



## SCIENTIFIC COUNCIL MEETING - JUNE 1985

## Assessment of the Cod Stock in NAFO Divisions 3NO

by

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P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1Nominal catch and catch at age

Cod catches from Div. 3NO since 1976, along with corresponding TAC's, are as follows:

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
TAC ('000 t)	43	30	15	25	26	26	17 <sup>b</sup>	17 <sup>b</sup>	26	33
Catch ('000 t)	24	18	15	28	20	24	32	28 <sup>a</sup>	25 <sup>a</sup>	-

<sup>a</sup>Provisional.<sup>b</sup>Excludes expected catches 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 1984. 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. Sampling data (Table 3) used to obtain catch at age for the commercial catch in 1983 were obtained by the Commercial Sampling and Foreign Cooperative Research Units of the Department of Fisheries and Oceans. 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 ( $\log \text{weight} = 3.0879 - 5.2106 \log \text{length}$ ) to the length frequencies and age length keys. The calculated total catch weight was 3% less than the total reported and estimated catch.

Survey Data

Stratified random research vessel surveys have been conducted in Div. 3NO since 1971, with the exception of 1983 as well as those for 1971-72 and 1974 in Div. 30. Surveys from 1971 to 1982 were conducted by the research vessel A.T. CAMERON while those for 1984 and 1985 were by the A. NEEDLER. The results in terms of biomass per stratum and per Division are shown in Tables 5 and 6.

Survey coverage was less than complete especially for the earlier years and for Div. 30 in 1981. During the most recent period when coverage has generally been adequate, it can be seen (Table 7; Fig. 1 and 2) that biomass and abundance, in terms of mean weight and number per standard tow, have shown an increasing trend.

Estimates of mean number of cod at age and per standard tow (Table 8) indicate that the 1978 year-class once again appears strong as do those of 1980 and 1981. An estimate of the strength of the 1982 year-class is available for the 1984 survey only, but it would appear to be above average.

Catch-effort data

Catch and effort information for 1959-82 was obtained from the NAFO Statistical Bulletin with similar preliminary data being available for 1983. Data for the Canadian otter trawl fleet in 1984 was provided by the Department of Fisheries and Oceans, Canada.

Catch and effort data from the otter trawl and pair trawl fisheries were once again analysed separately because of differences in their seasonal patterns. Estimated weights (log catch x effort) calculated according to Judge et al. (1980, p. 132) were applied in a weighted regression for the multiplicative model. Data with less than 10 t catch or 10 hours effort were excluded from the analysis to reduce the possible effect of truncation and rounding errors. The results of analyses using the multiplicative model for both are shown in Tables 9 to 12 and Fig. 3 and 4. The catch rate indices for both gears obtained using this model were combined and averaged as done in previous assessments (NAFO Res. Doc. 83/VI/53). In this method the indices 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 1976-84 were those from the Canadian OT fleet and these had been scaled by their 1959-75 mean. The combined catch rate index is indicated in Table 13. The Canadian OT catch rate series continues to represent a small portion (21% in 1984) of the total catch although it is distributed over a wider portion of the stock area than that for pair trawl. A considerable portion of the Canadian OT cod catch is taken as by-catch in the flounder fisheries.

#### Partial Recruitment

Estimates of partial recruitment in the 1984 fishery 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 thus obtained for the period 1974-82 (excluding 1976) as obtained from a cohort analysis having  $F_T = 0.10$

(Table 14) was used as the partial recruitment multiplier for the 1984 catch at age in subsequent cohort analyses over a range of  $F_T$  values.

#### Cohort Analyses

Catch and average weight at age data from the commercial fishery over the period 1959-84 (Table 15), along with partial recruitment estimates for 1984 (Table 14) were used in cohort analyses. The fishing mortality occurring on the last age group (12) in the cohort was estimated for each cohort run as the fully recruited fishing mortality for ages 6-10.

The relationships between catch rate indices and exploitable biomass (mid-year biomass x partial selection matrix) using both the combined otter trawl-pair trawl and pair trawl only indices were used to estimate a fully recruited fishing mortality appropriate to the fishery in 1984. The best estimate of  $F$  in 1984 was considered that which indicated a balance of positive and negative residuals about the fitted regression line over the period 1982-84. As in previous assessment the 1963 data point was considered anomalous and was excluded from regression analyses. Estimates of  $F_T$  in 1984 ranged from 0.10 using the otter trawl-pair trawl index to 0.30 using the pair trawl index (Table 16). Table 17 show population numbers, mid-year population biomass and fishing mortalities from cohort analyses at  $F_T = 0.10$  in 1984.

Figure 5 shows the relationship of exploitable biomass with catch rate index at  $F_T = 0.10$ .

#### References

- Bishop, C. A., and S. Gavaris. 1983. Assessment of the cod stock in NAFO Divisions 3NO. NAFO SCR Doc. 83/52, Ser. No. N711. 26 p.
- Judge, G. G., W. E. Griffiths, R. C. Hill, and T. C. Lee. 1980. The theory and practice of econometrics. John Wiley and Sons, New York, 793 p.

Table 1. Catch (metric tons) of cod in NAFO Divisions 3N0.

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	10,185	14,361	2,466	3,985	608	31,605
1983 <sup>a</sup>	11,374	12,320	1,109	3,238	778	28,818
1984 <sup>a</sup>	8702	13,520	945	3246	121	26,534

<sup>a</sup>Provisional.

Table 2. Cod landings (Mt) from NAFO Divisions 3N0 in 1984, 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					30					3N0				Total			
	Can(N)	Can(M)		Port.	France Cuba	Can(N)			Can(M)		Port.	France	USSR	Cuba		Spain	Japan	
		OT	LL	(GN)		OT	SSc	LL	OT	LL	SSc	(GN)						
Jan.	35																	
Feb.	36	1																
Mar.	52																	
Apr.	376																	
May	1053	73																
Jun.	684		13	183	115													
Jul.	494	57		98		10												
Aug.	139	26	12			1												
Sept.	1	49	11															
Oct.	4	51																
Nov.	75	20																
Dec.	15	6																
	2964	283	36	281	115	11	2625	129	3	2304	110	248	664	108	3246	12	12312	1
Total				3690						6191							15571	25452

Table 3. Commercial sampling data for Divisions 3NO cod in 1984.

