

# Estimates on Cephalopods Discards by Spanish NE Atlantic Trawl Fishing Fleets

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## Abstract

Yearly cephalopods discard estimations for Spanish trawl fleets operating in Northeast Atlantic area (ICES *VI*, *VII*, *VIII<sub>c</sub>* and *IX<sub>a</sub>*) over the period 2003-2010 are presented. Estimations are aggregated from métier to fishing ground level. Only information for the most important species in terms of discarded biomass and those included in the Data Collection Framework directive are presented. Squid species belonging to the family *Ommastrephidae* and the *Octopodidae* *Eledone cirrhosa* were the most discarded species in the northern fishing grounds, nevertheless volume discarded of those species are much higher in ICES Sub-area *VI – VII* than in Divisions *VIII<sub>c</sub>* and *IX<sub>a</sub>* north. Very low discard values were observed in ICES Division *IX<sub>a</sub>* south (Gulf of Cádiz), being *Octopus vulgaris* and *Eledone moschata* the most discarded species.

Keywords: Cephalops, Discards, Trawl, NE Atlantic.

## 1 Introduction

Spanish data on cephalopods discards (from the Instituto Español de Oceanografía (IEO)) have never been provided to ICES WGCEPH in the past.

Information herein presented have been obtained by the ‘Spanish Discards Sampling Programme’ for Otter Botton Trawlers (OTB) and Pair Trawlers fleets (PTB), covering ICES Subareas *VI-VII*, and Divisions *VIII<sub>c</sub>* and *IX<sub>a</sub>*. The programme started in 1988, with annual discontinuity until 2003, year of implementation of the Data Collection Framework (table 1).

Data series reveal cephalopods as common by-catches for the sampling fleets operating in the North East Atlantic Region. Once onboard, their sorting into marketable/discard fractions not always follows a clear pattern, and the skipper decisionmaking have described by the observers to be dependent on species, season, size, and many other factors acting alone or interacting each others.

The most common species found in discard fractions are squids species belonging to the family *Ommastrephidae*, such as *Illex coindetii* (Verany, 1839), or *Todaropsis eblanae* (Ball, 1841), and species representative to the family *Octopodidae* such as *Eledone cirrosha* (Lamarck, 1798) in the northern fisheries, and *Eledone moschata* (Lamarck, 1798) in the Gulf of Cádiz. Many other species, including deep species have been recorded during the onboard sampling, but their

rare presence give low discard amounts once data is raised to fleet level.

The main objective of this working document is to provide information of mean kg/trip of all caught and discarded species of cephalopods and also a selection of the most discarded cephalopods species caught by Spanish fleets operating in ICES Subareas *VI* and *VII* and Divisions *VIII<sub>c</sub>* and *IX<sub>a</sub>*. Data presented are only for the period with no discontinuity; 2003 to 2010. Total biomass discarded in 2011 are not presented due to no availability of total fleet effort information.

Year	Project
1988-1989	National Project
1994	EC Project: Pem/93/005
1997	EC Project: 95/ 094
1999-2000	EC Project: 98/095
2001	EC Project: 99/063
2003-2012	DCF

Table 1: Summary of funded projects which have supported the Spanish Discards Sampling Programme

## 2 Material and methods

### 2.1 Sampling strategy

The sampling strategy and the estimation methodology used in the ‘Spanish Discards Sampling Programme’ has been little modified since 1988, and since 2003 follows the guidelines established by ICES (ICES, 2003; ICES, 2007).

The observers-on-board programme is based on a hierarchical sampling design, applied to stratas defined by two dimensions. Year was considered the strata unit for the temporal dimension until 2009, when the DCF asked for quarterly estimates. Herein results are organised and presented at yearly basis. The second sampling dimension is technical, and the strata unit is the Métier. In regards to the sampling units, trips (the Primary Sampling Unit [PSU]) are randomly or quasi-randomly selected from the bidimensional strata. Once onboard, the observer systematically select hauls for sampling, (the Secondary Sampling Unit [SSU]) when the total number of hauls is expected to be high during the sampled trip; otherwise, all hauls are sampled. The Ultimate Sampled Unit (USU) is the numbers of individuals by cephalopods species found in discard sample.

Only trawl fleet information is used in this document. Other fleets (i.e. long line fleet) were evaluated, showing low cephalopods discards along the areas under study (Pérez et al., 1996). Gillnet discard information is being obtained since 2008, but the time series available has been considered too short to be presented in the present document.

### 2.2 Fleets stratification

Fishing area, gear and target species are the auxiliary covariates used to stratify fleets into métiers. Two Spanish trawl métiers are defined in the ICES Subareas *VI* and *VII*:

- OTB\_DEF\_70\_99\_0\_0 trips targeting Megrin, Monk and Hake

- OTB\_DEF\_100.119.0.0 trips targeting Hake and Monk

More complex structure is found for the Spanish trawl fleet operating in ICES Divisions  $VIII_c$  and  $IX_a$  north :

- OTB\_DEF\_>=55.0.0: trips targeting a mixed of demersal species using conventional OTB gears
- OTB\_MPD\_>=55.0.0: trips targeting a mixed of pelagics and demersal species using high vertical opening OTB gears
- PTB\_DEF\_>=55.0.0: trips targeting demersal species using bottom pair trawls

Finally, only one métier is defined for the ICES Division  $IX_a$  south :

- OTB\_MCD\_>=55.0.0: trips targeting demersal species using conventional OTB gear

Discard estimates by métier have been aggregated into fishing ground level, in order to present total discards by the whole Spanish trawl fleets operating in ‘Western Irish waters & Rockall bank’ (Subareas  $VI$  and  $VII$ ) , ‘north Iberian waters’ ( Divisions  $VIII_c$  and  $IX_a$  north) and Gulf of Cádiz ( Division  $IX_a$  south) separately.

## 2.3 Sampling scheme & Raising procedures

Let  $h_{ij}$  be the  $j$ -th ( $j = 1, \dots, J$ ) sampled haul in sampled trip  $i$  ( $i = 1, \dots, t$ ) and  $d_{ij}^s$  be a random sample drawn from the total discard volume ( $d_{ij}$ ) in  $h_{ij}$ . Let

$$r_{ij} = \frac{d_{ij}}{d_{ij}^s} \quad (1)$$

be the ratio of the sample weight to the total discard weight.

For a given species, let  $f_{ijk}$  be the  $k$ -th ( $k= 1, \dots, n$ ) sampled individual in  $d_{ij}^s$ . Total individuals in  $d_{ij}^s$  is denoted as  $F_{ij} = \sum_{k=1}^n f_{ijk}$ . Once counted,  $F_{ij}$  is weighed by using high precision dynamometers to obtain  $F_{ij}^w$ .

