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Report of the Meeting to Consider Young Fish Surveys

Bergen, 6-9 May 1974

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1. Introduction

1.1. Terms of reference and participation

For a number of reasons it is very desirable to determine the 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 both 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
Hans-Heinrich Reinsch	Germany (F.R.)
Helmut Schultz	Germany (F.R.)
Gerhard Wagner	Germany (F.R.)
John Molloy	Ireland
Hjálmar Viljhálmsson	Iceland
A.A.H.M. Corten	Netherlands
Niels Daan	Netherlands
Erling Bakken	Norway
Are Dommasnes	Norway
Olav Dragesund (Chairman)	Norway
Stein Hjalti i Jakupsstovu	Norway
Lars Midttun	Norway
Ingolf Röttingen	Norway
Roald Sætre	Norway
Øyvind Ulltang	Norway
Brian Jones	U.K. (England)
John Hislop	U.K. (Scotland)
Alan Saville	U.K. (Scotland)
Hans Ackefors	Sweden
Marvin D. Grosslein	U.S.A.

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. On the basis of the available data most of the time was used to discuss 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) O-group Fish Surveys in the Barents Sea,

2) O-group Fish Surveys at the Faroes, Iceland and East-Greenland,

3) Young Fish Surveys in the North Sea,

4) O-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. O-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 O-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 Finnmark (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 O-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 O-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 Barent 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 O-group herring from combined acoustic surveys, and fishing experiments with pelagic trawl and purse seine. The results obtained indicate a relationship between O-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 methods used and results of the surveys in 1965-1968 are given in Dragesund, Midttun and Olsen (1970).

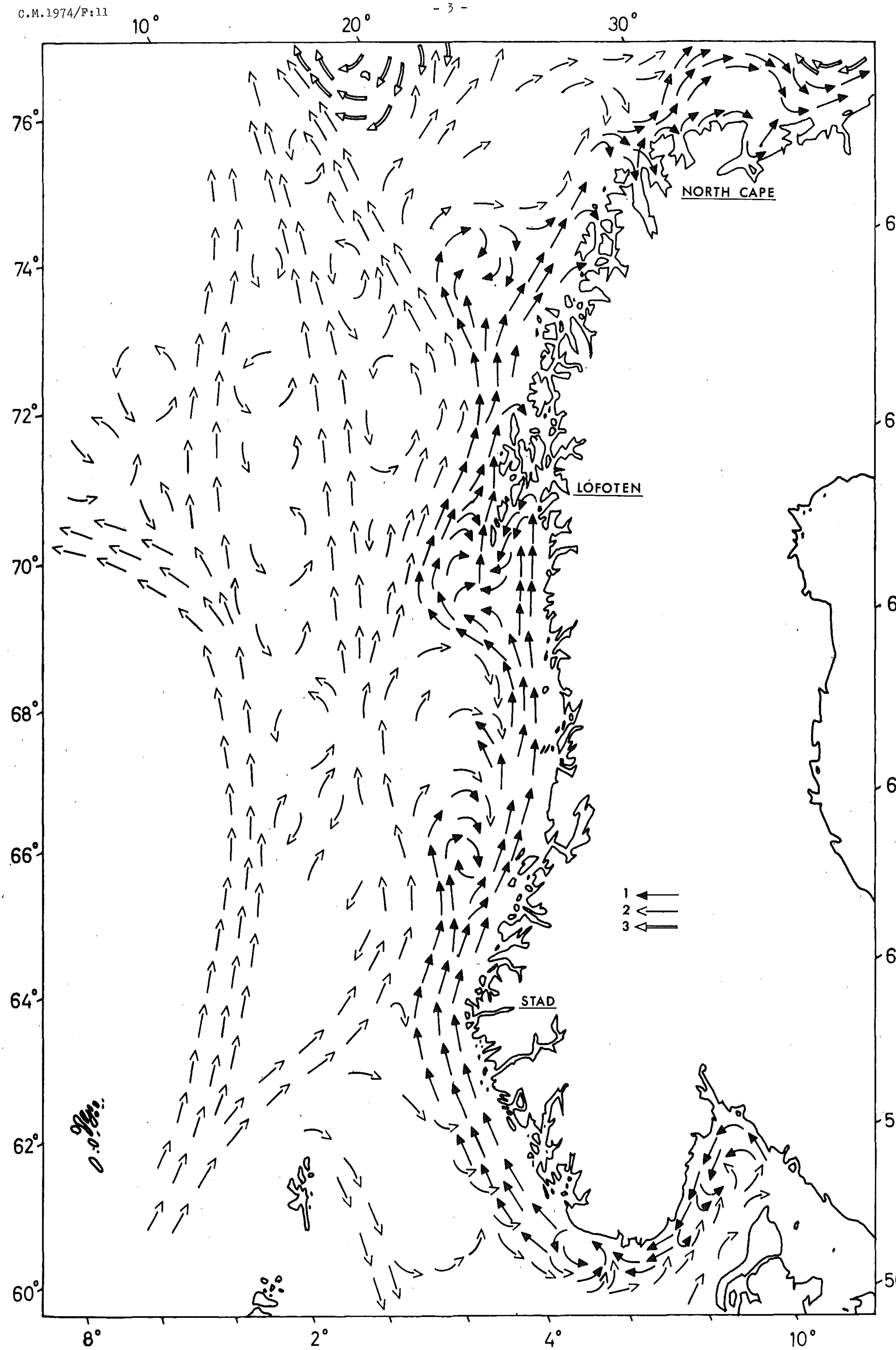


FIGURE 1. DISTRIBUTION OF WATER MASSES AND CURRENTS OFF THE NORWEGIAN COAST, 1) COASTAL WATER, 2) ATLANTIC WATER, 3) POLAR WATER (FROM SÆTRE AND LJOEN 1972).

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 later in the year. 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.

