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# Science, Technology, and Society Initiative to Minimize Unwanted Catches in European Fisheries

## WP1. Ecological, technical, social and economic characteristics of discarding fisheries.

## Deliverable 1.7 Ecological, technical, social and economic characteristics of discarding fisheries

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# Ecological, technical, social and economic characteristics of discarding fisheries

## 1. Summary

This report comprises a dissemination public document reporting the ecological, technical, social and economic characteristics of discarding fisheries. It extends on the results presented in the D.1.1 report (Compilation of baseline biological, economic and social data relevant to the CS areas) by focusing on more specific aspects of discarding fisheries such as catch profiles and discarding trends of commercial and sensitive species (annual, seasonal, by depth), as well as fate of major species in relation to size (inked to MLS/MCRS compliance). The source of the data analyzed originates from various national/international projects from the mid 90's, up to the most recent 2015 EU Data Collection Framework data.

It can be easily deduced that South EU fisheries studied herein are quite diverse not only in catches but also in discarding practices. Active gears such as bottom trawlers exhibit significantly higher discards, both in biomass as well as in number of species affected, than set gears. Sensitive taxa, such as invertebrates and elasmobranches are also more vulnerable to active gears. Besides the fishing gear, discarding is directly related to the operational capacity of the vessel, the range of fishing depths, as well as the financial 'strength' of the industry. Finally, compliance to technical measures such as the minimum landings size (MLS, now MCRS: Minimum Conservation Reference Size) is far from optimal, and market demand seems to dictate discarding practices.

## 2. Introduction

The term 'discards' in fisheries refers to the part of the catch returned to the sea, often dead (Catchpole et al., 2013). Reasons for discarding include legal obligations (e.g. minimum landing size, species quota exhausted) or economic incentives (e.g. low or no market value). Ethically they constitute a waste of natural resources; under an ecological standpoint they negatively impact the marine ecosystem. From a managers' perspective, the problem is to meet simultaneously socio-economic and biological objectives; from a fishers' angle it is an extra cost both in labour and money to deal with.

European Union (EU) fisheries are responsible for quite a high level of discarding (Feekings et al., 2012) attributed to unselective fishing techniques, excessive fishing effort, and patchy distribution of species (Johnsen and Eliasen, 2011). The European Commission (EC) has identified the 'discard problem' as a driver of poor economic performance and a significant component of marine ecosystem functioning

(Commission's green paper on the reform of the CFP - COM 2009/163 final). Towards eradicating this problem the reformed Common Fisheries Policy (CFP - EU regulation 1380/2013) introduced the obligation to land all catches. This represents a fundamental shift in the management approach to EU fisheries, switching from landings monitoring to catches monitoring. Furthermore, regionalised decision making becomes a management option.

MINOUW Action aspires to elucidate certain aspects of the discarding fisheries on a case-by-case basis. Some selected Case Study (CS) fisheries are described in the following sections.

# 3. Brief description of the Case Studies

A more detailed description of case studies can be traced in the D.1.1 Report: *Compilation of baseline biological, economic and social data relevant to the CS areas.*

## *Portugal*

### *CS 1.2 Algarve deep-water trawl fishery*

This Portuguese crustacean trawl fishery involves 26 trawlers (20-29 m, 90-150 GRT) plus 5 Spanish licenses under a bilateral agreement. The fleet operates at the edge of the continental shelf and slope in the SW and S of Portuguese continental waters (ICES Div IXa), all year round, at depths higher than 150 m and with a minimum distance of 6 miles from the coast. The main target species are deep-water rose shrimp, *Parapenaeus longirostris*, and Norway lobster, *Nephrops norvegicus*. The amount of by-catch can largely exceed the catch of target species. Tows directed at the deep-water rose shrimp may lead to significant discarding of small-spotted catshark *Scyliorhinus canicula*, conger eel, *Conger conger*, European hake *Merluccius merluccius*, horse mackerel *Trachurus trachurus*, boarfish, *Capros aper*, while those aiming at Norway lobster result in discarding mostly of deepwater fishes, e.g. silvery pout *Gadiculus argenteus*, roughtip grenadier *Nezumia sclerorhynchus*, Mediterranean slimehead *Hoplostetus mediterraneus*. The blue whiting *Micromesistius poutassou* is a ubiquitous species in both discard profiles, but particularly abundant in deeper waters. Discards ratios may vary considerable, ranging from an average minimum of 37% to a maximum of 70%.

### *CS 3.1 Algarve set nets*

<u>Trammel Nets</u>

Fixed nets (trammel nets and gillnets) are widely used in Portugal, second only to longlines in number of licenses. In the Algarve (Southern Portugal), 1443 licenses for fixed nets were issued, with 927 for the “local” category fleet (less than 9 m vessels) and 313 for the larger vessel “coastal” category fleet. Trammel net licenses accounted for approximately 60 and 45% respectively of the fixed net licenses for the local and coastal category fleets. Trammel nets regulations stipulate a maximum length of a set net according to vessel size, ranging from 4,000 m for vessels less than 9 meters to

20,000 m to vessels bigger than 20 meters (Length overall, LOA) and a fixed height of 5 m. Inner panel mesh sizes range from 80 to 99 mm stretched mesh for mixed species métiers targeting cuttlefish (*Sepia officinalis*), sea bass (*Dicentrarchus labrax*), sea breams (*Sparidae*), flatfishes (*Solea* spp.) and rays (*Raja* spp.) to inner mesh sizes greater than 220 mm for angler fish (*Lophius* spp.). Reported average discard rates range from 13% (chub mackerel (*Scomber japonicus*) and sardine (*Sardina pilchardus*) accounting for 58 and 11% of the total fish discards) up to 49%, with 105 discarded species, largely consisting of small pelagics. In experimental selectivity studies, 55 non-commercial discarded invertebrates accounted for almost 65% of the total discards in numbers. Elasmobranches, some with conservation status, constitute a significant part of trammel net catches and discards in Portugal. In addition to by-catch and discards of fish and invertebrates, trammel nets are also responsible for by-catch related mortality of sea birds and marine mammals and reptiles.

## *Spain*

### *CS 1.4 Catalan sea bottom trawl fishery*

Catalonian bottom trawl fleet (256 units in 2014 corresponding to fleet segments OTB1218, OTB1824 and OTB2440) produces 35% of the total landings in weight and 54% of the total landings in value. They exploit over 100 demersal and benthic species of finfish, crustaceans, and molluscs, but the main commercial species in the landings are: European hake (*Merluccius merluccius*), red mullets (*Mullus* spp), blue and red shrimp (*Aristeus antennatus*), Norway lobster (*Nephrops norvegicus*), octopus (*Octopus vulgaris*), anglerfish (*Lophius* spp), blue whiting (*Micromesisteus poutassou*), Sparidae and squids. Two broad bottom trawl fisheries can be differentiated in Catalonia, a continental-shelf fishery targeting hake, red mullets and octopus, and a deepwater fishery targeting the highly prized crustaceans (red shrimp and Norway lobster). All vessels can and do fish along the entire depth range, although smaller trawlers (DTS VL1218) tend to restrict their activity to coastal waters. The management of the trawl fisheries is based on effort control and technical measures such minimum landing size, which are not always observed. It has been reported that discard rates of species subject to the Landings Obligation are high (up to 30% of catches in number) for hake and red mullet during their recruitment season (spring and autumn, respectively). Other regulated species, such as mackerel and horse mackerel, have also very high discard rates year round. Deepwater fisheries targeting crustaceans have comparatively lower discard rates. An important part of the discarded biomass (30-50%) is composed of species of commercial interest (small sized or damaged specimens) and the rest are species with low or no economic value.

## *Italy*

### *CS 1.5 Bottom trawl crustacean fisheries in Sicily (Parapenaeus)*

Deep-water rose shrimp, *Parapenaeus longirostris* (DPS) is the first target species of bottom trawlers operating on the outer continental shelf and upper slope of the south-central Mediterranean in terms of catch (mean landings of 5790 t in 2012-2014) and values of landings (about 30 million € in 2014). The second target species is giant red shrimp (*Aristaeomorpha foliacea*, ARS), caught on the epi- and meso-bathyal fishing grounds with a yield amounting to a mean of 1620 t in 2012-2014 and a value of 24 million € in 2014. The main commercial by-catch of the deep water crustacean fisheries is the European hake, *Merluccius merluccius* (HKE), whose yields amount to a mean of 1440 t in 2012-2014 and a value of 8 million € in 2014. Another important part of the by-catch is represented by deep-water crustaceans, such as Norway lobster, Nephrops norvegicus (355 t and a value of 5 million € in the same period) and blue and red shrimp, *Aristeus antennatus* (95 t and a value of 2 million €). Sicilian (Italy) trawlers between 12 and 24 m LOA targeting deep-water rose shrimp are based in seven harbours along the southern coasts of Sicily. These trawlers operate mainly on short-distance fishing trips, which range from 1 to 2 days at sea, and fishing taking place on the outer shelf and upper slope. In recent years, the dynamic of this fleet component evolved resulting in a shift of fishing grounds to deeper waters. Italian trawlers over 24 m LOA are mostly based in Mazara del Vallo (south-west Sicily), and usually perform longer fishing trips, which may have a duration of up to 4 weeks. These vessels operate offshore, in both Italian and international waters of the south-central Mediterranean Sea at depth generally ranging from 200 to 400 m. Important by-catch species include scorpionfish (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), red Pandora (*Pagellus bogaraveo*), common Pandora (*Pagellus erythrinus*), monkfish (*Lophius* spp.), and horse mackerel (*Trachurus* spp). Depending on the different fishing grounds, discards range between 25 and 40% of the total catch, the main discarded fraction being horse mackerel and greater forkbeard. Undersized hake and deep water rose shrimps may also comprise important discards.

### *CS 1.6 – 1.8 North Ligurian and northern Tyrrhenian Seas bottom trawl fishery*

The trawl fleet operating in GSA09 is characterized by different "métiers" according to the resources exploited. The trawl fleet in the investigated area (2012) consists of 330 boats, with an overall tonnage of approximately 13,000 GT, representing about 70% of the fishing capacity employed in the area. The landings volume produced by trawlers was about 8,000 t featuring a high proportion of fish (58%), molluscs (27%) and crustaceans (15%). The most important species in terms of landings are European hake, red mullets and horned octopus; the crustaceans Norway lobster, deep-water rose shrimp, and red shrimps (giant red shrimp and blue and red shrimp) also play an important role especially in terms of economic value. By catch of deep-sea trawl fisheries in the Ligurian and northern Tyrrhenian Seas accounts for about 80% of the total annual average catch, while the remaining fraction is represented by target species. Even though the exploitation is devoted to the target species, the economic value of the landings is also enhanced by species belonging to the retained by-catch. Furthermore, on many fishing grounds catches are dominated by small sized species and specimens, which form the bulk of the rejected by-catch. The fisheries targeting crustaceans produce a significant amount of discards, representing about 20% of the total catch. Discards of commercial species are mostly constituted by individuals under the minimum landing size. Discards are particularly abundant in cases of low commercial value species, such as blackmouth catshark, *Galeus melastomus*, and greater forkbeard, *Phycis blennoides*.

### *Greece*

#### *CS 1.7. Aegean sea bottom trawl fishery*

The Greek Aegean bottom trawl fishery is multi-specific in its nature and is managed by technical measures such as: (i) a summer closure of 4 months (Jun-Sep), (ii) spatial closures (within a 1.5 mile coastal zone, several closed gulfs) and minimum landing sizes (national & EU). The main target species on which the fishery is based are: European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), striped red mullet (*Mullus surmuletus*), Picarel (*Spicara smaris*), Bogue (*Boops boops*), Anglerfish (*Lophius budegassa*), Deep water rose shrimp (*Parapenaeus longirostris*), Norway lobster (*Nephrops norvegicus*), Caramote prawn (*Melicertus kerathurus*) and European squid (*Loligo vulgaris*). The exploited fishing depths are in the range of 50 and 800 m, however the bulk of effort is exerted in the depth stratum between 100 and 350 m. During the past decade, around 250 vessels were putting forth their effort in the area (excluding Turkish and Italian trawlers visiting the area, the impact of which is currently unknown). Regarding unwanted catches, the main discarded taxa include *Parapenaeus longirostris, Trachurus trachurus, Liocarcinus depurator, Merluccius merluccius, Scyliorhinus canicula, Illex coindetii, Lepidopus caudatus, Gadiculus argenteus argenteus, Sardina pilchardus* and various other invertebrates. Market demand and regulation restrictions (e.g., MLS/MCRS) are dictating discarding; important commercial species may be frequently considered 'unwanted' by the fishers. Total discard rates are rarely below 25% and can go up to 45% in some years/seasons. It has been identified that at least 46 fish, 3 crustaceans and 10 cephalopod species are consistently marketed, in comparison to 82 fish, 52 crustaceans and 8 cephalopod species that are discarded in all cases.

# 4. Methods

The compilation of existing information on CS fisheries was carried out by reviewing past research projects and accessing data-bases resulting from these projects. A detailed description is provided in D.1.1 Report *Compilation of baseline biological, economic and social data relevant to the CS areas.*

It is common ground in all case studies, that moderate to extreme discrepancies were identified in the time series of data. Lack of an uninterrupted flow of research funding in the past has now materialized in knowledge gaps, that are difficult to overcome. These gaps were either in time and space coverage of data or even worst, in some cases valuable data types, such as size compositions are non-existent.

Catch profiles were analyzed as groups of major taxa (fish, cephalopods, crustaceans, other invertebrates) in relation to depth stratum, season, and year. Results were visualized as the contribution in total catch for the marketed and discarded fractions in polar coordinate plots.

Catch trends were assessed through Generalized additive models approaches, modelling the effects of various predictor variables (year, season, depth, longitude, latitude) on the relative abundance (expressed as catch per unit of effort, CPUE) of total and sensitive taxa catch (invertebrates, elasmobranchs). The functional relationships between population density of marine species and environmental variables are neither linear nor monotonic. Assuming an inherent non-linearity, generalized additive models (GAMs; Hastie and Tibshirani, 1990) were applied to identify influential variables, reveal the form of the relationships, and quantify their effect on the relative index of abundance (CPUE). Implementation was done in R v.3.3.2 (R Core Team, 2016) using the package *mgcv* (Wood, 2000, 2006), according to the general formulation:

$$f(E[CUE_i]) = LP_i = c + \sum_m s_m(Z_{mi}),$$

where f is the link function, LP is the linear predictor, c is the intercept, $s_m()$ is the one-dimensional smooth function of covariate $Z_m$, and $Z_{mi}$ is the value of covariate m for the ith observation. The smooth function $s_m()$ was represented using penalized regression splines (cubic splines with basis dimension q= 10), estimated by penalized iterative least squares. Identification of the underlying probability distribution for the errors in the dependent variable (CPUE) was performed using the Akaike information criterion (AIC-Akaike, 1973). After selecting the appropriate error distribution family, an information theoretic approach was followed (Burnham and Anderson, 2002) to discriminate among the best model including the most influential parameters affecting catches. A set of pre-defined candidate models were investigated, and the optimum one was selected on the basis of its GCV score.

For assessing the compliance to MLS, the probability of discarding by size was estimated for certain selected species, characterizing the CS fisheries. Once again through GAMs we modelled the 'fate' of each individual fish (C=Commercial, D=Discarded) in relation to a series of predictor variables (size, year, season, depth). Discarding probabilities were visualized as a logistic curve on a two-dimensional graph with distinctive two-level coloration.

Finally, the operational and economic characteristics of the fleets were linked to discards by regressing various factors (vessel capacity, vessel energy consumption, vessel annual landings value, vessel fishing depth) against the percentage of discards or the total number of species/taxa discarded. The trends were evaluated by a simple linear function and significance was assessed by the super-imposed corresponding standard errors.

# 5. Results & Discussion

## 5.1. Catch Profiles

### *CS 1.7. Aegean Sea bottom trawl fishery*

Fish comprised the majority of discards, being more pronounced within the continental shelf (depths <200m) and around autumn months. On the other hand, marketed species were equibalanced between fish and crustaceans, obviously indicating the high market value of crustaceans in the local markets. Furthermore, discarded fractions were considerably lower for crustaceans compared to fish. Invertebrates were discarded at large.

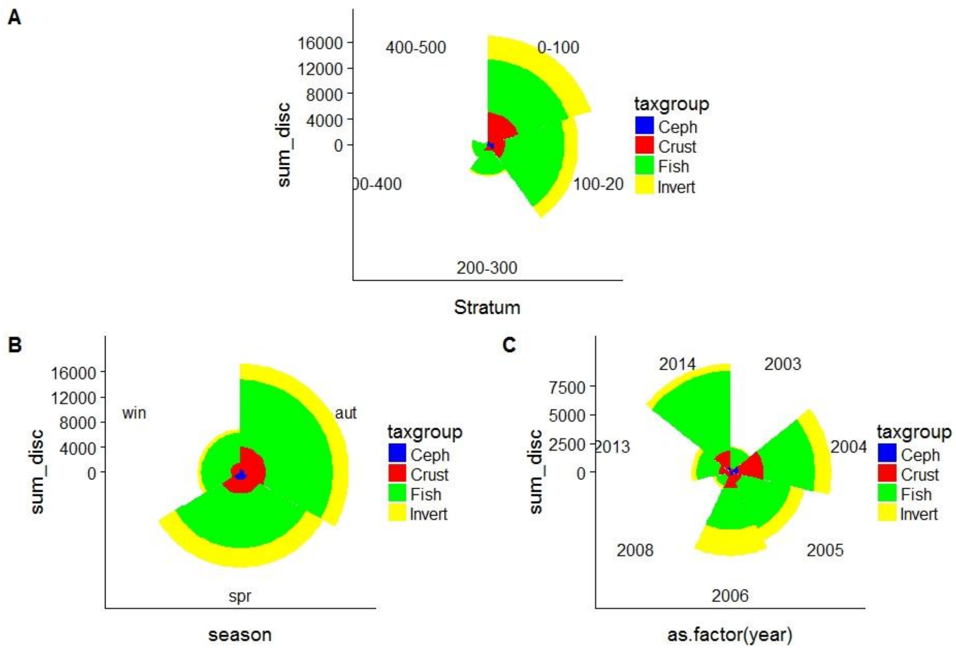



**Fig.5.a.1** Discard profiles of major taxonomic groups by depth stratum, season, and year

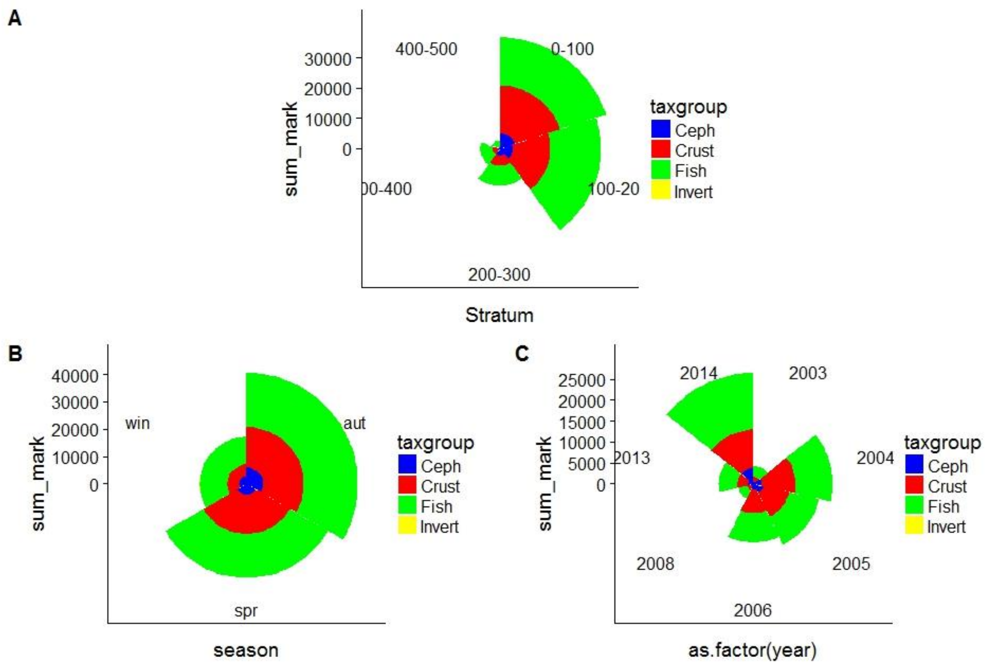
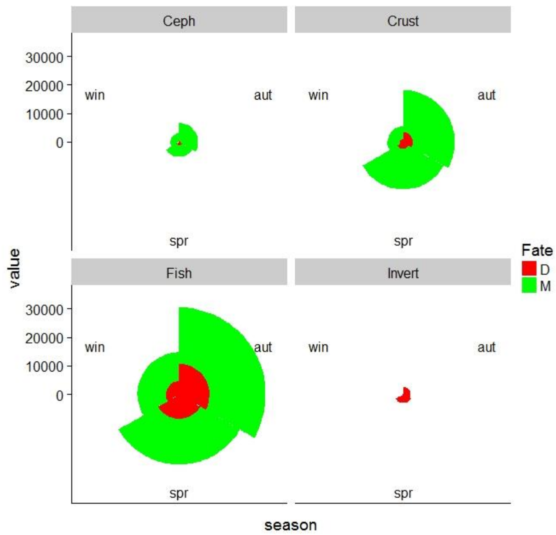
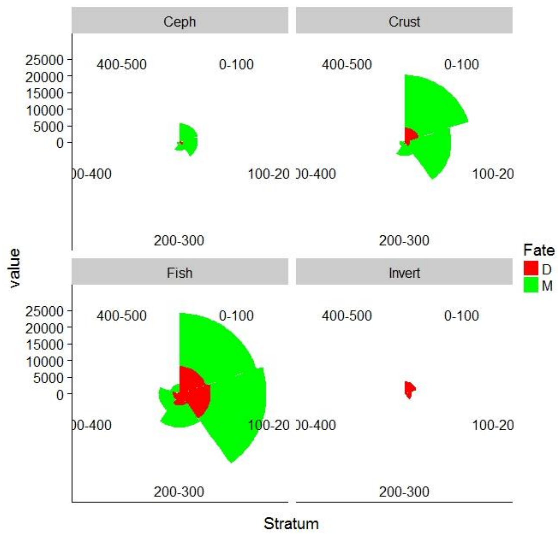



**Fig.5.a.2** Commercial (Marketed) catch profiles of major taxonomic groups by depth stratum, season, and year



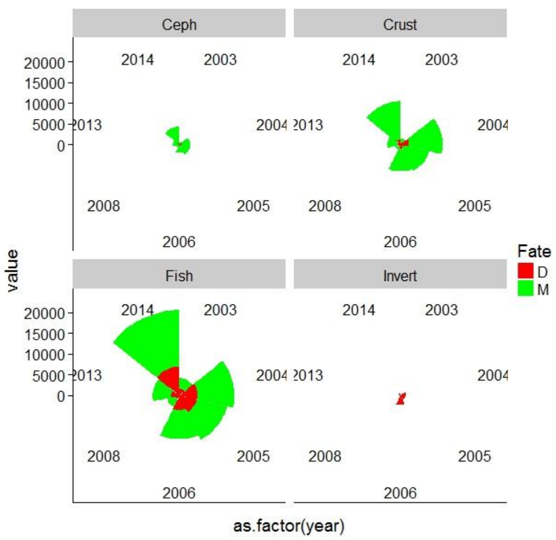




**Fig.5.a.3.** Fate (Discarded-Marketed) of major taxonomic groups by depth stratum, season, and year

### *CS 1.6 – 1.8 Ligurian and northern Tyrrhenian Seas bottom trawl fishery*

Fish dominated both discards and landings, being more pronounced within the continental shelf (depths <200m) and in the summer/autumn months. Marketed species included significant quantities of crustaceans and cephalopods, especially from deeper strata (>300m). Invertebrates were mostly discarded in contrast to crustaceans.

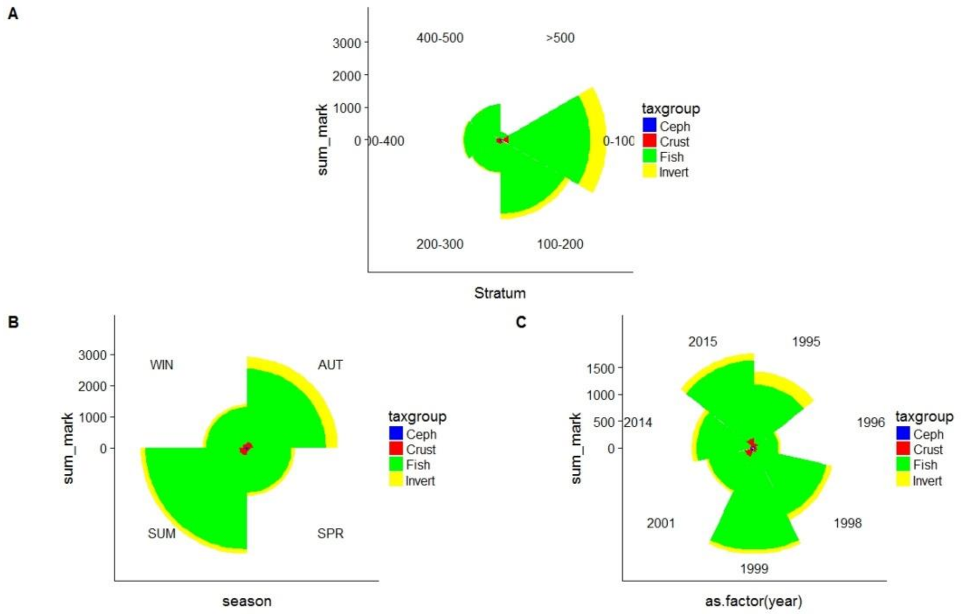



**Fig.5.a.4.** Discard profiles of major taxonomic groups by depth stratum, season, and year

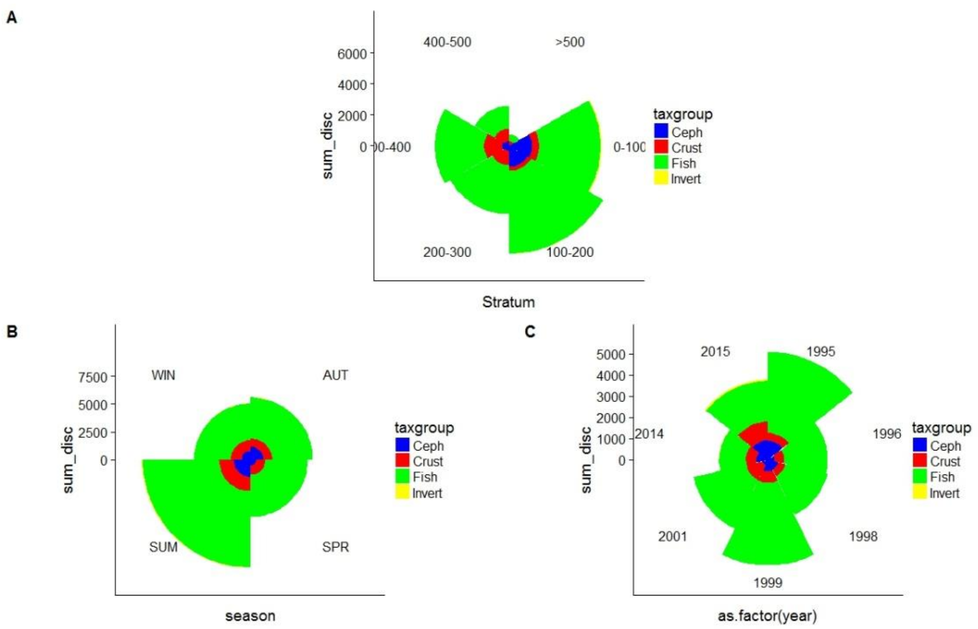



**Fig.5.a.5.** Commercial (Marketed) catch profiles of major taxonomic groups by depth stratum, season, and year

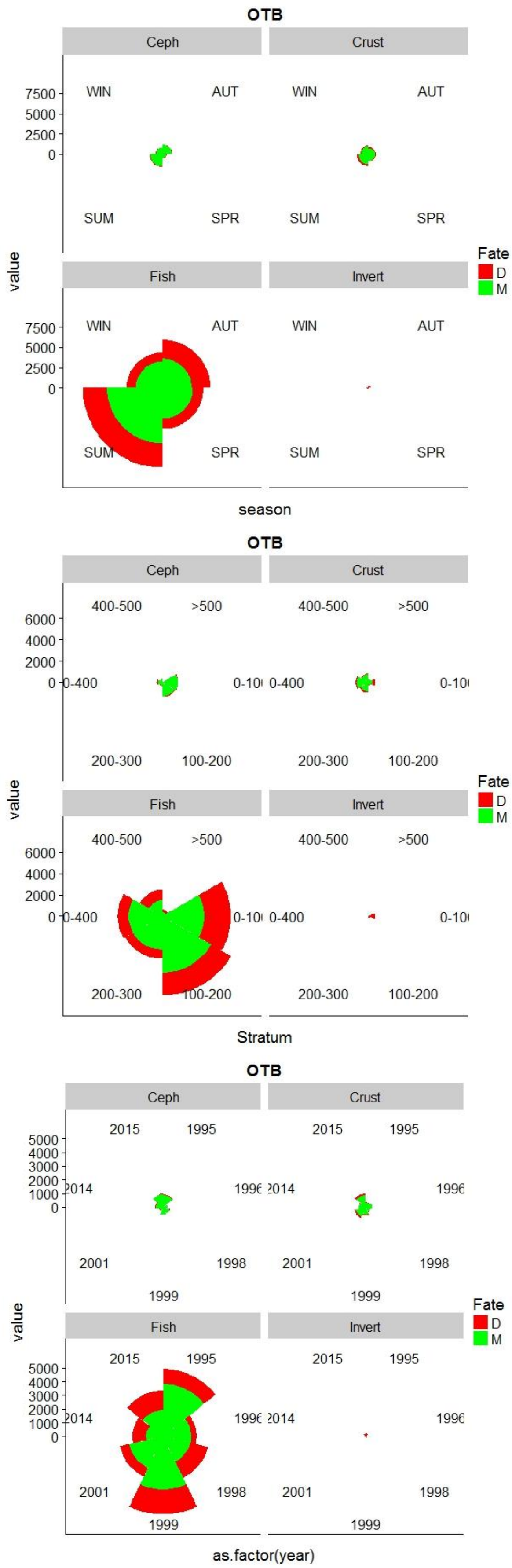



**Fig.5.a.6.** Fate (Discarded-Marketed) of major taxonomic groups by depth stratum, season, and year

### *CS 1.5 Bottom trawl crustacean fisheries in Sicily (Parapenaeus)*

No detailed data by taxon.