### 2.3.1 Trip level

To simplify the notation, further steps will be expressed in terms of numbers:

Let

$$y_{ij} = F_{ij} \times r_{ij} \quad (2)$$

be the estimated numbers of individuals discarded in haul  $j$ . The mean number of discarded in trip  $i$  is

$$\bar{y}_i = \frac{1}{J} \sum_{j=1}^J y_{ij} \quad (3)$$

with variance

$$Var(\bar{y}_i) = \frac{1}{J-1} \sum_{j=1}^J (y_{ij} - \bar{y}_i)^2 \quad (4)$$

if  $J$  is the total number of hauls carried out in trip  $i$ , then the estimated total discards (in numbers) is

$$Y_i = \sum_{j=1}^J y_{ij} \quad (5)$$

else,

$$Y_i = \bar{y}_i \times H_i \quad (6)$$

with  $H_i$  being the total number of hauls (sampled + unsampled). The variance associated to (6) is

$$Var(Y_i) = \left(1 - \frac{J}{H}\right) \times H^2 \times \frac{Var(\bar{y}_i)}{J} \quad (7)$$

### 2.3.2 Métier level

Estimates at trip level can be raised to métier level by using different auxiliary variables, such as fishing effort (used for the northern métiers), or total landings (used for the Gulf of Cádiz métier). As an example, steps for raising by effort is showed below:

Mean discarded by trip is estimated to be

$$\bar{Y} = \frac{1}{t} \sum_{i=1}^t Y_i \quad (8)$$

with associated variance

$$Var(\bar{Y}) = \frac{1}{t-1} \sum_{i=1}^t (Y_i - \bar{Y})^2 \quad (9)$$

(8) and (9) can be raised to the total fishing effort of the fleet ( $T$ ), to obtain an estimation of total Discarded ( $D$ ) of the fleet:

$$D = \bar{Y} \times T \quad (10)$$

with variance

$$Var(D) = \left(1 - \frac{t}{T}\right) \times T^2 \times \frac{Var(\bar{Y})}{t} \quad (11)$$

- Raising by landings (Method used for métiers operating in ICES  $IX_a$  south )

## 2.4 Cephalopods species selection

A selection of species/groups of species were carried out using yearly mean species discards per trip information (eq.8). Only the selected species/groups estimations are raised to fleet (eq.10). The species selection criterion were;

- Species or groups of species representing  $\sim 90\%$  of interannual cephalopods discards.

- Species not selected by the first criterion but included in the Data Collection Framework (DCF) list of target species for sampling.

The criterion were applied separately for every fishing ground. Taxonomic difficulties to distinguish species onboard caused the aggregation of species into higher level taxon, such as family.

### 3 Results

#### 3.1 Trip population and sampling coverage

Table 2 shows fishing effort of the fleets (T) sampled trips (t), sampling coverage (%),  $(\frac{t}{T}) \times 100$  and total number of sampled hauls (h). In average,  $1221 \pm 7$  trips were yearly performed by the fleet operating in the Western Irish waters & Rockall bank. The program covered around 1% of the total trips per year, increasing to 1.2 in the last two years. Concerning the north Iberian waters fishing activity, a yearly average of  $16701.6 \pm 379.3$  trips were carried out by the fleet for the same period. It can be noted a steady increase in sampling coverage from 0.2% to  $\sim 0.5\%$  in the last two years. Fleet effort for the Gulf of Cádiz yield high interannual  $23834 \pm 1910$  value, being the sampling coverage ( $\sim 0.1\%$ ) lower than the other fishing grounds (table 2) .

Fishing Ground	Year	T	t	%	h	
Western Irish waters & Rockall bank (VI-VII)	2003	1275	9	0.70	369	
	2004	1315	11	0.80	400	
	2005	1297	10	0.80	337	
	2006	1293	13	1.00	376	
	2007	1322	12	0.90	368	
	2008	1147	11	1.00	353	
	2009	1206	15	1.20	428	
	2010	1100	13	1.20	382	
	north Iberian waters (VIII,IXa north)	2003	18523	46	0.20	167
		2004	21257	43	0.10	177
2005		12065	84	0.50	264	
2006		18749	68	0.30	211	
2007		18506	78	0.30	258	
2008		15328	82	0.40	256	
2009		15177	99	0.50	308	
2010		14008	94	0.50	295	
Gulf of Cádiz (Division IXa south)		2005	31962	21	0.06	47
		2006	25924	29	0.11	72
	2007	23744	28	0.12	59	
	2008	18675	18	0.09	58	
	2009	21072	21	0.10	56	
	2010	21631	23	0.10	57	

Table 2: Trip population (T),sampled trips (t), sampling coverage (%) and number of sampled hauls (h) by fishing ground and year.

#### 3.2 Species selection

Table 3 shows yearly kg/trip estimations of cephalopods discards ( $\bar{Y}$ ) in Sub-areas VI-VII. The most discarded species over the sampling period 2003-2010 was found to be *Illex coindetii*  $\bar{Y} = 855.6 \pm 176.8$ , followed by *Eledone cirrhosa*  $\bar{Y} = 650.1 \pm 142.8$  and *Todaropsis eblanae*  $\bar{Y} = 533.5 \pm 95.6$ . Difficulties to distinguish *Illex coindetii* and *Todaropsis eblanae* during the onboard sampling explain the high values found for *Ommastrephidae* (the family containing both species),  $\bar{Y} = 353.5 \pm 154.7$ . Hereafter, *Ommastrephidae* species will be integrated into this family record. Discards of *Eledone cirrhosa* and individuals belonging to the family *Ommastrephidae* represents  $\sim 92\%$  of total cephalopd discards in this area. Discards of species

included in the DCF (*Anex III*) represents low percentage relative to the global cephalopods discards per trip; *Loligo vulgaris* represents 1.4% , whereas *Sepia officinalis* and *Octopus vulgaris* represents only 0.2% each.

Cumulative percentage of interannual cephalopods discards per trip shows more species diversity within 90% in the north Iberian waters (table 4), containing up to 8 species or groups. *Eledone cirrhosa* is the most discarded species in average,  $\bar{Y} = 35 \pm 6.60$ . As in the northern ground, short finned squids belonging to the family *Ommastrephidae*, and the taxon *Ommastrephidae* itself, are represented within the quantile 90. *Rossia macrosoma* represents  $\sim 7\%$  of the total average, being the 3<sup>er</sup> species in importance  $\bar{Y} = 5.1 \pm 2.1$ , whereas unidentified species belonging to the subfamily (*Sepiolinae*) represents  $\sim 6\%$ . Concerning species included in DCF, the *Octopus vulgaris* importance in discard profile is higher than in the northern fishery, representing 3.5%. Same pattern is found for *Sepia officinalis* (1.6%). Discard amounts for *Loligo vulgaris* are negligible.

