas
cubera	cubera	cubera snapper	*Lutjanus cyanopterus*	Only in Veracruz
esmedregal	medregal	banded rudderfish	*Seriola zonata*	
	medregal limón	almaco jack	*Seriola rivoliana*	
	medregal listado	lesser amberjack	*Seriola fasciata*	
gurrubata (berrugata)	berrugata	Atlantic croaker	*Micropogonias undulatus*	Only in Tamaulipas & Veracruz
huachinango	huachinango de castilla	red snapper	*Lutjanus campechanus*	Mainly in Yucatan
	huachinango ojo amarillo	silk snapper	*Lutjanus vivanus*	
	huachinango aleta negra	blackfin snapper	*Lutjanus buccanella*	
	huachinango seda	queen snapper	*Etelis oculatus*	
	huachinango navaja	wenchman	*Pristipomoides aquilonaris*	
jaiba	jaiba azul, jaiba roja, jaibón	blue crab	*Callinectes sapidus*	Coastal lagoons, estuaries and coastal zone (2); mainly Tamaulipas & Veracruz
	jaiba prieta, jaiba de puntas	sharptooth swincrab	*Callinectes rathbunae*	
	jaiba roma	bluntttooth swincrab	*Callinectes bocourti*	
	jaiba	crab	*Callinectes ornatus*	

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
	jaiba	dana swincrab	*Callinectes danae*	
	jaiba azul	lesser blue crab	*Callinectes similis*	
jurel	jurel amarillo, común	crevalle jack	*Caranx hippos*	
	jurel blanco, ojón	horse-eye jack	*Caranx latus*	
	jurel dentón	white trevally (FB)	*Pseudocaranx dentex*	
	jurel negro	black jack	*Caranx lugubris*	
langosta	langosta del caribe, espinoza	caribbean spiny lobster	*Panulirus argus*	Mainly Yucatan & Quintana Roo
	langosta pinta, moteada	spotted spiny lobster	*Panulirus guttatus*	
	langosta verde	smoothtail spiny lobster	*Panulirus laevicauda*	
	langosta zapatera		*Scyllarides nodifer*	
lebrancha	lebrancha	hospe mullet	*Mugil curema*	Mainly in Veracruz
lenguado	lenguado	two-spot flounder	*Bothus robinsi*	
	lenguado	spotfin flounder	*Cyclopsetta fimbriata*	
	lenguado arenoso, de playa	shoal flounder	*Syacium gunteri*	
	lenguado de florida	southern flounder	*Paralichthys lethostigma*	
	lenguado aleta manchada	mexican flounder	*Cyclopsetta chittendeni*	
	lenguado tres ojos	gulf flounder	*Paralichthys albigutta*	
	lenguado moreno	dusky flounder	*Syacium papillosum*	
lisa	lisa	striped mullet	*Mugil cephalus*	Mainly in Tamaulipas
	lisa amarilla	fantail mullet (FB)	*Mugil trichodon*	
macabí	Macabí de hebra	threadfin bonefish	*Albula nemoptera*	Only in Quintana Roo
	Macabí	bonefish	*Albula vulpes*	
	macabi, machete del Atlantico (FB)	ladyfish	*Elops saurus*	

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
mero	mero americano	red grouper	*Epinephelus morio*	Mainly in Yucatan
	mero extraviado, mero aleta amarilla	yellowedge grouper	*Epinephelus flavolimbatus*	
	mero negro	warsaw grouper, black jewfish	*Epinephelus nigritus*	
	mero del Caribe	Nassau grouper	*Epinephelus striatus*	
	mero aceitero, guacamayo	yellowfin grouper	*Mycteroperca venenosa*	
	mero pintaroja, lenteja	calico grouper, speckled hind	*Epinephelus drummondhayi*	
mojarra	mojarra caitapí, de estero	caitapi mojarra	*Diapterus rhombeus*	Mainly in Veracruz
	mojarra pinta	mottled mojarra	*Eucinostomus lefroyi*	
	mojarra blanca	irish pompano	*Diapterus auratus*	
	mojarra plateada	spotfin mojarra	*Eucinostomus argenteus*	
	mojarra rayada	srriped mojarra	*Eugerres plumieri*	
	mojarra, mojarra rayada, mojarra blanca	yellowfin mojarra	*Gerres cinereus*	
	mojarrita	silver jenny	*Eucinostomus gula*	
	mojarrita de ley	flatgfin mojarra	*Eucinostomus melanopterus*	
negrillo	abadejo	black grouper	*Mycteroperca bonaci*	Mainly in Tamaulipas
ostión	ostión americano	american cupped oyster	*Crassostrea virginica*	Mainly in Veracruz
	ostión de mangle	mangrove cupped oyster	*Crassostrea rhizophorae*	
pámpano	pampano amarillo	Florida pompano	*Trachinotus carolinus*	Mainly in Veracruz
	pampano listado	palometa	*Trachinotus goodei*	
	pampano de hebra	African pompano	*Alectis ciliaris*	
	pampano palometa	permit	*Trachinotus falcatus*	
	pampano sureño	southern pompano	*Trachinotus marginatus*	
pargo	pargo lunar, lunarejo	mutton snapper	*Lutjanus analis*	Mainly in Campeche

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
	pargo mulato, parguete	gray snapper	*Lutjanus griseus*	
	pargo perro, caballera	dog snapper	*Lutjanus jocu*	
	pargo juanito, pargo ojón	mahogany snapper	*Lutjanus mahogoni*	
	pargo canchix	schoolmaster	*Lutjanus apodus*	
	pargo rojo	red snapper	*Lutjanus purpureus*	
peto	carito lucio	king mackerel	*Scomberomorus cavalla*	Mainly in Veracruz
	peto	wahoo	*Acanthocybium solandri*	
pierna	blanquillo ojo amarillo (FB)	goldface tilefish	*Caulolatilus chrysops*	Only in Tabasco
	domingo (FB)	blackline tilefish	*Caulolatilus cyanops*	
	blanquillo payaso (FB)	anchor tilefish	*Caulolatilus intermedius*	
	blanquillo lucio (FB)	blueline tilefish	*Caulolatilus microps*	
pulpo	pulpo rojo, pulpo mexicano	mexican four-eye octopus	*Octopus maya*	Mainly in Yucatán, also in Veracruz, Campeche & Quintana Roo (1)
	pulpo patón, pulpo común	common octopus	*Octopus vulgaris*	
rayas	raya caribeña	chupare stingray (FB)	*Himantura schmardae*	Mainly in Campeche
	raya cola de rata	smooth butterfly ray	*Gymnura micrura*	
	raya de espina de estero	yellow stingray	*Urobatis jamaicensis*	
	raya de papel	spiny butterfly ray	*Gymnura altavela*	
	raya del Golfo	roundel skate	*Raja texana*	
	raya grande, raya latigo	southern stingray	*Dasyatis americana*	
	raya latigo chata	bluntnose stingray	*Dasyatis say*	
	raya latigo de espina	Atlantic stingray	*Dasyatis sabina*	
	raya latigo hocicona	longnose stingray	*Dasyatis guttata*	

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Local name	Spanish common name	English common name	Scientific names	Comments
	chucho, chucho pintado, obispo	spotted eagle ray	*Aetobatus narinari*	
	raya gavilán	cow-nosed ray	*Rhinoptera bonasus*	
	manta voladora	Atlantic manta	*Manta birostris*	
robalo	robalo blanco	snook	*Centropomus undecimalis*	Mainly in Veracruz
	robalo prieto	mexican snook	*Centropomus poeyi*	
	constantino	tarpon snook	*Centropomus pectinatus*	
	robalo de espolón	swordspine snook	*Centropomus ensiferus*	
	robalo gordo de escama grande	guianan snook (FB)	*Centropomus mexicanus*	
ronco	ronco	barred grunt	*Conodon nobilis*	Mainly in Veracruz
rubia	Canané, Rabirrubia	yellowtail snapper	*Ocyurus chrysurus*	Mainly in Yucatan
	villajaiba	lane snapper	*Lutjanus synagris*	
rubio	rubio volador	striped searobin (FB)	*Prionotus evolans*	
	testolín azul	bluewing searobin (FB)	*Prionotus punctatus*	
sabalo	sabalo	tarpon	*Megalops atlanticus*	Only in Tamaulipas & Veracruz
sardina	sardina vivita de hebra	Atlantic thread herring	*Opisthonema oglinum*	Mainly in Yucatan
	sardina vivita escamuda	scaled sardine	*Harengula jaguana*	
	sardina carapachona	false pilchard	*Harengula clupeola*	
	sardina de escama fina	finescale menhaden	*Brevoortia gunteri*	
	sardina lacha	Gulf menhaden	*Brevoortia patronus*	
sargo	sargo	sheepshead porgy	*Archosargus probatocephalus*	Mainly in Veracruz
	sargo amarillo	sea bream	*Archosargus rhomboidalis*	
	sargo rojo	red porgy	*Pagrus pagrus*	
	chopa espina	pinfish, pin pech	*Lagodon rhomboides*	

Table A1: List of reported fisheries taxa for the Gulf of Mexico and Carribean, by local names, Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific names	Comments
sierra	sierra	spanish mackerel	*Scomberomorus maculatus*	Mainly in Veracruz
tambor	tambor	black drum	*Pogonias cromis*	Only Tamaulipas & Yucatan
tiburón	tiburón curro, aleta negra, jaquetón	spinner shark	*Carcharhinus brevipinna*	Mainly in Veracruz
	tiburón sedoso	silky shark	*Carcharhinus falciformis*	
	tiburón chato	bull shark	*Carcharhinus leucus*	
	tiburón puntas negras	blacktip shark	*Carcharhinus limbatus*	
	tiburón prieto	dusky shark	*Carcharhinus obscurus*	
	tiburón aleta de cartón	sandbar shark	*Carcharhinus plumbeus*	
	tiburón poroso	smalltail shark	*Carcharhinus porosus*	
	tiburón nocturno	night shark	*Carcharhinus signatus*	
	tiburón cornuda, tiburón martillo	scalloped hammerhead shark	*Sphyrna lewini*	
	cornuda grande	great hammerhead shark	*Sphyrna mokarran*	
	tiburón angel	Atlantic angelshark	*Squatina dumeril*	

1) Secretaría de Pesca (1994); 2) DOF (2000); 3) McEachran & Fechhelm (1998); 4) McEachran & Fechhelm (2005); 5) Andrews (1977); 6) Abbott (1974); 7) www.fishbase.org

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
abulon	abulon amarillo	yellow abalone	*Haliotis corrugata*	Pacific coasts of the Peninsula of Baja California (from the USA border to Punta Malarimo) (3)
	abulon azul	blue abalon	*Haliotis fulgens*	
	abulon negro	black abalon	*Haliotis cracherodii*	
	abulon rojo	red abalone	*Haliotis rufescens*	
	abulon chino	white abalone	*Haliotis sorenseni*	
algas	alga pelo de cochi	seaweed	*Gigartina canaliculata*	Both coasts of Baja California and Pacific coasts of Baja California Sur
	sargazo rojo	seaweed	*Gelidium robustum*	
	alga roja, gracilaria	red algae	*Gracillaria pacifica*	
almeja	almeja catarina	Pacific calico scallop	*Argopecten circularis*	All Pacific coats, mainly Gulf of California
	almeja chocolata	scallop	*Megapitaria aurantiaca*	
	almeja pata de mula	ark	*Anadara tuberculosa*	
	almeja pismo	pismo clam	*Tivela stultorum*	
	almeja roñosa o chirla	frilled californina venus	*Chione undatella*	
	almeja roñosa o chirla	common californian venus	*Chione californinesis*	
	almeja burra	purplelip rock oyster	*Spondylus calcifer*	
	almeja blanca	disk dosinia	*Dosinia ponderosa*	
	almeja mano de leon	Pacific lion's paw	*Lyropecten subnodosus*	
	almeja voladora	scallop	*Pecten vogdesi*	
anchoveta	anchoveta	Californian anchovy	*Engraulis mordax*	Mainly on the Pacific coast of Baja California; scarce for other Pacific coasts
	sardina bocona	anchoveta	*Cetengraulis mysticetus*	
atun	atun aleta amarilla	yellowfin tuna	*Thunnus albacares*	
	atun aleta azul	northern bluefin tuna	*Thunnus thynnus*	
	atun blanco o albacora	albacore	*Thunnus alalunga*	
bacoco	ronco bacoco, burro	longspine grunt	*Pomadasys macracanthus*	Both coasts of Baja California, Sonora, Sinaloa & Nayarit
bagre	bagre marino, chihuil, bandera	gafftopsail catfish	*Bagre panamensis*	
	chihuil, bagre rojo	chihuil catfish	*Bagre pinnimaculatus*	

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
	bagre marino	sea catfish	*Arius guatemalensis*	
baqueta	baqueta	gulf coney	*Epinephelus acanthistius*	All Pacific coasts except in Chiapas
barracuda	barracuda agujona, de Cortez	lucas barracuda	*Sphyraena lucasana*	Only on the eastern coast of Baja California (4)
	barracuda picua, mexicana	mexican barracuda	*Sphyraena ensis*	
	barracuda plateada	Pacific barracuda	*Sphyraena argentea*	
barrilete	barrilete	skipjack tuna	*Katsuwonus pelamis*	All Pacific coasts, mainly Baja California, Baja California Sur and Sinaloa
	barrilete negro	black skipjack	*Euthynnus lineatus*	
berrugata	gurrubata, raton	kingcroaker	*Menticirrhus panamensis*	
	chano	highfin corvina	*Menticirrhus nasus*	
	berrugata	Gulf croaker	*Micropogon megalops*	
	berrugata californiana	California corvina	*Menticirrhus undulatus*	
	berrugata roncadora	polla drum	*Umbrina xanti*	
	berrugata aleta amarilla	yellowfin croaker	*Umbrina roncador*	
bonito	bonito del Pacifico oriental	eastern Pacific bonito	*Sarda chiliensis*	All Pacific coasts with exception of Michoacan and Chiapas. Mainly on the Peninsula of Baja California
botete	botete pintado	whitespotted puffer	*Arothron hispidus*	Only for Sinaloa & Nayarit
	botete globo	guineafowl puffer	*Arothron meleagris*	
	botete espinozo	spotted sharpnoused puffer	*Canthigaster punctatissima*	
	botete oceanico	oceanic puffer	*Lagocephalus lagocephalus*	
	botete	skinflap puffer	*Sphoeroides angusticeps*	
	botete tamborin	bullseye puffer	*Sphoeroides annulatus*	
	botete narizon	longnose puffer	*Sphoeroides lobatus*	
	botete peruano	peruvian puffer	*Sphoeroides sechurae*	
caballo	macarela caballa	mackerel scad	*Decapterus macarellus*	Only for Sonora
cabrilla	cabrilla de roca	spotted sandbass	*Paralabrax maculatofasciatus*	All Pacific coasts with exception of Michoacan and Chiapas. Mainly on Baja California Sur
	cabrilla pinta	spotted cabrilla	*Epinephelus analogus*	
	cabrilla piedrera	murique, flag cabrilla	*Epinephelus labriformis*	
	cabrilla verde de arena, verdillo	barred sand bass	*Paralabrax nebulifer*	

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
	cabrilla sargacera	kelp bass	*Paralabrax clathratus*	
	cabrilla extranjera. lucero	goldspotted sand bass	*Paralabrax auroguttatus*	
	cabrilla cachete amarillo, loro	parrot sand bass	*Paralabrax loro*	
	cabrilla cueruda	leather bass	*Dermatolepis dermatolepis*	
	sandia, mamey, indio	Pacific creole-fish	*Paranthias colonus*	
	cabrilla sardinera, rosa, mitan	leopard grouper	*Mycteroperca rosacea*	
	garropa jaspeada	broomtail grouper	*Mycteroperca xenarcha*	
calamar	calamar gigante	Jumbo flying squid	*Dosidicus gigas*	Center & southern Gulfo of California
callo de hacha	callo de hacha	rugose pen shell, pen shell	*Pinna rugosa*	Only for Sonora, Sinaloa and Colima
	callo de hacha china	maura pen shell, shell	*Atrina maura*	
camaron	camaron azul	blue shrimp	*Penaeus stylirostris*	All Pacific coasts, mainly Sonora and Sinaloa
	camaron café	northern brown shrimp	*Penaeus californiensis*	
	camaron blanco	white shrimp	*Penaeus vannamei*	
	camaron cristal o rojo	red or crystal shrimp	*Penaeus brevirostris*	
caracol	caracol panocha	wavy turban	*Astrea undosa*	Pacific coasts of the Peninsula of Baja California
	caracol panocha	wavy turban	*Astra turbanica*	Pacific coasts of the Peninsula of Baja California
	caracol chino rosa	pink murex	*Hexaplex erythrostomus*	All Pacific coasts, mainly Baja California Sur
	caracol burro	crown conch	*Melongena patula*	
	caracol chino negro	northern radix murex	*Muricanthus nigritus*	
	caracol de tinta	purpura conch	*Purpura pansa*	
	caracol burro	Cortez conch	*Strombus galeatus*	
cazon	aleta de carton, sedoso	silky shark	*Carcharhinus falciformis*	All Pacific coasts with exception of Pacific coast of Baja California and the Northern Gulf of California
	toro, chato	bull shark	*Carcharhinus luucas*	
	volador, puntas negras	blacktip shark	*Carcharhinus limbatus*	
	gambuso, prieto, obscuro	dusty shark	*Carcharhinus obscurus*	
	tiburon poroso, bayo	smalltail shark	*Carcharhinus porosus*	
	tintorera	tiger shark	*Galeocerdo cuvier*	

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
	tiburon gata	nurse shark	*Ginglymostoma cirratum*	
	tiburon mako, marrajo	shortfin mako	*Isurus oxyrinchus*	
	cazon californiano, gris	grey smooth-hound	*Mustelus californicus*	
	cazon aleta deshilachada, pardo	brown smooth-hound	*Mustelus henlei*	
	cazon mamon	sicklefin smooth-hound	*Mustelus lunulatus*	
	cazon coyotito, pico blanco	whitenose shark	*Nasolamia velox*	
	cazon bironche, platanillo picudo	Pacific sharpnose shark	*Rhizoprionodon longurio*	
	tiburon martillo, cornuda barrosa	scalloped hammerhead	*Sphyrna lewini*	
	cornuda, martillo, cornuda cruz	smooth hammerhead	*Sphyrna zygaena*	
	martillo grande, cornuda gigante	great hammerhead	*Sphyrna mokarran*	
	tiburon martillo, cornuda coronada	scalloped hammerhead	*Sprhyna corona*	
	angelote, tiburon angelito	angel shark	*Squatina californica*	
cochi	pez puerco	finscale triggerfish	*Balistes polylepis*	Only for Sinaloa
	cochino	orangeside triggerfish	*Sufflamen verres*	
cocinero	cocinero	cocinero	*Caranx vinctus*	All Pacific coasts with exception of Baja California Sur, Sinaloa, Nayarit and Chiapas
conejo	blanquillo cabezon, salmon	bighead tilefish	*Caulolatilus affinis*	Pacific coasts of Baja California, both littorals of Baja California Sur and Sinaloa
corvina	corvina rayada	striped weakfish	*Cynoscion reticulatus*	All Pacific coasts, mainly Sonora and Sinaloa
	coorvineta boquinete	silver drum	*Larimus argenteus*	
	corvina del golfo, golfina	Gulf weakfish	*Cynoscion othonopterus*	
	corvina azul de aleta corta	shortfin corvina	*Cynoscion parvipinnis*	
	corvina boca anaranjada (amarilla)	orangemouth corvina	*Cynoscion xanthulus*	
	corvina blanca	white seabass	*Atractoscion nobilis*	
	corvina chiapaneca, alba	whitefin weakfish	*Cynoscion albus*	
	corvineta armada	armed croaker	*Bairdiella armata*	
	corvineta ronco	bairdiella	*Bairdiella icistia*	
chile	lagarto chile	sauro lizarfish	*Synodus lacertinus*	Only for Nayarit
chopa	chopa azul	zebra perch	*Hermosilla azurea*	Eastern coast of Baja Caifornia Sur, Sonora, Jalisco, Michoacan & Guerrero

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
	chopa gris	blue-bronze chub	*Kyphosus analogus*	
	chopa de Cortez	Cortez chub	*Kyphosus elegans*	
choro (molusco)	mejillon	mussel	*Mytilus californianus*	Both coasts of Baja California. Scare for Sinaloa
	mejillon choro		*Modiolus carax*	
chucumite	robalo espina larga	armed snook	*Centropomus armatus*	Only for Chiapas
esmedregal	jurel de castilla, jurel aleta amarilla	yellow tail	*Seriola dorsalis*	Mainly for Oaxaca. Scarce for Sinaloa, Nayarit, Jalisco and Colima
	esmedregal	almaco; amberjack	*Seriola rivoiana*	
erizo	erizo purpura	sea urchin	*Strongylocentrotus purpuratus*	Mainly on the Pacific coasts of Baja California. Scarce for Pacific coasts of Baja California Sur
	erizo rojo	red sea urchin	*Strongylocentrotus franciscanus*	
gallineta	rubio gallineta	common searobin	*Prionotus ruscarius*	Only for Colima
garropa	baya	gulf grouper	*Mycteroperca jordani*	Golfo de California
	garropa aserrada	sawtail grouper	*Mycteroperca prionura*	
	garropa jaspeada	broomtail grouper	*Mycteroperca xenarcha*	
gurrubata	berrugata gurrubata, boca dulce	Panama kingcroaker	*Menticirrhus panamensis*	Only for esatern coasts of Baja California Sur, Sinaloa & Nayarit
	corvineta gurrubata	bluestreak drum	*Elatarchus archidium*	
huachinango	huachinango del Pacifico	Pacific red snapper	*Lutjanus peru*	All the Pacific coasta; mainly Baja California Sur, Sinaloa, Jalisco and Guerrero
jaiba	jaiba verde	crab	*Callinectes bellicosus*	
	jaiba azul	Pacific blue crab	*Callinectes arcuatus*	
	jaiba negra	crab	*Callinectes toxotes*	
jurel	jurel toro	jurel caninus	*Caranx caninus*	All Pacific coasts, mainly Peninsula of Baja California
	jurel voraz, ojo de perra, ojo grande	bigeye trevally	*Caranx sexfasciatus*	
	cocinero dorado	green jack	*Caranx caballus*	
langosta	langosta roja	red lobster	*Panulirus interruptus*	Red: Pacific coasts of the Peninsula of Baja California. Blue and Green: Gulf of California and central-south Pacific
	langosta verde	green lobster	*Panulirus gracilis*	
	langosta azul	blue lobster	*Panulirus inflatus*	
	langosta insular	lobster	*Panulirus penicillatus*	

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Local name	Spanish common name	English common name	Scientific name	Coments
lebrancha	lebrancha, liseta, lisa blanca	white mullet	*Mugil curema*	All Pacific with exception of Pacific coasts of the Peninsula of Baja California, Michoacan and Guerrero
lenguado	lenguado de California	California halibut	*Paralichthys californicus*	All Pacific, mainly Baja California Sur
	lenguado huarache	speckled flounder	*Paralichthys woolmani*	
	lenguado de Cortez	Cortez flounder	*Paralichthys aestuarius*	
	lenguado cola de abanico	fantail sole	*Xystreurys liolepis*	
	lenguado bocon	bigmouth sole	*Hippoglossina stomata*	
	lenguado diamante	diamond turbot	*Hypsopsetta guttulata*	
	lenguado cuatrojos	fourspot flounder	*Hippoglossina tetrophthalmus*	
	lenguado resbaloso	dover sole	*Microstomus pacificus*	
	lenguado	three-eye flounder	*Ancylopsetta dendritica*	
lisa	lisa rayada, cabezona	striped mullet	*Mugil cephalus*	All Pacific, mainly Sinaloa
	lisa hospes	hospe mullet	*Mugil hospes*	
macabi	macabi	bonefish	*Albula vulpes*	Only for Chiapas
macarela	macarela	chub mackerel	*Scomber japonicus*	From Nayarit to the notrthern coasts
mero	mero guasa	jewfish	*Epinephelus itajara*	All Pacific, mainly Baja California Sur
mojarra	mojarra de aletas amarillas	peruvian mojarra	*Diapterus peruvianus*	All Pacific, mainly Michoacan and Jalisco
	mojarra plateada	spotfin mojarra	*Eucinostomus argenteus*	
	mojarra tricolor	blackspot mojarra	*Eucinostomus currani*	
	mojarra mancha negra	darrkspot mojarra	*Eucinostomus entomelas*	
	mojarra charrita	Pacific flagfin mojarra	*Eucinostomus gracilis*	
	mojarra malacapa	black axillary mojarra	*Eugerres axillaris*	
	mojarra aleta corta	shortfin mojarra	*Eugerres brevimanus*	
	mojarra china	streaked mojarra	*Eugerres lineatus*	
	mojarra plateada, rayada, bandera	yellowfin mojarra	*Gerres cinereus*	
ostion	ostion de placer	oyster	*Crassostrea corteziensis*	All Pacific, except Chiapas. Mainly Nayarit and Guerrero
	ostion de roca	oyster	*Crassostrea iridescens*	
	ostion japones	giant Pacific oyster	*Crassostrea gigas*	

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Local name	Spanish common name	English common name	Scientific name	Coments
palometa	palometa del Pacifico	Pacific harvestfish	*Peprilus medius*	Only Nayarit and Sinaloa
	palometa plateada	Pacific pompano	*Peprilus simillimus*	
	palometa salema, pampanito	salema butterfish	*Peprilus snyderi*	
	palometa pampanito	shining butterfish	*Peprilus ovatus*	
	palometa cagavino	starry bvtterfish	*Stromateus stellatus*	
pampano	pampano fino, rayado	gafftopsail pompano	*Trachinotus rhodopus*	Pacific coast, mainly Baja California Sur, Sinaloa & Guerrero
	pampano paloma	blackblotch pompano	*Trachinotus paitensis*	
	pampano de hebra	African pompano	*Alectis ciliaris*	
	pampano acerado	steel pompano	*Trachinotus stilbe*	
	pampano plateado	blackblotch pompano	*Trachinotus kennedyi*	
papelillo	jorobado papelillo	Pacific moonfish	*Selene peruviana*	Only for Sinaloa & Nayarit
pargo	pargo lunarejo, flamenco, chivo	spotted rose snapper	*Lutjanus guttatus*	Boath coasts of Baja California Sur and from Sonora to Chiapas. Mainly on Baja California Sur and Sinaloa
	pargo amarillo, coyotito, alazan	yellow snapper	*Lutjanus argentiventris*	
	pargo rojo, colmillon	Jordan's snapper	*Lutjanus jordani*	
	pargo colorado, listoncillo	colorado snapper	*Lutjanus colorado*	
	pargo mulato, prieto, negro	dog snapper	*Lutjanus novemfasciatus*	
	pargo rabirrubia, barbirrubia	golden snapper	*Lutjanus inermis*	
	pargo azul-dorado, rayado	blue and gold snapper	*Lutjanus viridis*	
	pargo coconaco tecomate	mexican barred snapper	*Hoplopagrus guntheri*	
	pargo raicero, de manglar	mullet snapper	*Lutjanus aratus*	
peto	peto	wahoo	*Acanthocybium solandri*	Only for both coasts of Baja California
pierna	blanquillo fino, blanco	ocean whitefish	*Caulolatilus princeps*	Both littorals of Baja California Sur and Sinaloa
pulpo	pulpo		*Octopus hubbsorum*	From Sonora to Michoacan
	pulpo manchado	white spotted octopus	*Octopus macropus*	
	pulpo	two-spotted octopus	*Octopus bimaculatus*	
rayas	manta gavilan, gavilan negro	Pacific cownose ray	*Rhinoptera steindachneri*	Golfo de California to Chiapas
	raya latigo coluda, mantarraya	longtail stingray	*Dasyatis longus*	

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
	mantarraya	manta	*Myliobatis fitchi*	
	manta gigante, voladora	manta	*Manta birostris*	
	raya aguila picuda	snouted eagle ray	*Myliobatis longirostris*	
	raya coluda del Pacifico	Pacific stingray	*Himantura pacifica*	
	raya latigo comun	whiptail stingray	*Dasyatis brevis*	
	raya mariposa californiana	California butterfly ray	*Gymnura marmorata*	
robalo	robalo plateado, garabato	white snook	*Centropomus viridis*	Both coasts of Baja California Sur, Sonora to Chiapas
	robalo prieto, piedra	black snook	*Centropomus nigrescens*	
	robalo aleta prieta, aleta obscura	blackfin snook	*Centropomus medius*	
	robalo aleta amarilla	yellowfin snook	*Centropomus robalito*	
roncacho	ronco roncacho	white grunt	*Haemulopsis leuciscus*	Only for Sonora & Sinaloa
ronco	ronco chano,manchado, burro manchas	yellowspotted grunt	*Haemulon flaviguttatum*	All Pacific coasts; mainly Guerrero & Oaxaca
	ronco mapache	Panama grunt	*Pomadasys panamensis*	
	ronco rayadillo, ronco jopaton	wavyline grunt	*Microlepidotus inornatus*	
	burro ronco, burrito	burrito grunt	*Anisotremus interruptus*	
	burrito roncacho	bronze striped grunt	*Orthopristis reddingi*	
sabalo	popocha	Pacific gizzard shad	*Dorosoma smithi*	Only Oaxaca & Chiapas
sardina	sardina monterrey	Pacific sardine	*Sardinops caeruleus*	All coasts from Nayarit to the North. Scarce to the south of Nayarit
	sardina crinuda	Pacific thread herring	*Opisthonema libertate*	
	crinuda azul, machuelo de hebra crinuda	slender thread herring	*Opisthonema bulleri*	
	crinuda machete, machuelo de hebra mediana	middling thread herring	*Opisthonema medirastre*	
	sardina japonesa	round herring	*Etrumeus teres*	
sargazo	sargazo gigante	kelp	*Macrocystis pyrifera*	Pacific coasts fo the Peninsula of Baja California
sierra	sierra del Pacifico	Pacific sierra	*Scomberomorus sierra*	All Pacific. Mainly for Sonora and Sinaloa
	sierra del Golfo de Cortez	Gulf sierra	*Scomberomorus concolor*	
tiburon	tiburon zorro, zorro de mar	pelagic thresher	*Alopias pelagicus*	All Pacific coasts with exception of the Gulf of Californiaand northern Pacific coasts of Baja California

Table A2: List of reported fisheries taxa for the Pacific coast of Mexico, by local names, standard Spanish and English common names and scientific name.

