Northwest Atlantic



Fisheries Organization

NAFO SCR Doc. 80/II/28

Serial No. NO60

SPECIAL MEETING OF SCIENTIFIC COUNCIL - FEBRUARY 1980

Changes in the Size and Age Composition of the Cod Stock in Division 3M during the period 1959-1979

by

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INTRODUCTION

A cohort analysis of commercial age compositions of cod taken by the commercial fishery in Division 3M for the period prior to 1969 was presented (Wells, 1973) in 1973 to the Assessments Subcommittee of ICNAF. An attempt is made here to analyze the commercial data over the period 1959-1979.

Materials and Methods

Age composition of the removals

Nominal catch statistics were available in the Statistical Bulletins and revised figures issued from tome to time by the Assistant Executive Secretary (Summ. Doc. 74/25, Summ. Doc. 79/9). Sampling for length and age are contained in the Sampling Yearbooks or available upon request from the Secretariat.

Tables 1 and 2 show the procedure used in estimating removals by the fishery for the period 1959-79. No sampling data from the commercial fishery was available for 1969 or 1971, and for the years 1964, 1967 and 1970 length frequency data only were available.

For each quarter year, estimates were made of removals for each month for which sampling was available. If there were sampling for each of the three months, the addition of the removals comprised the removals for the quarter. In most cases samples were available for only one or two months of a quarter so that it was necessary to adjust the number of removals for the month(s) sampled to the total for the quarter. The addition of the removals by quarter gave the estimates of removals for the year or else a basis for adjustment to the removals for the year.

In most cases the average weight applicable to the length frequency was not recorded. In those cases the average weight was derived by applying to the average length the relationship (Hodder, 1964) log whole weight = 3.088 log length -5.211.

The estimates of the monthly length compositions of the removals were made by adjusting the number of fish-at-length in the frequency for a particular month by a constant factor so that the adjusted total equalled the estimate of removals for that month. Such adjusted monthly length compositions were combined (or if all months were not sampled, further adjusted) into quarterly and thence yearly length composition estimates. Estimates of the age composition of the removals were obtained by applying a quarterly age-length key to the estimated length composition for that quarter. Age compositions of the quarters in which there was sampling for ages were combined and this subtotal adjusted to the total for the entire year.

Age length keys from Canadian research vessel cruises in 1964 were applied to the length frequency samples from the commercial fishery in that year so as to derive an estimate of removals-at-age. For 1967 the corresponding year-classes in the 1966 and 1968 catch-at-age estimates were added so as to give an estimate of the pattern of the age composition in 1967. This age composition was adjusted by a constant factor so as to derive an age composition close to the number of removals and total nominal catch shown in Table 1 for 1967.

There were apparent differences in the interpretations of ages in 1978 in age compositions submitted to ICNAF by Portugal and Canada. These differences were confirmed by means of an otolith exchange by the ageing experts concerned. In this paper the age readings of the author are used for the estimation of removalsat-age in the Portuguese samples listed for that year in Table 2. In this case, the Canadian age determinations appeared to be about 1 year younger than the Portuguese. For 1975 and 1976, the age readings by Portugal were adjusted so that all ages reported were reduced by 1 year. Portuguese age determinations in other years (1966-1968) were used as reported.

The age compositions and length frequencies of the total estimated removals for the period are shown in Fig. 1.

Average weights-at-age were derived by applying the length-weight relationship from Hodder (1964) to calculated mean length-at-age. A considerable variation in mean weight-at-age (Table 3) is apparent over the period. When these mean weightsat-age were applied to the number of removalsatage, and a catch weight derived, discrepencies between the calculated catch weights and the nominal catches ranged from 33% in 1961 to -14% in 1972 (Table 4). No adjustments were made in order to reconcile these discrepencies.

No age compositions could be estimated for the years 1969-71 since the data were inadequate or lacking. Separate cohort analyses for the periods 1959-68 and 1972-79 were therefore attempted.

Selection patterns

To derive a gear selection pattern of fishing mortalities for 1968 and 1979, the removals in 1968 and 1979 were compared to Canadian research age compositions for the same years as shown in Table 5. The different patterns would suggest a change in fishing strategy by the commercial fleet to fish in 1979 concentrations of younger fish than in 1968.

Effort

Estimates of total standardized effort were taken from Table 4 of Gavaris (1980).

Terminal F

A series of trial cohort runs were made for the series 1959-68. F values in each year corresponding to the fishing mortality on all ages (3 years and older) were plotted against the effort exerted in each year. The plot is shown as Fig. 2 for a terminal F on ages 3+ of 0.114. For all years 1960-68 the regression parameters were: slope = 0.00275, intercept = 0.0528, r = 0.85 with 7 degrees of freedom. Catches, stock sizes and fishing mortality rates from this cohort run comprise Table 6.

