International Council for the Exploration of the Sea

C.M.1988 / G:43
Demersal Fish Committee

ESTIMATES OF STOCK SIZE OF NORTHEAST ARCTIC COD AND HADDOCK, SEBASTES MENTELLA AND SEBASTES MARINUS FROM SURVEY DATA, WINTER 1988

by

Arvid Hylen, Jan Arge Jacobsen, Tore Jakobsen, Sigbjørn Mehl, Kjell Nedreaas and Knut Sunnanå

Institute of Marine Research
P.O.Box 1870 - Nordnes
5024 Bergen, Norway

ABSTRACT

An acoustic survey and a bottom trawl survey for cod and haddock were carried out in the Barents Sea during the winter 1988.

The fish still had the westerly distribution established in the previous year, but the echo abundance was substantially lower for both cod and haddock. The results of the surveys confirm the declining trend in recruitment.

Abundance indices for redfish indicate that the stock situation is stabilizing for Sebastes mentella, but give cause for great concern for the Sebastes marinus stock.

An acoustic survey on the spawning grounds of cod in the Lofoten-Vesterålen area was carried out after the Barents Sea survey. The estimate of mature cod was only 37% of the 1987 estimate.

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 and the results are used in the stock assessment (Anon. 1988). In recent years attempts to estimate the number of redfish have also been made, primarily the species Sebastes marinus and S. mentella.

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), Hylen et al. (1985, 1986) and Godø et al. (1987).

After the Barents Sea survey, from 1982 onwards, an acoustic survey on spawning cod has been carried out, mainly in the Lofoten-Vesterålen area (Godø et al. 1982, 1983, 1984, 1985, 1987, Raknes and Sunnanå 1986).

The present paper reports on the results of the surveys in the winter 1988.

2. MATERIAL AND METHODS

The Barents Sea surveys in 1988 were mainly carried out in the period 26 January to 8 March using the two research vessels "G.O.Sars" and "Michael Sars" and the hired commercial trawler "T.O.Senior". However, some of the northern and eastern parts of the survey area were covered by "G.O.Sars" in connection with hydrographical investigations 10-24 January. The three vessels were equally equipped for bottom trawling, using a 1600 mesh shrimp trawl with rubber gear. Only the research vessels were equipped with midwater trawls.

Figs 3.1 and 3.2 show the survey grid, the 303 hydrographical stations and the 188 trawl stations worked by the research

vessels. The trawl stations include 27 taken with midwater trawl. Stations included in the bottom trawl survey were stratified on the areas shown on Fig. 3.3. Of the 192 stations, which are shown on Fig. 3.4., 111 were taken by the trawler. These stations were also included in the final calculations of the acoustic survey together with the additional trawl hauls taken by the two research vessels.

The survey for mature cod on the spawning grounds off northern Norway (mainly the Lofoten-Vesterålen area) was conducted in the period 1-21 March 1988. This is an acoustic survey where relatively few trawl stations are taken because of difficult bottom conditions and to avoid damage on commercial fishing gear in the area. The area was first covered by R/V "Michael Sars" 1-8 March. The survey grid and the 24 trawl stations (7 midwater hauls) are shown on Fig. 4.1. R/V "G.O.Sars" covered the area 8-21 March and the survey grid, the trawl stations, and the 101 hydrographical stations are shown on Fig. 4.2. One of the 10 trawl hauls (St. no. 172) was aborted, which left 5 bottom and 4 midwater hauls for the calculations.

2.1. The Acoustic Surveys

The acoustic surveys were carried out as in 1987, using the method described by Dalen et al. (1982) and Dalen and Smedstad (1979, 1983). The acoustic equipment used was:

"G.O.Sars": Simrad EK 400, 38kHz hull mounted 5^0 x 5.5^0 echosounder and towed echosounder.

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

Both 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 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 $C = 2.49 \times 10^6 \times L^{2\ 18}$. 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. For redfish the formula $C = 5.2 \times 10^5 \times L^2$ was used, corresponding to $TS = 20 \log L - 67.87$. This formula is based on preliminary information and may be considerably revised when more evidence becomes available.

The area units used in the acoustic surveys are $1/2^0$ latitude X 1^0 longitude in the Barents Sea survey, and 10' latitude X 20' longitude in the Lofoten-Vesterålen survey. Figs 3.4 and 4.3 shows the total areas and sub-areas (A-D and 1-5) in the two acoustic surveys.

2.2. The Bottom Trawl Survey

Fig. 3.3 shows the survey area with the strata used in the bottom trawl survey, and also the division into the four sub-areas for which the bottom trawl indices are given (which are identical to the four sub-areas used in the acoustic survey). The distribution of the 192 bottom trawl stations included in the calculations are shown in Fig. 3.4. The survey design described by Dalen et al. (1982) was used. The number of stations was set at the level which calculations on data from earlier years have indicated to be the minimum required to obtain a reliable estimate of fish abundance in the area. 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). The sweep wires are 40 m. The otter boards used are V-doors for the trawler and pelagic doors modified for bottom trawling on 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 m as the sweeping-width of the trawl. Table 3.1 gives the number of stations in each stratum.

3. THE BARENTS SEA SURVEYS

3.1. Hydrography

Fig. 3.5 shows the temperature distribution in the Barents Sea in the winter 1988 at the surface (A), at 100 m depth (B), and at the bottom (C). In 1988 the temperature in the central survey area had increased somewhat compared to 1987, especially in the upper layers, but on the sections used for reference the temperature was still slightly below the long-term mean and showed little change from 1987.

3.2. Geographical Distribution of Cod and Haddock

Fig. 3.6 shows the distribution of the total echo abundance of cod and haddock combined in 1988. Although the abundance was clearly lower than in 1987, the geographical distribution was similar and the fish still had the westerly distribution resulting from the large shift westward from 1986 to 1987 (Godø et al. 1987).

Fig. 3.7 shows the echo abundance in the 10 m layer above the bottom. The highest values were generally found in the areas with highest total echo abundance and made up a higher proportion of the total than in 1987. This is also seen in Table 3.2 which shows the echo abundance of cod/haddock 1981-1988, total and in the bottom layer, and the percentage found near the bottom. This percentage was at a low level of 14% in 1985/1986, but increased to 23% in 1987 and further to 34% in 1988, thus approaching the level of about 40% observed in 1981/1982. While total echo abundance in 1988 was reduced by 72% and 37%, respectively, from the 1986 and 1987 level, the corresponding reductions in echo abundance in the bottom layer were only 29% and 5%.

Fig. 3.8 shows the distribution of the echo abundance of cod alone (note that this plot is cruder and on a different scale than the combined cod/haddock plot). This distribution is even more to the west than the combined cod/haddock distribution. The

haddock (Fig. 3.9) accordingly had a more easterly distribution than the cod, but nevertheless occurred farther west than normal.

3.3. Acoustic Abundance Estimates of Cod and Haddock

The acoustic estimates of cod and haddock in 1986 and 1987 have been redused by about 20% from the numbers presented last year. The reason is that a factor of 4π has been introduced in the calculation of the instrument constant (Aglen 1985, unpublished information).

Table 3.3 shows the acoustic abundance estimates of cod in 1988 by age and sub-area. As in 1987, more than half was recorded in sub-area A, i.e. the northewestern part of the survey area. The only major change in relative terms is a shift from the coastal sub-area C to the northern/northeastern sub-area D.

Table 3.4 shows the full time series 1977-1988 of acoustic abundance estimates of cod by age group. The total number in 1988 was 46% of the 1987 estimate and only 12% of the 1986 estimate. A roughly corresponding decrease is observed for all the year classes before the 1986 year class.

The acoustic abundance estimates by age and sub-area for haddock are given in Table 3.5. The highest proportion (35%) was found in sub-area A and there was as usual relatively little found in sub-area B. Compared to 1987 there had been a substantial shift in the distribution from sub-area C to sub-area D.

The time series (Table 3.6) shows a reduction in total number of haddock which is even larger than for cod, the 1988 estimate being only 27% and 8%, respectively, of the 1987 and 1986 estimates. The reduction is seen in virtually all year classes.

3.4. Bottom Trawl Survey Indices of Cod and Haddock

Table 3.7 gives abundance indices from the bottom trawl survey for each age group of cod by sub-area. The distribution was

similar to the one shown by the acoustic estimates, but with a somewhat higher proportion in sub-area D and a correspondingly lower one in sub-area A. The relative distribution on sub-areas was little changed from 1987.

Indices, total and by age group, for the full time series 1981-1988 are given in Table 3.8. The total index in 1988 was reduced by 30% from 1987 and was still 42% of that in 1986, and the reduction in the indices has been much less than in the acoustic estimates. This difference between the two survey methods is seen mainly for the year classes 1983-1985.

The area distribution of haddock according to the bottom trawl survey (Table 3.9) was similar to the distribution from the acoustic survey, but with a slightly higher proportion (40%) in sub-area A. Compared to 1987 there has been a substantial shift from sub-areas C and D to sub-area A.

As for cod, the bottom trawl survey shows a clearly less pronounced reduction of total indices of haddock than the acoustic survey (Table 3.10), but the 1988 index was nevertheless only 46% of the 1987 estimate.

3.4. Acoustic Survey Results vs Trawl Survey Results

The difference in rate of reduction in recent years between the acoustic number estimates and the bottom trawl survey indices is to a considerable extent explained by the reduction in the proportion of pelagic echo abundance. It seems that a higher proportion of both cod and haddock tend to occur pelagically when the stock is abundant. This seems to indicate that the acoustic survey estimates are more reliable. However, recent investigations have shown that there are problems both regarding the acoustics (Ona 1987) and the trawl sampling (Engås and Godø 1986, 1987a,b) which have not yet been taken into account in the calculations, and no firm conclusions about the reliability of the two methods can be drawn at this stage.

