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RAC/SPA

ALBORAN SEA:

STATUS OF OPEN SEAS FISHERIES

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RAC/SPA – Tunis, 2015

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List of acronyms

AO:	Arctic Oscillation
BPUE:	Bycatch per unit effort
CPUE:	Capture per unit effort
COPEMED:	Co-ordination to Support Fisheries Management in the Western and Central Mediterranean
EAG:	Eastern Alboran Gyre
EEC:	European Economic Community
FAO:	Food and Agriculture Organization of the United Nations
GIS:	Geographic information system
GFCM:	General Fisheries Commission for the Mediterranean.
GSA:	Geographical-sub areas
ICCAT:	International Commission for the Conservation of Atlantic Tunas
LLALB:	drifting surface longline targeting albacore
LLJAP:	surface longliners targeting bluefin tuna
LLHB:	traditional drifting surface longliners targeting swordfish
NAO:	North Atlantic Oscillation
RFMO:	Regional Fisheries Management Organization
US:	Union States of America
WAG:	Western Alboran Gyre

Summary

The Alboran Sea extends from the Strait of Gibraltar to an adopted line running from Cabo de Gata (Almeria, Spain) to the Cape Fegalo (Algeria). Our study area includes 26 important fishing harbours (15 in Spain, 8 in Morocco and 3 in Algeria). Two important features characterize the open sea fisheries from Alboran Sea. On the one hand, there is a marked gradient between Spain, an EU socioeconomically developed member and Morocco and Algeria, two developing economies according to the IMF in 2015. On the other hand, the Alboran Sea is a globally important area for marine traffic as a corridor connecting the Mediterranean Sea with the Atlantic Ocean, bearing about the 25% of global maritime traffic. Therefore, there is a risk of collision for small boats and damage of the fishing gear during fishing operations. To avoid this risk -and also, because of the proximity of the continental slope to the coast- open sea's fishing grounds in the Alboran Sea keep a distance from the main shipping lanes and are closer to the coast than in other areas.

The Atlantic Ocean waters entering the Alboran Sea through the Strait of Gibraltar are richer in nutrients compared with the surface Mediterranean water. This fact jointly with the upwelling in the northern Alboran Sea (close to the Spanish coast) causes an important plankton productivity in northern Alboran Sea. This productivity levels are highest around the Bay of Malaga, coinciding with the flow of the Western Alboran Gyre (WAG). The peaks in the plankton productivity during spring, summer and autumn, coinciding with the spawning season of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*). Thus important spawning areas for many of the fish species are found near to the coast in the north of the Alboran Sea. Other important reproductive zones for demersal fish are found in the submarine canyons of the Alboran Sea, whose origin is related with ancient fluvial erosion processes.

Blue whiting (*Micromesistius poutassou*), horse mackerel (*Trachurus trachurus*), chub mackerel (*Scomber japonicus*), silver scabbardfish (*Lepidopus caudatus*), and Atlantic pomfret (*Brama brama*) are the most important targetted apart from non-tuna species, considering the total catch weight from the open sea. Bluefin tuna (*Thunnus thynnus*), little tunny (*Euthynnus alletteratus*), skipjack tuna (*Katsuwonus pelamis*), plain bonito (*Orcynopsis unicolor*), Atlantic bonito (*Sarda sarda*), bullet tuna (*Auxis rochei*), and swordfish (*Xiphias gladius*) are the main tuna fisheries in South Alboran's open sea. The main tuna and associated fisheries in the North Alboran's open sea, considering the total catch weight, are bullet tuna (*Auxis rochei*), Atlantic bonito (*Sarda sarda*), swordfish (*Xiphias gladius*) and little tunny (*Euthynnus alletteratus*).

Our study shows a gradual decline in the catches for the main target species from 1985 to 2012. The horse mackerel shows a fluctuating trend and a temporal autocorrelation. Thus two different peaks and a decline trend can be observed. The Spectral Analysis result shows a periodical cycle of twelve years' period. There is also a temporal autocorrelation for the chub mackerel.

The Sardine abundance trend is positively correlated with the winter North Atlantic Oscillation index (from October to December of the previous year) ($r= 0.375$; $p= 0.049$).

The North Atlantic Oscillation (NAO) is a dominant pattern of coupled ocean-climate variability in the North Atlantic and in the Mediterranean basin.

Our study also detects a gradual increase in the catches from 1985 to 2012, particularly for the little tunny landings. Moreover, there is a negative correlation between the landings of bullet tuna from the North Alboran Sea and the Arctic Oscillation (AO) ($r= -0.38$; $p= 0.046$).

Considering the last ten years, the main open sea fisheries in the Alboran Sea are: driftnets for the swordfish (*Xiphias gladius*), longliners (both bottom and surface modalities) for the bluefin tuna (*Thunnus thynnus*), little tunny (*Euthynnus alletteratus*) and swordfish, purse seiners for Sardine (*Sardina pilchardus*) and European anchovy (*Engraulis encrasicolus*) and the bottom trawl fisheries. This latter gear targets a group of bottom species such as European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), blue whiting (*Micromesistius poutassou*), red shrimp (*Aristeus antennatus*) and common octopus (*Octopus vulgaris*), in order of importance.

The loggerhead turtle (*Caretta caretta*) is the most common sea turtle specie in the Mediterranean Sea, whose nesting beaches are mainly in the Eastern basin. Each year hundreds of juvenile loggerhead turtles borning in the the North Atlantic and eastern Mediterranean beaches concentrate around the feeding grounds in the western Mediterranean, mainly around the Balearic Islands' waters. In this context, many loggerhead turtles strand along the southern Iberian Peninsula coast on their way to their feeding grounds or while returning to their natal regions. Due to the spatial overlap in fishing activity and loggerhead turtle distribution, there are tens of thousands of loggerhead turtle by-catches each year. The incidental capture of sea turtles is more frequent in the summer. Based on the testimony of interviewed fishermen, it seems that surface long-lines interact most frequently with marine turtles, followed by coastal trawlers, purse seiners and trammel nets. Sea turtles caught by purse seiners can be released undamaged as far as they are not entangled in the net. The incidental capture of sea turtles is rare on bottom trawlers.

The bycatch (or incidental capture) per Unit Effort values in the Alboran's open sea are low in comparison to other Mediterranean areas, for example Balearic Sea. However, the by-catch rate of loggerhead turtle by driftnets in the Alboran Sea (0.21–0.78 N/haul) was much higher than that reported for the Italian driftnet fleet (0.04–0.05 N/haul), probably due to a much higher turtle density in Alboran waters related to the strategic role of this sea in the Atlantic/Mediterranean exchanges.

The landing of sharks in surface longline was reported to be up a 34.3% in weight of total catches sampled in the Alboran Sea, which represented the highest shark incidental catches for the Mediterranean Sea. This high shark incidental catches from Alboran Sea, could be probably related to their location (Alboran Sea), i.e. an important migratory channel, adjacent to the Atlantic Ocean. The higher incidence of sharks in the Alboran Sea could also be due to the higher trophic potential of the western Mediterranean compared to the eastern part. Higher shark catches were observed in the swordfish longline fishery, where a nominal Catch Per Unit Effort (CPUE) value reached 3.8 sharks/1000 hooks in the Alboran Sea.

From the Alboran Sea, the most important sharks caught in number were blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*). Regarding to the pelagic

Batoidea, the common pelagic stingray (*Pteroplatytrygon violacea*) is the only bycatched species reported by the surface longline. The common pelagic sting ray is the major fish capture in the surface longline from Alboran Sea. The Bycatch per Unit Effort (BPUE) of common pelagic stingray is 28.1 individuals per 1000 hooks versus the CPUE of target species wich is 8.42 captures per 1000 hooks. We observed a gradual increasing in catches over time; for the landing of tope shark, since 1985 to 2012. Moreover, we found a negative correlation between the landing of tope shark from North Alboran Sea and North Arctic Oscillation (r= -0.385; p= 0.043). We found a positive correlation between the landing of blue shark from North Alboran Sea and winter Arctic Oscillation Index (between October and November previous year) (r= 0.57; p= 0.043).

The main fisheries bycatches demersal elasmobranchs from Alboran Sea are the bottom trawl fishery and bottom longline. The main gears bycatches demersal elasmobranchs from Alboran Sea are the trawlers and bottom longline. From Alboran Sea the most important demersal elasmobranch caught in number were: gulper shark (*Centrophorus granulosus*), small-spotted catshark (*Scyliorhinus canicula*), and *Raja* spp, that are bycatches of bottom trawl fishery targeting rose shrimp (Parapenaeus longirostris) and great red shrimp (*Aristaeopsis edwardsiana*).

We found a negative correlation between the landing of *Raja* spp. from North Alboran Sea and North Arctic Oscillation (r= -0.435; p= 0.021).

There are somo difficulties with the avalaible data on landings. As they are pooled it is very difficult to distinguish between coastal fisheries (i.e. small-scale fisheries) and open sea fisheries. Moreover, the GFCM have done the assessments on small pelagic and demersal fisheries using GSA areas, whose delimitations do not coincide with any definition of the Alboran Sea limits, vg.: the GSA01 area exceeds wich is condidered Alboran as it includes the area from Cape of Gata to Cape of Palos, and GSA03 does not include the Argelia’s coastal line. For these reasons for a better understanding of the fisheries dynamics in the Alboran open waters would be prioritary to have local disaggregated data. In adition to these caveats, the data available from Algeria and Morocco are not disaggregated per species and are scarce. This issue makes very difficult to analise the temporal trend and the fisheries profit. In this context, we did not found any paper about bycatch of the fleet from Algeria or about or trawlers and longliners fisheries from Morocco. To improve the data quality about CPUE, fisheries profit and bycatch per species is a first order necessity.

1. Introduction: the open sea of the Alboran Sea

The open sea, as the region at sea beyond the neritic zone may include the slope and the bottom of the sea (benthic region) as well as the water column (pelagic region). Therefore it presents a high diversity of habitats (i.e. pelagic, bathyal or abyssal habitats).

The Alboran Sea is the westernmost portion of the Mediterranean, lying between Spain, Morocco and Algeria. The Alboran Sea extends from the Strait of Gibraltar to an adopted line running from Cape of Gata (Almeria, Spain) to the Cape Fegalo (Algeria). Our study region is approximately between 35º–37º N and 0º–4º W, and includes the main harbours (see figure 1):

- Spain (listed from west to east) (figure 2): Tarifa, Algeciras, La Linea, Ceuta (located in northern Africa), Estepona, Marbella, Fuengirola, Málaga, Caleta de Vélez, Motril, Adra, Roquetas de Mar, Almería, Carboneras (out of Alboran Sea *sensu stricto*) and Garrucha (out of Alboran Sea *sensu stricto*). Tarifa harbour is excluded because the fishing-ground of these vessels mainly are outside Alboran area, moreover, the fish vessels from this port are mainly artisanal vessels.

- Morocco (listed from west to east) (figure 3): Tanger[1,2], M´diq, Stehat[3], Jebha[4], Cala Iris, Al Hoceïma[5], Beni Ansar (Nador), and Ras El Ma (or Ras Kebdana).

- Algeria (listed from west to east) (figure 4): Ghazaouet (Tlemecen)[6], Bouzed jar (Ain Témouchent)[7] and Oran.

[1] The fishing-ground of vessels from Tanger port is mainly are outside Alboran area.

[2] It is possible view a short film of this port in the link: http://www.youtube.com/watch?v=ZsVKYLz7zxk (titled: *The Port of Tangier - 26th July, 2010*).

[3] The fish vessels from this port are mainly artisanal vessels.

[4] The fish vessels from this port are mainly artisanal vessels.

[5] It is possible view a short film of this port in the link: http://www.youtube.com/watch?v=Ewt1yTXrn2U (titled: *port de pêche Al Hoceima 2012*).

[6] It is possible view a short film of this port in the link: http://www.youtube.com/watch?v=CNjZyPoRMRI (titled: *Port de Ghazaouet (Algérie)*).

[7] It is possible view a short film of this port in the link: http://www.youtube.com/watch?v=n9730S1o1uE (le port de Bouzedjar Ain Témouchent Algérie).

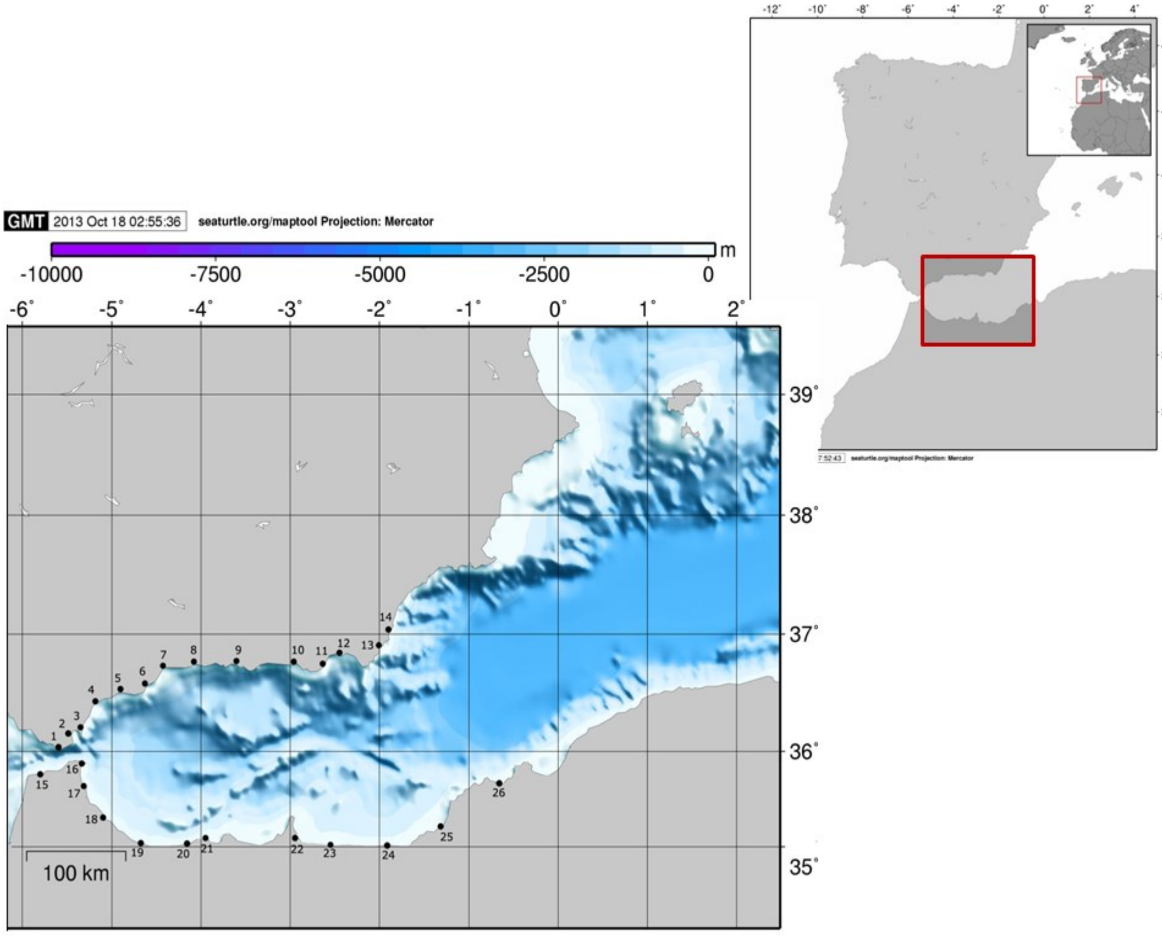

Figure 1. Map of Alboran sea. The most important landing ports, for the fishery vessels from Alboran Sea in the fishing-ground of open sea, are showed: (1) Tarifa, (2) Algeciras, (3) La Linea, (4) Estepona, (5) Marbella, (6) Fuengirola, (7) Málaga, (8) Caleta de Vélez, (9) Motril, (10) Adra, (11) Roquetas de Mar, (12) Almería, (13) Carboneras (out of Alboran sea in sensu stricto), (14) Garrucha (out of Alboran sea in sensu stricto), (15) Tanger, (16) Ceuta, (17) M´diq, (18) Stehat, (19) Jebha, (20) Cala Iris, (21) Al Hoceïma, (22) Beni Ansar (Nador), (23) Ras El Ma, (24) Ghazaouet (Tlemecen), (25) Bouzed jar (Ain Témouchent), and (26) Oran.

Figure 2. Some typical Spanish fishing ports. A) Algeciras; B) Carboneras. Images from the author.

A

B

Figure 3. A) port of Jebha (source: http://commons.wikimedia.org/wiki/File:Port_de_P%C3%AAche_de_Jebha,_Province_de_Chefchaouen,_Maroc.jpg); B) port of Ras El Ma (source: http://www.lesexpertsdumaroc-pro.com/eductour_roadshow/zoom_img_etr.php?img=etr40_img9.jpg).

Figure 4. Images of the port of Ghazaouet (Tlemecen) (source: http://ports.com/algeria/port-of-ghazaouet/photos/).

There is a marked socioeconomic gradient between Spain (within the European Union) and Morocco and Algeria (two least-developed countries). Spain is the ninth country in the world in the export of fish products, as well as being a major importer (FAO, 2012). However, Morocco is the major fisheries producer in Africa (FAO, 2012). Fisheries and aquaculture in Africa provide more than 7% of the work force engaged in the primary sector of fish production in the world (FAO, 2012). This provides an indication of the socio-economic importance of this activity in the three countries around the Alboran Sea. According to the FAO (2012) report, the countries that should improve their data collection and reporting systems are found mainly in Africa.

The Alboran Sea is an important area globally for marine traffic as it provides an important corridor that connects the Mediterranean Sea with the Atlantic Ocean which is crossed by 25% of global maritime traffic, which corresponds to approximately 90,000 vessels per year (Robles et al., 2007). Independent of the problems of ocean pollution spills or accidents at sea (e.g. the "Sea Spirit" in 1990 in Moroccan waters), this feature characterizes the fishing activity in the open sea areas from the Alboran Sea. Therefore, the bigger boats of greater gross tonnage could break the fishing gear or collide with slower fishing boats during fishing operations (Baez et al., 2009). Thus, the fishing grounds from open sea in the Alboran Sea are away from the main shipping lanes, and are closer to the coast than in other areas.

1.1. Oceanographic context

The Mediterranean is a peculiar sea from an oceanographic point of view, as important oceanic events occur on a small scale (Rodriguez, 1982). In this context, the Alboran Sea is the border with the Atlantic Ocean. Here, the superficial and less salty waters from the Atlantic come in the Mediterranean, where at the same time the deep Mediterranean waters, more saline, leave the Mediterranean. The Alboran Sea basin is considered as a channel bordered to the north by Spain and to the south by Morocco and is a water mixture transition zone between the Atlantic and Mediterranean waters (Parrilla & Kinder, 1987). The Atlantic Current in the Alboran Sea traces two anticyclonic gyres where surface waters accumulate (i.e. Alboran gyre) (figure 5). The surface current brings water from the Atlantic Ocean and it is that which is pushed towards the shore, and due to the shape of the shoreline, this current carries out two anticyclonic gyres (i.e. clockwise as viewed from above in the northern hemisphere), which together are termed the Alboran Gyre: The Western Alboran Gyre and the Eastern Alboran Gyre (WAG, EAG) (figure 5). As a result, the surface water of the Alboran Sea exhibits a lower salinity than Mediterranean water, mixing as it progresses eastwards with the higher salinity Mediterranean water. The Atlantic current surrounds and feeds the two anticyclonic gyres: the WAG and the EAG. Approximately two thirds of the Atlantic Ocean water entering the Strait of Gibraltar participates in the kinetic energy and flow of the Alboran Gyre (Parrilla & Kinder, 1987; Hogan, 2011).

The circulation exhibits considerable variability, characterized by the stability of the WAG, mainly in the summer months, and the instability of the EAG (Bás, 2002). This general circulation pattern creates a strong frontal system known as the Alboran Sea front. Many authors have reported an Alboran–specific upwelling process (Sarhan et al., 2000) which coincides approximately with the northern boundary of the Atlantic current and which is evidenced by strong thermal, haline and trophic north–south gradients. Moreover, the oceanography of the Alboran Sea responds to changes in the anticyclone of the Azores, as described by Parrilla and Kinder (1987). The Sea Surface Temperature factor in the Alboran

Sea is a complex variable, which is also influenced by factors other than downwelling and upwelling water masses. However, the annual average value of SST shows a low deviation in the Alboran Sea.

The Alboran basin presents the peculiar shape of a funnel, surrounded by a rugged coastline, with high peaks near to the sea, where it snow accumulates during the winter season, for example, Mulhacen and Veleta peaks (over 3.000 meters high from the southern Iberian Peninsula), Tidirhin and Akra (over 2.100 m from Rif Mountains, Morocco), and Tell Atlas (over 1.500 m, Algeria). Thus, the accumulated snow is an important fresh-water reservoir. This snow melting down in spring-summer of the following year, with the consequent increase in runoff of freshwater the sea and a consequent lessening of sea surface salinity and density and blocking of the local upwelling of colder water. This phenomenon could have an important effect on the marine productivity and larval growth (Báez et al., 2013a).

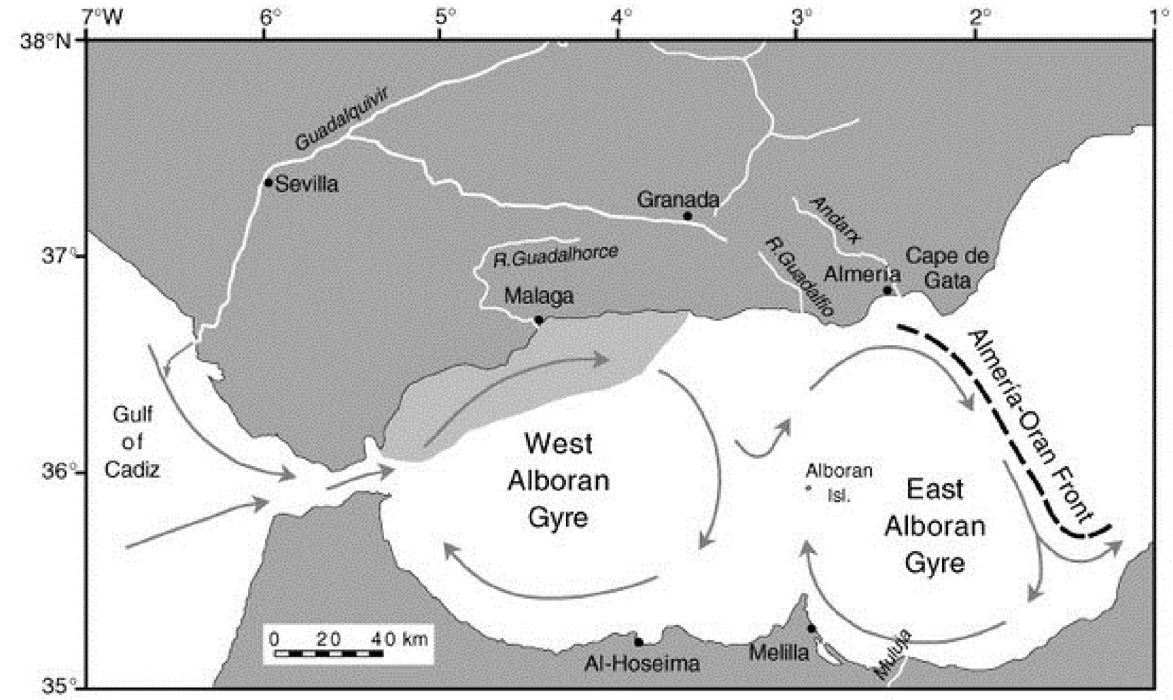

Figure 5. Alboran gyre, with the anticyclonics Western Alboran Gyre and the Eastern Alboran Gyre (WAG, EAG). The grey area shows the major phytoplankton productivity area. Source: Hauschildt et al. (1999), modified by Minas et al. 1984).

1.2. Regional Fisheries Management Organization: General Fisheries Commission for the Mediterranean (GFCM), and International Commission for the Conservation of Atlantic Tunas (ICCAT)

The Regional Fisheries Management Organisations (RFMOs) are international organisations formed by countries with fishing interests in an area and with fisheries management purposes. Thus, while some RFMOs have a purely advisory role, most have management powers to set catch and fishing effort limits, technical measures, and control obligations. The RFMOs provide reports and data about the principal exploited stocks. In the Alboran Sea two RFMOs have competence: the General Fisheries Commission for the Mediterranean (GFCM), and the International Commission for the Conservation of Atlantic Tunas (ICCAT). The GFCM is focused in the managing the principal exploited stocks in this sea, while that ICCAT is focused in fisheries management of highly-migratory species, mainly tuna, and swordfish.

The Alboran Sea corresponds to FAO area 37 and to Management Geographical Sub-Areas (GSA) of the General Fisheries Commission for the Mediterranean: GSA01 (north Alboran Sea), GSA02 (Alboran Island), and GSA03 (South Alboran Sea) and small portion of the GSA04 (Algeria) (GFCM, 2001) (figure 6).