For the period 1972-76, it is clear from Table 7 that correlations between the stock biomass estimates from cohort analyses of cod of ages 3 and older with commerical catch rates are unreasonable since the slopes are negative. Correlations of stock biomass estimates from cohort analyses and catch rates from Soviet surveys were reasonably good, with R^2 values of 0.75 and 0.68 at terminal F values of 0.064 and 1.30 respectively. From these correlations, the 3+ biomass would be estimated at 70 and 68 thousand tons respectively. The cohort run at terminal F of 0.64 shown in Table 8 implies a stock biomass of 3+ cod in 1979 of 69 thousand tons. Since the selection pattern imputed for 1979 in the cohort analysis was derived from a comparison of numbers-at-age from the survey results in 1979 and the commercial catch in the same year, the good correspondence between the stock sizes-at-age from cohort analysis and the survey results shown in Table 9 is not surprising. The excellent correspondence in 1977, however, when the effect of the imput values in 1979 would have been very much lessened in the cohort analysis, seems to lend support to the idea that the sampling in the period 1977-79 has been sufficient for the estimation of relative age compositions.

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Stock size at the beginning of 1980

Given the catch-at-age in 1979 and assuming that stock sizes in 1979 consistant with a terminal F of 0.64 on ages 3^+ are reasonable, stock sizes of ages 4 and older at the beginning of 1980 are implied. The number of 3 year-olds in 1980 was estimated as follows.

The biomass estimates of ages 2+ cod were calculated for the 1972-79 period under the assumptions that there was insignificant fishing mortality on 2-year-olds and that natural mortality was 0.20. In Table 10 for the correlation between biomasses of age 2+ cod implied from the cohort analysis and Soviet research vessel catch rates for the period 1972-78 the R² was 0.46 and with the 1977 point excluded, the R² was 0.79. The biomass of ages 2+ in 1979 estimated from the latter correlation was 83 thousand tons, and since the biomass of ages 3+ in 1979 was estimated above as 69 thousand tons or about 41 million fish. Assuming that natural mortality in 1979 on this year-class was 0.2 and that fishing mortality was negligible, the recruitment of age 3 cod in 1980 was estimated to be 34 million fish.

Catch in 1980 at F_{0.1}

If the average recruitment pattern (ICNAF Redbook 1979, p. 71) were to apply in 1980, the catch in 1980 at F=0.20 would be about 8000 tons (See Table 11).

CONCLUSIONS

- 1. Fishing mortality (age 3+) in the period 1959-68 ranged from about 0.05 to about 0.20.
- 2. Fishing mortality (age 3+) in the period 1972-79 ranged from a low of about 0.3 to about 1.0 or even higher.
- 3. The average year-class size at age 3 in the period 1959-68 was about 58 million. Year-class sizes at age 3 in the period 1972-79 were generally much below this level, with the 1973 year-class above and the 1972 year-class somewhat below this average.

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Table 1. Estimates of removals of cod by the commercial fishery in Division 3M, 1959-67.

YEAR	QUARTER	COUNTRY	# OTOLITHS	MONTH	# LENGTHS	AV WT	NOMINAL CATCH (tons)	ADJUSTED NUMBERS (DCO)	NOTE
1959	2	USSR	_ ,	5	282	1.79			
				4+5+6		1.79	1112	621	
	3	USSR	298	7	216	1.55	640	413	
		USSR		8	1793	1.45	648	447	
		USSR		9	402	1.42			
		FRG		9	619	1.47	056	,	
		AVERAGE		7+8+9		1.45	2144	1450	
	4	USSR		12	132	1 05			
				10+11+12		1.00	3485	3310	
	2+3+4			10.11.12		1 25	67/1	5300	
	1+2+3+4					1.25	60/0	5550	
						1.25	0343		
1960	1	USSR	393	1	1786				1
				3	1721				1
	2	USSR		4	1675	0 929			
		0001		т Л+Б+б	1075	0.020	5064	54 51	
	з	ASSB	283	7	16/18	1 50	5004	5451	
	5	033K	205	7+9+0	1040	1.50	51 27	2/10	
	٨	UCCD		10	1100	1.50	5127	3410	
	4	UJJK		12	4423	1.30	2146	1555	
	0±0±4			10+11+12		1.30	2140	10424	
	2+3+4					1.10	12337	10424	
1961	1	USSR	757	3	3687	1 37			
	·	ocon		1+2+3	0007	1.37	6349	4634	
	2	USSR		6	192	2.07	0015	1001	
	-	ocon				2 07	1267	612	
	3	S ΡΔ ΤΝ		8	273	0.865	1207	UIL	
	5			8 8	1762	1 60			
		AVEDACE		· g	1702	1.00	1080	3317	
				0	382	1.23	4000	3317 A	
		UK		010 A	200	1.01	1096	2221	
				7+9+0		1 22	7215	50/5	
				7+0+9		1.23	/315	5945	
	4	USSR	300	10	10553	0.868			
				10+11+12		0.868	5410	6233	
	1+2+3+4					1.17	20341	17424	
1962	1	USSR	664	3	975	1.00			
				1+2+3		1.00	6560	6560	
	3	SPAIN		7	461	2.38	4008	1684	
		CANADA		8	531	1.64	883	538	
		CANADA		9	249	1.68	223	133	
				7+8+9		2.17	5114	2355	

