Scientific Advice for Fisheries Partnership Agreements

CRUSTACEAN AND CEPHALOPOD STOCKS EXPLOITED BY THE EUROPEAN FLEET UNDER FISHERIES PARTNERSHIP AGREEMENTS SIGNED WITH MAURITANIA AND GUINEA-BISSAU

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15 June 2011

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INTRODUCTION

a.- Description of the fishing grounds

a.1-. Mauritania

Mauritania has nearly 720 km of Atlantic coastline, with a 200 miles exclusive economic zone (EEZ) extending from 20° 36’ N (southern limit of Western Saharan waters, near Cape Blanc) to 16° 04’ N (northern limit of Senegalese EEZ, at the Senegal River mouth). The EEZ surface is of 234 000 km^2 of which approximately 16% (39 000 km^2) are over the continental shelf. This continental shelf is around 40 miles wide near Cape Blanc, attaining its maximal width (80 miles) in front of the Arguin Bank (between Cape Blanc and Cape Timiris). South Cape Timiris, the shelf reduces to a minimum of 30 miles wide (Figure 1).

Therefore, two areas can be clearly separated, north and south Cape Timiris (19º 21’ N), where the 200 m isobaths are as near as 10 miles from coast (Sobrino and García, 1992).

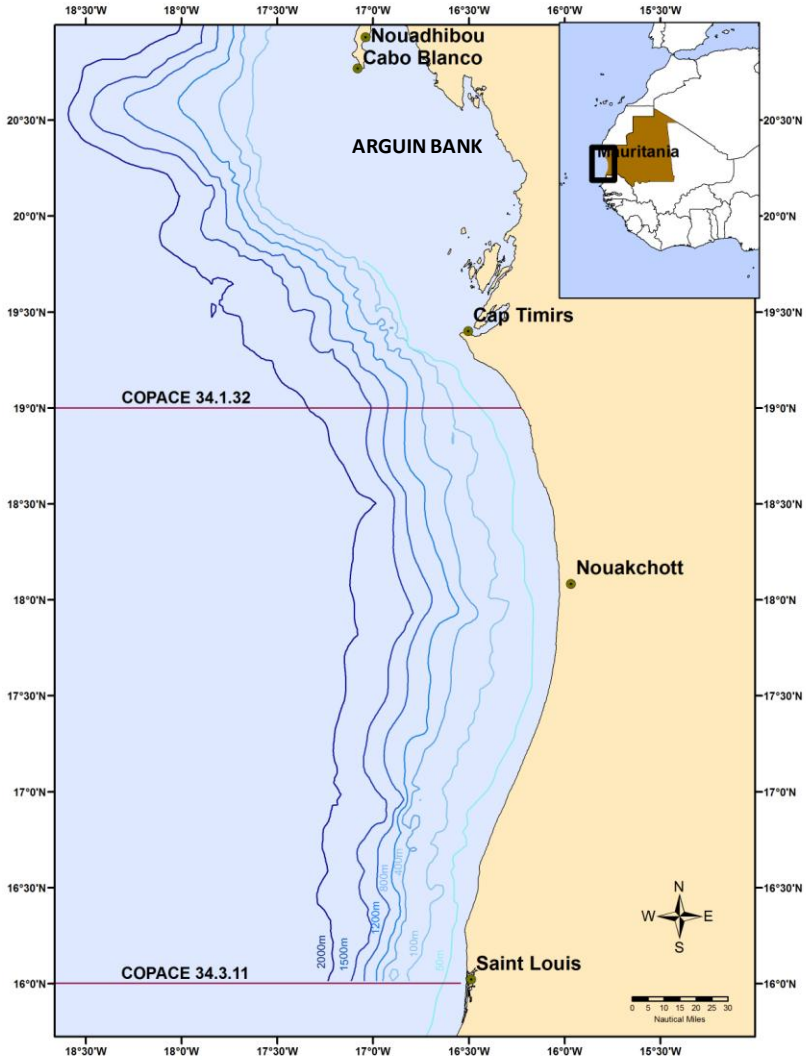


Figure 1.- Map of the Mauritanian EEZ.

In general, bottoms are not very rough, with dominance of sandy and sandy-muddy sediments. Mud and rocky bottoms are not very spread, although some longitudinal rocky banks are located near the southern coast of Cape Timiris. The shelf edge at SW of Cape Timiris is characterized by a number of underwater rocky valleys and canyons separating areas of 10 m depth from others of 300-400 m depth (Sobrino and García, 1992).

The Mauritanian coast is part of one of the four major trade-wind driven continental margin upwelling zones in the world oceans, the northwestern African upwelling system (or the Canary Current System). In the Eastern Central Atlantic, the dynamics of an eastern boundary current interacting with trade wind-driven upwelling controls this marine ecosystem with exceptionally high primary and secondary productivity (Cury and Roy, 1989; Binet, 1997; Demarcq and Faure, 2000). The region off the Mauritanian coast is part of this coastal ecosystem characterized by seasonal or permanently strong equatorial winds. A persistent wind-induced offshore drift of the surface waters tends to advect particles from the coastal environment and generate upwelling of deep, nutrient-rich water (Wooster and Reid, 1963; Brink, 1983). In the northern part of Mauritania, the trade winds blow from early winter to late spring (October to June), generating strong seasonal upwelling, whereas north of Cape Blanc (20°-25° N), upwelling is quasi-constant, with periods of stronger intensity. However, upwelling lasts around nine months off Nouakchott. Large seasonal and yearly environmental variations in such areas are mainly caused by fluctuations in upwelling, which induce changes in productivity, food availability, sea temperature and water column stability

Both annual and seasonal fluctuations of upwelling intensity, wind-induced turbulence, and coastal retention show the strong temporal instability of the environment in the Mauritanian upwelling area (Faure *et al*., 2000). The upwelling season starts in October, reaching maximal intensities from January to May and minimal values around September. The coastal retention phenomenon is minimal in January and maximal from April to June. In autumn, despite an increase in upwelling intensity, cold-water intrusions onto the Arguin Bank induce a large reduction of the coastal retention index. Such inshore water movement occurs only towards the end of the upwelling season when westerly winds dominate, suggesting that the direction and intensity of the wind must be a limiting factor for inshore water penetration on the bank. The intrusion of cold water may enhance productivity over the bank as the upwelled waters are advected onto the Arguin Bank and supply the nursery area with nutrients. For the remainder of the year, variations in coastal retention mainly reflect the sea surface temperature fluctuations because of upwelling variations or changes in light intensity. Maximal values of wind-induced turbulence are observed from April to June and minimal values in November and December.

The marked seasonality of upwellings and their latitudinal displacement off Mauritanian and Senegalese coasts produce important changes in the structure of the biological communities. The system can then switch in short time periods (weeks) from a warm equatorial phase to a cold subtropical phase, thus provoking an alternating dominance of tropical and temperate communities (Meiners, 2007).

a.2.- Guinea-Bissau

The Guinea-Bissauan EEZ is located between Senegalese (at north) and Guinean waters (at south). Its marine ecosystem is strategically situated between two large marine ecosystems (LME): the southern limit of the Canary Current LME and the western limit of the Guinea LME, both being considered as highly productive (Heileman, 2009; Heileman and Tandstad, 2009). In the tropical West African region, the combination of a number of climatic and hydrologic factors contribute to the existence of an exceptional environment, even more marked in Guinea-Bissau due to the great extension of its continental shelf, which has encouraged the presence of foreign industrial fleets for

decades. The Guinea-Bissauan continental shelf is the largest in Western Africa, with a width of more than 75 miles in the north, 60 miles in the south, and an extension of about 10 800 m2 (Ramos *et al*., 1991). In the southern area, the shelf reduces its extension to an effective width of 30 miles due to the presence of the Bijagos Islands. The coasts are deeply cut out by the numerous rivers that open into the sea in this area (Domain, 1980). It contains one of the biggest estuarine areas and one of the most extensive mangrove zones in West African coastal waters (Binet *et al*., 1995).

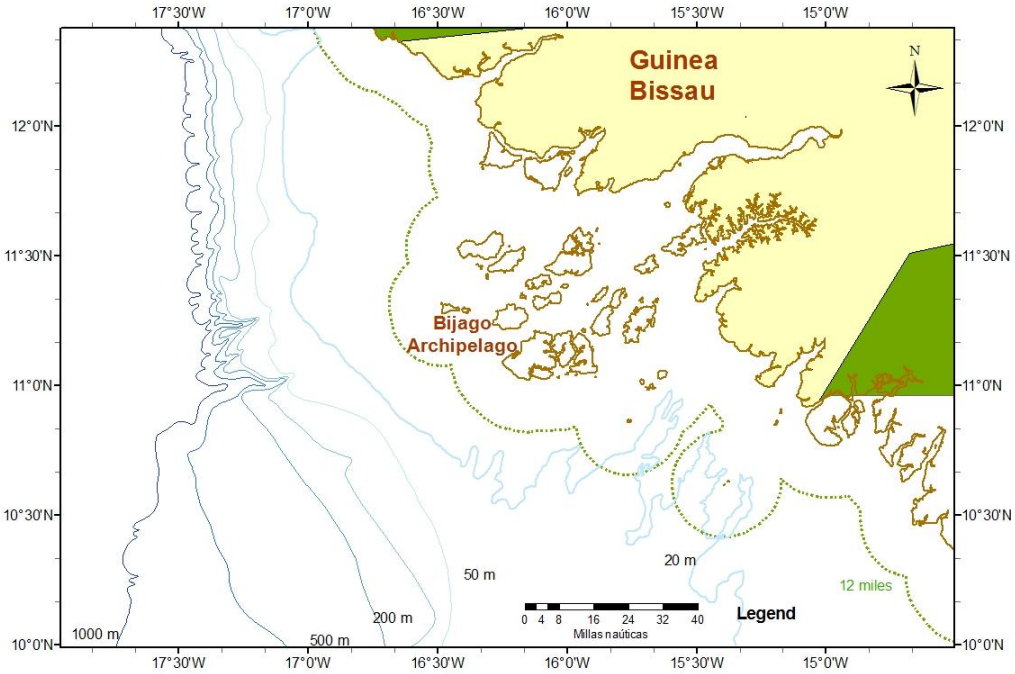


Figure 2.- Map of the Guinea-Bissauan EEZ.

Three main zones can be distinguished depending on the sediment´s nature and bathymetry. There is a shallow area (20-75 m depth), with soft bottoms (mud and sand) in the northern area (mainly related to the river mouth), and with hard bottoms from Bijagos to the Guinean border in the south, externally associated to coral reefs and crossed by numerous submarine canyons and valleys (McMaster *et al*., 1970). At bottoms deeper than 200 m, deposits vary from soft (mud and sand) to hard (rubble, gravel, and rocks). At depths between 400 and 600 m, sediments are all soft.

The Guinea-Bissau ecosystem is characterized by strong seasonal variations of oceanographic conditions (Berrit and Rebert, 1977), with higher productivity during the dry season (Longhurst, 1983) due to the upwelling events that mainly occur from January to February. Characteristically warm and salty tropical waters dominate from May to June. With the progression of the rainy season, the intrusion of warm, low salinity inner waters tend to dominate. As a result of upwelling events and the input of organic matter from river run-off, primary productivity is relatively high in the area (Berrit & Rebert, 1977). The coastal areas are also under the influence of strong currents and occasional strong winds. The biota have adopted strategies compatible with this variability, as reflected, e.g., in feeding migrations of fish along the coast and the reproductive migration of shrimp into estuaries following the cycle of wet and dry seasons.

b.-Crustacean fisheries in North West African waters

The exploitation of crustacean resources in West African coasts is relatively old (Thiam *et al.*, 1981). Two main groups of species fished in waters from Morocco to Guinea-Bissau are particularly interesting from a commercial point of view:

- The coastal shrimps: the Southern pink shrimp *Farfantepenaeus notialis* (Pérez Farfante, 1967) is the most valuable species, followed by the caramote prawn *Melicertus kerathurus* (Forskål, 1775)
- The deep-water shrimps: the deep-water rose shrimp *Parapenaeus longirostris* (Lucas, 1846) is the species with the highest commercial interest, followed by other exploited species such as the red shrimp *Aristeus antennatus* (Risso, 1816); the striped red shrimp *Aristeus varidens* Holthuis, 1952; the scarlet shrimp *Aristaeopsis edwardsiana* (J. Y. Johnson, 1868); the giant red shrimp *Aristaeomorpha foliacea* (Risso, 1827); and the arrow shrimp *Plesionika heterocarpus* (Costa, 1871).

While the coastal group is exploited by both artisanal and industrial fleets, deep-water crustaceans are exclusively targeted by the industrial fleet.

The industrial shrimp's exploitation in West African waters was initiated by the Spanish bottom-trawl fleet traditionally fishing in Moroccan grounds and targeting both European hake *Merluccius merluccius* (Linnaeus, 1758) and deep-water rose shrimp. From 1986 onwards, some of these vessels, mainly from Huelva (SW Spain), transformed their fish holds with freezing facilities (Cervantes *et al.*, 1992), giving birth to a specific European freezer shrimp fishery in West African waters. The European shrimp fishery in Moroccan waters was closed after the fishing agreement came to an end in 1999. Currently, the European crustacean fishery is uniquely carried on in waters off Mauritania and Guinea-Bissau.

The Spanish fleet is the main European shrimper fleet operating in waters off Mauritania and Guinea-Bissau. It is composed of freezer shrimp-trawlers traditionally based in the Spanish port of Huelva. These vessels carry out fishing trips of different duration, which can oscillate from one to three months. Depending on the target species, they usually alternate the use of outriggers with the classic bottom otter trawl rigged with trawl doors ("baka" type). Thus, outriggers are used to fish *P. longirostris* and *F. notialis*, mainly during daylight hauls, while the classic "baka" trawl is the preferred choice for deep-fishing of *A. varidens* and the deep-sea red crab *Chaceon maritae* (Manning and Holthuis, 1981) generally at night. Catches are frozen and transferred to reefers vessels, which transport them to the port of Huelva. Main crustacean species are sorted in commercial categories by size.

b.1.-Mauritania

The shrimp fishery in Mauritania is only carried out by an industrial fleet composed of national and foreign fleets (from the EU and other countries).

The industrial exploitation of shrimps in Mauritanian waters started in the 1960s, when the technological advances and the improved freezing capacity allowed the Spanish industrial fleet to operate in southernmost waters other than the traditionally exploited Moroccan fishing grounds. Other foreign shrimper fleets were operating in Mauritania from 1985 to1990, but the Spanish fleet was always dominant in the area (Diop, 1989).

The total number of shrimpers operating in Mauritanian waters increased from 20 to 90 units from 1993 to 2002. After reaching its maximum number in 2002, the number of fishing units significantly decreased and is nowadays close to 20 vessels (2010).

Mauritanian shrimper fleet

The Mauritanian shrimper industrial fleet originated in 1994 as a consequence of the scarcity of other fished resources (mainly cephalopods) and the economical interest of exploiting shrimps. It progressively developed, reaching in 2006 a maximum number of 27 vessels, either properly Mauritanian or operating as joint ventures. After 2006, the Mauritanian shrimper fleet suffered an important reduction, with only 2 vessels in 2010, that may be attributed to the decline of *F. notialis* abundance (the target species of this fleet) and to an increase in the octopus yields, a species also targeted by certain units. On the contrary, size of Mauritanian vessels considerably increased from average values of 23 m length during the first years (1994-1998) to 30 m since 2000.

European Union shrimper fleet

The shrimper industrial fleet´s operations in Mauritanian waters are mainly carried out by Spanish vessels, the only fleet constantly operating in the area until the 1990s, when the Mauritanian industrial fleet started to develop. In 1996, other European fleets (from Italy, Greece, and Portugal) joined the Spanish fleet to operate in Mauritanian waters under European licenses, reaching a maximum of 15 vessels (all together but Spain) in 2006. After this peak, the number of European vessels was reduced to a minimum of 2 units in 2010 (one Portuguese and one Italian). In 2010, 18 Spanish vessels fished in Mauritanian waters.

The Spanish fishery has been traditionally developed into the framework of fishing agreements. The first one was signed in 1964 between the Spanish Government and Mauritania. From 1987 onwards, these agreements were negotiated and established through the EU. Currently, the Spanish shrimper fleet operates in Mauritanian waters under annual and renewable EU-licences. Most of the vessels shared licences with other fishing grounds, as Guinea-Bissau, Guinea (until 2008), or Senegal (until 2006). *P. longirostris* and *F. notialis* are the target species of the European crustacean fishery in Mauritanian waters, where both species account for 80% of the catches (Spanish data) and are fished in shallow shelf waters, while other species such as *A. varidens* and *C. maritae* are caught in deeper fishing grounds. The main by-catch species are *M. kerathurus*, *A. foliacea* and *A. edwardsiana*. Fishing depths differ depending on the target species: < 60 m for *F. notialis*, 170-300 m for *P. longirostris*, and 350-700 m for *A. varidens* and *C. maritae*.

Nowadays, the EU fleet is allowed to fish in Mauritanian waters north of Cape Timiris (19º 15.6' N), into an area delimited by the Fishery Agreement and South Cape Timiris, beyond 6 miles. The average technical characteristics of the Spanish fleet during the last years are 135 GRT, 30 m length and power of 583 hp.

Other (non European) foreign fleets

Other foreign fleets of different nationalities had until 2007 also been operating in Mauritanian waters, although with great annual variations in their activities. These foreign vessels could reach lengths of 38 m in 2006.

b.2.- Guinea-Bissau

Guinea Bissau fishery resources are currently supporting both artisanal and industrial fishing. The distinction among these two fleet segments was established by the Law 6-A/2000 of 22 August. Artisanal fishing is considered to be carried out by vessels powered by motors of less than 40 hp Industrial fishing is practiced from 12 miles outside territorial waters.

The artisanal fleet is composed of a large number of small boats (canoes) carrying out their activities in inland waters, estuaries of existing big rivers, and in the vicinity of the Bijagos Archipelago. These canoes are both Guinea-Bissauan and Senegalese. Their catches are composed of a variety of species of fish and shallow water prawns.

Since 1978, industrial fishing operates under a licensing system. It is cyclically used exclusively by foreign vessels rigged with trawling nets and longlines. The former Soviet Union was one of Guinea-Bissau's original main partners, as that country played an important role in the war against Portuguese colonization. Because of the abundance of fishing resources, with high-value species in the international market, Guinea-Bissauan waters attracted foreign ship owners from the EU, the People's Republic of China (PRC), and Senegal. The former Soviet Union fleet was slowly replaced by fleets from the EU and Asian countries exploiting different stocks, namely crustaceans, molluscs, and finfish in the EEZ of Guinea-Bissau. The Spanish fleet was the first European fleet established in Guinea-Bissau.

The average number of vessels licensed for crustacean fishing from 2007 to 2009 was 20 (for the EU), 13 (for the PRC fleet) and 8 (for other nationalities' fleets).

European Union shrimper fleet

Spain has the largest EU crustacean-fishing fleet operating in the Guinea-Bissauan EEZ. Spanish fishing vessels first came to this zone in the 1960s, as a consequence of the fleet's southwards expansion when traditional ships acquired the ability to freeze their catch. After extension of the EEZ to 200 miles in 1976, the Spanish fleet operated under the scope of bilateral agreements between Spain and the Republic of Guinea-Bissau. After Spain joined the European Economic Community (EEC) in 1986, it was the EEC, and later the EU, which had the authority to negotiate access of European fleets to third countries waters. Since 1986, part of the Spanish freezer bottom trawl shrimp fleet has operated in Guinea-Bissauan EEZ under EU licences for "shrimper trawlers". There have been several EU-Guinea Bissau fishery agreements during this period, with their conditions becoming more restrictive as time went on. Current EU fleets operating in Guinea-Bissau come from Spain, Italy, Portugal, and Greece.

Under the current agreement, the Spanish crustacean-fishing fleet increased its vessels from 12 (2007) to 22 (2010). This increase may be related to the closure of fishing zones in neighbouring areas to European crustacean-fishing fleet, such as Senegal (2006) and Guinea-Conakry (2009). The average technical characteristics of the Spanish fleet during the period of the agreement (2007-2010) are 125 GRT, 29 m length, and 545 hp. Their target species are deep-water rose shrimp (*P. longirostris*), striped red shrimp (*A. varidens*), and Southern rose shrimp (*F. notialis*), accounting for more than 80% of the catches. Deep-water rose shrimp is the species most frequently caught, accounting for 65% of the total, followed by *A. varidens* (11%), and *F. notialis* (5%).

Portuguese fleet has been operating in waters off Guinea-Bissau, with 5-6 vessels under the last agreement. Although smaller in size (average length of 27 m), Portuguese vessels are more powerful (average of 883 hp) and have more capacity (average of 187 GRT) than the Spanish ones. Portuguese fleet targets *F. notialis*, the species with the highest catch rate (29%), followed by *P. longirostris* (9%) and *A. varidens* (3%). Other crustaceans averaged around 10% of the catch from 2007 to 2009. The remaining 50% are fish and cephalopod by-catch.

By volume of catch, the European is the second largest shrimper industrial fleet in waters off Guinea-Bissau. Since 1999, Spanish historic catch database shows an increase in total catch over the last two years, with maximum volumes of 1500 t, mostly of deep-water rose shrimp (*P. longirostris*). Portuguese data also show a catch increase from 2007 to 2009, with maximum values of 585 t in 2009. Portuguese vessels tend to fish closer to the coast than the Spanish units, mainly because they target species under the "others" group heading (mostly fish), followed by the Southern rose shrimp (*F. notialis*).

Table I.- European Union (EU) shrimper fleet average catch, in tons (t) and percentage (%) from 2007 to 2009.

EU Shrimper Trawlers (licensed for crustaceans)		
Crustacean	Catch (t)	1127
	%	78
Cephalopod	Catch (t)	91
	%	6
Finfish	Catch (t)	231
	%	16

Other (non European) foreign shrimper fleets

In addition to the EU fleet, vessels of various nationalities have licenses to fish in Guinea-Bissauan waters. Since 2007, the PRC fleet is the most important non-European one, with 15 active vessels in 2009. In addition to this Chinese fleet, other vessels from Angola, Belize, Gabon, and Senegal also have fishing licenses.

PRC is one of the countries with a recently renewed fishing agreement with Guinea-Bissau. The Chinese shrimper fleet has an average gross tonnage of 195 GRT, length of 38 m, and power of 937 hp (mean values for the period 2007-2009). The number of Chinese shrimper vessels has decreased from 14 (2007) to 9 (2009).

From 2007 to 2009, the Chinese shrimper fleet had the largest catch, whose total volume varied between 7100 and 15 200 t. However, although Chinese vessels are licensed for crustaceans, most of the reported catches are species other than shrimps, where finfish are predominant (see table II). For the three years mentioned, the Chinese fleet recorded the lowest catch in 2008, coinciding with a decrease in the fishing effort in that year.

Table II.- Chinese shrimper fleet average catch in tons (t) and percentage (%) from 2007 to 2009.

Chinese Trawlers (licensed for crustaceans)		
Crustacean	Catch (t)	140
	%	2
Cephalopod	Catch (t)	1071
	%	14
Finfish	Catch (t)	6711
	%	85

Compared to EU fleets (Table I), Chinese vessels catch less shrimps and show a significant proportion of by-catch despite the high number of vessels licensed for crustacean fishing.

c.- Cephalopod fisheries in North-West African waters (Mauritania and Guinea-Bissau)

The cephalopod fishery in West African waters is carried out either by fleets specifically targeting cephalopods or by other fleets that capture them as by-catch in non-targeted fisheries (FAO, 2006). These fisheries are developed by a heterogeneous fleet of vessels, ranging from small canoes to bottom trawlers and using a number of different fishing gears such as pots, jigs, and bottom trawls. There are two main fleet segments targeting cephalopods: artisanal and industrial, the latter including both domestic and foreign units. European vessels operate within the framework of fishing agreements signed by the EU with Mauritania and Guinea-Bissau.

The cephalopod industrial fishery started at the beginning of the 1960s when a Japanese fleet came to fish octopus in Western Sahara waters between Cape Bojador (26º N) and Cape Blanc (21º N) (FAO, 2006). As early as 1963, this Japanese fleet was taken over by small Spanish wet-fish trawlers supplying their catch to both Japanese and Spanish motherships where catches were sorted, frozen and packed to be distributed to the international market. These small trawlers were rapidly substituted by Spanish flagged modern freezer trawlers operating autonomously. Technical characteristics of these freezer trawlers were converging along the years towards a standard vessel of 32 m length overall, 245 t GRT and 900 hp engine, very well adapted to fishing conditions, mean annual production, and type of processing.

The fleet left Western Sahara (under Moroccan administration) when the EU-Morocco fishing agreement came to an end in December 1999. The restrictions of the access to fishing grounds under Moroccan administration forced the Spanish cephalopod fleet to extend the scope of fishing agreements to other countries, first to Mauritania, from where it extended progressively to southern latitudes (Senegal, Guinea-Bissau, and Guinea). As the access conditions in these countries were also becoming more and more restrictive, the European cephalopod fleet fishing in the whole region (North-West African waters) has been reduced dramatically. The last EU-Senegal fishery agreement expired in June 2006, and was not renewed. In December 2008, the end of the agreement with Guinea meant the closure of this fishery. Therefore, Mauritania and Guinea-Bissau remain the unique fishing grounds where cephalopods can be caught under EU fishing agreements.

The Spanish fleet is the most important European fleet in the region, but other countries such as Italy, Greece and Portugal also have vessels operating in waters off Mauritania and/or Guinea-Bissau. The main landing port of the Spanish fleets is Las Palmas (in Gran Canaria, Canary Islands, Spain) although in recent years an increasing number of vessels are landing at the port of Nouadhibou (Mauritania). Freezer trawlers use bottom trawls rigged with chains (Spanish trawl). As the catch is frozen, the duration of the fishing trips can be extended to an average duration of 50 to 60 days at sea.

The species targeted by the cephalopod fleets are the common octopus *Octopus vulgaris* Cuvier, 1797; the squid *Loligo vulgaris* Lamarck, 1758; and several cuttlefish species. The most important cuttlefish species are *Sepia hierredda* Rang, 1835 (the most abundant) and *Sepia officinalis* Linnaeus, 1758, whose catch proportion decreases southwards. The “sepiola” *Sepia bertheloti* D'Orbigny, 1835 is another relatively important species in the area. In general, octopus is the most abundant and valuable species of the commercial cephalopods in the region, although its abundance decreases southwards. The squid catch is relatively important in Mauritanian waters, but squids are virtually absent in waters off Guinea-Bissau.

Thus, most common cephalopod species exploited in Mauritania are octopus (*O. vulgaris*), squid (*L. vulgaris*), and cuttlefish (*S. hierredda* and *S. officinalis*), while the most common cephalopod species exploited in Guinea-Bissau used to be cuttlefish (*Sepia* spp.). However, in recent years octopus catch has considerably increased and can be even higher than cuttlefish catch.

Onboard Spanish industrial trawlers octopus are eviscerated and sorted into commercial categories depending on their weight before being frozen. Squids and cuttlefish are sorted in different commercial categories according to their mantle length (squids) or weight (cuttlefish) and directly frozen.

From North to South, there are four main cephalopod fishing grounds in North West African waters, more or less coincident with the geographical distribution range of the identified octopus stocks: i) the area between Cape Bojador (26º N) and Cape Blanc (21º N) in Western Sahara; ii) the area between Cape Blanc and the Senegal River mouth (16º N) in Mauritania; iii) the area between the Senegal River mouth and the Senegal-Guinea Bissau border (12º N) in Senegal and the area between the Senegal-Guinea Bissau and the Guinea-Sierra Leone borders.

c.1.-Mauritania

Two fleet segments exploit cephalopods in Mauritanian waters: the artisanal and the industrial vessels.

Artisanal fleet

The cephalopod artisanal fishery in Mauritania is relatively modern. Its development was simultaneous to the one of the domestic industrial cephalopod fishery, due to the success of FAO pilot experiences carried out at the beginning of the ‘1980s (Inejih, 2000).

The Mauritanian artisanal fleet is composed of small vessels made of wood, aluminium or plastic, usually smaller than 16 m length, and with a power less than 50 hp. These vessels use a wide range of gears as hand-lines, squid nets, octopus pots, traps, and trammel nets, among others. The octopus pots are the most common gear for fishing this species, being especially extended in the northern coast. The use of jigs, which was quite extensive in the southern area to catch octopus, is not currently used. For cuttlefish traps and trammel nets are the preferred artisanal gears, especially in the Mauritanian southern coast.

Industrial fleet

The industrial exploitation of cephalopods (mainly octopus) in Mauritanian waters begun in the 1960s, with the activity of foreign vessels from Japan, Korea or PRC. By the mid 1970s, Spanish vessels targeting cephalopods joined the industrial fleet operating in the Cape Blanc zone, from where it extended progressively to southern latitudes. Since the 1990s, and after the development of a domestic Mauritanian fleet, the cephalopod resources in Mauritanian waters have been exploited by several industrial fleets.

Currently, Mauritanian, Chinese and EU industrial fleets, among others, are targeting cephalopods in Mauritania. The highest effort is developed by the Mauritanian vessels, which represent 70% of the total number of units, although a certain decrease in the fishing effort has been observed during the last years, also followed by a decrease of the EU fleet. Over recent years, the reported effort made by other foreign vessels is almost negligible.

In 2009, octopus catch from all the industrial fleets stabilized around 19 000 t. While from 2002 to 2007, 40%-50% of the catch was made by the European fleet, the percentage of European catch decreased to 30%-33% from 2008 to 2009. In 2009, total catch of squid and cuttlefish were approximately 1 600 t (77 % fished by Mauritanian vessels) and 3600 t, respectively.

The activity of the cephalopod industrial fleet has suffered a quite general decrease probably due to a number of factors, such as the withdrawal of some foreign vessels from Mauritanian fishing grounds, the cessation of activity of some Mauritanian vessels, and the extension of the closed season from 2 months (September-October) to 4 months (September-October and April-May) from 2008 onwards.

Cephalopod trawlers have traditionally been in operation in the Mauritanian North zone, south of Cape Blanc although a southwards extension of the fishing grounds has been observed in recent years.

Mauritanian cephalopod industrial fleet

The Mauritanian fleet, practically inexistent before 1980, started developing in 1982 (Inejih, 2000). The fast establishment of this fleet was first due to a simple reflag of former foreign fleets, followed by the acquisition of a small fleet of wet-fish trawlers, exploited by local enterprises. A number of Chinese vessels working in Mauritanian waters under leasing systems between 1991 and 1997 were reflagged to Mauritania, in a way that the Mauritanian national fleet became more and more numerous due to the nationalizations of these PRC vessels. The number of Mauritanian vessels reached a maximum at the end of the 1990s (around 200) but has decreased since then due to the non-operation of some of them. In 2009, the Mauritanian cephalopod fleet was the biggest in the area, with 112 trawlers. This domestic fleet is composed of wet-fish and freezer vessels, mainly targeting octopus exported to the Japanese market. The effective Mauritanian effort varies from one year to another as this fleet is composed of chartered vessels and of old vessels with infrequent activity.

Mauritanian cephalopod trawlers are bigger (average length of 38 m) than the EU ones, although less powerful (850 hp) and with less capacity (250 TRB). Furthermore, the Mauritanian fleet is composed of quite old vessels (84% of the fleet is between 15-25 years old) while 46% of the European vessels are less than 10 years old.

Mauritanian cephalopod industrial fleet uses bottom trawls rigged with bobbins in the footrope (Korean trawl).

European Union cephalopod industrial fleet

Traditionally, the Spanish fishery is the most important cephalopod fishery in Mauritania, among the total EU fleets operating in this area. The access of Spanish trawlers to the fishery has been regulated by the technical conditions imposed by successive fishing agreements, first signed between Spain and Mauritania, and lately between the EU and this country. As the access conditions to the fishery are becoming more and more restrictive, the Spanish cephalopod fleet has been reduced dramatically from the 279 vessels operating in 1980 to less than one tenth of that nowadays. In 2010, only 24 Spanish cephalopod trawlers were operating in Mauritania. The average characteristics of these vessels are 32 m length, 245 GRT and 900 hp. The effort exerted by the Spanish fleet has importantly decreased since 2002. Nowadays, most of the Spanish vessels land at Nouadhibou (Mauritania) and subsequently freight the catch to Gran Canaria (Canary Islands, Spain).

EU cephalopod industrial fleet uses bottom trawls rigged with chains (Spanish trawl).

Other European countries such as Italy and Portugal also have licenses to operate in Mauritanian waters, although they number fewer. While Italy has a relatively stable number of 4-6 vessels, only 1 Portuguese trawler has been operating during the last four years.

The Octopus catch by the EU fleet has progressively declined from 2005 to 2008 (less than 5300 t), mainly due to a reduction of the deployed fishing effort.

c.2.- Guinea-Bissau

The cephalopod fishery in Guinea Bissau is carried out by foreign fleets, mainly from the EU and PRC. The average number of vessels licensed for cephalopod fishing during the period 2007-2009 was 15 (for the EU), 11 (for the Chinese fleet), and 10 (for fleets of other nationalities).

European Union cephalopod fleet

Traditionally, the Spanish fleet has been the most important European fleet operating in Guinea-Bissauan waters. The restrictions of the access to West Sahara fishing grounds since 1999, forced the Spanish cephalopod fleet to extend the scope of fishing agreements to other countries, first to Mauritania, from where it extended progressively to southern latitudes (Senegal, Guinea Bissau, and Guinea). Originally targeting cuttlefish (*Sepia hierredda*), the considerable increase in octopus catches in recent years has led to a change in the species targeted by the fleet.

Currently, Spain and Portugal are the only EU countries operating in waters off Guinea-Bissau with fishing licenses for cephalopods. The number of Spanish vessels increased from 12 (2007) to 21 (2009), probably due to the closing of the Senegalese fishing grounds (in 2006) and of those off Guinea-Conakry (in 2008). Mean technical characteristics of the Spanish vessels from 2007 to 2009 were 125 GRT, 29 m length overall and 548 hp. Portuguese vessels were slightly smaller (27 m) but more powerful (883 hp) and with more capacity (187 GRT). From 2007 to 2009, 5-6 Portuguese vessels have been operating per year.

Table III.- European Union (EU) cephalopod fleet average catch in tons (t) and percentage (%) from 2007 to 2009.

EU Cephalopod Trawlers (licensed for cephalopods)		
Crustacean	Catch (t)	19
	%	0
Cephalopod	Catch (t)	1831
	%	31
Finfish	Catch (t)	4077
	%	69

Spain's historical catch database shows increased values in recent years, reaching maximum values around 6700 t in 2007. Portuguese catch is under 100 t per year.

Other foreign cephalopod fleets

PRC, Mauritania, Morocco, Senegal, and Russia have also been operating with licenses for cephalopods in Guinea-Bissau from 2007 to 2009. The Chinese is the most important of these fleets, with a number of vessels that increased from 6 (2007) to 12 (2009). Even if the number of Chinese vessels is lower than this of the Spanish fleet, their total catch is higher, varying between 8158 t and 11 964 t. It is worth noting that although Chinese vessels operate under a fishing license for cephalopods, most of their catch is actually of other species ("others" group heading), dominated by finfish, and followed in importance by octopus and cuttlefish.

Table IV.- Chinese cephalopod fleet average catch in tons (t) and percentage (%) from 2007 to 2009.

Chinese Trawlers (licensed for cephalopods)		
Crustacean	Catch (t)	113
	%	3
Cephalopod	Catch (t)	937
	%	21
Finfish	Catch (t)	3399
	%	76

BACKGROUND

The Fisheries Partnership Agreements (FPAs) allow the European fleet to have access to surplus resources which the third country is not able to exploit. There are presently three fishing agreements with West African countries which provide access to demersal stocks: Morocco, Mauritania and Guinea-Bissau.

The scientific advice on the stock status and on exploitation levels is provided by the Joint Scientific Committees (JSC) established by the fishing agreements, which include scientists from the EU and the third country. For the agreements with West African countries, the JSC base their advice on available data and information, and also on reports by the FAO Committee for the Eastern Central Atlantic Fisheries (CECAF), in particular its Scientific Sub-Committee and the Working Groups.

For the FPAs with Mauritania and Guinea-Bissau the STECF is requested to provide the following advice on the demersal stocks exploited by European vessels:

1. Demersal shrimp and cephalopod stocks status and classification of stocks according to biological reference points,
2. Whether the EU fleets targeting demersal shrimp and cephalopod species are presently fishing the surplus of the exploited resources[1],
3. Level of catches or fishing effort for the EU fleets targeting shrimp and cephalopod demersal species, corresponding to fishing the surplus of the resources - if possible, with short and medium term projections,
4. Closed seasons or closed areas which could be defined for demersal shrimp and cephalopod fisheries,
5. Whether management of the demersal shrimp and cephalopod stocks concerned is in accordance with the Marine Strategy Framework Directive (environmental pillar of the Integrated Maritime Policy) to reach Good Environmental Status by 2020[2],
6. Assessment of present management measures against the MSY strategy[3] (catch limit, effort limit, closed seasons or areas),
7. Assess the relative impact of the EU fishing fleets targeting demersal species considering the overall demersal fishing activity in the area of the FPA,
8. Whether the analysis and methods applied to provide scientific advice are adequate to the available data/information (biological and fishery).

[1] Surplus, as defined by UNCLOS - UN, United Nations Convention of the Law of the Sea of December 1982, Part V: Exclusive Economic Zone.

[2] DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), and COMMISSION DECISION (2010/477/EU) of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (Descriptor 3, part B, of the Annex).

[3] COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT - Implementing sustainability in EU fisheries through maximum sustainable yield - COM(2006) 360 final

STECF should base its advice on the reports of the JSC, on information available from CECAF and on any other available information. In general, the biological and fishery information available to perform analysis and on which to base the scientific advice is limited both in terms of quality and quantity. As an example, fishery-independent information is scarce. Also, it is crucial that not only fishery information from the EU is available, but also from other fleets active in the same area.

Advice should be provided for the stocks listed below by management area. The management areas of the species listed below might overlap different EEZ.

Mauritania

Cephalopods:

- *Octopus vulgaris*
- *Sepia* spp.
- *Loligo vulgaris*

Crustaceans:

- *Parapenaeus longirostris*
- *Farfantepenaeus notialis*

Guinea-Bissau

Cephalopods:

- *Octopus vulgaris*
- *Sepia* spp.

Crustaceans:

- *Parapenaeus longirostris*
- *Aristeus varidens*
- *Farfantepenaeus notialis*

SCIENTIFIC ADVICE

1. DEMERSAL SHRIMP AND CEPHALOPOD STOCKS STATUS AND CLASSIFICATION OF STOCKS ACCORDING TO BIOLOGICAL REFERENCE POINTS

1.1.-MAURITANIAN STOCKS

1.1.1.-Shrimps

***Parapenaeus longirostris*- Mauritanian stock**

The deepwater rose shrimp is distributed along the entire Mauritanian coast, with two main density concentrations found in both North and South areas and having a certain discontinuity between them, approximately located around latitude 18º 45' N. No biological studies have confirmed the existence of two different populations, so only one single stock of *P. longirostris* is considered for assessment purposes off Mauritania, arbitrary defined within the country geographical limits.

The Mauritanian stock status was assessed during the last FAO/CECAF Working Group on the Assessment of Demersal Resources (Subgroup North), carried out in Agadir (Morocco) in February 2010 (FAO, 2010). The Schaefer dynamic production model and its fitting were implemented in a MS Excel spreadsheet under the BIODYN package (Punt and Hilborn, 1996; Barros, 2007). The historical series of *P. longirostris* total catch in Mauritanian waters and the longest CPUE available series (of the Spanish freezer shrimpers from 1996 to 2008) were used as input data for the model. In addition, and taking into account the uncertainty of the geographical limits of this stock, an assessment of *P. longirostris* in the zone Mauritania-Senegal-The Gambia was attempted, using the total catch of these three countries, and the CPUE series (1996-2008) of the Spanish freezer shrimpers in Mauritania as abundance index.

The results of the assessment concluded that the Mauritanian stock of *P. longirostris* is under-exploited. Current biomass (biomass of the stock in the last year of data, B_{cur}) was above the target biomass ($B_{0.1}$) and the current fishing effort (fishing mortality by fishery in the last year, $_{Fcur}$) was lower than the effort $F_{0.1}$ that corresponds to the target biomass (see table 1.I). Figure 1.1 shows the estimated stock biomass for the last year of data and the corresponding catch in relation to the biomass that would provide the maximum sustainable yield (MSY) and to the sustainable yield (SY).

The assessment carried out considering one single stock for the area Mauritania-Senegal-The Gambia, led to the same conclusions. However, the Working Group adopted the first assessment due to the uncertainty in stock identity.

Although the quality of the model fit applied to the Mauritanian stock of *P. longirostris* was acceptable, other factors should be taken into account to analyse the situation of this stock. The Mauritanian stock of *P. longirostris* seems to be not fully exploited. This could be explained by a good recruitment in 2007, together with a fishing effort decrease because of the reduction of the number of vessels targeting this species in Mauritanian waters. In any case, the assessment results should be considered with caution, both due to natural fluctuations typical of this short-living species (highly recruitment-dependent) and to the fact that the current fishing effort (F_{cur}) was

slightly higher than the effort that would provide sustainable catches at the current biomass level (F_{SYcur}).

Table 1.I.- Indicators of the stock status of *Parapenaeus longirostris* in Mauritania and in Mauritania-Senegal-The Gambia, according to the estimated Reference Points.

Stock/abundance index	F_{cur}/F_{SYcur}	$B_{cur}/B_{0.1}$	$F_{cur}/F_{0.1}$	B_{cur}/B_{MSY}	F_{cur}/F_{MSY}
Mauritania/ Spanish freezer shrimpers (1996-2008)	102%	121%	77%	133%	69%
Mauritania-Senegal-The Gambia/ Spanish freezer shrimpers (1996-2008)	123%	144%	56%	159%	51%

F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide a sustainable catch at the current biomass level.

$B_{cur}/B_{0.1}$: Relationship between the biomass estimated for the last year and the target biomass.

$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the target effort.

B_{cur}/B_{MSY}: Relationship between the biomass estimated for the last year and the biomass that would provide the Maximum Sustainable Yield (MSY).

F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide the Maximum Sustainable Yield (MSY).

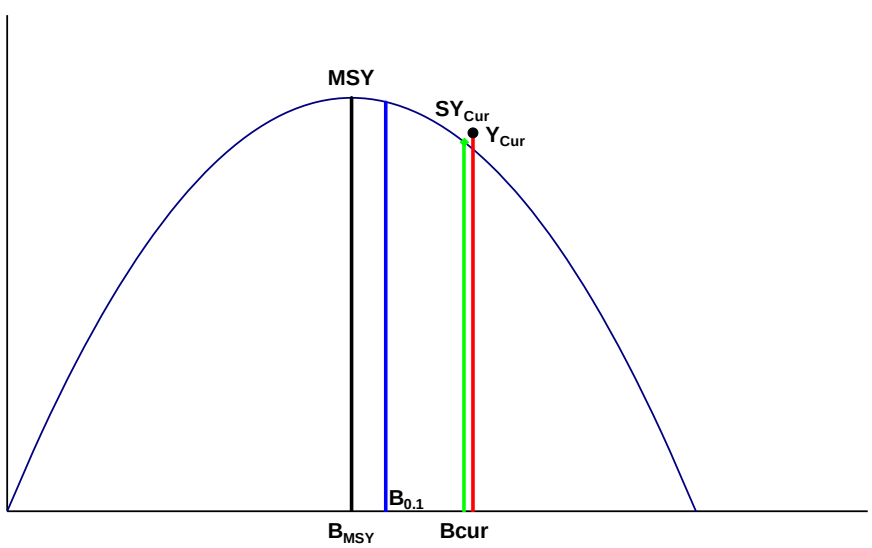


Figure 1.1.- Graphical presentation of the status of the stock and the fishery of *Parapenaeus longirostris* in Mauritanian waters in the last year considered (2008), in relation to the Reference Points estimated for the stock.

Conclusion: The Mauritanian stock of *P. longirostris* is not fully exploited.

Farfantepenaeus (Penaeus) notialis- Stock Mauritania

Two zones of high concentration of Southern rose shrimp are found along the Mauritanian coast: one in the north area (around 19º 45' N), and another along the southern boundary of the Mauritanian shelf (16º 15' N). These spatial distribution suggests the existence of two independent stocks: (i) the North stock, located in the Arguin Bank (between 18º 50' N and 20º 00' N), with some dispersion zones as far as the Levrier Bay (probably coming from a nursery area in the Arguin Bank or, more specifically around Tidra Island); and (ii) the South stock, located between Nouakchott and Saint Louis related to the Senegal River. However, due to practical reasons of data availability, one single Mauritanian stock has been considered for the assessment.

The last assessment of the Mauritanian stock of *F. notialis* was carried out in the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ, which took place in Nouadhibou (Mauritania) in December 2010 (IMROP, unpublished). They showed a completely different situation of the assessed some months before, in the FAO/CECAF Working Group on the Assessment of Demersal Resources (Subgroup North) carried out in Agadir (Morocco) in February 2010 (FAO, 2010). In both cases, a Schaefer dynamic production model was used to assess the state of this stock and data were entered into a MS Excel spreadsheet under the BIODYN package (Punt and Hilborn, 1996; Barros, 2007). Input data were time series of *F. notialis* total catch from all fleets operating in Mauritanian waters and CPUE time series of the Spanish freezer shrimpers in Mauritania, used as an abundance index, for the periods 1998-2008 (in the FAO/CECAF assessment) and 1993-2009 (in the 7th Working Group IMROP).

Table 1.II.- Indicators of the Mauritanian stock status of *Farfantepenaeus notialis*, according to the estimated Reference Points in the last two assessments.

Assessment	Stock/abundance index	F_{cur}/F_{SYcur}	$B_{cur}/B_{0.1}$	$F_{cur}/F_{0.1}$	B_{cur}/B_{MSY}	F_{cur}/F_{MSY}
FAO/CECAF WG (Subgroup North) February 2010	Mauritania/ Spanish freezer shrimpers (1998-2008)	41%	71%	55%	78%	49%
7th Working Group Mauritanian EEZ December 2010	Mauritania/ Spanish freezer shrimpers (1993-2009)	35%	97%	37%	106%	33%

F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide a sustainable catch at the current biomass level.

$B_{cur}/B_{0.1}$:Relationship between the biomass estimated for the last year and the target biomass.

$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the target effort.

B_{cur}/B_{MSY}: Relationship between the biomass estimated for the last year and the biomass that would provide the Maximum Sustainable Yield (MSY).

F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide the Maximum Sustainable Yield (MSY).

The dynamic production model showed a good fit to these data in both assessments. However, while the Mauritanian stock of *F. notialis* was over-exploited in terms of biomass in the FAO/CECAF assessment, the situation changed to full exploitation in the second assessment of that year. This is due to the fact that this second assessment considered the 2009 catch and CPUE data that reflected a recovery of the stock. In fact, the Spanish CPUE series shows an abundance peak in 2010, which is the highest in more than ten years (Figure 1.3). In this last assessment, current biomass (biomass of the stock in the last year of data, B_{cur}) was at similar levels than the target biomass $B_{0.1}$ and the effort of the last year (F_{cur}) was much lower than the target fishing effort $F_{0.1}$ (See table 1.II). Figure 1.2 shows the status of the Mauritanian stock of *F. notialis* and its fishery in the last year considered (2009), in relation to the estimated Reference Points for the stock.

