Chapter 18
Demersal Resources

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18.1 Introduction

Fishery in the Mediterranean has been around for centuries, so the current fishery model is the result of this long history, and not only the result of a specific management policy. Several Greek and Latin authors attest to fishing activities in the Mediterranean, among which the works of Aristotle and Pliny should be highlighted. For example, Pliny dedicates the Book IX of his *Natural History* to aquatic animals and to describe the places where fishing was exercised using the concurrence of dolphins (Camiñas et al. 2004). As for the Alboran Sea, numerous salsary piles, created in Roman times to make garum, have been found around the coast (Camiñas et al. 2004). Technological progress and new techniques developed over centuries have gradually increased the fishery capacity of coastal peoples, but the expansion in the use of engine 100 years ago saw a significant increase in fishery pressure, with serious consequences for the state of the resources (Lleonart 2011).

Total landings in the Mediterranean and the Black Sea increased irregularly from about 1 million tons in 1970 to almost 2 million tons in 1982. They remained relatively stable during most of the 1980s before declining abruptly in 1989 and 1990, largely due to the collapse of pelagic fisheries in the Black Sea. In the Mediterranean, landings continued to increase until 1994, reaching 1,087,000 tons, and subsequently declined irregularly to 787,000 in 2013 (Fig. 18.1). Algeria, Greece, Italy, Spain, Tunisia, Turkey, and Ukraine are together responsible for slightly more than 80 percent of total landings in the Mediterranean and the Black Sea (FAO 2016).

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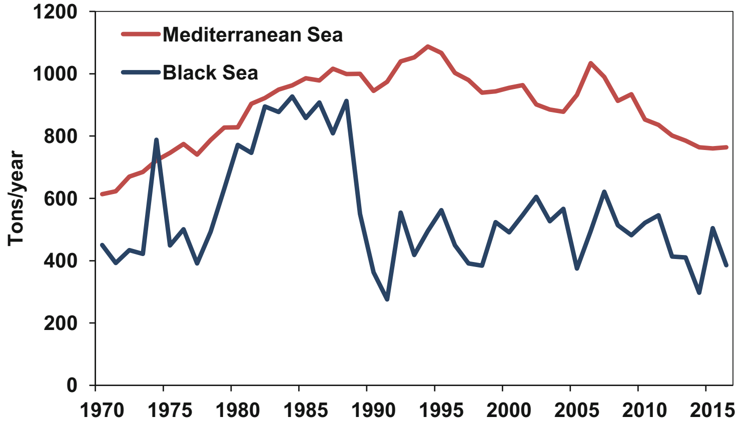

Fig. 18.1 Time series of official landings for the Mediterranean and Black Sea. Data source: FAO-GFCM (General Fisheries Commission for the Mediterranean Sea) Capture Fisheries Dataset (2019)

Despite these figures, Mediterranean fisheries only account for a small proportion of world production (some 80 million tons). However, the average prices of landings (which are mainly sold fresh) are above the average prices of world markets, and from a socioeconomic point of view, fishing activities in the Mediterranean employ a large number of people. Fishing in the Mediterranean is very diverse and varies geographically, not only because of the existence of different marine environments but also because of different socioeconomic situations. They are characterized by certain distinct features, like high diversity of the catches, high number of marketable and not marketable species, absence of large single stocks, and small-scale vessels (Damalas 2017).

Mediterranean and Black Sea waters are divided into 30 geographical subareas (GSAs), established in 2009 by the GFCM to compile data, monitor fisheries, and assess fisheries in a georeferenced manner. Therefore, from the fishery point of view, the Alboran Sea includes GSAs 01 (Northern Alboran Sea), 02 (Alboran Island), and 03 (Southern Alboran Sea). Spanish fleet operates in GSAs 01 and 02 (Fig. 18.2).

The fishing area of the Northern Alboran Sea is characterized by a very narrow shelf affected by several shelf-indenting canyons (Durán et al. 2018). Due to its oceanographic and ecological importance, with the confluence of Atlantic and Mediterranean masses, this sea supports a great marine biodiversity (García-Raso et al. 2010; Templado 2011), including a large number of commercial species. A wide variety of fishing techniques have been developed, of which bottom trawling is one of the most widely used and is responsible for the largest catches of demersal species in the area (Camiñas et al. 2004). The target species of bottom trawlers are mainly European hake, mullets, octopus, and shrimps. However, catches are composed of a large number of species (Gil de Sola 1993).

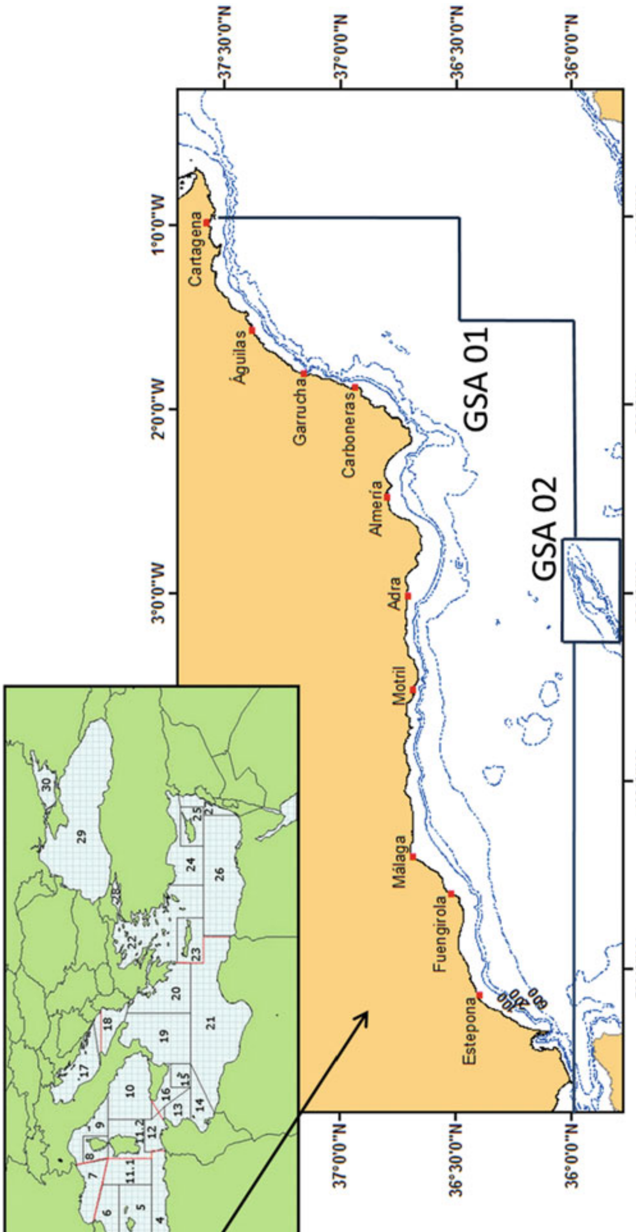

Fig. 18.2 FAO-GFCM geographical subareas in the Mediterranean Sea (green map). In detail, GSAs of the Alboran Sea where the Spanish fleet operates, with main ports

18.2 Material and Methods

The fundamental source of information scrutinized in this chapter was collected in the context of the activities of the data collection framework (DCF), carried out from 2002 to the present in the Spanish Mediterranean, both from the commercial fishery and through an experimental survey carried out in spring, from 1994, to evaluate the demersal resources (MEDITS, Mediterranean International Trawl Survey).

18.2.1 Sampling of Commercial Fishery

Sampling staff are dispersed at several locations around the coast to reduce traveling time. In general the different fisheries (otter trawls, purse seines, artisanal fleet, etc.) are widely distributed along the coast. There is a complete vessel registry and census data for landings, effort, gear, etc. as required by EU logbooks and sales notes.

The sampling design in the area is done at the metier level, for those metiers selected by the ranking system, as stated in the GFCM-DCRF Regulation (GFCM 2018a). The design has been done taking into account the representativeness of the data to collect with relation to the population (catches from the commercial fleet), considering that these data should be obtained cost-effectively, and the information obtained can be used to estimate the population characteristics of interest precisely (low variability) and accurately (unbiased). For the proposed sampling schemes, it is possible to calculate estimates of the precision of the estimators of the population parameters.

Both, for at-sea sampling and on-shore sampling, four different strata areas are considered: GSA, metier, selected ports, and time frame. For each GSA, metiers are non-probabilistic selected based on the rules of the regional RFMO (GFCM). For each combination of GSA-metier, the ports to sample have previously been selected according to previous knowledge which include their importance for each metier (both in terms of biomass landed and effort as the number of vessels) as well as their availability to carry out the sampling (both predisposition and adequate facilities). Finally, the time frame (quarter or month) is set to force the sampling to cover the entire year.

For the collection of individual information in order to estimate age, maturity, sex ratio, and weight of the main species, a number of individuals by length class every period (month, quarter, or year) will be selected.

The estimation of the biological parameters and their uncertainties will be carried out using the tool INBIO 2.0 ("Estimation of biological parameters and their uncertainties through simulation techniques"), developed in R environment by the IEO. INBIO makes it possible to fit the most usual models and to estimate the coefficient of variation for parameters by using the nonparametric bootstrap methodology.

18.2.2 MEDITS Survey

The data from the MEDITS Survey (Bertrand et al. 2002) are obtained from a total of 25 bottom trawl surveys carried out during the spring of 1994 to 2018. The covered area was between 30 and 800 m depth (in GSA 02, between 150 and 800 m). The randomized stratified sampling design defined five bathymetric strata: 30–50 m, 51–100 m, 101–200 m, 201–500 m, and 501–800 m. Haul duration varied according to depth: 30 min at depths above 200 m and 60 min below 200 m. All the surveys were carried out with the same otter bottom trawler (GOC-73) using a net with a cod mesh size of 20 mm. The mean towing speed of the vessels was 3.0 knots. The values of the vertical and horizontal opening of the gear were monitored by a SCANMAR trawl sensor device. For each sampling station, all specimens were sorted, identified, counted, and weighed on board. In this chapter, the mean abundance (num.individuals/km2) and biomass (kg/km2) of the main target species of bottom trawl fishery were calculated per year. Also, length data for these species (mean values±standard error, mode, and size range) were calculated throughout the 25 trawl surveys. Distribution maps of the species comprise data from the last year of the MEDITS survey (from 2012 to 2018).

18.3 Fishing Fleet and Main Ports

The total fishing fleet in GSA01 and GSA02 accounts for a total of 645 vessels. The fleet is composed mainly of artisanal vessels between 6 and 12 m of overall length and trawlers and purse seiners between 18 and 24 m of overall length (Table 18.1).

The number of vessels in this area has been continuously decreasing in the last decades, from more than 1045 vessels in 2004 to 645 in 2017. The biggest reductions have taken place in the set longliners, purse seiners, and bottom trawlers (Fig. 18.3).