Table 1. (Cont'd)

	YEAR	QUARTER	COUNTRY	OTOLITHS	MONTH	LENGTHS	AV WT	NOMINAL CATCH (tons)	ADJUSTED NUMBERS (000)	NOTE
		4	USSR	299	12	1708	1.54			
					10+11+12		1.54	1460	948	
		1+3+4	1 A				1.21	13134	9863	
		1+2+3+4					1.21	1 5907	11945	
	1963]	POLAND	534	3	4041	1.54			
			USSR		3	3263	1.62			
		1+2+3+4					1.58	38216	24187	
	1964	1	SPAIN		3	227	2.10			2
		1+2+3+4					2.10	47819	22770	
2 1.		2	POLAND		6	258				3
	1965	1	UK		3	258	1.89			
					1+2+3		1.89	558	295	
		3	UK		7	376	1.51	2978	1972	
			UK		8	56 5	1.80	715	397	
					9	166	1.61	1447	899	
					7+8+9		1.58	5140	326 8	
		4	UK		. 11	2053	1.62	6461	3988	
					12	2676	1.70	20596	12115	
					11+12		1.68	27057	16103	
					10+11+12		1.68	38837	23114	
		1+3+4					1.65	53850	32726	
		1+2+3+4					1.65	60313	36654	
		2	POLAND	278	4+6	468				4
b	1966	1	PORTUGAL	275	3	825	2.08	-		
					1+2+3		2.08	4194	2016	
		2	PORTUGAL	177	4	833	1.98	2970	1 500	
			UK		5	7,58	2.27	1185	522	
					4+5		2.05	4155	2 022	
					4+5+6		2.05	5821	2833	
		. 3	UK		7	622	2.06	3736	1814	
			UK		8	14566	1.70			
			USSR		8	322	1.64			
			AVERAGE		8		1.67	9049	5419	
			UK		9	1264	1.86	376	202	
					7+8+9		1.77	13161	7435	
		4	UK		10	495	1.49	3718	2495	
					11	266	1.59	405	255	
					10+11		1.50	4123	2750	
					10+11+12		1.50	5780	3855	
		1+2+3+4					1.79	33834	18858	
		3	FRANCE		8	79				5

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Table 1. (Cont'd)

YEAR	QUARTER	COUNTRY	OTOLITHS	MONTH	LENGTHS	AV WT	NOMINAL CATCH (tons)	ADJUSTED NUMBERS (000)	NOTE
1967	1	USSR		1	1127	2.03	45	22	
	i,	UK		2	218	1.55	239	154	
				3	670	1.71	19095	11167	
				1+2+3		1.71	19379	11343	
	3	UK		7	246	1.98	1186	599	
		· .		8	657	1.66	4342	2616	
				7+8		1.72	5528	3215	
· •				7+8+9		1.72	7150	4158	
	4	UK		10	258	1.83			
				10+11+12		1.83	1603	876	
	1+3+4					1.72	28132	16377	
	1+2+3+4					1.72	42163	24545	
1968	1	PORTUGAL	300	3	750	2.63			
		USSR	299	3	12119	2.55			
		SPAIN	42	- 3	1254	2.23			
		AVERAGE		1+2+3		2.47	19163	7758	
	3	SPAIN	29	9	1661	2.07			
				7+8+9		2.07	7824	3780	
	1+3					2.34	26987	11538	х ,
	1+2+3+4	. · · ·				2.34	40385	17266	

NOTES

- 1. USSR Exploratory fishing. No nominal catches reported in quarter 1 by any country in 1960.
- 2. Age-length keys from Canadian research vessel cruises used to establish an age composition from the commercial length frequency.
- 3. Polish research length frequency in 1964 was remarkably different from the Spanish commercial length frequency and was not included. Average length 38.6 cm compared to 61.9 cm.
- 4. Polish research length frequency in 1965 using 40 mm mesh. The age-length key only was used.
- 5. French research length frequency in 1966 was comprised of much smaller fish than the other frequencies and was therefore omitted.