Cephalopods discards estimations per sampled trip from the Gulf of Cádiz (*IX<sub>a</sub>* South) fisheries are shown in table 5. Lower discards biomass are estimated in comparison to the northern fisheries. In general, species from the family *Octopodidae* represents  $\sim 85\%$  of cephalopods discards. *Octopus vulgaris*, the unique species under legal regulation (Minimum Landing Weight (MLW) = 1 Kilogram), is the most discarded species  $\bar{Y} = 1.27 \pm 1.09$  in the area. Personal observations indicates that MLW induces discard practices on the species. *Eledone moschata* present similar discard estimation with  $\bar{Y} = 1.13 \pm 0.89$ ; this species low commercial values contribute to discard it.

species	1994	1999	2000	2003	2004	2005	2006	2007	2008	2009	2010	$\bar{Y}$	$Error_{\bar{Y}}$	cum %
<i>Illex coindetii</i>	1072.60	171.80	524.30	814.60	497.20	364.70	447.00	1147.30	958.90	2439.50	973.20	855.60	176.80	32.80
<i>Eledone cirrhosa</i>	170.10	224.40	314.70	854.40	229.20	651.70	527.20	1031.50	850.10	1864.60	432.70	650.10	142.80	57.80
<i>Todaropsis eblanae</i>	417.00	385.60	593.40	1317.90	280.20	629.80	627.20	816.80	307.40	439.30	54.20	533.50	95.60	78.30
<i>Ommastrephidae</i>	0.00	0.00	27.30	0.00	519.30	1554.80	857.80	0.00	920.20	8.80	0.00	353.50	154.70	91.90
<i>Todarodes sagittatus</i>	76.20	0.00	5.10	38.00	57.50	160.40	37.90	18.30	475.60	130.00	0.00	90.80	39.70	95.40
<i>Loligo vulgaris</i>	56.90	0.00	0.00	26.30	5.50	18.00	15.30	195.70	31.10	2.70	44.50	36.00	16.10	96.80
<i>Sepiola</i> spp.	1.40	0.00	0.00	0.00	10.60	148.20	8.10	53.80	0.00	7.30	0.00	20.90	13.00	97.60
<i>Sepia orbignyana</i>	11.10	0.00	0.80	18.40	2.10	183.60	2.80	10.40	0.00	0.00	0.00	20.80	15.60	98.40
<i>Rossia</i> spp.	0.00	0.00	0.00	84.00	1.20	0.00	60.50	0.00	1.90	0.00	0.00	13.40	8.50	98.90
<i>Loligo</i> spp.	1.70	0.00	0.00	0.50	0.00	0.80	80.70	1.60	4.10	4.40	0.00	8.50	6.90	99.20
<i>Sepia officinalis</i>	0.00	0.00	2.50	16.50	1.10	0.90	39.30	0.50	4.00	0.30	0.00	5.90	3.50	99.40
<i>Octopus vulgaris</i>	16.90	0.00	0.00	0.00	0.00	44.10	0.00	0.00	0.00	0.00	3.80	5.90	3.90	99.60
<i>Octopus</i> spp.	2.70	0.00	0.00	0.00	8.00	14.90	17.00	0.00	0.00	0.00	0.00	3.90	1.90	99.70
<i>Rossia macrosoma</i>	7.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.50	0.00	0.00	3.50	2.70	99.80
<i>Loligo forbesi</i>	0.00	0.00	1.90	14.40	0.40	4.50	0.00	0.00	0.00	0.40	0.50	2.00	1.20	99.90
<i>Sepia</i> spp.	0.00	0.00	0.00	0.00	5.20	0.00	0.20	0.10	0.00	0.00	0.00	0.50	0.40	99.90
<i>Alloteuthis</i> spp.	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	1.60	0.00	0.20	0.10	99.90
<i>Sepia elegans</i>	0.10	0.00	0.00	0.10	0.00	0.40	0.00	0.40	0.00	0.00	0.00	0.10	0.00	99.90
<i>Sepietta oweniana</i>	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.10	0.10	99.90

Table 3: Mean kg/trip per year of cephalopoda discards in Spanish fleets operating in the Western Irish waters & Rockall bank.

### 3.3 Total fleet discard estimates

Yearly Estimations of the selected species discards for the northern fisheries are presented in terms of biomass for data series 2003-2010 (table 6), whereas discard estimations in terms of numbers are only available since 2007 (table 7).Estimations for the Gulf of Cádiz are presented for the period 2005-2010 in both cases (tables 8- 9). Biomass estimations present high CV values, ranging from 20.2% to 99.9%. *Ommastrephidae* is the most discarded cephalopods family in the Western Irish waters & Rockall bank fisheries exceeding 1400 tons in average for all sampled

Species	1994	1997	1999	2000	2003	2004	2005	2006	2007	2008	2009	2010	$\bar{Y}$	$Error_{\bar{Y}}$	cum %
Eledone cirrhosa	71.40	28.00	19.30	13.10	47.80	63.40	13.90	36.80	50.70	8.40	63.10	3.70	35.00	6.60	46.40
Todaropsis eblanae	5.00	42.70	0.00	7.00	6.00	0.70	58.50	0.40	6.10	16.30	5.50	0.30	12.40	5.20	62.80
Rossia macrosoma	14.20	16.00	0.00	0.30	12.50	0.00	0.00	0.00	0.30	17.80	0.00	0.00	5.10	2.10	69.60
Sepiolo spp.	0.30	0.00	0.00	0.30	0.00	4.00	17.80	0.80	24.40	0.10	0.00	0.00	4.00	2.30	74.90
Illex coindetii	0.80	6.00	4.30	10.00	6.10	2.90	0.50	1.40	4.00	0.00	2.00	0.00	3.20	0.80	79.10
Ommastrephidae	2.40	0.00	1.50	1.70	1.50	24.10	1.20	0.30	0.20	3.10	0.00	0.00	3.00	1.90	83.10
Octopus vulgaris	2.50	6.10	6.20	8.30	2.00	0.50	1.20	0.00	0.00	0.00	3.50	0.70	2.60	0.80	86.50
Todarodes sagittatus	0.20	15.60	0.00	0.00	1.30	6.90	0.00	0.00	0.00	0.00	0.30	0.00	2.00	1.30	89.10
Sepia spp.	0.20	15.60	0.00	0.00	1.30	6.90	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.30	91.70
Octopodidae	2.60	0.00	0.00	0.00	0.00	0.00	2.70	0.80	12.10	0.30	0.00	0.00	1.50	1.00	93.70
Sepia orbignyana	1.10	0.00	0.00	0.00	2.40	12.00	1.90	0.00	0.00	0.00	0.00	0.00	1.40	0.90	95.60
Sepia officinalis	0.20	0.00	0.00	0.00	2.90	0.00	3.10	7.30	0.00	0.20	1.00	0.20	1.20	0.60	97.20
Sepiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.40	0.00	0.00	0.00	0.50	0.50	97.90
Loligo vulgaris	0.00	0.40	0.00	0.00	0.10	0.10	4.60	0.20	0.00	0.40	0.20	0.20	0.50	0.40	98.60
Alloteuthis spp.	0.40	4.10	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.30	99.10
Sepiolo atlantica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	0.00	0.20	0.20	99.40
Alloteuthis media	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	99.50
Loligo forbesi	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	99.60
Rossia spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.60	0.10	0.00	99.70
Sepia elegans	0.60	0.10	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	99.80
Loligo spp.	0.30	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.10	0.00	99.90
Alloteuthis subulata	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.90

