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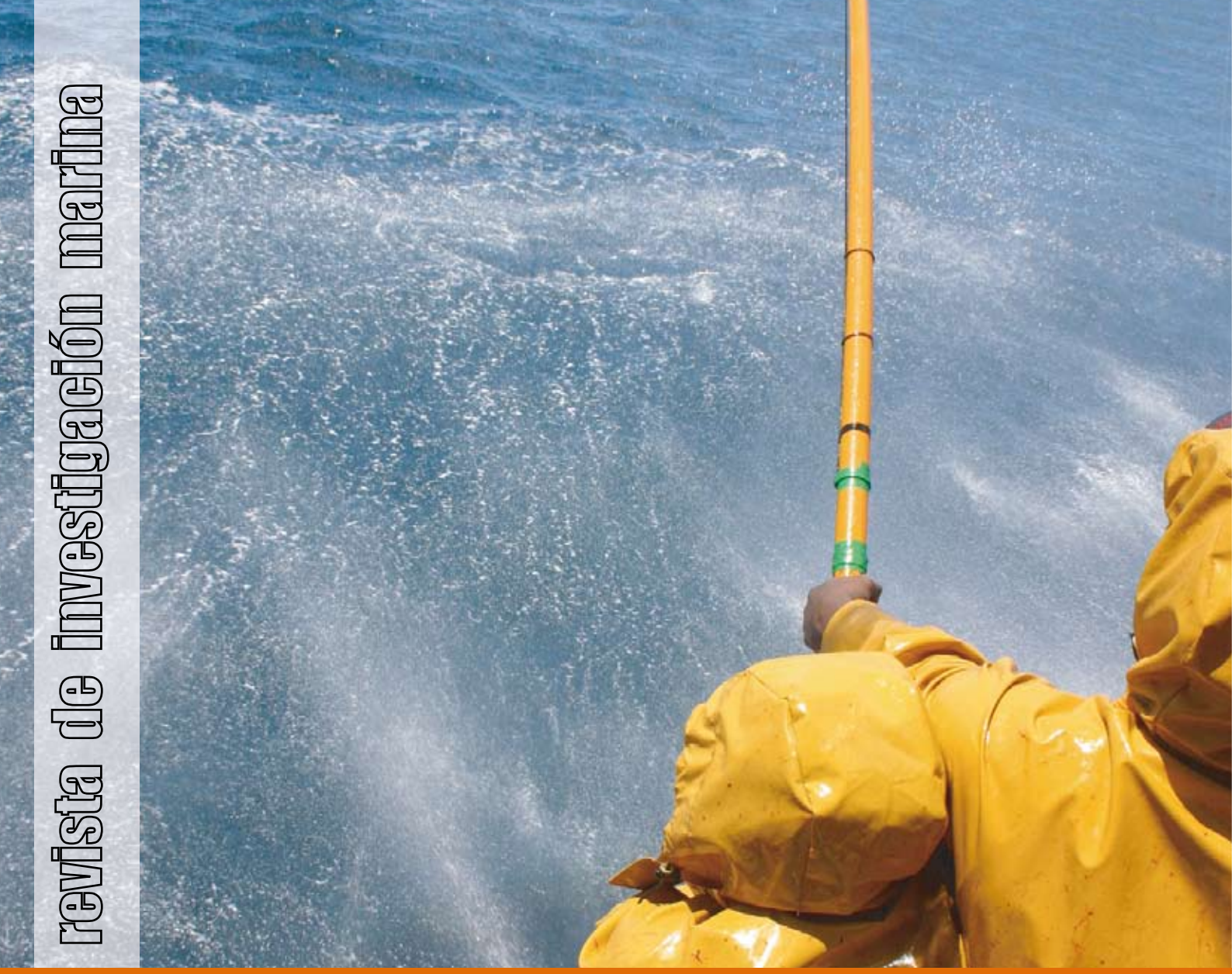

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A multivariate approach for metier definition: A case study of Basque Country trawlers

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Abstract

In this paper a classification into metiers of the trawling fleet of the Basque Country (North East of Spain) operating in the Northeast Atlantic ICES Subareas VI, VII, and Divisions VIIIa,b,d from 2003 to 2008 is presented. Principal Component Analysis (PCA) and Cluster analysis approach are used to obtain homogeneous groups of metiers using trip by trip catch data information. The characterization of these groups is based on target species, fishing area, gear and period of the year. After analyzing the clusters obtained and taking into account the knowledge of the fishery, seven Basque trawl metiers are proposed: 1) pair trawl in Divisions VIIIa,b,d targeting demersal fish, 2) otter trawl in Divisions VIIIa,b,d targeting demersal fish , 3) otter trawl in Divisions VIIIa,b,d targeting mixed cephalopods and demersal fish 4) otter trawl in Division VIIIa,b,d targeting horse mackerel, 5) otter trawl in Divisions VIIIa,b,d targeting mackerel, 6) otter trawl in Subarea VII targeting megrim and monkfish, 7) otter trawl in Subarea VI targeting hake, megrim and monkfish and seasonally blue ling. Five of them are considered consistent along the years 2003-2008 and two of them are seasonal.

