NAFO Sci. Coun. Studies, 19: 51–58

Use of Survey Data Trends to Obtain Biological Reference Points for Flemish Cap Cod (*Gadus morhua*) Stock

Enrique de Cárdenas
Instituto Español de Oceanografia
Aptdo. 240, Santander, Spain

and

Antonio Avila de Melo
Instituto Nacional de Investigacao das Pescas
Av. Brasilia, 1400 Lisboa, Portugal

Abstract

Fluctuations in recruitment and biomass indices from surveys of the cod (*Gadus morhua*) stock in Div. 3M were studied for the period 1978–90. Data collected during three different survey series conducted by Canada, European Economic Community (EEC) and Union of Soviet Socialist Republics (USSR) were standardized to overcome discrepancies between the indices, and compared with the catch rates of the Faroe Islands longline fishery to observe patterns. All the stock components were found to be declining during the period of this study, and were at a depressed level in 1990.

Biological reference points of F_{low}, F_{med} and F_{high} were estimated at 0.1, 0.5 and 0.9, respectively. The critical size of the spawning stock biomass was assessed to be between 25 000 tons and 30 000 tons, although its value, obtained by July 1990 EEC survey, was 21 662 tons expressed in standardized unit.

Key words: Cod, *Gadus morhua*, fishing mortality, Flemish Cap, surveys

Introduction

Since the signing of the NAFO Convention in October 1978, the Scientific Council has provided advice to the Fisheries Commission for the management of the cod (*Gadus morhua)* stock in Div. 3M. After a moratorium was placed on the Div. 3M cod fishery in 1987 (NAFO, 1987), the Fisheries Commission has on several occasions requested the Scientific Council to comment on the appropriateness of establishing a minimum target level for biomass for the Flemish Cap cod stock, upon which the reopening of this fishery could be reconsidered (NAFO, 1989). In 1990 the Scientific Council brought to focus the view that "establishing a minimum level for the exploitable biomass is not an appropriate target to judge the status of a stock, while spawning stock biomass is the relevant variable to be taken into account" (NAFO, 1990).

At the Scientific Council Meeting in June 1990, the Scientific Council considered two sources of information which attempted to gather the available data related to the assessment of this stock, and conduct a preliminary analysis of its contents (Serchuk, 1990, unpublished data; de Cárdenas and Avila de Melo, 1990, unpublished data). Data from research surveys during 1977–90 and virtual population analyses (VPA) conducted in 1980 for the time period 1959–68 (Wells, MS 1980) and in 1984 for the time period 1972–83 (Wells *et al.*, MS 1984), provided a historical overview of the status of the stock. Those data along with a Faroe Islands longline catch-per-unit-effort (CPUE) series for 1973–88 (Reinert, MS 1990) were used in the assessment of the stock.

At the Scientific Council Meeting in June 1991, de Cárdenas and Avila de Melo (MS 1991) suggested that, for this cod stock, the analysis of data taken from the commercial catches should not be mixed with data from research surveys and/or sampling data directly collected onboard survey vessels. It was suggested that the commercial catch type of data seem to be strongly biased depending mainly on the catch levels that are declared, and also that the reliability of the basic information could not be assessed.

In the present study, an attempt is made to detect trends in the Flemish Cap component of the cod stock through the 1980s up to 1990, based only on survey data. Consequently an attempt is made to contribute to the comments of the Scientific Council (NAFO, 1990) to the Fisheries Commission, based on the views that spawning stock biomass should be considered.

Materials and Methods

Three series of research surveys have been carried out on the Flemish Cap since 1977: a Canadian bottom-trawl series from 1977 to 1985, an Union of Soviet Socialist Republics (USSR) bottom trawl/acoustic series since 1983, and an European Economic Community (EEC) bottom-trawl series which started in 1988.

