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Assessment of the Cod Stock in Division 3M

by

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DATA

Commercial catch and effort data was derived from the ICNAF Statistical Bulletin for 1960-78, from the preliminary STATLANT report for 1979 and from the Foreign Observer Program for 1980. Portuguese otter trawl data for 1978 and 1979 were not used (see Appendix 1).

Sampling for lengths and ages was obtained from the Foreign Observer Program. Only two age lengths keys (161 and 186 otoliths) and four length frequencies (3429, 243, 1225, and 2416 fish) were available.

Abundance estimates from four years of survey data by the research vessel M.V. Gadus Atlantica were computed. The log transformation was used to estimate total abundance but the age composition from the untransformed data was applied. This strategy was used to overcome difficulties with 0 observation points. Furthermore strata 516, 517, 518 and 519 (Wells, 1977) were not used because of a consistent absence of cod in these areas.

ANALYSIS

The catch and effort data were standardized by use of a multiplicative model (Gavaris, 1980) using a weight of $(\text{catch} \times \text{effort})^{0.25}$. There was slight seasonal variation in catch rates but fairly significant differences in the fishing power of different gears (Table 1). The proportion of the total catch which was available for use in 1980 was extremely low (Table 2). There is a fairly consistent decreasing trend in catch rate during the 1970's.

A symmetric surplus production model was fitted to the catch and effort data. Since it seemed evident that the stock was not at equilibrium the non-equilibrium version described by Fletcher (1978) was used. The regression accounted for 64% of the variation in the data. Examination of the predicted and observed yield indicated that the 1980 catch rate is substantially less than expected (Fig. 1). It should be noted from Fig. 2 that the adjustment level is negative during some years. This can be interpreted to mean that the stock would eventually become extinct if the existing level of fishing mortality were maintained. The equilibrium maximum sustainable yield was approximately 29,000 t. The non-equilibrium catch for 1981 at a fishing level of 2/3 effort_{MSY} was 951 t.

The length frequencies and age length keys were used along with the monthly catches reported in the circular letters to obtain the catch at age. This is shown in Table 3 along with the catch at age for previous years (Wells, 1980). The catch at age was divided by the standardized effort to obtain an abundance matrix which was used to estimate the population size at the end of 1980 (Rivard, 1980). The results are not presented here because the estimates were unreasonably low and their coefficients of variation were extremely high.

(ADDENDA 1 and 2 ARE ATTACHED)

Relationships between standardized catch rate and biomass from cohort and standardized effort and fishing mortality were generally poor. Furthermore the 1980 data was inadequate for determining terminal F with these relationships. An estimate of the fishing mortality during 1980 for fully recruited ages was obtained from the research survey data using Paloheimo's method for calculating total mortality (Table 4). The partial selection pattern was obtained by smoothing the ratio of commercial age frequency to research age frequency catches. Table 5 summarizes the results from the cohort analysis using this selection pattern and a terminal F of 0.74 for fully recruited ages. The major portion of the production in recent years is due to growth rather than recruitment and removals by the fishery have generally exceeded total production (Fig. 3). The weights at age which were used (Table 3) were calculated by applying the length frequency and a length-weight relationship (Hodder 1964) to the age length key for otter trawls. For 1980 however there is good recruitment and positive net production.

The age length keys from research surveys in 1978, 1979 and 1980 were combined and the combined length frequency and the length weight relationship was applied to obtain an average weight at age for use in the yield per recruit analysis (Table 6). The computed $F_{0.1}$ value was 0.13. This value could be somewhat low if growth of cod is slower at higher densities, however information for older fish was only available for recent years therefore current weight at age had to be used.

Projections of the $F_{0.1}$ level based on the population numbers from the cohort analyses resulted in a catch of approximately 2,000 t for 1981 (Table 7). It should be noted that, the population biomass at the beginning of 1981 is only about 30,000 t.

DISCUSSION

Comparison of the biomass from the surplus production model and from the cohort analysis for 1972-77 resulted in a rank correlation coefficient of 0.89, although the biomass from the surplus production was generally higher. Some of this difference is due to the exclusion of younger and older ages in the cohort analysis.

The $F_{0.1}$ from the yield per recruit analysis was in close agreement with the corresponding value of fishing mortality which was obtained by applying the coefficient of catchabilit to 2/3 $effort_{MSY}$. These values were 0.13 and 0.21 respectively. As was noted earlier the former may have been a little low.

Results from both the research surveys and the surplus production are in agreement that the stock has continued to decline in abundance from 1978-81. In fact both results indicate that stock abundance has declined approximately one order of magnitude. It should be noted that in the cohort analyses the fishing mortality in 1977-79 greatly exceeds the $F_{0.1}$ level. The catch biomass projection from the the sequential analysis is about twice as large as the non-equilibrium catch from the general production but both are relatively low.

