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ACOUSTIC ESTIMATES OF SPAWNING COD
OFF LOFOTEN AND MØRE IN 1985

by

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ABSTRACT

The annual surveys on the spawning stock of North-east Arctic cod were carried out in the Lofoten and Møre areas in March - April 1985. These surveys were undertaken to estimate the size and age structure of the spawning cod on the main spawning grounds. The area used in the estimation this year is somewhat larger than previous years, including a larger part of the area north of Lofoten. The estimated number of spawning cod in the same area as previous years was found to be about 32 million specimens with the addition of about 5 million in the area north of Lofoten. This is a reduction of 15 - 20 percent compared to the result in 1984. No estimate is given for the Møre area because of bad weather conditions during survey. However it is clear that the abundance of cod at Møre is far less than in 1984.

INTRODUCTION

Since 1982 the areas off Lofoten and Møre have been surveyed in the spawning period of North-east Arctic cod to get an estimate of the actual number of cod present at the major spawning grounds. Additional areas have been included in the investigations some years, e.g.

Helgeland. A description of the survey design have been given by Godø et al. (1982, 1983, 1984) together with the results of the respective years. The results of these investigations are used to assess the total spawning stock of the North-east Arctic cod (Hyllen and Nakken, 1982, 1983, 1984). In this paper the results from the surveys in 1985 are reported and discussed.

MATERIAL AND METHODS

The two areas investigated by the surveys are shown in Fig. 1 together with indications of major spawning grounds found along the Norwegian coast.

The survey design and area covering were mainly as in previous years. The area north of Lofoten (Sub area 5, Vesterålen - Troms) was covered more extensive this year. This sub area is limited by $68^{\circ}50'N$ and $19^{\circ}E$. The division of the other subareas is given in Fig. 3 for the Lofoten area. The Lofoten area was covered from 10. March to 15. April and the Møre area was covered from 26. March to 3. April.

In Table 1 is given the time table of the coverings of the various sub areas and the vessels used in the different surveys.

All the vessels used in the Lofoten surveys were equipped with 38kHz echosounders of type Simrad (EK-S, EK-A and EK-400) connected to a digital echointegration system developed at the Institute of Marine research, Bergen (Blindheim et al. 1982). The vessel "Håkon Mosby" used an echo integrator of type Simrad QD in connection to a 38kHz Simrad EK400. The acoustic systems were calibrated according to the method described by Foote et al. (1983) and the survey design and data sampling were as described by Godø et al. (1982, 1983).

The target strength (TS) of cod used to convert echo density to number of fish per area was set to $TS = 10 \log (\sigma/4\pi) = 21.8 \log L - 74.9$ where L is the length of the fish and σ is the back scattering surface of a single fish of that length.

RESULTS AND DISCUSSION

In Figures 2 and 3 are given some of the course lines from the surveys in the Lofoten area.

In Table 1 is shown the area covering of the various surveys. In this table is also indicated whether or not the covering of the area is assumed to be sufficient to give a proper estimate of cod abundance. In the Lofoten area the first and the fourth covering were the best ones. Sub area 5 is not assumed to be sufficiently covered, but estimates are given to indicate that mature cod is present in this area. The estimates in this subarea are therefore underestimates.

The Møre area was not covered sufficiently this year because of very bad weather in the period.

Lofoten

In Figures 4 to 10 is shown the distribution of acoustic abundance of cod measured in the various surveys. The length distributions obtained by trawling are given in Table 2. The percentage of mature fishes is given in sub area 5 and is used to extract the mature fishes from the estimated total number in this area. In the other sub areas all the cod were found to be mature. In Table 3 is given the corresponding estimated number of cod in each area.

The first covering is assumed to give a good estimate of the cod present in the area. The second covering of the inner part of Vestfjorden (sub area 1) does not include the waters close to the coast and some of the fjords with known spawning sites. Because of this the estimate of cod is too low in this sub area, but is assumed to be good in sub area 2.

The third covering is also assumed to be sufficient in all areas, but the high estimate of cod in area 4b is probably caused by the inclusion of saithe in the cod group while judging the echo values. This "misjudging" occurs when trawl catches are not available to give the relative abundance of saithe and cod. The sub areas 1 and 2

show almost equal abundance as in covering no 1.

