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Status of the Cod Stock in Division 3M

by

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Introduction

Catches of cod declined substantially over the period 1963-83 (Table 1). Because of apparently inadequate sampling in 1981 and 1982, no analytical assessment has been presented in NAFO which included these last years. At the request of STACFIS, the sampling materials available for 1981 and 1982, together with that of 1983, have been used to estimate the age compositions of cod taken by the fishery in those years. Age compositions for each year in the period 1972-1980 were available in Gavaris (1981). A virtual population analysis was carried out and results compared with trends in abundance from research vessel survey results.

Sampling of the Commercial Fishery

Sampling for length and age compositions of cod in 1981-83 listed in Table 2 is rather scanty. Age compositions of the total removals by the commercial fishery were estimated as follows:

1981

The May sampling by Portugal was adjusted up to the total nominal catch for the year excluding longline (Table 3).

The April and May sampling for Denmark (Faroes) was adjusted up separately to the nominal catches in each month for longline. These monthly age compositions were combined and that total was adjusted up to the total longline catch for the year.

1982

The May sampling by Spain was adjusted up to the total nominal catch for the year excluding longline (Table 3).

The October and November sampling for Denmark (Faroes) was adjusted up separately to the nominal catch in each month for longline. These monthly age compositions were combined and that total was adjusted up to the total longline catch for the year.

1983

The March sampling by Portugal was adjusted up to the total nominal catch for January-March excluding longline (Table 3). The percent age compositions for Spanish pair trawl estimated by Spain (April-June) and by Canada (June) were combined and this combined age composition was adjusted to the total nominal catch for April-June excluding longline. The January-March and April-June age compositions were combined and this combined age composition was adjusted to the total nominal catch for the year excluding longline.

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The April sampling for Denmark (Faroes) was adjusted up to the April-June nominal catch by longline. The October sampling for Denmark (Faroes) was adjusted up to the October-December nominal catch by longline. The age compositions for April-June and October-December were combined and adjusted up to the total longline catch for the year.

For each of the years 1981-83, average weights-at-age were derived by applying the formula $\log \text{ weight (kg)} = 3.088 \log \text{ length (cm)} - 5.211$ to the average lengths-at-age (Table 4).

The estimated age compositions for 1981-83 show that the 1977 and 1978 year-classes were predominant in the catches in 1981 and 1982 and that the 1980 year-class entered the fishery in strength in 1983 as age 3 fish. A small proportion of age 2 fish (1981 year class) were present in the sampling both of pair trawl and longline in 1983.

Cohort Analysis

Catch at age and average weights-at-age for the period 1972-1980 were available from Gavaris (1981) (Table 5).

A comparison of commercial catches-at-age in the years 1981-83 with corresponding age compositions from the Canadian research vessel survey (Table 6) suggested a dome shaped partial recruitment to the gears used in the commercial fishery. The average partial recruitment pattern was smoothed arbitrarily for use in the final year of the analysis as follows:

age	3	4	5	6	7	8	9	10	11	12
partial mortality	.55	.75	.90	1.0	.95	.75	.55	.40	.40	.40

For the oldest specimens at age 12, the fishing mortality used each year was that which would equal the fishing mortality on ages 10 and 11 fish in the population resulting in the numbers left ages 11 and 12 in the succeeding year, given $M = 0.2$.

Population numbers, mid-year population biomasses and fishing mortalities for the period 1972-83 are presented in Table 7 for a terminal F in 1983 of 0.3. The r^2 statistic for the comparison of 3+ numbers from this table with 3+ numbers from the Canadian survey was 0.90 (Table 8). Similar cohort runs at other terminal Fs indicated that the terminal F for 1983 might be much higher than 0.3.