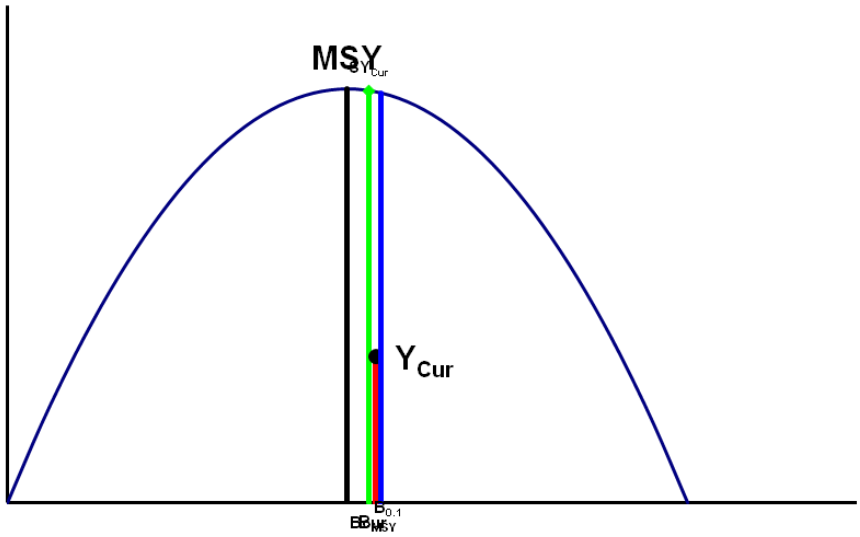


Figure 1.2.- Graphical representation of the status of the stock and the fishery of *Farfantepenaeus notialis* in Mauritanian waters in the last year considered (2009), in relation to the Reference Points estimated for the stock.

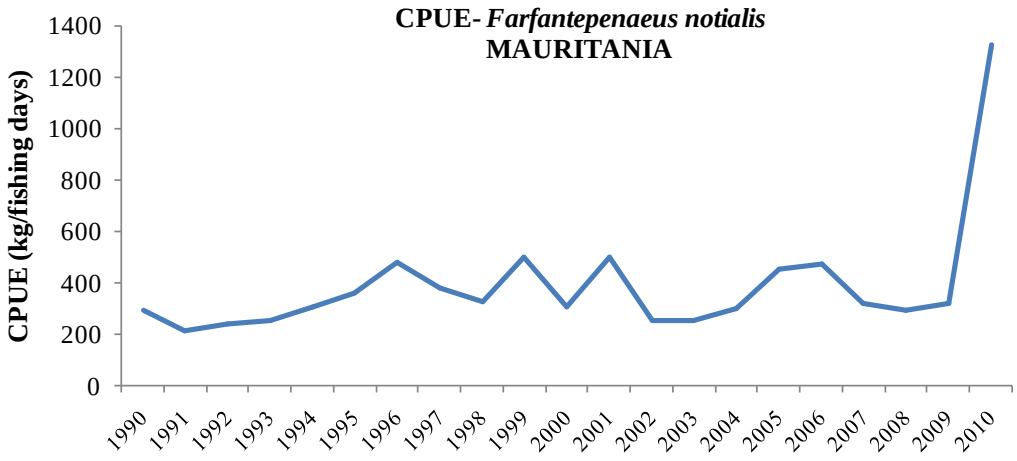


Figure 1.3.- Evolution of CPUE (kg/fishing days) of Southern rose shrimp (*Farfantepenaeus notialis*) for the period 1990-2010. Data from the Spanish shrimper fleet.

The Southern rose shrimp *F. notialis* is a short-living species. Thus, its abundance is strongly dependent on the recruitment, which is highly related to environmental factors, such as temperature, rainfall, and productivity in the area. From 2006 to 2008 a decrease was noted in this species' abundance, probably due to the combined effects of environmental factors and fishing pressure that led to the situation of overexploitation observed by the FAO/CECAF Working Group (FAO, 2010). However, in only one year, the stock seems to have recovered, due to the combined effects of an effort reduction and a probable good recruitment during the previous year, reaching a situation of fully exploitation, assessed by the IMROP Working Group.

Conclusion: The Mauritanian stock of *F. notialis* is fully-exploited, and seems to have recovered from an overexploitation situation in one single year.

1.1.2.-Cephalopods

***Octopus vulgaris*- Cape Blanc stock**

Three different octopus stocks have been identified in the North subregion of the CECAF area since the first assessment Working Group held in 1978: Dakhla stock (26 °N-21 °N), Cape Blanc stock (21 °N-16 °N) and Senegal-The Gambia stock (16 °N-12 °N). This separation of the stocks, firstly based on the fishery information, was recently confirmed by genetic analyses (Murphy *et al*., 2002) and more accurate fishery information including vessel satellite tracking (VMS) data.

The Mauritanian octopus stock corresponds to the Cape Blanc stock, located between 21º N and 16º N.

The last formal assessment of the Cape Blanc octopus stock was carried out in the FAO/CECAF Working Group on the Assessment of Demersal Resources (Subgroup North) carried out in Agadir (Morocco) in February 2010 (FAO, 2010). The model and its fitting were implemented into a MS Excel spreadsheet under the BIODYN package (Punt and Hilborn, 1996; Barros, 2007). The input data were the time series (1999-2008) of total octopus catch (including data from both the industrial and the artisanal fleets) and the CPUE series of the Mauritanian cephalopod wet-fish trawlers used as abundance index.

The adjustment of the model was relatively good and the results were consistent with those of the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ, which was held in Nouadhibou (Mauritania) in December 2010. Nevertheless, these results are not included in this report due to the unavailability of data and because this last assessment has to be validated by the responsible Scientific Committee. The two Working Groups conducted in 2010 evidenced the over-exploitation of this octopus stock, both in terms of biomass and fishing effort, since the current biomass (B_{cur}) was lower than the target biomass $B_{0.1}$ and the fishing effort of the last year F_{cur} was higher than the target effort ($F_{0.1}$). Table 1.III shows the main indicators of *O. vulgaris* Cape Blanc stock, according to the different Reference Points estimated in the two assessments made in 2010.

Although the indicator values are quite similar from one assessment to another, they reflect a slightly worse situation in 2010 compared to 2009.

The fishery and stock status are represented in Figure 1.4 for the last year considered (2008) in the assessment of February 2010 (FAO, 2010).

Table 1.III.- Indicators of the Cape Blanc stock status of *Octopus vulgaris* (Mauritania), according to the estimated Reference Points in the last two assessments.

Assessment	Stock/abundance index	F_{cur}/F_{SYcur}	$B_{cur}/B_{0.1}$	$F_{cur}/F_{0.1}$	B_{cur}/B_{MSY}	F_{cur}/F_{MSY}
FAO/CECAF WG (Subgroup North) February 2010	Cape Blanc/ Mauritanian cephalopod wet-fish trawlers (1999-2008)	119%	79%	150%	86%	135%
7th Working Group Mauritanian EEZ December 2010	Cape Blanc/ EU cephalopod freezer trawlers (1995-2009)	133%	76%	172%	83%	155%

F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide a sustainable catch at the current biomass level.

$B_{cur}/B_{0.1}$: Relationship between the biomass estimated for the last year and the target biomass.

$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the target effort.

B_{cur}/B_{MSY}: Relationship between the biomass estimated for the last year and the biomass that would provide the Maximum Sustainable Yield (MSY).

F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide the Maximum Sustainable Yield (MSY).

Therefore, the last two assessments carried out in 2010 confirm the situation of over-exploitation of the Cape Blanc Stock of *O. vulgaris*. These results agree with the previous assessments carried out by FAO/CECAF Working Groups in 2004 (FAO, 2006b) and 2007 (FAO, 2007), and IMROP Working Group in 2006 (Gascuel *et al*., in press). Thus, the reduction of the fishing effort has not led to a change in the situation. Despite this clear over-exploitation status, the octopus abundance indices estimated in the scientific surveys carried out by the Institut Mauritanien de Recherches Océanographiques (IMROP) on board the R/V AL AWAN have shown a general increasing trend in octopus abundance (FAO, 2010).

Conclusion: The Cape Blanc stock of *O. vulgaris* is overexploited, both in terms of biomass and fishing mortality.

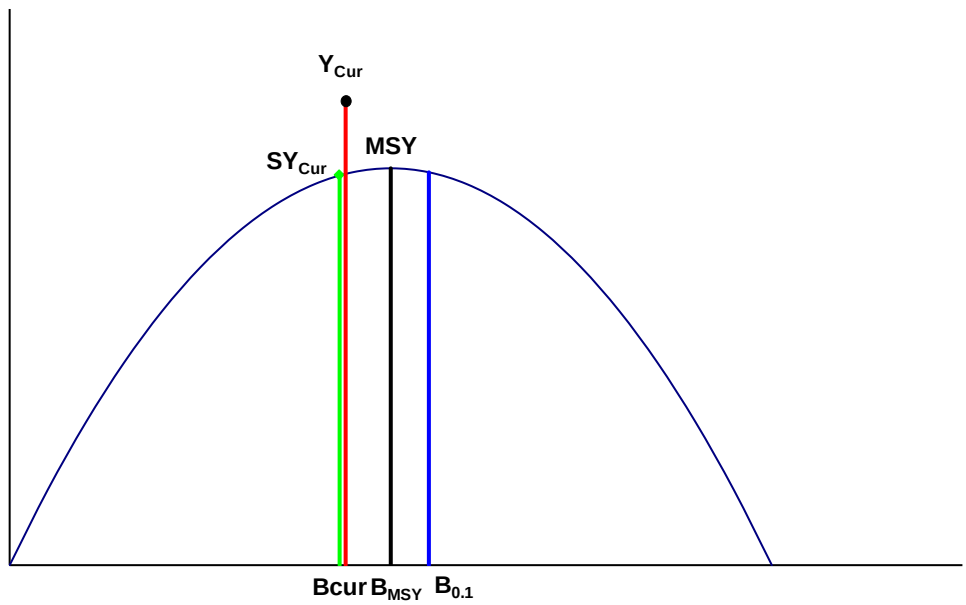


Figure 1.4.- Graphical presentation of the status of the Cape Blanc stock and the fishery of *Octopus vulgaris* in Mauritanian waters in the last year considered (2008), in relation to the Reference Points estimated for the stock.

Sepia spp. – Cape Blanc stock

The three administrative stocks adopted for the cuttlefish in North West African waters are the same as those identified for octopus in the area: Dakhla Stock (26 °N-21 °N); Cape Blanc Stock (21 °N-16 °N), and Senegal-The Gambia Stock (16 °N-12 °N). In absence of new biological data, the cuttlefish stocks' structure was no longer discussed and these three stocks were those examined by the last FAO/CECAF Working Group (FAO, 2010). The Cape Blanc stock is exploited in Mauritanian fishing grounds.

The 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ (Nouadhibou -Mauritania- December 2010) carried out the most recent cuttlefish Cape Blanc stock assessment. Previously, the assessment attempted in the FAO/CECAF Working Group on the Assessment of Demersal Resources (Subgroup North) (Agadir –Morocco-, February 2010), was rejected due to a bad fit of the model to the available data (FAO, 2010). Both assessments implemented the Schaefer dynamic production model into an Excel spreadsheet under the BIODYN package (Punt and Hilborn, 1996; Barros, 2007). The IMROP Working Group used as input data the total *Sepia* spp. catch time series (1995-2009) in Cape Blanc together with the Mauritanian wet-fish trawlers CPUE series for the same period considered as abundance indices.

The last assessment (IMROP, unpublished) showed a situation of under-exploitation of the Cape Blanc stock of cuttlefish, both in terms of biomass and fishing mortality. Indeed, the biomass of the last year (B_{cur}) was above the target biomass ($B_{0.1}$), while the fishing mortality of the last year (F_{cur}) was below the fishing effort that would provide a sustainable catch at the current biomass level (F_{SYcur}) (see table 1.IV). The cuttlefish stock state has apparently improved compared with the situation depicted by the 2004 assessment (FAO, 2006b), which established the over-exploitation of the stock in terms of biomass. Figure 1.5 shows the Cape Blanc cuttlefish stock status and its fishery in the last year of data considered (2009).

Table 1.IV.- Indicators of the Cape Blanc stock status of *Sepia* spp. (Mauritania), according to the estimated Reference Points.

Stock/abundance index	F_{cur}/F_{SYcur}	$B_{cur}/B_{0.1}$	$F_{cur}/F_{0.1}$	B_{cur}/B_{MSY}	F_{cur}/F_{MSY}
Cape Blanc/ Mauritanian cephalopod wet-fish trawlers (1995-2009)	81%	120%	61%	132%	55%

F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide a sustainable catch at the current biomass level.

$B_{cur}/B_{0.1}$: Relationship between the biomass estimated for the last year and the target biomass.

$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the target effort.

B_{cur}/B_{MSY}: Relationship between the biomass estimated for the last year and the biomass that would provide the Maximum Sustainable Yield (MSY).

F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide the Maximum Sustainable Yield (MSY).

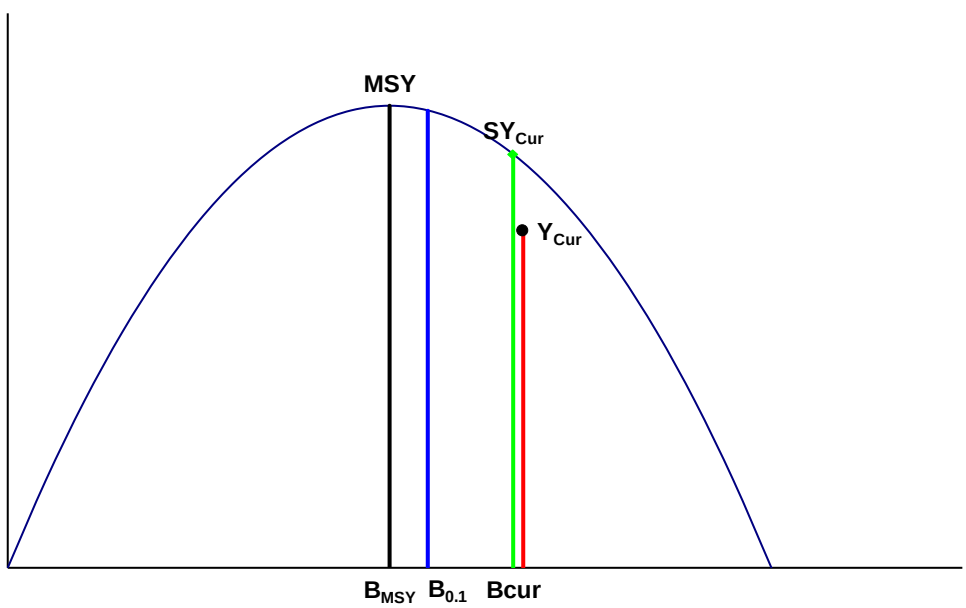


Figure 1.5.- Graphical presentation of the status of the Cape Blanc stock and the fishery of *Sepia* spp. in Mauritanian waters in the last year considered (2009), in relation to the Reference Points estimated for the stock.

These results should be considered with caution, due to the uncertainty of certain parameters estimated by the model. Furthermore, even if the assessment has to be validated by the

responsible Scientific Committee, this information is the only one currently available about the status of the Mauritanian cuttlefish resource.

Bearing in mind the required caution, the assessment showed a situation of under-exploitation where an eventual increase of the fishing effort could be allowed. However, it is also important to consider that the assessed resource is composed of a mix group of species of the genus Sepia (where *S. hierredda* is the most abundant in the catch), which may have different biological characteristics and vulnerability to the fishing pressure. In addition, the cuttlefish is commonly exploited as by-catch by several fleets operating in Mauritanian waters.

Conclusion: The Cape Blanc stock of *Sepia* spp. is underexploited, both in terms of biomass and fishing mortality.

***Loligo vulgaris*- Cape Blanc stock**

As there are no data available to enable the identification of possible squid stocks in North West African waters, the three same stocks considered for octopus and cuttlefish are used for squid assessment purposes: Dakhla, Cape Blanc and Senegal-The Gambia. However, the species is rarely fished beyond the southern Mauritanian boundary.

To date, no assessments of the Cap Blanc squid stock have ever been carried out under the scope of FAO/CECAF Working Groups. Therefore, to have an idea of the stock situation, the only possible analysis is that of the evolution of abundance indices (CPUEs) in historical data series. It is worth mentioning that there is not a specific fishery targeting squids in Mauritanian waters and that they are mainly caught as by-catch of fleets mainly targeting octopus. Thus, as the CPUEs of different fleet segments catching squids in Mauritanian waters (Figure 1.6) are not the best indicators of squid's abundance, the analysis also considers the trend of the abundance indices obtained in scientific surveys (non fisheries-dependent) (Figure 1.7).

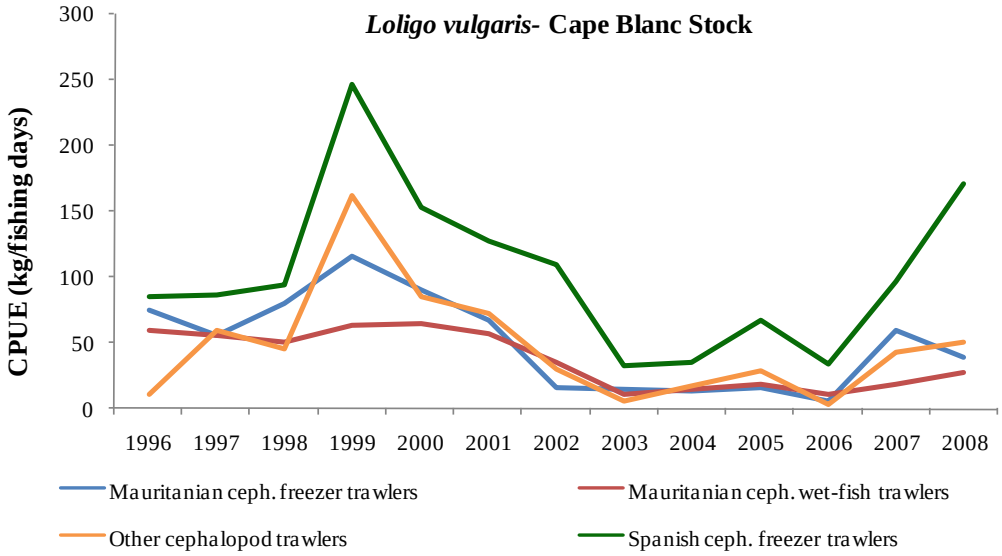


Figure 1.6.- Evolution of CPUE (kg/fishing days) of *Loligo vulgaris* (Cape Blanc stock). Data from different fleet segments in Mauritanian waters.

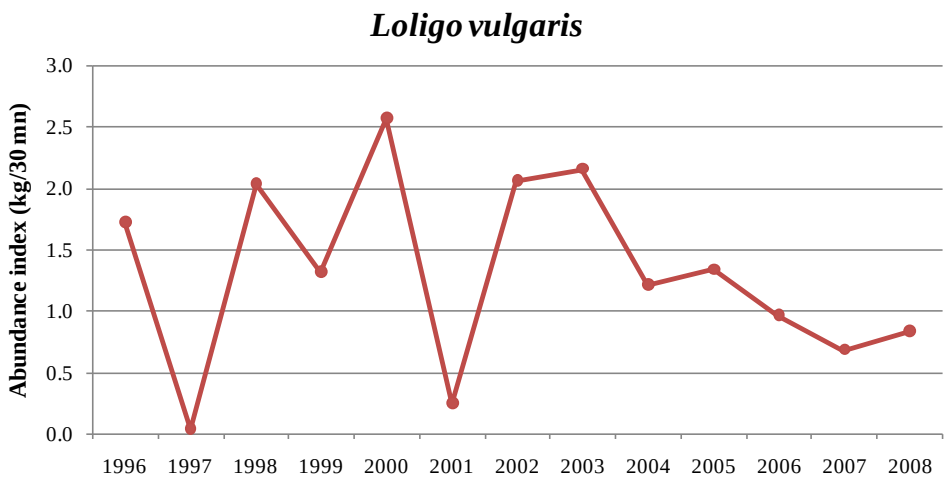


Figure 1.7.- Evolution of abundance index of *Loligo vulgaris* obtained in scientific surveys carried out in Mauritanian waters.

Both abundance indices (CPUEs and abundance indices from scientific surveys) show a general decreasing trend, although with the typical oscillations of short-living species, very dependent on their recruitment. In both figures, the abundance peak detected in 1999 (fishery data) or 2000 (survey data), is followed by a decrease subsequent years. However, fishery data seem to show a stock recovery during the last years of the series (from 2006 onwards), while survey data only show a slight increase in the last year of the series (2008).

Conclusion: The state of the Cape Blanc stock of *Loligo vulgaris* is unknown. Abundance indices seem to indicate a slight recovery of the stock since 2007.

1.2- GUINEA-BISSAU STOCKS

1.2.1.-Shrimp

***Parapenaeus longirostris*- Guinea-Bissauan stock**

The assumption of the existence of one stock of *P. longirostris*, defined within the geographic boundaries of Guinea-Bissau, is arbitrary and a consequence of the absence of biological studies enabling the identification of shrimp stocks in West African waters. This decision was adopted by the FAO/CECAF Working Group on the Assessment of Demersal Resources (Subgroup South) (Cotonou -Benin, September 2005) (FAO, 2005).

The deep-water rose shrimp stock status in Guinea-Bissau was assessed during the last Joint Scientific Committee between UE-Bissau (Bissau, March 2011) (unpublished). The Schaefer dynamic production model and its fitting were implemented into a MS Excel spreadsheet under the BIODYN package (Punt and Hilborn, 1996; Barros, 2007), considering the *P. longirostris* total

catch in Guinea-Bissau and the longest available CPUE series (2000-2009, Spanish freezer shrimpers) as abundance indices.

The assessment concluded that the stock of *P. longirostris* in Guinea-Bissau was under-exploited. Current biomass (biomass of the stock in the last year of data, B_{cur}) was above the target biomass ($B_{0.1}$) and the current fishing effort (fishing mortality by fishery in the last year, F_{cur}) was lower than the target effort ($F_{0.1}$), achieving $B_{0.1}$ (see table 1.V). The estimated stock biomass for the last year of data and the corresponding catch are presented in relation to the biomass that would provide the maximum sustainable yield (MSY) and to the sustainable yield (SY) (Figure 1.8).

Table 1.V.- Indicators of the stock status of *Parapenaeus longirostris* in Guinea-Bissau, according to the estimated Reference Points.

Stock/abundance index	F_{cur}/F_{SYcur}	$B_{cur}/B_{0.1}$	$F_{cur}/F_{0.1}$	B_{cur}/B_{MSY}	F_{cur}/F_{MSY}
Guinea-Bissau/ Spanish freezer shrimpers (2000-2009)	114%	153%	39%	169%	35%

F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide a sustainable catch at the current biomass level.

$B_{cur}/B_{0.1}$: Relationship between the biomass estimated for the last year and the target biomass.

$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the target effort.

B_{cur}/B_{MSY}: Relationship between the biomass estimated for the last year and the biomass that would provide the Maximum Sustainable Yield (MSY).

F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide the Maximum Sustainable Yield (MSY).

The assessment presented here should be considered with great caution. On one hand, the available data evidenced some uncertainties and the series of total catch used may be under-estimated. On the other hand, the effort used to calculate the CPUE was the total effort exerted by the Spanish shrimper fleet, without distinction of the effort deployed to fish *P. longirostris*, which should be separated from the effort targeting *F. notialis* or *A. varidens*. In addition, the fit of the model to available data was not very good.

Furthermore, the natural fluctuations typical of this short-living species, strongly recruitment-dependent, as well as the fact that the current fishing effort (F_{cur}) was higher than the effort that would provide sustainable catches at the current biomass level (FSY_{cur}), suggest that caution should be applied when advising on the current status of this deep-water rose shrimp stock.

Conclusion: The Guinea-Bissau stock of *P. longirostris* seems to be underexploited, both in terms of biomass and fishing mortality.

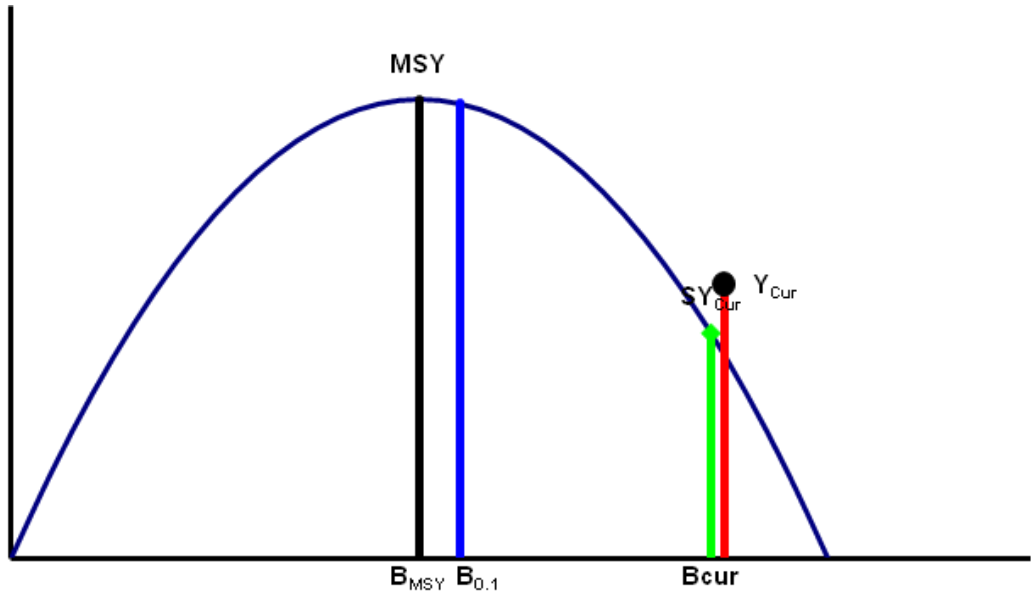


Figure 1.8.- Graphical presentation of the status of the stock and the fishery of *Parapenaeus longirostris* in Guinea-Bissauan waters in the last year considered (2009), in relation to the Reference Points estimated for the stock.

Farfantepenaeus notialis and *Aristeus varidens*- Guinea-Bissauan stocks

No assessments of the stocks of either Southern rose shrimp (*F. notialis*) or striped red shrimp (*A. varidens*) of Guinea-Bissau have ever been carried out. In the absence of any other available type of information, the analysis of yields variations of these two species may give some indication of their resources' status.

The analysis of the abundance variations of the Southern rose shrimp and striped red shrimp stocks of Guinea-Bissau was based on the CPUE historical series of the Spanish fleet, as this was the longest available time series (Figure 1.9).

Even if fluctuating, the abundance indices are generally stable over the long term, and without dramatic recent drops. However, it is necessary to keep in mind that this CPUE is based on total effort, and that this fleet mainly targets the deep-water rose shrimp *P. longirostris*. The two species considered in this analysis have a short-life span, making their population dynamics very dependent on their recruitment.

Conclusion: the state of the Guinea-Bissauan stocks of *F. notialis* and *A. varidens* is unknown. Abundance indices show a stable situation for both stocks.

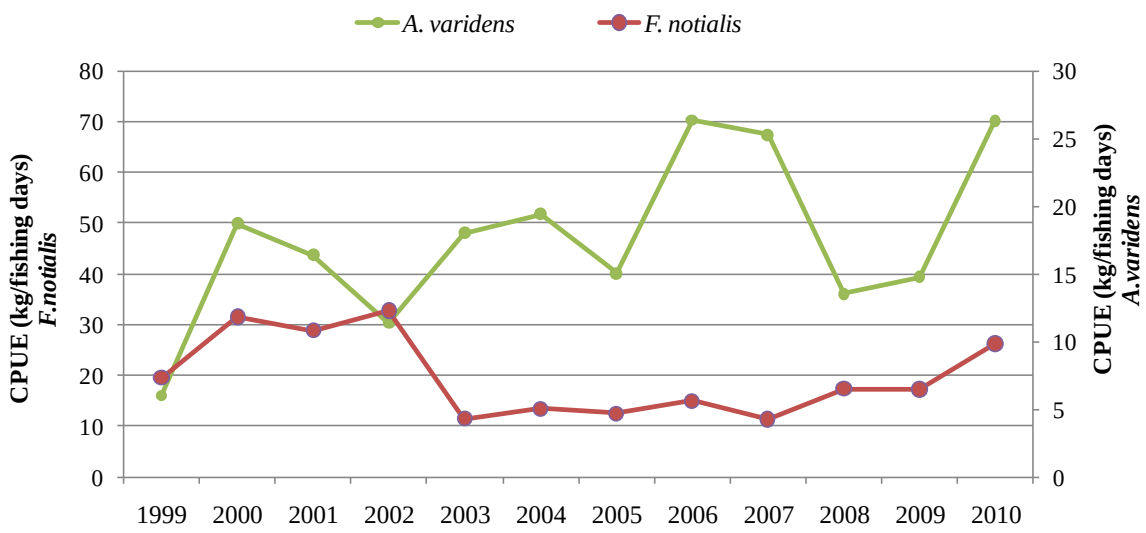


Figure 1.9.- Evolution of CPUE (kg/fishing days) of Southern rose shrimp (*Farfantepenaeus notialis*) and striped red shrimp (*Aristeus varidens*). Data from the Spanish shrimper fleet.

1.2.1.-Cephalopods

Octopus vulgaris- Guinea-Bissauan stock

Like *P. longirostris*, the absence of any biological information enabling the identification of *O. vulgaris* stocks in the area, means that an arbitrary assumption has been made that it is a single stock defined within geographical limits of Guinea-Bissau. This decision was adopted in the FAO/CECAF Working Group on the Assessment of Demersal Resources (Subgroup South) (Cotonou, Benin, September 2005) (FAO, 2005).

The octopus stock status in Guinea-Bissau was assessed during the last Joint Scientific Committee between UE-Guinea-Bissau (Bissau, March 2011) (unpublished). The Schaefer dynamic production model was implemented into a MS Excel Spreadsheet under the BIODYN package, considering the total catch of *O. vulgaris* in Guinea-Bissau and the longest available CPUE time series (2000-2008) of the Spanish cephalopod freezer trawlers as abundance indices.

The assessment concluded that the stock of *O. vulgaris* in Guinea-Bissau was under-exploited. The current biomass (biomass of the stock in the last year of data, B_{cur}) was above the target biomass ($B_{0.1}$) and the current fishing effort (fishing mortality by fishery in the last year, F_{cur}) was lower than the target effort $F_{0.1}$ that corresponds to the target biomass (see table 1.VI, Figure 1.10).

As the data sets used to assess the octopus resource in waters off Guinea-Bissau have the same abovementioned problems as the deep-water rose shrimp, the results should be considered with great caution. Furthermore, there was a poor fit of the model to the Guinea-Bissauan *O. vulgaris* stock data.

Table 1.VI.- Indicators of the stock status of *Octopus vulgaris* in Guinea-Bissau, according to the estimated Reference Points.

Stock/abundance index	F_{cur}/F_{SYcur}	$B_{cur}/B_{0.1}$	$F_{cur}/F_{0.1}$	B_{cur}/B_{MSY}	F_{cur}/F_{MSY}
Guinea-Bissau/ Spanish freezer trawlers targeting cephalopods (2000-2008)	130%	149%	53%	164%	48%

F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide a sustainable catch at the current biomass level.

$B_{cur}/B_{0.1}$: Relationship between the biomass estimated for the last year and the target biomass.

$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the target effort.

B_{cur}/B_{MSY}: Relationship between the biomass estimated for the last year and the biomass that would provide the Maximum Sustainable Yield (MSY).

F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient effectively observed in the last year of the series and the fishing mortality coefficient that would provide the Maximum Sustainable Yield (MSY).

In addition, due to the natural fluctuations typical of this short-living species, strongly recruitment-dependent, as well as the fact that the current fishing effort (F_{cur}) is higher than the effort that would provide sustainable catches at the current biomass level (FSY_{cur}) mean caution should be exercised when interpreting the under-exploited status of this octopus stock.

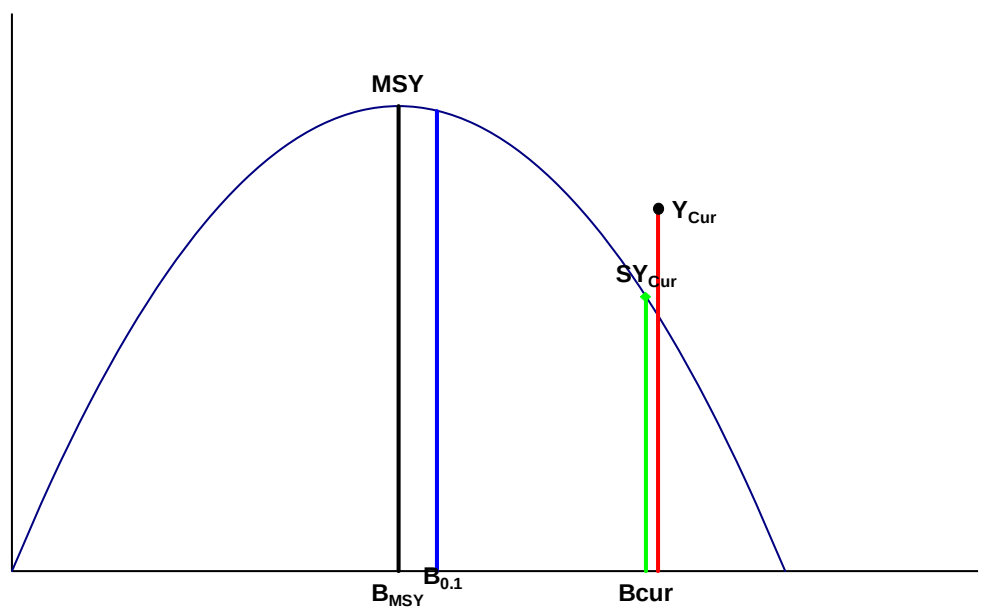


Figure 1.10.- Graphical presentation of the status of the stock and the fishery of *Octopus vulgaris* in Guinea-Bissauan waters in the last year considered (2008), in relation to the Reference Points estimated for the stock.

Conclusion: The Guinea-Bissauan stock of *O. vulgaris* is under-exploited, both in terms of biomass and fishing mortality.

Sepia spp.- Guinea Bissauan stock

There is not any assessment of the Guinea-Bissauan stock of *Sepia* spp. The CPUE series from Spanish cephalopod fleet is the only available historical database capable of giving an idea of the evolution of this stock (Figure 1.11).

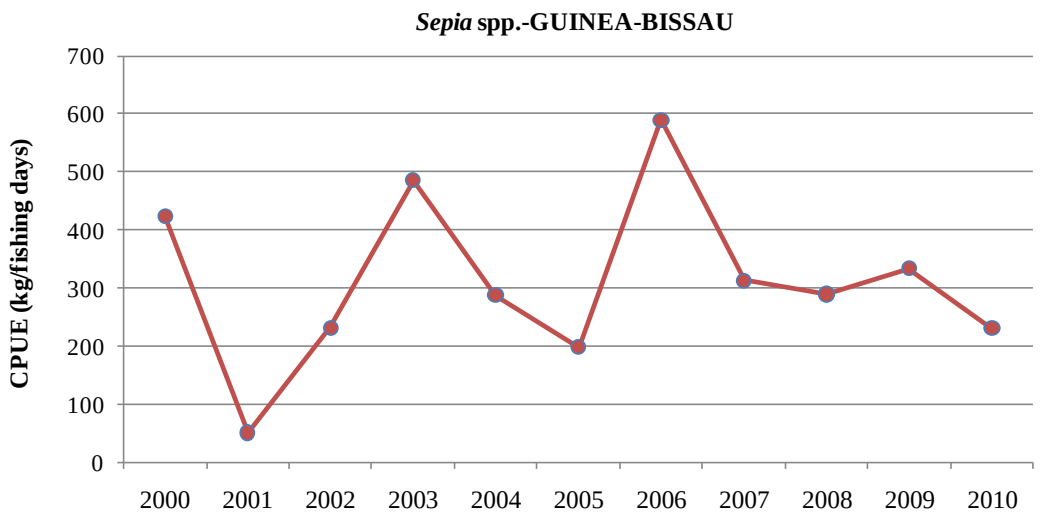


Figure 1.11.- Evolution of CPUE (kg/fishing days) for the cuttlefish (*Sepia* spp.) of the Spanish cephalopod fleet.

The CPUE time series shows the typical abundance fluctuations of a short-living species, such as cuttlefish, although some stability can be seen over the last four years. Two important considerations should be taken into account when interpreting these results: (i) the *Sepia* spp. stock is composed of different species of genus *Sepia*, although *S. hierredda* is supposed to be the dominant one; and (ii) the CPUE has been calculated considering the total effort of the Spanish cephalopod fleet, without separating the effort exerted targeting octopus and the effort exerted targeting cuttlefish. Taking into account these restrictions, the presented data give a general indication of the stock trends in the Guinea-Bissauan fishing grounds.

Conclusion: the state of the Guinea-Bissau stock of *Sepia* spp. is unknown. Abundance indices show a relatively stable situation during the last four years.

2. ARE THE EU FLEETS TARGETING DEMERSAL SHRIMP AND CEPHALOPOD SPECIES PRESENTLY FISHING THE SURPLUS OF THE EXPLOITED RESOURCES?

The coastal states shall determine its capacity to harvest the living resources of the Exclusive Economic Zone (EEZ). Where the coastal states do not have the capacity to harvest the entire allowable catch, it shall, through agreements or other arrangements and pursuant to certain terms, conditions, laws and regulations, give other states access to the **surplus of the allowable catch** (UNCLOS, 1982).

To answer the question addressed in this point, we have to review all the assessments explained in the previous chapter.

2.1. MAURITANIA

2.1.1.- Shrimps

***Parapenaeus longirostris*- Mauritanian stock**

The last assessment of the Mauritanian stock of *P. longirostris* was made in 2010 with a data series up to 2008. In that year, the Mauritanian stock of the deep-water rose shrimp *P. longirostris* was mainly targeted by the EU (mainly Spanish) freezer shrimper fleet, followed by the Mauritanian shrimper fleet and vessels of other nationalities. Table 2.I shows the catch levels (in tons) of the different fleets targeting shrimps during the last five years of available data, as well as the average values during the period 2004-2008, and the catch percentage by fleet. However, as currently both Mauritanian and other foreign shrimpers' fleets have been significantly reduced, the EU is almost the only "official" fleet targeting this species.

The results of the last assessment concluded that the Mauritanian stock of *P. longirostris* was under-exploited, leaving a surplus that could still be exploited.

Table 2.I.- Catch (tons) of *Parapenaeus longirostris* in Mauritania over the period 2004-2008 with average values and percentages by fleet.

FLEET	2004	2005	2006	2007	2008	AVERAGE	%
Spanish Freezer Shrimpers	1939	996	1757	4922	2867	2496	72
Mauritanian Freezer Shrimpers	1016	457	344	685	271	555	16
Other Nationalities Shrimpers	556	270	964	265	104	432	12
Other Trawlers (by-catch)	11	5	1	3	0	4	0

The current biomass estimated by the model ($B_{cur,}$ that corresponded to year 2008) was around 11 600 t, and produced a sustainable yield of 3164 t, corresponding to the surplus of the *P. longirostris* stock (see CSY in Table 2.II). The average catch value of the Spanish fleet (the biggest fleet in the area) was 2867 t in 2008 (Table 2.I). Thus, in 2008 the Spanish fleet was indeed fishing less than the total surplus at that moment. If the Mauritanian vessels were fishing at the 2008 level (even if we definitively know this not to be the case, as this fleet has almost disappeared), the surplus available to the EU fleet would then be the value of the sustainable production in the last year (CSY) minus the average catch of the Mauritanian fleet (2609 t) (Table 2.II). This surplus estimation is still greater than the EU catch. As this stock was not fully exploited, if the fishery developed to be fully exploited and reached the maximum sustainable yield (MSY), a surplus of 2990 t (without factoring in the average catches of the Mauritanian fleet) would still be available for other fleets (Table 2.II).

Table 2.II.- Parameters of *Parapenaeus longirostris* production in Mauritanian waters, estimated by the model and used as indicators of the surplus production, and differences between these indicators and the catch of the Mauritanian fleet from 2004 to 2008 (Mau. Mean Catch).

PARAMETERS *(P. longirostris)*	Value (t)
CSY	3164
MSY	3545
Mau. Mean Catch (2004-2008)	555
CSY - (Mau. Mean Catch)	2609
MSY- (Mau. Mean Catch)	2990

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

Mau. Mean Catch (2004-2009) = Average catch values by the Mauritanian fleet during the period 2004-2008.

CSY - (Mau. Mean Catch) = Surplus at the current year (last year of the assessment).

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

In conclusion, it could be considered that the EU fleet is currently fishing the surplus of the exploited *P. longirostris* resource. Furthermore, if the Mauritanian shrimper fleet continues its reduction, the estimated surplus would probably be higher than the given values.

Farfantepenaeus (Penaeus) notialis- Mauritanian stock

The Spanish fleet reports the highest catch of the Southern rose shrimp *F. notialis* in Mauritanian waters (Table 2.IV), followed by the Mauritanian industrial shrimper fleet and by other shrimper vessels from other nations. Even if, as said above, the last two fleet segments have almost currently disappeared, the level of unreported catches is assumed to be higher, both due to other coastal trawlers that legally/illegally catch *F. notialis* and to artisanal vessels (especially Senegalese), whose catches have not been reported.

The last assessment carried out in December 2010 (7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ), indicated a recovering of

the stock, which evolved from an over-exploitation to a full-exploitation situation in only one year. Unfortunately, catch data used for this assessment were not available by fleet, which made impossible to perform the same analysis done with *P. longirostris*. Therefore, data reported to the last FAO/CECAF demersal Working Group (FAO, 2010) were used to estimate the catch percentages by fleet (Table 2.III), subsequently applied to the total Mauritanian catch data (provided by Mauritania to the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ). The results are presented in table 2.III.

Table 2.III.- Catch percentage of *Farfantepenaeus notialis* in Mauritania over the period 2004-2009, with average values by fleet.

% OF TOTAL CATCHES BY FLEET	2004	2005	2006	2007	2008	2009*	AVERAGE
% Spanish Freezer Shrimpers	40	40	66	36	69	50	50
% Mauritanian Freezer Shrimpers	31	26	26	24	18	25	25
% Other Nationalities Freezer Shrimpers	29	34	8	40	13	25	25

* Percentages of 2009 have been estimated as an average of the percentages over the period 2004-2008.

Table 2.IV.- Estimation of catch (tons) of the Mauritanian stock of *Farfantepenaeus notialis* over the period 2004-2009 and average value by fleet.

FLEET	2004	2005	2006	2007	2008	2009*	AVERAGE
Spanish Freezer Shrimpers	963	1108	1791	699	555	705	970
Mauritanian Freezer Shrimpers	748	703	707	458	142	347	518
Other Nationalities Freezer Shrimpers	698	929	217	785	103	348	513
TOTAL*	2409	2740	2715	1942	799	1400	2001

*Total catch was provided by Mauritania to the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ

The last assessment (December 2010) provided only the value of the maximum sustainable yield (MSY), which is supposed to be very similar to the current (last year) sustainable yield (CSY), as the stock was fully exploited. If the fishery continued to be fully-exploited and abundance was at the MSY level, a surplus of 1266 t (once the Mauritanian catch has been subtracted) would still be available for other fleets (Table 2.V). This surplus is close to the mean catch levels of the EU (mainly Spanish) shrimper fleet).

Table 2.V.- Parameters of *Farfantepenaeus notialis* production in Mauritanian waters, estimated by the model and used as indicators of the surplus production, and differences between these indicators and the catch of the Mauritanian fleet from 2004 to 2009 (Mau. Mean Catch).

PARAMETERS *(F. notialis)*	Value (t)
MSY	1784
Mau. Mean Catch (2004-2009)	518
MSY- (Mau. Mean Catch)	1266

MSY= Maximum Sustainable Yield

Mau. Mean Catch (2005-2009) = Average catch values by the Mauritanian fleet over the period 2004-2008.

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

Data from the Spanish shrimper fleet in Mauritania show a great increase of the Southern rose shrimp abundance in 2010. In that year, the abundance of this species reached the maximum value ever attained since 1990 (see Figure 1.3), probably due to an exceptional recruitment the preceding year. Considering this fact, probably a higher surplus than estimated could be available for the EU fleet. However, taking into account the great inter-annual variability in the abundance of this short-living species, very dependent on the recruitment, this situation could change oppositely in the short-term if the environmental conditions were not favourable to the species recruitment processes. Furthermore, the calculation of the surplus is based on estimated values of the last year of the fishery. Therefore, we recommend being cautious when addressing this subject.

It could be concluded that the EU fleet is currently fishing the surplus of the exploited *F. notialis* resource.

2.1.2.-Cephalopods

***Octopus vulgaris*- Cape Blanc stock**

Mauritanian octopus fishery is very developed and is carried out by several fleet segments: cephalopod freezer trawlers, cephalopod wet-fish trawlers, other trawlers that fish octopus as by-catch, and a very large artisanal fleet. In Mauritanian waters, most of the octopus is caught by domestic vessels operating in coastal areas (see table 2.VI), followed by EU vessels (mainly composed of Spanish freezer trawlers) and other foreign fleets targeting this species.

In this situation of over-exploitation of the octopus Cape Blanc stock, the current biomass (B_{cur} referred to 2008) was around 23 800 t, with a surplus of almost 27 000 t. If Mauritanian average catch were eliminated, the available surplus for other fleets in that year would have been 7516 t (Table 2.VII), a value beyond the catch from all foreign fleets in 2008. If the stock is brought to the biomass level of MSY (what could be possible with a change in the current exploitation pattern), the surplus not harvested by Mauritanian fleets would be around 8000 t (or higher), that could be made available for both the EU and other foreign fleets operating in the area.

Table 2.VI.- Catch (tons) of *Octopus vulgaris* of the Cape Blanc stock over the period 2004-2008 with average values and percentages by fleet.

FLEET	2004	2005	2006	2007	2008	AVERAGE	%
Spanish Cephalopod Freezer Trawlers	7321	9306	6482	4639	3757	6301	24
Mauritanian Cephalopod Fleets (industrial + artisanal)	17237	19717	14503	18945	26743	19429	73
Other Nationalities Cephalopod Trawlers	514	615	629	1382	1516	931	3

Table 2.VII.- Parameters of *Octopus vulgaris* of the Cape Blanc stock in Mauritanian waters estimated by the model and used as indicators of the surplus production. Differences between these indicators and the catch of Mauritanian (industrial and artisanal) fleets from 2004 to 2008 (Mau. Mean Catch).

PARAMETERS *(O. vulgaris)*	Value (t)
CSY	26946
MSY	27447
Mau. Mean Catch (2004-2008)	19430
CSY - (Mau. Catch-2008)	7516
MSY- (Mau. Catch 2008)	8016

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

Mau. Mean Catch (2004-2009) = Average catch values by the Mauritanian fleet during the period 2004-2008.

CSY - (Mau. Mean Catch) = Surplus at the current year (last year of the assessment).

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

Nevertheless, as octopus is also a short-living species very dependent on the recruitment processes, if fishing pressure diminishes and environmental conditions are appropriate for its recruitment, the stock could recover in a relatively short-term.

According to the last available information, it could be concluded that EU fleet is currently fishing the surplus of the exploited Cape Blanc stock of *O. vulgaris*.

Sepia spp. - Cape Blanc Stock

As above mentioned for octopus fishery, the majority of the cuttlefish catch in Mauritanian waters is due to the activity of an industrial domestic fleet (Table 2.VI) composed of artisanal boats and both freezer and wet-fish cephalopod trawlers, although other Mauritanian trawlers also fish *Sepia* spp. as by-catch. The EU fleet (mainly Spanish) is the second most important fleet in terms of catch

of this species, followed by fleets of other nationalities.

The last assessment carried out in 2010, by the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ, indicated a good stock situation, which seemed to be under-exploited, although it is worth remembering that this assessment should be considered with caution. Unfortunately, catch used for this assessment was not available by fleet, which made the same analysis as done with the above mentioned resources, impossible to perform. Therefore, data reported to the last FAO/CECAF demersal Working Group (FAO, 2010) were used for the estimations of catch percentage by fleet (Table 2.VIII). These catch percentages by fleet were applied to the total catch data provided by Mauritania to the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ (IMROP, unpublished). The results are presented in table 2.VIII.