### *CS 1.4 Catalan sea bottom trawl fishery*

The lack of detailed info by species limited the analysis of data. Absence of invertebrates in the outputs does not imply that this taxonomic group is not affected by the fishery. As a result, the following visualizations can be considered to depict only partially the discarding status. Fish dominated both discards and landings, being more pronounced within the continental shelf (depths <200m). Marketed species included significant quantities of cephalopods, almost homogeneously divided among seasons.

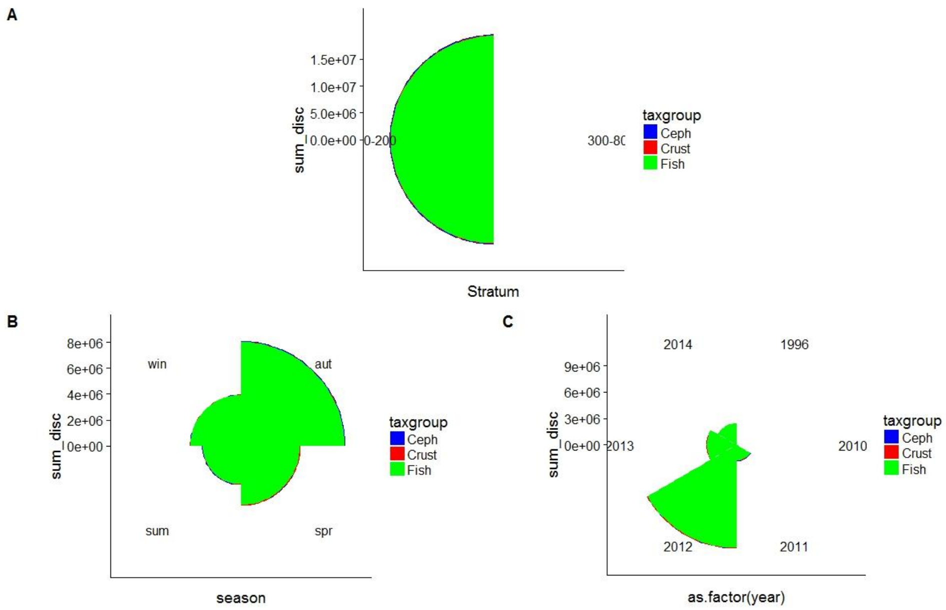



**Fig.5.a.7.** Discard profiles of major taxonomic groups by depth stratum, season, and year

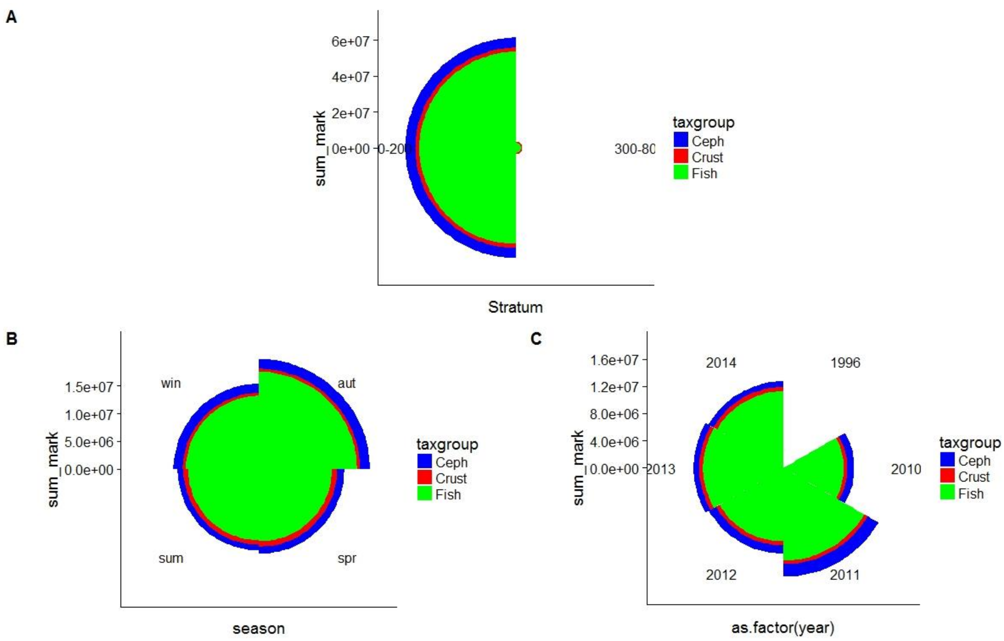



**Fig.5.a.8.** Commercial (Marketed) catch profiles of major taxonomic groups by depth stratum, season, and year

### *CS 1.2 Algarve deep-water trawl fishery*

Although fish drove discarding values, landings were governed by crustaceans. Deep waters comprised the main fishing ground while summer and autumn were the main fishing period. Commercial (Marketed) species included significant quantities of crustaceans and cephalopods, especially from deeper strata (>300m). Invertebrates were insignificant.

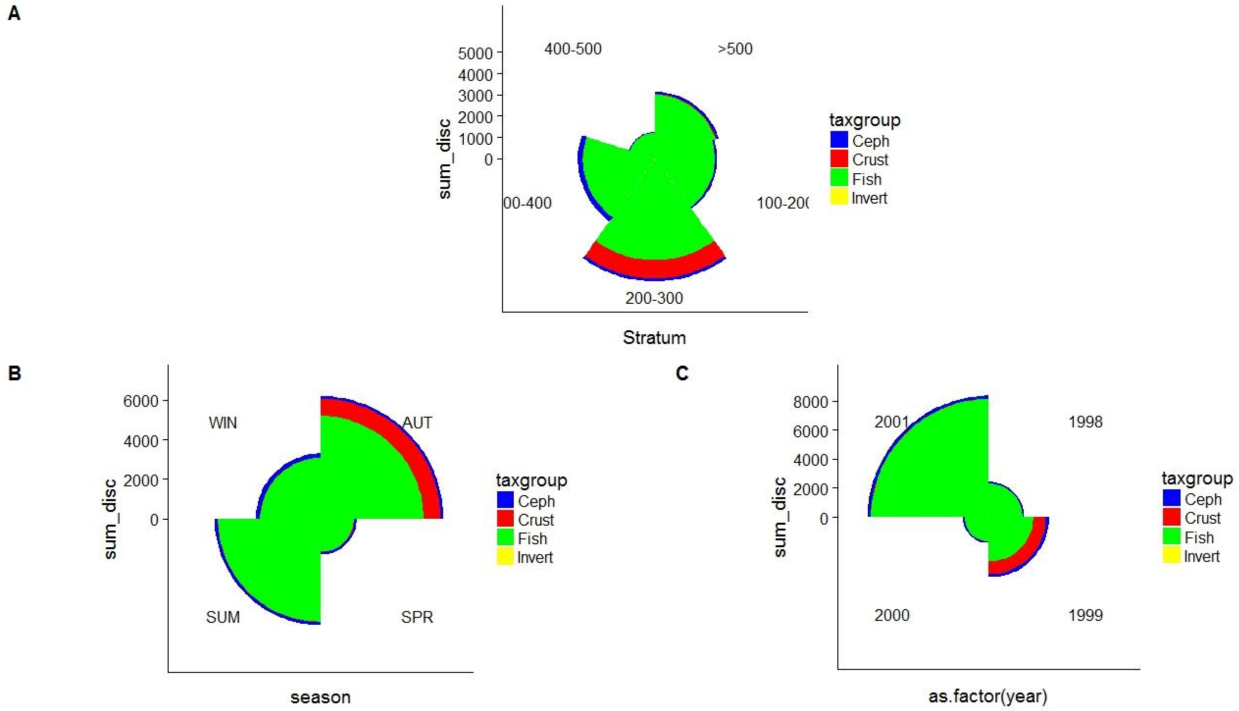



**Fig.5.a.9.** Discard profiles of major taxonomic groups by depth stratum, season, and year

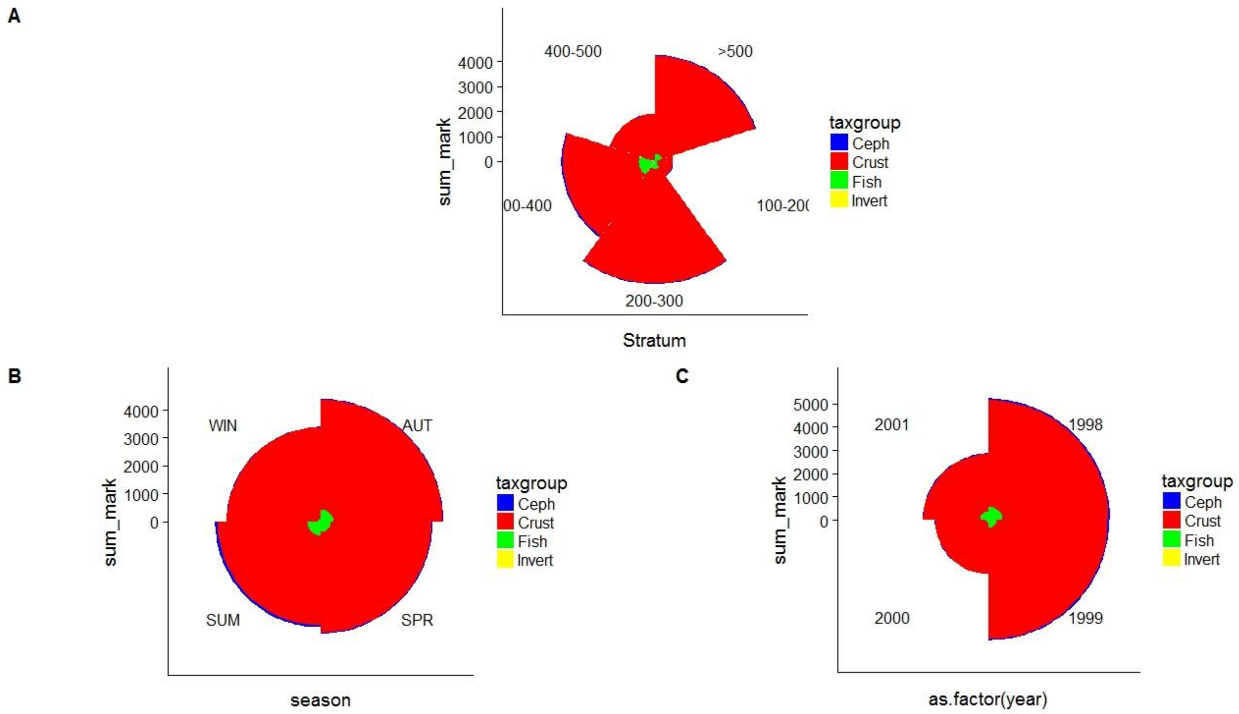



**Fig.5.a.10.** Commercial (Marketed) catch profiles of major taxonomic groups by depth stratum, season, and year

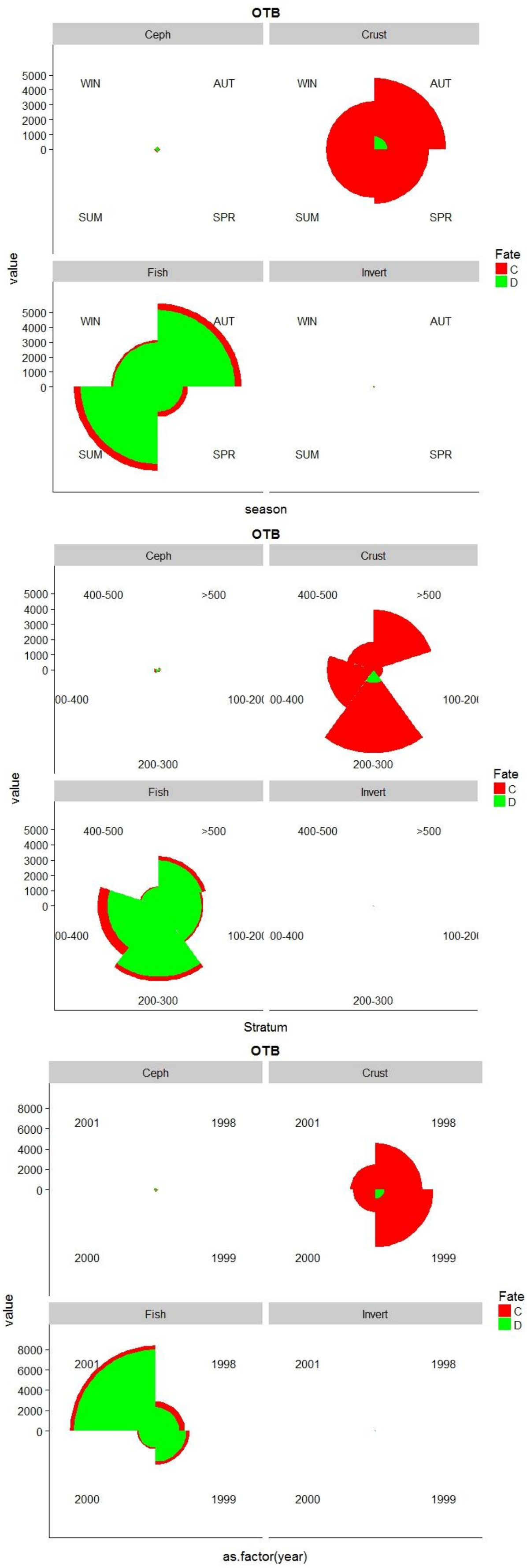



**Fig.5.a.11.** Fate (Discarded-Marketed) of major taxonomic groups by season, depth stratum and year

### *CS 3.1 Algarve set net*

The limited availability of data (only one year) and the restricted fishing grounds (all fishing depths < 80m) does not allow for partitioning discarding behaviour any further. Invertebrates dominated the discards, followed by fish. Marketed species were almost exclusively fish and cephalopods, more pronounced during winter.

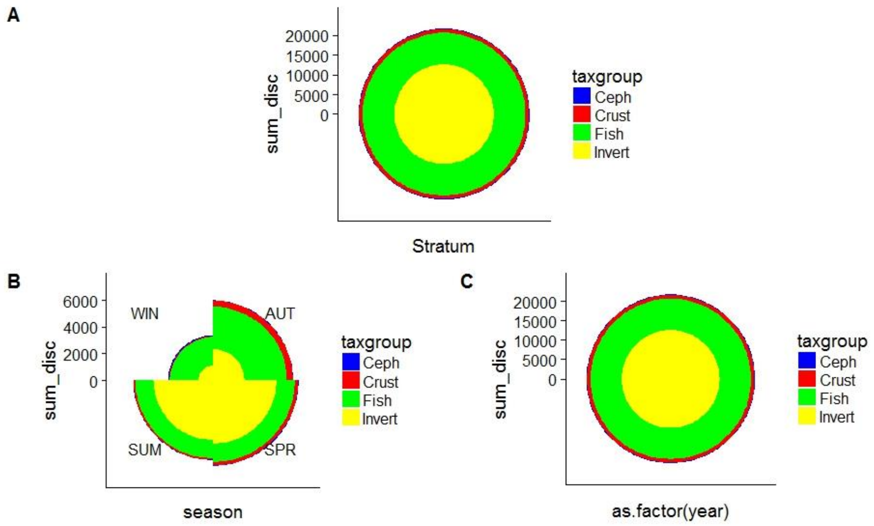



**Fig.5.a.12.** Discard profiles of major taxonomic groups by depth stratum, season, and year

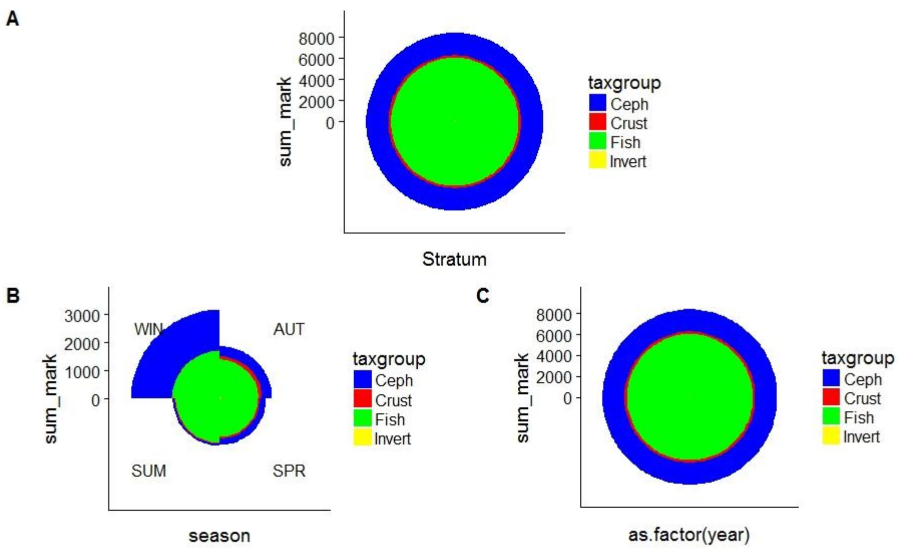



**Fig.5.a.13.** Commercial (Marketed) catch profiles of major taxonomic groups by depth stratum, season, and year

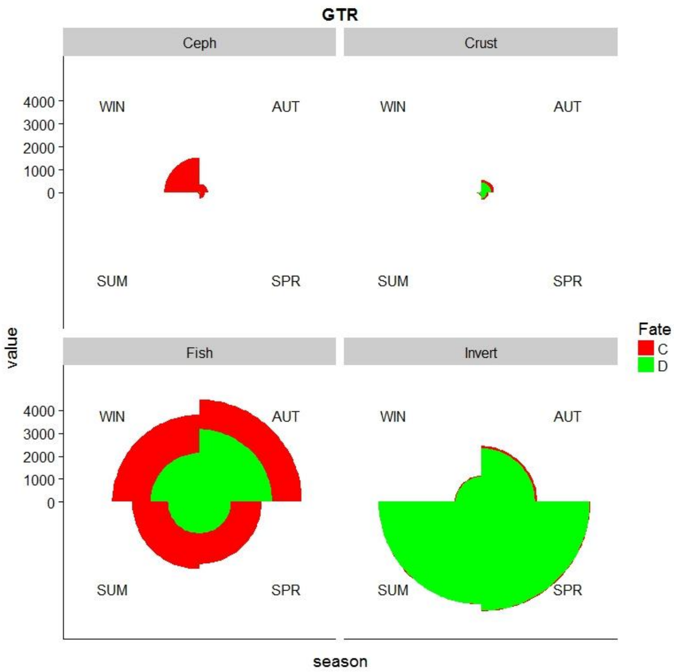



**Fig.5.a.14.** Fate (Discarded-Marketed) of major taxonomic groups by season

## 5.2. Catch trends

### *CS 1.7. Aegean Sea bottom trawl fishery*

**<u>Discards in general</u>**

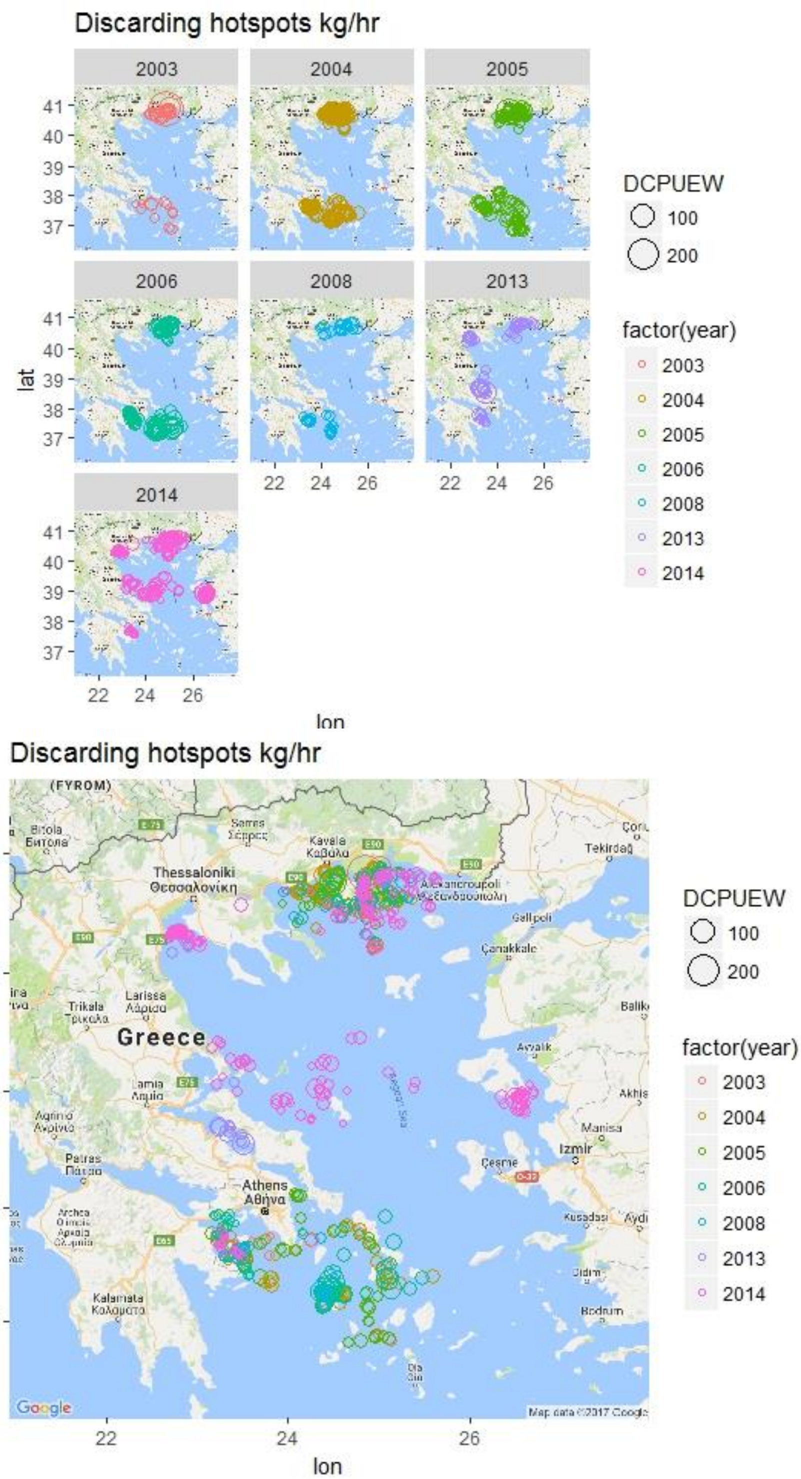



**Fig.5.b.1.** Map of discarding locations for the Greek OTB fleet (annual and total)

Modelling total discards in relation to various driving factors, revealed spatial-temporal differences; higher discards occurred in the north-eastern part of the Aegean Sea, in waters less than 100m. Discarding as a practice was less pronounced during winter and showed a diminishing trend through the years.

Analysis of sensitive taxa, did not uncover any dissimilar trends in comparison to total discards.

