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DEEPWATER FISH AND FISHERIES

C.P.U.E. ABUNDANCE INDICES OF THE MAIN TARGET SPECIES OF THE FRENCH DEEP-WATER FISHERY IN ICES SUB-AREAS V, VI AND VII).

By

Pascal Lorance(*) and Hervé Dupouy(**).

(*) IFREMER, 150 quai Gambetta, BP 699, 62321 Boulogne-sur-mer
(**) IFREMER, 8 rue François Toullec, 56100 Lorient

ABSTRACT

Three major fleets of high sea trawlers practising deep-water fishing are defined. Altogether, these fleets catch more than 90 % of the French landings of deep-water species. A multiplicative model has been adjusted to monthly catch per unit effort (c.p.u.e.) weighted by effort to estimate annual indices.
C.p.u.e.'s of roundnose grenadier (*Coryphaenoides rupestris*), orange roughy (*Hoplostethus atlanticus*), black ùscabbard fish (*Aphanopus carbo*) and deep-sea squalids (*Centroscymnus coelolepis* and *Centrophorus squamosus*) are analysed in relation to the trends in fishing effort and to the development of the deep-water fishery. C.p.u.e.'s of other species : saithe (*Pollachius virens*), blue ling (*Molva dipterygia*) and ling (*Molva molva*) are treated in the same way because they are targeted by the same fishing fleets. Their analysis allows to investigate interaction between the different targets of the fleets and to compare the species trends.
For the recently exploited deep-water species, the c.p.u.e. trends are not consistent between fleets. The differences are interpreted to be due to technical changes and the indices from the fleet of larger specialised deep-water trawlers is considered to be the most representative of the actual fish abundance. For saithe and blue ling the declining trend in c.p.u.e. previously documented are observed again with slope differences probably due to method.
The c.p.u.e. of deep-water species show strong declining trends suggesting severe impact of the fishery. However, possible effect of the fishing strategy on the amount of effort counted as species directed effort cannot be excluded because the catch and effort data available is detailed by statistical squares while the proper scale would be the trawl haul. Moreover, the indices cannot be considered as indices for the whole ICES sub-areas investigated because a distribution the fishing effort was concentrated in a restricted area of ICES division VIa.

RÉSUMÉ

Trois flottilles principales de chalutiers hauturiers pratiquant la pêche profonde ont été définies. Elles représentent ensemble plus de 90% des débarquements français d'espèces profondes. Un modèle multiplicatif a été ajusté aux captures par unité d'effort (c.p.u.e.) mensuelles pondérées par les efforts pour calculer des indices d'abondance annuels.
Les c.p.u.e. du grenadier de roche (*Coryphaenoides rupestris*), de l'empereur (*Hoplostethus atlanticus*), du sabre noir (*Aphanopus carbo*) et des sikis (*Centroscymnus coelolepis* et *Centrophorus squamosus*) sont analysées par rapport aux tendances de l'effort de pêche et au développement de la pêcherie profonde. Les c.p.u.e. du lieu noir (*Pollachius virens*), de la lingue bleue (*Molva dipterygia*) et de la lingue franche (*Molva molva*) sont également

traitées parce que ces espèces sont ciblées ou capturées par les mêmes flottilles. L'analyse de leurs c.p.u.e. permet de regarder les interactions entre les différentes cibles et de comparer les tendances par espèce.
Pour les espèces profondes d'exploitation récente, les tendances des c.p.u.e. des différentes flottilles sont contradictoires. Les différences sont attribuées aux évolutions techniques des flottilles et seuls les indices de la flottilles de chalutiers hauturiers spécialisés dans la pêche profonde sont considérés comme représentatifs des changements réels des abondances. Pour le lieu noir et la lingue bleue, la baisse connue des c.p.u.e. est retrouvée avec, cependant, des pentes différentes de celles indiquées par d'autres études du fait des méthodes utilisées.
Les c.p.u.e. des espèces profondes sont en forte baisse et suggèrent un impact majeur de la pêche sur l'abondance de ces espèces. Cependant, un effet des stratégies de pêche sur les estimations ne peut pas être exclu parce que les données de capture et d'effort cumulent l'activité de pêche par rectangle statistique et par marée ; seule l'information trait par trait serait affranchie de ce risque. Enfin, les c.p.u.e. calculées ne peuvent pas être considérés comme des indices d'abondance moyens sur l'ensemble des sous-régions analysées parce que l'effort de pêche est fortement concentré dans une partie de la division CIEM VIa.

KEY-WORDS : catch per unit effort, deep-water fishery, indices of abundance, multiplicative model.

1. INTRODUCTION

The landings of deep-water species in France increased by the late eighties. Roundnose grenadier (*Coryphaenoides rupestris*) ; orange roughy (*Hoplostethus atlanticus*) black scabbard fish (*Aphanopus carbo*) deep-water squalids (mainly *Centroscymnus coelolepis* and *Centrophorus squamosus*) now support a main part of the activity of the larger French high sea trawlers. These four species (or pseudo-species) are termed here "deep-water species" while species exploited for a longer time (blue ling (*Molva dipterygia*), ling (*Molva molva*) and saithe (*Pollachius virens*) are called "other species". However there are depth distribution overlaps, this terminology allows to distinguish recent and more ancient species in the French landings (reported landings of deep-water species did not began before 1989 while blue ling exploitation started in the early seventies). The catch of the 4 deep-water species exceeded 15 000 tonnes in 1996, almost all this catch comes from ICES sub-areas V, VI and VII.
Catch-per-unit effort (c.p.u.e.) of French trawlers are analysed to get some abundance indices of their recent deep-water target species. Other species are also analysed because they are targeted by the deep-water fleets as well and there are possible interactions between c.p.u.e. on different species.
Three fleets, defined according to vessels size and activity, are analysed. These different categories of vessels have different fishing powers and range of operation but have wide common fishing grounds. As they did not begin deep-water fishing at the same time, it has been felt that they should be treated independently and possibly combined then. Such a combination appeared inappropriate as discussed in this paper. The c.p.u.e. analysed here, are directed : they are calculated from the catch realised when targeting one species and the associated effort. As shown by Biseau (1998) a directed c.p.u.e. seems more relevant than a global c.p.u.e.. However, the approach used here is easier than the method developed by Biseau and the results should be consider as preliminary.

2. MATERIAL AND METHOD

2.1 FLEETS

According to the French administration regulation, the larger French offshore trawlers are called *chalutiers de pêche industrielle*. These vessels, which fish only for human consumption have an overall length between 49 to 55 meters. Two fleets are defined in this size category :
- fleet a : an homogeneous fleet (in terms of power, age and equipment) of vessels which were almost specialised in exploitation of deep-water species and blue ling during the last decade. It seems there was no important technical changes in these vessels during the 90's ;
- fleet b : all the other 49 to 55 meters long trawlers.

A third fleet (fleet c) is defined as the class of smaller high sea trawlers. Termed *chalutiers semi-industriels* by the French administration, these vessels are mainly 30 to 38 m long.

2.2 DIRECTED CATCH AND EFFORT

The catch and effort data of each fleet has been extracted for each fleet from the fishery statistic files. For the offshore fisheries, such data are available for the years 1983 to 1996. Some recording problems (deep-water squalids being reported as "miscellaneous shark" or orange roughy as *Beryx splendens*) could be overcome, however, at the beginning of deep-water fishery there has certainly been some landings recorded as miscellaneous fish which cannot be re-allocated to actual species.
The effort used to calculate c.p.u.e. is a directed effort (expressed in fishing time in hours). The directed effort to one species is the effort expected to have been actually spent targeting this species.

As detailed by Biseau (1998), each fishing trip is divided into as many sub-trips as there were statistical squares visited. For each species, catch during one sub-trip is taken into account only if the percentage of the species in the total landing of the sub-trip is higher than 10 % (lower percentage is considered as by-catch while targeting other species). If so, the effort during the sub-trip is accounted as directed effort on the species. A second threshold excludes sub-trip catch and effort from trawlers whose yearly directed effort on the species is lower than 20% of total effort. This second threshold is designed to exclude occasional catches and effort from trawlers usually practising other "métiers".