Table 2.VIII.- Catch percentage of *Sepia* spp. in Mauritania by fleet over the period 2004-2009, with average values by fleet.

% OF TOTAL CATCH BY FLEET	2004	2005	2006	2007	2008	2009*	AVERAGE
% Mauritanian Cephalopod Freezer and Wet-fish Trawlers	73	77	80	85	77	79	79
% Spanish Cephalopod Freezer Trawlers	22	18	15	12	19	17	17
% Other Nationalities Cephalopod Trawlers	5	5	4	4	4	4	4

* Percentages of 2009 have been estimated as an average of the percentages over the period 2004-2008.

This stock is mainly exploited by the Mauritanian fleet (see tables 2.VIII and 2.IX), which harvested almost 80% of the catch. The EU (Spanish) fleet only harvested 17% of the total catch.

The biomass produced during the last year considered (B_{cur}, referred to 2009) produced a sustainable yield (CSY) of 6260 t (Table 2.X). Mauritanian mean catch was around 3250 t, which means that there was a surplus of 3000 t not harvested by the Mauritanian vessels in that year. Both the EU and other foreign fleets together fished around 1000 t in 2009. The EU fleets were then fishing the surplus produced. Furthermore, if the stock reached the biomass level of MSY, the surplus production (once the Mauritanian catch has been subtracted) would be around 3700 t, a value clearly higher than the average EU catch.

Although these results suggest the possibility of continuing and even increasing cuttlefish harvesting, it is important to bear in mind that this assessment should be considered with caution due to some uncertainties in the estimated parameters. Furthermore, it is worth remembering that this assessment was done with a mix of species of *Sepia* (although *S. hierredda* is dominant). In addition, some suspicion exists about significant unreported *Sepia* spp. by-catch. But the most important factor is that octopus and cuttlefish are exploited in a joint fishery by most of the cephalopod fleets and that the octopus Cape Blanc stock is currently over-exploited.

Table 2.IX.- Estimation of catch (tons) of the Cape Blanc stock *Sepia* spp. over the period 2004-2009 and average value by fleet.

FLEET	2004	2005	2006	2007	2008	2009*	AVERAGE
Mauritanian Cephalopod Freezer and Wet-fish Trawlers	3064	3221	2796	3310	3103	4005	3250
Spanish Cephalopod Freezer Trawlers	920	766	537	454	759	880	719
Other Nationalities Cephalopod Trawlers	189	191	152	151	146	214	174
TOTAL*	4173	4178	3485	3915	4007	5099	4143

*Total catch was provided by Mauritania to the 7th Working Group IMROP for Stocks Assessment and Fisheries Management of the Mauritanian EEZ

Table 2.X.- Parameters of *Sepia* spp. of the Cape Blanc stock in Mauritanian waters, estimated by the model and used as indicators of the surplus production. Differences between these indicators and the catch made by the Mauritanian (industrial and artisanal) fleets from 2004 to 2009 (Mau. Mean Catch).

PARAMETERS *(Sepia* spp.*)*	Value (t)
CSY	6260
MSY	6991
Mau. Mean Catch (2004-2009)	3250
CSY - (Mau. Mean Catch)	3010
MSY- (Mau. Mean Catch)	3741

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

Mau. Mean Catch (2004-2009) = Average catch values by the Mauritanian fleet over the period 2004-2009.

CSY - (Mau. Mean Catch) = Surplus at the current year (last year of the assessment).

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

It can be concluded that the EU fleet is presently fishing less than the estimated surplus of the exploited Cape Blanc *Sepia* spp. resource.

***Loligo vulgaris*- Cape Blanc stock**

The Cape Blanc squid stock is mainly targeted by several Mauritanian fleet segments (cephalopod freezer and wet-fish trawlers), followed by the EU fleet (mainly Spanish cephalopod freezer trawlers) and by other foreign cephalopod trawlers (Table 2.XI). In the absence of any assessment of the Cape Blanc stock of *L. vulgaris* we are unable to provide estimations of surplus parameters of this resource.

Table 2.XI.- Catch (tons) of the Cape Blanc stock *Loligo vulgaris* over the period 2004-2008, with average values and percentages by fleet.

FLEET	2004	2005	2006	2007	2008	AVERAGE	%
Spanish Cephalopod Freezer Trawlers	339	681	246	641	747	531	41
Mauritanian Cephalopod Freezer and Wet-fish Trawlers	474	590	192	1512	800	714	55
Other Nationalities Cephalopod Trawlers	20	32	3	117	91	52	4

In conclusion, with the available data, it cannot be estimated whether or not the EU fleet is presently fishing the surplus of the *Loligo vulgaris* resource in Mauritania.

2.2.- GUINEA-BISSAU

2.2.1-. Shrimps

***Parapenaeus longirostris*- Guinea-Bissauan stock**

The deep-water rose shrimp is currently caught almost exclusively by the EU fleet (mainly Spanish) (See table 2.XII). From 2007 to 2009, catch levels fluctuated between 480 and 1180 t, with an average value of 881 t.

Table 2.XII.- Catch (tons) of the Guinea-Bissau stock of *P. longirostris* over the period 2007-2009, with average values and percentages by fleet.

FLEET	2007	2008	2009	AVERAGE	%
EU Freezer Shrimpers	480	984	1180	881	99.8
Chinese	6	0	0	2	0.2
Other Nationalities	0	0	0	0	0

The results of the assessment presented in the previous chapter showed that the biomass of that year B_{cur} (6899 t in 2009) would produce an annual surplus of 1031 t (Figure 1.8 and table 2.XIII), which is above the EU fleet´s average catch. As Guinea-Bissau has no national shrimper fleet, the entire surplus is available to foreign fleets. Furthermore, the assessed situation of under-exploitation indicates that deep-water rose shrimp production could increase to a MSY of 1861 t, a higher value than the current EU catch.

Table 2.XIII.- Parameters of the *Parapenaeus longirostris* stock in Guinea-Bissau, estimated by the model and used as indicators of the surplus production. Differences between these indicators and the catch made by the national fleets from 2007 to 2010 (G.B. Mean Catch).

PARAMETERS *(P. longirostris)*	Value (t)
CSY	1031
MSY	1861
G.B. Mean Catch (2007-2010)	__
CSY - (G.B. Mean Catch)	1031
MSY- (G.B Mean Catch)	1861

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

G.B. Mean Catch (2007-2010) = Average catch values by the Guinea-Bissau fleet during the period 2007-2010.

CSY - (G.B. Mean Catch) = Surplus at the current year (last year of the assessment).

MSY- (G.B. Mean Catch) = Surplus in an equilibrium situation (MSY level)

In conclusion, it can be considered that the EU fleet is at present fishing less than the available surplus of the exploited *P. longirostris* resource in Guinea-Bissau.

***Farfantepenaeus notialis*- Guinea-Bissauan stock**

The status of this species has not been assessed. Its situation is undoubtedly more complex than the other crustaceans considered, because this species is fished by industrial fleets and by the artisanal Guinea-Bissauan fleet, whose fishing areas are completely different. The catch by the EU industrial fleets have fluctuated in recent years between 143 and 236 t (2007-2009). The EU fleet made the greatest catch (61%), followed by the Chinese fleet with 27% and the other foreign fleets (18%). The evolution of CPUE values of the Spanish fleet are quite stable (Figure 1.9), although the problems related to effort values used to calculate CPUE (see section 1) must be kept in mind.

There are no data of *F. notialis* catches attributable to artisanal vessels in Guinea-Bissau. Furthermore, an important Illegal, Unregulated and Unreported (IUU) fishing is supposed to be catching important volumes of the species.

In conclusion, with the available data, it cannot be estimated whether or not the EU fleet is at present fishing the surplus of the *F. notialis* resource in Guinea-Bissau.

Table 2.XIV.- Catches (tons) of the Guinea-Bissauan stock of *Farfantepenaeus notialis* over the period 2007-2009, with average values and percentages by fleet.

FLEET	2007	2008	2009	AVERAGE	%
EU Freezer Shrimpers	168	143	236	182	61
Chinese	203	14	51	89	27
Other Nationalities	63	79	39	60	18

***Aristeus varidens*- Guinea-Bissauan stock**

As for deep-water rose shrimp, almost all of the red striped shrimp *A. varidens* is harvested by the EU fleet (mainly Spanish vessels).

In the last four years (2007-2010), catch levels have fluctuated between 116 and 162 t in 2008 and 2009, respectively, with an average value of 143 t (see table 2.XV).

Table 2.XV.- Catches (tons) of the Guinea-Bissauan stock of *Aristeus varidens* over the period 2007-2009, with average values and percentages by fleet.

FLEET	2007	2008	2009	AVERAGE	%
EU Freezer Shrimpers	150	116	162	143	100
Chinese	0	0	0	0	0
Other Nationalities	0	0	0	0	0

No assessment has ever been done to ascertain the status of this species in Guinea-Bissauan waters. Trends in CPUE values of the Spanish fleet show oscillations over the years, although relative stability is observed along the last years of the series (Figure 1.9). As mentioned for *F. notialis*, there are certain issues in the use of this CPUE as an abundance index of *A. varidens*, as the effort values used for CPUE calculations correspond to the total fishing days of the Spanish fleet, without taking into account the fishing effort deployed to target each of the three main species: *F. notialis*, *P. longirostris* and *A. varidens* (from shallow to deeper waters). Improvements must be made in order to split the effort directed to cover the catch of each species.

In conclusion, with the available information, it cannot be estimated whether or not the EU fleet is at present fishing the surplus of the *A. varidens* stock in Guinea-Bissau, since the current situation of the species is unknown. However, it is important to know that the EU fleet is almost the only one exploiting this resource.

2.2.2.-Cephalopods

Octopus vulgaris- Guinea-Bissauan stocks

Octopus is targeted by the industrial fleets operating in waters off Guinea-Bissau (Table 2.XVI). Almost the total catch is due to the industrial fleets of foreign countries. The biggest catches correspond to the EU fleet (38%), followed by those of the Chinese fleet (32%), and by those of a group of other foreign fleets (30%). Octopus catch made by the EU fleet from 2007 to 2009 has slightly decreased from 1230 t in 2007 to 968 t in 2009.

The results of the preliminary assessment of the Guinea-Bissauan stock presented in the previous chapter showed that the current biomass (corresponding to the last year) B_{cur} (11 229 t) would produce a yearly surplus of 3081 t. This value is similar to the average catch of the total fleet during the last three years, although lower than total catch in the last year (3651 t). The assessment concluded that the stock was under-exploited. The annual surplus corresponding to MSY was estimated in 4092 t, much higher than the average catch (2622 t).

Table 2.XVI.- Catch (tons) of the Guinea-Bissauan stock of *Octopus vulgaris* over the period 2007-2009, with average values and percentages by fleet.

FLEET	2007	2008	2009	AVERAGE	%
EU Freezer Shrimpers	1230	766	968	988	38
Chinese	346	285	1791	837	32
Other Nationalities	1242	257	892	797	30

Table 2.XVII.- Parameters of the *Octopus vulgaris* stock in Guinea-Bissau, estimated by the model and used as indicators of the surplus production. Differences between these indicators and the catch made by the national fleets from 2007 to 2010 (G.B. Mean Catch).

PARAMETERS *(O. vulgaris)*	Value (t)
CSY	3081
MSY	4092
G.B. Mean Catch (2007-2010)	—
CSY - (G.B. Mean Catch)	3081
MSY- (G.B Mean Catch)	4092

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

G.B. Mean Catch (2007-2010) = Average catch values by the Guinea-Bissau fleet during the period 2007-2010.

CSY - (G.B. Mean Catch) = Surplus at the current year (last year of the assessment).

MSY- (G.B. Mean Catch) = Surplus in an equilibrium situation (MSY level)

In absence of information about the artisanal catch, it can be considered that the EU fleet is at present fishing the surplus of the exploited *Octopus vulgaris* resource in Guinea-Bissau.

Sepia spp.- Guinea-Bissauan stock

This species is caught by the three groups of industrial fleets fishing for cephalopods in Guinea-Bissau. The biggest catch is made by the Chinese fleet (60%), followed by the EU fleet (22%) and finally by the group of other foreign fleets (18%) (Table 2.XVIII). Total catch level for the EU fleet in the last three years (2007-2009) has decreased from 634 t (2007) to 347 t (2009).

Table 2.XVIII.- Catch (tons) of the Guinea-Bissauan stock of *Sepia* spp. over the period 2007-2009, with average values and percentages by fleet.

FLEET	2007	2008	2009	AVERAGE	%
EU Freezer Shrimpers	634	530	347	504	22
Chinese	1049	657	2394	1367	60
Other Nationalities	482	279	683	421	18

No assessment has been done to ascertain the state of this stock in waters off Guinea-Bissau. Trends of the CPUE series of the Spanish fleet (Figure 1.11) show oscillations over the years, a typical feature for these short-living species, whose abundances are very dependent on annual recruitments. As mentioned for shrimps, the problem in using CPUE values as abundance indices of *Sepia* spp. in Guinea-Bissau is that their calculation is based on the total effort exerted by the fleet, and not split into different effort series, depending on the targeted species (octopus or cuttlefish).

No advice can be provided, due to the lack of stock assessments and other types of information. It can just be noted that practically the total catch is made by industrial fleets. Therefore, apparently, the stock is not being exploited by Guinea-Bissau.

In conclusion, due to the lack of information available, it cannot be estimated whether or not the EU fleet is at present fishing the surplus of the *Sepia* spp. resource in Guinea-Bissau.

3. EU DEMERSAL FLEET CATCH (FISHING EFFORT), CORRESPONDING TO RESOURCE SURPLUSES AND, WHEN POSSIBLE, SHORT AND MEDIUM TERM FUTURE YIELDS AND STOCK ABUNDANCE PROJECTIONS

This section compares the catch levels of the EU demersal fleets (targeting crustaceans and cephalopods) currently operating in waters off Mauritania and Guinea-Bissau with the previously estimated surpluses of the different resources considered (see section 2).

Furthermore, projections of both catch and abundance are presented for all the assessed stocks. These projections have been run through the MS Excel workbook created by Barros (2007), to enter the model parameters estimated for the stock, historical data available for the stock and the fishery, and for defining the conditions for the projections.

Short-term projections are usually made for a period of 1-2 years after the current year/period. They depend strongly on the current state of the stock and the fishery, and assess their evolution at different times after the current moment/time (Barros, 2007). Because they consider time explicitly, they can be used to assess the effects of management measures varying with time, and to predict the status of the stocks and fisheries at different points in time within the time-frame under consideration.

Mid-term projections are usually made for a period of 3-10 years from current time. They use the same equations as short-term projections, prolonging them for a longer period. They can thus be used for the same purposes as short-term projections. As they extend farther from the current year, however, they become more and more dependent on the assumptions of the model, and less on the estimates of current stock and fishery status (Barros, 2007).

It should be noted that projections should not be taken for predictions of actual stock abundance or catch values (Barros, 2007). They should be used to assess the relative merits of alternative competing management options, and as such inform better the process of deciding which management measures are more likely to drive the stock and the fishery in the direction desired by managers. When the data available for a fishery are only catch and effort, or catch and abundance indices, as is the case of all the shrimps and cephalopods fisheries presented, only production models can be used (see section 2), and thus the only management measures that can be assessed are those based on input or output control.

The projections presented below, for those stocks that could be assessed, are short- and medium-term projections, over a 5 year period. As the workbook cannot be used to simulate management strategies based on technical measures, only measures based on fishing effort have been examined. All the following projections assume a *status quo*, in which fishing effort is kept at a constant value for all years being projected at the current level (i.e., last year of the assessment).

3.1.-MAURITANIAN STOCKS

3.1.1.-Shrimps

***Parapenaeus longirostris*- Mauritanian stock**

Table 2.I presents the average catch of deep-water rose shrimp made by the EU and other fleets harvesting this species from 2004 to 2008, the last year of the assessment. EU vessels were fishing

95% of the surplus of the resource (not harvested by Mauritanian fleet), while other foreign fleets were fishing 17% of this surplus (Table 3.I). Thus, all non-domestic fleets were harvesting 112% of the surplus, exceeding the surplus by 12%. However, if the system were in equilibrium, the EU fleet could capture 83% of the surplus production (at the MSY level).

Table 3.I.- Catch percentage for the EU shrimper fleet and other foreign fleets corresponding to the surplus of *Parapenaeus longirostris* in Mauritania.

PARAMETERS *(P. longirostris)*	Value (t)	% Surplus EU fleet	% Surplus Other foreign fleets
CSY - (Mau. Mean Catch)	2609	95%	17%
MSY- (Mau. Mean Catch)	2990	83%	14%

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

Mau. Mean Catch = Average catch values by the Mauritanian Fleet over the period 2004-2008

CSY - (Mau. Mean Catch) = Surplus at the current year (last year of the assessment)

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

The projections show that if the fishing effort is kept at the current (last year) level, the catch will decrease in 2009, maintaining a stable trend during the following years (Figure 3.1, left). Catch will be below the MSY but at a sustainable level. On the other hand, the relative abundance index will drop in 2009, and subsequently stabilize with a slight increase during the following four years (Figure 3.1, right). In any case, the abundance index will always be well over the relative abundance index corresponding to the MSY and the precautionary level $U_{0.1}$.

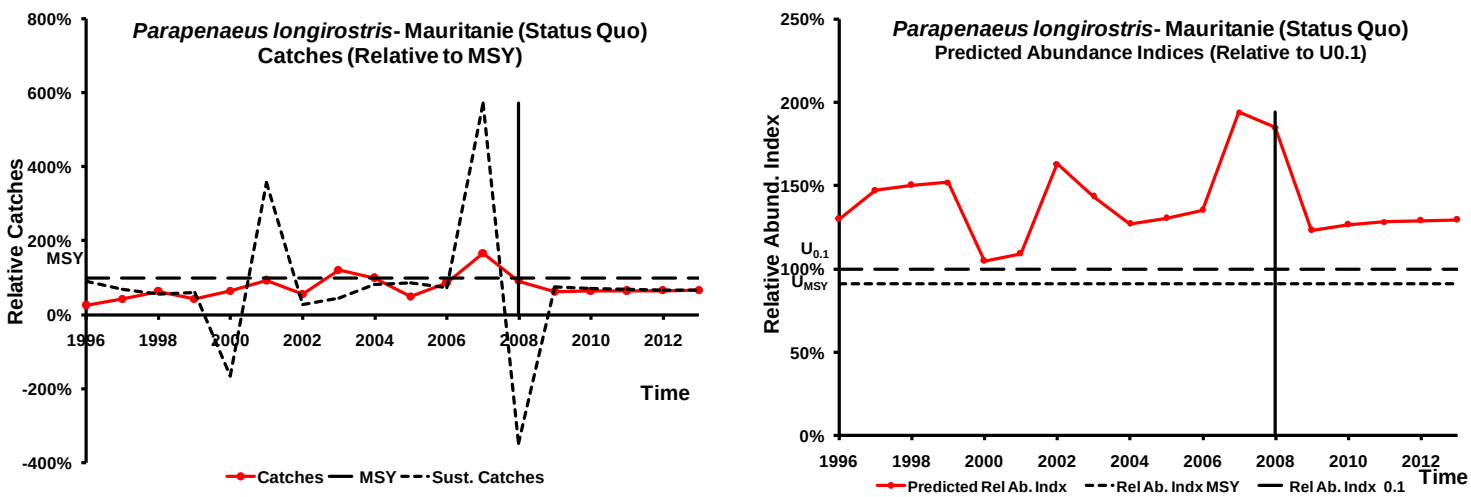


Figure 3.1.-Short- and medium-term predictions of catch (left) and abundance (right) of *Parapenaeus longirostris* in Mauritania, maintaining the current exploitation pattern (*status quo*).

These projections suggest that if maintaining the same conditions of fishing effort, *P. longirostris* would continue to be under-exploited, but close to the equilibrium (MSY level). However, it is important to bear in mind that these types of short-living species are very dependent on the strength of their recruitment, which is greatly influenced by environmental factors, and this important factor is not considered in these projections.

Farfantepenaeus notialis-Mauritanian Stocks

Average catch of Southern rose shrimp by the EU and other fleets harvesting this species from 2004 to 2009 (2009 are estimated catches) are presented in table 2.IV. Due to the fact that all data from this last assessment are not available, only surplus calculations were made based on the MSY. EU vessels would fish 56% of the surplus of the resource (not harvested by Mauritanian fleet), while other foreign fleets would fish 27% of this surplus, both assuming the equilibrium situation (Table 3.II). Thus, all the foreign fleets will harvest 83% of the surplus in the MSY level.

As explained in previous chapters, the Southern rose shrimp was assumed to be fully-exploited in Mauritania (assessment carried out with data until 2009). In fact, one year later greater abundances were registered, probably due to an exceptional recruitment in 2009.

Table 3.II.- Catch percentage for the EU shrimper fleet and other foreign fleets corresponding to the surplus of *Farfantepenaeus notialis* in Mauritania.

PARAMETERS *(F. notialis)*	Value (t)	% Surplus EU fleet	% Surplus Other foreign fleets
MSY- (Mau. Mean Catch)	1266	56%	27%

MSY= Maximum Sustainable Yield

Mau. Mean Catch = Average catch values by the Mauritanian Fleet over the period 2004-2009

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

Due to the unavailability of the last projections (IMROP WG, December 2010), the projections showed below are those carried out during the last FAO/CECAF WG (FAO, 2010) with input data corresponding to an assessment of overexploitation. The abundance projections (Figure. 3.2, right), showed that maintaining the fishing effort at the current level will bring a progressive increase of the predicted abundance index, reaching higher values over the MSY level from 2010 onwards, and over the cautionary level ($U_{0.1}$) since 2011. This situation is very close to the one that indeed has already happened. The catch projection indicated a slight and progressive increase in catches after 2008, followed by stabilization in 2012 and 2013. In spite of this increase, the catch would always be below those corresponding to the MSY level (Figure 3.2, left). In this case, the situation was not similar that the one that has already happened, as 2009 catch already led to a full exploitation, which means that catch was at levels to that producing the MSY.

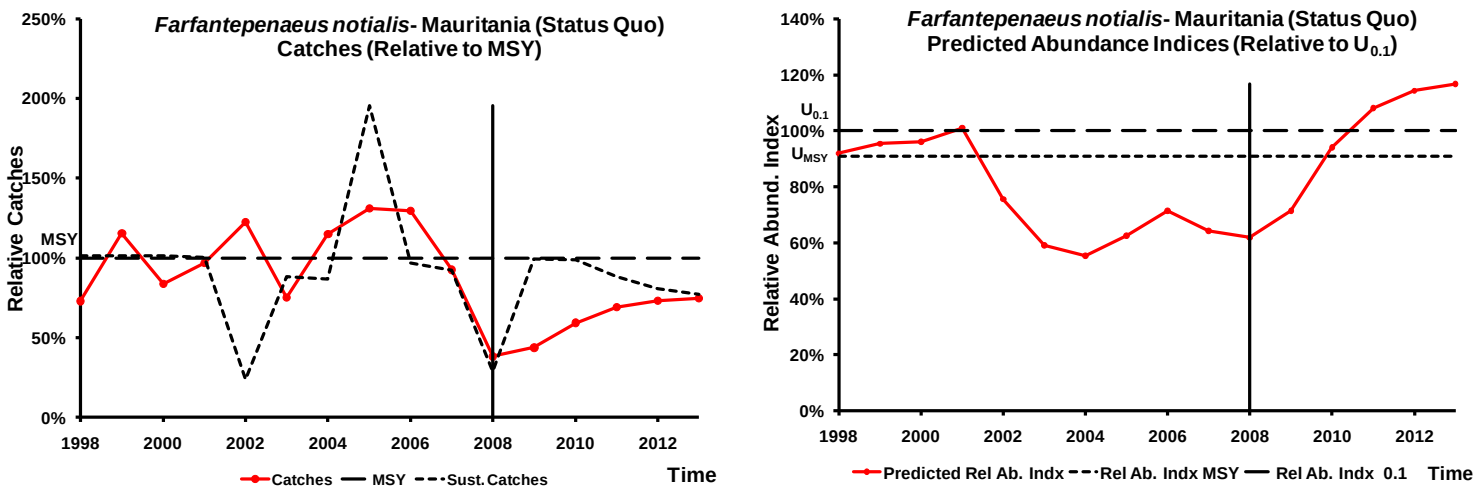


Figure 3.2.-Short- and medium-term projections of catch (left) and abundance (right) of *Farfantepenaeus notialis* in Mauritania, maintaining the current exploitation pattern (*status quo*).

3.1.2.-Cephalopods

Octopus vulgaris- Cape Blanc stock

The octopus EU mean catch during the period 2004-2008 was around 6300 t (see table 2.VI). This represents 84% of the surplus produced by the stock in the last year of the assessment (2008), while the other foreign fleets harvested 12% of this surplus. This means that foreign fleets almost used the whole surplus. In an equilibrium situation, EU catch would account for 78% of the surplus produced by the biomass corresponding to the MSY (Table 3.III).

Table 3.III.- Catch percentage of the EU cephalopod fleet and other foreign fleets corresponding to the surplus of the Cape Blanc stock of *Octopus vulgaris* in Mauritania.

PARAMETERS *(O. vulgaris)*	Value (t)	% Surplus EU fleet	% Surplus Other foreign fleets
CSY - (Mau. Mean Catch)	7538	84%	12%
MSY- (Mau. Mean Catch)	8039	78%	12%

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

Mau. Mean Catch = Average catch values by the Mauritanian Fleet over the period 2004-2008

CSY - (Mau. Mean Catch) = Surplus at the current year (last year of the assessment)

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

If the fishing effort level is maintained, the projection will show an improvement of the catch at short-/medium-term compared to previous years. After a drop occurring in 2009 and 2010, there

will be an increase in 2011, to subsequently stabilize during the last three years of the projection at sustainable levels, and even at levels producing the MSY (Figure 3.3, left). The projected abundance index will follow the same trend as the catch, (i.e. continuing its decrease until stabilization after 2010) (Figure 3.3, right), but being lower than the relative abundance index at the MSY level during the 5-year period covered by the projection.

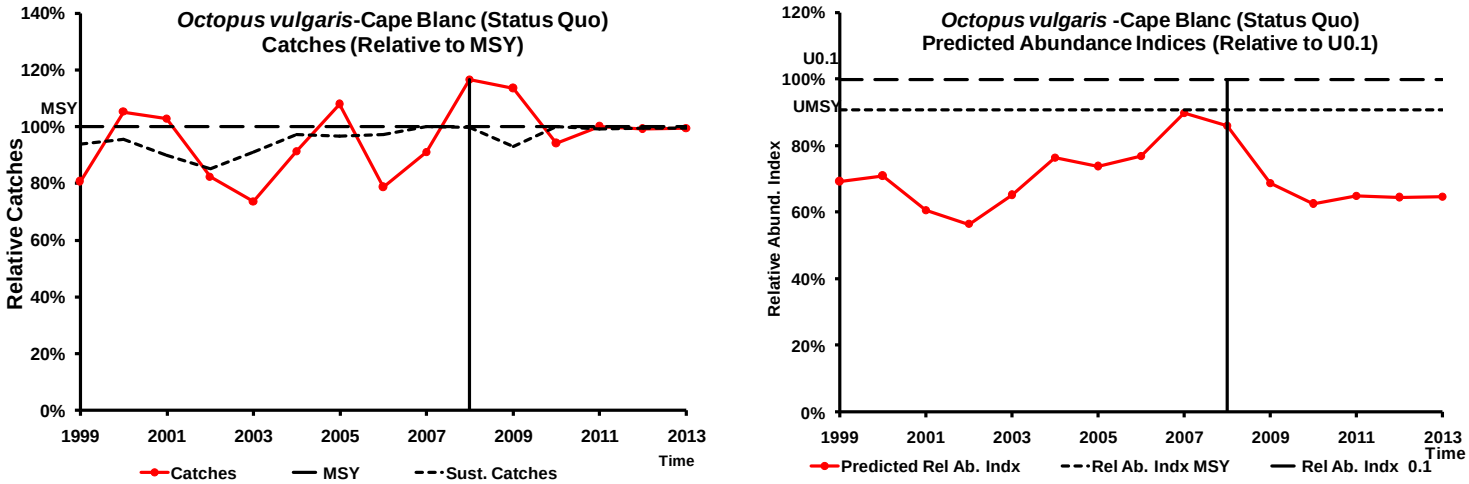


Figure 3.3.- Short and medium-term projections of catch (left) and abundance (right) of the Cape Blanc stock of *Octopus vulgaris* in Mauritania, maintaining the current exploitation pattern (*status quo*).

Sepia spp. – Cape Blanc stock

The assessment of the cape Blanc stock of cuttlefish showed a situation of under-exploitation, although it is worth remembering that this assessment should be considered with caution since it is still being validated by the responsible Scientific Committee. The EU average catch for the period 2004-2009 was 719 t (Table 2.IX), which represents a low percentage of the surplus yield of that year (24%). All the international fleets together harvested 30% of the surplus. In a situation of equilibrium, the EU catch would be around 19% of the surplus (see table 3.IV).

Table 3.IV.- Catch percentage of the EU cephalopod fleet and other foreign fleets corresponding to the surplus of the Cape Blanc stock of *Sepia* spp. in Mauritania.

PARAMETERS *(Sepia spp.)*	Value (t)	% Surplus EU fleet	% Surplus Other foreign fleets
CSY - (Mau. Mean Catch)	3010	24%	6%
MSY- (Mau. Mean Catch)	3741	19%	5%

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

Mau. Mean Catch = Average catch values by the Mauritanian Fleet over the period 2004-2008

CSY - (Mau. Mean Catch) = Surplus at the current year (last year of the assessment)

MSY- (Mau. Mean Catch) = Surplus in an equilibrium situation (MSY level)

Figure 3.4 shows the projections of catch at short-/medium-term, and the *status quo*, when the last fishing effort deployed is maintained. Catch will be maintained stable after a little decrease in 2010, but always below the level that would produce the MSY. Abundance projection could not be made, probably due to the uncertainty of the parameters used.

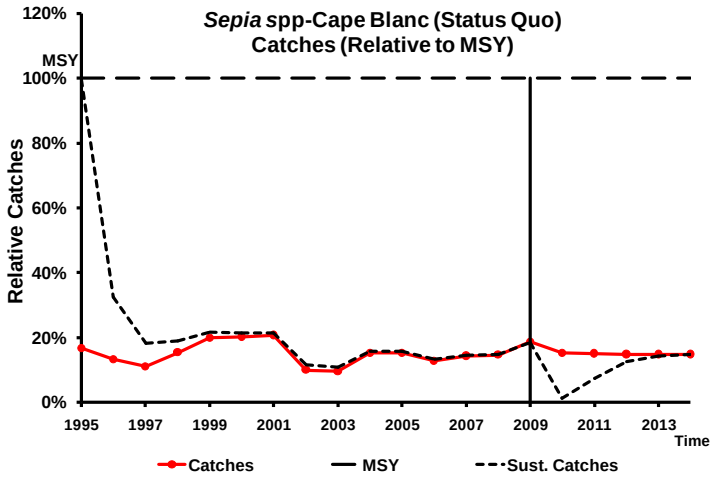


Figure 3.4.- Short and medium-term projections of catch (left) of the Cape Blanc stock of *Sepia* spp. in Mauritania, maintaining the current exploitation pattern (*status quo*).

Loligo vulgaris- Stock Cape Blanc

As the Cape Blanc squid stock has not been recently assessed, we can neither estimate the level of EU catch in relation to the surplus nor attempt any short-/medium-term projection. The greatest catch was made by Mauritanian fleets. EU catch was around 530 t (average value) during the period 2004-2008 (Table 2.XI).

3.2- GUINEA-BISSAUAN STOCKS

3.2.1. Shrimps

Parapenaeus longirostris- Guinea-Bissauan stocks

The assessment attempted for *P. longirostris* caught in Guinea-Bissauan waters showed that the stock was under-exploited, although this result should be cautiously interpreted due to the uncertainties of the input data used in the model (see section 2). In this situation, the EU mean catch during the period 2004-2008 (881 t) will assume to have harvested 85% of the surplus of the last year considered (Table 3.V), which added to the catch of other foreign fleets will have harvested 95% of the estimated surplus. If the production of the stock allows reaching a MSY, the EU catch would harvest 47% of the surplus in equilibrium. It is worth remembering that the EU fleet is practically the only one targeting deep-water rose shrimp in Guinea-Bissauan fishing grounds.

Table 3.V.- Catch percentage for the EU shrimper fleet and other foreign fleets corresponding to the surplus of *Parapenaeus longirostris* in Mauritania.

PARAMETERS *(P. longirostris)*	Value (t)	% Surplus EU fleet	% Surplus Other foreign fleets
CSY - (G.B. Mean Catch)	1031	85%	10%
MSY- (G.B. Mean Catch)	1861	47%	6%

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

G.B. Mean Catch = Average catch values by the Guinea-Bissau fleet over the period 2004-2008

CSY - (G.B. Mean Catch) = Surplus at the current year (last year of the assessment)

MSY- (G.B.. Mean Catch) = Surplus in an equilibrium situation (MSY level)

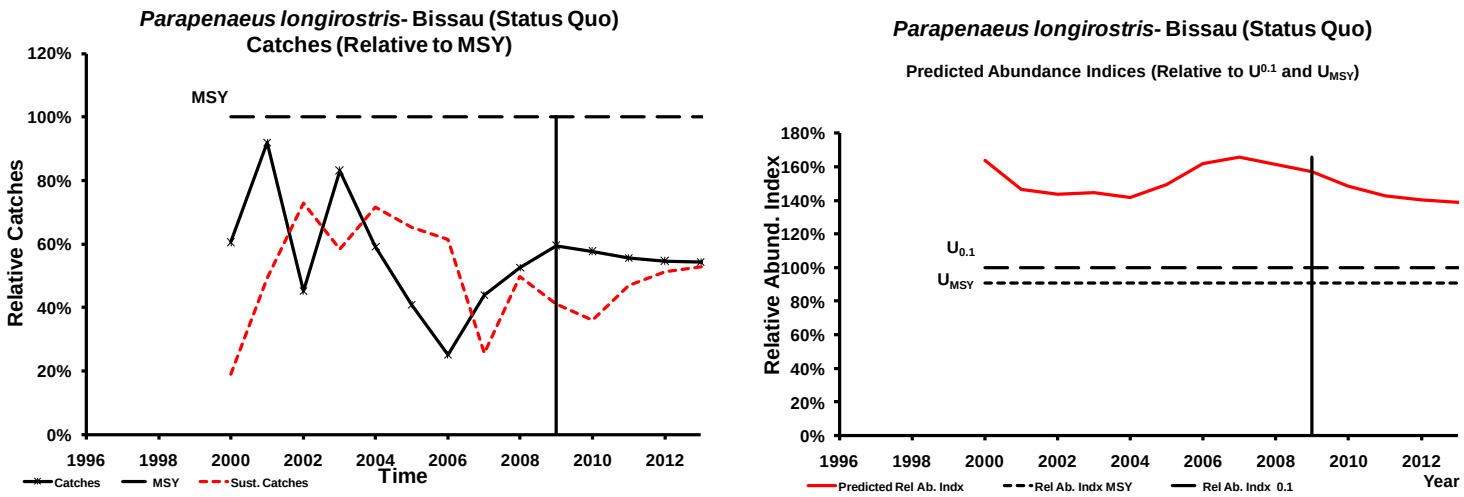


Figure 3.5.- Short and medium-term projections of catch (left) and abundance (right) of *Parapenaeus longirostris* in Guinea-Bissau, maintaining the current exploitation pattern (*status quo*).

Short-/medium-term projections were made on the basis of the results of the last assessment and assuming the maintenance of the current exploitation pattern (fishing effort of the last year of data). Figure 3.5 presents the results of the catch (left) and abundance (right) projections over a 5-year period beginning in 2009. Projected sustainable catch will tend to slightly decrease until stabilizing in 2013. Catch values would always be below those corresponding to the MSY level. Projected abundance would follow the same trend as catch, at levels above the MSY and the cautionary level ($U_{0.1.}$).

***Farfantepenaeus notialis*- Guinea-Bissauan stock**

This stock has not been assessed and therefore, the EU catch level corresponding to the surplus cannot be estimated. It is worth remembering that the EU fleet catch is quite low (mean value of 189 t), although it accounts for 61% of the total reported catch. Short-/medium-term projections are not available due to the lack of assessments.

***Aristeus varidens*- Guinea-Bissauan Stocks**

Like *F. notialis*, this stock has not been assessed and it is therefore impossible to calculate the EU fleet catch level corresponding to the surplus. The EU fleet is supposed to be the only one fishing this species (100% of the reported catch) but in small quantities (around 143 t per year) as it is caught as by-catch. Projections could not be made due to the absence of assessments.

3.2.2.-Cephalopods

***Octopus vulgaris*- Guinea-Bissauan Stocks**

The assessment of the octopus stock in waters off Guinea-Bissau showed that this stock was under-exploited (even if the interpretation of this result should be considered with certain caution). This means that EU mean catch (988 t) accounts for 32% of the estimated surplus produced the last year considered in the assessment (2008). If the EU fishes this species at similar levels and the production reaches MSY, the level of the EU catch could then account for 24% of the surplus production.

Table 3.VI.- Catch percentage of the EU cephalopod fleet and other foreign fleets corresponding to the surplus of *Octopus vulgaris* in Guinea-Bissau.

PARAMETERS *(O. vulgaris)*	Value (t)	% Surplus EU fleet	% Surplus Other foreign fleets
CSY - (G.B. Mean Catch)	3081	32%	41%
MSY- (G.B. Mean Catch)	4092	24%	31%

CSY= Current Sustainable Yield

MSY= Maximum Sustainable Yield

G.B. Mean Catch = Average catch values by the Guinea-Bissau fleet over the period 2004-2008

CSY - (G.B. Mean Catch) = Surplus at the current year (last year of the assessment)

MSY- (G.B. Mean Catch) = Surplus in an equilibrium situation (MSY level)

Short-/medium-term projections (5 years) of both catch and abundance have been made, considering the results of the octopus assessment and the *status quo*, where the fishing effort is maintained.

The prediction shows a catch decrease in 2010, and another small one in 2011, followed by a very slight decreasing trend, that will stabilize from 2012 onwards at sustainable levels. Catch levels will be below those reaching the MSY during the 5-years period covered by the projection (Figure 3.6, left). Abundance was predicted to fall in 2010, and to stabilize in subsequent years following the

same trend described for catch. The predicted abundance indices will be over both the MSY and the cautionary level $U_{0.1.}$This means that if the effort is maintained at the 2009 level, an equilibrium status will be reached (from 2012 until the end of the projection), and always assuming an under-exploitation situation.

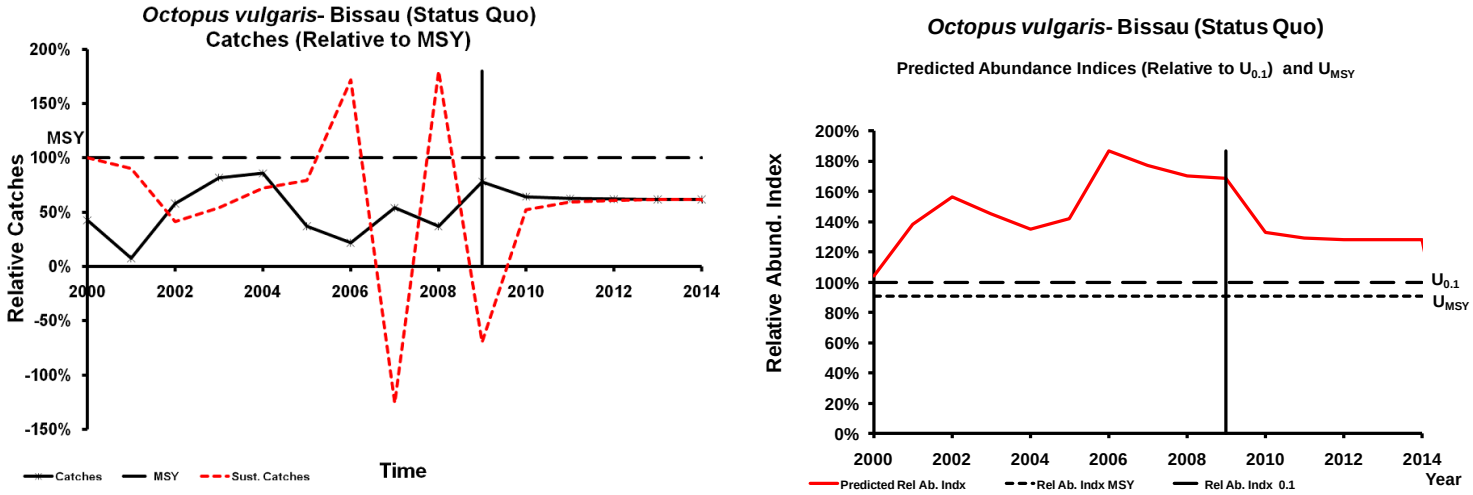


Figure 3.6.- Short-/medium-term projections of catch (left) and abundance (right) of *Octopus vulgaris* in Guinea-Bissau, maintaining the current exploitation pattern (*status quo*).

Sepia spp.- Guinea-Bissauan stocks

As no assessment of this stock has been carried out, there is no possibility of knowing the catch level of the surplus due to fishing activities of EU fleet. However, it is worth remembering that EU catch accounts for 22% of total catch of cuttlefish species, with low mean annual values, around 500 t. Furthermore, projections were not made due to the absence of assessment data.

4. CLOSED SEASONS OR CLOSED AREAS WHICH COULD BE DEFINED FOR DEMERSAL SHRIMP AND CEPHALOPOD FISHERIES

To define possible closed seasons or closed areas for demersal shrimp and cephalopod fisheries in waters off Mauritania and Guinea-Bissau, it is important to know both the basic facts about the biology of the targeted species and the seasonal and spatial activity of the involved fleets.

For these reasons, the following two main aspects will be described for every fishery:

a) Available biological information of the target species (spatial distribution, spawning/recruitment seasons and areas, size at first maturity, possible migrations, abundance fluctuations, etc.)

b) Information on seasonal and spatial distribution of the fleets operating in the area.

4.1.-MAURITANIA

4.1.1 -SHRIMP FISHERY

4.1.1.a- Biological information on the target species

Deep-water rose shrimp *Parapenaeus longirostris*

Spatial distribution

The deep water rose shrimp, *P. longirostris* is one of the three species in this genus inhabiting the Atlantic Ocean (Pérez-Farfante and Kensley, 1997). The species shows a wide geographic distribution, from the eastern Atlantic in the north of Spain to the southern waters of Angola, as well as in the Mediterranean and its adjacent seas (Sobrino *et al.*, 2005). It inhabits muddy or muddy-sandy bottoms.

The bathymetric range of this species changes with latitude. In four research surveys carried out in Mauritanian waters by the Spanish R/V VIZCONDE DE EZA (from 2007 to 2010), the presence of *P. longirostris* was detected in a wide depth range, from 84 m to 473 m.

The bathymetric distributions of these shrimps are linked to the specimen's size, in a way that biggest individuals (females) are distributed at deeper waters. Thus, there is segregation by size (and sex-related) in relation to depth. After the larval dispersion phase in shallow waters, the shrimps move towards deeper waters throughout their life. Juveniles settle at around 100 m depth, although they can be detected up to 300 m, whereas larger individuals (which correspond to females) are always found at depths over 350 m (Sobrino *et al.*, 2005).

Besides these ontogenetic migrations, *P. longirostris* also performs vertical daily migrations and other migrations related to the moon phases. In fact, maximum daily yields are obtained during full moon periods (Crosnier and Tanter, 1968).

The highest densities in terms of biomass have generally been recorded in different regions between 100 and 300 m depth (Sobrino *et al*., 2005).

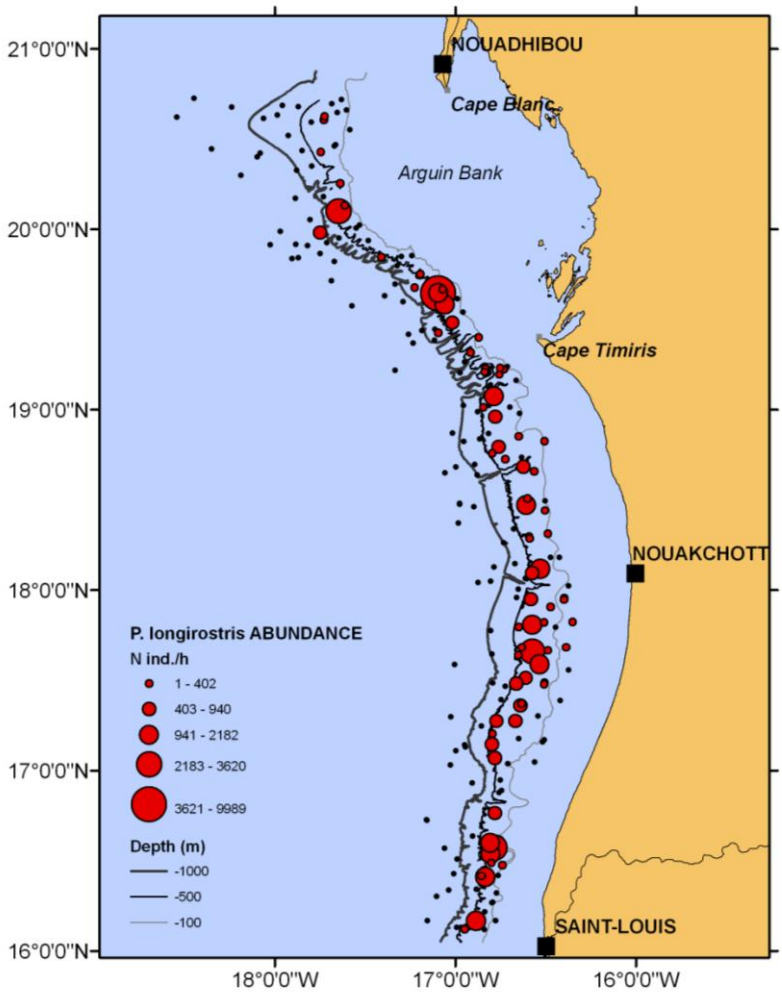


Figure 4.1.- Spatial distribution of abundance (number of individuals per trawl hour) of *Parapenaeus longirostris* in Mauritanian waters during the Spanish research surveys carried out in 2007, 2008, 2009, and 2010.

In the Spanish surveys carried out from 2007 to 2010 (Figure 4.1), *P. longirostris* was more or less evenly distributed south to 20º 30' N. Main abundance concentrations were located at 20º 10' N and 19º 40' N (in front of Tidra Island), both in deep waters of the northern area, around the Arguin Bank. In the southern area, the distribution is more homogeneous (although with lower abundances) from cape Timiris to the Senegalese border, and deep-water rose shrimps are found up to the 500 m isobath. It should be noted that these surveys were always carried out in the same season (November-December) and do not reflect any eventual seasonal variation of the species' distribution.

Reproduction/Recruitment areas and seasons

P. longirostris is a short-living species with high growth rates. The life span of each generation is of two or three years, with males growing more slowly than females (Sobrino *et al.*, 2005). The eggs, kept under the abdomen, are released into the water at the time of spawning which takes place at depths between 200 and 300 m, mostly on the edge of the continental slope. The young shrimp

migrate towards the coast and are concentrated at depths of 50-150 m. Once they reach adulthood they migrate to depths between 200 and 300 m to reproduce.

In absence of biological studies that could confirm the identity of *P. longirostris* stocks in West African waters, a single stock is considered for Mauritania. Taking into account that the species is found in different geographical zones, the FAO/CECAF Working Group has arbitrarily adopted three different stock units in North West African waters: Morocco, Mauritania and Senegal-The Gambia (FAO, 2010). However, biological studies are needed to confirm the identity of these stocks.