Table 4: Mean kg/trip per Year of Cephalopoda discards in Spanish fleets operating in the north Iberian waters.

years. It must be noted a marked decrease in terms of biomass discarded during 2010 for this species. *Eledone cirrosa* discards are estimated to be lesser than those obtained for *Ommastrephidae*, being the annual average estimated in  $\sim 500$  tons. Cephalops species included in the DCF list represent minor amounts compared to the most discarded ones.

Estimations for the north Iberian waters give lower values than those obtained for the western Irish waters & Rockall bank. Interannual discard estimate for the most discarded species in the area, *Eledone cirrosa*, represents 105 tons per years, while *Ommastrephidae* discard estimates is found to be  $\sim 71$  tons per year. Notable quantities of *Sepiolo spp.* discards were found only for years 2004, 2005 and 2007 whereas peaks of *Rossia macrosoma* discards biomass were found in years 2003 and 2008. DCF species discards were also found to be low, except for *Sepia officinalis* in 2006 (35.6 tons).

Species	2005	2006	2007	2008	2009	2010	$\bar{Y}$	$Error_{\bar{Y}}$	cum %
Octopus vulgaris	0.00	0.23	0.00	0.69	6.68	0.00	1.27	1.09	40.84
Eledone moschata	0.00	0.00	0.03	0.00	5.44	1.29	1.13	0.89	77.17
Alloteuthis spp	0.05	1.41	0.08	0.00	0.00	0.00	0.26	0.23	85.53
Eledone spp	0.00	0.00	0.00	1.05	0.00	0.00	0.18	0.18	91.32
Eledone cirrhosa	0.00	0.00	0.00	0.00	0.00	0.47	0.08	0.08	93.89
Sepia elegans	0.00	0.00	0.00	0.04	0.23	0.05	0.05	0.04	95.50
Alloteuthis media	0.00	0.00	0.00	0.00	0.17	0.10	0.05	0.03	97.11
Sepia officinalis	0.02	0.12	0.00	0.00	0.00	0.06	0.03	0.02	98.07
Sepiolo spp	0.11	0.00	0.00	0.00	0.00	0.00	0.02	0.02	98.71
Todaropsis eblanae	0.00	0.00	0.00	0.00	0.00	0.11	0.02	0.02	99.36
Illex coindetii	0.00	0.00	0.00	0.00	0.01	0.09	0.02	0.01	100.00
Sepia orbignyana	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	100.00
Loligo vulgaris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Ommastrephidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Todarodes sagittatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Table 5: Mean kg/trip per year of Cephalopoda discards in Spanish fleets operating in the Gulf of Cádiz fisheries

Only four species discard estimations are presented for the Gulf of Cádiz. In terms of biomass, *Octopus vulgaris* was the most discarded species, ranging between 25.8 and 235.1 tons in 2006 and 2009, respectively. This species discards show very high between-year variation, being 2005, 2007 and 2010 estimated to be 0. Discards of *Eledone mostacha*, the second most discarded species in terms of biomass, are reported since 2007 with a maximum values of 44.2 tons in 2009. *Alloteuthis spp* and *Sepia officinalis* showed very low discards, lower than 3.5 tonnes, with one peak of 27.5 tonnes in 2006, in both cases.

Fishing Ground	Species	2003	2004	2005	2006	2007	2008	2009	2010
Western Irish waters & Rockall bank (VI-VII)	Ommastrephidae	1828(27.8)	1066(30.7)	2067(50.1)	1281(44.4)	1585(27.1)	1673(31.2)	1837(29.2)	586(27.4)
	Eledone cirrhosa	615.7(52.1)	177.8(24.8)	430.2(42.1)	364.8(33.8)	790(21)	561.9(30.9)	1011(36.6)	290.2(20.2)
	Loligo vulgaris	21.2(98.3)	4.5(59.6)	14.5(49.3)	11.2(58.7)	158.4(61.8)	24.3(73.8)	2.2(56.9)	17.8(87.8)
	Sepia officinalis	15.9(52.6)	0.9(99.5)	0.7(99.6)	29.5(76.7)	0.4(97.4)	3(65.9)	0.3(72.7)	0(-)
north Iberian waters ( <i>VIII<sub>c</sub></i> , IXa North)	Octopus vulgaris	0(-)	0(-)	21.6(60.4)	0(-)	0(-)	0(-)	0(-)	2.7(99.4)
	Eledone cirrhosa	86.1(51.2)	155.4(53.4)	44.1(21.8)	189.9(52.9)	138.8(27.1)	20.6(31.5)	153.4(29.7)	54.8(27.9)
	Ommastrephidae	66(25)	214(56.6)	108(38.4)	29(39.9)	38(32.9)	57(46.2)	49(29.3)	21(26.4)
	Sepiola spp.	0(-)	33.6(61.9)	50.9(58.8)	4.5(64.4)	57.3(42.2)	0.1(99.6)	0(-)	0.7(99.7)
	Rossia macrosoma	32(52.5)	0(-)	0(-)	0(-)	1.8(72.7)	53.8(65.5)	0(-)	0(-)
	Sepia officinalis	9.2(62.1)	0.4(99.9)	5.3(60.3)	35.6(62.1)	0.1(99.8)	0.6(91.9)	1.9(41.6)	1(48.4)
	Octopus vulgaris	8.3(82.8)	4(70)	3.2(62.8)	0(-)	0(-)	0.5(84.9)	3.1(97.4)	4.1(44.2)
	Loligo vulgaris	0.1(99.9)	1(73.8)	4.8(66.4)	0.7(58.4)	0.3(53.3)	1.2(50.4)	3.8(40.2)	2.2(30.1)