In covering no 4 it is clear that there is less cod in the inner part of Vestfjorden (sub area 1) and more cod in the outer part of Vestfjorden (sub area 2) and on Røstbanken (sub area 4). This indicates that the migration out of the area is more dominant. It seems, however, that the larger part of the cod is still present within the investigated area.

For sub area 5 two estimates are given and both are more inaccurate than the estimates of the other areas. They do, however, indicate that some amount of spawning cod is found in the areas north of Lofoten.

Based on a judgement of these estimates and the age readings available, an estimate of the spawning cod present in the area during the spawning period is given in Table 4. The age readings are obtained from the same trawl stations that gave the length distributions.

As in previous years (Hysten and Nakken 1982, 1984, 1984) the estimates of spawning cod made from these surveys are not the total spawning stock of North-east Arctic cod. This is because the cod spawns over a larger area than these surveys cover.

Møre

The cruise lines and the distribution of echo abundance of cod, haddock and to some extent saithe is shown in Figure 11 and 12. Cod was most prominent in the small patches of recordings near the coast (based on results from our trawl catches and commercial catches). Compared to previous years results a marked decrease of the cod abundance is indicated based on a comparison of the distribution maps from the two years. In 1984 an estimate of the cod abundance was given, but it was stressed to be unreliable because of the technical difficulties of recording low fish densities in under rough bottom conditions. In 1985 a further decrease of the cod abundance is indicated. In addition the weather conditions were rough and unfavourable for acoustic recording and the area coverage bad because

of the same reason. An estimated figure is consequently not presented, but the abundance is assumed to be lower than ⁱⁿ previous year (2.1 million indiv.) and thus the lowest obtained in this area since these investigations started.

FINAL REMARKS

Based on the surveys treated in this paper a final estimate of the spawning stock will be performed as a part of the work using the results from all the surveys on North-east Arctic cod and haddock to assess the total stock of these species. These results will be presented in another paper (Hysten and Nakken, 1985).

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Table 1. Area covering during various cruises in Lofoten and Møre.
 + is sufficiently covered, - is insufficiently covered.

Ships	Period	Subarea					
		1	2	3	4a	4b	5
LOFOTEN							
G.O.Sars	Mar.10-16	+	+	+	+	+	
G.O.Sars	Mar.16-19	-	+				
Eldjarn and M.Sars	Mar.21-30	+	(-)	+	-	+	-
M.Sars and G.O.Sars	Apr. 3-16	+	+	+	+	+	-
J. Ruud	Apr.10-12	+					
MØRE							
Håkon Mosby	Mar.26-Apr.3		1	2	3	4	
			-	-	-		

Table 2. Length distributions used in acoustic estimation and percentage of mature fishes in area 5. (All fish in area 1-4 are mature)

Length cm	40	45	50	55	60	65	70	75	80	85	90	95	100	Number
	-44	-49	-54	-59	-64	-69	-74	-79	-84	-89	-94	-99	>	measured

LOFOTEN 10. march - 12. April

Area 1-2	0.2	0.5	1.9	2.4	7.7	12.8	14.1	19.1	13.8	9.6	5.8	5.3	6.4	337
Area 3-4			1.5	1.0	6.3	11.1	21.2	17.9	14.5	8.4	5.3	3.7	5.7	196

LOFOTEN 21.March - 30. March

Area 5	2.8	9.3	16.4	9.3	15.7	12.1	18.6	5.7	7.1	1.4			1.4	54
% mature					36	75	100	100	100	100			100	

LOFOTEN 6.april - 16. april

Area 5	5.7	19.4	30.4	19.8	12.4	5.5	3.3	3.3						93
% mature					12	0	50	50						

Table 3. Estimated number of cod in the different areas and periodes.
Numbers are in million specimens.

Period	Subarea						Total
	1	2	3	4a	4b	5	
LOFOTEN							
Mar. 10-16	17.9	3.8	1.3	3.4	5.7		32.1
Mar. 16-19	9.1	3.8					
Mar. 21-30	15.8	2.6	0.7	1.3	21.4	5.2	47.0
Apr. 3-16	8.9	6.3	2.3	1.6	14.7	3.4	37.2
Apr. 10-12	4.6						

Table 4. Estimated number at age for the various areas. Numbers are in million specimens.

