Scenarios for the implementation of management measures reported in Article 11.3 of the western Mediterranean Multiannual Plan and Presidency Statement of December 2021

Size selectivity trials and the economic impact in GSA6 of increasing square mesh codend size from the actual 40mm to 45- and 50mm for coastal and deep-sea otter trawl fisheries, respectively

Edited by: Joan B. Company, Laura Recasens, Nixon Bahamon, José Antonio García del Arco, Belén Calero, Ana Maurer, Juliana Quevedo and Joan Sala

Technical Report

November, 18th of 2021

Institut Català de Recerca per a la Governança del Mar

Institut de Ciències del Mar
CSIC Consejo Superior de Investigaciones Científicas

Generalitat de Catalunya
Departament d'Acció Climàtica, Alimentació i Agenda Rural

Plan de Recuperación, Transformación y Resiliencia

Gobierno de España
Ministerio de Agricultura, Pesca y Alimentación
Secretaría General de Pesca

Gobierno de España
España Puede

The General Secretariat of Fisheries of the Spanish Ministry of Agriculture, Fisheries and Food asked for technical advice to scientists of the Renewable Marine Resources Department of the Institute of Marine Sciences (ICM-CSIC) regarding the implementation of Article 11.3 of the EU Regulation nº 1967/2006 and the posterior Statement of December 2020.

This document was produced by the Catalan Institute for Ocean Governance Research (ICATMAR), which is a cooperation organism between the General-Directorate of Maritime Policy and Sustainable Fisheries (DGPMPS) of the Ministry of Climate Action, Food and Rural Agenda of the Government of Catalonia and the Institute of Marine Sciences (ICM) of the Spanish National Research Council (CSIC).

Collaborations and source of the scientific funds:
This technical report uses data and shows results from several scientific projects, all in collaboration with the Catalan Government (Generalitat de Catalunya) through the ICATMAR and with Spanish Ministry of Agriculture, Fisheries and Food and Ministry of Ecological Transition through the Spanish General Directorate of Fisheries. See below logos of all funding agencies.
This technical report was funded by European Union – NextGenerationEU.

How to cite this document: Institut Català de Recerca per a la Governança del Mar (ICATMAR). Size selectivity trials and the economic impact in GSA6 of increasing square mesh codend size from the actual 40mm to 45- and 50mm for coastal and deep-sea otter trawl fisheries, respectively (ICATMAR, 21-05), 41 pp. DOI: 10.2436/10.8080.05.13

The working group involved in scientific coordination, field trials, data analysis and technical work of this report are (alphabetical order):

CSIC staff: Nixon Bahamon, Joan B. Company, José Antonio García del Arco, Juliana Quevedo, Laura Recasens and Joan Sala.

TRAGSATEC staff: Belén Calero, José R. Casado, Isabel Esteso, Arturo Jiménez, Ana Maurer and Samuel Valverde.

INDEX

0. Executive summary

In Western Mediterranean Sea, there is an urgent need for the improvement of managing its fishing stocks. A reduction of 15-25% of bycatch was demanded in the last Statement of the Presidency published in December 2020. In Mediterranean fishing grounds, where the nature of its multi-specific fisheries do not allow the application of quota regulation and important reductions in fishing efforts and new no-take areas have been recently implemented, technical improvements of the fishing gears are a key tool to reach a sustainable fishing sector. The aim of this study is to reveal the results obtained after the use of selectivity technical measures on bottom trawler fishing gears in the GSA6 of the Western Mediterranean Sea. The reference species of the Western Mediterranean Multiannual Plan were the objective of this study: *Mullus barbatus*, *Merluccius merluccius, Parapenaeus longirostris, Nephrops norvegicus and Aristeus antennatus.*

A total of 98 experimental hauls were conducted during summer 2021 in fishing grounds off the main fishing harbors along the GSA6 to cover the heterogeneity of the area. Two experimental codends of 45- and 50mm square mesh size were used on selectivity trials for coastal and deep-sea fishery respectively.

Selectivity parameters −mean retention length (L50) and selection ranges (SR)− and percentages of catches reduction were calculated together with the estimation of biological and short-time economic impact. Significant differences were found when experimental hauls were conducted in presence, or absence, of reference species recruits, so that, different approaches were taken into account in every case.

Percentages of individuals catch reduction were calculated, resulting in 19.9% for coastal fisheries and 11.4% for deep-sea fisheries. Reductions in undersized and unwanted catches are consistent with the relatively low economic impact on the total income of the GSA6 fishing fleets. In contrast, a positive biological impact in terms of recruitment for the fishing stocks will be produced over time, being a positive measure in terms of recovery of the overexploited stocks.

Selectivity improvements are permanent management measures that reduce fishing mortality, mainly of unwanted and undersized individual's catches. Short-term economic losses would be compensated by the expected size increase of commercial species individuals.

1. Introduction

1.1. State of the art

The Regulation (EU) 2019/1022 of the European Parliament and of the Council establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea (MAP) establishes the legal deadline to the recovery of stocks to MSY levels by 1st January 2025.

In order to comply with the articles 7 and 11 of the Regulation several measures have been implemented. Nevertheless, a general concern by the Member States were expressed in the last Statement of the Presidency published in December 2020 where a reduction of 15-25% of bycatch was demanded.

Under this scope, part of the Renewable Marines Resources Department of the Institute of Marine Sciences (ICM-CSIC) with the technical support of Catalan Institute of Research for the Sea Governance (ICATMAR) was asked for technical advice by the General Secretariat of Fisheries – Spanish Ministry of Agriculture Fisheries and Food, and a technical report was presented in June 2021. That report was product of the study of the fishing effort reduction and the proposal of new no-take areas establishment. The report was also a first approximation to the effect of introduction of the new size selectivity measures in the bottom trawlers fleet of GSA6.

In the scope of the Common Fisheries Policy (R. (EU) No 1380/2013) and with the aim of following up the objective of eliminating unwanted and undersized catches, the scientists that have written the technical report have been studying the use of improving size selectivity by increasing the codend mesh size, as an effective measure of protection of juveniles, also allowing reduction of discards. An assessment on the possible effects of new selectivity measures for bottom trawl fishing gears in the reduction of catches and its economic impact was required.

The five reference species considered in the MAP and this present report show an overexploitation status in the GSA6. The results on recent assessments show that corrective measures are necessary to revert the status of the species (**Table 1**).

Table 1. Summary of the recent status of the five reference species of MAP in GSA6, indicating the Fishing mortality, F current and $F_{0.1}$ as a reference point of F_{MSY}.

GSA6	F current	$F_{0.1}$	Status	Assessment method	Year	Reference
Mullus barbatus	1.37	0.3	overexploitation	a4a	2021	GFCM-FAO
Merluccius merluccius	1.2	0.14	overexploitation	XSA, a4a	2021	GFCM-FAO
Parapenaeus longirostris	1.02	0.75	overexploitation	XSA	2020	GFCM-FAO
Nephrops norvegicus	0.56	0.15	overexploitation	a4a	2020	GFCM-FAO
Aristeus antennatus	2.47	0.36	overexploitation	a4a	2020	GFCM-FAO

The objective of this pilot selectivity experiment was to study the effects of new square mesh codends size of 45- and 50mm in bottom trawler fleet of GSA6 at Spanish Mediterranean fishing grounds and to evaluate its economic impact. A number of 98 sampling stations associated to the main fishing harbors were visited over the whole GSA6 area. The collaboration with a large part of the fishing fleet has allowed strengthening the connections with the fishing sector by involving them in the fishing experiments.

1.2. Commercial catches yield

The GSA6, with 1 072 kilometers of coastline (according to the Spanish National Institute of Statistics), is one of the largest areas of the Western Mediterranean Sea representing the most important fishing area on the Spanish Mediterranean coast. Distribution of the species varies depending on the biology of each one, changing therefore the fishing patterns when directed to certain species. The accumulated kg/km^2 of commercial landings for the five reference species during the period 2016-2019 is shown in **Figure 1**. The MAP demands the particular implementation of the measures to red mullet (*Mullus barbatus*), European hake (*Merluccius merluccius*), deep water rose shrimp (*Parapenaeus longirostris*), Norway lobster (*Nephrops norvegicus*), blue and red shrimp (*Aristeus antennatus*) and giant red shrimp (*Aristeomorpha foliacea*). In the GSA6, landings of red mullet are also composed by a certain percentage of red stripped mullet (*Mullus surmuletus*), and usually are not sold separately in fish auctions. For this reason, in the present report data are referred to as *Mullus* spp. except for the case of selectivity analysis in which *Mullus barbatus* is specifically addressed. In addition, in the GSA6 the giant red shrimp *Aristeomorpha foliacea* is not present and therefore is not considered in the present report.

Data of the Vessel Monitoring System (VMS) and data of first sales at the auction, obtained from the General Secretariat of Fisheries, were used to map the spatial distribution of catches (**Figure 1**). VMS were interpolated to 10min ping frequency using VMS base (Russo et al, 2011) and linked to landings by fishing trip (day and vessel). Georeferenced landings were accumulated in a 1km^2 grid and yearly mean calculated by grid cell.

As shown in **Figure 1**, both *Mullus* spp. and *Merluccius merluccius* catches present regular and wider distribution along the continental shelf. *Parapenaeus longirostris* shows high catch concentrations in the upper-slope, down to 400m depth. *Nephrops norvegicus* and *Aristeus antennatus* show a greater concentration over the middle continental slope. Following this bathymetric distribution of species, this technical report shows the results accordingly, from *Mullus* spp. (the shallowest distributed) to *A. antennatus* (the deepest distributed).

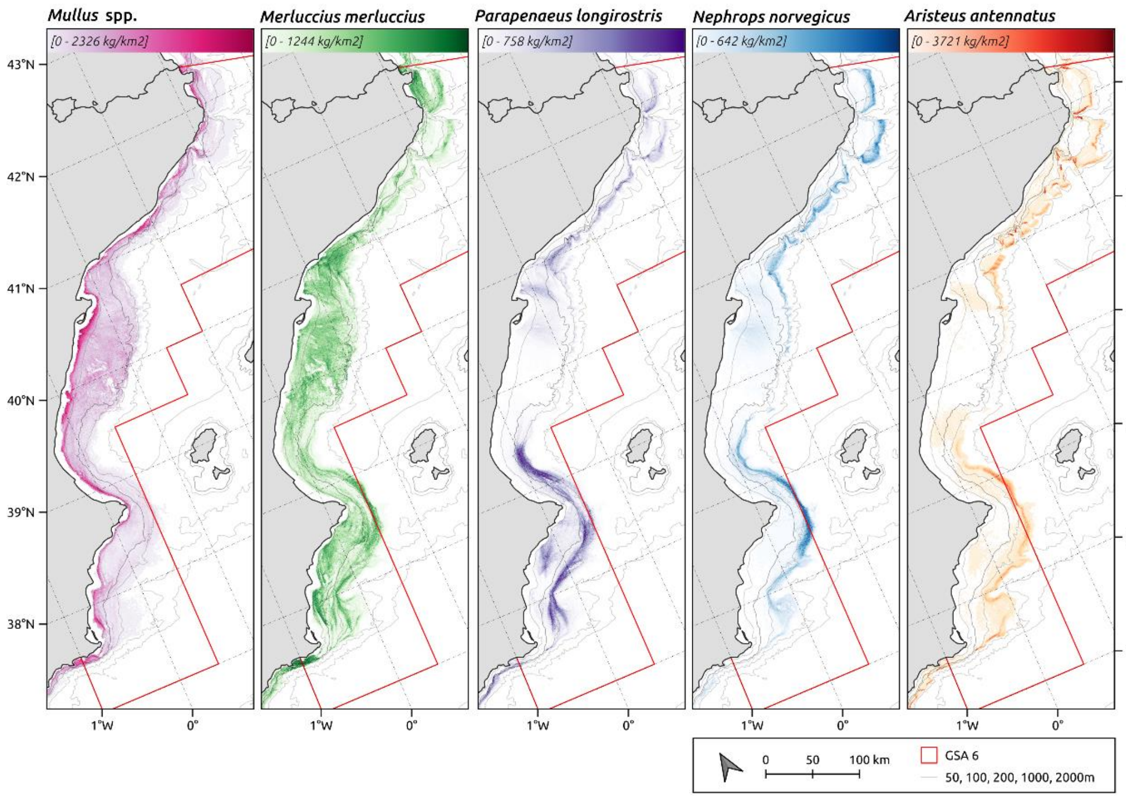

Figure 1. Bathymetric and geographic distribution of landings for the five reference species in GSA6 based on VMS data (mean estimates for the reference period, 2016-19).

2. Material and Methods

2.1. Study area and methodology

Experimental hauls were conducted during summer 2021 in fishing grounds off the main fishing harbors along the GSA6 (**Figures 2** and **3**). The two types of bottom trawl fisheries considered in the Regulation (EU) 2019/1022 (coastal and deep-sea), were covered during the experiments using two different experimental square mesh codends. Square mesh codends of experimental 45mm were used for those coastal fishery hauls targeting *Merluccius merluccius*, *Nephrops norvegicus*, *Parapenaneus longirostris* and *Mullus barbatus.* Square mesh codends of experimental 50mm were used for those deep-sea fishery hauls targeting *Aristeus antennatus.* Control hauls with a fishing gear equipped with a commercial 40mm square mesh codend were carried out in every case. In order to calculate the retention of the fishing gears, all hauls were conducted with a cover of 16mm mesh size. A total of 98 experimental hauls, were carried out, from which 85 were considered valid (**Table 2**). The recruitment period of some species was covered from additional 71 experimental hauls carried out earlier, within the framework of the selectivity projects 50SELS and GAP2, conducted by the scientist team responsible of the present technical report, using same field methodology (**Table 2**).

Bottom trawl hauls were performed in a total of eight different locations next to relevant fishing harbors of the GSA6 (**Figure 2**). Coastal and deep-sea hauls were carried out in the same fishing grounds where the bottom trawl fleet usually fish, following the technical decisions of the skippers.