Examination of the age frequencies from the commercial catch and from research surveys shows that the age base of the stock has been substantially reduced. This situation could lead to large fluctuations in stock size, due to variation in individual year classes. In summary, the data and analyses clearly indicate that th stock abundance is below the optimal level, and is very probably severely depleted. This condition linked with the lack of a wide age distribution raises the question of whether the $F_{0.1}$ or 2/3 $effort_{MSY}$ principles should be applied. It is doubtful that such strategies would be $_{optimal}$ for stocks at low levels. Furthermore there is the danger of overfishing certain age classes by applying principles from the population dynamics of healthly stocks. Support for such speculation comes from observing that both the age distribution and the abundance did not appear to improve despite the record low TAC in 1980.

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Rivard, D. 1980. APL porgrams for stock assessment. Can. Tech. Fish. Aquat. Sci. No. 153.

Wells, R. 1977. Stratification scheme used and age composition of cod catches taken on Flemish Cap, 2-25 Feb. 1977 by R/V A. T. Cameron. ICNAF Res. Doc. 77/VI/29. Ser. No. 5054, 2 p.

1980. Changes in the size and age composition of the cod stock in Division 3M during the period 1959-1979. NAFO SCR Doc. 80/II/28, Ser. No. N060, 18 p..

Table 1. Regression coefficients for grouped categories and the analysis of variance from the regression of ln catch rate.

Country-gear		ln power	Month	ln power
FRG	OT-7	0.578	Mar.	0.157
Pold	OT-7	0.159	Jan.	
Port	OT-7		Feb.	0.000
			Oct.	
Port	OT-6	0.000		
USSR	OT-7		Apr.	
			May	
Norw	LL-4		June	
Span	OT-6	-0.438	July	-0.156
USSR	OT-5		Aug.	
			Nov.	
Span	PT-4	-0.674	Dec.	
UK	OT-6			
			Sep.	-0.260
Den(F)	LL-	-0.700		
CanN	OT-5			
UK	OT-5	-0.966		
USSR	OT-6			
Icel	OT-5	-1.045		
Span	PT-5			

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.797
MULTIPLE R SQUARED..... 0.636

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
TYPE 1	7	7.54316E1	1.07759E1	35.829
TYPE 2	3	8.36414E0	2.78804E0	9.270
TYPE 3	20	9.12546E1	4.56273E0	15.170
REGRESSION	30	3.07579E2	1.02526E1	34.089
RESIDUALS	585	1.75942E2	3.00755E-1	
TOTAL	615	4.83521E2		

Table 2. Historical catch and standardized effort and catch rate. The proportion of the catch used in estimating the catch rate is indicated.

Year	Catch (t)	Prop.	Catch rate		Effort (hr)
			Mean (t/hr)	Std. Err.	
1960	5,573	0.119	3.283	1.117	1,698
1961	22,996	0.131	3.068	0.691	7,495
1962	16,175	0.203	1.442	0.256	11,217
1963	38,216	0.289	2.589	0.449	14,761
1964	47,819	0.150	1.494	0.204	32,007
1965	60,313	0.617	1.490	0.123	40,479
1966	33,834	0.364	1.650	0.204	20,505
1967	42,163	0.465	1.854	0.189	22,742
1968	40,385	0.375	1.721	0.206	23,466
1969	31,845	0.313	1.962	0.226	16,231
1970	26,529	0.412	1.187	0.143	22,350
1971	33,692	0.247	1.149	0.144	29,323
1972	57,691	0.711	1.046	0.077	55,154
1973	22,900	0.903	0.783	0.069	29,246
1974	24,941	0.580	1.155	0.112	21,594
1975	22,375	0.735	0.904	0.079	24,751
1976	22,266	0.710	0.728	0.066	30,585
1977	27,239	0.578	0.682	0.056	39,940
1978	33,131	0.342	0.448	0.049	73,953
1979	29,710	0.311	0.497	0.056	59,779
1980	10,375	0.004	0.078	0.036	133,013

Table 3. Computed catch at age and weight at age.

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	278	2035	5999	7090	17564	119	428	167	551
4	19303	116	11130	2436	10653	17581	3092	2616	500
5	12372	11709	2232	1241	386	8502	18077	5599	1423
6	6555	3470	1894	238	100	436	3615	5882	1051
7	3083	853	271	281	63	267	329	316	1318
8	1672	271	21	96	1	45	91	63	92
9	1106	504	75	35	1	151	95	19	1
10	269	39	43	46	1	90	50	27	1
11	96	155	75	31	1	16	13	27	0
12	34	116	43	50	1	16	21	1	1

