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SCIENTIFIC COUNCIL MEETING - JUNE 1983

An Assessment of the Cod Stock in NAFO Divisions 3NO

by

C. A. Bishop and S. Gavaris

Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans
P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Data presented in Table 1 indicate the relationships of catch rate indices from each of otter trawl (A) and pair trawl (B) with exploitable biomass from cohort analyses using a range of values for fully recruited fishing mortality.

Tables 2 to 4 show population numbers and biomass along with fishing mortality values from a cohort analysis using $F_t = 0.25$. Projections of population size to 1984 were obtained using data presented in Table 5. Recruitment at age 3 in 1983 was estimated at 25 million based on survey abundance while that for age 3 in 1984 was assumed as 35 million, the geometric mean recruitment over the period 1972-80 as calculated from the cohort analysis. Other assumptions include a catch of 26,000 t in 1983 and a fishing mortality in 1984 at $F_{0.1} = 0.18$. The results of this projection (Table 6) indicated that the 1984 mid-year age 3+ biomass would be approximately 194,000 t.

Table 1. Results from regression analyses of exploitable biomass versus catch rate indices from otter trawl (A) and Spanish pair trawl (B) for cod in NAFO Divisions 3NO for the period 1959-82.

	F_t .05	F_t .30	
A.			
R^2	.27	.10	
Intercept	-46320	63398	
Slope	220872	60179	
1980 residual	207363	-31464	
1981 residual	244457	-43330	
1982 residual	303871	-57228	
	F_t .30	F_t .40	
B.			
R^2	.63	.67	.68
Intercept	22126	11501	5143
Slope	104245	111372	115636
1980 residual	38553	31052	26583
1981 residual	9811	-4764	-13472
1982 residual	27833	9773	-1075

Table 2. Population numbers from a cohort analysis for cod in NAFO Divisions 3NO using a fishing mortality of 0.25 in 1982 for the fully recruited ages.

POPULATION NUMBERS										
AGE	1	1959	1960	1961	1962	1963	1964	1965	1966	1967
3	1	53623	52379	81956	107685	78128	111687	162347	210082	183210
4	1	93903	42354	41214	66365	87237	63682	85830	132002	171319
5	1	19549	65086	28793	29762	50823	66214	38064	63385	91413
6	1	16663	11419	33336	12990	22371	31467	36571	24270	34087
7	1	12142	8191	6549	13487	9205	13928	18597	17945	9198
8	1	4723	6380	4555	3539	7790	5786	9347	6304	7014
9	1	3308	2607	2958	2217	2198	2904	3733	3285	1119
10	1	3100	2024	1607	1655	1210	746	1664	2079	1034
11	1	2327	1701	1307	1139	963	441	314	233	169
12	1	311	801	580	1047	728	497	328	109	81
3+	1	209648	192942	202854	239887	260653	297352	356795	459694	498645
4+	1	156026	140563	120898	132202	182526	185665	194448	249612	315434
5+	1	62123	98209	79684	65837	95289	121982	108618	117610	144116
6+	1	42574	33123	50892	36075	44466	55768	70554	54225	52702
AGE	1	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	1	100581	127888	80369	84820	62461	34712	36061	23592	30566
4	1	131825	67547	97327	63896	68585	51077	19319	23710	18708
5	1	83764	56557	43608	61657	27973	38240	16845	7220	11467
6	1	29314	24598	21921	25932	33228	11783	17647	3922	2719
7	1	11153	7274	10013	9368	10645	6863	4228	4610	945
8	1	3211	3398	4066	4899	4503	3392	3836	1429	1009
9	1	1534	1189	1521	1849	1749	2161	1898	1198	211
10	1	703	799	504	756	1062	1174	1130	635	147
11	1	684	414	390	278	438	674	741	313	103
12	1	74	479	218	114	137	286	428	220	29
3+	1	362844	290142	259938	253770	200781	150364	102131	66849	65906
4+	1	262263	162255	179569	168950	138320	115652	66071	43258	35338
5+	1	130438	94708	82242	105054	69735	64575	46752	19547	16630
6+	1	46673	38150	38633	43197	41762	26336	29907	12327	5163
AGE	1	1977	1978	1979	1980	1981	1982			
3	1	53297	37390	15495	16064	17525	1838			
4	1	21359	43086	29780	12621	12899	13916			
5	1	8500	15253	31352	20919	9304	9627			
6	1	4009	4669	10210	17337	13698	6537			
7	1	1245	1925	3082	5840	12333	9249			
8	1	582	502	1253	1725	4180	8464			
9	1	610	317	319	788	1245	2931			
10	1	133	311	207	208	578	854			
11	1	87	50	208	154	146	392			
12	1	73	34	34	160	120	84			
3+	1	89896	103537	91943	75816	72027	53893			
4+	1	36599	66147	76447	59752	54502	52055			
5+	1	15240	23061	46668	47131	41603	38139			
6+	1	6740	7808	15316	26212	32299	26512			

Table 3. Mid-year population biomass from a cohort analysis for cod in Divisions 3NO using a fishing mortality of 0.25 in 1982 for the fully recruited ages.

POPULATION BIOMASS (MID-YEAR)										
AGE		1959	1960	1961	1962	1963	1964	1965	1966	1967
3	1	20062	19561	31032	40783	29677	41241	61594	125428	103033
4	1	64465	28814	28846	47784	62519	40819	60714	112677	124812
5	1	18902	59317	24818	32363	50468	62418	38314	72264	83540
6	1	23263	17081	42773	21429	34744	47718	51017	36195	47831
7	1	25250	17474	13792	29270	20765	32389	32044	40145	19627
8	1	12073	15092	11007	9546	16786	15882	19651	13917	16729
9	1	10401	8228	8931	6619	5348	8863	11246	12698	5834
10	1	10908	7670	6363	5983	3566	2335	3409	6163	6862
11	1	7513	5468	6153	4819	3701	2002	1018	1429	1144
12	1	1409	3714	2442	5186	3413	2433	1370	802	569
3+	1	194247	182419	176157	203762	230987	256100	280378	421717	409981
4+	1	174185	162858	145124	162979	201310	214859	218784	296289	306948
5+	1	109720	134045	116279	115216	138791	174040	158070	183612	182135
6+	1	90818	74727	91461	82852	88323	111622	119756	111348	98595
AGE		1968	1969	1970	1971	1972	1973	1974	1975	1976
3	1	54761	73863	47400	50434	37342	17337	19440	13897	16955
4	1	90725	55802	79822	44359	52982	31476	12539	17191	13198
5	1	73877	55911	52033	60341	28651	40742	13566	7052	10858
6	1	36846	37810	34405	40004	31275	17175	22630	4873	4397
7	1	22510	19028	24681	22913	21880	17953	8901	8177	2584
8	1	9442	10835	13054	14190	14803	11939	10517	2956	3679
9	1	7348	5204	7136	9253	9404	10369	7522	3269	1104
10	1	4421	4620	3079	4719	6909	7623	5157	2371	929
11	1	5717	3036	2230	1982	3557	5381	4263	1182	864
12	1	493	3847	1765	903	986	2354	2867	1302	250
3+	1	306140	269958	265604	249099	207789	162350	107403	62268	54819
4+	1	251380	196095	218204	198665	170448	145013	87962	48372	37864
5+	1	160655	140294	138382	154305	117466	113536	75424	31181	24666
6+	1	86778	84382	86350	93964	88815	72794	61857	24129	13809
AGE		1977	1978	1979	1980	1981	1982			
3	1	27366	24077	9106	10241	14086	1551			
4	1	18135	38754	24587	11314	14202	13884			
5	1	9463	19473	32883	28822	14424	11819			
6	1	7045	8597	16349	36733	30474	11581			
7	1	2872	5860	6711	18316	36485	28526			
8	1	2067	1860	3715	8079	18753	35852			
9	1	3182	1596	1234	5407	7396	17676			
10	1	750	1851	1280	1618	4360	6054			
11	1	663	394	1459	1442	1014	3103			
12	1	606	368	275	1744	1041	835			
3+	1	72150	102830	97599	123717	142235	130881			
4+	1	44784	78753	88493	113476	128149	129330			
5+	1	26649	39999	63904	102162	113946	115446			
6+	1	17186	20526	31023	73340	99522	103628			

Table 4. Fishing mortalities from cohort analysis for cod in Divisions 3NO using a fishing mortality of 0.25 in 1982 for fully recruited ages.

