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An Assessment of the Cod Stock in NAFO Division 3M

by

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INTRODUCTION

Registered cod catches from Flemish Cap start in 1954, but reported total catch was incomplete in the initial years. Reported catches in the 1963 - 1979 period ranged between 20,000 and 57,000 tonnes (NAFO 1995) and consequently, the annual sustainable yield of the fishery was estimated at 40,000 tonnes. Compared with this period all subsequent reported catches are lower. A decline in the fishery had already been recognized in 1977 (Redbook 1977), and the reduction of the TAC in 1980 produced an immediate decrease in reported catches, ending this initial period. Confidence in reported fisheries data was raised in 1986 (NAFO Sci. Council. Rep., 1986) due to large discrepancies observed between reported catches from member countries and Canadian surveillance estimates. Cessation of the direct fishery for cod was advised since 1982 (NAFO Sci. Council. Rep., 1982). A moratorium was agreed by the Fisheries Commission for the period 1988-1990. Despite the moratorium, cod catches were estimated at around 40,000 tonnes in 1989, coinciding with the occurrence of the relatively abundant 1985 and 1986 year-classes. Independent estimates of total annual catches since 1988 substantially differ from total reported catches in the same period (Table 1). This level of misreporting probably also occurred during the previous period, 1980-1987.

An improper catch record since 1980 has prevented any analytical study of the evolution of the stock. Furthermore, the last sequential population analysis (Wells et al., 1984) including 1972-1983 data was objected to due to the inadequacy of sampling in 1981 and 1982 (NAFO Sci. Council. Rep., 1984). Since then, no new sequential analysis was attempted due to doubts about catch data reliability (Vazquez, 1991 a).

MATERIAL AND METHODS

Commercial fishery data

Portuguese catch and effort data for 1988 - 1994

The catch and effort data series for Portuguese trawl and gillnets fisheries on Flemish Cap have been reconstructed by revising skipper logbooks, kindly supplied by their owners. Data from 8 trawlers and 5 gillnetters have been made available and, although not all cover the same period of time, at least a couple of logbooks for each gear were revised for each year from 1988 to 1994. With the exception of one year (1988), for one trawler, where the existing information regards the overall catches (by species) and the corresponding fishing effort by trip, all the other information has been recorded and put on file on a daily basis as regards round weight of the catch by species and on a tow basis as regards fishing effort, positions and depths. The conversion factors used in each vessel were also used to convert its processed landings in catches.

The annual catch on Division 3M of former Portuguese trawlers with non-Contracting Parties flags was estimated using the number of those vessels having fishing activity recorded each year in the NAFO Regulatory Area (presented in the STACFAC working papers). This number was multiplied by the product of the average number of hours that a Portuguese trawler spent each year fishing on Flemish Cap with its corresponding average catch rate by species.

Pair-trawl catch data

All pair-trawlers, both Spanish and from non-Contracting Parties, are considered in the same vessel category, only being differentiated into tonnage classes, because they were all formerly Spanish. Annual catch of this group of vessels since 1983 was calculated with the following information sources:

a) catch and effort records of observers on board. This is the most valuable information source.

b) personal skipper log-books. More than half of the pair-trawl skippers allowed us to revise their personal log-books, where most reliable information was recorded. This source of information was absolutely different from one vessel to another. At best, the log-books contained a tow by tow information similar to the one recorded by observers on board. Information from fourteen pair-trawlers was in this category, four of these being from non-Contracting Parties. The reliability of the information in log-books was checked for coincidences with observers on board, when there were data records from the same vessel and the same time period from observers on board and log-books. These two sources coincided fairly well.

c) daily effort information. Three skipper log-books did not contain a tow by tow detailed information, but the zone where the vessel was every day was clearly recorded. Although they generally contained monthly catch records, only effort in number of days per month was used from this source.

d) number of pair-trawlers that participate annually in NAFO fisheries. This information was obtained from Spanish Administration records on past activity of the Spanish fleet, and from NAFO records for non-Contracting Parties (STACFAC WP 92/9, 93/14 and 94/3).

