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Flemish Cap Cod Stock Analysis

by

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Introduction

Flemish Cap is a traditional fishery for cod and redfish. The position of the bank was exactly determined for the first time in 1750 during the hydrographic campaign of M. de Chabert (de la Morandiere, 1962). It is difficult to accept that at that time the Flemish Cap could be an alternative fishing area to other banks of the American continental platform. The reasons for which we suspect that the cod fishing on Flemish Cap would have a secondary importance are the geographic isolation of the bank, what was important in sail times, and its great depth, an important circumstance for hook fishing. The arrival of steam propulsion and trawl fishing system would change the marginal interest of the bank. Since 1978, when Canada established a 200-mile economic zone, Flemish Cap is one of the few areas under international regulation where fishing is not always controled.

The best cod catches on Flemish Cap are taken in February-March, months of pre-spawning and spawning concentrations (Gavaris, 1979).

A complete description of Flemish Cap was made by Templeman (1976) who includes a reference saying that large cod was not common in the bank at the end of XIXth century, according to US fishermen who were familiar visitors of the area in spring and summer. Actually, greater than 100 cm length cod is rare due to discontinued annual recruitment and premature fishing of abundant cohorts. Althought there were some recaptures of cod tagged in Flemish Cap, most of the available information sugests that the cod stock on the bank is isolated from other stocks in the area (Lear and Wells, 1979).

Flemish Cap cod was considered by ICNAF Scientific Council for the first time at 1973 meeting. This Council recomended a TAC for 1974 equal to the estimated sustainable yield of the fishery (Redbook, 1973). Four years later, in 1977, the decline of the fishery was recognized and to reduce the TAC below 40.000 tons for 1978 was recomended (Redbook 1977). Cesation of direct fishery for cod was advised since 1982 (NAFO Sci. Counc. Rep., 1982). A moratorium was agreed by the Fisheries Commission for 1988-1990 period. Despite the moratorium, cod catches were estimated around 40,000 tons in 1989.

The most common fleets in the modern fishery are Spanish pair-trawlers, Portuguese OTB6 trawlers, Portuguese gillnets and Faroese longliners. Cod is also caught as by-catch of the Portuguese and USSR trawl fisheries for redfish and the Spanish one for flatfish. Portuguese trawlers fishing directly cod were among the most traditional fleets. NAFO non-member countries freezers and pair-trawlers are alse common visitors of Flemish Cap for fishing cod directly or as by-catch of, mainly, redfish.

Commercial fishery

Historical catches:

Nominal catches of fish from the ICNAF area were first separated by Divisions in 1953. Registered cod catch from Flemish Cap starts in 1954

(Table 1), but reported total figures must be quite incomplete for about ten years. Total catch increases steadly until 1965, when a peack catch of 54.000 tons was reported, mainly by USSR, who also reported a very high redfish catch in that year. First record catch is registered seven years later, in 1972, of 57,000 tons, due to a very high catch of Portugal. Compared with this initial period all posterior catches are lower. The lower catch in the 1980-85 period may be attributed to lower TACs. The confidence in reported fisheries data was rised in 1986 (NAFO Sci. Counc. Rep., 1986) due to large discrepancies obseved between reported catches from member countries and Canadian surveillance estimates. Reported cod catches in 1989 were 594 tons, but they were estimated to be around 40,000 tons, including catches from non-member non-reporting countries (NAFO Sci. Counc. Rep., 1990).

Catch in 1990:

Reported cod catches in Flemish Cap during 1990 amount 2,002 tons, but 31,500 tons total catch was judged to be a more realistic figure (Table 2).

Catch-rate series:

Oldest cod catch-rate series in Flemish Cap is Portuguese otter trawl tonnage class 6 (1000-2000 GRT) expresed in cod catch in tons per hour trawling (Table 3). Faroese longliners catch per thousand hooks is also presented in two diferents manners: 1 and 5 vessels.