Key words: cluster analysis, demersal species, metier, principal component analysis, trawlers, Basque Country

Introduction

The Data Collection Regulation (DCR) established in 2000 a community framework for the collection, management and use of fisheries data sector in support of the scientific advice under the Common Fisheries Policy (EU Data Collection Regulations (EC) No 1543/2000, 1639/2001 and 1581/2004). The DCR until 1st January 2009 which was based on stock data collection, had established the minimum and extended mandatory sampling programmes for the collection of fishery data. This stock based sampling programmes provided the basis for a single stock fishery assessment and management process of EU stocks. In this context, multifleet and mixed-species fisheries management were currently based on single-species assessment and advice, with some adjustments based on other information to take into account the mixed nature of the fisheries. However this approach was recognized as inadequate, particularly when applied to mixed fisheries due to interaction across species and the use of different technologies depending on the target species. Thus the process of moving towards an ecosystem approach for fisheries management (EAF) (FAO, 2008) is currently being developed. The move towards an ecosystem approach to fisheries management requires that the ecosystem, rather than single fish stocks, is the focus for the assessment and management. Moreover, the reform of the Common Fisheries Policy (EC, 2009) also includes a regional approach to management.

In the ligth of the need to move forward to EFM, the DCR was reviewed by the European Commission's Directorate of Fisheries in 2008, which resulted in new legislation that came into effect on 1st January 2009 (Council Regulation (EC) No 199/2008). Under the new DCR, so-called Data Collection Framework (DCF), there is a distinction between fishery-related data as catch and effort, which will be collected by type of fishing activity or metier, and population-related data collected by stock. Moreover, in this regulation the collection of biological variables and specifically on metier-related variables, data shall be collected by metier refered to as level 6 of the matrix defined in Appendix IV (1 to 5) and for stocks listed in Appendix VII as specified in the Commission Decision 2008/949/EC.

Although there are many definitions of fleets and metiers published during recent years, here we have followed the definitions used in the Multiannual Community Programme pursuant to Council Regulation (EC) No 199/2008, (2008/949/EC). In this document, a fleet segment is defined as "a group of vessels with the same length class (LOA) and predominant fishing gear during the year, according to the Appendix III. Vessels may have different fishing activities during the reference period, but might be classified in only one fleet

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segment". A metier is "a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterised by a similar exploitation pattern". So, in the same fleet segment different metiers could be identified.

Metiers should reflect the fishing intention, e.g. the species targeted, the area visited, and the gear used, at the start of a fishing trip. However, there are situations where fishing intention cannot be observed directly, and can only be estimated retrospectively by examining the catch profiles resulting from fishing trips. The approaches used in the past to identify metiers may then be classified into input-based, output-based, and combined methods (Marchal, 2008). Input-based methods either make use of existing records of the technical features of fishing trips, which are typically available in fishers' logbooks, e.g. gear and mesh size used, fishing grounds visited, season (Ulrich *et al*., 2001; Marchal *et al*., 2006), or build on direct interviews with stakeholders (Neis *et al*., 1999; Christensen and Raakjer, 2006). There are several direct interviews done to the Basque fleet stakeholders for some years but they do not cover all the time series analyzed in this manuscript. So, as in the present analysis the landing information was used to define metier, the output-based approach was applied. It assumes that landing profiles reflect fishing intention. The approach used consists of conducting multivariate analyses of landing profiles and then grouping fishing trips of similar landing profile into metiers.

Therefore, the aim of this paper is to define Basque trawl metier using data from 2003 to 2008 in order to propose an appropriate segmentation useful for the application of data collection program which will support the scientific advice of fishery management of the concerned EU stocks. Moreover, a second objective of the paper is to explore whether metier definitions obtained using the approach investigated are consistent along years or they change their fishing activities depending on external factors like quota restrictions, markets demands or economic reasons.

Material and methods

Description of the fleet analyzed

The analysis is focused on the trawl fishing fleets of the Basque Country in the Northern Spain operating in ICES Divisions VIIIa,b,d & Subareas VI & VII (Figure 1). The gear classes are Otter bottom trawlers ("Baka"), and Bottom Pair trawlers operating with Very High Vertical Opening nets (VHVO). The base fishing ports are Ondarroa and Pasaia.

Fishing characteristics of the fleets change according to the gear used. Hence, "Baka" Otter trawlers are defined as a single vessel which trawls a "bottom net" operating in contact with the seabed with a net of 2-3 metres height and 25 metres width. Trips last a mean of 5, 6 or 7 days depending on the ICES area where they fish, and the haul duration is between 3 to 4 hours. Catches are generally landed in Basque ports (Ondarroa and Pasaia) and in English, Irish and French ports from where the catch is transported by trucks to be sold on local Basque markets.