Directed catch and effort by sub-trips are summed up over sub areas and months. Data aggregated by sub-area is then used to calculate monthly c.p.u.e. which are then processed trough a multiplicative model to provide annual c.p.u.e. abundance indices.

2.3 MULTIPLICATIVE MODEL

A c.p.u.e. model is a requisite because the catch and effort of some of the studied species display strong seasonal patterns, this is especially obvious for blue ling (Fig. 1). Monthly variations of c.p.u.e. and effort on deep-water species have also been observed (FAIR, 1997). Laurec & Le Gall (1975) demonstrated the appropriateness of multiplicative model in such case. C.p.u.e. of species which could be considered as stable throughout the year have been estimated from the same model because vessels change their target species according to the expected seasonal yield as well as for consistency of results provided here.
Following Laurec & Fonteneau (1978) the monthly c.p.u.e. in one single sub-area is noted $C_{i,k}$ and is considered as the product of an annual abundance index (R_i) and a monthly factor (Q_k) :

$$C_{i,k} = R_i \times Q_k \quad (1);$$

(1) is linearised by log-transformation. The logarithmic model includes a residual term $\varepsilon_{i,k}$ to allow adjustment estimates l_{ri} and l_{qk} of Ln(R_i) and Ln(Q_k) :

$$Ln(C_{i,k}) = Ln(R_i) + Ln(Q_k) + \varepsilon_{i,k} \quad (2);$$

This model is adjusted by weighted least square method, the quantity to minimise being :

$$\sum_{i,k} E_{i,k}\left[Ln(C_{i,k}) - (lr_i + lq_k)\right]^2$$

where the weighting factor $E_{i,k}$ is the directed effort of the month in the sub-area. Weighting is expected to reduce variance of estimations from reducing the effect of c.p.u.e. calculated from low effort (Laurec & Fonteneau, 1978).
The model is the same when taking into account more than one zone. In the present case, k ranges from 1 to 24 or 36 spatiotemporal strata instead of 12 simply temporal (monthly) strata.
Simple c.p.u.e. indices of abundance are obtained by exponentiation of the log estimates. Those indices are biased and Gavaris (1980) detailed the bias correction which have not been used here considering that, according to the number of degrees of freedom of the regressions, the bias should be very low compared to the effects (discussed below) which can have an influence on the indices.

3. RESULTS

3.1 CATCH

The total landings of the 3 fleets in ICES sub-area V, VI and VII are given in Table 1. These figures made up the bulk of the landings of deep-water species. Only a few landings are from vessels not taken into account here or from other areas. However these species are caught by the same depth, landings of black scabbard fish and squalids increased latter than the ones of roundnose grenadier. Actually, grenadier has been the first target of deep-water, other species may have been subject of high discarding rate (squalids) or reporting as miscellaneous fish at the start of the fishery.

3.2. TOTAL AND DIRECTED EFFORT BY FLEET

FLEET A :

In the 80's, this fleet developed an increasing effort on blue ling in sub-areas V and VI, during a few years almost all its effort in sub-area V was directed to this species (Fig. 2). From 1988 to 1991, its total effort to the west of British Isles continued to increase while deep-water species became its main target. No effort was spent in sub-area VII before 1991. In sub-area VI, the directed effort on blue ling decreased before raising again from 1993. Total effort of the fleet in sub-areas V, VI and VII is fairly stable from 1991 as well as its distribution in the 3 sub-areas. Effort on saithe and ling has always been very low and it reduced again with the development of deep-water fishing.

FLEET B:

The total effort of this fleet strongly declined over the studied time-period (Fig. 3) due to reduction of the number of vessels. However its total effort in the three sub-areas in 1996 is still around 2.5 times the effort of fleet a. Since the late 80's, changes in the ship-owning structure occurred, some vessels being sold while some others were re-equipped suggesting that the remaining vessels are, on average, more efficient than the former larger fleet. That fleet used to catch mainly gadoid species (hake, haddock, whiting, saithe, ling, blue ling), saithe being the most important. The catches of all these species declined by the late 80's. In the 90's, roundnose grenadier became the main target species in term of effort. Like for fleet a, most of the effort is spent in sub-area VI. Effort targeting saithe, ling, blue ling and probably redfish in sub-area V declined in the late 80's and is now negligible.

FLEET C:

Fleet c also shows a reduction of its total effort (Fig. 4). In the 80's, more than 90% of the effort in the studied sub-areas was in VII and targeted to shelf species. In the 90's, while total effort decreased in relation to reduction of fleet size the effort spent in sub-area V and VI became balanced. In the sub-area VI, the increase during the 90's is related to development of slope fishing but there is an accompanying increase for saithe and ling whereas, for fleets a and b, reduced effort on these species was linked to development of deep-water effort. Lastly, the amount of effort spent in sub-area V is negligible.

3.3 C.P.U.E. TRENDS

The oldest catch and effort data available for deep-water species are from year 1989. Some catches of roundnose grenadier have been landed in 1988 but not reported separately. Then, all the time series of c.p.u.e. for deep-water species are short. For some fleet and species only 5 years (1992 to 1996) are available.
The three fleets have different c.p.u.e. on all species. Fleet a has the highest c.p.u.e. on each of the 7 studied species while fleet c have the lowest one (Fig. 5 to 11). As the fleets had changing total and species directed effort over the studied time period, global c.p.u.e. calculation (not taking into account the fleet differences) would provide trends strongly depending on the changes in the relative effort by fleet.

DEEP-WATER SPECIES.

The c.p.u.e. has been computed for each fleet in the division where calculation was possible (Fig. 5 to 8). For the 4 species and the 3 fleets, the combined index in sub-areas V, VI and VII are close to the index for sub-area VI alone. This is due to the higher proportion of effort spent in VI (as the combined indices are weighted by effort).

However for the fleet of specialised deep-water trawlers c.p.u.e. in sub-area V has some effect on the combined indices.
The general trends for the 4 deep-water species are :
- fleet a shows a declining c.p.u.e. from 1990 or 1991 after an increase in the 1 or 2 first years of deep-water fishing ;
- fleet b and c show increasing c.p.u.e. indices.
Exceptions to these rules are observed for orange roughy for which there is an increase in c.p.u.e. of fleet a in 1996, and a decrease of c.p.u.e. of fleet b from 1991 to 1996.

OTHER SPECIES.

Blue ling
The c.p.u.e. for blue ling shows a formerly observed declining trend (Anon., 1998). This trend is consistent over fleets ; for fleet a, which allowed computation for sub-areas V and VI, the trend is similar in both. That consistency between fleets is the important point to stress here. However, for fleet c the end the of series is flat or even increasing.

Ling
C.p.u.e. could be computed for two fleets only (Fig. 6). As for blue ling, a declining trend is observed along the time series. However, there is an increase from 1992 for both fleets b and c.

Saithe
C.p.u.e. for fleet a have been calculated from very low effort (1% of the of fleet 2 effort) and then it cannot be used as abundance index. For fleet b, c.p.u.e. could be computed in the 3 sub-areas. The global c.p.u.e. is again very similar to the c.p.u.e. in division VI and it shows a declining trend. Lastly, for fleet c there is a decline in division VI from 1986. In division VII the c.p.u.e. is stable from 1983 to 1992 and then it increases sharply. C.p.u.e. indices of fleet c in sub-areas VI and VII combine in a quite stable global index.