Total annual cod catches in Flemish Cap were calculated by extrapolating the results of known vessels to all the fleet, assuming that the behaviour of all the fleet was homogeneous. Monthly catch per pair-trawl which were fishing was calculated with data from observers on board and detailed skipper log-books. But some other pair-trawlers were resting or fishing in other areas at the same time, according to effort information and an analysis of annual activity of each vessel. Monthly catch per pair-trawl was adjusted so as to refer to all pair-trawls being monitored. Activity of the vessels is usually linked with skipper activity. So, periods of several months without records in skipper log-books would imply vessel repose. But some vessels have two alternate skippers and the previous rule is not always correct. To solve this situation, it was assumed that vessels (other than those monitored by observers on board) were active up to three months before and after any record. So intermediate periods of six months were considered as repose and greater periods are assumed to be not monitored.

Total annual catch was calculated totalling monthly mean catches per vessels and raising the result to the total number of pair-trawlers active during that year.

The same procedure was used to calculate discards, although information was more scarce, mainly from observers on board.

Catch of other countries

No direct information from vessels of other countries was available. Catches from other countries with reported catches were, as a norm, accepted as they were. For non-member country vessels, their presence was deduced from STACFAC reports where sightings are recorded.

Sampling catch

Portuguese catches in the NAFO Regulatory Area have been sampled at sea regularly over the past 7 years, and data obtained each year from Division 3M used to obtain the length and age composition of the respective cod catches. Mean weight in the catch and mean weights at age for each gear were derived using the length weight relationships given each year by the EU bottom trawl survey series.

Nevertheless, for some of the years, sampling data for trawl or for gillnets was missing, leading to the following procedures in order to obtain the catches at age:

a) For trawl, the 1988 and 1994 catches were estimated using the respective cod age length keys from the EU surveys.

b) For gillnets, and since no biological sampling was made in 1989 and 1990 from the catches of this fleet on Flemish Cap, the relative length composition (per thousand) of the 1989 cod catch was considered to be similar to the 1988 values, the same assumption being adopted for 1990 as regards the 1991 length composition of the cod gillnet catches. This assumption seems reasonable taking into account the similarities in the relative length composition of the cod survey catches between these years and within the 55-75 cm size range, where most of the lengths fall in the 3M cod gillnet catches. These relative length compositions of 1988 and 1991 were matched with the length weight relationships of 1989 and 1990 to obtain the mean weights in the gillnet catches of 1989 and 1990 and the absolute length compositions for those years. The 1989 and 1990 age length keys for the Spanish pair-trawler cod catches were then used to obtain the respective gillnet catches at age. The same procedure was adopted in 1988 as regards the conversion of lengths to catches at age, since no cod otoliths for gillnets were aged that year.

For Spanish pair-trawlers, sampling coverage during this period was fairly good. Catch at age has been presented in annual national research reports and by Vazquez (1991 b). Mean weight at age is included in the same documents or it was calculated from original data.

Total catch and catch at age for the 1988-1994 period

Portuguese and pair-trawler catches were calculated as previously indicated. Cod catch of Spanish freezers was estimated with information from observers on board, and catch at age structure was assumed to be equal to that of Portuguese trawlers.

Faroese catch figures for 1988 and 1991 according to NAFO Statistical Bulletin were used. Catch at age structure were assumed to be equal to that of Portuguese gillnetters. There was no Faroese fishery in 1989 (NAFO SCS Doc. 91/11) and catch data and sampling for 1990 was presented by Reinert (1991).

Total annual catch estimates as presented in Table 1 in comparison with reported catch. The agreement is low and supports the initial supposition that nominal catches since 1980 underestimate real catches.