Trawlable abundances and mean length-at-age have been made available for the three series of surveys (Kuzmin, MS 1990; Vázquez, MS 1989; MS 1990; MS 1991; Wells, MS 1983; MS 1986; Wells and Baird, MS 1985). Age compositions and mean length-at-age for the USSR surveys have been kindly provided for these analyses by V. A. Rikhter (AtlantNIRO, Kaliningard, USSR, 1990 pers. comm.). The length-weight equation developed by Hodder (1964) was

TABLE 1. Mean lengths-at-age, trawlable abundance and biomass indices from the survey series on the Flemish Cap by Canada, 1978–85.

	Year							
Age	1978	1979	1980	1981	1982	1983	1984	1985
				Abundance ('000s)				
1	0	0	0	32	628	293	43	56
2	95	4 675	1 030	0	1 781	71 001	1 526	974
3	4 757	1 067	19 475	5 172	21	7 824	15 833	6 485
4	15 531	5 610	2 377	15 479	1 663	319	1 897	18 981
5	45 688	5 437	2 990	975	978	2 357	73	974
6	12 135	6 712	2 737	2 108	32	958	645	56
7	476	1 706	3 912	1 041	150	45	426	111
8	181	108	160	2 069	137	84	12	83
9	65	55	23	102	219	68	44	0
10	154	20	6	23	11	237	63	28
10+	169	224	35	17	11	11	98	83
				Mean lengths-at-age (cm)				
1	0.00	0.00	0.00	13.00	11.05	12.37	14.64	12.00
2	19.46	24.49	22.86	0.00	30.97	23.61	21.83	20.71
3	27.92	29.47	36.15	37.53	0.00	43.95	35.32	29.41
4	35.29	40.64	40.40	48.08	52.31	59.96	58.18	45.94
5	48.40	45.77	54.26	52.24	60.85	66.37	65.95	69.44
6	58.19	56.07	59.48	62.50	66.82	72.50	80.64	75.90
7	77.56	65.07	69.37	66.43	74.57	76.37	85.11	88.85
8	87.24	86.72	81.96	75.73	79.19	82.19	92.31	91.37
9	88.35	95.17	97.25	80.75	94.87	83.71	95.17	94.00
10	101.80	104.03	103.00	91.00	112.00	94.79	95.29	104.50
10+	113.60	103.9	121.00	109.00	111.92	125.50	103.20	109.20
				Biomass-at-age (tons)				
1	0.0	0.0	0.0	0.5	6.4	4.3	1.1	0.7
2	5.6	558.6	99.5	0.0	439.0	7 577.4	127.9	69.4
3	851.6	225.7	7 735.3	2 306.0	0.0	5 677.9	5 853.9	1 362.9
4	5 727.2	3 197.5	1 330.3	14 819.3	2 065.1	603.5	3 270.5	15 790.8
5	44 645.0	4 471.7	4 156.8	1 205.8	1 936.4	6 100.3	185.3	2 898.2
6	20 932.1	10 325.3	5 051.5	4 532.9	84.6	3 256.2	3 044.2	219.2
7	1 992.2	4 154.0	11 604.4	2 701.8	556.1	179.6	2 374.6	706.5
8	1 088.9	637.9	793.9	8 044.6	611.4	420.4	85.9	575.9
9	406.6	432.7	193.4	483.4	1 706.4	360.1	346.2	0.0
10	1 491.5	207.1	60.2	157.6	143.0	1 841.9	497.6	294.0
10+	2 295.7	2 310.5	57.6	203.3	142.7	203.2	990.0	998.1
1+	79 436.4	26 520.9	31 603.0	34 455.1	7 691.2	26 224.8	16 777.1	22 915.8
3+	79 430.8	25 962.4	31 503.5	34 454.6	7 245.7	18 643.1	16 648.1	22 845.7
[a] 5+	50 529.5	20 303.3	20 359.5	16 726.5	4 212.4	9 311.6	7 431.2	4 242.9

[a] SSB = 50% at age 5 and age 6+

TABLE 2. Mean lengths-at-age, trawlable abundance and biomass indices from the survey series on the Flemish Cap by USSR, 1983–89.

