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"Factors Affecting Discards by the Coastal Spanish North Atlantic Trawlers"

by

Trujillo V.*, N. Pérez* and P. Pereda**

ABSTRACT

Variations in the total discard in weight were evaluated by Spanish trawler fleet operating in the North Atlantic Spanish coast in 1994. The data used for this study came from observers on board commercial fishing boats in ICES Divisions VIIIc and IXa during normal fishing activity. A total of 493 hauls were analysed and 221 commercial and non-commercial species discarded were determined. The response variable studied is the whole discard of all species per unit effort. A general analysis of covariance was carried out with the following sources of variation: trip, quarter, area, port, three types of gears, groups of boats (using multivariant analysis of classification) and as covariables: total catch per unit effort, fishing hours, depth, tonnage, horsepower and length of the boats studied. The results show a great variation in the discard values by unit of effort for this fleet, except for the intra-annual variation.

Keywords: discard, Iberian Peninsula, trawl.

* C.O. de Vigo, Instituto Español de Oceanografía. Apdo. 1552, 36280 Vigo, Spain.
** C.O. de Santander, Instituto Español de Oceanografía. Apdo. 240, 39080 Santander, Spain

Introduction

Throughout the 1980's and continuing into this decade, the growing importance of discards in world fishery management is further reflected in the increased attention paid to this topic by international research. Alverson et. al., 1994 estimate a global discard range of 17.9 to 39.5 million t.

EU fisheries policy emphasises the protection of juvenile fish and the need to find the causes and consequences of bycatches and discarding practices. Knowledge of discard rates of commercial species is an important input in the assessment of fish stocks. Discard data will be of great importance for the evaluation of general management, calculating strategies and also for the effects of specific proposals for technical measures.

The main reason for the scarce information on discards is the large amount of research effort needed to sample these data. Obtaining adequate discard information requires an intensive discard sampling programme (Cotter 1995). These factors make it very difficult and expensive to estimate the number of fish of a certain species discarded on a yearly basis. Although sending observers to monitor discards on commercial boats is the most accurate method for estimating discard rates, this method has some drawbacks. The observer method is costly and often inefficient, e.g. when bad weather causes cancellation of sampling trip (Cotter 1995). Also, a source of bias is added since fishing boats within a given fleet do not have an equal probability of being sampled. Several factors influence the quality of the estimate, such as bad weather, bad working conditions on board, the small size of the boat and the tasks to be performed on deck, the alternation of observers and differences in the on-board processing of discards by the crew, or biases associated with having an official on board (Cotter 1995).

Data used for this study are a part of a project carried out in the framework of a contract between the European Union (EU) and the Instituto Español de Oceanografia (IEO) in conjunction with Instituto Tecnológico Pesquero y Alimentario (AZTI) during 1994 (Pérez et al. 1996). It covers the activities of some of the most important Spanish trawl fleets: "baka", pair trawlers and large openings, in ICES Divisions VIIIc and IXa. Data were taken from observers on board commercial fishing boats during normal fishing activity. Estimates were made of the catch corresponding to all levels of the marine organisms available to the gears in the sampled area, and the proportion of the catch that is returned to the ecosystem.

Trawlers in ICES Division VIIIc work in a multispecies fishery with Hake, Blue Whiting, Horse Mackerel and both species of Anglerfish as its target species (68% of all retained species) and a great number of species as bycatch. Trawlers in Division IXa also work in a multispecies fishery unit with Horse Mackerel, Blue Whiting, Mackerel and Hake as target species (making up 69% of all retained species) and a large number of commercial species as bycatch, such as Nephrops, Four Spot Megrim, Anglerfish, etc. (Pérez et al 1996). Around 20 thousand tonnes of fresh fish are landed annually in these areas (Olaso et. al., 1996).

Murawski (1993) recognises the complexity of interactions among resources and their fisheries that determine mixed fisheries and emphasises the necessity to find the factors influencing bycatch and discard rates. The aim of this study is to analyse factors affecting variations in the total discard in weight by the Spanish trawl fleet operating in the North Atlantic Spanish area. Sources of variation are: quarter, area, port, type of gear, group of boats (using multivariant analysis of classification), and as covariables: total catch per unit of effort, fishing hours, depth, tonnage, horsepower and lengths of boats studied.

Material and Methods

The information obtained comes from observers on board commercial boats of the Spanish trawl fleet operating in North Atlantic waters of the Iberian Peninsula in 1994. Taking the lack of experience and previous knowledge as well as the logistical difficulties involved in sampling all the factors which could, in principle, affect variability and behaviour of this fleet's discards, an effort was made to cover, more homogeneously and with relative intensity, all of the most important ports at which this fleet lands its catch, as well as the different trawl gears and areas in which it works. The possible influence of seasonality of the resource and the behaviour of this fleet were also taken into account.

To cover these needs, randomly stratified sampling was carried out of a total of 493 hauls. 11 observers boarded boats for this purpose and carried out a total of 70 trips on 31 different boats of the Spanish fleet fishing with trawl gears. These gears were sorted into three large groups: bakas (with small vertical opening), large vertical opening and pairs (gears with large openings, trawled by two boats). The working area of this fleet was divided in four areas: a) ICES area IXa in the north of Portugal (from Filgueira da Foz to Caminha). b) Area IXa in Spain (from the river Miño to Cape Finisterre). c) Area VIIIc West (from Cape Finisterre to Cape Estaca de Bares). d) Area VIIIc East (from Cape Estaca de Bares to river Bidasoa).

The landing ports studied correspond to the most important and representative ports of this fleet, as are Vigo, Marín, Riveira, Muros, La Coruña, Avilés, Gijón and Santander. To study the influence of possible seasonality, information has also been analyzed by quarter.

Of the set of 31 different boats sampled, grouping was performed and the resulting groups were later introduced in the source of variation. The grouping of these boats began by applying a principal components analysis (PCA) using two sets of variables. One set of variables was associated with the technical characteristics of boats, such as: horse power (HP), gross registered tonnage (GRT) and length. The other related to variables associated with the working method or operative variables of these boats, taking the following as variables: mean trawling times together with their standard deviation and the mean depth of hauls together with their standard deviation. Firstly, the descriptive statistics were calculated as part of the exploratory data analysis of (EDA) and the normality of the variables under study were checked through the Kolmogorov-Smirnov test (Smirnov, 1948). The absolute and partial matrices of correlation were then studied through the Kaiser-Meyer-Olkin (KMO) index (Kaiser, 1974) for the set of the two matrices and the indices of measure of sampling adequacy MSA for each variable. The multiple coefficients of determination between one variable and the rest of the variables were also calculated. Despite the initial results of exploration, the principal components extraction stage was carried out, through the triple criteria of absolute values of the eigenvalues, relative values of the eigenvalues and accumulated percentage of variance. Finally, the axes were rotated with the aim of increasing the interpretation of the principal components extracted.

Although the results obtained were satisfactory, the assumption of the model of factorial analysis was not ideal. For this reason, it was finally decided to opt for the same data matrix as the grouping of boats through agglomerative hierarchical cluster analysis. The variables were standardised to values of z and Euclidean quadratic distances were used as the distance index (Sneath and Sokal, 1973. Anderberger, 1973. Romesburg, 1984). The criteria of combination of clusters was through the UPGMA (unweighted pair-group method using arithmetic average) (Milligan, 1980). Finally, a dendogram was used with re-pondered final distances and it was decided to form four groups of boats. The same grouping method was also applied to the variables, obtaining a grouping of these, coherent with the result obtained through the PCA.

