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**ESTIMATES OF STOCK SIZE OF NORTHEAST ARCTIC COD AND HADDOCK FROM
SURVEY DATA 1986/1987**

by

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ABSTRACT

Combined acoustic and bottom trawl survey for cod and haddock were carried out in the Svalbard area in autumn 1986 and in the Barents Sea during the winter 1987. An acoustic survey for spawning cod was carried out in March 1987 in the Lofoten area. The results show that the stocks are still increasing, but not as fast as previous surveys have indicated. One possible reason for this is that fish abundance in relatively shallow waters may have been generally overestimated by the current acoustic survey method.

1. INTRODUCTION

Each year since 1975 a Norwegian acoustic survey has been carried out during the winter in the Barents Sea. The aim of the survey is to estimate the number of cod and haddock by age group in 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) and Hysten et al. (1985, 1986).

After the Barents Sea survey, from 1982 onwards, one vessel has continued to the Lofoten area to carry out an acoustic survey on spawning cod (Godø et al. 1982, 1983, 1984, 1985, Raknes and Sunnanå 1986).

The Svalbard area has been covered by a stratified bottom trawl survey in the autumn since 1981 (Randa and Smedstad 1982, 1983, Godø et al. 1984. In 1985, with a rapidly increasing cod stock, the investigations were carried out as a combined acoustic and bottom trawl survey (Godø and Nedreaas 1986).

Since 1977 the results of these surveys have been used more or less directly in the stock assessments of North-East Arctic cod and haddock. This year the results from all three investigations are presented together in the current paper.

2. MATERIAL AND METHODS

The survey in the Svalbard area was carried out from 8 September to 10 October 1986 using the research vessel R/V "Eldjarn" and the hired commercial trawler M/T "Anny Krømer". The survey was conducted as both a bottom trawl survey (mainly by the vessel M/T "Anny Krømer") and as an acoustic survey (using data from both vessels).

The total number of trawl stations in the survey was 288, of which 33 were taken with midwater trawl. The commercial trawler took the 191 stations in the bottom trawl survey. A total of 229 hydrographical stations were taken by the research vessel. Figs 3.1 and 3.2 show the survey tracks, hydrographical stations and trawl stations worked by "Eldjarn". Fig. 3.4 shows the trawl stations taken in the bottom trawl survey.

The survey in the Barents sea area was carried out in the period 26 January to 3 March 1987 using the two research vessels R/V "G.O.Sars" and R/V "Michael Sars" and the hired commercial trawler M/T "Masi". The survey was conducted as a combined bottom trawl survey (by the vessel M/T "Masi" and partially by the two research vessels) and as an acoustic survey (by the two research vessels, also using trawl data from the trawler).

The total number of trawl stations in the survey was 284, of which 21 were taken with midwater trawl. The commercial trawler took 116 of the 209 stations in the bottom trawl survey. A total of 166 hydrographical stations were taken by the research vessels. Figs 4.1 and 4.2 show the survey tracks, hydrographical stations and trawl stations worked by "G.O.Sars" and "Michael Sars". Fig 4.4. shows the trawl stations in the bottom trawl

survey.

The survey for mature cod at the spawning grounds off the northern coast of Norway, Lofoten-Vesterålen, was conducted from 4 March to 20 March 1987 using the research vessel R/V "G.O.Sars". This survey was an acoustic survey with limited number of trawl stations taken, only 19 of which 11 were pelagic hauls. A total of 109 hydrographical stations were taken. Figs. 5.1 and 5.2 show the survey tracks, hydrographical stations and trawl stations.

2.1 Acoustic Surveys

The acoustic surveys were carried out as in 1986. The method is described by Dalen et al. (1982) and Dalen and Smestad (1979, 1982, 1983). The acoustic equipment used was:

"Eldjarn" : Simrad EK-400, 38kHz hull mounted echosounder.

"G.O.Sars" : Simrad EK-400 and ES-380, 38kHz hull mounted modified "split-beam" echosounder and 38kHz towed echosounder.

"Michael Sars": Simrad EK-S, 38kHz hull mounted echosounder.

All ships used a digital echo integrator system developed at the Institute of Marine Research, run on NORD 10 computers (Blindheim et al., 1982). The acoustic systems are calibrated using the method described by Foote et al. (1983).

All the echo integrator systems produce output in units of sound reflecting surface per square nautical mile (m^2/nm^2). The factor used to convert this to number of cod and haddock per square nautical mile is set to $C = 2.49 \times 10^6 \times L^{1.18}$. This factor equals a target strength $TS = 10 \log(\sigma/4\pi) = 21.8 \log L - 74.9$ where L is the length of the fish and σ is the back scattering surface of a single fish of that length.

The area units used in the acoustic surveys are $1/2^\circ$ latitude \times 1° longitude in the Svalbard and Barents sea surveys, and $10'$ latitude \times $20'$ longitude in the Lofoten-Vesterålen survey. The average reflection is calculated for each area unit and multiplied by the area to give the "echo abundance". These echo abundances are first added up for a number of sub-areas and finally, pooled to the total echo abundance for the whole survey area.

2.2 Bottom Trawl Surveys

Figs 3.3 and 4.3 show the Barents Sea and Svalbard survey areas respectively with the strata used in the bottom trawl surveys, and also the division into the sub-areas for which the bottom trawl indices are given (which are the same sub-areas as for the acoustic surveys). The distribution of the bottom trawl stations included in the calculations are shown in Figs 3.4 and 4.4. Following the survey design described by Dalen et al. (1982) and Randa and Smedstad (1982) the number of stations was reduced to the minimum required for keeping the accuracy at an acceptable level.

In the Svalbard survey the area stratification is based on geographical areas which are divided into strata according to the bottom depth. The depth intervals are 0-100m, 100-200m, 200-300m, 300-400m and >400m. In the Barents sea survey, geographical and depth considerations have been used without following specific depth boarders.

The trawl used in the bottom trawl surveys is a shrimp trawl (Campelen, 1800 meshes, with rubber bobbins and 35 mm meshes in the codend). In the Svalbard survey the sweep wires are 80m and in the Barents sea survey they are 40m. The otter boards used are V-doors for the trawlers, and pelagic doors modified for bottom trawling for the research vessels. The method used to calculate the abundance indices is based on the stratified swept-area considerations described by Dalen et al. (1983) using 25.0 m as the sweeping-width of the trawl. The towing distance of a standard trawl haul is 1.5 and 3.0 nautical miles at a speed of 3 knots in the Barents Sea and Svalbard survey respectively.

3. THE SVALBARD SURVEY

3.1 Hydrography

Hydrographic observations at 50m and bottom (Fig. 3.5A-B) indicate a decrease in temperature compared to the 1985 situation, especially in the eastern part of the area.

3.2 Acoustic survey

The area coverage and trawl stations made during the acoustic survey are shown in Fig. 3.2. Also stations from the bottom trawl survey were used in the conversion of acoustic abundance to fish density (Fig. 3.4). The geographic distribution of the acoustic abundance of cod and haddock show high density patches along the Spitzbergen west coast and in shelf/slope areas around Bear Island and towards Hopen Island (Fig. 3.6).

The estimated total abundance of cod (in numbers) was 310 mill., which is more than a 100% increase compared to 1985. The estimates in 1985 and 1986 were distributed on year classes as follows:

YEAR	YEAR CLASS									TOT
	1985	1984	1983	1982	1981	1980	1979	1978	1977	
1985		13.7	73.3	41.6	13.1	2.9	1.3	0.4	0.1	146.4
1986	13.0	71.0	145.0	50.0	16.0	3.0	2.0	+		300.0

All major year classes increased in absolute abundance from 1985 to 1986. The increase was most prominent for the youngest fish. The abundance of cod and haddock in the Svalbard area was very low in the beginning of the 1980'ies. Further the fish were concentrated very close to the bottom and difficult to detect and integrate acoustically. The distribution improved from 1984 to 1985 (Godø and Nedreaas 1986), i.e. a considerable part of the cod-haddock abundance became acoustically detectable. The vertical distribution showed a favourable change also from 1985 to 1986, and the corresponding substantial increase in abundance is probably mainly caused

by this. Also during the 1986 survey the recordings were located close to the bottom. The methodological problems experienced in the Svalbard area indicate that the results might not yet be fully reliable.

Haddock in the Svalbard area are far less numerous than cod. Estimated numbers in 1985 and 1986 were 27 mill. and 31 mill. respectively. The estimates will suffer from the same problems as those discussed for cod.

3.3 Bottom trawl survey

3.3.1 Cod

Cod were found in all strata. The geographic distribution was similar to previous year. The highest concentrations were observed in patches off the Spitzbergen west coast, around the Bear Island and between Bear Island and South Cape (Spitzbergen) (Fig. 3.7). As in 1984 and 1985, the highest mean catch in numbers (5209) was obtained in stratum 6. The mean catches (in numbers) decreased with depth. The mean catch north of 76° N was about the double of the corresponding from the southern area. The areas of high abundance corresponds with the acoustic observations (Fig. 3.6).

In the northern area the catches were dominated by the 1983 and 1984 year classes whereas the 1982 and 1983 year classes were strongest in the south (Table 3.7). This north-south difference in relative year class strength, is in accordance with the results from previous surveys (Godø and Nedreaas 1986). The 1983 year class dominated at all depths except between 300 and 400 m, where the 1982 year class was most numerous.

The abundance index of cod (in numbers) in the southern area was 2.4 times the northern index in spite of the higher density observed in north (Table 3.1). The mean fish length was higher south of 76° N, and thus the difference in the weight indices was larger (Table 3.2).

The indices distributed on age and area (Table 3.3), underline the information from the relative age distribution. Especially the discrepancy in year class strength between north and south should be noticed: The northern indices of the 1982, 1983 and 1984 year classes making up 13%, 25% and 62% of the total respectively.

The 1986 survey information on the 1982-1984 year classes confirm earlier results in showing them to be strong; the 1982 year class ranged as the weakest and the 1983 year class as the strongest (Table 3.4). The 1985 survey gave a surprisingly high index of the 1981 year class. Its index in 1986 decreased considerably, nevertheless this year class seems to be stronger than indicated at age 1-3. The 1985 year class is indicated to be the weakest since the 1982 year class, in spite of the high index at the 0-group stage.

There was a tremendous increase in the abundance of cod from 1983 to 1985 (Table 3.5, 3.6). This development levelled out in 1986. There was no significant increase in the indices in numbers from 1985 to 1986 neither in the north nor in the south as a result of the low recruitment of the 1985 year class. The total weight index increased with 28% caused by individual growth.

In the discussion of the bottom trawl indices, it must be kept in mind that the confidence limits are generally high (Table 3.3).

The total stratified bottom trawl abundance index is of same magnitude as the acoustic abundance estimate, but the acoustic survey indicate relatively higher recruitment of the 1985 year class. The most plausible reason for this discrepancy is the use of primary squares (0.5° latitude x 1.0° longitude) during the calculations. Such squares will cover slope areas with large differences in depth, and considerable variation in length composition of cod. It is believed that this might have caused unrepresentativity of the length distributions applied in the calculations.

3.3.2 Haddock

The abundance of haddock is low compared to cod (Table 3.1, 3.2). The geographical distribution is shown in Fig. 3.8. There is no major change in the weight index compared to 1985, but the index on numbers is reduced with more than 50 %. The age distribution (Table 3.8) indicate low recruitment of the 1985 year class. The abundance estimated by the acoustic method is more than 50 % higher than the stratified bottom trawl index.

3.3.3 Sebastes mentella

The distribution of S.mentella was very much the same as in 1985 (Fig. 3.9, Godø and Nedreaas 1986). Large catches were scattered on the deeper stations outside West-Spitzbergen, in the Storfjord channel, and south and east of Bear Island. The amount of S.mentella has decreased since 1985, especially in numbers and north of 76° N (Table 3.5 and 3.6). Indices, both in numbers and weight, increased with depth.

3.3.4 Sebastes marinus

The greatest concentrations of S.marinus was found off the Icefjord, West-Spitzbergen, and west-northwest of Bear Island (Fig. 3.10), which is similar to the situation in 1985 (Godø and Nedreaas 1986). The estimated amount of S.marinus in the Bear Island and West-Spitzbergen areas is both in numbers and weight very much the same as in 1985 (Table 3.5 and 3.6). However, the fish north of 76° N in 1986 were smaller compared to the 1984 and 1985 results. The highest concentrations of S.marinus were found between 200 and 300 meter (Table 3.1 and 3.2). The average size of the individuals increase with depth.

3.3.5 Other species

Geographic distribution and abundance of some other major species are given Table 3.1, 3.2, 3.5, 3.6 and Figs. 3.11 - 3.13. Length distributions are presented in Table 3.11 - 3.12

4. THE BARENTS SEA SURVEY

4.1 Hydrography

Figs. 4.5A-4.5C show the temperature distributions in the winter 1987 at the surface, at 100 m depth, and at the bottom respectively. In 1987 the temperatures were similar to 1986 and lower than in 1984 and 1985 when the values in most of the Barents Sea were close to the 30-years mean (Hyllen et al. 1985).

4.2 Distribution of Cod and Haddock

Fig. 4.6 shows the distribution of the total echo abundance of cod and haddock combined in 1987. In 1984 and 1985 high concentrations of fish, mostly of the 1983 year class, were found east of 37° E in the northeastern part of the survey area (Dalen et al. 1984, Hyllen et al. 1985). In 1986 the concentrations in the same area were small and contained mostly fish of the year classes 1984 and 1985 (Hyllen et al. 1986). In 1987 the fish were far more westerly distributed and there were almost no fish registrations east of 33° E. In 1985 and 1986, the highest echo abundances were found between 30° E and 36° E. In 1987 the highest concentrations of fish were found west of 33° E and south of 72° 30' N. From 1985 to 1986 the area of main distribution became split into two components, one between 70° N and 72° N and one from about 72° 30' N and northwards beyond 74° N. The northern component was not found in 1987 and the southern component was distributed further to the west.

Fig. 4.7 shows the echo abundance in the 10 m layer above the bottom. This distribution is similar to the total distribution with the highest values generally found in the areas with highest total echo abundance.

Table 4.2 shows the echo abundance of cod/haddock 1981-1987, total and in the bottom layer. From 1983 to 1986, the total echo abundance increased by a factor of 10. During the same period, the echo abundance in the 10 m layer above the bottom also increased, but only by a factor of 4.9. The proportion of the echo abundance found in the bottom layer accordingly decreased, from 28% in 1983 to 14% in 1986. Thus, 88% of the increase in total echo abundance of cod/haddock has come from pelagic concentrations. From 1986 to 1987, the total echo abundance decreased by a factor of 2.2. During the same period, the echo abundance in the 10 m layer above the bottom also decreased, but only by a factor of 1.3. The proportion of the echo abundance found in the bottom layer accordingly increased, from 14% in 1986 to 23% in 1987. Thus, 94% of the decrease in total echo abundance of cod/haddock has come from pelagic concentrations.

4.3 Acoustic Abundance Estimates of Cod and Haddock

In acoustic surveys, one problem is that wind- and wave-induced bubbles cause excess attenuation of the transmitted and received energy. The integrated echo abundance will therefore be underestimated in bad weather (Dalen and Løvik 1981). Before 1986 R/V "G.O.Sars" was the only research

vessel used in the acoustic surveys for cod and haddock in the Barents Sea and for this vessel a compensation function has been established (Dalen and Løvik 1981). During the 1987 survey measurements were made to estimate the excess attenuation due to bad weather and to compare this estimate with the number of pulses rejected by the integration system due to weak bottom echoes (Ona unpubl.). These results were used to correct the R/V "M.Sars" data from 1986 and 1987.

In 1987 the acoustic estimates were made on the basis of the total echo abundance combined (pooled data), and no values based on separated data, alternative a in Tables 3 to 6 in Høyen et al. (1986), are presented in this report.

The results for cod and haddock are given in Table 4.3 and 4.5 respectively. Tables 4.4 and 4.6 show the full time series of the acoustic estimates.

The age groups 3 - 5 of cod were the most abundant and nearly 60% of the the abundance was found in the western offshore part (A) of the survey area (Table 4.3). In the eastern offshore area (D) the abundance of cod was only 8% of the total abundance in 1987 (age groups 2 - 4) compared to 84% in the same area in 1986 (age groups 1 - 4). In the western coastal area (B) which made up only 9% of the total, the age groups 4 and 5 were the most abundant. In the eastern coastal area (C) which made up 25% of the total, the age groups 2 - 5 were found with age group 4 as the most abundant. In 1987 very few one year old cod were found. Refer to Figs. 4.8-4.13 for the geographical distribution of the different year classes.

Table 4.4 shows that the total estimate of cod is reduced considerably from 1986 to 1987 (27%), but the 1983 year class still appears as a strong year class. In the 0-group survey the index for the 1984 year class was nearly on the same level as the 1983 year class (Anon. 1986), but the indications from the acoustic survey so far are that the 1984 year class is of average abundance. For the 1985 year class, the 0-group index was very high, but the estimates of this year class have decreased from 1986 to 1987. In the acoustic survey the 1986 year class appears to be nearly absent. However, the estimates from the acoustic survey is unreliable for 1-group fish.

Table 4.5 shows that for haddock the echo abundance was clearly highest in area C (45%) and in area A (32%) and distributed further to the west in 1987 than in 1986. Compared to cod relatively more of the abundance occurred in the coastal area C. Most of the one year old haddock was distributed in the western coastal area (B) and most of the two year old haddock was distributed in the eastern coastal area (C). The 1984 and 1982 year classes were distributed more evenly in the whole area while the 1983 year class was most abundant in the areas A and C. Refer to Figs. 4.14-4.18 for the geographical distribution of the different year classes.

Table 4.6 shows that the total estimate of haddock is reduced considerably from 1986 to 1987 (32%). Also for haddock the 1983 year class still appears as a very strong year class. The 1982 and 1984 year classes appears to be above the long-term average, but the estimates of the 1985 and 1986 year classes indicate that they are relatively poor.

Recent estimates of the effective width of the equivalent beam angle indicate that the abundance of cod and haddock that occur at relatively small depths generally have been overestimated (Ona 1987). Thus it is possible that the shift of fish towards deeper water in 1987 will have given an apparently large reduction in the biomass estimate this year.

4.4 Bottom Trawl Survey Indices

4.4.1 Cod and Haddock

The number of trawl stations taken in each stratum in the bottom trawl survey are given in Table 4.1. Tables 4.7 and 4.9 give abundance indices from the bottom trawl survey for each age group of cod and haddock by sub-area and total area. Indices for the total area for the period 1981-1987 are given in Table 4.8 and 4.10.

The bottom trawl indices show less reduction from 1986 to 1987 than the acoustic estimates. One reason for this may be that a lower portion of the fish occurred pelagically in 1987, but it may also be connected with the problems concerning depth variation in the effect of the acoustic signals as discussed in the previous section.

4.4.2 Sebastes marinus

The results from the last years winter surveys show a decrease in numbers of S. marinus, from 517 millions in 1985 to 91 millions in 1987 (Table 4.13). Last year the decrease occurred in area C and D in the eastern part of the investigated area. However, the numbers of fish in the youngest age groups (less than 20 cm) have not changed very much since winter 1986. The distribution of S. marinus in the trawl catches in winter 1987 is shown in Fig. 4.19. The age distributions in the different areas are given in Table 4.11.

4.4.3 Sebastes mentella

Numbers of S. mentella in the Barents Sea seem to have fluctuated during the last years winter surveys (Table 4.13), but the results from the winter survey in 1987 show a decrease of more than 54% compared to 1986, from 919 millions to 417 millions. The decrease occurred in all length groups but 15-19 cm. Accepting fluctuations the last years, the most outstanding decrease occurred in the usually most important recruiting area D. The distribution of S. mentella in the trawl catches in winter 1987 is shown in Fig. 4.20. The age distributions in the different areas are given in Table 4.12.

5. THE LOFOTEN VESTERÅLEN SURVEY

The results from this survey are presented in Tables 5.1, 5.2 and 5.3. Reference should be made to Figure 5.3 for the area divisions. The distribution of echo abundance for cod and haddock combined are shown in Fig. 5.4.

The total estimates in the area was 37 million cod and 9 million haddock. The estimate of mature cod, "skrei", was 23 million which is 1 million below the estimate in 1986. However, the age distribution has changed considerably towards younger fish. The development of the number of mature cod in each yearclass found in the area is as follows: The 1983 yearclass have recruited 1.5 million fish to the estimate in 1987, the 1982 yearclass is increased by 10 million fish to 11.5, the 1981 yearclass is at the same level, 7 million, the 1980 yearclass decreased by 2 million to 1.5 million and the 1979 yearclass decreased by 6 million to 1 million.

The estimate of haddock is not calculated by age, but the individuals represented in the estimates are all fish above 40 cm, which is also the case for cod.

As in 1986 most of the cod was found in the areas north and west of Lofoten. The fish was found rather deep at the shelf edge, probably following the slope southwards. Probably no significant migration into the traditional spawning grounds in the eastern Lofoten occurred.

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Table 3.1. Stratified indices on numbers (thousands) for different depths and areas in 1986.