3.5. Acoustic Abundance Estimates of Redfish

Although the estimates are given as numbers of fish, they should be regarded as indices only. The surveyed area was enlarged from 1986 to 1987 and from 1987 to 1988. To look at eventual changes in the stocks from year to year, estimates from the same areas must be compared. Figs 3.10 and 3.11 show the combined distributions of Sebastes marinus, S.mentella and S.viviparus in 1987 and 1988, respectively. There is no acoustic registration of redfish east of 36^0-37^0E in winter-time. The main difference between the observed distributions in 1987 and 1988 is caused by the enlargement of the surveyed area in west and northwest.

The estimates for S.marinus give great cause for concern. The results show a large decline in numbers, especially for fish less than 25 cm. The relatively high number in 1987 may be an artifact caused by wrong species identification of fish less than 25 cm, since fish from the strong 1982 year class of S.mentella were between 15 and 20 cm at that time. The results for S.mentella show a stabilizing trend, but it should be noted that this is caused by an increase in the possibly unreliable estimate for length group 5-9 cm, which outweighs the losses of the strong 1982 year class (around 20 cm) in 1988. The acoustic abundance estimates for S.viviparus show a great increase in numbers for this species, especially of fish less than 20 cm.

3.6. Bottom Trawl Survey Indices of Redfish

Sebastes marinus. The total abundance indices show a 29% reduction in numbers from 1987 to 1988 (Table 3.11), which is caused by a severe decrease of fish less than 20 cm. Taking into account that the total abundance in the Svalbard area in autumn 1987 was reduced by a similar percentage, the stock situation is alarming, especially in the Barents Sea.

Sebastes mentella. The index for 5-9 cm S.mentella in 1988 was considerably higher than in the previous years, indicating a stronger 1987 year class (Table 3.12). However, there is some

evidence that the time of occurrence of redfish of this size group near the bottom varies from year to year, and the bottom trawl indices are therefore not very reliable for the smallest individuals. Nevertheless, the situation for the S.mentella stock seems at least to have been stabilized.

Sebastes viviparus. The abundance indices increased for all length groups from 1987 to 1988 (Table 3.13), but since the investigations cover only the northernmost part of the area where S.viviparus live, migration may influence the indices. However, as also found in the autumn 1987, the area of distribution has increased.

4. THE LOFOTEN-VESTERÅLEN SURVEY

4.1. Hydrography

The water temperatures in the Lofoten area were clearly higher than in 1987 (Fig 4.4). The depth of the transition layer between coastal and Atlantic water varied on three standard sections between 80 and 150 m depth. On the coastal banks the temperatures were slightly lower than last year.

4.2. Acoustic Abundance Estimates of Cod and Haddock

Figs 4.5 and 4.6 show the distribution of echo abundance of cod and haddock combined recorded by "Michael Sars" and "G. O. Sars", respectively. In general, the abundance was clearly lower than in 1987. The difference was most noticeable in the northern part of the area.

The acoustic estimates presented in Tables 4.1-4.4 are from "G. O. Sars" only. The estimates from "Michael Sars" gave nearly the same total, but about 4 million less cod and 3 million more haddock.

Tables 4.1 and 4.2 show the acoustic estimates of mature and immature cod, respectively, by age and sub-area. The estimate of

mature cod was only 8.5 million, about 37% of the 23 million estimate in 1987. More than half (nearly 5 million) were observed in the Vestfjord, east of the Lofoten Islands (sub-area 1-2). This was roughly the same as last year and the decrease in mature fish has therefore been observed mainly on the shelf area west of Lofoten and Vesterålen. The mature fish were predominantly of age 5-7. About 8 million immature fish, mostly 3-7 years old, were recorded, compared to 14 million in 1987. Most of these were also found in the Vestfjord, whereas virtually none were recorded in that area in 1987. According to the otolith readings a high proportion of the cod in the Vestfjord were coastal cod.

Tables 4.3 and 4.4 show the acoustic estimates of mature and immature haddock, respectively, by age and area. The haddock were mostly 4-6 years old mature fish and the total haddock estimate was nearly three times that of 1987. The haddock were also in 1988 found chiefly on the shelf, but in general farther south than in 1987.

REFERENCES

Anon. 1988. Report of the Arctic Fisheries Working Group. Coun. Meet. int Coun. Explor. Sea, 1988 (Assess:5) : 1-141.

Blindheim, J., Eide, P. K., Knudsen, H. P. and Vestnes, G. 1982. A shipborne data logging and processing system for acoustic fish surveys. Fish. Res., 1: 141-153.

Dalen, J., Hylen, A., Jakobsen, T., Nakken, O. and Randa, K. 1984. Preliminary report of the Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1983. Coun. Meet. int. Coun. Explor. Sea, 1984 (G:44) : 1-24.

Dalen, J., Hylen, A., Nakken, O., Randa, K. and Smedstad, O. M. 1982. Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1982. Coun. Meet. int. Coun. Explor. Sea, 1982 (G:4): 1-32.

Dalen, J., Hylen, A., Nakken, O., Randa, K. and Smedstad, O. M. 1983. Preliminary report of the Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1983. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:15) : 1-23.

Dalen, J. and Smedstad, O. M. 1979. Acoustic method for estimating absolute abundance of young cod and haddock in the Barents Sea. Coun. Meet. int. Coun. Explor. Sea, 1979 (G:51): 1-24.

Dalen, J. and Smedstad, O. M. 1983. Abundance estimation of demersal fish in the Barents Sea by an extended acoustic method. In: Nakken, O. and Venema, S. C. eds. Symposium on fisheries acoustics. Bergen, Norway, 21-24 June 1982. FAO Fish. Rep., 300: 232-239.

Engås, A. and Godø, O. R. 1986. Swept area variation with depth and its influence on stratified trawl survey indices on Arcto-Norwegian cod. Coun. Meet. int. Coun. Explor. Sea, 1986 (D:18) : 1-12.

Engås, A. and Godø, O. R. 1987a. Near-bottom sampling with bottom and pelagic trawls. Coun. Meet. int. Coun. Explor. Sea, 1986 (B:15) : 1-9.

Engås, A. and Godø, O. R. 1987b. Escapement of fish under the fishing line of a Norwegian sampling trawl and its influence on survey results. International Symposium on Fisheries Acoustics, June 22-26, 1987, Seattle, Washington, USA: 1-18.

Foote, K. G., Knudsen, H. P. and Vestnes, G. 1983. Standard calibration of echo sounders and echo integrators with optimal copper spheres. FiskDir Skr. Ser. HavUnders., 17: 335-346.

Godø, O. R., Nakken, O., Raknes, A. and Sunnanå, K. 1982. Acoustic estimates of spawning cod off Lofoten and Møre in 1982. Coun. Meet. int. Coun. Explor. Sea, 1982 (G:62) : 1-16.

Godø, O. R., Nakken, O., Raknes, A. and Sunnanå, K. 1983. Acoustic estimates of spawning cod off Lofoten and Møre in 1983. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:37) : 1-24.

Godø, O. R., Nakken, O., Raknes, A. and Sunnanå, K. 1984. Acoustic estimates of spawning cod off Lofoten and Møre in 1984. Coun. Meet. int. Coun. Explor. Sea, 1984 (G:47) : 1-24.

Godø, O. R., Nakken, O., Raknes, A. and Sunnanå, K. 1985. Acoustic estimates of spawning cod off Lofoten and Møre in 1985. Coun. Meet. int. Coun. Explor. Sea, 1985 (G:66) : 1-14.

Godø, O. R., Hylen, A., Jacobsen, J. A., Jakobsen, T., Mehl, S., Nedreaas, K. and Sunnanå, K. 1987. Estimates of stock size of Northeast Arctic Cod and Haddock from survey data 1986/1987. Coun. Meet. int. Coun. Explor. Sea, 1987 (G:37): 1-18.

Hylen, A., Jakobsen, T., Nakken, O. and Sunnanå, K. 1985. Preliminary report of the Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1983. Coun. Meet. int. Coun. Explor. Sea, 1985 (G:68) : 1-28.

Hylen, A., Jakobsen, T., Nakken, O., Nedreaas, K. and Sunnanå, K. 1986. Preliminary report of the Norwegian investigations on young cod and haddock in the Barents Sea. Coun. Meet. int. Coun. Explor. Sea, 1986 (G:76) : 1-25.

Ona, E. 1987. The equivalent beam angle and its effective value when applying an integrator threshold. Coun. Meet. int. Coun. Explor. Sea, 1987 (B:35): 1-13.

Raknes, A. and Sunnanå, K. 1986. Acoustic estimates of spawning cod off Lofoten in 1986. Coun. Meet. int. Coun. Explor. Sea, 1986 (G:79): 1-9.

Table 3.1. Trawl hauls taken in the bottom trawl survey 1988.

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

Table 3.2. Cod/Haddock. Total echo abundance and echo abundance in the 10 m layer above the bottom 1981-1988. (m^2 reflecting surface x 10^{-3}).

Echo Abundance	Year 1981	1982	1983	1984	1985	1986	1987	1988
Total	2097	686	597	2284	5187	5990	2676	1696
Bottom	799	311	169	604	736	820	608	579
Ratio bottom/total	.38	.45	.28	.26	.14	.14	.23	.34

Table 3.3. Cod. Acoustic abundance estimates for each age group/year class in the surveyed areas in 1988. (Numbers in millions).

Area	Age (Year class) 1 (87)	2 (86)	3 (85)	4 (84)	5 (83)	6 (82)	7 (81)	8 (80)	9 (79)	10+ (78)	Total
A	+	2	31	46	119	17	3	+	+	0	219
B	+	+	+	1	13	4	+	+	+	0	20
C	+	1	7	7	27	3	1	+	0	0	46
D	1	19	41	20	21	2	+	+	0	0	104
Total	1	23	79	74	179	26	6	+	+	0	389
%	0.3	6.0	20.4	18.9	46.0	6.7	1.5	0.2	0.0	0.0	100.0

Table 3.4. Cod. Estimates of year class abundance from acoustic surveys in the period 1977-1988. (Numbers in millions).

