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PRELIMINARY REPORT OF THE NORWEGIAN INVESTIGATIONS ON YOUNG COD AND HADDOCK IN THE BARENTS SEA DURING THE WINTER 1985

by

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ABSTRACT

An acoustic survey and a bottom trawl survey for cod and haddock were carried out in the Barents Sea during the winter 1985. The acoustic data and the biological data from trawl stations were combined in two different ways, giving two series of acoustic estimates of abundance which differed greatly. The first series which was based on the assumption that the catch compositions in the bottom trawl catches were representative for the whole water column, resulted in considerably higher figures for haddock than for cod. The second series which was based on the assumption that the catch compositions in midwater trawls were

representative for the fish recorded in midwater and that the bottom trawl catches represented the fish recorded in the near-bottom layer, resulted in significantly more cod than haddock. However, both series of acoustic estimates as well as the bottom trawl indices supported previous findings showing that the recruitment of both cod and haddock in recent years had been substantially higher than in the period 1976-1981.

INTRODUCTION

Each year since 1975, a Norwegian acoustic survey has been carried out during the winter in the Barents Sea, and since 1977 the results have been used in the stock assessments of North-East Arctic cod and haddock. The aim of the survey is to estimate the absolute number of cod and haddock within the survey area.

Since 1981 a stratified random bottom trawl survey has been carried out in the same area and at the same time as the acoustic survey. Preliminary results from both surveys are reported by Dalen et al. (1982, 1983, 1984). The present paper reports on the survey results during winter 1985.

MATERIAL AND METHODS

The surveys in 1985 were carried out in the period 26 January to 8 March with three vessels which were equally equipped concerning the trawls. RV "G.O.Sars" was used in the acoustic survey and the commercial stern trawlers MT "Masi" and MT "Stallo" carried

out the bottom trawl survey, which also includes 20 stations taken east of 40°E and 8 stations south of 69°30'N and east of 37°E worked by "G.O.Sars". A total of 389 trawl stations were taken: 117, including 25 with pelagic trawl, by "G.O.Sars", and 272 by the commercial trawlers. In addition, 143 hydrographical stations (CTD) were taken by "G.O.Sars".

Figs 1 and 2 show the survey tracks, hydrographical stations and trawl stations worked by "G.O.Sars".

The Acoustic Survey

The acoustic survey was carried out as in previous years (Dalen et al. 1982). The echo integration system and its performance as well as the conversion factor used were as reported in 1984 (Dalen et al. 1984).

The Bottom Trawl Survey

Fig. 3 shows the survey area, the four subareas for which abundance estimates are given, and the strata. A total of 300 trawl stations were included in the bottom trawl survey (Fig. 4). The survey design was as described by Dalen et al. (1982), and the indices of abundance were calculated on the basis of swept area considerations as described by Dalen et al. (1983). Table 1 gives the number of trawl stations in each stratum.

RESULTS AND DISCUSSION

Hydrography

Fig. 5 shows the temperature distributions at the surface, at 100 m depth and at the bottom. In most areas these distributions were similar to those observed in winter 1984 (Dalen et al. 1984), but in the southeasternmost shallow waters off USSR the temperatures were considerably below the 1984 values. This is in agreement with observations made by The Polar Research Institute (PINRO), Murmansk, indicating that the distribution of winter temperatures in the Barents Sea were close to the 30-years mean value both in 1984 and 1985, except for the nearshore areas of USSR where the 1985-values were well below average (Borovkov: personal communication).

Distribution of cod and haddock

Fig.6 shows the distribution of the total echo abundance of cod and haddock combined. The distribution pattern shows similarity with that observed in 1984 (Dalen et al. 1984), but the northward extension was greater and in addition the echo integration values were generally higher in the whole surveyed area in 1985 than in 1984. Hence, these observations indicated that the increase in abundance of cod and haddock which took place from 1983 to 1984 (Dalen et al. 1984) has continued and that the quantities of fish of the two species in the Barents Sea at present are considerably above the low level experienced during the period 1979-1983. The

distribution of the echo abundance in 1984 and 1985 are similar to what was observed in the years 1976-1978 when the relative abundant year classes 1973 and 1975 were predominant in the stocks of young cod and haddock.

The recordings in the coastal and bank waters off U.S.S.R. and eastern Norway were found to originate mainly from haddock of the 1982, 1983 and 1984 year classes while cod belonging to the 1982 and 1983 year classes were more numerous in the western and in the offshore central and eastern areas.

The distribution of echo abundance of cod and haddock in the 10 m depth layer above the bottom is shown in Fig. 7. The recordings in this layer were slightly less than in 1984 in the eastern- and westernmost coastal areas of the sea but somewhat higher in the central offshore areas. In 1985, these recordings amounted to 14 percent of the total echo abundance (Fig. 6) which is less than in previous years. The observations thus indicate that it is particularly the midwater distribution of fish that has increased in abundance in recent years; a matter which will affect the sampling and the consistency of the bottom trawl indices as discussed by Hylen et al. (1985) and later in this paper.

Acoustic Abundance Estimates

For reasons explained below two sets of estimates were worked out by combining the acoustic data and the length/species compositions from the trawl catches in two different ways.

Alternative a) is the usual standard method by which values of total echo abundance within each strata were used together with pooled data from all trawl stations (midwater and bottom trawls) in the same area. In alternative b) the echo abundance values for the midwater and near-bottom layers were used separately together with the data from midwater trawl and bottom trawl respectively. The distribution maps in Figs 8-13 and 16-19, and Tables 2 and 5 show details of the results obtained applying alternative a), while Tables 3 and 6 show the summary results for both alternatives, together with estimates from previous years.

It appears from Tables 3 and 6 that the two alternative ways of treating the data produced estimates which differed greatly. Alternative a) resulted in total numbers of cod and haddock of about 2200 and 4200 million respectively, while alternative b) gave 4900 million cod and 1700 million haddock. For cod alternative b) produced lower estimates of older fish (age $\geq$ 5) and higher estimates of the younger age groups than alternative a). For haddock the estimates of all age groups were significantly lower for alternative b). The differences between the two alternatives were greatest for the 1983 year class of cod and the 1984 year class of haddock. In alternative b) the 1983 year class of cod was 4 times as abundant as in alternative a), whereas the 1984 year class of haddock was considerably less abundant in alternative b).

In order to fully explain such large differences between estimates of abundance originating from the same basic set of data a thorough discussion on all aspects of both sampling and

processing is needed (Hylen et al. 1985). In the following sections are presented some preliminary considerations which may explain most of the differences between the alternative estimates for 1985.

During acoustic surveys the primary aim of the fishing is to provide representative samples of the acoustically recorded fish. The basic requirements are that each trawl catch should provide a representative estimate of the density ratios between cod and haddock over the entire length range and that also the length distributions obtained are representative (Dalen and Nakken 1983). These requirements are met only rarely (Dalen and Smedstad 1983, Dalen et al. 1984, Hylen and Nakken 1984) and unrepresentative sampling of the recordings is by far the largest source of error in the cod and haddock survey.

Fig. 14 illustrates a part of the problem. This figure shows the development of the bottom trawl indices for the 1977-1980 year classes of cod (Dalen et al. 1984) clearly indicating that the young fish has been underestimated as compared to the older one. The LIKELY LINE is drawn through back-calculated values based on 5 year olds, i.e. it represents an estimate of the figures that should have been obtained. The 1 and 2 year olds appear to be underestimated in the surveys by a factor of 8-10. When age groups are mixed in the sea we must therefore assume that length and age distributions from our bottom trawl catches are heavily biased, the small and young individuals being significantly underestimated as compared to the larger fish. This affects the acoustic estimate in exactly the same manner. The problem becomes particularly serious in years when abundant

young age groups enter an almost depleted stock as in 1984 and 1985 when strong year classes (1982 and 1983) entered the stocks of North-East Arctic cod and haddock. The occurrence of large quantities of small fish in the Barents Sea produced much higher echo abundance values than in the preceeding years. However, our inability to obtain representative length distributions of the fish in areas were these young individuals were mixed with older ones, resulted in gross overestimates of the older age groups and corresponding underestimates of the young ones in these areas. In 1984 Hylen and Nakken (1984) therefore neglected the acoustic estimate of 3 year and older cod for the eastern Barents Sea and estimated the abundance of these age groups from the previous year's acoustic estimates of the respective year classes and the ratio between the bottom trawl indices in 1984 and 1983. Preliminary examination of the 1985 data indicates that errors introduced by biased trawl sampling are more pronounced this year and it seems as if the species composition, cod versus haddock, is even more influenced than the length and age distributions (Tables 3 and 6).

The problem of representative sampling includes gear efficiency, vertical distribution of fish and fish behaviour in relation to the fishing system (vessel and gear). Fig. 15 shows a schematic presentation of the distribution of the echo abundance of cod and haddock in the Barents Sea in winter 1985. Approximately 14 per cent of the echo abundance was recorded in the bottom channel, 40-45 per cent in the layer between the bottom and 50 m above the bottom while the remaining 40 per cent was recorded higher up in the water column.

Table 4 shows the average species and length compositions in selected trawl catches from the western (A and B) and eastern (C and D) areas of the Barents Sea respectively. In both areas the species compositions were quite different for the two types of gear used, the pelagic and the bottom trawl. When comparing the numbers caught of the two species, it appears that in the pelagic trawl hauls cod was far more abundant than haddock whereas the bottom trawl captured more haddock than cod. These observations indicate that haddock was mainly distributed in the near-bottom layers (Table 4) in which a smaller fraction of the echo abundance was recorded (Fig. 15) than in the midwater layers where cod was predominant. There was also a clear tendency that the pelagic trawl captured cod and haddock of smaller size than the bottom trawl in the eastern areas (Table 4). In the western parts of the sea the cod has similar length distributions in the two types of gear, while the bottom trawl caught the smallest haddock. It was therefore decided to combine the acoustic and biological data in accordance with the observations given above (alternative b), in addition to the standard procedure which has been used in previous years (alternative a). The differences between the two sets of estimates demonstrate the large effect of treating the data in different ways. By choosing alternative b) instead of a) there is an enormous transfer of fish from haddock to cod and also a shift from older (larger) individuals to younger (smaller) (Tables 3 and 6). Yet the very smallest fish, the 1-group, was reduced in numbers. It is felt that the estimates arrived at under alternative b) are the more reliable, mainly because the vertical species and length compositions were taken into account in the computations instead of assuming bottom

trawl catches being representative for the entire water column (alternative a). In addition the alternative b) estimates compare better with the historic data series regarding the ratio number of cod/number of haddock in the two stocks (Anon. 1985). This ratio has mainly been within the range 2-5 and it has never been observed to be 0.3-0.4 for a series of abundant year classes as indicated by the results under alternative a).