The reproduction period of shrimps should be estimated on the basis of the proportion of mature females, as males mature very young. Currently, there is a lack of clear information about the shrimp maturation season in Mauritanian waters. In other areas of the West African coast, two spawning peaks have been described: June and October (Sobrino and García, 1994) or October and January-February (Laghmari *et al.*, 2001) in Moroccan waters; one spring peak (April-May) and a second weaker autumn peak (September-October) in Congolese waters (Crosnier *et al.*, 1970) (Table 4.I).

Table 4.I.- Spawning periods of *Parapenaeus longirostris* in West African coastal countries (from North to South).

AREA	SPAWNING PERIOD	REFERENCES
MOROCCO	Two peaks: * Summer (June) * Autumn (October)	Sobrino and García, 1994
	Two peaks: *Winter (January-February) *Autumn (October)	Laghmari *et al.*, 2001
MAURITANIA	Two peaks: *Summer (June-July-…?) *Winter (December-February)	García-Isarch (*pers.comm.*)
	December-January	EU/RIM WG, 1997
	June-October	Diop (*pers.comm.*)
	October	FAO, 2006a
CONGO	Two peaks: Spring (April-May) Autumn (September-October)	Crosnier *et al.*, 1970

The Spanish Institute of Oceanography (IEO) has carried out biological studies based on the sampling (from 2003 to 2008) of *P. longirostris* landed by the Spanish shrimper fleet operating in Mauritanian fishing grounds. The gathered data have some gaps due to the lack of samples of all the commercial size categories every month, and also due to the existence of closed seasons in Mauritanian waters. Thus, the IEO scientists were not able to complete an annual biological cycle to identify the reproduction period of *P. longirostris*. However, we suspect the existence of two spawning peaks also in Mauritanian waters: a winter peak and a summer one (García-Isarch, *pers. comm.*). The winter peak was coincident with the descriptions of the EU/RIM Working Group (1997) but no coincidence was showed for the spawning period from June to October proposed by

Diop (*pers. comm.*). Other authors have set the spawning period of the Mauritanian deep-sea rose shrimp in October (FAO, 2006a). During 2010, the IEO launched a programme of scientific observations onboard Spanish shrimper vessels in Mauritanian fishing grounds. A very low percentage of mature females were found when the fleet was targeting *P. longirostris*. In addition, the sampling of the deep-water rose shrimp was interrupted during the closed seasons observed by Spanish shrimper vessels (May-June and September-October) and also when the fleet was targeting another shrimp species (*F. notialis)*, mainly during the summer and in December. Thus, *P. longirostris* was not sampled for 7 months (from May to October and December). However, we can suppose that the maturation of the deep-water rose shrimp occurs during this "not sampled period", especially from May to October, which is more or less in agreement with the spawning peak proposed by Diop (*pers. comm.*).

Males of *P. longirostris* mature very early and with small sizes, and mature males are usually found throughout the year. Then, the size at first maturity of females is the one that should be considered for management measures related to the establishment of minimum catch size. Table 4.II shows the estimated cephalothorax length (CL, in mm) at first maturity (L_{50}), estimated for males and females of *P. longirostris* along the West African Coast. First maturity sizes of shrimps from Senegal and Mauritania have been estimated by the IEO and should be considered with caution, due to the sampling bias explained above.

The size at first maturity of *P. longirostris* is unclear for the Mauritanian populations of this resource, but considering other estimations in North West African waters, it could range between 12.9 and 16,5 mm of cephalotorax length (CL) for males and 23,6 mm and 28,8 mm CL for females (Table 4.II).

Table 4.II.– First maturity length (cephalothorax length, CL in mm) of deep-water rose shrimp *Parapenaeus longirostris* estimated along the West African coast (from North to South).

AREA	L_{50} (mm CL)	REFERENCE
MOROCCO	♂: 15 ♀: 24,5-27,7	Sobrino y García, 1994
	♀: 25	Laghmari *et al.*, 2001
	♀: 23,4	FAO/CECAF, 2007
MAURITANIA	♀: 65 mm LT	Anon., 1992
	♂: 12,9-14,8 ♀: 25-28,5	García-Isarch (*pers.comm.*)
SENEGAL	♂: 16,5 ♀: 27-28,8	García-Isarch (*pers.comm.*)
GULF OF GUINEA	♀: 25,5 mm	Sobrino and Fernández, 1991
CONGO	♀: 22 mm	Crosnier *et al.*, 1970
ANGOLA	♂: 14,7 ♀: 21,6 mm	García-Isarch (*pers.comm.*) Sobrino and de Cárdenas (1996a)

Sex-ratio obtained from the IEO observers' sampling programme onboard Spanish shrimpers showed the same percentages of males and females in the whole population (F:M=1:1). However, as observed for many shrimps of the Family Penaeidae, *P. longirostris* has a differential growth by sex, with females reaching bigger sizes than males. Therefore, the sex-ratio varies among the different CL classes: for deep-water rose shrimps samples of CL>24 mm, more than 50% of the sampled specimens were females; for samples CL>31 mm, 100% of the sampled specimens were females. Maximal CL sampled during the IEO sampling programme of the commercial landings from 2003 to 2008 was 33.5 mm for males and 36.5 mm for females.

Although smaller individuals were occasionally caught, the analysis of the length frequencies of the commercial landings sampled over the period 2003-2008 estimated that the recruitment size was of approximately 18 mm CL.

Abundance fluctuations

The deep water rose shrimp exhibits great interannual fluctuations, mainly attributed to recruitment strength. Long-term changes in the abundance of *P. longirostris* in the Mediterranean Sea were found to correlate significantly with identified environmental and anthropogenic factors. The increasing abundance of the species was correlated to a rise of sea surface temperature, a corresponding decrease of wind circulation and to the reduction of fishing effort (Ligas *et al.*, 2011). The availability of suitable information on environmental characteristics, such as appropriate sea-floor topography, sediment composition, hydrographical characteristics, and trophic webs (prey availability, presence and abundance of predator species) is necessary to better understand the temporal change in this species abundance, distribution and biology.

Southern rose shrimp *Farfantepenaeus (Penaeus) notialis*

Spatial distribution

The Southern rose shrimp *F. notialis* is found in intertropical and subtropical areas, both in the West and East Atlantic Ocean. In the Eastern Atlantic, its distribution areas extend from Cap Blanc in Mauritania (northern limit) to Cape Frio, in southern Angola (southern limit) (Lhomme, 1981).

F. notialis is a short-living species, with high growth rate and a life span of around 20 months (Caverivière, 2002). Life cycles of all *Penaeus* species are related to estuarine and coastal waters, since most of the time, they inhabit in areas under the influence of deltas, estuaries and lagoons, on muddy or muddy-sandy bottoms, rich in organic matter. The sediment nature is considered as a major factor influencing the geographical distribution of this species and partially responsible of the upper bathymetric limit of the species distribution (Lhomme and Vendeville, 1993).

A total of 14 stocks of *F. notiali*s have been identified along the West African coast (Garcia and Lhomme, 1979; Lhomme, 1981). Two different unities have been identified in the northern region of the West African coast, one in Mauritania and another in Senegal. In Mauritania, the species is found from the Arguin Bank (in the north) to the Senegal River mouth (in the South) and these two areas have been suggested to correspond to 2 different stocks: (i) the North stock located in the Arguin Bank (between 18º 50' N and 20º 00' N), with some dispersion zones as far as the Levrier Bay (probably coming from a nursery area in the Arguin Bank or, more specifically around Tidra Island); and (ii) the South stock, located between Nouakchott and Saint Louis related to the Senegal River, this shared between Mauritania and Senegal. Furthermore, two subpopulations have been defined in the northern area (North stock): one in the Arguin Bank and another south of Cape

Timiris. During the winter, a northwards displacement of the sub-population in Cape Timiris has been observed (Sobrino and García, 1993).

The Southern rose shrimp is distributed in a depth range between 2 and 100 m. Its highest abundance is found at different depths, depending on the area. In nearer West African coasts, maximal abundance has been found at 50 m (Saint-Louis), and 35 m (Roxo), in Senegal. The Spanish surveys carried out during the last four years (2007-2010) in Mauritanian waters prospected grounds of depths over 84 m that did not bring any information about the species distribution.

The life cycle of *F. notialis* is quite complex, being composed of a juvenile phase, that takes place in estuaries or coastal lagoons, and an adult phase that is developed at sea (Garcia and Le Reste, 1981; Lhomme, 1981; Lhomme and Garcia, 1984 ; Lhomme and Vendeville, 1993; Lhomme, 2001). This life cycle can be summarized as follows: Spawning takes place in the open sea. Larvae and first postlarvae are planktonic. At the end of their planktonic phase at sea (around 3 weeks), larvae develop into postlarvae and move to coastal and brackish zones (estuaries and coastal lagoons) by a semi-active process in which they displace themselves by using the tide floods. This migration is explained because the juveniles search the fresh water. Juveniles remain into the estuaries for approximately 3 months, before they migrate back to the sea. Juveniles use again the tide floods to their seawards migration, but in this case, the night descendent tides. Once at sea, juveniles acquire benthic habits and continue their growing, which is maximum at 3-4 months. At this moment, the females start their maturation processes, as male maturation is much more precocious and usually has occurred previously, in coastal areas. Southern rose shrimps continue their maturation while they grow and expand to deeper areas, already into the fishing grounds. After reaching their first maturity size, and when the environmental conditions are favourable, the spawning takes place and a new cycle begins. The more precocious individuals can spawn at 6-7 months, although massive maturation (when most of the individuals of the same cohort spawn), takes place at around age 1 year (Garcia, 1977).

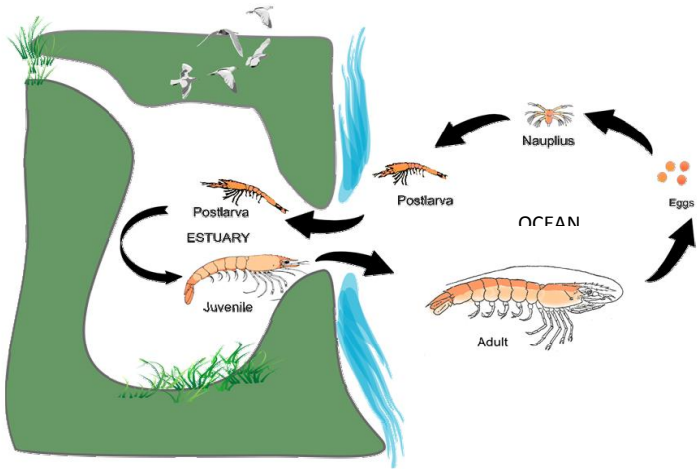


Figure 4.2.-Life cycle of *Farfantepenaeus notialis*. Based on Forbes and Demetriades (2005).

Nevertheless, the above explained life cycle of *F. notialis*, which is similar for all the species of the Genus Penaeus worldwide, surprisingly is not the same for the Northern stock of this species in Mauritania. Its life cycle occurs around the Arguin Bank, which constitutes an important reproduction and nursery area for this stock. However, there are not any estuaries, coastal lagoons, river mouths or, in general, brackish waters in the Arguin Bank, where juvenile phase develops, as

it occurs in other areas. Therefore, the Arguin Bank stock constitutes a great exception in relation to the biological behaviour of *F. notialis*, whose biological explanation remains unclear.

Reproduction/Recruitment areas and seasons

As explained above, two main unities, belonging to 2 different stocks of *F. notialis* have been described in Mauritania: one in the Arguin Bank (North stock) and another in the Senegal River mouth (South stock), the last being shared between Mauritania and Senegal.

As *F. notialis* males develop very early and are mature through all the year, the reproductive seasons of *F. notialis* should be identified following the proportion of the mature females in the female population. The IEO programme of scientific observers onboard Spanish shrimper vessels in Mauritanian fishing grounds during 2010 showed that although mature females were present during all sampled months (Figure, 4.3), a spawning peak may occur between August and October, as higher proportions were found during July and August. However, no data can confirm that the spawning peaks last until October, as this month could not be sampled due to the closed season (as previously explained for *P. longirostris*).

Other studies of this species carried out in Senegal (Lhomme and Garcia, 1984) and in Côte d'Ivoire (Lhomme and Vandeville, 1993), showed a continuous reproductive period all year round, although the existence of 2 spawning peaks by year is very frequent, even if their timing varies depending on the concerned area. In Senegalese waters, the reproductive periods of the Saint-Louis and Roxo-Bissagos stocks have been described (Lhomme and Garcia, 1984). In Saint-Louis, (which probably is the same Mauritanian South stock, shared by Mauritania and Senegal), the spawning period of *F. notialis* extends from August to December, with a peak between September and November. These reproductive peaks are related to the start and the end of the warm season.

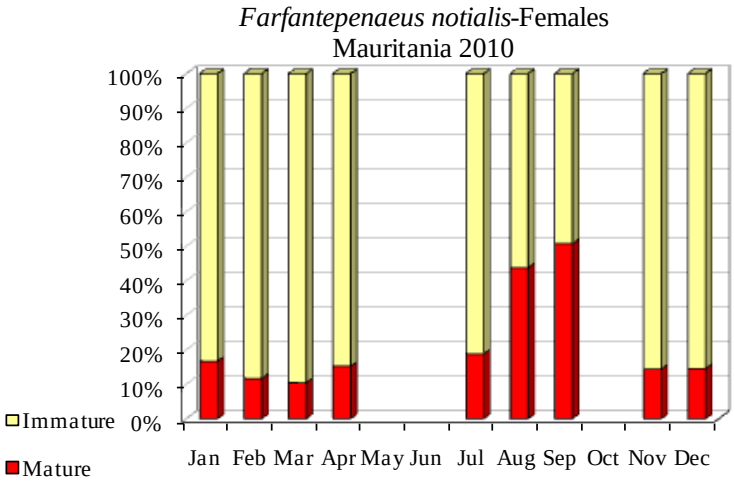


Figure 4.3.- Proportion of mature and immature females of *Farfantepenaeus notialis* sampled by IEO observers on board the Spanish shrimper fleet during 2010.

Relative abundance of mature females of *F. notialis* has been related to the moments with highest planktonic abundance, both in Senegal (Lhomme, 1981) and in Côte d'Ivoire (Lhomme and Vandeville, 1993). This adjustment of the Southern rose shrimp reproductive cycle and the primary production cycle ensures a higher larval survival, due to the planktophagous feeding habits of the larvae (Garcia, 1977). Therefore, primary production plays a very important role in the reproduction of the species.

A recruitment season, coincident with maximum yields of the industrial fleet, was identified in Mauritanian waters during the last months of the year (Sobrino and García, 1993)

There is not any published information about size at first maturity of *F. notialis* in Mauritania. Males mature very early and throughout the year, and therefore, females' first maturity length should be the significant information for the establishment of any management measures related to the minimal catch size. Size (CL) at first maturity (L_{50}) was estimated considering that the spawning peak occurs in August and September, and was 36.9 mm CL. This L_{50} is to be considered with caution, as is quite higher than those estimated in other West African areas, ranging between 25 mm and 31 mm CL (Table 4.III).

The mean age at first maturity has been estimated in 7,7 months for the Senegalese stock of Saint-Louis, based on the age of the individuals during the spawning peak (Lhomme, 1981). The maximal age of the Senegalese *F. notialis* has been estimated in approximately 23 months, corresponding to females of 50 mm CL.

Females reach bigger sizes than males. The 2010 samplings of the IEO observers onboard Spanish shrimper vessels in Mauritanian fishing grounds showed that most of the specimens bigger than 30 mm CL were females. At sizes of approximately 36 mm CL, almost 100% of the specimens were females. The sex-ratio estimated from these samplings was 1:0.7 (F:M). This higher proportion of females in the population has also been described for the species in Guinea-Bissau (García-Isarch *et al*., 2009) and Côte d'Ivoire (Garcia, 1977). However, the proportions of both sexes are the same in estuarine environments (Garcia, 1977).

The biggest individual sampled during the IEO sampling programme of the commercial landings from 2003 to 2008 was of 58 mm CL. The recruitment size to the industrial fishery has been estimated around 23-24 mm CTL, based on the sampling of commercial landings (García-Isarch, *pers.comm.*).

Table 4.III.– First maturity size (CL, in mm) of Southern pink shrimp (*Farfantepenaeus notialis*) females in West African waters (from North to South).

AREA	L_{50} (mm CL)	REFERENCE
Mauritania 2010	♀: 36.9	García-Isarch (*pers. comm.*)
Senegal (Saint Louis)[1]	♀: 25	Lhomme, 1981
Senegal-G. Bissau (Roxo-Bissagos)[2]	♀: 28-29	Lhomme, 1981 Lhomme and Garcia, 1984
Côte d'Ivoire	♀: 30-31	Lhomme and Vendeville, 1993
Nigeria	♀: 28	De Vries and Lefévere, 1969

[1]Probably corresponds to the South Stock of Mauritania

[2] Probably corresponds to the Stock of Guinea-Bissau

Growth rates are very variable, depending on the different stages of the life cycle. The theoretical growth of the Saint-Louis stock (which may correspond to the South stock of Mauritania) ranges

between 29 and 46 mm of total length (TL) per month, for juveniles with sizes between 10 and 100 mm TL (Lhomme, 1981). In general, juveniles' growth, occurring in estuarine and brackish waters, is very fast. Adults' growth, occurring at sea, is more difficult to study. There are important seasonal variations in growth, related to hydroclimatic fluctuations (Lhomme and Garcia, 1984). It has been generalized that monthly growth rate varies between 30 and 60 mm of TL during the juvenile stage and decreases with age since a certain moment. Furthermore, growth also varies depending on the population abundance and the temperature (Garcia and Le Reste, 1981): faster growth during the warm season and slowing down during both the cold season and, apparently, the spawning season (Lhomme and Garcia, 1984).

Concerning the migratory features of the species, it can be said that *F. notialis* carry out three main migratory movements in the course of its life-cycle:

1) Larvae and postlarvae move from the open sea to coastal waters, entering into brackish waters of estuaries or coastal marshes (with the exception of the North stock in Mauritanian), searching for appropriate bottoms for their nursery and feeding. In this phase they are only available to the artisanal fishery that can be developed in coastal areas.
2) During the juvenile stage they move back to the sea, to deeper and more saline waters, where reproduction takes place. In this phase they become available to the industrial fishery.
3) Southern pink shrimps do not only move in the coast-open ocean axis, but also along the coast, searching for more favourable ecological conditions related to their requirements on bottom type, trophic richness, and hydrology.

Abundance fluctuations

The dynamics of penaeid shrimps populations worldwide have long been a subject of study for research scientists and obviously of interest to the industry because of the fluctuations in annual population size and the consequent variations in annual catch which characterize the fast growing-highly fecund organisms (Forbes and Demetriades, 2005). The catch is based on the generation of the year on the 0+ year class in fisheries terms. The biomass which contributes to the catch is therefore generated each year.

Initial correlation analysis (Demetriades *et al.*, 2000) developed in South Africa supported the relation between summer rain and offshore catch of *Farfantepenaeus indicus* the following winter. Subsequent more detailed consideration of the possible interactions between this species and catchment runoff included the possible negative effect of very low salinities in the nursery areas which would make them inaccessible and secondly, the possibility of the introduction of terrestrially derived nutrients into inshore waters which would contribute to phytoplankton production and thereby potential enhance survival of the planktonic larval stages. Favourable conditions for larval development in combination with favourable nursery ground conditions for the juveniles would then be reflected in greater offshore catch in the following winter. Reductions in salinity in the nursery grounds would simply act as a trigger for earlier emigration.

4.1.1.b.- Information on seasonal and spatial distribution of the shrimper fleets operating in Mauritania

Seasonality

The EU is the main shrimper fleet currently operating in Mauritanian waters. Among the European fleets, the Spanish fleet is the one with the highest activity in the area.

The Spanish fishery shows a clear seasonal pattern, mainly related to the exploitation of the target species. Figure 4.4 (A) shows the monthly effort deployed by the Spanish shrimper fleet in Mauritanian waters from available data of the last EU-Mauritania fishing agreement period. Monthly data have not been averaged for the three years due to the differences found in the closed season periods. Although presently these closed seasons are established in May-June and October-November, some variations occurred over the period considered. In 2008, the spring closed season was established for the first time, in April and May. However, from 2009 onwards, it was switched to May-June. In 2010, Mauritanian authorities brought forward the second peak (usually in October-November) to September-October. This differences from one year to another can be appreciated in Figure 4.4(A).

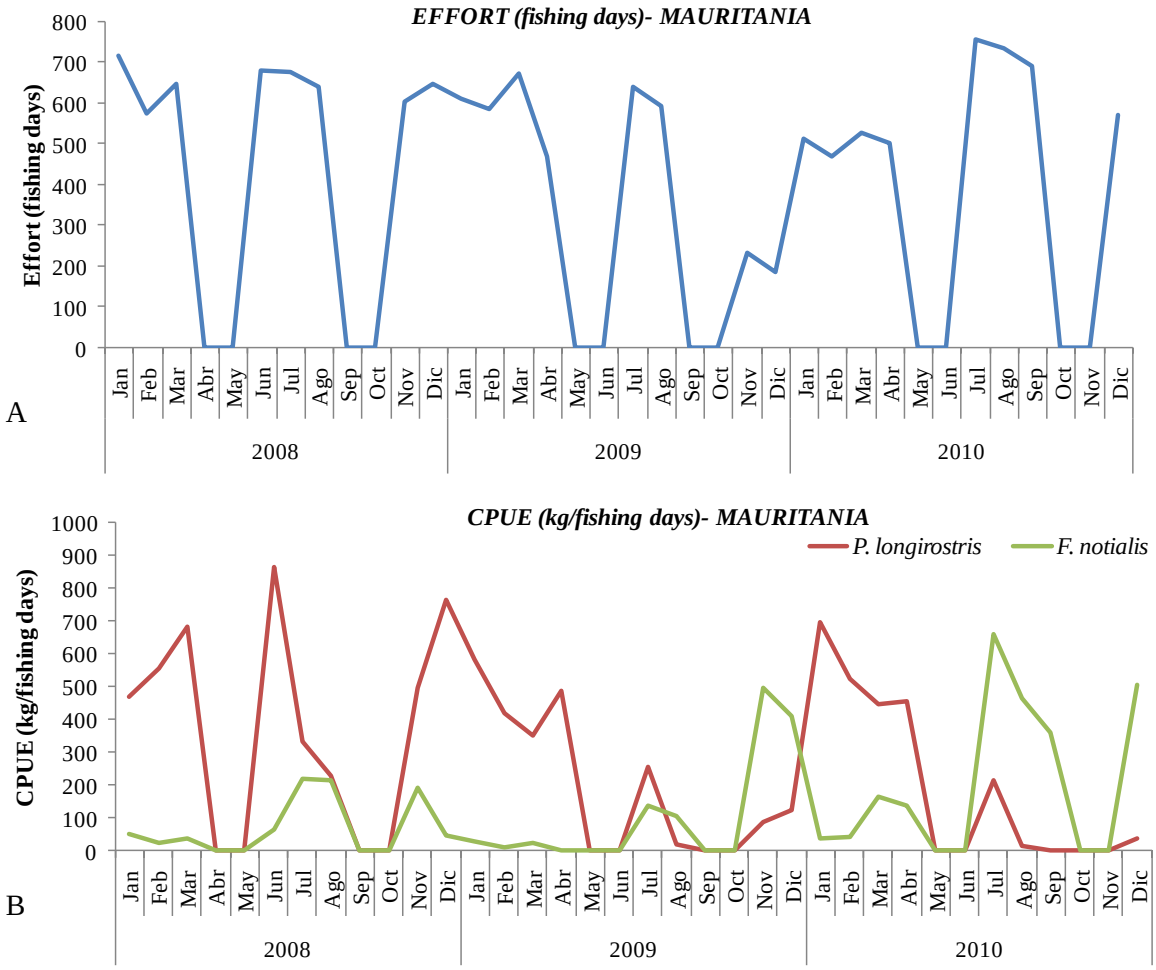


Figure 4.4.- Monthly effort (fishing days) of the Spanish shrimper fleet in Mauritania (A) and monthly CPUE (kg/fishing days) (B) of *Parapenaeus longirostris and Farfantepenaeus notialis* over the period 2008-2010.

The effort level is quite constant at the reopening of the fishery after the closed season, excepting at the end of 2009 and the beginning of 2010, when a general effort decrease was appreciated. In spite of this constant effort, the fishery changes its activity during the year, depending on the target species. For previous years, the fishing effort was split into specific effort targeting *P. longirostris* and specific effort targeting *F. notialis* (Figure 4.5). This gives an idea of the seasonal pattern followed by this fishery. In general, deep-water rose shrimps are targeted during the winter months (from December to May-April), when the resource is more abundant. The length of the "gamba" season depends, indeed, on the abundance of this species that can be very variable from one year to another. The Southern rose shrimp is especially targeted during the summer months (from June to August) and at the end of the year (November-December).

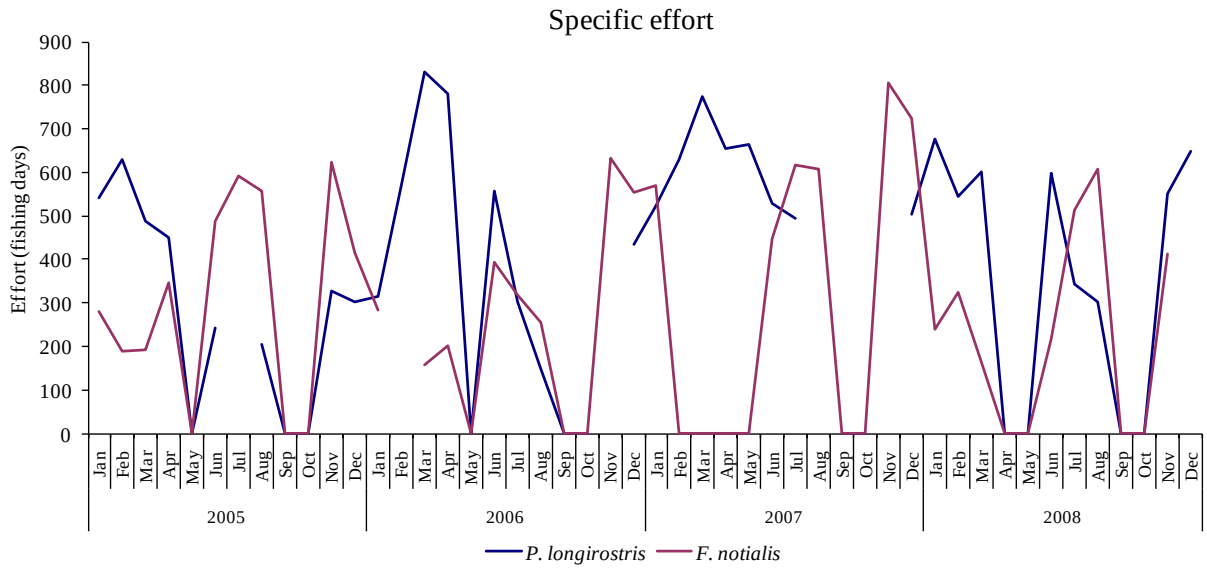


Figure 4.5.- Monthly Specific effort (fishing days) for *Parapenaeus longirostris* and *Farfantepenaeus notialis* from the Spanish shrimper fleet in Mauritanian fishing grounds. Period 2005-2008.

Monthly yields (CPUEs) of *P. longirostris* and *F. notialis* from the Spanish fleet are shown in Figure 4.4 (B) for years 2008, 2009, and 2010. Three main yield peaks occurred in 2008: one in March (before the first closed season), the most intense in June (after the second closed season), and another one in December. Deep-water rose shrimp yields remained at quite high levels until the spring closed season in 2009. During 2009, a second summer peak occurred in July, but less marked than the previous year. In 2010, main yields occurred during the winter (before the first closed season), and again, a smaller peak in July.

Regarding the Southern rose shrimp *F. notialis*, CPUE trends were very similar in 2008 and 2009, with main peaks occurring in summer (July-August), before the second closed season, and in November (Figure 4.4 (B)). However, the intensity of these peaks was opposite from one year to another. While the summer peak was the most intense in 2008, the November peak was especially intense in 2009. As explained in previous chapters, great abundances of *F. notialis* were noted in 2010, attributable to an exceptional recruitment the year before, and probably favoured by the effort reduction. This was reflected in much higher yields during March-April (months with insignificant yields in previous years) and especially in the summer from July to September (peak in July) and in December.

Spatial patterns

The only recent information about the spatial patterns followed by the shrimper fleet in the Mauritanian fishing grounds comes from the IEO programme of scientific observers onboard Spanish freezer shrimper vessels carried out in 2010 (Figure 4.6). Although this data are not representative of the activity of all the shrimper fleets operating in the area, they reflect the activity of the Spanish vessels, which usually operate together in the same area over the year. Furthermore, as it has been mentioned in previous sections, 2010 was an exceptional year for *F. notialis*, which reached its maximal abundance in more than a decade. For this reason, the fleet deployed a bigger effort than usual targeting this species during this year. Therefore, 2010 is not a good example of the "regular" activity of this fleet. The positions of a total number of 1174 fishing operations are shown in Figure 4.6, 58% of them targeted *F. notialis* while 40% targeted *P. longirostris.* Only 2% of the operations were made to catch *A. varidens*.

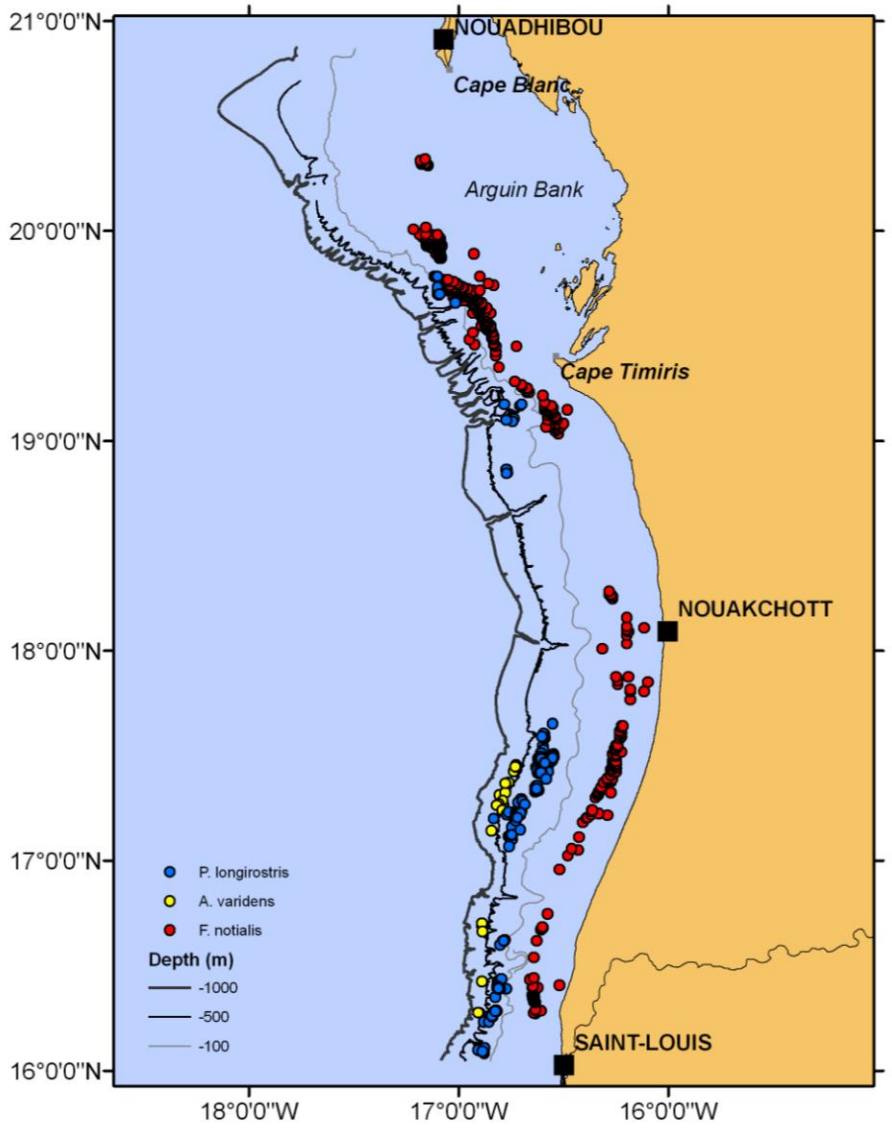


Figure 4.6.- Spatial distribution of hauls targeting *Parapenaeus longirostris* (blue), *Farfantepenaeus notialis* (red) and *Aristeus varidens* (yellow) during surveys of observers onboard Spanish shrimper vessels operating in Mauritania in 2010.

Two main fishing grounds can be distinguished: the North zone (north of 19º N), covering the surrounding area and north of Cape Timiris, with the northern limit at 20º 34’ N, and the South zone, from 18º 28’ N (north of Nouakchott) to the southern limit in the Mauritanian-Senegalese border. Both zones are separated by a quite wide area, between 19º N and 18º 28’ N, with no fishing activity (with the exception of one single trawl for deep-water rose shrimp).

Most of the fishing operations deployed in the North area targeted the Southern rose shrimp *F. notialis*, in a depth range from 13 to 70 m, with the majority of the trawls performed between 30-50 m and between 19º N and 20º N. Some trawls for *P. longirostris* were performed, from 18º30’ N to 19º 28’ N, in depths ranging from 100 to 237 m.

In the South area, the distribution of the fishing trawls perfectly shows the bathymetrical distribution of the three target species. The most coastal trawls (20-60 m) are those targeting *F. notialis* and operating in a longer coastal area, from 18º 23’ N (at north) to 16º 10’ N (at south), in the Senegalese border. Fishing operations to catch P. *longirostris* are carried out between 150-300 m in this south area, from 17º 23’ N to 16º N. A reduced number of deep hauls targeting *A. varidens* were performed at depths from 600 to 730 m, south of 16º N.

These spatial patterns of the Spanish shrimper activity can be compared with that identified using vessel monitoring system (VMS) data available for the same fleet during the period 1999-2001. In this last case, hauls could not be split into those targeting *P. longirostris*, *F. notialis* and *A. varidens*. Therefore, the above mentioned spatial distribution of the fleet depending on the target species is not shown. However, the fishing zones described in the North and South area, based on the information from observers onboard, is more or less coincident: North zone (north Cape Timiris), surrounding the Arguin Bank, and South zone, which in this case is located south Cape Timiris, without the spatial discontinuity observed in 2010.

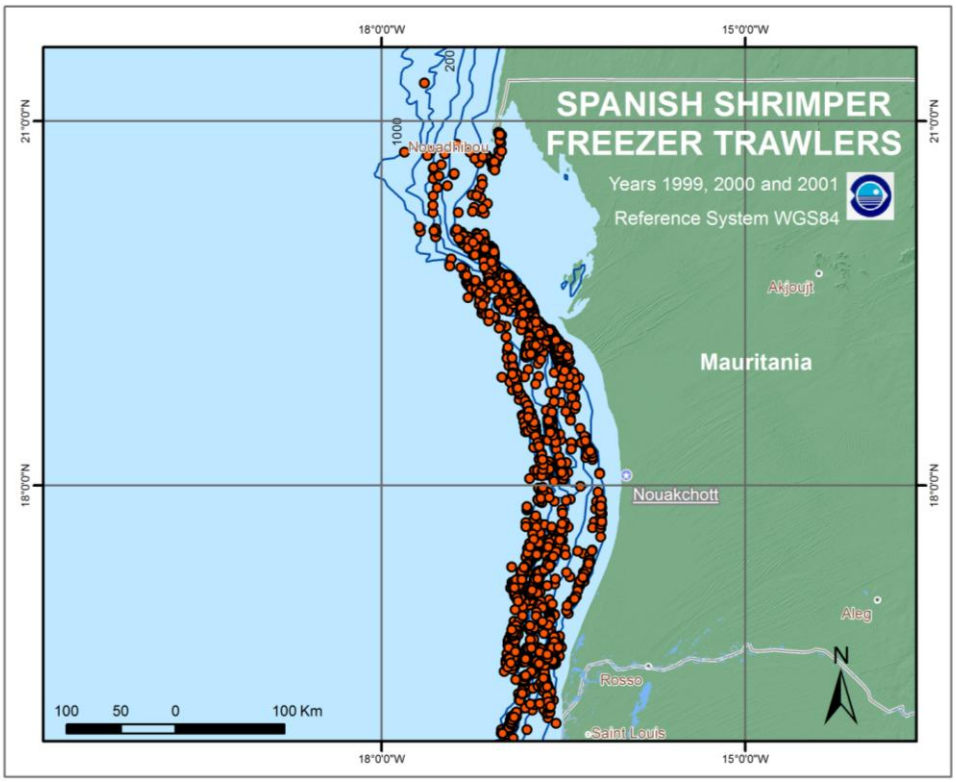


Figure 4.7.- Spatial distribution of hauls carried out by the Spanish shrimper freezer fleet in Mauritanian fishing grounds during the period 1999-2001. Data from VMS.

Conclusions:

The EU (Spanish) fishery has been traditionally carried out in Mauritanian waters and nowadays it is the main fleet operating in this fishing ground. Its main target species are the deep-water rose shrimp *P. longirostris*, which is fished at depths around 150-300 m, followed by the Southern rose shrimp, fished in shallower waters up to 60 m and, to a lesser extent by deep catches of *A. varidens*. While this last deep species is harvested by means of the typical bottom trawl ("baka" type), the fishing gears are changed to outriggers ("tangon" type) to fish the main two species.

- **Closed season**

  The biology of the main target shrimps species in Mauritania is quite unknown. The discrepancy of several studies carried out in these waters does not allow the establishment of an adequate closed season, accurately based on the biological reproduction period of *P. longirostris*.

  Two main unities, that could be related to two different stocks of *F. notialis* have been described in Mauritania: one in the Arguin Bank (North stock) and another one in the Senegal River mouth (South stock), the last being a shared stock between Mauritania and Senegal. Taking into account that the industrial fishery does not catch recruits of this species (having a shallower distribution than the operational distribution area of the fleet), any closed season should be established to protect the reproductive fraction of the populations. Although mature individuals are found all year round, the main spawning season of the South stock of *F. notialis* peaks between September and November, in coincidence with the autumn closed season currently established to protect the octopus resources, and also enforced for the shrimper fleet. Having no more information, we recommend maintaining the autumn closed season. In any case, and until new data are available, the spring closed season does not seem to have any ecobiological sense for shrimps.

- **Closed areas**

  The lack of information on the biology of *P. longirostris* in Mauritania does not allow making any recommendation related to possible closed areas to protect this species. The Arguin Bank has been described as a reproduction and nursery area for *F. notialis*. Therefore, the ban of the fishing activities in the Banc d'Arguin National Park is thought to be a good measure to protect spawners and juveniles of this species.

Further studies are required to improve our knowledge on the biology of both shrimp's species in Mauritanian waters. This will allow the establishment of correct management measures targeting the protection of these populations. Taking into account the great vulnerability of these short-living species to environmental changes, the establishment of correct measures to protect both the recruit and the reproductive fractions are strongly recommended.

4.1.2.- CEPHALOPOD FISHERY

4.1.2.a- Biological information on the target species

Octopus *Octopus vulgaris*

O. vulgaris is a short-living species, with a life-span of less than two years and a high growth rate (Mangold, 1983; Lamboeuf, 1997; Inejih, 2000; Perales-Raya, 2001). Reproductive females deposit their eggs in shallow water, always attached to a substrate, usually in sheltered and protected places. Females usually do not feed during the entire period of spawning and egg care and they die shortly after the hatching of the last embryos. Eggs hatch in planktonic paralarvae. About 40 days after the hatching (this period varies in relation to temperature) and with a size around 12 mm of dorsal mantle length (DML), juveniles change their habits to gradually adapt to a benthic habitat and to new feeding behaviours (Guerra, 1979c; Mangold, 1983; Roper *et al.*, 1984).

The life-cycle characteristics of the species includes early and semelparous breeding, rapid growth, short lifespan (around 12 months in West Africa), little overlap of generations and vulnerability to predation and environmental variables. All of which may result in wide inter-annual fluctuations in abundance (Boyle & Boletzky, 1996).

Spatial distribution

O. vulgaris is cosmopolitan and widely distributed worldwide. It is a benthic and neritic species that inhabits very different habitats, from shallow coastal waters down to the slope (around 200 m depth) (Guerra, 1979a; Roper *et al.*, 1984).

Horizontal distribution of octopus is not uniform, as individuals of similar size tend to form groups. Furthermore, there are strong seasonal segregations by sex. Thus, females migrate to coastal waters for spawning, this increasing their proportion in shallow waters during the spawning peaks (Guerra, 1979b; Lamboeuf, 1997; Inejih, 2000; Balguerías *et al.*, 2002; Caverivière *et al.*, 2002).

Octopus is essentially a non-migratory species, with its Mauritanian fishing ground covering offshore regions where the water depth ranges from 10 to 200 meters (Girardin, 1988). However, a maximum distribution depth of 307 m was recorded for this species in the Spanish surveys carried out in the Mauritanian EEZ from 2007 to 2010. Spatial distribution of *O. vulgaris* during these surveys is shown in Figure 4.8. It is worth remembering that the minimum depth of these surveys was around 80 m. The fact that the shallower waters were not sampled explains the low abundance values, as octopus may be mostly distributed in shallower areas. In spite that the sampled zone did not cover the whole octopus distribution area, a nearly continuous distribution from Cape Blanc to the Senegalese border was observed. In the North zone (north of Cape Timiris), the octopus distribution is more scattered and showed two main concentration areas at 20º N and 20º 30’ N. Another concentration area is observed just in front of Cape Timiris. In the south area, the distribution is more continuous and the highest abundance was recorded in the coastal area between Nouakchott (around 18º N) and 17º N.

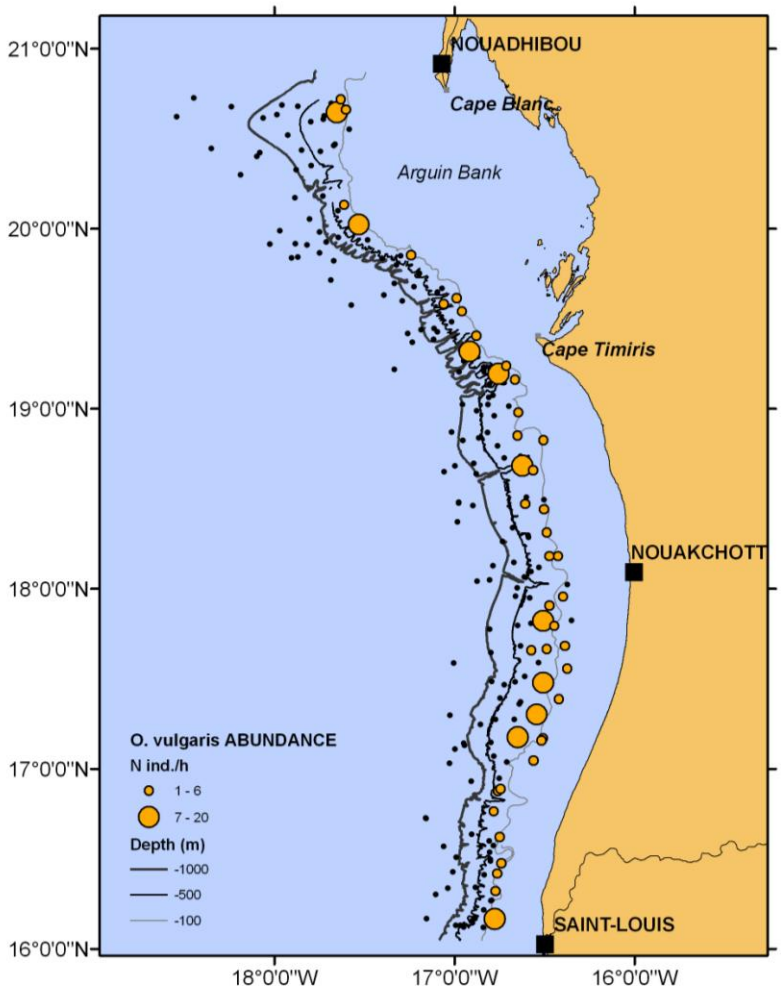


Figure 4.8.- Spatial distribution of abundance (number of individuals per trawl hour) of *Octopus vulgaris* in Mauritanian waters during the Spanish research surveys carried out in 2007, 2008, 2009 and 2010.

In Mauritania, there is a clear population structure of octopus, in terms of distribution, evidenced in two opposite seasonal patterns (Inejih, 2000):

- During the cold season (December-May), the octopus is widely distributed along the continental shelf in deeper waters, up to 30 m (in the North) or up to 60 m depth (in the South).
- During the warm season (June-November), the octopus distribution area is narrower and restricted to shallower and more coastal waters (up to 30 m), especially north of Cape Timiris. Thus, the octopus latitudinal distribution (north-south) experiences a contraction, as evidenced by the weak octopus yields usually obtained in southern areas.

In this spatial distribution pattern, the spawners and juveniles concentrate at depths between 40-20 m (respectively) in the area of Cape Blanc (Inejih, 2000). Maturing individuals are mainly located at deeper waters (probably for trophic reasons: food more abundant), while spawners move to shallower waters (for ontogenetic reasons: search of sheltered areas for spawning).

Reproduction/Recruitment areas and seasons

As males mature at very early ages and throughout all the year, the reproductive period of *O. vulgaris* is set by analysing the proportion of mature females (Mangold, 1983). Although mature females are found all year round, two annual spawning peaks have been described in Mauritanian waters: the first spawning peak occurs in spring (mainly from April-May to June) and the second and more important one occurs in September (autumn peak), but this can last from August to November (Hatanaka, 1979c; Bravo de Laguna, 1988; Dia, 1988; Nigmatullin and Barkovsky, 1990; Inejih and Dedah, 1996). The length and the timing of both spawning peaks vary depending on the referenced study (see table 4.IV). Spawning may extend up to 1 month. The fact that two spawning peaks occur in the same year is explained by the co-existence of two cohorts overlapping in time and space (Dia, 1988; Inejih, 2000; Idrissi *et al*., 2006). The existence of 2 semestrial cohorts has been well described for the Cape Blanc area (Perales-Raya, 2001). It is worth noting that the post-spawning mortality of the octopus (males and females) greatly affects the demographic structure and the lower yields achieved by the commercial fleets (Inejih, 2000).

The recruitment period is also extended, as there is an almost continuous supply of juveniles to the exploited population (Guerra, 1979b). Two recruitment peaks clearly occurs every year: in November to January (winter peak) and in July and August (summer peak). The octopus recruited to the fishery in summer is presumed to be that born from the precedent autumn spawning, and the individuals recruited in winter are those from the spring spawning (Hatanaka, 1979).

Therefore, the seasonal spatial distribution previously explained is related to the two identified cohorts in the octopus population (Inejih, 2000). The winter recruitment follows the population distribution pattern described for the cold season, with a more coastal fraction (waters shallower than 20 m) in the north zone (where the continental shelf is wider). The summer recruitment corresponds to the more coastal distribution pattern. This has been related to the existence of two different stocks (Inejih, 2000), as it will be later explained.

The recruits' size varies depending on the spawning season of their cohorts. The recruitment occurring from November to January (winter peak) is composed of individuals with mean weights between 650 and 800 g, particularly abundant in deeper waters (over 60 m). The June-July recruitment (summer peak) is composed of smaller individuals, mainly concentrated in shallow waters. The bigger sizes recorded for the individuals belonging to the cold season cohort are probably due to the favourable conditions during their first developmental stages.

