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PRELIMINARY REPORT OF THE NORWEGIAN INVESTIGATIONS ON YOUNG
COD AND HADDOCK IN THE BARENTS SEA DURING THE WINTER 1984

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 1984. The two surveys gave different results, both in absolute terms and when changes from the 1983 surveys are considered. The acoustic survey showed an average 1982 year class and a strong 1983 year class of cod, which is in good agreement with previous estimates. The estimates of the year classes 1979-1981 were increased. For haddock, the acoustic survey confirmed that the year classes 1982 and 1983 are strong, and the estimates of the year classes 1980 and 1981 increased. In the bottom trawl survey, the index of 1-year-old cod (1983 year class) is lower than in the acoustic survey. A decrease was observed in the indices of the 1979 year class of cod and the 1980 year class of haddock. Discrepancies with the 1983 survey results and the differences between the results from the acoustic and the bottom trawl surveys are discussed. Variation in the availability of different size groups of fish for the bottom trawl is a major factor.

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 arctic cod and haddock. The aim of the survey is to estimate the absolute number of cod and haddock within the survey area. The results from the acoustic surveys can be found in Dalen and Smedstad (1982) and in Dalen et al. (1982, 1983).

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 these surveys are reported by Dalen et al. (1982, 1983).

MATERIAL AND METHODS

The surveys in 1984 were carried out in the period 28 January to 9 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 "Vesttind" carried out the bottom trawl survey, which also includes 32 stations taken east of 35°E by "G.O.Sars". A total of 352 trawl stations were taken: 107, including 12 with pelagic trawl, by "G.O.Sars", and 245 by the commercial trawlers. In addition, 140 hydrographical stations (CTD) were taken by "G.O.Sars".

The Acoustic Survey

The acoustic survey was carried out as described in Dalen et al. (1982). A new echosounder (SIMRAD EK 400 - 38 kHz) replaced the older EK 38 S in 1983; otherwise the integration system was as in previous years. However, the echo abundance previously given in relative values is in 1984 calculated in absolute values. Calibrations on a standard target (Foote et al. 1981, 1982) gave an instrument constant = 0.83 and the value of C (integration conversion factor) for cod was scaled accordingly, the new value being

$$c = 3.13 \cdot 10^6 \cdot L^{-2.18} \quad (\text{in 1983: } c = 1.87 \cdot 10^6 \cdot L^{-2.18})$$

where L is the length of the fish in cm.

For haddock there are few measurements of target strength and some doubt has arisen concerning the validity of the C-value ($6.10 \cdot 10^6 \cdot L^{-1.69}$) used in 1983 and also of the value used in earlier years. However, the C-value for haddock is unlikely to differ very much from that of the cod. Therefore, in 1984 the C-value for cod which is well established from specific measurements (Foote 1979) was used also for haddock. This slightly increases the number of large haddock and decreases the number of small haddock compared with the C-values used earlier.

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

The Bottom Trawl Survey

Fig. 3 shows the stratified area, the four subareas for which abundance estimates are given, and the strata. A total of 271 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

Hydrography

Fig. 5 shows the temperatures at the surface, at 100 m depth and at the bottom. The temperatures in the Barents Sea in the winter 1984 were generally close to the ten-years-mean and 0.5-1.0⁰C lower than the abnormally high temperatures of the winter 1983. Observations from Norwegian research cruises and additional information from PINRO show the following development in the hydrography of the Barents Sea over the last two years: During the second half of 1982 and the first half of 1983 a rapid warming up of the Barents Sea took place, and in September-October 1983 the temperatures in large parts of the sea had reached a level 1.0-1.2⁰C higher than the ten-years-mean. In late autumn 1983 and in the winter 1984, this trend has been reversed by decreased influx of warm water masses and severe cooling.

Distribution of Cod and Haddock

Fig. 6 shows the distribution of the echo abundance of cod and haddock combined. This is the first year since 1978 that a significant abundance of either of these species have been observed east of $36-37^{\circ}\text{E}$ and the abundance in 1984 is due exclusively to the 1983 year class of cod. The broken line in Fig. 6 shows the approximate border between pure concentrations of 1-year-old cod and mixed concentrations of different age groups farther west.

The high echo abundance east of about 31°E along the Murman coast was due mainly to haddock of the year classes 1982 and 1983.

In the area west of about 34°E the distribution is split into a coastal and an offshore concentration. The fish in the offshore area were mainly young individuals which followed the western branch of the spawning migration of capelin.

The distribution of cod and haddock in 1984 was quite different from the distribution in 1983 when most of the young fish were found near the coast. In the western part of the area there is some resemblance to the distribution in 1982 with much of the fish found in the offshore areas. In the eastern part the conditions are more like those of the years 1976-1978 when the 1975 year class of cod was dominating.

Fig. 7 shows the echo abundance of cod and haddock in the 10 m depth interval above the bottom. Especially in coastal waters and in the western part of the area these values are high and make up a significant part of the total values shown in Fig. 6.

Acoustic Abundance Estimates

Cod

Table 2 gives the acoustic estimates of the number of cod of the different year classes in each subarea and in the total area. In contrast to 1983, the cod were most numerous in the offshore subareas A and D. Table 3 gives the acoustic abundance estimates for each age group from the surveys in 1977-1984. The total number of more than 3000 million individuals in 1984 is the highest recorded in the acoustic surveys in the period 1977-1984. The year classes 1983 (2400 millions) and 1982 (500 millions) make up nearly 90% of the total number. Both these year classes are concentrated chiefly in the eastern part of the area (subarea D) with the 1983 year class most to the east. The abundance indices for these two year classes on the whole confirm earlier results, i.e., the 1983 year class is very abundant and the 1982 year class about average.

The indices for 6 year and older fish are reduced from 1983, which is reasonable, both because the year classes have been reduced by fishing and because much of the cod reach sexual maturity at those ages and migrate out of the survey area in winter to spawn.

The indices for the age groups 3-5 (year classes 1979-1981) are all increased compared to the indices from the 1983 survey. This is not unusual for these age groups and has generally been explained by higher trawl efficiency for large and medium sized fish than for small fish. However, the increase from 1983 to 1984 was larger than expected. There are several factors which may have contributed to the increase. Three of the most likely are:

1. Fish from the 1982 year class have been included in the estimate of the 1981 year class.
2. Migration from the Bear Island - Spitsbergen area to the Barents Sea.
3. The efficiency of the trawl varies with the age (size) of the fish.

The preliminary age-length distribution from the survey is shown in Table 4. It seems that too much of the cod in the length group 15-19 cm have been classified as two year olds. There are differences in growth within the survey area and the age readings for this length group may not have been representative for the length group as a whole. It is also possible that there have been errors in the age readings. Although it is not so clearly indicated in the table, some two year old fish may also have been erroneously classified as three year olds, especially in the length group 30-34 cm. There is no clear indication that such errors have influenced the estimates of older age groups.

The age-length relationship will be given a more thorough examination when data from more recent surveys in the same area are available.

When PINRO in November-December 1983 carried out a trawl survey for cod in the Barents Sea and Spitsbergen area, relatively high concentrations were found south of Bear Island between 73°N and 74°N . This was mainly fish of 40-60 cm length and thus probably predominantly of the year classes 1979 and 1980. It is quite possible that the cod during the winter have migrated southwards and made up the concentrations which were found south of 73°N and west of the North Cape Bank in February. This fish has probably not been recorded in the Barents Sea winter surveys before 1984.

In 1984 the echo abundance of cod was much higher than in 1983 and the increase is due chiefly to the year classes 1982 and 1983. As previously mentioned, in the trawl catches the larger fish tend to be overrepresented relative to the smaller fish. Samples from the trawl catches are used to estimate the length frequency distribution of the fish recorded in the echo survey. The most conspicuous result of this is that the youngest year classes normally are clearly underestimated in the acoustic surveys. The combination of increased echo abundance, predominantly of young fish, and the biased length frequency distribution of the trawl samples, will have made this error, in absolute numbers, extra large in 1984. However, since the youngest year

classes are so much more numerous than the older ones in 1984, the error is most notable in the medium age groups because a large part of the echo abundance of the youngest year classes will have been attributed erroneously to older ones.

Haddock

Table 5 gives the acoustic estimates of the number of haddock of the different year classes in each subarea and in the total area. As for cod, the main concentrations have shifted from coastal areas (B,C) in 1983 to offshore areas (A,D) in 1984. Table 6 gives the acoustic abundance estimates for each age group from the surveys in 1977-1984. The total number in excess of 3000 million individuals is virtually the same as for cod and is the highest number recorded in the acoustic surveys. More than 97% come from the year classes 1982 (1000 millions) and 1983 (2100 millions). These results showing two strong year classes 1982 and 1983 and a very low abundance of older fish mainly confirm earlier observations.

Bottom Trawl Survey Indices

Cod

Figs. 8-14 show the distribution of cod of each age group in the bottom trawl survey. Table 7 gives the abundance indices from the trawl survey for each age group by subarea and total area. As for the echo abundance, the total indices are highest in the offshore areas A and D. However, in the bottom trawl survey this was the case also in 1983, although the difference in the indices between the coastal and offshore areas is much larger in 1984 than in 1983. The index for the year class 1983 is scaled down considerably compared to the results from the acoustic survey. This is linked with the low efficiency of the bottom trawl in catching small fish relative to larger fish, but the difference from the acoustic estimate is increased because a large part of the year class is found in pure concentrations in the eastern part of the area, and to a large extent

pelagically. Thus, all the echo abundance in this area is attributed to this year class, while the bottom trawl indices still will be too low.

Abundance indices from each of the trawl surveys 1981-1984 are given in Table 8. The indices for the older age groups show changes from 1983 which are more in line with what could be expected than the changes in the acoustic survey. Possible reasons for this discrepancy is discussed in the section on echo abundance. Errors in the age-length-key will have affected also the bottom trawl indices, but probably to a lesser extent than in the acoustic survey. The main results from the acoustic and the bottom trawl surveys can be summed up as showing a stock with the two youngest year classes average or strong and the rest of the year classes of immature fish poor.

Haddock

Figs. 15-20 show the distribution of haddock of each age group in the bottom trawl survey. Table 9 gives the abundance indices from the trawl survey for each age group by subarea and total area. The indices indicate an age distribution which is quite similar to the one from the acoustic survey, with two strong year classes of 1 and 2 year old fish and poor year classes of older fish. The better correspondence between the surveys for haddock than for cod is probably due to the fact that the 1983 year class of haddock was not found in pure concentrations but was mixed with older fish.