The response variable analyzed was the total discard in weight per unit effort by haul (DPUE). The unit used was kg per effective hour of trawling. In previous studies of discards there are few cases in which the total discard in weight is studied (Murawski, 1993). The objective of choosing this variable is because it is the variable which provides the best approximation to the discard set of a fleet, since the estimation of discards usually has a great deal of sensitivity, obtaining very different results according to the estimation criteria. For this reason, to get a global vision of the discard of a fleet the weight per unit effort provides a much more robust estimate, although for purposes of resource management other variables are of greater interest. However, from the point of view of the impact on the system and behaviour of the fleet as a whole, the measurement presented here is considered much more valid and useful. This variable was distributed normally through logarithmic transformation.

Once the response variable and the different sources of variation had been chosen, such as observers, quarters, fishing gears, areas where the fleet works, landing ports and groups of boats (obtained through cluster analysis), the exploratory data analysis was performed. This was made using box-whisker plots of the discard per unit effort (DPUE) at the different levels of each of the sources of variation, and the descriptive statistics were calculated with the aim of detecting possible errors in the data matrix. As part of the bi-variante EDA and also with the aim of selecting the possible covariables to integrate in the analysis, the correlation matrix was calculated for the following variables: discard per unit effort, retained catch per unit effort, total catch per unit effort (TCPUE), total discard, total landings, trawling hours, depth, boat's horse power, gross registered tonnage and length of boats. Once it had been checked that there were no errors in the database, the following were finally selected as covariables: the logarithm of the total catch per unit effort - to normalise this variable -, trawling hours, mean depth of each haul, the boat's power, tonnage and lastly, length.

Owing to the possible interference which may exist among all the factors initially studied, and that the study of these interactions is impossible for many of those possible, we opted to carry out a one-way analysis for each of the factors. Firstly, the possible observer effect was studied and for this purpose the two ports were chosen in which there had been the highest number of observers. Later, the factors of quarter, area, port, gear and groups of boats were studied.

After all these previous analyses, A final study was chosen to integrate into the general factorial covariance analysis (ANCOVA) the following sources of variation: gear, area, port and groups of boats, and as covariables those previously mentioned. Owing to the complexity of the fleet under study and to the sampling requirements in the study of the set of interactions, it is very limited, and in fact it was only possible to study three double interactions such as: gear/port, gear/area and port/groups of boat.

Results

The number of hauls sampled in 1994 and the estimation of discards in kg per 100 f.h. by ICES rectangle in the area of study are shown in Figure 1. It is seen that the highest values are found on the west coast of the Iberian Peninsula corresponding to ICES Division IXa.

Table 1 shows a summary of the total catch and discards by species, estimated in kg per 100 f.h., and the percentage of discard estimated for the fleet in relation to the total catch. The great diversity of species which make up the catch and discard in this area is noteworthy, with a total of 277 commercial and non-commercial species discarded (221 determined). The total discards/catch rate for all species was 51% and for fish this value was 43%. The main species caught was blue whiting (*Micromesistius poutassou*) and the most commonly discarded was the snipe fish (*Macroramphosus scolopax*) followed by blue whiting, which is a species of commercial interest in this area. Another major discarded fish species were Dogfish *(Scyliorhinus canicula*). The remaining species of commercial interest have a discard rate lower than 10%. A very high number species were discarded in their entirety.

Results in number (Table 2) show snipe fish is also the most discarded species (due to the small size of the fish), blue whiting and silver pout (*Gadiculus argenteus*) also presenting high values of discard in number.

Figure 2 shows the percentage of the total discard and the percentage of the discard/total catch of the set of main species with respect to the set of all species for this fleet.

Technical and operative characteristics of the 31 boats sampled are presented in Table 3. Furthermore, a test of normality of the goodness of fit of normality was performed, whose results that all variables were normally distributed. The coefficients of variation of the variables associated to the technical characteristics of boats are lower than the values corresponding to the operative variables.

To group boats in a homogeneous way and include them as another source of variation in the analysis of the factors affecting the discard through the PCA, a previous analysis of the matrices of correlation of technical and operative variables of these boats was performed. The KMO index for the set of matrices of absolute and partial correlation obtained is 0.55 and the MSA values for each variable are situated between 0.42 and 0.61. The coefficients of multiple determination obtained varied between 0.41 and 0.78. These results indicate that the use of PCA for the grouping of these boats is not the most suitable model, and finally a hierarchical cluster analysis was chosen. Table 4 shows the result of the agglomeration schedule between groups and the dendogram and the rescaled distance clusters combine (cut relative distance = 17) for the choice of four groups of boats based on the descriptive statistics obtained from these groups, which are presented below, and which clearly characterise this fleet. Despite the accurate characterisation - easy interpretation of the groups - obtained, one single boat would always be assigned to one group.

Mean

Boat Group	CV	GRT	Length	Mean Hours	Hours std. dev.	Mean Depth	Depth std. dev.
Gp. 1	495.3	145.6	23.6	3.5	0.953	210.2	78.373
Gp. 2	710.0	217.7	29.3	3.8	0.884	211.4	32.735
Gp. 3	729.0	134.7	24.0	6.0	2.416	356.5	127.970
Gp. 4	500.0	202.0	32.0	4.7	0.780	498.4	203.221

To analyse the possible observer effect, a one-way variance analysis for this factor in the ports of Marín (IXa) and Avilés (VIIIc), where a greater number of observers worked, giving the result that there were no significant differences ($p<0.05$).

A summary of the descriptive statistics of the main sources of variation studied, with their respective levels, is shown in Table 5. It can be seen that the factors are unbalanced, fundamentally ports, gears and groups of boats. This is mainly due to the heterogeneity of this fleet, both in number of boats per port and in type of gear used by these boats. In summarised form: the mean of the total catch per hour of trawling is 126 kg/h (between 7 and 2615 kg/h), Pair trawl being the gear which catches the most per hour of trawling. The mean DPUE of all gears is 68 kg/h (between 0.03 and 2000 kg/h), whose highest values are Pair trawl and in Division IXa. Mean hours of trawling is 4.6 (between 0.8 and 14.5 hours), mean depth at which the fleet works is 295 m (between 73 and 823 m). Among groups of boats, the first stands out as the highest DPUE, corresponding to boats of smaller capacity and which fish at lesser depths.

The result of the one-way variance analysis carried out on ln(DPUE) by quarter does not show significant differences ($p<0.05$), indicating that there is no seasonality in the discard for this fleet. Figure 3 shows the confidence intervals to 95% of ln(DPUE) of the main sources of variation. In this figure we observe that landing ports corresponding to Division IXa have higher values than those of VIIIc. The mean discard rate (on the logarithmic scale) by gear is greater in baka than in large vertical opening. Pair trawl being the one with the lowest discard rate, although having great variability. With respect to groups of boats, group one is that which has the highest mean.

Figure 4 shows the graph of the matrix of covariables used in the general covariance analysis. The highest coefficients of correlation are obtained between GRT vs. length (+0.74), followed by ln(DPUE) vs. Ln TCPUE (+0.72). Although the correlation values between ln(DPUE) vs. hours (-0.54) are low, it is the negative value which calls the attention, as happens in the case of depth ln(DPUE) vs. prof (- 0.44).

Table 6 shows the results of the final ANCOVA for the response variable analyzed. Of the factors used, only the groups of boats do not present significant differences. The coefficient of determination of the model is 0.74. Of the covariables used, the highest coefficients are found in ln(TCPUE) (0.84), hours (-0.63) depth (-0.51). Only the regression coefficients for ln(TCPUE) and hours are significant. It was only possible to analyse three double interactions (gear/area, gear/port and port/group of boats), but they are not included in the analysis as they are not very representative. Of these three interactions, only gear/port gave a significant interaction.