Species	North of 76° N						South of 76° N						Total
	0-100	100-200	200-300	300-400	>400	Total	0-100	100-200	200-300	300-400	>400	Total	
Cod	33700	38400	8970	1770	675	83515	149000	21400	11500	13000	6570	201470	284985
Haddock	1840	338	172	19	0	2369	1450	20700	5	5	49	22209	24578
<u>S. Marinus</u>	0	35	1860	241	0	2136	0	1490	5730	278	69	7567	9703
<u>S. Mentella</u>	24	30	4140	22000	25500	52194	0	332	17300	85000	193000	295632	347826
Greenland halibut	0	271	593	739	5370	6973	0	317	809	4420	7000	12546	19519
Long rough dab	280	19500	4550	2100	228	26658	4170	47400	56300	31000	12900	151770	178428
Blue whiting	0	0	0	49	37	86	0	13	1840	987	2070	4910	4996
Jelly cat	0	9	6	23	3	41	12	619	687	261	374	1953	1994
Catfish	139	741	937	153	0	1970	106	1990	111	132	0	2339	4309
Smaller catfish	20	312	390	313	40	1075	214	1370	519	511	22	2636	3711

Table 3.2. Stratified indices on weight (thousands kg) for different depths and areas in 1986.

Species	North of 76° N						South of 76° N						Total
	0-100	100-200	200-300	300-400	>400	Total	0-100	100-200	200-300	300-400	>400	Total	
Cod	9660	23100	9040	3480	1530	46810	99900	17400	14200	22600	12900	167000	213810
Haddock	585	89	168	19	0	861	638	9880	10	5	23	10556	11417
<u>S. Marinus</u>	0	5	129	109	0	243	0	212	1320	64	46	1642	1885
<u>S. Mentella</u>	0	294	379	1740	3680	6093	0	8	1710	4130	18900	24748	30841
Greenland halibut	0	100	271	878	3250	4499	0	441	308	2820	8180	11749	16284
Long rough dab	25	1060	589	305	44	2023	592	7280	5540	4720	1920	20052	22075
Blue whiting	0	0	0	16	12	28	0	0	562	309	523	1394	1422
Jelly cat	-	-	-	-	-	-	-	-	-	-	-	-	-
Catfish	50	494	392	176	0	1112	168	763	148	114	0	1166	2278
Smaller catfish	118	833	496	289	40	1776	1730	4580	997	429	8	7744	28170
Shrimps	0	0	382	237	42	661	7	17	615	67	1850	2556	3217

Table 3.5. Stratified trawl indices on numbers (thousands) for different species in 1981 - 1986.

	Year	Number of hauls	Cod	Haddock	<u>S.marinus</u>	<u>S.mentella</u>	Greenland halibut	Long rough dab	Blue whiting	Jelly cat	Catfish	Smaller Catfish
North of 76°N	1981	66	1 467	327	3 415	45 680	13 600	48 720	1 821	35	621	1 209
	1982	70	4 140	56	204	59 190	12 940	34 190	537	30	1 527	279
	1983	70	3 251	362	36 330	58 360	14 360	32 560	128	56	690	975
	1984	72	20 700	38 490	373	278 600	12 680	73 410	422	34	2 167	1 518
	1985	77	82 810	30 090	695	198 430	13 970	85 100	322	116	3 376	2 481
	1986	69	83 600	2 370	2 140	57 200	6 970	26 700	86	40	1 970	1 070
South of 76°N	1981	119	48 310	481	58 250	133 800	6 492	287 500	26 650	1 235	790	1 242
	1982	121	41 460	928	11 790	218 500	13 070	336 100	27 230	1 360	1 082	1 452
	1983	117	42 670	3 358	6 070	248 100	12 330	339 800	30 480	1 456	960	2 155
	1984	122	90 810	30 160	33 100	273 500	23 960	592 400	67 110	2 083	1 358	4 190
	1985	125	197 700	25 760	7 711	338 400	25 520	403 500	25 950	2 323	1 561	6 686
	1986	122	201 000	22 200	7 570	296 000	12 500	152 000	4 910	1 950	2 340	2 640
Total	1981	185	49 770	808	61 670	179 500	20 100	336 300	28 470	1 270	1 411	2 450
	1982	192	45 600	984	11 990	277 600	26 000	370 300	27 760	1 391	2 609	1 730
	1983	187	45 920	3 720	42 400	306 500	26 690	372 400	30 610	1 511	1 650	3 130
	1984	194	111 500	68 640	33 470	552 100	36 630	665 800	67 530	2 117	3 525	5 709
	1985	202	280 600	55 850	8 405	536 820	39 450	488 600	26 270	2 439	4 936	9 167
	1986	191	284 600	24 570	9 710	353 000	19 470	178 700	4 996	1 990	4 310	3 710

Table 3.6. Stratified trawl indices on weight (thousands kg) for different species in 1981 - 1986.

Year		Cod	Haddock	<u>S. marinus</u>	<u>S. mentella</u>	Greenland halibut	Long rough dab	Blue whiting	Jelly cat	Catfish	Smaller Catfish	Shrimps
North of 76°N	1981	3 156	942	453	11 030	3 645	4 125	400	30	1 032	343	17 060
	1982	3 348	5	63	9 804	6 550	2 858	158	130	1 359	363	24 810
	1983	3 226	35	3 984	6 869	4 967	2 322	38	217	462	1 104	13 240
	1984	5 704	5 136	127	19 250	6 840	5 132	83	197	1 238	1 376	6 901
	1985	32 980	4 068	295	15 130	7 880	7 082	79	373	1 638	3 055	3 830
	1986	46 700	860	243	6 100	4 510	2 020	28	-	1 110	1 760	661
South of 76°N	1981	73 270	988	10 230	31 510	5 794	40 770	4 968	9 427	1 054	3 764	50 650
	1982	61 180	469	4 325	49 830	15 660	45 510	7 741	12 590	1 849	6 425	68 780
	1983	54 350	474	1 252	35 350	18 170	46 610	9 349	14 130	2 335	6 309	60 090
	1984	66 510	3 201	3 262	65 670	24 220	82 160	20 530	19 260	4 538	13 480	31 740
	1985	133 500	7 122	1 346	22 030	19 270	53 010	7 643	20 290	3 323	25 110	12 670
	1986	167 000	10 600	1 640	24 700	11 700	20 100	1 390	-	1 190	7 740	2 550
Total	1981	76 430	1 930	10 680	42 530	9 439	44 890	5 368	9 457	2 086	4 407	67 710
	1982	64 530	502	4 388	59 640	22 221	48 370	7 899	12 720	3 209	6 788	93 590
	1983	57 580	509	5 236	42 350	23 130	48 930	9 387	14 350	2 797	7 412	74 330
	1984	72 210	8 337	3 389	84 920	31 060	87 290	20 610	19 450	5 776	14 850	38 640
	1985	166 400	11 119	1 641	37 160	27 160	60 090	7 721	20 660	4 961	28 170	16 500
	1986	213 700	11 460	1883	30 800	16 210	22 120	1 418	-	2 300	9 500	3 210

Table 3.7. Age distribution (percent) of cod. A:0-100m, B:100-200m, C:200-300m, D:300-400m, E:Deeper than 400m, F:Northern area, G:Southern area, H:Total area.

AGE	A	B	C	D	E	F	G	H
1	0.8	2.8	1.7	0.6	+	1.9	1.0	1.2
2	17.5	22.2	20.2	3.5	2.4	37.4	9.4	17.6
3	64.0	55.5	38.1	24.8	31.1	48.9	61.1	57.6
4	14.0	11.8	19.2	37.2	28.3	6.5	19.2	15.4
5	3.3	5.6	15.0	26.0	24.1	4.0	7.3	6.4
6	0.3	1.4	3.5	4.6	7.7	1.1	1.2	1.1
7	0.1	0.4	1.6	2.1	4.2	0.3	0.5	0.5
8	+	0.1	0.5	0.6	1.2	0.1	0.1	0.1
9	+	0.1	0.2	0.2	0.6	+	0.1	0.1
10+	+	0.1	0.2	0.2	0.6	+	0.1	0.1

Table 3.8. Age distribution (percent) of haddock. A:0-100m B:100-200m, C:200-300m, D:300-400m, E:Deeper than 400m F:Northern area, G:Southern area, H:Total area.

AGE	A	B	C	D	E	F	G	H
1	6.2	1.0	1.1	0	0	11.0	0.6	1.6
2	23.8	7.9	2.9	0	0.3	31.4	7.4	9.6
3	65.8	81.9	16.1	17.1	67.6	53.0	82.4	79.6
4	3.8	9.7	76.4	82.8	32.0	7.5	9.8	9.6
5	0	+	3.3	0	0	0.2	+	+

Table 3.9. Age distribution (percent) of Sebastes mentella.
 A:0-100m, B:100-200m, C:200-300m, D:300-400m,
 E:Deeper than 400m, F:Northern area, G:Southern
 area, H:Total area.

LENGTH	A	B	C	D	E	F	G	H
0- 4	0	0	0	0.1	0	0.2	0	+
5- 9	0	5.7	7.3	1.4	0.9	0.8	1.7	1.5
10-14	0	62.6	33.3	47.0	20.3	29.6	29.9	29.9
15-19	0	23.8	46.4	48.4	62.0	53.6	56.8	56.3
20-24	0	6.0	4.2	2.0	7.0	6.6	5.0	5.3
25-29	0	0.8	4.8	0.4	4.4	4.4	2.9	3.2
30-34	0	0.9	1.7	0.2	2.6	2.5	1.7	1.8
35-39	0	0.2	0.6	0.2	0.6	0.4	0.5	0.5
40-44	0	0	1.0	0.3	2.0	1.8	1.3	1.4
45-49	0	0	0.6	0	0.2	0.1	0.1	0.1

Table 3.10. Age distribution (percent) of Sebastes marinus.
 A:0-100, B:100-200m, C:200-300m, D:300-400,
 E:Deeper than 400m, F:Northern area, G:Southern
 area, H:Total area.

LENGTH	A	B	C	D	E	F	G	H
5- 9	0	0	5.9	0	0	8.7	0.3	2.2
10-14	0	28.6	34.7	21.8	0	48.3	28.5	33.1
15-19	0	26.9	18.5	30.7	0	31.3	16.2	19.8
20-24	0	19.9	4.9	3.8	0	2.8	7.1	6.1
25-29	0	15.4	6.1	9.6	24.1	1.1	9.0	7.2
30-34	0	4.2	18.8	7.8	25.9	2.1	21.6	17.0
35-39	0	0	7.7	10.7	0	3.5	8.3	7.1
40-44	0	5.0	4.7	11.8	25.9	1.2	6.5	5.2
45-49	0	0	0	3.8	24.1	1.1	0.2	0.4
50-54	0	0	0.9	0	0	0	1.0	0.8
55-59	0	0	0.2	0	0	0	0.3	0.2
60-64	0	0	0.9	0	0	0	1.0	0.8

Table 3.11. Age distribution (percent) of Long rough dab.
 A:0-100m, B:100-200m, C:200-300m, D:300-400m,
 E:Deeper than 400m, F:Northern area, G:Southern
 area, H:Total area.

LENGTH	A	B	C	D	E	F	G	H
5- 9	18.9	5.4	2.3	3.1	0	9.5	2.9	3.9
10-14	26.6	20.2	33.6	14.5	1.6	30.5	21.2	22.6
15-19	6.0	25.6	19.0	12.7	5.3	27.3	17.6	19.0
20-24	10.0	19.6	22.4	27.2	34.3	16.4	23.9	22.8
25-29	16.7	12.4	13.1	23.5	41.1	8.5	18.3	16.8
30-34	11.9	9.3	5.7	13.1	13.9	6.7	9.6	9.2
35-39	8.8	5.6	3.3	5.2	3.5	1.1	5.3	4.7
40-44	1.3	1.9	0.5	0.8	0.3	0.1	1.3	1.1

Table 3.12. Age distribution (percent) of Greenland halibut.
 A:0-100, B:100-200m, C:200-300m, D:300-400m,
 E:Deeper than 400m, F:Northern area, G:Southern
 area, H:Total area.

LENGTH	A	B	C	D	E	F	G	H
5- 9	0	0	0.9	0	0	0	0.1	0.1
10-14	0	8.5	0	0	0	0.7	0	0.3
15-19	0	0	0	0.9	0.1	0	0.5	0.3
20-24	0	2.8	10.1	4.0	1.2	2.5	2.6	2.6
25-29	0	5.6	9.8	9.5	3.3	5.0	5.8	5.5
30-34	0	7.1	28.1	17.9	8.8	14.6	11.4	12.6
35-39	0	9.4	14.5	18.0	14.2	17.1	13.9	15.1
40-44	0	8.2	26.0	22.5	26.1	31.6	20.7	24.6
45-49	0	2.7	9.6	13.3	21.8	21.6	16.2	18.1
50-54	0	28.9	0.5	6.5	10.7	4.0	12.5	9.4
55-59	0	26.7	0.4	3.4	4.7	0.8	6.9	4.7
60-64	0	0	0	1.0	3.9	0.3	4.1	2.8
65-69	0	0	0	1.2	2.5	0.7	2.5	1.9
70+	0	0	0	1.9	2.5	1.1	2.6	2.0

Table 4.1. Trawl hauls taken in the bottom trawl survey 1987.

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

Table 4.2. Cod/Haddock. Total echo abundance and echo abundance in the 10 m layer above the bottom 1981-1987. (m^2 reflecting surface $\times 10^{-3}$).

Echo Abundance	Year						
	1981	1982	1983	1984	1985	1986	1987
Total	2097	686	597	2284	5187	5990	2676
Bottom	799	311	169	604	736	820	608
Ratio bottom/total	.38	.45	.28	.26	.14	.14	.23

Table 4.7. Cod. Abundance indices from the bottom trawl survey for each age group/year class in the different areas in 1987.

Area	Age (Year class)										Total
	1 (86)	2 (85)	3 (84)	4 (83)	5 (82)	6 (81)	7 (80)	8 (79)	9 (78)	10+ (77+)	
A	0.3	14.9	41.0	135.0	27.8	7.4	0.7	0.2	0.0	0.0	227.3
B	0.0	0.2	1.4	13.4	8.0	2.6	0.2	0.1	+	0.0	25.9
C	0.3	2.1	11.5	49.7	5.6	1.3	0.3	+	0.0	0.0	70.8
D	4.0	72.1	41.8	30.8	0.6	0.1	0.1	0.0	0.0	0.0	149.5
Total	4.5	89.3	95.8	229.0	42.0	11.4	1.3	0.3	+	0.0	473.6
%	1.0	18.9	20.2	48.4	8.9	2.4	0.3	0.1	+	0.0	100.2

Table 4.8. Cod. Abundance indices for each year class from the bottom trawl surveys 1981-1987.

Year of investig.	Year class													Total	
	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974		1973+
1981							0.7	11.0	8.6	16.9	34.1	37.9	4.8	1.3	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
1986		82.5	93.0	356.0	119.0	62.6	8.3	2.1	0.3	0.1	0.1				724.0
1987	4.5	89.3	95.8	229.0	42.0	11.4	1.3	0.4	+	+					437.7

Table 4.9. Haddock. Abundance indices from the bottom trawl survey for each age group/year class in the different areas in 1987.

Area	Age (Year class)								Total
	1 (86)	2 (85)	3 (84)	4 (83)	5 (82)	6 (81)	7 (80)	8+ (79+)	
A	0.9	5.2	42.7	52.4	9.5	0.1	0.1	0.0	110.9
B	4.0	0.8	6.0	17.4	7.9	0.0	+	0.0	36.1
C	0.6	3.2	39.1	123.0	31.4	0.0	0.1	0.0	197.4
D	9.7	22.7	61.5	120.0	13.2	+	0.0	+	227.1
Total	15.2	31.9	149.3	312.8	62.0	0.1	0.2	+	571.5
%	2.7	5.6	26.1	54.7	10.9	+	+	+	100.0

Table 4.10. Haddock. Abundance indices for each year class from the bottom trawl surveys 1981-1987.

Year of invest.	Year class												Total	
	1987	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975		1974+
1981							0.3	4.8	2.3	9.5	2.0	6.1	0.7	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
1986		77.9	135.0	314.0	123.0	0.4	0.1	0.1	0.2					651.5
1987	15.2	31.9	149.3	312.8	62.0	0.1	0.2	+						571.5

Table 4.11 . Length distributions (%) of S. marinus from the different areas in the Barents Sea winter 1987.

		A R E A				
		A	B	C	D	Total
L E N G T H I N C M	5- 9	2.1	38.4	0.5	36.5	15.9
	10-14	18.4	21.3	0.4	16.0	16.4
	15-19	54.7	13.6	1.2	24.3	35.9
	20-24	6.2	5.3	11.2	13.2	8.4
	25-29	3.4	6.3	29.1	5.7	6.9
	30-34	2.1	6.2	14.5	1.3	3.7
	35-39	3.2	3.3	17.7	1.6	4.2
	40-44	3.9	2.1	17.0	0.7	4.1
	45-49	3.4	2.6	5.5	0.3	2.7
	50-54	2.0	0.7	2.8	0.2	1.4
	55-59	0.4	0.1			0.2
	60-64	0.1			0.1	
	65-69					
	70+					
Mean		20.6	16.5	33.4	15.0	19.8
St.dev		10.4	11.2	8.3	8.1	11.0

Table 4.12. Length distributions (%) of S. mentella from the different areas in the Barents Sea winter 1987.

		A R E A				
		A	B	C	D	Total
L E N G T H I N C M	5- 9	10.4	15.1	2.3	40.9	14.0
	10-14	4.8	12.2	0.3	10.0	5.4
	15-19	65.1	33.6	20.5	24.7	54.5
	20-24	9.0	16.5	47.6	14.7	13.5
	25-29	6.5	18.6	21.8	6.6	8.3
	30-34	2.3	3.2	6.4	2.4	2.7
	35-39	1.4	0.5	0.9	0.7	1.3
	40-44	0.3	0.2			0.3
	45-49			0.1		
	50-54					
	55-59					
	60-64					
	65-69					
	70+					
Mean		17.9	18.5	22.7	14.6	17.9
St.dev		5.8	7.1	4.8	7.5	6.3

Table 4.13. Stratified trawl indices on numbers (thousands) and weight (tonnes) for S. marinus and S. mentella in the Barents Sea in winter 1983 - 1987.

Area and year	Numbers		Area and year	Weight	
	<u>S. marinus</u>	<u>S. mentella</u>		<u>S. marinus</u>	<u>S. mentella</u>
A 1983	109000	270000	A 1983	43700	65800
1984	88500	286000	1984	26500	63300
1985	233000	185000	1985	42000	21300
1986	38800	431000	1986	4770	129000
1987	46000	308000	1987	12200	26700
B 1983	10200	32800	B 1983	5140	6010
1984	21100	41700	1984	9040	7380
1985	68100	5670	1985	21800	985
1986	5170	144000	1986	1920	59600
1987	12200	15100	1987	1990	1560
C 1983	11400	20200	C 1983	3850	5050
1984	16900	37700	1984	4570	7540
1985	55600	31400	1985	16300	3200
1986	43000	57900	1986	22000	15900
1987	8920	36600	1987	5490	5460
D 1983	102000	503000	D 1983	8300	36900
1984	871000	824000	1984	45300	10800
1985	160000	399000	1985	21300	16100
1986	68100	286000	1986	8420	11600
1987	24300	57000	1987	3570	4550
TOTAL			TOTAL		
1983	233000	826000	1983	61000	114000
1984	998000	1190000	1984	85400	89000
1985	517000	622000	1985	101000	41600
1986	155000	919000	1986	37100	216000
1987	91400	417000	1987	23200	38300

Table 5.1. The number of mature cod (skrei) estimated in the respective areas distributed on age. Figures are in million fish.

Age Area	4	5	6	7	8	9	10+	Tot
1	.05	.47	.34	.10	.14	.03		1.13
2	.14	1.42	1.03	.32	.43	.11		3.45
3	+	.07	.02	.02	+	+	+	.11
4	.22	3.73	1.33	1.15	.08	.02	.02	6.55
5	1.15	5.77	4.30		.47			11.69
Tot	1.56	11.46	7.02	1.59	1.12	.16	.02	22.93

Table 5.2. Number of immature cod estimated in the respective areas distributed on age. Figures are in million fish.

Age Area	4	5	6	7	8	9	10+	Tot
3	+	.01	.01					.02
4	.30	.68	.21					1.19
5	3.18	5.65	4.00					12.83
Tot	3.48	6.34	4.22					14.04

Table 5.3. Number of haddock estimated in the respective areas. Figures are in million fish.