Area	Age							Total
	4	5	6	7	8	9	10+	
1	0.22	1.79	5.04	6.31	1.40	2.21	0.81	17.8
2	0.14	0.38	1.06	1.33	0.30	0.47	0.17	3.9
3	0.02	0.04	0.39	0.57	0.16	0.11	0.04	1.3
4	0.14	0.30	2.74	3.93	1.06	0.76	0.24	9.2
5		0.23	2.87	2.11	0.20	0.17		5.6
Age								
total	0.52	2.74	12.10	14.25	3.12	3.72	1.26	37.7

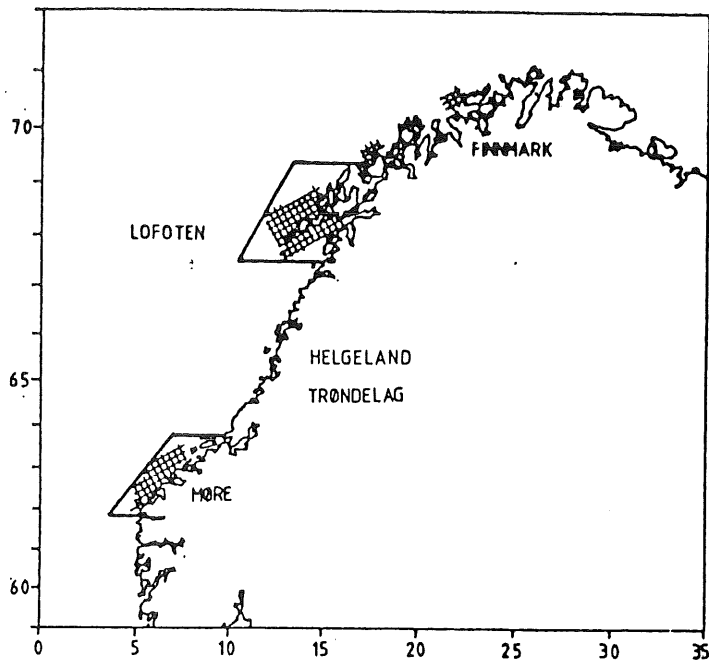


Figure 1. The Norwegian coast. Investigation areas are framed. Spawning grounds of north-east arctic cod are indicated by hatching.

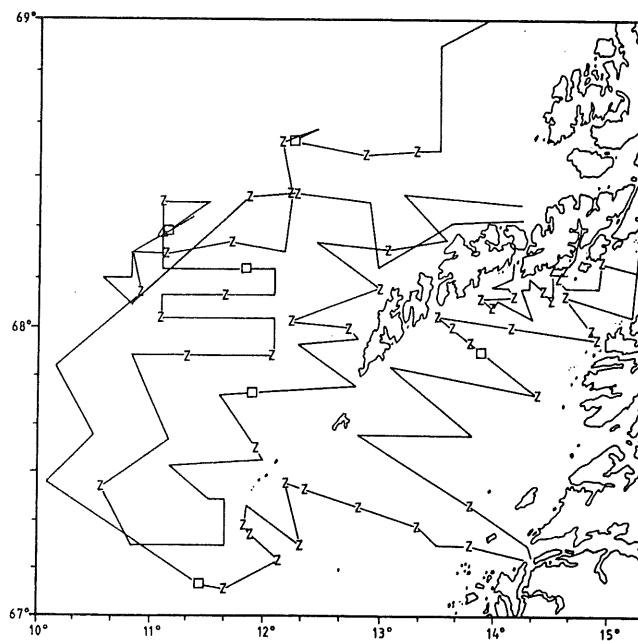


Figure 2. Course lines from the cruise with R/V G.O.Sars 10. to 16. March 1985 in the Lofoten area.