Conclusions

The great variety of species discarded (221 determined), with a percentage of 51% with respect to the total catch (in weight) of all species is the most outstanding data. Fish make up 43% of this percentage, around half of them corresponding to only two species (snipe fish and blue whiting). Although most of the discard weight of all group of species corresponds to the fish group, the discard of commercial species of this group makes up less than 10%. It can be seen that some of the species discarded may be commercialized, although with very low fishing and economic yields. These values are similar to those obtained by the same gear types in other areas (Alverson et al. 1994 and Pérez et al., 1996).

It is curious to see that the technical characteristics - CV, GRT, and above all length - of the trawl boats studied, show little variation, while characteristics denominated as operative - hours and depth - are much more variable, which confirms the heterogeneity in the development of the activities of the fleet in the North Atlantic Spanish coast.

Group four corresponds to one single boat, and is characterised mainly by the depth at which it worked. Among the groups of boats, the first stands out for its high discard rate. Boats of lower capacity and which fish at lesser depths are assigned to this group. This is coherent with the coefficients of correlation estimated, where the duration of hauls is greater at greater depth and at these depths TCPUE's are lower, the main covariable along with DPUE. The same results can be interpreted with another sequence similarly logical. This reasoning should be supplemented with the knowledge of the distribution and abundance of species. To analyse these results in greater detail would require approaching the study from the perspective of composition by species in the total catch. This is the point of primordial - initial - importance of the overall study of the discard, as that carried out by Murawski, 1993.

Great variation is observed in the factors analysed. This fact implies a series of problems such as the following: the enormous demand on sampling intensity to obtain suitable estimations of the discard rate, to establish a new sampling strategy based on information presented and added problems in the management of resources in an attempt to minimise discards by this fleet.

The lack of seasonality of DPUE for the set of species is surprising, and does not point to the existence of seasonal differences in the composition of species. A higher total discard rate is observed in Division IXa than in Division VIIIc. On a logarithmic scale, the discard rate is greater in baka than in pair trawl, and this is something which does not happen when the variable is transformed, although the influence of the low level of sampling and the great variability observed in the case of pair trawl must be taken into account. With respect to the groups of ships established, the discard rate falls progressively from the first to the third group (the groups which contain a higher number of ships).

Problems encountered in the interpretation of these results were the following: a) the problem of heterocedasticity, which made the analysis fragile. b) the unbalance existing in some factors, such as: gear (great aperture - 14 hauls - and pair trawls - 9 hauls -), ports (Gijón - 9 hauls -), and lastly groups of ships (Group four consisted of one ship making 11 hauls). c) Inevitably, sampling design is of a random effects or components of variance (Winer et al. 1991), which implies a need for some prudence in the interpretation of results. d) the study of interactions is, also inevitably, very limited and may have repercussions on significance, detected or not detected, in the main sources of variation. e) the contradiction observed, fundamentally for gears and groups of ships, between mean DPUE and the mean of ln(DPUE) - not in the median -, is due to the low level of sampling and variability in these factors.

It is important to stress the lack of any relationship between retained catch and discards for this fleet. This means that much care must be taken when estimating the discard rate of this fleet from the data obtained of the retained catch or landings in port.

The main covariable is total catch, which obviously means that the best way to reduce the discard rate is to reduce the total catch. Although the values of correlation between ln(DPUE) versus hours and/or depth are low, what is interesting to observe is that they are negative, meaning that the more hours of trawling and/or greater depth, the lower the discard, which can be explained by the low density of the resource. Trawling takes longer in order to obtain profitable landings, although it must be taken into consideration that there is a certain correlation between depth and hours of trawling. Lastly, it should be mentioned that the higher hours and/or greater depth of trawling, the lower the total catch rate obtained.

All of these considerations must be taken into account when trying to manage, from the point of view of discards, such a complex resource with so much variation, where socio-economic repercussions have considerable relevance.

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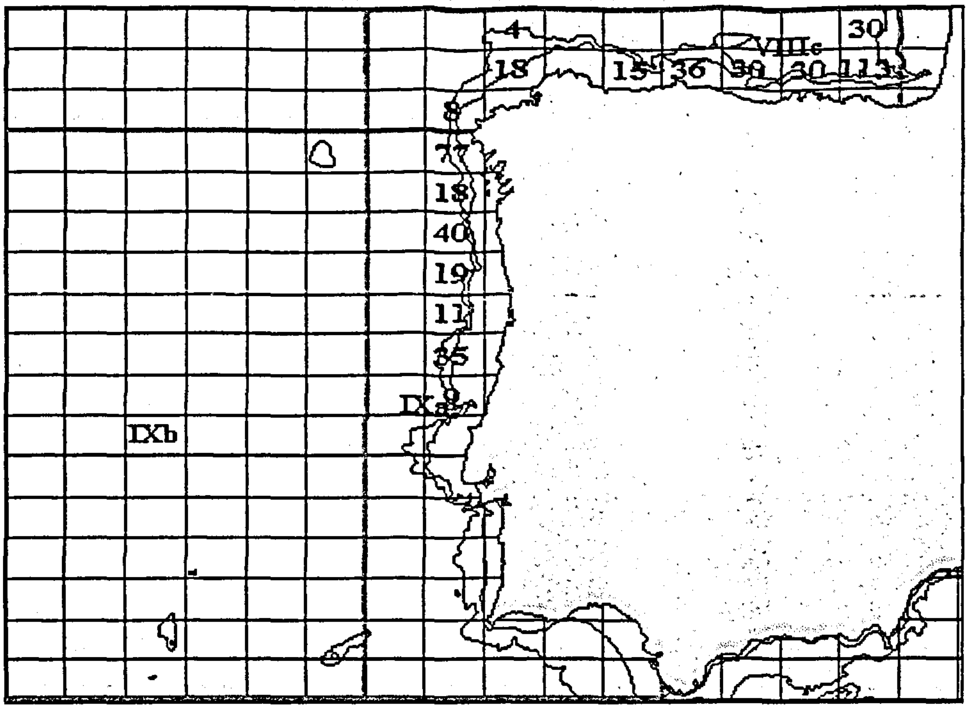
Figure 1. Number of hauls carried out by ICES rectangle and intensity of DPUE obtained.