The two main spawning periods of octopus in Mauritania occur both during and out of the upwelling season, suggesting that the timing of octopus spawning is not directly related to seasonality in upwelling. This could be due to the quasi-permanent coastal retention processes around the Arguin Bank (Faure *et al*., 2000). The two spawning seasons occur under very different environmental conditions. During the spring spawning, the index of upwelling intensity is high and the wind-induced turbulence index is large, but coastal retention is at its maximum. On the contrary, autumn spawning occurs under fairly stable environmental conditions: the upwelling and retention indices are moderate and turbulence is weak. The hatching of the spring spawning takes place during a transition season, characterized by a fast decrease of the upwelling intensity and by a temperature rise. Octopus paralarvae from this spring spawning appear at the end of a 7 month period of strong upwelling, with high mixing and productive conditions. Coastal retention is beneficial in such a period by limiting mixing and dispersion that seems to be detrimental processes. The hatching of the October spawning also occurs in a transition phase, characterized by a lower intensity upwelling (it is the beginning of the upwelling season) and decreasing temperatures. Coastal retention is lower and the wind-induced turbulence is weak. Upwelling intensity (which is at its seasonal minimum) becomes the main factor determining recruitment variability, suggesting that nutrient and food availability limit larval survival during this period (Faure *et al*., 2000).

Therefore, environmental conditions play a main role in the octopus population dynamics, especially during the pre-recruitment stage (pelagic paralarvae stage). Once recruited, the stock behaviour depends more on the ground conditions. During the exploited phase (lasting for 5 to 7 months, depending on the cohorts), fishing mortality becomes a very important factor affecting the population dynamics, but post-spawning mortality is the factor mostly affecting the population structure, as it involves the death of big individuals (Inejih, 2000).

To apply management measures about minimal catch sizes, first maturity size of females must be considered, as male maturation is very precocious and it occurs at small sizes. First maturity sizes of Mauritanian octopus have been estimated in several studies (see table 4.IV), some of them included in the revision carried out by Lamboeuf (1997), about the biology of *O. vulgaris* in the West African coast (from 26º N to 9º N). Size at first maturity of males ranges between 8 and 12.2 cm DML, and that of females range between 9.6 and 12.8 cm DML.

O. vulgaris has a clear differential growth by sex, with males reaching bigger sizes than females. At DML between 15 and 20 cm, 50% of the population are males (Inejih, 1991; Bravo de Laguna and Balguerías, 1992), while for individuals bigger than 30 cm DML, 100% are males (Bravo de Laguna and Balguerías, 1992). In terms of weight, females dominate below 500 g, while males tend to increase their proportion in heavier weight classes. In general, females from the North area are bigger than those of the South area (South Cape Timiris) (Inejih, 2000).

Regarding possible migrations, seasonal movements from abundance centres to deeper waters have been described during the cold seasons in Mauritanian waters (Lamboeuf, 1997). In fact, as explained above, octopus distribution is not homogeneous (Inejih, 2000). There is a clear seasonal heterogeneity, explained by the species moving from coastal to offshore waters (Dia, 1988; Hatanaka, 1979; Inejih and Joufre, 1996). But these movements are not necessarily related to migrations.

The most probable life-span of octopus in Mauritania is of approximately 1 year (Inejih, 2000), with two cohorts alternating into their exploited phases: one of 5 months (warm season) and the other of 7 months (cold season).

Some authors think that, instead of two cohorts of the same stock, there are two different octopus stocks in Mauritanian waters, with their exploited stages clearly separated (Inejih, 2000). The first stock would be found in deeper waters and in the north zone (Cape Blanc) and would be composed of bigger spawners. This stock, mainly exploited during the cold season, is a transboundary stock also occurring in the Western Saharan. The second stock would be located in the central-southern area (Cape Timiris-Nouakchott), in shallow waters, and would be mainly exploited during the warm season (from June to August). This theory is not only based on the spatio-temporal separation of the two cohorts, but in the clear differences found in length categories, sex-ratios, and even interannual evolution of abundance indices between the two cohorts (Inejih, 2000). The existence of two octopus stocks is under study, but some preliminary results of genetic analyses seem to confirm this hypothesis (Murphy *et al*., 2002). This stock identification in West African region is crucial and has important consequences in terms of assessment and management of the octopus fisheries. In fact, these two fractions of the population could mix during the cold season, when being exploited from November to December in the northern area (waters off Western Sahara), and during the warm season from June to October in southern areas (waters off Senegal).

Table 4.IV.– Reproductive characteristics of *Octopus vulgaris*: Size at first maturity in total length (TL), dorsal mantle length (DML), and/or weight (W) and spawning and recruitment periods, as compiled from several studies in areas including the Mauritanian waters. Based on the revision of Lamboeuf (1997), with later additional records.

AREA	First maturity size	Spawning period	Recruitment period	Reference
CE Atlantic (26ºN-9ºN)	♂: <50 cm TL ♀: 60 cm TL (higher in Nouakchott)	Spring: May-June Autumn: Sept.-October Sept. Peak→Cape Blanc May Peak→ Nouakchott		Hatanaka, 1979
26ºN-19ºN	♂: 8 cm DML/60 cm TL/ 260 g W ♀: 12-13 cm DML/ 85 cm TL/ 1100 g W	May-June September		Bravo de Laguna, 1988
Cape Blanc	Spring group: 11,8 cm DML Autumn group: ♂: 12,2 cm DML/1100-1300 g ♀: 13,5 cm DML/1300-1500 g	Spring: May-July Autumn: Sept.-Nov. Mature females throughout the year		Dia, 1988
Cape Blanc	Spring group: 11-21 cm DML Autumn group: 13-25 cm DML	Spring: March-June Autumn: Aug.-Octob. Maximum peak in September Depth: 30-60 m	Spring Group: autumn Autumn Group: spring Depth: 150 m	Nigmatulin and Barkovsky, 1990
Cape Blanc		Spring: April-May (Coastal area) Autumn: September (Big area)	June-July Octob.-Novemb.	Inejih and Dedah, 1996
Mauritania	♂: 580-700 g W (February-April) 540-600 g W (July-Septemb.) ♀: ~1300 g W (March-May) ~ 700 g W (Septemb.-October)	April-May October	June-July Novem.-January (Decem. peak)	Inejih, 2000
Mauritania	♂: 8,8 cm DML ♀: 12,3-12,8 cm DML			FAO/CECAF WG, 2010
Mauritania	♀: 9,61			Sancho, 2011 (*pers. comm.*)

Abundance fluctuations

Several authors have tried to explain the great variability and instability of the octopus abundance from one year to another. Hydroclimatic fluctuations are very important for a short-living species such as *O. vulgaris*, since they directly affect the survival of the larvae subsequently determining the recruitment success and the abundance of next year population.

Recruitment of Mauritanian octopus populations is highly variable from year to year (Faure *et al.*, 2000). Coastal retention has been described as a key factor for recruitment success of *O. vulgaris* of the Arguin Bank, in Mauritania.

Owing to seasonal variations in enrichment and mixing processes, larvae benefit from retention in the spring but are negatively affected by a breakdown in retention in the autumn. Increasing upwelling intensity is beneficial for octopus recruitment, as the Arguin Bank limits the detrimental dispersive effects linked to upwelling (Faure *et al.*, 2000).

Other studies developed in the Saharan Bank, Mauritania and/or Senegal also identify the fishing effort exerted on the resource as a very important factor influencing the great octopus abundance fluctuations (Lamboeuf, 1997; Faure *et al.*, 2000; Balguerías *et al.*, 2002; Diallo *et al.*, 2002).

We conclude that the environmental conditions, the fishery patterns, as well as the species bio-ecological characteristics play a significant role in the high variability observed in the inter-annual abundances of *O. vulgaris*.

Cuttlefish *Sepia* spp.

Unlike *O. vulgaris*, whose main biological features are quite well studied, there is little information on the biology of *Sepia* spp. in Mauritanian waters.

Two species appear mixed in cuttlefish catches: *Sepia hierredda* and *Sepia officinalis*. This question should be taken into account for the assessment of this stock, as although both species are jointly exploited, some differences exist in their biological characteristics (Hatanaka, 1979a; Boletzky, 1983; Guerra *et al.*, 2001; Jereb and Roper, 2005).

The species of Genus Sepia are short-living and have high growth rates. Therefore, their abundances are very dependent on their recruitment, which is highly influenced by the environmental conditions.

Spatial distribution

S. hierredda is distributed in Central and South East Atlantic, from Cape Blanc in Mauritania (21º N) to Angola (16º 30’ S). Its distribution overlaps with the one of *S. officinalis*, which is widely distributed in East Atlantic, from the Shetland Islands (south of Norway) to the north of the Mauritanian-Senegalese border (16º N).

Both species are demersal and neritic, predominantly occurring on sandy to muddy bottoms from the coastline to about 200 m depth, although they are most abundant in the upper 100 m. While *S. officinalis* is found up to 200 m depth, with higher abundance over 100 m, *S. hierredda* inhabits waters up to 50 m (Jereb and Roper, 2005). Therefore, very few *S. hierredda* individuals were caught in the Spanish surveys carried out in Mauritanian waters (2007-201o), carried out at depths over 80 m. Bathymetric distribution of cuttlefish varies in relation to size and water temperature. In general, the biggest individuals inhabit near the deepest limits of their bathymetric distribution (Roper *et al*., 1984).

It is believed that the species has limited migratory movements although seasonal migrations (mainly vertical) have been shown to occur in all stocks, related to spawning processes and to the sea temperature. There is no information about possible geographical migrations in Mauritanian waters. For the population off Senegal a seasonal north-south and an offshore-inshore migration pattern has been suggested (Bakhaykho and Drammeh, 1982).

Reproduction/Recruitment areas and seasons

The reproductive period of cuttlefishes along West African coasts covers almost the whole year. Therefore, mature individuals, both males and females can be found throughout the year (Hatanaka, 1979b; Bakhaykho, 1983; Fernández-Núñez *et al.*, 1994). During the spawning season, cuttlefishes move close to the coast, where females deposit their eggs on different types of substrate, generally at depths under 40 m (Hatanaka, 1979b; Bakhaykho, 1983). In the adult phase the males are predominant because of massive post-spawning mortality of large females (Bakhaykho, 1983; Boletzky, 1983; Fernández-Núñez *et al.*, 1994; Jereb and Roper, 2005).

In Atlantic African waters between Western Sahara and Senegal, *Sepia* spp. spawning occurs in shallow waters, all year round, peaking when the water temperatures are comprised between 13°C and 15°C. Two spawning peaks have been described: one in spring , mainly corresponding to later spawners (big adults), which have reached sexual maturity in their second year; and a second minor spawning peak in autumn, due to the precocious spawners (medium and small-sized individuals), which complete their maturity in their first year of life (Hatanaka, 1979b, Bakhaykho, 1983; Fernández-Núñez *et al.*, 1994). In Mauritanian waters, the spring peak takes place in May and the autumn peak in September (Hatanaka, 1979b). Larvae hatched in early summer from the spring brood usually participate in the autumn spawning of the following year, while those from the autumn brood will spawn in spring in their second year of life.

Males of *Sepia* spp. mature at a very early ages and have smaller first maturity sizes than females. There is very little information on first maturity sizes of cuttlefish from Mauritania. The IEO has carried out biological samplings of *Sepia* spp. specimens coming from the Spanish cephalopod freezer fleet operating in Mauritanian fishing grounds. A first maturity length (DML) around 10 mm and 13 mm have been estimated for males and females, respectively (Sancho, *pers.comm*.). However, these estimations should be considered with caution due to certain methodological bias in the samplings and to the possible mixing of species.

These species have high growth rates and relatively short life-span (up to 2 years in the fishery). Although males usually reach bigger sizes than females, a significant different growth among sexes has not been demonstrated (Bakhaykho, 1983; Perales-Raya, 2001). Growth rate is positively correlated with temperature (seasonal variations) and negatively correlated with individuals size (Bakhaykho, 1983; Roper *et al.*, 1984; Perales-Raya, 2001; Royer, 2002). Cuttlefish growth is very dependent on sea temperature. Therefore, growth rates can vary for individuals living in the same area, depending on the spawning and hatching moments. Some authors consider different growth rates for the hatching-recruitment period and for the recruitment-adult period, with the first group having the highest growth rate (Bakhaykho, 1983; Royer, 2002). In general, cuttlefish born in the most favourable seasons for nursery (spring), grow faster and, as a consequence, they reach recruitment size and start their spawning before cuttlefishes born during other seasons (Fernández-Núñez *et al.*, 1995).

Longevity has been established between 12 and 24 months, depending on the environmental characteristics of the area (Bakhaykho, 1983; Royer, 2002; Jereb and Roper, 2005). Life-span is shorter in those areas where the sea temperature is highest, due to the advanced sexual maturity. While in Senegalese waters the cuttlefish longevity was estimated in 22-24 months (Bakhaykho,

1983), recent studies in the Saharan Bank estimate a life-span shorter than 12 months (Perales-Raya, 2001).

Abundance fluctuations

Given the short life span, large inter-annual fluctuations in landings, and the regular annual migration cycle, it is expected that marine environment conditions have an important impact on cuttlefish recruitment and distribution (Boletzky, 1983).

Squid *Loligo vulgaris*

The squid *L. vulgaris* is a neritic species living in temperate waters in the eastern Atlantic, from the North Sea and around the British Isles (55°N) to the western African coast (20°S), and throughout the Mediterranean Sea (Roper *et al.,* 1984).

The species is neither pelagic nor fully benthic. It inhabits circumlittoral zone and upper bottoms of bathyal systems (Cunha *et al.,* 1995) and exhibits benthic behaviour during spawning season and pelagic behaviour at other times, e.g., during hunting (Worms, 1983). Its maximum life span has been estimated in 1.5 to 2 years in females and 3 to 3.5 years in males (Worms, 1983).

Spatial distribution

Squid inhabits coastal waters of the continental shelf, with a maximum depth distribution of 400-500 m. They carry out vertical migrations through their life-cycle (ontogenetic migration) (Vecchione, 1987), as well as daily vertical movements, concentrating near the bottom in daylight hours and dispersing in the water column at night. Spatial seasonal migrations have been described in European waters.

Off Northwest Africa, the common squid *L. vulgaris* is mainly restricted to the northern part of the sub-region, being very rare south of Senegal.

In the annual Spanish surveys carried out in Mauritanian waters in November-December, from 2007 to 2010, squid distribution showed to be very scattered and with generally low abundances (Figure 4.9). However, these surveys were always carried out in the same period (November-December) and it is known that squids carry out both vertical and horizontal migrations depending on the environment and season. Furthermore, as waters shallower than 80 m were not sampled, the real distribution of squid is probably not accurately reflected by these data. In any case, two main abundance locations were identified in the north area, at depths between 100 and 300 m: in front of Cape Blanc (more abundant) and in front of Cape Timiris. In the south area, the squid distribution was shallower (under 100 m depth) and concentrated in two main abundance zones: the greatest zone, around 17º 15’ N, and a second concentration area, less abundant, near Nouakchott (around 17º 50’ N).

The squid is mostly fished in relatively coastal waters off Mauritania, although it is believed to achieve migrations, as it occurs in other regions. In the zone between Cape Bojador and Cape Blanc, an offshore migration has been detected during the winter. A migration towards the coast also takes place for spawning.

Reproduction/Recruitment areas and seasons

Spawning occurs at depths less than 100 m. Juveniles concentrate over bottoms between 10 to 100 m between Cape Chica and Cape Blanc. In the surrounding waters off the Saharan Bank (21º-26º N), spawning occurs throughout the year, but mainly from November until January.

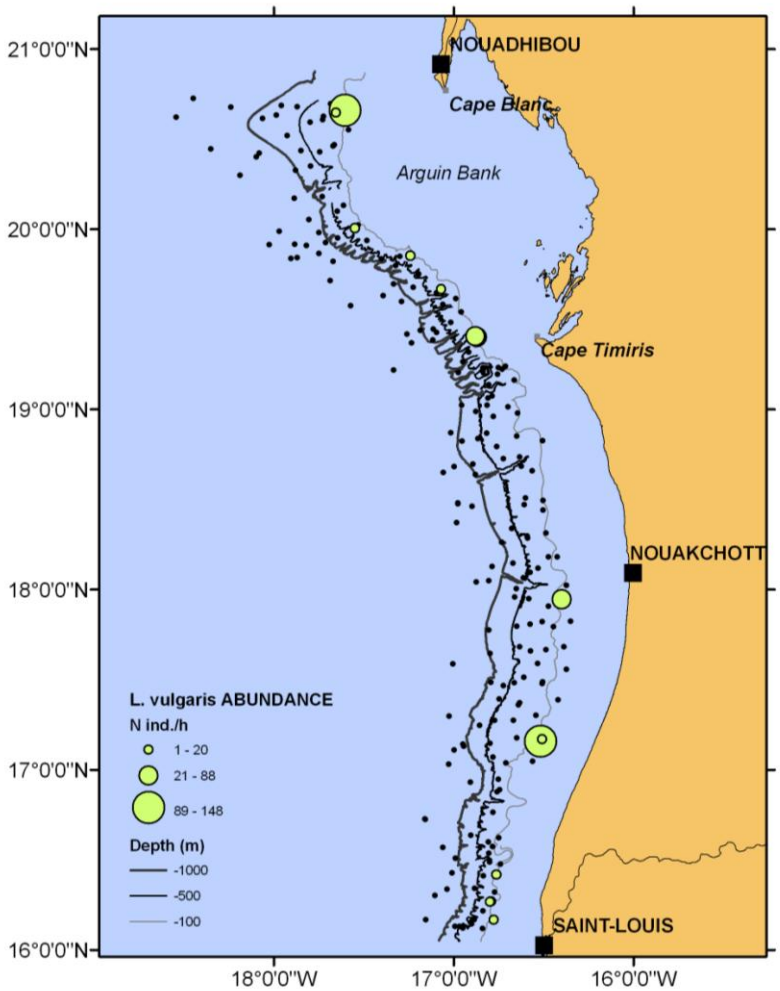


Figure 4.9.- Spatial distribution of abundance (number of individuals per trawl hour) of *Loligo vulgaris* in Mauritanian waters during the Spanish research surveys carried out in 2007, 2008, 2009 and 2010 (November-December).

Secondary spawning peaks in May and recruitment peaks in November-December occur in some years (Raya *et al*., 1999). Squids from the spring peak of hatching are presumably mostly recruited to the fishery from June to September. Thus, the main recruitment season in this area occurs in the summer/autumn. These population features and a high inter-annual variability result in a complex population structure. The squid life-span has been estimated to be of 1 year in the Saharan Bank (Raya *et al*., 1999).

Across its geographic distribution *L. vulgaris* males mature at a lower size than females. Age studies confirm that males mature earlier in life than females, and that small mature squid are younger than large mature squid (references included in Moreno *et al*., 2002). Males show smaller DML_{50}s than females in the Saharan Bank. In this area there were two male size modes at maturity (which biases the estimation of DML_{50}), the first lower than that of females (Raya *et al*., 1999).

Abundance fluctuations

Annual abundance cycles and functional relationships with environmental variables have been widely described for some squid species (references included in Balguerías *et al.*, 2002). Most of these studies demonstrated that there is an apparent effect of sea temperature on squid abundance, however, the precise form of the relationships, and mechanisms underlying them are generally unclear.

4.1.2.b.- Information on seasonal and spatial distribution of the cephalopod fleets operating in Mauritania

The dynamics of the cephalopod fleets operating in Mauritanian waters targeting octopus have been well studied until 1997 (Inejih, 2000). From 1997 onwards, only information of the Spanish freezer trawlers is available for this report. It is worth reminding that *Sepia* spp. and *L. vulgaris* are by-catch species of the octopus fishery.

Seasonality

The cephalopod (mainly octopus) fishery in Mauritanian waters is dependent on the fleet type and is markedly seasonal, alternating seasons of high and low catches. This seasonality was very well explained for fisheries occurring before 1997 (Inejih, 2000). However, the cephalopod fishery has undergone a series of major changes after that year that could have also affected its seasonal pattern.

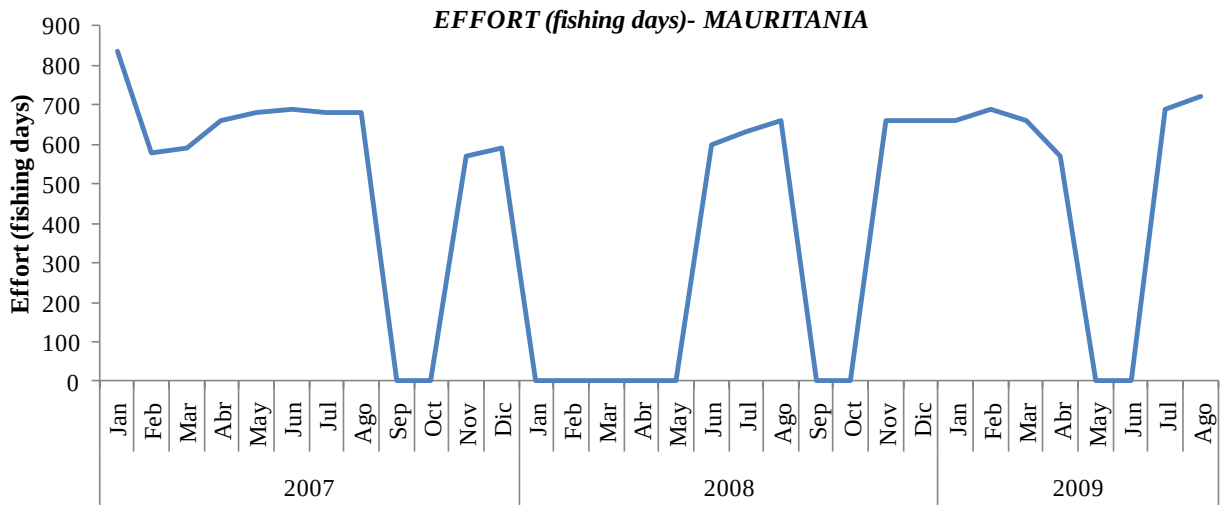
The great seasonality of octopus catches recorded by Inejih (2000) in Mauritania seems to be a general characteristic of the *O. vulgaris* fishery, and linked with the different sexual maturity stages. Hatanaka (1979) explained that high yields and maximal catch were achieved when the mean stomach repletion size is higher in the area of Cape Blanc, corresponding to the moment when octopus are searching for food. On the other hand, periods with lower yields correspond to the spawning seasons, when catchability of both males and females decreases due to the post-spawning mortality and/or the sheltering of females to protect the spawning.

The Mauritanian artisanal octopus fishery is very specific. The monthly artisanal catch clearly follows the two seasonal octopus recruitment periods (Hatanaka, 1979). Thus, the recruitment variability of the Mauritanian octopus populations is assumed to be reflected in the catch of the smallest octopus from the artisanal fishery (Faure *et al.*, 2000). In accordance with the information available until 1997, the lowest catch was achieved by the artisanal fleet from April to June and in October, which are the months when the fleet exerts the lowest effort targeting octopus.

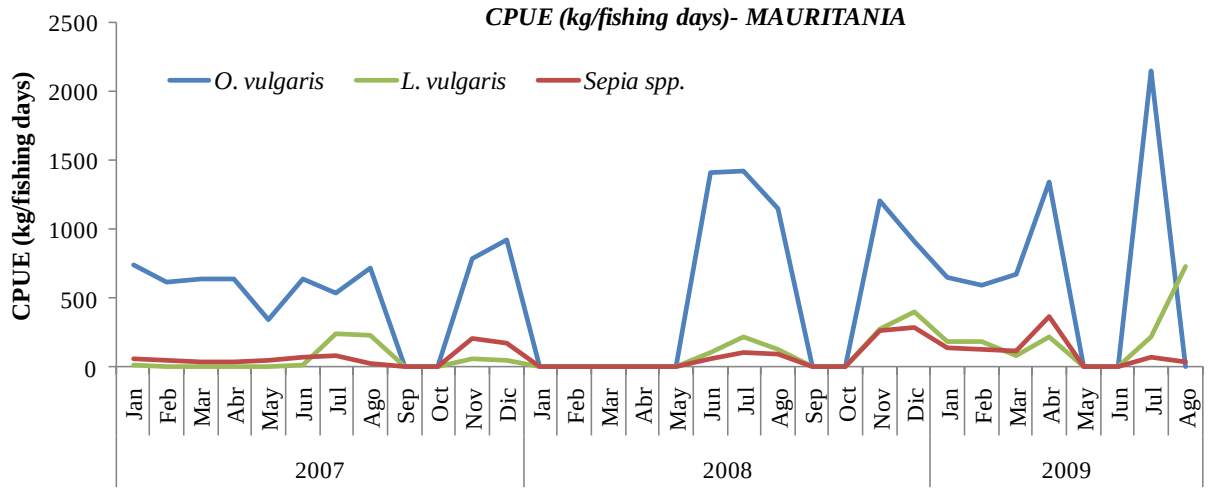
The only available information about the seasonality of the cephalopod fishery in the Mauritanian fishing grounds in recent years, especially those covering the last (current) EU-Mauritania fishing agreement, corresponds to the Spanish fleet. However, this information does not cover all the agreement period and is only available until August 2009. Due the great differences in the fishing strategy followed by the Spanish fleet during the considered period, we did not calculate any average values.

The activity of the Spanish cephalopod fishery has been quite irregular during the last years (Figure 4.10-A), due to changes of the closed seasons (as explained for shrimps) and to certain problems concerning this fleet that caused a voluntary stop of the fishery in 2008. The effort during 2007 was quite stable. Only one closed season of two months (September-October) was still implemented in that period. However, 2008 was a difficult year for the Spanish cephalopod fleet, which started with

a voluntary cease of the activity in protest to the more and more restrictive management measures discriminating the EU fleet, since they were not enforced for the domestic fleet. This is the case of the minimum catch weight of 500 g imposed for the EU fleet, while 300 g is the minimum "tolerated" catch weight for the Mauritanian fleet, and the exclusion of the EU fleet out of the 6 miles zone, while Mauritanian vessels are not spatially limited, and are allowed to operate in shallower waters. This voluntary ceased was followed by the second closed season established on that year (April-May in 2008 and May-June the following years).



A



B

Figure 4.10.- Monthly effort (fishing days) of the Spanish cephalopod freezer fleet in Mauritania during the period January 2007-August 2009 (A) and monthly CPUE (kg/fishing days) of *Octopus vulgaris*, *Loligo vulgaris* and *Sepia* spp. during the period January 2007-August 2009 (B).

This effort discontinuity is reflected in the yields (CPUEs) obtained (Figure 4.10-B). The greatest octopus yields were recorded in summer (June-August, whenever the fleet was operational) and

November-December. However, the general trend for the octopus yield is similar to that of the effort. CPUEs of *Sepia* spp. and *L. vulgaris*, although at a lesser extent, followed the same trend than the octopus, and therefore, than the effort. Cuttlefish and squids are by-catch species of the fleet, which specifically targets octopus. A yield peak of octopus occurred in July 2009, followed by another squid peak in August 2009. Unfortunately, the fishery data for 2010 are not available yet.

Spatial distribution of cephalopod fleets

Figure 4.11 shows the traditional octopus fishing areas in Mauritania, with statistical grids and bathymetric lines, as described by Inejih (2000) based on fishery data until 1997. Therefore, there may have been changes in the fishing strategy of the different fleets since that year.

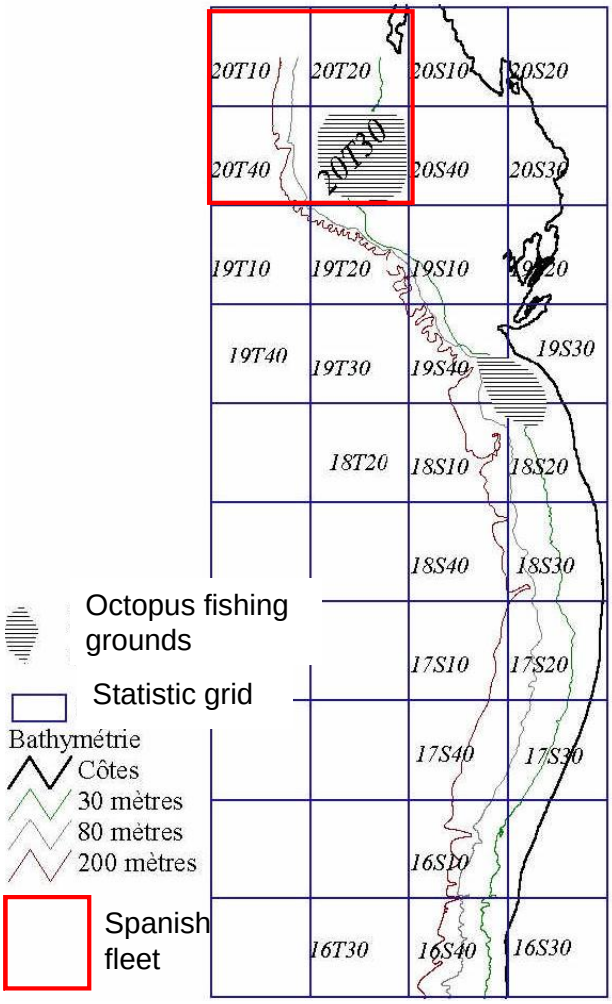


Figure 4.11.- Map of Mauritania, with statistical grids and bathymetry Traditional octopus fishing zones are marked. Based on Inejih (2000).

Octopus catch was mainly concentrated in the north zone, with the exception of the Spanish fleet (Inejih, 2000). There were changes in the spatial distribution of the fleets through the period analysed by Inejih (2000). In 1996 and 1997, the catch in the central zone, mainly due to the Mauritanian and the Chinese fleets, lost importance in relation to previous years. The catch in the

south zone was almost negligible during all the analysed period.

Catch composition from the industrial fleet differed among different fleets, depending on their fishing strategy. In general, the north zone, and especially the sector 20T30 (see Figure 4.11) concentrated the effort of most of the industrial fleets targeting octopus during the studied period (Inejih, 2000), although there were variations in the spatial activity among the different fleets. The Spanish freezers were the less linked to this sector, as they usually harvested deeper stocks. Three other sectors of the north zone seemed to be quite important for the Spanish freezer vessels. These sectors were 20T20, where catch was even higher than in 20T30, followed by the sectors 20T40 and 20T10, almost equivalent to 20T30. These four sectors accounted for more than 75% of the catch in the north zone.

The wet-fish trawler fleets and the originally Chinese freezer trawlers were more associated to the coastal zone in front of Cape Blanc, where they spent around 90% of their fishing time. The Mauritanian freezer vessels were in an intermediate situation between the Spanish and the Chinese fleets, but were more similar to the Chinese ones. Even if these Mauritanian units changed the area, they usually fished in shallower waters (below 60 m) than the Spanish vessels (Inejih, 2000).

The domestic artisanal fleet is developed in shallower waters than the industrial fleet. It is especially important the artisanal fishery carried out with pots, due to the great impact they have on the octopus populations, as they fish on reproductive females that use them as shelter during the spawning and posterior care of the hatching into these pots.

This distribution pattern of the fleets targeting *O. vulgaris* should be related to the distribution pattern of *O. vulgaris* in Mauritanian waters, as explained above. Thus, different fleets (especially domestic fleet and more specifically reflagged national vessels -formerly Chinese-) used to operate in the zone north of Cape Timiris (north zone) and more precisely in the sector 20T30, in depths under 40 m. This area concentrated more than 50% of the total fishing time in the analysed period. But this operational pattern was not considering neither the yield drops during the spawning periods (May-June and September-October) nor the average catch, probably higher than in other areas (as the central area, in waters deeper than 30 m, and the south area, in waters deeper than 80 m). In other words, if octopus distribution along the coast covers all the continental shelf, the fleet distribution, on the opposite, was characterized by a low coverage of the abundance areas (Inejih, 2000). Due to the lack of concordance between the fleet and effort distribution in relation to the species distribution, the fishing strategy described by Inejih (2000) may not optimize the catch possibilities offered by some areas (particularly the grounds deeper than 40 m surrounding Cape Blanc and between 30-80 m south of Cape Timiris.

The only available information on the spatial distribution of the cephalopod fleet later to that provided by Inejih (2000), is that given by the analyses of VMS information from the Spanish cephalopod freezer fleet during the period 1999-2001 (Figure 4.12). The spatial patterns of their fishing operations show that the cephalopod fishing activity in fact has extended to deeper areas surrounding Cape Blanc and to other fishing grounds south Cape Timiris, as suggested by Inejih (2000) to optimize the catch possibilities.

Conclusions

The cephalopod fishery in Mauritanian waters is composed of three major species: octopus *O. vulgaris*, cuttlefish *Sepia* spp., and squid *L. vulgaris*. Octopus is essentially a non-migratory species, with its Mauritanian fishing grounds covering offshore regions where the water depth ranges from 10 to 200 meters (Girardin, 1988). Octopus have two major reproductive seasons, variable from one year to another, that can last from April-May to June-July (spring spawning) and from August-September to October-November (autumn spawning). During the reproduction season, they tend to

concentrate in the Mauritanian fishing grounds in ways that make them more vulnerable to the fishery (Dia, 1988). In contrast, cuttlefish exhibit distinct migratory behaviour in Mauritanian waters, moving from deep to coastal areas (north to south) in response to changes in water temperature and/or reproductive maturity (Dia and Inejih 1991). The squid tends to be captured in relatively near coastal waters, although it is also believed to be migratory.

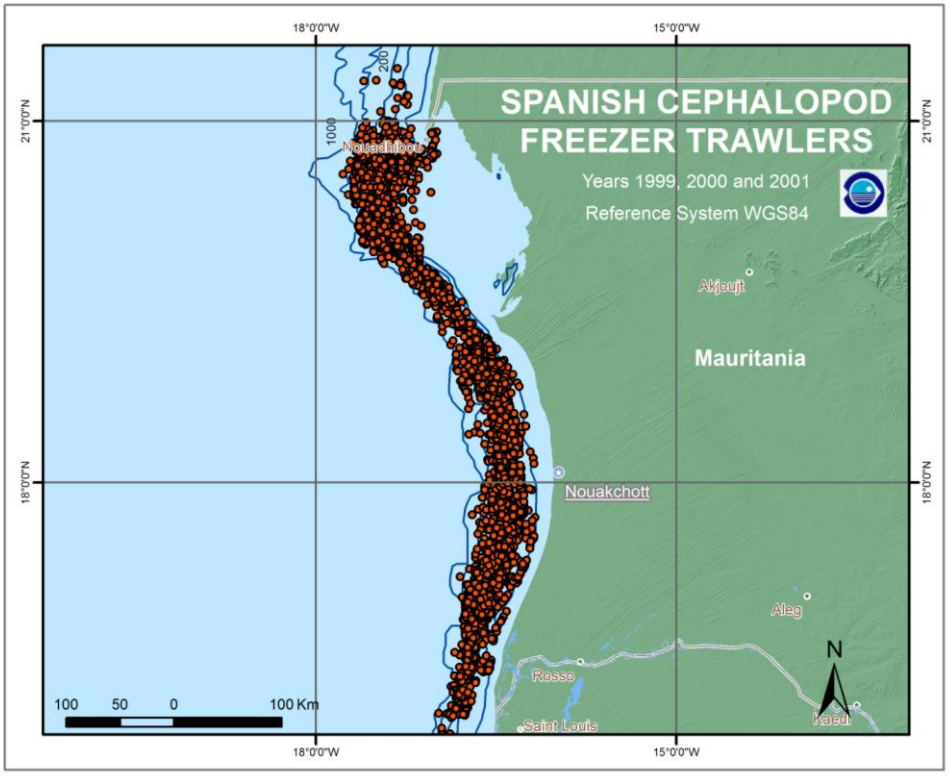


Figure 4.12.- Spatial distribution of hauls carried out by the Spanish cephalopod freezer fleet in Mauritanian fishing grounds during the period 1999-2001. Data from VMS.

Closed season

Two closed seasons (of two months each) are currently established by the Mauritanian legislation to the cephalopod and shrimper fleets. There is a spring closed season (May-June) and an autumn closed season (October-November, brought forward to September-October in 2010). These closed seasons seem to be correctly established in order to simultaneously protect the octopus reproductive and recruitment fractions of the population. However, the octopus yields continue dropping, even after the establishment of the spring closed season in 2008. The problem seems to be related to the fact that after the closed reasons, when the fishery is re-open, the fleet tends to concentrate in the recruitment areas, which are especially vulnerable to exploitation. Yields notably increase during those periods, next sharply dropping. When yields decrease, the fleet tends to disperse, searching for other concentration areas.

It is worth remembering that shrimps biology is quite unknown and that as far as we know, only the autumn closed season seems to protect the reproductive fraction of *F. notialis* population during a main peak. Therefore, the application of the closed seasons during four months is only advised for the cephalopod fishery. In any case, and until further studies will lead to a better knowledge of the shrimps biology, only the autumn closed season, if any, should be maintained for the shrimper fleet.

Closed areas

Spatially, the north area of Mauritania (Cape Blanc) and in particular, during the warm season, is the most important zone for octopus reproduction and recruitment (Hatanaka, 1979; Inejih, 2000). This is an important consideration to take into account for the establishment of management measures aiming at the protection of these fractions of the population.

Currently, a project is being developed with the aim of modelling the dynamic of the octopus spatio-temporal distribution in Mauritanian waters, to identify specific areas and seasons with high concentrations of recruits and/or reproductive stages. The final objective is proposing a dynamic system of closed areas/seasons that facilitate the management of the octopus fishery (Balguerías, *pers. comm.*).

4.2.- GUINEA-BISSAU

4.2.1 -SHRIMP FISHERY

4.2.1.a- Biological information of the target species

Deep-water rose shrimp *Parapenaeus longirostris*

General aspects on the biology of *P. longirostris* have already been described in section 4.1.1.a. Therefore, only aspects concerning the particularities of the species in Guinea-Bissau are illustrated in this section. Most of the information comes from two Spanish surveys carried out onboard the Spanish R/V VIZCONDE DE EZA, in October-November of 2002 and 2008.

Spatial distribution

P. longirostris is distributed along the Guinea-Bissauan coast, at depths ranging from 60 to 430 m, showing a discontinuity located around 11º N (coinciding with the location of a submarine canyon) and separating the 2 main concentration areas, one in the north zone (north of 11º N) and another one in the south (south of 11º N) (García-Isarch *et al*., 2009 and 2010). The north zone, on the Senegalese border is the area with the highest abundance, especially between 11º 28' N and 11º 47' N (Figure 4.13).

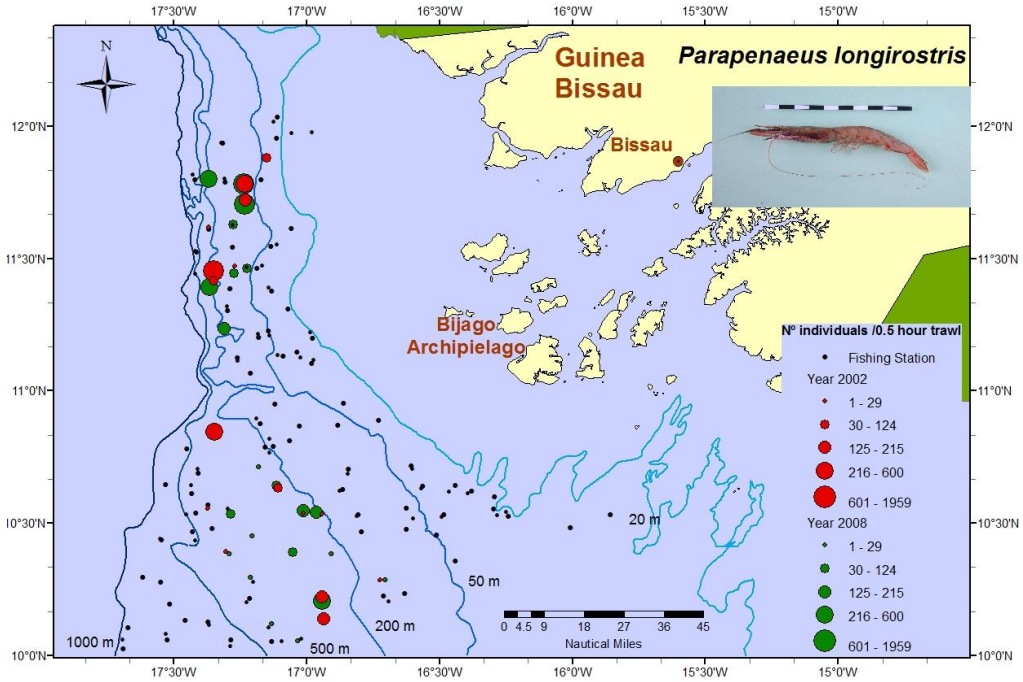


Figure 4.13.- Spatial distribution of abundance (number of individuals per ½ h trawl) of *Parapenaeus longirostris* in waters off Guinea-Bissau during the Spanish research surveys carried out in October-November 2002 and 2008 (R/V Vizconde de Eza).

In the north area, the species lives in shallower waters (Figure 4.13), while in the south area, the deep-water rose shrimps were found in deeper waters, from 200 to 400 m. In general, the maximal abundances were recorded for the depth stratum between 200 and 500 m. However, in the 2008 survey, most of the fished specimens were caught between 50 and 200 m depth, probably corresponding to the numerous recruits detected in that year, that tend to concentrate in shallower waters.

Reproduction/Recruitment areas and seasons

The reproductive behaviour of the deep-water rose shrimp shows a clear depth segregation of the females according to their maturity stage. Most of the mature females sampled in the 2008 survey were caught in the 200-500 m depth stratum. Males, much more precocious, were mature in their entire depth range (García-Isarch *et al*., 2010). The minimal size of mature females was 21 mm CL. However, it was impossible to attempt the calculation of a first maturity size (CL) due to the low proportion of mature females found. Therefore, the sampling period (October-November) was not covering the reproductive period of the species.

The analysis of the population structure of the deep-water rose shrimp during the 2008 survey showed that the north zone may constitute a recruitment area for the species in October-November (García-Isarch *et al*., 2009 and 2010). Furthermore, the high recruitment detected in the 2008 survey suggests the existence of a recruitment peak in this area in October-November, when the survey was carried out.

Sex-ratio obtained in the 2008 survey was 0.5:1 (M:F). Thus, females were twice as abundant as males in the total population. However, bathymetrical differences were found in sex-ratio. In shallow waters (50-200 m), the sex-ratio was 0.8:1(M:F), while the male proportion highly decreased in deeper waters (sex ratio 0.4:1 in 200-500 m depths). This, together with the length frequency analysis (García-Isarch e*t al*., 2009), confirm the existence of bathymetrical population movements between the shallow waters preferred by the smaller males and females (mainly recruits) and deeper waters where inhabit the largest individuals (mostly females).

Southern rose shrimp *Farfantepenaeus notialis*

In addition of the general biological information on the species provided in section 2.1.1.a, some specific aspects concerning *F. notialis* in waters off Guinea-Bissau are described below. This information is mainly provided by the Spanish research surveys carried out in the Guinea-Bissau EEZ in October-November 2002 and 2008 onboard the R/V Vizconde de Eza.

Spatial distribution

Among the 14 stocks of *F. notialis* identified in the West African coast (Garcia and Lhomme, 1979; Lhomme, 1981), one single stock is considered to be found in Guinea-Bissauan waters (FAO, 2006 b). However, as the Senegalese most southern stock (Roxo-Bissagos) is very close to the northern area of Guinea-Bissau, it is probably a shared stock between these two countries. Maximum abundance of the species in Roxo-Bissagos is found at 35 m depth (Lhomme and Vendeville, 1993). In the Spanish surveys carried out in waters off Guinea-Bissau, the species was only found in the north east sector of the prospected area (north of 11º 36’ N), near the Senegalese border (Figure 4.14) and in the shallowest stratum, at depths under 44 m (García-Isarch *et al.*, 2009). However, most of the distribution area of the species was not sampled during these surveys, as they were

performed out of the 12 nautical miles zone, coinciding with the deeper distribution limit of the species.

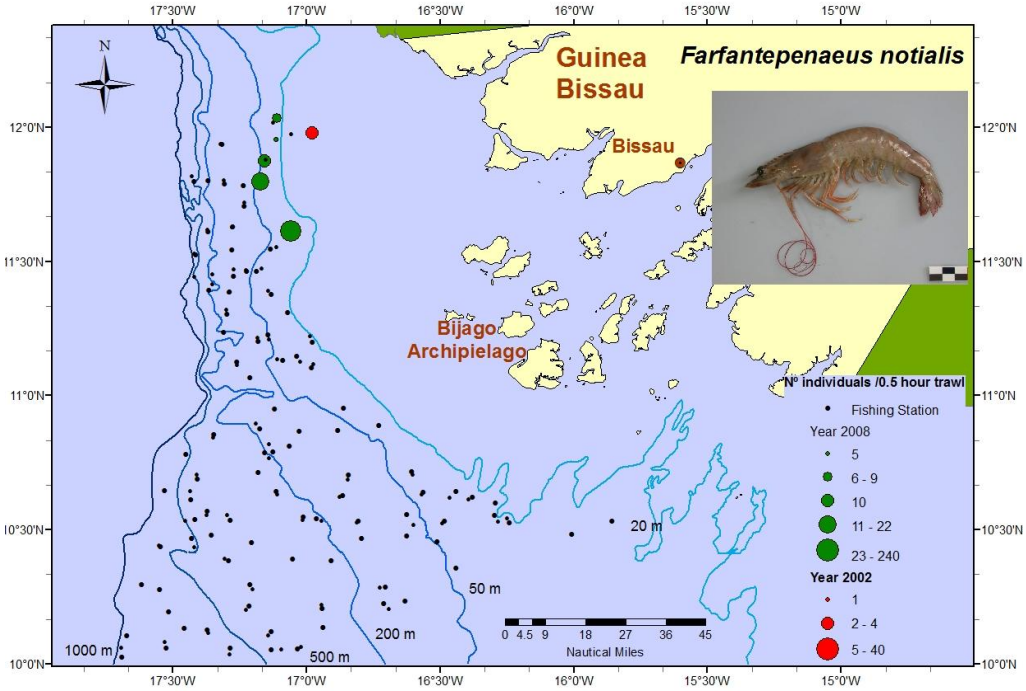


Figure 4.14.- Spatial distribution of abundance (number of individuals per ½ h trawl) of *Farfantepenaeus notialis* in waters off Guinea-Bissau during the Spanish research surveys carried out in October-November 2002 and 2008 (R/V Vizconde de Eza).

Reproduction/Recruitment areas and seasons

Life cycles of the different Senegalese stocks of *F. notialis* were studied by Lhomme and Garcia (1984). Among them, the Roxo-Bissagos stock is of special interest, due to the possibility of being part of the same Guinea-Bissauan stock.

For the Roxo-Bissagos stock, the age at which juveniles migrate offshore has seasonal variations, from 2-3 months during the rainy season to 4-5 months in the dry season. The recruitment occurs one month later in the rainy season and about 2.5 months later in the dry season (Lhomme and Garcia, 1984).

Studies carried out in neighbouring coastal countries have evidenced a continuous reproduction period throughout the year, although with a typical two seasonal peaks pattern, variable in time, depending on the area (Lhomme and Garcia, 1984, Lhomme and Vandeville, 1993). The spawning season for the Roxo-Bissagos stock is also extended over the year, with some maximal peaks, very irregular both in their timing and intensity (Lhomme and Garcia, 1984). In general, significant peaks are detected during the warm season (August), during the transition period (November) but also in the hydrological cold season (January). Thus, a not well marked but relatively more intense seasonal cycle seems to occur from August to January. Females' first maturity length of the Roxo-Bissagos stock was estimated in 28-29 mm CL (Lhomme, 1981; Lhomme and Garcia, 1984) (see Table 4.III). First maturity mean age was 4.3 months, based on the individuals of the first annual peak (Lhomme, 1981).

Minimal sizes of apparition of mature individuals were 9 mm CL (for males) and 32 mm CL (for females) in the Spanish surveys carried out in Guinea-Bissauan waters. However, this information was not conclusive due to the low percentages of mature females found (García-Isarch *et al.*, 2009).