Abundance indices from each of the trawl surveys 1981-1984 are given in Table 10. Relative to 1983 the trawl survey in contrast to the acoustic survey shows a substantial decrease of the year classes 1979 and 1980. The reasons for this discrepancy are likely to be partly the same as those discussed in the section on cod, but in addition the very low abundance of the older year classes of haddock increases the chances that sampling errors may significantly affect the results.

Growth of the Cod

Table 11 shows the average length at age for cod in the surveys 1978-1984. The age groups 4-6 were clearly larger in 1984 than in the previous years. The same trend is not evident in the age groups 1-3, but it may be masked by the possible errors in the age-length relationship discussed earlier. Increased individual growth in the youngest year classes means that they will recruit to the fisheries earlier than previously anticipated.

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Table 1. Trawl hauls taken in the bottom trawl survey 1984.

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

Table 2. Cod. Acoustic abundance estimates for each age group/year class in the surveyed areas in 1984. (Numbers in millions).

AREA	Age (Year class)										TOTAL	
	1 (83)	2 (82)	3 (81)	4 (80)	5 (79)	6 (78)	7 (77)	8 (76)	9 (75)	10+ (74+)		
A	2	38	37	19	19	10	2	+	+	+	+	127
B	1	6	14	14	15	14	5	+	+	+	+	70
C	6	26	17	14	11	6	2	+	+	+	0	82
D	2373	436	105	33	18	17	7	1	+	+	0	2990
TOTAL	2382	506	174	80	63	46	16	1	+	+	+	3269
%	72.9	15.5	5.2	2.4	1.9	1.4	0.5	+	+	+	+	100.0

Table 3. Cod. Estimates of year class abundance from acoustic surveys in the period 1977-1984. (Numbers in millions).

Year of investigation	Year class										TOTAL				
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974					
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															
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	

Table 4. Cod. Provisional acoustic abundance estimates of each age and length group in the Barents Sea in 1984. (Numbers in millions).

Length (cm)	Age (years)								TOTAL	
	1	2	3	4	5	6	7	8		
5-9	23									23
10-14	1738									1738
15-19	620	106								726
20-24	1	79	3							83
25-29		162	7							169
30-34		151	76							227
35-39		5	65							70
40-44		1	12	13	1					27
45-49			8	34	1					43
50-54			3	27	19					49
55-59				5	22					28
60-64					13	12				25
65-69					5	21	1			27
70-74					1	9	9	1		21
75-79						2	4			6
≥80							2			2
TOTAL	2382	506	174	80	63	46	16	1		3269

Table 7. Cod. Abundance indices with confidence limits from the bottom trawl survey for each year class in the different areas in 1984.

AREA	Age (Year class)										TOTAL 1-10+	
	1 (83)	2 (82)	3 (81)	4 (80)	5 (79)	6 (78)	7 (77)	8 (76)	9 (75)	10+ (74+)		
A	1.5±	28.7±33.8	24.2±22.0	8.8±3.4	7.8±2.7	3.5±0.8	0.6±0.2	0.1±0.1	0.1±0.1	0	74.9±	59.4
B	0.1±	0.8±	0.3	1.8±0.5	2.2±0.7	2.0±1.0	0.8±0.6	0.1±0.1	0.1±0.1	0	9.8±	3.2
C	1.1±	6.0±	3.5	3.7±	1.4	3.0±1.7	1.6±0.6	0.6±0.2	0.1±0.1	+	19.6±	5.8
D	352.6±107.6	91.2±24.3	30.5±11.6	5.1±1.3	2.7±0.5	2.3±0.5	1.0±0.3	0.1±0.1	+	0	485.3±	195.9
TOTAL	355.3±187.3	126.6±41.7	60.2±25.0	19.2±3.9	15.6±3.1	9.4±1.3	3.0±0.9	0.4±0.1	0.2±0.1	+	589.6±	204.9
Z	60.3	21.5	10.2	3.3	2.6	1.6	0.5	0.1	+	+	100.0	

Table 8. Cod. Abundance indices for each year class from the bottom trawl surveys 1981-1984.

Year of investigation	Year class										Total		
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974		1973	1972+
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

Table 9. Haddock. Abundance indices with confidence limits from the bottom trawl survey for each year class in the different areas in 1984.

AREA	Age (Year class)							TOTAL 1-8+	
	1 (83)	2 (82)	3 (81)	4 (80)	5 (79)	6 (78)	7 (77)		8+ (76+)
A	120.3± 41.6	47.4± 22.6	0.3±0.1	0.1±0.1	0.2±0.1	+	+	0.1±0.1	168.5± 60.3
B	5.1± 1.7	5.7± 3.0	0.2±0.1	0.2±0.1	0.2±0.1	0.1±0.1	0.1±0.1	0.2±0.1	11.8± 4.1
C	40.9± 13.6	34.7± 16.6	5.1±3.3	0.5±0.1	0.3±0.1	0.1±0.1	0.1±0.1	0.1±0.1	81.6± 23.0
D	496.9±175.4	268.1±117.3	9.5±4.1	0.8±0.3	0.1±0.1	+	+	+	775.5±278.8
TOTAL	663.2±180.7	355.8±121.1	15.2±5.3	1.6±0.5	0.7±0.1	0.2±0.1	0.3±0.1	0.4±0.1	1037.4±286.5
Z	63.9	34.3	1.5	0.2	0.1	+	+	+	100.0

Table 10. Haddock. Abundance indices for each year class from the bottom trawl surveys 1981-1984.

Year of investigation	Year class								Total			
	1983	1982	1981	1980	1979	1978	1977	1976		1975	1974	1973
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

Table 11. Cod. Mean length for each age group from the acoustic surveys 1978-1984.

Year of investigation	Age (years)								
	1	2	3	4	5	6	7	8	9
1978	14.17	23.97	32.13	45.86	54.19	64.63	67.56	76.87	
1979	12.82	22.91	33.10	42.02	53.27	64.37	74.73	82.97	
1980	17.58	24.75	34.15	42.50	52.45	63.46	73.58	83.61	
1981	17.00	26.08	35.50	44.65	52.96	61.28	69.59	77.90	
1982	14.75	25.78	37.55	46.32	54.71	63.09	70.84	82.87	
1983		26.07	34.85	46.77	56.02	64.45	73.30	80.38	
1984*	13.76	26.24	35.79	49.23	57.89	67.39	74.60	82.20	89.98

*) Provisional data

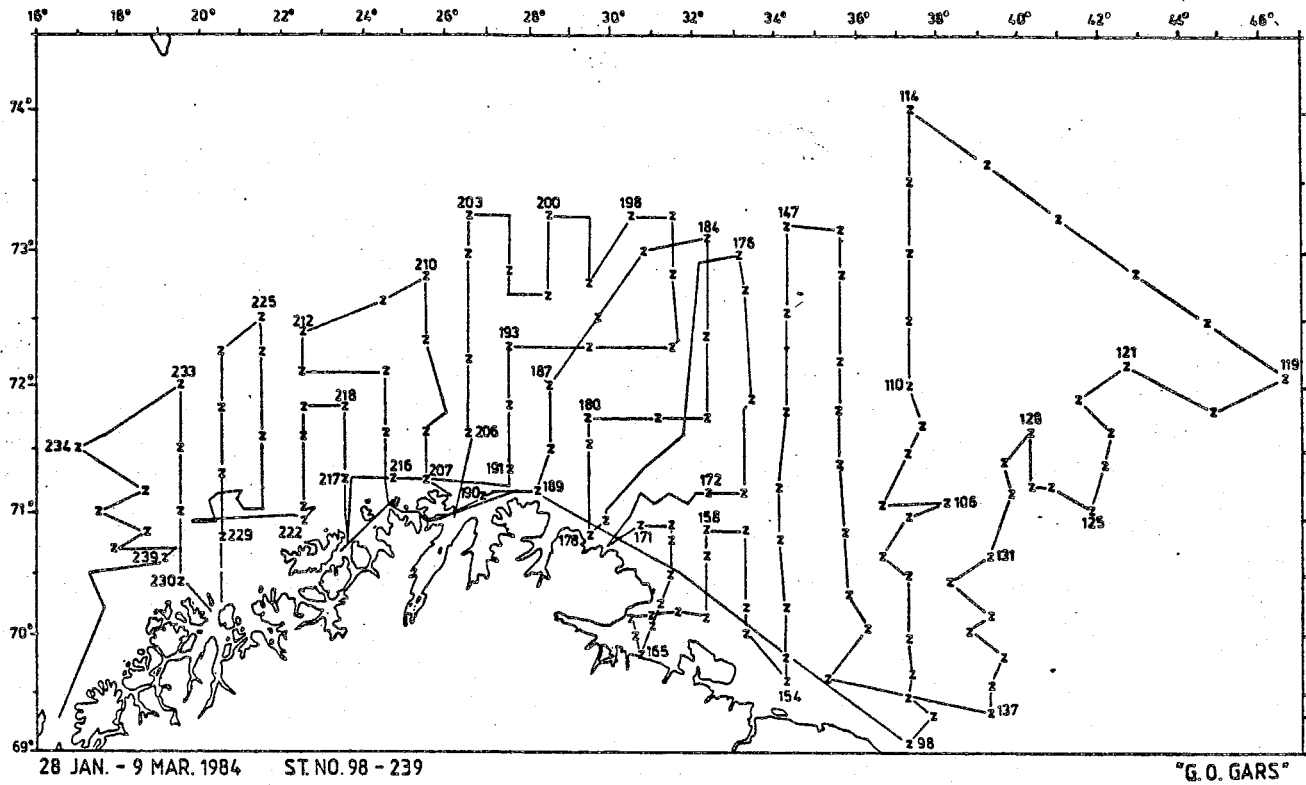


Fig. 1. Survey tracks and hydrographical stations taken by RV "G.O.Sars" 28.1.-9.3.1984.

