Elasmobranches Results from Spanish Discard Sampling Programme

Santos J., H. Araújo, I. Salinas and N. Pérez

*IEO, Centro Oceanográfico de Vigo, Cabo Estai-Canido, Apdo 1552. 36200 Vigo, Spain.

Abstract

A discard Elasmobranches species composition estimates for the Spanish bottom otter and pair trawl fleets operating in the Northeast Atlantic ICES Subareas VI, VII, VIII and North IX are presented. Information has been obtained from the "Spanish Discard Sampling Programme" carried out by the IEO. Time series provide information on discarded catch (in weight and number) and length distributions since 2003 to 2009. Eighteen species were selected in order to show the most important ones occurring in Spanish discards. Trip was the sampling unit, being raised to fleet level using fishing effort as auxiliary variable. Discard estimates for these species show high between-years variation, exceeding 50% CV in all cases. Further exploratory data analysis was carried for the four most discarded species.

Keywords: Discards, Elasmobranches, Celtic Seas, Iberian Waters, Bottom Trawl.

1. Introduction

The "Spanish Discards Sampling Programme" for Otter and Pair Bottom Trawl (OTB and PTB) fleets, covering *ICES Subareas VI, VII, VIIIc and North IX*, was started in 1988 (Table 1), however, it did not have yearly continuity until 2003. This lack of continuity is the main reason that led to omit in this paper the estimates from previous years to 2003.

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
2003-2008	DCR

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

Spanish results on Elasmobranches discards (in this case from the Instituto Español de Oceanografía (IEO)) have never been provided to ICES WGEF in the past (ICES 2009). The main objective of this working document is to provide the information of the most discarded species by the Spanish fleets operating in ICES Sub-areas VI and VII (Celtic Sea) and VIIIc and IXa (Iberian Waters).

2. Material and methods

2.1 Sampling strategy

The sampling strategy and the estimation methodology used in the "Spanish Discards Sampling Programme" are quite similar since 1988, and since 2003 follows the "*Workshop on Discard Sampling Methodology and Raising Procedures*" guidelines (ICES, 2003). The observers-on-board programme is based on a stratified random sampling design. Métier is the lower stratum and trips (the sampling units) are randomly or quasi-randomly selected for sampling within métiers. Until 2009 the DCR asked for annual estimates and, hence, sampling was organised so as to obtain annual results.

Only the trawl fleet is considered in this working document. This is because previous observations carried out on long line vessels showed low discarding levels for this species and area (Pérez et al., 1996). Information is available for gillnet, but discards sampling have started in 2008, and information is too short for using. Although, it can be thought that discards of elasmobranches have low levels for this kind of gears.

2.1 Fleets stratification

Fishing area, gear and target species are the auxiliary covariates used to stratify fleets into métiers. Two métiers are considered within the Spanish trawl fleets operating in the Celtic Sea (ICES Sub-areas VI and VII):

- OTB-DEF_70_99_0_0 trips targeting Megrim and Monk
- OTB-DEF_100_119_0_0 trips targeting Hake and Monk

In the other hand, five métiers are defined in this document for the Northern Spanish coastal bottom trawl fleet (ICES VIIIc and IXa divisions):

- OTB_DEF _>=55_0_E: trips targeting a mixed of demersal species in East VIIIc.
- OTB_DEF _>=55_0_W: trips targeting a mixed of demersal species in West VIIIc and North IXa.
- OTB_MPD_>=55_0_HOM: trips targeting horse mackerel (*Trachurus trachurus*).
- OTB_MPD_>=55_0_MAC: trips targeting mackerel (*Scomber scombrus*).
- PTB_DEF_>=55_0_0: trips targeting blue whiting and hake (*Micromesistius poutassou, Merluccius merlucius, respectively*).

2.1 Raising procedures

For each trip sampled in a given métier, several hauls are, in turn, sampled as follows. A random sample of discarded species is selected. Individuals for a given species present in this sample are measured for size information. Estimates of weight are calculated from length distribution using weight/length relationships (Dorel, 1986; Cull et al., 1989; Pereda and Pérez, 1995; www.fishbase.org/). Species with not length/weight relationship available are weighted onboard. The resulting by-species weight obtained from the sample is raised to haul level according to the total discarded weight of the haul and the proportion of these species in the sample. Length/weight relationship is used again to calculate numbers of discarded in the haul. Estimates are further raised to trip level taking into account the total number of hauls in the trip. Trip estimates are subsequently raised to year using the available fishing effort (total trips) of the former métier as auxiliary variable. As fishing effort by ICES area was not available, métier information was added up to obtain yearly estimates by fishing ground.

We present the results of the most discarded species in Celtic Sea and Iberian Waters. The selection was carried out by applying a threshold of 1 ton to the unraised total annual catch data, therefore only those species which have been discarded in more than one caught ton along the aggregated trips sampled are showed in the paper, with the exception of Kitefin shark (*Dalatias licha*), herein included because it is a species of interest in the Working Group.

In a second step, a selection of the four most discarded species was carried out in order to a further exploratory data analysis of elasmobranches discards. Numbers Discarded per Unit of Effort (DCPUE, numbers/h) by haul is plotted in a spatial basis to detect areas with higher discard occurrence. The same variable is plotted against CPUE (Catch per Unit of Effort), DR (Discard Rate; Numbers of Discarded/Total Catch for a given species) and haul variables as depth, towing duration, and spatial coordinates. Interaction plots using DPUE (kg/h), quarter, year and fishing ground are also including in the analysis in order to explore conditioned changes in discarding patterns. The same plots are also used to explore trends in DR conditioned by year, quarter or fishing ground.

Density plots using annual abundance (numbers) of discarded individuals are plotted showing shapes of length distribution and modal tendencies.

3. Results

3.1 Summary of the resulting estimates

The sampling level varies depending on the year (Table 2). Values are more or less stable since 2003 in the Celtic Sea, and a steady increase occurred in the Iberian Waters sampling scheme. Mean Proportion of sampled hauls within trip is ~0.5 in the Northern Area, while short trips and low effective hauls characterizing the Iberian Waters require higher sampling coverage within trip; therefore the mean rate of sampled hauls was ~0.8. The information can be considered representative of the discard behaviour of the whole fleets operating in the areas.

Table 3 shows the discard estimates of the selected species. Figure 1 shows annual trends in discarded amounts of the former species. Only three species: Lesser spotted dogfish (*Scyliorhinus canicula),* Cuckoo ray (*Leucoraja naevus)* and blackmouth catshark (*Galeus melastomus*) appeared in the discarded catch continuously over the years sampled in the two areas (Figure 1)

Lesser spotted dogfish is the most discarded elasmobranches both in abundance and biomass terms in Celtic Sea and Iberian Waters. Higher values of discarded have been estimated for Celtic Sea (3523.3 ± 757.3 *tons* / *year*) in comparison to Iberian Waters (899.9 ± 180.7 *tons* / *year*). Cuckoo ray is the second most discarded species in the Northern ground (821.3 ± 278.4 *tons* / *year*) follow by blackmouth catshark (337.5 ± 130.1 *tons* / *year*) and velvet belly shark (*Etmopterus spinax*) (165.3 ± 90.8 *tons* / *year*). Cuckoo ray is less abundant in the Iberian Waters elasmobranches discard composition (47.2 ± 24.0 *tons* / *year*), preceded in terms of biomass discarded by blackmouth catshark (565.5 ± 131.4 *tons* / *year*) and velvet belly (71.7 ± 58.07 *tons* / *year*). Because these species are found to be the most discarded ones in the areas under study, a deeper descriptive analysis is carried out subsequently in the next subsection.

Thornback ray (*Raja clavata),* birdbeak dogfish (*Deania calcea)* are also important components in elasmobranches discard composition, but in lower amounts comparing with the earlier species.

Spotted ray (*Raja montagui)* was found to be discarded only in Iberian Waters (3.0 ± 2.0 *tons* / *year*), while shagreen ray (*Leucoraja fullonica)* (39.9 ± 32.3 *tons* / *year*), spurdog *(Squalus acanthias)* (23.2 ± 23.0 *tons* / *year*), Tope (*Galeorhinus galeus)* (20.2 ± 15.7 *tons* / *year*) and Small-eyed ray (*Raja microocelata)* (11.1 ± 10.9 *tons* / *year*) were solely found in Celtic Sea discards

Scattered and lower ocurrence of discards (Table 3; Figure 1) was found for smooth hounds (*Mustelus asterias),* sandy ray *(Leucoraja circularis),* gulper shark *(Centrophorus squamosus),*and kitefin shark *(Dalatias licha).*

3.2 Exploratory Data Analysis by species

Lesser spotted dogfish discards

Maps of discard distribution (Figure 2) show that the largest amounts of discards of lesser spotted dogfish in Celtic Sea are located between 48-51º North and ~10º West (Grand sole area), while less incidence occurs further north (Porcupine Bank). Figure 3a shows that highest discards of this species is related to hauls towed at between 100-200m depth and ~3.5 hours of towing duration. Both spatial distribution and physical variables are related with the métier directed to megrim and monk (OTB-MEG/MNZ-70_99_0_0). DR (Figure 3a) is the proportion of lesser spotted dogfish discarded from its total catch (Discard/Total catch). For a given haul, DR = 1 means that all sharks were discarded and the opposite when DR = 0. High variability of the binary variable is found in the area with higher occurrence of discards (Figure 3a), meaning that sorting behaviour change depending on unaccounted factors in this working document, however, the relationship between CPUE and DR shows that high

abundance of lesser spotted dogfish in the catch does not result in higher retention rates (1-DR) for this species.