	Year						
Age	1983	1984	1985	1986	1987	1988	1989
				Abundance ('000s)			
1	9 856	2 065	639	663	27 709	50	1 621
2	25 606	10 804	881	17 557	2 765	16 842	915
3	15 091	22 267	9 208	6 471	3 757	8 418	54 320
4	3 566	16 811	15 786	5 550	848	1 146	13 243
5	6 297	5 402	8 643	6 559	999	106	283
6	2 644	1 823	1 547	518	628	106	67
7	1 150	969	262	114	113	81	0
8	592	303	81	40	0	0	0
9	235	121	7	40	0	0	0
10	148	61	7	7	0	0	0
10+	309	61	0	740	0	0	0
				Mean length-at-age (cm)			
1	15.40	16.92	13.23	16.00	17.08	14.50	16.42
2	23.81	26.31	20.15	27.63	27.23	25.49	21.8
3	28.26	33.80	28.01	33.92	42.41	35.03	35.3
4	40.52	38.83	41.24	42.87	53.11	47.25	46.21
5	49.06	45.42	51.42	59.69	57.08	63.80	62.6
6	53.17	56.15	60.18	73.18	69.11	71.60	75.00
7	64.88	63.31	73.07	87.37	88.00	80.75	79.00
8	75.07	71.56	87.08	94.00	94.00	0.00	91.00
9	80.12	77.95	76.00	99.14	116.50	0.00	100.00
10	82.12	81.57	114.00	97.00	116.50	0.00	0.00
10+	98.31	93.33	0.00	108.77	0.00	0.00	0.00
				Biomass-at-age (tons)			
1	281.5	78.9	11.4	21.3	1 089.2	1.2	56.4
2	2 804.8	1 610.3	57.7	3 043.4	458.2	2 276.6	76.4
3	2 804.3	7 188.0	1 664.8	2 111.9	2 442.4	3 034.2	20 048.5
4	2 014.1	8 325.5	9 413.7	3 730.1	1 103.5	1 039.8	11 218.2
5	6 415.8	4 339.0	10 179.5	12 237.9	1 623.8	242.9	611.5
6	3 452.7	2 816.7	2 960.2	1 812.1	1 841.4	346.7	252.8
7	2 775.0	2 168.1	912.3	689.0	698.2	383.9	0.0
8	2 240.5	989.3	484.5	302.9	0.0	0.0	0.0
9	1 087.2	514.3	27.5	357.0	0.0	0.0	0.0
10	738.8	298.3	96.1	58.4	0.0	0.0	0.0
10+	2 687.3	451.9	0.0	8 791.2	0.0	0.0	0.0
1+	27 302.0	28 780.2	25 807.8	33 155.2	9 256.8	7 325.3	32 263.8
3+	24 215.8	27 091.0	25 738.7	30 090.5	7 709.3	5 047.4	32 131.0
[a] 5+	16 189.5	9 408.1	9 570.4	18 129.7	3 351.6	852.0	558.6

[a] SSB = 50% at age 5 and age 6+

then used to calculate the mean weight-at-age, and the abundances were transformed to biomass-at-age.

For each year and survey series, the total and exploited biomass, and spawning stock biomass (SSB) were estimated assuming a mean age of maturity for both sexes to be 5 years (Kuzmin, MS 1990) (Tables 1, 2 and 3). With these parameters and the annual recruitment (abundance of age 3), the Canadian and EEC series of data were standardized to "USSR units", using a conversion factor (CF) between the indices of the Canadian and USSR surveys and another one between the EEC and USSR indices as follows:

$$C F = \frac{\sum V_i}{\sum S_i}$$

TABLE 3. Mean lengths-at-age, trawlable abundance and biomass indices from the survey series on the Flemish Cap by EEC, 1988–90.