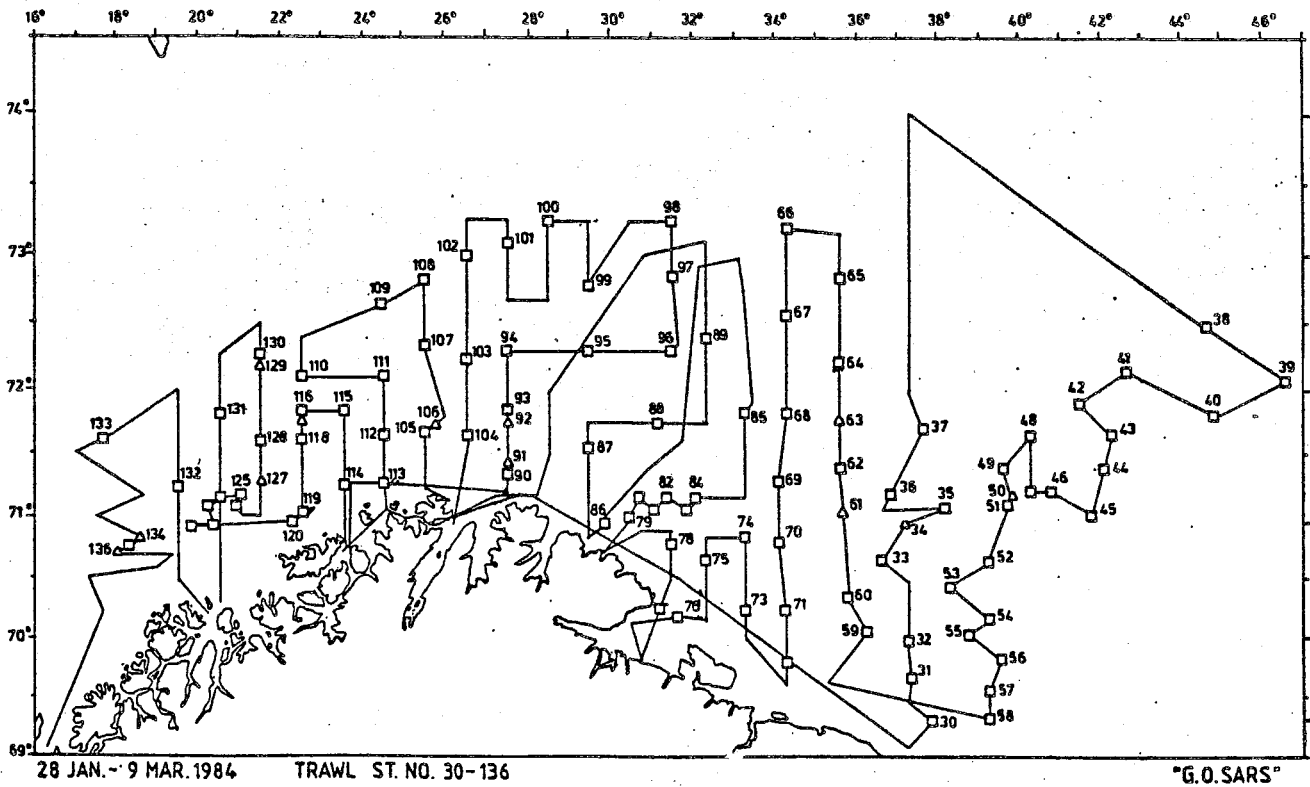


Fig. 2. Survey tracks and trawl stations taken by RV "G.O.Sars" 28.1.-9.3.1984. □ Bottom trawl. △ Pelagic trawl.

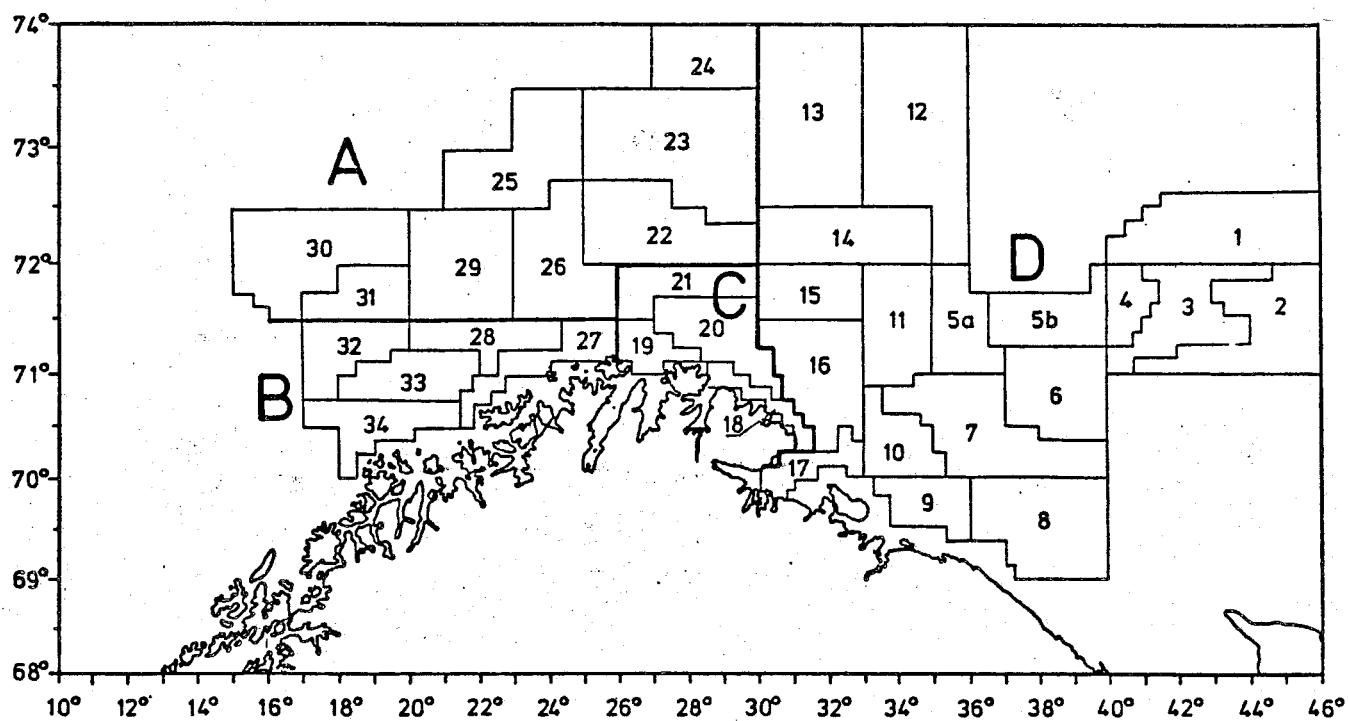


Fig. 3. The survey area with subareas (A, B, C, D) and strata used in the bottom trawl survey.

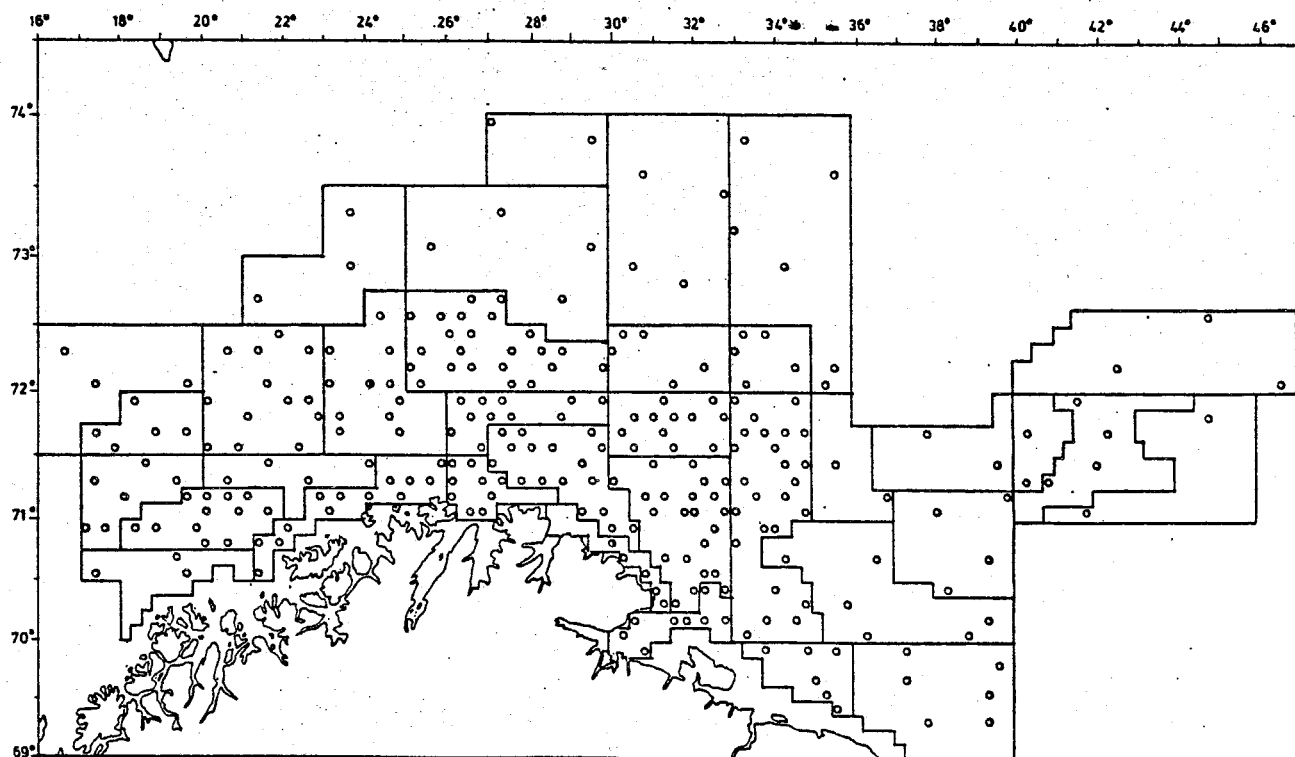


Fig. 4. Bottom trawl stations taken by MT "Masi" and MT "Vesttind" 30.1.-6.3.1984, and by RV "G.O.Sars" east of 35°E 28.1.-5.2.1984.