Geographical distribution of cod and haddock

Figs 8-13 show the geographical distribution of the various age groups of cod. As in previous years there appeared to be a westward shift in distribution with increasing age, the youngest age groups were found to be distributed more to the east than the older fish. To some extent a similar pattern was observed for haddock (Figs 16-19) but less pronounced as compared to cod.

Bottom Trawl Survey Indices

Cod

Table 7 gives abundance indices from the trawl survey for each age group by subarea and total area. Indices for the total area for the period 1981-1985 are given in Table 8. As in 1983 and 1984 the indices were higher in the offshore areas A and D than in coastal waters areas B and C. The indices (table 8) indicate a substantial increase in the abundance of cod from 1982 to 1984 due to the contribution from the 1982 and 1983 year classes.

From 1984 to 1985 the total index is lowered considerably mainly because of a pronounced reduction of the 1983 year class and smaller reduction of the 1982 year class. The observed reduction in abundance indices for these two year classes is in contradiction with the results found for the preceeding year classes (Table 8 and Fig. 14) indicating an increase in the bottom trawl indices for a given year class until the fish is 4-5 years old. It is believed that the midwater distribution of cod in 1985 - discussed previously in this paper - leads to a significant downward bias in the bottom trawl indices for these year classes in 1985.

Haddock

Table 9 and 10 show the bottom trawl indices for haddock. The indices for 1985 were in accordance with those obtained in previous years, indicating that the abundance of haddock has increased considerably during the last 2-3 years because of the contribution from the 1982, 1983 and possibly 1984 year classes.

The abundance of the 1981-1983 year classes

Since these are the year classes which are the important ones for stock prediction purposes it is of particular interest to investigate the consistency of the acoustic estimates. The text table below shows the estimates obtained in 1984 and 1985 (alternative b). The figures are taken from Tables 3 and 6.

	1984			1985		
Year class	Cod	Haddock	Cod+Haddock	Cod	Haddock	Cod+Haddock
1981	174	53	227	664	14	678
1982	506	1002	1508	667	479	1146
1983	2382	2148	4530	3392	1057	4449

When comparing the estimates obtained in 1984 and 1985 for each year class and species the consistency seems to be rather poor. However, it appears that for the 1983 year class the sum of cod and haddock compares reasonably well for the two years of observation. It is also seen that in 1984 the total number of fish estimated in the 1981 and 1982 year classes, 1735, is only slightly lower than the corresponding figure for 1985, 1824.
In total about 6300 million fish of these three year classes were observed in both 1984 and 1985. On the basis of the results for 1984 a total of about 5000 million fish should be expected in 1985 when a natural mortality of about 0.2 is accounted for. However, at present there is no independent measure of these young year classes which permits conclusions about reliability of the results from either of the two years, but it seems as if the consistency is fair regarding the total figures and that the main problem is to have representative species and length/ age compositions of the fish.

The large increase in the estimate of the 1981 year class of cod may also to some extent have been caused by erroneous age readings of the otoliths. There is doubt about the correct interpretation of the growth zones of 3-4 year old fish, and it is possible that cod from the 1981 year class should be

transferred to the 1982 year class. This would improve the consistency of the cod+haddock estimates.

CONCLUSIONS

The 1985 acoustic and bottom trawl survey has confirmed the findings from earlier years which shows a vast improvement in recruitment to the stocks of North-East Arctic cod and haddock.

The introduction of strong year classes of young fish to nearly depleted stocks has clearly demonstrated shortcomings in the trawl sampling which is representative neither for the size groups nor the cod/haddock ratio in the whole water column. This relates especially to the bottom trawl, which is restricted to the near-bottom layer. Two alternative estimates have been presented and it is thought that the most reliable estimates are obtained by splitting the acoustic layer and applying samples from bottom and pelagic trawl respectively.

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Table 1. Trawl hauls taken in the bottom trawl survey 1985.

Stratum	1	2	3	4	5a	5b	6	7	8	9	10	11	12	13	14	15	16	17
Number of hauls	5	6	6	3	7	4	8	15	13	7	9	16	14	11	10	9	18	7
Stratum	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
Number of hauls	4	6	13	8	17	11	2	4	11	10	4	13	4	4	5	12	4	

Table 2. Cod. Acoustic abundance estimates (alternative a) for each age group/year class in the surveyed areas in 1985. (Numbers in millions).

Area	Age (Year class) 1 (84)	2 (83)	3 (82)	4 (81)	5 (80)	6 (79)	7 (78)	8 (77)	9 (76)	10+ (75+)	Total
A	+	42	173	179	41	13	5	1	0	+	455
B	4	4	16	23	13	9	5	1	+	+	77
C	+	6	19	20	7	4	2	+	+	0	58
D	64	825	342	289	47	22	8	+	0	0	1597
Total	69	878	550	510	109	48	20	2	1	1	2187
%	3.2	40.1	25.1	23.3	5.0	2.2	0.9	0.1	0.0	0.0	100.0

Table 3. Cod. Estimates of year class abundance from acoustic surveys in the period 1977-1985. (Numbers in millions).

Year of investigation	Year class 1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970+	Total
1977									45	882	104	315	139	52	59	1596
1978								28	235	797	153	172	25	14	18	1442
1979							16	14	109	502	77	45	14	4	2	783
1980						Malfunction of the acoustic instruments										
1981					3	73	58	124	243	270	41	8	3	4		827
1982				1	4	71	86	93	73	74	5	1				408
1983				15	17	45	65	38	17	10	2	1				210
1984		2382	506	174	80	63	46	16	1	+	+					3269
1985a	69	878	550	510	109	48	20	2	1	1						2187
1985b	118	3392	667	664	48	14	3	+	+	+						4906

Table 4. Length distribution of cod and haddock in pelagic (PT) and bottom (BT) trawl hauls in the western and eastern part of the Barents Sea in 1985. Bottom trawl hauls are located within 10 nautical miles from each pelagic haul. Per cent of numbers caught.

Length (cm)	Western area Cod PT	Cod BT	Haddock PT	Haddock BT	Eastern area Cod PT	Cod BT	Haddock PT	Haddock BT
10-14		0.1	1.7	9.7	1.7	1.0	0.9	2.0
15-19		0.5	15.5	46.7	3.8	5.0	6.1	13.5
20-24		1.9	6.9	20.8	38.4	17.7	40.4	16.1
25-29		3.0	6.9	17.8	41.0	21.6	31.3	16.2
30-34	1.2	2.9	10.4	2.9	4.1	9.1	7.5	11.0
35-39	2.8	3.6	15.5	1.9	0.8	7.0	9.7	28.3
40-44	16.5	16.4	36.2	0.5	2.6	12.5	4.0	12.0
45-49	42.2	36.3	5.2	0.1	5.3	12.0	0.5	0.7
50-54	30.4	19.1	1.7		1.8	5.2		0.1
55-59	2.4	5.0			0.1	2.1		
60-64	0.9	4.3			0.1	3.2		
65-69	1.2	3.4			0.1	2.0		
70-74	0.2	1.6				0.6		
75-79		1.0				0.6		
80-84	0.2	0.4			0.1	0.2		
85-89		0.2				0.1		
90+		0.3				0.1		
Numbers caught	1817	4500	425	17125	425	2736	58	5383

Table 5. Haddock. Acoustic abundance estimates (alternative a) for each age group/year class in the surveyed areas in 1985. (Numbers in millions).

Area	Age (Year class) 1 (84)	2 (83)	3 (82)	4 (81)	5 (80)	6 (79)	7 (78)	8+ (77+)	Total
A	416	438	173	2	1	+	+	1	1030
B	98	74	79	4	+	+	+	+	256
C	127	139	77	3	1	+	+	+	347
D	394	1321	859	24	+	+	+	1	2599
Total	1034	1972	1187	33	2	1	1	2	4233
%	24.4	46.6	28.0	0.8	0.0	0.0	0.0	0.0	100.0

Table 6. Haddock. Estimates of year class abundance from acoustic surveys in the period 1977-1985. (Numbers in millions).

Year of investigation	Year class 1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970+	Total
1977									267	755	198	60	10	9	29	1328
1978								111	149	737	55	1				1053
1979							17	11	181	251	13	+	2			475
1980							Malfunction of the acoustic instruments									
1981					2	25	14	66	160	50	2	1				320
1982				3	4	7	10	12	29	14	1					80
1983				10	7	9	5	4	10	5						50
1984		2148	1002	53	15	7	2	2	2							3231
1985a	1034	1972	1187	33	2	1	1	1	1	1						4233
1985b	158	1057	479	14	+	+	+	+	+							1708

Table 7. Cod. Abundance indices from the bottom trawl survey for each age group/year class in the different areas in 1985.

Area	Age (Year class) 1 (84)	2 (83)	3 (82)	4 (81)	5 (80)	6 (79)	7 (78)	8 (77)	9 (76)	10+ (75+)	Total
A	0.1	4.6	24.8	25.8	6.3	2.1	0.9	0.1		+	64.7
B	1.0	0.9	1.6	2.2	1.4	1.0	0.4	0.1	+	+	8.6
C	0.1	1.3	13.9	10.1	1.9	0.7	0.4	+	+		28.4
D	6.2	162.0	50.0	40.0	6.1	2.5	0.9	0.1			267.8
Total	7.3	168.9	90.3	78.1	15.7	6.3	2.5	0.2	+	0.1	369.4
%	2.0	45.7	24.5	21.1	4.2	1.7	0.7	0.1	+	+	100.0

Table 8. Cod. Abundance indices for each year class from the bottom trawl surveys 1981-1985.

