COOPERATIVE RESEARCH REPORT

No. 52

I. REPORT OF A MEETING TO CONSIDER YOUNG FISH SURVEYS

Bergen, 6 - 9 May 1974

II. REPORT OF THE WORKING GROUP ON NORTH SEA YOUNG HERRING SURVEYS

IJmuiden, 19 April - 3 May 1974

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International Council for the Exploration of the Sea
Charlottenlund Slot, DK-2920 Charlottenlund
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I. REPORT OF A MEETING TO CONSIDER YOUNG FISH SURVEYS

1. INTRODUCTION

1.1 Terms of Reference and Participation

For a number of reasons it is very desirable to determine year class strength at an early stage in the life history of commercial fish species. In recent years, therefore, there has been an increase of international interest in young fish surveys; largely because of the need for earlier and more accurate forecasts of year class strength in relation to management of fish stocks.

In order to assess the value of existing data from young fish surveys carried out in the ICES area, the Statutory Meeting of ICES in 1973 adopted the following resolution (C.Res.1973/2:12):-

"It was decided, that:

a meeting should be convened in Bergen in the first half of 1974, to investigate the methodology of young fish surveys for both pelagic and demersal species, and to appraise the existing data from those surveys which have been conducted for many years, and that

Professor O Dragesund will be Chairman".

The meeting was held in Bergen at the Institute of Marine Research from 6-9 May 1974.

The following persons participated:

S N Messieh	Canada
E J Sandeman	Canada
Vögg Jakobsen	Denmark
H-H Reinsch	Germany (Fed.Rep.of)
H Schultz	Germany (Fed.Rep.of)
G Wagner	Germany (Fed.Rep.of)
J Molloy	Ireland
H Vilhjálmsson	Iceland
A Corten	Netherlands
N Daan	Netherlands
E Bakken	Norway
A Dommasnes	Norway
O Dragesund (Chairman)	Norway
S Hjalti i Jakupsstovu	Norway
L Midttun	Norway
I Röttingen	Norway
R Sætre	Norway
Ø Ulltang	Norway
Brian Jones	UK (England)
J Hislop	UK (Scotland)
A Saville	UK (Scotland)
H Ackefors	Sweden
M D Grosslein	USA

1.2 Material and Agenda

The task of the meeting was facilitated by the availability of former reports of young fish surveys carried out in the ICES area. Most of the time was used to discuss - on the basis of the available data - the sampling techniques and survey pattern required to refine the estimates of young fish abundance, to judge the best time to carry out surveys and the total effort needed to achieve the required level of sampling.

The following surveys were dealt with:

1) 0-group fish surveys in the Barents Sea;
2) 0-group fish surveys at the Faroes, Iceland and East-Greenland;
3) Young fish surveys in the North Sea;
4) 0-group sprat surveys in Norwegian fjords.

Since no representatives from USSR were able to attend the meeting, the USSR trawl surveys carried out for many years in the Barents Sea could not be dealt with.

2. 0-GROUP FISH SURVEYS IN THE BARENTS SEA

2.1 Introduction

Fish larvae spawned at the Norwegian coast north of Stad are transported along the path of the most important water currents off northern Norway and in the Barents Sea (Figure 1). During late summer and early autumn 0-group fish of many species occur pelagically in the Barents Sea, including the western shelf of Svalbard. Larvae hatched off the Norwegian coast south of North Cape (herring, cod, haddock, saithe and redfish) are transported northwards by the coastal current. When passing the banks off Troms and western Finmark (between Lofoten and North Cape) the drift of the larvae becomes more influenced by Atlantic water which in this area is intensively mixed with the coastal water.

Larvae hatched along the coast east of North Cape (capelin and long rough dab) are transported eastwards by the North Cape current. The distribution of 0-group capelin and long rough dab indicates that spawning also takes place west and south of North Cape. For the latter species, spawning may also occur offshore in the Barents Sea. Detection of 0-group fish by means of echo-sounder dates back to the early 1950s, when sound scatters were frequently recorded in the top layers of water in the Barents Sea (Midttun and Sætersdal, 1959). However, no systematic routine programme of identifying the different species was developed until 1959. Since then Norwegian investigations have been carried out in the Barents Sea in order to estimate the distribution and abundance of 0-group herring from combined acoustic surveys and fishing experiments with pelagic trawl and purse seine. The results obtained indicate a relationship between 0-group abundance and subsequent year class strength (Dragesund, 1970).

With the promising results obtained for herring, an initiative was taken to carry out surveys jointly by the laboratories conducting fisheries research in the area, and to expand the work to include the other important commercial species, e.g. cod, haddock, redfish, capelin etc. and to make hydrographic observations.

The first joint survey was carried out in 1965 by two Norwegian and two Soviet research vessels. In accordance with the enlarged scope of the survey, an English research vessel was invited to participate in 1966. Thus, during most of the following years, altogether five research vessels took part in the surveys, which were carried out each year during 12-15 days in late August and early September. A description of the methods used and the results of the surveys in 1965-68 are given in Dragesund, Midttun and Olsen (1970).

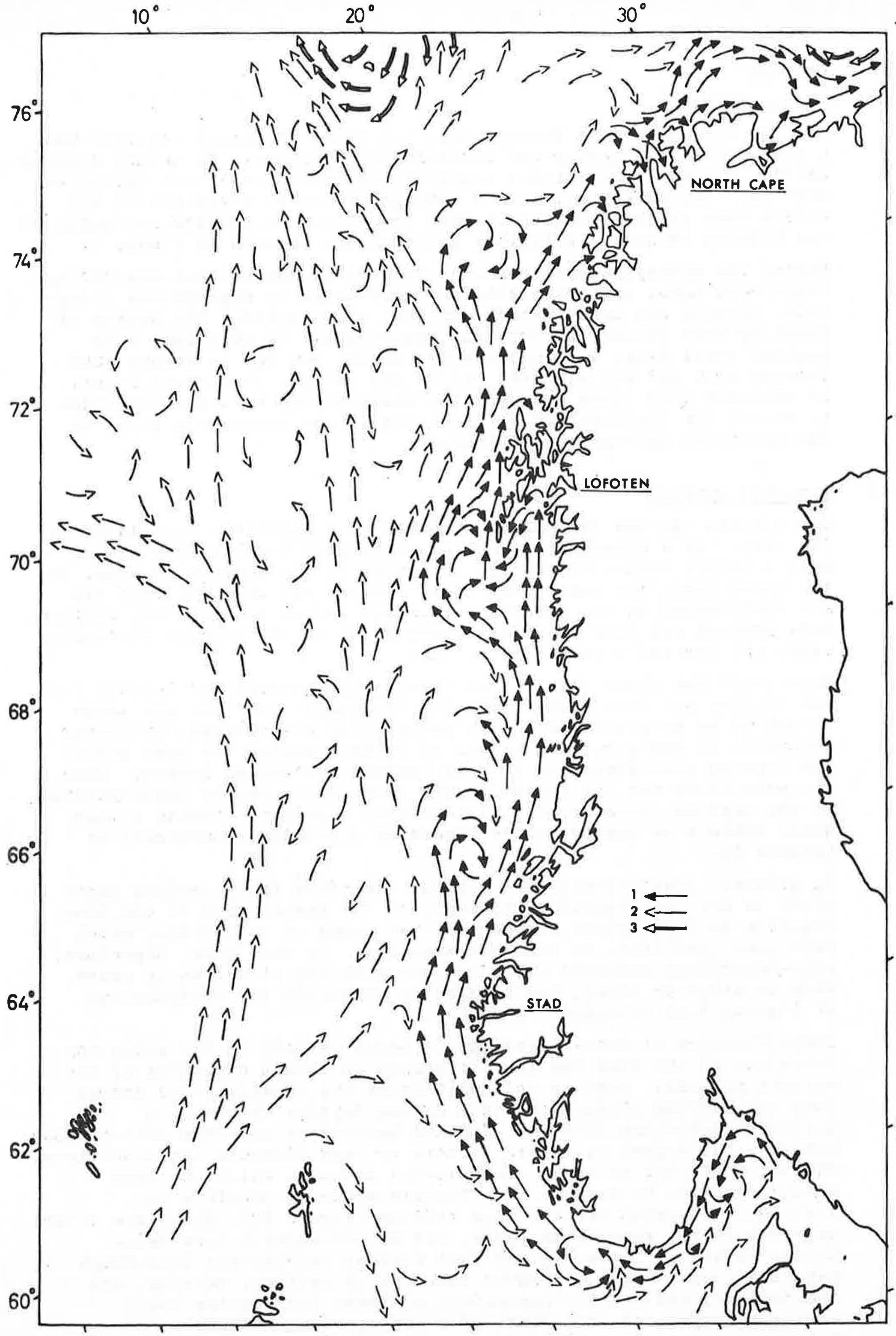


Figure 1. Distribution of water masses and currents off the Norwegian coast; 1: coastal water; 2: Atlantic water; 3: Polar water (from Sætre and Ljøen, 1972).

2.2 Methods

2.2.1 Survey design

For the surveys in the Barents Sea, the basic technique employed was a combined echo-sounding and midwater trawl survey. To ensure comparability of results, intership calibrations were carried out during the surveys. The survey grids were arranged so as to cover almost the entire area of distribution of fish fry of commercial species north of the Lofoten Islands. A typical grid pattern is seen in Figure 2.

During the survey, continuous echo-records of the pelagic scattering layer were made, and trawl stations were taken at appropriate intervals, usually not more than 40 nautical miles apart. The depths of trawling were determined from the recordings. In addition, some control trawl hauls were carried out on the sea bed to ensure that 0-group fish had not migrated out of the pelagic scattering layer. At selected grid lines hydrographic observations were made in order to relate the distribution of organisms in the scattering layer to the principal hydrographic features.

2.2.2 Acoustic surveys

For a given species the target strength of a scatterer is related to its size. As a consequence, an echo-survey of 0-group fish should have a better chance of success the later in the year it is done. On the other hand, the survey has to be carried out when the fish fry are distributed in the upper layers, i.e. before species like redfish, cod, haddock and long rough dab migrate out of the pelagic scattering layer and descend towards the bottom.

Experience has shown that if the Barents Sea surveys for 0-group fish are carried out from August to early September, the fish are large enough to be detected; they are pelagically distributed, and occur generally in the upper 100 metres of water. During the dark period the 0-group fish form more or less uniform scattering layers. When concentrations are not dense, single individuals can be distinguished. In the daytime, however, the fish cluster together, forming either small schools or discontinuous layers of schooling concentrations (Figure 3).

In general, identification of 0-group fish from the recording paper alone is not yet possible. However, in the Barents Sea it has been possible to distinguish between several types of recordings, which have been identified by midwater trawling. In this area, therefore, echo-recordings combined with frequent sampling with fishing gears such as midwater trawl, can be used to establish the distribution of 0-group fish in August-September.

Identification of echo-recordings is based largely on the schooling behaviour of the fish and the difference in target strengths of the various species. 0-group cod and haddock are usually found deeper than the herring (Figure 3B), and during daytime they show a different schooling pattern. Cod and haddock do not form well-defined schools, but appear as layers of more or less discrete concentrations. The herring occur in small concentrated schools, which are also easily detected by sonar. This feature makes it possible to distinguish 0-group herring from redfish (Figure 3E), which are often observed in the same depth range, but do not usually form well-defined schools. It was found that 0-group capelin and long rough dab have lower target strengths than fry of redfish, herring, cod and haddock, and usually recordings of these two species could easily be separated from those of other species. However, in situations where several of the species of fish occur together, it was necessary to supplement the acoustic identification with fishing experiments.

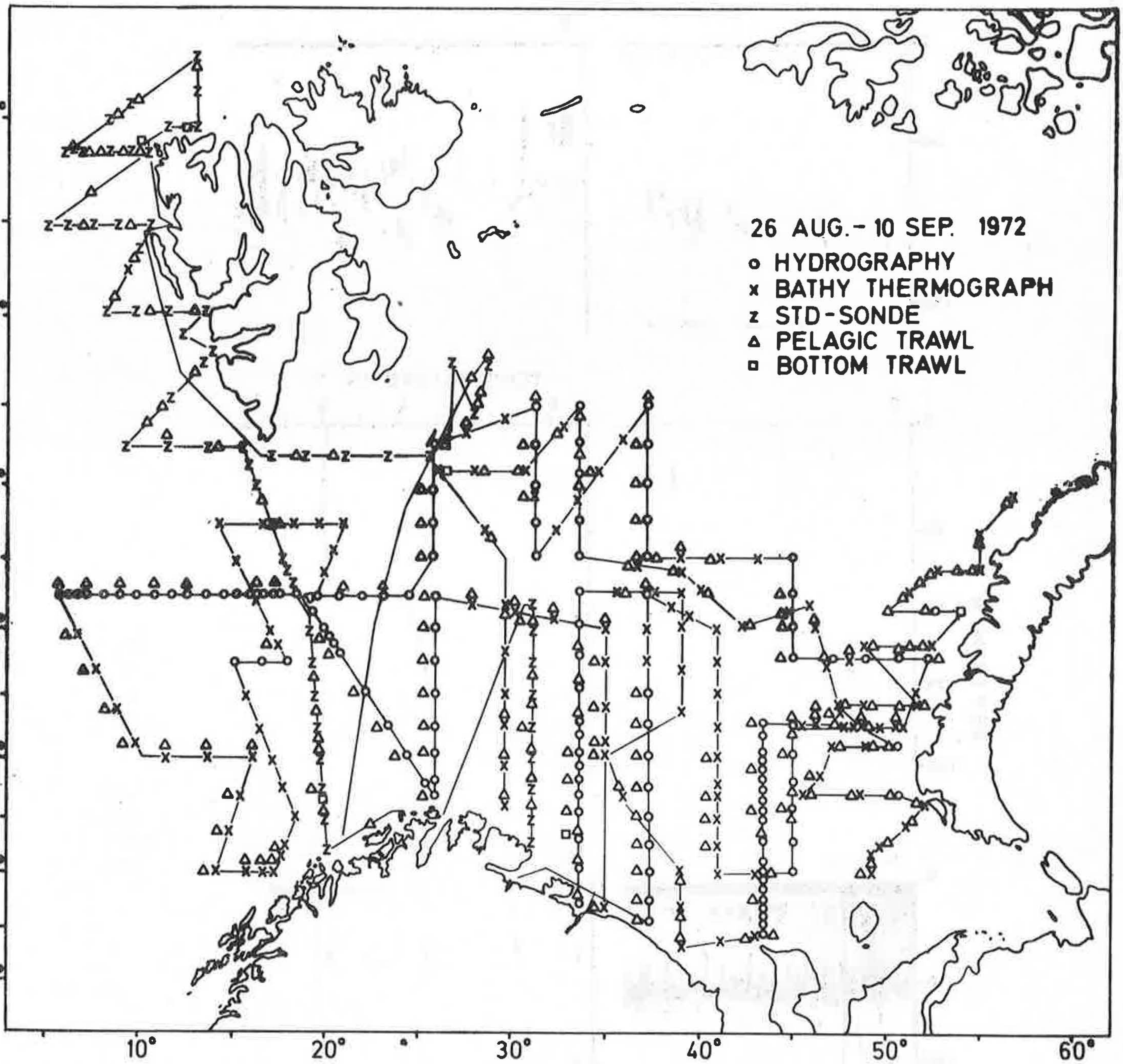


Figure 2. General survey routes and grid of stations in the Barents Sea surveys.

2.2.3 Fishing gear

The catching gear used by all participating vessels was a fine-meshed pelagic midwater trawl. In some of the years, attempts were made to test the relative catching capacities of the trawl used. The depth of trawling was checked by a depth recorder attached to the trawl. Since 1970 the Norwegian research vessel "G. O. Sars" has been equipped with a net sonde. This facilitates exact adjustment of the trawling depth to the depth of the scattering layer, even if the scattering layer changes its depth during the haul. The trawl used by the Norwegian vessels has been a modified capelin trawl with headline and footline of 18.3 m, sidelines of 15.3 m and mesh size from 100 mm (wings and square) graded down to 8 mm (cod end). This trawl has been used by the English vessels since 1972.

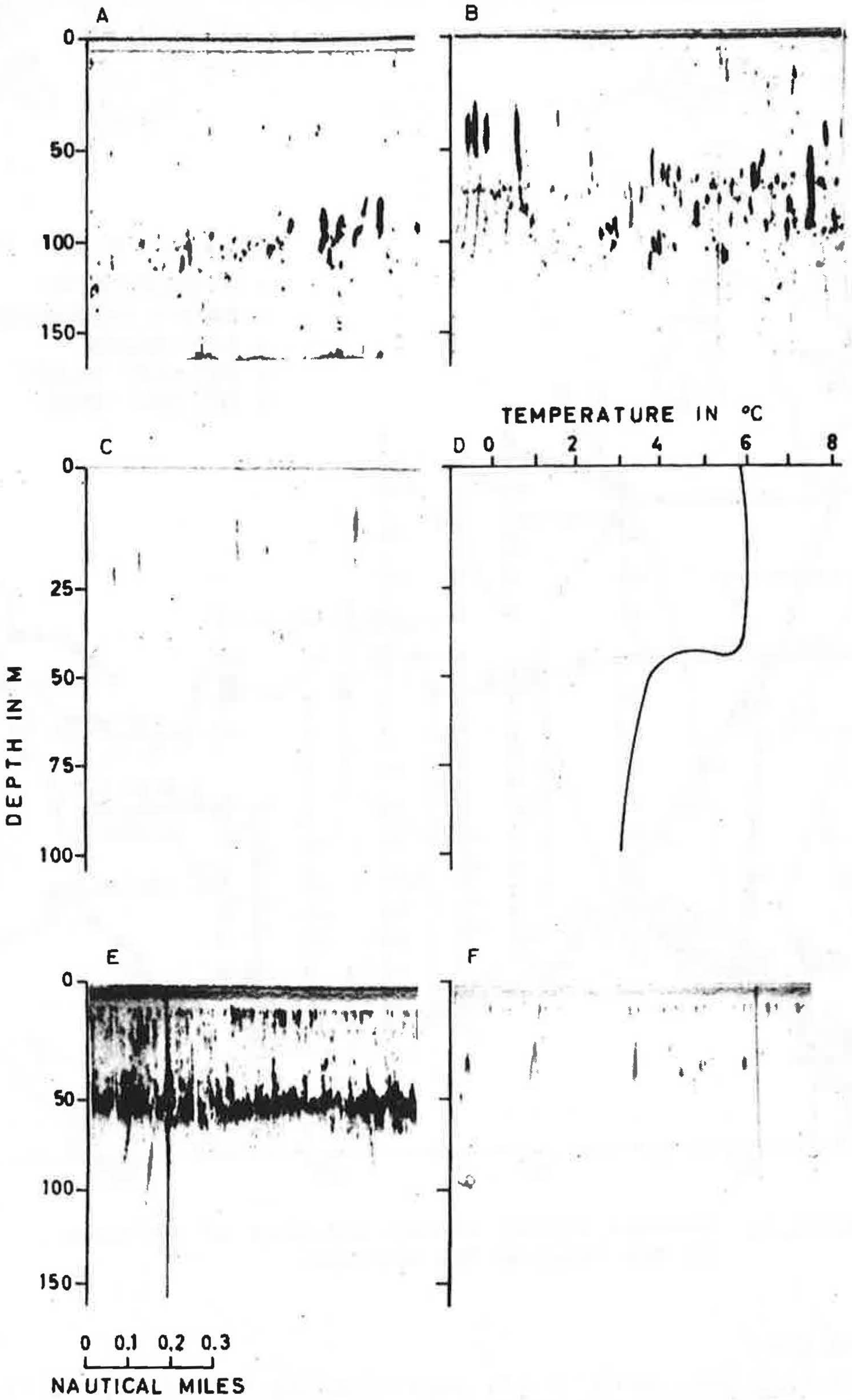


Figure 3. Echo-recordings of 0-group fish by day.
A: cod or haddock or both;
B: herring (top left) and cod or haddock;
C: herring recorded above the thermocline;
D: bathythermogram from the same region;
E: herring and redfish;
F: herring.

2.2.4 Estimation of 0-group abundance

A simple counting method can be applied as long as the single fish can be distinguished on the echo-records. In dense layers and in schools, this method cannot be used, and on standard echo-sounder equipment the 0-group fish are most frequently recorded as multiple echo-traces.

Exact measurement of multiple echoes is possible, but somewhat sophisticated instrumentation is then necessary. However, experience has shown that fairly reliable density classification can be made by visual grading of paper recordings of multiple scatterers into:

0) No recording, 1) Very scattered, 2) Scattered,
3) Dense, 4) Very dense.

When the echo-abundance indices were calculated, areas with scattered recordings (density 1 and 2) were discriminated from areas with dense recordings (density 2 and 3). When classifying the density, data from trawl catches were also used. Figure 4 is an example of a distribution of cod based on grading of the echo-records, combined with trawl catch data. The abundance indices of year class strength given by Dragesund and Nakken (1973) and Hylen and Dragesund (1973) are found from formula

$$T = A_s + k.A_d \qquad (1)$$

where A_s and A_d denote areas with scattered (A_s) and dense (A_d) recordings. The coefficient k, the ratio between fish densities classified as dense and scattered, was set to 10 (Dragesund, 1970).

By later re-examination of all the distribution charts, it appeared that the criteria used to discriminate between scattered and dense may have varied somewhat from year to year. Haug and Nakken (1973) have on the basis of material collected during the 0-group surveys adopted the following method for estimating the abundance indices:

(i) A certain number of fish per haul was used to discriminate between scattered and dense in the distribution charts. This number was found by examining the trawl catches, which contained only one species. The number of fish per haul was compared with the corresponding visual density grading. Assuming a linear relationship between the logarithm of the catch and the visually estimated densities, they arrived at the following values for discrimination between scattered and dense:

Species:	Cod	Capelin	Redfish	Polar Cod
No. of fish per haul:	85	1 050	85	110

(ii) New distribution charts were drawn up for each species where these values were used for the above-mentioned discrimination.

(iii) The abundance indices, T, were calculated from Formula (1).

The Haug and Nakken method was not used in the original survey reports, but the data have subsequently been re-analysed using this method.

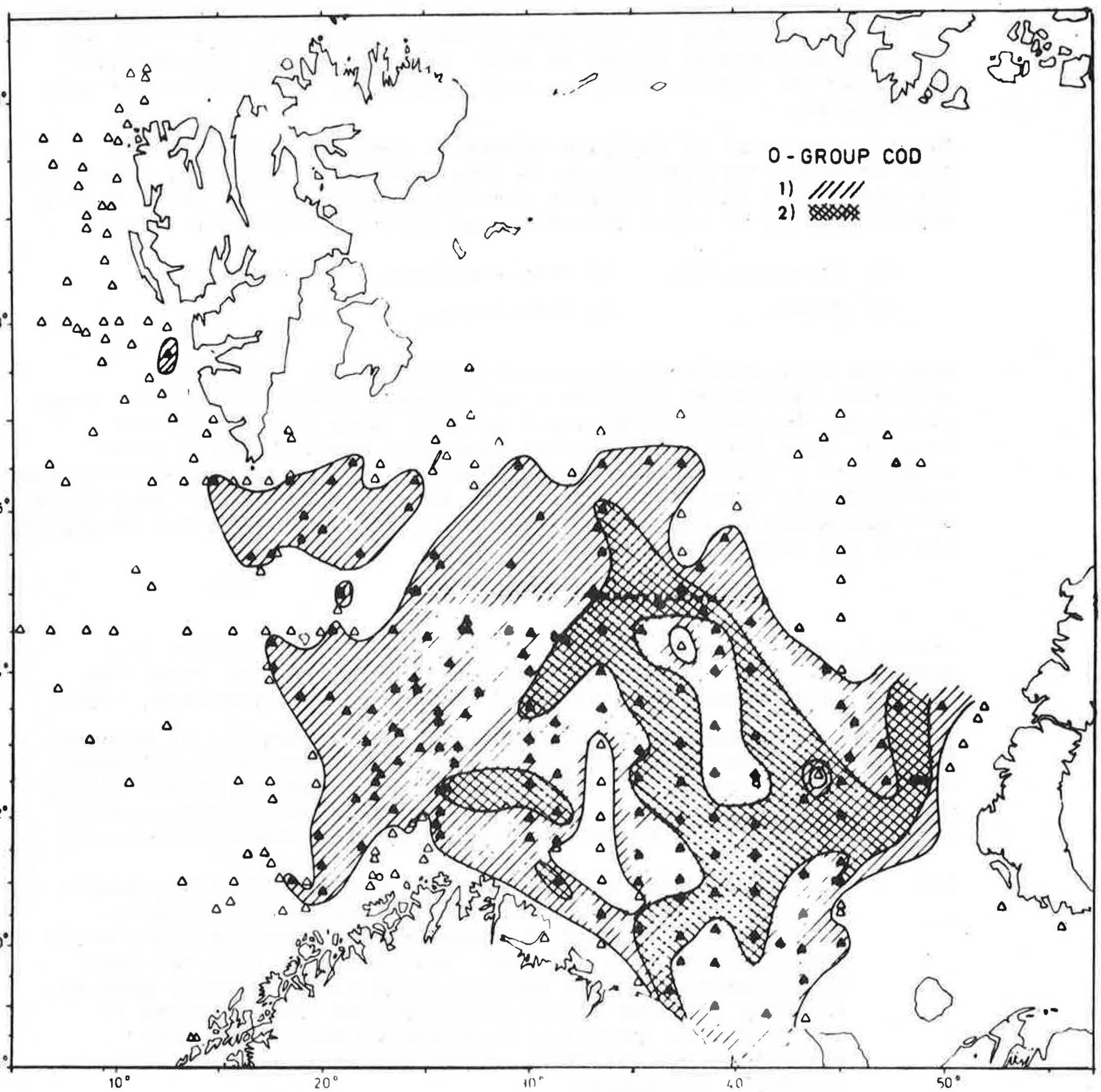


Figure 4. Distribution of O-group cod in autumn 1973.
1) area with scattered recordings;
2) area with dense recordings.

2.3 Results

2.3.1 Estimates of year class strength

The calculated indices for the period 1965-72, using the Haug and Nakken method for k = 10, are listed in Table 1.

For cod and haddock additional estimates of year class strength in the pre-recruit phase are available from the USSR trawl surveys. Abundance indices of 3 year old fish from these surveys are given in Tables 2 and 3. The data are from the report of the 1974 meeting of the North-East Arctic Fisheries Working Group (Anon., 1974).

Virtual Population Analysis (VPA) estimates of absolute year class strength at the age of recruitment are available for herring, cod and haddock, and these data are given in Tables 2 to 4. In Table 5 the preliminary results obtained for capelin are given.

2.3.2 Relationship between 0-group abundance and subsequent year class strength

In general there appears to be good agreement between abundance estimates as determined from 0-group and pre-recruit surveys, and year class strength as subsequently determined from VPA. The VPA estimates for the more recent year classes should be regarded as provisional because there are relatively few years of catch data available and therefore the VPA estimates are subject to error. The number of year classes for which there are abundance estimates from both 0-group surveys and VPA are too few at present for any statistical analysis to be made. However, the indications are that the 0-group and pre-recruit survey data are sufficiently good to provide useful estimates for prediction of future catches. Indeed the North-East Arctic Fisheries Working Group now uses these data as estimates of the sizes of cod and haddock year classes recruiting to the fishery for predictions of catches and stock size. These predictions are used in the case of cod for determining the Total Allowable Catch now that the fishery is subject to regulation by catch quota.

For herring there seems to be a fairly close relationship between the two independent estimates of year class strength. Two of the year classes, those of 1963 and 1964, were very heavily fished as juveniles, and the year class strength measured at four years of age is accordingly relatively low.

For capelin, the 0-group abundance indices may only be used as a very rough indication of subsequent year class strength. One of the reasons for the unsatisfactory relationship may be that some of the 0-group capelin have too low a target strength to be properly recorded under all conditions.