There is a differential growth by sex, with females reaching higher sizes than males. In the surveys, the population bigger than 31 mm CL were females, which reached a maximum CL of 45 mm. However, most of the individuals were small-sized, with modes of 14 mm (males) and 16 mm (females) in 2008 (García-Isarch *et al*., 2009). This suggests a recruitment peak of *F. notialis* in its area of occurrence during October-November, when the survey was carried out.

Females were slightly more numerous than males, with an estimated sex-ratio of 0.9:1 (M:F) in the 2008 survey (García-Isarch *et al*., 2009). This higher proportion of females at sea was also detected in Côte d'Ivoire, where, on the other hand, proportions are the same into the estuarine areas (Garcia, 1977).

Striped Red Shrimp *Aristeus varidens*

The biology of this species in its distribution area is greatly unknown. Most of the biological information of Guinea-Bissau is provided by the Spanish surveys carried out in the period October-November of 2002 and 2008 onboard the R/V Vizconde de Eza.

Spatial distribution

The striped red shrimp *A. varidens* is a deep sea species found in West African coasts, from 24º N (Western Sahara) to 18º S (Namibia). Its bathymetrical range varies between 300 and 1120 m (Crosnier and Forest, 1973), although maximal abundance occurs between 400 and 600 m.

The shallowest limit of the species in Guinea-Bissau is around 380 m (García-Isarch *et al*., 2010). Its deepest limit could not be established due to the fact that the maximum surveyed depth was 950 m during the 2002 and 2008 Spanish research surveys. *A. varidens* was found up to this maximum depth. Maximal abundances were found in the deepest surveyed depth stratum (500-1000 m), where almost 90% of the total biomass was estimated (García-Isarch *et al*., 2009 y 2010). The species distribute along the entire coastline with a gap located in the canyon area, around 11º N (Figure 4.15).

The surveys carried out in waters off Guinea-Bissau showed a clear size segregation pattern according to depth for *A. varidens*. But this pattern was only observable for females, as males do not show clear bathymetrical differences in size. However, the females size increases with depth, so the biggest females are found in the deepest stratum (500-1000 m). In the 2008 survey, while the mode size of males was 30 mm CL in both strata where they were found, the mode of the females increased from 42 mm (200-500 m depth stratum) to 46 mm (500-1000 m depth stratum). Females CL ranged between 20 and 50 mm in the first stratum and between 24 and 60 mm in the deepest one. Thus, the size increase with depth was only observed for females, as is also described for *A. varidens* in Angola (Sobrino and de Cárdenas, 1996b).

Reproduction/Recruitment areas and seasons

The displacement of the biggest females to deeper waters may be associated with the reproduction processes, as the highest proportions of spawning females were detected in waters deeper than 500 m in Guinea-Bissau (García-Isarch *at al*., 2009 and 2010) and between 600-700 m depth in Angolan waters (Sobrino and de Cárdenas, 1996b).

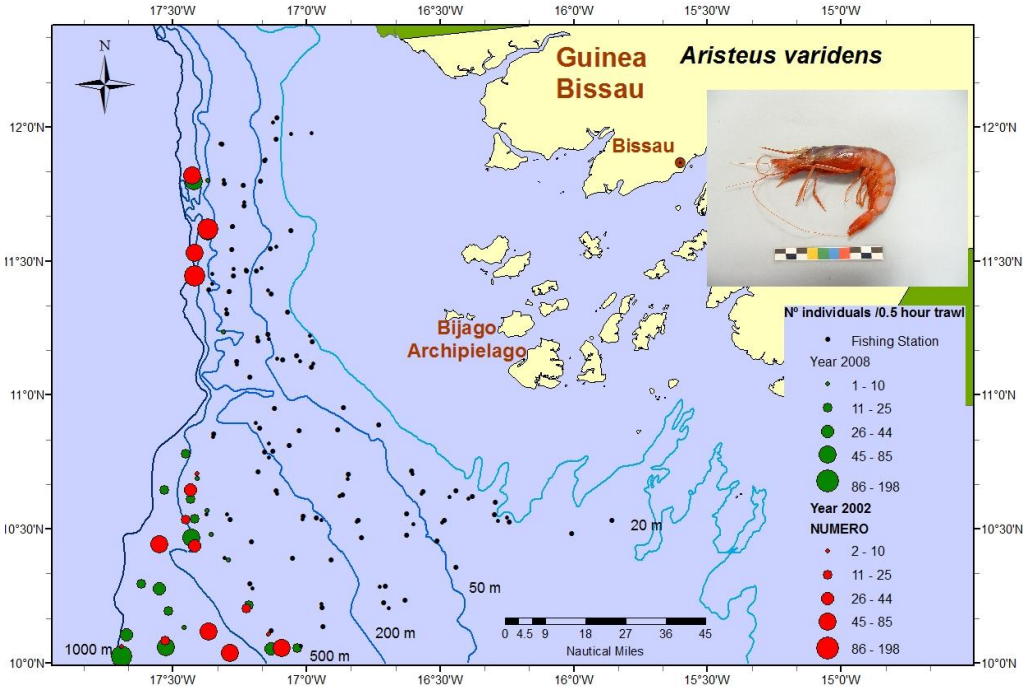


Figure 4.15.- Spatial distribution of abundance (number of individuals per ½ h trawl) of *Aristeus varidens* in waters off Guinea-Bissau during the Spanish research surveys carried out in October-November 2002 and 2008 (R/V Vizconde de Eza).

In spite of the fact that both Spanish surveys in Guinea-Bissau were performed during the same period of the year (October-November), the proportion of mature females found in 2002 (41%) considerably differs from the one recorded in 2008 (75%). Furthermore, in 2008, 92% of females were fecundated. These proportions of 2008 indicated that the survey was carried out just into the reproduction period of *A. varidens* that year. The variations in the reproduction period found from one year to another may be attributed to differences in the environmental conditions.

Spawning occurs in deep waters (García-Isarch *et al.*, 2010), as 93% of mature females were fished in the deepest stratum (500-1000 m), while only 7% of mature females were found between 200 and 500 m). In the Spanish surveys performed in Angola, the biggest proportions of mature females were located at 600-700 m depth (Sobrino and de Cárdenas, 1996b) and 600-800 m (Diedhiou *et al*., 2004). Therefore, there is a clear bathymetrical segregation of females depending on their maturity stage, not found in males because almost the entire male population was mature.

As it has been described for the other two shrimp species, the maturation of males occurs very early and at very small sizes, and mature males are found all year round. First maturity size of males has been estimated in 17.3 mm CL. For females, fist maturity size was estimated in 31.7 mm CL and first fecundity size (based on the percentage of inseminated females) was 25.6 mm CL (García-Isarch *et al.*, 2010).

Clear growth differences are appreciated between sexes, as females reach greater sizes than males. Maximal CLs registered in the Spanish surveys were 74 mm (females) and 39 mm (males), with modes of 45-46 mm and 28-29 mm, respectively. At sizes bigger than 33 mm CL, almost the whole population was composed of females.

During the surveys, the number of females was higher than those of males, with an estimated sex-ratio of 0.7:1 (M:F). However, there are important bathymetric variations of the sex-ratio, due to the movement of the females to deeper waters. Thus, the males are almost three times more numerous than females in the shallowest stratum (200-500 m), with a sex ratio of 2.9:1 (M:F). However, this proportion radically changes in the deepest stratum, where the females are twice as numerous as males, with a sex-ratio of 0.5:1 (M:F). This, together with the analysis of length frequencies showed a clear bathymetric segregation pattern by sex and size: males (small-sized) live in shallower depths, while females (big-sized) move to the deepest waters of their bathymetric range (García-Isarch, 2009 and 2010).

4.2.1.b.- Information on seasonal and spatial distribution of the shrimper fleets operating in Mauritania

To know the fishery pattern of the shrimper fleet in Guinea-Bissau, available information on catch and effort trends over the period 2007-2010 (current fishing Agreement), as well as the spatial distribution of the fishing effort of the Spanish fleet (the most important in the fishing ground) are analysed.

Seasonality

The Spanish shrimper fleet operates all the year round in waters off Guinea-Bissau. However, the effort deployed greatly depends on the closed seasons imposed in Mauritania, as most of the vessels are sharing fishing licences between both fishing grounds. Therefore, 2 peaks of major activity occur in May and October, coincident with the two closed seasons in Mauritania, when many Spanish shrimpers that mainly operate in Mauritania, move to Guinea-Bissau. The reason explaining the concentration of these 2 peaks in 2 months, instead of in 4 months (as will be logical because the Mauritanian fishery is closed during 4 months) is related to the inter-annual variations of the timing of the closed season, already explained (see section 4.1.1.b). From 2008 to 2010, only May and November remained unchanged as closed months in Mauritania.

Figure 4.16.- Monthly mean effort of the Spanish shrimper fleet in Guinea-Bissau (2007-2010).

P. longirostris is the target species of the Spanish shrimper fleet in Guinea-Bissau and is almost totally caught by the EU (mainly Spanish) fleet. Its greatest yields were obtained from March to May (Figure 4.17), coinciding with a period of major effort deployed. A decreasing of the CPUE

values is observed from June to September, when the yield is minimal. After an increase in October, when the effort newly peaks, the decreasing trend of the CPUE continues until the end of the year.

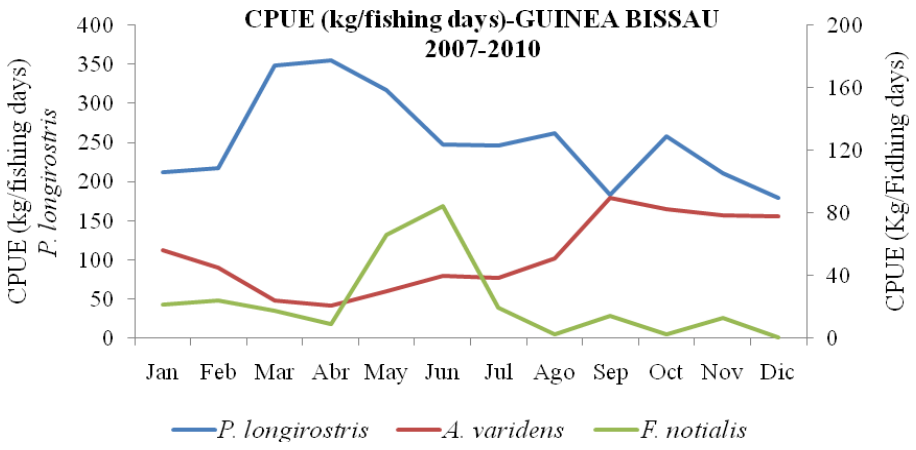


Figure 4.17.- Monthly mean CPUE (kg/fishing days) of *Parapenaeus longirostris, Aristeus varidens and Farfantepenaeus notialis* of the Spanish shrimper fleet in Guinea-Bissau during the period 2007-2010.

The highest yields of *F. notialis* occurred in May-June, being maintained at quite low levels for the rest of the year. This peak is more or less coincident with a maximum effort deployed during those months. However, maximal yields from other foreign fleets (mainly Chinese) are obtained during the summer months (June-August) and in January. This vessels operated in much more coastal (shallower) waters, and although they fish with shrimps licences, their catches are more opportunistic, with only 2% of crustaceans, and the highest part (85%) corresponding to finfish (see Table II in the Introduction) The differences in the fishing strategies followed by the EU fleet (which specifically targets shrimps), and the non-EU fleet, mainly Chinese (opportunistic), together with the general lack of knowledge about the biology of the species in the area, makes difficult to get to any conclusion.

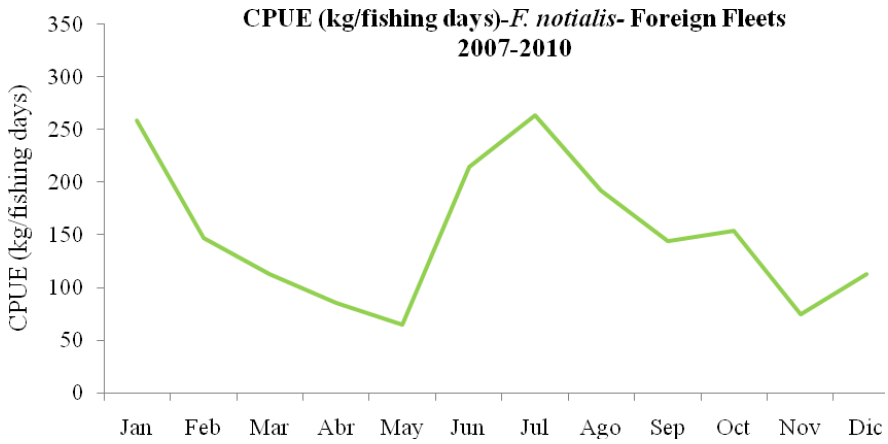


Figure 4.18.- Monthly mean CPUE of *Farfantepenaeus notialis* caught by non-EU foreign fleets (mainly Chinese), in Guinea-Bissau over the period 2007-2010.

The striped red shrimp *A. varidens* is caught only by the Spanish shrimper fleet in Guinea-Bissauan fishing grounds. A seasonal pattern can be observed, as higher yields are achieved during the last four months of the year, from September to November (Figure 4.17).

Spatial patterns

Spatial distribution of the Spanish shrimper fleet operating in waters off Guinea-Bissau is analysed on the basis of the effort deployed by the vessels (in number of hauls) during 2008 and 2009. Figures 4.19, 4.20 and 4.21 show the spatial distribution of the fishing effort exerted by the Spanish shrimpers targeting *P. longirostris, F. notialis* and *A. varidens* in 2008 and 2009.

The fishery of the deep-water rose shrimp *P. longirostris* (Figure 4.19) is mainly carried out at depths between 100 and 500 m. Outriggers ("tangon" type) are used as fishing gear. The same north and south zones identified from the data obtained in the Spanish scientific surveys are also clearly inferred from the fishery information. The gap between these two zones is supposed to be due to the presence of a large submarine canyon, located around 11º N. The spatial strategy followed by the fleet is practically the same in the two analysed years, although more effort was deployed in deeper waters in 2008.

The Southern rose shrimp *F. notialis* is a coastal species, caught at depths up to 100 m (Figure 4.20). In fact, most of the fishing operations targeting this species were carried out below 50 m. The species is mainly caught in the north zone, especially in areas under the influence of the Cacheu River mouth (around 12º 10' N) and the Geba River mouth (around 11º 50' N). As it was explained before, *F. notialis* populations are associated with estuarine areas and river mouths, where they develop during their juvenile stages. It is difficult to know if the populations of Cacheu and Geba rivers constitute different stocks, as there must be a certain mix among them. Furthermore, this stock could be the same than the stock Roxo-Bissagos, described for Senegalese waters (Lhomme and Garcia, 1984). The fishing operations targeting *F. notialis* in the south zone (south of 11º N) are very scarce and quite scattered. Compared to the previous year, a greater activity was observed in the north zone during 2009. The gear used by Spanish vessels to fish *F. notialis* is the same outrigger used for *P. longirostris*.

Fishing operations targeting the red striped shrimp *A. varidens* mainly occurs over 500 m depth, where the species abundance is higher. They are mainly fished at night, when the yields of the deep-water rose shrimps greatly decrease. Similar situation is found in other neighbouring areas (Mauritania and Senegal). The outriggers used to catch *P. longirostris* and *F. notialis* are switched to the classic bottom otter trawl with trawl doors ("baka" type). The same north and south zones described from the surveys, with a gap around 11º N, are inferred from the fishery information. While most hauls were carried out in the south zone during 2008, the fleet targeting this species was especially concentrated in the north zone in 2009 (Figure 4.21).

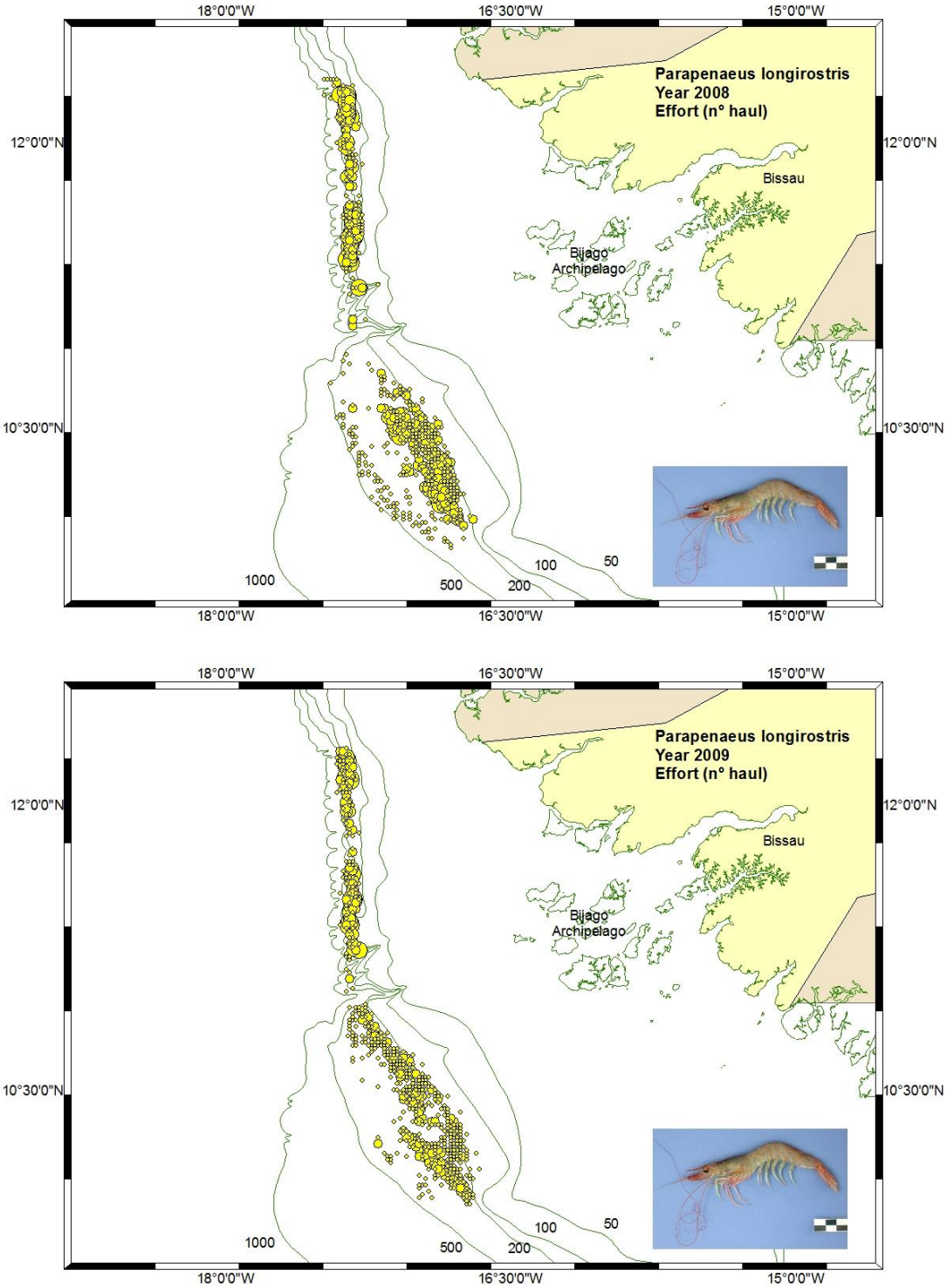


Figure 4.19.- Spatial distribution of effort (No. of hauls) exerted by the Spanish shrimper fleet targeting *Parapenaeus longirostris* in Guinea-Bissau. Years 2008 (up) and 2009 (down).

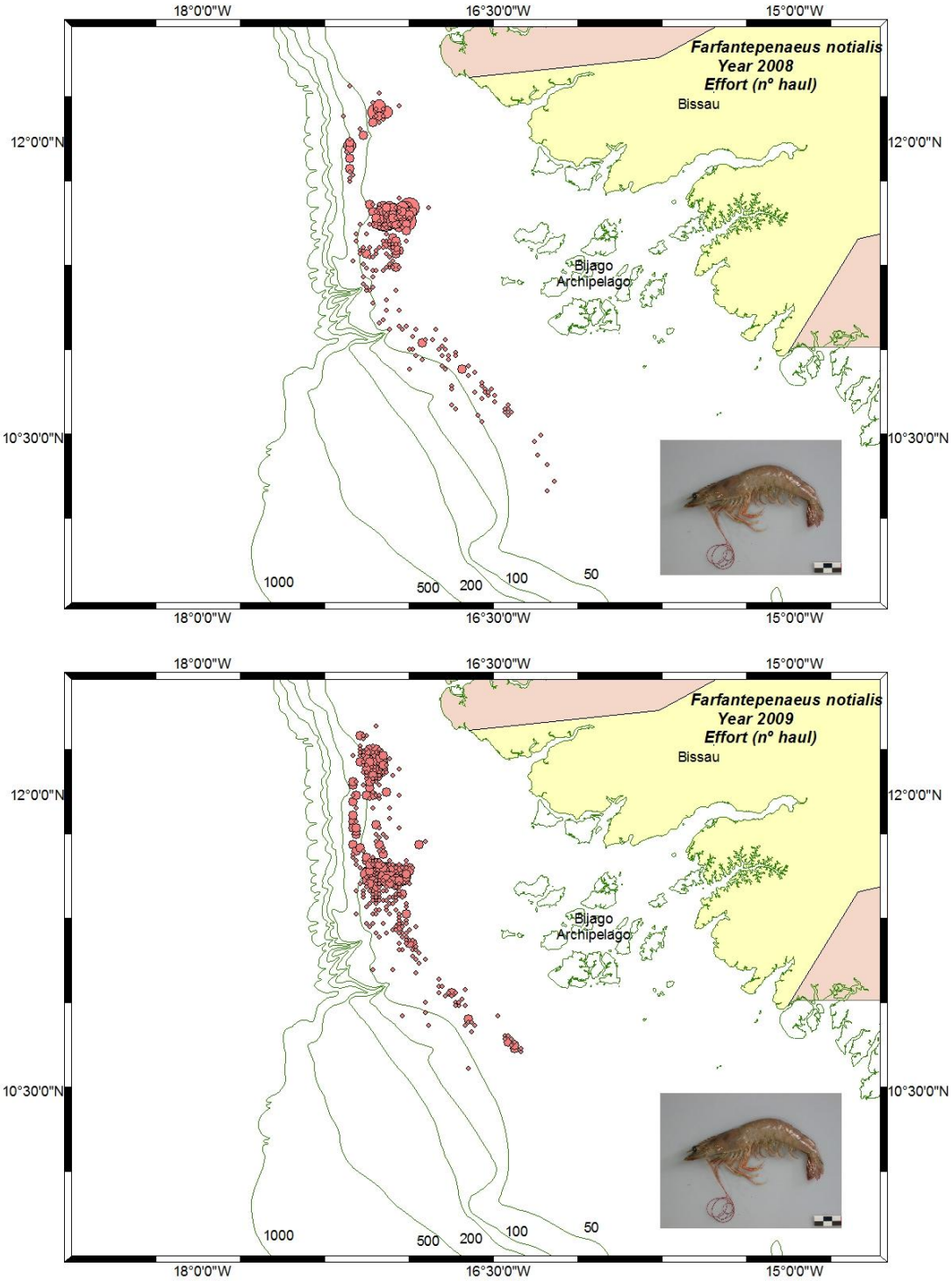


Figure 4.20.- Spatial distribution of effort (No. of hauls) exerted by the Spanish shrimper fleet targeting *Farfantepenaeus notialis* in Guinea-Bissau. Years 2008 (up) and 2009 (down).

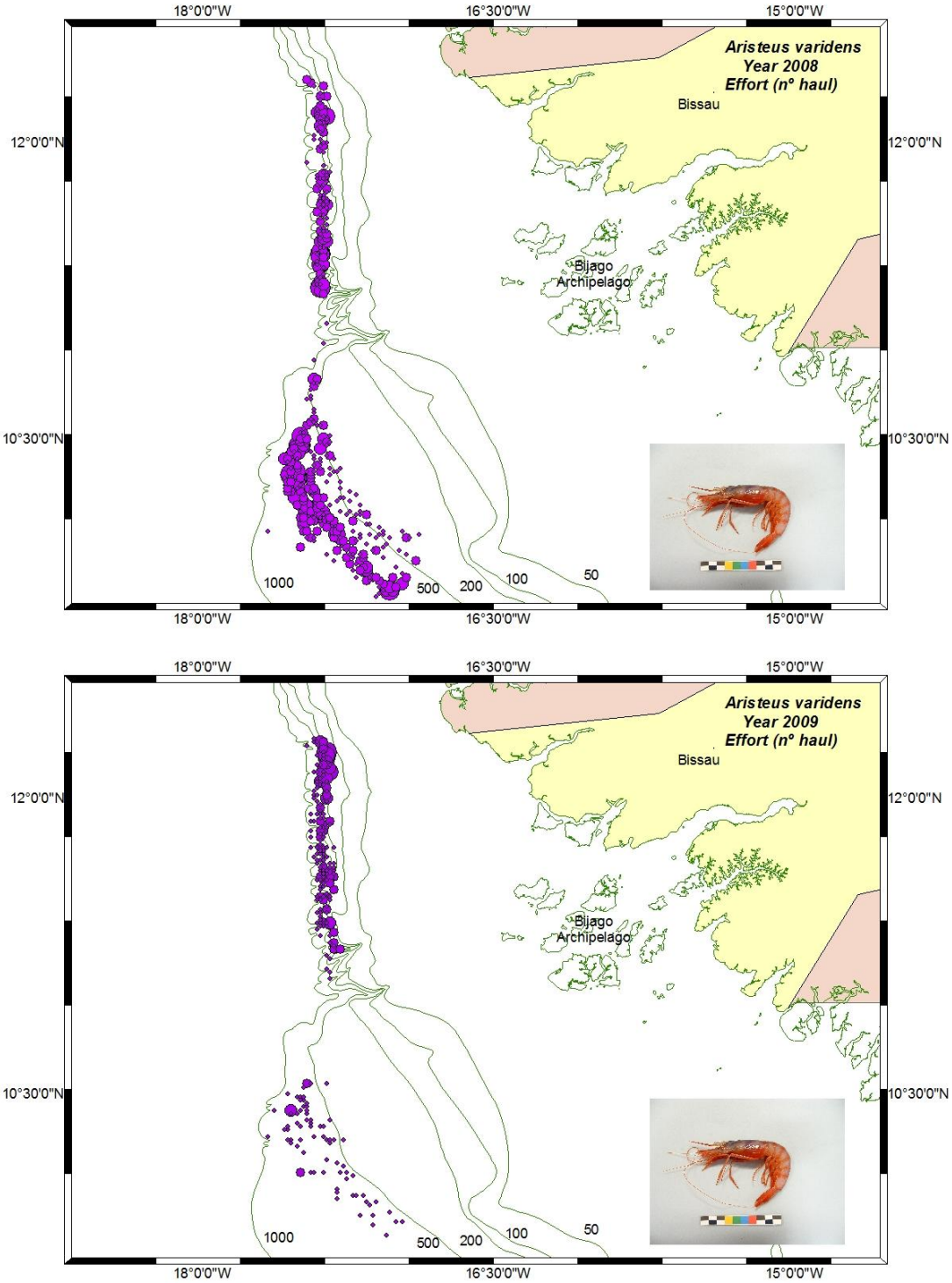


Figure 4.21.- Spatial distribution of effort (No. of hauls) exerted by the Spanish shrimper fleet targeting *Aristeus varidens* in Guinea-Bissau. Years 2008 (up) and 2009 (down).

4.2.2.- CEPHALOPOD FISHERY

4.2.2.a- Biological information on the target species

As for crustacean fishery, the available general biological information of the target species of the cephalopod fleets in waters off Guinea-Bissau was described in the section 4.1.2.a. Only aspects specifically concerning the biology of these species in this fishing ground are explained below, mostly based on the analysis of the information provided by the Spanish surveys carried out in Guinea-Bissauan waters in 2002 and 2008.

It is worth remembering that the southern distribution limit of *L. vulgaris* is located in Senegalese waters. Therefore, the main species targeted by the cephalopod fleets in Guinea Bissau are the octopus *O. vulgaris* and the cuttlefish (*Sepia* spp. and *S. hierredda* [the most abundant]).

Octopus *Octopus vulgaris*

Spatial distribution

Although the species distribution covers most of the Guinea-Bissauan coastline, *O. vulgaris* is mainly concentrated in the north zone (north of 11º N), where the species is more abundant (Figure 4.22). In the south zone, its distribution is more scattered, with the higher abundances occurring at depths between 50 and 200 m, but always lower than in the north zone (García-Isarch *et al*., 2009). In fact, the species was not found in the south zone in the 2002 survey.

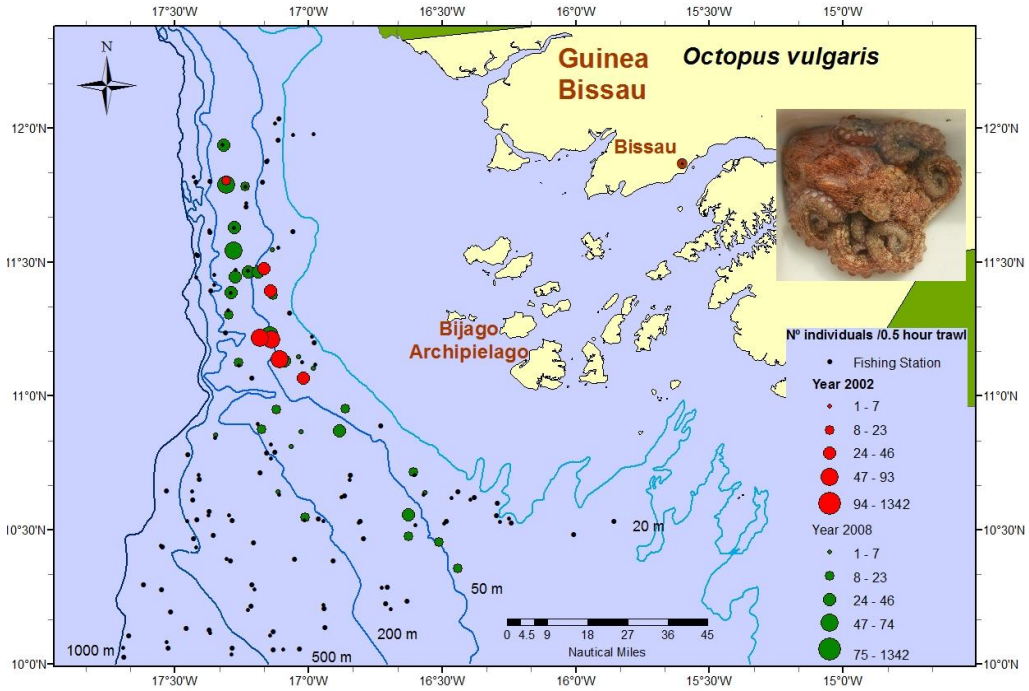


Figure 4.22.- Spatial distribution of abundance (number of individuals per ½ h trawl) of *Octopus vulgaris* in waters off Guinea-Bissau during the Spanish research surveys carried out in October-November 2002 and 2008 (R/V Vizconde de Eza).

The general bathymetric range of the octopus in Guinea-Bissau ranged between 24 and 300 m depth (García-Isarch *et al*., 2009). Most of the biomass estimated during the surveys corresponded to the 50-200 m stratum. However, bigger individuals were found below 50 m depth (García-Isarch *et al*.,2009). In 2002, the octopus population was scarce and very concentrated in shallow waters in front of the Bissagos Archipelago, between 11º N and 11º 30' N (Figure 4.22).

Reproduction/Recruitment areas and seasons

There is no information about the reproductive biology of *O. vulgaris* in waters off Guinea-Bissau. The period when the Spanish surveys were carried out (October-November) probably covered part of the octopus reproduction period, but not a spawning peak, as the percentages of mature individuals were not especially high (56% of males and 40% of females in 2008). Mature specimens were preferably located in the 50-200 m depth stratum. If spawning peaks were more or less coincident with those occurring in other areas of the North West African coast (Idrissi *et al*., 2006; Hatanaka, 1979c), the survey period may correspond to the end of the second peak detected in those areas (see section 4.2.1.a).

First maturity sizes estimated for octopus in Guinea-Bissau were 7.3-8.3 cm DML (males) and 10.8-12.7 cm DML (females). During 2008, first maturity sizes could be estimated also in total weight, corresponding to 288 g (males) and 621 g (females).

Maximal sampled sizes were 21.5 cm DML (3000 g) and 19 cm DML (960 g) for males and females, respectively (García-Isarch *et al*., 2009). In general, no important differences were found between the percentage of sexes in the population, with sex-ratios of 1.2:1 (M:F) (2002 survey) and 1:1 (M:F) (2008 survey), respectively. However, the sex proportions varied according to depth, with males dominating in shallowest waters (sex-ratio of 1.2:1 below 50 m depth) and females dominating in deeper waters of 50-200 m depth (sex-ratio of 0.9:1) (García-Isarch *et al.*, 2009). In general, the population is quite mixed until reaching a certain size, from which most of the individuals are males. However, the DML from which 50% of the population are males differed from one survey to another, being 17.5 cm in 2002 and 14 cm (much smaller) in 2008.

The analysis of the population structure during the surveys showed that it was mostly composed of small-sized individuals in 2002, a fact suggesting the coincidence of a recruitment season with the period of the survey (October-November) and the existence of a recruitment area in shallow waters between 11º N and 11º 30' N, where the population was concentrated that year.

Cuttlefish *Sepia* spp.

Spatial distribution

Sepia hierredda is the most abundant species of this Genus in waters off Guinea Bissau, although it is found mixed in the catch with *S. officinalis*. In Guinea-Bissau, the bathymetric distribution of *S. hierredda* ranges between 20 and 100 m depth, although the species may be even found in shallower waters, not prospected during the Spanish survey. Most of the biomass was estimated to be located below 50 m depth. In general, biomass, abundance and individuals mean size decrease with depth (García-Isarch *et al*, 2009).

The species is distributed along all the coast of Guinea-Bissau (Figure 4.23), with certain abundance variations depending on the zone. In general, the greatest abundances are located in the south east area, especially in shallow waters below 50 m and in latitudes around 10º 30' N. In the north zone

(north of 11º N), the abundances were lower but the species was distributed in deeper waters, with some individuals located at depths up to 100 m. The different type of bottoms in the north and south area (Amorim *et al*., 2002) may be related to the geographical differences in the species distribution.

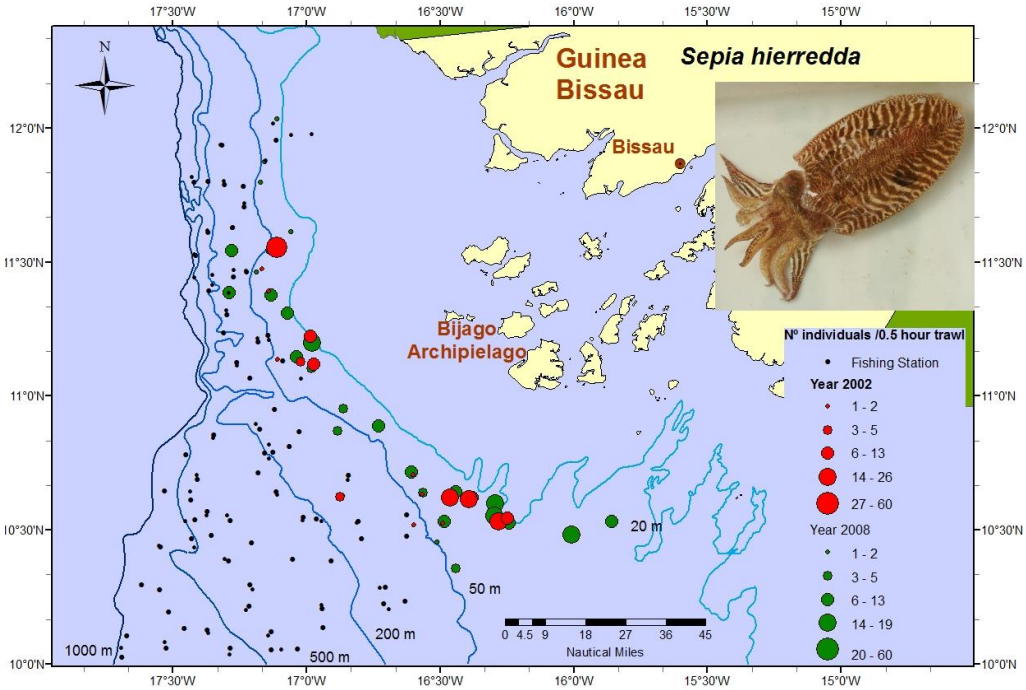


Figure 4.23.- Spatial distribution of abundance (No. of individuals per ½ h trawl) of *Sepia hierredda* in waters off Guinea-Bissau during the Spanish research surveys carried out in October-November 2002 and 2008 (R/V Vizconde de Eza).

Reproduction/Recruitment areas and seasons

There is a general lack of knowledge on the biology of cuttlefish in Guinea-Bissau. The IEO has carried out biological samplings of *Sepia* spp. specimens obtained from the Spanish cephalopod freezer trawlers operating in Guinea-Bissau in 2009 and 2010. However, the continual movements of this fleet from Guinea-Bissau to Mauritania greatly hinder the obtaining of samples throughout a whole annual cycle. The cephalopod freezer trawlers are mainly operating in Guinea-Bissauan fishing grounds during the Mauritanian closed seasons (May-June and October-November [in 2009], and May-June and September-October [in 2010]). Thus, the lack of monthly samples of every commercial category can significantly bias the sampling scheme and must be considered when interpreting the obtained results.

The analysis of these sampling data indicated the presence of mature females in all the sampled months, which is in agreement with the information from other West African coastal areas, where a reproduction period throughout the year has been described (Hatanaka, 1979b; Bakhaykho, 1983; Fernández-Núñez *et al.*, 1994). Furthermore, we suspect the existence of two spawning peaks in April and November 2009, more or less coincident with the two main seasonal spawning peaks described for the African Atlantic coast between the Western Sahara and Senegal: one in spring and a second minor spawning peak in autumn (Hatanaka, 1979b, Bakhaykho, 1983; Fernández-Núñez *et al*., 1994). Unfortunately, we were hampered by the lack of monthly samples and we have been

unable to confirm the hypothesis of two spawning peaks also existing for cuttlefish in waters off Guinea-Bissau.

The percentages of mature individuals estimated from the Spanish surveys carried out in 2002 and 2008 showed that *S. hierredda* was in a reproductive phase, even if a spawning peak was not identified during the survey months (October-November).

Table 4.V shows first maturity size (DML_{50}) of cuttlefish in Guinea-Bissau, estimated from samplings carried out in the Spanish surveys and from the commercial fleet. Male first maturity DML ranges between 9.4 and 13.7 cm. As it is common for this species, females mature later and at bigger sizes, in this case ranging from 13.7 to 17.2 cm DML, depending on the year, the sampled months and the origin of the samples.

Table 4.V.– First maturity length (DML- Dorsal mantle length, in cm) of *Sepia* spp. estimated for Guinea-Bissau.

AREA SAMPLING YEAR	DML_{50} (cm)	SPECIES	REFERENCE
GUINEA BISSAU 2002 (1)	♂: 9,4	*Sepia hierredda*	García-Isarch, 2011 (*pers. comm.*)
	♀: 15,4		
GUINEA BISSAU 2008 (2)	♂: 13,7	*Sepia hierredda*	García-Isarch, 2011 *(pers. comm.)*
	♀: 17,2		
GUINEA BISSAU 2010 (3)	♂: 10,5	*Sepia* spp.	Sancho, 2011 *(pers. comm.)*
	♀: 13,7		

(1)Data from the Spanish survey of 2002

(2)Data from the Spanish survey of 2008

(3)Data from samplings of the Spanish cephalopod fleet in Guinea-Bissau (IEO).

S. hierredda individual sizes ranged between 1.5 and 47 cm DML in the Spanish surveys of 2002 and 2008. In 2008, two cohorts were identified: one of very small individuals (modal DML of 4 cm) and another of bigger individuals (modal DML of 17 cm).

The sex-ratio obtained from the samples of commercial cephalopod freezer trawlers was 0.85:1 (M:H), a very similar value to the obtained in the 2008 scientific survey, 0.9:1 (M:H). Males were more abundant than females (sex ratio 1.2:1) only in the 2002 survey. In *S. hierredda* no differences were found in sex distribution by depth.

The proportion of males and females by length range both form surveys and from the sampling of commercial cephalopod freezer trawlers show that males reach bigger sizes than females. Males account for more than 50% of the population from sizes around 20 cm DML.

4.2.2.b.- Information on seasonal and spatial distribution of the cephalopod fleets operating in Guinea-Bissau

Seasonality

The possible seasonal patterns of the cephalopod fleets in Guinea-Bissau are analysed on the basis of the fishery data from the two main fleets operating with licences for cephalopods in this fishing ground. These are the Spanish fleet (the most representative of the EU) and the Chinese fleet (the most representative of the non-EU foreign fleets).

The Spanish cephalopod fleet shows a seasonal pattern very similar to the Spanish shrimper fleet, very influenced by the closed seasons in the Mauritanian fishing ground (Figure 4.24). In the cephalopod fleet, the highest activity during the closed seasons is even more marked than for the shrimper fleet, as the permanent cephalopod fleet in Guinea-Bissau is smaller and the effort exerted during the rest of the year is quite low. Therefore, Guinea-Bissau is mainly used as an alternative fishing ground for cephalopod Spanish vessels, which mainly operate in Mauritania.

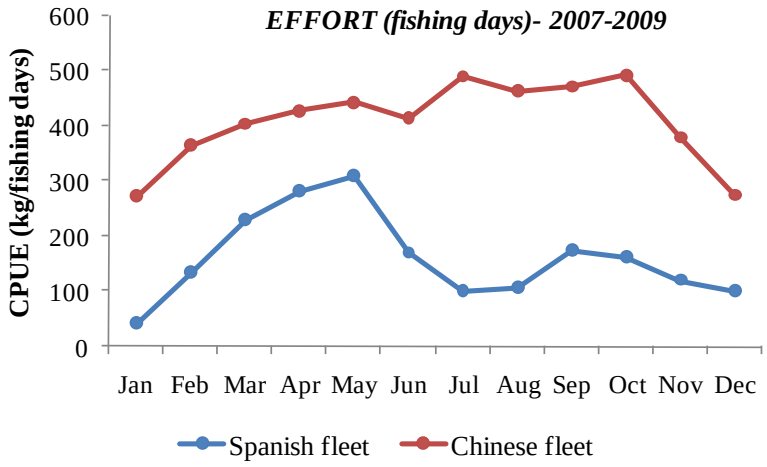


Figure 4.24.- Monthly mean effort of the Spanish and Chinese fleets fishing with licence for cephalopods in Guinea-Bissau during the period 2007-2009.

The activity of the Chinese fleet is more continuous around the year than was that of the Spanish trawlers. Although it is worth remembering that it is a very opportunistic fishery. Although they have licence for cephalopods, these species only account for 21% of the total catch, while the greater proportion (76%) of the catch are of finfish (see table IV of the Introduction). For the Spanish fleet, these proportions are 31% of cephalopods and 69% of finfish. Unfortunately, the effort estimations for both fleets, do not specifically represent the effort deployed on cephalopods.

Figure 4.25 shows the monthly average values of CPUEs over the period 2007-2009, for *O. vulgaris* (top) and *Sepia* spp. (down) for both the Spanish and the Chinese fleets operating in Guinea-Bissau.

Higher octopus yields are achieved by the Spanish fleet from February to May (peak in April) and in August-October, while Chinese CPUE peaks in January and April-May (Figure 4.25). The lack of information about the population structure and the biology of the species do not allow establishing any relationship of these abundance peaks with specific fractions of the population (i.e., recruits, spawners).

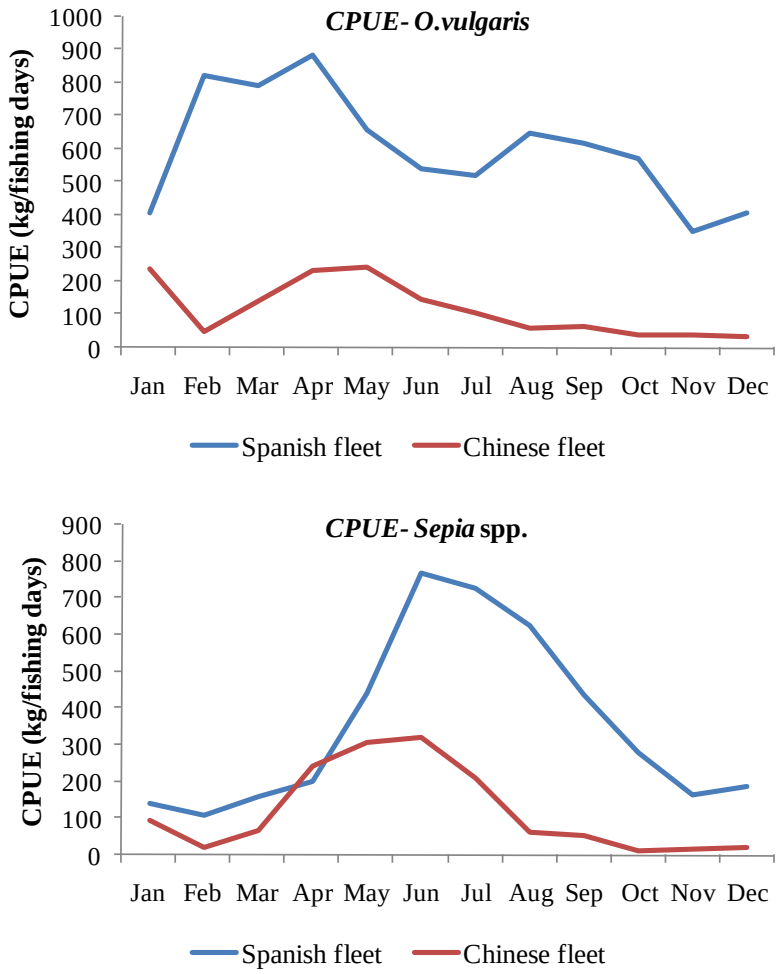


Figure 4.25.- Monthly mean CPUE (kg/fishing days) of *Octopus vulgaris* and *Sepia* spp. of the Spanish and Chinese fleets operating with licence for cephalopods in Guinea-Bissau over the period 2007-2009

Both the Spanish and the Chinese fleets obtained maximal cuttlefish yields during the spring-summer period. However, while the Chinese fleet main CPUEs were recorded from May to July, the maximal CPUEs of the Spanish fleet occurred from June to August. Therefore, although maximum yields obtained by both fleets partially overlap, the Spanish CPUEs show a certain delay compared to Chinese.

Spatial patterns

The spatial distribution of the Spanish cephalopod fleet for 2008 and 2009 is presented in Figures 4.26 and 4.27. The similar dispositions of hauls where octopus (Figure 4.26) and cuttlefish (Figure 4.27) have been captured indicate that both species are caught together, as they have very similar distributions. Most of the trawls were carried out at depths below 200 meters.

In 2008, the fleet operations were more evenly distributed between the north and the south areas (separated by latitude 11º N). However, in 2009 the effort was especially concentrated in the north area, with more scattered and lower number of hauls carried out in the South area. These differences in the fleet activity may be attributed to differences in the species abundance into these areas. The scientific surveys showed that although both species were continuously distributed along the coast, the highest abundance was found in the north (for *O. vulgaris*) and in the south (for *S. hierredda*). If the survey distribution reflects approximately the real distribution of both cephalopod species, without important variations in time, the differences found from one year to another could be attributed to a higher effort directed to catch octopus. This could be supported by the fact that the proportion of octopus among the two species increased from 59% in 2008 to 74%, in 2009.