Age	1988	1989	1990
	Abundance ('000s)		
1	4 580	20 850	2 370
2	71 960	11 000	11 790
3	40 370	84 220	4 670
4	10 850	49 220	15 880
5	1 280	18 580	14 530
6	220	1 270	3 940
7	280	150	320
8	110	120	130
9	0	0	80
10	0	10	3
10+	0	0	0
	Mean length-at-age (cm)		
1	15.20	15.67	16.30
2	22.36	22.03	26.40
3	35.11	32.70	33.20
4	40.34	44.53	44.70
5	58.86	51.46	54.40
6	70.51	60.69	63.70
7	82.65	75.88	75.20
8	89.00	89.28	83.80
9	0.00	92.00	91.70
10	0.00	115.00	100.30
10+	0.00	0.00	0.00
	Biomass-at-age (tons)		
1	125.6	628.3	80.7
2	6 493.3	948.1	1 775.9
3	14 653.8	24 549.1	1 426.5
4	6 044.4	37 193.1	12 141.6
5	2 287.3	21 935.7	20 361.3
6	686.3	2 494.2	8 984.2
7	1 425.8	586.8	1 217.5
8	703.8	775.3	690.8
9	0.0	0.0	561.3
10	0.0	141.1	27.8
10+	0.0	0.0	0.0
1+	32 420.3	89 251.5	47 267.5
3+	25 801.4	87 675.2	45 411.0
[a]5+	3 959.5	14 965.2	21 662.2

[a] SSB = 50% at age 5 and age 6+

where i is the overlapping year between the two series,

S is the total calculated USSR biomass

and V is the total calculated biomass of the series to be transformed.

Total biomass indices were used in all computations, since some discrepancy probably due to different criteria in otolith readings was detected between the series, when data by age-classes were compared. From the three series standardized to USSR units in this way, an unique series was obtained by averaging the indices in the overlapping years. This last series was then normalized to be graphically representive (Table 4).

To get a better picture of the trends in this stock since the late-1970s, the total (at age 1+) and exploitable (at age 3+) biomass and SSB (50% at age 5, and age 6+) indices were compared with the Faroe Islands longline CPUE values. Similarly, recruitment (at age 3+) was compared with SSB for the study period. The slopes corresponding to the biological points of reference were then estimated by plotting the SSB indices against recruitment, and studied in terms of the abundance of the age-class 3, three years later.

To calculate the yield-per-recruit and SSB-per-recruit curves, the partial recruitment vector was obtained by comparing the age composition of the July 1989 commercial stern-trawl catches of Div. 3M cod with the one from the EEC survey, done in the same month and year (Table 5). The mean length-at-age was obtained through the results of the EEC surveys from 1988 to 1989 (Vázquez, MS 1989 and MS 1990), and converted to mean weight-at-age using the Hodder (1964) length/weight equation.

Results and Discussion

From the comparison of the standardized series of survey data (Table 4) with the Faroe Islands longline CPUE (Fig. 1), it can be observed that the age 1+, age 3+ and SSB indices suffered a drop from 1978 to the 1979–81 period, followed by a smaller second decline to the 1982–86 period. The years 1987 and 1988 recorded the lowest values of the series. A downward trend was also seen in the Faroe Islands longline CPUE series, although the values prior to 1976 seemed to fluctuate within the same range of the 1980–85 period.

From the plot of recruitments with SSB (Fig. 2), it was noted that recruitment fluctuated rather independent of the size of the parental SSB. In particular, two of the three years (1978 and 1979) recording the largest values of biomass of spawners in the series corresponded to some of the lowest numbers of recruits.

The concept of biological reference points have been introduced by the ICES Working Group on Methods (Anon., 1984; 1985). Jakobsen (1992) defines the biological reference points as:

F_{low} represents a level of fishing mortality where recruitment has been sufficient to balance the mortality about 9 years out of 10.