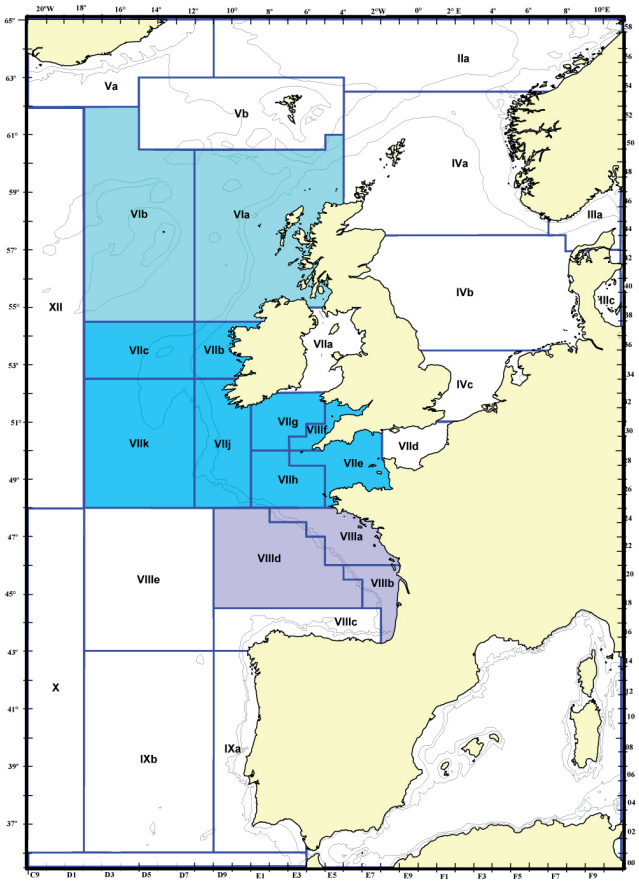

Figure 1. Trawl fishing fleet of the Basque Country (Spain) operating in ICES Division VIIIa,b,d & Subareas VI & VII**.**

On the other hand, Pair trawlers are composed of two vessels towing a single very high vertical opening net (VHVO). The most common VHVO net is between 25-35 metres height and 75 to 90 meters width. The mean days for trip are 5 or 6. In this case, haul duration is longer than the Otter trawls. Thus, pair trawling takes 6-7 hours on average for each haul. Catches are landed at French ports (Lorient, La Rochelle) and transported by trucks to the Basque ports (Ondarroa and Pasaia) or landed at these main Basque ports and sold on their local markets.

Data used

Trip by trip data obtained from selling sheets, including catches of all species landed, ICES divisions, fishing days and vessels characteristics from year 2003 to 2008 were used in the analysis. The specific variables included are: the base harbour of the vessel, the gear used (Otter trawl or Bottom Pair trawl), landings by species in weight per trip (retaining the most important twenty species and grouping the rest in a group called "others"), and the landing date.

The summary of the input data used for the analysis is presented in Table 1 and Table 2.

Table 1. Number of fishing trips analyzed by fleet and ICES area.

		Number of vessels	VIII	VII	VI	Total
2003	Otter trawl	20	528	139	94	761
	Pair trawl	17	399	2		401
	Total 2003	**37**	**927**	**141**	**94**	**1162**
2004	Otter trawl	19	456	122	70	648
	Pair trawl	15	371	6		377
	Total 2004	**34**	**827**	**128**	**70**	**1025**
2005	Otter trawl	16	483	95	64	642
	Pair trawl	13	317	27		344
	Total 2005	**29**	**800**	**122**	**64**	**986**
2006	Otter trawl	16	496	62	63	621
	Pair trawl	15	312	7		319
	Total 2006	**31**	**808**	**69**	**63**	**940**
2007	Otter trawl	20	437	70	60	587
	Pair trawl	11	223	11		245
	Total 2007	**31**	**660**	**81**	**60**	**832**
2008	Otter trawl	16	474	13	60	563
	Pair trawl	5	192			197
	Total 2008	**21**	**666**	**13**	**60**	**760**

Table 2. Variables from the selling sheets used in the multivariate approach.

Variables	Description
Vessel	Vessel name
Harbour	Base harbour: Ondarroa and Pasaia
Month	Month of the fishing operation
Area	Ices Subareas VI, VII and Divisions VIIIa,b,d,
Gear	Bottom otter trawlers and bottom pair trawlers
Species landings	All species landed in kg.

Statistical approach

Based on trip by trip landing data profile of the Basque trawling fleets, Principal Component Analysis (PCA) and Cluster analysis approach are used to obtain homogeneous groups of trips and to characterize them taking into account target species, fishing area, gear and period of the year.

To aggregate the information to a metier group, multivariate approaches are able to provide reduced descriptions of large data sets. In that sense it is a helpful tool when describing fleets by each fishing trip done by each individual vessel along the year. Furthermore, multivariate approaches as the PCA and the cluster analysis, are able to provide linear factors that accumulate the mayor part of the variance of the data (PCA) and that classify trips into homogeneous groups (cluster analysis). Following this idea, the literature provides examples of using these procedures in order to classify fisheries (Biseau and Gondeaux, 1988 and Laurec *et al*., 1991, Murawski *et al*., 1986 and Lewy and Vinther, 1994).