Year of investig.	Year class 1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972+	Total
1981					0.7	11.0	8.6	16.9	34.1	37.9	4.8	1.0	0.3	115.3
1982				0.1	0.9	16.1	20.4	21.4	16.0	15.8	1.4	0.2		92.3
1983			44.6	5.9	10.8	28.0	31.9	14.3	4.7	3.0	0.6			143.8
1984		355.3	126.6	60.2	19.2	15.6	9.4	3.0	0.4	0.2				589.6
1985	7.3	168.9	90.3	78.1	15.7	6.3	2.5	0.2	+	0.1				369.4

Table 9. Haddock. Abundance indices from the bottom trawl survey for each age group/year class in the different areas in 1985.

Area	Age (Year class) 1 (84)	2 (83)	3 (82)	4 (81)	5 (80)	6 (79)	7 (78)	8+ (77+)	Total
A	75.7	71.1	17.6	0.3	0.2	0.1	0.2	0.1	165.3
B	20.8	9.0	3.4	0.3	+	0.1	0.1	+	33.7
C	17.5	17.0	12.6	0.3	0.1	+	+	0.1	47.6
D	53.8	519.1	346.5	6.3	+	+	+	0.1	925.8
Total	167.8	616.2	380.2	7.2	0.4	0.2	0.3	0.3	1172.4
%	14.3	52.6	32.4	0.6	+	+	+	+	100.0

Table 10. Haddock. Abundance indices for each year class from the bottom trawl surveys 1981-1985.

Year of invest.	Year class 1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	Total
1981					0.3	4.8	2.3	9.5	2.0	6.1	0.5	0.2	25.7
1982				0.5	0.9	1.8	2.1	2.2	5.5	2.7	0.2		15.9
1983			314.5	5.7	4.1	3.6	1.9	2.3	3.9	1.6			379.0
1984		663.2	355.8	15.2	1.6	0.7	0.2	0.3	0.4				1037.4
1985	167.8	616.2	380.2	7.2	0.4	0.2	0.3	0.3					1172.6

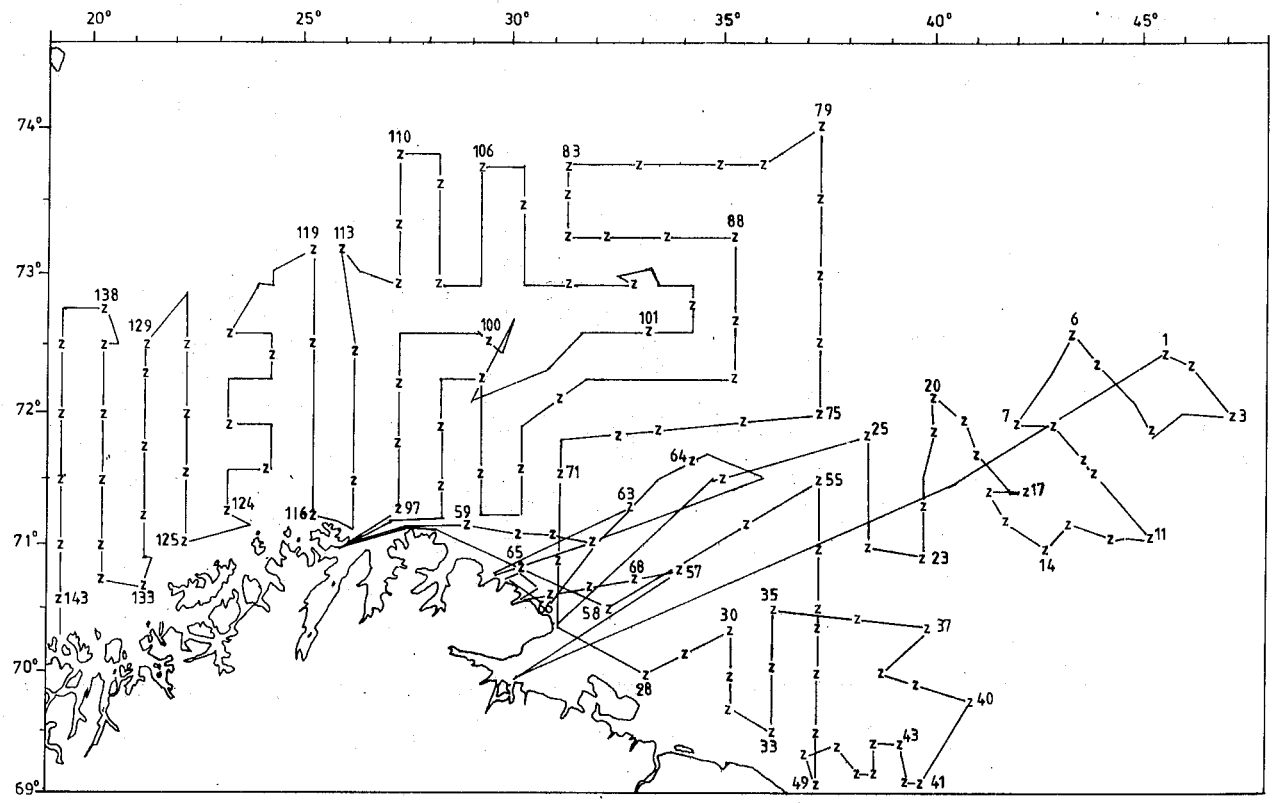

Fig. 1. Survey tracks and hydrographical stations, RV "G.O.Sars". 25.1. - 8.3.1985.

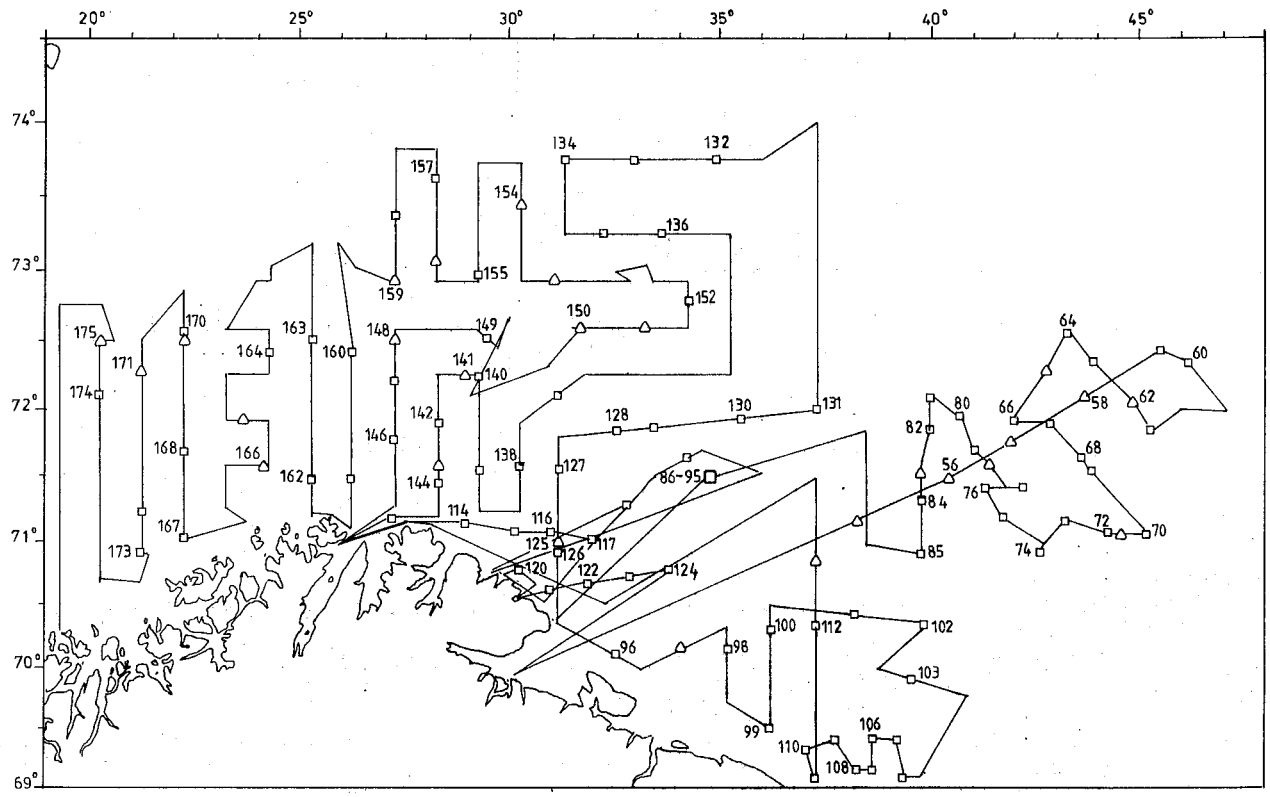

Fig. 2. Survey tracks and trawlstations, RV "G.O.Sars", 25.1. - 8.3.1985. □ Bottom trawl, Δ Pelagic trawl.