Pair-trawlers, Spanish or from other countries, are a quite homogeneus category of cod fishing units. Several catch-rates for this category are available and also presented in Table 3. Most recent CPUE data observed on board of pair-trawlers are comparable with same indices of Spanish pair-trawlers (Vazquez, 1991 b). Theese data in 1989 belong mainly to the third quarter of the year and data from 1990 are mainly from the first half of the year. The yields calculated showed an increasing trend in the fishery. An convertion factor equal 1.25 was calculated from 1987 data and the combined series in Kg/hour is included in the same table. Since 1987 an acoustic stock evaluation is made at the same time of the random bottom trawl survey (Mamylov, 1988).

Research surveys

Research surveys were conducted by USSR in NAFO area since 1954 (Bulatova and Chumakov, 1986). Bottom trawl surveys carried out during the period 1962-1970 were made with a 16-20 mm mesh bar inserted in the codend with the purpose of estimate yearly recruitment of cod and other demersal species. The stratified-random survey series starting in 1971 was carried out with the R/S Persey III or vessels of the same MB-1202 type using different methods along the period. Cod abundance and biomass estimations were recently standarized to 30 minutes trawl time (Bulatova et al., 1989).

Stratified-random designed surveys were conducted by Canada in Flemish Cap from 1977 to 1985. Results of the survey in 1977 and November 1988 are not usually included in the series because the research vessel used. The A.T. Cameron, was a side trawl of presumably much less fishing power than the Gadus Atlantica (Wells, 1980 a, 1983 a) although later calibration fishing experiments were not conclusive (Gavaris and Brodie, 1984). In all surveys tow duration was half-hour and the gear used since 1978 onwards was the standard Engels's net having 1 1/8 inch liner in the codend (Wells, 1980 b). Reseach cruises of limited scope were conducted in 1949-51, 1964 and 1968 by Canadian research vessels (Wells, 1983 c).

Stratified-random designed survey were conducted by EEC since 1988. The vessels used in 1988, 1989 and 1989 were different but gear and fishing doors were the same to maintain the same catchability.

Details of these three survey series are presented in Table 4.

The gear used in these three survey series have quite similar design. The three gears have botton wing shorter than upper one to prevent net damage in the rough bottom of Flemish Cap. Main characteristics of the gears are:

Country gear denomination	USSR 31/27.2 m	Canada Engels's 145'	EEC Lofoten
Length of headline (m)	31	28 (90')	31.20
Length of footrope (m)	42	48 (145')	41.25
Footrope with net (m)	18.8	33 (100')	17.70
Bobbins diameter	?	14-18-21"	14"
Doors weight (Kg)		1500	850
Vessel speed during tow	3.5	3.5	3.6
Wing spread (m)	14.3	13.72	13.5
swept area per tow	0.0135	0.01332	0.0135

The USSR and EEC gears are particularly similar and the swept area per tow calculated is the same in both cases. Size of the gear is the main characteristic in determining its catchability, in spite of the commercial fishing, where the skiper's hability is of prime importance. USSR and EEC surveys in 1988, 1989 and 1990 show differences in cod biomass estimations of 5, 3 and 14 times, been greater the EEC survey estimation in all cases. Trawlable biomass survey estimations have very hight statistical variability with variation coeficient around 10%. Nevertheless, differences in 1990 estimations from USSR and EEC survey are statistically significative.

With the view of getting a single combined series of stock biomass and abundance estimates that would cover the longest period, the following analysis of survey results was made: cod stock abundance at age estimated by the USSR, Canada and EEC surveys (Tables 5, 8 and 11) were used to calculate fishing mortality of each cohort in each year (Tables 6, 9 and 12). Corresponding annual catch at age were also deduced and catch in weight was calculated using them (Tables 7, 10 and 13). In these tables F+3 and Y+3 means fishing mortality and yield for 3+ age-groups and they are presented jointly in Table 14. They were calculated as an annual reference of both magnitudes without the effect of recruitment in youngest fish. Full recruited age was asumed equal 4 years in USSR survey and 3 year in Canadian and EEC surveys.

Analysis of survey total biomass or total abundance are a difficult task because both of these magnitudes can increase or decrease for many different reasons. Cohort abundance may increase only in the pre-recruitment ages but it may subsequentely decrease by natural and fishing mortalities. Fishing mortality was calculated as an index of abundance change in one year. Negative values in older age groups are due commonly to scarcy at those ages. Negative values at intermediate ages, particularly when it hapens in the same year in most of age groups, must be due to under estimation of abundances at that year. An alternative explanation would be that abundance of next year was over estimated, but we discard that explanation because gear can catch less than what is present but never more. Statistical variability should not produce so high negative values as those obtained.