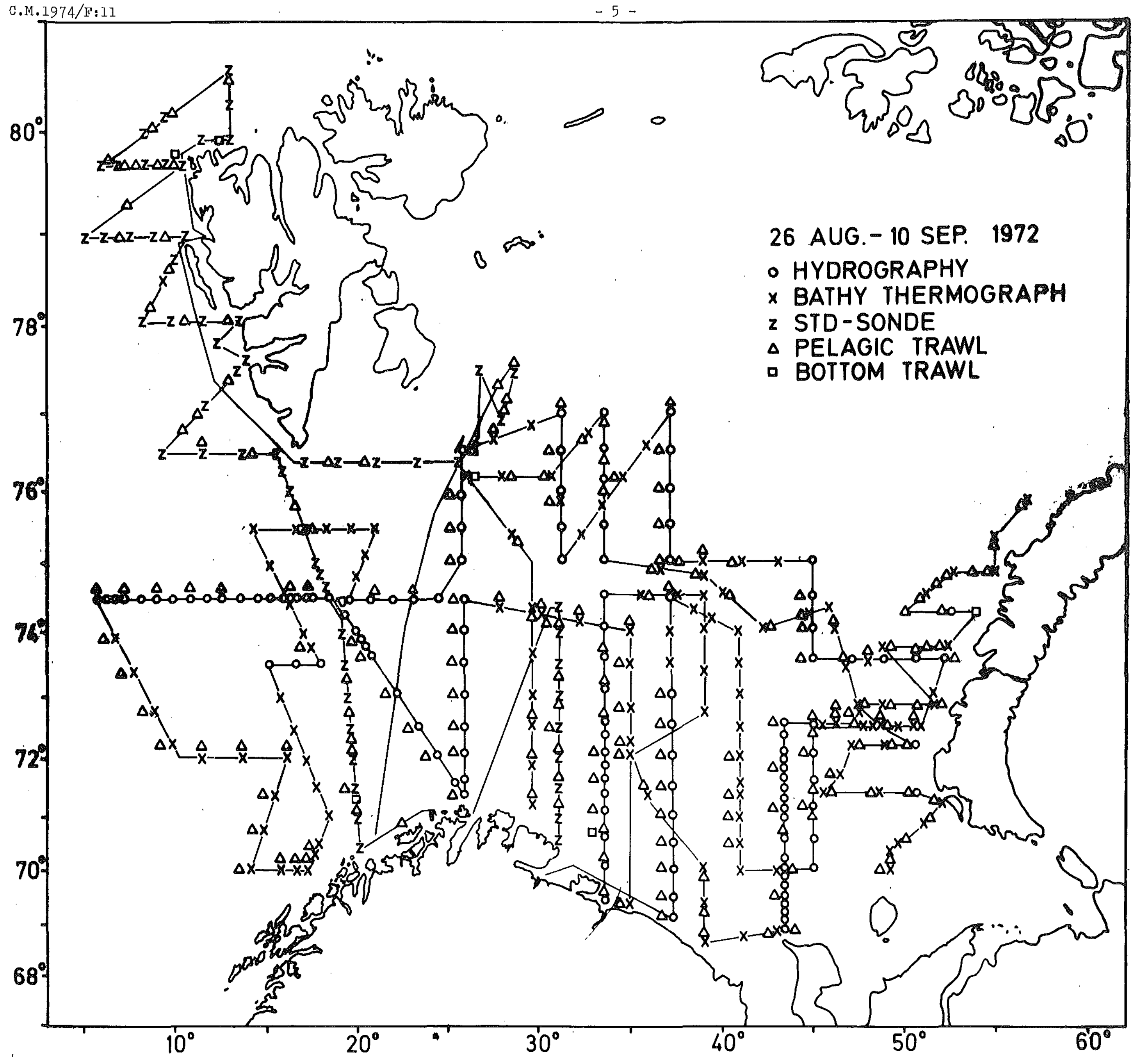


Figure 2. General survey routes and grid of stations in the Barents Sea surveys.

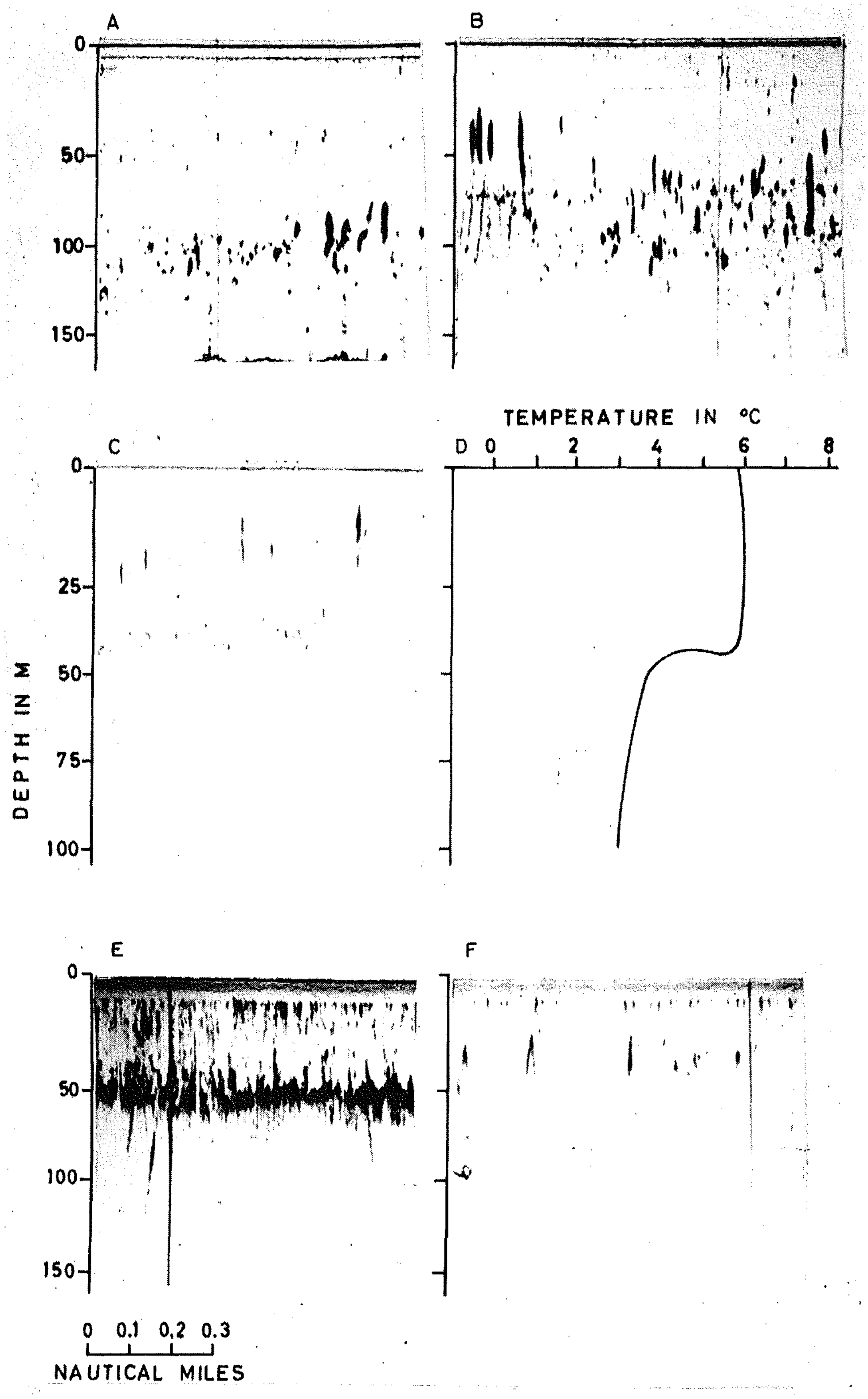


Figure 3. Echo-recordings of 0-group fish by day, A) cod or haddock or both and B) herring (top left) and cod or haddock, C) herring recorded above the thermocline, D) bathythermogram from the same region, E) herring and redfish and F) herring.

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 trawls 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.

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. In Figure 4 an example of a distribution of cod based on grading of the echo-records, combined with trawl catch data, is shown. The abundance indices of year class strength given by Dragesund and Nakken (1973) and Hylen and Dragesund (1973) are found from formula

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

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:

A) 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:

