

Northwest Atlantic



Fisheries Organization

Serial No. N550

NAFO SCR Doc. 82/VI/57

SCIENTIFIC COUNCIL MEETING - JUNE 1982

Assessment of Cod Stock in Divisions 3NO

by

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NOMINAL CATCH AND CATCH AT AGE

Cod catches from Div. 3NO since 1973, along with corresponding TAC's, are as follows:

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
TAC ('000 t)	103	101	88	43	30	15	25	26	26 <sup>a</sup>	26
Catch ('000 t)	80	73	44	24	18	15	28	19	23 <sup>a</sup>	

<sup>a</sup>Provisional data.

Total landings in 1981, by country and gear, are shown in Table 1. Landings by Can(N&M) were obtained from the Economics and Statistics Branch of the Department of Fisheries and Oceans while that for other countries was obtained from NAFO circular letters and/or FLASH records. Spanish landings were estimated from information obtained by the Offshore Surveillance Section of Fisheries and Oceans. As in previous years, the majority of the catch was obtained by otter trawl and pair trawl. Catch at age data for the commercial fishery in 1981 was obtained using sampling data as shown in Table 1. The sampling data was obtained by the Commercial Sampling and Foreign Cooperative Research units of Fisheries and Oceans. Sampling data was not available for estimated Spanish landings and as such, these were adjusted to numbers at age based on the breakdown of numbers at age obtained from landings by other countries. The total catch at age, along with average weights at age, are shown in Table 6. 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 2.2212 MT or 96% of total observed catch.

Figure 2 shows the percent age composition of the commercial catch in 1981. As in 1979 and 1980, the 1974 and 1975 year-classes were the most abundant (53%).

SURVEY DATA

The results of stratified random research surveys in 3NO in terms of mean number per tow for the years 1971-81 are shown in Table 2. There has been considerable fluctuation in the age 3+ numbers over this period. It would be unrealistic to assume that changes in survey numbers by factors as high as five (1979-80) are indicative of changes in stock biomass. Availability factors most likely influence these abundance estimates.

The age composition of the research survey in 1981 (Fig. 1) indicates that the 1978 year-class once again appears to be strong to the extent that it is the most abundant in the survey. The 1975 year-class was also strong in the surveys as well as in the commercial fishery. Figure 3 shows the length frequency of the survey catch.

CATCH-EFFORT DATA

Catch and effort information for 1959-79 was obtained from the NAFO (ICNAF) Statistical Bulletin. Preliminary statistics for 1980 were provided by the NAFO Secretariat. Data for Canadian vessels in

1981-82 was supplied by the Economics and Statistics Branch of the Department of Fisheries and Oceans. The catch and effort for Portuguese and Spanish vessels from 1977 on were not incorporated in the analysis due to inconsistencies. In addition, one catch rate for Portugal in 1976 and two Canadian catch rates, one in January of 1979, the other in December of 1981 were not used. The Canadian catch rate in 1979 which was discarded was reported by vessels fishing very close to the boundary of Subdivision 3Ps and the same is suspected of the 1981 point.

The multiplicative model (Gavaris 1980) was applied to the data using a weight of (catch X effort) 0.25. Catch rates tended to be better in early summer and late fall with little difference between divisions (Table 3). The annual catch rate index shows greater fluctuations in recent years (Fig., 4) which may be due to the small amount of data which can be used (Table 4).

#### PARTIAL SELECTION

Estimates of partial selection in 1981 were obtained from cohort selectivity coefficients. These coefficients were derived by dividing fishing mortality by fully recruited fishing mortality for ages 6-10. The average of the coefficients for the period 1974-79 (excluding 1976) was used as the partial selection multiplier (Table 5) for the 1981 catch at age in cohort analyses. The average selectivity indicated in Table 5 was obtained from the cohort run at  $F_t = 0.18$  while the values used in the cohort were obtained from previous iterations.

#### COHORT ANALYSIS

Catch and average weight at age from the commercial fishery for the period 1959-81 are shown in Table 6. This data, along with partial recruitment estimates for 1981 (Table 5), was used in a cohort analysis to obtain population numbers and biomass estimates for 1981. The fishing mortality occurring on the last age group (age 12) in the cohort was estimated as the fully recruited fishing mortality for ages 6-10 as obtained by iteration using cohort runs at different terminal F's in 1981.