In Iberian Waters, most of the hauls presenting high discards of lesser spotted dogfish are located in Cantabrian Sea (VIIIc) (Figure 2). Towing depth and haul duration related with high discard quantities present similar range than in Celtic Sea. The retention rate (1-DR) show a decreasing trend as CPUE gets larger, in the same way as in Celtic sea (Figure 3a).

The interaction plot relating fishing ground, year, quarter and DCPUE (Figure 4a) has not shown any clear pattern and discards amounts seems to be independent of the quarter.

Figure 5a shows a change in discard behaviour since 2006 for Celtic sea. After this year fewer hauls are observed with discard ratio less than 1.0, meaning that, in relation to the total catch of lesser spotted dogfish, higher proportion of discard/total catch has been observed since 2006.

Median length size discarded in Celtic Sea range from 29-44cm and from 35-44cm in the Iberian waters over the years sampled (Figure 6a).

Cuckoo ray discards

Figure 2 shows that highest abundance of this species discards takes place in the in Celtic Sea, area (48-50º North and 8-10º West) to a depth of approximately 150m. Whereas, in Iberian Waters, the larger discards for this ray take place in Eastern Cantabrian sea (43.5º North and 3-5ºWest). As in the case of lesser spotted dogfish, DCPUE increases in linear relation with CPUE in both fishing grounds, and the relationship between CPUE and DR shows that high abundance of this species in the catch does not result in higher retention rates. In Celtic Sea, discard proportion seems to decrease at deep waters tows, and the opposite occurs in high duration tows. No clear relationship is found in Iberian Waters when comparing the former variables (Figure 3b).

Figure 4b does not show any clear trend in the occurrence of cuckoo ray discards neither related to year nor to quarter. Sorting behaviour of this ray onboard does not show any seasonal pattern along the years sampled in both fishing ground (Figure 5b).

Median length size discarded range from 29-37cm in Celtic Sea and from 21-49cm in Iberian Waters. Unstructured shapes of size distributions in Iberian Waters differs from the regular shapes found in Celtic Sea over the years sampled (Figure 6b).

Blackmouth catshark discards

In Celtic Sea discards of blackmouth catshark takes place mainly in the Porcupine Bank (51-53º North and ~14 West) (Figure 2), mean towing depth of approximately 500m (Figure 3c),while in Iberian Waters, the Eastern Cantabrian Sea (43.5º North and 2-4.5º West) and North West Atlantic (42º-44º North and 9-10ºWest) are the hot spots for this species discards. The mean towing depth is approximately 300-500m (Figure 2 and 3c). In general, higher discards quantities are found at towing duration longer than 4.0 hours in the northern fishing ground, while hauls with less .than 5 hours of towing duration yield highest discards. Low retention rates are found for blackmouth in both areas (Figure 3c).

No trend was found in the relation between quarter and amounts over the years sampled for both fishing grounds (Figure 4c).

Median length size discarded in Celtic Sea shows a wide interval over the years (24-60cm.), while Iberian waters median values range from 27-37cm (Figure 6b).

Belly shark discards

Belly shark discards were recorded in Celtic Sea mainly in Porpupine and Rockall banks at deep waters around 500m with mean haul duration shorter than 5.5 hours. No retention was recorded for this species in the area (Figure 2; Figure 3d). Scarce and scattered discarding of this species has taken place in Iberian Waters and the larger amounts were recorded in west coast of Galicia and off the coast of Cabo Peñas at depths ranging from 300-400m.. Low retention rates were found in the Spanish waters (Figure 2; Figure 3d).

Scattered boxplots with no trend was the output from the interaction plot of discards of *E. spinax* (Figure 4d).

Median length size discarded range from 17-34cm in Iberian Waters and an interval of 19-41cm. was obtained from Celtic Sea samplings (Figure 6d).

References

ICES, 2003. Report of ICES Workshop on Discard Sampling Methodology and Raising Procedures. Charlottenlund, Denmark, 2-4 September 2003.

ICES, 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

Cull, K.A., A.S. Jeremyn, A.W. Newton, G. I. Henderson, and W.B Hall. 1989. Length/Weight relationships for 88 species of fish encountered in the North East Atlantic. Scottish Fisheries Research. 43: 1-81.

DorelL, D. 1986. Relations taille/poids pour l' atlantique nord-est. IFREMER DRV/86-001/RH Nantes.

Pereda, P. and N. Pérez., 1995. Relaciones talla-peso de peces capturados en las campañas de arrastre demersal " Demersales 0993 y Demersales 0994". Inf. Téc. Inst. Esp. Oceanogra., 159:1-16.

Pérez, N., P. Pereda, A. Uriarte, V. Trujillo, I. Olaso y S. Lens. 1996. Discards of the Spanish fleet in ICES Divisions Study Contract DG XIV. PEM/93/005.

UNESCO, 1989. Fishes of the North-eastern Atlantic and Mediterranean, Volume 1. UNESCO, Paris.

Fishing ground	Year	Trips sampled	Quarter	Hauls sampled	p	Total trips
Celtic Sea (Subareas VI-VII)	2003	9	1	0	0.63	1172
			2	107		
			3	122		
			4	141		
	2004	11	1	102	0.58	1222
			2	118		
			3	86		
			4	94		
	2005	10	1	71	0.49	1194
			2	105		
			3	109		
			4	52		
	2006	13	1	132	0.46	1152
			2	122		
			3	109		
			4	14		
	2007	12	1	81	0.49	1233
			2	100		
			3	71		
			4	116		
	2008	11	1	58	0.54	1206
			2	66		
			3	112		
			4	118		
	2009	15	1	91	0.53	1304
			2	144		
			3	118		
			4	75		
Iberian Waters (Divisions VIIIc-IXa)	2003	51	1	0	0.84	18036
			2	65		
			3	61		
			4	41		
	2004	53	1	49	0.91	20819
			2	48		
			3	40		
			4	40		
	2005	97	1	74	0.93	11693
			2	70		
			3	80		
			4	45		
	2006	75	1	53	0.82	18352
			2	60		
			3	75		
			4	21		
	2007	95	1	47	0.84	17750
			2	51		
			3	67		
			4	78		
	2008	103	1	87	0.81	15114
			2	85		
			3	54		
			4	30		
	2009	116	1	58	0.86	14486
			2	94		
			3	82		
			4	74		

Table 2. Sampling effort on Spanish trawl fleets operating in the Celtic Sea and Iberian Waters.