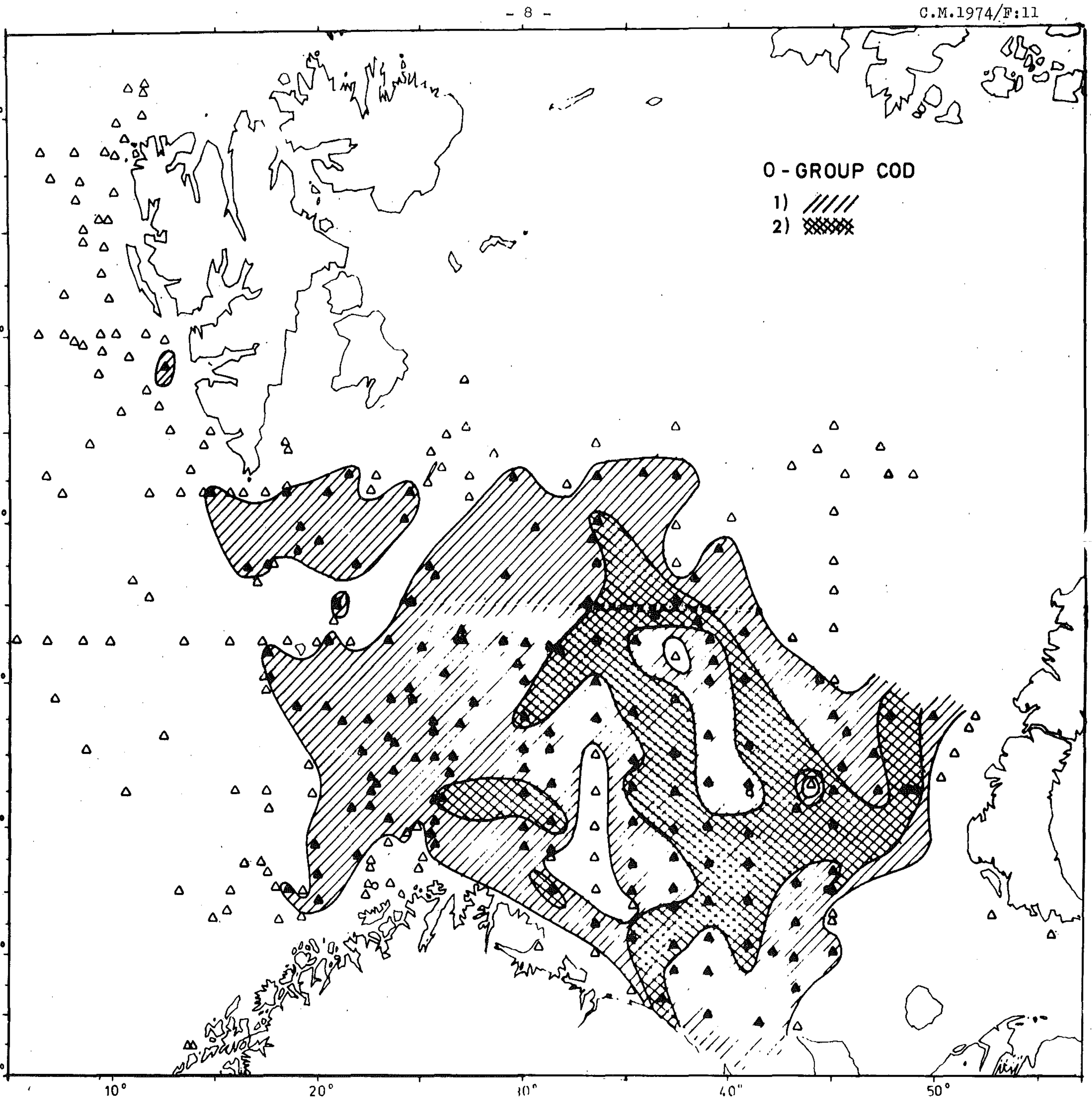


Figure 4. Distribution of O-group cod in autumn 1973, 1) area with scattered and 2) area with dense recordings.

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

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

C) The abundance indices, T, were calculated from formula (1).

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

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 Northeast 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 2-4. In Table 5 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 Northeast 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.

Table 1. Abundance indices [(nautical mile)^2 x 10^{-3}] of 0-group fish during the period 1965-1972.

$T = A_s + 10\ A_d$

	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

	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 Northeast Arctic cod.

Year Class	0-Group Abundance		1) III-Group USSR Trawl Surveys	1) Stock Size (in millions) at 3 years old from VPA
	Hylen & Dragesund (1973)	Haug & 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[x)]	-
1972	-	140	16[x)]	-
1973	-	-	18[x)]	-

1) From 1974 Report of the Northeast Arctic Fisheries Working Group (Anon.1974).

x) Estimated from catches of young age groups.

Table 3. Estimates of year class strength of Northeast Arctic haddock.

Year Class	0-Group Abundance: Hylen & Dragesund (1973)	0-Group Abundance: Haug & Nakken (1973)	1) III-Group from USSR Trawl Surveys Sub-Area I	1) Stock Size (in millions) at 3 years old from VPA
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 ※)	-

1) From the 1974 Report of the Northeast 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 & Nakken (1973)	0-Group Abundance: Haug & Nakken (1973)	Stock Size (in millions) as 4 year olds from VPA (Dragesund & 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	all 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 is Norwegian catches during the capelin winter fishery 4 years after the 0-group abundance measurements.

Year Class	0-Group Echo-Abundance (Haug & Nakken 1973)	As 4 years old (unpublished data)	Catches (in million hecto-litres) 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 x)	-
1972	275	S x)	-

x) Estimates from catches of younger age groups.

It is likely, therefore, that I-group abundance indices made up in the same way will give better basis for prediction of the stock size as adults.

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 operation 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 overestimate the deeper layers.

The reflecting properties of different species is an important factor. 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 utilized. 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 millimeters, 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. The constant C 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

$$M = M_1 + M_2 + M_3 \quad \ldots\ldots\ldots\ldots \quad (2)$$

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

Further

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

If k is true density composition between the three groups:

$$\begin{aligned} k_1 &= \frac{\rho_1}{\rho_1 + \rho_2 + \rho_3} \\ k_2 &= \frac{2}{\rho_1 + \rho_2 + \rho_3} \\ k_3 &= \frac{3}{\rho_1 + \rho_2 + \rho_3} \end{aligned} \quad \ldots\ldots\ldots\ldots \quad (4)$$

From the equations 2-4 the values of M_1, M_2 and M_3 can be calculated.

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 0-group investigations in the Barents Sea are likely to rely more on the acoustic estimates than previously, more knowledge of the relative densitities 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.

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 O-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. The table below lists the nationality of the participants and the timing and duration of the cruises.

1970		Iceland - East Greenland	Faroes
Iceland	1 vessel	1 - 11/8	
Norway	"	1 - 11/8	
W. Germany	"	21/8 - 12/9	
Iceland	"	28/8 - 12/9	
1971			
F.R. Germany	1 vessel	28/6 - 10/7	
U.K.	"	18/7 - 29/7	
Iceland	2 vessels	5/8 - 18/8	
Norway	1 vessel	5/8 - 18/8	

1972		Iceland - East Greenland	Faroes
U.K.	1 vessel	13/7 - 20/7	1/7 - 12/7
Iceland	"	15/7 - 25/7	
USSR	"	28/7 - 13/8	
Iceland	"	2/8 - 25/8	
1973			
USSR	1 vessel	31/7 - 14/8	
Iceland	"	9/8 - 29/8	
"	"	28/8 - 7/9	
U.K.	"	14/9 - 27/9	1/7 - 12/7

Due to the crowded research schedules of each nation, complete coordination has up to now been impossible. This, together with unavoidable mishaps onboard some vessels, has caused a relatively high scatter of the 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 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 research vessel samples collected in 1974 off northwest and northern Iceland and

