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Further Analysis of Subarea 1 Cod, 1985 and Projections for Subsequent Years

by

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1. Introduction

The ICES Working Group on Cod Stocks off East Greenland, at its meeting in January 1986, found it necessary to use data derived from the assessments of the West Greenland cod and hence carried out assessments for both East and West Greenland cod and presented both assessments in its report (ICES C.M. 1986/ Assess: 11). The West Greenland part and some general parts of that report are presented as a research document to the Scientific Council of NAFO at its present meeting (SCR Doc. 86/55).

The present paper presents some updating of information in the former document and projections carried out in accordance with the request by Denmark on behalf of Greenland (SCS Doc. 86/12).

2. Updated catch statistics

Total nominal catch of cod for Subarea 1 in 1985 was reported as 12,935 tons when the ICES Working Group met in January 1986. New information now available, although still as provisional figures, shows a total catch of 14,489 tons (2,170 for the Federal Republic of Germany and 12,319 tons for Greenland). The distribution on divisions and the estimated distribution on gears is shown in Table 1.

3. Catch in numbers by age, 1985

As a consequence of the revised catch statistics the catch in numbers by age has also been revised. Due to the rather poor sampling in 1985 the figures are still very rough estimates. The revised figures are given in Table 2.

4. Weight at age in 1985 and subsequent years

Weight at age for 1985 was obtained as given in Table 3. The weight-at-age figures for the various components of the fishery in the table are taken from Table 6.3.1. in SCR Doc. 86/55. For 1986 and subsequent years weight-at-age figures are achieved by weighting figures for catches by Greenland vessels other than trawlers by a factor 5 times that for weight-at-age found by trawl surveys. This weighting was made to take into account the regulation for 1986 whereby direct cod fishing by trawlers is not allowed. The actual mean weight for the projection years will depend upon both the actual fishing pattern and the growth rate. The latter fluctuates between years and between year-classes and seems to be dependent upon environmental factors (H. H. Hansen, 1986).

5. Other parameters used for projections

The maturity ogive found in the Report of the ICES working group (NAFO SCR Doc. 86/55, Fig. 6.4.7) was used for calculating spawning biomass for 1985 and for the projections. The figures are given in Table 4.

Partial recruitment (partial F) was not analyzed separately in the 1985 material. Figures were taken from last year's report (Sc. Coun. Rept. 1985, p. 47) and are also listed in Table 4.

Natural mortality was as previously taken as $M = 0.20$ for all ages except for age-groups 3 for which a value of 0.30 is used to account for possible discarding in relation to the minimum landing size of 40 cm.

Emigration coefficient was taken to be 0.05 for age-group 6 and older fish in accordance with the conclusions of the ICES working group (SCR Doc. 86/55, section 6.8).

The stock by 1 January 1986 and the various parameters used for the projections are listed in Table 4.

6. Future recruitment

At its initial discussion at the present meeting, of recruitment prospects for Subarea 1 cod the Standing Committee on Fisheries Science (STACFIS) took note of the information on future recruitment supplied to the ICES working group in January 1986 (SCR Doc. 86/55). STACFIS noted that year-classes 1984 and 1985 seems to be much better than the poor year-classes preceding them. STACFIS also noted that the initial suggestion for year-class 1982, based upon number of cod larvae in the plankton in 1982 and the water temperature off West Greenland that summer, was that the year-class would be a good one. However, subsequent adverse environmental conditions seem to have prevented sufficient survival of larvae and/or young fish to form more than a poor year-class at time of recruitment (1985-86).

STACFIS found it premature to quantify the two year-classes in question (1984 and 1985). However, since these year-classes, especially that of 1984, still seems to be much better than the preceding ones, it was found that illustrative examples should be given of development in the stock when one or more good year-classes recruit after a period of poor recruitment. The authors, therefore, carried out projections for a recruitment of 200 million fish at age 3 of year-class 1984 in 1987 and 100 million fish of year-class 1985 in 1988, while year-classes 1981-83 are regarded poor (20 million fish at age 3). Year-class 1986 was arbitrarily set as a poor one (20 million fish). The 200 million fish for year-class 1984 is in the same order as that found for year-class 1973 in previous VPA analyses (Horsted, Messtorff and Schumacher, 1983).

