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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 Exclusive 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.

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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).

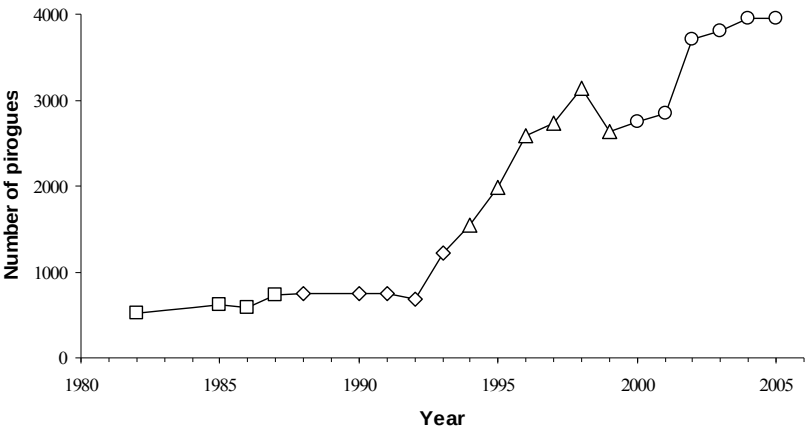

Figure 1: Pirogues number in Mauritania. Based on data from: □ Josse (1989); ◇ FAO-CNROP (1995); Δ Inejih *et al.* (2004); o Boncoeur *et al.* (in press). Data for 1983-84 were interpolated. Annual pirogue numbers are averaged for the two surveys per year.

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

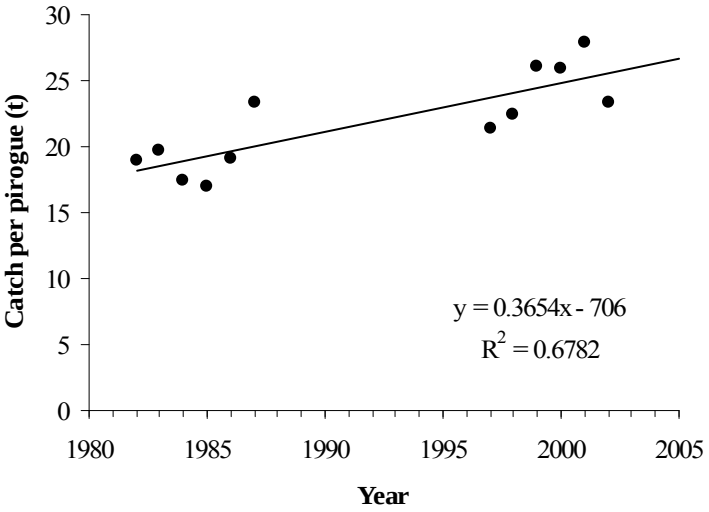

Figure 2: Trend in the mean annual catch per pirogue of the artisanal fishery in Mauritania.

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.

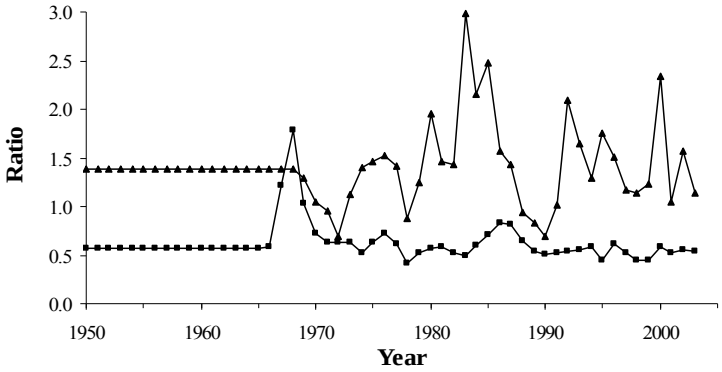

Figure 3: Ratio between our estimates and previous estimates based on FAO data and surface area ratios. Values from 1950 to 1965 (■ demersals) or to 1968 (▲ pelagics) have been fixed to the 1980-2003 and 1979-2003 means, respectively.

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.