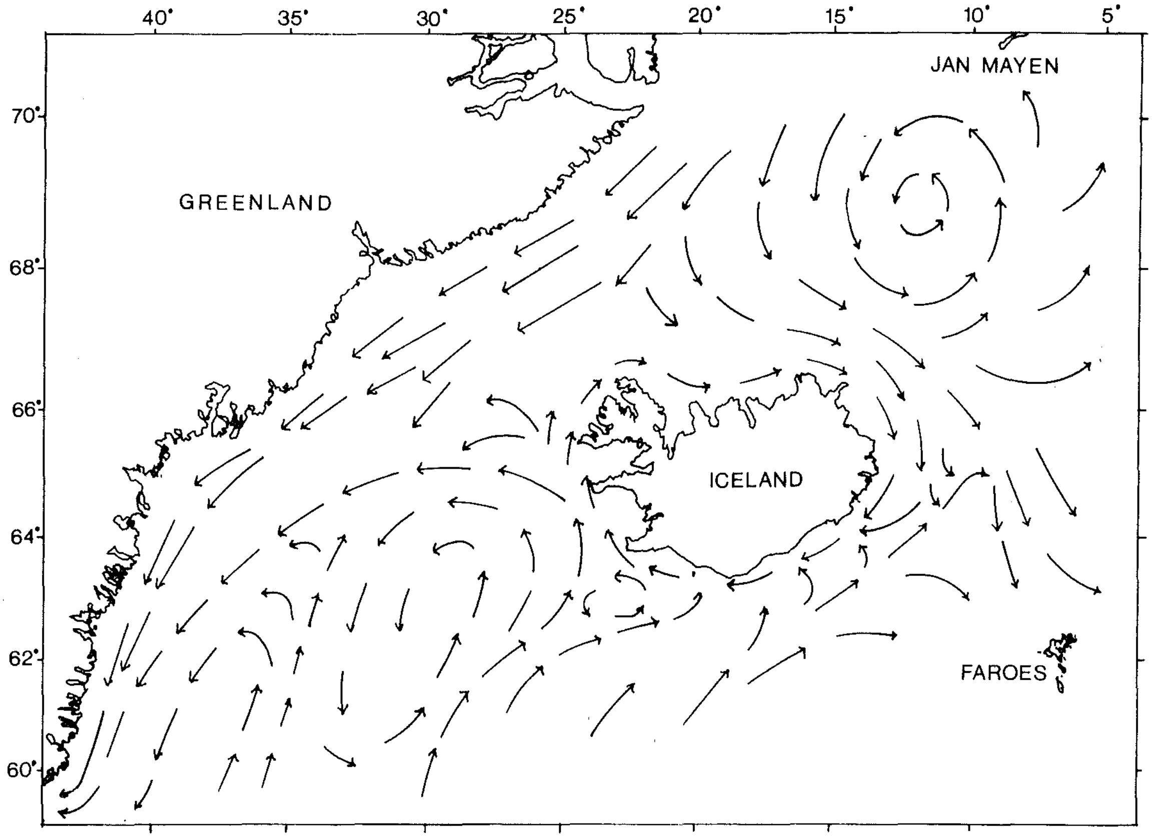
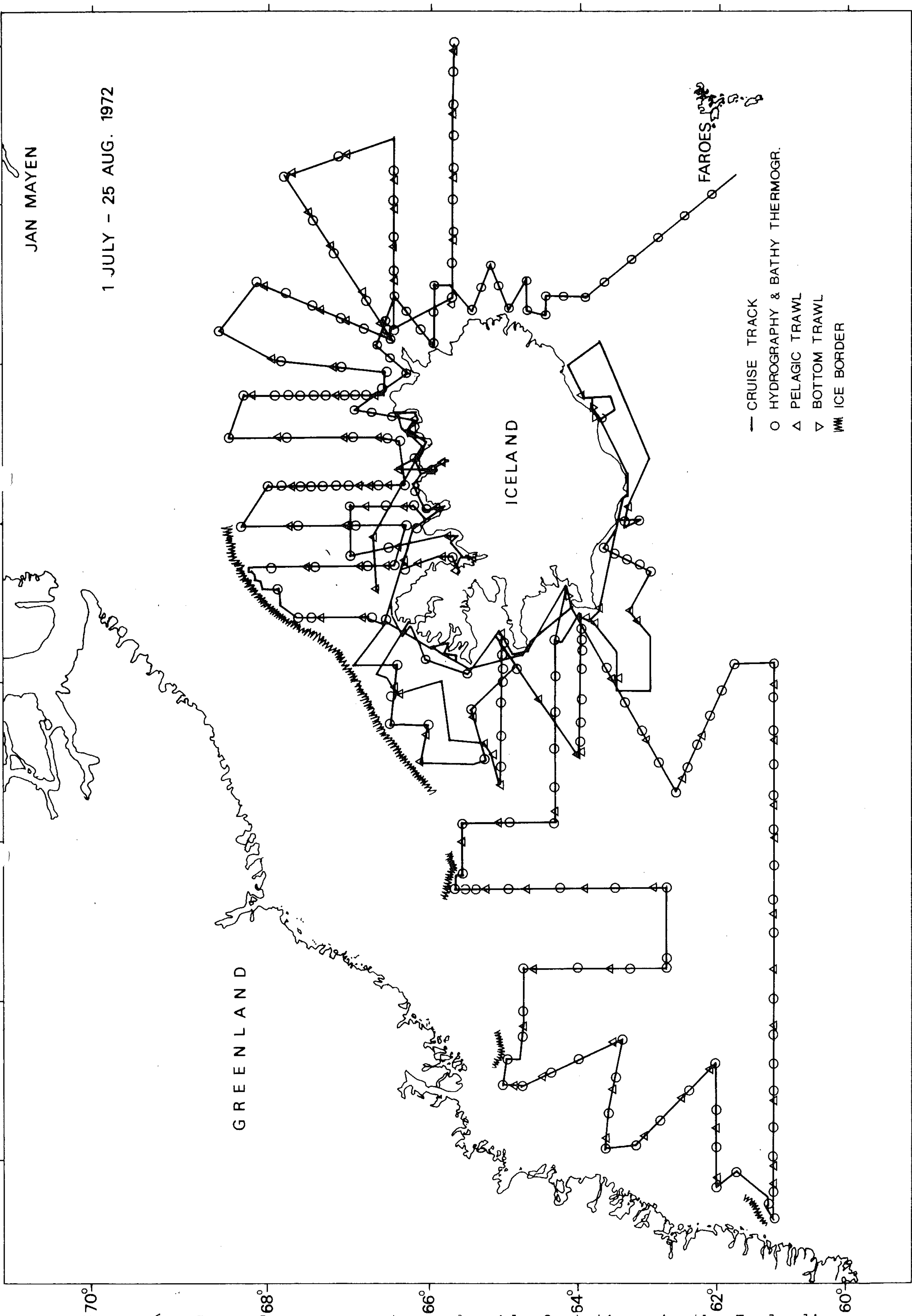


Figure 5. Main features of the systems of water currents in the Iceland - East Greenland area (Vilhjálmsson 1973). The map is redrawn from published data and verbal information from S.Aa. Malmberg.



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

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.

From the results 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 probably 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 in 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.

The Faroes

3.5. 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. Results

In the table below are listed the tentative appraisals for cod and haddock relative to the 1972 survey.

	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.