TABLE 4. Recruitment and biomass indices from the Canadian and EEC survey series converted to USSR indices, using the conversion-factors: Canada/USSR = 0.805 and EEC/USSR = 3.070. Mean values for the period 1978–90 are also normalized. (The units for the biomass are tons and for recruits are recruits x 10^3 at age 3.)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Recruitment (age 3)													
Canada	5 910	1 326	24 194	6 425	26	9 720	19 669	8 056					
USSR						15 091	22 267	9 208	6 471	3 757	8 418	54 320	
EEC											13 135	27 403	1 520
Mean	5 910	1 326	24 194	6 425	26	12 405	20 968	8 632	6 471	3 757	10 777	40 862	1 520
Mean norm.	0.14	0.03	0.59	0.16	0.00	0.30	0.51	0.21	0.16	0.09	0.26	1.00	0.04
Stock Biomass (biomass 1+)													
Canada	98 684	32 947	39 261	42 804	9 555	32 579	20 842	28 468					
USSR						27 302	28 780	25 808	33 155	9 257	7 325	32 264	
EEC											10 549	29 040	15 380
Mean	98 684	32 947	39 261	42 804	9 555	29 941	24 811	27 138	33 155	9 257	8 937	30 652	15 380
Mean norm.	1.00	0.33	0.40	0.43	0.10	0.30	0.25	0.27	0.34	0.09	0.09	0.31	0.16
Exploitable Biomass (biomass 3+)													
Canada	98 677	32 253	39 137	42 803	9 001	23 160	20 682	28 381					
USSR						24 216	27 091	25 739	30 091	7 709	5 047	32 131	
EEC											8 395	28 527	14 776
Mean	98 677	32 253	39 137	42 803	9 001	23 688	23 887	27 060	30 091	7 709	6 721	30 329	14 776
Mean norm.	1.00	0.33	0.40	0.43	0.09	0.24	0.24	0.27	0.30	0.08	0.07	0.31	0.15
Spawning Stock Biomass (50% at age 5 and age 6+)													
Canada	62 773	25 223	25 293	20 779	5 233	11 568	9 232	5 271					
USSR						16 189	9 408	9 570	18 130	3 352	852	559	
EEC											1 288	4 869	7 048
Mean	62 773	25 223	25 293	20 779	5 233	13 879	9 320	7 421	18 130	3 352	1 070	2 714	7 048
Mean norm.	1.00	0.40	0.40	0.33	0.08	0.22	0.15	0.12	0.29	0.05	0.02	0.04	0.11

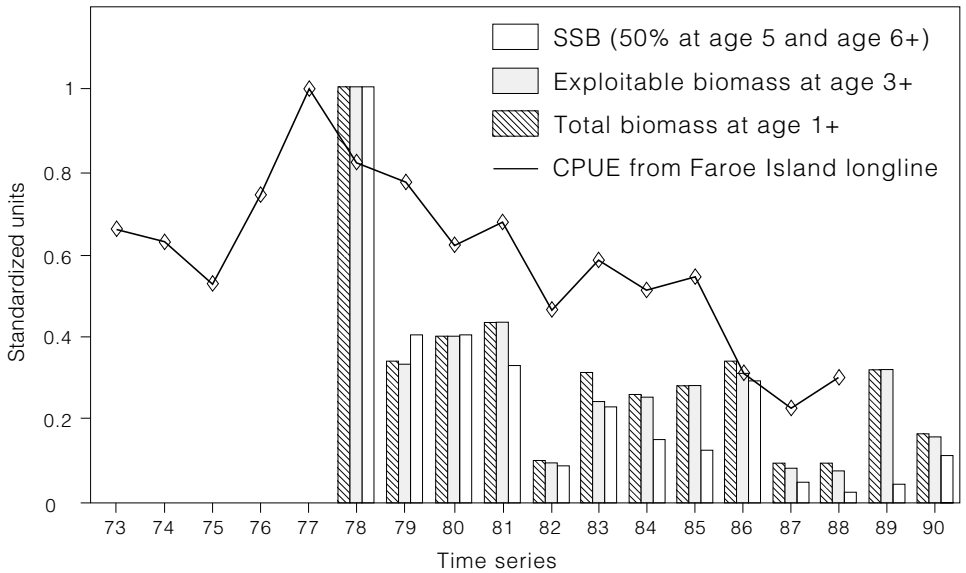

Fig. 1. Trends in the total, exploitable and spawning stock biomass (SSB) of the Division 3M cod for the period 1978–90. All the series have been normalized dividing each value by its respective higher point and the units are Percentage of maximum value of each series.

