

PRELIMINARY ESTIMATION OF REALISTIC FISHERIES REMOVALS FROM MAURITANIA, 1950-2010¹

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ABSTRACT

Mauritania enjoys large fisheries resources, exploited by an important domestic small-scale sector and industrial fleets operated mainly by foreign countries. Total marine fisheries catches by Mauritania were estimated from 1950 to 2010, including commercial landings, subsistence, illegal and unreported domestic catches, as well as catches by non-Mauritanian legal and illegal fleets. Commercial landings were obtained from FAO fisheries statistics database and from the Mauritanian Institute of Oceanography and Fisheries Research (IMROP) for both domestic and foreign fleets. Non-commercial data were obtained from field surveys and grey literature, which were converted to per capita rates and catch per unit of effort estimates using population data. Illegal catches and discards were estimated using recent at-sea observer data, collected by IMROP expanded to cover the 1950-2010 time period. Total reconstructed catches were estimated to be 72.1 million tonnes over the study period, increasing from 59,400 t·year⁻¹ in 1950 to a peak of 2.3 million t·year⁻¹ in 1976, and then decreasing to 1.9 million t·year⁻¹ in 2010, and were overwhelmingly by foreign fleets. Domestic catches were reconstructed to be three times as high as official landings data reported by Mauritania, with 11.8 million t compared to 3.9 million t reported to the FAO. In addition, we noted that catches, including illegal catches, from the Banc d'Arguin National Park, an important marine protected area, were twice as high as official landings. This poses questions about protection of the park area. The data presented here are preliminary, and will be improved using local expertise.

INTRODUCTION

Mauritania is located in Northwest Africa, and is member of the Committee for the Eastern Central Atlantic Fishery (CECAF) and the Sub-Regional Fisheries Commission (SRFC) of the West Africa sub-region created in 1985 (FAO 2002). The waters off Mauritania are influenced by upwelling systems and the Canary island current which stimulates high levels of marine resource productivity (M'Barek and Mahfoudh 1995; Campredon and Cuq 2001). This makes these waters some of the richest fishing grounds in the world (Goffinet 1992).

Fisheries in Mauritania have been historically the subject of exploitation by foreign fleets, particularly from Europe (Gascuel *et al.* 2007). After the independence from France in 1960, it took almost 20 years for Mauritania to implement its first fisheries policy 'nouvelle politique de pêches' adopted in 1979 (Ould Cheikhna *et al.* 2005), shortly after the government declared the Mauritanian EEZ, and promoting nationalization of catches, artisanal fisheries development and monitoring with the first fisheries landings surveys in the 1980s (Bakhayokho *et al.* 1988). In 1994, a monitoring body was created to enforce fisheries legislations (Anon. 2002a).

There are two distinct fishing sectors active in Mauritanian waters. The industrial (large-scale) sector is operated almost exclusively by foreign fleets under fishing access agreement or joint ventures (Josse and Garcia 1986), and more recently flags of convenience. This sector directs the vast majority of catches to the international market (UNDP 2001). The artisanal sector mainly operates canoes under 12 m long, pirogues and Tarifian purse-seine boats of 14 to 15 m (Josse and Garcia 1986). Small-scale fishing was largely aimed for subsistence until the 1980s (Nancy 2010). It was a seasonal activity, where fishers were often migrating to follow moving fish stocks (Campredon and Cuq 2001).

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This activity, historically operated by the Imraguen and N'Diogo populations (Sall and Thioye 2006), had the main purpose of sustaining fishers and their families, and mainly targeted grey mullets for the Imraguen (Bakhayokho *et al.* 1988; Sall and Thioye 2006) and mainly groupers, mullets, sardinellas, blackspot seabreams for the N'Diogo (Sall and Thioye 2006).

In 1958, the urbanization of coastal cities attracted agricultural populations to part-time fishing practices (Marfaing 2005). Furthermore, in the south of Mauritania, N'Diogo fishers were fishing for subsistence following the same pattern than the Imraguen in the North until the mid-1980s (Trouillet *et al.* 2011). Subsistence fishing decreased thereafter and gradually shifted to commercial cephalopod fishing for the N'Diogo fishers (CMAP 2010) and shark fishing for the Imraguen (Anon. 2002b) along with the industrialization of the artisanal fleet and fisheries harbours in Nouadhibou and Nouakchott. This marketing pattern, along with climate change, and droughts in the 1970s and the 1980s in the Sahel area, contributed to increased migrations towards the coast of Mauritania (Tacko Kandji *et al.* 2006), thus increasing fishing pressure on coastal areas and the dependence of the Mauritanian population on seafood. At the same time the number of pirogues increased from less than 500 in the 1970s to more than 2,000 in the 1990s and about 4,000 in recent years.

Artisanal fishing is particularly important because of its contribution to food security in Mauritania (Lenselink 2004). Imraguen traditional fishing communities depend directly on fish for their livelihood. These communities have the exclusive fishing rights in the Parc National du Banc d'Arguin (Picon 2002), the largest marine protected area in Africa stretching along the Mauritanian coast from Cape Blanc to Cap Timiris (Campredon and Cuq 2001). This park was created in 1976 and stretches along about a third of the Mauritanian coast. Designated as a Ramsar Convention Wetland site in 1982, and considered as a 'gift to earth' in 2001 by the United Nations (UNEP 2011), the PNBA is particularly important because it represents the main spawning ground for many commercially important and endangered species (Boëly *et al.* 1979; Troadec and Garcia 1980; Jager 1993).

Over almost half a century, fishing pressure on the coastal areas, the extent of foreign fishing and a lack of reliable catch data created serious concerns over the Mauritanian resources sustainability, which is not an exception in Western Africa (Goffinet 1992). This, along with a high corruption profile and a low governance rate (MRAG 2005) frames a perfect opportunity for overfishing and under-reporting by the industrial fleet, and overcapitalization by the domestic artisanal fleet (Goffinet 1992; Agnew *et al.* 2010). Furthermore, of a total population of 3.3 million in Mauritania, 1.5 million is dependent on fishing (Ould Mohamed Vall 2004; Anon. 2011), especially in the northern maritime areas where communities livelihood is based almost entirely on this activity, with no other opportunities apart from fishing (Njock 2007). Hence, reconstructing fisheries catches would enhance chances for better management, as required for poverty reduction and food security. This study will update the reconstruction of Mauritanian catches by Gascuel *et al.* (2007), including the under-reported catches, as well as unreported artisanal catches. It will also provide the first comprehensive estimate of the Imraguen fisheries catch being an important subsistence and traditional activity for the Imraguen population, and the total removals from the Banc d'Arguin National Park (PNBA), which is itself of significant importance for West African fish stocks (Lefeuvre 2007).

METHODS

Electronic time series of reported landings data from 1950 to 2010 were available and used in this study. In addition, we used data available from Gascuel *et al.* (2007), and unpublished data from the Mauritanian Institute of Oceanographic and Fisheries Research (IMROP) covering the period 1990 to 2005, and statistical time series covering the period from 2004 to 2010 (Kane Élimane 2011). Reported landings are distinguished by species or higher taxonomic grouping and 'miscellaneous groups'. Since the main goal of this study is to estimate the total catches per species or higher taxonomic group, we used previously reconstructed data (Gascuel *et al.* 2007) as a more comprehensive baseline for foreign fishing, and FAO data as a reported baseline for artisanal fishing, to which we added: (1) illegal, unreported, and unregulated commercial catches; (2) non-commercial catches; (3) discards; and (4) illegal foreign flag catches.

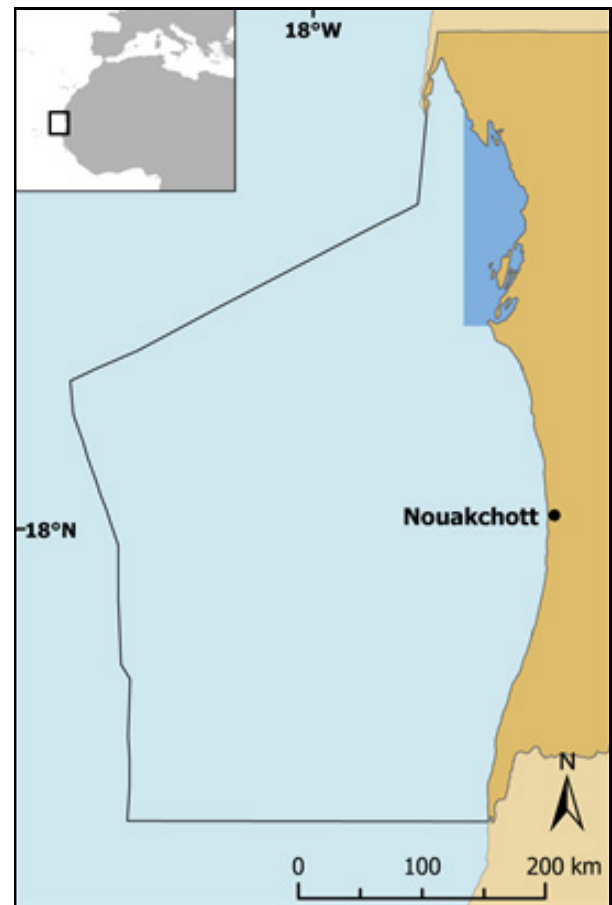


Figure 1. Map of the Mauritanian Exclusive Economic Zone highlighting the Banc D'Arguin National Park.

This reconstruction is tentative and an improved version, including official data from IMROP and additional input from IMROP experts will be produced later. In the meantime, we hope that this contribution may serve as a place-holder, as it broadly identifies the catch in the Mauritanian EEZ.