4. DISCUSSION.

4.1. FLEETS AND EFFORT.

Discrepancies between the c.p.u.e. of the different fleets can be explained by fleets characteristics and observed trends have to be considered with regard of technical equipment of the vessels which has certainly increased the fishing power of most of them over the period 1983-1996.
Looking first to deep-water species, it seems that few technical improvement could be made on fleet a from 1991-1992 as these vessels were, at that time, completely equipped for deep-water fishing (that fleet has been defined here according to this characteristic). Others 50 m long vessels (fleet b) were then equipped for shallower fishing depth, then some technical improvement of deep-water fishing power have probably been done while the reduction in deep-water (and total) effort of this fleet b is linked to removal of some units, probably the less efficient.
Over the studied time period, fleet c is characterised by a global effort decline and a change of fishing areas. That fleet of smaller vessels is likely to have encountered more difficulties to adapt to deep-water fishing than the longer ships of fleets a and b. The technical adaptation may have been progressive.
Then, the increasing c.p.u.e. on deep-water species in the 90's for fleets b and c are believed to be mainly related to a combination of:
- acquisition of knowledge about new fishing grounds ;
- new equipment allowing increasing fishing power especially along the slope ;
- fleet effect as more vessels in one area can exchange information and concentrate on the fish.
Because of these likely technical trends, c.p.u.e. of fleets b and c cannot be used as abundance indices for deep-water species.
Similar trends should explain increasing c.p.u.e. of fleet a in 1989-1991. In these years there was also strong changes in effort amount and geographic distribution (Fig. 2). As a consequence, only the c.p.u.e. for fleet a, after the starting years, can be considered as significant in term of deep-water fish abundance. A better analysis than the one presented here would be to regress the c.p.u.e. against the technical characteristics of the vessels. However, if the length, age and power of trawlers are available data, some other information (navigation, acoustic, trawl and deck equipment) which can be very relevant to efficiency of deep-water trawling are not

available from files while proper methodologies to assess fishing power are still under question. The homogeneity and stability over time in the 90's of fleet a allow to leave these points aside.
The general higher level of c.p.u.e. of fleet a is not surprising according to the definition of the fleet. The reduction of the difference of c.p.u.e. between fleets a and b for the 4 deep-water species probably illustrates the increasing fishing power of fleet b. C.p.u.e. of fleet a are still about twice the ones of fleet b in 1996. However, this cannot be considered as difference in fishing power as there is possible effect of the fishing strategy. Along the slope, some statistical rectangles cover depth range from the shelf to the abyssal plain, then for sub-trips (see material and method) during which hauls for saithe and deep-water species are towed, the total sub-trip effort will be counted as directed effort to each species. Of course, detailed catch and effort data by haul would be more appropriate but they are not available.

4.2. DEEP-WATER SPECIES

Considering only the indices from fleet a, it should however be noted that the time series are short and refer to a young fishery. The meaning of the c.p.u.e. for the 4 species are also different. Roundnose grenadier, black scabbard fish and squalids are species which live dispersed over wide areas. Basically, they are found everywhere within there geographical area and depth range. Conversely, orange roughy, which has a world-wide distribution, makes dense aggregations (which are relatively easy to target by trawlers) and is at very low density elsewhere. For such aggregating species, c.p.u.e. has poorer meaning and only reflects the density of the fish on the aggregation under exploitation but cannot be taken as a stock abundance index. Then, the main conclusion for orange roughy is that the biomass of the exploited aggregations was quickly fished down. This has been faster in area VI (Table 2), while aggregations exploited in area VII should be more slowly declining under a currently lower effort. For this species, c.p.u.e. in recent years may have higher variance as they rely on low catch and effort.

Table 2. Total catch (metric tonnes) of orange roughy by ICES sub-area for the three fleets combined.

Sub-area	1991	1992	1993	1994	1995	1996
V	36	4	1	0	1	2
VI	2190	1297	429	179	74	116
VII	1135	2628	1175	1408	829	879
Total	3361	3929	1605	1587	904	997

Over 1992-1996, directed effort to roundnose grenadier and squalids varied from year to year within no consistent trend. During the same time-period, directed effort on black scabbard fish was almost multiplied by 2. The reason for that trend is difficult to understand. Fishing effort on orange roughy decline and may have been transferred on other deep-water species and blue ling. This may explain the increasing effort on blue ling. It is more difficult to find reason for the increase of effort on black scabbard fish as this species is caught with grenadier and squalids. As the proportion of the total catch of the species counted as directed catch shows no trend, this increase effort cannot be a side effect of decreasing yields of grenadier and squalids. Then, this increase can reflect either a change in fishing ground/depth or in fishing gear (the catch of this species should be sensitive to vertical opening of the trawl). Anyhow, this increase is not accompanied by higher catch. The wide geographical distribution of black scabbard fish, its known water-column distribution, its vertical swimming behaviour observed twice during recent submersible surveys (unpublished data) and the long-time exploitation in southern areas could have suggested that this species should not be too much sensitive to exploitation by bottom trawls.
In the early 80's, almost all the catch of deep-water species came from the division VIa. For slope species, the fish density was probably higher in that area (Bridger, 1978). A high proportion of the catch still comes from that area but wider fishing grounds are now visited. Then, the decline in c.p.u.e. observed here appears as a combination of declining fish densities on the most productive areas under intense exploitation and development of fishing effort in sectors of lower densities. In any case, the fishery does not yet covers the full geographical and depth ranges of these species. Then however, they clearly indicate reduction of the fish abundance, the indices calculated here may amplify the actual stock reduction.

4.3. OTHER SPECIES

For other species, there is no strong reason to exclude indices from fleets b and c.

Blue ling

The analysis of this species is interesting because it is a longer established fishery. French units began to exploit blue ling in the early seventies (Moguedet, 1985). The consistent blue ling c.p.u.e. drop (Fig. 5) suggests that the decrease in abundance of that species overcomes other trends like increased fishing power. However, it is not clear if there has been changes in fishing power for that species. In particular, the changes made to fish by greater depth may have no effect on the ability to catch blue ling, however, it's worth noting that the average c.p.u.e. over the years 94-96 are 31%, 47% and 44 % of the 87-89 ones respectively for fleets a, b and c (previous years, of increasing effort on the species provide bigger figures). It's likely that fleet a, more efficient in early year had less space for further improvement. This observation allows to put more confidence in the c.p.u.e. indices of fleet a for deep-water species ; it matches with the explanation proposed for increasing c.p.u.e. of other fleets on deep-water species and the lower reduction of blue ling c.p.u.e. of fleets b and c.

Ling

The trends observed for ling are much less steep than for blue ling. As noticed by Biseau (1998) ling is a by-catch species. Then ling c.p.u.e. can change according to the current target species and fishing grounds. As this fish has a wide depth range, it can be a by-catch of saithe as well as roundnose grenadier and the c.p.u.e. calculated here can be misleading in term of abundance index. However, detailed information by hauls or by depth not being available from catch statistics files, better process cannot be proposed. It can only be noted that the increasing c.p.u.e. observed from 1992 to 1996 are similar to the ones ascribed to changes in fishing powers of the same fleets for deep-water species.

Saithe

The global declining trend as well as the peak in 1986 observed for fleet b, is consistent with previous analysis but the slope of the trend obtained here seems weak. Biseau (1998), shows the effect of the c.p.u.e. calculation method on the slope of the trend. The c.p.u.e. indices calculated here return a lower slope than the indices that he proposes.

4.4. COMPARISON OF THE TRENDS BY SPECIES

As seen earlier, for deep-water species, confidence is given only to indices from fleet a. For saithe, the indices from fleet b is consistent with other studies, but better analysis which have been proposed for this species returns steeper slope. Lastly, for blue ling the 3 series are reasonably consistent and the method is probably not relevant for ling. Then, considering that years before 1991 were a period of know-how or equipment acquisitions at the beginning of deep-water fishery, the relevant indices, scaled to 100 in 1991 can be compared (Fig. 12). They provide a crude sight of which species are likely to be the most sensitive to the level of effort they currently undergo (bearing in mind that saithe and blue ling stocks severely declined well before 1991). On that short time period, saithe and blue ling do not show dramatic changes.

Only blue ling allows between fleets comparisons. As seen earlier, the depletion seems stronger when seen from fleet a ; other fleets rather suggest a stable situation.

