ICES Journal of Marine Science
May 2008, Volume 65 (4) : Pages 674-686
http://dx.doi.org/10.1093/icesjms/fsn044

A comparative analysis of métiers and catch profiles for some French demersal and pelagic fleets

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Abstract:

A quantitative comparison between métiers and resulting catch profiles was carried out for seven French demersal and pelagic fleets operating in the North Sea, the eastern Channel, and the Bay of Biscay. Typologies for four métiers have been attempted, based on different factors (gear, mesh size, fishing ground, and/or a priori target species), data sources (logbooks or harbour enquiries), and aggregation levels. Catch profiles were selected through cluster analysis. The linkage between métiers and catch profiles was quantified using uncertainty coefficients, which depended on the métier typology being used and the fleet under consideration, but were not subject to substantial inter- or intra-annual fluctuations. Future catch profiles and métiers were forecast in 2005 based on the 2001–2004 métier/catch profile correlations. When contrasted with the 2005 observations, the forecasting score was greatest (80–85%) for pelagic trawlers and gillnetters, and lowest for demersal trawlers (5–60%).

Keywords: catch profiles, fishing intention, fleets, métiers, uncertainty coefficients

1. Introduction

Fisheries data collection, advice and management have traditionally been based on a stock by stock basis. However, this approach has long been recognized as inadequate, particularly when applied to mixed fisheries. Mixed fisheries are subject to technical interaction between fishing units and across species. Ignoring such interactions could lead to the undesirable situation where fishing for one species may lead to discards of another, the quota of which has already been exceeded.

Thus, a number of steps have been undertaken in the last decade to incorporate explicitly technical interactions between fishing units within the cycle of observing, assessing, forecasting and managing the fishery system. First, in waters of the European Union, the future sampling program of fisheries biology and economics data that will come into force in 2008, will explicitly build in fishing units as sampling strata (EC; 2005, 2006). Second, a number of modeling approaches have been developed to account for technical interactions between fishing units in forecasting the status of fish stocks (Murawski and Finn, 1986; Laurec et al., 1991; Marchal and Horwood, 1996; Vinther et al., 2004). Third, direct effort limitations, applied to specific fishing units, are increasingly being used to complement single-species TAC (Total Allowable Catches), so to improve the efficiency of managing fisheries around the world, also in EU waters.

The cornerstone of all these approaches is the fishing unit. The ICES (International Council for the Exploration of the Sea) considers three types of fishing units: the fleet, the fishery and the métier (ICES, 2003). A fleet is as a physical group of vessels sharing similar characteristics in terms of technical features and/or major activity. A fishery is a group of vessel voyages targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area. Finally, a métier is a homogeneous sub-division, either of a fishery by vessel type, or of a fleet by voyage type. Two out of the three fishing units defined are sufficient to fully categorize both fishing vessels and fishing trips, and I focus on fleets and métiers in that study. Several methods may be contemplated to identify fleets and métiers.

The fleet classification depends on, (i) the technical feature considered to categorize the physical characteristics of fishing vessels (e.g. vessel length, horsepower, tonnage, or economic structure), (ii) the variable used to characterize fishing activity (e.g. fishing effort by gear, area, target species or métier), (iii) the value of the activity threshold above which a vessel falls into a given fleet category and, (iv) the period chosen to calculate fishing activity in relation to the threshold identified in (iii) (e.g. a calendar year, a quarter).

Métiers should reflect the fishing intention (e.g. species targeted, area visited, gear used) at the start of a fishing trip. However, there are many situations where fishing intention can not be observed directly, and can only be estimated retrospectively by examining the catch profiles which come out of fishing trips. The approaches which have been used in the past to identify métiers may then be classified into input-based, output-based and combined methods.

Input-based methods either make use of existing records of the technical features of fishing trips, which are typically available in fishers' log-books , 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).

Output-based methods assume that catch profiles perfectly reflect fishing intention. The simplest approach consists in selecting the fishing trips where a certain catch proportion (in weight or value) of selected key species is exceeded. Each set of fishing trips discriminated by this approach may then be drawn into a métier category (Biseau, 1998). Another approach consists in conducting multivariate analyses of catch profiles, and then grouping fishing trips of similar catch profiles into métiers. Métiers can be identified by direct visual inspection when using principal component analysis (Biseau and Gondeaux, 1988; Laurec et al., 1991) or automatically through a hierarchical cluster analysis algorithm (Lewy and Vinther, 1994; Holley and Marchal, 2004).

Combined methods have categorized métiers by clustering catch profiles (outputs), and then relating these clusters to fishing trip characteristics (inputs) using multivariate analyses (Pelletier and Ferraris, 2000; Ulrich and Andersen, 2004).

Both input- and output-based have benefits and limitations.

Collecting information on fishing intentions through direct face-to-face interviews has at least two merits. First, there are some fleet segments for which reporting fisheries data in log-books is not mandatory. This derogation applies in particular to the EU vessels below 10 m, although these may represent up to 70% of the entire EU fleet (EU, 2005; EU, 2006). For such vessels, direct interviews are the only way to collect quantitative information on the fleets and fisheries. Second, interviews are the only way to collect information on the species initially targeted, when this field is not recorded in log-books. In some countries, like New Zealand, the target species is reported in log-books (Anonymous 2004), and it is frequently used as a criterion to classify fishing trips and derive the tuning series used in stock assessments. The target species is however not documented in EU log-books, although it is considered a key factor to group fishing intentions into the categories, which would desirably be used as the sampling strata for collecting stock assessment data (EU 2005, EU 2006).
The main drawback of the face-to-face interview approach is that data collection may be time-consuming.
The second best proxy to estimate fishing intention is based on the gear, mesh size and fishing grounds recorded in fishers' log-books. There are two main drawbacks to this approach. First, the quality of information recorded in log-books may be variable. In particular, anecdotal evidence suggest that mis-reporting of mesh size used and of fishing grounds visited may occur, when management is restrictive. Second, fishing intention may in some cases be expressed, not only by combinations of gear, mesh size and area, but also by fine-scale tactical features – referred to as the skipper effect - which are generally not reported in log-books.
Catch profiles should be the last hope basis for defining métiers, as there are at least two reasons why fishing intentions may not be reflected by species composition. First, catch profiles are often estimated from landings, so the discard fraction is ignored. Many mixed fisheries are subject to discards, and ignoring those may seriously bias the catch composition estimated from landings. Second, because all the species caught in the same fishery do not necessarily follow the same temporal and spatial dynamics, the relative species catch composition may differ from the expected one. Despite these problems, catch profiles often remain the only source of information available to classify métiers.

The main scope of this paper is to evaluate in a quantitative way the extent to which, (i) fishing intentions can be used to forecast catch profiles and, (ii) catch profiles may be reasonable proxies of fishing intentions. Different typologies of fishing métiers are carried out, based on both input and output methods. The linkage between the input- and output-based métiers is then quantified using uncertainty coefficients, and the variations of these are analyzed. Catch profiles and fishing intentions are then forecasted using different predictors and different annual lags. The study is applied to the main French demersal and pelagic fleets over the period 2001-2005.

2. Material and methods

2.1. Data

This study has been performed using logbooks data, national fisheries registers and activity calendars registered by the French Fishery ministry (DPMA) and extracted from Harmonie, the database of the French Fisheries Information System managed by Ifremer[1].
The catch and effort data used for this analysis have been derived from fishers' log-books and national fisheries registers. Data are disaggregated by vessel, fishing trip, statistical rectangle (surface: 1° longitude × 0.5° latitude or approximately 30 nautical miles (n.mi.) × 30 n.mi. (1 n.mi. = 1.853 km)), and gear used. The recorded vessels characteristics are length, tonnage, and horsepower. The type of gear (otter trawl, pair trawls, beam trawl, gill net, etc.) and, for most fleets, the mesh size used, were also made available. These data were made available over the period 2001-2005.
Since 2000, Ifremer has implemented an annual census in all harbours located on the Channel and the Atlantic coast (i.e. from Dunkerque to Bayonne), to collect the activity calendar of each vessel belonging to the National official fleet register. In a first stage, fishermen record in a dedicated form, the fishing slip, all the métiers (combination of gear, target species and fishing areas) practiced by a vessel during a month and for each month of a given year. The information collected in the fishing slips is then checked and validated by a network of observers, which have a regional portfolio of vessels to survey. Part of the validation process consists in meeting face-to-face with a sample of

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fishermen, following a sampling plan specified by Ifremer. The target is that the skippers of at least 30% of the French vessels should be interviewed every year. Because these interviews are held on a voluntary basis, the achievement of the targeted interview rate may vary from one year to another. Finally, the information validated by the network of observers is entered in the Harmony database and recorded as activity calendars.

