OCEANOGRAPHY OF THE BAY OF BISCAY.
*X.A.G. Morán, J.M. Rodríguez and P. Petitgas (eds.)*

**SCIENTIA MARINA** 70S1
June 2006, 173-181, Barcelona (Spain)
ISSN: 0214-8358

# Discards of Spanish trawler fleets operating in the Bay of Biscay in 2000

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SUMMARY: A stratified sampling programme by gear and port was carried out by observers on board vessels in 2000 to study the discard behaviour of trawler fleets operating off Spanish North Atlantic coasts. No relationship between discards in weight or numbers and haul duration was found, so the results in weight are presented in kilograms per haul instead of kilograms per hour, as is usual for catches. The data were analysed in order to find groups of ports with a similar behaviour and to reduce the number of strata (30 as a result of the crossing of 10 main ports and 3 types of towed gears). The reduction in the number of strata (from the 30 original strata to the 9 new groups obtained) would mean a high improvement in efficiency for raising purposes, for stock assessment needs and for new Spanish sampling programmes. Significant differences in discards between groups of ports were found. Species composition of discards by stratum is given as a percentage of the total weight, based on data collected by the observers on board vessels. There are also differences in the discarded species composition for the different groups of ports obtained.

*Keywords*: discards, trawling, observers programme, Spanish North Atlantic waters.

RESUMEN: DESCARTES DE LAS FLOTAS ARRASTRERAS ESPAÑOLAS EN EL GOLFO DE VIZCAYA EN EL AÑO 2000. – Para estudiar los descartes de las flotas de arrastre que pescan en las costas Noratlánticas españolas se llevó a cabo, durante el año 2000, un programa de muestreo con observadores a bordo. El tipo de muestreo fue estratificado por arte y puerto. No se ha encontrado relación entre los descartes en peso o en número y la duración del lance, por lo tanto, los resultados se presentan en kilos por lance en lugar de kilos por hora, como es habitual para las capturas. Para reducir el número de estratos (que eran 30 como resultado de cruzar 10 puertos principales con los tres tipos de arte de arrastre considerados) se analizaron los datos en busca de los grupos de puertos con comportamiento similar. La reducción en el número de estratos (de los 30 originales a los 9 nuevos grupos obtenidos) podría aumentar la eficiencia de los muestreos especialmente con vista a la estimación de valores totales útiles en evaluación y futuros programas de muestreo. Las diferencias entre los descartes de los distintos grupos de puertos obtenidos resultaron significativas. Los resultados incluyen la composición específica del descarte por estrato, en porcentaje del peso total, basada en datos recogidos con observadores a bordo. Estos resultados también muestran diferencias entre los diferentes grupos de puertos.

*Palabras clave*: descartes, arrastre, programa de observadores, aguas españolas del Atlántico Norte.

## INTRODUCTION

Estimation of the discard volume of commercial vessels is important since discarding of target and also non-target species may cause a reduction in yield in medium and long-term predictions. Discards must be included in the assessments where they constitute a significant fraction of the total catch, otherwise the results may be seriously biased. These could include bias in recruitment and fishing mortality estimates in Virtual Population Analysis (VPA) and evaluations of mixed-fisheries where discards are more important. This is the case of Spanish fleets characterised by their continuous changes, targeting a wide range of species (including horse mackerel (*Trachurus trachurus*), blue

whiting (*Micromesistius poutassou*), mackerel (*Scomber scombrus*), hake (*Merluccius merluccius*), two species of anglerfish (*Lophius piscatorius* and *L. budegassa*), megrims (*Lepidorhombus boscii* and *L. whiffiagonis*), Norway lobster (*Nephrops norvegicus*) and cephalopods (as *Illex coindetii*, *Eledone cirrhosa* or *Todaropsis eblanae*).

The main reason for the scarcity of information on discards is the large amount of research effort needed to sample this kind of data. Obtaining adequate discard information requires an intensive discard-sampling programme. An estimate of the total weight and number of fish discarded by a fleet in a year would require a sampling scheme that at least takes into account the spatial and temporal distribution of the fleets. These factors make it very difficult and expensive to estimate the amount of fish of a certain species discarded on a yearly basis.