Year of investigation	Year class 1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	Total
1977												45	882	104	315	250	1596
1978											28	235	797	153	172	57	1442
1979										16	14	109	502	77	45	20	783
1980									Malfunction of the acoustic instruments								
1981								3	73	58	124	243	270	41	8	7	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
1985				69	878	550	510	109	48	20	2	1	1				2187
1986			625	578	1246	424	225	27	8	1	+	+					3136
1987		1	47	126	506	128	37	4	2	1							852
1988	1	23	79	74	179	26	6	+	+								389

Table 3.5. Haddock. Acoustic abundance estimates for each age group/year class in the surveyed areas in 1988. (Numbers in millions).

Area	Age (Year class) 1 (87)	2 (86)	3 (85)	4 (84)	5 (83)	6 (82)	7 (81)	8+ (80)	Total
A	3	3	4	23	54	12	+	0	99
B	2	1	1	3	15	3	0	0	25
C	+	1	4	19	43	4	0	0	71
D	1	2	12	26	38	4	+	0	84
Total	8	7	20	70	150	23	0	0	279
%	2.7	2.5	7.3	25.1	53.9	8.3	0.2	0.0	100.0

Table 3.6. Haddock. Estimates of year class abundance from acoustic surveys in the period 1977-1988. (Numbers in millions).

Year of investigation	Year class 1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972+	Total
1977												267	755	198	60	19	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
1985				1034	1972	1187	33	2	1	1	1	1	1				4233
1986			346	502	1720	751	2	1	1	+	+	+					3323
1987		37	29	175	640	166	+	+	+		+						1049
1988	8	7	20	70	150	23	+			+							279

Table 3.7. Cod. Abundance indices from the bottom trawl survey for each age group/year class in the different areas in 1988.

Area	Age (Year class) 1 (87)	2 (86)	3 (85)	4 (84)	5 (83)	6 (82)	7 (81)	8 (80)	9 (79)	10+ (78)	Total
A	+	1.5	15.8	22.1	84.5	10.4	1.5	0.3	+	0.0	136.1
B	0.1	0.1	0.6	1.2	8.9	2.8	0.6	0.2	+	0.0	14.6
C	0.0	2.0	7.8	7.3	21.6	2.1	0.6	0.1	0.0	0.0	41.5
D	0.6	14.1	45.3	22.2	27.6	2.6	0.9	0.1	0.0	0.0	113.4
Total	0.7	17.7	69.5	52.8	142.6	17.9	3.6	0.7	0.0	0.0	305.6
%	0.2	5.8	22.7	17.3	46.7	5.9	1.2	0.2	0.0	0.0	100.0

Table 3.8. Cod. Abundance indices for each year class from the bottom trawl surveys 1981-1988.

Year of investig.	Year class 1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974+	Total
1981								0.7	11.0	8.6	16.9	34.1	37.9	6.1	115.3
1982							0.1	0.9	16.1	20.4	21.4	16.0	15.8	1.6	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
1988	0.7	17.7	69.5	52.8	143.0	17.9	3.6	0.6	0.1						305.9

Table 3.9. Haddock. Abundance indices from the bottom trawl survey for each age group/year class in the different areas in 1988.

Area	Age (Year class) 1 (87)	2 (86)	3 (85)	4 (84)	5 (83)	6 (82)	7 (81)	8+ (80)	Total
A	1.7	3.3	5.1	27.2	56.7	11.0	0.2	0.0	105.2
B	1.9	1.1	1.0	2.3	12.2	1.8	0.0	0.0	20.3
C	0.4	1.1	2.9	17.2	38.8	3.5	0.0	0.0	63.9
D	1.0	2.8	14.9	25.8	26.5	2.6	+	0.0	73.6
Total	5.0	8.3	23.9	72.5	134.2	18.9	0.2	0.0	263.0
%	1.9	3.1	9.1	27.6	51.0	7.2	0.1	0.0	100.0

Table 3.10. Haddock. Abundance indices for each year class from the bottom trawl surveys 1981-1988.

Year of invest.	Year class 1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975+	Total
1981								0.3	4.8	2.3	9.5	2.0	6.8	25.7
1982							0.5	0.9	1.8	2.1	2.2	5.5	2.9	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
1988	5.0	8.3	23.9	72.5	134.1	19.0	0.2							263.0

Table 3.11. Sebastes marinus. Abundance indices from the bottom trawl survey for each length group in the Barents Sea in winter 1985-1988.

Year of investigation	Length group 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45+	TOTAL
1985	6.4	169.9	52.4	81.9	69.4	52.8	68.8	13.9	5.3	521
1986	3.0	11.7	26.4	34.3	17.7	21.0	12.8	4.4	2.6	134
1987	7.7	12.7	32.8	7.7	6.4	3.4	3.8	3.8	4.2	83
1988	1.0	5.6	5.5	14.2	12.6	7.3	5.2	4.1	3.7	59

Table 3.12. Sebastes mentella. Abundance indices from the bottom trawl survey for each length group in the Barents Sea in winter 1985-1988.

Year of investigation	Length group 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45+	TOTAL
1985	55.5	380.5	42.3	70.1	39.1	18.1	7.9	2.3	0.6	622
1986	81.3	151.9	205.4	87.7	169.2	129.8	87.5	23.6	13.8	951
1987	71.8	25.1	227.4	56.1	34.6	11.4	5.3	1.1	0.1	433
1988	587.0	25.2	132.6	182.1	39.6	50.1	47.9	3.6	0.1	1070

Table 3.13. Sebastes viviparus. Abundance indices from the bottom trawl survey for each length group in the Barents Sea in winter 1985-1988.

Year of investigation	Length group 5-9	10-14	15-19	20-24	25-29	30+	TOTAL
1985	1.9	8.9	5.6	3.1	1.2	0.2	21
1986	1.0	2.3	4.8	6.4	1.3	+	16
1987	+	0.5	4.4	8.0	1.9	0.2	15
1988	6.9	6.2	6.4	10.0	3.6	0.3	33

Table 4.1. Estimates of mature cod (skrei) by sub-area and age. (Numbers in thousands)

Area	Age 3	4	5	6	7	8	9	10+	TOTAL
1-2	52	767	1327	2127	603	[illegible]	-	-	4922
3-4	-	-	510	1520	707	[illegible]	9	37	2792
5	-	-	419	334	58	[illegible]	3	-	828
TOTAL	52	767	2256	3981	1368	[illegible]	12	37	8542

Table 4.2. Estimates of immature cod by sub-area and age. (Numbers in thousands)

Area	Age 2	3	4	5	6	7	8	TOTAL
1-2	139	687	944	1538	599	322	1	4230
3-4	-	-	195	1413	459	185	-	2252
5	6	26	113	1200	126	7	1	1479
TOTAL	145	713	1252	4151	1184	514	2	7961

Table 4.3. Estimates of mature haddock by sub-area and age. (Numbers in thousands)

Area	Age 3	4	5	6	7	TOTAL
1-2	-	376	1024	143	257	1800
3-4	16	1523	6724	4341	-	12604
5	-	234	3514	1437	36	5221
TOTAL	16	2133	11262	5921	293	19625

Table 4.4. Estimates of immature haddock by sub-area and age. (Numbers in thousands)

Area	Age 1	2	3	4	5	6	7	TOTAL
1-2	57	344	1203	54	36	-	1	1695
3-4	23	53	198	109	374	-	-	757
5	10	51	-	201	561	[illegible]	-	824
TOTAL	90	448	1401	364	971	[illegible]	1	3276

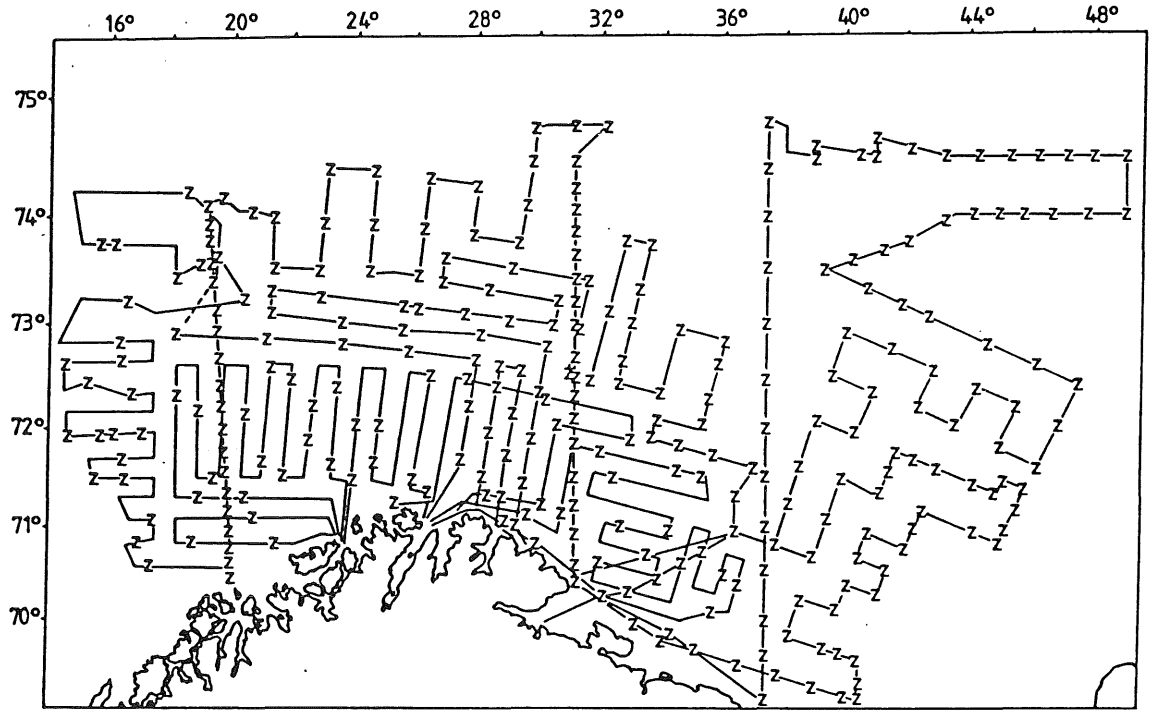


Fig. 3.1. Survey tracks and hydrographical stations; R/V "G.O.Sars" 10.1.-8.3. and R/V "Michael Sars" 27.1.-26.2.1988.