Local name	Spanish common name	English common name	Scientific name	Coments
	tiburon grillo, zorro ojon	bigeye thresher	*Alopias superciliosus*	
	tiburon zorro	thresher shark	*Alopias vulpinus*	
	tiburon tunero	silky shark	*Carcharhinus falciformis*	
	tiburon volador	blacktip shark	*Carcharhinus limbatus*	
	tiburon puntas blancas, oceanico	oceanic whitetip shark	*Carcharhinus longimanus*	
	tiburon aleta de carton, aleton	sandbar shark	*Carcharhinus plumbeus*	
	tiburon espinozo, negro espinozo	prickly shark	*Echinorhinus cookei*	
	tiburon mako	shortfin mako	*Isurus oxyrinchus*	
	tiburon coyote	whitenose shark	*Nasolamia velox*	
	tiburon limon	lemon shark	*Negaprion brevirostris*	
	tiburon azul	blue shark	*Prionoce glauca*	
	cornuda comun	scalloped hammerhead	*Sphyrna lewini*	
	tiburon martillo	smooth hammerhead	*Sphyrna zygaena*	

1) Secretaria de Pesca (1994); 2) Escobar-Hernández & Siri (1997); 3) DOF (2000); 4) www.fishbase.org

RECONSTRUCTED CATCHES IN THE MAURITANIAN EEZ[1]

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ABSTRACT

The present catch reconstruction for 1950-2005 refers to the three main fisheries operating in the waters of the Mauritanian Excusive Economic Zone (EEZ): the artisanal fishery, the demersal industrial fishery and the pelagic industrial fishery. This reconstruction is based on all information available, including data coming from the national surveys system of the Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP) and from assessment working groups regularly held in the country since 1985. Additionally, approximate estimates of the unreported catch and by-catch of the two industrial fisheries are proposed, and the catches of the national Mauritanian fisheries were estimated. Here, we provide the first picture of long term catch trends by the various fisheries. The demersal fisheries, overwhelmingly dominated by the industrial sector, developed in the 1960s, while artisanal fisheries remained under-developed until the 1990s, followed by a very rapid increase. In the context of rapidly increasing fishing effort, landings were estimated around 160,000 t·year^{-1} over the last 40 years (including 40,000 to 70,000 t of unreported by-catch). While total landings remained rather stable, the composition in term of taxa significantly changed since the 1970s, suggesting severe overexploitation and the harvest of an increasingly wider range of ecosystem compartments. For the more recent years, artisanal demersal catches are estimated around 60,000 t·year^{-1} (80,000 t·year^{-1} including pelagic fishes). Thus, demersal fisheries, in particularly the artisanal fishery, appears much more important than usually considered. Regarding the pelagic industrial fishery, landings exhibit a high year to year variability, but with a clear and still increasing trend. Estimates suggest unreported catches larger than several hundred thousand tonnes per years, mean total landings reaching 900,000 t·year^{-1} during the last years. We also show that several hundred thousand tons officially caught by foreign vessels operating as 'Mauritanian chartered vessels' (and recorded in the IMROP database) have not been reported to the global community via FAO statistics. More generally, we underline the substantial importance of foreign countries in the exploitation of Mauritanian waters. Finally, the present case study of Mauritania is the first independent test of the results obtained by the spatial allocation approach of FAO data as undertaken by the *Sea Around Us* project. This test appears successful, i.e., catches from the *Sea Around Us* for Mauritania's EEZ waters being very close to our estimates of the official landings of the industrial fisheries.

INTRODUCTION

Mauritania is one of the countries in the world where the fisheries sector is of the highest macro-economic importance. In 2005, official landings were estimated at approximately 720,000 t, representing 6% of the national Gross Domestic Product (GDP) and generating 30% of the value of Mauritanian exports and 30% of public receipts (IMROP, in press). The largest component of the gross production comes from industrial, pelagic fisheries. However, demersal resources, generally consisting of more valuable taxa, are also of major importance. They support both an industrial and a small scale fisheries sector, including about 300 bottom trawlers and 4,000 pirogues, respectively. Each sector lands approximately 60,000 t of demersal groups.

[1] Cite as: Gascuel, D., Zeller, D., Taleb Sidi, M.O. and Pauly, D. 2007. Reconstructed catches in the Mauritanian EEZ. p. 105-119 *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

The demersal fisheries have increased substantially over the last few decades, but few studies have been conducted that estimate and describe catches and fishing effort on a long term basis (Chavance, 2004). In such cases, statistics from the Food and Agriculture Organization of the United Nations (FAO) are rarely applicable or appropriate. Indeed, a major part of the fishery is undertaken by foreign countries, which normally declare their catches as being taken in FAO sub-areas 'Sahara coastal' and 'Cape Verde costal', which cover much more than the Mauritanian EEZ. As a consequence, neither the catches by area, nor the catches by country (especially for Mauritania) identify the Mauritanian EEZ as source of origin.

Since the early 1980s, the national fisheries research institute (Institut Mauritanien de Recherches Océanographiques et des Pêches, or IMROP, previously know as CNROP) has been developing its own survey system. However, its implementation faced difficulties, and a complete database is available only since 1991 for the industrial, and 1997 for the small scale fisheries. Only scattered and heterogeneous statistics were published earlier, covering short periods.

Using all available information, and especially those provided during the international assessment working groups regularly organized by IMROP since 1985, we present here a 'catch reconstruction' (*sensu* Zeller *et al.*, 2006a) for the three fisheries present in the waters constituting the present Mauritanian EEZ: the artisanal fishery, the demersal industrial fishery and the pelagic industrial fishery, covering the period 1950-2005. Additionally, estimates of the unreported catch and by-catch of the two industrial fisheries are proposed, and the catches corresponding to the Mauritanian fisheries were estimated.

Materials and Methods

Data and methods used for the reconstruction of time series of catches are summarized in Table 1. The key aspects and complementary information are described hereafter.

Artisanal fishery

The Mauritanian small-scale, artisanal fishery involves pirogues, which use a large diversity of gears (e.g., hook-and-line, seine nets, traps) and target both demersal resources (i.e., octopus and demersal fishes) as well as small pelagics (i.e., sardinella).

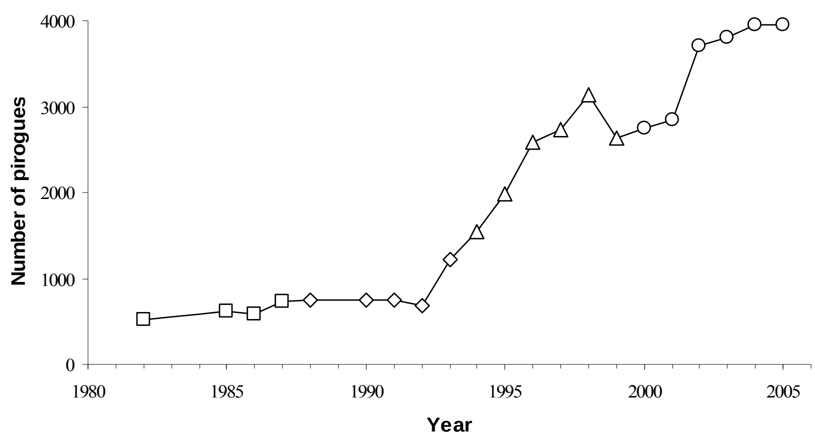

Figure 1: Pirogues number in Mauritania. Based on data from: □ Josse (1989); ◇ FAO-CNROP (1995); Δ Inejih *et al.* (2004); o Boncoeur *et al.* (in press). Data for 1983-84 were interpolated. Annual pirogue numbers are averaged for the two surveys per year.

Initiated in 1982, and since 1985 on a more regular basis, IMROP undertakes periodic surveys, usually twice a year, to estimate the total number of pirogues operating in Mauritanian (Figure 1). Monthly surveys, recording catches by gear in the main landing locations (Nouakchott and Nouadhibou), began in the 1980s, but did not cover all fisheries, and were not published for every year. Two periods seem to be correctly covered, allowing for estimation of total artisanal catches: 1980-1987 (Josse and Garcia, 1986; Josse, 1989), and 1997-2005 (Gascuel *et al.*, in press).

Based on these data, a mean annual catch per pirogue was estimated (Figure 2). The observed increase in catch rate, from around 18 t·year^{-1} in 1982 to 25 t·year^{-1} in 2002, suggests a strong increase in fishing efficiency, which over-compensated for the decrease in resource biomass. Catches for the 1988-1996 intermediate period were estimated as the product of the pirogues number by the mean yearly catch per pirogue.

Table 1: Methods, assumptions and references, for the reconstruction of catches in the Mauritanian EEZ.

Fishery	Period	Methods/Assumptions/References
Artisanal	1950-51	Fixed at 3,000 t, based on subsequent years
	1952-61	Salted and dried production extracted from StatBase (Thibaut *et al.*, 2004), adjusted by conversion factor of 45% (Infoconseil-Paoa, 2005).
	1962-79	Linear interpolation between the two adjacent 5-year averages.
	1980-84	CNROP database and the 1985 working group (Josse and Garcia, 1986).
	1985-87	CNROP database and the 1988 working group (Josse, 1989).
	1988-96	Number of pirogues (from CNROP surveys) multiplied by the mean yearly production per pirogue (see Figure 2).
	1997-05	IMROP database and the 2006 working group (Gascuel *et al.*, in press), values smoothed due to high sampling variability.
Demersal industrial (reported landings)	1950-65	*Sea Around Us* Project values corrected (multiplied by a factor F=0.57 according to 1980-2003 results).
	1966-68	From octopus catches, source FAO-Copace (Failler *et al.*, 2006), extrapolated to total demersal catches according to 1969-1971 data.
	1969-79	From Josse and Garcia (1986) based on FAO data. Corrected by a factor of F=0.57 according to 1980-2003 results.
	1980-85	CNROP database and the 1985 working group (Josse and Garcia, 1986); due to inconsistency in data, year 1983 interpolated.
	1986-91	From CNROP database and the 1993 working group (FAO-CNROP, 1995), total catches of fishes, cephalopods and crustaceans minus artisanal fishery catches.
	1992-05	From IMROP database and the 2006 working group (Gascuel *et al.*, in press). Because of incomplete data, year 2003 interpolated.
Demersal industrial (unreported by-catch)	1950-90	Declared landings of the demersal industrial fishery, multiplied by 0.720 according to the mean 1992-05 estimate.
	1991-05	From mean profiles of catches by species, estimated by license types (recalculated from Failler *et al.*, 2006), extrapolated to catches by license type.
Pelagic industrial (reported landings)	1950-68	SAUP values corrected (multiplied by a factor F=1.388 according to 1979-2003 results).
	1969-78	From Josse and Garcia (1986), based on FAO data.
	1979-91	From CNROP database and the 1993 working group (FAO-CNROP, 1995).
	1992-05	From IMROP database and the 2006 working group (Gascuel *et al.*, in press).
Pelagic industrial (unreported by-catch)	1950-90	Declared landing of the pelagic industrial fishery multiplied by 0.013, according to the mean 1992-05 estimate
	1991-05	From mean profiles of catches by specie, estimated for pelagic licenses (recalculated from Failler *et al.*, 2006) extrapolated to catches.
Pelagic industrial (unreported catches)	1950-90	Declared landing of the pelagic industrial fishery multiplied by 0.363, according to the mean 1991-05 estimates
	1991-05	From IMROP database, assuming that unreported days constitute 70% of the allowed days (licensed boats) without reported catches

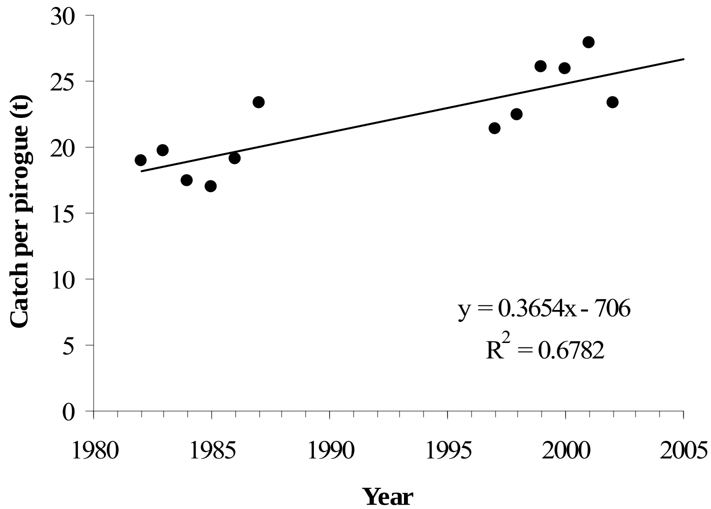

Figure 2: Trend in the mean annual catch per pirogue of the artisanal fishery in Mauritania.

Before 1982, the artisanal fishery remained little developed in Mauritania, involving a few hundred pirogues (Chavance and Girardin, 1991; Chavance, 2004). No statistics could be identified, except from 1952 to 1961. For that period CNROP estimated the national production of salted and dried fishes (in StatBase, described in Thibaut *et al.*, 2004), which appears to represent the bulk of national production. The salted and dried productions were converted to wet-weight catch equivalents using a 45% yield ratio (Infoconseil-Paoa, 2005). Finally, landings from 1962 to 1979 were estimated based on linear interpolation between the above described known values. These estimates were also compared to a simple linear extrapolation over the whole period of the previous trend observed in the mean year catch per pirogue.

Industrial fisheries

Since the early 1980s, IMROP estimated the landings of the industrial fisheries based on logbook and onboard observer data. However, a complete database is presently available only from 1990 onward, and is considered incomplete for the first years. Thus, data from this source (cited in Brahim and Jouffre, in press and in Gascuel *et al.*, in press) were considered for the 1992/2005 period. From 1979 (for the pelagic fishery) or 1980 (for the demersal) to 1991, catch estimates were extracted from the literature (Josse and Garcia, 1986; FAO-CNROP, 1995, 1999), generally based on the IMROP statistical bulletins.

For the 1969-1979 period, Josse and Garcia (1986) estimated the annual catch per species group, using the FAO database, and considering catches proportional to the percentage of FAO areas 34.1.3 (Sahara coastal) and 34.3.1 (Cape Verde coastal) that belong to the Mauritanian EEZ.

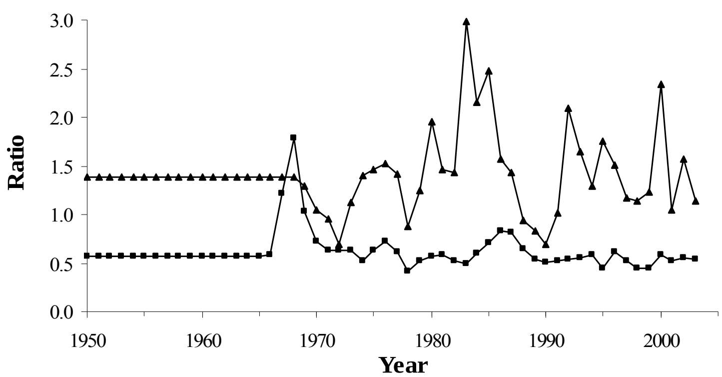

Figure 3: Ratio between our estimates and previous estimates based on FAO data and surface area ratios. Values from 1950 to 1965 (■ demersals) or to 1968 (▲ pelagics) have been fixed to the 1980-2003 and 1979-2003 means, respectively.

Regarding demersal fisheries, these estimates appear very high and have to be corrected. Indeed, a similar estimation, also based on FAO database and taking into account surface area ratios of fishing grounds, i.e., shelf, was performed by the *Sea Around Us* Project (SAUP, www.seaaroundus.org). Such an approach regularly leads to overestimation when compared to the 1980-2003 demersal catches coming from the IMROP database (Figure 3). This seems appropriate, given that demersal fisheries have always been less developed in Mauritania than in adjacent countries, and particularly in Senegal; thus they would represent less than surface area ratios should have implied. As a consequence, we used the mean 1980-2003 ratio of IMROP/SAUP demersal catches as a correction coefficient. This coefficient is equal to 0.57 and has been applied to Josse and Garcia (1986) estimates.

Similarly, the 1950-1968 catches were calculated using previous SAUP estimates (based on FAO database and surfaces) multiplied by the correction coefficient. However, this approach fails to reconstruct the catches for the very first years of octopus exploitation, in the late 1960s. Indeed, for the three years 1966-

1968, it leads to total demersal catches that are lower than octopus catches commonly cited in the literature (Failler *et al.*, 2006). Thus, for these years, we considered demersal catches equal to the octopus catches, multiplied by an extrapolation factor (the mean ratio of demersal to octopus landings during the three following years 1969-1971).

Regarding the pelagic fishery, estimates from Josse and Garcia (1986) appear consistent for the 1969-1978 period and have not been corrected. On the other hand, values coming from SAUP appear underestimated for the 1979-2003 period, when they are compared to IMROP data. This may be partly due to the fact that pelagic fisheries are more important in the Mauritanian EEZ than it would have been deduced from a simple surface area ratios. However, pelagic catches are also influenced by landings of foreign boats, operating with a special agreement as 'Mauritanian chartered boats', that appear to have been strongly underreported to the FAO during the 1980s and 1990s (see below). Therefore, pelagic catches are underestimated in the SAUP database as well. Thus, a correction coefficient was calculated here as well; it was used to estimate the 1950-1965 pelagic catches.

Unreported catches and by-catches

Industrial catch statistics, based on logbooks declarations, underestimated total catches for two reasons. First, catches reported by vessels from each license type are almost exclusively comprised of target species or species groups, but report no or very little by-catch. For demersal fisheries, this is incorrect. For example, the shrimp fishery declares by-catch as low as 15 % of their total landings, whereas realistic values should be greater than 70-80%. Secondly, it is well known that some targeted catches are not reported to the IMROP database. For example, some IMROP surveys show that Dutch vessels may report more catches to their government than to the Mauritanian statistical system (Taleb Sidi, unpublished data). More generally, some vessels are known to not report all their fishing days. Unreported by-catch may be estimated for each license type, for both the demersal and the pelagic industrial fisheries. Firstly, a mean taxon composition profile was calculated (Table 2), based on the 1996-2001 onboard observer data (Failler *et al.*, 2006). Then, we assumed that this profile has been encountered each year, from 1991 to 2005, the targeting species catches being equal for each license to the reported landings for this target. Finally, unreported by-catch was summed for the four demersal license types constituting the demersal fishery.

Table 2: Mean taxon composition profile (%), per license type (by main target taxon); based on values in Table 5.5 in Failler *et al.* (2006), by aggregating results of species groups.

Taxa	License type (defined by main target taxon)				
	Cephalopods	Fish	Hake	Shrimps	Pelagic
Mollusks	6.3	20.3	3.9	6.7	0.0
Octopus	53.1	22.1	20.5	7.2	0.0
Demersal fish	23.4	38.3	34.9	32.8	3.0
Hake	2.9	9.1	31.0	18.8	0.0
Crustaceans	0.8	1.3	1.0	24.0	0.0
Pelagic fishes	13.5	8.9	8.7	10.5	96.9

With regards to unreported catches of target species, data exist that allow rough estimates to be derived for the pelagic industrial fisheries. All foreign vessels have to buy monthly licences, which define the number of permitted fishing days per year estimated since 1991. Compared to the logbooks, a proportion of days reporting no catch was calculated (Figure 4). This proportion is around 50%, but decreases for the last few years, likely due to increasing controls. Obviously, vessels would not buy licences and then spend time at sea without fishing, thus a large proportion of the above estimated no-fishing days simply correspond to unreported fishing days. Based on our local knowledge, we considered that approximately 15% of no fishing days seems more realistic. Thus, we assumed that 70% of the unreported days were actually fishing days, with daily catches equal to those of the reported days.

Unfortunately, this approach is currently not applicable to the demersal fishery, due to lack of time-effort data. However, unreported catches of targeted species seem much lower in this sector, with most misreporting being related to by-catch (already estimated, as explained above).

For the 1950-1990 period, unreported catches and by-catch were estimated by multiplying the reported landings by mean under-reporting coefficients, based on the means of the 1991-2005 estimates (for the three sectors: demersal and pelagic by-catch, and pelagic unreported catch).

Disaggregation of taxa and estimate of national catches

For the 1969-2005 period, reported catches can be readily disaggregated into the six main species groups: crustaceans, cephalopods, Hake, Mullets, other demersal fishes, and pelagic fishes.

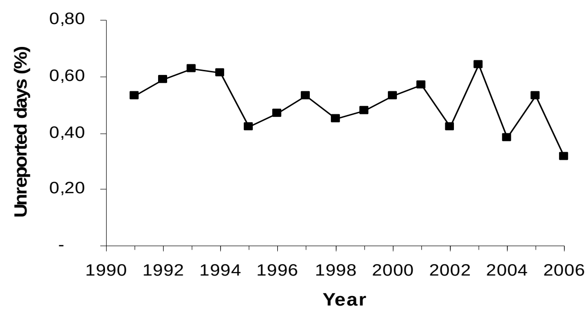

Figure 4: Proportion of days during which pelagic industrial vessels are allowed to fish but declare no catch

With regards to the demersal taxa (the first five groups above), we considered that total catches were equal to the total demersal industrial catches (see above) plus the demersal part of the small-scale fishery. The latter is known for the 1997-2005 period from the IMROP database, and have been assumed to be equal to 80% of the total small-scale landings. Subsequently, the proportion of catches by species groups were calculated for 1969-1983 based on Josse and Garcia (1986), for 1984-1990 (industrial) and for 1984-1992 (small-scale) based on FAO-CNROP (1995), and since 1991 (industrial) and since 1997 (small-scale) based on the IMROP database (Gascuel *et al.*, in press). For the small scale fishery, the missing years 1992-1996 were estimated by interpolation.

With regards to pelagic species, total catches were considered equal to total catches of the industrial fishery plus the pelagic component of the small-scale fishery. The latter is known for the 1997-2005 period from the IMROP database, and were assumed to account for 20% of the total small-scale landings for earlier periods.

Finally, the total national Mauritanian catches were determined. For the early period (1950-1979), statistics provided by FAO appear quite realistic, and no additional information exists to change them. During that period, national fisheries remained limited, involving the small scale fishery and a limited industrial fisheries. The increase in total EEZ catches in the late 1960s and during the 1970s was mainly driven by national policy granting licenses to foreign vessels (and therefore their catches do not appear in the national statistics).

With the establishment of the Mauritanian EEZ in the late 1970s and early 1980s, a new policy ('Nouvelle Politique des Pêches') was introduced. It declared all demersal resources to be reserved for Mauritanians, and a national company was created for cephalopod exploitation. At the same time, foreign countries who wanted to exploit pelagic resources had to obtain special agreements by which vessels operated as 'Mauritanian chartered boats'. Catches were to be landed in Mauritania (but in fact, transshipments onto commercial boats in the Nouadhibou Bay was considered as 'landed') and reported as national exports. We assumed that this policy was progressively (i.e., linearly) applied between 1979 and 1982. For 1982 to 1991, we assumed that national Mauritanian catches were equal to the sum of: (i) all catches of demersal species (except Hake and Crustaceans that continued to be exploited by foreign countries, mainly Spain); (ii) the pelagic catches of the small-scale fishery (the demersal catches being already included in (i)); and (iii) 96% of the total catches of the industrial pelagic fishery (based on the estimates of the 1992-95 period). For 1992 onwards, we considered the national landings equal to the sum of the small-scale fishery catches and the catches of the industrial boats registered in the IMROP database as 'national vessels' and 'chartered vessels'. Additionally, the amount of unreported by-catch that should be considered as 'national' was estimated each year assuming it was proportional to the national component of declared catches for both pelagic and demersal industrial fisheries.

RESULTS

Sector trends (reported catches)

With regards to small-scale fisheries, Mauritania has no long-standing historic tradition, and this sector remained little developed until relatively recently. However, in the 1950s an early development stage did occur, when production increased from around 3,000 t·year^{-1} to over 7,000 t·year^{-1}, driven by the development of the salted and dried market (Appendix Table A1). From the 1960s to the 1980s, catches remained less than 15,000 t·year^{-1} with less than 750 pirogues involved. Catches strongly increased during the 1990s, reaching more than 80,000 t·year^{-1} in the most recent years (Figure 5), while the number of pirogues increased to 4,000 units.

Regarding the industrial demersal fishery, catches for the 1950s and early 1960s were likely limited. This fishery developed in the late 1960s with Japanese vessels targeting octopus beginning in 1966. These boats were nationalized in the late 1970s, and replaced by Korean, and more recently, Chinese vessels in the form of joint agreements. Foreign vessels, mainly Spanish, also targeted cephalopods in the 1970s before the 'Nouvelle Politique des Pêches', and more recently according to the agreements signed in 1996, 2001 and 2006 between Mauritania and the EU. During the entire time period, foreign boats were also authorized for particular fishing such as those targeting hake, pink spiny lobster and shrimps. Total reported landings, half of which were cephalopods, remained around 80-100,000 t·year^{-1} during the 1970s and 1980s, but have decreased during the last fifteen years to approximately 60,000 t·year^{-1} (Figure 5).

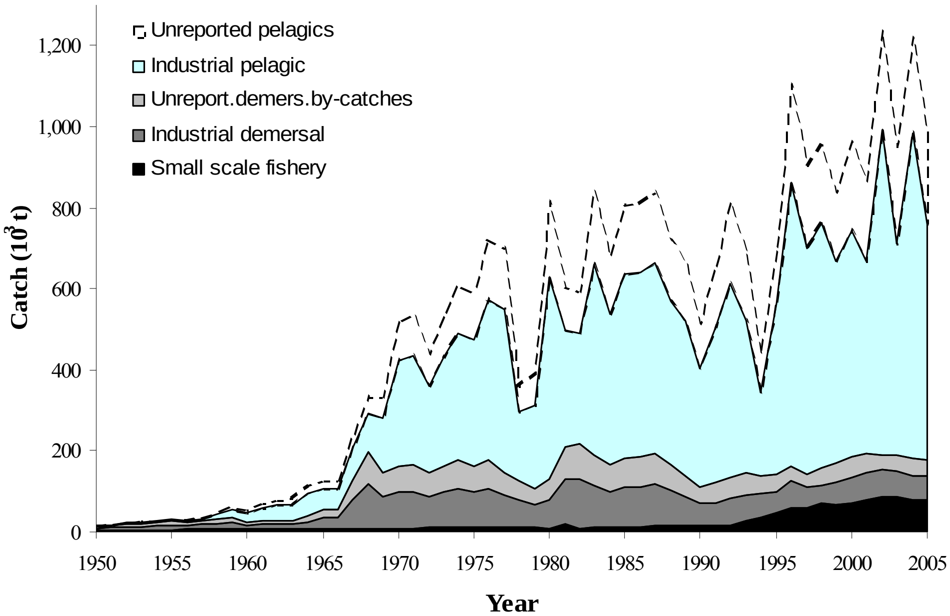

Figure 5: Trends in the catches of fisheries operating in the waters now encompassing the Mauritanian EEZ: reported catches and unreported by-catch of the industrial sector.

Catches of the industrial pelagic fishery exhibit high year-to-year variability due to environmental variability (a common pattern for pelagic fisheries), specifically related to the strength and seasonal timing of the local upwelling. However, the Mauritanian EZZ has always been one of the more important areas for the production of fishmeal by the reduction fishery sector. This fishery seemed to start slowly in the 1950s, but annual catches increased strongly from less than 100,000 t·year^{-1} in the 1960s to nearly 300,000 t·year^{-1} by the 1970s. The number of boats increased rapidly at that time, with vessels coming from former Warsaw Pact countries (USSR, Romania, East Germany, Bulgaria, Poland etc.). Simultaneously, Dutch and Norwegian vessels also operated in the Mauritanian area, before retiring in the late 1970s. In the context of the 'Nouvelle Politique des Pêches', vessels from Eastern Europe operated during the 1980s and the early 1990s as 'Mauritanian chartered boats'. During that period, landings reached more than 450,000 t·year^{-1}, before temporarily decreasing with the collapse of communism in Eastern European and the USSR (Figure 5). However, new agreements were signed with the newly independent countries, particularly Russia and Ukraine, as well as Lithuania and Latvia. Furthermore, since the mid 1990s the EU became a major partner through the engagement of Dutch industrial vessels. Additionally, a significant part of total landings (more than 100,000 t·year^{-1}) are by flag of convenience vessels (e.g., Belize, Cyprus). In recent years, catches exceeded 600,000 t·year^{-1} (Figure 5).

Unreported industrial catch and by-catch

Table 3: Unreported by-catch (t·year^{-1}) per license type.

Taxa	License type						% of total industrial catch
	Cephalopod	Fish	Hake	Shrimp	Pelagic	Total	
Octopus	0	1,461	6,291	1,169	3	8,924	30.0
Other mollusks	0	1,209	1,162	846	57	3,274	29.0
Demersal fish	550	0	9,782	4,985	6,056	21,373	48.0
Hake	1,010	0	0	2,959	581	4,520	29.0
Crustacean	167	30	253	0	77	527	11.0
Pelagic fish	6,180	589	2,665	1,699	0	11,132	2.1
Total	7,907	3,257	20,152	11,658	6,774	-	-
% of catches	17.0	49.0	66.0	72.0	1.2	-	-

Observer data show that unreported by-catch in the industrial fisheries is very important (Table 3). This is particularly relevant for vessels holding a shrimps license, whose unreported by-catch can reach 72% of their total catches. In the case of Hake and demersal fish licenses, the proportions are slightly lower, at around 66% and 50%, respectively. In contrast, pelagic vessels seem to declare almost all demersal by-catch.

Taking into account the importance of each license type suggests that around 50,000 t·year^{-1} of by-catches, including nearly 40,000 t·year^{-1} of demersals, are not reported. This means that almost half of demersal fish and around 30% of molluscs and hake are missing from the industrial reports. Thus, taking all taxa combined, we estimate that catches reported by the demersal industrial fishery have to be multiplied by a factor of 1.7 to take into account unreported by-catch. Regarding pelagic fish,

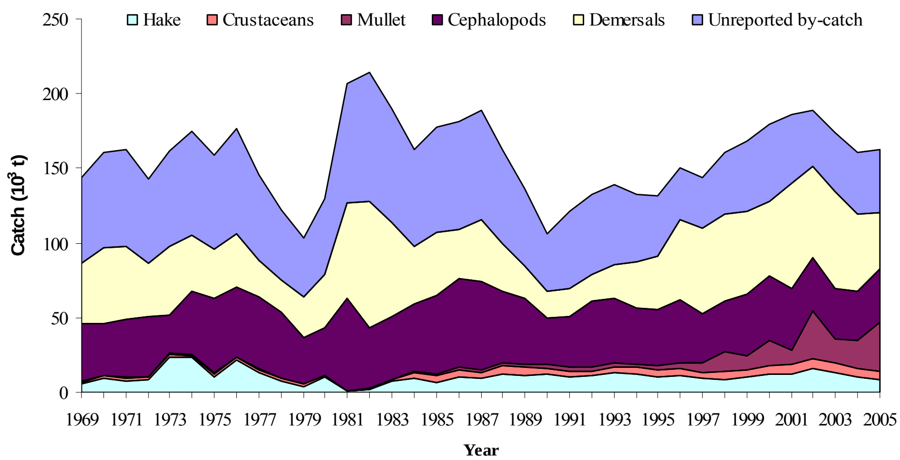

Figure 6: Trends in Mauritanian demersal catches by species group and unreported by-catch.

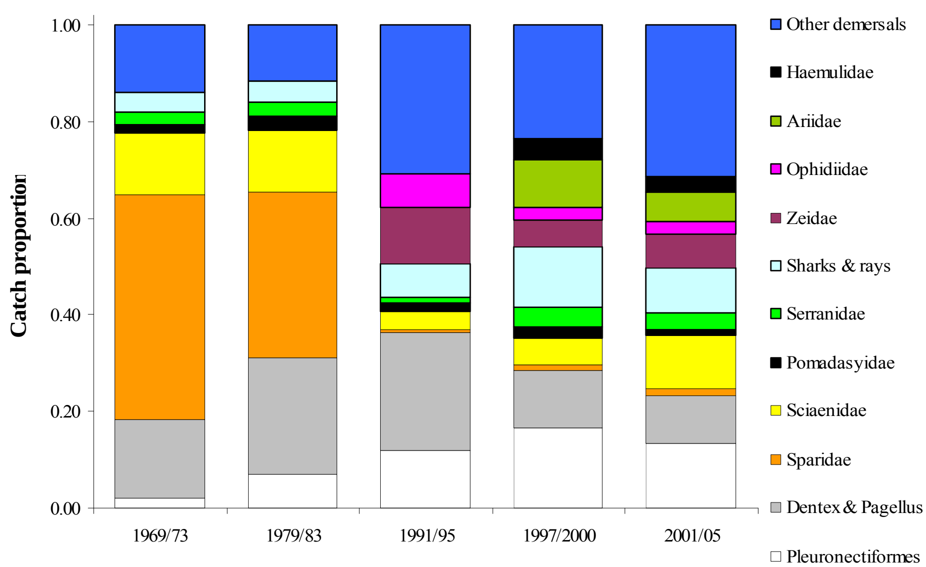

Figure 7: Taxonomic composition of demersal fish catches in Mauritania by time periods.

by-catch due to the demersal fishery appears rather negligible compared to total landings. In that case, misreporting comes from the industrial pelagic fishery itself. Indeed, results suggest that unreported catch by licensed boats might constitute more than 35% of the reported catch, resulting in several hundred thousand tons of unreported catch per year (Figure 5 and Appendix). During the last few years, total pelagic landings, including unreported and artisanal catches, would be close to 900,000 t·year^{-1}; and may have exceeded 1 million tons in 2002 and 2004. Note, however, this does not include catches by illegal boats entering the Mauritanian EEZ.

