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International Council for the
Exploration of the Sea

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Pelagic Fish Committee
Ref. Demersal Fish Cttee

REPORT OF THE INTERNATIONAL NORTH SEA, SKAGERRAK, AND KATTEGAT BOTTOM TRAWL SURVEY WORKING GROUP

Copenhagen, 26 February - 1 March 1990

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1 TERMS OF REFERENCE AND PARTICIPATION

At the 1989 ICES Statutory Meeting, the Council decided (C.Res.1989/2:13) that an International North Sea, Skagerrak, and Kattegat Bottom Trawl Survey Working Group would be established under the chairmanship of Dr H.J.L. Heessen (Netherlands) to replace the Working Group on International Young Fish Surveys and would meet at ICES Headquarters from 26 February - 1 March 1990 to:

a) evaluate the usefulness of existing bottom trawl surveys in the North Sea, Skagerrak, and Kattegat;

b) coordinate all ongoing bottom trawl surveys in the North Sea, Skagerrak, and Kattegat;

c) coordinate data exchange between countries and ICES Headquarters;

d) evaluate differences in catch rates among different gears presently used in national surveys;

e) consider the possibility of redeployment of IYFS effort in 1991 to other quarters of the year in order to improve the coverage of the North Sea required for the Stomach Sampling Programme.

The meeting was attended by the following:

T. Boon	UK
R.M. Cook	UK
S. Ehrich	Germany, F.R.
O. Hagström	Sweden
H.J.L. Heessen (Chairman)	Netherlands
P.-O. Larsson	Sweden
A. Laurec	France
J. Shepherd	UK
O.M. Smedstad	Norway
A. Souplet	France
H. Sparholt	Denmark

Mr W. Panhorst from the ICES Secretariat also attended the meeting.

2 INTRODUCTION

At the 1984 ICES Statutory Meeting, both the Pelagic and Demersal Fish Committees resolved to merge the Working Group on "North Sea Young Herring Surveys" and the "International Gadoid Survey Working Group". The "Working Group on International Young Fish Surveys in the North Sea, Skagerrak and Kattegat" met for the first time in January 1985 to address the overall task of coordinating the international young fish surveys. Further meetings took place during January 1987 and January 1989. Over this period, the survey, besides providing abundance indices for its original customers (Industrial, Herring and Roundfish Working Groups), has provided data for the Multispecies Working Group and the STCF. The 1989 ICES Statutory Meeting extended the terms of reference for this Working Group to include evaluation and coordination of all bottom trawl surveys in the North Sea, Skagerrak, and Kattegat to provide facilities for better serving the original customers and those more recently acquired as well as any future customers. To this end a survey design is recommended and possible effort identified to give a good coverage of the North Sea in each quarter of the year. The Group agreed to abandon its full title - the International North Sea, Skagerrak and Kattegat Bottom Trawl Surveys Working Group - in favour of the International Bottom Trawl Surveys Working Group.

3 EXISTING SURVEYS

3.1 The International Young Fish Survey

The IYFS surveys on the North Sea, Skagerrak and Kattegat conducted in February each year, began in the years 1960-1961. The first surveys were aimed exclusively at juvenile herring and only a part of the North Sea was covered. Over the years the objectives of the survey were broadened to include sampling of young gadoids and a plankton sampling program mainly for late herring larvae. This meant that the survey area had to be extended to cover the distribution of all species and the northern North Sea and the Skagerrak/Kattegat were included. The area covered since 1980 and the target number of hauls, about 400, are shown in Figure 3.1. The primary objectives of the survey are to provide annual indices of recruitment for the standard species: herring, sprat, cod, haddock, whiting, Norway pout and mackerel. The survey also provides synoptic hydrographical data and information on the distribution and abundance of a large number of by-catch species. The basic data from the survey are stored in the IYFS data base at ICES Headquarters. Data, however, for years prior to 1982 are as yet incomplete.

In 1976 a standard gear, the French GOV bottom trawl was proposed and the introduction was completed in 1978. The haul duration is 30 minutes and trawling is carried out both day and night. Details on the methodology of the survey are given in the Survey Manual (Anon., 1986).

3.2 The English Groundfish Survey

The English groundfish survey began in its present form in 1982, although for 5 previous years (from 1977) the survey operated in a different form (Harding et al., 1986). It takes place in the third quarter of each year and uses a standard 78 ft Granton trawl with a 20 mm mesh codend liner. The trawl is usually deployed with wooden doors, rubber bobbins on the footrope and a bunt tickler chain, but on rough ground around the Shetland Islands the rubber bobbins are replaced with 21 inch steel bobbins and the tickler chain is removed. The survey attempts to cover the entire North Sea with 80-90 one hour hauls at fixed locations (Figure 3.2). These locations were originally randomly selected within five depth bands (0-30, 30-50, 50-100, 100-150, 150-200 m) attention being only given to the suitability of the sea bed for trawling. The objectives of the survey are:

1) To identify trends in species abundance with time;

2) To determine the proportions of species caught in order to describe a mixed fishery;

3) To describe the distribution of gadoids and other industrial fish species;

4) To estimate the abundance and the distribution of species poorly sampled by the commercial fleet;

5) To investigate growth differences for selected species in different parts of the North Sea;

6) To examine the stomach contents of fish to establish interactions between species and to assess mortality due to predation by or upon commercial fish species.

3.3 Scottish Groundfish Survey

The Scottish Groundfish Survey began in its present form in 1982. It covers the northern North Sea as shown in Figure 3.3. The sampling design is systematic, with the aim to sample one station per statistical square. As far as possible the same stations are repeated each year. The gear used is an Aberdeen 48' trawl with a 75 mm cod-end and 35 mm small mesh cover (the information on gear type is incorrect in the 1985 Working Group report - Anon., 1985). The survey typically takes place in August over a period of three weeks during which time approximately 86 hauls of 1 hour are completed. Hauls are normally monitored using Scanmar equipment to measure headline height. Age length keys are collected on a haul basis so that statistical rectangles can be aggregated in any combination. In common with other groundfish surveys the objectives are broad and include;

1) Estimation of abundance of major demersal fish populations;

2) Mapping the distribution of these populations;

3) Biological monitoring including feeding and growth studies.

3.4 The Groundfish Survey by the Federal Republic of Germany

In 1983, the Institute for Sea Fisheries started an annual groundfish survey in summer in the North Sea. The main objectives of this survey are:

- to estimate trends in species abundance with time, especially for cod, haddock, and whiting;
- to describe the distribution pattern of these species;
- to determine the fluctuations in the age composition of these species with time;

- to investigate haul variables which influence the catch in order to improve generally the strategy of bottom fish surveys;

- to get a qualitative and quantitative description of the fish fauna within small areas (10 x 10 nm), in order to detect possible long-term variations (biological monitoring).

The area covered in Divisions IVa and IVb changed each year. But from 1987 onwards, the area was restricted to only 57 statistical rectangles (Figure 3.4). In 1989, the area was extended to the south and has included Division IVc.

Since 1987, small "boxes" (10 x 10 nm) were additionally established, where the number of hauls normally varies between 22 and 27. In the standard area only one haul of half an hour is done per rectangle. The gear used is the standard GOV with its standard rigging. The survey takes place during 4 weeks in June/July.

Since 1983 there were some breaks in the data series due to changes in vessels and gears. The standardization of the method and the correction of the data is processed to a level that first results will be presented in 1990.

3.5 The Dutch Groundfish Survey

The main aim of this survey, which is carried out since 1980, is to provide recruitment indices for cod. The survey is conducted in the 4th quarter and the area covered is restricted to the southeastern North Sea. The gear used is the GOV-trawl and methods are the same as those applied during the International Young Fish Survey. In 1980 and 1982 a chartered commercial vessel was used, in the other years RV "Tridens", since 1984 in combination with RV "Isis".

Per statistical rectangle 1 to 5 hauls are made, with the highest sampling intensity in the coastal area. During the last 6 years the total number of hauls ranged from 67 to 97. Area covered and standard area used for the calculation of indices are shown in Figure 3.5.

3.6 The French Groundfish Survey

In 1988, France began an annual survey in the Eastern Channel in October. The objective is to study the distribution of commercial species and to obtain abundance indices by age group for the most important species. The gear used is a 20/25 GOV trawl (which is a smaller version of the standard IYFS GOV trawl) towed by a 25 m vessel. The mesh size in the codend is 20 mm. This gear/vessel combination was chosen to allow trawling in shallow waters, especially along the French coast. In this area important nurseries of whiting, plaice, and dab are found. About 100 stations are planned on the basis of rectangles of 15' x 15' (8 rectangles per ICES statistical rectangle). Per rectangle, one 30 minutes haul or two 15 minutes hauls are made (Figure 3.6).

All commercial species are measured and the most important are aged.

In the near future, the study of the results of the first surveys will lead to a re-design of this survey on a stratum basis to reduce the number of hauls. Furthermore, the survey will be extended to the southern North Sea up to 51^0N or $51^0$30'N in order to extend the survey area to the area covered by the Dutch Groundfish Survey.

3.7 Norway Deeps Survey

In October 1984, Norway started a stratified trawl survey in the Skagerrak and Norway Deeps. The hauls are distributed in strata in four depth zones: 100-200 m, 200-300 m, 300-500 m, and deeper than 500 m. The strata are shown in Figure 3.7.

The trawl used is a Campelen 1800 meshes shrimp trawl with 6 mm mesh inner net. Up till 1988, a normal rubber disc gear was used, but from 1989 a "rockhopper" gear was introduced as standard. Towing speed is 3 knots. In 1989, the towing distance was reduced from 3.0 to 1.5 nautical miles. Approximately 100 hauls have been taken each year.

The main target of the survey is to study the abundance and distribution of the shrimp stock (Pandalus), but all fish species are recorded and measured.

In 1990, Sweden will take part in the survey.

3.8 Swedish Nephrops Surveys

The main purpose is to study the fluctuation of the Nephrops stocks in the Kattegat and the Skagerrak attempting to distinguish fishing mortality from the effects of a deteriorating environment, especially the lethal oxygen concentrations frequently occurring in the bottom waters of the Kattegat.

Specific objectives are:

- Testing assessment methods using length frequency distributions of Nephrops.
- Tagging of Nephrops to study migration and growth.
- Study by-catches in the Nephrops fishery.
- From 1990 on, extension of the fish sampling (especially cod and plaice) to collect information on maturity, spawning areas, growth, and feeding, partly to improve the assessment of those stocks.

The survey started in 1977 but has not had 100% coverage in all years. The area covered is shown in Figure 3.8. Normally about 10 hauls are made in the Skagerrak and 40 in the Kattegat. One cruise is made during 2 weeks in April/May and another for 2-3 weeks in September.

The gear used is a standard Nephrops trawl with 60 mm meshes in the codend.

3.9 Usefulness of Existing Surveys

Present surveys satisfy a number of national and international needs. Apart from the IYFS which is wholly international other national surveys are undertaken by coastal states with specific interests. Most of these surveys are used by ICES working groups in one form or another (Table 3.1).

The principal immediate use of survey data is in the form of abundance indices of recruiting year classes which are used primarily by assessment working groups for catch and stock projections. A major customer for these indices in the North Sea is the Roundfish Working Group. This Group currently uses the IYFS, EGFS, SGFS, and DGFS in the estimation of recruitment of cod, haddock, and whiting. Separate indices are derived from each survey and these are analysed using the standard ICES RCRTINX2 program. This program combines the abundance estimates according to the estimated precision of the survey. It may appear that using so many surveys is unnecessary. However, because the recruitment index is critical to the forecast, the most precise estimate possible is highly desirable. Abundance indices are used similarly by the Herring Working Group and the Industrial Fisheries Working Group (sprat and Norway pout) where they have a similar importance. Survey data for older fish are also used to tune the VPA.

Although the provision of annual abundance indices is of considerable importance in the formulation of TAC advice, it is important to appreciate that other uses of survey data are of equal value, particularly in the long-term monitoring of fish populations. Surveys are one of the few sources of mapping the spatial distribution of populations, especially for those age classes outside the range taken by commercial fisheries. An ability to evaluate spatial characteristics is necessary where the effect of box closures, for example, is being considered. Similarly, temporal changes in populations may be important where seasonal management of the fishery is contemplated. This underlines the value of having a number of surveys conducted throughout the year aimed at similar target species. Major users at present of data of this type are in the Multispecies Assessment Working Group and the STCF Working Group, on improvement of the the exploitation pattern of North Sea fish stocks. These Working Groups require the space-time distribution in order to evaluate the biological interactions between fish populations and the technical interactions between different fisheries.

Bottom trawl surveys provide information on many other species besides those which are of primary economic importance. Thus the Multispecies Working Group was able to use data from the IYFS and EGFS in order to estimate the predation mortality on commercial fish by non-commercial species. Additionally, there is the potential in the future to assess those species which are not currently the subject of scientific advice on management. Routine surveys also provide a means of investigating a large number of other topics such as growth, diel behaviour, monitoring pollutants, etc. For specific use of the IYFS data see Anon., (1989a).