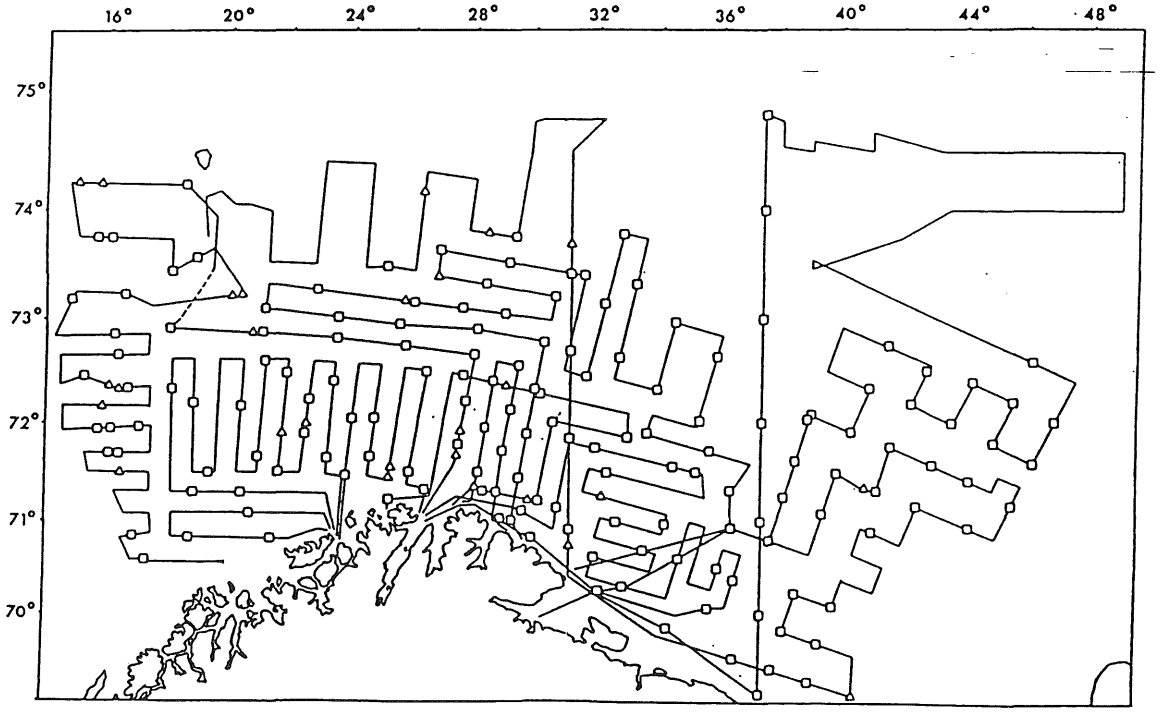


Fig. 3.2. Survey tracks and trawl stations; R/V "G.O.Sars" 10.1.-8.3. and R/V "Michael Sars" 27.1.-26.2.1988.

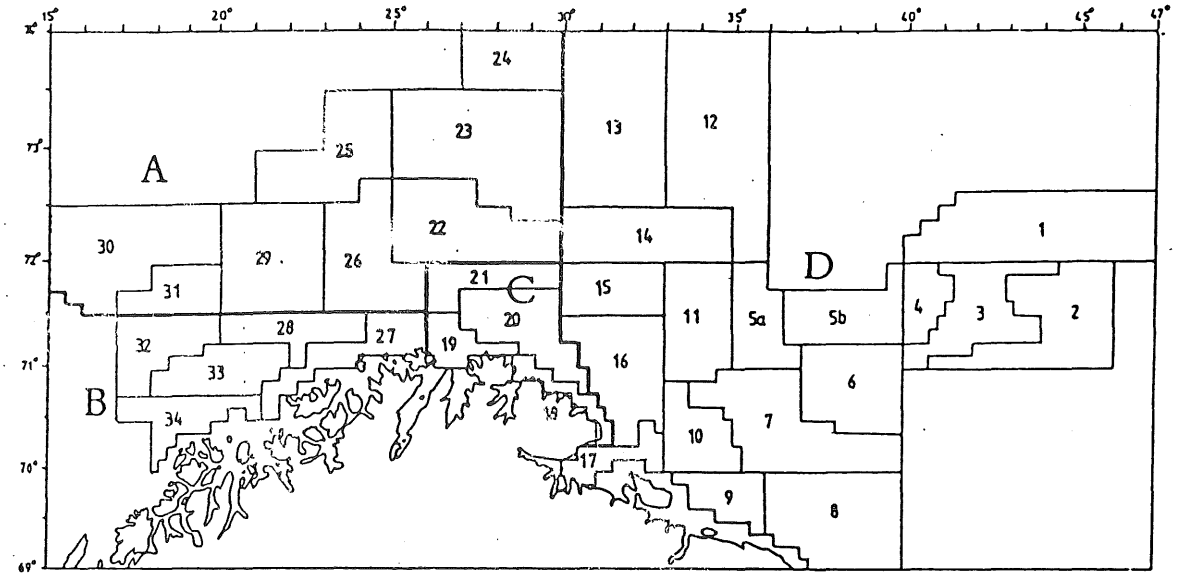


Fig. 3.3. The survey area with sub-areas (A - D) and strata used in the bottom trawl survey.

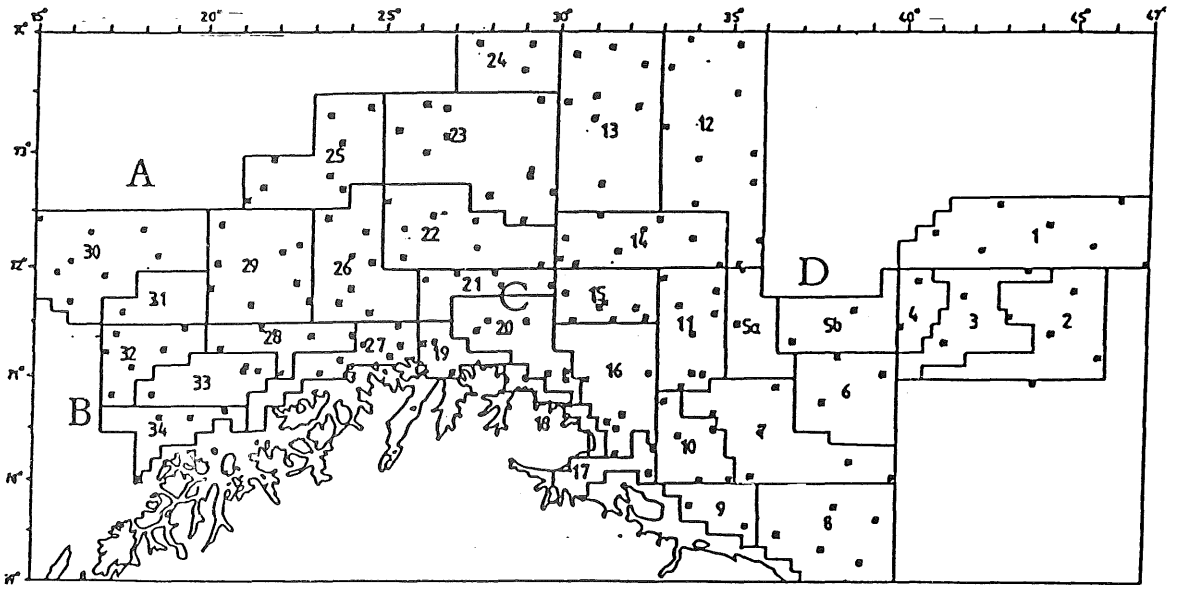


Fig. 3.4. Trawl stations taken in the bottom trawl survey by M/T "T.O.Senior" 28.1.-12.2., R/V "G O.Sars" 10.1.-8.3. and R/V "Michael Sars" 27.1.-26.2.1988.