2.3.3 Sources of error in abundance indices

How a certain fish concentration will be recorded on the echo-sounder paper will depend on the power and gain settings of the echo-sounder.

Only an echo-sounder with a TVG (time varied gain) function operating at $20 \log R + 2 \alpha R$ will give the correct picture of the density grading throughout the vertical layer. Echo-sounders without TVG-function will underestimate the density of the deeper layers on the paper record while operating the TVG-function at $40 \log R$ will over-estimate the deeper layers.

(ctd. on page 14..)

Table 1. Abundance indices [(nautical mile)^2 x 10^{-3}] of 0-group fish during the period 1965-72. (T = A_s + 10 A_d).

	Herring	Capelin	Polar Cod			Cod
			West	East	W + E	
Year	T	T	T	T	T	T
1965	4	37	0	0	0	6
1966	21	119	28	101	129	<1
1967	2	89	0	165	165	34
1968	0	99	34	26	60	25
1969	<1	109	17	191	208	93
1970	0	51	29	168	197	606
1971	0	151	31	150	181	157
1972	0	275	16	124	140	140

ctd.

	Haddock	Saithe	Redfish	Mackerel	Long rough dab	Greenland halibut	Sum of species
Year	T	T	T	T	T	T	T
1965	7	0	159	0	66	0	279
1966	1	1	236	0	97	0	602
1967	42	33	44	0	73	0	284
1968	8	4	21	0	17	0	234
1969	82	0	295	20	26	0	833
1970	115	<1	247	0	12	<1	1 228
1971	73	0	172	0	81	<1	815
1972	46	<1	177	<1	65	8	851

Table 2. Estimates of year class strength of North-East Arctic cod.

Year class	0-group abundance		III-group from USSR trawl surveys*	Stock size (in millions) at 3 years old from VPA*
	Hylen and Dragesund (1973)	Haug and Nakken (1973)		
1956	-	-	14	932
1957	-	-	13	1 060
1958	-	-	19	1 253
1959	-	-	16	1 044
1960	-	-	13	697
1961	-	-	2	527
1962	-	-	6	1 156
1963	230	-	76	2 263
1964	140	-	46	1 930
1965	10	6	<1	258
1966	20	<1	1	137
1967	30	34	1	243
1968	-	25	5	507
1969	-	93	9	1 178
1970	-	600	79	(2 000)
1971	-	157	18**	-
1972	-	140	16**	-
1973	-	-	18**	-

* From 1974 Report of the North-East Arctic Fisheries Working Group (Anon., 1974).

** Estimated from catches of younger age groups.

Table 3. Estimates of year class strength of North-East Arctic haddock.

Year class	0-group abundance		III-group from USSR trawl surveys, Sub-area 1*	Stock size (in millions) at 3 years old from VPA*
	Hylen and Dragesund (1973)	Haug and Nakken (1973)		
1956	-	-	27	325
1957	-	-	14	241
1958	-	-	5	110
1959	-	-	33	240
1960	-	-	72	273
1961	-	-	34	314
1962	-	-	4	97
1963	29	-	12	232
1964	35	-	15	282
1965	9	7	<1	14
1966	4	<1	<1	16
1967	50	42	8	152
1968	-	8	3	126
1969	-	82	120	1 393
1970	-	115	31	(385)
1971	-	73	3**	-
1972	-	46	2**	-
1973	-	-	2**	-

* From the 1974 Report of the North-East Arctic Fisheries Working Group (Anon., 1974)

** Estimated from catches of younger age groups.

Table 4. Estimates of year class strength of Norwegian spring spawning herring.

Year class	0-group abundance: Dragesund and Nakken (1973)	0-group abundance: Haug and Nakken (1973)	Stock size (in millions) as 4 year olds from VPA (Dragesund and Ulltang 1973)
1959	326	-	15 819
1960	147	-	5 492
1961	38	-	1 748
1962	15	-	91
1963	54	-	66
1964	75	-	7
1965	9	4	3
1966	23	21	6
1967	4	2	very poor
1968	2	0	" "
1969	5	<1	" "
1970	-	0	" "
1971	-	0	-
1972	-	0	-

Table 5. Estimates of year class strength of capelin. The estimates as adults are based on acoustic surveys, egg and larvae surveys and data from tagging experiments. P = poor; A = average; S = strong. Also given are Norwegian catches during the capelin winter fishery 4 years after the 0-group abundance measurements.

Year class	0-group abundance (Haug and Nakken 1973)	As 4 years old (unpubl.data)	Catches (in million hectolitres) during the Norwegian winter capelin fisheries 4 years after the 0-group abundance measurements
1965	37	A	4.5
1966	119	S	10.0
1967	89	S	13.4
1968	99	A	12.4
1969	109	A	11.2
1970	51	P	7.7
1971	151	A**	-
1972	275	S**	-

** Estimates from catches of younger age groups.

2.3.3 (ctd)

The reflecting properties of different species is an important factor. The smaller 0-group capelin and long rough dab appear to have a lower reflecting coefficient and target strength than the other species occurring in the Barents Sea. This will underestimate densities of capelin and long rough dab compared with other species when the echo-sounder is run at a constant amplifier setting.

Having decided which parts of the survey lines are scattered or dense, the areas of scattered and dense concentrations are found by drawing isolines through points of equal density. The drawing of isolines will be a variable factor, and the procedure here may well differ between scientists.

The crude equation (1) for calculation of abundance indices has only two density gradings. The factor $\underline{k}$ is uncertain. Fishing experiments indicate a $\underline{k}$ value of 10 (Dragesund, 1970), but echo-integrator readings indicate a value of $\underline{k}$ between 6 and 8.

The short-term space and time variations in distribution might affect the abundance estimate of 0-group fish. Space variability will contribute to the variance of the estimate. If a randomly distributed survey grid is assumed, this variance is likely to increase with decreasing distribution area. Time variations will result mainly in a bias of the abundance estimate.

2.4 Improvements

2.4.1 Acoustics

The acoustic method applied in the 0-group surveys of the Barents Sea has taken advantage only to a limited degree of recent improvements within this technique. Several of the participating vessels have now been equipped with echo-integrators to measure the density of the scattering layers formed by the 0-group fish. There is still some experimental work to be done before these methods can be fully utilised. The general method for electronic integration is described in an FAO Manual (Forbes and Nakken, 1972), but a short review is given below referring to density measurements.

When the echo-sounder is operated with a time varied gain compensating for one way spreading loss and two way attenuation loss and the incoming signal voltage is squared, the squared signals can be integrated over a given depth layer and summed over a unit distance (say one nautical mile). The resulting signals which can be given as millimetres deflection (M) on a recorder are then proportional to the mean density of the scattering layer integrated.

$$\rho_A = C\ M$$

where ρ_A is density, i.e. numbers of fish per unit surface area within the layer integrated, M is integrator deflection in millimetres, and C is a constant expressing the density required to give one millimeter deflection per mile. The constant C changes with fish size and species; it can be found from calibration.

The method is easily applied as long as the different species can be observed as separate layers, but when species are mixed the integrator values M must be split to give the contribution from the different species.

If three size or species groups are in the integrated layer one will have

$$M = M_1 + M_2 + M_3 \qquad (2)$$

where the M_1, M_2 and M_3 are the contribution of the three groups to the observed total integrator deflection.

Further

$$\begin{aligned} M_1\, C_1 &= \rho_1 \\ M_2\, C_2 &= \rho_2 \\ M_3\, C_3 &= \rho_3 \end{aligned} \qquad (3)$$

If k is true density composition between the three groups:

$$\begin{aligned} k_1 &= \frac{\rho_1}{\rho_1 + \rho_2 + \rho_3} \\ k_2 &= \frac{\rho_2}{\rho_1 + \rho_2 + \rho_3} \\ k_3 &= \frac{\rho_3}{\rho_1 + \rho_2 + \rho_3} \end{aligned} \qquad (4)$$

The values of M_1, M_2 and M_3 can be calculated from the equations (2) to (4).

The different values of C must be known, as well as the true compositions, k. The latter must be found from the trawl catches.

2.4.2 Sampling technique

As future O-group investigations in the Barents Sea are likely to rely more on the acoustic estimates than previously, more knowledge of the relative densities of the different species in a mixed layer is needed. Comparative fishing experiments with different gears or the use of Scuba divers and underwater photography could increase our knowledge of the degree to which the gear is sampling representatively. Experience has shown the need for accurate regulation of the fishing depth of trawls in order to fish precisely on the scattering layer being investigated. Multiple netsonde devices enable the trawl to be accurately aimed with the possibility of continuous depth adjustment if the depth of the scattering layer varies during the haul.

3. O-GROUP FISH SURVEYS AT THE FAROES, ICELAND AND EAST-GREENLAND

3.1 Introduction

In general the most intensive spawning of commercial species of fish at Iceland takes place off the south and southwest coasts with auxiliary activity elsewhere. To begin with, the movements of the young are almost entirely dependent upon the current system and the surveys were designed with this in mind.

A general outline of the system of water currents in the Iceland-East-Greenland area is shown in Figure 5. Warm Atlantic water arriving at the south coast of Iceland sets up a clockwise coastal current round the island. At the same time a westward deflection of this watermass takes place producing a circulation in the Iceland-East-Greenland Basin as well as a current of warm water running across to East Greenland and then south along the shelf. The Arctic Current arriving from the north through the Strait between Jan Mayen and Greenland is split in two, the East Greenland current running south over the East Greenland shelf and a second branch, the East Iceland Current, rounding Northeast Iceland in a southeasterly direction and sometimes extending as far south as the northern edge of the Faroe Plateau before receding to the north again.

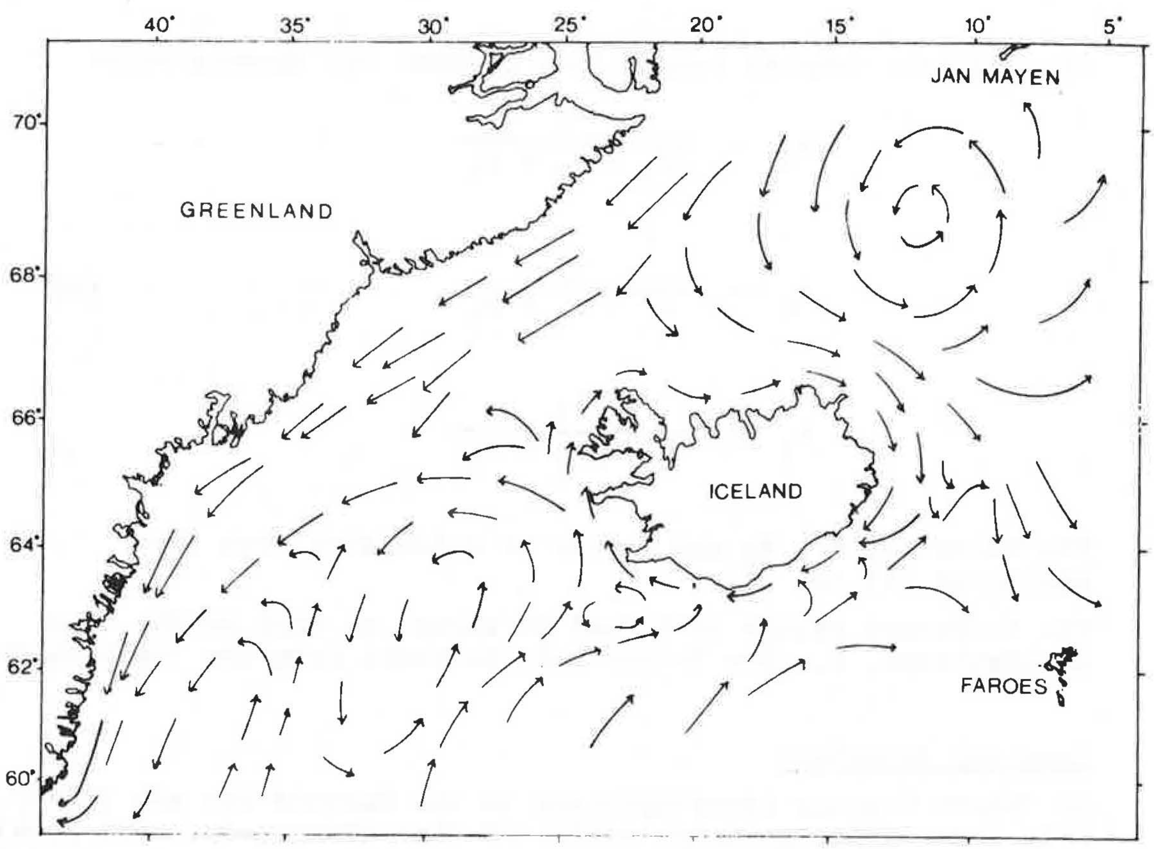


Figure 5. Main features of the systems of water currents in the Iceland-East Greenland area (Vilhjálmsson,1973). The map is redrawn from published data and verbal information from S.Aa. Malmberg.

It is clear that not only is there a migration of Greenland fish to spawn at Iceland, but also possibly a feed-back of larvae from Iceland to East Greenland. These areas must, therefore, be considered together as far as possible. A connection between Iceland and the Faroes is more uncertain or, at any rate, not at all obvious.

Following reports of considerable success in the Barents Sea in forecasting year class strength of fish at the 0-group stage by employing a combined technique of acoustic observations and fishing with pelagic trawls, an ICES meeting in the autumn of 1969 recommended that a multinational programme should be prepared in order to extend the method to the Iceland-East Greenland area.

In the following year (1970) work commenced and a series of four years of surveys have now been completed in the waters around Iceland, the northern Irminger Sea and over the East Greenland Continental Shelf as well as the banks to the north of the basin separating the two countries. In addition it was soon felt, that an attempt should be made to survey the Faroe region in the same way,and from 1972 this area has also been included.

The effort in the Iceland-East Greenland area has chiefly been concentrated in August, but some of the work has taken place in July and September. The Faroe area was on both occasions surveyed in the first half of July (Table 6).

Table 6. Surveys carried out in Icelandic and East Greenland waters and at the Faroes, 1970-1972.

Period		Country and number of vessels participating		Area
1970	1 Aug - 11 Aug	Iceland	1	Iceland-East Greenland
"	1 Aug - 11 Aug	Norway	1	" " "
"	21 Aug - 12 Sep	Germany (F.R.)	1	" " "
"	28 Aug - 12 Sep	Iceland	1	" " "
1971	28 Jun - 10 July	Germany (F.R.)	1	" " "
"	18 Jul - 29 Jul	U.K. (England)	1	" " "
"	5 Aug - 18 Aug	Iceland	2	" " "
"	5 Aug - 18 Aug	Norway	1	" " "
1972	1 Jul - 12 Jul	U.K. (England)	1	Faroes
"	13 Jul - 20 Jul	U.K. (England)	1	Iceland-East Greenland
"	15 Jul - 25 Jul	Iceland	1	" " "
"	28 Jul - 13 Aug	USSR	1	" " "
"	2 Aug - 25 Aug	Iceland	1	" " "
1973	1 Jul - 12 Jul	U.K. (England)	1	Faroes
"	31 Jul - 14 Aug	USSR	1	Iceland-East Greenland
"	9 Aug - 29 Aug	Iceland	1	" " "
"	28 Aug - 7 Sep	Iceland	1	" " "
"	14 Sep - 27 Sep	U.K. (England)	1	" " "

Due to the crowded research schedules of each nation, complete co-ordination has up to now been impossible. This, together with unavoidable mishaps onboard some vessels, has caused a relatively high scatter of effort, a poorer coverage than planned, and decreased reliability of the results. On the other hand, the very scattered effort has proved useful in deciding whether the predetermined timing was really suitable or not.

3.2 Methods

In view of the experience gained during the Barents Sea surveys, it was decided to employ a similar technique, i.e. assess the amount and distribution of 0-group fish by a study of the echo-trace and referring frequently to trawl-caught samples to determine the proportion of each species contributing to the echo-abundance. A detailed description of the general procedure is given in a paper by Dragesund, Midttun and Olsen (1970).

With experience it soon became evident that effort should not be evenly distributed over the whole of this area. In the Greenland Sea and to some extent over the East Greenland Shelf, the Dohrn Bank and deeper waters off northwest and northern Iceland, 0-group fish have a reasonably uniform distribution. In coastal areas, however, particularly off western and northern Iceland, the distribution is much more patchy, often with high concentrations. As a result, it has been found inadvisable to use a fixed survey and sampling grid for a large part of the area. Figure 6 shows the coverage and sampling grid for the surveys in 1972, which can be taken as a representative average of the four years so far surveyed.

3.3 Results

As far as possible a meeting has been held in Reykjavik subsequent to each survey, in order to make a preliminary appraisal of the data. Tentative appraisals for cod, haddock, capelin and redfish relative to the 1970 survey are given below:

	1970	1971	1972	1973
Cod	1	1/2	1/10	2
Haddock	1	?	1/5	2
Capelin	1	2/3	1	2
Redfish	1	1/2	1	2

At present it is not possible to suggest to what extent these surveys reflect the true size of the year classes. However, it is noteworthy that the 1970 year class of cod seems to be a good one as it is numerically responsible for 38% of the research vessel samples collected in 1974 off Northwest and North Iceland and appeared in high numbers off Northwest Iceland during a cruise in January 1973. With regard to the capelin, the 1970 year class has now gone through the fishery and yielded about 450 000 tons, which is only a small fraction of the quantity which appeared on the spawning grounds. The size of the 1971 and 1972 year classes has been verified on scouting cruises. It is not possible to speculate further on the year class strength of other species.

3.4 Discussion

In the first cruises the trawls and echo-sounders used were not standardised. This situation has progressively improved and in 1973 most ships participating used calibrated echo-sounders and integrators as well as standardised types of trawls (see Section 2.2.3). So far the technique of combined acoustics and fishing seems promising in these waters. (Instrumentation of the vessels has now reached a standard that should allow more sophisticated abundance estimates in the future (see Section 2.4.1)). As elsewhere, the main shortcomings are in the identification of the traces through fishing operations, which give problems in allocating integrator values to the different species.

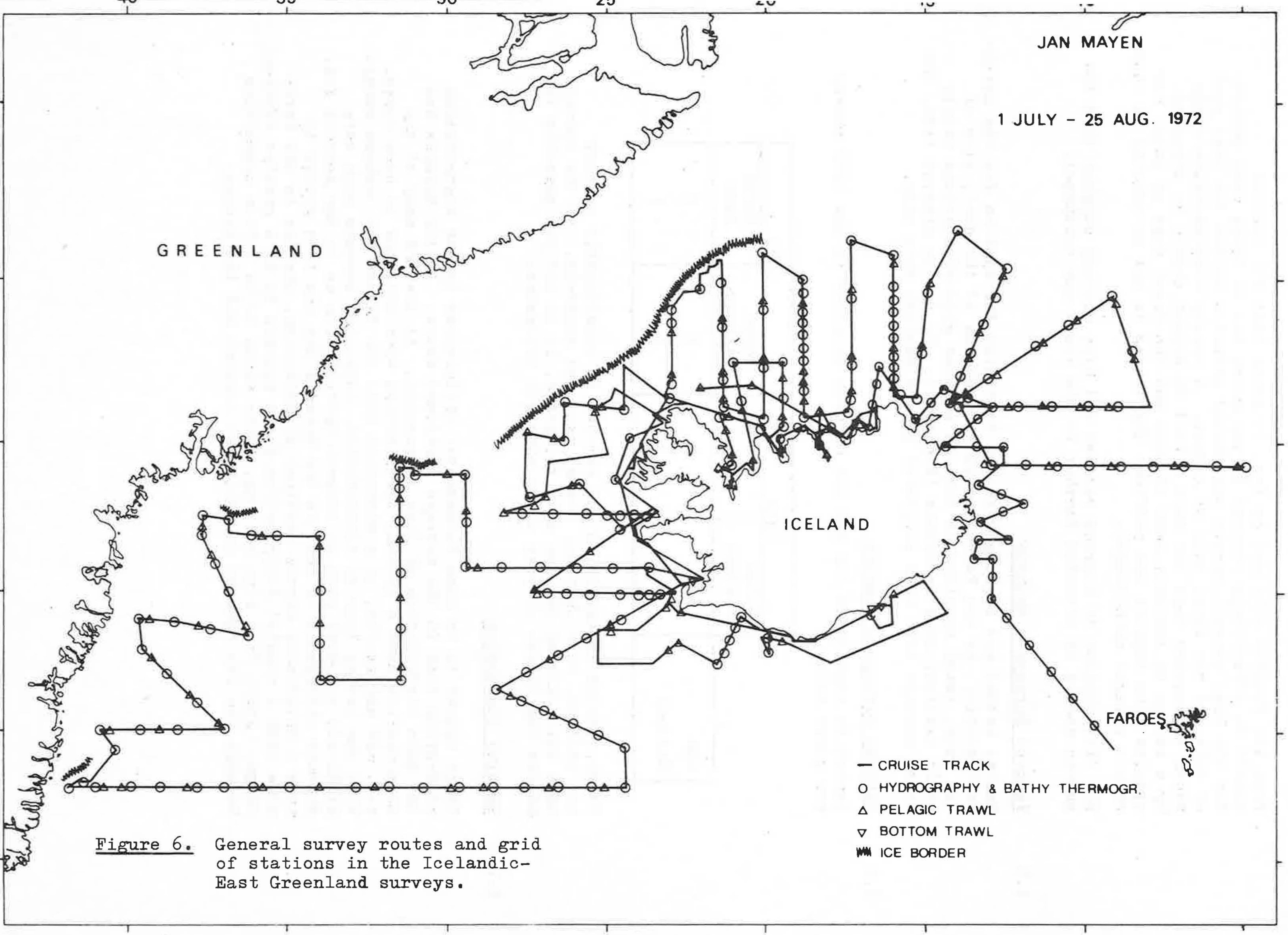


Figure 6. General survey routes and grid of stations in the Icelandic-East Greenland surveys.

From the results obtained so far, it seems that all species cannot be effectively covered in any given two to three week period. For the best overall result one should probable choose the last week of July and the first half of August. A really comprehensive study seems to require that the main effort in August should be preceded by a survey on the last week of June and the first days of July. For species like capelin and redfish, the timing is not so crucial as they remain pelagic much longer.

The distribution of 0-group redfish and blue whiting suggest that the survey should be extended further to the south and southeast.

3.5 Faroese Surveys - Methods

Survey method and fishing gear are basically the same as for the northwest Arctic. At the Faroes, however, because of the small size of the area, trawl sampling is done on a fixed grid of stations mainly at 15 nautical mile intervals (Figure 7). Up to the present time, the Faroe surveys have been completed by the English ship only.

3.6 Faroese Surveys - Results

Tentative appraisals for cod and haddock relative to the 1972 survey are given below.

	1972		1973	
	Faroe Plateau	Faroe Bank	Faroe Plateau	Faroe Bank
Cod	1	1	3	2
Haddock	1	1	1	1

Other species appearing in the catches in considerable numbers are redfish, blue whiting, Norway pout and sandeels. As the surveys have been carried out for only two years, it is not yet possible to assess the values of year class strength estimates.

3.7 General Discussion

There appear to be some fundamental differences in the distribution of 0-group fish in the surveys mentioned above. In the Barents Sea the main distribution of fish is oceanic. At Iceland many of the main species have a coastal distribution with evidence in some cases, e.g. cod and saithe, of a migration into the fjords and inshore areas. With the latter type of distribution, surveying becomes much more difficult compared with an oceanic distribution as in the Barents Sea. Another difference is that in the Barents Sea the fish appear to have a relatively narrow vertical distribution, whereas in the Faroe area with a coastal distribution there appears to be a greater vertical range. Apart from blue whiting, there seems to be little connection between the fry spawned at Southeast Iceland and the Faroes.

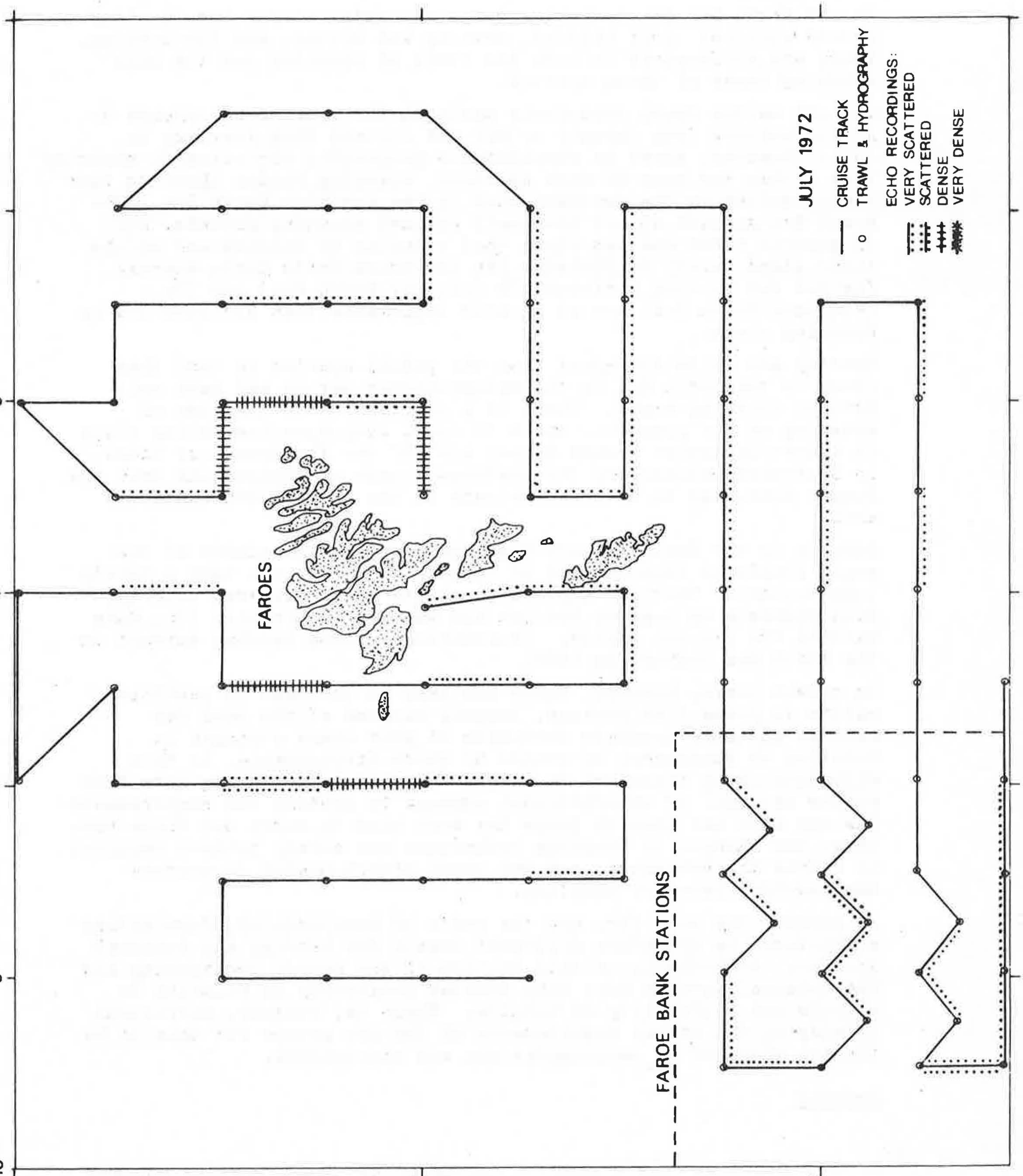


Figure 7. General survey routes and grid of stations at the Faroes.

4. YOUNG FISH SURVEYS IN THE NORTH SEA

4.1 Introduction

In the North Sea pre-recruit surveys are made chiefly for the four gadoid species: cod, haddock, whiting and saithe, and for herring. There are differences in both the times of spawning and the main spawning areas of these species.

