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Assessment of the Cod Stock in NAFO Divisions 3NO*

by

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Nominal catch and catch at age

Cod catches from Div. 3NO since 1975, along with corresponding TAC's, are as follows:

	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>
TAC ('000 tons)	88	43	30	15	25	26	26	17 ^b	17 ^b	26
Catch ('000 tons)	44	24	18	15	28	20	24	32 ^a	25 ^a	

^aProvisional

^bExcludes expected catch by Spain

Landings by country for Div. 3NO since 1953 are shown in Table 1, while Table 2 indicates catch information available by country, month, and year for 1983. Canadian landings were obtained from the Statistics and Systems Branch of the Department of Fisheries and Oceans, Canada, while that for other countries was obtained from NAFO circular letters and/or FLASH records. Catches by Spain were estimated by the Resource Management Branch of the Department of Fisheries and Oceans. Sampling data (Table 3) used to obtain catch at age for the commercial catch in 1983 was obtained by the Commercial Sampling and Foreign Cooperative Research Units of the Department of Fisheries and Oceans. Estimated Spanish landings were adjusted to the numbers at age obtained for all other countries because sampling and detailed catch information were not available. The total estimated catch at age, along with average weights and lengths at age, are shown in Table 4. Average weights at age were obtained by applying a length-weight relationship ($\log \text{weight} = \log \text{length} \times 3.0879 - 5.2106$) to the length frequencies and age length keys. The calculated total catch weight was 4% less than the total reported and estimated catch.

Survey data

Stratified random research vessel surveys were not conducted in Div. 3N and 3O during 1983 because of research vessel mechanical problems. A survey was conducted in April-May of 1984 using a different research vessel (A. Needler) than that used for previous surveys (A. T. Cameron). Biomass estimates from stratified-random research surveys in 3N and 3O including that for 1984 are shown in Table 5 and 6 and Fig. 1. Estimates for 3N and 3O showed substantial increases in biomass from 1982 to 1984 (Fig. 1). The length frequency of the cod caught during the 1984 survey is shown in Fig. 2. Table 7 shows mean number per standard tow data from 1972-82 as no similar age material was available for 1983.

Catch-effort data

Catch and effort information for 1959-81 was obtained from the NAFO Statistical Bulletin with similar preliminary data being available for 1982. Data for the Canadian otter trawl fleet in 1983 was provided by the Department of Fisheries and Oceans, Canada.

* Subsequent to the preparation of this document for the June 1984 Meeting, some additional information became available during the meeting. This resulted in the analysis given in the Appendix (pages 19-22).

As in the previous assessment, catch and effort data from the otter trawl and pair trawl fisheries were analyzed as separate units using the multiplicative model for both. The results of these analyses are shown in Tables 8 to 11. The catch rate indices obtained separately were combined for the same reasons and in the same manner as described in NAFO Res. Doc. 83/VI/53. The indices obtained for each gear were combined and averaged over the period 1959-75 after scaling each to its respective mean for that period. The catch rate indices for 1976-83 were those from the Canadian OT fleet which had been scaled by their 1959-75 mean. The combined catch rate is indicated in Table 12 and Fig. 3.

Table 13 shows a breakdown of directed catch by statistical unit area (Fig. 4) and catch per unit effort by Canadian vessels from 1978 to 83. There have been some fluctuations over the unit areas in terms of the amount of directed catch which continues to be small relative to the total catch. Unadjusted yearly catch rates show considerable fluctuation for some tonnage classes but there have been general increases in recent years, particularly in 1983.

Partial selection'

Estimates of partial selection in 1983 were obtained by iteration using cohort selectivity coefficients obtained by dividing fishing mortality by fully recruited fishing mortality for ages 6-10. The arithmetic mean of the coefficients for the period 1974-81 (excluding 1976) as obtained from a cohort analysis having $F_t = 0.10$ (Table 14) was used as the partial selection multiplier for the 1983 catch at age in subsequent cohort analyses.

Cohort analyses

Catch and average weight at age data from the commercial fishery over the period 1959-83 (Table 15) along with partial selection estimates for 1983 (Table 14) were used in cohort analyses. The fishing mortality occurring on the last age group (12) in the cohort was estimated as the fully recruited mortality for ages 6-10.

The relationship between the combined otter trawl-pair trawl catch rate index and exploitable biomass (mid-year biomass x partial selection matrix) was used to estimate a fully recruited F appropriate to the fishery in 1983. A cohort analysis at $F_t = 0.10$ indicated a balance of positive and negative residuals about the fitted line (Table 16, Fig. 5) over the period 1981-83 with the 1963 data excluded. Tables 17-19 show population numbers, mid-year population biomass, and fishing mortalities from a cohort analysis at $F_t = 0.10$ in 1983. Catchability coefficients over the period considered, defined as the ratio of catch rate indices to exploitable biomass are shown in Fig. 6.

Table 1. Catch (metric tons) of cod in NAFO Divisions 3NO.

Year	Canada	Spain	Portugal	USSR	Others	Total
1953	39,884	12,633	7,919	-	5,761	66,197
1954	17,392	88,674	24,045	-	4,650	134,761
1955	6,053	64,987	27,711	-	15,605	114,356
1956	5,363	42,624	15,505	-	1,390	64,882
1957	9,641	51,990	21,740	-	6,819	90,190
1958	4,812	29,436	11,608	-	2,195	48,051
1959	3,687	39,994	17,730	48	2,911	64,370
1960	3,408	33,972	14,347	24,204	3,746	79,677
1961	5,428	32,284	9,059	22,854	3,099	72,724
1962	3,235	17,413	3,653	7,971	2,712	34,984
1963	5,079	37,632	10,004	10,184	6,843	69,742
1964	2,882	37,185	8,095	9,510	6,789	64,461
1965	4,229	64,652	1,692	17,166	11,448	99,187
1966	6,501	52,533	5,070	39,023	5,792	108,919
1967	3,446	77,948	9,703	118,845	16,842	226,784
1968	3,287	69,752	6,752	78,820	6,900	165,511
1969	3,664	71,160	4,940	29,173	8,768	117,705
1970	4,771	67,034	3,185	28,338	8,233	111,561
1971	2,311	89,915	6,589	19,307	8,174	126,296
1972	1,736	76,324	11,537	12,198	1,579	103,374
1973	1,832	42,403	7,759	27,849	586	80,429
1974	1,360	38,338	6,602	26,911	178	73,389
1975	1,189	16,616	5,560	20,785	24	44,174
1976	2,065	9,880	2,620	8,992	726	24,283
1977	2,532	8,827	1,742	4,041	462	17,604
1978	6,246	5,813	641	1,819	199	14,718
1979	9,938	13,782	1,140	2,446	545	27,941
1980	5,084	8,999	1,145	3,261	871	19,360
1981	6,096	13,299	1,091	3,187	671	24,344
1982 ^a	10,185	14,361	2,466	3,985	608	31,605
1983 ^a	11,374	10,000	1,109	2,675	220	25,378

^aProvisional

Table 2. Cod landings (tons) from Divisions 3NO, by country, month, and gear as obtained from monthly FLASH reports, NAFO circular letters, and the Statistics and Services Branch of the Department of Fisheries and Oceans, Canada.

Mo.	3N Can(M)				Port. Fra. Total (GN)	3Ø Can(M)				Port. Fra. Total (GN)	USSR			
	Can(N)	ØT	LL	SCS		Mo.	Can(N)	ØT	LL			SCS		
J	26					J	1076	739			87			
F	24					F	188	34			373			
M	2					M	269	5	3		671			
A	36					A	454	13			87			
M	137	51	1	31		M	687	152		168	20			
J	113	3		110	44	J	295	200	61	40	9	5		
J	337	157			4	J	64	7	40	112	25	22		
A	626			106		A	54		93		99	26		
S	255	6		80		S	88			4	88	64		
O	366	163		43		O	686	15	36			860		
N	80	7				N	2357	276		58	40	47	460	
D	29				11	D	353	536			304	80		
	2031	387	1	370	59	2848	6571	1976	234	174	739	161	9855	2675

Total = 15378

Table 3. Commercial sampling data for Divisions 3NO cod in 1983.

Gear	Qtr.	Country	Div.	# Aged	Month	# Meas.	Landings				
							Count/month	Total			
OT	1	Can(N)	30	436	Jan.	1,325	1,076	1,928			
					Feb.	260	188	619			
						<u>436</u>	<u>1,585</u>	<u>3,497</u>			
	2	Can(N)	30	112	May	417	687	2,368			
					3	Can(N)	3N	263	Aug.	493	626
	Sept.	228	255	417							
	Other			768							
						<u>721</u>		<u>1,984</u>			
	4	Can(N)	3N	204	Oct.	974	366	2,126			
						3022	686				
30					383	Nov.	907	2357	3,285		
						Can (M)	30	Nov.		618	276
								Other			
			<u>587</u>	<u>5,521</u>	<u>6,420</u>						
GN	2	Port	3N	170	May	966	31	31			
					June	264	110	110			
					May	1,958	168	168			
						<u>383</u>	<u>3,188</u>	<u>349</u>			
	3	Port	3N	127	Aug.	217	106	373			
4	Port	30	184	Nov.	890	40	387				
All	1-4	All	3NO	2,092		12,539		15,378			
	1-4	Spain	3NO					10,000*			
								<u>25,378</u>			

*Estimate provided by Fisheries Operations Branch of Department of Fisheries and Oceans Canada.

Table 4. Estimated catch, average weight and average length at age along with associated variances for the commercial cod fishery in NAFO Divisions 3NO during 1983.