Several survey indices of cod stock abundance and biomass are presented in Table 15. Swept area biomass estimates are presented in table 16. In the combined series of total biomass (Table 17), the value for each year was calculated as the mean of estimations in each survey. Data from 1990 USSR survey was excluded because it was not consistent with present catch levels. An alternative series was made excluding data from years with negative fishing mortalities. Taking into account that differences between values are statistically significative in some years: 1977, 1978, 1980, 1988 and 1989, another alternative series could be made calculating the lowest limit of greater biomass estimate in each case. These alternatives did not produce noticeable differences with the former. The above indicated biomass estimate series did not show any strong declining tendency in the period but a minimun in 1987 followed to a recovery to roughly the same original level.

Spawning and recruitment

No relationship was found between cod recruitment in Flemish Cap and spawning stock biomass, water temperature and salinity (Rice and Evans, 1986). Years with poor recruitment did tend to occur together as did the infrequent years with very large abundance. Length for 50% first

maduration was calculated in 52 cm for females and 50 cm for males (Wells, 1979). Histological analysis of female gonads during prespawning season shows that not all female spawn every year (Walsh et al., 1986). It was estimated that on the average 1/3 of the spawning population would not have spawned during the 1978-85 period, limiting the production of eggs. Fecundity in number of eggs at length was calculated by Wells (1986).

Year-class abundance indices were calculated in USSR young fish surveys for the 1961-1981 period (Konstantinov, 1983), and they are summarized in Table 18.

Biological parameters

Growth rate of Flemish Cap cod have change from 1949-51 to 1980-82 period, increasing mean length at age (Bishop, 1977; Wells, 1983 c; Kuzmin, 1990). The gowth rate seems to be strongly dependet of year class abundance, been greater for less abundant cohorts (P-Gandaras and Zamarro, 1990).

General production models

Mari and Terre (1976) presented a general production model analysis based on catch and effort data from Portugal and Spain as it was recorded in ICNAF Statistical Bulletin. Maximum sustainable yield values ranged from 39 to 43.5 thousand tons with a best fit of 39,100 tons. This analysis was updated with no significant changes (Mari and Terre, 1977; Mari and Dominguez, 1978). A similar analysis based on Portuguese side trawl, tonnage class 6, estimated MSY at the same lavel: 39,400 tons (Wells, 1978) and 38,900 tons (Gavaris, 1979).

The usefulness of general production models analysis is questioned for stocks like Flemish Cap cod which are far from an equilibrium situation.

Sequential population analysis

First sequential population analysis was presented by Wells (1973) for year 1959 to 1968. At that time cod age 10 and older was common and first full recruited age was calculated as 7 years. A later analysis includes 1960-1968 and 1972-1979 periods (Wells, 1980 c). Fishing mortality was higer in the second period than in the first one. Last analysis (Wells et al., 1984) includes 1972-1983 data. A dome shape partial recuitment curve is used with maximum recruitment at age 6. An objection to this analysis in the inadequacy of sampling in 1981-82, which reduce confidence in estimates of biomass and abundance for the last years (NAFO Sci. Counc. Rep., 1984). Since then no new sequencial analysis was atempted due to doubts of catch data realiability.

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Table 1 - Cod catches and TACs on Flemish Cap.

TACs and catches in thousand tons.

year	recommended TAC	agreed TAC	reported landings
1953			0.017
1954			0.48
1955			0.792
1956			17
1957			18
1958			4.6
1959			6.9
1960			0.8
1961			20
1962			16
1963			38
1964			48
1965			60
1966			34
1967			42
1968			40
1969			32
1970			27
1971	-	-	34
1972	-	-	56
1973	-	-	23
1974	35	40	25
1975	40	40	22
1976	40	40	22
1977	25	25	27
1978	<40	40	33
1979	<40	40	30
1980	10-15	13	10
1981	-	12.7	14
1982	-	12.4*	13
1983	0	12.4*	10
1984	0	13	13
1985	0	13	14
1986	0	13	15
1987	0	13	11
1988	0	0	2
1989	0	0	1
1990	0	0	2 **
1991	0	13	.

