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ACOUSTIC ESTIMATES OF SPAWNING COD

OFF LOFOTEN AND MØRE IN 1984

by

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ABSTRACT

Acoustic surveys on northeast Arctic spawning cod were carried out in Lofoten and off Møre in March-April 1984 in order to estimate the stock size and structure. Within the investigated areas the total number of spawning cod was estimated to about 40 million specimens. This was a reduction of 25-30 percent as compared to the results in 1983 when a total of 56 million specimens was estimated within the same areas. Particularly in the Møre area spawning cod was far less abundant in 1984 than in 1983.

INTRODUCTION

The main spawning areas of northeast Arctic cod, the Lofoten grounds have been more or less regularly echo surveyed since 1935 (Sund 1938). During the last 2-3 years the estimates of abundance obtained from such surveys in Lofoten and off Møre have been used in order to assess the size of the spawning stock (Godø et al. 1982 and 1983, Hysten and Nakken 1982 and 1983). In the present paper the results from the 1984 surveys are reported and discussed.

## MATERIAL AND METHODS

The survey design and area coverage were approximately as in previous years. The Lofoten area was covered five times in the period March 9 to April 8 while a complete survey of the Møre coast was carried out only once from April 1 to April 15. In addition, the area between Møre and Lofoten was fragmentarily covered at March 20-21 and at April 10-11.

The two main areas were divided into four subareas and estimates of numbers of spawning cod were worked out for each subarea. Figs. 1, 2 and 3 show the locations of the two main areas and the subareas. Course lines and station grids appear in Figs. 4 and 5. In Lofoten the coverages in subareas 1, 2 and 3 during all five surveys were approximately as indicated in Fig. 4, while the course line density in subarea 4 varied considerably. The names of the research vessels and the cruise periods in Lofoten are given in table 1, where the coverage of the various subareas are indicated.

The three research vessels which took part in the investigations, used echosounders at a frequency of 38 kHz in conjunction with digital echo integrators. "G.O.Sars" carried the Simrad EK-400, while "Michael Sars" and "Johan Ruud" were equipped with Simrad EK-S and EK-A respectively. The integration systems developed by the Institute of Marine Research, Bergen were used on all ships (Blindheim, Eide, Knudsen and Vestnes 1982). The acoustic systems were calibrated according to Foote et al. (1983). The acoustic data logging and sampling of the echo recordings as well as the data processing methods were described by Godø et al. (1982 and 1983).

## RESULTS AND DISCUSSION

Figs. 6 and 7 show the distributions of echo abundance in Lofoten and off Møre. The length distributions which were used in the calculations when converting the echo-abundances to fish densities are presented in table 2. These length distributions originated from various types of sampling.

For subareas 1 - 3 in Lofoten the distribution was established from samples of Danish seine catches in Eastern Lofoten. In subarea 4 the lengths of fish in the trawl catches of "G.O.Sars" were used. Off Møre the length distribution for subarea 1 - 2 was obtained from Danish seine catches in subarea 2, while the lengths of the fish in the trawl catches of "Michael Sars" were used in subarea 3.

Table 3 shows the estimated numbers of spawning cod.

### Lofoten

The estimated total number of spawners varied between 24 and 35 million specimens (Table 3). Several factors contributed to this variation. During the first cruise the fish in subarea 1, the inner Vestfjord, was located close to the bottom over large distances and thus partly excluded from the acoustic integration by the bottom discriminator. The estimate, 11 million specimens in subarea 1 for the period 9-11 March is therefore too low. In subarea 4, the area coverage was considered sufficient for only two of the cruises, 9-14 March and 20-24 March and it was therefore believed that the estimates from these two cruises were more reliable than the two others. Immigration and emigration of fish may also have introduced variations in the estimates, both within and between cruises. In particular the figures for the first and last cruise may be effected by fish moving to and fro, and also partly crossing the Lofoten area on its way to more southern spawning grounds. (Godø 1984).