Sampling of commercial fishing vessels by means of observers on board to estimate the quantities of fish discarded, usually involves a multistage sampling comprising up to six levels of variability: vessels, trips, hauls, boxes, fish length and fish age (Allen *et al.*, 2002). Spanish fleets are characterised by their continuous changes. Some examples are variations in the type of gear and range of sizes targeted. Trip and haul duration is another of the highly variable aspects in the various Spanish fleets. Economic importance and the market for the species also differ between fleets and seasons. Most of the Spanish fleets studied are based in different ports, so another level of variability is added.

This stratified methodology assumes that the use of different raising factors in different strata is straightforward computationally (Stratoudakis, 1999). However, strata may be difficult to define (for example, due to changes between "traditional" trawl and very high vertical opening (referred to as VHVO trawl) gears during the same trip), may change over time (vessels change fishing areas and landing harbours frequently) and may overlap. Estimates of variance require at least two samples in each stratum, but they are not always achievable (due to bad weather, insufficient sampling effort, etc.) and relative undersampling of the least important strata may result in inefficiency (ICES CM, 2000).

The growing importance of discards in world fishery management is further reflected in the increasing attention paid to this topic by international research organisations throughout the 1990s and continuing into this decade. In this period, by-catch and discards have also become the subject of discussion at a variety of national workshops and conferences (Alverson *et al.*, 1994). Andrew and Pepperell (1992) estimated a global by-catch in world shrimp fisheries as high as 16.7 million tonnes, whereas Alverson *et al.* (1994) estimated a global discard range of 17.9 to 39.5 million tonnes. Nevertheless, obtaining adequate discard information requires an intensive discard sampling programme. This factor makes it very difficult and costly to estimate the number or weight of fish of a certain species discarded on a yearly basis.

Reducing the high number of strata in the Spanish sampling strategy by reducing the port strata used to describe discards would lead to a considerable improvement in efficiency for raising purposes and for new sampling programmes, and is one of the main objectives of this paper. In order to reduce this number of strata, ports with similar behaviour were grouped together.

We also identify the most discarded species and its contribution in weight to the total composition of discards.

## MATERIAL AND METHODS

Taking the above factors and the previous knowledge of these fleets in the area (Pérez *et al.*, 1996; Allen *et al.*, 2001; Allen *et al.*, 2002) into account, a sampling programme was implemented to collect information on discards. This was based on a stratified random sampling per quarter, gear and harbour and was carried out by observers on board commercial vessels of the Spanish trawler fleet operating in the North Atlantic waters off the Iberian Peninsula in 2000.

Discards are expected to vary in species composition and quantity due to fishing gear, fishing zones and targeted species. Ships based at different fishing ports are expected to have a different behaviour. For these reasons, a stratified random sampling by gear and port was used.

Gear strata were 3: baka trawl, pair trawl and very high vertical opening trawl (VHVO).

Baka Otter trawls use a cod end mesh size of 65 mm. The ground gear was set for use on clean or medium ground. The gear has a vertical opening of 1.2-1.5 m and a wingspread of 22-25 m. High vertical opening bottom (VHVO) trawls are designed for using a cod end mesh size of 65 mm and present a