Fishing Ground	Species	2003	2004	2005	2006	2007	2008	2009
Celtic Sea (Subareas VI-VII)	*Centrophorus squamosus*	**0.0**	**0.0**	**0.0**	**3.2**	**0.0**	**67.3**	**61.1**
		-	-	-	*99.5*	-	*65.7*	*86.3*
	Dalatias licha	**0.0**	**90.9**	**13.9**	**1.3**	**0.0**	**0.0**	**2.9**
		-	*99.7*	*99.7*	*98.8*	-	-	*99.3*
	Deania calcea	**0.0**	**9.8**	**87.3**	**17.3**	**17.3**	**6.1**	**2.6**
		-	*99.7*	*76.0*	*49.5*	*99.6*	*62.1*	*99.3*
	Etmopterus spinax	**16.2**	**296.1**	**117.7**	**2.8**	**5.2**	**657.1**	**61.7**
		63.5	*94.4*	*59.5*	*84.7*	*99.6*	*92.4*	*38.9*
	Galeorhinus galeus	**0.0**	**14.6**	**0.0**	**11.1**	**1.9**	**113.6**	**0.0**
		-	*99.5*	-	*99.4*	*99.5*	*97.9*	-
	Galeus melastomus	**47.8**	**509.8**	**169.5**	**12.8**	**176.1**	**458.6**	**988.1**
		91.2	*64.5*	*57.1*	*36.6*	*46.9*	*73.2*	*81.1*
	Leucoraja circularis	**9.4**	**0.0**	**0.0**	**0.0**	**0.0**	**128.9**	**0.0**
		99.6	-	-	-	-	*99.5*	-
	Leucoraja fullonica	**50.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**228.8**
		40.2	-	-	-	-	-	*59.5*
	Leucoraja naevus	**764.8**	**331.6**	**867.3**	**517.0**	**466.9**	**371.1**	**2430.6**
		38.8	*48.5*	*71.7*	*45.8*	*76.1*	*29.0*	*44.0*
	Mustelus asterias	**0.0**	**0.0**	**44.9**	**0.0**	**0.0**	**28.0**	**2.8**
		-	-	*99.6*	-	-	*99.6*	*98.3*
	Raja brachyura	**7.0**	**6.4**	**0.0**	**21.3**	**0.0**	**11.3**	**1.5**
		99.6	*99.4*	-	*75.4*	-	*70.6*	*99.1*
	Raja clavata	**0.0**	**18.5**	**5.2**	**108.7**	**43.0**	**25.5**	**0.0**
		-	*87.9*	*91.0*	*68.1*	*55.2*	*49.9*	-
	Raja microocellata	**0.0**	**0.0**	**76.5**	**0.0**	**1.0**	**0.0**	**0.0**
		-	-	*99.6*	-	*98.0*	-	-
	Scyliorhinus canicula	**4420.4**	**2943.5**	**1840.6**	**2219.4**	**1355.2**	**4938.8**	**6945.5**
		22.0	*32.3*	*28.4*	*26.9*	*34.1*	*20.0*	*28.6*
	Squalus acanthias	**1.3**	**0.0**	**161.5**	**0.0**	**0.0**	**0.0**	**0.0**
		100.1	-	*99.7*	-	-	-	-
Iberian Waters (Divisions VIIIc-IXa)	*Centrophorus squamosus*	**0.0**	**0.0**	**4.5**	**4.1**	**0.0**	**0.0**	**102.5**
		-	-	*89.5*	*80.6*	-	-	*55.9*
	Dalatias licha	**0.0**	**0.0**	**1.3**	**2.6**	**0.0**	**0.0**	**0.0**
		-	-	*102.6*	*100.2*	-	-	-
	Deania calcea	**8.0**	**0.0**	**5.5**	**19.9**	**1.8**	**17.9**	**34.6**
		65.8	-	*61.4*	*83.6*	*69.9*	*96.6*	*55.4*
	Etmopterus spinax	*0.5*	*384.9*	*5.6*	*18.4*	*1.7*	*19.5*	-
		0.0	*92.8*	*49.5*	*90.0*	*59.4*	*58.9*	-
	Galeorhinus galeus	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		-	-	-	-	-	-	-
	Galeus melastomus	*382.6*	*204.5*	*527.3*	*544.8*	*1054.6*	*225.8*	*1018.8*
		36.6	*56.0*	*36.0*	*61.5*	*36.9*	*28.5*	*61.2*
	Leucoraja circularis	**0.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**
		0.0	-	-	-	-	-	*0.0*
	Leucoraja naevus	**39.9**	**183.8**	**6.5**	**61.7**	**19.7**	**2.7**	**16.5**
		77.2	*58.6*	*69.3*	*52.6*	*63.9*	*52.0*	*77.0*
	Mustelus asterias	**0.0**	**28.1**	**18.0**	**0.0**	**0.0**	**0.0**	**0.0**
		-	*99.7*	*95.7*	-	-	-	-
	Raja brachyura	**0.1**	**84.8**	**1.2**	**11.6**	**31.6**	**2.1**	**13.0**
		0.0	*53.3*	*63.9*	*92.7*	*59.2*	*47.8*	*45.5*
	Raja clavata	**0.0**	**1.0**	**9.9**	**54.5**	**10.9**	**6.3**	**43.6**
		-	*0.0*	*54.6*	*77.4*	*45.5*	*67.9*	*44.6*
	Raja microocellata	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		-	-	-	-	-	-	-
	Raja montagui	*14.9*	*1.3*	*0.2*	*0.7*	*0.4*	*1.2*	*2.0*
		89.2	*0.0*	*125.4*	*0.0*	*0.0*	*98.6*	*73.7*
	Scyliorhinus canicula	**1119.0**	**757.5**	**394.8**	**1696.2**	**944.2**	**289.4**	**1098.3**
		44.2	*40.4*	*34.3*	*64.7*	*23.5*	*33.6*	*38.5*
	Squalus acanthias	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		-	-	-	-	-	-	-

Table 3. Biomass discarded (tons) of demersal elasmobranches (Bold) and CV of estimations (Italics) by fishing ground.

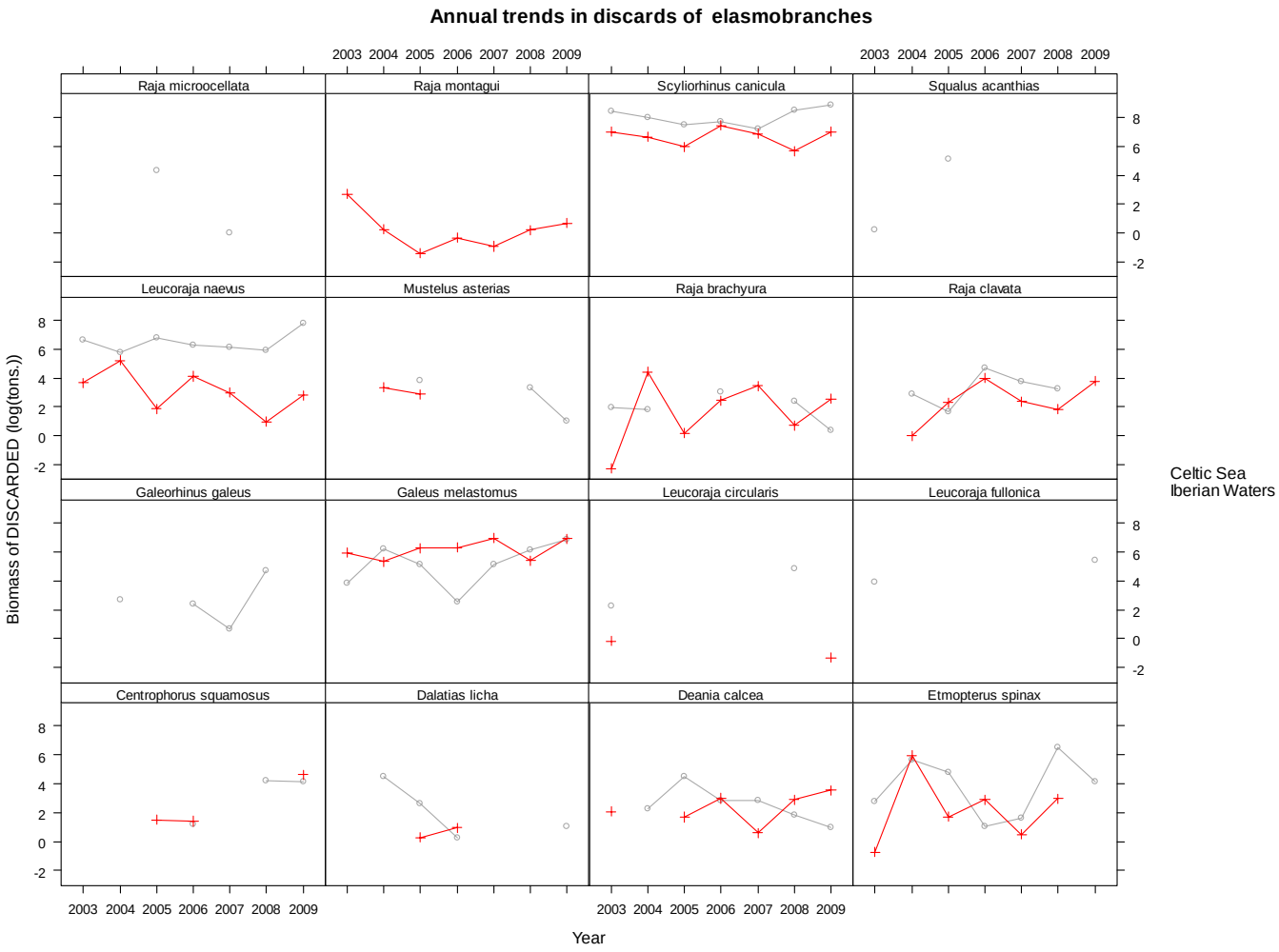

Figure 1. Annual biomass of discarded log(tons) by species and fishing ground.