## GAM model

```
Family: Gamma
Link function: log
Formula:
DCPUEW + 0.1 ~ as.factor(year) + as.factor(season) + s(depth) +
s(Longitude, k = 4) + s(Latitude, k = 4)

Parametric Terms:
                  df      F  p-value
as.factor(year)    6 13.277 1.86e-14
as.factor(season)  2  5.665  0.00359

Approximate significance of smooth terms:
               edf Ref.df     F  p-value
s(depth)     8.553  8.941  4.61 6.12e-06
s(Longitude) 2.595  2.885 15.27 4.26e-08
s(Latitude)  2.877  2.983  8.29 1.98e-05
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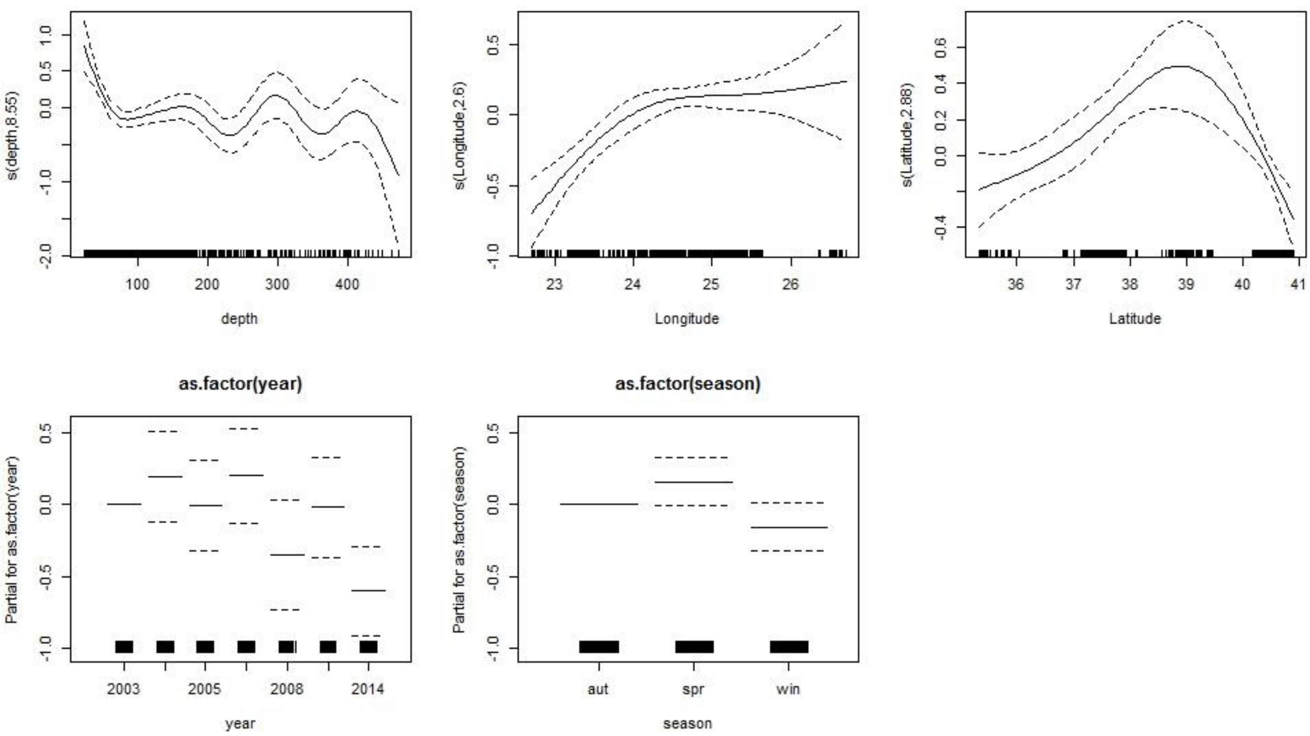



**Fig.5.b.2.** Generalized additive models (GAM) derived effects of various parameters on the discard probability of the catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## Discard trends of sensitive taxa

### Invertebrates

### GAM model

```
Family: Gamma
Link function: log

Formula:
Disc    +    0.1    ~    as.factor(year)    +    as.factor(month)    +
as.factor(season) +
    s(depth)

Parametric Terms:
                  df      F  p-value
as.factor(year)    6 10.266 7.81e-11
as.factor(month)   5  9.268 1.64e-08
as.factor(season)  1  0.006    0.941

Approximate significance of smooth terms:
           edf Ref.df     F p-value
s(depth) 1.630  2.031 2.375  0.0937
```

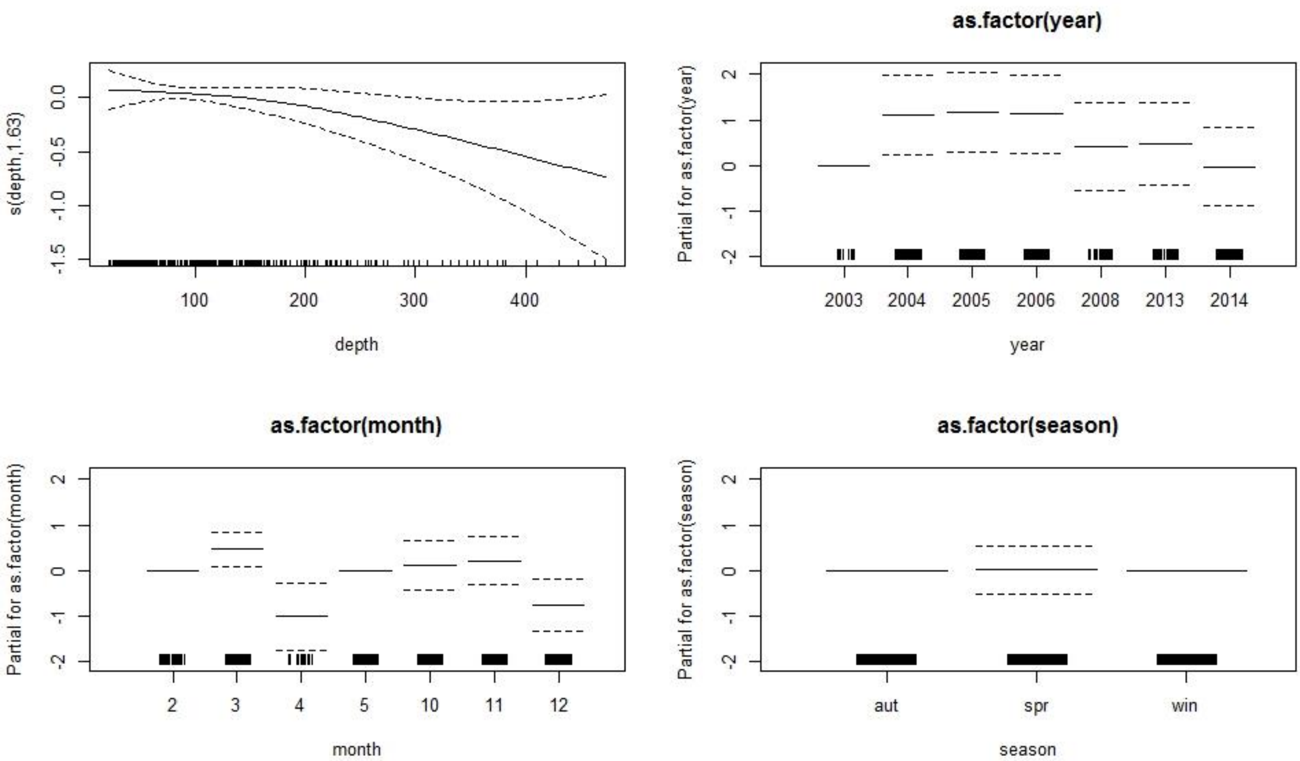



**Fig.5.b.3.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the invertebrate catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## Elasmobranches

### GAM model

```
Family: Gamma
Link function: log

Formula:
DCPUEW  +  0.1  ~  as.factor(year)  +  as.factor(season)  +
s(depth)

Parametric Terms:
                   df      F p-value
as.factor(year)     6 15.247  <2e-16
as.factor(season)   2  1.455   0.234

Approximate significance of smooth terms:
           edf Ref.df     F  p-value
s(depth) 8.645  8.964 4.999 1.71e-06
```

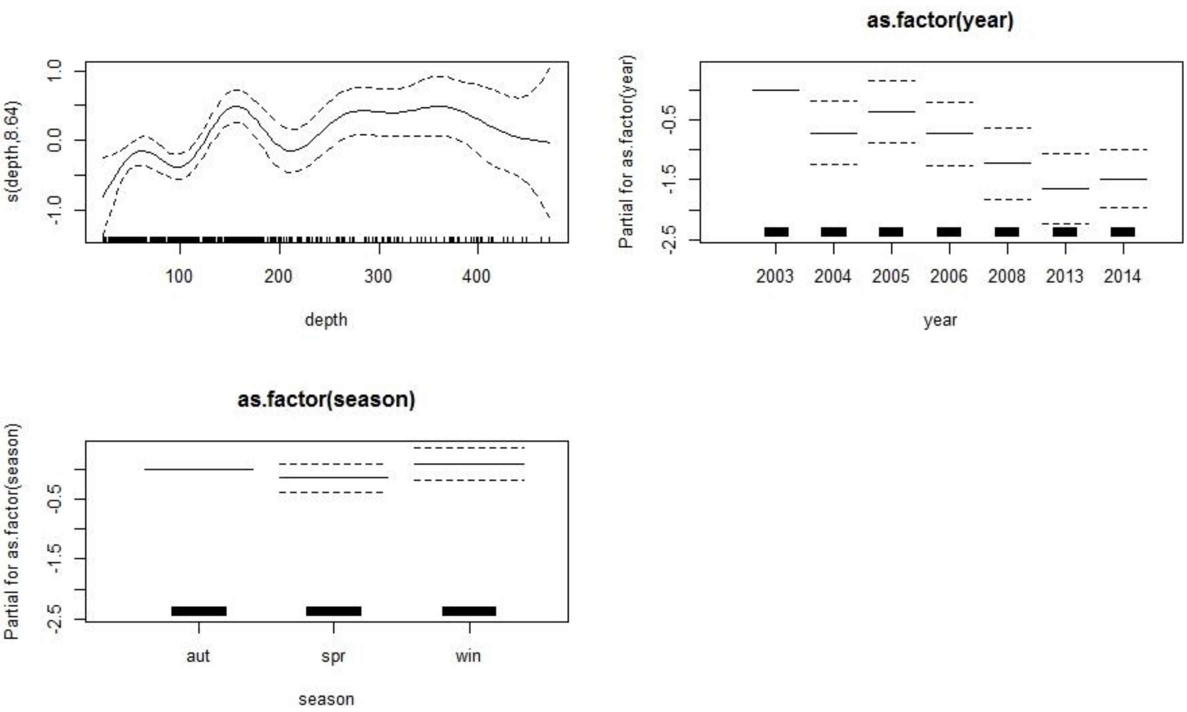



**Fig.5.b.4.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the elasmobranch catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## *CS 1.6 – 1.8 Ligurian and northern Tyrrhenian Seas bottom trawl fishery*

### <u>Discards in general</u>

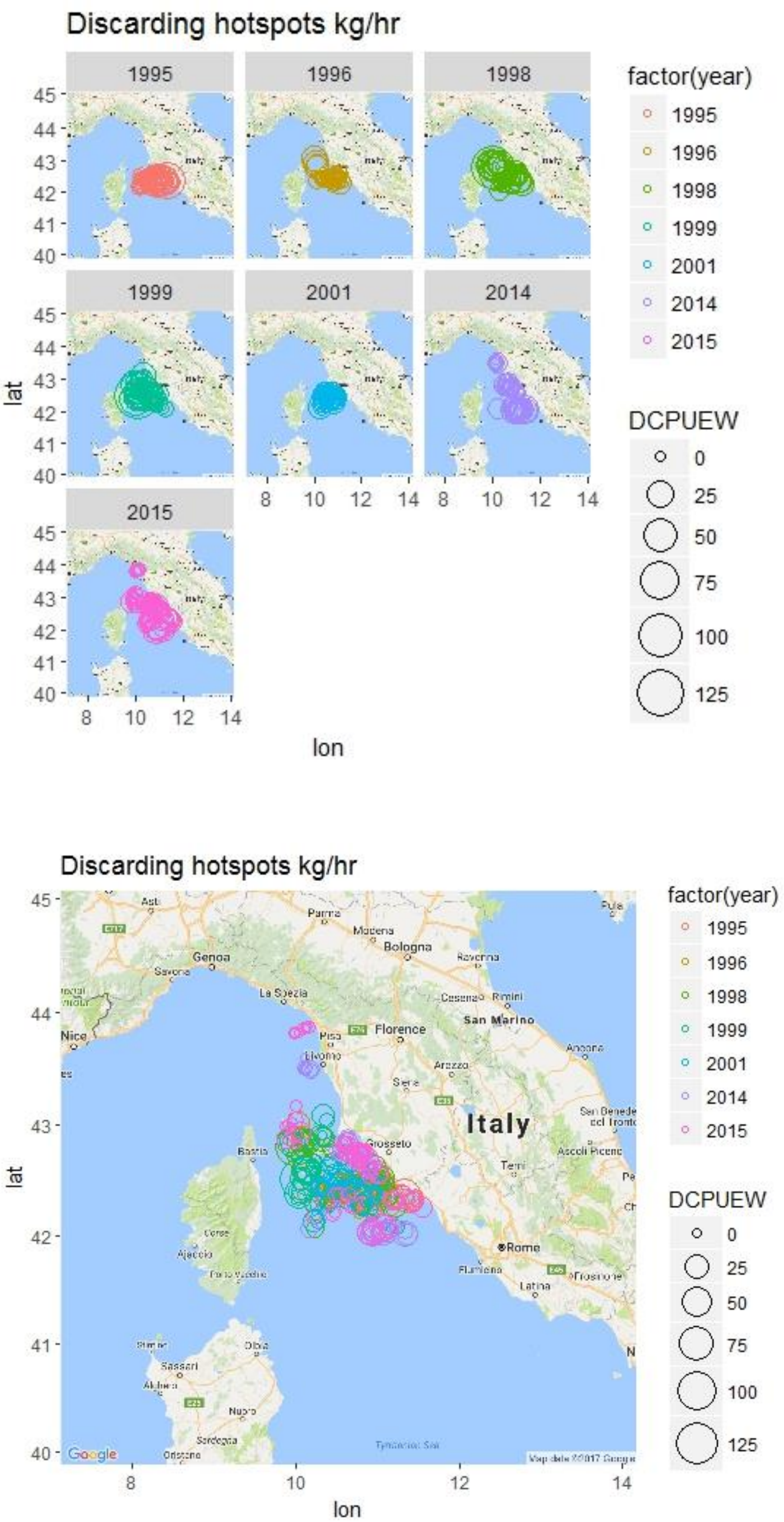



**Fig.5.b.5.** Map of discarding locations for the Italian OTB fleet (annual and total)

Higher discards occurred to the south-west with a fluctuating pattern in relation to depth strata, indicating no extensive discarding within certain depth ranges. No apparent annual or seasonal trend.

Analysis of sensitive taxa, showed that elasmobranches residing in deeper waters were more prone to discarding.

## GAM model

```
Family: Gamma
Link function: log

Formula:
DCPUEW + 0.1 ~ as.factor(year) + as.factor(season) + s(depth) +
    s(Longitude, k = 4) + s(Latitude, k = 4)

Parametric Terms:
                  df     F  p-value
as.factor(year)    5 4.448 0.000642
as.factor(season)  3 1.298 0.275427

Approximate significance of smooth terms:
               edf Ref.df      F  p-value
s(depth)     7.969  8.722  4.767 5.81e-06
s(Longitude) 2.553  2.859 12.425 1.07e-06
s(Latitude)  2.815  2.969 14.581 7.35e-09
```

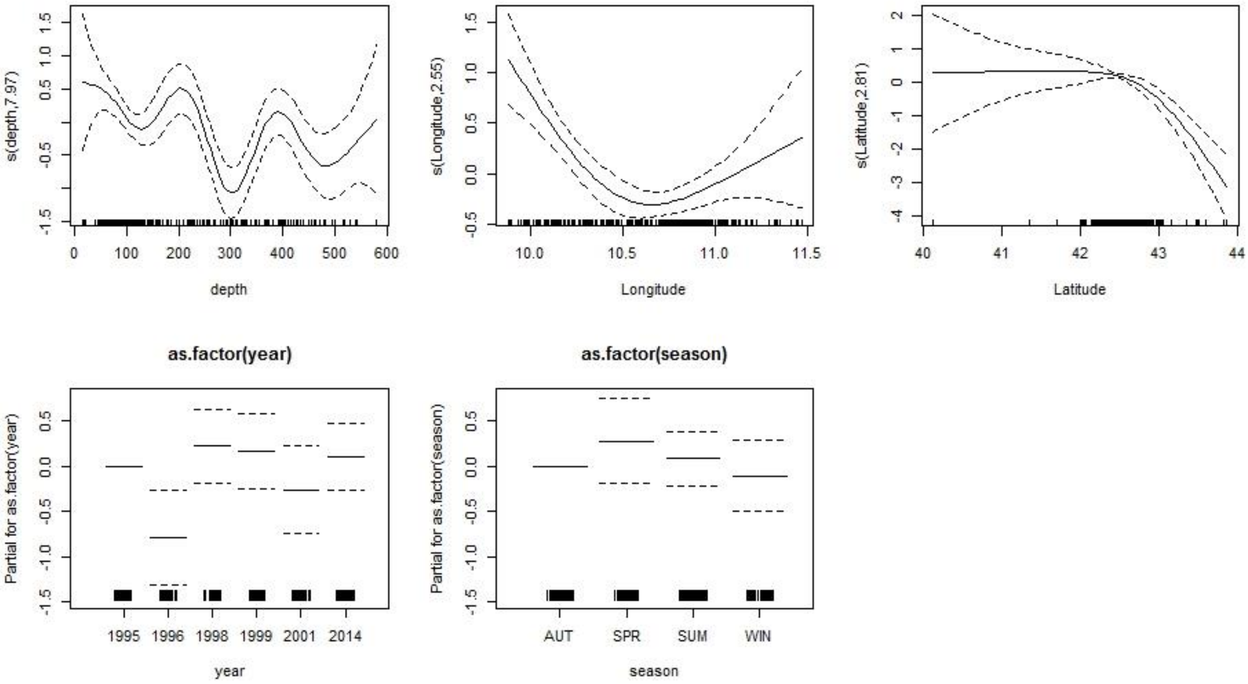



**Fig.5.b.6.** Generalized additive models (GAM) derived effects of various parameters on the discard probability of the catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

# <u>Discard trends of sensitive taxa</u>

## <u>Invertebrates</u>

### GAM model

```
Family: Gamma
Link function: log

Formula:
Disc + 0.1 ~ as.factor(year) + as.factor(month) + as.factor(season)
    + s(depth)

Parametric Terms:
                  df      F  p-value
as.factor(year)    6 17.003  <2e-16
as.factor(month)   8  0.995   0.438
as.factor(season)  3  0.803   0.492


Approximate significance of smooth terms:
           edf Ref.df     F  p-value
s(depth) 8.755  8.983 7.014 6.77e-10
```

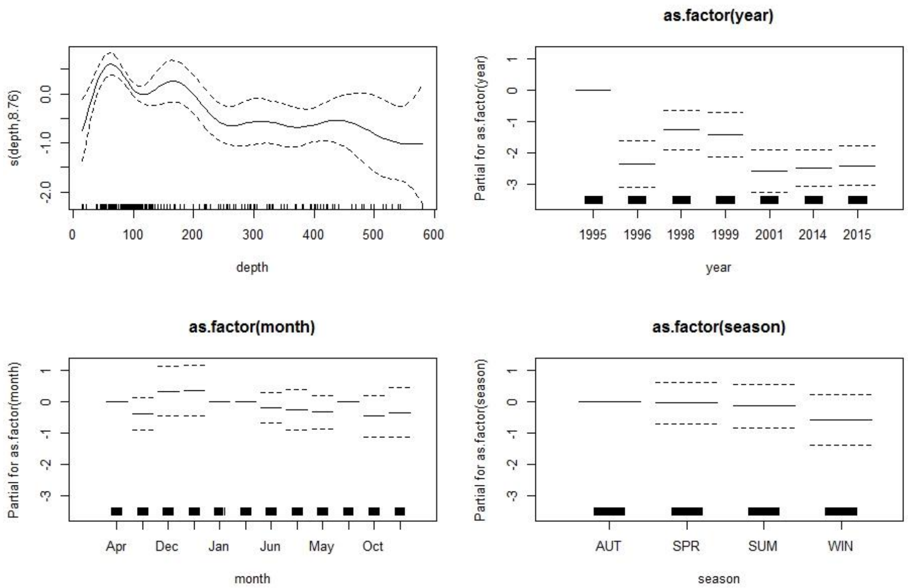



**Fig.5.b.7.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the invertebrates catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## Elasmobranches

### GAM model

```
Family: Gamma
Link function: log

Formula:
Disc    +    0.1    ~    as.factor(year)    +    as.factor(month)    +
as.factor(season) + s(depth)

Parametric Terms:
                   df      F p-value
as.factor(year)     6 12.421 8.7e-13
as.factor(month)    8  0.426   0.906
as.factor(season)   3  0.404   0.751

Approximate significance of smooth terms:
           edf Ref.df     F p-value
s(depth) 5.124  6.245 32.64  <2e-16
```

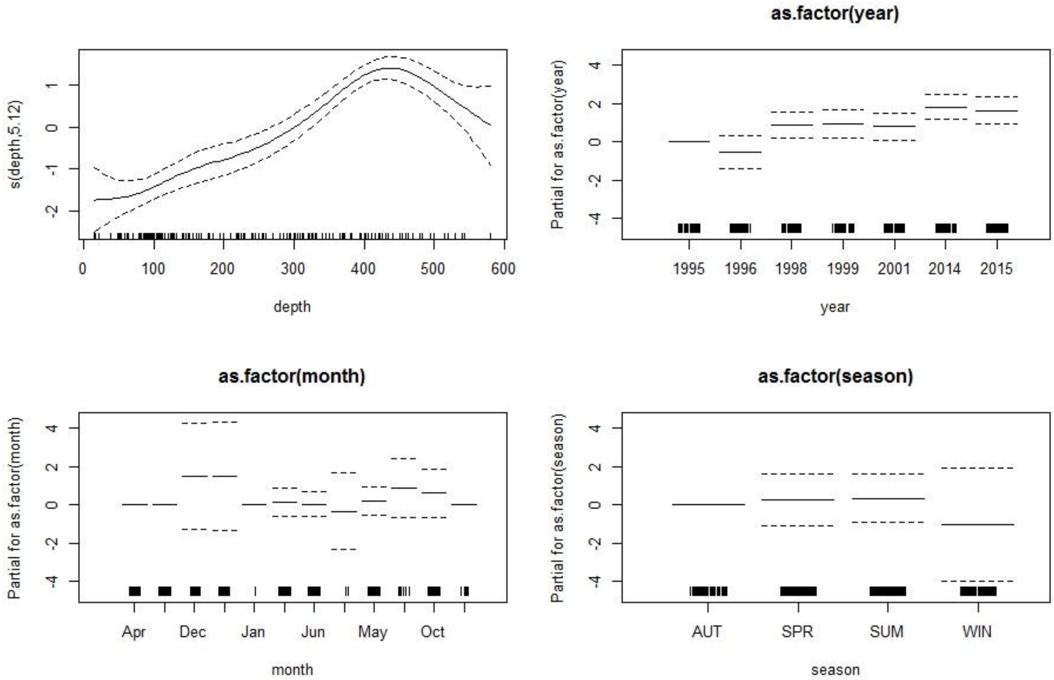



**Fig.5.b.8.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the elasmobranch catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

### *CS 1.5 Bottom trawl crustacean fisheries in Sicily (Parapenaeus)*

## Discards in general

### GAM model

```
Family: Gamma
Link function: log

Formula:
DCPUEW + 0.1 ~ as.factor(year) + as.factor(season) +
as.factor(stratum) + as.factor(gsa)

Parametric Terms:
                   df      F  p-value
as.factor(year)     5  2.412 0.035610
as.factor(season)   4  4.802 0.000843
as.factor(stratum)  6  5.527 1.55e-05
as.factor(gsa)      6 13.949 1.50e-14
```

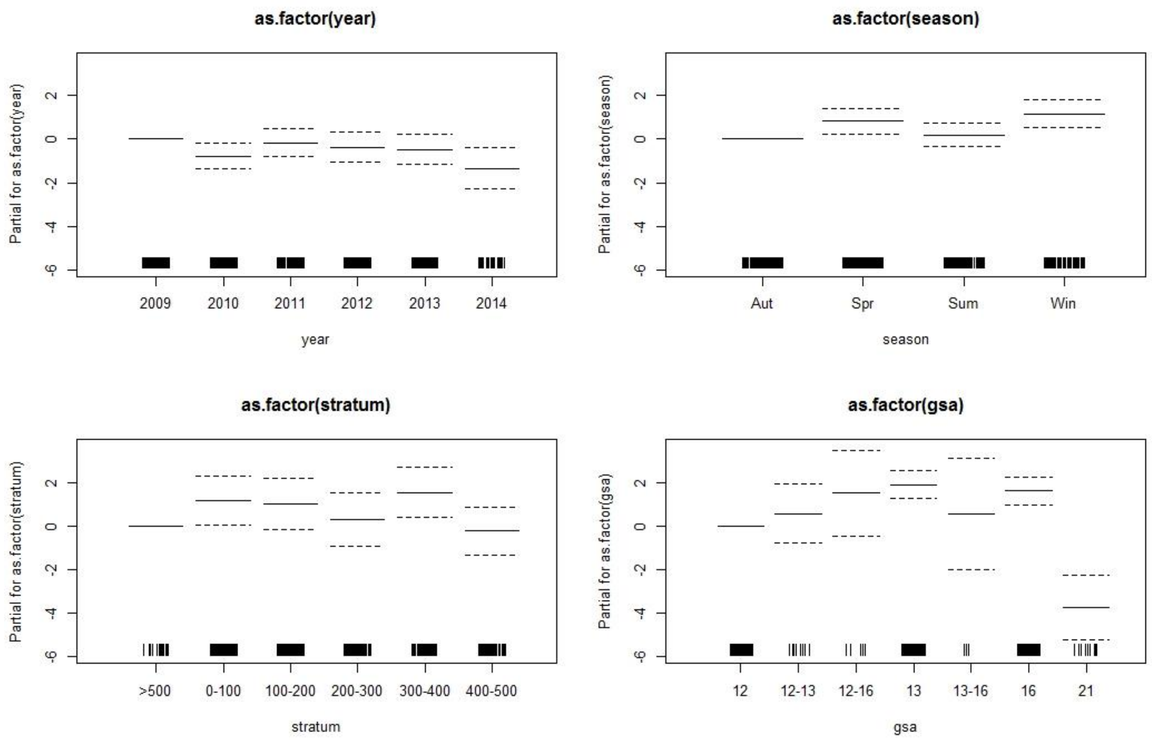



**Fig.5.b.9.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the total discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

Modelling total discards in relation to various driving factors, revealed no apparent trends. The only conspicuous finding was the very low discarding in the fishery conducted at open seas (GSA 21 - South Ionian Sea).

## Discard trends of sensitive taxa

No data available by taxon for sensitive species assessment.

### *CS 1.4 Catalan sea bottom trawl fishery*

**<u>Discards in general</u>**

**GAM model**

```
Family: Gamma
Link function: log

Formula:
DCPUEW   +   0.1   ~   as.factor(year)   +   as.factor(season)   +
as.factor(stratum)

Parametric Terms:
                   df       F  p-value
as.factor(year)     5  40.930 9.38e-13
as.factor(season)   3   1.464    0.243
as.factor(stratum)  1 332.676  < 2e-16
```

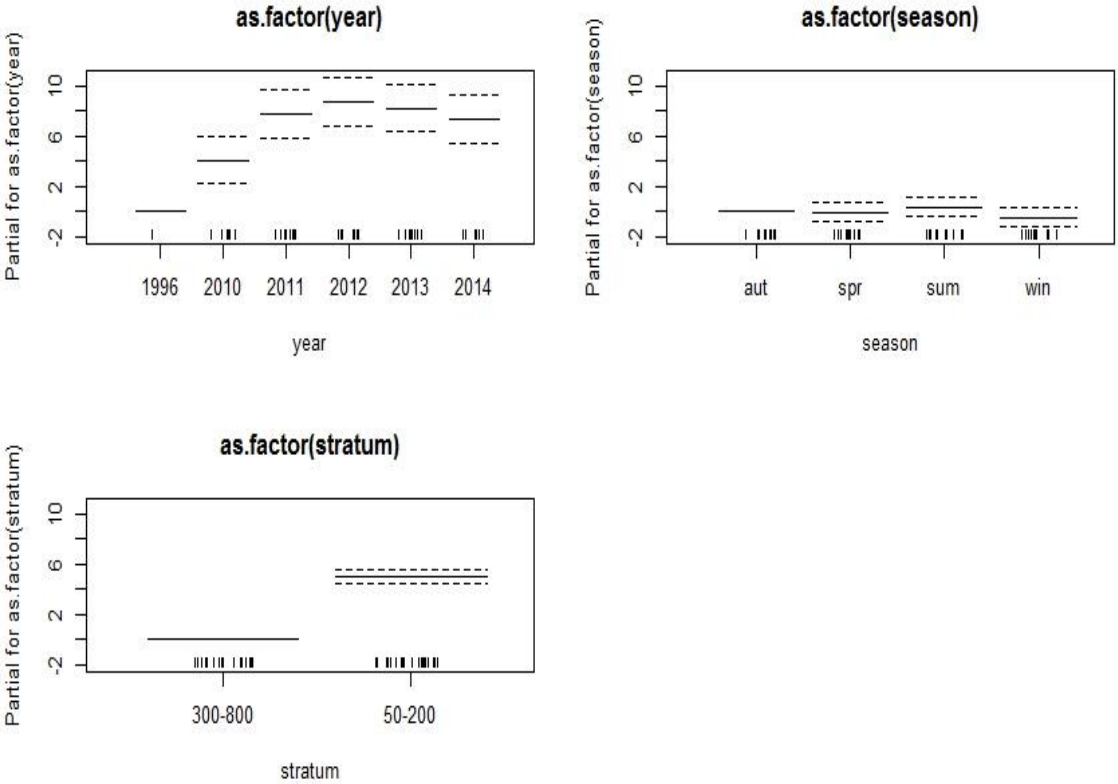



**Fig.5.b.10.** Generalized additive models (GAM) derived effects of various parameters on the discard probability of the catch. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

Two striking outcomes were evident: the increasing annual trend in discarding and the fact that discarding is mostly occurring on the continental shelf (< 200m), where the fleet may exert the larger amount of effort.

Analysis of sensitive taxa, was not possible.

**<u>Discard trends of sensitive taxa</u>**

No such data available.

## *CS 1.2 Algarve deep-water trawl fishery*

### Discards in general

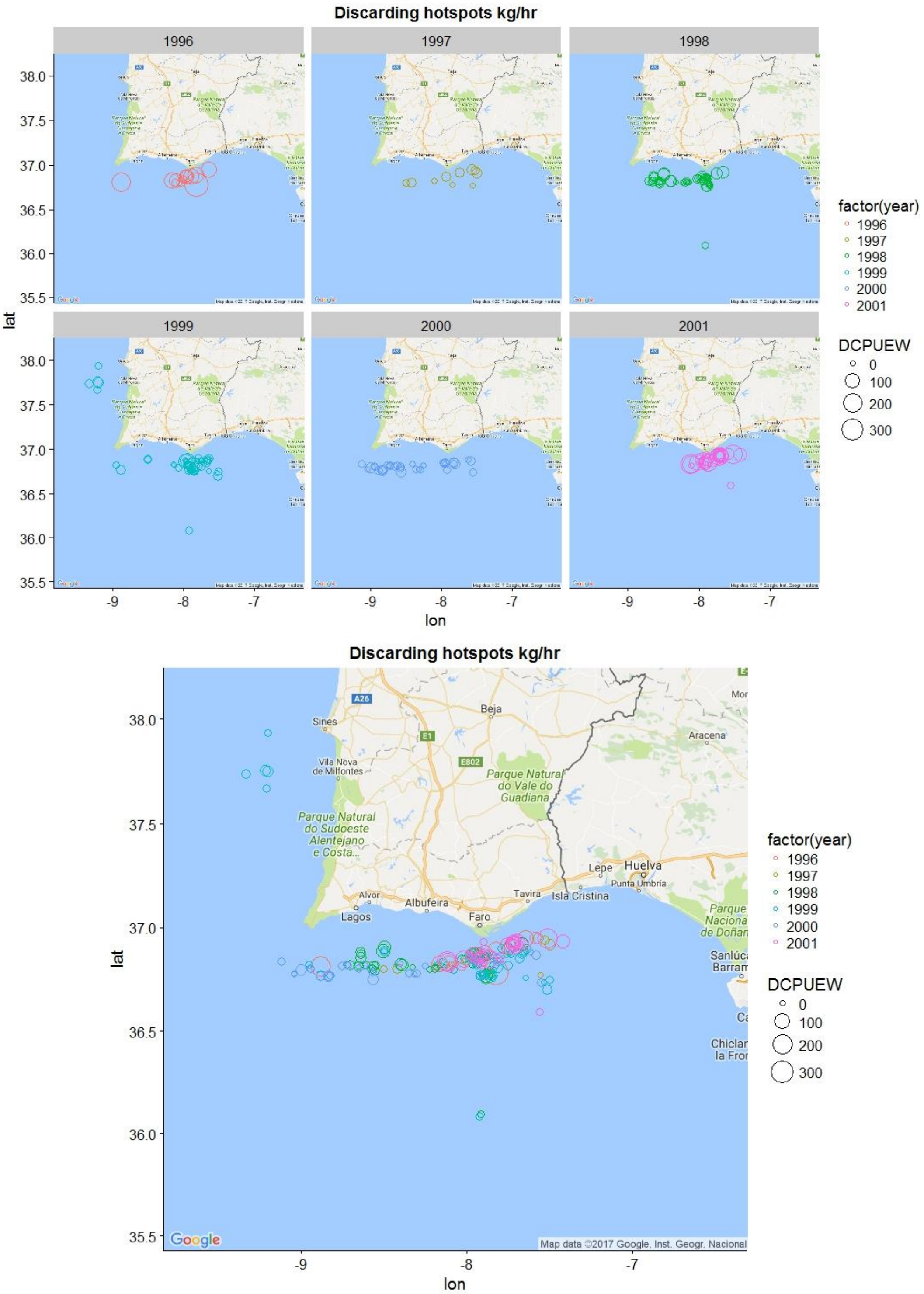



**Fig.5.b.11.** Map of discarding locations for the Algarve OTB fleet (annual and total)

Once again, fishing depth was inversely proportional to discards. No apparent annual or seasonal trend was observed.

Analysis of sensitive taxa, was more revealing: invertebrates were increasingly discarded in the (brief) period studied, and this was more pronounced to the north-east, a fact also true for elasmobranches as well.

## GAM model