Area	3	4	5	Tot
	.04	2.41	6.11	8.56

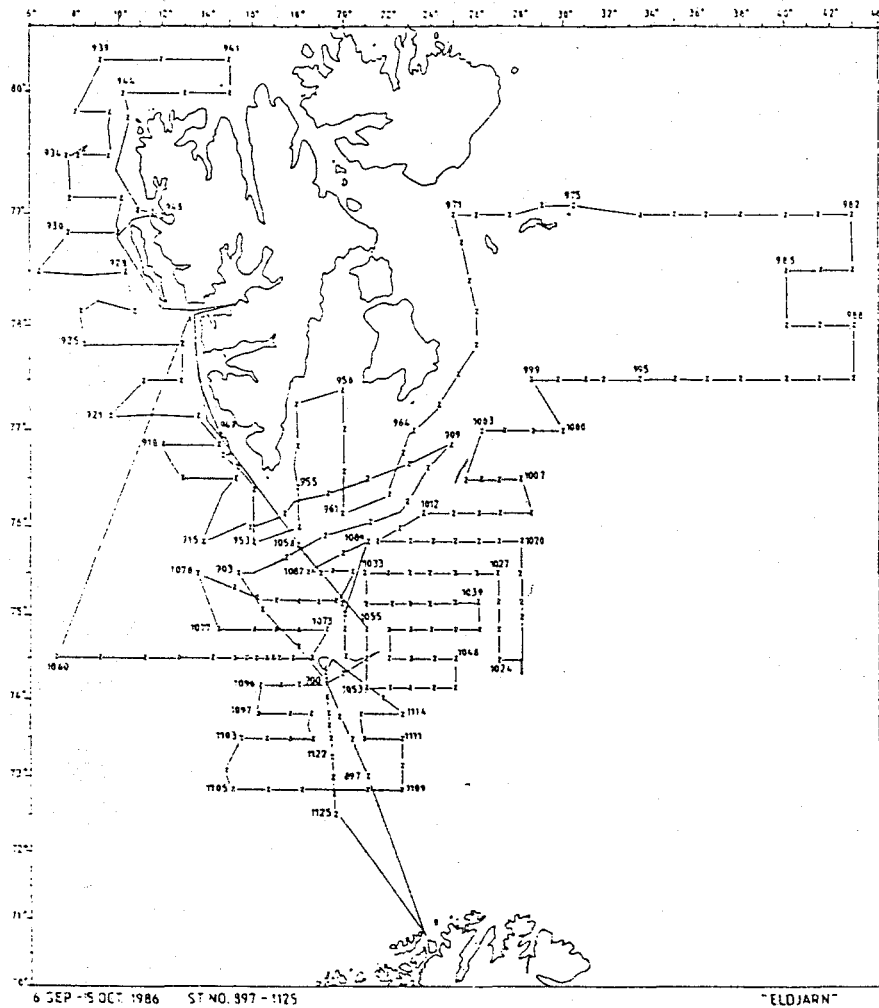


Fig. 3.1. Survey tracks and hydrographic stations taken by R/V "Eldjarn" 8.9 - 10.10. 1986.

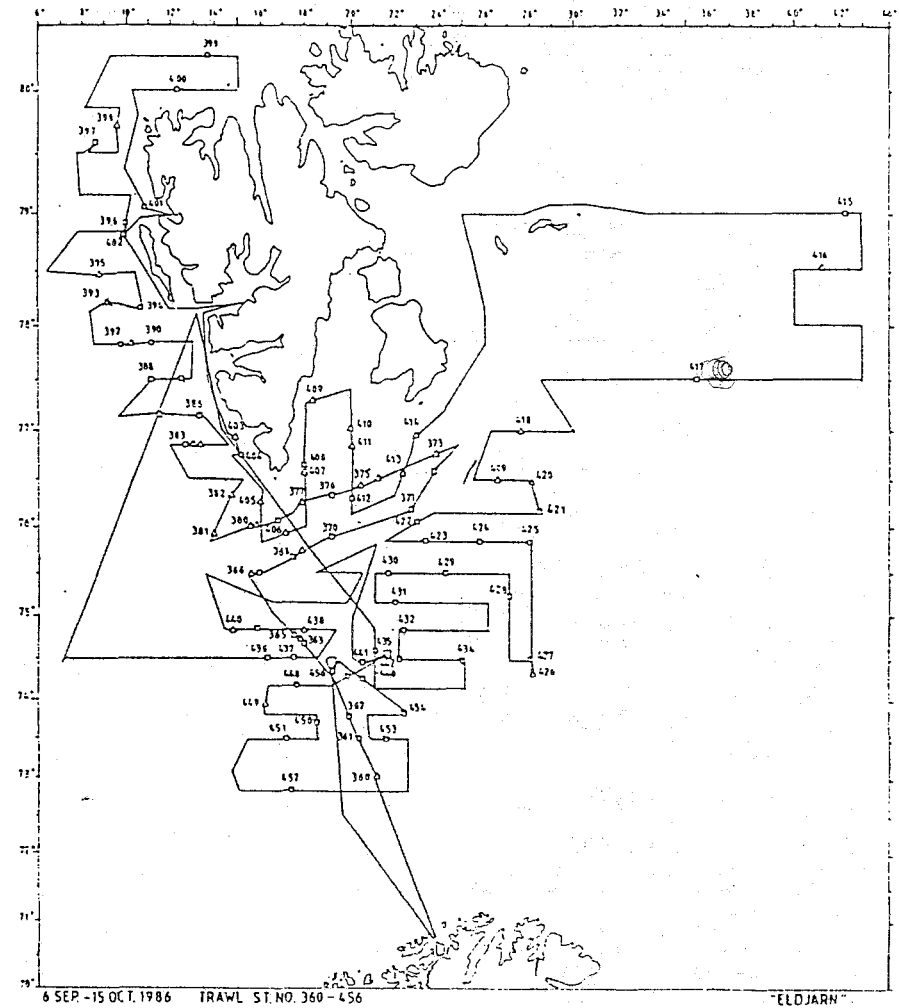


Fig. 3.2. Survey tracks and bottom (□) and pelagic (Δ) trawl stations taken by R/V "Eldjarn" 8.9. - 10.10. 1986.

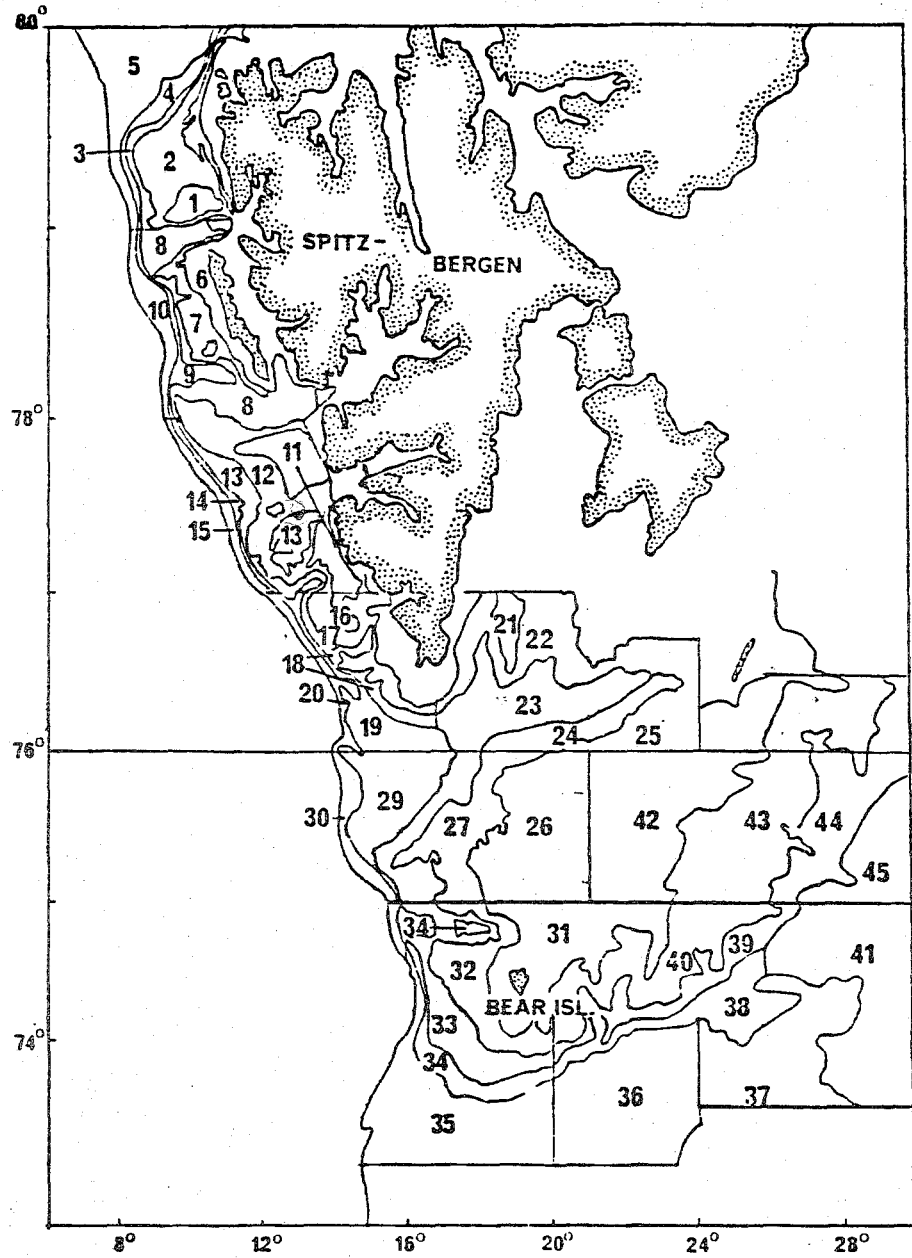


Fig. 3.3. The area of investigation with the different strata.

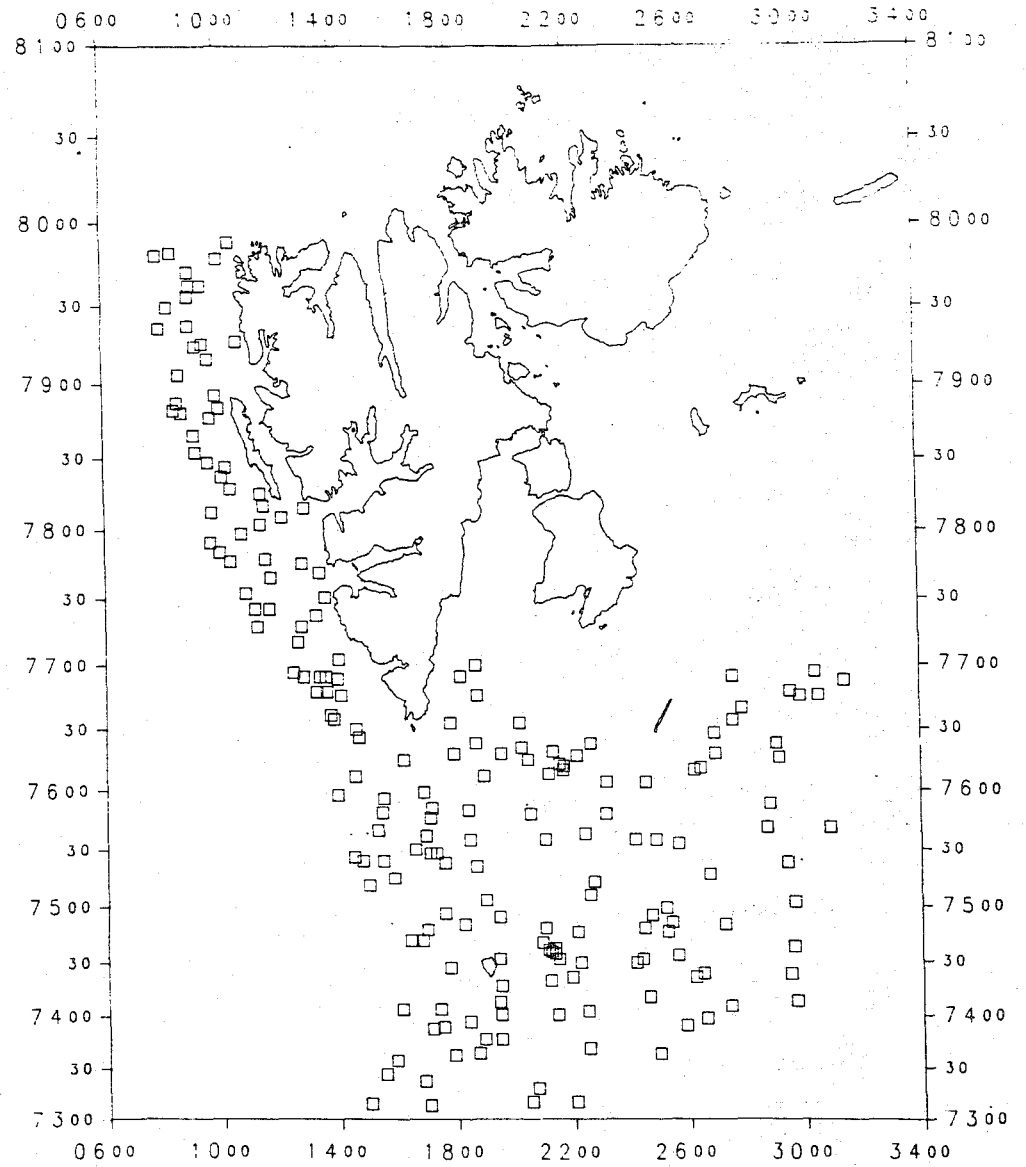


Fig. 3.4. Bottom trawl stations taken by R/V "Eldjarn" and M/T "Anny Kræmer" 8.9. - 10.10. 1986.

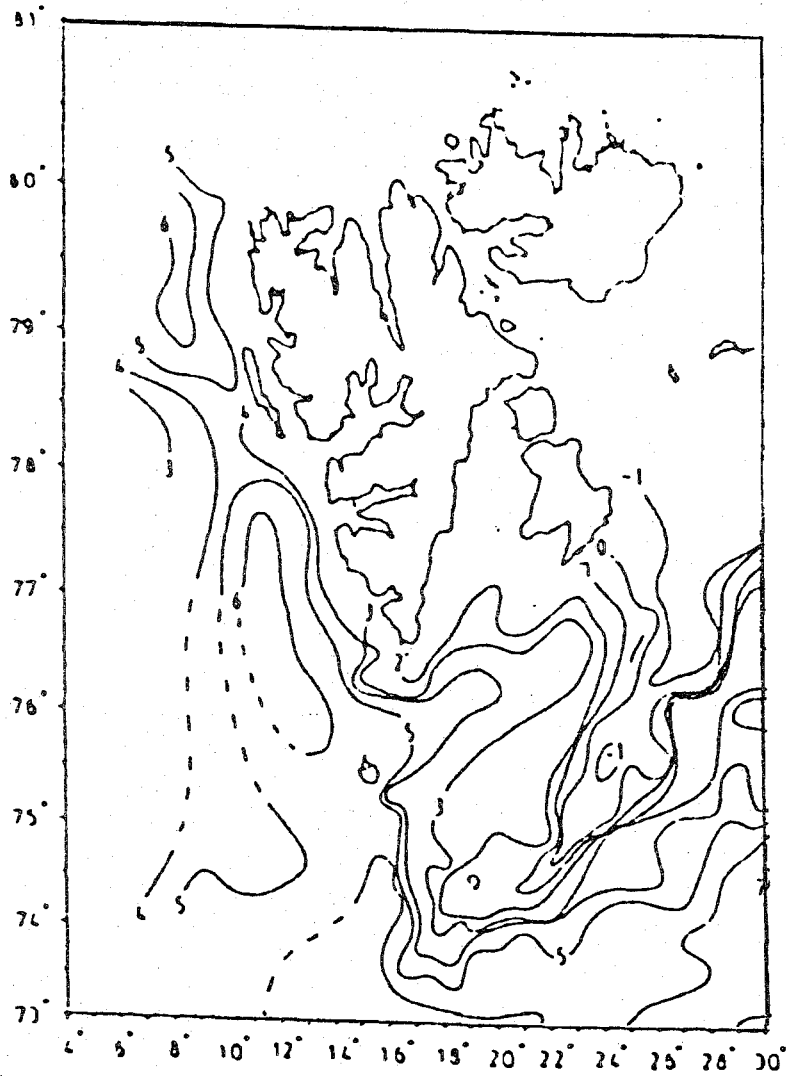


Fig. 3.5a. Temperature ($^{\circ}\text{C}$) in 50 meters depth.

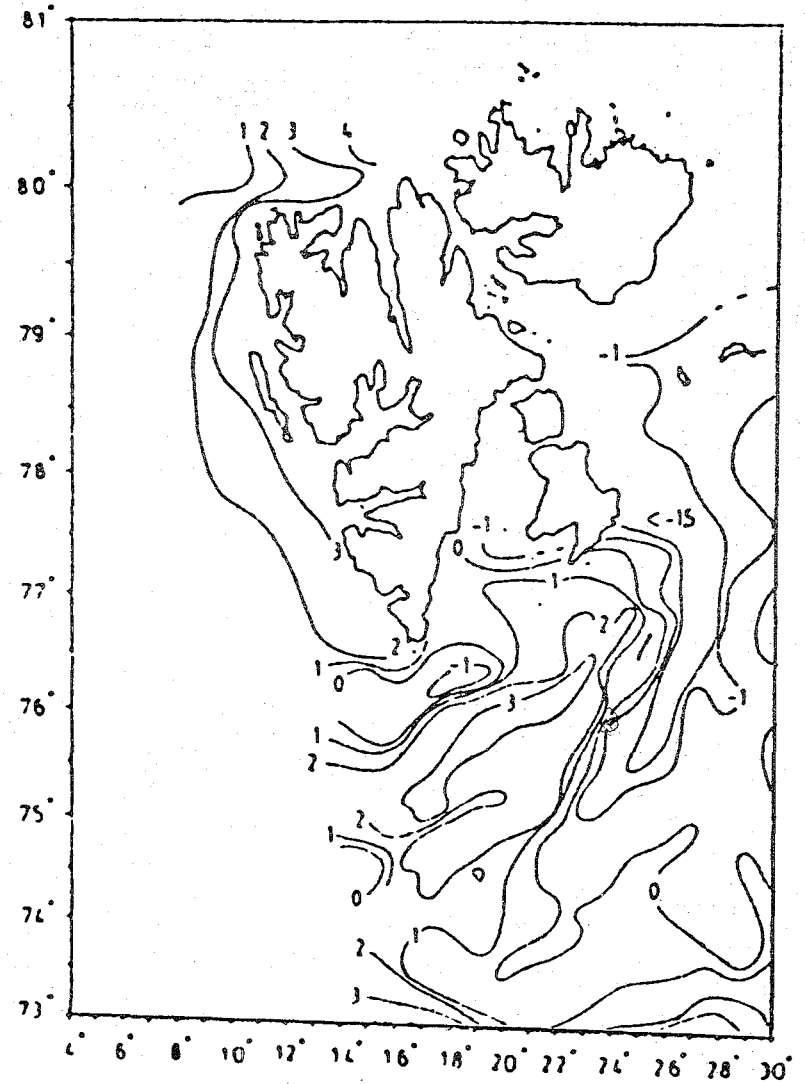


Fig. 3.5b. Temperature ($^{\circ}\text{C}$) at the bottom.

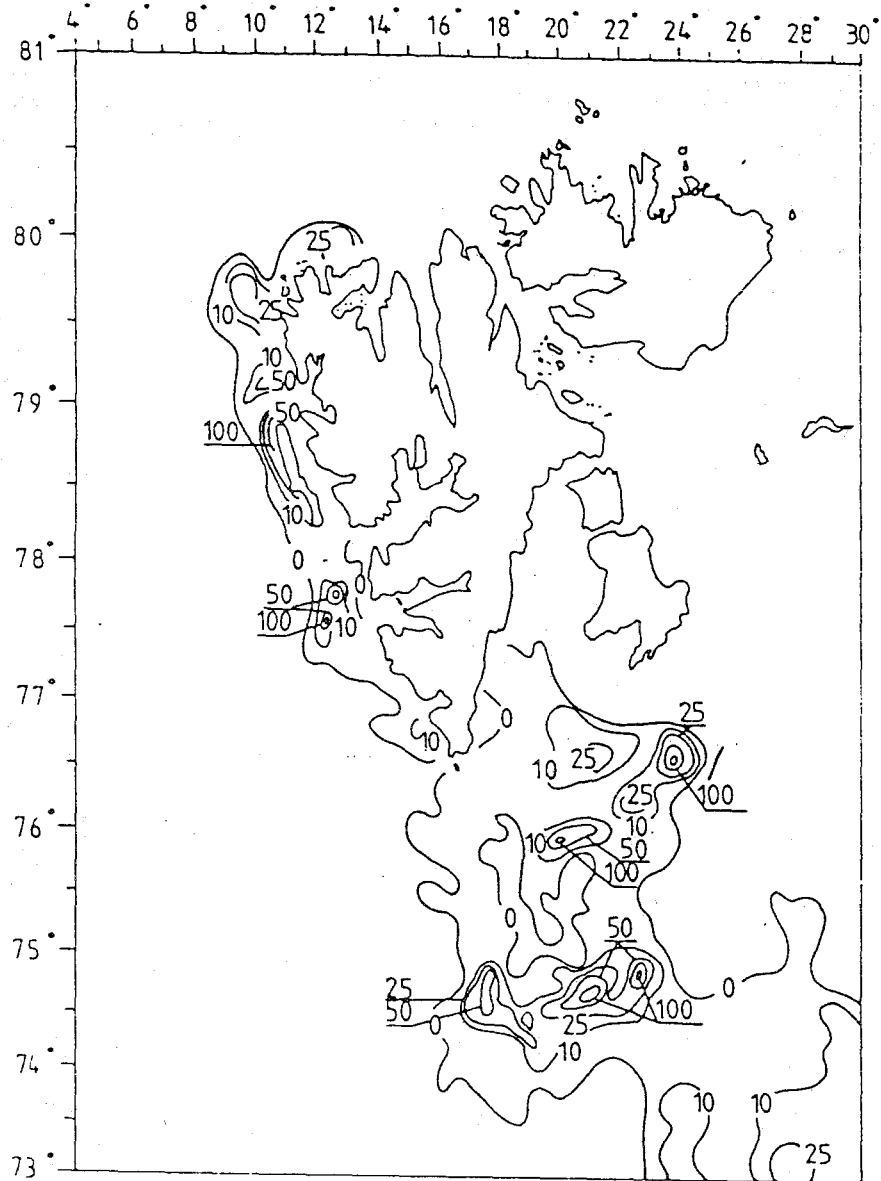


Fig. 3.6. Distribution of acoustic abundance of cod and haddock (m/naut. mile)².