The fleet is distributed in 14 ports along the coast. As concerns the number of vessels, the main harbors in GSA 01 are Almeria, Vélez-Malaga, Algeciras, and Estepona. In general terms, the small-scale fleet seems to decrease from the west to the east (Table 18.2).

On the other hand, bottom otter trawl is the second fleet in the number of vessels with respect to the other fishing modalities developed in the area (Table 18.2), being the biggest in tonnage and power (Table 18.1). Also it is the second fleet in landings (the first one of the demersal fisheries) and the first fleet in economic value of the landings (Fig. 18.4).

This chapter focuses on the bottom otter trawl fishery both for its importance in demersal fisheries (Sánchez et al. 2004) and for the existence of other chapters dedicated to artisanal, purse seine, and longline fisheries.

Table 18.1 Characteristics of the Spanish fishing fleet that currently operates in GSAs 01 and 02 by fishery, showing average values (± standard deviation) of capacity (gross tonnage: GT), length (overall length: LOA), and engine power (horsepower: HP)

Fisheries	Length (m)	Vessels	GT	LOA	HP
Small scale	<6	47	0.89 ± 0.28	5.29 ± 0.61	15.64 ± 8.54
	6–12	338	2.95 ± 1.83	8.23 ± 1.40	35.59 ± 20.19
	12–18	20	11.31 ± 5.87	13.20 ± 1.15	92.05 ± 41.12
	18–24	–	–	–	–
	24–40	1	91.07	24.50	350.00
	Total	**406**	**3.34 ± 5.23**	**8.18 ± 2.15**	**37.23 ± 29.79**
Otter bottom trawl	6–12	4	6.73 ± 3.25	9.39 ± 0.88	48.50 ± 30.61
	12–18	35	24.89 ± 11.17	15.63 ± 1.43	111.85 ± 45.00
	18–24	58	64.83 ± 22.39	20.85 ± 1.80	200.79 ± 107.33
	24–40	13	100.18 ± 16.51	24.65 ± 0.52	298.85 ± 96.97
	Total	**110**	**54.19** ± 31.66	**19.23** ± 3.87	**178.54** ± 108.42
Purse seine	06–12	11	6.26 ± 2.67	9.85 ± 1.32	59.82 ± 25.81
	12–18	37	22.49 ± 10.91	15.77 ± 1.64	144.27 ± 60.69
	18–24	30	51.40 ± 15.96	20.48 ± 1.86	261.60 ± 87.86
	Total	**78**	**31.32** ± 20.90	**16.75** ± 3.93	**177.49** ± 99.90
Set longline	06–12	2	6.88 ± 1.94	10.20 ± 1.55	107.03 ± 7.11
	12–18	2	10.85 ± 5.80	13.5 ± 1.41	166.00 ± 124.45
	Total	**4**	**8.87** ± 4.21	**11.85** ± 2.26	**136.51** ± 79.61
Drifting longline	06–12	3	4.02 ± 2.76	11.23 ± 1.06	75.00 ± 58.95
	12–18	23	30.53 ± 24.56	15.06 ± 1.49	111.06 ± 33.22
	18–24	17	92.07 ± 25.79	21.61 ± 1.31	221.94 ± 96.82
	24–40	4	125.79 ± 24.90	24.94 ± 0.65	370.50 ± 74.75
	Total	**47**	**59.21** ± 44.21	**18.02** ± 4.25	**167.38** ± 103.74
Total		**645**	**19.50** ± 29.69	**11.84** ± 5.66	**89.53** ± 95.55

Data source: Spanish Fleet Register of the Secretary of Fishing (December 2017)

18.4 Trawl Fishery

The gear used is bottom otter trawl nets (in the Spanish Mediterranean, fishing with pelagic trawl nets is forbidden), which present a continuous evolution and a great variety of shapes according to the localities, vessels, and target species (Gil de Sola 1993).

Trawlers (Fig. 18.5) are distributed along the coast. The number of vessels is not related to the size of the town (Table 18.2), but it seems to depend on other variables, like tradition, activity of the port, or distance to the fishing grounds. The activity of this fleet is subject to the European Union national and regional regulations. The main measures are related to the minimum working depth (50 m), duration of fishing trips per day (12 hours) and maximum of fishing days per week (5 days), spatio-temporal closures to fishing, minimum mesh size in the cod end of the net (40 mm

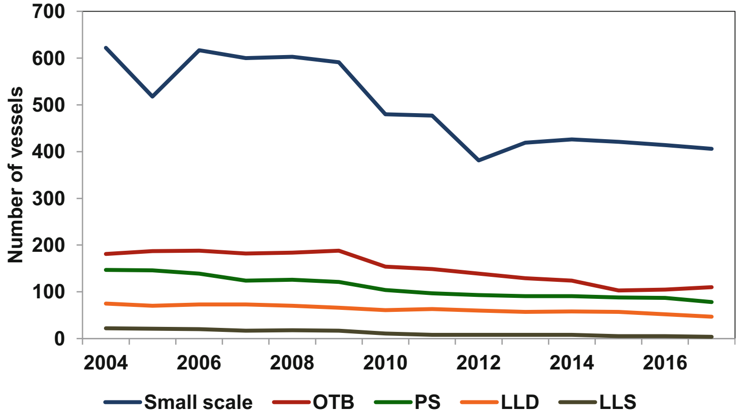

Fig. 18.3 Evolution of the number of vessels in GSA 01. *OTB* bottom otter trawl; small scale, small-scale fleet; *PS* purse seine; *LLS* set longline; *LLD* drifting longline

Table 18.2 Distribution of fleets in the main ports of GSA 01. Ports are ordered from western to eastern

Port	Trawlers	Small scale	Purse seine	Set longline	Drifting longline
Algeciras		68	1	2	2
Estepona	6	51	5		
Marbella	4	25	8		
Fuengirola	8	30	2		
Vélez-Málaga	18	42	15		
Motril	13	17	2	1	1
Adra	1	16	7		1
Roquetas de Mar		8	2		6
Almería	27	40	11		2
Carboneras	4	14	4	1	31
Garrucha	8	16			1
Águilas	9	19	3		
Mazarrón	5	14	11		
Cartagena	7	24	2		3
Total	110	406	78	4	47

Source of data: Spanish Ministry Fleet Register (January 2018). In black, ports of the Alboran Sea sensu stricto. In red, ports of the Gulf of Vera

square or 50 mm diamond meshes of 3 mm twine thickness), and maximum engine power (500 HP). Sometimes part of these measures, like the maximum engine power, is not followed by all fishermen, increasing the fishing power and causing, in the end, overfishing of resources and the ecosystems.

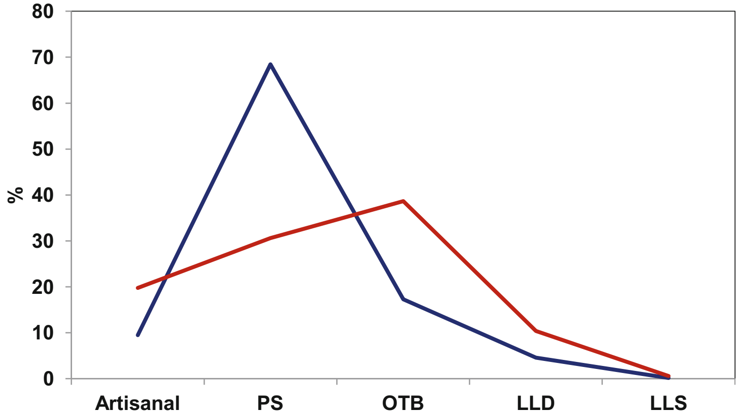

Fig. 18.4 Percentage of landings (blue) and value of landings (red) in the fleets of GSA 01. Source of data: 2017 sale notes. *OTB* bottom otter trawl; artisanal, artisanal fleet; *PS* purse seine; *LLS* set longline; *LLD* drifting longline

Fig. 18.5 Spanish bottom otter trawl operating in the Alboran waters

18.4.1 Metiers of the Bottom Trawl Fleet

One of the most commonly used terms in the description and management of fisheries is the metier (Punzón et al. 2010). A metier is a group of fishing operations targeting a similar assemblage of species, using similar gear, during the same period of the year and/or within the same area and which are characterized by a similar exploitation pattern (Commission Decision (EU) 2016/1251). In the Mediterranean, two main metier have been defined in the bottom otter trawl fishery (Commission Decision (EU) 2016/1251): bottom otter trawl targeting demersal species and bottom otter trawl targeting deepwater species. The main characteristics of the two metiers in the Alboran Sea where the Spanish fleet operates are described down below:

18.4.1.1 GSA01 (Northern Alboran Sea)

Bottom Otter Trawl Targeting Demersal Species (OTB_DEF)

European hake (*Merluccius merluccius*), deepwater rose shrimp (*Parapenaeus longirostris*), red mullet (*Mullus barbatus*), stripped red mullet (*Mullus surmuletus*), Norway lobster (*Nephrops norvegicus*), and common octopus (*Octopus vulgaris*) are the most commercially valuable species in the area and are an important component of a species assemblage that is the target of the bottom trawling fleets operating near the shore (Fig. 18.6).

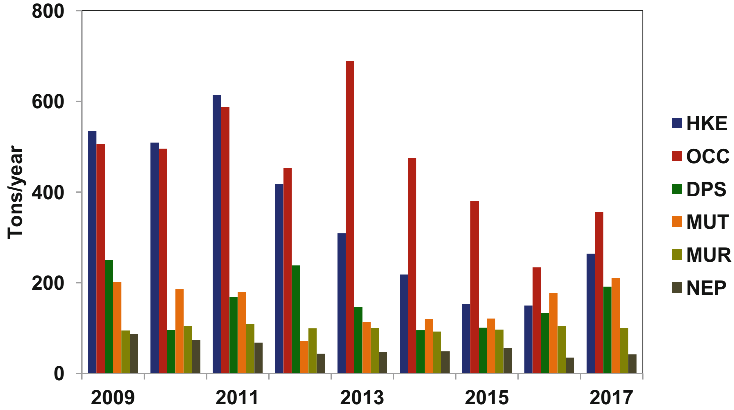

Fig. 18.6 Main species landings (tons) of trawlers targeting demersal species. GSA 01. HKE, *M. merluccius*; OCC, *O. vulgaris*; DPS, *P. longirostris*; MUT, *M. barbatus*; MUR, *M. surmuletus*; NEP, *N. norvegicus*

European hake is one of the target demersal species of the Mediterranean fishing fleets, largely exploited in GSA 01 mainly by trawlers (95% landings) on the shelf and slope and by small-scale fisheries using gillnets or set longlines on the shelf.