RESULTS

CPUE analysis

A CPUE analysis was carried out on cod directed fisheries of Portugal and Spain. Monthly catch and effort data from Portuguese trawlers in Division 3M cover years 1988-1994 and are exclusively derived from the revised logbooks. Spanish pair-trawl data from both observers on board and skipper logbooks cover NAFO Divisions 3LMN and ICES Division IIB, years 1983-1994. Vessel factor for some vessels was calculated twice: those with observers on board and whose skipper allowed his logbooks to be reviewed. The agreement between both series was good, indicating the consistency of data used.

Analysis was carried out independently for each fleet. Annual factor (CPUE indices) in Division 3M show different tendencies for Spanish pair-trawlers and Portuguese trawlers in the last years, indicating that both fleets were fishing over different portions of the

stock. In such a case, any one of these CPUE series may reflect the evolution of the recent stock. Similarly, an annual CPUE series derived from both fleets data combined was also rejected for VPA calibration.

Sequential population analysis (SPA)

An Extended Survivors Analysis was carried out for ages 1 to 8+ and years 1988 to 1994. Catch in number data (Table 2) correspond to the estimated total annual catch. Tentative analysis including ages 9 and 10 was not convergent due to the scarcity of older age-groups in the catch. Also, ages 1 and 2 were excluded from the calibration process due to their poor representation in commercial catch.

Mean weight at age in the catch (Table 3) was calculated from national reports and fleet components. Mean weight at age in the stock (Table 3) was assumed to be equal to their value in the EU survey, at midyear.

Natural mortality was set equal to 0.2. The partial recruitment-at-age vector is not an input data for the Extended Survivors model used in the analysis.

The analysis was tuned with the results of the EU survey from 1988 to 1994 (Table 4).

Results are shown in Table 5. Fishing mortality has its lowest value in 1988 and 1991, which coincides with the assumed recent evolution of the fishery.

According to SPA results, 1985 and 1991 were the most abundant year-classes over the period, and those from 1993 and 1994 seem to be the weaker ones. Total biomass reached its maximum in 1989 and in 1994 (Figure 2). The first maximum was observed in both Russian and EU surveys (Kiseleva and Vaskov, 1994; Vazquez, 1995), but the peak of 1994 was not observed in the survey. This apparent disagreement must derive from the differences in the date the estimations refer to. SPA biomass estimates refer to the beginning of the year and the surveys were made in the middle of the year. The high fishing mortality may cause such deep changes in the stock as to modify total biomass in a noticeable amount in a six-month period.

DISCUSSION

The agreement between calculated and reported catches (Table 1) is low and this supports the initial supposition that nominal catches since 1980 underestimate real catches. The annual catches actually calculated are somewhat larger than previously estimated by the NAFO Scientific Council (1989: 40,000, 1990: 32,000, 1991, 1992: 11,000, 1993: 12,500 tonnes). The sharp decline in catch in 1980 probably did not occur, or it was not so marked as catch figures indicate. The mean reported catch in the period 1963-1979, 32,000 tonnes, is at the same level as the present mean catch estimation for the 1988-1994 period, 29,000 tonnes.

The present catch estimates indicate an increase of the catches in 1989 and 1990, as repeatedly noted by the NAFO Scientific Council. Several fleets move into the zone, in spite of the moratorium to fish for cod in the 1988-1990 period, not only as a consequence of the occurrence of several relatively abundant year classes, those of 1985 and 1986, but also due to the poorer yield in other zones of the Regulatory Area: Flemish Cap became the most attractive fishery for cod in 1990.

In 1991, the cod trawl fishery almost finished in Division 3M due to larger than usual concentrations of cod in division 3L outside the 200 mile limit (Avila de Melo et al., 1995). CPUE reached a minimum in that year when the 1986 year-class had already lost its strength and no other abundant year-class had yet started to recruit. However, since 1992 the CPUE increased steadily, reaching a maximum in 1994. The consecutive recruitment of two abundant year-classes from 1990 and 1991 and its continuous growth allowed a juvenile cod fishery from age 3 with high yields in 1993 and 1994 (Table 2).