The trends for deep-water species and blue ling (indices of fleet a) are similar. Amongst deep-water species, squalids look the most resilient while orange roughy show the earliest decline. Beyond the comments made for each species, quicker changes appear for orange roughy while fleet a indices of the 3 other deep-water species (roundnose grenadier, black scabbard fish and deep-sea squalids) and blue ling are quite similar with an overall reduction around 50% or more for black scabbard fish.

The year 1991 was the start of the fishery for orange roughy, no landing have been reported before that year and only very minor ones may have occured. Then, for this species the 1991 index can be considered as operating on unexploited fishing grounds. Blue ling and deep-water species have overlapping depth ranges and, however blue ling is mainly caught on dense spawning aggregation, its fishery should have occasioned deep-water species discards. Then roundnose grenadier, black scabbard fish and deep-water squalids () undergo fishing mortality well before the 90's.

5. Conclusion

Amongst the 3 fleets analysed only one provides reliable c.p.u.e. abundance indices of deep-water species, the two other fleets giving indices distorted by technical trends. The selected indices strongly declined since the beginning of the fishery : c.p.u.e. indices reduced by around 50 % in five years for each of the 4 deep-water species analysed suggesting that the current level of catches may correspond to high rates of exploitation. Since the beginning of the fishery, some aggregations of orange roughy have obviously been fished down. As c.p.u.e. analysis may hardly apply to aggregating species, the decline shown here is rather believed to reflect the density of fish on aggregations under exploitation than any stock abundance. Amongst the 3 other deep-water species, less confidence is put in the trend observed for black scabbard fish because of unexplained trend in directed effort. Some not quantified aspects can have effects on the c.p.u.e. indices :

- as seen from different trends over the studied fleets, the c.p.u.e. indices may be specious ;
- the fishing strategy and the relative species abundance may lead to count more or less species catch and effort as species directed ones ;
- the deep-water fishery was young over the studied time series and fishing ground and depth may have been gradually extended.

Some of these points having opposed effects, the indices calculated here should be considered as preliminary. The current stabilisation of the fishery in terms of fleet size, equipment and probably fishing grounds should allow to confirm or invalidate these results in the near future.

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Table 1. Total landings from ICES sub-areas V, VI and VII for the 3 fleet analysed. Prior to 1989, some landings of deep-water species may have occured but were not reported separately. At least, roundnose grenadier was landed in 1988.

	Roundnose grenadier	Orange roughy	Black scabbard fish	Deepsea squalids	Blue ling	Ling	Saithe
1983					5141	8948	21795
1984					6140	7288	16451
1985					14205	8501	26656
1986					12435	6890	36413
1987					12660	6487	30553
1988					10135	7184	30538
1989	2392		308		9309	5467	24807
1990	6639		1451	392	6359	4202	18191
1991	8680	3361	2537	1163	6334	2798	13649
1992	7249	3929	3529	2802	4012	1827	8441
1993	7093	1605	3459	3248	3908	2142	11580
1994	6378	1587	3067	3270	2850	2310	11315
1995	6923	904	3431	3175	3441	2371	7852
1996	6433	997	3779	3237	3403	2244	6465

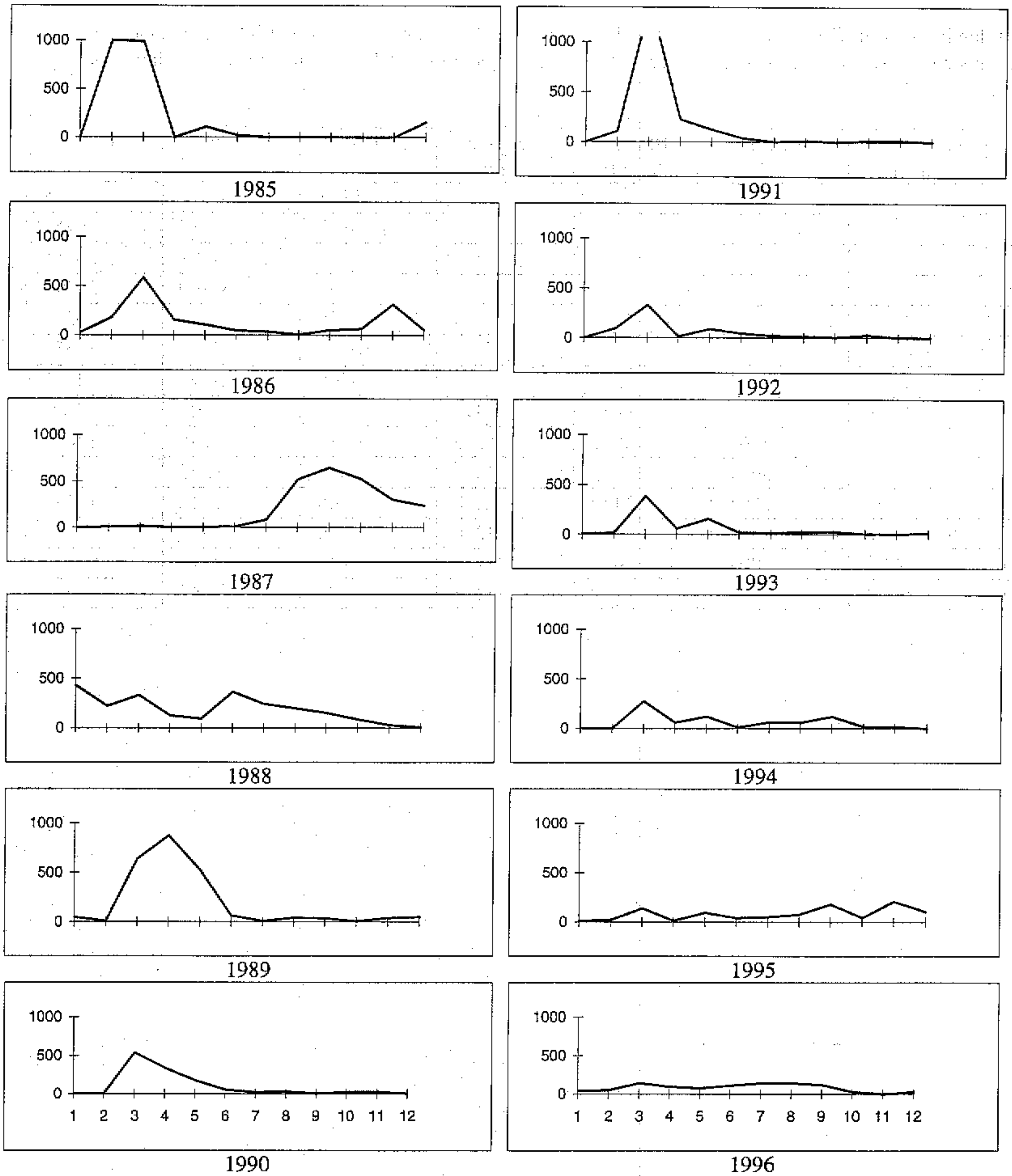

Figure 1. Seasonality of blue ling catches: catch in tonnes by year and by month in ICES sub-area VI for fleet a.