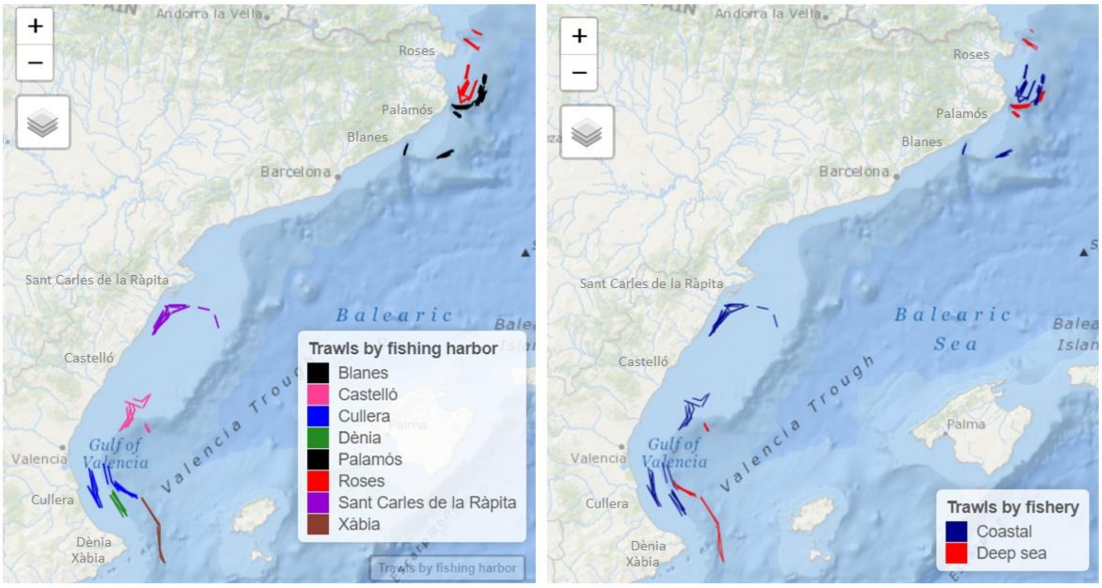

Figure 2. Location of the otter bottom trawl hauls on each fishing harbor (left) and by each of the two separate fisheries considered on the MAP (right) in GSA6.

2.2. Experimental hauls

In each location, samples were collected simultaneously on board two fishing vessels, one directed to coastal fishing grounds and other to deep-sea fishery (**Figure 2**; see also **Table 2** for details on sampling period and location). Four consecutively days of sampling were carried out by harbor. The samples conducted during the first day were done with commercial codends of 40mm mesh size. The following three days, two experimental codends of 45- or 50mm were used for coastal or deep-sea fishing grounds, respectively. Unknotted mesh codends built by the same provider were used in all vessels.

The experimental fishing gears were adapted for every vessel, adjusting both codend and cover to the characteristics of the current fishing gear of the vessel. Covers had a mesh size of 16mm and twice the length of the codend. They were fixed by a structure formed by two rigid rings rounding the codend, in order to keep separation between cover and codend. The codends of the vessels varied from 1 to 3m in length and from 1.8 to 3m in width. Both types of codends (commercial and experimental) had a twine thickness of 3mm.

Experimental codends underwent minor changes in mesh sizes after the first week of use. For 45mm mesh size codend, the variations ranged from 46-47mm as registered at the beginning of each sampling week, to a minimum of 45mm at the end of the experiments. For deep-sea fishery, the variations were from 51mm at the beginning to 50mm after the one-week experiments. Records of mesh sizes were taken with an official Omega Mesh gauge. Samples from all catches were collected and measured mainly on board. For the cases in which the vessel arrived to the harbor before finishing the species classification or the data collection, samples were brought to laboratory. The samples were classified in three categories: commercial and bycatch from the codend and escapees from the cover. Taxonomic identification and biometric data of the individuals collected were registered.

Table 2. List of hauls conducted in the experimental trials.

Project	Harbor	Vessel	Codend mesh size (mm)	Total hauls	Valid hauls	Species number	Data recorded
4550SELS	Castelló (19-23th July)	El Paraiso	40 50	6 8	6 7	71	11 041
4550SELS	Castelló (19-23th July)	Nova Gaya	40 45	3 4	2 3	56	5 371
4550SELS	Dènia (02-06th August)	Astraleta	40 45	4 4	3 3	65	8 974
4550SELS	Xàbia (02-06th August)	Cap Prim Segon	40 50	1 3	1 3	48	4 801
4550SELS	Cullera (17-20th August)	Platja De Cullera	40 45	2 6	2 5	85	8 967
4550SELS	Cullera (17-20th August)	Segon Marenyero	40 50	2 6	2 6	74	9 149
4550SELS	Palamós (24-31th August)	Solraig	40 45	6 10	6 10	82	20 848
4550SELS	Roses (31th August - 06th September)	Port De Roses	40 50	3 6	3 6	69	7 411
4550SELS	Roses (31th August - 06th September)	Toni-Li Segundo	40 45	2 4	2 4	68	8 795
4550SELS	Sant Carles de la Ràpita (14-17th September)	Los Palmeros	40 45	6 3	2 3	57	7 923
4550SELS	Sant Carles de la Ràpita (14-17th September)	Port Alfacs	40 45	3 6	3 3	79	10 670
50SELS(1)	Blanes (April-September 2019)	Na Teresa	40	12	10	-	17 154
GAP2(1)	Palamós (April-June 2012/13-2015/16)	Nova Gasela	40 50	30 29	30 29	- -	1 260 13 665
			TOTAL	169	156	243(2)	121 104

[1] Scientific data from earlier selectivity experiments.
[2] Total number of identified species.

Caught individuals were measured to obtain size frequencies. In the case of red mullet and European hake, the total length (TL) was measured at the lower mm and in the case of deep-water rose shrimp, Norway lobster and blue and red shrimp, the length of the cephalothorax (CL) at the lower mm was measured. The weights were obtained from the size/weight ratio of the selected species obtained from the ICATMAR Database.

2.3. Selectivity Parameters

The selectivity parameters are the mean retention length (L50) and the selection range (SR). The L50 represents the size at which 50% of individuals are retained in the codend. The SR represents the 25th and 75th percentiles of retention length. The selectivity parameters are generally provided after accounting for intra-haul, inter-haul by vessel and inter-vessel variability i.e. standard statistics for selectivity parameter estimates, as recommended by Fryer (1991).

In order to fit the selectivity curves, only valid hauls with a number of individuals greater than 100 were considered (see all selectivity curves in **Annex 1**).

3. PART A – SIZE SELECTIVITY ON CATCHES

3.1. Percentage of retentions on total catches

Percentages of total catch retention in coastal and in deep-sea fisheries were calculated using the whole catch retained in codend and the escapees in cover (**Figure 3**, **A-D**). Coastal fisheries show a 35.7% of individuals catch retention in commercial codend (i. e. 40mm) and a 15.8% for experimental codend (i. e. 45mm). The reduction in retention percentages by individuals between commercial and experimental codends was 19.9%. The reduction in retention percentages by individuals between commercial and experimental codends was 11.4% in deep-sea fisheries. Regarding the percentages of retention on weight, coastal and deep-sea fisheries show a reduction between commercial and experimental codends of 14.1% and 9.3%, respectively.

Note that the reduction in retention percentages in experimental codends by number of individuals are greater than the reduction in retention percentages by weight, showing that the part of catches that is not retained with the experimental codend is mainly composed by the smallest individuals of the population with relatively low weight.

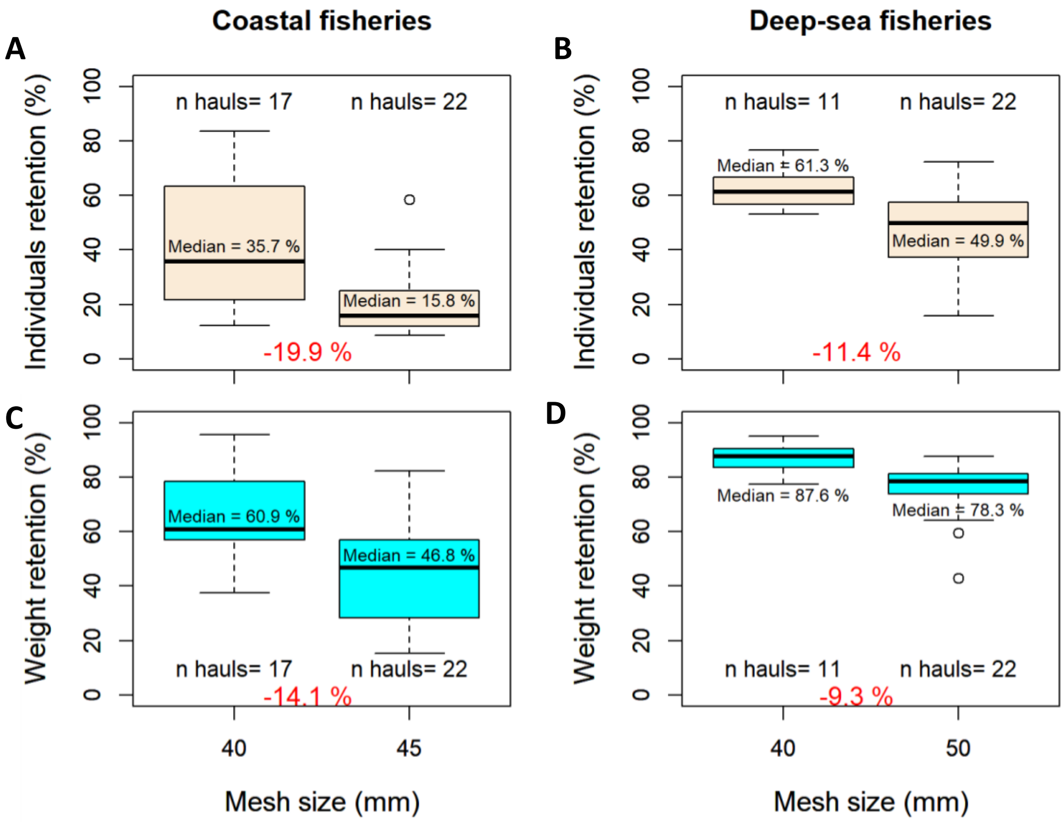

Figure 3. Boxplots showing total catch retention percentage by individuals **(A-B)** and by weight **(C-D)** for commercial 40mm square mesh codend and experimental 45- and 50mm square mesh codends in coastal fisheries and deep-sea fisheries.

3.2 Selectivity parameters for reference species

Selectivity parameters calculated for each of the five species subject of this study are presented ordered according to their bathymetric range of distribution (**Figure 1**), starting with *Mullus barbatus* which individuals are mainly found in shallow shelf fishing grounds and ending with *Aristeus antennatus* with their individuals mainly concentrated in the deep continental slope.

a. *Mullus barbatus*

Results of retention percentages of *Mullus barbatus* are shown in **Figure 4**, following three different approaches. The first approach (**Figure 4**, **A** and **D**), considers all hauls conducted along the GSA6. The second approach (**Figure 4**, **B** and **E**) is considering the hauls conducted during the main recruitment period for this species. The recruitment period of *M. barbatus* occurs in late summer and coincided with the experimental hauls carried out in Sant Carles de la Rápita (14-17th of September; See **Table 2** for further details). The last approach (**Figure 4**, **C** and **F**), considers all hauls conducted except for those carried out during the season of recruitment (i.e. the ones from Sant Carles de la Ràpita). Different percentages of total catch retention by individuals (**Figure 4**, **A-C**) for each type of codend (40- and 45mm mesh size) are calculated for each of the three approaches. Results show higher variation between the two codend mesh sizes when excluding the data from the season of recruitment. **Figure 4A** shows a high variability of percentage of retention due to the different results obtained between B and C approaches. Percentages of retention by individuals when recruitment is occurring, are 13.3% for commercial codend (40mm mesh size) and 14% for experimental codend (45mm mesh size), with a minor variation near to zero (0.7%). Both types of codends present very low percentages of retention, meaning that almost all recruits escape from the codend. In the scenario without recruitment (**Figure 4**, **C**) the use of 45mm mesh size allowed a reduction of 36.6% of individual retention, compared to the 40mm mesh size.

Regarding the retention percentages by weight, similar patterns of variation is found with no significant variation (2.1%) between 40- and 45mm codend mesh sizes on hauls conducted during the recruitment period (**Figure 4**, **E**). For the approach with no recruitment season (**Figure 4**, **F**), the retention percentages by weight are greater than those by individuals. These results suggest that mainly small individuals are escaping.

