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Data and Preliminary Assessment of *Subarea* 1 Cod

by

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Introduction

The fishery for cod in Subarea 1 is partly an offshore fishery carried out by large trawlers, and partly a coastal and fjord fishery, in which the main part of the landings usually is taken by pound nets.

During the 1955-68 period, when the major part of the catch was taken by non-Greenland vessels, catches fluctuated between 234,000 and 451,000 tons (1962). Catches declined gradually after 1968 to a low of 33,000 tons in 1976, after a number of years of recruitment failure. Recruitment of the very abundant 1973 year-class in 1976-77 resulted in increased catches up to 1979. During 1980-83, catches fluctuated between 53,000 and 58,000 tons but decreased thereafter by about 50% each year to a low level of only 6,600 tons in 1986, the lowest catch on record since ICNAF began compiling statistics. Catches and TACs in recent years are given in Table 1. After 1987 when no directed trawl fishery was allowed in the first ten months, fishing by trawlers was allowed in 1988 under quotas set by the Greenland Home Rule authorities.

The nominal catch in 1989 was about 103,000 tons, which is a 78% increase compared to the 1988 catch and nearly fifteen times the record-low catch of 1986. The increase during 1987 to 1989 reflects the recruitment of the very abundant 1984 year-class.

Commercial fishery data

i) Catch per unit effort for Greenland trawlers.(SCR Doc.90/28)

Catch and effort data for Greenland trawlers in 1975-89 have been carefully scrutinized and the earlier figures have been revised. In 1989, the trawlers operated only in Divisions 1D, 1E and 1F. During the second part of the year, effort had a more southerly distribution than in the first part of the year.

The overall catch per unit effort increased by about 1 t/hour compared to 1988. The catch per unit effort in the second quarter of the year was the highest on record.

CPUE has been analyzed using a multiplicative model including effects of year, division and month. The data consist of logbooks from 6 sister trawlers owned by the Greenland Home Rule Government, which account for about 90% of the total effort in the Greenlandic trawl fishery for cod.

The estimated year index is shown in Figure 1.

ii) Age composition

Catch statistics for the Greenlandic fishery are now collected on a gear-basis, but due to technical problems in Greenland catches could only be split into trawl catches and catches by other gears (inshore catches).

Greenland trawl catches were well sampled throughout the year. All samples from other gears regardless of month and division were pooled and used to convert the total inshore catch into numbers. Trawl catches of the Federal Republic of Germany and the United Kingdom were raised according to samples from the Federal Republic of Germany commercial fishery as their length frequency distributions differed from those of the Greenland trawl catches.

Greenland trawl catches were dominated by the age group 5 (96% by numbers) throughout the year and in all areas. The domination of age group 5 was also evident in the Federal Republic of Germany catches (80%) with age group 4 the next most abundant (18%). Some of this difference may have been due to discarding of age 4 fish by Greenlandic trawlers, as a part of this age group was still below minimum landing size of 44 cm in Greenland.

In the inshore catches, age groups 5 and 4 dominated with 77% and 21% by numbers, respectively.

Overall, the 1984 year-class accounted for 86% by numbers (88% by weight) whereas the 1985 year-class accounted for 12% (7% by weight).

iii) Weight-at-age data

In the 1979-85 period, mean weight-at-age decreased, but increased again in 1986 and 1987, only to decrease in 1988 and further in 1989. Overall mean weight in the fisheries increased to 1.24 kg.

Research data.

i) Groundfish surveys by the Federal Republic of Germany (SCR Doc. 90/74).

Stratified-random bottom trawl surveys off West Greenland have been conducted in late autumn since 1982. Cod biomass and abundance estimates for the total survey area off West Greenland on the basis of the swept-area and a catchability factor of 1 are given in Table 2.

From 1982-1984, the survey results reveal a drastic decline in cod biomass and abundance which was observed not only for the whole survey area but for all divisions. The total survey biomass and abundance, however, increased considerably after 1984 and particularly in 1987 due to increased recruitment, mainly of the outstanding 1984 year-class.