Bottom Otter Trawl Targeting Deepwater Species (OTB_DWS)

The blue and red shrimp (*Aristeus antennatus*) is the most important resource of slope bottom trawling in GSA 01 and is targeted by the largest vessels of the deepwater trawl fleet segment. A total of 49 vessels (average 2011–2013) had fishing activities directed towards this species in GSA 01 fishing grounds. The most important landings port in 2017 was Garrucha with 34 tons landed, followed by Almeria (22.5 t) and Aguilas (11 t). The pattern of this fishery can be considered monospecific, where the discard is practically zero for this species. The bycatch is composed of anglerfishes (*Lophius budegassa* and *L. piscatorius*) and European hake (Fig. 18.7).

18.4.1.2 GSA02 (Alboran Island)

In GSA 02, only the bottom trawl operates, mainly in the middle slope, targeting blue and red shrimp. In this GSA, fishing trips last for 4–5 days, in contrast to the rest of the western Mediterranean, where fishing trips for trawlers only last for a single day. The main base port of this fleet is Almeria, and the fishing period goes from May to October. The number of vessels operating in this area is variable because of weather conditions, and it ranges from 1 in April to 13 in August, the month with

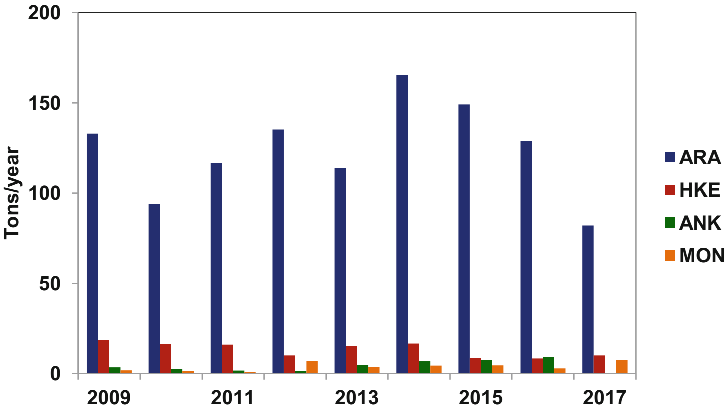

Fig. 18.7 Main species landings (tons) of trawlers targeting deepwater species. GSA 01 (ARA, *A. antennatus*; HKE, *M. merluccius*; ANK, *L. budegassa*; MON, *L. piscatorius*)

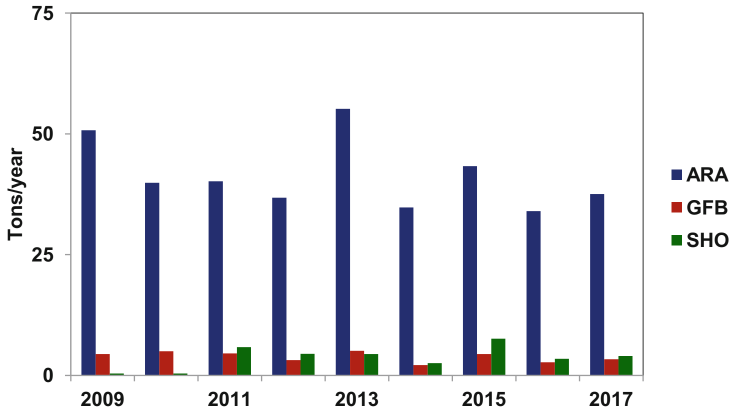

Fig. 18.8 Main species landings (tons) of trawlers targeting deepwater species. GSA 02. ARA, *A. antennatus*; GFB, *P. blennoides*; SHO, *G. melastomus*)

more fishing effort. Bycatch is composed mainly of greater forkbeard (*Phycis blennoides*) and blackmouth catshark (*Galeus melastomus*) (Fig. 18.8).

18.5 Target Species

Despite its multi-specific nature, the target species of bottom trawlers are mainly the crustaceans *Aristeus antennatus* and *Parapenaeus longirostris*; the cephalopod *Octopus vulgaris*; and the fishes *Merluccius merluccius* and *Mullus barbatus*.

18.5.1 Aristeus antennatus *("Blue and Red Shrimp")*

Aristeus antennatus (Risso, 1816) (Fig. 18.9) is an eurybathic species. It is widely distributed throughout the Mediterranean Sea, as well as in the Atlantic Ocean, from southern Portugal to the Green Cape Islands (Holthuis 1980). It is the only species of the genus *Aristeus* present in the Mediterranean Sea, where it has a wide distribution with the exception of the Adriatic and Aegean Sea where the bathymetric characteristics of them limit their presence (Holthuis 1987). It is a demersal species characteristic of the muddy bottoms of the continental slope and is characterized by a wide bathymetric distribution ranging between 80 and 3300 m (Sardà et al. 2003, 2004).

This species makes important migration, both of circadian, spatial, and seasonal character (Cartes 1993; Demestre and Martin 1993; Sardà 1993; Sardà et al. 1994, 1997; Mura and Cau 1994). In adult populations, these migrations are related to reproductive processes and habitat use. It has also been found that several

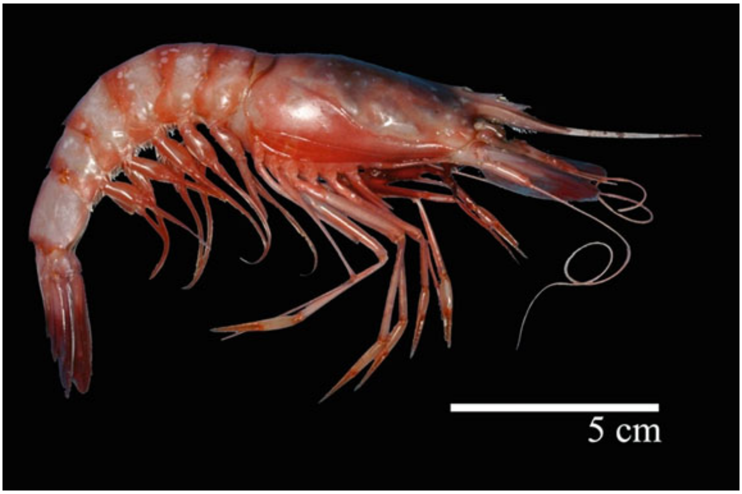

Fig. 18.9 *Aristeus antennatus* (adult female) (source IEO)

characteristics, such as the mean size of individuals, female maturity stages, and sex ratio, varied according to the spatial location (Sardà et al. 1997, 2003; Demestre 2003; Tudela et al. 2003; Cartes et al. 2018).

Sexual dimorphism is a dominant condition between species of crustaceans. The females of *A. antennatus* are larger than the males (Sardá and Demestre 1987), and the rostrum is short in adult males and long in juveniles and adult females (Sardá and Demestre 1989) (Fig. 18.10). It is estimated that they have longevity between 5 and 7 years for females and 3 and 5 years for males (Carbonell et al. 1999). The reproductive period starting at the end of the spring and lasting through the summer, with the greatest intensity in the months of June to September (Sardá and Demestre 1987; García-Rodríguez and Esteban 1999). There is variability in the size of the first maturity described in the bibliography in response to the geographic area, where the study has been conducted, fluctuating it in a range between 18.1 mm and 26.0 mm for males and 21.9 mm and 31.8 mm for females (García-Rodríguez and Esteban 1999; Carbonell et al. 1999).

It began to be exploited on the Mediterranean coasts of Spain in the decade of the 1940s of the last century. Studies on its biology and fisheries began to develop from the 1960s (Bas 1960, 1965, 1966, 1967; Massutí 1961, 1973, 1975). Studies on the biology and population dynamics are abundant on the coasts of the Spanish Mediterranean Sea, with the exception of Alboran Sea: e.g., Catalan coast (Demestre and Martin 1993; Demestre and Lleonart 1993; Sardà et al. 1994), Balearic Islands (Carbonell et al. 1999; Guijarro et al. 2008), Ibiza channel (García-Rodríguez and Esteban 1999), and Alicante gulf (García-Rodríguez 2003).

Aristeus antennatus is one of the main target species of Mediterranean deepwater trawling (Demestre and Martin 1993; Carbonell et al. 1999; Mouffok et al. 2008), and its fishing has certain characteristics which differentiate it considerably from

Fig. 18.10 Morphological rostral types of *Aristeus antennatus* (source IEO)

other Mediterranean bottom trawling fisheries. It can be considered as a monoespecific fishery (Demestre and Martin 1993); it is very lucrative, due to the high commercial value of the product, and it is performed at depths where the abundance of other commercial species is very low, since the majority of the catch is blue-red shrimp (Fig. 18.11). It does not usually contribute more than 5% of the landings by weight; it can amount to 50% of the landings by value in some ports. The fishing involves high risks as it is conducted in deep waters, and commercial trawling catches are made on the continental slope depths of 350 to 850 m (Carbonell et al. 2000), on grounds where the continental shelf and slope form submarine canyons (Sardà et al. 1994, 1997; Tudela et al. 2003). Rose shrimp abundance is higher on the slope in spring and summer (Sardà et al. 1997).

Fig. 18.11 Catches of blue-red shrimp obtained by a trawler (source IEO)

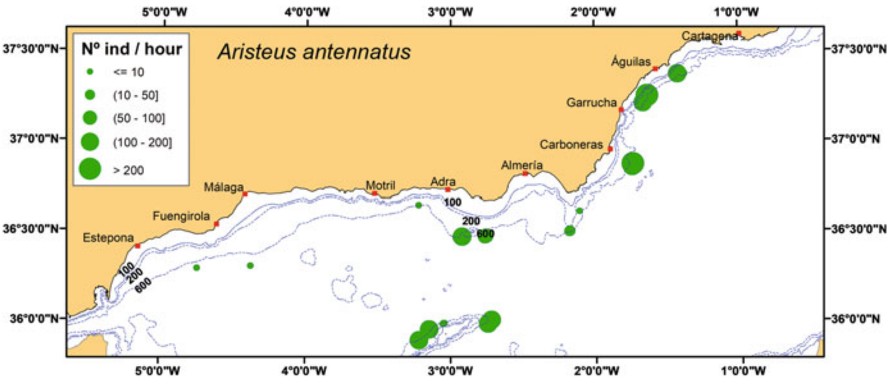

Fig. 18.12 MEDITS indices of abundance (individuals/hour) of *Aristeus antennatus* in GSA 01 and GSA 02, from 2012 to 2018

During the MEDITS surveys, the species was caught on the upper and middle slope between 414 and 786 m depth (Fig. 18.12), being more abundant at 600–800 m. For males, sizes range from 2 mm to 40 mm carapace length (CL), mean values are 25 (± 3.8 SD) mm CL, and the most common size is 25 mm CL; for