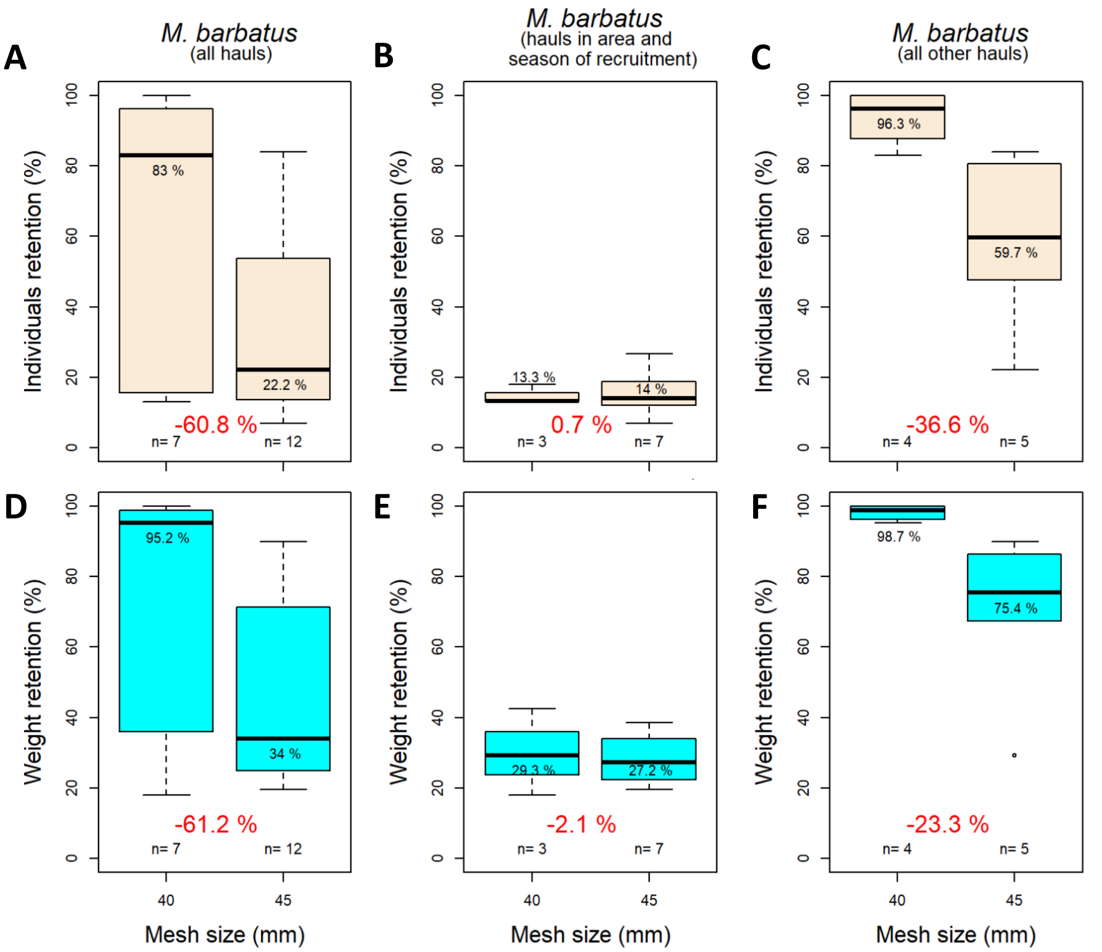

Figure 4. Boxplots showing catch retention percentages of *Mullus barbatus* by individuals **(A-C)** and by weight **(D-F)** for commercial 40mm square mesh codend and experimental 45mm square mesh codends in coastal fisheries. The recruitment period took place while conducting the experimental hauls in Sant Carles de la Ràpita (mid-September). Horizontal bold line in boxplots represents the median value.

The 45mm mesh codend allowed an overall improvement of the selectivity parameters. The L50 increases from 10.8cm TL with the commercial mesh codend up to 14.1cm TL using the experimental 45mm mesh codend (**Table 3**, **Annex 1**).

Table 3. Values of selectivity parameters of *Mullus barbatus*.

Codend mesh size (mm)	Approach	L50 (cm)	SR (cm)
40	All hauls	10.8	2.3
	Hauls in recruitment season	12.1	2.8
	All other hauls	10.8	1.6
45	All hauls	12.6	2.3
	Hauls in recruitment season	11.4	2.5
	All other hauls	14.1	1.6

b. *Merluccius merluccius*

Four different approaches were considered for the retention percentages of *Merluccius merluccius*. When considering all hauls (**Figure 5**, **A** and **E**), the variations of retention percentages are 25.1% by individuals and 13.2% by weight. Considering hauls conducted on continental shelf fishing grounds (< 150m depth), the percentages of variations between commercial and experimental codend are 43.8% by individuals and 27.6% by weight (**Figure 5**, **B** and **F**). The recruitment of this species is found mainly in the range of 150-250m depth where the lowest retention ranges were recorded (**Figure 5**, **C** and **G**). As seen in **Figure 1**, catches of *Merluccius merluccius* are distributed along the continental shelf and upper slope, thus different retention ranges are shown and higher variability is found (**Figure 5**, **A** and **E**) when all hauls are considered.

In the case of the hauls carried out deeper than 250m (**Figure 5**, **D** and **H**), retention percentages, both by individual and by weight are 100%. This is because all the individuals entering the net are relatively large individuals.

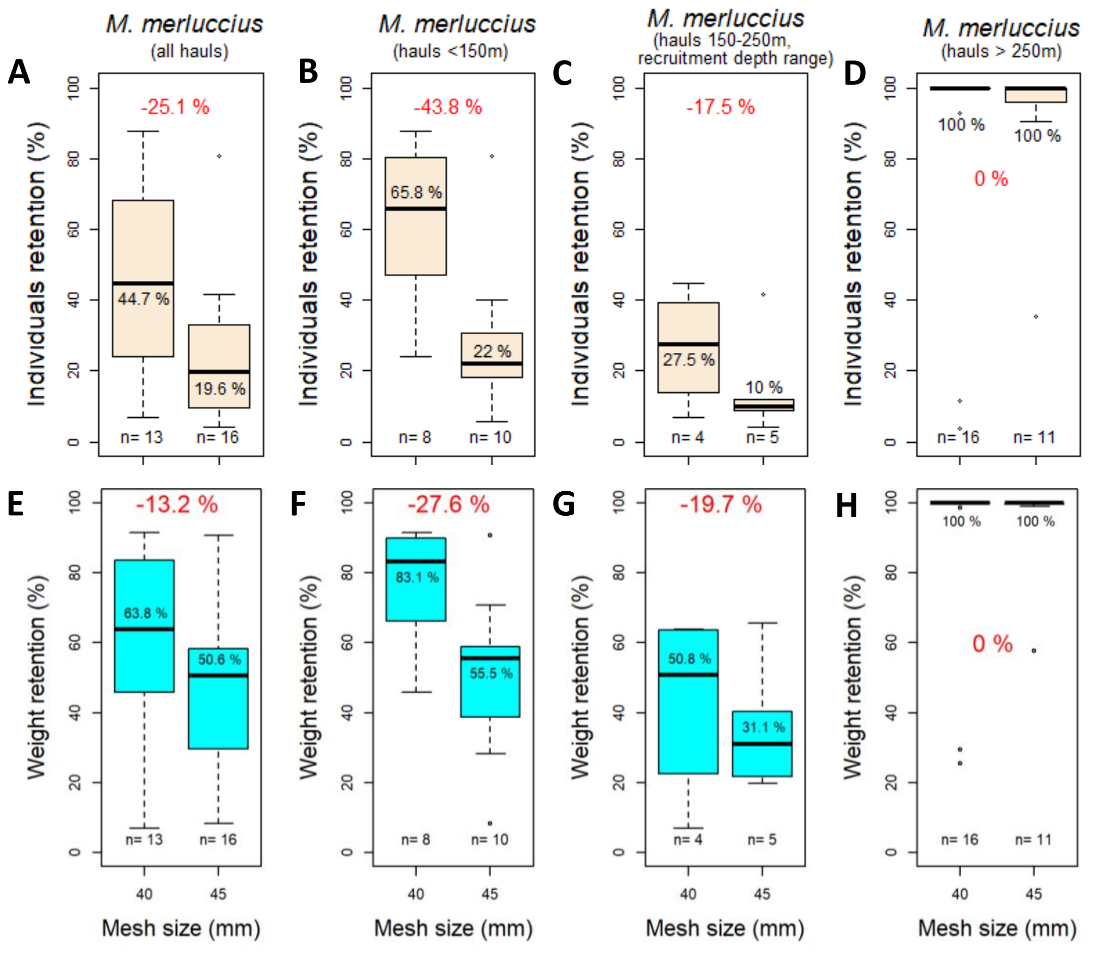

Figure 5. Boxplots showing catch retention percentages of *Merluccius merluccius* by individuals **(A-D)** and by weight **(E-H)** for commercial 40mm square mesh codend and experimental 45mm square mesh codends in coastal fisheries. Note that the recruitment bathymetric range for this species is between 150 and 250m depth (along the shelf-slope break). Juveniles are generally found all over the year within this bathymetric range. Horizontal bold line in boxplots represents the median value.

Selectivity parameters and size frequencies by each of the three approaches are shown in **Table 4** and **Annex 1**. The approach for the deepest depth range (> 250m) did not allow adjusting selectivity curves, because of the low number of small individuals caught.

Table 4. Values of selectivity parameters *Merluccius merluccius*.

Codend mesh size (mm)	Approach	L50 (cm)	SR (cm)
40	All hauls	13.6	1.9
	Hauls < 150 m	14.3	1.6
	Hauls in recruitment depth range (<150-250m)	13.0	2.8
45	All hauls	16.8	1.8
	Hauls < 150 m	16.9	1.8
	Hauls in recruitment depth range (<150-250m)	16.6	1.6

c. *Parapenaeus longirostris*

For the study of retention percentages of *Parapenaeus longirostris,* three different approaches are described, considering the bathymetric range where recruitment of the species was found. In the first scenario, with all hauls considered (**Figure 6**, **A** and **D**), higher retention percentages are obtained compared to the shallower bathymetric range above 200m depth, where recruits are found (**Figure 6**, **B** and **E**). At depths below 200m (**Figure 6**, **C** and **F**), almost all individuals are retained and very small differences are found when using commercial or experimental codend mesh size.

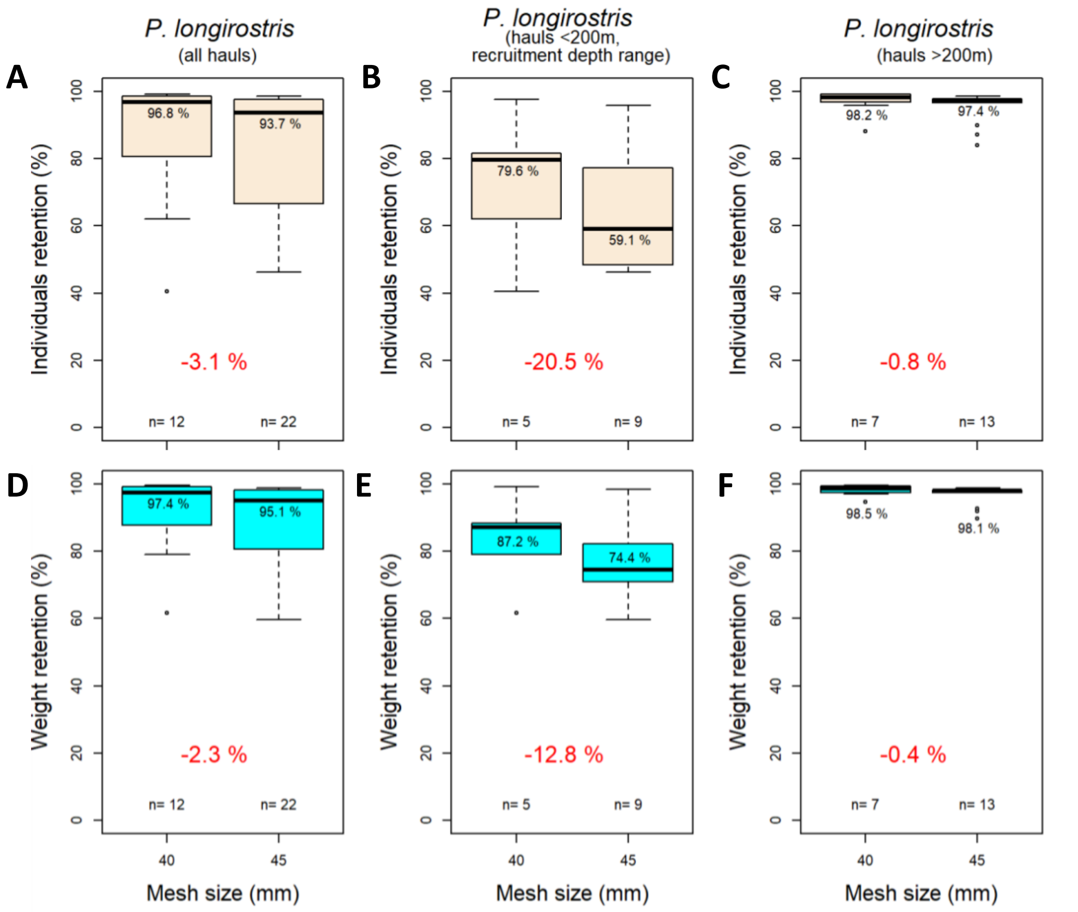

Figure 6. Boxplots showing the catch retention percentages of *Parapenaeus longirostris* by individuals **(A-C)** and by weight **(D-F)** for commercial 40mm square mesh codend and experimental 45mm square mesh codends in coastal fisheries. The recruitment bathymetric range for this species is in continental shelf areas, in a depth range shallower than 200 m. Horizontal bold line in boxplots represents the median value.

Selective parameters and size frequencies by each of the three approaches are shown in **Table 5** and **Annex 1**. The highest L50 (19.1mm CL) is estimated from hauls carried out with the experimental 45mm mesh codend at recruitment depth range over the continental shelf (< 200m depth), representing an increasing of 2mm CL, compared to the L50 of the 40mm mesh codend.

Table 5. Values of selectivity parameters of *Parapenaeus longirostris*.

Codend mesh size (mm)	Approach	L50 (mm)	SR (mm)
40	All hauls	16.0	4.8
	Hauls in recruitment depth range (< 200m)	17.1	4.0
	Hauls > 200 m	16.1	6.0
45	All hauls	18.5	3.9
	Hauls in recruitment depth range (< 200m)	19.1	3.2
	Hauls > 200 m	18.8	5.0

d. *Nephrops norvegicus*

Retention ranges for *Nephrops norvegicus* were calculated following three different approaches (**Figure 7**). The bathymetric range, between 300 and 400m depth (**Figure 7**, **B** and **E**), shows the main abundance of recruits. All retention percentages for this species by individuals and weight are relatively high (higher than 78.8%), meaning that very few individuals escape from the fishing gear. Regarding the retention in all hauls (**Figure 7**, **A**), a reduction of 6.2% in the retention percentages by individual was estimated after using the 45mm squared mesh codend. Higher differences between commercial and experimental codend are found at recruitment depths (**Figure 7**, **B** and **E**).

