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STOCK SIZE OF NORTH-EAST ARCTIC COD,
ESTIMATES FROM SURVEY DATA 1983/84

by

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ABSTRACT

Both the total and spawning stocks of North-East Arctic cod were assessed using Norwegian survey data and commercial landings. The total stock at 1 January was estimated to about 3250 million specimens, of which age group 1 and 2 amounted to about 2400 and 500 million specimens respectively whereas the older agegroups (3+) were estimated to 350 million specimens altogether. The last figure, 350 million, is somewhat higher than the estimate of about 275 million specimens arrived at by the Working Group on Arctic Fisheries. The spawning stock at 1 January 1984 was estimated to 87 million specimens which is a considerable reduction as compared to 1983. The bulk of the spawning stock were made up by 6, 7 and 8 years old fish.

INTRODUCTION

In 1982 an attempt to estimate the total stock, the spawning stock size and the maturity ogive for North-East Arctic cod was

made by Hysten and Nakken (1982) on the basis of survey results. The results of the work were promising and the estimates arrived at were useful to the Working Group of Arctic Fisheries in assessing the state of the North-East Arctic cod stock and the effect of different TAC's strategies (Anon., 1983 and 1984). This work was followed up in 1982/83 and 1983/84 by intensified survey effort on cod. The results of each particular survey in the season 1983/84 are given in separate reports to this meeting (Dalen et al., 1984, Godø et al., 1984a and Godø et al., 1984b). In the present paper these results have been utilized in an attempt to estimate the total stock and spawning stock size at the beginning of January 1984.

MATERIAL AND METHODS

The assessments are based on data from a series of surveys:

1. The Svalbard bottom trawl survey, 6 September - 1 October 1983 (Godø et al., 1984a).
2. The Barents Sea acoustic survey, 26 January - 1 March 1983 (Dalen et al., 1984).
3. The Lofoten acoustic surveys, 15 - 20 March 1984 (Godø et al., 1984b).
4. The Møre acoustic survey, 1 - 15 April 1984 (Godø et al., 1984b).

The approximate areas covered by the acoustic surveys are given in Fig. 1. Details of each survey are given in the respective reports.

In addition to survey data, preliminary commercial landing statistics, including landings from foreign vessels, for the period 1 January to the end of the surveys in the respective areas were used. Biological data from Norwegian landings in February were also taken into account.

ASSESSMENT OF THE TOTAL STOCK SIZE

The number of fish by age at 1 January 1983 were arrived at, by adding the 1984 - commercial catches prior to the acoustic surveys and the stock sizes estimated from each of the surveys. The natural mortality between 1 January and the dates of completion of the surveys was not accounted for. Below is given a brief description of each of the components in the assessment.

Commercial landings

Landings during the period from 1 January up to the dates for finishing the different parts of the surveys are given for each statistical area (Table 1A). Total landings from the actual areas and periods were 104 123 tons, representing a total of 25 million fish (Table 1A). In total, the landings were dominated by the 1977-, 1976- and 1978 year-classes, given in successive order. The importance of the 1975 year-class is remarkably reduced compared with the 1983 catches.

No catches have been reported from the Svalbard region in the last quarter of 1982. Even so, some catches might have been taken. However, the fishing activity in the region between 1 October 1983 and 1 January 1984 was low.

The Barents Sea region

As in 1981, 1982 and 1983 both an acoustic and a bottom trawl survey were carried out in 1984 at the same time in the Barents Sea during winter 1984. The total Barents Sea component of the stock was estimated to 3252 million specimens on the basis of the acoustic results (Dalen et al., 1984). This is the highest number of fish that has been recorded since the start of the acoustic surveys in 1977. The 1983- and 1982 year-classes made up nearly 90% of the total number.

The main errors affecting the estimates cannot yet be quantified, but the sources of errors will be discussed in brief. As in

previous years the youngest fish appeared to be underestimated. Both the bottom trawl indices and the acoustic estimates for the age groups 3-5 years were higher in 1984 than the figures arrived at for these year-classes in 1983, at age 2-4 years. This bias is probably caused by a higher trawling efficiency for large and medium sized fish than for small fish. In 1984 this lead to a serious upward bias of the acoustic estimates of 3+ in the eastern part of the investigation area. Other important sources of error this year were difficulties in establishing representative age/length keys for the 1-3 year old fish which lead to a transfer of fish between these age groups, and a possible migration of fish of the Bear Island - Spitsbergen component into the area of investigation (Dalen et al., 1984).