Principal Component Analysis

Principal component analysis (Pearson, 1901) involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

The different species landing information by trip was presented with landings in kilograms of all retained species. In some trips, the list of landed species was very long so the most important twenty species in weight, were retained and the others were compiled in the group ‘others’. A principal component analysis was carried out to the landing list by trip in order to obtain a reduced description of the large species landing data set and to merge all those species in principal components.

Although a PCA analysis is not completely necessary for the clustering analysis, the information from PCA analysis

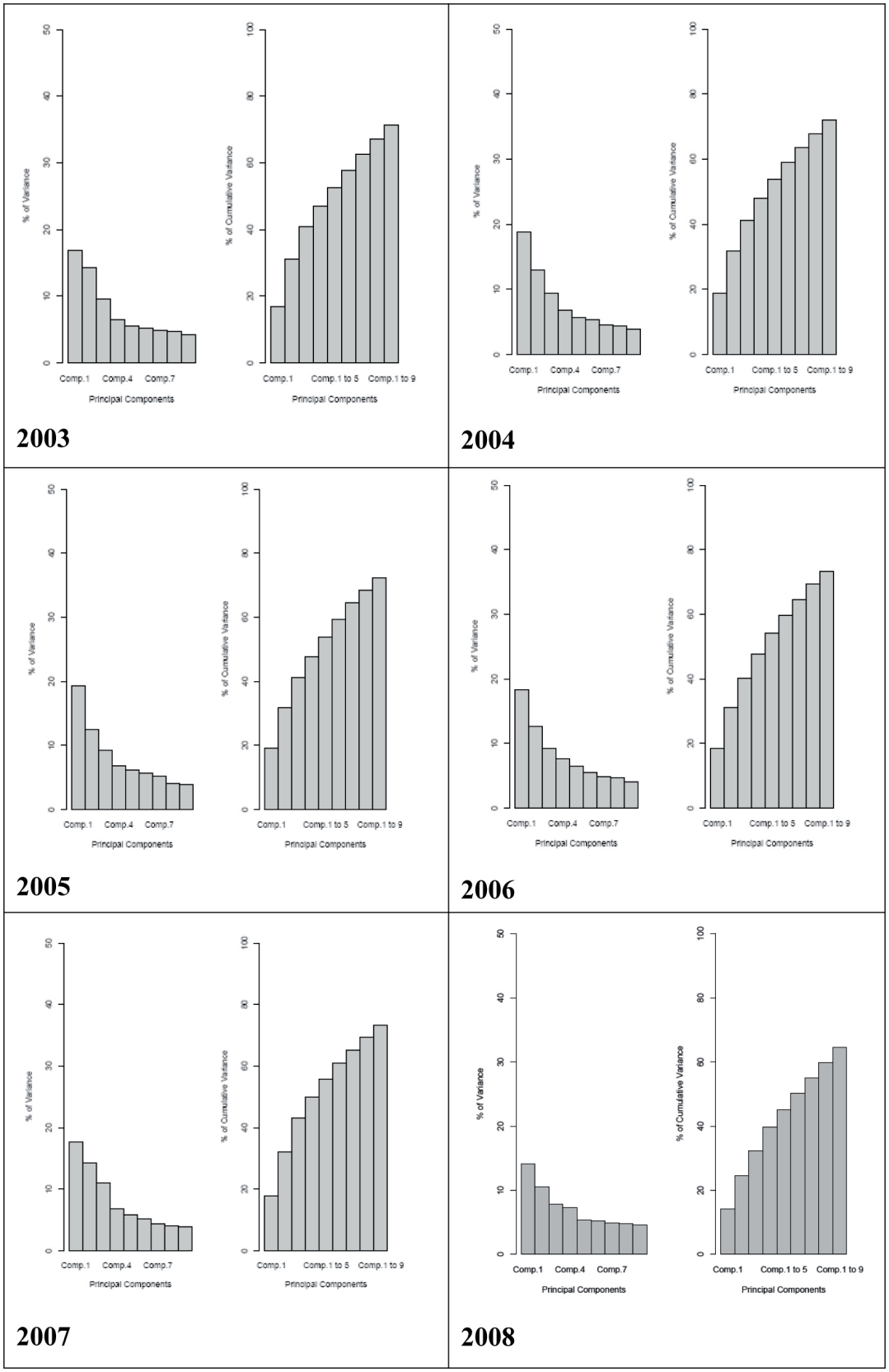

Figure 2. Contribution of each of the 9 principal components to the variance by year.

can be valuable to characterize each cluster and the procedure followed to generate these clusters, i.e. each factor of the PCA informs about the variance of the data series.

Cluster Analysis

Once the number of landed species was reduced to principal components, all the principal components obtained (nine principal components) are retained, and a hierarchical descending classification procedure (clustering) has been performed using Ward's (1963) algorithm.

Cluster analysis is the assignment of a set of observations into subsets (called *clusters*) so that observations in the same cluster are similar in some sense. Hierarchical algorithms find successive clusters using previously established clusters. The descending algorithms begin with the whole set and proceed to divide it into successively smaller clusters.