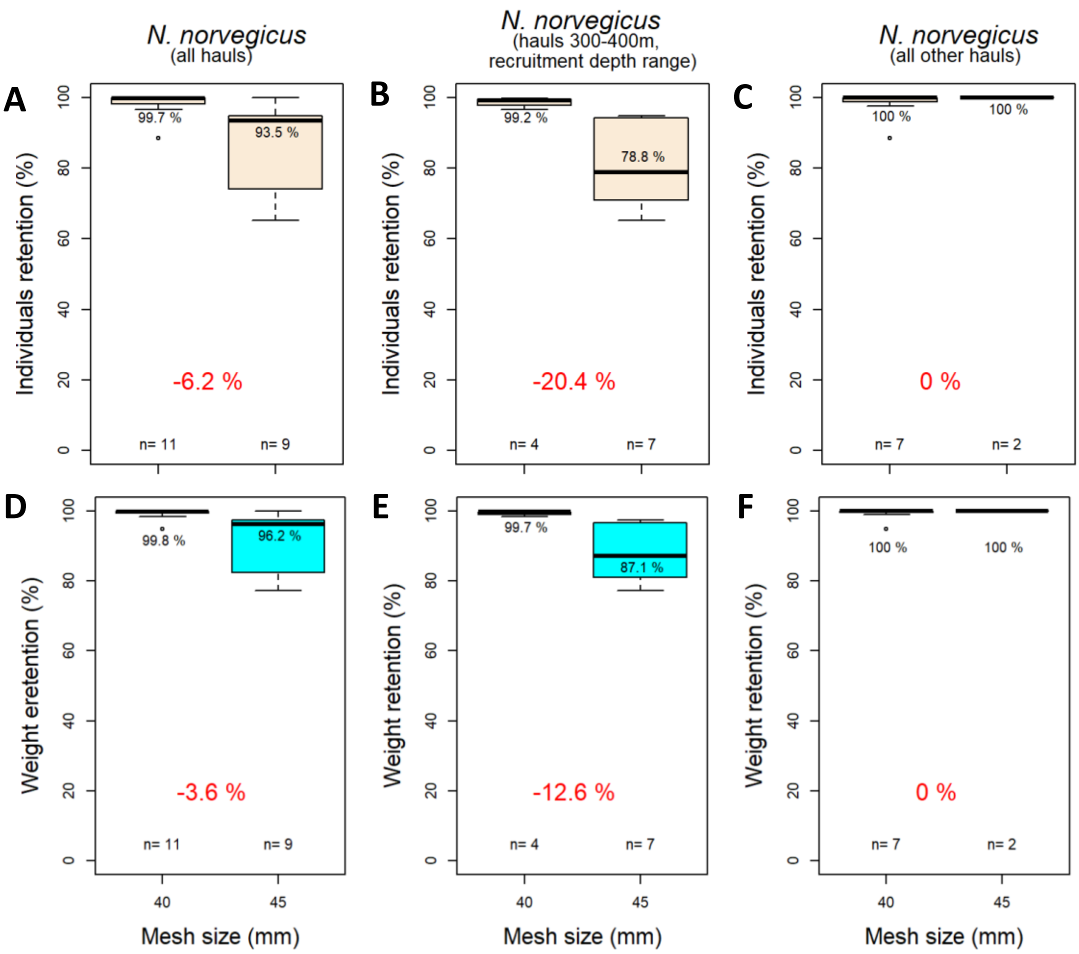

Figure 7. Boxplots showing catch retention percentages of *Nephrops norvegicus* by individuals **(A-C)** and by weight **(D-F)** for commercial 40mm square mesh codend and experimental 45mm square mesh codends in coastal fisheries. The main recruitment bathymetric range for this species is found at depth range between 300 and 400m depth. Horizontal bold line in boxplots represents the median value.

Selectivity parameters and size frequencies for the three approaches are shown in **Table 6** and **Annex 1**. The highest L50 values (25.8mm CL) are estimated from hauls carried out with experimental 45mm mesh codend at recruitment depth range between 300 and 400m depth, representing an increasing of 1.4mm CL, compared to the L50 of the 40mm mesh codend. No selectivity curve of *all other hauls* approach was adjusted for catches with 45mm square mesh codend due to the small number of individuals.

Table 6. Values of selectivity parameters of *Nephrops norvegicus*.

Codend mesh size (mm)	Approach	L50 (mm)	SR (mm)
40	All hauls	23.4	2.7
	Hauls in recruitment depth range (300-400m)	24.4	2.2
	All other hauls	22.6	3.2
45	All hauls	23.7	6.3
	Hauls in recruitment depth range (300-400m)	25.8	5.6
	All other hauls	-	-

e. *Aristeus antennatus*

Three approaches have been considered for *Aristeus antennatus,* according to the presence of recruits (**Figure 8**). The recruitment period (by end of winter and early spring) for this species was not coincident with the sampling period. Therefore, data from two earlier selectivity projects (**Table 2**) carried out in spring season for the same scientific team were used. The reduction of individual retention percentages by using the 50mm square mesh codend ranged from 6.7% (**Figure 8**, **B**) considering the hauls performed at a period different from that of recruitment, to 28.2% during the recruitment period (**Figure 8**, **B**). The reduction by weight of the 50mm square mesh codend shows relatively low variability in the three approaches, between 3.6 and 6.7% (**Figure 8**, **D-F**).

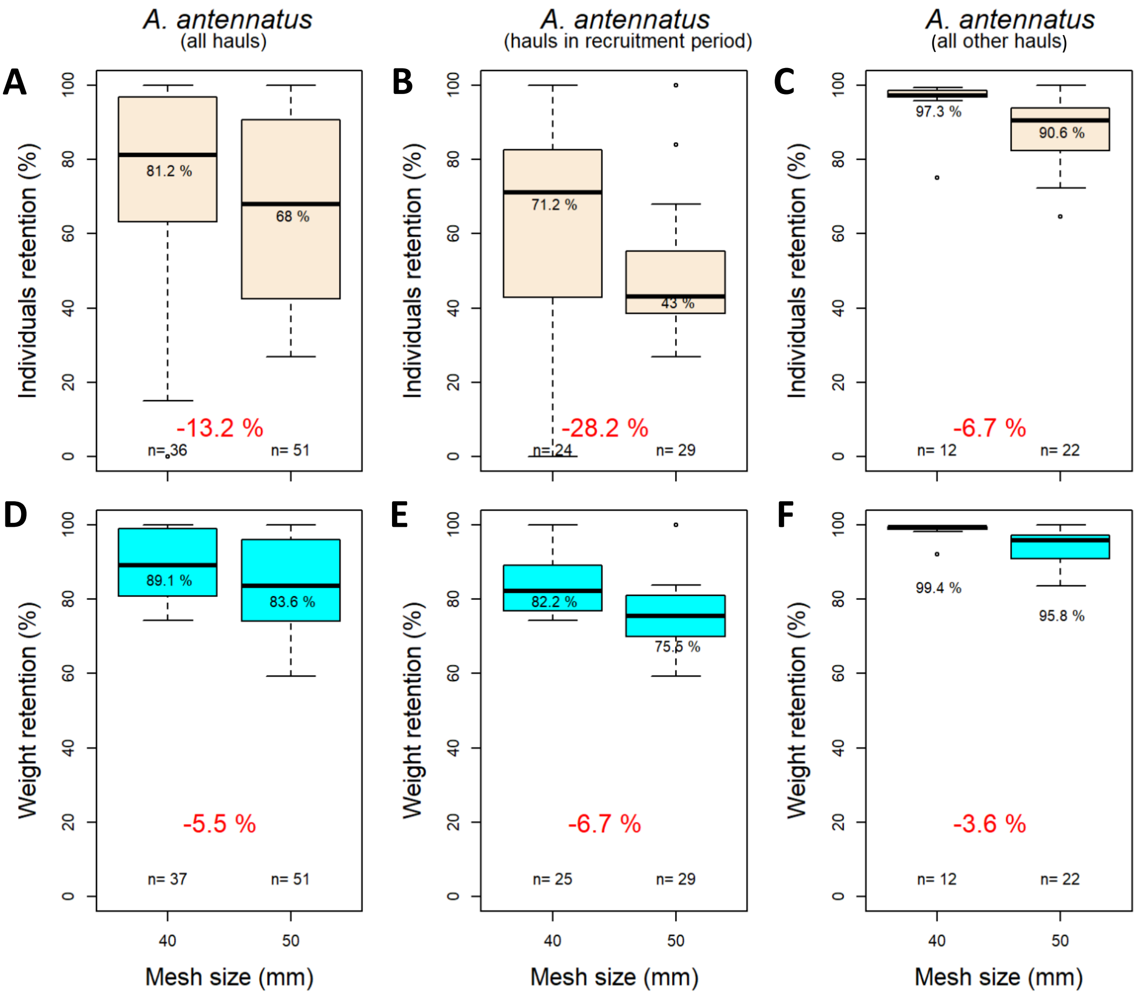

Figure 8. Boxplots showing the catch retention percentage of *Aristeus antennatus* by individuals **(A-C)** and by weight **(D-F)** for commercial 40mm square mesh codend and experimental 50mm square mesh codend in deep-sea fisheries. Horizontal bold line in boxplots represents the median value.

The sampling period of this experiment did not provided enough data to obtain selectivity curves for the recruitment period or depth range of recruitment. Therefore, data from earlier projects (**Table 1**) were used to cover the late recruitment period (April to June) of this species.

Selectivity parameters and size frequencies by each of the three approaches are shown in **Table 7** and **Annex 1**. The improvement in the percentage of size selection by using the 50mm square mesh codend, is from 20.9 to 26.2mm CL (Gorelli et al, 2017) during the recruitment season.

Table 7. Values of selectivity parameters of *Aristeus antennatus*.

Codend mesh size (mm)	Approach	L50 (mm)	SR (mm)
40	All hauls	20.9	5.6
	Hauls in recruitment season [(1)]	21.1	5.7
50	All hauls	23.4	5.9
	Hauls in recruitment season [(1)]	26.2	7.2

[(1)] According to Gorelli et al (2017).

4. PART B. Economic impact on landings

4.1. General remarks and methods

As a consequence of an increment of the codend mesh size change in the otter bottom trawl fleet, a short-term economic impact is expected. That is, a proportion of commercial individuals will no longer be retained by trawling activity and therefore fleet landings and income will decrease. It is important to notice that, in a mid-long term, first economic losses would be compensated by the expected increase in the size of individuals of commercial species, which will also increase catch economic value and reduce discards.

An evaluation of the fleet short-term economic losses is provided based on selectivity parameters from this technical report and from landing data. Landings and economic yields data are provided by the Spanish General Secretariat of Fisheries and selectivity data from the sampling surveys detailed in the first part of the report (Part A). Landings are referred to the period 2016-2019 as 2020 data were not considered due to the fleet activity anomalies caused by COVID-19 pandemic. Yearly average values were calculated for the five reference species and for coastal/deep-sea landings. Moreover, a comparison of total landing incomes (€) with all other fleets (small-scale, purse seine and longline fisheries) is provided.

Firstly, yearly mean landings and economic yields were calculated by species and fleet sections. Landings for deep-sea fisheries were calculated based on Article 3 of Orden APA/423/2020 from the Spanish Food, Agriculture and Fisheries Ministry. That is, using fishing trips with >20% in weight of *Aristeus antennatus*. The rest of fishing trips were considered Coastal fisheries.

Secondly, changes in commercial landings from the implementation of selectivity measures were calculated. Otter bottom trawl data from ICATMAR surveys were used (2019 period) as a reference of the individuals size caught with the current 40mm square mesh codend commercial catch (***baseline***) for the five reference species (**Figure 9**). Then, proportions from selectivity curves from experimental codends (45- and 50mm square mesh codend) from this study (**Part A**) were applied to 40mm size frequencies (**Figure 9**) to calculate weight loses when using 45- and 50mm square mesh codend with respect to 40mm square mesh codend. Selectivity curves and size frequencies for the five reference species and by each of the approaches used in **Part A** (*Size selectivity on catches*) are shown in **Annex 1**.

To evaluate the economic impact of the implementation of the experimental codend mesh size, two scenarios were considered:

- ***Sel1***: changes in species size frequency from commercial to experimental codends using selectivity parameters from this study, considering the *all hauls* approach defined in Part A.

- ***Sel2***: changes in species size frequency from commercial to experimental codends using selectivity parameters from this study, considering the *recruitment period* or recruitment *bathymetric range* approach defined in Part A.

A third scenario with *no recruitment* data was not addressed due to the number of valid hauls was generally very low. The small number of individuals caught prevented from estimating accurate selectivity parameters.

4.2. Catch losses and size frequency distribution changes after implementing the 45- and 50mm squared mesh codend

During recruitment periods, small individuals are proportionally more abundant as well as weight losses (**Table 8**). Therefore, losses in *recruitment period* (Sel2) are considered a proxy of the highest possible commercial losses whereas estimates using the selectivity curve (or indicators) obtained for *all hauls* (Sel1) would be a proxy of a yearly mean estimate of losses.

Table 8. Catch losses percentages in number and weight for the five reference species comparing each one of the two scenarios (Sel1, all hauls; Sel2, recruitment hauls) *vs* the baseline size frequencies (commercial 40mm square mesh codend).