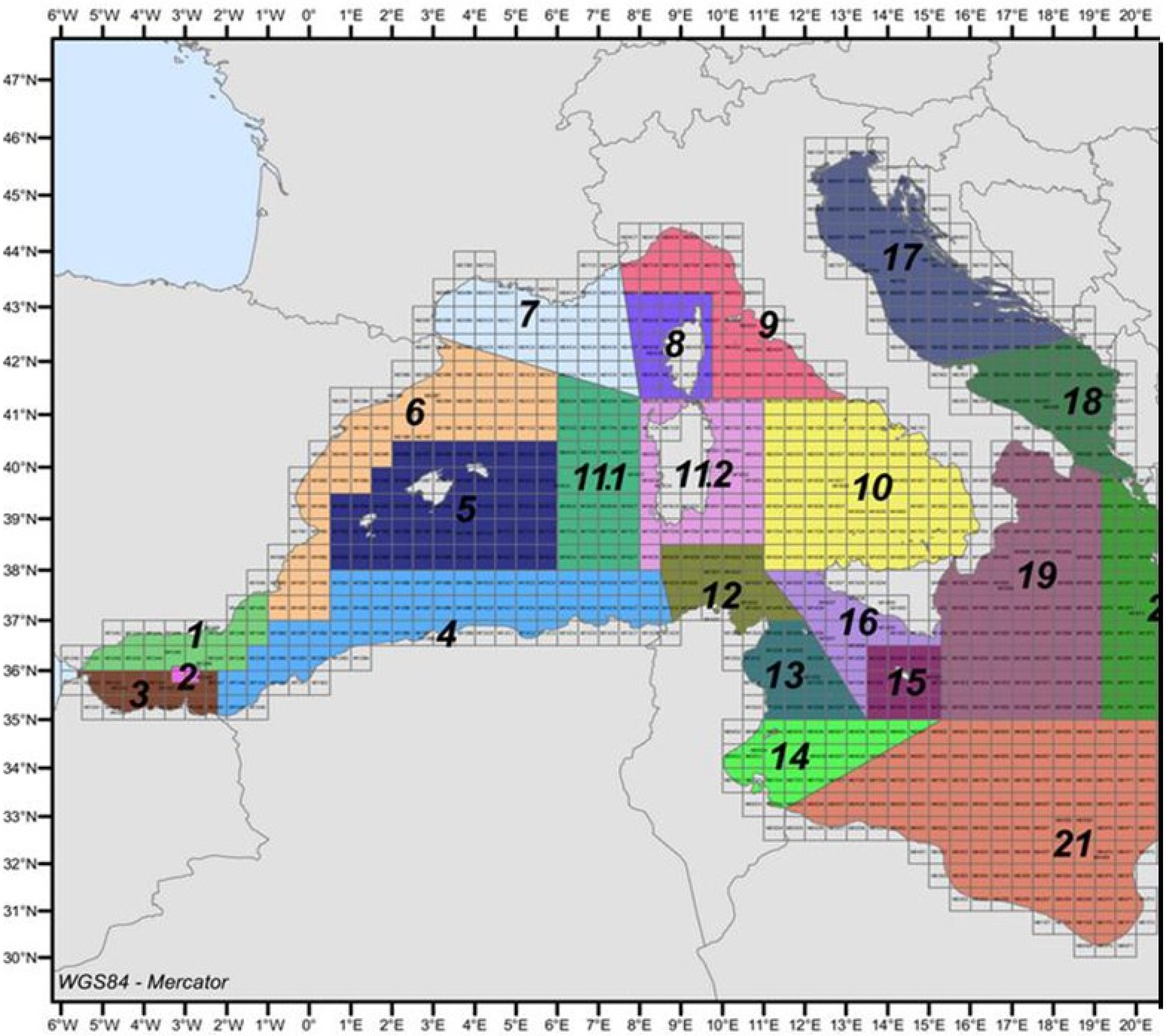

Figure 6. Management Geographical Sub-Areas (GSA) of the General Fisheries Commission for the Mediterranean: GSA01 (north Alboran Sea), GSA02 (Alboran Island), and GSA03 (South Alboran Sea) and a small portion of the GSA04 (Algeria) (GFCM, 2001) (Figure 2), coordinates: GSA01, Coast Line, 36º N 5º 36' W, 36º N 3º 20' W, 36º 05' N 3º 20' W, 36º 05' N 2º 40' W, 36º N 2º 40' W, 36º N 1º 30' W, 36º 30' N 1º 30' W, 36º 30' N 1º W, 37º 36' N 1º W; GSA02, 36º 05' N 3º 20' W, 36º 05' N 2º 40' W, 35º 45' N 3º 20' W, 35º 45' N 2º 40' W; GSA03, Coast Line, 36º N 5º 36' W, 35º 49' N 5º 36' W, 36º N 3º 20' W, 35º 45' N 3º 20' W, 35º 45' N 2º 40' W, 36º N 2º 40' W, 36º N 1º 13' W, Morocco-Algeria border.

Table 1. Principal exploited stocks studied by General Fisheries Commission for the Mediterranean(available from website: http://www.gfcm.org/gfcm/topic/166221/en).

Scientific name	CGPM code	English name	French name	Spanish name
Acipenser gueldenstaedtii	APG	Danube sturgeon	Esturgeon du Danube	Esturión del Danube
Acipenser stellatus	APE	Starry sturgeon	Esturgeon étoilé	Esturión estrellado
Acipenser sturio	APU	Sturgeon	Esturgeon commun	Esturión
Anguilla anguilla	ELE	European eel	Anguille d'Europe	Anguila europea
Aristaeomorpha foliácea	ARS	Giant red shrimp	Gambon rouge	Gamba española
Aristeus antennatus	ARA	Blue and red shrimp	Crevette rouge	Gamba rosada
Auxis rochei	BLT	Bullet tuna	Bonitou	Melva(=Melvera)
Boops boops	BOG	Bogue	Bogue	Boga
Coryphaena hippurus	DOL	Common dolphinfish	Coryphène commune	Lampuga
Eledone cirrosa	EOI	Horned octopus	Elédone commune	Pulpo blanco
Eledone moschata	EDT	Musky octopus	Elédone musquée	Pulpo almizclado
Engraulis encrasicolus	ANE	European anchovy	Anchois	Boquerón
Euthynnus alletteratus	LTA	Little tunny	Thonine commune	Bacoreta
Huso huso	HUH	Beluga	Béluga	Esturión beluga
Isurus oxyrinchus	SMA	Shortfin mako	Taupe bleue	Marrajo dientuso
Katsuwonus pelamis	SKJ	Skipjack tuna	Listao	Listado
Lamna nasus	POR	Porbeagle	Requin-taupe commun	Marrajo sardinero
Loligo vulgaris	SQR	European squid	Encornet	Calamar
Lophius budegassa	ANK	Blackbellied angler	Baudroie rousse	Rape negro
Lophius piscatorius	MON	Angler(=Monk)	Baudroie commune	Rape

Scientific name	CGPM code	English name	French name	Spanish name
Merlangius merlangus	WHG	Whiting	Merlan	Plegonero
Merluccius merluccius	HKE	European hake	Merlu européen	Merluza europea
Micromesistius poutassou	WHB	Blue whiting(=Poutassou)	Merlan bleu	Bacaladilla
Mullus barbatus	MUT	Red mullet	Rouget de vase	Salmonete de fango
Mullus surmuletus	MUR	Surmullet	Rouget de roche	Salmonete de roca
Nephrops norvegicus	NEP	Norway lobster	Langoustine	Cigala
Octopus vulgaris	OCC	Common octopus	Pieuvre	Pulpo común
Orcynopsis unicolor	BOP	Plain bonito	Palomette	Tasarte
Pagellus bogaraveo	SBR	Blackspot(=red) seabream	Dorade rose	Besugo
Pagellus erythrinus	PAC	Common pandora	Pageot commun	Breca
Palinurus elephas	SLO	Common spiny lobster	Langouste rouge	Langosta común
Palinurus mauritanicus	PSL	Pink spiny lobster	Langouste rose	Langosta mora
Parapenaeus longirostris	DPS	Deepwater rose shrimp	Crevette rose du large	Gamba de altura
Pecten jacobaeus				Peregrina
Pomatomus saltatrix	BLU	Bluefish	Tassergal	Anjova
Prionace glauca	BSH	Blue shark	Peau bleue	Tiburón azul
Psetta maxima	TUR	Turbot	Turbot	Rodaballo
Raja alba	RJA	White skate		Raya
Sarda sarda	BON	Atlantic bonito	Bonite à dos rayé	Bonito del Atlántico
Sardina pilchardus	PIL	European pilchard(=Sardine)	Sardine commune	Sardina europea

Scientific name	CGPM code	English name	French name	Spanish name
Sardinella aurita	SAA	Round sardinella	Allache	Alacha
Scomber scombrus	MAC	Atlantic mackerel	Maquereau commun	Caballa del Atlántico
Sepia officinalis	CTC	Common cuttlefish	Seiche commune	Sepia común
Solea solea	SOL	Common sole	Sole commune	Lenguado común
Squatina squatina	AGN	Angelshark		tiburon angel
Sprattus sprattus	SPR	European sprat	Sprat	Espadín
Thunnus alalunga	ALB	Albacore	Germon	Atún blanco
Thunnus thynnus	BFT	Atlantic bluefin tuna	Thon rouge de l'Atlantique	Atún rojo del Atlántico
Trachurus mediterraneus	HMM	Mediterranean horse mackerel	Chinchard à queue jaune	Jurel mediterráneo
Trachurus trachurus	HOM	Atlantic horse mackerel	Chinchard d'Europe	Jurel
Xiphias gladius	SWO	Swordfish	Espadon	Pez espada

2. Review of species distribution and population dynamics of fish in the priority area open sea, with particular emphasis on target areas for fisheries and reproductive zones

Due to the Atlantic Ocean water entering the Alboran Sea through the Strait of Gibraltar (i.e. the Alboran Gyre), the western Alboran Sea had marine species (plants and animals) with a strong Atlantic component wich are gradually replaced towards the eastern Alboran Sea, with a Mediterranen composition (Báez et al., 2004, 2005; Bermejo et al., 2013). In addition, the Atlantic Ocean waters entering the Alboran Sea through the Strait of Gibraltar are richer in nutrients than the surface Mediterranean water. For this reason, the plankton productivity levels are highest around the Bay of Malaga, coinciding with the flow of the western Alborán gyre (WAG). The plankton productivity peaks occur during spring, summer and autumn, and coinciding with spawning season of European anchovy (*Engraulis encrasicolus*), and sardine (*Sardina pilchardus*) (Giráldez & Abad, 1995; Camiñas et al., 2004). Thus, in the north of the Alboran Sea there are important areas for the spawning of many of fish species near to the coast (Camiñas et al., 2004). The European Anchovy and other important stocks perform their life cycle near to the coast (Giráldez & Abad, 1995; García et al., 2012). Moreover, recruitment in the fisheries could be related mainly to the climatic oscillations in contraposition to fisheries harvest (Camiñas et al., 2004, Báez & Real, 2011, García et al., 2012). On the other hand, the low recruitment of small pelagic fish could have cumulative impacts on large, long-lived, pelagic predators such as albacore (*Thunnus alalunga*) (Báez et al., 2011).

The submarine canyons of the Alboran Sea are also important reproductive zones for demersal fish. The origin of the submarine canyons is related with ancient fluvial erosion processes. They are generally short but in front of Almería there is a long submarine canyon of 75 km. The submarine canyon in front of Motril is near to the shoreline, while the submarine canyon off Algeciras and La Linea is very steep (Camiñas et al. 2004; Baro et al., 2012).

According to Camiñas et al. (2004), the principal target species of fisheries vessels of the Alboran Sea are mainly (in order of importance): bluefin tuna (*Thunnus thynnus*), sardine (*Sardina pilchardus*), European anchovy (*Engraulis encrasicolus*), European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), blue whiting (*Micromesistius poutassou*), red shrimp (*Aristeus antennatus*), and common octopus (*Octopus vulgaris*).

The bluefin tuna fishery consists of mainly traditional trap nets (*almadrabas*), bait boats and artisanal fisheries, that all fish over the continental shelf, although the south Andalusian longliners use a drifting longline targeting bluefin tuna (Camiñas et al., 2006; García-Barcelona et al., 2010a). Regarding sardine and European anchovy, they are heterogeneously distributed in a W-E axis near to the shoreline, for this reason the fishery is mainly by purse seiners near to the coast. Although, some purse seiners could operate on shelf slope. In addition, European hake, red mullet, and common octopus are fished over the continental shelf near to the coast by trawlers (Camiñas et al., 2004, Báez & Real, 2011, García et al., 2012).

Twenty-eight year historical series of fish landings were obtained from Galisteo et al. (2001a, 2001b, 2002, 2004, 2005) Alonso-Pozas et al. (2007), Galisteo et al. (2007, 2008, 2009a, 2009b, 2011, 2012, 2013) for the North Alboran Sea. According to these data, for the North Alboran Sea, the most important target non-tuna species, in weight from open sea are: blue whiting (*Micromesistius poutassou*), horse mackerel (*Trachurus trachurus*), chub mackerel (*Scomber japonicus*), silver scabbardfish (*Lepidopus caudatus*), and Atlantic pomfret (*Brama brama*). No data are available for the weight landings of non-tuna species from the southern Alboran Sea, however it should not be so different of the reporting for the northern Alboran.

According to the data available from ICCAT (2013), regarding tunas fisheries in open sea from South Alboran Sea the mainly target species are: bluefin tuna (*Thunnus thynnus*)[8], little tunny (*Euthynnus alletteratus*), skipjack tuna (*Katsuwonus pelamis*), plain bonito (*Orcynopsis unicolor*), Atlantic bonito (*Sarda sarda*), bullet tuna (*Auxis rochei*), and swordfish (*Xiphias gladius*). On the other hand, the most important target -tuna and associates fish, in weight for open sea from North Alboran Sea are (according to Galisteo et al. 2001a, 2001b, 2002, 2004, 2005; Alonso-Pozas et al. 2007, and Galisteo et al. 2007, 2008, 2009a, 2009b, 2011): bullet tuna (*Auxis rochei*), Atlantic bonito (*Sarda sarda*), swordfish (*Xiphias gladius*), and little tunny (*Euthynnus alletteratus*).

2.1. Population dynamics of non-tuna fish in the priority area open sea of the Alboran Sea

There exist previous assessments done by the GFCM on small pelagic and demersal fisheries by GSA areas (for example see the recent assessment GFCM: SAC 14/2012/Inf.8). The open sea limits of the Alboran Sea don't coincide with a complete GSA (vg. the GSA01 exceeds including the area from Cape of Gata to Cape of Palos or GSA03 border excludes the Argelia's shore) (figure 7). Thus we used for the analysis of the non-tuna species population dynamics in the priority area's open sea the available local data.

According to the data available in Galisteo et al. (2001a, 2001b, 2002, 2004, 2005), Alonso-Pozas et al. (2007), and Galisteo et al. (2007, 2008, 2009a, 2009b, 2011, 2012, 2013), for the North Alboran Sea, the evolution of the landlings trend (in weight) was plotted for the most important non-tuna species targeted. We analysed the time series of each fish stock. We searched for temporal autocorrelation, which implyes a overfish harvest. In addition, using the Spectral Analysis, we identified a periodicity in the time series. All the time series' analysis were performed with the software PAST (available from http://folk.uio.no/ohammer/past/) (Hammer et al., 2001; Hammer & Harper, 2006).

[8] We refer to fish caught by surface longliners and puserse seiners

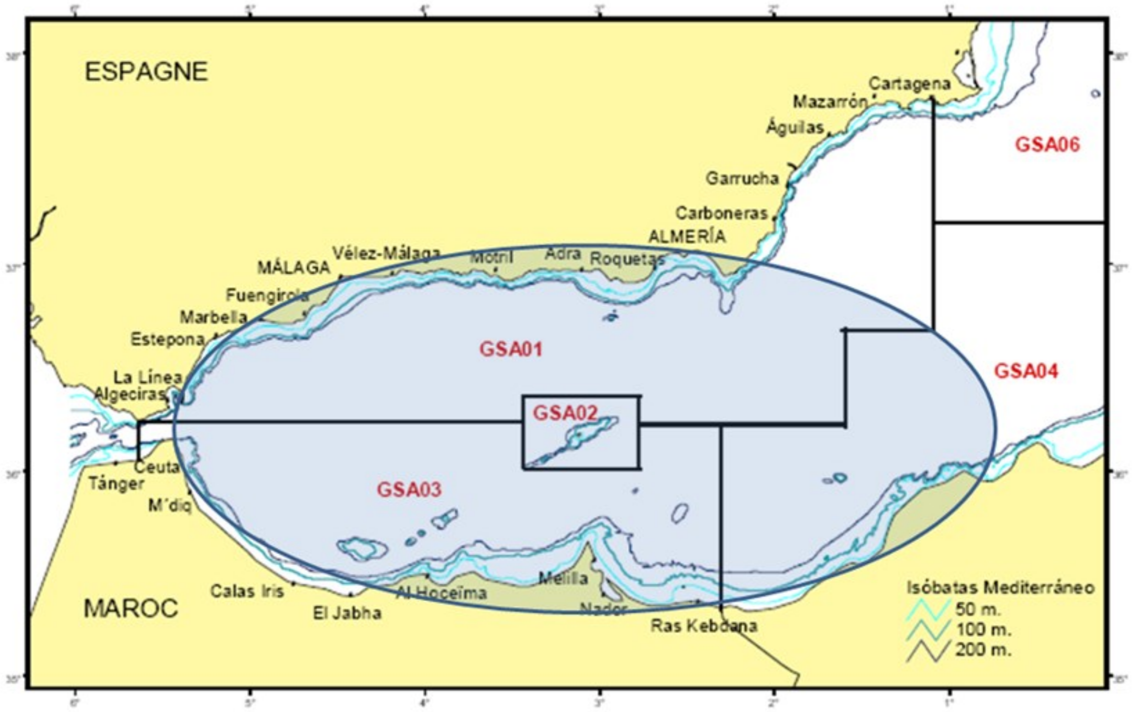

Figure 7. Limits of GSA01, GSA02, GSA03 and GSA04 on the Alboran Sea (the Alboran Sea limits are shadowed).

The figures 8 and 9 show the evolution from the northern Alboran Sea of the landings trend in sardine and European anchovy catches, respectively since 1985 to 2012. In both cases there is a gradual decline in catches over time. According to previous GFCM's assessments on small pelagics from GSA03, the Southern Alboran sea *Sardina pilchardus* showed a moderate exploitation rate in the east and high in the west; its biomass level was lower than previous year. In conclusion, the *Sardina pilchardus* fishery in the Southern Alboran sea is fully exploited (GFCM:SAC14/2012/Inf.8) (figure 10). The management recommendations were:

- Maintain the current fishing mortality;

- Reduce the mortality of fishing on the spawning fish

- Introduce seasonal closure during January which coincides with the peak of the spawning;

- Prohibition of fishing during May near Short-nap, close Kebdana, to preserve the young fish.

Simlarly Giráldez (2010 in CopeMed II. 2011) observed a gradual decline in European anchovy catches over time from GSA01 (figure 11).

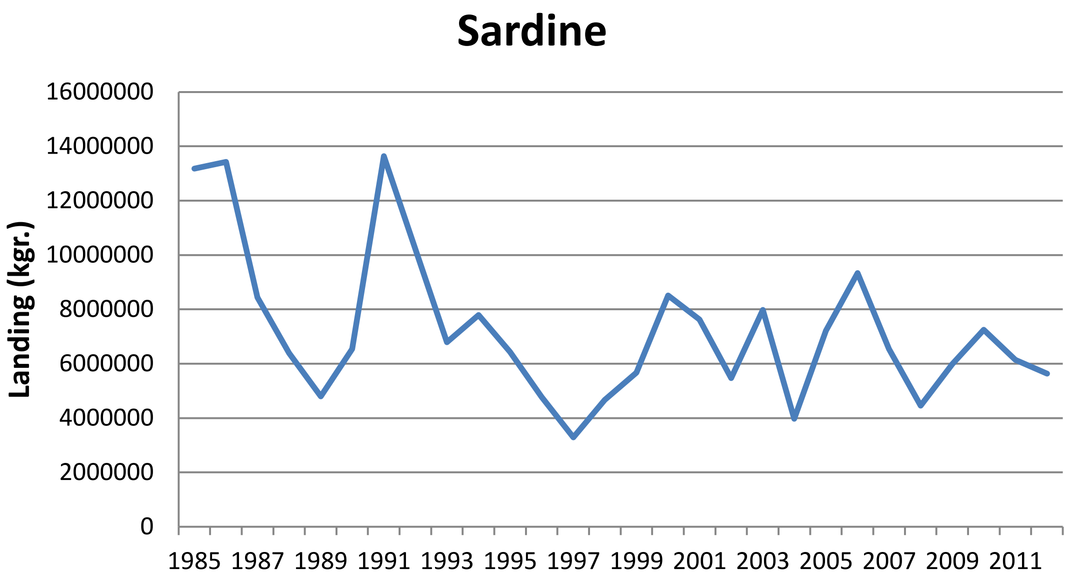

Figure 8. Evolution from the northern Alboran Sea of the landings trend from sardine, since 1985 to 2012. We observed a gradual decline in catches over time, but there is an oscillation trend.

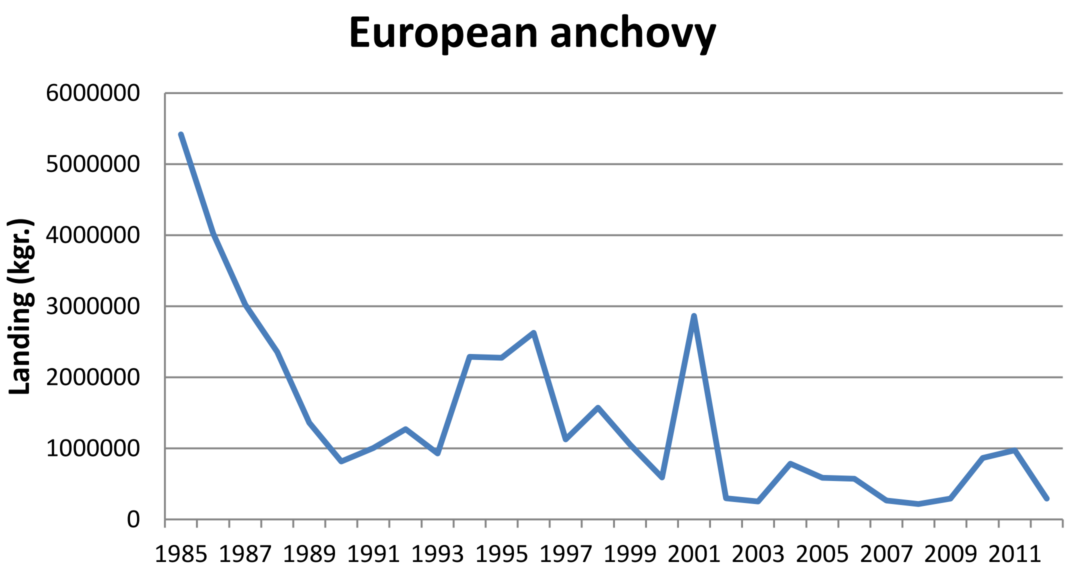

Figure 9. Evolution from the northern Alboran Sea of the landings trend from European anchovy, since 1985 to 2012. A gradual decline in catches over time is observed.

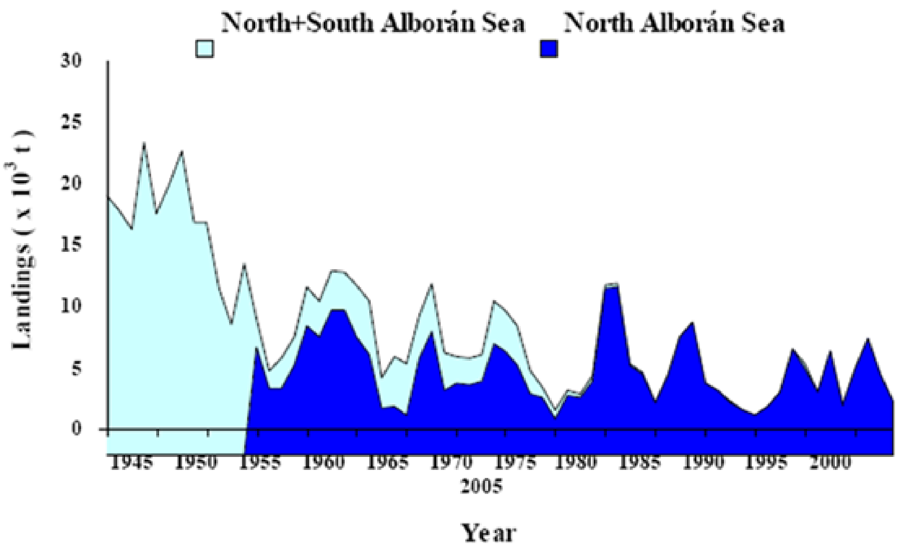

Figure 10. Landings of sardine captured by the Spanish fleet in the southern Mediterranean region (1945-2008). Modified Giraldez (2010 in in CopeMed II. 2011).

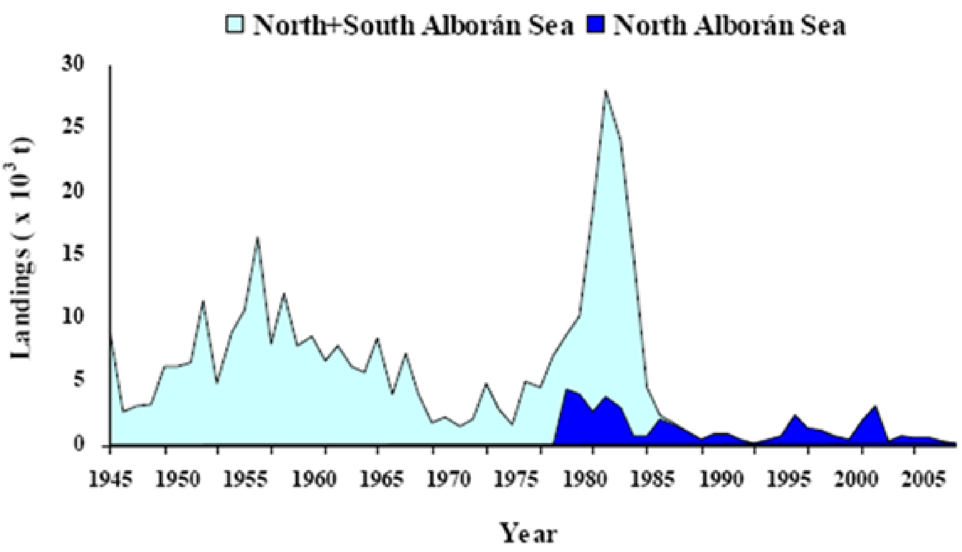

Figure 11. Landings of European anchovy captured by the Spanish fleet in the southern Mediterranean region (1945-2008). Modified Giraldez (2010 in in CopeMed II. 2011).

The figures 12 to 16 show the evolution of the landings trends in blue whiting (*Micromesistius poutassou*), horse mackerel (*Trachurus trachurus*), chub mackerel (*Scomber japonicus*), silver scabbardfish (*Lepidopus caudatus*) and Atlantic pomfret (*Brama brama*).

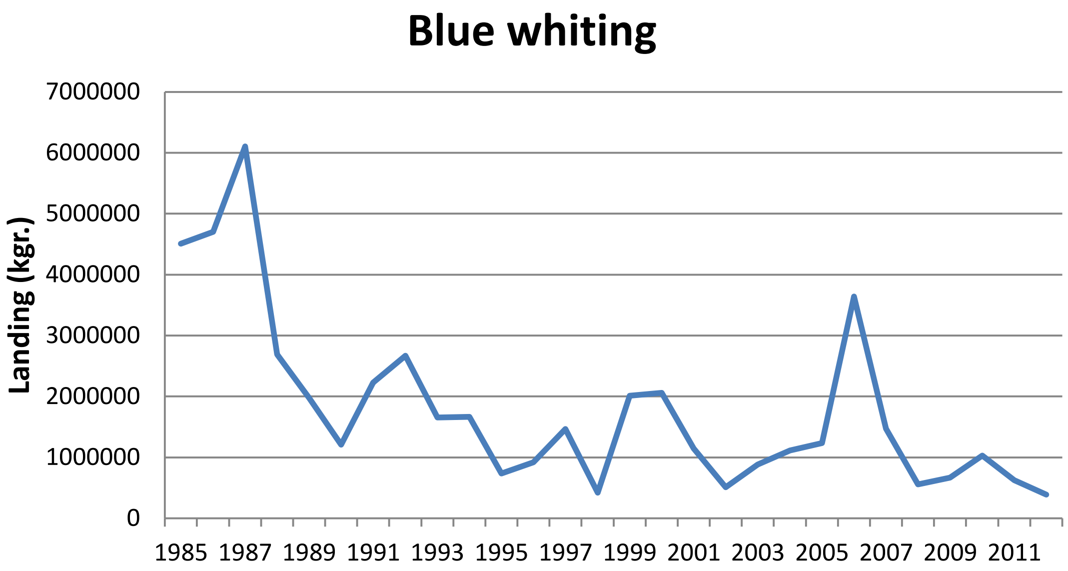

Figure 12. Evolution from the northern Alboran Sea of the landing trend from blue whiting, since 1985 to 2012. We observed a gradual decline in catches over time.