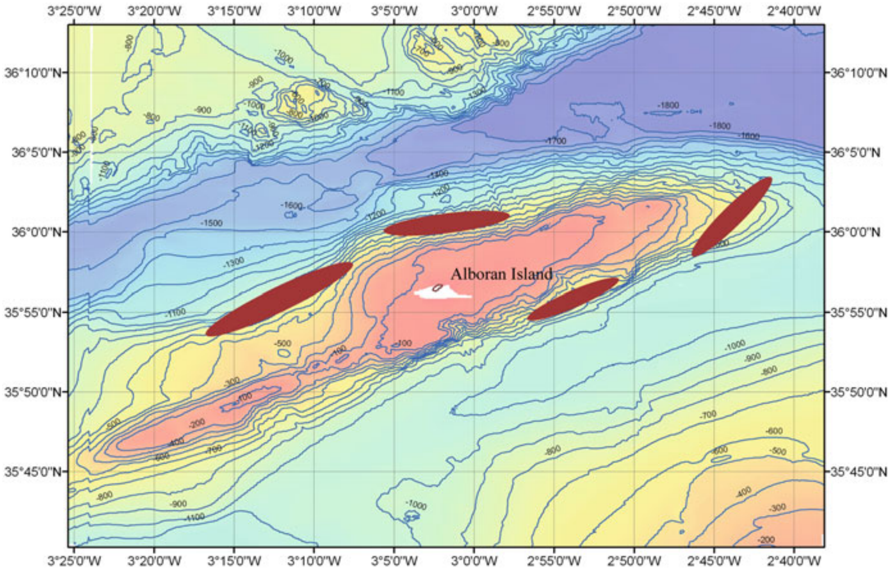

Fig. 18.13 *Aristeus antennatus* fishing grounds in the Alboran Island (GSA02)

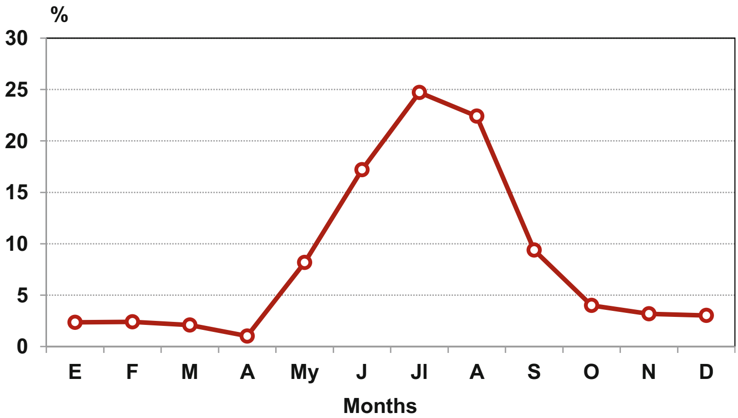

Fig. 18.14 Monthly catches of *Aristeus antennatus* in the Alboran Island (GSA02)

females, sizes range from 14 mm to 63 mm CL; mean values are 36 (± 8.2SD) mm, and the most common size is 35 mm CL.

The most important fishing grounds in the Alboran Sea are located in the vicinity of the Alboran Island (Fig. 18.13). According to Spanish regulation, trawlers can operate in the Alboran Island between 100 and 1000 m depth. The maximum duration of fishing trips is 10 days. The number of vessels authorized in the fishing grounds is currently 51, most of them >24 m length. The highest fishing activity of this fleet is carried out between May and September, and the monthly catch

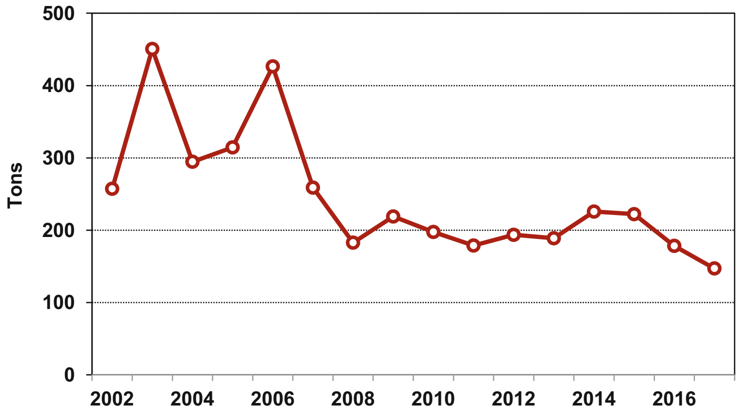

Fig. 18.15 *Aristeus antennatus* annual landings (in tons) by trawl fishery through historical series analyzed (2002–2017) in the Alboran Sea (GSA01-GSA02)

(Fig. 18.14) closely followed this pattern. A total of 35% of the landings from the fishing grounds of the island were red shrimp, while the landings coming from the fishing grounds closest to the peninsula only accounted for 5%.

The annual landings in the whole area (GSA01 and GSA02), over the period of the data series (2002–2017), have shown several oscillations, ranging between the maximum value of 451 t in 2003 and minimum value of 147 t in 2017. A large decrease in catches took place in 2007 and 2008 (Fig. 18.15). Landing sizes ranged between 14 and 66 mm CL, the mean value was 32.3 (± 8.0 SD) mm, and the most common size was 28 mm.

Following the results of the WGSAD (Working Group on Stock Assessment) GFCM carried out in 2018, the exploitation of *A. antennatus* in GSA 01 and GSA 02 shows a similar pattern. However in GSA 02, the stock status shows a low overexploitation situation, while in GSA 01, the stock status shows a high overexploitation (GFCM 2018b).

18.5.2 Parapenaeus longirostris *("Deepwater Pink Shrimp")*

Parapenaeus longirostris (Lucas, 1846) (Fig. 18.16) is one of the most important commercial crustaceans in the Mediterranean Sea, especially for the trawl fishery throughout its distribution range.

It is a demersal species found on sandy and sandy-muddy bottoms in the Mediterranean Sea as well as in the eastern and western Atlantic Ocean, from Portugal to Namibia and from Massachusetts to Venezuela, respectively (Zariquiey 1968). In the Mediterranean Sea, the species shows a wide bathymetric distribution, occurring from 20 to 750 m being more abundant at depths between 100 and 200 m (García-Rodríguez et al. 2009; Guijarro et al. 2009) and in the eastern and central

Fig. 18.16 *Parapeaneus logirostris* (source: IEO)

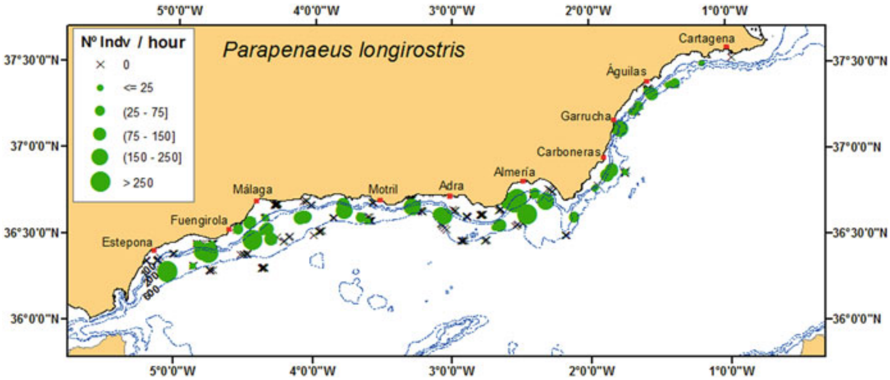

Fig. 18.17 MEDITS indices of abundance (individuals/hour) of *Parapenaeus longirostris* in GSA 01, from 2012 to 2018

basins than in the western basin. Biomass is higher between 200 and 400 m depth with a marked size-dependent distribution by depth: small individuals are found at the edge of the continental shelf while larger individuals are distributed in deeper waters (Abelló et al. 2002). In addition, some authors suggest that adults move during the spawning period to shallower waters, where the occurrence of larvae has been detected (Dos Santos 1998). In the Northern Alboran Sea, one of the most representative species on the upper continental slope (200–500 m depth) is *Plesionika heterocarpus* and *Solenocera membranacea* (Ciércoles et al. 2018).

During the MEDITS surveys carried out in GSA 01, species was caught between 50 and 700 m depth, but its abundance drops considerably below 400 m. It is distributed throughout the entire study area (Fig. 18.17). Size ranges between

3 and 41 mm CL in GSA 01; mean values are 23.8 (±5.0 SD) mm CL, common between 23 and 24 mm. Female sizes range between 5 and 41 mm CL, and mean values are 24.9 mm CL((±5.9 SD) common between 26 and 27 CL. Male sizes range between 3 and 40 CL, mean values are 22.6(±3.6 SD), and common values are 23 mm CL.

Parapenaeus longirostris is an epibenthic short-lived species characterized by higher rates of growth and mortality (Abelló et al. 2002). Continuous spawning is common both in the Mediterranean Sea and the Atlantic Ocean, with peaks of reproductive activity varying between areas without a clear trend. In the Balearic Islands, although maturing females were found all year round, two peaks were detected, one in November and a larger one in August and June (Guijarro et al. 2009). In the Gulf of Alicante, spawning can take place throughout the year too, with massive events at some points in the year, especially in spring, summer, and fall, being the most important summer (García-Rodríguez et al. 2009). According to these authors, those events can fluctuate, advancing or delaying slightly as a function of the oceanographic conditions of the year and the area studied. The size at first maturity of 25.6 mm for females in this adjacent area indicates that maturation will have to occur from the second year of life. The species shows a sexual size dimorphism, with a negative allometry of relative growth that is more pronounced in males and thus results in lower sizes of males than of females. Estimates gave higher K values for males than for females, indicating that males would reach 13.2 mm CL in the first year and females 14.8 mm CL, which would represent a maximum life expectancy of 4 and 6 years, respectively (García-Rodríguez et al. 2009).

According to the trophic guild classification from Cartes et al. (2002), *P. longirostris* is an infaunal feeder. The species displays a highly diversified diet and consumes a broad range of prey items (Cartes 1995; Kapiris 2004). In the western Mediterranean Sea, Cartes (1995) reported that *P. longirostris* had highly diversified diets based mainly on benthic organisms (polychaetes, bivalves, gastropods, and echinoderms), suprabenthic organisms (mainly gammarid amphipods), and a small proportion of pelagic organisms.

P. longirostris is one of the main crustacean species for trawl fisheries in GSA 01. It is an important component of landings in some ports and occasionally a target species of the trawl fleet targeting demersal species operates on the upper slope (GFCM 2018b). The annual landings in this area fluctuated during the all assessed series and increased in the last 3 years reaching up 201 t in 2017 with two peaks during 2009 and 2012 (Fig. 18.18). Landing sizes ranged between 10 and 49 mm with a maximum around 22–23 mm CL. The mean of landings sizes is 24.4 (±4.5 SD) mm CL.

Abundance and biomass indices from fishery-independent survey MEDITS (Fig. 18.19) do not reveal any significant trends since 1994, but interannual oscillations. For this survey the abundance and biomass indices show similar trends, peaking during 2012 and 2009. Both of them show a very sharp increment during the 2018 survey.