Demersal catches by taxa

The analysis of demersal catches per species group, including both artisanal and industrial fisheries, reveals interesting trends (Figure 6). Total declared landings increased during the last fifteen years due to the development of the artisanal fishery. But this apparent positive trend masks more negative changes. Firstly, we note that total landings, including unreported by-catch, have remained more or less constant around 150,000 t·year^{-1} since the 1970s, as the decrease in the industrial sector resulted in a decrease in the total by-catch. In other words, a strong increase in total fishing effort, due to artisanal fishery development, has lead to almost constant landings. Secondly, some groups are characterized by increasing landings; this is the case for crustaceans (mainly shrimps) and mullets. These groups are well known as low trophic level taxa, and such a catch trend may contribute to 'fishing down the marine food web' (Pauly *et al.*, 1998). Conversely, cephalopod catches (mainly *Octopus*) slightly increased until the mid 1980s, but exhibited afterwards a clear decreasing trend from more than 55,000 t·year^{-1} to around 35,000 t·year^{-1}.

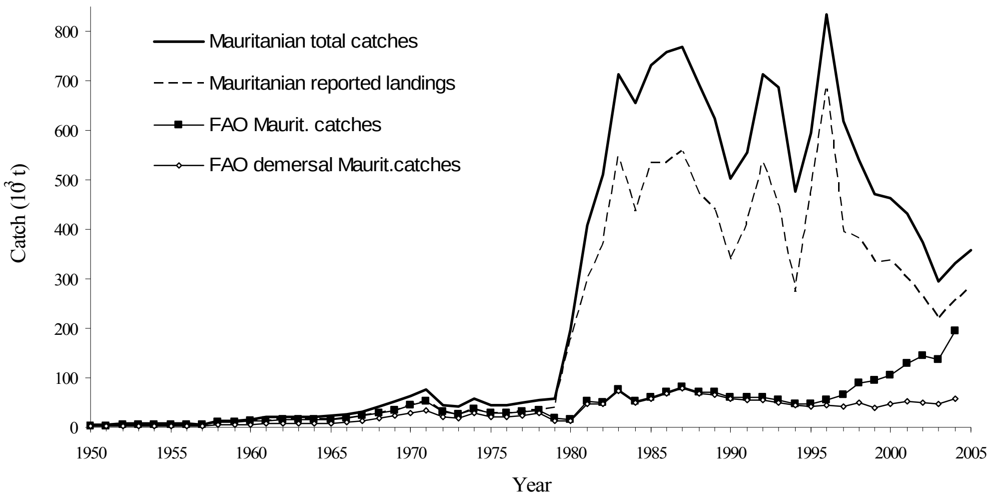

Figure 8: Mauritanian national catch trends as derived by the present study, and comparison to FAO data as reported by Mauritania.

Lastly, the composition of demersal fish catches was highly variable, and changed considerably over time (Figure 7). Sparidae largely dominated until the early 1980s, before decreasing. Thus, the "various Sparidae" category constituted more than 40% in 1969/73, while it appears to have almost disappeared in the recent periods. However, it may be included in the "Other demersals" category, which has increased since then. *Dentex* and *Pagellus* reached 24% of the total catches before decreasing to around 10% in the most recent period. Conversely, Pleuronectiformes and elasmobranches seem to increase and new categories appeared in the catch statistics. This is especially the case of very coastal species such as *Arius* sp. (Aridae), and *Plectorynchus mediteraneus* (Haemulidae), likely due to the development of the artisanal fishery. But significant landings of more offshore species such as *Zeus faber* (Zeidae) and *Brotula barbata* (Ophidiidae), were also recently recorded. Globally, these changes indicate that more species become intensively exploited. As the species are overexploited, fisheries target new resources, a wider range of ecosystem compartments being progressively exploited.

National catches

Until the late 1970s, the development of fisheries in Mauritanian waters was mainly driven by foreign vessels. National catches remained below 50,000 t·year^{-1} (Figure 8). Thereafter, national catches rapidly increased to over 500,000 t·year^{-1} around 1980 (or 700,000 t.year^{-1} if unreported catch estimates are included). This was largely the result of the new policy 'Nouvelle Politique des Pêches' which resulted in charter agreements for essentially foreign industrial boats targeting pelagics, and in the nationalization of vessels targeting demersals (mainly *Octopus*). This resulted in the sudden increases in apparent national catches (Figure 8). We note that pelagic catches by chartered boats recorded in the Mauritanian database were not reported at that time to the FAO, whose data overwhelmingly relates to demersal catches only (Figure 8). Not until the mid 1990s do FAO statistics progressively include larger pelagic catches, and thus begin to approach the real Mauritanian reported landing (Figure 8). However, these statistics still underestimate demersal catches, especially from the artisanal fishery and do not take into account unreported catches.

In addition, we observe a decrease in national catches over the last twenty years (Figure 9), which seems driven by a new policy regarding agreements with foreign countries. Chartered boats still exist, but are progressively replaced by licensed foreign boats, mainly from Eastern Europe, the Netherlands, or increasingly flag of convenience. These vessels are considered as fully foreign, and their catches are not reported by Mauritania, but deemed the responsibility of the catching country (flag country of the vessel). Thus, national landings are now around 350,000 t·year^{-1}, of which approximately half are demersal species (Figure 9).

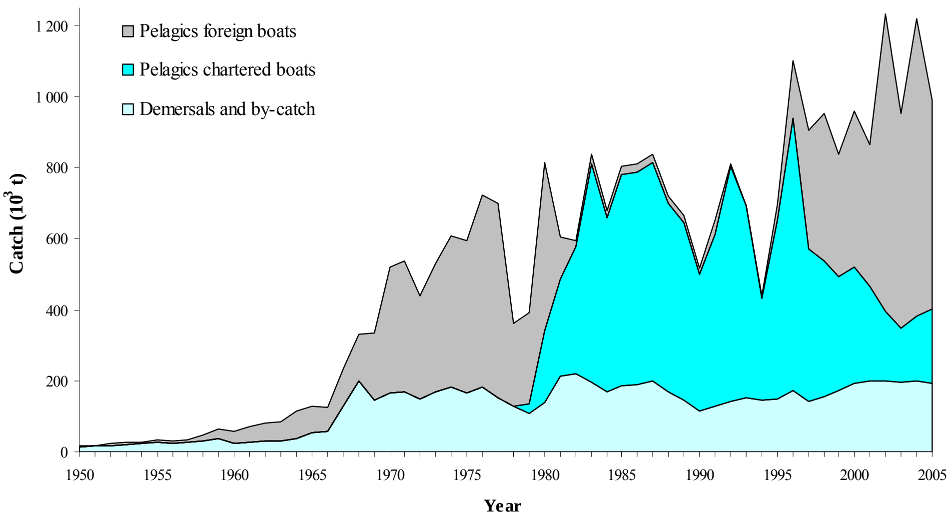

Figure 9: Catch trend in Mauritanian waters, illustrating the importance of 'charter' boats for pelagic catches during the 1980s and 1990s (unreported included).

Discussion

Catch time series reconstruction, under conditions of data-gaps, remains a difficult task and our estimates contain uncertainty, including:

For periods prior to 1979, we used empirical coefficients based on 1980-2003 data to estimate industrial catches. Compared to previous estimates, this contributes to lowering demersal catches and thus, results appear more realistic over the whole period. In particular, values cited by Josse and Garcia (1986) for the 1968-1979 period are too high and inconsistent with later estimates of maximum potential yields. Therefore, empirical corrections such as ours are likely to improve the catch statistics, but accuracy remains low.

Unreported catches and by-catch were estimated over the whole period based on data covering only the recent years. Because by-catch and misreporting practices may have greatly changed over time, these estimates are highly uncertain. They do, however, underline the importance of considering by-catch in national accounting.

Three types of catches might be still be missing in our estimates. First, artisanal Senegales pirogues have been allowed in Mauritanian waters since 1999, according to a fishing agreement between both countries. No data have been identified for this fishery, but Gascuel *et al.* (in press) estimated landings of approximately 6,000 to 12,000 t.years^{-1}. Second, we noticed that unreported catches of the demersal industrial fishery have not been estimated, due to the lack of data. At last, and probably the most important: illegal foreign vessels may operate without any licenses in the Mauritanian EEZ and their IUU catches have not been considered in our results.

Thus, the current catch time series are likely to constitute minimal estimates and should be considered with caution, especially for the 1950s and 1960s. Nevertheless, the present reconstruction is extremely useful in that it provides the first picture of long term catch trends by the various fisheries which have exploited the waters that now represent the Mauritanian EEZ. Six main lessons emerge from this reconstruction:

1. The results can be compared with the catch estimates by the *Sea Around Us* project (www.seaaroundus.org). The latter relied on Watson *et al.* (2004), who allocated FAO catch by groups of species to ½ degree cells, and regrouped these into different EEZs. The present case study of Mauritania is the first independent test of the results presented by the *Sea Around Us* project, and it passed the test with flying colors: total catches in the Mauritanian EEZ from the *Sea Around Us* are very close to our estimates of the official landings of the industrial fisheries (Figure 10). On the other hand, a more detailed examination, requiring local knowledge, identifies a limitation of the global method of Watson *et al.* (2004). For example, we found that demersal catches taken in the waters off Mauritania were overestimated in the *Sea Around Us* database, while pelagic catches were underestimated. The main reason for this relates to the different fisheries history between Mauritania and its neighbours, particularly Senegal. Mauritanian marine resources have been exploited mainly by foreign countries targeting small pelagic fishes. On the other hand, small-scale fisheries targeting demersal resources developed very early in Senegal. Thus, the catch ratios of demersal and pelagic fishes between these two countries are not simply proportional to their fishable areas, as is assumed by the globally applied method of Watson *et al.* (2004) when no additional information is available. Their method, however, allows for the incorporation of information such as provided here, and thus it is possible to correct the results in subsequent renditions of the *Sea Around Us* spatial allocation.

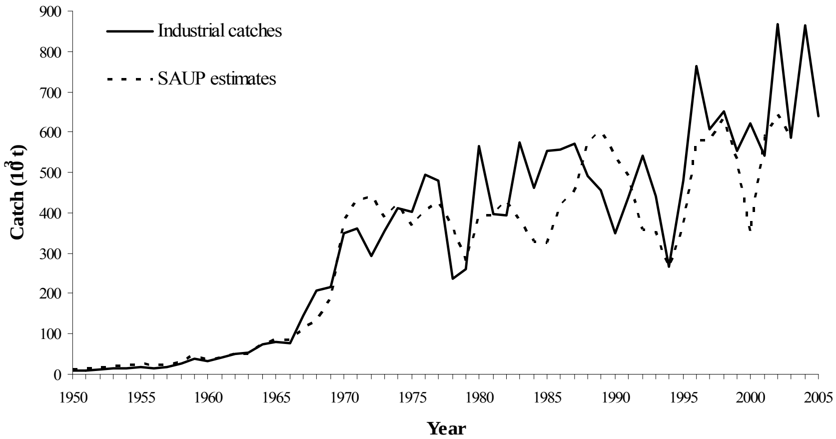

Figure 10: Comparison between present estimates for Mauritania and *Sea Around Us* project allocation of catches to Mauritanian waters.

2. Several hundred thousand tons of small pelagic fishes, recorded in the IMROP database during the 1980s and 1990s have simply disappeared from the statistics reported to the FAO. These had been caught by foreign boats (particularly from Eastern Europe), operating on the basis of special agreements as 'Mauritanian chartered boats' (Figure 11). Therefore, as 'chartered boats' their catches should have been declared as Mauritanian catches. However, they were not reported, and neither do they appear (or only partially) in the landings reported by the foreign countries in question[2].

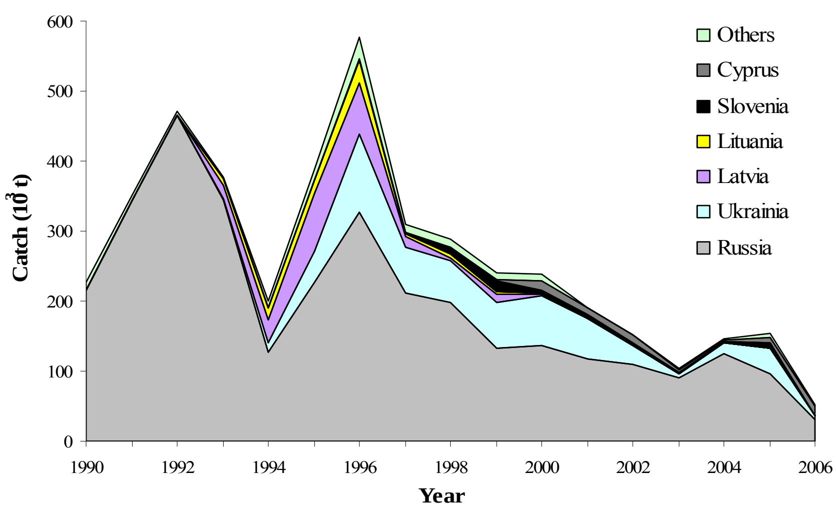

Figure 11: Catches of pelagic species by the chartered boats in the Mauritanian EEZ (data from IMROP database).

3. A further several hundred thousand tons of small pelagic fishes caught by industrial vessels were also unreported in the Mauritanian database (and thus do not appear in the FAO statistics). While Mauritanian

[2] For example, pelagic catches by chartered boats coming from Russia and operating in the Mauritanian EEZ amounted to 460,000 t and 340,000 t in 1992 and 1993, respectively, based on the IMROP database. However, only 185,000 t and 105,000 t were recorded in the FAO database regarding Russian pelagic catches for the entire FAO subareas 34.1.3 (Sahara coastal) and 34.3.1 (Cap Verde coastal), which also includes Morocco and Senegal. This implies that some (likely substantial) Russian vessel catches in Mauritania are missing in the FAO reporting.

supervision capacities have been recently reinforced, for a long time they were very limited, and illegal catches, especially by foreign vessels (with or without proper licence), were obviously very important.

4. As in many other countries, official landings of demersal fishes are also underestimated due to a large amount of unreported by-catch, and a neglect of the small-scale fisheries sectors (see Zeller *et al.*, 2006a; Zeller *et al.*, 2007). Indeed, the latter have always been considered insignificant in Mauritania. This may have been true before the early 1990s, when a few hundreds 'pirogues' were involved. However, since then, their number has increased nearly ten-fold, generating catches of approximately 80,000 t·year^{-1}. Obviously, a 'small-scale' fishery of such magnitude is a major economic factor (Zeller *et al.*, 2006b), whose impacts on the ecosystem can no longer be ignored. As for the by-catch, it has been so far ignored because the vessels report overwhelmingly the species they target, and for which they have a license. Clearly, shrimp trawlers do not only catch shrimps, and cephalopod fishers do not catch only octopus. We find here that taking into account unreported by-catch leads to an increase of the industrial demersal catches by a factor of 1.7.

5. As a consequence, the overall picture of Mauritanian fisheries catches is strongly modified. Until now, it was thought that the industrial fishery for small pelagics overwhelmingly dominates the fisheries sector. While this is still true in term of tonnage (indeed Mauritania has one of the world largest reduction fisheries, where the catch is reduced to fishmeal), this may not be true in term of value or value added, as the demersal fisheries (industrial and small-scale), catching higher-priced species such as hake, octopus, shrimp, etc., have much higher catches than previously thought.

6. Having established that demersal resources are important, we must then deal with the fact that these resources suffer from tremendous overexploitation. The industrial demersal fisheries developed in the late 1960s, mainly targeting octopus, whose abundance increased at that time, probably due to the previous overexploitation of bottom fish, notably porgies (family Sparidae). Since then, total demersal catches have remained around 180,000 t·year^{-1}, albeit with a huge increase of fishing effort. For instance, the number of industrial trawlers grew from around 150 in the early 1980s to 300-350 in the late 1990s/early 2000s. Given that their fishing efficiency has also increased, this further increases the effective effort. In the process, various species groups have been successively exploited, then overexploited. This was probably the case for several fishes belonging to the Sparidae community in the 1960s and 1970s; octopus is overexploited since the mid 1980s (Gilly and Maucorps, 1987; Chassot *et al.*, in press), which induced a decrease in cephalopods landings from a maximum of 55,000 t·year^{-1} to presently about 35,000 t·year^{-1}; and coastal fishes of the Scianidae community reached their maximum in the 1990s and are now decreasing, too. At the present, it is mullets and shrimps that are on target for overexploitation. Overall, the biomass of demersal resources has been substantially depleted: at present it is about 25% of what it was in 1982, when regular trawl surveys began (Gascuel *et al.*, in review). This corresponds to a loss of 20,000 t·year^{-1}. Moreover, the biomass of top predators has been reduced by a factor of 8 to 10, and of up to 20 for the most affected species. The mean trophic level of the catch, and its biodiversity decreased, inducing a higher sensitivity to the effects of climate change (Gascuel *et al.*, in review).

Conclusion

Mauritania is a very clear case study of an inequitable allocation of fisheries resources. Almost all the large fishing countries of the world have exploited Mauritanian waters. Octopus and demersal fishes have been targeted by Japanese, Spanish, Korean, and Chinese vessels. Pelagic fishes have attracted vessels from Russia, Ukraine and other eastern European countries, and more recently Dutch vessels. The national Mauritanian industrial fisheries remained limited in spite of several attempts to develop national or joint ventures, especially during the 1980s. Foreign countries have to pay for licenses or fishing agreements, for example resulting in presently about 30% of Mauritanian public receipts coming from the EU. While the opportunity to earn revenue in this manner is obvious, such policies may not be a good basis for exerting national sovereignty. But the majority of catches were never and still are not landed in Mauritania. Instead, foreign vessels offload in the Canary Islands (i.e., Spain), or directly in their country of origin. Mauritania benefits neither through jobs, nor value added returns. As for the small-scale fishery, it was limited for a long time, and developed only since the mid 1990s, partially in competition with industrial fisheries – and only after resources were reduced.

The context in which Mauritanian fisheries scientists operate, and try to assess stocks and fisheries is thus very challenging. Perhaps the recent development of an oil industry will make it possible for Mauritania to acquire more weight in international negotiations, and to manage its fisheries resources, and the access of foreign fishing fleet to its waters in a more equitable fashion. It is hoped that this will contribute to more of the benefits accruing to Mauritania. There is no doubt that international scientific cooperation will remain useful in this process.

ACKNOWLEDGEMENTS

This study would not have been possible without the work of several generations of scientists, technicians and onboard observers involved in the Mauritanian fisheries. A special thanks to those involved in the IMROP database implementation and maintenance, and who provided statistics, notably B. Meissa, B. Tfeil and S. Yahya. This study was also supported by an international Marie Curie fellowship, funded under the sixth EU Framework Programme. D. Zeller and D. Pauly acknowledge the support from the *Sea Around Us* Project, funded by the Pew Charitable Trusts, Philadelphia.

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APPENDIX

Table A1: Reconstructed Mauritanian catches for the artisanal and industrial (demersal, pelagic) fisheries; unreported catch and by-catch of industrial fisheries; total catches in the Mauritanian EEZ and national catches (unreported included). All values in tonnes.

Year	Artisanal	Industr. dem	Industr. pel	Unrep. dem	Unrep. pel	Tot. EEZ	National
1950	3,000	6,835	1,800	4,918	677	17,230	4,439
1951	3,000	7,285	2,013	5,242	757	18,296	4,439
1952	2,844	9,079	3,495	6,532	1,314	23,264	7,159
1953	3,724	10,079	3,623	7,252	1,362	26,041	7,159
1954	4,833	10,565	3,272	7,602	1,230	27,502	7,159
1955	4,100	13,343	4,328	9,601	1,627	33,000	6,799
1956	6,124	10,755	4,662	7,739	1,753	31,034	6,799
1957	7,280	11,613	5,039	8,356	1,895	34,183	6,439
1958	6,867	13,389	12,103	9,634	4,551	46,544	13,598
1959	6,264	17,538	20,102	12,620	7,558	64,083	13,598
1960	6,331	10,614	22,818	7,637	8,580	55,980	16,317
1961	7,667	11,521	30,513	8,290	11,473	69,463	19,756
1962	7,158	12,935	37,231	9,307	13,999	80,630	20,756
1963	7,434	12,353	39,898	8,888	15,002	83,575	20,756
1964	7,710	17,461	56,691	12,564	21,316	115,743	20,756
1965	7,986	26,435	53,885	19,021	20,261	127,588	23,476
1966	8,262	28,024	50,054	20,165	18,820	125,326	26,915
1967	8,539	69,336	75,950	49,891	28,557	232,272	32,054
1968	8,815	110,405	95,601	79,443	35,946	330,210	41,952
1969	9,091	79,169	136,336	56,967	51,262	332,825	51,550
1970	9,367	88,921	259,125	63,983	97,431	518,827	64,437
1971	9,643	90,258	270,595	64,945	101,743	537,185	77,493
1972	9,919	78,480	214,348	56,471	80,595	439,813	45,147
1973	10,195	89,417	265,592	64,340	99,862	529,407	41,022
1974	10,472	96,818	313,244	69,666	117,779	607,979	59,099
1975	10,748	87,219	315,219	62,759	118,522	594,467	43,579
1976	11,024	97,462	395,800	70,129	148,820	723,235	43,787
1977	11,300	79,297	399,879	57,059	150,354	697,889	49,812
1978	11,576	65,917	170,698	47,431	64,182	359,804	56,094
1979	11,852	54,546	207,000	39,249	77,832	390,479	57,299
1980	9,821	71,002	495,000	51,090	186,119	813,032	198,443
1981	19,871	111,090	286,000	79,935	107,536	604,432	408,924
1982	9,831	120,136	274,000	86,444	103,024	593,435	511,231
1983	10,916	105,074	469,000	75,606	176,343	836,939	712,515
1984	10,203	90,011	373,000	64,768	140,248	678,230	655,199
1985	10,591	98,641	454,000	70,977	170,703	804,912	732,062
1986	11,088	100,440	456,000	72,272	171,455	811,256	759,175
1987	17,129	101,726	470,000	73,198	176,719	838,772	767,758
1988	15,311	87,304	403,000	62,820	151,528	719,962	691,102
1989	15,528	71,949	383,000	51,771	144,008	666,256	623,122
1990	15,743	54,625	295,000	39,306	110,920	515,593	502,063
1991	15,961	57,058	381,000	51,051	146,508	651,577	556,092
1992	14,898	67,461	475,686	53,519	200,353	811,916	714,304
1993	27,069	63,465	376,440	54,195	170,624	691,793	686,875
1994	34,816	59,391	206,018	45,439	93,217	438,880	475,959
1995	45,624	54,946	423,456	40,265	132,868	697,158	594,795
1996	60,376	67,376	697,553	34,322	241,075	1,100,702	833,498
1997	58,083	51,150	554,508	33,778	206,227	903,746	617,681
1998	70,558	45,298	605,209	40,911	190,746	952,721	539,985
1999	68,904	53,516	500,149	46,645	169,947	839,161	470,856
2000	71,160	63,032	558,247	50,984	217,235	960,658	464,258
2001	79,506	67,745	474,556	45,833	196,055	863,695	430,760
2002	86,485	67,253	800,555	37,484	242,644	1,234,421	374,981
2003	85,811	63,763	522,859	39,555	241,662	953,650	293,746
2004	78,473	60,274	805,295	41,625	232,775	1,218,442	332,562
2005	78,447	58,765	581,061	42,344	227,750	988,367	357,230

RECONSTRUCTION OF GREEK MARINE FISHERIES LANDINGS: NATIONAL VERSUS FAO STATISTICS[1]

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ABSTRACT

We reconstructed Greek fisheries catches from 1950-2003. The landings data recorded by the National Statistical Service of Greece have been compared with those reported by FAO for 1964-2003. For 1969-2003 we also reconstructed landings derived from rowing boats and coastal boats with engine power <19HP, which are not reported by either dataset. We disaggregated these landings by taxon, based on recent reports of the mean catch per unit of effort of all species caught by different small-scale gears. This allowed estimation of the total Greek marine fisheries landings and comparison with the corresponding FAO data. The reconstructed total landings indicated an average underestimation by 35% (range: 10-65%) of Greek landings based on the reported landings as presented by FAO on behalf of Greece. Except for the taxonomic differences (e.g., the case of *Sardinella aurita*) and the different taxonomic resolution (e.g., the case of *Spicara* spp.), which accounted for several discrepancies between the two datasets, the two datasets also differed for most taxa over the period 1964-1969 and for the years 1997 (FAO landings are overreported) and 1998 (FAO landings are underreported). With respect to catches by individual taxa through time, the two datasets generally agreed for the small pelagics and, to a lesser extent, for demersal taxa. The taxa which accounted for the larger and more consistent difference between the two datasets were the large pelagics (swordfish, bluefin tuna and other tuna-like fishes), which were commonly underreported by the national dataset by a factor of 2 for the years following 1990.

INTRODUCTION

Fisheries statistics offer, among other things, direct or indirect background information for evaluating several ecological aspects of fisheries (e.g., assessing 'fishing down the marine food web': Pauly *et al.*, 1998; primary production required to sustain fisheries: Pauly and Christensen, 1995; Tudela, 2000; mapping fisheries resources: Watson *et al.*, 2001). In addition, long time-series of fisheries landings are also useful for developing short- and long-term forecasting (e.g., Stergiou, 1989; 1991; Stergiou and Christou, 1996; Stergiou *et al.*, 1997a; Lloret *et al.*, 2000; 2001), for defining management zones using multivariate analyses (e.g., Murawski *et al.*, 1983; Stergiou *et al.*, 1997b; Tsikliras and Stergiou, 2007), for defining target species (Stergiou *et al.*, 2003), and for testing various ecological hypotheses (e.g., Watson and Pauly, 2001; Halley and Stergiou, 2005).

Since 1950, world fisheries landings are routinely reported by the Food and Agriculture Organization (FAO) of the United Nations, based on reports provided by member countries (Pauly and MacLean, 2003). FAO publishes the 'Yearbook of Fishery Statistics', which contains the annual landings of fish, crustaceans, molluscs and other aquatic animals/plants. Such data refer to the commercial, industrial and small-scale inland, coastal and oceanic fisheries (excluding recreational or sport fishing). FAO data often suffer from serious drawbacks and biases, thus in order to better reflect reality they must be complemented by specific evaluation studies at the national level. As mandated, FAO has to rely on statistics provided by member countries, even if it is doubtful that these correspond to reality (e.g., Watson and Pauly, 2001). Erroneous or incomplete statistics may systematically distort world fisheries landing trends, whether over-reported (Watson and Pauly, 2001) or underreported (Pauly and Maclean, 2003). The most important bias is that

[1] Cite as: Tsikliras, A., Moutopoulos, D. and Stergiou, K. 2007. Reconstruction of Greek marine fisheries landings: National versus FAO statistics. p. 121-137. *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

FAO statistics do not include: (i) Unreported, Unregulated and Illegal catches (IUU catches), which may reach up to 50% of the total landings (Pitcher *et al.*, 2002), and (ii) discarded by-catches (e.g., Alverson *et al.*, 1994; Pauly *et al.*, 2003; Zeller and Pauly, 2005).

The global fisheries crisis requires changes in management regimes, which should be based on reliable research and evaluation of the existing fisheries statistics (e.g., *Sea Around Us* Project, www.seaaroundus.org). The *Sea Around Us* Project aims to analyze the impacts of fisheries on marine ecosystems, and develop strategies for sustainability of fisheries. Among other goals, the project attempts to correct the FAO data for individual countries based on various sources of each country's statistics, as well as on the knowledge of local experts (e.g., Zeller *et al.*, 2006; 2007).

Within this framework, we compared the national fisheries statistics for Greek waters recorded by the National Statistical Service of Greece (NSSH) with those reported by FAO in order to identify/quantify discrepancies between the two data sources. A discrepancy in the total landings reported between these two sources has only been recently realised (Stergiou *et al.*, 2004). In the present study, we:

a) compared the FAO marine captured production reported for Greece with that reported by NSSH for the period 1964-2003 on a taxon by taxon basis;
b) re-evaluated the taxon groups reported by FAO and NSSH (1964-1981) by revising taxon names and splitting, when necessary, groups into taxa;
c) assembled the national statistics for the small-scale fishery (i.e., landings for rowing boats and boats with engines <19 HP), which are not included in the FAO marine statistics, and allocated these landings to taxa (or groups) using previously published information; and
d) developed a completely reconstructed time series of marine fisheries catches for Greece, from 1950-2003 (i.e., including the landings for rowing boats and boats with engines <19 HP).

Materials and Methods

Data sources

Greek fisheries statistics are collected by four independent organisations (Papaconstantinou, 2002): (a) the National Statistical Service of Greece (NSSH, since 1964, for 16 fishing subareas, Figure 1); (b) the Agricultural Bank (since 1974, from approximately 110 ports); (c) the National Company for the Development of Fisheries (since 1969, from all existing auction sites); and (d) the Ministry of Agriculture (not routinely involved in data collection). Each of these organizations collects and/or processes fisheries data for its own purposes, without co-ordination among organisations. Thus, collected information is overlapping, contradictory, and sometimes leads to confusion (e.g., two or more differing sets of figures for the same variable surveyed). Although NSSH statistical data may suffer from certain biases, which may be higher for inshore fisheries, they are considered the best figures available (Stergiou *et al.*, 1997b; Papaconstantinou, 2002) with respect to: (a) the length of available time-series, (b) spatial and temporal resolution of collected data (covering all Greek waters), (c) the consistency and degree of subjectivity in data collection, and (d) the statistical design. It should be pointed out that the degree of bias cannot be easily estimated. Yet, NSSH records show signs of biological, ecological, oceanographic and technical relevance, and reasonably agree with the results of trawl and echo-surveys conducted in the Greek Seas (Stergiou *et al.*, 1997b). Important in the present context is that the NSSH dataset forms the basis of the Greek data reported to FAO for the vast majority of species.

The landings of the Greek commercial fleets have been routinely recorded since 1964 by the NSSH and are published in yearly bulletins (NSSH, 1967-2005). Landings (and fishing effort) records are derived via questionnaires, which are distributed to a subset of fishing vessels (using a stratified random sampling design). Surveys are conducted by local Customs Authorities. The statistical questionnaire includes the quantity of each main taxon caught on a daily basis for actual periods of activity. Since 1969, the catches of the small-scale coastal boats with engine horsepower <19 HP (i.e., small inshore ring netters, drifters and liners), as well as rowing boats are monitored by a different NSSH branch (Agricultural Statistics of Greece). However, a rough estimate of the total catch of the small-scale coastal fleets is provided in the marine catches bulletin (NSSH, 1967-2005) This estimate for 1970-1994 averages approximately 25,000 $t \cdot year^{-1}$ (range: 20,000 - 30,000 $t \cdot year^{-1}$; Stergiou *et al.*, 1997b). However, this estimate changed for the period following 1995, averaging approximately 55,000 $t \cdot year^{-1}$ (range: 50,400 - 58,800 $t \cdot year^{-1}$), that is 14,000 boats powered with less than 19 HP catching 300-350 $kg \cdot boat^{-1} \cdot month^{-1}$ (NSSH, 1967-2005), possibly following the 1988 census of fishing boats operating in Greek waters (Papaconstantinou, 2002).