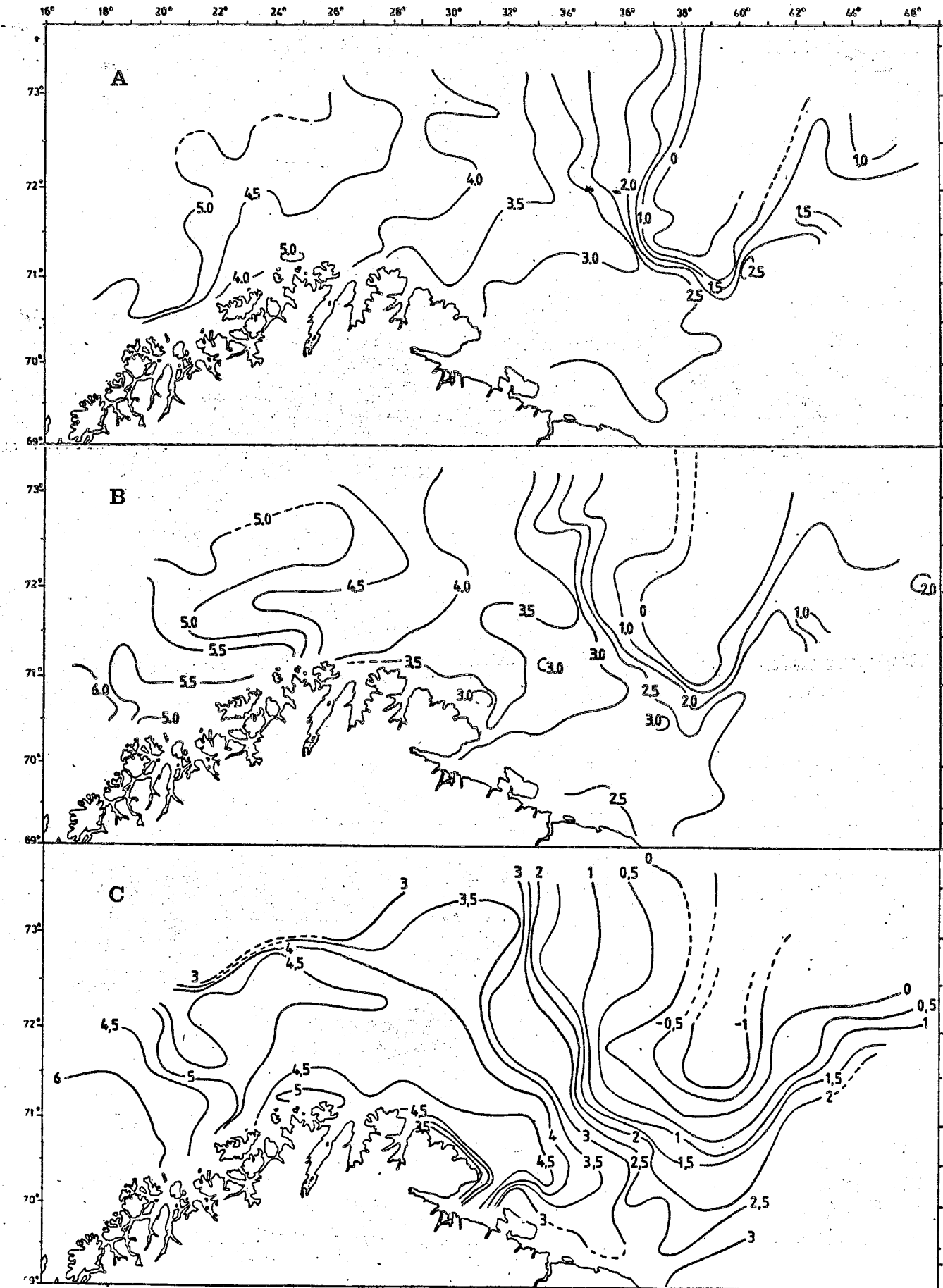


Fig. 5. Temperature distribution A) at the surface, B) at 100 m depth, C) at the bottom. RV "G.O.Sars" 28.1.-9.3.1984.

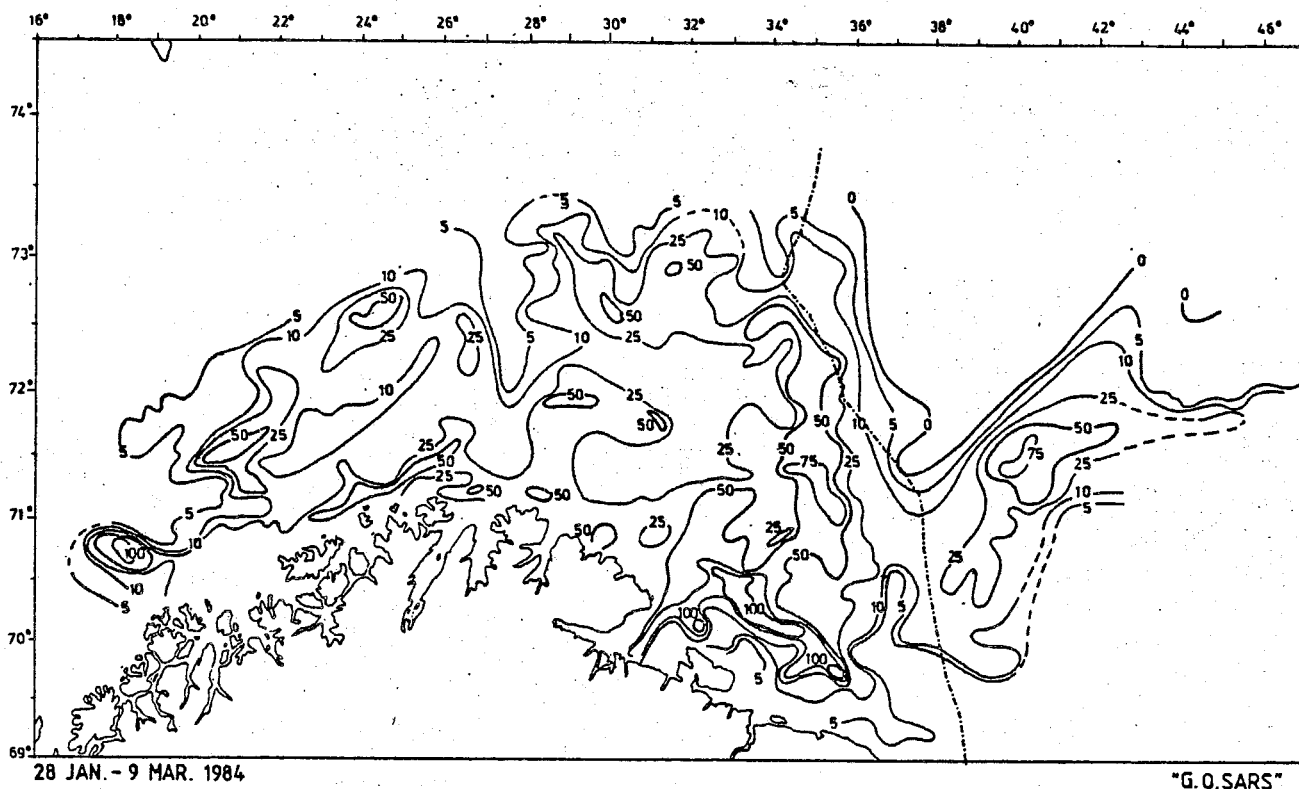


Fig. 6. Cod and haddock combined. Distribution of echo abundance. The values are absolute ($10 \cdot \text{m}^2/\text{n.m.}^2$; integrated backscattering cross-section per square nautical mile).

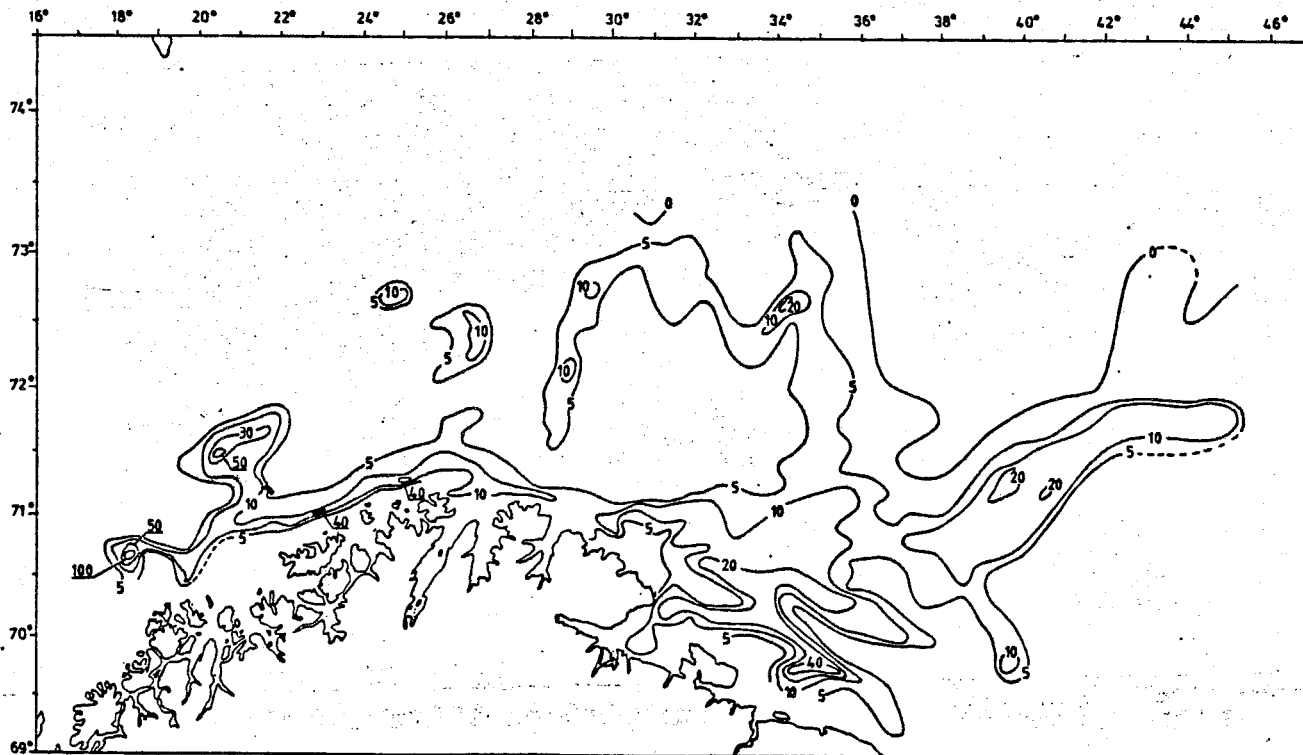


Fig. 7. Cod and haddock combined. Distribution of echo abundance in the 10 m interval above the bottom.