Artisanal catches

Fishing effort surveys conducted by IMROP started along the coast of Mauritania in 1982 and have been expanding to cover most of the coast since 1985 (Ferraris and Chaboud 1995). While the number of pirogues was believed to be estimated fairly well since that period (based on two surveys performed each year in all the Mauritanian fishing camp sites), artisanal catches were monitored by IMROP only in Nouakchott and Nouadhibou from 1981 to 1992 (Josse and Garcia 1986; Josse 1989; Failler *et al.* 2004), and expanded to cover the north area and Nouakchott from 1993 to 1997, and the PNBA and the central areas from 1997 onward (Labrosse *et al.* 2010). These surveys were based on samples taken by IMROP observers twice a week, directly when pirogues arrived on the beach (Chaboud and Ferraris 1995).

To conservatively estimate artisanal catches, we first assembled anchor points for the number of pirogues and the observed CPUEs, reported at two landings sites, for the 1980s and 2000s. We interpolated the number of pirogues to complete the time series from 1950 to 2005 (Table 1). We estimated the geometric mean for the CPUEs observed at both landing sites (Table 2), then performed an extrapolation back and forward to complete the time series. We multiplied the number of pirogues by the annual CPUE, which is the overall average – regardless of the number of fishing days – and estimated the artisanal catch between 1950 and 2005, then added to the officially IMROP recorded data 8% of artisanal unreported catches, which represents the general rate of under-reporting estimated by MRAG (2005) from 2005 and 2010. Our method is conservative, since catches are based on effort data that are known to be fragmentary and started covering the entire coast after the 1980s (Bakhayokho *et al.* 1988). The fishing efficiency of pirogues is known to have strongly increased over time, especially due to the motorization of pirogues in the 1970s, but also to the introduction of ice, more efficient gear and more recently electronic devices (such as GPS). At the same time, the decrease in resources abundance is also well documented (Christensen 2005; Gascuel *et al.* 2007). This compensated for the increase in CPUE caused by the increasing fishing technology, which here translated into a slow decline as observed.

Artisanal catches in the PNBA

In the Banc d'Arguin waters, fishing for flathead grey mullet (*Mugil cephalus*) by the nomadic Imraguen population has been described since the 15th century mainly for subsistence (Picon 2002). These fishers developed a rudimentary, but unique land-based fishing technique using a net on a wooden stick fishers carried on their shoulders (Anon. 2002b; Bernardon and Ould Mohamed Vall 2004). This selective technique, combined with traditional territorial fishing rights per village and seasonal closure of the fishery (Picon 2002; Bernardon and Ould Mohamed Vall 2004), was a recipe for durability.

Imraguen fishers started using small wooden sailing boats introduced by Canarian fishers, in the early 1950s. This, along with growing commercial interest, intensified fishing for mullets and meager (*Argyrosomus regius*) which developed quickly in the 1950s (Anon. 2002b; Picon 2002) and for shark fins from 1980 to 2003, when this fishery was banned in the park area (Diop and Dossa 2011). This activity was practiced in the Parc National du Banc d'Arguin, created in 1976, where Imraguen maintain exclusive fishing rights, as well as north up to Villa Cisneros and south to Cape-Timiris (Lotte 1937).

From 1950 to 1980, the establishment of fishing villages South of Cape Timiris (Chaboud *et al.* 1988) contributed to increasing fishing effort and capacity. Imraguen catches, as part of the total artisanal catch, were grossly under-reported before 1985 (Bakhayokho *et al.* 1988; Trouillet *et al.* 2011) and are still under-estimated (Failler *et al.* 2002). Therefore, we estimated Imraguen catches as a portion of the artisanal catch to have an estimate of the total removals from the PNBA area, and to be able to determine unreported catches taken by Imraguen from the park

Table 1. Anchor points representing the number of pirogues operating in Mauritania between 1950 and 2010.

Year	Pirogues	Source
1950	125	Chavance 2004
1982	519	IMROP unpublished data
1985	622	IMROP unpublished data
1986	580	IMROP unpublished data
1987	735	IMROP unpublished data
1988	703	IMROP unpublished data
1989	748	IMROP unpublished data
1990	763	Inejih <i>et al.</i> 2004
1991	785	Inejih <i>et al.</i> 2004
1992	729	Inejih <i>et al.</i> 2004
1993	1,263	Inejih <i>et al.</i> 2004
1994	1,565	Inejih <i>et al.</i> 2004
1995	2,295	IMROP unpublished data
1996	2,842	IMROP unpublished data
1997	2,728	IMROP unpublished data
1998	3,142	IMROP unpublished data
1999	2,640	IMROP unpublished data
2000	2,750	IMROP unpublished data
2001	2,850	IMROP unpublished data
2002	3,700	IMROP unpublished data
2003	3,800	IMROP unpublished data
2004	3,950	IMROP unpublished data
2005	3,950	IMROP unpublished data

Table 2. CPUE anchor point used for the extrapolation of the average CPUE per pirogue ($t \cdot \text{pirogue}^{-1} \cdot \text{year}^{-1}$) in two areas of Mauritania.

Year	Nouadhibou	Nouakchott	Total
1982	17.7	18.3	-
1985	33.6	14.7	-
1986	39.9	18.0	-
1987	45.7	26.5	-
1998	-	-	22.5
1999	-	-	26.1
2000	-	-	25.9
2001	-	-	27.9
2002	-	-	23.4

area. Surveyed catch data time series were available only recently, i.e, since 1997 (Bernardon and Ould Mohamed Vall 2004; Kane 2012 unpub. data).

Therefore, to reconstruct Imraguen catches, from 1950 to 1993, we combined CPUE estimates for land-based fishers with the number of land-based fishers, and CPUE estimates for boats with the number of boats. We conservatively assumed the catch per land-based fisher in the 1950s and 1960s was 80% of the 1980s catch per land-based fisher of 8.5 t·year⁻¹·fisher⁻¹ (Bakhayokho *et al.* 1988), i.e., 6.8 t·year⁻¹·fisher⁻¹. The catch per boat in 1959 was estimated at 55.3 t·year⁻¹·boat⁻¹, by dividing the catch of 700 t·year⁻¹ of dried fish (Ould Mohamed 2010), converted to wet weight using a conversion factor of 2.37 (FAO Fishstat) by the effort of 30 boats in 1959 (Ould Mohamed 2010). The catch

Table 3. Anchor points representing the population of Imraguen in the PNBA equivalent waters.

Year	Land-based CPUE	Source	Fishers	Source	Boat-based CPUE	Source	Boats	Source
1950	6.8	Assumption ^a	461	Estimated	N/A	N/A	0	Assumption
1960	6.8	Assumption ^a	400	Anthonioz (1967)	55.3	Assumption ^a	31	Anthonioz (1967)
1970	8.5	Bakhayokho <i>et al.</i> (1988)	164	Assumption	49.2	Interpolated	73	Picon (2002)
1980	8.5	Bakhayokho <i>et al.</i> (1988)	125	Assumption	43.1	Interpolated	95	Estimated
1997-2010	Between 1997 and 2010, surveyed catch data were available and directly used.							

a) assumed to be 20% lower than the estimate provided by Bakhayokho *et al.* (1988).

b) assumed to be 10% higher than estimate provided by Chaboud *et al.* (1988).

per boat in 1988 was estimated based on Chaboud *et al.* (1988) at 38.2 t·year⁻¹·boat⁻¹ (Table 3). In 1950, when fish were exclusively caught by land-based fishers, the number of land-based fishers² was derived to be 461. In 1960, 31 boats and 400 land-based fishers were operating (Anthonioz 1967). In 1970, 73 boats were operating (Maigret 1970 in Picon 2002) employing 4.5 fishers on average (Anthonioz 1967) for a number of 164 land-based fishers, assuming the number of land-based fishers was proportionally half the number of boat-based fishers, as the use of boats was increasingly attractive for the Imraguen (Table 3). We applied the same method for 1980, when 95 boats were operating for 125 land-based fishers, i.e., a third of the number of boat-based fishers. We interpolated CPUE estimates and the corresponding effort linearly from 1950 to 1980, which we multiplied to estimate the total Imraguen catch per year. Thereafter, we performed a linear interpolation from the estimated catch in 1980 to the surveyed catch of 1,000 t·year⁻¹ in 1997 (Bernardon and Ould Mohamed Vall 2004).

Subsistence catches

Subsistence fisheries in Mauritania comprise: (1) Imraguen subsistence catches in the PNBA including catches given or shared as almsgiving, Neerane, fish offered to people who help landing catches; and Ndawal, catches offered to retired fishers who can't operate anymore (Chaboud *et al.* 1988), and (2) N'Diago subsistence catches.

Imraguen subsistence catches

Inside the PNBA, Imraguen fishing from June to September was mainly for subsistence, while mullets fishing (from October to January) and meager (from January to June) was partly commercial (Josse and Garcia 1986). Outside the PNBA, Imraguen historically fished for subsistence during the wet season from August to January (Murray-Lee 1987). To estimate subsistence catches in the PNBA, we first aggregated available data on Imraguen population from 1,500 in 1950 to 1,800 in 1960 (Picon 2002), and then to 2,750 on average from 2001 to 2010 (Anon. 2002b), which we interpolated to complete the time series. For 1978, Doucet *et al.* (1981) estimated a total Imraguen catch of 7,000 t·year⁻¹, which were referred to as being for subsistence (Doucet *et al.* 1981). However given the nature of Imraguen catches, this number is more likely to include both subsistence and artisanal catches. Subsistence catch here is not defined as the consumption per capita, since part of the subsistence catch is sold to markets outside the PNBA, this rather shows both the consumption of the Imraguen population and catches that are taken by the Imraguen and sold informally. Therefore, the difference between the latter and the estimated artisanal catch represents the subsistence catch of the Imraguen population for 1978, i.e., a subsistence catch of 1,981 t·year⁻¹. The subsistence catch divided by a total interpolated Imraguen population of 2,217 landed a per capita catch of 0.89 t·capita⁻¹·year⁻¹ for 1978. We assumed this consumption rate (including Neerane and Ndawal) was 10% higher in 1950, i.e., 0.98 t·capita⁻¹·year⁻¹, since evidence suggests catches aimed at personal consumption decreased since the 1950s (Failler *et al.* 2002), with expanding market (COPACE 1993) and the growing interest in trading the catch (Diop and Ould Cheibani 2000). We performed a linear interpolation to estimate the catch per capita per year from 1950 to 1978. Total subsistence catches in the Imraguen area were obtained as the product of the total Imraguen population per year and the per person estimated catch from 1950 to 1978. In 1988, 15% of the Imraguen catch was consumed, 10% was offered as Neerane and 10% was allocated to the Ndawal (Chaboud *et al.* 1988), to which 2% of catch consumed by the crew is added (Chaboud and Ferraris 1995), leading to the equivalent of 37% of Imraguen artisanal catches being for subsistence in 1988, thus not reported. In 2009, the subsistence portion was equivalent to 11% of the total artisanal catch, whereas 9% was donated for almsgiving (Ly and Zein 2009). This, added to the crew consumption of 2%, represented the equivalent of 22% of the Imraguen artisanal catch not reported nor accounted for previously.