In 1988, the survey biomass of age 4 and younger cod increased by 122,000 tons. The biomass of age 5 and older fish, however, decreased by 39,000 tons. The resulting increase in total biomass of 83,000 tons was less steep than previously.

The survey results of 1989 reveal a pronounced decrease, in abundance by 221 million fish (39%), together with an obvious southward displacement of the stock with 91% of the total survey biomass and 92% of the total survey abundance occurring in Divisions 1E and 1F. This decrease was mainly caused by a reduction in the abundance of the 1984 year-class. The abundance estimate for NAFO Division 1E has been revised

since the ICES Working Group on Cod Stocks off East Greenland met in February 1990 (SCR Doc.90/74).

ii) Inshore longline survey by Greenland (SCR Doc. 90/29).

Since 1987, Greenland has conducted annual inshore longline surveys at the same time as the trawl surveys were undertaken by the Federal Republic of Germany. Inshore abundance of cod above has been calculated by converting longline catch per unit effort to swept area estimates.

The survey in 1989 was carried out in inshore areas of Divisions 1B, 1C, 1D and 1E. The inshore component was estimated to 21% of the total in 1989, and is in consistency with the results of previous years of survey. Based on these three years results it seems reasonable that the offshore survey stock estimates from the trawl survey should be raised by a factor of 1.28 to account for the stock component in the non-covered coastal and inshore area.

iii) Young cod survey by Greenland (SCR Doc. 90/30).

During June-July 1989, Greenland carried out gillnet survey on young cod in three inshore areas of West Greenland.

During the survey, a total of 2,005 cod was caught. In Division 1B catches were dominated by 2- and 3-year-old with a substantial amount of older fish as well. In Division 1D the 2-year-old dominated, and few older fish were caught, whereas catches of all age groups in Division 1F were very low.

Based on this survey, the 1987 year-class is estimated to be about 70% of the 1985 year-class, whereas the 1988 year-class seems to be poor.

Assessment

In previous years' assessments (except in 1989) STACFIS used uncorrected survey abundance estimates in two consecutive years and catches between the times of the surveys to arrive at estimates of fishing mortality and emigration. Due to variability in survey results this method resulted in high variation between years in the resultant estimates of emigration rate.

In 1989 STACFIS decided to correct the survey abundance by a factor taken a survey overestimation of abundance into account. Recent trends in spawning stock biomass and fishing mortalities were estimated by the ADAPT method.

This year is was decided to assess the West Greenland stock by a VPA incorporating the period 1975-1989 and age groups 3-12+.

Natural mortality was assumed to be 0.2 for age 5 and older. For age groups 3 and 4, the natural mortality was increased to 0.3 to account for discarding.

An emigration coefficient of 0.15 was applied for age groups 6 and older to account for emigration to East Greenland. This value was chosen because it produces the number of emigrants which on average over the years is necessary to account for the immigrants to East Greenland as calculated by the ICES Working Group on cod stocks off East Greenland in its reports. Previously, a migration coefficients of 0.05 was applied for cod age 6+ based on interpretations of former tagging experiments. However, in some years higher values have been applied, e.g., 0.30 for 1986.

The stock distribution in 1989 indicates that the 5-year-old cod (1984 year-class) have shown a considerable migration from West Greenland to East greenland. Therefore, it was decided to apply an emigration coefficient of 0.25 to age 5 fish in 1989.

Tuning a VPA using ADAPT with linear defined residuals revealed that the solution was heavily dependent on just two observations. Using ADAPT with logarithmic residuals is hampered by very large variations in observations for year-classes which are very poor.