Conclusions:

The Spanish shrimper fleet operates in waters off Guinea-Bissau following the typical pattern traditionally deployed in other areas. The deep-water rose shrimp is the main target species. It is captured throughout the year at medium-deep waters, with higher yields from March to May, partially coinciding with a higher effort due to the movement of the fleet coming from Mauritanian fishing grounds in May-June. The striped rose shrimp is a secondary species, fished at deep waters (from 500 m depth). Maximal yields of this species are obtained at the end of the year (from September to December). The Southern rose shrimp, also a secondary species for the shrimper fleet, is caught in shallow waters, up to 70-80 m and mainly in May-June. Therefore, there is a clear seasonal pattern depending on the target species, probably related to higher abundances during certain periods of the year.

While *P. longirostris* and *A. varidens* are almost exclusively fished by the Spanish fleet, the Southern rose shrimp *F. notialis* is jointly exploited by other foreign industrial fleets and by a domestic artisanal fleet that mainly operates in coastal and estuarine areas. Although the population structure of the species in Guinea-Bissau is not well known, the knowledge of the life cycle of the species allows supposing that while the artisanal fleets may target the juvenile fraction, associated to brackish waters (mangroves, river mouths, coastal lagoons), the industrial fleet may harvest the deeper waters, where most of the population are adults.

Regarding cephalopods, octopus is the main target species, while cuttlefish is caught as by-catch in the same hauls. Therefore, any management measure addressed to this fishery should be based on the protection of reproductive and recruitment stages mainly of octopus.

However, the lack of information on the population structure and on spatial distribution of the considered species throughout the year, together with other unknown biological aspects concerning its reproduction and recruitment processes, do not allow us to give any advice about possible closed seasons or closed areas to protect these shrimps and cephalopods stocks.

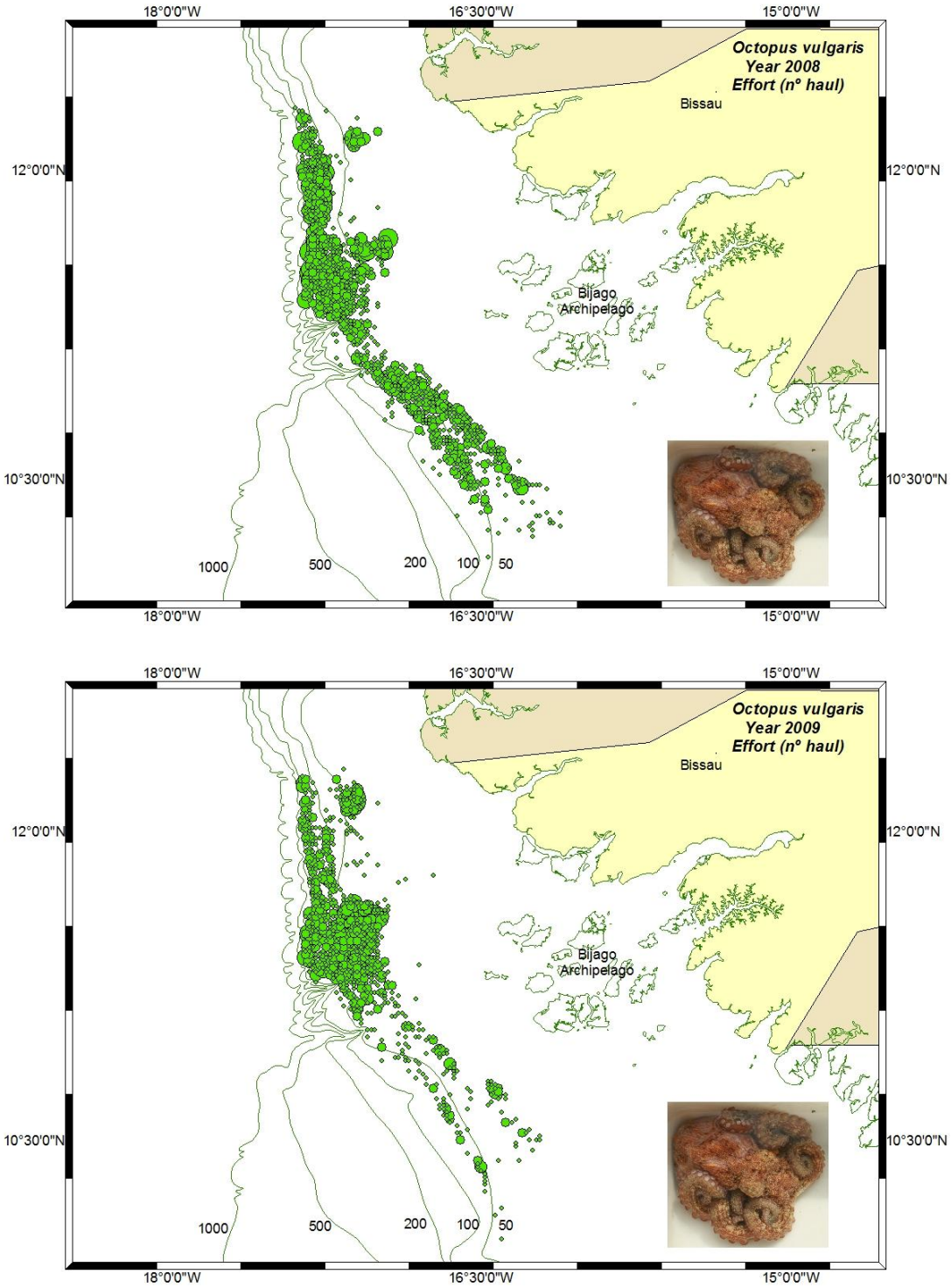


Figure 4.26.- Spatial distribution of effort (No. of hauls) exerted by the Spanish cephalopod fleet targeting *Octopus vulgaris* in Guinea-Bissau. Years 2008 (up) and 2009 (down).

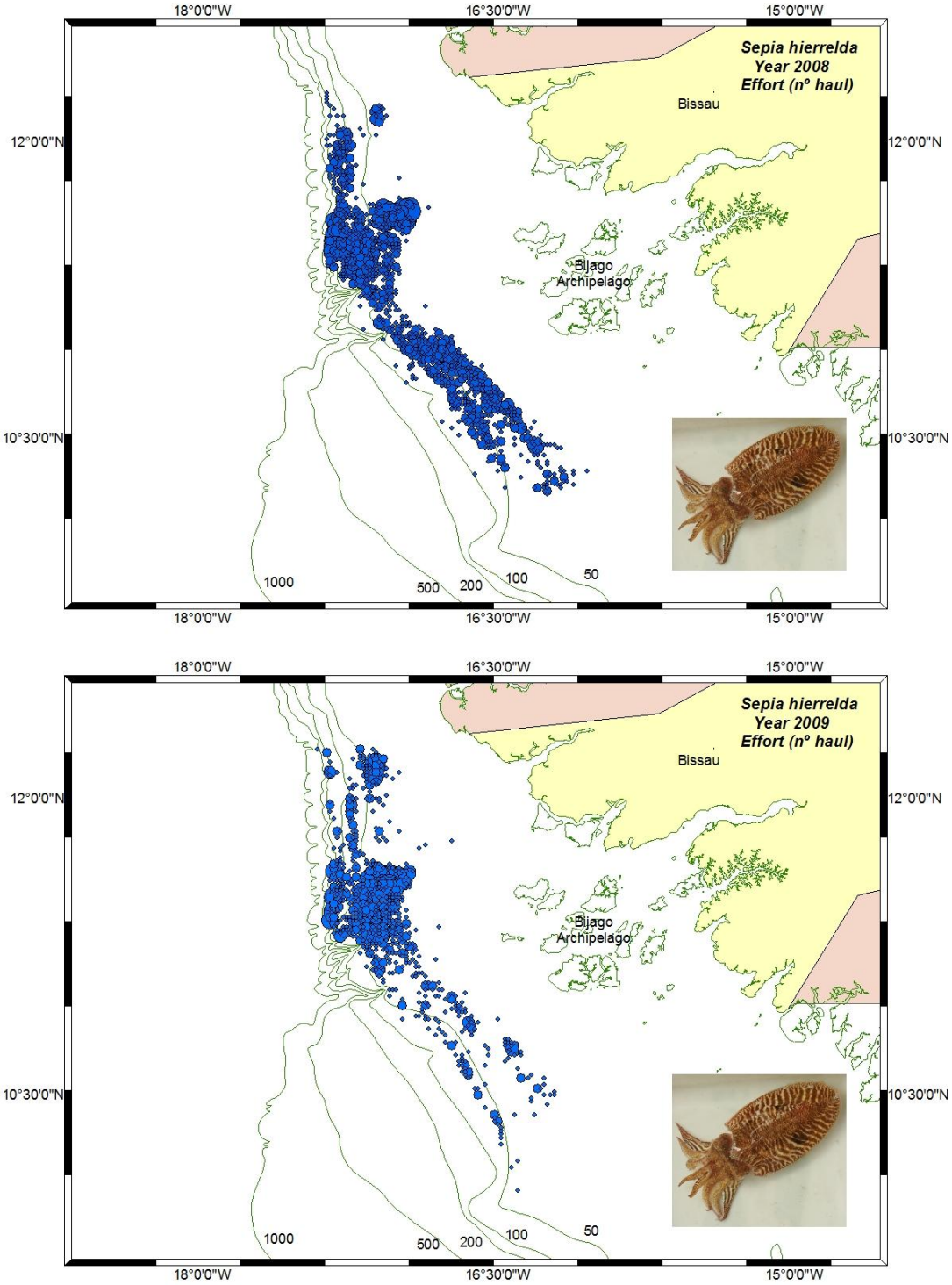


Figure 4.27.- Spatial distribution of effort (No. of hauls) exerted by the Spanish cephalopod fleet targeting *Sepia* spp. in Guinea-Bissau. Years 2008 (up) and 2009 (down).

5. IS MANAGEMENT OF THE CRUSTACEAN AND CEPHALOPOD STOCKS IN ACCORDANCE WITH THE MARINE STRATEGY FRAMEWORK DIRECTIVE (ENVIRONMENTAL PILLAR OF THE INTEGRATED MARINE POLICY) TO ACHIEVE GOOD ENVIROMENTAL STATUS BY 2020?

The first step to assess if the management of the crustacean and cephalopod stocks is in accordance with the Marine Strategy Framework Directive is the analysis of the management measures currently in force.

The management measures established for the crustacean and cephalopod fisheries are included in both National Management Plans developed by the coastal countries (when they exist) and in the regulations included in the Protocols of Fisheries Agreements.

Once the management measures of crustacean and cephalopod fisheries have been reviewed for Mauritania and Guinea-Bissau, next step will be to know if they are in accordance with the Marine Strategy Framework Directive (MSFD)[1] to achieve Good Environmental Status (GES) by 2020. **Descriptor 3** is identified as one GES descriptor covering aspects of marine environmental status impacted by fishing, as explained in Part B of the Annex of the COMMISSION DECISION (2010/477/EU) on criteria and methodological standards on GES of marine waters. Descriptor 3 is defined as: **"Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock".** Therefore, the estimations of the parameters used as criteria for assessing progress towards GES for Descriptor 3 are presented here.

Mauritania and Guinea-Bissau are considered separately because of the existence of some differences (explained below).

5.1.- MAURITANIA

5.1.1.- Mauritanian Management Measures

Mauritania has its own Management Plans for the Shrimp and Octopus Fishery. The Mauritanian Management Plan for Octopus (established in 2006) concerns the species *O. vulgaris* and all the parts involved in its fishery, but without taking into account the other exploited cephalopods (cuttlefish and squids). Management Plans concerning these species are expected to be developed by Mauritanian authorities when the knowledge of the assessment of these resources and their biology improves.

Furthermore, most of the Mauritanian management measures for the industrial shrimper and cephalopod fleets, affecting the EU vessels, are included in the current fishery agreement between the European Community and the Islamic Republic of Mauritania (OJ L 203, 31.07.2008, p. 4–59[2])

[1] DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

[2] Protocol setting out the fishing opportunities and financial contribution provided for in the Fisheries Partnership Agreement between the European Community and the Islamic Republic of Mauritania for the period 1 August 2008 to 31 July 2012. (OJ L 203, 31.07.2008, p. 4–59)

under the Fishing Category 1: "Vessels fishing for crustaceans other than spiny lobster and crab" (for crustacean fishery) and Fishing Category 5: "Cephalopods".

Current management measures for shrimps and octopus fisheries in Mauritania include: a) Management measures of access to the fisheries, and b) Technical management measures.

a) Management measures of access to the fishery

The system of fishing effort control currently in force in Mauritania is based on the use of fishing licences. Mauritanian Fishing Law No.2000-025 and its application decree No.2002-73 establish that the fishing activity is subordinate to obtaining a licence. The article 18 of this decree defines the different types of licences.

The current system of access to the fishery is based on the control of nominal effort, in terms of GRT for the industrial fleets, and in terms of vessel length overall for the artisanal fleet. The obtaining of a fishing licence is subordinate to the payment of certain fees.

For foreign fishing trawlers, the obtaining of a licence requires the existence of previous conventions or agreements among States or private agreements. This is the case of the EU vessels, which operate in the Mauritanian EEZ into the framework of Fishing Agreements between the EU and Mauritania. The EU shipowners must pay a certain fee (established in the Agreement) to obtain their fishing licences. These fees are fixed for the four-year period of validity of the Protocol

For the national artisanal fleet, the access to the resources is free, but not gratuitous. Artisanal vessels may pay certain fees, depending on their length overall. There is a Fishing Agreement between Mauritania and Senegal (signed in 2000 and renewed every year), that allows Mauritanians to charter Senegalese artisanal fishing units. This agreement is submitted to the payment of a territorial tax, as for the national artisanal vessels.

In the case of the crustacean fishery, two kinds of licences can be obtained, corresponding to fishing category "Langostinos" (for *F. notialis*) and fishing category "Gambas" (for *P. longirostris*). The distinction among these two fishing types is related to the bio-ecological differences of the two species. However, while the separation is clear for the artisanal fleet, which mainly targets *F. notialis*, it is unclear for the industrial fleet that can operate targeting *P. longirostris* (at deeper waters) or *F. notialis* (in shallower waters) depending on the seasonal abundance of these species throughout the year. This circumstance explains why, in practice, the shrimp fishery is managed by a unique type of licence "Crustaceans other than spiny lobster" (category 1), because the EU fleets actually operate only under licences for this specific category.

b) Technical management measures

The technical management measures currently implemented in the Mauritanian EEZ are of five main types: closed areas, closed seasons, minimum catch size, gear types, and by-catch limits.

b.1.- Closed areas:

Certain marine areas of the Mauritanian EEZ have been protected, under the declaration of Marine Protected Areas (MPAs):

- Banc d'Arguin National Park closed to all type of motorized fishing vessels. There is a law (Nº2000-024) that defines the conditions of the fishing activity into this maritime space that

covers near 43% of the total non-trawlable area in the North zone (between Nouadhibou and Cape Timiris).

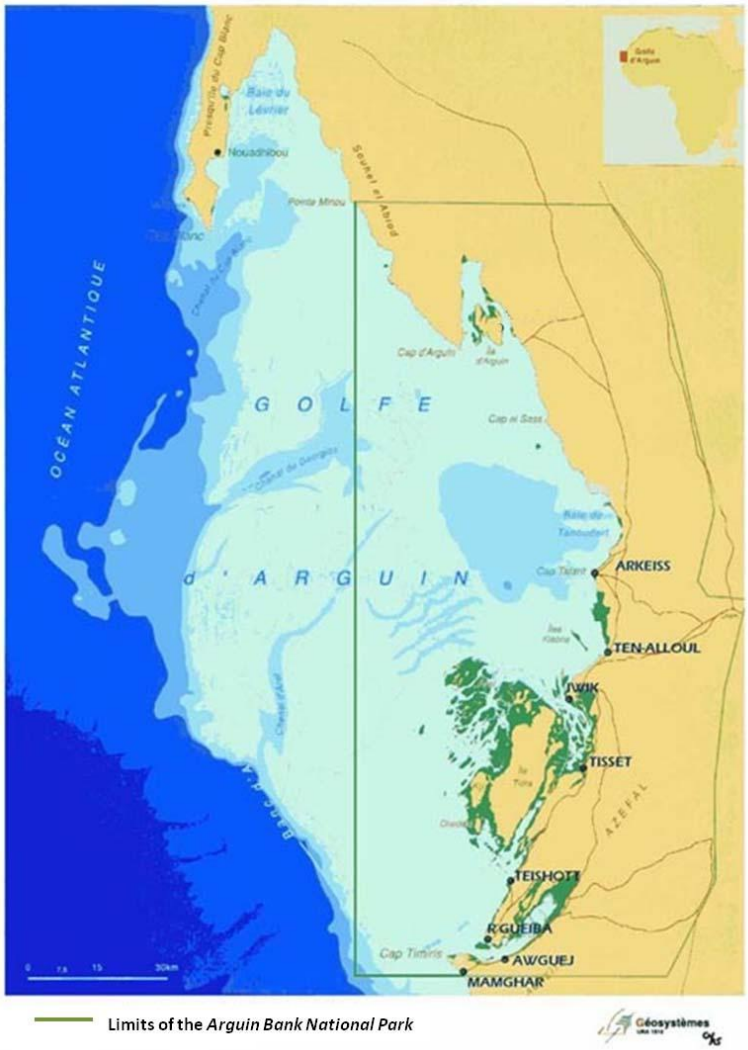


Figure 5.1.- Map of the bay showing the Banc d'Arguin National Park. Source: http://www.effectivempa.noaa.gov/sites/bancdarguin.html .

- Diawling National Parc and Chat Boul Reserve, where the fishing conditions are still in a developmental phase.
- The Satellite Reserve of Cape Blanc, closed to the fishery for the protection of the monk seal (*Monachus monachus*) population.

Apart from these MPAs, which affect all the national and international fleets, the Protocol of the Fisheries Partnership Agreement between EU and Mauritania establishes Fishing Zones, out of where the EU vessels are not allowed to fish.

The fishing area for the EU shrimper fleet is located:

- North of latitude 19° 21’ N, outside the zone marked by the following points: 20° 46,3’ N-17° 03’ W/ 20° 40’ N 17° 07,5’ W/ 20° 05,0’ N 17° 07,5’ W/ 19° 35,5’ N 16° 47,0’ W/ 19° 28,0’ N 16° 45,0’ W and 19° 21,0’ N 16° 45,0’ W.
- South of latitude 19° 21,0’ N, west of the six-mile.

The fishing area for the EU cephalopod fleet is:

- North of latitude 19° 15,6’ N, outside the zone marked by the following points: 20° 46,3’ N 17° 03,0’ W/ 20° 40,0’ N 17° 07,5’ W/ 19° 57,0’ N 17° 07,5’ W/ 19° 28,2’ N 16° 48,0’ W/ 19° 18,5’ N 16° 48,0’ W/ 19° 18,5’ N 16° 40,5’ W and 19° 15,6’ N 16° 38,0’ W.
- South of latitude 19° 15,6’ N as far as latitude 17° 50,0’ N, west of 9 miles from the 6-mile line.

From 2005 onwards, the non-trawlable extension of the reserved area for the artisanal fishery was enlarged.

b.2.- Closed seasons

The closed season established for the shrimp fishery is adjusted to the close seasons established for cephalopods. Therefore, the biological characteristics of both target species (*P. longirostris* and *F. notialis*) have not been taken into account for its implementation. In fact, these close seasons were created as a conservation measure, based on an effort reduction, aiming at protecting the octopus during the periods when the stock is mainly composed of juveniles and spawners.

The Fishery Agreement between the EU and Mauritania contemplates two close seasons, as recovering periods for both the cephalopod and the shrimp fishery. Two periods of two months each are established: May-June and September-October. The Agreement establishes that the two Parties may decide by mutual agreement within the Joint Scientific Committee to adjust, increase, or reduce the above biological recovery period. However, during 2010, the Mauritanian authorities unilaterally switched the second closed season to the months of October and November.

b.3.- Minimum catch size

This measure is aimed at minimizing the catches of immature specimens and juveniles.

Minimum catch sizes were established for the two target species of the shrimper fleet: 6 cm total length (TL) for the deep-water rose shrimp *P. longirostris* and 200 ind/kg for the Southern rose shrimp *F. notialis.* Total length is measured from the tip of the rostrum to the end of the tail.

For cephalopods, minimum catch sizes are: 500 g (eviscerated body weight, BW) for the octopus *O. vulgaris*, 13 cm mantle length (ML) for the squid *L. vulgaris* and for the cuttlefish *S. officinalis,* and 7 cm ML for the African cuttlefish *S. berthelotii.*

It is worth reminding that first maturity sizes are generally unknown for most of the Mauritanian exploited stocks. Therefore, biological studies should be aimed at establishing minimum catch sizes in agreement with the species’ biology.

b.4.- Gear types

Industrial fishery authorized gears for shrimps are bottom shrimp trawls, either outriggers (“tangon” type) or classic bottom otter trawls rigged with trawl doors (“baka” type). Bottom trawl is the authorized gear type for the cephalopod industrial fleet.

Minimum authorized mesh size for shrimpers and cephalopod trawlers are 50 mm and 70 mm, respectively. Both doubling of the cod-end and doubling of the cod-end twine forming are prohibited for the two fishing categories (crustacean and cephalopod fleets).

When preparing this report, we were informed of certain problems concerning the use of tickler chains by the EU shrimper fleet in Mauritanian waters. Tickler or jump chains are pieces of chain adjusted to the ground rope of the fishing gear in order to scare the shrimps up from the bottom and drive them more easily into the net. They have traditionally been used by most shrimper fleets worldwide for decades (Kristjonsson, 1969; Vendeville, 1985; Sainsbury, 1996). There is an inconsistency among the two sources of shrimp fishery management in Mauritania regarding the use of tickler chains. Although the Mauritanian law prohibits their use, there is a legal gap in relation to this matter in the Protocol of the Fishing Agreement between the EU and Mauritania. However, Mauritanian authorities are asking the EU shrimper vessels to fish without tickler chains, even if this matter has not been agreed by the two Parties. An experimental survey was jointly carried out in November 2011 by IEO and IMROP to assess the effects of using tickler chains in the fishery. The results should have been evaluated by the Joint Scientific Committee before implementing any measure in relation to it.

b.5.- By-catch limits

The by-catch limits are established in the Mauritanian legislation and included in the Protocol of the Fishing Agreement between the EU and Mauritania. In accordance with Mauritanian law, the percentage of by-catch shall be calculated at any time during fishing trip according to the total live weight of the catch on board.

Limitations of by-catch for shrimper vessels are: 20% fish, 15% cephalopods and 7.5 % crabs. Furthermore, catches of spiny lobster are prohibited. Cephalopod trawlers are limited to capture less than 5% of shrimps as by-catch.

5.1.2.- Descriptor 3: "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock".

For this descriptor, the three criteria for assessing progress towards GES and the indicators related to them are the following:

1) **Level of pressure of the fishing activity**

- **Primary indicator**: **Fishing mortality (F)**

The use of F as indicator is based on the fact that achieving or maintaining GES requires that F values are equal to, or lower than, F_{MSY}, the level capable of producing (MSY). This means that in mixed fisheries and where ecosystem interactions are important, long term management plans may result in exploiting some stocks less than at F_{MSY} levels in order not to prejudice the exploitation at F_{MSY}, of other species. This indicator is supposed to be estimated either from appropriate analytical assessments based on the analysis of catch at age or at length and ancillary information or from scientific judgment of F values associated to the yield-per-recruit curve (Y/R), combined with other information on the historical performance of the fishery, or on the population dynamics of similar stocks. However, although none of these assessments are currently used in the FAO/CECAF demersal assessments Working Groups, the Biomass Dynamic model applied (BIODYN), used as a standard assessment model in these working groups, enabled the estimations of both F and F_{MSY}, as well as the analysis of historical trends of both parameters (see table 5.I).

Table 5.I.- Values of F in relation to F_{MSY}, as estimated in the successive assessments of shrimps and cephalopod Mauritanian stocks, since 2004 to nowadays. Years correspond to the last year of data used in the assessments.

	F/F_{MSY}			
Stock/Last Year	**2003**	**2006**	**2008**	**2009**
P. longirostris- Mauritania	212%	71%	69%	53%
F. notialis- Mauritania	51%	116%	58 %	37%
O. vulgaris- Cape Blanc	205%	90%	135%	155%
Sepia spp.- Cape Blanc	141%	__	__	55%

For Mauritanian shrimp and cephalopod stocks, the observed trends of the index F/F_{MSY} indicate:

- ***P. longirostris*-Mauritanian stock**: F/F_{MSY} has progressively decreased, from values where the F was not able to produce the MSY (212%) to values of 53%, where the F is well under the F that would produce the MSY (F_{MSY}). In fact, the 2010 assessments (FAO, 2010; IMROP, unpublished) showed a clear recovering of the stock that was fully-exploited. At this point, it is worth reminding the great decrease of the number of shrimper vessels targeting the deep-water rose shrimps observed over recent years.
- ***F. notialis*- Mauritanian stock:** After an increase of the index F/F_{MSY} from 2003 to 2006, to levels where F exceeded those that would permit a production of MSY (F/F_{MSY} = 116%), this index highly decreased to F values capable of producing MSY in 2008 and 2009. This fact could also be attributed to the significant reduction on the number of industrial vessels targeting this species.
- ***O. vulgaris*- Cape Blanc stock**: Most of the assessments show levels of F higher than the F_{MSY}. In 2003, F value was twofold than the F_{MSY}. This index decreased over the following years, until F was under F_{MSY} in 2006 (due to an effort reduction of the industrial domestic fleet in 2006). However, a new increasing of this index was registered throughout 2010 two assessments. Currently, the F exerted to octopus would not achieve the MSY, as the stock is over-exploited.
- ***Sepia* spp.- Cape Blanc stock**: only two relatively recent assessments have been carried out on *Sepia* spp. The 2003 assessment showed an F much higher than F_{MSY}. However, the index greatly decreased in the last assessment, since F was half the value of F_{MSY}. This is in agreement with the under-exploitation described by the assessment, although it is worth reminding that this should be cautiously analysed due to several considerations about the input data and the quality of the assessment, explained in section 1.

We could think that this indicator could be useful for the management of Mauritanian resources, but taking into account certain uncertainties, such as the fact that F estimations are only based on declared catches and thus, not considering all the removals from the stock, nor including discards and undeclared catch. Efforts should be made to achieve better estimations of real catch to consider the use of F as a good indicator of the stocks' health in Mauritanian waters.

In fact, it should be noted that CECAF management recommendations to the Coastal States are based on fishing effort and therefore, on the fishing mortality F. However, CECAF decisions are not compulsory to the member countries.

2) **Reproductive capacity of the stock**

- **Primary indicator**: **Spawning Stock Biomass (SSB)-** The SSB should be estimated from appropriate analytical assessments based on the analysis of catch at age or at length and ancillary information. As explained above, no analytical methods are currently used to assess the CECAF stock status, which makes impossible the use of this indicator. Furthermore, although surveys have been carried out onboard the Spanish R/V Vizconde de Eza in the period 2008-2010 (that could allow a direct estimation of the SSB), parameters needed as length/age composition in catch, length/weight relationship and the parameters of the maturity logistic curve could not be obtained for our target species.

  However, the analysis of the information from the surveys carried out by IMROP on an annual basis could provide direct estimations of the SSB from the target species. Unfortunately, this information is not available.

- **Secondary indicators** (if analytical assessments yielding values for SSB are not available): **Biomass indices, which can be used if they can be obtained for the fraction of the population that is sexually mature.** To estimate this secondary indicator we would need knowledge on the population structure and first maturity sizes of the different stocks and, a biomass index for every exploited stock. However, none of these data are jointly available for any of the studied Mauritanian stocks. In fact, size at first maturity is only available for octopus (from the literature) but, its population structure is still unknown, as the octopus distribution range during Spanish surveys was not totally covered by the prospected area.

  As explained above, probably IMROP surveys could provide the needed information for the estimations of this indicator.

3) **Population age and size distribution**

- **Primary indicators**: **Indicators based on the relative abundance of large fish**. As the shrimp, *P. longirostris* was the only species whose distribution area was well covered during the Spanish fishing surveys in Mauritanian waters, primary indicators could be estimated only for this stock:

  i) Proportion of fish larger than the mean size of first sexual maturation- This indicator could not be estimated due to the lack of a reliable size at first maturity for this stock.
  ii) Mean maximum length across all species found in research vessel surveys.
  iii) 95% percentile of the fish length distribution observed in research vessel surveys.

Table 5.II.- Mean maximum length (Cephalothorax Length (CL) in mm) and 95% percentile of *P. longirostris* length distribution (CL in mm) estimated from research surveys carried out in Mauritanian waters in 2007, 2008, and 2009.

***P. longirostris*-Mauritania**	**2007***	**2008**	**2009**
Mean Maximum CTL	38	40.5	35.5
95% percentile of the CTL distribution	33.1	30.5	31.5

*2007- Minimum sampled depth= 400 m

The results of the primary indicators ii) and iii) are showed in Table 5.II. These indicators do not show any clear trend during the three surveys analyzed, as they oscillate in the three years. While mean maximum length increased from 2007 to 2008, it decreased again during the following year. Opposite, the 95% percentile of the CTL distribution decreased from 2007 to

2008, followed by a new increase in 2009. It is word reminding that the 2007 surveys undersampled the distribution area of *P. longirostris*, as the minimum surveyed depth was 400 m.

- **Secondary indicator**: **Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation**. As explained in section 4, sizes at first maturation are unreliable or unknown for most of the Mauritanian shrimp and cephalopod stocks. Furthermore, if this secondary indicator was available (as it is the case for octopus, although there are some inconsistencies on the size at first maturity estimation), it is not available for a time series, as it is required for a reliable analysis. This analysis, together with any other information on the biology of the species, should determine whether there is a high probability that the intrinsic genetic diversity of the stock will not be undermined.

  In spite of the scarcity of our data, Mauritanian scientists carry out two seasonal surveys in Mauritanian ZEE every year, an excellent possibility of estimating the population age and size distribution based on either direct estimations of SSB in these surveys, or by estimating the secondary indicator. In any case, efforts to improve the knowledge of the biology of the target species have to be made.

5.2.- GUINEA-BISSAU

5.2.1.- Guinea-Bissauan Management Measures

As far as we know, current management measures for shrimps and octopus fisheries in Guinea-Bissau are those included in the Fisheries Partnership Agreement between the EU and Guinea-Bissau[3], in accordance with Guinea-Bissauan law. However, there is a general lack of knowledge about the management measures controlling the other foreign (non EU) fleet operating in this fishing ground. Management measures included in the EU-Guinea-Bissau Fishing Agreement are quite limited.

Current management measures for shrimps and cephalopod fisheries in Guinea-Bissau include: a) Management measures of access to the fisheries and b) Technical management measures.

a) Management measures of access to the fishery

As in Mauritania, the Guinea-Bissauan system of fishing effort control is based on the control of nominal effort, in terms of GRT. Thus, fishing opportunities established in the current Fishing Agreement allow 4400 GRT per year for freezer fin-fish and cephalopod trawlers, and 4400 GRT per year for freezer shrimp trawlers. These vessels operate with licences for 3-months, 6-months, or annual, under the fishing categories 1: “Freezer, fin-fish, and cephalopod trawlers” and fishing category 2: “Shrimp trawlers”. The obtaining of a fishing licence for both fishing categories is subordinated to the payment of the fee for the period of validity of the licence and of the amount established in the Fishing Agreement. The access to the fishery to other foreign fleets is also based on the payment of fishing licences.

[3] Protocol setting out the fishing opportunities and financial contribution provided for in the Fisheries Partnership Agreement between the European Community and the Republic of Guinea-Bissau for the period 16 June 2007 to 15 June 2011 . (OJ L 342, 27.12.2007, p. 10-36)

b) Technical management measures

The technical management measures currently implemented in the Guinea-Bissauan EEZ are quite reduced and are limited to those included in the EU-Guinea Bissau fishing Agreement for each Category type, which are in accordance with Guinea-Bissau law. The only technical measures currently included are the following:

b.1.- Closed areas

Although there is not a closed area *sensu stricto*, the fishing zone of EU vessels in Guinea-Bissau is restricted to the area beyond 12 nautical miles from the coastline, including the Guinea-Bissau/Senegal joint management area, extending north to the azimuth 268°, for finfish freezers, cephalopod trawlers, and shrimper trawlers.

b.2.- Gear types

Standard otter trawls, outriggers, and other selective gears are authorized for both fishing categories. No methods or devices may be used to seek to obstruct the mesh of the nets or reduce their selectivity effect in any case. However, in the interests of reducing wear or damage, protective aprons of netting or other material may be attached, but only to the underside of the codend of a bottom trawl. Such aprons must be attached only to the forward and lateral edges of the codend of the trawl. Protective devices may be used for the top of the trawl, but these must consist of a single section of net of the same material as the codend, with the mesh measuring at least 300 mm when stretched out. Doubling of the codend's netting yarn, whether single or multiple is prohibited.

Minimum authorized mesh sizes are 70 mm for the freezer, fin-fish and cephalopod trawlers and 40 mm for the shrimper trawlers.

b.3.- By-catch limits

The by-catch limits established in the Protocol of the Fishing Agreement are the following:

- 9% of crustaceans for cephalopod vessels.
- 50% of finfish and cephalopods for shrimper vessels.

Neither measures related to closed seasons nor minimum catch size exists, in the absence of such provisions enforced by Guinea-Bissauan laws. However, the fishing agreements contemplate the need of scientific advice for establishing the most appropriate recovery period for the target species.

5.2.2.- Descriptor 3: "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock".

For this descriptor, the three criteria for assessing progress towards GES and the indicators related to them are the following:

1) **Level of pressure of the fishing activity**

- **Primary indicator**: **Fishing mortality (F)**

As explained in section 3.2., the Biomass Dynamic model applied (BIODYN), used as a standard model in the FAO/CECAF Working Groups allows the estimation of both F and F_{MSY}, whose relation in a temporal series should be used to estimate the level of pressure of the

fishing activities. However, no temporal series are available, as most of the shrimps and cephalopod stocks of Guinea-Bissau have never been assessed in the FAO/CECAF demersal Working Groups. The estimations of the index F/F_{MSY} provided in table 5.III correspond only to the two assessments described in previous sections (deep-water rose shrimp and octopus). The assessments were attempted including the last data series available and taking into account the restrictions explained in section 1.

Table 5.III.- Values of F in relation to F_{MSY}, estimated from the assessments of the Guinea-Bissauan stocks of *Parapenaeus longirostris* and *Octopus vulgaris*.

STOCK	F/F_{MSY} 2010
P. longirostris- Stock Guinea-Bissau	35%
O. vulgaris-Stock Guinea-Bissau	48%

Only one year is available, enabling the analysis of last year (2010) status:

- ***P. longirostris*- Stock Guinea-Bissau**: F was much lower than F_{MSY} (F/F_{MSY}= 35 %). This means that, considering the assessed situation of under-exploitation, the resource could allow an F increase. However, this assessment should be considered with precaution for the already explained reasons.
- ***O. vulgaris*- Stock Guinea-Bissau**: The index F/F_{MSY} indicated that F was half the value of F_{MSY}. As this stock was also under-exploited, F could be increased. However, as for *P. longirostris*, the results should be considered with caution.

As explained before, CECAF management recommendations to the Coastal States are based on fishing effort and therefore, on the fishing mortality (F). However, CECAF decisions are not binding for member countries. We could think that this indicator could be useful for the management of Guinea-Bissauan resources, if resources were assessed in the FAO/CECAF Working Groups. It is important to take into account certain restrictions, such as the fact that F estimations are only based on declared catches and thus, not considering all the removals from the stock, nor including discards and unreported catch, which is very high in Guinea-Bissau, due to the enormous Illegal, Unreported and Unregulated (IUU) fishing. Efforts should be made to achieve better estimations of real catch to consider the use of F as a good indicator of the stocks' health in these waters.

2) **Reproductive capacity of the stock**

- **Primary indicator**: **Spawning Stock Biomass (SSB)-** The SSB should be estimated from appropriate analytical assessments based on the analysis of catch at age or at length and ancillary information. As explained above, no analytical models are currently used to assess the status of CECAF stocks. However, octopus data for assessment purposes were obtained by direct methods during the surveys carried out onboard the Spanish R/V Vizconde de Eza in 2002 and 2208. These data were: SSB (estimated for both years from the recorded abundance indices); length composition in catch; length/weight relationship; and the parameters of the maturity logistic curve. As the fit of the maturity logistic curve was not good for the rest of the target species, the estimations of SSB could be made only for *O. vulgaris*.

Table 5.IV.- Estimations of SSB and total Biomass (in tons, t) of *Octopus vulgaris* in the Spanish surveys carried out in the Guinea-Bissauan EEZ in 2002 and 2008, and percentage of diminution of both parameters from one year to the other.

O. vulgaris GUINEA BISSAU	2002	2008	% Diminution
SSB (t)	316	196	38 %
Total Biomass (t)	1705	954	44 %

The SSB considerably decreased from 2002 to 2008, a fact consistent with the observed decrease in the total biomass. However, taking into account how dependent the abundance, in general, and the SSB, in particular is on the annual recruitment, and considering that the recruitment is highly influenced by environmental factors affecting paralarval stages, this analysis of the annual trends does not accurately depict the health status of the stock.

- **Secondary indicators** (if analytical assessments yielding values for SSB are not available): **Biomass indices, which can be used if they can be obtained for the fraction of the population that is sexually mature.** The estimation of the fraction of the population sexually mature was not possible for the shrimps and cephalopod species (other than octopus) exploited in Guinea-Bissau, due to the lack of general information about the size at first maturity of these species. Scientific surveys provided poor information on that issue, either due to the low catch of mature females or to bad fittings to the logistic maturation curves (as for *A. varidens*).

  Therefore, neither primary nor secondary indicators could be used to estimate the reproductive capacity of the stocks of *P. longirostris*, *F. notialis*, *A. varidens* and *Sepia* spp. in Guinea-Bissauan waters. Furthermore, estimations of these indicators are unlikely to be available at short-medium term, due to the backward state of the fishery and biological research in this country and the scarcity of data required for using analytical assessment methods.

3) **Population age and size distribution**

- **Primary indicators**: **Indicators based on the relative abundance of large fish**.

  i) Proportion of fish larger than the mean size of first sexual maturation.
  ii) Mean maximum length across all species found in research vessel surveys. See Table 5.V.
  iii) 95% percentile of the fish length distribution observed in research surveys. See Table 5.V.

The first indicator only could be estimated for *O. vulgaris*, which was the only species with reliable estimations of size at first maturity. Results, shown in table 5.V, evidence a general decrease of the proportion of fish larger than the mean size of first sexual maturation from 2002 to 2008, both for males and females, although much intense for males. However, this difference could be attributed to a high recruitment peak detected in the second survey, with a very low proportion of big individuals.

Table 5.V.- Proportion of *Octopus vulgaris* larger than the mean size of first maturation in the Spanish surveys carried out in waters off Guinea-Bissau in 2002 and 2008.

O. vulgaris GUINEA BISSAU	2002	2008
Male	70%	39%
Female	21%	11%

For the second indicator (mean maximum length) two groups of species were made to work separately: on one hand, the cephalopods *O. vulgaris* and *Sepia spp.* and, on the other hand, the middle-deep water shrimps *P. longirostris* and *A. varidens*. Indicators were calculated for each group, with data from the Spanish surveys carried out in 2002 and 2008, and following the methodology of Piet *et al*. (2007). The values obtained are presented in table 5.VI. They show a reduction of the mean maximum length in the shrimps group, and an increase of this indicator in the cephalopods group, both from 2002 to 2008.

The third indicator, the 95% percentile of the species length distribution observed in research vessel surveys, has been estimated independently for the four mentioned species: *P. longirostris, A. varidens, O. vulgaris* and *Sepia* spp. This indicator increased from 2002 to 2008 for both shrimp species (*P. longirostris* and *A. varidens*) and for the cuttlefish *Sepia* spp. However, a reduction of the 95% percentile of the DML distribution was appreciated for *O. vulgaris*.

- **Secondary indicator**: **Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation**. As explained above, size at first maturity data are unreliable or unknown for most of the shrimp and cephalopod stocks in Guinea-Bissauan waters, with the exception of octopus. Even if this secondary indicator was known for the remaining species, it will not be available over a period of time, as it is required for an analysis by expert judgement. This analysis, together with any other information on the biology of the species, should determine whether there is a high probability that the intrinsic genetic diversity of the stock will not be undermined.

Table 5.VI.- Mean maximum length estimated for the medium-deep water shrimps group (*Parapenaeus longirostris* and *Aristeus varidens)* and the cephalopods group (*Octopus vulgaris* and *Sepia* spp.) and 95% percentile length distribution of each species in research surveys carried out in waters off Guinea-Bissau in 2002 and 2008.

	GUINEA-BISSAU	INDICATOR	2002	2008
Medium-deep water shrimps	*P. longirostris* + *A. varidens*	Mean Maximum CTL	47.3	43.8
	P. longirostris	95% percentile of the CTL distribution	26.9	30.8
	A. varidens	95% percentile of the CTL distribution	47.1	50.5
Cephalopods	*O. vulgaris* + *Sepia* spp.	Mean Maximum DML	19.9	20.8
	O. vulgaris	95% percentile of the DML distribution	15	12.3
	Sepia spp.	95% percentile of the DML distribution	8.9	22.6

CONCLUSION:

Most of the indicators required to assess whether the populations of all commercially species exploited in Mauritania and Guinea-Bissau are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock, are difficult to estimate with the information available about each species' biology.

The first criterion to assess the health state of the stocks is the level of pressure of the fishing mortality, which is easily estimated using the primary indicator (F). The standard Biomass Dynamic model (BIODYN) currently applied in the FAO/CECAF working groups allows the estimations of F and F_{MSY}. Therefore, this indicator (F) is only available once the concerned stock assessment has

been performed. The analysis of the available time series of the index F/F_{MSY} showed improved situations for the Mauritanian stocks of *P. longirostris, F. notialis* and Cape Blanc stock of *Sepia* spp. For the Cape Blanc octopus stock, although we appreciated a reduction of the index F/F_{MSY}, F is still higher than F_{MSY}, as should be expected for an over-exploitation of this stock. As Guinea-Bissauan stocks have not been assessed, the historical series of these parameters are not available. Only recent assessments (2010) of *P. longirostris* and *O. vulgaris,* showed that F was below F_{MSY}, suggesting a healthy situation of both stocks, to be interpreted with caution due to already evoked limitations. CECAF recommendations on management measures are based on the F.

The reproductive capacity of the stock (second criterion) could be estimated only for the Guinea-Bissauan stock of *O. vulgaris,* by using the primary indicator (SSB). SSB estimations from surveys carried out in 2002 and 2008 showed a decreasing trend, as did the total biomass. However, we believe that, for short-living species (as all of the cephalopod and shrimp species exploited in Mauritanian and Guinea-Bissauan waters), the time series analysis of SSB does not accurately depict the health status of the stocks, because they are highly dependent on their annual recruitments.

Regarding population age and size distribution (third criterion), primary indicators have been estimated, when possible, showing:

- A decrease of the proportion of *O. vulgaris* larger than the mean size of first maturation in Guinea-Bissau.
- A mean maximum length decrease for *P. longirostris* of Mauritania and *P. longirostris* + *A. varidens* of Guinea-Bissau, and an increase for *O. vulgaris* + *Sepia* spp. of Guinea-Bissau.
- A variable situation (decrease-increase) of 95% percentile of *P. longirostris* length distribution (CTL, in mm) estimated in research surveys carried out in Mauritanian waters; an increase of this 95% percentile for medium-depth shrimps of Guinea-Bissau; and an increase of the Guinea-Bissauan cephalopods group.

A general appreciation is that many of the indicators are based on the use of appropriate analytical assessments based on the analysis of catch at age or at length and ancillary information. However, it is worth noting that most of the countries involved in the CECAF assessments have not the capacity of developing sampling systems and research programs that could allow the use of this type of models. Therefore, the Biomass Dynamic model (BIODYN) has been standardized in the FAO/CECAF working groups. Efforts should be made to improve the quality of data, and to obtain catch at length or catch at age data, as well as other required biological information.

6. ASSESSMENT OF PRESENT MANAGEMENT MEASURES AGAINST THE MSY STRATEGY (CATCH LIMIT, EFFORT LIMIT, CLOSED SEASONS OR AREAS)

The Communication from the Commission to the Council and the European Parliament-Implementing sustainability in EU fisheries through maximum sustainable yield (MSY) (COM, 2006, 360 final) sets a new political orientation as regards fisheries management in the Community, in order to implement this approach, by accelerating its move towards a longer-term management system that focuses on obtaining the best from the productive potential of living marine resources. The Commission is developing long-terms plans with the aim of bringing all major fish stocks in EU waters to rates of fishing at which MSY can be achieves.

The MSY framework assumes that it is possible to reliably estimate the current fishing effort (F_{cur}) and the spawning stock biomass (SSB), and based on the assumed F, to infer appropriate management measures (e.g. TAC, effort restriction, MPAs) that will generate the desired F.

The concept of MSY is widely interpreted as the maximum long term average catch that can be achieved under prevailing conditions (including both the state of the ecosystem and size selectivity of the fishery). MSY is considered to be achieved by a fishing mortality (F_{MSY}) that produces a high long term average yield while the stock fluctuates around the stock size where production is at or close to the maximum. **A strategy for achieving MSY can be expressed as a harvest control rule where F is a fixed target which may also be a function of stock size. This is the form of the** International Council for the Exploration of the Sea (**ICES) MSY framework** (ICES, 2010b). The MSY framework is consistent with National and International policies and agreements, as well as the precautionary approach (ICES, 2010a).

ICES (2010b) suggested exploring the sensitivity of the estimates of candidates to the estimation of F_{MSY} proxies, to uncertainty and assumptions in the model parameters, and finally, where possible, to check the response of the stock to fishing at any proposed target in the long term (through simulation). With regard to the criteria for advice when there is no forecast, it was suggested that F advice in relation to putative F_{MSY} targets should be framed in terms of moving exploitation rates towards the target, rather than specifying a harvest in relation to the current stock status and/or expected short term development of the stock. Thus advice arising from circumstances where there is no short term forecast, has to be seen in the context of a “soft” evaluation of stock status relative to crudely estimated proxies. There are no new methods or techniques proposed in this report, and indeed the most basic equilibrium based methods are those used in the early years of fisheries science.

The EC consider that the F_{MSY} reference point can be used as a target, and that measurement error and uncertainty must be taken into account in its derivation. **Averaged F expected to be realised through the implementation of a management plan, should be consistent with the F_{MSY} estimate for the stock and that projected average catches should be similar** (ICES, 2010b).

Management measures of the crustacean and cephalopod fishing activities in Mauritania and Guinea-Bissau were described in detail in section 5. In this section, their consistency with the MSY strategy explained above is analysed:

6.1.- MAURITANIA

Mauritanian management measures include fishing effort control and technical management measures, such as closed areas, closed seasons, minimum catch size, gear types, and by-catch limits. Only the measures related to effort or catch limits, closed seasons and closed areas are analysed in relation to the MSY strategy:

- **Closed seasons:** The closed season established for the shrimp and cephalopod fisheries in Mauritania was created as a conservation measure, aiming at protecting the octopus during the periods when the stock is mainly composed of juveniles and/or spawners. Therefore, the two closed seasons, one in spring and another in autumn (of two months each), used in this case as an effort limit, are only aimed to the protection of the octopus populations. In our opinion, the fact that the shrimper fleet has to stop during the resting period of the cephalopod fishery has not any sense, as this fleet operates in much deeper waters when targeting *P. longirostris* and, the biology cycles of shrimps and octopus should not be coincident. As far as we know, only the autumn closed season could protect the reproductive fraction of the South stock of *F. notialis* during a spawning peak that seems to occur in autumn.
- **Closed areas**: There are a number of closed areas established in Mauritanian waters for both the shrimp and cephalopod fisheries. Some are marine protected areas (MPAs), such as the Banc d'Arguin National Park, which covers near 43% of the total non-trawlable area in the North zone (between Nouadhibou and Cape Timiris) and is closed to all type of motorized fishing vessels. As this area was created to protect the natural resources and the valuable fisheries of the Banc d'Arguin (Hoffmann, 1988), this measure could be considered in agreement with the general approach of the MSY strategy of reducing the proportion of fish that are captured from the sea in order to allow them to grow more (COM, 2006).
- **Catch limits:** Only catch limits established in the Mauritanian legislation are those referring to by/catch limits. Limitations of by-catch for shrimper vessels are: 20% of fish, 15% of cephalopods and 7,5 % of crabs. Furthermore, catch of spiny lobster is prohibited. Cephalopod trawlers are limited to capture less than 5% of shrimps as by-catch. However, no other catch limitations, such as total allowable catch (TACs), have been implemented.
- **Effort limit**: Fishing effort control is based on the use of fishing licences. Control of nominal effort is developed in terms of GRT for the industrial fleets, and in terms of vessel length overall for the artisanal fleet. The access to the fisheries is managed through the acquisition of fishing licences. Although CECAF recommendations are based on the fishing effort control, as far as we know, those recommendations are not followed by Mauritanian authorities for fishing management, as CECAF decisions are not legally binding on coastal countries. The use of $F_{MSY,}$ proposed as a target Reference Point by the EC, and recommended by other regional fishery bodies (RFBs) as ICES, is considered a biological Reference Point by CECAF. It is considered a very logical and easily implemented measured for CECAF members, as the assessments provide these values. In those cases of data poor stocks, when data are inadequate to estimate stock size and to project future stock size and catch, there are other approaches proposed by ICES (2010a) that could be considered by CECAF.