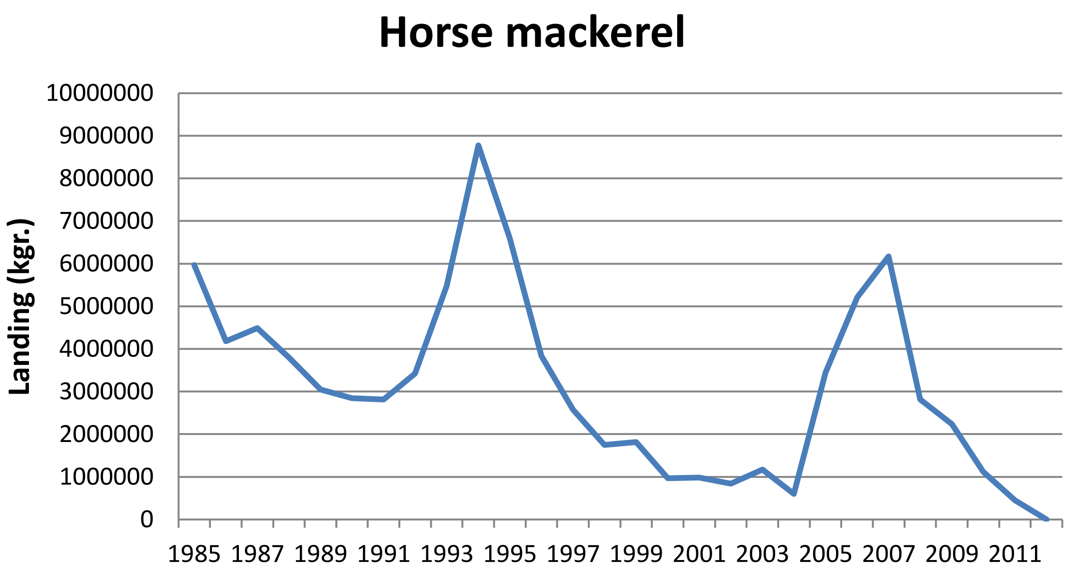

Figure 13. Evolution from the northern Alboran Sea of the landing trend from horse mackerel, since 1985 to 2012. We observed two different peaks, and a decline trend.

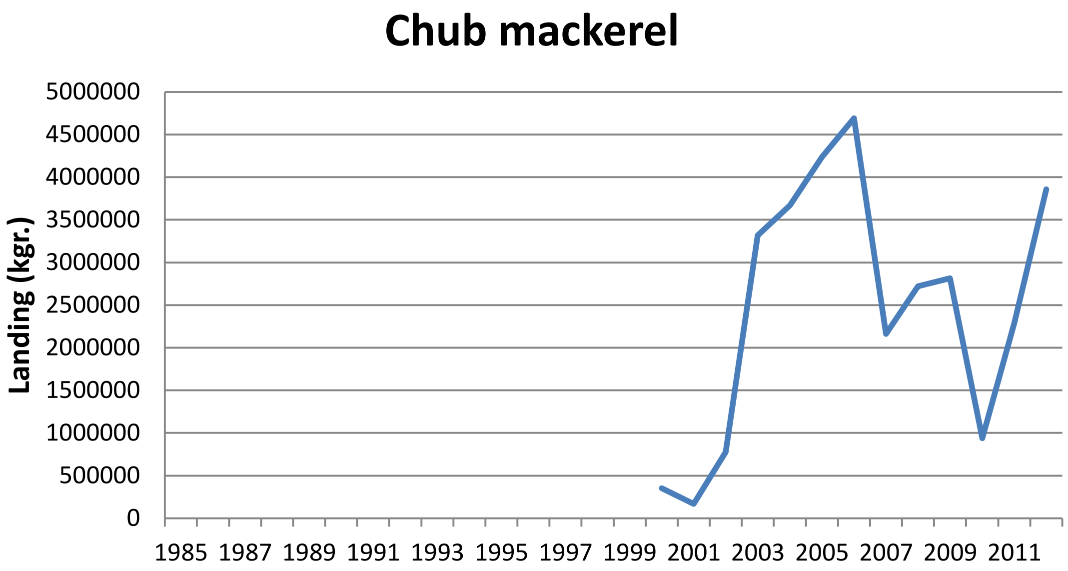

Figure 14. Evolution from the northern Alboran Sea of the landing trend from chub mackerel, since 2000 to 2012. We observed an irregular trend. This could be motivated by the oscillation of prices and market demand, and not in the abundance of the resource.

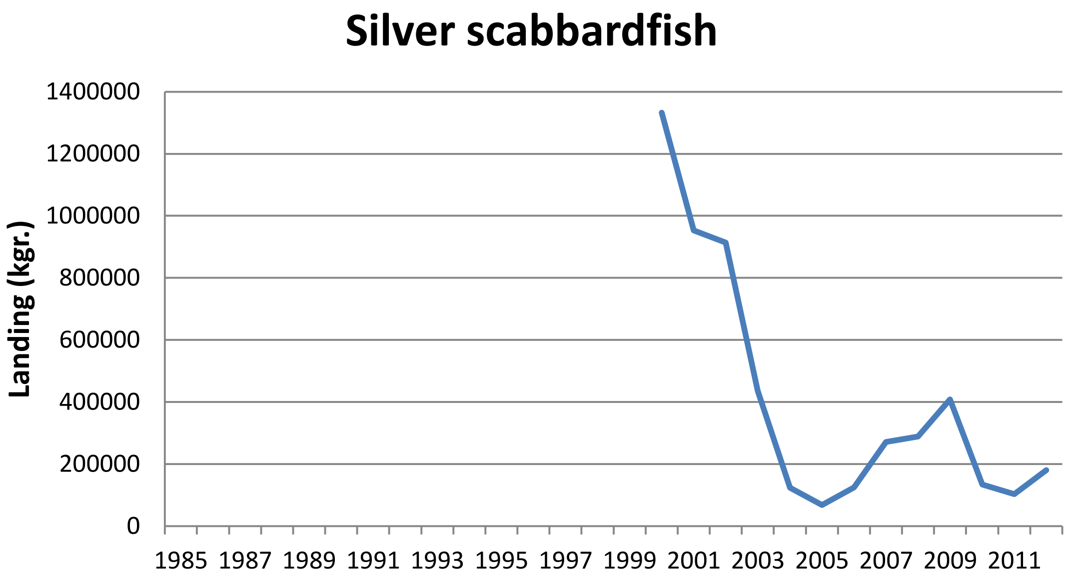

Figure 15. Evolution from the northern Alboran Sea of the landing trend from silver scabbardfish, since 2000 to 2012. We observed a marked decline in the abundance of the resource.

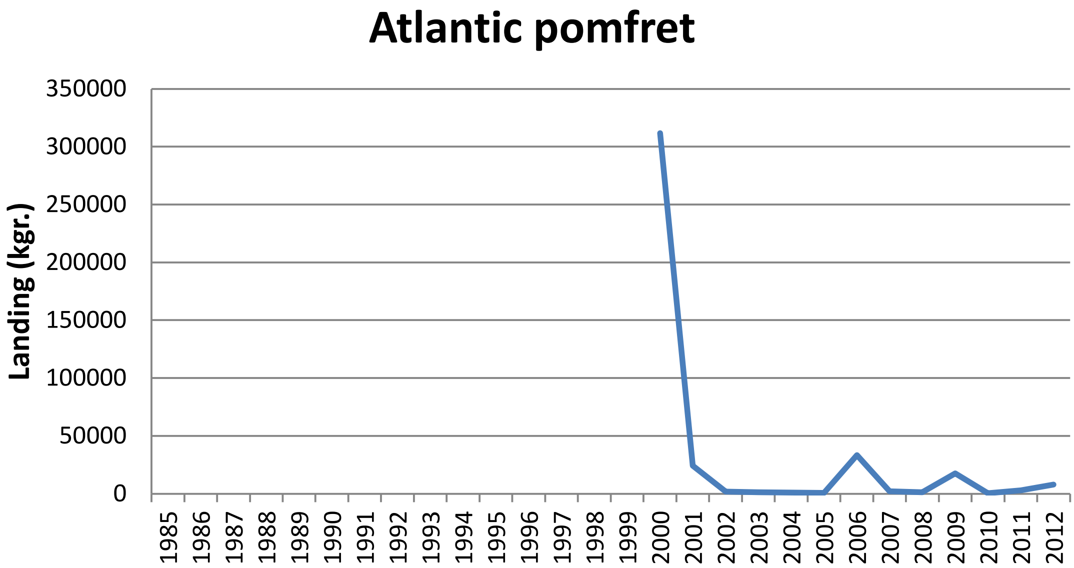

Figure 16. Evolution in the northern Alboran Sea of the landing trend from Atlantic pomfret, since 2000 to 2012. We observed a marked decline in the abundance of the resource.

The figures 14 to 20 show the temporal autocorrelation for each fish stock.

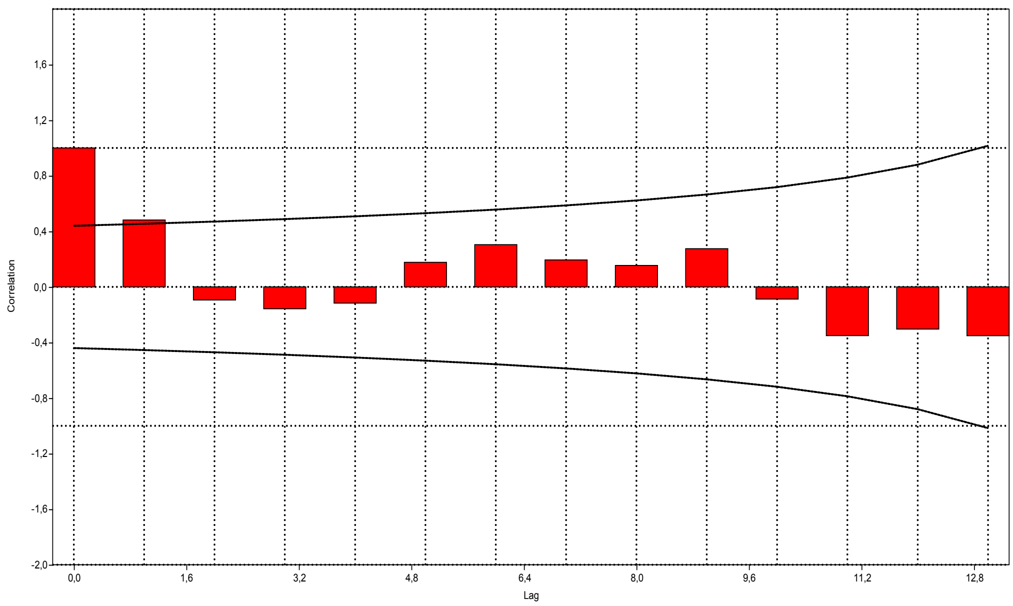

Figure 17. Temporal autocorrelation of the sardine, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelation.

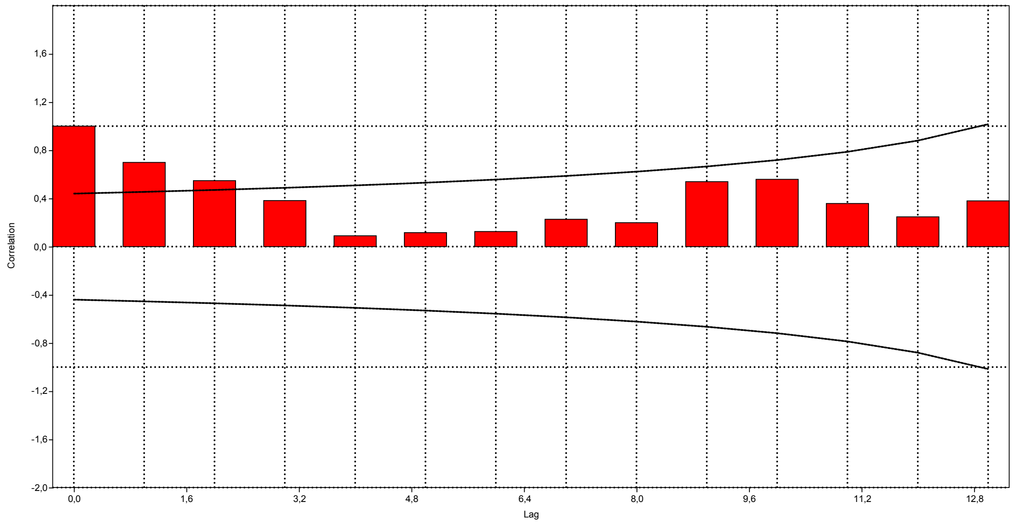

Figure 18. Temporal autocorrelation of the European anchovy, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelation.

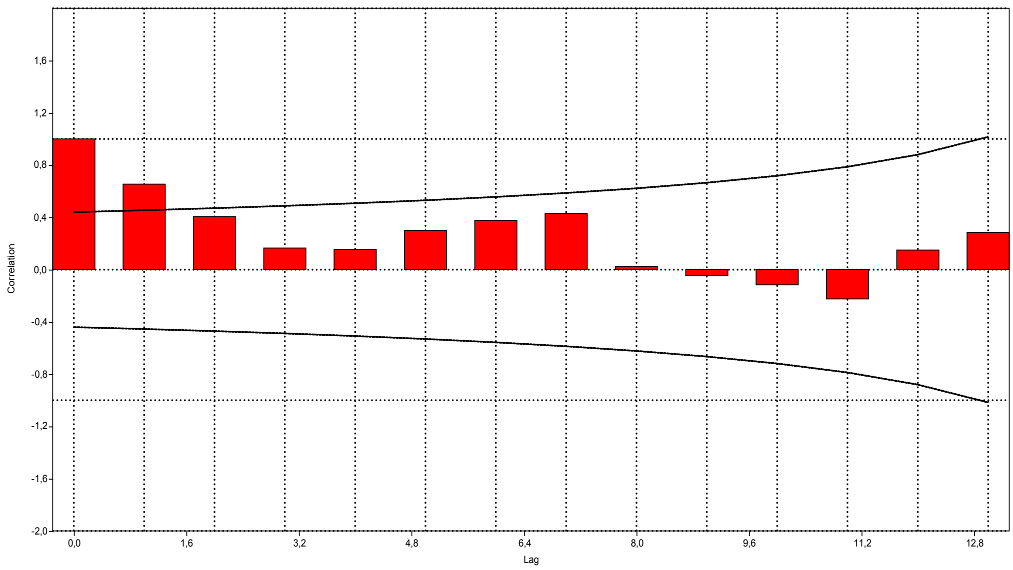

Figure 19. Temporal autocorrelation of the blue whiting, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelation.

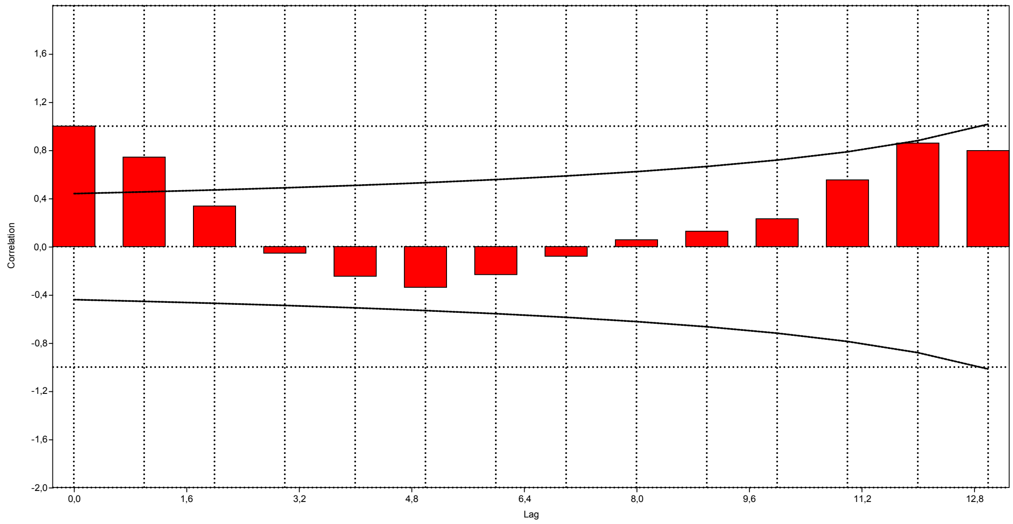

Figure 20. Temporal autocorrelation of the horse mackerel, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case the temporal autocorrelations is low.

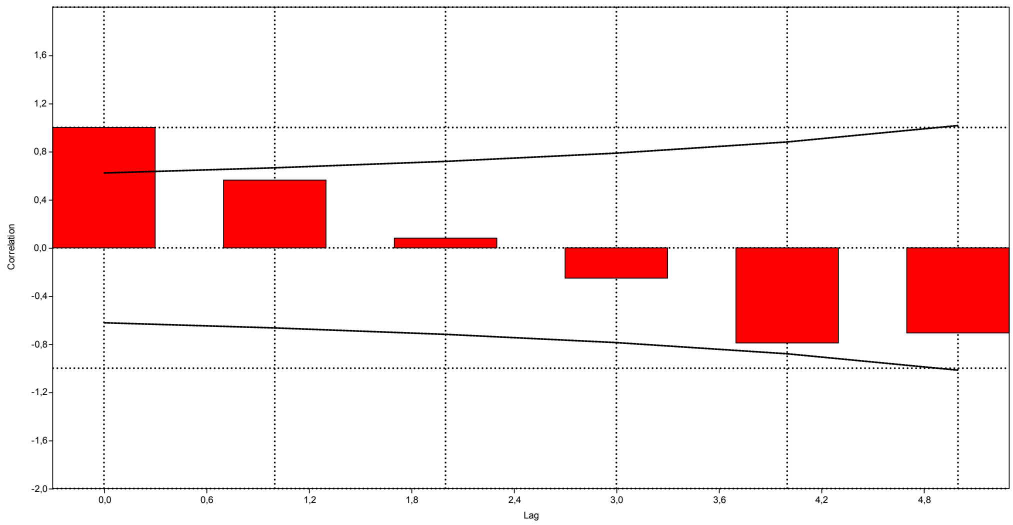

Figure 21. Temporal autocorrelation of the chub mackerel, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelation; however, the number of years analysed is low (since 2000 to 2012).

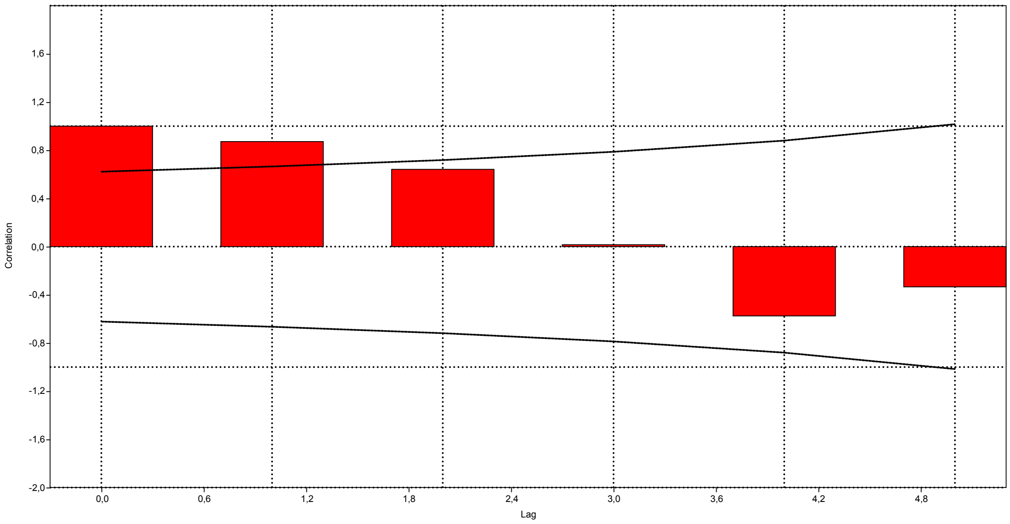

Figure 22. Temporal autocorrelation of the silver scabbardfish, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelation; however, the number of years analysed is low (since 2000 to 2012).

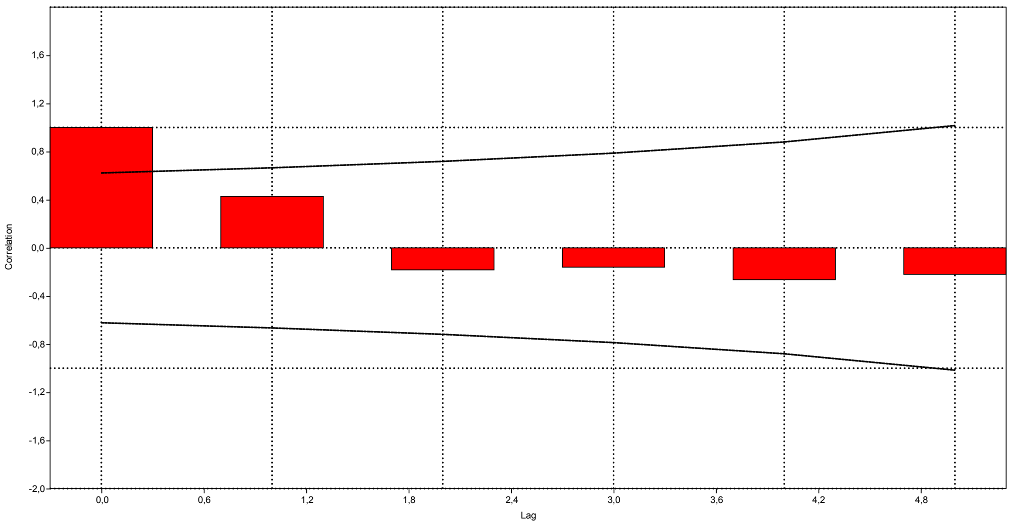

Figure 23. Temporal autocorrelation of the Atlantic pomfret, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelation.

Our models show a clear decline in the fish stocks of European anchovy, blue whiting, silver scabbardfish and Atlantic pomfret. The evolution of the chub mackerel, since 2000 to 2012, could be related to the oscillation of prices and market demand, and not to the abundance of the resource.

On the other hand, we found that the sardine abundance trend is positively correlated with the winter North Atlantic Oscillation index (from October to December of previous year) ($r= 0.375$; $p= 0.049$). The North Atlantic Oscillation (NAO) is a dominant pattern of coupled ocean-climate variability in the North Atlantic and Mediterranean basin (Hurrell 1995; Hurrell et al., 2003). Many authors have observed a relationship between the NAO and changes in fisheries abundance (Báez et al. 2011; Báez and Real 2011) and recruitment (Fromentin 2001). The NAO reflects fluctuations in atmospheric pressure at sea-level between the Icelandic Low and the Azores High. The NAO is associated with many meteorological variations in the North Atlantic region, affecting wind speed and direction and differences in temperature and rainfall (Hurrell 1995; Hurrell et al., 2003). This results show how the stock of sardine is related with the climate. The fluctuation of the landing trend from horse mackerel, since 1985 to 2012, is remarkable. We observed two different peaks, and a decline trend. The results of the Spectral Analysis (see figure 21) indicate that exists a periodical cycle of twelve years. Thus, considering the mackerel's population dynamics the stock could recover from the overfishing.

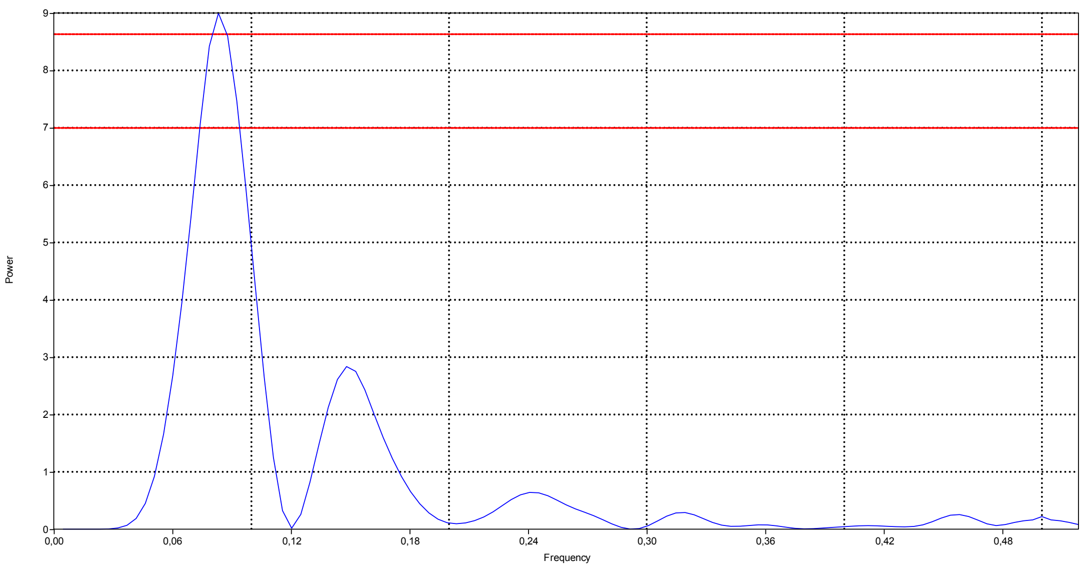

Figure 24. Spectral Analysis for horse mackerel. The vertical axis shows the power value while the horizontal axis shows the frequency. The red lines indicate the significant values (0.05 and 0.01, respectively). In this case the significant peak has a frequency of 0.0833 (i.e. twelve years of periodicity).

2.2. Population dynamics of tuna and associate fishes in the priority area open sea from Alboran Sea

According to the data available in Galisteo et al. (2001a, 2001b, 2002, 2004, 2005) Alonso-Pozas et al. (2007), and Galisteo et al. (2007, 2008, 2009a, 2009b, 2011, 2012, 2013), the evolution of the landing trend from North Alboran Sea is plotted for the most important tuna and associate fishes targeted (in weight) from open sea. According to the data available in ICCAT (2013) for South Alboran Sea, the evolution of the landing trend is plotted from the most important target tuna species in weight from open sea, and listed above. Then, we analysed the time series of each fish stock. We searched for temporal autocorrelation, which imply an overfish harvest. In addition, we identify periodicity in the time series, using the Spectral Analysis. All the time series analysis were performed with the software PAST (available from web site: http://folk.uio.no/ohammer/past/) (Hammer et al., 2001; Hammer & Harper, 2006).

The figures 22 and 25 show the evolution in the northern Alboran Sea of the landings trends in tuna catches, listed above, since 1985 to 2012. The figures 26 to 30 shows the evolution in the Southern Alboran Sea of the landings trends in tuna catches.