The stock is dominated by the 1984 and to a less extent by the 1985 year-class. Consequently any projection will be largely determined by the assumption of the total mortality in 1989 for the 1984 year-class. From the surveys Z is estimated as being 0.85 which suggests that the terminal F for 1989 for that year-class should be 0.40 (F=Z-M-E). This value tallies with the accepted estimate of 500 million of the 1984 year-class at age 3, the VPA estimate being 570 million. Lower terminal F's and hence lower Z values would suggest a very high year-class strength of the 1984 year-class which is thought unrealistic. The estimates of F of 0.40 is considered high but not unrealistic and was used for VPA and projections. For age groups 3 and 4 the terminal F's have been estimated as their relative F values multiplied by F = 0.40 for the fully recruited age-groups. The results from the VPA are shown in Appendix 1.

The biomass of the 4+ group multiplied with the relative F for the years 1975 to 1989 has been plotted against the annual indices derived from the multiplicative analysis of CPUE in Figure 2 and a linear relation is apparent.

The age 5+ abundance of the stock from the VPA is compared with the abundance of the same year-classes in the preceding November surveys from 1983 to 1990 in Appendix 2. The Z values by year-class show great differences between the survey and the VPA estimates for one year comparisons, while there is to be reasonable agreement between mean values of year-class.

Recruitment prospects

1986 year-class

Both in the trawl survey and the young cod survey this year-class shows a northerly distribution (Division 1D and north thereof). The abundance is low in all surveys and the 1986 year-class is expected to be low. The conventional figure for poor year-classes of 20 million fish at age 3 has been used for this year-class in the projections.

1987 year-class

This year-class shows a very low abundance in the south (Division 1F) in both surveys, and higher abundance in the northern divisions. The young-cod index shows values around 70% of the 1985 year-class, and according to this, the year-class might account for some 70 million fish at age 3. This is in contrast to the trawl survey results which only give an estimate of 7% of the 1985 year-class. It is the first time that the two surveys have shown disagreement. In both the surveys last year, this year-class showed only low densities. Twenty (20) million fish at age 3 has been used in the projections although it is known that this could be too pessimistic.

1988 year-class

Very few fish of the 1988 year-class were caught in the two surveys, and then only in Division 1B. This indicates that the year-class is poor. Twenty (20) million fish at age 3 has been used in the projections.

1989 year-class

Few 0-group fish were caught in the trawl survey in Division 1F, and little inflow of larvae from Iceland can be expected as the Iceland 0-group survey gives an index value of almost zero for the East Greenland area. This year-class is, therefore expected to be small. Twenty (20) million fish at age 3 has been used in the projections.

Projections of catch and stock size for 1991-94

The parameters used to project catch and biomass are shown in Table 3. Stock size at 1 January 1990 is taken from the VPA. The natural mortality and the mean weight are the same as those for the VPA. The fishing pattern, i.e. the relative F's is that used in 1989. The E value of 0.25 for the 1984 year-class is used for this year-class throughout the period projected. Furthermore, the same E value is applied to the 1985 year-class at age 5 and older as this year-class also has a very southern distribution. The older year-classes have been given the value of 0.15 as in the VPA.

Cod has been sex determined on a cruise in March 1990 on board a Greenland trawler fishing in Division 1F (Appendix 3). Very few mature or maturing cod were seen (8% of the 1984 year-class and 6% of the 1985 year-class). Because of these surprising low percent of mature fish no attempt has been made to project the spawning stock biomass, which have to wait for the discussion at the Scientific Council meeting.

The parameters in Table 3 were used to calculate a yield-per-recruit curve (Fig. 3) from which F0.1 and Fmax were estimated as 0.409 and 1.363. Fmax is, however, not clearly defined.

All projections are carried out assuming the catch in 1990 to be 110,000 tons, the TAC set by Greenland. This catch corresponds to a fishing mortality of F=0.729, which is more than double the value projected last year for a catch in 1990 of 112,000 t.

The results of the projections of catches in 1991 for a range of fishing mortalities is given in Fig.4.