*) Excludes expected catch by Spain.
**) provisional.

Table 2 - Reported nominal cod catches (tons) on Flemish Cap in 1990.

country	
Faroes	1,319
Japan	24
Portugal	550
Spain	87
USSR	22
non-reported	22,000
non member countries	7,500
Total	31,502

Table 3 - Cod commercial fishing catch-rates on Flemish Cap.

year	Portugal OT-6 (1)	Faroes: (2)	(3)	pair-trawlers (4)	(5)	(6)	(7)
	t/h	CPUE (days)	CPUE	CPUE	CPUE	CPUE (hours)	CPUE
1962	1.13						
1963	3.05						
1964	2.81						
1965	1.33						
1966	1.57						
1967	1.85						
1968	1.56						
1969	2.21						
1970	1.31						
1971	0.933						
1972	0.921						
1973	0.859	210 (171)	267				
1974	1.28	208 (22)	255				
1975	0.456	229 (123)	212				
1976	0.936	368 (104)	299				
1977		398 (174)	403				
1978		333 (165)	333				
1979		277 (88)	312				
1980		250 (123)	251				
1981		305 (40)	273				
1982		338 (16)	187				
1983		286 (102)	199	0.789			631
1984		- -	206	1.302			1041
1985		223 (61)	218	1.169			935
1986		142 (176)	124	0.796			637
1987		75 (56)	89	0.413		333 (1555)	333
1988		- -	118		944	485 (881)	485
1989		- -	-		853	609 (581)	609
1990		210 (222)	210			666 (1380)	666

1) Portuguese side trawlers (1000-2000 tons) catch per hour (Wells, 1978).
2) Longline exploratory fishery by M/S Hans Erik. CPUE (Kg / thousand hooks) and fishing days (Reinert, 1991 a)
3) Longliners CPUE (Kg / thousand hooks) (Reinert, 1990, 1991 b)
4) Spanish pair-trawlers CPUE index (Vazquez et al., 1991)
5) Pair-trawlers of non-member countries yield in Kg/hour (Vazquez, 1990: NAFO SC WP 90/15)
6) Pair-trawlers CPUE in Kg/hour (Vazquez, 1991 b)
7) Series 4) and 6) combined.

Table 4 - Main characteristics of Flemish Cap fishing surveys.

USSR (Chumakov et al., 1984, Bulatova and Chumakov, 1986, Mamylov, 1988, Kuzmin, 1991)

year	vessel	valid tows	trawling time	date
1971	Persey III	12	1 h	11-13/5
1972	"	19	"	4-7/4
1973	"	20	"	15-18/7
1974	"	20	"	22-26/8
1975	"	18	"	21-24/6
1976	"	19	"	10-16/3
1977	"	24	"	22-25/4
1978	"	30	"	26/7 - 1/8
1979	Suloy	64	"	20-26/4 + 5-18/6
1980	Nikolai Kononov	76	"	23/4 3/5
1981	" "	29	"	24/7-1/8 + 1-7/6
1982	Suloy	62	"	17-31/6
1983	"	103*	"	24/4 - 24/5
1984	"	103*	30 min	April
1985	Genichesk	106*	"	-
1986	Persey III	108*	"	-
1987	"	104*	"	21/06 4/07
1988	"	97*	"	4-16/6
1989	"	109*	"	June-July
1990	"	85*	"	June-July

*) stratified random design

CANADA (Wells, 1983 b; Anon., 1990)

year	vessel	valid tows	trawling time	date	
1977	A.T. Cameron	36	30 min	2-15/2	(Wells, 1977)
1978	Gadus Atlantica	134	"	27/1-12/2	(Wells, 1979)
1978	A.T. Cameron	34	"	Nov	
1979	Gadus Atlantica	95	"	29/1-18/2	
1980	"	130	"	6-21/1	(Wells, 1980 b)
1981	"	142	"	7-22/1	
1982	"	109	"	28/1-14/2	
1983	"	142	"	5-21/2	
1984	"	129	"	2-14/2	
1985	"	129	"	1-13/2	

EEC (Vazquez, 1989, 1990, 1991)

year	vessel	valid tows	trawling time	date
1988	Cornide de Saavedra	115	30 min	8-22/7
1989	Cryos	116	"	12/7 - 1/8
1990	Ignat Pavlyuchenkov	113	"	16/7 - 6/8

Table 5 - Cod stock age composition ('0000) according to USSR's surveys.