The NSSH dataset is divided in two time periods depending on the taxonomic resolution of the species recorded. For the period 1964-1981, separate NSSH statistics are available for 23 taxa (or groups of taxa), while for the years 1982 onwards catch statistics are available for 66 commercially important fish, cephalopod and crustacean taxa. Bivalve species were excluded from our analysis, as a large proportion of the reported values are derived from aquaculture. For a better evaluation of the data, Greek waters have been divided in 16 fishing subareas (Figure 1). Subareas 1 and 2 are outside Greek waters (Atlantic Ocean and North African Mediterranean coast, respectively).

For 1950-1963, Greek landings are available as a total (i.e., freshwater, coastal, Greek seas and overseas) but the percentage of the marine landings of Greek waters during that period was about 65% (Ananiades, 1968). Based on this percentage, we estimated the total Greek marine landings for 1950-1963, but no attempt was made to disaggregate to taxon level. For this period we consider the FAO landings and taxonomic resolution as the valid ones.

The Greek marine captured landings from 1950 to 2003, as reported by FAO, were accessed and downloaded from FAO FishStat (www.fao.org) for comparison.

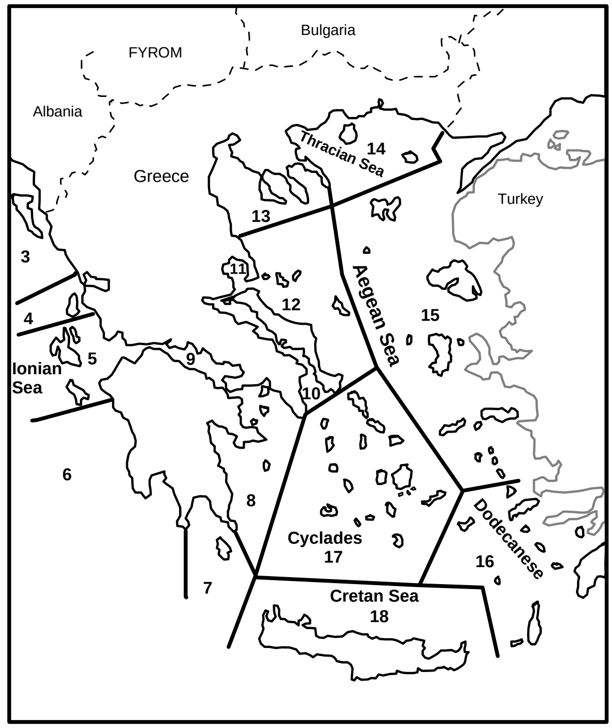

Figure 1. Map of the Greek seas showing the division to 16 fishing sub-areas. Subareas 1 and 2 are outside Greek waters (Atlantic Ocean and North African Mediterranean coast, respectively).

Taxonomic composition

We used the scientific names provided by FAO. The common names reported by the two datasets were kept as originally used. However, a recommended English common name, based on standardized common names as per FishBase (www.fishbase.org) will be suggested to the NSSH for future use.

Spatial and taxonomic disaggregation

Taxonomically highly aggregated landings statistics are problematic for various reasons, as they do not allow the best use of ancillary information, such as species distributions (Close *et al.*, 2006). A large proportion of Greek landings is reported as 'miscellaneous marine fishes' or 'marine fishes n.e.i.' (not elsewhere included), while further taxonomic aggregations exist at the genus and family level. The degree of taxonomic aggregation is not always the same between FAO and NSSH datasets. We tried to split the taxonomically aggregated landings to species level whenever possible. We did this for taxa that were reported by the NSSH as aggregated groups for the 1964-1981 period, but were reported as individual species for the 1982-2003 period, as follows: (a) we calculated the average contribution to the combined landings of each species during 1982-1990, for species that were reported aggregated during 1964-1981, and (b) we split the reported landings of the aggregated group during 1964-1981 using the average percentage per species derived from the 1982-1990 period. We used the average percentage for 1982-1990 as opposed to the 1982-2003 because the nature of Greek fisheries changed considerably after 1990 due to geographic expansion and modernization of the fleet (Anonymous, 2001).

Small-scale coastal fisheries landings

For 1969-2003, neither NSSH nor FAO include landings derived from rowing boats and coastal boats with engine power <19HP (henceforth called small-scale coastal boats). We collected these total landings data (no taxonomic composition data are available) for the period 1975-1999 from Agricultural Statistics of Greece (ASG, 1977-2000). We disaggregated these landings by taxon based on a recent technical report concerning the mean catch per unit of effort (CPUE) of all species caught by different small-scale gears (<10 m; longliners, netters, beach seiners, other gears) in Greek waters for 1996-2000 (Anonymous, 2001). The total small-scale coastal landings (ASG, 1977-2000) varied from a minimum of 16,701 t in 1979 to a maximum of 26,998 t in 1989. We fitted a linear trend to the 1975-1989 landings, and used this time trend to hindcast landings for the period 1970-1974. For the period 1964-1969 the NSSH total marine landings included those of the small coastal boats (possibly excluding rowing boats). However, the small-scale coastal boat landings as derived here are 2.45 times less than the estimate provided by the NSSH for the period 1995-2003 and 1.1 times less for the period 1975-1994 (see Data Sources). Thus, we multiplied the small-scale coastal boat landings (from ASG) by 2.45 for 1995-2003 and by 1.1. for 1975-1994 before adding these landings to the NSSH recorded figures. This analysis should be considered preliminary and will be refined should more sources and data become available to us.

Results and Discussion

Total landings

Total NSSH reported landings (i.e., fish, cephalopods and crustaceans) increased from 49,544 t in 1964 to 162,018 t in 1994, and subsequently declined to approximately 85,000 t in 2003 (Figure 2). This trend mirrors general global patterns (Watson and Pauly, 2001). Fish landings, which made up the main part of the total landings, increased exponentially from 47,000 t in 1964 to a peak of 150,000 t in 1994, followed by a sharp decline to 73,000 t in 2003 (Figure 3a). Crustacean landings (Figure 3b) varied around 1,100 t for the period 1964-1985 and increased to about 3,500 t during the remaining period. Cephalopod landings (Figure 3c) also varied around 2,000 t during 1964-1985, increased exponentially to a peak of about 8,000 t in 1995, and declined thereafter. While the distinct peak in 1994 (Figures 2, 3) may be attributable to an internal change in the NSSH data reporting system, it was not possible to verify this through other sources.

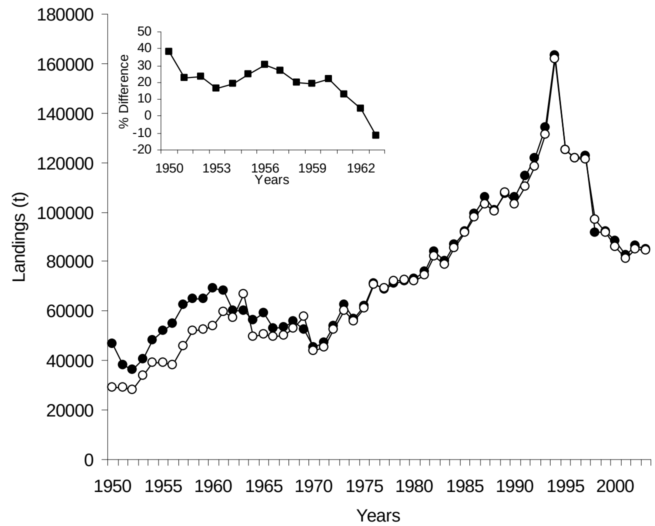

Figure 2. Total annual Greek landings of fishes, crustaceans and cephalopods as reported by the NSSH (open circles) and FAO (solid circles) for 1950-2003. The small insert shows the percentage by which FAO reported catches differ from the national ones during 1950-1963.

The total landings reported by FAO during 1964-2003 (solid circles, Figure 2) followed the same pattern and generally agreed with those of NSSH, implying a relatively good data transfer mechanism between the Greek national level and FAO. This is not true for the 1950-1962 period, when FAO reported higher catches than the national data agency (Figure 2). Thus, FAO reported catches were 5% to 38% higher than the national data, and the percentage difference declined over time (Figure 2 insert). Similarly, FAO landings for fish, crustaceans and cephalopods followed the same pattern and generally agreed with those of NSSH with the exception of cephalopods for 1964-1969 (Figure 3).

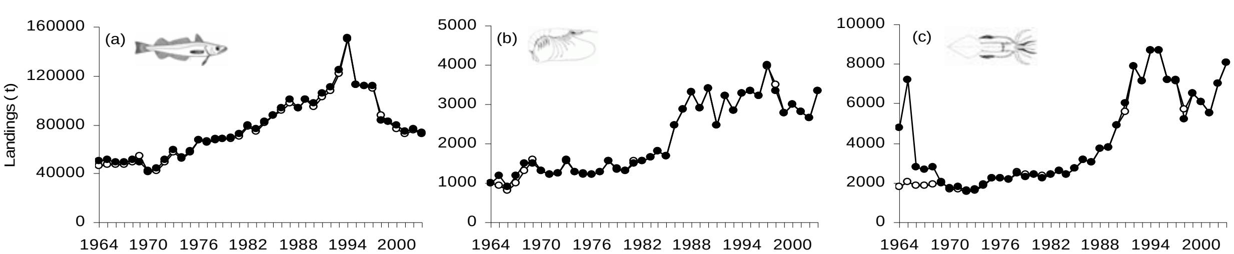

Figure 3. Annual Greek landings of (a) fishes, (b) crustaceans, and (c) cephalopods, as reported by the NSSH (open circles) and FAO (solid circles) for 1964-2003.

The small-scale coastal boat landings for 1975-1999 increased from 22,151 t in 1975 to a maximum of 26,998 t in 1989, thereafter declining to 22,356 t in 1999 (Figure 4). The trend for 1975-1989 was used for the hindcast estimation of landings for the period 1970-1974 (Figure 4). The original and reconstructed FAO and NSSH landings per taxon (1964-2003), as well as the suggested landings per taxon or groups of taxa, including the small-scale coastal boat component are available from the authors.

Overall, the reconstructed total NSSH landings (i.e., including rowing boats and boats with engines <19 HP) increased from 49,544 t in 1964 to 188,296 t in 1994, and subsequently declined to approximately 138,000 t in 2003 (Figure 5). NSSH landings are, as expected, higher than the FAO reported data (owing to the inclusion of the small-scale coastal landings in the NSSH dataset). We consider the NSSH reconstructed landings as the best estimate of total landings for the period 1970-2003, and the FAO data as the more accurate for the period 1950-1969.

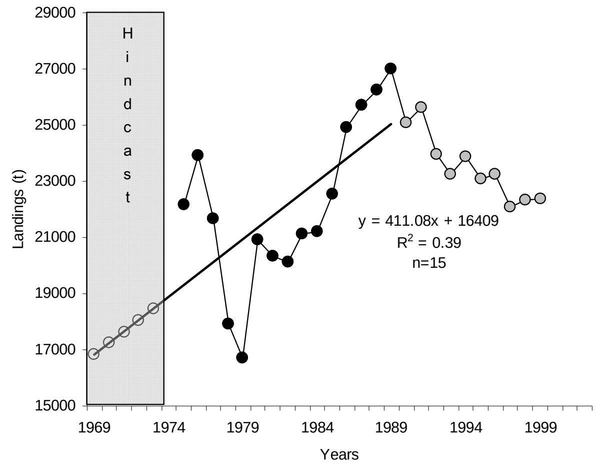

Figure 4. Annual Greek landings of small coastal boats. Data derived from the Agricultural Statistics of Greece yearly bulletins from 1975-1999.

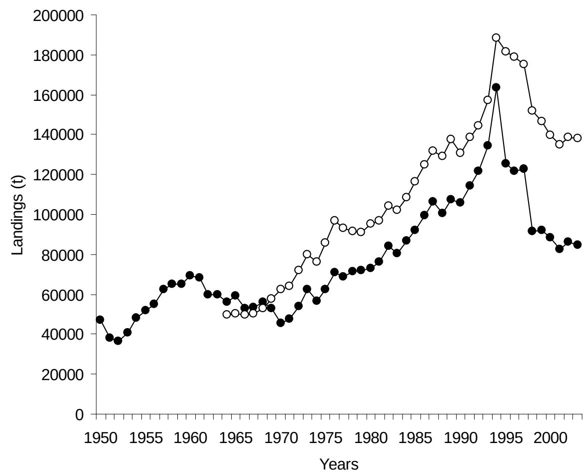

Figure 5. Reconstructed total annual Greek landings of fishes, crustaceans and cephalopods as reported by the NSSH including the small-scale coastal fisheries for 1964-2003 (open circles) and FAO reported landings (solid circles) for 1950-2003.

Taxonomic breakdown

For 1964-1981, NSSH reported groups of taxa that contained two or more species. Most of these individual species do not appear in FAO statistics, instead, FAO reported the entire catch for each group only under the first species of each group mentioned by NSSH. For example, the NSSH reported catches for *Boops boops* and *Sarpa salpa* as one group, while FAO reported the entire catch of this group as *B. boops* (Table 1). In contrast, in only one case does FAO provide landings for two species separately, which are reported as a combined group by NSSH: *Merluccius merluccius* and *Micromesistius poutassou*. We are unable to identify how FAO split the NSSH group catch into species specific data, since NSSH reported only one figure for both species' landings.

A detailed analysis and comparison for every taxon appearing in both datasets is presented in Appendix A1 (end of article), while an overview is given in Table 2. The final reconstructed landings per taxon (including our estimate per species for the small-scale coastal boats) for 1970-2003 are available from the authors.

Despite the common basis of the two datasets, some taxonomic differences were apparent. The greatest differences occurred for the large pelagic fish (swordfish and large scombroids), and larger differences were observed for demersal rather than small pelagic fish.

For the 1964-1969 period, the differences between the two datasets were most probably due to: (a) the fact that for that period the landings of the small-scale coastal boats were taken into account by the NSSH, (b) the different taxonomic aggregation (higher taxonomic resolution by FAO for that period), and (c) rounding effects. The differences between the two datasets were smoothed out since 1982, when the common taxonomic aggregation started, and for 1982-2003, there is a general agreement between the two datasets regarding each taxon landings. For that period, the problem is focused on the individual landings of 1997 and 1998, and large pelagic fish from 1990 onwards. Some individual cases are particularly interesting and mainly concern taxonomic (in terms of resolution and nomenclature) and aggregation discrepancies.

Table 1. Taxonomic grouping and corresponding taxa reported by FAO and NSSH for 1964-1981 and 1982-2003.

FAO	NSSH
1964-1981	
Boops boops	*Boops boops, Sarpa salpa*
Solea solea	*Solea solea, Psetta maxima*
Pagellus erythrinus	*Pagellus erythrinus, Dentex macrophthalmus*
Sarda sarda	*Sarda sarda, Katsuwonus pelamis*
Trachurus mediterraneus	*Trachurus mediterraneus, T. trachurus*
Scorpaenidae	Scorpaenidae, Triglidae, 'gurnards'
Dentex dentex	*Dentex dentex, Pagrus pagrus*
Serranidae	*Epinephelus marginatus, E. alexandrinus, Polyprion americanus*
Mullus spp.	*Mullus barbatus, M. surmuletus*
Merluccius merluccius	*Merluccius merluccius, Micromesistius poutassou*
Micromesistius poutassou	*Merluccius merluccius, Micromesistius poutassou*
1982-2003	
Spicara spp.	*Spicara flexuosa*
	Spicara maena
	Spicara smaris
Mullus spp.	*Mullus barbatus*
	Mullus surmuletus

The round sardinella (*Sardinella aurita*) is one of the most problematic cases in terms of taxonomy and nomenclature. The NSSH landings of *S. aurita* exactly match those of FAO for shads (*Alosa* spp.), the abundance of which is very low in Greek waters (Figure 6). The close taxonomic relationship of the two species suggests that the two datasets refer to the same species and we consider the species' name and the landings of NSSH to be the correct ones. The problem probably arises from the Greek common names of the two species that are often confused. The result is that the Greek fleet appears to have fished almost 2,000 t of shads (*Alosa* spp.) in 2000 instead of round sardinella which is the third most targeted clupeoid species in the Greek Seas, and is mainly caught by purse seiners (Tsikliras, 2004). The twaite shad (*Alosa fallax*) is the only commercially exploited shad species in the Greek Seas, but very low quantities are landed (Anonymous, 2001). Its exploitation is seasonal, confined to spring/early summer, and is performed by the small scale coastal fleet whose landings are not taxonomically disaggregated. Thus, this record clearly refers to *S. aurita*.

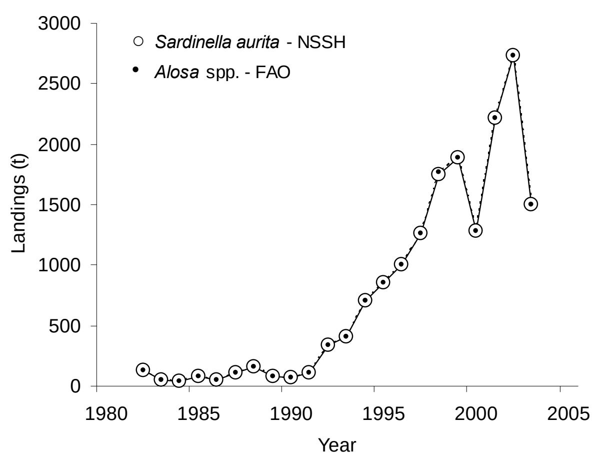

Figure 6. Annual Greek landings of round sardinella (*Sardinella aurita*) as reported by NSSH (open circles), and shads (*Alosa* spp.) as reported by FAO (solid circles) from 1982-2003.

Similarly, there is a peculiarity regarding FAO landings of common grey-mullet (*Mugil cephalus*), which include the catches of all seven mugilid species (*M. cephalus*, *M. soiuy*, *Chelon labrosus*, *Liza aurata*, *L. ramada*, *L. saliens* and *Odeachilus labeo*) inhabiting the Greek Seas. It is difficult for the fishers to distinguish these species - and pointless, as all of them have the same market value. The contribution of each of the seven species to the total landings is impossible to estimate. Thus, fishers usually report all of these species as grey mullets. Hence, FAO's *M. cephalus* refers to all mugilid species, i.e., the NSSH Mugilidae ('common grey mullet') landings.

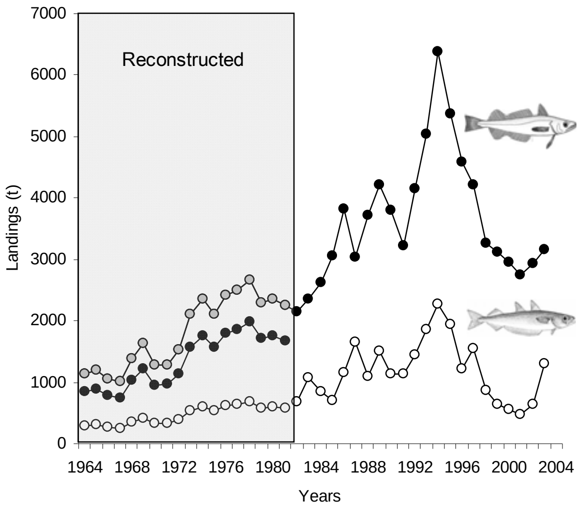

Figure 7. Annual Greek landings of European hake (*Merluccius merluccius*, solid circles) and whiting (*Micromesistius poutassou*, open circles) as recorded by NSSH during 1982-2003, and their backward reconstructed values for 1964-1981 (shaded area) based on their reported combined landings for the same period (grey circles).

A case of different taxonomic resolution between datasets is that of the three species of the genus *Spicara* (*S. smaris*, *S. maena* and *S. flexuosa*). FAO records *Spicara* spp., while NSSH records separate landings for each species. For 1982-2003, the sum of the NSSH landings of the three species exactly matches the FAO landings for *Spicara* spp., and we consider the taxonomic resolution of NSSH the correct ones.

The European hake (*Merluccius merluccius*) is recorded by NSSH since 1982 and by FAO since 1964. For 1964-1981, NSSH landings were aggregated and recorded together with those of blue whiting (*Micromesistius poutassou*) and possibly with those of whiting (*Merlangius merlangus*), which appears separately since 1982 but it does not appear as part of any group in 1964-1981. This NSSH grouping might also include small quantities of the poor cod (*Trisopterus minutus capelanus*). For 1982-2003, landings completely match between the two datasets except for 1997 and 1998. We split the NSSH *M. merluccius* landings for 1964-1981 to landings for each species (*M. merluccius* and *M. poutassou*) based on the average participation of these two species in the total *M. merluccius* and *M. poutassou* NSSH landings during 1982-1990 (Figure 7). We consider these NSSH backwards estimated values as the valid ones.

The large pelagic fishes (Scombridae and Xiphiidae) were the main source of discrepancy between the two datasets. The Atlantic bonito (*Sarda sarda*) is recorded separately by NSSH since 1982, whereas FAO reports it separately since 1964. For 1964-1981 it is recorded by NSSH together with the skipjack tuna (*Katsuwonus pelamis*). For the period 1982-2003, the landings of *S. sarda* agree between the two datasets from 1982 to 1989 and from 1994 to 1997 (Figure 8). For the remaining years, FAO landings are higher. For the period 1964-1981, we split the NSSH *K. pelamis* and *S. sarda* combined landings into landings for each species based on the average contribution of each species to the total combined NSSH landings during 1982-1990. We consider these NSSH backwards estimated values as the valid ones.

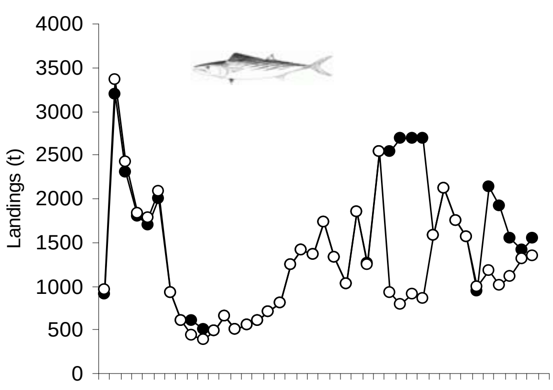

Figure 8. Annual Greek landings of the Atlantic bonito (*Sarda sarda*) as reported by FAO (solid circles) and NSSH (open circles) for 1964-2003.

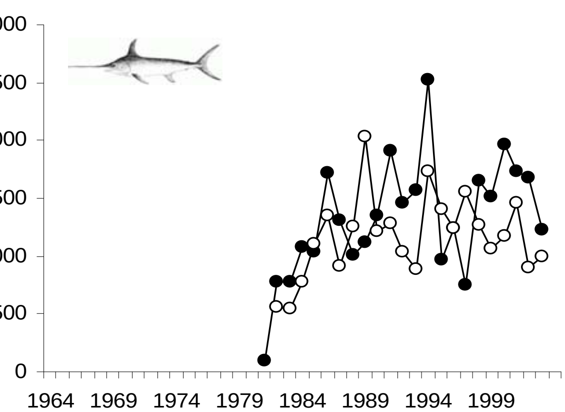

Figure 9. Annual Greek landings of swordfish (*Xiphias gladius*) as reported by FAO (solid circles) for 1981-2003 and by NSSH (open circles) for 1982-2003.

Table 2. FAO scientific and common names, NSSH greek and english common names, dates from which taxa start to be reported by each source, and our suggested scientific name of taxa based on the analysis presented in this report.

	Scientific name	Common english name as reported by FAO	Common english name as reported by NSSH	Greek name	Reported since FAO	Reported since NSSH	Suggested	Reconstructed
1	*Alosa* spp.	Shads nei			1982		*Sardinella aurita*	1982-2003
2	*Anguilla anguilla*	European eel	Eel	Χέλια	1982	1982	*Anguilla anguilla*	
3	*Auxis rochei, A. thazzard*	Frigate Bullet tunas			1981		*Auxis rochei, A. thazzard*	
4	*Belone belone*	Garfish	Garfish	Ζαργάνες	1964-1969, 1982	1982	*Belone belone*	
5	*Boops boops*	Bogue	Bogue	Γόπες	1964	1982*	*Boops boops*	1964-1981
6	-	-	Gurnard	Βραστόψαρα		1982	Marine fishes nei	1964-1981
7	*Conger conger*	European conger			1994		Marine fishes nei	
8	*Dentex dentex*	Common dentex	Dog's teeth	Συναγρίδες	1964	1982*	*Dentex dentex*	1964-1981
9	*Dentex macrophthalmus*	Large-eye dentex	Large eyed dog's teeth	Μπαλάδες	1982	1982*	*Dentex macrophthalmus*	1964-1981
10	*Dicentrarchus labrax*	European seabass	Bass	Λαβράκια	1964-1969, 1982	1982	*Dicentrarchus labrax*	
11	*Diplodus annularis*		Couch's seabream	Σπάροι		1982	*Diplodus annularis*	1982-2003
12	*Diplodus sargus sargus*	White seabream	White bream	Σαργοί	1982	1982	*Diplodus sargus sargus*	
13	*Engraulis encrasicolus*	European anchovy	Anchovy	Γαύροι	1964	1964	*Engraulis encrasicolus*	
14	*Epinephelus marginatus*	Dusky grouper	Grouper	Ροφοί	1985	1982*	*Epinephelus marginatus*	1964-1981
15	*Epinephelus* spp.	Groupers nei			1964			
16	*Epinephelus alexandrinus*		Dusky sea perch	Σφυρίδες		1982*	*Epinephelus alexandrinus*	1964-1981
17	*Euthynnus alletteratus*	Little tunny (=Atl black Skipj)			2002			
18	*Helicolenus dactylopterus*		Snapper	Κοκκινόψαρα		1982		
19	*Katsowonus pelamis*	Skipjack tuna	Skipjack	Ρίκια	2003	1982*	*Katsowonus pelamis*	1964-1981
20	*Lophius piscatorius*	Angler (=monk)			1982		*Lophius* spp.	
21	*Lophius* spp.		Anglerfish	Πεσκανδρίτσες		1982	*Lophius* spp.	
22	*Merlangius merlangus*	Whiting	Daouki	Νταούκια	2002	1982	*Merlangius merlangus*	
23	*Merluccius merluccius*	European hake	Hake	Βακαλάοι	1964	1982*	*Merluccius merluccius*	1964-1981
24	*Micromesistius poutassou*	Blue whiting (=Poutassou)	Couch's whiting	Προσφυγάκια	1964	1982*	*Micromesistius poutassou*	1964-1981
25	*Mugil cephalus*	Flathead greymullet			1964		Mugilidae	
26	Mugilidae		Common grey mullet	Κέφαλοι		1964	Mugilidae	
27	*Mullus barbatus*		Goatfish	Κουτσομούρες		1982*	*Mullus barbatus*	1964-1981
28	*Mullus surmuletus*	Surmulet	Red mullet	Μπαρμπούνια	1982	1982*	*Mullus surmuletus*	1964-1981
29	*Mullus* spp.	Surmulets (=Red mullets) nei			1964	1964-1981	*Mullus barbatus*	
30	*Mustelus* spp.	Smooth hounds nei	Blackmouthed godfish	Γαλέοι	1982	1982	*Mustelus* spp.	
31	*Oblada melanura*	Saddled seabream	Blackbream	Μελανούρια	1982	1982	*Oblada melanura*	
32	Osteichthyes	Marine fishes nei	Others	Διάφορα ψάρια	1964	1964	Osteichthyes	
33	*Pagellus erythrinus*		Redbream	Λιθρίνια		1982*	*Pagellus erythrinus*	1964-1981
34	*Pagellus* spp.	Pandoras nei			1964		*Pagellus erythrinus*	
35	*Pagrus pagrus*	Red porgy	Common sea bream	Φαγγριά	1982	1982*	*Pagrus pagrus*	1964-1981
36	*Pagrus* spp.	Pargo breams nei			1964		*Diplodus annularis*	
37	*Polyprion americanus*		Stone bass	Βλάχοι		1982*	*Polyprion americanus*	1964-1981
38	*Pomatomus saltatrix*	Bluefish	Bluefish	Γοφάρια	1966-1969, 1982	1982	*Pomatomus saltatrix*	
39	*Psetta maxima*	Turbot	Brill	Καλκάνια	1982	1982*	*Psetta maxima*	1964-1981
40	*Raja clavata*	Thornback ray	Thornback ray	Βάτοι	2003	1982	*Raja clavata*	
41	*Raja* spp.	Raja rays nei	Rassa	Ράσσες	1964-1969, 1982	1982	*Raja* spp.	
42	Rhinobatidae	Guitarfishes etc nei	Guitarfish	Ρινόβατοι	1982	1982	Rhinobatidae	
43	*Sarda sarda*	Atlantic bonito	Bonito	Παλαμίδες	1964	1982*	*Sarda sarda*	1964-1981
44	*Sardina pilchardus*	European pilchard (=Sardine)	Pilchard	Σαρδέλες	1964	1964	*Sardina pilchardus*	
45	*Sardinella aurita*		Gilt sardine	Φρίσσες		1982	*Sardinella aurita*	
46	*Sarpa salpa*	Salema	Goldline	Σάλπες	1982	1982*	*Sarpa salpa*	1964-1981
47	*Scomber japonicus*	Chub mackerel	Chub mackerel	Κολιοί	1964	1964	*Scomber japonicus*	
48	*Scomber scombrus*	Atlantic mackerel	Mackerel	Σκουμπριά	1964-1969, 1982	1982	*Scomber scombrus*	
49	Scombroidei	Tuna-like fishes nei			1982			
50	Scorpaenidae	Scorpionfishes nei	Scorpion fish	Σκορπιοί	1964	1964	Scorpaenidae	1964-1981
51	*Seriola dumerili*	Greater amberjack	Yellowtail	Μαγιάτικα	1982	1982	*Seriola dumerili*	
52	*Serranus* spp.		Comber	Χάνοι		1982	*Serranus* spp.	
53	Serranidae	Groupers, seabasses nei			1964	1964-1981		
54	*Solea solea*	Common sole	Sole	Γλώσσες	1964	1982*	*Solea solea*	
55	*Sparus aurata*	Gilthead seabream	Red sea bream	Τσιπούρες	1964-1969, 1982	1982	*Sparus aurata*	
56	*Spicara flexuosa*		Blotched pickerel	Τσέρουλες		1982*	*Spicara flexuosa*	1964-1981
57	*Spicara maena*		Blotched pickerel	Μένουλες		1982*	*Spicara maena*	1964-1981
58	*Spicara smaris*		Pickerel	Μαρίδες		1982*	*Spicara smaris*	1964-1981
59	*Spicara* spp.	Picarels nei			1964	1964-1981		
60	*Spondyliosoma cantharus*	Black seabream	Black seabream	Σκαθάρια	1964	1964	*Spondyliosoma cantharus*	
61	*Sprattus sprattus*	European sprat	Sprat	Παπαλίνες	1982	1982	*Sprattus sprattus*	
62	Squalidae	Dogfish sharks nei	Dogfish	Σκυλόψαρα	1964-1969, 1982	1982	Squalidae	
63	*Thunnus alalunga*	Albacore			1986			
64	*Thunnus thynnus*	Atlantic bluefin tuna			1964-1969, 1985			
65	*Trachurus mediterraneus*	Mediterranean horse mackerel	Horse mackerel	Σαυρίδια	1964	1982	*Trachurus mediterraneus*	1964-1981
66	*Trachurus trachurus*	Atlantic horse mackerel	Jack mackerel	Σαμπανοί	1982	1982	*Trachurus trachurus*	1964-1981
67	*Trachurus* spp.					1964-1981		
68	Triglidae	Gurnards, searobins nei	Tubfish	Καπόνια	1982	1982*	Triglidae	1964-1981
69	*Umbrina cirrosa*	Shi drum	Croaker	Μυλοκόπια	1964-1969, 1982	1982	*Umbrina cirrosa*	
70	*Xiphias gladius*	Swordfish	Swordfish	Ξιφίες	1981	1982	*Xiphias gladius*	
71	*Zeus faber*	John dory	John dory	Χριστόψαρα	1982	1982	*Zeus faber*	
72	-	-	Tune fish	Τόννοι		1982		
	Cephalopods							
73	Loliginidae, Ommastrepidae	Various squids nei	Flying squid	Θράψαλα	1970	1964	Loliginidae, Ommastrepidae	
74	*Loligo* spp.	Common squids nei	Common squid	Καλαμάρια	1972	1964	*Loligo* spp.	
75	Octopodidae	Octopuses etc nei	Poulp	Μοσκιοί	1970	1982	Octopodidae	
76	*Sepia officinalis*	Common cuttlefish	Cuttle fish	Σουπιές	1964	1964	*Sepia officinalis*	
77	*Octopus vulgaris*	Common octopus	Octapus	Χταπόδια	1982	1964	*Octopus vulgaris*	
	Crustacueans							
78	*Hommarus gammarus*	European lobster	Lobster	Αστακοί	1982	1982		
79	*Penaeus kerathurus*	Caramote prawn	Common prawn	Γαρίδες (γάμπαρη)	1982	1964	*Penaeus kerathurus*	
80	Natantia	Natantian decapods nei	Shrimp(common)	Γαρίδες (λοιπές)	1964	1982		
81	*Carcinus aestuarii*	Mediterranean shore crab	Crab	Καβούρια	1982	1982		
82	*Nephrops norvegicus*	Norway lobster	Crayfish	Καραβίδες	1964	1982	*Nephrops norvegicus*	
83	-	-	other crustacean	Διάφορα καρκινοειδή		1964-1981		

* See also Table 1

The northern bluefin tuna (*Thunnus thynnus*) is recorded by FAO for 1964-1969 and then again since 1985. It has never been separately recorded by NSSH. As for most scombroids (except *S. sarda* and *K. pelamis*) we consider the FAO landings as the likely correct ones, as they are derived from a different and supposedly reliable source, i.e., the International Commission for the Conservation of Atlantic Tuna (ICCAT). Similarly, the swordfish (*Xiphias gladius*) is recorded by FAO since 1981 and by NSSH since 1982. In general, FAO *X. gladius* landings are higher (differences reach up to 787 t in 2000) indicating the difference in data sources. No difference was observed only in 1996 (Figure 9). As with the other large pelagic taxa, such as the tunas and tuna-like fishes, FAO's source of data for the landings of *X. gladius* is not the NSSH, but ICCAT.