2.2. Fleet typology

Fishing vessels registered in fishers' log-books and activity calendars were grouped into fishing fleets. Consistent with ICES (2003), a fleet was defined as a group of vessels sharing similar characteristics in terms of technical features and (or) major activity. In practical terms, fleets were defined as a combination of vessel harbors, vessel length range and of the main gear used during a calendar year. Subsequently, each vessel can belong to only one fleet during a calendar year, but vessels may move to another fleet segment from one year to another. The study has focused on a selection of seven major pelagic and demersal French fleets, which have been mainly fishing in the Bay of Biscay, Eastern Channel and North Sea, over the period 2001-2005. The characteristics of and the codes given to these fleets are shown in Table 1. It should be noted that the log-books of a number of vessels belonging to fleet FL1 have not been recorded in 2004.
Both input- and output-based methods have been applied to group fishing trips into métiers. Four input-based approaches have been attempted to estimate fishing intention, two building on métiers as recorded in activity calendars, and two building on different combinations of gear, mesh size and fishing grounds as recorded in fishers' log-books.

Input-based approaches: estimating fishing intention

Métiers, as reflected in activity calendars, are given every month as a combination of gear, *a priori* target species and fishing areas. This is the finest level at which information can be disaggregated, and it is here referred to as "level 2". In order to harmonize métiers definitions across EU countries, a coarser level of aggregation has been suggested by EC (2006), and this is here referred to as "level 1". The difference between level 1 and level 2 is that the target species identified at level 2, e.g. cod (*Gadus morhua*), whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), are grouped into broader categories at level 1 (e.g. demersal fish, mixed crustaceans and demersal fish). The grouping was primarily based on available knowledge on the biology and ecology of the target species (crustaceans, mollucs, cephalopods, demersal fish, small/large pelagic fish, deep-water species). In addition, some target species were aggregated in "mixed" categories to reflect evidenced technical interactions. For instance, French fishers who target Norway lobster or squids with otter-trawlers also catch substantial amounts of demersal fish. Therefore, the level 2 métiers "Norway lobster" and "squids", as reported in the activity calendars, respectively became "Mixed crustaceans and demersal fish" and "Mixed cephalopods and demersal fish" at level 1. Examples of level 1 and 2 métiers are shown in Tables 2 and 3.
In order to group the fishing trips, as defined in log-book data, into the métiers at levels 1 and 2, as defined in activity calendars, a link needs be generated between the two data sets. The difficulty in generating that link is that log-book information is aggregated at the fishing trip level, while activity calendars are reported by month. In order to circumvent that difficulty, a selection of the fishing trips has been made in the log-book dataset. When several métiers were operated by the same vessel during the same calendar month, all the corresponding fishing trips were eliminated. That selection procedure has been applied to métiers defined at levels 1 or 2. In the restricted log-book dataset, information may then be aggregated by month, as only one métier is operated per month. The aggregation level of log-books is then consistent with that of activity calendars, and both datasets may now be linked directly.

Métiers, as derived from national log-books, have been defined as a combination of gear, mesh size and fishing area. Gears were defined as for levels 1 and 2 (Tables 2 et 3). Mesh sizes were grouped into 13 categories defined on the basis of current management regulations: [1-69 mm], [70-79 mm], [80-89 mm], [90-99 mm], [100-109 mm], [110-119 mm], [120-129 mm], [130-139 mm], [140-159 mm], [160-179 mm], [180-199 mm], [200-249 mm], [over 250 mm]. Two levels of aggregation have been considered for fishing areas. The coarse aggregation level includes only two fishing areas: the North Sea and the North-East Atlantic. The fine-scale aggregation level is that of the ICES rectangle, which represents the best spatial resolution achievable with log-book data.

Table 4 shows the number of métier categories depending on the typology being applied.

Output-based approach: estimating catch profiles

The output-based approach applied in this study is a cluster analysis (Léwy and Vinther, 1994; Holley and Marchal, 2004), which has been implemented using the SAS/STAT (1999) procedures CLUSTER and TREE. Clusters were defined using the Ward method. The variables analyzed were the catch proportions (in value) of each species relative to the total catch. The analysis was conducted for the whole dataset rather than by fleet, so each clustered catch profiles derived from the analysis may potentially be allotted to fishing trips operated by any of the seven fleets under consideration. The decision on the most appropriate number of clusters was made by inspecting dendograms and a number of statistics (cubic clustering criterion, R-square and partial t-square), which have been made available for each cluster configuration.

2.3. Linking fishing intention with catch profiles

Uncertainty coefficients (Goodman and Kruskal, 1979) have been used to quantify the association between clustered catch profiles, in the one hand, and the four estimates of fishing intention.

The first series of uncertainty coefficients (IO_i) measures the proportion of uncertainty in the catch profiles that is explained, *a priori*, by fishing intention. The second series of uncertainty coefficients (OI_i) measures the proportion of uncertainty in the fishing intention that is explained, *a posteriori*, by catch profiles.
The index i characterizes the method used to estimate fishing intention; i=1: métiers recorded in activity calendars aggregated at level 1, i=2: métiers recorded in activity calendars aggregated at level 2, i=3: combined gear, mesh size and area aggregated in two levels, i=4: combined gear, mesh size and area disaggregated by ICES rectangle.
IO_i and OI_i may be respectively formulated as equations (1) and (2):

$$IO_i = \frac{-\sum_{m=1}^{M} p_{i,m,.} \ln\left(p_{i,m,.}\right) - \sum_{c=1}^{C} p_{i,.,c} \ln\left(p_{i,.,c}\right) + \sum_{m=1}^{M}\sum_{c=1}^{C} p_{i,m,c} \ln\left(p_{i,m,c}\right)}{-\sum_{c=1}^{C} p_{i,.,c} \ln\left(p_{i,.,c}\right)} \quad (1)$$

and

$$OI_i = \frac{-\sum_{m=1}^{M} p_{i,m,.} \ln\left(p_{i,m,.}\right) - \sum_{c=1}^{C} p_{i,.,c} \ln\left(p_{i,.,c}\right) + \sum_{m=1}^{M}\sum_{c=1}^{C} p_{i,m,c} \ln\left(p_{i,m,c}\right)}{-\sum_{m=1}^{M} p_{i,m,.} \ln\left(p_{i,m,.}\right)} \quad (2)$$

where, for each combination of fleet and month, and for each method i applied to derive fishing intention:
m is the index of fishing intention category,
M is the total number of fishing intention categories,
c is the index for catch profile cluster,
C is the total number of catch profile clusters,
$p_{i,m,c}$ is the proportion of fishing vessels and trips, which intended to operate métier m, and which landings composition could be clustered into catch profile c,
$p_{i,m,.}$ is the proportion of fishing vessels and trips, which intended to operate métier m,
$p_{i,.,c}$ is the proportion of fishing vessels and trips, which landings composition could be clustered into catch profile c,

The different uncertainty coefficients have been analysed, for each fleet, by two analyses.
First, the variations of each uncertainty coefficient have been analysed by GLM (explanatory variables: year and quarter as class variables, fishing effort as continuous variable; distribution function: binomial; link function: logit).

Second, pairwise comparisons of the different uncertainty coefficients (IO_i versus $IO_{j \neq i}$ and IO_i versus $IO_{j \neq i}$) have been carried out.

2.4. Forecasting fishing intentions and catch profiles

For each fleet, it was tested the extent to which the knowledge of past and present knowledge of the correlation between fishing intentions and catch profiles could be used to forecast, (i) future catch profiles given fishing intention is known and also, (ii) future fishing intentions given catch profile is known.
To that purpose, the probability of catch profile *c* given fishing intention *m* and the probability of fishing intention *m* given catch profile *c*, has been estimated based on the frequency of fishing trips and vessels for each category, for each fleet and for years 2001 to 2004.
For each *m*, the 2001-2004 catch profile category with the highest probability was used to forecast the 2005 catch profile given *m*. Conversely, for each catch profile category *c*, the 2001-2004 fishing intention with the highest probability was used the forecast the 2005 fishing intention given *c*. The 2005 fishing intention and catch profile forecasts were then contrasted with the 2005 observations.
In order to further evaluate the benefits of using the past correlations between fishing intentions and catch profiles to make forecasts, it has been investigated the extent to which the past seasonal distribution of fishing intentions and catch profiles could be used to forecast those two factors.
For each quarter *q*, the 2001-2004 catch profile (respectively fishing intention) category with the highest probability was used to forecast the 2005 catch profile (respectively fishing intention) given *q*. The 2005 fishing intention and catch profile forecasts were then contrasted with the 2005 observations.