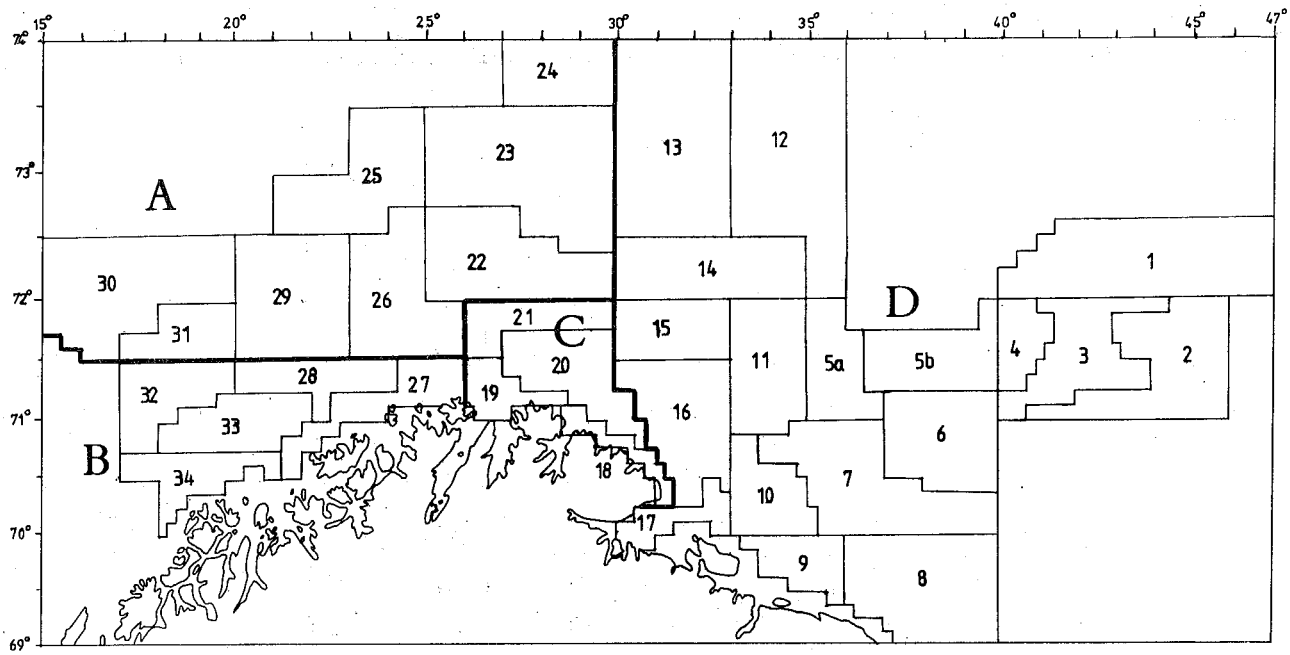

Fig. 3. The survey area with subareas (A,B,C,D) and strata used in the bottom trawl survey.

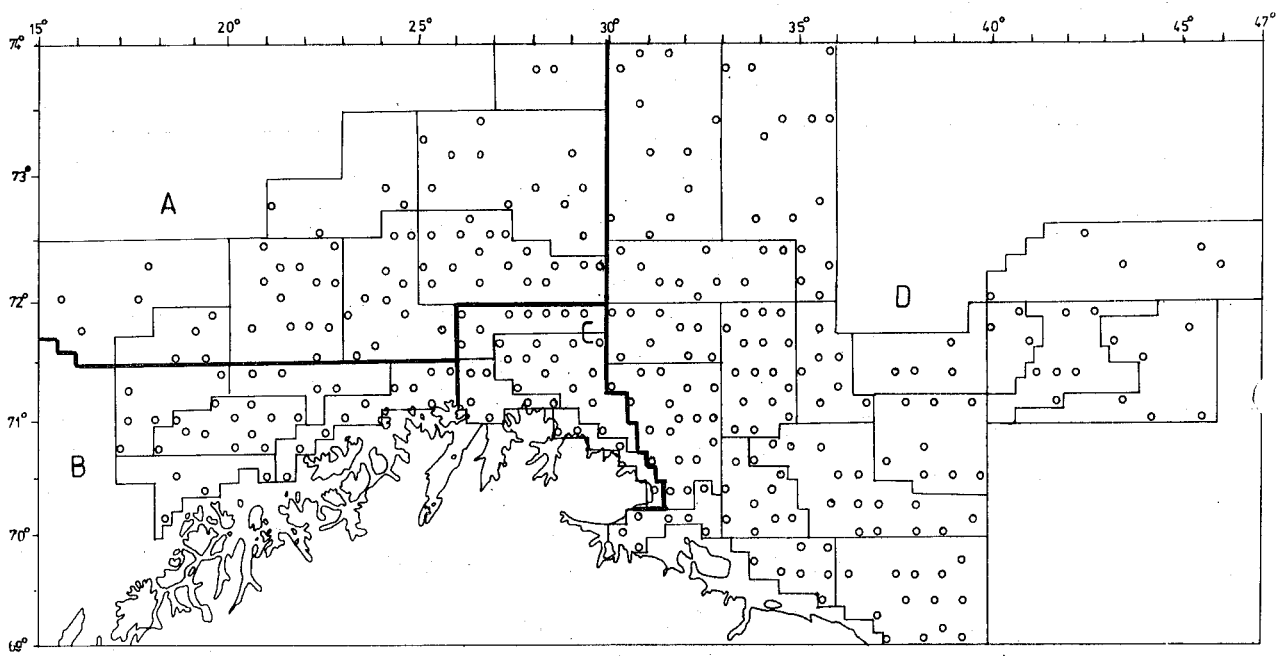

Fig. 4. Bottom trawl stations, MT "Masi" and MT "Stallo" 30.1. - 1.3.1985 and by "G.O. Sars" east of 35°E 27.1. - 6.2.1985.

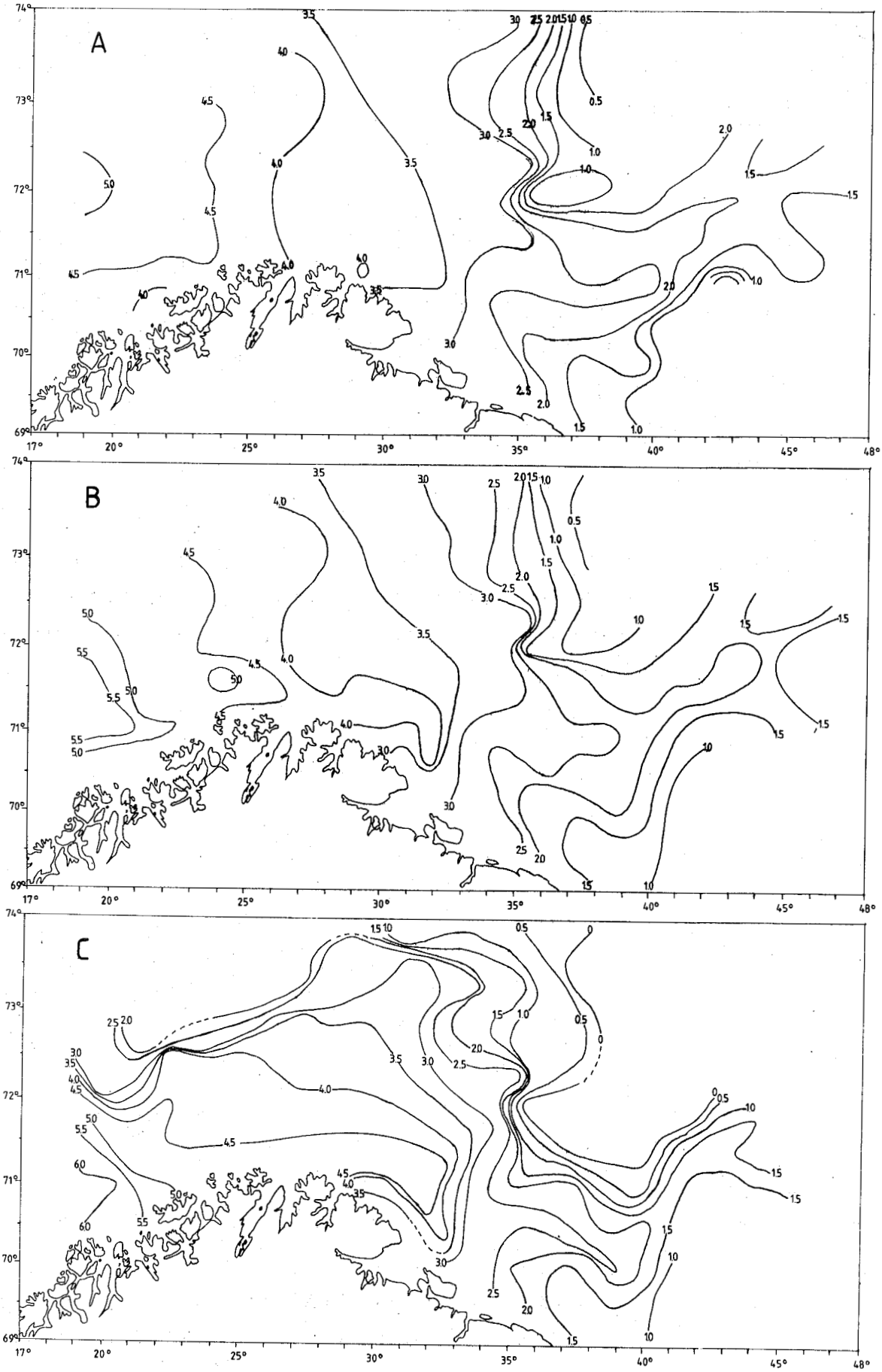

Fig. 5. Temperature distribution. A) at the surface, B) at 100 m depth, C) at the bottom. RV "G.O. Sars" 25.1. - 8.3.1985