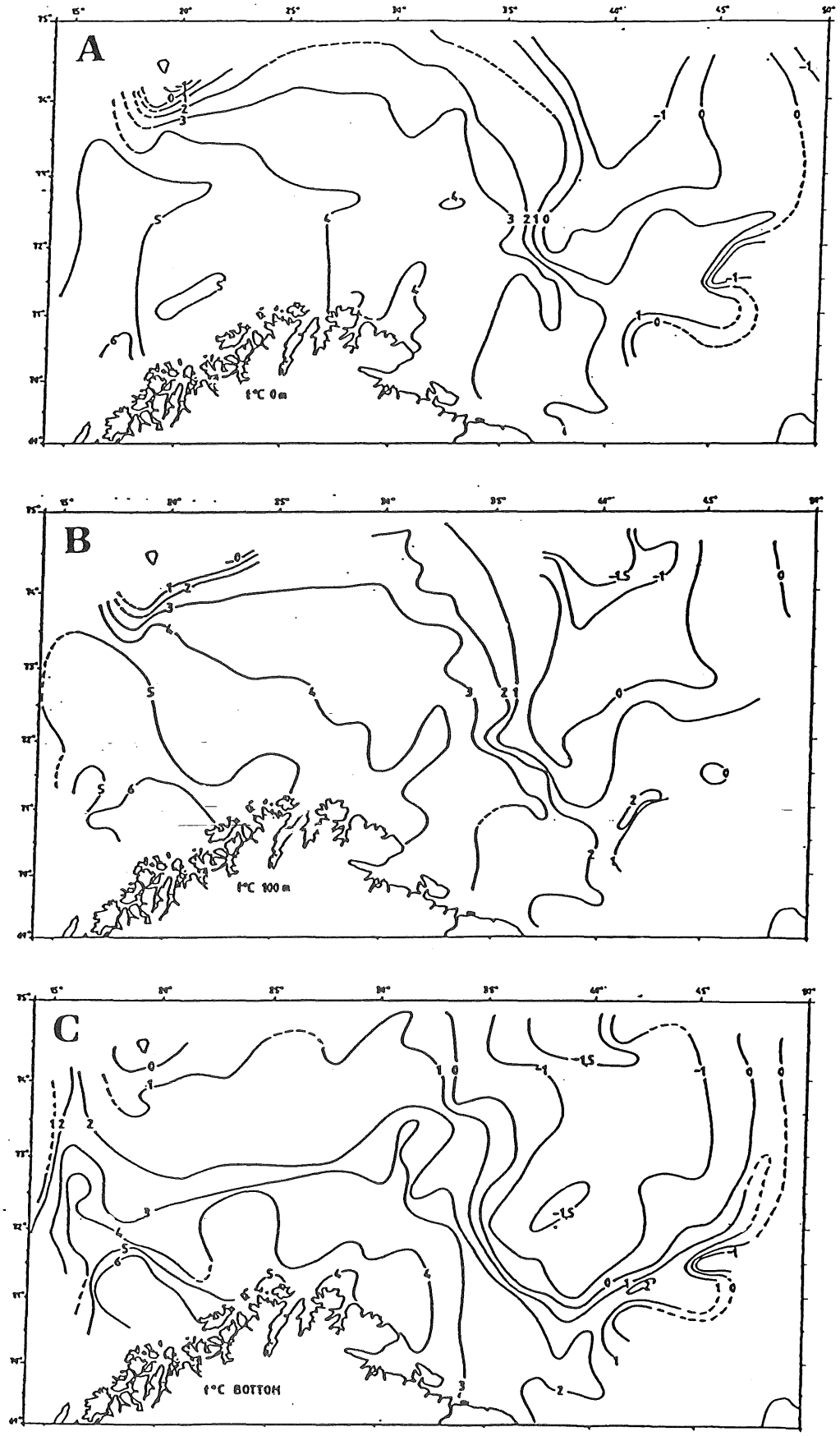


Fig. 3.5. Temperature distribution; R/V "G.O.Sars" 10.1.-8.3. and R/V "Michael Sars" 27.1.-26.2.1988. A) At the surface, B) at 100 m depth, C) at the bottom.

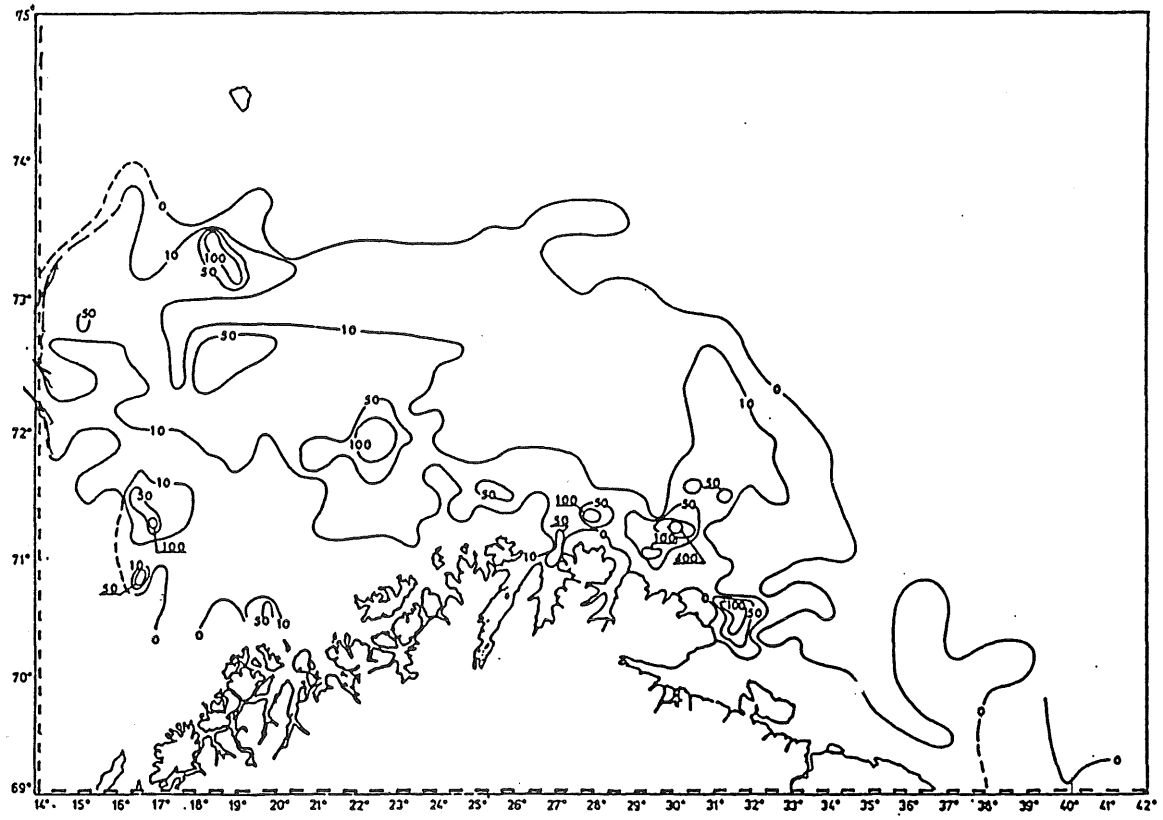


Fig. 3.6. Distribution of total echo abundance; cod and haddock. Units are integrated back scattering surface per square nautical mile $(m/n.mile)^2$.

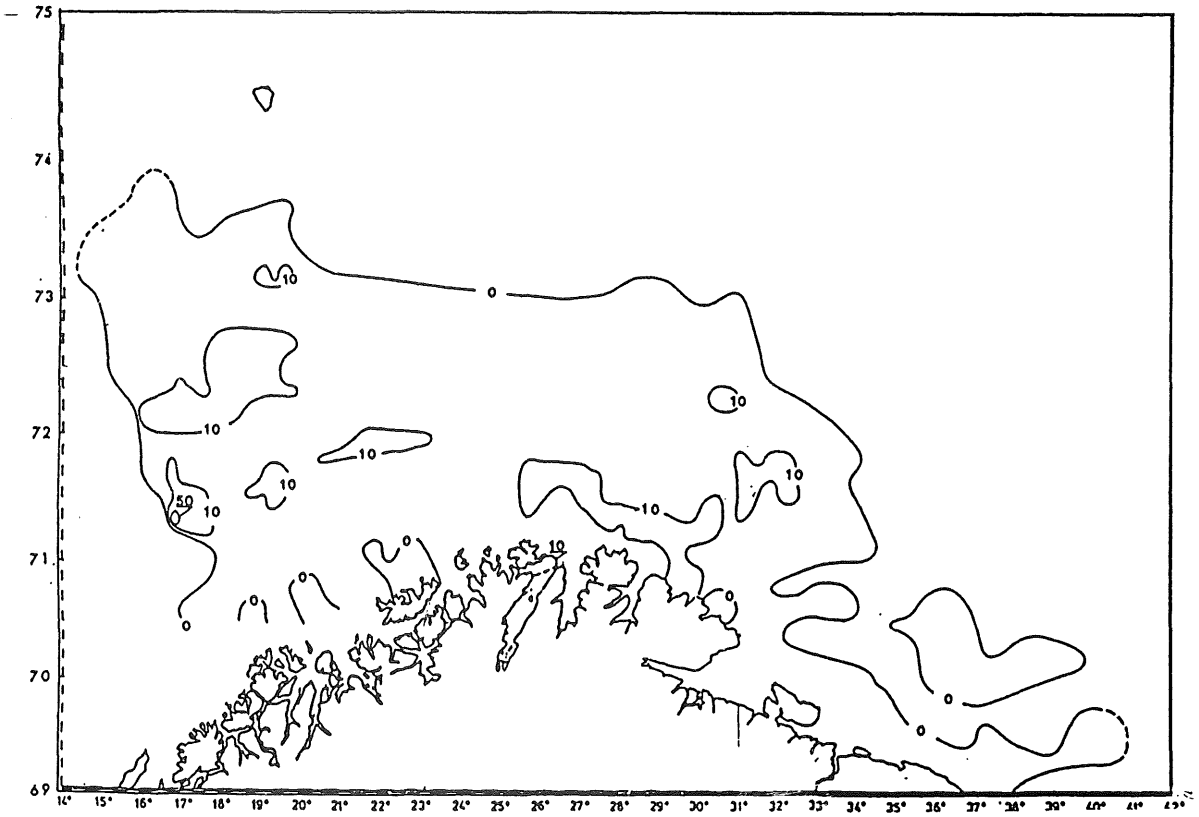


Fig. 3.7. Distribution of echo abundance in the 10 m layer above the bottom; cod and haddock. Units are integrated back scattering surface per square nautical mile $(m/n.mile)^2$.