Variation in total cod catch on Flemish Cap (Figure 1) depends of, not only the abundance in that zone, but the relative abundance of cod in all available zones. The decline of the catch in 1993 must be attributed to the end of the pair-trawl fishery for the rest of the 1985

and 1986 year-classes, besides the fact that the best option for the cod fishery was, at that time, Division 3N. Also, this was due the involvement of part of the fleet in the Greenland halibut fishery. Increase of catch in 1994 was a consequence of the return to Flemish Cap of all fleets fishing directly for cod.

Spawning of cod in Flemish Cap was assumed in the past to start at age 5, but new studies indicate a shift to younger ages in the most recent period (Saborido-Rey and Junquera, 1995). Mean weight at age 4 was also observed to increase steadily in recent years (Table 2). The 5+ biomass in Table 5 is a rough estimate of the spawning stock biomass, and its trend indicates a peak in 1990, a decline since then, and a possible future increase as the still abundant 1991 year-class became mature. The spawning biomass should increase much more than the B 5+ figure in the near future (Table 5) if most of the 1991 year-class spawns at age 4 in 1995, thus increasing the probability of a better natural recruitment this year. However, this favourable situation involves an emergency for cod, and should not be used to maintain the present high level of fishing mortality.

For catches to stop following recruitment fluctuations and to stabilize at the potential replacement yield of the stock, it is necessary not only to reduce the high fishing mortalities between ages 3 and 5, but also for fishing effort directed to this stock to be kept, in future, at a lower level than the one observed in recent years. This reduction should imply a reduction in the actual level of juvenile catches and trawl directed effort. Simultaneously, such reduction would increase Division 3M cod survival to maturity (in turn, increasing the probability of good recruitments) at the same time increasing the exploitable biomass and its age spectrum. The probability of having a more stable cod stock supporting attractive catches seems so closely linked to a reduction of fishing effort along with the shift of the exploitable pattern towards larger fish.

Acknowledgements

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Table 1 - Total cod catch on Flemish Cap. Reported nominal catches and current estimation. (tonnes)

year	total estimated	reported								total	
		Faro.	Japan	Korea	Norw.	Port.	Russ.	Spain	UK othrs		
1988	28899	1100	5	6		421	39	141		6	1718
1989	48373		38	321		170	10	378			917
1990	40827	1262	24	815		551	22	87		1	2762
1991	16229	2472	54	82	795	2838	1	1416	26	1196	8989
1992	25089	747	2	18		2201	1	4215	5		7226
1993	15958	2075		3		3130		2249			7458
1994	29916					2587		1952			459

references: NAFO, 1995a and b.

Table 2 - Catch in numbers. ('000)

year	age:							
	1	2	3	4	5	6	7	8+
1988	1	3500	25593	11161	1399	414	315	162
1989	0	52	15399	23233	9373	943	220	205
1990	7	254	2180	15740	10824	2286	378	117
1991	1	561	5196	1960	5151	1688	368	76
1992	0	16086	10519	4569	1314	2466	1102	471
1993	0	2657	14530	3547	931	284	426	213
1994	0	1219	25400	8273	386	185	14	182

Table 3 - Weights at age in both catch and stock. (Kg)

weight in catch

year	age:							
	1	2	3	4	5	6	7	8+
1988	0.058	0.198	0.442	0.821	2.190	3.386	5.274	7.969
1989	0.050	0.209	0.576	0.918	1.434	2.293	4.721	7.648
1990	0.080	0.153	0.500	0.890	1.606	2.518	3.554	7.166
1991	0.118	0.229	0.496	0.785	1.738	2.622	3.474	6.818
1992	0.050	0.298	0.414	0.592	1.096	1.702	2.616	3.863
1993	0.050	0.210	0.509	0.894	1.829	2.233	3.367	4.841
1994	0.142	0.289	0.497	0.792	1.916	2.719	2.158	4.239

weight in stock

year	age:							
	1	2	3	4	5	6	7	8+
1988	0.031	0.103	0.308	0.678	1.973	3.594	5.772	6.926
1989	0.034	0.103	0.341	0.840	1.295	2.205	4.269	6.930
1990	0.039	0.170	0.342	0.846	1.501	2.426	4.083	5.635
1991	0.054	0.166	0.495	0.855	1.611	2.606	4.255	7.692
1992	0.054	0.246	0.490	1.377	1.702	2.633	3.133	6.685
1993	0.043	0.222	0.655	1.209	2.270	2.371	3.449	5.890
1994	0.060	0.211	0.624	1.241	1.974	3.940	4.034	6.282