In the framework of the GFCM stock assessment (WGSAD) carried out in GSA 01 for *P. longirostris* during 2018, the stock status was "in overexploitation" being

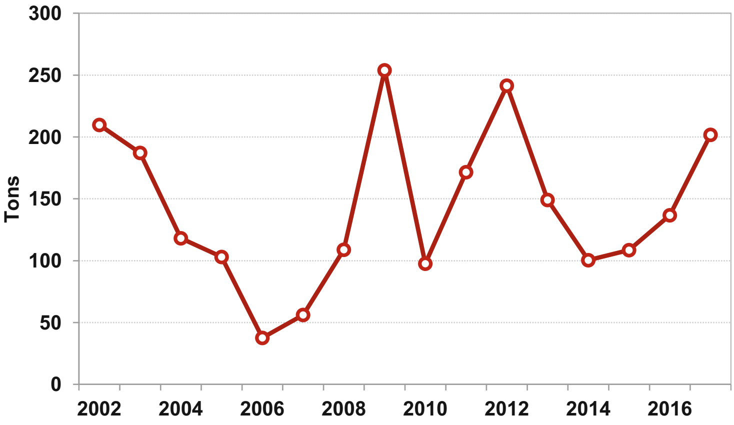

Fig. 18.18 *Parapenaeus longirostris* annual landings (in tons) by trawl fishery through historical series analyzed (2002–2017) in the Alboran Sea (GSA 01)

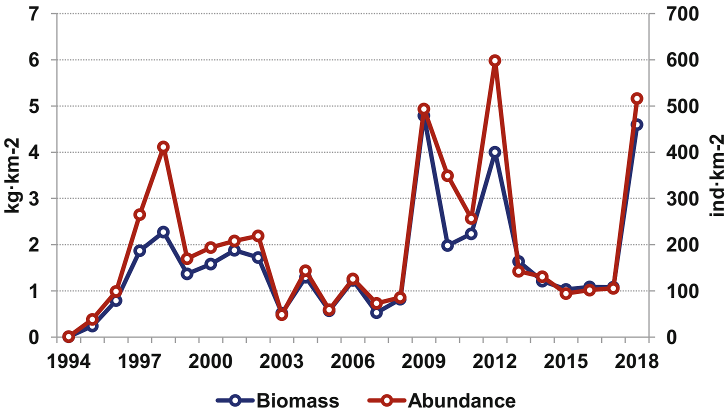

Fig. 18.19 *Parapenaeus longirostris* biomass (kg·km^{-2}) and abundance indices (individuals·km^{-2}) in GSA 01 from the MEDITS surveys through historical series analyzed (1994–2018)

the scientific advice for management of the progressive reduction of the fishing effort (GFCM 2018b).

18.5.3 Octopus vulgaris *("Common Octopus")*

Octopus vulgaris Cuvier, 1797 (Fig. 18.20) is a benthic cephalopod distributed, in a strict sense, throughout the Mediterranean Sea and central and northeast Atlantic Ocean (Norman et al. 2014).

Fig. 18.20 *Octopus vulgaris* (source: IEO)

Most of its population is confined to the continental shelf, with greatest densities shallower than 100 m depth (rare or occasionally below 200 m) habiting diverse ecological niches like rocky, gravel, sandy, and muddy bottoms (Guerra 1981; Mangold 1983; Belcari and Sartor 1999; Borges et al. 2000; Belcari et al. 2002; Norman et al. 2014). Its bathymetric distribution depends on its life cycle. *O. vulgaris* migrates from offshore to inshore waters during the breeding season for the female necessity of rocky substrate for spawning. After, the adults die, while youngers migrate to deeper water where growth and mature take place (Mangold-Wirz 1963; Guerra 1981; Quetglas et al. 1998; Garcia-Martínez et al. 2017).

In the MEDITS survey carried out in GSA 01, *O. vulgaris* was caught between 40 and 341 m depth (Fig. 18.21).

In the Mediterranean Sea, *O. vulgaris* is predatory feed predominantly on crustaceans (mainly decapods), mollusks (mainly bivalves), and fishes; it can also be cannibal, feeding occasionally other cephalopods (Guerra 1978; Quetglas et al. 1998; Norman et al. 2014; Sánchez et al. 2015). A wide range of predators prey on this species, mainly vertebrates (cetaceans, birds, teleost fishes, and elasmobranch) and other cephalopods (Hanlon and Messenger 1996; Norman et al. 2014).

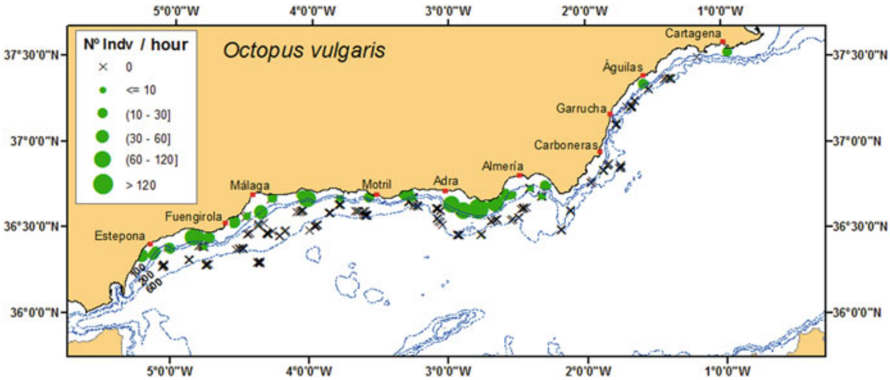

Fig. 18.21 MEDITS indices of abundance (individuals/hour) of *Octopus vulgaris* in GSA 01, from 2012 to 2018

O. vulgaris is a short lifespan species (1–2 years) with rapid growth and large individual variation in growth rates (Mangold 1983; Domain et al. 2000). Spawning takes place once in their lifetime, often seasonally, with a high fecundity and an indirect embryonic development with a planktonic phase (paralarval) (Rocha et al. 2001). The natural mortality in this species is high (especially on the paralarvae phase) and depends on environmental conditions, with highly variable recruitment success (Faure 2002; Sánchez et al. 2015).

In the Northern Alboran Sea, *O. vulgaris* is the most important marketed cephalopod, with a great commercial interest and economic value (Junta de Andalucía 2016). It is mainly fished by coastal trawlers and small-scale fleets (pots and traps). Trawl fleet operates on depths below 50 m only in soft, sandy, or muddy bottoms, while small-scale fleet operates in any type of bottoms in coastal areas and is a highly selective gear, focusing on *O. vulgaris* (Sánchez and Obarti 1993; Quetglas et al. 1998; Borges et al. 2000; Tsangridis et al. 2002; Belcari et al. 2002). The annual average landings for 2002–2017 in the Northern Alboran Sea were 1009.9 t (56.40% was caught by trawl fleet). These annual landings showed significant fluctuations, from 600 t to more than 1600 t. Similar trend occurs in the MEDITS survey (Fig. 18.22).

The cause of these fluctuations in *O. vulgaris* landings are unknown; although different assumptions are suggested, like the following: (i) the influence of environmental conditions on recruitment through influence on adult fecundity, hatching success, growth and mortality of paralarvae, and the food availability and (ii) the increase of the fishing effort (Sobrino et al. 2002; Vargas-Yáñez et al. 2009; Caballero-Alfonso et al. 2010; González et al. 2011; Rodhouse et al. 2014). Furthermore, intra-annual landings and population structure of *O. vulgaris* reveal a marked seasonality reflecting the octopus's annual life cycle in the study area: the migration of mature individuals to shallower waters for reproduction purposes in summer and followed by the dead of post-spawning specimens. The incorporation of recruitment of young individuals to the fishery is in autumn and their fast growth and

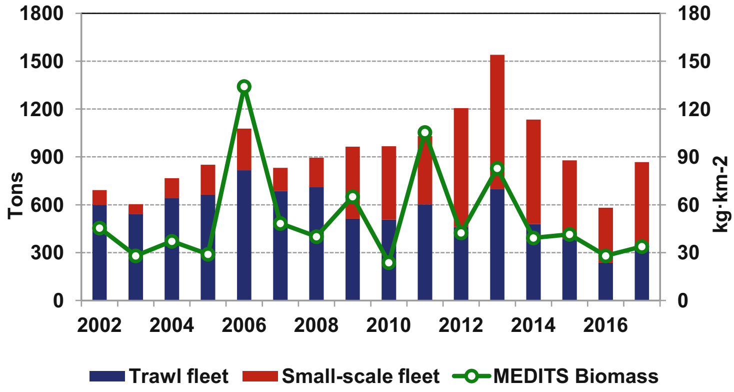

Fig. 18.22 *Octopus vulgaris* annual landings (in tons) and MEDITS abundance indices (kg·km^2) in GSA 01 through historical series analyzed (2002–2017)

migration from inshore to offshore in winter (Garcia-Martínez et al. 2017, 2018; Ciércoles et al. 2019). As with annual fluctuations, this seasonality in population abundance and structure of *O. vulgaris* could be modulated by environmental variables (Vargas-Yáñez et al. 2009; Puerta et al. 2016).

The maximum size reported in European waters is 40 cm mantel length (ML) (Guerra 1992; Pierce et al. 2010; Sanchez et al. 2015). In GSA01 *O. vulgaris* size landings range between 10 and 29 cm dorsal mantel length (DML) with an average of 16.36 cm (±2.88 SD) and modal size of 15 cm for a small-scale fleet. For trawl fleet size landings range between 5 and 32 cm DML with an average of 12.76 cm (±4.10 SD) and a modal size of 13–14 cm. Taking into account the landings of both fleets, the *O. vulgaris* size ranges between 5 and 32 cm DML with an average of 12.76 cm (±4.10 SD) and modal size of 15 cm. Regarding this biometric characteristics, pots catch large specimens associated with the selectivity of the gear and the octopus's annual life cycle (migration of mature individuals to shallower waters for reproduction), while trawlers catch all sizes, but especially the small ones probably owing to migration of young individuals to offshore (Quetglas et al. 1998). For MEDITS data, the size catches range between 1 and 21 cm DML with an average of 9.64 cm (±10.06 SD) and a modal size of 9 cm DML.

Males become mature at a smaller size (600 gr in the Northern Alboran Sea according to Tirado et al. 2003 and 9.67 cm DLM according to González et al. (2011) in adjacent areas Gulf of Alicante) than females (1000 gr in the Northern Alboran Sea according to Tirado et al. (2003) and 14.38 cm DML according to González et al. (2011) in adjacent areas Gulf of Alicante). Males are in the reproductive state throughout the year, while females are in sexual inactivity state most of the year (Tirado et al. 2003; González et al. 2011). Regarding the trawl fleet, *O. vulgaris* was one of the five most important species, being the third one in landings (8.33%) and the fifth one in economic value (7.61%) (Junta de Andalucía

2016). Also, *O. vulgaris* reported a significant increase in their economic value (from 4.5 €·kg^{-1} average in first sale price in 2012 to more than 7 €·kg^{-1} in 2017) making *O. vulgaris* an increasingly valuable resource (Ciércoles et al. 2019).