```
Family: Gamma
Link function: log

Formula:
DCPUEW + 0.1 ~ s(depth, k = 3) + as.factor(year) +
as.factor(season)

Parametric Terms:
                  df      F  p-value
as.factor(year)    5 14.684 3.45e-12
as.factor(season)  3  3.217    0.024

Approximate significance of smooth terms:
         edf Ref.df     F p-value
s(depth)   1      1 3.856   0.051
```

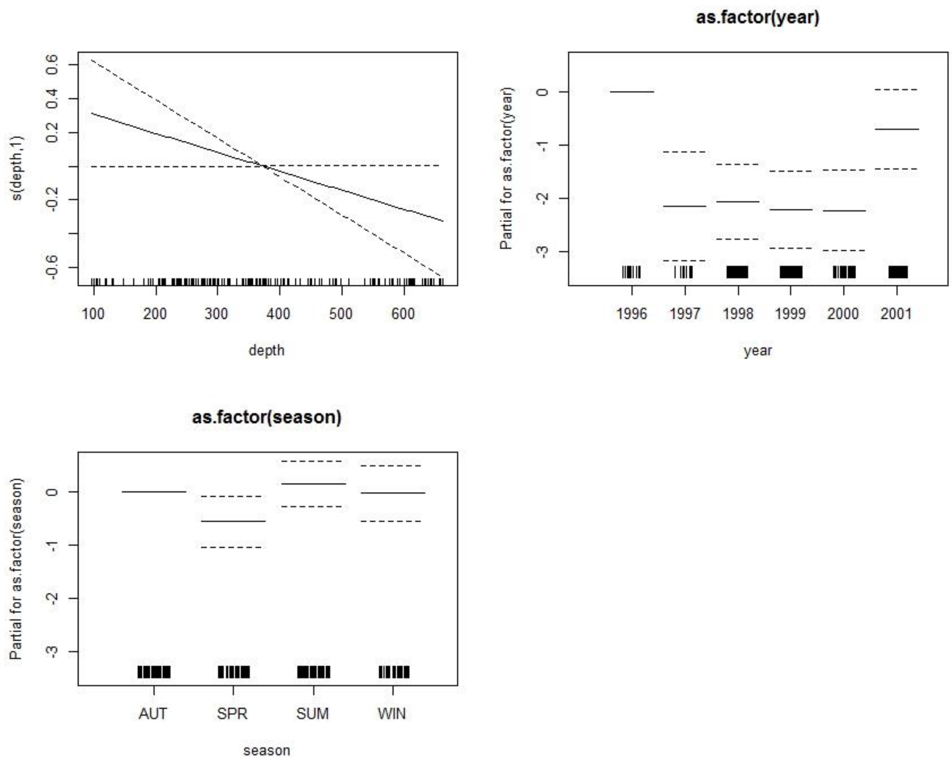



**Fig.5.b.12.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the total discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## Discard trends of sensitive taxa

## Invertebrates

### GAM model

```
Family: Gamma
Link function: log

Formula:
DCPUEW + 0.1 ~ as.factor(year) + as.factor(season) + s(lat, k =
4) +   s(lon, k = 4) + as.factor(Stratum)

Parametric Terms:
                   df      F  p-value
as.factor(year)     3 11.102 2.10e-06
as.factor(season)   3 12.759 3.43e-07
as.factor(Stratum)  4  0.669    0.615

Approximate significance of smooth terms:
       edf Ref.df       F p-value
s(lat)   1      1   0.351   0.555
s(lon)   1      1 103.785  <2e-16
```

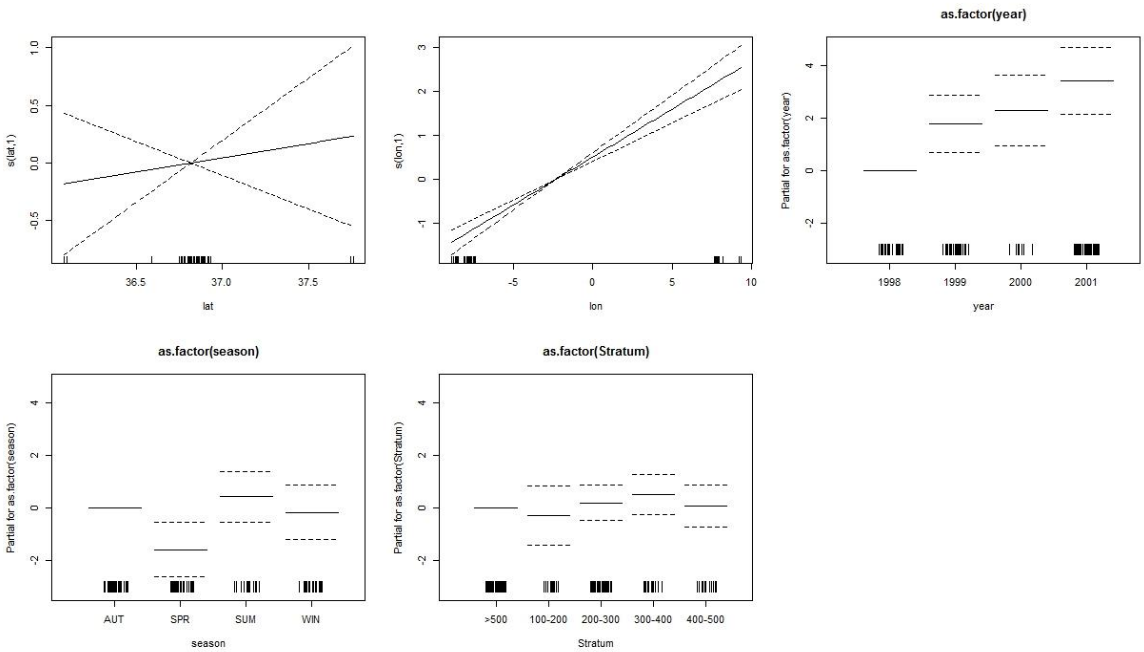



**Fig.5.b.13.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the invertebrate discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## Elasmobranches

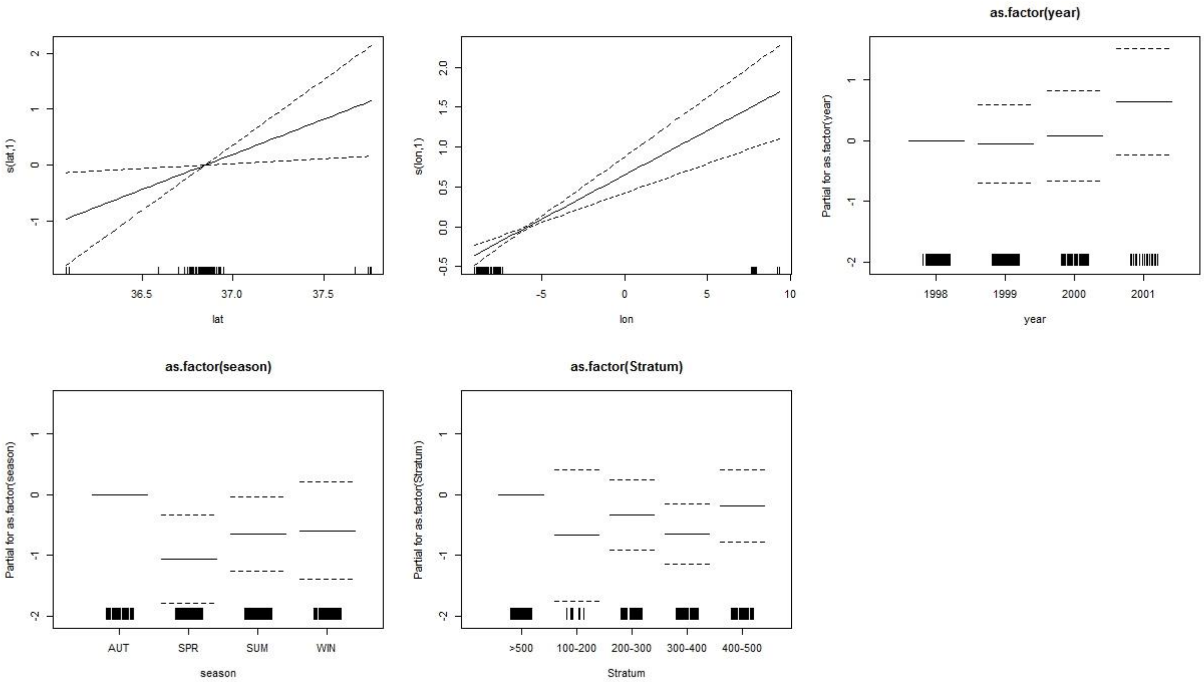
### GAM model

```
Family: Gamma
Link function: log

Formula:
DCPUEW + 0.1 ~ as.factor(year) + as.factor(season) + s(lat, k =
4) + s(lon, k = 4) + as.factor(Stratum)

Parametric Terms:
                   df     F p-value
as.factor(year)     3 1.429  0.2341
as.factor(season)   3 3.249  0.0220
as.factor(Stratum)  4 2.028  0.0902

Approximate significance of smooth terms:
          edf Ref.df      F  p-value
s(lat) 1.000  1.000  5.392   0.0208
```




```
s(lon) 1.000  1.001 33.673 1.43e-08
```

**Fig.5.b.14.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the elasmobranch discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

### *CS 3.1 Algarve set nets*

**<u>Discards in general</u>**

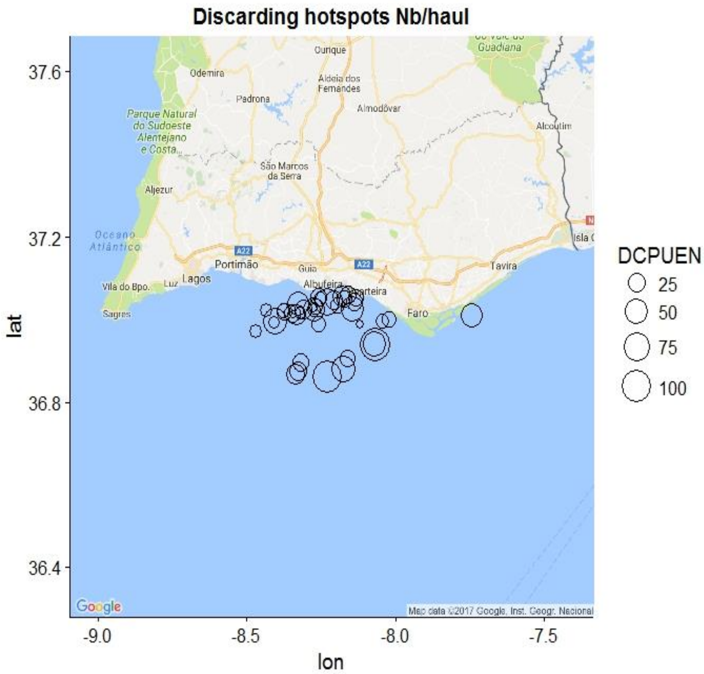



**Fig.5.b.15.** Map of discarding locations for the Algarve small coastal fleet.

The analyses did not provide any clear indications on the discarding practices. Most variables investigated were not significant and had very low contribution to the total variance explained by the model. As a result, no safe conclusions can be drawn.

### GAM model

```
Family: Gamma
Link function: log
Formula: DCPUEN + 0.1 ~ s(depth, k = 5) + as.factor(season)
Parametric Terms:
                  df     F p-value
as.factor(season)  3 6.142 0.00181
Approximate significance of smooth terms:
         edf Ref.df     F p-value
s(depth)   1      1 0.063   0.804
```

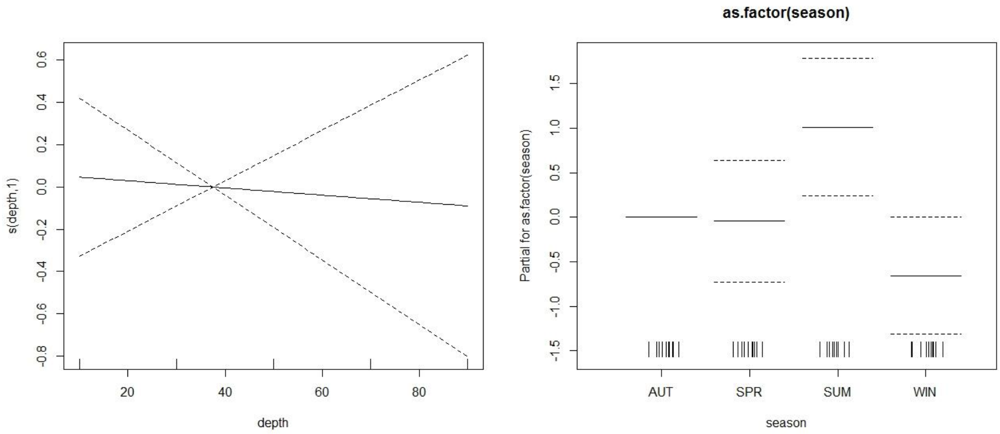



**Fig.5.b.16.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the total discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

## Discard trends of sensitive taxa

## Invertebrates

### GAM model

```
Family: Gamma
Link function: log

Formula:
DiscN + 0.1 ~ as.factor(season) + s(lat, k = 4) + s(lon, k = 4)
+
    s(depth, k = 4)

Parametric Terms:
                  df     F p-value
as.factor(season)  3 4.015 0.00783

Approximate significance of smooth terms:
           edf Ref.df     F p-value
s(lat)   2.716  2.936 0.872   0.437
s(lon)   2.642  2.898 1.191   0.230
s(depth) 1.000  1.001 1.446   0.230
```

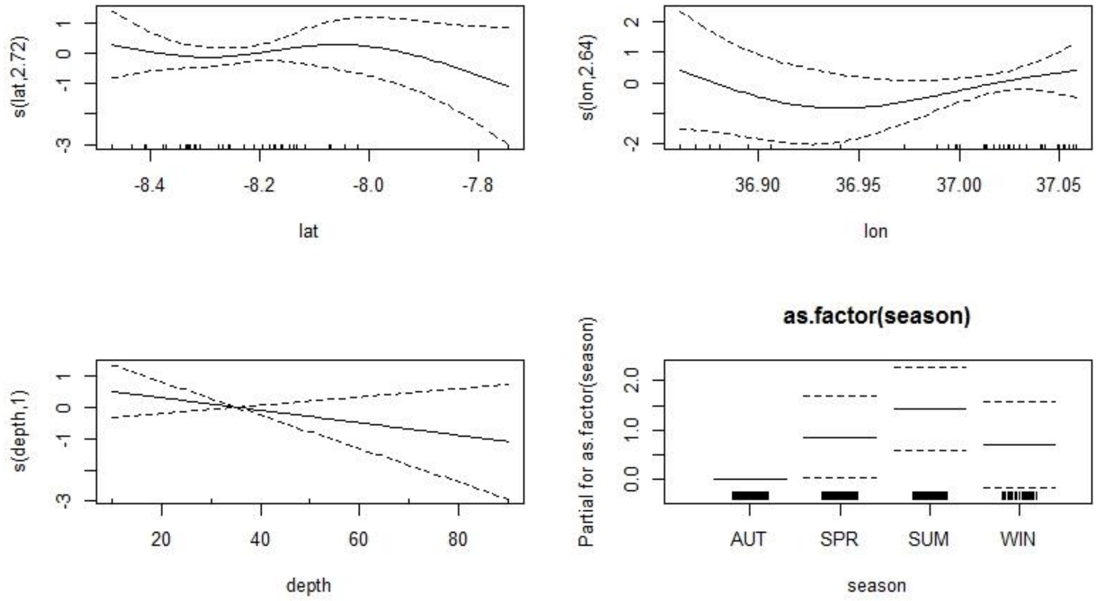



**Fig.5.b.17.** Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the invertebrates discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis

## Elasmobranches

## GAM model

```
Family: Gamma
Link function: log

Formula:
DiscN + 0.1 ~ as.factor(season) + s(lat, k = 6) + s(lon, k = 6)
+
    s(depth, k = 4)

Parametric Terms:
                  df     F p-value
as.factor(season)  3 1.053   0.372