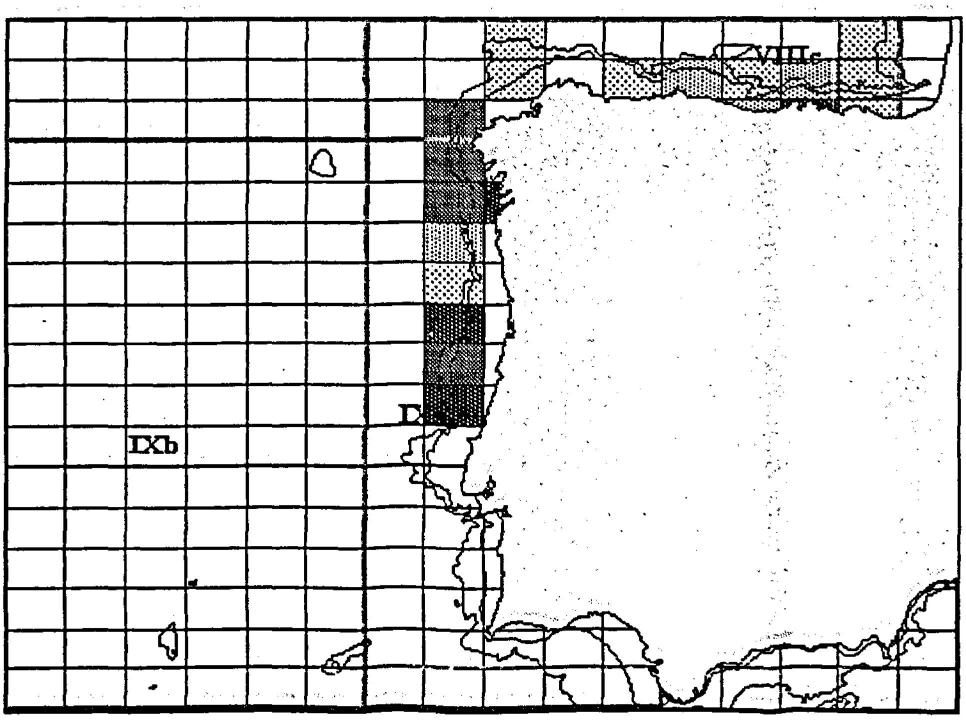
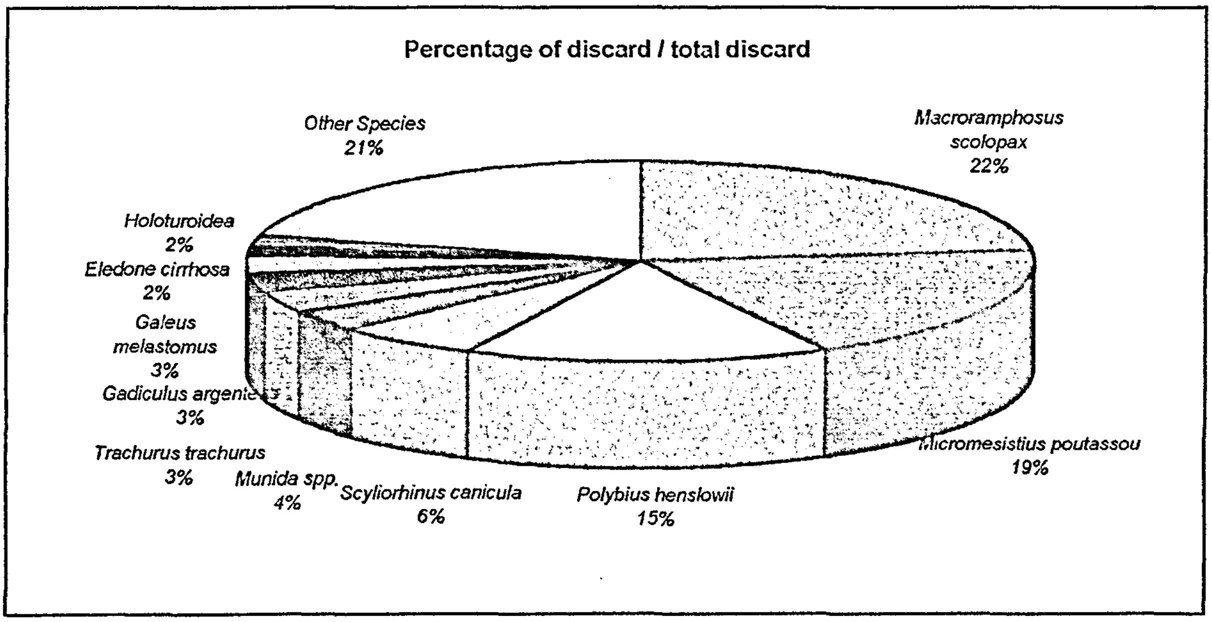


Figure 2. Percentage of discard/total discard and discard/total caught of the main species for all trawl fleets in 1994.



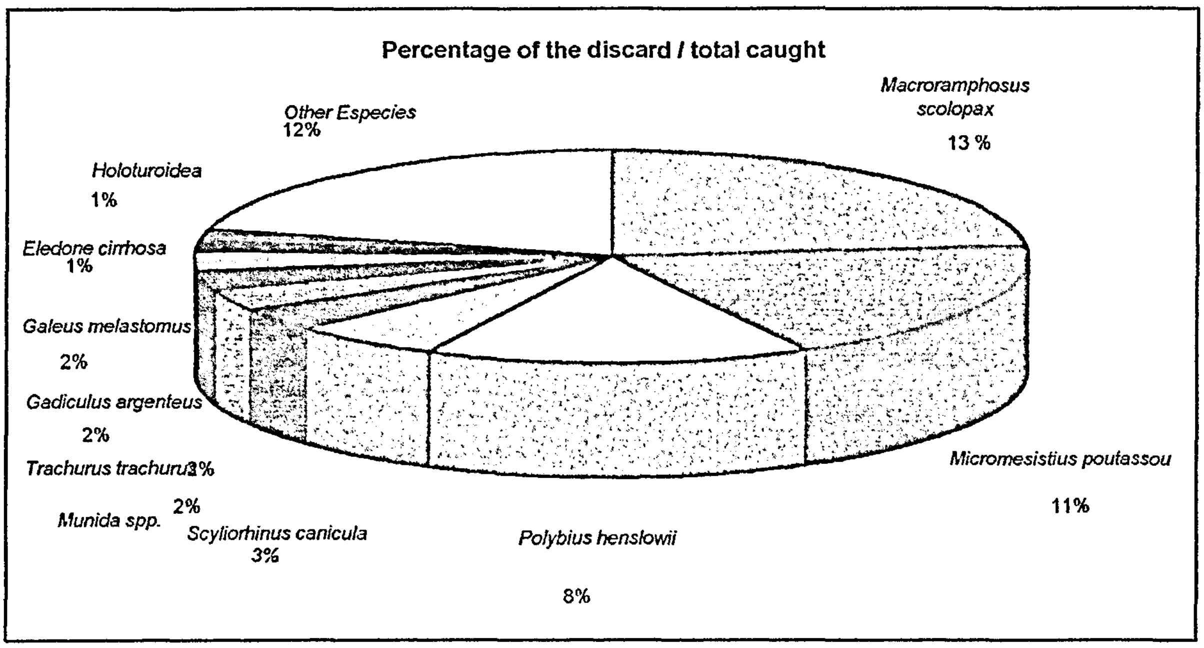


Figure 3. Confidence interval (95%) of the main sources of variation.