Gear	Qtr.	Country	Div.	# Aged	Month	# Meas.	landings	
							Country/month	Total
OT	1	Can(N)	30	514	Jan.	919	455	798
					Feb.	520	361	1551
					Mar.	1711	715	1980
							3150	4329
	2	Can(N)	3N	378	Apr.	316	376	1782
					May	429	1053	2625
					Jun.	308	684	2482
						1053	6889	
	4	Can(N)	30	264	Oct.	1338	152	1176
					Nov.	780	1031	3117
					Nov.	174	453	
					Nov.	187	75	
					2479	4293		
2+4	All	3NO	642			6682	11182	
						6682	8996	
							20178	
GN	2	Port.	3N	198	June	1207	183	299
					July	248	98	98
						1455	397	
	4		30	25	Nov.	562	115	548
					Nov.	215		
						777	548	
All	1-4	All	3NO	1468		8914	25452	

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 1984.

AGE	AVERAGE		CATCH		
	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
3	0.788	44.502	85	33.13	0.39
4	1.148	50.507	846	89.91	0.11
5	1.514	55.330	1456	137.48	0.09
6	2.278	63.125	3184	165.47	0.05
7	3.041	69.149	1223	114.58	0.09
8	4.050	75.623	462	60.26	0.13
9	5.759	84.900	527	49.28	0.09
10	7.225	91.627	391	33.90	0.09
11	8.917	98.071	100	17.17	0.17
12	12.611	109.865	38	10.06	0.27
13	13.660	112.625	24	8.80	0.36
14	15.085	116.608	15	6.13	0.42
15	16.955	121.059	7	4.67	0.70
16	21.571	131.392	17	7.95	0.47
17	20.580	129.130	6	4.44	0.72
18	21.975	131.828	3	2.80	0.93
19	19.309	126.640	9	4.91	0.52
20	27.255	142.000	2	0.05	0.03
21					
22					
23					
24					
25					
26					
27	14.211	115.000	2	2.58	1.11

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	1985
357			1383				29		52	332	135	92	0	2102
358			1772				383		483	1054	229	236	182	122
359		1061	312			660	147		190	478	208	13	71	0
360		1966	258		306	1950	4040	2182	1416	1738	3743	1238	7877	9161
361	2909	4525	2525	350	3246	2618	5894	8203	2666	4173	8125	8125	12838	29220
362	2127	9695	4222	2233	306	1666	6836	6621	1632	5847	8701	3708	40764	16509
373	8159	3423	1855	2362		1031	1750	4300	1838	857	4578	6647	17916	2446
374	501	702	273	0	135		1248	1324	479	0	146	2369	8335	877
375	3270	9977	1042	955	10601		5429	3598	369	3229	29835	5943	2404	18475
376		1892	806		383	77	9672	102	868	855	2208	2	1049	391
377		550	14	83	283		1380	130	22	287	428	22	29	13
378	530	4146	404	632			687	90	281	939	104	303	133	470
379			1828	515			50	0	601	178	53	179	129	324
380	9	322	1317	206			52		232	57	25		224	847
381	480	1429	2386	359	122		2677	393	196	427	533	2186	478	1544
382	142	2458	9	69		42	948	2215	220	285	182	36	0	16
383	231	1479	1	16		44	324	1564	146	0	430	5	294	0
Total	18357	43935	20096	7781	15381	8088	41546	30722	11692	20736	51538	31104	92725	82515
Upper Limit	35959	58509	29260	13257	35224	13399	61360	37915	16334	28150	120675	46068	123845	108355
Lower Limit	755	29362	10931	2304	-4462	2776	21732	23529	7051	13322	-17600	16141	61605	56674

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

Strata	1973	1975	1976	1977	1978	1979	1980	1981	1982	1984	1985
329	211		6422	180	2008	357	18	487	373	560	840
330	9251	475	287	593	2218	3753	470	3371	123	3626	4642
331	288	729	454		342	150	609		38	2630	3423
332		830	351	940	4525	2266	9		3474	2358	13471
333		525	82	0	2	0	28		153	0	147
334			6	0	6	0	43		8	0	570
335	22		3		0	0	10		11	0	0
336	29	0	0	136	3	1	286		104	0	34
337	78	1906	32	630	614	23	153		610	434	1203
338	4298	5563	1876	6953	1334	5729	1795		5659	29905	7485
339	1547	40			249	1475		505	610	1087	359
340		2029	2690	298	966	3718	386	4294	2849	6827	5431
351	3092	1562	2684	8141	4334	47954	5629	6621	4498	43455	23490
352	3075	426	1429	6120	3961	10008	5625		6236	34168	29692
353	3265	77	2	262	84	1573	2		472	0	6083
354	439		38	8		34	273	44	125	489	219
355	76	0	4			24	367	32	135	0	135
356	11					11	49	9		0	0
Total	25681	14161	16360	24261	20646	76966	15733	15363	25478	125339	97223
Upper Limit	35514	58392	65071	38015	34853	133278	24517	25164	33764	169942	126100
Lower Limit	15848	30070	-32350	10508	6442	20645	6950	5561	17191	80736	68346

Table 7. Mean number and weight of cod per standard tow from research vessel surveys in NAFO Div. 3N, 3O, and 3NO.

Div.	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1984	1985
<u>Mean Number per tow</u>														
3N	44.60	33.33	12.17	8.91	17.10	10.30	32.37	25.00	5.59	11.28	18.38	15.54	40.01	24.96
3O			10.48		10.31	12.63	18.93	16.93	46.36	8.52	8.62	21.86	36.36	15.84
3NO			12.46		13.23	11.61	25.70	20.78	26.28	9.85	14.60	18.77	38.03	20.24
<u>Mean Weight per tow</u>														
3N	24.51	34.05	18.03	8.91	17.57	8.24	33.32	25.98	9.34	16.56	46.30	25.01	74.05	65.90
3O			25.19		12.17	12.63	19.42	15.93	57.28	12.17	22.32	19.13	93.8	72.35
3NO			21.40		14.48	10.71	26.36	20.72	32.74	14.29	37.00	21.92	84.01	69.24

Table 8. Mean number of cod at age and per standard tow from research vessel surveys in NAFO Divisions 3NO.