7. Yield per recruit

With the observed changes in growth rate and in migration rate it was necessary to calculate a revised yield-per-recruit function. This is illustrated in Fig. 1A. By the new analysis F_{max} is found to be 0.38 and $F_{0.1}$ to be 0.19. Values found last year were 1.00 and 0.392, respectively. The change is due mainly to changes in estimates of migration rate. The F -value found in 1985 for fully recruited age groups is 0.685 while that corresponding to the TAC of 12,500 tons in 1986 is found to be 0.517.

8. Projections carried out

The revised assessment of the stock in 1985 is given in Table 5 while the projections carried out in accordance with the request (SCS Doc. 86/12) are presented in Table 6 and in Fig. 1B. In addition to the specific options requested also an example of full stop of cod fishing in 1987 and 1988 and with only 6,000 tons taken in 1986 has been made. For some of the management strategies the calculations have been carried forward to 1990/1991 (Table 7) in order to illustrate the relative influence of year-classes 1984 and 1985 should they achieve a size level as used here (200 and 100 million fish at age 3, respectively).

Table 6 mainly illustrates that in spite of the strength of the 1984 year-class, catches in 1987 will continue at a very low level. By 1988 catches could be higher, but if so the rate of rebuilding will be lower. Thus a catch of about 12,000 tons in 1988 equals a component of 22,000 tons in stock size (age 3+) in 1989.

Table 7 illustrates that by 1987 3-year-old fish will dominate the stock. If the year-class achieves the size used for illustration the 3-year-olds will account for 72% of the stock biomass, although only 11% of the landings (at $F_{0.1}$ level). However, by 1988 the year-class could account for more than 62% of the landings (by weight). This clearly illustrates that actual catch level in the projections depends heavily on a more precise estimate of recruitment of year-classes 1984 and 1985.

9. Information of spatial distribution of year-classes 1984 and 1985

a) Offshore information

Table 6.5.1 in the report of the ICES working group (SCR Doc. 86/55) shows age distribution by division of the stock estimates resulting from the trawl surveys by the Federal Republic of Germany, 1985.

Approximately 50% by number of the estimated amount of cod of year-class 1984 were found in Div. 1C and that part of Div. 1B covered by the survey, i.e. south of 67°N lat. In terms of numbers the year-class was, however, the predominant one also in Div. 1D-1F. It thus seems important throughout the offshore area at least from southern part of Div. 1B through to Div. 1F. If the usual southward migration takes place as the individuals grow up Div. 1C and 1D would be expected to be those showing the highest percentage of this year-class in 1987 and 1988, but it seems likely

that it will be predominant in all divisions in those years. Also the 1985 year-class was found in relatively high numbers in all divisions in the survey mentioned, the highest estimate being for Div. 1F. Due to the selectivity of the gear and the small size of the individuals of the 0-group fish it is, however, premature to advise further on the spatial distribution of this year-class before its distribution as 1-year-old fish has been observed in the 1986 survey.

b) Inshore information

Results of the Danish inshore young-fish survey carried out by gill nets are reported by Hansen and Lehmann (SCR Doc. 86/42). The gill nets will not be expected to catch fish of the 0-group size. Thus information is available only for the 1984 year-class. The major part of the fishing was done in Div. 1D-1F but with some effort also in Div. 1A-1C as far north in Div. 1A as at Umanak. Table 6 in SCR Doc. 86/42 gives catch per hour of age-group-1 fish. Best catches were in shallow water in Div. 1F, but catch rates indicate a rather even distribution in Div. 1B-1F, while catches in Div. 1A were insignificant.

The 1984 year-class is thus expected to be a major contributor to inshore catches in 1988, at least from Holsteinsborg and southwards. It would also be expected to occur as small fish generally below 40 cm length in pound-net catches in 1987 (see next section).