The catch rate (kg/hour) from the Soviet research survey series (SCR Doc 84/VI/41) for 1972-1980 were related to the 3+ population biomass with $r^2 = 0.57$, slope = 0.12 and intercept of 29. Using this relationship, the 1981, 1982, and 1983 3+ population biomasses were predicted to be 40, 33, and 37 thousand tons. These biomasses are not inconsistent with a terminal F of 0.4 in 1983 (Table 8).

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Table 1. Nominal catches of cod taken on the Flemish Cap in the period 1963-1983. Catches reported for 1983 are provisional.

Year	Denmark (Faroes)	Portugal	Spain	Soviet Union	France	Others	Total
1963	4,444	7,028	4,005	8,528	9,501	4,710	38,216
1964	7,056	3,668	862	26,643	3,966	5,624	47,819
1965	4,654	1,480	1,530	37,047	2,039	13,563	60,313
1966	4,695	7,336	4,268	5,138	4,603	7,794	33,834
1967	4,838	10,728	3,012	5,886	6,757	10,942	42,163
1968	5,765	10,917	4,045	3,872	13,321	2,465	40,385
1969	8,354	7,276	2,681	283	11,831	1,420	31,845
1970	6,925	9,847	1,324	494	6,239	1,700	26,529
1971	7,280	7,272	1,063	5,536	9,006	3,535	33,692
1972	6,902	32,052	5,020	5,030	2,693	5,994	57,691
1973	7,754	11,129	620	1,145	132	2,120	22,900
1974	1,872	10,015	2,619	5,998	-	4,434	24,938
1975	3,288	10,430	2,022	5,446	-	1,189	22,375
1976	2,139	10,120	2,502	4,831	229	2,445	22,266
1977	5,664	6,652	1,315	2,982	6,009	4,397	27,019
1978	7,922	10,157	2,510	3,779	5,096	3,667	33,131
1979	7,484	9,636	4,907	4,743	1,525	1,415	29,710
1980	3,248	3,615	706	1,056	301	1,531	10,457
1981	3,874	3,727	4,100	927	79	1,166	13,873
1982	3,121	3,316	4,513	1,262	119	422	12,753
1983	1,489	2,930	4,407	1,264	-	115	10,205

Table 2. Sampling of cod in the commercial fishery in Division 3M for the period 1981-83. (Port = Portugal, Den(F) = Denmark Faroes, Can = Canada)

Year	Country	Gear	Quarter	Month	Otoliths	Meas.	Source
1981	Port	OT	2	May	74	700	SCR 81/IX/101
	Den(F)	LL	2	April	343	881	SCR 82/VI/66
	Den(F)	LL	2	May	-	1007	SCR 82/VI/66
	Can	OT	2	June	-	200	SCR 82/VI/66
1982	Den(F)	LL	4	Oct	184	1176	SCR 83/VI/64
	Den(F)	LL	4	Nov	-	2168	SCR 83/VI/64
	Port	OT	2	June	33	911	SCR 83/VI/64
	Spain	PT	2	May	122	2864	SCR 83/VI/20
1983	Port	OT	1	March	190	224	SCS 84/VI/14
	Spain	PT	2	April	55	-	SCR 84/VI/29
	Spain	PT	2	June	-	1114	SCR 84/VI/29
	Den(F)	LL	2	April	105	1471	SCR 84/VI/47
	Den(F)	LL	4	Oct.	101	1995	SCR 84/VI/47
	Spain	PT	2	June	110	1644	SCR 84/VI/47
	Port	OT	4	Dec.	35	263	SCR 84/VI/47

Table 3. Estimated age compositions of the commercial catch of cod on the Flemish Cap in 1981-83 (OT = Otter trawl, PT = Pair Trawl, and LL = Longline).