# Sets	1971*	1972*	1973	1974*	1975	1976	1977	1978	1979	1980	1981	1982	1984
	38	45	94	37	58	78	88	88	172	140	77	130	116
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	0.01
2	4.18	1.17	2.64	1.39	3.16	3.89	2.35	0.71	0.93	5.39	0.38	9.37	6.28
3	42.14	9.01	2.69	4.97	4.70	2.89	9.71	7.07	2.33	1.38	5.39	1.18	12.46
4	5.80	19.28	1.88	0.89	2.64	1.83	6.29	8.17	9.25	0.67	1.58	3.54	12.26
5	4.43	1.78	2.48	0.44	0.59	1.66	4.63	2.48	7.84	1.07	1.83	.60	6.63
6	1.06	.71	0.50	0.38	0.31	0.26	1.54	0.96	1.76	0.44	2.32	.47	7.39
7	1.08	.58	0.28	0.14	0.60	0.07	0.49	0.61	0.52	0.21	1.13	.78	2.60
8	0.48	.41	0.20	0.04	0.25	0.13	0.22	0.04	0.26	0.18	0.50	.58	1.43
9	0.24	.30	0.22	0.01	0.25	0.06	0.10	0.01	0.10	0.18	0.53	.26	2.37
10	0.03	.17	0.13	0.07	0.08	0.07	0.10	0.03	0.02	0.09	0.24	.16	1.99
11	0.08	.08	0.06	0.03	0.01	0.02	0.01	0.04	0.06	0.05	0.04	.07	1.08
12	0.14	.05	0.09		0.02		0.04	0	0	0.07	0.14	.05	.41
13			0.14		0.01		0.09	0.04	0.04	0.03	0.06	.01	.15
13+	0.47	.36	0.50	0.15	0.15	0.05	0.12	0.01	0.10	0.12	0.17	.14	.38
Mean no. per tow	60.13	32.73	11.89	8.56	13.23	11.51	25.70	20.72	26.30	9.89	14.66	18.76	38.03
Upper Limit													
Upper Limit	117.35	51.51	15.47	12.50	25.93	17.94	33.96	31.81	47.18	12.85	23.61	25.28	47.82
Lower Limit													
Lower Limit	2.93	16.10	8.33	4.62	0.52	5.09	17.45	9.90	5.49	6.91	5.70	12.24	28.25

\* survey 3N only

Table 9. Regression coefficients and the analysis of variance from the regression of  $\ln$  catch rate for cod in Divisions 3N0 from 1959-83 using Spanish pair trawl data.

Country	Gear	$\ln$ power	Month	$\ln$ power
ESP	PT 4	0.000	January	
ESP	PT 5	0.369	February	
ESP	PT 6		March	0.000
			April	
			September	
			October	
Div. 3N and 30		0.000	May	
			August	0.232
			November	
			June	
			July	0.435
			December	

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.817  
 MULTIPLE R SQUARED.....0.667

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.483E1	1.483E1	
REGRESSION	27	2.090E2	7.741E0	45.831
TYPE 1	1	1.117E1	1.117E1	66.111
TYPE 2	2	2.031E1	1.015E1	60.113
TYPE 3	24	1.943E2	8.094E0	47.925
RESIDUALS	618	1.044E2	1.689E-1	
TOTAL	646	3.282E2		

Table 10. Regression coefficients and the analysis of variance from the regression of  $\ln$  catch rate for cod in Divisions 3NO from 1959-83 using otter trawl data.

Country	Gear	$\ln$ power	Month	$\ln$ power
Can N	OT 4	-0.629	October	-0.882
Can N	OT 5	-0.472		
Can M	OT 4	-0.221	March April May	
Can M	OT 5	-0.028	June July	-0.589
ESP	OT 6	0.000	August September	
PRT	OT 6	0.096	November	
			December February	-0.166
Div. 3N and 30		0.000	January	0.000

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.609  
 MULTIPLE R SQUARED.....0.370

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.645E1	6.645E1	
REGRESSION	33	7.270E1	2.203E0	8.503
TYPE 1	5	3.119E1	6.239E0	24.081
TYPE 2	3	1.790E1	5.967E0	23.032
TYPE 3	25	2.893E1	1.157E0	4.467
RESIDUALS	477	1.236E2	2.591E-1	
TOTAL	511	2.627E2		



Table 11. Catch rate indices for cod in NAFO Divisions 3NO using Spanish pair trawl data from 1959 to 1983.

YEAR	TOTAL CATCH	CATCH RATE		EFFORT
		MEAN	S.E.	
1959	62459	0.776	0.067	80437
1960	79677	0.925	0.081	86093
1961	72724	0.890	0.073	81723
1962	34948	0.719	0.067	48629
1963	69742	1.392	0.133	50110
1964	64461	1.246	0.101	51721
1965	99187	1.358	0.115	73041
1966	108919	1.298	0.113	83916
1967	22674	1.347	0.111	16831
1968	165512	1.239	0.108	133570
1969	117705	1.134	0.092	103755
1970	111561	1.127	0.091	99030
1971	126296	1.110	0.089	113787
1972	103374	0.745	0.047	138794
1973	80429	0.539	0.035	149213
1974	73389	0.490	0.035	149874
1975	44174	0.419	0.043	105445
1976	24283	0.754	0.066	32193
1977	17604	0.305	0.029	57700
1978	14718	0.109	0.009	135479
1979	27940	0.857	0.099	32613
1980	19990	0.264	0.024	75595
1981	24344	0.564	0.058	43161
1982	31605	0.405	0.037	78025
1983	28818	0.561	0.057	51404

AVERAGE C.V. FOR THE MEAN:0.087

Table 12. Catch rate indices for cod in NAFO Divisions 3NO using otter trawl data from 1959 to 1984.

YEAR	TOTAL CATCH	CATCH RATE		EFFORT
		MEAN	S.E.	
1959	62459	0.962	0.154	64912
1960	79677	0.854	0.154	93291
1961	72724	0.934	0.183	77831
1962	34948	1.222	0.219	28600
1963	69742	1.644	0.283	42409
1964	64461	1.215	0.209	53072
1965	99187	1.204	0.211	82366
1966	108919	1.327	0.187	82064
1967	22674	1.711	0.267	13255
1968	165512	0.870	0.129	190270
1969	117705	0.915	0.143	128611
1970	111561	0.869	0.156	128392
1971	126296	0.719	0.119	175591
1972	103374	0.987	0.192	104717
1973	80429	0.510	0.141	157852
1974	73389	0.809	0.246	90768
1975	44174	0.899	0.189	49151
1976	24283	0.859	0.175	28263
1977	17604	0.888	0.176	19829
1978	14718	0.937	0.142	15715
1979	27940	1.234	0.169	22649
1980	19990	0.982	0.170	20358
1981	24344	1.216	0.201	20016
1982	31605	1.464	0.213	21589
1983	28818	1.587	0.208	18158
1984	25452	1.375	0.192	18517

AVERAGE C.V. FOR THE MEAN:0.177

Table 13. Catch rate index from a combination of OT and PT Indices.