YEAR	QUARTER	COUNTRY	# OTOLITHS	MONTH	# LENGTHS	AV. WT.	NOMINAL CATCH (tons)	ADJUSTE NUMBER (000)	S NOTE
1970	1	Japan	-	2	331	2.07	26529	12816	
1972	1	Spain	63	3	158	2.08			
		USSR	· <u>-</u>	3	822	2.28			
		Av				2.18	7066	3241	
		Spain	×	2	705	1.39	2367	1703	
				2+3		1.91	9433	4944	
				1+2+3		1.91	9545	5003	
	2	UK	67	6	1402	1.20			
				4+5+6		1.20	12146	10122	
	3	UK	78	8	402	1.18	11713	9926	
	• •			9	274	1.24	2415	1948	
				8+9		1.19	14128	11874	
				7+8+9		1.19	26853	22569	
	1.0.2					1 00	AOE A A	27604	
	1+2+3					1.29	48544	3/094	
+1	2+3+4		· · · ·			1.29	21031	44/9/	
1973	2	UK	27	6	499	1.18	22900	19423 (a	3K+3M combined)
1974	2	UK	23	6	219	1.13	7524	6607	
	2	אוו	34	41510	215	1 22	1850	30.97	
	J	UK	54	2 Q	215	0.006	1252	1257	
				7+8	599	1 16	6102	5244	
				7+8+9		1.10	8001	6876	
and the second sec	2+3			7.015		1 14	15535	13573	
1	+2+3+4					1.14	24941	21783	
1975	2	Can.	488	6	2250	2.52			
				4+5+6		2.52	1932	767	
	4	Port.	116	11	609	0.520			
		UK	_	11	105	1.21			
		AV	-	11	_	0.865	556	642	
		Port.		12	400	0.705	2816	3995	
				11+12		0.727	3372	4637	
			10	+11+12		0.727	3889	5349	
	2+4				· _	0 952	5821	6116	
	1+2+3+4		-			0.952	22375	23503	
1976	3	Port	295		310	0.488	1698	3478	
	~		250	9	2148	0.752	4698	.6242	
				8+9 7+2+0		0.658	6396	9720	
	4	Port.	70	10	220	0.658	00/4	9987	
			1	0+11+12		0.716	8309	11603	
	3+4		•			0.689	14883	21590	
	- •.								

Table 2. Estimates of removals of cod by the commercial fishery in Division 3M. 1970, 1972-78.

Table 2. (Cont'd)

YEAR	QUARTER	COUNTRY	OTOLITH	s month	L ENGTHS	AV.WT.	NOMINAL CATCH (tons)	ADJUSTED NUMBERS (000)	NOTE
1977	1	USSR	- 1	3	3899	0.857			
				1+2+3		0.857	4716	5510	
	2	Spain	220	4	1762	1.20	2356	1966	
		UK	-	5	616	0.961	1925	2002	
				4+5		1.08	4281	3968	
				4+5+6		1.08	6125	5679	
	4	Can.	201	10	607	1.07	1799	1680	
				11	1139	1.03	2166	2104	
				10+11		1.05	3965	3784	
			10	+11+12		1.05	4842	4621	
	1+2+4					0.992	15683	15810	
	1+2+3+4					0.992	27019	27239	
1978	.1 .	USSR	698	1 3 1+3 1+2+3	10208 429	1.186 1.20 1.20 1.20 1.20	1834 3382 5216 6708	1546 2818 4364 5615	
	2	Portugal UK	263(130) 37	4 5 5	500 600 243	1.064 1.414 1.983	1778	1672	· }
		Spain AV	565	5 5 4+5 4+5+6	1951	1.56 1.65 1.30 1.30	1902 3680 6529	1154 2826 5014	1
	3	USSR		8 7+8+9	809	1.356	5216	3847	
	4	Portugal	363(225)	10 11 12 10+11+12	2209 1647 300	1.13 1.09 0.963 1.08	1739 2623 910 5272	1539 2406 945 4890	1
	1+2+4					1.19	18509	15519	
	1+2+3+4					1.19	23725	19892	Otter Trawl
	1+2+3+4	Norway				1.56	9506	6101	Longline
	1+2+3+4						33231	25993	Total
1979) 3	Spain	2603	8 9 8+9 7+8+9	3321 6610	1.61 1.84 1.69 1.69	1525 965 2490 3981	948 525 1473 2355	2
	4	Spain	330	10 11 10+11 10+11+12	945 738	2.00 2.14 2.06 2.06	2117 1566 3683 4583	1059 732 1791 2228	2
	3+4					1.87	8564	4583	
	1+2+3+4					1.87	19030	10185	Otter Trawl
	1+2+3+4	Den(F)	· -		2696	1.88	8795	4686	Longline
	1+2+3+4					1.87	27825	14871	Total

Note

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1. 130 and 225 age determinations reported by Portugal in quarters 2 and 4. Through an otolith exchange, Canadian readings of 263 and 363 were made.

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2. Sampling by means of the Canadian observer programme.