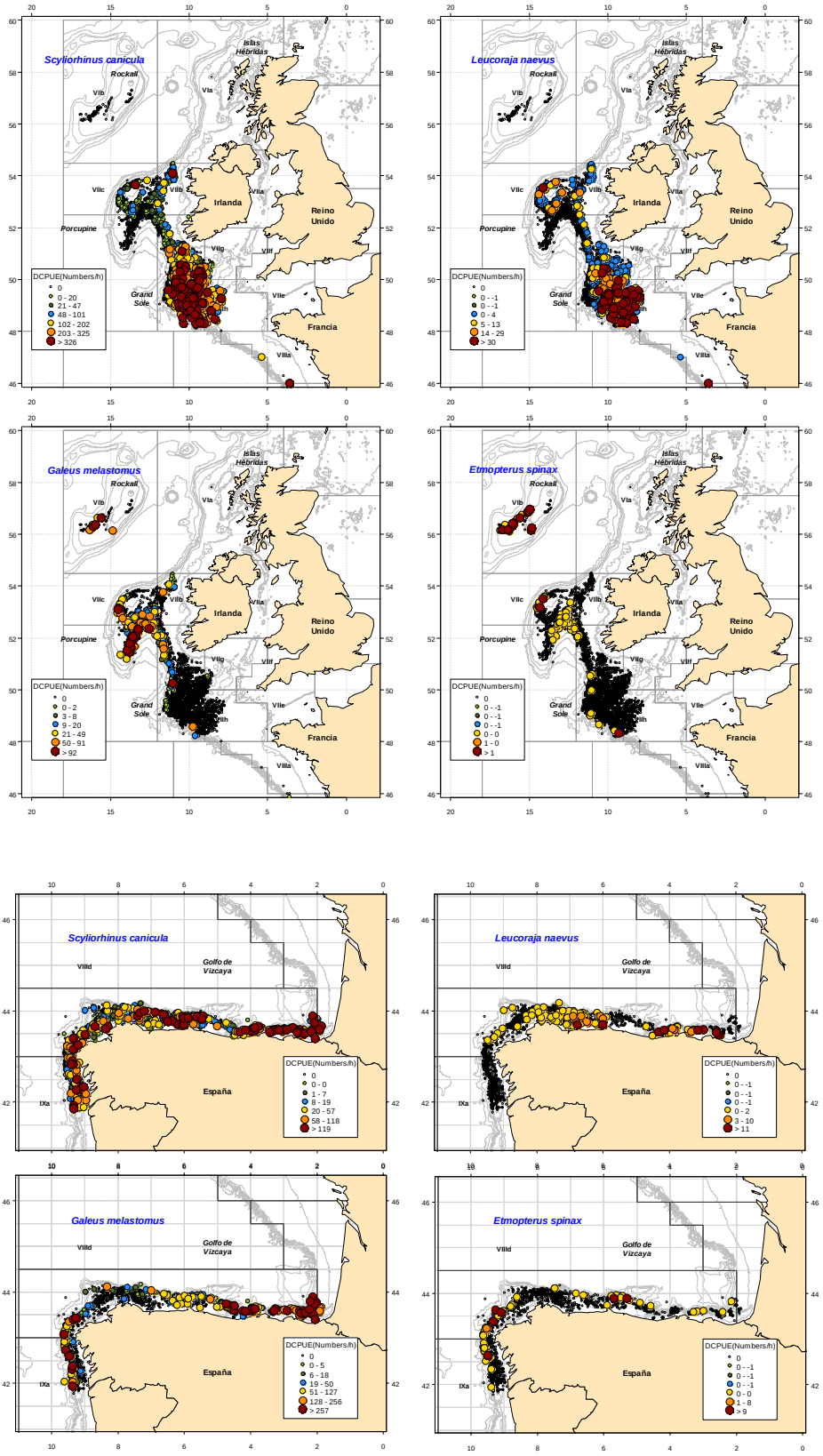

Figure 2. Spatial distribution of discards for the most discarded species in Celtic Sea and Iberian Waters.

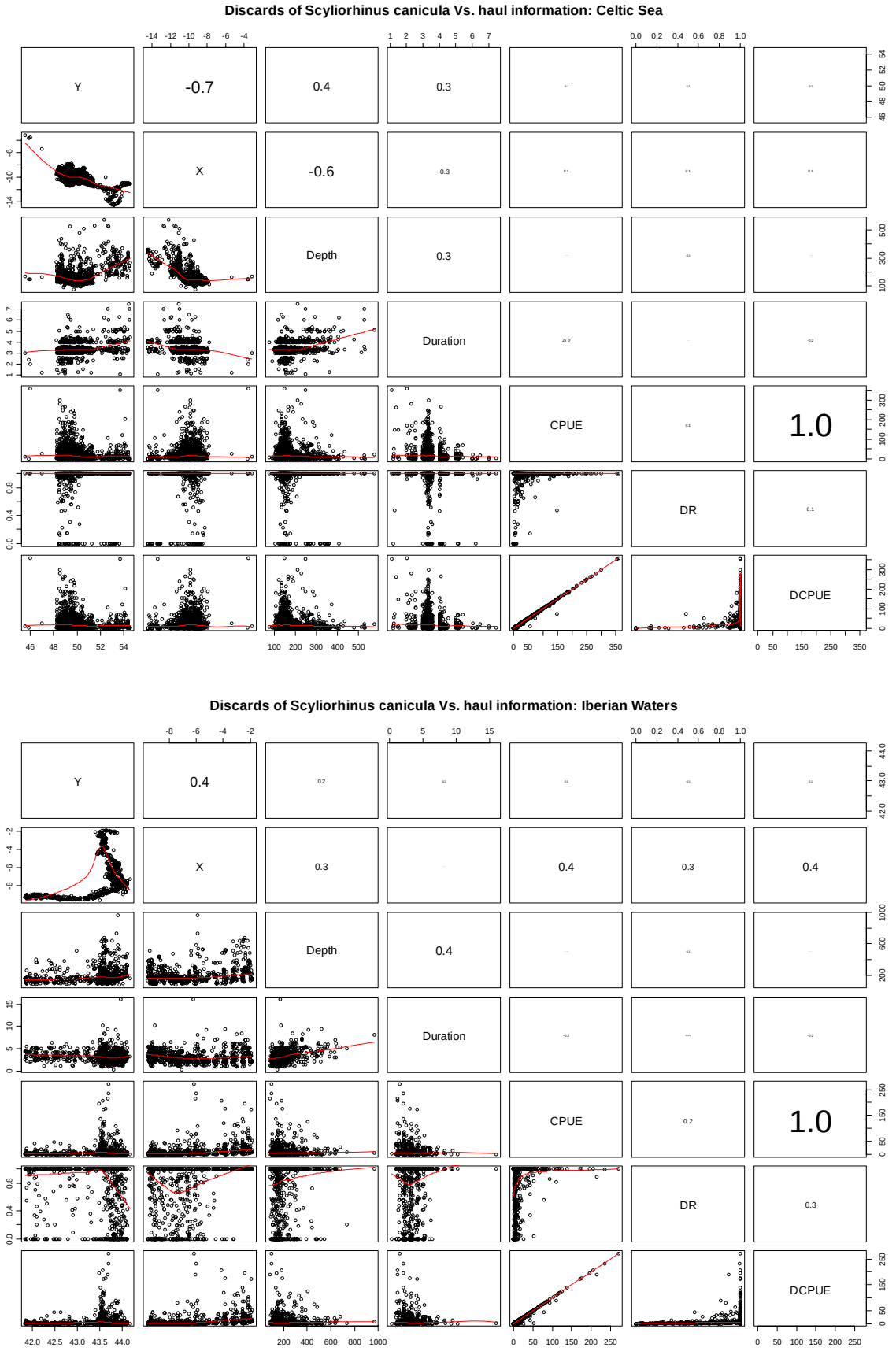

Figure 3a. DCPUE (kg discarded/h) against catch and haul information for *S. canicula* in Celtic Sea and Iberian Waters.