Table 4 - EU survey abundances at age used for tuning SPA
(8+ group not used). ('0000)

year	age:							
	1	2	3	4	5	6	7	8+
1988	458	7196	4037	1085	128	22	28	11
1989	2085	1100	8422	4922	1858	127	15	13
1990	237	1179	467	1588	1453	394	32	24
1991	13780	2560	1548	192	622	173	25	6
1992	7118	3706	475	203	33	127	21	2
1993	438	13274	2852	102	127	17	50	10
1994	314	385	4710	844	18	9	0.1	19

Table 5 - Results of the Extended Survivors Analysis.

Fishing mortality (F) at age

YEAR	1988	1989	1990	1991	1992	1993	1994
AGE							
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.058	0.006	0.016	0.029	0.367	0.036	0.118
3	0.406	0.386	0.367	0.530	1.116	0.671	0.554
4	0.518	0.811	0.886	0.666	1.391	1.867	1.094
5	0.492	1.190	1.244	0.843	1.493	1.392	1.299
6	0.583	0.741	1.144	0.635	1.488	2.414	1.323
7	0.436	0.721	0.771	0.545	1.229	1.283	0.949

Population numbers ('000) at age (start of year) and terminal
population estimates. (biomass 1+ to 5+ in tonnes)

YEAR	1988	1989	1990	1991	1992	1993	1994	term.
AGE								
1	11800	21200	26600	70700	102000	14800	3990	0
2	68800	9640	17300	21700	57900	83500	12100	3270
3	84700	53200	7850	14000	17300	32800	66000	8820
4	30500	46200	29600	4450	6720	4640	13700	31000
5	3980	14900	16800	9990	1870	1370	587	3770
6	1040	1990	3710	3970	3520	345	279	131
7	985	473	777	967	1720	651	25	61
8+	502	435	237	198	720	318	323	110
total	202338	147970	102861	125982	191761	138501	97054	47162
B 1+	74971	87380	70430	50232	60135	54313	65366	
B 2+	74606	86659	69393	46414	54627	53677	65127	53560
B 3+	67519	85666	66452	42812	40383	35140	62574	52870
B 4+	41432	67525	63767	35882	31906	13656	21390	47366
B 5+	20753	28717	38725	32077	22653	8046	4388	8895