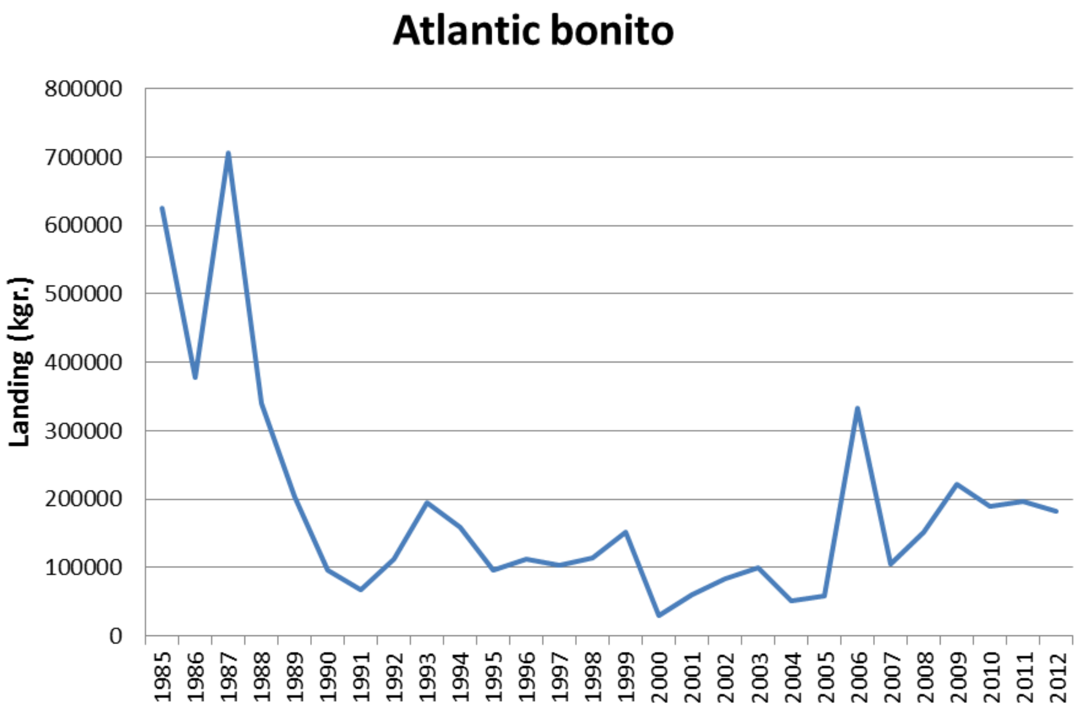

Figure 25. Evolution from the northern Alboran Sea of the landing trend from Atlantic bonito, since 1985 to 2012. We observed a gradual decline in catches over time.

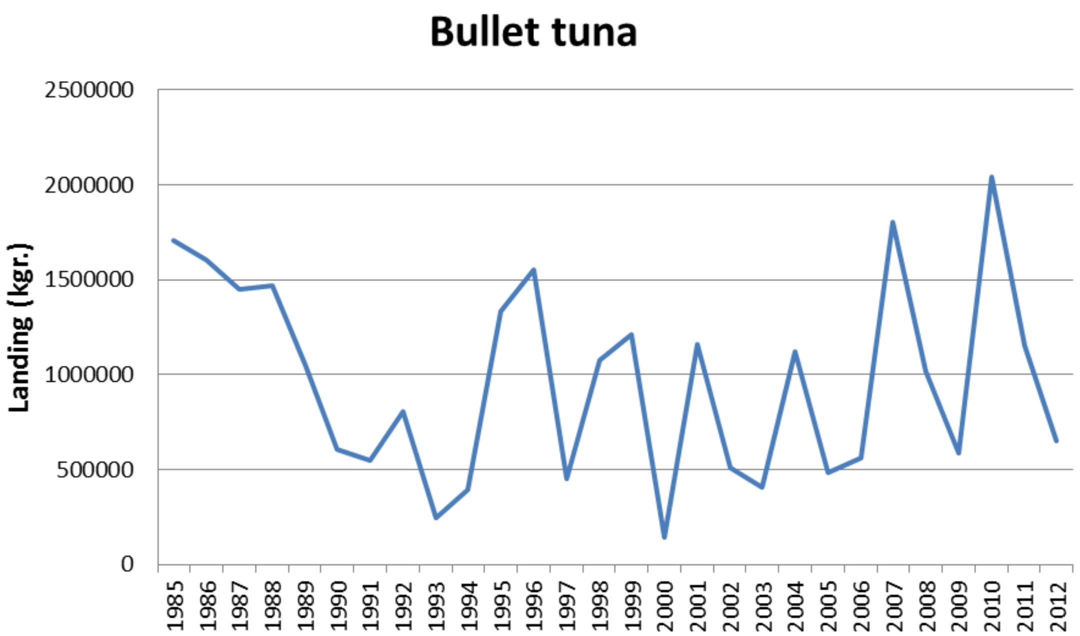

Figure 26. Evolution from the northern Alboran Sea of the landing trend from bullet tuna, since 1985 to 2012. We observed an oscillation trend.

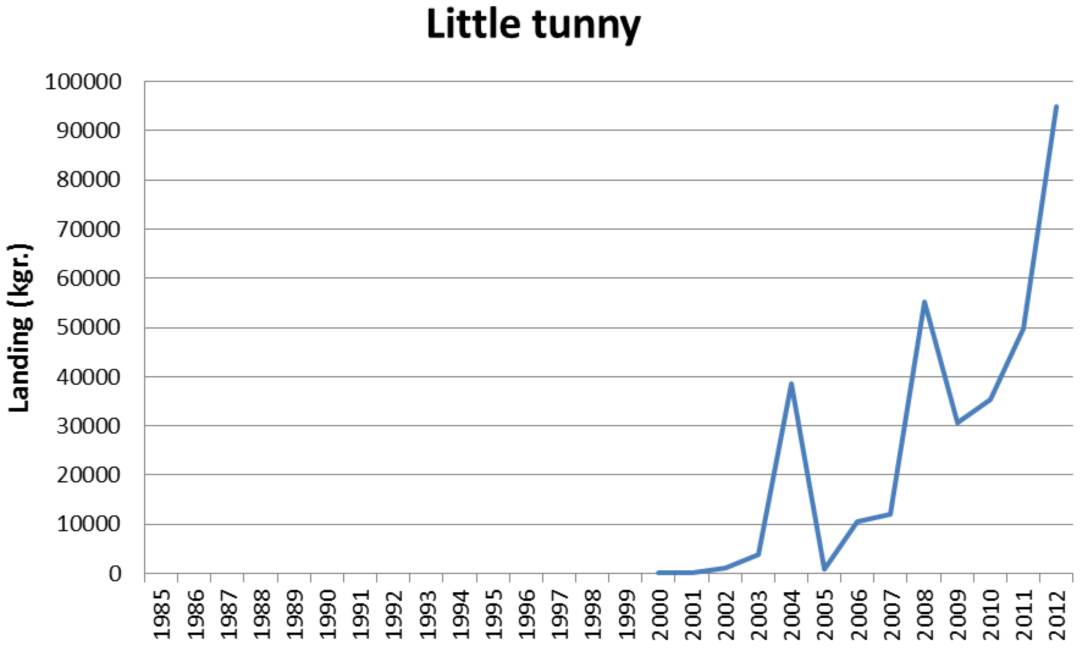

Figure 27. Evolution from the northern Alboran Sea of the landing trend from little tunny, since 1985 to 2012. We observed a gradual increasing in catches over time.

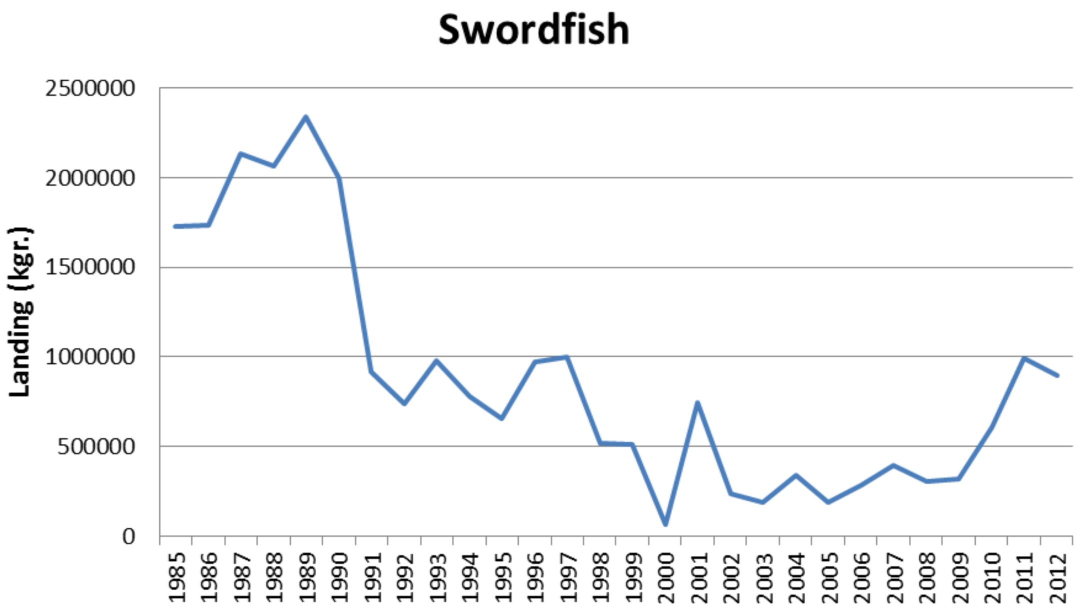

Figure 28. Evolution from the northern Alboran Sea of the landing trend from swordfish, since 1985 to 2012. We observed a gradual decline in catches over time.

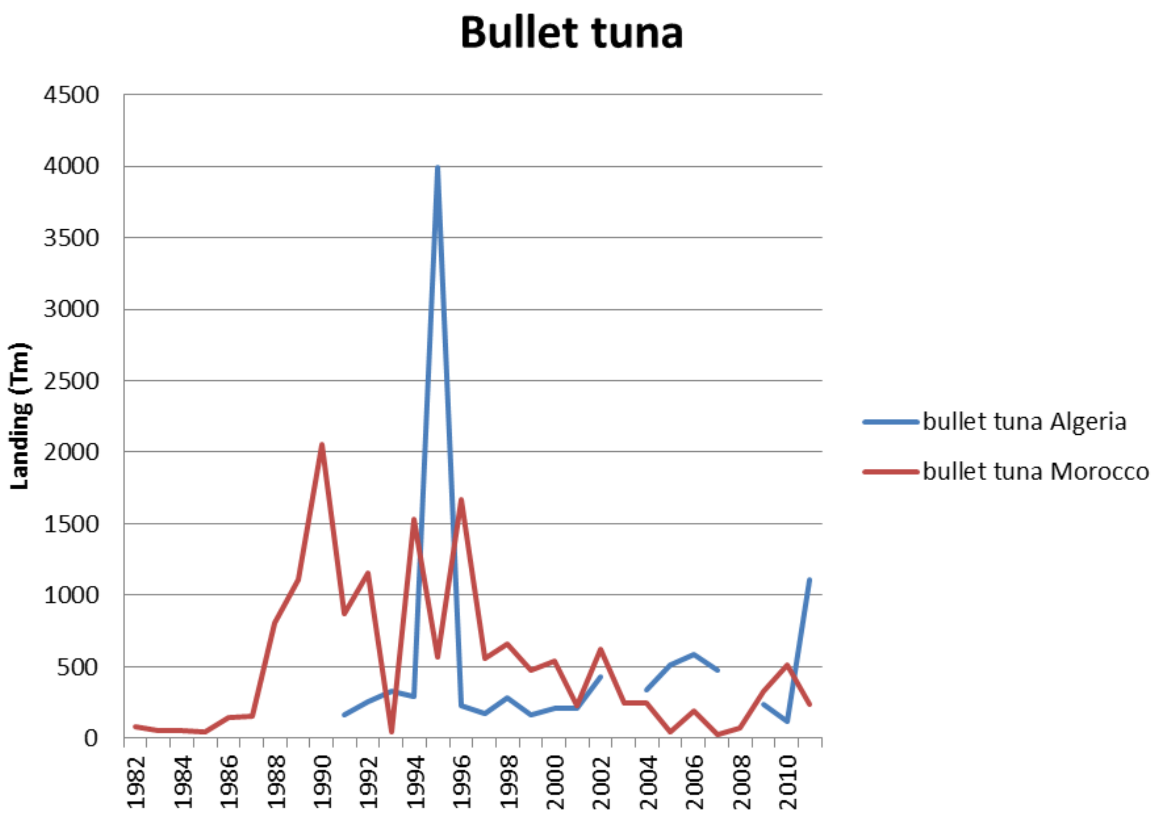

Figure 29. Evolution from the northern Alboran Sea of the landing trend from bullet tuna, since 1982 to 2011. We observed an irregular trend. Algeria data correspond to the pooled data of the country.

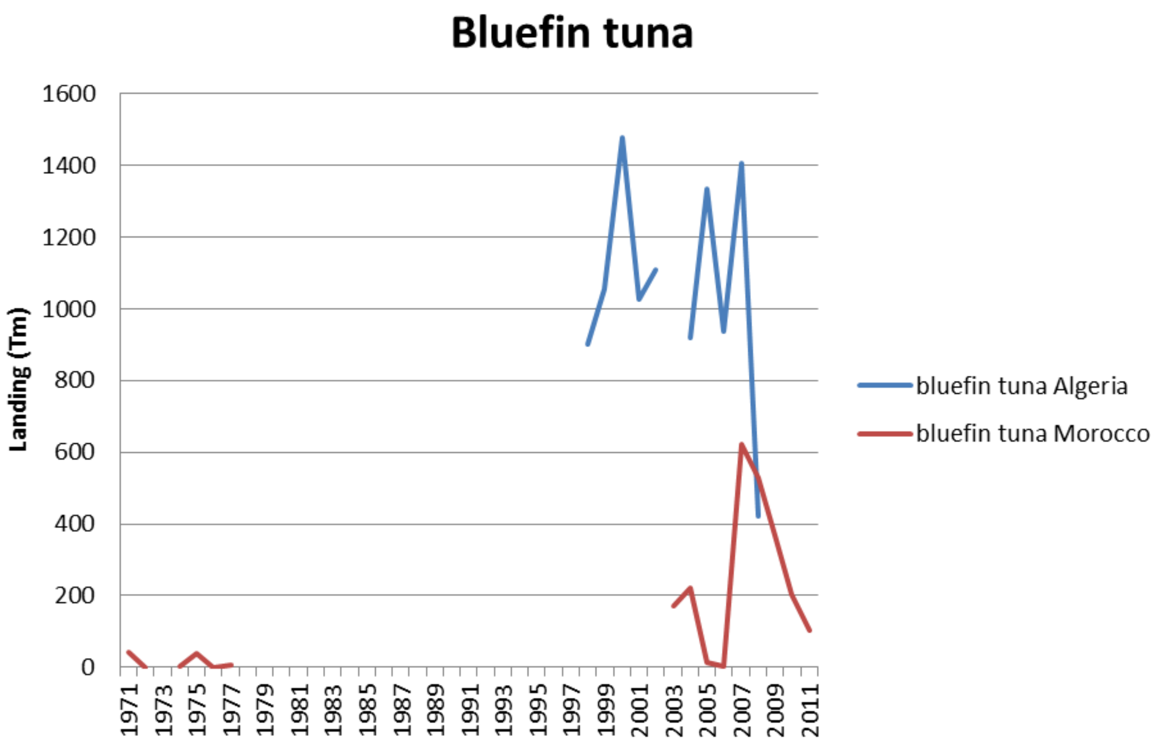

Figure 30. Evolution from the northern Alboran Sea of the landing trend from Bluefin tuna, since 1971 to 2011. We observed an irregular trend. Algeria data correspond to the pooled data of the country.

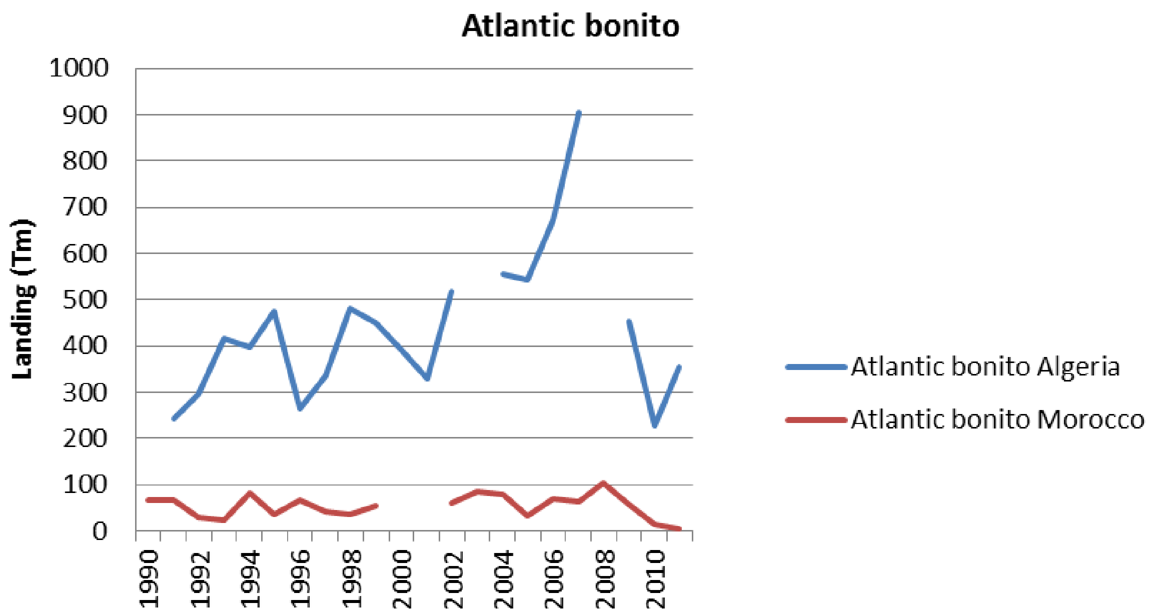

Figure 31. Evolution from the northern Alboran Sea of the landing trend from Atlantic bonito, since 1990 to 2011. Algeria data correspond to the pooled data of the country.

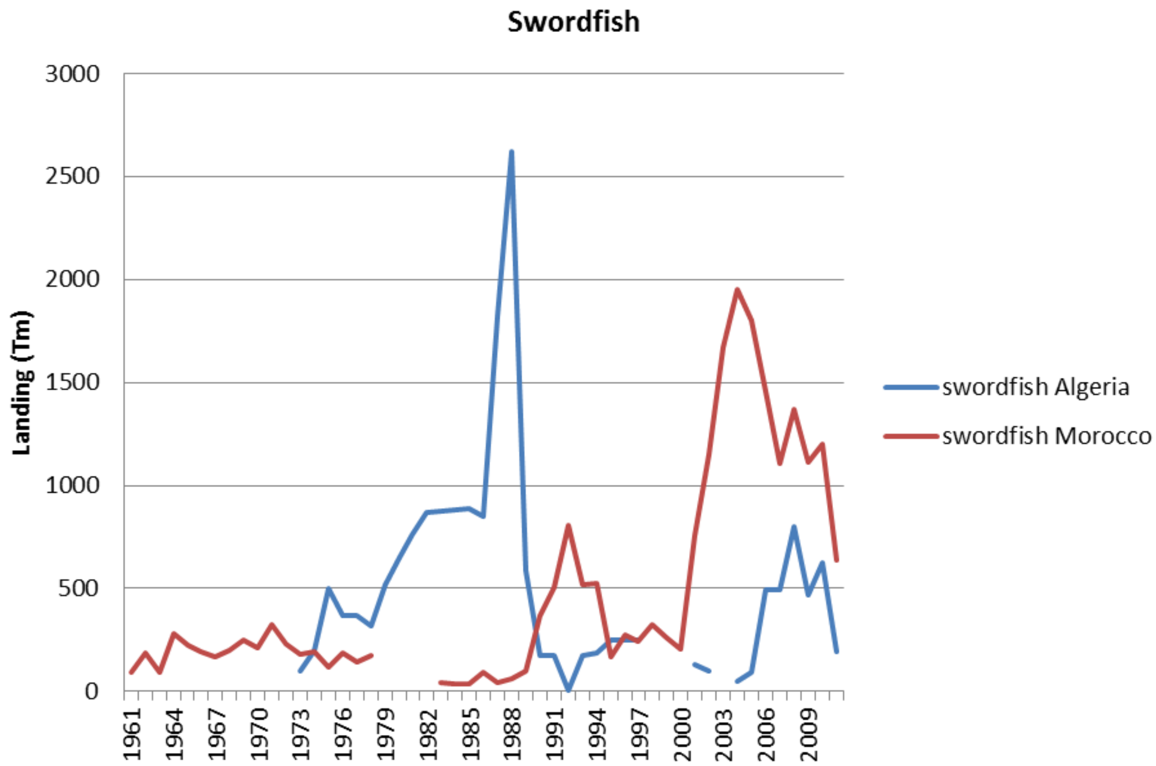

Figure 32 Evolution from the northern Alboran Sea of the landing trend from swordfish, since 1961 to 2011. Algeria data correspond to the pooled data of the country.

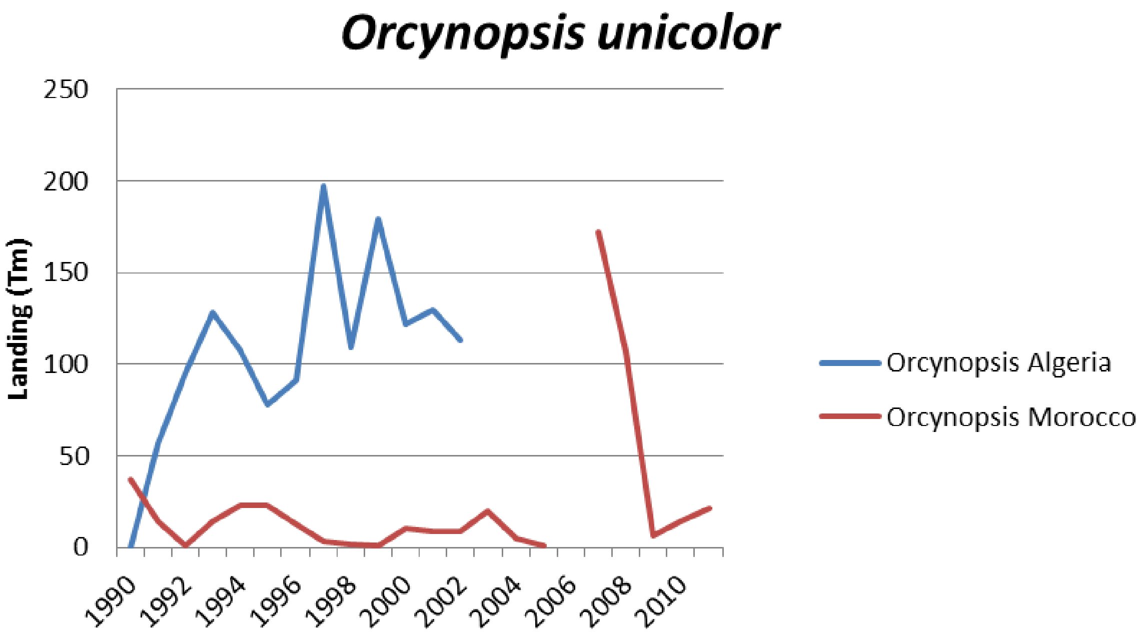

Figure 33. Evolution from the northern Alboran Sea of the landing trend from *Orcynopsis unicolor*, since 1990 to 2011. Algeria data correspond to the pooled data of the country.

The figures 34 to 36 shows the temporal autocorrelation for each fish stock from north of Alboran Sea, and the figures 37 and 38 shows the temporal autocorrelation from bullet tuna and swordfish from south of Alboran Sea.

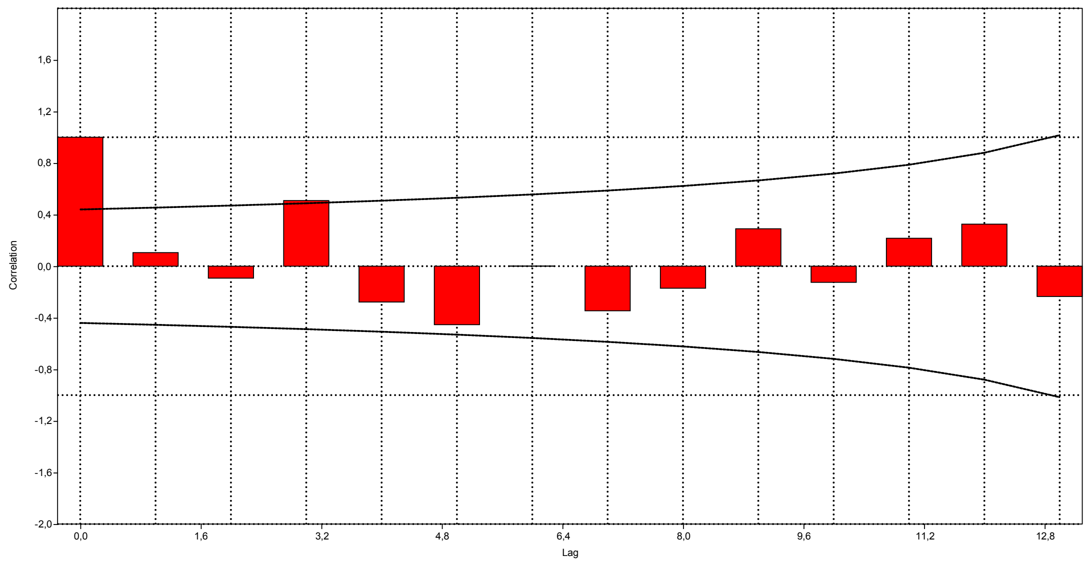

Figure 34. Temporal autocorrelation of the bullet tuna from North of Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

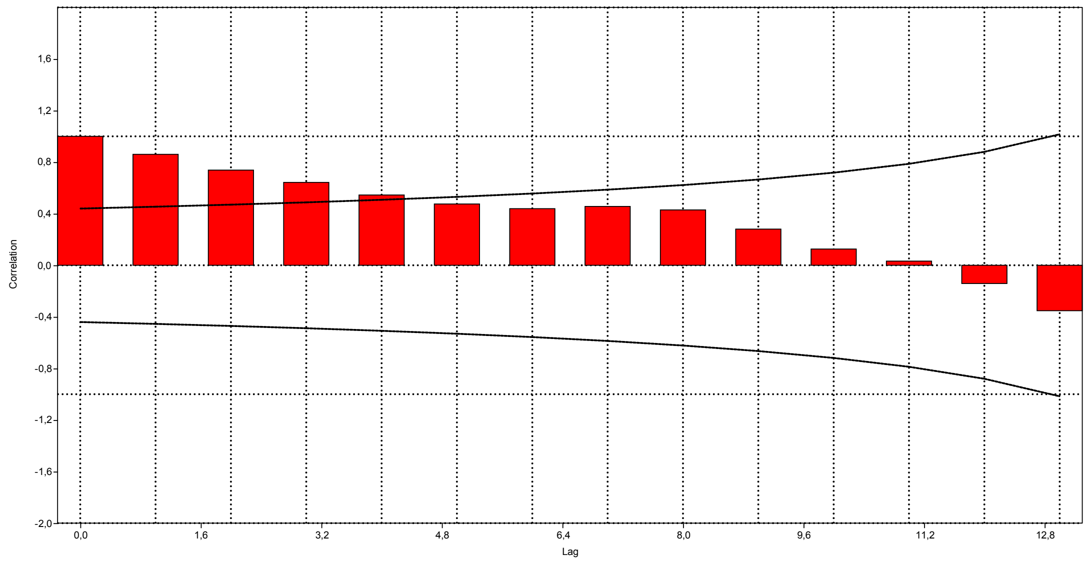

Figure 35. Temporal autocorrelation of the swordfish from North of Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is temporal autocorrelations.