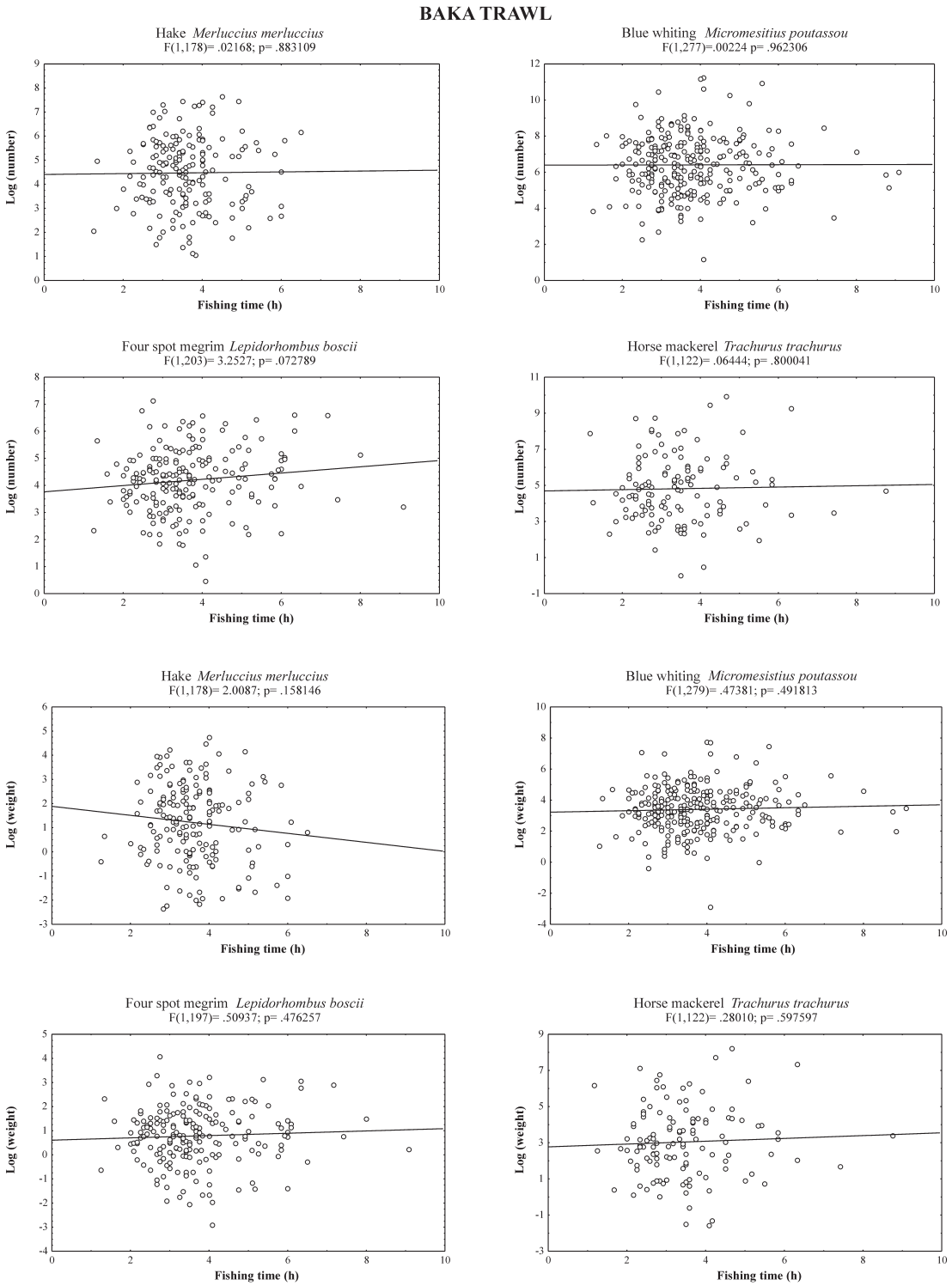


FIG. 1. – Discards by haul (through logarithmic transformation) vs. fishing time for main commercial discarded species, by gear (baka trawl).

vertical opening of 5.0-5.5 m and a wingspread of 18-20 m (Fonseca *et al.*, 2000).

Ten different ports were studied (Santander, Gijón, Avilés, Burela, Celeiro, A Coruña, Muros, Ribeira, Marín and Vigo).

A total of 372 hauls (58 vessels) were sampled: 303 hauls in the baka trawl stratum (35 vessels), 35 (in 15 vessels) in the pair trawl stratum and 34 hauls (8 vessels) in the VHVO stratum. Despite the sampling effort, only Baka trawls had a sufficient num-

ber of samples to show the differences between ports when they were compared.

The variable studied might have been discard per unit effort (DPUE), the effort unit being the hours of trawling, as is normal practice in catch studies. Trenkel *et al.* (2001) found no relationship between discards in weight and the haul duration for the Celtic Sea trawlers. Regression analyses were carried out by gear and species to detect any possible relationship between discards (in weight or numbers) and the haul duration. The significance level selected for the F test was 0.05.

If this relationship does not exist, the variable to be studied will be directly the number per haul instead of the DPUE.

The normality test used in this work to explore the distribution of the variables of interest was the Kolmogorov-Smirnov-Lilliefors test, at a significance level of 0.05. Data have been logarithmically transformed.

In order to reduce the high number of strata used to describe discards in the area by grouping ports with a similar behaviour, an ANOVA analysis and a least significant difference (LSD) test for post-hoc comparison of means (discard in numbers and weight per haul) was conducted to assist in making an appropriate decision.