The objective of the cluster was to group homogeneous trips and to characterize them using the most important explanatory variables, which were: species composition of the landings which were reduced to nine factors in the previous principal component analysis, ICES divisions, month and fishing gear.

The analysis has been done separately by each year from 2003 to 2008. Different numbers of clusters were chosen to define different metiers depending on the year analyzed. The use of different numbers of clusters defining each year's metiers was considered the most appropriate method to describe each fishery taking into account the knowledge of the fishery and all the variables describing the fishery.

Results

In the PCA analysis, all the principal components (nine principal components) identified were retained for all analyzed years explaining around 62% of the variance captured (Figure 2). The analysis of these factors may not be very clarifying simply because the variance captured by each component is not very large. The number of factors complicates the interpretation of the results but a lower number of factors would result in less variance explained by the analysis. In Figure 3 only components 1 and 2

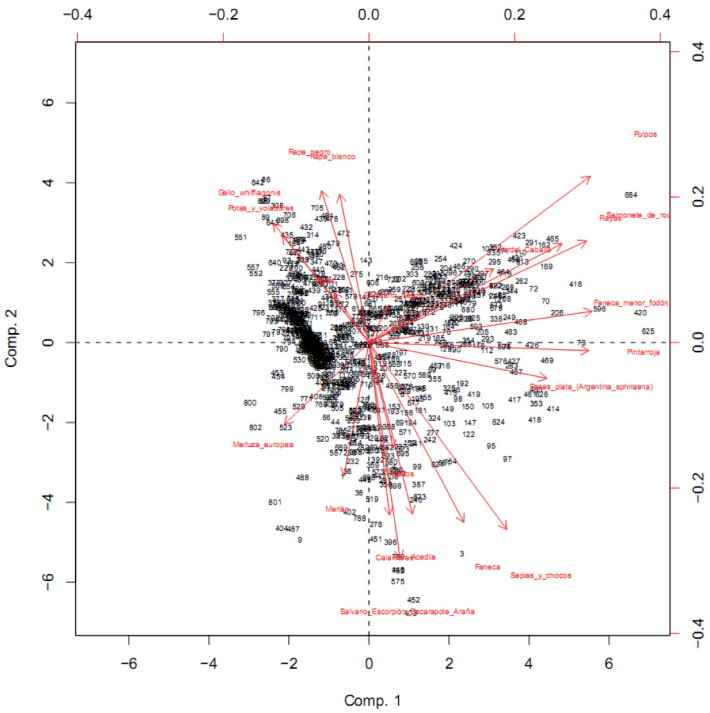

Figure 3. Component 2 versus component 1 in year 2007.

Table 3. Metiers obtained by each gear, subarea, target species, season and year. Percentage of trips done by each metier by year.

Metier	Nantes proposal	Gear	Subarea	Species	Season	2003	2004	2005	2006	2007	2008
1	Bottom pair trawl, demersal fish	PTB	VIII	hake	all	22%	28%	25%	23%	16%	23%
2	Bottom otter trawl, demersal fish	OTB	VIII	mixed especies (hake, megrim, monkfish, catshark, pouting…)	all	17%	46%	19%	49%	32%	6%
3	Bottom otter trawl, mixed cephalopods and demersal fish	OTB	VIII	squids, red mullet, pouting,cuttefish	oct-feb	9%	5%	19%	5%	31%	33%
4	Bottom otter trawl, small pelagic fish	OTB	VIII	horse mackerel	dec-feb	31%					
5	Bottom otter trawl, small pelagic fish	OTB	VIII	mackerel	nov-jan			20%	16%		38%
6	Bottom otter trawl, demersal fish	OTB	VII	megrim, monkfish	all	17%	16%	13%	6%	10%	
7	Bottom otter trawl, mixed demersal and deep water species	OTB	VI	hake, monkfish, megrim	all	4%	4%	4%	1%	11%	
						100%	**100%**	**100%**	**100%**	**100%**	**100%**