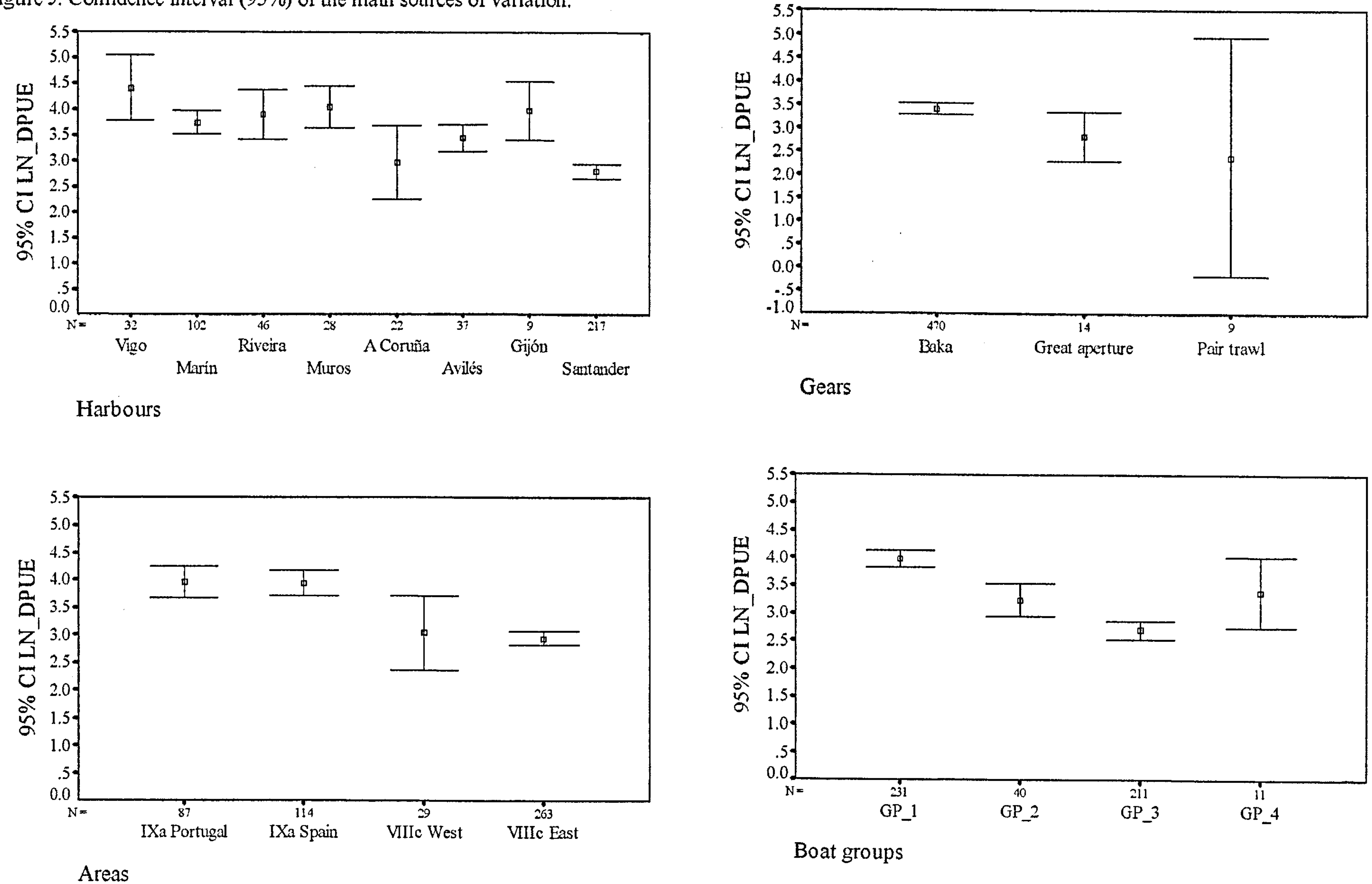


Figure 4. Matrix of covariables used in the analysis.

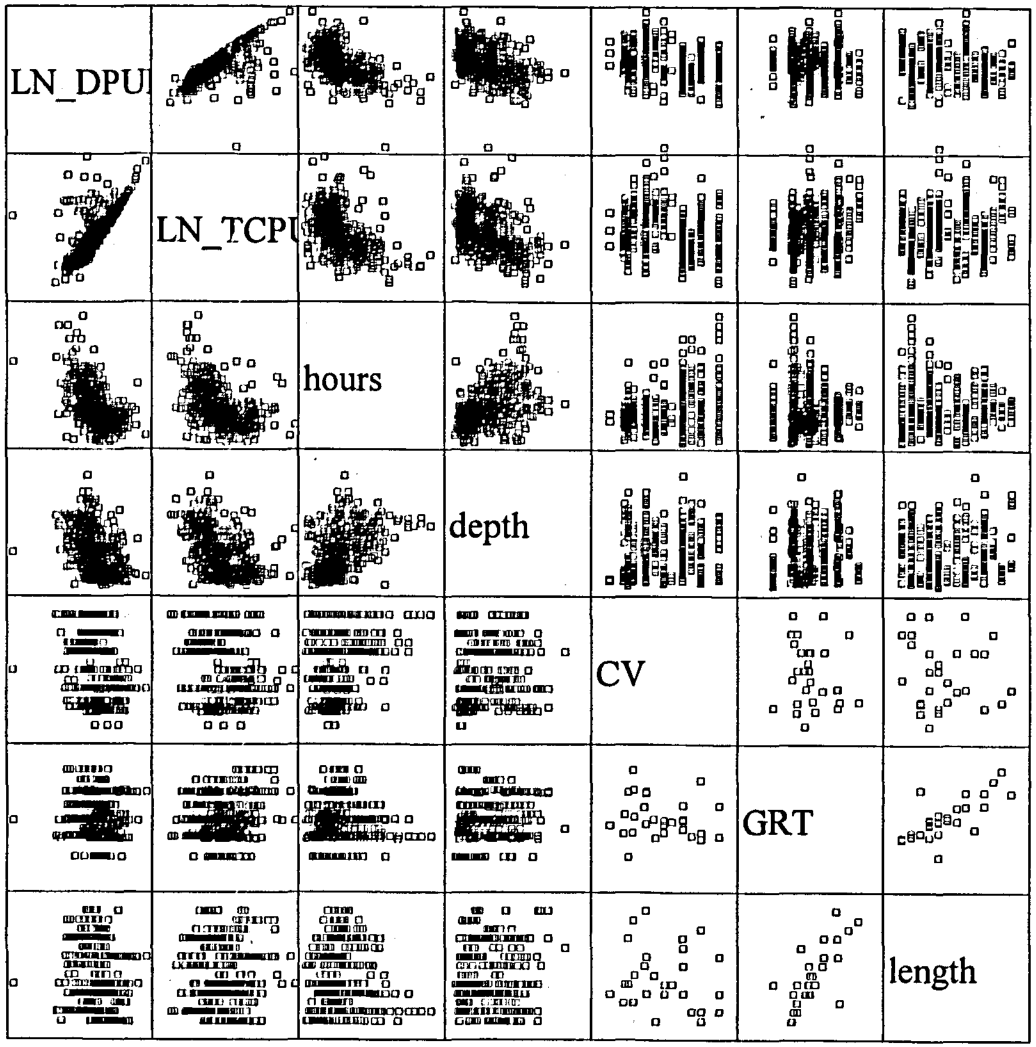


Table 1. Total Catch and discard in kg per 100 f.h. of the Spanish trawl in Divisions VIII and IXa in 1994.