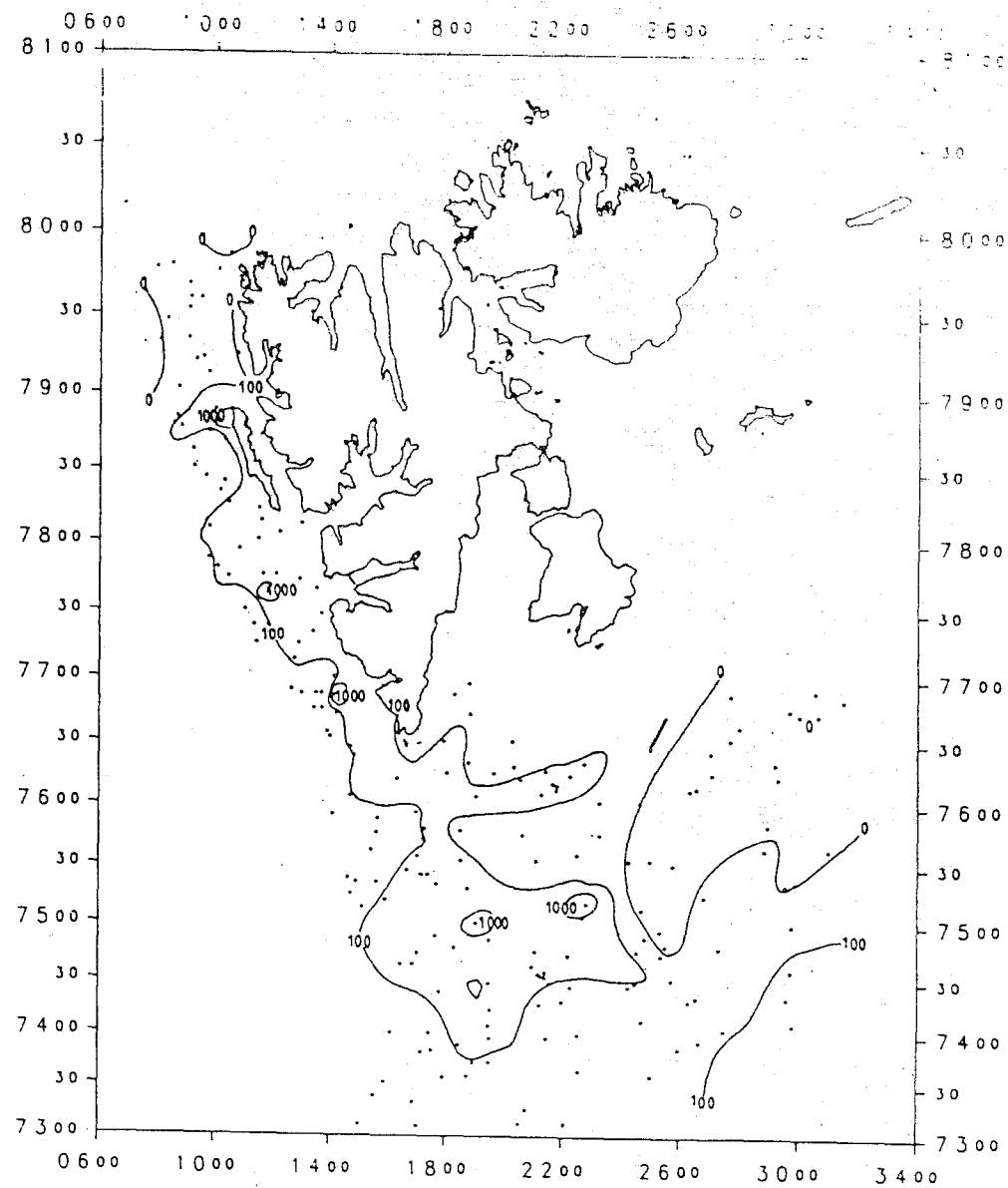


Fig. 3.7. Distribution of cod in the trawl catches (numbers per hour trawling).

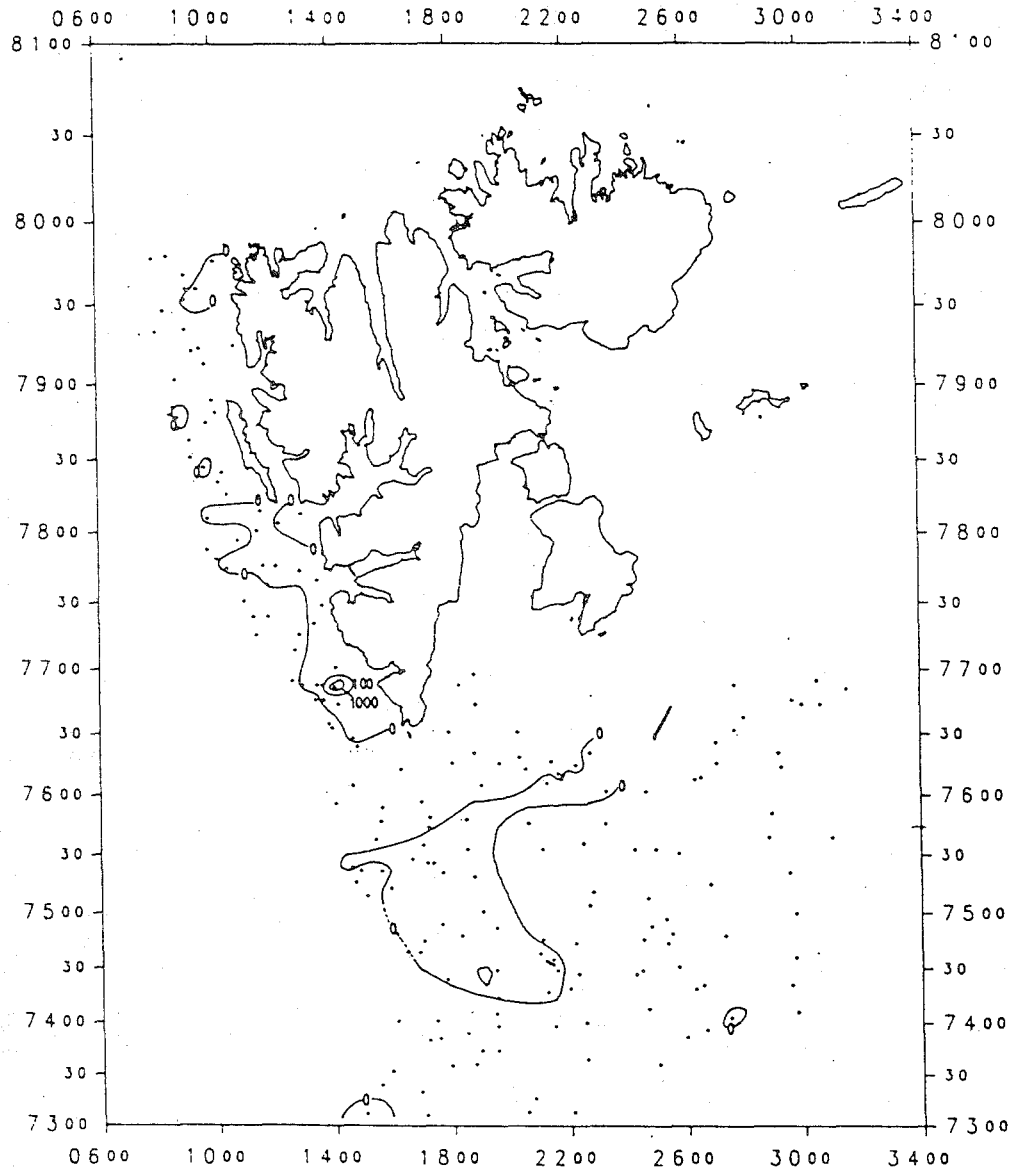


Fig. 3.8. Distribution of haddock in the trawl catches (number per hour trawling).

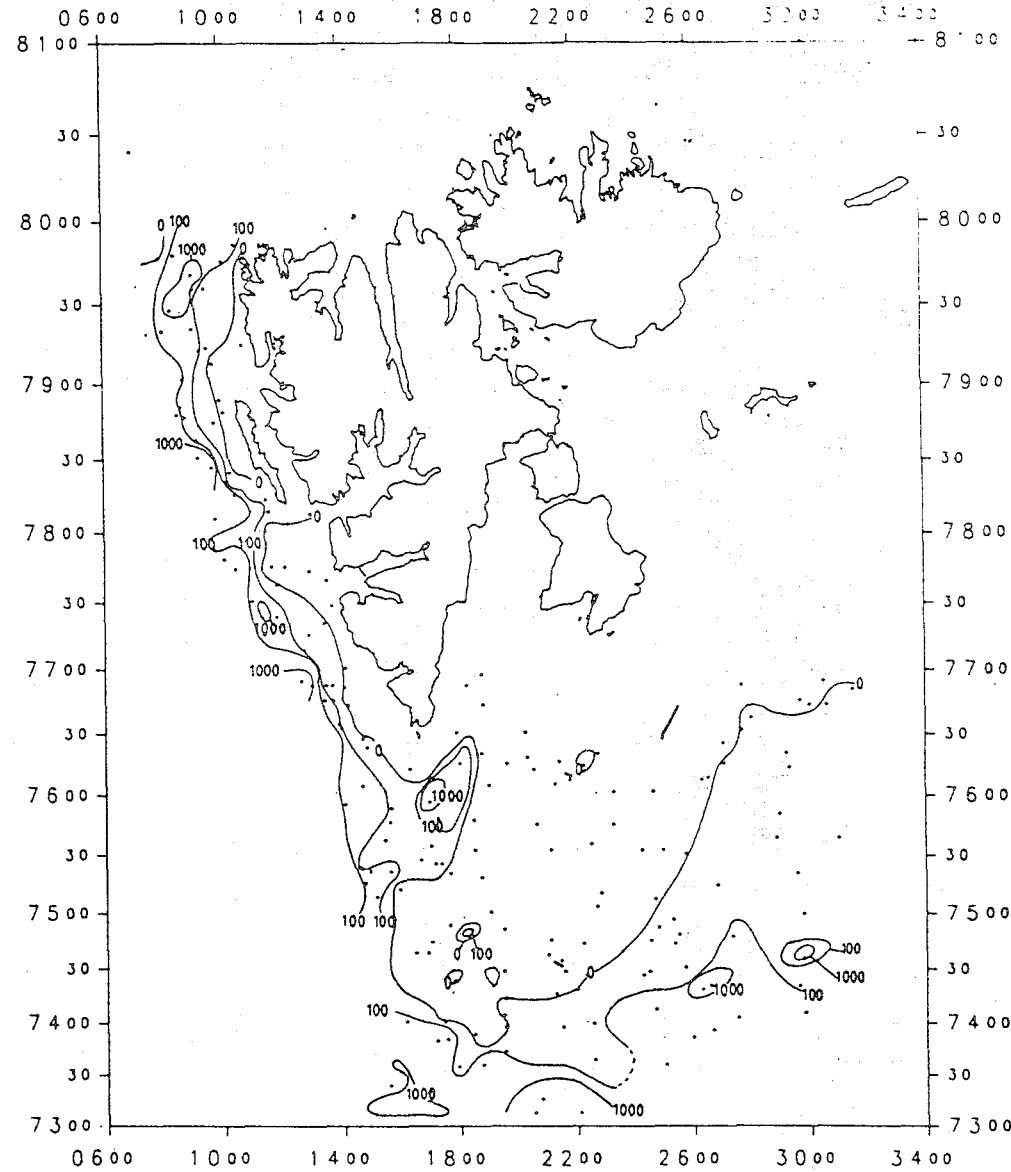


Fig. 3.9. Distribution of *Sebastes mentella* in the trawl catches (number per hour trawling).

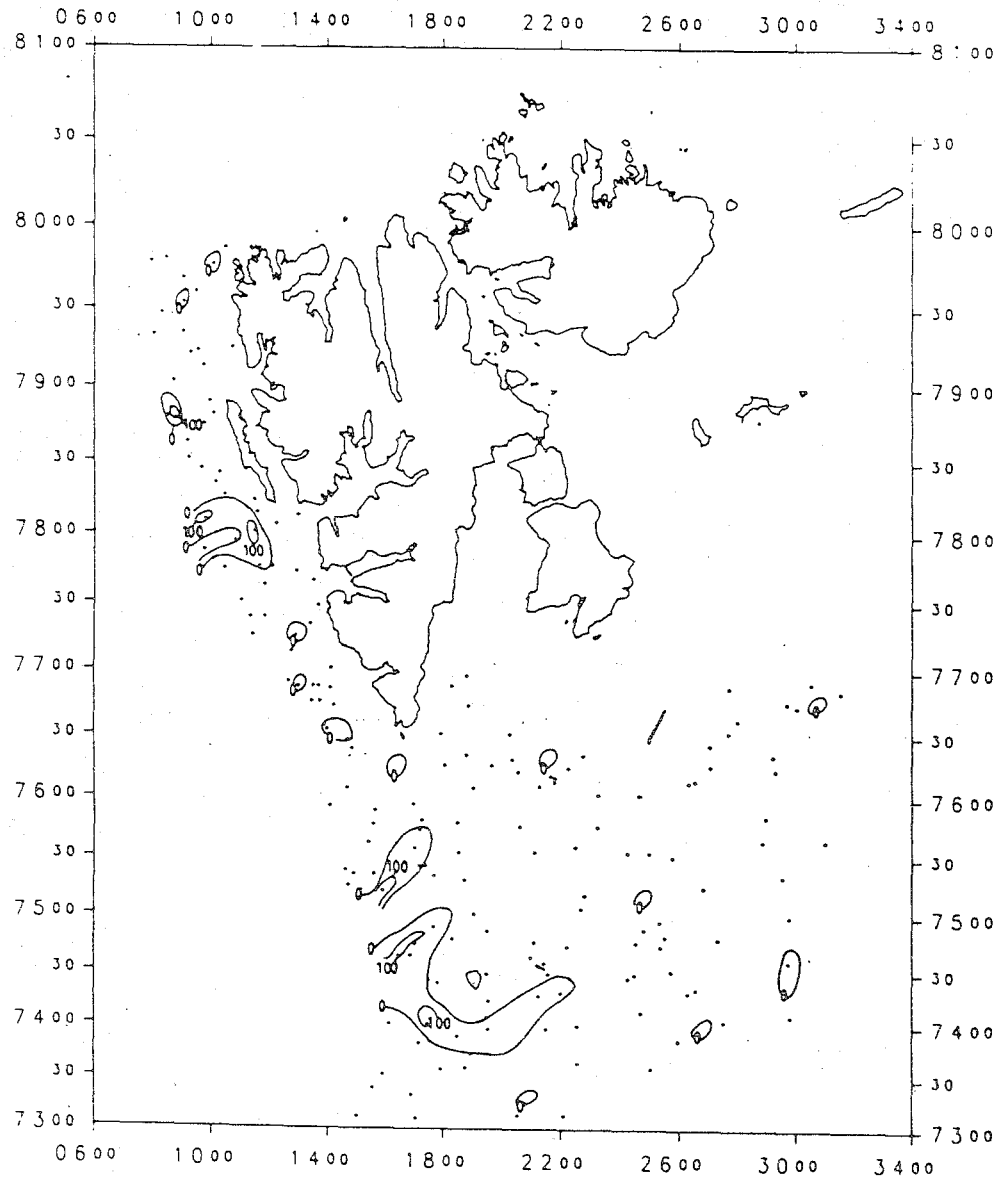


Fig. 3.10. Distribution of Sebastes marinus in the trawl catches (number per hour trawling).

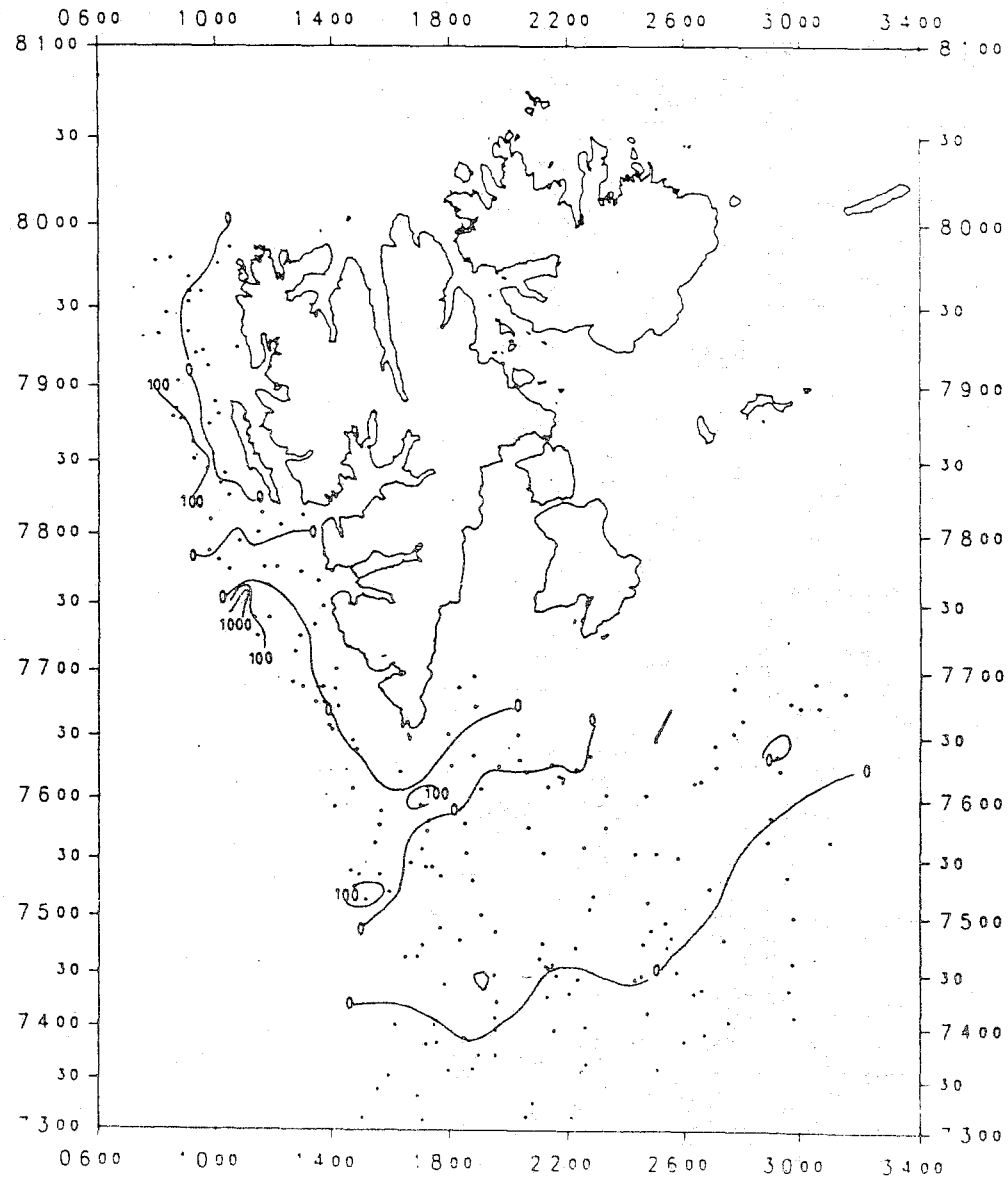


Fig. 3.11. Distribution of Greenland halibut in the trawl catches (number per hour trawling).