AGE	AVERAGE		CATCH		
	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
3	0.854	46.184	55	11.48	0.21
4	1.168	50.928	430	39.56	0.09
5	1.871	59.256	2323	89.77	0.04
6	2.624	66.154	1558	88.17	0.06
7	3.995	74.460	770	54.75	0.07
8	5.204	82.506	1006	54.31	0.05
9	6.269	87.623	675	41.10	0.06
10	8.075	95.218	212	19.51	0.09
11	8.986	98.697	58	10.11	0.17
12	11.006	105.207	22	5.96	0.27
13	9.932	101.464	10	4.20	0.40
14	17.650	122.484	5	1.43	0.30
15	15.075	116.569	8	4.37	0.58
16	15.407	117.865	6	3.70	0.58
17	19.308	127.000	2	0.05	0.03
18	20.751	130.000			0.01
19	23.672	135.585	1	0.03	0.03
20					
21	17.934	124.000	1	0.03	0.03

Table 5. Biomass estimates (MT) by stratum from survey cruises in Div. 3N

Strata	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1984
357			1383				29		52	332	135	92	0
358		1061	1772				383		483	1054	229	236	182
359		312	258			660	147		190	478	208	13	71
360		1966			306	1950	4040	2182	1416	1738	3743	1238	7877
361	2909	4525	2525	350	3246	2618	5894	8203	2666	4173		8125	12838
362	2127	9695	4222	2233	306	1666	6836	6621	1632	5847	8701	3708	40764
373	8159	3423	1855	2362		1031	1750	4300	1838	857	4578	6647	17916
374	501	702	273	0	135		1248	1324	479	0	146	2369	8335
375	3270	9977	1042	955	10601		5429	3598	369	3229	29835	5943	2404
376		1892	806		383	77	9672	102	868	855	2208	2	1049
377		550	14	83	283		1380	130	22	287	428	22	29
378	530	4146	404	632			687	90	281	939	104	303	133
379			1828	515			50	0	601	178	53	179	129
380	9	322	1317	206			52		232	57	25		224
381	480	1429	2386	359	122		2677	393	196	427	533	2186	478
382	142	2458	9	69			948	2215	220	285	182	36	0
383	231	1479	1	16		44	324	1564	146	0	430	5	294
Total	18357	439356	20096	7781	15381	8088	41546	30722	11692	20736	51538	31104	92725
Upper limit	35959	58509	29260	13257	35224	13399	61360	37915	16334	28150	120675	46068	123845
Lower limit	755	29362	10931	2304	-4462	2776	21732	23529	7051	13322	-17600	16141	61605

Table 6. Biomass estimates (MT) by stratum from survey cruises in Div 3O

Strata	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1984
329	211			6422	180	2008	357	18	487	373	560
330	9251		475	287	593	2218	3753	470	3371	123	3626
331	288		729	454		342	150	609		38	2630
332			830	351	940	4525	2266	9		3474	2358
333			525	82	0	2	0	28		153	0
334				6	0	6	0	43		8	0
335	22			3		0	0	10		11	0
336	29		0	0	136	3	1	286		104	0
337	78		1906	32	630	614	23	133		610	434
338	4298		5563	1876	6953	1334	5729	1795		5659	29905
339	1547		40			249	1475		505	610	1087
340			2029	2690	298	966	3718	386	4294	2849	6827
351	3092		1562	2684	8141	4334	47954	5629	6621	4498	43455
352	3075		426	1429	6120	3961	10008	5625		6236	34168
353	3265		77	2	262	84	1573	2		472	0
354	439			38	8		34	273	44	125	489
355	76		0	4			24	367	32	135	0
356	11						12	49	9		0
Total	25681		14161	16360	24261	20646	76966	15733	15363	25478	125339
Upper limit	35514		58392	65071	38015	34853	133278	24517	25164	33764	169942
Lower limit	15848	-	30070	-32350	10508	6442	20645	6950	5561	17191	80736

Table 7. Mean number of cod per standard tow from research vessel surveys in NAFO Divisions 3NO.

# Sets	1971*	1972*	1973	1974*	1975	1976	1977	1978	1979	1980	1981	1982
	38	45	94	37	58	78	88	88	172	140	77	130
Age												
1	0.0	0.01	0.07	0.05	0.46	0.58	0.01	0.55	3.09	0.01	0.35	1.56
2	4.18	1.17	2.64	1.39	3.16	3.89	2.35	0.71	0.93	5.39	0.38	9.29
3	42.14	9.01	2.69	4.97	4.70	2.89	9.71	7.07	2.33	1.38	5.39	1.14
4	5.80	19.28	1.88	0.89	2.64	1.83	6.29	8.17	9.25	0.67	1.58	3.33
5	4.43	1.78	2.48	0.44	0.59	1.66	4.63	2.48	7.84	1.07	1.83	0.51
6	1.06	.71	0.50	0.38	0.31	0.26	1.54	0.96	1.76	0.44	2.32	0.39
7	1.08	.58	0.28	0.14	0.60	0.07	0.49	0.61	0.52	0.21	1.13	0.63
8	0.48	.41	0.20	0.04	0.25	0.13	0.22	0.04	0.26	0.18	0.50	0.47
9	0.24	.30	0.22	0.01	0.25	0.06	0.10	0.01	0.10	0.18	0.53	0.23
10	0.03	.17	0.13	0.07	0.08	0.07	0.10	0.03	0.02	0.09	0.24	0.14
11	0.08	.08	0.06	0.03	0.01	0.02	0.01	0.04	0.06	0.05	0.04	0.06
12	0.14	.05	0.09		0.02		0.04	0	0	0.07	0.14	0.05
13			0.14		0.01		0.09	0.04	0.04	0.03	0.06	0.01
13	0.47	.36	0.50	0.15	0.15	0.05	0.12	0.01	0.10	0.12	0.17	0.12
Total	60.13	32.73	11.89	8.56	13.23	11.51	25.70	20.72	26.30	9.89	14.66	17.93
Total Age 3+	55.95	31.55	9.18	7.12	9.61	7.04	23.34	19.46	22.28	4.49	13.93	7.08
Upper Limit	117.35	51.51	15.47	12.50	25.93	17.94	33.96	31.81	47.18	12.85	23.61	24.43
Lower Limit	2.93	16.10	8.33	4.62	0.52	5.09	17.45	9.90	5.49	6.91	5.70	11.39

* survey in 3N only

Table 8. Regression coefficients and the analysis of variance from the regression of ln catch rate for cod in Divisions 3N0 from 1958-83 using otter trawl data.

<u>Country</u>	<u>Gear</u>	<u>ln power</u>	<u>Month</u>	<u>ln power</u>
Can N	OT 4	-0.633	October	-0.823
Can N	OT 5	-0.454	March	
Can M	OT 4	-0.257	April	
Can M	OT 5	-0.013	May	
ESP	OT 6	0.000	June	-0.513
PRY	OT 6	0.092	July	
			August	
			September	
			November	
			December	-0.100
<u>Division</u>	<u>ln power</u>		February	-0.056
3N			January	0.000
30	0.000			

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.609
 MULTIPLE R SQUARED.....0.371

ANALYSIS OF VARIANCE

<u>SOURCE OF VARIATION</u>	<u>DF</u>	<u>SUMS OF SQUARES</u>	<u>MEAN SQUARES</u>	<u>F-VALUE</u>
INTERCEPT	1	6.433E1	6.433E1	
REGRESSION	33	6.896E1	2.090E0	7.840
TYPE 1	5	2.634E1	5.268E0	19.764
TYPE 2	4	1.764E1	4.410E0	16.545
TYPE 3	24	2.327E1	9.696E-1	3.638
RESIDUALS	439	1.170E2	2.665E-1	
TOTAL	473	2.503E2		

Table 9. Regression coefficients and the analysis of variance from the regression of ln catch rate for cod in Divisions 3N0 from from 1959-82 using Spanish pair trawl data.

<u>Country</u>	<u>Gear</u>	<u>ln power</u>	<u>Month</u>	<u>ln power</u>
ESP	PT 4	0.000	January	
ESP	PT 5	0.402	February	
ESP	PT 6		March	0.000
			April	
			September	
			October	
<u>Division</u>	<u>ln power</u>		<u>Month</u>	
3N	0.000		May	
30			August	0.231
			November	
			July	0.399
			June	0.444
			December	

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.821
 MULTIPLE R SQUARED.....0.675

ANALYSIS OF VARIANCE

<u>SOURCE OF VARIATION</u>	<u>DF</u>	<u>SUMS OF SQUARES</u>	<u>MEAN SQUARES</u>	<u>F-VALUE</u>
INTERCEPT	1	1.382E1	1.382E1	
REGRESSION	27	2.085E2	7.722E0	45.955
TYPE 1	1	2.428E0	2.428E0	14.449
TYPE 2	3	2.995E1	9.983E0	59.411
TYPE 3	23	1.984E2	8.626E0	51.334
RESIDUALS	598	1.005E2	1.680E-1	
TOTAL	626	3.228E2		

Table 10. Mean catch rate indices for cod in NAFO Divisions 3NO using otter trawl data from 1959-83.

YEAR	TOTAL CATCH	PROP.	CATCH RATE		EFFORT
			MEAN	S.E.	
1959	62459	0.084	0.912	0.152	68515
1960	79677	0.050	0.816	0.152	97701
1961	72724	0.027	0.884	0.179	82281
1962	34948	0.079	1.163	0.215	30043
1963	69742	0.207	1.563	0.230	44617
1964	64461	0.092	1.160	0.207	55555
1965	99187	0.033	1.137	0.206	87249
1966	108919	0.067	1.265	0.188	86097
1967	226784	0.074	1.619	0.263	140094
1968	165512	0.011	0.813	0.126	203597
1969	117705	0.017	0.857	0.139	137349
1970	111561	0.008	0.820	0.152	136131
1971	126296	0.006	0.681	0.116	185512
1972	103374	0.011	0.930	0.186	111184
1973	80429	0.003	0.491	0.138	163883
1974	73389	0.001	0.758	0.235	96860
1975	44174	0.021	0.841	0.182	52529
1976	24283	0.054	0.807	0.169	30079
1977	17604	0.052	0.834	0.170	21115
1978	14718	0.222	0.888	0.142	16574
1979	27940	0.187	1.172	0.169	23839
1980	19990	0.080	0.925	0.168	31603
1981	24344	0.064	1.147	0.176	21220
1982	31605	0.241	1.375	0.209	22991
1983	25378	0.326	1.569	0.217	16176

Table 11. Mean catch rate indices for cod in NAFO Divisions 3NO using Spanish pair trawl data for the period 1959-82.