Table 5. Data used in a projection for Division 3NO cod.

Age	Pop ⁿ 1982 (#sX10 ⁻³)	Catch 1982 (#sX10 ⁻³)	Partial recruitment	Average weight (kg) (1981-82)
3	25,000	33	0.08	0.92
4	28,200	1,513	0.51	1.22
5	9,627	1,694	0.86	1.67
6	6,537	1,316	1.00	2.44
7	9,249	1,862	1.00	3.69
8	8,464	1,704	1.00	5.30
9	2,931	590	1.00	7.31
10	854	172	1.00	8.95
11	392	79	1.00	9.42
12	84	17	1.00	11.22

Table 6. Results of a projection for cod in Divisions 3NO

POPULATION NUMBERS				POPULATION BIOMASS (AVERAGE)			
	1982	1983	1984		1982	1983	1984
3+1	25000	25000	35000	3+1	20831.39	20701.06	28982.18
4+1	28200	20438	20175	4+1	30281.39	21623.15	21347.24
5+1	9627	21723	15261	5+1	13158.45	30532.08	21455.18
6+1	6537	6357	15226	6+1	12870.64	12927.32	30972.13
7+1	9249	4168	4345	7+1	27482.92	12792.11	13337.72
8+1	8464	5897	2849	8+1	36089.61	25971.43	12548.94
9+1	2931	5397	4031	9+1	17253.66	32811.46	24511.65
10+1	854	1869	3688	10+1	6154.58	13911.94	27463.54
11+1	392	544	1277	11+1	2971.59	4263.45	10004.84
12+1	84	250	372	12+1	758.09	2330.73	3471.88
3+1	91338	91644	102224	3+1	167852.11	177864.73	194095.30
4+1	66338	66644	67224	4+1	147020.82	157163.67	165113.13
5+1	38138	46205	47049	5+1	116739.53	135540.52	143765.89
6+1	28511	24483	31788	6+1	103581.08	105008.44	122310.70
CATCH BIOMASS				FISHING MORTALITY			
	1982	1983	1984		1982	1983	1984
3+1	30	299	417	3+1	0.001	0.014	0.014
4+1	1846	1992	1560	4+1	0.061	0.092	0.092
5+1	2829	4743	3321	5+1	0.215	0.155	0.155
6+1	3218	2335	5575	6+1	0.250	0.181	0.180
7+1	6871	2310	2601	7+1	0.250	0.181	0.180
8+1	9023	4691	2259	8+1	0.250	0.181	0.180
9+1	4313	5926	4412	9+1	0.250	0.181	0.180
10+1	1539	2513	4943	10+1	0.250	0.181	0.180
11+1	744	770	1801	11+1	0.250	0.181	0.180
12+1	191	421	625	12+1	0.251	0.181	0.180
3+1	30603	26000	27714	3+1	0.120	0.110	0.102
4+1	30573	25701	27297				
5+1	28727	23709	25337				
6+1	25898	18966	22016				

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Nominal catch and catch at age

Cod catches from Div. 3NO since 1974, along with corresponding TAC's, are as follows:

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
TAC ('000 tons)	101	88	43	30	15	25	26	26	17 ^b	17 ^b
Catch ('000 tons)	73	44	24	18	15	28	20	24	32 ^a	

^a Provisional.

^b Excludes expected catch by Spain.

Total reported landings in 1982, by country, month, and gear are shown in Table 1. Canadian landings were obtained from the Statistics and Systems Branch of the Department of Fisheries and Oceans, while that for other countries was obtained from NAFO circular letters and/or Flash records. Catches by Spain were estimated by the Regulations and Compliance Branch of the Department of Fisheries and Oceans from surveillance data in 1982 and catch rate data from previous years. The sampling data (Table 2) used to obtain a catch at age for the commercial catch in 1982 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 3. Average weights at age were obtained by applying a length-weight relationship (weight = log length x 3.0879 - 5.2106) to the length frequencies and age length keys. The calculated total catch weight was 30,712 or 97% of the total reported and estimated catch.

Survey data

Biomass estimates from stratified random research surveys in 3N and 30 are shown in Tables 4 and 5 and Fig. 1 and 2. Although all strata were not covered in each year, there would appear to be sufficient coverage in most years and in important strata to provide comparisons. The data suggest that apart from minor yearly fluctuations, there is little or no indication of a change or trend in biomass in the survey period. Mean number per tow estimates for 3NO are shown in Table 6 and Fig. 3. The age composition from the research surveys in 1982 indicate that the 1978 year-class continues to be relatively strong as do the 1980 and 1981 year-classes.

Catch-effort data

Catch and effort information for 1959-80 was obtained from the NAFO (ICNAF) Statistical Bulletin while similar preliminary data for 1981 were provided by the NAFO Secretariat. Data for the Can (N) fleet in 1982 was obtained by the Statistics and Systems Branch of the Department of Fisheries and Oceans. Canada (Maritimes) data were not included due to suspected problems with that information. As in a previous assessment, NAFO SCR Doc. 82/VI/57, and for the same stated reasons certain data points were not included in the determination of catch rate indices.

In the current assessment the catch and effort data from the otter trawl and pair trawl fisheries were not combined and analyzed as a unit using the multiplicative model. Preliminary analyses of these data, using this model, indicated a different seasonal pattern (Tables 7 and 8). Because the model assumes that different catch rate series have similar seasonal patterns it was felt that a combination of these catch rate series would not best represent the data. However, the use of only one of these catch rate series as representative of the stock, for purposes of tuning cohort analyses, was not practical because of problems associated with each data base. The catch rates for the Spanish PT fleet (Table 9, Fig. 4) were used only up to 1976 in the 1982 assessment (NAFO SCR Doc. 82/VI/57) and it is apparent that the 1976 value may also be anomalous. The Can (N) OT fleet, which provides the only OT data in recent years, obtains cod mainly as a by-catch in the flounder fishery such that the directed cod fishery represents a small proportion of the total cod catch. An estimate of catch rate indices, representative of the fishery, was obtained from a combination of indices, obtained from individual analyses of these two gear components. The indices obtained by use of the multiplicative model for OT (Table 10, Fig. 5) and PT were combined and averaged over the period 1959-75 after scaling each of its respective mean for that period. The catch rate indices for the period 1976-82 were those from the Can (N) OT fleet which had been scaled by the 1959-75 mean. This catch rate is indicated in Table 11 and Fig. 6.

Partial selection

Estimates of partial selection in 1982 were obtained from cohort selectivity coefficients which were obtained by dividing fishing mortality by fully recruited fishing mortality for ages 6-10. These values were first estimated from preliminary runs of the cohort. The average of the coefficients (Table 12) for the period 1974-80 (excluding 1976) as obtained from a cohort run at $F_t = 0.15$ was used as the partial selection multiplier for the 1982 catch at age in cohort analyses.

Cohort analysis

Catch and average weight at age data from the commercial fishery over the period 1959-82 (Table 13), along with partial recruitment estimates for 1982, were used in a cohort analysis to obtain population numbers and biomass estimates. The fishing mortality occurring on the last age group (12) in the cohort was estimated as the fully recruited mortality for ages 6-10 using cohort runs at different values of terminal F in 1982.