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 :	63		33	5	47	125	986	209	64	25	2765
2 :	1482	16	613	57	10	83	2563	1081	88	1757	276
3 :	3530	344	1117	246	236	247	1510	2227	921	649	376
4 :	4255	852	445	433	751	52	357	1678	1578	553	84
5 :	5264	951	727	60	358	173	630	540	864	653	105
6 :	757	148	1426	30	114	186	265	181	155	52	64
7 :	158	23	819	68	75	31	115	94	27	12	11
8 :	63		201	48	28	44	60	31	8	5	1
9 :	95		22	19	10	32	24	14	1	4	
10 :	63	7	11	10		44	14	5	1	1	1
11 :	32		11	6		17	16	6		4	
12 :							8	2			
13 :							7			4	
14 :										1	
15 :											
16 :											
total	15761	2342	5422	982	1628	1034	6553	6068	3706	3720	3682
Abund	157610	23420	54220	9820	16280	10340	65530	60680	37060	37200	36820
Biom.	135	22	41	12	25	14	23	31	28	26	10
SOP	119037	19143	64572	9907	14058	13302	29385	31326	28426	27274	9787

age	1988	1989	1990
1 :	5	163	3
2 :	1684	88	8
3 :	842	5431	80
4 :	114	1327	305
5 :	10	28	29
6 :	10	4	3
7 :	8	1	
8 :		3	2
9 :		1	0
10 :			
11 :			
12 :	1		
13 :			
14 :			
15 :			
16 :			
total	2673	7044	431
Abund	26730	70440	4310
Biom.	8	37	4
SOP	7992	35245	3950

Table 6 - Cod stock fishing mortality between USSR's surveys.

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 :	1.15		-0.76	-0.89	-0.76	-3.22	-0.29	0.67	-3.52	-2.61	0.30
2 :	1.26	-4.42	0.71	-1.62	-3.43	-3.10	-0.06	-0.04	-2.20	1.34	-1.32
3 :	1.22	-0.46	0.75	-1.31	1.32	-0.57	-0.31	0.14	0.31	1.85	1.00
4 :	1.30	-0.04	1.80	-0.01	1.27	-2.70	-0.61	0.46	0.68	1.46	1.97
5 :	3.37	-0.61	2.97	-0.84	0.45	-0.63	1.05	1.05	2.61	2.13	2.19
6 :	3.28	-1.91	2.85	-1.10	1.10	0.29	0.83	1.71	2.35	1.36	1.92
7 :		-2.35	2.63	0.70	0.32	-0.85	1.10	2.25	1.47	2.79	
8 :			2.18	1.39	-0.35	0.42	1.28	3.71	0.40		
9 :	2.40		0.59		-1.72	0.61	1.41	2.88	-0.91	1.10	
10 :		-0.63	0.41			0.82	0.65		-2.01		
11 :						0.56	1.87				
12 :											
13 :											
14 :											
15 :											
16 :											
F 4+	2.05	-0.68	2.52	-0.06	0.73	-0.88	0.34	0.68	1.07	1.76	2.06

age	1988	1989	1990	mean
1 :	-3.05	2.79		-0.82
2 :	-1.37	-0.11		-0.57
3 :	-0.65	2.68		0.53
4 :	1.21	3.61		0.69
5 :	0.70	2.02		1.17
6 :	1.80			0.77
7 :	0.89	-0.49		1.01
8 :		1.59		1.16
9 :				0.65
10 :				0.78
11 :				1.96
12 :				-0.19
13 :				1.90
14 :				
15 :				
16 :				
F 4+	1.16	3.47		

Table 7 - Cod catch-at-age ('000) and yield according to USSR's surveys.