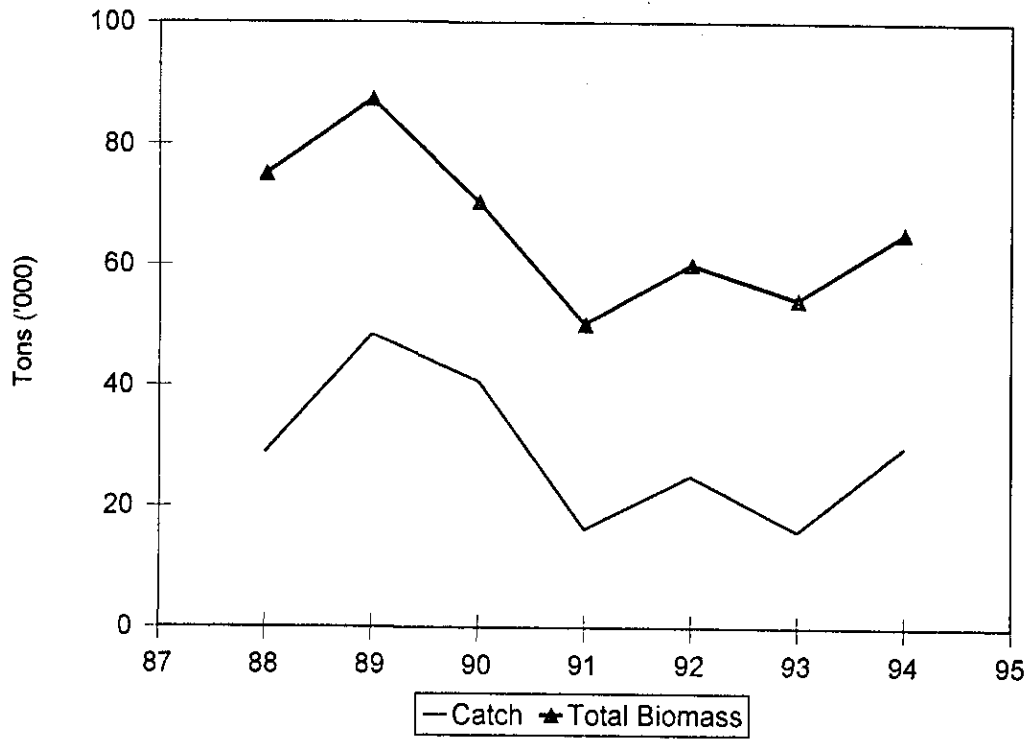


Figure 1 - Total annual cod catch and CPUE indices.

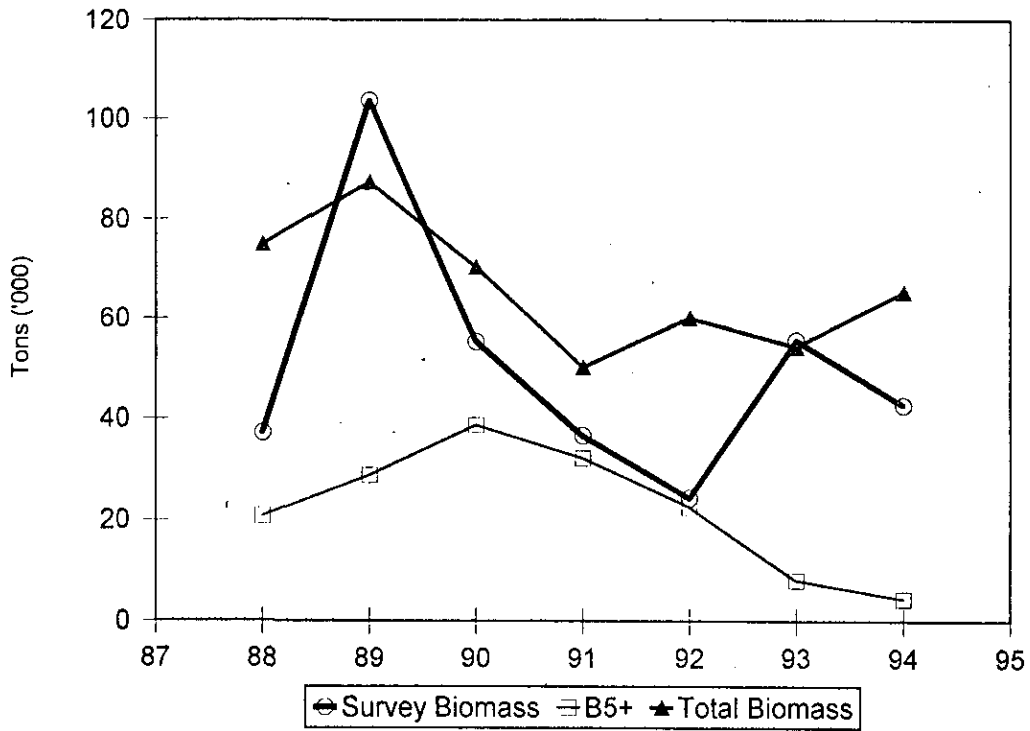


Figure 2 - Total cod biomass according to EU survey and total biomass and 5+ biomass (rough estimate of spawning biomass) according to SPA results.