The relationship between the combined otter trawl-pair trawl catch rate indices and exploitable biomass (mid-year biomass x partial recruitment matrix) was used to determine a terminal F appropriate to the fishery in 1982. The effect of change in terminal F on the biomass for the period 1980-82 in terms of their relationship to the fitted regression line was used as the selection criteria for F_t in 1982. A cohort analysis of $F_t = 0.15$ indicated a balance of positive and negative residuals about the fitted line over the period 1980-82 (Table 14, Fig. 7) with the 1963 point excluded. Inclusion of the apparently anomalous 1963 data points would suggest a slightly higher F_t in 1982. Tables 15-17 indicate population numbers, mid-year population biomass, and fishing mortalities from a cohort analysis at $F_t = 0.15$. The 3+ biomass (Table 16) in 1982 from the cohort at $F_t = 0.15$ is 218,000 tons.

Discussion

Assessments of the 3NO cod stock in recent years indicated that it was in a depressed condition but showed signs of improvement. A cautious approach to exploitation was recommended to permit rebuilding. In 1982 the Fisheries Commission of NAFO (NAFO/FC Doc. 82/IX/14) decided that the TAC for the stock would remain at 26,000 tons until the age 3+ annual mean biomass reached 200,000 tons. The present assessment suggests that this target biomass may be reached but the uncertainties expressed previously (NAFO SCS Doc. 82/IX/22) still exist. These include: lack of sampling data for the Spanish fleet in 1981 and 1982, and fluctuations in catch rates in recent years along with the use in recent years of catch rates only from the Canadian (Nfld.) otter trawl fleet which takes cod mainly as a by-catch in the flounder fishery. Biomass estimates from research surveys do not reflect the increases suggested by the cohort. The results of the cohort analysis may once again be providing an overly optimistic outlook.

Table 1. 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 DFO.

Gear Month	Can(N) OT	3N GN	Can(M) OT	Port. OT	France OT	Can(N) OT	Can(GN) OT	Can(M) OT	30 LL	Port. GN	Japan OT	USSR OT	3NO LL	Den(F) OT	Cuba OT
Jan.															
Feb.	68					659									
Mar.						449									
Apr.	1					122		144	1						
May	192			39		3195	338	1201	7	30		16		446	
June	161	100		32		990	700	364	16	22	116				35
July	240	17	7	308	11	6	212	2		95	24				
Aug.	462			52		5				52					1
Sept.	203			8		16	5	34		38					
Oct.	490			12		36	3			20					
Nov.	212			79		538	2			51					
Dec.	10					140	98	2		59					
2039	117	7	530	11	6156	1250	1873	60	22	461	24	16	3768	35	1

Total = 16370 t.

Table 2. Commercial sampling data for Divisions 3NO cod in 1982.

Gear	Qtr	Country	Div	#	Month	#	Landings (t)	Country/Month	Total
				Aged		Measured			
OT	1	Can(N)	30	411	Feb.	691	659		1320
					Mar.	922	449		1148
		Other							338
									<u>2806</u>
2		Can(N)	30	370	Apr.	145	122		714
					May	3688	3195		3413
		Can(M)			May	201	1201		1208
		Other							1553
									<u>6888</u>
3		Can(N)	3N	229	July	251	240		348
					Sept.	1607	462		607
		Other							548
									<u>1503</u>
4		Can(N)	3N	296	Oct.	3908	490		2780
				<u>1306</u>		<u>11413</u>			<u>13977</u>
LT	2	Den(F)	3NO	187	May	754	35		35
GN	2	Port	3NO	500	June(3N)	1076	32		171
					May(30)	1231	30		368
					June(30)	4991	116		816
3		Port	3NO	329	July(3N)	993	308		325
					Aug(3N)	1028	52		52
					Sept(3N)	211	8		8
		Other							91
									<u>476</u>
		Port			July(30)	1555	95		307
					Sept(30)	392	38		38
		Other							182
									<u>527</u>
A11	1-4	A11	3NO	2322		22890			16370
	1-4	Spain	3NO	-	-	-	-		15400*

*Estimated by Regulations & Compliance Branch of Dept. of Fisheries & Oceans.

Table 3. Estimated average weight and length at age plus catch at age along with the variance of the catch for the commercial fishery in NAFO Division 3NO during 1982.

AGE	WEIGHT (kg)	LENGTH (cm)	CATCH (No. x 10 ⁻³)	VAR(CATCH)	STD. ERROR	COEF. VAR
3	0.944	47.725	33	479.681	21.90	0.67
4	1.173	50.858	1513	5506.777	74.21	0.05
5	1.495	54.898	1694	8273.341	90.96	0.05
6	2.204	62.303	1316	5582.207	74.71	0.06
7	3.829	74.371	1862	5757.218	75.88	0.04
8	5.261	82.507	1704	5484.300	74.06	0.04
9	7.492	92.791	590	2040.325	45.17	0.08
10	8.800	97.855	172	571.595	23.91	0.14
11	9.816	101.162	79	237.236	15.40	0.20
12	12.284	109.014	17	20.285	4.50	0.26
13	14.627	115.349	3	1.576	1.26	0.40
14	13.170	110.742	2	2.454	1.57	0.67
15	16.705	120.976	5	5.238	2.29	0.51
16	19.055	126.277	5	3.654	1.91	0.42
17	20.170	128.126	6	3.627	1.90	0.35
18	17.660	123.091	2	1.748	1.32	0.68
19						
20	20.751	130.000	1	2.630	1.62	1.14
21	13.097	112.000	2	4.811	2.19	1.02
22						
23						
24						
25	16.628	121.000	1	0.557	0.75	1.09

Table 4. Biomass estimates (MT) by stratum from survey cruises in Div. 3N

Strata	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
357			1383				29		52	332	135	92
358		1061	1772				383		483	1054	229	236
359		312	258			660	147		190	478	208	13
360		1966			306	1950	4040	2182	1416	1738	3743	1238
361	2909	4525	2525	350	3246	2618	5894	8203	2666	4173		8125
362	2127	9695	4222	2233	306	1666	6836	6621	1632	5847	8701	3708
373	8159	3423	1855	2362		1031	1750	4300	1838	857	4578	6647
374	501	702	273	0	135		1248	1324	479	0	146	2369
375	3270	9977	1042	955	10601		5429	3598	369	3229	29835	5943
376		1892	806		383	77	9672	102	868	855	2208	2
377		550	14	83	283		1380	130	22	287	428	22
378	530	4146	404	632			687	90	281	939	104	303
379			1828	515			50	0	601	178	53	179
380	9	322	1317	206			52		232	57	25	
381	480	1429	2386	359	122		2677	393	196	427	533	2186
382	142	2458	9	69		42	948	2215	220	285	182	36
383	231	1479	1	16		44	324	1564	146	0	430	5
Total	18357	439356	20096	7781	15381	8088	41546	30722	11692	20736	51538	31104
Upper limit	35959	58509	29260	13257	35224	13399	61360	37915	16334	28150	120675	46068
Lower limit	755	29362	10931	2304	-4462	2776	21732	23529	7051	13322	-17600	16141

Table 5. Biomass estimates (MT) by stratum from survey cruises in Div 30

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

Table 6. Mean number of cod per standard tow from research vessel surveys in NAFO Divisions 3N0.

# 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	0.02	0.04	0	0	0	0.07	0.14	0.05
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 7. Regression coefficients and the analysis of variance from the regression of ln catch rate for cod in Divisions 3NO from 1959-81, using pair trawler data.