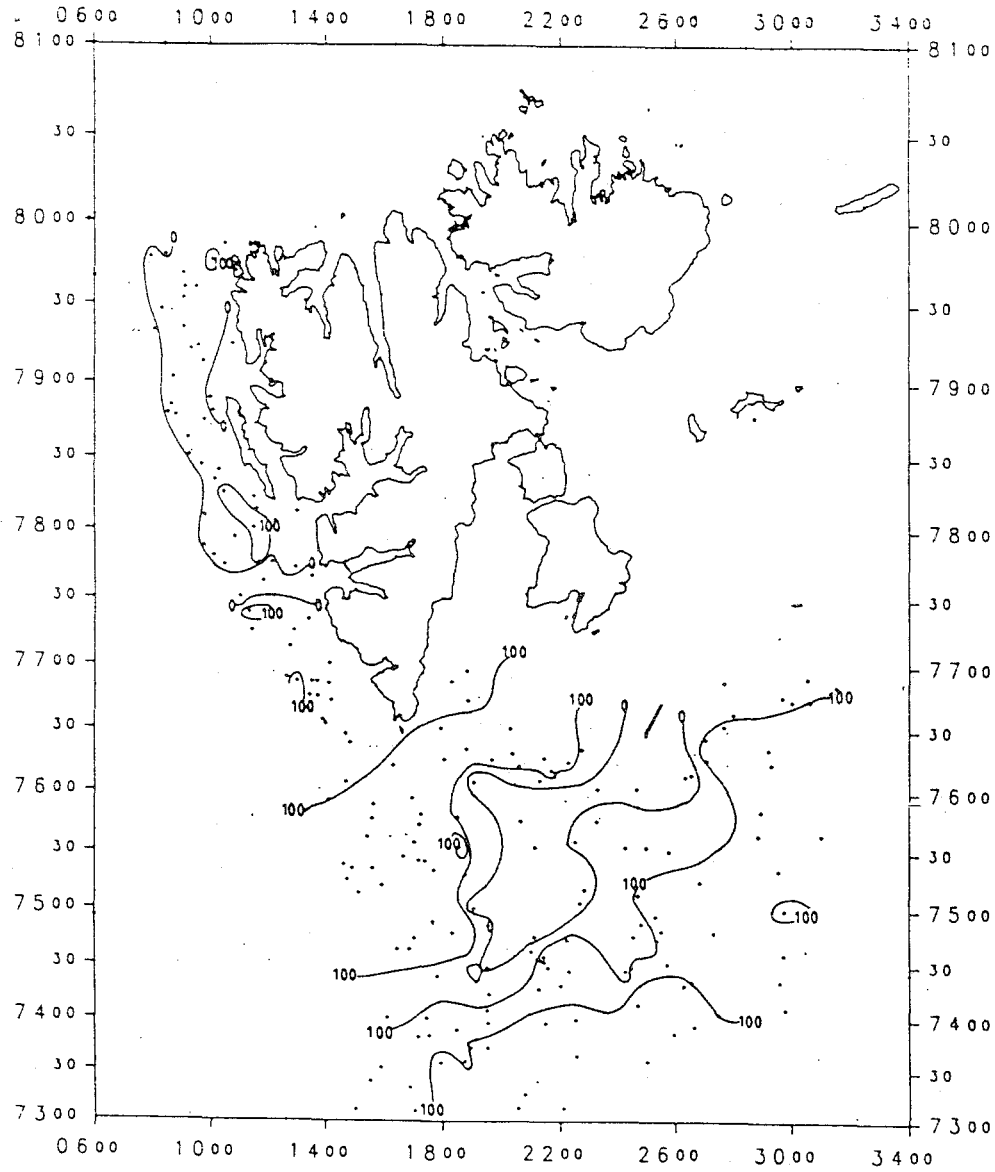


Fig. 3.12. Distribution of long rough dab in the trawl catches (number per hour trawling).

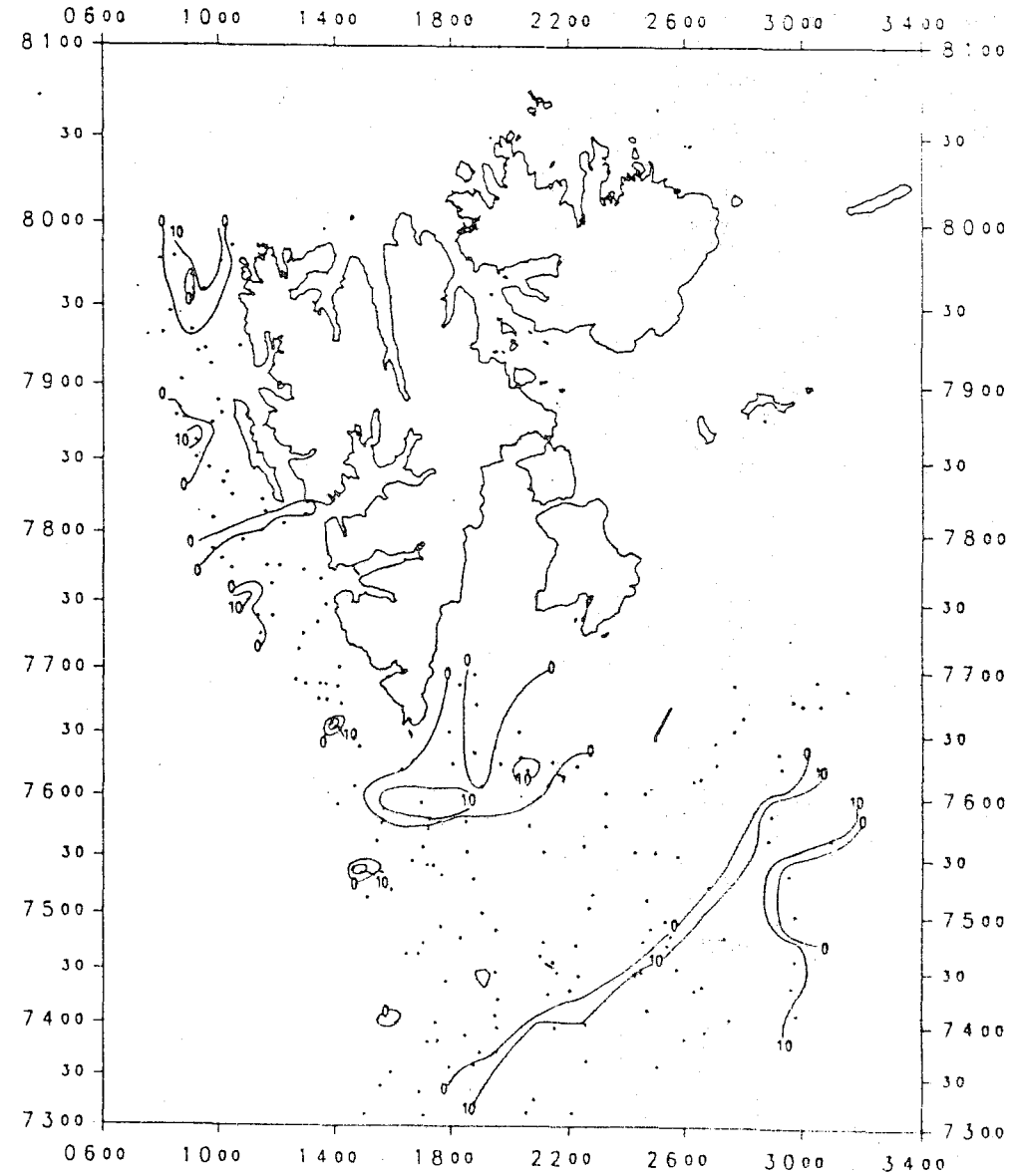


Fig. 3.13. Distribution of shrimps in the trawl catches (kilograms per hour trawling).

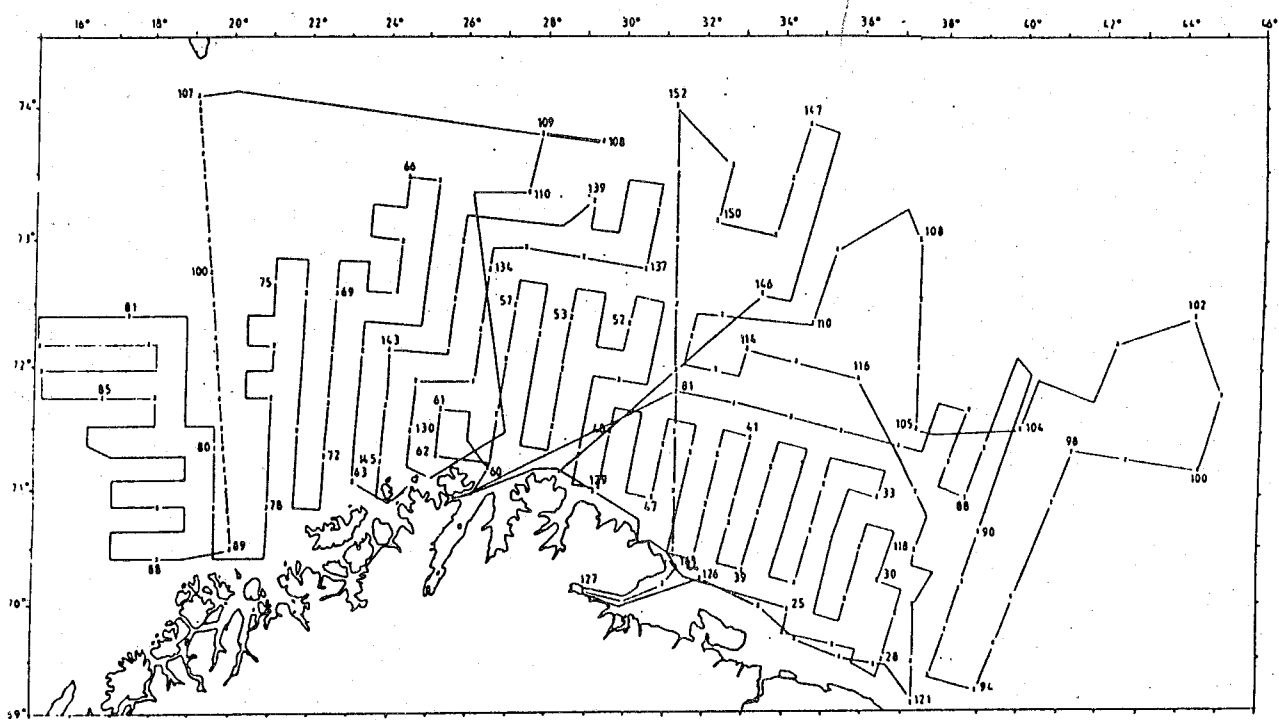


Fig. 4.1. Survey tracks and hydrographical stations R/V "G.O. Sars" 26.1 - 23.2 and R/V "M. Sars" 27.1 - 1.3.

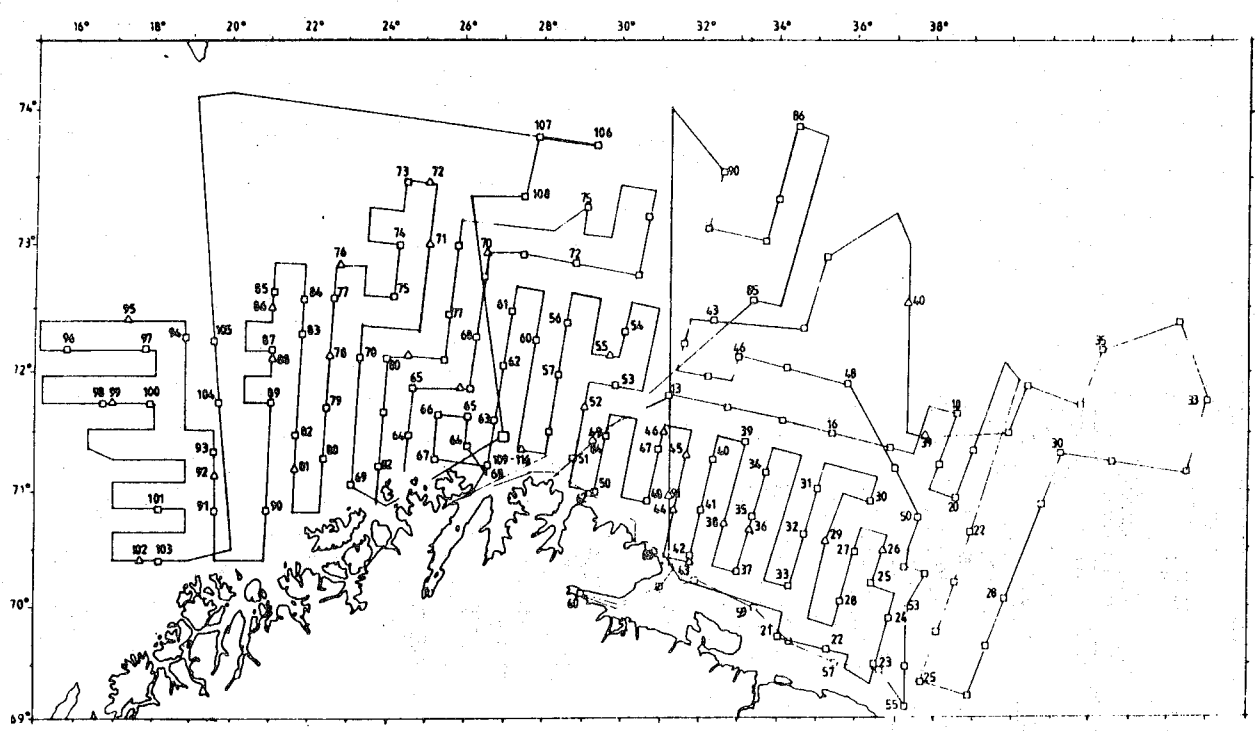


Fig. 4.2. Survey tracks and trawlstations R/V "G.O. Sars" 26.1 - 23.2 and R/V "M. Sars" 27.1 - 1.3.

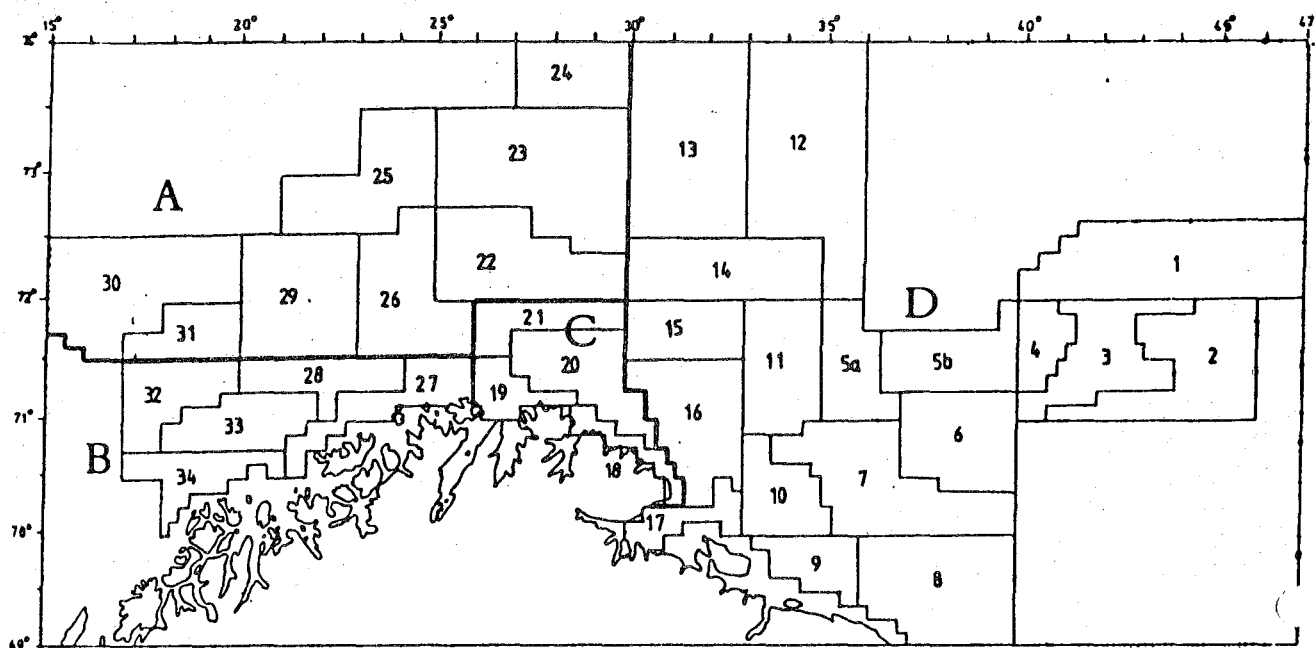


Fig. 4.3. The survey area with subareas (A,B,C,D) and strata used in the bottom trawl survey.

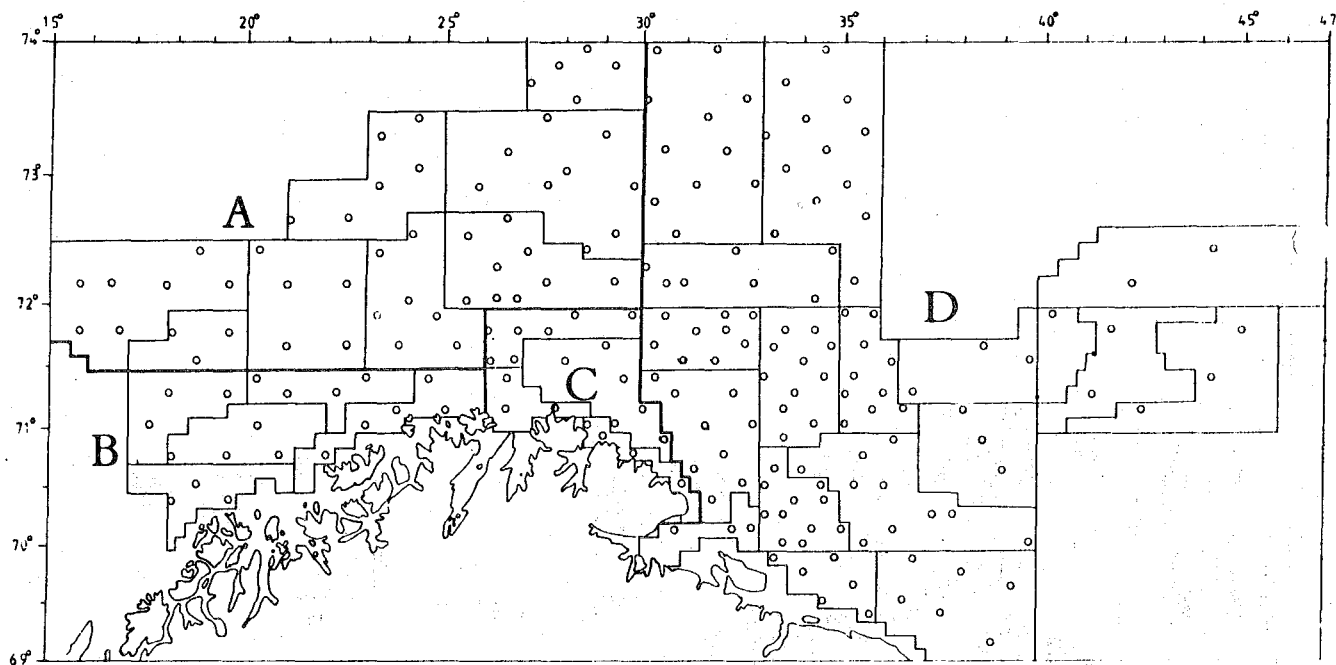


Fig. 4.4. Bottom trawl stations M/T "Masi" 27.1 - 1.3, R/V "G.O. Sars" 26.1 - 23.2 and R/V "M.Sars" 27.1 - 1.3.

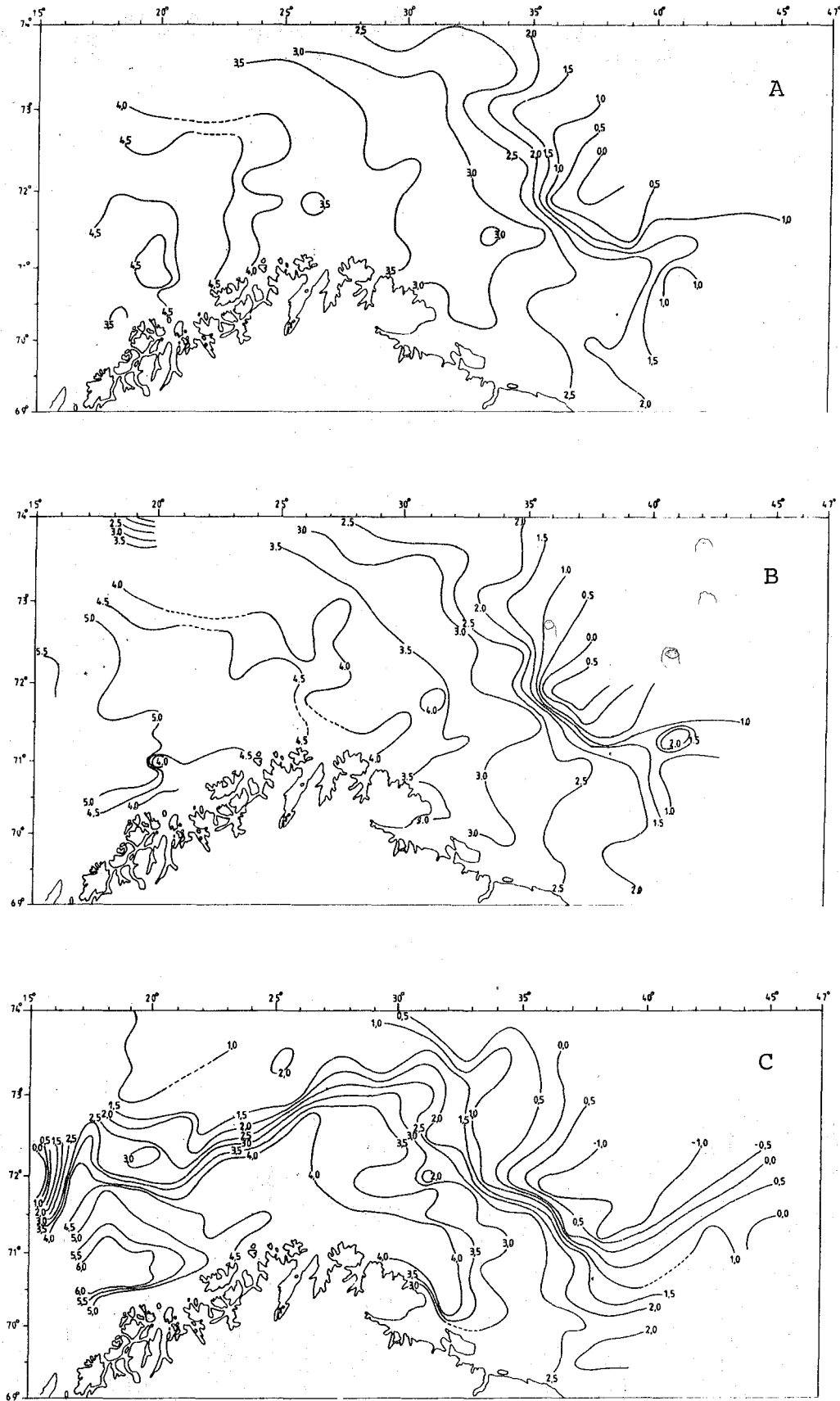


Fig. 4.5. Temperature distribution. A) At the surface, B) at 100 m depth, C) at the bottom. R/V "G.O. Sars" 26.1 - 23.2 and R/V "M. Sars" 27.1 - 1.3.