Cod and saithe spawn relatively early in the year, from January to April, haddock from January to May and whiting from February to June. However, there is considerable geographic variation in spawning time within the area of each species; spawning begins three to four weeks earlier in the southern than in the northern North Sea. The North Sea gadoids do not have well defined spawning grounds, but in general terms one can state that spawning by haddock and saithe takes place mainly in Division IVa (northern North Sea), whereas for cod and whiting Division IVb (central North Sea) and IVc (southern North Sea) are of greater importance than Division IVa as spawning areas.

Herring are quite different from the gadoid species in that they spawn in the North Sea in the autumn-winter period and have well defined spawning areas. There is a progression in the time of spawning as one goes from north to south with spawning taking place in August/September around Orkney and off the Aberdeenshire coast, in September/October off the northeast coast of England and over the Dogger Bank, and in November/January in the Channel and Sandettié area.

Surveys in the North Sea aimed at measuring the abundance of the young stages of fish species of commercial importance have a fairly long history. Scottish surveys to sample young gadoids, with the main emphasis on I-group haddock and whiting in Division IVa, date back to the pre-war period. International young herring surveys in the North Sea started in 1960.

In recent years, however, there has been an increase in participation in young fish surveys, largely because of the need for earlier and more accurate forecasts of year class strength in relation to management of stocks by quota arrangements. In this situation it is necessary to assess the value of existing data from either national or international surveys in meeting the requirements. One can also use them to judge the best time to carry out these surveys, the changes in sampling techniques and survey pattern required to refine the estimates, and the total effort needed to achieve the required level of sampling.

At present the need for, and the state of knowledge of, forecasting recruitment is at rather different levels for herring and demersal species. Accordingly in this section of the report the herring and the demersal species have been treated separately in relation to methods and reliability of results. There is, however, sufficient overlap in the survey requirements of the two groups for them to be treated together in recommendations and conclusions.

Herring

In this section, only a general review of the Young Herring Surveys is given. For a more detailed evaluation of these surveys the reader is referred to the Report of the Working Group on North Sea Young Herring Surveys (this volume).

4.2 Methods

4.2.1 Distribution of hauls

Initially the International Young Herring Surveys (IYHS) covered the North Sea from 51°30'N to 58°N. In recent years the coverage has been extended northwards, and into the Skagerak and Kattegat. The area sampled in 1973 is shown in Figure 8. In 1960 and 1961 two surveys were carried out in each year, one in spring and one in autumn. Since 1964, surveys have been made only in spring, and in recent years they have been confined to the month of February. The area covered is sub-divided into statistical rectangles of 30' latitude and 1°longitude. The time needed for each vessel to complete its series of squares is two to three weeks.

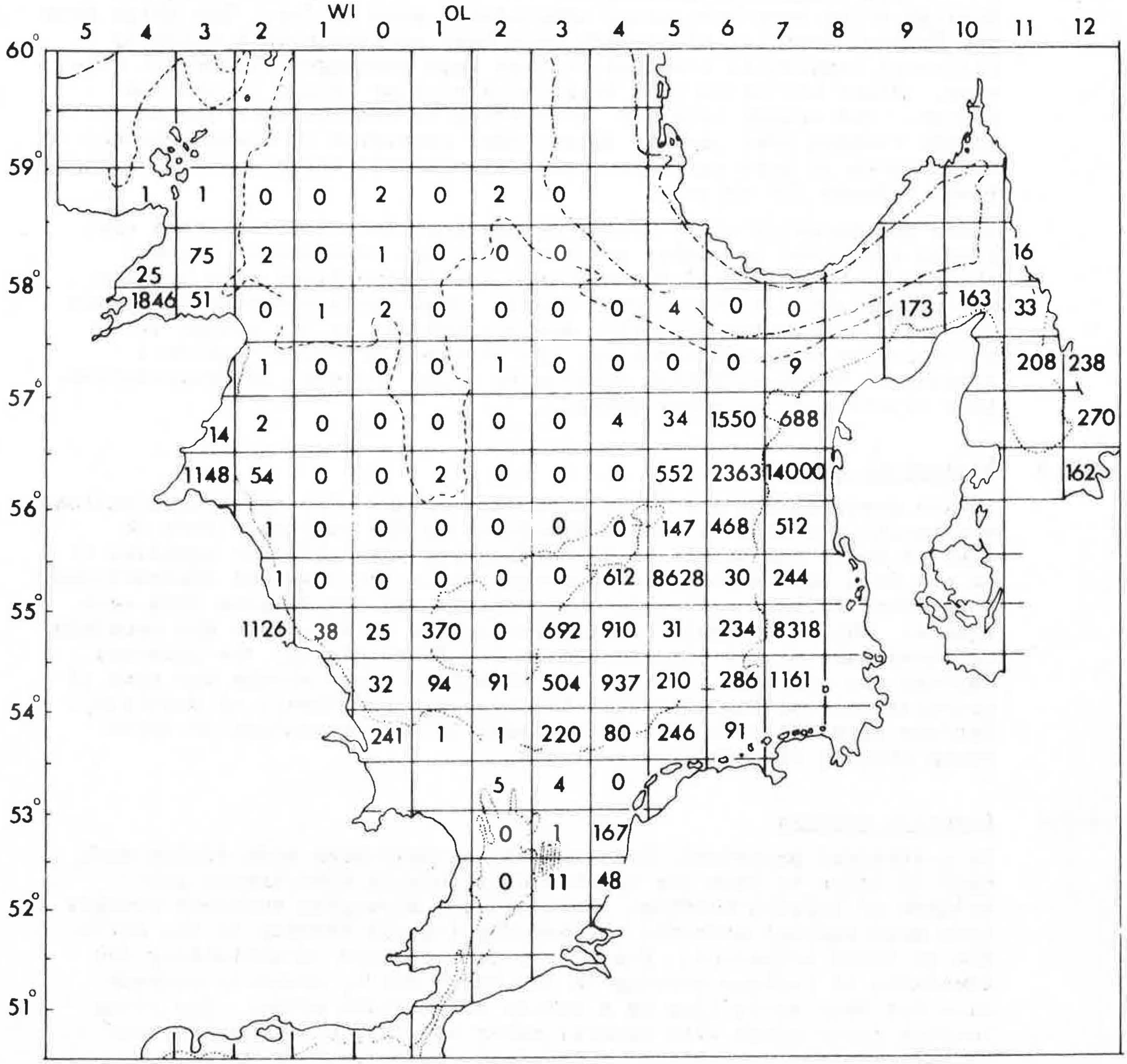


Figure 8. Mean density of I-group herring per statistical square, February 1973 (numbers per hour trawling).

In past years, the sampling effort has been distributed evenly over the whole survey area. The statistical squares were grouped in blocks of four and allocated to the participating countries. Normally each country would work in several regions of the North Sea. At least one haul was made in each square. If the first haul contained more 1 000 herring, a second haul had to be made in that square. The Working Group on North Sea Young Herring Surveys has recently adopted a scheme for stratified sampling, which concentrates sampling effort in the areas of high fish density.

4.2.2 Fishing gear

During the IYHS programme, all participating ships used bottom trawls with a fine mesh cod end. The instructions have been to use a Dutch type commercial herring trawl. However, only the Dutch and English ships have been using identifical gear so far. The ships from the Federal Republic of Germany have been working with a slightly different commercial trawl which they kept unchanged during all surveys. Other countries have been using similar trawls of national design. Not enough detailed information is available at the moment on the fishing gear used by these other countries to assess whether differences in gear may have caused significant differences in fishing power between the ships.

Hauls are normally of half-hour or one-hour duration. Catches are always expressed in number per hour fishing. Because of diurnal changes in behaviour of the herring, the instructions have been to restrict fishing to "daylight" hours. Trawl sets are made at random positions within the allocated square, subject to the bottom being suitable for demersal trawling. No attempts are made to direct fishing at spots with high density by using acoustic instrumentation, past experience, or other means.

4.2.3 Biological sampling

Length measurements are taken from each catch. For age determination and racial characters, the instructions in the past have been to take at least one sample of 50 herring per block of four squares. It is now felt that this sampling frequency is too low, and instructions for future surveys will call for meristic and age samples from each square. While the adult herring population in the North Sea consists of three pure stocks (Banks, Buchan and Downs stocks) the immature herring are composed of a mixture of all of these stocks and also of recruits originating from ICES Division VIa (northwest of Scotland). Various problems have been encountered in the separation of these young herring into their sub-groups.

4.2.4 Acoustic surveys

As a standard procedure, echo-recordings have been made during each haul in order to test the relationship between echo-traces and catches of I-group herring. In addition, Norwegian research vessels have made special acoustic surveys for I-group herring in the North Sea on three occasions. Results so far obtained in estimating the abundance of I-group herring in the North Sea by acoustic methods have not been satisfying as a series of problems arise. The young herring occur mixed with several other species, and normally make up only a minor proportion of the total echo-sampling volume. Allocation of integrator values to herring is therefore to a large degree subjective. Other problems are caused by the shallowness of the area. During daytime, herring may be distributed very close to the bottom, while at night they may be close to the surface layers, above the depth of the transducer. By improvements of the acoustic technique and sampling procedure, such surveys may in future gain increased importance.

4.2.5 Calculation of abundance indices

As outlined above, the herring population in the North Sea is made up of three major, independent spawning groups. Because of the difficulties of separating these in the catches from the feeding fisheries and the overwintering fisheries, assessments have been done by treating the North Sea population as a homogenous unit stock. Similarly, the recruitment to the North Sea has had to be treated for the population as a whole. The biological sampling discussed in Section 4.2.3 is aimed at getting independent annual recruitment indices for the individual stocks in due course, but this is not yet possible.

Because of the gradual expansion of the survey area over the years, the mean numbers per square for each survey are not directly comparable. To overcome this problem, a standard area of 53 squares has been defined, and the mean abundance within this standard area has been calculated for each of the surveys.

4.3 Results

Abundance indices from the International Young Herring Surveys have been compared with actual recruitment of the corresponding year classes. Estimates for recruitment were derived from Virtual Population Analysis for the whole North Sea excluding Skagerak (See the Report of the Working Group on North Sea Young Herring Surveys in this volume).

A significant correlation between IYHS-estimates and VPA values was found, indicating that IYHS estimates can be used - to some extent - to predict actual recruitment. However, the regression line has a large intercept on the Y-axis. For an IYHS-estimate of zero, the regression line would still predict a year class strength of 40% below average. Obviously, a very small year class cannot be predicted in this way.

4.4 Other Surveys

In addition to the International Young Herring Surveys, regular surveys have also been made on young herring by both England and the Netherlands. The English survey for 0-group herring has been carried out by pelagic trawl at fixed stations in inshore water along the English coastline, extending from the mouth of the Thames to the Scottish/English border. It takes place during the summer months. The Dutch survey for larval herring has been carried out during spring and early summer in estuarine water on the Dutch coast. The larvae are caught by a 2 m diameter plankton net, which fishes on the tidal stream from an anchored ship.

Both of these surveys are aimed at getting earlier measures of recruitment to one or more of the distinct North Sea spawning stocks rather than to the total North Sea population. The series of data so far available is too short to assess their accuracy in doing this, but the initial results look promising.

4.5 Discussion

The highly significant correlation found between IYHS-estimates of I-group abundance, and the year class strength at the same age as calculated by VPA, shows that IYHS-estimates can be used in forecasting year class strength and setting a Total Allowable Catch. It should be noted, however, that the regression line of year class strength on IYHS abundance cuts the Y-axis at 60% of the mean year class strength. The present method will therefore be misleading at low year class strengths, because it cannot give a forecast less than 40% below average.

For further comments on sources of error and improvements in the abundance estimates, the reader is referred to the Report of the Working Group on North Sea Young Herring Surveys in this volume.

Acoustic methods have not yet been successful in measuring abundance of young herring in the North Sea because of the problems connected with the vertical distribution of the herring and the mixing with other species. Further investigations concerning methodology and equipment should be made by those countries which have the greatest experience and expertise in acoustic methods. When improvements in these respects are available,acoustic surveys will have to be made in conjunction with the present trawling surveys for some years.

A disadvantage of the present surveys is that they give an estimate of the abundance only of I-group herring. Because I-group herring are already making a substantial contribution to the total catch of North Sea herring, an estimate of their abundance at this age is of limited value when the Total Allowable Catch is being estimated. It would be desirable to obtain abundance estimates at an earlier stage of the life history, i.e. when the herring are 0-group, if the current exploitation of juveniles is to continue. This would then enable an earlier and more accurate estimate of the Total Allowable Catch to be made under the present fishing regime.

Demersal species in the North Sea

4.6 Methods

There are currently three series of surveys of demersal species being carried out in the North Sea. Each will be discussed separately in relation to methods and results below.

4.6.1 International Young Herring Surveys

The methods employed in these surveys have been described in the previous part of this report and need not be discussed further here.

4.6.2 Other demersal I+ surveys

Scottish research vessels have carried out routine demersal surveys in the northern North Sea for the last 50 years. Two or three surveys each of about three weeks' duration were made each year. These surveys were normally carried out in March/April, June/July and October/November. Trawl hauls of one hour's duration were made at the fixed sampling positions shown in Figure 9. The end products of the surveys were estimates of year class strength expressed as the numbers of I+ haddock and whiting caught per 10 hours' trawling. Catch rates were calculated for sub-areas separately and the overall indices obtained by applying weighting factors to the sub-area values.

In recent years, vessels from USSR have carried out demersal surveys covering virtually the whole of ICES Sub-area IV. Information is not available on the way sampling positions were chosen for the surveys.

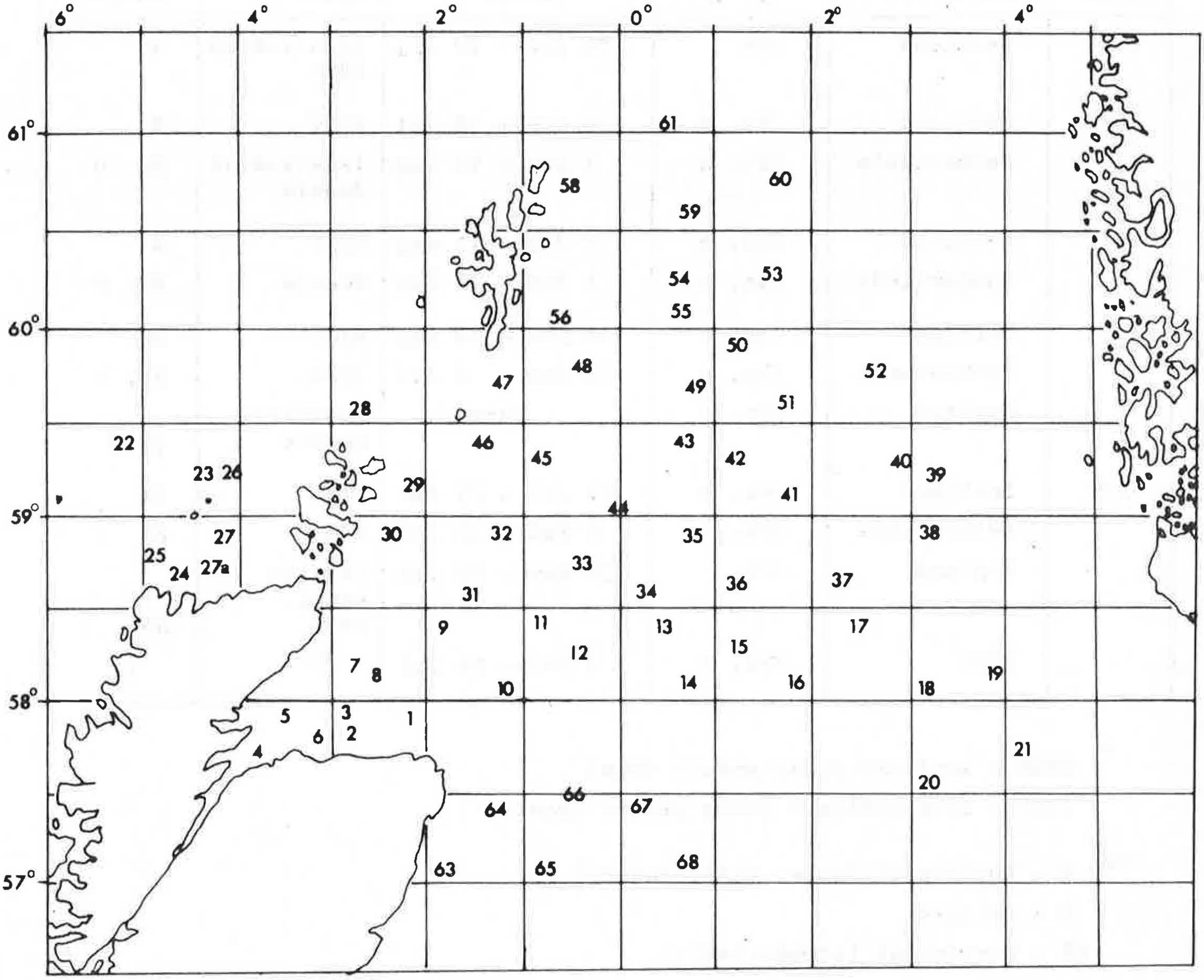


Figure 9. Sampling positions of Scottish demersal surveys.

4.6.3 Pelagic 0-group surveys

These surveys are of recent origin, having been initiated by Scotland in 1969. Table 7 shows that there has been a rapid increase in research effort in this field, and it is believed that Denmark will participate in 1974.

For the first four years there was a wide divergence in the gears used by different countries, as shown in Table 7, and even when the same gears were used by different nations they were frequently used in different ways. There have also been large differences in the timing of the surveys. However, at a meeting of the Roundfish Working Group in 1973, recommendations were made on the standardisation of the gear used in pelagic surveys, the choice of sampling positions and the manner in which the water column should be sampled (Anon., 1973). The

Table 7. Gadoid pelagic 0-group surveys in the North Sea.

Year	Participant	Area surveyed	Sampling period	Gear used*	Sampling method**
1969	Scotland	IVa	26 Jun - 22 Jul	Isaacs-Kidd SYGT	H
1970	Scotland	IVa, b	20 Jun - 30 Jul	SYGT	H
	Netherlands	IVa, c	1 Jun - 10 Jun	Isaacs-Kidd Engels	HS, O
1971	Scotland	IVa, b	7 Jul - 11 Aug	SYGT	H
	Netherlands	IVa, b	1 Jun - 10 Jun	Engels	HS, O
1972	Scotland	IVa, b	14 Jul - 10 Aug	SYGT	H
	Netherlands	IVa, b	15 Jun - 4 Jul	IYGT	HS, O
	England	IVb, c	June	Boothbay, Engels	O, H
1973	Scotland	IVa, b	11 Jul - 29 Jul	IYGT	HS
	Netherlands	IVa, b	2 Jul - 11 Jul	IYGT	HS
	England	IVb	30 May - 20 Jun	Capelin trawl, IYGT	HS
	USSR	IVa, b	1 Jul - 15 Jul	?	?

* SYGT = Scottish young gadoid trawl
IYGT = International young gadoid trawl

** H = Horizontal (upper water layers)
O = Oblique
HS = Horizontal (stratified).

4.6.3 (ctd) recommendations were that hauls should last for one hour and that each tow would consist of fishing for 20 minutes near the sea bed, for 20 minutes near the thermocline and for 20 minutes between the thermocline and the surface. Hauls were to be made in the centre of each statistical rectangle. The standard procedure was used by England, Scotland and the Netherlands for the 1973 survey, but it is not yet known whether the USSR used the same method.

4.7 Results

4.7.1 International Young Herring Surveys

Abundance indices were calculated for I-group cod, haddock and whiting, using data obtained from the catches of gadoids made during the surveys. The mean catch per 1 hour fishing was calculated for each statistical rectangle separately and those values were averaged to give an annual for the whole of the area surveyed.

There is a high degree of correlation between the cod year class strength estimates obtained in this way and the estimates of recruitment based on the VPA for Divisions IVb and c. This is shown in Figure 10.

The surveys are less suitable for the estimation for haddock year class strength because young haddock occur predominantly in Division IVa and coverage of this part of the North Sea was often poor.

Insufficient data were collected prior to 1972 during the surveys to allow one to assess whether the surveys are likely to be of value in estimating whiting year class strength.

4.7.2 Other demersal I+ surveys

The Scottish routine surveys have generally given reliable estimates of the year class strengths of haddock in Sub-area IV and agree well with those subsequently obtained from the VPA (see Figure 10). In the case of whiting the agreement is less good. This may be due to the fact that the VPA refers to recruitment over the whole of Sub-area IV, whereas the Scottish surveys only relate to Division IVa and a small portion of Division IVb. No satisfactory estimates of cod year class strengths have been obtained from the Scottish surveys.

Sufficient data are not yet available to assess the value of the USSR surveys.

Estimates of year class strength derived from VPA and demersal surveys are summarised in Table 8.

4.7.3 Pelagic O-group surveys

The comparatively short time-span covered by these surveys, coupled with the fact that there have been major differences in sampling techniques, both within and between nations, makes evaluation of the method difficult. The longest series of data are those collected by Scotland, and these have been used to calculate the indices of year class strength given below as numbers per 10 hours fishing:

Species/Year	1969	1970	1971	1972	1973
Haddock	450	480	3 030	100	1 220
Whiting	40	10	210	1 150	300
Cod	20	80	13	3	25

The values given here differ from those presented to the 1973 ICES Statutory Meeting (Anon., 1973). The revised indices are based only on hauls made during daylight, taken as extending from 0400 - 2200 hours and, in the case of haddock and whiting, only on hauls made within the parts of the survey area where the two species were normally found to occur regularly.

The data on which these indices are based are open to criticism on two main grounds. Firstly, the sampling periods were not the same in each year and secondly, the sampling methods was changed in 1973.

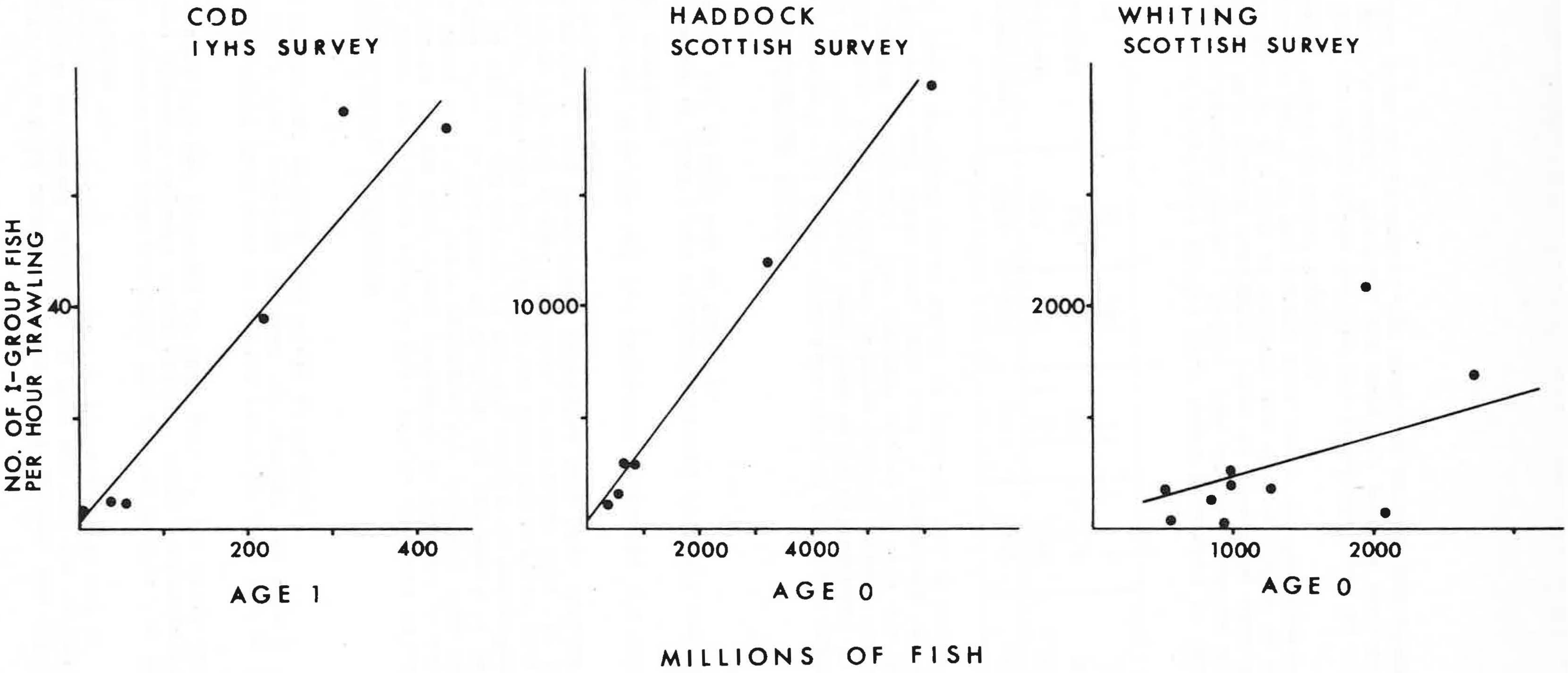


Figure 10. Calculated regression lines of year class strength estimates obtained from VPA and young fish surveys.

Table 8. Estimates of year class strength of North Sea gadoids.

Year class	Cod (IVb,c)		Haddock (IV)			Whiting (IV)		
	A VPA[1)]	B IYHS[4)]	C VPA[2)]	D IYHS[4)]	E Scottish survey[3)]	F VPA[2)]	G IYHS[4)]	H Scottish survey[3)]
1960	-	-	154	-	310	524	-	350
1961	-	-	619	-	1 560	1 282	-	390
1962	61	-	3 253	-	12 000	1 978	-	2 170
1963	205	-	64	-	20	545	-	80
1964	157	-	64	-	80	1 003	-	540
1965	230	-	145	-	90	833	-	290
1966	220	38	720	-	3 060	1 005	-	400
1967	39	5	6 178	-	20 000	2 769	-	1 380
1968	63	5	391	(34)	1 100	950	-	60
1969	315	75	141	(25)	970	2 093	-	160
1970	437	72	785	1 668	3 000	-	-	140
1971	11	3	127	567	7 000	-	277	1 000
1972	-	50	-	127	1 606	-	1 051	3 600
1973	-	(8)	-	(415)	-	-	-	-

Correlation B on A	Correlation E on C	Correlation H on F
r = 0.964	r = 0.949	r = 0.6386
a = 0.191	a = 3.168	a = 0.582
b = 1.44	b = 762.57	b = 172.53

1) Millions of fish at age 1.

2) Millions of fish at age 0.

3) Numbers of I+ fish per 10 hrs trawling.

4) Numbers of I+ fish per 1 hour trawling.

4.7.3 (ctd) However, it is encouraging to note that the year classes that were caught in largest numbers in the pelagic surveys (1971, haddock; 1972, whiting; 1970, cod) were subsequently confirmed as being of above average strength by the Scottish I-group demersal surveys and for the 1970 cod year class from the results of the commercial fisheries.

4.8 Discussion

Generally, there are two periods in their life history when the abundance of young gadoids can be estimated. Firstly, the O-group can be sampled during the pelagic phase, and secondly, the I-group can be surveyed once the year class has gone to the bottom. The change from the pelagic to the bottom phase is a gradual process and because there is no single gear to sample both the pelagic and bottom phases, a certain part of the first year of life is unsuitable for surveying. This period may vary from species to species, but in general it can be taken as somewhere between mid-summer and early winter.