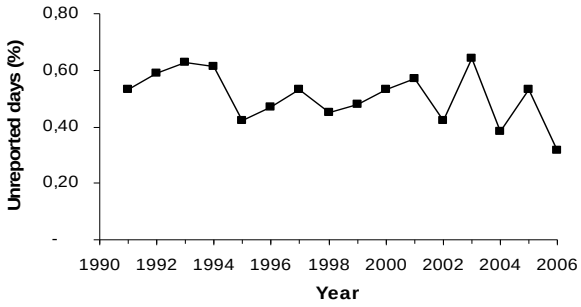

Figure 4: Proportion of days during which pelagic industrial vessels are allowed to fish but declare no catch

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.

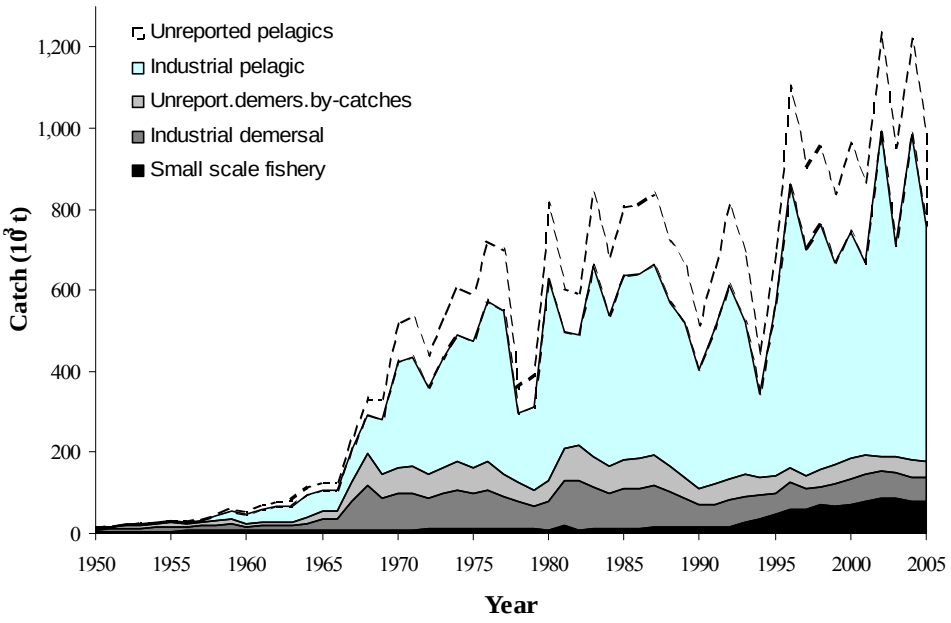

Figure 5: Trends in the catches of fisheries operating in the waters now encompassing the Mauritanian EEZ: reported catches and unreported by-catch of the industrial sector.

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).

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,

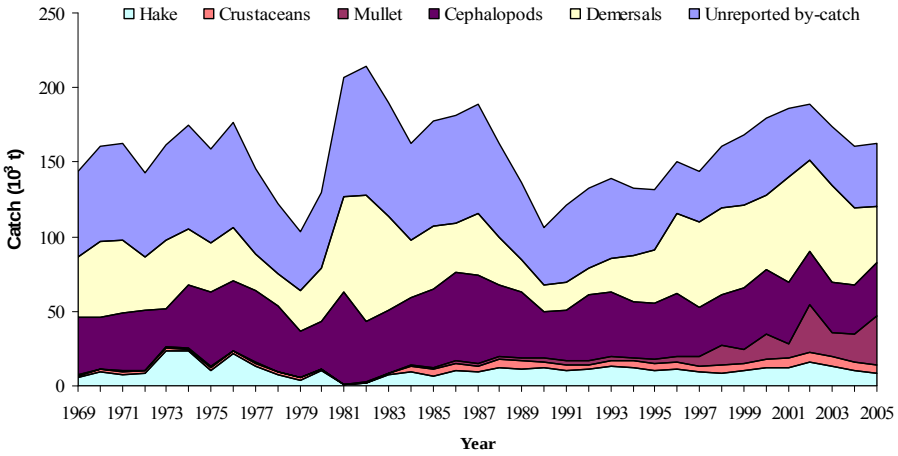

Figure 6: Trends in Mauritanian demersal catches by species group and unreported by-catch.