YEAR	TOTAL CATCH	PROP.	CATCH RATE		EFFORT
			MEAN	S.E.	
1959	62459	0.578	0.778	0.368	80274
1960	79677	0.386	0.929	0.081	85804
1961	72724	0.437	0.891	0.073	81614
1962	34948	0.430	0.720	0.067	48532
1963	69742	0.373	1.396	0.133	49958
1964	64461	0.494	1.249	0.101	51598
1965	99187	0.630	1.360	0.116	72939
1966	108919	0.455	1.302	0.113	83672
1967	226784	0.302	1.351	0.112	167845
1968	165512	0.418	1.242	0.109	132294
1969	117705	0.601	1.136	0.092	103575
1970	111561	0.595	1.128	0.091	98866
1971	126296	0.711	1.112	0.089	113551
1972	103374	0.729	0.734	0.046	140921
1973	80429	0.527	0.532	0.035	151249
1974	73389	0.519	0.484	0.035	151710
1975	44174	0.357	0.413	0.043	106869
1976	24283	0.405	0.745	0.045	32584
1977	17604	0.482	0.299	0.029	58865
1978	14718	0.383	0.107	0.009	138051
1979	27940	0.481	0.840	0.097	33260
1980	19990	0.443	0.262	0.023	76355
1981	24344	0.546	0.559	0.057	43519
1982	31605	0.450	0.398	0.036	79332

Table 12. Catch rate index from a combination of OT and PT Indices.

Year	Index	Year	Index
1959	0.86	1972	0.84
1960	0.89	1973	0.52
1961	0.90	1974	0.63
1962	0.96	1975	0.64
1963	1.50	1976	0.82
1964	1.22	1977	0.85
1965	1.27	1978	0.90
1966	1.30	1979	1.19
1967	1.51	1980	0.94
1968	1.04	1981	1.17
1969	1.01	1982	1.40
1970	0.99	1983	1.60
1971	0.91		

Table 13. A - Cod directed catch by tonnage class from Statistical Unit areas in use by DFO, Canada for 1978-83. B - Catch ratios by tonnage class for the Canadian otter trawl fleet in Division 3N0 for 1978-83.

Div.	Unit area	Can(N)						Can(M)	
		1978	1979	1980	1981	1982	1983	1983	
T.C. 4									
A.	30	310	67	399	120	26	262	155	164
		311	171	463	20		23	78	237
		312	1	5	13	4	4	3	
		313	1	3	12	74	559	556	
		314	13	19	23		19	365	33
	3N	315		1			37	4	
		316		6	7				
		317					18		
		318							
		319		13		13	4	33	
		320							
T.C. 5									
	30	310	663	1,220	682	330	546	502	631
		311	219	1,521	97	34	476	925	105
		312	46	109	3	4	156	49	4
		313	14	52	27	562	3,207	777	232
		314	270	81	76	295	81	2,320	413
	3N	315	85	28	12	68	54	351	
		316		33	18	116	227	118	
		317	28	10	38			17	
		318		22	76	25			
		319	350	24	86	58	93	46	
		320	2	0	2	4	78	6	
B.	T.C.								
	30	Can(N)	4	0.43	0.52	0.38	0.54	0.55	1.01
			5	0.49	0.71	0.78	0.94	0.67	1.15
		Can(M)	4	0.84	0.96	0.21	-	1.14	1.18
			5	0.44	1.23	0.83	0.25	1.27	2.00
	3N	Can(N)	5	0.45	0.47	0.42	0.52	0.56	0.55
		Can(M)	5	0.75	0.74	0.69	-	-	1.36

Table 14. Selectivity coefficients for NAFO Divisions 3NO cod from a cohort analysis at $F_t=0.10$. Average values for 1974-80 (excluding 1976) were used as cohort input in 1983.

SELECTIVITY COEFFICIENTS																			
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
3	0.08	0.10	0.02	0.04	0.01	0.22	0.01	0.00	0.14	0.18	0.12	0.05	0.02	0.00	0.65	0.20	0.02	0.34	
4	0.37	0.47	0.21	0.25	0.18	1.08	0.15	0.18	0.55	0.60	0.38	0.42	0.96	0.43	1.54	0.72	0.37	1.31	
5	0.75	1.19	0.98	0.32	0.68	1.35	0.37	0.46	1.01	0.95	1.20	0.53	1.20	0.74	0.98	1.18	0.52	1.95	
6	1.13	0.90	1.15	0.54	0.67	1.12	0.75	0.84	0.98	1.11	1.12	1.09	1.06	1.14	1.40	1.08	0.85	1.23	
7	0.98	0.98	0.68	1.31	0.64	0.68	1.30	0.80	0.91	0.92	0.61	0.86	0.82	1.06	0.65	0.83	0.94	0.66	
8	0.88	1.44	0.85	1.04	1.91	0.82	1.25	1.66	1.42	0.74	0.97	0.98	1.27	0.60	0.65	0.91	1.21	0.74	
9	0.65	0.72	0.62	1.52	2.14	1.23	0.57	1.04	0.28	0.42	1.05	0.83	0.55	0.22	0.76	0.85	1.35	0.63	
10	0.89	0.61	0.24	1.27	1.97	2.29	2.60	2.51	0.33	0.30	0.83	0.66	0.53	0.29	0.44	1.01	1.19	0.80	
11	1.92	2.22	0.04	0.94	1.11	0.34	1.26	0.94	0.67	0.15	0.71	1.72	0.78	0.25	0.43	0.95	1.52	0.39	
12	1.00	1.01	1.01	0.98	0.92	0.96	0.94	0.91	1.00	0.99	1.00	1.00	1.00	0.98	0.98	0.99	0.95	0.97	
AGE	1977	1978	1979	1980	1981	1982	1983												
3	0.02	0.09	0.01	0.06	0.08	0.02	0.07												
4	0.27	0.49	0.34	0.55	0.31	0.27	0.43												
5	0.69	0.87	1.05	1.29	0.67	0.54	0.82												
6	0.98	0.96	1.01	1.00	0.92	0.83	1.00												
7	1.13	1.09	1.11	1.01	1.07	0.90	1.00												
8	0.76	0.98	0.86	1.06	1.02	1.20	1.00												
9	0.96	1.11	0.55	0.99	1.21	1.31	1.00												
10	1.56	1.09	0.32	1.01	1.46	1.38	1.00												
11	1.52	1.08	0.25	0.48	1.88	1.64	1.00												
12	1.03	1.01	1.01	0.99	0.96	1.00	1.00												

Table 15. Catch numbers and average wt. at age from the commercial cod fishery in Divs. 3N0 over the period 1959-83.

		CATCH AT AGE (numbers x10 ⁻³)														
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	
3	1711	1846	812	1026	313	6202	1013	753	20086	16359	8154	2105	950	69	10058	
4	13036	8503	4400	3882	5757	15555	7611	18413	62442	56775	12924	19703	26900	19797	27600	
5	5068	22050	11696	2204	11210	19496	7619	19681	50317	48608	26949	10799	30300	12289	15098	
6	6025	3095	15258	1581	4849	7919	13258	11795	18517	18485	11191	9481	11700	13432	5989	
7	3935	2377	2014	3594	1935	2273	9861	8486	4774	6337	2089	3646	3500	5883	1971	
8	1392	2504	1672	773	3840	1109	4827	4467	4651	1592	1393	1635	2500	1686	972	
9	757	583	847	668	1165	788	1081	1829	236	505	518	541	500	285	707	
10	926	367	196	433	508	328	1248	1694	180	178	292	149	200	216	243	
11	1220	896	25	226	322	37	163	122	71	90	134	227	100	78	137	
12	103	242	245	216	208	112	141	57	45	45	202	90	50	74	116	
3+	34173	40485	37165	14605	30207	53819	46822	67297	161319	148974	63846	48376	76700	53809	62891	
4+	32462	39639	36353	13579	29894	47617	45809	66544	141233	132615	55692	46271	75750	53740	52833	
5+	19426	32136	31953	9697	24137	32062	38198	48131	78791	75840	42768	26568	48850	33943	25233	
6+	14358	10086	20257	7491	12927	14566	30579	28450	28474	27232	15819	15769	18550	21654	10135	
AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983						
3	6425	671	4054	607	920	72	280	478	33	55						
4	9501	8781	7534	2469	4337	3827	1133	1032	1513	430						
5	10907	3528	5945	2531	2518	9208	3789	1194	1694	2323						
6	10872	2505	1084	1500	818	2784	2057	2173	1316	1558						
7	2247	3057	211	572	354	883	665	1805	1862	770						
8	2147	1059	238	177	103	265	185	541	1704	1006						
9	1015	931	44	209	58	58	75	182	590	675						
10	676	461	37	65	51	17	27	89	172	212						
11	458	292	13	41	8	12	7	39	79	58						
12	257	152	9	25	5	7	13	12	17	22						
3+	44475	21387	19169	8196	9171	17133	8236	7547	8980	7109						
4+	39050	29716	15115	7589	8251	17061	7956	7069	8947	7054						
5+	20549	11935	7581	5120	3914	13234	6818	6037	7434	6624						
6+	16442	8407	1636	2589	1396	4026	3029	4843	5740	4301						