Table 6: Biomass discarded (tons) of Cephalopoda species and CV of estimations (brackets) obtained in the northern fishing grounds

Fishing Ground	Species	2007	2008	2009	2010
Western Irish waters & Rockall bank (VI-VII)	Ommastrephidae	12257.1(35.9)	13921.2(26.7)	7302.8(23.9)	3038.4(29.7)
	Eledone cirrhosa	4654.5(17.2)	4138.9(37.8)	3218.4(28.5)	1751.3(19.1)
	Loligo vulgaris	2176.6(55.9)	879.4(75.5)	31.6(66)	245.7(91.5)
	Sepia officinalis	2.1(99.5)	72.7(70.9)	14(71.8)	0(NA)
north Iberian waters ( <i>VIII<sub>c</sub></i> , IXa north)	Octopus vulgaris	0(-)	0(-)	0(-)	11.5(99.4)
	Ommastrephidae	584(42.5)	1331.8(61.4)	894.6(44.3)	369.5(31.4)
	Rossia macrosoma	136.2(73.2)	2697.7(57.1)	0(-)	0(-)
	Eledone cirrhosa	538.1(27.7)	217.7(39.2)	903.4(27.9)	507.9(38.3)
	Sepiola spp.	987.7(47.6)	1.4(99.7)	0(-)	7.3(99.7)
	Sepia spp.	487.6(98.7)	0(-)	0(-)	0(-)
	Sepia officinalis	9.7(99.8)	16.5(95)	59.9(35.5)	45.7(54.8)
	Loligo vulgaris	14.4(68.6)	17.6(65.9)	34.7(41)	39.7(30.7)
Octopus vulgaris	0(-)	1.9(109.9)	2.2(91.1)	41.7(61.8)	

Table 7: Numbers discarded (thousands) of Cephalopoda species and CV of estimations (brackets) obtained in the northern fishing grounds

Fishing Ground	Species	2005	2006	2007	2008	2009	2010
Gulf of Cádiz (Division IXa south)	Octopus vulgaris	0 (-)	25.8 (79.4)	0 (-)	153.9 (23.7)	235.1 (80.1)	0 (-)
	Eledone moschata	0 (-)	0 (-)	0.9 (99.3)	6.3 (83.0)	44.2 (17.1)	22.6 (67.6)
	Alloteuthis spp	3.5 (85.9)	27.6 (99.4)	3.2 (90.8)	0 (-)	1.8 (43.3)	2.1 (27.0)
	Sepia officinalis	1.18(66.1)	27.47 (93.4)	0(-)	0(-)	0(-)	3.50 (60.0)

Table 8: Biomass discarded (tons) of Cephalopoda species and CV of estimations (brackets) obtained in the Gulf of Cádiz fisheries



Fishing Ground	Species	2005	2006	2007	2008	2009	2010
Gulf of Cádiz (Division IXa south)	<i>Octopus vulgaris</i>	0 (-)	126.6 (13.6)	0 (-)	423.5 (33.2)	648.2 (68.3)	0 (-)
	<i>Eledone moschata</i>	0 (-)	0(-)	8.7 (-)	53.5 (71.9)	424.1 (78.8)	303.7 (114.0)
	<i>Alloteuthis</i> spp	692.6 (141.6)	5713.1 (146.9)	643 (128.8)	0 (-)	579.3 (94.8)	381.9 (77.4)
	<i>Sepia officinalis</i>	32.73(-)	938.99 (85.5)	0(-)	0(-)	0(-)	111.40 (56.9)

Table 9: Numbers discarded (thousands) of Cephalopoda species and CV of estimations (brackets) obtained in the Gulf of Cádiz fisheries

### 3.4 Exploratory Data analysis (EDA)

Maps presented in figures 1 to 7 show spatio-temporal discard patterns for the most discarded species. Color points indicates class intervals defined by discard amounts in terms of biomass (Kg/haul). Interval breaks have been generated by *Kmeans* technique. Black crosses represent sampled hauls with no catch for the plotted species. Maps presented in figures 1 and 2 indicates a wide distribution of *Ommastrephidae* and *Eledone cirrhosa* discards along the Celtic sea and Porcupine bank, and a negligible discard volume are found in the rockall bank. Same species are mapped in figures 3 and 4 for the north Iberian waters fishing ground, showing no clear pattern neither in spatial nor in temporal terms. The low cephalopods discard amounts estimated for the Gulf of Cádiz explain the prevalence of light colored points (figures 5 to 7 ).

Figures 8 to 10 show correlations between discard amounts at haul level (KD) and physical haul characteristics. They can be interpreted as it follows: shape visually indicates degree of correlation between pairs; The more narrower the ellipse, the more correlation between pairs. In the other hand, color and tilt orientation of the ellipse indicate the sign of the correlation. Pairs between KD with the rest of variables included in the analysis show low correlation for all species and fishing grounds.

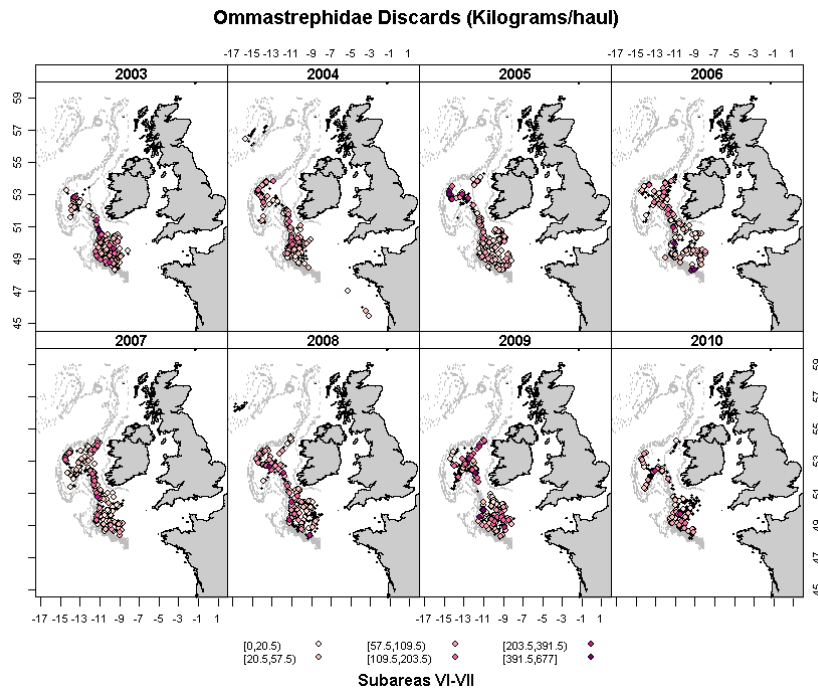


Figure 1: Estimated discards of species from family *Ommastrephidae* at haul level in the western Irish waters & Rockall bank fisheries