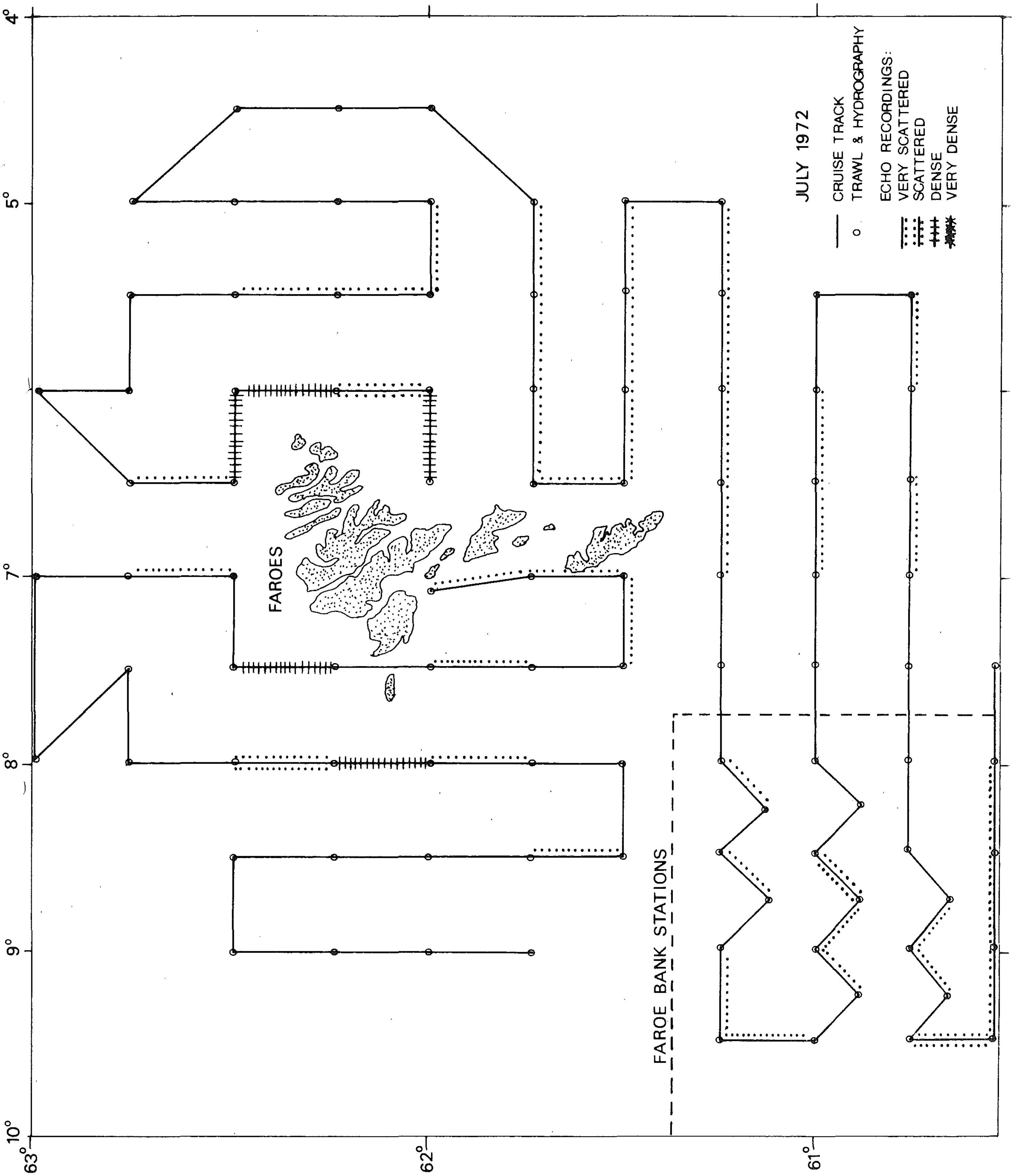


Figure 7. General survey routes and grid of stations at the Faroes.

3.7. 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.

4. Young Fish Surveys in the North Sea

4.1. Introduction

In the North Sea pre-recruit surveys are convened chiefly with the four gadoid species: cod, haddock, whiting and saithe, and with 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, beginning to spawn 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 in Division IVb (Central North Sea) and IVc (Southern North Sea) are of greater importance than 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 timing 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 Sandettie 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 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

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 annually, one in spring and one in autumn. Since 1964, surveys have been done 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.

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 different regions of the North Sea. At least one haul was made in each square. If the first haul contained more than 1 000 herring, a second haul had to be made in that square.

At the meeting of the Working Group on Young Herring Surveys in April 1974, it was decided to adopt a different distribution of the sampling effort in the future. The standard deviation of the number caught in an individual haul is about proportional to the mean. This means that the variance of the estimated mean abundance indices for the whole area will be minimised if the area is stratified and the sampling effort is allocated so that the number of hauls in each stratum is proportional to the abundance. It was therefore decided to divide the North Sea into three strata and use the mean relative abundance indices of each square for the period 1960-1973 to allocate the squares to the different strata. This resulted in the following stratification if a total of 214 hauls is made as in recent years:

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

Some squares will not be sampled at all if this stratification is used. These are squares which have not been sampled regularly in the past and which have shown a very low abundance of herring whenever they have been sampled. It should be noted that all of these 53 squares are distributed in the area between 52°30'N and 57°30'N and with most of the sampling within this area being concentrated in the southeast.

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 English and Dutch ships have been using identical gear so far. The German ships 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.

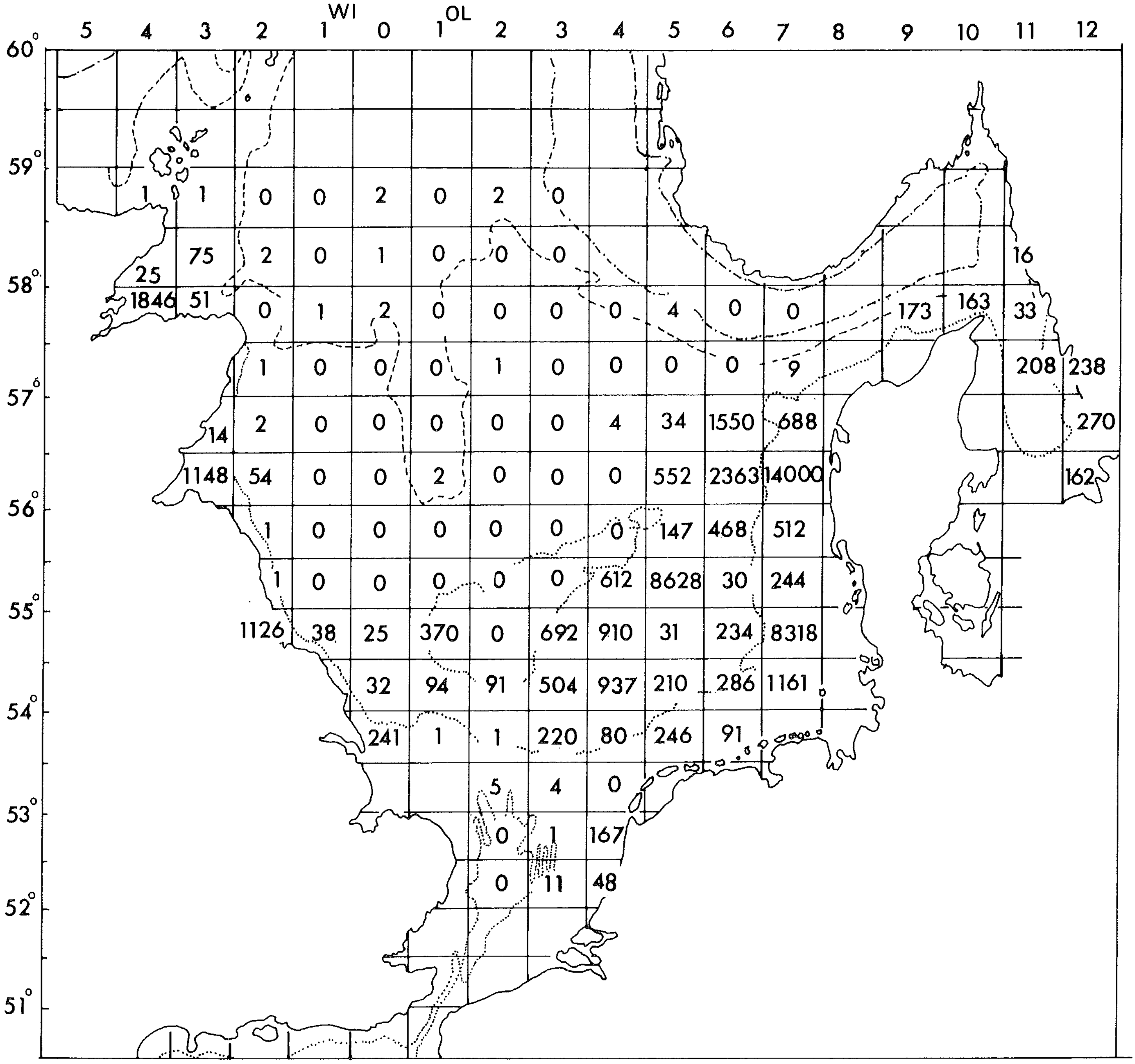


Figure 8. Mean density of I-group herring per statistical square, February 1973 (numbers per hour trawling).