Year	Index	Year	Index
1959	.86	1972	0.85
1960	.88	1973	0.52
1961	.90	1974	0.64
1962	.95	1975	0.64
1963	1.50	1976	0.83
1964	1.22	1977	0.86
1965	1.27	1978	0.90
1966	1.30	1979	1.19
1967	1.51	1980	0.95
1968	1.05	1981	1.17
1969	1.02	1982	1.41
1970	.99	1983	1.53
1971	.91	1984	1.32

Table 14. Historical partial recruitment for NAFO Divisions 3NO cod from a cohort analysis at  $F_T = 0.10$ . Average values for 1974-82 (excluding 1976) were used as cohort input in 1984.

SELECTIVITY COEFFICIENTS

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
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	0.39	0.03	0.12	0.01	0.06	0.05
4	0.37	0.46	0.20	0.26	0.20	1.00	0.16	0.20	0.55	0.60	0.38	0.42	0.96	0.44	1.00	0.70	0.34	1.00	0.31	0.60	0.38	0.57	0.24
5	0.75	1.00	0.96	0.33	0.74	1.00	0.39	0.50	1.00	0.96	1.00	0.53	1.00	0.75	0.99	1.00	0.49	1.00	0.94	1.00	1.00	1.00	0.66
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

AGE	1982	1983	1984
3	0.07	0.42	0.07
4	0.23	0.26	0.42
5	0.46	0.42	0.81
6	1.00	1.00	1.00
7	1.00	1.00	1.00
8	1.00	1.00	1.00
9	1.00	1.00	1.00
10	1.00	1.00	1.00
11	1.00	1.00	1.00
12	1.00	1.00	1.00

Table 15. Catch numbers ( $\times 10^{-3}$ ) and average weight (kg) at age from the commercial cod fishery in Divisions 3N0 over the period 1959-84.

CATCH AT AGE																	
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	
3	1711	1846	812	1026	313	6202	1013	753	20086	16359	8154	2105	950	69	10058	6425	
4	13036	6503	4400	3882	5757	15555	7611	18413	62442	56775	12924	19703	26900	19797	27600	9501	
5	5068	22050	11696	2206	11210	19496	7619	19631	50317	48608	26949	10799	30300	12289	15098	10907	
6	6025	3095	15258	1581	4849	7919	13258	11795	18517	18485	11191	9481	11700	13432	5989	10872	
7	3935	2377	2014	3594	1935	2273	9561	9486	4774	6337	2089	3646	3500	5883	1971	2247	
8	1392	2504	1672	773	3840	1109	4827	4467	4651	1592	1393	1635	2500	1686	972	2147	
9	757	583	847	668	1165	788	1081	1829	236	505	518	541	500	285	707	1015	
10	926	387	196	433	608	328	1248	1694	180	178	292	149	200	216	243	676	
11	1220	898	25	226	322	37	163	122	71	90	134	227	100	78	137	428	
12	103	242	245	216	208	112	141	57	45	45	202	90	50	74	116	257	
3+	34173	40485	37165	14605	30207	53819	46822	67297	161319	148974	63846	48376	76700	53809	62891	44475	
4+	32462	38639	36353	13579	29894	47617	45809	66544	141233	132615	55692	46271	75750	53740	52833	38050	
5+	19426	32136	31953	9697	24137	32062	38198	48131	78791	75840	42768	26568	48850	33943	25233	28549	
6+	14358	10086	20257	7491	12927	12566	30579	28450	28474	27232	15819	15769	18550	21654	10135	17642	
AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984							
3	671	4054	607	920	72	280	478	305	1179	85							
4	8781	7534	2469	4337	3827	1138	1032	1978	647	846							
5	3528	5945	2531	2518	9208	3789	1194	1591	1893	1456							
6	2505	1084	1500	818	2784	2057	2173	1012	1204	3184							
7	3057	211	572	354	883	665	1805	1528	686	1223							
8	1059	238	177	102	265	185	543	1492	1152	462							
9	921	44	209	58	58	75	182	595	774	527							
10	461	37	65	51	17	27	89	211	238	391							
11	252	13	41	8	12	7	39	162	81	100							
12	152	9	25	5	7	13	12	27	41	38							
3+	21387	19169	8196	9171	17133	8236	7547	8901	7895	8312							
4+	20716	15115	7589	8251	17061	7956	7069	8596	6716	8227							
5+	11935	7581	5120	3914	13234	6818	6037	6618	6069	7381							
6+	8407	1636	2589	1396	4026	3029	4843	5027	4176	5925							
AVERAGE WEIGHT AT AGE																	
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
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	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	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	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	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	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	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	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	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	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	11.77
AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984								
3	0.66	0.57	0.72	0.65	0.71	0.90	0.94	0.85	0.79								
4	1.02	1.00	1.05	0.98	1.04	1.27	1.17	1.17	1.15								
5	1.53	1.48	1.55	1.39	1.69	1.84	1.50	1.87	1.51								
6	2.33	2.48	2.25	2.09	2.50	2.69	2.20	2.63	2.28								
7	3.45	3.51	3.74	2.87	3.69	3.55	3.83	3.80	3.04								
8	4.64	4.74	4.61	3.70	5.49	5.33	5.26	5.20	4.05								
9	6.52	7.17	6.19	4.75	7.98	7.13	7.49	6.27	5.76								
10	8.10	8.81	7.23	7.15	9.22	9.10	8.80	8.08	7.22								
11	9.94	11.70	9.48	7.98	10.60	9.01	9.82	8.99	8.92								
12	11.77	11.47	12.87	10.11	12.61	10.15	12.28	11.01	12.61								

Table 16. Results of regressions used for cohort tuning for cod in Divisions 3NO.

$F_t$	0.075	0.10	0.15	0.25	0.30	0.35
<u>Combined catch rate vs. average exploit. biomass</u>						
Slope	185618	145410	102943			
Intercept	-39971	-6477	28896			
R <sup>2</sup>	0.47	0.39	0.21			
1982 Residual	-26190	-36651	-50581			
1983 "	20970	-7918	-38374			
1984 "	101973	47081	-7777			
<u>Spanish pair trawl catch rate vs. average exploit. biomass</u>						
Slope				132226	139130	141155
Intercept				20912	12644	10136
R <sup>2</sup>				0.63	0.65	0.66
1981 Residual				-2941	-8190	-10454
1982 "				17319	11309	7698
1983 "				3215	-7227	-14344

Table 17. Results of a cohort analysis on cod in NAFO Divisions 3NO using a fully recruited  $F = 0.10$ . Population numbers  $\times 10^{-3}$ . Population biomass (tons).