10. Information on size composition of catches in 1987 and 1988

In SCR Doc. 86/43 Hansen has shown that in the offshore stock component length-at-age and thereby weight-at-age decreased significantly from 1979 to 1984. Although growth rate will continue to vary between year and year-classes the authors suggest the latest information be taken as basis for projections.

A local minimum landing size of 40 cm is enforced in Greenland. The main question, therefore, seems to be the size of age-groups 3-5, especially age-group 4 in 1987 and 1988. Since, due to gear selectivity the figures given in SCR Doc. 86/43 are not reflecting the true size composition in the stock of the younger age groups, the results of the offshore trawl survey and the inshore gill net survey in 1985 may be the best background for advice at present.

The age and length distribution of the material from the Federal Republic of Germany 1985 trawl survey is presented in Table 8. Provided the 1984 year-class follows the growth of the preceding four year-classes, and taking into account that the survey took place at the end of the year, the table indicates that by age 3 (in 1987) and in the major fishing season more than half the individuals could be expected to be below 40 cm. Also at age 4 (in 1988) a good part of the individuals may still be below that size.

Material (age-length keys) from the inshore gill net survey (SCR Doc. 86/42, Table 2) seems to indicate that in the inshore area the mean length by age was lower in 1985 than in the offshore area. Thus, it would be expected that by 1987 the major part of age 3 cod will be below 40 cm although of a size where they could be retained in pound nets. Also in 1988 a considerably part of the individuals of the 1984 year-class might not yet have achieved a length of 40 cm.

If the 1985 year-class is also a relatively strong one, then by 1987 and 1988 the proportion of small fish in catches will be even higher than indicated above.

References

- Anon., 1986. Report of the Working Group on Cod Stocks off East Greenland, Copenhagen, 14-23 January 1986. ICES C.M. 1986/Assess:11.
- Anon., 1986. Status of Subarea 1 Cod and the Fisheries. NAFO SCR Doc. 86/55.
- Hansen, H. Hovgård, 1986. Changes in Size at Age of Cod off West Greenland, NAFO SCR Doc. 86/43.
- Hansen, H. Hovgård, and K. M. Lehmann. 1986. Distribution of Young Cod in Coastal Regions of West Greenland, 1985. NAFO SCR Doc. 86/42.
- Horsted, Sv. Aa., J. Messtorff, and A. Schumacher. 1983. Status of Subarea 1 Cod and Estimates of Stock and Yield for 1983-1985. NAFO SCR Doc. 83/60 (revised).

Table 1. Nominal catch of cod in Subarea 1, 1985 (provisional figures by divisions and gear. For assumptions see text to Table 6.1.2 in SCR Doc. 86/55. The additional catch of 1569 tons for Greenland as compared to the figures given in that document has been allocated for each division to the miscellaneous gear and pound net proportional to figures in the table mentioned above. Figures for otter trawl and gillnets are minimum figures for these gears.

Division	Otter trawl offshore	Gillnet inshore and offshore	Miscellaneous gear inshore and offshore	Pound Net inshore	Total
1A	-	-	99	-	99
1B	-	63	1297	1360	2720
1C	-	27	494	354	875
1D	140	123	985	1811	3059
1E	1972	4	676	1264	3916
1F	1922	130	676	1092	3820
Total	4034	347	4227	5881	14489

Table 2. Numbers by age of cod in Subarea 1, 1985 for catches listed in Table 1. Figure for age 3 is an estimate (no fish of this age found in the samples used) based upon exploitation pattern and a year-class estimate of 20 million fish at age 3.

Age	No.
3	456
4	1266
5	1303
6	4915
7	161
8	750
9	42
10	140
11	15
12	8
13	-
14	-
15+	14
Total	9070

Table 3. Mean weight (kg, whole, round fish) at age in the main cod fisheries at West Greenland in 1985, and overall weighted mean weight for 1985 and for projections. Weight for age 3 is an estimate.