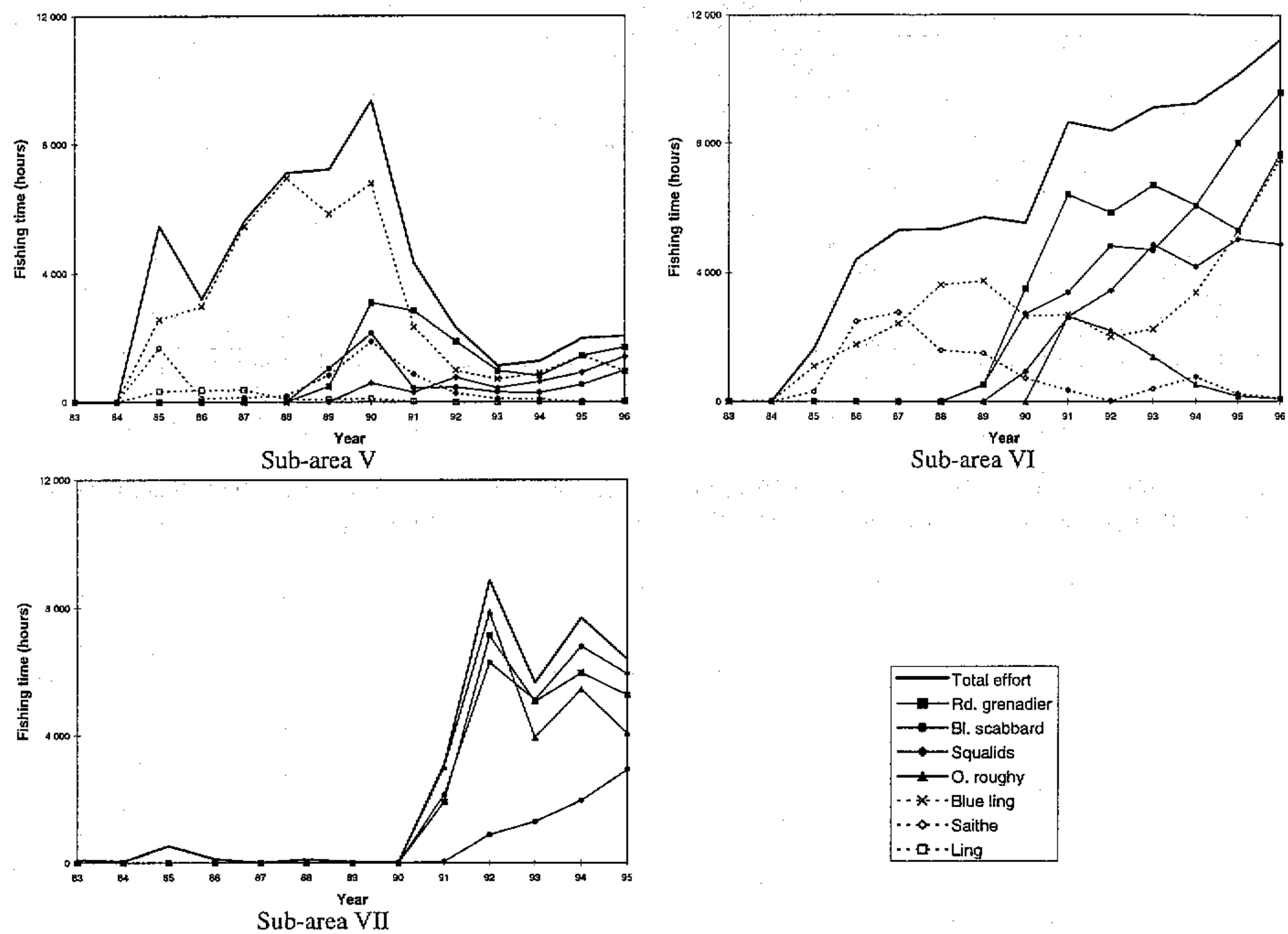

Figure 2. Total effort and directed effort by species of fleet a by ICES sub-area from 1983 to 1996.

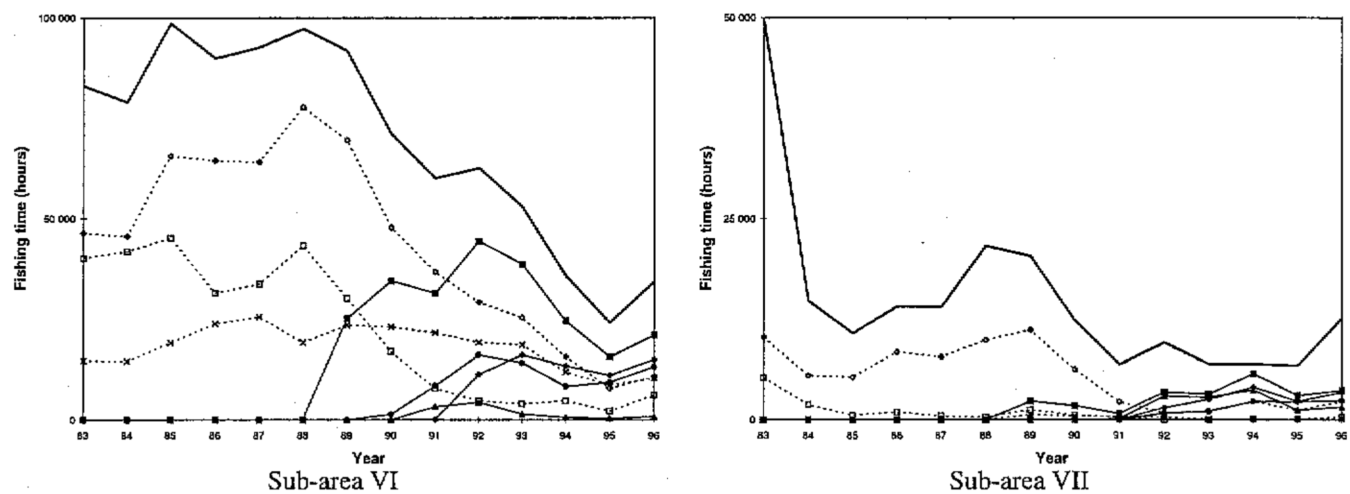

Figure 3. Total effort and directed effort by species of fleet b in ICES sub-areas VI and VII from 1983 to 1996, effort in ICES sub-area V (not represented) declined from 2500 hours in 1985 to less than 100 in 1996 (legend as in Fig. 2).

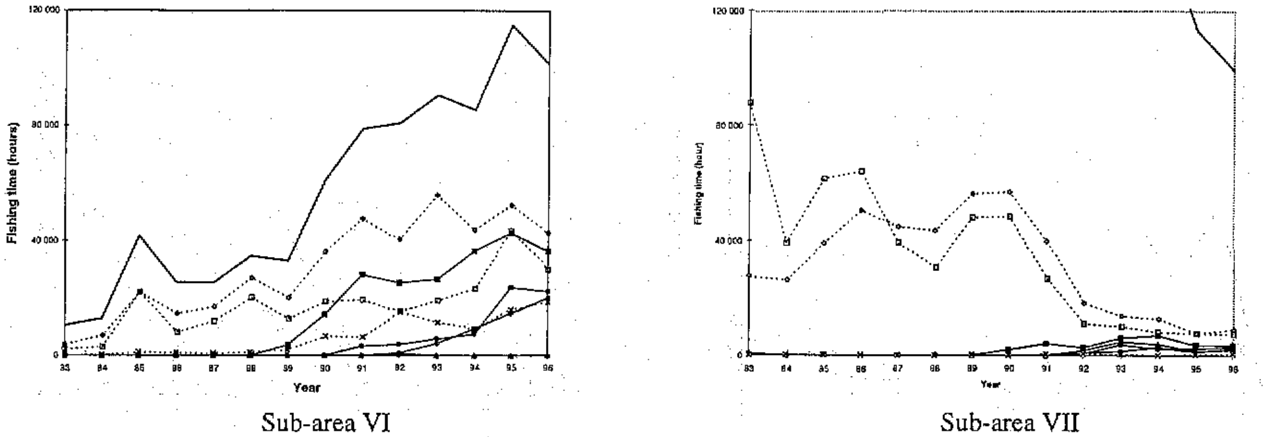

Figure 4. Total effort and directed effort by species of fleet c in ICES sub-areas VI and VII from 1983 to 1996. From 1983 to 1996 total effort in sub-area VII declined from about 350 000 to 120 000 hours. (legend as in Fig.2).