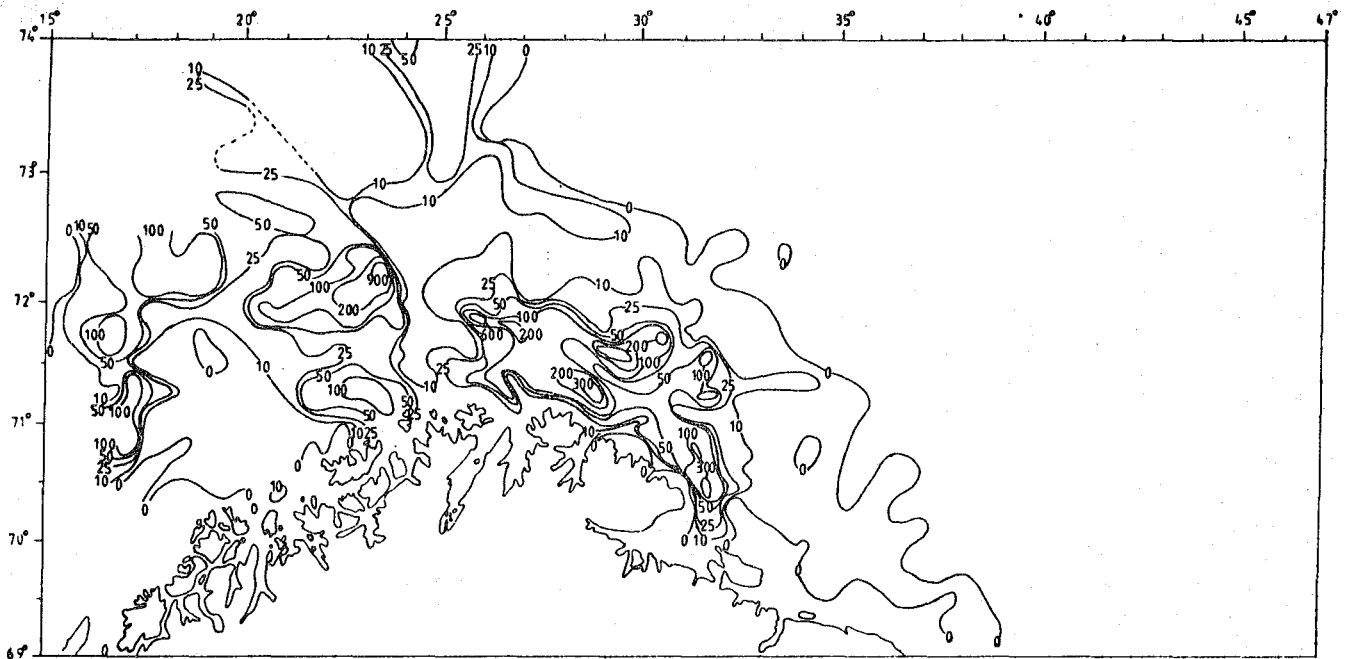


Fig. 4.6. Distribution of total echo abundance, cod and haddock. Units are integrated back scattering surface pr. square nautical mile. (m/naut. mile)².

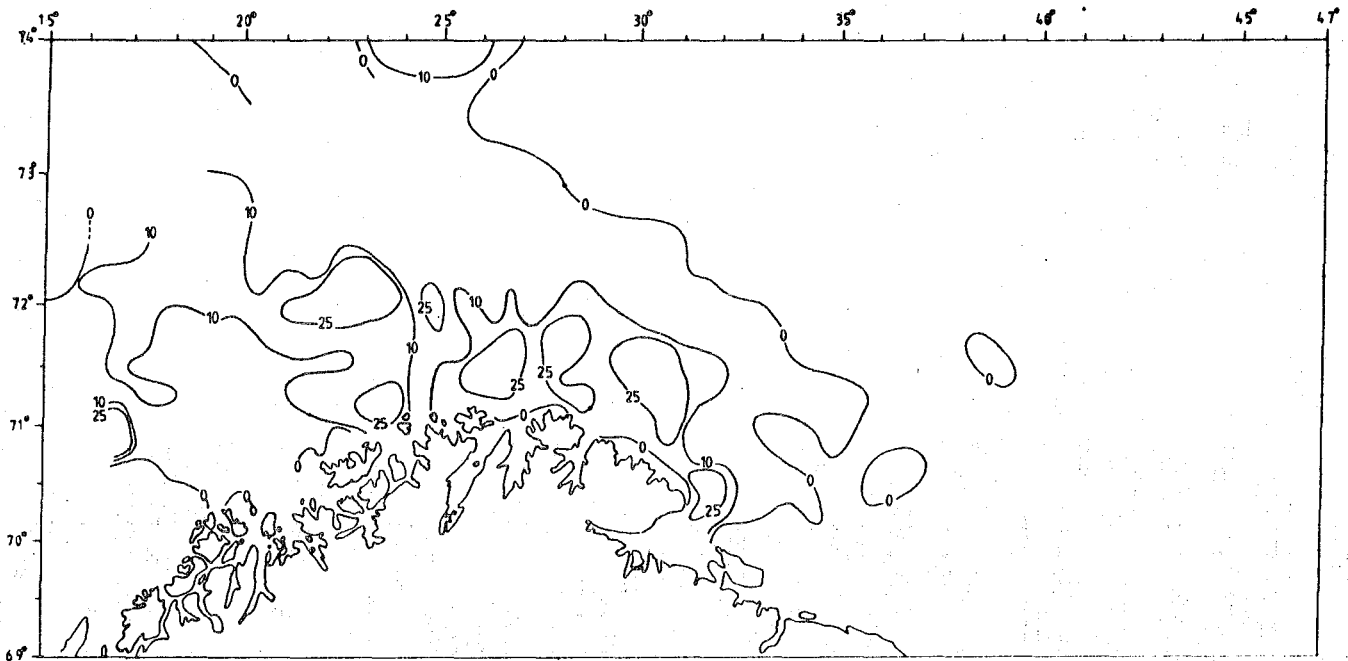


Fig. 4.7. Distribution of echo abundance in the 10 m depth layer above the bottom. Cod and haddock combined.

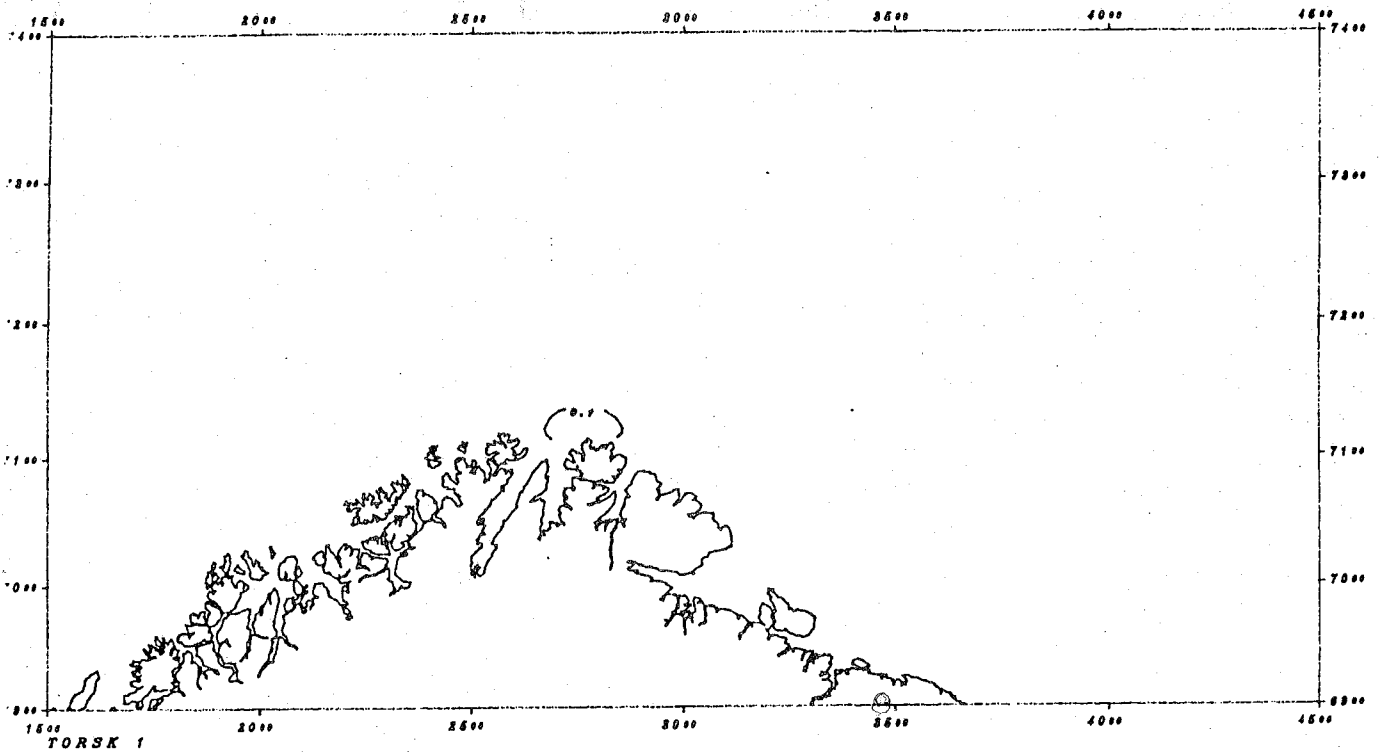


Fig. 4.8. The distribution of 1-year old cod (number of fish in 1000 per square nautical mile).

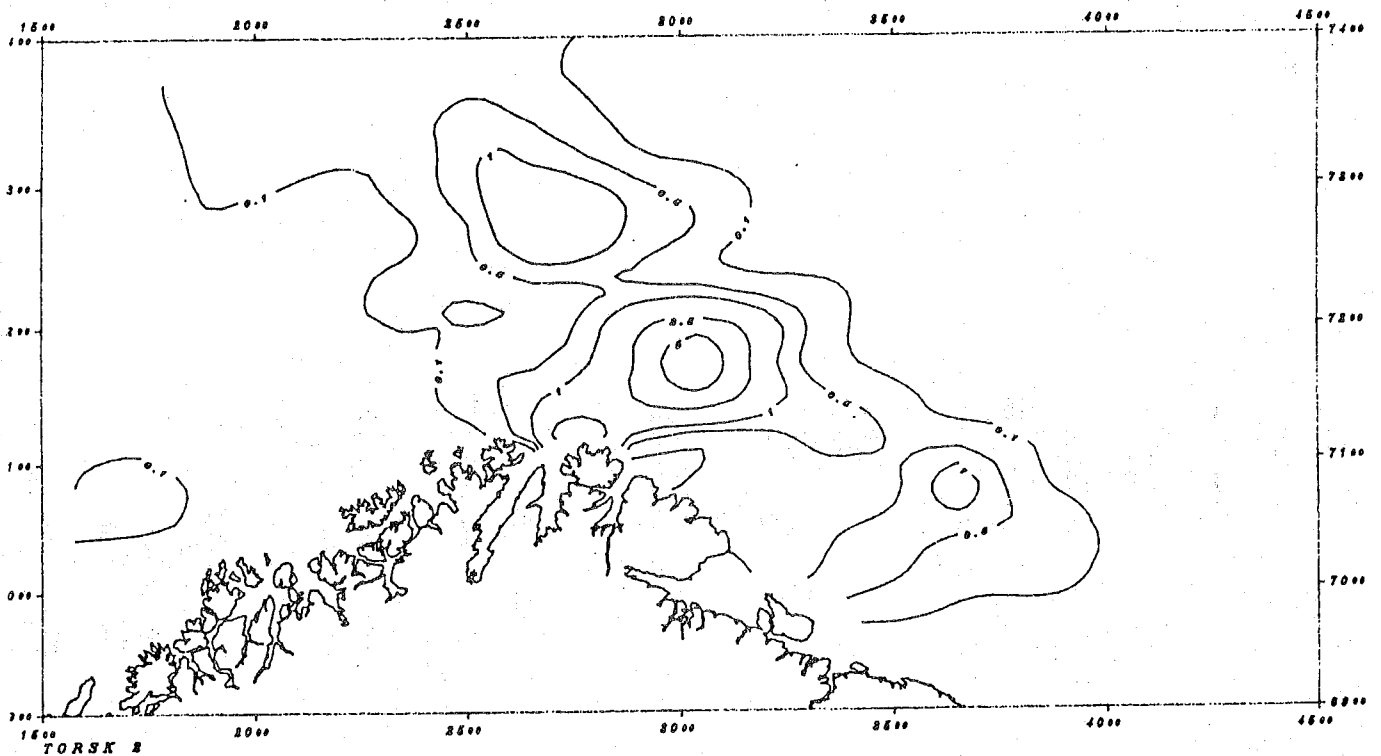


Fig. 4.9. The distribution of 2-year old cod.

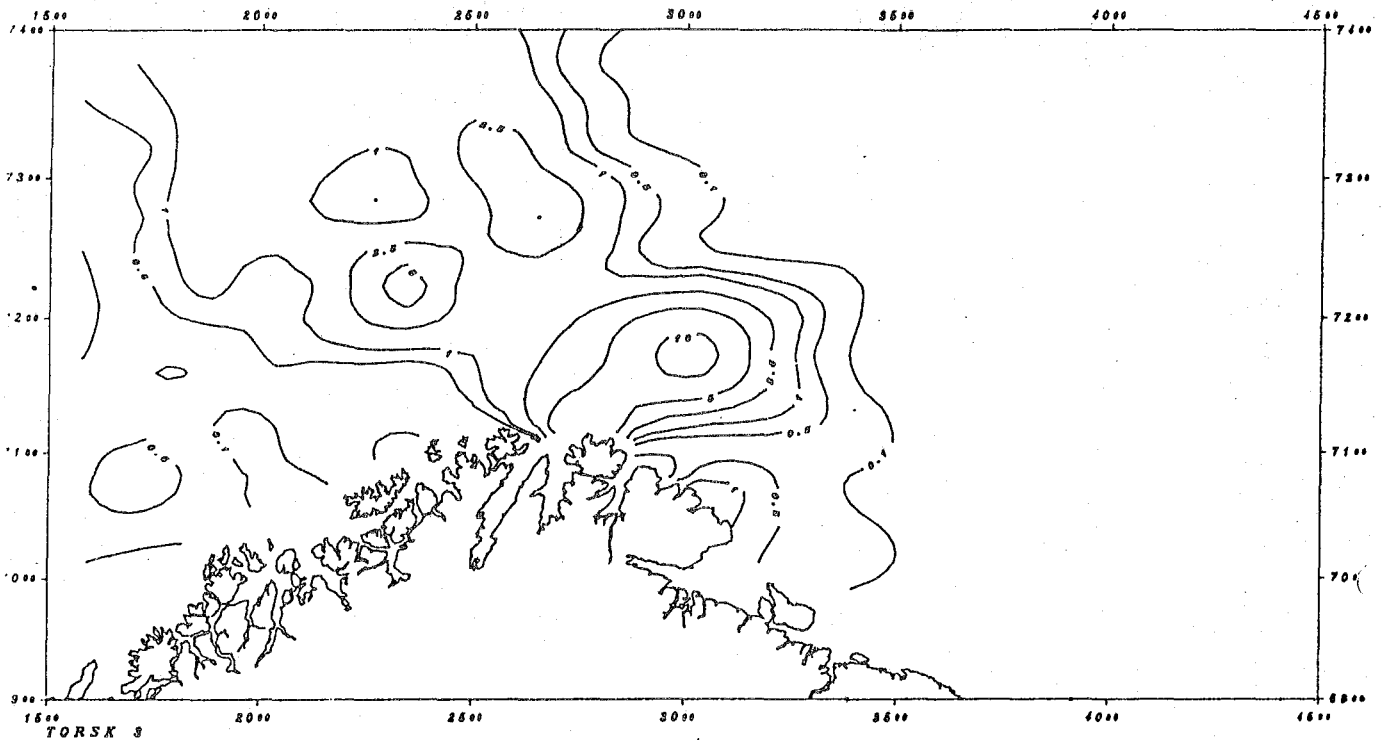


Fig. 4.10. The distribution of 3-year old cod.

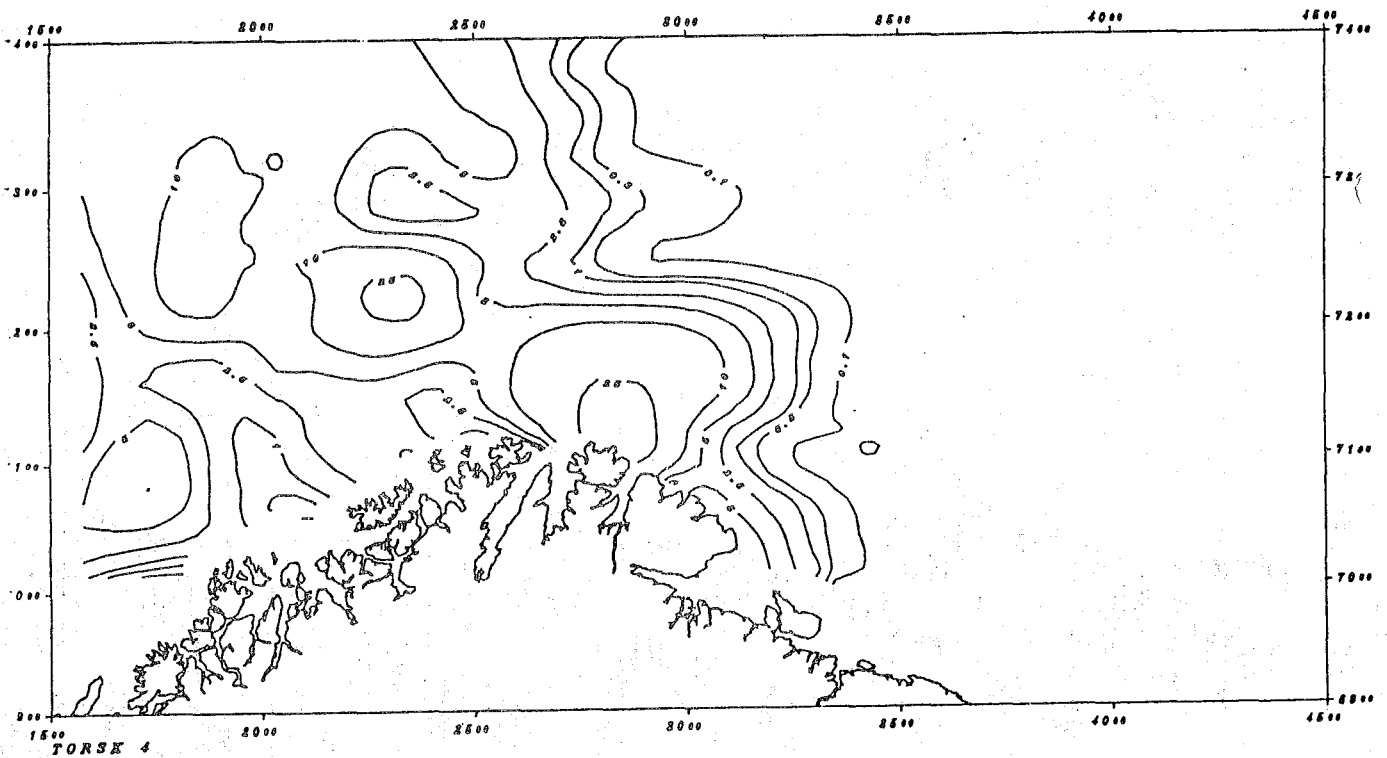


Fig. 4.11. The distribution of 4-year old cod.