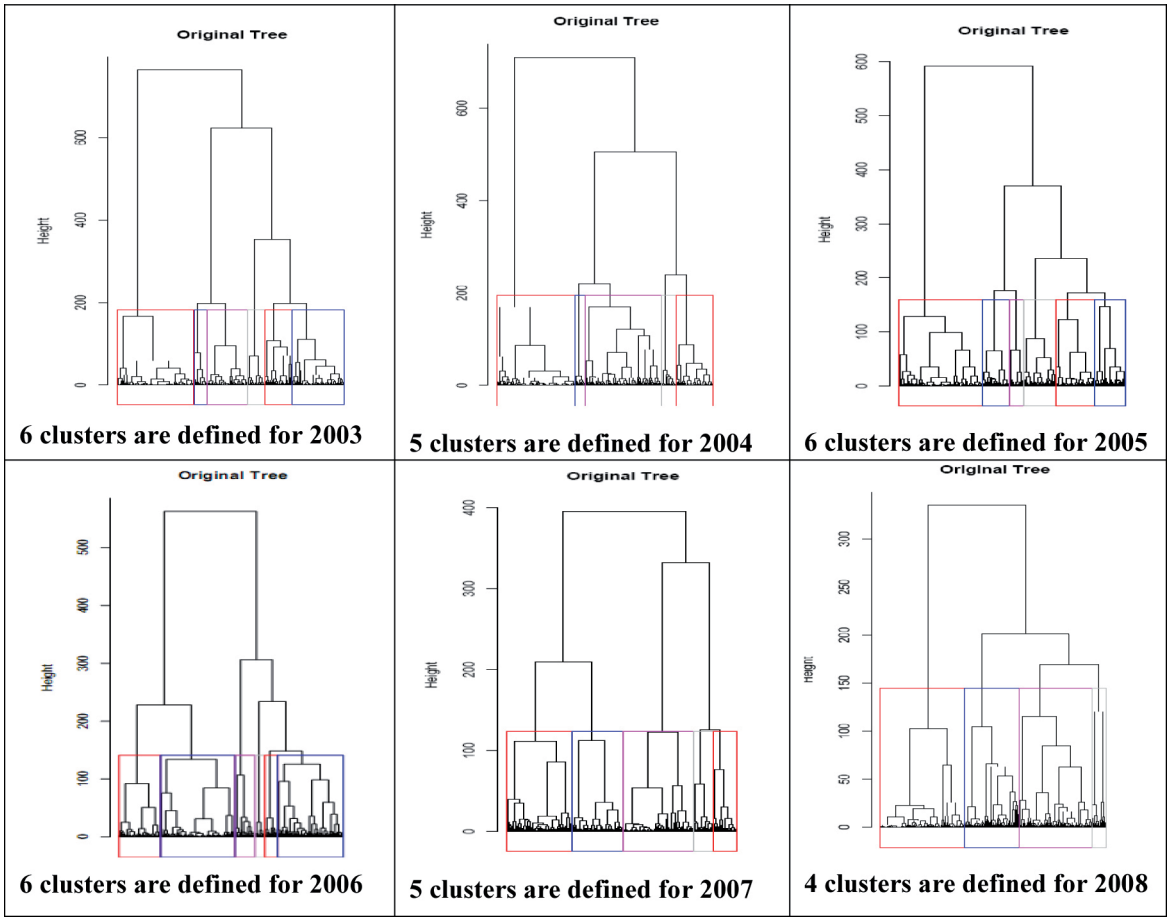

Figure 4. The final clusters created through cluster analysis for years 2003 to 2008.

(those capturing the mayor variance, 18% and 14% respectively) for year 2007 are presented as an example, using a bi-plot representation. In each plot the position of each observation (trip) and the average of each variable (species) are represented in order to describe the meaning of each component.

Figure 3 is the representation of the two components with the highest accumulation of variance. The representation of the trips in these two factors manifest four clear directions. The first one is the north-east which is characterized only by those trips that harvest octopus, red mullet and rays. South-east is a clear second direction defined by cuttlefish and squids, the third one is defined by the south-west side targeting hake and finally north-west is defined by trips fishing megrims and anglerfish. Thus it can be said that component 1 is separating trips targeting hake from those targeting mixed cephalopods and demersal while component 2 separates trips targeting megrim and anglerfish from those targeting mixed cephalopod and demersal.

In Figure 4 all the clusters created using the factors identified in the principal component analysis for the years 2003 to 2008 are shown. The groups obtained are characterized in terms of size of the cluster (in number of trips), target species (one if there is a single-species fishery or two or more if there is a mixed fishery), fishing area, gear and the typical time allocation (in order to see if we are facing a seasonal fishery). In Table 3 the summary of the metiers is shown.

The Basque trawl fleet is segmented in different years into seven metiers, but not all of them are present all the years. The number of metiers chosen by year has been defined by the cluster analysis and the knowledge of the fishery. For example, only 1 metier has been defined for the pair-trawl fleet, whereas the activity of the "bottom otter trawl" fleet includes 6 different metiers depending on the fishing area and target species. More extended description of the seven metiers is below:

- **Metier 1:** "Typical" VHVO bottom pair trawler fishery targeting hake as single species. Accounting around 22-28% of the total trips during all the years and performed in Divisions VIIIa,b,d. It is interesting to point out that in 2007 landings from May to October, whiting (*Merlangius merlangus*) is a new target species together with hake. In year 2008, the landings of whiting are not as high as in 2007.
- **Metier 2**: Bottom otter trawl, targeting mixed demersal species (hake, megrim, monkfish, catshark, pouting,…) in Divisions VIIIa,b,d. It changes from 6% of trips in 2008 to 49% of trips in 2006. The years where the percentages are lower are due to a seasonal fishery targeting horse mackerel in 2003 and targeting mackerel in 2005 and 2008.