The main species considered to make the groups were: hake, four-spot megrim, megrim, blue whiting and horse mackerel for baka trawl stratum; blue whiting and hake for pair trawl stratum and horse mackerel, mackerel and blue whiting for VHVO trawl strata. The conditions for selecting these species were that they had to be i) a target species

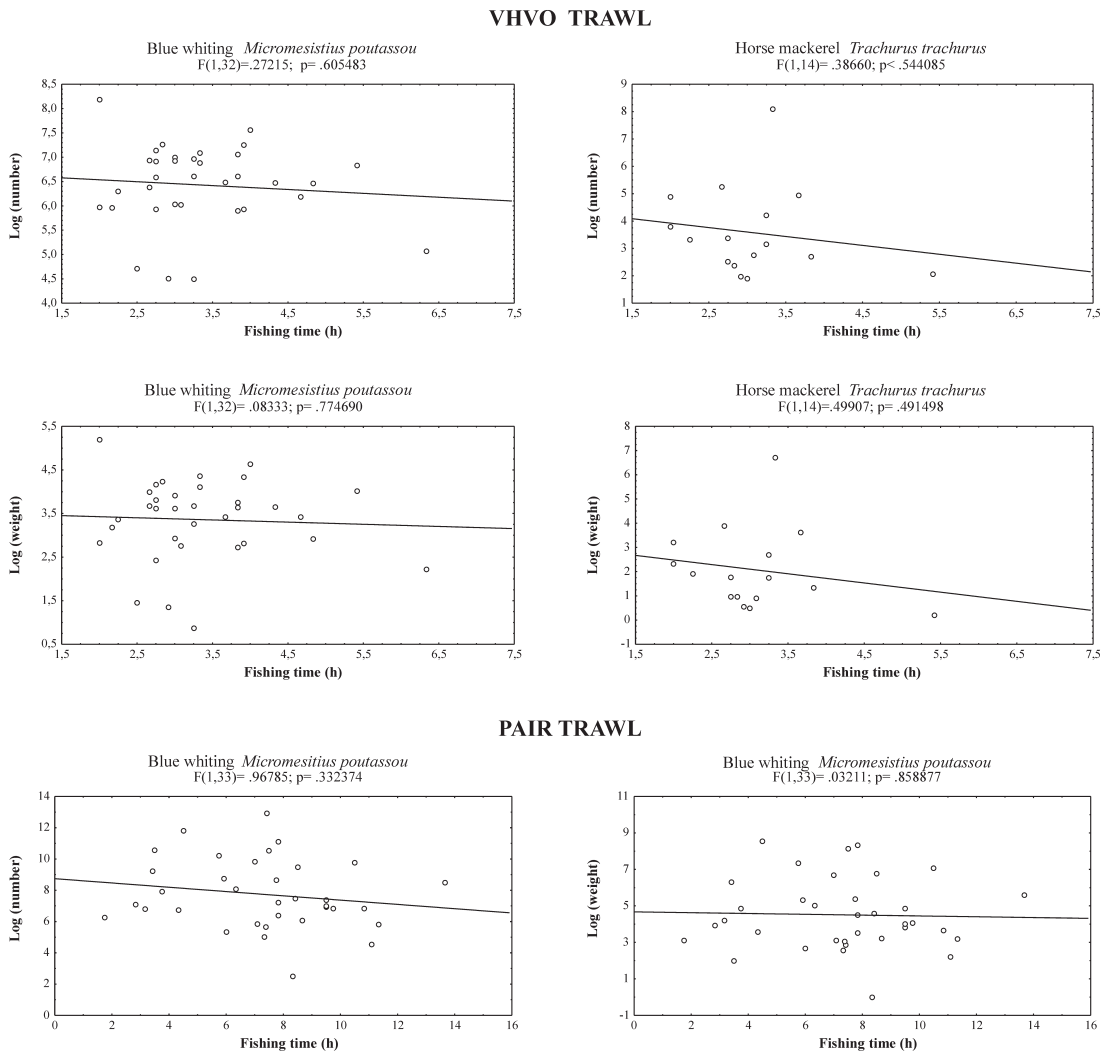


FIG. 2. – Discards by haul (through logarithmic transformation) vs. fishing time for main commercial discarded species, by gear. (pair trawl and VHVO trawl).