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.811	0.633	0.657	0.697	0.671	0.314	0.374	0.790	0.859
4	0.722	0.314	0.805	1.636	1.293	0.845	0.600	1.070	1.137
5	0.981	1.300	1.769	1.798	4.192	1.400	1.102	1.480	1.747
6	1.500	0.994	2.829	2.658	5.085	3.433	1.582	2.450	2.466
7	1.930	0.828	3.983	3.766	5.923	5.156	2.658	4.350	3.167
8	1.820	3.340	5.923	4.225	7.555	5.403	3.557	5.340	4.420
9	2.540	3.180	4.684	5.702	5.278	8.203	7.712	6.610	6.667
10	3.570	8.180	6.619	5.724	5.278	8.748	6.765	7.210	6.667
11	3.140	3.180	9.043	7.448	6.381	6.381	11.375	11.040	12.029
12	5.300	4.140	12.571	11.445	7.000	5.278	8.205	15.080	16.901

Table 4. Abundance at age and total mortality rates calculated from research surveys.

Age	1978	1979	1980	1981
1	0	0	0	6258
2	61094	2245833	264708	0
3	3067063	512412	4971441	998912
4	10023043	2695016	619649	2989894
5	2945824	2611863	740912	188237
6	7829720	3219964	695342	407201
7	307111	823629	1021475	201124
8	116522	52002	47045	399686
9	41703	26198	6459	19649
10	99537	9531	1507	4459
11	45742	14567	0	1102
12	11392	5036	2970	0
13	20337	24891	1521	2216
14	23613	13869	0	0
15	4328	4495	3006	0
16	0	29810	0	0
17	0	5036	0	0
18	0	4630	0	0
19	3473	5036	0	0
20	0	0	0	0
Total	51112960	12303822	8376041	5218744
Lower	43312688	9401680	6655309	3939028
Upper	60296192	16041239	10500325	6852875

Age	78-79	79-80	80-81
3-4	0.129		0.508
4-5	1.344	1.291	1.191
5-6	2.213	1.323	0.598
6-7	2.251	1.148	1.240
7-8	1.775	2.862	0.939
8-9	1.492	2.085	0.873
9-10	1.476	2.855	0.370
4-10	1.958	1.322	0.942

Table 5. Cohort analysis for a terminal F of 0.74 in 1980.

POPULATION NUMBERS 19/ 2/81

	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	5383	20530	12439	44811	90906	17528	8429	2746	13988
4	41632	4156	14968	4756	30273	58535	14243	6514	2097
5	19325	16620	3298	2184	1690	15146	32017	8864	2966
6	8671	4627	3012	680	665	1034	4708	9856	2191
7	4256	1168	649	753	342	454	452	583	2747
8	2908	695	185	286	362	223	130	73	192
9	2453	868	323	132	147	295	142	24	2
10	1013	1008	255	197	77	120	105	30	3
11	500	586	790	170	120	62	16	41	0
12	269	323	340	579	111	97	36	2	9
3+	86411	50581	36258	54547	124692	93495	60279	28733	24196
4+	81028	30050	23818	9736	33785	75966	51850	25987	10208
5+	39395	25894	8851	4980	3512	17431	37606	19473	8110
6+	20070	9275	5553	2796	1822	2284	5589	10609	5144

MEAN POPULATION BIOMASS (KG) 19/ 2/81

	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	3847	11143	5250	25837	49343	4970	2779	1902	10660
4	19666	1165	5346	4848	28244	37138	6805	4826	1874
5	10087	10358	2933	2296	5598	12506	20728	7066	3359
6	5614	2013	4609	1307	2810	2416	3125	13634	3502
7	3792	441	1763	2009	1646	1335	552	1531	5641
8	3071	1622	929	883	2474	967	223	110	550
9	4127	1591	1195	580	701	1511	554	63	11
10	2786	7316	1386	888	363	455	460	37	12
11	1271	1437	6138	1029	689	305	74	233	1
12	1201	960	3604	5722	700	422	172	15	130
3+	55462	38045	33154	45399	92569	62026	35473	29417	25740
4+	51616	26903	27903	19563	43225	57056	32694	27515	15080
5+	31950	25738	22557	14715	14982	19917	25889	22690	13206
6+	21863	15380	19624	12419	9384	7411	5161	15624	9847

FISHING MORTALITY 19/ 2/81

	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.059	0.116	0.761	0.192	0.240	0.008	0.058	0.070	0.044
4	0.718	0.031	1.725	0.835	0.493	0.403	0.274	0.587	0.303
5	1.229	1.508	1.379	0.989	0.291	0.969	0.978	1.198	0.740
6	1.805	1.765	1.187	0.489	0.182	0.627	1.888	1.077	0.740
7	1.613	1.645	0.619	0.532	0.228	1.050	1.629	0.913	0.740
8	1.009	0.564	0.134	0.464	0.003	0.253	1.486	3.191	0.740
9	0.690	1.026	0.296	0.346	0.008	0.832	1.353	2.058	0.592
10	0.347	0.044	0.206	0.299	0.015	1.783	0.745	5.656	0.570
11	0.238	0.346	0.111	0.226	0.009	0.338	2.061	1.310	0.296
12	0.150	0.500	0.150	0.100	0.010	0.200	1.000	1.000	0.126
5+	1.305	1.423	0.998	0.648	0.198	0.938	1.103	1.144	0.739

Table 6. Weight at age and partial selection which were used to calculate yield per recruit.