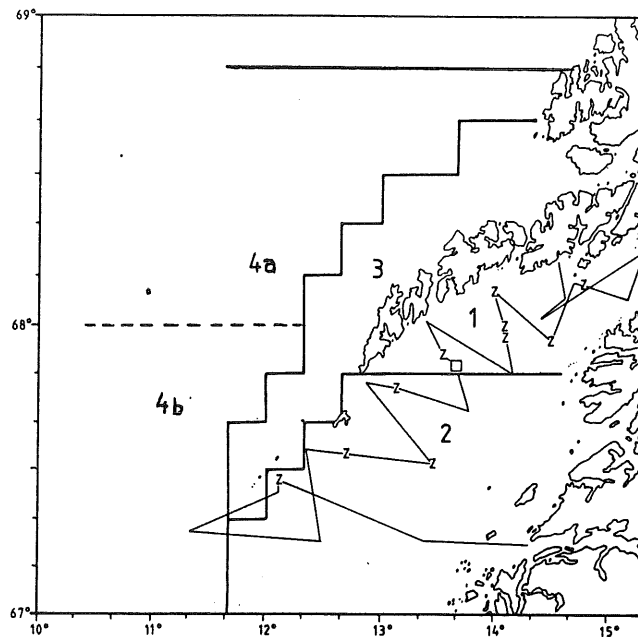


Figure 3. Course lines from the cruise with R/V G.O.Sars 17. to 19. March 1985 in the Lofoten area. The sub area division is indicated.

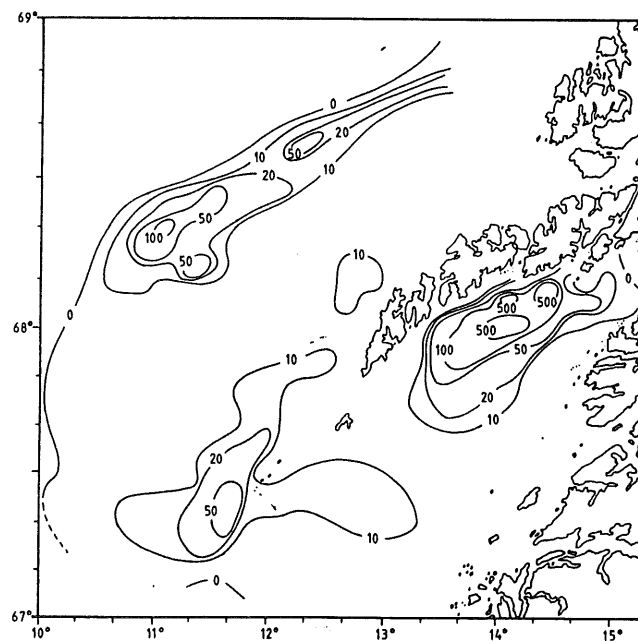


Figure 4. Distribution of cod in the Lofoten area measured with acoustic methods by R/V G.O.Sars 10.- 16. March 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).

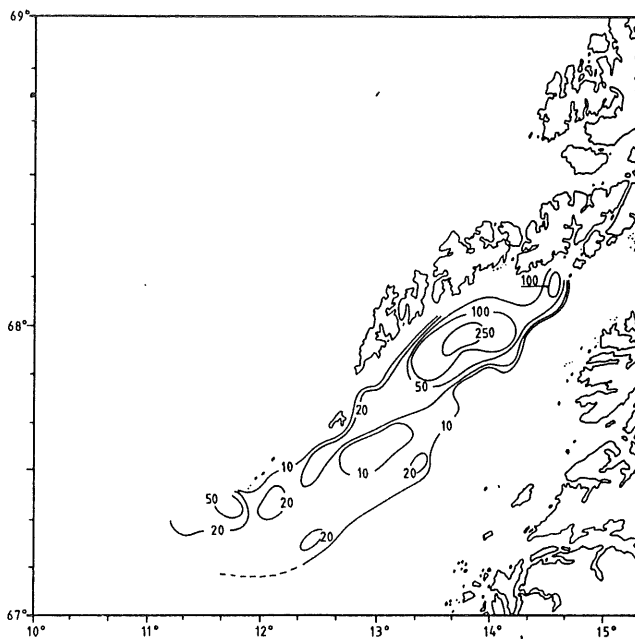


Figure 5. Distribution of cod in the Lofoten area measured with acoustic methods by R/V G.O.Sars 17.- 19. March 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).