AGE	1960	1961	1962	1963	1964	1965	1966	1967	1968	
3	.382	.420	.208		.681	.365	.428	.428	-	
4	.696	.814	.676	.938	1.050	.714	.823	.792	.760	
5	1.087	1.168	1.188	1.133	1.419	.975	1.039	1.281	1.523	
6	1.432	1.418	1.536	1.532	2.036	1.237	1.571	1.892	2.212	
7	1.479	1.857	1.701	1.965	2.576	1.854	1.674	2.124	2.574	
8	1.593	1.878	2.150	2.371	2.452	2.144	2.346	2.734	3.121	
9	1.852	1.926	2.092	2.360	2.326	2.382	2.664	3.086	3.507	
10	1.955	2.232	2.396	2.440	3.161	2.519	4.172	4.264	4.355	
11	2.125	2.599	2.353	2.643	2.577	2.823	3.610	4.205	4.800	÷.
12	2.482	2.900	3.398	3.749	-	2.399	4.098	5.585	7.072	
13	3.954	2.754	2.398	3.163	-	-	6.219	5.353	4.487	
14	-	3.275	3.492	3.492		· _	9.548	9.387	9.226	
							, , , ,			
	1072	1072	1074	1075	1076	1077	1078	1070		
AGE	1972	1973	1974	1975	1976	1977	1978	1979		
AGE3	<u>1972</u> .811	<u>1973</u> .633	1974	1975	1976	.314	1978	<u>1979</u> .790		
AGE 3 4	1972 .811 .722	<u>1973</u> .633 .314	1974 .657 .805	1975 .697 1.636	1976 .671 1.293	<u>1977</u> .314 .845	<u>1978</u> .374 .600	1979 .790 1.070		
AGE 3 4 5	1972 .811 .722 .981	1973 .633 .314 1.300	1974 .657 .805 1.769	1975 .697 1.636 1.798	1976 .671 1.293 4.192	1977 .314 .845 1.400	1978 .374 .600 1.102	1979 .790 1.070 1.480		
AGE 3 4 5 6	1972 .811 .722 .981 1.500	1973 .633 .314 1.300 .994	1974 .657 .805 1.769 2.829	1975 .697 1.636 1.798 2.658	1976 .671 1.293 4.192 5.085	1977 .314 .845 1.400 3.433	1978 .374 .600 1.102 1.582	1979 .790 1.070 1.480 2.450		
AGE 3 4 5 6 7	1972 .811 .722 .981 1.500 1.930	1973 .633 .314 1.300 .994 .828	1974 .657 .805 1.769 2.829 3.983	1975 .697 1.636 1.798 2.658 3.766	.671 1.293 4.192 5.085 5.923	1977 .314 .845 1.400 3.433 5.156	1978 .374 .600 1.102 1.582 2.658	1979 .790 1.070 1.480 2.450 4.350		
AGE 3 4 5 6 7 8	1972 .811 .722 .981 1.500 1.930 1.820	1973 .633 .314 1.300 .994 .828 3.340	1974 .657 .805 1.769 2.829 3.983 5.923	1975 .697 1.636 1.798 2.658 3.766 4.225	1976 .671 1.293 4.192 5.085 5.923 7.555	1977 .314 .845 1.400 3.433 5.156 5.403	1978 .374 .600 1.102 1.582 2.658 3.557	1979 .790 1.070 1.480 2.450 4.350 5.340		
AGE 3 4 5 6 7 8 9	1972 .811 .722 .981 1.500 1.930 1.820 2.540	1973 .633 .314 1.300 .994 .828 3.340 3.180	1974 .657 .805 1.769 2.829 3.983 5.923 4.684	1975 .697 1.636 1.798 2.658 3.766 4.225 5.702	1976 .671 1.293 4.192 5.085 5.923 7.555 5.278	1977 .314 .845 1.400 3.433 5.156 5.403 8.203	1978 .374 .600 1.102 1.582 2. 658 3.557 7.712	1979 .790 1.070 1.480 2.450 4.350 5.340 6.610		
AGE 3 4 5 6 7 8 9 10	1972 .811 .722 .981 1.500 1.930 1.930 1.820 2.540 3.570	1973 .633 .314 1.300 .994 .828 3.340 3.180 8.180	1974 .657 .805 1.769 2.829 3.983 5.923 4.684 6.619	1975 .697 1.636 1.798 2.658 3.766 4.225 5.702 5.724	1976 .671 1.293 4.192 5.085 5.923 7.555 5.278 5.278 5.278	1977 .314 .845 1.400 3.433 5.156 5.403 8.203 8.203 8.748	1978 .374 .600 1.102 1.582 2.658 3.557 7.712 6.765	1979 .790 1.070 1.480 2.450 4.350 5.340 6.610 7.210		
AGE 3 4 5 6 7 8 9 10 11	1972 .811 .722 .981 1.500 1.930 1.820 2.540 3.570 3.140	1973 .633 .314 1.300 .994 .828 3.340 3.180 8.180 3.180	1974 .657 .805 1.769 2.829 3.983 5.923 4.684 6.619 9.043	1975 .697 1.636 1.798 2.658 3.766 4.225 5.702 5.724 7.448	1976 .671 1.293 4.192 5.085 5.923 7.555 5.278 5.278 5.278 6.381	1977 .314 .845 1.400 3.433 5.156 5.403 8.203 8.748 6.381	1978 .374 .600 1.102 1.582 2.658 3.557 7.712 6.765 11.375	1979 .790 1.070 1.480 2.450 4.350 5.340 6.610 7.210 11.040		

Table 3. Average weight-at-age estimates derived from commercial sampling

Table 4. Discrepancies between calculated catch weight and reported nominal catch of Div. 3M cod in the periods 1960-68 and 1972-79.

