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STOCK SIZE OF NORTH-EAST ARCTIC COD, ESTIMATES  
FROM SURVEY DATA 1984/85

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 1985 was estimated to about 5100 million specimens, of which age group 2 and 3 amounted to about 3400 and 1200 million specimens respectively. The total number of fish of age 3 and older (3+) were estimated to 1500 million specimens which is 2.5 times higher than the estimate of about 575 million specimens arrived at by the Working Group on Arctic Fisheries. The spawning stock at 1 January 1985 was estimated to 72 million specimens which is a 17 percent reduction as compared to 1984. The bulk of the spawning stock were made up by 5, 6, 7 and 8 years old fish.

## INTRODUCTION

Since 1982, estimates of the total stock, the spawning stock and the maturity ogive for North-East Arctic cod have been worked out on the basis of survey results (Hysten and Nakken, 1982, 1983 and 1984). Because these estimates have proved useful to the Working Group of Arctic Fisheries in the assessments and predictions of the stocks of both North-East Arctic cod and haddock (Anon., 1983, 1984a and 1985) the work has been carried on also in 1985.

The results of each particular survey in the season 1984/85 are given in separate reports to this meeting (Hysten et al., 1985a, Godø et al., 1985a and Godø et al., 1985b). In the present paper these results have been utilized to estimate the total stock and spawning stock size at the beginning of January 1985.

## MATERIAL AND METHODS

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

1. The Svalbard bottom trawl survey, 7 September - 3 October 1984 (Godø et al., 1985a).
2. The Barents Sea acoustic survey, 25 January - 8 March 1985 (Hysten et al., 1985a).
3. The Lofoten acoustic surveys, 10 March - 15 April 1985 (Godø et al., 1985b).
4. The Møre acoustic survey, 26 March - 3 April 1985 (Godø et al., 1985b).

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 1985 were arrived at, by adding the 1985 - 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 completion of the various surveys are given for each statistical area (Table 1A). Total landings from the actual areas and periods were 72 724 tons, representing a total of 18 million fish (Table 1A). In total, the landings were dominated by the 1978-, 1979- and 1977 year-classes, given in successive order. The importance of the 1975 year-class is significantly reduced compared with the 1984 catches.

No catches have been reported from the Svalbard region in the last quarter of 1984. Even so, some catches might have been taken. However, the fishing activity in the region between 1 October 1984 and 1 January 1985 was low.

##### Barents Sea region

As in previous years both an acoustic and a bottom trawl survey were carried out at the same time in the Barents Sea during winter 1985. The total Barents Sea component of the stock was estimated to about 4900 million specimens on the basis of the acoustic results (Hysten et al., 1985a). 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 83% of the total number.

The sources of the main errors affecting the estimates have been discussed by Hysten et al. (1985a, 1985b). As in previous years the older fish ( $\geq 4$  years of age) appeared to be over-sampled by the bottom trawl as compared to the younger age groups thus biasing both the bottom trawl indices and the acoustic estimates. In addition, in 1985, and probably also in 1984, difficulties were encountered in obtaining representative species compositions of the acoustically recorded fish. Analyses of the 1985-survey data clearly indicated that neither the length compositions of cod and haddock nor the number of cod versus haddock in bottom trawl catches were representative for the whole water column. A comparison between pelagic- and bottom-trawl catches within the same areas showed that young haddock was predominant in the bottom trawl catches while young cod outnumbered the haddock in the pelagic hauls. Hence, when catch compositions from bottom trawl catches are combined with the acoustic data for the entire water column, which to a great extent have been done in the past, the abundance of haddock is overestimated while the cod abundance is under-estimated (Hysten, et al. 1985b). In 1985 two alternative series of acoustic estimates were worked out. One alternative a) combined the acoustic and biological data in the same way as in previous years. The other alternative b) which utilized the available information on the vertical distribution of the two species was believed to produce the more reliable estimates.