Species	Total		Percentage Discard/	Species	Total		Percentage Discard/
	Caught	Discard	Total Caught		Caught	Discard	Total Caught
PISCES							
Acantholabrus palloni	0	0	0	*Lophius piscatorius*	431	10	2
Alepocephalus bairdii	0	0	100	*Macroramphosus scolopax*	2535	2535	100
Alepocephalus rostratus	2	2	100	*Malacocephalus laevis*	45	45	100
Anthias anthias	0	0	100	*Merluccius merluccius*	952	75	8
Antonogadus macrophthalmus	1	1	100	*Microchirus variegatus*	38	22	58
Aphanopus carbo	2	2	100	*Micromesistius poutassou*	5235	2386	46
Argentina silus	2	1	70	*Molva dipterygia*	9	8	82
Argentina sphyraena	73	57	77	*Molva molva*	4	0	0
Argentina spp.	1	1	100	*Mullus barbatus*	0	0	100
Argyropelecus gigas	+	+	100	*Mullus surmuletus*	20	1	3
Argyropelecus hemigymnus	+	+	100	*Mustelus asterias*	0	0	0
Argyropelecus olfersi	+	+	100	Myctophidae	2	2	100
Argyropelecus spp.	+	+	100	*Nemichthys scolopaceus*	+	+	100
Arnoglossus imperialis	2	2	100	*Nezumia aequalis*	4	4	100
Arnoglosus laterna	81	81	100	*Nezumia sclerorhynchus*	5	5	100
Aspitrigla obscura	15	2	14	*Notacanthus bonapartei*	1	1	100
Asplitrigla cuculus	34	32	96	*Pagellus acarne*	30	0	0
Atherina presbyter	1	1	100	*Pagellus bogaraveo*	3	0	0
alistes carolinensis	0	0	100	*Pagellus erythrinus*	2	0	0
elone belone	0	0	100	*Pagrus pagrus*	0	0	0
Beryx decadactylus	30	0	0	*Phycis blennoides*	254	17	7
Beryx splendens	0	0	0	*Phycis phycis*	2	0	16
Blennius ocellaris	6	6	100	Pisces undeterminated	10	1	6
Boops boops	12	12	100	*Pollachius pollachius*	1	0	0
Brama brama	0	0	0	*Pollachius virens*	1	0	0
Buglossidium luteum	5	5	100	*Polyprion americanus*	1	0	0
Callionymus lyra	67	67	100	*Pomatoschistus spp.*	1	1	100
Callionymus maculatus	2	2	100	*Psetta maxima*	4	0	0
Capros aper	103	103	100	*Raja asterias*	96	15	15
Centroscymnus coelolepis	9	9	100	*Raja brachyura*	1	0	15
Cepola macrophthalma	22	22	98	*Raja clavata*	34	8	24
Chaunax spp.	0	0	100	*Raja montagui*	12	2	12
Chimaera monstrosa	15	15	100	*Raja naevus*	6	1	25
Chlorophthalmus agassizi	6	6	100	*Raja oxyrinchus*	1	0	0
Cittopsis roseus	0	0	100	*Raja spp.*	67	1	1
Coelorhynchus coelorhynchus	1	1	100	*Sardina pilchardus*	89	89	100
Conger conger	47	1	2	*Scomber scombrus*	975	57	6
Deania calceus	21	19	94	*Scorpaena porcus*	1	0	0
Deltentosteus quadrimaculatus	+	+	100	*Scorpaena scrofa*	0	0	0
Dicologoglossa cuneata	1	1	100	*Scorpaena spp.*	1	1	100
Diplodus cervinus	0	0	0	*Scyliorhinus canicula*	591	506	86
Echiodon dentatus	2	2	100	*Scyliorhinus stellaris*	4	4	100
Engraulis encrasicholus	0	0	100	*Scymnodom ringens*	1	1	100
mopterus pusillus	0	0	100	*Sebastes spp.*	11	5	44
mopterus spinax	8	8	100	*Serranus cabrilla*	0	0	100
Eutrigla gurnardus	79	45	57	*Solea spp.*	14	0	0
Gadiculus argenteus	282	282	100	*Solea vulgaris*	5	0	0
Gaidropsarus vulgaris	11	10	91	*Sparus aurata*	0	0	0
Galeorhinus galeus	1	0	0	*Spondyliosoma cantharus*	1	0	0
Galeus melastomus	254	221	87	*Stomias boa*	0	0	100
Gobius niger	1	0	28	*Trachinus draco*	5	5	100
Helicolenus dactylopterus	45	19	42	*Trachurus mediterraneus*	9	9	100
Hexanchus griseus	0	0	100	*Trachurus trachurus*	2823	224	8
Hoplostethus atlanticus	7	7	100	*Trachyrhynchus trachyrhynchus*	28	28	100
Hoplostethus mediterraneus	1	1	67	*Trichiurus lepturus*	3	3	100
Labrus bergylta	0	0	0	*Trigla lucerna*	33	13	39
Labrus bimaculatus	+	+	100	*Trigla lyra*	11	2	15
Lampanyctus crocodilus	+	+	100	Triglidae	70	39	56
Lepidion eques	2	2	100	*Trigloporus lastoviza*	46	22	47
Lepidopus caudatus	1	1	100	*Trisopterus luscus*	129	12	10
Lepidorhombus boscii	471	62	13	*Trisopterus minutus*	75	13	17
Lepidorhombus whiffiagonis	101	4	4	*Trisopterus spp.*	158	10	7
Lepidotrygla cavillone	0	0	100	*Xenodermichthys copei*	0	0	100
Lophius budegassa	450	3	1	*Zeus faber*	15	4	25
				Total pisces	**17185**	**7306**	**43**

\+ less than 1 kg per moth in the sampling
0 less than 0.1 kg per 100 f.h.

Table 1 cont. Total Catch and discard in kg per 100 f.h. of the Spanish trawl in Divisions VIII and IXa in 1994.

Species	Total Caught	Total Discard	Percentage Discard/ Total Caught
CRUSTACEA			
Alpheus glaber	0	0	100
Atelecyclus rotundatus	+	+	100
Atelecyclus undecimdentatus	+	+	100
Bathynectes maravigna	4	4	100
Calappa granulata	0	0	100
Cancer bellianus	1	0	42
Cancer pagurus	5	1	11
Chlorotocus crassicornis	1	1	100
Corystes cassivelaunus	+	+	100
Crangonidae	+	+	100
Crustacea undeterminated	36	36	100
Dichelopandalus bonnieri	17	8	49
Galathea spp.	0	0	100
Geryon longipes	89	82	92
Gnatophausia gigas	+	+	100
Goneplax rhomboides	1	1	100
Homarus vulgaris	1	0	0
Lepas spp.	0	0	100
Liocarcinus depurator	87	87	100
Macropipus tuberculatus	11	11	100
Macropodia spp.	2	2	100
Maja squinado	1	0	1
Munida intermedia	13	13	100
Munida perarmata	+	+	100
Munida sarsi	1	1	100
Munida spp.	445	409	92
Nephrops norvegicus	369	8	2
Paguroidea	43	43	100
Pagurus alatus	8	8	100
Pagurus bernhardus	+	+	100
Pagurus excavatus	0	0	100
Pagurus prideauxi	37	37	100
Palaemon serratus	+	+	100
Palinurus elephas	3	0	0
Parapagurus pilosimanus	0	0	100
Parapeneus longirrostris	1	1	100
Paromola cuvieri	0	0	100
Pasiphaea multidentata	0	0	100
Pasiphaea sivado	1	1	100
Penaeidae	0	0	83
Plesionika heterocarpus	25	9	37
Polybius henslowii	2177	2177	100
Polycheles typhlops	2	2	100
Pontophilus spinosus	0	0	100
Pontophilus spp.	+	+	100
Processa spp.	1	1	100
Rochinia carpenteri	0	0	100
Scalpellum scalpellum	+	+	100
Sergestes robustus	+	+	100
Solenocera membranacea	42	38	89
Xanthidae	0	0	100
Total crustacea	**3426**	**2984**	**87**