Reference species	Baseline *vs* scenarios	ind/km^2	kg/km^2	Catch losses (%)	
				Number	Weight
***Mullus* spp.**	Baseline: 40mm	550.0	34.4		
	Sel 1: 45mm	477.7	32.6	13.1	**5.03**
	Sel 2: 45mm	251.3	22.9	54.3	**9.74**
Merluccius merluccius	Baseline: 40mm	220.3	36.7		
	Sel 1: 45mm	213.2	36.5	3.2	**0.61**
	Sel 2: 45mm	214.0	36.5	2.8	**0.51**
Parapenaeus longirostris	Baseline: 40mm	1 462.7	13.8		
	Sel 1: 45mm	1 216.9	12.9	16.8	**6.78**
	Sel 2: 45mm	1 192.5	12.8	18.5	**7.25**
Nephrops norvegicus	Baseline: 40mm	1 588.6	38.6		
	Sel 1: 45mm	1 335.6	35.1	15.9	**8.98**
	Sel 2: 45mm	1 219.8	33.3	23.2	**13.55**
Aristeus antennatus	Baseline: 40mm	4 320.1	63.8		
	Sel 1: 50mm	3 512.7	58.5	18.7	**8.36**
	Sel 2: 50mm	3 499.3	58.3	19.0	**8.64**

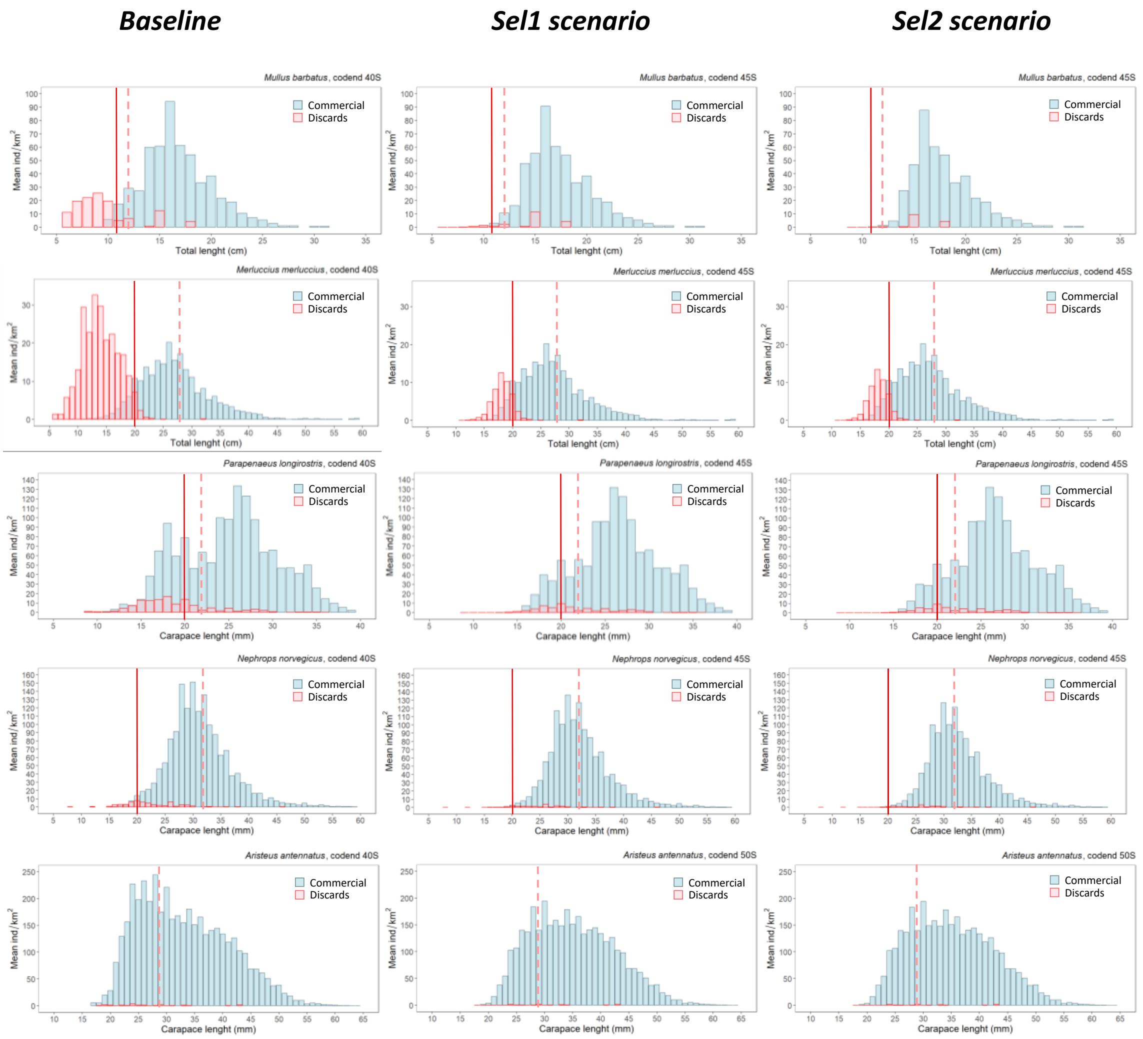

Figure 9. Size frequencies for the five reference species for baseline (commercial 40mm square mesh codend size) and Sel1 and Sel2 scenarios (experimental 45- and 50mm square mesh codend sizes). Continuous red line: MCRS for each species; Dashed red line: average of length at first maturity (LFM), obtained from the literature (Bianchini et al, 1998; Carlucci et al, 2006; Dereli & Erdem, 2011; Manasirli & Avsar, 2008; Orsi Relini et al, 1998; Özyurt et al, 2014; Recasens et al, 1998; Recasens et al, 2008; Sardà & Demestre, 1987; Sobrino & Garcia, 2007).

4.3. Estimations of the economic impact after implementing the experimental codends

In order to calculate losses of landings and incomes after using experimental codend mesh sizes, reduction percentages were applied from selectivity proportions provided by the selectivity curves of experimental codends for the five reference species (**Part A**, **Annex 1** and **Tables 9** and **11**). Coastal fisheries reduction was calculated using total landings and estimated losses for the rest of the reference species together (**Tables 10** and **12**). For deep-sea fisheries, only *Aristeus antennatus* value was used as it represents 54% in weight and 85% in economic income of this fishery.

Landing economic losses were calculated using an estimation of the smallest commercial individual values (€/kg). With this purpose, landings by size categories were analysed for six reference ports (Roses, Palamós, Vilanova i la Geltrú, Cullera, Dènia and Xàbia). For each reference species, the mean value of the cheapest commercial category (corresponding to the smallest individuals) was calculated. For coastal and deep-sea fisheries, the mean value (€/kg) was calculated taking into account the five reference species (the smallest commercial size) along with the rest of species without size category, as they are less likely classified by size categories.

The importance of otter bottom trawl activity and in particular of the five reference species is relevant in the GSA6 fish market. Economic losses range for the five reference species varies from 2.6 to 3.3 million € corresponding to 4.1 – 5.2% of bottom trawlers overall losses (**Tables 9** and **11**). Species with the highest proportional economic reduction is red mullet (5.0 – 9.7%) followed by Norway lobster (5.7 – 8.5%), blue and red shrimp (5.0 – 5.1%), deep-water rose shrimp (4.4 – 4-7%) and finally European hake (0.6 – 0.7%, **Tables 9** and **11**).

Bottom trawl landings represent 57% of all GSA6 fishing incomes (117.5 million €) of which 54% corresponds to the five reference species (63.5 million €, **Tables 9** and **11**). The reference species are the first five most important in bottom trawlers income although not in landed weight (**Tables A2.1** and **A2.2** on **Annex 2**). When adding other fleets landings, species typically caught by purse seine fleet become also economically important although red shrimp, hake, deep-water rose shrimp, Norway lobster and red mullet are still between the ten economically most important species (**Table A2.3**). Finally, when comparing with all fleet species in weight (**Table A2.4**) the five reference species loose importance as purse seine fleet represent 56% of all GSA6 landed tonnes.

Overall estimated economic losses in GSA6 as a consequence of implementing experimental codends of this study (45- and 50mm codend mesh sizes for coastal and deep-sea fisheries, respectively) are 4.8 – 6.7 million € on a short term, which represents 4.1 – 5.7% of bottom trawlers GSA6 incomes and 2.4 – 3.3% of all GSA6 incomes (including all fishing fleets, **Tables 10** and **12**). Higher losses values in data ranges correspond to those calculated with Sel2 scenario (**Tables 11** and **12**) and smaller losses values correspond to Sel1 scenario (**Tables 9** and **10**). Income losses in deep-sea fisheries (6.0 – 6.2 %) are higher compared to those in coastal fisheries (3.6 – 5.6%).

Table 9. Estimates of bottom trawlers landing reduction in weight (tons) and income (K€) of the five reference species for the GSA6 using selectivity proportions from all hauls (**Sel1**). Blue and red shrimp tonnes reduction is calculated without Palamós landings, as 50mm mesh size is already used in the port since year 2017.

Reference species	Landings annual mean (2016-19)		Weight reduction (%)	Landings reduction (Tn)	€/Kg of the smallest commercial size	Economic loss	
	Tn	K€				K€	%
Mullus spp.	1 656.6	8 667.6	5.03	83.3	5.2	435.0	5.0
Merluccius merluccius	1 951.5	13 103.2	0.61	11.9	8.0	95.6	0.7
Parapenaeus longirostris	745.1	10 207.9	6.78	50.5	8.9	448.1	4.4
Nephrops norvegicus	339.2	8 140.1	8.98	30.5	15.1	460.0	5.7
Aristeus antennatus	641.1	23 344.3	8.36	45.5	25.4	1 156.8	5.0
Total OTB GSA6, five reference species	5 333.5	63 463.1		221.8		**2 595.4**	**4.1**

Table 10. Estimates of overall GSA6 bottom trawlers landing reduction in weight (tons) and income (K€) using selectivity proportions from all hauls (**Sel1**) by fishery and fleet. Bottom trawling fishing trips are divided between coastal and deep-sea fisheries and compared to global GSA6 landings including all fishing gears (purse seine, longline, bottom trawl and small-scale fisheries).

Fisheries / Fleets	Landings annual mean (2016-19)		Weight reduction (%)	Landings reduction (Tn)	Estimated €/Kg	Economic loss	
	Tn	K€				K€	%
Total GSA6 OTB coastal fisheries	17 465.4	92 653.8	3.75	655.0	5.1	3 353.4	3.6
Total GSA6 OTB deep-sea fisheries	1 088.9	24 877.5	8.36	91.0	16.3	1 482.3	6.0
Total GSA6 bottom trawl fleet	18 554.3	117 531.3		746.0		**4 835.4**	**4.1**
Total GSA 6 all fleets	53 668.0	204 786.9		746.0		**4 835.4**	**2.4**

Table 11. Estimates of bottom trawlers landing reduction in weight (tons) and income (K€) of the five reference species for the GSA6 using recruitment period selectivity estimates (**Sel2**). Blue and red shrimp tonnes reduction is calculated without Palamós landings as 50mm mesh size is already used in the port since year 2017.

Reference species	Landings annual mean (2016-19)		Weight reduction (%)	Landings reduction (Tn)	€/Kg of the smallest commercial size	Economic loss	
	Tn	K€				K€	%
Mullus spp.	1 656.6	8 667.6	9.74	161.4	5.2	842.3	9.7
Merluccius merluccius	1 951.5	13 103.3	0.51	10.0	8.0	79.9	0.6
Parapenaeus longirostris	745.1	10 207.9	7.25	54.0	8.9	479.2	4.7
Nephrops norvegicus	339.2	8 140.1	13.55	46.0	15.1	694.1	8.5
Aristeus antennatus	641.1	23 344.3	8.64	47.1	25.4	1, 195.5	5.1
Total OTB GSA6, five reference species	5 333.5	63 463.1		318.4		**3 290.9**	**5.2**

Table 12. Estimates of overall GSA6 bottom trawlers landing reduction in weight (tons) and income (K€) using recruitment period selectivity estimates (**Sel2**) by fishery and fleet. Bottom trawlers fishing trips are divided between coastal and deep-sea fisheries and compared to global GSA6 landings including all fishing gears (purse seine, longline, bottom trawl and small-scale fisheries).

Fisheries / Fleets	Landings annual mean (2016-19)		Weight reduction (%)	Landings reduction (Tn)	Estimated €/Kg	Economic loss	
	Tn	K€				K€	%
Total GSA6 OTB coastal fisheries	17 465.4	92 653.8	5.78	1 009.5	5.1	5 168.7	5.6
Total GSA6 OTB deep-sea fisheries	1 088.9	24 877.5	8.64	94.1	16.3	1 531.6	6.2
Total GSA6 bottom trawl fleet	18 554.3	117 531.3		1 103.6		**6 700.3**	**5.7**
Total GSA 6 all fleets	53 668.0	204 786.9		1 103.6		**6 700.7**	**3.3**

5. Conclusions

The main conclusions of the present Technical reports are:

1. The results of this Technical Reports shows that the catch reductions due to the improvement of fishing gears selectivity are in line with the requirement of a 15-25% of bycatch reduction laid down at the Statement of the Presidency published in December 2020. Selectivity measures along with the fishing effort reduction and the no-take areas already implemented, may reach the change demanded for the Spanish Mediterranean fishing grounds.

2. The use of the two proposed codend square mesh sizes (45- and 50mm for coastal and deep-sea fisheries) would produce a significant reduction in catches below MCRS. ***The biological benefits of this management measure would be relatively high instead the economic impact along the GSA6 will be relatively low***. A positive biological impact in terms of recruitment for the fishing stocks will be produced with time, being also a positive measure in terms of recovery of overexploited stocks.

3. The catch reductions on individuals results on 19.9% and 11.4% for coastal and deep-sea fisheries, respectively (i.e. percentage variation of total catch for 40mm codend mesh size compared with the 45- and 50mm codend square mesh sizes). These reductions are greater in number of individuals than in weight, which means that mainly the smallest individuals of the catches escape. Thus, a decrease in unwanted and undersized catches of all species affected by the otter bottom trawl fishery is expected with the use of 45- and 50mm codend mesh sizes.

4. Short-term economic losses vary from 2.4% to 3.3 %, depending on the temporal or spatial variability of recruitment. This variation is the result of considering all of the hauls conducted in this Technical Report (2.4% losses) or a maximum percentage of economic losses (3.3%) when selectivity parameters on recruitment seasons and/or areas are taken into account.

5. This range is calculated as the immediate impact after the application of these new selectivity measures. Further calculations about the positive effects of using new codend mesh size are necessary in order to measure the real effect in middle term. Early improvements in the profitability and exploitation levels of the whole fishing ground are expected. Therefore, in a mid-long term, short-term economic losses would be compensated by the expected size increase of commercial species individuals.

6. The implementation of 45- and 50mm mesh size codends will reduce discards of target and bycatch species, improving on board working conditions and reducing the landing of unmarketable catches that may not be offered for direct human consumption. Therefore, selectivity measures will ease the correct implementation of landing obligation by the bottom trawl fleet.

7. Selectivity improvements are a permanent measure over time and space that entails a reduction on the fishing impact of all the otter bottom trawl fishing fleet, allowing them to evolve towards sustainable exploitation of the stocks.

8. The effects produced for all measures implemented since the application of the MAP for western Mediterranean Sea together with the Landing Obligation needs to be monitored over the coming years 3 to 4 years. This period is necessary for the correct assessment of the Western Mediterranean Sea fisheries.

9. It is worth to mention that together with the application of the Article 11.2 and 11.3 of the Regulation (EU) 2019/1022, the implementation of the 45- and 50mm codend mesh sizes will represent an additional reduction of juveniles of *Merluccius merluccius* on catches (object of Art. 11.2), so on other reference species of the MAP.