Year	Age	OT/PT Jan-Dec	LL April	LL May	LL April-May	LL Jan-Dec	Grand Total
1981	3	1535	6	17	23	197	1732
	4	5158	42	146	188	1610	6768
	5	50	3	10	13	111	161
	6	78	4	25	29	248	326
	7	35	2	16	18	154	189
	8	212	2	31	33	283	495
	9	7	-	3	3	26	33
	10	-	-	1	1	9	9
Total		7075	59	249	308	2638	9713
Average Weight		1.25	1.39	2.03	1.91	1.91	1.43
Nominal Catch		8845	82	505	587	5028	13873

Year	Age	OT/PT Jan-Dec	LL Oct	LL Nov	LL Oct-Nov	LL Jan-Dec	Total
1982	2	-	.01	.08	.09	9	9
	3	18	-	.03	.03	3	21
	4	2734	.56	2.41	2.97	306	3040
	5	1504	.68	3.42	4.10	422	1926
	6	310	-	-	-	-	310
	7	18	.13	.64	.77	79	97
	8	82	.08	.33	.41	42	124
	9	90	.26	.87	1.13	116	206
	10	18	.02	.05	.07	7	25
	11	-	-	.01	.01	1	1
	12	-	-	.01	.01	1	1
Total		4774	1.74	7.85	9.59	986	5760
Av. Weight		1.94	4.02	3.44	3.55	3.55	2.21
N. Catch 9257		9257	7	27	34	3496	12753

Year	Age	OT/PT Jan-Mar	OT/PT Apr-June	OT/PT Jan-June	OT/PT Jan-Dec	LL Jan-June	LL July-Dec	LL Jan-Dec	Total
1983	2	11	6	17	47	3		3	50
	3	335	512	847	2340	129	349	478	2818
	4	171	80	251	693	6	14	20	713
	5	11	211	222	613	110	42	152	765
	6	54	154	208	575	50	32	82	657
	7	20	12	32	88	1	5	6	94
	8	-	1	1	3	3	10	13	16
	9	9		9	25	1	7	8	33
	10	23	1	24	66	5	2	7	73
	11	-	-	-	-	1	-	1	1
	12	3	-	3	8	-	-	-	8
Total		637	977	1614	4458	309	461	770	5228
Av. Weight		1.80	2.01	1.93	1.93	2.10	2.07	2.08	1.95
N Catch		1147	1965	3112	8605	645	955	1600	10205

Table 4. Estimated weight-at-age of the commercial catch of cod on the Flemish Cap in 1981-83 (OT = Otter trawl, PT = Pair trawl, and LL = Longline).

Year	Age	OT/PT Jan-Dec	LL April	LL May	LL Apr-May	Total		
1981	3	0.62	0.64	0.65	0.65	0.62		
	4	1.25	1.21	1.24	1.23	1.25		
	5	2.09	1.76	1.80	1.79	1.88		
	6	2.82	2.38	2.67	2.63	2.68		
	7	3.58	2.93	3.12	3.10	3.19		
	8	4.42	4.13	4.67	4.64	4.55		
	9	11.05	5.66	5.74	5.74	6.87		
	10	-	6.24	6.23	6.23	6.23		
	11	-	5.59	5.59	5.59	5.59		
	12	-	-	17.93	17.93	17.93		
1982	Age	OT/PT Jan-Dec	LL Oct	LL Nov	LL Oct-Nov	Total		
	2	-	0.64	0.67	0.67	0.67		
	3	0.73	0.98	0.94	0.94	0.76		
	4	1.23	2.33	2.38	2.37	1.34		
	5	2.26	3.08	3.14	3.13	2.45		
	6	2.87	-	-	-	2.87		
	7	5.29	4.68	4.50	4.54	4.68		
	8	5.25	6.06	6.00	6.01	5.51		
	9	5.57	6.80	6.33	6.46	6.07		
	10	8.81	11.18	10.85	10.85	9.38		
	11	-	11.93	11.90	11.90	11.90		
	12	-	14.21	14.21	14.21	14.21		
1983	Age	OT/PT Jan-Mar	OT/PT Apr-June	OT/PT Total	LL Jan-June	LL July-Dec	LL Total	Total
	2	.14	-	.14	-	-	-	.14
	3	.75	1.17	1.00	.96	1.51	1.36	1.33
	4	1.09	1.23	1.13	1.89	2.12	2.05	1.14
	5	1.93	2.11	2.10	2.72	3.22	2.86	2.24
	6	2.88	3.75	3.52	3.64	3.65	3.64	3.53
	7	4.46	(5.3)	4.78	6.90	2.32	3.08	4.76
	8	-	6.90	6.90	6.60	2.76	3.65	6.48
	9	6.67	-	6.67	-	-	-	6.67
	10	10.00	-	10.00	-	-	-	10.00
	11	-	-	-	-	-	-	-
	12	16.63	-	16.63	-	-	-	16.63