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 :	40	-748	-37	-7	-54	-3005	-334	93	-2082	-312	645
2 :	981	-1348	286	-231	-292	-1761	-158	-44	-704	1202	-753
3 :	2301	-199	540	-670	160	-189	-540	272	224	510	219
4 :	2864	-35	346	-4	499	-718	-302	569	716	394	67
5 :	4830	-791	652	-79	119	-151	378	323	755	539	87
6 :	691	-852	1269	-61	70	42	137	138	131	36	51
7 :	158	-222	716	31	19	-42	70	79	19	11	11
8 :	63	-26	167	34	-11	14	40	29	2	5	1
9 :	81	-13	9	19	-45	13	17	12	-1	3	
10 :	63	-6	3	10	-20	23	6	5	-4	1	1
11 :	32		11	6		6	13	6		4	-1
12 :						-8	8	2	-5		
13 :							7		-2	4	
14 :										1	
15 :											
16 :											
Y 4+	95058	-28050	52930	2349	2041	-4357	11232	12429	16737	17393	4792

age	1988	1989	1990
1 :	-102	144	
2 :	-4948	-10	
3 :	-778	4769	
4 :	74	1229	
5 :	4	23	
6 :	7	4	
7 :	4	-1	
8 :	-1	2	
9 :		1	
10 :			
11 :			
12 :	1		
13 :			
14 :			
15 :			
16 :			
Y 4+	1353	11672	

Table 8 - Cod stock age composition ('0000) according to Canadian surveys.

age	1977	1978	1979	1980	1981	1982	1983	1984	1985
1 :	1				3	63	29	4	4
2 :	213	9	467	103		178	7100	153	52
3 :	1027	476	107	1947	517	2	782	1583	621
4 :	2720	1553	561	238	1548	166	32	190	1995
5 :	596	4569	544	299	97	98	236	7	77
6 :	77	1213	671	274	211	3	96	64	5
7 :	16	48	171	391	104	15	4	43	10
8 :	1	18	11	16	207	14	8	1	9
9 :	18	6	5	2	10	22	7	4	1
10 :	4	15	2	1	2	1	24	6	1
11 :	1	7	3		1		1	10	2
12 :		2	1	1					3
13 :	2	3	5	1	1				1
14 :		4	3						1
15 :	1	1	10	1					
16 :						1			
total	4678	7925	2561	3274	2702	563	8320	2066	2784
Abund	46778	79252	25612	32740	27020	5631	83197	20660	27836
Biom.	42302	83422	30847	33940	39371				25190
SOP	41588	86176	28804	33662	39382	8162	28722	18214	24930

Table 9 - Cod stock fishing mortality between Canadian surveys.

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	mean
1 :	-2.27				-4.22	-4.93	-1.85	-2.69		-4.58
2 :	-1.00	-2.62	-1.63	-1.81		-1.68	1.30	-1.60		0.11
3 :	-0.61	-0.36	-1.00	0.03	0.93	-2.92	1.22	-0.43		-0.18
4 :	-0.72	0.85	0.43	0.69	2.56	-0.55	1.27	0.70		-0.03
5 :	-0.91	1.72	0.49	0.15	3.22	-0.18	1.10	0.18		0.73
6 :	0.28	1.76	0.34	0.77	2.44	-0.54	0.61	1.62		1.00
7 :	-0.29	1.28	2.17	0.44	1.83	0.38	1.12	1.39		0.83
8 :	-1.81	0.99	1.35	0.25	2.05	0.50	0.45	0.49		1.36
9 :	-0.06	0.98	2.02	-0.20	2.03	-0.28	-0.12	1.10		0.16
10 :	-0.77	1.44		-0.20		-0.20	0.68	0.72		0.63
11 :	-0.53	1.76	0.72					0.95		0.97
12 :		-1.26	0.31	-0.20						-1.25
13 :	-0.59	-0.10								0.37
14 :		-1.20	0.68							-0.84
15 :										2.32
16 :										
F 3+	-0.71	1.18	0.34	0.17	1.93	-0.44	1.10	-0.30		

Table 10 - Cod catch-at-age ('000) and yield according to Canadian surveys.