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 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.

In former years, the mean number per haul (of one hour duration) was calculated for each square, and then all squares were averaged. However, over the period 1965 to 1973, there has been a gradual expansion of the survey area as more vessels participated in the surveys. When the abundance is calculated as the mean number per haul for all squares fished, the abundance indices for the various years are not comparable because they refer to different areas covered.

In order to obtain estimates in a standardised form, the coverage of each statistical square over the various years was examined. It appeared that 41 squares had been fished in each year during the period 1965-73. These squares were then taken as a basis for defining a standard area. Because important concentrations of young herring had sometimes been encountered outside these 41 squares, it was decided also to include any square in which there had been a catch of more than 1 000 herring.

This added another 12 squares to the standard area, which then consisted of 53 squares. Interpolated values were calculated for the additional 12 squares in years when they had not been sampled. Full details of the method of calculating interpolated values are given in the Report of the Working Group on North Sea Young Herring Surveys (Anon.1974).

4.3. Results

4.3.1. Relationship between abundance indices of I-group herring and subsequent year class strength

The estimates of year class strength, calculated as described in section 4.2.5. for each year class sampled as I-group during the International Young Herring Surveys are given in Table 6. The estimates of the abundance of the same year classes as I-group from VPA (Anon.1973) are also given. One would hope to be able to use the YHS-estimates to predict the year class strength one year earlier than when the first estimate is available from VPA. These predicted values can then be used in setting the Total Allowable Catch (TAC).

Table 6. Estimates of year class strength at the I-group stage.

Year Class	Estimated Strength from International Young Herring Survey	Estimated Strength from VPA ($X\ 10^{-9}$)
1958	2 413	7.07
1959	37	1.63
1963	4 064	9.44
1964	815	5.07
1965	429	4.44
1966	419	6.30
1967	320	6.29
1968	1 042	4.93
1969	2 570	7.75
1970	1 632	6.29
1971	837*)	?
1972	1 144*)	?

*) Preliminary

The regression of the VPA estimates on the IYHS estimates (Figure 9) has been calculated. The regression equation is $y = 0.0013477\ X + 4.069$, where y is the predicted value of year class strength from VPA and X is the estimate of year class strength from the IYHS. The coefficient of regression is significantly different from zero ($P < 0.01$). 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 regression line can therefore not be used to predict year class strength from the International Young Herring Surveys where this survey gives a low abundance index.

It should further be noted that the comparison made is between the IYHS indices and the VPA estimates, and not with the actual year class strength as I-group. VPA estimates may be subject to considerable errors if there are changes in natural mortality or if there are errors in the catch figures (catch in number per year class). This makes it difficult to judge how good the IYHS indices are for forecasting year class strength.

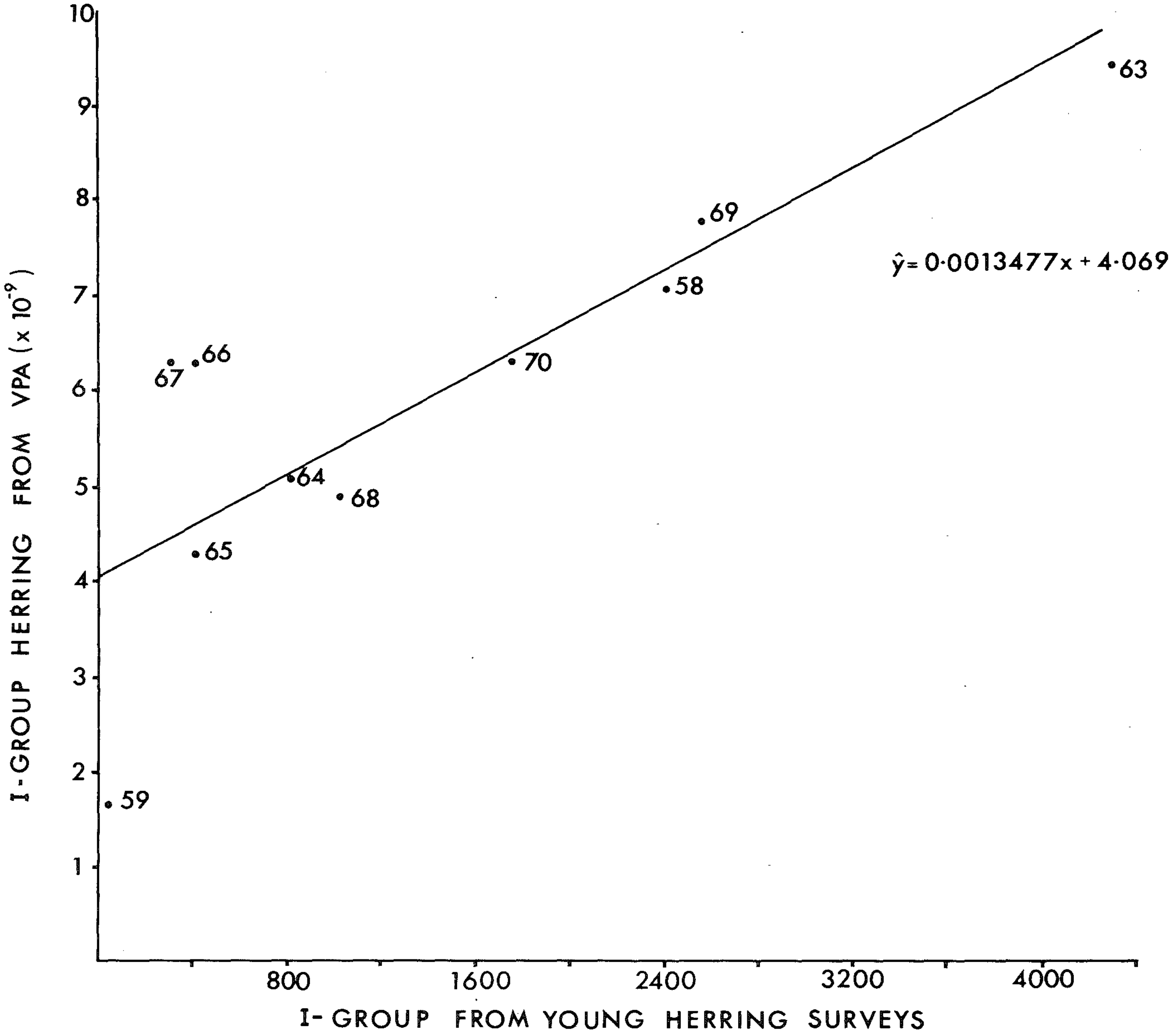


Figure 9. Calculated regression line of year class strength estimates obtained from VPA and International Young Herring Surveys.