The text table below shows the acoustic estimates of the 1980-1984 year classes of cod in the Barents Sea for 1984 and 1985.

	Year class				
Year	1984	1983	1982	1981	1980
1984		2382	506	107	53
1985	118	3392	667	664	48

The 1984 figures are taken from Hylén and Nakken 1984, and the 1985 figures from Hylén et al. (1985b).

The discrepancies between the 1984 and 1985 results for the year classes 1983, 1982 and 1980 might be accepted for reasons explained in the survey report and to some extent outlined above, but we find it difficult to accept the large increase of the 1981 year class from 1984 to 1985. According to previous observations that year class was estimated to be very poor in abundance both as 0-group and as 1- and 2-group (Anon. 1984b, Dalén et al. 1982 and 1983). It thus seems reasonable to assume that the 1985-estimate is heavily biased upwards because of inadequate sampling, wrong ageing or incorrect establishing or application of age length keys. The possibility of wrong ageing has been discussed, but at present there is no justification for such an explanation.

Although we are not able to explain why the 1981-year class was overestimated in the 1985 survey, comparison of the 1985-estimate with estimates obtained in previous years strongly indicate that this was the case. At the 0-group stage the abundance of the 1981 year class was estimated to be 1/6 of the abundance of the 1982 year class. Assuming the same ratio between the abundances of these two year classes as 3 year olds and accounting for an annual mortality of 0.2 for the 1981 year class during its fourth year of life resulted in the following estimates for 1985:

Year class:	1981	1982
Number (million):	160	1171

Where the sum of the acoustic estimates for the 1981 and 1982 year classes in 1985 have been accepted (Hylén et al. 1985b). A different way of working out an estimate for 1985 for the

1981 year class is to use the 1984 estimate and scale it by the ratio between the bottom trawl indices in 1985 and 1984. This procedure gives:

$$\text{Estimate}_{1985} = \text{Estimate}_{1984} \frac{\text{Index 1985}}{\text{Index 1984}} = 107 \frac{78}{60} = 140$$

Where the estimate for 1984 is taken from the text table above and the bottom trawl indices from Hysten et al. (1985b). Both these figures, 140 million and 160 million individuals are slightly higher than the 1984 estimate but the increase from age 3 (in 1984) to age 4 (in 1985) are in line with the trends observed for the preceding poor year classes (Hysten et al. 1985b), fig. 14). There is no information which permits us to judge the reliability of either of these two estimates and we have chosen 160 million individuals for our further use. This implies that the 1982 year class is estimated to about 1170 million individuals in 1985 which is more than twice the estimated abundance of that year class in 1984. The main reason for the larger increase is a shift in estimates of abundance from haddock to cod between 1984 to 1985 of both the 1982 and 1983 year classes as explained in the survey report (Hysten et al. 1985b). A similar shift was observed in the late 70'ies where the abundant 1975 year classes were predominant in the young fish stocks of cod and haddock (Nakken and Ulltang 1983).

On the basis of the considerations made above, we have corrected the 1985 estimates of the 1981 and 1982 year classes to 160 and 1171 million individuals respectively (Table 1B). The other estimates in table 1B are in accordance with those given in the survey report. It should, however, be noted that also the 1985 estimate of the 1980 year class might be slightly biased upwards for the same reasons as that of the 1981 year class.

#### The Vesterålen region

Due to bad weather conditions and lack of survey time this region could not be surveyed in 1985. The total catch in the

area up to the end of the Barents Sea survey was 30 000 tons compared to 37 000 tons during the same period in 1984. In Lofoten the corresponding catches were 14 000 tons in 1985 and 30 000 tons in 1984. Thus, the catches in Lofoten and the Vesterålen area were considerably reduced from 1984 to 1985. Furthermore the amount of spawning cod on the banks to the west and north of the Lofoten Islands was observed to be 9 million fish in 1985 compared with 11 million in 1984, a reduction of 18% (Godø, et al., 1985b).