² http://www.la-croix.com/Archives/2004-03-24/La-petite-communaute-des-Imraguen-veut-preserver-ses-ressources-halieuitiques-_NP_-2004-03-24-204732 [Accessed on November 24th 2011].

We interpolated these rates linearly, which we applied to the total Imraguen artisanal catch to estimate subsistence catches by this population in the PNBA, and kept the subsistence catch constant for 2009 and 2010.

N'Diago subsistence catches

The N'Diago people, living in south Mauritania, accounted for around a tenth of the total artisanal catch in the 1950s (E.K., Pers. Obser., IMROP) and 8% of the artisanal fisheries removals in the 1980s (Bakhayokho *et al.* 1988). We interpolated these rates assuming these were constant from 1980 to 2010. Thereafter, we applied these rates to the total Mauritanian artisanal catch to estimate commercial catches by the N'Diago people for the 1950-2010 time period. We calculated the percentage of subsistence catches over artisanal catches for 1950 and 1978 for the Imraguen subsistence catch, i.e., 82% and 48% for 1950 and 1978, and 37% and 22% for 1988, 2009-2010, respectively. We then applied the same rates then for N'Diago subsistence catches, given that the fish market was homogenous between both areas and that both populations share the same fishing tradition in Mauritania (Trouillet *et al.* 2011).

Industrial fishing

The Mauritanian industrial fleet is made up of vessels of foreign origin that have either been reflagged to Mauritania or operate under chartering arrangements (Bru and Hatti 2000; Gascuel *et al.* 2007), being mostly Chinese and European vessels for the most recent period (Obaidullah and Osinga 2010; Mallory 2012). This reflagging of boats was common in Mauritania, and driven by reduced fishing fees. For example, 109 Chinese and 44 EU industrial fishing vessels were reflagged in 1999 (Agnew *et al.* 2010), while in the past it was mostly Soviet Union vessels that were offered joint ventures in Mauritania.

Mauritania started chartering vessels and encouraging joint ventures in the 1970s (Gibbs 1984) to nationalize the catch after the bankruptcy of the Société Mauritanienne de l'Armement des Pêches with its 13 industrial vessels, which cost over \$10 million (using a French loan). Joint ventures were 43% Mauritanian state owned, 49% foreign owned and 7.6% private owned (Gibbs 1984). Flags of convenience appeared in Mauritania in 1995 and have been increasing since then (Obaidullah and Osinga 2010). We updated Gascuel *et al.* (2007) reconstructed industrial catches from 2005 to 2010 data using data from CMAP (2010). While Gascuel *et al.* (2007) used an under-estimation percentage of 30%, we believe catches were still grossly under-estimated. Ould Taleb Ould Sidi (2000) estimated the total catch to be twice as high, i.e., under-estimated by 100%. However here, to remain conservative, we used Gascuel *et al.* (2007) under-reporting rate. Gascuel *et al.* (2007) already estimated foreign catches with the under-reporting of 30% of catches, We here updated this estimate by applying the same under-reporting rate to the data by IMROP from 2005 to 2010. To allocate catches to actual beneficiary or owner country, we assumed the year of first reported catch data in Fishstat by each country in FAO area 34 as the same year of fishing in Mauritania, and used IMROP catch data per country thereafter (Gascuel *et al.* 2007). To disaggregate USSR catches to member country, we used the most recent data by IMROP per member country (Gascuel *et al.* 2007), which we aggregated and estimated the percentage of catch per country assuming a constant figure since the start of USSR fishing operations in the Mauritanian EEZ in 1958.

Domestic industrial catch data from Gascuel *et al.* (2007) was updated using the domestic industrial catch data from 2005 to 2010 from CMAP (2010) on one hand, and the conservative under-estimation rate estimated by Gascuel *et al.* (2007) on the other hand, given that Mauritanian flagged vessels are more likely to land catches in Mauritania.

Canarian fishing

The period between the early 1950s and the beginning of the 1980s was characterized by the presence of a relatively important Canarian purse-seine fleet, estimated between 100 and 200 wooden vessels of 8 to 25 m, landing their catches in Las Palmas, and supplying the 'Société industrielle de la grande pêche' (SIGP, 'industrial fishing company') since 1924 (Ould Mohamed 2010) and IMAPEC later, a fish processing factory based in Nouadhibou (Mohamed Mahmoud Ould Sadegh, *Fédération nationale des pêches*, pers. comm.). In some cases, several hundred Canarian vessels were believed to have operated in Mauritanian waters until 1980, when Canarian fishers left Mauritanian fishing grounds (Mohamed Mahmoud Ould Sadegh, *Fédération nationale des pêches*, pers. comm.). Herein, we averaged the number of vessels at 150 in 1950, interpolated to 200 in 1959 (Ould Mohamed 2010) and then to zero in 1980. While in 1980, 7,000 t-year⁻¹ were caught by Canarian fishers in the waters of the PNBA (Ould Mohamed 2010); in 1959 Ould Mohamed (2010) estimated that 16,000 t-year⁻¹ of meager were caught by the Canarian fleet and in 1968, around 15,000 t-year⁻¹ were supplied to the IMAPEC³, and 4,000 t-year⁻¹ in 1978 and 1979 as reported by Doucet *et al.* (1981) and Bakhayokho *et al.* (1988). We estimated the CPUE in 1959 by dividing the catch of 15,000 t-year⁻¹ by the effort of 200 vessels, i.e., 80 t-year⁻¹-vessel⁻¹, multiplied this CPUE by the averaged effort of 150 Canarian vessels in 1950, and then interpolated catches to complete the time series from 1950 to 1980.

Illegal fishing

Massive illegal fishing is taking place in the Mauritanian EEZ (Scharm and Schack 2006). Four types of illegal fishing are known to occur in Mauritania: unlicensed fishing practiced by foreign fishers; illegal gear use by the industrial

³ <http://mauritania.lezajsk.pl/development-program/125> [Accessed on April 9th 2013].

fleet, illegal demersal and small pelagic artisanal fisheries; and fishing in the protected PNBA. These illegal activities were inferred to be the equivalent of 9% of the total current legal catch reported by Mauritania to the FAO in the late 2000s (Agnew *et al.* 2010). Illegal or pirate fishing decreased since 1996-1998 because of the increase in the level of monitoring, control and surveillance (Agnew *et al.* 2010), but still remained at high levels (Ould Taleb Ould Sidi 2005). Here, we estimated three categories: illegal unlicensed artisanal Senegalese fishing, illegal fishing in closed areas using illegal artisanal gear (in the PNBA), and illegal industrial fishing which was either unlicensed or operated in closed areas in conflict with exclusive artisanal fishing areas.

Senegalese illegal artisanal catches

Senegalese fishers operated in Mauritanian waters due to the depletion of local fish stocks in Senegal (Obaidullah and Osinga 2010). Illegal Senegalese fisheries catches have been estimated to be 13,000 t·year⁻¹ in 2005, the equivalent of 15% of the reconstructed Mauritanian artisanal catches, with an estimated 704 unlicensed Senegalese artisanal vessels in Mauritanian waters (Agnew *et al.* 2010). There is evidence of proportionality between Senegalese illegal fishing activities and Mauritanian artisanal fisheries in the 2000s. Indeed, many Senegalese fishers operate two thirds of the time for Mauritanian fishers and one third of the time on their own accounts (Marfaing 2005). Therefore, we assumed illegal Senegalese catches were the equivalent of 15% of the Mauritanian artisanal reconstructed catch per year from 2005 (13,000 t·year⁻¹) to 2010 (13,200 t·year⁻¹). In 1989, political relations between Mauritania and Senegal resulted in border closure, and expatriation of Senegalese workers from Mauritania (Gousseau 2007). Therefore, illegal Senegalese fisheries practices increased and fishers were operating frequently in Mauritanian waters without authorization (Marfaing 2005). We assumed catches in 1989 were 50% of the 2001 illegal catch, since closure of boarders increased the segment of unreported and illegal Senegalese fisheries catches off Mauritania from 1989 to 2001. Since then, 705 illegal Senegalese boats per year were operating in Mauritania (Marfaing 2005). During the same period, Mauritania handed over fishing licenses to Senegalese fishers for pelagic fish (mainly *Sardinella*) excluding mullets and high value species, with 250 licenses in 2001, and 270 in 2004 and 2005. The ratio illegal:legal boats decreased by 8% from 2001 to 2005. Thus, we assumed catches in 2001 were conservatively 8% higher than catches in 2005. From 1950 to 1989, we referred to catches as being unregulated, and assumed the same trend as for Mauritanian artisanal fisheries, since the most recent periods show similar patterns. To disaggregate these catches, we used the Senegalese migrants catch description by Sall and Thioye (2006). In order to derive a species disaggregation index, we assumed the number of months spent targeting these species relatively to the total time allocated to fishing all these species, is a good indicator of the quantity caught, then we derived the proportion of each species catch relatively to the total catch (Table 4).