Approximate significance of smooth terms:
           edf Ref.df     F p-value
s(lat)   4.361  4.787 3.584 0.00496
s(lon)   3.912  4.491 2.982 0.03274
s(depth) 2.392  2.769 0.791 0.59884
```

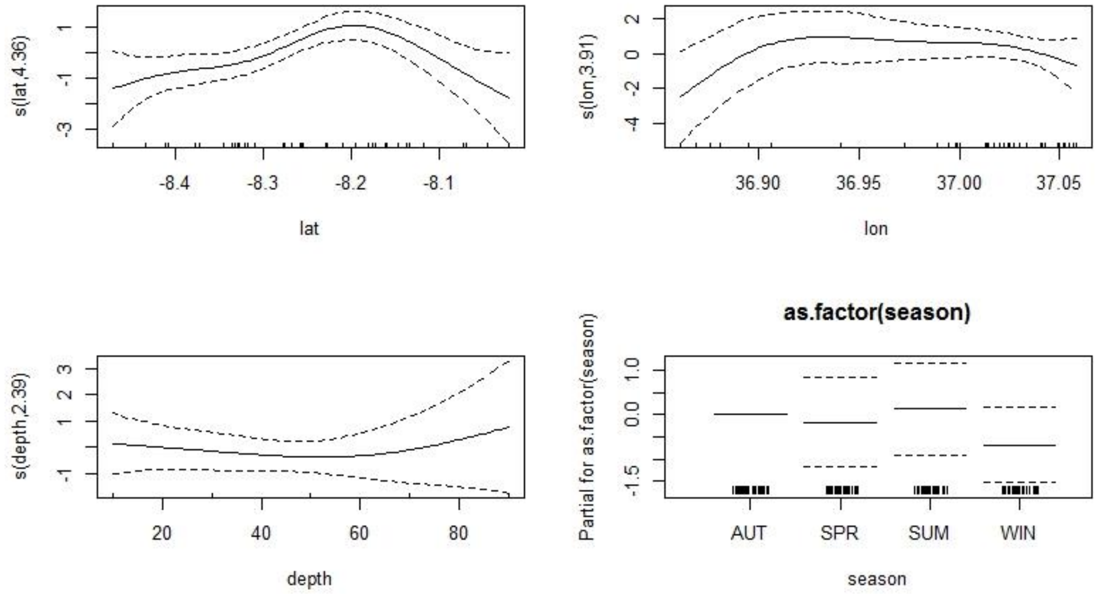



**Fig.5.b.18**. Generalized additive models (GAM) derived effects of various parameters on the discarded probability of the elasmobranch discards. Dashed lines indicate two standard errors above and below the estimates. Relative density of data points is shown by the 'rug' on the x-axis.

# 6. Discards of undersized major commercial species

### *CS 1.7. Aegean Sea bottom trawl fishery*

Assessing the probability of discarding by size, a feature linked to MLS compliance, revealed that the prohibition of landing undersized individuals was not widely respected. For hake, although the overall investigation of pooled data indicates that almost all fish lower than MLS were discarded, analyses by season and depth strata demonstrated that numerous undersized specimens were landed in winter, mostly fished at depths <100m.

For red mullet, fish between 9-11 cm of total length were retained, largely ignoring the 11 cm MLS. Discarding occurred mostly for fish caught in waters <200m of depth.

Obviously, horse mackerel and Mediterranean horse mackerel were not discarded due to MLS restrictions, but rather to market considerations. Almost all fish < 20cm were discarded, this size being way above the MLS threshold of 15 cm.

Deep-water rose shrimp landings respected the established MLS (20 mm), however this was ignored during winter when all specimens above 17mm were retained.

Anglerfish, in the absence of any MLS limitation, was landed solely based on market demand. As a general rule, almost all fish < 20 cm TL (total length) were discarded.

Finally, all bogues discarded were above the national MLS/MCRS of 10 cm.

## *Merluccius merluccius (MLS = 20cm)*

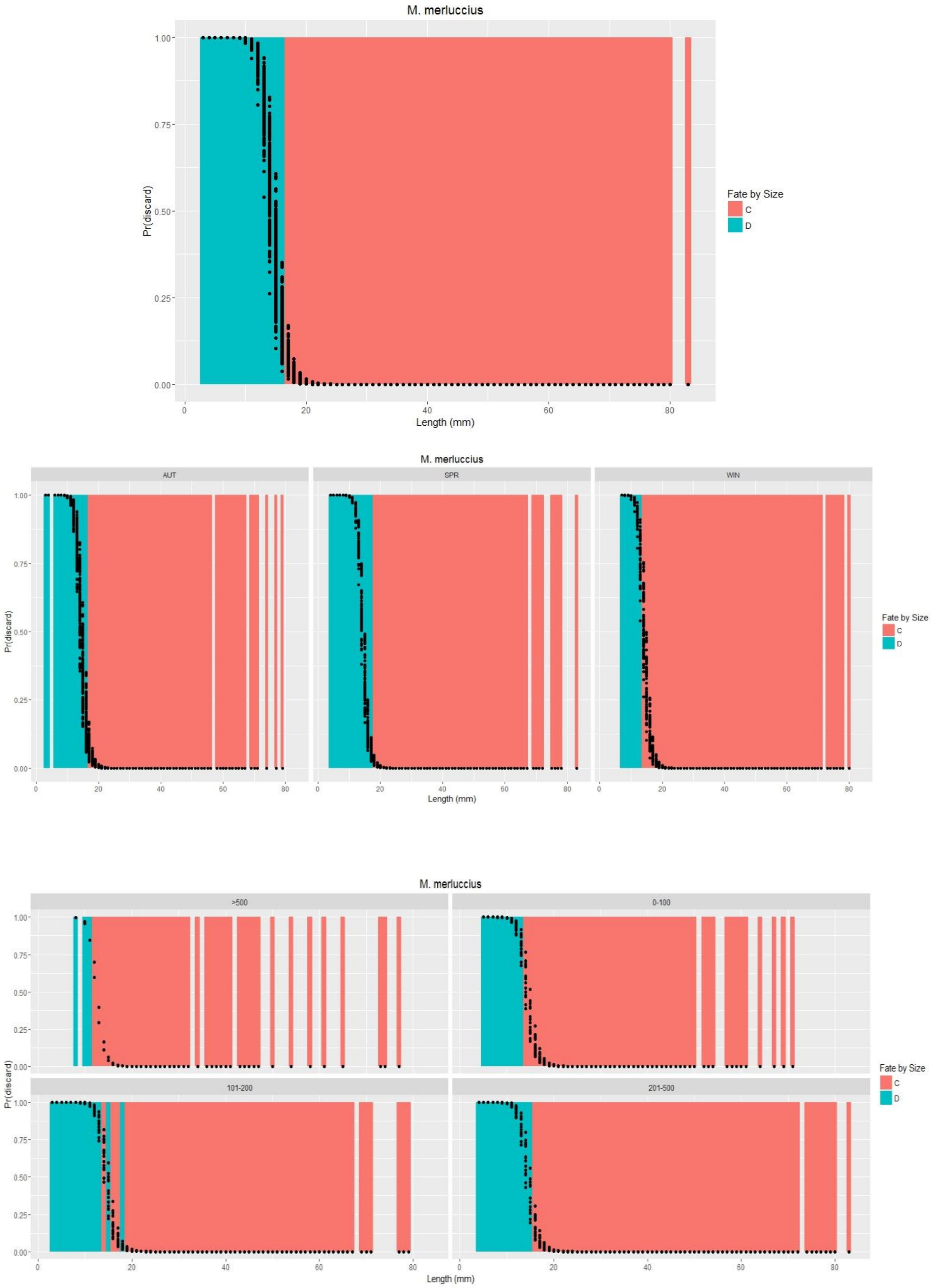



**Fig.5.c.1.** GAM derived discard probability by total length with super-imposed discard ogive for hake (top-global, mid-by season, bottom-by depth stratum).

### *Mullus barbatus (MLS= 11cm)*

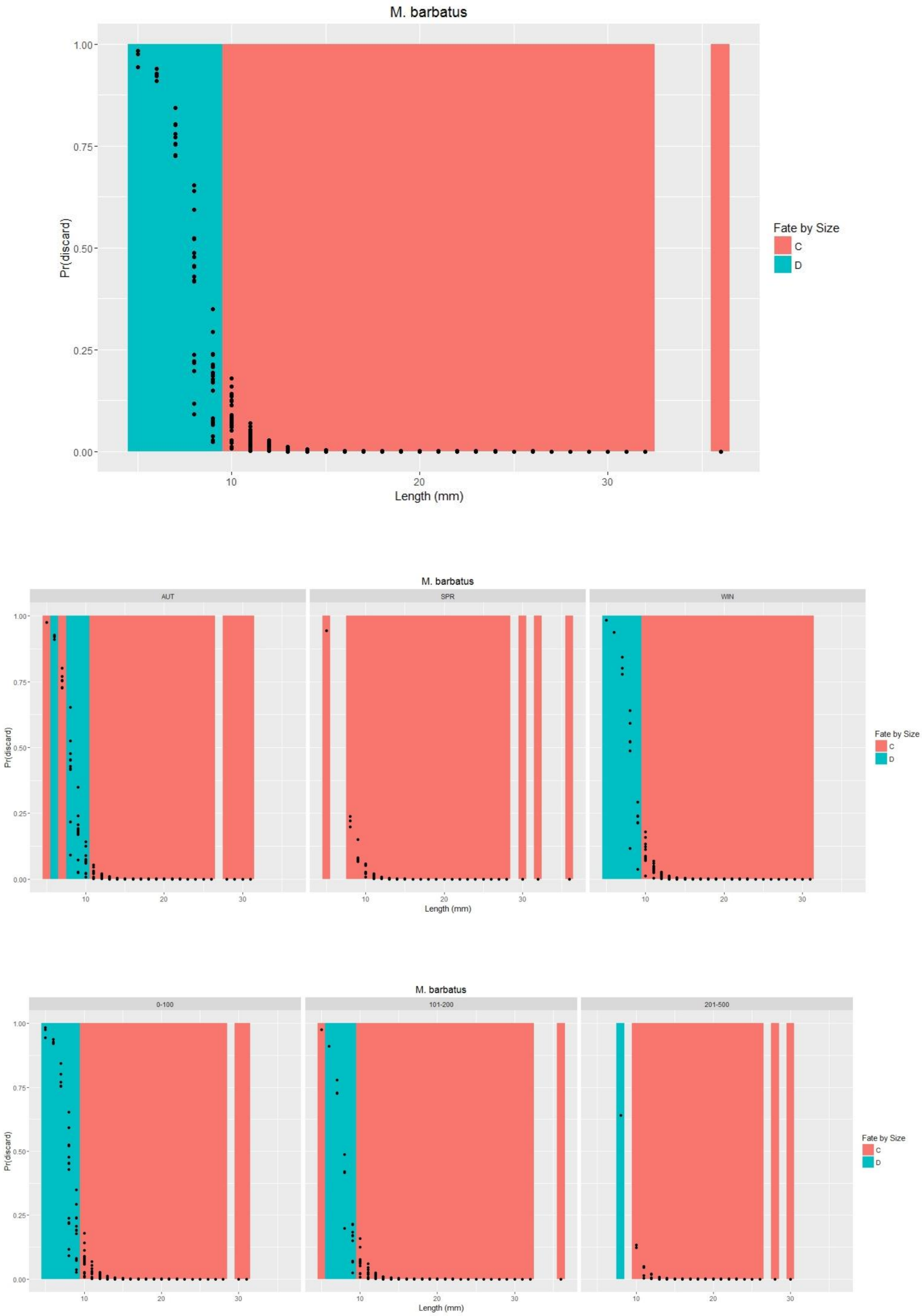
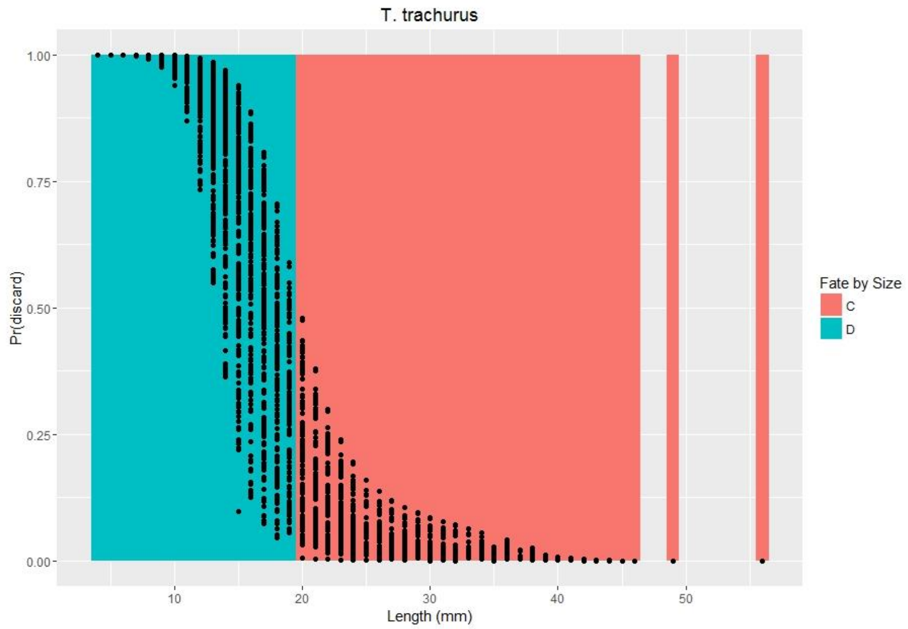
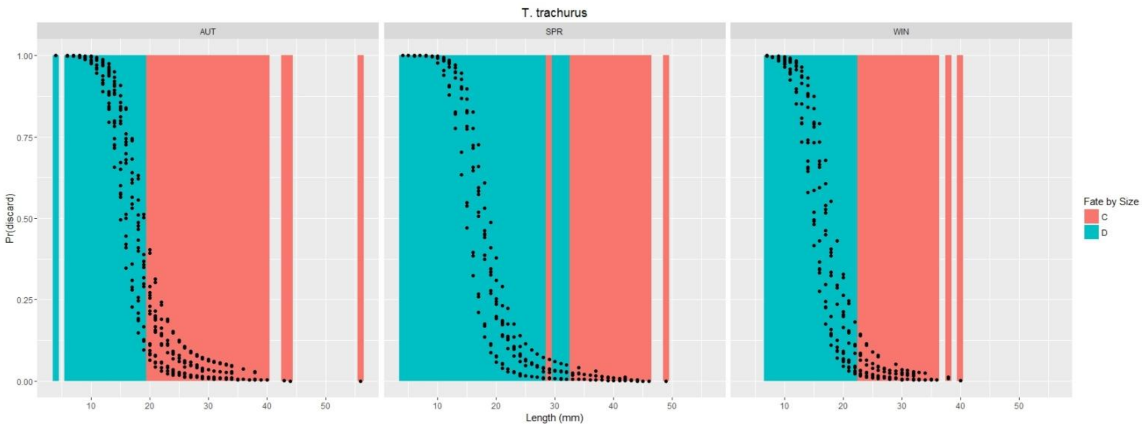



**Fig.5.c.2.** GAM derived discard probability by total length with super-imposed discard ogive for red mullet (top-global, mid-by season, bottom-by depth stratum).

### *Trachurus trachurus (MLS=15 cm)*



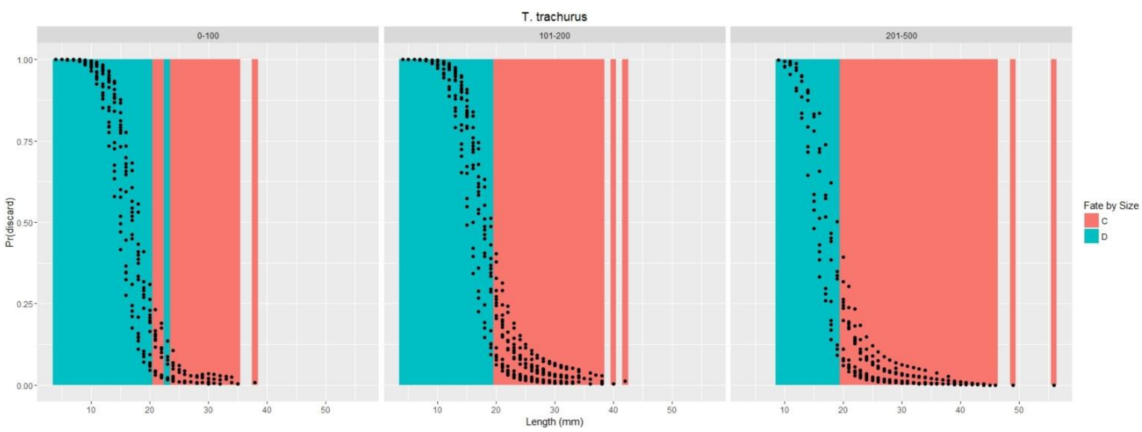




**Fig.5.c.3.** GAM derived discard probability by total length with super-imposed discard ogive for horse mackerel (top-global, mid-by season, bottom-by depth stratum).

## *Trachurus mediterraneus (MLS=15 cm)*

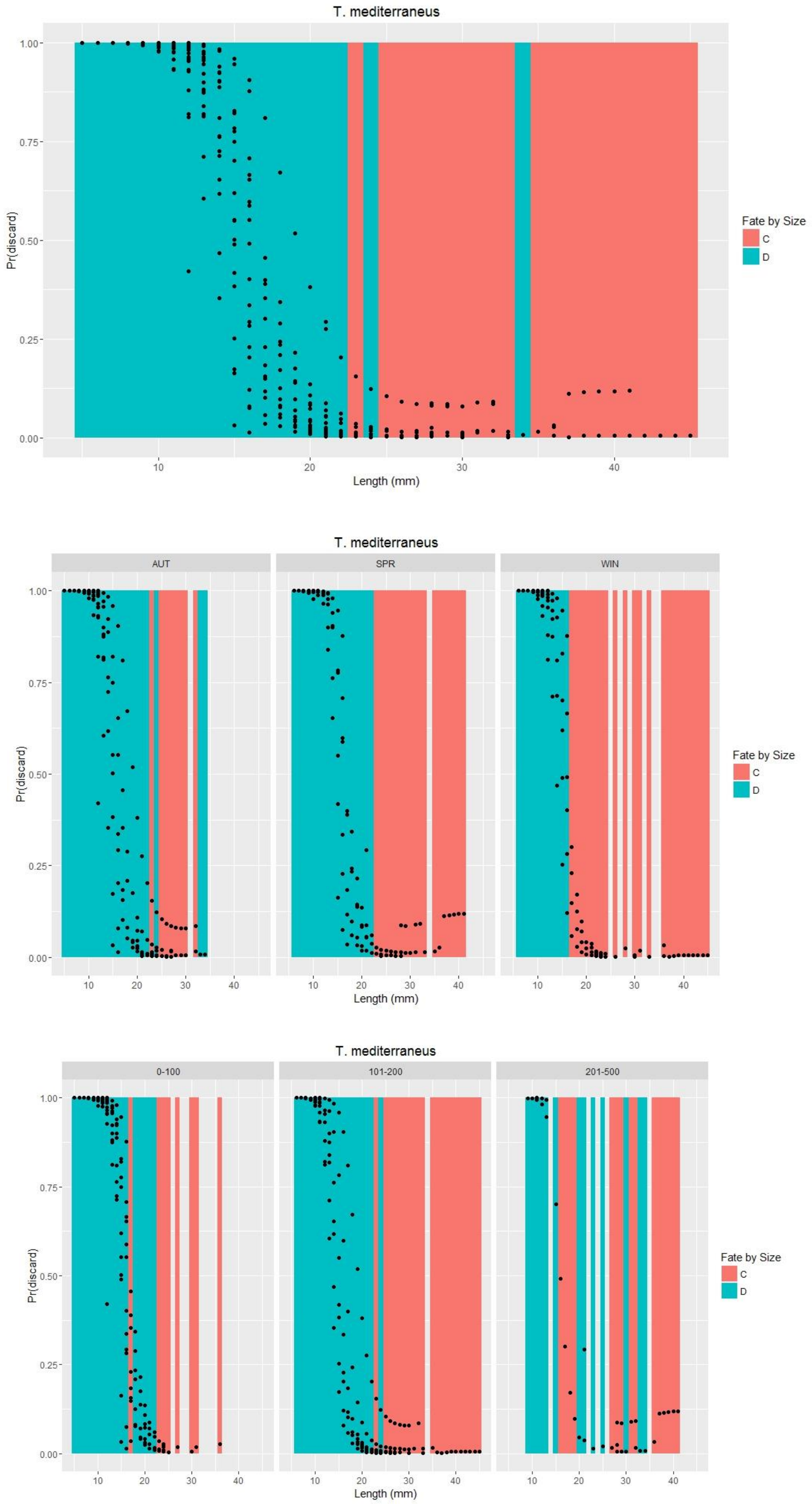
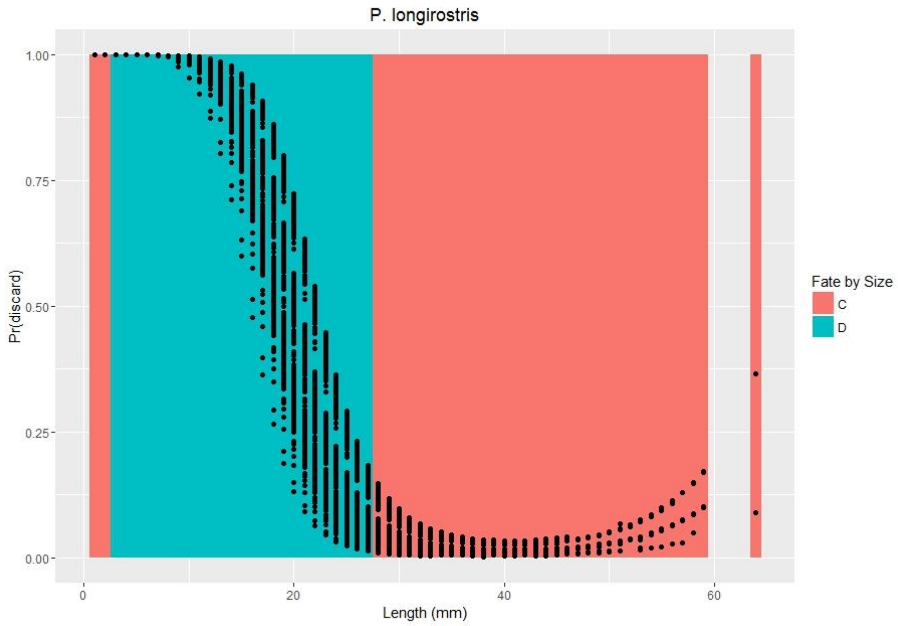



**Fig.5.c.4.** GAM derived discard probability by total length with super-imposed discard ogive for Mediterranean horse mackerel (top-global, mid-by season, bottom-by depth stratum).

### *Parapenaeus longirostris (MLS = 20mm)*



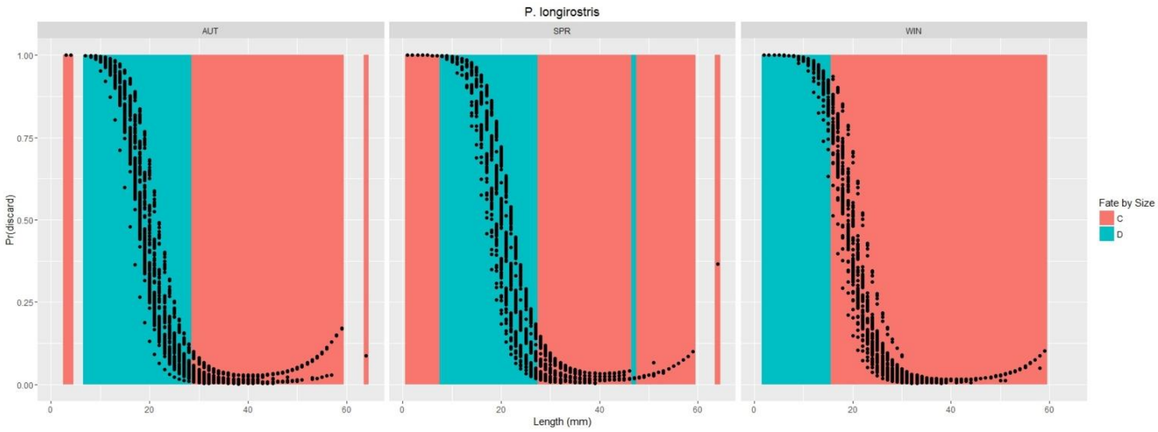
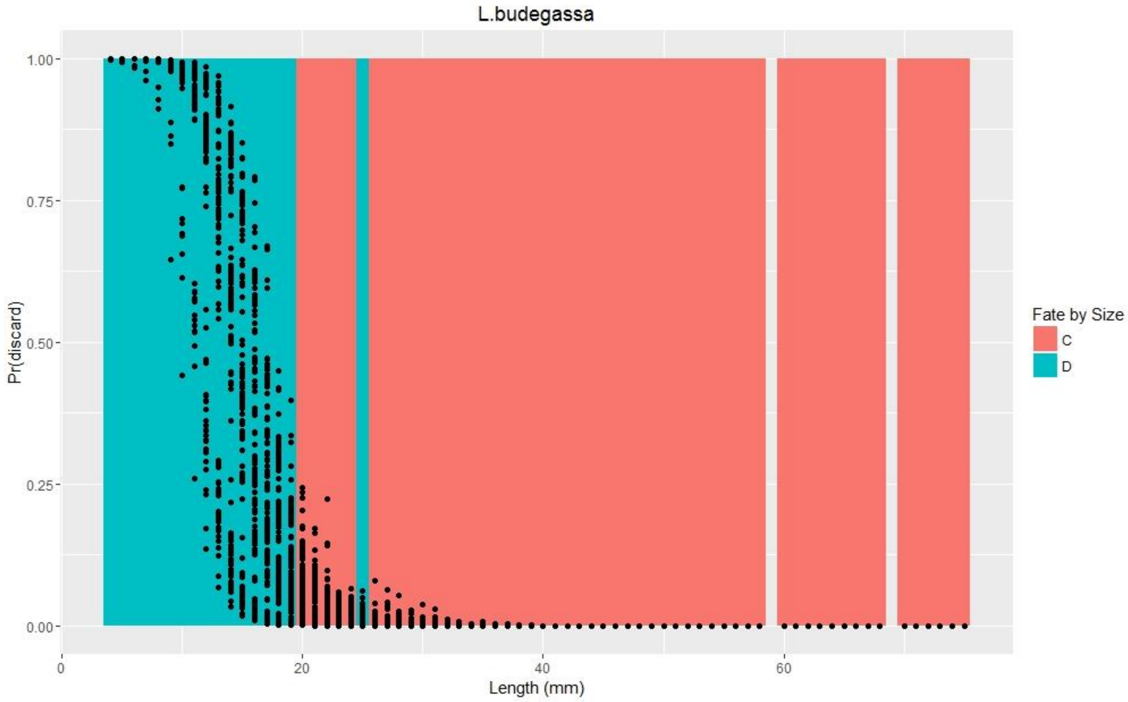
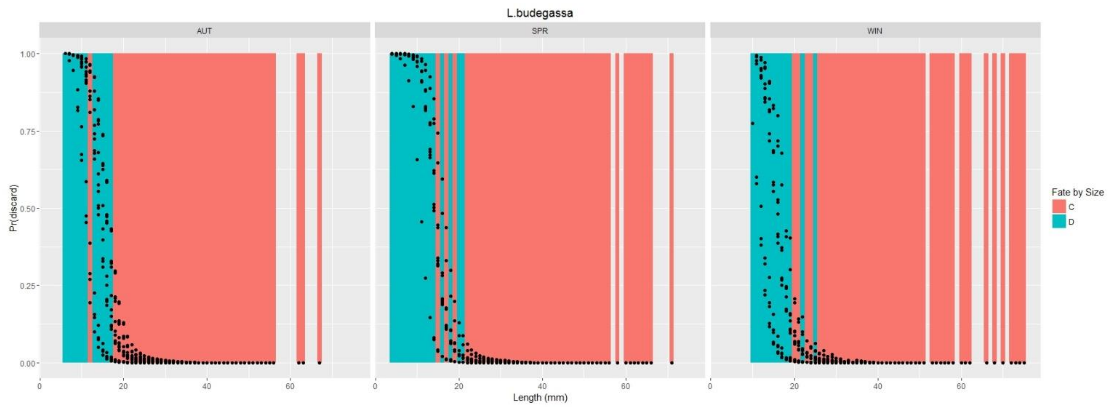




**Fig.5.c.5.** GAM derived discard probability by total length with super-imposed discard ogive for deep water rose shrimp (top-global, bottom-by season).

## *Lophius budegassa (currently no MLS - old MLS =30 cm)*



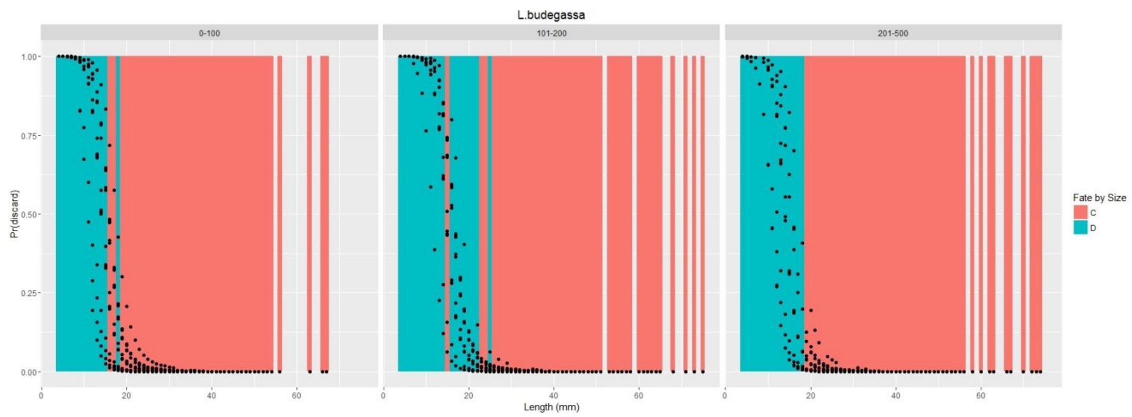
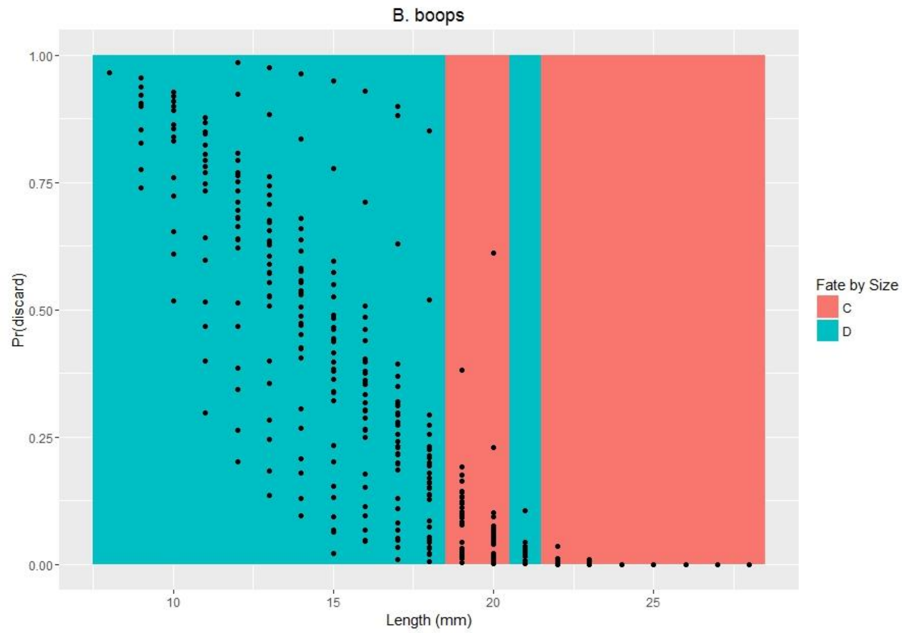
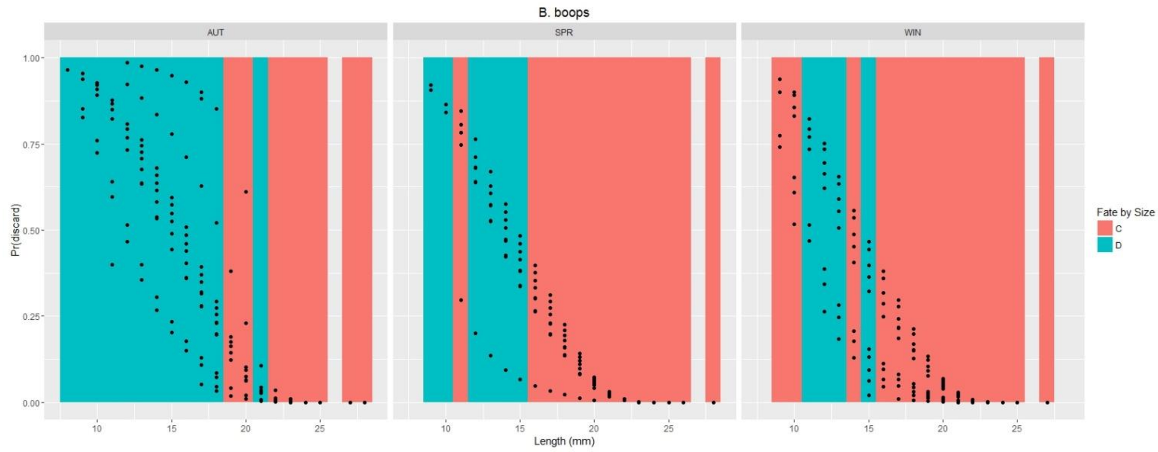




**Fig.5.c.6.** GAM derived discard probability by total length with super-imposed discard ogive for anglerfish (top-global, mid-by season, bottom-by depth stratum).

## *Boops boops (MLS= 10 cm)*



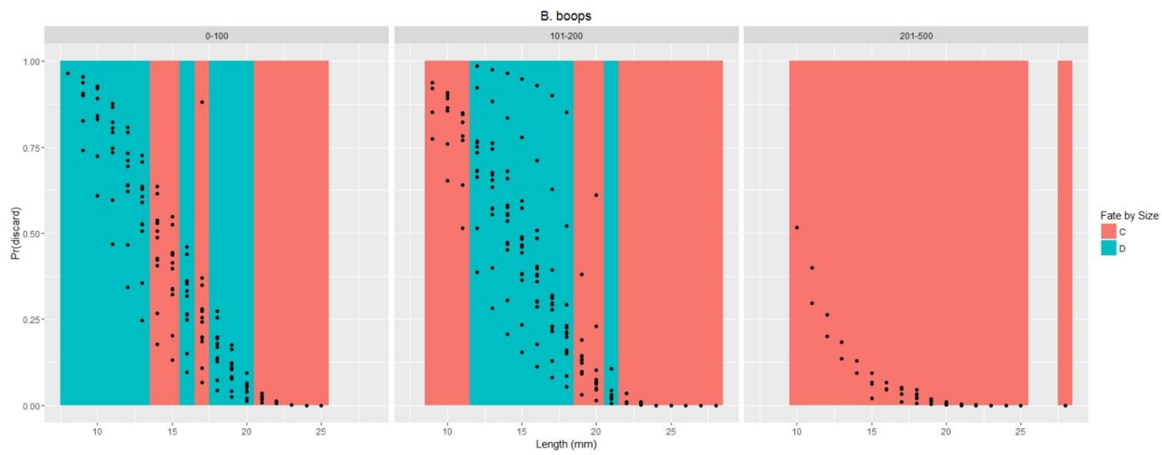




**Fig.5.c.7.** GAM derived discard probability by total length with super-imposed discard ogive for bogue (top-global, mid-by season, bottom-by depth stratum).

***CS 1.6 – 1.8 Ligurian and northern Tyrrhenian Sea bottom trawl fishery***

Hake discarding was more or less driven by (MLS), with the exception of winter/spring where fish less than 20cm of TL were landed.

All horse mackerel marketed were above the MLS of 15 cm, and actually most of them were even above 20 cm of TL.

Picarel, lacking MLS, were discarded when smaller than 17 cm of TL.

In a similar way, only large bogue were marketed; however, in the distant 1995, even very small specimens were landed.

All blue whiting above 15 cm of TL were usually retained. The discarded fraction originated mainly from the depth strata between 100 and 300 m.