6. References

Bianchini, M.L., Stefani Di, L., Ragonese, S. (1998). Size and age at onset of sexual maturity of female Norway lobster *Nephrops norvegicus* L. (Crustacea: Nephropidae) in the Strait of Sicily (Central Mediterranean Sea). Scientia Marina 62(1-2): 151-159.

BOE-A-2020-5163. Orden APA/423/2020, de 18 de mayo, por la que establece un plan de gestión para la conservación de los recursos pesqueros demersales en el mar Mediterráneo. https://www.boe.es/eli/es/o/2020/05/18/apa423

Carlucci, R., D'Onghia, G., Sion, L., Maiorano, P., Tursi, A. (2006). Selectivity parameters and size at first maturity in deep-water shrimps, *Aristaeomorpha foliacea* (Risso, 1827) and *Aristeus antennatus* (Riso, 1816), from the North-Western Ionian Sea (Mediterranean Sea). Hydrobiologia, 557: 145-154.

Dereli, H., Erfem, M. (2011). Spawning period and first maturity size of deep water rose shrimp (*Parapenaeus longirostris*) in the Aegean Sea. African Journal of Biotechnology, 10: 15407-15415.

Fryer, R.J. (1991). A model of between-haul variation in selectivity. ICES Journal of Marine Sciences, 48: 281-290.

Gorelli G., Company J.B., Bahamón, N., Sardà F. (2017). Improving codend selectivity in the fishery of the deep-sea red shrimp *Aristeus antennatus* in the northwestern Mediterranean Sea. Scientia Marina, 81(3): 381-386.

Manasirli, M., Avsar, D. (2008). Reproductive biology of female *Parapenaeus longirostris* (Lucas, 1846) (Decapoda, Caridea) in Babadillimani Bight in the northeastern Mediterranean. Crustaceana, 81(3): 289-298.

Orsi Relini, L., Zamboni, A., Fiorentino, F., Massi, D. (1998). Reproductive patterns in Norway lobster *Nephrops norvegicus* (L.), (Crustacea Decapoda Nephropidae) of different Mediterranean areas. Scientia Marina, 62(Sup. 1): 25-41.

Özyurt, C.E., Cicek, E., Avsar, D., Yeldan, H., Manasirli, M. (2014). The relationship among spawning period, length at first maturity and depth distribution of *Mullus barbatus* and *Upeneus moluccensis* inhabiting the Northeastern Mediterranean coast of Turkey. International Journal of Aquatic Biology, 2(4): 215-222.

Recasens, L., Chiericoni, V. Belcari, P. (2008). Spawning pattern and batch fecundity of the European hake (*Merluccius merluccius*, Linnaeus, 1758) in the Northwestern Mediterranean. Scientia Marina, 72(4): 721-732.

Recasens, L., Lombarte, A., Morales-Nin, B., Torres, G.J. (1998). Spatiotemporal variation in the population structure of the European hake in the NW Mediterranean. Journal of Fish Biology, 53: 387-401.

REGULATION (EU) 2019/1022 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea and amending Regulation (EU) No 508/2014.
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1022&from=EN

REGULATION (EU) No 1380/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1380&from=ES

Russo, T., Parisi, A., & Cataudella, S. (2011). New insights in interpolating fishing tracks from VMS data for different métiers. Fisheries Research, 108(1), 184–194. https://doi.org/10.1016/j.fishres.2010.12.020

Sardà F., Demestre M. (1987). Estudio biológico de la gamba *Aristeus antennatus* (Risso, 1816) en el Mar Catalán (NE de España). Investigaciones Pesqueras, 51: 213- 232.

Sobrino, I., & García, T. (2007). Reproductive aspects of the rose shrimp *Parapenaeus longirostris* (Lucas, 1846) in the Gulf of Cadiz (southwestern Iberian Peninsula). Bol. inst. esp. oceanogr, 23(1-4), 57-71.

Statement by France and Spain On closure areas in the area of the Western Mediterranean MAP 5415/1/21 REV 1
https://data.consilium.europa.eu/doc/document/ST-5415-2021-REV-1/es/pdf

ANNEX I: Selectivity figures for the five species of reference

A1.1. *Mullus barbatus* approach for *all hauls*

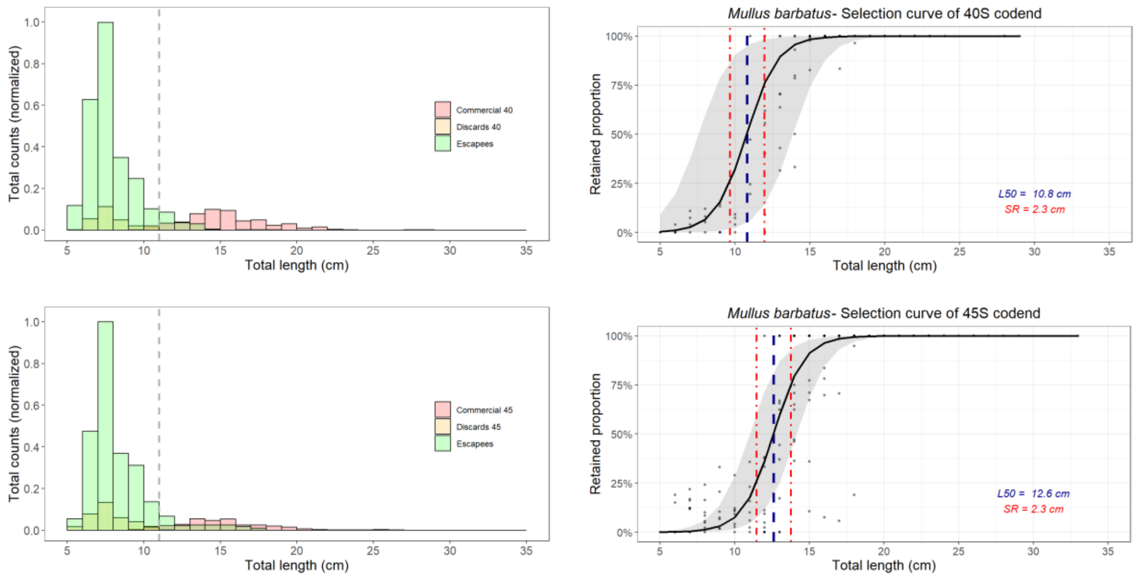

Figure A1.1. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Mullus barbatus* obtained for *all hauls* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.2. *Mullus barbatus* approach for *recruitment season*

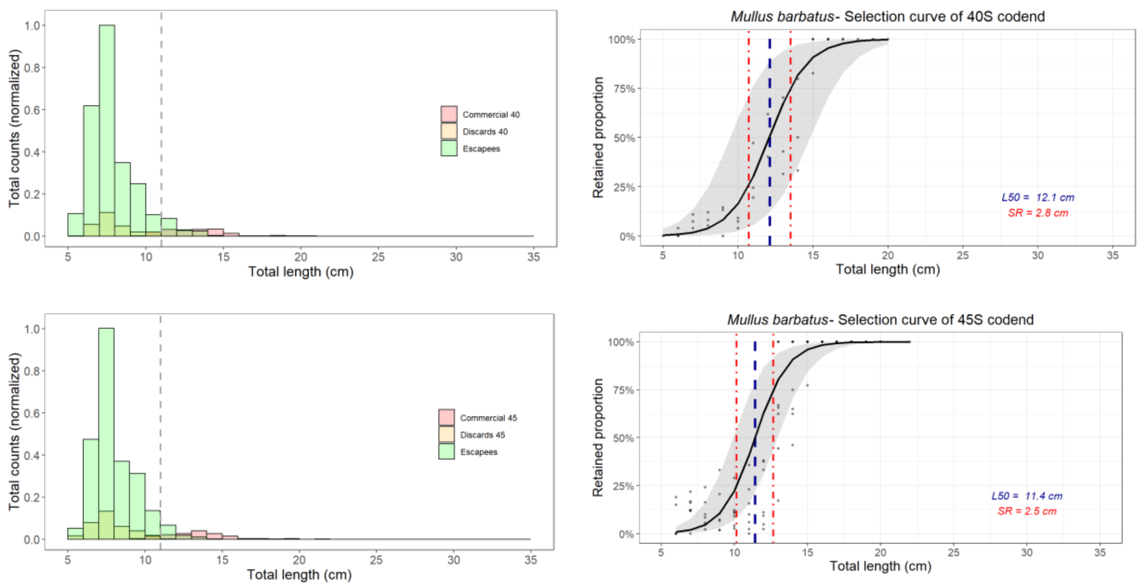

Figure A1.2. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Mullus barbatus* obtained for *recruitment season* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.3. *Mullus barbatus* approach for *all other hauls (no recruitment season)*

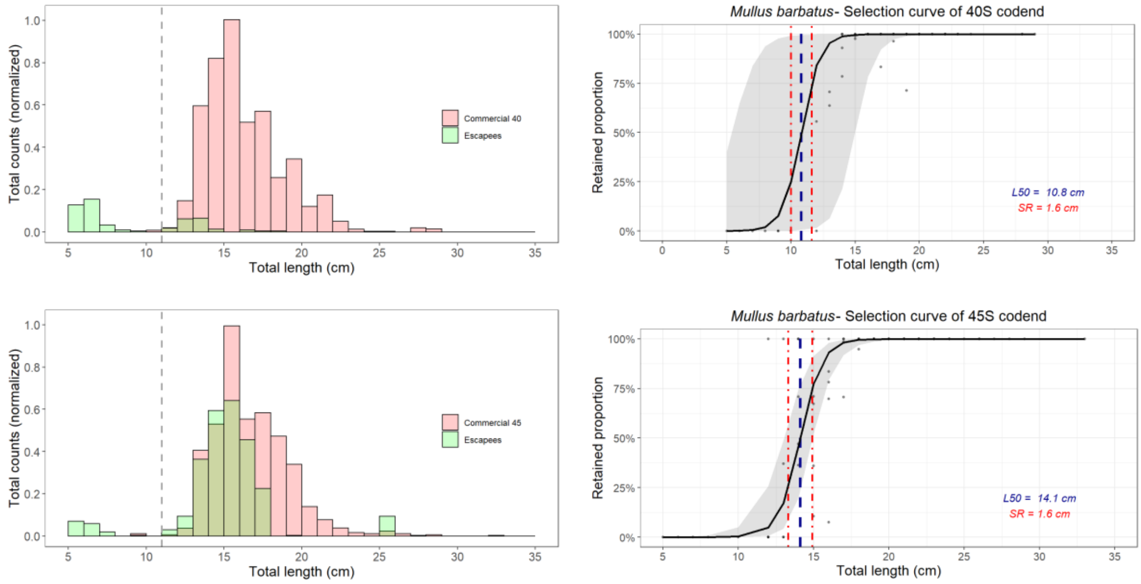

Figure A1.3. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Mullus barbatus* obtained for *all other hauls (no recruitment season)* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.4. *Merluccius merluccius* approach for *all hauls*

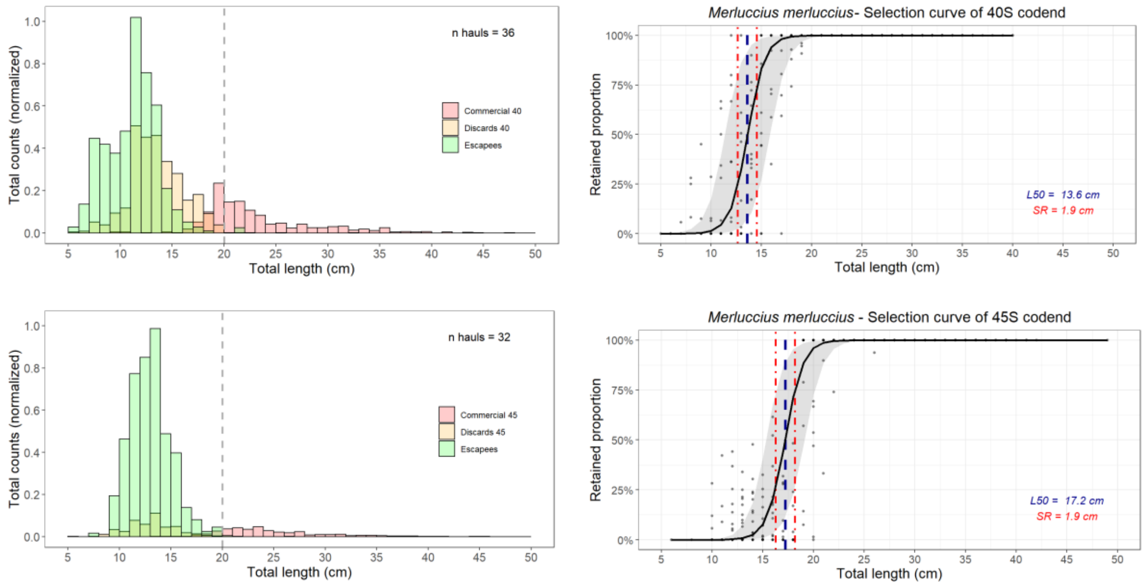

Figure A1.4. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Merluccius merluccius* obtained for *all hauls* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.5. *Merluccius merluccius* approach for *hauls <150m depth*