Table 4. Taxonomic composition of illegal Senegalese catches and N'Diogo subsistence catches.

Taxon name	Common name	Frequency	Contribution to catches (%)	Source
<i>Sardinella</i> spp.	Sardinellas	All year	12.5	Sall and Thioye (2006)
<i>Pagrus</i> spp.	Seabreams	All year	12.5	Sall and Thioye (2006)
<i>Epinephelus aeneus</i>	White grouper	All year	12.5	Sall and Thioye (2006)
<i>Octopus</i> spp.	Octopus	9 months	10.5	Sall and Thioye (2006)
<i>Sepia</i> spp.	Sepia	9 months	10.0	Sall and Thioye (2006)
<i>Mugil</i> spp.	Mulletts	6 months	5.0	Sall and Thioye (2006)
<i>Solea</i> spp.	Soles	5 months	1.0	Sall and Thioye (2006)
<i>Pomatomus saltatrix</i>	Bluefish	2 months	1.0	Sall and Thioye (2006)
Selachians	Selachians	-	30.0	Vernet (2007)
Miscellaneous	-	6 months	5.0	Sall and Thioye (2006)
Total	-	-	100	-

Illegal catches in the PNBA

Illegal fishing in the PNBA refers to all unreported catches by non Imraguen fishers inside PNBA waters, and Imraguen or non-Imraguen catches using motorized boats inside the PNBA. The park is referred to as a 'tank' for illegal fishers by Failler *et al.* (2002) to highlight the extent of illegal fishing in the park area. The number of infractions and the corresponding number of illegal boats observed in the PNBA were available from 1999 to 2003 (Table 5) from Marfaing (2005), including pirogues and occasional sightings of trawlers. Here, we assumed that the real number of illegal boats would realistically be 20% higher, since not all illegal boats have been observed. In 2002, 2,500 t·year⁻¹ of illegal fish were caught in the waters of the PNBA (Failler *et al.* 2002). Using this catch, with the corresponding number of boats, we estimated a CPUE of 5.8 t·year⁻¹·boat⁻¹, which we applied to the available effort data, i.e., from 1999 to 2003, assuming a constant CPUE. From 1976 to 1999, we assumed illegal catches were proportional to the legal component from the PNBA, which is justified by the popularity of the park and the 'tank' effect described by Failler *et al.* (2002). These activities were already widespread in 1976, and illegal fishing has decreased since then, thus, we assumed illegal catches in 1976 were 50% higher than the catch in 1999. With the advancement of monitoring techniques (Agnew *et al.* 2010) and the implementation of a locally implemented surveillance system in 1998 (FAO 2006), illegal catches in the PNBA decreased considerably (Marfaing 2005; Scharm and Schack 2006; Agnew *et al.* 2010), therefore we assumed in 2010, they were 50% of the 2003 illegal catch (Table 5). Thereafter, we interpolated between the three estimates linearly to complete the time series from 1976 to 2010.

Catches by illegal industrial fleets

Although Mauritania made significant improvements in reducing foreign illegal fishing during the 2000s (Pramod *et al.* 2008), illegal fishing was, and still is, of major concern (Gibbs 1984; Anon. 2002a; Addico 2008; Pramod *et al.*

2008). Illegal catches in West Africa were at least 1.3 times the reported catch in the late 1970s (Gibbs 1984). In Mauritania, from 1973 to 1977, most of the industrial catch was taken by unlicensed vessels from the Mauritania (Gibbs 1984), and probably in territorial waters. Right after independence and before the declaration of the Mauritanian EEZ, these waters were legally accessible for large foreign fleets with no government regulations, as they were legal High Seas waters.

Therefore, before the declaration of the Mauritanian EEZ in the late 1970s, these catches are considered unregulated rather than illegal. Catches in 1978 were therefore considered to be twice as high as the legal industrial catch. In the 1990s and the 2000s, 30 to 40 boats from Asia were operating illegally in the Mauritanian waters⁴, thus, despite significant improvements in monitoring techniques, illegal catches in 2010 were assumed to be 50% lower than the illegal/unregulated catch in 1978. Therefore, we assumed illegal catches from 1950 to 1969 were 1.3 times the industrial catch from Gascuel *et al.* (2007), twice as high as the industrial reconstructed catch from 1975 to 1985, and decreased thereafter by 50% in 2010. We interpolated the estimated illegal catch to complete the time series. Before the declaration of the Mauritanian EEZ, we consider catches as being unregulated rather than illegal.

Table 5. Illegal *pirogues* and corresponding catches in the waters of the PNBA.

Year	Number of boats ^a	CPUE (t·boat ⁻¹ ·year ⁻¹)	Catch (t·year ⁻¹)	Method
1950-1975	0	-	0	Assumed
1976	-	-	3,071	Assumed to be 50% higher than 1999 catches
1999	355	5.8	2,047	Effort multiplied by CPUE
2000	493	5.8	2,842	Effort multiplied by CPUE
2001	386	5.8	2,227	Effort Multiplied by CPUE
2002	299	5.8	2,500	Effort multiplied by CPUE
2003	185	5.8	1,065	Effort Multiplied by CPUE
2010	-	-	533	Assumed to be 50% of the 2003 catches

a) From Mainfraing (2005) adjusted by +20%

Discards

Discards of the artisanal sector

The discard rate is around 5% of the total artisanal catch, based on direct observations in 2009 (Ly and Zein 2009). Thus, we assumed a constant rate of 5% from 1950 to 2010, and applied this to the reconstructed artisanal and subsistence catch from 1950 to 2010.

Discards of the industrial sector

Discards of the domestic industrial sector were estimated using data from Gascuel *et al.* (2007) from 1950 to 2005, then updated based on the percentage of discards derived from Gascuel *et al.* (2007) for 2005. This discard rate was then applied to industrial catches from 2006 to 2010, to allowing the update of the 1950-2005 discards time series provided by Gascuel *et al.* (2007).

Recreational catches

The 'Baie de l'étoile', located in the Nouadhibou, is the only recreational fishing centre in Mauritania, allowing 24 tourists to fish for 5 days during a trip of 8 days (Tomatis 2001). This facility opened in 1960 (Ould Mohamed 2010), and in 1972, the first records of tourist fishing were found in the 'livres d'or' reporting number of fishes, species and the weight caught for a period of 25 years from 1972 to 1997. Using these records, we estimated the average CPUE per tourist by dividing total catches reported by the number of tourists, and assumed the CPUE was constant from 1995 to 2010. We then assumed the number of tourists fishing was zero in 1970s when this activity began, 10% of the total number of tourists visiting Mauritania as reported by Diarra (2009) between 1997 and 2006, corresponded to the number of 'reporters' in the 'livre d'or' from 1972 to 1995, and decreased by 50% between 2006 and 2010 because of political and security reasons in the Sahel area. Recreational tourist catches from the waters of the PNBA are estimated as the product of the CPUE by the number of tourists and the number of fishing days per tourist (i.e., 5 days·boat⁻¹·year⁻¹).

Species disaggregation

Artisanal, subsistence and illegal artisanal catches in the PNBA were disaggregated to taxon level using survey data from the Mauritanian Institute of Fisheries (IMROP) in the Banc d'Arguin National Park (Kane Elimane 2011). To disaggregate catches by the N'Diogo for subsistence, and illegal Senegalese catches, we estimated a percentage per taxon based on the number of months that fishers spend targeting the latter taxon (Table 3), assuming the same species composition for both sectors, since market value and food preferences are homogenous between

⁴ <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+WQ+E-2001-1464+0+DOC+XML+Vo//EN> [Accessed on November 23rd 2011].

the southern areas of Mauritania and Senegal (Sall and Thioye 2006). Similarly, we converted IMROP artisanal catch data per taxon (IMROP, unpub. data) to percentages and applied this to the difference between total artisanal catches and Imraguen artisanal catches. We applied the same method to estimate foreign legal catches per taxon, where reported catch data in the Mauritania EEZ per country were available from IMROP for the late 1990s to the mid-2000s for Spain, Korea, China, Lithuania, France, Cyprus, Netherlands, Latvia, Italy, Romania, Ireland, Slovenia, Japan, Ukraine and Iceland, whereas for Russia we applied the same species breakdown as for Lithuania, a former USSR member, and the Irish species breakdown to the UK where data were not reported. To disaggregate illegal catches by non-African countries, we aggregated reported catches by all foreign countries (IMROP, unpub. data) and estimated percentages per taxon which we applied to the illegal catch per country, i.e., Russia, Ukraine, Romania, Lithuania, Netherlands, Spain, Italy, Japan, Korea, China and other non-identified flags.

Domestic discards for trawlers were assumed to have the same taxonomic composition as trawlers operating in Senegal, i.e., *Brachydeuterus auritus*, *Galeoides decadactylus*, *Chloroscombrus chrysurus*, *Sepia* spp., *Trichiurus lepturus*, *Arius* spp., *Pseudolithus* spp., and *Cynoglossus monody*, while small-pelagic trawlers (joint ventures with Russia) were assumed to discard the same species described by ter-Hofstede and Dickey-Collas (2006), i.e., 24.9% of *Sardina pilchardus*, 16.2% of *Scomber japonicus*, 15% of *Trachurus trecae*, 5.1% of *Sardinella maderensis*, 2.9% of *Sardinella aurita* and 35.9% of 'marine fishes nei'.