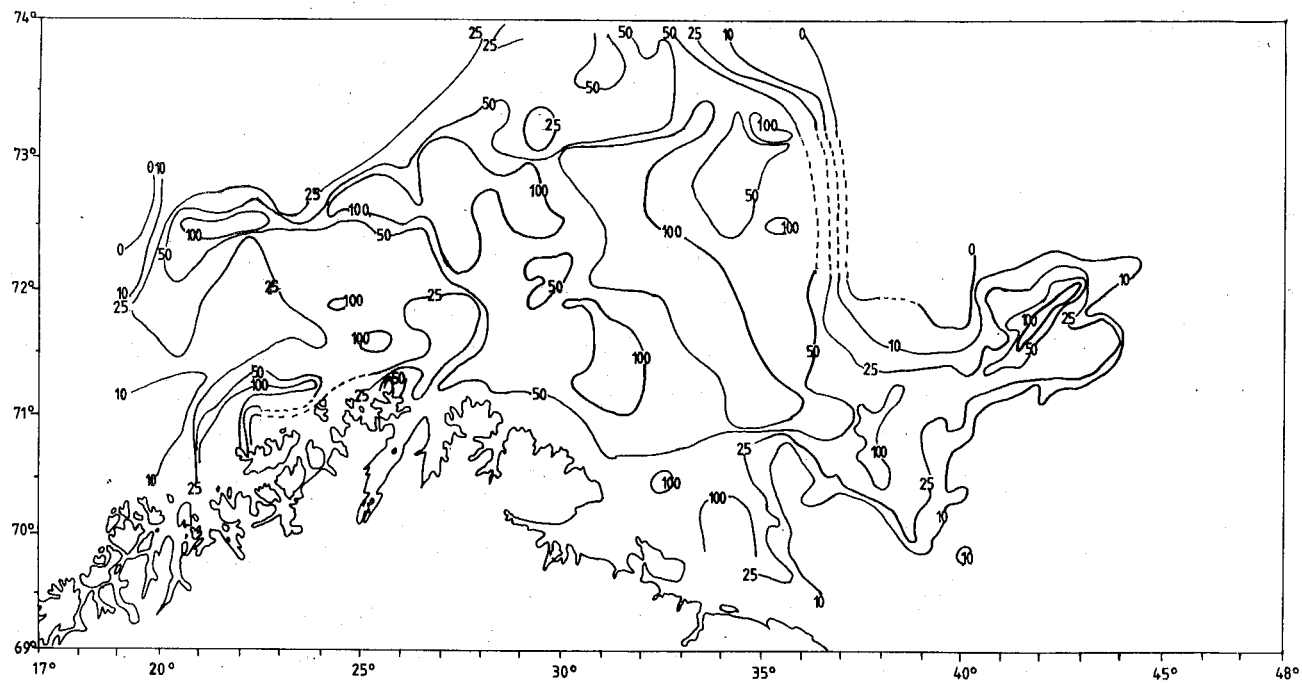

Fig. 6. Distribution of total echo abundance. Cod and haddock combined. Units are 10 times integrated back scattering cross section per square nautical mile ($10 \cdot m^2/naut.mile^2$).

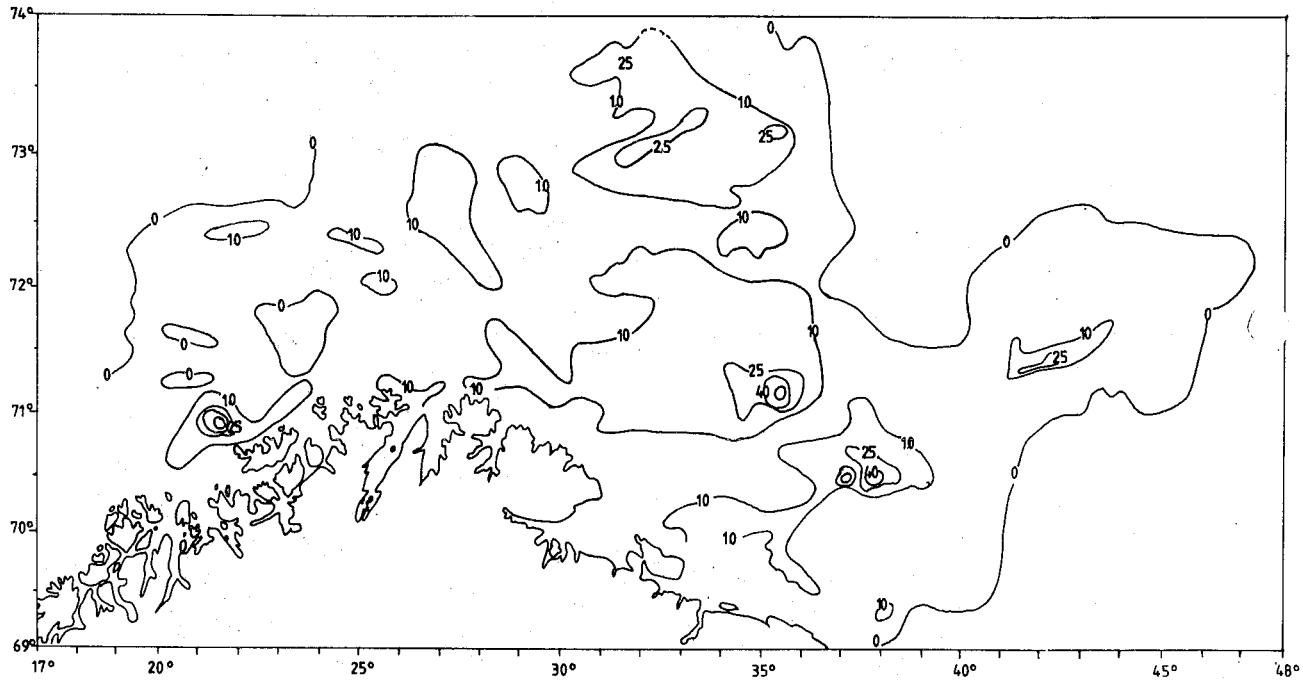

Fig. 7. Distribution of echo abundance in the 10 m depth layer above the bottom. Cod and haddock combined.

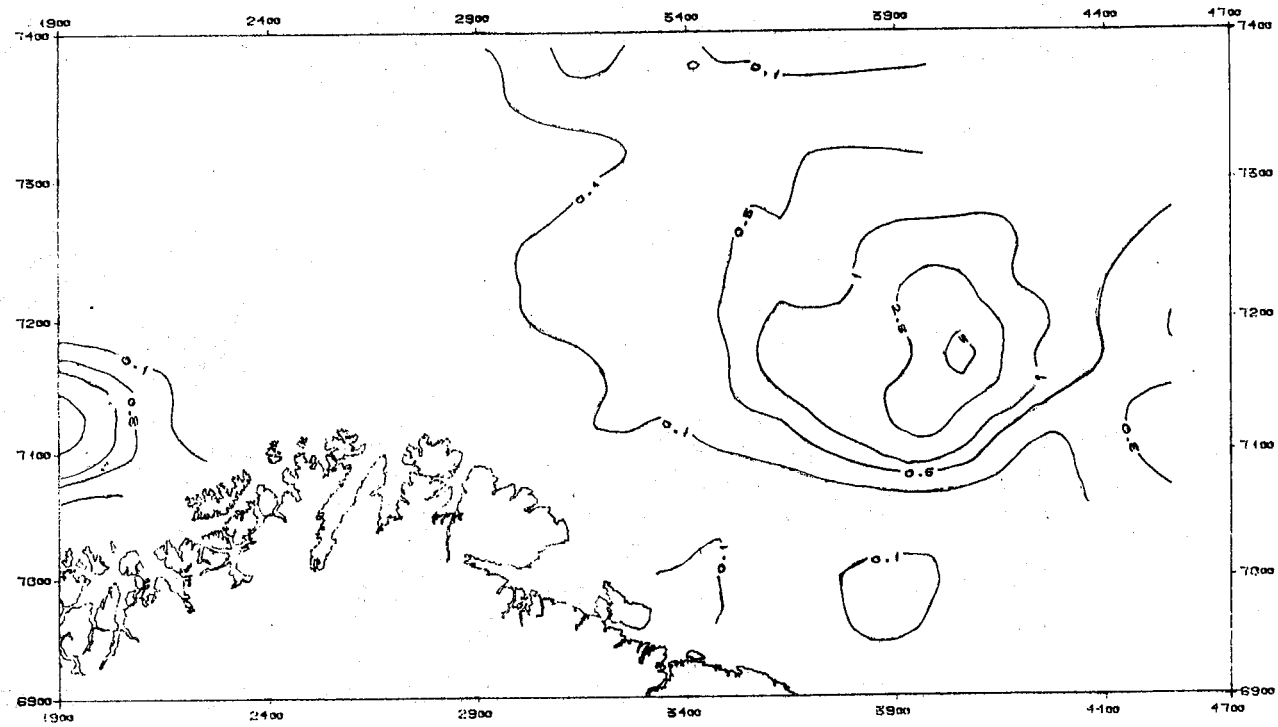

Fig. 8. The distribution of 1-year old cod (Number of fish in 1000 per square nautical mile).