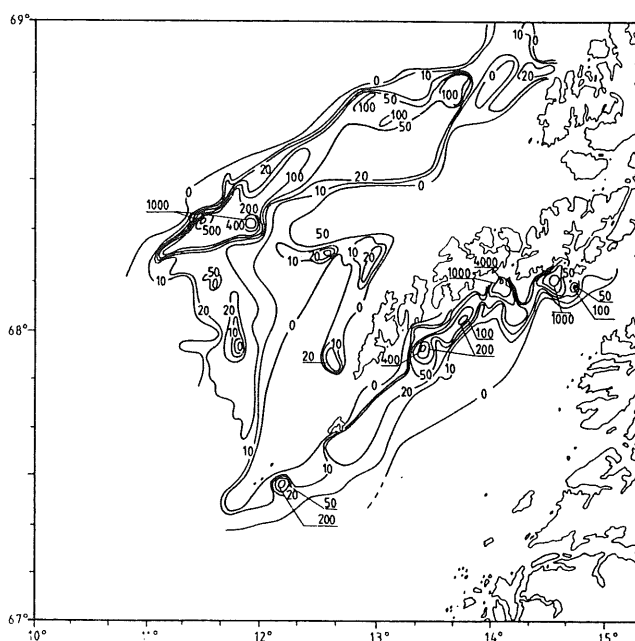


Figure 6. Distribution of cod in the Lofoten area measured with acoustic methods by R/V Eldjarn and R/V Michael Sars 25.- 30. March 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).

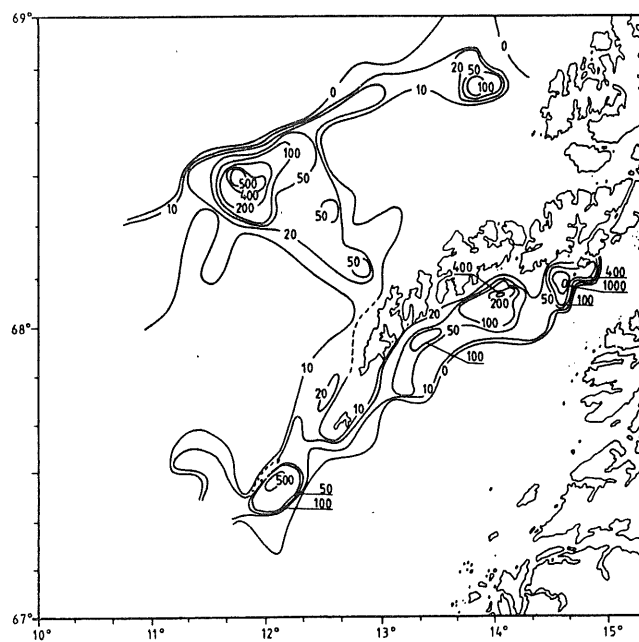


Figure 7. Distribution of cod in the Lofoten area measured with acoustic methods by R/V G.O.Sars and R/V Michael Sars 3.- 6. April 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).

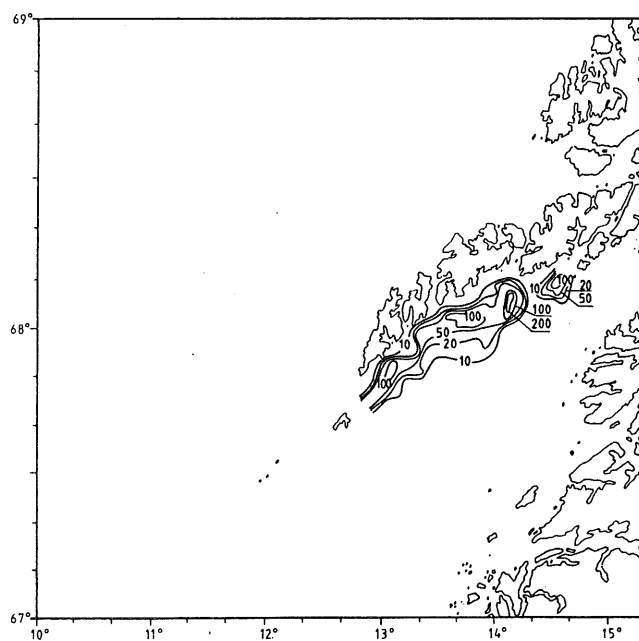


Figure 8. Distribution of cod in the Lofoten area measured with acoustic methods by R/V Johann Ruud 10.- 12. April 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).