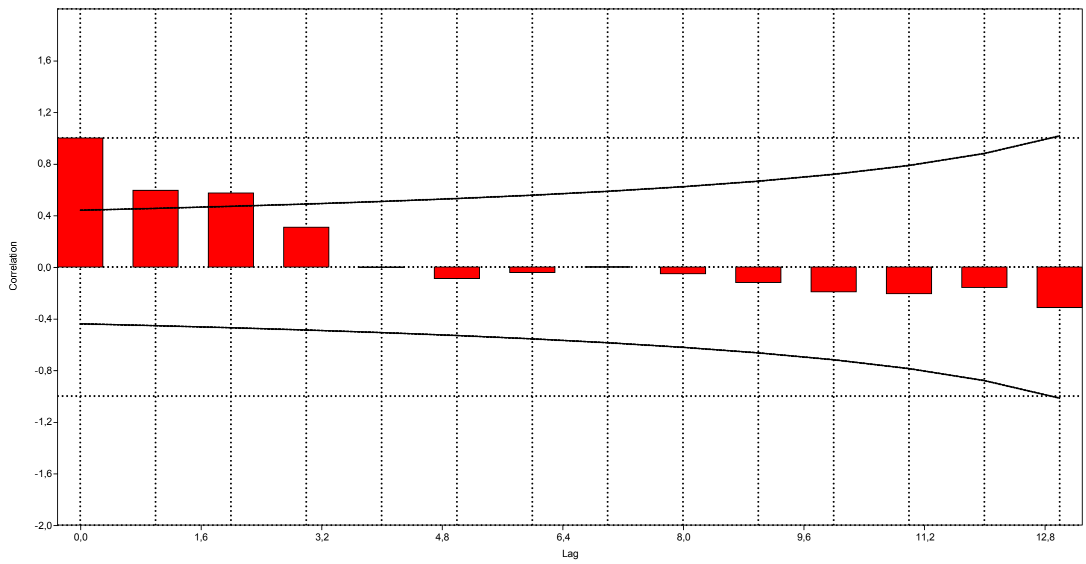

Figure 36. Temporal autocorrelation of the Atlantic bonito from North of Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

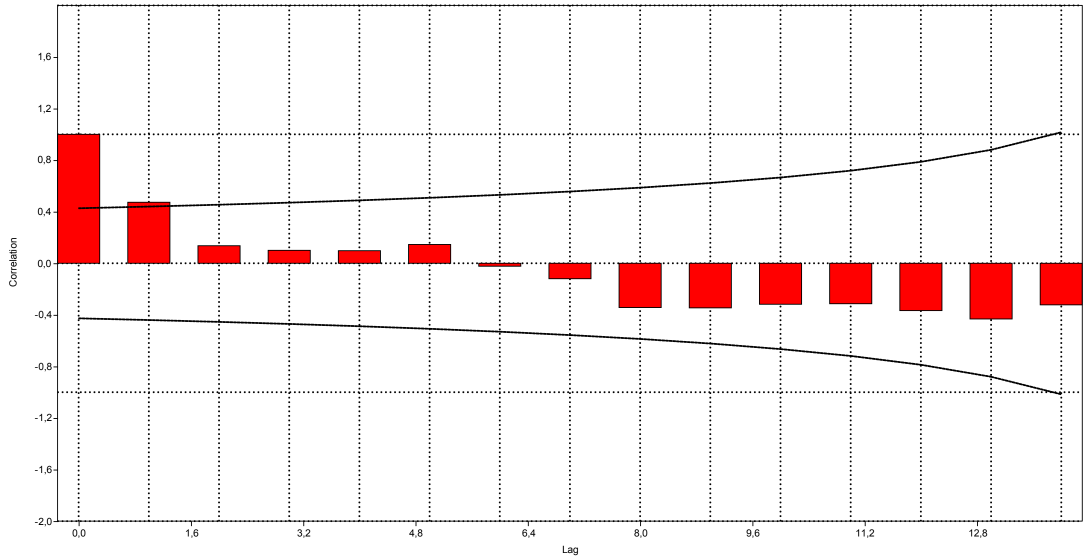

Figure 37. Temporal autocorrelation of the bullet tuna from South Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

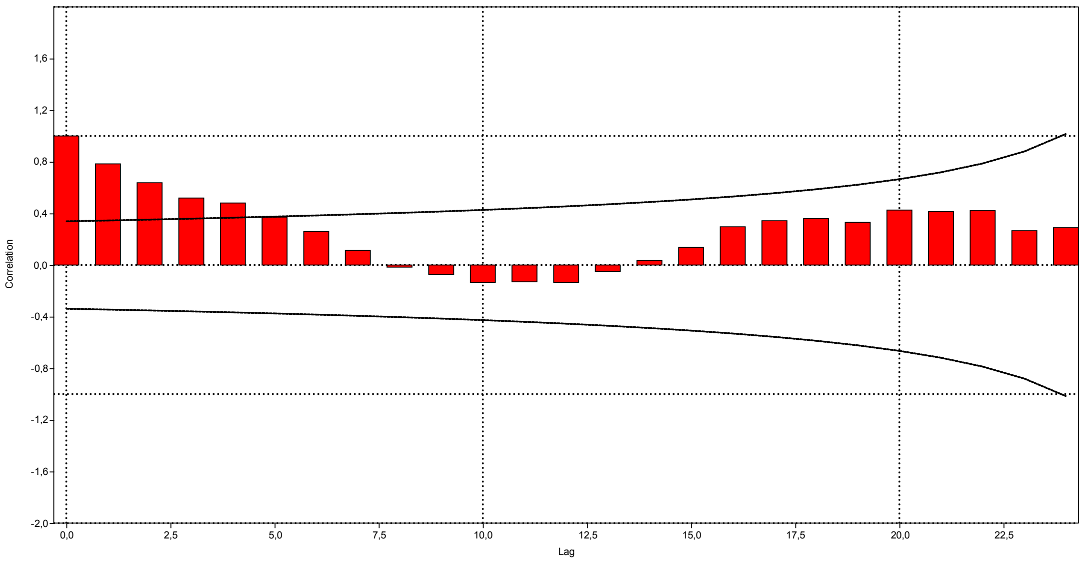

Figure 38. Temporal autocorrelation of the swordfish from South Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

The information about the data reported from southern Alboran Sea is quite poor in terms of quality. Furthermore, *Orcynopsis unicolor* is a fishery in the southern Alboran Sea (from 1990 to 2011) but it isn't a catch in the northern. It seems to be a latitudinal gradient for tunas in the Alboran Sea. We found a negative correlation between the landings of bullet tuna between the northern Alboran Sea and the Arctic Oscillation (AO) ($r = -0.38$; $p = 0.046$). According to Ambaum et al. (2001), the AO is an important climatic oscillation of northern hemisphere, closely correlated with NAO. This results show the relation between stock of bullet tuna and the climate.

3. Aquaculture and fisheries activities conducted within open sea of the Alboran Sea

Aquaculture is practiced activity in the Alborán Sea. However, it is always executed over the continental shelf, sheltered by the coast. There were plans for the development of marine wind-farms in of the Strait of Gibraltar as a potential source of renewable energy. These plans considered to use the basis of the turbines for aquaculture. Actually these plans have been rejected as this kinf of developments seemed to be incompatibles with maritime traffic.

Regarding to the fishing activity, the main fisheries performed in the Alboran's open sea in the last ten years are: driftnets, longline, purse seine, and bottom trawl. The swordfish (*Xiphias gladius*) is the target specie for the driftnets fishery. Bluefin tuna (*Thunnus thynnus)*, little tunny (*Euthynnus alletteratus*), and swordfish are the main longline fishery targeted species, both surface and the bottom longline modalities. Sardine (*Sardina pilchardus*) and European anchovy (*Engraulis encrasicolus*) are the most important small pelagic species targeted for the purse seiners. Finally, the bottom trawl fisheries is characterize for a multispecific bottom fisheries, targeting (in order of importance) European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), blue whiting (*Micromesistius poutassou*), red shrimp (*Aristeus antennatus*), and common octopus (*Octopus vulgaris*).

3.1. Driftnets (redes a la deriva, filet maillant dérivant)

A driftnet are defined as a fishing gear *“consisting of a string of gillnets kept more or less vertical by floats on the upper line and weights on the lower line, drifting with the current, in general near the surface or in mid-water”* (FAO, on-line Fisheries Global Information System – FIGIS). Worldwide, light synthetic fibers allow medium-scale and even small-scale boats to deploy driftnets many kilometers long. In the Mediterranean, driftnets have been used to capture several species of tuna and mostly swordfish. Swordfish come into the Mediterranean Sea from April to June, returning westwards from August to November. This migratory behavior determines the seasonal mobility of the driftnet fleet around the Alboran Sea, the Gibraltar Straits and adjacent Atlantic grounds (Silvani et al., 1999; Tudela et al., 2003, 2005). The use of driftnets in the Alboran Sea started in the 1980s; with about 100 Spanish boats using driftnets targeting swordfish in the Alboran Sea in 1990. The activity of this fishery was permanently halted in August 1994 due to the increasing scientific evidence of the low selectivity of this gear. In this framework, the Mediterranean driftnet fisheries for swordfish in Morocco (involving the ports of Tangiers, Al Hoceima and Nador) experienced a significant development during the 1990s while this fisheries were banned in European waters.

In 2003, ICCAT adopted a binding recommendation to ban the use of driftnets in large pelagic fisheries in the Mediterranean. The following year, Morocco presented a 4-year plan for eliminating its use of driftnets through public education, buyback and destruction of driftnet gear, and assistance to fishermen. For these purposes Morocco received U.S. and EU funds. At the 2008 ICCAT Annual Meeting, Morocco confirmed that it would require 3 more years for the total conversion of its driftnet fleet. In August 2010, Morocco published Law No. 19-7 in State Bulletin 1431 no. 5861, prohibiting the import, manufacture, retention, sale, as well as the use of driftnets at sea for fishing fish and/or other fishing species. In 2012

Morocco continue to be identified by the non-governmental environmental community as countries that conduct large-scale driftnet fishing (NOAA, 2012).

Tudela et al. (2005) reported that the Moroccan driftnet fleet in the Alboran Sea probably exceeded 200 vessels and that the length of the net used was known to often exceed 2.5 km in the 2000s. This fishery has a particular economic relevance in the Mediterranean waters contributed 27% of the total production of coastal fisheries and associated value (Abid and Idrissi, 2007). This fleet was based in Tanger (73%), Al Hoceima (14%) and Nador (8%). This fishing fleet was very diverse, many of the coastal vessels were small boats but the range varied from large to medium-low. Fishing operations generally took place at 5 to 30 nautical miles from the coast. The duration of the coastal fishing trips generally fluctuated between 8 and 20 hours on average. The trip is up to 3 days. Bycatch in this fishery are composed mainly of small tunas and sharks (mainly blue shark, shortfin mako, and thresher shark), as well as sea turtles and cetaceans (Silvani et al., 1999; Tudela et al., 2003, 2005).

3.2. Purse Seiners (cerqueros, sardiniers)[9]

A purse seine is defined by FAO as a fishing gear consisting of *"a long wall of netting framed with floatline and leadline (usually, of equal or longer length than the former) and having purse rings hanging from the lower edge of the gear, through which runs a purse line made from steel wire or rope which allow the pursing of the net. For most of the situation, it is the most efficient gear for catching large and small pelagic species that is shoaling"* (FAO, on-line Fisheries Global Information System – FIGIS).

The purse seine can be used by a large range of vessel sizes, ranging from open boats and canoes up to large oceanic vessels. Puse seines can be operated by one or two boats. Most usual is a purse seine operated by a single boat, a purse seiner, with or without an auxiliary skiff (Figure 39). At the Alboran Sea the purse seiners normally lead an auxiliar skiff with powerful lights which concentrates the fish in one place, or they lead an auxiliar that helps to close the ring net.

[9] It is possible view a short film about the fishing maneuvers of this gear in these links: http://www.youtube.com/watch?v=jkVOTcOTkdc ; http://www.youtube.com/watch?v=LOp8-MlNohE

Figure 39. Purse seiners lead an auxiliar skiff with powerful lights from port of Carboneras.

Purse siners usually target small pelagics such as sardine and European anchovy. Horse mackerel (*Trachurus trachurus*), the bug (*Boops boops*), the mackerel (*Scomber scombrus*) and *Sardinella aurita* are bycatched species. Table 2 shows the main characteristic of purse seiners from the most important ports for the Alboran Sea (according to Zahriet al. 2004; Zahri, 2006; Zeghdoudi, 2006; MAGRAMA[10]). The southern Alboran vessels are majoritary made of wood versus the Spanish vessels, which they are made of poliester. They make daily trips as they sell fresh fish. Zahri (2006) observed a decrease in the demand of fish coinciding with the higher temperatures during the summer in Morocco.

The length of the seine varies between from 200 to 900 m, while the drop fluctuates between 40 to 150 m. The net's mesh can be either 11 mm or 9 mm. A typical crew goes between 8 to 20 fishermen per boat. The simplest hauler has one wheel while the most complex could have three wheels. The vast majority of vessels from southern Alboran have one simple wheel (Figure 40), while the Spanish purse seiners have two wheeled haulers (Figure 41).

[10] http://www.magrama.gob.es/es/pesca/temas/la-pesca-en-espana/censo-de-la-flota-pesquera/censo.asp

Figure 40. Purse seiners with one simple hauler from port of Algeciras (Spain).

Figure 41. Purse seiners with one complex hauler (port of Carboneras, Spain).

Table 2. The main characteristic of purse seiners from the most important ports from each country in Alboran Sea (according to Zahriet al. 2004; Zahri, 2006; Zeghdoudi, 2006; Zahri & Bernardon, 2013 and MAGRAMA).

Country	Ports	Gross registered tonnage	Engine power CV.	Length	Number
Morocco	Al Hoceima	59	370	NA	28
	Ras Kebdana	42	310	NA	35
	M'Diq	30	185	NA	43
Algerie	Oran	NA	400*	16.5	NA
	Ain Temouchent	NA	400*	16.5	NA
	Tlemcen	NA	400*	16.5	NA
Spain	Adra	27.86	400*	16	17
	Almería	21.39	400*	15	21
	Velez-Málaga	16	400*	15	14

3.3. Longliners (palangeros, palangriers) [11]

A set longline consists of a mainline kept near the surface or at a certain depth by means of regularly spaced floats (Figure 42) and/or leads, and with relatively long snoods with baited hooks, evenly spaced on the mainline, moreover on the snoods are placed lights for the attraction of captures (Figure 43). According to the FAO on-line Fisheries Global Information System (FIGIS), a longline set could be or drifting longlines or bottom lonline. The drifting longline may be of considerable length. A longline for pelagic fishing is traditionally stored in pieces, in a series of baskets (Figure 44) which may take much space on the deck. More modern solutions include the storage of the longline on reels (Figure 45). Thicker multifilament longline are stored in large bin (a coiling machine is normally used for setting the line into the bin). The baiting of the hooks is done manually, not using a baiting machine. Usually at the end of each unit, a buoy is placed for marking purposes (Figure 46). The hooks are baited and the branch lines are fixed on the main line, in general, during setting (FIGIS). The longliners have a wide rank of sizes (Figure 47 and figure 48). The main characteristics of Spanish drifting longliners are: mean gross registered tonnage= 35.28, and mean length= 18.74 m. The number of longliners based from northern Alboran Sea ports is approximately 60 boats, however, only fisheries 5% of this fleet fished in the fishing-ground from Alboran Sea.

Figure 42. Some floats used by surface longliners.

[11] It is possible view a short film about the fishing maneuvers of this gear in this link: http://www.youtube.com/watch?v=q2PxKswZNcA

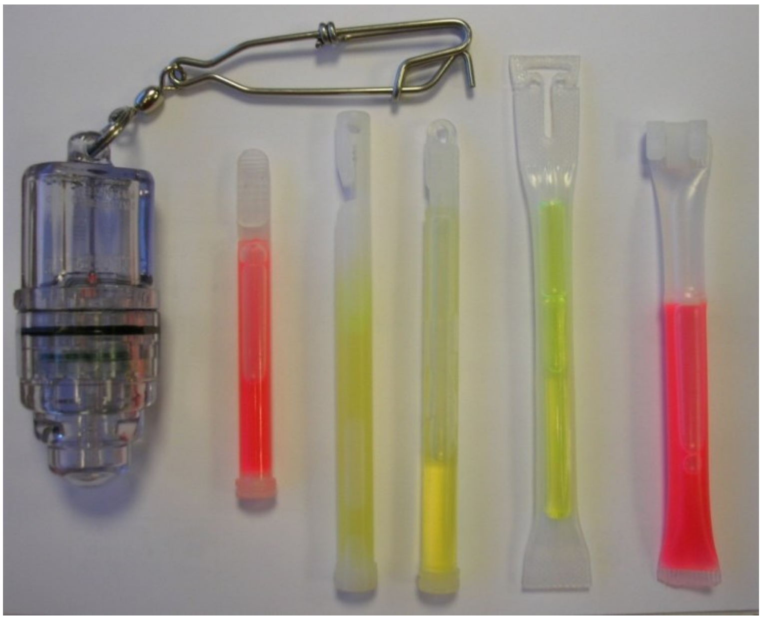

Figure 43. Some attractive lights used by longliners.

Figure 44. Typical basket, where the mainline is stored.

Figure 45. Hydraulical reel, where the mainline is stored.

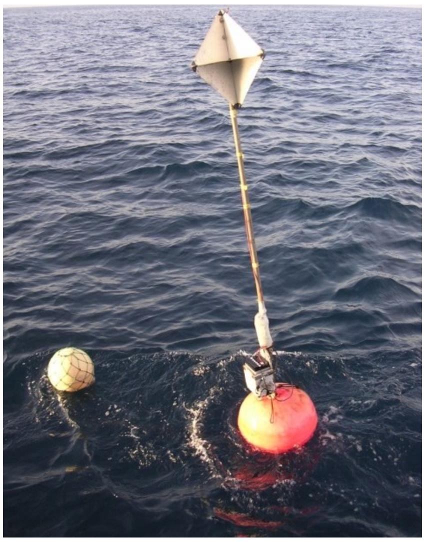

Figure 46. Buoy setting at the end a longline unit.

Figure 47. A large Spanish drifting longliner, from port of Carboneras.

Figure 48. A small Spanish semi-artisanal surface longliner.

In the Alboran open sea, surface longlines catch swordfish, bluefin tuna or albacore, stretch up to 40 miles and contain hundreds of baited hooks. Accidentaly, they by-catch sea turtles, marine mammals and seabirds.

3.3.1. The drifting surface longline

The drifting surface longline gears reported within this area by the International Commission for the Conservation of Atlantic Tunas (ICCAT) include: drifting surface longline targeting albacore (LLALB), surface longliners targeting bluefin tuna (LLJAP), and traditional drifting surface longliners targeting swordfish (LLHB) (Figure 45) (Valeiras & Camiñas, 2003; Camiñas et al., 2006; García-Barcelona et al., 2010a,b; Báez et al., 2013). Briefly, the main differences in longline gear between the three different fleet strata are:

- LLJAP (Japanese longline): is an imitation of the longline used by the Japanese fleet operating in the Mediterranean to catch bluefin tuna. It is a monofilament longline used exclusively during the months of May, June and the first half of July. The bait is nearly always squid (*Illex* sp.) bigger than 500 g. LLJAP typically use a C-shaped hook and its number per set does not exceed 1200, layed in a circle.
- LLHB: is used throughout the year. The number of hooks is between 1,500 and 4,000 which are usually baited with mackerel (*Scomber* sp.) and squid (*Illex* sp.). The dimensions and forms of the hooks used are J-shaped Mustad-2 (approximately 7.5 × 2.5 cm).
- LLALB: is the shallowest longline gear. Both the size of the hook and the thickness and length of the fishing lines are lower than other longlines, usually J-shaped Mustad number 5 (approximately 5 × 2 cm). Between 2,000 and 7,000 hooks are set and sardine (*Sardina pilchardus*) is the common bait. This gear is used mainly from July to October. The Spanish fleet is licensed all year round and targets highly migratory species, such as tuna and swordfish. In the studied period it had an average of 89 vessels per year, with a vessel length ranging from 12 to 27 m.

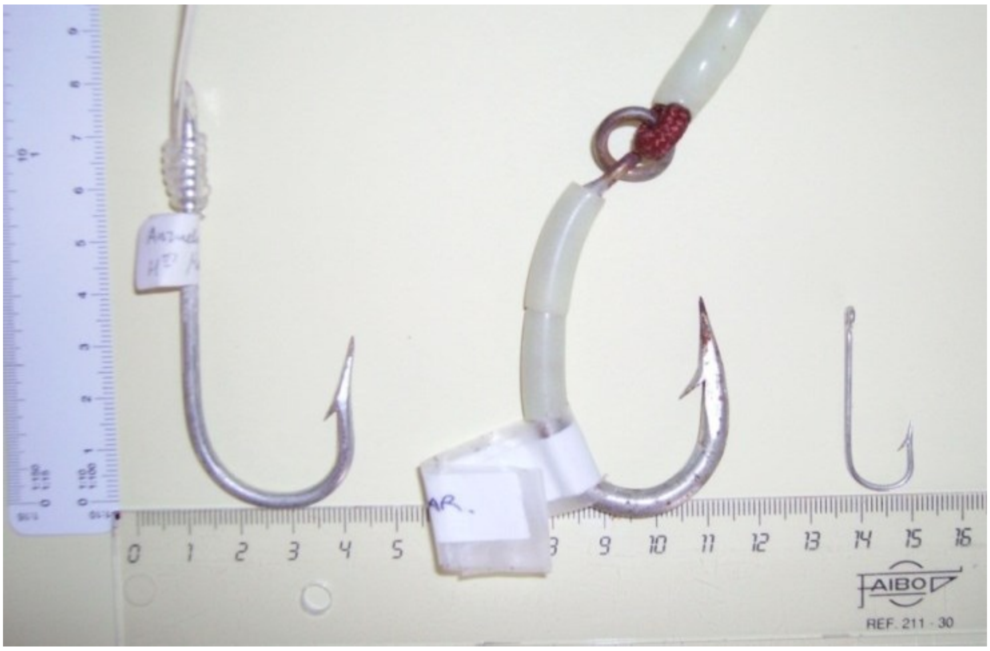

Figure 49. Hooks used to catch swordfish, bluefin tuna, albacore (left to right).

ICCAT recommended a reduction in fishing mortality and a seasonal closure from October 1 to November 30 anually for Mediterranean swordfish. This organization also considers that a reduction in the volume of juvenile catches would improve the yield per recruit and spawning biomass. In 2008, ICCAT imposed the closure of the fishery in the Mediterranean and an annual two-month closure since 2009. In addition, ICCAT will adopt a management plan for the swordfish fishery in the Mediterranean which would ensure that the restoration of stock in a maintained levels in consistency with the objectives of this international organization.

The species checklist by catches reported by Valeiras et al. (2003), Macias et al. (2004), and Báez et al. (2009) include:

- Teleostei: *Tetrapturus belone, Istiophorus albicans, Tetrapturus albidus, Brama brama, Coriphaena hippurus, Mola mola, Seriola dumerli, Xiphias gladius, Thunnus albacares, Thunnus thynnus, Euthynnus alletteratus, Katsuwonus pelamis.*
- Sharks: *Alopias superciliosus, Alopias vulpinus, Isurus oxyringhus, Prionace glauca, Galeorhinus galeus,* and *Sphyrna zygaena.*
- Batoidea: *Dasiatys pastinaca, Pteproplatytrygon violacea* (synonymous of *Dasiatys violacea*), and *Mobula mobula*.
- the sea turtle *Caretta caretta*; and the seabird *Larus michahellis*.

According to Abdelhadi et al. (2011), in Algeria there is a powerful industria of large migratory pelagic species of high economic value such as bluefin tuna (*Thunnus thynnus*). This specie is being captured by fleets from outside the Alboran shores, in particular from Japan. Japanese companies fish in these waters with a little national control under an agreement with the Algerian government, paying an annual fee for fishing. There are 48 longliners with almost exclusively Japanese crew which exploits the resource for a month and a half per year. In general, fishing effort is concentrated mainly in three areas, where there are also the highest rates of catch. In the area studied the Bluefin tuna is under high fishing pressure. Due to the abandonment of driftnet fishing, the Morrocan fleet has begun development research on longline and buoy gear (NOAA, 2012).

3.3.2. The bottom longline

The bottom longline is characterized by leads and weights (Figure 50). Spanish longliners are very diverse, from large vessels (Figure 51) to small boats. Spanish longliners mainly target swordfish and silver scabbardfish. The bottom longliners from Morocco are coastal, artisanal longline. This longline mainly catch bream, conger and others. Its length can exceed 1000 m, with a number hook which varies between 200 and 800. Hooks are commonly used reference numbers 5, 6 and 7, and usually are baited with sardine, squid, octopus and cuttlefish (Mohammed, 2004).

Figure 50. Basket full of stones used as leads by a longliners.

Figure 51. A large Spanish bottom longliner, from port of Carboneras.

3.4. Bottom trawlers (arrastreros de fondo, chalutiers)[12]

This is the main fishing modality in terms of catch and fleet power in the Mediterranean (Lleonart and Maynou, 2003). It is widespread and it plays an important socioeconomic role. The target catch is characterized by a great diversity of fishes, crustaceans and molluscs of commercial interest. In the North Alboran Sea, bottom trawl is the most important fishing gear in terms of landings and fishing effort over the continental slope and shelf to depths of 900 m (Camiñas et al., 2004). For the all fleet (artisanal gears not included), the trawlers represent approximately the 39% of the fleet from northern Alboran Sea (Camiñas et al., 2004). This fleet in the study area comprised an average of 141 boats (varying from 133 to 150), averaging 34.9 GRT and 175.8 HP. The port of Almeria has the largest number of boats with an average of 40 units. The fleet with the largest GRT corresponded to the port of Garrucha (55.3 t), followed by the port of Motril (44.7 t) and Almeria (43.1 t). Engine power was correlated to the size of the fishing vessel. Highest engine power was associated with those vessels based in the port of Garrucha (289.8 HP), Almeria port (205.7 HP) and Motril port (190.7 HP). The HP of fishing vessels is directly related to the distance to the fishing grounds where they normally operate (Mendoza et al., 2012).

According to Slimani & Hamdi (2004) trawlers are the most important fisheries in the Mediterranean coast of Moroccan. Moroccan demersal fishing fleet consists in 120 trawlers. Trawlers are based in three main ports: Nador (62.6%), Al Hoceima (23.2%), and M´diq (14.2%). The hull is usually made of wood (97%). The Moroccan trawlers could combine their fishing activity with the pelagic trawl targeting small pelagic fishes such as the sardine. The average power of the registered trawlers is 338 hp for average capacity of 53 GRT and an age of 24 years in average. The fleet based at the port of Tanger operates in the Atlantic. The majority of these vessels have their activity near their home ports in waters of less than 200 m deep and trips from 1 to 3 days. The most powerful trawlers have a wider range and venture to depths of 500 m depending on the boat engine. The length of the cable is regular, varying between 450 m and 1,500 m. The mesh of the net is about 40 mm.

The Algerian bottom trawl fishery consists of about 502 vessels (with an average engine power of 449 HP and a mean GRT of 49 T, and a maximum length of 19.2 m). The Algerian bottom trawl fishery is multispecific, targeting *Merluccius merluccius* and other demersal species (CopeMed, 2012).

In general, the trawling activity in the Alboran Sea is performed next to the coast (Camiñas et al., 2004; Slimani & Hamdi, 2004). Although they are are a multispecies fishery, the trawlers operating in the open sea mainly target the rose shrimp (*Parapenaeus longirostris*) (a particularly important specie in the Moroccan Mediterranean) and the great red shrimp (*Aristaeopsis edwardsiana*, synonym of *Plesiopenaeus edwardsianus*)[13].