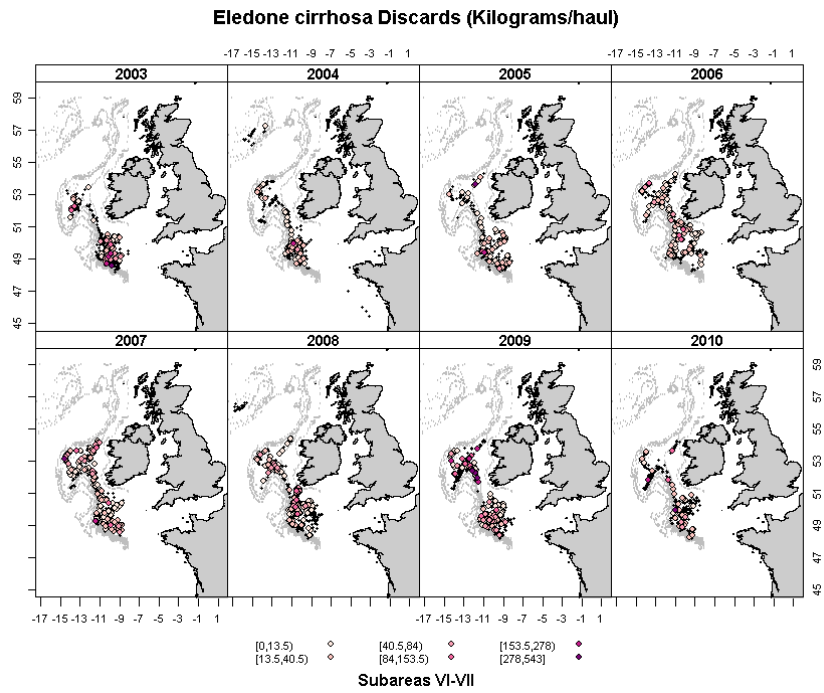


Figure 2: Estimated discards of *Eledone cirrhosa* at haul level in the western Irish waters & Rockall bank fisheries

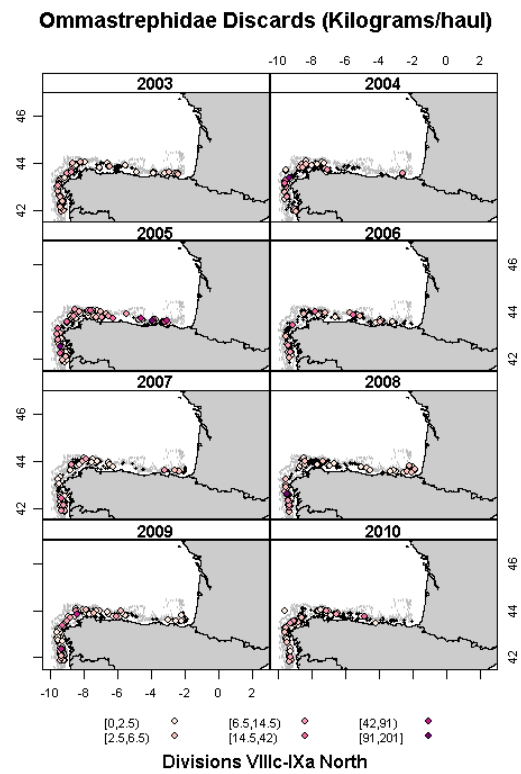


Figure 3: Estimated discards of species from family *Ommastrephidae* at haul level in the north Iberian waters fisheries

**Eledone cirrhosa Discards (Kilograms/haul)**

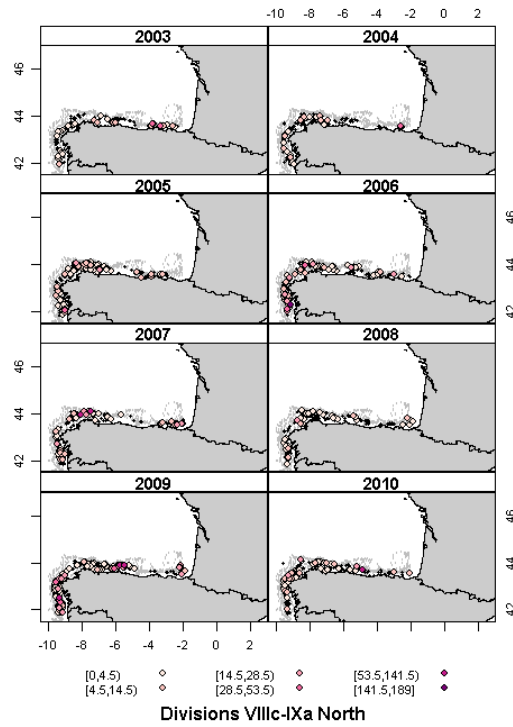


Figure 4: Estimated discards of *Eledone cirrhosa* at haul level in the north Iberian waters fisheries

**Octopus vulgaris Discards (Kilograms/haul)**

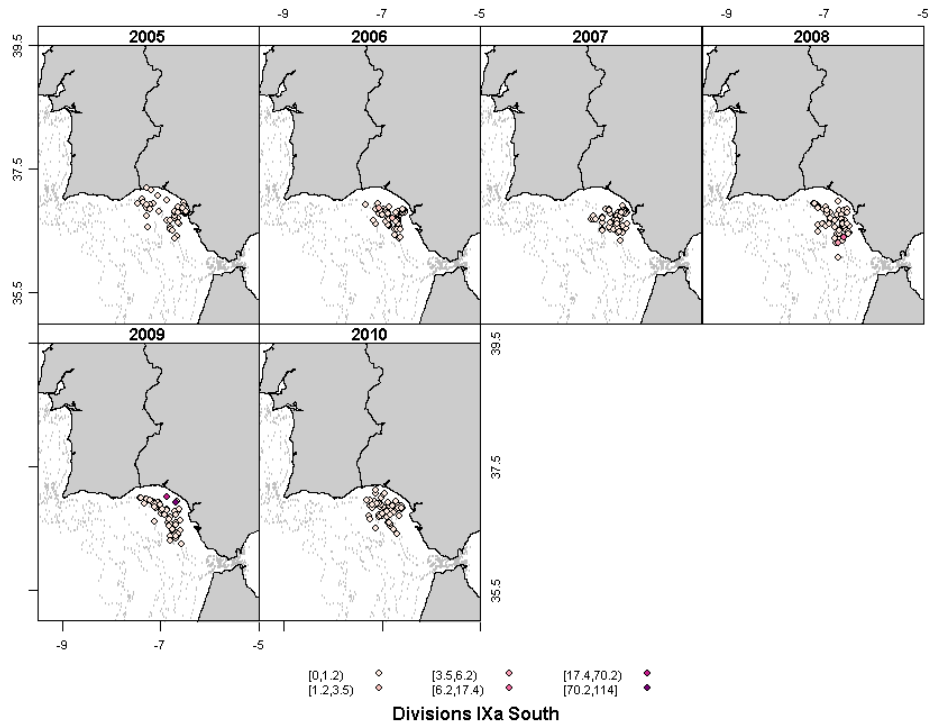


Figure 5: Estimated discards of *Octopus vulgaris* at haul level in the Gulf of Cádiz fisheries