AGE	POPULATION NUMBERS													
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	53623	52382	81958	107686	78127	111693	162325	210041	183205	100565	127856	80320	84564	62291
4	93903	42355	41217	66366	87237	63682	85826	131984	171285	131821	67534	97302	63856	68376
5	19549	65086	28793	29764	50824	66215	38063	63382	91398	83737	56553	43598	61836	27941
6	16663	11419	33336	12991	22373	31468	36571	24270	34085	29302	24575	21918	25924	23210
7	12142	8191	6549	13487	9205	13930	18598	17946	9198	11151	7264	9995	9366	10638
8	4723	6380	4555	3539	7790	5786	9348	6304	7014	3211	3396	4057	4884	4501
9	3308	2607	2958	2217	2198	2904	3734	3286	1120	1534	1188	1520	1842	1736
10	3100	2024	1607	1655	1210	746	1664	2079	1035	702	799	504	755	1056
11	2327	1701	1307	1139	963	441	314	233	169	685	415	390	278	437
12	311	801	580	1047	728	497	328	109	81	74	479	218	114	137
3+	209649	192946	202859	239891	260656	297350	356771	459633	498589	362784	290061	259822	253419	206323
4+	156026	140564	120901	132205	182529	185667	194446	249592	315385	242218	162205	179502	168854	138033
5+	62123	98209	79685	65839	85292	121986	108620	117609	144100	130397	94671	82200	104999	69657
6+	42574	33123	50892	36075	44468	55771	70556	54227	52701	46660	38117	38602	43163	41716
AGE	POPULATION BIOMASS (TONS)													
AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984		
3	35417	37672	24177	29821	55964	44277	21846	38255	73472	31970	29002	13443		
4	50937	19896	25030	19187	20747	45270	35419	17821	31067	59722	25899	22678		
5	38068	16730	7692	12547	8692	14752	33140	25536	13561	24502	47106	20619		
6	11758	17506	3828	3106	4894	4990	9800	18801	17478	10022	18621	36854		
7	6849	4206	4496	868	1562	2649	3345	5504	13531	12344	7290	14156		
8	3387	3824	1411	915	520	761	1849	1940	3905	9445	8724	5348		
9	2160	1893	1188	197	534	265	531	1274	1421	2706	6393	6100		
10	1164	1128	632	140	121	248	165	382	975	999	1677	4526		
11	669	733	312	100	81	40	157	119	289	718	627	1157		
12	287	424	213	28	70	29	26	117	91	201	441	440		
3+	150694	104013	68979	64907	93383	113282	106276	109749	155791	152628	145770	125321		
4+	115277	66341	44802	37086	37420	69005	84430	71494	82318	120658	116767	111879		
5+	64340	46445	19772	17899	16673	23735	49012	53673	51251	66936	90868	89200		
6+	26272	29715	12079	5352	7781	8983	15872	28138	37690	36434	43762	68581		

Table 17. Continued.

POPULATION BIOMASS (AVERAGE)															
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	
3	20062	19562	31033	40783	29677	41239	61585	125403	103030	54752	73844	47370	50281	37239	
4	64465	28814	28848	47765	62520	40819	60711	112660	124780	90720	55790	79798	44321	52786	
5	18902	59317	24818	32366	50469	62419	38314	72260	83517	73835	55906	52018	60310	28604	
6	23263	17081	42773	21429	34747	47719	51017	36194	47825	36817	37761	34398	39985	31235	
7	25250	17474	13792	29270	20766	32393	32046	40146	19626	22504	18996	24622	22905	21857	
8	12073	15092	11007	9546	16786	15882	19655	13920	16730	9441	10828	13018	14123	14794	
9	10401	8229	8931	6619	5348	8863	11247	12705	5837	7349	5203	7128	9213	9331	
10	10908	7670	6363	5983	3566	2335	3409	6164	6868	4424	4621	3078	4711	6869	
11	7513	5468	6153	4819	3701	2002	1018	1429	1145	5724	3041	2232	1981	3548	
12	1409	3714	2442	5186	3413	2433	1376	802	569	494	3853	1768	904	985	
3+	194247	182420	176160	203766	230992	256104	280373	421682	409928	306059	269843	265430	248734	207248	
4+	174185	162859	145127	162983	201316	214865	218798	296278	306898	251308	195999	218060	198453	170009	
5+	109720	134045	116279	115218	138796	174047	158077	183619	182117	160587	140209	138262	154132	117223	
6+	90818	74727	91461	82852	98327	111628	119763	111359	98600	86752	84303	86244	93822	88619	
AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984			
3	17764	20408	14247	16507	28744	28572	12847	24521	59724	27099	21854	9593			
4	31338	13099	18437	13654	17580	40834	29604	16218	35122	62203	27096	23164			
5	48498	13385	7737	12437	9996	18767	35162	35918	21532	32141	78112	27143			
6	17115	22300	4647	5234	9070	9254	15563	40055	39711	18884	42834	72595			
7	17908	8827	7759	2342	3910	8322	7402	17191	40350	39944	23821	37179			
8	11915	10464	2858	3281	1793	2947	5711	9152	17422	41105	38136	19711			
9	10358	7493	3192	1016	2671	1306	2150	8920	8538	16106	33867	30355			
10	7548	5146	2336	871	648	1437	1007	3072	7643	7025	11321	28230			
11	5340	4181	1167	836	591	309	1088	1111	2181	5580	4745	8920			
12	2346	2824	1219	240	579	306	200	1261	781	2072	4180	4792			
3+	162130	108127	63600	56417	75583	112054	110733	157418	233004	252158	295964	260682			
4+	144367	87719	49353	39910	46839	83482	97886	132897	173280	225060	264110	251090			
5+	113029	74620	30916	26256	29259	42647	68282	116679	138158	162857	237014	227925			
6+	72531	61235	23178	13819	19263	23881	33120	80762	116626	130716	158902	200783			