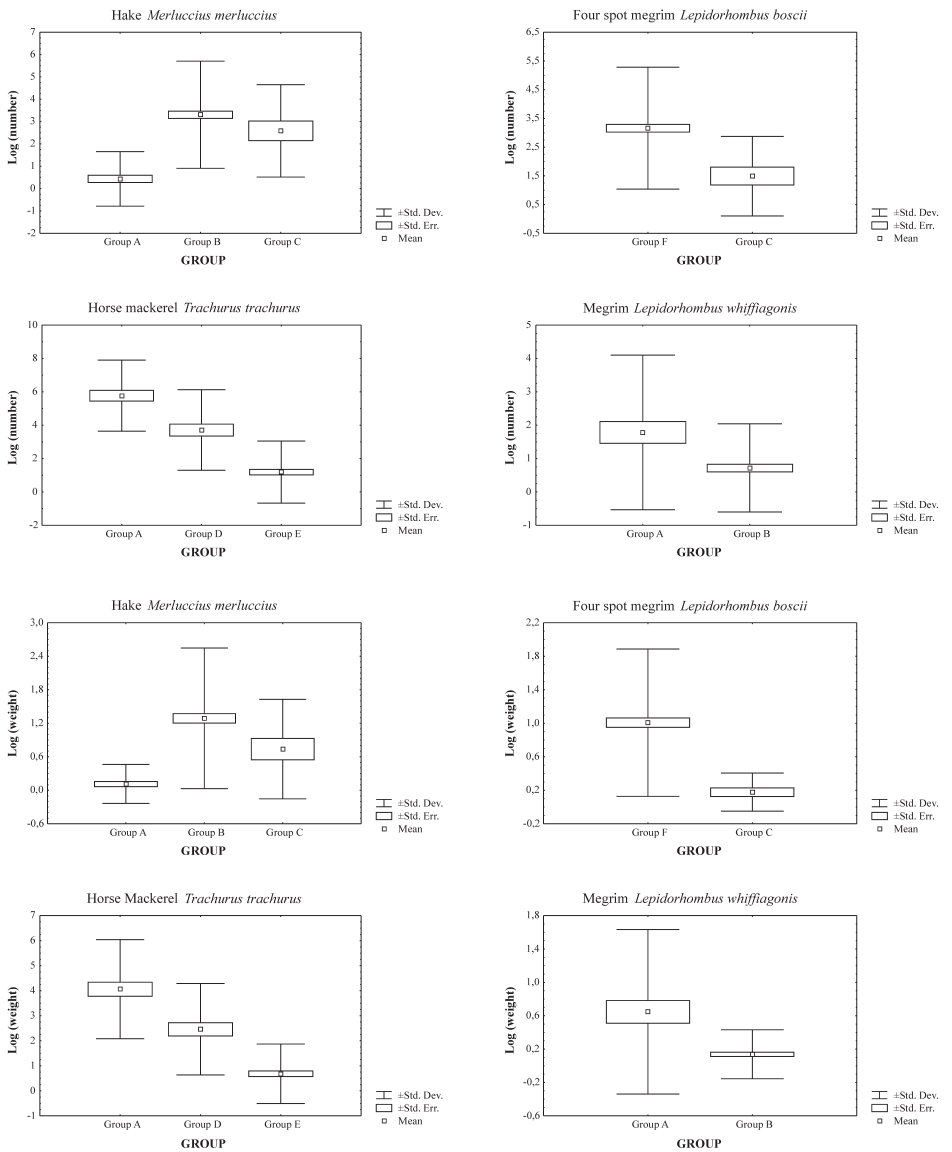


FIG. 3. – Comparison of discard between groups of ports for the Spanish baka trawlers by species. In numbers (A) and in weight (B).

for any trawl fleet; ii) of economic importance, and iii) abundant in discards related to their total catch.

## RESULTS

Plots of the variable discards in number and weight per haul through logarithmic transformation against haul duration by species and gear are shown in Figure 1 and 2. Figure 1 shows the case of baka trawlers and Figure 2 the other two gears (pair and VHVO trawl).

There is no relationship between the discards in number or weight per haul and the duration of the haul for any of the species.

Figure 3 highlights the significant differences in the discards in number and weight per haul between the groups of ports found. We do not show the names of ports belonging to each group to preserve data confidentiality.