The European Common Fisheries Policy (CFP) regulates the access to the fisheries resources in an attempt to guarantee their conservation, management and exploitation. For

[12] It is possible view a short film about the fishing maneuvers of this gear in this link: http://www.youtube.com/watch?v=v8N8VHmoLa0

[13] There is a Western-Eastern gradient for both species, thus from Eastern of the Motril harbour predominate fishing of red shrimp, while towards Western of the Motril harbour predominate fishing of rose shrimp.

The direct control over the fishing effort is the method that historically has been applied for the management of the Mediterranean fisheries. There is an annual closure of this fishery in a season that varies among the years. The closure can be between March and April, or April and May, or April and October, or May and June, or May and October. Mendoza et al. (2010) found a positive effect of the closed season in April and May. Contrarily, May and June or May and October closed seasons have negative consequences in fishing yields (Mendoza et al. 2010). The figure 52 shows a summary of the season closed per year. The figures 53 and 54 show the image of a typical trawler vessel and hauling operation respectively.

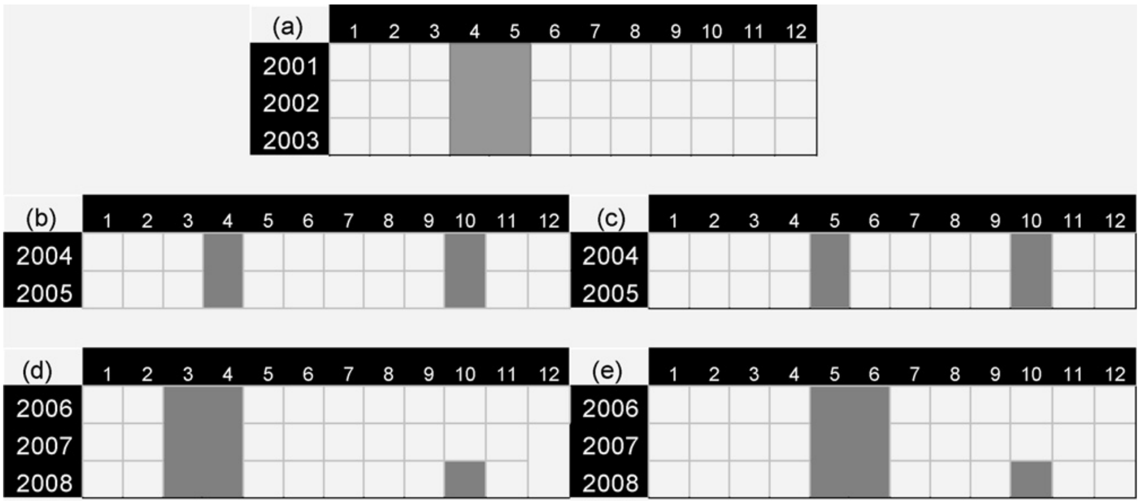

Figure 52. The months in which the closure is performed are grey shaded. All Andalusia Mediterranean coast (a); waters off Almeria province (b); waters off Granada, Málaga and Cádiz provinces(c); area between the parallel of latitude 37◦23.00N and the meridian of longitude 003◦46.57W (d); area between the meridian of longitude 003◦46.57W longitude and Punta Moroccan 005◦36.00 (e) (Mendoza et al., 2010).

Figure 49. Image of a typical trawler. Picture provided by Ldo. Jose Luis Perez Gil.

Figure 50. Hauling operation in a trawler. Picture provided by Ldo. Jose Luis Perez Gil.

According to Abad et al. (2007) the composition of megabenthic fauna caught by the commercial trawl fleet in the Alboran Sea, between 50[14] to 640 m in depth, consists by four different assemblages: (1) the outer shelf group (50-150 m), characterized by *Octopus vulgaris* and *Cepola macrophthalma*; (2) the upper slope group (151-350 m), characterized by *Micromesistius poutassou*, with *Plesionika heterocarpus* and *Parapenaeus longirostris* as secondary species; (3) the middle slope group (351-640 m), characterized by *M. poutassou*, *Nephrops norvegicus* and *Caelorhincus caelorhincus*, and (4) the smalls seamounts (approx. 350 m), characterized by *M. poutassou*, *Helicolenus dactylopterus* and *Gadiculus argenteus*, together with *Chlorophthalmus agassizi*, *Stichopus regalis* and *Palinurus mauritanicus*.

The results also revealed significantly higher abundances in the *Seco de los Olivos* seamount, probably related to a higher food availability caused by strong localised currents and upwellings that enhanced primary production. Although depth proved to be the main structuring factor, others such as sediment type and food availability also appeared to be important. Differences between shelf and slope assemblages could be in part related to a greater dependence on benthic resources in the former and a higher use of planktonic resources in the latter.

The species checklist bycatches reported by Abad et al. (2007) for open sea trawlers of the North of Alboran Sea (from 11 hauls with scientific observers) include:

FISHES: *Arnoglossus rueppelii*, *Bathysolea profundicola*, *Caelorinchus caelorinchus*, *Capros aper*, *Centrophorus granulosus*, *Chimaera monstrosa*, *Chlorophthalmus agassizi*, *Conger conger*, *Dalatias licha*, *Epigonus denticulatus*, *Etmopterus spinax*, *Gadiculus argenteus*, *Gaidropsaurus biscayensis*, *Galeorhinus galeus*, *Galeus melastomus*, *Helicolenus dactylopterus*, *Hoplostethus mediterraneus*, *Lampanyctus crocodilos*, *Lepidopus caudatus*, *Leucoraja naevus*, *Lophius spp.*, *Macroramphosus scolopax*, *Merluccius merluccius*, *Microchirus variegatus*, *Micromesistius poutassou*, *Molva macrophthalma*, *Mullus surmuletus*, *Nezumia aequalis*, *Pagellus acarne*, *Pagellus bogaraveo*, *Peristedion cataphractum*, *Phycis blennoides*, *Scorpaena elongata*, *Scyliorhinus canícula*, *Stomias boa*, *Symphurus nigrescens*, *Synchiropus phaeton*, *Torpedo marmorata*, *Trachurus picturatus*, *Trachyrincus scabrus* and *Trigla lyra.*

CRUSTACEANS: *Alpheus glaber*, *Bathynectes maravigna*, *Calappa granulata*, *Chlorotocus crassicornis*, *Dardanus arrosor*, *Goneplax rhomboide*, *Inachus communissimus*, *Liocarcinus depurator*, *Macropipus tuberculatus*, *Macropodia longipes*, *Macropodia longirostris*, *Monodaeus couchii*, *Munida intermedia*, *Munida iris*, *Nephrops norvegicus*, *Pagurus excavatus*, *Pagurus prideaux*, *Palinurus mauritanicus*, *Parthenope macrochelo*, *Pasiphaea sivado*, *Philocheras echinulatus*, *Plesionika edwarsii*, *Plesionika giglioli*, *Plesionika heterocarpus*, *Plesionika martia*, *Pontocaris lacazei*, *Pontophilus spinosus*, *Processa canaliculata*, *Sergestes arcticus*, *Solenocera membranacea* and *Xantho pilipes.*

[14] According to the current Spanish legislation (Real Decreto 1440/1999, 10[TH] of septiembre of 1999 por el que se regula el ejercicio de la pesca con arte de arrastre de fondo en el caladero nacional del Mediterráneo), the trawl fisheries should be performed in depths upper to 50 metres with few exceptions.

MOLLUSCS: *Bathypolipus sponsalis*, *Eledone cirrhosa*, *Eledone moschata*, *Illex coindetti*, *Loligo vulgaris*, *Lunatia catena*, *Neorosia caroli*, *Pteroctopus tetracirrhus*, *Rossia macrosoma*, *Sepia orbignyana* and *Todarodes sagittatus.*

OTHER INVERTEBRATES: *Alcyonum palmatum*, *Astropecten spp.*, *Cidaris cidaris*, *Echinaster sepositus* and *Stichopus regalis.*

4. Assessing the impact of incidental catch of sensitive species within northern Alboran Sea, with particular emphasis on marine turtles and elasmobranchs

It is widely known that there was a great decline in global fisheries, especially in the North Atlantic, after the Second World War. Some studies (e.g. Thurstan et al. 2010) have suggested that during the past decade, 88% of monitored marine fish stocks have been overfished. In this context, some authors (Worm et al. 2006) have predicted a global collapse of fisheries within the next few decades. The observed decline in fisheries is mainly due to the capacity to overfish at an industrial scale (Worm and Myers 2004; Pitcher 2005). However, the non-natural mortality due to fisheries could most critical global threats to longlived animals (Lewison et al., 2004 a,b), due in part to their low fecundity, slow population growth and late sexual maturity. For this reason, longlived animals tend to be particularly vulnerable to and the population recovery may take decades (Musick, 1999). For this reason, there is an increasing global interest in studying of by-catch and mortality of sea turtles and elasmobranchs. In this context, the Alboran Sea is an important corridor to marine migrant species such as sea turtles, blue shark, and *Alopias* spp.

4.1. By-catch of sea turtle

Five of the seven species of sea turtles are considered to be ‘critically endangered’ or ‘endangered’ by the International Union for Conservation of Nature (IUCN, 2013). During the last two decades, our understanding of sea turtle conservation biology has increased significantly. It is now widely believed that the major threat for the sea turtles is caused by unnatural death, humans being the main cause (Lewison et al., 2004a; Finkbeiner et al., 2011). Early evidence suggests that longline fishing is a major source of unnatural mortality in the Mediterranean Sea (Casale, 2010). Although there are fishing gears which have been recorded as resulting in high levels of incidental capture and mortality of marine turtles in the region include driftnets, and bottom trawls (Camiñas, 2004; WWF 2003; Tudela et al., 2003, 2005; Báez et al., 2006).

The endangered loggerhead turtle (*Caretta caretta*) is the most common sea turtle species in the Mediterranean Sea, where it utilizes nesting beaches which are mainly in Eastern basin. Annually, hundreds of juvenile loggerhead turtles, born on the beaches of both the North Atlantic (Eckert et al., 2008; Monzon-Arguello et al., 2010) and eastern Mediterranean, are concentrated around the feeding grounds in the western Mediterranean, mainly in waters around the Balearic Islands (Camiñas and de la Serna, 1995; Carreras et al., 2006, 2011). Revelles et al. (2008) suggest the existence of a permeable barrier north of the Balearic Islands that divides the north-western and the southern Mediterranean basin which affects the distribution of loggerhead turtles. This barrier could have an impact on the distribution of both migrant turtles from the Atlantic and the eastern Mediterranean. Regardless, many juveniles born in the Atlantic, they remain in the Mediterranean until they reach a minimum size to overcome the flow from the Strait of Gibraltar (Revelles et al., 2007). In this context, many loggerhead turtles examples are stranded along the southern Iberian Peninsula coast on their way to their feeding grounds or while returning to their natal regions (Bellido et al., 2010).

The western Mediterranean is an important fishing area for the Spanish drifting longline fleet which mainly targets swordfish (*Xiphias gladius*), bluefin tuna (*Thunnus thynnus*) and albacore (*Thunnus alalunga*) (Valeiras and Camiñas, 2003; García-Barcelona et al., 2010a). Due to the spatial overlap in fishing activity and loggerhead turtle distribution, there are tens of thousands of loggerhead turtle by-catches each year (Lewison et al., 2004b; Casale, 2011). There are several studies about the loggerhead turtle by-catch by the Spanish longline fishery in the Mediterranean (Camiñas et al., 2006, Báez et al., 2006, 2007a,b; Wallace et al., 2008; Báez et al., 2009, 2010a, 2011b and Báez et al., 2013b). The main results of these early studies are that gear configurations (e.g. hook and bait type) by Spanish Mediterranean longliners can determine by-catch frequency (Camiñas et al., 2006), and catch selectivity of size-classes (Wallace et al., 2008; Báez et al., 2013b). In addition, Báez et al. (2007a) and Báez et al. (2011b) concluded that the loggerhead turtles by-catches were spatially structured only according to mean distance to the coast. Moreover, the loggerhead turtles by-catches increased significantly within longline transect hauling during daylight (Báez et al., 2007b).

The Alboran Sea is the marine region, where the Mediterranean Sea and the Atlantic Ocean connect. For this reason, this region is an important area for the conservation of both Atlantic and Mediterranean loggerhead populations (Camiñas & de la Serna, 1995; Camiñas & Valeiras, 2003). Báez et al. (2006) performed interviewed to fishermen in the main fishing harbours of the Northern part of the Alboran Sea. Interviews were carried out at the fishing dock, when the fishing boats had returned to harbour. Interviews from North Alboran Sea were carried out in 6 harbours, selected to encompass fleets using a range of fishing gears that can be grouped into 5 categories: trawlers, artisanal gears, purse seiners, surface longliners, and bottom longlines. A total of 73 interviews were carried out, with only one interview per vessel (Table **3**).

Table 3. Interviews carry out by Báez et al. (2006) per boat type and harbors.

Harbours	**Trawlers**	**Artisanal gears**	**Purse seiners**	**Surface LL**	**Bottom LL**	
La Linea	0	2	0	0	1	
Marbella	5	4	3	0	0	
Motril	12	0	1	2	1	
Adra	1	2	1	2	0	
Carboneras	0	1	0	20	0	
Garrucha	7	5	0	2	1	
Total	25	14	5	26	3	**73**

Approximately 10% of the total fleet of the North Alboran Sea was interviewed. All the fishermen interviewed agreed that turtle incidental capture is more frequent in the summer. Based on the testimony of the fishermen interviewed, it appears that surface long-lines interact most frequently with marine turtles, followed by coastal trawlers, purse seiners, and trammel nets (Table **4**). Sea turtles captured by the purse seiners can be released without damage because they do not get tangled up in the net. Fishermen using artisanal coastal trammel nets also suggested that sea turtles incidentally captured by this gear are released in good physical conditions. There may be more concern for turtles captured by trawlers but as suggested by Báez & Silva (2013) incidental capture of sea turtles is rare on trawlers.

Moroccan surface driftnets (Tudela *et al*. 2003; 2005) and Spanish surface long-lines targeting swordfish have in previous studies been shown to be the fishing gears that interact most significantly with sea turtles in this region.

Table 4. Results of the interviews in terms of quantum estimated average levels of annual incidental capture rates. Key accidental capture frequency: Never= 0, Exceptional= 1 turtle per year, Rare >1<10 turtles per year, Frequent >10 turtles per year, Irregular= highly variable among years.

Gear type	Trawlers	Purse seiners	Surface LL	Bottom LL
Never	16	1		3
Exceptional	7	2		
Rare	1	2		
Moderate			1	
Frequent			25	
Irregular	1			

Báez et al. (2007c) estimated the incidental capture of loggerhead in the Northern Alboran Sea during 2004. The data used were compiled by scientific projects from the Spanish Oceanographic Institute (IEO). The Andalusia surface long-line fleet consists of 78 vessels from 12 to 27 m total length fishing along the year. During the observed period, Báez et al. (2007c) observed 36 loggerheads incidentally captured, which 8 loggerheads (22%) died as a result of the capture. Báez et al. (2009) observed a BPUE of loggerhead from North Alboran Sea of 0.094 turtles per 1000 hooks (Figure 55).

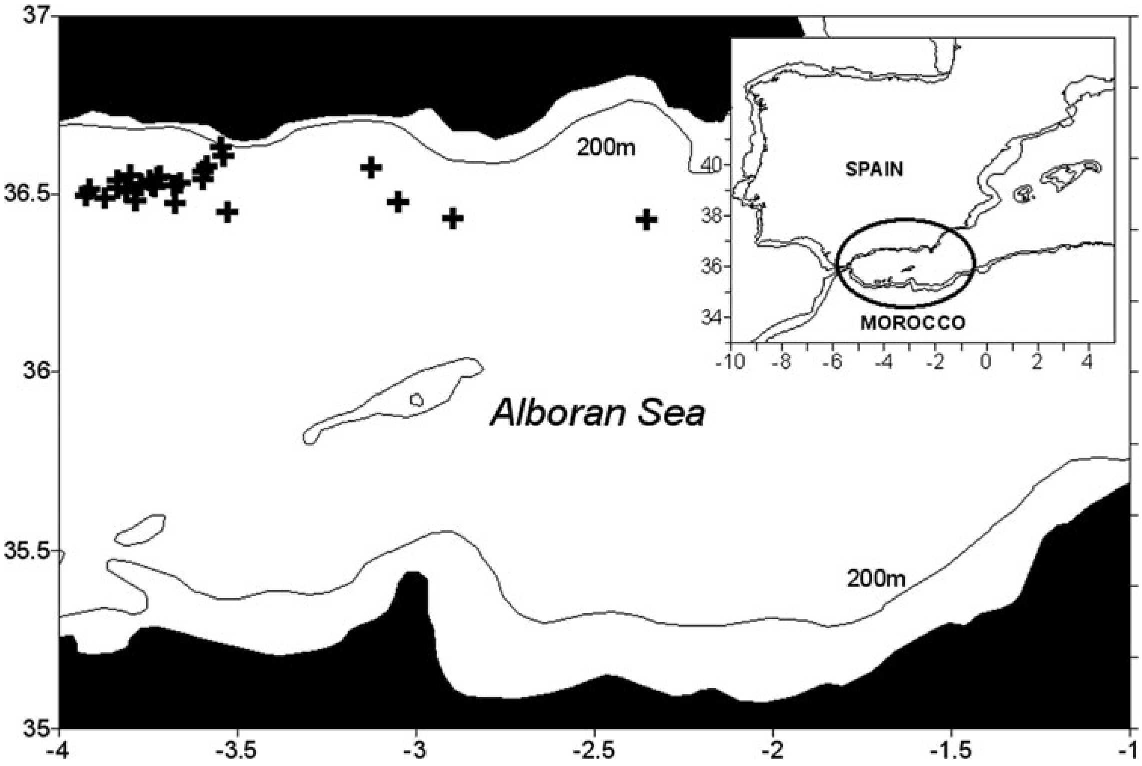

Figure 55. Fishing operation observed by Báez et al. (2009).

The bycatch (or Incidental capture) per Unit Effort (BPUE) values in open sea from Alboran Sea are low in comparison to other Mediterranean areas (for example Balearic Sea) (Báez et al. 2007c, 2009). However, Tudela et al. (2005) reported that by-catch rate of loggerhead turtle by driftnets in the Alboran Sea (0.21–0.78 N/haul) is much higher than that reported for the Italian driftnet fleet (0.04–0.05 N/haul), probably due to a much higher turtle density in Alboran waters linked to the strategic role of this sea in the Atlantic/Mediterranean exchanges.

The Alboran Sea represents an important connecting corridor also others marine turtle species, such as Leatherback sea turtle (*Dermochelys coriacea*), green sea turtle (*Chelonia mydas*), and hawksbill sea turtle (*Eretmochelys imbricata*) (Camiñas & Valeiras, 2003; Camiñas, 2004). Leatherback sea turtle (*Dermochelys coriacea*) is listed as Critically Endangered on the UICN red-list and is the second most common chelonian migratory species in the Mediterranean, where nesting beaches do not exist (Camiñas, 2004; Marcos et al., 2009). Leatherback turtles are also caught accidentally by Spanish longliners, but these turtles have small by-catches per unit of fishing effort (Lewison et al., 2004a, Báez et al., 2010b). According to Camiñas & Valeiras (2003), the Alboran Sea is an important area for this species.

4.2. By-catch of elasmobranchs

The subclass Elasmobranchii includes Sharks and Batoidea (rays). Predators that occupy high trophic levels in marine habitats, including marine mammals, large teleosts, rays and sharks, have been declining worldwide at a rapid pace (Heithaus et al., 2008). Recent estimates suggest that populations of large sharks have declined regionally by 90% or more worldwide (Heithaus et al., 2008). Evidence for severe declines in large predatory fishes is increasing around the world. In this way, because of its long history of intense fishing, the Mediterranean Sea offers a unique perspective on fish population declines over historical timescales (Heithaus et al., 2008).

We divide Sharks and Batoidea in pelagic and demersal Elasmobranchs, hereafter.

4.3. By-catch of pelagic elasmobranchs

According to Ferretti et al. (2008), only 5 of the 20 species of sharks present from Mediterranean Sea, had sufficient records for an analysis: Hammerhead (*Sphyrna* spp.), blue shark (*Prionace glauca*), mackerel (*Isurus oxyrinchus* and *Lamna nasus*), and thresher sharks (*Alopias vulpinus*), which declined between 96 and 99.99% relative to their former abundance. According to World Conservation Union (IUCN) criteria, these species would be considered critically endangered. So far, there is a lack of quantitative population assessments (Ferretti et al. 2008). These five pelagic sharks together with bigeye thresher (*Alopias superciliosus*), and tope shark (*Galeorhinus galeus*), are the typical pelagic shark bycatch from Mediterranenan Sea, that include from northern and southern of the Alboran Sea (Mohammed, 2004; Tudela et al., 2003, 2005; Báez et al., 2009). Others bycatch pelagic sharks are mainly from the Carcharhinidae family (Tudela et al., 2005). Other potential species are: *Carcharhinus altinus*, *C. Brachyurus, C. limbatus, C. longimanus*, and *C. plumbeus* (Guisande-González et al., 2011).

The main gears bycatches pelagic sharks are driftnets and surface longline, and in rare occasion trawlers. The landing of sharks, in surface longline, was 34.3% in weight of total catches sampled in the Alboran Sea, which represented the highest shark incidental catches for the Mediterranean Sea (Castro et al., 1999; Valeiras et al., 2003; Macías et al., 2004; Megalofonou et al., 2005). This high shark incidental catches from Alboran Sea, could be probably related to their location (Alboran Sea), i.e. an important migratory channel, adjacent to the Atlantic Ocean (Megalofonou et al., 2005). The higher incidence of sharks in the Alboran Sea could also be due to the higher trophic potential of the western Mediterranean compared to the eastern part. Higher shark catches were observed in the swordfish longline fishery, where a nominal CPUE value reached 3.8 sharks/1000 hooks in the Alboran Sea.

From Alboran Sea the most important shark caught, in number was blue shark (*Prionace glauca*) (Figure 56). Thus, blue shark bycatches in the Spanish surface longline fisheries in the Mediterranean targeting swordfish (*Xiphias gladius*) from 1999 to 2001 represented 2% of the total catch. Information from onboard observers during 861 fishing sets in 26 longliners indicated that the highest catches were made in Alboran Sea, which represents 75.6% of the total observed catch of blue shark. The observed CPUE are from 5.5 to 34.1 kg/1000 hooks. Mean size at capture was 141.6 cm (SD=35.88). The proportion of females from the total was 0.5 (Valeiras & de la Serna, 2003). The second landing shark species from Alboran Sea was shortfin mako (*Isurus oxyrinchus*) (Macías et al., 2004). Báez et al., (2009) observed a BPUE of sharks from North Alboran Sea of 1.41 blue sharks per 1000 hooks, 0.26 shortfin mako per 1000 hooks, 0.07 thresher (*Alopias superciliosus*) per 1000 hooks, and 0,023 tope shark per 1000 hooks.

Figure 56. Blue shark (*Prionace glauca*) by-caught in a surface longline. Picture provided by Ldo. Miguel Ángel Puerto.

According to Tudela et al. (2005), even though sharks are by-catch species or at best a secondary target in the Moroccan swordfish fishery, sometimes – obeying to the scarcity of the target species– some boats deploy the driftnets less offshore, at only 1–2 miles from the coast, where the chances of capturing some pelagic sharks (especially the thresher shark) are higher. According to catch rates reported by Tudela et al. (2005), *I. oxyrinchus* is the species most affected by the change from the by-catch scheme to the target fishery. Indeed, the catch rate per fishing operation for shortfin mako is near three times higher in those boats apparently behaving as active shark fishers (from 0.6 to 1.9 N/fishing operation) and the catch per km net follows a similar difference (from 0.06 to 0.14). The high catch figures of sharks presented in this study sharply contrast with the information available on the activity of the former Spanish driftnet fleet in the Alboran Sea. Indeed, Silvani et al. (1999) reported only an anecdotic occurrence of shortfin mako and blue shark in the catch (i.e. 3 and 4 individuals in 1994, from a total 54 fishing operations monitored) and did not report any capture of thresher shark. Thus, these results indicate a direct exploitation of sharks from the Alboran Sea.

Regarding to the pelagic Batoidea, the unique species reported is the common pelagic stingray (*Pteroplatytrygon violacea*, synonym of *Dasyatis violacea* and confounding with *Dasyatis pastinaca*), a bycacthes of surface longline (Macías et al., 2004; Báez et al., 2009). According to Báez et al. (2009), the common pelagic stingray is the major fish capture in the surface longline from Alboran Sea (Figure 57). Thus, the BPUE of common pelagic stingray is 28.1 stringay per 1000 hooks versus the CPUE of target species 8.42 swordfish per 1000 hooks. In turn, this stingray is poisonous, so that fishermen do not bother to hauling the hook; they cut the line in much cases. No estimates of their abundance. Others pelagic Batidea bycatches are: *Myliobatis aquila, Mobula mobular,* and *Pteromylaeus bovinus*.

Figure 57. A fisherman release a common pelagic stingray (*Pteroplatytrygon violacea*, synonym of *Dasyatis violacea* and confounding with *Dasyatis pastinaca*).

According to the data available in Galisteo et al. (2001a, 2001b, 2002, 2004, 2005) Alonso-Pozas et al. (2007), and Galisteo et al. (2007, 2008, 2009a, 2009b, 2011), from North Alboran Sea, the evolution of the landing trend from blue shark (*Prionace glauca*), mackerel (*Isurus oxyrinchus*), thresher sharks (*Alopias vulpinus*), and tope shark (*Galeorhinus galeus*) are plotted. In a second step, we analysed the time series of each fish stock. We searched temporal autocorrelation, which imply a overfish harvest. All the time series analysis were performed with the software PAST (available from web site: http://folk.uio.no/ohammer/past/) (Hammer et al., 2001; Hammer & Harper, 2006).

The figures 58-61 show the evolution from the northern Alboran Sea of the landing trend in from blue shark (*Prionace glauca*), mackerel (*Isurus oxyrinchus*), thresher sharks (*Alopias vulpinus*), and tope shark (*Galeorhinus galeus*). The figures 62-65 show the temporal autocorrelation trend from the northern Alboran Sea of the landing trend in from blue shark (*Prionace glauca*), mackerel (*Isurus oxyrinchus*), thresher sharks (*Alopias vulpinus*), and tope shark (*Galeorhinus galeus*).

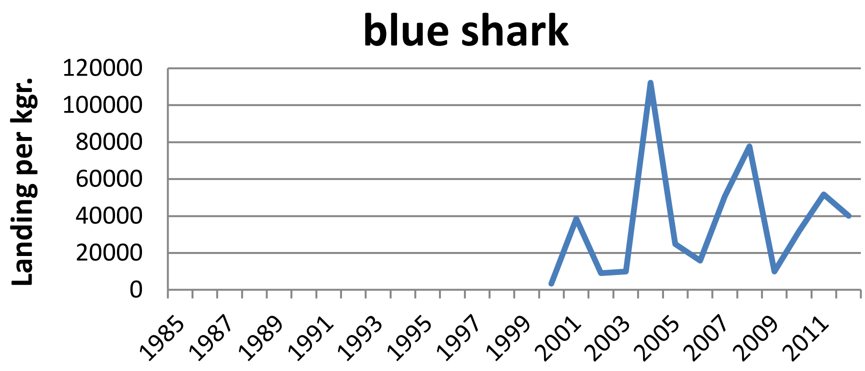

Figure 58. Evolution from the northern Alboran Sea of the landing trend from blue shark, since 2000 to 2012. We observed an oscillation pattern.