Table 5. Catches-at-age and weights-at-age of cod taken by the commercial fishery on the Flemish Cap in the period 1972-83.

CATCH MATRIX 3M COD												
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	278	2035	5999	7090	17564	119	428	167	551	1732	21	2818
4	19303	116	11130	2436	10653	17581	3092	2616	500	6768	3040	713
5	12372	11709	2232	1241	386	8502	18077	5599	1423	161	1926	765
6	6555	3470	1894	238	100	436	3615	5882	1051	326	310	657
7	3083	853	271	281	63	267	329	316	1318	189	97	94
8	1672	271	21	96	1	45	91	63	92	495	124	16
9	1106	504	75	35	1	151	95	19	1	33	206	33
10	269	39	43	46	1	90	50	27	1	9	25	73
11	96	155	75	31	1	16	13	27	1	1	1	1
12	34	116	43	50	1	16	21	1	1	1	1	8

WEIGHT MATRIX 3M COD												
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0.811	0.633	0.657	0.697	0.671	0.314	0.374	0.790	0.859	0.620	0.760	1.330
4	0.722	0.314	0.805	1.636	1.293	0.845	0.600	1.070	1.137	1.250	1.340	1.140
5	0.981	1.300	1.769	1.798	4.192	1.400	1.102	1.480	1.747	1.280	2.450	2.240
6	1.500	0.994	2.829	2.658	5.085	3.433	1.582	2.450	2.466	2.680	2.870	3.530
7	1.930	0.828	3.983	3.766	5.923	5.156	2.658	4.350	3.167	3.190	4.680	4.760
8	1.820	3.340	5.923	4.225	7.555	5.403	3.557	5.340	4.420	4.550	5.510	6.480
9	2.540	3.180	4.684	5.702	5.278	8.203	7.712	6.610	6.667	6.970	6.070	6.670
10	3.570	6.180	6.619	5.724	5.278	8.748	6.765	7.210	6.667	6.230	9.380	10.000
11	3.140	3.180	9.043	7.448	6.381	6.381	11.375	11.040	12.029	5.590	11.900	13.500
12	5.300	4.140	12.571	11.445	7.000	5.278	8.205	15.080	16.901	17.930	14.210	16.630

Table 6. Numbers of cod of ages 3-10 years available to the research gear used in the Canadian surveys in the period 1981-1983.

Age	1981	1982	1983
3	21	7,824	15,833
4	1,663	319	1,897
5	978	2,357	73
6	32	958	645
7	150	45	426
8	137	84	12
9	219	68	44
10	11	237	63

Table 7. Population numbers, mid-year population biomasses and fishing mortalities for the period 1972-1983 implied by $F_T = 0.3$ in 1983.