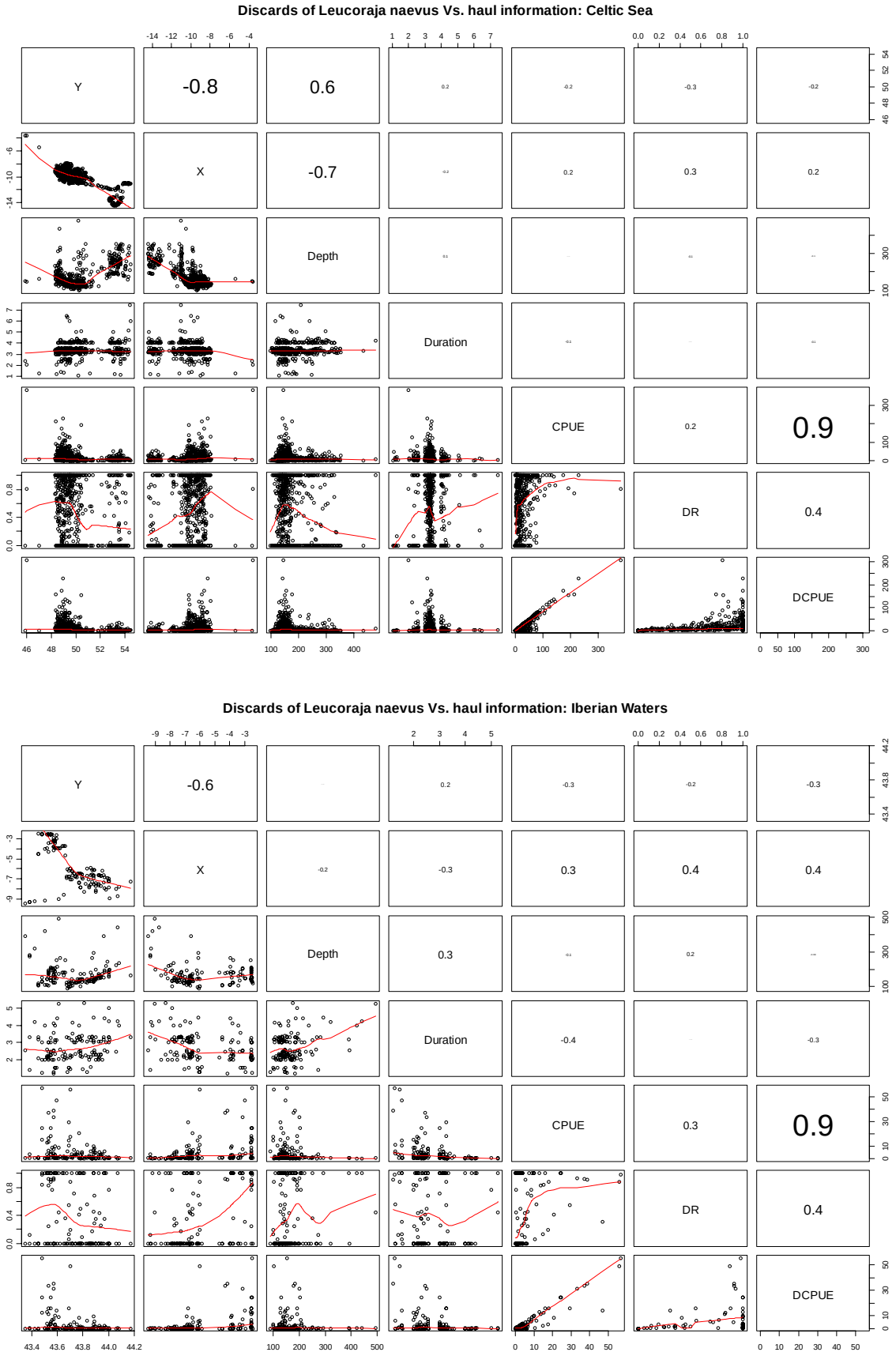

Figure 3b. DCPUE (kg discarded/h) against catch and haul information for *L. naevus* in Celtic Sea and Iberian Waters.

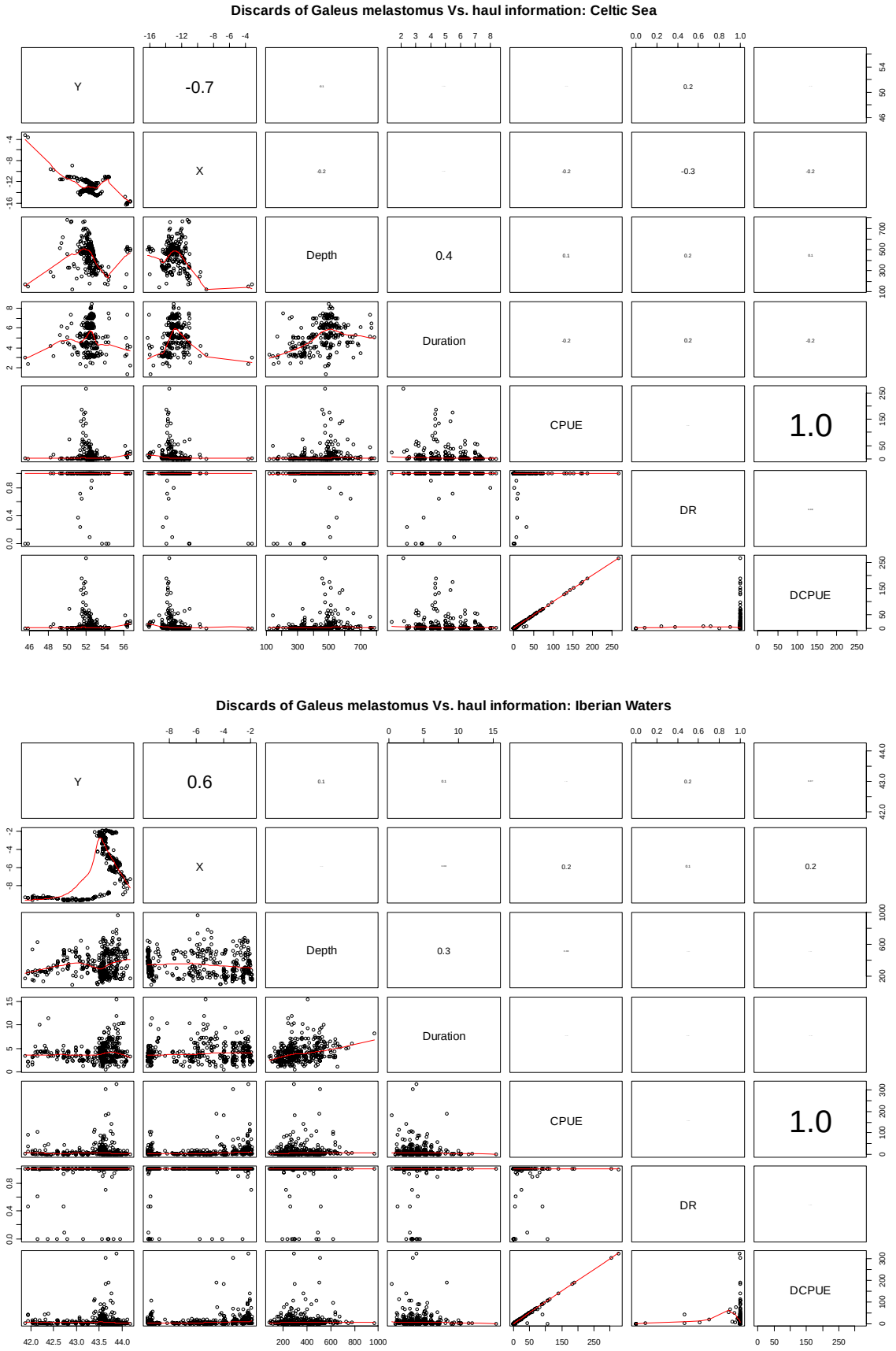

Figure 3c. DCPUE (kg discarded/h) against catch and haul information for *G. melastomus* in Celtic Sea and Iberian Waters.