It is obvious that in the North Sea where gadoids start to enter the fishery in their second year of life, timing of the survey in such a way that the earliest possible estimates become available is of major importance. In this respect the pelagic O-group surveys are of great potential value. However, there are a few drawbacks. Firstly, in much of the southern North Sea, cod and whiting have no clearly defined pelagic phase, and are not available to the pelagic gear, because the young of these species are concentrated in very shallow continental waters. Thus it is possible that pelagic surveys will only give reliable information for the northern North Sea. Secondly, as little is known about the behaviour of the fish during the pelagic phase, the most suitable timing and design of the surveys has not yet been established. Lastly, it is not yet possible to evaluate the reliability of the abundance indices derived from these surveys, although the results seem promising. Now that more countries are putting effort into these surveys, international coordination, especially in respect to basic research which would provide the knowledge required for planning of efficient routine survey techniques, seems extremely important. Up to now, coordination has been completely on the basis of individual contacts, but this should be formalised in future.

The Scottish surveys of I-group gadoids have been successful in giving reliable estimates of year class strength for North Sea haddock and to a lesser extent for whiting, but have not given adequate estimates of cod year class strengths. The International Young Herring Surveys in the past have more or less complemented the Scottish surveys in respect of the area coverage. The results so far indicate that reliable estimates can be derived for cod, but because the young haddock concentration is partly outside the area, the data are possibly not valid for this species unless the survey is extended to 62°N, as it was in 1974. A major advantage in comparison with the Scottish survey is the three months' gain in the time at which the estimates become available.

The Meeting did not have the opportunity to study details of the different surveys carried out, and from those to assess the possibility of combining the results of the Scottish trawling survey and the International Young Herring Survey. However, in view of the difference in timing and in gear, a combination of these data raises some problems. The most efficient use of the effort currently available for carrying out these I-group surveys should be re-examined by the appropriate Working Group of the Demersal Fish (Northern) Committee.

The possibilities of using echo-abundance were discussed, but at the moment there appears to be no solution to the problems involved in these methods. These relate to the shallowness of part of the area where fish may be difficult to detect, either near the bottom or near the surface. Also the variety of species, compared with other areas, makes it difficult to split the recordings among these species reliably. For the pelagic surveys, difficulties arise in acoustic detection of very small gadoids (generally 15-50 mm) distributed among planktonic organisms.

A problem arising from the use of the young herring survey data for gadoids is that these surveys are primarily directed towards herring. Now that the Working Group on North Sea Young Herring Surveys has decided to reorganise the distribution of sampling, the roundfish data might become less adequate, especially should part of the total area no longer be sampled. Such problems could be solved if the status of these surveys was to be changed into a general young fish survey in which the demands of both herring and gadoids could be given due consideration.

Up till now the analysis of the International Young Herring Surveys gadoid data has been a matter of individual initiative, which, although supported by recommendations by the North Sea Roundfish Working Group, has not yet been formalised. In addition, there has not been an opportunity for a thorough analysis and it appears that in view of the need for reliable recruitment estimates, something should be done about this.

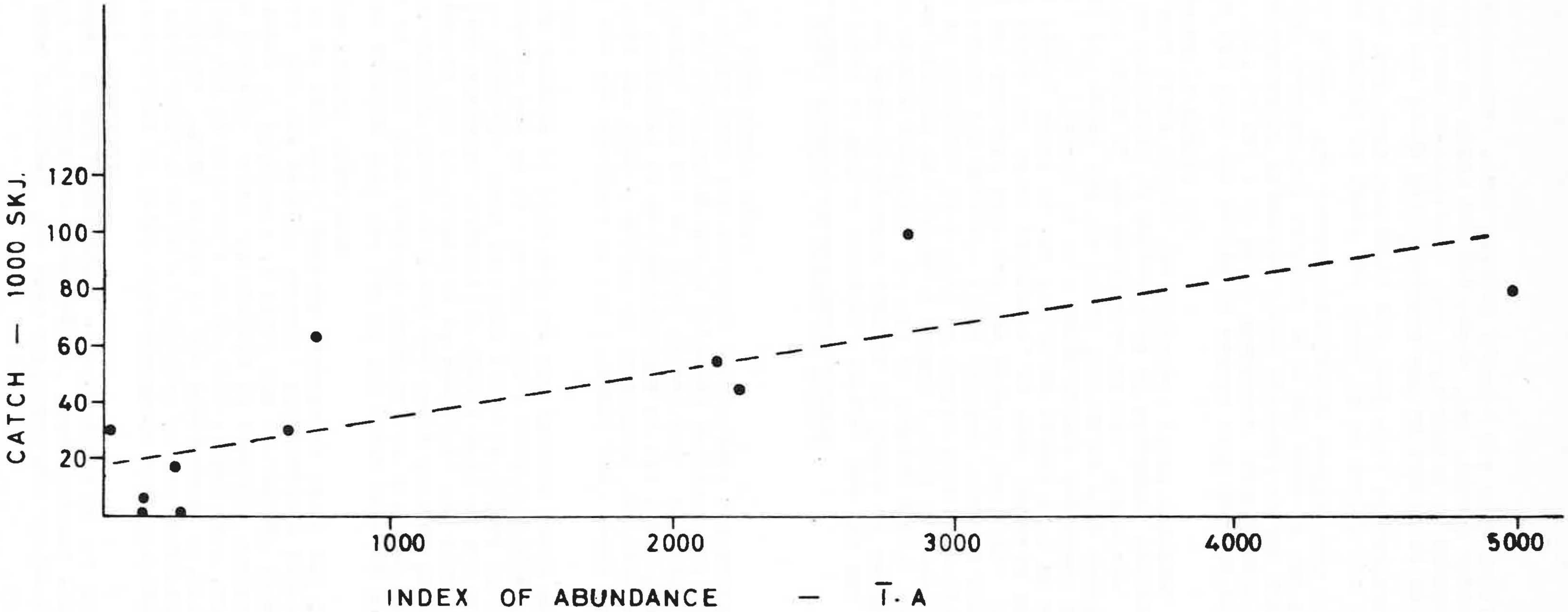
5. O-GROUP SPRAT SURVEYS IN NORWEGIAN FJORDS

The Institute of Marine Research, Bergen, has for the last four years carried out echo-integrator surveys in fjords of western Norway in order to obtain abundance indices of O-group sprat. These surveys have been carried out during a 10-day period in October-November. Indices of abundance have been estimated from echo-integrator readings and calculated for separate fjord systems from the mean integrator reading per nautical mile and the size of the area. These indices are the basis for catch prognosis, as they indicate the abundance of O-group sprat, which in the following summer will be available to the fishery. The fishery is to a large extent dependent on the stock of one year old sprat and the yield fluctuates with availability. The predictive value of the abundance indices, therefore, can to a certain extent be evaluated by comparisons of abundance indices and catch half a year later within the different fjord systems. This is illustrated in Figure 11.

The data are from the survey in autumn 1972 and the catch in June-October 1973 (1 skj = 17 kg). Abundance indices were calculated for 11 topographically separated fjord systems, as the product of mean integrator reading per nautical mile and area of the fjord in square nautical miles. The linear correlation coefficient is 0.79 ($p < 0.01$).

The echo surveys of sprat are found to be useful for the purpose for which they were designed, and they will be continued.

Regarding the North Sea, Skagerak and Kattegat, no integrator surveys have been carried out. But information on abundance and distribution of sprat are available from various sources, particularly the International Young Herring Surveys and also national surveys.



<u>Figure 11.</u> Comparison between 0-group sprat abundance and subsequent catch.

If this information is collected by a coordinator it may be possible to provide data for assessing the relative strength of the sprat year classes. As the life-span of the sprat is very short and the stock is exploited as O- and I- group fish, it is of great importance that a summary report of the data should be available shortly after the surveys.

6. RECOMMENDATIONS

6.1 General

6.1.1 Further work should be done to develop better methods of determining the contribution of each species to the echo-integrator record when a mixture of species is present.

6.1.2 There is a general need to investigate the sampling efficiency of trawls in relation to species and fish size, and to develop better gears if the present ones are found to be inadequate.

6.1.3 Because of the differing conditions and also the differing techniques used, it is suggested that the scientists involved in the various surveys might benefit if they were occasionally to take part in some of the surveys outside their normal area of interest.

6.2 Barents Sea O-Group Surveys

6.2.1 It is recommended that the Barents Sea O-group surveys should be continued.

6.2.2 There is a need for a more objective measurement of O-group fish density. This could be achieved by a more widespread use of modern intergrator technique.

6.2.3 Fishing gear and sampling techniques should be standardised in order to fish more precisely on a scattering layer. The multiple net sonde should be used.

6.2.4 More research effort should be devoted to experimental work in order to obtain better knowledge of the biological behaviour of the fish.

6.3 Iceland, East Greenland,and Faroe Surveys

6.3.1 The O-group surveys should be continued in the Iceland, East Greenland and Faroe areas in generally the same manner as previously.

6.3.2 The area surveyed should be extended in 1974 to provide better coverage to the south and southeast of Iceland. The possibility of a short two-week pre-survey in the latter half of June in coastal waters off south and west Iceland should be considered.

6.3.3 A Working Group of participants should assemble in the early winter of 1975 to work up in detail the results of the five surveys to date (including 1974).

6.3.4 Examination of the future O-group surveys in the Iceland-East Greenland area, and in particular any consideration of possible changes in the area covered in these surveys, should await the deliberations of the Working Group referred to in Recommendation 6.3.3 above.

6.3.5 In view of the apparent isolation of the Faroe region, it is recommended that surveys in this area be considered separately from O-group surveys in Icelandic waters.

6.3.6 Following the experience gained in the last two years, it is suggested that the distribution of the research effort at the Faroes should be reconsidered and that the survey work should be coordinated if more than one nation participate.

6.4 North Sea Surveys

6.4.1 The countries with the necessary expertise and resources should continue to study the problems of utilising acoustic methods for the study of pre-recruit abundance in the North Sea.

6.4.2 The study of 0-group herring should be intensified with a view to deriving earlier estimates of year class strength.

6.4.3 The Meeting endorses the conclusion of the Working Group on North Sea Young Herring Surveys that every effort should be made to improve the precision of the estimates of year class strength derived from these surveys.

6.4.4 The Demersal Fish (Northern) Committee at its Annual Meeting in 1974 should consider the need for recruitment estimates of roundfish from trawling surveys and the possibility of changing the status of the International Young Herring Surveys to a general Young Fish Survey.

6.4.5 The Demersal Fish (Northern) Committee should consider the need for a Young Roundfish Working Group to analyse the former data from 0- and I-group surveys and coordinate future work.

6.4.6 The Meeting noted with interest the efforts currently being made by the USSR on surveying young gadoids in the North Sea. Every effort should be made to improve coordination of these surveys with those being carried out by other ICES members.

6.5 Sprat Surveys

6.5.1 The Pelagic Fish (Northern) Committee should consider establishing a system for exchange and processing of data on young sprat abundance, particularly from the International Young Herring Surveys.

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II. REPORT OF THE WORKING GROUP ON NORTH SEA YOUNG HERRING SURVEYS

1. INTRODUCTION AND PARTICIPATION

At the 61st Statutory Meeting of ICES it was decided that the Working Group on North Sea Young Herring Surveys should meet in Ymuiden for one week in May 1974 in order to consider the interpretation of the results and the proposals for extension of these surveys to include demersal species (C.Res.1973/2:19). Consequently, the Working Group met in Ymuiden from 29 April to 3 May 1974, with the following participation:

Mr A C Burd	England
Mr A Corten (Chairman)	Netherlands
Dr H Dornheim	Germany (Fed.Rep. of)
Mr K Popp Madsen	Denmark
Mr K H Postuma	Netherlands
Mr A Saville	Scotland
Mr K A Smith	U.S.A.
Mr Ø Ulltang	Norway
Mr G Wagner	Germany (Fed.Rep. of)

During its first session, the Group decided that the emphasis of the meeting should be on evaluating the results of the past surveys, and deciding whether the results obtained so far were promising enough to warrant a continuation of the surveys.

2. EVALUATION

2.1 Abundance Estimates of I-Group Herring

ICES International Coordinated Young Herring Surveys (IYHS) were first made in 1960 and 1961. After a lapse of five years, the surveys were revived in 1967. Small-scale surveys were made in 1965 and 1966 by vessels from the Netherlands and the Federal Republic of Germany. A list of all International Young Herring Surveys up till the date of the meeting is given in Table 1. For each of these surveys, the distribution of I-group herring is shown in Figures 1 to 11.

Table 1. List of International Young Herring Surveys 1960-74.

Year	Participating countries*	No. of squares	No. of hauls	Results reported by:
1960	D, E, G, N, S	119	247	Anon., 1969
1961	D, G, N, S	126	286	Anon., 1969
1965	N	22	29	Not published
1966	G, N	14	51	Zijlstra, 1966
1967	E, G, N, S	61	96	Saville, 1967
1968	E, G, N, S	63	135	Postuma, 1968
1969	E, N, S, SW	72	87	Postuma & Zijlstra 1969
1970	E, G, N, S, SW	90	135	Schubert, 1970
1971	D, E, G, N, NO, S, U	106	190	Postuma & Kuiter 1971
1972	D, E, G, N, NO, S, SW, U	123	256	Postuma & Kuiter 1972
1973	D, E, G, N, S, SW, U	123	223	Corten & Kuiter 1973
1974	D, E, G, N, S, SW, U, NO	151	276	Corten & Kuiter 1974

*) Denmark (D); Germany, Federal Republic of (G); England (E); Netherlands (N); Scotland (S); Sweden (SW); USSR (U); Norway (NO).

2.1.1 Correction for standard area

Over the period 1965 to 1973, more vessels have entered the programme and the area fished has been gradually expanded. This results in difficulties in obtaining comparable abundance indices over longer periods.

In order to obtain estimates in a standardised form, the coverage of each statistical square over various time periods was examined. Squares which have been fished each year during 1965-73, 1967-73 and 1969-73 are represented in Figure 12. The different periods give standard areas of 16, 41 and 65 squares respectively.

For each standard area, abundance indices of I-group herring were calculated for the various years:

Year class	Mean abundance indices for standard areas of 16, 41 and 65 squares		
	16	41	65
1963	3900	-	-
1964	1092	-	-
1965	584	319	-
1966	360	285	-
1967	121	244	170
1968	180	733	573
1969	2449	1707	1518
1970	1645	1851	1227
1971	722	394	312

The mean abundance indices for 41- and 65-squares have been plotted on the basic 16-square estimates (Figure 13). The 41-square estimates tend to be distributed near the bisector. The effect of increasing to 65 squares has been to reduce the abundance indices.

For calculation of North Sea total abundance indices it was decided to take as standard the 41-square distribution and to add to these any square in which a catch of over 1000 herring per haul had been made in any year.

12 further squares were thus added making a total of 53 squares.

Equivalent abundance indices for the 1963 and 1964 year classes were obtained by raising the 16-square abundances by the mean ratio of the 16-square and 41-square abundance indices for the parallel data series.

Because of the lack of sampling in some of the additional 12 squares in some years it was decided to interpolate estimated values in order to obtain standardisation. For those years when catches were recorded the ratio of the abundance in that square to the 41-square abundance was calculated and means were taken for all years. This mean ratio per square was used to calculate an interpolated value by raising by the 41-square mean for that year.

This procedure was also applied to the data from the 1960 and 1961 surveys.

Standardised abundance indices were calculated for each year class of I-group herring by summation of the catches in the standard areas and dividing by 53 (Table 2):

Table 2. Abundance indices of I-group herring as mean number per square.

Year class	Standardised	Uncorrected*
1958	2413	1269
1959	37	340
1963	4064	2797
1964	815	714
1965	429	245
1966	419	265
1967	320	433
1968	1042	469
1969	2570	1536
1970	1632	922
1971	837	489

*) from Corten and Kuiter, 1973.

2.1.2 Daylight effect

Participating countries were originally instructed to trawl only during daytime, as herring are known to leave the bottom at night. However, it was suspected that this rule had not always been applied very strictly, in which case both the mean number per haul and the variance on it might have been influenced.

To test whether past results had been affected this way, data for 1971 were split into "daylight" and "darkness" hauls. Daylight hours were defined as hauls between 08.30 - 16.00 GMT in February, and between 08.00 - 16.30 GMT in March.

Two sources of data were then examined.

In 1971 "Anton Dohrn" fished in 7 squares, both in "daylight" and in "darkness", which contained appreciable numbers of herring. The "daylight" to "dark" ratios of catches for these squares were 1.1, 2.1, 1.9, 4.9, 17.6, 8.0 and 3.1 giving a mean "daylight" to "dark" ratio of 5.5.

The ratios of the mean "daylight" to "dark" catch in all squares which were fished under both conditions in 1971 were also calculated. There were 38 such squares of which only 23 gave higher "daylight" than "dark" catches. The overall mean catch per square of these squares for "daylight" hauls was 2084 against 1823 for "dark" hauls; this difference is certainly not significant.

The evidence of the 1971 survey does not prove the hypothesis that past results have been affected by a too liberal interpretation of "daylight". The data from "Anton Dohrn" might be the more reliable in that they are not affected by differences in fishing power between ships, which may mask the daylight and dark effect in the other data. On the basis of the conflicting data available, it was decided that while any such effect could not currently be corrected for in the past data, more rigid guidelines regarding the times of first and last hauls each day should be applied in future surveys.

2.1.3 Variance in the mean number per haul

Experience from past surveys have shown that the mean number per haul for the whole North Sea is sometimes influenced very strongly by one or two hauls of exceptional size. Year class 1971 for instance, was sampled in 223 hauls, containing a total of 92 623 herring. This gives a mean number per haul of 415. Out of the 223 hauls, one haul contained 26 166 herring, and another one 16 166. If by chance these two hauls had been omitted, the mean number per haul for the whole North Sea would have been 228 instead of 415.

This consideration indicates that the mean, even of a large number of hauls, may be subject to a considerable variance. For a proper interpretation of data from the IYHS, one should at least have some idea about the level of precision that can be ascribed to the mean number per haul.

Data for the 1971 survey were used to get an estimate of the variance in the abundance estimates and to see how the variance in the number per haul varies over the area. As the number of observations within a statistical square is too low for estimating the variance, the North Sea was divided into strata of four squares each. The squares used in the analysis and the stratification are shown in Figure 15. No information on the distribution of herring was used in stratifying the area. Neighbouring squares were simply put together into one stratum.

Table 3 shows the mean number per haul, the estimated standard deviation on an individual haul, and the number of hauls in each stratum. It appears from the table that the standard deviation is of about the same size as the mean which is what one should expect for such a distribution. Using the formulas for stratified sampling, the mean for the whole area ($\overline{Y}st$) and variance of this mean ($S^2(\overline{Y}st)$) were calculated. The values found for $\overline{Y}st$ and $S(\overline{Y}st)$ were 3.1×10^3 and 0.58×10^3 respectively.

Assuming that $\overline{Y}st$ is approximately normally distributed, the 95% confidence limits for the mean are then given by 3.1 ± 1.2.

Table 3. Stratification of data from the 1971 survey.

Strata h	Mean number per haul = $\overline{Y}_h$ (thousands)	Standard deviation S_h (thousands)	No. of hauls	No. of hauls if optimum sampling
1	3.7	2.7	5	5
2	8.2	13.5	13	27
3	0.6	0.7	8	2
4	1.1	1.2	15	2
5	2.6	2.7	8	5
6	2.2	4.3	15	8
7	0.8	1.7	9	3
8	7.5	7.9	8	10
9	6.4	7.9	9	16
10	8.0	9.8	4	20
11	0.4	0.4	5	1
12	1.8	4.0	5	8
13	0.1	0.1	4	1

Taking the estimated standard deviation in each stratum as the true standard deviation, it was also calculated what the precision of the estimate would have been if the total number of hauls used in the analysis (108)had been allocated on the different strata in an optimum way, which means that the number of hauls in each stratum should be proportional to the standard deviation. In that case $S(\overline{Y}st)$ would decrease from 0.58 to 0.40.

In practise we will never be able to distribute the sampling effort in an optimum way because we do not know enough about the distribution of the herring before we start the survey. Past surveys have shown that this distribution varies considerably from year to year. Still, some squares have a rather high abundance each year compared with others.

For the selected area of 53 squares, the ratio between the mean abundance in each square and the overall mean was calculated for each year. Indices of relative mean abundance for individual squares were then established by calculating mean ratios over all the years (Figure 16). These indices can be used for future stratification of the sampling area, as further discussed in Section 4.1.

2.2 Relation between Abundance Estimates of I-Group Herring from Young Herring Surveys and from Virtual Population Analysis (VPA)

The estimates of year class strength, calculated as described in Section 2.1.1, for each year class sampled as I-group are given in Table 4. The abundance estimates of the same year classes as I-group from VPA (Doc. C.M.1973/H:27) are also given. One would hope to be able to use the Young Herring Survey estimates to predict year class strength one year earlier than the first estimate is available from VPA. The year class strength, in VPA equivalents, could then be used in setting the Total Allowable Catch (TAC).

Table 4. Abundance of I-group from YHS and VPA.

Year class	Estimated strength from Young Herring Survey	Estimated strength from VPA ($\times 10^{-9}$)
1958	2413	7.07
1959	37	1.63
1963	4064	9.44
1964	815	5.07
1965	429	4.44
1966	419	6.30
1967	320	6.29
1968	1042	4.93
1969	2570	7.75
1970	1632	6.29
1971	837	?
1972	1144*	?

*) preliminary.

The regression of the VPA estimates on the Young Herring Survey estimates has been calculated. The regression equation is $\hat{y} = 0.0013477\ X + 4.069$ where $\hat{y}$ is the predicted value of year class strength for VPA and X is the measured estimate of year class strength from the Young Herring Surveys (Figure 17). The coefficient of regression is significantly different from zero at less than the 1% probability level. It should be noted, however, that the constant in the regression accounts for a major part of the predicted value; about 60% for an average year class. The standard error of the predicted y is 0.6 for an average year class.

From the values of the strength of the 1971 and 1972 year classes given in Table 4, one can predict the VPA estimates for the strength of these year classes using the regression equation above. The values are 5.2×10^9 and 5.6×10^9 respectively; that is, these year classes would be expected to be 23% and 17% below the long-term mean.

2.3 Relation between YHS Estimates and Abundance Estimates from the Bløden Industrial Fishery

Estimates of year class strength in the commercial young herring fishery from Esbjerg have been made since 1957 and are shown in Table 5. Measured in millions of herring caught per 1000 hours of pair trawling they represent straight means derived from the total effort and the total number caught per season. They do not include corrections for the area covered by the fishery or by the herring stock nor has any distinction been made between effort directed towards herring capture and effort which only produced herring as a by-catch. It is likely that an increase in fishing power has taken place in recent years, but neither in this case have any corrections been made.

Table 5. Abundance indices from the Bløden fishery (thousands of fish per hour pair trawling).

Winter rings	0	I		II
Year class	Autumn	Spring	Autumn	Spring
1956	12.3	67.8	37.7	38.2
1957	1.6	7.2	15.8	7.0
1958	0	26.9	28.8	18.0
1959	3.6	6.7	2.3	0.5
1960	20.2	48.2	34.5	0.2
1961	2.9	17.4	19.6	2.7
1962	8.5	46.8	18.1	15.6
1963	6.1	41.7	17.6	6.9
1964	2.1	44.5	10.1	4.5
1965	8.7	30.2	6.7	7.0
1966	21.9	74.6	7.6	2.3
1967	13.5	34.5	12.3	4.3
1968	3.3	19.7	6.6	4.1
1969	20.9	31.8	15.7	5.9
1970	9.2	39.8	19.1	6.2
1971	11.5	23.3	24.2	22.4
1972	6.5	10.1	-	-
Average	8.2	33.6	17.0	9.1

In Figure 18 YHS indices are plotted against indices of I-group strength obtained from the Bløden fishery in January to April. The lack of correlation between the two sets of indices is obvious and seems mainly to be due to the high Bløden indices for the year classes 1964-1967. It appears that the IHY give a better estimate of the strength of incoming year classes than the present estimates from the Bløden fishery. It is likely that the Bløden indices are heavily influenced by dense coastal concentrations of young herring which sometimes occur in January and February and which were a prominent feature in the case of the 1966 year class.

Figure 19 shows the relation between the YHS indices and those from the Bløden fishery in autumn (i.e. July to November). Again the correlation is not significant.

2.4 Identification of Subpopulations in Juvenile Herring

Two of the specified objectives of the 1960 and 1961 surveys were to attempt to identify the nursery areas of the Bank, Downs and Buchan herring and to attempt to make quantitative estimates of their respective abundances as I-group. A discriminant function analysis was used for the latter purpose and the results were published in Cooperative Research Report, Ser.A, No.14.

No satisfactory solution could be found with regard to the spatial distribution of the subpopulations.

During the recent series of surveys meristic characters have also been collected in order to try to obtain further information on the spatial distribution of Downs, Bank and Buchan recruits. At present considerable evidence is available that fish, belonging to spawning stocks to the north and northwest of Scotland are also present in the North Sea as I-group. In the absence of any technique for identifying these recruits, their presence leads to an overestimate of the recruitment to the true North Sea herring populations.

The distribution of meristic characters in the 1971 and 1972 Young Herring Surveys has been examined to see if the centres of abundance of herring of relatively homogeneous meristic characters could be identified. The procedure followed was to select a square and to compare the data on length, V.S., and K_2 with those in surrounding squares. If these lay within the variances of the selected square the data were then combined. The combination was made either by addition of length distributions or by calculation of weighted means and variances in the case of V.S. and K_2.

In this summation length played a major part. A number of small loci were established and a simple correlation matrix was calculated. As a result of this some further additions of adjacent areas of similar characters were made.

The identification of any centre is dependent on the adequacy of the biological sampling. Figure 20 shows for the 1971 survey the distribution of squares fished and those with stations having sufficient numbers of vertebrae and K_2 counts. The data available consisted of the station sheets reporting the biological samples. In these, only means, variances and number of observations are reported for the meristic characters, while length data were reported in full.

The centres of abundance derived for the 1971 survey are shown in Figure 21. Within each centre the mean length, V.S., and K_2 are given. It is seen that in the northwestern North Sea an area of fish with low mean length and high V.S. and K_2 has been delineated from patches of larger fish to the east and west. Mean V.S. and K_2 values are also given from the English 0-group surveys made in July preceding the Young Herring Surveys. The 0-group from the East Anglia coast are seen to have characters similar to the I-group off the Dutch coast and into the German Bight. The 0-group taken between Flamborough and the Wash have similar values to the offshore patch west of Dogger, and again there is a similarity between the offshore northeast English coastal I-group patch and the O-group inshore the previous summer.

The coverage of stations with adequate biological data was somewhat greater in 1972 (Figure 22). However, as in 1971 there were some areas with large catches where no biological sampling had been made. The results of the analysis are shown in Figure 23 together with the English O-group estimates.

There is in general a similar pattern to that described in 1971, with a I-group patch along the Dutch coast similar to the East Anglia O-group herring. Again there is similarity between the O-group taken south of Flamborough Head and the offshore patch of I-group, while the northeast coast O-group have the high V.S. and low K_2 means similar to the I-group immediately to the north. Two very distinct patches are seen in the Skagerak.

The population parameters within the patches for the 1970 year class are calculated in Table 6, as an example of the effects of grouping. The variances for V.S. and K_2 approach those derived from large samples of pure stocks.

Table 6. Population parameters within patches: 1970 year class.

Patch	Length		V.S.		K_2	
	Mean	Var	Mean	Var	Mean	Var
A	14.16	.78	56.60	.46	14.06	.55
B	15.25	1.53	56.46	.54	14.12	.63
C	14.27	1.56	56.41	.41	14.67	.69
D	17.74	1.77	56.47	.54	14.06	.59
E	18.16	1.06	56.43	.51	14.33	.86
F	19.37	.67	56.67	.55	14.40	.71
G	17.64	1.35	56.44	.44	14.19	.73
H	14.88	1.39	56.27	.61	14.17	.66

Pure stock characters were available for the 1970 year class from Dutch, Scottish and English sources (Table 7), estimated from 2-ringed fish in 1973.