Only sizeable European pilchard (>17cm) were marketed, being above the MLS of 11cm. However, this fishery targets demersal assemblages and the results herein cannot be considered conclusive on the fate of the species.

## *Merluccius merluccius (MLS=20cm)*

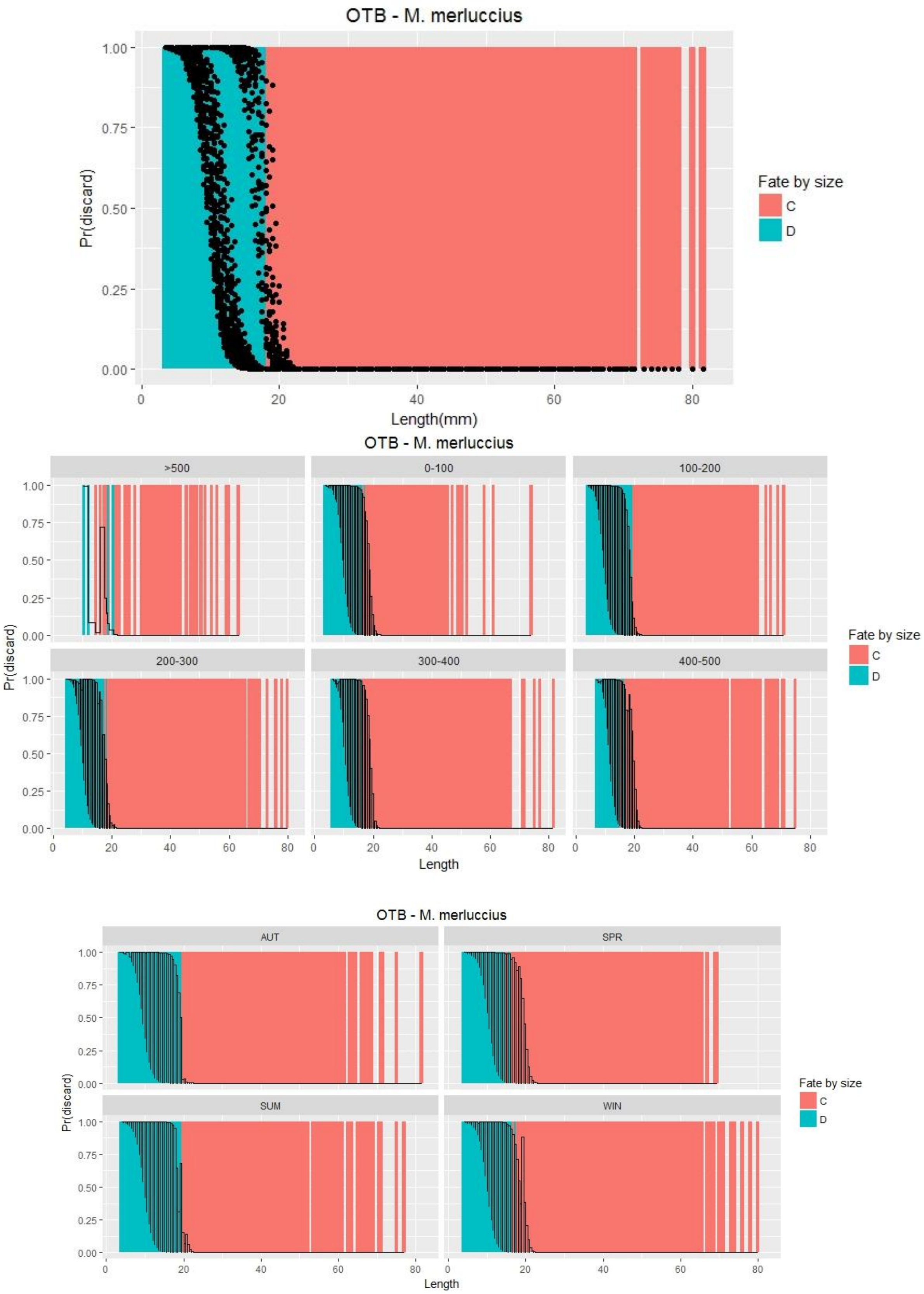



**Fig.5.c.8.** GAM derived discard probability by total length with super-imposed discard ogive for hake (top-global, mid-by depth stratum, bottom-by season).

## *Trachurus trachurus (MLS=15cm)*

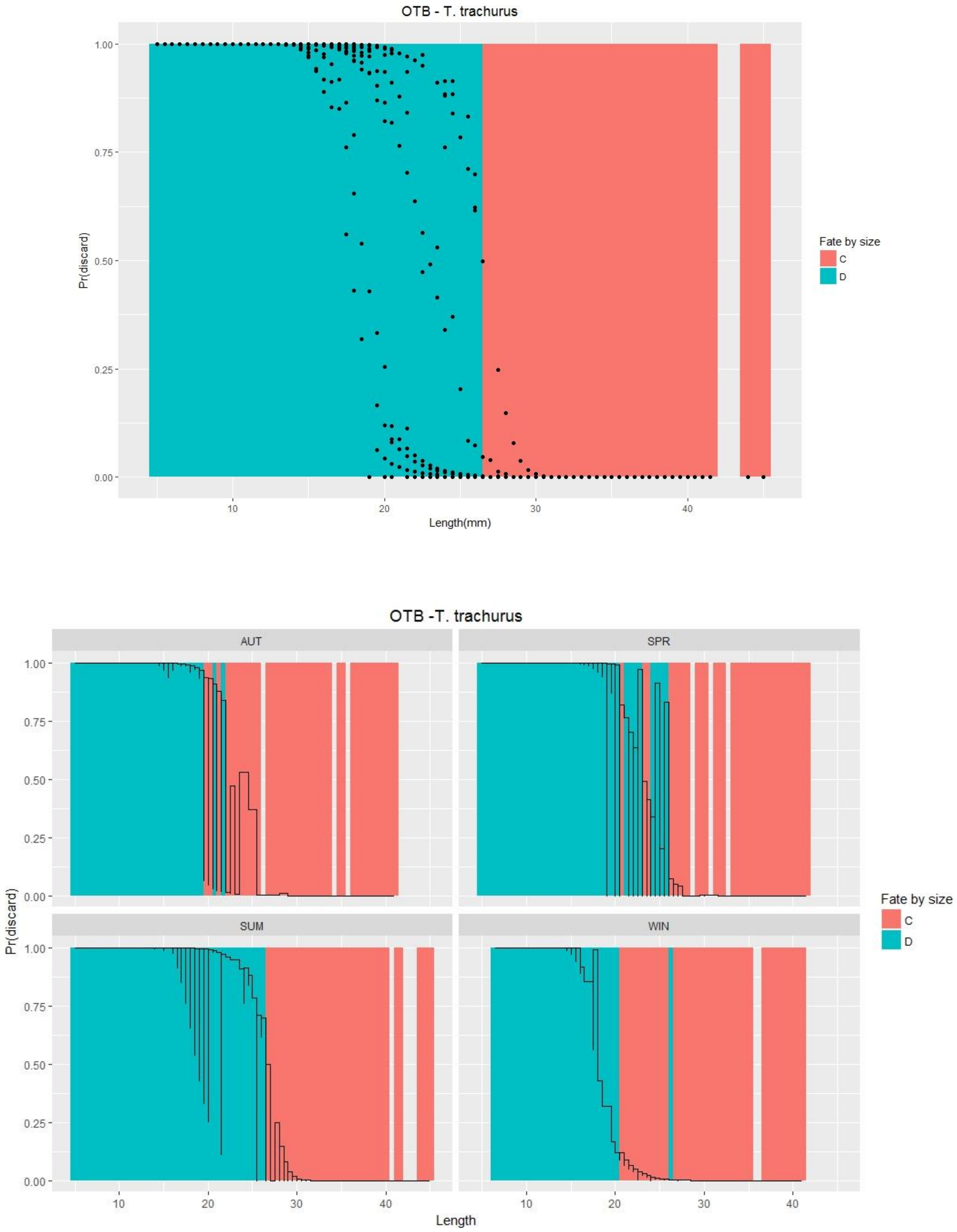



**Fig.5.c.9.** GAM derived discard probability by total length with super-imposed discard ogive for horse mackerel (top-global, bottom-by season)

## *Spicara smaris*

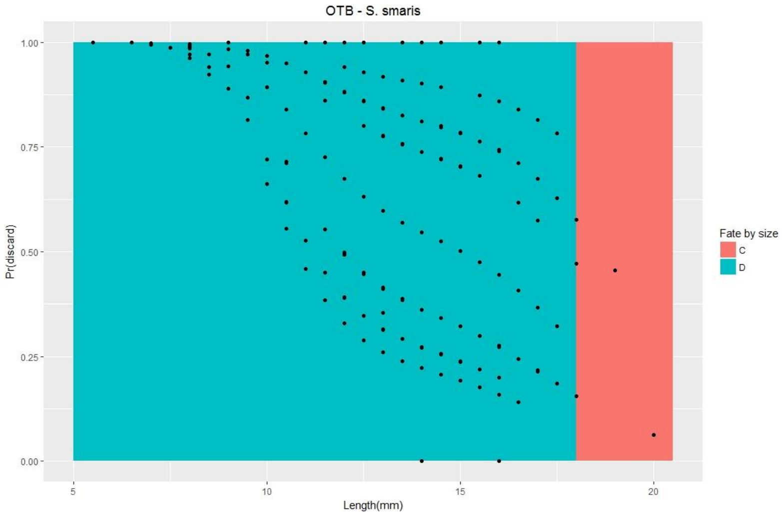



**Fig.5.c.10.** GAM derived discard probability by total length with super-imposed discard ogive for picarel

## *Boops boops*

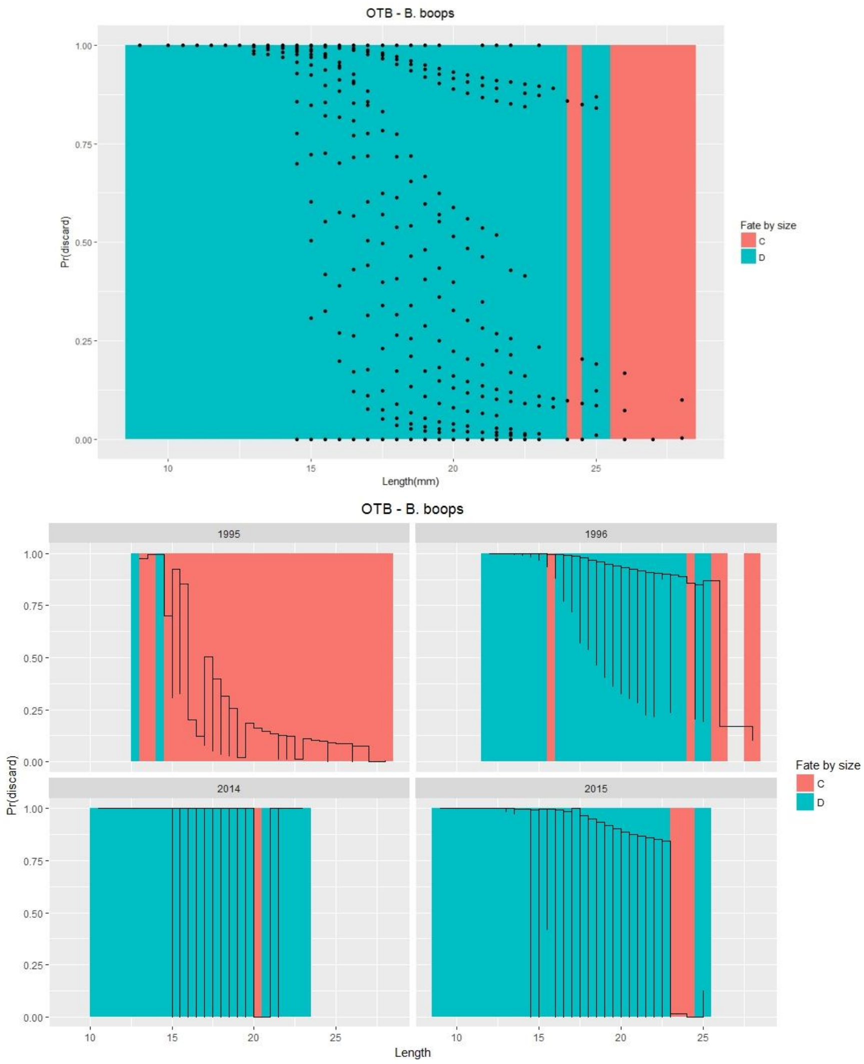
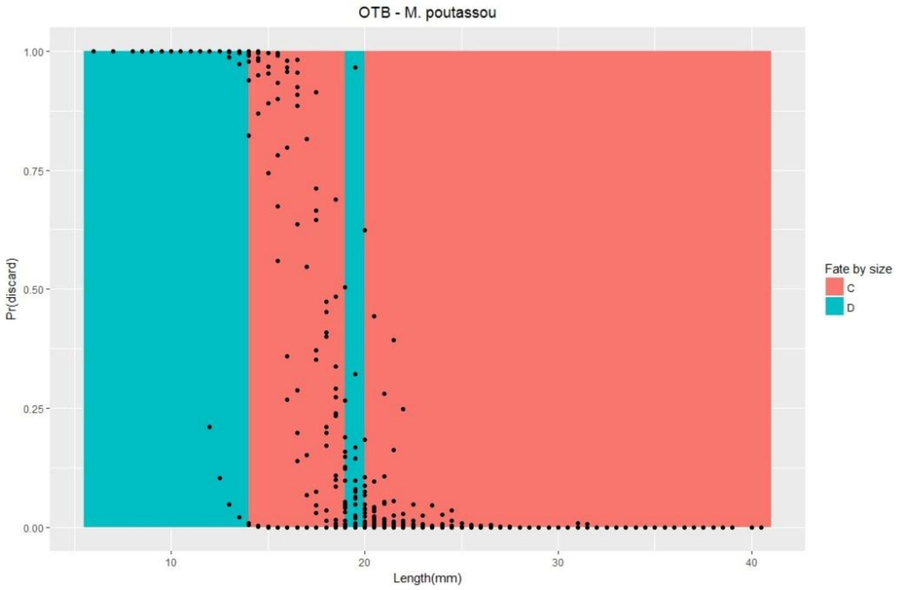



**Fig.5.c.11.** GAM derived discard probability by total length with super-imposed discard ogive for bogue (top-global, bottom-by year)

### *Micromesistius poutassou*



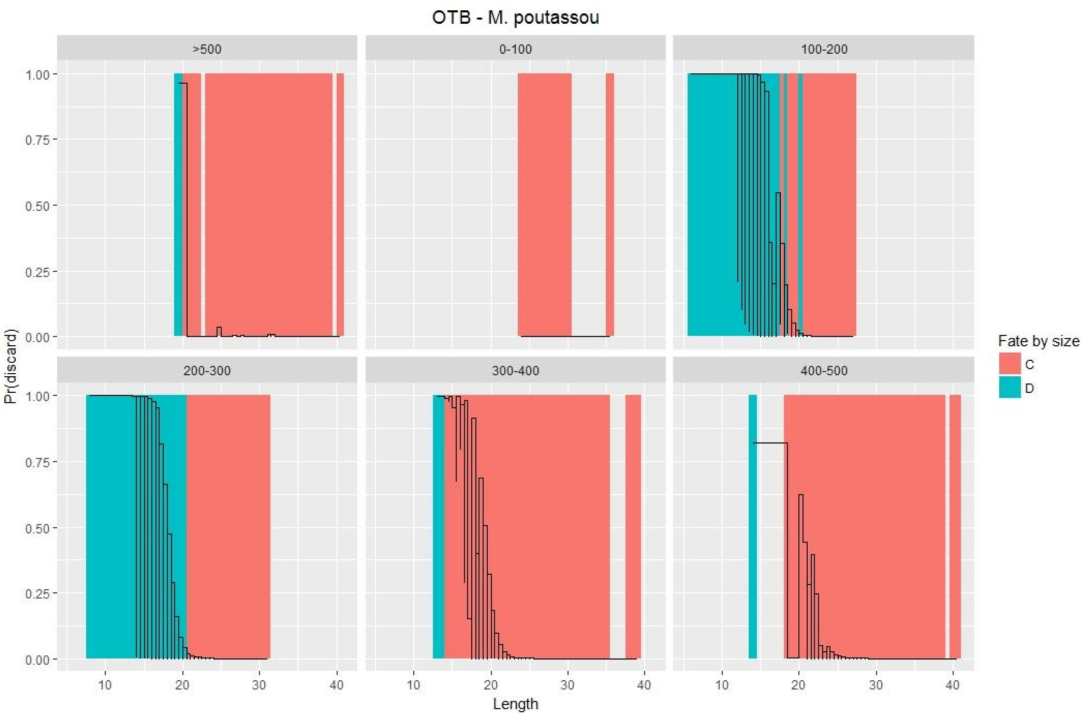




**Fig.5.c.12.** GAM derived discard probability by total length with super-imposed discard ogive for blue whiting (top-global, bottom-by stratum)

### *Sardina pilchardus (MLS = 11cm)*

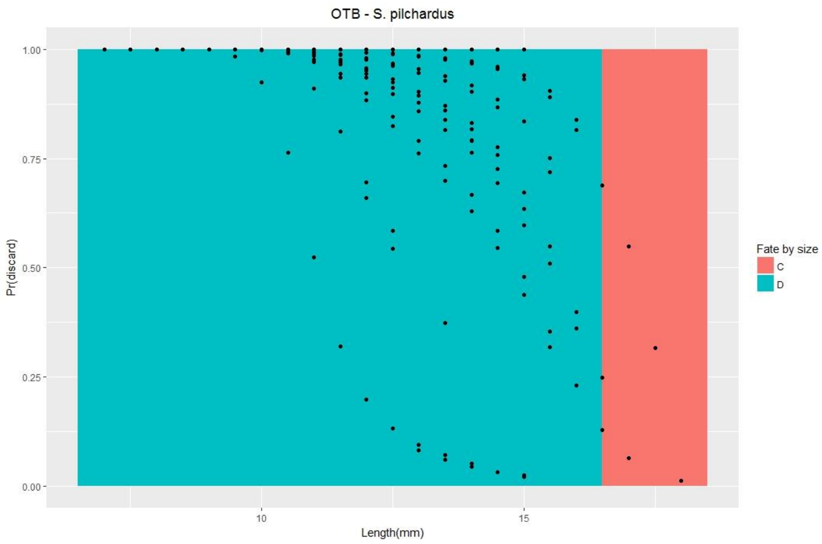



**Fig.5.c.13.** GAM derived discard probability by total length with super-imposed discard ogive for European pilchard

### *CS 1.5 Bottom trawl crustacean fisheries in Sicily (Parapenaeus)*

In general, European hake below MLS were discarded. 2014 is an exception to this rule; apparently all catches during this year were landed. Furthermore, discarding was seasonal in nature; summer and autumn were the periods where undersized specimens made it to the market.

Deep-water rose shrimp below MLS were observed in the market during summer months, while the bulk of discards came from the 0-100m depth stratum

Horse mackerel were always above the MLS of 15 cm TL, without any striking differences among depth strata or seasons.

## *Merluccius merluccius (MLS=20cm)*

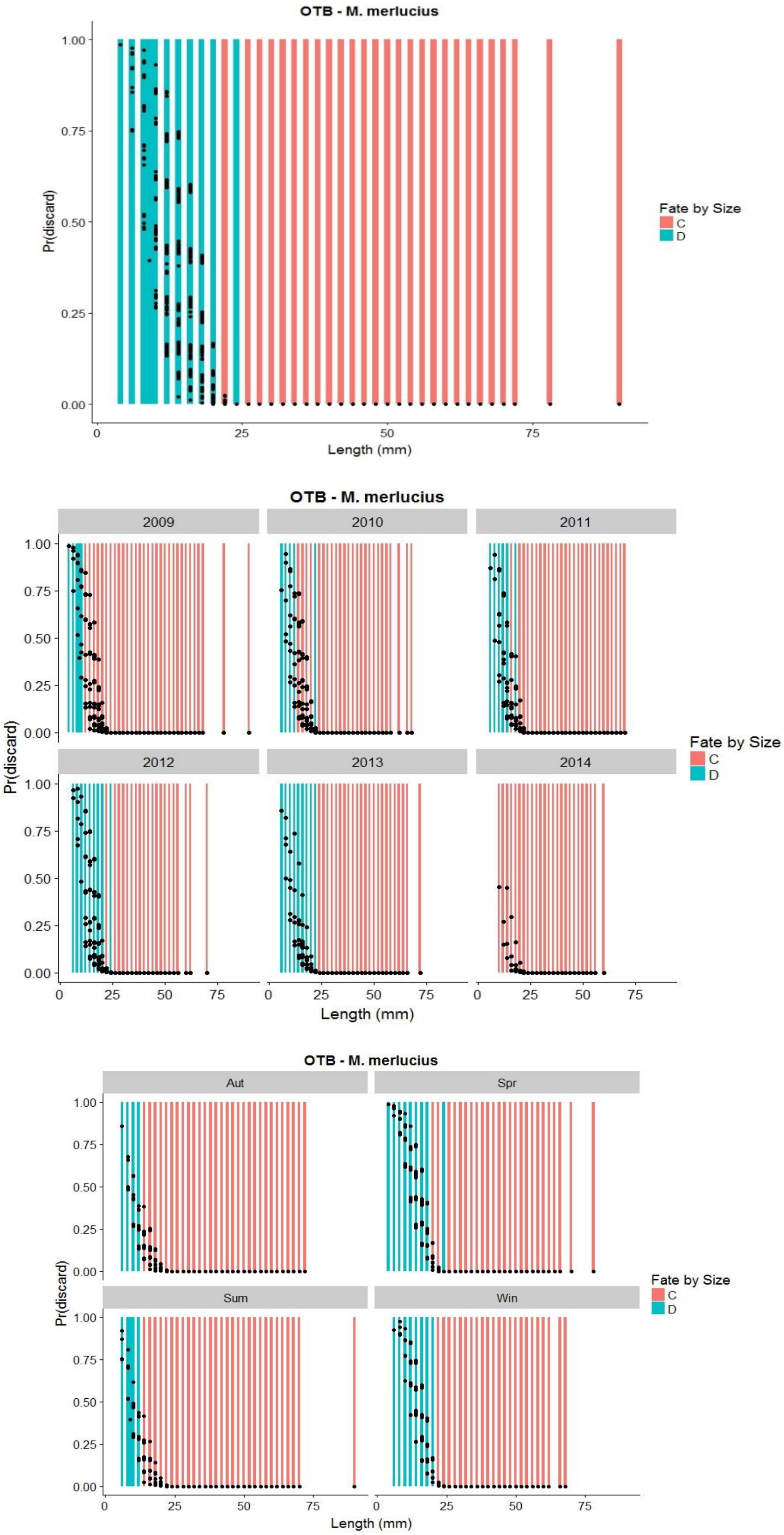



**Fig.5.c.14.** GAM derived discard probability by total length with super-imposed discard ogive for hake (top-global, mid-by year, bottom-by season)

## *Parapenaeus longirostris (MLS = 20mm)*

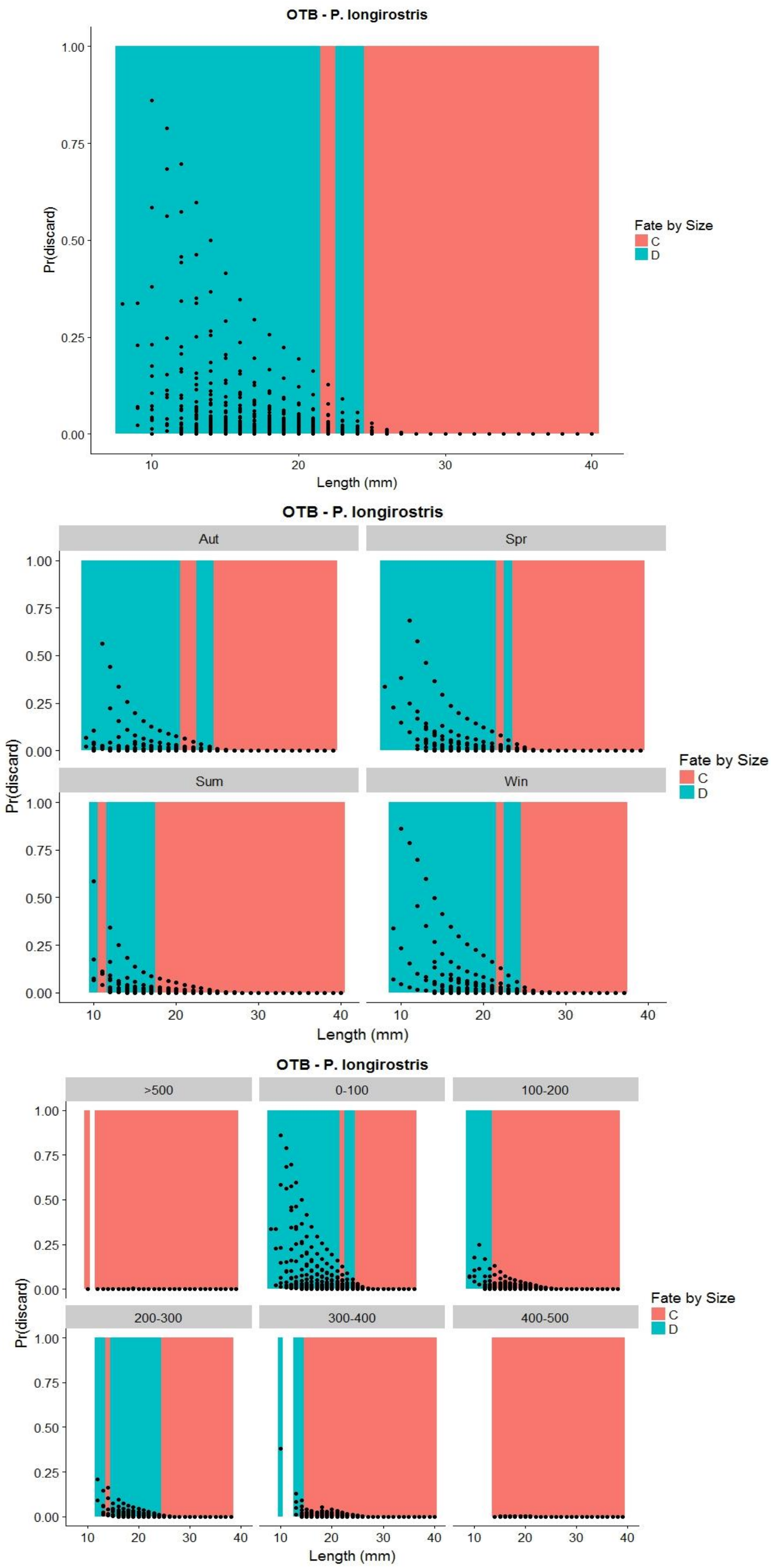



**Fig.5.c.15.** GAM derived discard probability by total length with super-imposed discard ogive for deep water rose shrimp (top-global, mid-by season, bottom-by stratum)

## *Trachurus trachurus (MLS = 15cm)*

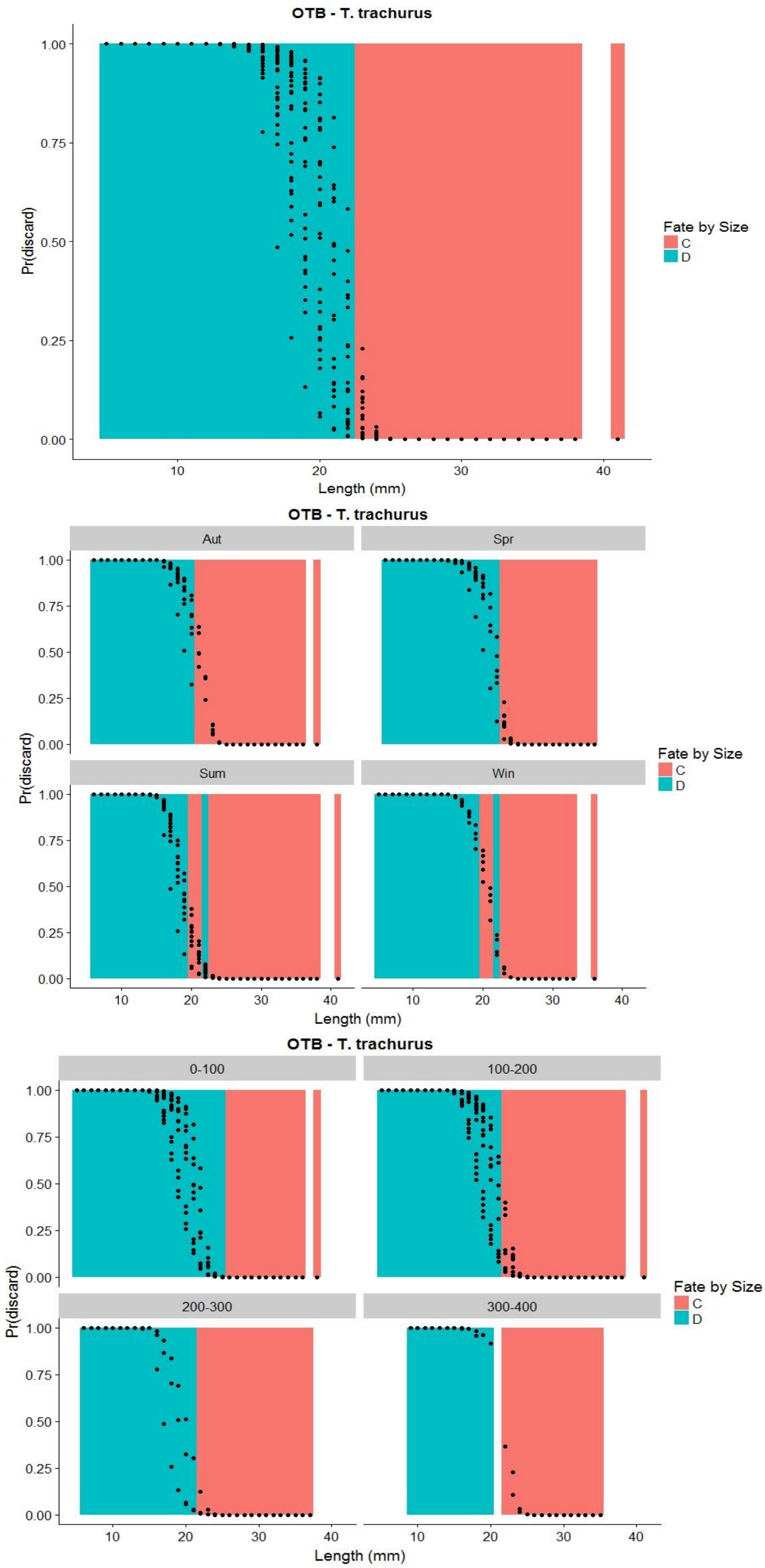



**Fig.5.c.16.** GAM derived discard probability by total length with super-imposed discard ogive for horse mackerel (top-global, mid-by season, bottom-by stratum)

### *CS 1.4 Catalan sea bottom trawl fishery*

Very few can be deduced for this fishery, due to the lack of detailed information. The graphs provided are more exploratory in nature than conclusive.

### *Merluccius merluccius*

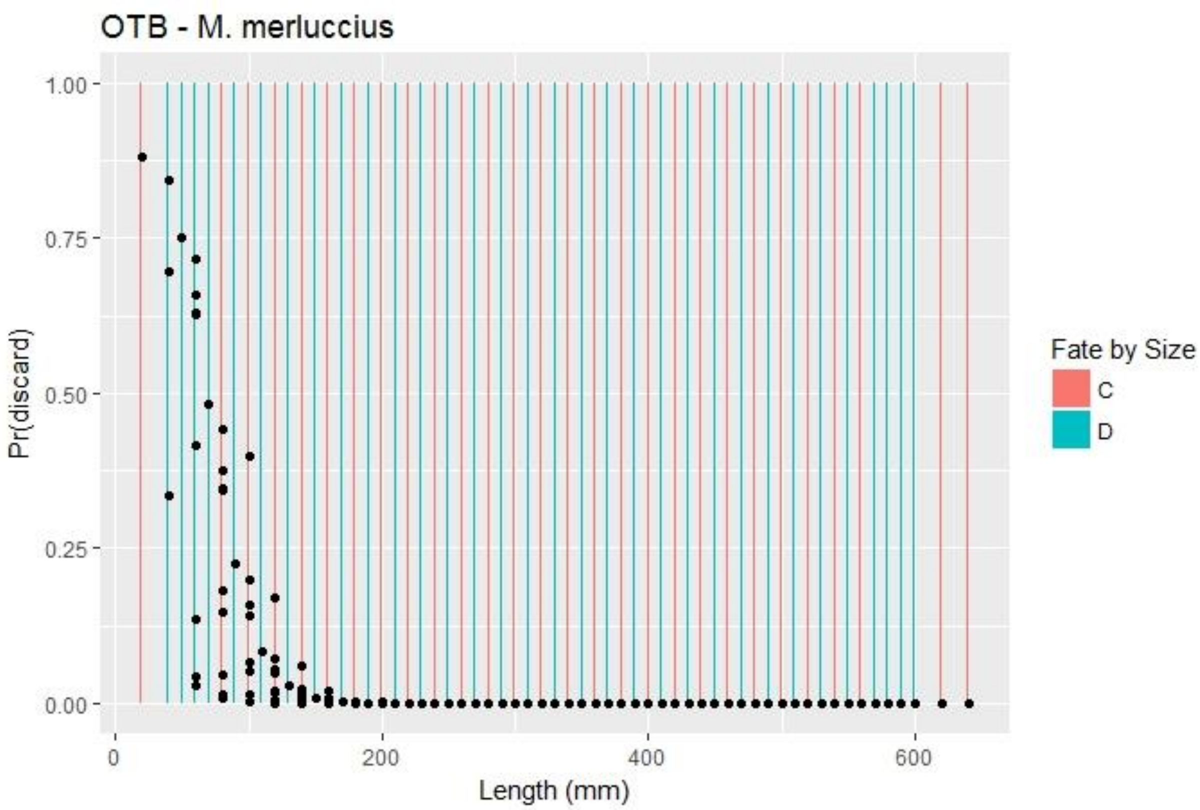
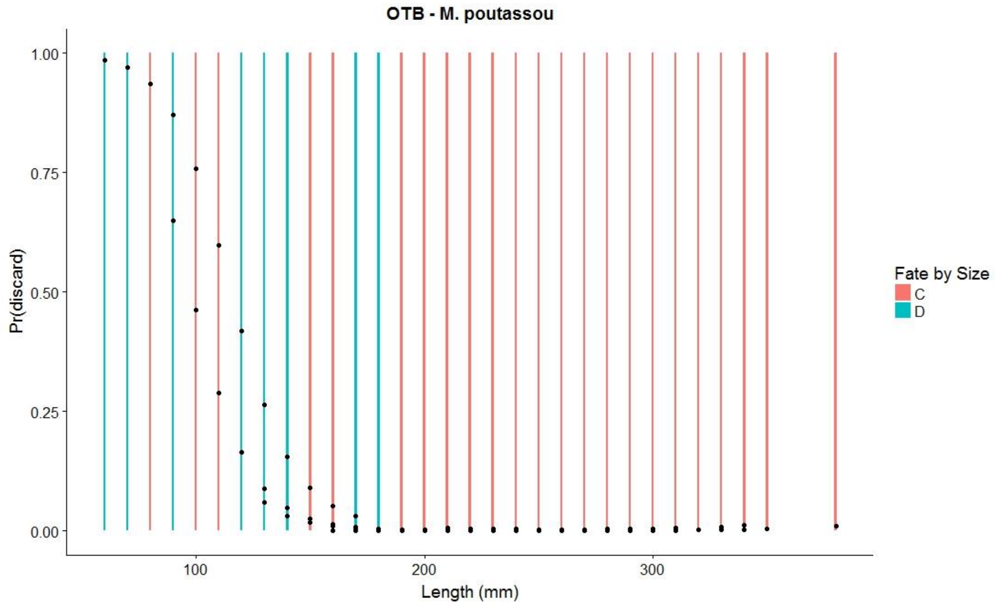



**Fig.5.c.17.** GAM derived discard probability by total length with super-imposed discard ogive for hake

### *Micromesistius poutassou*



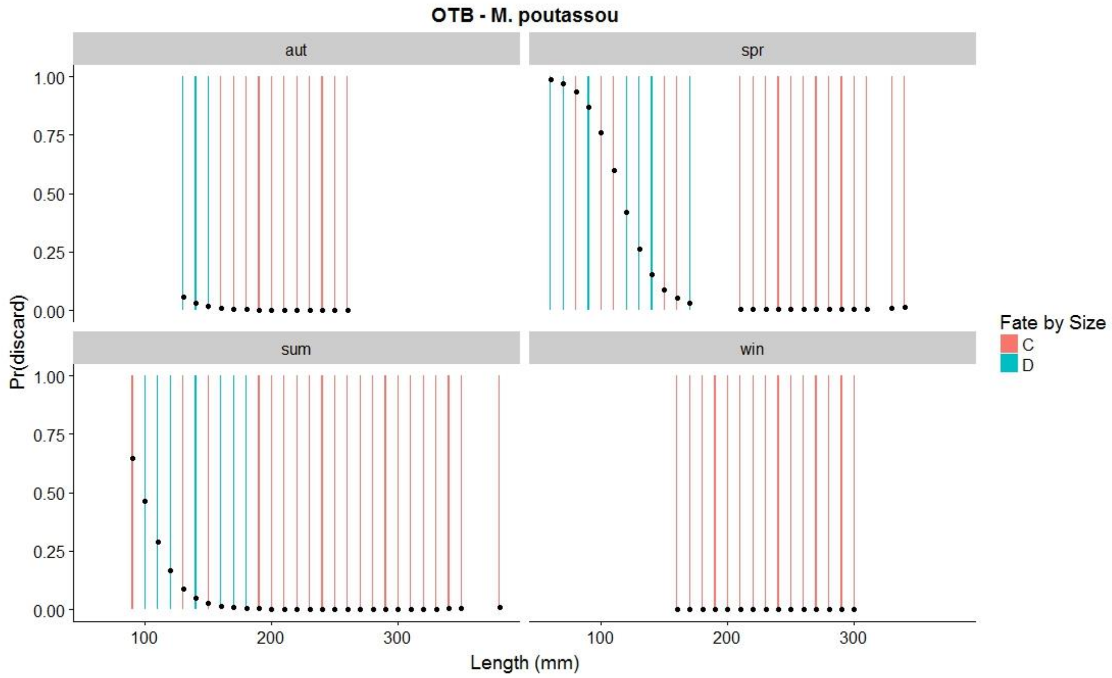
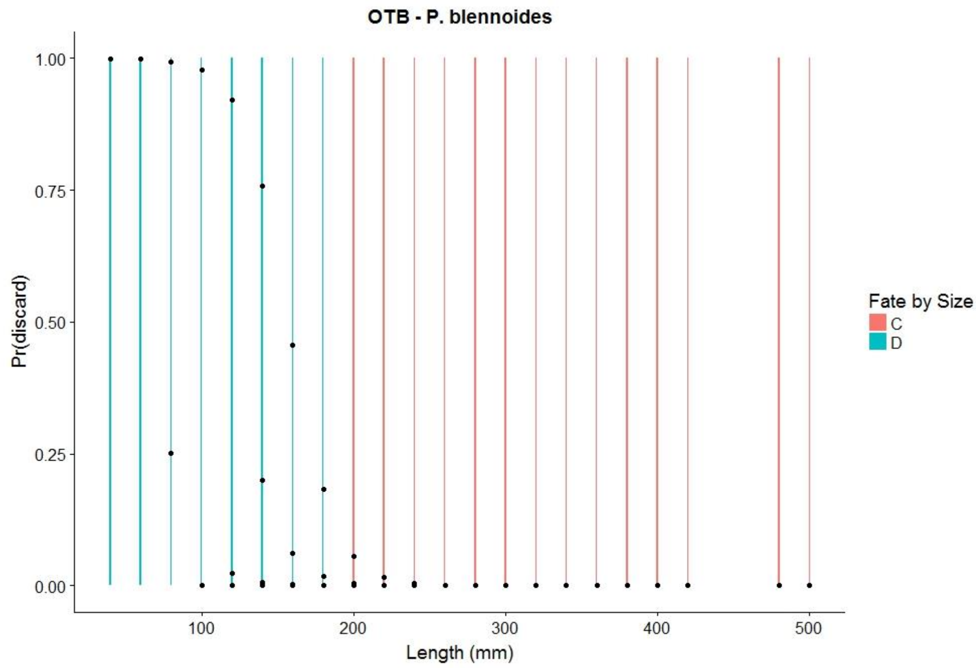




**Fig.5.c.18.** GAM derived discard probability by total length with super-imposed discard ogive for blue whiting (top-global, bottom-by season)

## *Phycis blennoides*



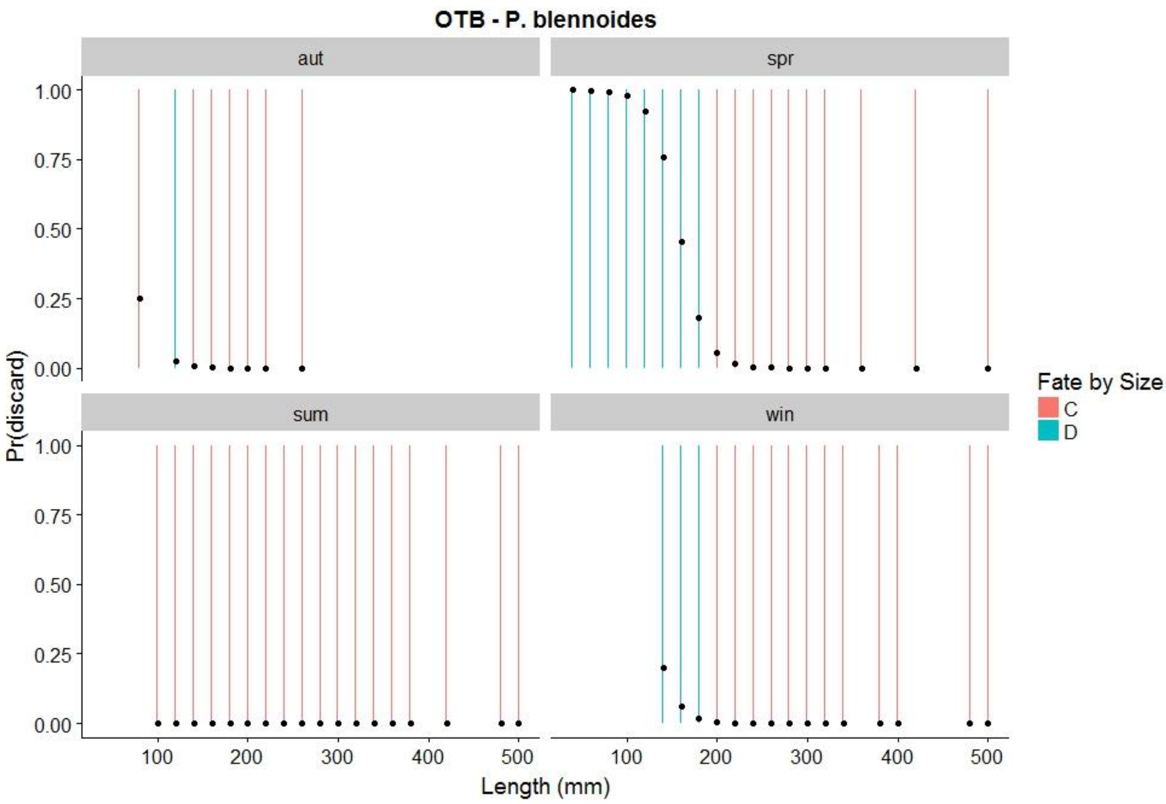




**Fig.5.c.19.** GAM derived discard probability by total length with super-imposed discard ogive for greater forkbeard (top-global, bottom-by season)

## *CS 1.2 Algarve deep-water trawl fishery*

For all 4 species investigated, it seems that discarding was not linked to size, and very small or very large specimens were either marketed or discarded, respectively. Most likely, MLS did not decide the fate of them, since only *Conger conger* has an MLS restriction.

### *Micromesistius poutassou*

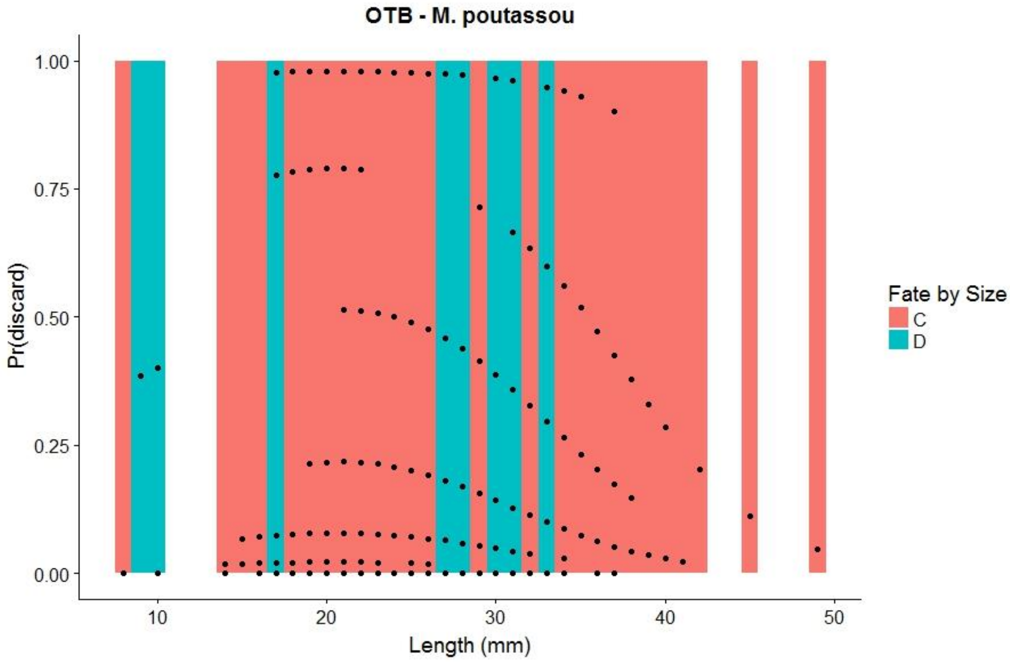



**Fig.5.c.20.** GAM derived discard probability by total length with super-imposed discard ogive for blue whiting

### *Conger conger*

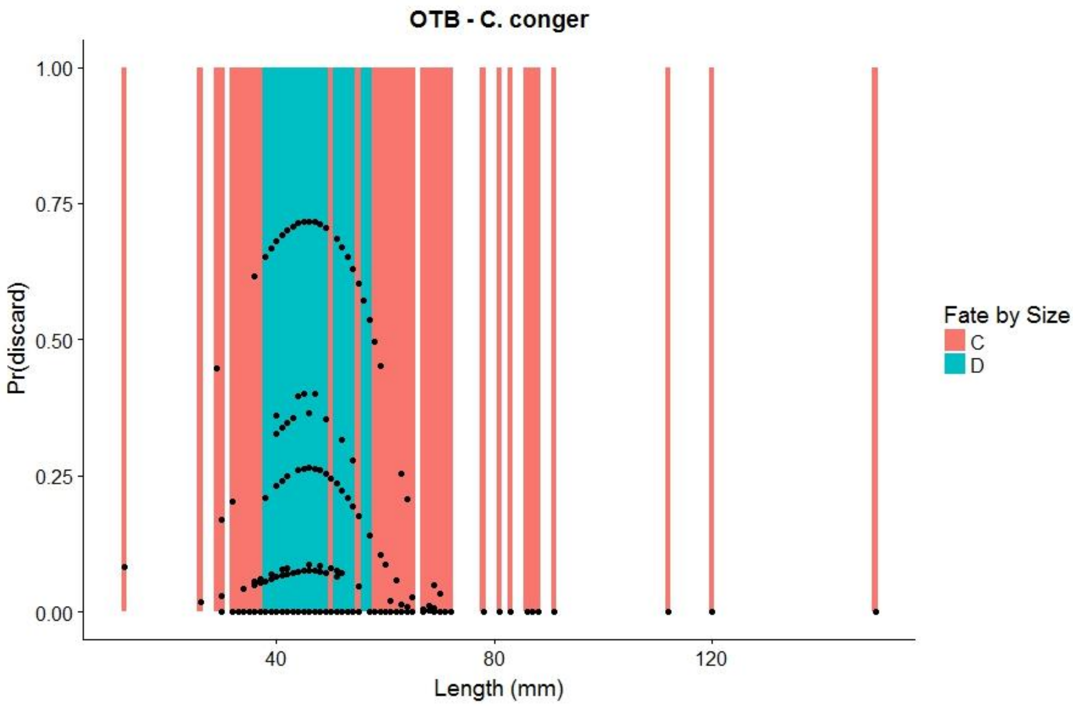



**Fig.5.c.21.** GAM derived discard probability by total length with super-imposed discard ogive for European conger

## *Galeus melastomus*

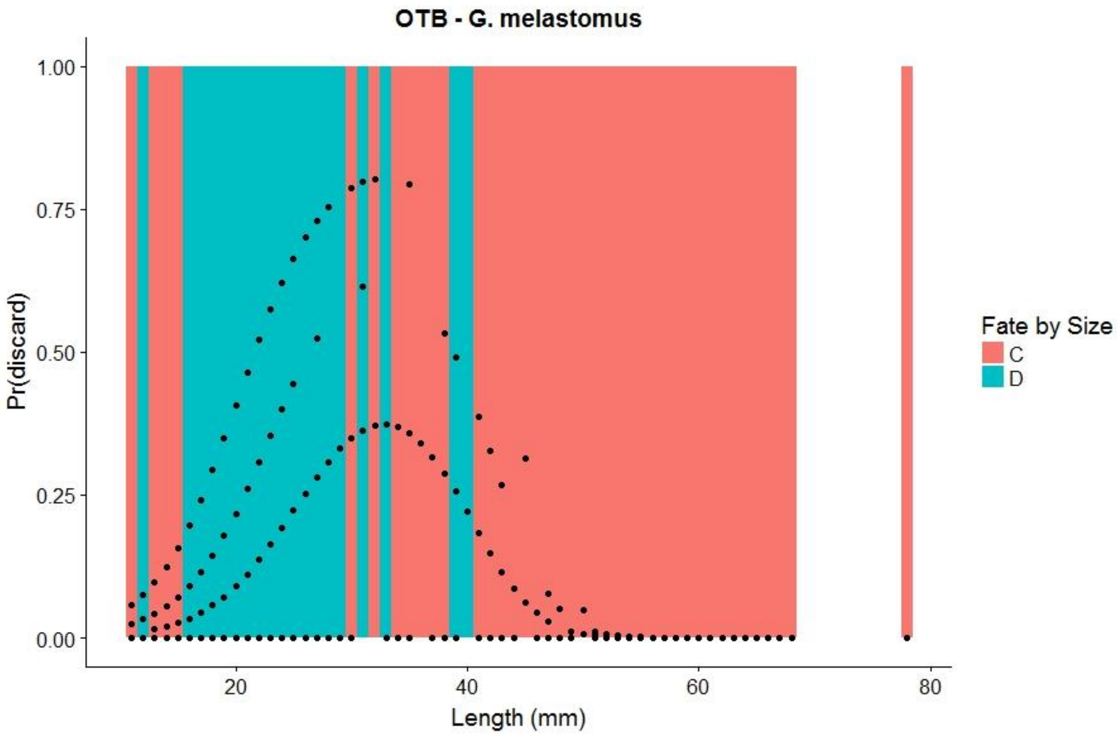