When taking into account the factors mentioned above and in addition considering the intensive fishing during the investigation period, the main trend of the estimates seems reasonable; a spawning stock of about 35 million specimens was reduced to about 25 million specimens between the middle of March and the middle of April.

It is believed that the number of cod which actually spawned within the investigated area was somewhat higher than indicated by the estimates. In the eastern part of Lofoten (subarea 1) safe navigation prevented a satisfactory coverage of the spawning

grounds and in addition it is not known how long the "average" cod stays on the spawning grounds. The best estimate of the number of spawners in the Lofoten area in 1984 is therefore considered to be 35-40 million specimens, which is 10-15 million specimens less than in 1983.

The age distribution of the spawning cod in the Lofoten area was as follows:

Age (years)	:	5	6	7	8	9	10+	Total
Number (million)	:	4	8	10	10	6	2	40

This age distribution was based on the length distributions in Table 2. and age determinations of 222 specimens. It is seen that the contribution to the spawning stock by the 1975 yearclass (9 year old fish) was about 15 percent, which is considerably less than in 1983 when that yearclass amounted to about 50 percent of the number of spawners in the area (Hysten and Nakken 1983).

#### Møre

The recordings shown in Fig. 6 were exclusively cod in subarea 1 and 2, but a mixture of cod, haddock and saithe in subarea 3. The survey off Møre indicated a spawning stock of about 2 million specimens. This is only one third of the 1983 estimate. In the previous years the main part of the spawning stock was recorded in subarea 2, while in 1984 the estimates from the southern spawning grounds, subareas 1 and 2 were very low. In subarea 3 the calculated number of cod was between the two figures obtained in 1983. The vertical and horizontal distribution of the fish caused the same difficulties for acoustic abundance estimation as in Lofoten. The main problem in the Møre area was, however, that the abundance of cod on the spawning grounds was much lower than in previous years, and so low that the separation of "pure" cod recordings from other recordings was very difficult. This problem was so prominent in large parts of the area that the estimate arrived at must be considered highly unreliable. However, a reasonable conclusion is that the

spawning stock of northeast Arctic cod off Møre in 1984 was considerably below the 1983 estimate of 6 million specimens.

The age distributions (percent) of the catches from subareas 2 and 3 are given in the following text table:

Age (years):	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
Subarea 2 :			1	4	2	2	10	9	19	16	12	15	5	5
Subarea 3 :	1	5	24	28	16	8	6	3	5	3	1			

About 75 percent of the cod in subarea 2 were northeast Arctic cod, whereas coastal cod dominated in subarea 3. The 1975-year-class of northeast Arctic cod dominated in subarea 2. It is likely that the relatively large reduction of the spawning stock off Møre from 1983 to 1984 as compared to Lofoten may be caused by a lack of recruitment from the yearclasses 1976-1978 which dominated in Lofoten in 1984.

#### Helgeland - Trøndelag

Parts of the area were covered twice (Table 1.) Cod was recorded off Ytterholmen and on the Sklinna Bank during the first cruise and off Vikna in the second period. The estimates of abundance suffered from the same types of errors as off Møre, and the figures given in Table 3. are therefore unreliable. It was concluded that the spawning stock of northeast Arctic cod in this area was insignificant as compared to the Lofoten population.

#### Final remarks

The northeast Arctic cod spawns over considerably larger areas than those covered by the investigations reported here. Thus, the total spawning stock must be larger than the figures arrived at by us. According to Hysten and Nakken (1982 and 1983) the estimates from Møre and Lofoten in 1982 and 1983 amounted to about 50 percent of the total spawning stock.

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Table 1. Area coverage during the various cruises in Lofoten.  
Sufficient coverage (+), insufficient coverage (-).