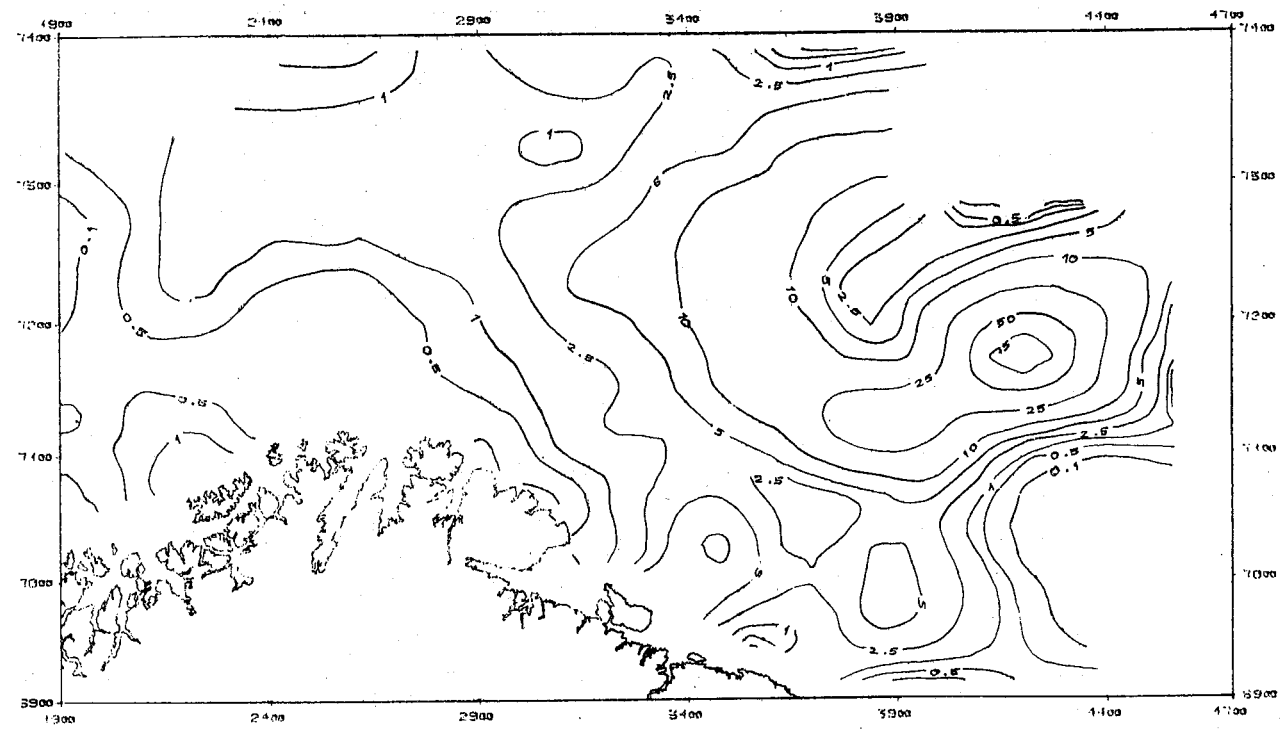

Fig. 9. The distribution of 2-year old cod. (Units as in fig. 8).

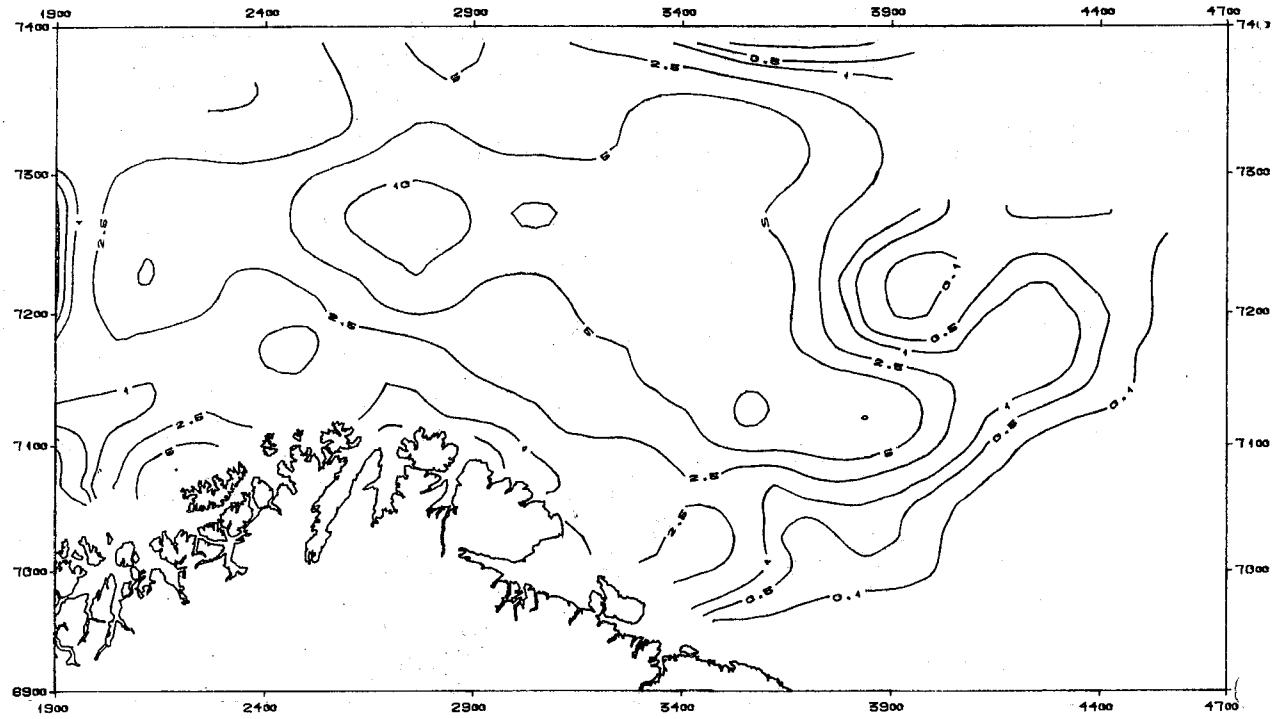

Fig. 10. The distribution of 3-year old cod. (Units as in fig. 8).

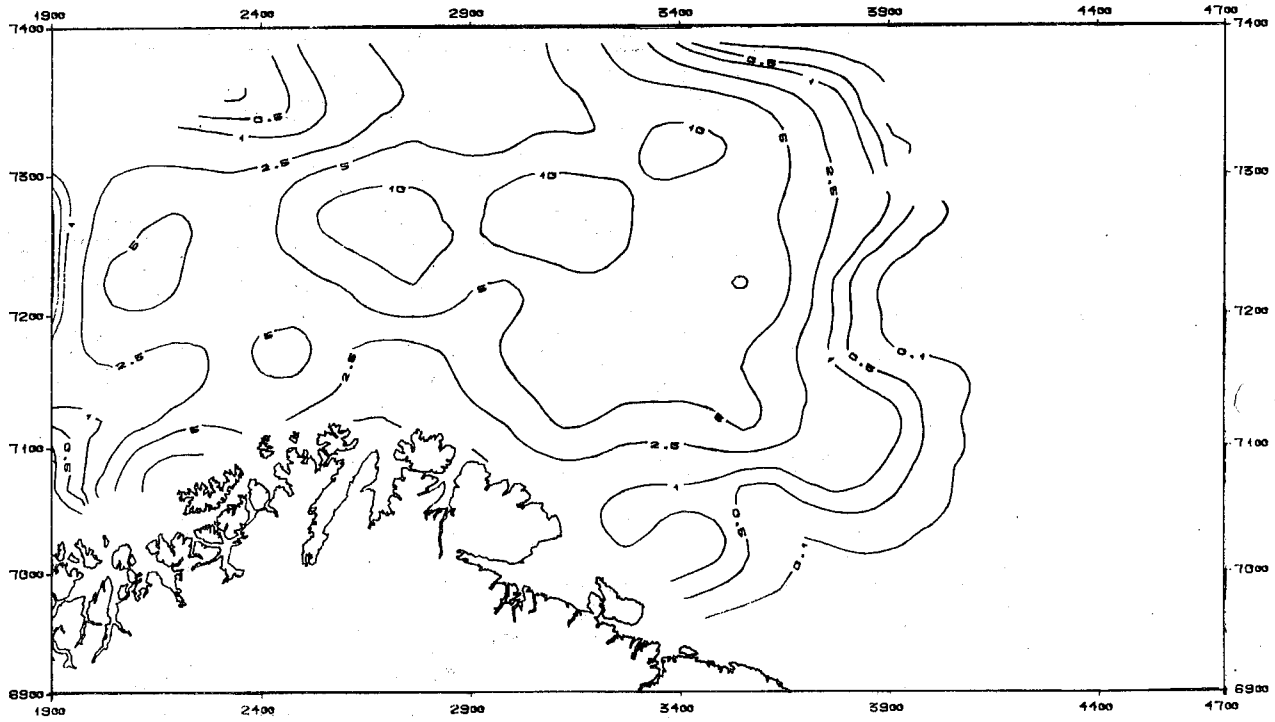

Fig. 11. The distribution of 4-year old cod. (Units as in fig. 8).

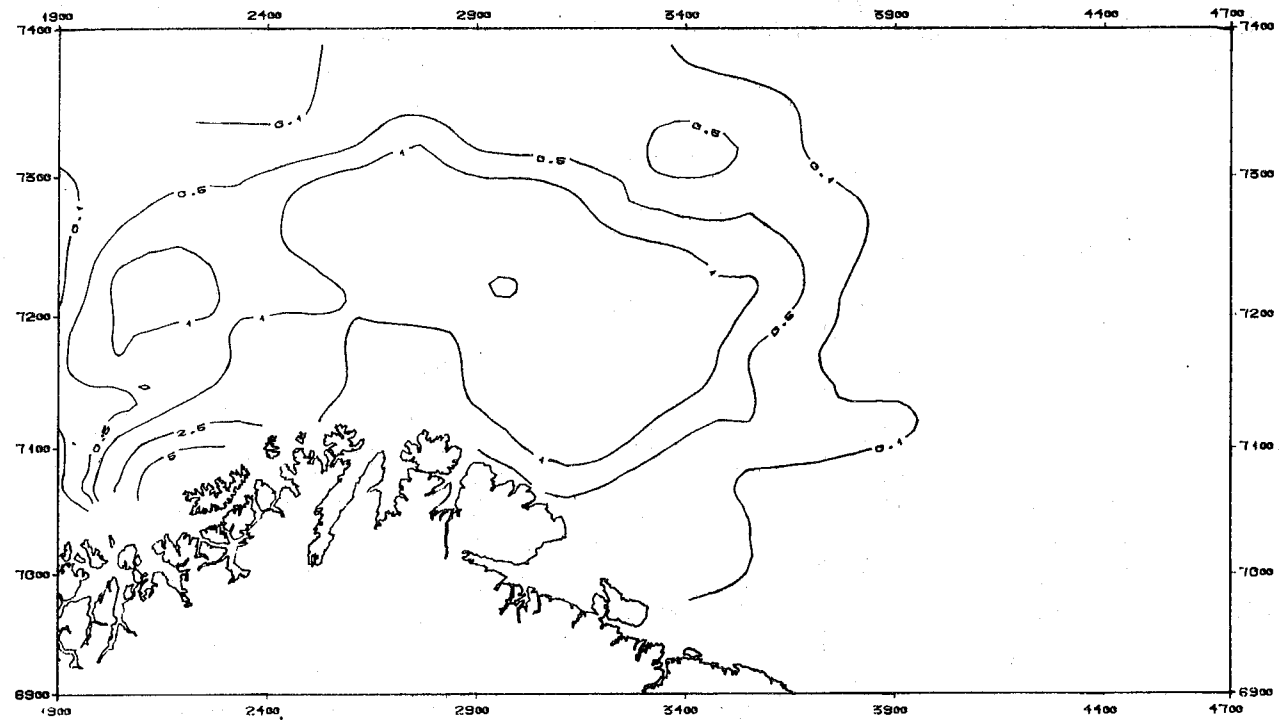

Fig. 12. The distribution of 5-year old cod. (Units as in fig. 8).