4.3.2. Variance

At the meeting of the Working Group on Young Herring Surveys, data for 1971 were used to get an estimate of the magnitude 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 are too few for estimating the variance, the North Sea was divided into strata of four squares each. No information about the distribution of herring was used in stratifying the area. Neighbouring squares were simply put together in one stratum.

The mean number per haul and standard deviation on an individual haul were calculated for each stratum. It was found 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 ($\bar{Y}st$) and variance of this mean ($S^2_{\bar{Y}st}$) were calculated. The values found for $\bar{Y}st$ and $S^2_{\bar{Y}st}$ were 3.1×10^3 and 0.58×10^3 respectively. Assuming that $\bar{Y}st$ is approximately normally distributed, the 95% confidence limits for the mean are then given by 3.1 ± 1.2. Using a slightly different technique and another year, the relative precision of the estimates was found to be similar.

4.4. Other surveys

In addition to the International Young Herring Survey, 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 2m 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

A highly significant correlation has been found between IYHS estimates of I-group abundance, and the year class strength at the same age as calculated by VPA. This 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.

It has been mentioned that abundance indices derived from past surveys probably have wide confidence limits, due to the extremely high variance on a single haul. There may be some scope to increase the precision of the IYHS estimate by allocating sampling effort proportionally to fish density. This will be done in future surveys by adopting the sampling scheme described in section 4.2.1.

Another method of reducing the error in the abundance index will be to apply a more stringent standardisation of fishing gear. However, because no data are available at present concerning the actual differences in fishing power between the various ships, the gains from a further standardisation cannot be calculated.

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 improvement 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 10. 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 the 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.

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.

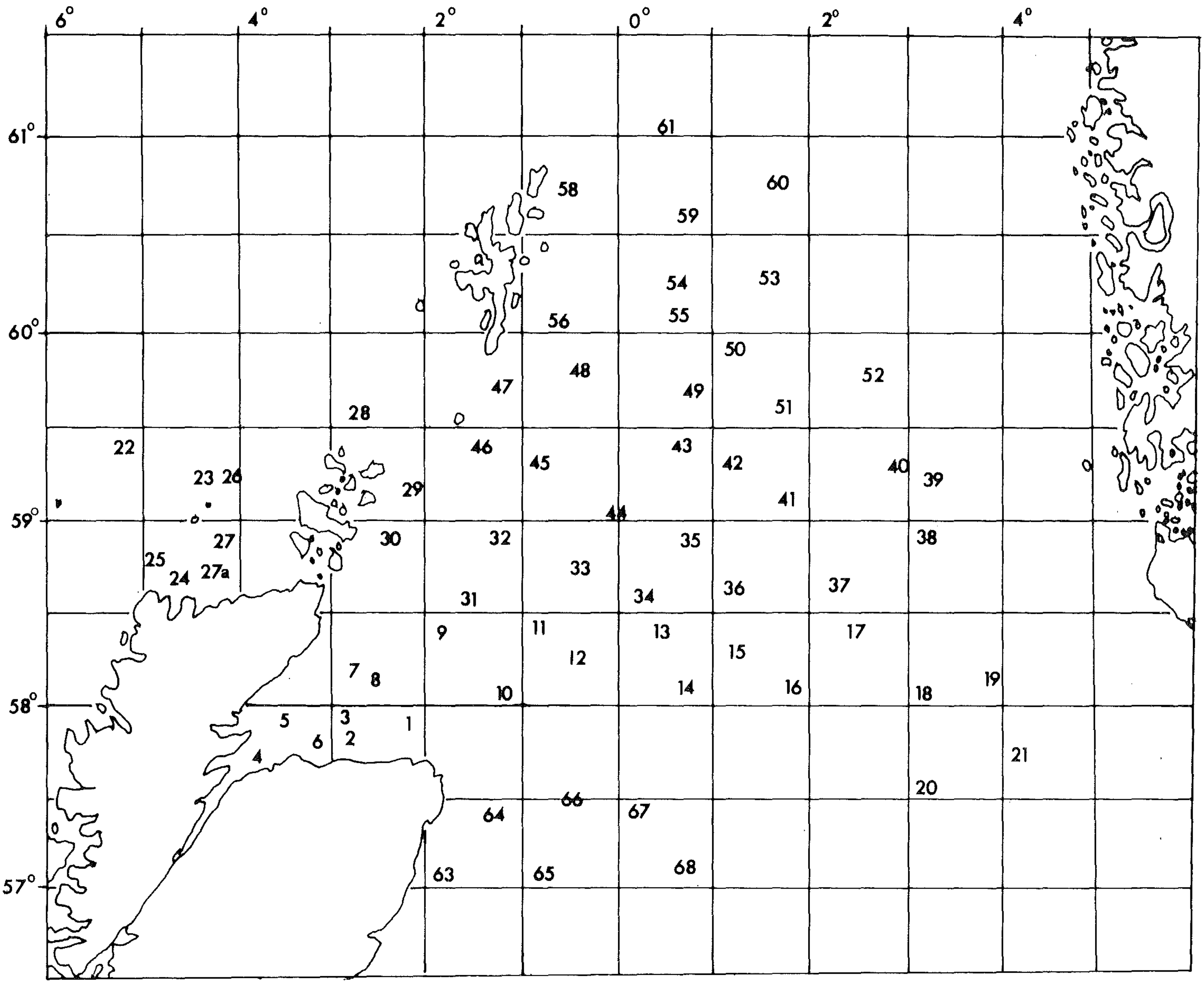


Figure 10. Sampling positions of Scottish demersal surveys.

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

Year	Participant	Area Surveyed	Sampling Period	Gear Used°	Sampling Method^x
1969	Scotland	IVa	26/6 - 22/7	Isaacs-Kidd SYGT	H
1970	Scotland	IVa, b	20/6 - 30/7	SYGT	H
	Netherlands	IVa, c	1/6 - 10/6	Isaacs-Kidd Engels	HS, O
1971	Scotland	IVa, b	7/7 - 11/8	SYGT	H
	Netherlands	IVa, b	1/6 - 10/6	Engels	HS, O
1972	Scotland	IVa, b	14/7 - 10/8	SYGT	H
	Netherlands	IVa, b	15/6 - 4/7	IYGT	HS, O
	England	IVb, c	June	Boothbay, Engels	O, H
1973	Scotland	IVa, b	11/7 - 29/7	IYGT	HS
	Netherlands	IVa, b	2/7 - 11/7	IYGT	HS
	England	IVb	30/5 - 20/6	Capelin trawl, IYGT	HS
	USSR	IVa, b	1/7 - 15/7	?	?

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

^xH = Horizontal (upper water layers)
O = Oblique
HS = Horizontal (stratified)

For the first four years there was a wide divergence in the gear 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 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 brood 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 11.

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 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 (Figure 11). 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 IVb. No satisfactory estimates of cod year class strength 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 (see page 34).