3. Results

3.1. Fleet and métier typologies

The fleets size has not changed much between 2001 and 2005 (Figures 1a and 1b). In 2005, the number of vessels ranged between around 35 (FL2) and 150 (FL5) units.
Table 5 shows the occurrences where 1, 2, 3, 4 or 5 métiers (defined at level 1 or 2) were operated by the same vessel during the same calendar month. A large majority of trips followed the same métier during a month (70-80% and 60-73% when métiers are defined at levels 1 and 2 respectively), and this number has increased over the period 2001-2005. Both métiers at levels 1 and 2 are needed in the forthcoming analyses. If only one métier, as defined at level 2, is operated in a given month, then only one métier, as defined at level 1, is operated during the same month. However, when one métier, as defined at level 1, is operated in a given month, several métiers, as defined at level 2, may be operated during the same month. In order to ensure that one single métier, defined at level 1 or 2, is operated each month, the fishing trips have been selected on the basis of métiers defined at level 2. The number of trips excluded based on the level 2 métier definition (23-40% of the fishing trips) is only slightly higher than if the selection had been based on the level 1 métier definition (20-30% of fishing trips excluded).
Figures 1c and 1d suggest that the relative proportion of fishing effort allotted to each fleet and each métier (as defined at level 1) has changed between 2001 and 2005. However most of the métiers operated in 2001 were still conducted in 2005, although in different proportion.
The results of the cluster analysis of catch profiles are shown in Table 6 and Figures 2 and 3. A high peak in the pseudo t^2 statistic is observed with 16 clusters (Figure 2d), while significant increases in the cubic clustering criterion are observed up to 16 clusters, but not with a larger number of clusters (Figure 2b). With 16 clusters, the R^2 is of 85%, with little increase with a higher level clustering ($R^2 <$ 90% with 24 clusters). Based on these criteria, 16 clusters were chosen to classify catch profiles in subsequent analyses. Table 6 shows the species composition of each clusters. For 11 out of the 16 clusters, only one species contributes to more that 50% of the landings). For the remaining 5 clusters, the bulk of the landings is from 2 or 3 species. Figure 3 suggests that the catch profile composition of fleets has changed over time, but more particularly for fleets FL1, FL2 and FL6. The quasi absence of catch profile c8 (Atlantic tuna) for fleet FL1 in 2004 is due to missing information (see “Data” section).

3.2. Linking fishing intention with catch profiles

The results of the GLM analyses of the different uncertainty coefficient did not indicate any annual or seasonal effects. The detailed results of that analysis are not presented here.

Pairwise comparisons of the uncertainty coefficients IO_1-IO_4 and OI_1-OI_4 are shown for each fleet in Figures 4 and 5.
As could be anticipated, the more disaggregated the métiers, the better explained catch profiles, so we consistently have $IO_1 < IO_2$ and $IO_{i\neq4} < IO_4$. The linkages between IO_1 and IO_3, in the one hand, IO_2 and IO_3, in the other hand, are clearly fleet-dependent. Defining métiers based on gear and *a priori* target species, as aggregated at level 2, better contributes to explain catch profiles than defining métiers based on gear and mesh size ($IO_2 > IO_3$), for all bottom trawling fleets (FL2, FL4, FL5, FL6) and also the Bay of Biscay gill-netters (FL7). The same assessment can be made when métiers are defined based on gear and *a priori* target species, as aggregated at level 1 ($IO_1 > IO_3$) for all bottom trawling fleets except FL6. For pelagic trawlers (FL1), métiers based on gear and mesh size contribute more to subsequent catch profiles than métiers based on gear and target species, irrespective of these being aggregated at level 1 or 2 ($IO_1 < IO_2 < IO_3$). If we consider IO_2, the ability to explain catch profiles ranges from low 20% (FL2) to high 80% (FL7). FL2 is the fleet for which catch profiles are the least explained by métiers, irrespective of the typology method being applied.

As a general rule, we have $OI_{i\neq4} > OI_4$. and $OI_1 \cong OI_2$ on average for all fleets. The linkages between OI_2 (or OI_1) and OI_3 are fleet-dependent. Catch profiles better contribute to explain métiers defined on the basis of gear and *a priori* target species (aggregated at level 1 or 2), then métiers defined on the basis of gear and mesh size ($OI_1 > OI_3$ and $OI_2 > OI_3$), for all fleets except FL1, for which OI_1, OI_2, and OI_3 have comparable low values. If we consider OI_2, the ability to explain métiers categories based on catch profiles ranges from low 25% (FL2) to 70% (FL7).
Overall, grouping métiers as combinations of gear and a priori target species, as aggregated at level 2, generally appears to be the most appropriate typology, in terms of explaining both catch profiles given métiers (as reflected by IO_2) and also métiers given catch profiles (as reflected by OI_2). This typology was retained to generate forecasts.

3.3. Forecasting fishing intentions and catch profiles

Figures 6a-d indicate that the precision of the forecasts (catch profiles or métiers) does not depend much on the year where information on past correlations between catch profiles, métiers and seasons was last made available (2001, 2002, 2003 or 2004), except for fleets FL1 (Figures 6a-d) and FL6 (Figures 6b & d). For fleet FL1, the drop in 2004 (Figure 6a) is an artifact due the mis-representation of vessels having a major contribution to catch profile c8 (see “Data” section and Figure 3). As for fleet FL6, the linkage between catch profiles and métiers over the most recent period (2003-2004) was a better predictor of métiers than the 2001-2002 correlation (Figure 6b).
The proportion of fishing trips and vessels for which catch profiles have been correctly forecasted in 2005, given the past correspondence between catch profiles and métiers was available, is greatest (90%) for both gill-net fleets and lowest for pelagic and demersal trawlers (20-75%), with the minimum value attained by FL2 (Figure 6a). These results are consistent with the values taken by IO_2, except for FL3, for which IO_2 was second lowest (Figure 5). The comparison between Figures 6a and 6c suggests that the past correlation between catch profile and métiers is a better predictor of future catch profiles than the past seasonal distribution of catch profiles, except for fleets FL2 and FL3.

The proportion of fishing trips and vessels for which métiers have been correctly forecasted in 2005, given the past correspondence between catch profiles and métiers was available, is greatest (80-85%) for pelagic trawlers and both gill-net fleets, and lowest for demersal trawlers (5-60%), with the minimum value attained by FL2 (Figure 6b). These results are consistent with the values taken by OI_2, except for FL3, for which OI_2 was second lowest (Figure 5). The comparison between Figures 6b and 6d suggests that the past correlation between catch profile and métiers is a better predictor of future métiers than the past seasonal distribution of métiers, except for fleets FL2 and FL3.

4. Discussion

The framework suggested in this study allows to assess the extent to which métiers and catch profiles are inter-exchangeable concepts. While earlier studies have characterized catch profiles using input-based métier definition and vice versa (Laurec et al., 1991; Pelletier and Ferraris, 2000; Ulrich and Andersen, 2004), it is in my best knowledge the first time that the linkage between those two concepts has been, (i) quantified for different fleets using specific indicators and also, (ii) used to forecast catch profiles and métiers in the short term.

Four typologies have been proposed to classify métiers. Overall, grouping métiers as combinations of gear and *a priori* target species, at the most disaggregated level, generally appears to be the most appropriate typology, in terms of explaining both catch profiles given métiers and also métiers given catch profiles. This result suggests that initiatives to collect information on fishing intentions before the fishing trip (e.g. target species), which can not currently be accessed directly from log-books, should be encouraged.