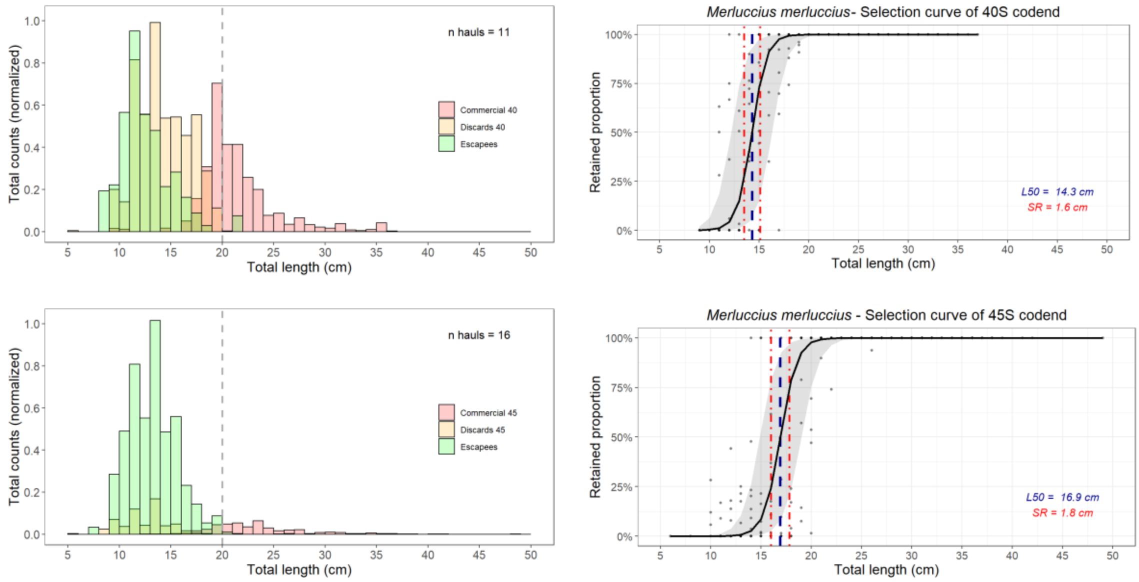

Figure A1.5. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Merluccius merluccius* obtained for *hauls <150m* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.6. *Merluccius merluccius* approach for *recruitment depth range between 150 and 250m*

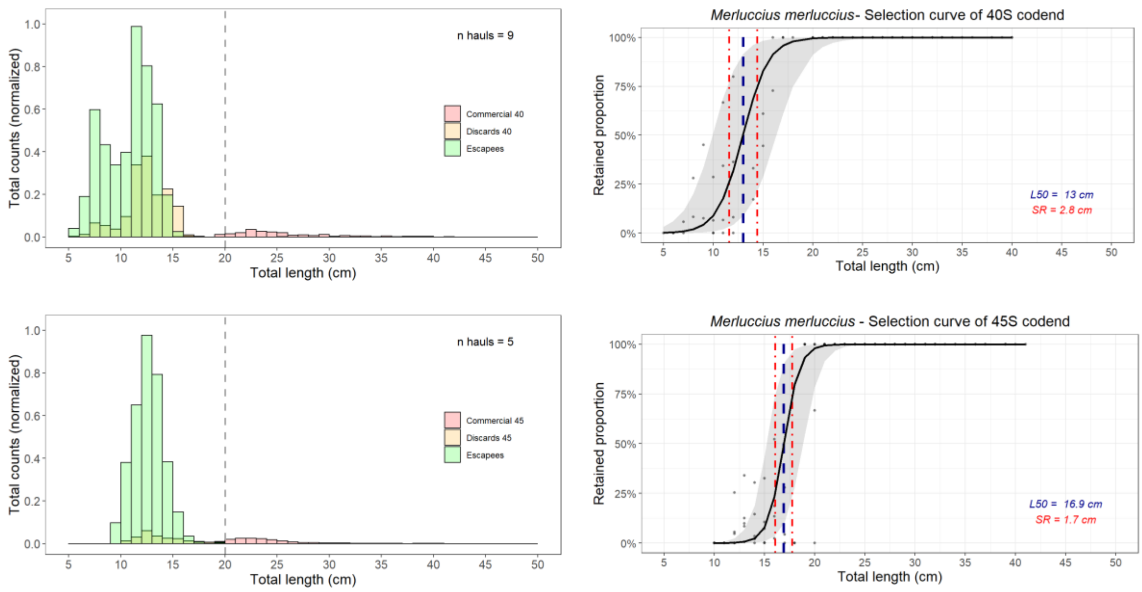

Figure A1.6. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Merluccius merluccius* obtained for *recruitment depth range (150-250m depth)* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.7. *Parapenaeus longirostris* approach for *all hauls*

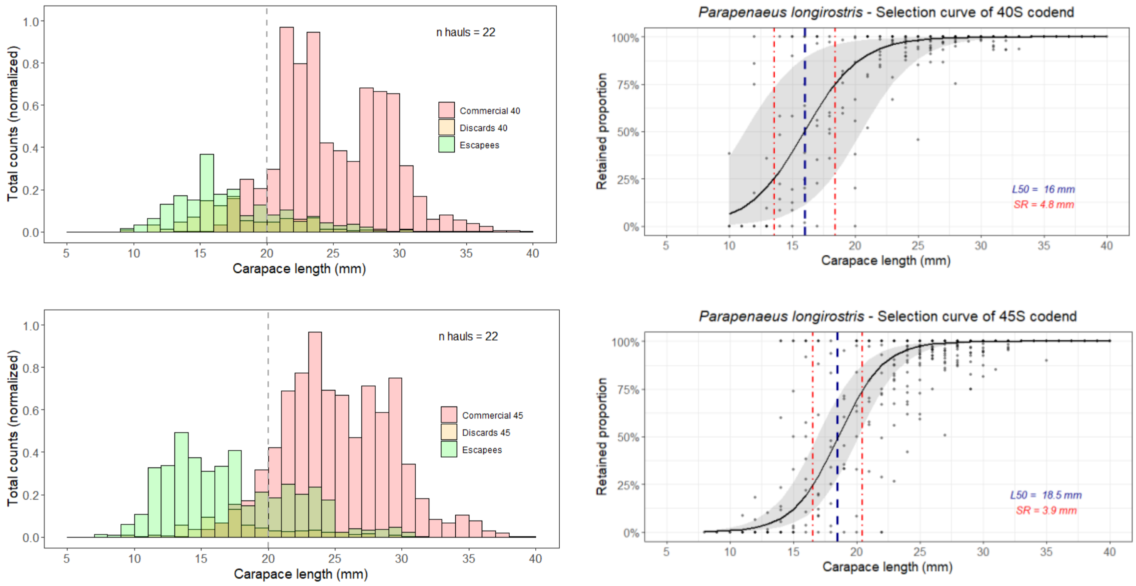

Figure A1.7. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Parapenaeus longirostris* obtained for *all hauls* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.8. *Parapenaeus longirostris* approach for *recruitment depth range <200m*

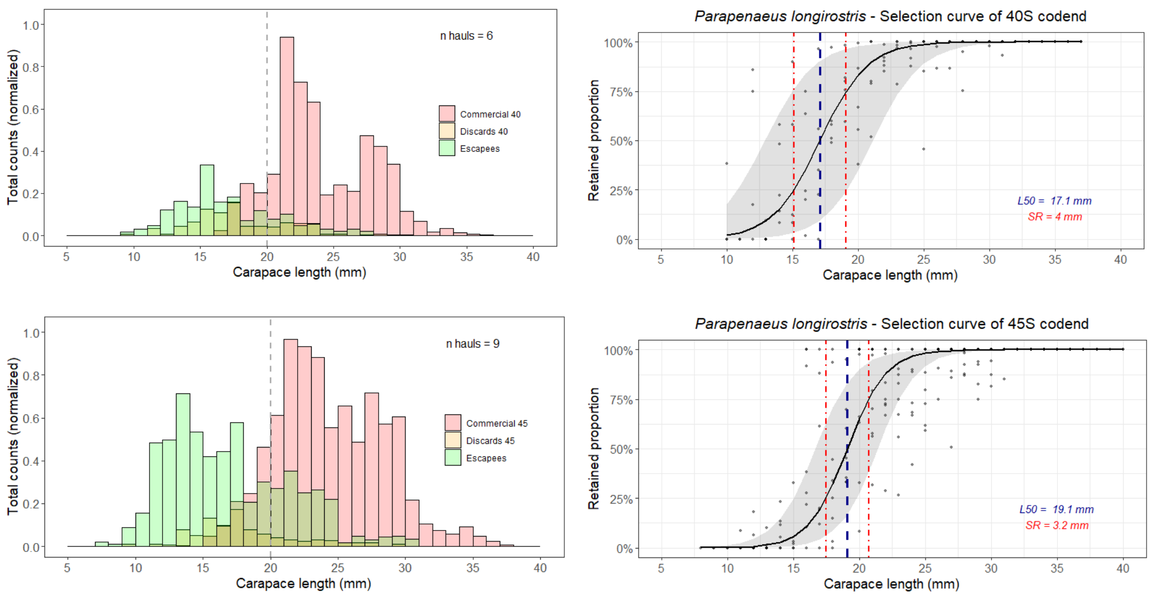

Figure A1.8. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Parapenaeus longirostris* obtained for *recruitment depth range (<200m depth)* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.9. *Parapenaeus longirostris* approach for *hauls >200m depth*

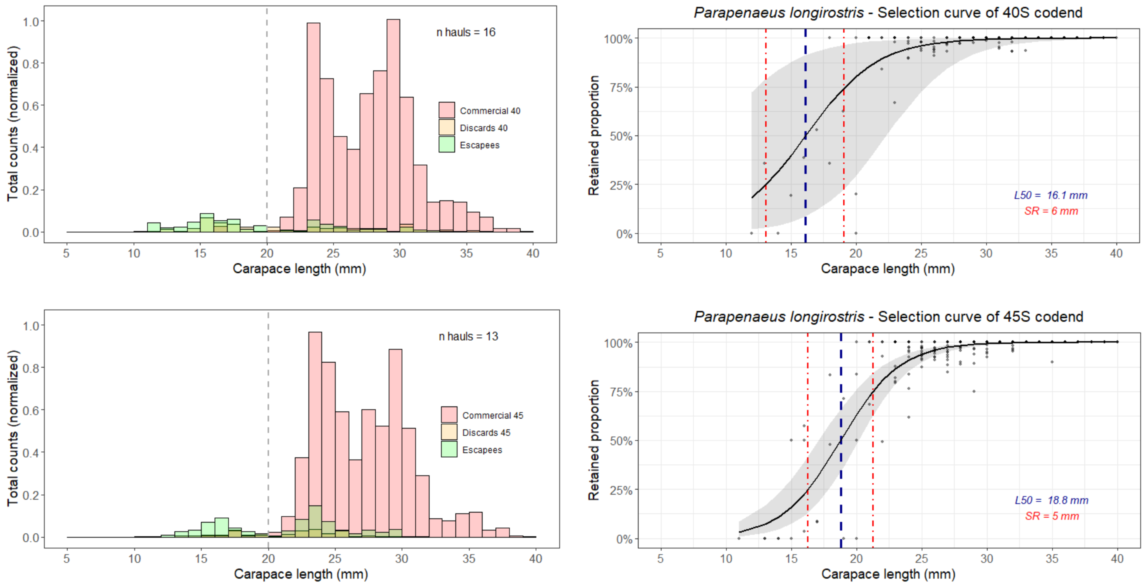

Figure A1.9. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Parapenaeus longirostris* obtained for *hauls >200m depth* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.10. *Nephrops norvegicus* approach for *all hauls*

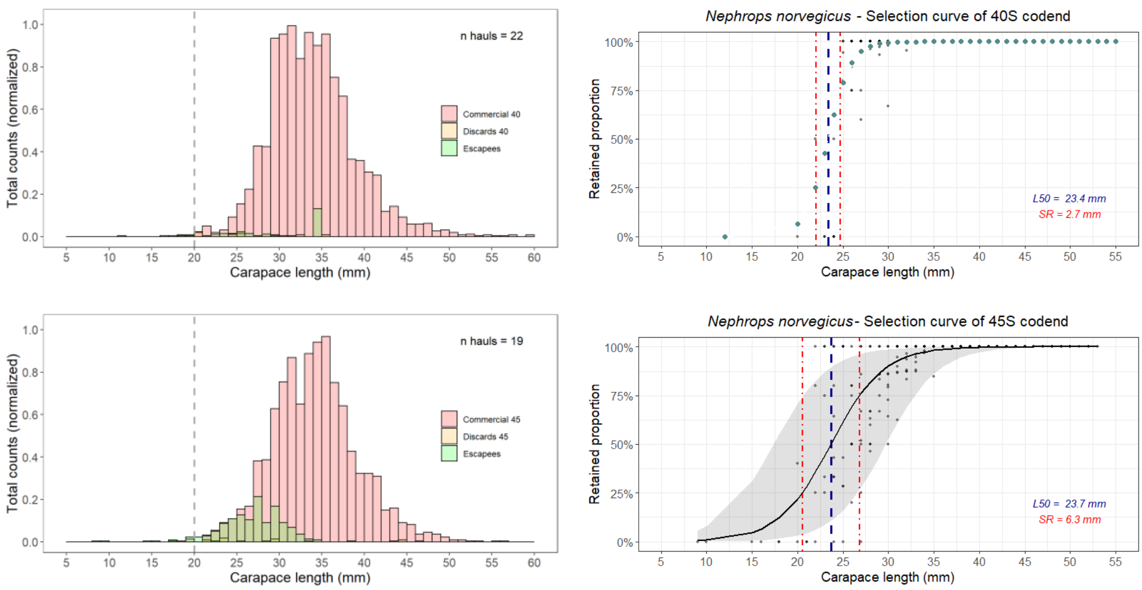

Figure A1.10. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Nephrops norvegicus* obtained for *all hauls* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.11. *Nephrops norvegicus* approach *recruitment depth range between 300 and 400m*

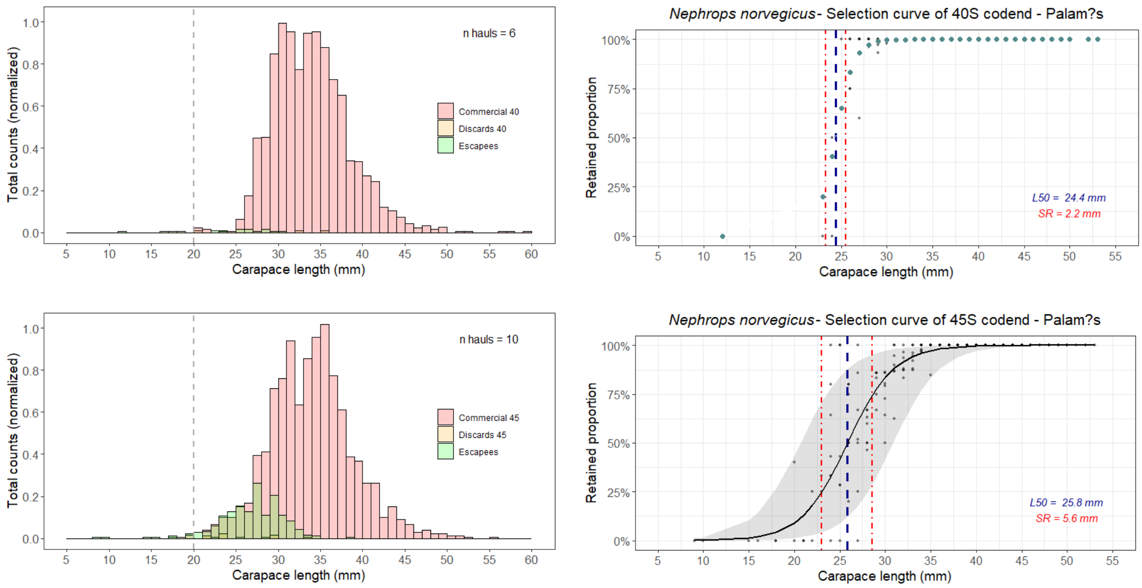

Figure A1.11. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Nephrops norvegicus* obtained for *recruitment depth range (300-400m)* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval.