Age	Weight	Selection
3	.305	.2
4	.469	.5
5	1.022	1
6	1.820	1
7	3.171	1
8	6.148	1
9	8.948	1
10	9.022	1
11	10.813	1
12	13.782	1
13	14.199	1
14	14.966	1
15	13.279	1
16	15.982	1
17	15.576	1
18	22.978	1
19	13.942	1

Table 7. Projections using results from cohort analysis.

POPULATION NUMBERS 10/ 3/81

	1980	1981	1982
3	13988	10000	10000
4	2097	10955	8124
5	2966	1267	8504
6	2191	1158	911
7	2747	856	833
8	192	1073	615
9	2	75	771
10	3	1	55
11	0	2	1
12	9	0	1
3+	24195	25387	29816
4+	10207	15387	19816
5+	8110	4432	11692
6+	5144	3165	3188

POPULATION BIOMASS (AVERAGE)

	1980	1981	1982
3	10660.03	7756.50	7756.50
4	1873.30	11003.88	8160.49
5	3358.90	1886.02	12654.38
6	3502.69	2433.25	1913.94
7	5639.36	2308.83	2246.59
8	550.43	4039.05	2316.59
9	8.48	431.71	4434.23
10	14.68	4.30	319.13
11	0.00	16.58	5.87
12	129.53	0.00	18.37
3+	25737.40	29880.11	39826.09
4+	15077.37	22123.61	32069.59
5+	13204.07	11119.73	23909.10
6+	9845.17	9233.71	11254.72

CATCH NUMBERS

	1980	1981	1982
3	551	70	70
4	500	515	382
5	1423	140	942
6	1051	128	101
7	1318	95	92
8	92	119	68
9	1	7	69
10	1	0	5
11	0	0	0
12	1	0	0
3+	4938	1074	1729
4+	4387	1004	1659
5+	3887	489	1277
6+	2464	349	335

CATCH BIOMASS

	1980	1981	1982
3	473	60	60
4	569	586	434
5	2486	245	1645
6	2592	316	249
7	4174	300	292
8	407	525	301
9	7	45	461
10	7	0	32
11	0	1	0
12	17	0	0
3+	10731	2079	3475
4+	10257	2019	3415
5+	9689	1433	2981
6+	7203	1188	1336

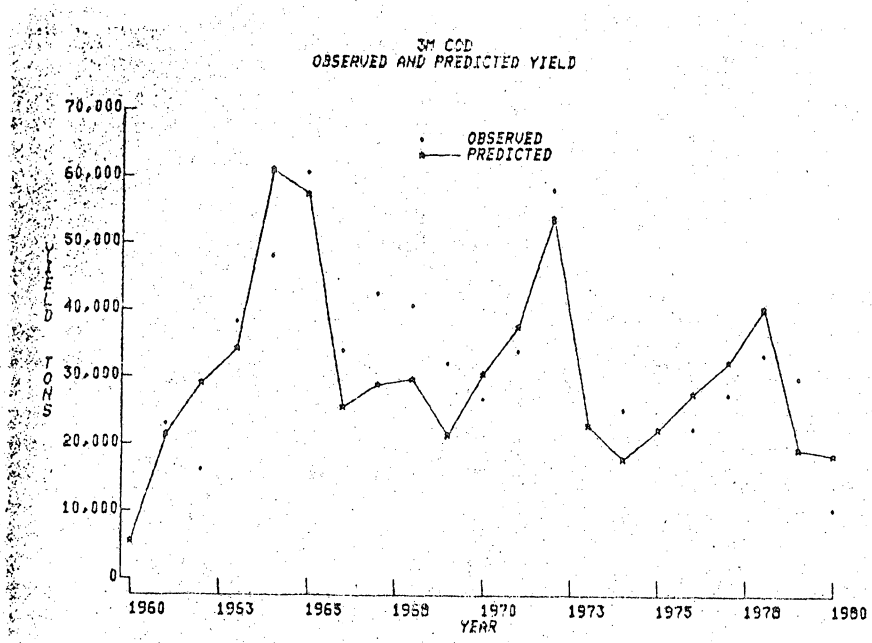

Fig. 1. Observed and predicted yield based on the results of a symmetric non-equilibrium production model.