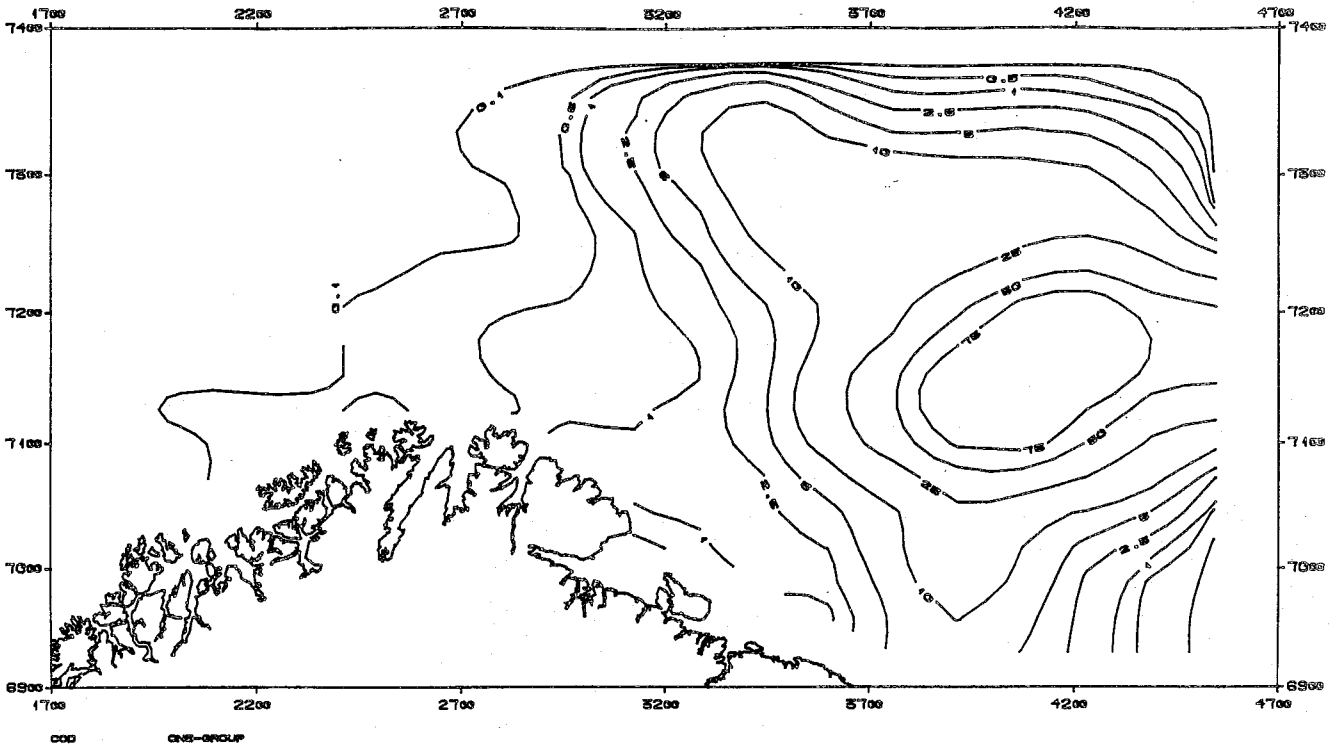


Fig. 8. The distribution of 1-year-old cod 30.1.-6.3.1984.
(1000 per square n.m.)

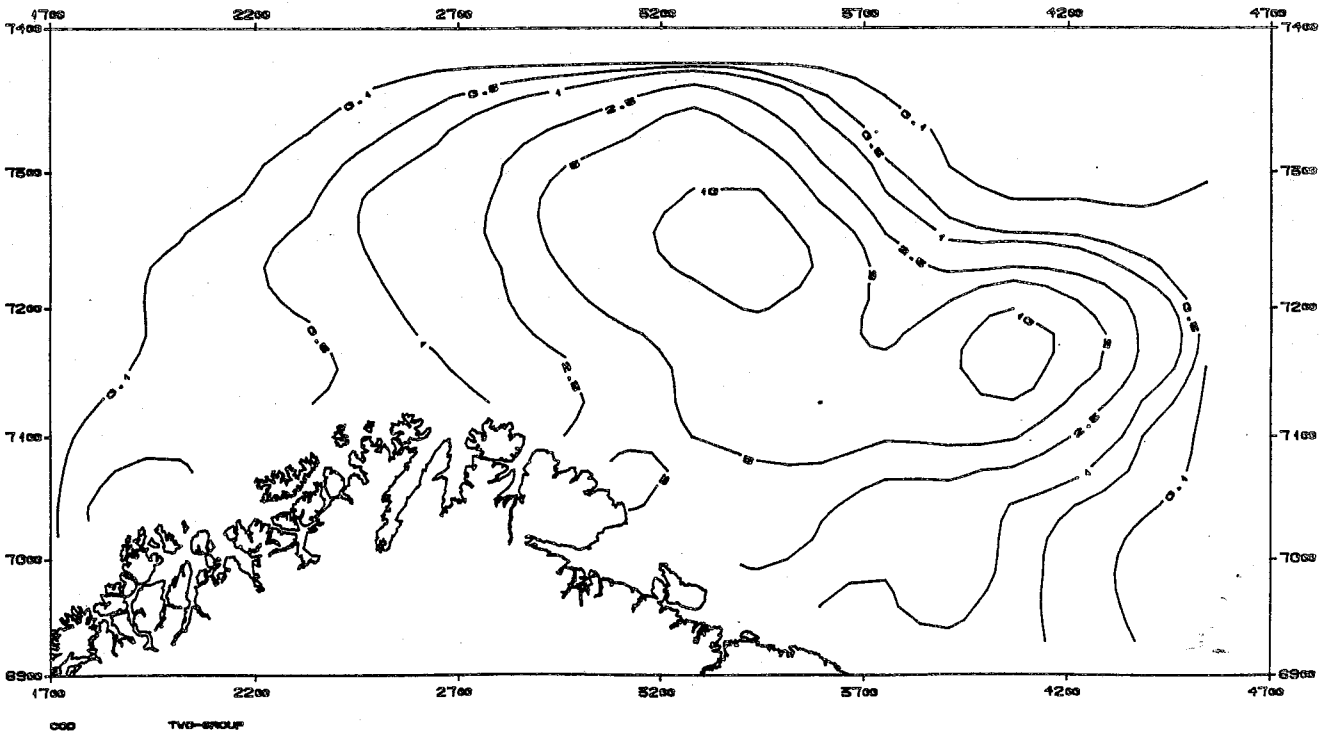


Fig. 9. The distribution of 2-year-old cod 30.1.-6.3.1984.
(1000 per square n.m.)

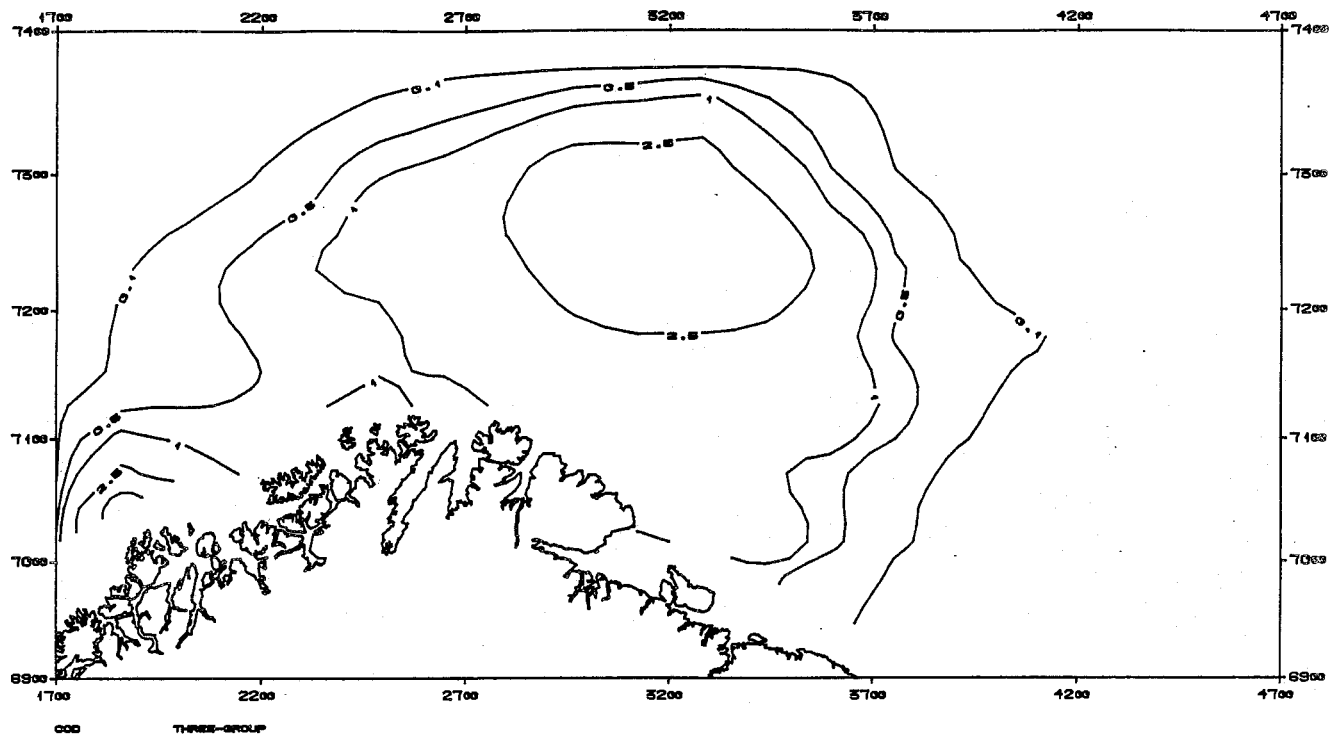


Fig. 10. The distribution of 3-year-old cod 30.1.-6.3.1984.
(1000 per square n.m.)