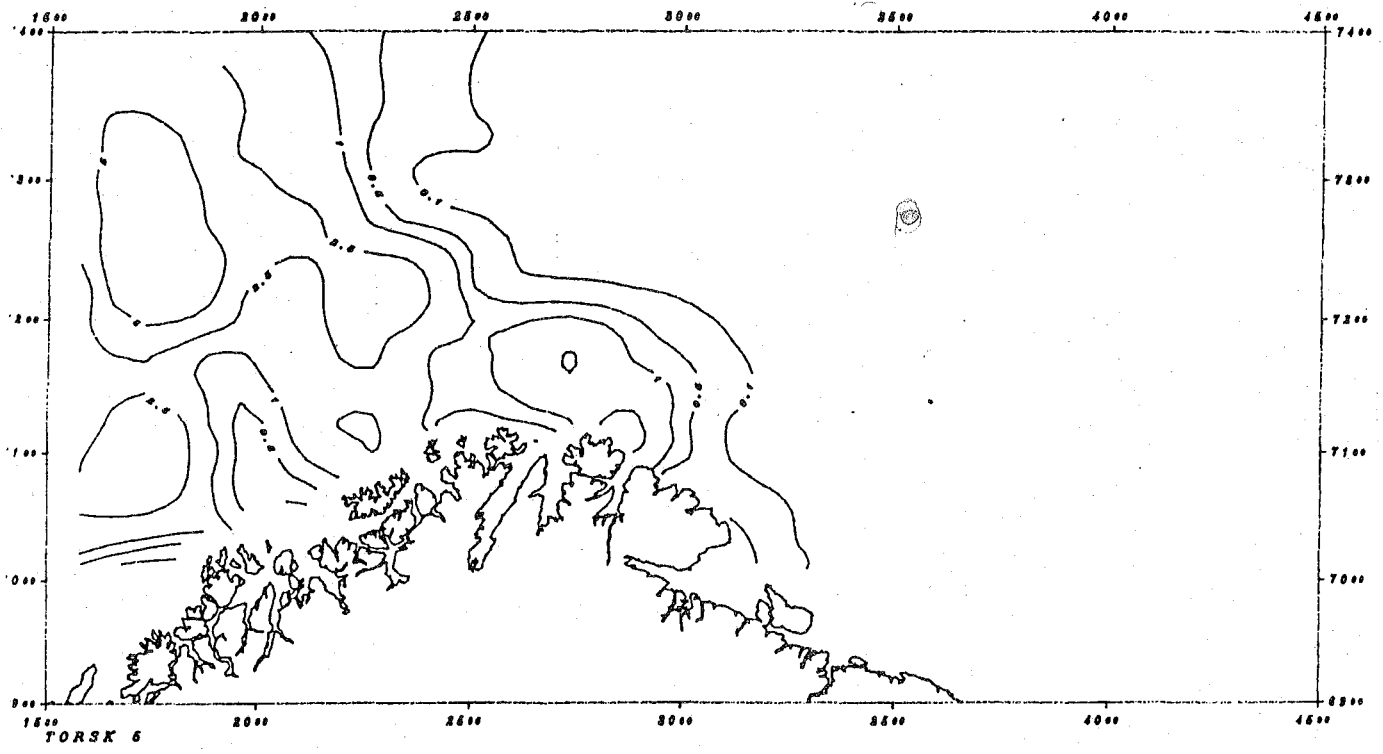


Fig. 4.12. The distribution of 5-year old cod.

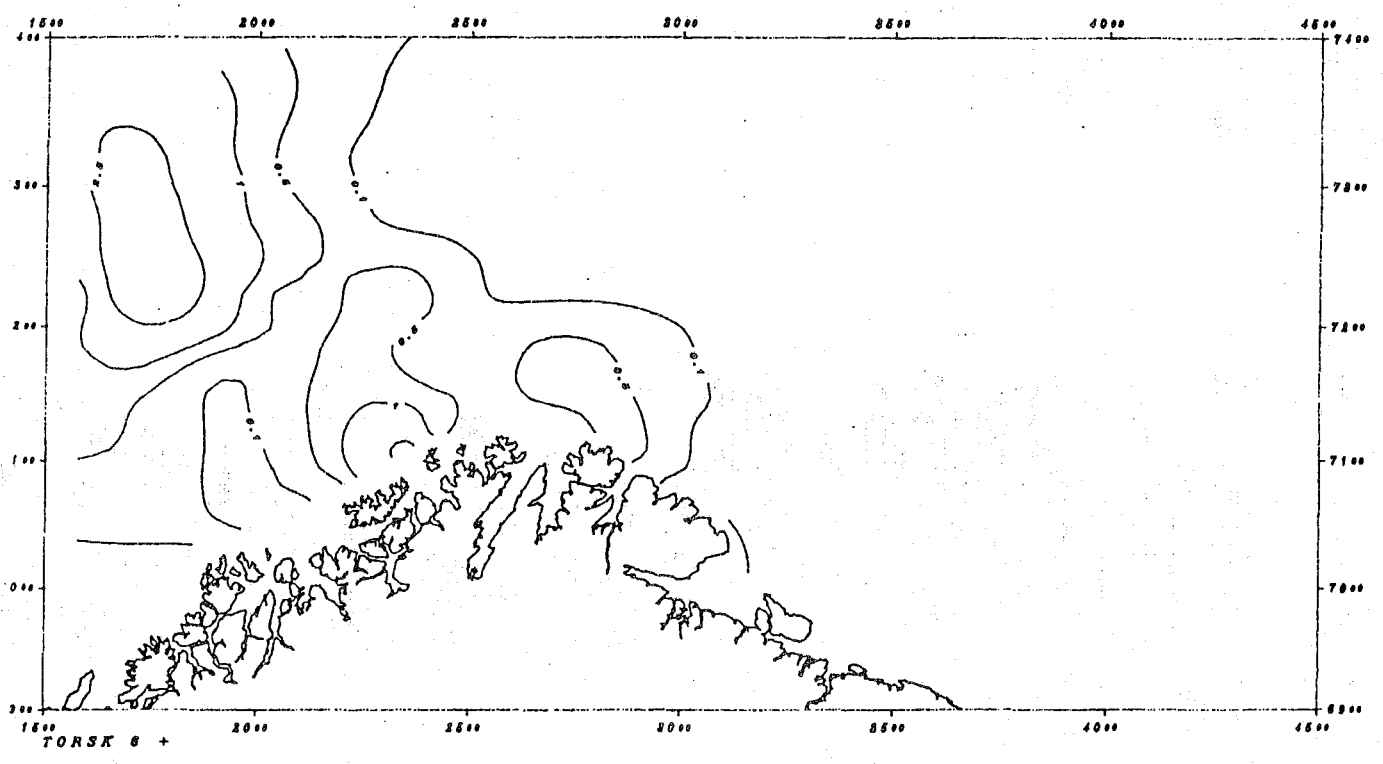


Fig. 4.13. The distribution of 6-10 year old cod.

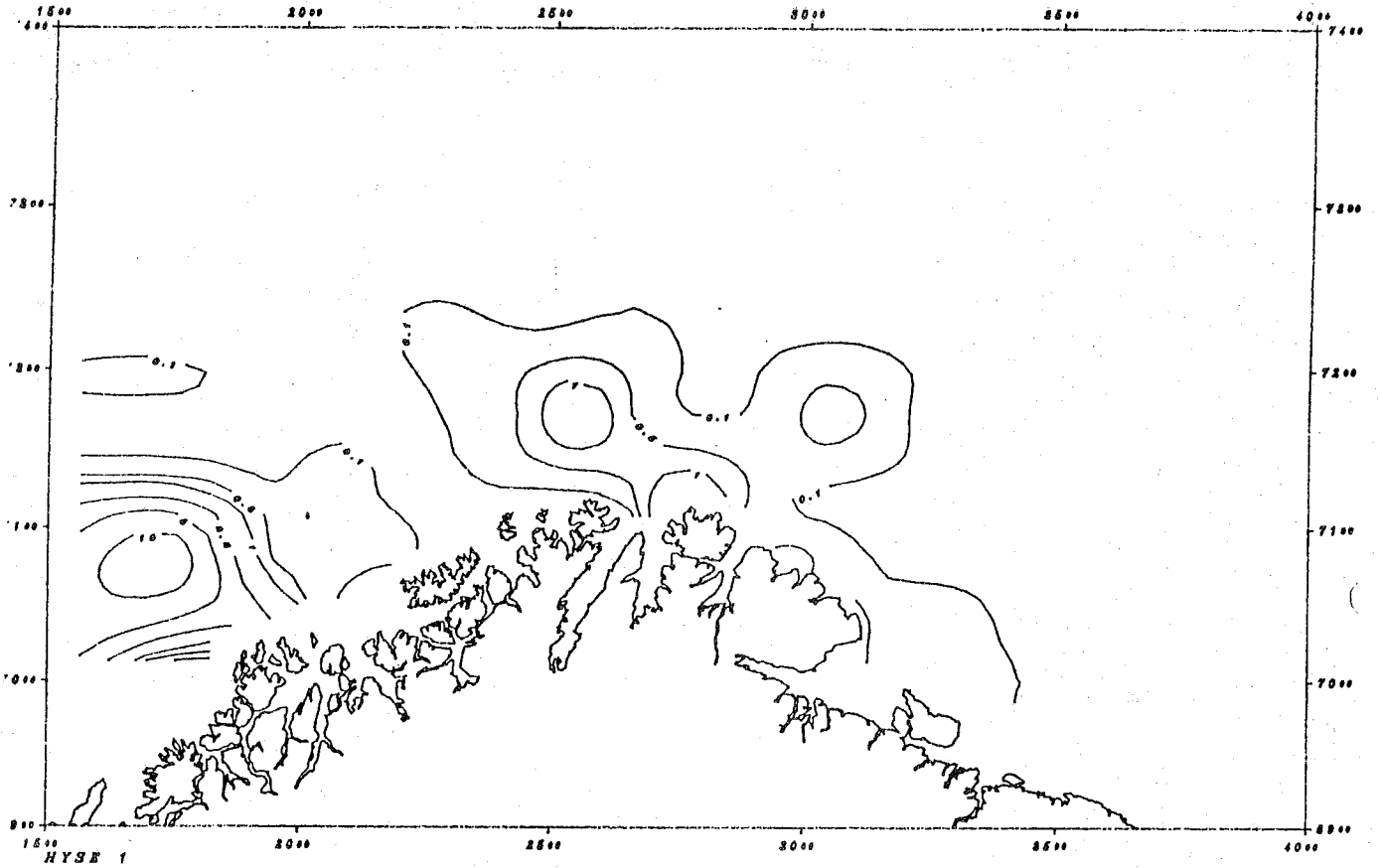


Fig. 4.14. The distribution of 1-year old haddock. (Units as in fig. 11).

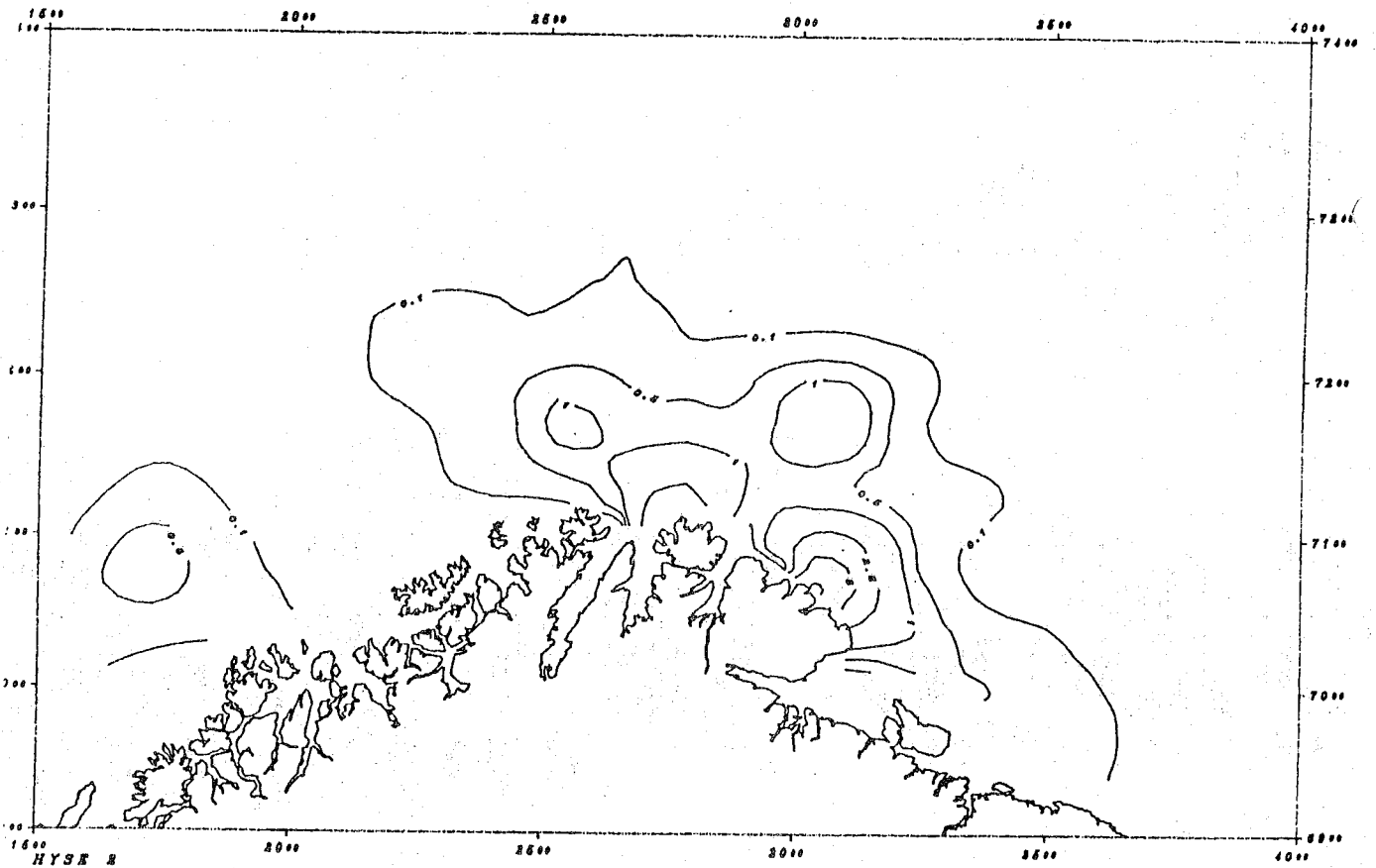


Fig. 4.15. The distribution of 2-year old haddock.

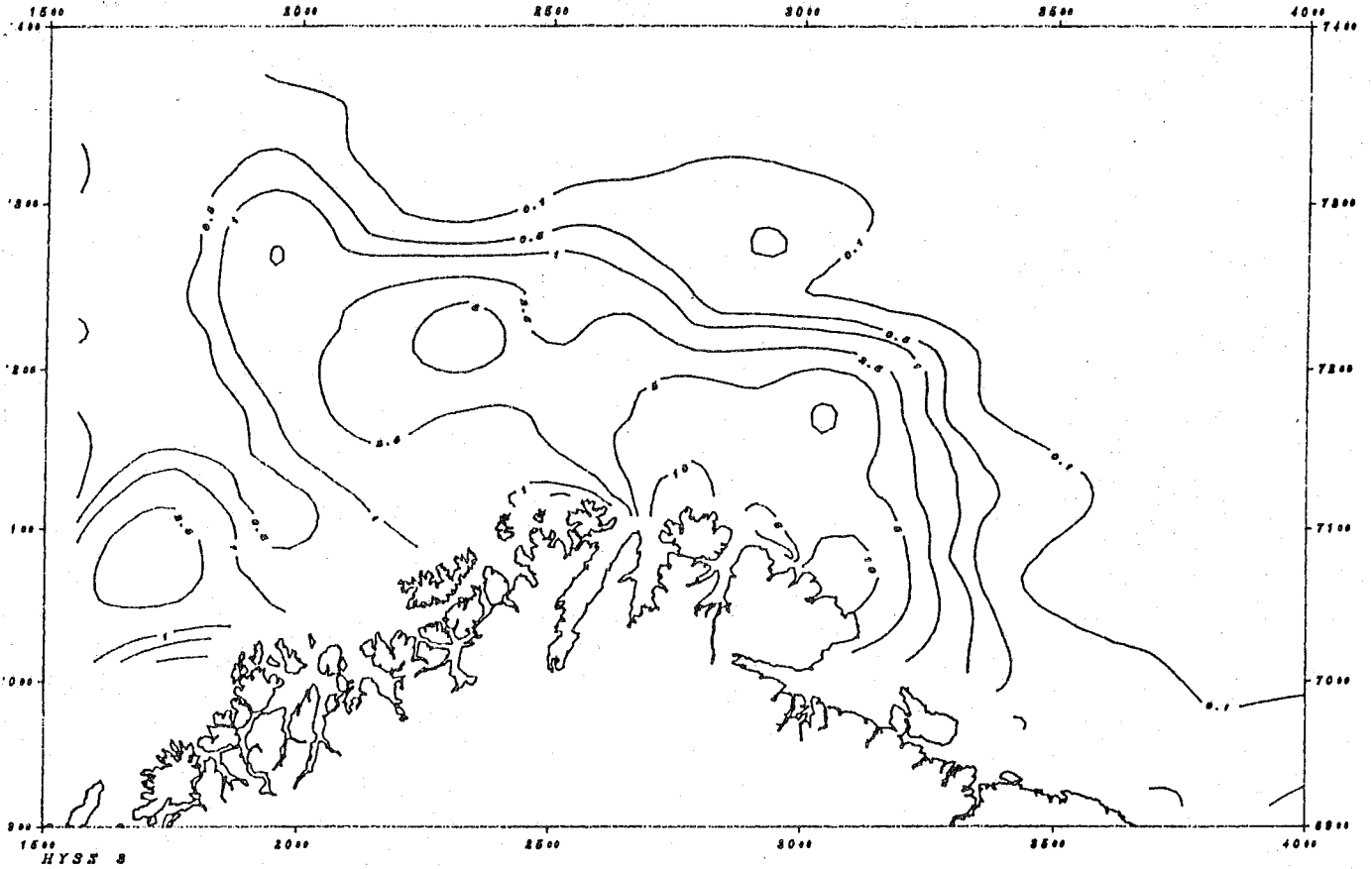


Fig. 4.16. The distribution of 3-year old haddock.

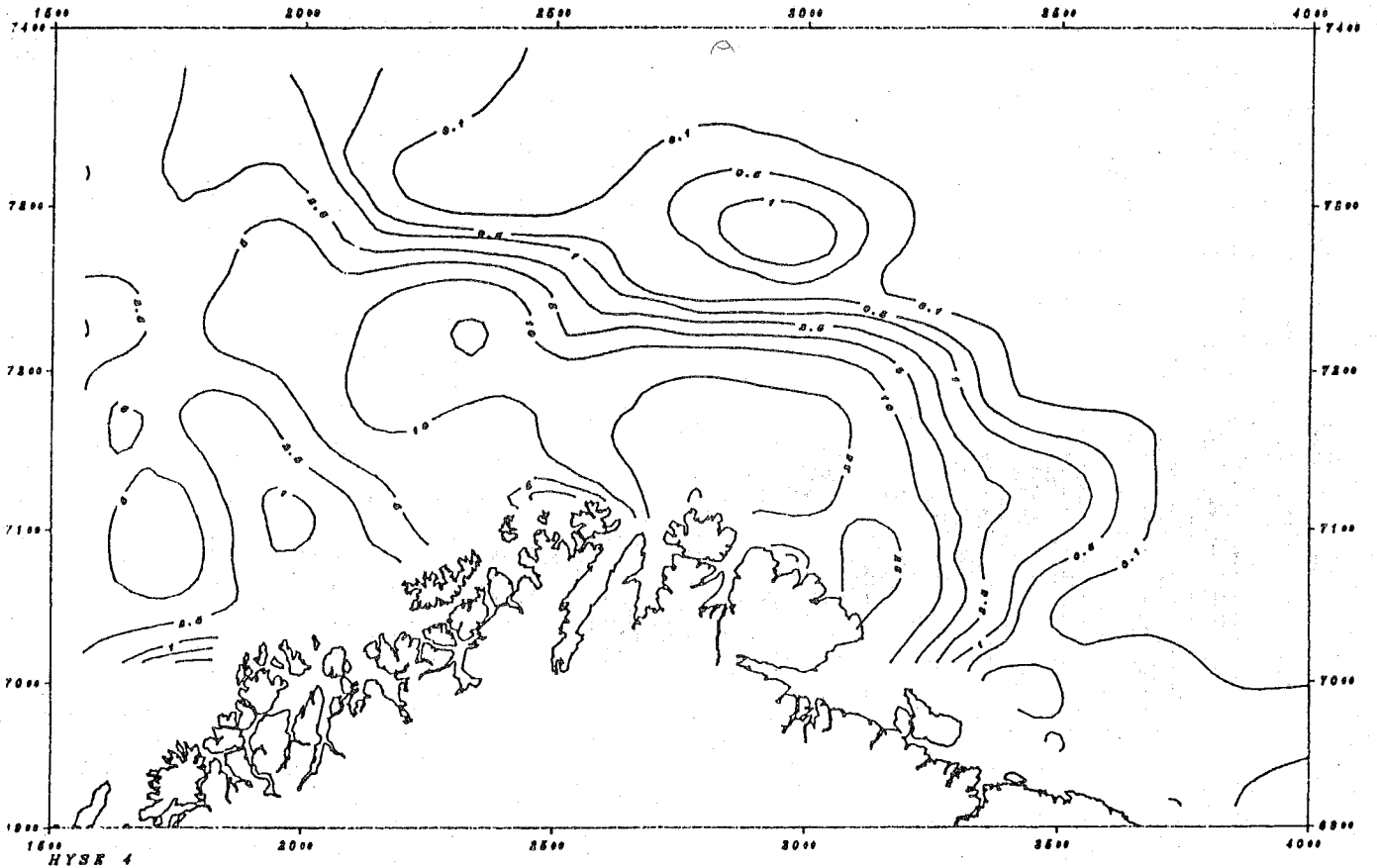


Fig. 4.17. The distribution of 4-year old haddock.