A1.12. *Nephrops norvegicus* approach for *all other hauls (no recruitment depth range)*

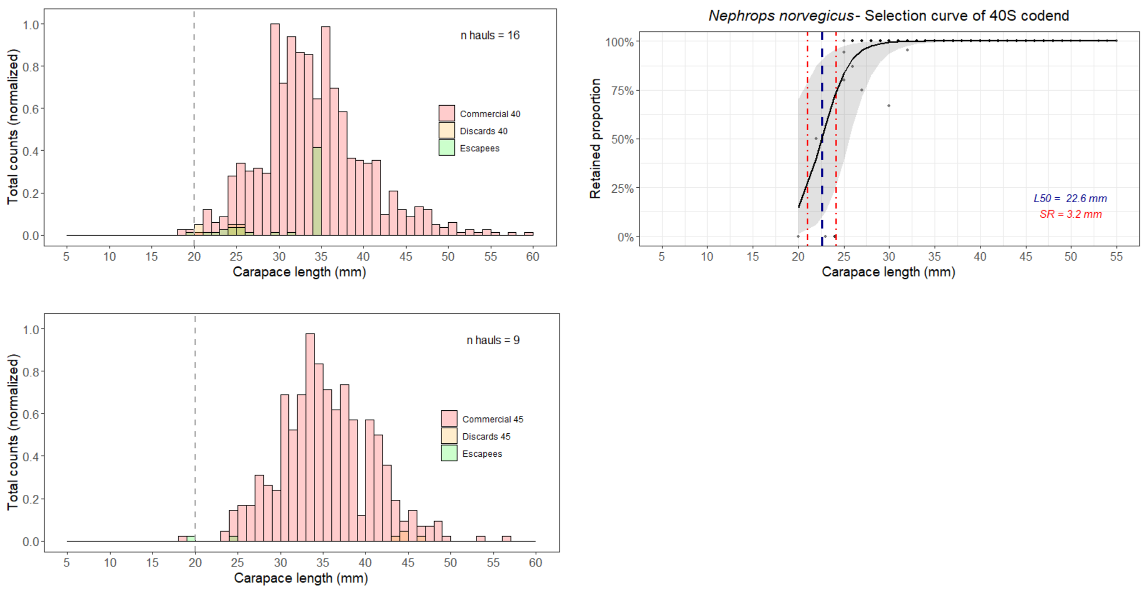

Figure A1.12. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Nephrops norvegicus* obtained for *all other hauls (no recruitment depth range)* approach, for 40- and 45mm square mesh codends. Dashed grey line in size frequencies indicates the MCRS. Shadow area in selection curves indicates confidence interval. No selectivity curve was adjusted for catches with 45mm square mesh codend due to the small number of individuals.

A1.13. *Aristeus antennatus* approach for *all hauls*

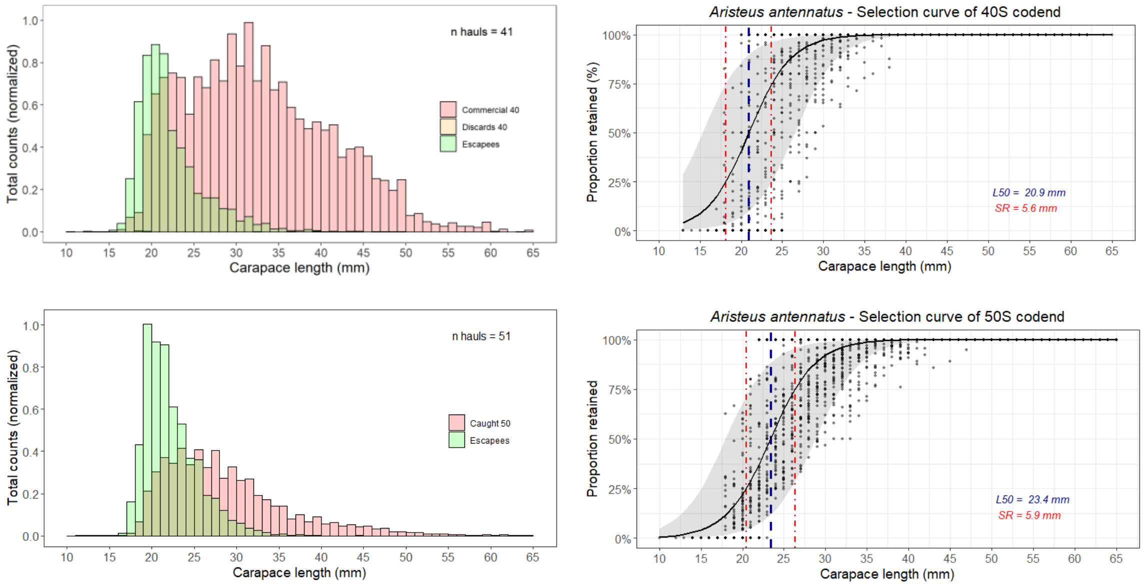

Figure A1.13. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves and parameters (right) of *Aristeus antennatus* obtained for *all hauls* approach, for 40- and 50mm square mesh codends.

A1.14. *Aristeus antennatus* approach for *recruitment season*

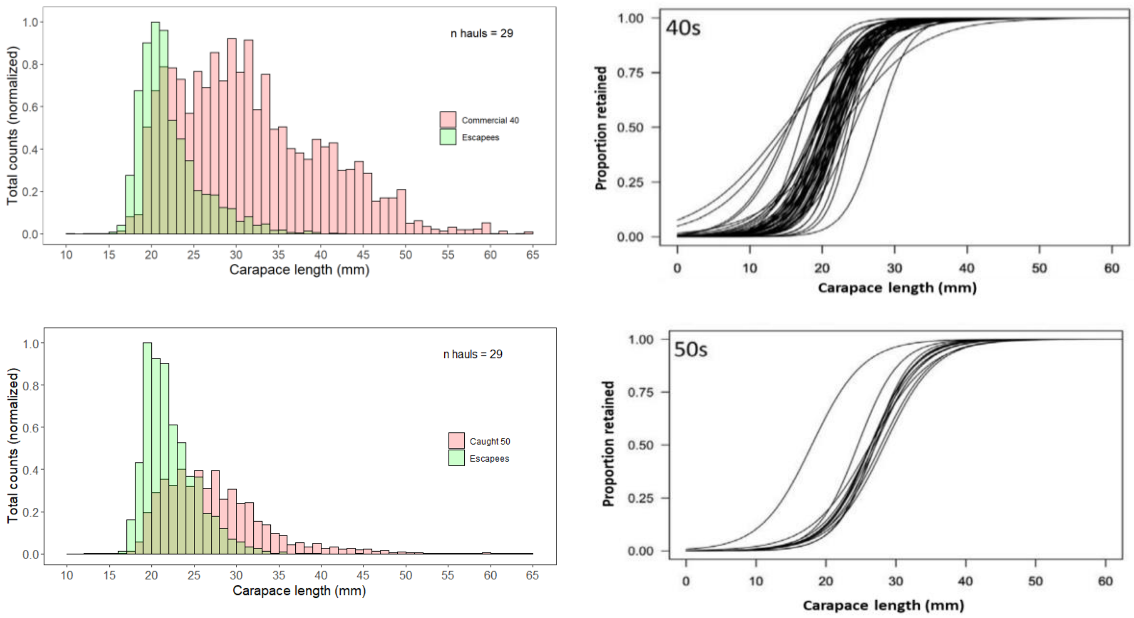

Figure A1.14. Size frequencies of commercial catches, discards and escaped individuals (left) and selectivity curves from Gorelli et al (2017) (right) of *Aristeus antennatus* obtained for *recruitment season* approach, for 40- and 50mm square mesh codends.

ANNEX 2: GSA6 landings and incomes by species and fleets

Table A2.1. The twenty most important species in GSA6 bottom trawls landings. Species are ordered based on its importance in annual mean of landed weight for the reference period (2016-2019).

Species	Tn	%	Accumulated %
Merluccius merluccius	1 951.5	10.5	10.5
Mullus barbatus	1 132.5	6.1	16.6
Squilla mantis	810.4	4.4	21.0
Parapenaeus longirostris	745.1	4.0	25.0
Octopus vulgaris	737.0	4.0	29.0
Illex coindetii	729.4	3.9	32.9
Pagellus erythrinus	708.3	3.8	36.7
Trachurus trachurus	703.0	3.8	40.5
Aristeus antennatus	641.1	3.5	44.0
Eledone cirrhosa	634.2	3.4	47.4
Micromesistius poutassou	597.6	3.2	50.6
Lophius piscatorius	570.3	3.1	53.7
Trisopterus capelanus	546.8	3.0	56.6
Mullus spp.	387.5	2.1	58.7
Phycis blennoides	385.9	2.1	60.8
Sepia officinalis	361.4	2.0	62.8
Citharus linguatula	351.7	1.9	64.6
Nephrops norvegicus	339.2	1.8	66.5
Sparus aurata	324.4	1.8	68.2
Trachurus spp.	294.8	1.6	69.8
Remaining species	5 602.0	30.2	100.0

Table A2.2. The twenty most important species in GSA6 bottom trawls landings. Species are ordered based on its importance in annual mean of economic yields for the reference period (2016-2019).

Species	K€	%	Accumulated %
Aristeus antennatus	23 344.3	19.9	19.9
Merluccius merluccius	13 103.3	11.2	31.0
Parapenaeus longirostris	10 207.9	8.7	39.7
Nephrops norvegicus	8 140.1	6.9	46.6
Mullus barbatus	5 590.4	4.8	51.4
Octopus vulgaris	4 860.0	4.1	55.5
Lophius piscatorius	3 766.5	3.2	58.7
Squilla mantis	3 444.6	2.9	61.7
Sepia officinalis	2 917.5	2.5	64.1
Eledone cirrhosa	2 596.8	2.2	66.3
Illex coindetii	2 221.3	1.9	68.2
Mullus spp.	2 126.2	1.8	70.0
Citharus linguatula	1 938.3	1.7	71.7
Micromesistius poutassou	1 693.8	1.4	73.1
Loligo vulgaris	1 508.1	1.3	74.4
Sparus aurata	1 409.1	1.2	75.6
Penaeus kerathurus	1 369.3	1.2	76.8
Pagellus erythrinus	1 195.3	1.0	77.8
Loligo spp.	1 187.5	1.0	78.8
Trisopterus capelanus	1 181.9	1.0	79.8
Remaining species	23 729.1	20.2	100.0

Table A2.3. The twenty most important species in GSA6 global fleet landings. Species are ordered based on its importance in annual mean of landed weight for the reference period (2016-2019).

Species	Tn	%	Accumulated %
Engraulis encrasicolus	17 651.5	32.9	32.9
Sardina pilchardus	8 073.8	15.0	47.9
Merluccius merluccius	2 063.1	3.8	51.8
Sardinella aurita	1 853.8	3.5	55.2
Octopus vulgaris	1 421.4	2.7	57.9
Mullus barbatus	1 212.3	2.3	60.1
Pagellus erythrinus	906.0	1.7	61.8
Trachurus trachurus	901.7	1.7	63.5
Sparus aurata	840.5	1.6	65.1
Squilla mantis	834.8	1.6	66.6
Parapenaeus longirostris	745.5	1.4	68.0
Illex coindetii	738.3	1.4	69.4
Scomber japonicus	663.2	1.2	70.6
Sepia officinalis	655.7	1.2	71.9
Aristeus antennatus	641.6	1.2	73.1
Eledone cirrhosa	636.0	1.2	74.2
Micromesistius poutassou	598.5	1.1	75.4
Lophius piscatorius	587.4	1.1	76.4
Trisopterus capelanus	548.8	1.0	77.5
Mullus spp.	489.4	0.9	78.4
Remaining species	11 604.6	21.6	100.0

Table A2.4. The twenty most important species in GSA6 global fleet landings. Species are ordered based on its importance in annual mean of economic yields for the reference period (2016-2019).

Species	K€	%	Accumulated %
Engraulis encrasicolus	28 516.6	13.9	13.9
Aristeus antennatus	23 365.2	11.4	25.3
Sardina pilchardus	14 600.1	7.1	32.5
Merluccius merluccius	14 092.5	6.9	39.4
Parapenaeus longirostris	10 219.6	5.0	44.3
Octopus vulgaris	9 902.0	4.8	49.2
Nephrops norvegicus	8 165.1	4.0	53.2
Mullus barbatus	6 078.9	3.0	56.1
Sparus aurata	5 820.4	2.8	59.0
Sepia officinalis	5 618.9	2.7	61.7
Lophius piscatorius	3 914.8	1.9	63.6
Squilla mantis	3 565.1	1.7	65.4
Penaeus kerathurus	3 069.4	1.5	66.9
Mullus spp.	2 899.7	1.4	68.3
Xiphias gladius	2 888.5	1.4	69.7
Eledone cirrhosa	2 603.5	1.3	71.0
Pagellus erythrinus	2 303.7	1.1	72.1
Illex coindetii	2 237.6	1.1	73.2
Seriola dumerili	2 043.3	1.0	74.2
Citharus linguatula	1 999.7	1.0	75.2
Remaining species	50 882.2	24.9	100.0