		AVERAGE WEIGHT AT AGE (kg)														
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
3	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
4	0.82	0.82	0.82	0.82	0.82	0.82	0.82	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
5	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
6	1.95	1.95	1.95	1.95	1.95	1.95	1.95	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
7	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
8	3.39	3.39	3.39	3.39	3.39	3.39	3.39	4.64	4.64	4.64	4.64	4.64	4.64	4.64	4.64	4.64
9	3.98	3.98	3.98	3.98	3.98	3.98	3.98	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52
10	4.68	4.68	4.68	4.68	4.68	4.68	4.68	8.10	8.10	8.10	8.10	8.10	8.10	8.10	8.10	8.10
11	5.25	5.25	5.25	5.25	5.25	5.25	5.25	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94
12	6.17	6.17	6.17	6.17	6.17	6.17	6.17	11.77	11.77	11.77	11.77	11.77	11.77	11.77	11.77	11.77
AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983							
3	0.66	0.66	0.57	0.72	0.65	0.71	0.90	0.94	0.85							
4	1.02	1.02	1.00	1.05	0.98	1.04	1.27	1.17	1.17							
5	1.53	1.53	1.48	1.55	1.39	1.69	1.84	1.50	1.87							
6	2.33	2.33	2.49	2.25	2.69	2.50	2.69	2.20	2.63							
7	3.45	3.45	3.51	3.74	2.97	3.69	3.55	3.83	3.80							
8	4.64	4.64	4.74	4.61	3.70	5.49	5.33	5.26	5.20							
9	6.52	6.52	7.17	6.19	4.75	7.98	7.13	7.49	6.27							
10	8.10	8.10	8.91	7.23	7.15	9.22	9.10	8.80	8.08							
11	9.94	9.94	11.70	9.48	7.98	10.80	9.01	9.82	8.99							
12	11.77	11.77	11.47	12.87	10.11	12.61	10.15	12.28	11.01							

Table 16. Relationship of standard CPUE indices with exploitable biomass for cod in Divisions 3M0 from cohort analyses at a range of fully recruited F's. Residuals (observed-calculated) are indicated for recent years. (1963 excluded from the regressions).

Year	CPUE	0.75		0.10		0.125		0.15	
		Observed	Residuals	Observed	Residuals	Observed	Residuals	Observed	Residuals
1959	0.86	130							
60	0.89	150							
61	0.90	122							
62	0.96	107							
64	1.22	224							
65	1.27	144							
66	1.30	165							
67	1.51	265							
68	1.04	221							
69	1.01	170							
70	0.99	150							
71	0.91	198							
72	0.84	133	14	133	16	134	18	134	18
73	0.52	155	100	155	88	156	81	156	77
74	0.63	88	11	88	4	89	0	89	-3
75	0.64	34	-44	34	-51	35	-55	35	-57
76	0.82	45	-69	44	-69	44	-69	44	-69
77	0.85	29	-90	29	-88	29	-67	29	-87
78	0.90	70	-60	65	-60	61	-62	59	-62
79	1.19	100	-87	87	-83	78	-82	72	-81
80	.94	176	38	146	14	127	-1	115	-10
81	1.17	211	29	170	4	144	-12	128	-22
82	1.40	244	17	189	-12	156	-30	135	-41
83	1.60	317	52	239	7	191	-21	159	-38
R ²		0.52		0.42		.32		.24	
intercept		-45.95		-11.87		8.67		22.3	
slope		195.05		152.34		126.88		109.78	

Table 17. Population numbers from a cohort analysis on cod in NAFO Divisions 3NO using a fully recruited F=0.10.

POPULATION NUMBERS (x10 ⁻³)													
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3+	53624	52372	81956	107686	78129	111487	162340	210083	183211	100528	127856	80338	84686
4+	93903	42355	41208	36365	87238	63684	85830	131996	171320	131826	67503	97302	63871
5+	19548	65086	28793	29757	50823	66215	38065	63385	91408	83765	56558	43572	61836
6+	16657	11418	33336	12991	22367	31467	36572	24271	34087	29310	24599	21921	25903
7+	12158	8186	6548	13487	9206	13925	18597	17946	9199	11153	7271	10014	9369
8+	4709	6394	4551	3539	7791	5786	9344	6304	7015	3212	3398	4063	4900
9+	3289	2594	2969	2213	2198	2904	3734	3283	1119	1535	1189	1521	1847
10+	3094	2008	1598	1665	1208	745	1664	2079	1033	703	799	505	756
11+	2331	1700	1294	1131	971	439	313	233	189	683	414	390	278
12+	311	805	579	1036	721	504	326	109	81	74	477	219	114
3+	209629	192919	202933	239871	260651	297356	356736	459689	498643	362789	290065	259845	253559
4+	156005	140547	120877	132185	182522	185668	194446	249606	315431	262261	162209	179507	168873
5+	62102	98192	79667	65620	95284	121984	108616	117610	144111	130435	94706	82205	105003
6+	42555	33106	50875	36062	44461	55769	70550	54225	52702	46669	38148	38633	43167
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	
3+	62444	35014	36090	24223	32954	61348	53038	26070	37355	51072	13795	8698	
4+	68475	51063	19566	23734	19225	23312	49678	42591	21279	30330	41381	11264	
5+	27953	38150	16833	7422	11487	8923	16852	36749	31408	16392	23899	32511	
6+	23210	11766	17573	3913	2885	4025	5015	11519	21754	22286	12340	18034	
7+	10621	6649	4214	4550	937	1381	1938	3366	6912	15951	16280	8913	
8+	4504	3372	3824	1417	959	576	613	1267	1957	5057	11426	11644	
9+	1749	2162	1802	1188	202	570	312	410	797	1435	3649	7813	
10+	1060	1174	1130	622	140	126	278	203	283	585	1010	2454	
11+	439	672	742	314	92	81	44	181	150	207	398	671	
12+	136	268	426	220	29	64	29	29	137	117	134	255	
3+	200592	150510	102280	67604	68909	100405	127797	122384	122035	143432	124313	102257	
4+	138147	115497	66190	43381	35955	39057	74759	96314	84680	92360	110519	93559	
5+	69672	64434	46624	19646	16730	15745	25081	53723	63401	62030	69137	82295	
6+	41719	26284	29791	12224	5243	6822	8229	16974	31992	45638	45239	49784	

Table 18. Mid-year population biomass from a cohort on cod in NAFO Divisions 3NO using a fully recruited F=0.10.

POPULATION BIOMASS (AVERAGE) (mt)													
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3+	20063	19558	31032	40784	29677	41241	61591	125429	103034	54729	73844	47381	50354
4+	64465	28814	28841	47764	62520	40820	60714	112672	124814	90726	55761	79798	44335
5+	18901	59313	24819	32350	50466	62419	38316	72264	83533	73879	55912	51982	60310
6+	23257	17090	42774	21430	34737	47718	51018	36197	47831	36837	37813	34406	39939
7+	25294	17461	13790	29171	20766	32381	32044	40147	19630	22510	19018	24684	22915
8+	13028	15135	10994	9544	16786	15883	19643	13917	16731	9445	10835	13043	14193
9+	10331	8186	8972	6607	5346	6863	11247	12685	5834	7350	5207	7136	9240
10+	10904	7603	6322	6022	3554	2334	3410	6166	6849	4421	4622	3082	4719
11+	7533	5464	4091	4762	3738	1992	1017	1430	1146	5705	3038	2233	1986
12+	1412	3733	2436	5126	3377	2468	1359	799	570	495	3835	1765	905
3+	194184	182351	176074	203687	230970	256118	280359	421704	409971	306097	269885	265510	248896
4+	174121	162792	145042	162904	201292	214877	218768	296275	306937	251368	196041	218129	198543
5+	109456	133978	116200	115140	138772	174057	158054	183604	182124	160643	140280	138331	154207
6+	90755	74661	91381	82782	88304	111638	119738	111340	98591	86764	84368	86349	93897
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	
3+	37331	17520	19458	14274	18384	31526	34289	15336	23942	41451	11737	6679	
4+	52879	31463	12777	17214	13690	19908	45034	35982	19479	34273	43019	11700	
5+	28621	40614	13548	7346	10887	10038	21726	39754	44932	26258	31243	52976	
6+	31235	17138	22457	4651	4756	7082	9306	18852	46758	51450	23174	40975	
7+	21799	17908	8855	7958	2560	3319	5905	7457	21905	48148	52981	29260	
8+	14805	11955	10464	2895	3470	2040	2326	3752	9237	22999	49998	52312	
9+	7406	10371	7420	3192	1049	2914	1567	1626	5471	8628	22561	42322	
10+	6894	7426	5159	2248	871	686	1634	1253	2241	4419	7297	17130	
11+	3557	5368	4266	1195	766	591	340	1263	1409	1515	3154	5214	
12+	990	2354	2854	1366	752	512	306	228	1490	1015	1392	2422	
3+	207521	162216	107259	62469	56685	78616	122433	125503	176864	240156	246556	260990	
4+	170189	144696	87801	48195	38300	47091	88144	110167	152922	198705	234818	254312	
5+	117310	113233	75023	30981	24611	27183	43110	74185	133443	164432	191800	242612	
6+	93689	72619	61475	23635	13724	17145	21394	34431	88511	138174	160557	189636	

Table 19. Fishing mortalities from a cohort analysis on cod in NAFO Divisions 3NO using a fully recruited $F=0.10$.