The most serious of these errors was the upward bias of the acoustic estimates of age group 3 and older fish in the eastern Barents Sea. In this area large quantities of 1 and 2 year old fish made up the bulk of the echoabundance, but since the trawlcatches oversample the larger fish and the length distributions from these samples are used directly in the conversion of echo abundances to fish densities, the older age groups (3+) were overestimated. We have therefore neglected the acoustic estimates for the eastern Barents Sea (area D) and estimated the number of fish in each age group in the following way:

$$N_{1984} = \frac{N_{1983}}{IND_{1983}} \cdot IND_{1984}$$

where N_{1983} is the acoustic estimate in 1983
 IND_{1983} is the bottom trawl index in 1983
 IND_{1984} is the bottom trawl index in 1984

This estimator simply expresses the assumption that the ratio between the acoustic estimates and the bottom trawl indices for each age group were equal in 1983 and 1984. The procedure resulted in the following estimates for area D:

age (years)	3	4	5	6	7
number (mill.)	39	6	3	3	1

The estimates for the total Barents Sea survey were accordingly

age (years	1	2	3	4	5	6	7
number (mill.)	2382	506	107	53	48	33	10

where the estimates of 1 and 2 year old fish are in accordance with (Dalen et al., 1984), while those for the other age groups are the corrected ones.

The Vesterålen region

Due to bad weather conditions this region could not be surveyed in 1984. The total catch in the area up to the end of the Barents Sea survey was 37 000 tons as compared to 32 000 tons during the same period in 1983. In Lofoten the corresponding catches were 30 000 tons in 1984 and 44 000 tons in 1983. Thus, while the catches in Lofoten were considerably reduced from 1983 to 1984, the catches in the Vesterålen area increased significantly. Furthermore the amount of spawning cod on the banks to the west and north of the Lofoten Islands was observed to be larger in 1984 than in 1983 (Godø et al., 1984).

In 1983 the survey of the Vesterålen region resulted in 9 million specimens. It would perhaps have been likely to reduce this number in accordance with the reduction in the total number of spawners from 1983 to 1984, but in view of the differences in the geographical distribution of the spawners and the tendency of the commercial catches we have assumed that 9 million fishes were present in this area also in 1984. The total age composition of all landings - gill nets excluded - up to the middle of March 1984 in the area was accepted to represent the age distribution of the population. The resulting age composition was dominated by the 1977-, 1976-, 1975- and 1978 year classes (Table 1A), in successive order.

The Lofoten region

This area was surveyed five times during the fishing season

(Godø et al., 1984). The surveys showed an increasing abundance between the second and third week of March. Thereafter the abundance decreased up to early April. The best estimate of the stock was taken to be that in the third week of March, about 40 million fish.

Only a limited number of length measurements and age readings were available from research vessels. However, length distributions from Danish seine catches were available for March. These were accepted to be appropriate for the stock in the area. Applying an age/length key from long-line catches in February to these length distributions resulted in an age composition which were dominated by the 1976-, 1977- and 1978 year-classes (Table 1B).

Helgeland - Trøndelag region

Parts of the area was surveyed twice, and the stock was estimated to 0.8 million fish. This estimate must, according to Godø et al. (1984), be considered highly unreliable. The main problem in this area was that the abundance of cod on the spawning grounds was so low that the separation of "pure" cod recordings from other recordings was difficult. The age distribution was assumed to be the same as in the Møre area (Table 1B).

Møre region

The stock off Møre was estimated to 2.1 million fish at the middle of April (Godø et al., 1984b). However, as in the Helgeland - Trøndelag region, this estimate must be considered highly unreliable, caused by the difficulties in separation of "pure" cod recordings from other fish, a problem which increases at low levels of spawning stock sizes. It can, however, be concluded that the number of spawners of North-East Arctic cod in the Møre and Helgeland/Trøndelag regions was insignificant as compared to the Lofoten component.

As in 1983 the 1975 year-class was the most abundant year-class in this region (Table 1B). The relatively large reduction of the spawning component off Møre, from 6.0 million in 1983 to 2.1 million fish in 1984 seems to be caused by less recruitment to this area from the year-classes 1976-1978 which dominated in Lofoten in 1984.