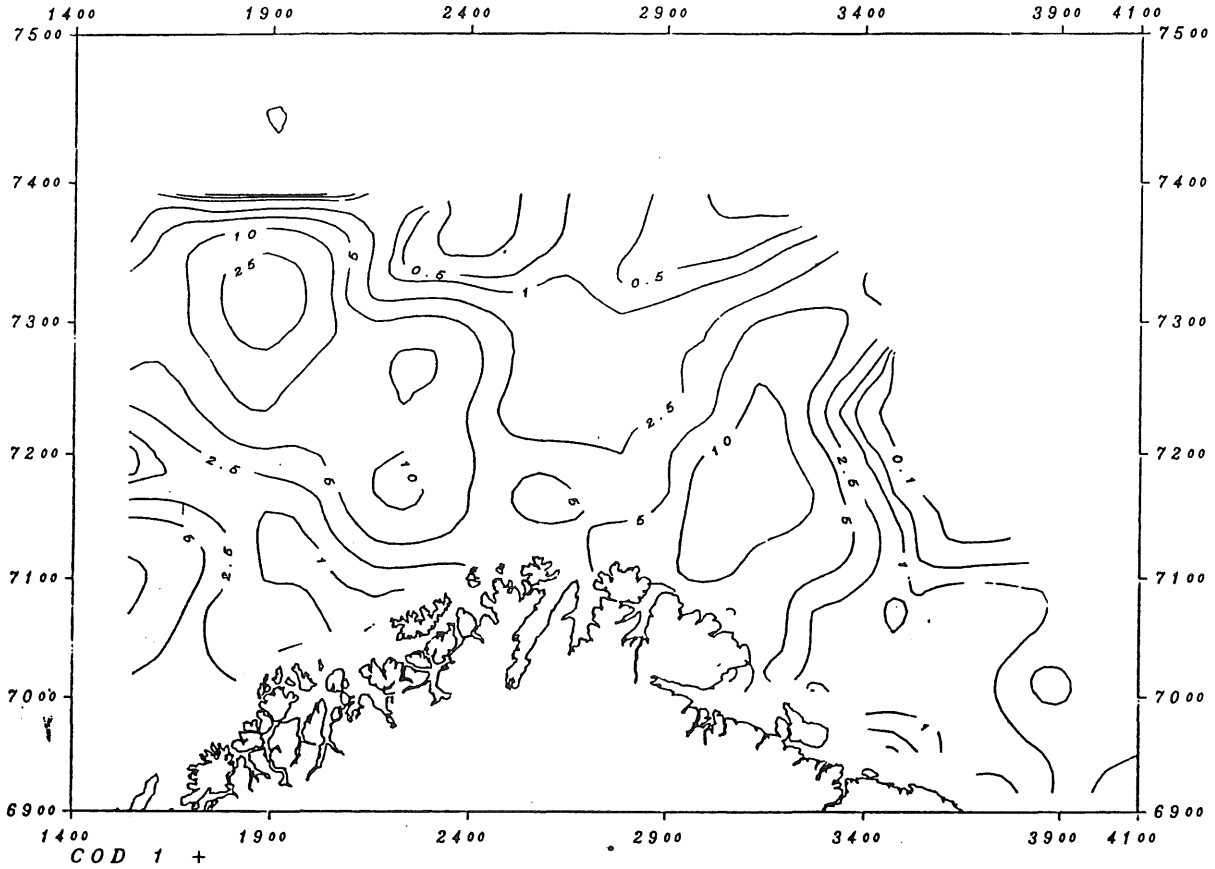


Fig. 3.8. Distribution of cod (number of fish in 1000 per square nautical mile).

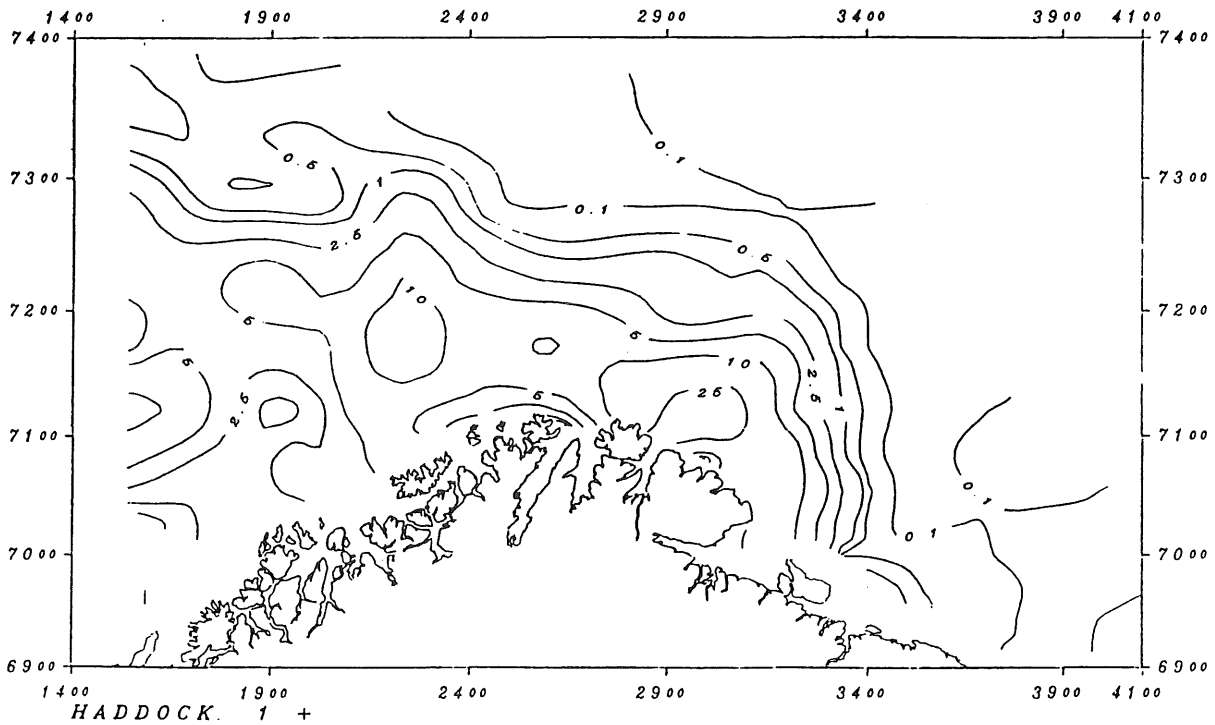


Fig. 3.9. Distribution of haddock (number of fish in 1000 per square nautical mile).

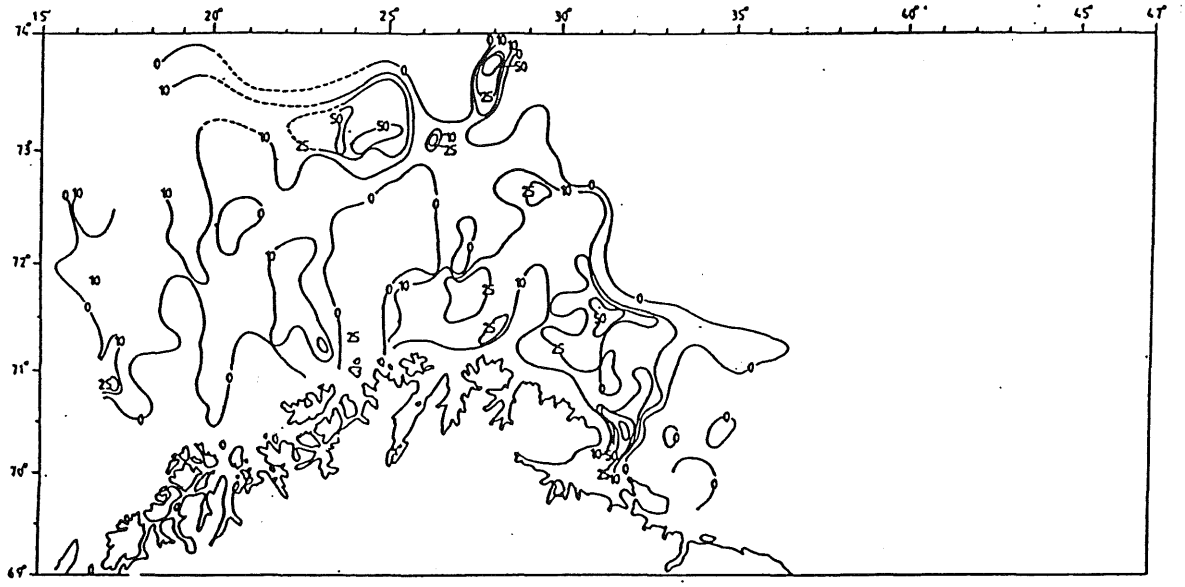


Fig. 3.10. Distribution of redfish in 1987. Units are integrated back scattering surface per square nautical mile $(m/n.mile)^2$.