FISHING MORTALITY																	
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.036	0.040	0.011	0.011	0.004	0.063	0.007	0.004	0.129	0.198	0.073	0.029	0.012	0.001	0.382	0.219	0.031
4	0.167	0.186	0.126	0.067	0.076	0.315	0.103	0.167	0.516	0.646	0.238	0.253	0.626	0.385	0.910	0.769	0.526
5	0.338	0.469	0.596	0.085	0.279	0.394	0.250	0.420	0.937	1.025	0.748	0.320	0.790	0.665	0.575	1.259	0.745
6	0.510	0.356	0.705	0.144	0.274	0.326	0.512	0.770	0.917	1.194	0.699	0.650	0.692	1.020	0.827	1.151	1.229
7	0.443	0.387	0.415	0.349	0.264	0.199	0.882	0.739	0.852	0.989	0.382	0.515	0.533	0.947	0.383	0.890	1.357
8	0.396	0.567	0.521	0.276	0.787	0.238	0.844	1.529	1.320	0.794	0.604	0.588	0.830	0.534	0.384	0.969	1.748
9	0.294	0.285	0.379	0.406	0.881	0.357	0.386	0.957	0.265	0.452	0.657	0.499	0.355	0.199	0.449	0.907	1.942
10	0.401	0.240	0.146	0.339	0.813	0.666	1.764	2.309	0.214	0.328	0.517	0.395	0.346	0.255	0.260	1.082	1.709
11	0.864	0.877	0.022	0.250	0.456	0.098	0.855	0.862	0.623	0.157	0.442	1.029	0.506	0.219	0.255	1.015	2.189
12	0.450	0.400	0.620	0.260	0.380	0.280	0.640	0.840	0.930	1.070	0.620	0.600	0.650	0.880	0.580	1.060	1.370

AGE	1976	1977	1978	1979	1980	1981	1982	1983
3	0.146	0.011	0.019	0.063	0.008	0.010	0.003	0.907
4	0.368	0.124	0.101	0.105	0.061	0.038	0.041	0.043
5	0.849	0.376	0.180	0.324	0.143	0.084	0.082	0.082
6	0.537	0.531	0.199	0.311	0.110	0.114	0.125	0.100
7	0.286	0.612	0.225	0.342	0.112	0.134	0.135	0.100
8	0.320	0.415	0.203	0.263	0.110	0.126	0.180	0.100
9	0.275	0.520	0.230	0.170	0.110	0.151	0.197	0.100
10	0.347	0.848	0.237	0.097	0.111	0.184	0.208	0.100
11	0.169	0.823	0.224	0.076	0.053	0.233	0.247	0.100
12	0.420	0.560	0.210	0.310	0.110	0.120	0.150	0.100

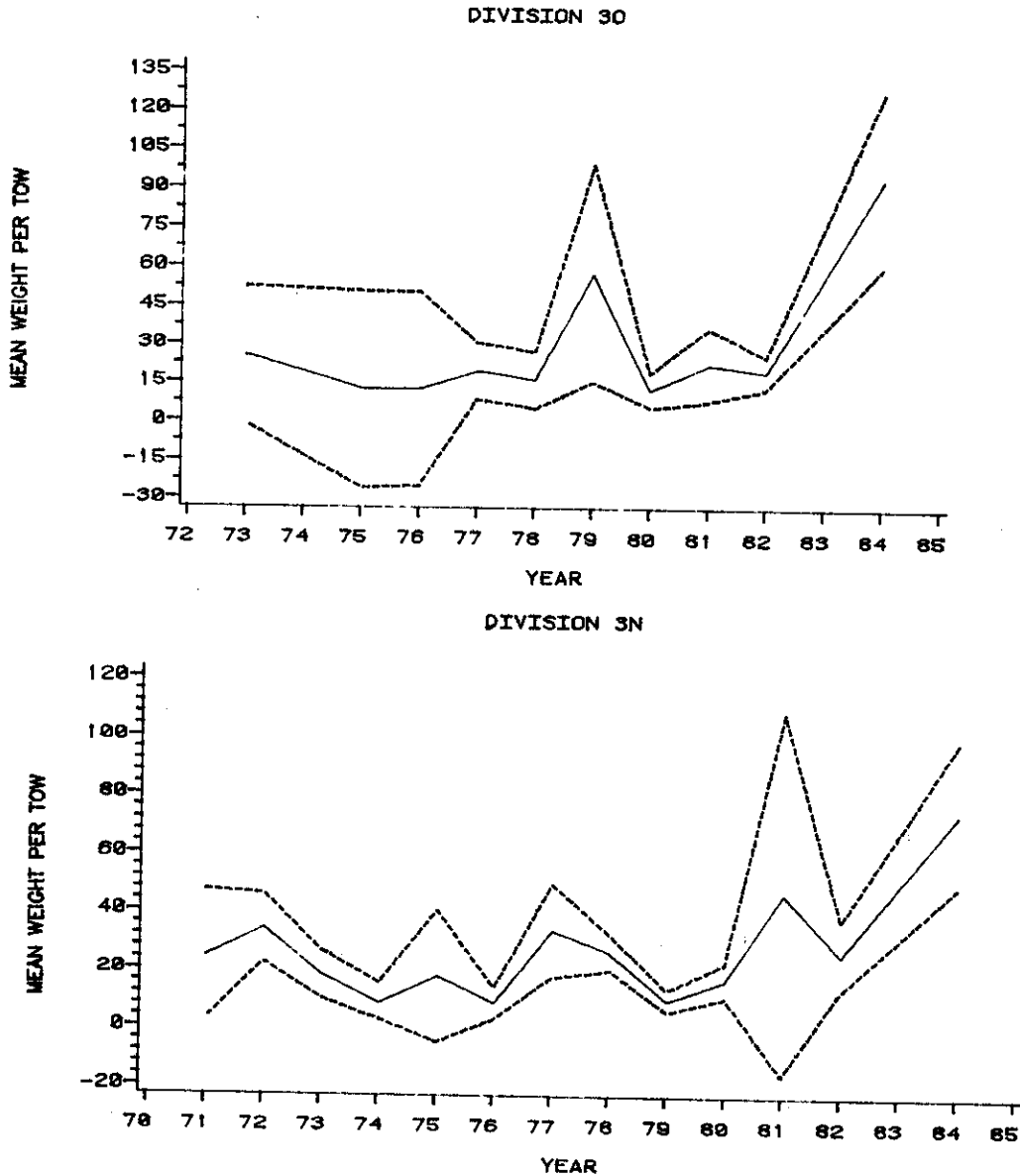


Fig. 1. Mean weights per tow with their associated confidence limits for cod in Divisions 3N and 30.