The fishery management is based on the establishment of a minimum legal weight of landed of 1 kg (National Order: APA/973/2002 - BOE 106, 3/05/2002- and Regional Order of 24 of February of 2016 - BOJA 41, 02/03/2016-). Also small-scale fleet has a closed season of 3 months (July until September) to protect spawning stock, a vessel census, and a gear limitation in the maximum number of clay pots or traps for boat and time regulation to control the fishing effort (Regional Order: 7 of April of 2004 - BOJA 76, 20/04/2004-).

Octopus vulgaris is a difficult resource to manage, and the traditional methods of fish stock assessment have generally been thought unsuitable for assessing cephalopods due to their biological characteristics (short life span, rapid growth, high natural mortality, and sensitivity to environmental conditions) (Pierce et al. 2010). In consequence there are no catch quotas and no formal stock assessment in the Northern Alboran Sea (like most octopus fisheries in European waters). In order to improve the situation, the ICES Working Group on Cephalopod Fisheries and Life History (WGCEPH) organizes some stock assessment workshops with the objective of providing the opportunity for European and invited non-European scientists to discuss assessment issues and methodologies (Pierce et al. 2010; ICES 2018 and others). Nowadays the production models and the model Catch-MSY seem to be the most appropriate for the *O. vulgaris* assessment. In adjacent areas the experts are working on applying these statistical models and including the effect of environmental factors (Quetglas et al. 2013, 2015; Sobrino et al. 2020).

18.5.4 Merluccius merluccius *("European Hake")*

Merluccius merluccius (Linnaeus, 1758) (Fig. 18.23) is one of the most important demersal species of the Mediterranean demersal ecosystem. It is a target species of the Mediterranean fishing fleets, largely overexploited in Europe (Casey and Pereiro 1995; Oliver and Massuti 1995; Mendoza et al. 2010; and references therein).

Fig. 18.23 *Merluccius merluccius* (redrawn from García et al. 2015)

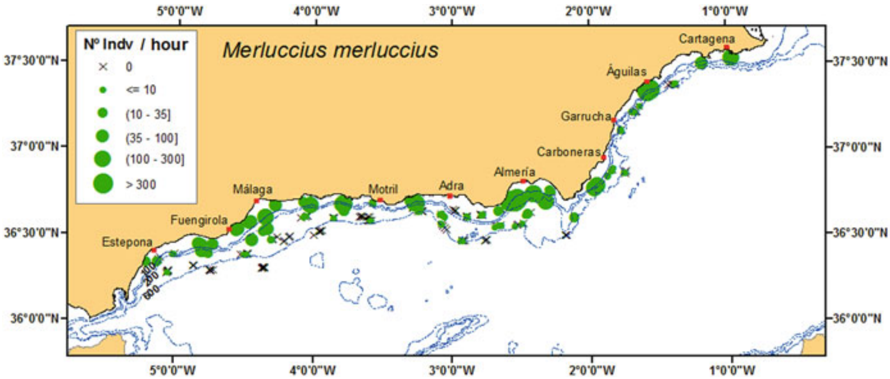

Fig. 18.24 MEDITS indices of abundance (individuals/hour) of *Merluccius merluccius* in GSA 01 from 2012 to 2018

It is a benthopelagic species that lives on muddy or mud-sand grounds on the continental shelf and slope, at depths between 50 and 370 m, although it can also be found between 30 and 1075 m depth (Lloris et al. 2005). In the Mediterranean Sea, the species is mainly abundant at depths ranging from 100 to 400 m, and the highest abundance values coincide with the 100–200 m depth zone in which most nursery grounds in the Mediterranean Sea are located (Orsi Relini et al. 2002). It occurs in the eastern Atlantic, from Norway and Iceland coasts to Mauritania coasts, in the Mediterranean Sea, and along the southern coast of the Black Sea (Cohen et al. 1990).

Two subspecies can be distinguished in the western Mediterranean Sea: *Merluccius merluccius merluccius*, with pectoral fins larger than ventral fins, and *Merluccius merluccius smiridus* with pectoral and ventral fins of equal size (Lloris et al. 2005).

During the MEDITS surveys carried out in the Northern Alboran Sea, species was caught between 30 and 700 m, but its abundance drops considerably below 300 m, and it is more abundant in the outer continental shelf (100–200 m), jointly with species as *Capros aper*, *Gadiculus argenteus*, *Maurolicus muelleri*, *Pagellus acarne*, *Micromesistius poutassou*, *Helicolenus dactylopterus*, and *Scyliorhinus canicula* (García-Ruiz et al. 2015). It is heterogeneously distributed throughout the Alboran Sea, being very abundant in the Almeria area declining sharply in Estepona (Fig. 18.24). The size of catches ranges between 1 and 80 cm total length (TL) with a general prevalence of small sizes and mean values of 14 (±7 SD) cm TL (MEDITS surveys).

The spawning period is long and varies according to population. In the Mediterranean, hake populations seem to have an active reproduction throughout the year in general (Reñones et al. 1995; Recasens et al. 2008), but mostly spawning fluctuates between January and April (García-Rodríguez 2005). Females reach maturity at 36 to 40 cm TL and males at 26 to 27 cm TL. In the western Mediterranean Sea, there are two recruitments per year, in the spring and in autumn, at between 50 and 250 m depth, with relatively stable oceanographic conditions. Fecundity is very high,

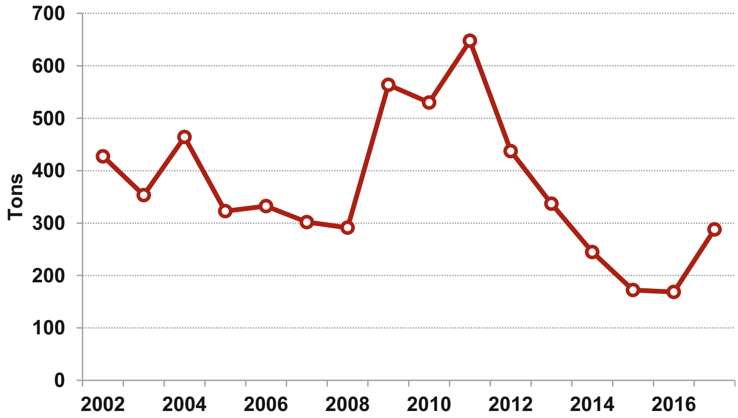

Fig. 18.25 *Merluccius merluccius* annual landings (in tons) by trawl fishery through historical series analyzed (2002–2017) in GSA 01

between 2 and 7 million oocytes per female (Lloris et al. 2005). Batch fecundity increases proportionally with the size of hake, and it should be noted that correlations between batch fecundity and energy reserves are still stronger than the correlations with hake size (Ferrer-Maza et al. 2014). According to Recasens et al. 2008, the total number of eggs per female increases with size, but in relative terms the egg production per gram of females is similar.

Prey comprises benthopelagic organisms with ontogenic changes in the diet. Morote et al. (2011) found that larvae presented a clear preference for adult calanoid copepods and they foraged even at low light intensity (Korta et al. 2015). Small juveniles prey on small crustaceans (euphausiids, natantian decapods, and mysids), while fish assume an increasing importance in the diet with increasing size of hake (Cartes et al. 2004). According to Bozzano et al. (1997), the main preys for hakes between 14.5 and 39.5 cm TL are anchovy and for hakes larger than 40 cm are sardine in autumn and winter and red bandfish (*Cepola macrophthalma*) in spring and summer. Hakes perform vertical migrations from near the bottom to mid-water or near the surface to feed at night (Pitcher and Alheit 1995). One of the components of the diet of adults is other hakes, which indicates the existence of cannibalism (Oliver and Massuti 1995).

Merluccius merluccius is a target demersal species of the Mediterranean fishing fleets. It is largely exploited in GSA01, mainly by trawlers on the shelf and slope (96% landings) but also by small-scale fisheries using set longlines (1%) and gillnets and trammel nets (4%) (average percent estimated between 2016 and 2017). The trawler fleet is the largest in landings (274 tons in 2017). The main ports in landings in GSA 01 during 2017 were Vélez-Málaga (50 t), Almería (47 t), Garrucha (40 t), Cartagena (32 t), and Fuengirola (30 t) (GFCM 2018b).

Landings have shown oscillations along the period of the data series (2002–2017), ranging between 427 and 288 tons, respectively, with a maximum in 2011 (648 tons) and minimum in 2016 (168 tons) and 2015 (172 tons) (Fig. 18.25).

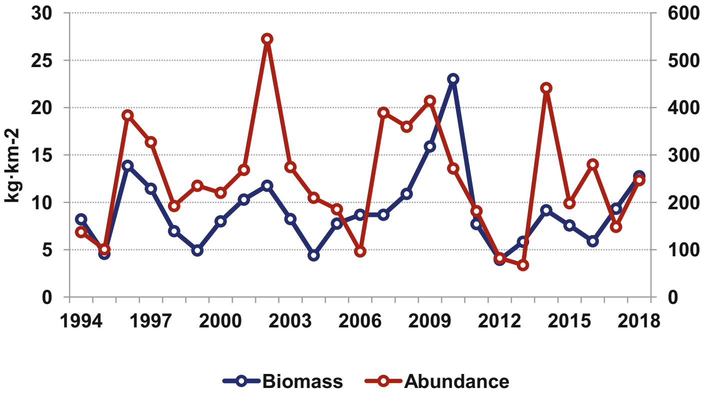

Fig. 18.26 *Merluccius merluccius* biomass and abundance indices in GSA 01 from the MEDITS surveys through historical series analyzed (1994–2018)

A sharp decreasing trend was recorded from 2011 onward (Fig. 18.25). Landing sizes ranged between 8 and 82 cm TL with a maximum of around 20 and 24 cm TL. Mean values are 24.19 (±8.02 SD).

Abundance and biomass indices from fishery-independent MEDITS survey (Fig. 18.26) do not reveal any significant trends since 1994 but interannual oscillations.

In the framework of the GFCM stock assessment as in previous years, the 2017 WGSAD session recognized that "European hake was the demersal species suffering from the highest fishing mortality. Therefore, the WGSAD recommended that the SAC consider immediate management actions to reduce the fishing mortality of European hake stocks in order to allow the stocks to recover. It was remarked that the current measures (minimum landing size, mesh size, etc.) were not providing tangible effects on the status of the stocks and that a series of measures should be adopted at the same time to reduce fishing mortality, improve fishing exploitation patterns and protect the most vulnerable life stages of the populations (i.e. juveniles and spawners in appropriate periods and areas)" (GFCM 2017). From 2016, stock assessment of the European hake was performed for GSA 01 and GSA 03 together. The joint assessment revealed that the stock was in overexploitation (GFCM 2016, 2017, 2018b). Previously, the individual stock assessment for the species in GSA 01 showed also the status of overexploitation (i.e., GFCM 2015; 2014).