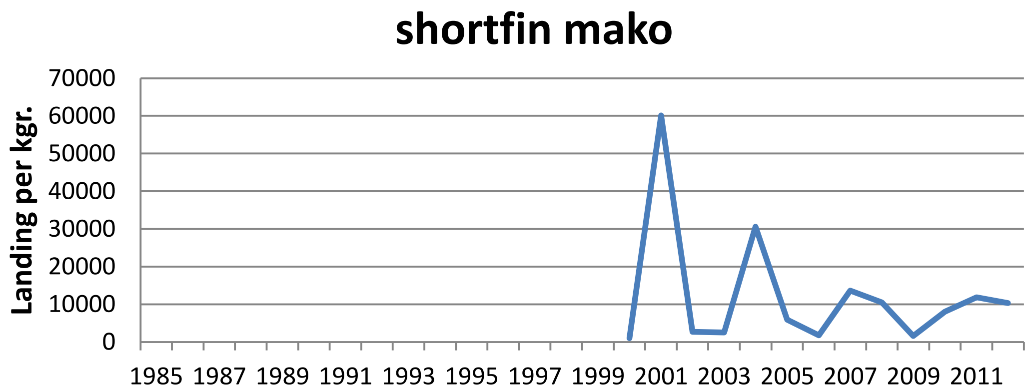

Figure 59. Evolution from the northern Alboran Sea of the landing trend from shortfin mako, since 2000 to 2012. We observed a gradual decline in catches over time.

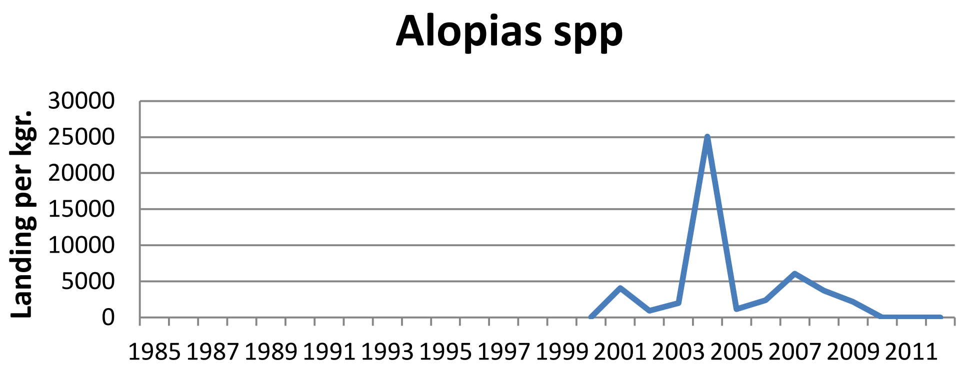

Figure 60. Evolution from the northern Alboran Sea of the landing trend from *Alopias* spp., since 2000 to 2012. We observed a peak, and marked decline in catches over time.

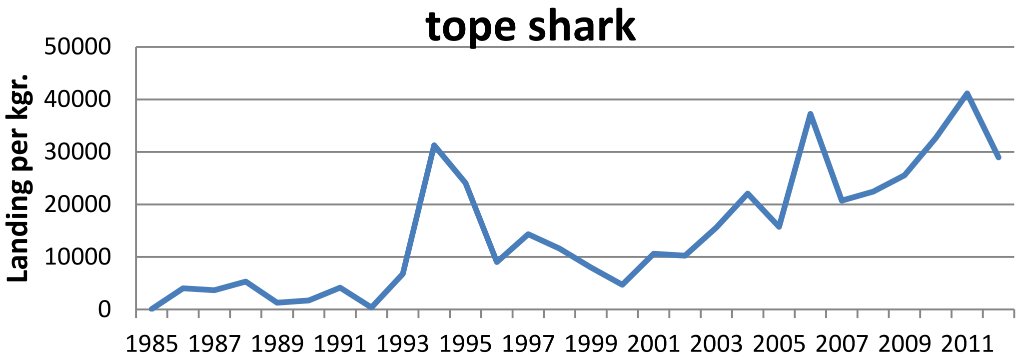

Figure 61. Evolution from the northern Alboran Sea of the landing trend from tope shark, since 1985 to 2012. We observed a gradual increase in catches over time.

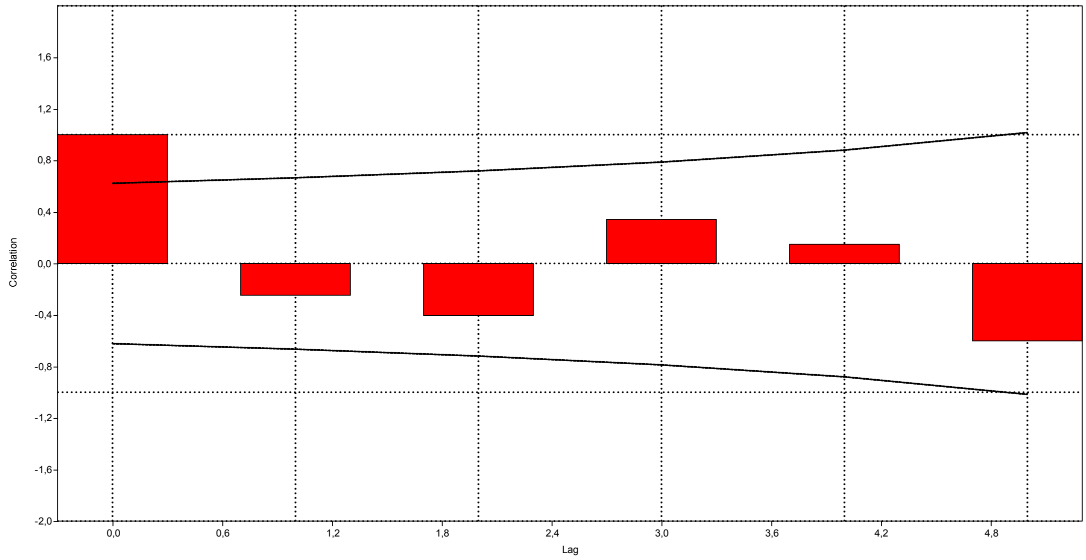

Figure 62. Temporal autocorrelation of the blue shark from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

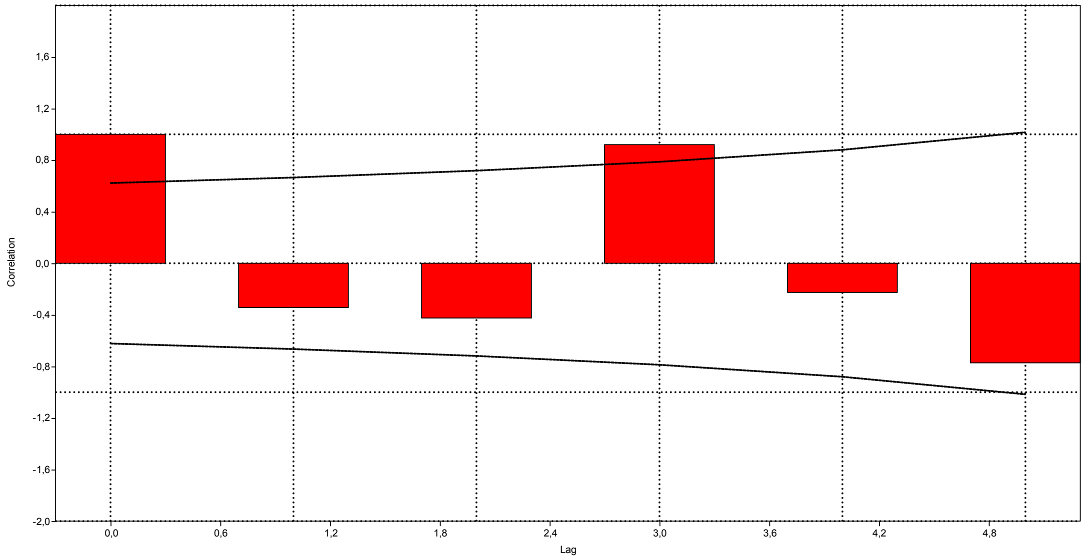

Figure 63. Temporal autocorrelation of the shortfin mako temporal autocorrelation from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is temporal autocorrelations.

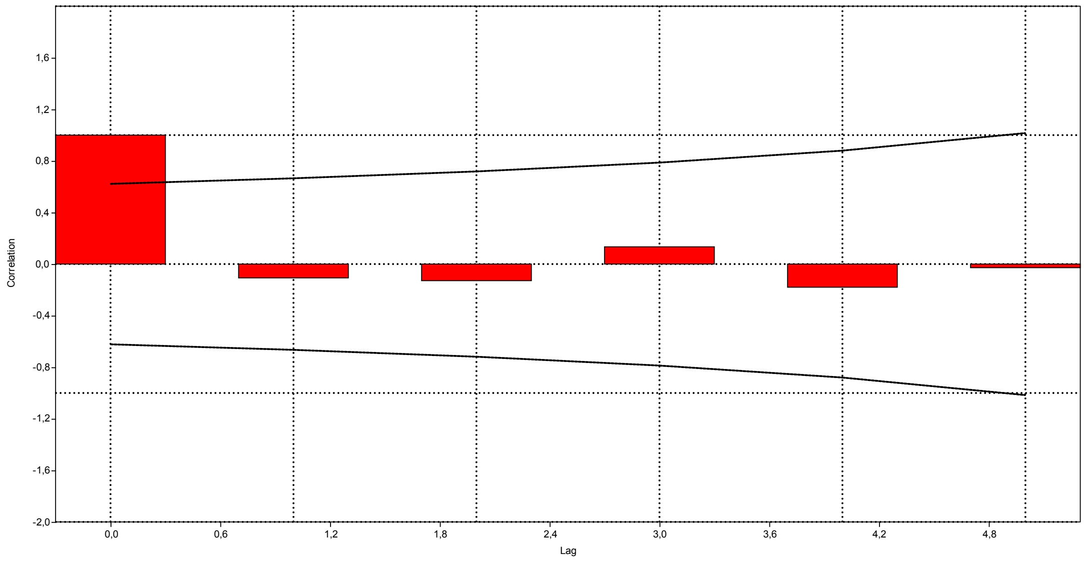

Figure 64. Temporal autocorrelation of the *Alopias* spp. from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

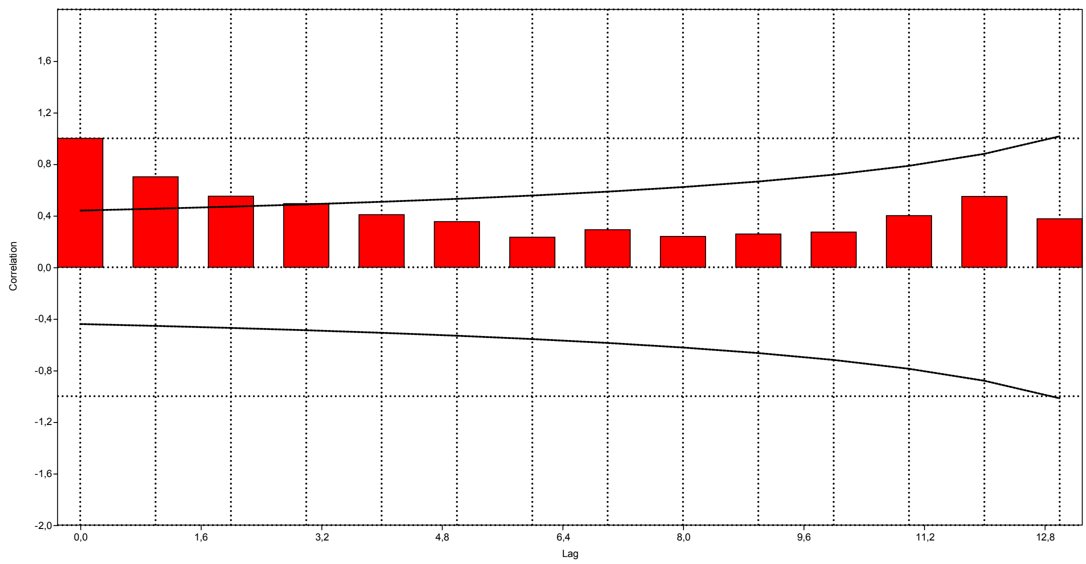

Figure 65. Temporal autocorrelation of the Tope shark temporal autocorrelation from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

We found a positive correlation between the landing of blue shark from North Alboran Sea and winter Arctic Oscillation Index (between October and November previous year) (r= 0.57; p= 0.043). According to Ambaum et al. (2001), the AO is an important climatic oscillation of northern hemisphere, closely correlated with NAO. This results show the relation of blue shark with the climate. We found a negative correlation between the landing of tope shark from North Alboran Sea and North Arctic Oscillation (r= -0.385; p= 0.043). This results show the relation of tope shark with the climate.

4.4. By-catch of demersal elasmobranchs

The main gears bycatches demersal elasmobranchs from Alboran Sea are the trawlers and bottom longline. From Alboran Sea the most important sharks caught in number were: gulper shark (*Centrophorus granulosus*), and small-spotted catshark (*Scyliorhinus canicula*); that are bycatches of trawlers targeted rose shrimp (*Parapenaeus longirostris*) and great red shrimp (*Aristaeopsis edwardsiana*, synonym of *Plesiopenaeus edwardsianus*) (see figure 66).

Figure 66. Gulper shark (*Centrophorus granulosus*), *Oxynotus centrina* and small-spotted catshark (*Scyliorhinus canicula*) by-caught in a fishing operation of a trawler targeted red shrimp (*Aristaeopsis edwardsiana*, synonym of *Plesiopenaeus edwardsianus*). Picture provided by Ldo. Jose Luis Perez Gil.

Muñoz-Chapuli (1985) observed ten demersal sharks species in 86 fishing operation by trawler from Alboran Sea: *C. granulosus*, *Dalatias licha* (synonym of *Scymmorhinus licha*), *Heptranchias perlo, Hexanchus griseus* (Figure 67)*, Mustelus asterias, M. mustelus, Scyliorhinus canicula* (synonym of *Squalus canicula), Squalus acanthias, S. blainville*, Squatina squatina*.* Others demersal sharks potentially bycatches are: *Galeus melastomus, Odontaspis ferox, Velvet belly Etmopterus spinax, Oxynotus centrina, Centroscymnus coelolepis, Somniosus rostratus,* and *Squalus megalops* (Guisande-González et al., 2011). According to Coelho et al. (2010) the differences in mean densities based exclusively on research trawl surveys in both regions were found, with the NE Atlantic population having lower mean density values than the Mediterranean population.

Regarding to the demersal Batoidea bycatches are: *Dasyatis centroura*, *D. pastinaca*, *Gymnura altavela*, *Dipturus batis*, *D. oxyrinchus*, *Leucoraja circularis*, *L. fullonica*, *L. naevus*, *Raja asterias*, *R. brachyura*, *R. clavata*, *R. miraletus*, *R. montagui, R. undulata*, *Squatina oculata,* and *S. squatina*.

Figure 67. Bluntnose sixgill shark (*Hexanchus griseus*) by-caught in a bottom longline.

According to the data available in Galisteo et al. (2001a, 2001b, 2002, 2004, 2005) Alonso-Pozas et al. (2007), and Galisteo et al. (2007, 2008, 2009a, 2009b, 2011), from North Alboran Sea, the evolution of the landing trend from gulper shark (*Centrophorus granulosus*), small-spotted catshark (*Scyliorhinus canicula*), rays (*Raja asterias, R. brachyura, R. clavata, R. miraletus, R. montagui,* and *R. undulata*) and Anglerfish (*Squatina oculata*, and *S. squatina*) are plotted. In a second step, we analysed the time series of each fish stock. We searched temporal autocorrelation, which imply a overfish harvest. All the time series analysis were performed with the software PAST (available from web site: http://folk.uio.no/ohammer/past/) (Hammer et al., 2001; Hammer & Harper, 2006).

The figures 68-71 show the evolution from the northern Alboran Sea of the landing trend in from gulper shark (*Centrophorus granulosus*), small-spotted catshark (*Scyliorhinus canicula*), rays (*Raja asterias, R. brachyura, R. clavata, R. miraletus, R. montagui,* and *R. undulata*) and Anglerfish (*Squatina oculata*, and *S. squatina*).

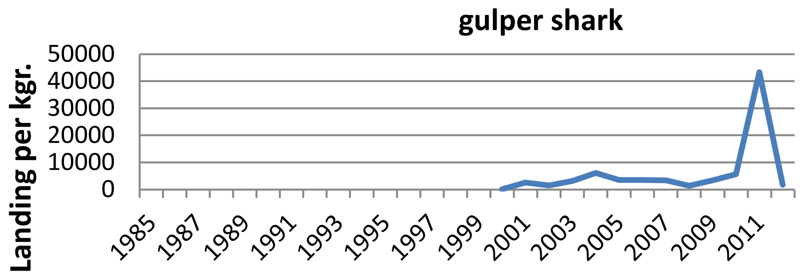

Figure 68. Evolution from the northern Alboran Sea of the landing trend from gulper shark, since 2002 to 2012. We observed a peak, and a rapid decline.

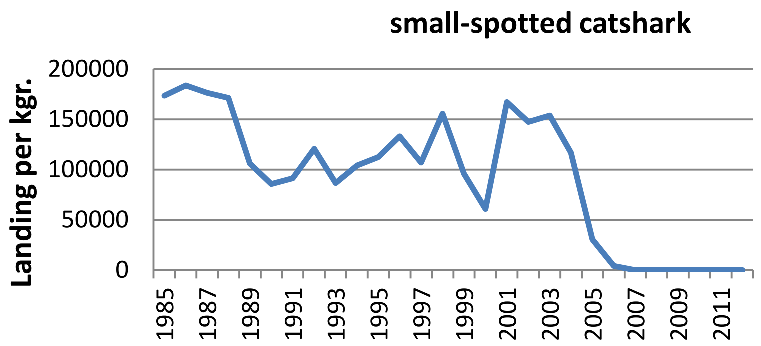

Figure 69. Evolution from the northern Alboran Sea of the landing trend from small-spotted catshark, since 1985 to 2012. We observed a gradual decline in catches over time.

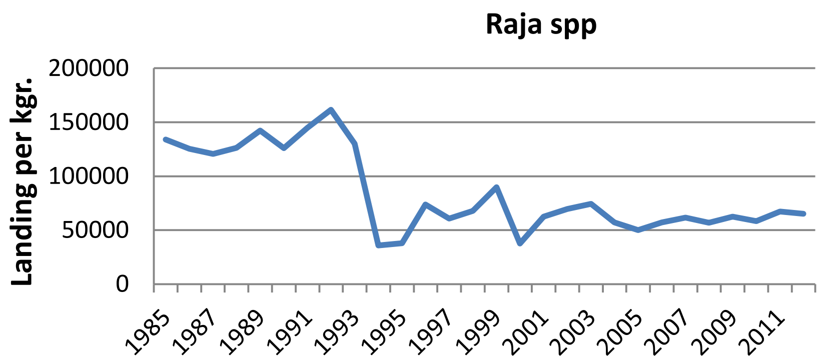

Figure 70. Evolution from the northern Alboran Sea of the landing trend from Raja spp. (include *Raja asterias, R. brachyura, R. clavata, R. miraletus, R. montagui, R. undulata*), since 1985 to 2012. We observed a gradual decline in catches over time.

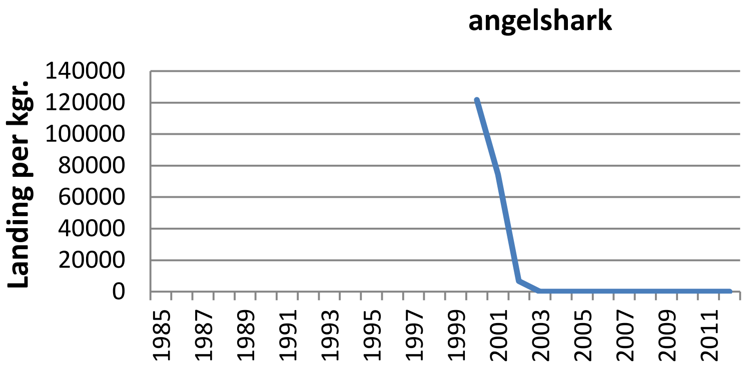

Figure 71. Evolution from the northern Alboran Sea of the landing trend from angelshark, since 2000 to 2012. We observed a gradual decline in catches over time.

The figures 68-71 show the temporal autocorrelation trend from the northern Alboran Sea of the landing trend in from gulper shark (*Centrophorus granulosus*), small-spotted catshark (*Scyliorhinus canicula*), rays (*Raja asterias, R. brachyura, R. clavata, R. miraletus, R. montagui,* and *R. undulata*) and Anglerfish (*Squatina oculata*, and *S. squatina*).

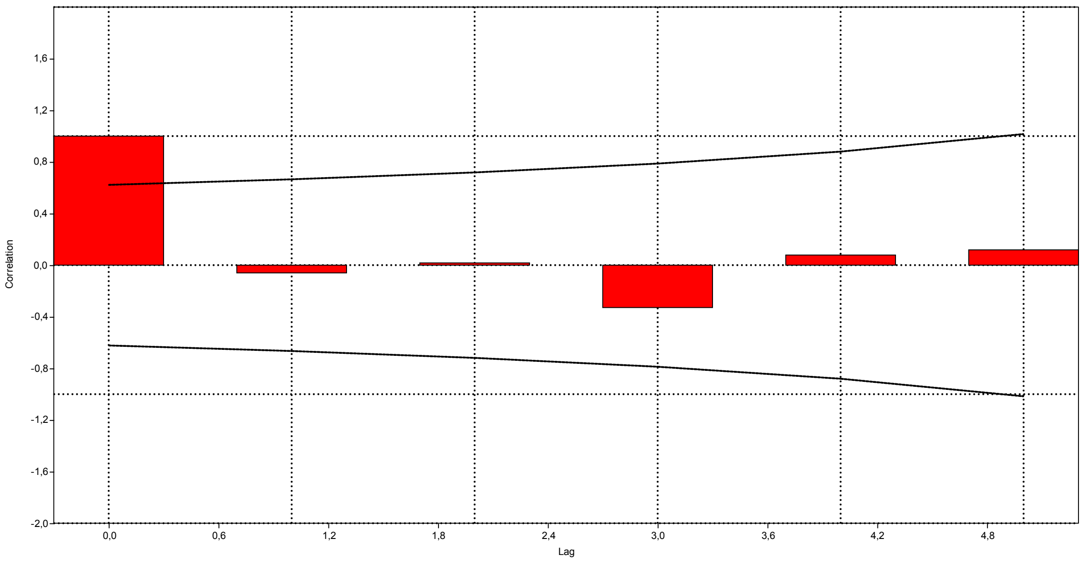

Figure 72. Temporal autocorrelation of the gulper shark temporal autocorrelation from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

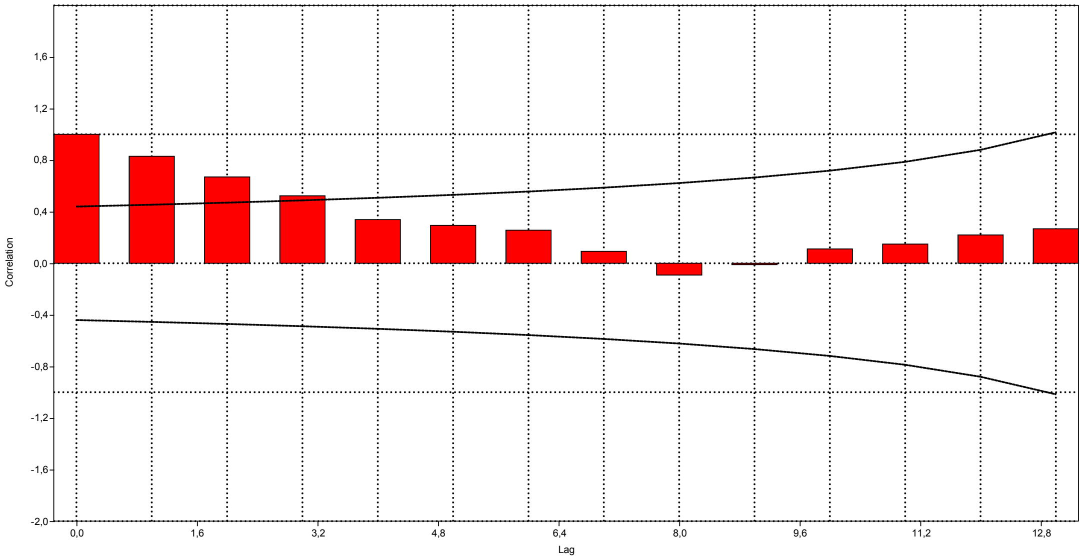

Figure 73. Temporal autocorrelation of the small-spotted catshark from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

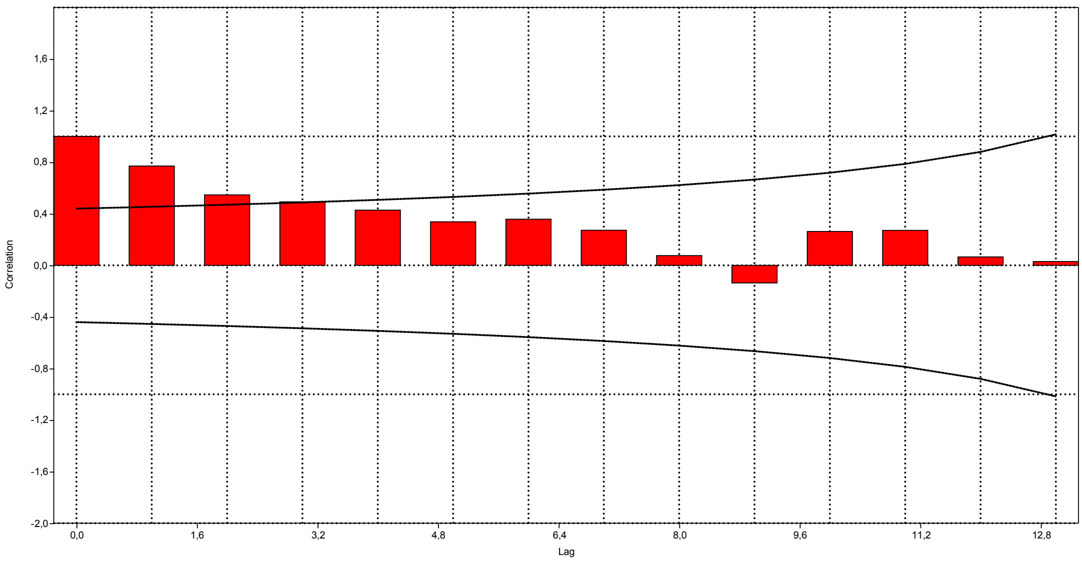

Figure 74. Temporal autocorrelation of the *Raja* spp. from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

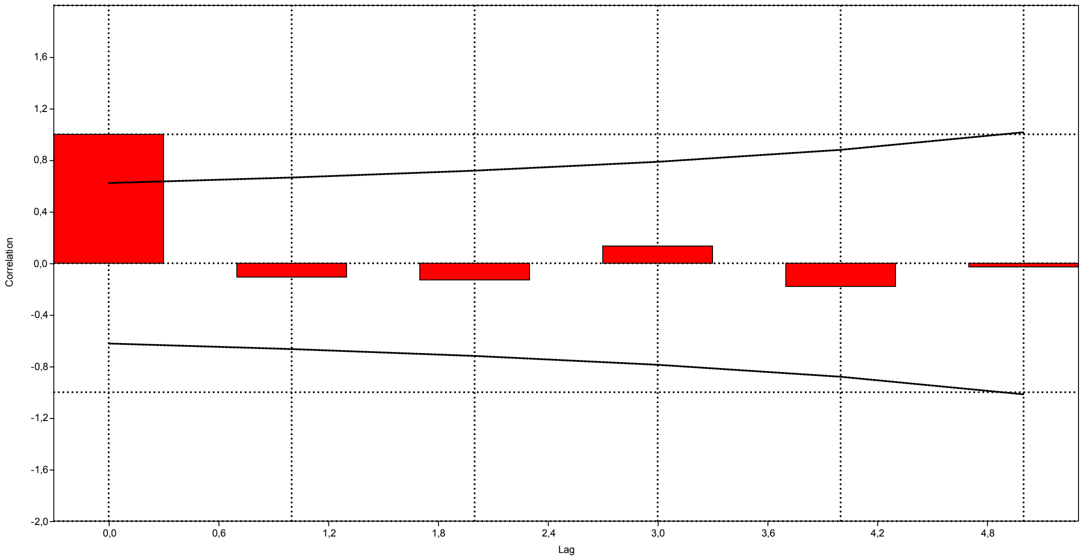

Figure 75. Temporal autocorrelation of the Angelshark from northern Alboran Sea, the vertical axis shows the value of the autocorrelation (which can range between -1 and 1), while the horizontal axis shows the lags in which the correlation is performed, the black lines indicate the signification. In the present case there is not temporal autocorrelations.