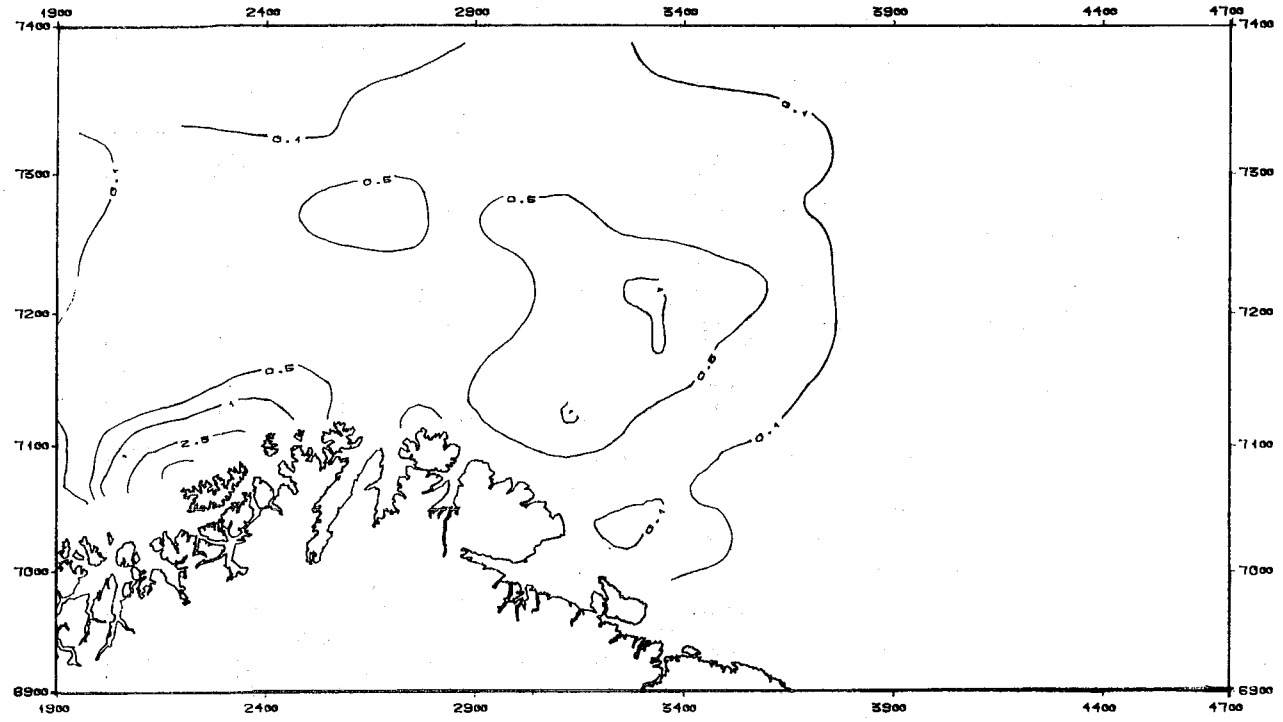

Fig. 13. The distribution of 6-year old cod. (Units as in fig. 8).

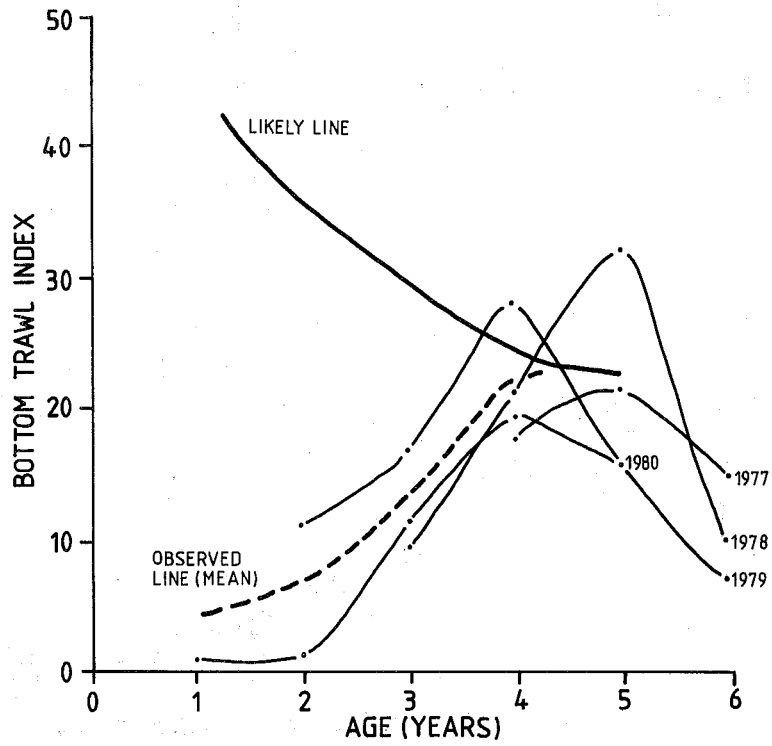

Fig. 14. Bottom trawl indices at age for the 1977 - 1980 year classes of cod (see text for explanation).

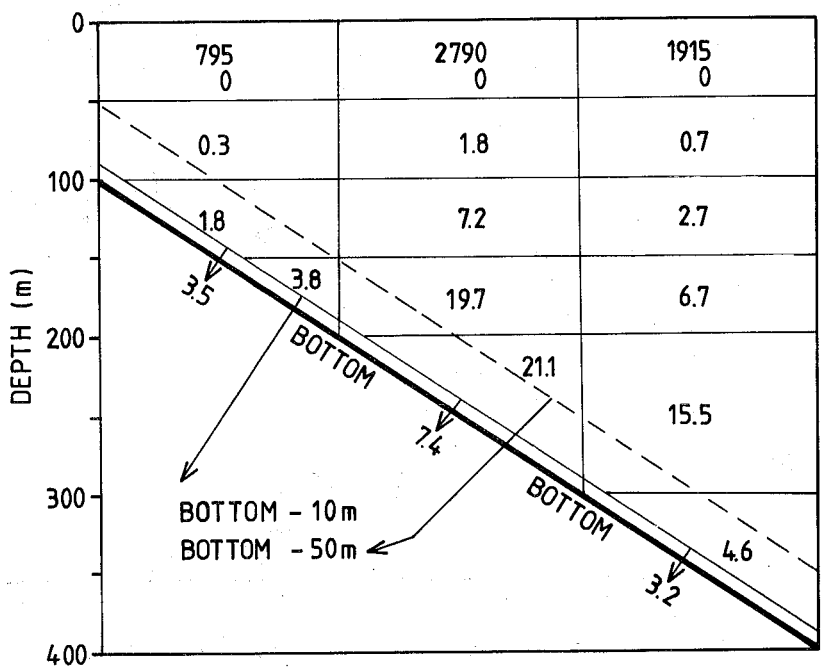

Fig. 15. Schematic presentation of the distribution of echo abundance (in percent of the total within the whole area surveyed) of cod and haddock in the Barents Sea in February 1985. Figures at top show number of nautical miles sampled.

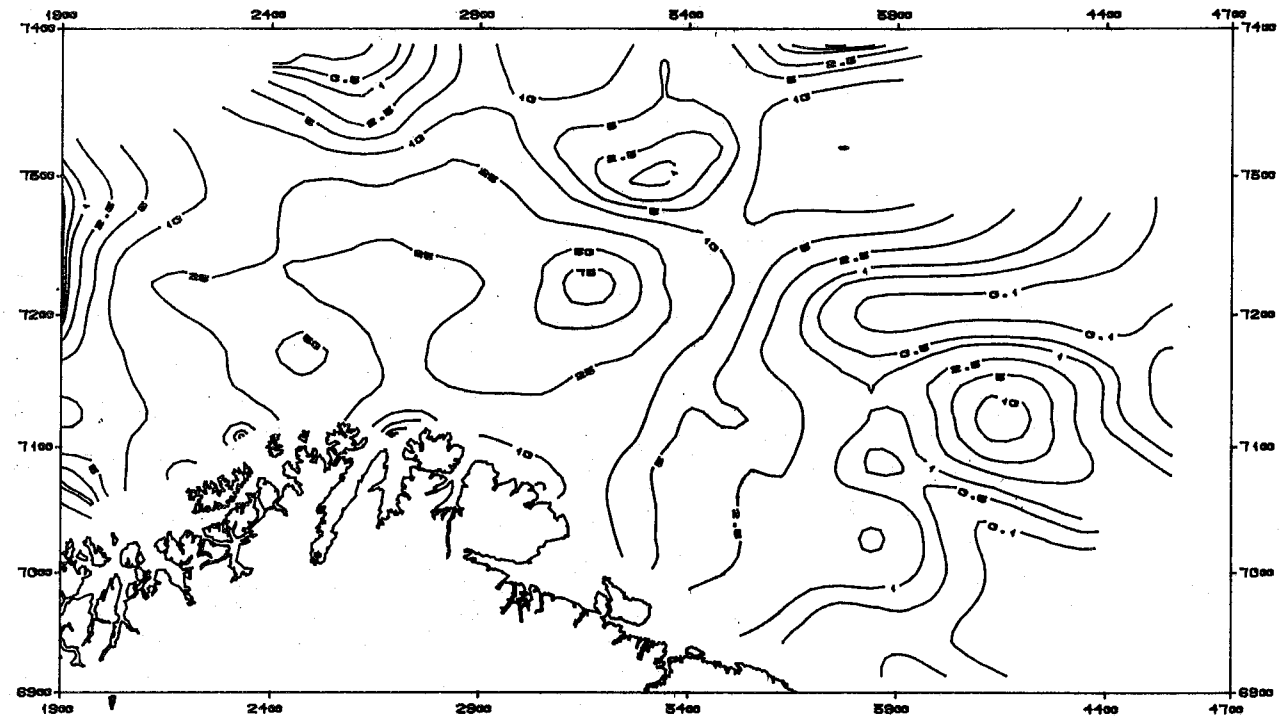

Fig. 16. The distribution of 1-year old haddock. (Units as in fig. 8).