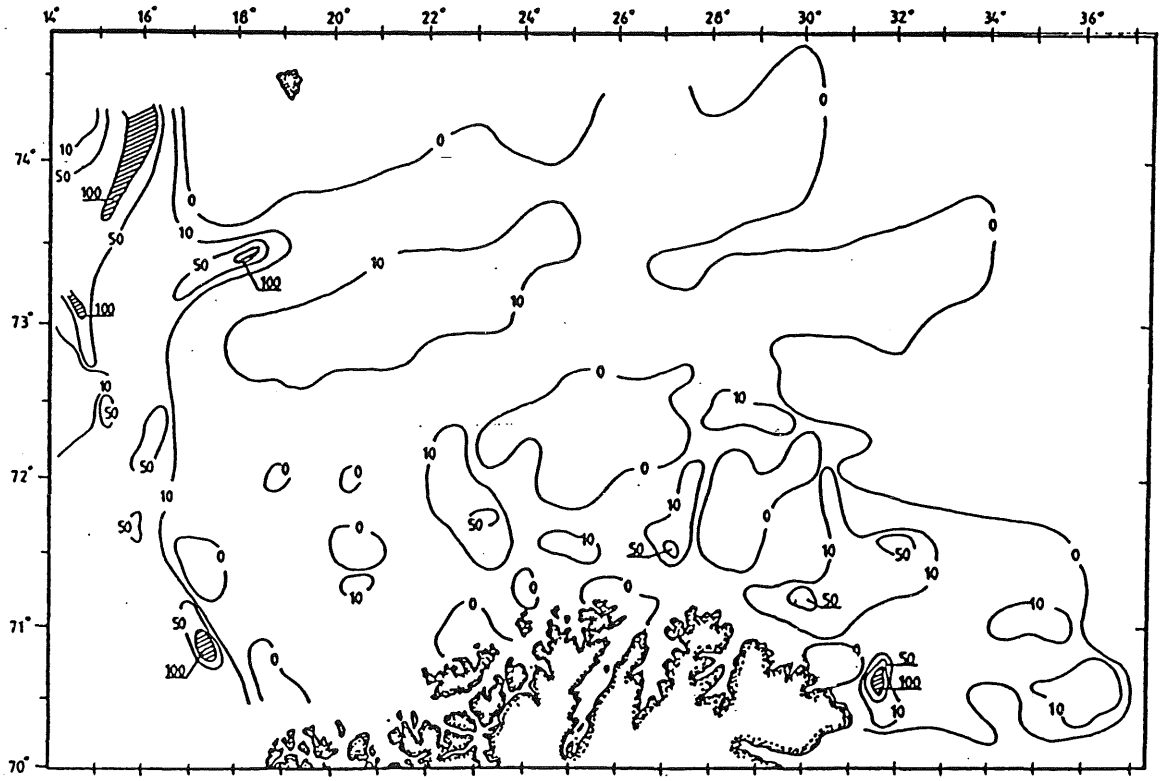


Fig. 3.11. Distribution of redfish in 1988. Units are integrated back scattering surface per square nautical mile $(m/n.mile)^2$.

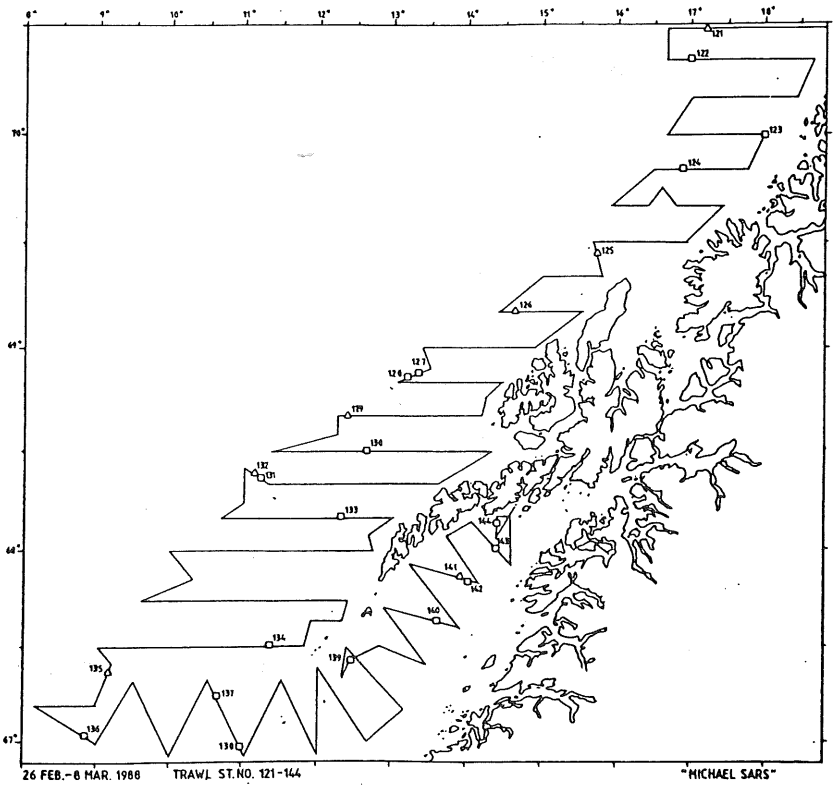


Fig. 4.1. Survey track and trawl stations; R/V "Michael Sars" 1.-8.3.1988.

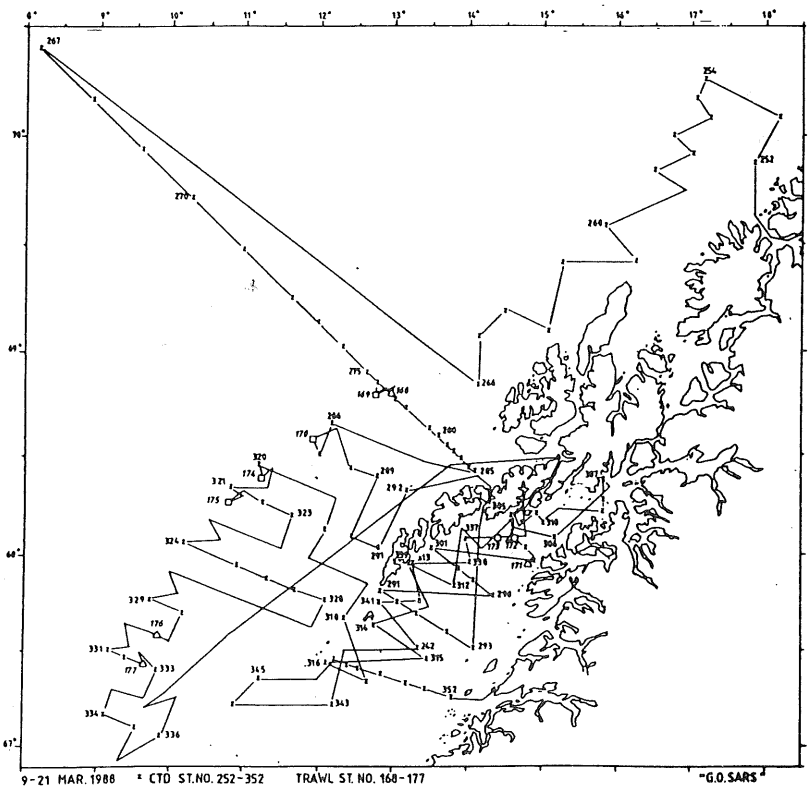


Fig. 4.2. Survey track, hydrographical stations and trawl stations; R/V "G.O.Sars" 8.-21.3.1988.

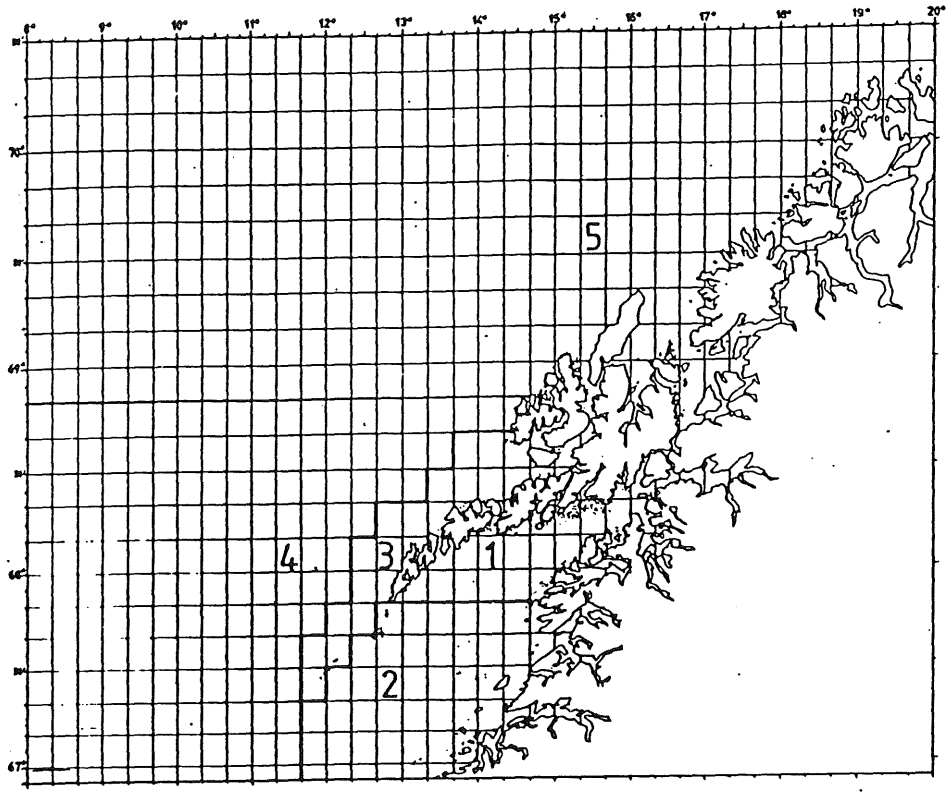


Fig. 4.3. The survey area with sub-areas (1 - 5) and unit areas used in the acoustic survey.