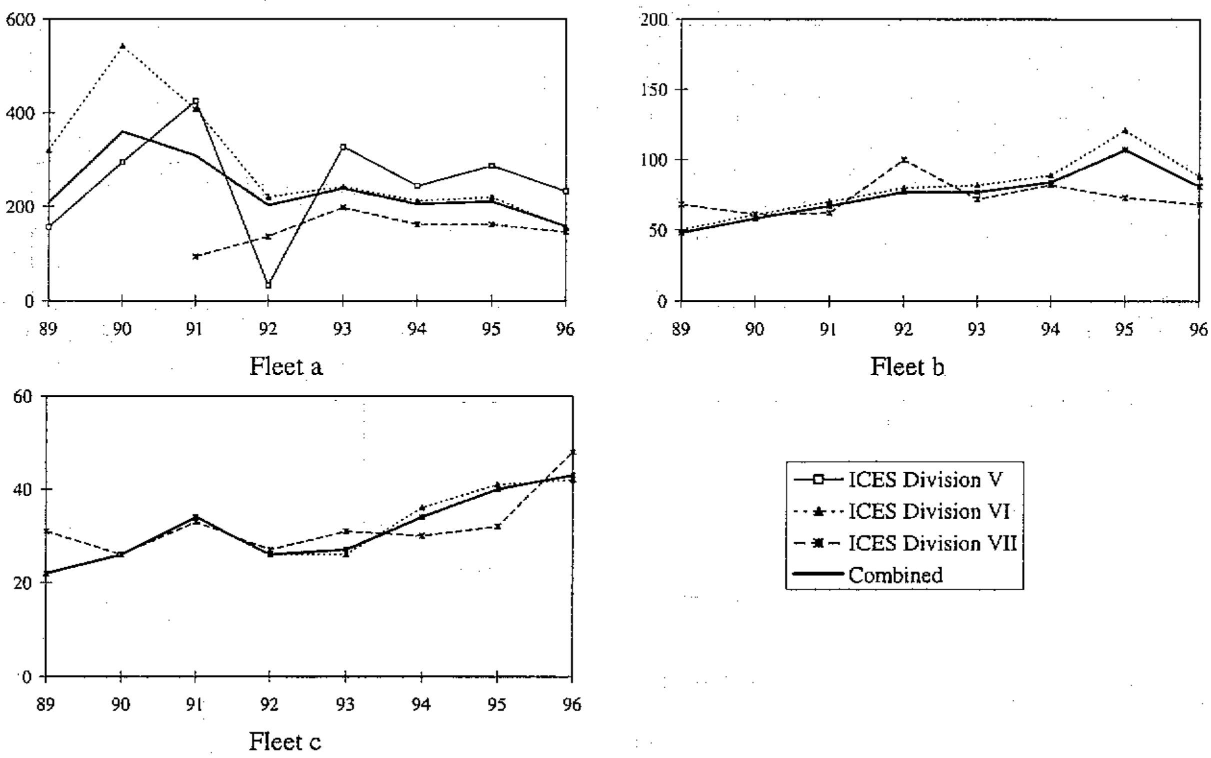

Figure 5. Roundnose grenadier (*Coryphaenoides rupestris*) : c.p.u.e. (kg/fishing hour) of fleets a, b and c in ICES sub-areas V, VI and VII from 1989 to 1996.

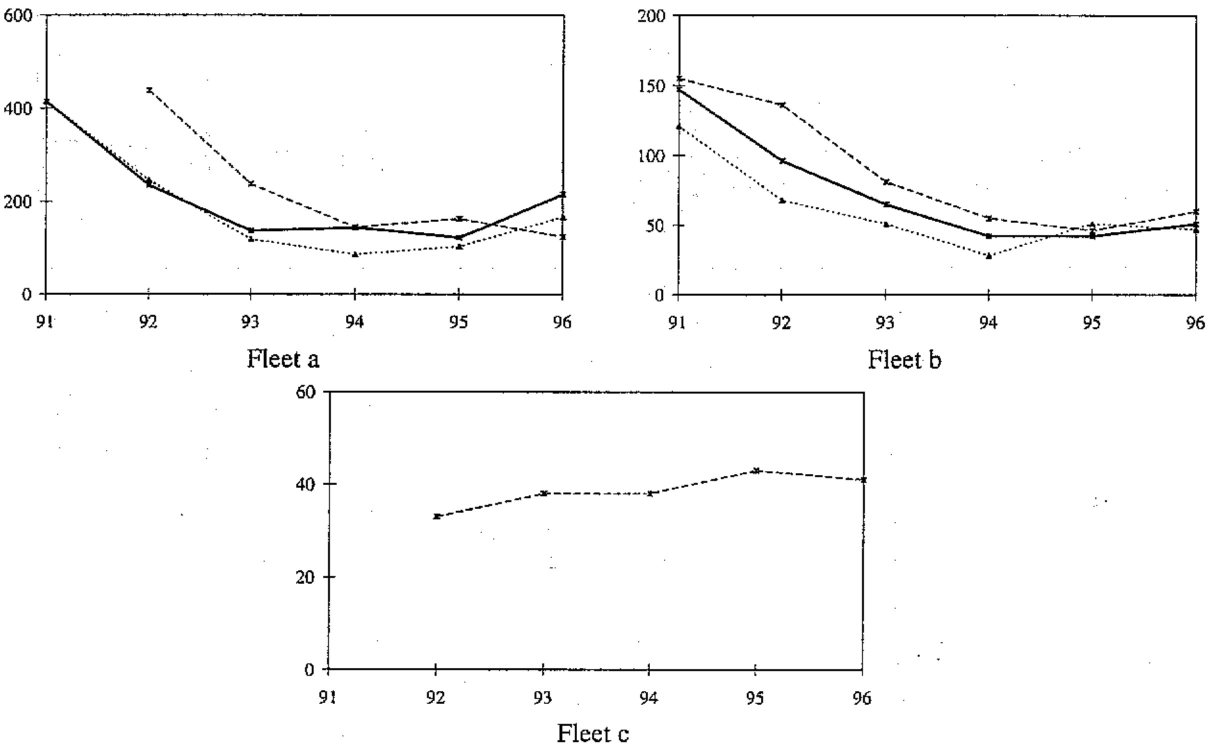

Figure 6. Orange roughy (*Hoplostethus atlanticus*) : c.p.u.e. (kg/fishing hour) of fleets a, b and c in ICES sub-areas V, VI and VII from 1991 to 1996 (legend as in Fig.5).