The relationship between the standard CPUE indices and exploitable biomass was used in determining an appropriate  $F_t$  for 1981. It was felt that exploitable biomass would give a more realistic relationship instead of the total biomass which includes ages with varying levels of recruitment to the commercial fishery. Because of the considerable fluctuations in the catch rate indices in recent years, it was decided to give equal weight to the 1980 and 1981 values rather than adjust the cohort biomass to the last year (1981). Using different values of  $F_t$  in 1981 several cohort analyses were computed to determine which  $F_t$  would predict, from a relationship between CPUE and biomass, exploitable biomass values for 1980 and 1981 which would be intermediate between the observed values for the same years. A cohort analysis at  $F_t = 0.18$  was found to produce a suitable prediction of this intermediate value (Table 7). Tables 8 and 9 indicate population numbers, mid-year population biomass, and fishing mortalities from a cohort analysis at  $F_t = 0.18$ . Figure 5 shows the relationship between standard CPUE and exploitable biomass at  $F_t = 0.18$ . The corresponding 3+ biomass (Table 9) in 1981 from the cohort at  $F_t = 0.18$  is approximately 163,000 t.

#### DISCUSSION

Recent assessments on this stock have indicated that the stock was in a depressed condition and was made up mainly of young fish. Lower fishing mortalities were advised so as to provide a gain in yield per recruit and a return to a more broadly-based age structure in the stock. A cautious approach to exploitation was recommended.

At the third special meeting of the Fisheries Commission of NAFO (NAFO/FC Doc. 81/IX/14), it was decided that the TAC for this stock would remain at 26,000 t until the age 3+ annual mean biomass reached 200,000 t.

The present assessment indicates that the stock is improving but there are remaining uncertainties and inadequacies. Some of these are as follows:

1. Lack of adequate catch information for 1981.
2. Research surveys indicate that the majority of the stock is still small fish.
3. Catch rate series have fluctuated a great deal in recent years.
4. Catch rate information for the years 1980 and 1981 was obtained from the Can(N) otter trawl fleet for which cod catches are obtained mainly as a by-catch in the flounder fishery.

It would appear that the results of cohort analysis provide an optimistic indication of stock size when compared to survey results.

Table 1. Catch and sampling data for 3NO cod in 1981.

Gear	Qtr.	Country	Div.	No. aged	Month	No. measured	Monthly landings	Total adjusted landings
OT	1+2	Can(N)	30	81	Jan.	303	119	
			3N	96	June	216	298	2,072
		USSR	30	28	Jan.	154	283	
3		Can(N)	3N	479	876	July (3N)	942	441
			30	397		(30)	1,716	335
					Aug. (3N)	586	1,289	1,289
					Sept. (3N)	1,285	346	770
					(30)	359	54	
4		Can(N)	3N	190	323	Oct. (3N)	1,157	645
			30	111		(30)	3,297	935
		Port.	3N	22	June (3N)	2,693	236	2,951
GN	3	Port	3N	132		(30)	596	693
			30	139	July (3N)	4,761	632	
4		Port.	3N	304	Oct. (3N)	1,059	320	617
					(30)	424	30	
					Nov. (3N)	382	393	792
								Total 11,034
		Can(N) OT	-	3,893				
		GN	-	1,970				
		Can(M) OT	-	193				
		Den(F)		480				
		France		219				
		USSR		3,187				
		Cuba		1				
		Portugal		1,091	(assumed GN)			
				11,034				
		Spain		12,000	(estimated from surveillance data)			
		Total landings		23,034				

Table 2. Cod 3NO - mean number per standard tow from research.