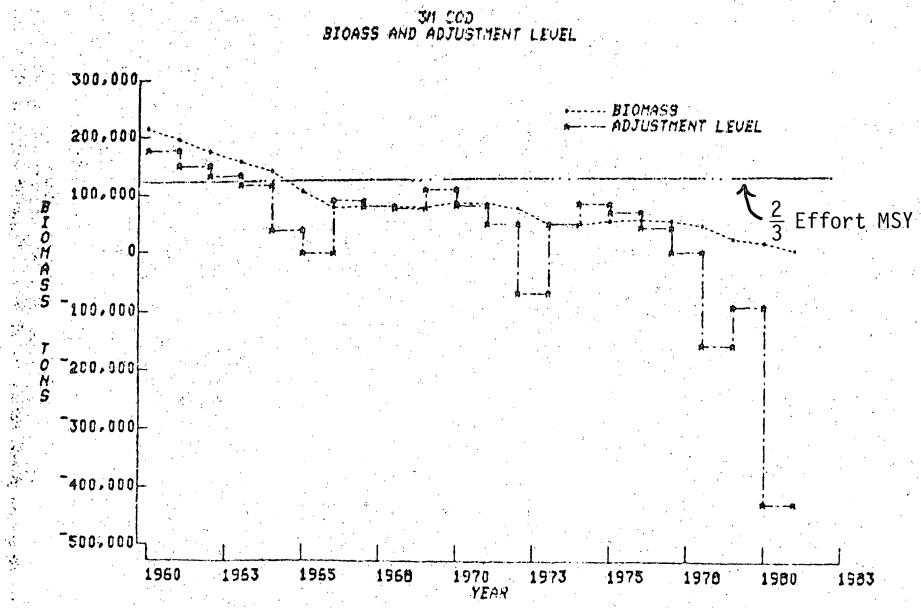

Fig. 2. Annual biomass and the adjustment levels for the annual fishing mortality.