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	0.377	0.209	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	0.627	0.386	0.913	0.750	0.491
5	0.338	0.469	0.596	0.085	0.279	0.394	0.250	0.420	0.938	1.026	0.748	0.320	0.780	0.666	0.577	1.275	0.707
6	0.510	0.356	0.795	0.144	0.274	0.326	0.512	0.770	0.917	1.195	0.700	0.650	0.691	1.020	0.828	1.159	1.284
7	0.443	0.387	0.415	0.349	0.264	0.199	0.882	0.739	0.852	0.989	0.382	0.516	0.533	0.945	0.383	0.893	1.392
8	0.394	0.569	0.520	0.276	0.787	0.238	0.846	1.528	1.320	0.794	0.604	0.589	0.834	0.534	0.382	0.969	1.771
9	0.292	0.284	0.380	0.405	0.681	0.357	0.386	0.955	0.265	0.452	0.657	0.500	0.357	0.200	0.449	0.898	1.942
10	0.401	0.237	0.145	0.341	0.810	0.666	1.764	2.309	0.213	0.328	0.517	0.395	0.346	0.256	0.262	1.085	1.643
11	0.866	0.876	0.021	0.248	0.461	0.097	0.854	0.862	0.624	0.157	0.442	1.030	0.507	0.220	0.257	1.037	2.224
12	0.451	0.402	0.619	0.257	0.376	0.284	0.635	0.837	0.931	1.073	0.617	0.599	0.651	0.884	0.582	1.071	1.468
AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984								
3	0.163	0.012	0.023	0.004	0.008	0.007	0.011	0.046	0.007								
4	0.569	0.141	0.112	0.127	0.073	0.037	0.037	0.028	0.042								
5	0.742	0.378	0.209	0.367	0.179	0.102	0.074	0.045	0.081								
6	0.487	0.414	0.200	0.377	0.129	0.148	0.118	0.074	0.100								
7	0.313	0.519	0.160	0.345	0.143	0.159	0.147	0.110	0.100								
8	0.339	0.472	0.160	0.172	0.111	0.167	0.192	0.158	0.100								
9	0.284	0.567	0.277	0.129	0.067	0.153	0.278	0.144	0.100								
10	0.347	0.899	0.258	0.121	0.081	0.106	0.266	0.171	0.100								
11	0.155	0.823	0.247	0.088	0.067	0.162	0.287	0.154	0.100								
12	0.441	0.495	0.210	0.353	0.130	0.156	0.160	0.108	0.100								

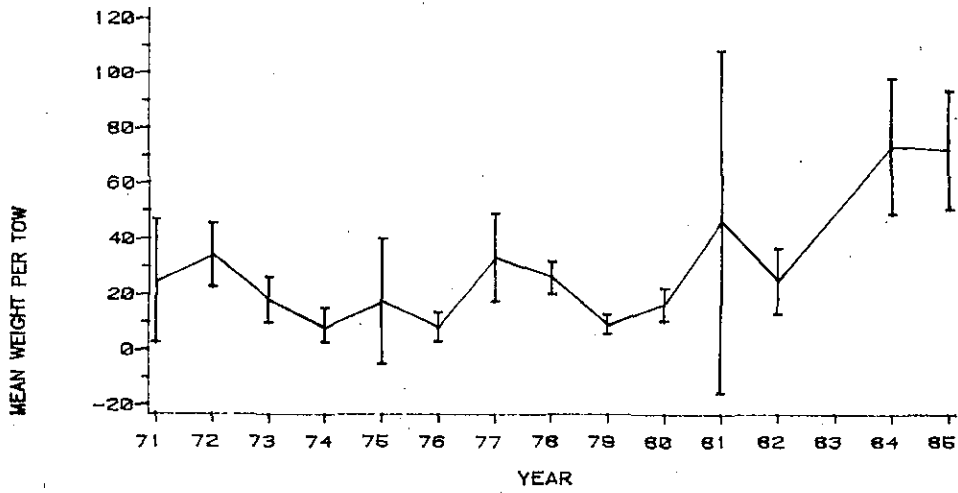


FIG. 1. MEAN WEIGHT PER TOW AND THEIR ASSOCIATED CONFIDENCE LIMITS FROM RESEARCH VESSEL SURVEYS FOR COD IN DIVISION 3N.

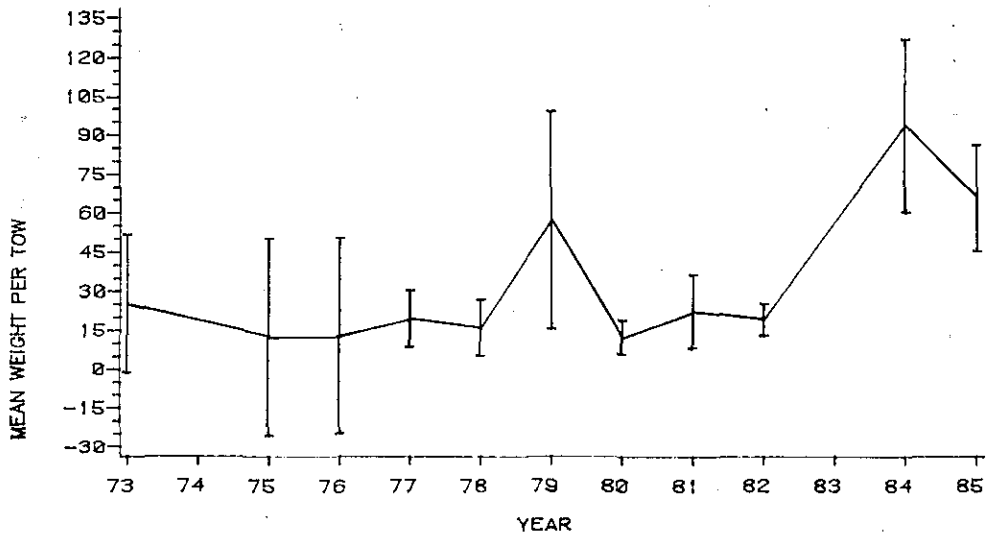


FIG. 2. MEAN WEIGHT PER TOW AND THEIR ASSOCIATED CONFIDENCE LIMITS FROM RESEARCH VESSEL SURVEYS FOR COD IN DIVISION 30.