The linkage between métiers and catch profiles, and the ability to forecast those, were clearly fleet-dependent.
It is striking that the best scores, in terms of forecasting either catch profiles (Figure 6a) or métiers (Figure 6b) is achieved by the two gill-net fleets (FL3 and FL7) and by the pelagic fleet (FL1). For the latter, the drop observed in 2004 (Figure 6a) should be interpreted as an artifact, as explained in the "Results" section. Gill netters and pelagic trawlers are known to be generally more species-selective than bottom trawlers. Trammel nets are used to target sole (*Solea solea*) at night (catch profile no. 11 in Table 6), and fixed nets to target either cod, in the North Sea (catch profile 13), or hake in the Bay of Biscay with small mesh size (catch profile 4), or anglerfishes (*Lophius sp.*) in the Bay of Biscay with a large mesh size (catch profile 15). Depending on mesh size used, the pelagic fleet may target anchovy (*Engraulis encrasicolus*, catch profile c7), mackerel (*Scomber scombrus*, catch profile c6), sea bass (*Dicentrarchus labrax*, catch profile c5) or Atlantic tuna (*Thunnus alalunga*, catch profile c8). Therefore, relatively fewer catch profiles, and consequently a lower probability of mis-predicting those catch profiles, may be expected by métier category and vice-versa. One would also have anticipated that the uncertainty coefficients IO_2 and OI_2 be the greatest for both gill-net fleets (Figure 5). However, this is true for FL7 (both IO_2 and OI_2) and FL1 (OI_2), but not for FL3 (both IO_2 and OI_2) and FL1 (IO_2), which deserves some comments. Of all seven fleets, FL3 and FL1 are the ones for which IO_2 and OI_2 have the greatest variability (across fishing vessels and trips). Despite that variability, when averaging over vessels and trips by métier (respectively catch profile), the catch profile (respectively métier) drawn with the greatest probability is generally the one observed in future years. The score reached is of 90% (respectively 75%) for forecasting the catch profiles of FL3 (respectively FL1), and of 85% (respectively 80%) for forecasting the métiers operated by FL3 (respectively FL1). This suggests that the relatively small value taken by the median value of uncertainty coefficients only reflects a large variability between vessels and trips, but not a bias.
In comparison with the gill-netters and pelagic trawlers, the bottom trawlers (FL1, FL4, FL5, FL6) are less species-selective, and therefore reach a lower score (in terms of forecasting both catch profiles and métiers). These results are consistent with the relative values taken by the uncertainty coefficients. The forecasting scores achieved by the three Bay of Biscay bottom trawl fleets (FL4, FL5, FL6) are of the same order of magnitude (at least for the forecasts building on the 2003-2004 catch profile/métier correlations), suggesting no effect of vessel length.
The scores and the uncertainty coefficients values obtained with the North Sea bottom trawl fleet (FL2) are the lowest of the seven fleets under investigation. Although the reasons for these low values are not completely clear, it may be hypothesized that, (i) either the typologies applied here to define métiers and catch profiles may not be fully adequate or, (ii) recent changes in the relative distribution of fish stocks of the North Sea are such that fishing intentions rarely match catch profiles. Figure 3, and the outcomes of recent investigations, may provide some support to hypothesis (ii). These suggest in particular that species, which were considered in the past as valuable by-catches, e.g. red mullet (*Mullus surmuletus*), sea bass, squids (*Loligo sp.*), have become in recent years an increasing component of the landings of that fleet, concurrent with the decline of some traditionally targeted species (e.g. cod, whiting) (Mahé et al., 2005; ICES, 2007).

More generally, one would have *a priori* expected the relative resources availability to be an important determinant of the linkage between fishing intentions and catch profiles.

For instance, the decline of some traditionally important stocks might be regarded as a reason for the very poor forecasting scores for fleet FL2 (North Sea bottom trawlers).
However, FL1 (Bay of Biscay pelagic trawlers) is an example of a fleet, the traditionally main target species of which (anchovy in ICES sub-area VIII) is known to have declined dramatically between 2001 and 2005 (according to the latest ICES advice available on the URL: http://www.ices.dk/committe/acfm/comwork/report/2007/oct/ane-bisc.pdf depleted), and yet for which the forecasting score is high. Our results that the observed shift has been reflected by a lower number of trips dedicated to anchovy fishing (métier NEA27 in Figures 1c and 1d) and an increased number of trips dedicated to demersal species –mainly sea bass- (métier NEA28 in Figures 1c and 1d), rather than by a discrepancy between the fishing intention and the catch profiles for those trips. In other words, the catch composition from vessels rigged to fish for anchovy is still dominated by anchovy, but fishers operate that métier less often than they used to. In other words, the results of this investigation suggest that fishers belonging to fleet FL1 have managed to adapt their strategy to prevailing stock and TAC conditions, and have made limited attempts to target anchovy when they knew their had low chances to catch this species in an economically efficient way. This is confirmed by the fact that both the number of vessels and the total fishing effort have remained stable for fleet FL1 between 2001 and 2005 (Figures 1a and 1b).

Overall, it seems reasonable to forecast both catch profiles and métiers of gill-netters and pelagic trawlers building on past information, the risk of error being of 10-25%. For Bay of Biscay bottom trawlers, the risk of error is more important (20-40% when using information available at year n-1), but still lower than using past seasonal distributions. No forecast of either catch profiles or métiers should reasonably be attempted for North Sea bottom-trawlers with the current typology, as the risk of error ranges between 70 to 95%. These results have practical implications. First, some management tools are applied to métiers (e.g. licensing systems). The efficiency of these greatly depends on the adequacy between the métier being implemented and resulting catch composition. Second, catch profiles are less onerous to calculate than organizing interviews to collect information on fishing intentions. Therefore, when catch profiles can be seen as a good proxy for fishing intention (e.g. for fleets FL1, FL3 and FL7), the priority for collection *a priori* information on fishing intentions could be regarded as lower than for the other fleets.

This study is subject to a number of limitations.
First is the quality of data recorded in log-books and activity calendars. The data included in the log-books include only the part of the catches which is landed, and not that which is discarded or unreported. Therefore, the catch profiles used in the study are in fact only landings profiles, which may be a source of bias. With regards activity calendars, the quality of the information collected on fishing intentions will depend to an unknown extent on the relations between the interviewer (the scientist) and the interviewee (the fisher).
Second, the results of the investigation are sensitive to the métier typology being used. When using métiers as sampling strata or management units, there is always a trade-off between maintaining a reasonably low number of categories and describing as comprehensively as possible the fleets' activity. A range of four typologies, building on different sources of information (log-books or activity calendars) and grouping procedures (partly or fully disaggregated) have been explored here. In order to further test the robustness of the results obtained in this study, other typologies could be investigated and their outcomes compared with those achieved here.

Future research could aim at evaluating the consistency between métiers and catch profiles over a longer period that that considered in this study. Also, it remains to be tested the extent to the typology advocated here would affect the outcomes of sampling strategies and management plans which would build on these métier categories.

Acknowledgements

The work was funded through the CAFE project of the European Union (DG-Fish, contract no. 022644), for which support we are very grateful. I would also like to thank Jan-Jaap Poos, IMARES (The Netherlands), for making up the programs which were applied to carry out the cluster analysis. Finally, we are indebted to skippers for their cooperation during harbor enquiries.

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Tables

Table 1. Characteristics of the 7 French fleets investigated (main area fished, home harbors, main gear, length range and code).

Main area	Home harbors	Main gear	Length (m)	Code
Bay of Biscay	All from Douarnenez	Pelagic trawl	18-23.99	FL1
	to Bayonne	Demersal trawl	12-17.99	FL2
			18-23.99	FL3
			24-39.99	FL4
		Drift and fixed nets	18-23.99	FL5
Eastern Channel	All from Dunkerque	Demersal trawl	18-23.99	FL6
& North Sea	to Caen	Drift and fixed nets	10-11.99	FL7

Table 2. Characteristics (gear, target species, main area fished and code) of the main métiers, aggregated at level 1 (aggregated level), operated by the 7 French fleets being investigated, as identified through harbour enquiries.

Gear	Target species	Code	
		North-East Atlantic	North Sea
Boat dredge	Molluscs	NEA01	NOS01
Bottom otter trawl	Crustaceans	NEA04	NOS04
	Demersal fish	NEA05	NOS05
	Mixed crustaceans and demersal fish	NEA06	NOS06
	Mixed cephalopods and demersal fish	NEA07	NOS07
	Small pelagic fish	NEA08	NOS08
	Deep-water species	NEA09	-
Multi-rig otter trawl	Molluscs	NEA12	-
	Demersal fish	NEA14	NOS14
	Deep-water species	NEA15	-
	Mixed crustaceans and demersal fish	NEA16	-
Bottom pair trawl	Demersal fish	NEA18	-
	Crustaceans	NEA19	-
Midwater otter trawl	Small pelagic fish	NEA25	NOS24
	Demersal fish	NEA26	-
Pelagic pair trawl	Small pelagic fish	NEA27	NOS26
	Demersal fish	NEA28	NOS27
Hand and pole lines	Finfish	NEA29	NOS28
Drifting longlines	Large pelagic fish	NEA32	-
Set longlines	Demersal fish	NEA35	-
Pots and traps	Crustaceans	NEA37	NOS31
Trammel net	Demersal fish	NEA42	NOS34
Set gillnet	Demersal fish	NEA44	NOS36

	Crustaceans	-	NOS37
Driftnet	Small pelagic fish	-	NOS38
	Demersal fish	-	NOS39
Purse seine	Large pelagic fish	NEA50	-
Others	Others	ZZZ	ZZZ

Table 3. Characteristics (gear, target species, main area fished and code) of the level 2 métiers (disaggregated level), which are part of the level 1 métier "NEA05" (area: North-East Atlantic, gear: bottom otter trawl, target species: demersal fish).