Three management options were selected to cover the range of the fishing mortality of 0.729 (the F generated by the 1990 fishery by a catch of 110,000 tons), 0.409 (F0.1) and 1.363 (Fmax). In addition, two management options with fixed annual catches were calculated : 90,000 (TAC of 1989) and 110,000 tons (TAC of 1990). Furthermore, the two fixed-catch options mentioned above have also been carried out subject to the constraint that F should not be allowed to exceed 0.60 in any year. However, the projections are similar for the two last options mention, because the F values exceed 0.60 already in 1991.

All projections are carried forward to include catches in 1994 (Table 4).

The projections show that the catch will decrease rapidly in the coming years. Applying a fishing mortality in 1991 equal to F(90) results in a decrease of the catch in 1991 to 49,000 t and further decreases would occur in the following years if such a fishing level is maintained. However, exploitation at the lower level of F0.1 in 1991 leads not to a substantial increase in the catch level in 1993 and 1994. Although the SSB will increase in the nearest future for F-values below F(90) it would stay at a rather low level. if the TAC of 110,000 tons is taken in 1990, catch levels of 90,000 or 110,000 tons do not seem possible in 1991 and would leave no prospect for a viable fishery thereafter.

Table 1. Cod in Subarea 1: catches and TACs for the entire area and catch-per unit effort for Greenland trawlers (500-999 GRT) in Div. 1D and 1E.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Trawlers	16	14	29	42	20	7	1	4	40[1]	73[1]	
Other vessels	38	39	27	21	13	8	6	12	22[1]	30[1]	
Total (000 tons)	54[2]	53	56	58	33	15	7	16	62[1]	103[1]	
TAC (000 tons)	20[1]	50	62	62	68	28.3	12.5	12.5	53	90	110
CPUE (tons/hr)	1.08	2.90	1.93	1.23	0.89	0.7	-	1.61	2.87[1]	4.33[1]	

1 Provisional data.
2 Estimates used for assessments.

Table 2. Cod in Subarea 1: Estimate of total biomass and abundance (with 98% confidence intervals) and mean weights from autumn surveys off West Greenland, 1982-89.

Year	Tonnes	Number ('000)	W kg
1982	189,934 + 37.0%	109,039 + 36.1%	1.65
1983	98,843 + 28.5%	59,362 + 26.5%	1.67
1984	24,945 + 39.7%	16,104 + 39.1%	1.55
1985	31,860 + 60.1%	52,466 + 33.3%	0.61
1986	76,220 + 30.8%	134,716 + 31.8%	0.57
1987	464,286 + 47.0%	582,868 + 42.6%	0.80
1988	547,566 + 42.1%	563,601 + 42.3%	0.97
1989		217,840	

Table 3. The parameters used to project catch and biomass are as follows:

Age	Year class	Stock size('000) 1 Jan 1990	M+E	Relative F	Mean Weight (kg)	Percent Mature
3	1987	20,000	0.3	0.039	0.52	1
4	1986	1,013	0.3	0.52	0.72	3
5	1985	41,294	0.45	1	1.27	6
6	1984	113,646	0.45	1	1.67	8
7	1983	1,099	0.35	1	2.31	65
8	1982	163	0.35	1	3.71	90
9	1981	321	0.35	1	4.21	98
10+	<1980	1,195	0.35	1	4.72	100

Table 4. Cod in Subarea 1. Projections of annual age 3+ biomass (B3+), spawning stock biomass at the beginning of the year, and catch and fishing mortality (F) during the year for different management strategies (weights in '000 tons).

		Stable fishing mortality			Stable catch level		Stable catch level but F never above 0.6
Year	Parameter	F(90)	F(0.1)	Fmax	TAC=90	TAC=110	TAC=90
1990	B3+	263					
	SSB	28					
	F(5-10)	0.729					
	Catch	110					
1991	B3+	127	127	127	127	127	127
	SSB	59	59	59	59	59	59
	F(5-10)	0.729	0.409	1.363	2.229	5.909	0.6
	Catch	49	32	73	90	110	43
1992	B3+	85	107	56	37	20	93
	SSB	48	66	26	11	1	54
	F(5-10)	0.729	0.409	1.363	B(3+)<TAC		0.6
	Catch	31	27	28			30
1993	B3+	56	81	35			65
	SSB	23	45	7			29
	F(5-10)	0.729	0.409	1.363			0.6
	Catch	19	19	14			19
1994	B3+	44	64	30			50
	SSB	11	26	2			15
	F(5-10)	0.729	0.409	1.363			0.6
	Catch	15	18	11			16
1995	SSB	6	17	1			9