Age	Greenland trawlers	German (F.R.) survey	Greenland vessels other than trawlers	Weighted mean	
				1985	projections
3	-	-	-	0.50	0.50
4	0.97	0.67	0.78	0.82	0.76
5	1.20	0.98	1.05	1.08	1.04
6	1.66	1.61	1.60	1.62	1.60
7	2.27	2.64	2.14	2.25	2.22
8	2.61	4.50	2.80	3.00	3.03
9	3.97	4.68	3.82	3.99	3.96
10	4.19	5.53	4.16	4.37	4.39
11	-	-	-	5.80 ¹	4.75 ²
12+	-	-	-	6.50 ¹	6.00 ²
weighting factor 1985 ³	4317	2170	8002	14489	
weighting factor for projections	0	1	5		

¹ Figures used previously (Sci. Coun. Reports, 1985, p. 47)

² Figures calculated using VonBertalanffy growth equation

³ The figures are catch figures by weight but in comparison with Table 1 a figure of 2453 tons for Greenland has been transferred from miscellaneous gears to trawl. Preliminary statistics does not allow for an allocation of this catch on divisions.

Table 4. Cod in Subarea 1. Stock size by 1 January 1986 and parameters used in stock and catch projections. Estimated mortality due to discard of age -3 fish and loss due to emigration of fish of age 6 and older fish is accounted for by the relative -M values (M = 0.20)

Age	Stock size 1 Jan 1986 (ooo)	Relative M (M = 0.20)	Mean weight (kg)	Percent maturity	Relative F
3	20,000	1.5	0.50	1	0.039
4	14,367	1.0	0.76	3	0.52
5	7,137	1.0	1.04	15	1.0
6	2,360	1.25	1.60	48	1.0
7	5,845	1.25	2.22	83	1.0
8	281	1.25	3.03	96	1.0
9	606	1.25	3.96	99	1.0
10	20	1.25	4.39	100	1.0
11	1	1.25	4.75	100	1.0
12+	1	1.25	6.00	100	1.0

Table 5. NAFO Subarea 1 Cod Assessment Table 1985. For further explanation see Table 6.7.1 of SCR Doc. 86/55.

Age	Year Class	Stock size		Z	F	Catch 1985	M	E	Losses due to	
		1 Jan	31 Dec						M	E
		(A)	(B)						(C)	(D)
5	1980	1286	2360	-0.607	0.736	1303	0.2	-1.543	354	-2731
6	1979	7994	5845	0.313	0.716	4915	0.2	-0.603	1373	-4139
7	1978	716	281	0.940	0.348	161	0.2	0.391	93	181
8	1977	1901	606	1.143	0.662	750	0.2	0.281	227	318
9	1976	80	20	1.386	0.970	42	0.2	0.208	9	9
10+	<1976	242	2	4.796	3.537	177	0.2	1.059	10	53
Total 5-9		11977	9112	0.273	0.683	7171	0.2	-0.606	2056	-6362
Total 6-9		10691	6752	0.460	0.685	5868	0.2	-0.424	1702	-3631

Table 6. Cod in Subarea 1: Projections of Age 3+ biomass and spawning stock biomass at the beginning of the year and catch during the year for different management strategies.

YEAR	Catch in 1986 = TAC = 12500 t					Catch 1986 Different from TAC			
	TAC = 12.5	F = 0	F _{0.1}	F _{max}	F ₁₉₈₅	Catch 87/88=0	Catch 1987/88 at 1986 level		
						Catch 86 = 6000 t	F(86) = F _{0.1}	F(86) = F _{max}	F(86) = F(85)
1986									
Biom.3+	48	48	48	48	48	48	48	48	48
SSB	17	17	17	17	17	17	17	17	17
F(6-9)	0.517	0.517	0.517	0.517	0.517	0.220	0.190	0.380	0.685
Catch	12.5	12.5	12.5	12.5	12.5	6.0	5.3	9.7	15.5
1987									
Biom.3+	138	138	138	138	138	146	147	142	135
SSB	17	17	17	17	17	22	23	19	15
F(6-9)	0.449	0	0.190	0.380	0.685	0	0.137	0.304	0.660
Catch	12.5	0	5.8	10.9	17.6	0	5.3	9.7	15.5
1988									
Biom3+	190	205	198	192	184	214	208	197	182
SSB	20	29	25	21	17	36	32	25	15
F(6-9)	0.165	0	0.190	0.380	0.685	0	0.057	0.117	0.226
Catch	12.5	0	15.5	27.5	41.8	0	5.3	9.7	15.5
1989									
Biom3+	207	238	212	190	164	247	235	218	195
SSB	39	56	44	34	24	64	57	46	32