Species	Total Caught	Total Discard	Percentage Discard/ Total Caught
MOLUSCA			
Alloteuthis media	6	4	76
Alloteuthis spp.	1	1	86
Alloteuthis subulata	1	1	86
Anomia ephippium	4	4	100
Aporrhais pespelicani	+	+	100
Aporrhais serreseanus	1	1	100
Argobuccinum olearium	2	2	100
Bathypolipus arcticus	2	2	100
Bathypolipus sponsalis	21	21	100
Bivalvia undeterminated	+	+	100
Buccinum spp.	+	+	100
Calliostoma granulatum	2	2	100
Calliostoma zigziphinum	+	+	100
Cassidaria tyrrhena	0	0	100
Charonia lampax	7	7	100
Charonia rubicunda	11	11	100
Colus spp.	6	6	100
Coralliophila spp.	6	6	100
Dentalium spp.	+	+	100
Eledone cirrhosa	292	109	37
Galeodea thyrrhena	4	4	100
Gasteropoda	58	58	100
Histhiotheutidae undeterminated	0	0	100
Illex coindetii	2	2	87
Laevicardium crassum	0	0	100
Loligo forbesi	0	0	0
Loligo spp.	3	1	16
Loligo vulgaris	17	0	0
Lunatia fusca	+	+	100
Mollusca undeterminated	1	1	100
Neptunea contraria	0	0	100
Octopidae	0	0	100
Octopus macropus	4	4	100
Octopus vulgaris	38	3	8
Ommastrephidae	70	7	10
Opistoteuthis agassizi	85	85	100
Pinna nobilis	+	+	100
Pinna pectinata	2	2	100
Rossia macrosoma	29	29	100
Scaphander lignarius	1	1	100
Semicassis saburon	0	0	100
Sepia elegans	2	2	100
Sepia officinalis	3	0	8
Sepia orbignyana	3	2	56
Sepia spp.	1	0	26
Sepiola spp.	1	1	100
Todarodes sagittatus	59	5	8
Todaropsis eblanae	51	10	19
Venus spp.	+	+	100
Total Mollusca	**797**	**393**	**49**

\+ less than 1 kg per moth in the sampling

0 less than 0.1 kg per 100 f.h.

Table 1 cont. Total Catch and discard in kg per 100 f.h. of the Spanish trawl in Divisions VIII and IXa in 1994.

Species	Total Caught	Total Discard	Percentage Discard/ Total Caught
ECHINODERMATA			
Anseropoda membranacea	0	0	100
Antedon bifida	9	9	100
Asteroidea undeterminated	10	10	100
Asteronyx loveni	1	1	100
Astropecten auranticus	+	+	100
Astropecten irregularis	10	10	100
Brisingella coronata	3	3	100
Echinoidea undeterminated	98	98	100
Echinus acutus	59	59	100
Echinus esculentus	0	0	100
Echinus melo	1	1	100
Holothuroidea undeterminated	164	164	100
Leptometra celtica	2	2	100
Luidia ciliaris	2	2	100
Luidia spp.	0	0	100
[illegible]thasterias glacialis	1	1	100
[illegible]padonus spp.	2	2	100
Nymphaster arenatus	1	1	100
Ophiocten sericeum	5	5	100
Ophiothrix fragilis	0	0	100
Ophiura texturata	21	21	100
Ophiuroidea undeterminated	30	30	100
Ostrea spp.	+	+	100
Phormosoma placenta	1	1	100
Stichopus regalis	41	41	100
Stichopus spp.	21	21	100
Stichopus tremulus	42	42	100
Tethyaster subinermis	0	0	100
Total Echinodermata	**524**	**524**	**100**

Species	Total Caught	Total Discard	Percentage Discard/ Total Caught
OTHER GROUPS			
Actinauger richardi	79	79	100
Actiniaria	5	5	100
Alcynium spp.	+	+	100
Alcyonium digitatum	0	0	100
Algae	3	3	100
Anthozoa undeterminated	+	+	100
Aphroditae aculeata	6	6	100
Ascidiacea	+	+	100
Briozoa	+	+	100
Caryophillia clavus	+	+	100
Cerianthus spp.	+	+	100
Cnidaria undeterminated	1	1	100
Dendrophyllia ramea	9	9	100
Epizoanthus spp.	0	0	100
Epizoantus paguriphilus	1	1	100
Funiculina quadrangularis	+	+	100
Hialinoecia tubicola	+	+	100
Invertebrata undeterminated	24	24	100
Nudibranchia	+	+	100
Pelagia noctiluca	2	2	100
Pennatula rubra	0	0	100
Phakelia ventilabrum	0	0	100
Plumularia spp.	+	+	100
Polychaeta undeterminated	+	+	100
Porifera	1	1	100
Salpidae undeterminated	3	3	100
Total Other Groups	**136**	**136**	**100**

	Caught	Discard	Percentage
Total all species	**22068**	**11343**	**51**

\+ less than 1 kg per moth in the sampling
0 less than 0.1 kg per 100 f.h.

Tabla 2. Main discarded species in number per 100 f.h. of the Spanish trawl fleet in Divisions VIIIc and IXa in 1994.

Species	N per 100 f.h.
Macroramphosus scolapax	257445
Micromesistius poutassou	62297
Gadiculus argenteus	40908
Capros aper	4649
Trachurus trachurus	4128
Lepidorhombus boscii	2364
Galeus melastomus	2213
Scyliorhinus canicula	2025
Sardina pilchardus	1546

Tabla 3. Descriptive statistics of boats used in the analysis.

Variable	Mean	Std Dev	CV	Minimum	Máximum	N.	K-S/Normality	Unit
CV	591.61	171.96	0.29	300	900	31	n. s.	HP
GRT	160.39	73.84	0.26	72	500	31	n. s.	tn
Length	24.58	3.21	0.13	20	32	31	n. s.	m
X_HOUR	4.41	1.45	0.33	2.33	8.58	31	n. s.	Hours
D_HOUR	1.41	.89	0.63	.43	4.13	31	n. s.	
X_Depth	266.83	107.95	0.40	108.0	498.4	31	n. s.	m
D_Depth	93.98	62.25	0.66	7.0	203.2	31	n. s.	

Table 4. Results of Hierarchical cluster analysis for boats. Agglomeration schedule and Dendogram.

Agglomeration Schedule using Average Linkage (Between Groups)

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	21	26	.202090	0	0	3
2	14	25	.606411	0	0	5
3	21	27	.740792	1	0	9
4	2	4	1.003017	0	0	13
5	12	14	1.275822	0	2	12
6	3	7	1.288735	0	0	15
7	18	22	1.517936	0	0	16
8	15	23	1.649222	0	0	14
9	16	21	1.754620	0	3	12
10	6	30	1.853771	0	0	15
11	19	28	2.669746	0	0	16
12	12	16	2.767929	5	9	22
13	2	5	3.324114	4	0	20
14	15	24	3.551363	8	0	18
15	3	6	3.753041	6	10	17
16	18	19	3.920685	7	11	19
17	3	9	4.323197	15	0	20
18	11	15	4.521621	0	14	21
19	18	20	5.347086	16	0	24
20	2	3	6.468183	13	17	25
21	8	11	6.506229	0	18	22
22	8	12	7.233993	21	12	24
23	13	17	7.595221	0	0	26
24	8	18	10.168764	22	19	28
25	1	2	11.224503	0	20	27
26	10	13	12.251108	0	23	28
27	1	31	14.771606	25	0	29
28	8	10	15.580747	24	26	29
29	1	8	18.168428	27	28	30
30	1	29	23.016676	29	0	0

Dendrogram using Average Linkage (Between Groups)