RESULTS

Total reconstructed catches

Reconstructed Mauritanian domestic catches totaled 11.8 million tonnes for the 1950-2010 time period (Figure 2a), compared to total removals by foreign countries of 60.3 million tonnes within the Mauritanian EEZ (Figure 2a). The Mauritanian small-scale catch was estimated to be only 4% of the total reconstructed catch including foreign removals. Total reconstructed domestic Mauritanian catches (11.8 million tonnes) were 200% higher than the officially reported data (Figure 2a). The under-reporting tendency decreased by half during the last six decades, which shows improvement in monitoring (Figure 2a). However, foreign catches still constitute the bulk of catches (Figure 2a). Over the total 72.1 million tonnes reconstructed catches, over 60 million tonnes were caught by foreign vessels during the 1950-2010 time period, of these catches, 27.9 million tonnes (47%) were caught by illegal vessels/pirogues.

Domestic catches include carangids, sardinellas and cephalopods (Figure 2b).

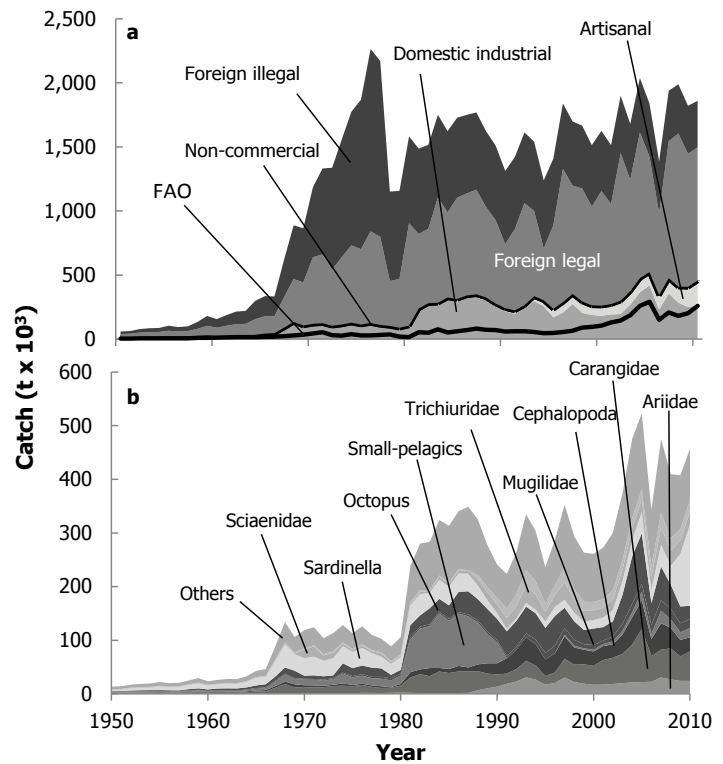


Figure 2. Reconstructed total removals from Mauritanian waters compared to the data supplied to FAO a) by the foreign and domestic fleets and b) by taxon, 1950-2010.

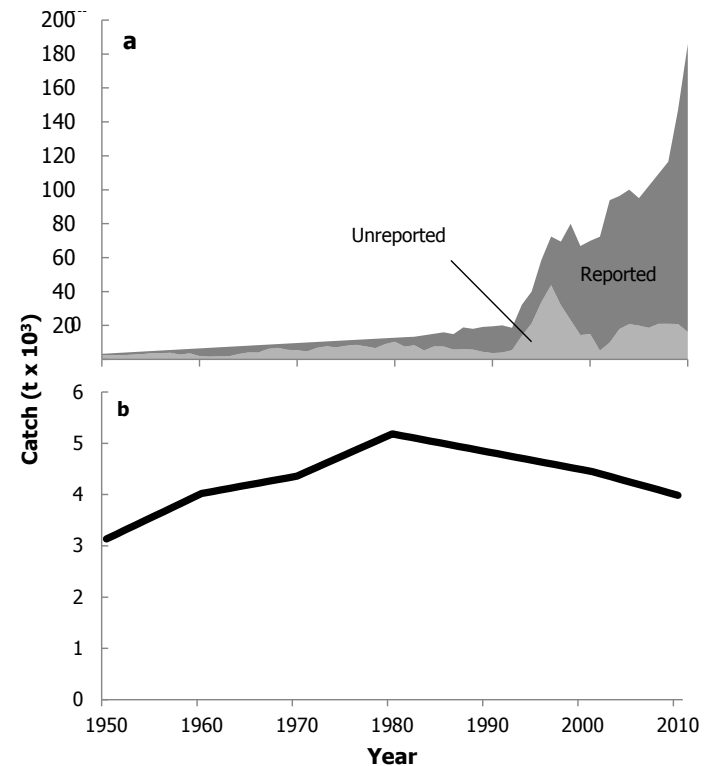


Figure 3. Estimated artisanal catches from a) Mauritania and b) the PNBA, 1950-2010.

Reconstructed catches by sector

Artisanal catches

Artisanal reconstructed catches totaled 2.2 million tonnes over the 1950-2010 time period (Figure 3a). Reconstructed artisanal catches increased from around 3,500 t-year⁻¹ in 1950 to around 110,000 t-year⁻¹ on average in the 2000s (Figure 3a). A sharp increase was observed in the mid-1990s driven by the high interest in the shark fin fishery. Imraguen catches were part of the artisanal catch, and were estimated to be 268,000 tonnes from 1950 to 2010, i.e., 16% of the total artisanal catch. These catches increased from around 3,100 t-year⁻¹ in 1950, to a peak of 5,200 t-year⁻¹ in 1980, when shark fishing began (Figure 3b).

Subsistence catches

Total reconstructed subsistence catches, including catches by the Imraguen and N'Diago, were estimated to be over 139,000 tonnes for the 1950-2010 time period, i.e., more than 1% of the total reconstructed domestic catch (Figure 2a). Subsistence catches increased slightly from around 1,600 t-year⁻¹ in 1950 to 2,900 t-year⁻¹ in 2010, driven by the increase of N'Diago subsistence fishing activities in southern waters (Figure 4). The contribution of Imraguen catches to subsistence fisheries decreased from 90% in 1950 (1,500 t-year⁻¹) to less than 25% in 2010 (680 t-year⁻¹, Figure 4).

Industrial catches by legal fleets

Domestic industrial catches in Mauritania were estimated at 9.4 million tonnes between 1950 and 2010, of which 5.2 million tonnes were discards. Industrial Mauritanian catches increased from 8,300 t-year⁻¹ in 1950 to a peak of 420,000 t-year⁻¹ in 2005, then decreased to 260,000 t-year⁻¹ in 2010 (Figure 5a).

Legal industrial catches by the foreign fleet from Mauritanian waters, estimated at 32.1 million tonnes between 1950 and 2010, were the equivalent of around three times the domestic catch (Figure 5a). Foreign industrial catches increased from 14,230 t-year⁻¹ in 1950 to be almost hundred times higher in 2008 (1.2 million t-year⁻¹), decreasing slightly thereafter to 1.04 million t-year⁻¹ in 2010. Very large quantities were caught by eastern European and former Soviet Union countries (Latvia, Lithuania, Romania, Russian Federation, Slovenia and Ukraine) with 37% of the legal foreign catch, i.e., around 12 million tonnes for the period from 1950 to 2010. Flag of convenience (FOC) countries (mainly Chinese flying the flags of Cyprus and Belize) caught between 1987 and 2010 as much fish as Western Europe countries (France, Germany, Iceland, Italy, Netherlands, Spain, United Kingdom) in 60 years, with over 8.1 million tonnes (25%), whereas East Asian countries (China, Japan and Korea) were responsible of 8% of the total legal foreign removals (Figure 5b).

Canarian catches

Canarian catches were estimated at 372,500 tonnes between 1950 and 1980, when Canarian fishers left Mauritania. Catches increased slightly from 12,000 t-year⁻¹ in 1950 to 16,000 t-year⁻¹ in 1959, and then

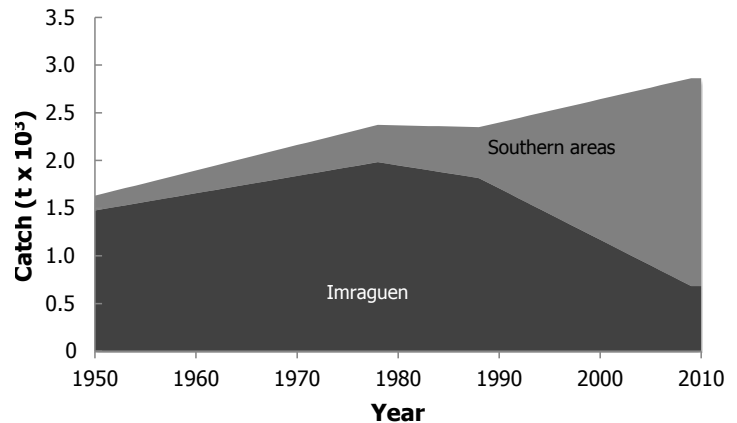


Figure 4. Reconstructed subsistence catches from Mauritania, 1950-2010.