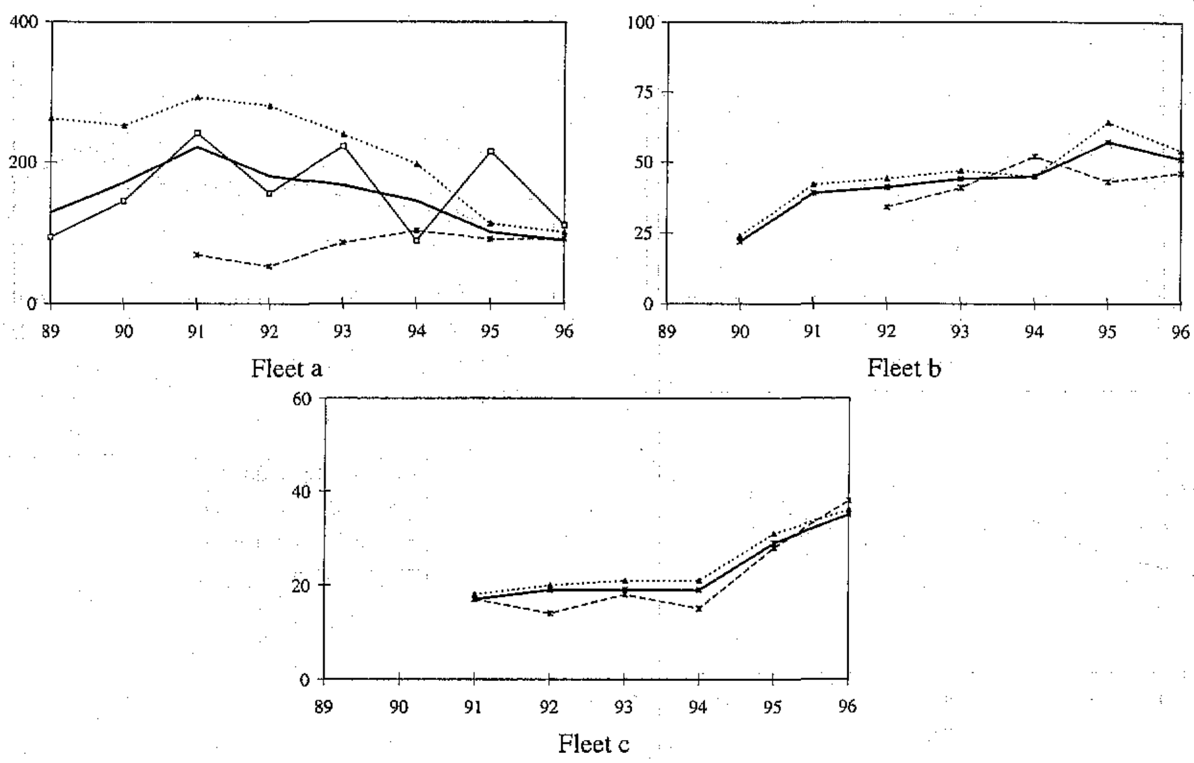

Figure 7. Black scabbard fish (*Aphanopus carbo*) : c.p.u.e. (kg/fishing hour) of fleets a, b and c in ICES sub-areas V, VI and VII from 1989 to 1996 (legend as in Fig. 5).

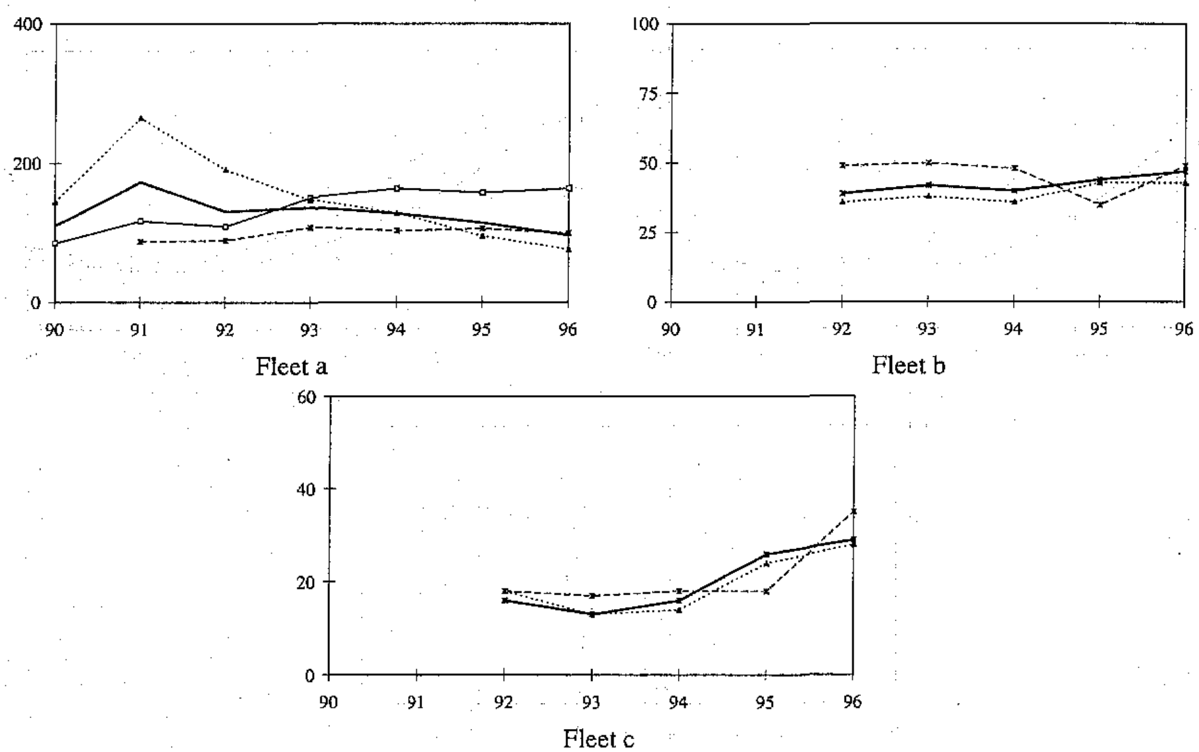

Figure 8. Deep-water squalids (*Centroscymnus coelolepis* and *Centrophorus squamosus*) : c.p.u.e. (kg/fishing hour) of fleets a, b and c in ICES sub-areas V, VI and VII from 1990 to 1996 (legend as in Fig. 5).

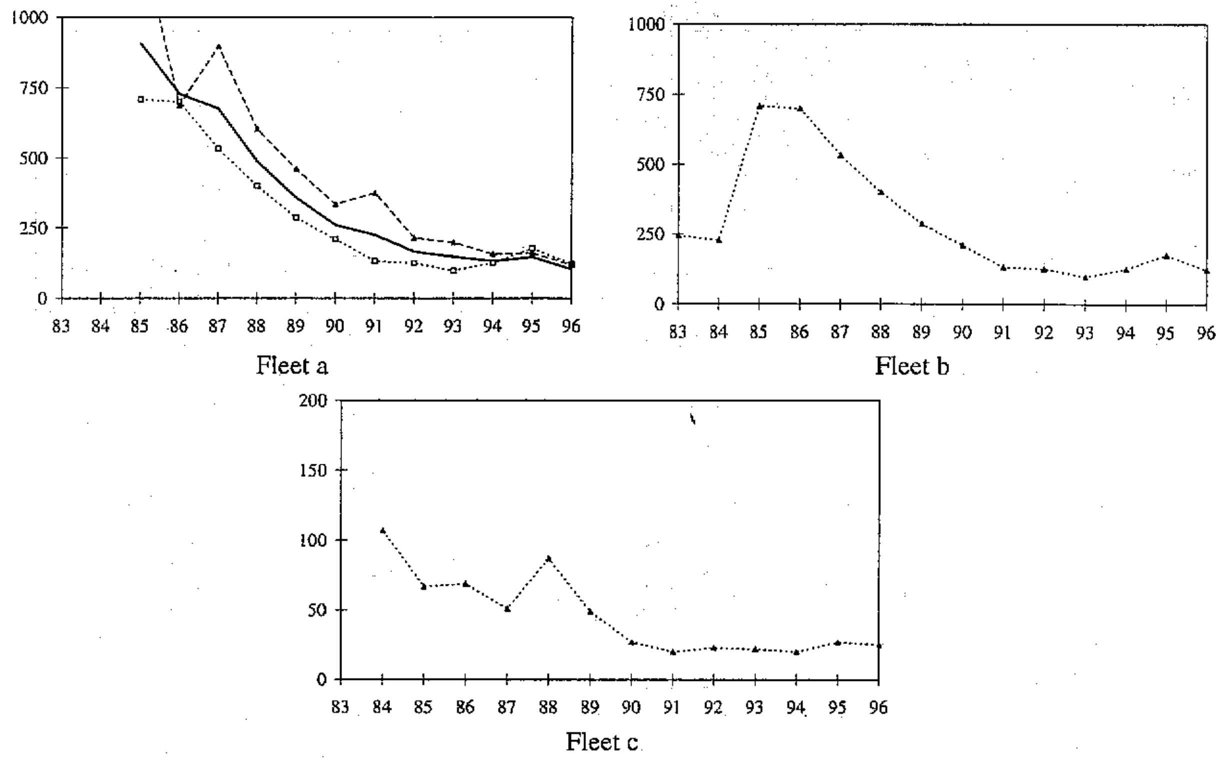

Figure 9. Blue ling (*Molva dipterygia*) : c.p.u.e. (kg/fishing hour) of fleets a, b and c in ICES sub-areas V and VI from 1983 to 1996 (legend as in Fig. 5).