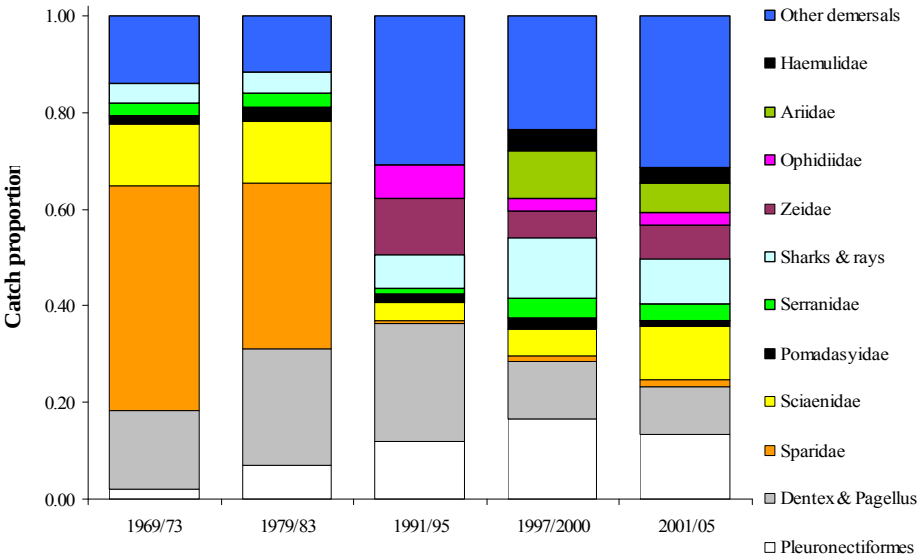

Figure 7: Taxonomic composition of demersal fish catches in Mauritania by time periods.

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}.

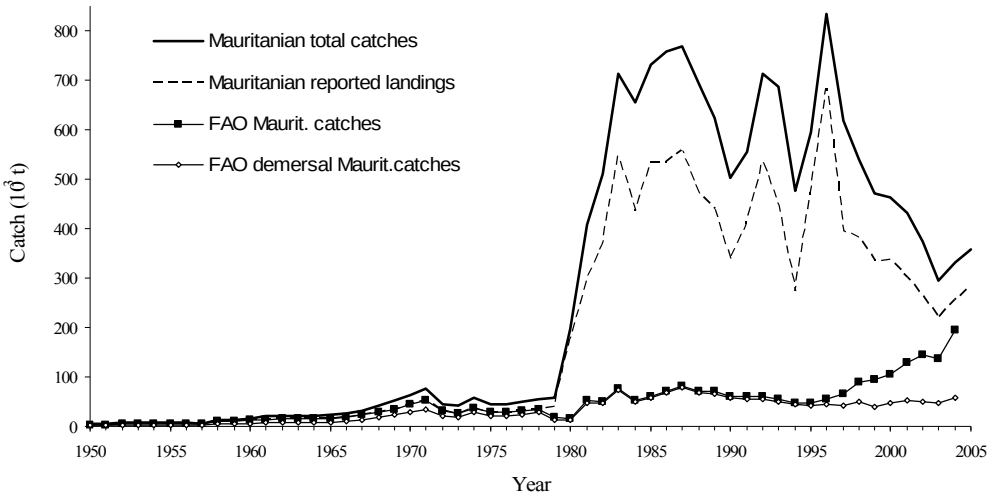

Figure 8: Mauritanian national catch trends as derived by the present study, and comparison to FAO data as reported by Mauritania.

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).