4 STATISTICAL ANALYSIS OF SURVEY DATA

4.1 Between Gear Differences

A preliminary investigation of catch rates between dissimilar trawls was carried out using data from three groundfish surveys carried out during a similar time period. The gears compared were a GOV trawl, a Granton trawl, and an Aberdeen trawl. The results indicated that the catch ratio for 1 year old cod was different from that for 2 year old cod (Anon., 1989b). Further comparison of these gears using data from a different year showed a change in the catch ratio for 1-year-old cod and varying catch ratios for various size classes of nineteen other species. This indicates problems in any attempt to combine surveys using dissimilar gears both to describe spatial distribution patterns or provide abundance indices.

4.2 A GLM Analysis of IYFS Data

Before and during the meeting several analyses were carried out to investigate between ship variations in catch in the IYFS. For these analyses 6 data files were prepared by the IYFS Data Base Manager, which contained data for the surveys in the period 1982-1989. Per species (cod, haddock, whiting, Norway pout, herring and sprat), one record per haul gives a number of haul specifications (ship, position, depth, day/night etc.) and the number per age group 1, 2 and 3+.

The catch rates of 1-group herring, cod, whiting, haddock, Norway pout, and sprat were explained by a general linear model (GLM), referred to as model O:

$$\ln (\text{catch}) = \text{year} + \text{ship} + \text{rectangle} + \text{day/night} + \text{depth} + \varepsilon$$

where year, ship, rectangle, and day/night were included as class variables and depth as a continuous variable. ε is the error term. The ship effect was in fact a ship x gear effect, but only "Eldjarn" operated more than one gear in the time period covered, 1982-1989. The day/night effect was obtained from the day/night parameter as given in the IYFS data base.

Log (catch) was assumed to be normally distributed and this was justified by plotting the standard deviation against the mean of the catch rate by year, rectangle, ship, and day/night. This plot showed that the Sd. was significantly increasing with the mean with a slope of 1.0. A similar plot with log-transformed data showed no trend.

To avoid taking the log of zero, 0.5 was added to all observations.

The GLM analysis should avoid rectangles with only, or virtually only, zero catches. For herring, this meant exclusion of all rectangles south of $52^0 30'$ and north of $58^0 30'$N. For cod and whiting, no rectangles could be excluded. For haddock and Norway pout, hauls made in depths of less than 50 m were excluded. For sprat, hauls made in depth of more than 111 m were excluded.

The results of the GLMs are given in Table 4.1. Generally, the year and rectangle effects are very significant with high mean ss. The ship effect is very significant and with high mean ss for all species except haddock. The day/night effect is significant with a high mean ss for herring, haddock, and Norway pout. Depth is significant for herring, whiting, haddock, and Norway pout.

The effect of the length of the sweeps was also analyzed using a GLM model similar to the above model, but with sweep lengths added as a continuous variable for age 1 herring. The effect was estimated to be a 65% increase in catch rate when the sweeps increased by 50 m.

4.2.1 Day/Night effect

Table 4.2 shows the day/night effect on the catch rate by species as estimated by the GLM analysis. For herring, haddock, and Norway pout the catch rate differs significantly between day and night. Compared to the total ss, the explained ss are, however, small. For all three species, the catch rate during night-time is about one half of the catch rate during day-time. For cod and whiting, the effect can be neglected. For sprat it is not significant but there could be some effect.

4.2.2 Differences between vessels

Table 4.3 shows the fishing power by vessel and species estimated by the GLM. Only age 1 is considered. The unit used is arbitrary. As can be seen, the differences between vessels are very substantial. For herring, for instance, the fishing power of "Scotia" is about 8 times that of "Thalassa". Only for haddock does the fishing power not vary very much between the vessels.

There seems to be one group of vessels, consisting of "Cirolana", "Dana", "Scotia", and "Tridens" with almost equal and rather high fishing power. "Eldjarn" seems to have a rather low fishing power for all species. "Thalassa" has a low fishing power for the pelagic species, herring, sprat, and Norway pout (if Norway pout can be called pelagic). "Walter Herwig" seems to be better than "Anton Dohrn" to catch cod, which is probably due to the use of bobbins by "Anton Dohrn". It has been shown that young cod can easily escape under the groundrope when this is lifted off the ground by the bobbins (Ehrich, 1987).

The above GLM analysis is rather crude and does not take into account the effect of yearly changes in distribution of the various species. A proper analysis of the fishing power would probably allow for this.

See also Pope and Boon (1990, Appendix 1 to this report) for another example of the analysis of between ship variation in fishing power.

4.3 The Potential Influence of Neglected Interactions

The basic model described in Section 4.2 does not take into account interactions. However, such interactions may have a strong effect on the estimation of ship effects, or yearly changes in abundance. The latter has been discussed during the 1989 meeting of the Methods Working Group (Anon., 1990). But the estimation of the relative fishing powers, corresponding to the ship effects can also be affected.

Two types of interactions have been considered: year/rectangle and year/ship interactions.

Year/rectangle interactions.

They correspond to changes in the relative abundance of fish in the various rectangles from year to year. Two models incorporating such interactions have been fitted to IYFS data for cod and haddock age 1.

(I) $\ln(\text{catch} + 0.5) = \text{ship} + \text{year} \times \text{rectangle} + \varepsilon$

(II) $\ln(\text{catch} + 0.5) = \text{ship} + \text{year} \times \text{rectangle} + \text{day/night} + \varepsilon$

"Cirolana" has been kept as the standard vessel.

Such models include a large number of parameters. They correspond to Robson's model (1966), where a stratum corresponds to a year and a rectangle in model I, while in model II for a given year and a given year day and night hauls are related to two different strata.

The software developed by Laurec and Perodou (1987) has been used. Results are given in Table 4.4. They suggest that, for these examples, year-rectangle interactions do not seriously affect the estimation of fishing powers.

It could also be noticed that the inclusion of the day/night effect does not affect very much the ship effect. For cod, this result is coherent with Table 4.2. The estimated residual standard deviation even increased from 1.53 to 1.58 by the incorporation of day/night effects: the increase in the number of parameters that have to be estimated overcomes the decrease in the residual least squares.

For haddock including the day/night effects creates slightly higher changes, and does reduce the residual standard error from 1.47 to 1.33.

Year/ship interactions

Year-ship interactions would correspond to year to year changes in the relative fishing power of the research vessels, which is exactly what has to be avoided. They can nevertheless exist. In order to study such interactions directly, relative fishing powers have been calculated for individual years. Model III has so been fitted for all individual years.

(III) $\ln(\text{catch} + 0.5) = \text{ship(year)} + \text{rectangle} + \varepsilon$

"Cirolana" was again kept as the standard vessel. Results are given in Table 4.5. This table suggests possible trends at least in the relative fishing power of Cirolana, "Thalassa", and "Tridens", the two latter vessels showing a decline in their efficiency compared to the first one. The apparent variations are strong enough to simulate further examinations. Since the constant added prior to logarithmic transformation was chosen arbitrarily, instead of adding C = 0.5 , two other possibilities have been considered, namely C = 0.1 and C = 1. Results are given in Tables 4.6 and 4.7. The previously mentioned phenomena can be reduced or amplified but the trends are always there.

Excluding zero catches, which makes it unnecessary to add any constant, has also been tried. This procedure cannot be recommended since it may introduce a severe bias, but was used here to check the robustness of the apparent yearly changes in relative fishing power. Results are given in Table 4.8. They do confirm the previous conclusion on apparent changes in relative fishing power of the different vessels over time.

The same approach has also been atttempted on haddock, age 1, for four vessels. Results are given in Table 4.9. They suggest similar phenomena as encountered for cod, but the changes appear to have been smaller.

4.4 The Effect of Reducing the Number of Hauls in the IYFS

A proposal to undertake quarterly surveys requires re-allocation of effort from the existing IYFS to other times of the year. This naturally raises the question as to whether such a re-allocation will adversely affect the precision of abundance indices presently used by assessment working groups.

In order to estimate the effect which a reduction of the number of hauls in the IYFS might have on the precision of the indices the GLM models, described in Section 4.2, were run with various subsets of the data base for 1982-1989.

Table 4.10 shows the estimated year effect in log-transformed version for herring, cod, whiting, haddock, Norway pout, and sprat for two independent subsets of the data, the first one containing only the even numbered hauls and the other only the odd numbered hauls. The standard deviation of the year effect can then be approximated by taking the mean of $|X_1 - X_2|/\sqrt{2}$ over the years, where X_1 is the year effect based on the even numbered hauls and X_2 is based on the odd numbered hauls. These mean values are shown in Table 4.11.

Generally, the S.E.s are around 0.2 which means that in back-transformed estimates the C.V.s are around 30%.

The haddock data were analysed in more detail and several new subsets of the data were selected and yearly indices were calculated for each of the following subsets:

i) a subset containing only every second row of rectangles;
ii) a subset containing the alternate rows;
iii) a subset containing only hauls made in the western half of each rectangle;
iv) subset containing the alternate columns;
v) a subset containing only the rectangles in every second row and in every second column, say even numbered rows and columns;
vi)-viii) three more sets based on the other three combinations of rows and columns.

The estimated year effects are shown in Table 4.12.

Table 4.13 shows the year effect estimated from subsets of data where only data from 1989 have been deleted. The principles were the same as above with taking a subset of only even numbered hauls from 1989 (and all hauls from the other years) etc.

Of course, the year effect is approximately identical for all subsets for the years 1982-1988 (year classes 1981-1987). The interesting thing is that the year effect for 1989 (the 1988 year class) varies significantly by subset. This means that the improved estimate of the ship, rectangle, day/night and depth effects compared to the GLM on restricted data sets in all years does not improve the precision of the 1989 index.

Table 4.14 shows the standard error of the residuals calculated from the regressions of the various indices on the log VPA series. For all species, the indices based on subsets of the data perform no worse than the index based on the full data set. This suggests that a reduction of effort in the IYFS would not have an adverse effect on the precision of existing abundance estimates. The table indicates that the present IYFS indices perform better than the multiplicative model, and it would be desirable to repeat the analysis presented in Table 4.14 using the standard abundance index calculation.

4.5 Recommended Future Analysis

The data processing which took place before and during the meeting should be continued. Along this line, a special workshop, as recommended by the Working Group on Methods of Fish Stock Assessment (Anon., 1990a), should take place, possibly in the first quarter of 1991.

Prior to this workshop, work should be developed within the national institutes in order to

- extend the data processing to other age groups/species and surveys;

- extend the modelling to evaluate the possibility of including various auxiliary variables (e.g., swept area or filtered volume);

- develop reliable and robust statistical inference techniques;

- analyze whenever there appear to be significant and important changes in research vessel fishing powers;

- study intensively the spatial distributions and their changes from year to year.

This would imply the use of various mapping techniques, the fitting of adopted regression models which would allow for year/ space interactions, and various spatial scales.

For purposes of coordination, laboratories undertaking any processing should indicate this to the Chairman of this Working Group.

The Chairman of the Working Group should liaise with the Chairman of the Working Group on Methods of Fish Stock Assessment to prepare the recommended workshop.

5 INTERNATIONAL BOTTOM TRAWL SURVEYS IN THE NORTH SEA

5.1 Proposal for Quarterly Coordinated Surveys

At present, the principal coordinated North Sea survey, the International Young Fish Survey, takes place in February. This involves 400 hauls in about 150 rectangles and occupies 24 weeks of ship time. There is also a number of other surveys undertaken by individual countries at other times of the year (see Chapter 3), but these are only informally coordinated, and some use gears which are substantially different to the IYFS standard.

There is a number of reasons for believing that this may not be an optimal deployment of the ship time involved. First, it does not provide a full description of the seasonal distribution of the stocks sampled. This is becoming urgently necessary for the further improvement of multispecies assessments (Anon., 1989c) and for the spatially disaggregated assessment models being developed under the auspices of the EC/STCF Working Group on Improvement of the Exploitation Pattern of the North Sea Fish Stocks. At present, adequate distributional information is obtained only in February and August/September, and this is insufficient to characterize the annual cycle of fish movements adequately.

Second, it appears from experience with national surveys that useful estimates of spatial distribution and adequate abundance indices can be obtained from surveys having substantially less dense sampling than that employed by the IYFS (Anon., 1990a, and Anon., 1990b). In particular, it now seems that the principal sources of error are not simply random sampling errors, and are not efficiently reduced by denser and/or replicated sampling.

The Working Group, therefore, considered whether it might be possible to redeploy some of the effort from the February survey, and/or deploy additional effort, in order to obtain full spatial coverage on a quarterly basis. Since February and August/ September are already substantially covered, the target times for additional surveys would be in the second and fourth quarters, ideally May/June and November/December.

In order to get good spatial coverage (of about 150 rectangles at one haul per rectangle), with several ships participating in any-one survey to provide robustness in case of one ship becoming un-available, and allowing for substantial overlapping to permit intership calibration, it was concluded that a single survey would require about 12 ship weeks corresponding to about 240 hauls.