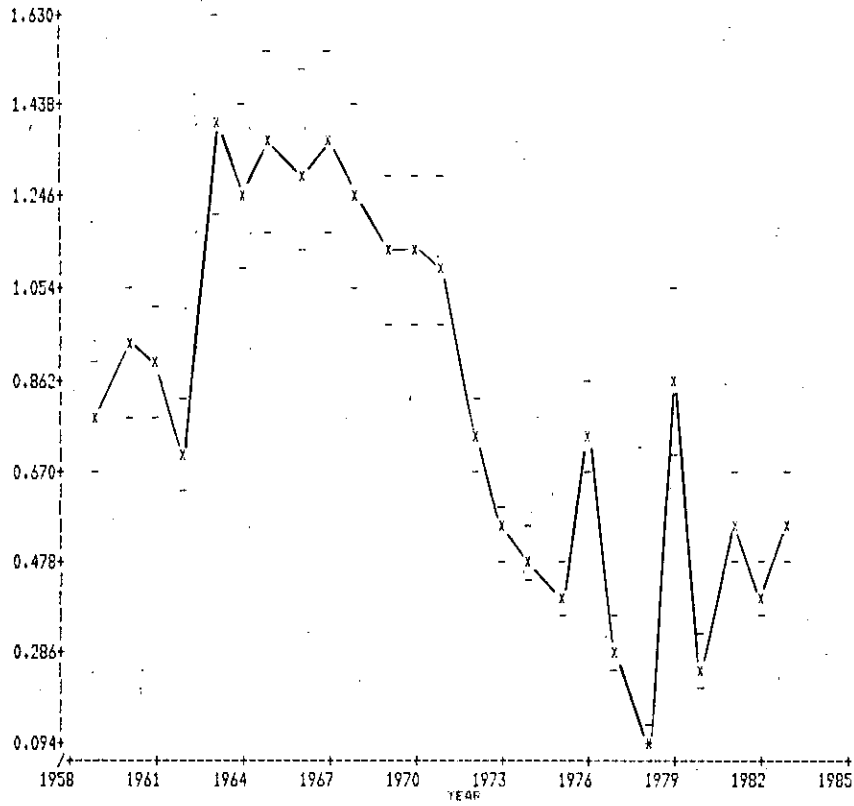


Fig. 3. Catch rate index with approximate 90% confidence interval for cod in Divisions 3NO using Spanish pair trawl data from 1959 to 1983.

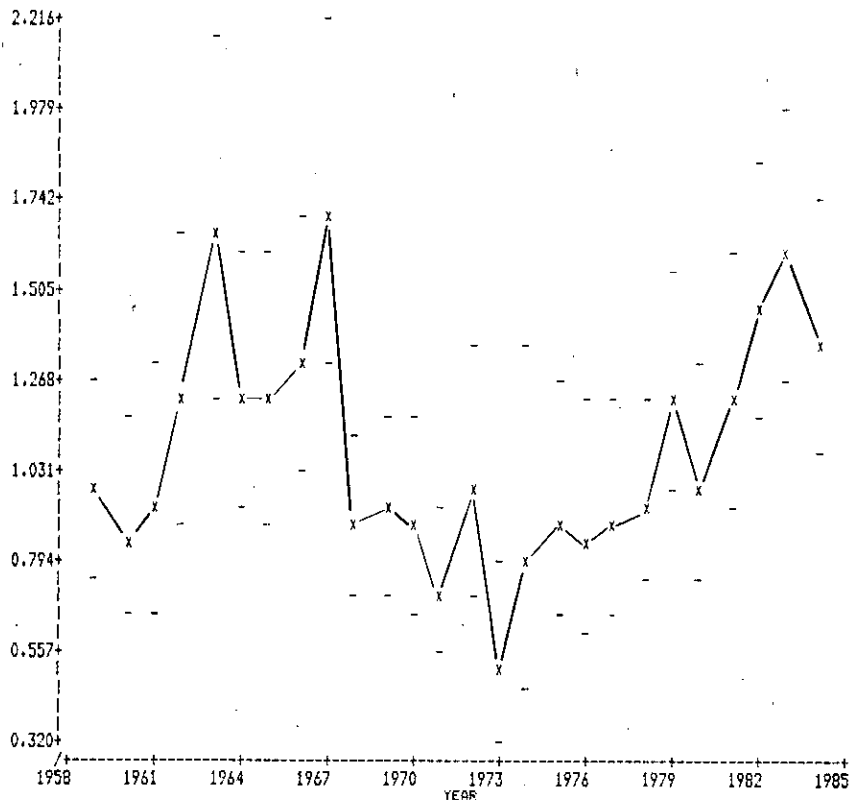


Fig. 4. Catch rate index with approximate 90% confidence interval for cod in Divisions 3NO using other trawl data from 1959 to 1984.