Country / Gear		ln power	Month	ln power
ESP	PT-4	0.000	Jan.	
ESP	PT-5	0.432	Feb.	
ESP	PT-6	0.372	Mar.	0.000
			Apr.	
			Sept.	
			Oct.	
Division		ln power	Aug.	0.169
3N			May	
30		0.000	Nov.	0.244
			July	0.360
			June	
			Dec.	0.442

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.820

MULTIPLE R SQUARED....0.673

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.695E0	6.695E0	
REGRESSION	28	2.156E2	7.700E0	46.793
TYPE 1	2	1.533E1	7.664E0	46.575
TYPE 2	4	2.198E1	5.496E0	33.400
TYPE 3	22	2.022E2	9.191E0	55.859
RESIDUALS	637	1.048E2	1.645E-1	
TOTAL	666	3.271E2		

Table 8. Regression coefficients and the analysis of variance from the regression of ln catch rate for cod in Divisions 3NO from 1959-82, using otter trawl data.

Country / Gear	ln power	Month	ln power
CAN-N OT-4	-0.520	Oct.	-0.672
CAN-N OT-5	-0.245	Sept.	-0.425
ESP OT-6	0.000	July	
PRT OT-6	0.240	Aug.	
		Nov.	-0.287
		Dec.	
Division	ln power	Mar.	
3N		Apr.	
30	0.000	May	-0.137
		June	
		Jan.	0.000
		Feb.	0.168

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R 0.502
 MULTIPLE R SQUARED..... 0.252

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.050E2	2.050E2	
REGRESSION	31	8.480E1	2.735E0	5.928
TYPE 1	3	3.093E1	1.031E1	22.344
TYPE 2	5	9.896E0	1.979E0	4.290
TYPE 3	23	4.859E1	2.113E0	4.573
RESIDUALS	546	2.519E2	4.614E-1	
TOTAL	578	5.417E2		

Table 9. Mean catch rate indices for cod in NAFO Divisions 3NO using Spanish PT (TC.4, 5 and 6) data for the period 1959-81.

YEAR	TOTAL CATCH	PROP.	CATCH RATE INDEX		
			MEAN	S.E.	EFFORT
1959	62459	0.578	1.000	0.000	62459
1960	79677	0.386	1.197	0.130	66553
1961	72724	0.437	1.130	0.119	64364
1962	34948	0.430	0.919	0.106	38029
1963	69742	0.373	1.762	0.200	39581
1964	64461	0.495	1.582	0.165	40758
1965	99187	0.630	1.697	0.180	58451
1966	108919	0.455	1.659	0.181	65669
1967	226784	0.302	1.672	0.180	135609
1968	165512	0.418	1.622	0.179	102069
1969	117705	0.601	1.443	0.152	81578
1970	111561	0.595	1.426	0.147	78218
1971	126296	0.711	1.416	0.148	89166
1972	103374	0.730	0.920	0.087	112332
1973	80429	0.527	0.688	0.067	116844
1974	73389	0.522	0.646	0.065	113665
1975	44174	0.370	0.617	0.076	71639
1976	24283	0.407	0.889	0.103	27301
1977	17604	0.488	0.349	0.042	50439
1978	14718	0.385	0.126	0.014	117089
1979	27940	0.481	1.005	0.142	27803
1980	19990	0.443	0.374	0.045	53451
1981	24307	0.547	0.699	0.085	34771

Table 10. Mean catch rate indices for cod in NAFO Divisions 3NO using otter trawl data from 1959 to 1982.

YEAR	TOTAL CATCH	PROP.	CATCH RATE INDEX		
			MEAN	S.E.	EFFORT
1959	62459	0.086	1.000	0.000	62459
1960	79677	0.051	0.986	0.175	80803
1961	72724	0.027	0.999	0.194	72828
1962	34948	0.079	1.614	0.297	21652
1963	69742	0.208	2.137	0.373	32637
1964	64461	0.092	1.443	0.254	44676
1965	99187	0.034	0.910	0.155	109042
1966	108919	0.067	1.530	0.235	71206
1967	226784	0.074	1.816	0.282	124874
1968	165512	0.011	0.915	0.147	180935
1969	117705	0.018	0.967	0.170	121740
1970	111561	0.008	0.982	0.184	113568
1971	126296	0.006	0.813	0.155	155346
1972	103374	0.011	1.047	0.198	98767
1973	80429	0.003	0.698	0.218	115215
1974	73389	0.002	0.516	0.142	142319
1975	44174	0.021	1.021	0.222	43277
1976	24283	0.056	0.749	0.155	32439
1977	17604	0.047	0.813	0.182	21646
1978	14718	0.134	0.939	0.175	15667
1979	27940	0.109	1.293	0.208	21607
1980	19990	0.066	1.129	0.227	17700
1981	24307	0.049	1.415	0.276	17176
1982	31769	0.184	1.573	0.266	20197

Table 11. Catch rate index from a combination of OT and PT indices.

Year	Index	Year	Index
1959	.836	1971	.919
1960	.908	1972	.824
1961	.887	1973	.579
1962	1.073	1974	.483
1963	1.637	1975	.692
1964	1.261	1976	.656
1965	1.073	1977	.713
1966	1.329	1978	.824
1967	1.460	1979	1.134
1968	1.045	1980	.990
1969	.997	1981	1.241
1970	.997	1982	1.379

Table 12. Selectivity coefficients for 3NO cod for 1974-81 with an average (1974-80, omitting 1976), from a cohort run at $F_t = 0.15$.

Table 13. Catch numbers and Average weight at age matrices used in cohort analyses of cod in NAFO Divisions 3NO.

AGE	CATCH NUMBERS ($\times 10^3$)											
	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	13036	6503	4400	3882	5757	15555	7611	18413	62442	56775	12924	19703
5	5068	22050	11696	2206	11210	19496	7619	19681	50317	48608	26949	10799
6	6025	3095	15258	1581	4849	7919	13258	11795	18517	18485	11191	9481
7	3935	2377	2014	3594	1935	2273	9861	8486	4774	6337	2089	3646
8	1392	2504	1672	773	3840	1109	4827	4467	4651	1592	1393	1635
9	757	583	847	668	1165	788	1081	1829	236	505	518	541
10	926	387	196	433	608	328	1248	1694	180	178	292	149
11	1220	898	25	226	322	37	163	122	71	90	134	227
12	103	242	245	216	208	112	141	57	45	45	202	90
AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	950	69	10058	6425	671	4054	607	920	72	280	478	33
4	26900	19797	27600	9501	8781	7534	2469	4337	3827	1138	1032	1513
5	30300	12289	15098	10907	3528	5945	2531	2518	9208	3789	1194	1694
6	11700	13432	5989	10872	2505	1084	1500	818	2784	2057	2173	1316
7	3500	5883	1971	2247	3057	211	572	354	883	665	1805	1862
8	2500	1686	972	2147	1059	238	177	102	265	185	543	1704
9	500	285	707	1015	921	44	209	58	58	75	182	590
10	200	216	243	676	461	37	65	51	17	27	89	172
11	100	78	137	428	252	13	41	8	12	7	39	79
12	50	74	116	257	152	9	25	5	7	13	12	17
AVERAGE WEIGHT (KG.)												
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
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
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
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
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
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
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
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
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
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
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
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	
3	0.66	0.66	0.66	0.66	0.66	0.57	0.72	0.65	0.71	0.90	0.94	
4	1.02	1.02	1.02	1.02	1.02	1.00	1.05	0.98	1.04	1.27	1.17	
5	1.53	1.53	1.53	1.53	1.53	1.48	1.55	1.39	1.69	1.84	1.50	
6	2.33	2.33	2.33	2.33	2.33	2.48	2.25	2.09	2.50	2.69	2.20	
7	3.45	3.45	3.45	3.45	3.45	3.51	3.74	2.87	3.69	3.55	3.83	
8	4.64	4.64	4.64	4.64	4.64	4.74	4.61	3.70	5.49	5.33	5.26	
9	6.52	6.52	6.52	6.52	6.52	7.17	6.19	4.75	7.98	7.13	7.49	
10	8.10	8.10	8.10	8.10	8.10	8.81	7.23	7.15	9.22	9.10	8.80	
11	9.94	9.94	9.94	9.94	9.94	11.70	9.48	7.98	10.60	9.01	9.82	
12	11.77	11.77	11.77	11.77	11.77	11.47	12.87	10.11	12.61	10.15	12.28	

Table 14. Results from regression analyses of exploitable biomass versus catch rate indices for cod in NAFO Divisions 3NO for the period 1959-82 (A-1963 omitted from regression. B-all years included in regression)

A	.12	.15	.20
R ²			
Intercept	-36959	-22082	-7207
Slope	191896	169727	147561
1980			
residual	39942	15959	-8009
1981 residual	25595	-2315	-30211
1982 residual	24411	-10311	-45034
B	.42	.37	.31
R ²			
Intercept	4174	12688	21200
Slope	144872	129978	115086
1980			
residual	45362	20541	-4266
1981 residual	42818	12244	-18316
1982 residual	48124	9734	-28657

Table 15. Population numbers from a cohort analysis for cod in NAFO Divisions 3NO using a fishing mortality of 0.15 in 1982 for fully recruited ages.