The scheduling of ship time is, of course, subject to many com-peting factors external to the remit of this Working Group, and participants were not in a position to make any firm commitments. Nevertheless, on the basis of preliminary indications from each country about what would be likely to be feasible, a preliminary allocation of ship weeks was constructed (see text table below).

Country	Feb	May/Jun	Aug/Sep	Nov
Netherlands	5 → 3	3	3	3
UK (England)	4 → 0	[4*]	4	4*
UK (Scotland)	3	3*	3	[3*]
France	3	-	3	-
Fed. Rep. of Germany	3+	4 (Jun)	-	-
Norway	4	2	-	2
Denmark	3	3* ?	-	3* ?
Total	19	12 + 3 ?	13	9 + 3 ?

* : alternatives.
? : doubtful/uncertain.
[]: less likely alternatives.
→ : reduction of existing IYFS effort.

This indicated that there is a reasonable prospect of achieving the minimum of 12 ship weeks except perhaps in November. The Working Group, therefore, recommends that members seek to obtain firm commitments from their institutes to dedicate the ship time indicated in the text table. It would be highly desirable if the new cruises could commence in 1991, to provide sampling platforms for the second ICES Year of the Stomach Programme (see below). A minimum of three years work will be required to permit evaluation and calibration of the data, and for this reason, and in order to allow year-to-year variations of the distribution patterns to be determined, it is recommended that this programme of International North Sea Bottom Trawl Surveys be planned to run for five years, with continuation thereafter dependent on a major review to be held near the end of that period (possibly early in 1985).

It should be noted that at present the English and Scottish Groundfish Surveys use non-IYFS standard gears. It would be de-sirable for these surveys to adopt the standard gear, but this is not urgent because it should be possible to determine conversion factors (probably for each species and length or age group) to allow the data to be consolidated with other cruises' data (see also Section 4.1). An orderly and staged transition is required, and it is suggested that this could be achieved by the English survey switching to the GOV after two years of overlap with "Tridens" (i.e., probably for the 1993 survey), with the Scottish survey switching over when "Scotia" is replaced.

It should be noted that the new series of surveys are envisaged as slightly less rigorously coordinated than the existing IYFS, in the sense that each ship's surveys are intended to provide a self-standing series, conducted according to a standard protocol, probably using inter-ship calibration factors rather than as exchangeable contributions to a common and undifferentiated data set as in the past. This will allow some of the practical difficulties which have arisen in practise (e.g., the difficulty of enforcing 100% compliance to the standard gear design) to be handled more gracefully, and also provide a larger measure of resilience in the event of a ship being withdrawn for any reason - the other time series of survey indices would remain valid, even if part of the spatial coverage (or resolution) were lost. In addition, this permits the inclusion of existing non-standard surveys in the overall coordinated programme.

To this end, and to provide extensive overlap for calibration and validation purposes, it is suggested that the new surveys should be planned as interlocking (and alternating) rows of stations, somewhat similar to the existing EGFS track.

It should be noted that the plan envisages the deployment of 56 weeks of shiptime, compared with 25 in the existing IYFS, but that 14 weeks are accounted for by existing surveys, so that the increase is actually from 39 to 56 (i.e., about 45% increase). This is considered reasonable in order to more than double the coverage in space and time of the North Sea by bottom trawl surveys.

5.2 IBTS (North Sea): Survey Design

It is necessary for the future survey plans to maintain continuity with past IYFS surveys, and to incorporate the existing surveys at other times of year within the overall scheme, whilst maintaining the continuity of the indices which they provide. Since a principal aim of the new surveys is to provide good spatial (mapping) coverage, and to maintain continuity with the IYFS, it was agreed that the new design should continue to use the ICES statistical rectangles as the basic sampling unit. It was also agreed that the standard gear should continue to be that defined for the IYFS.

Some re-allocation of effort within the IYFS (February) survey is required to allow for the withdrawal of shiptime for use at other times. Various options were considered, with the aim of providing each country with a coherent sampling area (related to their existing effort), and deploying two hauls per rectangle, consistent with the reduced effort available. In addition, the Working Group attempted to ensure that at least half the hauls in each rectangle continue to be made by the same country as at present, and to maintain adequate Isaacs-Kidd coverage for herring larvae. The proposals finally reached are presented in Figure 5.1.

It would be possible and desirable if these changes could be implemented in 1991, so that the shiptime released can be redeployed to provide sampling coverage for the Year of the Stomach.

The Working Group, therefore, <u>recommends</u> that every effort be made to implement the revised plan for 1991.

For the other quarters, the Working Group noted that for geographical reasons some countries would prefer to work primarily in the northern or southern part of the North Sea, and that it is very important to ensure that the survey design is as robust as possible against the non-availability of any individual vessel. This can be achieved by overlapping extensive surveys with rather coarse resolution by any single vessel, at the cost of approximately one days extra steaming time per 76 stations worked.

It is desirable to maintain continuity with existing surveys, in particular the English and Scottish surveys in August/September and the Dutch survey in November, which provide what is now essential data for the North Sea roundfish assessments. The EGFS provides a slightly peculiar example of extensive coarse coverage, working more-or-less alternate rows of rectangles (see Figure 3.2). For obscure historical reasons, even numbered rows of rectangles are worked south of 57°N, and odd rows north of this latitude, causing a hiatus in this region. A tidy pattern of alternate sampling of odd and even rows would of course be possible, but offers no tangible advantage over the existing untidy pattern, which has the advantage of maintaining a much higher degree of continuity with the existing dataset.

It is, therefore, proposed that each survey in the second to fourth quarters should comprise a "Northern" survey (by Scottish or Norwegian vessels), a "Southern" survey (by French and Dutch vessels), plus extensive coarse coverage (by English, Danish, Dutch, or German vessels). The primary "coarse" survey grid (Figure 5.2) is based on the EGFS pattern, with some tidying up [the existing EGFS would continue with a few additional stations and (possibly) a few deleted]. Whereever possible, a "complementary" coarse grid (Figure 5.3) would also be worked if a fourth vessel is available. These two grids together provide coverage at one haul per rectangle of the entire IYFS area in the North Sea, with some deliberate duplication (for intercalibration) in the hiatus area around 57°N.

The grids would be worked in each quarter, if possible, in addition to the Northern and Southern surveys for which the station patterns have not yet been defined in detail; they should be based upon the existing Scottish and Dutch surveys so far as possible, with at least one haul per rectangle and coverage of all rectangles within the survey areas.

In addition to these, the Groundfish Survey by the Federal Republic of Germany in June provides coverage of the central and northern North Sea, and should be extended, if possible, to the south (possibly alternate rows of rectangles) and in the missing area around 55 and 56°N.

The outline plan is summarized in Table 5.1.

Following the findings of the ICES Working Group on Methods of Fish Stock Assessment (Anon., 1990a), the Working Group considers that it would be desirable for each ship to work <u>fixed</u> stations within each rectangle (chosen initially in any convenient way), as this should reduce the variability of indices derived, at the expense of a little small-scale (sub-rectangle) inexactitude in any maps produced. It is not essential that all ships work the same stations in each rectangle, though this is probably desirable if it can be arranged for new surveys being established.

The quarterly surveys should be coordinated by different national laboratories: quarter 1 Netherlands, quarter 2 Scotland, quarter 3 France and quarter 4 England. Details of the survey design should be worked out by the quarterly coordinators in correspondance with the participating countries and the Chairman of this Working Group.

5.3 Basic Stratification

Since the results of these quarterly surveys will be used for mapping, which appears to be strictly necessary even for constructing an overall annual index of abundance, a complete coverage of the North Sea remains necessary. Although, in theory, another basis than statistical rectangles could be considered, for practical considerations (historical continuity - compatibility with log books) they should be kept for the stratification scheme. An alternate solution, used in other regions, would be to use depth-based strata. In fact, most rectangles correspond to quite homogeneous depths. For some rectangles a sub-division according to depth could, however, be considered. For most rectangles, it does not seem necessary, and depth effects could just be included in the final processing of the data, as illustrated in Section 4.3.

5.4 Spatial Location of the Stations Within Rectangles

Within a pure stratified sampling scheme, locations of hauls should be taken at random within a stratum. It can, however, be shown that a systematic allocation, corresponding to some regular grid, generally leads to smaller variances. This is due to the fact that hauls allocated at random can by chance correspond to neighbouring locations, in which case they will bring (partially) redundant information. This can be analyzed through statistical techniques (spatial autocorrelations/variogrammes), but it justifies the common practice of avoiding hauls too close to one another.

Since systematic sampling appears statistically preferable, the only historical reason for random sampling is due to the simplicity of variance estimation formulas within simple random sampling schemes. In fact, as pointed out by the Methods Working Group, the variances obtained by these simple formulas are not really relevant (see Anon., 1990a Section 2.4.2).

No major reason exists so far for maintaining strictly random allocations within rectangles. This question is closely related to the problem of fixed or changeable stations from year to year. As pointed out by the Methods Working Group, there is no major reason for avoiding fixed stations, when the surveys are used to monitor relative changes in abundance from year to year, in which case constant biases can be accepted.

Keeping fixed stations will potentially reduce the variability of yearly abundance indices, the real reduction being related to the stability of spatial patterns within rectangles (and to the possibility of keeping locations really fixed). Keeping fixed stations will also make it possible to monitor local changes in abundance (Myers and Stokes, 1989).

Finally, if non-random allocations within a rectangle are accepted, it could be dangerous to change them from year to year, since it could result in non-constant biases.

The Working Group recommends the use of a fixed station scheme, accepting non-random haul allocation within rectangles.

5.5 Statistical Consequences of the Re-Allocation of Sampling Effort Over Various Quarters

When an abundance index is built, for a given year and quarter, the corresponding estimation necessary involves an error. Various components exist within the error term.

- The pure sampling error, which could be reduced to zero by increasing the sample size indefinitely;

- other components, including changes from year to year in the spatial distribution of the fish, and the vessels' fishing efficiency, that will be grouped under the overall expression "changes in the catchability".

This second component does not depend on the sample size. From the retrospective comparison of IYFS indices against VPA results it appears that the sampling variance is not the dominating factor.

Grouping all the hauls within a limited period increases the potential influence of yearly changes in catchability. Considering various quarters makes it less likely that the same anomaly will affect catchabilities in the same way for those various periods. Some balancing or smoothing effect will take place.

Since the sampling variance depends on the number of hauls, for any given number it is, therefore, potentially more efficient to spread the hauls over several quarters.

During a transitional period this will be partially compensated by the fact that calibration factors corresponding to quarters not previously surveyed will have to be estimated. This justifies maintaining continuity in the existing survey series. The reduction in the accuracy of the corresponding indices will be limited if a moderate decrease of the corresponding haul numbers takes place. This is clearly shown by the retrospective simulations of a reduction of the number of hauls considered (see Section 4.4), and is again related to the fact that sampling errors are not dominating the other components of the error.

For species where this has still to be finally confirmed, keeping a higher sampling intensity in the corresponding rectangles at the appropriate time, for the time being, will avoid any real trouble.

5.6 Data Exchange Between Countries and ICES

The exchange of IYFS data between countries and ICES is now a routine process, in which few notable problems are encountered. Also the standard retrievals, which are made when all data have been received, need currently little attention.

The exchange of data of surveys other than the first quarter of the year, can be implemented by utilizing the same exchange format as currently in use for the IYFS exchange. Some minor modifications might be necessary, that are not expected to create major modifications in the computer programs employed by the participating institutes. A new format will be distributed by the ICES Secretariat as soon as sufficient information on the structure of the additional surveys is available.

It is expected that by the extension of the surveys, the volume of the data set will increase by a factor of 2 till 3. In Anon., (1989b), it was mentioned that the Secretariat cannot establish a data base for summer survey data without adjustments in manpower and the budget for computer operations. This statement is still relevant, and as the Working Group considers it desirable that all data from the surveys in all 4 quarters are placed in a central data base managed by the Secretariat, it recommends that ICES will make resources available for this purpose.

It is evident from the results of various analyses performed during the meeting, that the data of the IYFS data base will be subject to further, intensive, studies. The same will be true for the data from the new surveys. These studies will mainly be made at the national laboratories, but it is felt that the Secretariat's computer facilities are most suitable to extract the data files for these studies from its data base. This should be taken into account when discussing the Secretariat's manpower and computer resources.

6 MATTERS CONCERNING THE INTERNATIONAL YOUNG FISH SURVEY

6.1 Redistribution of IYFS Effort for the 1991 Year of the Stomach

The survey plan outlined in Table 5.1 should provide an excellent basis for the sampling of fish stomachs required by the "Year of the Stomach" program. It will not, however, be possible to carry out all the additional work required within the ship-time allocated, and additional ship-time will almost certainly be required in 1991. For this reason it would be highly desirable if the reconfiguration of the IYFS survey could be implemented in February 1991, since the ship-time released would be available for re-allocation to other times of the year. It is probable, for example, that an English ship could be made available for 3 or 4 weeks for stomach sampling (e.g., in the second quarter of 1991) if this were possible. The Working Group was not able to consider the problem in any detail in the absence of detailed estimates of sampling requirements or likely availability of extra ship-time for this programme, and recommends that this matter be considered by the Coordinator of the Stomach Sampling Programme in 1991, who is advised to consult the coordinators of the individual surveys to resolve any problems.