Despite the common basis of the two datasets, the biggest differences seem to relate to the large pelagic fish (Figure 10). Indeed, the landings of the five large scombroid taxa (i.e., tunas, albacore, bonito, swordfish) are the main source of difference for the 1982-2003 period (Figures 8, 9, 10). This discrepancy first appeared in 1990. As mentioned above, the discrepancy arises from the fact that, at least for *Thunnus thynnus*, *T. alalunga* and *Xiphias gladius*, FAO landings are derived via ICCAT. It seems that the national authorities may mask the landings of these species by including part of the landings in 'others' (i.e., marine fishes n.e.i.) and by reporting about half of the likely true landings. Indeed, total FAO landings for large pelagic fish were 1.5-2 times higher than those reported by the NSSH for 1990-2000, except for 1998 (Figure 10). Thus, we consider the FAO reported landings for *T. thynnus*, *T. alalunga Euthynnus alletteratus* and *X. gladius* as the likely more correct data (see Appendix 1), while the NSSH landings are valid only for *Sarda sarda* and *Katsuwonus pelamis*.

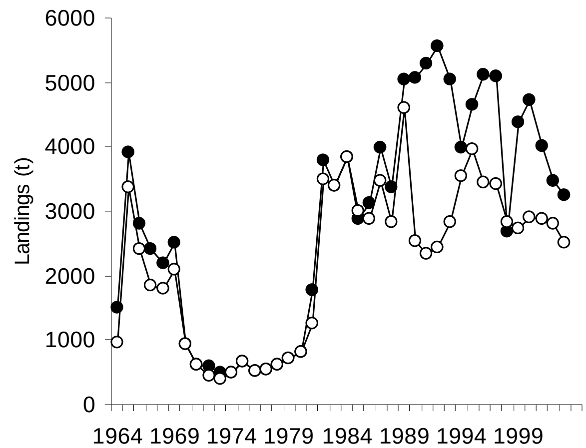

Figure 10. Annual Greek landings of all tuna and tuna like fishes (*Thunnus thynnus*, *T. alalunga* and *Euthynnus alletteratus*) combined (but excluding *Katsuwonus pelamis* and *Sarda sarda*) as reported by FAO (solid circles) and NSSH (open circles) from 1964-2003.

The years 1997 and 1998 were the most problematic in terms of comparing individual taxa as almost none agreed between the two datasets. In 1997, the majority of the FAO landings were slightly greater than the equivalent NSSH data, while in 1998, almost all individual FAO records were 10-15% lower than those of the NSSH. The 1997 discrepancy can be explained by a correction that was applied on the number of boats appearing in the statistical bulletin of the NSSH a year later. The Greek 1997 landings were probably corrected only in the NSSH bulletin but not in the FAO yearbook.

Our reconstructed estimates will be useful for re-evaluating the state of Greek fisheries and data reporting. The reconstruction of Greek landings is a dynamic process which will be continued in the future.

Acknowledgements

The authors would like to thank D. Zeller for his useful criticism and constructive comments on the content and structure of the report and the methodology of the analysis, and D. Pauly for his inspiration for undertaking this task.

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APPENDIX

Taxonomic comparison between data sources

Fishes

Alosa spp.: It is reported only by FAO since 1982. It is one of the most problematic cases in terms of taxonomy. The FAO landings for *Alosa* spp., the abundance of which is very low in Greek waters, exactly match those of NSSH for *Sardinella aurita* (except for 1997 when FAO landings are overreported by 5 t and for 1998 when FAO landings are underreported by 25 t). The close taxonomic relationship of the two species and the match of the reported figures suggest that the two datasets refer to the same species. **We consider the NSSH species' name and the landings to be the valid ones, i.e., the FAO landings for *Alosa* spp. refer to *S. aurita*.**

Anguilla anguilla: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 6 t. **We consider the NSSH landings as the valid ones.**

Auxis rochei, A. thazzard: The landings of these species are reported as a group only by FAO since 1981. These species have never been reported by the NSSH. For 1983-1984 the FAO *Auxis rochei, A. thazzard* landings exactly match those of the NSSH for 'tune-like fishes'. **Although the FAO landings are constant and mysteriously rounded to 1400 t for 1985-1997, we consider those as the valid ones**.

Belone belone: It is reported by NSSH since 1982, whereas by FAO it is also reported for 1964-1969 (being constant and rounded to either 100 or 200 t) and then again from 1982. Landings completely match between the two datasets for all years except for 1997 and 1998 (i.e., FAO landings are over-reported in 1997 by 3 t and underreported in 1998 by 19 t). **We consider the NSSH landings as the valid ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Boops boops: It is reported by FAO since 1964 and by NSSH since 1982. FAO landings for 1964-1969 are rounded between 2600 and 3600 t. NSSH landings for 1964-1981 are reported together with *Sarpa salpa* and, during this period, landings generally agree between the two datasets but do not completely match (maximum difference recorded in 1969: FAO landings are underreported by 488 t). From 1970 onwards, the two datasets generally agree with only small differences, except for 1971 (FAO landings are overreported by 211 t). Since 1982, the two datasets completely agree with two exceptions: FAO landings are overreported in 1998 by 227 t and underreported in 1997 by 28 t. We split the NSSH *B. boops* landings for 1964-1981 to landings for each species (*B. boops* and *S. salpa*) based on the average participation of these two species to the total *B. boops* and *S. salpa* NSSH landings during 1982-1990 (see also entry for *S. salpa*). **We consider these backwards estimated NSSH landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Conger conger: It is reported by FAO since 1994 and has never been reported by the NSSH. FAO landings perfectly match those of the NSSH for 'gurnard' (see entry for Gurnard). Despite the taxonomic distance, we assume that both datasets refer to the same species, which is not *C. conger*. **We consider adding those to 'marine fishes nei'.**

Gurnard: It is reported by NSSH since 1982 and has never been reported by FAO. The NSSH landings refer to scorpaenid, triglid, serranid species (it may also include other species of low commercial interest) added together. NSSH landings for 1964-1981 are reported together with Scorpaenidae ('scorpion fishes') and Triglidae ('tubfish'). For 1982-1993 the sum of 'gurnard' and Triglidae of NSSH make up the exact value of FAO's Triglidae ('gurnards, searobins nei'). We split the NSSH Scorpaenidae landings for 1964-1981 to landings for each species (Scorpaenidae, Triglidae and 'gurnards') based on the average participation of these three species to the total Scorpaenidae, Triglidae and 'gurnards' NSSH landings during 1982-1990 (see also entry for Scorpaenidae and Triglidae). **We consider these backwards estimated landings as the valid ones and that the NSSH 'gurnards' landings should be added to the marine fishes nei because they refer to more than three species many of which may not be gurnards.**

Dentex dentex: It is separately reported by NSSH since 1982 and by FAO since 1964. FAO landings for 1964-1969 are rounded to 400, 600 or 700 t. For 1964-1981, NSSH landings are reported together with *Pagrus pagrus*. FAO landings are slightly overreported for the period 1964-1976 (differences range between 3 and 179 t), except for 1969 when FAO landings are underreported by 192 t. For the 1982-2003 period, the FAO and NSSH landings match except for 1998 (i.e., FAO landings are underreported by 23 t). We split the NSSH *D. dentex* landings for 1964-1981 to landings for each species (*D. dentex* and *P. pagrus*) based on the average participation of these two species to the total *D. dentex* and *P. pagrus* NSSH landings during 1982-1990 (see also entry for *P. pagrus*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Dentex macrophthalmus: It is reported by NSSH (and FAO) since 1982. For 1964-1981, NSSH landings are reported together with *Pagellus erythrinus*. No differences exist between the two datasets for the 1982-2002 period, with two exceptions: FAO landings are overreported in 1997 by 7 t and underreported in 1998 by 82 t. We split the NSSH *P. erythrinus* landings for 1964-1981 to landings for each species (*D. macrophthalmus* and *P. erythrinus*) based on the average participation of these two species to the total *D. macrophthalmus* and *P. erythrinus* NSSH landings during 1982-1990 (see also entry for *P. erythrinus*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Dicentrarchus labrax: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1964-1969 (being constant and rounded to either 400 or 500 t) and then again for 1982. FAO landings are overreported in 1997 by 3 t and underreported in 1982, 1983 and 1998 by 11, 20 and 40 t respectively. Otherwise the two datasets completely match for 1982-2003. **We consider the NSSH landings as the valid ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Diplodus annularis: It is reported by NSSH since 1982. It has never been reported by FAO. However, for 1982-2003, the NSSH landings of *D. annularis* match those of FAO for *Pagrus* spp., which are recorded since 1964. We consider the FAO landings for *Pagrus* spp. are misreported and refer to *D. annularis*. In this case, In this case, the problem probably arises from the English common name of *D. annularis* ('couch's seabream') which is used by the NSSH. FAO landings are overreported in 1995 by 2 t and in 1997 by 3 t and underreported in 1998 by 47 t. **We consider the NSSH taxonomy and landings as the valid ones, i.e., the FAO landings for *Pagrus* spp. refer to *D. annularis*.**

Diplodus sargus: It is reported by the NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1997 and 1998 (i.e. FAO landings are over-reported in 1997 by 3 t and underreported in 1998 by 45 t). **We consider the NSSH landings as the valid ones.**

Engraulis encrasicolus: It is reported by NSSH (and FAO) since 1964. Slight differences are observed for the 1964-1969 period when FAO landings are rounded between 4300 and 7300 t. FAO landings are overreported in 1964 by 614 t, in 1965 by 112 t, in 1967 by 38 t, and in 1968 by 71 t, and underreported in 1966 by 53 t, in 1969 by 535 t, and in 1998 by 432 t. As the *E. encrasicolus* is the species with the highest landings in the Greek Seas, which may exceed 24 000 t per year (1987), the above differences are insignificant. **We consider the NSSH landings as the valid ones.**

Epinephelus marginatus: It is reported by NSSH since 1982 and by FAO since 1985. For 1964-1981, NSSH *E. marginatus* landings are reported together with *Epinephelus alexandrinus* and *Polyprion americanus* as Serranidae. The close taxonomic relationship and the summation of the landings of *E. marginatus* with those of *Epinephelus* spp. indicate that for the years 1982, 1983 and 1984, the FAO landings of the latter species included those of the former. After their separation, in 1985, the FAO landings of *E. marginatus* are underreported only in 1998 by 10 t. We split the NSSH Serranidae landings for 1964-1981 to landings for each species (*E. marginatus*, *E. alexandrinus* and *P. americanus*) based on the average participation of these three species to the total *E. marginatus*, *E. alexandrinus* and *P. americanu* (=Serranidae) NSSH landings during 1982-1990 (see also entries for *E. alexandrinus* and *P. americanus*). **We consider these backwards NSSH estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Epinephelus spp: It is reported by FAO since 1964 and has never been reported by NSSH. FAO landings for 1964-1969 are constant and rounded to 300, 500, 600 or 1000 t. For 1982-1984, the *Epinephelus* spp. landings include those of *E. marginatus* (see entry for *E. marginatus*). Since 1985, the FAO landings for *Epinephelus* spp. are recorded separately and completely match those of NSSH for *Epinephelus alexandrinus* except for 1998 (i.e., FAO are underreported by 5 t). **Thus, we consider that the FAO *Epinephelus* spp. refers to the NSSH *E. alexandrinus*.**

Epinephelus alexandrinus: It is reported by NSSH since 1982 and has never been reported by FAO. For 1964-1981, NSSH *E. alexandrinus* landings are reported together with *Epinephelus marginatus* and *Polyprion americanus* as Serranidae. For 1985-2003, the NSSH landings for *E. alexandrinus* completely match those of FAO for *Epinephelus* spp. except for 1998 (i.e., FAO are underreported by 5 t). Thus, we consider that the NSSH *E. alexandrinus* refers to the FAO *Epinephelus* spp. We split the NSSH Serranidae landings for 1964-1981 to landings for each species (*E. marginatus*, *E. alexandrinus* and *P. americanus*) based on the average participation of these three species to the total *E. marginatus*, *E. alexandrinus* and *P. americanus* (=Serranidae) NSSH landings during 1982-1990 (see also entries for *E. marginatus* and *P. americanus*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Euthynnus alletteratus: It is reported by FAO since 2002 and has never been reported by NSSH. **We consider the FAO landings as the valid ones.**

Helicolenus dactylopterus: It is reported by NSSH since 1982 and has never been reported by FAO. Between 1982 and 1994, the 'various fishes' plus *Merlangius merlangus* and *Helicolenus dactylopterus* of NSSH equal the 'marine fishes nei' of FAO, except for 1986 (FAO higher by 37 t). **We consider the NSSH landings as the valid ones.**

Katsuwonus pelamis: It is reported by NSSH since 1982 and by FAO since 2003. NSSH landings for 1964-1981 are reported together with *Sarda sarda*. The NSSH landings of *K. pelamis* match those of FAO for Scombroidei ('Tuna-like fishes nei') for the period 1982-1989. Due to the close taxonomic relationship and the perfect match of the landings we assume that 'Scombroidei' refers to *K. pelamis*, at least for the period 1982-1989. We split the NSSH *K. pelamis* and *S. sarda* combined landings for 1964-1981 to landings for each species (*K. pelamis* and *S. sarda*) based on the average participation of these two species to the total *K. pelamis* and *S. sarda* NSSH landings during 1982-1990 (see also entry for *S. sarda*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Lophius piscatorius: It is reported by FAO since 1982 and has never been reported by NSSH. We consider that the FAO landings for *L. piscatorius* also include those of the other anglerfish inhabiting Greek waters, *L. budegassa* (see entry for *Lophius* spp.). **Thus, we consider that the valid name is *Lophius* spp. and that the NSSH landings are the correct ones.**

Lophius spp.: It is reported by NSSH since 1982 and has never been reported by FAO. The NSSH landings refer to the combined landings of *Lophius piscatorius* and *L. budegassa*, which are not sold separately in the Greek fish markets. No differences exist between the NSSH landings for *Lophius* spp. and the FAO landings for *L. piscatorius* for the period 1982-2003, with two exceptions: FAO landings are over-reported in 1997 by 18 t and underreported in 1998 by 27 t. **Despite the lower taxonomic resolution, we consider the species grouping of NSSH as the valid one (see entry for *L. piscatorius*).**

Merlangius merlangus: It is reported by NSSH since 1982 and by FAO since 2002. Between 1982 and 1994, the 'various fishes' plus *M. merlangus* and *Helicolenus dactylopterus* of NSSH equal the 'marine fishes nei' of FAO, except for 1986 (FAO higher by 37 t). **We consider the NSSH landings as the valid ones.**

Merluccius merluccius: It is reported by NSSH since 1982 and by FAO since 1964. FAO landings for 1964-1969 are rounded between 700 and 1400 t. For 1964-1981, NSSH landings were reported together with *Micromesistius poutassou* and possibly with *Merlangius merlangus* (which appears separately since 1982 but it does not appear as part of any group in 1964-1981) or small quantities of *Trisopterus minutus capelanus* (which never appear after 1981). Hence, for 1964-1981, NSSH landings are overreported and the difference refers to the landings of *M. poutassou*. For the period 1982-2003, landings completely match between the two datasets except for 1997 and 1998 (i.e. FAO landings are over-reported in 1997 by 30 t and underreported in 1998 by 226 t). We split the NSSH *M. merluccius* landings for 1964-1981 to landings for each species (*M. merluccius* and *M. poutassou*) based on the average participation of these two species to the total *M. merluccius* and *M. poutassou* NSSH landings during 1982-1990 (see entry for *M. poutassou*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Micromesistius poutassou: It is reported by NSSH since 1982 and by FAO since 1964. FAO landings for 1964-1969 are rounded between 200 and 400 t. For 1964-1981, NSSH landings were reported together with *Merluccius merluccius* and possibly with *Merlangius merlangus* (which appears separately since 1982) or small quantities of *Trisopterus minutus capelanus* (which never appear after 1981). Hence, for 1964-1981, the FAO landings of *M. poutassou* equal the difference of the NSSH and FAO landings for *M. merluccius*. For 1982-2003, landings completely match between the two datasets except for 1997 and 1998 (i.e., FAO landings are over-reported in 1997 by 12 t and underreported in 1998 by 16 t). We split the NSSH *M. merluccius* landings for 1964-1981 to landings for each species (*M. merluccius* and *M. poutassou*) based on the average participation of these two species to the total *M. merluccius* and *M. poutassou* NSSH landings during 1982-1990 (see entry for *M. merluccius*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Mugil cephalus: It is reported by FAO since 1964 and has never been reported by NSSH. FAO landings for 1964-1969 are rounded between 800 and 1200 t. There is a peculiarity regarding this species since the FAO landings most probably include the catches of all seven mugilid species (*M. cephalus*, *M. soiuy, Chelon labrosus*, *Liza aurata*, *L. ramada*, *L. saliens* and *Odeachilus labeo*) inhabiting Greek seas. It is difficult for the fishers to distinguish these species - and pointless, as all of them have quite the same market value. The contribution of each of the seven species to the total production is impossible to be estimated. Thus, fishers usually report all of these species as grey-mullets. Hence, the *M. cephalus* FAO landings refer to all mugilid species i.e. the NSSH Mugilidae ('common grey mullet') landings (see entry for Mugilidae). When compared to the NSSH Mugilidae landings, the FAO *M. cephalus* landings are overreported for the period 1964-1968 by about 150 t each year, in 1978, 1979 and 1981 by *ca.* 200 t and in 1997 by 19 t. FAO landings are underreported only in 1998 by 290 t. **We consider the NSSH taxonomic level as the valid one, i.e., FAO *Mugil cephalus* refers to NSSH Mugilidae.**

Mugilidae: It is reported by NSSH since 1964 and has never been reported by FAO. The landings include the catches of all seven mugilid species inhabiting Greek Seas (see entry for *Mugil cephalus*). Because of the close taxonomic relationship and the similarity of the landing figures, the NSSH Mugilidae landings refer to the FAO landings for *M. cephalus*. **Despite the lower taxonomic resolution, we consider the NSSH landings as the valid ones.**

Mullus barbatus: It is reported separately by NSSH since 1982 and together with *M. surmuletus* for 1964-1981. It is not reported by FAO. Since there is no other *Mullus* species in Greek waters and because of the close taxonomic relationship we conclude that these figures refer to the FAO landings for *Mullus* spp. For 1982 and 1983, the reported landings of NSSH for *M. barbatus* match those of FAO for *M. surmuletus* and the reported landings of NSSH for *M. surmuletus* match those of FAO for *Mullus spp*. In 1984, FAO reported only *M. surmuletus* but the landings referred to the added landings of *M. barbatus* and *M. surmuletus* as reported by the NSSH. As from 1985, these species have been reported separately and correctly (following the NSSH landings) regarding the common and scientific names. For the period 1985-2003, landings completely match between the two datasets except for 1997 and 1998 (i.e. FAO landings are over-reported in 1997 by 32 t and underreported in 1998 by 73 t). We split the NSSH *Mullus barbatus* and *M. surmuletus* landings for 1964-1981 to landings for each species (*M. barbatus* and *M. surmuletus*) based on the average participation of these two species to the total *Mullus barbatus* and *M. surmuletus* NSSH landings during 1982-1990 (see also entry for *M. surmuletus*). **We consider these backwards NSSH estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Mullus surmuletus: It is reported separately by NSSH since 1982 and together with *M. barbatus* for 1964-1981. It is reported by FAO since 1982 and together with *Mullus* spp. for 1964-1981. For 1982 and 1983, the reported landings of NSSH for *M. barbatus* match those of FAO for *M. surmuletus* and the reported landings of NSSH for *M. surmuletus* match those of FAO for *Mullus spp*. In 1984, FAO reported only *M. surmuletus* but the landings referred to the added landings of *M. barbatus* and *M. surmuletus* as reported by the NSSH. As from 1985, these species have been reported separately and correctly (following the NSSH landings) regarding the common and scientific names. For the period 1985-2003, landings completely match between the two datasets except for 1997 and 1998 (i.e. FAO landings are over-reported in 1997 by 32 t and underreported in 1998 by 73 t). We split the NSSH *Mullus barbatus* and *M. surmuletus* landings for 1964-1981 to landings for each species (*M. barbatus* and *M. surmuletus*) based on the average participation of these two species to the total *Mullus barbatus* and *M. surmuletus* NSSH landings during 1982-1990 (see also entry for *M. barbatus*). **We consider these backwards NSSH estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Mullus spp.: It is reported by NSSH for 1964-1981 and by FAO since 1964. FAO landings for 1964-1969 are rounded between 1500 and 3000 t. NSSH landings for 1964-1981 refer to the sum of *Mullus barbatus* and *M. surmuletus* landings, which are reported separately since 1982. Hence, FAO landings for 1964-1981 refer to the same thing, i.e., the combined *M. barbatus* and *M. surmuletus* landings. **As from 1982, we consider that the FAO landings for *Mullus* spp. refer to the NSSH landings for *M. barbatus* (see entries for *M. barbatus* and *M. surmuletus*).**

Mustelus spp.: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1997, 1998 and 2000 (i.e. FAO landings are over-reported in 1997 by 2 t and in 2000 by 40 t and are underreported in 1998 by 25 t). **We consider the NSSH landings as the valid ones.**

Oblada melanura: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 33 t. **We consider the NSSH landings as the valid ones.**

Osteichthyes: It is reported by NSSH (and FAO) since 1964. FAO landings for 1964-1969 are rounded between 800 and 4300 t. NSSH records 'various fishes' with no indication whether teleosts or chondrichthyans, while FAO records 'marine fishes nei' which refers to osteichthyes (=teleost fishes). Landings do not completely match between the two datasets. For the period 1964-1969, the differences between them were enormous reaching over 5000 t in favour of the NSSH. This was probably due to the higher taxonomic resolution of FAO for that period. Between 1982 and 1994, the 'various fishes' plus *Merlangius merlangus* and *Helicolenus dactylopterus* of NSSH equal the 'marine fishes n.e.i.' of FAO, except for 1986 (FAO higher by 37 t).

Pagellus erythrinus: It is reported by NSSH since 1982 and has never been reported by FAO. For 1964-1981, NSSH landings of *P. erythrinus* were reported together with *Dentex macrophthalmus*. The comparison of NSSH landings for *P. erythrinus* with FAO landings for *Pagellus* spp. indicates that both figures refer to the same species, at least for the period after 1977. We consider the taxonomy of the NSSH landings to be the correct one for 1982-2003 indicating that the FAO landings refer to *P. erythrinus*. The two datasets differ for 1964-1976, with FAO landings generally being overreported by about 100 t per year (except for 1969 when FAO landings were underreported by 70 t). For the period 1977-2003, the FAO landings are overreported in 1997 by 9 t and underreported in 1998 by 44 t. We split the NSSH *P. erythrinus* landings for 1964-1981 to landings for each species (*D. macrophthalmus* and *P. erythrinus*) based on the average participation of these two species to the total *D. macrophthalmus* and *P. erythrinus* NSSH landings during 1982-1990 (see entry for *D. macrophthalmus*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Pagellus spp.: It is reported since 1964 by FAO and has never been reported by NSSH. For 1964-1969 FAO landings were rounded to 800, 900 or 1000 t. For the period after 1977, the FAO landings for *Pagellus* spp. refer to *P. erythrinus* (see entry for *P. erythrinus*). The higher, by about 100 t per year (except for 1969 when FAO landings were underreported by 70 t), FAO landings for *Pagellus* spp. for 1964-1976, suggest that they might have also included those for *Dentex macrophthalmus*. For the period 1977-2003, the FAO landings for *Pagellus* spp. completely match those of NSSH for *P. erythrinus* but are overreported in 1997 by 9 t and underreported in 1998 by 44 t. **We consider that the FAO landings for *Pagellus* spp. refer to those of NSSH for *P. erythrinus*.**

Pagrus pagrus: It is reported separately by NSSH (and FAO) since 1982. For 1964-1981, NSSH landings are reported together with *Dentex dentex*. For 1982-2003, landings completely match between the two datasets for all years except for 1986, 1997 and 1998 (i.e. FAO landings are over-reported in 1986 by 6 t, and in 1997 by 3 t and are underreported in 1998 by 43 t). We split the NSSH *D. dentex* landings for 1964-1981 to landings for each species (*D. dentex* and *P. pagrus*) based on the average participation of these two species to the total *D. dentex* and *P. pagrus* NSSH landings during 1982-1990(see entry for *D. dentex*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Pagrus spp.: It is reported by FAO since 1964 and has never been reported by NSSH. For 1964-1969 FAO landings were rounded to either 900 or 1000 t. **Because of the similar landings and despite the taxonomic distance, we conclude that the FAO landings for *Pagrus* spp. refer to the NSSH landings for *Diplodus annularis* (see entry for *D. annularis*).**

Polyprion americanus: It is reported separately by NSSH since 1982 and has never been reported by FAO. For 1964-1981, NSSH landings are reported together with *Epinephelus marginatus* and *E. alexandrinus* as Serranidae. We split the NSSH Serranidae landings for 1964-1981 to landings for each species (*E. marginatus E. alexandrinus* and *P. americanus*) based on the average participation of these three species to the total *E. marginatus E. alexandrinus* and *P. americanus* (=Serranidae) NSSH landings during 1982-1990 (see also entry for *E. marginatus* and *E. alexandrinus*). **We consider the NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Pomatomus saltatrix: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1966-1969 (being constant and rounded to 100 t) and then again for 1982. For 1982-2003, landings completely match between the two datasets except for 1998 (i.e. FAO landings are underreported by 15 t). **We consider the NSSH landings as the correct ones and that the FAO landings for 1966-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Psetta maxima: It is reported by NSSH (and FAO) since 1982. For 1964-1981, NSSH landings are reported together with *Solea solea*. Landings completely match between the two datasets for all years. We split the NSSH *S. solea* landings for 1964-1981 to landings for each species (*S. solea* and *P. maxima*) based on the average participation of these two species to the total *S. solea* and *P. maxima* NSSH landings during 1982-1990 (see also entry for *S. solea*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Raja clavata: It is reported by NSSH since 1982 and by FAO since 2003. The NSSH distinguishes *R. clavata* from the rest of the rays, while the FAO landings include all rays (*Raja* spp.) under a single landing value at least until 2002. The summation of *R. clavata* and other *Raja* spp. landings of NSSH exactly matches the *Raja* spp. landings of FAO except for 1997 (FAO landings are overreported by 10 t) and 1998 (FAO landings are underreported by 21 t). **We consider the NSSH landings and taxonomy as the valid ones.**

Raja spp.: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1964-1969 and then again from 1982. For 1964-1969, FAO landings are rounded to either 700 or 900 t. The summation of *R. clavata* and other *Raja* spp. landings of NSSH exactly matches the *Raja* spp. landings of FAO except for 1997 (FAO landings are overreported by 10 t) and 1998 (FAO landings are underreported by 21 t) (see entry for *Raja clavata*). **We consider the NSSH landings and taxonomy as the valid ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Rhinobatidae: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 2000 when FAO landings are overreported by 20 t. **We consider the NSSH landings as the valid ones.**

Sarda sarda: It is reported separately by NSSH since 1982 whereas by FAO since 1964. For 1964-1969, FAO landings are rounded between 900 and 3200 t. For 1964-1981 it is reported by NSSH together with *Katsuwonus pelamis*. For 1982-2003, no differences are reported between the two datasets between 1982 and 1989 and between 1994 and 1997. For the remaining years, FAO landings are overreported in 1990 (1607 t), 1991 (1896 t), 1992 (1788 t), 1993 (1826 t), 1999 (963 t) and 2000 (900 t). We split the NSSH *K. pelamis* and *S. sarda* combined landings for 1964-1981 to landings for each species (*K. pelamis* and *S. sarda*) based on the average participation of these two species to the total *K. pelamis* and *S. sarda* NSSH landings during 1982-

1990 (see also entry for *K. pelamis*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Sardina pilchardus: It is reported by NSSH (and FAO) since 1964. For 1964-1969, FAO landings are rounded between 9000 and 13000 t. Landings completely match between the two datasets for all years except for the period 1964-1968 when FAO landings are slightly over-reported and for 1969 and 1998 when FAO landings are underreported by 1615 and 750 t respectively. **We consider the NSSH landings as the valid ones.**