Table 7. Pure stock characters, 1970 year class.

Area	Mean V.S.	Mean K_2
Minch	56.50	14.04
Longstone	56.40	14.40
Whitby	56.42	14.55
Flamborough/Whitby	56.36	14.51
Dogger	56.24	14.49
Dowsing	56.27	14.66
Sandettié	56.57	14.79
Channel	56.55	14.54

Comparing these data, patches having the low K_2 characteristic of the Minch spawners are seen in the northwest patch A, the English coastal O-group, and the central North Sea patch D.

There is a closer similarity between the coastal 0-group and the offshore I-group than between the offshore patches and the fish recruited to the adult spawning stocks.

The 1969 year class pure stock characters are shown in Table 8.

Table 8. Pure stock characters, 1969 year class.

Area	Mean V.S.	Mean K_2
Minch	56.45	14.10
Flamborough/Whitby	56.49	14.47
Dogger	56.18	14.83
Dowsing	56.41	14.80
Sandettié	56.59	14.78
Channel	56.66	14.69

As with the 1970 year class, the fish with low K_2 characteristics of the Minch are found in the northwestern North Sea, while fish with characteristics similar to the Downs spawning stock are seen in the southern area.

While patches can be delineated in the juvenile herring, no allocation to stock can be made directly, though there are indications of areas of lesser mixing. In the central North Sea patches of mixed origin must be expected and it is intended to further investigate the possibilities of discriminating these fish between spawning stocks.

2.5 Distribution of I-Group Herring in relation to Water Temperature

As a preliminary attempt of establishing a possible relationship between young herring abundance and water temperature, the largest catches from the 1971-1973 surveys were plotted on temperature charts for the years concerned (Figures 24-26).

These charts indicate that squares with high catches are situated in the temperature range of 4 - 6.5° C and that the temperature regime at this time of the year may have an important influence upon the distribution area and hence on the density of the young herring. This corroborates the conclusions drawn from another preliminary analysis of the early surveys in 1960 and 1961 (Cooperative Research Report, Ser.A, No.14), and indicates that a full analysis of the relationship between individual catches and temperature observations should be undertaken.

As other factors (e.g. salinity and depth) may influence the distribution pattern of the herring and because of the large amount of data collected up to now, the Working Group felt that further analysis would require the use of automatic data processing.

2.6 Echo Surveys

Acoustic surveys carried out by Norwegian vessels in February 1971, February 1972 (Bakken et al., 1972) and in April 1973 show that there are several methodological problems in using echo sounders and echo integrators as a means of determining the abundance of young herring in the North Sea.

Herring often constitute only a minor part of the total biomass and therefore contribute little to the total integrator value. This makes it difficult to estimate with reasonable precision how much of the integrator readings should be assigned to herring. This problem may possibly be solved by a combination of improved sampling and refinement of the electronic technique.

Another serious problem is the vertical distribution of herring in the North Sea. In shallow waters and especially at day, the herring stay close to the bottom and it is difficult to discriminate echoes of herring from the bottom echo. This problem might be solved by choosing a time of the year when herring has a more pelagic distribution.

Few attempts have yet been made to measure the abundance of 0-group herring in the North Sea by acoustic surveys. When the 0-group has a pelagic distribution the problem of bottom echo would be eliminated, but difficulties in allocating the integrator readings to various organisms would still exist.

3. CONCLUSIONS

3.1 A highly significant correlation has been demonstrated between corrected YHS estimates of I-group abundance and VPA values for the same age group. This shows that YHS estimates can be used in forecasting year class strength and in setting a total allowable catch (TAC). It should be noted, however, that the technique will be misleading at low year class strength because a zero YHS estimate will, according to the regression equation, still predict a year class strength of only 40% below average.

3.2 Abundance indices from the Bløden industrial fishery which were available to the Working Group are not related to the YHS estimates. From the nature of the Bløden fishery, which actively searches for herring concentrations, the abundance index derived from it may sometimes not be a good index of year class strength.

3.3 The variance on the overall mean number per haul from the YHS is likely to be rather high. This will in some years introduce a considerable error in predictions of year class strength. It is possible to decrease the variance on the mean by allocating the sampling effort in an optimum way. This can be done by stratifying the area and distributing the hauls in proportion to the expected density in each square. Considering the importance of these surveys for North Sea herring management, every attempt should be made to improve the reliability of the recruitment estimates. A plan for modifying the survey pattern to meet these needs follows.

3.4 Meristic characters might be useful in identifying subpopulations in young herring by grouping neighbouring squares with similar characters. In the western part of the North Sea, concentrations with uniform meristic characters can be related to 0-group herring sampled along the English coast the previous summer, and also to adult stocks spawning in the Flamborough-Whitby area. However, it is not clear whether concentrations of young herring with uniform meristic characters in other parts of the North Sea can also be related to adult stocks. It is recommended that the sampling of meristic characters should be continued in the meantime, pending the results of further analysis.

The Working Group noted that sampling of the area was rather uneven. As this appears to be due to insufficient manpower available to some participants, the Working Group envisaged that exchange of technical personnel might be a way to amend this deficiency in sampling.

3.5 From the preliminary appraisals carried out by the Working Group no definite conclusions could be drawn on the effect of daylight and darkness on the catches, nor on the effect of hydrographic factors on the distribution of young herring. The study of these subjects needs a thorough analysis of the basic material, which requires automatic data processing.

3.6 Echo surveys made by various countries have so far failed to prove their usefulness as a means of estimating I-group abundance.

3.7 In view of the modified plan for the Young Herring Surveys (Appendix I), the Working Group did not consider that it could take a decision on a possible extension of the survey area in order to obtain a better coverage for demersal species. The Demersal Fish (Northern) Committee should consider how far this modified plan meets their need for gadoid surveys.

3.8 In view of the need for further analysis of several facets of the past data, the Working Group considers that a further meeting will be required in 1975.

APPENDIX I - STRATIFICATION OF SAMPLING AREA FOR FURTHER SURVEYS

Assuming that the mean relative abundance indices for each square calculated for the period 1960-1973 (Figure 16) give a representative picture of the distribution of herring, these abundance indices can be used to construct a stratification of the area for future surveys. Cochran (1963) has described a method to use the frequency distribution for constructing strata.

Given the frequency distribution f(y), the method is to form a cumulative frequency $\sqrt{f(y)}$ and choose stratum boundaries Y_1, Y_2, ---- Y_r so that they create equal intervals on the cumulative $\sqrt{f(y)}$ scale.

Using this method, we will be very near optimum sampling if we take the same sample size in each stratum. Taking into consideration the great variation in distribution of herring from year to year we should not divide the area into too many strata. The Working Group decided to divide the 53 squares into 3 strata. Using the method described above, we then get one stratum containing the squares with mean relative abundances below 1, one stratum for the squares with relative abundance indices in the interval 1-3, and one stratum for squares which have relative abundance greater than 3. This results in 35 squares in the first stratum, 12 squares in the second and 6 squares in the third. The stratification is shown in Figure 27. The total number of hauls should be divided equally among the three strata. This means that if 210 hauls are to be taken in the 53 squares, 70 hauls should be taken in each strata. If we will take the same number of hauls in each square within a stratum, the following stratification could be used:

Stratum	No. of squares	No. of hauls in each square	Total no. of hauls
1	35	2	70
2	12	6	72
3	6	12	72

APPENDIX II - STANDARDISATION OF FISHING GEAR

Sampling trawls

Young Herring Surveys are carried out by participating countries using bottom fishing otter trawls designated as the "Dutch Herring Trawl". It is not clear whether all trawls of this designation are of identical design and rigging. On the contrary, since survey trawls are assembled by the separate individual countries in their institutions or by local fishing equipment supply companies, it is quite likely that considerable variation in material, twine sizes, accessory equipment and even dimensions of the "survey trawls" exists. It is well known and generally accepted that small differences can and do result in significant variations in performance of otter trawls.

In addition it was noted during the current meeting that all countries do not necessarily adhere to the recommended design for Young Herring Surveys. For example, Norway reported to have used on some of the hauls a "small shrimp trawl". Obviously, results from surveys with such a trawl cannot be directly compared with those from a large herring trawl of any type.

In view of the above, it is recommended that detailed specifications for the survey trawl used by each nation participating in North Sea Young Herring Surveys should be reported. Specifications should include drawings and dimensions of all parts: twine material, type and size; mesh size in all sections; bobbins (if any); headrope; footrope; hanging method, and all other details.

Fishing procedure

Survey results, even those obtained with a standard trawl, will not be directly comparable if survey procedures are not also standardised and closely controlled. Fishing practices vary considerably from vessel to vessel and from country to country (even aboard the research vessels). In addition, the personal preference of individual captains, vessel crews, and research personnel come into play. Accordingly, it is recommended that a standardised procedure for the conduct of survey trawl tows be established including but not limited to the following factors:

1. time of tow, from the time the trawl has settled to the bottom and is towing in a straight line until it is hauled from the bottom;
2. speed of tow;
3. recording of position at start and completion of tow (distance covered);
4. ratio of trawl warp payed out to water depth. This ratio should be established and specified for optimum fishing at the various depths;
5. lengths of bridles and groundropes (between trawl doors and trawl wings);
6. weight (or wire rope diameter) of trawl warps, bridles and accessory rigging devices;
7. specification of time of day (daylight hours) during which survey tows should be conducted.

Ship factors

The size, weight, power and design of research vessels vary greatly. The fishing power of such vessels must also exhibit considerable variation. While it is obviously quite impractical to attempt a standardisation of research trawlers, some effort to utilise similar vessels would likely be beneficial. Factors for consideration are:

1. total displacement weight,
2. length,
3. draft,
4. propulsion power,
5. propellor thrust while towing trawl,
6. type of trawler, i.e. stern or side mode.

All survey trawlers should as a minimum requirement be equipped with an accurate calibrated speed and distance log and precise navigation system (Decca navigator or equivalent).

APPENDIX III - SAMPLING OF MERISTIC CHARACTERS IN FUTURE SURVEYS

In each square fished all herring up to 100 specimens should be subject to an analysis of meristic characters (V.S. and K_2) in addition to age and length. If the catch contains more than 100 herring a subsample should be drawn at random.

In squares which are covered by more than one vessel, arrangements can be made by radio as to how the meristic sampling will be allocated among the vessels.

All length measurements should be done on fresh material, i.e. before this has been frozen or preserved by other means.

For racial analysis, length should be measured to the millimeter below, while bulk measurements are made to the half centimeter below.

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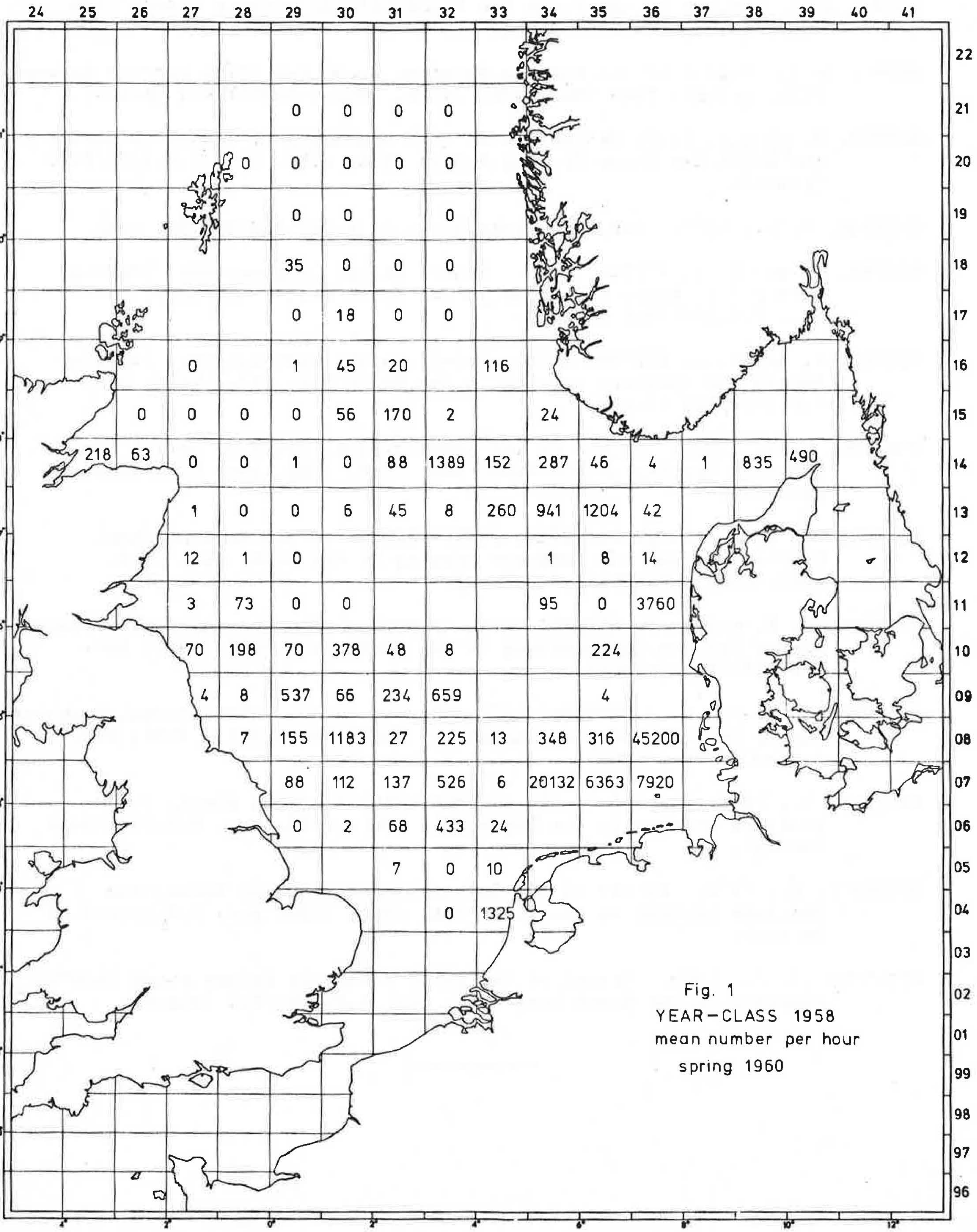