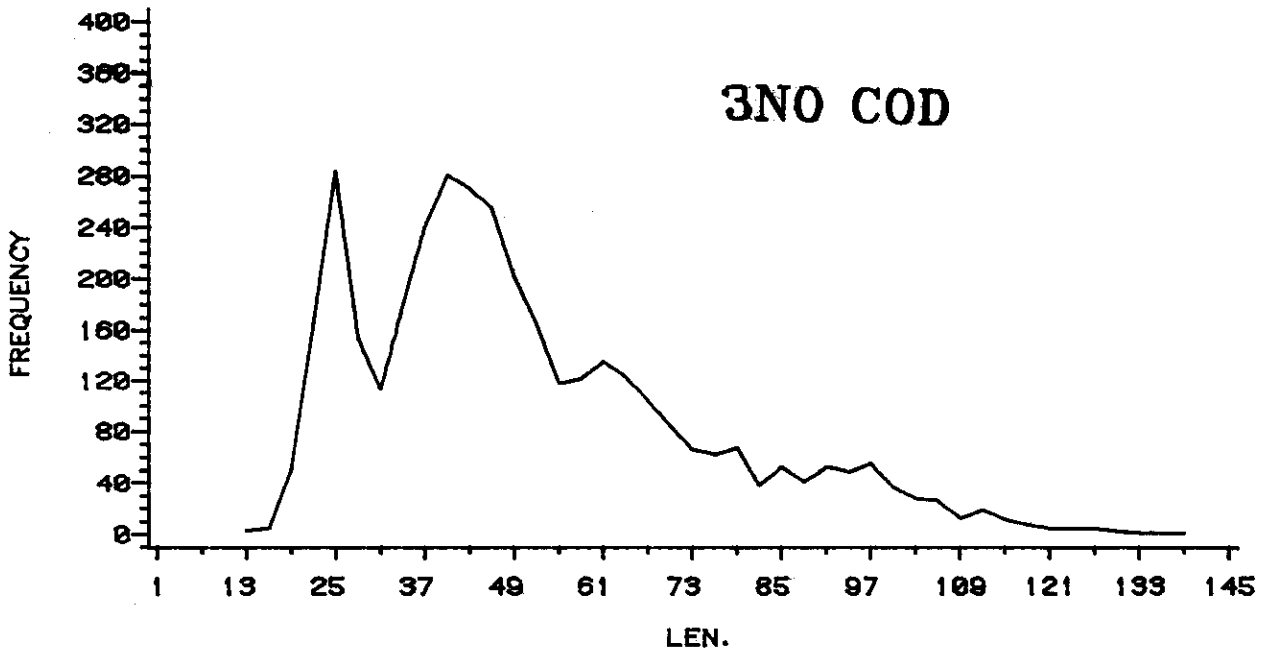


FIG. 2. 3NO RESEARCH COD FREQUENCY FOR 1984. 3694 FISH MEASURED

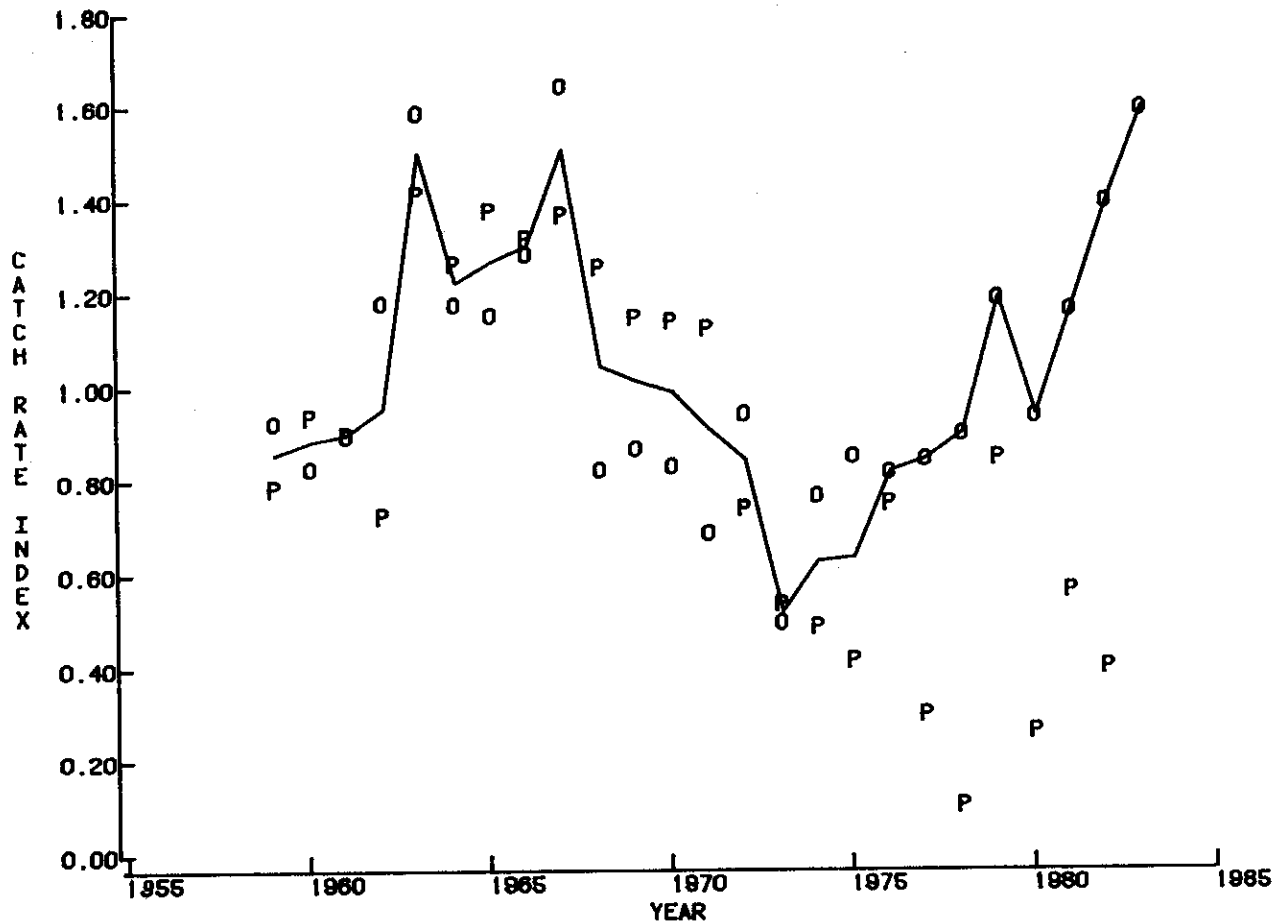


Fig. 3 Catch rate index for cod in NAFO Div. 3NO obtained from a combination of other trawl (O) and pair trawl (P) catch rates.

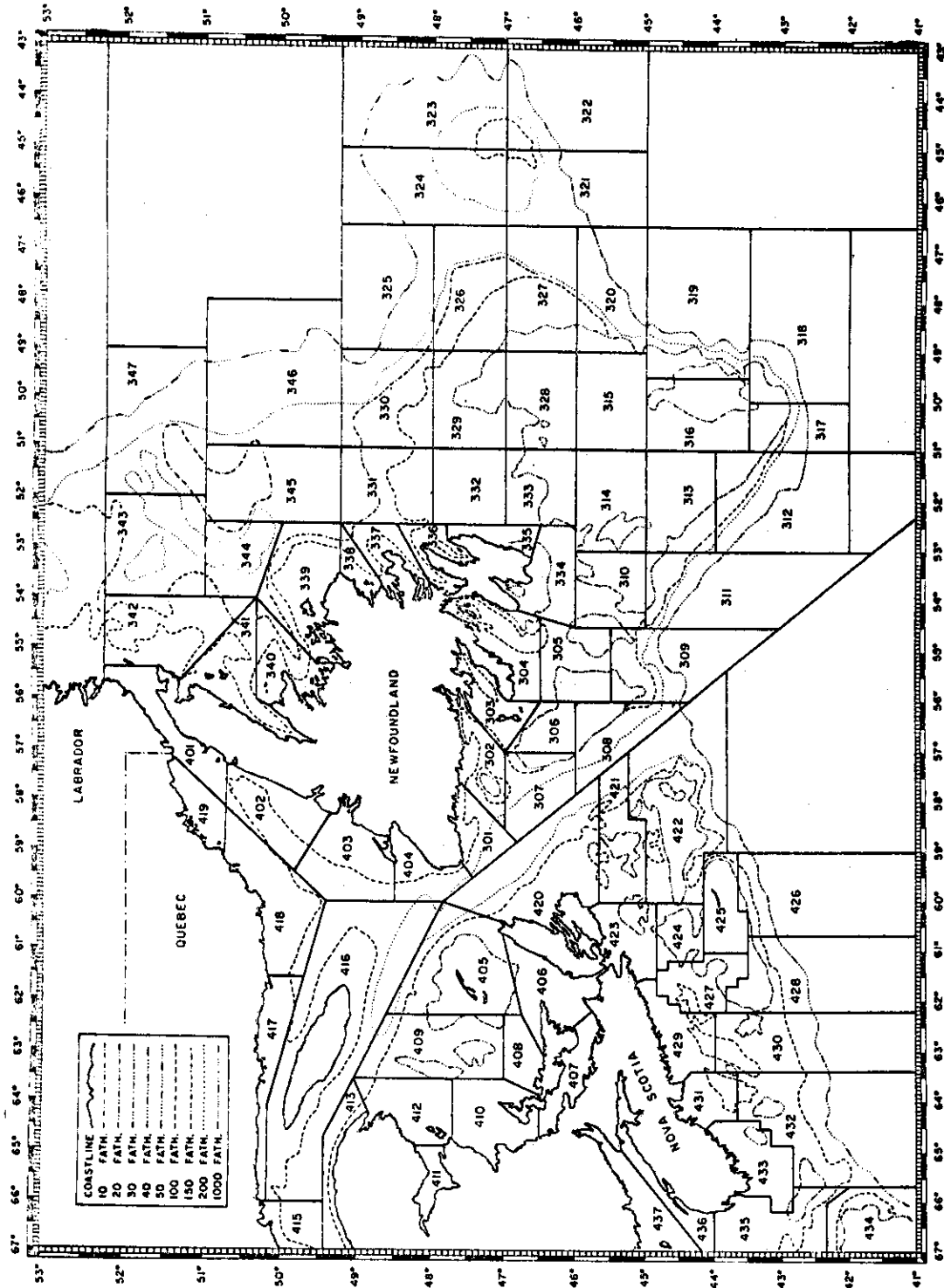


Fig. 4. Statistical unit areas used by the Dept. of Fisheries and Oceans, Canada in the NAFO convention area.

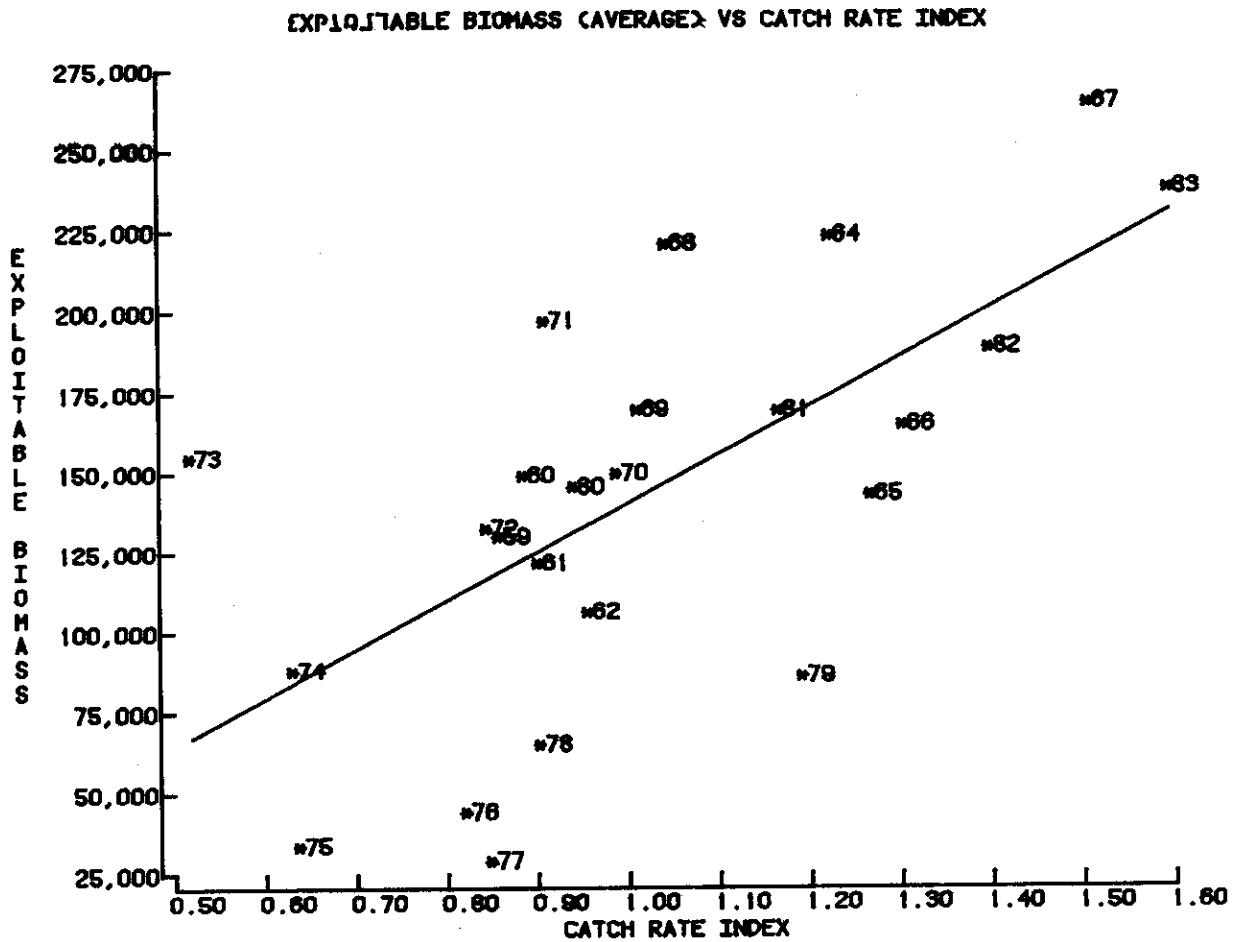


Fig. 5. The relationship of exploitable biomass to cohort rate indices for cod in NAFO Divisions 3NO using a fully recruited fishing mortality of 0.10 in 1983.