Ship	Period	Subarea			
		1	2	3	4
G.O. Sars	Mar. 9-14	+	+	+	+
G.O. Sars	Mar.15-20	+	+	+	-
J. Ruud	Mar.20-24	+	+	+	+
J. Ruud	Mar.27-31	+	+	+	-
J. Ruud	Apr. 2 -8	+	+	+	-

Table 2. The length distributions which were applied in the calculation of fish densities.

Length cm	≤	55	60	65	70	75	80	85	90	95	100	105	Total
	54	59	64	69	74	79	84	89	94	99	104	≥	
<u>LOFOTEN</u>													
Subarea 1-3	1	6	29	104	178	159	137	115	90	57	40	37	953
Subarea 4	2	7	9	19	17	11	9	12	15	8	10	7	126
<u>MØRE</u>													
Subarea 1-2	1	1	1	3	5	8	5	13	15	34	20	79	185
Subarea 3	71	40	22	28	15	10	11	7	6	5	6	3	224

Table 3. Estimates of spawning cod (in millions). Brackets indicate uncertain figures due to insufficient coverage.

Period	Subarea				Total
	1	2	3	4	
<u>LOFOTEN</u>					
Mar. 9-14	(11)	3	4	11	29
Mar.15-20	20	2	2	(11)	35
Mar.20-24	15	4	3	9	31
Mar.27-31	12	3	5	(7)	27
Apr. 2- 8	10	5	5	(4)	24
<u>MØRE</u>					
Apr. 1-15	0.1	0.4	1.6	+	2.1
<u>HELGELAND</u>					
Mar.20-21					<0.5
<u>TRØNDELAG</u>					
Apr.10-11					<0.3

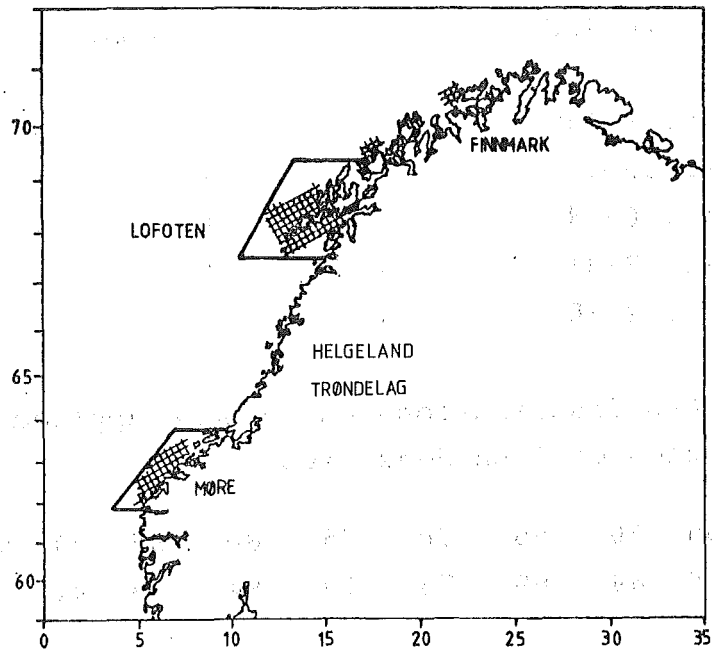


Fig. 1. The Norwegian coast. Investigation areas are framed. Spawning grounds of north-east arctic cod are indicated by hatching.

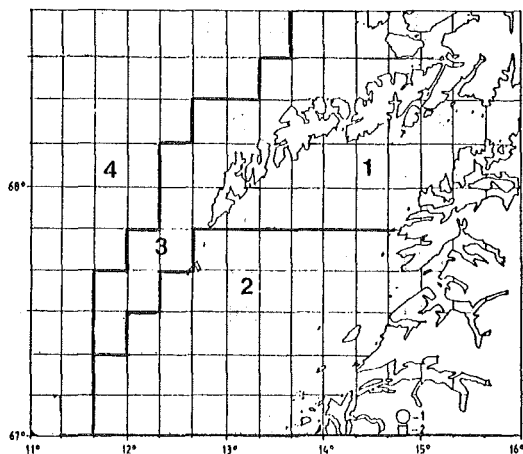


Fig. 2. The Lofoten area. Subareas are indicated.