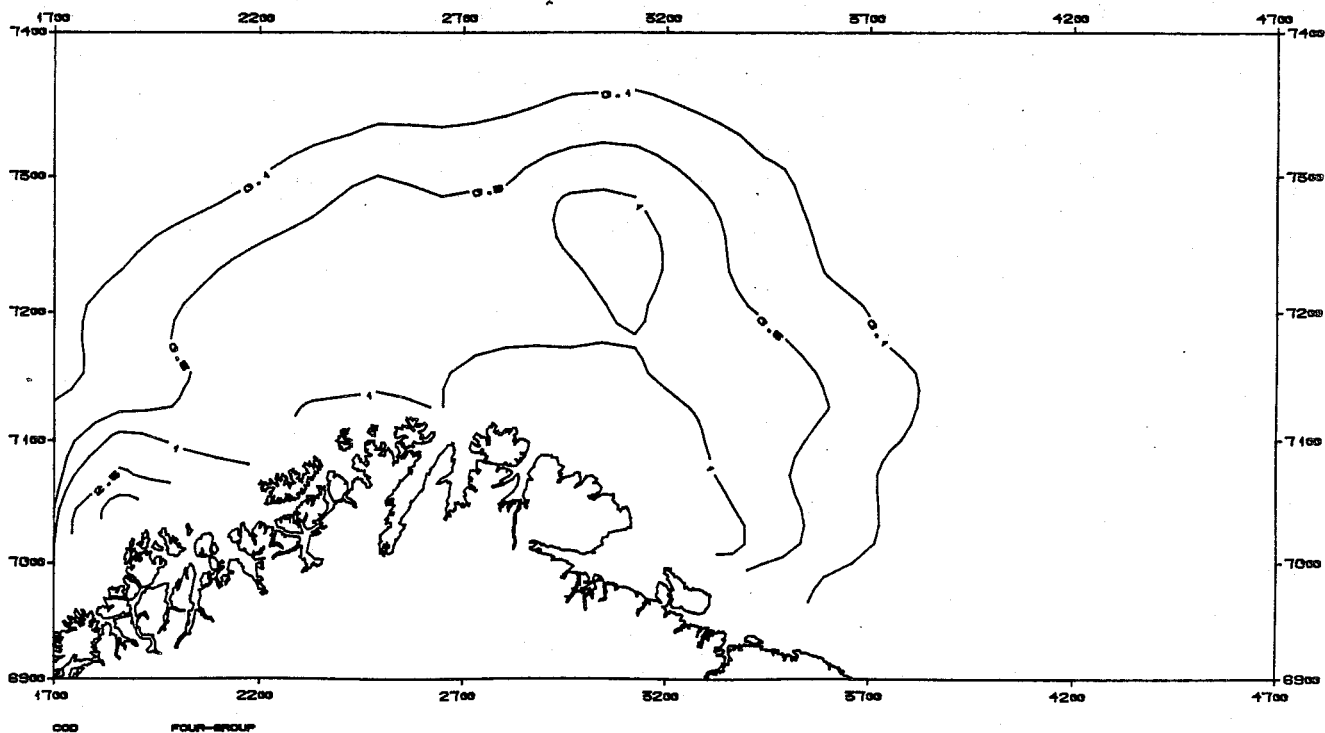


Fig. 11. The distribution of 4-year-old cod 30.1.-6.3.1984.
(1000 per square n.m.)

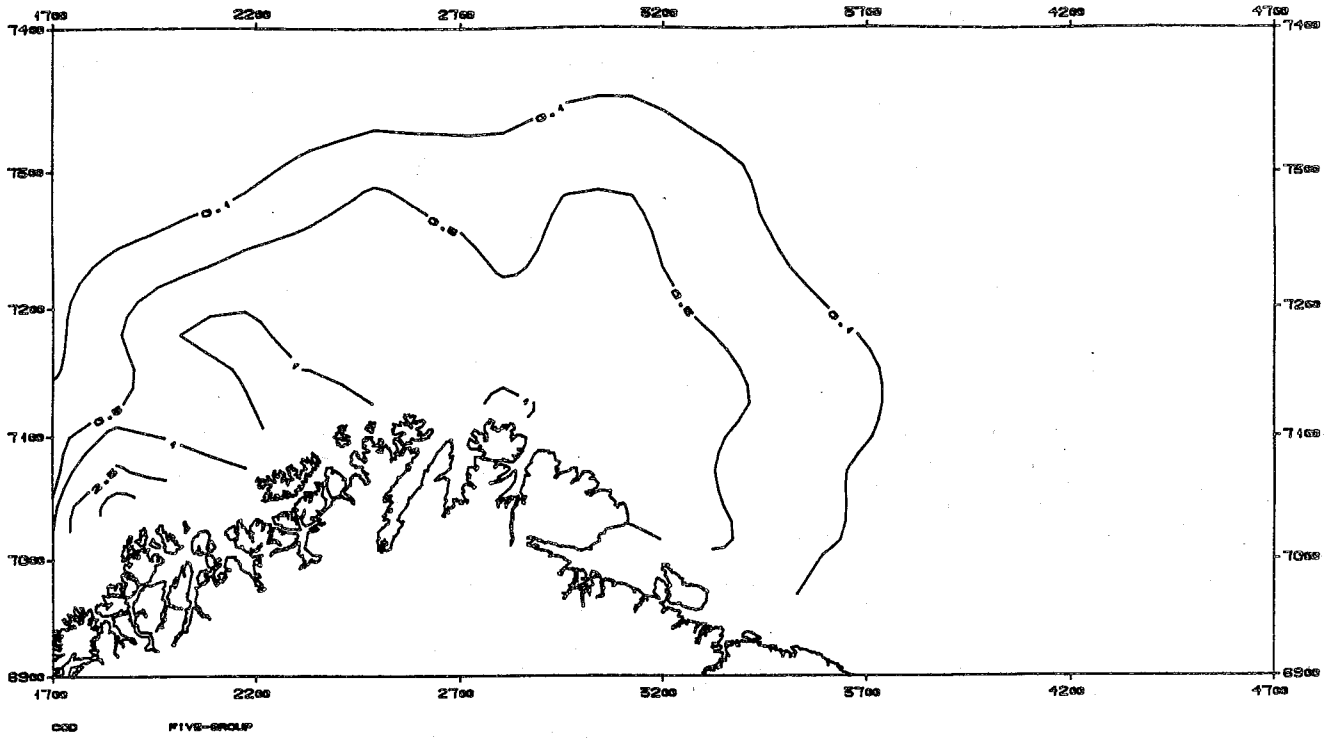


Fig. 12. The distribution of 5-year-old cod 30.1.-6.3.1984.
(1000 per square n.m.)

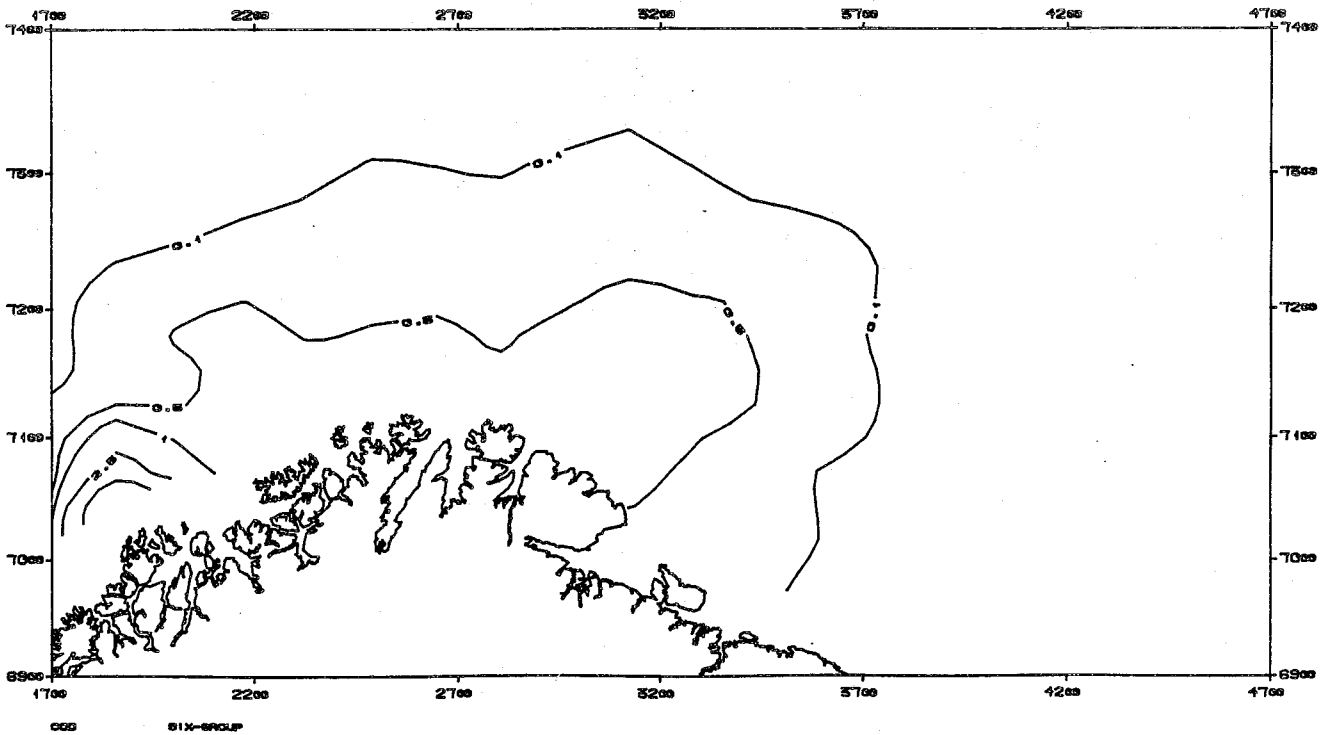


Fig. 13. The distribution of 6-year-old cod 30.1.-6.3.1984.
(1000 per square n.m.)

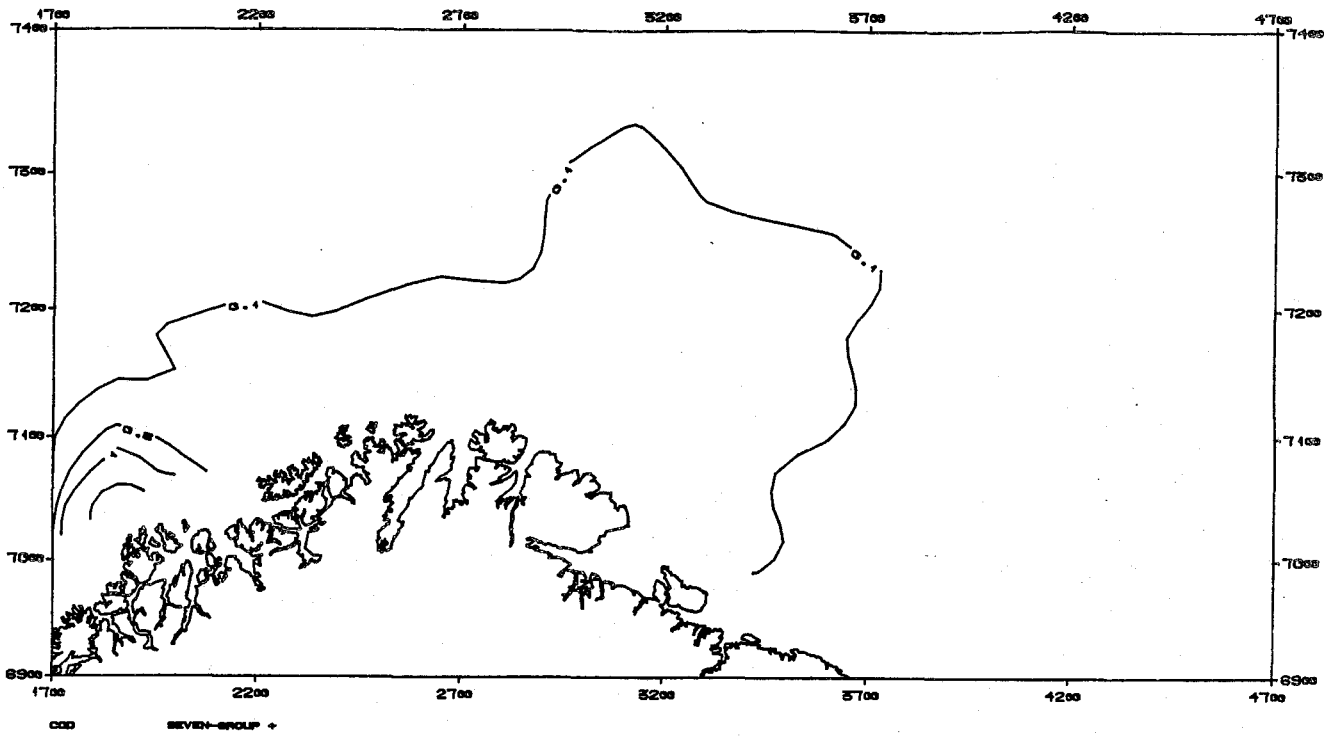


Fig. 14. The distribution of 7-year-old and older cod
30.1.-6.3.1984. (1000 per square n.m.)