AGE	Population Numbers ($\times 10^{-3}$)									
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
3	53623	52379	81956	107685	78128	111687	162347	210082	183210	100581
4	93903	42354	41214	66365	87237	63682	85830	132002	171319	131825
5	19549	65086	28793	29762	50823	66214	38064	63385	91413	83764
6	16663	11419	33336	12990	22371	31467	36571	24270	34087	29314
7	12142	8191	6549	13487	9205	13928	18597	17945	9198	11153
8	4723	6380	4555	3539	7790	5786	9347	6304	7014	3211
9	3308	2607	2958	2217	2198	2904	3733	3285	1119	1534
10	3100	2024	1607	1655	1210	746	1664	2079	1034	703
11	2327	1701	1307	1139	963	441	314	233	169	684
12	311	801	580	1047	728	497	328	109	81	74
3+	209648	192942	202854	239887	260653	297352	356795	459694	498645	362844
4+	156026	140563	120898	132202	182526	185665	194448	249612	315434	262263
5+	62123	98209	79684	65837	95289	121982	108618	117610	144116	130438
6+	42574	33123	50892	36075	44466	55768	70554	54225	52702	46673
AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	127888	80369	84820	62461	35014	37209	25638	36315	66887	49548
4	67547	97327	63896	68585	51077	19566	24650	20384	26064	54213
5	56557	43608	61857	27973	38240	16845	7422	12237	9872	19106
6	24598	21921	25932	23228	11783	17647	3922	2885	4639	5792
7	7274	10013	9368	10645	6863	4228	4610	945	1381	2441
8	3398	4066	4899	4503	3392	3836	1429	1009	582	613
9	1189	1521	1849	1749	2161	1898	1198	211	610	317
10	799	504	756	1062	1174	1130	635	147	133	311
11	414	390	278	438	674	741	313	103	87	50
12	479	218	114	137	288	428	220	29	73	34
3+	290142	259938	253770	200781	150666	103526	70038	74264	110329	132424
4+	162255	179569	168950	138320	115652	66318	44400	37948	43442	82876
5+	94708	82242	105054	69735	64575	46752	19750	17565	17378	28664
6+	38150	38633	43197	41762	26336	29907	12327	5328	7506	9558
AGE	1979	1980	1981	1982						
3	22531	24692	28178	3052						
4	39734	18381	19963	22638						
5	40462	29069	14020	15410						
6	13364	24795	20371	10398						
7	4002	8422	18439	14712						
8	1678	2478	6294	13464						
9	410	1134	1861	4662						
10	207	283	861	1359						
11	208	154	207	624						
12	34	160	120	134						
3+	122629	109568	110314	86453						
4+	100098	84876	82135	83401						
5+	60364	66495	62173	60763						
6+	19903	37426	48153	45353						

Table 16. Mid-year population biomass and fishing mortality from a cohort analysis for cod in Divisions 3NO using a fishing mortality of 0.15 in 1982 for fully recruited ages.

Population Biomass (mid-year) (mt)

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
3	20062	19561	31032	40783	29677	41241	61594	125428	103033	54761
4	64465	28814	28846	47764	62519	40819	60714	112677	124812	90725
5	18902	59317	24818	32363	50468	62418	38314	72264	83540	73877
6	23263	17081	42773	21429	34744	47718	51017	36195	47831	36846
7	25250	17474	13792	29270	20765	32389	32044	40145	19627	22510
8	12073	15092	11007	9546	16786	15882	19651	13917	16729	9442
9	10401	8228	8931	6619	5348	8863	11246	12698	5834	7348
10	10908	7670	6363	5983	3566	2335	3409	6163	6862	4421
11	7513	5468	6153	4819	3701	2002	1018	1429	1144	5717
12	1409	3714	2442	5186	3413	2433	1370	802	569	493
3+	194247	182419	176157	203762	230987	256100	280378	421717	409981	306140
4+	174185	162858	145124	162979	201310	214859	218784	296289	306948	251380
5+	109720	134045	116279	115216	138791	174040	158070	183612	182135	160655
6+	90818	74727	91461	82852	88323	111622	119756	111348	98595	86778
AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	73863	47400	50434	37342	17520	20130	15121	20399	34387	32012
4	55802	79822	44359	52982	31476	12779	18079	14788	22405	49353
5	55911	52033	60341	28651	40742	13566	7346	11985	11324	24899
6	37810	34405	40004	31275	17175	22630	4873	4756	8490	10894
7	19028	24681	22913	21880	17953	8901	8177	2584	3319	7614
8	10835	13054	14190	14803	11939	10517	2956	3679	2067	2326
9	5204	7136	9253	9404	10369	7522	3269	1104	3182	5137
10	4620	3079	4719	6909	7623	5157	2371	929	750	1596
11	3038	2230	1982	3557	5381	4263	1182	864	663	1280
12	3847	1765	903	986	2354	2867	1302	250	606	368
3+	269958	265604	249099	207789	162532	108332	64675	61338	87193	131307
4+	196095	218204	198665	170448	145013	88202	49554	40939	52806	99295
5+	140294	138382	154305	117466	113536	75424	31475	26151	30401	49943
6+	84382	86350	93964	88815	72794	61857	24129	14167	19077	25043
AGE	1980	1981	1982							
3	15793	22776	2585							
4	16746	22337	23140							
5	41342	22299	19698							
6	53652	46775	19301							
7	26961	56166	47543							
8	11829	28980	59754							
9	7910	11386	29461							
10	2241	6699	10091							
11	1442	1515	5172							
12	1744	1041	1392							
3+	179660	219973	218136							
4+	163868	197197	215551							
5+	147121	174860	192411							
6+	105779	152561	172713							

Table 17. Fishing mortalities from a cohort analysis for cod in Divisions 3NO using a fishing mortality of 0.15 in 1982 for fully recruited ages.