POPULATION NUMBERS												
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	5470	20562	12952	44848	93159	17283	7483	2676	17991	11315	4774	20385
4	41656	4227	14993	5176	30303	60380	14042	5739	2039	14231	7697	3690
5	19325	16639	3356	2204	2034	15171	33527	8699	2332	1217	5528	3551
6	8692	4627	3028	728	682	1316	4728	11093	2056	621	851	2783
7	4068	1185	649	766	380	468	683	600	3760	732	214	416
8	2796	541	199	266	373	254	141	261	205	1886	429	87
9	1635	776	198	144	147	304	168	33	157	85	1096	239
10	734	338	180	94	86	120	112	51	10	128	40	711
11	610	357	242	108	35	69	17	47	18	7	96	10
12	125	413	152	130	60	28	42	2	14	13	5	78
3+	85111	49666	35947	54483	127260	95393	60943	29201	28582	30237	20729	32149
POPULATION BIOMASS (MID-YEAR)												
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	3910	11160	5570	25860	50720	4900	2458	1851	13776	5822	3261	22715
4	19682	1185	5370	5503	28280	38569	6695	4048	1811	11504	7182	3613
5	10087	10385	3041	2333	6911	12540	22352	6816	2260	1924	9799	6347
6	5651	2013	4655	1423	2889	3312	3163	16605	3162	1024	1745	7731
7	3374	457	1764	2055	1855	1407	1166	1600	8601	1809	661	1570
8	2869	1139	1004	883	2547	1124	266	1093	602	6621	1788	461
9	2090	1296	653	640	702	1580	757	129	945	407	5399	1334
10	1868	2349	932	343	408	456	506	227	58	692	199	6083
11	1586	764	1628	611	201	349	75	298	155	35	1032	112
12	506	1304	1459	1048	380	87	222	16	204	210	60	1109
3+	51624	32053	26077	40699	94894	64325	37661	32683	31604	30049	31146	51074
FISHING MORTALITY												
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0.058	0.116	0.717	0.192	0.234	0.008	0.065	0.071	0.034	0.185	0.005	0.165
4	0.718	0.031	1.717	0.734	0.492	0.388	0.279	0.701	0.316	0.746	0.574	0.225
5	1.229	1.504	1.329	0.973	0.235	0.966	0.906	1.242	1.122	0.158	0.486	0.270
6	1.792	1.765	1.175	0.449	0.177	0.456	1.865	0.882	0.832	0.867	0.515	0.309
7	1.817	1.587	0.619	0.520	0.202	0.996	0.761	0.873	0.490	0.336	0.496	0.289
8	1.081	0.807	0.124	0.464	0.003	0.217	1.242	0.310	0.684	0.343	0.385	0.225
9	1.376	1.264	0.543	0.314	0.008	0.796	0.985	0.988	0.007	0.563	0.233	0.165
10	0.520	0.136	0.307	0.778	0.013	1.779	0.677	0.873	0.115	0.061	1.301	0.120
11	0.191	0.653	0.420	0.381	0.032	0.294	2.027	1.018	0.065	0.161	0.012	0.120
12	0.356	0.368	0.371	0.546	0.018	0.966	0.777	0.939	0.083	0.085	0.238	0.120

Table 8. Comparison of biomasses and population numbers of cod age 3 and older from cohort analyses and from Canadian and Soviet surveys.

Biomass (000t) from cohort runs at 3 terminal F's and kg/hour towed from survey				Population numbers (millions) from cohort runs at 3 terminal Fs and estimated numbers from survey (000)			
Year	$F_T=.3$	$F_T=.4$	$F_T=1.0$	Soviet survey	$F_T=.3$	$F_T=.4$	$F_T=1.0$ Canadian survey
1972	52	52	52	75	85	85	85
1973	32	32	32	46	50	50	50
1974	26	26	26	51	36	36	36
1975	41	41	40	121	54	54	54
1976	95	94	93	296	127	126	125
1977	64	64	62	448	95	95	93
1978	38	37	36	79	61	60	59
1979	33	31	29	108	29	28	27
1980	32	29	25	35	29	27	24
1981	30	27	20	91	30	28	23
1982	31	25	15	36	21	18	12
1983	51	38	15	29	32	25	12
Period	1972-1980				1978-83	1978-83	1978-83
r^2		0.57			0.90	0.95	0.95
Slope		0.12			0.50	0.54	0.63
Intercept		29			19	15	8