In 1985 the survey of the southern part of the Vesterålen area resulted in about 6 million fish which was definitely an underestimate for this region (Godø, et al., 1985b). In view of a 18-19% reduction, both in catches and stock size estimate on the banks west and north of the Lofoten Islands, the Vesterålen stock was assumed to be reduced from 9 million fish in 1984 (Hysten and Nakken 1984) to 7.3 million in 1985 (Table 1B).

The age composition of the survey catches in the area was accepted to represent the age distribution of the population. The resulting age composition was dominated by the 1979 and 1978 year classes (Table 1B), in successive order.

#### Lofoten region

This area was surveyed three times during the fishing season (Godø, et al., 1985b). 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 from the third week of March, about 35 million fish.

A limited number of length measurements and age readings from research vessels were accepted to be appropriate for the stock in the area. This age composition was dominated by the 1978 and 1979 year-classes (Table 1B).

### Helgeland - Trøndelag region

The abundance of cod was expected to be low and the area was therefore not surveyed in 1985 (Godø et al., 1985b).

Total catches up to the end of March was of the same order as last year and the stock was assumed to be 0.8 million fish as in 1984. The age distribution was assumed to be the same as in Lofoten (Table 1B).

### Møre region

Due to bad weather conditions the Møre region was insufficiently surveyed (Godø et al., 1985b). The stock estimate must therefore be considered highly unreliable, caused by the difficulties in separation of "pure" cod recordings from other fish, a problem which increases at low fish densities. It can, however, be concluded that the number of spawners of North-East Arctic cod in the Møre region was much less than in 1984, and the total number of spawners in the Møre and Helgeland/Trøndelag regions was assumed to be 1.5 million fish, half the numbers in 1984. The relatively large reduction of the spawning component off Møre, Trøndelag and Helgeland from 8.8 million in 1983 to 1.5 million fish in 1985 seems to be caused by less recruitment to this area.

The age data collected during the survey was not worked up in time and the biological data from Lofoten was applied for this region (Table 1B).

### 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 1984 (Godø et al., 1985a). By the swept area method the stock size at the beginning of October was estimated to 114.8 million fish which was reduced



by natural mortality ( $M=0.20$ ) to 108 million fish at 1 January 1985.

The 1984 year class was not available to the bottom trawl survey in autumn 1984. However, this year class had a 12% higher abundance at the 0-group stage (data at the Institute. By accepting the same relation between the swept area figures at the 1 October in their second year of life and a natural mortality,  $M=0.20$ , the index at 1 January 1985 would be 67 million fish for the 1984 year class (Table 1B).

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 51 million fish (Table 1B). This component was dominated by the 1982 year-class.

#### Total stock size

The sum of survey estimates and landings make up the total stock size at the beginning of 1985 (Table 1B). Total stock size of 3 year and older fish was assessed to 1510 million fish as compared to 576 million fish given by the Arctic Fisheries Working Group (Anon, 1985). 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 33 and 31 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 1985 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 72 million fish, dominated by the 1978 and 1979 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:	+	13	63	96	100	100	100	100	100

These figures are slightly higher than those given by Hylén and Nakken (1984), and considerably higher than the percentages arrived at by other authors in previous years.

## DISCUSSION

The Helgeland region was not surveyed in 1982, 1983 and 1985, and the stock size in the region had to be stipulated. These calculations involved an assumption that the catch in 1984 and 1985 in this region made up the same portion of the stock both years.

The stock size in the Møre region had also to be stipulated in 1985. Survey results and catches give some guidance. The catches decreased by 43% from 1984 to 1985 and the estimated stock size is an insignificant part of the total stock size in 1985. These information give basis for assuming a stock size in

the Møre and Trøndelag/Helgeland regions of half the size in 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 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, the survey estimates are higher than given by the Working Group, while the Working Group figures are higher for 6 year olds and older. The present stock size of 3 year old fish and older, is 931 million higher than estimated by the Working Group. The discrepancies reflects mainly the deviations in the Barents Sea estimates between 1984 and 1985, since the Working Group used the survey results from 1984 in the assessment. As explained previously large errors may occur in these estimates due to inadequate sampling. 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, as strongly pointed out by Hysten et al., 1985b.