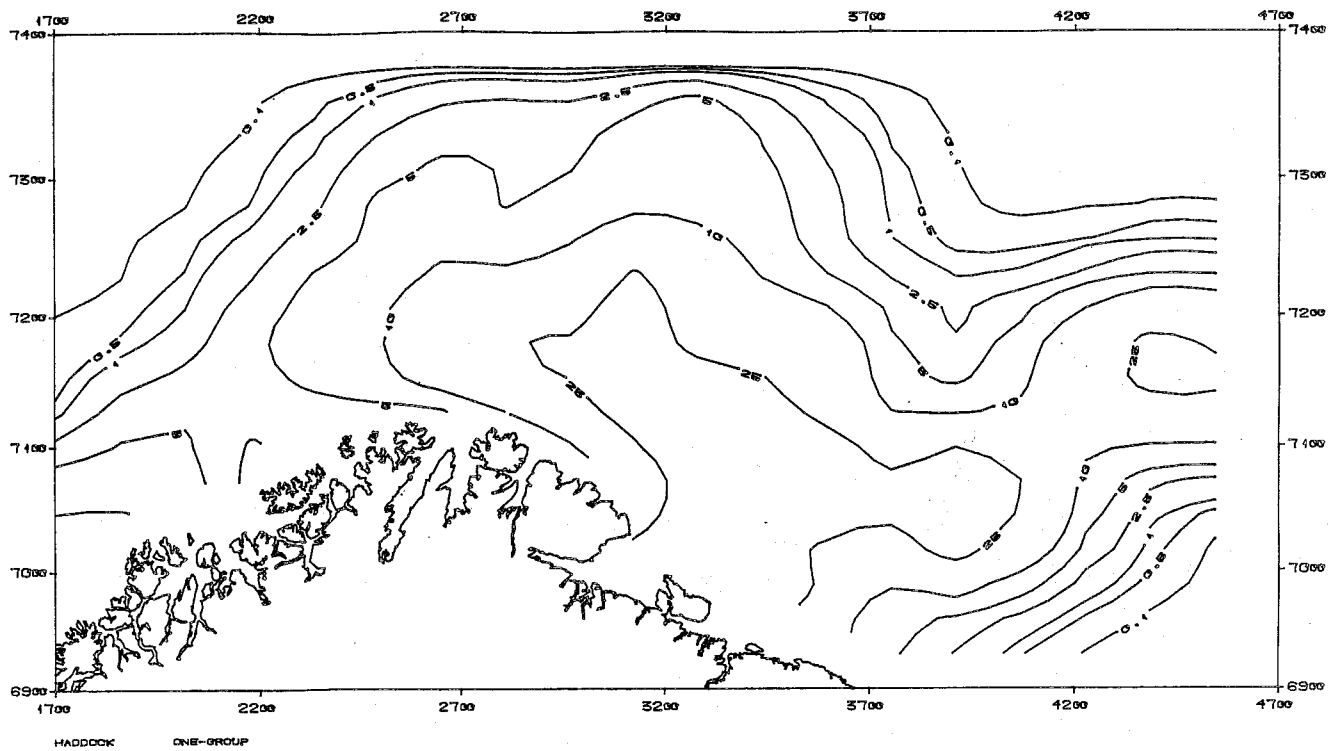


Fig. 15. The distribution of 1-year-old haddock 30.1.-6.3.1984.
(1000 per square n.m.)

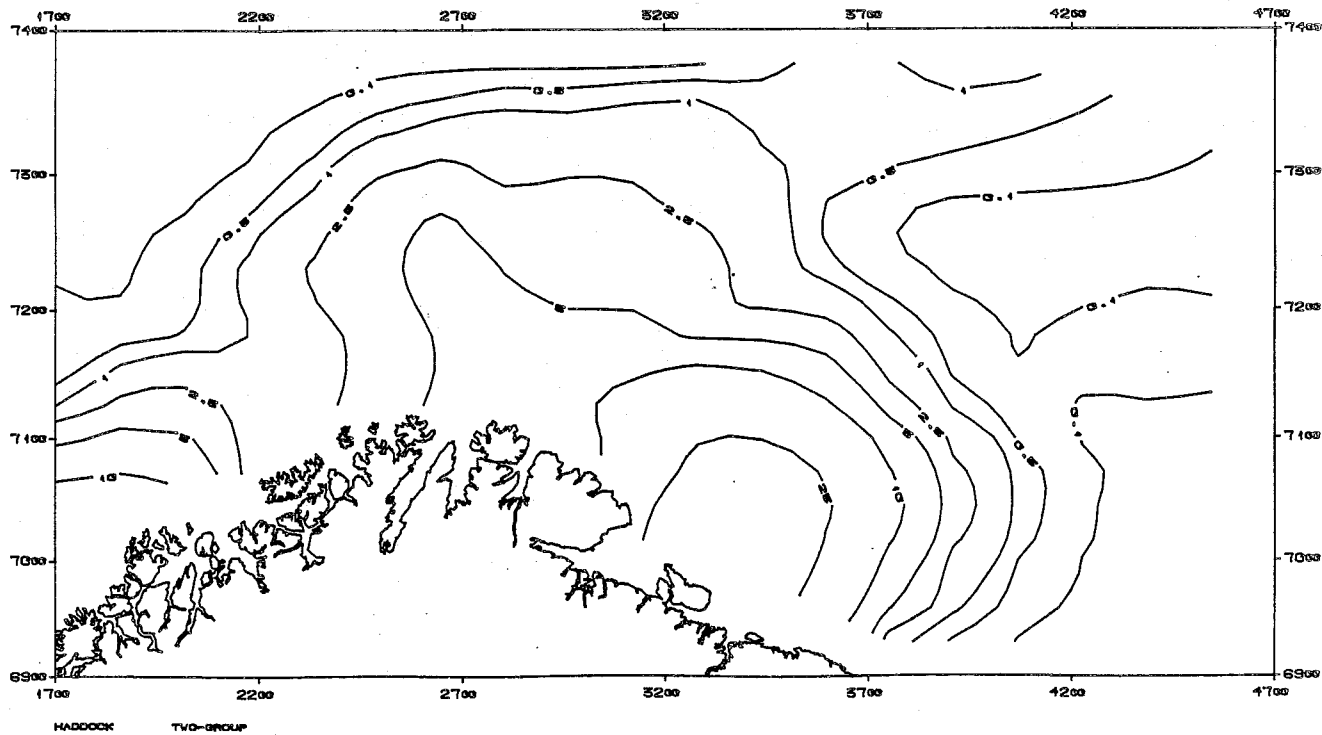


Fig. 16. The distribution of 2-year-old haddock 30.1.-6.3.1984.
(1000 per square n.m.)

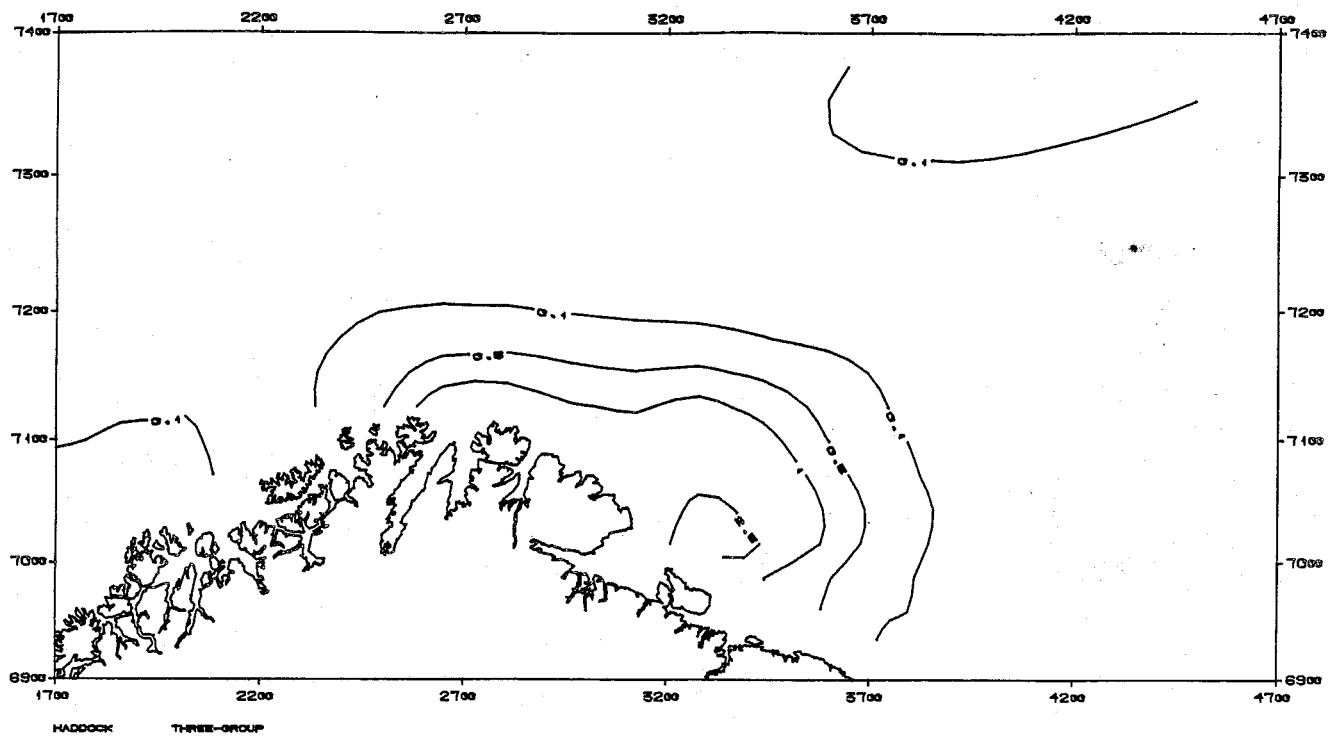


Fig. 17. The distribution of 3-year-old haddock 30.1.-6.3.1984.
(1000 per square n.m.)