AGE	FISHING MORTALITY												
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
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
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
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	0.779
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	0.690
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
8	0.394	0.569	0.520	0.276	0.787	0.238	0.846	1.529	1.320	0.794	0.604	0.588	0.830
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
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
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
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
AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982		
3	0.001	0.382	0.212	0.029	0.132	0.010	0.021	0.004	0.013	0.019	0.012		
4	0.384	0.909	0.769	0.500	0.525	0.111	0.093	0.113	0.071	0.059	0.076		
5	0.665	0.573	1.257	0.745	0.770	0.333	0.157	0.290	0.156	0.099	0.129		
6	1.019	0.825	1.142	1.224	0.537	0.442	0.170	0.262	0.096	0.125	0.150		
7	0.944	0.382	0.885	1.320	0.284	0.612	0.175	0.280	0.091	0.114	0.150		
8	0.534	0.381	0.964	1.711	0.302	0.409	0.203	0.192	0.086	0.100	0.150		
9	0.199	0.449	0.894	1.895	0.261	0.475	0.226	0.170	0.076	0.114	0.150		
10	0.255	0.260	1.082	1.619	0.325	0.775	0.200	0.095	0.111	0.121	0.150		
11	0.219	0.255	1.016	2.195	0.150	0.734	0.193	0.066	0.052	0.233	0.150		
12	0.883	0.580	1.055	1.374	0.423	0.473	0.175	0.257	0.094	0.117	0.150		

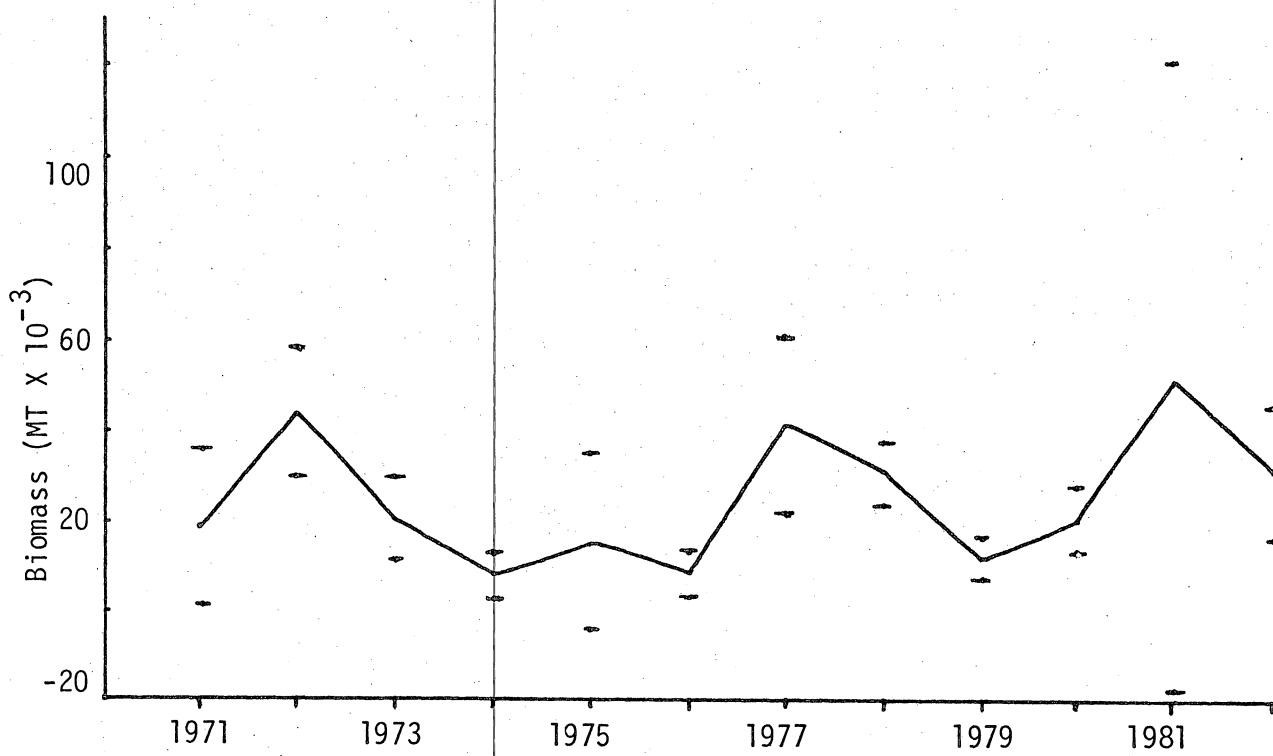


Fig. 1. Biomass estimates with their associated confidence limits for cod in Division 3N.

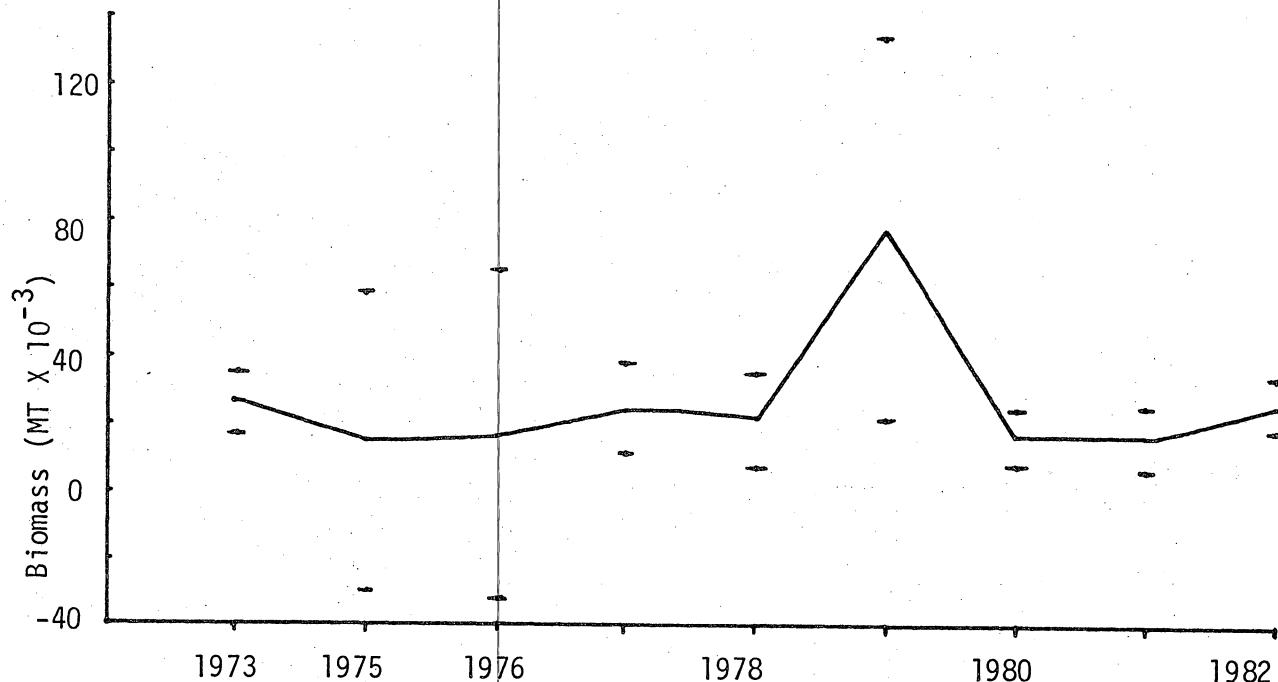


Fig. 2. Biomass estimates with their associated confidence limits for cod in Division 30.

