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STOCK SIZE OF NORTH-EAST ARCTIC COD, ESTIMATES FROM SURVEY DATA 1982/83

by

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ABSTRACT

Assessments of the total stock and spawning stock sizes of North-East Arctic cod were carried out on the basis of Norwegian survey data and commercial landings. The total stock at 1 January 1983, fish which was 2 years old and older was estimated to about 400 million specimens and the spawning stock estimate was approximately 130 million specimens. The figure for the total stock was considerably lower than the estimate of 615 million specimens of 3 year old and older fish arrived at by the Working Group on Arctic Fisheries.

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 Hylen 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). In 1982-1983 the Institute of Marine Research intensified the survey effort on cod. The results of each particular survey are given in separate reports to this meeting (Dalen et al., 1983, Godø et al., 1983 Randa and Smedstad, 1983). In the present paper these results have been utilized in an attempt to estimate the total stock and spawning stock sizes at the beginning of January 1983.

MATERIAL AND METHODS

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

1. The Barents Sea acoustic survey, 26 Janury - 2 March 1983 (Dalen et al., 1983).
2. The Vesterålen acoustic survey, 2 - 5 March 1983 (Godø et al., 1983).
3. The Lofoten acoustic survey, 6 - 14 March 1983 (Godø et al., 1983).
4. The Møre acoustic survey, 15 - 30 March 1983 (Godø et al., 1983).
5. The Svalbard bottom trawl survey, 7 September - 6 October 1982 (Randa and Smedstad, 1983).

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 the survey data, preliminary commercial landing statistics, including landings from foreign vessels, for the period from 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 1983 - commercial catches prior to the acoustic surveys and the results from each of the surveys. The natural mortality between 1 January and the dates of the completion of the surveys was not accounted for. Below is given a brief description of each of the component in the assessment.

Commercial landings

Landings in the period January up to the dates for finishing the differents parts of the surveys are given for each statistical areas (Table 1A). Total landings from the actual areas and periods were 117 961 tons, representing a total of 28.3 million fish (Table 1A). In total, the landings were dominated by the 1975, 1976 and 1977 year-classes, given in successive order. The importance of the 1975 year-class is remarkably reduced compared with the 1982 catches.

No catches has 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 the survey which ended the 7 October 1982 and the 1 January 1983 was low.

The Barents Sea region

As in 1981 and 1982 an acoustic and a bottom trawl survey were carried out at the same time in the Barents Sea during winter 1983. The total Barents Sea component of the stock was estimated to 210 million specimens on the basis of the acoustic results, but it was pointed out that there were large discrepancies between the estimates from the two types of surveys (Dalen et al., 1983).

The estimates for the total survey area in the three years of observation were as follows (in millions of specimens):

	1981	1982	1983
Acoustic estimate:	828	408	210
Bottom trawl estimate:	115	92	100

Clearly, the two sets of results differ considerably; the bottom trawl estimates do not even reflect the decreasing tendency of the acoustic results. Why? If we accept that both sets of data are representative for the waterlayers which have been sampled by the two methods, then the only possible explanation is that a large portion of the fish which have contributed to the bottom trawl estimates have not been sampled by the acoustics at all. The echosounder has a deadzone of 1-2 m at the bottom, depending on water depth and bottom configuration. Hence we may regard the "acoustic bottom" to be 1-2 m above the real bottom. On the other hand this near bottom layer is efficiently sampled by the trawls. But the trawls will catch fish effectively only up to a certain height above the bottom. An illustration of the problem is given in Fig. 2. Both methods will result in underestimates of the number of fish; the acoustics by not sampling the fish in the near bottom layer while the bottom trawl is not catching the fish distributed pelagically above the "sampling height".