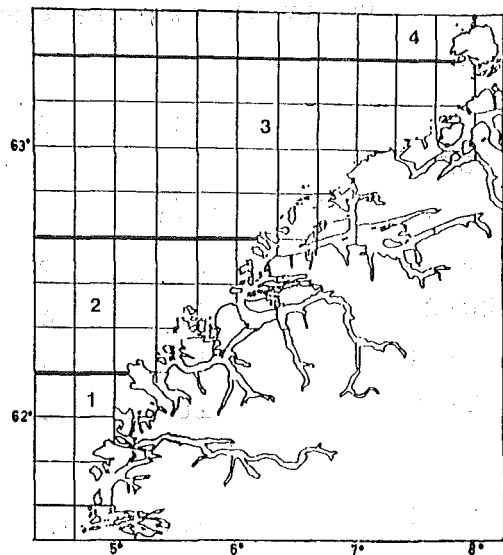


Fig. 3. The Møre area. Subareas are indicated.



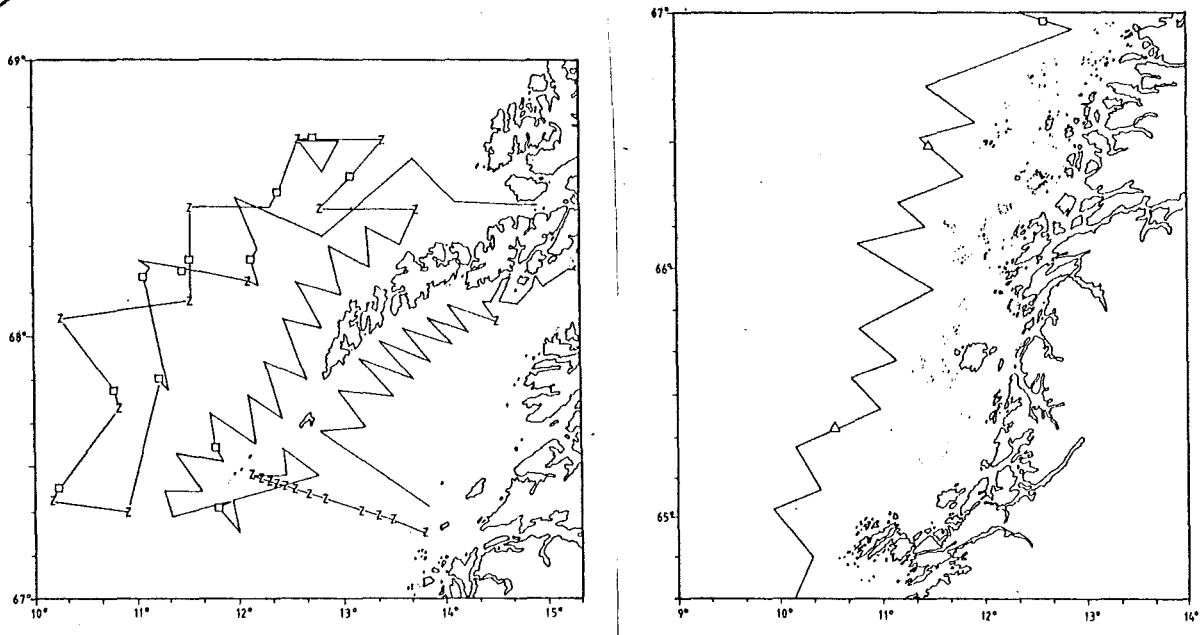


Fig. 4. Course lines in Lofoten March 9 - 15 (left) and off Helgeland March 20 - 21 (right) 1984.  $\square$  - bottom trawl station,  $\Delta$  - pelagic trawl station, z - CTD sonde station.