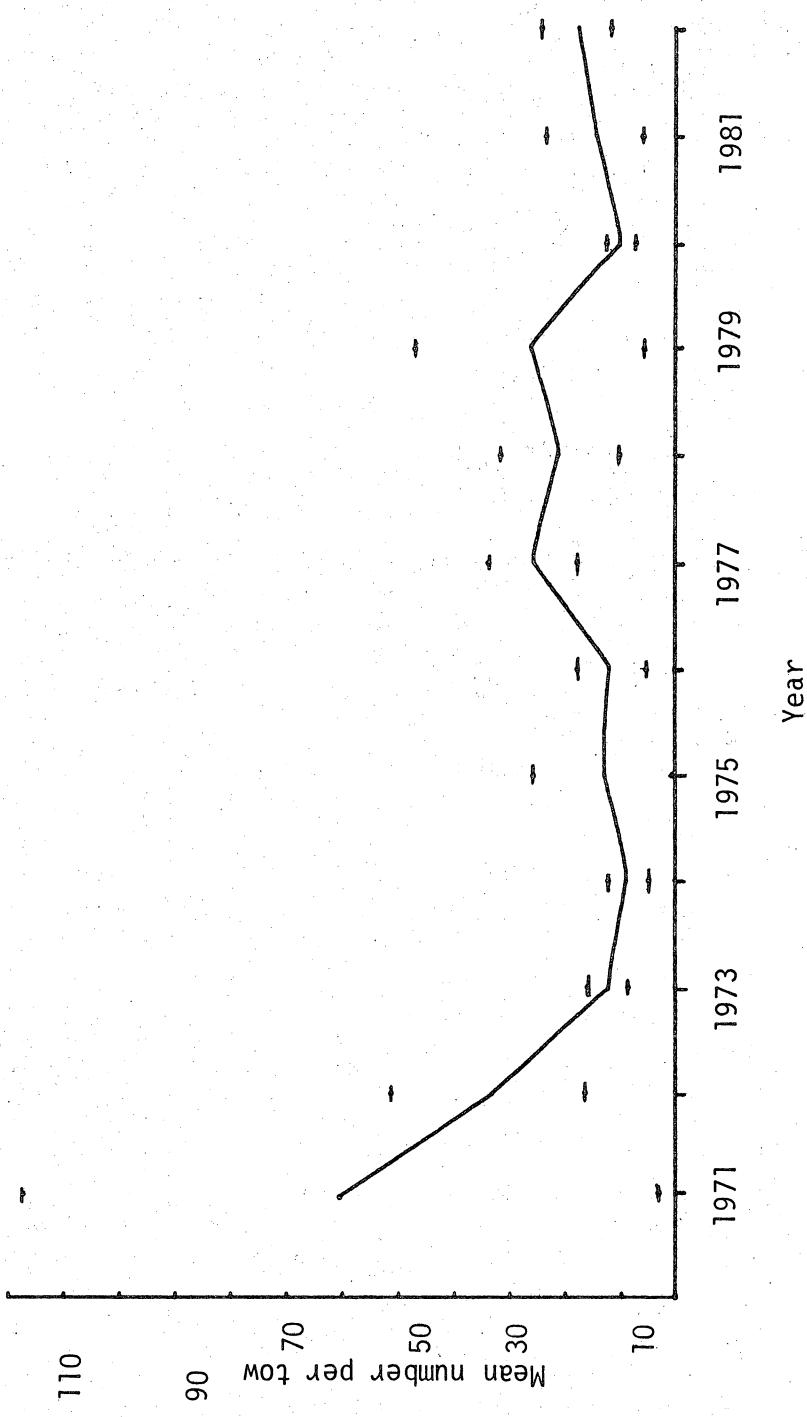


Fig. 3. Mean number of cod per tow from research surveys in Divisions 3NO with associated confidence limits.

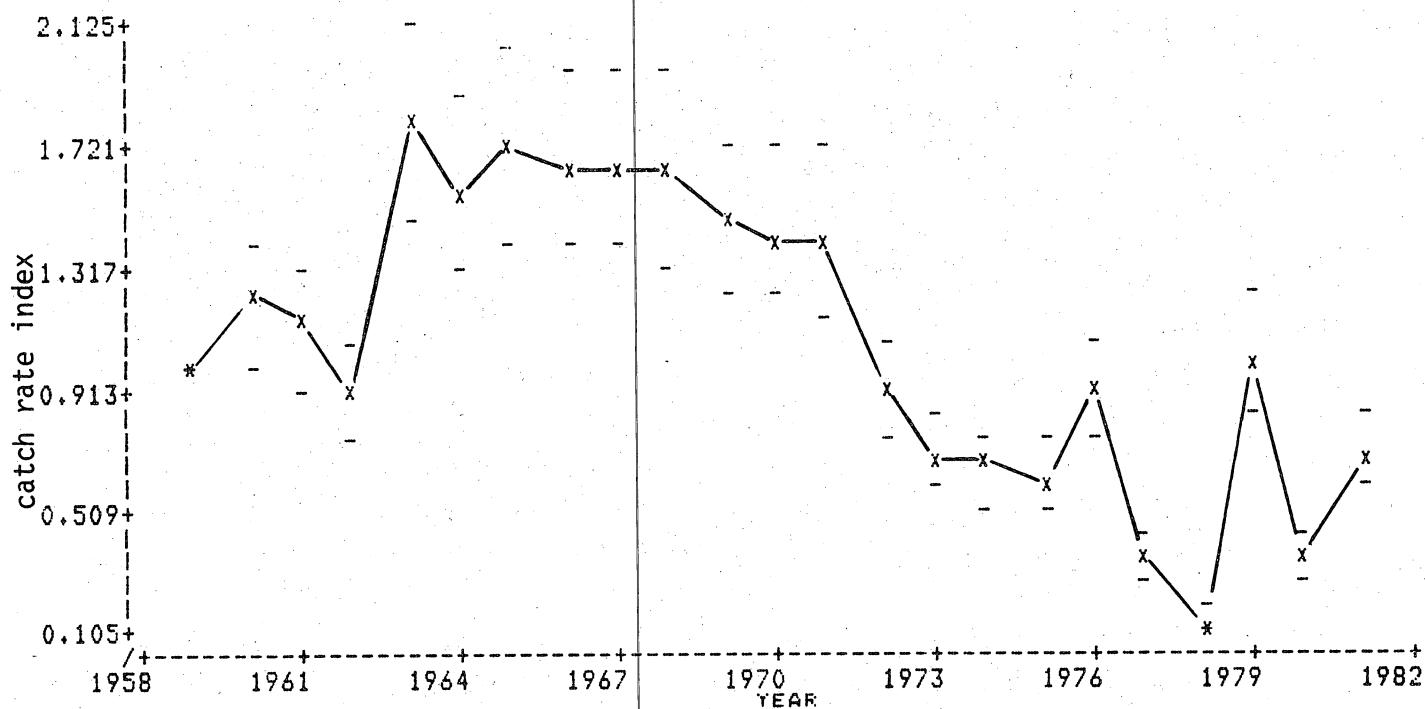


Fig. 4. Relative catch rate index by Spanish PT with approximate 90% confidence interval for cod in NAFO Divisions 3NO.