**Fig.5.c.22.** GAM derived discard probability by total length with super-imposed discard ogive for blackmouth catshark

## *Lepidopus caudatus*

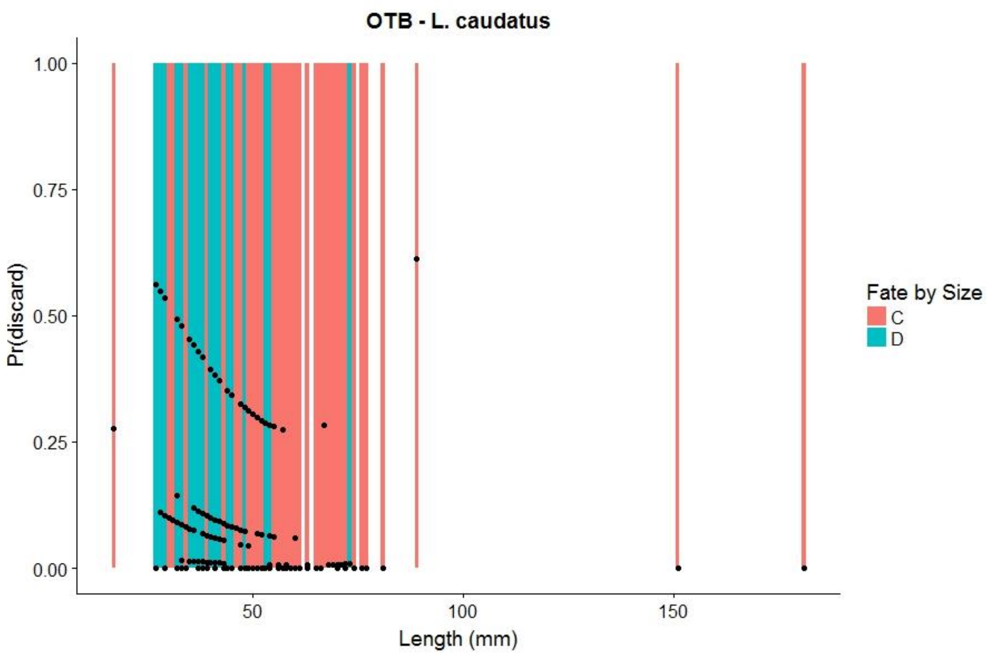



**Fig.5.c.23.** GAM derived discard probability by total length with super-imposed discard ogive for silver scabbardfish

# 7. Economic and operational characteristics of discarding fisheries

**Table 5.d.1.** Summary description of the economic characteristics of the discarding fisheries under study

| Gear | Are a | Year | NbVe ssels | Capaci ty.GT | CapacV essel | MeshSize | Depth .Avg | Depth .Min | Depth. Max | Nb.Sp .Disc | Perc Dis | Perc Reg Dis | LndVal (x1000€) | LndValVes (x1000€) | EnerCost (x1000€) | EnerCostVes (x1000€) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OTB | GSA | 2003 | 288 | 26003. | 90 | 40 | 84 | 25 | 170 | 103 | 33% | | | | | |
| OTB | GSA | 2004 | 281 | 26910. | 96 | 40 | 122 | 26 | 395 | 166 | 33% | | 91060 | 324 | 37111 | 132 |
| OTB | GSA | 2005 | 284 | 28138. | 99 | 40 | 124 | 22 | 373 | 165 | 30% | | 318072 | 1120 | 3683 | 13 |
| OTB | GSA | 2006 | 283 | 28002. | 99 | 40 | 131 | 28 | 463 | 153 | 35% | | 212745 | 752 | 28153 | 99 |
| OTB | GSA | 2008 | 272 | 27414. | 101 | 40 | 122 | 33 | 255 | 103 | 29% | | 101934 | 375 | 34752 | 128 |
| OTB | GSA | 2013 | 242 | 24178. | 100 | 40 | 124 | 29 | 415 | 168 | 29% | | 21964 | 91 | 33577 | 139 |
| OTB | GSA | 2014 | 241 | 23992. | 100 | 40 | 144 | 35 | 472 | 206 | 26% | | 71237 | 296 | | |
| **OTB** | **GS A22** | **AVER AGE** | **270** | **26377** | **98** | **40** | **122** | **28** | **363** | **152** | **31%** | **9%** | **136169** | **504** | **27455** | **102** |
| **LLD** | **GS A22** | **AVER AGE** | **120** | **2045** | **17** | **x** | **x** | **x** | **x** | **7** | **13%** | **7%** | **8990** | **75** | **1608** | **13** |
| OTB | GSA | 2010 | 310 | 12158 | 39 | 50D_40S | 207 | 13.5 | 570 | 251 | 23% | 3% | 64812 | 209 | 19977 | 64 |
| OTB | GSA | 2011 | 304 | 11949 | 39 | 50D_40S | 250 | 18 | 590 | 221 | 19% | 6% | 68022 | 224 | 24634 | 81 |
| OTB | GSA | 2012 | 285 | 11254 | 39 | 50D_40S | 250 | 20 | 597 | 221 | 18% | 2% | 59212 | 208 | 19411 | 68 |
| OTB | GSA | 2013 | 277 | 10792 | 39 | 50D_40S | 255 | 15 | 530 | 239 | 19% | 5% | 52690 | 190 | 21649 | 78 |
| OTB | GSA | 2014 | 277 | 10810 | 39 | 50D_40S | 211 | 16 | 444 | 237 | 28% | 4% | 57617 | 208 | 23722 | 86 |
| **OTB** | **GS A9** | **AVER AGE** | **291** | **11393** | **39** | **50D_40S** | **235** | **17** | **546** | **234** | **21%** | **4%** | **60471** | **208** | **21878** | **75** |
| PGP | GSA | 2010 | 1374 | 3630 | 3 | | 70 | 3 | 450 | 29 | 4% | 1% | 43769 | 32 | 6265 | 5 |
| PGP | GSA | 2011 | 1377 | 3614 | 3 | | 71 | 2 | 300 | 175 | 9% | 4% | 47386 | 34 | 8161 | 6 |
| PGP | GSA | 2012 | 1349 | 3554 | 3 | | 67 | 3 | 480 | 123 | 15% | 11% | 30846 | 23 | 7615 | 6 |
| PGP | GSA | 2013 | 1342 | 3469 | 3 | | 43 | 3 | 400 | 109 | 47% | 19% | 36595 | 27 | 8517 | 6 |
| PGP | GSA | 2014 | 1339 | 3411 | 3 | | 70 | 5 | 427 | 116 | 15% | 4% | 38856 | 29 | 4411 | 3 |
| ***PGP** | **GS** | **AVER** | **1356** | **3535** | **3** | | **64** | **3** | **411** | **110** | **18%** | **8%** | **39490** | **29** | **6994** | **5** |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(GTR+GNS+ PS)** | **A9** | **AGE** | | | | | | | | | | | | | | |
| PS | GSA | 2010 | 43 | 1832 | 42 | | 147 | 57 | 290 | 0 | 0.00 | 0.00 | 10751 | 249 | 1485 | 34 |
| PS | GSA | 2011 | 42 | 1710 | 41 | | 111 | 50 | 250 | 9 | 1.3 | 0.7 | 13170 | 315 | 2345 | 56 |
| PS | GSA | 2012 | 39 | 1666 | 43 | | 93 | 41 | 120 | 0 | 0.00 | 0.00 | 12886 | 331 | 2253 | 58 |
| PS | GSA | 2013 | 41 | 1705 | 41 | | 120 | 50 | 450 | 0 | 0.00 | 0.00 | 11312 | 274 | 1603 | 39 |
| PS | GSA | 2014 | 50 | 1792 | 36 | | 107 | 72 | 127 | 2 | 0.00 | 0.00 | 10912 | 218 | 1264 | 25 |
| **PS** | **GS A9** | **AVER AGE** | **43** | **1741** | **41** | | **116** | **54** | **247** | **2.2** | **0.3 %** | **0.1 %** | **11806** | **277** | **1790** | **42** |
| OTB | GSA | 2007 | 467 | 83736 | 179 | 40 mm | 275 | 50 m | 500 m | | | | 170200 | 364 | 49921 | 107 |
| OTB | GSA | 2008 | 469 | 72701 | 155 | 40 mm | 275 | 50 m | 500 m | | | | 134494 | 287 | 55473 | 118 |
| OTB | GSA | 2009 | 460 | 70934 | 154 | 40 mm | 375 | 50 m | 700 m | 274 | 27% | 9% | 136399 | 297 | 37112 | 81 |
| OTB | GSA | 2010 | 471 | 76393 | 162 | 40mm | 425 | 50 m | 800 m | 322 | 11% | 0% | 139839 | 297 | 46535 | 99 |
| OTB | GSA | 2011 | 438 | 74936 | 171 | 40mm | 348 | 45 m | 650 m | 321 | 23% | 4% | 134820 | 308 | 52144 | 119 |