Fig. 1
YEAR-CLASS 1958
mean number per hour
spring 1960

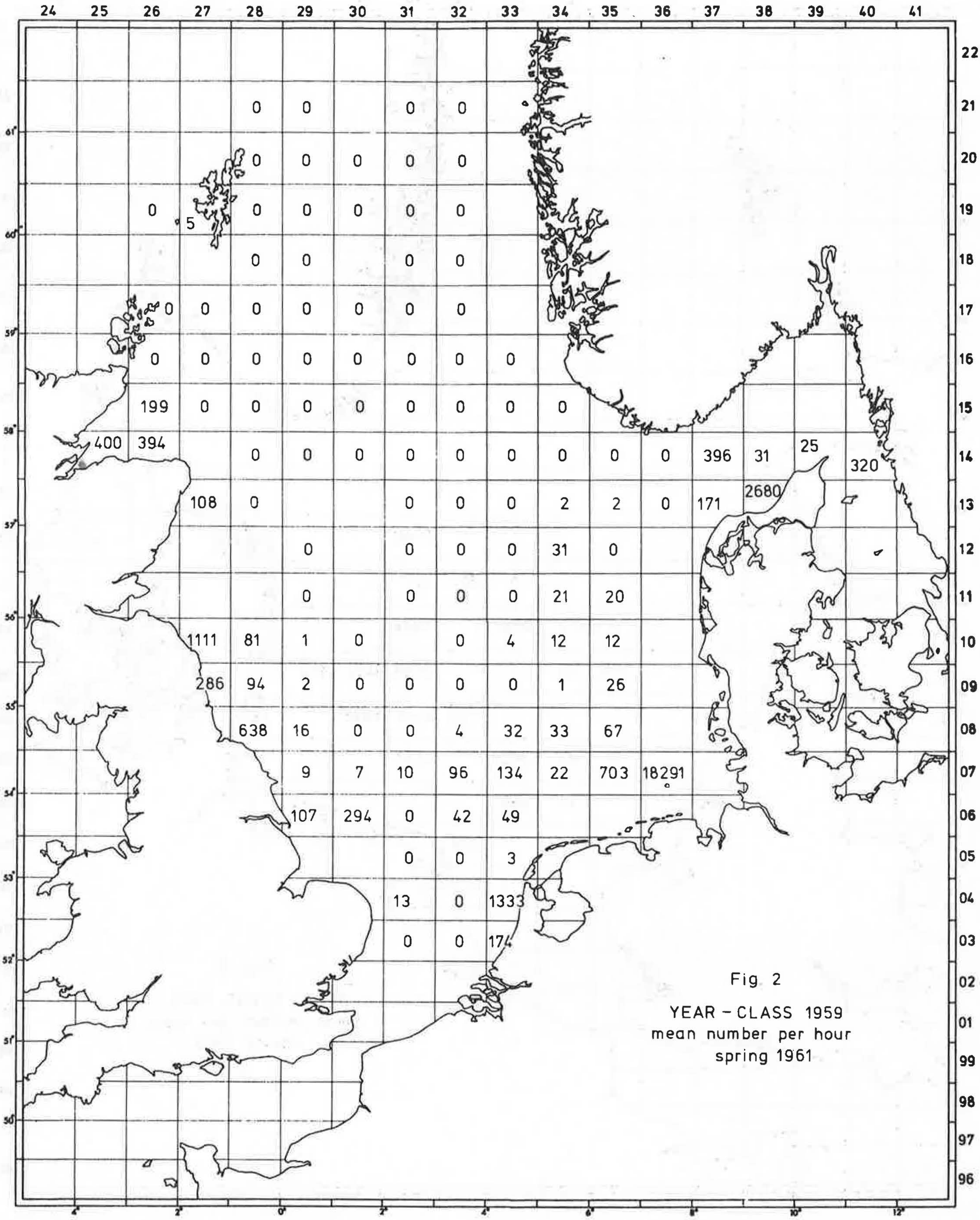


Fig. 2

YEAR - CLASS 1959
mean number per hour
spring 1961

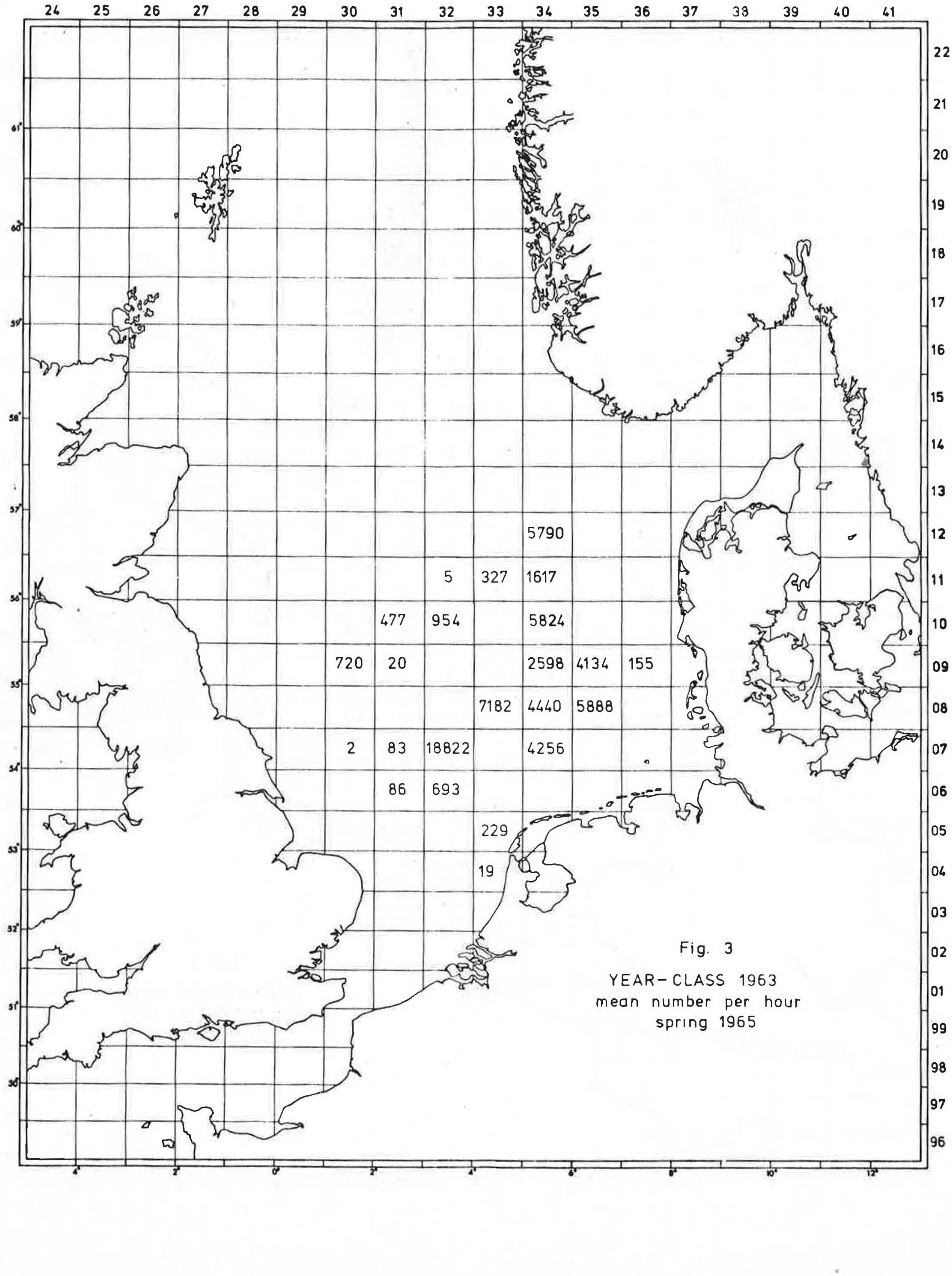


Fig. 3
YEAR-CLASS 1963
mean number per hour
spring 1965

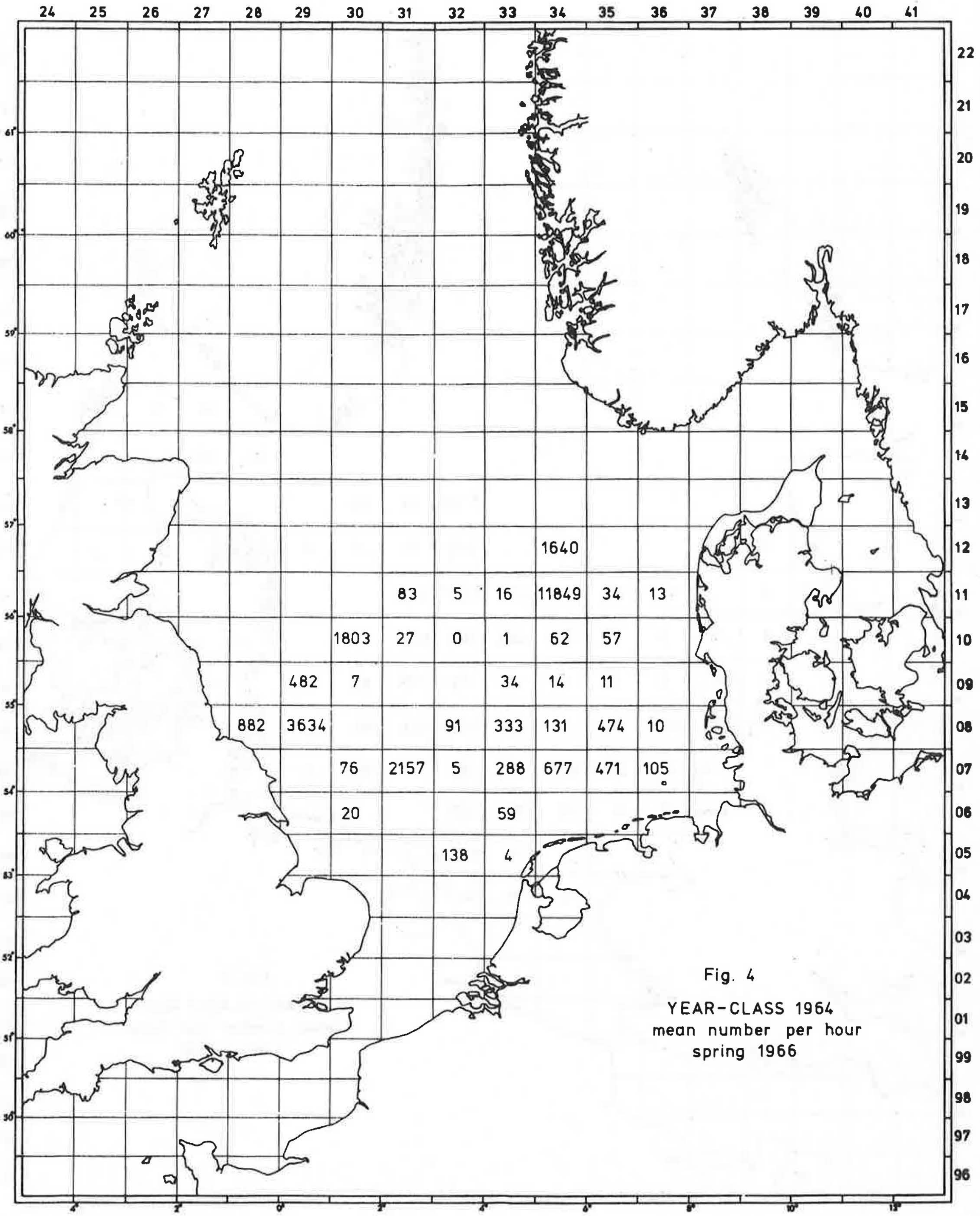


Fig. 4

YEAR-CLASS 1964
mean number per hour
spring 1966

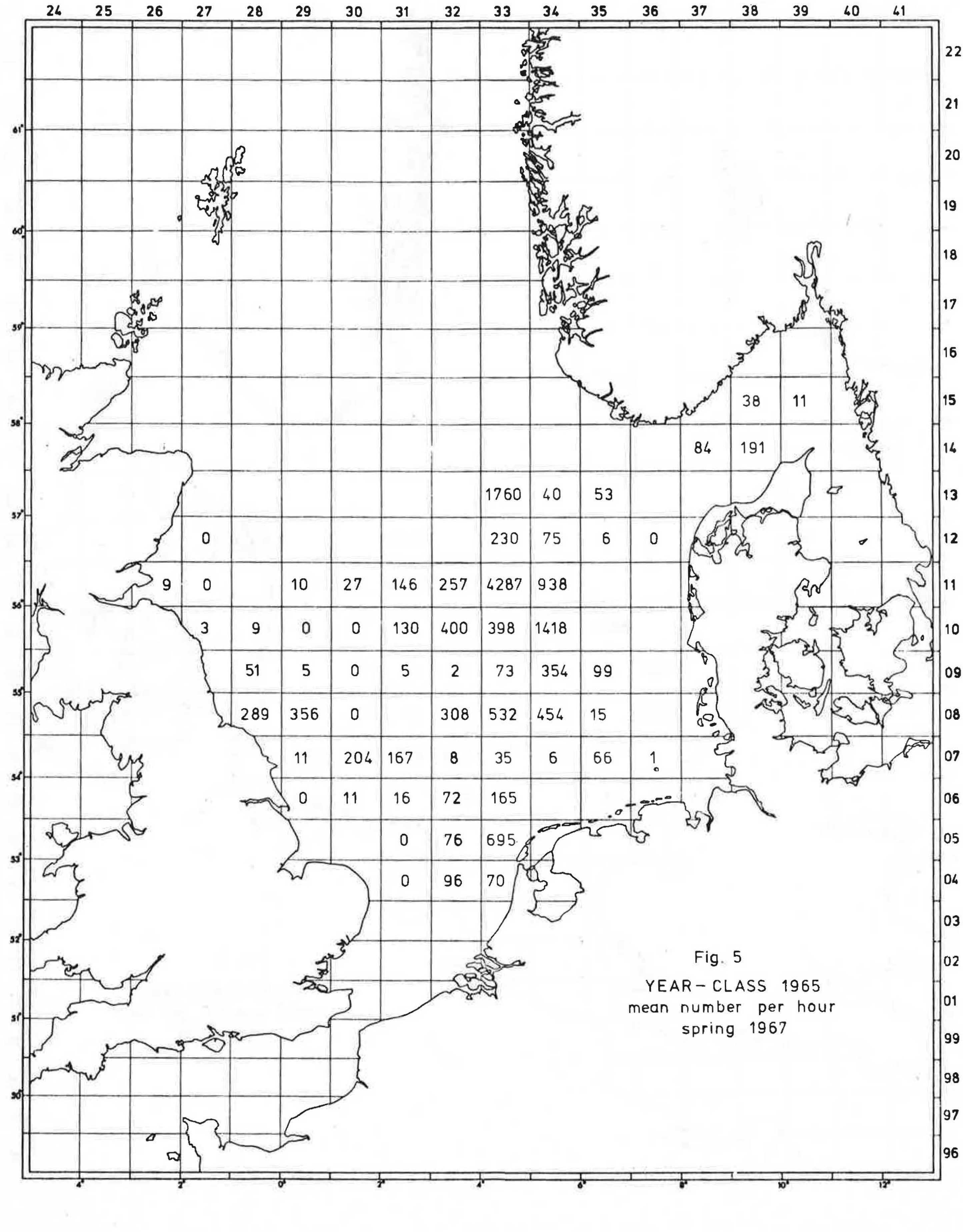


Fig. 5
YEAR-CLASS 1965
mean number per hour
spring 1967

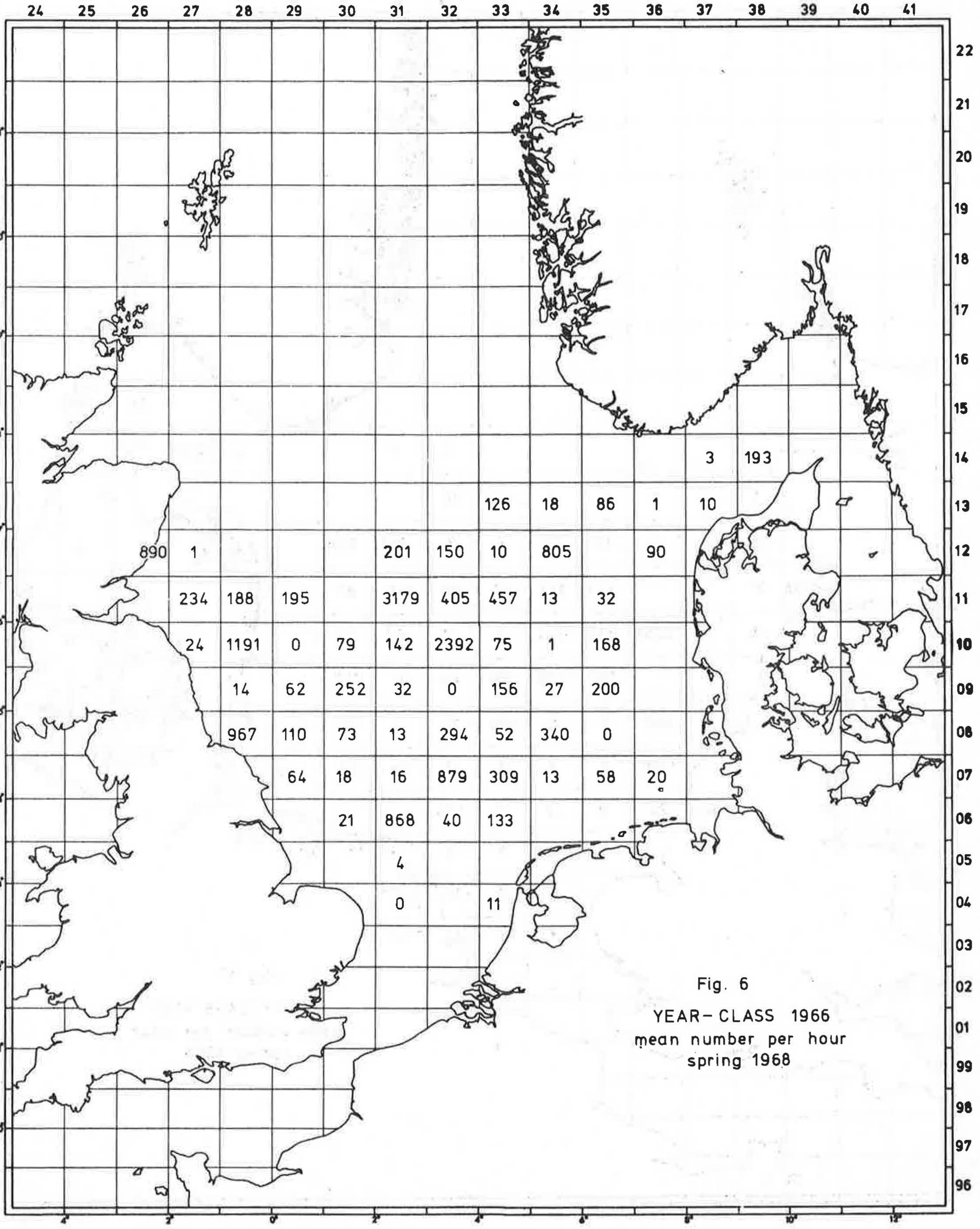


Fig. 6
YEAR-CLASS 1966
mean number per hour
spring 1968

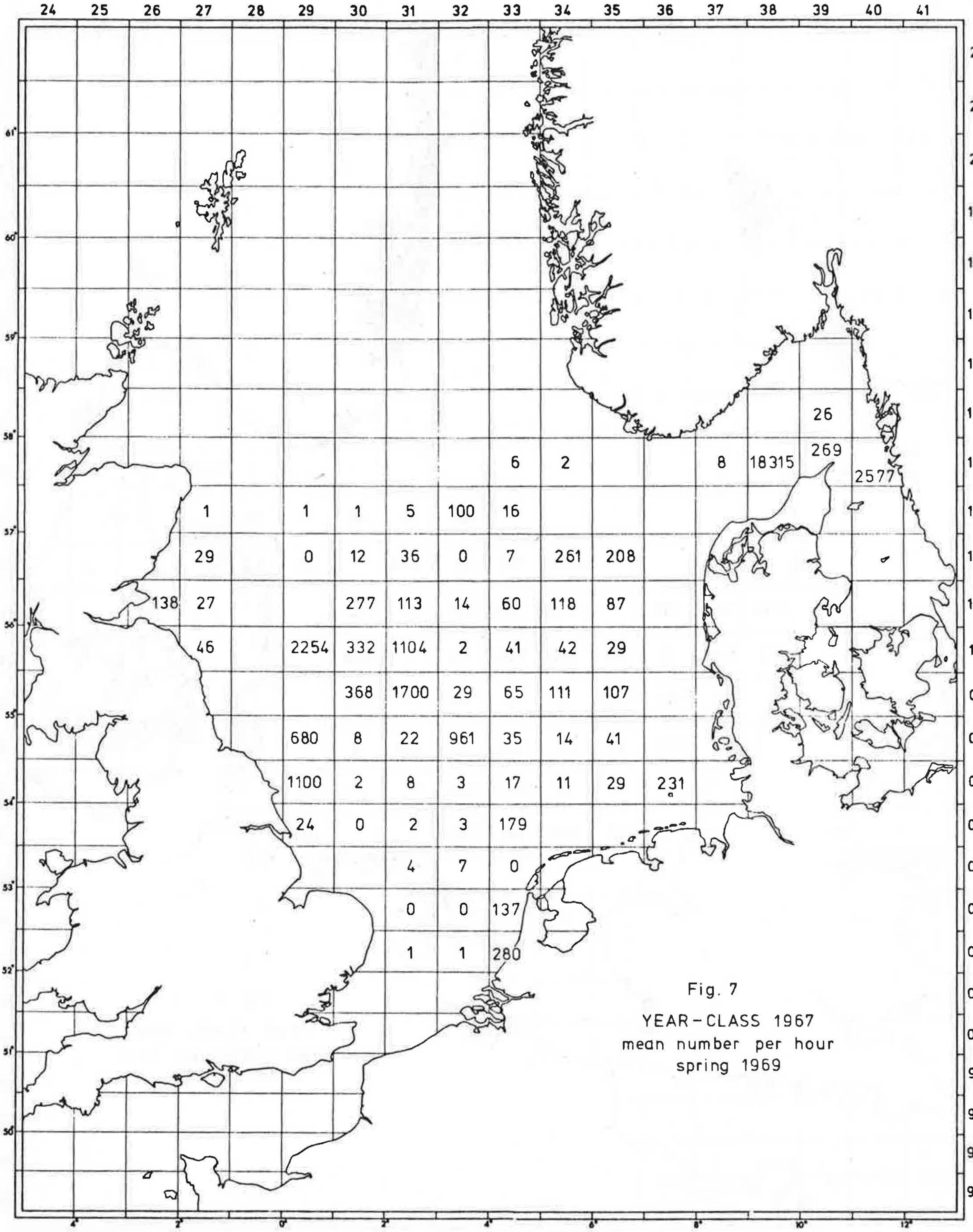


Fig. 7
YEAR-CLASS 1967
mean number per hour
spring 1969

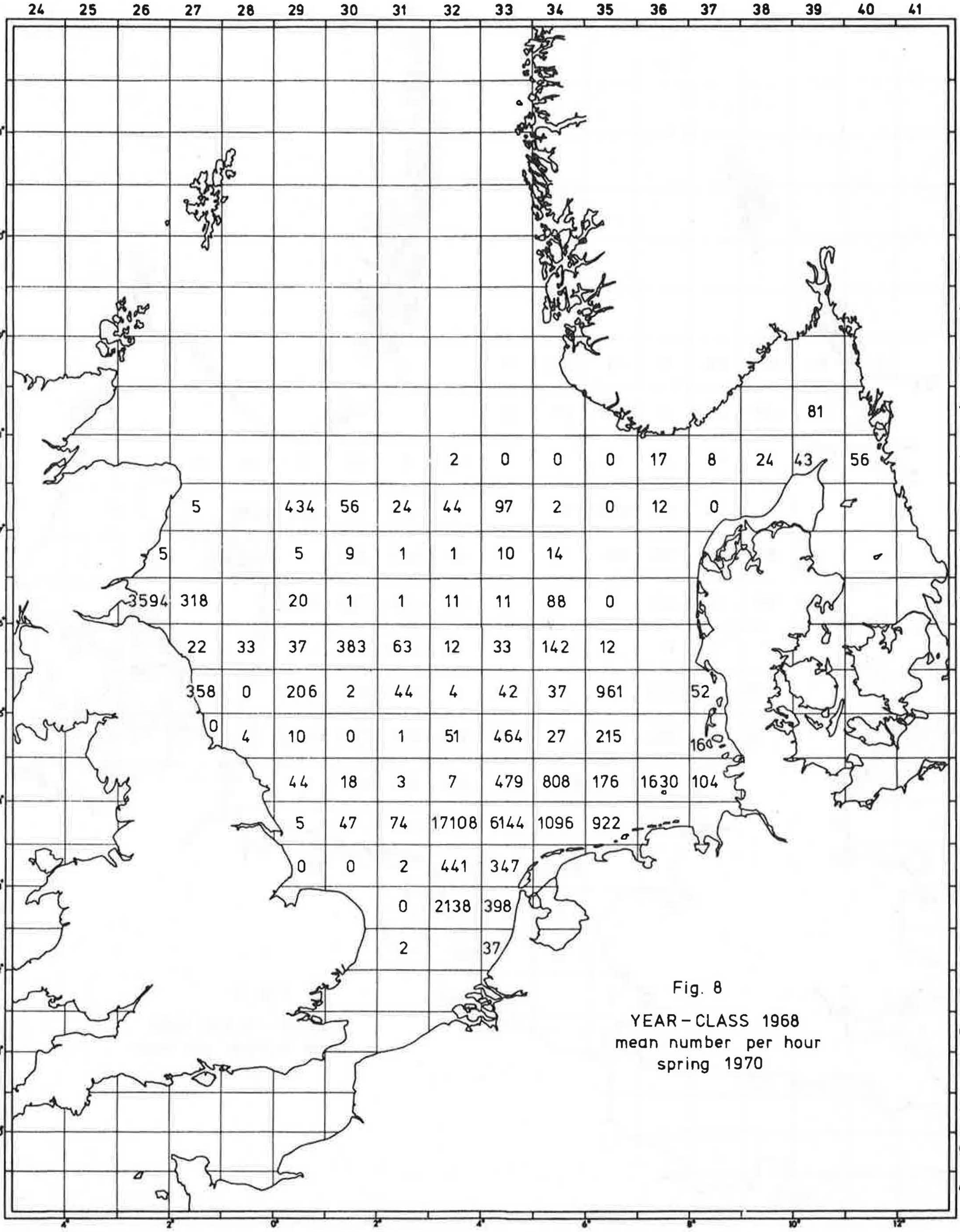


Fig. 8

YEAR-CLASS 1968
mean number per hour
spring 1970

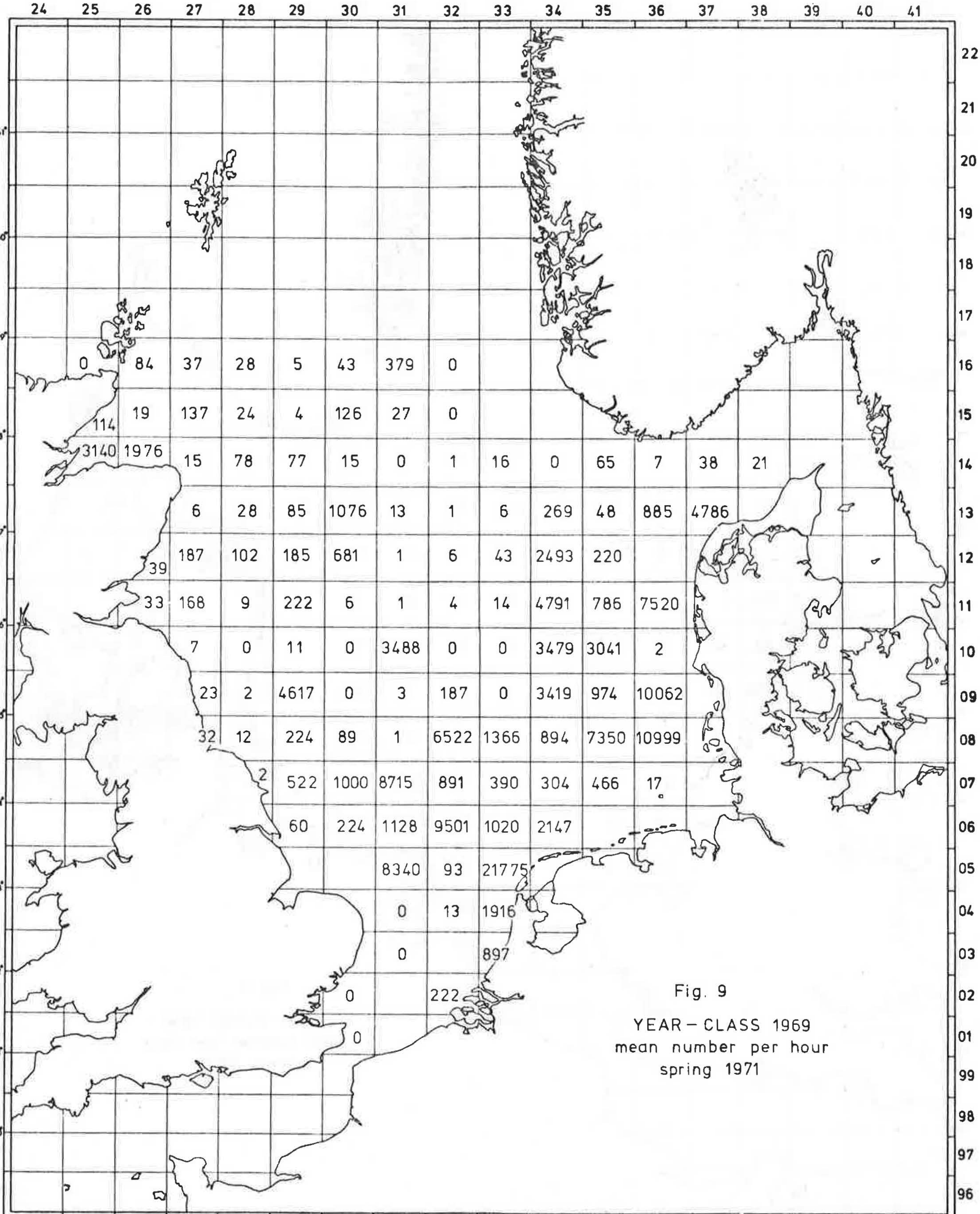


Fig. 9

YEAR – CLASS 1969
mean number per hour
spring 1971

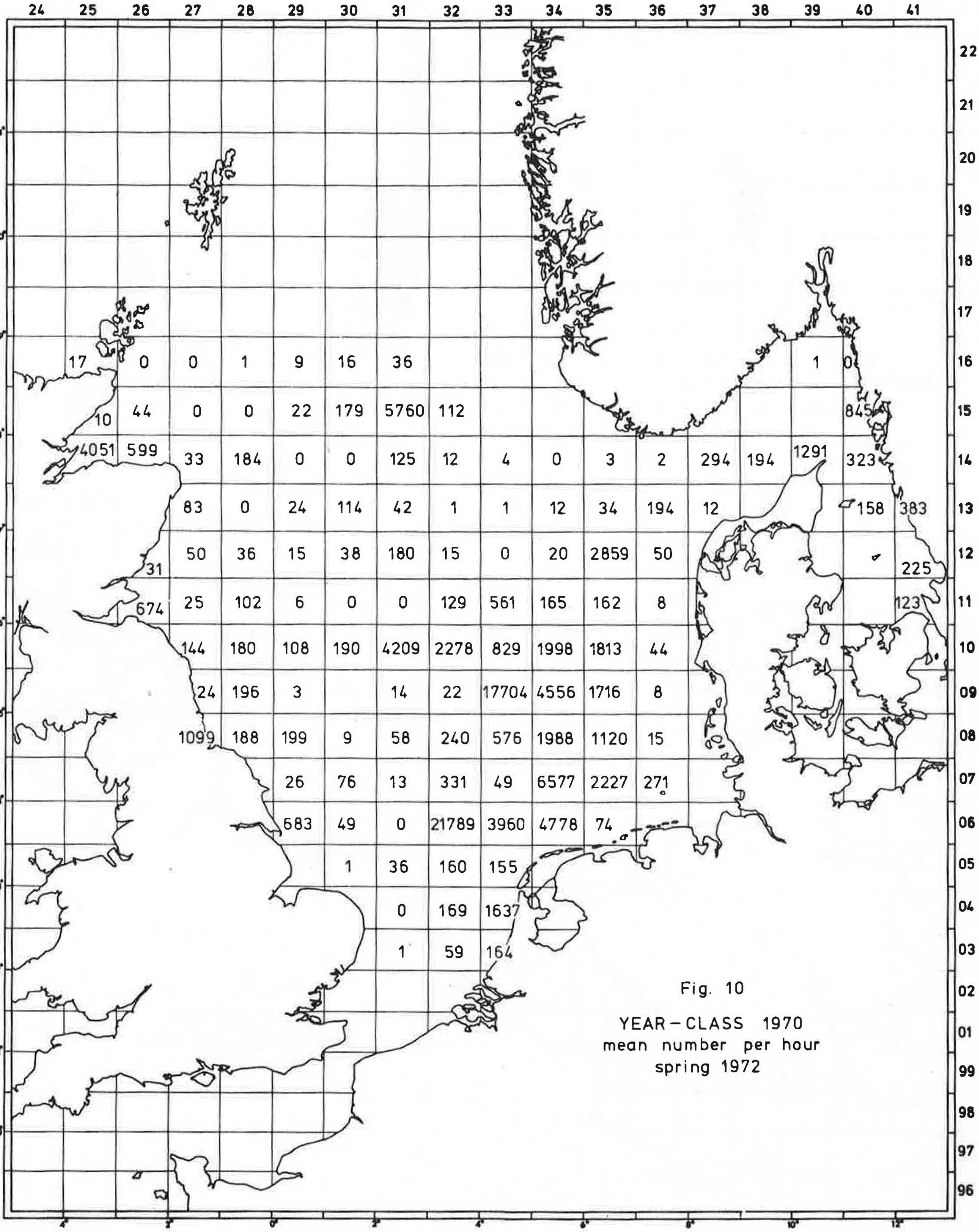


Fig. 10

YEAR-CLASS 1970
mean number per hour
spring 1972

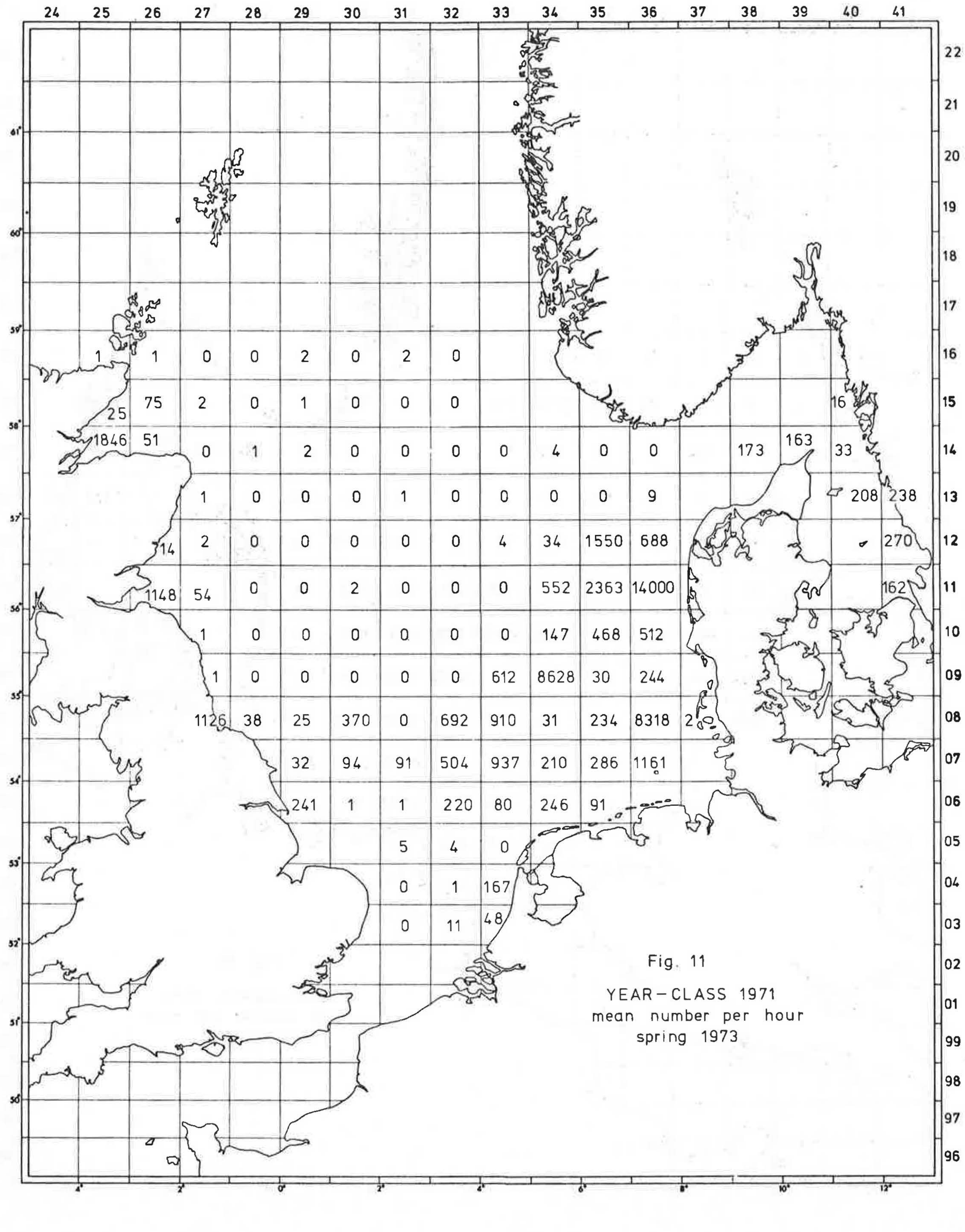


Fig. 11

YEAR-CLASS 1971