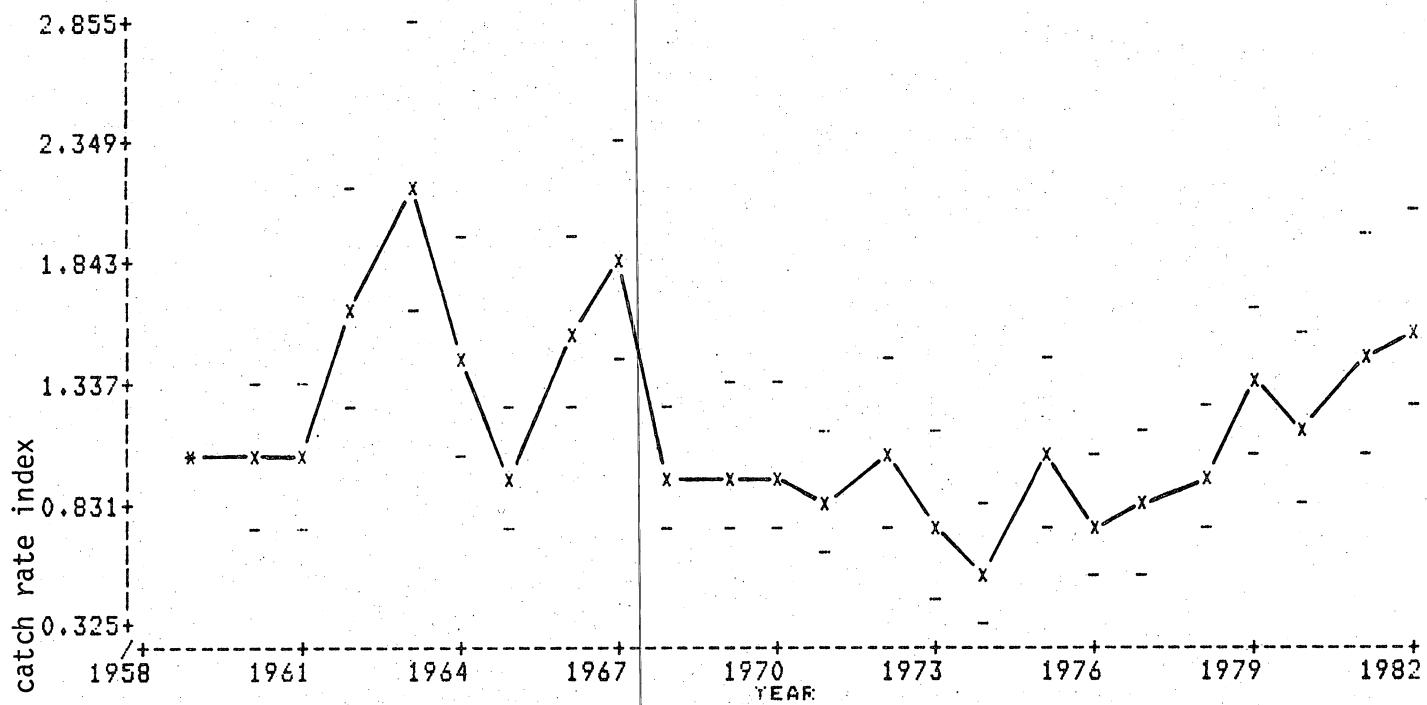


Fig. 5. Relative catch rate index by otter trawl with approximate 90% confidence interval for cod in NAFO Divisions 3NO.

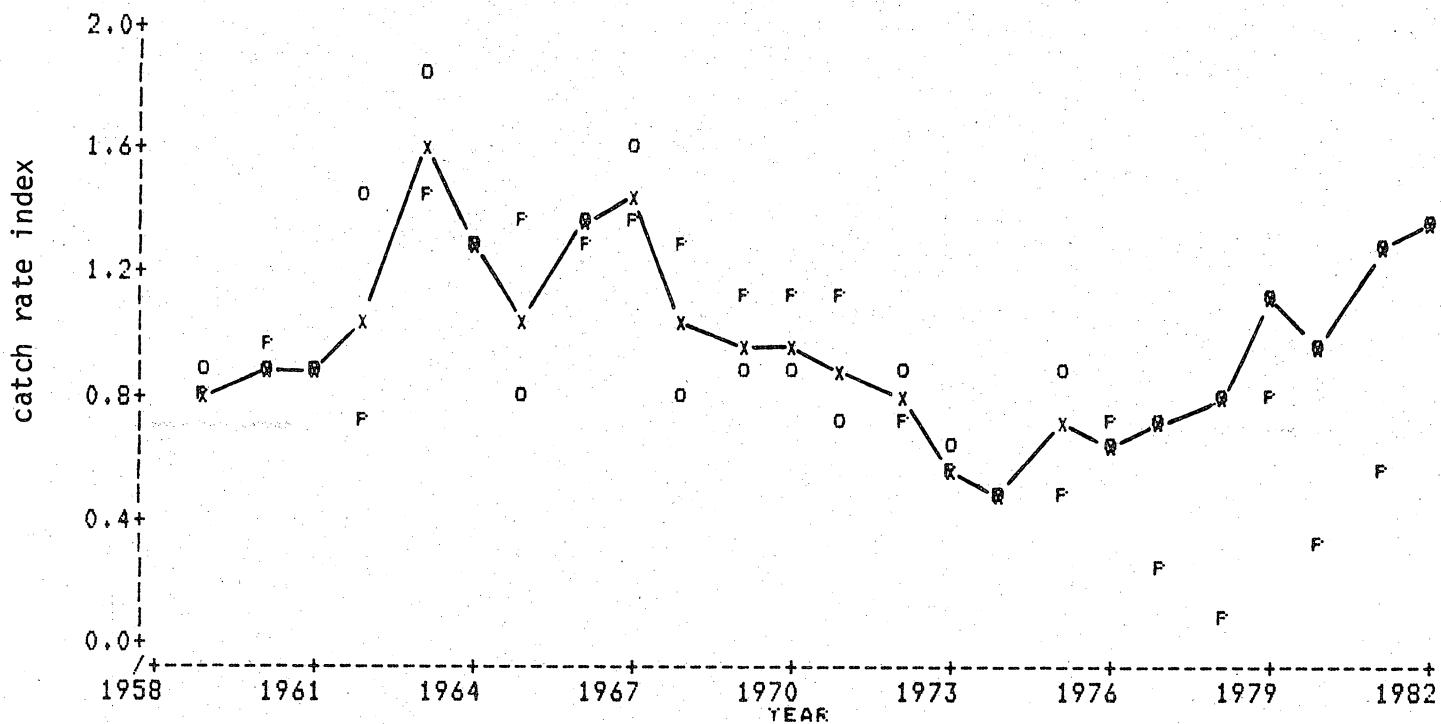


Fig. 6. Catch rate index (x) for cod in Div. 3NO obtained from a combination of otter trawl (o) catch rates and pair trawl (P) catch rates from 1959-82.

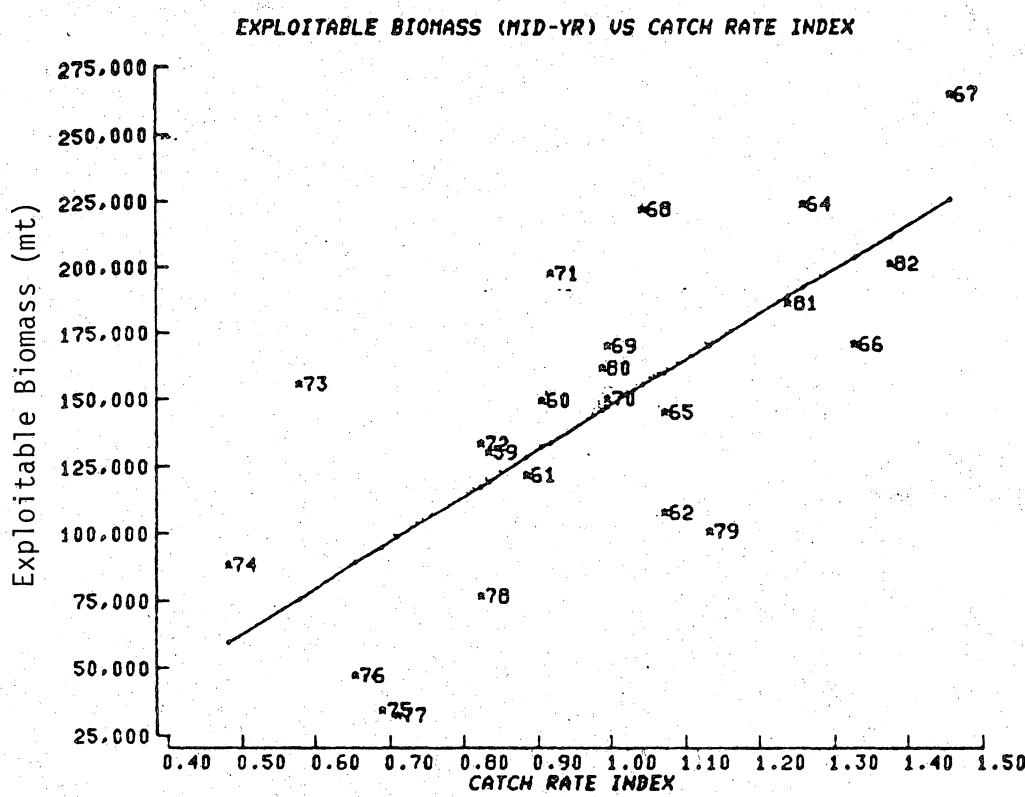


Fig. 7. Plot of the regression of exploitable biomass vs catch rate index for cod in NAFO Divisions 3NO using a fishing mortality of 0.15 for fully recruited ages in 1982.