Sets	1971 <sup>a</sup> 38	1972 <sup>a</sup> 45	1973 95	1974 <sup>a</sup> 37	1975 56	1976 75	1977 87	1978 88	1979 166	1980 140	1981 77
<u>Age</u>											
1	.00	.01	.07	.05	.44	.58	.01	.54	3.19	.01	.35
2	4.18	1.17	2.54	1.39	3.15	3.88	2.34	.70	.86	5.51	.38
3	42.14	9.01	2.76	4.97	4.58	2.85	9.69	6.99	2.08	1.23	5.39
4	5.80	19.28	1.81	.89	2.58	1.84	6.27	8.40	8.65	.65	1.58
5	4.43	1.78	2.43	.44	.54	1.70	4.62	2.62	8.68	1.12	1.83
6	1.06	.71	.58	.38	.29	.26	1.54	.76	1.99	.42	2.32
7	1.08	.58	.30	.14	.49	.07	.49	.56	.64	.22	1.13
8	.48	.41	.19	.04	.21	.13	.22	.07	.27	.17	.50
9	.24	.30	.27	.01	.17	.06	.10	.02	.11	.22	.53
10	.03	.17	.08	.07	.09	.07	.10	.03	.01	.07	.24
11	.08	.08	.05	.03	.00	.02	.01	.03	.05	.02	.04
12	.14	.05	.06	.00	.02	.00	.04	.04	.00	.02	.14
13	.47	.36	.49	.15	.13	.06	.20	.04	.03	.04	.06
13+								.03	.11	.06	.17
Total age 3+	32.73	9.02	7.12	9.10	7.06	23.28	19.59	22.62	4.33	13.93	

<sup>a</sup>Survey in 3N only.

Table 3. Regression coefficients for grouped categories and the analysis of variance from the regression of ln catch rate for cod in Divisions 3NO.

Country	Gear	ln Power	Month	ln Power
SUN	OTB-4	-1.849	March	
SUN	OTB-5	-0.862	April	-0.155
SUN	OTB-6		September	
CAN-N	OTB-4	-0.530	October	
CAN-N	OTB-5	-0.373	January	
ESP	OTB-6	0.000	February	0.000
SUN	OTB-7		November	
PRT	OTB-6	0.125	May	
CAN-M	OTB-4	0.338	July	
ESP	PTB-5		August	0.111
CAN-M	OTB-5		June	
ESP	PTB-5	0.688	December	0.179
ESP	PTB-6		Division	ln Power
			30	-0.044
			3N	0.000

Table 4. Mean catch rate indices for cod in NAFO Divisions 3NO for 1959-81 relative to 1959 with their respective standard errors. The proportion of the total catch which was used in the analysis for each year is indicated.

PREDICTED RELATIVE POWER

YEAR	TOTAL CATCH	PROF.	RELATIVE POWER		
			MEAN	S.E.	EFFORT
1959	62459	0.088	1.000	0.000	62459
1960	79677	0.437	1.153	0.155	69103
1961	72724	0.483	0.970	0.130	74965
1962	34948	0.559	1.103	0.154	31689
1963	69742	0.585	1.973	0.264	35342
1964	64461	0.594	1.616	0.215	39878
1965	99187	0.723	1.620	0.210	61215
1966	108919	0.569	1.663	0.215	65512
1967	226784	0.901	2.007	0.240	113016
1968	165512	0.429	1.518	0.201	109062
1969	117705	0.619	1.387	0.183	84876
1970	111561	0.616	1.265	0.166	88218
1971	126296	0.717	1.404	0.184	89951
1972	103374	0.741	1.014	0.130	101989
1973	80429	0.531	0.745	0.099	107964
1974	73389	0.524	0.705	0.095	104066
1975	44174	0.391	0.669	0.097	65986
1976	24283	0.466	0.907	0.132	26772
1977	17575	0.051	0.704	0.162	24974
1978	14718	0.228	0.965	0.158	15249
1979	28049	0.190	1.208	0.185	23218
1980	19360	0.085	0.866	0.167	22354
1981	23034	0.053	1.314	0.273	17529

AVERAGE C.V. FOR THE MEAN: 0.140

Table 5. Historical partial selection for 1974-79, their average (omitting 1976) and the partial selection pattern used in the current cohort analysis for cod in NAFO Divisions 3NO.

## SELECTIVITY

Table 6. Catch numbers and average weight at age matrices used in cohort analysis of cod in NAFO Divisions 3NO.