  The projections presented in section 3 resulted from the assessments of the Mauritanian stocks. They are analysed in order to ascertain if the current effort restrictions are in accordance with the MSY strategy:

Shrimps stocks:

- ***P. longirostris:*** although abundance was over the relative abundance index of MSY, catch was below the catch level corresponding to the MSY level (Figure 3.1). An exercise has been carried out in order to estimate the effort level that would produce catches corresponding to a MSY (Figure 6.1). According to this projection, an increase of the effort in 60% would be necessary to produce catches at the MSY level. This indicates that the management measures currently in force in Mauritania are not in accordance with the MSY strategy.

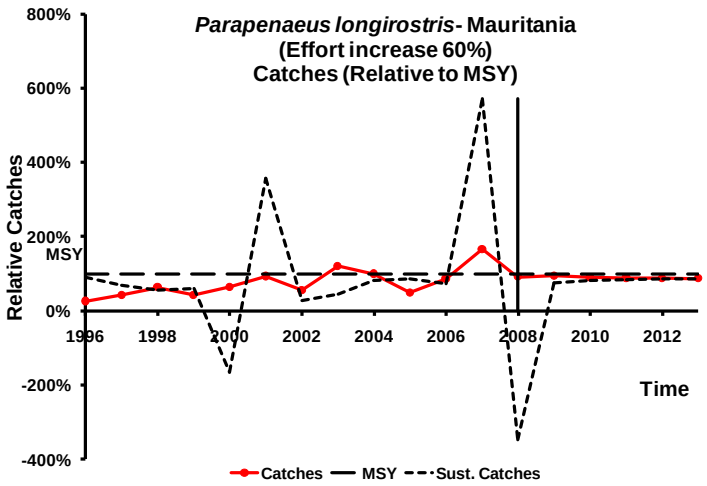


Figure 6.1.-Short- and medium-term projections of *Parapenaeus longirostris* catch in Mauritania, increasing the effort level of 2008 in 60%.

- ***F. notialis:*** as explained in section 3, the last projections of *F. notialis* were carried out with input data of the last FAO/CECAF assessment WG (FAO, 2010), when this stock was over-exploited. This was due to the unavailability of data from the last assessment (IMROP WG, December 2010), when the stock seemed to have recovered and reached a full-exploitation status. The abundance projections (Figure 3.2), showed that maintaining the fishing effort at the current level would produce abundance indices over the MSY level from 2010 onwards, which indeed, is a very close situation the one that has already occurred. However, the catch projection indicated that expected catch would always be below those corresponding to the MSY level. An essay of increasing the effort until catch levels reach those values that would produce the MSY, showed that an effort increase of 80% (in relation to the effort of 2008), would be necessary to harvest the catch that would produce the MSY.

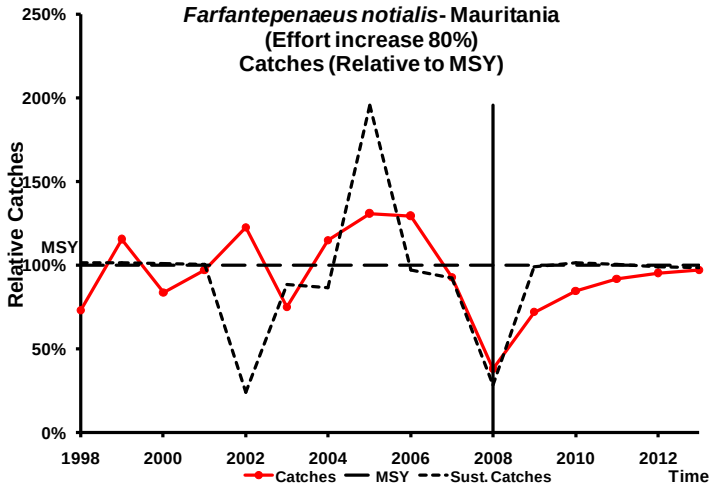


Figure 6.2.-Short- and medium-term projections of *Farfantepenaeus notialis* catch in Mauritania, increasing the effort level of 2008 in 80%.

These projections show that current effort is clearly not harvesting the MSY. CECAF management recommendations for both stocks were that the fishing effort should not exceed the 2008 level. In fact, we agree with precautionary measures, since they are more adequate for short-living species, highly dependent on the recruitment strength, as is *F. notialis*, and that increasing the effort in such proportions should not be recommended. In any case, it seems quite clear that the 4-months closure of the fishery imposed for the shrimper fleet but addressed to the protection of the reproduction and the recruitment of octopus is not in accordance to an MSY strategy for shrimp stocks.

Cephalopod stocks:

- ***O. vulgaris:*** the octopus projections of section 3 showed that although abundance of the Cape Blanc stock of *O. vulgaris* was below the relative abundance index of MSY (due to its over-exploitation), the catch would reach the values corresponding to the MSY level since 2011 onwards, in a situation of *status quo*, where the fishing effort level is maintained (Figure 3.3). Therefore, if management measures ensure leading to maintain the effort level at last year' level (2008), it would be a measure in agreement with the MSY strategy.
- ***Sepia* spp.:** as explained in section 3, cuttlefish projections were not very reliable, due to the uncertainty of the input data of the assessment. The catch projection shows that the effort should be considerably increased (compared to 2008) to reach the catch levels producing the MSY (Figure 3.4). However, this measure is not feasible, as this species is caught as by-catch of the octopus fisheries.

We conclude that, although CECAF recommended an effort reduction of the cephalopod fleets, the choice management measure in accordance with the MSY strategy would be to keep the fishing effort at level of 2008 (last year of data). Nevertheless, precautionary management measures should be considered for these short-living species, because of their high inter-annual variations, due to the high influence of the environmental factors on the recruitment, and thus on the annual abundance.

6.2.- GUINEA-BISSAU

Guinea-Bissau management measures are very limited (see review in section 5) and are basically those included in the EU-Guinea-Bissau fishing agreement. We have certain doubts about the existence of management measures for the remaining foreign fleets, which, as far as we know, are quite unregulated. The measures included in the EU-Guinea-Bissau fishing agreement are basically referred to the control of nominal effort, in terms of GRT, through the purchase of fishing licences. Technical measures are only related to fishing gears and by-catch limits.

The projections of *P. longirostris* and *O. vulgaris* (Figures 3.1 and 3.3) showed that, to manage the resources in accordance to the MSY strategy, an effort increase would be required to increase the catch to those levels achieving the MSY. However, as mentioned in this section these assessments and projections should be considered with great caution until obtaining quality fishery data and good biological information about the target species.

7. ASSESSMENT OF THE RELATIVE IMPACT OF THE EU DEMERSAL FISHING FLEETS CONSIDERING THE OVERALL FISHING ACTIVITY IN THE AREA OF THE FISHING PARTNERSHIP AGREEMENTS

To assess the relative impact of the EU shrimper and cephalopod fleets in relation to the overall fishing activities in Mauritania and Guinea-Bissau, we need a compilation of data from all the fleets operating in these EEZs. The data concerning the fleets operating in Mauritania have been obtained from the last FAO/CECAF WG on demersal assessments (FAO, 2010), and those concerning the fleets operating in Guinea-Bissauan fishing grounds come from the First Joint Scientific Committee EU-Bissau, carried out in Bissau, September 2010 (unpublished).

7.1.- MAURITANIA

7.1.1.- Shrimp fishery

Parapenaeus longirostris

The relative importance of the EU fleet in relation to other fleets catching shrimps in Mauritania, in terms of catch, and effort, along the decade of the 2000s can be graphically observed in Figure 7.1 These data come from the last FAO/CECAF WG on assessment of demersal resources-North region (FAO, 2010). Only Spanish data are presented, because information from European vessels has never been submitted to FAO/CECAF Working Groups. In absence of information of other EU shrimper fleets operating in the area (Portuguese and Italian), and taking into account that the Spanish is the most important EU shrimper fleet operating in Mauritania, we can consider its fishery statistics as representative for the EU. Table 7.I presents the catch and effort percentages by fleet over the last five years of available information for all fleets. The effort values correspond to the specifically effort deployed to catch *P. longirostris*, as total effort values have been split up in effort targeting *P. longirostris*, *F. notialis* and *A. varidens*, following the methodology by Sobrino *et al.* (2002).

Table 7.I.- Catch and effort percentages of *Parapenaeus longirostris* by shrimper fleet in Mauritanian waters and total catch (tons, t) and effort (fishing days, f.d.) of all fleets, from 2004 to 2008.

	FLEET	2004	2005	2006	2007	2008
% CATCH	Spanish Freezer Shrimpers	55	58	57	84	88
	Mauritanian Freezer Shrimpers	29	27	11	12	8
	Other Nationalities Shrimpers	16	16	31	5	3
Total Catch (t)	ALL FLEETS	3523	1727	3065	5876	3242
% EFFORT	Spanish Freezer Shrimpers	35	28	43	55	83
	Mauritanian Freezer Shrimpers	34	27	26	21	10
	Other Nationalities Shrimpers	30	45	31	24	8
Total effort (f.d.)	ALL FLEETS	12533	10254	9370	8862	5055

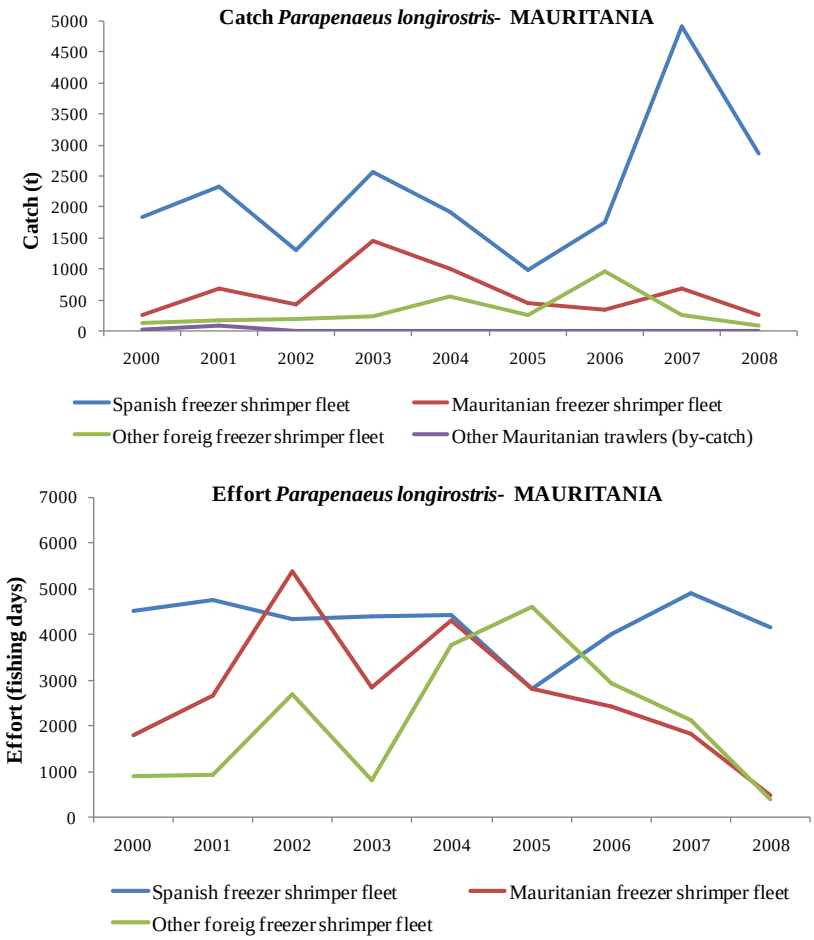


Figure 7.1.- Evolution of catch (tons, t) and effort (fishing days) of *Parapenaeus longirostris* from fleets operating in Mauritanian waters during the period 2000-2008.

In terms of catch and effort, the Spanish fleet has been the most important in Mauritanian waters, compared to the rest of the fleets operating in the area (Mauritanian freezer shrimpers and other foreign freezer shrimpers) over the last years. Only in 2005, the effort of other foreign fleets (mainly Chinese) was higher.

According to IEO data, the general decrease of the Spanish effort, occurred in 2009 and 2010 was due to a reduction of the number of vessels operating in this fishing ground. At the same time, the Mauritanian freezer shrimper fleet greatly decreased in 2009, due to its transformation into cephalopod trawlers or to its abandon of the zone, as reported by the IMROP to the 4th Joint Scientific Committee RIM-EU Meeting, held in Cádiz (Spain), in October 2010 (unpublished). The IMROP also indicated that the 97% of the 2009 total effort of shrimper vessels was exerted by the EU fleet and, to be precise, 80% by the Spanish fleet.

Farfantepenaeus notialis

EU fleet (mainly Spanish) seems to report the highest catch of *F. notialis*, except for 2007, when other foreign shrimpers (mainly Chinese) exceeded the Spanish catch level. In spite of the

difficulties in analysing the efforts by fleet due to the different estimators, as explained above, we can say that in general and over the last three years reported, the effort of the Spanish fleet is higher than the effort of the other fleets (Figure 7.2 and Table 7.II).

Italian and Portuguese vessels are also fishing for *F. notialis* in Mauritanian waters. Italy has especially increased its catch from 2001 to 2009, as was reported by the IMROP to the 4th Joint Scientific Committee RIM-EU (Cádiz, 2010, unpublished). According to the IMROP, the 25 EU vessels operating in Mauritania were exerting the 97% of the fishing effort in 2009, 80% of which was attributed to Spanish vessels. However, it must be said that the Italian fleet mainly targets the Southern rose shrimp, which accounts for 84% of its catch (IMROP, unpublished).

Among the fleets targeting *F. notialis*, the EU is considered to be the one mostly impacting the resource. However, it is worth mentioning the significant catch of *F. notialis* that may be attributed to the illegal, unregulated and unreported (IUU) fishing activities. It has been estimated that in Mauritanian waters operate 704 undetected illegal artisanal vessels, catching around 13 000 t of fish (MRAG, 2010). Most of these illegal vessels are Senegalese boats, supposed to be landing 100% of their catches in Senegal and thus contravening the obligation of landing 15% of their catch in Mauritania (as required by the terms of the Mauritania-Senegal agreement). Therefore, the level of unreported catch of *F. notialis* made by this artisanal fleet is supposed to be very high.

Table 7.II.- Catch and effort percentages of *Farfantepenaeus notialis* by shrimper fleet in Mauritanian waters and total catch (tons, t) and effort (fishing days, f.d.) of all fleets, from 2004 to 2008.

	FLEET	2004	2005	2006	2007	2008
% CATCH	Spanish Freezer Shrimpers	40	40	66	36	69
	Mauritanian Freezer Shrimpers	31	26	26	24	18
	Other Nationalities Shrimpers	29	34	8	40	13
Total Catch (t)	ALL FLEETS	2411	2747	2716	1942	800
% EFFORT	Spanish Freezer Shrimpers	26	25	41	36	73
	Mauritanian Freezer Shrimpers	35	28	26	30	15
	Other Nationalities Shrimpers	39	48	33	35	12
Total effort (f.d.)	ALL FLEETS	12506	10198	9362	6140	3226

In conclusion, the EU fleet, particularly the Spanish one, has traditionally been the most important fleet targeting shrimps (especially *P. longirostris*) in Mauritania. The available data indicate that, among all the fleets targeting both species in the area, the EU is that having more impact over the resource. However, this impact is relatively low, considering both the general reduction of the fishing effort occurred over the last years and the apparent good situation of the stocks (see section 1), with the greatest abundance of *F. notialis* recorded in 2010. However, this "good situation" should be considered with caution due to the high variability of this short-living species depending on their natural fluctuations. In addition, it is very important to keep in mind that the total catch figures of *F. notialis* may be underestimated due to the existence of a significant IUU artisanal fishing.

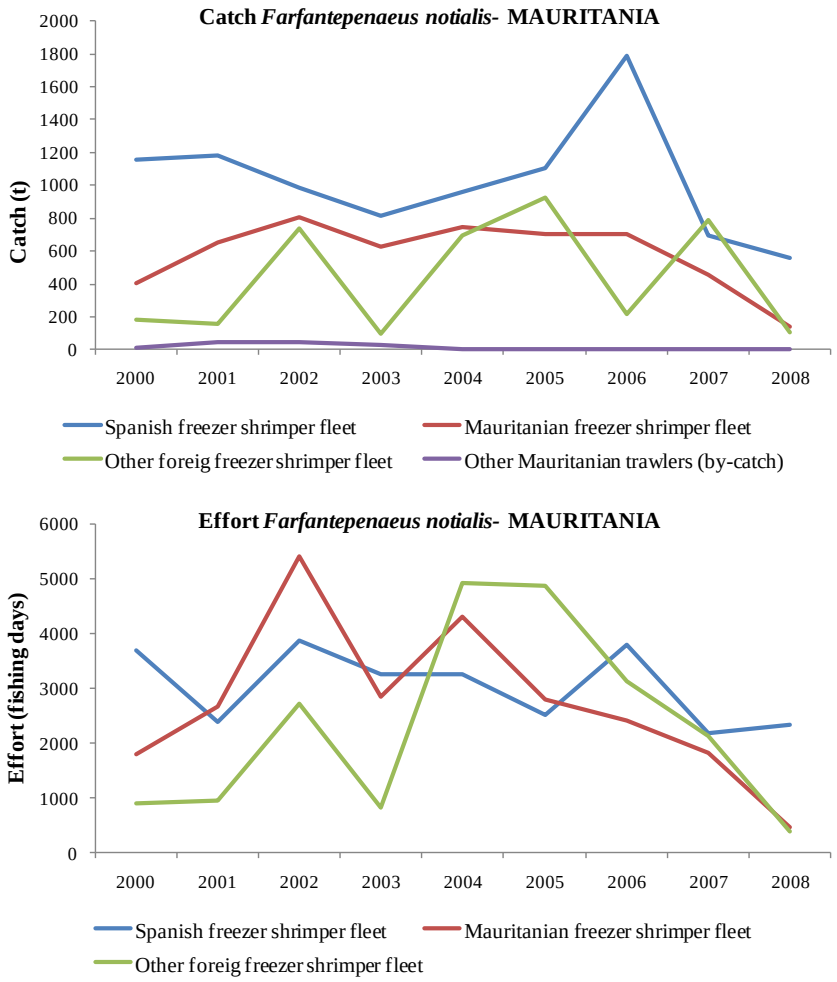


Figure 7.2.- Evolution of catch (tons, t) and effort (fishing days) of *Farfantepenaeus notialis* from fleets operating in Mauritanian waters during the period 2000-2008.

7.1.2.- Cephalopod fishery

Octopus vulgaris

The situation of the EU cephalopod (mainly octopus) fishery in relation the overall fishing activity in Mauritania is opposite of that presented for shrimps. As for shrimps, the Spanish fleet is the most important EU fleet operating in Mauritanian fishing grounds. Since data from the other European fleets fishing in Mauritania (from Portugal, Italy, and Greece) have never been submitted to the FAO/CECAF WGs, only the Spanish cephalopod fishery data are available.

Table 7.III presents the catch and effort percentages by fleet and available for the last five years. Figure 7.3 shows the trends of both parameters, from 2000 to 2008, as it was the last year reported to the FAO/CECAF WG of 2010 (FAO, 2010).

The catch and effort data of the Spanish cephalopod fleet show a decreasing trend since 2000. From 2004 to 2006, the catch of this fleet accounted for 30% of the total catch, decreasing to around 12% in 2008. Similarly, the effort proportions decreased from 5% to 1% in the mentioned period. This

effort reduction was due to the reduction of the number of EU cephalopod vessels operating in the area since 2005. However, this effort reduction is higher since 2008, mainly because the closed season for fishing was extended from 2 to 4 months per year.

Table 7.III.- Catch, effort and CPUE percentages of *Octopus vulgaris* by fleet in Mauritanian waters and total catch (tons, t), effort (fishing days, f.d.) and CPUE (kg/fishing days) of all fleets, from 2004 to 2008.

	FLEET	2004	2005	2006	2007	2008
% CATCH	Spanish cephalopod freezer trawlers	29	31	30	19	12
	Mauritanian cephalopod freezer trawlers	32	35	30	40	30
	Mauritanian cephalopod wet-fish trawlers	16	15	14	11	9
	Mauritanian artisanal fleet	20	17	22	24	44
	Other foreign trawlers fleet	2	2	3	6	5
Total Catch (t)	ALL FLEETS	25073	29638	21614	24966	32016
% EFFORT	Spanish cephalopod freezer trawlers	5	5	3	3	1
	Mauritanian cephalopod freezer trawlers	11	11	6	8	5
	Mauritanian cephalopod wet-fish trawlers	7	6	4	4	2
	Mauritanian artisanal fleet	76	77	86	84	92
	Other foreign trawlers fleet	1	1	0	1	1
Total effort (f.d.)	ALL FLEETS	193223	203583	249517	266331	344646

As shown in the table, the Mauritanian fleet has the greatest octopus catch and effort values. When considered together all the Mauritanian fleet segments (industrial freezer trawlers, wet-fish trawlers, and artisanal fleet), their account for catch percentages increase from 68% (2004) to 83% (2008). The total effort deployed by all the domestic fleets together increased from 94% to 99% over the same period. The artisanal fleet is the fleet segment with the highest development during the last years, achieving the highest catch and effort values in 2008 (see Figure 7.3) The catch proportions of octopus from the Mauritanian artisanal fleet increased more than twofold from 2004 to 2008, while the effort increased from 76% (2004) to 92% of the total effort exerted targeting octopus (Table 7.III).

Although here are not presented data from 2009 and successive years, a CPUE decrease in 2009 was reported by the IMROP to the 4th Joint Scientific Committee RIM-EU (Cádiz, 2010, unpublished). This CPUE decrease was attributed to a bad recruitment, being its consequences detected after the end of the second closed season (autumn).

As explained for *F. notialis*, in the Mauritania-Senegal fishing agreement, Senegalese artisanal vessels should land 15% of their catch in Mauritania, but it is well-known that most of these catches are landed in Senegal (MRAG, 2010). This fact also includes, among other species, the octopus. Therefore, there must be a significant underestimation of the octopus catch made by the artisanal fleet in Mauritanian waters.

Consequently, the EU cephalopod fleet has a relatively low impact on the octopus fishery in Mauritanian waters, considering the great catch and effort levels achieved by the different segments

of the domestic fleet (especially the artisanal fleet and during the last years). However, due to the bad situation of the stocks, this impact should not be underestimated.

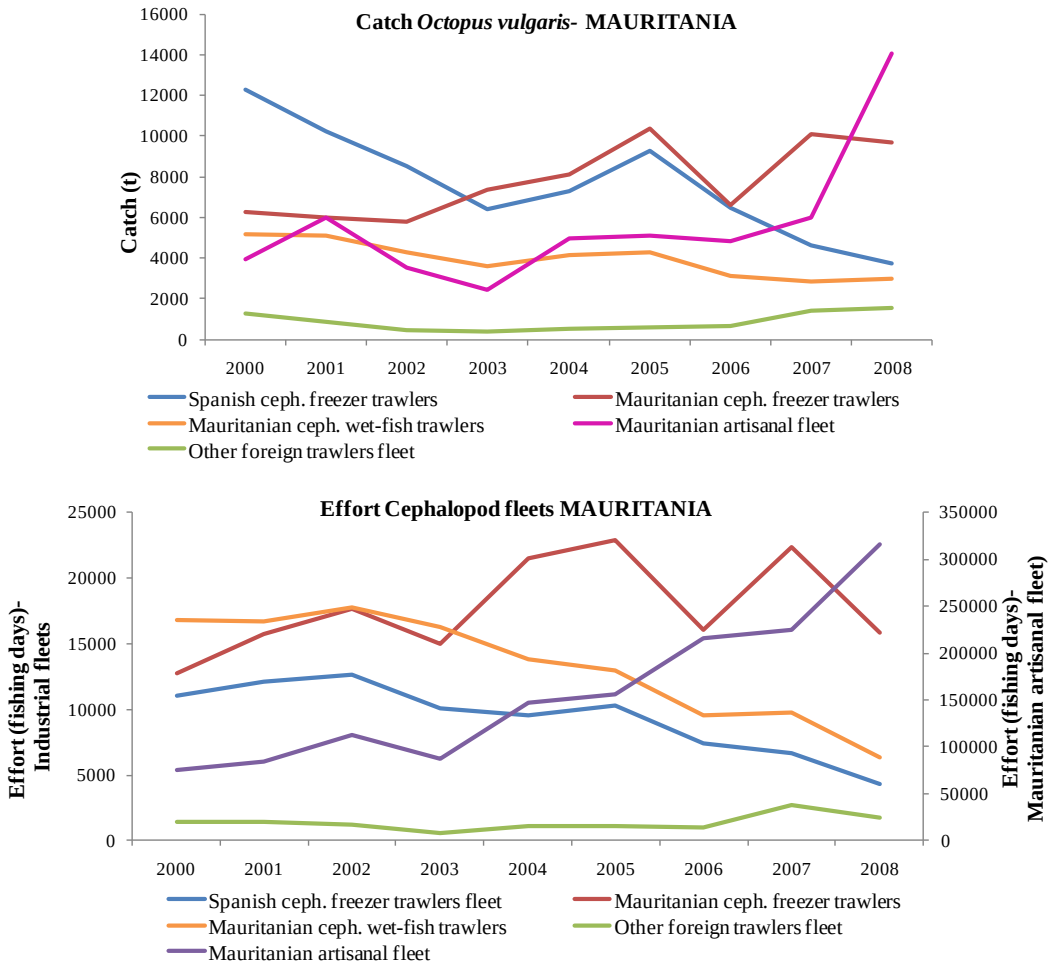


Figure 7.3.- Evolution of catch (tons, t) and effort (fishing days) of *Octopus vulgaris* from fleets operating in Mauritanian waters during the period 2000-2008.

Sepia spp.

The cuttlefish *Sepia spp.* is a by-catch species, both for the EU cephalopod fleet and for the Mauritanian fleet (domestic cephalopod freezer and wet-fish trawlers), as well as for other foreign fleets (non-EU), mostly from PRC. Therefore, the effort time series and proportion by fleet are the same than that explained for the cephalopod fleet targeting octopus.

The EU (Spanish) catch was well below to that corresponding to the Mauritanian fleets during the analyzed time series from 2000 to 2008 (Figure 7.4), averaging 17% of the total catch for the period of the last five years of available data (Table 7.IV). Mauritanian fleets captured between 75%-85% during the same period.

Table 7.IV.- Catch percentages of *Sepia* spp. by fleet in Mauritanian waters and total catch (tons, t) of all fleets, from 2004 to 2008.

	FLEET	2004	2005	2006	2007	2008
% CATCH	Spanish cephalopod freezer trawlers fleet	22	18	15	12	19
	Mauritanian cephalopod freezer trawlers	34	43	56	55	57
	Mauritanian cephalopod wet-fish trawlers	40	34	24	30	19
	Other foreign trawlers fleet	5	5	4	4	4
Total Catch (t)	ALL FLEETS	3712	4025	2373	3362	3061

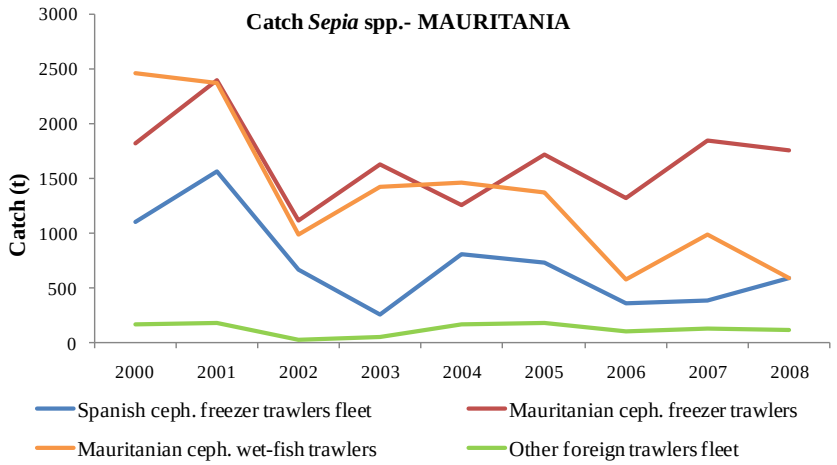


Figure 7.4.- Catch (tons, t) evolution of *Sepia* spp. from fleets operating in Mauritanian waters during the period 2000-2008.

Loligo vulgaris

The squid *L. vulgaris* is another by-catch species for all the cephalopod fleets operating in Mauritanian waters.

Table 7.V.- Catch percentages of *Loligo vulgaris* by fleet in Mauritanian waters and total catch (tons, t) of all fleets, from 2004 to 2008.

	FLEET	2004	2005	2006	2007	2008
% CATCH	Spanish cephalopod freezer trawlers	41	52	56	28	46
	Mauritanian cephalopod freezer trawlers	34	27	21	59	38
	Mauritanian cephalopod wet-fish trawlers	23	18	23	8	11
	Other foreign trawlers	2	2	1	5	6
Total Catch (t)	ALL FLEETS	833	1303	441	2270	1637

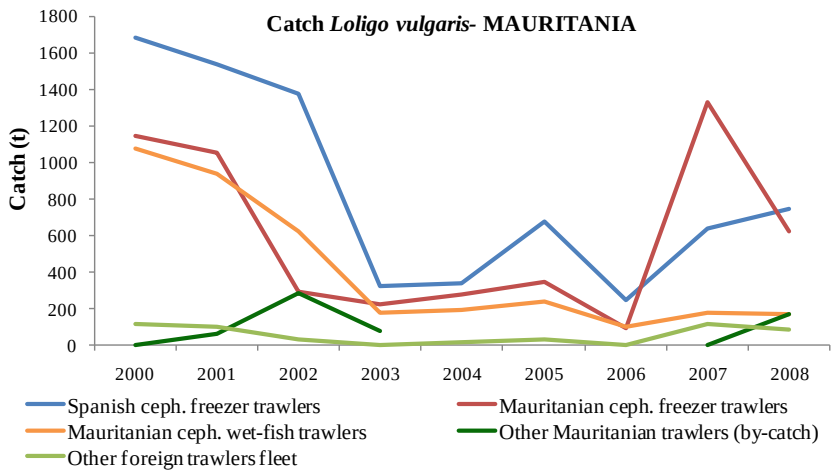


Figure 7.5.- Catch (tons, t) evolution of *Loligo vulgaris* from fleets operating in Mauritanian waters during the period 2000-2008.

Since 2000, there has been a drop in the catch levels of the EU (Spanish) fleet (Figure 7.5), being now ranging between 300 and 600 t over the last five years. This corresponds to an average of 45% of the total catch during this period (**Table 7.V**), while the Mauritanian freezer and wet-fish trawlers accounted for around 52%.

In conclusion, all the cephalopod fleets operating in Mauritanian waters target octopus, while cuttlefish and squid are caught as by-catch. The impact of the EU cephalopod fleet is relatively low in comparison to the impact of the domestic fleet, and in spite of the effort reduction occurred over the lasts years, it cannot be neglected due to the bad situation of the octopus stock.

7.2.- GUINEA-BISSAU

7.2.1.- Shrimp fishery

Parapenaeus longirostris* and *Aristeus varidens

Current available information suggests that practically the totality of *P. longirostris* and *A. varidens* is fished by the EU (mainly Spanish) fleet, with an almost negligible contribution of the other foreign industrial fleets to the total catch of these species. Future analysis of fisheries statistics, currently being compiled by Guinea-Bissauan scientists, should allow a better estimation of the impact level of the EU fleet on these resources.

Furthermore, to date the compiled statistics are not taking into account the great impact of the IUU fishing activities, a well-known practice in this area, and that may have an unknown impact on these resources.

Farfantepenaeus notialis

This species is caught by both the industrial and the artisanal fleets. Only information of industrial fleet is available. The catch proportions by fleet are highly variable from one year to another (Table 7.VI), probably due to the uncertain data from non-EU fleets. The available data show an increase

in the proportion of total catch made by the EU fleet over the analysed period, with an average value of 29% for the three years (2007-2009). The main catch corresponded to the Chinese fleet (averaging 41% of the total catch), whereas the rest of foreign fleets averaged 30%.

Unfortunately, there is not any fishery information about the artisanal fishery in Guinea-Bissau. Furthermore, the impact of the IUU fishing activities is supposed to be very high on this species (see section 8). These considerations make our estimations of the EU impact level unreliable and probably overestimated.

Table 7.VI.-Catch percentages of *Farfantepenaeus notialis* by shrimper fleet in Guinea-Bissauan waters and total catch (tons, t) of all fleets, from 2007 to 2009.

	FLEET	2007	2008	2009
% CATCH	Spanish shrimper freezer trawlers	10	28	57
	Chinese freezer trawlers	69	12	24
	Other foreign trawlers fleet	21	61	19
Total Catch (t)	ALL FLEETS	298	164	208

The fishing efforts of different fleets have not been compared due to the differences in their fishing strategies: while the EU (Spanish) fleet specifically targets shrimps, the other foreign (non-EU) fleets are more opportunistic, mainly fishing for finfish.

Octopus vulgaris

The only available fishery statistics of *O. vulgaris* are those from the industrial fishery. The EU fleet (mainly Spanish), accounted for an average value of 42% of the total catch, while the rest was caught by Chinese (23%) and other foreign fleets (35%) (Table 7.VII).

The same problems mentioned for *F. notialis* (uncertainty of non-EU fleet data, lack of information of the artisanal fishery, and IUU fishing) may greatly overestimate the impact attributed to the EU fishery.

Table 7.VII.- Catch percentages of *Octopus vulgaris* by fleet in Guinea-Bissauan waters and total catch (tons, t) of all fleets, during the period 2007-2009.

	FLEET	2007	2008	2009
% CATCH	Spanish cephalopod freezer trawlers	42	59	35
	Chinese freezer trawlers	15	20	33
	Other foreign trawlers fleet	43	20	33
Total Catch (t)	ALL FLEETS	2907	1249	2723

***Sepia* spp.**

As for the octopus, the only available fishery statistics of *Sepia* spp. are those from the industrial fishery, although we suppose there is also a significant artisanal fishery exploiting this resource. The European fleet (mainly Spanish), captured an average proportion of 49% of the total catch from 2007 to 2009, followed by the Chinese fleet (36%) and other foreign fleets (25%). The catch proportions are highly variable for each fleet from one year to another (Table 7.VIII)

Table 7.VIII.- Catch percentages of *Sepia* spp. by fleet in Guinea-Bissauan waters and total catch (tons, t) of all fleets, from 2007 to 2009.

	FLEET	2007	2008	2009
% CATCH	Spanish cephalopod freezer trawlers	29	46	26
	Chinese freezer trawlers	48	27	37
	Other foreign trawlers fleet	23	27	37
Total Catch (t)	ALL FLEETS	2177	1115	1269

In any case, the real impact of the EU fleet on the cuttlefish fishery cannot be reliably estimated due to the uncertainties attributed to the quality of the fishery statistics of the other industrial fleets and to the unknown catch achieved by the artisanal fleet and the IUU fishing activities.

In conclusion, the impact of the EU fishing fleet on the resources exploited in Guinea-Bissau is variable depending on the target species. Two groups can be distinguished:

- Species that are presumably only caught by the EU fleets (deep-water rose shrimp and striped red shrimp);
- Cephalopod species (octopus and cuttlefish) and coastal shrimps (*F. notialis*), simultaneously harvested by EU fleets, other foreign fleets (non-EU), and artisanal fleet, whose catches are totally unknown.

Furthermore the IUU fishing activities harvesting these resources may have a significant impact on them.

8. ARE THE ANALYSIS AND METHODS APPLIED TO PROVIDE SCIENTIFIC ADVICE ADEQUATE TO THE AVAILABLE BIOLOGICAL AND FISHERY DATA/INFORMATION?

The West African stocks under the scope of this report are exploited by the coastal countries as well as by foreign fleets. This fact advises the establishment of a scientific cooperation framework, over-arching cooperative actions, such as the assessment of the exploited resources. This scientific framework is provided by the Committee for the Eastern Central Atlantic Fishery (CECAF). There are five CECAF permanent Working Groups (artisanal fisheries, small pelagic resources [subgroups north and south], demersal resources [subgroups north and south]), created as CECAF advisory bodies. Mauritanian shrimp and cephalopod stocks are assessed in the Working Groups (WGs) on the Assessment of Demersal resources-Subgroup North, covering the main demersal stocks exploited from Morocco to Senegal-The Gambia. Guinea-Bissauan shrimps are assessed in the Working Groups (WGs) on the Assessment of Demersal resources-Subgroup South, which include the rest of the CECAF countries, from Guinea-Bissau to Angola. CECAF aimed at celebrating these WGs on an annual basis, but unfortunately and due to economical reasons, the WGs are held with no scheduled periodicity. The main objectives of these WGs are assessing the status of the resources and providing scientific advice to ensure an optimal and sustainable use of the resources.

The assessment process followed in the WGs covers four major steps (Balguerías, 2009):

1) Gathering of basic information from the fisheries. The compilation of information from both artisanal and industrial fisheries is under the responsibility of flagging countries, which are obliged to submit periodical data (usually on an annual basis) about vessels characteristics, gears, fishing strategies, fishing effort, and catch, both by species and statistical divisions.

2) Biological and population studies of the most important species and stocks. Research institutions from countries belonging to the CECAF are requested to conduct national sampling programmes to estimate biological and population parameters needed for stock assessment. These studies mainly refer to stock identification, growth, reproduction, alimentation, length structure, and natural mortality of the most important species in their respective fisheries.

3) Estimation of abundance indices by fishery independent methods. This task is also under the responsibility of national research institutions. Many of the CECAF countries, particularly those from the North region conduct periodical surveys to obtain abundance indices of the main fish resources in their respective EEZs. This regular activity is sometimes complemented by occasional surveys carried out by foreign countries.

4) Stock assessment by indirect methods. This task is always carried out during the regular meetings of the CECAF permanent WGs. Assessment methods applied have evolved over the years. Lately, they have converged to a standard methodology based on dynamic production models. The Schaefer dynamic production model and its fitting are implemented in a MS Excel spreadsheet under the BIODYN software (Punt and Hilborn, 1996; Barros, 2007). This is very simple and friendly software, containing data handling, analysis, diagnostics, and short-medium term projection routines developed for general use at all working groups. Also, analytical methods are occasionally applied to assess specific stocks.

Problems associated to the assessment process

1) Data gathering

The data gathering is one of the most crucial steps in the assessment process. The nature and the quality of this information determine the assessment methods to be applied and more important, the reliability of the results. Regarding this question, several constraints have been identified (Balguerías, 2009). They mainly refer to the geographical and fleet coverage and the information updating.

- Some of the CECAF countries do not have an appropriate statistical network and/or administrative services able to collect the needed information. This is the case for most of the southern countries in the region, whose statistics are inexistent or are rough estimates based on occasional interviews made over the years.

  The situation for industrial fisheries is generally good, since there is a compulsory standard declaration system (logbooks) in force in most of the countries, which permits disposing of quite reliable estimates of their respective production, at least for the target species. This is the case of Mauritania, where the industrial fishery information is compiled through logbooks and is relatively well updated. However, certain disparities have been found in the data provided to different meetings, fact that indicates that efforts should be made to improve the Mauritanian databases. However, Guinea-Bissau has not provided fishery information to CECAF WGs since 2005 (FAO, 2005), even if we must acknowledge the improvement on the compilation of industrial fishery information that could be noticed during the 2nd Meeting of the Scientific Committee between the Republic of Guinea-Bissau and the European Union (2010, unpublished).

  Major difficulties arise in artisanal fisheries where the establishment of reliable and long lasting information systems has failed in many cases. Mauritania is making efforts to improve the compilation of artisanal fishery information. However, there is an absolute lack of information about the artisanal fishery in Guinea-Bissau, which is a very important fishing sector in the country.

- Another problem attached to data gathering in the CECAF region is the **updating of the time series**. The statistics preparation is a long time consuming work and the information generally available for assessments at the time of the working groups do not contain data from the most recent fishing season. That is, stocks are being assessed with data series already one or more years old and therefore results do not reflect their current situation but the situation of the year/s preceding the assessment.

- **Illegal, unreported and unregulated (IUU) fisheries** are another serious source of uncertainty when estimating actual catches in the CECAF region. Illegal fishing is known to be a particular problem in the South area of CECAF (Central West Africa). In fact, Central West Africa has been highlighted as the area with the highest level of IUU fishing in the world.

  Guinea-Bissau is one of the countries more affected by this fishing, with an estimated level of IUU of 41% of the legal catch (MRAG, 2005). In Guinea-Bissau, both the artisanal and the industrial fleets (national and foreign) are involved in numerous IUU fishing activities. Problems related to the industrial fleet include, among others, fishing vessels transhipping their catch to larger freezer vessels that transport the fish products to be sold in distant markets without being reported (MRAG, 2010). Regarding the artisanal vessels, the illegal activity having the greatest impact is those of a large number of highly efficient artisanal fishing boats coming from neighbouring countries, particularly Senegal. The majority of this illegal artisanal catch is landed in Senegal and exported to major markets. It has also been reported that these

fishermen are engaged in transhipping their most valuable catch across to foreign trawlers in exchange for food items, fuel and money (MRAG; 2010). In addition to the economic losses to Guinea-Bissauan revenues, this IUU involves a great underestimation of catch in this country.

On the contrary, the overall rates of illegal activity in Mauritania are relatively low. The estimated level of IUU fishing was 9% of legal catch (MRAG, 2005). This is mainly due to a greater capacity of monitoring, control and surveillance (MCS), practically inexistent in Guinea-Bissau. Some infractions related to IUU in the Mauritanian industrial sector include false nationalization, whereby foreign vessels registered as Mauritanian (thus qualifying for the reduced national licence fees for fishing) do-not complete the re-registration and reflagging process. More than 150 Chinese vessels have committed in recent years this type of infraction. The main IUU activities related to the artisanal fleet in Mauritania include fictitious or lack of registration, unlicensed fishing or transhipment of catches at sea. In the Mauritanian-Senegal fishing agreement, Senegalese artisanal vessels should land 15% of their catch in Mauritania, but it is a common practice to land most of these catches in Senegal (MRAG, 2010). This problem also concern, among other species, to *O. vulgaris, Sepia* spp. and *F. notialis*.

Discards and by-catch of both legal and illegal fisheries constitutes a great part of the unreported fishing. The IUU fishing has an impact on data quality for stock assessment, which may lead to management decisions being based on incorrect stock assessment estimates, as those resulting of false catch declarations.

2) **Estimation of population and biological parameters** used for stock assessment would require the existence of long term sampling programmes at each of the countries in the region. Most of these countries do not have neither the required human and economic means nor the infrastructures to maintain such activity. The review of biological information compiled in section 4 indicates that, with the exception of the Cape Blanc stock of *O. vulgaris* in Mauritania, there is a generalized lack of knowledge of population and biological information for shrimps and cephalopod stocks in Mauritania and Guinea-Bissau, needed for stock assessment.

3) **Surveys** carried out periodically to obtain fishery independent abundance indices are restricted to the northern countries of the CECAF region (i.e. Morocco, Mauritania and Senegal). Some of the series are quite long, starting already in the 1970s or in the 1980s with, in some cases, two or more cruises per year. Nevertheless, many of these surveys had stock oriented objectives: collecting information of a single target species (octopus, hake, sardine, sardinelles, etc.) and paying limited attention (or no attention at all) to other species in the ecosystem. Furthermore, sampling methodologies (geographical coverage, seasons, research vessel, fishing gears, etc.) have changed across the years making sometimes difficult any kind of comparisons on the estimated abundance indices and parameters from species. This situation is reflected in the high variability of the calculated values for many of the species and eventually in their contradiction with estimates obtained from other data sources (i.e. CPUE from fisheries) (Balguerías, 2009).

4) **Stock assessments**:

- The first difficulty encountered by the working groups refers to the accurate **identification of biological stocks**. This has been more or less satisfactorily solved for the octopus. Nevertheless, there are still efforts to be made to identify the remaining stocks and it is particularly important for crustaceans, which are currently assessed on a national basis whereas many of them are supposed to be transboundary.

- **Catch and effort** are the general information common to the majority of the fisheries. The different working groups agreed on using this kind of information as an interim solution for the assessment of the regional stocks by using surplus production models with the commitment of evolving to more appropriate methodologies as new biological and population data were

becoming available. This decision permitted the development of a standard software (BIODYN) based on dynamic production models, that has since then being used in all permanent CECAF WGs for stock assessment.

- However, the model has some problems (Balguerías, 2009). The main recognized problem associated to this model is that it is not adapted to the life cycle of many of the species. This is particularly true for short-living species, such as cephalopods and crustaceans. Furthermore, in many cases CPUE series or abundance indices used to run the model do not seem to represent the biomass evolution of the stocks concerned. Another difficulty associated to the model is its unavailability to calculate the variability of the estimates (fishing mortality, current biomass, MSY, etc.). The unfeasibility of the current assessment methodology for calculating variability around estimates hinders any advice on the accuracy of the diagnostics on the actual state of the stocks, as well as on the risks eventually associated with the introduction of different management options. This uncertainty around the results of the assessments explains why most of the management advices provided by the CECAF working groups are rather poor and imprecise.

Therefore, for a better assessment process it is important:

- To identify the biological boundaries of the stocks.
- To establish a monitoring routine of basic information from fisheries concurring on these selected stocks
- To continue or to initiate continuous biological studies on selected species.
- To analyse existing survey data to propose standard methodologies to be applied in the region.
- To continue developing or adapting assessment models and methodologies better adapted to the biological characteristics of the species.
- To assure the periodic celebration of the meetings of the permanent assessment working groups.

In conclusion, there are several problems related to the assessment of the Mauritanian and Guinea-Bissauans stocks, which are common to most of the stocks in the CECAF area. They include:

- Poor fishing data (uncompleted, irregular or not updated statistics; unreported by-catch and discards and illegal, unregulated and unreported catches).
- Scarcity of available biological information about these species in the area makes that stocks have to be defined arbitrarily, for assessment purposes, within the geographical limits of the countries where they are exploited. As a consequence of that, many attempted assessments have to be rejected because of poor data and/or the uncertainty of the stock identity.

The lack of basic biological information and the poor data from the fisheries does not allow the use of appropriate specific assessments models. Because of this, a standard assessment methodology has being applied, which is based on a dynamic production model. Although this model has certain advantages, its application is not adapted to the lifespan cycle of many of the assessed species, which mainly are short living species.

Besides, the climatic conditions affecting the variability of these short-living species should be analysed to set the basis for the development of predictive models which might contribute to a better management of the stocks.

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