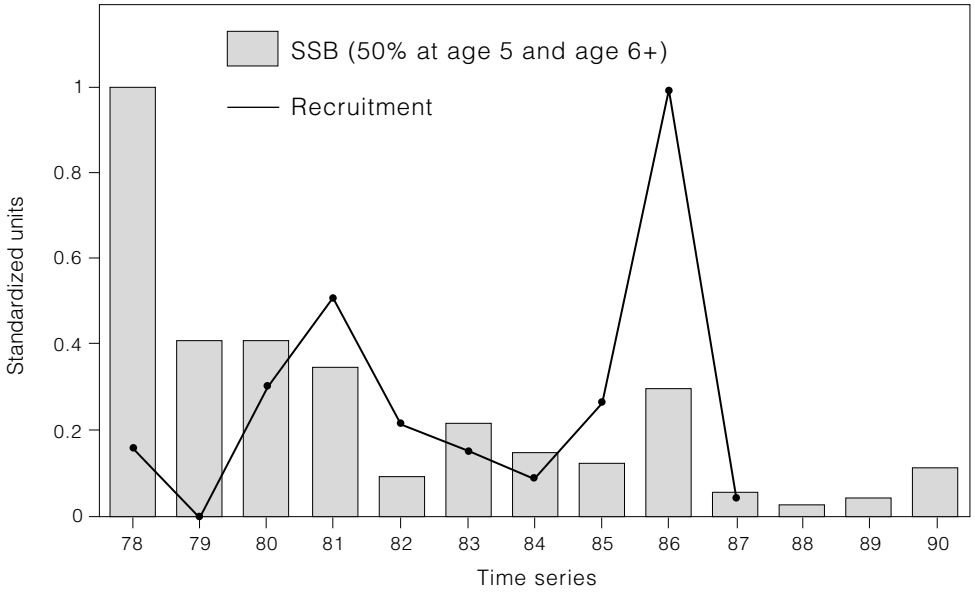

Fig. 2. Comparison of spawning stock biomass (SSB) and recruitment (at age 3) for the period 1978-90. The units are normalized as on Fig. 1.

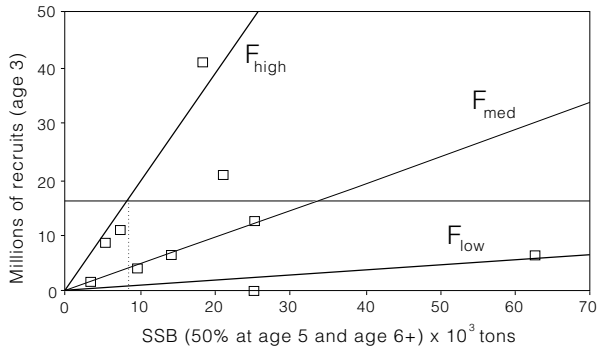

Fig. 3. Relationship of spawning stock biomass (SSB) and recruitment to determine biological reference points.

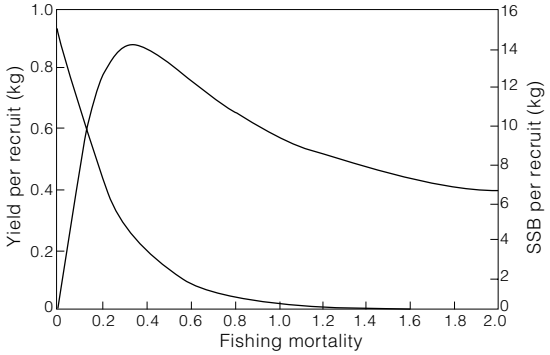

Fig. 4. Plot of yield-per-recruit (Y/R) and spawning stock biomass-per-recruit (SSB/R) used to determine biological reference points.