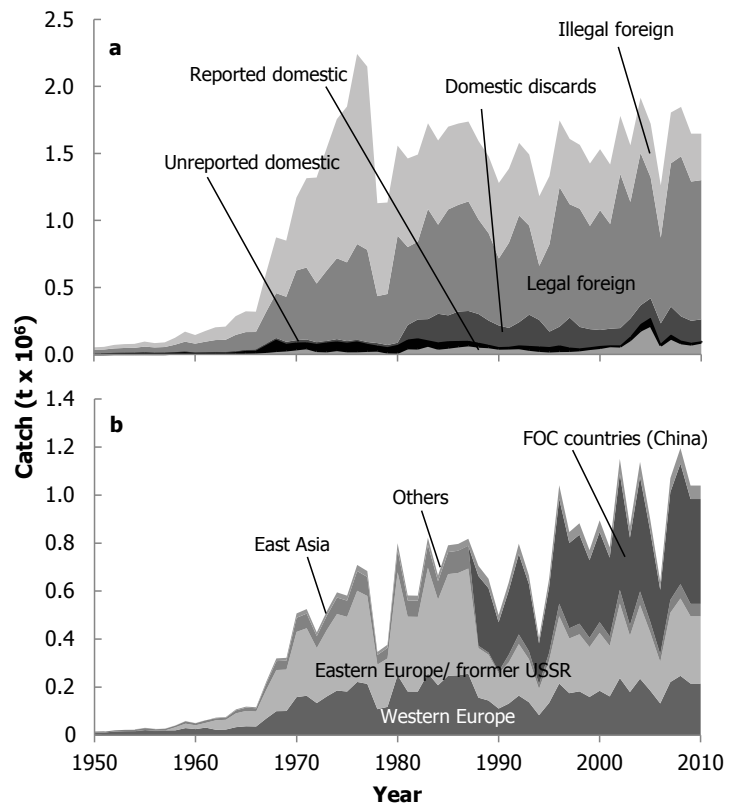


Figure 5. a) Estimated industrial domestic and foreign catches from the Mauritanian EEZ, and b) catches by the foreign legal fleets from Mauritania per country/region of origin, 1950-2010.

decreased to zero in 1980. Canary catches were overwhelmingly from the PNBA waters (Figure 6).

Illegal catches

Unregulated and illegal catches by foreign fleets in Mauritania were estimated to be over 27.9 million tonnes for the period from 1950 to 2010, which represented about 40% of the total removals by legal domestic and foreign vessels in Mauritania (Figure 2). Catches increased from 19,900 t·year⁻¹ in 1950 to their maximum of 1.4 million t·year⁻¹ in 1976, before the declaration of the Mauritanian EEZ, when they were considered unregulated rather than illegal. Illegal catches decreased thereafter to 359,000 t·year⁻¹ in 2010 (Figure 7).

Illegal catches in the PNBA: Illegal catches in the Park National du Banc D'Arguin area totaled around 75,400 tonnes between 1950 and 2010 (Figure 8). Illegal fishing in the PNBA started in 1976 at around 3,070 t·year⁻¹, i.e., the equivalent of 26% of the total Imraguen catch (Figure 8). Catches decreased thereafter to 533 t·year⁻¹ in 2010 representing 10% of the Imraguen artisanal and subsistence catch in the park area (Figure 8).

Illegal Senegalese catches: Illegal Senegalese catches in Mauritania totaled 435,200 tonnes between 1950 and 2010 (3% of the total illegal catch). Illegal Senegalese catches increased from 1,400 t·year⁻¹ from 1950 to a peak of 15,600 t·year⁻¹ in 2001, right when Mauritania handed over fishing authorizations to some 300 Senegalese pirogues, before increasing again to 17,000 t·year⁻¹ in 2010 (Figure 8).

Illegal foreign (non-African) catches: Illegal catches by non-African countries (i.e., excluding Senegal) were estimated at 27.4 million tonnes from 1950 to 2010 (Figure 9). Illegal catches by non-African countries increased from 18,500 t·year⁻¹ in 1950 to reach a peak of 1.4 million t·year⁻¹ in 1976, and then decreased to an average of 370,000 t·year⁻¹ in the late 2000s (Figure 9). The former Soviet Union members and Eastern Europe countries (Lithuania, Romania, Russian Federation and Ukraine) totaled around 11.9 million tonnes between 1950 and 2010, i.e., 43% of the total non-African illegal catch (Figure 9). The Netherlands, Spain and Italy together caught more than 5.4 million tonnes over the same period, with Spain being responsible for most of the illegal catch by Western Europe (2.8 million tonnes) (Figure 9). Catches by Asian countries led by China (1.1 million tonnes) represented 14% of the total illegal non-African catch (Figure 9). Other countries (suspected to be of Chinese and Korean origins) contributed to 24% of these catches with over 6.5 million tonnes (Figure 9). These are most likely vessels flying flags of convenience.

Domestic discards

Discards, estimated to be around 5.3 million tonnes for the period from 1950 to 2010, increased from 1,700 t·year⁻¹ in 1950 to 16,000 t·year⁻¹ in 1980 (Figure 10) and then increased rapidly with the increase of industrial domestic catches to 213,000 t·year⁻¹ in 1984, and remained relatively at a high level since then (Figure 10).

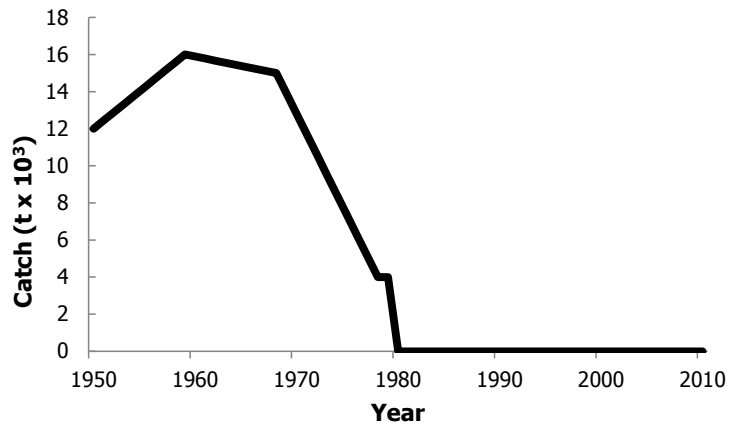


Figure 6. Reconstructed catches by fishers from the Canarian islands from Mauritania, 1950-2010.

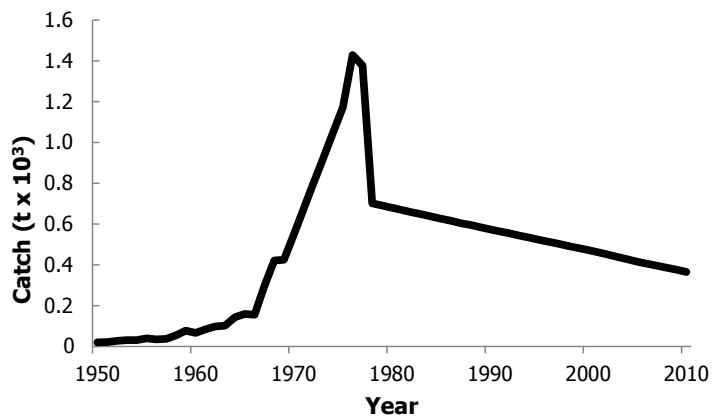


Figure 7. Estimated catches by illegal fleets from the waters of Mauritania, 1950-2010.

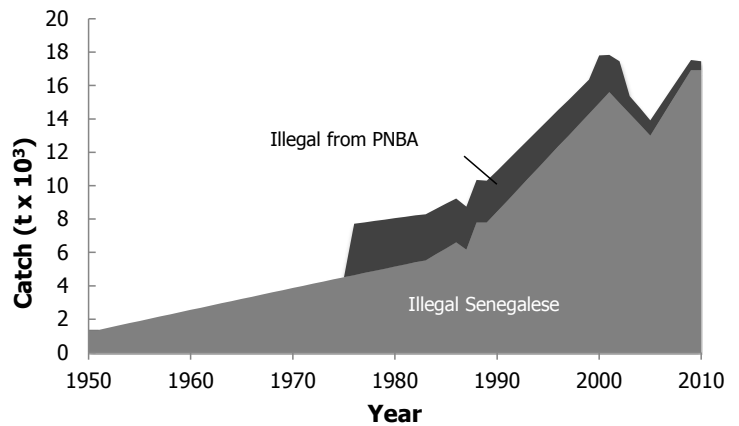


Figure 8. Illegal catches from the waters of the PNBA and by Senegalese illegal fishers in Mauritania, 1950-2010.

Recreational catches

Reconstructed recreational catches in Mauritania, particularly in the PNBA, were relatively low, estimated at 1 t-year⁻¹ in 1971, increased to a peak of 138 t-year⁻¹ in 1984, decreased drastically to less than 8 t-year⁻¹ in 1989, with the conflict between Mauritania and Senegal and then increased again to 108 t-year⁻¹ in 2003, before decreasing to a minimum of 3 t-year⁻¹ in 2010 (Figure 11).

DISCUSSION

Total reconstructed catches taken from Mauritanian waters were estimated to be 72.1 million tonnes over the 1950-2010 time period. These catches went overwhelmingly to fleets of foreign origin, i.e., 60 million tonnes, of which over 27.9 million tonnes were illegally caught. The foreign legal catch provided few and low domestic benefits, and most of the value was going overseas (Barbut 2008). Mauritanian domestic catches, including the artisanal and subsistence catch, and the industrial sector operated by vessels of foreign origin, were estimated at 11.6 million tonnes, three times the catch data of 3.8 million tonnes supplied to the FAO. However, this work excluded the relatively high Senegalese catch under agreement with Mauritania, which in 2012 was estimated at around 100,000 t-year⁻¹.

The political context played an important role on how Mauritanian fisheries evolved over time. Indeed, the ten years that followed Mauritanian independence from France (in 1960) exposed Mauritanian waters to the bulk of illegal foreign fishing. Furthermore, prior to the 1989 events between Mauritania and Senegal, Senegalese illegal catches were a matter of lack of regulation and monitoring. It is only after the political events that the Mauritanian government began to enforce prohibition of unregulated 'foreign' fishing in its territorial waters. Senegalese fishers seeking economic refuge were forced to operate in waters off Mauritania because of the scarcity of the resources in their traditional fishing grounds (Failler and Binet 2012). These fishers accuse EU and Asian illegal vessels of depleting fisheries resources (UNEP 2006). Although ignored by the management body, this activity contributed to the extraction of over 422,000 tonnes during the last 60 years, which is almost as high as the Imraguen catch in the PNBA. Furthermore, another 100,000 t-year⁻¹ caught by legal Senegalese fisheries could be added to the equation in the late 2000s according to anonymous official sources.