The sampling height of the trawl is unknown. The vertical opening is approximately 6 meters (measured by netzonde), but let us assume that it on an average has sampled the cod up to a height of 11-12 meters above the bottom. The upper ten meters of this layer has also been sampled regularly by the bottom channel of the integration system. The table below shows the estimates from the bottom channel and the bottom trawl estimates arrived at in subareas A and D (see Dalen et al., 1983) for the three years:

	1981		1982		1983	
	Bott.ch.	Bott.tr.	Bott.ch.	Bott.tr.	Bott.ch.	Bott.tr.
A	21	20	27	34	14	32
D	152	67	87	37	33	32
A+D	173	87	116	71	47	64

The total figures for A and D are plotted in Fig. 3. Assuming now that the number of fish in the "deadzone" within the subareas A and D has been the same all the three years of observation, we can estimate this number from the intercept. A straight line relationship (Fig. 3) would result in an intercept - i.e. a "deadzone" stock of 50 million fish, while a curved line would give approximately 60 million fish.

A similar procedure should not be applied to assess the "deadzone" stock in the subareas B and C. These two subareas cover the nearshore waters where the fish distribution is closely related to the bottom contour; the bulk of the fish being distributed at or just off the steep bottom slopes. Hence, relatively small horizontal movements of the fish concentrations may lead to large changes in the estimates in the bottom channel, and the angles between the bottom contour lines and the ships course - along the slope or at right angles to the slope - may then also be of significance. Therefore, we have assumed the deadzone density in subareas B and C to be equal to that in subareas A and D, so that the total "deadzone" stock for the Barents Sea is arrived at as follows:

$$55 \cdot \frac{\text{Total area}}{\text{Area (A+D)}} = 55 \cdot 1.2 \cong \underline{65 \text{ million fish}}$$

where we have chosen 55 million fish as the best estimate for subareas A and D, and 1.2 is the ratio between the total area and the area of subareas A and D.

There are several weak points in the procedure by which the "deadzone" stock is estimated. The sampling height of the

bottom trawl does probably vary with the size of the fish as does the sampling width. The number of fish in the "deadzone" have of course varied considerably; both geographically in one and the same year and perhaps also from year to year. The assumption that the "deadzone" stock has been constant over the three years, was made in order to be able to work out a rough estimate for it. A similar analysis, but on a statistical square basis or on trawlstation basis, would throw light on the variabilities which always will be present in such data sets, but which did not appear from the rather coarse analyses above.

The significance of 65 million - or rather somewhere between 40 and 100 million - specimens are of course highly dependant on the size of the stock. At a normal stock level of 1000-1500 million specimens the figure is hardly noteworthy, but at the present low stock level it is highly significant.

The size of the Barents Sea component was in accordance with these indications taken as 275 million fish (Table 1B). This component was dominated by the 1978, 1979 and 1977 year-classes.

The Vesterålen region

The stock in this area was estimated to 9.1 million fish. (Godø et al., 1983). Only length distribution from research vessel was available. In lack of an age-length key from the survey, an age length relationship from commercial long-line catches in the area, was accepted to be appropriate for the stock. The resulting age composition was dominated by the 1978, 1977 and 1976 year-classes.

The Lofoten region

This area was surveyed twelwe times during the fishing season (Godø et al., 1983). The surveys showed an increasing stock size during February and nearly a stabilized stock level from the end of February up to early April. The best estimate of

the stock in the last part of March was taken to be about 50 million fish.

Only a limited number of length measurements and age readings were available from research vessels. However, length distributions from purse seine catches were available for March. These were accepted to be appropriate for the stock in the survey area. Applying an age/length key from long-line catches in February give an age composition dominated by the 1975 year-class (Table 1B).

Helgeland region

As last year, this region was not covered by surveys, due to bad weather and lack of time. Only 2909 tons were landed from this region in the first quarter of 1983, compared with 6287 tons from the Møre. As in 1982 it was assumed that the ratio between the catch and the stock in this area was the same as for the Møre area which was surveyed in the last half of March. The resulting size of this stock component was 1.2 million fish. The age distribution was assumed to be the same in the two areas (Table 1B).