YEAR	NOMINAL CATCH (000 t)	CALCULATED CATCH (000 t)	% ERROR
1960	12.3	13.8	12
1961	20.3	27.0	33
1962	15.9	18.0	13
1963	38.2	40.5	6
1964	47.8	48.3	1
1965	60.3	58.7	-3
1966	33.8	39.8	18
1967	42.2	44.6	6
1968	40.4	41.2	1

Table 4. (Cont'd)

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YEAR	NOMINAL CATCH (000 t)	CALCULATED CATCH (000 t)	% ERROR
1972	57.7	49.6	-14
1973	22.9	24.5	7
1974	24.9	25.3	2
1975	22.4	19.5	-13
1976	22.3	28.6	28
1977	27.0	32.3	2 0
1978	33.2	30.4	-8
1979	27.8	28.0	1

Table 5. Derivation of selection patterns for cod in Div. 3M

AGE	TS RESEARCH MARCH	968 AGE C JULY	OMPOSITIO TOTAL	NS COMMERCIAL CATCH	RELATIVE EXPLOITATION RATE	PATTERN RELATIVE TO AGE 12	SMOOTHED PATTERN USED
1	6	1	7				,
2	32	<u></u>	32				
3	262	55	317	1	.0032	0.0003	0.0003
4	51	18	69	35	. 507	0.043	0.04
5	158	215	373	3049	8.17	0.70	0.69
6	101	164	265	8628	32.56	2.79	2.70
. 7	10	40	50	2565	51.3	4.40	4.29
8	5	38	43	1399	32.53	2.79	4.29
9	2	11	13	717	55.15	4.73	4.29
10	4	29	33	639	19.36	1.66	1.63
11	3	6	9	121	13.44	1.15	1.11
12	3		3	35	11.66	1.00	1.00
	637	577	1214				

AGE	1979 AGE CO RESEARCH	DMPOSITIONS COMMERCIAL CATCH	RELATIVE EXPLOITATION RATE	PATTERN RELATIVE TO AGE (7-11)
3	1067	167	.157	. 67
4	5610	2616	.466	1.98
5	5437	5599	1.03	4.38
6	6703	5882	.878	3.74
7	1713	316	.184)	1.00
8	108	63	. 583	1.00
9	55	19	.345 .235	1.00
10	20	27	1.35	1.00
11	30	27	.900)	1.00
12	10			

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Table 6.	Result	s of cohort	analysis, 195	9-68.							
	AGE/	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
CATCH (000)	まままま 多410の2000年21941 9410の20042194	4 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	1 807 807 807 807 807 807 807 807 807 807	1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	101 01 01 01 01 01 01 01 01 01 01 01 01	А 263 265 265 265 265 265 265 265 265 265 265	4 4 4 4 4 4 4 7 4 7 4 8 7 7 4 8 7 7 7 4 7 7 7 7	4974 4974 49736 497756 497736 4984 49974 400 41	8 4 8 8 6 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	18 19 19 19 19 19 19 19 19 19 19	жаал мала
FISHING MORTALITY	まれます まままま ろうちょう ちょう ちょう ちょう ちょう ちょう ちゅう ちゅう ちょう ちょう ちょう ちょう ちょう ちょう ちょう ちょう ちょう ちょ	00 0401 04000 0440100 0440100 00040 00040	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000004004740 40070070004000 0004004004000	000100040000 440000040000 801400044400	ы м осон миларарии осон миларарии осон миларарии осон а миларарии осон а миларарии осон а миларарии осон а миларарии осон осон миларарии осон осон осон осон осон осон осон осон	00000000000000000000000000000000000000	00004040404000 00040404000 000804080080080 000840800800000000	000 00 00 00 00 00 00 00 00 00 00 00 00	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000 000 000 000 00 00 00 00 00 00 00 0
		. 053	074	. 085	. 054	.127	.1.43	£67°	, 087	120	114
STOCK SIZI (000)	14 15 15 15 15 15 15 15 15 15 15 15 15 15	0 0 0 4 0 0 0 4 0 0 0 0 0 4 0 0 0 0 4 4 0 0 4 0 0 0 4 0 0 4 0 0 0 4 0 0 0 0	6 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	4 4 30858 30858 4174 4124 4124 4288 4284 428 428 428 428 428 428 428	M 4 8 0 7 0 0 8 7 0 0 8 7 0 0 8 7 0 0 0 7 0 0 0 7 0 0 0 7 0 0 0 8 0 0 0 8 0 0 0 8 0 0 0 8 0 0 8 0 0 8 0 0 8 0 0 8 0 7 0 0 0 0	имида 740474 2040474 204044 2040424 2000024480 2000024080 20000240800	978 978 978 979 979 979 979 979 979 979	9 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	4 4 4 4 4 4 4 4 4 4 4 4 4 4	0014 40044 40004 40034 40034 4000 4000 4
		118778.	154867.	251579.	238917	223290.	188501.	231261.	249930.	200764.	176098,