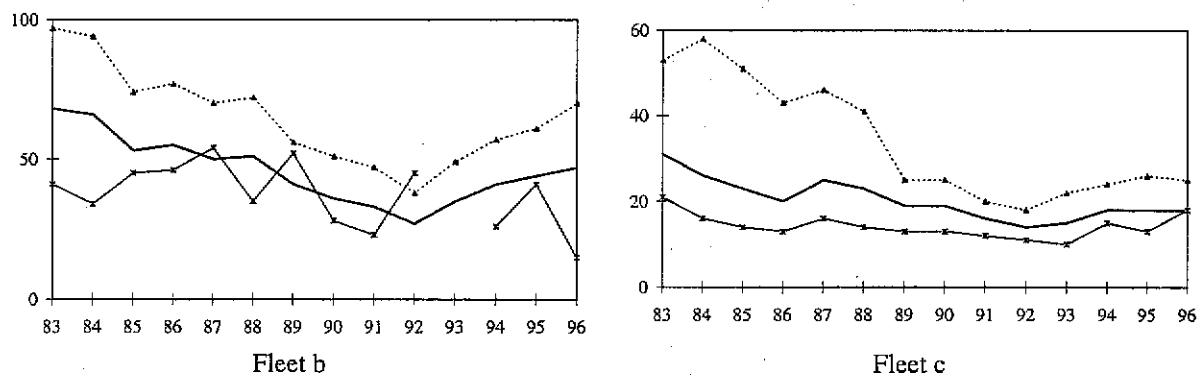

Figure 10. Ling (*Molva molva*) : c.p.u.e. (kg/fishing hour) of fleets b and c in ICES sub-areas VI and VII from 1983 to 1996 (legend as in Fig. 5).

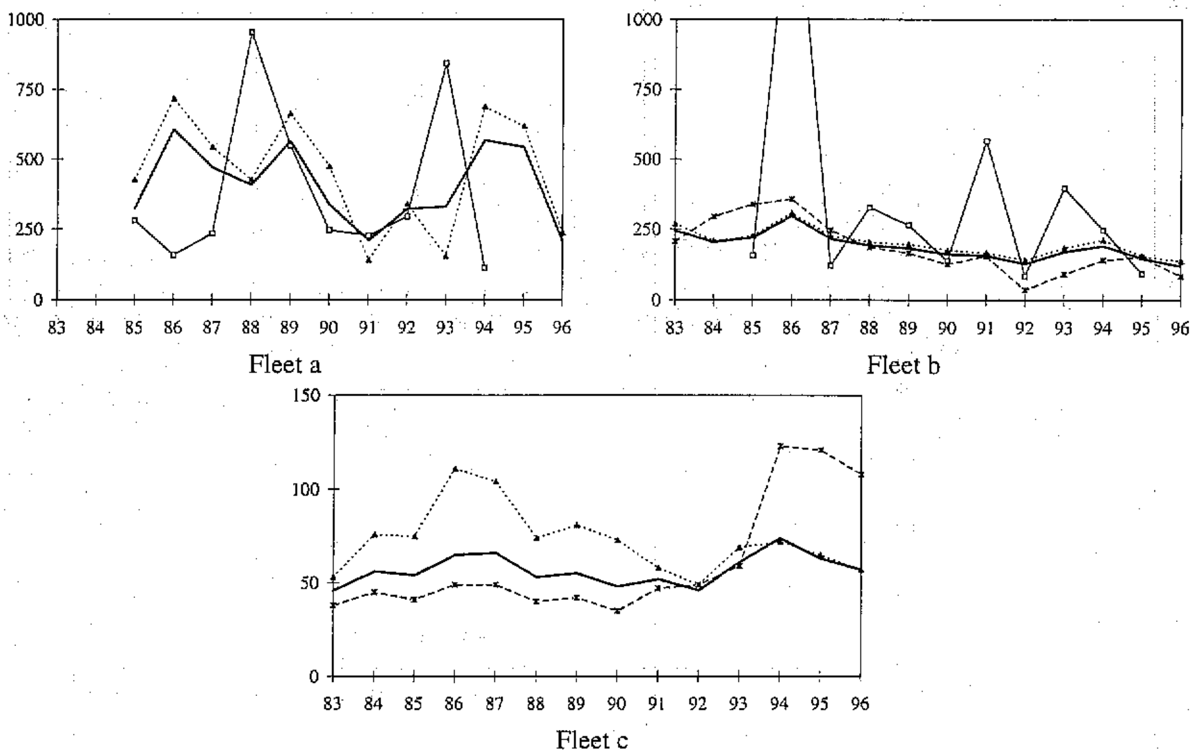

Figure 11. Saithe (*Pollachius virens*) : c.p.u.e. (kg/fishing hour) of fleets a, b and c in ICES sub-areas V, VI and VII from 1983 to 1996 (legend as in Fig. 5).

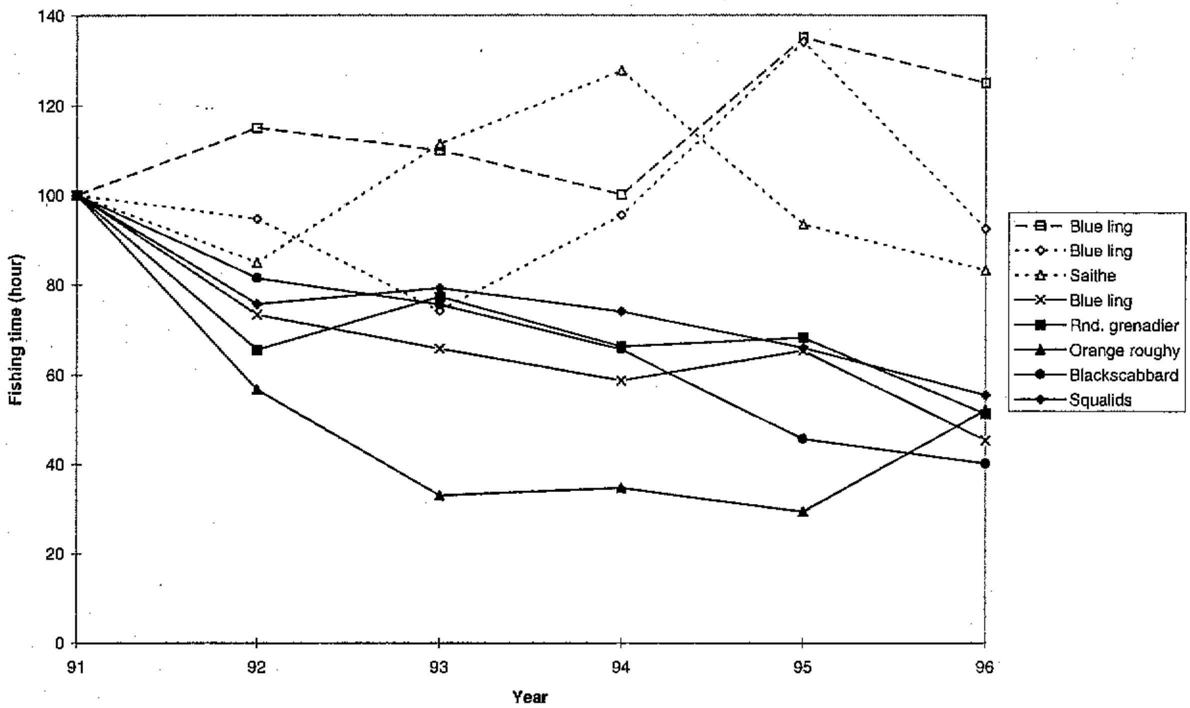

Figure 12. Comparitive evolution of c.p.u.e. indices of abundance by species from 1991 taken as reference year (indices scaled to 100 in 1991). Continued lines stand for fleet a, doted lines for fleet b and dashed lines for fleet c.