Figure 9. Distribution of cod in the Vesterålen area measured with acoustic methods by R/V Eldjarn 21.- 26. March 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).



Figure 10. Distribution of cod in the Vesterålen area measured with acoustic methods by R/V G.O.Sars 7.- 16. April 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times \text{m}^2 / \text{nm}^2$).

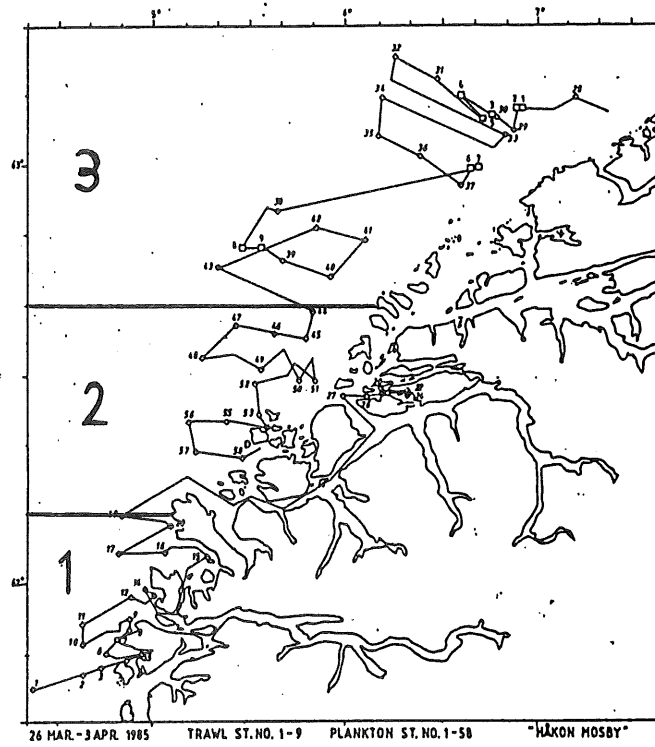


Figure 11. Course lines from the cruise with R/V Håkon Mosby 26. March -3. April 1985 in the Møre area. The division into sub areas are indicated.

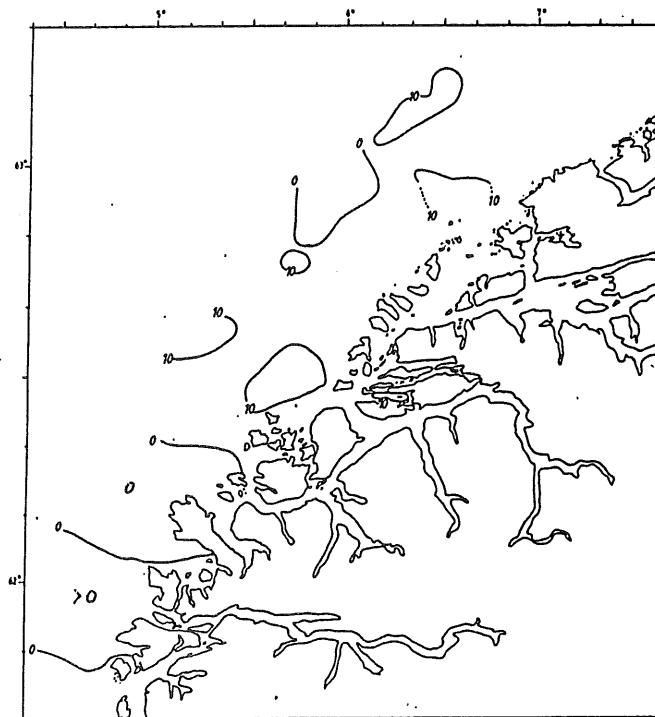


Figure 12. Distribution of cod in the Møre area measured with acoustic methods by R/V Håkon Mosby 26. March - 3. April 1985. Units are 10 times back scattering cross section per square nautical mile ($10 \times m^2 / nm^2$).