| OTB | GSA | 2012 | 414 | 78266 | 189 | 40mm | 345 | 40 m | 650 m | 334 | 14% | 4% | 111480 | 269 | 37271 | 90 |
| OTB | GSA | 2013 | 403 | 73109 | 181 | 40mm | 305 | 10 m | 600 m | 359 | 21% | 4% | 104289 | 259 | 38171 | 95 |
| **OTB** | **GS A16** | **AVER AGE** | **446** | **75725** | **170** | **40** | **335** | **42.1** | **629** | **322** | **19%** | **4%** | **125365** | **286** | **42247** | **97** |
| OTB | GSA | 2009 | | | | | | | | 36 | 4% | 2% | | | | |
| OTB | GSA | 2010 | | | | | | | | 38 | 5% | 1% | | | | |
| OTB | GSA | 2011 | 542 | 31321 | 58 | SM40 | 100 | 50 | 800 | 42 | 13% | 12% | 108742 | 201 | 45774 | 84 |
| OTB | GSA | 2012 | 513 | 29833 | 58 | SM40 | 100 | 50 | 800 | 36 | 16% | 19% | 94877 | 185 | 42625 | 83 |
| OTB | GSA | 2013 | 490 | 28644 | 58 | SM40 | 100 | 50 | 800 | 38 | 19% | 18% | 80144 | 163 | 40129 | 82 |
| OTB | GSA | 2014 | 485 | 29045 | 60 | SM40 | 100 | 50 | 800 | 41 | 17% | 13% | 80085 | 165 | 39883 | 82 |
| **OTB** | **GS A6** | **AVER AGE** | **508** | **29711** | **59** | **SM40** | **100** | **50** | **800** | **39** | **14%** | **13%** | **90962** | **179** | **42103** | **83** |

The diversity of fishing gears studied, allowed for identifying fisheries prone to discarding. Active gears, such as trawlers clearly stood out, both in the discarding amounts as well as the number of taxa/species affected by their activities. The extended depth ranges that trawlers operate are also a reason for interacting with a larger part of the marine biota.

On the other extreme can be found the purse seiners, which due to their selective nature, exhibit insignificant levels of discarding both in quantities as well as taxa/species affected.

In between, we can place the small scale fisheries (SSF) using passive gears such as nets. Although they demonstrate discarding rates lower than active gears, the very large size of the SSF fleets may actually have a sizeable cumulative effect on the marine environment. This effect is also concentrated on the narrow coastal zone, which already faces extreme pressure by various anthropogenic activities, other than fishing.

Of interest is the fact that Italian fleets discard less MLS/MCRS regulated species (as a % of total catch) in comparison with the remaining fleets. On the other hand, discards of the Catalan trawler fleet are largely due to MLS regulated species.

Going into more detail, fishing depth was positively related to the number of taxa/species affected by discarding. Greater depths usually host less non-commercial species than the continental shelf. There was a positive relationship between vessel capacity (expressed in tonnage) with both discarding percentages as well as species/taxa discarded. Moreover, vessels being financially 'successful', achieving higher revenues, were also more likely to discard. Large “energivorous” vessels were also discarding intensively; fuel consumption was positively associated to discarding rates.

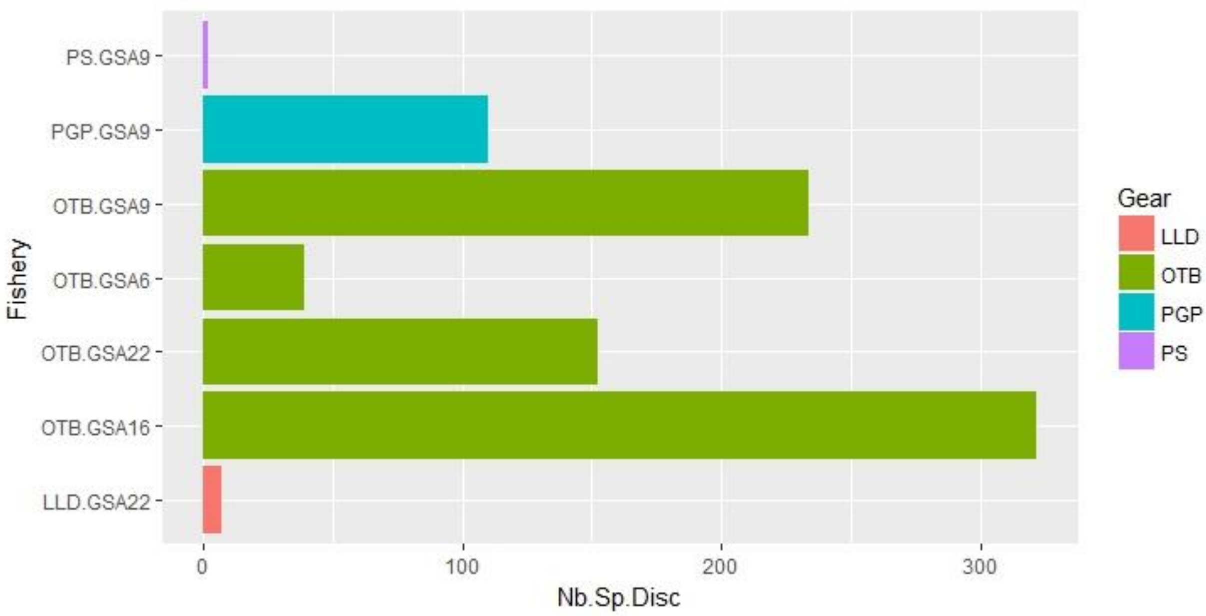
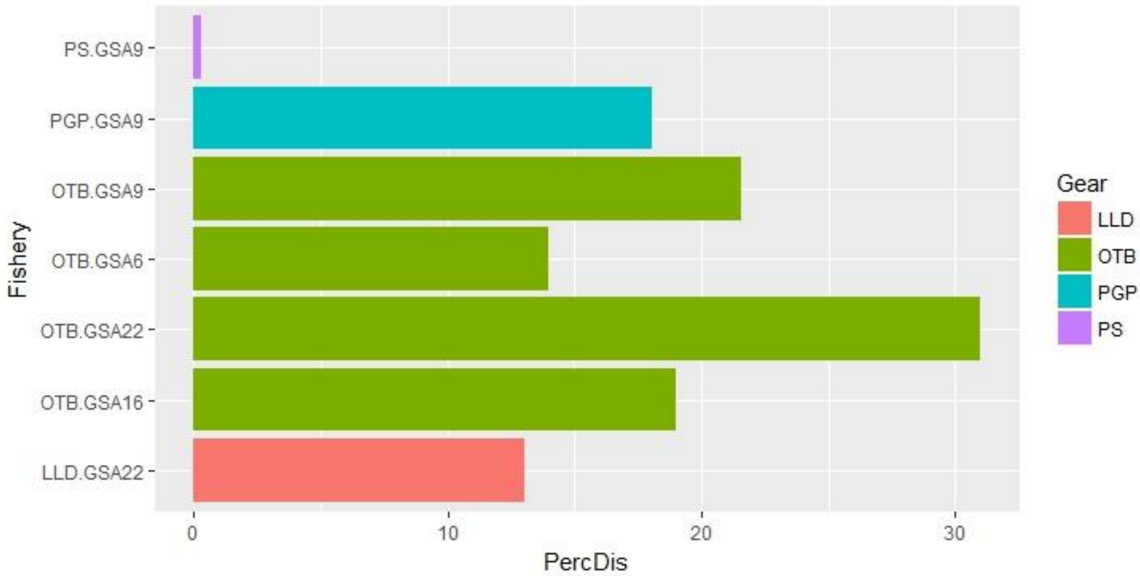



**Fig.5.d.1.** Number of species discarded (bottom) by fishing gear and geographical area



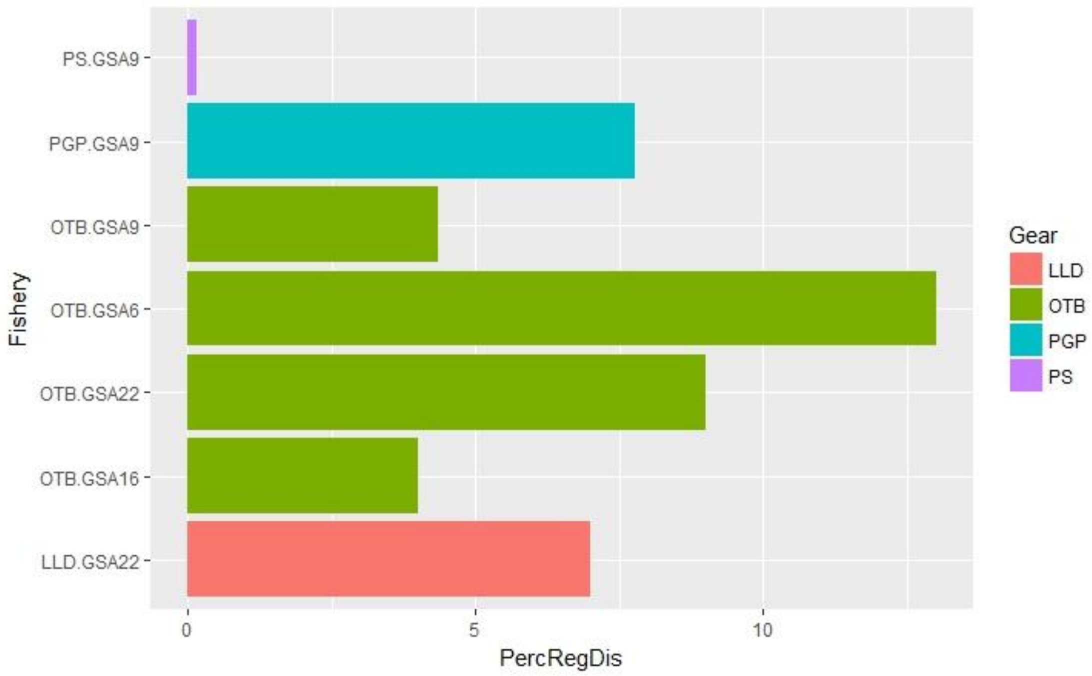




**Fig.5.d.2.** Percentage of total catch discarded (top) and catch of regulated species discarded (bottom) by fishing gear and geographical area

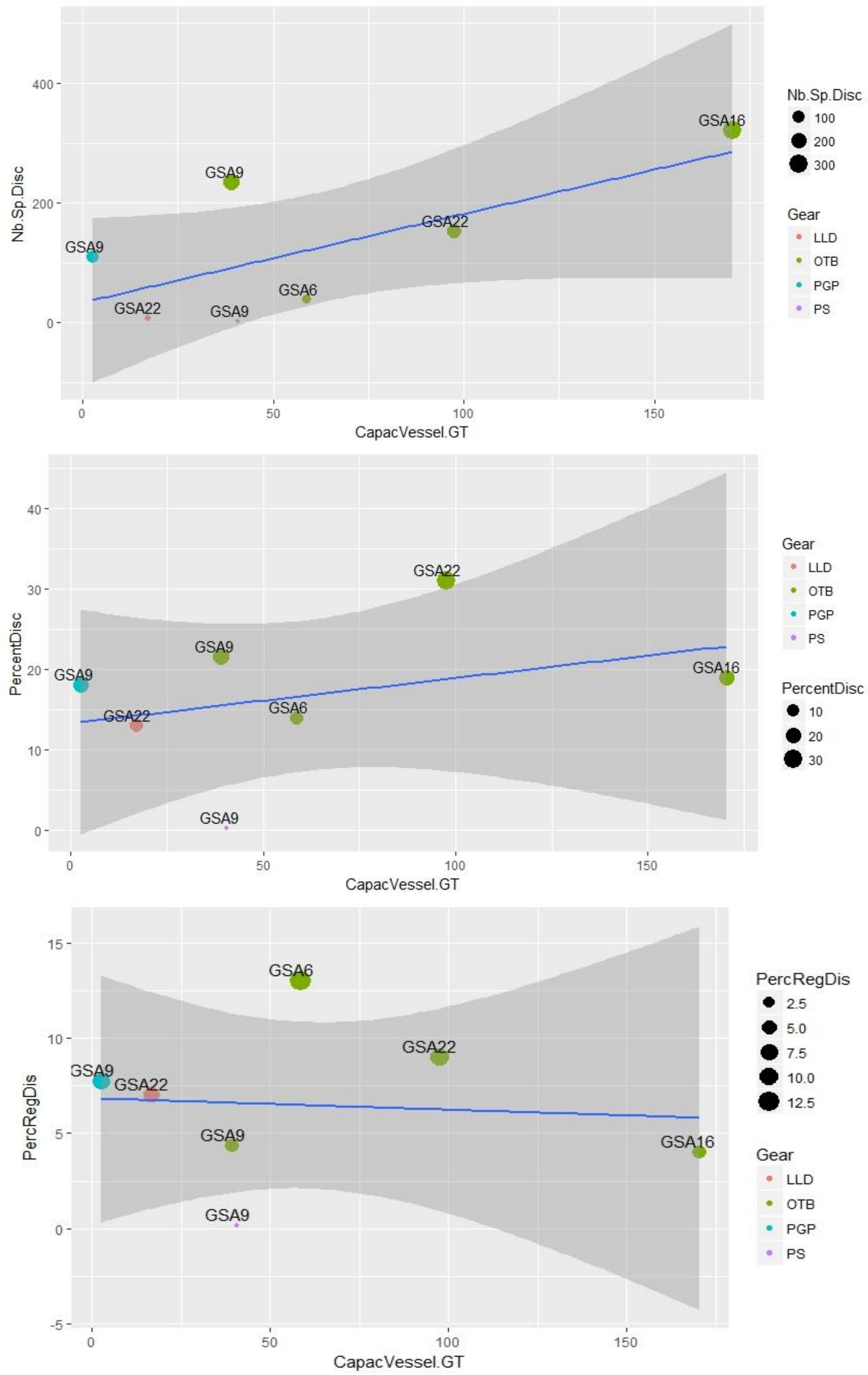
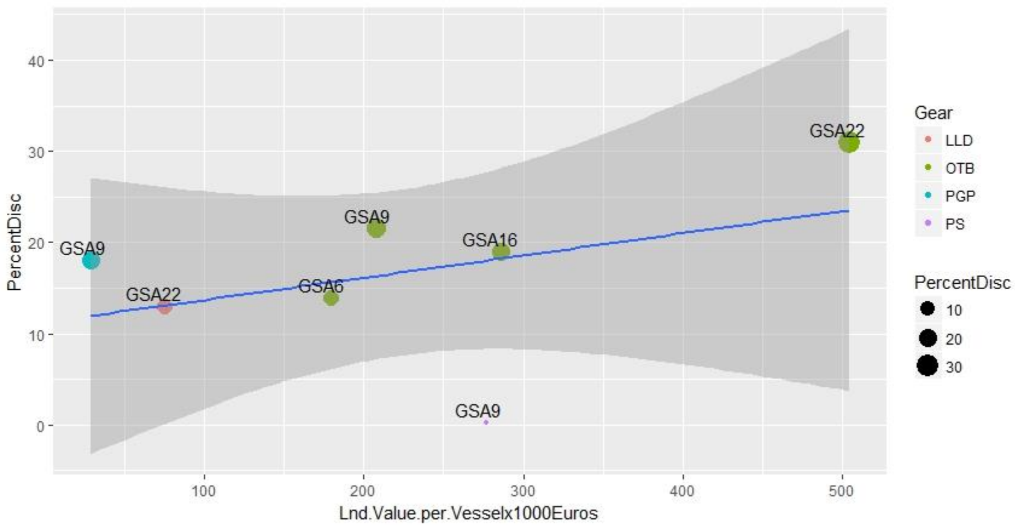



**Fig.5.d.3.** Vessel capacity (GT) regressed upon number of species discarded, Percentage of total catch discarded (top) and Percentage of catch of regulated species discarded (bottom) by fishing gear and geographical area



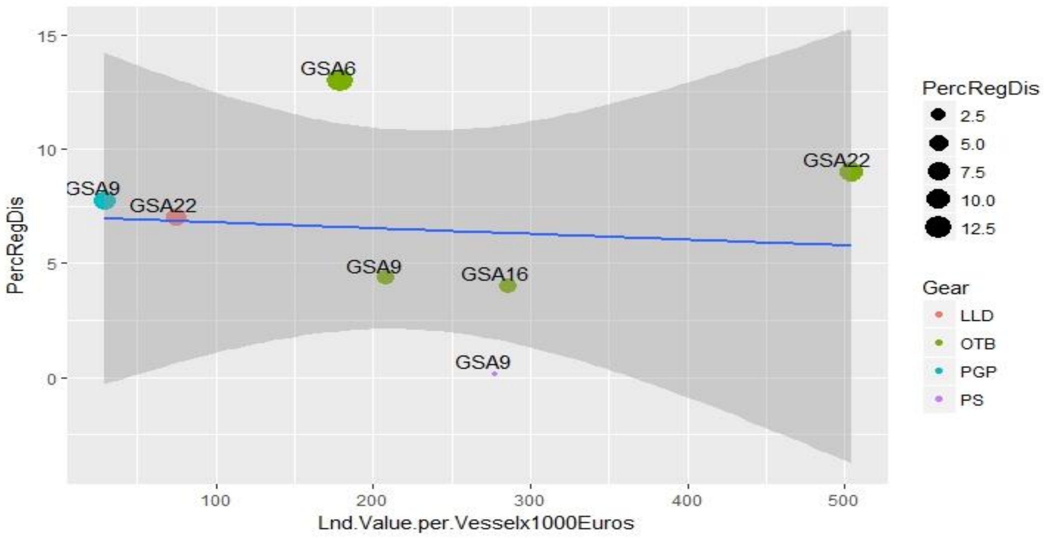




**Fig.5.d.4.** Landings value per vessel (x1000 €) regressed upon Percentage of total catch discarded (top) and Percentage of catch of regulated species discarded (bottom) by fishing gear and geographical area

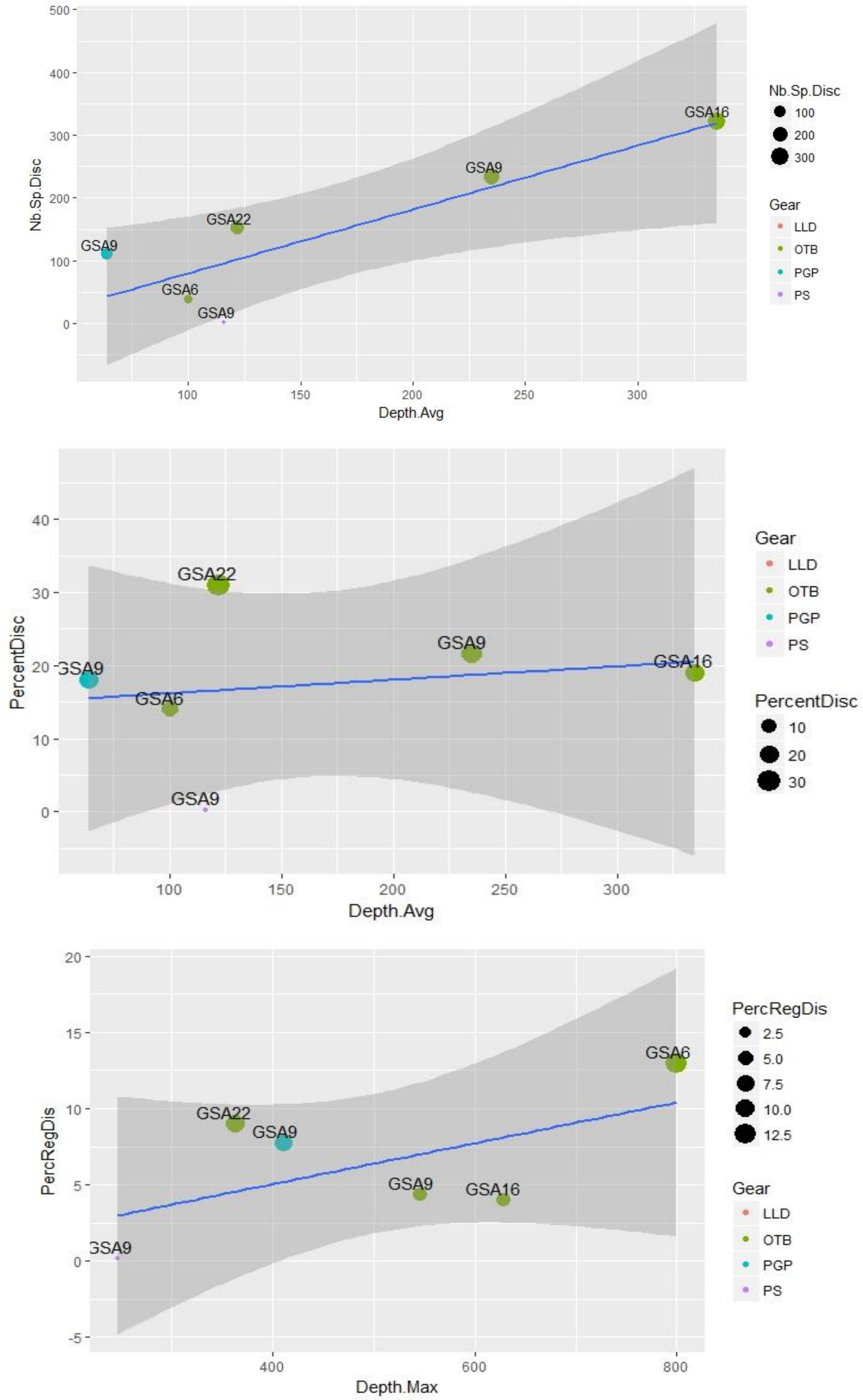



**Fig.5.d.5.** Fishing depth (m) regressed upon Number of species discarded (top), percentage of total catch discarded (mid) and percentage of catch of regulated species discarded (bottom) by fishing gear and geographical area

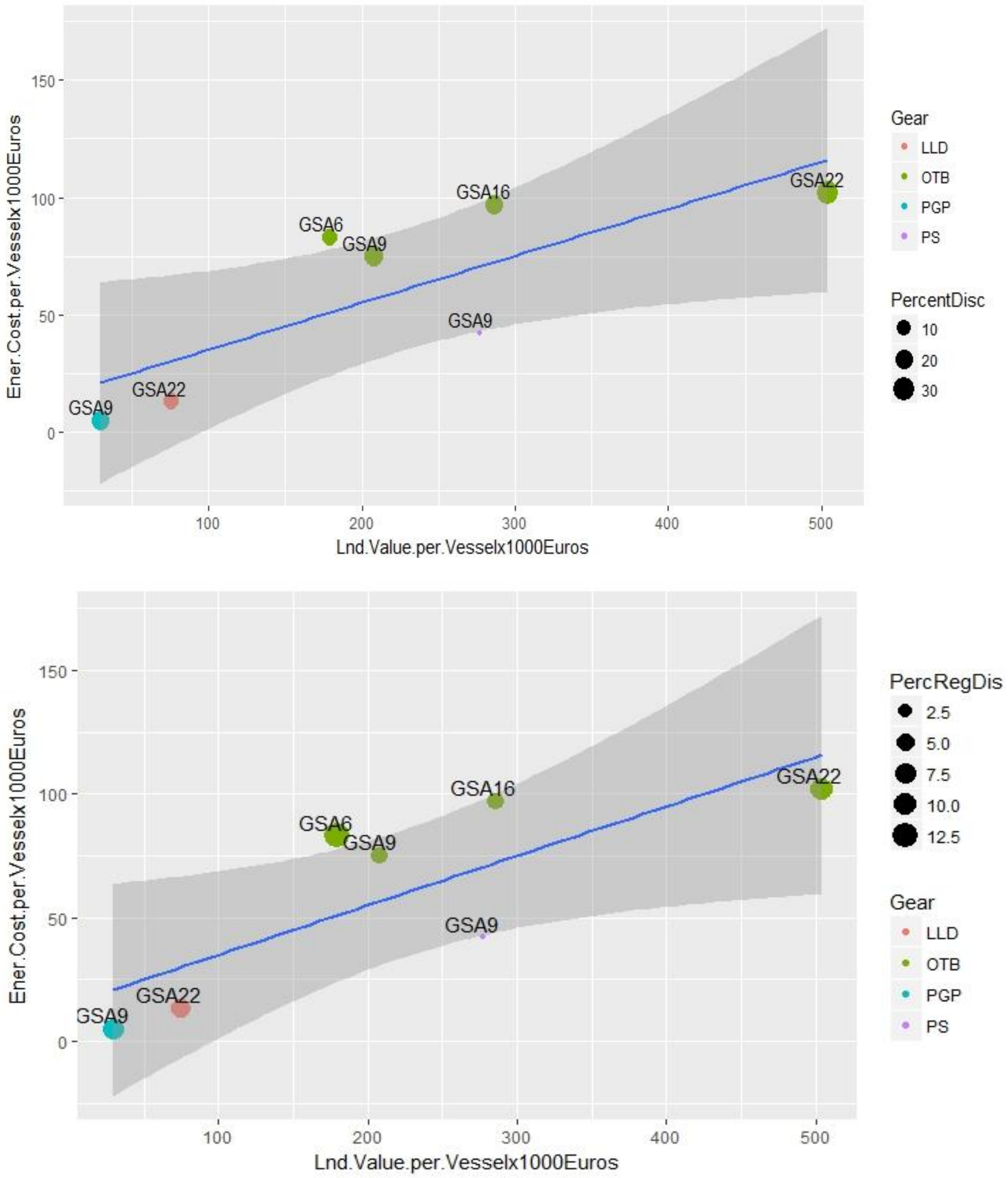



**Fig.5.d.6.** Landings value per vessel (x1000 €) regressed upon Energy Costs per vessel (x1000€) with an indication of Percentage of total catch discarded (top) and Percentage of catch of regulated species, by fishing gear and geographical area

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