According to the proposals from this Working Group, the reduction in effort for the International Young Fish Surveys would mean a reduction in the number of hauls in the southeastern North Sea from 4 to 2 hauls per rectangle. Any extra ship-time available in February should be used to increase sampling intensity in the southeastern North Sea.

6.2 Sampling Areas for Herring and Sprat Otoliths

During the last meeting of the Working Group on International Young Fish Surveys (Anon., 1989a), it was proposed that herring and sprat otoliths should no longer be collected using a relatively high number (26) of 'herring sampling areas' but in the same way as the other species using 'roundfish sampling areas'.

The members of the Herring Assessment Working Group considered this proposal and saw no reason to continue the use of the old sampling areas.

For sprat, the Industrial Fisheries Working Group advised to keep using the smaller herring sampling areas, especially in roundfish area 6, where there might be a need for depth-stratified sampling (Anon., 1989d).

To facilitate the work at sea and the analysis of the data, the Working Group decided to use roundfish sampling areas for all species from the 1991 IYFS onwards. If problems arise from the analysis of the sprat age distributions, the age-length data should then be aggregated in a special way. Since countries are asked to provide their age-length data on a haul basis this possibility will remain.

6.3 Standardization of Methods

In the 1989 report of the IYFS Working Group (Anon., 1989a), the standard fishing method was evaluated. The recommended amendments were:

- use warp length to depth ratios with a minimum warp length of 150 m;

- target fishing speed is 4 knots measured over the ground;

- door spread as well as vertical opening should be monitored during trawling.

The GLM analysis (see Section 4) indicates that a substantial variation of fishing power still exists between vessels in spite of the fact that all vessels use the same standard gear. The vessels "Cirolana", "Dana", "Scotia", and "Tridens" showed almost equal and high fishing power whereas "Eldjarn" has a low fishing power for all species and "Thalassa" specifically for pelagic species.

In the case of "Eldjarn" the recommended kite is not used and onboard "Thalassa" door spread is not monitored. Even if the real cause of the large variation in fishing power is not known, it is a strong indication that something could be wrong with the actual rigging or the handling of the gear or both.

At present door spread is monitored onboard the vessels from England, Denmark, Scotland, and Sweden. The combined experience with monitoring of both spread and opening clearly shows that large variation in swept areas or volume can occur without the indication of a similar variation in vertical opening. The Working Group, therefore, reiterates the recommendation that all vessels should continuously measure doorspread and vertical net opening during trawling and the recommended rigging and handling should be followed as strictly as possible.

7 RECOMMENDATIONS

Recommendations requiring action by members of the Working Group:

1) Before the International Young Fish Survey in 1991 a revision should be made of the survey manual.

2) The IYFS exchange format should be revised to cope with the exchange of data for surveys in other quarters.

Recommendations for the 1990 Statutory Meeting:

1) National laboratories should make available ships time for 4 quarterly coordinated bottom trawl surveys for a period of 5 years, starting in 1991.

2) Resources should be made available by ICES to store the data from these quarterly surveys in the IYFS Data Base maintained by the ICES Secretariat.

3) A workshop should be held, in the first quarter of 1991, to:

   - extend the statistical analysis of trawl survey data;

   - analyse differences and changes in the fishing power of research vessels;

   - study temporal changes in spatial distributions.

   This workshop should be organised by the Chairman of the Working Group on Fish Stock Assessments and the Chairman of this Working Group.

8 REFERENCES

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Table 3.1 ICES Working Groups' use of different surveys.

Working Group	IYFS	EGFS	SGFS	DGFS	NDS
Herring	x				
Baltic Pelagic	x				
Industrial	x	x	x		
Roundfish	x	x	x	x	
Division IIIa Demersal	x				
Multispecies	x				
Flatfish		x			
Atlas of North Sea Fishes	x	x	x		
Pandalus					x

Table 4.1 General results of the GLM analysis.

HERRING

Cause	D.F	SS	Mean SS	P	
Year	7	579	82.7	0.0001	
Ship	12	2060	171.7	0.0001	
Rectangle	111	9059	81.6	0.0	R^2 = 0.44
Day/night	1	43	43.0	0.0093	
Depth	1	34	34.0	0.0206	
Error	2411	15068	6.25		

COD

Cause	D.F	SS	Mean SS	P	
Year	7	1048	149.7	0.0	
Ship	12	831	69.3	0.0001	
Rectangle	158	2042	12.9	0.0	R^2 = 0.41
Day/night	1	0	0.1	0.7649	
Depth	1	3	3.2	0.1897	
Error	3097	5703	1.8		

WHITING

Cause	D.F	SS	Mean SS	P	
Year	7	1787	255.3	0.0	
Ship	12	1806	150.5	0.0001	
Rectangle	158	6560	41.5	0.0	R^2 = 0.51
Day/night	1	1	0.7	0.7225	
Depth	1	51	51.3	0.0001	
Error	3095	9741	3.2		

ctd.

Table 4.1 (ctd.)

HADDOCK

Cause	D.F	SS	Mean SS	P	
Year	7	1338	191.1	0.0	
Ship	11	394	35.8	0.0232	
Rectangle	118	4936	41.8	0.0	$R^2 = 0.58$
Day/night	1	69	69.0	0.0001	
Depth	1	37	36.7	0.0005	
Error	1631	4965	3.04		

NORWAY POUT

Cause	D.F	SS	Mean SS	P	
Year	7	2329	332.7	0.0	
Ship	11	891	81.0	0.0001	
Rectangle	118	9041	76.6	0.0	$R^2 = 0.60$
Day/night	1	106	105.6	0.0001	
Depth	1	658	657.9	0.0001	
Error	1627	8815	5.42		

SPRAT

Cause	D.F	SS	Mean SS	P	
Year	7	802	114.6	0.0001	
Ship	12	3924	327.0	0.0	
Rectangle	139	8876	63.9	0.0	$R^2 = 0.55$
Day/night	1	7	7.5	0.1955	
Depth	1	6	5.8	0.2576	
Error	2508	11294	4.5		

Table 4.2 Difference in catch rate between day and night according to the GLM analysis.

Species	Significance in %	Explained ss	No. of hauls Day	Night	Night/day catch ratio in %
Herring	0.9	42	2.221	323	64
Cod	76.5	0.16	2.786	491	98
Whiting	72.2	0.40	2.784	491	97
Haddock	0.01	66	1.395	375	59
N. pout	0.01	16.7	1.392	374	54
Sprat	11.0	2.6	2.025	227	75

Table 4.3 Fishing power by vessel (all using the GOV trawl) and species (age 1) estimated by the GLM analysis . Unit arbitrary.

Species	Anton Dohrn	Cirolana	Dana	Eldjarn	Explorer	Isis	Scotia	Thalassa	Tridens	Walter Herwig
Herring	56	111	103	37	51	122	142	18	78	46
Cod	11	25	26	18	16	15	23	29	18	25
Whiting	27	58	49	29	36	9	43	48	31	51
Haddock	39	44	35	35	34	-	36	42	46	46
N.pout	30	60	49	29	72	-	46	11	50	31
Sprat	80	62	113	30	48	90	54	9	59	27

Table 4.4 Influence of year/rectangle interactions and day/night effects on the estimation of relative fishing powers.

Ship code	Cod age 1			Haddock age 1		
	Model-0	Model-I	Model-II	Model-0	Model-I	Model-II
AND	0.44	0.48	0.47	0.89	0.96	1.06
CIR	1.0	1.0	1.0	1.0	1.0	1.0
DAN	1.04	1.06	1.13	0.79	0.87	0.97
ELD	0.72	0.65	0.62	0.79	0.71	0.82
EXP	0.64	0.75	0.78	0.76	0.95	1.09
ISI	0.60	0.72	0.58	-	-	-
SCO	0.92	0.86	0.92	0.80	0.75	0.85
THA	1.16	1.17	1.14	0.93	1.08	1.13
TRI	0.72	0.75	0.70	1.02	1.04	1.13
WAH	1.02	0.90	0.95	1.02	0.95	1.17

Ship's Codes

AND - Anton Dohrn
CIR - Cirolana
DAN - Dana
ELD - Eldjarn
EXP - Explorer
ISI - Isis
SCO - Scotia
THA - Thalassa
TRI - Tridens
WAH - Walter Herwig

Table 4.5 Yearly changes in relative fishing powers as calculated from the model
ln (catch + 0.5) = ship (year) + rectangle + ε
Cod - Age 1. IYFS

Ship	1982	1983	1984	1985	1986	1987	1988	1989
AND	-	0.46	0.41	0.89	0.37	-	-	-
CIR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DAN	1.11	0.89	1.95	1.05	0.83	1.18	0.61	1.01
ELD	-	0.31	1.74	0.91	0.66	0.61	0.22	0.39
EXP	0.97	0.96	0.70	-	-	-	-	-
ISI	-	-	0.43	1.16	0.28	1.09	-	1.52
SCO	-	-	-	0.79	0.96	0.92	0.25	0.83
THA	4.07	1.92	2.37	1.0	1.09	0.82	0.61	0.78
TRI	1.47	1.08	0.90	0.99	0.47	0.59	0.35	0.55
WAH	-	-	-	-	-	0.67	0.33	1.11

Table 4.6 Yearly changes in relative fishing powers as calculated from the model

ln (catch + 0.1) = ship(year) + rectangle + ε
Cod - age 1. IYFS

Ship	1982	1983	1984	1985	1986	1987	1988	1989
AND	-	.24	.28	.81	.27	-	-	-
CIR	1.	1.	1.	1.	1.	1.	1.	1.
DAN	1.	.67	2.10	1.07	.79	1.28	.36	.95
ELD	-	.16	2.09	.82	.61	.55	.11	.26
EXP	1.01	.91	2.67	-	-	-	-	-
ISI	-	-	.33	1.30	.18	.92	-	2.19
SCO	-	-	-	.66	.91	.92	.11	.80
THA	6.22	2.25	2.51	1.04	1.09	.72	.48	.71
TRI	1.73	.97	.83	1.03	.39	.51	.21	.45
WAH	-	-	-	-	-	.54	.18	1.18

Table 4.7 Yearly changes in relative fishing powers as calculated from the model.
ln (catch + 1.0) = ship (year) + rectangle + ε.
Cod - age 1. IYFS

Cod Age 1 IYFS								
Ship	1982	1983	1984	1985	1986	1987	1988	1989
AND	-	.57	.48	.93	.43	-	-	-
CIR	1.	1.	1.	1.	1.	1.	1.	1.
DAN	1.15	.98	1.88	1.05	.85	1.15	.73	1.04
ELD		.40	1.60	.94	.70	.66	.30	.46
EXP	.98	.97	.73	1.12	-	-	-	-
ISI	-	-	.47	-	.34	1.17	-	1.33
SCO	-	-	-	.84	.98	.93	.34	.84
THA	3.38	1.78	2.28	.99	1.09	.86	.67	.81
TRI	1.38	1.10	.93	.99	.51	.63	.42	.60
WAH	-	-	-	-	-	.74	.41	1.07

Table 4.8 Yearly changes in relative fishing powers as calculated from the model
ln (catch) = ship(year) + rectangle + ε
Cod - Age 1 IYFS (zero catches excluded)

Ship	1982	1983	1984	1985	1986	1987	1988	1989
AND	-	0.71	0.35	0.72	0.45	-	-	-
CIR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DAN	0.99	1.55	1.45	0.98	1.10	1.25	1.62	1.0
ELD	-	0.27	1.26	0.84	1.48	0.58	0.59	0.66
EXP	0.52	0.78	0.39	-	-	-	-	-
ISI	-	-	0.59	0.65	0.61	2.12	-	0.69
SCO	-	-	-	1.39	1.61	0.92	0.39	0.95
THA	2.72	2.03	3.37	0.72	1.19	1.04	1.15	1.04
TRI	1.15	1.47	0.93	0.49	0.59	0.57	0.67	0.68
WAH	-	-	-	-	-	0.75	0.60	1.12

Table 4.9 Yearly changes in relative fishing powers as estimated from the model

$$\ln(\text{catch} + 0.5) = \text{ship(year)} + \text{rectangles} + \varepsilon$$

Haddock - Age 1 - IYFS

Ship	1982	1983	1984	1985	1986	1987	1988	1989
CIR	1.	1.	1.	1.	1.	1.	1.	1.
DAN	1.57	.62	1.44	.50	1.08	1.01	.63	.97
THA	1.27	1.31	1.38	.79	1.05	1.03	1.02	1.
TRI	1.47	.87	1.50	.83	1.06	1.13	.67	1.21

Table 4.10 The year effect (in log values) by species (1-group) based on even and odd numbered hauls, respectively.