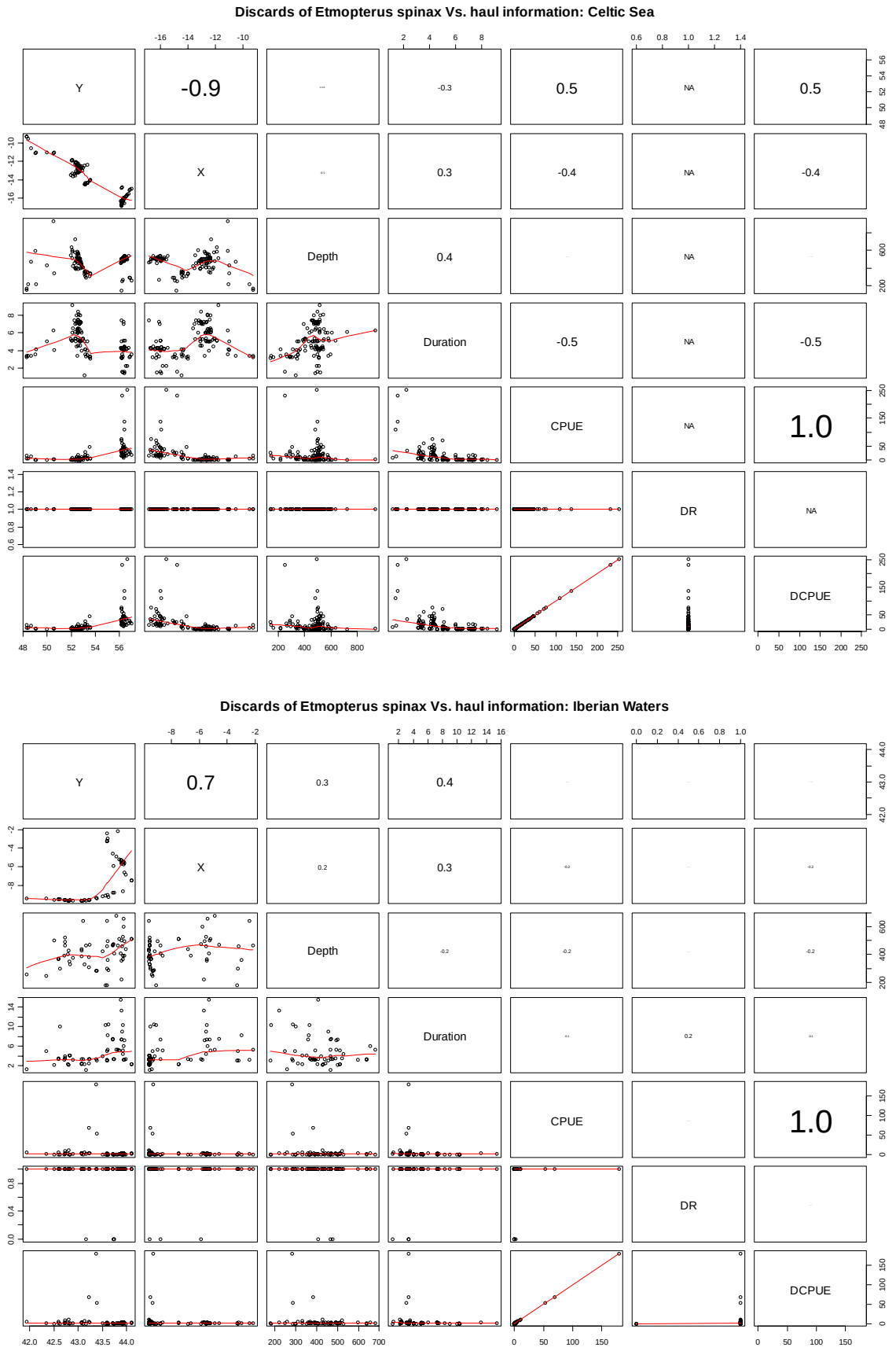

Figure 3d. DCPUE (kg discarded/h) against catch and haul information for *E. spinax* in Celtic Sea and Iberian Waters.

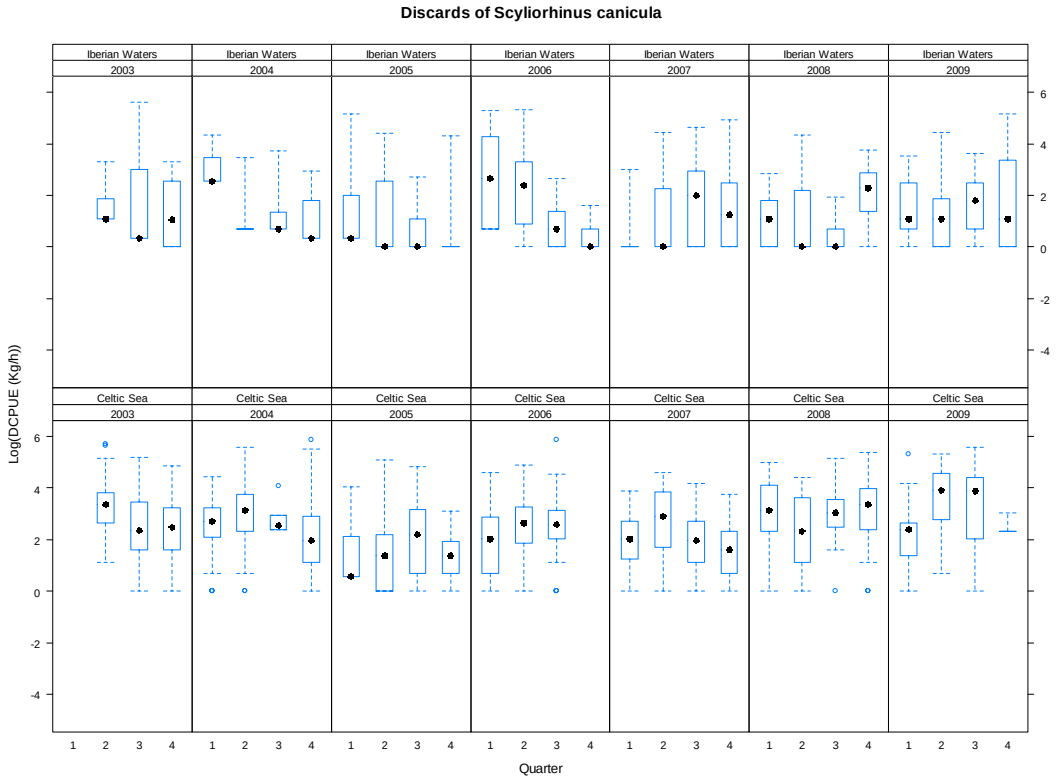

Figure 4a. Interaction plot relating log (DCPUE (kg discarded/h)) of S. canicula with fishing ground, year and quarter.

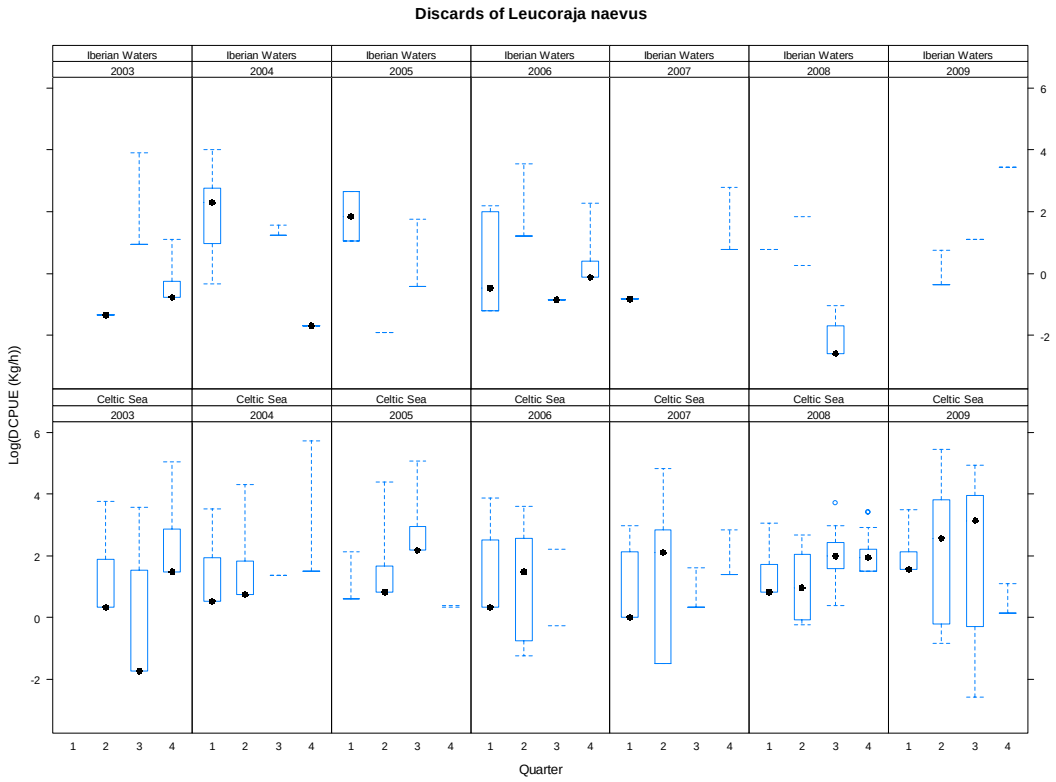

Figure 4b. Interaction plot relating log (DCPUE (kg discarded/h)) of *L. naevus* with fishing ground, year and quarter.

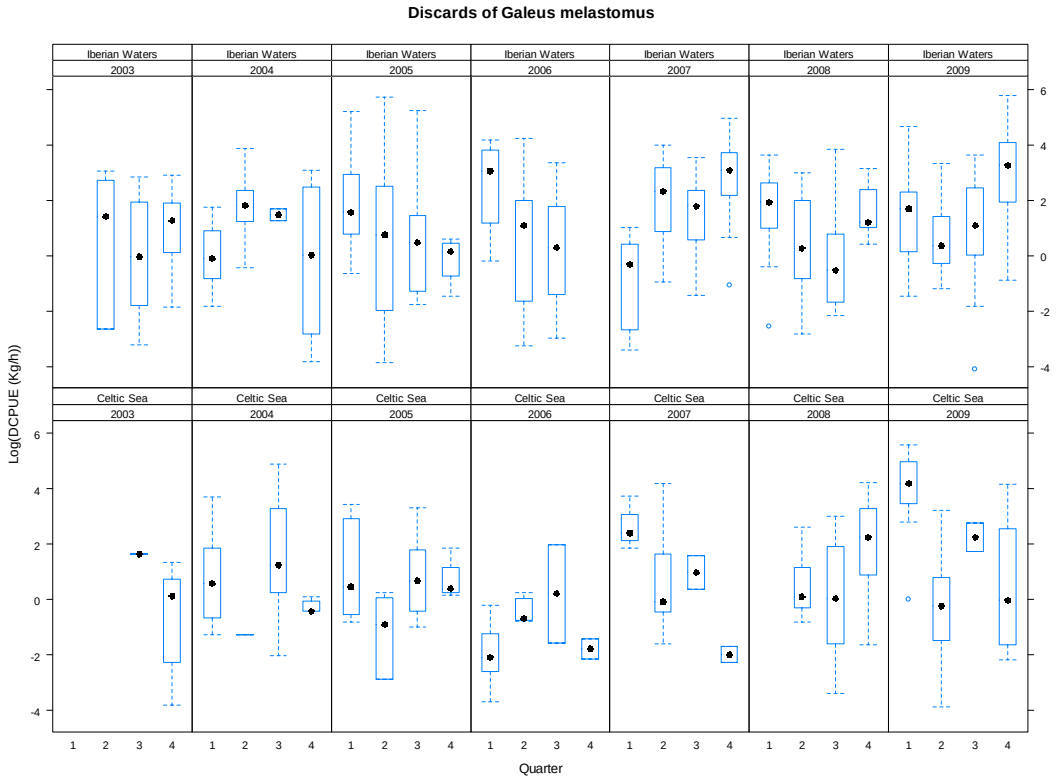

Figure 4c. Interaction plot relating log (DCPUE (kg discarded/h)) of *G. melastomus* with fishing ground, year and quarter.