The Svalbard region

In February the mature part of the Svalbard stock component will be in Norwegian waters between North Cape and 62°N, and therefore accounted for by the acoustic surveys. The total Svalbard stock component was investigated by a groundfish survey in September - October 1983 (Godø et al., 1984). By the swept area method the stock size at the beginning of October was estimated to 44.4 million fish which was reduced by natural mortality ($M=0.20$) to 42.2 million fish at 1 January 1984. A maturation ogive, similar to that estimated for the rest of the stock was applied, and the immature stock 3 years and older was estimated to 29.2 million fish (Table 1B). This component was dominated by the 1981 year-class.

Total stock size

The sum of survey estimates and landings make up the total stock size in the beginning of 1984 (Table 1B). Total stock size of 3 year and older fish was assessed to 358 million fish as compared to 274 million fish given by the Arctic Fisheries Working Group (Anon, 1984). Fairly good agreement was found for all age groups older than 4 years, but the Working Group figures of 3 and 4 years olds were 25 and 42 percent of the survey figures, respectively.

ASSESSMENT OF THE SPAWNING STOCK SIZE

The spawning stock was estimated on the basis of survey data and biological sampling of commercial landings from the different areas and periods described earlier. Biological samples from the Møre - Lofoten areas showed that nearly all cod both

in commercial landings and research vessel catches was mature and hence the total stock within these areas was assumed to be spawners (Table 1 and 2).

The next step was, on the basis of the maturity stages, to exclude the immature fish caught off Vesterålen and Finnmark and from the stock estimates of the other areas north of Lofoten. The age composition of the mature fish in landings and the components from Vesterålen and the Barents Sea was arrived at by applying the respective area distributions found in landings and surveys respectively. The mature fish in the Svalbard component was on migration to the spawning grounds during the period of the acoustic surveys and is thus included in the acoustic stock estimates.

The total spawning stock at the beginning of 1984 was estimated by summing the landings and the estimates of the different spawning stock components in the surveys (Table 2), resulting in a spawning stock level of 87 million fish, dominated by the 1977-, 1978- and 1976 year-classes.

The estimates of the total stock and the spawning stock were used to calculate the following maturation ogive:

Age in years:	4	5	6	7	8	9	10	11	12
Percent mature:	1	18	32	69	100	100	100	100	100

These figures are slightly higher than those given by Hylén and Nakken (1983), and considerably higher than the percentages arrived at by other authors in previous years.

DISCUSSION

Neither in 1982 nor in 1983 the Helgeland region was surveyed, and the stock size in the region had to be stipulated. These calculations involved an assumption that the catch in this region made up the same portion of the stock as in the Møre region.

A survey in a narrow area along the coastline in the Helgeland/Trøndelag region showed very low densities of fish. However, this region covers large offshore areas and even a very low mean density offshore will result in a significant stock component in the region, and our estimate might thus easily be an underestimate. Attention should also be drawn to the fact that the very low mean density in the Helgeland/Trøndelag and Møre regions gave stocks estimates with high confidence limits (Godø et al., 1984).

Some of the fishes included in the surveys and landings were coastal cod. Both in Lofoten and off Møre these fishes were found in the younger age groups (Hysten, 1971; Godø et al., 1983). This is not accounted for in the present assessments, and hence the figures for the younger age groups of the spawning stock (Table 2B) are overestimates for the North-East Arctic cod stock. Consequently, also the percentage of mature fish might be somewhat overestimated for the younger age groups. On the other hand, the maturation ogive arrived at were found by taking the ratio between the number of fish actually estimated in the spawning stock and the number of fish in the total stock, at a time when most of the spawners were on the spawning grounds. This procedure should at least in principle be more safe than estimating the proportion of spawners from samples at a time when the population is mixed.

The discrepancies between the present assessment and that of the Working Group appear from Table 1B. For the 3 and 4 years old fish the present estimates are significantly higher than those of the Working Group. Concerning the 5 year olds and older, the survey estimates are lower than given by the Working Group. For the total stock of 3 year old fish and older, our estimate is 83 million higher than estimated by the Working Group. These discrepancies reflects mainly the deviations in the Barents Sea estimates between 1983 and 1984, since the Working Group used the survey results from 1983 in the assessment. As explained previously large errors may occur in these estimates due to inadequate sampling gears. In order to increase the accuracy of both the bottom trawl indices as well as

the acoustic estimates, more effort should be put into the construction and design of sampling trawls.