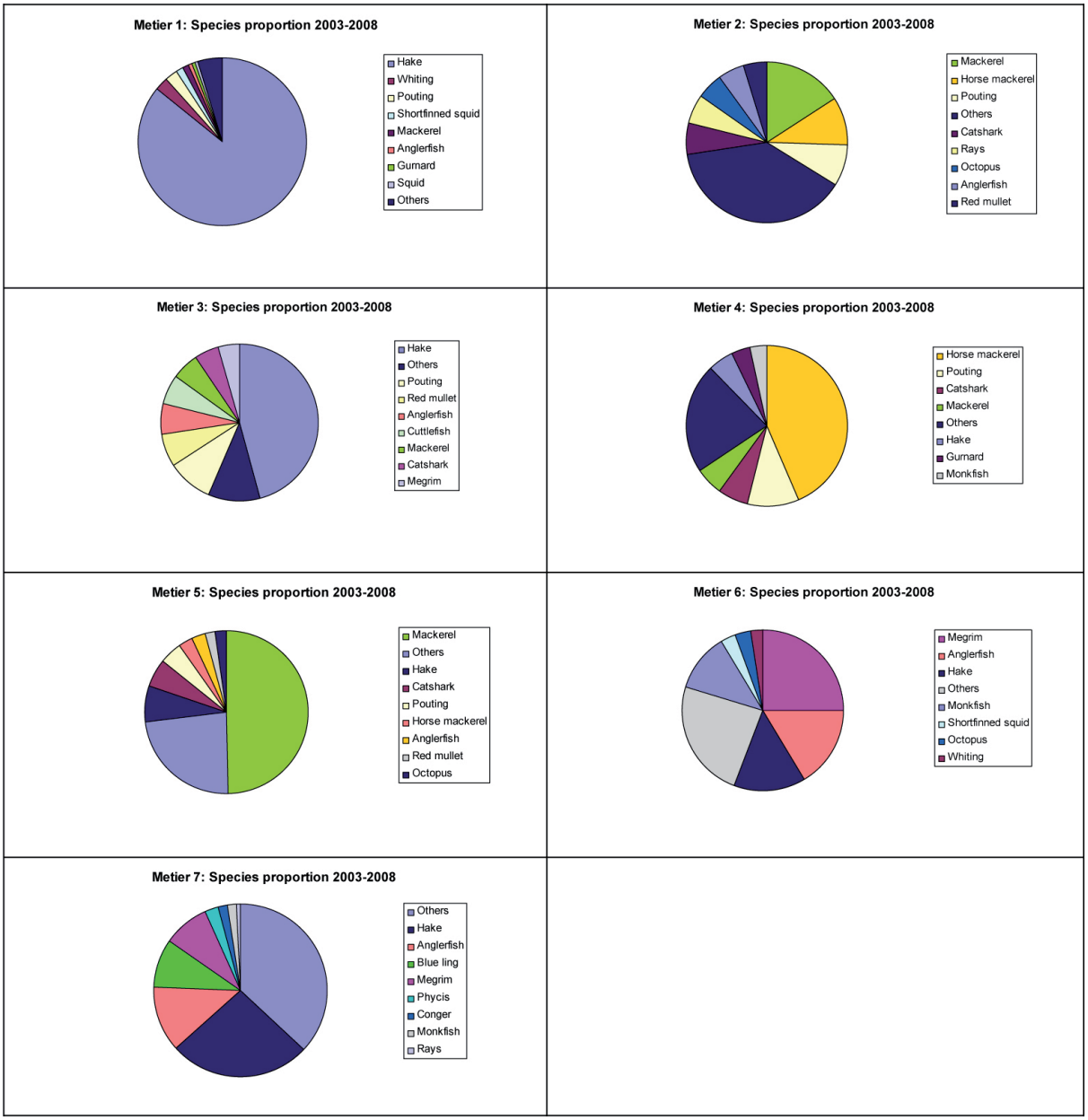

Figure 5. Mean species composition by metier for years 2003-2008.

- **Metier 3**: Bottom otter trawl, targeting mixed cephalopods like squids, pouting or cuttlefish and demersal fish like red mullet, in Divisions VIIIa,b,d. It increases from 5% of the trips in 2004 to 33% trips in 2008. It is a clearly seasonal fishery from October to February next year. In 2007 and 2008 there has been a big increase in the percentage of the trips that target cephalopods; which can be easily explained by the price for squids.
- **Metier 4:** Bottom otter trawl, targeting horse mackerel in Divisions VIIIa,b,d. It is a seasonal fishery from December to February. This fishery appears only in 2003 with 31% of the trips due to a high demand of a new market from Portugal and because the Basque inshore fleet was not working in that period.
- **Metier 5:** Bottom otter trawl, targeting mackerel in Divisions VIIIa,b,d. It is a seasonal fishery from November to January. This metier appears in 2005, 2006 and 2008 with around 25% of the trips. Although this metier targets mackerel during the rest of the years, the landing percentage in those years is lower and, thus, there has been not identified by the clustering as metiers.
- **Metier 6**: "Typical" pure mixed fishery accounting for the 6% to 17% of the total trips in different years, except 2008 where this metier was not present. Performed in sub-area VII during

all years, mainly from April to June and composed only of trips made by "baka" otter trawlers. This metier mainly targets megrim, anglerfish and hake (even if there are other species in their landing compositions). This metier has shown a decreasing trend in the last years with only a few trips in 2008. Those trips are not separated by the cluster and this could be due to low percentage in total trips or similarities with another metier trip where have been merged.