## REFERENCES

- Anon. 1983. Report of the Arctic Fisheries Working Group. Copenhagen, 21-28 September 1982. Coun. Meet. int. Coun. Explor. Sea, 1983 (Assess:2): 1-62 (Mimeo.)
- Anon. 1984a. Report of the Arctic Fisheries Working Group. Copenhagen. 15-22 September 1983. Coun. Meet. int. Coun. Explor. Sea, 1984 (Assess:3): 1-66 (Mimeo.)
- Anon. 1984b. Report of the international 0-group fish survey in the Barents Sea and adjacent waters in August/September 1981. Annls. Biol., Copenh., 38: 288-236.
- Anon. 1985. Report of the Arctic Fisheries Working Group. Copenhagen, 26 September - 3 October 1984. Coun. Meet. int. Coun. Explor. Sea, 1985 (Assess: 2): 1-52 (Mimeo.)
- Dalen, J., Hysten, A., Nakken, O., Randa, K. and Smedstad, O.M., 1982. Norwegian investigations on young cod and haddock in the Barents Sea during winter 1982, Coun. Meet. int. Coun. Explor. Sea, 1982 (G:41): 1-22 (Mimeo.)
- Dalen, J., Hysten, A., Nakken, O., Randa, K. and Smedstad, O.M., 1983. Preliminary Report of the Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1983. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:15) 1-23 (Mimeo.)
- Godø, O.R., Nakken, O. and Sunnanå, K. 1983. Acoustic estimates of spawning cod off Lofoten and Møre in 1983. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:37): 1-24 (Mimeo.)
- Godø, O.R., 1985a. Preliminary report of the Norwegian ground-fish survey at Bear Island and West-Spitsbergen in the autumn 1984. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:65): 1-20 (Mimeo.)
- Godø, O.R., Raknes, A. and Sunnanå, K., 1985b. Acoustic estimates of spawning cod off Lofoten and Møre in 1985.

- Coun. Meet. int. Coun. Explor. Sea, 1984 (G:66): 1-14  
(Mimeo.)
- Hylen, A. 1971. Introduction. Annls. Biol., Copenh., 27: 75-77
- Hylen, A. and Nakken, O. 1982. Stock size of North East Arctic cod, estimated from an acoustic survey data 1982. Coun. Meet. int. Coun. Explor. Sea, 1982 (G:61): 1-12 (Mimeo.)
- Hylen, A. and Nakken, O. 1983. Stock size of North East Arctic cod, estimated from survey data 1983/84. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:57): 1-14 (Mimeo.)
- Hylen, A. and Nakken, O. 1983. Stock size of North East Arctic cod, estimates from survey data 1984/85. Coun. Meet. int. Coun. Explor. Sea, 1984 (G:545): 1-12 (Mimeo.)
- Hylen, A., Jakobsen, T., Nakken, O. and Sunnanå, K. 1985a. Preliminary report of the Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1984. Coun. Meet. int. Coun. Explor. Sea, 1984 (G:545): 1-12 (Mimeo.)
- Hylen, A., Nakken, O. and Sunnanå, K. 1985b. The use of acoustic and bottom trawl surveys in the assessment of North-East Arctic cod and haddock stocks. A workshop on comparative biology, assessment, and management of gadoids from North Pacific and Atlantic Oceans. Seattle, Washington 24-28 June, 1985. 25 pp. (Mimeo.)
- Nakken, O. and Ulltang, Ø. 1983. A comparison of the reliability of acoustic estimates of fish stock abundances and estimates obtained by other assessment methods in the North-East Atlantic. In O.Nakken and S.C.Venema (eds.) 1983. Selected papers of the ICES/FAO symposium on fisheries acoustic, Bergen, 22-24 June 1982 FAO Fish. Rep. 300.
- Randa, K. 1984. Abundance and distribution of 0-group Arcto-Norwegian Cod and haddock 1965-1982. The proceedings of the soviet and Norwegian symposium on reproduction and recruitment of Arctic cod, Leningrad, 26-30 Sept. 1983: 197-212.