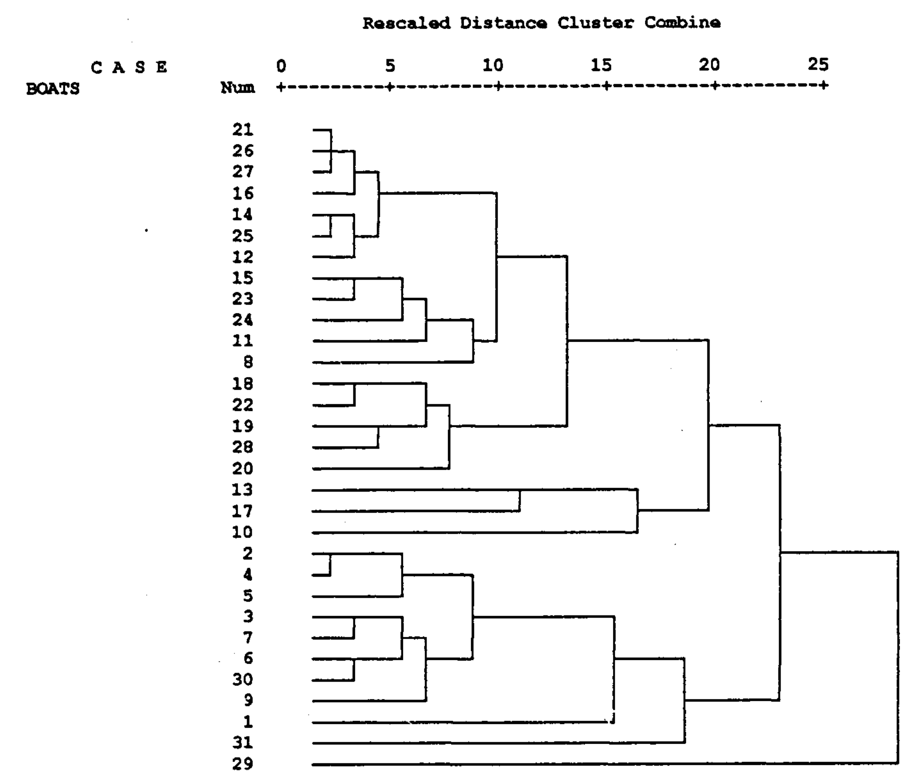


Table 5. Descriptive statistics of the main sources of variation studied.

		DPUE				CTPUE				HOURS				DEPTH			
	N°	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mear	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Quarters																	
1°	83	45.8	69.2293	2.62	446.3	132.2	139.8871	18.1	996.8	4.5	1.7383	1.5	9.5	247	123.8755	73	600
2°	124	93.0	226.7795	0.03	2000.0	143.5	247.7477	6.6	2048.0	5.0	2.7393	1.0	14.5	304	157.1791	99	823
3°	139	69.4	79.1852	1.61	444.4	108.6	125.7208	8.5	1069.8	4.3	2.2978	0.8	12.0	306	137.0461	86	713
4°	147	56.9	100.6661	1.33	948.8	123.8	252.3006	13.6	2614.8	4.6	1.8793	1.1	9.3	304	169.1081	91	713
Harbour																	
Vigo	32	254.6	396.8809	2.25	2000.0	288.1	400.1959	10.9	2048.0	3.8	0.9385	1.5	5.3	241	151.5222	99	630
Marín	102	79.6	93.0316	3.29	446.3	117.8	100.5083	11.8	515.8	3.8	1.0817	1.1	6.2	295	169.5141	104	713
Riveira	46	122.4	167.9990	1.33	948.8	350.9	429.8288	33.2	2614.8	3.7	1.8150	0.9	9.3	310	121.7971	121	566
Muros	28	91.5	85.5610	6.67	342.9	131.8	92.6669	28.0	399.8	3.2	0.7064	2.0	4.8	134	38.7095	86	267
A Coruña	22	31.5	20.5168	0.03	67.0	138.3	200.8722	22.0	996.8	5.0	1.3996	3.0	9.5	335	46.5772	287	457
Avilés	37	43.3	34.4692	9.33	138.1	85.6	50.8099	18.0	243.2	4.1	1.9757	1.5	9.1	251	167.6896	91	823
Gijón	9	68.1	47.7180	15.01	145.7	278.4	151.7760	66.7	484.5	2.3	0.7500	1.0	3.5	126	20.4207	110	158
Santander	217	27.5	31.8424	1.10	248.9	56.6	51.1855	6.6	400.7	5.6	2.6265	0.8	14.5	331	143.2184	73	658
Area																	
XIa South	87	135.6	261.7720	2.25	2000.0	166.8	266.0094	10.9	2048.0	3.7	0.9971	1.1	6.1	273	160.7163	99	713
IXa North	114	103.0	127.8730	1.33	948.8	185.8	181.4719	26.0	1357.6	3.6	1.2172	0.9	7.2	259	151.8099	86	713
VIIIc West	29	55.7	96.3223	0.03	473.7	290.3	514.5843	22.0	2614.8	5.0	1.7566	2.8	9.5	341	75.8355	179	566
VIIIc East	263	31.1	33.8682	1.10	248.9	68.3	69.9289	6.6	484.5	5.3	2.6158	0.8	14.5	313	151.0088	73	823
Gear																	
Trawl	470	66.6	131.9370	1.10	2000.0	106.8	147.7782	6.6	2048.0	4.6	2.2438	0.8	14.5	297	152.4241	73	823
Gr. Apert.	14	23.1	19.1311	2.62	78.3	362.5	226.2109	79.7	944.9	4.4	0.9186	2.7	6.6	172	27.7508	121	219
Pair Trawl	9	189.9	329.4768	0.03	948.8	756.1	812.0271	154.9	2614.8	6.0	2.7201	2.8	9.5	386	111.1749	179	566
Boat Group																	
Gp. 1	231	106.9	176.6908	2.25	2000.0	145.7	180.3993	10.9	2048.0	3.6	1.2676	0.9	9.5	246	141.8448	73	713
Gp. 2	40	36.7	32.5025	2.62	145.7	254.0	227.8459	22.0	996.8	4.1	1.3376	1.0	7.0	236	101.1739	110	457
Gp. 3	211	31.4	77.4227	0.03	948.8	82.8	218.0328	6.6	2614.8	5.8	2.6321	0.8	14.5	349	139.4974	99	823
Gp. 4	11	50.3	66.4741	12.54	189.5	72.7	70.6166	26.0	230.8	4.7	0.7797	3.2	5.6	498	203.2205	206	713
TOTAL	493	67.6	3036.3428	0.03	2000.0	125.9	4555.7353	6.6	2614.8	4.6	49.5140	0.8	14.5	295	3364.0679	73	823

Table 6. Results of general factorial analysis of covariance for LN_DPUE.

Tests of Significance for LN_DPUE using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	214.08	472	.45		
REGRESSION	372.20	6	62.03	136.77	.000
GEAR	53.77	2	26.88	59.27	.000
HARBOUR	7.02	7	1.00	2.21	.032
AREA	3.85	2	1.92	4.24	.015
BOAT GROUP	2.01	3	.67	1.48	.220
(Model)	617.63	20	30.88	68.09	.000
(Total)	831.71	492	1.69		

R-Squared = .743
Adjusted R-Squared = .732

Correlations between Covariates and Predicted Dependent Variable

	COVARIATE					
VARIABLE	LN_TCPUE	HOUR	DEPTH	CV	GRT	LENGTH
LN_DPUE	.837	-.630	-.505	-.349	-.016	-.119

Squared Correlations between Covariates and Predicted Dependent Variable

VARIABLE	AVER. R-SQ
LN_TCPUE	.700
HOUR	.397
DEPTH	.255
CV	.122
GRT	.000
LENGTH	.014

Regression analysis for WITHIN+RESIDUAL error term
Individual Univariate .9500 confidence intervals
Dependent variable .. LN_DPUE

COVARIATE	B	Beta	Std. Err.	t-Value	Sig. of t
LN_TCPUE	1.04000	.79512	.046	22.466	.000
HOUR	-.04807	-.08246	.018	-2.617	.009
DEPTH	-.00022	-.02531	.000	-.780	.436
CV	-.00012	-.01516	.000	-.267	.790
GRT	-.00110	-.03600	.002	-.604	.546
LENGTH	-.01427	-.03702	.019	-.763	.446