Discard per haul and species (in number and weight) was normally distributed by logarithmic transformation. It is interesting to consider the probability of being discarded since most of the species studied are totally retained on board in part of the hauls (discard = 0). Probabilities of being discarded (to some extent or totally) in an average haul for each species are shown in Table 1.

Table 2 shows the mean, standard deviation (S.D.), coefficient of variation (C.V.) and sample

TABLE 1. – Probability of being discarded per haul (to some extent or totally) for the main commercial species by gear and group of ports.

| Gear | Species | Group | prob | n |
|---|---|---|---|---|
| BAKA | Hake (*Merluccius merluccius*) | Group A | 0,12 | 59 |
| | | Group B | 0,72 | 208 |
| | | Group C | 0,73 | 22 |
| | Four-spot megrim (*L.boscii)* | Group F | 0,73 | 248 |
| | | Group C | 0,60 | 20 |
| | Megrim (*L.whiffiagonis)* | Group A | 0,40 | 52 |
| | | Group B | 0,24 | 135 |
| | Blue whiting (*Micromesistius poutassou*) | All ports | 0,99 | 284 |
| | Horse mackerel (*Trachurus trachurus*) | Group A | 0,96 | 47 |
| | | Group D | 0,77 | 48 |
| | | Group E | 0,33 | 124 |
| PAIR | Blue whiting (*Micromesistius poutassou*) | No groups | 1,00 | 35 |
| | Hake (*Merluccius merluccius*) | No groups | 0,42 | 33 |
| VHVO | Horse mackerel (*Trachurus trachurus*) | No groups | 0,47 | 34 |
| | Mackerel (*Scomber scombrus*) | No groups | 0,48 | 27 |

TABLE 2. – Discards per haul in number and weight for the main commercial species by gear and group of ports.

| Gear | Species | Group | Discard in weight kg/haul mean | S.D. | C.V. | n (hauls) | Discard in number number/haul mean | S.D. | C.V. | n (hauls) |
|---|---|---|---|---|---|---|---|---|---|---|
| BAKA | Hake (*Merluccius merluccius*) | Group A | 0.223 | 0.746 | 334% | 59 | 5 | 16 | 300% | 59 |
| | | Group B | 7.897 | 15.448 | 196% | 208 | 178 | 348 | 196% | 208 |
| | | Group C | 2.339 | 4.306 | 184% | 22 | 62 | 102 | 164% | 22 |
| | Four spot megrim (*L.boscii)* | Group F | 3.298 | 5.776 | 175% | 248 | 96 | 159 | 166% | 257 |
| | | Group C | 0.231 | 0.361 | 156% | 20 | 9 | 11 | 128% | 20 |
| | Megrim (*L.whiffiagonis)* | Group A | 2.960 | 7.707 | 260% | 52 | 74 | 202 | 272% | 52 |
| | | Group B | 0.212 | 0.520 | 245% | 135 | 6 | 13 | 234% | 135 |
| | Blue whiting (*Micromesistius poutassou*) | All ports | 90.044 | 249.828 | 277% | 284 | 2432 | 8028 | 330% | 281 |
| | Horse mackerel (*Trachurus trachurus*) | Group A | 303.209 | 669.798 | 221% | 47 | 1772 | 3834 | 216% | 47 |
| | | Group D | 53.303 | 122.235 | 229% | 48 | 290 | 656 | 226% | 48 |
| | | Group E | 4.855 | 13.391 | 276% | 124 | 25 | 65 | 256% | 124 |
| PAIR | Blue whiting (*Micromesistius poutassou*) | No groups | 555.077 | 1212.705 | 218% | 35 | 23161 | 72295 | 312% | 35 |
| | Hake (*Merluccius merluccius*) | No groups | 9.365 | 20.596 | 220% | 33 | 128 | 303 | 237% | 33 |
| VHVO | Horse mackerel (*Trachurus trachurus*) | No groups | 29.209 | 140.839 | 482% | 34 | 118 | 563 | 476% | 34 |
| | Mackerel (*Scomber scombrus*) | No groups | 53.734 | 262.961 | 489% | 27 | 521 | 2613 | 502% | 27 |
| | Blue whiting (*Micromesistius poutassou*) | No groups | 40.560 | 34.181 | 84% | 34 | 823 | 652 | 79% | 34 |