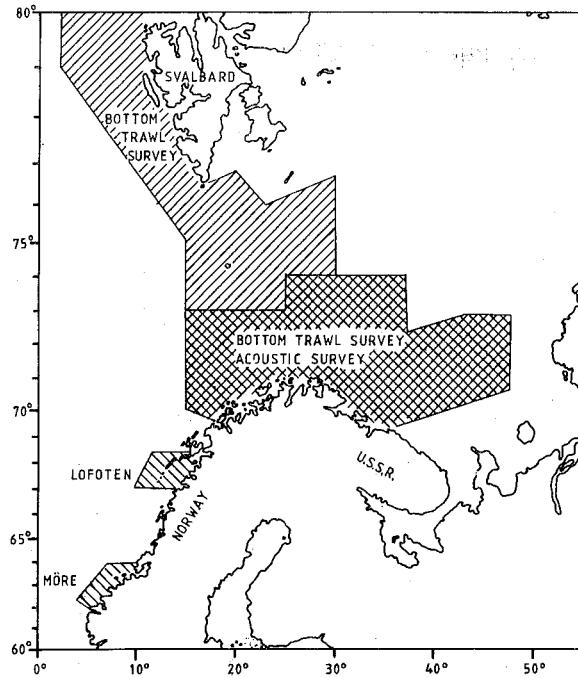


Fig. 1. The areas covered by cod and haddock surveys in the period 1981 - 1985.

Table 1. North-East Arctic Cod. Stock size by numbers at the beginning of 1985.  
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			3	105	311	430	223	40	15	3	1130	3318
North Cape Bank			1	2	6	11	9	4	3	2	38	151
West Finmark			93	777	1020	1591	1881	430	184	59	6035	19683
Vesterålen			3	91	323	1699	2537	1238	577	409	6877	30040
Lofoten	1	-	22	85	496	1017	758	268	256	2903	13570	
Helgeland			5	17	97	211	174	60	51	615	2934	
Møre			4	19	111	230	177	59	47	647	3028	
Total		1	100	1006	1781	4435	6108	2821	1166	827	18245	72724

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

Svalbard	(67)	50	41	5	3	2	+	+	+	+	168
Barents Sea	(118)	3392	1171	160	48	14	3	+	+	+	4906
Vesterålen					+	4	3	+	+		7
Lofoten				1	3	10	13	3	4	1	35
Helgeland/Møre				+	+	1	1	+	+	+	2
Subtotal	(185)	3442	1212	166	55	30	20	4	4	2	5118
Total stock	(185)	3442	1212	167	56	35	26	7	6	2	5136
Stock size (Anon 1985)			400	51	34	35	25	15	8	8	576

Table 2. North-East Arctic Cod. Spawning stock size by numbers at the beginning of 1985.  
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				35	208	386	216	40	15	3	903
North Cape Bank				1	5	10	9	4	3	2	34
West Finmark				372	840	1495	1881	430	184	59	5261
Vesterålen				52	285	1576	2520	1238	577	409	6657
Lofoten				7	60	464	1015	758	268	256	2828
Helgeland				1	12	89	210	174	60	51	597
Møre				1	14	102	230	177	59	47	630
Total				469	1424	4122	6081	2821	1166	827	16910

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

Barents Sea				+	2	3	3	2	+	+	12
Vesterålen					+	4	3	+	+		7
Lofoten				1	3	10	13	3	4	1	35
Helgeland/Møre				+	+	1	+	+			2
Subtotal				+	3	6	18	19	4	2	56
Spawning stock				+	4	7	22	25	7	5	72