F_{med} represents a level of fishing mortality where recruitment has been sufficient to balance the mortality about 5 years out of 10.

F_{high} represents a level of fishing mortality where recruitment has been sufficient to balance the mortality about 1 year out of 10.

Figure 3 shows the recruitment/SSB lines for the biological levels of reference. If a line is drawn parallel to the x axis such that it would leave the two highest recruitments of the series above it, this parallel would intercept the F_{high} line at a point corresponding to biomass of spawners between 8 000 tons and 10 000 tons (USSR units). From that point to the left, the probability of having a recruitment above the parallel line would then be 10% and not 25%.

TABLE 5. Input parameters of the yield-per-recruit curve.

Age	Mean[a] length	Mean[b] weight	PR 89[c]
3	33.91	0.324	0.39
4	42.44	0.647	1.00
5	55.16	1.452	1.00
6	65.60	2.480	1.00
7	79.27	4.446	0.50
8	89.10	6.376	0.50
9	91.30	6.875	0.50
10	102.37	9.785	0.50
11	110.40	12.353	0.50
12	113.00	13.272	0.50

[a] Average mean lengths from the 88/89 EEC surveys.
[b] Hodder (1964) length/weight equation.
[c] Partial recruitment from age composition of commercial and EEC survey catches in July 89.

TABLE 6. Yield-per-recruit and SSB-per-recruit (SSB/R) values for a range of Fs between 0 and 2. Biological reference points are indicated as F_{low}, F_{med} and F_{high}.

		F(5–12)	Y/R	SSB/R	
		0.0	0.000	15.363	
F_{low}	→	0.1	0.597	9.995	←
		0.2	0.829	6.596	
		0.3	0.887	4.419	
		0.4	0.868	3.008	
F_{med}	→	0.5	0.819	2.081	←
		0.6	0.762	1.464	
		0.7	0.708	1.047	
		0.8	0.659	0.761	
F_{high}	→	0.9	0.617	0.563	←
		1.0	0.582	0.422	
		1.1	0.552	0.322	
		1.2	0.526	0.249	
		1.3	0.505	0.194	
		1.4	0.486	0.154	
		1.5	0.471	0.123	
		1.6	0.457	0.099	
		1.7	0.445	0.081	
		1.8	0.435	0.066	
		1.9	0.426	0.055	
		2.0	0.418	0.045	

The biomass of spawners has been increasing since 1988, when its minimum value was recorded. In 1990 this represented about 46% of the total biomass and with the estimated standardized value from the EEC survey it represented about 7 048 tons (USSR units) (Table 4). The main reason for this increase was the partial entry of the 1985 year-class (the second largest year-class for the 1988–90 period) to the spawning component of the stock in 1990 (Avila de Melo and Alpoim, 1991). This increase of the SSB was expected to continue during 1991, when fish from the strong 1986 year-class attained maturity. The magnitude of this increase will depend on the level of depletion of the 1986 and 1985 year-class in 1991.

The curves computed of yield-per-recruit and SSB-per-recruit (Fig. 4), estimated from the data presented in Table 5, show that the EEC survey values, for reasons explained below, were closer to the real population size with the critical SSB level somewhere between 25 000 tons and 30 000 tons, while its size in July 1990 was 21 662 tons. The biological levels of reference were estimated as F_{low} = 0.1, F_{med} = 0.5 and F_{high} = 0.9 (Table 6). The values for $F_{0.1}$ and F_{max} were 0.28 and 0.31 respectively.

From July 1989 to July 1990, the mean value of F, derived from the abundances-at-age (since age 3) found from the EEC surveys, was about 1.3. Using these survey estimates of the abundances and F-at-age to get the predicted catches-at-age for that period, a total level of catches of 60 000 tons was estimated (Vázquez, Vigo, Spain, 1990 pers. comm.). Although this figure can be expected to be an overestimation due to a change in the catchability induced by the use of different research vessels in each year, this figure is in the same order of magnitude as the 40 000 tons estimated as the level of the Div. 3M cod catches for 1989 by the Scientific Council (NAFO, 1990).