18.5.5 Mullus barbatus *("Red Mullet")*

Mullus barbatus (Linnaeus, 1758) (Fig. 18.27) is a common demersal fish along the coasts of the Mediterranean Sea. This species has a high commercial value, and it is

Fig. 18.27 *Mullus barbatus* (redrawn from García et al. 2015)

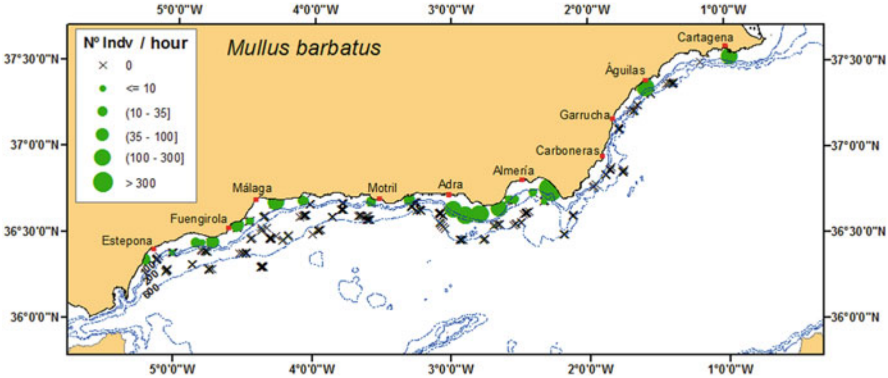

Fig. 18.28 MEDITS indices of abundance (individuals/hour) of *Mullus barbatus* in GSA 01 from 2012 to 2018

one of the main target species of many demersal fisheries operating in the Mediterranean Sea (Tserpes et al. 2002).

This species inhabits sandy and muddy bottoms, and it is distributed all around the Mediterranean basin, including the Black Sea, and also in the eastern Atlantic Ocean from Scandinavia to Senegal (Fischer et al. 1987). Its density is especially high at sites characterized by a wider continental shelf. In the Mediterranean Sea, it is reported between 5 and 300 m depth, with maximum population densities at 50–200 m while below 200 m depth catches are very low (Lombarte et al. 2000). During the MEDITS surveys carried out in Alboran Sea, species was caught between 35 and 250 m depth, and it is more abundant on the eastern part of the Alboran Sea (Fig. 18.28) and in the inner continental shelf (30–100 m), jointly with species as *P. acarne*, *Serranus hepatus*, *Boops boops*, *C. aper*, *Trachurus trachurus*, *Cepola rubescens*, *M. merluccius*, *Arnoglossus thori*, *Spicara maena*, and *Callionymus maculatus* (García-Ruiz et al. 2015). The size is 30 cm TL, usually 10–20 cm TL (Whitehead et al. 1986). In the Alboran Sea, the size of catches ranges between

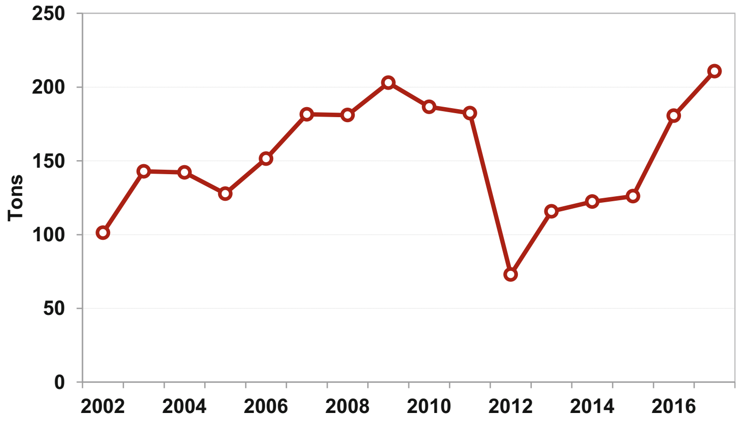

Fig. 18.29 *Mullus barbatus* annual landings (in tons) by trawl fishery through historical series analyzed (2002–2017) in GSA 01

10 and 30 cm TL, with a maximum at 13–14 cm TL. The mean values are 14.84 (±2.53 SD) cm TL (MEDITS surveys).

Sexual maturation begins in spring (in early summer most are mature individuals). Spawning occurs from March to June, and larvae are found in the plankton during June–July in the upper levels of the water column (Aguirre 2000 and references therein). The recruitment to fishery is in autumn (Suau and Vives 1957). The size at first maturity is around 13 cm TL at an age of 1.3 years (STECF 2015).

Most of the species consumed by *M. barbatus* are associated mainly with detritus, silts, and muds. Gharbi and Ktari (1979) found that, in *M. barbatus* diet, small polychaetes and crustaceans play an important role in the feeding of juveniles while larger crustaceans (decapods), mollusks, and polychaetes are the basis of the essential diet of adults (Aguirre 2000 and references therein). *M. barbatus* is characterized by having barbels with greater structural complexity and higher density of taste buds than *M. surmuletus*, a sympatric species of the same genus. Studies suggest the existence of adaptive morphological and anatomical characteristics that allow *M. barbatus* to exploiter sources from muddy and turbid bottoms better than its congeneric species that prefer more transparent and shallower waters (Lombarte and Aguirre 1997).

In Alboran, *Mullus barbatus* are among the most important target species for the trawl fisheries. It is largely exploited in all the trawlable areas, both sandy and muddy bottoms mainly by trawlers on the shelf and by small-scale fisheries in particular trammel nets (about 12% of the catches). The amount of discards reported is very low and considered to be negligible with the highest percentage in the catch of 3% in 2016 and an average of 1% throughout the years (STECF 2008). Over the period 2002–2017, annual landings for trawl fisheries oscillated between 101 and 211 tons, respectively, with maximum landings in 2017 (Fig. 18.29). Landing sizes range between 7 and 30 cm (2002–2017), maximum between 13 and 15 cm TL. The medium values are 14.86 (±3.31 SD) cm TL.

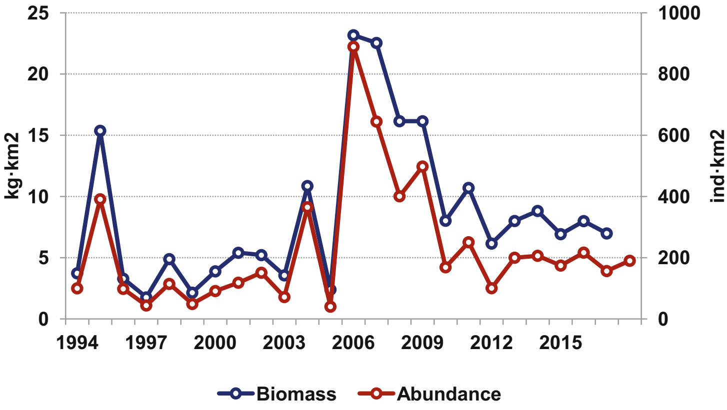

Fig. 18.30 *Mullus barbatus* biomass and abundance indices in GSA 01 from the MEDITS surveys through historical series analyzed (1994–2018)

Abundance and biomass indices from the fishery-independent MEDITS survey (Fig. 18.30) do not reveal any significant trends since 1994 but interannual oscillations with a maximum on the 2006 survey.

According to the Mediterranean stock assessment carried out by the Scientific, Technical and Econimic Committee for Fisheries (STECF 2018), "red mullet in GSA 01 is stable but is being overfished. Catches should be reduced by at least 85% to reach FMSY in 2019. The size composition of landings indicates that the exploitation is concentrated on age classes 1–2." Management recommendation advice was to reduce fleets' effort in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed fishery considerations (STECF 2015).

18.6 Discards

The capture of non-target organisms has been globally acknowledged as an important issue for fishery resource management and ocean conservation. The catch of unwanted organisms and their subsequent discarding are significant in several European fisheries (STECF 2007). Such practices are a wasteful use of resources, both from an economic point of view, losing future opportunities of catch, and from a perspective of ecological sustainability, because the negative impact on the marine ecosystem (STECF 2008).

The United Nations Food and Agricultural Organization's (FAO) Fisheries Glossary (FAO 2018) describes discards as "the proportion of the total organic material of animal origin in the catch, which is thrown away or dumped at sea, for whatever reason. It does not include plant material and postharvest waste such as offal," and bycatch is defined in the aforementioned glossary "as the part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying." The GFCM includes incidental catch of vulnerable species as a subset of bycatch, which includes species such as marine mammals, sea turtles, seabirds, and some elasmobranchs (FAO 2018).

In general, the main reason for discarding is the lack of commercial value of some caught species (Kelleher 2005), although it also sometimes occurs because the fish do not reach the minimum landing size, because catch quotas have been exceeded or because the fish are damaged. The incidence of discards in species with commercial interest is low, although part of the commercial catch may also be discarded to comply with fishing regulations (Uhlmann et al. 2014). It is estimated that 7.3 million tons of fish (usually dead or dying) are discarded annually by marine fisheries throughout the world, with the proportion of the catch discarded at sea estimated at 8% t (Kelleher 2005). In the Mediterranean a rough estimation of discards around 230,000 t, or 18.6% (13.3–26.8%) of the catch is produced (Tsagarakis et al. 2014).

In order to tackle the problem of discards in European fisheries, the new Common Fisheries Policy (CFP) (European Parlament and Council Regulation (EU) 1380/2013), establishes as a conservation measure the monitoring and reduction of incidental catches and discards. This measure is part of the concept known as "ecosystem approach," which considers fisheries not only as a relationship between the resource and the fleet but also considers the ecosystem that hosts the resource and the socioeconomic scope of the fleet (Bellido et al. 2014). The new regulation establishes the obligation to land catches of stocks subject to minimum sizes, which is considered one of the easiest management instruments to apply and is established with the aim of discouraging the capture of juveniles, since although this type of regulation has influenced the sizes of the species landed, it has not done so in the sizes of the species caught, which leads to their subsequent discarding (Catchpole et al. 2005).

Under the Commission Delegated Regulation (EU) 2017/86 establishing a discard plan for certain demersal fisheries in the Mediterranean Sea, all catches of species subject to catch limits and catches of species subject to minimum sizes must be landed. An exemption from the landing obligation applies to bivalve mollusk scallops (*Pecten jacobaeus*), clams (*Venerupis* spp. and *Venus* spp.) in the Western Mediterranean Sea, as high survival rates can occur, taking into account the characteristics of fishing gears and practices and the ecosystem. This regulation provides for "*de minimis*" exemptions affecting demersal fisheries in the Alboran Sea. According to these exemptions, hake (*Merluccius merluccius*) and red mullet (*Mullus* spp.) may be discarded up to a maximum of 7% in 2017 and 2018 and 6% in 2019 of the total annual catch of these species by trawlers and 1% of the total annual catch of these species by vessels using gillnets.