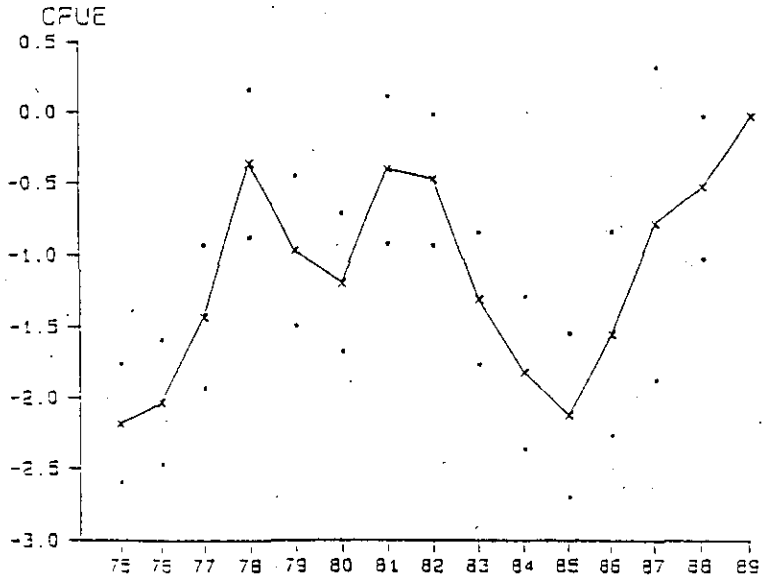

Figure 1. CPUE from multiplicative model, with error bars (+-2 x SE), for cod in Subarea 1.

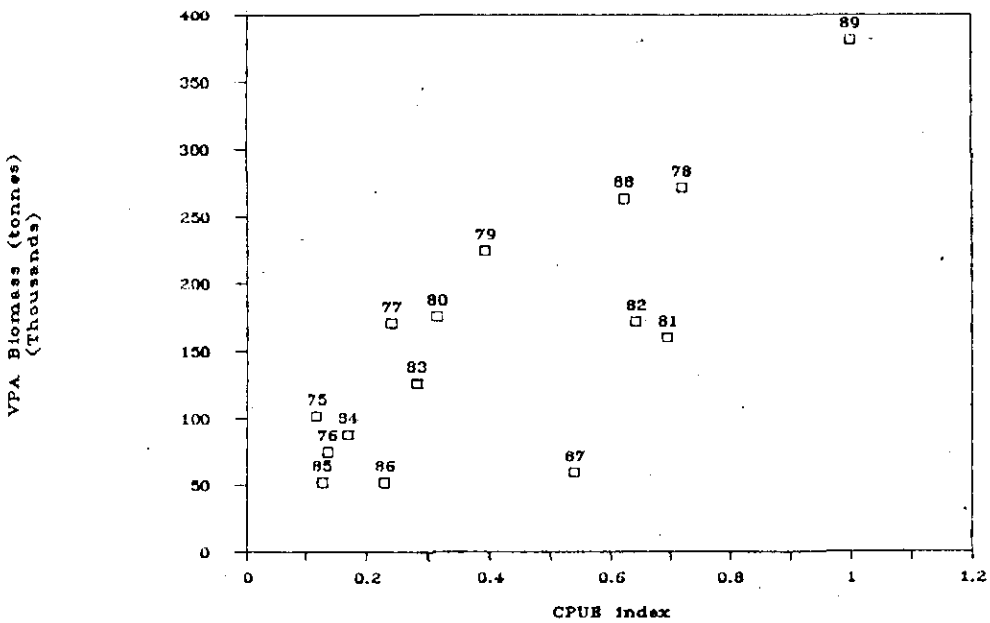

Figure 2. Cod biomass ('000 t) calculated from VPA vs. annual CPUE index from Greenland Home Rule Goverment trawlers. West Greenland, 1975-1989.