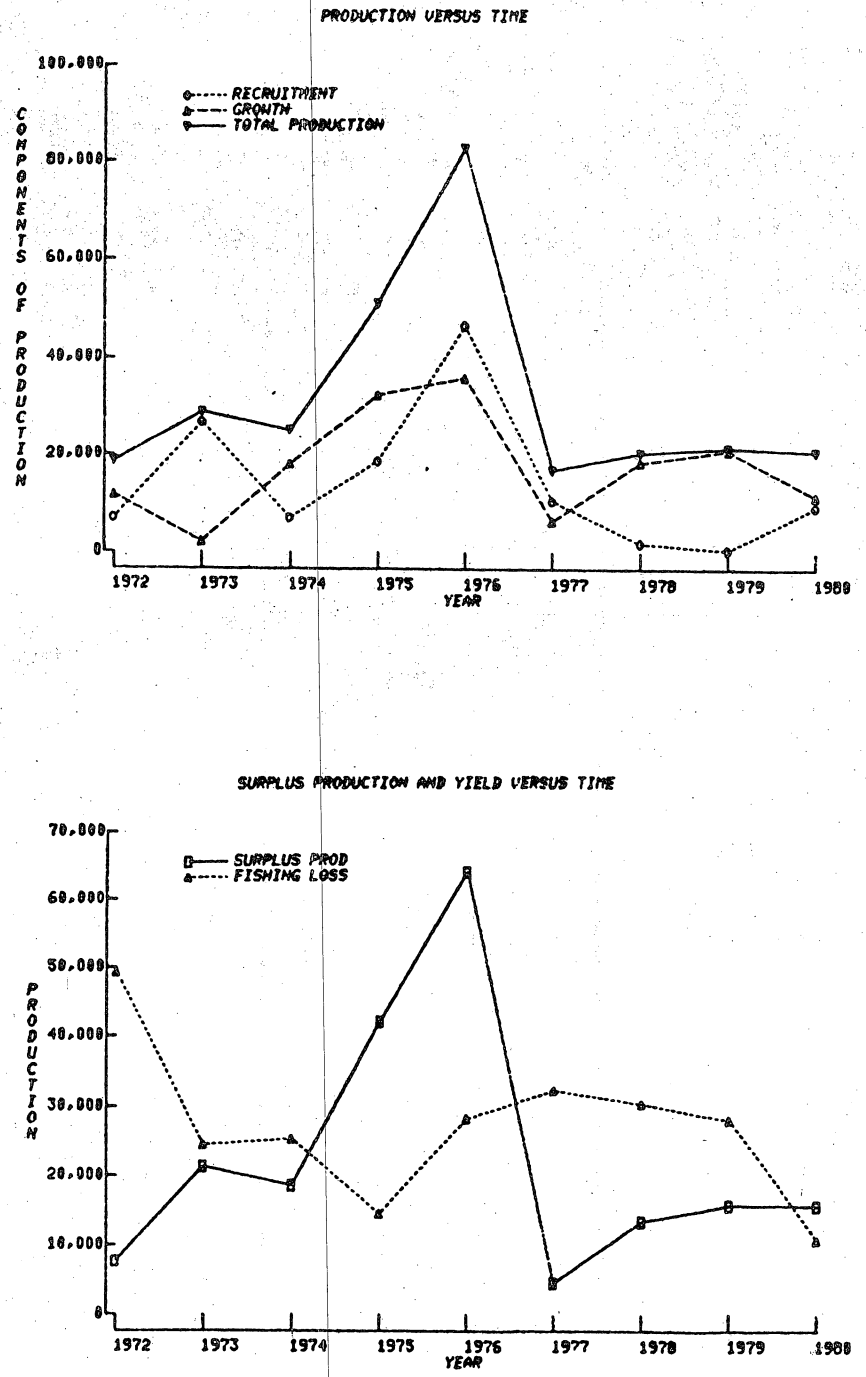

Fig. 3. Analysis of production for the cohort model.

APPENDIX I. Observations on Catch Rates of Portuguese otter trawlers.

INTRODUCTION

In 1978 and 1979 the catch, effort and particularly the catch rate reported for Portuguese otter trawls have shown remarkable consistency within each year. It was demonstrated based on previous years data, the probability of such results occurring is extremely low.

METHOD AND RESULTS

No seasonal pattern was evident in the catch rates for Portugese side otter trawls in tonnage class 6 (Table 1). The monthly catch rates were therefore treated as replications and the median, mean and variance for each year were computed. The extremely low variability for 1978 and 1979 should be noted. Both the mean and variance for 1974 appeared anomalous and consequently they were not used in further analyses.

The samples were tested for homogeneity of variance using a modification of Levene's statistic. Brown and Forsythe (1974) recommended that for skewed distributions the median be used instead of the mean in order to obtain the absolute deviations. The test statistic is:

$$W = \frac{\sum_i n_i (\bar{Z}_{i\cdot} - \bar{Z}_{\cdot\cdot})^2/(g-1)}{\sum_i \sum_j (Z_{ij} - Zi\cdot)^2/\Sigma(n_i-1)}$$

Where Z_{ij} is the absolute deviation of the jth catch rate in year i from the median catch rate in year i, g is the number of years and n_i is the number of observations in the ith year.

$$\text{Also } Z_{i\cdot} = \sum_j Z_{ij}/n_i$$

$$\bar{Z}_{\cdot\cdot} = \sum_i \sum_j Z_{ij}/\sum_i n_i$$

Under the null hypothesis the variances are equal, W has an F distribution with g-1 and $\Sigma(n_i-1)$ degrees of freedom.

The results indicate that 1972, 1973, 1975, 1976, 1977, 1978 and 1979 do not have equal variances ($P < .001$) however if the last two years are removed there is no reason to doubt the homogeneity of the other variances ($.975 < P < .99$). Therefore a weighted pooled estimate of the variance for these years can be used for subsequent comparison. This is computed as

$$S_p^2 = \sum_i (n_i-1)\, S_i^2/\sum_i (n_i-1)$$

If it is assumed that the pooled estimate is representative of the recent situation on the Flemish Cap and take it as a measure of the true population variance then the probability of observing a value less than or equal to either the 1978 or 1979 variance is less than 0.001.

CONCLUSION

Since it could not be shown that a real change had occurred on the Flemish Cap which would cause catch rates to be much less variable over a single year, the current Portugese otter trawl data were not included in subsequent analyses. It should be noted that the little data that is available from other countries does not show a marked reduction in variance.

REFERENCES

Brown, M. B., and A. B. Forsythe. 1974. Robust tests for the equality of variances. J. Amer. Statis. Assoc. 69: 364-367.

Table 1. Catch rates for Portugese OTSI-6 during the months in which effort directed for cod exceeded 100 hours are listed. The median, mean and variance of the catch rates for each year are indicated in the last two rows.

	Year							
	'72	'73	'74	'75	'76	'77	'78	'79
Jan.						.364	.899	
Feb.	.995						.891	.968
Mar.	.719	.605	1.098	.897		1.051	.854	.966
Apr.						.572	.898	.968
May	.568		1.533			.568	.889	.967
June	1.080	.375	1.511			.637	.898	.965
July	1.034		.244	.200		.714	.894	.963
Aug.	.852	.985	.494	.500	1.002	.748	.871	.912
Sept.	.626	.842	.834	.700	.899	.885	.881	
Oct.	.614	.981	3.358		1.114	.902	.908	.966
Nov.	.821	.750	2.779		.723		.886	.969
Dec.				.798	.478		.891	1.021
Med.	.821	.796	1.305	.700	.899	.714	.891	.9665
Mean	.812	.756	1.481	.619	.843	.716	.888	.967
Var.	.037	.056	1.183	.076	.062	.044	.0002	.001

Note: Data for 1972-1978 are from the ICNAF statistical bulletin and 1979 data are from a preliminary report supplied by the NAFO secretariat.