GE	1959	CATCH NUMBERS ( $\times 10^3$ )											
		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	1711	1846	812	1026	313	6202	1013	753	20086	16359	8154	2105	950
2	1336	6503	4400	5757	15555	18113	62442	56775	12924	19703	26900	19797	69
3	5668	22050	11692	2206	11210	19495	7619	1981	10799	3030	12289	15098	6425
4	6025	3095	15258	1581	14849	17959	13258	18517	11191	9481	11200	13432	5945
5	7	3935	2377	2504	3594	3840	2223	9861	4774	6337	20893	3646	3500
6	847	1392	1672	1773	1935	1109	4827	4467	4651	1592	1635	2500	1686
7	5983	757	926	942	943	1165	788	1081	1829	2316	505	541	500
8	947	924	1220	898	892	1248	608	1264	180	178	292	227	200
9	103	242	245	245	245	112	37	163	122	190	45	141	57
10	2	103	216	216	208	112	112	141	141	141	141	141	141

GE	1959	AVERAGE WEIGHT (KG)											
		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
3	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
4	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65
5	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
6	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39
7	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89
8	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
9	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98
0	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68
1	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25
2	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17

Table 7. Results from regression analyses of exploitable biomass versus catch rate indices for cod in NAFO Divisions 3NO for the period 1959-81.

	Ft 1981	.17	.18	.19
R <sup>2</sup>	.55			
Intercept	-6.327			
Slope	115.4			
1980 residual	22			
1981 residual	18			

.54  
-9.234  
116.5  
14  
-30

.54  
-9.234  
116.5  
14  
-30

Table 8. Population biomass and fishing mortality from a cohort analysis for cod in NAFO Divisions 3NO using a fishing mortality of 0.18 in 1981 for fully recruited ages.

POPULATION BIOMASS (MID-YEAR)														
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969			
3	20062	19561	31032	40783	29676	41238	61581	125399	103030	54735	73840			
4	64465	28814	28846	47764	62519	40818	60710	112653	124775	90721	55769			
5	18902	59317	24818	32363	50468	62418	38313	72258	83508	73828	55906			
6	23263	17081	42773	21429	34744	47718	51016	36192	47823	36804	37752			
7	25250	17474	13792	29270	20765	32389	32044	40144	19624	22500	18982			
8	12073	15092	11007	9546	16786	15882	19651	13917	16727	9439	10824			
9	10401	8228	8931	6619	5348	8863	11246	12698	5834	7346	5201			
10	10908	7670	6363	5983	3566	2335	3409	6163	6862	4421	4618			
11	7523	5468	6153	4819	3701	2002	1018	1429	1144	5717	3038			
12	1409	3724	2442	5186	3413	2433	1370	802	569	493	3847			
3+	194257	182428	176157	203762	230986	256096	280359	421654	409896	306005	269778			
4+	174195	162867	145124	162979	201310	214858	218778	296255	306866	251270	195938			
5+	109730	134054	116279	115216	138791	174040	158068	183602	182091	160550	140169			
6+	90828	74737	91461	82852	88323	111622	119755	111345	98583	86722	84263			
AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981		
3	47366	50245	37199	17679	19481	13838	16052	27045	25043	9069	11589	34143		
4	79794	44316	52740	31282	12988	17243	13123	17016	38269	25666	11266	16181		
5	51992	60304	28597	40441	13312	7602	10925	9375	18051	32350	30348	14359		
6	34398	39952	31228	17107	22221	4556	5069	7131	8488	14766	35958	32474		
7	24612	22905	21815	17899	8817	7659	2245	3707	5963	6596	16050	35599		
8	13003	14111	14795	11872	10454	2845	3186	1683	2732	3799	7901	16079		
9	7124	9195	9318	10359	7440	3178	1004	2549	1189	1969	5555	7209		
10	3075	4707	6851	7535	5147	2273	860	633	1338	897	2785	4499		
11	2229	1979	3544	5323	4167	1168	786	578	297	997	978	1952		
12	1765	901	983	2342	2806	1204	241	531	295	190	1146	677		
3+	265359	248616	207070	161839	106834	61567	53491	70248	101666	96300	123577	163172		
4+	217992	198371	169871	144160	87353	47729	37438	43203	76622	87230	111988	129029		
5+	138198	154055	117131	112877	74365	30486	24316	26187	38354	61565	100722	112848		
6+	86206	93751	88534	72437	61053	22883	13391	16812	20303	29215	70374	98489		
FISHING MORTALITY														
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970		
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	0.938	1.026	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	1.195	0.700	0.650	0.691	1.021
7	0.443	0.387	0.415	0.349	0.264	0.199	0.882	0.739	0.853	0.989	0.383	0.516	0.533	0.946
8	0.394	0.569	0.520	0.276	0.787	0.238	0.846	1.529	1.320	0.794	0.604	0.590	0.835	0.534
9	0.292	0.284	0.380	0.405	0.881	0.357	0.386	0.955	0.265	0.452	0.658	0.500	0.357	0.200
10	0.401	0.237	0.145	0.341	0.810	0.666	1.764	2.310	0.214	0.328	0.517	0.396	0.347	0.257
11	0.865	0.876	0.021	0.248	0.461	0.097	0.854	0.862	0.624	0.157	0.442	1.031	0.507	0.220
12	0.451	0.401	0.619	0.257	0.376	0.284	0.635	0.837	0.931	1.074	0.618	0.600	0.653	0.886
AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1970	1971	1972		
3	0.378	0.219	0.032	0.167	0.013	0.027	0.005	0.017	0.013					
4	0.915	0.757	0.525	0.592	0.146	0.119	0.147	0.105	0.081					
5	0.578	1.282	0.720	0.846	0.403	0.217	0.399	0.212	0.153					
6	0.828	1.164	1.310	0.503	0.527	0.218	0.397	0.144	0.180					
7	0.383	0.894	1.411	0.327	0.547	0.223	0.387	0.154	0.180					
8	0.383	0.970	1.779	0.349	0.504	0.173	0.260	0.129	0.180					
9	0.449	0.904	1.951	0.288	0.595	0.304	0.140	0.108	0.180					
10	0.263	1.085	1.690	0.351	0.919	0.277	0.136	0.090	0.180					
11	0.257	1.040	2.223	0.165	0.842	0.257	0.096	0.076	0.180					
12	0.583	1.078	1.486	0.440	0.540	0.218	0.372	0.143	0.180					