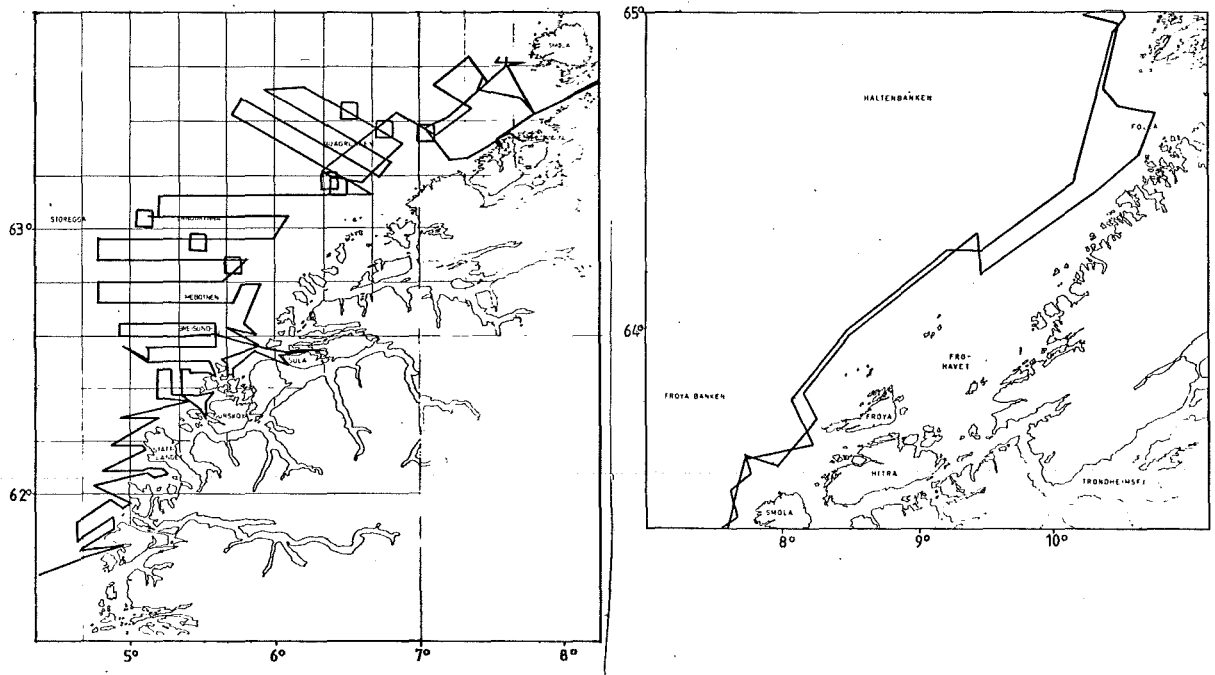


Fig. 5. Course lines off Møre - Trøndelag April 1 - 11, 1984. Left: Southern part, right: Northern part.  $\square$  - bottom trawl station.