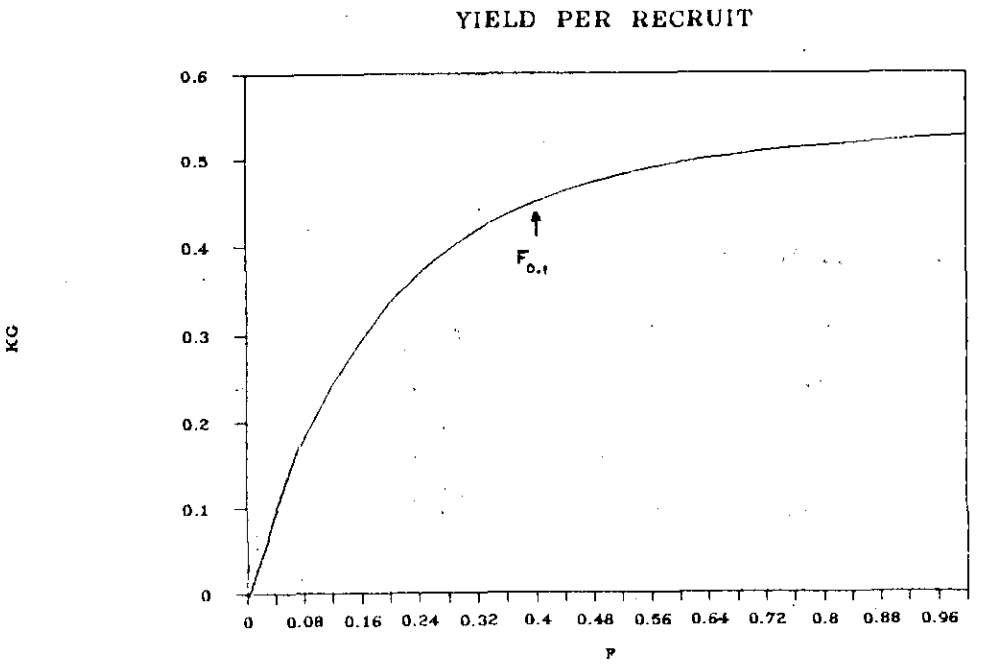

Figure 3. Cod in Subarea 1: yield-per-recruit curve.