Area	**Gear**	**Target species**
North-East Atlantic	Bottom otter trawl	sea bass (*Dicentrarchus labrax*)
		wedge sole (*Dicologlossa sp.)*
		seabreams
		mixed gadoids
		pollock (*Pollachius pollachius*)
		anglerfishes (*Lophius sp.*)
		saithe (*Pollachius virens*)
		hake (*Merluccius merluccius*)
		whiting (*Merlangius merlangus*)
		flatfish
		skates and rays
		red mullet (*Mullus surmuletus*)
		sole (*Solea solea*)
		sharks

Table 4. Number of métier categories by fleet, and for all fleets combined, for each typology used (typology 1: main area, gear and *a priori* target species grouped at level 1 (aggregated level), typology 2: main area, gear and *a priori* target species grouped at level 2 (disaggregated level), typology 3: main area, gear and mesh size, typology 4: ICES rectangle, gear and mesh size.

Typology	**No. of métiers**							
5.	FL1	FL2	FL3	FL4	FL5	FL6	FL7	All fleets
1	13	11	12	20	13	13	8	42
2	24	22	30	45	34	29	28	105
3	27	20	31	33	26	28	23	97
4	322	142	111	364	589	545	367	1805

Table 5. Number and proportion of fishing trips as a function of the number *n* of métiers operated per calendar month (*n* = 1, …, 5). Métiers are defined either at level 2 (disggregated level) or level 1 (aggregated level).

Year	No. Métiers	Métiers defined at level 1		Métiers defined at level 2	
	per month	No. Trips	Proportion of trips	No. Trips	Proportion of trips
2001	1	23388	70	20074	60
	2	8556	26	7935	24
	3	1190	4	4212	13
	4	81	0	874	3
	5	3	0	123	0
2002	1	24156	74	21360	66
	2	7269	22	7411	23
	3	1073	3	2534	8
	4	74	0	676	2
	5	8	0	599	2
2003	1	25133	78	23071	72
	2	5965	19	6595	21
	3	866	3	1992	6
	4	77	0	308	1
	5	11	0	86	0
2004	1	23562	78	21916	73
	2	5684	19	6409	21
	3	849	3	1559	5
	4	58	0	236	1
	5	3	0	36	0
2005	1	23492	80	21672	73
	2	5222	18	5846	20
	3	756	3	1657	6
	4	61	0	306	1
	5	6	0	56	0

Table 6. Landing profiles of each cluster, expressed as the average proportion of species value, in euros, relative to total landings. The species or the two species contributing to more than 50% of the landings value are highlighted. N is the number of fishing trips belonging to each cluster.

Cluster	N	Atlantic tuna *Thunnus alalunga*	Anchovy *Engraulis encrasicolus*	Anglerfish *Lophius. sp*	Sea bass *Dicentrarchus labrax*	Cod *Gadus Morhua*	Haddock *Melanogrammus aeglefinus*	Hake *Merluccius Merluccius*	Megrim *Lepidorhombus sp.*	Mackerel *Scomber Scombrus*	Red mullet *Mullus surmuletus*	Norway lobster *Nephrops norvegicus*	Squids *Loligo sp.*	Sole *Solea solea*	Whiting ***Merlangius merlangus***	Others
1	7586	0.00	0.00	0.00	0.02	0.06	0.00	0.00	0.00	0.07	0.07	0.00	0.12	0.00	**0.50**	0.16
2	9500	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	**0.93**
3	7713	0.00	0.01	0.04	**0.12**	0.03	0.01	0.08	0.00	0.04	0.08	0.00	0.07	0.03	0.07	**0.41**
4	4407	0.00	0.00	0.01	0.01	0.00	0.00	**0.88**	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.06
5	2117	0.00	0.00	0.00	**0.92**	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.04
6	1185	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.00	**0.75**	0.02	0.00	0.02	0.00	0.03	0.14
7	3087	0.00	**0.99**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
8	1089	**0.89**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
9	5412	0.00	0.00	0.01	0.02	0.03	0.00	0.01	0.00	0.03	0.11	0.00	**0.47**	0.03	0.08	**0.19**
10	6609	0.00	0.00	**0.38**	0.00	0.02	0.01	0.07	0.11	0.00	0.02	0.09	0.03	0.05	0.01	**0.21**
11	17404	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	**0.86**	0.00	0.08
12	3639	0.00	0.00	0.02	0.06	0.01	0.00	0.06	0.00	0.01	0.05	0.01	0.03	**0.37**	0.02	**0.36**

13	5547	0.00	0.00	0.09	0.02	**0.32**	0.09	0.03	0.02	0.01	0.02	0.01	0.04	0.02	0.13	**0.18**
14	14024	0.00	0.00	0.10	0.00	0.02	0.01	0.08	0.03	0.00	0.01	**0.63**	0.00	0.05	0.01	0.06
15	6972	0.00	0.00	**0.74**	0.00	0.00	0.00	0.02	0.05	0.00	0.01	0.00	0.02	0.01	0.00	0.14
16	3638	0.00	0.00	0.00	0.02	0.03	0.00	0.01	0.00	0.09	**0.53**	0.00	0.07	0.00	0.05	0.18

Figures

Figure 1. Marchal

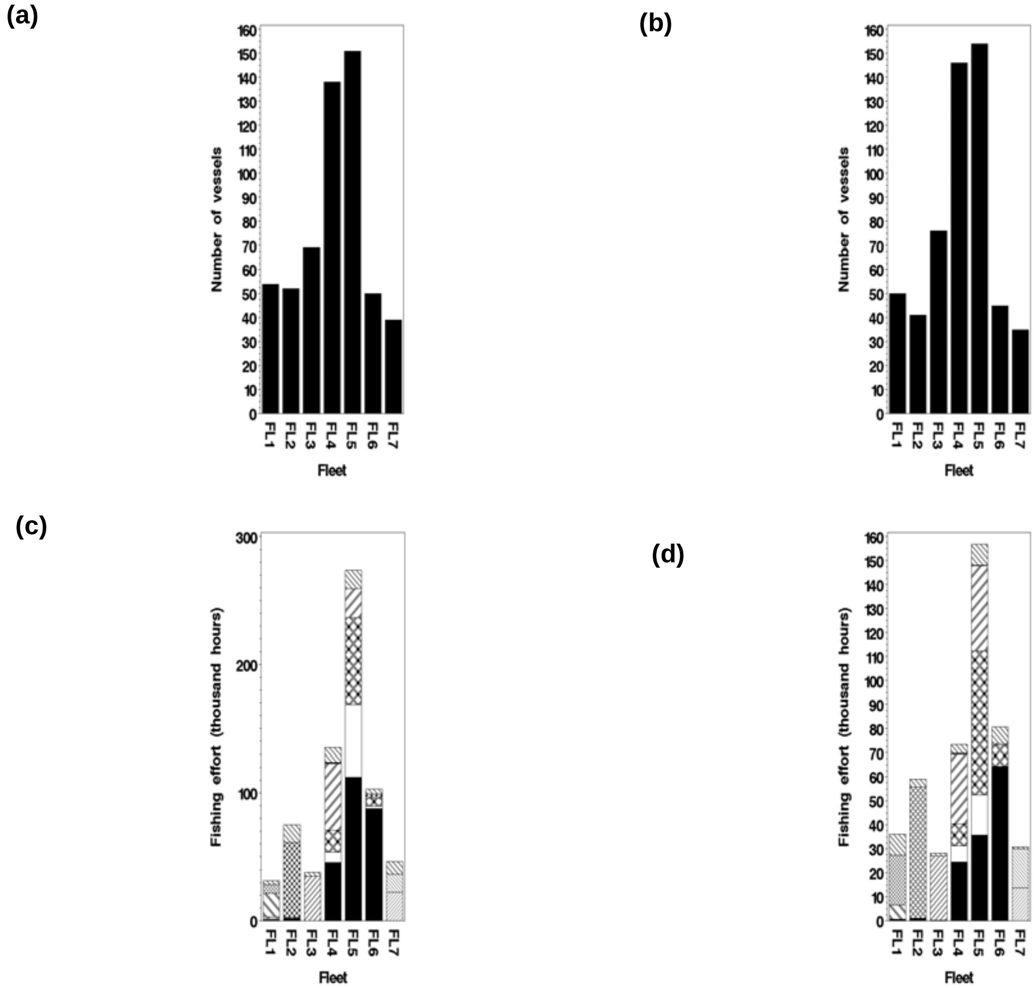

Figure 1. (a, b) Number of vessels by fleet; (c, d) fishing effort by fleet and by main métier categories, as defined at level 1 (black: ‘NEA05’, white: ‘NEA06’, treble cross: ‘NEA14’, treble slash: ‘NEA16’, treble anti-slash: ‘NEA27’, single cross: ‘NEA28’, single slash: ‘NEA42’, single anti-slash: ‘NEA44’, double cross: ‘NOS05’, double slash: ‘NOS34’, double anti-slash: all other métiers); in (a, c) 2001 and (b, d) 2005.