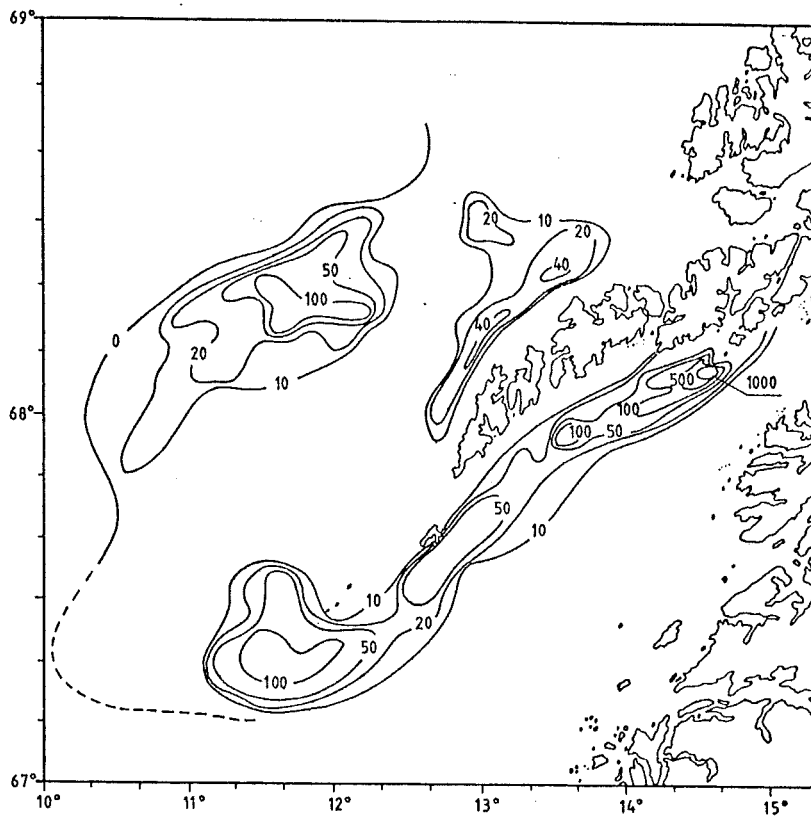


Fig. 6. The distribution of spawning cod in the Lofoten area March 9 - 15, 1984. Isolines indicate back scattering per unit surface, [ $10 \times \text{m}^2/\text{nm}^2$ ].

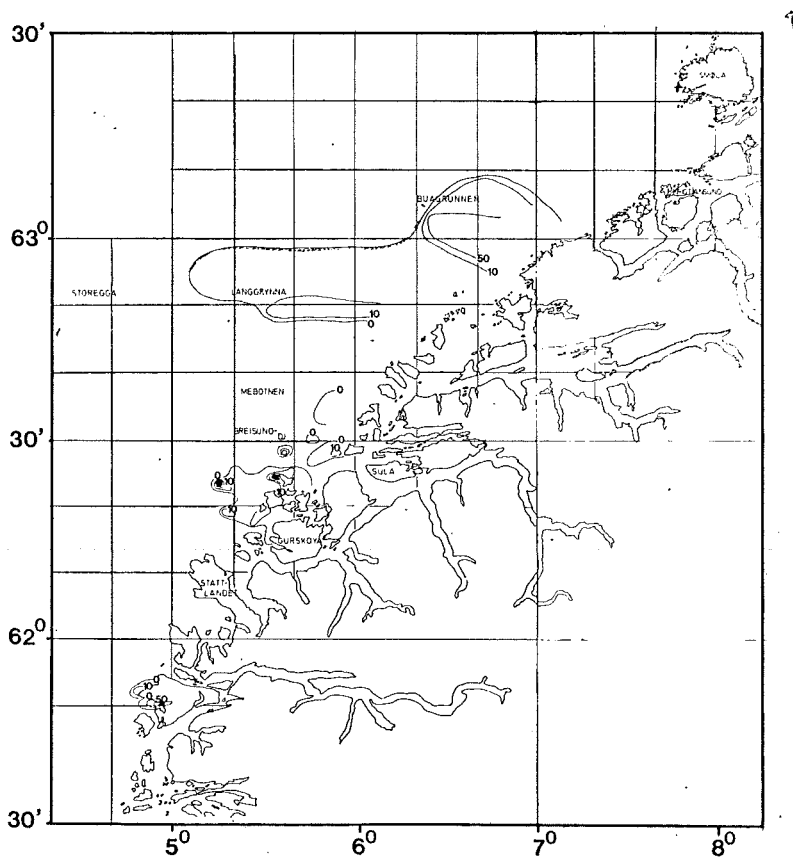


Fig. 7. The distribution of cod, saithe and haddock in the Møre area April 1 - 11, 1984. Isolines indicate back scattering per unit surface, [ $10 \times \text{m}^2/\text{nm}^2$ ]. Areas with more than 100 units are hatched.