Accordingly, a fishing mortality higher than F_{high} has most probably been applied to the Div. 3M cod stock during 1990, while the biomass of spawners was reaching the lower limit of its critical size range.

References

ANON. 1984. Report of the Working Group in Methods of Fish Stock Assessment. *ICES Coop. Res. Rep.*, **127**: 67–134.

ANON. 1984. Report of the Working Group in Methods of Fish Stock Assessment. *ICES Coop. Res. Rep.*, **133**: 1–53.

AVILA DE MELO, A. M., and R. R. ALPOIM. 1991. Análise dos principais resultados das companhas dermersais da CEE no Flemish Cap, de Julho de 1988 a Julho de 1990. *Relat. Téc. Cient. INIP*, **39**, 22 p.

DE CÁRDENAS, E., and A. M. AVILA DE MELO. MS 1991. The effect of misreported catches in the assessment of the Flemish Cap cod: a simulation exercise. *NAFO SCR Doc.*, No. 44, Serial No. N1927, 4 p.

HODDER, V. M. 1964. Assessment of the effects of fishing and increasing in the mesh size trawls on the major commercial fisheries of the Newfoundland area (ICNAF Subarea 3). *Fish. Res. Board Can. Manu.. Rept.*, Ser. (Bio.), No. **801**:116 p.

JAKOBSEN, T. 1992. Biological reference points for North-East Arctic cod and haddock. *ICES J. Mar. Sci.*, **49**: 155–166.

KUZMIN, S. A. MS 1990. Stock assessment, age-length composition and maturity stages of the Flemish Cap cod. *NAFO SCR Doc.*, No. 53, Serial No. N1774, 16 p.

NAFO. 1987. Reports of Scientific Council. *NAFO Sci. Coun. Rep.*, 1987, p. 43.

NAFO. 1989. Reports of Scientific Council. *NAFO Sci. Coun. Rep.*, 1989, p. 17.

NAFO. 1990. Reports of Scientific Council. *NAFO Sci. Coun. Rep.*, 1990, 187 p.

REINERT, J. MS 1990. The Faroese longline fishery for cod on Flemish Cap 1973–88, data on catch and effort from three longliners. *NAFO SCR Doc.*, No. 43, Serial No. N1760, 4 p.

VÁZQUEZ, A. MS 1989. Results from bottom-trawl survey of the Flemish Cap in July 1988. *NAFO SCR Doc.*, No. 60, Serial No. N1640, 15 p.

MS 1990. Results from bottom-trawl survey of the Flemish Cap in July 1989. *NAFO SCR Doc.*, No. 68,

Serial No. N1790, 25 p.

MS 1991. Results from bottom trawl survey on Flemish Cap in July–August 1990. *NAFO SCR Doc.*, No. 28, Serial No. N1908, 25 p.

WELLS, R. MS 1980. Changes in the size and age composition of the cod stock in Div. 3M during the period 1959–1979. *NAFO SCR Doc.*, No. 28, Serial No. N060, 18 p.

MS 1983. An examination of age compositions estimated for cod of the Flemish Cap in the period 1977–82. *NAFO SCR Doc.*, No. 26, Serial No. N677, 13 p.

MS 1986. On the validity of age determination of cod from Canadian research vessel cruises to Flemish Cap, 1977–85. *NAFO SCR Doc.*, No. 90, Serial No. N1215, 17 p.

WELLS, R., and J. BAIRD. MS 1985. Age compositions of cod in longline samples in 1984 and an abundance estimate from a research vessel survey in 1985 on the Flemish Cap. *NAFO SCR Doc.*, No. 65, Serial No. N1017, 6 p.

WELLS, R., M. F. BORGES, and A. V ÁZQUEZ. MS 1984. Status of the cod stock in Division 3M. *NAFO SCR Doc.*, No. 94, Serial No. N889, 8 p.