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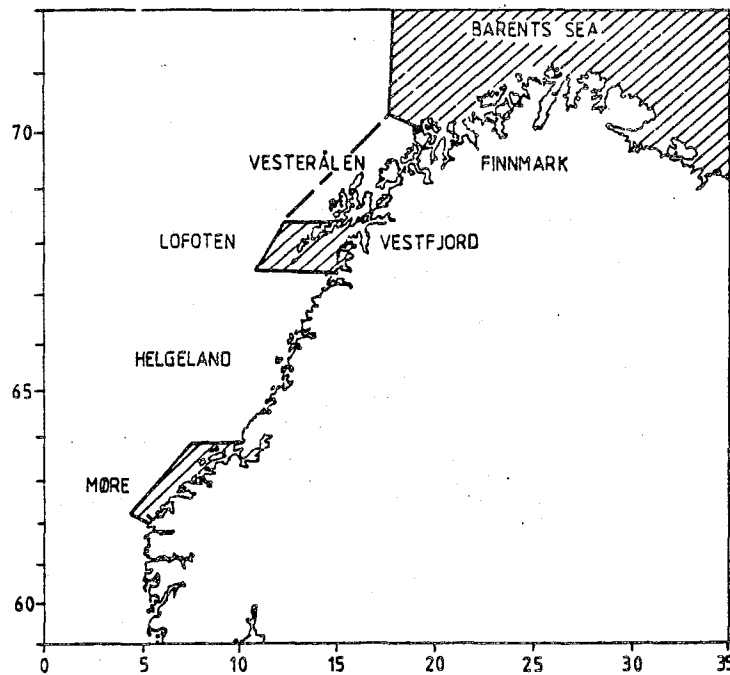


Fig. 1. The Norwegian coast. Areas where estimates of abundance were obtained from acoustic surveys during winter 1984 are indicated.

Table 1. North-East Arctic Cod. Stock size by numbers at the beginning of 1984.
A. Number of cod by age landed between 1 January and end of surveys (thousands)

Area	Age (year)										Total (No)	Landings (tons)
	1	2	3	4	5	6	7	8	9	10+		
East Finmark			12	56	268	714	520	321	86	11	1988	6647
North Cape Bank			2	9	53	146	93	49	10	-	362	1168
West Finmark			61	333	1237	2598	1633	617	147	38	6664	21182
Vesterålen				7	189	1076	2040	2488	1857	217	7874	37490
Lofoten				3	222	900	1671	1813	1555	143	6307	29710
Helgeland					15	77	140	163	145	13	553	2633
Møre					1	29	145	265	340	289	1103	5293
Total			75	409	2013	5656	6362	5791	4089	456	24851	104123

B. Stock size by age estimated from survey data (million)

Svalbard			13.9	4.8	4.8	5.4	0.8	0.2				30
Barents Sea	2382	506	107	53	48	33	10					3139
Vesterålen					0.4	1.5	2.6	2.3	1.7	0.5		9
Lofoten					4	8	10	10	6	2		40
Helgeland/Møre				0.1	0.1	0.1	0.3	0.3	0.5	1.5		3
Sub-total	2382	506	121	58	57	48	24	13	8	4		3221
Total stock	2382	506	121	58	59	54	30	19	12	4		3246
Stock size (Anon 1984)			30	24	61	61	40	25	24	10		275

Table 2. North-East Arctic Cod. Spawning stock size by numbers at the beginning of 1984.
A. Number of mature cod by age landed between 1 January and end of surveys (thousands)

Area	Age (year)										Total (No)
	1	2	3	4	5	6	7	8	9	10+	
East Finmark			1	22	185	571	471	321	86	11	1686
North Cape Bank				2	28	134	87	49	10		310
West Finmark			18	146	1004	2529	1590	617	147	38	6089
Vesterålen				7	189	1076	2040	2488	1857	217	7074
Lofoten				3	222	900	1671	1813	1555	143	6307
Helgeland					15	77	140	163	145	13	553
Møre					1	29	145	265	340	289	1103
Total			19	181	1672	5432	6264	5791	4089	456	23904

B. Mature stock size by age estimated from survey data (million)

Barents Sea					4.5	4.4	1.7	0.2				11
Vesterålen					0.4	1.5	2.6	2.3	1.7	0.5		9
Lofoten					4.0	8.0	10.0	10.0	6.0	2.0		40
Helgeland/Møre				0.1	0.1	0.1	0.3	0.3	0.6	1.3		3
Sub-total				0.1	9.0	14.0	14.6	12.8	8.3	3.9		63
Spawning stock				0.4	10.7	19.4	20.8	18.6	12.4	4.3		87