4.7.3. Pelagic 0-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.

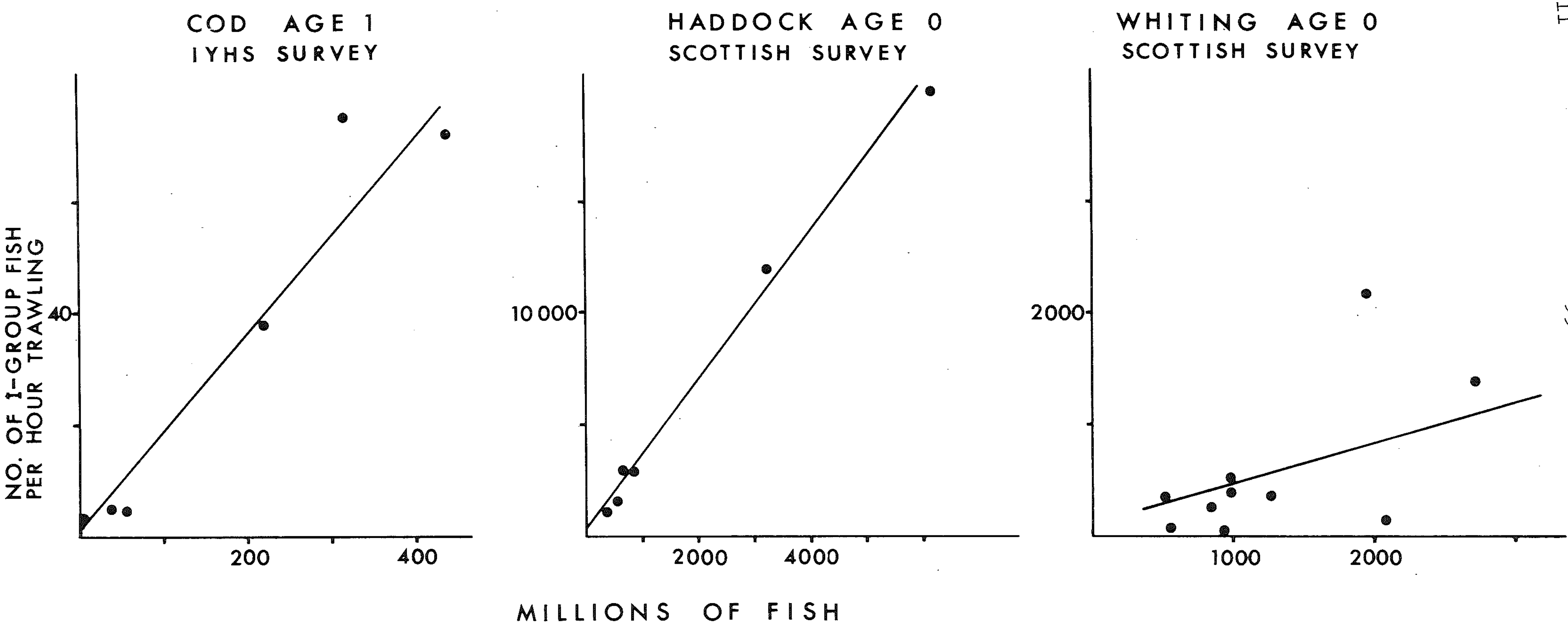


Figure 11. Calculated regression lines of year class strength estimates obtained from VPA and young fish surveys.

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

Year Class	Cod (IVb, c)		Haddock (IV)			Whiting (IV)		
	A VPA^{x}	B IYHS^{oo}	C VPA^{o}	D IYHS^{oo}	E Scottish Survey^{+}	F VPA^{o}	G IYHS^{oo}	H Scottish Survey^{+}
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

$r = 0.964$
$a = .191$
$b = 1.44$

Correlation E on C

$r = 0.949$
$a = 3.168$
$b = 762.57$

Correlation H on F

$r = 0.6386$
$a = 0.582$
$b = 172.53$

^{x}Millions of fish at age 1

^{o}Millions of fish at age 0

$^{+}$Numbers of I + fish per 10 hr trawling

^{oo}Numbers of I + fish per 1 hr trawling

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 method was changed in 1973. 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 0-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 0-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 has not had the opportunity to study details of the different surveys carried out, and from that 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 under the Demersal Fish (Northern) Committee.

The possibilities of using echo abundance were discussed, but at the moment there appears to be no solution to 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 abundant 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 North Sea Young Herring Surveys Working Group had 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 Survey 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 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 for the last four years. The purpose has been to determine the distribution and estimate the relative abundance from echo-integrator readings. Indices of abundance are 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 as one-year-olds. 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 10.

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. 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- or I-group fish, it is of great importance that a summary report of the data should be available shortly after the surveys.

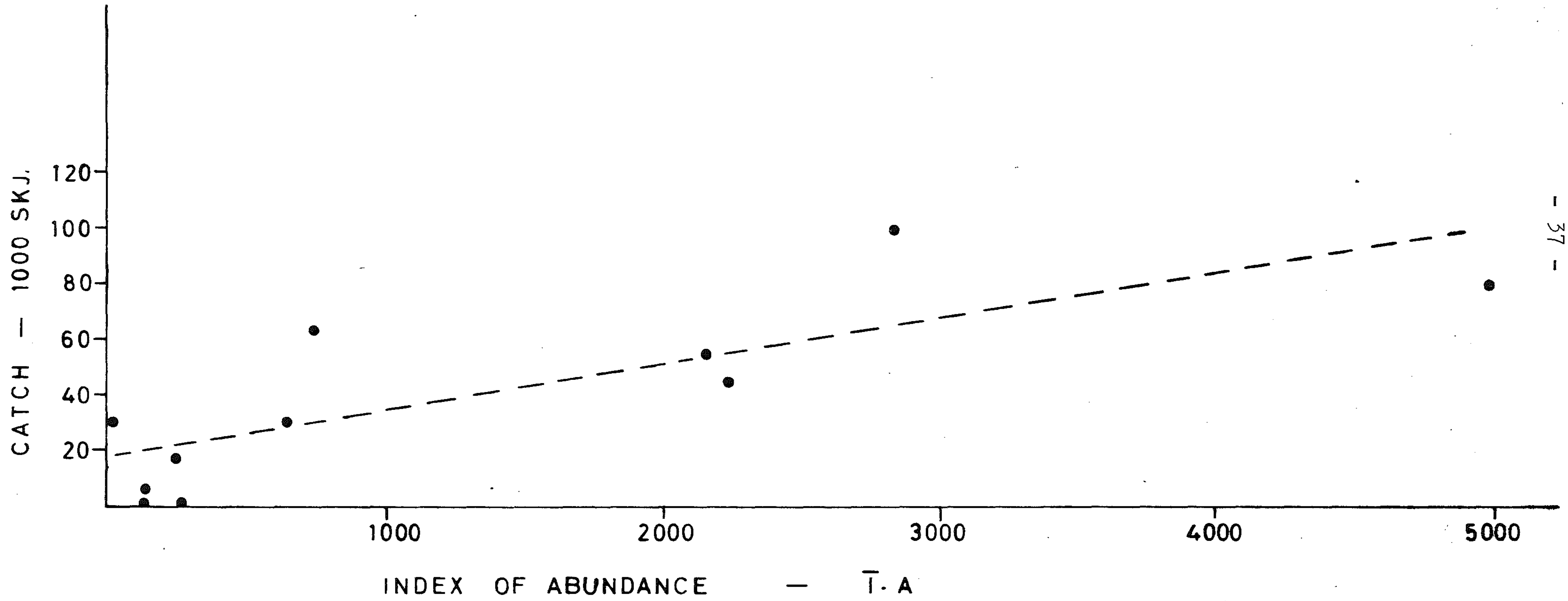


Figure 12. Comparison between O-group sprat abundance and subsequent catch.

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 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 0-group surveys

6.2.1. It is recommended that the Barents Sea 0-group surveys should be continued.

6.2.2. There is a need for a more objective measurement of 0-group fish density. This could be achieved by a more widespread use of modern integrator 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 0-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 of 0-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 0-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 participates.

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 Young Herring Survey 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 effort currently being effected 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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