Weights in 1000 tonnes, biomasses at 1 January

Table 7. Cod in Subarea 1: Calculated yields and biomasses 1987-1991 for various management strategies and the % contribution of the 1984 and 1985 year-classes. All strategies assume the TAC of 12,500 tons in 1986 to be taken.

		1987-88 (F=0)		% YC		F _{0.1}	% YC		F _{max}	% YC		F(85)	% YC	
		1989-90 (F _{0.1})		84	85		84	85		84	85		84	85
1987	Biom.3+	138		72	-	138	72	-	138	72	-	138	72	-
	SSB	17		6	-	17	6	-	17	6	-	17	6	-
	F(6-9)	0				0.190			0.380			0.685		
	Catch	0		-	-	5.8	11	-	10.9	12	-	17.6	13	-
1988	Biom.3+	205		55	24	198	56	25	192	58	26	184	60	27
	SSB	29		12	2	25	14	2	21	16	2	17	20	3
	F(6-9)	0				0.190			0.380			0.685		
	Catch	0		-	-	15.5	62	2	27.5	66	2	41.8	72	3
1989	Biom.3+	238		53	24	212	54	26	190	54	29	164	52	33
	SSB	56		34	3	44	39	4	34	45	5	24	53	7
	F(6-9)	0.190				0.190			0.380			0.685		
	Catch	31.8		62	15	27.7	65	17	45.1	65	20	60.2	65	25
1990	Biom.3+	248		53	23	213	55	27	176	50	29	125	44	34
	SSB	108		59	8	91	63	9	65	65	12	39	67	16
	F(6-9)	0.190				0.190			0.380			0.685		
	Catch	36.0		56	25	32.2	56	28	45.8	54	32	50.1	49	39
1991	Biom.3+	241		49	25	219	48	27	151	43	29	90	29	30
	SSB	159		61	18	140	63	20	87	62	24	43	58	30

Table 8. Age and length distribution of catches by the Federal Republic of Germany trawl survey at West Greenland 1985.

Age group	0	1	2	3	4	5	6	7	8	9	10	Total nos.
Year-class	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	
Midpoint of 3cm length group												
7.5	24											24
10.5	154											154
13.5	23	45										68
16.5		596	5									601
19.5		1684	0									1684
22.5		2257	0									2257
25.5		1308	40									1348
28.5		134	118	5								257
31.5		8	10	0	1							19
34.5		2	2	7	15							26
37.5				18	39							57
40.5				30	145							175
43.5				32	291	11						334
46.5				22	372	19	6					419
49.5				10	300	79	6					395
52.5				0	259	118	71					448
55.5				7	258	211	155					631
58.5					109	146	407					662
61.5					17	93	496	8	8			622
64.5					12	11	326	17	30			396
67.5						14	119	13	25			171
70.5							61	7	22			90
73.5							19	5	33			57
76.5							5	16	18		1	40
79.5								8	16	3		27
82.5								1	7	1		9
85.5									2	0		2
88.5										1		1
Total nos.	201	6034	175	131	1818	702	1671	75	161	5	1	10974
Mean length (cm)	10.49	21.80	27.71	42.54	48.85	55.69	61.26	70.26	71.36	81.90	(76.5)	