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(Addendum 1)

SPECIAL MEETING OF SCIENTIFIC COUNCIL - FEBRUARY 1981

Assessment of the Cod Stock in Division 3M

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Canada A1C 5X1

At the Special Meeting of the Scientific Council in February 1981, it was agreed to modify the cohort analysis of Table 5 of SCR Doc. 81/II/12 in two ways:

a) The number of 3-year-old recruits in 1980 would be set at 34 million, based on examination of arithmetic catch per tow at age in Canadian surveys; and

b) Age 5 and older cold would be considered to be fully recruited.

The cohort analysis and the projections, which are presented here in Tables 1 and 2 respectively, are consistent with these changes. These Tables are intended to replace Tables 5 and 7 of the original document (SCR 81/II/12).

Table 1. Cohort analysis with flat topped partial recruitment, a terminal fishing mortality of 0.74 in 1980 and .34 million recruits at age 3 in 1980.

POPULATION NUMBERS 19/ 6/81

	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	5383	20529	12438	44811	90906	17528	8429	2749	34000
4	41398	4156	14966	4755	30273	58535	14243	6514	2097
5	19325	16592	3297	2182	1689	15146	32017	8864	2966
6	8671	4627	2989	680	664	1034	4708	9856	2191
7	4256	1168	649	734	341	453	452	583	2747
8	2908	695	185	286	346	223	129	72	192
9	2453	868	323	132	147	283	141	24	2
10	1013	1008	255	197	77	120	95	30	2
11	500	586	790	170	120	62	16	32	0
12	269	323	340	579	111	97	36	2	2
3+	86376	50551	36232	54526	124675	93480	60267	28727	44200
4+	80993	30022	23794	9715	33768	75952	51838	25978	10200
5+	39395	25866	8828	4959	3495	17417	37595	19463	8103
6+	20070	9275	5530	2777	1806	2270	5578	10600	5136

MEAN POPULATION BIOMASS 19/ 6/81

	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	3846	11142	5250	25837	49343	4970	2779	1904	26295
4	19643	1165	5345	4846	28244	37138	6805	4826	1876
5	10087	10318	2933	2294	5595	12506	20728	7066	3359
6	5614	2013	4542	1306	2806	2413	3125	13634	3502
7	3792	441	1763	1943	1645	1331	550	1531	5641
8	3071	1622	929	883	2368	967	221	106	550
9	4127	1591	1195	580	701	1411	554	59	9
10	2786	7316	1386	888	363	455	393	33	9
11	1271	1437	6138	1029	689	305	74	122	0
12	1201	960	3604	5722	700	422	172	15	23
3+	55439	38004	33085	45329	92455	61919	35402	29295	41264
4+	51592	26863	27835	19493	43112	56949	32622	27391	14969
5+	31950	25698	22490	14646	14868	19811	25817	22565	13093
6+	21863	15380	19557	12352	9273	7304	5089	15499	9734

FISHING MORTALITY 19/ 6/81

	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.059	0.116	0.762	0.192	0.240	0.008	0.058	0.069	0.018
4	0.719	0.031	1.725	0.835	0.493	0.403	0.274	0.587	0.303
5	1.229	1.514	1.379	0.990	0.291	0.969	0.978	1.198	0.740
6	1.805	1.765	1.205	0.489	0.182	0.628	1.888	1.077	0.740
7	1.613	1.645	0.619	0.550	0.228	1.054	1.634	0.913	0.740
8	1.009	0.564	0.134	0.464	0.003	0.253	1.503	3.344	0.740
9	0.690	1.026	0.296	0.346	0.008	0.892	1.355	2.224	0.740
10	0.347	0.044	0.206	0.299	0.015	1.783	0.874	6.375	0.740
11	0.238	0.346	0.111	0.226	0.009	0.338	2.061	2.543	0.740
12	0.150	0.500	0.150	0.100	0.010	0.200	1.000	1.000	0.740
5+	1.305	1.426	1.004	0.651	0.199	0.939	1.103	1.148	0.740

Table 2. Projections at F = 0.2 based on the population size in 1980 from the accompanying table.