Year class	Herring		Cod		Whiting		Haddock		Norw. pout		Sprat	
	even	odd	even	odd	even	odd	even	odd	even	odd	even	odd
1980	3.13	3.41	-	-	-	-	-	-	-	-	-	-
1981	3.82	4.04	0.50	0.54	2.77	2.26	3.58	3.48	3.01	2.65	0.94	1.05
1982	3.22	3.78	0.27	0.17	2.29	2.09	3.56	3.07	4.59	4.56	1.53	1.42
1983	3.64	4.05	1.16	1.02	3.86	3.75	5.35	5.07	4.19	4.64	1.76	1.45
1984	3.84	4.38	-0.52	-0.70	2.30	2.06	3.15	3.08	2.57	2.88	0.96	0.81
1985	4.65	4.85	1.10	0.87	3.23	2.88	4.15	4.08	3.56	3.71	-0.12	-0.05
1986	3.50	3.92	0.37	0.23	3.95	3.80	4.12	3.89	3.71	3.85	1.33	1.45
1987	3.72	3.75	-0.03	-0.27	3.06	2.99	1.86	1.87	1.13	1.48	0.74	0.67
1988	-	-	0.67	0.44	3.83	3.97	3.22	2.73	5.10	5.04	1.75	2.06
R^2	0.47	0.45	0.43	0.44	0.54	0.52	0.60	0.62	0.62	0.62	0.58	0.56

R^2 is the percentage explained by the GLM.

<u>Table 4.11</u> Estimated standard deviation of the IYFS 1-group indices for various species for 1982-1989.

Species	S.E.	Number of hauls
Herring	0.28	2,544
Haddock	0.22	1,770
	0.14[1]	"
	0.26[2]	"
	0.37[3]	"
	0.10[4]	"
	0.20[5]	"
Cod	0.13	3,276
Whiting	0.18	3,275
Norway pout	0.19	1,766
Sprat	0.12	2,669

[1] From dataset 1 + 2 (see Table 4.12).
[2] From dataset 3 + 4 (see Table 4.12).
[3] From dataset 9 + 10 (see Table 4.13).
[4] From dataset 11 + 12 (see Table 4.13).
[5] From dataset 13 + 14 (see Table 4.13).

Table 4.12 The year effect of 1-group haddock estimated for various subsets, (see text) of the data set for 1982-1989.

Year class	Dataset no. 1 latm<31	2 latm>30	3 longm<31	4 longm>30
1981	3.37	3.50	3.76	3.46
1982	3.44	2.93	3.63	3.10
1983	4.95	5.05	5.16	5.31
1984	2.93	2.85	3.20	3.17
1985	3.94	3.84	4.23	3.81
1986	3.78	3.85	4.08	3.89
1987	1.48	1.76	1.92	1.64
1988	2.65	2.87	3.09	2.64
N	894	878	1,062	708
R^2	0.59	0.58	0.61	0.62

Year class	Dataset no. 5 latm <31 longm<31	6 latm <31 longm>30	7 latm >30 longm<31	8 latm >30 longm>30
1981	3.67	3.17	3.93	3.70
1982	3.74	3.42	3.54	2.78
1983	4.94	5.34	5.43	5.20
1984	3.03	3.25	3.44	3.16
1985	4.12	3.83	4.40	3.80
1986	3.89	3.62	4.30	4.07
1987	1.81	1.12	2.08	2.00
1988	2.79	2.63	3.45	2.53
N	561	331	501	377
R^2	0.62	0.62	0.61	0.64

Table 4.13 The year effect of 1-group haddock estimated for various subsets of the 1989 data but including all data from the other years 1982-1988. N = number of hauls, R^2 is the percentage explained by the model.

Year class	All	Dataset no. 9	10	11	12	13	14
		even	odd	latn<31	latm>30	longm<31	longm>30
1981	3.46	3.47	3.49	3.49	3.47	3.47	3.50
1982	3.21	3.17	3.21	3.19	3.20	3.19	3.20
1983	5.02	4.99	5.02	5.00	5.01	5.00	5.01
1984	2.92	2.88	2.91	2.88	2.90	2.90	2.89
1985	3.93	3.88	3.90	3.88	3.91	3.90	3.89
1986	3.86	3.86	3.88	3.87	3.87	3.89	3.85
1987	1.64	1.63	1.66	1.64	1.65	1.68	1.62
1988	2.78	3.05	2.53	2.70	2.82	2.93	2.65
N	1,770	1,671	1,668	1,640	1,699	1,667	1,672
R^2	0.58	0.59	0.59	0.59	0.58	0.58	0.59

Table 4.14 Standard error of the residuals of the regression of log-index vs log-VPA. MO refers to the index generated from model O.

HERRING

Index	Standard error of residuals
IYFS	0.23
MO all	0.18
MO even	0.25
MO odd	0.13
Mean s.e. of VPA series	0.35

COD

Index	Standard error of residuals
IYFS	0.30
MO all	0.25
MO even	0.32
MO odd	0.23
Mean s.e. of VPA series	0.59

WHITING

Index	Standard error of residuals
IYFS	0.21
MO all	0.38
MO even	0.41
MO odd	0.36
Mean s.e. of VPA series	0.41

NORWAY POUT

Index	Standard error of residuals
IYFS	0.80
MO all	1.09
MO even	0.94
MO odd	1.29
Mean s.e. of VPA series	0.96

ctd.

Table 4.14 (ctd.)

HADDOCK

Index	Standard error of residuals
IYFS	0.25
MO all	0.36
MO even	0.43
MO odd	0.39
MO lat <31	0.35
MO lat >30	0.41
MO lon <31	0.35
MO lon >31	0.35
MO lat<31 lon<31	0.35
MO lat<31 lon>30	0.44
MO lat>30 lon<31	0.41
MO lat>30 lon>30	0.35
Mean s.e. of VPA series	0.88

Table 5.1 *PROPOSED SURVEY PLAN*

	FEBRUARY	MAY/JUNE	AUG/SEP	NOVEMBER
Netherlands	3	3 coarse	3 complementary	3 Southern (existing +)
England	-	-	4 + coarse (existing +)	4 + coarse
Scotland	3	3 complementary	3 Northern (existing)	-
France	3	-	3 Southern (1992 et seq.)	-
Germany, F.R.	3+	4 central (existing +)	-	-
Norway	4	2 Northern	-	2 Northern
Denmark	3	-	-	3 complementary
Ship-weeks	19+	12	13+	12+

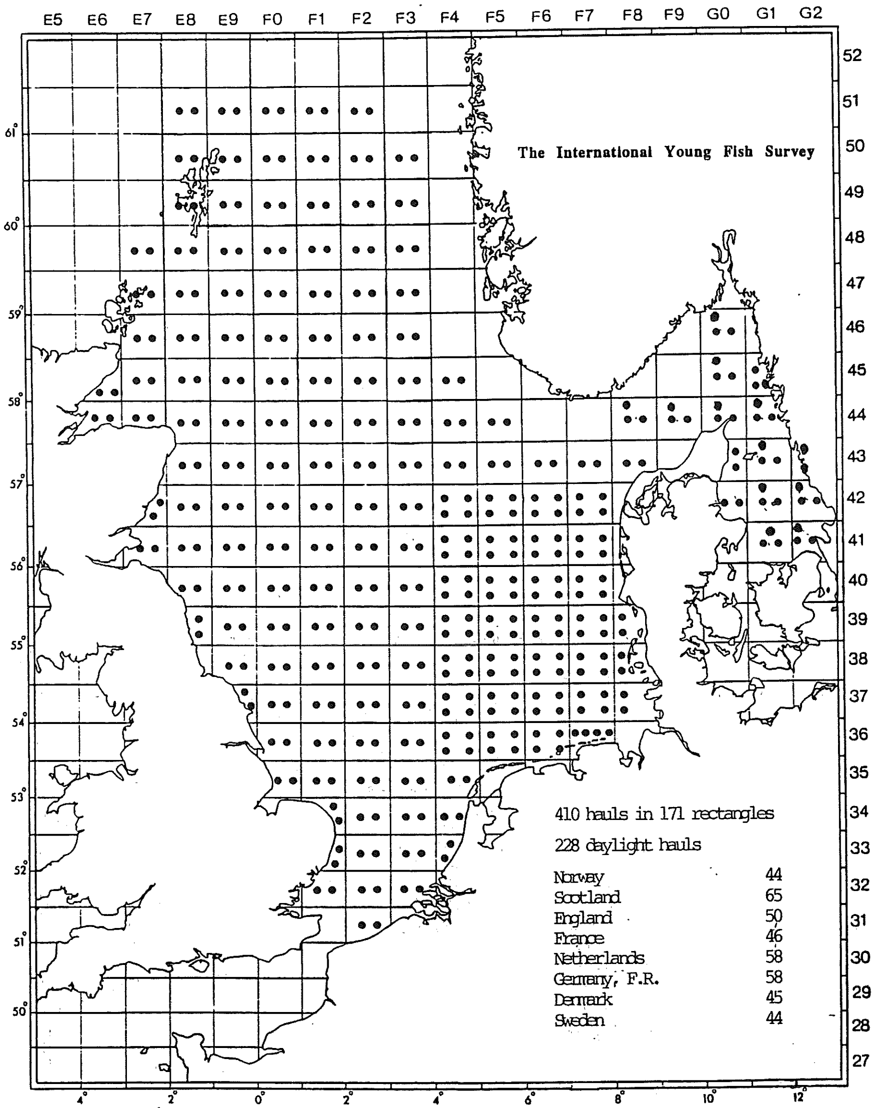


Figure 3.1 Station grid of the International Young Fish Survey.

Figure 3.2 Stations of the English Groundfish Survey.

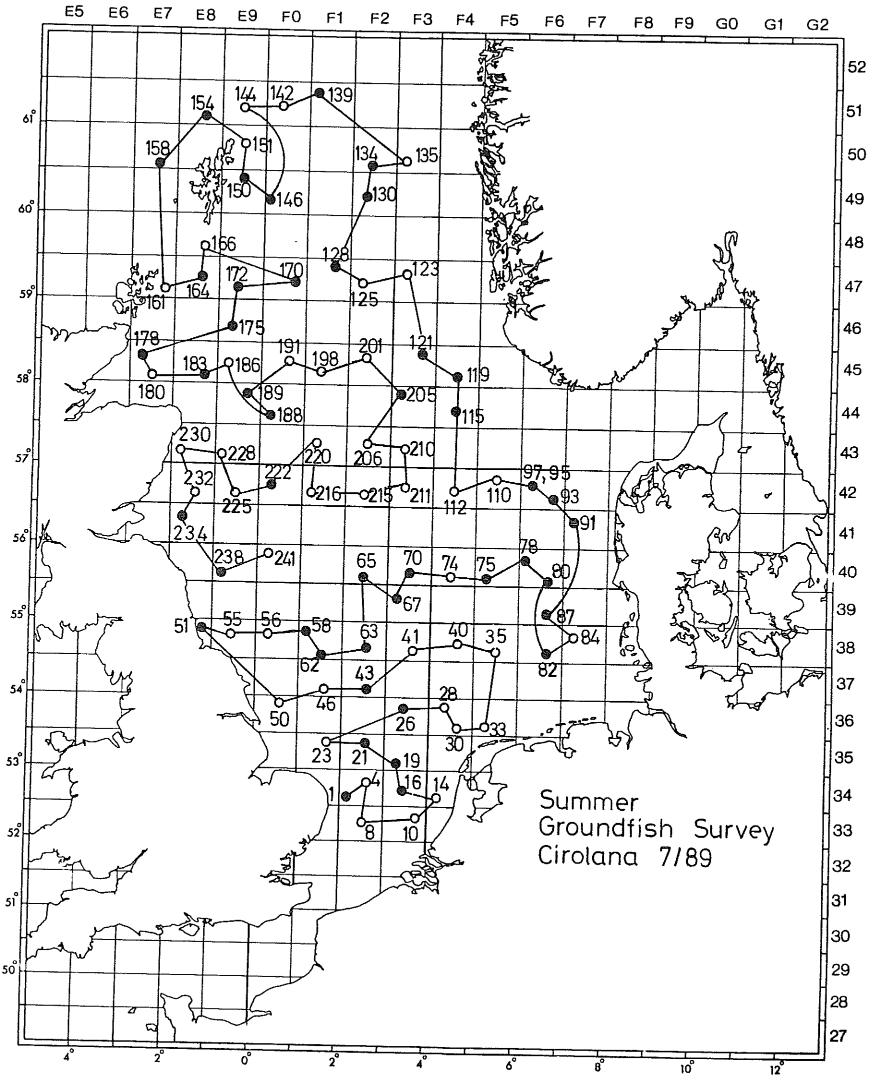


Figure 3.3 Station grid of the SGFS.