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YEAR	Biomass Fr F _T =0.64 (000 t	rom Cohort F _T =1.30 cons)		CPUE RESEARCH	STANDARD CPUE COMMERCIAL	LONGL CP Comm	INE UE ERCIAL
1972	89.5	89.1		75	1.35	-	
1973	50.1	49.6		57	.868	32	1.
1974	44.8	43.5		51	1.25	51	3
1975	56.7	53.6		121	.967	40	2
1976	128.8	118.5		296	.766	19	0
1977	98.2	87.5		4 48	. 593	42	9
1978	69.5	56.9		79	.758	21	7
1979	69.0	44.7		108	. 399	25	4
F _T	Y	Х		SLOPE I	NTERCEPT	R ²	ESTIMATED BIOMASS IN 1979
0.64	3+ Biomass	Researc	n CPUE	. 2983	38.18	.75	70
		Standard	d CPUE	-43.84	119.6	.10	
		Longline	e CPUE	-0.25	157.6	.72	
1.30	3+ Biomass	Researc	n CPUE	.2582	39.88	.68	68
		Standard	d CPUE	-32.89	105.1	.07	-
		Longlin	e CPUE	-0.22	144.9	.73	-

Table 7. Biomasses of cod of ages 3 and older (3+) from cohort analysis and various catch rate indices.

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Catch (000)										
	AGE	1972	1973	1974	1975	1976	1977	1978	1979	· · · · · · · · · · · · · · · · · · ·
	3 4 5 6 7 8 9 10 11	278 19,303 12,372 6555 3083 1672 1106 269 96 34	2035 116 11,709 3470 853 271 504 39 155 116	5999 11,130 2232 1894 271 21 75 43 75 43 75 43	7090 2436 1241 238 281 96 35 46 31 50	17,564 10,653 386 100 53 1 1 1 1 1 1	119 17,581 8502 436 267 45 151 90 16 16	428 3092 18,077 3615 329 91 95 50 13 21	167 2616 5599 5882 316 63 19 27 27 1	
				Stoc	k Size (000)) (
• • • • • • • •	3 5 6 7 8 9 10 11	5887 42,119 19,324 8698 4063 2693 1548 611 338 56	20,826 4568 17,018 4627 1190 537 692 266 257 190	13,262 15,210 3635 3339 648 203 194 111 183 70	47,703 5430 2382 957 1020 286 147 91 52 82	94,807 32,641 2242 827 568 581 147 89 33 14	19,706 61,729 17,085 1486 587 418 474 1 1 9 72 26	11,052 16,026 34,631 6295 822 239 301 252 16 44	1436 8662 10,323 11,997 1883 375 113 161 161 161 2	
		85,337	50,171	30,855	58,150	13,1949	101,702	09,078	35,113	
				Fishi	ng Mortalit	cies				
	3 4 5 6 7 8 9 10 11	.0536 .7062 1.2295 1.789 1.824 1.159 1.560 .666 .377 .315	.1143 .0285 1.4287 1.7652 1.571 .816 1.633 .177 1.097 .315	.6930 16,540 1.1349 .9861 .6198 .122 .556 .561 .604 .315	.1794 .6848 .8576 .3215 .3632 .4644 .306 .815 1.084 .315	.2291 .4474 .2111 .1434 .1067 .0019 .0075 .013 .034 .015	.0067 .3780 .7984 .3920 .6989 .1267 .4335 1.7887 .284 .315	.0437 .2398 .8601 1.0069 .5839 .5466 .4281 .2478 2.114 .315	.137 .402 .891 .764 .204 .204 .204 .204 .204 .204	
	3+	.87	. 55	1.16	.25	. 28	.35	. 53	.64	
				D 1	+don 11-2-11					
		89,508	50,099	44,795	56,694	.s 128,829	98,181	69,475	68,982	
						·				

<u>Table 8</u>. Cohort at F_T on ages 3+ in 1979 = 0.64

a s		1977		1	978	1979		
	AGE	COHORT	SURVEY	COHORT	SURVEY	COHORT	SURVEY	
	3	194	230	1 59	60	41	51	
	4	607	609	230	196	247	268	
	5	168	133	497	577	294	260	
,	6	15	17	90	1 53	342	320	
	7	6	4	12	6	54	82	
	8	4	+	3	2	11 ¹¹	5	
	9	5	4	4	1	3	3	
	10	1	1	4	2	5	1	
	11	1	+	+	1	5	1	
	12	+	1	1	1	+	9	
	Total	1001	999	1000 .	999	1002	1000	

Table 9. Comparison of per mille age composition (ages 3-12 only) of stock sizes from cohort analysis and abundance estimates from Canadian surveys.

Table 10. Estimates of stock biomass of cod of ages 2 and older in the period 1972-1978.