	Population Numbers			Population Biomass		
	1980	1981	1982	1980	1981	1982
3+	44,200	41,771		41,319	45,357	
4+	10,200	31,771	31,330	15,077	37,610	47,217
5+	8,103	4,432	23,224	13,204	10,754	39,254

	Catch Numbers			Catch Biomass		
	1980	1981	1982	1980	1981	1982
3+	4,938	3,183		10,731	4,914	
4+	4,387	3,093	4,529	10,257	4,836	8,647
5+	3,887	731	3,828	9,689	2,151	7,851

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Addendum 2

SPECIAL MEETING OF SCIENTIFIC COUNCIL - FEBRUARY 1981

Assessment of the Cod Stock in Division 3M

by

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On the basis of the population age structure for 1980 used in the cohort analysis (SCR Doc. 81/II/12, Addendum 1, Table 1) and listed below, projections of stock and catch biomass are presented for various options[1] in Table 1. The various management options specify either a constant catch or a constant fishing mortality.

Age	Numbers (000)
3	34,000
4	2,097
5	2,966
6	2,191
7	2,747
8	192
9	2
10	2
11	0
12	2

Longer term projections are provided in Table 2 using a recruitment of 46 million which is the arithmetic mean from 1959-68 (Wells 1980) and 1972-78 (original document 81/II/12).

[1] This information was requested at the April 1981 meeting of the Fisheries Commission of NAFO (NAFO/FC Doc. 81/VI/4) and is presented as an addendum to NAFO SCR 81/II/12 for reference purposes.

TABLE 1. 3M cod projections of mean stock biomasses, catches and fishing mortalities under various options.

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
			3+ STOCK BIOMASSES (000 tons)				
1981	45	43	44	43	43	41	41
1982	48	45	45	44	45	36	37
1983	58	55	52	51	56	40	41
1984	66	63	58	57	65	43	44
1985	76	73	65	65	78	48	49
1986	85	83	72	71	95	55	56
			FISHING MORTALITIES (6+)				
1981	0.2	0.346	0.27	0.346	0.346	0.612	1.122
1982	0.2	0.2	0.27	0.27	0.202	0.417	0.775
1983	0.2	0.2	0.27	0.27	0.186	0.464	0.645
1984	0.2	0.2	0.27	0.27	0.171	0.502	0.664
1985	0.2	0.2	0.27	0.27	0.134	0.422	0.643
1986	0.2	0.2	0.27	0.27	0.105	0.355	0.522
			CATCHES (000 tons)				
1981	5.0	8.0	6.7	8.0	8.0	13.0	13.0
1982	8.6	8.0	10.8	10.5	8.0	13.0	13.0
1983	9.5	8.9	11.3	11.0	8.0	13.0	13.0
1984	10.0	9.5	11.4	11.2	8.0	13.0	13.0
1985	12.0	11.5	13.4	13.2	8.0	13.0	13.0
1986	13.8	13.4	15.2	15.0	8.0	13.0	13.0

NOTE: (1) Option 1 - Fishing at $F_{0.1}$ = 0.2 in 1981-86
Option 2 - Catch of 8,000 tons in 1981, Fishing at $F_{0.1}$ 1982-86
Option 3 - Fishing at F_{max} = 0.27 in 1981-86
Option 4 - Catch of 8,000 tons in 1981, Fishing at F_{max} 1982-86
Option 5 - Catch of 8,000 tons each year 1981-86
Option 6 - Catch of 13,000 tons each year 1981-86
current partial recruitment pattern 5,50,100
Option 7 - Catch of 13,000 tons each year 1981-86
partial recruitment pattern 1,20,50,80,100

(2) Selection pattern and mean weights as in NAFO SCR Doc. 81/II/12.

(3) Recruitment at age 3 in 1980 = 34 million
1981 = 10 million
1982 = 2 million
1983-86 = 16 million

(4) Projections were made for ages 3-12 in each year. The affects of this truncation in the projections to 1986 is minimal since in 1980 the age composition contains almost no fish older than age 8.

TABLE 2. 3M Cod ($\bar{R}$ = 46 million)

Option	1980	1981	1982	1983	1984	1985	1988	1991	1994
				BIOMASS					
F=.20 (a)	41	73	111	148	182	212	285	333	347
F=.20 (b)	41	74	116	160	201	239	330	389	407
F=.27 (a)	41	72	108	140	167	190	239	265	271
F=.27 (b)	41	74	114	155	191	221	287	323	331
C=2000	41	72	113	164	222	285	513	779	927
C=8000	41	72	110	154	204	259	458	697	848
				CATCH					
F=.20 (a)	10	5	12	19	26	32	47	56	59
F=.20 (b)	10	3	7	13	21	28	46	58	62
F=.27 (a)	10	7	15	24	31	37	50	58	59
F=.27 (b)	10	4	9	17	26	34	52	61	63
C=2000	10	8	2	2	2	2	2	2	2
C=8000	10	8	8	8	8	8	8	8	8

PARTIAL RECRUITMENT AT AGE (%)

Option	3	4	5	6	7	8+
a	5	50	100	100	100	100
b	1	20	50	80	100	100