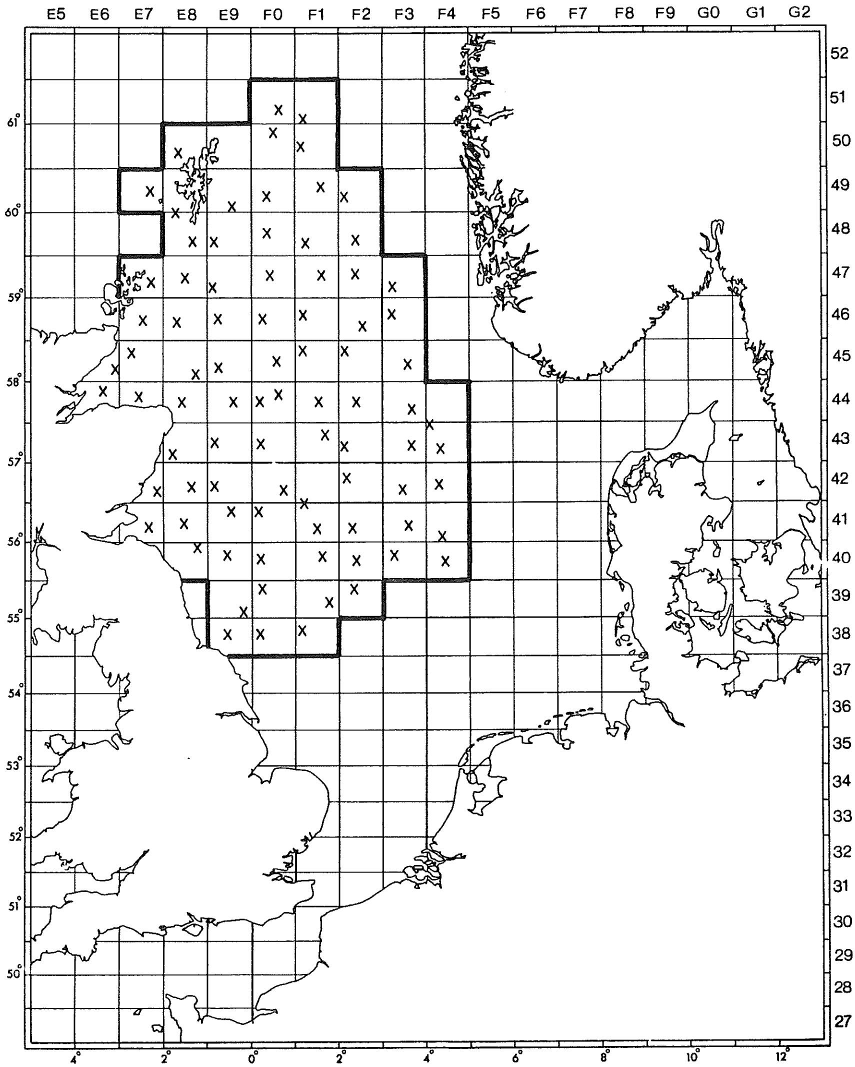


Figure 3.4 Area covered by the German Groundfish Survey.

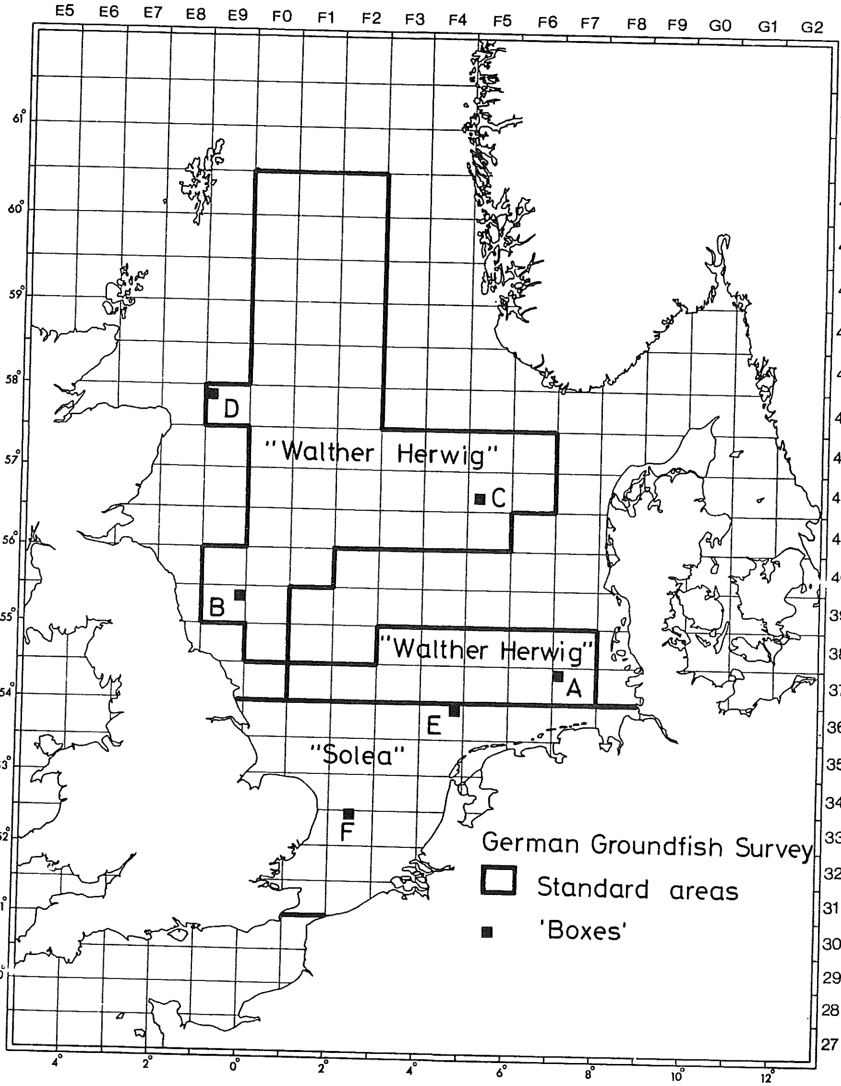


Figure 3.5 Dutch Groundfish Survey area covered and standard area.

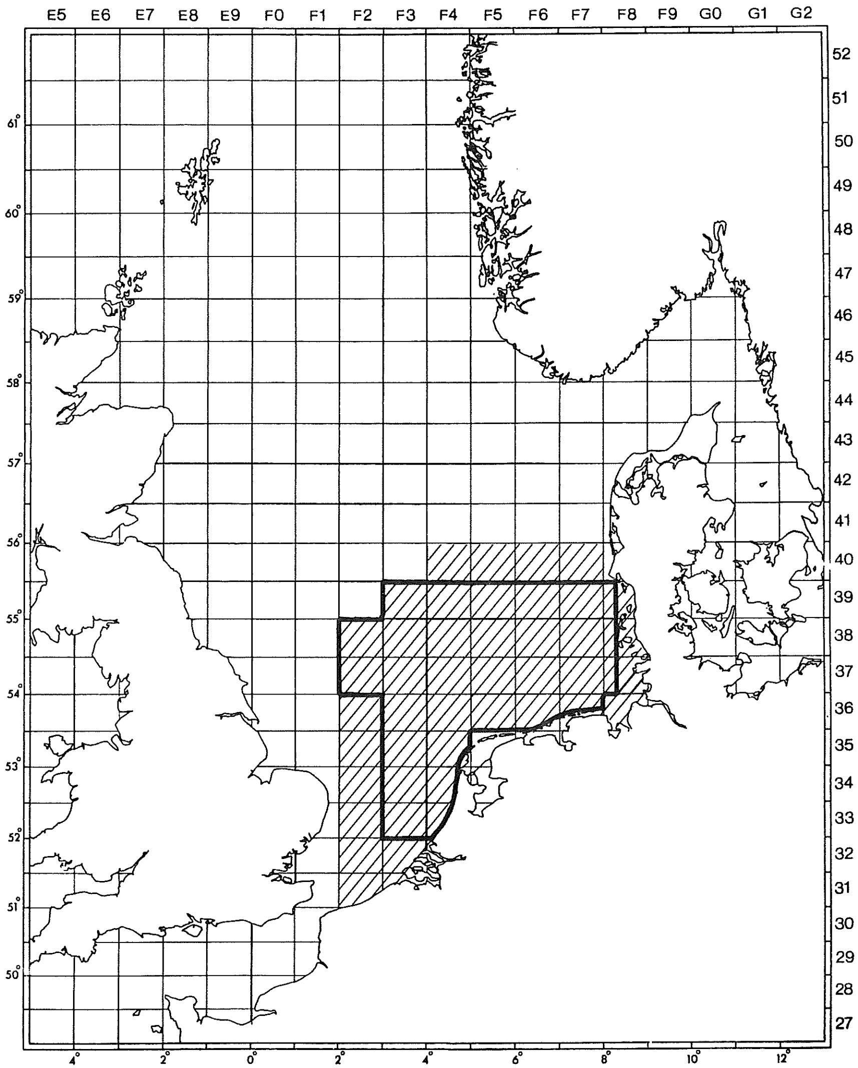


Figure 3.6 Area covered by the French Groundfish Survey.

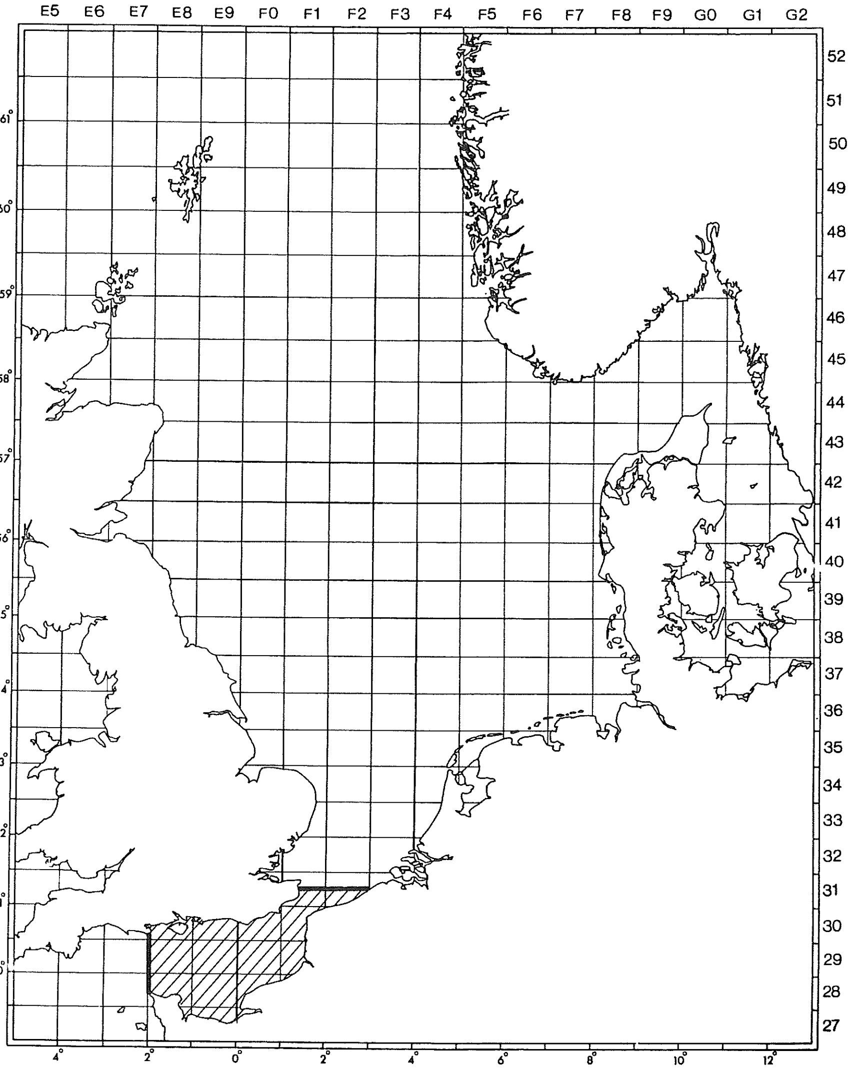


Figure 3.7 The stratification used in the Norway Deeps Survey.

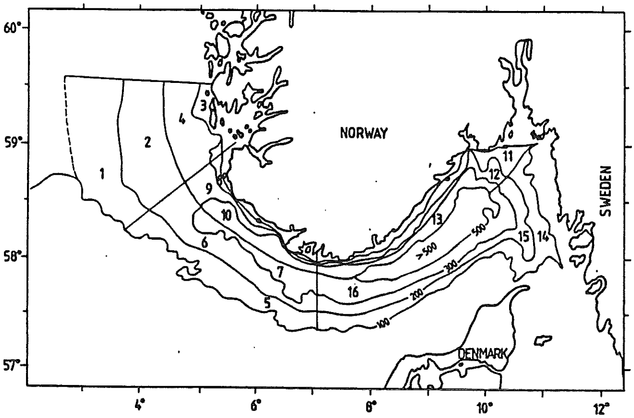


Figure 3.8 Area covered by the Swedish *Nephrops* Trawl Survey.