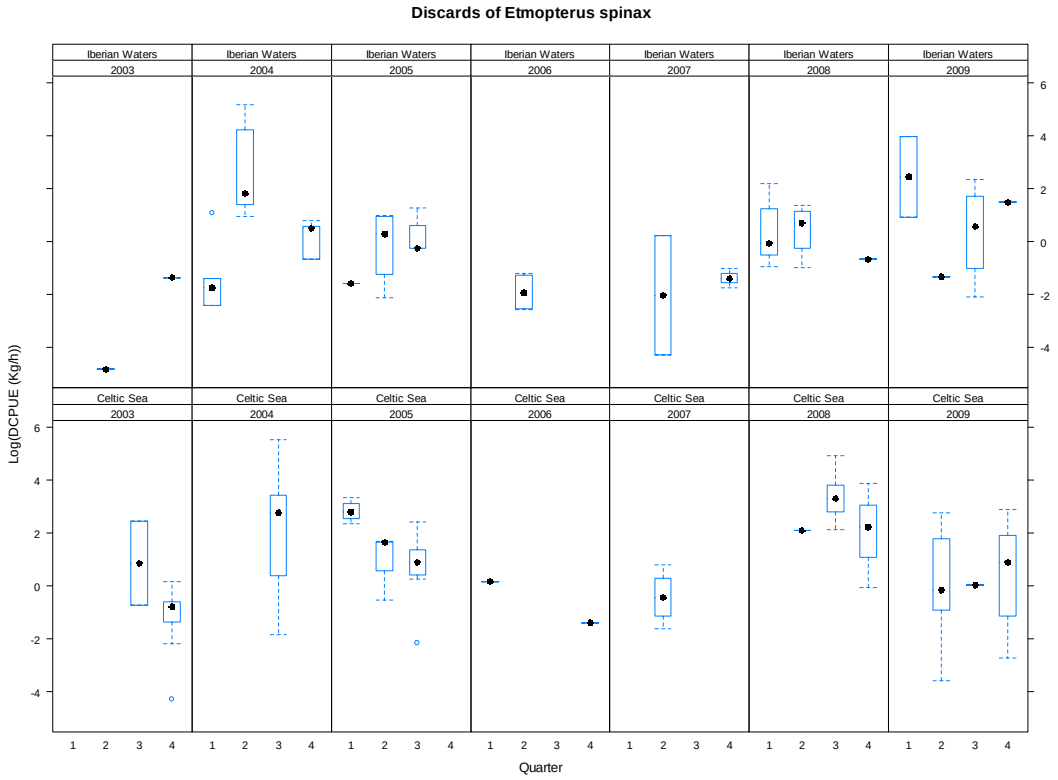

Figure 4d. Interaction plot relating log (DCPUE (kg discarded/h)) of *E. spinax* with fishing ground, year and quarter.

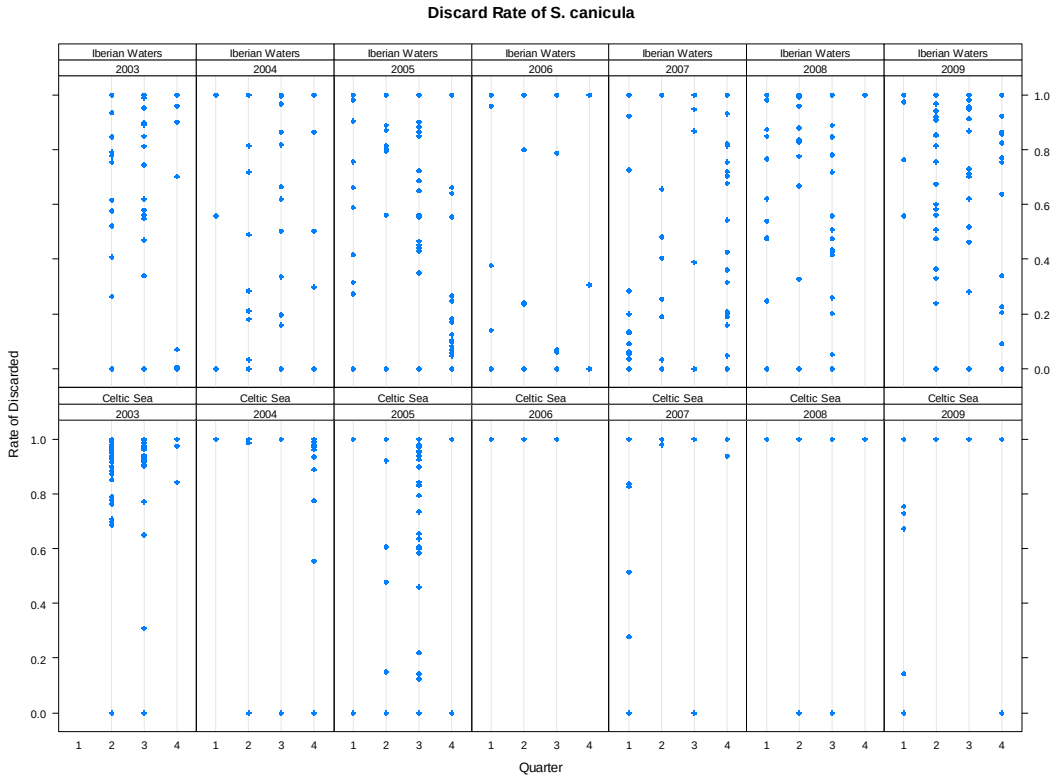

Figure 5a. Interaction plot relating rate of discard (discarded/total catch) of *S. canicula* with fishing ground, year and quarter.

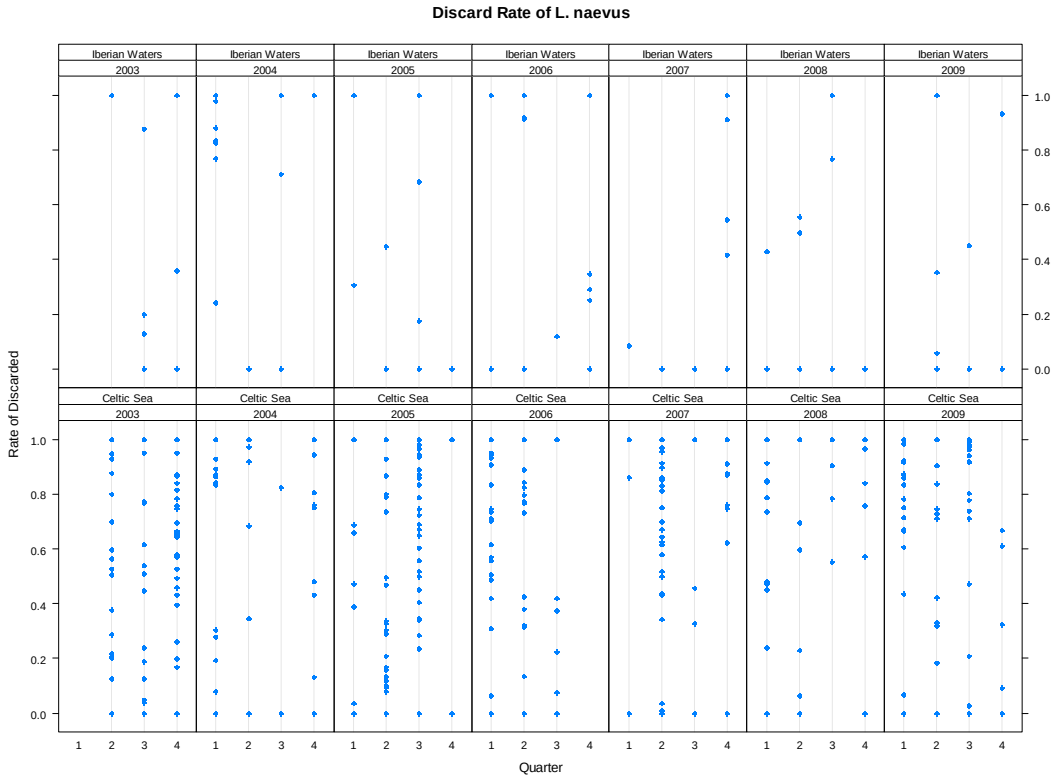

Figure 5b. Interaction plot relating rate of discard (discarded/total catch) of *L. naevus* with fishing ground, year and quarter.