EXPLOITABLE BIOMASS (AVERAGE) VS CATCH RATE INDEX

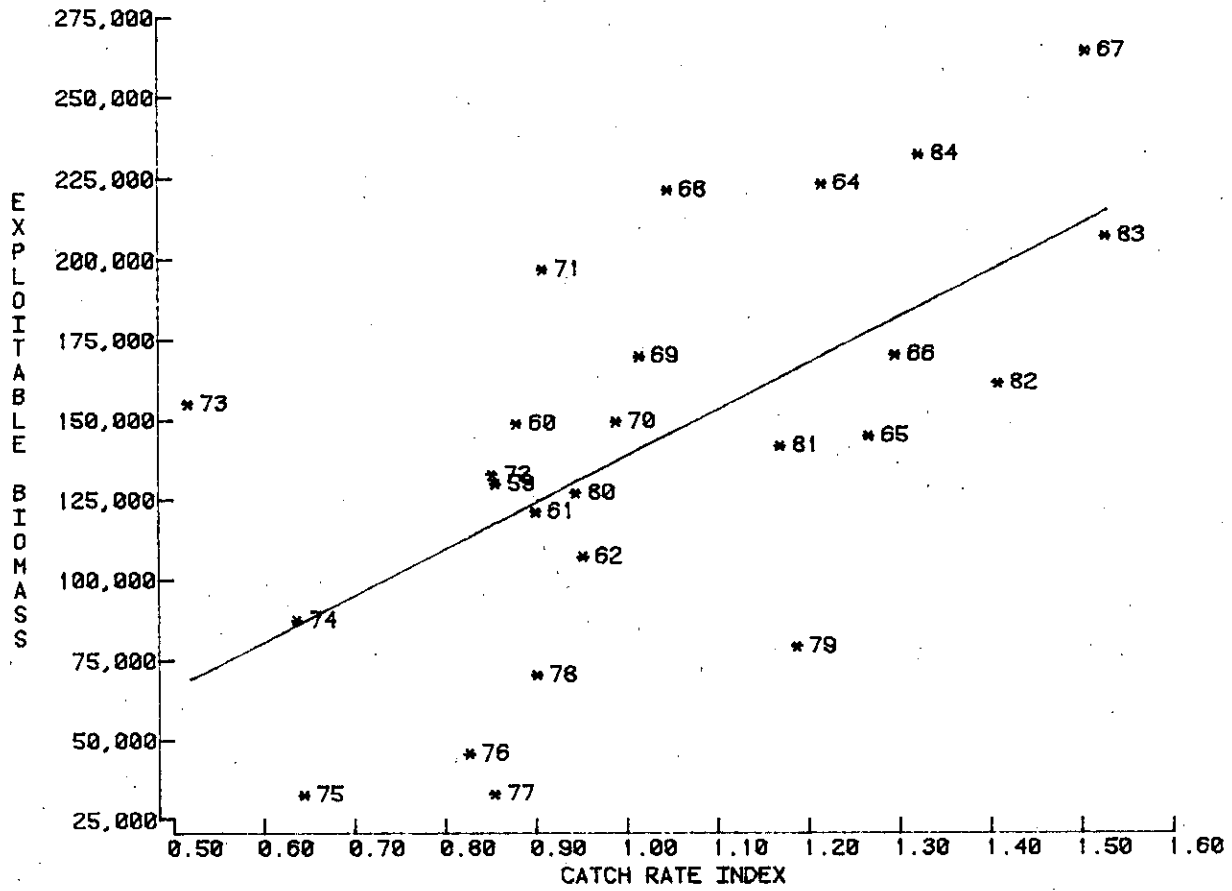


Fig. 5. The relationship of exploitable biomass to catch rate index for cod in NAFO Divisions 3NO using a fully recruited fishing mortality of 0.10 in 1984.



Further Assessment of the Cod Stock in Divisions 3NO

Catch at age for the period 1959-84 is given in Table 1, including sampling data provided by Spain for the Spanish pair trawl fishery in 1984.

Table 2 show the results from regressions using catch rate indices obtained from the otter trawl fleet with exploitable biomass for the period 1977-84. A range of fully recruited fishing mortalities from 0.15 to 0.25 were used in these regressions.

A survey biomass index (Table 3) was obtained for Divisions 3NO by taking the average 3N to 3O survey biomass over the period 1977-84 excluding 1981 and 1984. This average was applied to years when only one division was surveyed adequately to provide an estimate for the division not surveyed. The 3N and 3O values were then averaged to obtain a combined index.

Results of cohort analysis using a fully recruited fishing mortality in 1984 of 0.20 are shown in Table 4.

Table 1. Catch at age for cod in Divisions 3NO for the period 1959-84 including Spanish sampling in 1984.

AGE	CATCH AT AGE																
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	
3	1711	1846	812	1026	313	6202	1013	753	20086	16359	8154	2105	950	69	10058	6425	
4	13036	8503	4400	3882	5757	15555	7611	19413	82442	56775	12924	19703	26900	19797	27500	9501	
5	5068	22050	11696	2206	11210	19496	7619	19681	50317	48608	26949	10799	30300	12289	15099	10907	
6	6025	3095	15258	1581	4849	7919	13258	11795	19517	18485	11191	9481	11700	13432	5989	10872	
7	3935	2377	2014	3594	1935	2273	9861	8486	4774	6337	2089	3646	3500	5883	1971	2247	
8	1392	2504	1672	773	3840	1109	4927	4467	4651	1592	1393	1635	2500	1686	972	2147	
9	757	583	847	668	1165	788	1081	1829	236	505	518	541	500	285	707	1015	
10	926	387	196	433	608	328	1248	1694	180	178	292	149	200	216	243	676	
11	1220	898	25	226	322	37	163	122	71	90	134	227	100	78	137	428	
12	103	242	245	216	208	112	141	57	45	45	202	90	50	74	116	257	
3+	34173	40485	37165	14605	30207	53819	46822	67297	161319	148974	63846	48376	76700	53609	62891	44475	
4+	32462	38639	36353	13579	29894	47617	45809	66544	141233	132415	55692	46271	75750	53740	52833	38056	
5+	19426	32136	31953	9697	24137	32642	38198	48131	78791	75840	42748	36568	48850	33943	25233	28549	
6+	14358	10086	20257	7491	12927	12566	30579	28450	28474	27232	15819	15769	18550	21654	10135	17642	
AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984							
3	671	4054	607	920	72	280	478	305	1179	49							
4	8781	7534	2469	4337	3827	1139	1032	1978	647	768							
5	3528	5945	2531	2518	9208	3789	1194	1591	1893	1127							
6	2505	1084	1500	818	2784	2057	2173	1012	1204	1984							
7	3657	211	572	354	983	665	1805	1538	686	1004							
8	1059	238	177	102	265	185	543	1492	1152	558							
9	921	44	209	58	58	75	182	595	774	704							
10	461	37	65	51	17	27	89	211	338	430							
11	252	13	41	8	12	7	39	162	81	56							
12	152	9	25	5	7	13	12	27	41	40							
3+	21387	19169	8196	9171	17133	8236	7547	8901	7895	6750							
4+	20716	15115	7589	8251	17061	7956	7069	8596	6716	6761							
5+	11935	7581	5120	3914	13234	6818	6037	6618	6069	5935							
6+	8407	1636	2589	1395	4026	3029	4843	5027	4176	4306							

Table 2. Relationship of CPUE indices (OT) with exploitable biomass for cod in Divisions 3N0 from cohort analyses at a range of fully recruited F's over the period 1977-84.

Year	CPUE	0.15		0.20		0.25	
		Observed	Residuals	O	R	O	R
1977	.86	31	-26.9	31	-26.5	31	-26.3
1978	.90	63	-1.9	62	-0.1	62	1.0
1979	1.19	69	-37.4	65	-25.6	63	-18.5
1980	.95	111	39.8	101	33.9	94	30.4
1981	1.17	122	18.4	108	18.4	99	18.5
1982	1.41	136	03.2	114	1.0	101	3.5
1983	1.53	155	-1.6	123	-1.9	104	-2.0
1984	1.32	139	12.9	105	1.0	85	-6.4
r <sup>2</sup>		0.68		0.60		0.49	
intercept		-66.8		-27.7		-4.3	
slope		145.9		99.8		72.1	

Table 3. Survey biomass indices from Canadian research surveys in Div. 3N0 from 1972-85. Bracketed figures are estimates from the ratio of 3N to 30 over the period 1977-84 (excl. 1981 and 1983).

Year	3N	30	3N0
1972	33.33	(32.93)	33.13
1973	18.03	25.19	21.61
1974	-	-	-
1975	(12.59)	12.17	12.38
1976	(13.06)	12.63	12.84
1977	33.32	19.42	26.37
1978	25.98	15.93	20.96
1979	9.34	57.28	33.31
1980	16.56	12.17	14.37
1981	46.30	(44.77)	45.54
1982	25.01	19.13	22.07
1983	-	-	-
1984	74.05	93.80	83.93
1985	65.90	72.35	69.13