This raises serious concerns regarding the quality of data submitted to FAO by Mauritania, and highlights the significant correlation existing between IUU fishing and poor governance (Mallory 2012). Furthermore, the Mauritanian government reporting the chartered and joint-venture vessel catches as 'domestic', despite the majority of the benefit of these catches going overseas (e.g. most of them are Chinese), is only but aggravating the transparency issues around the low benefits received by the Mauritanian population (Agnew *et al.* 2010). Indeed, despite this large contribution to fisheries removals, the true economic, social and food security contribution of joint ventures and charter activities beyond access fees is questionable (Goffinet 1992; Ould Cheikhna *et al.* 2005; Folsom and Weidner 1976 in Pramod *et al.* 2008; Dobo 2009; Cherif 2011).

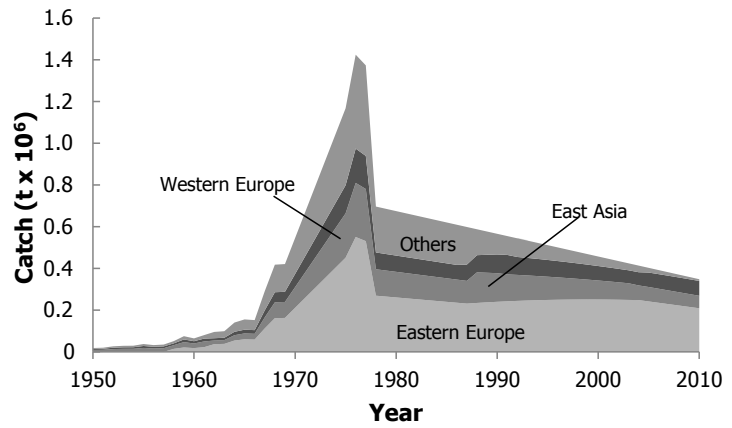


Figure 9. Catches by the illegal foreign (non-African fleets) from Mauritania, 1950-2010.

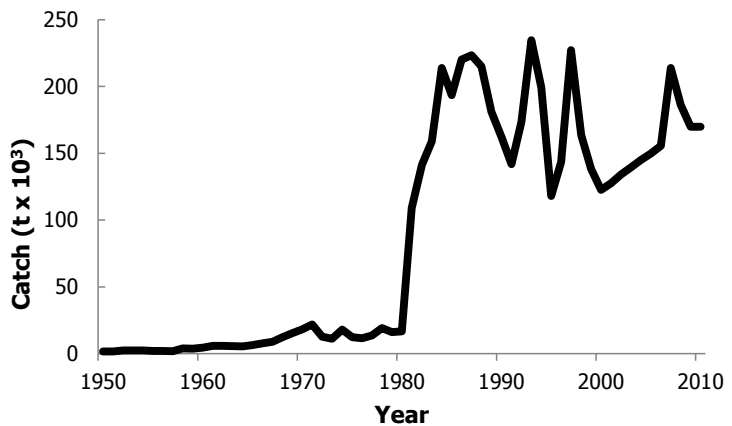


Figure 10. Discards by the domestic fisheries of Mauritania, 1950-2010.

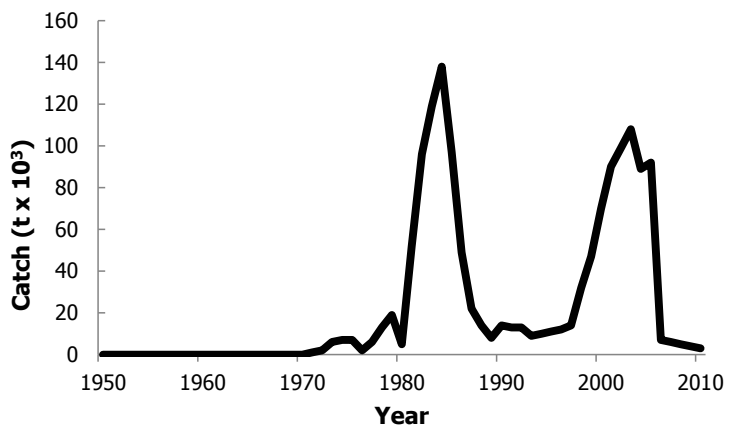


Figure 11. Recreational catches from Mauritania, 1950-2010.

Thus, in Mauritania, the extent of foreign fishing access agreements is strongly related to the level of debt of the country, and the fees paid suggest economic desperation (Gorez and Oriordan 2003). For example, in the case of foreign industrial tuna vessels operating off Mauritania, the cost of fishing licenses paid to Mauritania represented as little as 0.18% of the estimated catch value (Solie 2004). Another example is the octopus stock which has been driven to its lowest historical abundance (UNEP 2006), yet new fishing agreements have been signed with China to target these species (Cherif 2011). Moreover, subsidized access by the EU fleet to Mauritanian waters unfairly outcompeted the local artisanal industry (Gorez and Oriordan 2003; CTA 2011).

Mauritania does not have a long-standing fishing tradition (Scharm and Schack 2006; Gascuel *et al.* 2007), with official fish consumption figures between 6.8 kg·capita⁻¹·year⁻¹ and 17 kg·capita⁻¹·year⁻¹ in coastal areas, and 3 kg·capita⁻¹·year⁻¹ in eastern areas (Ould Cheikhna *et al.* 2005). However, such average official numbers do not reflect the vital importance of fish for traditional fishing communities, where fish consumption can reach up to 80 kg·capita⁻¹·year⁻¹ in the case of the Imraguen and N'Diogo (Failler *et al.* 2002). Unfortunately, fish consumption in the area is in rapid decline (Failler *et al.* 2002), due to the over-exploitation of fish stocks (UNEP 2006; Agnew *et al.* 2010) and trade liberalization on shark fisheries which are not traditionally consumed by Mauritanian people for religious and cultural reasons (UNEP 2006). In the PNBA, the Imraguen who are strictly dependent on fishing activities, have seen their catch decline by almost three fold. The increase shown by official reports may be due to an increase in reporting rather than an increase in catches, which would be questionable given the over-exploitation pattern the area witnessed. This suggests a shifting baseline (Pauly 1995). When compared to available recent survey data (Kane Élimane 2011), these catches are two fold the reported numbers. These estimates have low uncertainty, since onsite surveys from direct observations by Failler *et al.* (2002) showed similar catches in the waters of the PNBA. Likewise, artisanal catches in the 2000s were estimated to be around 80,000 t ± 10,000 t by Ould Cheikhna *et al.* (2005), which corresponds to our estimate in the present study.

Subsistence fishing, which in 1950 represented 36% of the small-scale catch, decreased to around 2% in recent years. This could be related to the increase in catch-based economic activities by both Imraguen and N'Diogo traditional fishing communities. The economic interest in species like sharks resulted in strong overfishing, which besides impacting livelihoods, increased conflict over fishing grounds and resources (Lenselink 2004). Furthermore, evidence suggests effort in Mauritania is focused on resource exploitation and profit maximization in the short term (Trouillet *et al.* 2011) rather than long term economic profitability and food security, with only 10% of the catch being landed in Mauritania (CTA 2011). Indeed, Mauritania was identified as suffering from abnormal food shortages in the 1980s (Pollnac 1985), yet most of the fish produced goes overseas. Furthermore, development strategies around fisheries are still based on exports and handing over fishing access agreements or joint ventures. This represents a danger, both for fisheries sustainability and for food security in Mauritania. Mauritania, like its neighbors is at risk of facing a major food security issue related to the lack of protein if the current questions around fisheries, such as the realistic benefits of fishing access agreements, illegal fishing, and short term profits are not addressed.

Our estimation of artisanal catches from the entire Mauritanian coast from 1950 to 2010 showed that the bulk of the artisanal Mauritania catches were caught by the Imraguen in the waters of the PNBA up until the early 1980s. This further supports the hypothesis that the data on Mauritania artisanal effort are heavily under-estimated and was fragmentary up until the 1980s when data collection started expanding to cover the rest of the Mauritanian regions. Furthermore, this illustrates the importance of fisheries to local communities dependant upon them.

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Appendix Table A1. Annual catches from Mauritania's EEZ, 1950-2010.