Sardinella aurita: It is one of the most problematic cases in terms of taxonomy. It is reported by NSSH since 1982 and has never been reported by FAO. However, the NSSH landings of *S. aurita* exactly match (except for 1997 when FAO landings are overreported by 5 t and 1998 when FAO landings are underreported by 25 t) those of FAO for *Alosa* spp., the abundance of which is very low in Greek waters. The close taxonomic relationship of the two species suggests that the two datasets refer to the same species and we consider the species' name and the landings of NSSH to be the correct ones (see entry for *Alosa* spp.). The problem probably arises from the Greek common names of the two species that are often confused. The result is that the Greek fleet appears to have fished almost 2000 t of shads (*Alosa* spp.) in 2000 instead of round sardinella (*S. aurita*) which is the third most targeted clupeoid species in the Greek Seas, mainly fished by purse seiners. The twaite shad, *Alosa fallax* is the only commercially exploited shad species in the Greek seas, but very low quantities are landed. Its exploitation is seasonal, confined to spring/early summer, and is performed by the small scale coastal fleet whose landings are not taxonomically disaggregated (see materials and methods). Thus, this record clearly refers to *S. aurita*. **We consider the NSSH landings as the valid ones.**

Sarpa salpa: It is reported by NSSH (and FAO) since 1982. For 1964-1981, it was reported by the NSSH together with *Boops boops*. For 1982-2003, landings completely match between the two datasets for all years except for 1997 and 1998 (i.e. FAO landings are overreported in 1997 by 6 t and underreported in 1998 by 43 t). We split the NSSH *B. boops* landings for 1964-1981 to landings for each species (*B. boops* and *S. salpa*) based on the average participation of these two species to the total *B. boops* and *S. salpa* NSSH landings during 1982-1990 (see also entry for *B. boops*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Scomber japonicus: It is reported by NSSH (and FAO) since 1964. For 1964-1969 FAO landings were rounded to 500, 900, 1000 and 1500 t. Records generally agree for 1964-1978 with small differences which mainly refer to the 1964-1969 period (reaching up to 233 t in favour of FAO for 1964). For 1980-1987 differences fluctuated between 810 and 1845 t always in favour of FAO. From 1988 onwards, datasets differed only in 1998 (FAO landings are underreported by 59 t). **We consider the NSSH landings as the valid ones.**

Scomber scombrus: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1964-1969 and then again from 1982. For 1964-1969 the FAO landings were rounded to 200, 300, 400 and 500 t. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 9 t. **We consider the NSSH landings as the correct ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Scombroidei: It is reported by FAO since 1982. The FAO landings match those of *K. pelamis* reported by the NSSH for 1982-1989 (see entry for *K. pelamis*). Due to the close taxonomic relationship and the perfect match of the landings **we assume that Scombroidei refers to *K. pelamis* at least for 1982-1989.**

Scorpaenidae: It is reported by NSSH (and FAO) since 1964. NSSH landings for 1964-1981 are reported together with 'gurnard' and Triglidae ('tubfish'). For 1964-1969, FAO landings were rounded between 800 and 1300 t. Landings generally match between the two datasets with FAO landings being slightly over-reported for the period 1964-1981. The differences, which reach up to 510 t for 1965, smoothed out gradually. For 1982-2003, FAO landings are overreported in 1997 (by 4 t) and underreported in 1998 (by 64 t). We split the NSSH Scorpaenidae landings for 1964-1981 to landings for each species (Scorpaenidae, Triglidae and 'gurnards') based on the average participation of these three species to the total Scorpaenidae, Triglidae and 'gurnards' NSSH landings during 1982-1990 (see also entry for 'gurnards' and Triglidae). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Seriola dumerili: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 13 t. **We consider the NSSH landings as the valid ones.**

Serranus spp.: It is reported by NSSH since 1982 and has never been reported by FAO. The NSSH landings refer mainly to *Serranus cabrilla* and *S. scriba*. **We consider these NSSH landings as the valid ones.**

Serranidae: It is reported by FAO since 1964 and by NSSH for 1964-1981. The NSSH landings for 1964-1981 refer to *Epinephelus marginatus*, *E. alexandrinus* and *Polyprion americanus*. For 1964-1969, FAO landings were rounded between 100 and 200 t. For 1970-1981 FAO landings were lower than 0.5 t. We split the NSSH Serranidae landings for 1964-1981 to landings for each species (*E. marginatus*, *E. alexandrinus* and *P. americanus*) based on the average participation of these three species to the total *E. marginatus*, *E. alexandrinus* and *P. americanus* (=Serranidae) NSSH landings during 1982-1990 (see also entry for *E. marginatus* and *E. alexandrinus*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Solea solea: It is reported separately by NSSH since 1982 and by FAO since 1964. NSSH landings for 1964-1981 are reported together with *Psetta maxima* ('brill'). For 1964-1969, FAO landings were rounded between 500 and 1000 t. Landings generally match between the two datasets for all years. However, FAO landings are overreported for the period 1964-1969 with differences reaching up to 625 t (1965). For 1970-1981 the two datasets were very similar (except for 1978 and 1979 when underreported by FAO) but never exactly matched each other. For 1982-2003, landings completely match between the two datasets except for 1997 and 1998 (i.e., FAO landings were over-reported in 1997 by 12 t and underreported in 1998 by 85 t). We split the NSSH *S. solea* landings for 1964-1981 to landings for each species (*S. solea* and *P. maxima*) based on the average participation of these two species to the total *S. solea* and *P. maxima* NSSH landings during 1982-1990 (see entry for *P. maxima*). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Sparus aurata: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1964-1969 and then again from 1982. For 1964-1969 FAO landings were constant and rounded to 200 t. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 17 t. **We consider the NSSH landings as the correct ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Spicara flexuosa: It is reported by NSSH since 1982 and has never been reported by FAO. For 1964-1981 NSSH landings are reported together with *S. maena* and *S. smaris*. For 1982-2003, the sum of the NSSH landings of *S. flexuosa* with *S. maena* and *S. smaris* completely matches the FAO landings of *Spicara* spp. except for 1997 and 1998 (i.e. FAO landings are over-reported by 57 t in 1997 and underreported by 210 t in 1998). We split the NSSH *Spicara* spp. landings for 1964-1981 to landings for each species based on the average participation of these three species to the total *Spicara* NSSH landings during 1982-1990. **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Spicara smaris: It is reported by NSSH since 1982 and has never been reported by FAO. For 1964-1981 NSSH landings are reported together with *S. flexuosa* and *S. maena*. For 1982-2003, the sum of the NSSH landings of *S. smaris* with *S. maena* and *S. flexuosa* completely matches the FAO landings of *Spicara* spp. except for 1997 and 1998 (i.e. FAO landings are over-reported by 57 t in 1997 and underreported by 210 t in 1998). We split the NSSH *Spicara* spp. landings for 1964-1981 to landings for each species based on the average participation of these three species to the total *Spicara* NSSH landings during 1982-1990. **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Spicara maena: It is reported by NSSH since 1982 and has never been reported by FAO. For 1964-1981 NSSH landings are reported together with *S. flexuosa* and *S. smaris*. For 1982-2003, the sum of the NSSH landings of *S. maena* with *S. smaris* and *S. flexuosa* completely matches the FAO landings of *Spicara* spp. except for 1997 and 1998 (i.e. FAO landings are over-reported by 57 t in 1997 and underreported by 210 t in 1998). We split the NSSH *Spicara* spp. landings for 1964-1981 to landings for each species based on the average participation of these three species to the total *Spicara* NSSH landings during 1982-1990. **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Spicara spp.: It is reported by NSSH for 1964-1981 and by FAO since 1964. For 1964-1969 FAO landings were rounded between 8500 and 9800 t. For 1964-1981, the FAO landings were always less than the NSSH ones, with differences reaching up to 1300 t. Those differences smoothed out gradually. From 1982 onwards, while FAO continued to report *Spicara* spp., NSSH started to report separate landings for the three different species (*S. smaris*, *S. maena* and *S. flexuosa*). For 1982-2003, the sum of the NSSH landings of these three species completely matches the FAO landings of *Spicara* spp. except for 1997 and 1998 (i.e. FAO landings are over-reported by 57 t in 1997 and underreported by 210 t in 1998). We consider the taxonomic resolution of NSSH the correct one (see also entries for *S. smaris*, *S. maena* and *S. flexuosa*). We split the NSSH *Spicara* spp. landings for 1964-1981 to landings for each species based on the average participation of these three species to the total *Spicara* NSSH landings during 1982-1990. **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings and taxonomy as the valid ones for 1982-2003.**

Spondyliosoma cantharus: It is reported by NSSH (and FAO) since 1964. Landings generally match between the two datasets for all years except for 1964-1968 when FAO landings are rounded to 300, 400 and 600 t and overreported (differences ranging between 25 and 430 t) and for 1969, 1970, 1971, 1978, 1979 and 1998 when FAO landings are underreported by 173, 106, 111, 30, 10 and 31 t respectively. **We consider the NSSH landings as the valid ones.**

Sprattus sprattus: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 3 t. **We consider the NSSH landings as the valid ones.**

Squalidae: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1964-1969 and then again from 1982. For 1964-1969, FAO landings are rounded to 200 and 300 t. Landings completely match between the two datasets for all years except for 1997 and 1998 (i.e. FAO landings are over-reported in 1997 by 11 t and underreported in 1998 by 30 t). **We consider the NSSH landings as the valid ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Thunnus alalunga: It is reported by FAO since 1986 and has never been separately recorded by NSSH. **Although the FAO landings are constant and mysteriously rounded to 500 t for 1986-1993, we consider those as the valid ones.**

Thunnus thynnus: It is reported by FAO for 1964-1969 and then again since 1985. It has never been separately reported by NSSH. For 1964-1969 FAO landings were rounded between 500 and 700 t. **We consider the FAO landings as the valid ones.**

Trachurus mediterraneus: It is reported by NSSH since 1982 and by FAO since 1964. For 1964-1981 the NSSH landings are reported together with *Trachurus trachurus*. The close taxonomic relationship with *T. trachurus* and the landings of the two species indicate that, for 1964-1981, the FAO landings report *T. mediterraneus* but refer to both species. Similarly, for the same period, the NSSH landings report *Trachurus* spp. but again refer to both species. As from 1982, the two species are separately recorded. For 1982-2000, the FAO landings are overreported in 1996 by 5 t and 1997 by 33 t and underreported in 1998 by 172 t. We split the NSSH *Trachurus* spp. landings for the period prior to 1982 to landings for each species based on the average participation of these two species to the total *Trachurus* NSSH landings during 1982-1990, **and we consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Trachurus trachurus: It is reported separately by NSSH (and FAO) since 1982. For 1964-1981 NSSH landings are reported together with *Trachurus mediterraneus*. The close taxonomic relationship with *T. mediterraneus* and the values of the landings of the two species indicate that, for 1964-1981, the landings of NSSH report *T. trachurus* but refer to both species. As from 1982, the two species are separately recorded. For 1982-2003, the FAO landings are overreported in 1997 by 19 t and underreported in 1998 by 10 t. We split the NSSH *Trachurus* spp. landings for the period prior to 1982 to landings for each species based on the average participation of these two species to the total *Trachurus* NSSH landings during 1982-1990, **and we consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Trachurus spp.: It is reported by NSSH for 1964-1981 and has never been reported by FAO. NSSH landings refer to *Trachurus trachurus* and *T. mediterraneus* and are very similar to FAO landings for *T. mediterraneus*. As from 1982, both FAO and NSSH started to report the separate landings for the two different species (*Trachurus mediterraneus* and *T. trachurus*). We split the NSSH *Trachurus* spp. landings for the period prior to 1982 to landings for each species based on the average participation of these two species to the total *Trachurus* NSSH landings during 1982-1990, **and we consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Triglidae: It is reported by NSSH (and FAO) since 1982. NSSH landings for 1964-1981 are reported together with 'gurnards' and Scorpaenidae ('scorpion fish'). Until 1993, the values of NSSH make up those of FAO when added with those of 'gurnards'. From then onwards Triglidae exactly match between the two datasets, except for 1997 (FAO landings are overreported by 4 t) and 1998 (FAO landings are underreported by 8 t). We split the NSSH Scorpaenidae landings for 1964-1981 to landings for each species (Scorpaenidae, Triglidae and 'gurnards') based on the average participation of these three species to the total Scorpaenidae, Triglidae and 'gurnards' NSSH landings during 1982-1990 (see also entry for 'gurnards' and Scorpaenidae). **We consider these NSSH backwards estimated landings as the valid ones for 1964-1981 and the NSSH landings as the valid ones for 1982-2003.**

Umbrina cirrosa: It is reported by NSSH since 1982 whereas by FAO it is also reported for 1964-1969 and then again from 1982. For 1964-1969, FAO landings are rounded to 100, 600 and 700 t. Landings completely match between the two datasets for all years except for 1998 when FAO landings are underreported by 4 t. **We consider the NSSH landings as the valid ones and that the FAO landings for 1964-1969 should be added to the FAO Osteichthyes ('marine fishes nei').**

Xiphias gladius: It is reported by FAO since 1981 and by NSSH since 1982. In general, FAO landings are overreported (differences reach up to 787 t in 2000). FAO landings are underreported only for 1985 (by 74 t), 1988 (by 243 t), 1989 (by 911 t), 1995 (by 428 t) and 1997 (by 803 t). No difference was observed only in 1996. **We consider the FAO landings as the valid ones.**

Zeus faber: It is reported by NSSH (and FAO) since 1982. Landings completely match between the two datasets for all years except for 1997 and 1998 (i.e. FAO landings are over-reported in 1997 by 3 t and underreported in 1998 by 11 t). **We consider the NSSH landings as the valid ones.**

Tuna: It is reported by NSSH since 1982 and has never been reported by FAO. Because of the low taxonomic resolution we consider the FAO records for individual tuna and tuna like fishes as the correct ones. **For all tuna and tuna like fishes (except for *Sarda sarda* and *Katsuwonus pelamis*), we consider the FAO landings as the valid ones.**

Cephalopods

Loliginidae, Ommastrepidae: It is reported by the NSSH since 1964 and by FAO since 1970. For 1970 and 1971 FAO's values were higher as they included the landings of *Loligo* sp. (its separate records started in 1972). As from 1972 the two datasets are exactly the same except for 1997 (FAO landings are overreported by 4 t) and 1998 (underreported by 4 t). **We consider the NSSH landings as the valid ones.**

Loligo spp.: It is reported by the NSSH since 1964 and by FAO since 1972. FAO landings are slightly overreported for 1972-1976, 1981 and 1997 and underreported in 1998 (by 16 t). **We consider the NSSH landings as the valid ones.**

Octopodidae: It is reported by FAO since 1970 and by the NSSH since 1982. The landings of FAO for 1970-1981 match those of NSSH for *Octopus vulgaris* and are generally overreported. **We consider the NSSH landings as the valid ones.**

Sepia officinalis: It is reported since 1964. For 1964-1969 FAO landings seemed to have included all the cephalopods recorded by the NSSH and still were twice higher. As from 1970, the two datasets were very close. From 1970-1977, FAO landings were slightly higher and from 1978-1981 those of the NSSH were slightly higher. Since 1982, landings are exactly the same except for 1998 (FAO landings are underreported by 271 t). **We consider the NSSH landings as the valid ones.**

Octopus vulgaris: It is reported by the NSSH since 1964 and by FAO since 1982. As from then the two datasets are exactly the same except for 1998 (FAO landings are underreported by 196 t). **We consider the NSSH landings as the valid ones.**

Crustaceans

Hommarus gammarus: It is reported by the NSSH (and FAO) since 1982. FAO landings are underreported in 1998 by 24 t. Despite the agreement between the two datasets, we conclude that they refer to the landings of two species: *H. gammarus* and *Palinurus elephas*. The latter has never been recorded by the NSSH or FAO. **We consider that the NSSH and FAO landings refer to both *H. gammarus* and *Palinurus elephas*.**

Penaeus kerathurus: It is reported by the NSSH (and FAO) since 1982. FAO landings are overreported in 1997 by 28 t and underreported in 1998 by 38 t. **We consider the NSSH landings as the valid ones.**

Natantia: It is reported by the NSSH and by FAO since 1964. As from 1970, the two datasets generally agree except for 1978, 1979 and 1981 (FAO landings are underreported by about 40 t). Since 1982 FAO landings are overreported in 1997 by 21 t and underreported in 1998 by 78 t. The majority of 'Natantia' landings refer to the *Parapeneus longirostris*. **We consider the NSSH landings as the valid ones.**

Carcinus aestuarii: It is reported by the NSSH and by FAO since 1982. FAO landings are underreported in 1998 by 9 t. **We consider the NSSH landings as the valid ones.**

Nephrops norvegicus: It is reported since 1964 by FAO and by the NSSH as 'other'. The two datasets generally agree from 1970 except for 1998 (FAO landings are underreported by 15 t). **We consider the NSSH landings as the valid ones.**

MULTIVARIATE ANALYSIS OF FISHERIES CATCH PER DAY IN GREEK WATERS[1]

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ABSTRACT

Data on Catch per Unit Effort (CPUE, here as catch·day^{-1}) for a large number of species for 21 stations throughout the Greek Seas have been collected by the Institute of Marine Biology of Crete (IMBC) since the second half of 1995. In the present study we analyzed the total catch·day^{-1} for various gears for the 1996-2000 period using univariate (K-dominance curves, diversity indices) and multivariate techniques (cluster and multidimensional scaling). The following vessel size groups for each main gear were considered for analysis: (a) trawlers smaller and larger than 20 m; (b) purse-seiners smaller and larger than 15 m; (c) beach-seiners; (d) long liners smaller and larger than 10 m; (e) netters smaller and larger than 10 m; and (f) "other gears". The mean percentage of vessels sampled ranged from 4.1 to 40.6% for trawlers, 6.5 to 66.4% for purse seiners, 2.1 to 4.6% for beach seiners, 2.2 to 11.8% for longliners, 1.3 to 5.1% for netters and 1.9 to 6.3% for other coastal boats. Collected data were also aggregated for five fishing subareas: North Aegean, Central Aegean, South Aegean, Cretan waters and Ionian Sea. The results of the univariate and multivariate analyses were in close agreement and suggested that the different gear/vessel-size/subarea combinations might generally be grouped into clusters corresponding to the different gears, irrespectively of subarea. The gears differed considerably with regard to species composition, species diversity and catch rates. The results also showed that despite the gear-related definition of groups, among-gear overlap was considerable. This emphasises the multigear nature of Greek fisheries.

INTRODUCTION

Accurate data on catches, corresponding fishing effort and catch per unit of fishing effort (CPUE) are important for: (a) stock assessment (e.g., Pauly, 1989; Hilborn and Walters, 1992; Pauly, 1994; Chen, 1996); (b) identifying the effects of fishing on marine ecosystems (e.g., fishing down the food web; Pauly *et al.* 1998; Stergiou and Koulouris, 2000, Pauly *et al.* 2001); (c) estimating the 'primary production required' to sustain fisheries (e.g., Pauly and Christensen, 1995); (d) mapping of fisheries resources (Watson and Pauly, 2001); (e) constructing fisheries-oriented ecological models (Christensen and Pauly, 1993; Walters *et al.*, 1997; Pauly *et al.*, 2000); (f) identifying target fishes (Stergiou *et al.*, 2003); and (g) identifying gear overlap and competition in terms of species fished (e.g., Stergiou *et al.*, 2002).

In Greece, fisheries statistics are collected by four independent organisations: (a) the National Statistical Service of Greece (NSSH, since 1964, for 16 fishing subareas); (b) the Agricultural Bank (since 1974, from a network of about 110 villages); (c) the National Company for the Development of Fisheries (ETANAL; since 1969, from all existing auction sites); and (d) the Ministry of Agriculture (not routinely involved in data collection). Each of these organizations is collecting and/or processing fisheries data for its own purpose and there is no co-ordination between them. Thus, collected information is overlapping, contradictory, and sometimes leads to confusion. Although NSSH statistical data may suffer from various biases that are higher for inshore fisheries, they are thought the best figures available with respect to: (a) the length of available time-series; (b) spatial and temporal resolution of collected data; (c) the consistency and degree of subjectivity in data collection; and (d) the statistical design (Stergiou, 1997a; Stergiou *et al.*, 1997). In addition, NSSH records show signs of biological, ecological, oceanographic and technical

[1] Cite as: Stergiou, K., Machias, A., Somarakis, S. and Kapantagakis, A. 2007. Multivariate analysis of fisheries catch per day in Greek waters. p. 139-148 *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

relevance and reasonably agree with the results of trawl and echo-surveys conducted in the Greek Seas (Stergiou, 1997 a, b).

Four important drawbacks of the above-mentioned data sources are: (a) fishing effort is not recorded on a subarea and monthly bases; (b) no data are available concerning fishing effort expressed as fishing days at sea, as required by European Union (EU) regulations; and (c) the various small-scale gears (i.e., longliners, netters) are generally grouped together under one category.

Because of the these drawbacks, the Institute of Marine Biology of Crete (IMBC) began in the second half of 1995 to collect data on fishing effort (expressed as engine horsepower, gross tonnage and days at sea) by main fishing gear (trawlers, purse seiners, longliners, netters, beach seiners and other inshore boats) as well as the corresponding catch·day^{-1} for a large number of species.

In the present study we analyzed the 1996-2000 monthly data of catch·day^{-1} for major contributing species, to identify patterns in groups of species exploited by different gears. Such analysis is useful for the reconstruction of the Greek fisheries landings (see Tsikliras *et al.* this volume) and especially of the small-scale fisheries component, which is characterized by a large number of operating vessels (>19,000) and a large number of landing sites, practically extending along the entire coastline of Greece. This renders efficient monitoring difficult.

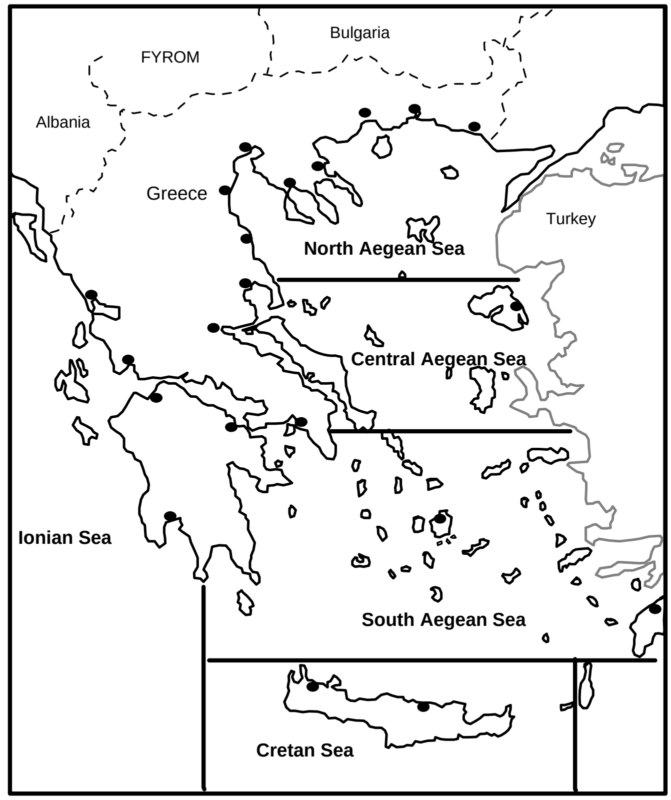

Figure 1. The main fisheries statistical subareas and sampling stations (black circles) throughout the Greek Seas, as used for the recording of fisheries effort data.

MATERIALS AND METHODS

Description of data sets

Mean monthly data on catch·day^{-1} for a large number of species have been collected by the IMBC since the second half of 1995. Data are collected by local Fisheries Inspectors through a network of 21 stations throughout the Greek Seas (Figure 1) and relate to vessels operating the major gears: trawlers, purse seiners, longliners, netters, beach seiners, and other boats, with the latter category including small-scale boats using a variety of fishing gears such as pots, traps, lines, dredges and small ring nets. At each station, data are collected from a sample of vessels displaying full activity. Note that there is a closed season for beach seiners and trawlers, between June 1st and September 30th, and for purse seiners, between December 10th and the last day of February. As a result, no data exist for these time-gear combinations.

Here, we used monthly data for 1996-2000, aggregated by the following vessel size categories for each gear: (a) trawlers smaller than 20 m and larger than 20 m; (b) purse-seiners smaller than 15 m and larger than 15 m; (c) beach-seiners; (d) long liners smaller than 10 m and larger than 10 m; (e) netters smaller than 10 m and larger than 10 m; and (f) 'other gears' (Table 1). Collected data were also aggregated for five fishing subareas, which generally differ in terms of NSSH catch composition and biological productivity (see review by Stergiou *et al.*, 1997): North Aegean Sea, Central Aegean Sea, South Aegean Sea, Cretan waters and Ionian Sea (Figure 1). Overall, 109 different taxa were identified, consisting of 93 fishes, five cephalopods, five crustaceans, five bivalves and one echinoderm, with 92 out of the 109 taxa referring to the species level (see Appendix Table A1).

Table 1. Mean number of vessels registered (N), and mean monthly percentages of vessels sampled for catch per unit effort, by sub-area and fishing gear-vessel size, for 1996-2000. CA = Central Aegean Sea; C = Cretan waters; I = Ionian Sea; NA = North Aegean Sea; SA = South Aegean Sea.

Gear	*Area*	Vessels size	catch·day^{-1}	N
Trawlers	CA	>20m	10.4	36.3
	CA	<20m	7.7	39.8
	C	<20m	12.8	51.7
	I	>20m	23.7	45.3
	I	<20m	4.1	37.8
	NA	>20m	40.6	50.7
	NA	<20m	6.3	45.3
	SA	>20m	32.4	47.0
	SA	<20m	9.2	37.2
Purse	CA	>15m	6.8	67.7
	CA	<15m	6.5	23.3
	C	>15m	66.4	5.0
	C	<15m	19.8	6.3
	I	>15m	21.1	23.6
	I	<15m	6.8	23.8
	NA	>15m	23.2	64.3
	NA	<15m	13.1	7.7
	SA	>15m	7.5	89.8
	SA	<15m	6.7	47.7
Beach	C		5.7	17.6
	CA		2.1	86.8
	I		3.1	142.8
	NA		4.6	42.8
	SA		2.8	225.3
Longliners[a]	CA	>10m	3.0	207.3
	CA	<10m	2.7	4,294.7
	C	>10m	11.8	101.5
	C	<10m	2.5	838.0
	I	>10m	7.1	161.0
	I	<10m	2.2	4,388.7
	NA	>10m	4.6	228.8
	NA	<10m	3.8	2,828.8
	SA	>10m	2.9	562.0
	SA	<10m	2.5	5,145.7
Netters[a]	CA	>10m	2.6	207.3
	CA	<10m	2.3	4,294.7
	C	>10m	2.7	101.5
	C	<10m	1.9	838.0
	I	>10m	5.1	161.0
	I	<10m	2.6	4,388.7
	NA	>10m	3.9	228.8
	NA	<10m	1.3	2,828.8
	SA	>10m	1.4	562.0
	SA	<10m	2.1	5,145.7
Other	C		6.3	4294.7
	CA		2.3	838.0
	I		1.9	4388.7
	NA		2.4	2828.8
	SA		2.3	5145.7

[a] Same vessels use longlines, nets and other gears.

Univariate and multivariate analyses

For each gear group and subarea we computed the number of taxa, the Shannon-Wiener diversity index H', Margalef's d index for species richness, and Pielou's J measure of evenness (Magurran, 1988). Comparisons of mean diversity indices between gears, gear sizes and subareas were based on one-way analysis of variance (ANOVA) (Zar, 1984). We also plotted K-dominance curves (i.e., percentage cumulative abundance is plotted against log taxa rank; Lambshead *et al.*, 1983), using catch·day^{-1}, for each gear size group, pooled over the whole study period, for each subarea and all subareas combined.

We constructed the following (rows) x (columns) matrix: (total catch·day^{-1} for 109 taxa) x (gear·size^{-1} x subarea), using data pooled over the whole study period. Original data were then log-transformed, in order to reduce the weight of abundant taxa (Field *et al.*, 1982). Consequently, we computed the triangular matrix of the Bray and Curtis (1957) similarity between all pairs of combinations. We then analysed the similarity matrix using both clustering (employing group-average linking) and non-metric multidimensional scaling (MDS). The two-dimensional plot is adequate when the 'stress coefficient' is lower than 0.2 (Field *et al.*, 1982). Group formation is realistic when the results of cluster and MDS agree (Field *et al.*, 1982; Car, 1997).

We also estimated the contribution of each taxon to the average Bray-Curtis dissimilarity both within- and between-groups of gear combinations identified by multivariate analysis using SIMPER (Car, 1997). SIMPER uses the standard deviation (SD) of the Bray-Curtis dissimilarity, attributed to a taxon, for all pairs and compares that with the average contribution of a taxon to the dissimilarity. We applied SIMPER on the (total catch·day^{-1}) x (gear·size^{-1} x subarea) matrix, considering all gear types as separate groups.

RESULTS

Catch composition by gear

The taxa characterized by the highest contribution in terms of catch·day^{-1} for the different gears can be identified in Table 2.

Table 2. Percentage catch contribution of the most abundant taxa in the six main fishing gears.

Species	Trawlers	Purse seiners	Beach seiners	Longliners	Netters	Other gear
Merluccius merluccius	11.81	-	-	11.31	10.18	-
Parapenaeus spp.	9.92	-	-	-	-	-
Spicara smaris	9.73	-	28.02	-	-	-
Trachurus spp.	8.12	15.04	-	-	-	-
Boops boops	7.50	11.46	14.80	-	6.48	-
Mullus barbatus	7.13	-	4.95	-	-	-
Scomber japonicus	-	8.66	-	-	-	-
Engraulis encrasicolus	-	23.69	-	-	-	-
Sardina pilchardus	-	24.23	19.29	-	-	12.06
Spicara flexuosa	-	-	5.55	-	-	-
Pagellus bogaraveo	-	-	-	6.44	8.47	-
Thunnus spp.	-	-	-	11.63	-	7.96
Xiphias gladius	-	-	-	39.33	-	-
Octopus vulgaris	-	-	-	-	-	14.25
Ostrea edulis	-	-	-	-	-	21.42
Mugilidae	-	-	-	-	9.46	-
Other molluscs	-	-	-	-	-	8.89

The species making up 50% or more of the catch·day^{-1} by gear and vessel size in the five subareas indicated that in general, catch composition varied with vessel size and area (Tables 3, 4, 5). For example, in the North Aegean Sea, *Mullus barbatus* and *Parapenaeus* spp. were represented by higher percentages in trawlers larger than 20 m, while *Trachurus* spp. dominated in trawlers smaller than 20 m (Table 3). Similarly the catches of longliners larger than 10 m were mainly composed of *Xiphias gladius*, whereas the catches of longliners smaller than 10 m were composed of a variety of taxa, depending on the subarea examined (Table 4). With respect to subarea, *Engraulis encrasicolus* was replaced by *Boops boops* in the South Aegean Sea and in Cretan waters (Table 3).

Table 3. The percentage contribution of the most abundant species in terms of catch?day^{-1} for trawlers and purse seiners in each subarea. NA = North Aegean, CA = Central Aegean, SA = South Aegean, CR = Cretan waters, I = Ionian Sea.

	Trawlers									**Purse seiners**									
	< 20 m				> 20 m					< 15 m					> 15 m				
Species	NA	CA	SA	I	NA	CA	SA	CR	I	NA	CA	SA	CR	I	NA	CA	SA	CR	I
Sarda sarda														13.8					
Trachurus spp.	10.7	8.3				13.5		6.0		18.2		32.4		12.0			22.8	23.1	
Various species	10.7	9.6	10.0		6.6														
Merluccius merluccius	13.4			28.3	12.8	12.1	14.4		19.8										
Penaeus kerathurus	22.4				14.0				15.6										
Parapaeneus spp.		8.0	10.1	12.8	5.8	21.2	17.8		13.2										
Engraulis encrasicolus										14.0	38.1	23.9		17.1	31.7	42.9			44.5
Boops boops		10.4		12.8				18.3					27.2				22.1	32.5	
Nephrops norvegicus						6.5													
Scomber japonicus																	26.7		
Mullus barbatus					9.6			10.4	6.5										
Sciara smaris			33.9				17.2	19.2											
Mullus surmuletus		11.9																	
Sardina pilchardus										30.7	24.9		29.2	11.6	43.6	29.4			18.2
Scorpaena spp.		7.2																	
Octopus vulgaris					6.4														

Table 4. The percentage contribution of the most abundant species in terms of catch·day^{-1} for longliners and netters in each subarea. NA = North Aegean, CA = Central Aegean, SA = South Aegean, CR = Cretan waters, I = Ionian Sea.