VEAR- AGE 3 FROM COHORTNUMBER AT AGE 2 $M=.20$ $F=0$ AVERAGE AGE 2 (KG) BIOMASS AGE 2 $AGE 2$ (KG) BIOMASS AGE 2 $AGE 2$ $(000 t)$ BIOMASS $YEAR$ BIOMASS AGE 2 $AGE 2$ $(000 t)$ BIOMASS $AGE 3+$ $AGE 3+$	_											
1969 5887 7190 $.272$ 2.0 1972 6.9 89.5 96.4 75 1970 $20,826$ $25,437$ $.272$ 6.9 1973 5.3 50.1 55.4 57 1971 $13,262$ $16,198$ $.330$ 5.3 1974 23.0 44.8 67.8 51 1972 $47,703$ $58,265$ $.394$ 23.0 1975 19.2 56.7 75.9 121 1973 $94,807$ $115,798$ $.166$ 19.2 1976 4.0 128.8 132.8 296 1974 $19,706$ $24,067$ $.165$ 4.0 1977 2.2 98.2 100.4 448 1975 $11,052$ $13,499$ $.865$ 2.2 1978 0.6 74.4 75.0 79 1976 1436 1754 $.342$ 0.6 1979 108		YEAR- Class	NUMBER AT AGE 3 FROM COHORT	NUMBER AT AGE 2 M=.20 F=0	AVERAGE WEIGHT AGE 2 (KG)	BIOMASS AGE 2 (000 t)	YEAR	BIOMASS AGE 2 (000 t)	BIOMASS AGE 3+ (000 t)	BIOMASS Age 2+ (000 t)	SOVIET SURVEY KG/HR	
1970 $20,826$ $25,437$ $.272$ 6.9 1973 5.3 50.1 55.4 57 1971 $13,262$ $16,198$ $.330$ 5.3 1974 23.0 44.8 67.8 51 1972 $47,703$ $58,265$ $.394$ 23.0 1975 19.2 56.7 75.9 121 1973 $94,807$ $115,798$ $.166$ 19.2 1976 4.0 128.8 132.8 296 1974 $19,706$ $24,067$ $.165$ 4.0 1977 2.2 98.2 100.4 448 1975 $11,052$ $13,499$ $.165$ 2.2 1978 0.6 74.4 75.0 79 1976 1436 1754 $.342$ 0.6 1979 108		19 6 9	5887	7190	.272	2.0	1972	6.9	89.5	96.4	75	
1971 13,262 16,198 .330 5.3 1974 23.0 44.8 67.8 51 1972 47,703 58,265 .394 23.0 1975 19.2 56.7 75.9 121 1973 94,807 115,798 .166 19.2 1976 4.0 128.8 132.8 296 1974 19,706 24,067 .165 4.0 1977 2.2 98.2 100.4 448 1975 11,052 13,499 .165 2.2 1978 0.6 74.4 75.0 79 1976 1436 1754 .342 0.6 1979 108		1970	20,826	25,437	. 272	6.9	1973	5.3	50.1	55.4	57	
1972 47,703 58,265 .394 23.0 1975 19.2 56.7 75.9 121 1973 94,807 115,798 .166 19.2 1976 4.0 128.8 132.8 296 1974 19,706 24,067 .165 4.0 1977 2.2 98.2 100.4 448 1975 11,052 13,499 .165 2.2 1978 0.6 74.4 75.0 79 1976 1436 1754 .342 0.6 1979 108		1971	13,262	16,198	.330	5.3	1974	23.0	44.8	67.8	51	
197394,807115,798.16619.219764.0128.8132.8296197419,70624,067.1654.019772.298.2100.4448197511,05213,499.1652.219780.674.475.079197614361754.3420.61979108		1972	47,703	58,265	.394	23.0	1975	19.2	56.7	75.9	121	
197419,70624,067.1654.019772.298.2100.4448197511,05213,499.1652.219780.674.475.079197614361754.3420.61979108		1973	94,807	115,798	.166	19.2	1976	4.0	128.8	132.8	296	
197511,05213,499.1652.219780.674.475.079197614361754.3420.61979108		1974	19,706	24,067	.165	4.0	1977	2.2	98.2	100.4	448	
1976 1436 1754 .342 0.6 1979 108		1975	11,052	13,499	. 165	2.2	1978	0.6	74.4	75.0	79	
		1976	1436	1754	.342	0.6	1979				108	

						*
YEAR	1979	1979	1980	1980	1980	
AGE	STOCK (000)	FISHING MORTALITIES	STOCK (000)	FISHING MORTALITIES	CATCH (000)	
3	1436	.137	34,000	.008	245	
4	8662	.402	1025	.034	31	
5	10,323	.891	4744	.180	710	
6	11,997	.764	3467	.200	571	
7	1883	. 204	4575	.200	7 54	
8	375	.204	1257	.200	207	
9	113	.204	250	.200	41	
10	161	.204	75	.200	12	
11	161	. 204	107	.200	17	

107

49,607

75,170

.200

17

2605

7904

2

35,113

68,982

.204

12

TOTAL

BIOMASS

Table 11. Projection of catch in 1980 with F=0.2



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Fig. 1. (Cont'd)

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1 Ages

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