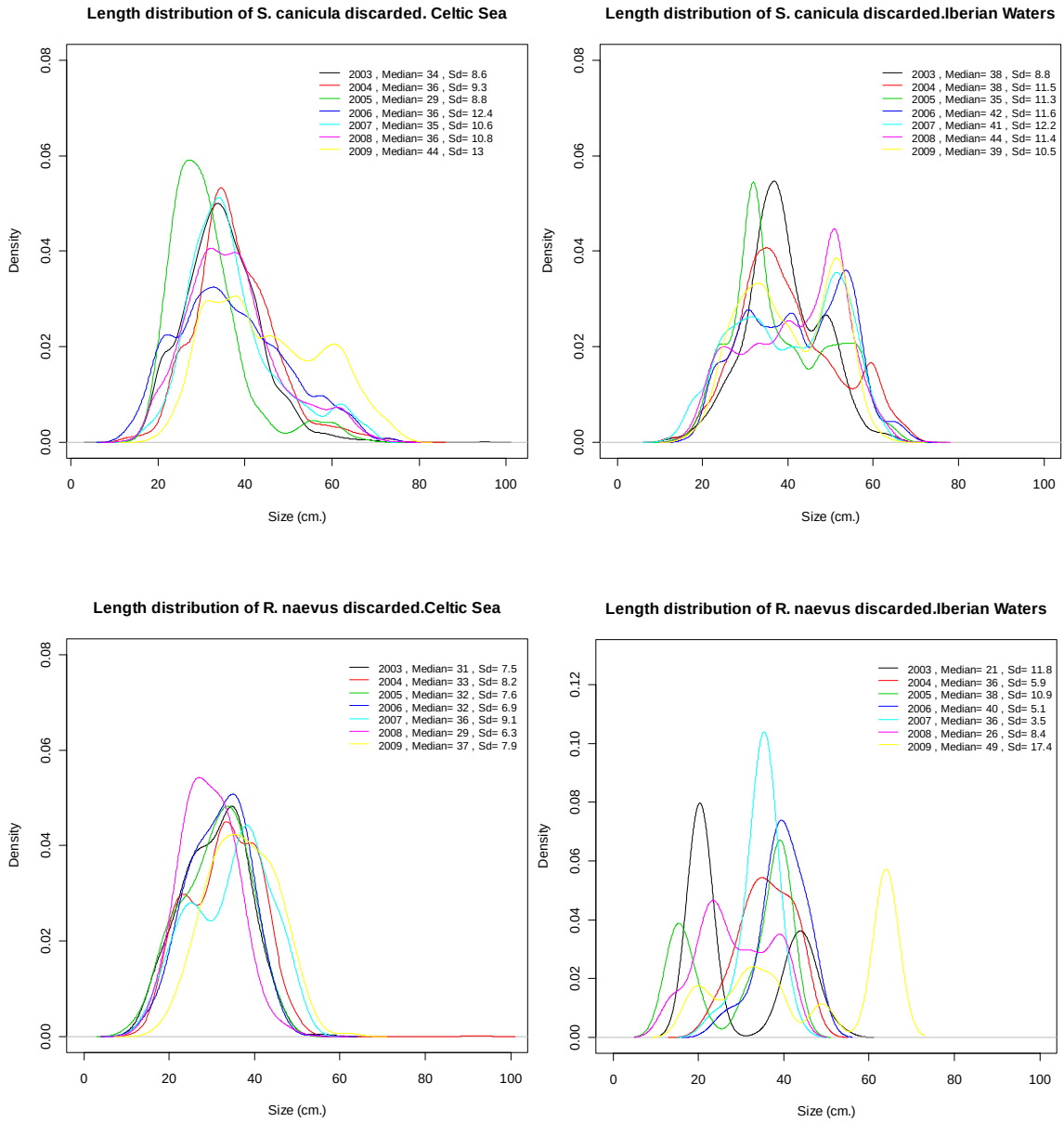

Figure 6a and 6b. Annual length size distribution for *S. canicula and L. naevus* in Celtic Sea and Iberian Waters (method = Kernel density estimator**).**

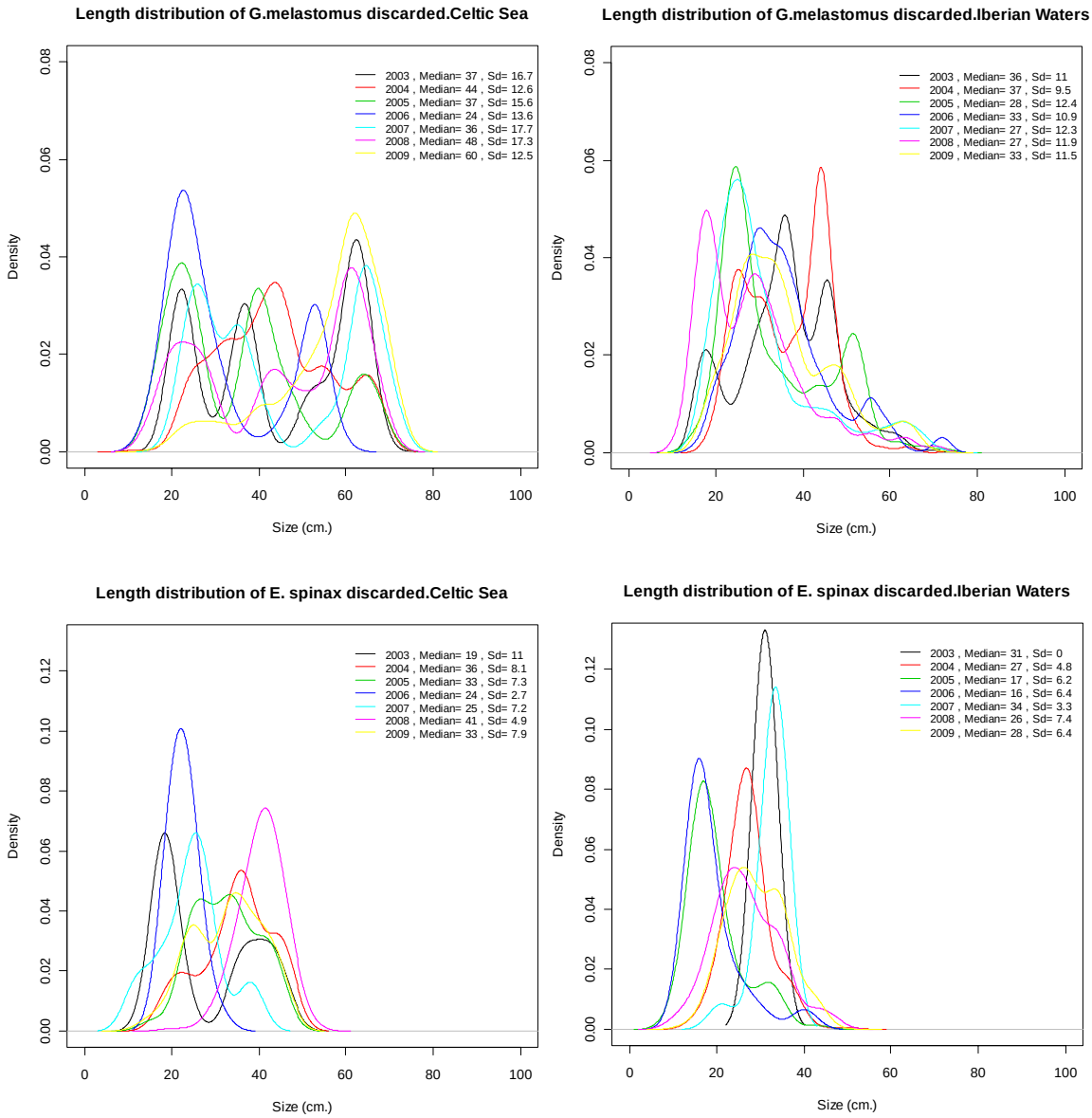

Figure 6c and 6d. Annual length size distribution for *G. melastomus and E. spinax* in Celtic Sea and Iberian Waters (method = Kernel density estimator).