We found a negative correlation between the landing of *Raja* spp. from North Alboran Sea and North Arctic Oscillation (r= -0.435; p= 0.021). This results show the relation of *Raja* spp. with the climate.

5. Geographical trend of the probability of capture of sea turtle and elasmobranch from spatial distribution of fishing activities

We do not found comprehensive studies on the geographical distribution of bycatch of sea turtles and elasmobranchs from Alboran Sea. The data available are empirical observations of punctual bycatches for boats based from northern of Alboran Sea, reported by: Báez et al. (2007c) for turtle from surface longline, Báez et al. (2009) for pelagic elasmobranch from surface longline, and Coelho et al. (2010) for demersal elasmobranch from trawlers. Thus, from the data available we modelled the probability of catching sea turtle, pelagic elasmobranchs and demersal elasmobranchs, from northern Alboran Sea in function of geographical components: depth, longitude and latitude. In a first step, we used the by-catches observed empirically by: Báez et al. (2007c) for turtle from surface longline, Báez et al. (2009) for pelagic elasmobranch from surface longline, and Coelho et al. (2010) for demersal elasmobranch from trawlers. Then, we link the data model and the capture map and represent the map with the probability points. Finally, continuous probability values were interpolated from probability maps of points using the KRIGING tool of ESRI ArcMap 9.3 software.

The final results are three probability maps of bycatches: (i) sea turtles bycatches from surface longline probability map, (ii) pelagic elasmobranch from surface longline probability map, and (iii) demersal elasmobranch from trawlers probability map; each of these maps is based on a probability model in function to geographical components: depth, longitude and latitude.

5.1. Statistical procedure

We considered such as presences, these by-catches reported by Báez et al. (2007c) for turtle from surface longline, Báez et al. (2009) for pelagic elasmobranch from surface longline, and Coelho et al. (2010) for demersal elasmobranch from trawlers. In the case of sea turtle we used the absence provide by Báez et al. (2007c), however, in the cases of pelagic and demersal elasmobranch we generate random absences. Then we modelled the probability of accidental capture of most caught species. So, to obtain the probability values we performed a binary logistic regression of the presence and absence of bycatch to test whether the probability of incidentally catching one or more specimens of these marine animals could be predicted by any of the explanatory variables selected (ie depth, longitude and latitude).

Logistic regression is a widely-used statistical tool for binary distribution models (e.g. Real et al. 2006).

The logistic regression is based in the natural logarithm of an odds ratio (logit). The odds ratio is derived from two odds (obtained from the following dichotomous outcome: presence (ie observed bycatch) or absence (ie not observed bycatch)). The logit is the natural logarithm (ln) of odds of a presence, and odds are ratios of probabilities (π) of a presence happening to probabilities ($1 - \pi$) of an absence. Thereby:

$$\text{logit}(y) = \ln(\pi/1-\pi) = \alpha + \beta x;$$

$$\text{Probability} = e^y/1+e^y$$

where α is the y intercept, β is the regression coefficient, and e is the base of the system of natural logarithms.

Regardless of the goodness-of-fit of the logistic model, it is sensitive to the presence/absence ratio (Hosmer and Lemeshow 2000). To solve this problem, Real et al. (2006) introduced a ***favourability function*** (F) based on a logistic regression model. This function adjusts the model, regardless of the presence/absence ratio. Favourability was easily calculated from the probability obtained from the logistic regression according to the expression:

$$F = [P/(1-P)]/[(n1/n0) + (P/[1-P])]$$

where P is the probability of an event occurring, $n1$ is the number of observed presences, and $n0$ is the number of observed absences. Then a ***favourability function*** (Real et al., 2006) was applied to make predictions independent form the presence/absence initial rate. We mapped the value ***favourability function*** of bycatch to provide different probability of capture maps of sea turtle and elasmobranch from spatial distribution of fishing activities according different fishing gear in the Alboran Sea.

In the Table **5**, we show the parameters for the probability model of the sea turtles bycatches from surface longline. In the Table **6**, we show the parameters for the probability model of the pelagic elasmobranch from surface longline. In the Table **7**, we show the parameters for the probability model of the demersal elasmobranch from trawlers.

Table 5. The parameters for the probability model of the sea turtles bycatches from surface longline. Key: **B**, coefficients for the parameters in the model, **Wald**, value of the Wald test, **d.f.**, degree free of the model, **Sig.**, the signification of the model.

	B	Wald	d.f	Sig.
Depth	0.004	1.455	1	0.228
Longitude	-1.139	0.349	1	0.554
Latitude	10.951	1.82	1	0.177
constant	-408.5	1.877	1	0.171

Table 6. The parameters for the probability model of the pelagic elasmobranch from surface longline. Key: **B**, coefficients for the parameters in the model, **Wald**, value of the Wald test, **d.f.**, degree free of the model, **Sig.**, the signification of the model.

	B	Wald	d.f.	Sig.
Longitude	23.268	0	1	0.995
Latitude	44.407	0	1	0.995
Depth	0.007	3.474	1	0.062
constant	-1533.78	0	1	0.996

Table 7. The parameters for the probability model of the demersal elasmobranch from trawlers. Key: **B**, coefficients for the parameters in the model, **Wald**, value of the Wald test, **d.f.**, degree free of the model, **Sig.**, the signification of the model.

	B	Wald	d.f.	Sig.
Longitude	-0.703	1.714	1	0.19
Latitude	4.715	10.251	1	0.001
Depth	0.009	7.841	1	0.005
constant	-181.649	10.619	1	0.001

Because we do not know *a priori* how effective is the logistic regression model generated, we need evaluate the logistic regression model using different approximations: parsimony of the models, goodness-of-fit, and discrimination capacity of our model.

The goodness-of-fit of the models was assessed using the Hosmer and Lemeshow test (the test statistic also follows a Chi-square distribution; low p-values would indicate lack of fit of the model (Hosmer and Lemeshow, 2000). The discrimination capacity of the models was evaluated with the Area Under the Curve (AUC) of the Receiving Operating Characteristic (ROC). To evaluate the classification capacity of the models, we obtained a set of measures of classification based on the 0.5-favourability threshold (as favourability is independent of prevalence, 0.5 is the favourability value at which both sensitivity and specificity are equals): the correct classification rate (CCR), sensitivity, specificity, and Cohen's Kappa (Fielding and Bell, 1997). We show in the Table **8** the good-of-fit parameters for each model.

Table 8. The good-of-fit parameters for each model are show.

	Probability model for sea turtles	Probalility model for pelagic elasmobranchs	Probability model for demersal elasmobranchs
Kappa	0.126	0.836	0.253
Sensitivity	0.667	0.958	0.444
Specificity	0.595	0.875	0.824
CCR	0.604	0.9205	0.75
AUC	0.702	0.991	0.580

5.2. Results

In the figure 76 we show the mapping of the probability model of the sea turtles bycatches from surface longline, from northern Alboran Sea. Thus, one surface longliner operating in the red area (see map), and during summer period (such as reported in Báez et al. 2007c), have high likely to capture at least one sea turtle per fishing operation.

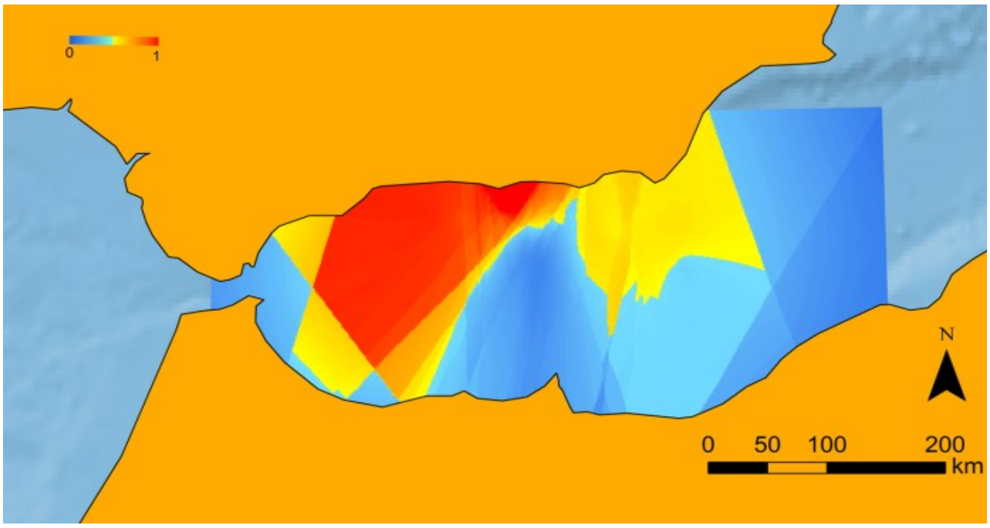

Figure 76. Mapping of the probability model of the sea turtles bycatches from surface longline. Top left shows the probability scale ranging from 0 (unlikely) to 1 (very likely).

In the figure 77 we show the mapping of the probability model of the pelagic elasmobranch from surface longline, from northern Alboran Sea. Thus, one surface longliner operating in the red area (see map), and during summer period (such as reported in Báez et al. 2009), have high likely to capture at least one pelagic elasmobranch per fishing operation.

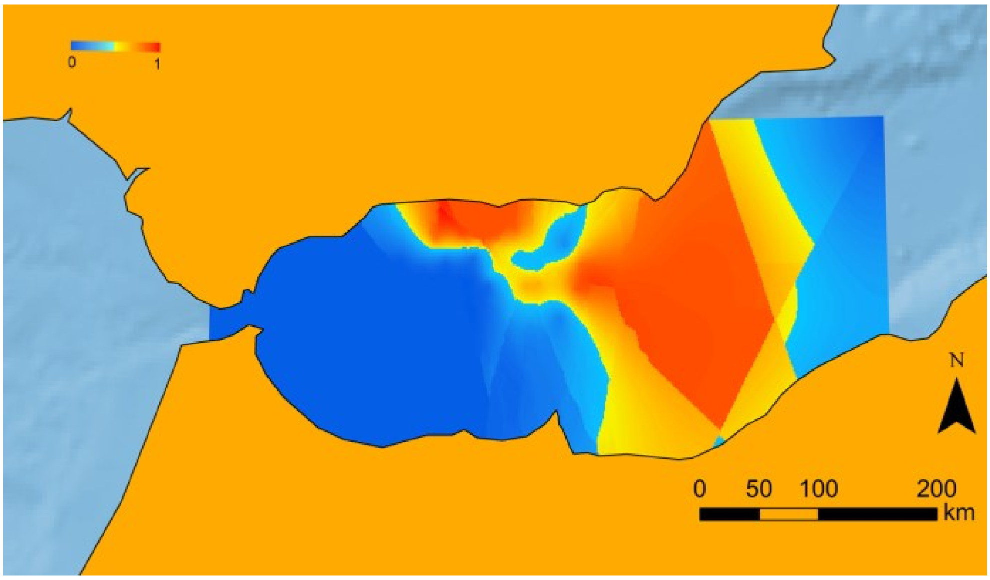

Figure 77. Mapping of the probability model of the pelagic elasmobranch from surface longline. Top left shows the probability scale ranging from 0 (unlikely) to 1 (very likely).

Figure 78 shows the results for the probability model of the demersal elasmobranch from surface longline, from northern Alboran Sea. Thus, one surface longliner operating in the red area (see map), and during summer period (such as reported in Coelho et al. 2010), have high likely to capture at least one pelagic elasmobranch per fishing operation.

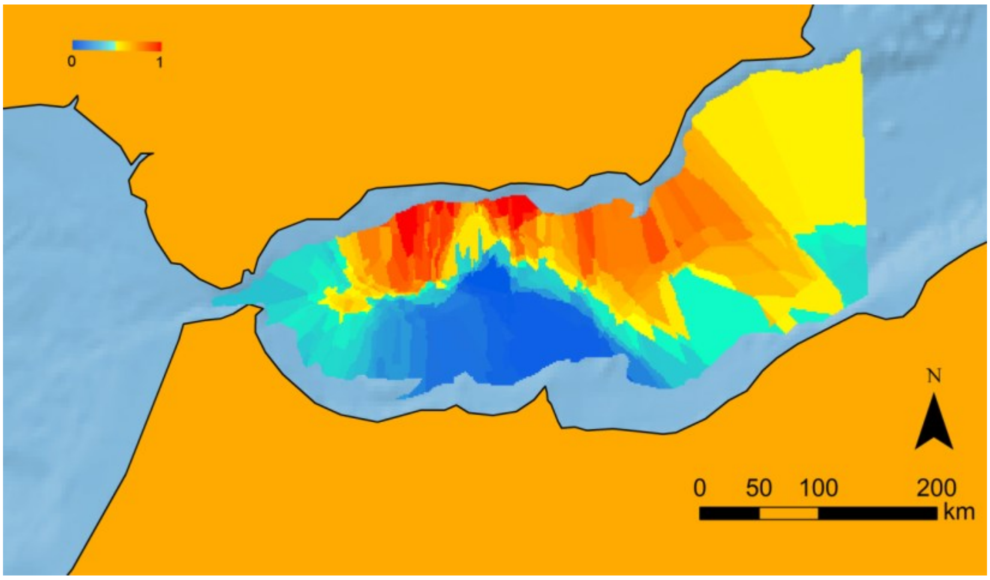

Figure 78. Mapping results of bycatch risk for demersal elasmobranchs northern Alboran Sea. Top left shows the probability scale ranging from 0 (unlikely) to 1 (very likely).

6. Conclusions and perspectives

The major problem with of the present data available is to difference between coastal fisheries (i.e. small-scale fisheries) and open sea fisheries. Thus, according to Gillet (2011), the most of the fishing fleet targeted tuna from Algeria and Morocco, are small-scale vessel, however the European fleet targeted tuna, are vessels fishing from open sea. On the other hand, the data available from Algeria and Morocco are global (i.e. it are not disaggregated per species) and scarce. Thus it is very difficult analyzed the temporal trend and fisheries profit. In this context, we did not found any paper about bycatch of the fleet from Algeria, or trawlers and longliners vessels from Morocco. For the whole open sea from Alboran Sea is necessary improving the data about CPUE, fisheries profit and bycatch per species.

6.1. Assessing the development of fishing activities within the area in the future

According to conversations with fishermen, we observed a clear currently trend, thus while the actual Spanish economic crash (which implies lower prices of fish market, as opposed to a rise in taxes and fuel), are forcing many owners to scrap their boats, in Morocco and Algeria had increased improvement of ships. In fact there are many boats Spanish-Moroccan joint ventures.

We show from the figures 79 to 82 the economic profit trend from the market prices by the mains targeted species per longliners (swordfish), trawlers (great red shrimp), and purse seiners (European anchovy and bullet tuna) from Andalusia market[15]. The correlation between the different prices and landings can be also analyzed in terms of the anomalies values. Annual prices were transformed into anomalies by subtracting the mean value calculated over the whole period 2000-2012 (figures 83 to 86).

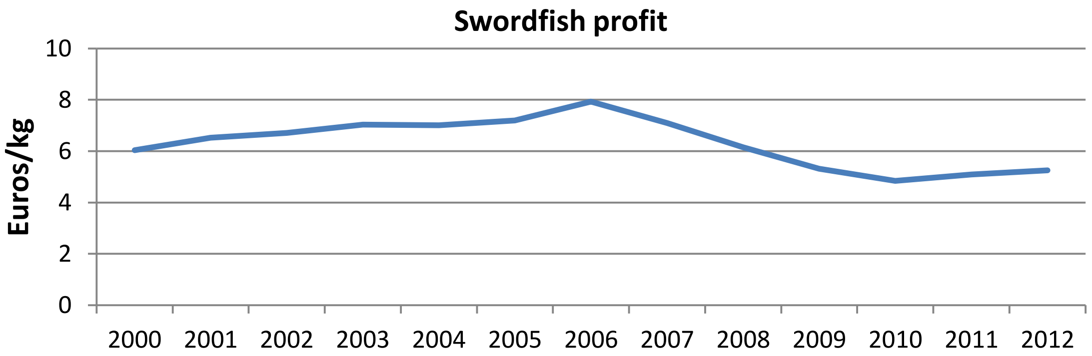

Figure 79. Trend for economic prices for the swordfish profit.

[15]Data available from web site: http://www.juntadeandalucia.es/agriculturaypesca/idapes/servlet/FrontController?action=ReportForm&table=13900&ec=default

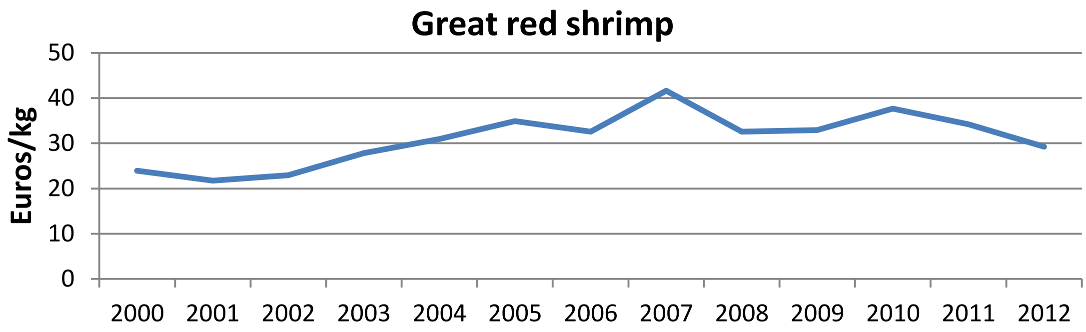

Figure 80. Trend of economic prices for the great red shrimp.

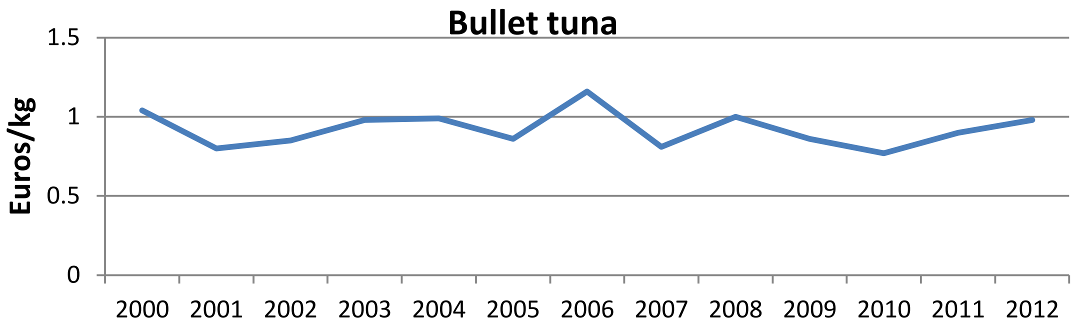

Figure 81. Trend of economic prices for the bullet tuna.

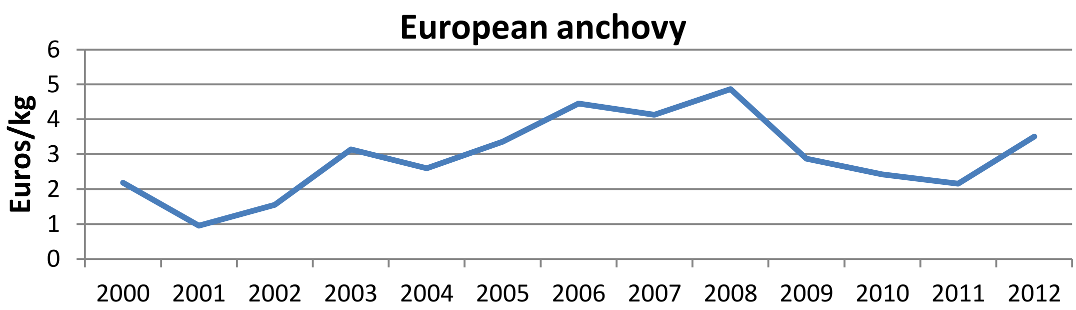

Figure 82. Trend of economic prices for the European anchovy.

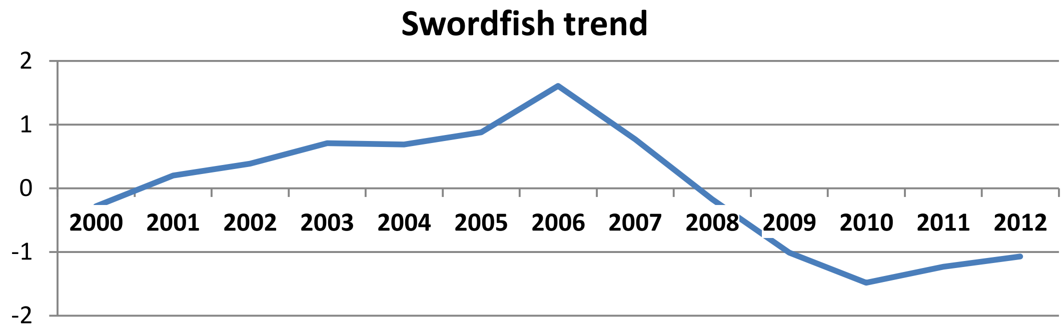

Figure 83. Anomalies values for the annual prices for the swordfish.

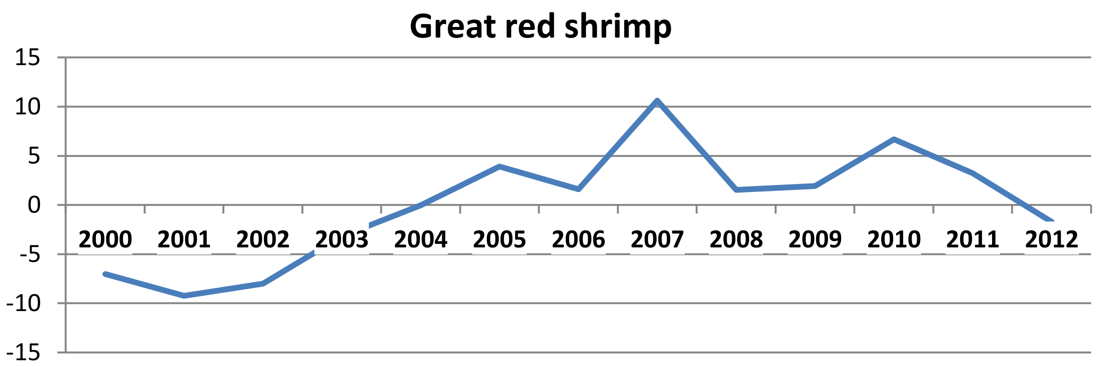

Figure 84. Anomalies values for the annual prices for the great red shrimp.

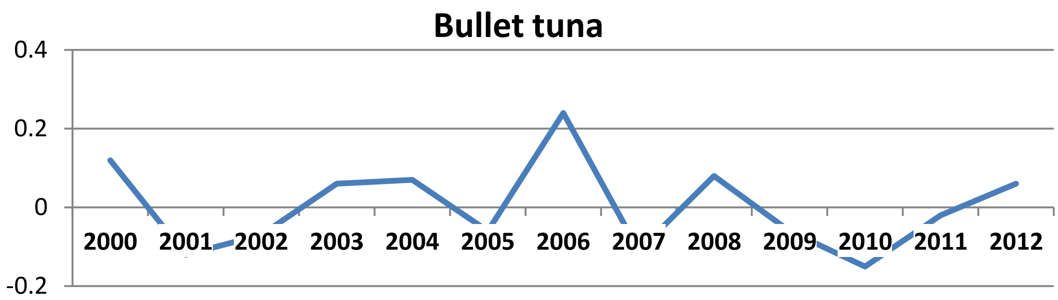

Figure 85. Anomalies values for the annual prices for the bullet tuna.

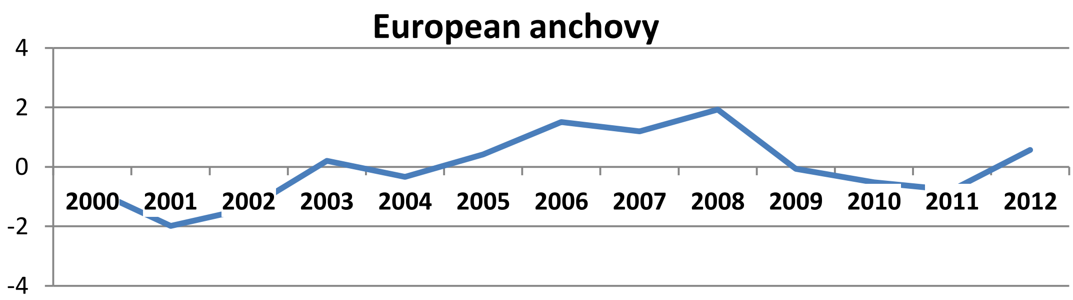

Figure 86. Anomalies values for the annual prices for the European Anchovy.

In all the above examples there is a maximum price between 2006 and 2008, and a decrease of the prices in the following years. In this context, the rest of fisheries boats should increase the fishery effort for the maintenance of economic profit. This represents an important task in the biodiversity conservation, because on the one hand, the Morocco and Algerian are increasing their technical fishery capacity, on the other hand the Spanish fleet should increase its fishery effort. Thus the whole bycatch could be increasing in these years. Slimani & Hamdi (2004) observed an overexploitation of fishing ground from coastal areas, for this reason proposed increased the exploitation of fishing ground from open sea areas, and reducing the fisheries from coastal areas. In this context, the future perspective is a decrease in fisheries capacity from northern Alboran Sea versus a increasing of fisheries capacity from southern Alboran Sea.

These observations are not a local problem; thus this problem had been observed in globally. In this context, Pitcher (2005) in a fresh policy initiative for fisheries and restoration ecology for ocean ecosystems proposed “back-to-the-future”, i.e. reduce the fishery technical capacity. For this reason, a good fisheries policy would encourage the reduction of fishing technical capacity of the fleet on both sides, improving management of fish prices.

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