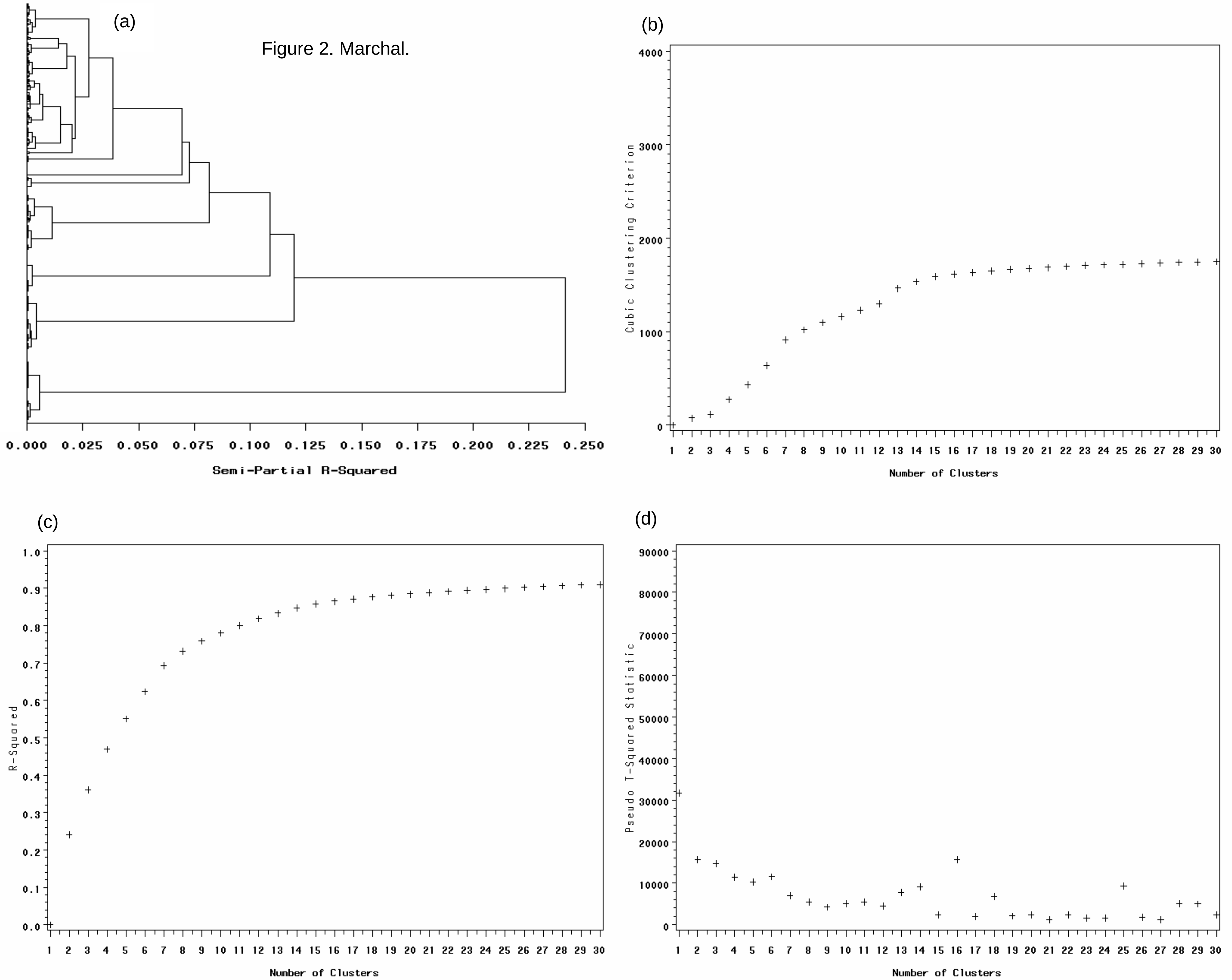

Figure 2. Marchal.

Figure 2. Outcomes and diagnostics derived from the HAC analysis: (a) dendrogram, (b) cubic clustering criterion, (c) R-square, (d) pseudo t-square statistic. One catch profile is associated to each cluster.

Figure 3. Marchal [in color]

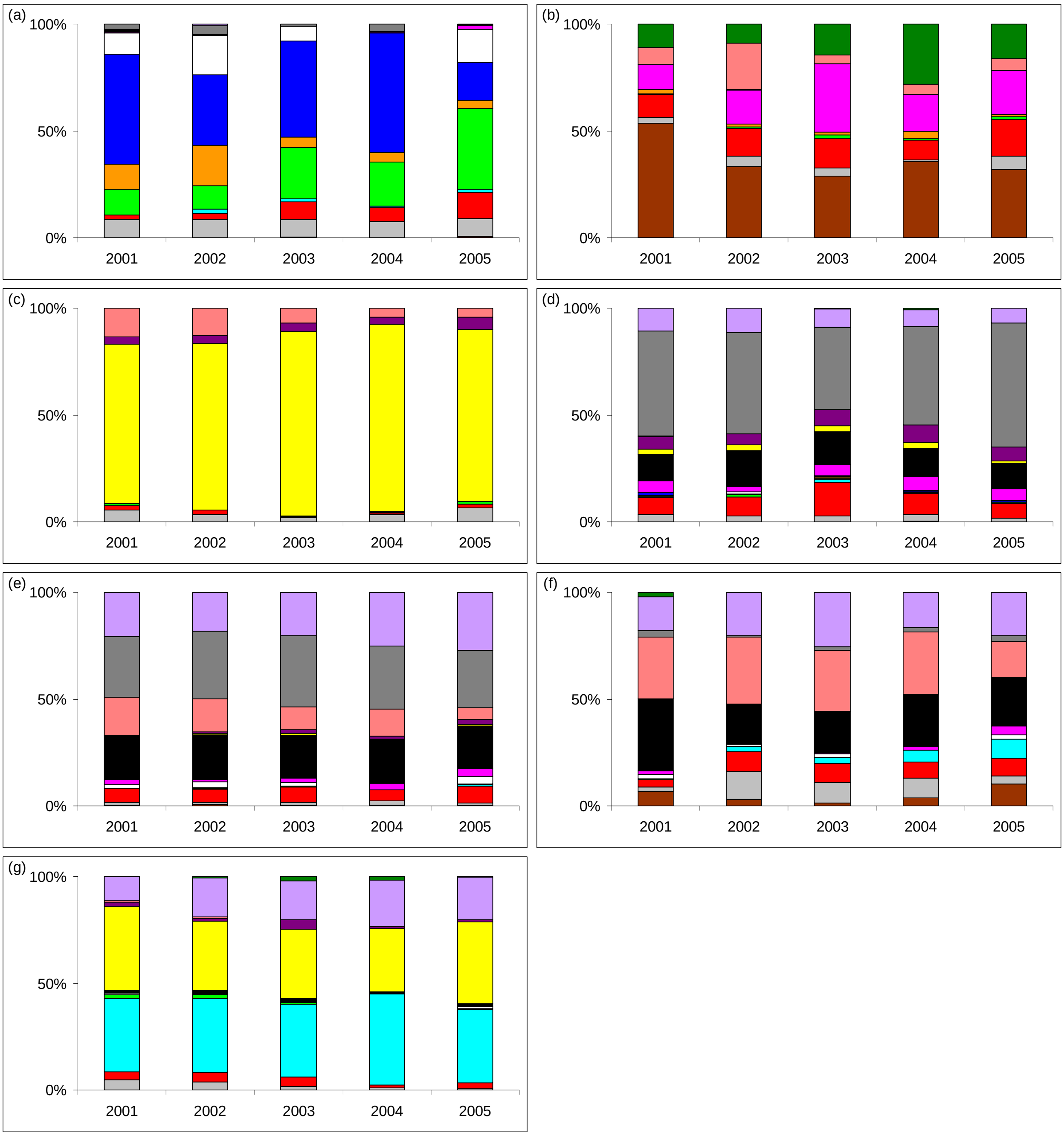

Figure 3. Catch profiles by year as derived over the period 2001-2005 for fleets (a) FL1, (b) FL2, (c) FL3, (d) FL4, (e) FL5, (f) FL6, (g) FL7. The catch profiles color codes are (c1) brown, (c2) light grey, (c3) red, (c4) light blue, (c5) light green, (c6) orange, (c7) dark blue, (c8) white, (c9) pink, (c10) black, (c11) yellow, (c12) purple, (c13) salmon, (c14) dark grey, (c15) indigo, (c16) dark green.