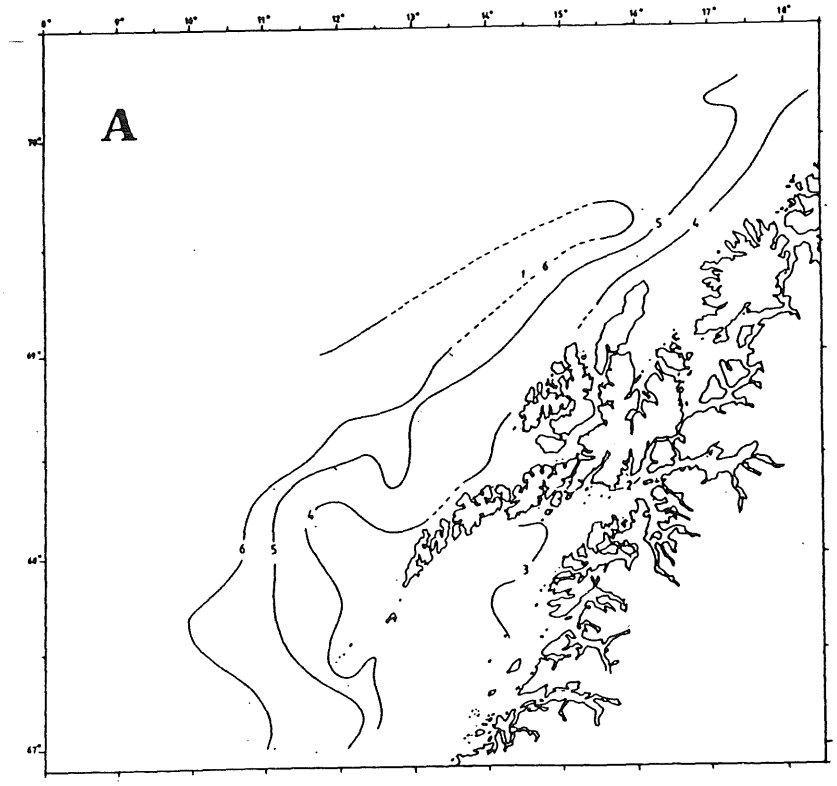
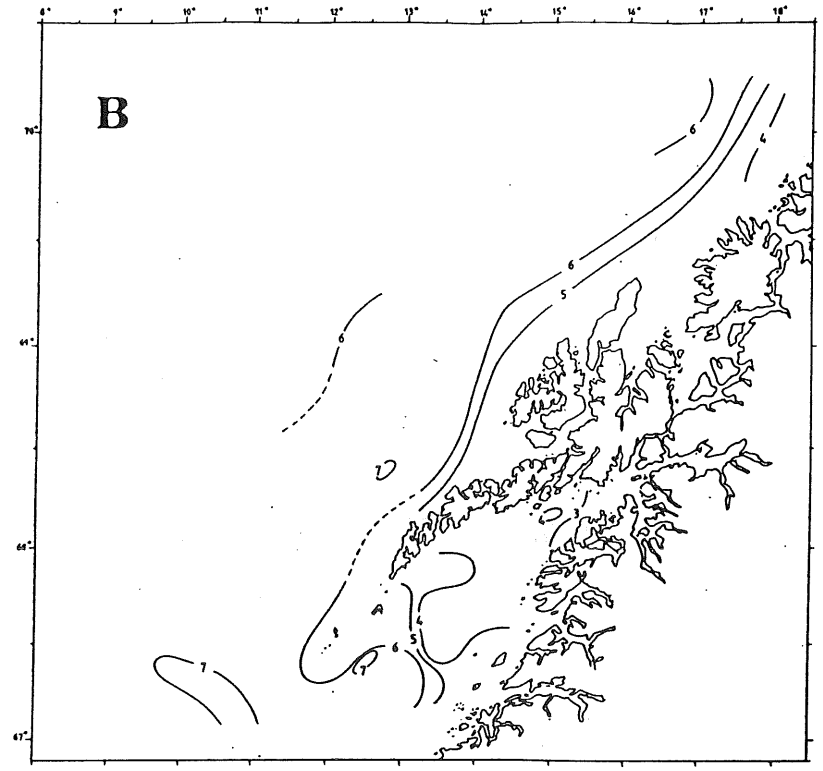


Fig. 4.4.A. (Legend: next page)



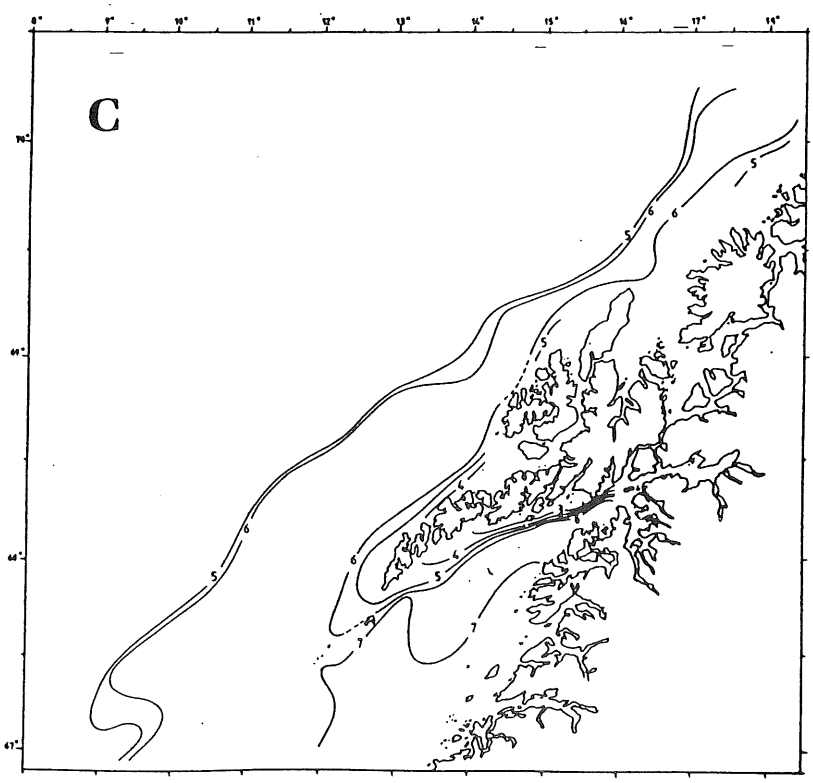


Fig. 4.4. Temperature distribution; R/V "G.O.Sars" 8.-21.3.1988. A) At 20 m depth, B) at 100 m depth, C) at the bottom.

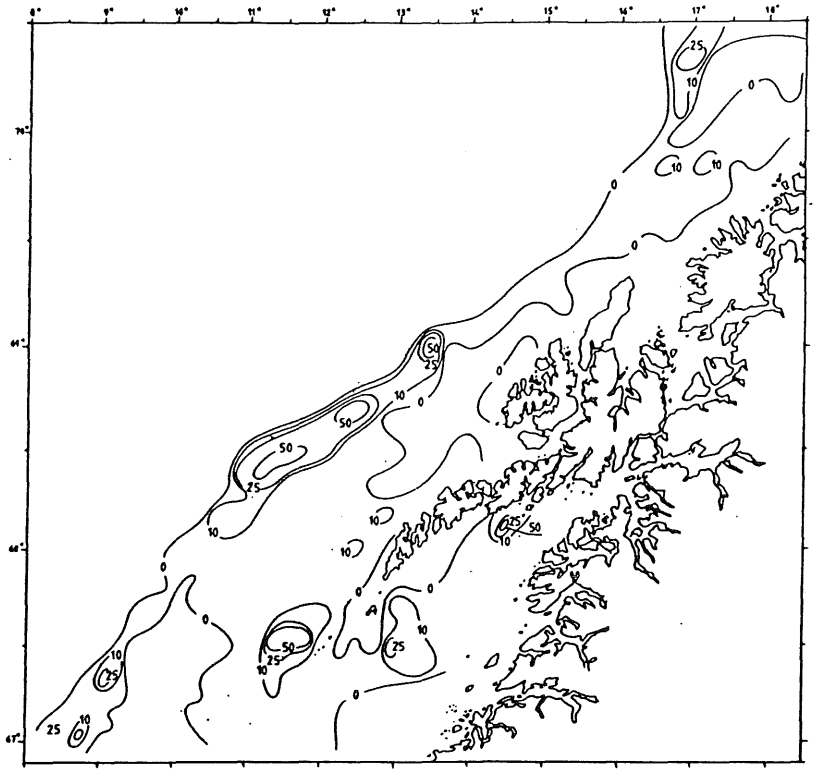


Fig. 4.5. Distribution of total echo abundance; cod and haddock. R/V "Michael Sars" 1.-8.3.1988. Units are integrated back scattering surface per square nautical mile $(m/n.mile)^2$.

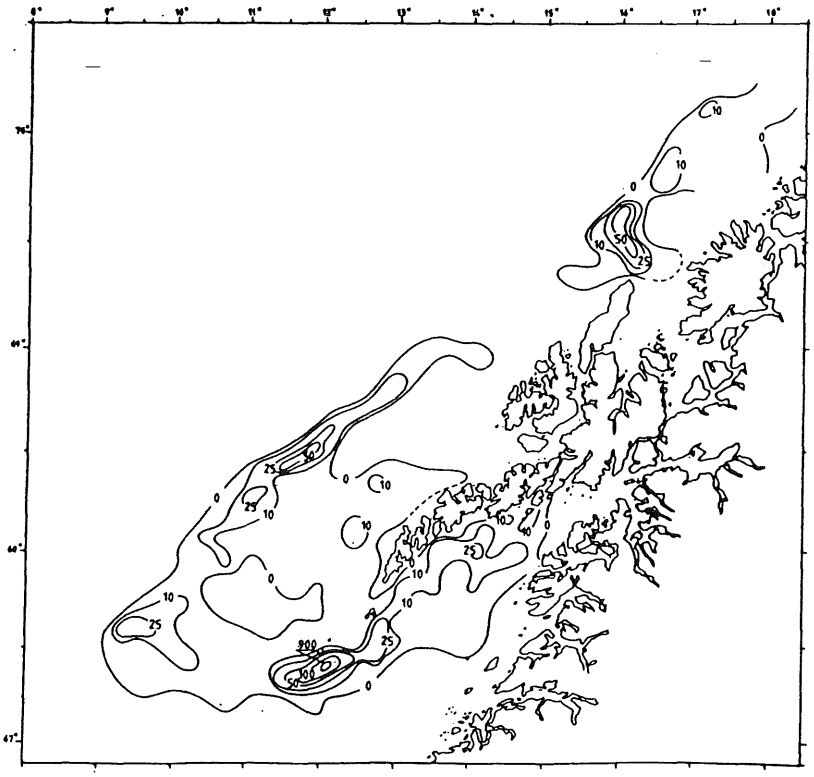


Fig. 4.6. Distribution of total echo abundance; cod and haddock. R/V "G. O. Sars" 8.-21.3.1988. Units are integrated back scattering surface per square nautical mile $(m/n.mile)^2$.