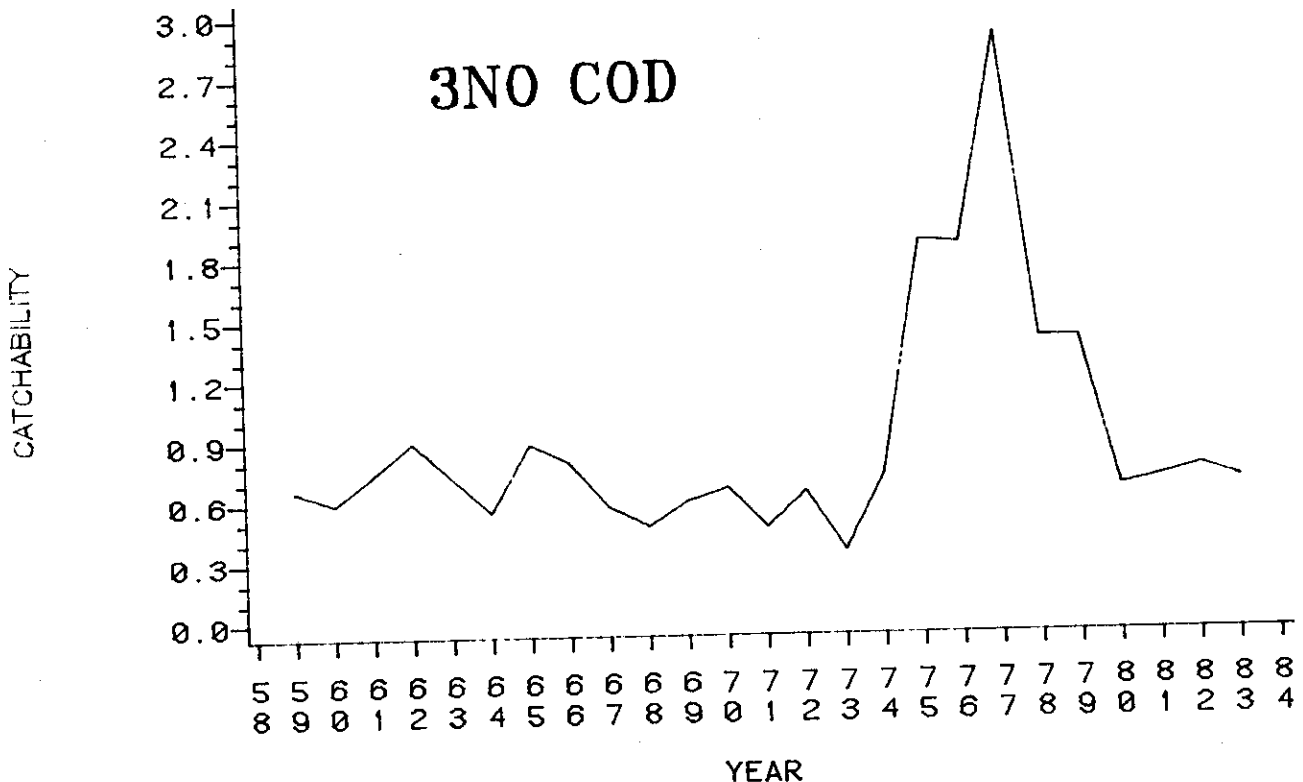


Fig. 6. Catchabilities (CPUE/exp. biomass) for cod in NAFO Divisions 3NO for the period 1959-83.

APPENDIX

Further Assessment of the Cod Stock in Divisions 3NO

Catch information for 1983 provided during the June, 1984 NAFO Scientific Council meeting was included with that previously used and is shown in Table 1. Additional sampling data available from the Spanish pair trawl fisheries in 1982 and 83 were combined with existing catch at age matrices (Table 2).

A cohort analysis having a fully recruited fishing mortality of 0.15 was considered appropriate to the fishery in 1983. The results of this analysis in terms of population numbers, mid year population biomass and fishing mortality are shown in Tables 3-5.

Table 6 indicates the relationships of catch rate indices from a combination of otter trawl and pair trawl as well as that from pair trawl with exploitable biomass from cohort analyses using a range of values for fully recruited fishing mortality.

Table 1. Catch (metric tons) of cod in NAFO Divisions 3NO.

Year	Canada	Spain	Portugal	USSR	Others	Total
1953	39,884	12,633	7,919	-	5,761	66,197
1954	17,392	88,674	24,045	-	4,650	134,761
1955	6,053	64,987	27,711	-	15,605	114,356
1956	5,363	42,624	15,505	-	1,390	64,882
1957	9,641	51,990	21,740	-	6,819	90,190
1958	4,812	29,436	11,608	-	2,195	48,051
1959	3,687	39,994	17,730	48	2,911	64,370
1960	3,408	33,972	14,347	24,204	3,746	79,677
1961	5,428	32,284	9,059	22,854	3,099	72,724
1962	3,235	17,413	3,653	7,971	2,712	34,984
1963	5,079	37,632	10,004	10,184	6,843	69,742
1964	2,882	37,185	8,095	9,510	6,789	64,461
1965	4,229	64,652	1,692	17,166	11,448	99,187
1966	6,501	52,533	5,070	39,023	5,792	108,919
1967	3,446	77,948	9,703	118,845	16,842	226,784
1968	3,287	69,752	6,752	78,820	6,900	165,511
1969	3,664	71,160	4,940	29,173	8,768	117,705
1970	4,771	67,034	3,185	28,338	8,233	111,561
1971	2,311	89,915	6,589	19,307	8,174	126,296
1972	1,736	76,324	11,537	12,198	1,579	103,374
1973	1,832	42,403	7,759	27,849	586	80,429
1974	1,360	38,338	6,602	26,911	178	73,389
1975	1,189	16,616	5,560	20,785	24	44,174
1976	2,065	9,880	2,620	8,992	726	24,283
1977	2,532	8,827	1,742	4,041	462	17,604
1978	6,246	5,813	641	1,819	199	14,718
1979	9,938	13,782	1,140	2,446	545	27,941
1980	5,084	8,999	1,145	3,261	871	19,360
1981	6,096	13,299	1,091	3,187	671	24,344
1982 ^a	10,185	14,361	2,466	3,985	608	31,605
1983 ^a	11,374	12,320	1,109	3,238	220	28,261

^aProvisional

Table 2. Catch numbers at age from the commercial cod fishery in Div. 3N0 over the period 1959-83.

		CATCH AT AGE											
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	
3	1711	1846	812	1026	313	6202	1013	753	20086	16359	8154	2105	
4	13034	3503	4400	3892	5757	15555	7411	18413	62442	56775	12924	17703	
5	5068	22050	11694	2264	11210	19496	7619	19681	50317	48608	24949	12789	
6	6025	3095	15258	1581	4849	7919	13258	11795	18517	18485	11191	9481	
7	3935	2377	2014	3574	1935	2273	9861	6486	4774	6337	2089	3646	
8	1392	2504	1672	773	3840	1109	4827	4467	4651	1592	1393	1635	
9	757	583	847	668	1165	788	1381	1827	236	505	518	541	
10	926	387	176	433	608	328	1248	1694	180	178	292	149	
11	1220	898	25	226	322	37	163	122	71	90	134	221	
12	103	242	245	216	208	112	141	57	45	45	202	90	
3+	34173	40485	37165	14605	30207	53819	46822	67297	141319	148974	63846	48376	
4+	32463	38639	36353	13579	29894	47617	45609	66544	141233	132815	55692	46271	
5+	19426	32136	31953	9597	24137	32062	38198	48131	78791	75840	42768	26556	
6+	14358	10086	20257	7491	12927	12566	30579	28450	28474	27232	15819	15769	
AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	950	69	10058	6425	671	4054	607	920	72	280	478	305	1179
4	26900	19797	27600	9501	8781	7534	2467	4337	3927	1138	1032	1978	647
5	30300	12289	15098	10907	3528	5945	2531	2518	9208	3789	1174	1591	1893
6	11700	13432	5989	10872	2505	1084	1500	818	2784	2057	2173	1012	1204
7	3500	5883	1971	2247	3057	211	572	354	693	665	1805	1528	686
8	2500	1686	972	2147	1059	238	177	102	265	185	543	1492	1152
9	500	395	707	1015	921	44	209	58	58	75	182	595	774
10	200	216	243	576	461	37	65	51	17	27	89	211	238
11	100	78	137	428	252	13	41	8	12	7	39	162	81
12	50	74	116	257	152	9	25	5	7	13	12	27	41
3+	76700	53809	62891	44475	21387	17169	8196	9171	17133	8236	7547	8901	7895
4+	75750	53740	52833	38050	20716	15115	7589	8251	17061	7956	7069	8596	4716
5+	48850	33943	35333	28549	11935	7581	5120	3914	13234	6818	6037	6618	6069
6+	18550	21654	10135	17642	8407	1636	2589	1396	4026	3029	4843	5027	4176

Table 3. Population number from a cohort analysis on cod in NAFO Div. 3N0 using a fully recruited F = 0.15.