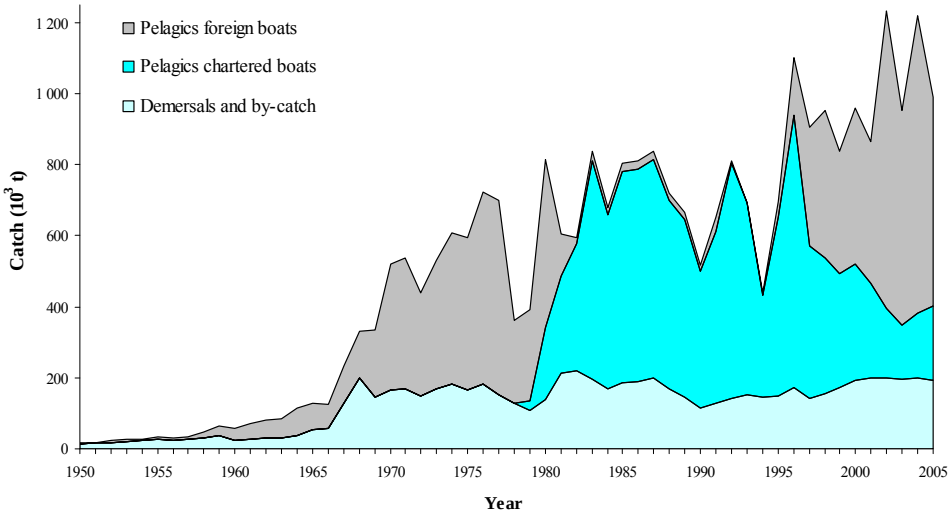

Figure 9: Catch trend in Mauritanian waters, illustrating the importance of 'charter' boats for pelagic catches during the 1980s and 1990s (unreported included).

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.

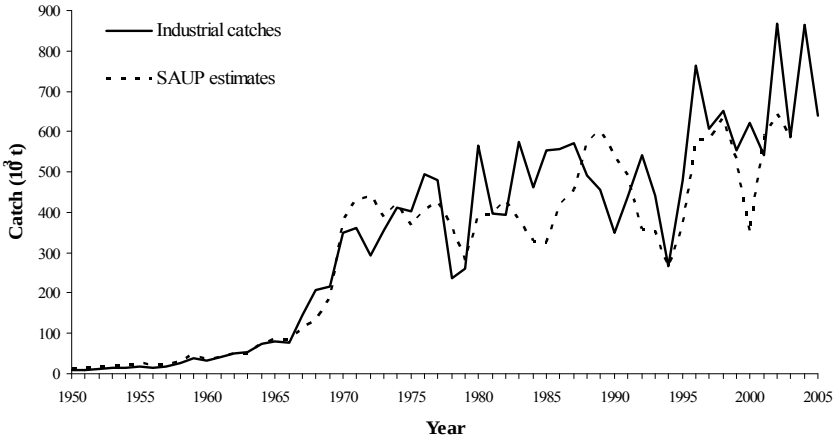

Figure 10: Comparison between present estimates for Mauritania and *Sea Around Us* project allocation of catches to Mauritanian waters.

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].

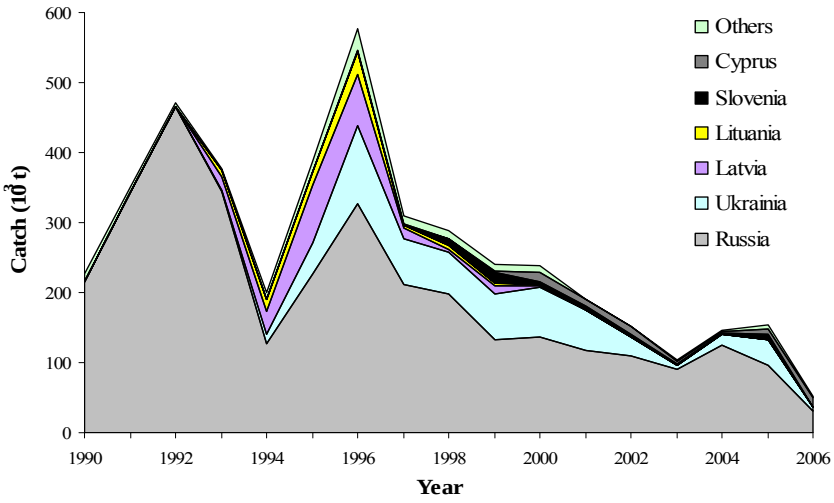

Figure 11: Catches of pelagic species by the chartered boats in the Mauritanian EEZ (data from IMROP database).

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.

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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