In the Alboran Sea, demersal fisheries are multi-species, and it is very difficult to identify target species, which influences the level and diversity of discards generated (Eliasen and Christensen 2012) (Fig. 18.31). According to García et al. (2015) in the

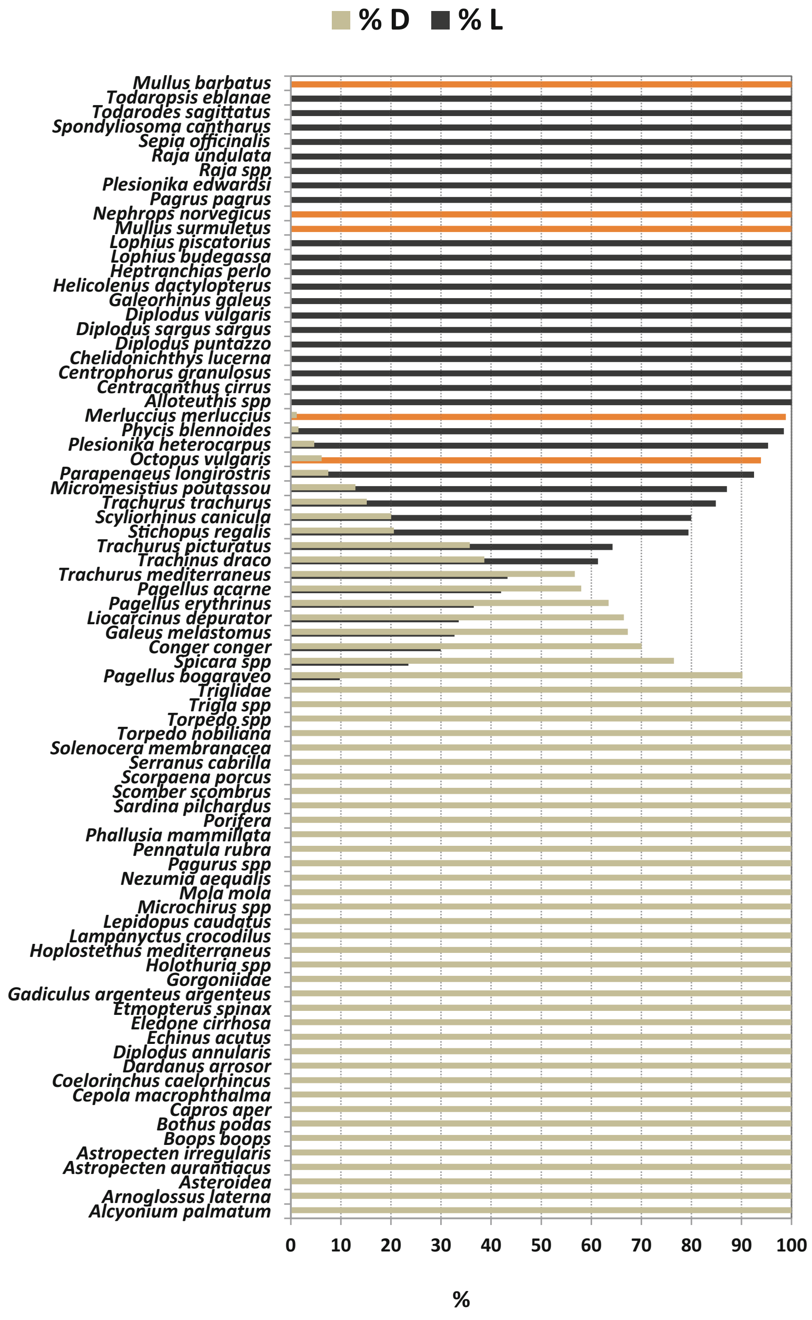

Fig. 18.31 Proportion of species weight in the commercial and discarded fraction of the metier OTB-DEF (Bottom otter trawl for demersal species) in Spanish waters Geographical Subarea 01 of the GFCM. %D, percentage discarded; %L, percentage landed. Highlighted in orange the target species of the metier. (Source: Bellido et al. 2014)

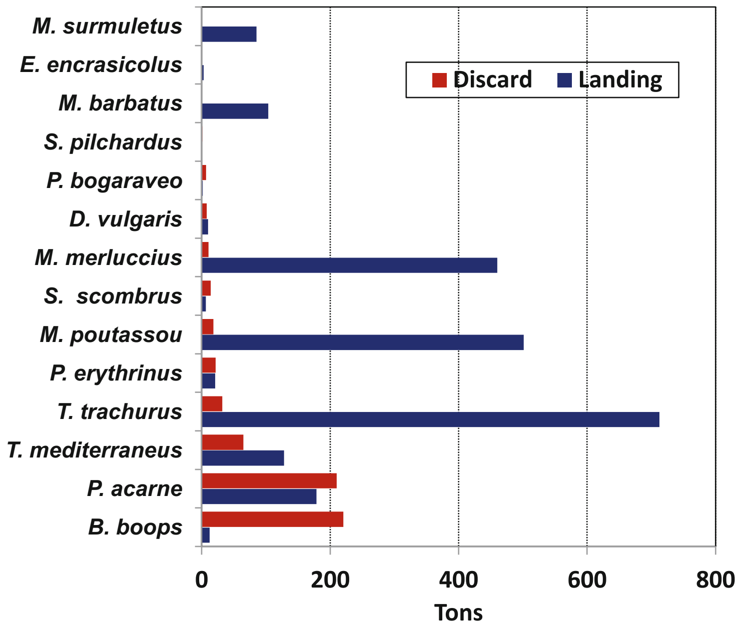

Fig. 18.32 Average total catch (tons) of the retained (commercial) and discarded fraction of the bottom trawl fleet during the period 2011–2012 (redrawn from García et al. 2015)

bottom trawl fleet, the discard of individuals above legal size is less than 20% by weight of the catch in the regulated species, with the exception of *Pagellus erythrinus* of which 44% by weight of specimens with legal size are discarded. In species such as *Merluccius merluccius*, 100% of discards are juveniles, although an analysis of their size distribution shows that a proportion of individuals traded are below the legal minimum size. Among the unregulated species, *B. boops* and *M. poutassou* have the highest percentages of discarded specimens with legal size with 98% and 85% by weight, respectively. The most discarded species was *B. boops*, constituting its discard 87% of its catches in weight in 2011 and 97% in 2012. Next in importance is *P. acarne*, a species that has a great impact on the catches of the demersal fleet since 75% in weight are small specimens (Figs. 18.32 and 18.33).

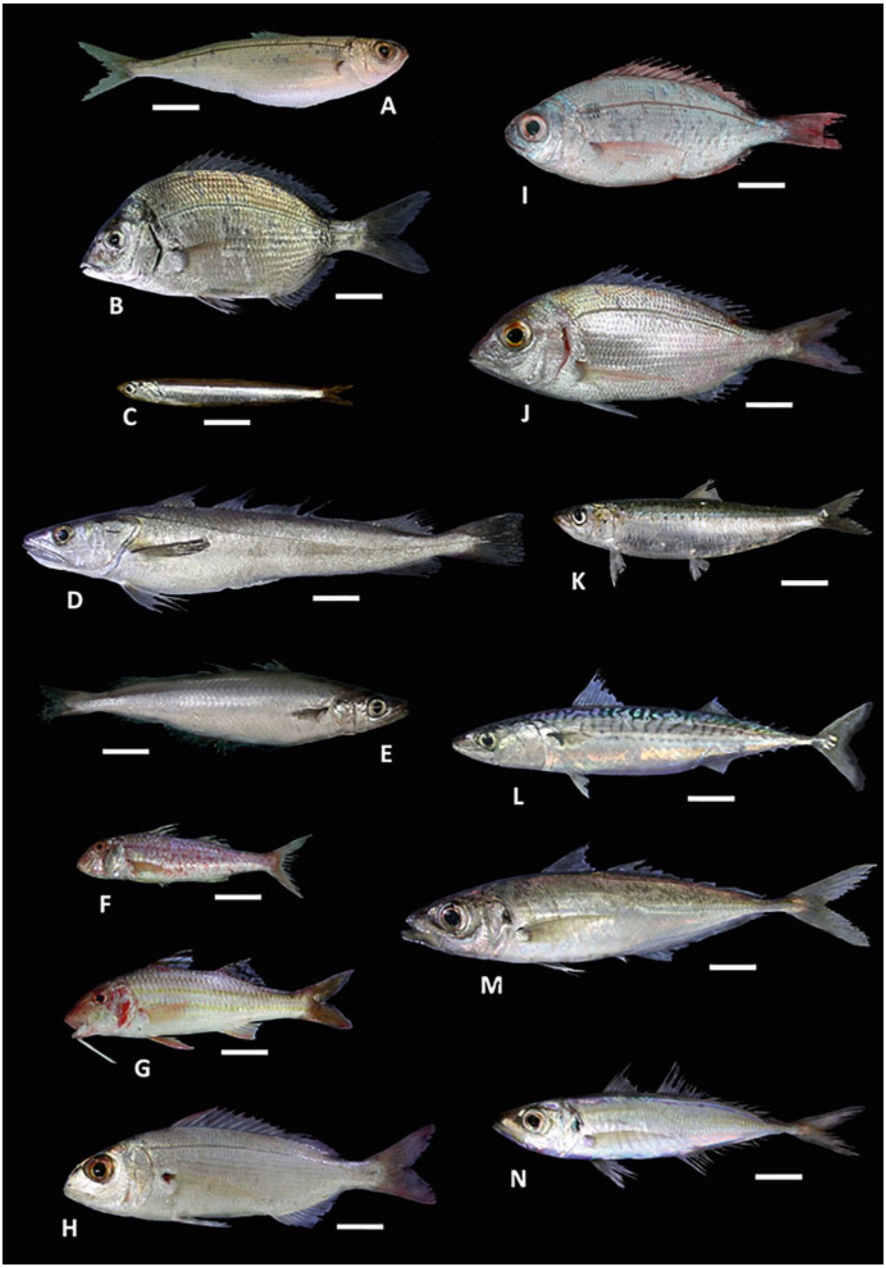

Fig. 18.33 Main species discarded by bottom trawl fleet (García et al. 2015): (**a**) *Boops boops*; (**b**) *Diplodus vulgaris*; (**c**) *Engraulis encrasicolus*; (**d**) *Merluccius merluccius*; (**e**) *Micromesistius poutassou*; (**f**) *Mullus barbatus*; (**g**) *Mullus surmuletus*; (**h**) *Pagellus acarne*; (**i**) *Pagellus bogaraveo*; (**j**) *Pagellus erythrinus*; (**k**) *Sardina pilchardus*; (**l**) *Scomber scombrus*; (**m**) *Trachurus mediterraneus*; (**n**) *Trachurus trachurus.* The scale bar represents 3 cm

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