		POPULATION NUMBERS										
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	
3	53673	52379	81955	107685	78129	111687	163347	210082	192210	100563	127850	
4	93903	42354	41214	36355	87237	63682	85830	132002	171319	131825	87531	
5	19549	65086	28793	29762	50923	66214	38064	63385	91413	33764	56597	
6	16663	11419	33336	12990	22371	31467	36071	24270	34087	29314	24598	
7	12142	8191	6549	13487	9205	13928	18597	17745	9199	11153	7274	
8	4723	6380	4555	3539	7790	5786	9347	6304	7014	3211	3398	
9	3388	2607	2958	2217	2198	3904	3733	3285	1119	1534	1108	
10	3100	2024	1607	1655	1218	746	1664	2079	1034	703	799	
11	2327	1701	1307	1139	963	441	314	233	169	684	416	
12	311	801	580	1047	728	497	328	109	81	74	479	
3+	209648	192942	202854	239887	260653	297352	356795	457694	498645	362826	290094	
4+	156026	140563	120898	132202	182526	185665	194448	248612	315434	262263	162239	
5+	62123	98209	79684	65837	95289	121982	108618	117610	144116	130438	94709	
6+	42574	33123	50892	36075	44466	55768	70554	54225	52702	46673	38150	
AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
3	80313	84468	62208	35192	37875	24243	30647	55075	45306	17685	21660	
4	97301	63850	68297	50869	19712	25196	19241	21423	44542	36261	14414	
5	43596	61835	27936	38004	16675	7542	12683	8936	15306	32544	26225	
6	21921	25922	23210	11753	17454	3785	2982	5005	5026	10253	18313	
7	10013	9368	10637	6849	4203	4452	831	1461	2740	3375	5875	
8	4066	4899	4503	3385	3824	1408	879	489	679	1923	1964	
9	1521	1849	1749	2161	1892	1188	195	504	240	463	1335	
10	504	756	1062	1174	1130	631	139	119	224	144	327	
11	390	278	438	674	741	313	99	81	39	137	103	
12	218	114	137	288	428	220	29	70	29	25	101	
3+	259843	253340	200176	150349	103933	68975	67725	93164	114132	102811	90318	
4+	179530	168872	137968	115157	66058	44733	37078	38088	68825	95126	68658	
5+	82229	105022	69671	64287	46346	19537	17937	16655	24283	48865	54244	
6+	38633	43187	41735	26284	29672	11995	5154	7729	8977	16321	28018	
AGE	1981	1982	1983									
3	28075	12161	96988									
4	17480	22553	9681									
5	10772	13378	16675									
6	18043	7739	9513									
7	13132	12806	5420									
8	4269	9118	9102									
9	1441	2954	6116									
10	1025	1015	1880									
11	243	759	640									
12	78	144	475									
3+	94497	82647	156490									
4+	66422	76486	59502									
5+	48942	47933	49822									
6+	38171	34555	33146									

Table 4. Mid-year population biomass from a cohort analysis on cod in NAFO Divisions 3NO using a fully recruited F = 0.15.

POPULATION BIOMASS (AVERAGE)											
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	20062	19561	31032	40783	29677	41241	61594	126429	103033	54750	73843
4	64455	28814	28846	47764	62519	40819	60714	112677	124812	90725	55787
5	18902	59317	24818	32363	50468	62418	38314	72284	83540	73877	55911
6	23263	17081	42773	21429	34744	47718	51917	36195	47831	36846	37810
7	25250	17474	13792	29270	20765	32387	32044	40145	19627	22510	19028
8	12073	15092	11007	9546	16786	15882	19651	13917	16729	9442	10835
9	10401	8228	8931	8619	5348	8863	11246	12696	5834	7348	5204
10	10908	7670	6363	5983	3566	2335	3409	6163	6862	4421	4620
11	7513	5468	6153	4819	3701	2002	1018	1429	1144	5717	3038
12	1409	3714	2442	5186	3413	2433	1370	502	569	493	3847
3+	194247	182419	176157	203762	230987	256100	280378	421717	409981	306129	269924
4+	174185	162858	145124	169779	201310	214859	218784	276289	306948	251380	196081
5+	109720	134045	116279	115216	138791	174040	158070	183612	182135	130655	140294
6+	90818	74727	91461	82852	88323	111622	119756	111348	98595	86778	84382
AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	47366	50224	37190	17628	20530	14286	17002	28285	29244	10396	13842
4	79797	44316	52712	31271	12921	18594	13705	18194	40141	30353	13005
5	52015	60309	28597	40406	13297	7519	12634	10056	19547	34403	36977
6	34405	39981	31234	17107	22175	4537	4968	9324	9328	16432	38948
7	24681	22913	21852	17906	8817	7599	2225	3581	8631	7480	18434
8	13054	14190	14803	11910	10463	2845	3130	1659	2601	5961	9272
9	7136	9253	9404	10369	7486	3191	1004	2477	1165	1858	9361
10	3079	4719	6909	7623	5157	3328	869	633	1280	875	2609
11	2230	1982	3557	5381	4263	1182	830	590	297	945	950
12	1765	903	986	2354	2867	1302	250	573	305	190	1078
3+	265529	248790	207245	161955	107975	63384	56617	75372	112539	108893	144477
4+	218162	198567	170055	144327	87446	49098	39615	47087	83295	98497	130636
5+	138365	154251	117343	113056	74525	30504	25910	28894	43154	68144	117631
6+	86350	93942	88745	72650	61228	22985	13276	18838	23606	33741	80654
AGE	1981	1982	1983								
3	22692	10221	74233								
4	19479	22776	9895								
5	16876	17004	26516								
6	41091	14324	21110								
7	39063	41552	17379								
8	18893	39541	39936								
9	8666	17805	32353								
10	8055	7155	12820								
11	1810	5947	4855								
12	655	1658	4409								
3+	177279	177982	243506								
4+	154587	167761	169273								
5+	135108	144985	159378								
6+	118232	127981	132861								

Table 5. Fishing mortalities from a cohort analysis on cod in NAFO Div. 3NO using a fully recruited F = 0.15.

FISHING MORTALITY														
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	0.036	0.040	0.011	0.011	0.004	0.063	0.007	0.004	0.129	0.198	0.073	0.029	0.013	0.001
4	0.167	0.186	0.126	0.067	0.076	0.315	0.103	0.167	0.516	0.646	0.238	0.253	0.627	0.386
5	0.338	0.469	0.596	0.085	0.279	0.394	0.250	0.420	0.937	1.025	0.748	0.320	0.780	0.666
6	0.510	0.356	0.705	0.144	0.274	0.326	0.512	0.770	0.917	1.194	0.699	0.650	0.691	1.020
7	0.443	0.387	0.415	0.349	0.264	0.199	0.882	0.739	0.852	0.989	0.382	0.515	0.333	0.945
8	0.394	0.569	0.520	0.276	0.787	0.238	0.846	1.529	1.320	0.784	0.604	0.588	0.830	0.534
9	0.292	0.284	0.380	0.405	0.881	0.357	0.386	0.955	0.265	0.452	0.657	0.499	0.355	0.199
10	0.401	0.237	0.145	0.341	0.810	0.666	1.764	2.310	0.214	0.328	0.517	0.395	0.346	0.255
11	0.866	0.876	0.021	0.248	0.461	0.097	0.854	0.862	0.624	0.157	0.442	1.031	0.506	0.219
12	0.451	0.402	0.619	0.257	0.376	0.284	0.635	0.837	0.931	1.074	0.618	0.600	0.652	0.883
AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983			
3	0.380	0.208	0.031	0.158	0.012	0.023	0.005	0.014	0.019	0.028	0.014			
4	0.915	0.761	0.486	0.567	0.136	0.114	0.124	0.091	0.067	0.102	0.077			
5	0.578	1.283	0.728	0.730	0.375	0.201	0.375	0.174	0.131	0.141	0.134			
6	0.828	1.166	1.316	0.514	0.402	0.198	0.357	0.133	0.143	0.156	0.150			
7	0.383	0.894	1.422	0.330	0.567	0.154	0.341	0.134	0.165	0.141	0.150			
8	0.382	0.969	1.779	0.355	0.511	0.182	0.165	0.110	0.154	0.199	0.150			
9	0.449	0.899	1.943	0.288	0.612	0.310	0.149	0.064	0.150	0.252	0.150			
10	0.260	1.082	1.649	0.347	0.919	0.290	0.140	0.096	0.101	0.261	0.150			
11	0.255	1.016	2.195	0.156	0.826	0.257	0.102	0.078	0.195	0.269	0.150			
12	0.580	1.055	1.374	0.423	0.500	0.211	0.372	0.152	0.186	0.200	0.150			

Table 6. Results of regressions used for tuning cohort.

F_T	0.1	0.15	0.2	0.3	0.4	0.5
<u>Combined catch rate vs average exploit. biomass</u>						
Slope	165,358	119,074				
Intercept	-20,100	16,368				
R ²	0.48	0.30				
81 residual	18,956	-11,118				
82 residual	9,530	-25,600				
83 residual	6,335	-38,248				

<u>Spanish pair trawl catch rate vs average exploit. biomass</u>						
Slope			130,058	134,895	137,813	
Intercept			23,481	17,726	14,256	
R ²			0.63	0.65	0.65	
80 residual			36,269	32,126	29,679	
81 residual			430	-8,378	-13,624	
82 residual			18,640	6,607	-588	