age	1977	1978	1979	1980	1981	1982	1983	1984	1985
1 :	-10	-571	-126		-214	-8609	-157	-59	
2 :	-368	-121	-1911	-529	-3	-778	4782	-606	
3 :	-870	-210	-184	52	289	-37	509	-854	
4 :	-2861	817	179	109	1345	-122	21	87	
5 :	-887	3491	191	38	89	-19	145	1	
6 :	17	937	176	135	181	-2	40	48	
7 :	-6	32	142	126	81	4	3	30	
8 :	-7	10	7	3	169	5	3	0	
9 :	-1	4	4	-1	8	-7	-1	3	
10 :	-5	11	2	-0	2	-0	11	3	
11 :	-1	5	1		1		1	6	
12 :	-4	-5	0	-0				-1	
13 :	-2	-0	5	1	1			-1	
14 :	-1	-9	1						
15 :	1	1	10	1	-1				
16 :									
Y 3+	-42093	60007	12145	8515	32513	-2476	11320	3146	

Table 11 - Cod stock age composition ('0000) according to EEC's surveys.

age	1988	1989	1990
1 :	458	2085	237
2 :	7196	1100	1179
3 :	4037	8422	467
4 :	1085	4922	1588
5 :	128	1858	1453
6 :	22	127	394
7 :	28	15	32
8 :	11	12	13
9 :			8
10 :		1	3
11 :			
12 :			
13 :			
14 :			
15 :			
16 :			
total	12965	18542	5374
Abund	129650	185420	53740
Biom.	37	104	55
SOP	33474	100217	51388

Table 12 - Cod stock fishing mortality between EEC's surveys.

age	1988	1989	1990	mean
1 :	-1.08	0.37		-0.09
2 :	-0.36	0.66		-0.27
3 :	-0.40	1.47		0.45
4 :	-0.74	1.02		0.40
5 :	-0.19	1.35		1.14
6 :	0.18	1.18		0.95
7 :	0.65	-0.06		0.34
8 :		0.21		0.86
9 :				
10 :				
11 :				
12 :				
13 :				
14 :				
15 :				
16 :				
F 3+	-0.47	1.28		

Table 13 - Cod catch-at-age ('000) and yield according to EEC's surveys.

age	1988	1989	1990
1 :	-886	588	
2 :	-3091	485	
3 :	-1975	6015	
4 :	-1184	2900	
5 :	-27	1275	
6 :	3	81	
7 :	12	-1	
8 :	11	2	
9 :	-1	-4	
10 :		1	
11 :			
12 :			
13 :			
14 :			
15 :			
16 :			
Y 3+	-13329	63039	

Table 14 - Mortalities and corresponding catches (or its defect) calculated between abundance estimates in a) USSR's survey, b) Canadian survey and c) EEC's survey, together with previous estimates of those mortalities.

Fishing mortality

	a) USSR F 4+	b) Canada F 3+	c) EEC F 3+	(1)	(2)
1977	2.05	-0.71			
1978	-0.68	1.18		1.45	1.70
1979	2.52	0.34		0.50	0.56
1980	-0.06	0.17		0.46	0.43
1981	0.73	1.93		2.45	2.02
1982	-0.88	-0.44		-0.36	-0.23
1983	0.34	1.10			
1984	0.68	-0.30			
1985	1.07				
1986	1.76				
1987	2.06				
1988	1.16		-0.47		
1989	3.47		1.28		
1990					

(1) Z from age-class 4+ and 5+ (Wells, 1983 a) minus 0.2
(2) Z for 1973 year class and older (Wells, 1983 a) minus 0.2

Catch (t)

	a) USSR Y 4+	b) Canada Y 3+	c) EEC Y 3+	reported or estimated catch ('000 t)
1977	95058	-42093		27
1978	-28050	60007		33
1979	52930	12145		30
1980	2349	8515		10
1981	2041	32513		14
1982	-4357	-2476		13
1983	11232	11320		10
1984	12429	3146		13
1985	16737			14
1986	17393			15
1987	4792			11
1988	1353		-13329	2
1989	11672		63039	40
1990				30