	Longliners										*Netters*								
	<10 m					***>10 m***					***<10 m***					***>10 m***			
Species	NA	CA	SA	CR	I	NA	CA	SA	CR	I	NA	CA	SA	CR	I	NA	CA	SA	CR
Raja spp.					21.7														
Thynnus spp.	23.5					41.6											26.3		
Various		10.6			10.3								9.2	14.7			11.8		
Merluccius	22.2		19.1			21.9		11.3						6.5	7.8				25.9
Mustelus spp.			8.9																
Solea											5.4								
Boops boops													17.1	6.2			13.1	11.2	
Mugilidae											20.8	29.0			13.9	26.1			
Mullus			9.3												10.5				
Dicentrarchus		46.3																	
Pagellus												5.1							
Spicara													10.3						
Lithognathus	23.5																		
Pagellus			11.4	26.0				13.8										22.1	27.2
Mullus													10.3	10.8				8.9	
Xiphias			8.5	15.5	28.2		86.5	25.7	51.0	66.2									
Lophius												7.9							
Sardina											5.6				16.6				
Scorpaena													9.1	9.6				10.6	
Sepia											15.5	9.9		7.9	6.2	6.6			
Pagrus				9.2															
Octopus											7.3					19.3			

Diversity and dominance

The number of taxa being caught differed considerably among gears. It was lowest (9 taxa) for longliners larger than 10 m in the Central Aegean Sea and highest (78 taxa) for netters smaller than 10 m in the North Aegean Sea (detailed data available from the senior author).

Table 5. The percentage contribution of the most abundant species in terms of catch·day^{-1} for beach seiners and 'other gears' in each subarea. NA = North Aegean, CA = Central Aegean, SA = South Aegean, CR = Cretan waters, I = Ionian Sea.

	Beach seiners					**Other gears**				
Species	NA	CA	SA	CR	I	NA	CA	SA	CR	I
Sarda sarda								26.2		
Thynnus spp.								44.2		
Polyprion americanus									33.1	
Boops boops		17.2	14.7	22.8	17.5					
Various mollusks										69.9
Spicara smaris	16.1	16.8	36.4	21.5	49.3					
Pagellus bogaraveo									43.4	
Sardina pilchardus	43.0	21.5				36.1				
Ostrea edulis							74.9			
Spicara flexuosa				19.3						
Octopus vulgaris						35.9				

The mean number of taxa, species richness, evenness and Shannon-Wiener diversity all differed (ANOVA: all F >5.5, P<0.05) among gear categories. In general, species richness was higher for netters smaller than 10 m (Figure 2a), evenness and Shannon-Wiener diversity were lower for longliners larger than 10 m, purse seiners larger than 15 m and other boats (Figures 2 b, c) and the number of taxa was higher for both size categories of netters and for trawlers larger than 20 m (Figure 2d).

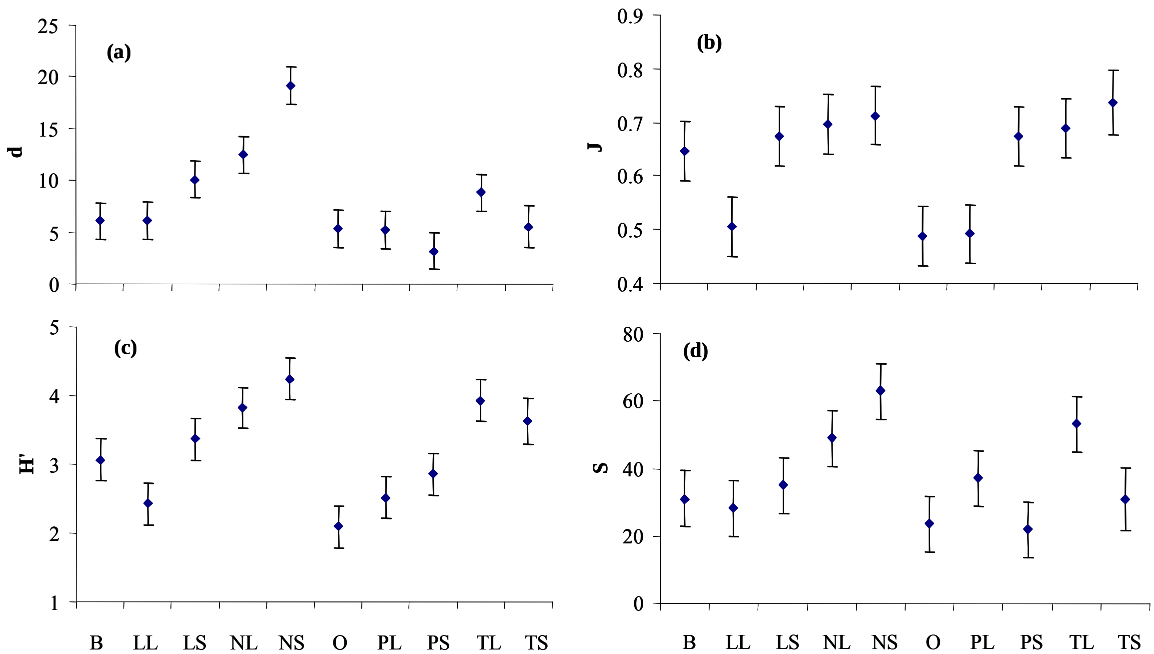

Figure 2. Mean diversity (± 95% CI) of subareas for each gear x vessel size for (a) d= species richness, (b) J= evenness, (c) H'= Shannon-Wiener, and (d) S= number of species. TS = Trawlers smaller than 20 m; TL = Trawlers larger than 20 m; PS = Purse seiners smaller than 15 m; PL = Purse seiners larger than 15 m; B = Beach seiners; LS = Longliners smaller than 10 m; LL= Longliners larger than 10 m; NS= Netters smaller than 10 m; NL= Netters larger than 10 m; O= other gears.

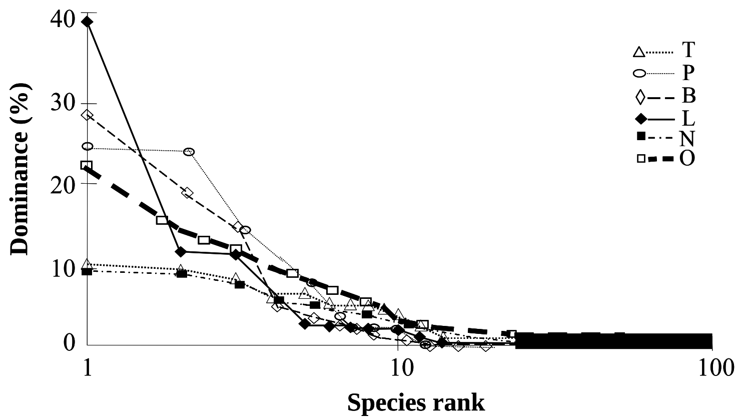

Figure 3. K-dominance curves across all subareas by each gear (T= Trawlers; P=Purse seiners; B=Beach seiners; L= Longliners; N= Netters; O= Other gears).

Dominance (percentage cumulative abundance plotted against log taxa rank) was more pronounced for longliners larger than 10 m and lower for longliners smaller than 10 m as well as for both size categories of trawlers and netters (not shown). When the 6 gears were considered irrespectively of size, dominance was also more pronounced for longliners and less so for netters and trawlers (Figure 3). Finally, dominance patterns of the different gear categories varied among subareas, reflecting differences in target taxa and local fishing practices. Generally, however, they were lower for trawlers and netters in all subareas and higher for longliners larger than 10 m in the Central Aegean Sea, Ionian Sea and Cretan waters.

Multivariate analysis

The classification of the log-transformed data of the matrix (catch·day^{-1} for all 109 taxa) x (gear·size^{-1} x subarea) showed that, at about the 35% similarity level, the 49 combinations formed five main groups (Figure 4). Group A: all purse seiners; Group B: all trawlers and beach seiners, with both gear types forming distinct subgroups; Group C: netters in the North and Central Aegean, and Ionian Seas; Group D: netters and longliners in the South Aegean Sea and netters in Cretan waters; and Group E: all remaining longliners. Apart from these main groups, six outlier cases were also identified, corresponding to the five individual cases of 'other gears' and longliners smaller than 10 m in the Central Aegean Sea. The groupings identified from applying MDS on the 49 combinations were consistent with those of the cluster analysis, and are thus not presented here.

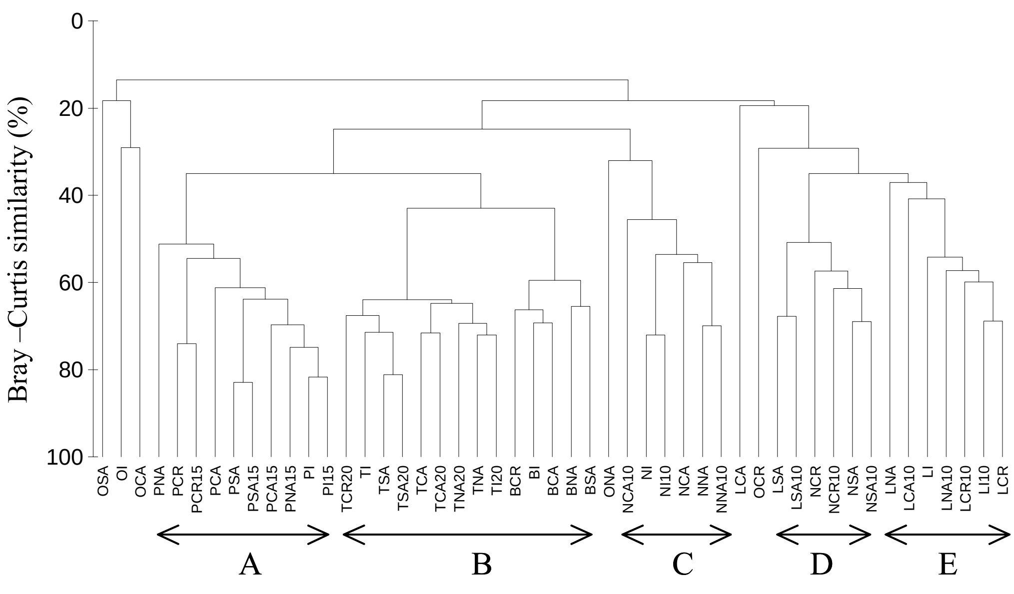

Figure 4. Results of cluster analysis applied on log-transform catch·day^{-1} data for all species per subarea, gear and gear size using the Bray-Curtis similarity index. T=Trawlers; P=Purse seiners; B=Beach seiners; L=Longliners; N= Netters; O=Other gears; NA=N. Aegean Sea, CA=Central Aegean Sea, SA=south Aegean Sea, CR=Cretan waters, I= Ionian Sea; Number next to symbols indicates boats larger than the number.

The taxa composition of the groups and outliers identified by multivariate analyses differed considerably from each other. Thus, the taxa making up the main part of the catches·day^{-1} of purse seiners (i.e., Group A) and trawlers and beach seiners (i.e., Group B) (see Table 2) differed from those making up the major part of the catches·day^{-1} of any of the other groups. In addition, the major part of the catch·day^{-1} of the outlier comprised by longliners smaller than 10 m in the Central Aegean Sea was composed of Mugilidae, *Sepia officinalis*, *Lophius budegassa*, *Pagellus erythrinus* and *Solea vulgaris*, which differed from those that made up the majority of the catch·day^{-1} for longliners as a group (Table 2). In addition, 'other boats' represented a wide variety of gears exploiting different species in different subareas. Thus, the taxa making up the major part of the catch·day^{-1} were *Sardina pilchardus*, *Octopus vulgaris* and Mugilidae in the North Aegean Sea, several bivalve taxa in the Central Aegean Sea, *Thunnus* spp. and *Sarda sarda* in the South Aegean Sea, *Pagellus bogaraveo* and *Thunnus* spp. in Cretan waters, and bivalves and *Xiphias gladius* in the Ionian Sea.

Because the groupings indicated by multivariate analysis corresponded, with few exceptions, to the six main gears operating in Greek waters (Figure 4), we decided to apply SIMPER analysis on a gear basis because this is more meaningful and better described the taxa exploited by each gear. SIMPER analysis indicated that the taxa contributing to the Bray-Curtis similarity within the six gears (Table 6) did not generally differ from those making up the main part of the gear catches (Table 2).

Table 6. Main species contributing to the similarity within gears, based on SIMPER analysis. Numbers in parentheses indicate the average Bray-Curtis similarity of the gear group. A= average abundance (in kg·day^{-1}); CS= cumulative contribution to the Bray-Curtis similarity of the gear groups.

Species/Gear	A	CS	Species/Gear	*A*	CS
Trawlers (66.0 %)			**Longliners (42.5 %)**		
Merluccius merluccius	38.4	9.5	**Xiphias**	23.1	18.9
Trachurus spp.	26.4	18.1	*Merluccius merluccius*	6.6	36.4
Parapenaeus spp.	32.2	26.0	**Dilplodus**	1.4	45.1
Mullus barbatus	23.2	33.3	Various species	1.8	53.2
Various species	19.4	39.9	*Thunnus* spp.	6.8	60.3
Boops boops	24.3	46.3			
Lophius budegassa	9.7	51.4			
Eledone moschata	8.47	60.81			
Purse seiners (60.0 %)			**Netters (45.6%)**		
Sardina pilchardus	209.5	16.7	Various species	2.3	10.1
Trachurus spp.	130.1	31.8	*Merluccius merluccius*	3.8	20.0
Boops boops	99.1	45.8	*Sepia officinalis*	1.8	29.6
Scomber japonicus	74.9	57.5	*Boops boops*	2.4	37.5
Engraulis encrasicolus	204.8	67.8	Mugilidae	3.5	44.7
			Mullus surmuletus	1.8	51.2
			Mullus barbatus	1.3	57.3
			Scorpaena spp.	1.7	62.0
Beach seiners (62.4 %)			**Other gears (21.5 %)**		
Spicara smaris	38.1	17.6	*Thunnus* spp.	5.3	44.2
Boops boops	20.1	34.2	*Octopus vulgaris*	9.5	64.5
Sardina pilchardus	26.3	47.1	Other molluscs	5.9	80.5
Mullus barbatus	6.7	57.4	*Sepia officinalis*	0.7	87.8
Loligo vulgaris	5.4	66.0	Various species	0.4	90.6

Discussion

The results of the different analyses used were consistent and complemented each other. This suggested that the different gear/vessel-size/subarea combinations could be generally grouped into clusters corresponding to different gears, irrespectively of subarea. The six gears differed considerably with regard to targeted species composition, catch rates, species diversity and dominance. The results also showed that despite the clear grouping by gear type, among-gear overlap in terms of species composition was generally considerable.

The application of multivariate analyses to the annual NSSH landings per major fishing gear (i.e., trawl, purse seine, beach seine and 'other gears') also indicated differences in the taxonomic compositions of the different main gears operating in Greek waters (Stergiou and Pollard, 1994). The gear overlap in terms of taxa indicated the strong multigear nature of Greek fisheries, i.e., different gears exploit many taxa at the same time.

The construction of K-dominance curves showed that longliners in the Central Aegean Sea, Ionian Sea and Cretan waters had the highest dominance (see also Stergiou *et al.*, 2000), which is attributed to targeted fishing in deep waters (e.g., Cretan Sea for *Pagellus bogaraveo*) and for *Xiphias gladius*. Although *X. gladius* was also the dominant species of the longline fishery operating in the eastern part of the South Aegean Sea, this was not reflected in the corresponding dominance curve because many other taxa also contributed to the catch in that area. Dominance was lower for netters and trawlers, clearly reflecting the strong multispecies nature of these fisheries. Finally, the high contribution of the 'other species' category to the total catch of trawlers was also indicative of the multispecies nature of this indiscriminate gear type. Purse seiners exhibited higher dominance in the North and Central Aegean and Ionian Seas (i.e., the main fishing grounds for the small pelagic species *Engraulis encrasicolus* and *Sardina pilchardus*) than in the South Aegean Sea and Cretan waters where the number of taxa dominating the catches increased (i.e., *E. encrasicolus*, *Trachurus* spp., *Scomber japonicus*, *Boops boops*, *S. pilchardus*). Finally, the 'other gear' category also exhibited high dominance in all subareas due to its targeted nature (i.e., Central Aegean: *Ostrea edulis*; South Aegean: *Thunnus* spp.; Cretan waters: *P. bogaraveo*; Ionian Sea: *Pecten* spp.; North Aegean: *S. pilchardus*).

Fisheries resources in Greek waters are overexploited (Stergiou *et al.*, 1997; Stergiou and Koulouris, 2000), a fact indicating the inadequacy of the management regulations currently in force (i.e., closed seasons and areas, limited issue of licenses, minimum legal landing sizes and mesh size regulations). The overexploited state of marine resources in Greek waters can also be attributed to the difficulties of sustainable managing multi-species, multi-gear fisheries such as those in Greece (and Mediterranean fisheries in general), and the lack of relatively reliable fisheries data. Both factors impose difficulties on designing and implementing uniform protective measures using traditional fisheries models (see Stergiou *et al.*, 2002). The data presented here for the small-scale fisheries were used for the reconstruction of small-scale fisheries landings in Greek waters (see Tsikliras *et al.* this volume), in order to finally provide a realistic estimate of the total Greek landings reported by NSSH (and thus by FAO). This is the first step for the re-evaluation of the state of Greek fisheries and management.

Acknowledgements

We wish to extend our gratitude to V. Karpouzi for her assistance in crosschecking and verifying raw data, J. Laurensen for extracting the data, and D. Zeller and A.C. Tsikliras for constructive comments and suggestions. This study was partially funded by the Commission of the European Union (Contract Number 00/018).

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COUNTRY DISAGGREGATION OF CATCHES OF FORMER YUGOSLAVIA[1]

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ABSTRACT

With the dissolution of the Federal People's Republic of Yugoslavia in the early 1990s, the fisheries catch time series data presented by FAO on behalf of its member countries consist of two sets: (1) the catch from the coast of the former Yugoslavia, reported as 'Yugoslavia (former)' from 1950-1991, and (2) the catch of the subsequently independent countries of Croatia, Slovenia, Montenegro and Bosnia-Herzegovina as independent entities since 1992. In order to better approximate the likely spatial distribution of catches along this coastline, and to streamline reporting entities, we disaggregated the reported catches from the 1950-1991 period into the spatial entities from which they likely originated, i.e., the former four republics with marine coastlines that contributed to the former Republic of Yugoslavia. This was achieved by assuming proportionality of catches (based on the average of the first five years of separate reporting) between the post- and pre-breakup period.

INTRODUCTION

The Federal People's Republic of Yugoslavia (hereafter referred to as 'former Yugoslavia') emerged after WW II and consisted of a Federation of six Republics (Serbia, Croatia, Bosnia and Herzegovina, Macedonia, Slovenia and Montenegro, Figure 1) under a central government. The gradual dismemberment of the former Yugoslavia towards the end of the 20th century, which saw its closing act in May 2006, when Montenegro became independent of 'Serbia-Montenegro', has implications for the *Sea Around Us Project*, which aims to provide catch statistics by 'country' that are consistent over time. The most straightforward way this can be achieved is by assuming that 'Yugoslavia' never existed and that, instead, the six contributing republics always did. In practice, this implies retroactively re-allocating the marine fisheries catch times series of the former Yugoslavia to each of the now independent countries. Of the six republics of the former Yugoslavia, only four have coastlines

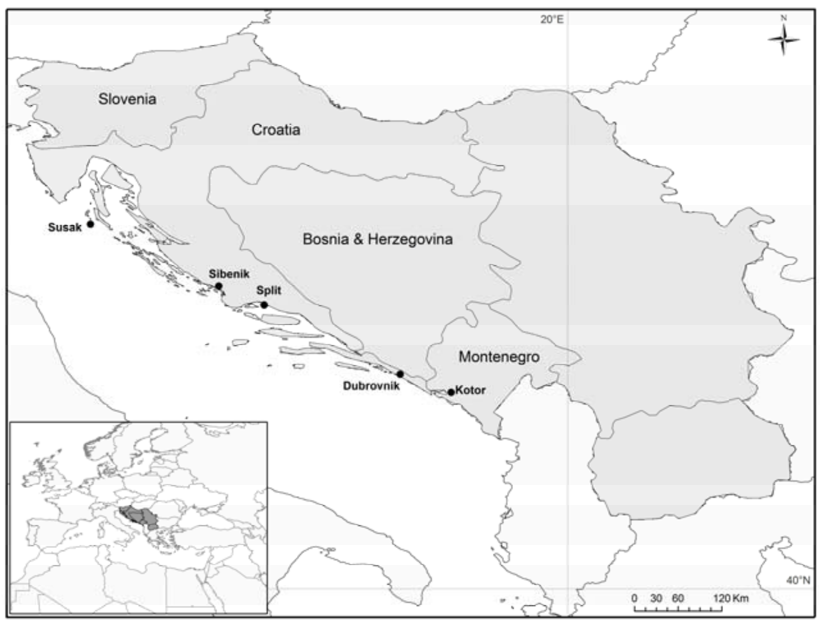

Figure 1. Map of the now independent republics of the former Republic of Yugoslavia, and the key ports of Susak, Sibenik, Split, Dubrovnik and Kotor.

[1] Cite as: Rizzo, Y. and Zeller, D. 2007. Country disaggregation of catches of former Yugoslavia. p. 149-155 *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches of key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia, Vancouver [ISSN 1198-6727].

and hence are of interest to this report: Slovenia, Croatia, Montenegro and Bosnia-Herzegovina. All have coastlines on the Adriatic Sea, which is part of the Mediterranean Sea (Figure 1).

The Adriatic is a semi-enclosed continental basin linked to the central Mediterranean at its southern end through a 72 km wide channel, the Strait of Otranto. On its western side, the Adriatic is flanked by Italy and the Apennine mountain range, and to the east are the western shores of the Balkan Peninsula. It is one of the most productive regions in the Mediterranean. The north-central sub-basins of the Adriatic are particularly productive across all trophic levels (Fonda Umani, 1996), due to both its shallow, continental nature and the high nutrient input through river outflows. It is estimated that the Po and other northern Italian rivers discharging into the Northern Adriatic supply about 20% of the nutrient input to the entire Mediterranean basin (Russo and Artegiani, 1996). The deeper, open waters of the southern Adriatic are less productive, and more typical of the Mediterranean as a whole (Fonda Umani, 1996; Russo and Artegiani, 1996).

Most resources of the Adriatic have been fished intensively for centuries. Pelagic and demersal stocks in the Adriatic are shared between the five surrounding countries. Small pelagics, in particular the European anchovy (*Engraulis encrasicolus*) and European pilchard (*Sardina pilchardus*), dominate catches and are caught by mid-water pelagic pair trawls and purse seines, the latter often using light attractions (Cingolani *et al.*, 2004a,b). The Eastern Adriatic small pelagic fishery still appears to be struggling, a result of an ongoing crisis in the fisheries sector of the countries of the former Yugoslavia (Cingolani *et al.*, 1996). Historically, sardines contributed the bulk of the catch of the Eastern Adriatic countries, and even today this species constitutes 85-90% of the marine fisheries landings of Slovenian and Croatian fisheries (Cingolani *et al.*, 2004a). Italy lands about 90% of Adriatic anchovy. Anchovy stocks declined dramatically in the late 1980s, the outcome of successive recruitment failures, and fishing and environmental pressures (Cingolani *et al.*, 1996). The stock has since partially recovered, although the current spawning stock biomass is only a fraction of the biomass before the collapse.

The bottom trawl fishery for demersal resources takes place over the entire Adriatic continental shelf. The main target species are European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), breams (*Pagellus* spp.), whiting (*Merlangius merlangus*), anglerfish (*Lophius* spp.), flatfish (*Solea* spp.), cephalopods such as *Eledone* spp., common cuttlefish (*Sepia officinalis*), and squid (*Loligo* spp. and *Illex* spp.), as well as Norway lobster (*Nephrops norvegicus*) and deepwater rose shrimp (*Parapenaeus longirostris*) (Vrgoc *et al.*, 2004).

Historical development of fisheries in the former Yugoslavia

Fisheries development on the western and eastern coasts of the Adriatic has been anomalous. Italy has one of the most developed fishing industries in the Mediterranean, including the Adriatic Sea. On the other hand, the fisheries of the Eastern Adriatic coastline are more typical of traditional Mediterranean fisheries, and consist of small-scale multipurpose vessels that mostly operate close to home-ports. In all coastal states of the former Yugoslavia, marine fisheries are technologically 'under-developed', particularly when compared with their western counterparts and despite having access to the same (fish) resources. Fishing vessels have been described as old and obsolete and fisheries are not professionally developed as other regions in the Adriatic, despite a long history of coastal fishing. The status of the fisheries sector in the countries of the former Yugoslavia may reflect the economic development of the region, which has been stifled throughout the centuries as a result of a history of foreign domination and conflicts. However, despite lacking economic importance at the national level, marine capture fisheries have been and still are very important to the coastal communities along the eastern Adriatic coast, as sources of revenue, employment, and hence social capital.

Howard *et al.* (1950) described the coastal marine and freshwater fisheries as well as fish and shellfish culture in the early 1930s in the then Kingdom of Yugoslavia (Table 1). Landings from freshwater fisheries in lakes and rivers were similar to marine landings, and included carp, pike, bream, roach, sturgeon, eels, mullets and trout. While the entire coast was exploited, the fleets were concentrated in five major districts: Susak, Sibenik, Split, Dubrovnik and Kotor (Figure 1). The fishing fleet was composed of over 6,000 vessels with a total tonnage of over 12,000 t. The total number of fishers between 1933-1939 was estimated at 19,000–29,500. Estimated yearly coastal landings from commercial fisheries between 1932 and 1939 ranged from 5,000-7,000 t. Migratory pelagic species, including sardines, anchovies, tunas and mackerels were the most important landed groups. Small pelagic landings supported a well developed coastal fish processing industry centered around Split. Small pelagics were caught using small lampara nets (lighted purse seines), while purse seining was introduced into the tuna fishery in the 1930s. Howard *et al.* (1950) also described two major forms of aquaculture: oyster mari-culture along the coast and pond culture. The latter was introduced in Yugoslavia in the early 20th century and developed very quickly into an important industry.

After WW II, the fishing industry of the former Yugoslavia remained small; however, landings increased steadily over the decades until the late 1980s, when the demise of the Federation of Republics contributed to a sharp decline in reported fisheries catches (Figure 2).

Following is a short description of the fisheries of the now independent countries that made up the coastal areas of former Yugoslavia.

Table 1. Landings for Yugoslavia during the pre WW II period (i.e., 1939), showing the relative importance of species groups in the catch (adapted from Howard *et al*., 1950).

Taxon	Landings (t)
Clupea pilchardus[1] and *C. papalina*[2]	2,500.00
Engraulis encrasicholus	79.43
Scombridae	512.81
Trachurus trachurus	103.50
Thynnidae	498.20
Smaris alcedo[3]	670.60
Mugillidae	204.24
Anguillidae	80.98
Crustacea	55.26
Lamellibranchiata	106.70
Cephalopoda	250.43
Total	**5,062.15**

[1] *Sardina pilchardus*. [2] *Sprattus sprattus sprattus*. [3] *Spicara smaris*

Croatia

Croatia is the most important coastal fishing country of the former Yugoslavia (Figure 3), and is second to Italy in the Adriatic in terms of landings of capture fisheries. Marine capture fisheries in Croatia dominate the fisheries sector and are more important than the smaller, freshwater/inland fisheries sector (Fredotovic and Misura, 2003). This is no surprise, given Croatia's extensive coastline and over 1,000 islands. There are about 150 fishing ports along Croatia's rugged coastline (AdriaMed, 2000). Large-scale industrial fisheries never developed in Croatia and, for the most part, fisheries are still small-scale, coastal and seasonal (Dulcic *et al*, 2005a). The vessels are on average around 40 years old, and have been described as obsolete and inefficient (Misura, 2002).

The 'professional' category is made up of 2,729 registered trawlers, seiners and smaller vessels that operate in the coastal and open waters of the Adriatic (Misura, 2002). The other category is the small-scale fishery in coastal waters up to a depth of 80 m. The number of licenses granted to small-scale fishers was up to 18,000 in 2004 (Dulcic *et al*., 2005a). There is no accurate estimate of the landings arising from this fishery. However, they may be substantial given the large number of fishers involved and the high productivity of the coastal zone. An estimate of this, as yet unaccounted catch of the small-scale fisheries will be provided at a later stage.

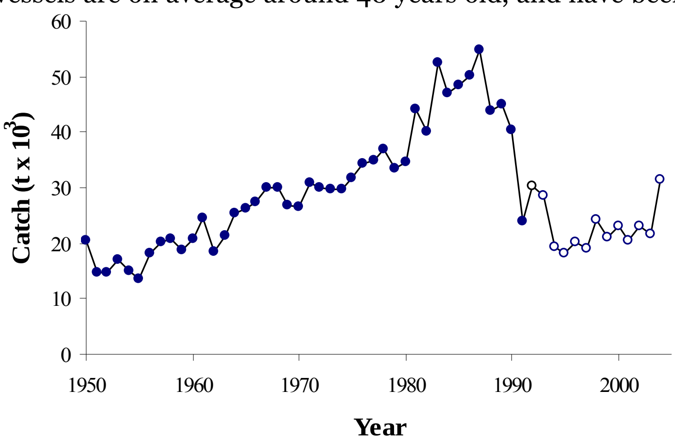

Figure 2. Total marine fisheries catch by the former Yugoslavia (closed circles, 1950-1991) and its component countries combined (open circles, since 1992). Data source: FAO FISHSTAT.

During the break-up of Yugoslavia and the ensuing violent conflicts, there was a substantial decline in the fisheries sector. The industry recovered somewhat in the 1990s, and the transition from socialist to market economy resulted in restructuring of the sector into small, privately owned enterprises (Fredotovic and Misura, 2003). The restructuring encompassed a redirection of the fishery from pelagic resources towards demersal resources which were considered to be underexploited. This led to the construction of more bottom-trawlers, until a ban was issued (Misura, 2002).

The growth in the fisheries sector slowed down after 1999, reflecting a general decreasing interest in the natural resource sectors, possibly offset by new tourism opportunities on the coast. Furthermore, average salaries for fishers are still very low and the industry is not very attractive for employment (Fredotovic and Misura, 2003). In a recent move to enhance the sector, the Croatian Government has proposed a strategy that seeks to improve fisheries management, double the aquaculture production of fish and shellfish within a decade, and revitalize the processing industry for small pelagics (Fredotovic and Misura, 2003; Marceta, 2003).

Slovenia

Slovenia has a coast in the Gulf of Trieste and borders Italy to the North and Croatia to the south (Figure 1). The southern limits of the territorial waters of Slovenia are still disputed with Croatia, and bilateral negotiations to define this boundary are ongoing (Sersic, 1992).

As in the other countries of the former Yugoslavia, marine and inland capture fisheries and aquaculture are only a small part of the country's economy (AdriaMed, 2000). Slovenia has a very short coastline and, therefore, inland fisheries and aquaculture are more significant than marine capture fisheries. Despite this, and unlike other countries of former Yugoslavia, Slovenia has developed industrial fisheries that exploit both coastal (although with declining catches, see Figure 3) and offshore international waters.