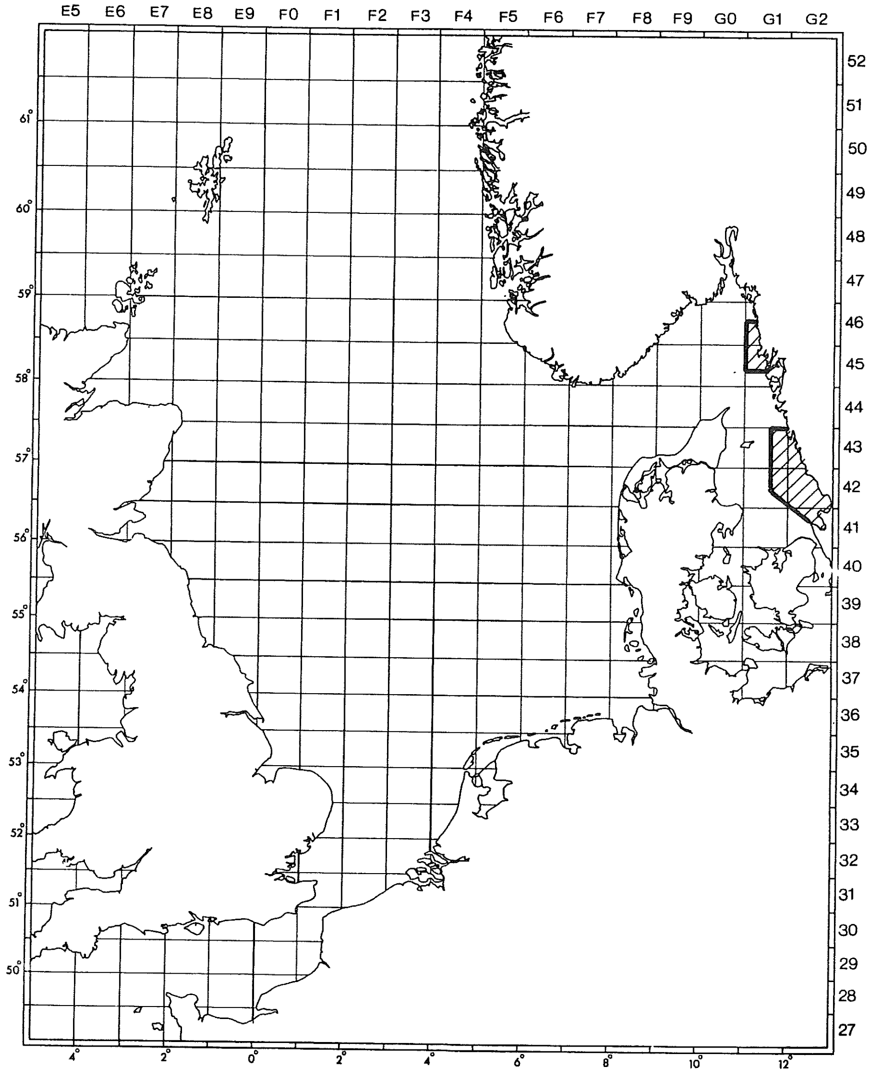


Figure 5.1 Proposed re-allocation for the International Young Fish Survey.

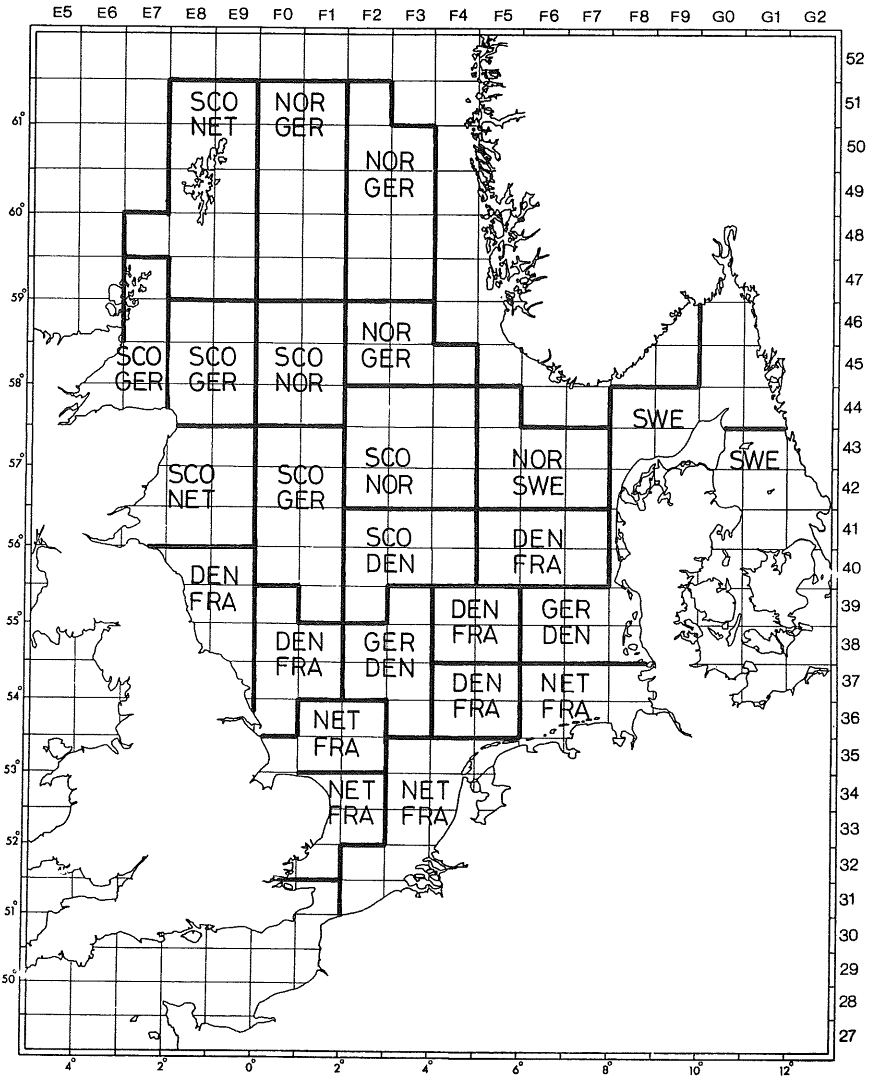


Figure 5.2 Possible "Coarse" survey grid (74 stations).

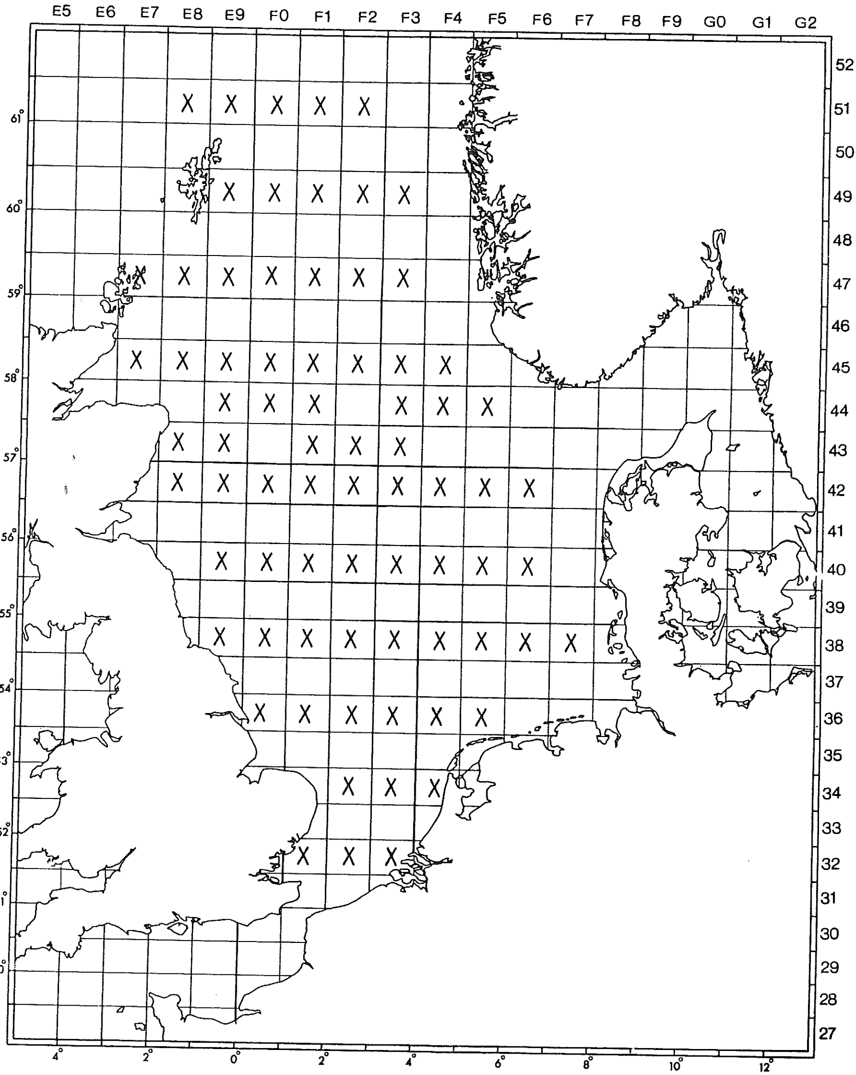


Figure 5.3 Possible complementary "Coarse" grid (71 stations).

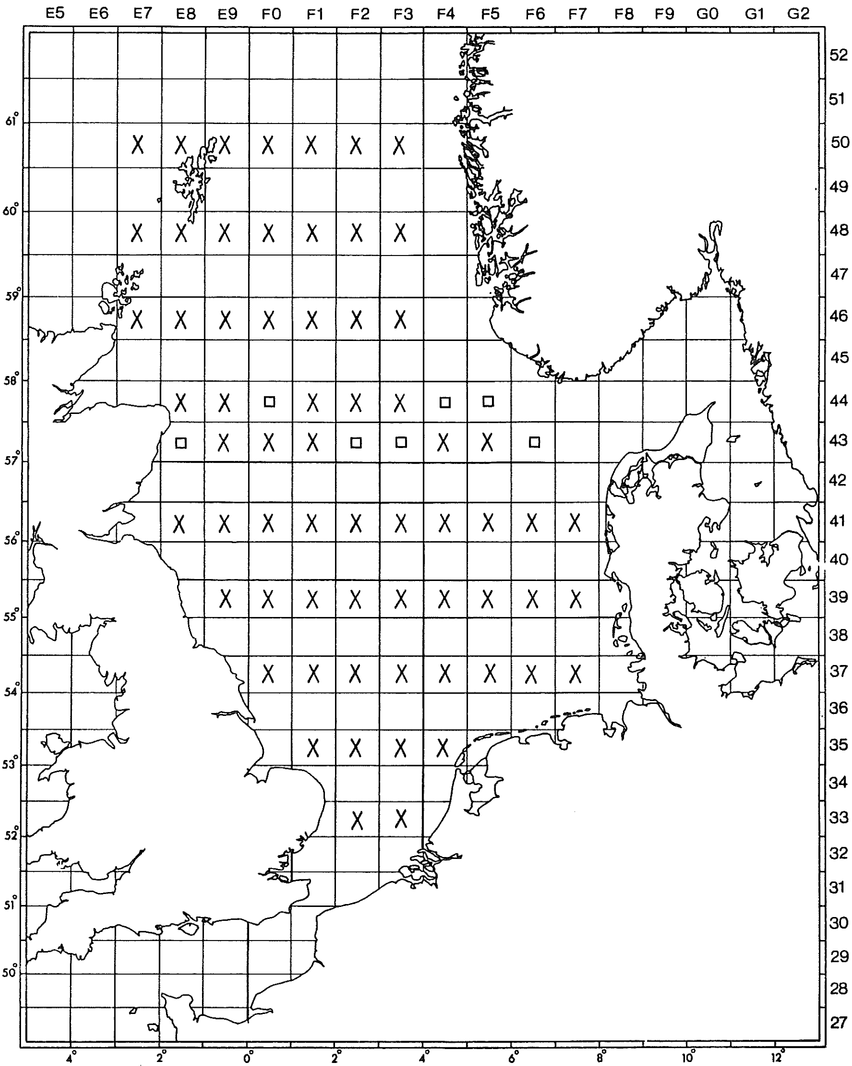
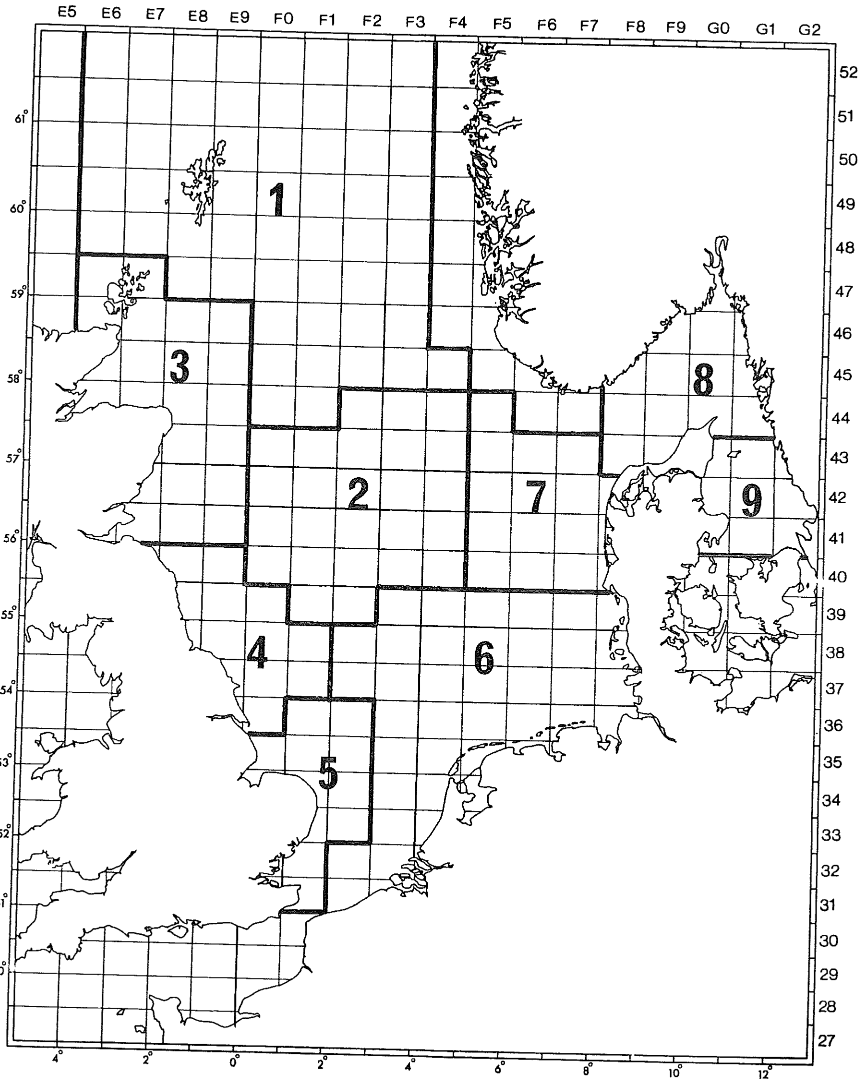


Figure 7.2 Sub-areas for sampling of otoliths of standard species.