mean number per hour
spring 1973

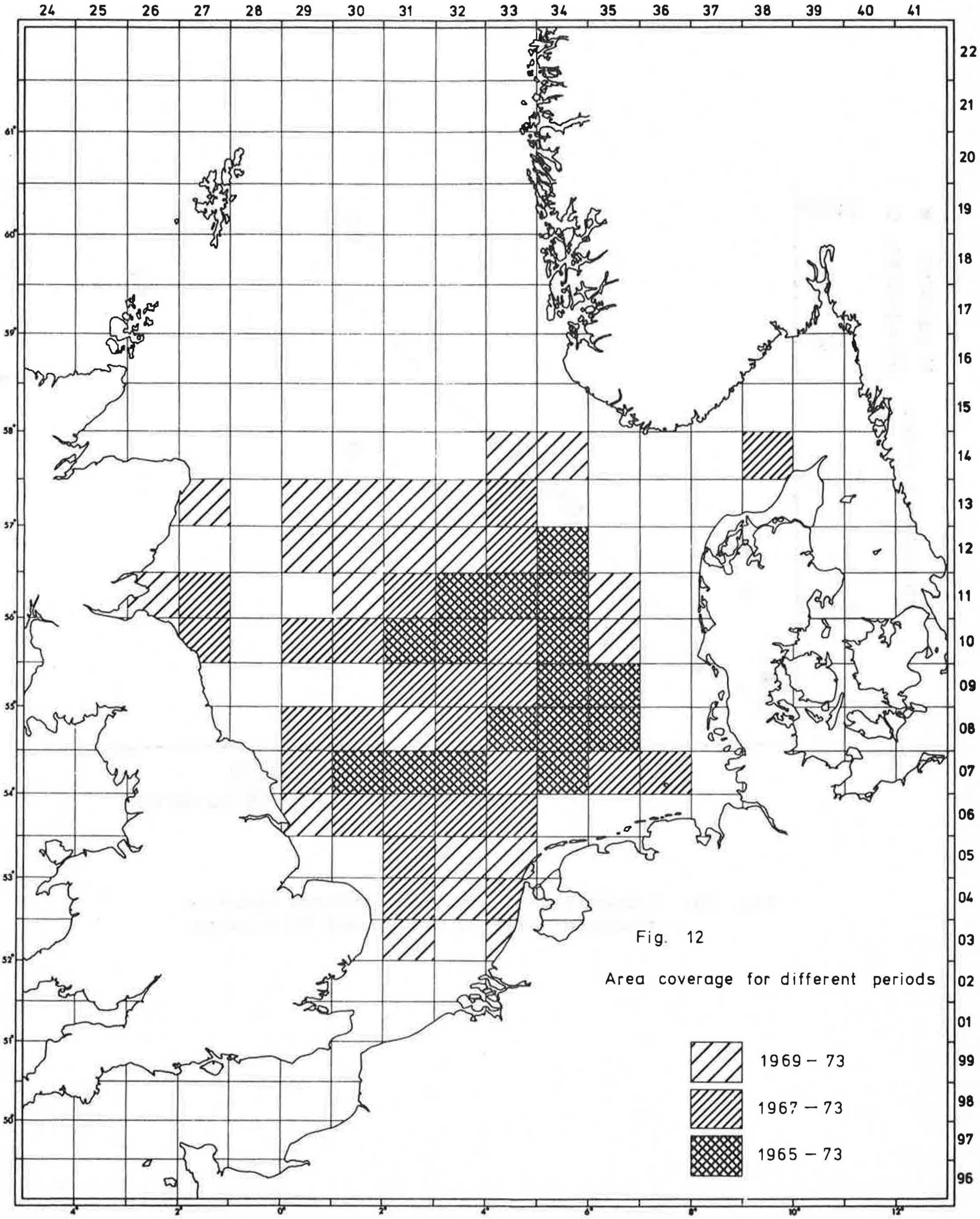


Fig. 12

Area coverage for different periods

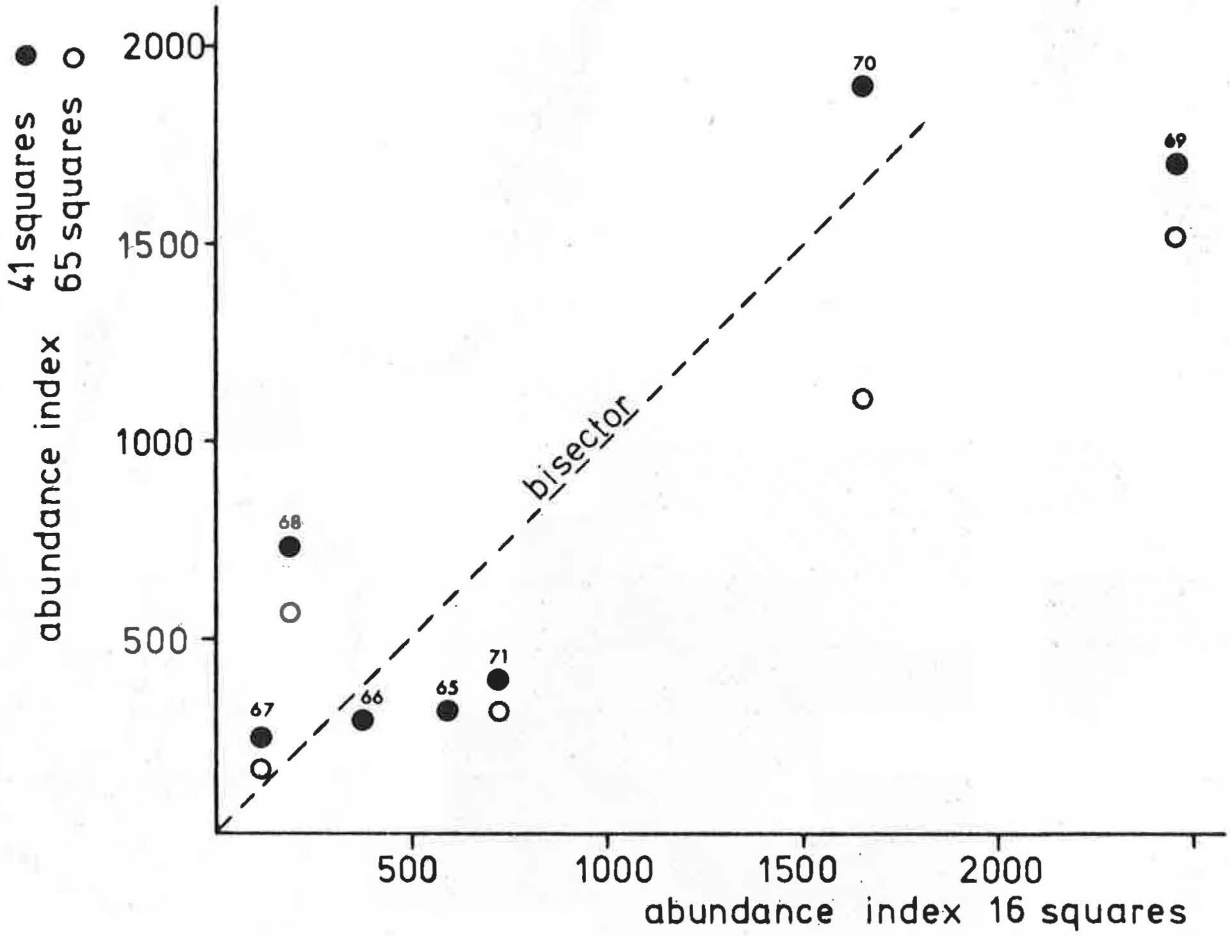


Fig. 13. Comparison of abundance indices based on standard areas of 16, 41 and 65 squares.

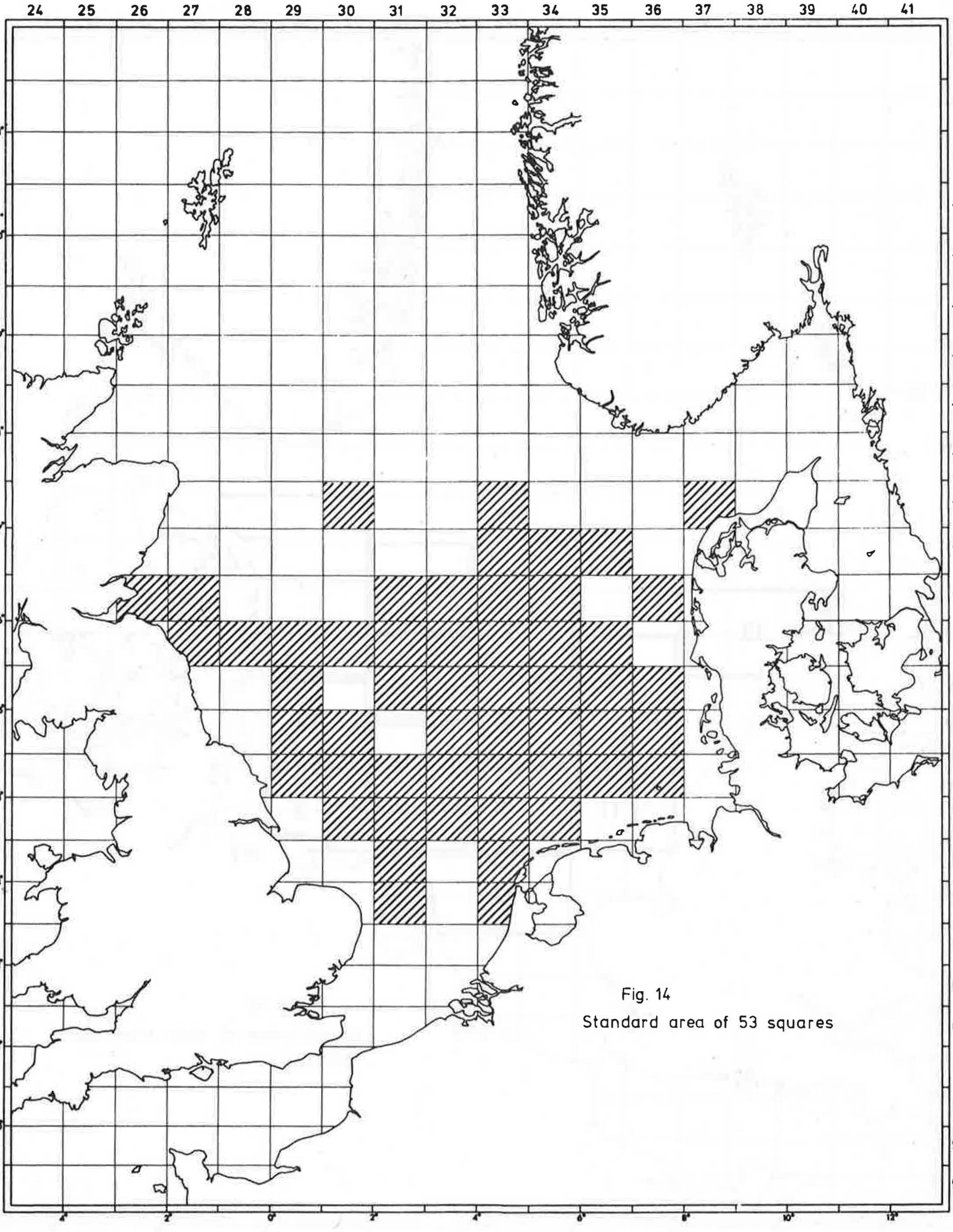


Fig. 14
Standard area of 53 squares

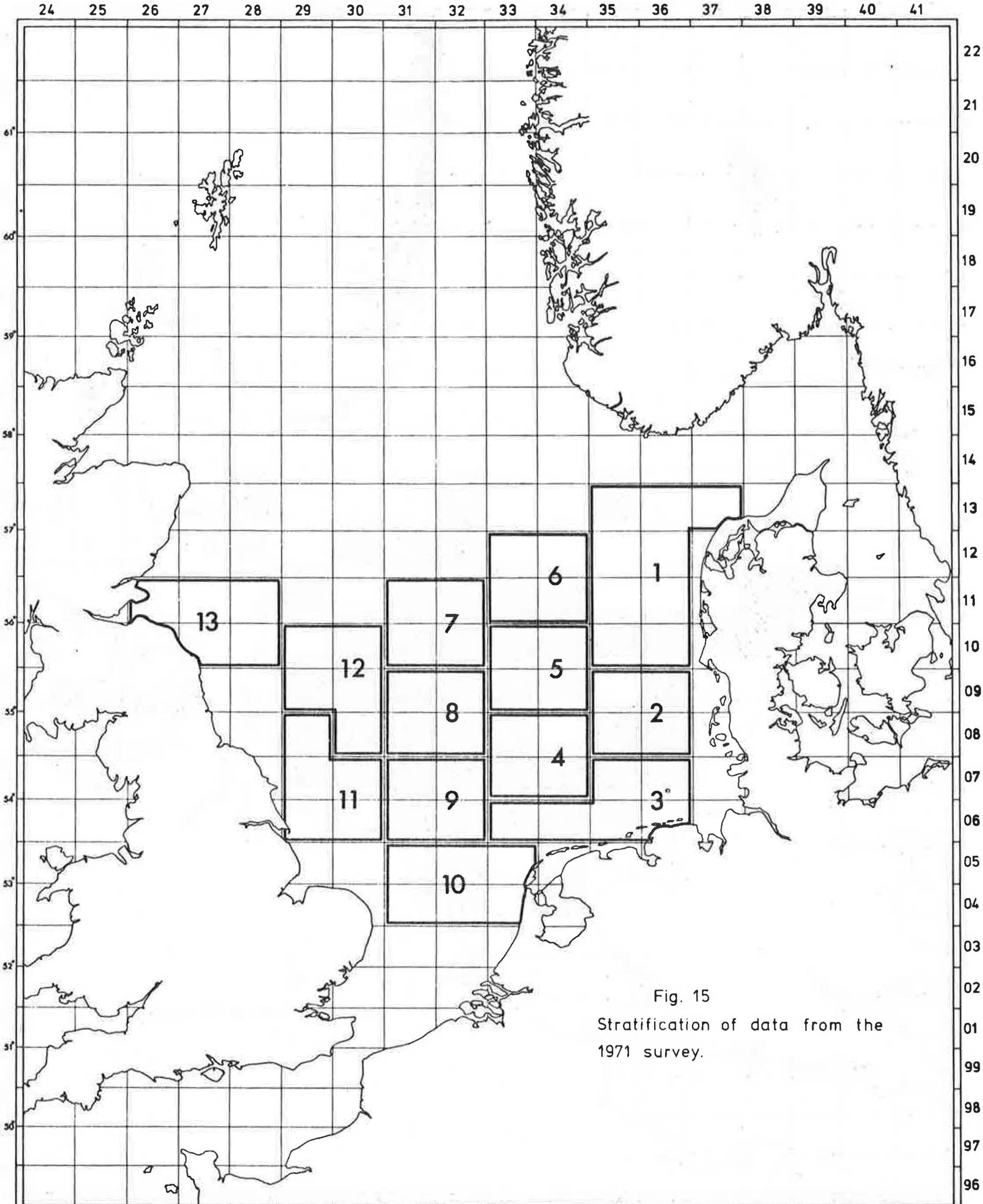


Fig. 15
Stratification of data from the 1971 survey.

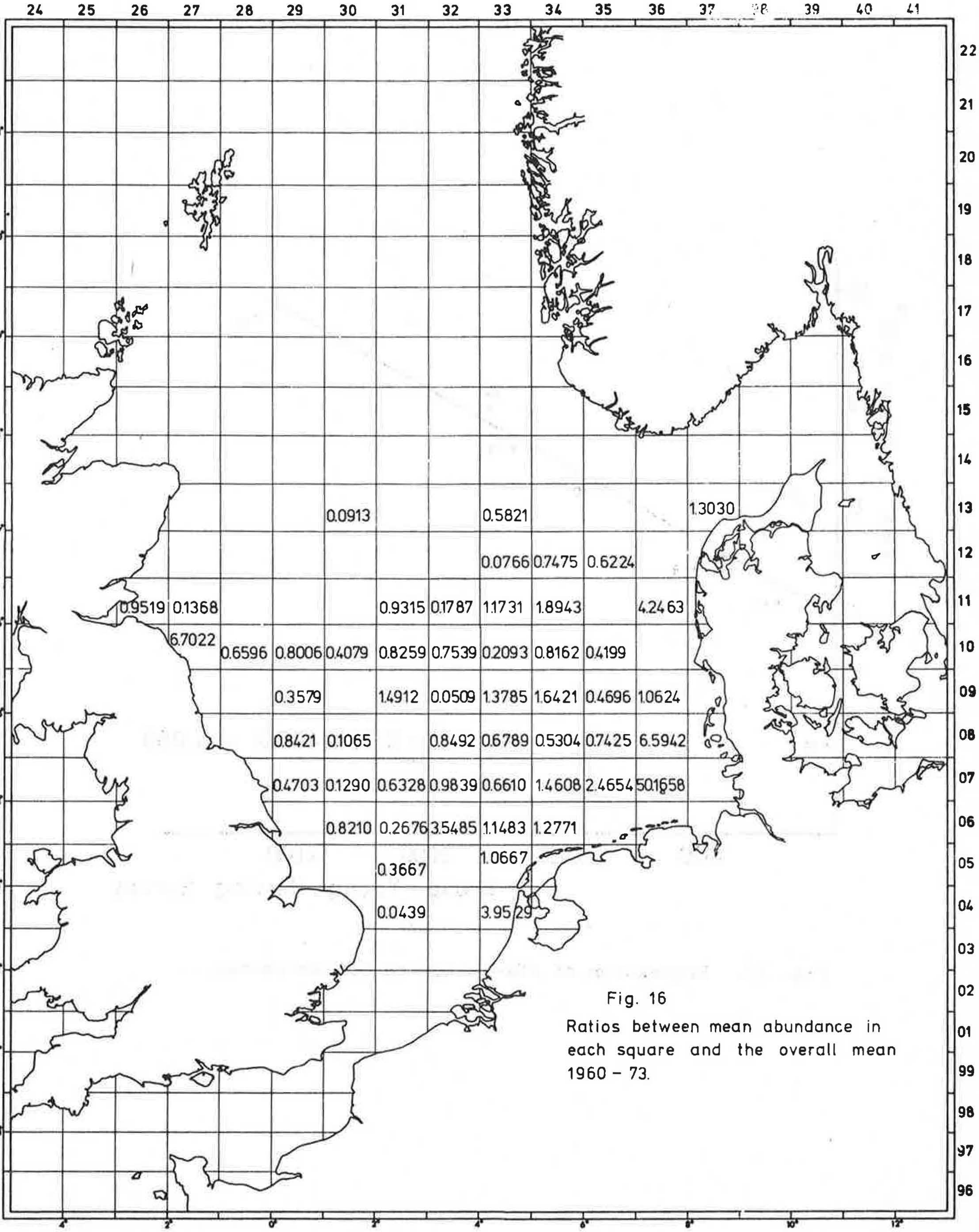


Fig. 16

Ratios between mean abundance in each square and the overall mean 1960 – 73.

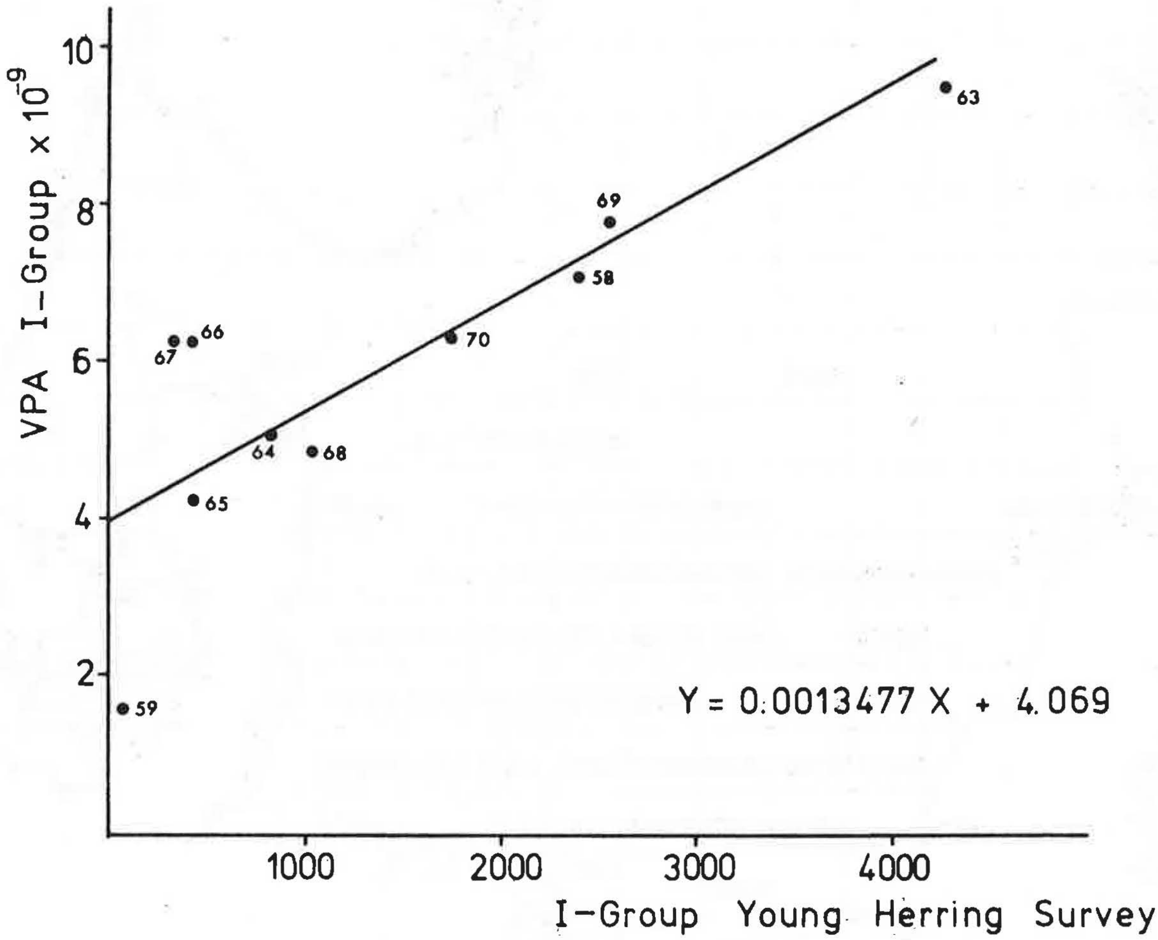


Fig. 17. Regression of VPA-values on YHS estimates.

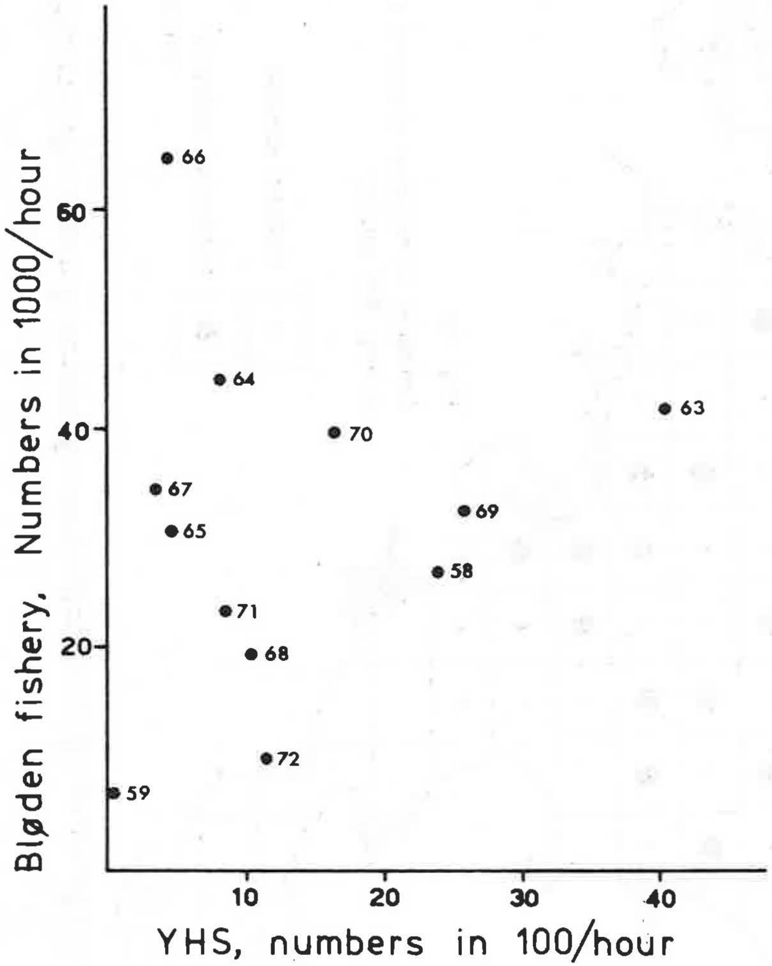


Fig. 18. Comparison of Bløden indices for I-group in winter/spring with YHS estimates.

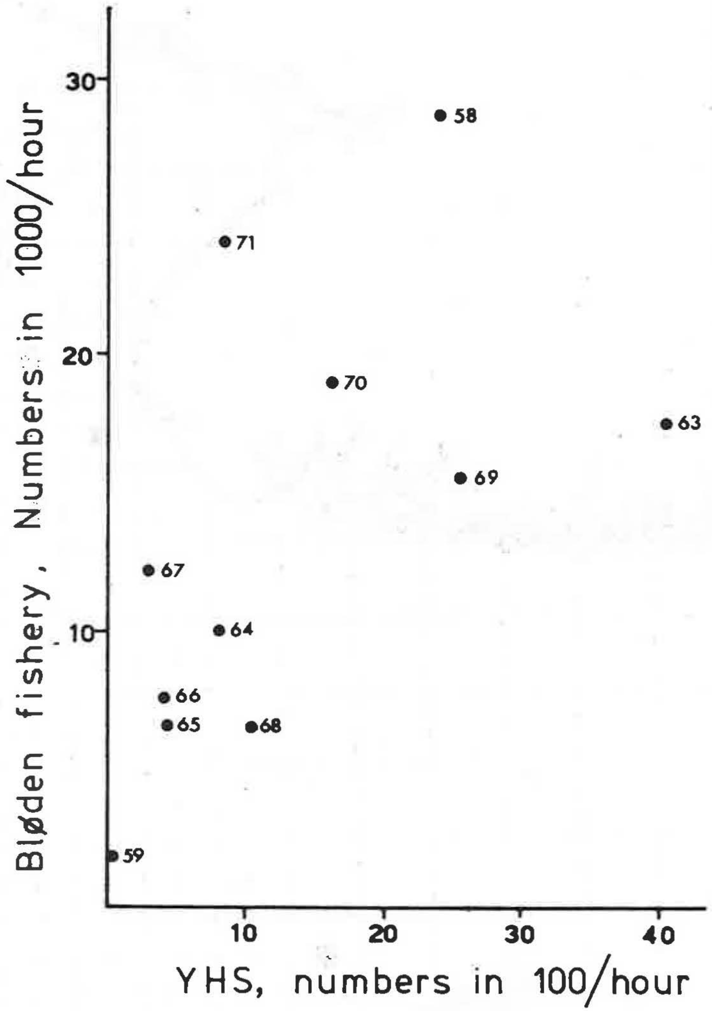


Fig. 19. Comparison of Bløden indices for I-group in summer/autumn with YHS estimates.

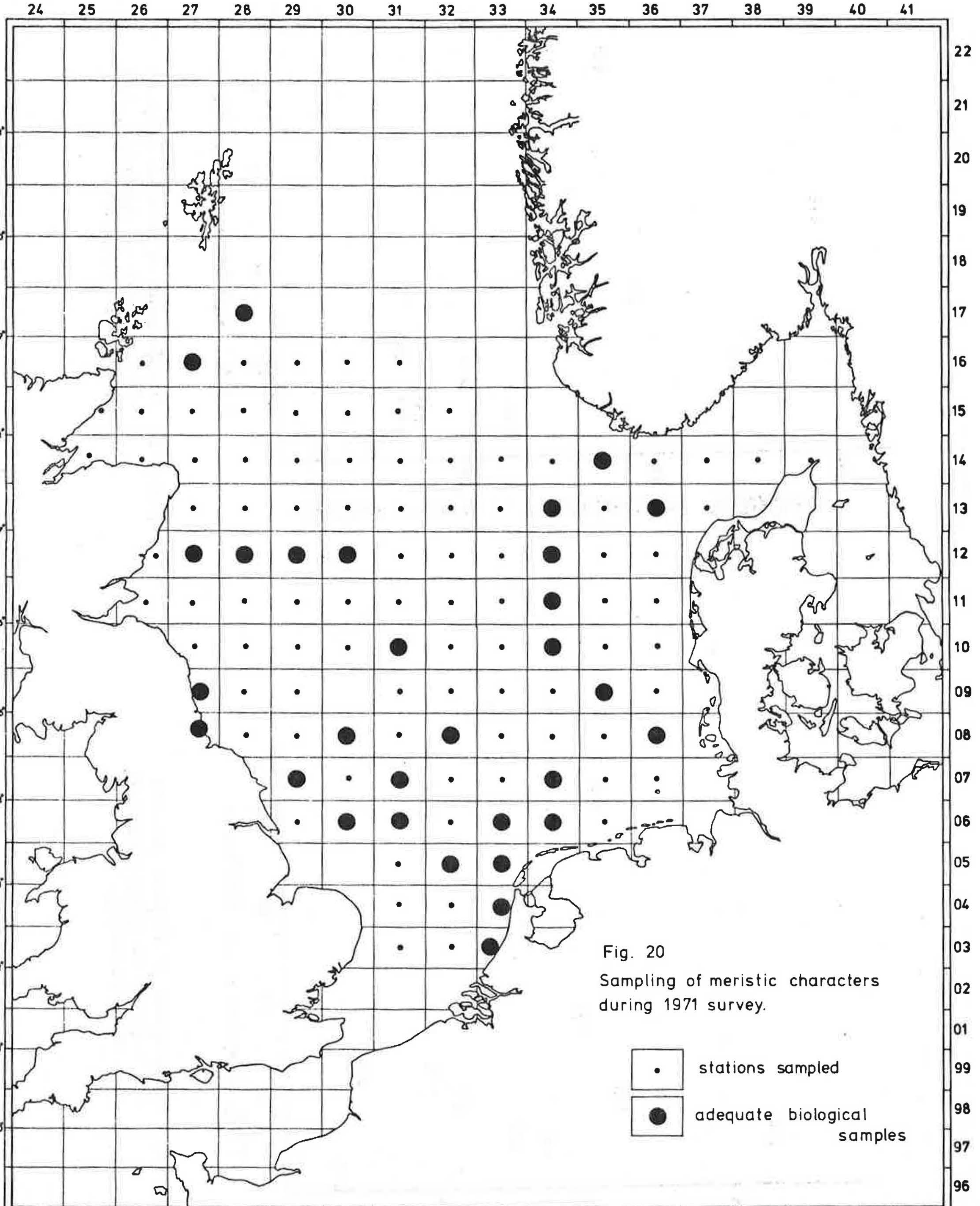


Fig. 20
Sampling of meristic characters during 1971 survey.