Figure 4a. Marchal [in color]

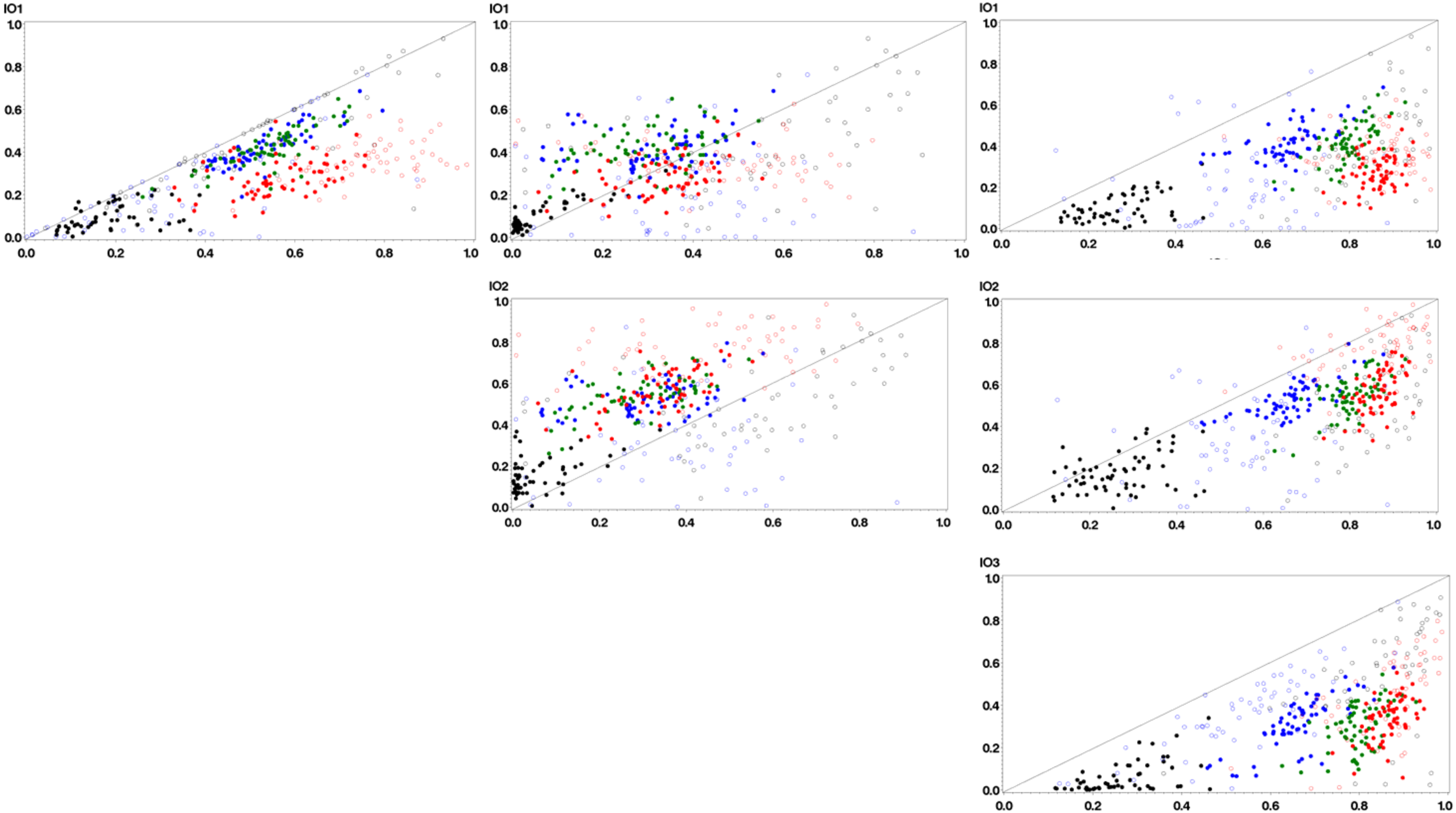

Figure 4a. Matrix of the pair-wise correlations between the different uncertainty coefficients, representing the proportion of uncertainty in catch profiles that is explained by the 4 indicators of fishing intention (IO1, IO2, IO3, IO4). Each data point represents a combination of fleet, year and month. The different fleets are indicated in black circles (FL1), black dots (FL2), blue circles (FL3), blue dots (FL4), green dots (FL5), red dots (FL6), red circles (FL7).

Figure 4b. Marchal [in color]

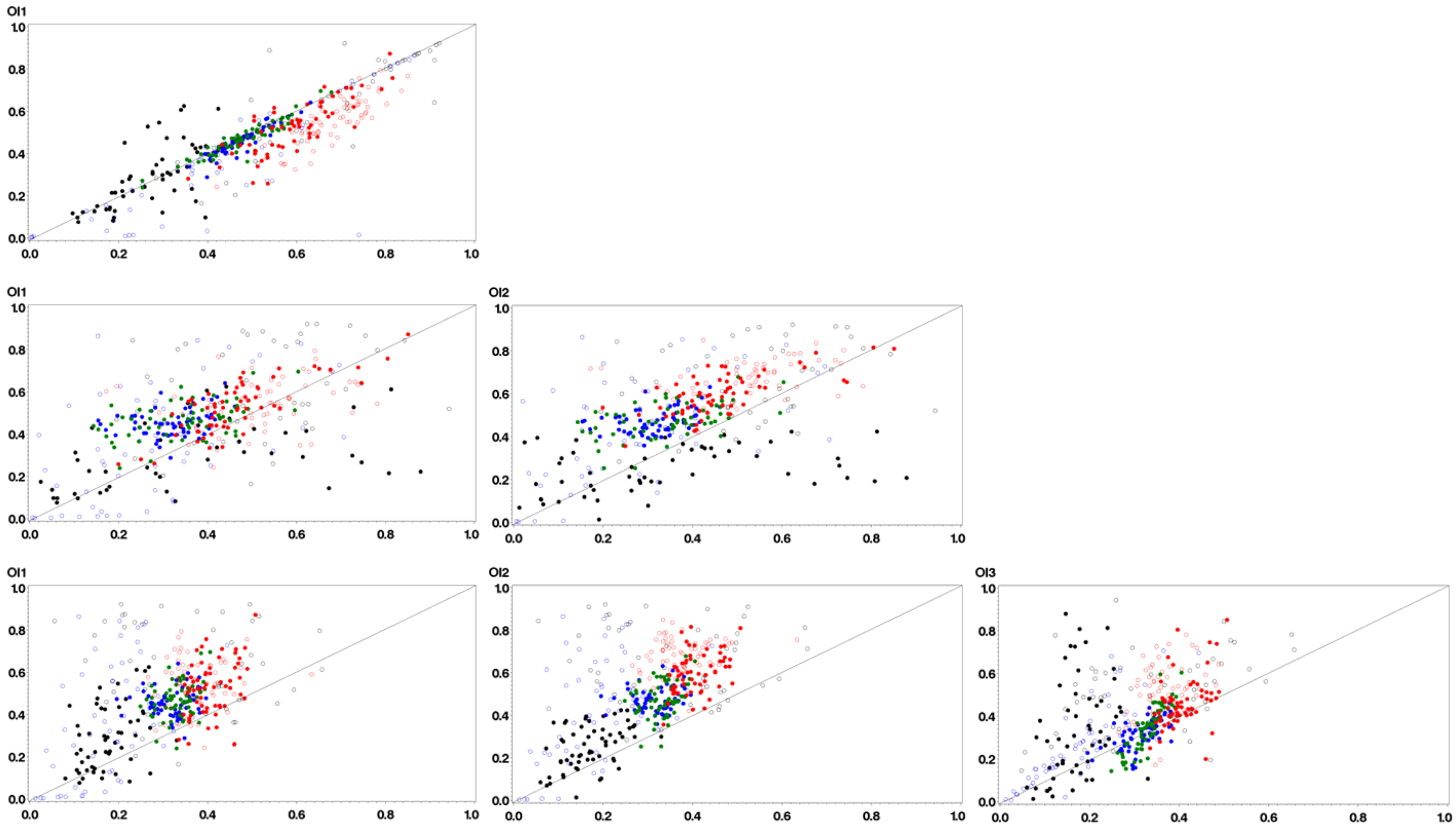

Figure 4b. Matrix of the pair-wise correlations between the different uncertainty coefficients, representing the proportion of uncertainty of the 4 indicators of fishing intention that is explained by catch profiles (OI1, OI2, OI3, OI4). Each data point represents a combination of fleet, year and month. The different fleets are indicated in black circles (FL1), black dots (FL2), blue circles (FL3), blue dots (FL4), green dots (FL5), red dots (FL6), red circles (FL7).