APPENDIX 1

An Examination of Ship Efficiency Factors in the ICES IYFS

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Introduction

Proposals were made at the ICES stomach sampling workshop, that the research vessel effort currently deployed on the IYFS should partly be reassigned to other times of the year. The reason for this suggestion was to make effort available for stomach sampling at other times of the year and, also to provide surveys at times of year currently not worked. If changes in the IYFS are to be made, then it would be prudent to have a clear idea of any variations in the efficiency of the various ships currently conducting this survey. This note gives an outline of how this might be done using the cod results by length in 1987 as an example.

Method of comparison

An approach, similar to that used by the ICES Atlas Working Party for comparing the summer groundfish surveys, was used. This involved categorising the cod catch in four length groups (10-19 cm, 20-29 cm, 30-39 cm and 40+ cm) by rectangle(r) and ship(s). Catch rate was then explained by the model:

$$\ln(\text{catch}(r,s)) = A(r) + B(s) + M + e,$$

Where A and B are rectangle and ship effects, M the mean and e an error term with a normal distribution. This model was fitted using GLIM. Alternative fits using a Poisson error structure and a log link function were also used, but these appeared not to fully account for the growth in variance with catch rate. The results of these fits produced estimates of relative ship effects and rectangle effects. They also provide an estimate of how much variation in catch rate is explained by rectangle effects and how much is additionally explained by including ship effects. Since there is not a complete factorial design between ships and stations, calculated ship effects may of course contain some element of rectangle. However, the design of the survey with multiple overlaps makes it unlikely to produce very misleading effects.

Results

Table 1 shows the efficiency of each ship relative to "Tridens". Averages across all four size groups suggest that "Tridens" had the lowest catch efficiency, but the variation between most vessels was not great and was in fact generally within the confidence region of + or - about 40%. DAN2 and ISI, however, do appear to be working at a systematically higher efficiency.

Table 2 shows the ANOVAS resulting from the four analyses. In general, the ship effect accounts for a small part of the total variation and the effect is seldom a statistically significant one. Figures 1-4 show the rectangle effects as catches standardised to "Tridens".

Conclusions

Ship effects seem rather small and might perhaps be ignored. As an alternative, an analysis similar to that above but based on a number of years results could be performed and the resulting efficiency factors found for each species could be used to correct for any ship effects.

Table 1 Ship efficiency relative to 'Tridens'. For cod.

Ship	10-19 cm	20-29 cm	30-39 cm	+40 cm	Av.
DAN2	136	173	191	142	161
CIR	149	129	110	124	128
THA	128	145	151	148	143
WAH	101	97	95	146	110
ISI	163	181	145	137	157
TRI	100	100	100	100	100
ELD	90	135	100	137	116
SCO	144	101	104	113	116
AV.	126	133	125	131	129

Table 2 ANOVA of rectangle and ship effects.

Cause	D.F.	Sum of Sq.	Mean Sq.	F ratio
Cod 10-19 cm				
Rectangle	153	339.7	2.2	2.02
Ship	7	9.8	1.4	1.27
Residual	330	363.2	1.1	-
Cod 20-29 cm				
Rectangle	153	583.5	3.8	2.75
Ship	7	13.7	2.0	1.41
Residual	330	457.4	1.4	-
Cod 30-39 cm				
Rectangle	153	568.0	3.7	3.12
Ship	7	16.0	2.3	1.92
Residual	330	392.1	1.2	-
Cod +40 cm				
Rectangle	153	370.3	2.4	1.75
Ship	7	6.8	1.0	0.70
Residual	330	457.4	1.4	-

Figure 1

DISTRIBUTION CHART OF 10-19 CM COD IN THE 1987 IYFS

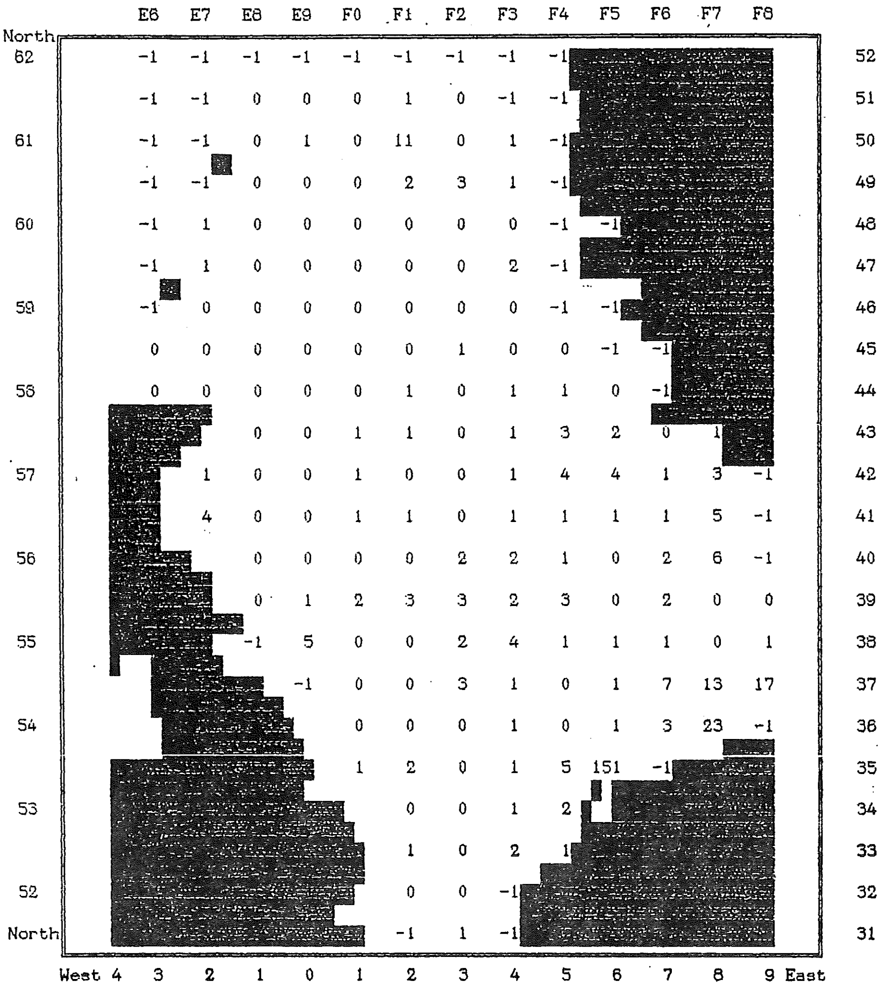

Figure 2

DISTRIBUTION CHART OF 20-29 CM COD IN THE 1987 IYFS

North		E6	E7	E8	E9	F0	F1	F2	F3	F4	F5	F6	F7	F8
62	52	-1	-1	-1	-1	-1	-1	-1	-1	-1				
	51	-1	-1	1	0	1	2	1	-1	-1				
61	50	-1	-1	1	9	2	10	1	5	-1				
	49	-1	-1	2	0	1	3	6	2	-1				
60	48	-1	11	1	2	5	5	1	5	-1	-1			
	47	-1	6	2	0	7	6	1	2	-1				
59	46	-1	2	1	1	5	2	1	7	-1	-1			
	45	0	5	2	0	1	12	0	3	5	-1	-1		
58	44	0	0	2	0	2	7	1	1	9	15	-1		
	43			2	2	13	9	5	0	11	20	0	17	
57	42		5	0	2	3	6	4	0	5	5	0	0	-1
	41		0	0	1	13	4	11	5	4	0	0	1	-1
56	40			7	15	31	16	22	3	0	0	1	0	-1
	39			28	10	85	13	3	2	3	2	2	0	0
55	38			-1	143	35	0	8	3	1	3	2	0	0
	37				-1	1	1	13	1	2	0	5	53	4
54	36					0	0	2	1	0	1	2	2	-1
	35					1	15	0	1	4	39	-1		
53	34						3	2	1	6				
	33						8	8	4	5				
52	32						10	11	-1					
North	31						-1	41	-1					

West 4 3 2 1 0 1 2 3 4 5 6 7 8 9 East

Figure 3

DISTRIBUTION CHART OF 30-39 CM COD IN THE 1987 IYFS

North	E6	E7	E8	E9	F0	F1	F2	F3	F4	F5	F6	F7	F8	
62	-1	-1	-1	-1	-1	-1	-1	-1	-1					52
	-1	-1	2	1	7	7	4	-1	-1					51
61	-1	-1	4	2	2	12	2	13	-1					50
	-1	-1	12	4	3	8	8	0	-1					49
60	-1	24	1	6	2	9	4	14	-1	-1				48
	-1	8	5	1	12	11	9	3	-1					47
59	-1	2	1	1	10	8	0	12	-1	-1				46
	0	0	10	5	4	9	0	1	14	-1	-1			45
58	0	0	3	2	4	8	1	1	5	20	-1			44
			2	2	19	7	6	1	3	11	0	34		43
57		12	0	4	5	9	1	0	1	3	0	0	-1	42
		2	1	3	6	1	9	2	1	0	0	0	-1	41
56			22	27	32	15	7	2	0	1	0	0	-1	40
			47	24	48	9	1	0	1	1	4	0	0	39
55			-1	47	17	0	0	1	1	2	4	0	0	38
				-1	0	0	19	0	0	0	4	24	1	37
54					0	2	1	0	0	0	0	0	-1	36
					5	7	0	0	4	9	-1			35
53						12	0	1	2					34
						5	1	5	2					33
52						10	24	-1						32
North						-1	62	-1						31

West 4 3 2 1 0 1 2 3 4 5 6 7 8 9 East

Figure 4

DISTRIBUTION CHART OF 40+ CM COD IN THE 1987 IYFS

North		E6	E7	E8	E9	F0	F1	F2	F3	F4	F5	F6	F7	F8
62	52	-1	-1	-1	-1	-1	-1	-1	-1	-1				
	51	-1	-1	15	5	5	0	3	-1	-1				
61	50	-1	-1	5	1	2	19	4	5	-1				
	49	-1	-1	6	15	5	5	6	4	-1				
60	48	-1	28	0	3	0	3	9	0	-1	-1			
	47	-1	0	2	0	2	5	5	3	-1				
59	46	-1	1	1	1	5	2	3	4	-1	-1			
	45	1	0	5	1	14	5	0	0	11	-1	-1		
58	44	3	0	2	6	1	3	1	0	1	2	-1		
	43			0	1	1	1	7	0	1	0	0	10	
57	42		13	0	0	1	0	0	0	0	2	0	0	-1
	41		2	0	0	0	0	2	8	11	2	0	0	-1
56	40			4	3	3	2	2	1	4	2	0	0	-1
	39			8	5	2	2	2	4	3	1	5	0	0
55	38			-1	6	5	5	0	1	2	1	2	0	0
	37				-1	2	5	10	5	1	2	10	10	0
54	36					2	1	2	3	3	2	0	0	-1
	35					1	0	1	1	8	1	-1		
53	34						9	1	4	1				
	33						25	5	18	3				
52	32						69	67	-1					
North	31						-1	55	-1					

West 4 3 2 1 0 1 2 3 4 5 6 7 8 9 East