- **Metier 7**: Pure mixed fishery with hake, monkfish and megrim as predominant species and deep water species. They work throughout the whole year and it takes around the 4% of total trips. In addition to these main species, a large number of other deep species with blue ling as one of the most important between April to June are targeted. Performed in sub-area VI and composed only of trips made by "baka" otter trawlers. In 2008 this metier is not created as another cluster in the statistical analysis, but there are 60 trips in year 2008. The reason could be the change in the catch composition of this fleet in the last year due to quota restriction of blue ling and tusk what implies an important decrease in the landings of deep water species.

The species distribution of the landings by metier for years 2003- 2008 is shown in Figure 5.

Discussion

Concerning the research question done about the usefulness of this segmentation for the sampling methodology currently in force under DCF, some points could be comment. First, the results obtained showed the picture of the Basque trawling fishery and help to know its segmentation based on statistical methods. Adding to this segmentation the expertise knowledge of the fishery, useful results could be obtained. Furthermore, the seven metiers described in this paper if needed, could be aggregated in more general metiers. For instance, the two bottom trawl metiers targeting mackerel and horse mackerel in Divisions VIIIa,b,d could be aggregated in one metier: Bottom otter trawl targeting small pelagic. According to the metier classification defined in the Commission Decision 2008/949/EC (DCF), this metier has been defined for the Spanish vessels landing in the Basque Country. So the same procedure could be followed with the other metiers.

This metier based information of catches, effort and more variables, will allow moving from single species data collection to multispecies and multifleet data collection. This is a step forward in the ecosystem approach to fisheries management where fisheries interaction and its relationship with ecosystem should be analyzed.

From multivariate analysis applied to the Basque trawl fleet operating in Division VIIIa,b,d and Subareas VI and VII, and the knowledge of the fishery, seven main trawl metiers have been obtained. The seven metiers defined are based on the catch profiles. The resulting metiers from these analyses correspond well with metiers that the Working Group on Fleet-Fishery based sampling proposed for fisheries management (EC, 2005, 2006).

Five of them are considered consistent along the years 2003-2007, but not in 2008. The percentage of them does not change too much among years. One metier that alternate between high and low trip percentages each year is the bottom otter trawl targeting mixed demersal species. The low percentages (17% and 6 % of trips in 2003 and 2008, respectively) can be explained by new metiers that have appeared targeting horse mackerel in 2003 and mackerel in 2008. Moreover, the change of the percentage of metier nº 2 could be also due to the fact that some trips, as the species composition is diverse, are assigned to the mixed cephalopod and demersal fish metier (metier nº 3) whereas should be considered in the demersal fish metier.

On the other hand, there are two seasonal metiers that appear due to new market requirements that had to be supplied in specific years. These metiers are not persistent along the time series and the appearance of them made the other metiers change to the occasional ones. The methodology presented (cluster analysis and PCA) allows the possibility of including these two seasonal metiers into less disaggregated metiers using the cluster trees presented in Figure 4. This possibility makes it easier to classify them for a sampling program based on consistent metiers, as well as if seasonal metiers are carried out, their localization and analysis will be easily done.

In 2008, an important change in the Basque metier composition is observed. Two of the metiers that were considered consistent along the time series disappear from the results of the analysis: bottom otter trawlers targeting demersal fish in subarea VII and bottom otter trawlers targeting mixed demersal fish and deep water species in subarea VI. Comparing with previous years there are very few trips in subarea VII of this metier. The reason of this could be that only one vessel goes to subarea VII to fish and it only fishes there from March to June. Otherwise as the other vessels are having important catches in division VIIIa,b,d it is not worth to go to subarea VII because it is more profitable to fish in division VIIIa,b,d. Concerning the metier in subarea VI, they follow fishing the similar amount of trips as in previous years, but the catch composition is different from previous years. These trips in subarea VI were characterized in previous years with an important percentage of deep water species in the landings. However, in the last two years (2007 and 2008) the catch profile of this metier is changing; the catches of this fleet are targeting more demersal species than deep water species .The reasons of this change are unknown but could be owing to a change in the strategy, or the result of a quota reductions in species like blue ling or tusk in 2008. The catch profile changed to a mainly demersal composition and as result of it, these trips were included in another cluster.

One limitation of the study was that based on their similarities, trips were put into groups without taking into account fishing area or gear used. Hence, in some cases a few trips of a metier where included in another metier with which they had statistically more similarities but they did not belong to. This could be the explanation to the disappearance of the metier bottom otter trawlers targeting mixed demersal fish and deep water species in subarea VI in 2008. This metier was

included in the Bottom pair trawl targeting demersal fish in 2008 due to the similarities of the trips.

Another limitation of the study was that the analysis was done in yearly basis. Despite results of six years (2003-2008) are presented together, the analysis was done separately by year. It implies that in seasonal fisheries the reference of the seasonality was taken from results of the same year and not from the previous or the next year what could be more precise.

Further research in relation to this analysis could be done. The DCF is implemented and data are compiled in base of metier segmentation, check if the information matches with the segmentation done with the multivariate analysis and see which the variance between two different segmentations is.

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