Table 15 - Survey indices of Flemish Cap cod abundance

	abundance			biomass			
year	USSR:(1)	(2)	CAN(3)	USSR:(1)	(2)	CAN(3)	EEC(4)
1971	77			69			
1972	66			75			
1973	108			46			
1974	346			51			
1975	550			121			
1976	693			296			
1977	489	234.30	87	448	201.30	79	
1978	96	42.35	100	79	39.90	105	
1979	122	80.60	32	108	60.95	39	
1980	34	14.60	41	35	17.90	45	
1981	53	28.35	34	91	43.45	52	
1982	29	15.35	9	36	20.55	13	
1983	214	97.40	105	69	34.30	37	
1984		90.20			46.40	25	
1985		55.09	35		41.70	32	
1986		55.30			38.70		
1987		58.60			16.20		
1988		42.90			12.40		
1989		104.72			54.30		
1990		7.40			6.80		

1) Cod number and weight (Kg) per one hour tow (Chumakov et al. 1984).
2) Mean catch per tow (equivalent to 30 min tow) (Bulatova et al., 1989, Kuzmin, 1990, 1991)
3) Mean number and catch (Kg) in half-hour tow (Wells, 1983, Wells and Baird, 1985)

Table 16 - Cod stock biomass survey estimations on Flemish Cap.

year	EEC(1)	Canada(2)	USSR:(3)	(4)
1977			135,400	
1978		83,442	22,070	
1979		30,847	40,990	
1980		33,940	12,020	
1981		39,371	24,930	
1982		8,162	13,830	
1983		28,722	23,070	
1984		18,214	31,210	
1985		25,190	28,070	
1986			26,060	
1987			10,150	21,600
1988	37,127		7,720	34,200
1989	103,644		36,520	78,300
1990	55,360		3,920	15,200

(tons)

1) Biomass estimates from bottom trawl survey (Vazquez, 1991)
2) Biomass estimated and presented in table 8.
3) Biomass estimates from bottom trawl survey (Chumakov, 1989, Kuzmin, 1990, 1991)
4) USSR's estimates of bottom trawlable plus pelagic biomass (Kuzmin, 1990, 1991)

Table 17 - Cod stock biomass estimation in surveys on Flemish Cap and combined series (thousand tons).

year	USSR	Canada	EEC	combined series a	b	c
1977 -	135+	42		135	101	88
1978 -	22	83+		83	62	53
1979 -	41+	31+		36	36	36
1980 -	12	34+		34	26	23
1981 -	25+	39+		32	32	32
1982 -	14	8		14	20	-
1983 -	23+	29+		26	26	26
1984 -	31+	18		31	25	25
1985 -	28+	25+		27	27	27
1986 -	26+			26	26	26
1987 -	10+			10	10	10
1988 -	8+		37	8	28	24
1989 -	37+		104+	71	78	71
1990 -	4		55+	55	41	55

a) Mean of accepted estimations (+ = accepted)
b) The lowest limit of higest estimation was chosen (except in 1982 where higest limit was acepted) when difference were significative.
c) Arithmetic mean of estimations.

Table 18 - Number of young cod of the 1961-1981 year-classes in average catch per trawling hour in 3M (from Konstantinov, 1983; Kovalev, 1985: WP/85-23).

year class	age 1	2	3
1961	-	-	6
1962	-	7	29
1963	0	6	14
1964	0	1	14
1965	3	2	9
1966	0	0	13
1967	0	13	20
1968	10	103	58
1969	0	2	2
1970	0	1	1
1971	22	87	3
1972	0	29	22
1973	303	350	568
1974	133	50	57
1975	5	17	17
1976	0	2	13
1977	8	51	8
1978	3	2	2
1979	0	0	2
1980	2	11	-
1981	4	111	66
1982	11	32	-
1983	6	-	-
mean	24	42	46

Table 19 - Year-class abundance in Flemish Cap cod stock.

year-class	observations	
1949		
1950		
–		
–		
1953	+	
1954	++	
–		
–		
1957	+	
1958	++	
–		
–		
–		
1962	++	
–		
–		
–		
–		
–		
1968	++	
–		poor
–		"
–		"
1972	+	
1973	+++	suported fishery 1976-1978 (Wells, 1979 b) (see Table 18)
–		
–		
–		
1977	++	
1978		
–		
–		
1981	+	
–		
–		
–		
1985		
1986		
–		
–		