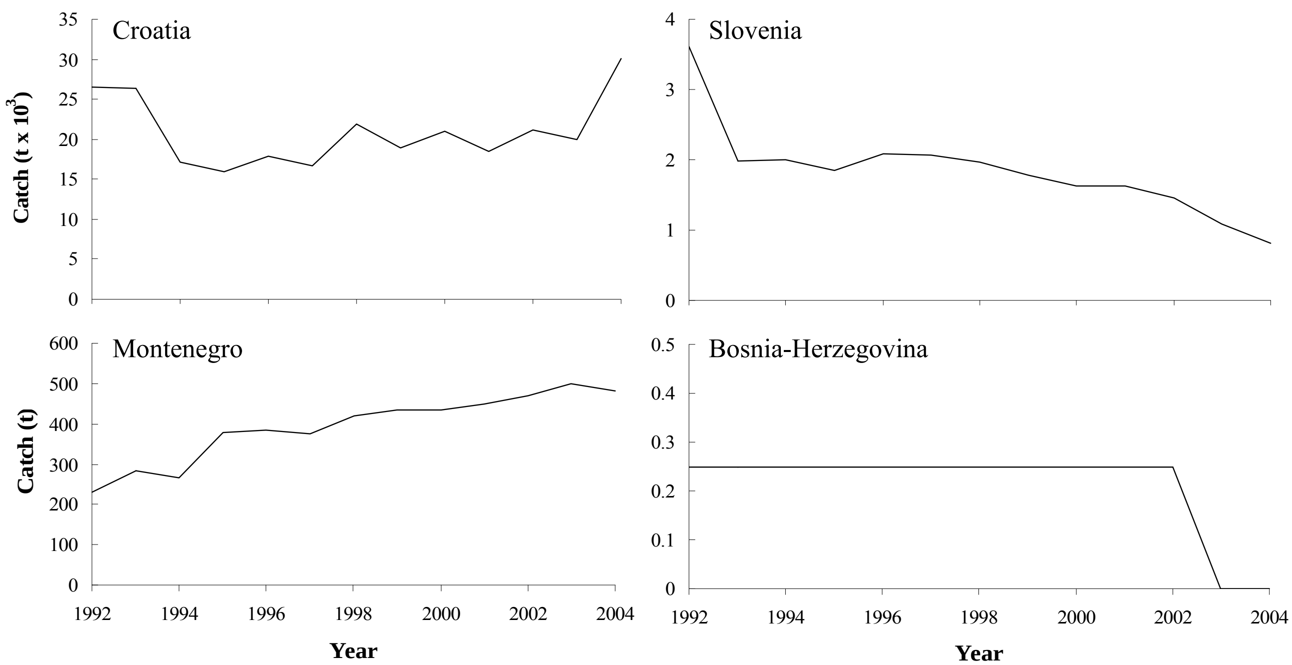

Figure 3. Marine catch trends based on FAO FishStat for the countries of former Yugoslavia after separate country reporting commenced in 1992. The catch from Bosnia-Herzegovina was reported as <0.5 t·year⁻¹, here taken as 0.25 t·year⁻¹. Note the variable Y-scale.

The official fishing vessel register for Slovenia for 2003 gives the number of vessels making up the marine fishing fleet as 100, ranging in length from 3–30 m. Registered fishing vessels include trawlers, gillnetters, purse-seiners and multi-purpose artisanal and small-scale industrial vessels. The number of small-scale vessels and their contribution to the total landings in Slovene marine fisheries is not comprehensively reported (Marceta, 2003). Pelagic fish including *Sardina pilchardus, Sprattus sprattus, Engraulis encrasicolus, Scomber scombrus, S. japonicus, Trachurus trachurus* and *T. mediterraneus* are predominant in the industrial catch and are caught in coastal and international waters. Demersal fish and cephalopod landings are important for the small-scale fishery. Aquaculture intensified since 1991. The species cultured are primarily European seabass *Dicentrarchus labrax* and gilt-head sea bream *Sparus aurata*.

Montenegro

Marine fisheries in Montenegro are very small (< 500 t·year^{-1}, Figure 3), but of higher significance than inland fisheries. The number of people employed in the sector was 168 in the year 2000. Landings are composed primarily of small pelagic fish and the fishery is small-scale and not well developed. The contribution of fisheries to the country's GDP is 0.07%; hence this sector does not contribute much to the country's economy.

Bosnia-Herzegovina

Bosnia-Herzegovina has a tiny coastline, and consequently, there is very little information available about the fisheries (mainly from www.nationsencycolpedia.com). There are no fishing ports and marine capture fisheries are very small and scattered. Since independent reporting started, Bosnia-Herzegovina has reported <0.5 t·year^{-1} (here taken as 0.25 t·year^{-1}, Figure 3), exclusively as 'miscellaneous marine fishes'. In contrast, there are significant landings from inland fisheries.

Materials and Methods

FAO reported landings (FAO Fishing Area 37, the Mediterranean and Black Sea) for marine fisheries from 1950-1991 for the former Yugoslavia were allocated to its component maritime countries: Croatia, Montenegro, Slovenia, and Bosnia-Herzegovina.

We adopted a method similar to that used to disaggregate landings for the former Soviet Union (see Zeller and Rizzo, this volume). Yugoslavia reported landings to FAO until 1991; separate reporting by its former republics commenced in 1992. As done for the former USSR, we assumed here that the distribution of landings between the four countries of the former Yugoslavia in the first few years of separate reporting reflected the proportion of total landings by each former republic prior to 1992. Thus, possible changes over time in the relative size of the fishing industry between regions were not considered.

We used landing data from FAO FishStat (FAO, 2004) from which we extracted the reported catches of marine taxa, excluding marine mammals, algae and other plants. Landings reported by FAO as <0.5 t were assumed to be 0.25 t.

For the FAO marine taxa reported by the former Yugoslavia from 1950-1991 (39 taxa from FAO Area 37), the proportion of catch $P_{i,l}$ of taxon i to be assigned to each of the four constituent countries l was calculated as the proportion of catch C each country reported over the 1992-1996 reference period j as[2]:

$$P_{i,l} = \sum_{j=1992}^{j=1996} C_{i,l} \Big/ \sum_{l=1}^{l=4} \sum_{j=1992}^{j=1996} C_{i,l} \qquad \text{...1)}$$

Therefore, catch CT reported by the former Yugoslavia for year y (1950-1991) was allocated to each of the l countries as:

$$C_{i,l,y} = P_{i,l} \times CT_{i,y} \qquad \text{...2)}$$

Results and Discussion

Overall, marine catches of the former republics of Yugoslavia declined substantially during and after the breakup of Yugoslavia (Figure 2). Catches appear to have stabilized at lower levels for at least two (Croatia and Montenegro) of the four now independent countries (Figure 3). By assuming proportionality of catches (based on the average of the first five years of separate reporting) between the post- and pre-breakup period, we were able to derive the likely distribution of the catches formerly reported as 'Yugoslavia', but taken by fishers from the constituent republics for the 1950-1991 period (Figure 4). This approach permits improved spatial allocation of catches as undertaken by the *Sea Around Us* project (www.seaaroundus.org).

It is worth noting that, in this disagregation method, each country is assigned a catch only for those taxa reported by the former Yugoslavia that it still reported after 1991 and for which the country had some catch before 2001. Consequently, 39 taxa were assigned to Croatia, 36 to Montenegro, 17 to Slovenia and only 1 taxon to Bosnia-Herzegovina. For detailed taxonomic catch breakdown, see www.seaaroundus.org.

Additional information and background material on the marine fisheries of former Yugoslavia can be found in Curtis (1990), Mannini and Massa (2000), Sinovcic (2000), AdriaMed (2002), Dulcic *et al.* (2005b), Brunner and Johnson (2006), and FAO (2006a,b).

[2] For the few taxa with no reported catch in the reference period, we used the catch from 1997-2001 for that taxon. Catches reported only after 2001 were assumed to originate from a new fisheries for the taxa and country in question, and was not used in the allocation.

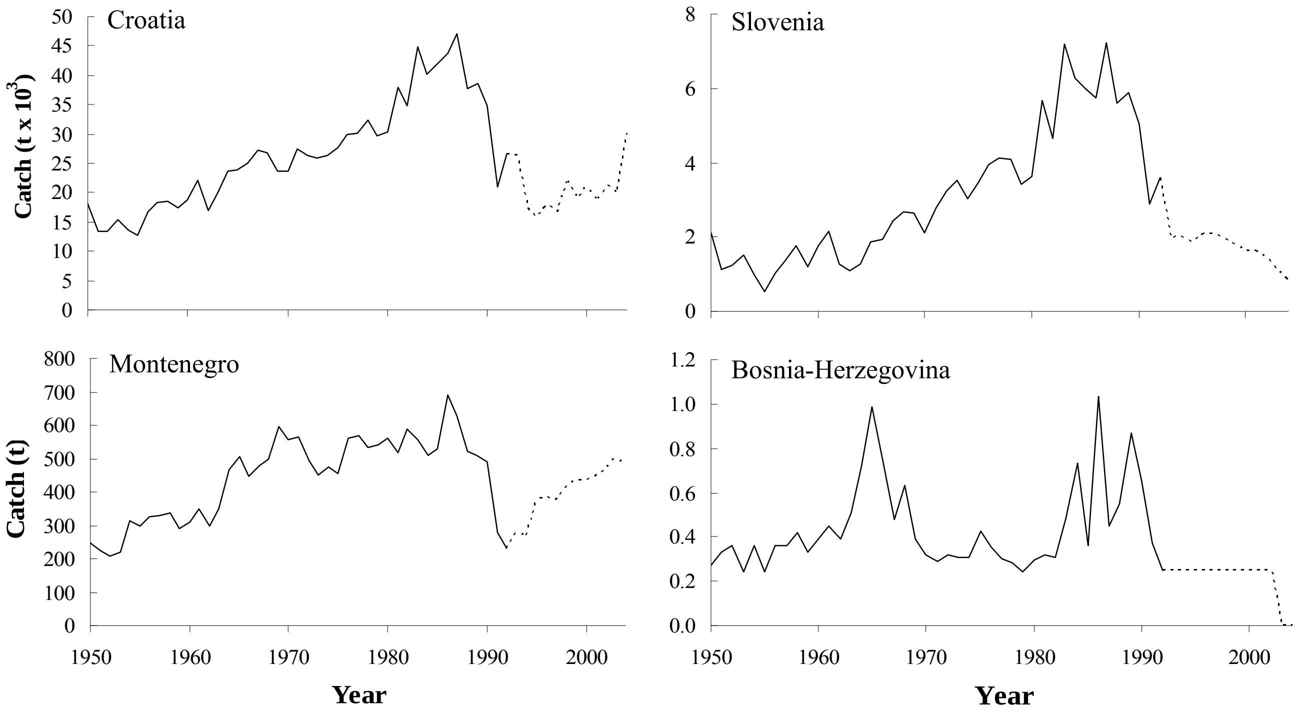

Figure 4. Marine fisheries catch for 1950-2004, disaggregated into the four now independent republics of the former Yugoslavia, for the period of combined data reported as 'Yugoslavia' (1950-1991, solid lines) and the subsequent separately reported period (since 1992, dashed lines).

Acknowledgements

We thank the Pew Charitable Trusts, Philadelphia, for its funding of the *Sea Around Us* Project.

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COUNTRY DISAGGREGATION OF CATCHES OF THE FORMER SOVIET UNION (USSR)[1]

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ABSTRACT

All now-independent republics of the former Soviet Union (USSR) collectively reported their catch from 1950-1987 as USSR landings to the Food and Agriculture Organization (FAO). After 1987, and leading up to the dissolution of the USSR, the previous component republics of the Soviet Union began reporting fisheries landings separately, with tonnage of reported catches having declined considerably. Here, we disaggregated the reported USSR marine fisheries catch from 1950-1987, and assigned USSR catches to the six former Soviet Union members that have marine fisheries (Georgia, Ukraine, Estonia, Latvia, Lithuania and the Russian Federation). We undertake this disaggregation by assuming proportionality of catches (based on the average of the first five years of separate reporting) between the post- and pre-dissolution period. We thus explicitly assume that fishing vessels were always affiliated with one of these six now independent former Soviet Union republics.

INTRODUCTION

In the fisheries landings database of the Food and Agriculture Organization of the United Nations (FAO FishStat), all now independent republics of the former Soviet Union (USSR) collectively reported their catch from 1950-1987 as USSR landings (Figure 1a). After 1987, in the years leading up to the dissolution of the USSR, Soviet Union republics began reporting fisheries landings separately, with tonnage of reported catches having declined considerably (Figure 1b). The since 1988 independently reported catches by FAO statistical areas for these republics (Figure 2) demonstrate the spatial reduction in distant water fleet fishing, especially by the Baltic countries (i.e., Estonia, Latvia and Lithuania), which have essentially ceased to fish outside of Atlantic waters (Figure 2c, d, e), while the Russian Federation's largest catches result from their North Pacific fleet based in Russia's Far East ports (Figure 2 a). Here, our goal was to develop and apply a method to disaggregate the reported USSR marine fisheries catch from 1950-1987, and assign it to the six republics of the former Soviet Union that have marine fisheries, i.e., Georgia, Ukraine, Estonia, Latvia, Lithuania and the Russian

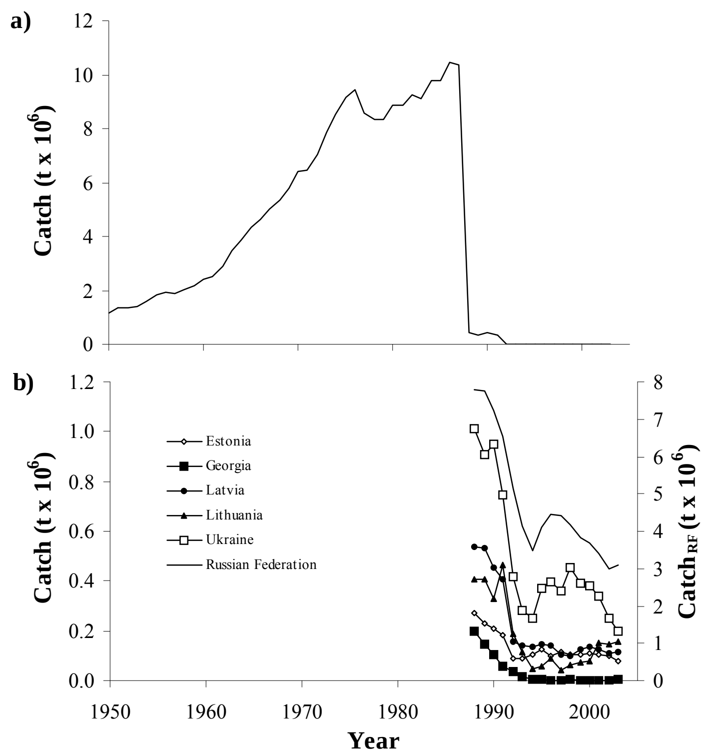

Figure 1. Marine fisheries landings reported by FAO on behalf of: a) USSR 1950-1991; and b) now independent former USSR republics 1988-2003. Note different scale for landings of Russian Federation (RF). Separate reporting commenced in 1988 for most fisheries, but not all (FAO, 2004).

[1] Cite as: Zeller, D. and Rizzo, Y.2007. Country disaggregation of catches of the former Soviet Union (USSR). p. 157-163 *In*: Zeller, D. and Pauly, D. (eds.) Reconstruction of marine fisheries catches by countries and regions (1950-2005). Fisheries Centre Research Reports 15(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Federation. We thus assumed that fishing vessels and fishers were always associated or affiliated with one of these six now independent former Soviet Union entities.

Furthermore, we made the assumption that, for each FAO statistical area, the distribution of landings between the six republics in the first few years of separate reporting approximated the distribution of USSR landings by former USSR republics in that FAO area prior to 1988. We acknowledge that this assumption may not accurately reflect historic developments of fishing fleets in these six republics, or temporal differences in expansion into FAO areas by each former USSR entity.

Here, we present the reported catch of the former USSR disaggregated to the six component republics, and report on the disaggregation method, which has also been used to disaggregate the historic catch data for former Yugoslavia (see Rizzo and Zeller, this volume).

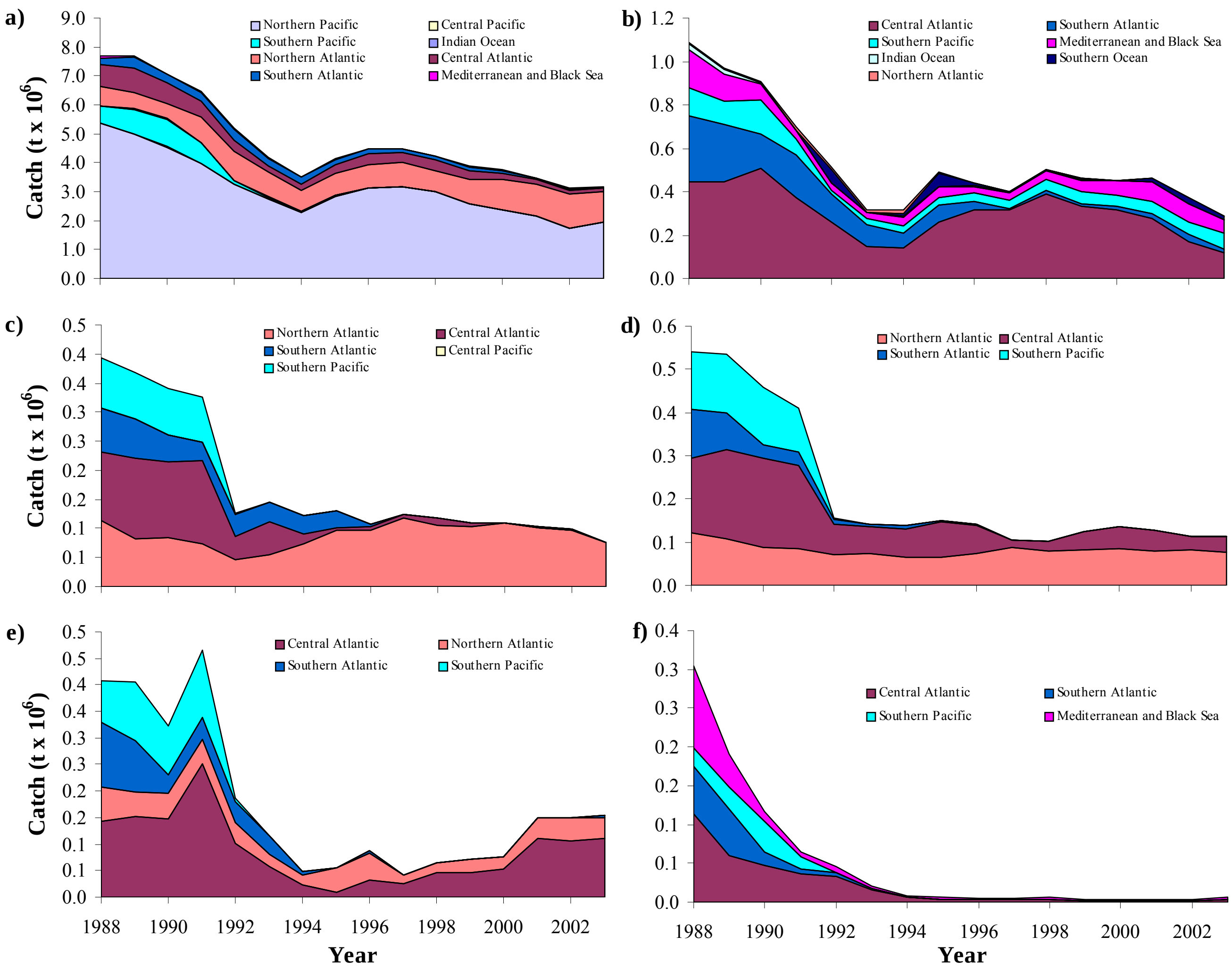

Figure 2. Catch by FAO statistical areas of the constituent republics of the former USSR, as separately reported since 1988 by a) Russian Federation, b) Ukraine, c) Estonia, d) Latvia, e) Lithuania, and f) Georgia.

Materials and Methods

The former USSR reported landings to FAO until 1991; however, separate reporting by its constituent republics (Georgia, Ukraine, Estonia, Latvia, Lithuania and the Russian Federation) commenced in 1988 (Figure 1b). Here, we assumed that, for each FAO statistical area, the distribution of reported landings between the component republics of the former USSR that fished in the first few years of separate reporting in the given FAO area reflected the proportion of total landings by these republics prior to 1988.

Thus, potential changes over time in the scale and size of the fishing industry between component republics in a given FAO area were not considered here.

We used landings data from the online version of FishStat available to us in late 2006 (FAO, 2004), from which we extracted the reported catches of marine taxa (based on the *Sea Around Us* Project [www.seaaroundus.org] commercial taxa database) for the USSR (1950-1991), and for the six component republics (1988-2003). Thus, we excluded freshwater species, marine mammals, algae and other plants. Landings reported by FAO as <0.5 t were assumed to be 0.25 t.

We first examined trends in total reported catch following separate reporting (starting 1988) and calculated the proportion each republic contributed to the total landings in each FAO area, averaged for a five year reference period 1988-1992. We based the proportions to assign to each republic on a period of five years, from 1988-1992, since reported catches immediately following separate reporting may likely be inaccurate. Thus

$$P_{k,l} = \sum_{j=1988}^{j=1992} C_{k,l} \;\Big/\; \sum_{j=1988}^{j=1992} C_k \qquad \text{...1)}$$

where $P_{k,l}$ is the average proportion of catch C in FAO area k reported by republic l in the reference years j (here limited to the reference period 1988-1992). We assumed that catch reported individually by republics only after 1992 constituted a new fishery or new target species that did not reflect catch composition from 1950-1987.

The resulting proportions of catch $P_{k,l}$ per FAO area for each republic are shown in Table 1. Countries whose reported catches accounted for less than 1% of total reported catch per FAO area for all republics combined for the period 1988-1992, were assumed not to have significant fisheries pre-1988 in that area and were excluded from the subsequent disaggregation of pre-1988 catches (note that the proportions for the remaining republics were adjusted to sum to unity).

The same concept was applied at the reported taxon level i as:

$$P_{i,k,l} = \sum_{j=1988}^{j=1992} C_{i,k,l} \;\Big/\; \sum_{j=1988}^{j=1992} C_{i,k} \qquad \text{...2)}$$

Subsequently, the catch CT by taxon i in FAO area k reported by the former USSR in year y (being 1950-1991) was allocated to each constituent republic l by FAO area k as:

$$C_{i,k,l,y} = P_{i,k,l} \times CT_{i,k,y} \qquad \text{...3)}$$

The following exceptions to our basic assumptions and rules applied:

i. For yellowtail flounder (*Limanda ferruginea)* in the Northwest Atlantic (FAO area 21), high landings were reported by three republics only after 1992, and we used these values to calculate republic allocations for USSR landings for this taxon in this area;

ii. Where USSR reporting extended beyond 1987 (i.e., into the early 1990s), the proportions to allocate to each republic were based on the catches for the period from the first year of individual reporting until 1992, and the USSR reported landings after 1987 were assigned to the Russian Federation;

iii. Some taxa reported by the USSR until 1987 disappeared from statistics after 1988. In such cases, the proportions of USSR catch to allocate to individual republics could not be calculated for these individual taxa. Instead, we used the percentage of the total catch each republic reported for that area (formula 1) to disaggregate the USSR data for these taxa; and

iv. USSR landings from the Arctic Sea (FAO area 18) were assigned to the Russian Federation exclusively (see Table 1). Note, however, that landings reported by FAO on behalf of the Russian Federation (and previously the USSR) for FAO area 18 are known to be substantial underestimates, and a correction has been proposed (see Pauly and Swartz, this volume).

Table 1. Sum total catch and proportions of total catch calculated for each republic in each FAO area for the 1988-1992 reference period. Landings of republics shown in bold represent less than 1% of the total catch from that area by all republics and were not allocated any former USSR catches in that FAO area for the 1950-1988 period.

FAO area code	FAO area name	Republic	Total reference period catch 1988-1992 (t)	Proportion of former USSR catch allocated
48	Atlantic, Antarctic	**Latvia**	**0**	**0.000**
		Russian Federation	103,617	0.651
		Ukraine	55,570	0.349
34	Atlantic, Eastern Central	Estonia	569,587	0.081
		Georgia	113,720	0.016
		Latvia	852,750	0.122
		Lithuania	794,814	0.113
		Russian Federation	3,093,377	0.441
		Ukraine	1,587,446	0.226
27	Atlantic, Northeast	Estonia	349,022	0.080
		Latvia	394,423	0.090
		Lithuania	160,817	0.037
		Russian Federation	3,426,332	0.784
		Ukraine	**40,697**	**0.009**
21	Atlantic, Northwest	Estonia	50,779	0.078
		Latvia	75,898	0.116
		Lithuania	83,682	0.128
		Russian Federation	443,484	0.678
		Ukraine	**0**	**0.000**
47	Atlantic, Southeast	Estonia	173,435	0.074
		Georgia	152,289	0.065
		Latvia	142,344	0.061
		Lithuania	192,174	0.082
		Russian Federation	957,875	0.411
		Ukraine	714,842	0.306
41	Atlantic, Southwest	Estonia	86,115	0.075
		Latvia	126,047	0.110
		Lithuania	142,432	0.124
		Russian Federation	507,071	0.441
		Ukraine	289,364	0.251
31	Atlantic, Western Central	Lithuania	368	0.302
		Russian Federation	849	0.698
58	Indian Ocean, Antarctic	Russian Federation	761	0.123
		Ukraine	5,446	0.877
57	Indian Ocean, Eastern	Ukraine	33	1.000
51	Indian Ocean, Western	**Georgia**[a]	**2,191**	**0.020**
		Lithuania	**353**	**0.003**

Table 1. Sum total catch and proportions of total catch calculated for each republic in each FAO area for the 1988-1992 reference period. Landings of republics shown in bold represent less than 1% of the total catch from that area by all republics and were not allocated any former USSR catches in that FAO area for the 1950-1988 period.

FAO area code	FAO area name	Republic	Total reference period catch 1988-1992 (t)	Proportion of former USSR catch allocated
		Russian Federation	47,713	0.437
		Ukraine	59,018	0.540
37	Mediterranean and Black Sea	Georgia	175,268	0.219
		Russian Federation	183,830	0.230
		Ukraine	439,768	0.550
88	Pacific, Antarctic	Russian Federation	0	1.000
77	Pacific, Eastern Central	**Estonia**	**0**	**0.000**
		Lithuania	8,991	0.571
		Russian Federation	6,686	0.425
		Ukraine	**68**	**0.004**
67	Pacific, Northeast	Russian Federation		1.000
61	Pacific, Northwest	Russian Federation	22,409,650	0.999
		Ukraine	**12,248**	**0.001**
87	Pacific, Southeast	Estonia	302,634	0.069
		Georgia	102,039	0.023
		Latvia	471,459	0.108
		Lithuania	387,632	0.088
		Russian Federation	2,673,831	0.610
		Ukraine	444,269	0.101
81	Pacific, Southwest	Estonia	21,346	0.033
		Georgia	**3,110**	**0.005**
		Latvia	34,991	0.053
		Lithuania	26,878	0.041
		Russian Federation	531,346	0.811
		Ukraine	37,888	0.058
71	Pacific, Western Central	Russian Federation	32,382	1.000

[a] Catches of Georgia in the Western Indian Ocean were reported only for 1988 and the country was assumed to have no fisheries there prior to 1988.

Results and Discussion

Using the method outlined and applied here, we suggest that the disaggregated reported catch for the former USSR and now independent republics may more reliably illustrate the potential contribution each former member of the USSR made to its globally reported catches during the 1950-1991 period (Figure 2). As expected, the Russian Federation dominated total catches throughout the period, with assigned catches peaking at just over 8 million t in the late 1980s (Figure 3a), followed by the Ukraine, whose assigned catches peaked at just over 1 million t (Figure 3b).

We emphasize that the present, assigned landings data are approximate values (by republic) based only on landings reported by FAO on behalf of the former USSR between 1950 and the early 1990s. Thus, these data do not, currently, account for IUU (Illegal, Unreported and Unregulated) catches. The area- and republic-specific catches as derived here for the disaggregated former USSR will be integrated into the spatially allocated global catch database of the *Sea Around Us* Project, and will be available on the project website in 2008 (www.seaaroundus.org). As part of this integration, the presently assigned catches for Estonia for the Baltic Sea (part of FAO area 27) will be corrected based on the previous reconstruction for this area by Ojaveer (1999).

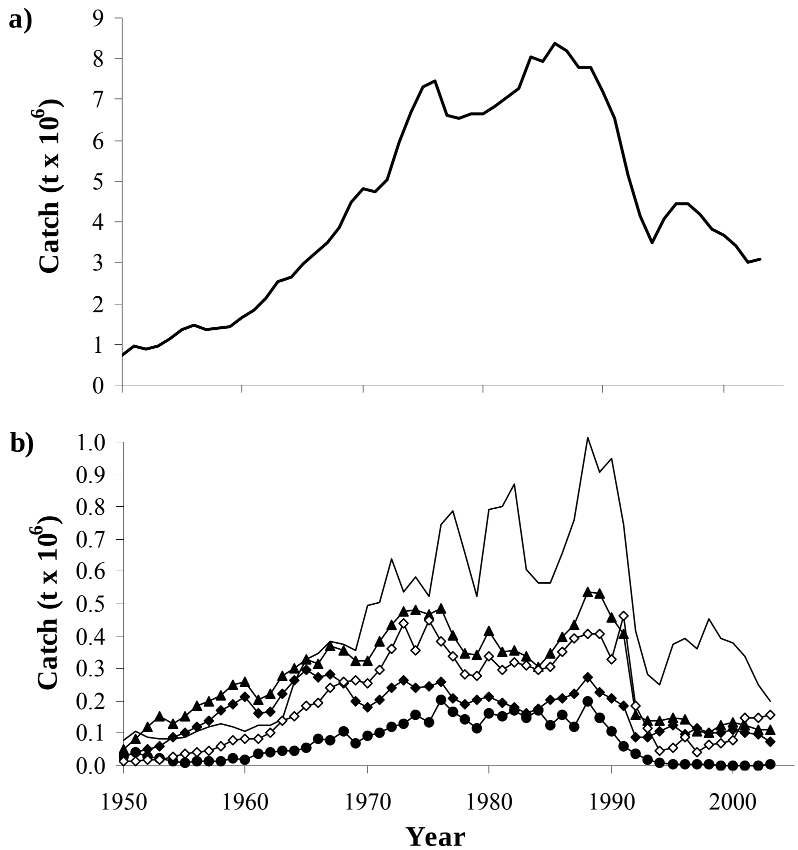

Figure 3. Disaggregated marine fisheries catch for the now independent countries of the former USSR: a) Russian Federation; and b) Lithuania (◊), Latvia (▲), Estonia (♦), Georgia (●), and Ukraine (thin line). Note differences in scale.

As a final note, we emphasize that the present data do not proclaim to be 'true' in terms of republic assignment over time. However, by using our assumption-based allocation approach to assign historic catches to country entities enables full time series to be derived for each now-independent republic of the former USSR. This will permit better evaluation of historic fisheries development and country specific trends in fisheries to be derived and evaluated, using only former USSR data for the pre-1988 period, which is currently not possible. Thus, the data as derived here should be considered as a move towards the likely 'true' country-specific patterns and trends over time.

Acknowledgements

We thank the Pew Charitable Trusts, Philadelphia, for funding the *Sea Around Us* Project.

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