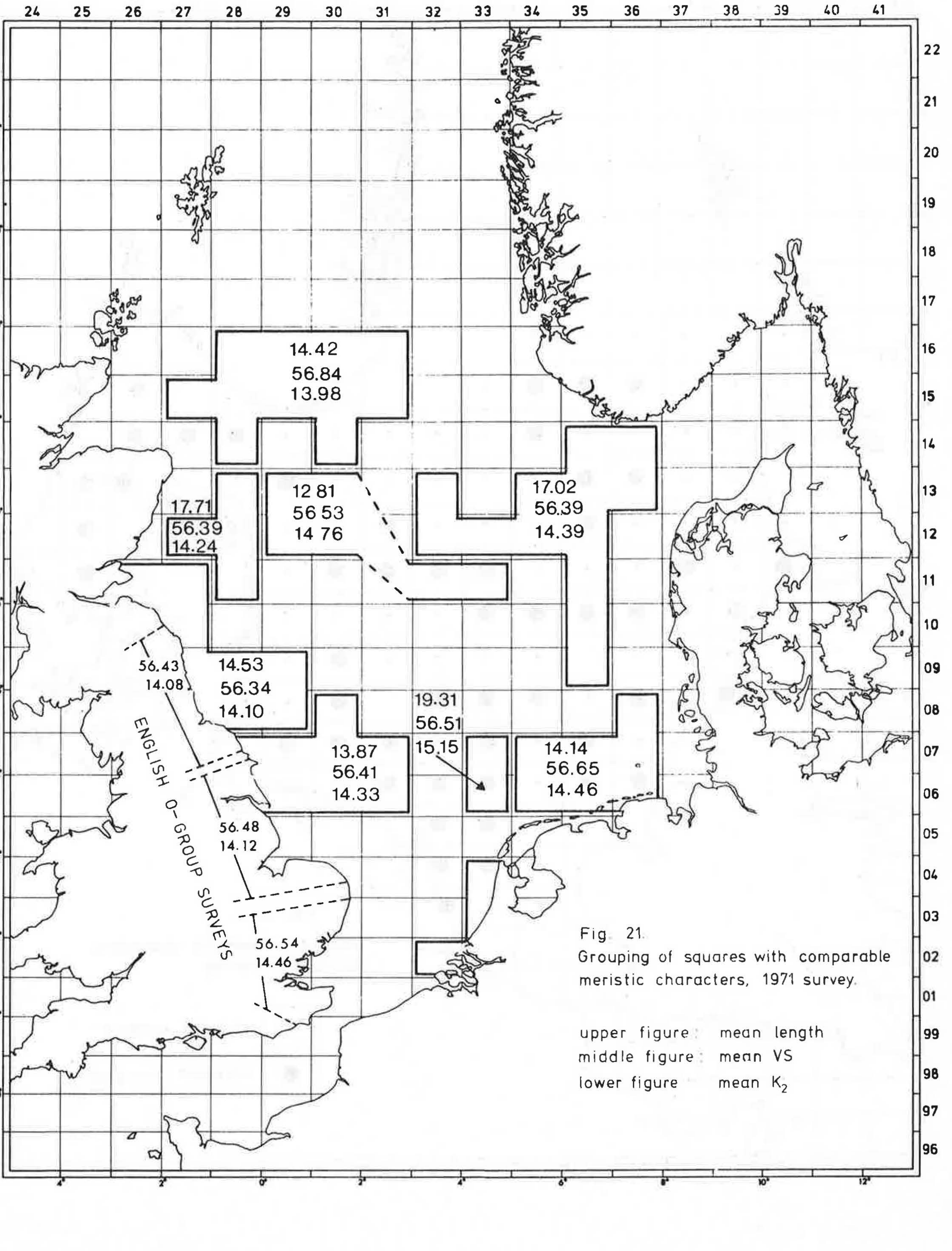
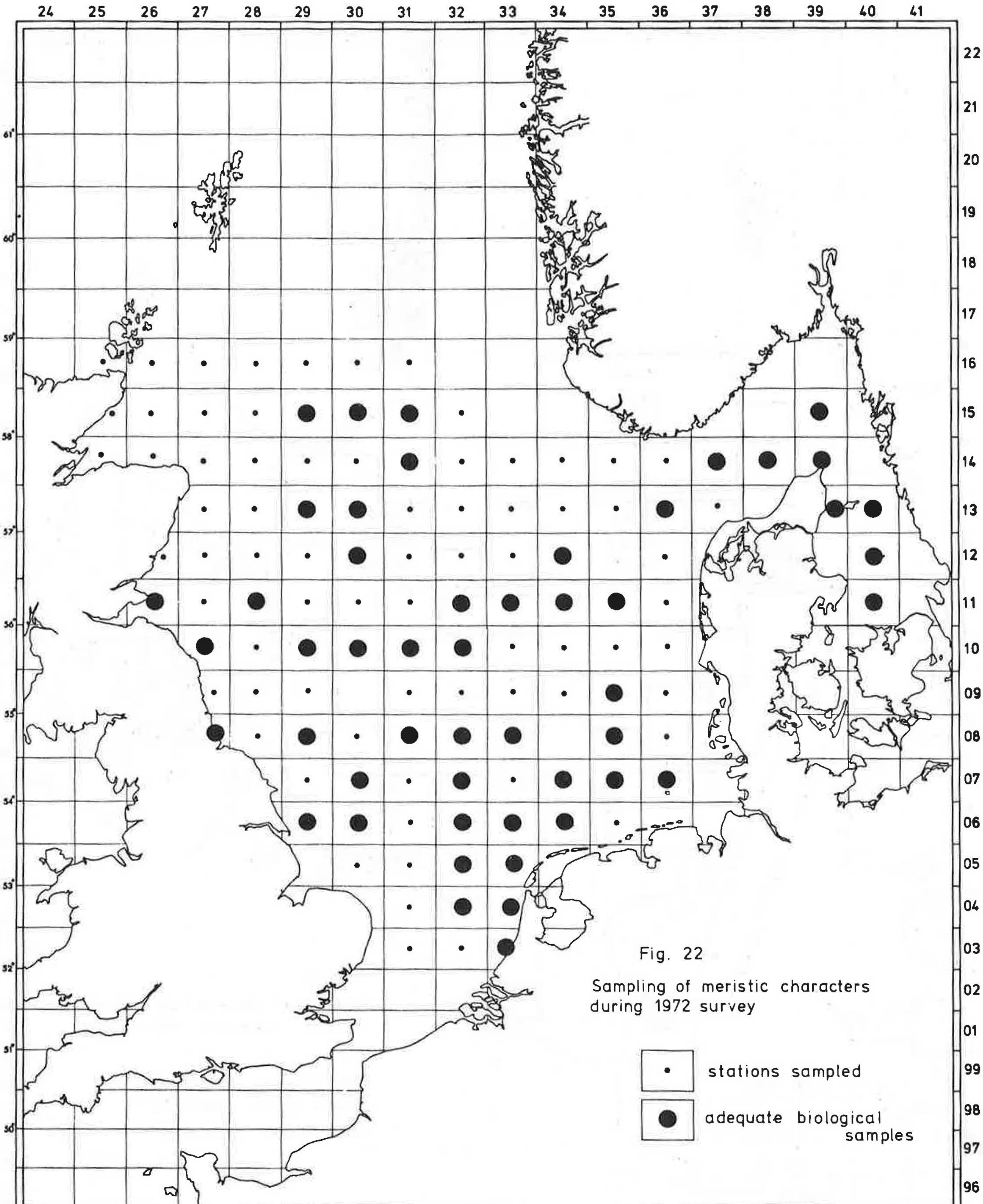


Fig. 21.
Grouping of squares with comparable meristic characters, 1971 survey.

upper figure : mean length
middle figure : mean VS
lower figure : mean K_2


24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
22 21 20 19 18 17 16 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 99 98 97 96
Fig. 22
Sampling of meristic characters during 1972 survey
stations sampled
adequate biological samples

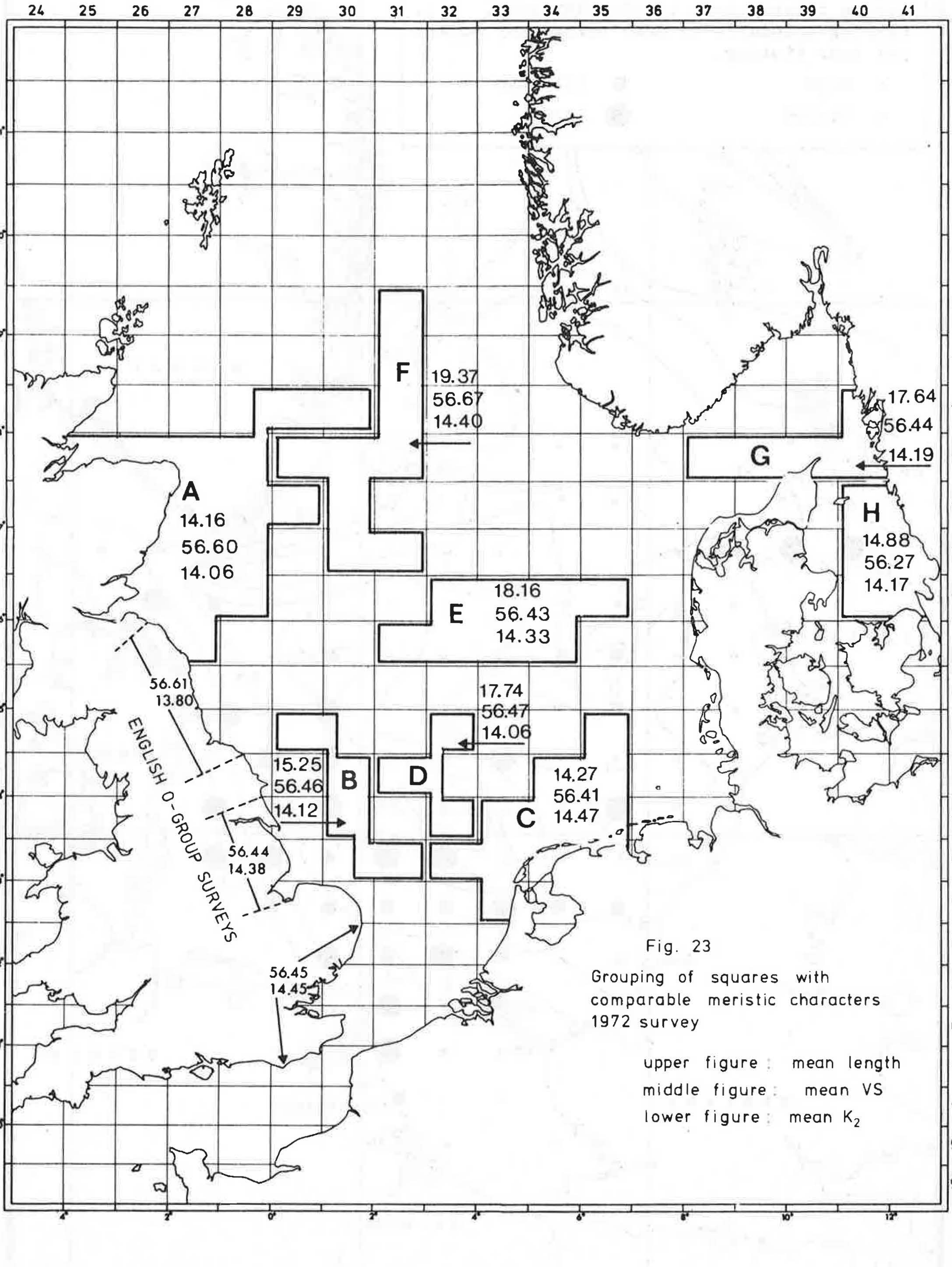


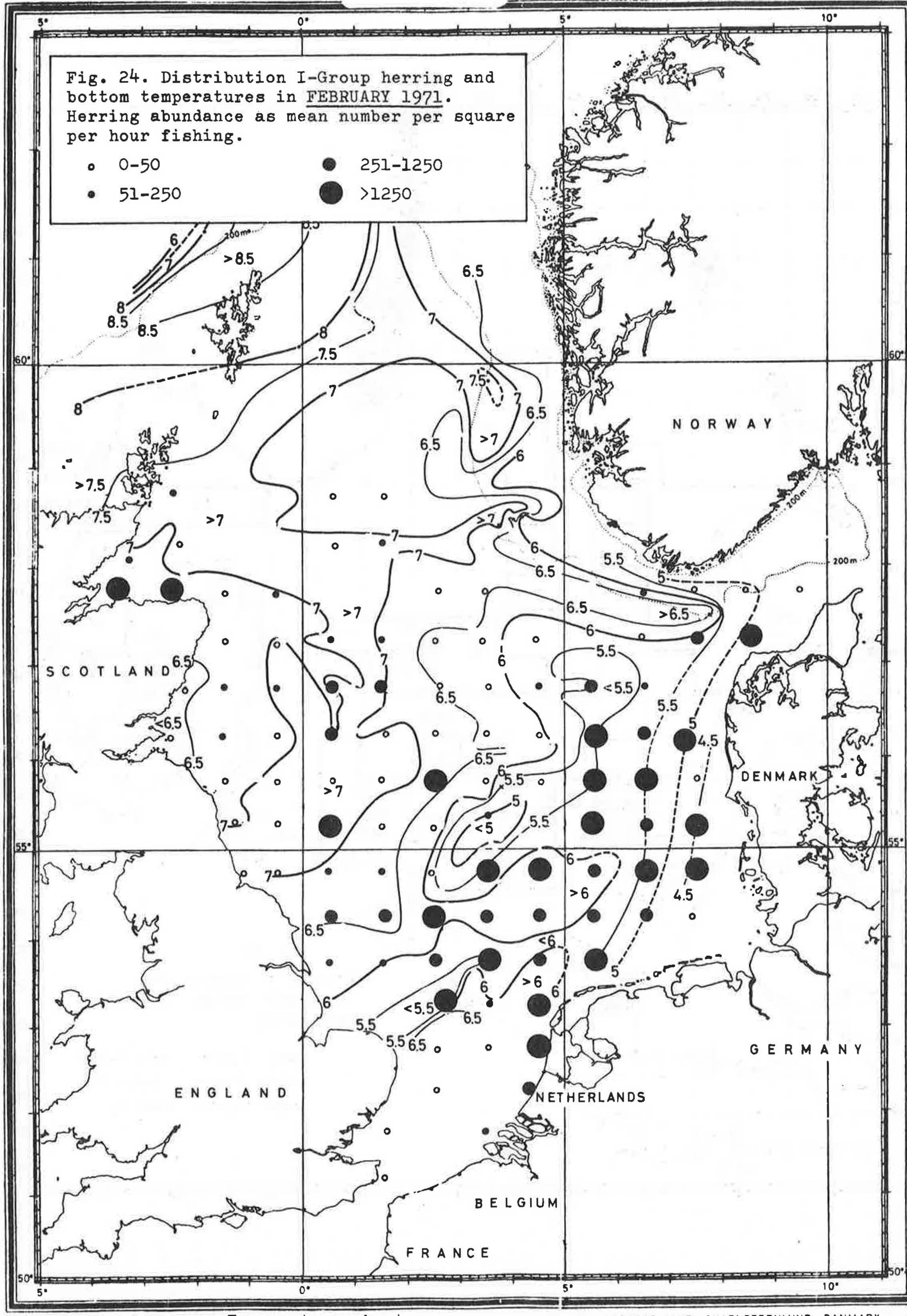
Fig. 23

Grouping of squares with comparable meristic characters 1972 survey

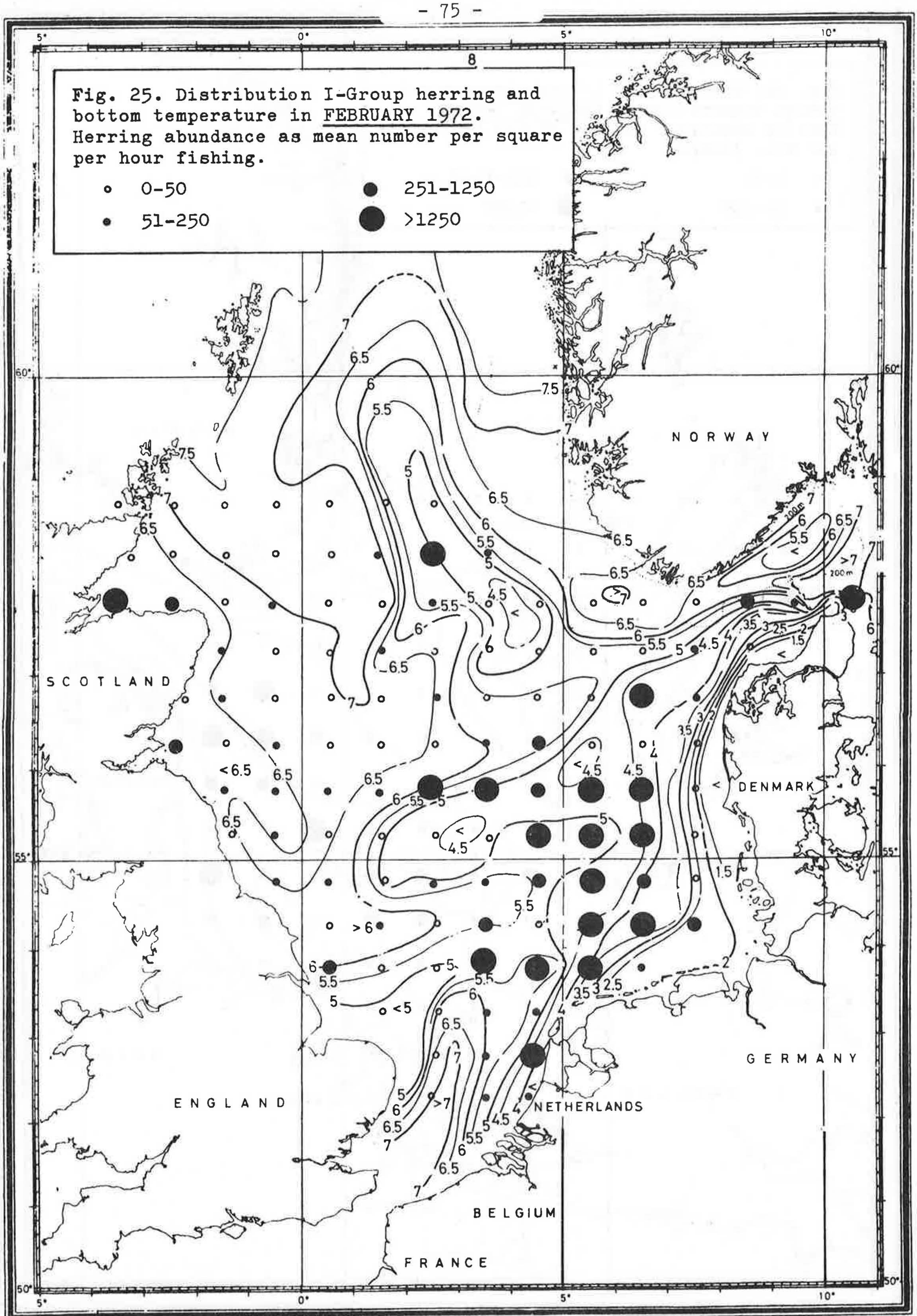
upper figure : mean length
middle figure : mean VS
lower figure : mean K_2

Fig. 24. Distribution I-Group herring and bottom temperatures in FEBRUARY 1971. Herring abundance as mean number per square per hour fishing.

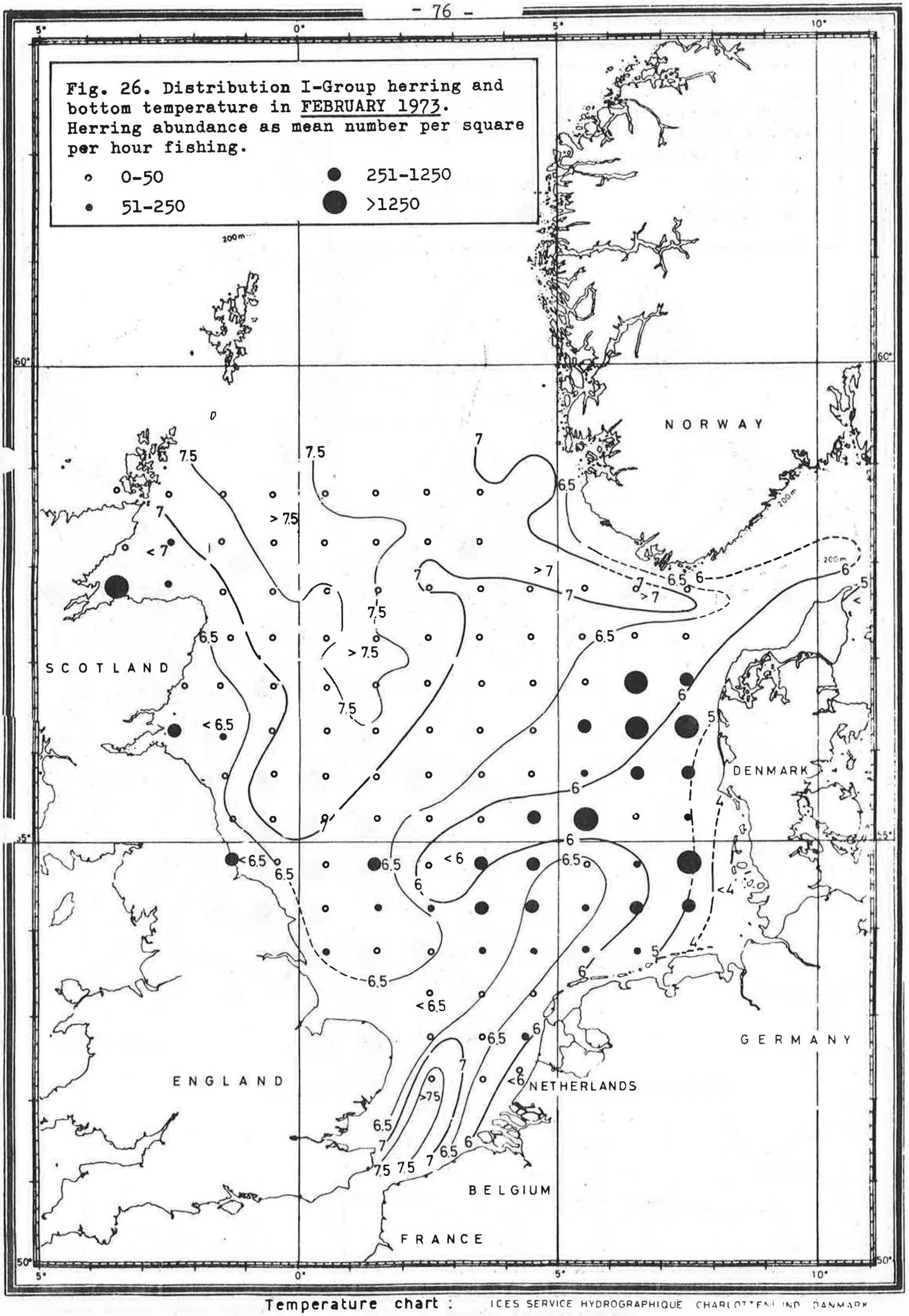
- o 0-50
- • 51-250
- ● 251-1250
- ⬤ >1250



Temperature chart : ICES SERVICE HYDROGRAPHIQUE, CHARLOTTENLUND, DANMARK



Temperature chart : ICES SERVICE HYDROGRAPHIQUE, CHARLOTTENLUND, DANMARK



Temperature chart : ICES SERVICE HYDROGRAPHIQUE CHARLOTTENLUND DANMARK

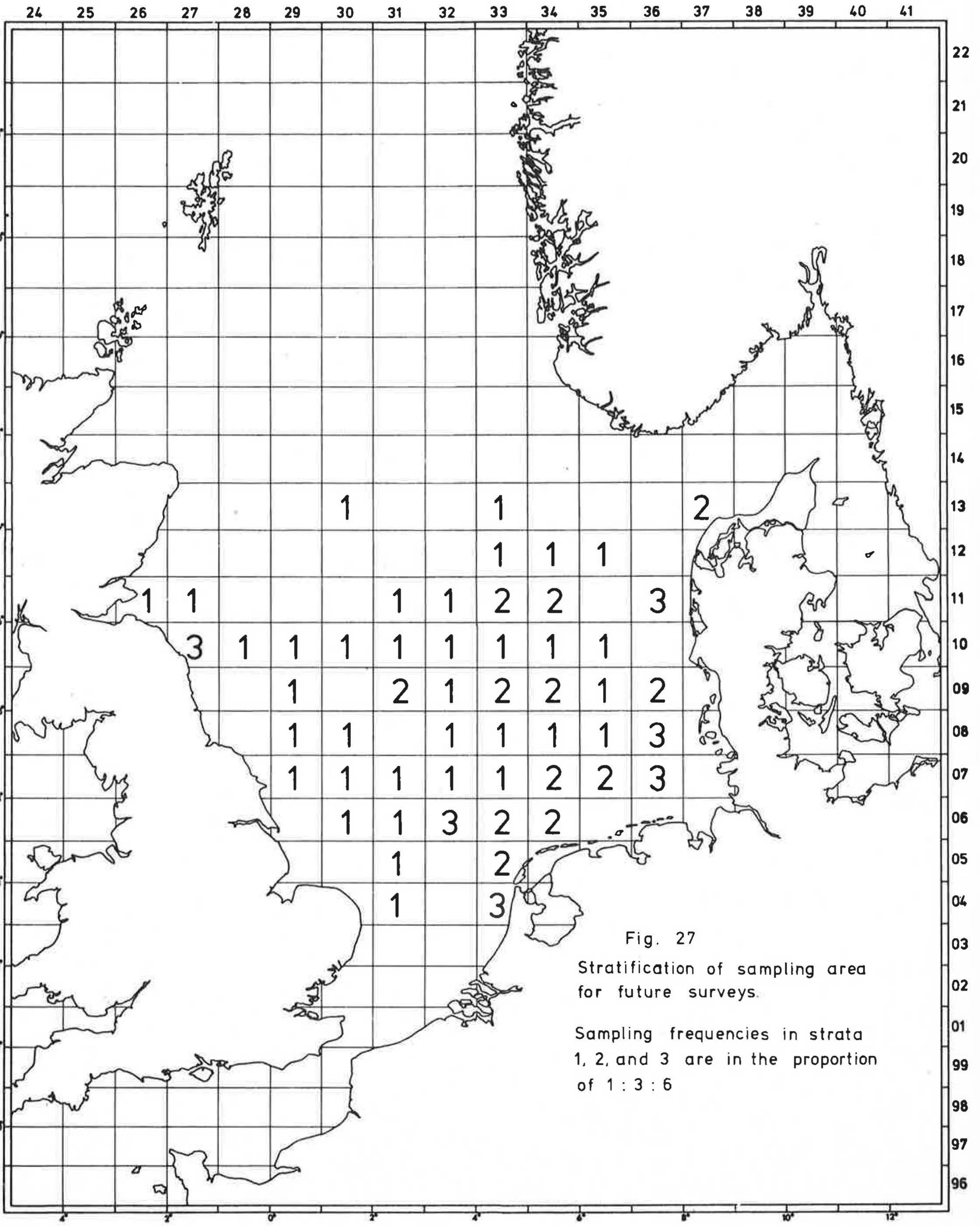


Fig. 27

Stratification of sampling area for future surveys.

Sampling frequencies in strata 1, 2, and 3 are in the proportion of 1 : 3 : 6