Table 9. Population numbers from a cohort analysis for cod in NAFO Divisions 3NO using a fishing mortality of 0.18 in 1981 for fully recruited ages.

POPULATION NUMBERS												
AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	
3	53623	52379	81956	107684	78126	111681	162315	210033	183205	100538	127850	
4	93903	42354	41214	66365	87236	63681	85825	131976	171279	131821	67512	
5	19549	65086	28793	29762	50823	66214	38063	63381	91392	83732	56554	
6	16663	11419	33336	12990	22371	31467	36570	24269	34084	29297	24572	
7	12142	8191	6549	13487	9205	13928	18597	17945	9197	11150	7260	
8	4723	6380	4555	3539	7790	5786	9347	6304	7014	3210	3395	
9	3308	2607	2958	2217	2198	2904	3733	3285	1119	1534	1188	
10	3100	2024	1607	1655	1210	746	1664	2079	1034	703	799	
11	2329	1701	1307	1139	963	441	314	233	169	684	414	
12	311	803	580	1047	728	497	328	109	81	74	479	
3+	209650	192944	202854	239886	260651	297343	356756	459613	498574	362743	290022	
4+	156028	140565	120898	132202	182525	185663	194441	249580	315369	262205	162172	
5+	62125	98211	79684	65837	95289	121982	108616	117604	144089	130384	94660	
6+	42576	33125	50892	36075	44466	55768	70554	54224	52698	46652	38106	
AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
3	80313	84504	62222	35277	36128	23494	29063	52674	38870	15433	18160	42112
4	97297	63850	68326	50881	19782	23766	18628	20127	42577	30992	12571	14615
5	43580	61832	27936	38028	16684	7599	11512	8435	14244	30935	21911	9262
6	21918	25909	23207	11753	17473	3791	3029	4046	4615	9384	16995	14511
7	9991	9366	10626	6847	4203	4468	837	1499	1956	3039	5164	12053
8	4054	4881	4501	3376	3822	1408	892	494	710	1281	1689	3626
9	1519	1840	1734	2160	1885	1187	195	515	245	489	809	1215
10	504	754	1054	1162	1129	625	138	119	233	148	348	594
11	390	278	437	667	732	312	94	80	39	144	106	260
12	218	114	137	287	422	212	28	66	28	25	107	80
3+	259784	253327	200180	150438	102260	66862	64418	88056	103517	91869	77859	98329
4+	179471	168824	137958	115160	66132	43368	35354	35381	64647	76436	59700	56217
5+	82174	104973	69632	64279	46350	19602	16726	15255	22070	45444	47129	41603
6+	38594	43141	41696	26252	29666	12003	5214	6820	7826	14509	25218	32341