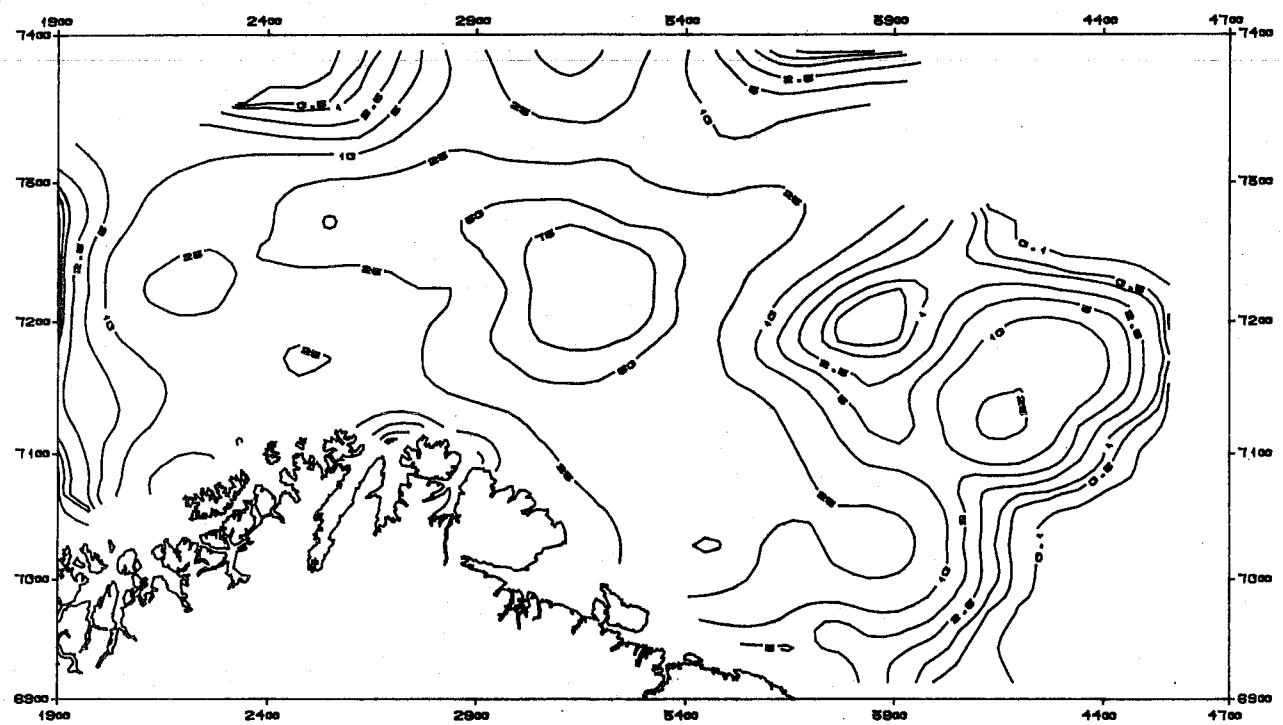

Fig. 17. The distribution of 2-year old haddock. (Units as in fig. 8).

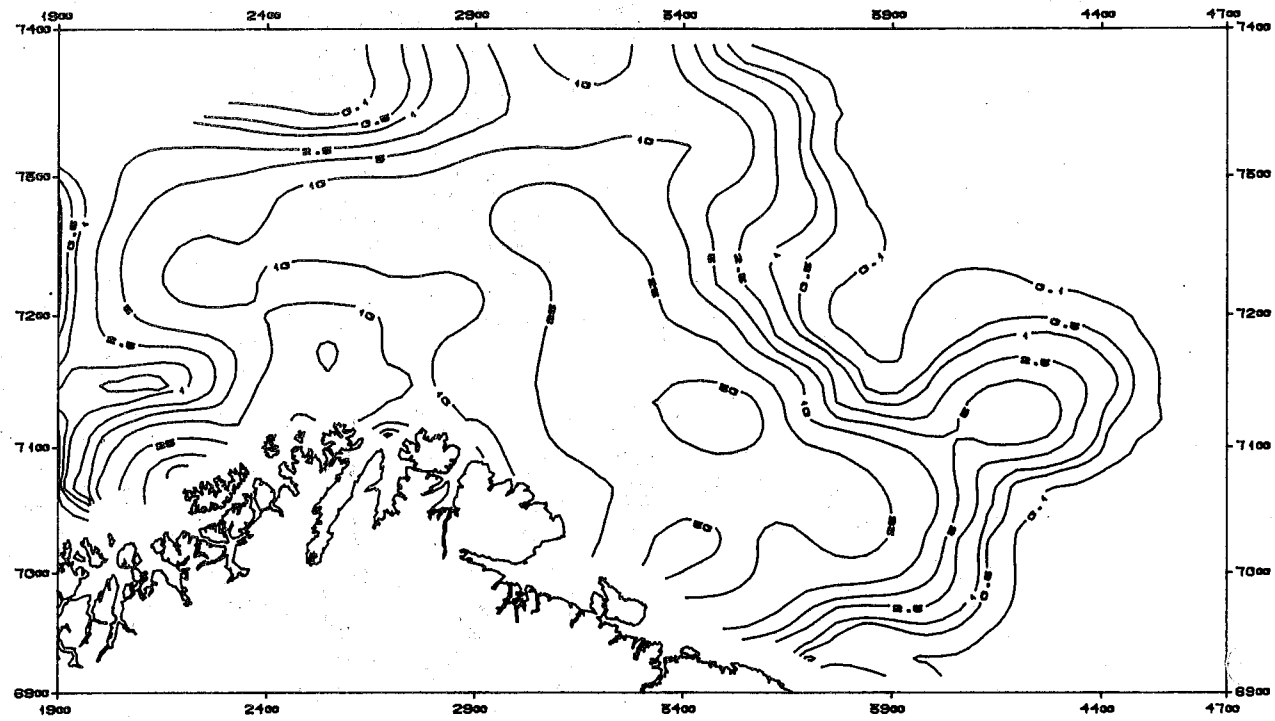

Fig. 18. The distribution of 3-year old haddock. (Units as in fig. 8).

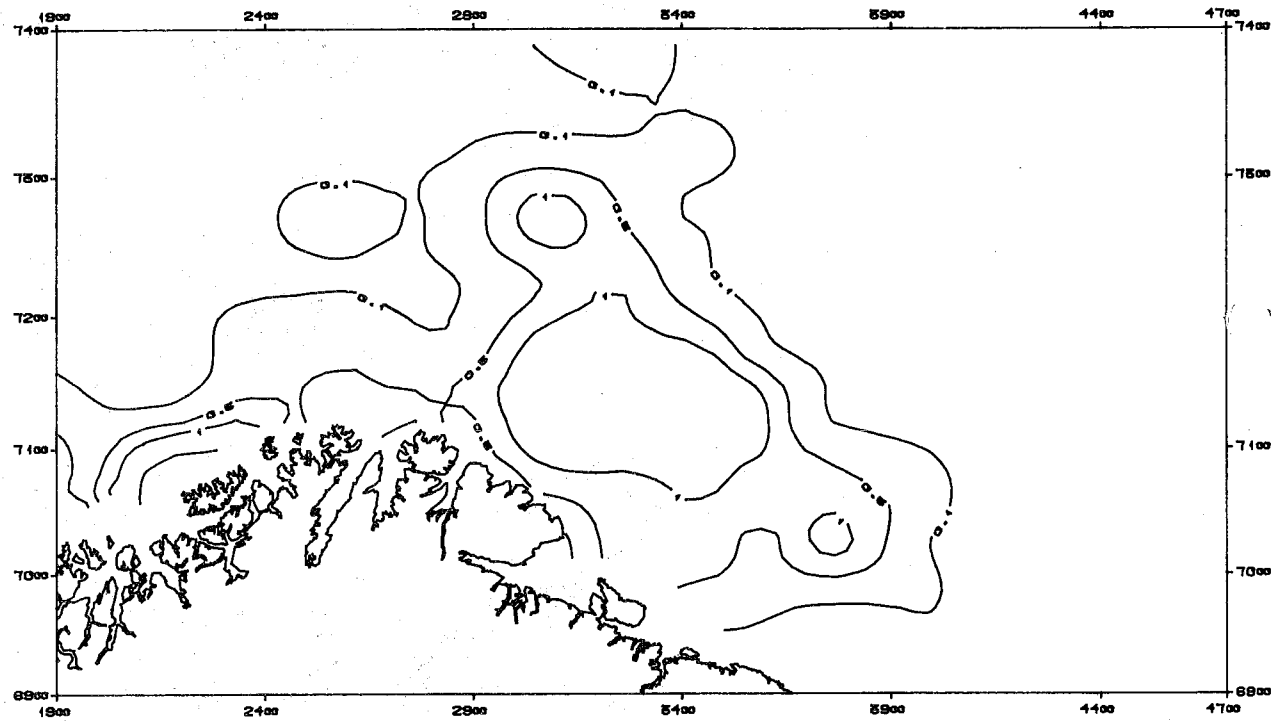

Fig. 19. The distribution of 4-year old haddock. (Units as in fig. 8).