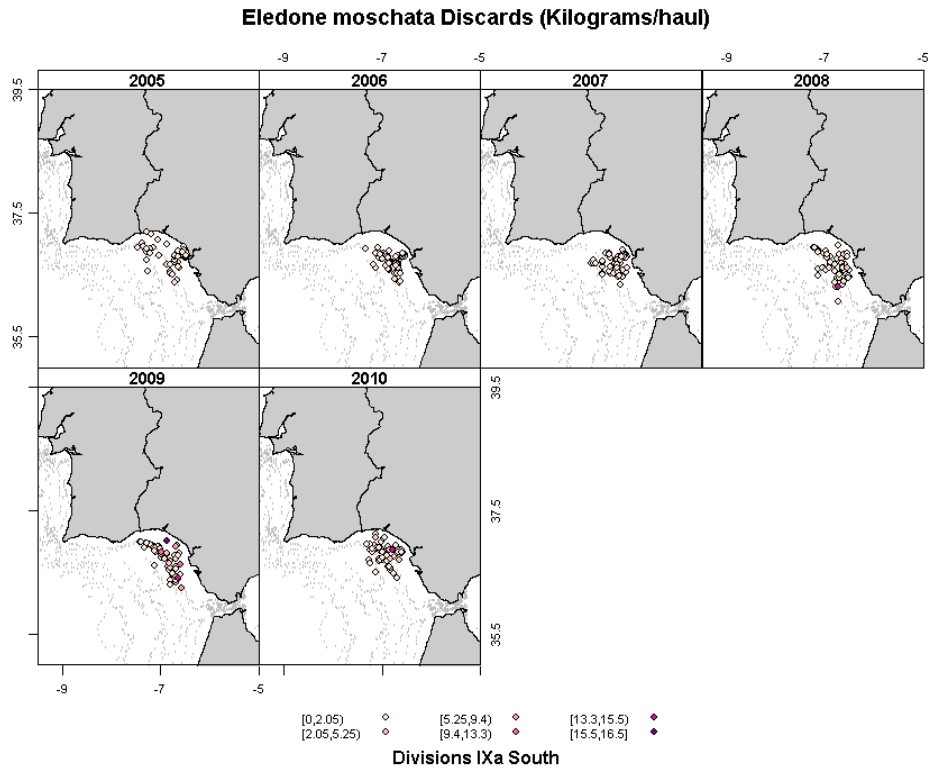


Figure 6: Estimated discards of *Eledone moschata* at haul level in the Gulf of Cádiz fisheries

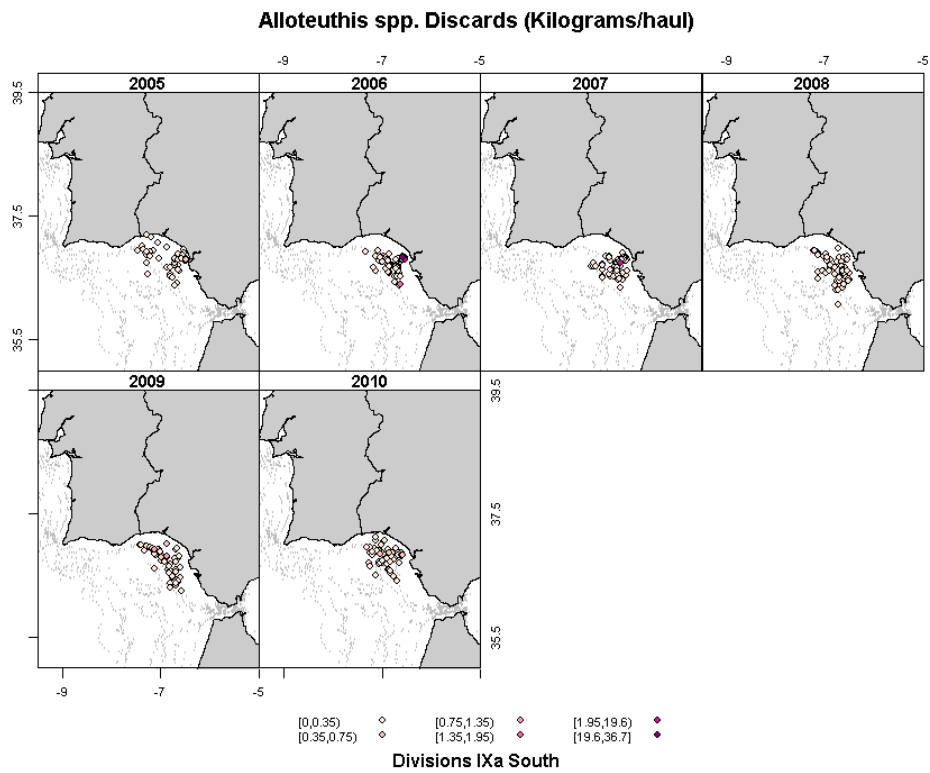


Figure 7: Estimated discards of *Alloteuthis* spp. at haul level in in the Gulf of Cádiz fisheries