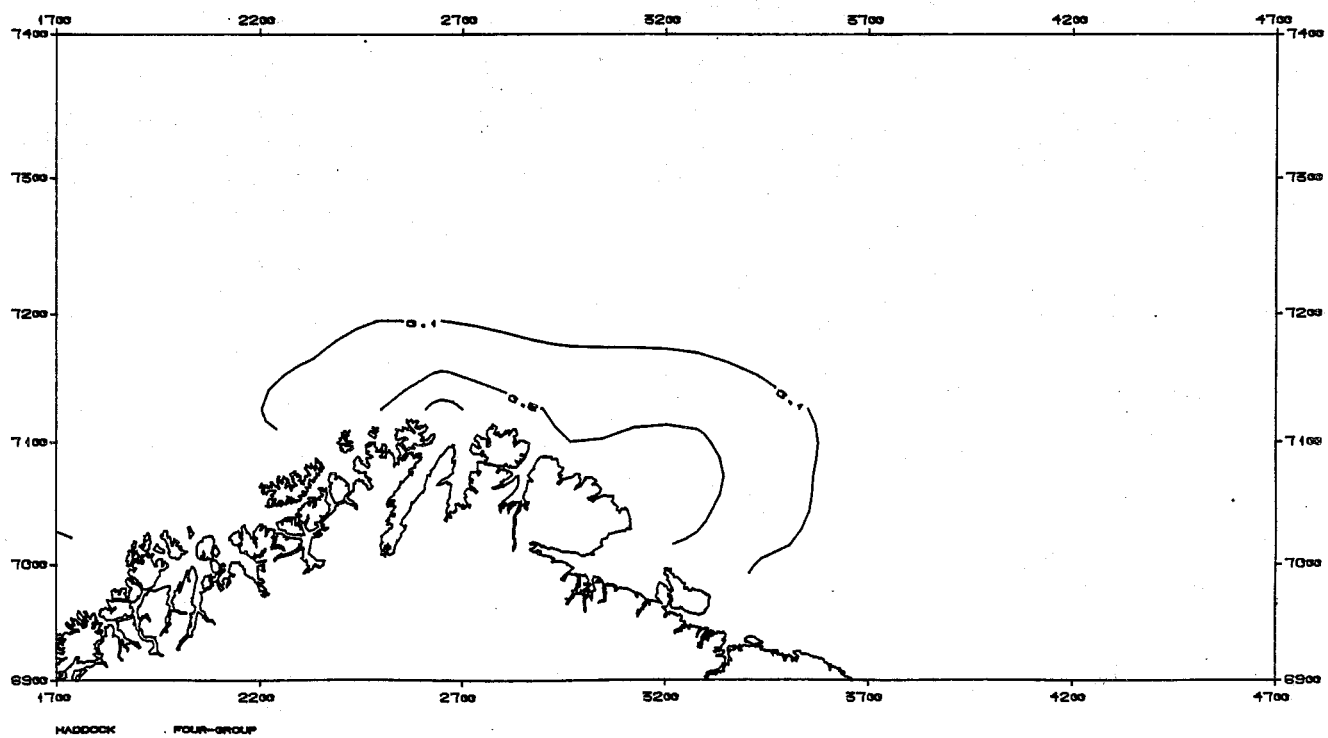


Fig. 18. The distribution of 4-year-old haddock 30.1.-6.3.1984.
(1000 per square n.m.)

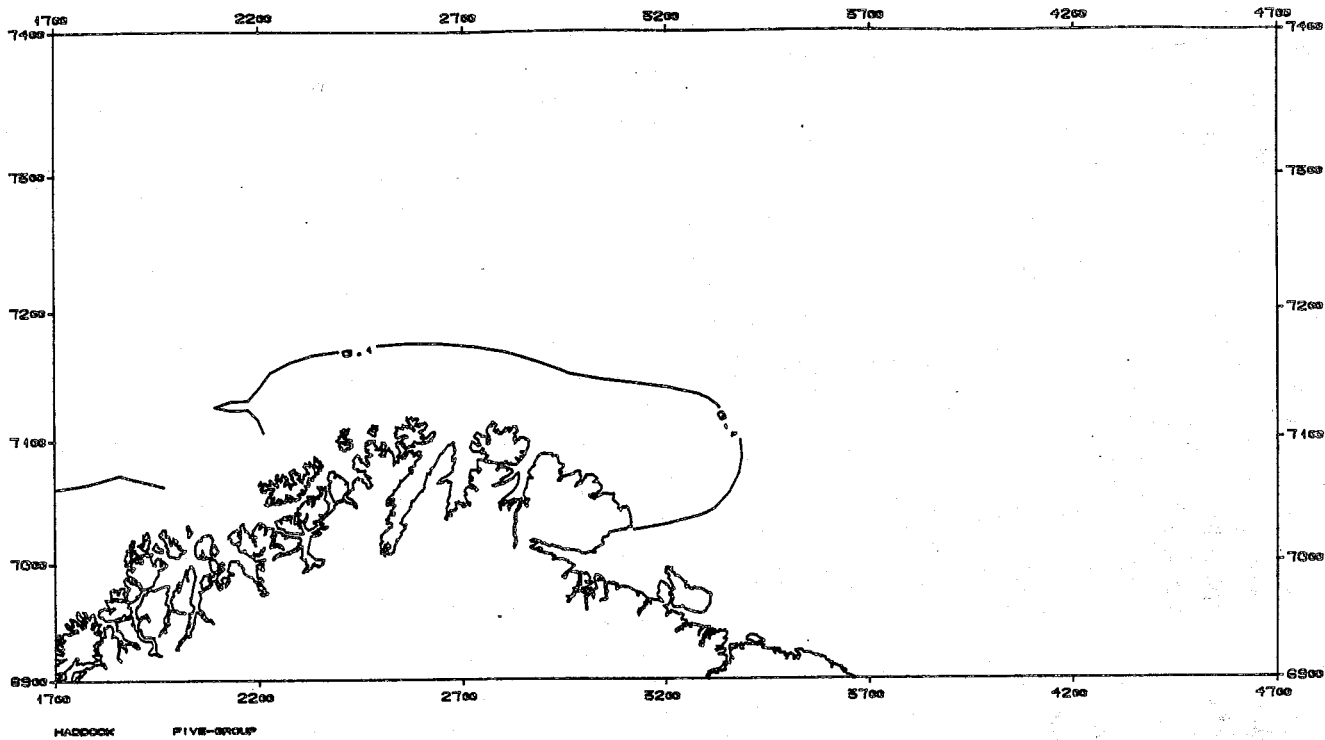


Fig. 19. The distribution of 5-year-old haddock 30.1.-6.3.1984.
(1000 per square n.m.)

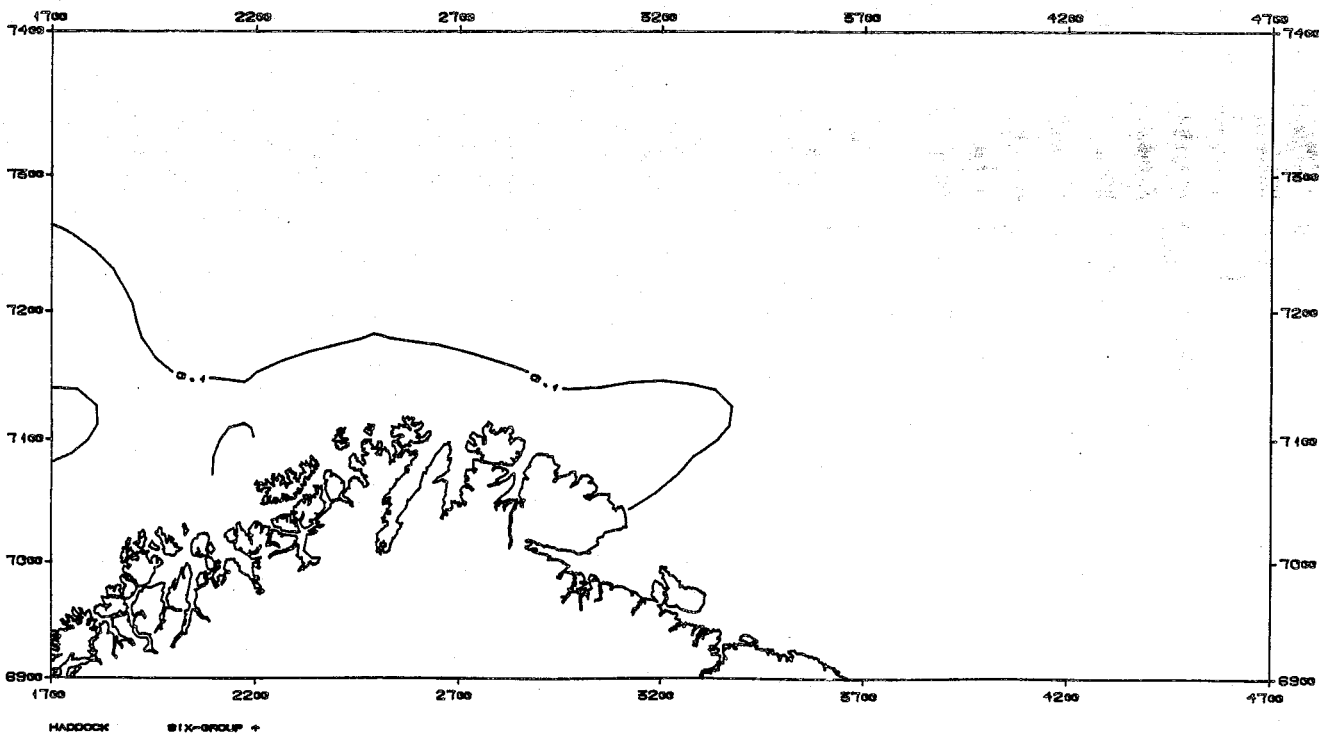


Fig. 20. The distribution of 6-year-old and older haddock
30.1.-6.3.1984. (1000 per square n.m.)