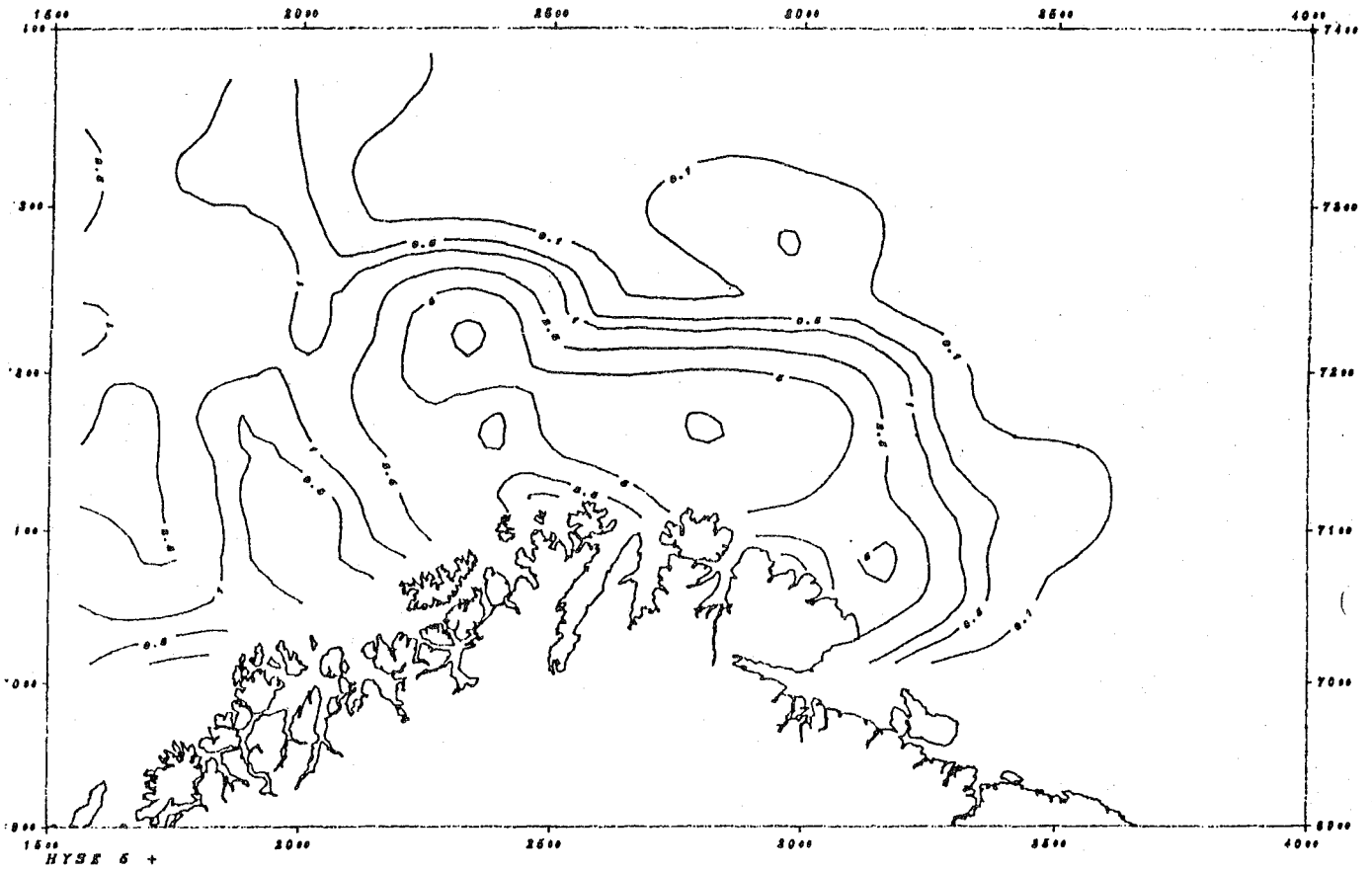


Fig. 4.18. The distribution of 5-10 year old haddock.

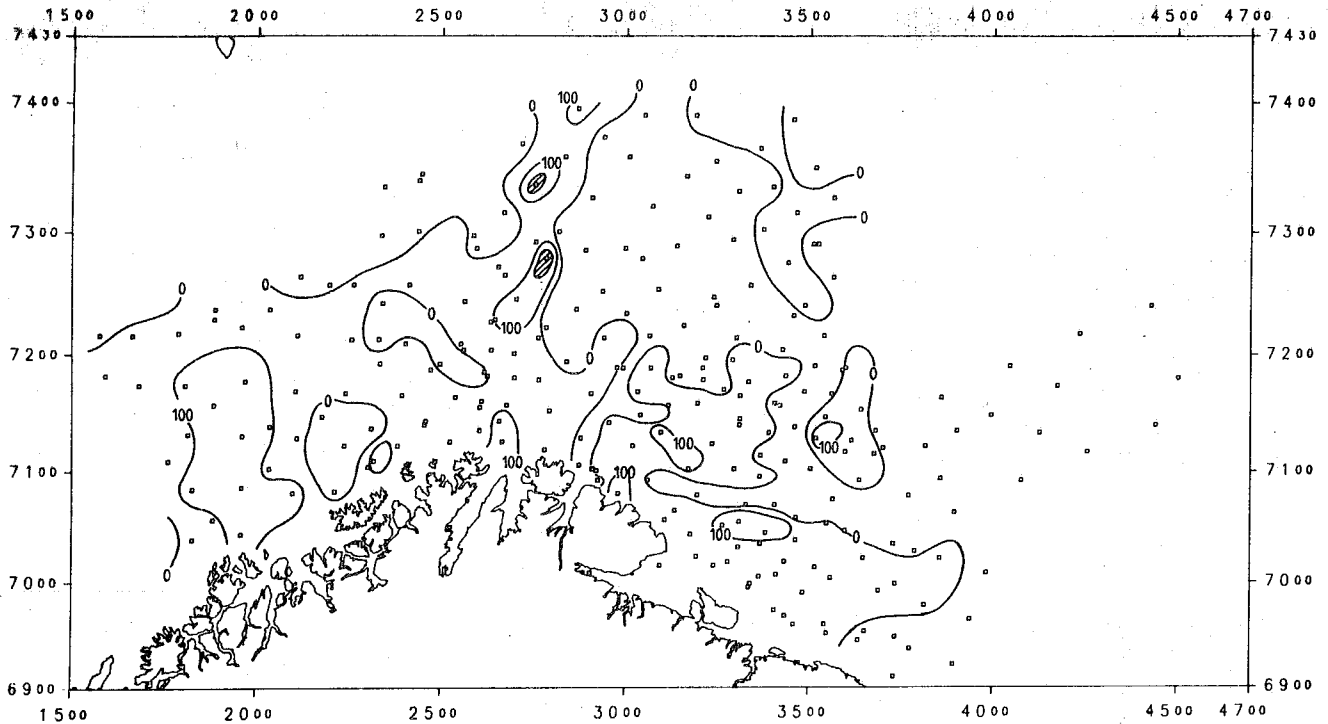


Fig. 4.19. Distribution of Sebastes marinus in the trawl catches in the Barents Sea winter 1987 (number per hour trawling). Areas with catches above 1000 specimens have been hatched.

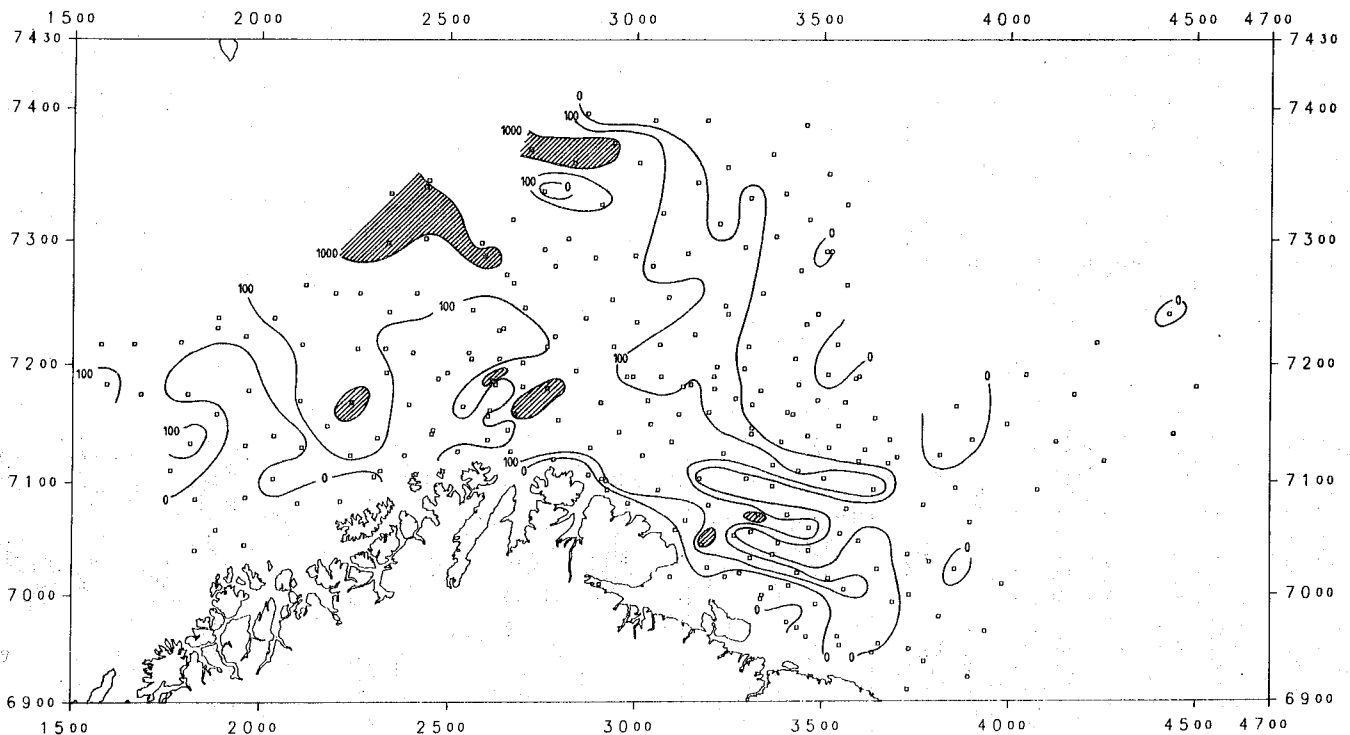


Fig. 4.20. Distribution of Sebastes mentella in the trawl catches in the Barents Sea winter 1987 (number per hour trawling). Areas with catches above 1000 specimens have been hatched.

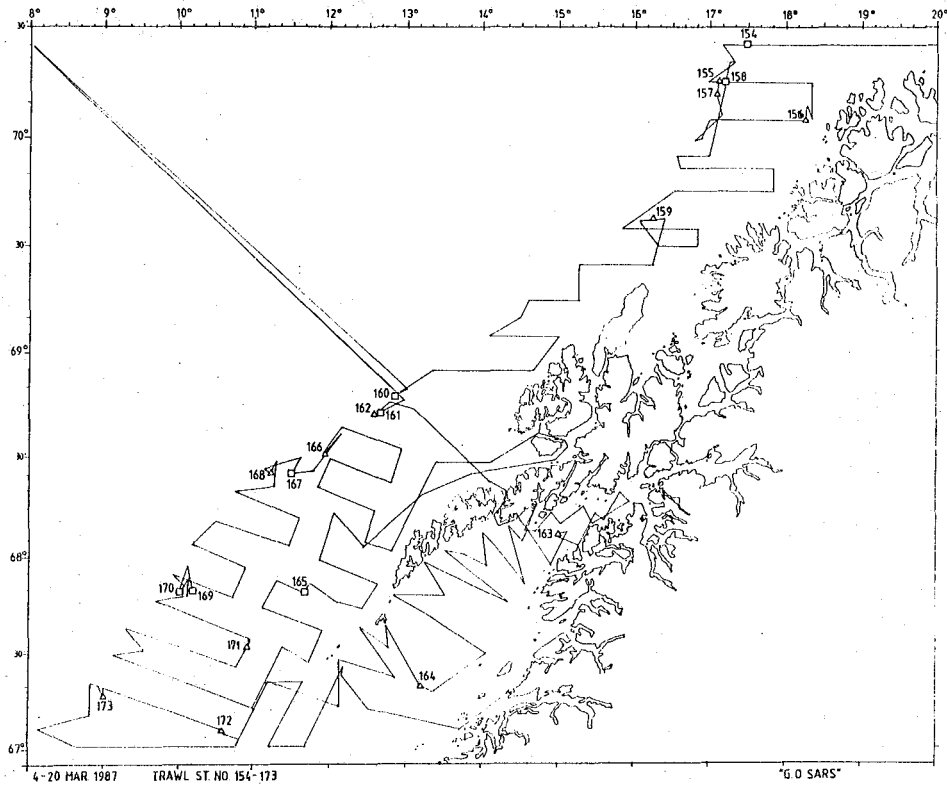


Figure 5.1 Map showing the survey tracks. Also showing the positions of trawl stations and the type of station. Squares are bottom trawl and triangles are pelagic trawl.

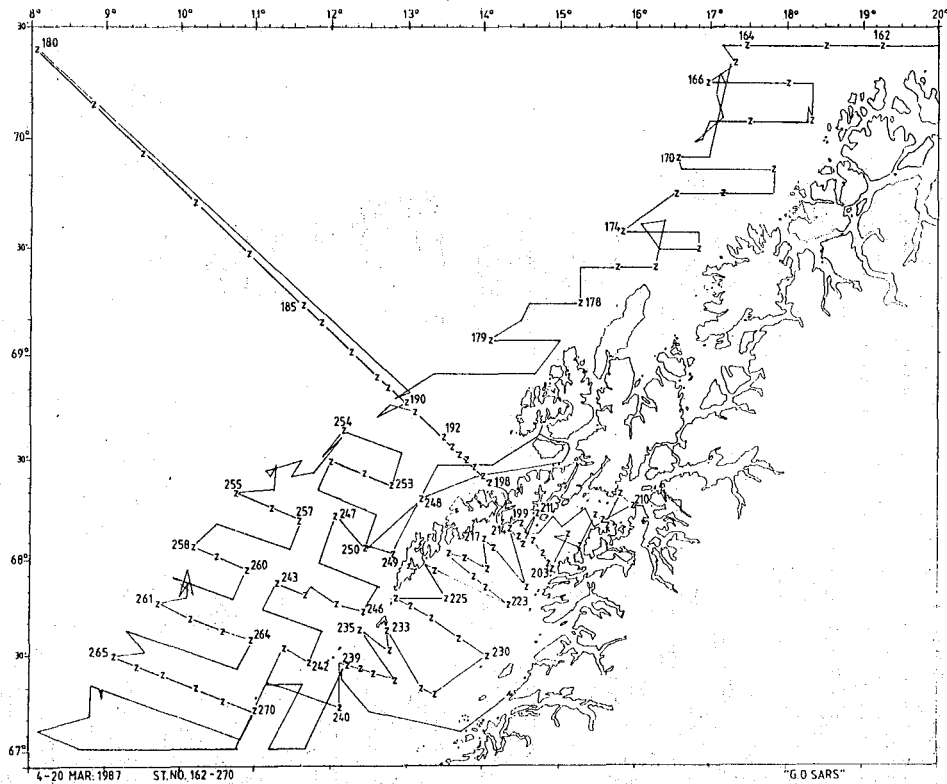


Figure 5.2 Map showing the hydrographical stations along the survey tracks. Z are CTD-sonde stations.

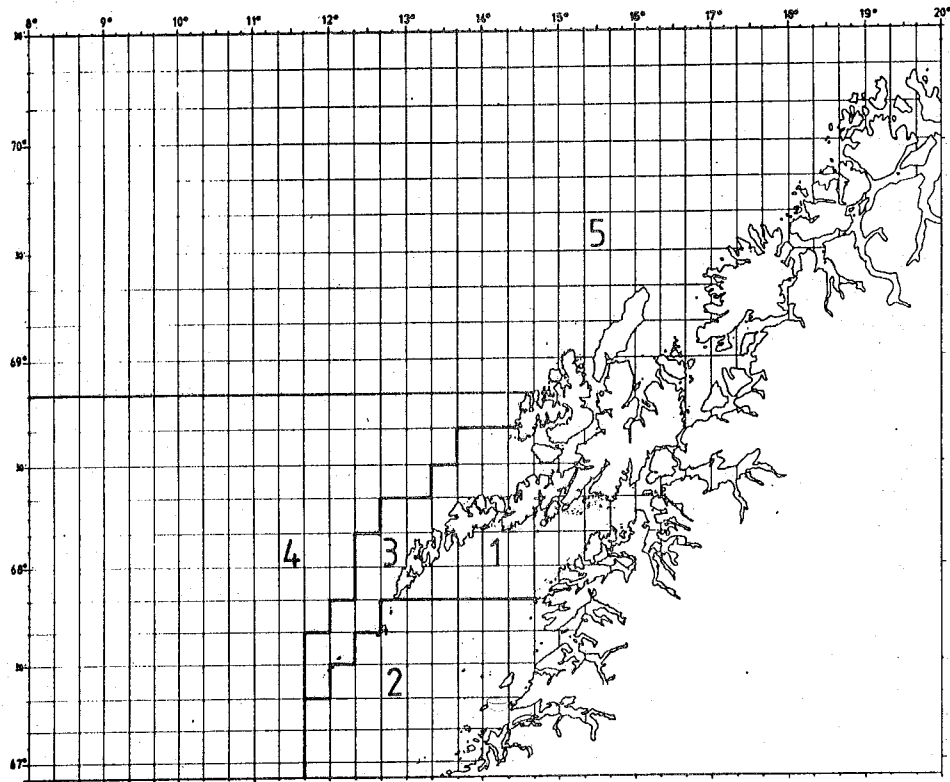


Figure 5.3 Map showing the area of investigation with squares for averaging the echo abundance and the sub areas used in the tables.

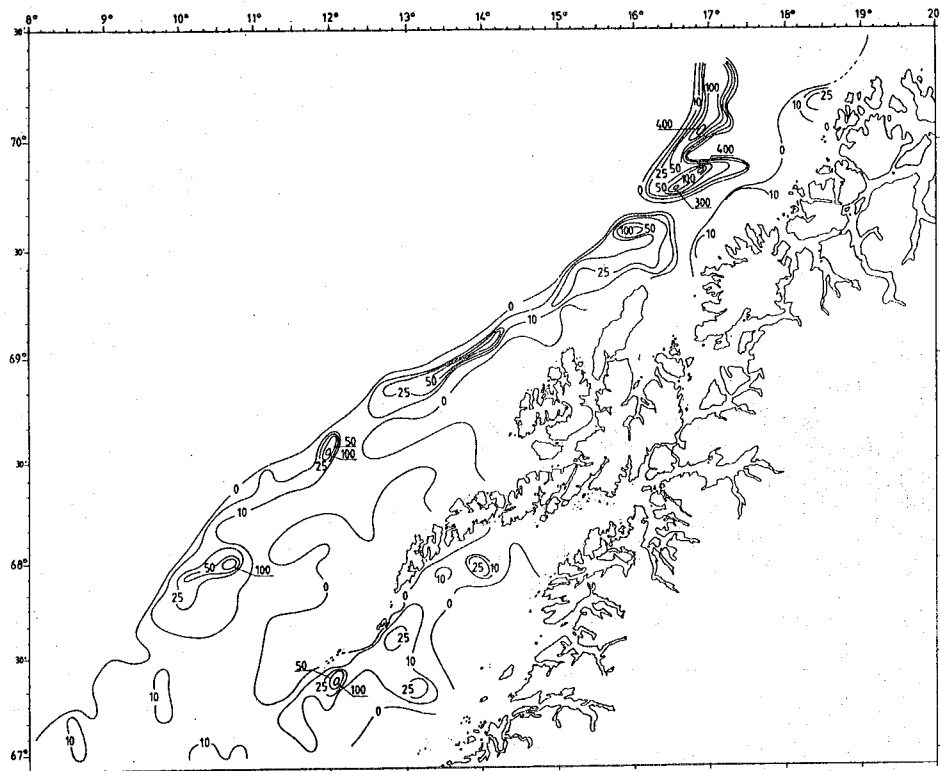


Figure 5.4 Map showing the distribution of echo abundance of cod and haddock. The values are sound reflecting surface per sea surface (m^2/nm^2).