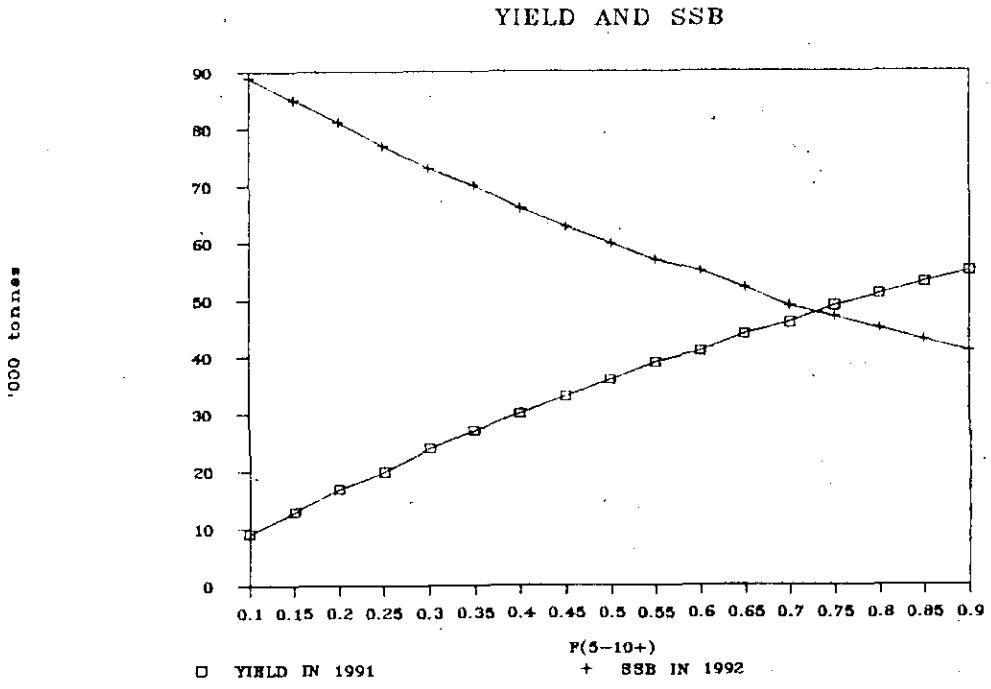

Figure 4. Cod in Subarea 1: Calculated yield in 1991 and spawning stock biomass (SSB) at beginning of 1992 for various levels of fishing mortality in 1991.

Appendix 1. Cod Subarea 1. Results of VPA.

RAW FISHING MORTALITIES at Age

YEAR	1975	1976	1977	1978	1979
AGE					
3	.012	.047	.013	.006	.009
4	.263	.266	.326	.169	.355
5	.550	.300	.968	.419	.837
6	.751	.638	.406	.494	.623
7	.957	.314	1.012	.274	.996
8	1.201	.967	1.263	.415	.432
9	.828	.412	1.037	.439	1.116
10	1.032	.581	1.840	.081	2.751
11	.970	.639	.894	.394	.683
12+	.970	.639	.894	.394	.683
Season					
F 6- 8 1	.970	.639	.894	.394	.683

YEAR	1980	1981	1982	1983	1984
AGE					
3	.024	.001	.015	.005	.057
4	.204	.204	.219	.242	.208
5	.292	.572	.401	.806	.380
6	.354	.289	.708	1.077	.915
7	.726	.386	.528	1.446	.882
8	.566	1.006	.709	.636	.383
9	.123	.494	.596	.966	.622
10	2.076	.224	2.043	1.027	1.050
11	.549	.560	.648	1.053	.726
12+	.549	.560	.648	1.053	.726
Season					
F 6- 8 1	.549	.560	.648	1.053	.726

YEAR	1985	1986	1987	1988	1989
AGE					
3	.139	.001	.012	.012	.016
4	.182	.051	.267	.150	.208
5	.231	.167	.193	.322	.400
6	.371	.095	.276	.783	.400
7	.693	.169	.207	.582	.400
8	.538	.114	.163	.511	.400
9	.305	.592	.105	.320	.400
10	.634	2.429	.111	.625	.400
11	.534	.126	.216	.625	.000
12+	.534	.126	.216	.000	.400
Season					
F 6- 8 1	.534	.126	.216	.625	.400

Appendix 1. continued

STOCK NUMBERS at Age (Thousands) at Start of Seasons

YEAR	1975	1976	1977	1978	1979
AGE					
3	27071.	272119.	55810.	55621.	38431.
4	17876.	19819.	192366.	40801.	40959.
5	7382.	10181.	11253.	102826.	25535.
6	3960.	3002.	5317.	3011.	47656.
7	10963.	1317.	1118.	2495.	1295.
8	2275.	2966.	678.	286.	1337.
9	1273.	482.	795.	135.	133.
10	520.	392.	225.	199.	61.
11	156.	131.	154.	25.	129.
12+	128.	207.	219.	58.	249.
Season					
Tot.B. 1	131760.	308896.	324945.	328785.	275134.
SSB 1	54760.	30392.	26845.	44430.	79751.
B 6- 8 1	64392.	26224.	18413.	19223.	140594.