The Møre region

The stock off Møre was estimated to 6.0 million fish at the end of March (Godø et al., 1983), and the 1975 year-class was predominant (Table 1B).

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 1982 (Randa and Smedstad, 1983). By the swept area method the stock size at the beginning of October was estimated to 45.6 million fish which was reduced by natural mortality (M=0.20) to 43.1 million fish at the

1 January 1983. A maturation ogive, similar to that estimated for the rest of the stock was applied, and the immature stock was estimated to 31.1 million fish (Table 1B). This component was dominated by the 1979 year-class.

Total stock size

The sum of survey estimates and landings make up the total stock size in the beginning of 1983 (Table 1B). Total stock size of 2 year and older fish was assessed to 406 million fish as compared to 615 million fish (3 years old and older) given by the Arctic fisheries Working Group (Anon, 1983). Fairly good agreements was found for all age groups older than 5 years, except for the 8 year olds, but the estimates of 3,4 and 5 year olds were only 29, 54 and 66 percent of the Working Group 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 stock 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 1983 was estimated by summing the landings and the stock estimates of the different spawning stock components in the surveys (Table 2), resulting in a spawning stock level of 127 million fish, dominated by the 1975 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:	3	4	5	6	7	8	9	10	11	12
Percent mature:	1	8	10	30	73	88	97	100	100	100

These figures are slightly higher than those given by Hylen and Nakken (1983), but considerably higher than the percentages arrived at by other authors in previous years, and they are also higher than the figures applied by the Working Group (Anon., 1983).

DISCUSSION

Neither in 1982 nor in 1983 the Helgeland region was surveyed and the stock size in the region had thus to be stipulated. The calculations involve an assumption that the catch in this region made up the same portion of the stock as in the Møre region. Since the Helgeland region covers large offshore areas along the coast even a very low mean fish density will result in a significant stock component in the region, and our estimate might thus easily be an underestimate.

Some of the fishes included in the surveys and landings are coastal cod. Both in Lofoten and off Møre these fishes were found in the younger age groups (Hylen, 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 by us 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 3,4,5 and 8 years old fish the present estimates are significantly lower than those of the Working Group. Concerning the 8 year olds - the 1975 year-class - the difference is probably mainly caused by an overestimation of that year-class in the Norwegian surveys 1982. Hylen and Nakken (1982) assumed the fish density in the Vesterålen-Troms area in March 1982 to be equal to the density in late January the same year. According to the results from the 1983 surveys this might have lead to a considerable overestimation of the stock in that area in 1982, where the 1975 year-class was predominant. Also the Barents Sea survey 1982 (Dalen et al., 1982) might have overestimated that year-class. During the 1982-survey a fast migration of cod feeding on capelin took place from northeast towards southwest in the Barents Sea. Since the survey proceeded from east to west, such a migration might cause that the same fish was recorded on several of the survey tracks.

Regarding the younger age groups, the 3,4 and 5 year old fish the deviations between the present estimates and those of the Working Group are more pronounced (Table 1B); the total amount of these three age groups being 209 million specimens in our assessment as compared to 399 million estimated by the Working Group.

Although there has been a tendency in the acoustic survey results that a year-class increases in numbers from age 3 to age 5, we find it difficult to explain that the 1983 survey have underestimated the 1978 and 1979 year-classes by respectively 34 and 45 percent when we accept the estimates for the older age groups. In addition the survey results in 1982 (Hylen and Nakken, 1982) indicated that these two year-classes

were less numerous than the 1983 results show. However, at the present low stock level we must expect that the overall accuracy of the acoustic estimates is poor, in particular for the Barents Sea survey on young cod, since the fish is distributed over relatively large areas in very low densities close to the bottom. The estimates of the spawning stock which is observed during the time of spawning when it occurs in higher concentrations are expected to be more reliable.