Figure 5. Marchal

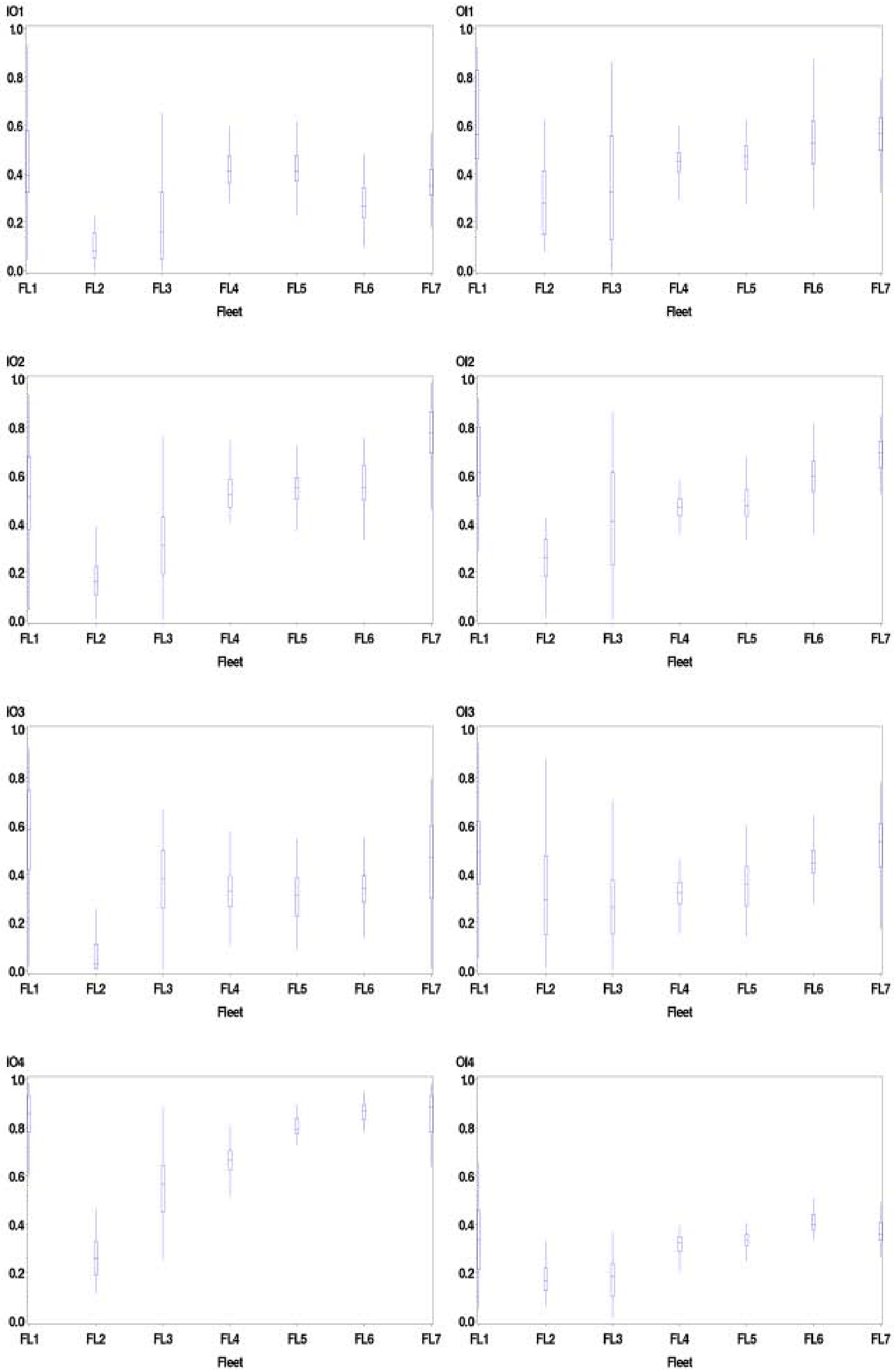

Figure 5. Box plots of the different uncertainty coefficients calculated for each fleet. These coefficients represent, either (left column) the proportion of uncertainty in catch profiles that is explained by the 4 indicators of fishing intention (IO1, IO2, IO3, IO4), or (right column) the proportion of uncertainty of the 4 indicators of fishing intention that is explained by catch profiles (OI1, OI2, OI3, OI4).

Figure 6. Marchal [in color]

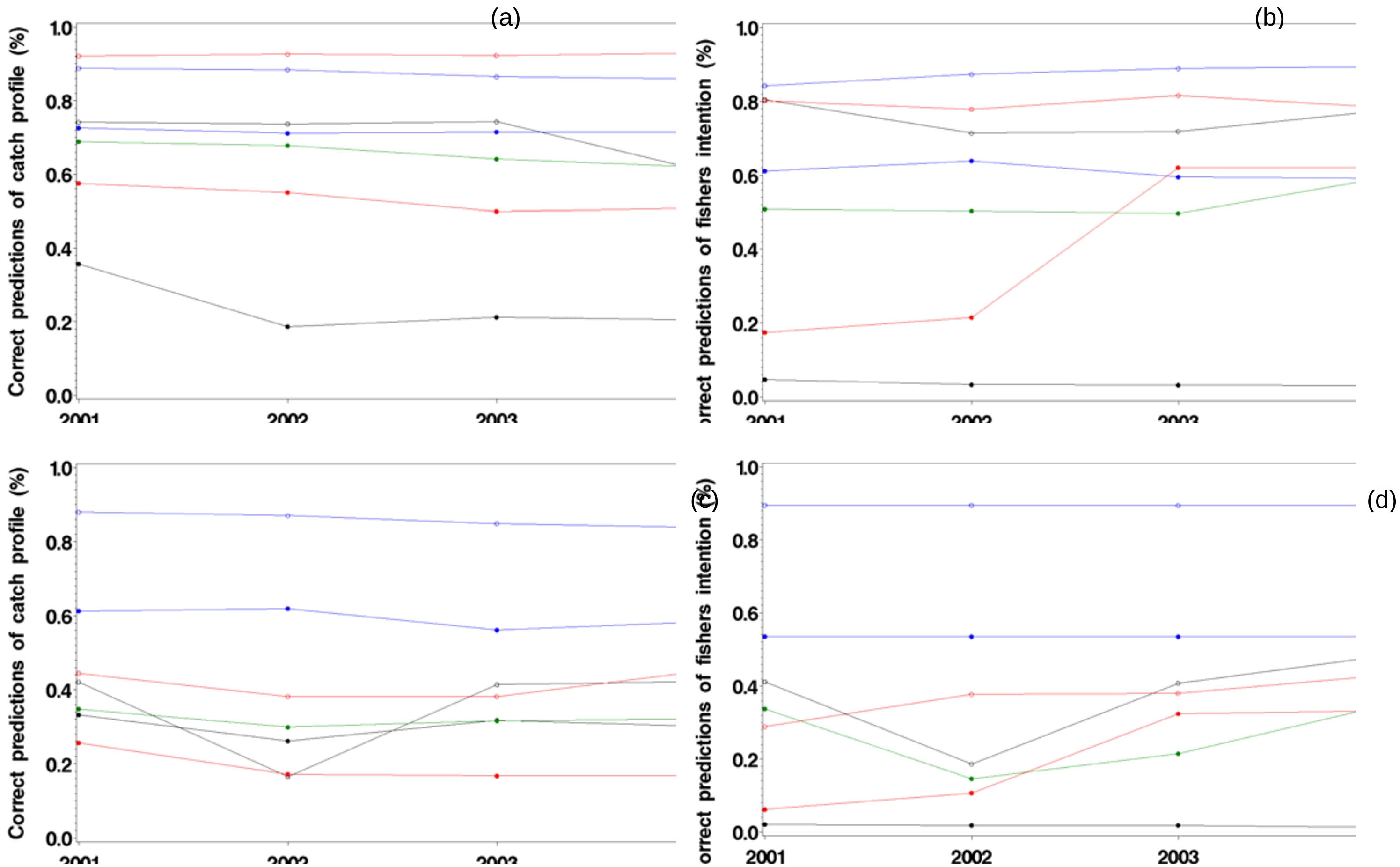

Figure 6. (a, c) Proportion of fishing trips and vessels for which catch profiles have been correctly forecasted in 2005, given the past correspondence between, (a) fishing intentions (as reflected by métiers aggregated at level 2) and catch profiles, (c) quarter and catch profiles, is available in 2001, 2002, 2003 or 2004; (b, d) Proportion of fishing trips and vessels for which fishing intention (as reflected by métiers aggregated at level 2 has been correctly forecasted in 2005, given the past correspondence between, (b) catch profiles and fishing intention, (d) quarter and fishing intention, is available in 2001, 2002, 2003 or 2004. The different fleets are indicated in black circles (FL1), black dots (FL2), blue circles (FL3), blue dots (FL4), green dots (FL5), red dots (FL6), red circles (FL7).