YEAR	1980	1981	1982	1983	1984
AGE					
3	145722.	9567.	90825.	16791.	12509.
4	28225.	105382.	7077.	66252.	12373.
5	21284.	17059.	63681.	4211.	38549.
6	7790.	11205.	6785.	30040.	1325.
7	18020.	3854.	5916.	2355.	7211.
8	337.	6143.	1846.	2460.	391.
9	612.	135.	1583.	640.	917.
10	31.	381.	58.	615.	172.
11	3.	3.	215.	5.	155.
12+	61.	22.	66.	76.	7.
Season					
Tot.B. 1	315398.	223538.	247671.	169768.	103081.
SSB 1	87608.	61655.	63130.	54801.	32768.
B 6- 8 1	102466.	65079.	42812.	78899.	23849.

YEAR	1985	1986	1987	1988	1989	1990
AGE						
3	4057.	10861.	569254.	79934.	2624.	0.
4	8758.	2616.	8036.	416822.	58497.	1913.
5	7445.	5407.	1841.	4560.	265892.	35198.
6	18584.	4165.	3224.	1070.	2328.	113646.
7	374.	9033.	2670.	1723.	345.	1099.
8	2104.	132.	5374.	1530.	679.	163.
9	188.	866.	83.	3217.	647.	321.
10	347.	98.	338.	53.	1645.	306.
11	42.	130.	6.	213.	0.	777.
12+	62.	349.	85.	0.	238.	112.
Season						
Tot.B. 1	57424.	60129.	557828.	521264.	399516.	0.
SSB 1	25557.	40944.	29058.	57246.	97074.	0.
B 6- 8 1	37259.	33602.	31215.	10192.	7201.	0.

Appendix 2 Comparisons between VPA and bottom trawl surveys.

Abundance (million) of age 5 cod and older

year	1983	1984	1985	1986	1987	1988	1989	1990
Survey	71	54	14	15	13	31	468	331
VPA	38	49	29	20	14	12	272	158
Ratio	1.87	1.10	0.48	0.75	0.93	2.58	1.72	2.09

Comparisons of Z values from the VPA and the preceding November (FRG) trawl surveys by year-class.

	Year-class 73		Year-class 74		Year-class 75	
age	Survey	VPA	Survey	VPA	Survey	VPA
5-6						
6-7						
7-8						
8-9					1.40	0.99
9-10			1.03	1.32	1.58	0.97
10+-11+	2.21	1.46	3.21	1.17	2.70	-0.06
mean			2.12	1.25	1.89	0.63

	Year-class 76		Year-class 77		Year-class 78	
age	Survey	VPA	Survey	VPA	Survey	VPA
5-6					0.61	1.16
6-7			1.10	1.80	1.98	1.27
7-8	1.81	1.80	1.84	1.23	0.83	1.04
8-9	3.25	0.73	1.22	0.89	1.22	0.46
9-10	1.36	0.66	0.30	0.94		
10+-11+	-0.47	1.85	0.42	0.70	2.02	0.06
mean	1.49	1.26	0.98	1.11	1.16	0.80

	Year-class 79		Year-class 80		Year-class 81	
age	Survey	VPA	Survey	VPA	Survey	VPA
5-6	1.24	0.73	-0.41	0.58	-0.29	0.52
6-7	0.40	0.72	0.87	0.45	-0.21	0.63
7-8	0.68	0.52	-0.29	0.56	2.09	0.93
8-9	3.58	0.51	0.80	0.86	1.30	0.75
9-10	1.36	0.67	1.94	0.75		
10+-11+	2.03	0.75				
mean	1.55	0.65	0.58	0.64	0.72	0.71

	Year-class 82		Year-class 83		Year-class 84	
age	Survey	VPA	Survey	VPA	Survey	VPA
5-6	-1.99	0.54	1.27	0.67	0.85	0.75
6-7	2.02	1.13	0.14	0.75		
7-8						
8-9						
9-10						
10+-11+						
mean	0.02	0.84	0.71	0.71	0.85	0.75