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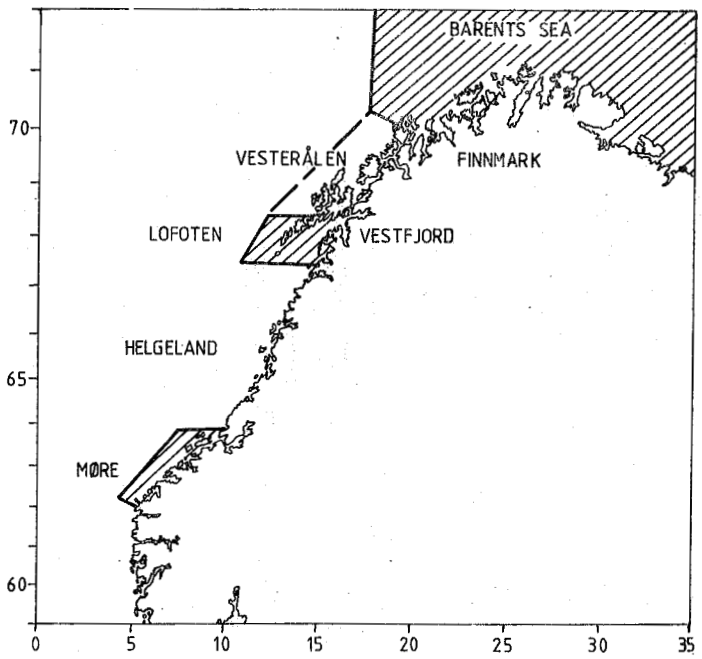

Fig. 1. The Norwegian coast. Areas where estimates of abundance were obtained from acoustic surveys during winter 1983 are indicated.

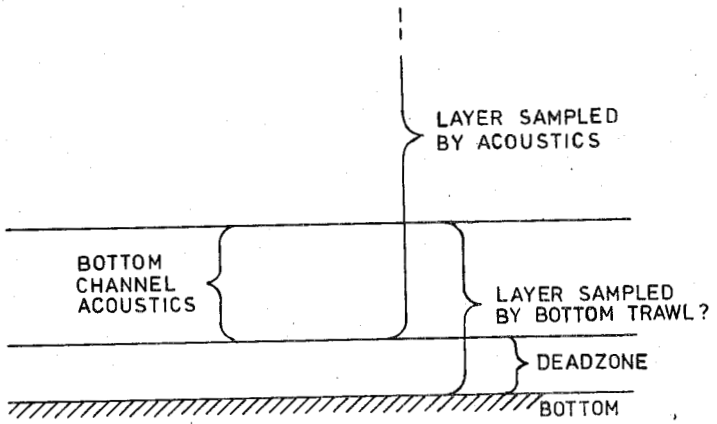

Fig. 2. Illustration of the layers sampled by the two methods, acoustics and bottom trawl.

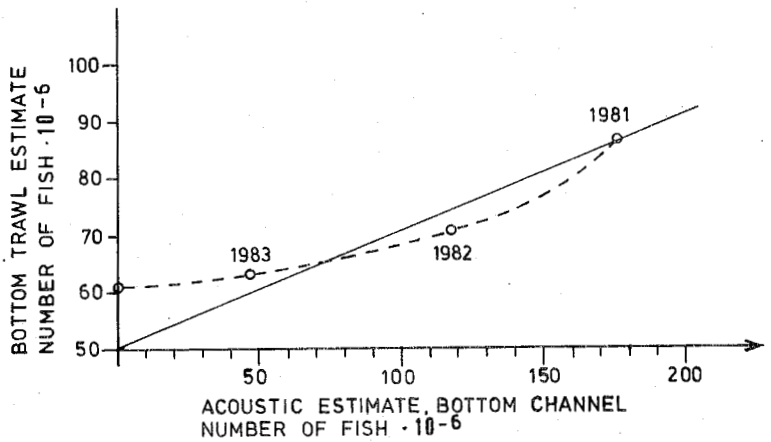

Fig. 3. Acoustic estimates in the bottom channel (from acoustic bottom to 10 m above) and bottom trawl estimates for the subareas A+D.