Year	Reported to FAO	Artisanal	Subsistence	Industrial	Discards	Total domestic	Total foreign
1950	3,000	3,286	1,629	6,835	1,680	13,166	34,089
1951	3,000	3,608	1,656	7,285	1,677	13,962	36,541
1952	5,000	3,930	1,682	9,079	2,395	16,806	48,460
1953	5,000	4,252	1,709	10,079	2,411	18,152	52,955
1954	5,000	4,573	1,735	10,565	2,433	18,991	53,899
1955	5,000	4,894	1,762	13,343	2,077	21,743	68,363
1956	5,000	5,214	1,788	10,755	2,090	19,498	59,317
1957	5,000	5,534	1,815	11,613	1,743	20,337	64,036
1958	10,000	5,853	1,841	13,389	3,829	24,528	93,550
1959	10,000	6,172	1,868	17,538	3,745	28,922	135,406
1960	12,000	6,491	1,894	10,614	4,447	23,028	116,749
1961	14,000	6,809	1,921	11,521	5,806	25,621	144,820
1962	15,000	7,127	1,947	12,935	5,738	27,293	171,805
1963	15,000	7,444	1,974	12,353	5,722	27,021	178,075
1964	15,000	7,761	2,000	17,461	5,526	32,260	251,557
1965	17,000	8,077	2,027	26,435	6,298	42,332	278,297
1966	19,000	8,393	2,053	28,024	7,803	45,751	272,590
1967	22,700	8,708	2,080	69,336	8,931	88,516	518,061
1968	29,000	9,023	2,107	110,405	12,297	133,276	742,815
1969	35,000	9,338	2,133	79,169	15,396	105,462	748,324
1970	43,570	9,652	2,160	88,921	18,174	118,316	1,058,611
1971	52,925	9,966	2,186	90,258	21,747	123,549	1,201,253
1972	30,291	10,279	2,213	78,480	12,764	103,112	1,228,166
1973	27,190	10,592	2,239	89,417	11,108	112,714	1,442,044
1974	37,697	10,905	2,266	96,818	18,091	127,421	1,644,901
1975	27,921	11,217	2,292	87,219	12,339	112,392	1,755,672
1976	27,834	11,528	2,319	97,462	11,630	125,317	2,141,277
1977	31,897	11,839	2,345	79,297	13,557	109,355	2,064,540
1978	35,467	12,150	2,372	65,917	19,190	101,883	1,049,584
1979	18,541	12,460	2,369	54,546	16,177	87,748	1,069,230
1980	15,598	12,770	2,367	71,002	16,742	105,016	1,483,061
1981	52,779	13,079	2,364	111,090	109,026	237,636	1,253,656
1982	50,288	13,349	2,362	120,136	141,297	279,162	1,241,946
1983	75,600	14,222	2,359	105,074	158,966	282,551	1,473,594
1984	51,676	15,094	2,357	90,011	213,978	323,283	1,305,077
1985	60,277	15,965	2,354	98,641	193,559	312,273	1,420,851
1986	70,614	14,877	2,352	100,440	220,257	339,690	1,416,175
1987	82,397	18,840	2,350	101,726	223,390	347,827	1,426,319
1988	71,666	18,007	2,347	87,304	214,993	324,169	1,300,084
1989	70,000	19,146	2,372	71,949	181,070	275,953	1,235,279
1990	60,000	19,517	2,396	54,625	162,129	240,018	1,074,170
1991	61,637	20,066	2,420	57,058	141,825	222,647	1,199,703
1992	61,054	18,621	2,445	67,461	173,519	263,351	1,350,873
1993	54,452	32,188	2,469	63,465	234,587	333,290	1,208,348
1994	46,746	39,920	2,494	59,391	199,384	301,337	937,455
1995	48,147	58,501	2,518	54,946	118,072	233,210	1,174,693
1996	55,324	72,394	2,542	67,376	143,450	284,196	1,553,252
1997	65,127	69,442	2,567	51,150	227,164	348,858	1,348,358
1998	89,043	79,924	2,591	45,298	163,527	289,306	1,374,626
1999	94,527	66,828	2,616	53,516	138,301	259,836	1,252,488
2000	104,456	69,856	2,640	63,032	122,560	257,305	1,366,374
2001	130,142	72,345	2,664	67,745	127,618	268,850	1,243,074
2002	144,131	93,856	2,689	67,253	133,984	295,455	1,600,210
2003	187,650	96,326	2,713	134,167	139,397	368,716	1,307,894
2004	258,733	100,058	2,738	226,558	144,874	470,077	1,564,616
2005	291,877	95,043	2,762	274,145	149,913	517,886	1,316,408
2006	150,312	102,204	2,786	81,530	155,562	337,669	1,045,176
2007	208,207	109,366	2,811	148,212	213,816	469,357	1,465,632
2008	180,328	116,528	2,835	103,388	186,296	403,764	1,580,825
2009	201,900	123,690	2,860	72,984	169,868	363,684	1,415,180
2010	261,238	123,690	2,860	64,403	169,868	355,027	1,404,298

Appendix Table A2. Six most important taxa caught by domestic fisheries in Mauritania's EEZ, 1950-2010.

Year	Ariidae	Carangidae	Cephalopoda	Small-pelagics	Mugilidae	Octopus	Sciaenidae	Trichiuridae	Othersa
1950	809	1,101	384	3,795	711	910	839	204	4,673
1951	840	1,188	382	4,067	779	923	875	224	4,943
1952	828	1,350	589	5,486	803	1,434	866	237	5,490
1953	863	1,527	595	5,996	874	1,466	906	278	5,941
1954	894	1,623	593	6,290	941	1,477	942	300	6,243
1955	916	2,038	523	7,950	999	1,324	969	410	6,943
1956	928	1,625	485	6,901	1,042	1,247	984	313	6,319
1957	939	1,723	397	7,717	1,084	1,049	999	349	6,445
1958	896	1,711	974	9,553	1,052	2,437	954	273	7,059
1959	959	2,366	1,037	11,343	1,161	2,608	1,025	430	8,391
1960	863	1,212	1,042	9,229	1,049	2,609	923	134	6,381
1961	899	1,337	1,399	9,518	1,128	3,484	965	116	7,208
1962	895	1,422	1,435	10,776	1,150	3,582	963	139	7,380
1963	906	1,370	1,392	10,677	1,193	3,491	978	127	7,354
1964	992	2,078	1,544	12,649	1,355	3,893	1,075	300	8,859
1965	1,051	3,336	1,915	16,988	1,480	4,815	1,144	569	11,535
1966	1,080	3,561	2,343	17,536	1,557	5,866	1,178	568	12,579
1967	1,191	10,166	3,189	36,690	1,777	7,943	1,305	2,083	24,705
1968	1,242	16,865	4,578	55,491	1,899	11,303	1,366	3,542	37,543
1969	1,217	10,906	5,642	40,591	1,886	13,869	1,341	2,028	28,551
1970	1,007	11,614	3,421	43,315	1,528	5,725	16,466	2,102	33,723
1971	955	10,884	3,893	45,269	1,440	6,839	19,380	1,805	33,690
1972	1,172	11,184	2,739	38,430	1,856	6,394	10,037	2,190	29,731
1973	1,241	13,347	2,330	42,636	1,998	4,848	10,424	2,759	33,776
1974	1,150	13,995	4,342	50,168	2,070	17,498	4,449	2,667	31,742
1975	1,205	13,049	2,292	44,323	2,367	14,790	3,365	2,647	29,031
1976	1,840	14,776	2,334	48,050	2,929	15,771	4,087	3,075	33,146
1977	1,734	11,275	2,749	40,379	2,565	17,260	3,571	2,184	28,346
1978	1,628	9,356	3,032	35,883	3,394	15,813	6,638	1,528	25,347
1979	1,840	9,498	1,036	33,311	3,864	6,318	3,282	1,672	27,682
1980	2,265	13,094	3,250	38,767	4,120	7,007	2,667	2,448	32,155
1981	1,891	28,324	10,219	97,848	3,760	23,115	3,525	2,707	67,067
1982	1,544	35,269	8,721	115,751	3,772	20,778	4,114	3,272	86,819
1983	1,510	31,381	15,226	106,668	3,315	30,183	3,688	1,631	89,893
1984	1,323	40,422	6,561	137,355	3,323	23,999	5,663	1,990	103,653
1985	1,277	37,557	7,307	124,512	3,687	25,324	5,868	2,044	105,704
1986	1,577	40,254	10,184	132,492	2,914	37,325	5,947	1,672	108,232
1987	1,815	40,006	7,474	127,929	3,269	43,416	5,228	1,409	118,358
1988	6,805	35,538	12,562	103,653	3,813	39,575	13,030	6,400	103,821
1989	10,406	27,335	19,234	70,624	4,173	42,519	15,019	9,590	78,132
1990	13,396	22,717	20,908	49,427	4,179	39,774	15,952	12,486	62,283
1991	18,712	19,083	28,552	4,546	4,504	45,958	19,737	17,678	65,010
1992	22,870	23,300	36,295	4,656	5,009	48,683	23,895	21,640	78,066
1993	30,767	30,860	44,084	6,721	7,011	49,945	31,995	29,208	104,438
1994	26,598	26,075	39,976	6,773	8,520	48,960	28,010	24,719	93,834
1995	16,935	16,357	30,948	11,814	11,920	46,796	18,687	14,479	68,332
1996	20,508	19,258	35,728	16,939	14,655	55,338	22,477	17,625	85,423
1997	30,423	34,915	41,957	18,049	12,140	38,172	32,197	28,147	116,469
1998	22,018	32,336	32,009	19,846	10,701	34,531	23,763	20,206	98,051
1999	18,851	36,159	27,252	17,979	7,844	26,503	19,912	17,204	91,647
2000	17,023	35,297	26,791	19,356	8,635	30,648	18,218	15,348	89,700
2001	17,150	45,912	26,045	21,522	6,529	25,083	18,120	16,074	96,252
2002	18,339	48,818	25,187	26,633	9,243	28,175	19,570	16,845	107,568
2003	19,956	54,668	36,163	32,272	13,021	53,826	21,294	17,607	124,966
2004	21,326	70,135	51,103	39,517	15,615	88,667	22,785	18,414	147,741
2005	21,976	98,652	53,752	55,766	14,642	94,066	23,248	19,178	141,585
2006	22,543	47,750	31,618	35,021	16,371	40,844	23,924	19,597	105,256
2007	30,528	51,854	49,301	63,968	19,680	62,729	32,155	26,705	138,050
2008	26,922	57,702	38,374	50,688	19,497	45,305	28,543	23,141	119,564
2009	24,211	45,611	30,856	112,101	16,528	31,516	25,557	20,623	100,582
2010	24,234	54,829	26,233	169,372	16,043	24,922	25,509	20,716	95,124

a) 'others' includes *Alectis alexandrinus*, *Brachydeuterus auritus*, *Cynoglossus goreensis*, *Decapterus rhonchus*, *Dentex* spp., *Dicentrarchus punctatus*, *Dicolocoglossa cuneata*, *Diplodus* spp., *Drepanidae*, *Epinephelus* spp., *Galeoides decadactylus*, *Gynglimostoma ceratum*, *Leptocharias smithii*, *Mycteroperca rubra*, *Pagellus bellottii*, *Panulirus regius*, elasmobranchii and other fishes and crustaceans.