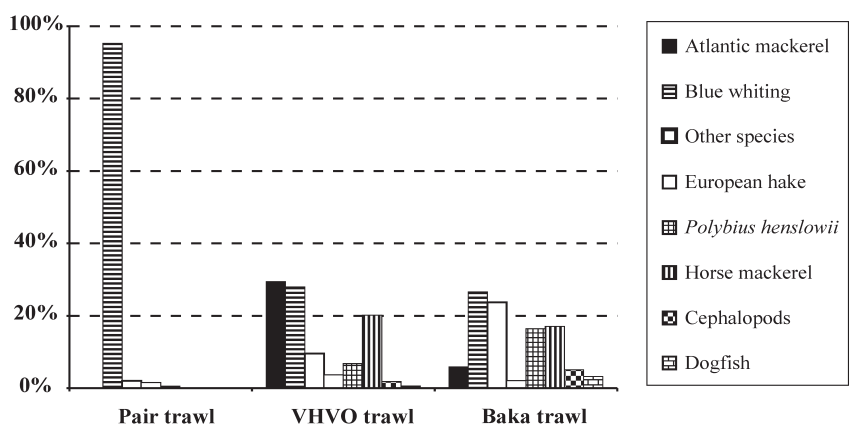


FIG. 4. – Discard composition in percentage of weight for the different gears.

size (n) for discards by haul in number and weight for the main species by gear and group of ports. It is important to highlight the high C.V., even within groups; this is usual in the study of discards and must be taken into account to avoid misinterpreting the mean. Discard composition for different gears is shown in Figure 4, and for different groups of ports using baka trawl it is shown in Figure 5.

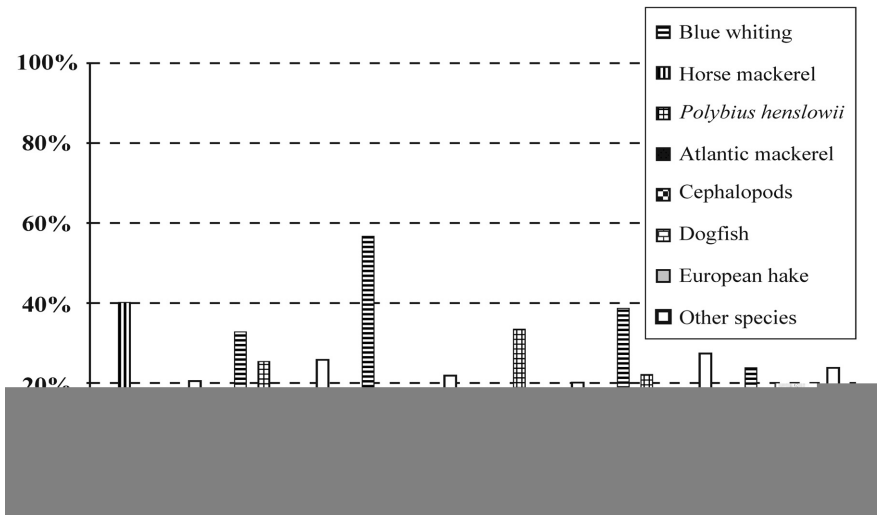


FIG. 5. – Discard composition of Baka trawlers by groups of ports.

## DISCUSSION

In order to reduce the number of strata for sampling discards of the Spanish trawling fleet, the first step was to choose the most appropriate variable to study the differences in discard patterns between all the ports analysed. No significant relationship was found between discards in number or weight and haul duration for Spanish trawlers operating in coastal waters of the Bay of Biscay, and for any of the species considered. This circumstance was previously studied by Trenkel *et al*. (2001) in Celtic Sea trawlers and is relevant, since it has consequences in the selection of the variable to study. As stated above, in this case there is no point in considering the DPUE variable as it has been used frequently assuming that discard had a similar behaviour to total catch (which is dependent on haul duration).

Analysis by gear of the variable selected (discard per haul and per species) was applied, but only Baka trawl gear had enough samples to show the differences between ports when they were compared. So Baka trawl was the only gear for which we obtained significant differences between ports.