Table 1. North-East Arctic Cod. Stock size by numbers at the beginning of 1983. A. Number of cod landed by age in the period 1 January - to the end of the respective surveys (thousands).

Area	Age- groups														Total Landings	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	(No)	(tons)
East-Finnmark				167	727	860	903	383	52	10		1			3103	8909
North Cape Bank				88	394	326	96	44	1						949	1975
West-Finmark				181	1171	1622	1631	1523	147	24	9	7	2		6317	22510
Vesterålen			9	98	805	1220	2062	2666	309	57	22	16	7		7271	31539
Lofoten					21	584	2735	4014	848	209	44	11	40	4	8510	43832
Helgeland	2	2	77	179	95	123	41	105	48	23	7	3			705	2909
Møre	3	3	139	345	189	259	92	239	108	54	16	5			1452	6287
Sub-total	5	5	225	1058	3402	4994	7560	8974	1513	377	98	43	49	4	28307	117961

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

Svalbard region	1,4	3,8	19,0	8,0	1,8	0,5	0,3	+						34,8	
Barents Sea	25,0	25,0	59,0	85,0	46,0	20,0	12,0	3,0						275,0	
Vesterålen	0,2	0,2	1,3	2,3	1,7	1,8	1,2	0,3	+					9,0	
Lofoten					2,5	11,2	24,5	7,6	3,0	0,6	0,2	0,2	0,2	50,0	
Helgeland			+	+	0,3	0,5	1,0	0,2	0,4	0,4					2,8
Møre			0,1	0,1	0,7	1,0	2,0	0,5	0,8	0,8				6,0	
Sub-total	26,6	29,0	79,4	95,4	53,0	35,0	41,0	11,6	4,2	1,8	0,2	0,2	0,2	376,0	377,6
Total stock size	26,6	29,2	80,5	98,8	58,0	42,6	50,0	13,1	4,6	1,9	0,2	0,2	0,2	404,3	405,9
Stock size (mill). (ANON 1983)		100,0	148,9	150.4	67,6	48,4	85,2	12,1	2,0	0,4	0,2	0,1			615,3

Table 2. North-East Arctic Cod. Spawning stock size by numbers at the beginning of 1983. A. Number of mature cod landed by age in the period 1 January-to the end of the respective surveys (thousands).

Area	Age-groups														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	(No)
East-Finnmark				33	507	773	881	383	52	10		1			2640
North Cape Bank					185	277	93	44	1						600
West Finnmark				47	373	1118	1605	1519	147	24	9	7	2		4851
Vesterålen			9	98	805	1220	2062	2666	309	57	22	16	7		7271
Lofoten					21	589	2735	4014	848	209	44	11	40	4	8510
Helgeland			31	107	95	123	41	105	48	23	7	3			583
Møre			56	207	189	259	92	239	108	54	16	5			1225
Sub-total			96	492	2175	4354	7509	8970	1513	377	98	43	49	4	25680

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

Barents Sea	0,2	5,5	7,0	9,7	10,2	6,9	2,7							42,2
Vesterålen[x)]		+	0,2	0,5	0.7	0,5	0,2							2,1
Lofoten				2,5	11,2	24,5	7,6	3,0	0,6	0,2	0,2	0,2		50,0
Helgeland		+	+	0,3	0,5	1,0	0,21	0,4	0,4					2,8
Møre		0,1	0,1	0,7	1,0	2,0	0,5	0,8	0,8					6,0
Sub-total	0,2	5,6	7,3	13,7	23,6	34,9	11,2	4,2	1,8	0,2	0,2	0,2		103,1
Spawning stock size	0,3	6,1	9,5	18,1	31,1	43,9	12,7	4,6	1,9	0,2	0,2	0,2		128,8