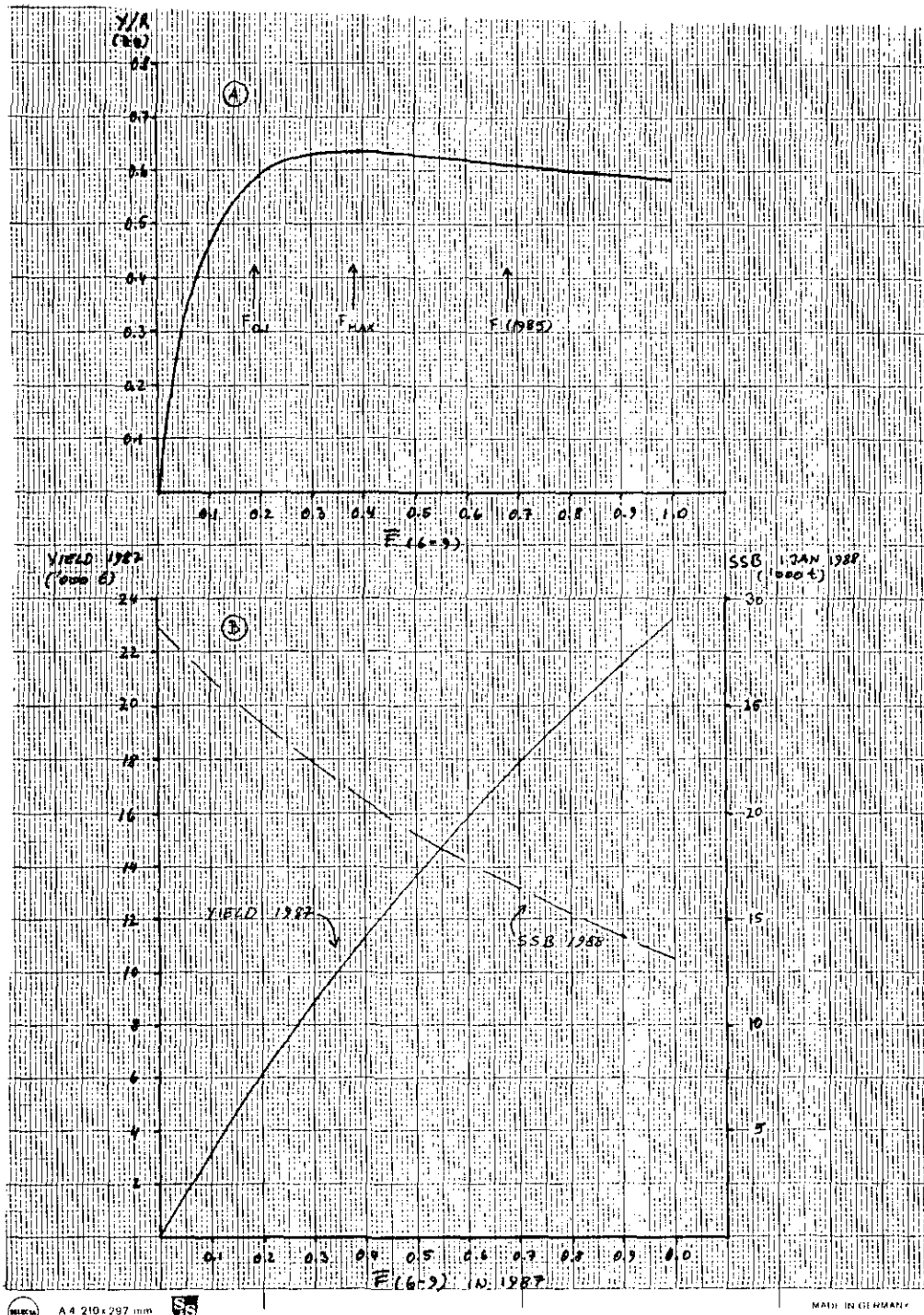


Fig. 1. Cod in Subarea 1: (A) yield-per-recruit curve, and (b) calculated yield in 1989 and spawning stock biomass (SSB) in January 1988 for various levels of fishing mortality in 1987.