There are significant differences in discards per species (measured in number or in weight) between groups of ports for the main species studied. For each species, ports with no significant differences in discard in number and weight were combined, greatly reducing the number of strata for each species. This was the case of both megrims, whose sample strata was reduced to just two out of the ten previous ports. Species such as hake and horse mackerel had their sample strata reduced to three. These differences could reduce the high cost of sampling discards, one of the main handicaps in estimating discards with observers on board (ICES CM, 2001), and could increase the possibilities of finding a ship to sample in case of difficulties. The use of these groups of ports with similar behaviour as new strata for sampling purposes means a reduction in the number of strata from the 30 original strata (ports) to the 9 new groups obtained: 7 groups for Baka trawl and no groups for pair trawl and for VHVO.

The 7 groups for Baka trawl are: A, B, C, D, E, F and the blue whiting "altogether group" (with all ports included).

A- Central VIIIc.
B- VIIIc West and IXa.
C- One small port in IXa division.
D- VIIIc west.
E- VIIIc south and IXa.
F- West and central VIIIc

The last group was made because no significant differences between ports for blue whiting were found. Although this species is a target species for all types of trawl, it is partially discarded in virtually every haul: 100% of the hauls for pair and VHVO trawl and 99% of the hauls in Baka trawl (Table 1).

We can identify a geographical gradient between these port groups from east to west: This gradient is neat for horse mackerel (A being the eastern ports, D the western ports and E the southern ports (Iberian-Atlantic front).

For hake it was necessary to create a new group, C, to isolate a single port from the rest due to its very different behaviour. This small group breaks the geographical gradient.

The singularity of the port included in group C is also confirmed by the four-spot megrim results, for which the rest of the ports did not show significant differences between them. That is, group F in four-spot megrim is, in fact, the addition of hake groups A and B.

Megrim results are substantially different from those of four-spot megrim. This could be due to their different geographical and bathimetric distribution (see Sánchez *et al.*, 1998; ICES CM, 2002). Although both species could be found in ICES Divisions VIIIc and IXa, megrim has its lowest abundance in Division IXa. This why there is no group C in the case of Megrim. Groups A and B are the same groups as in hake, this time showing a geographical gradient from east to west due to the lack of group C.

Although some differences in the groups would be explained by the geographical distribution of the species, we believe that the main underlying cause would be the different target species of the fleet in each port due to market forces. Even in a same trip the target species may change from haul to haul (as was demonstrated for another Spanish trawl fleet in Pérez *et al.*, 2002). This phenomenon would also explain the extraordinary high coefficients of variation of discards in number or weight.

It is not possible to go further in finding a compromise between species and/or gears to make fewer groups (doing that would mean mixing ports with proven different behaviours). Nevertheless, the present groups would lead to a considerable improvement in efficiency for raising purposes, for stock assessment needs and for new sampling programmes. Most of the species studied in this paper were assessed within the framework of the ICES assessment working groups. In some species, as in the case of northern hake and megrim, discard takes part in the total catch matrix used. For other species, discard data are not used in the assessment, although they are considered to be significant for younger ages (ICES CM, 2002).

As expected, the species composition of discards is also different for the different groups of ports obtained (Fig. 5).

The significant differences found between ports, not only in the total amount of discards by species but also in species composition, confirm the need to include stratification by port in the sampling scheme in order to avoid bias in discard estimates. If it were not possible to use such stratification (we have already remarked on the drawbacks), it would be necessary to use at least the groups constituted in this study as strata.

Mean discard results must be used with precaution due to the high coefficient of variation obtained for every species. It would be more appropriate to work with a median or geometric mean. These high C.V. are very common in the studies of discards (Cotter, 1999; Allen *et al.*, 2002).

## ACKNOWLEDGEMENTS

This study was carried out with financial assistance from the Commission of the European Communities and the Instituto Español de Oceanografía (IEO). We are grateful to the IEO for providing a "Formación como Personal Investigador" grant to Laura Lema. We also wish to express our gratitude to the Fisheries Organisation and to the owners of the vessels, as well as to the skippers and crews of these vessels. The co-operation of skippers and crews was at all times enthusiastic. We are also grateful to the observers' coordinator, José Lorenzo, who never gave up despite the difficulties encountered. We are especially grateful to the observers on board these vessels: Juan Carlos Arronte, Teo Patrocinio and Luis Cebrián, whose resolute co-operation and interest, despite the harsh and very dangerous working conditions, made this study possible.

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Received June 27, 2002. Accepted November 24, 2004.