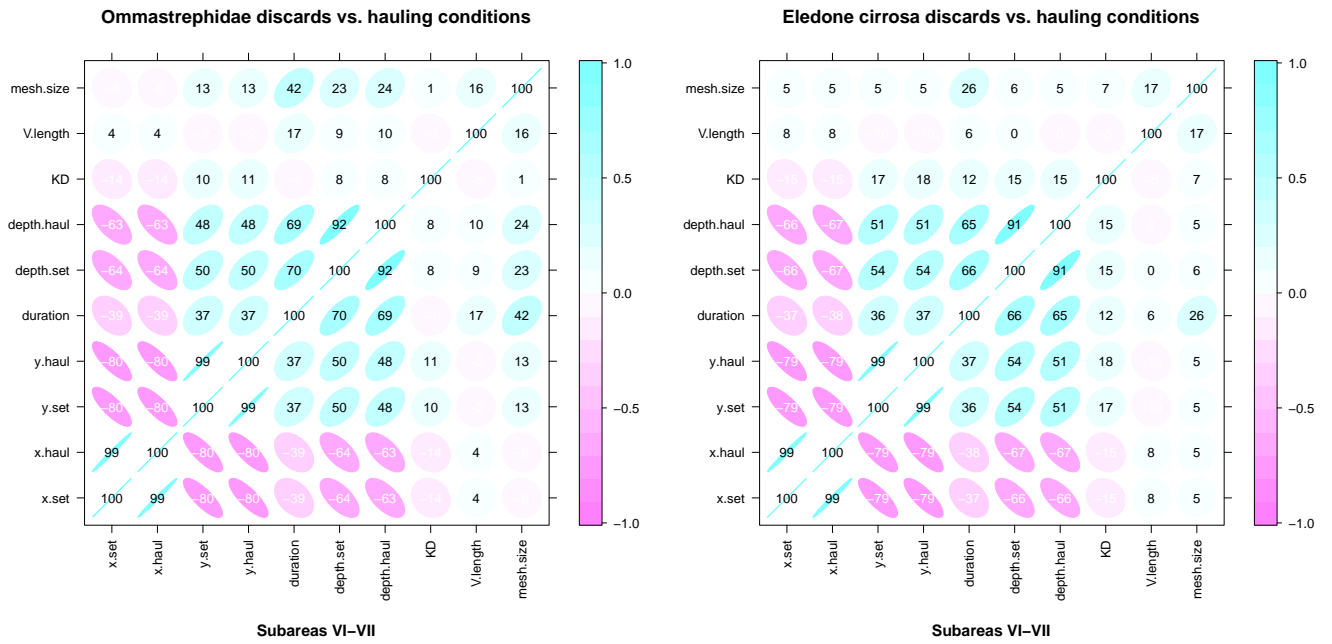


Figure 8: Correlogram representing correlations between *Ommastrephidae* (left) and *Eledone cirrosa* (right) and physical variables obtained at haul level in the western Irish waters & Rockall bank fisheries.

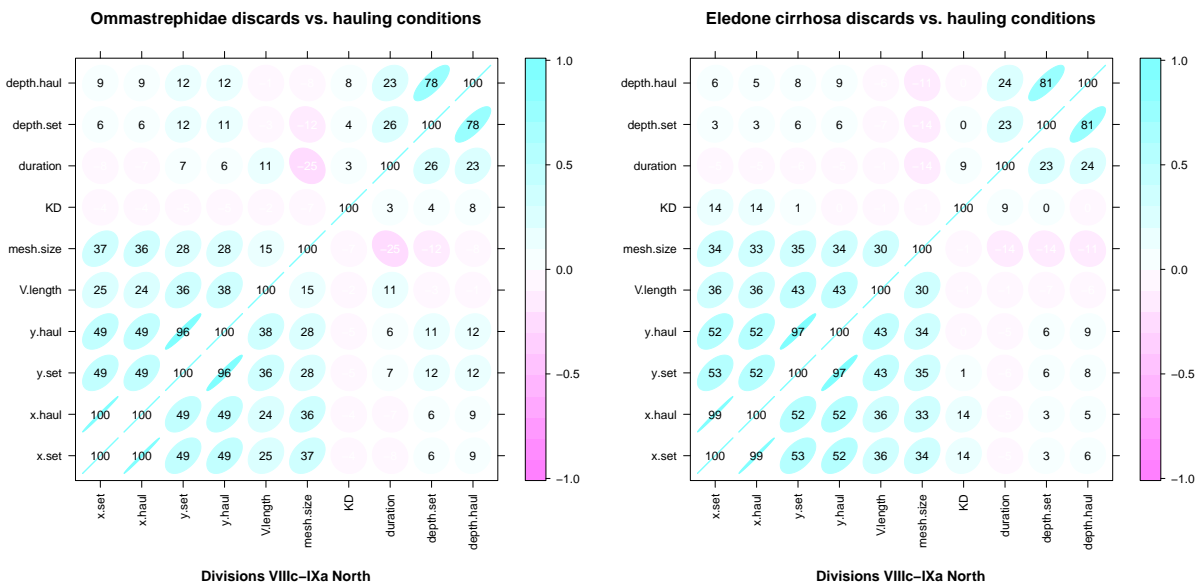


Figure 9: Correlogram representing correlations between *Ommastrephidae* (left) and *Eledone cirrosa* (right) and physical variables obtained at haul level in the north Iberian waters fisheries.

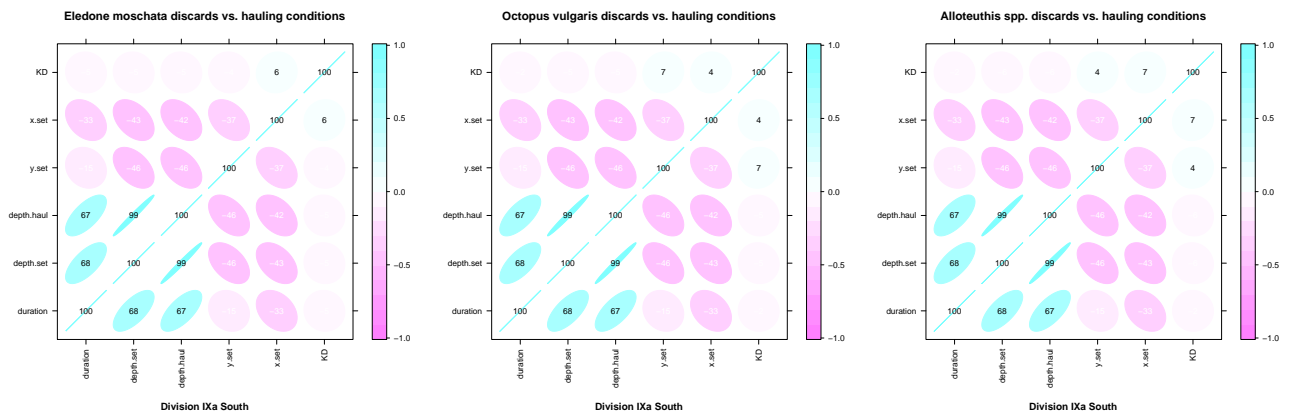


Figure 10: Correlogram representing correlations between *Eledone moschata* (left) , *Octopus vulgaris* (center) and *Alloteuthis spp.* and physical variables obtained at haul level in the Gulf of Cádiz fisheries.

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