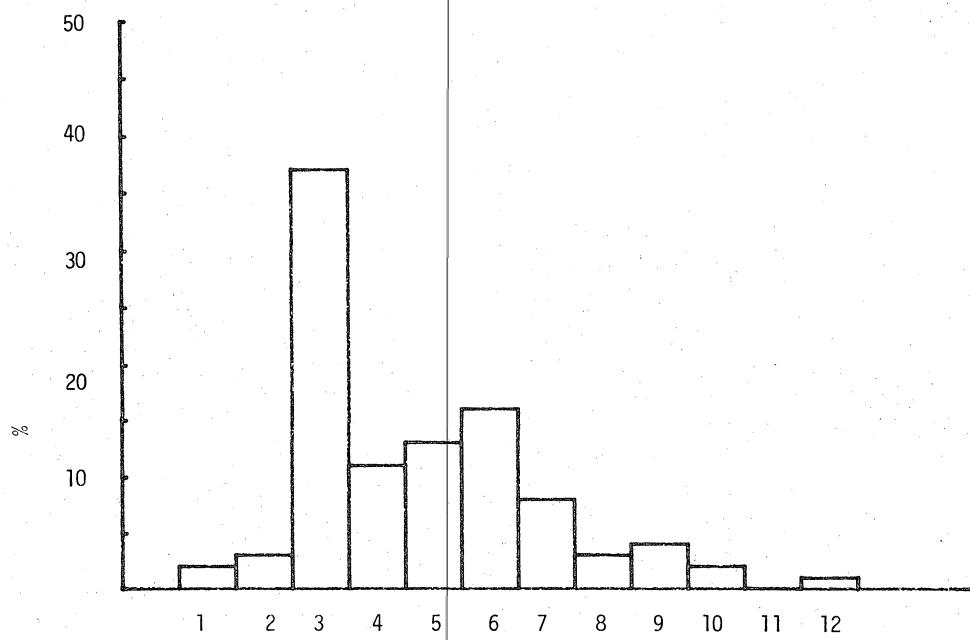


Fig. 1. Percent age frequency of the research vessel catch in 3NO during 1981.

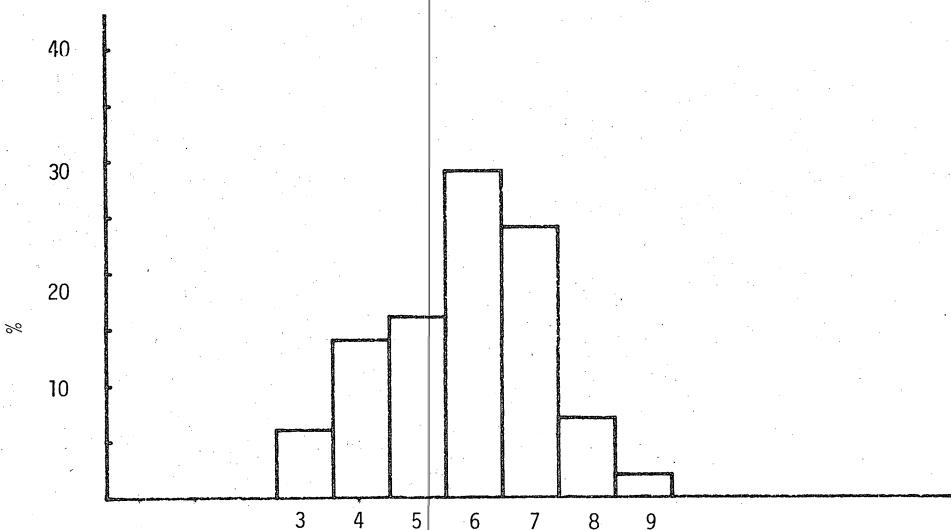


Fig. 2. Percent age frequency of the commercial catch in 3NO during 1981.

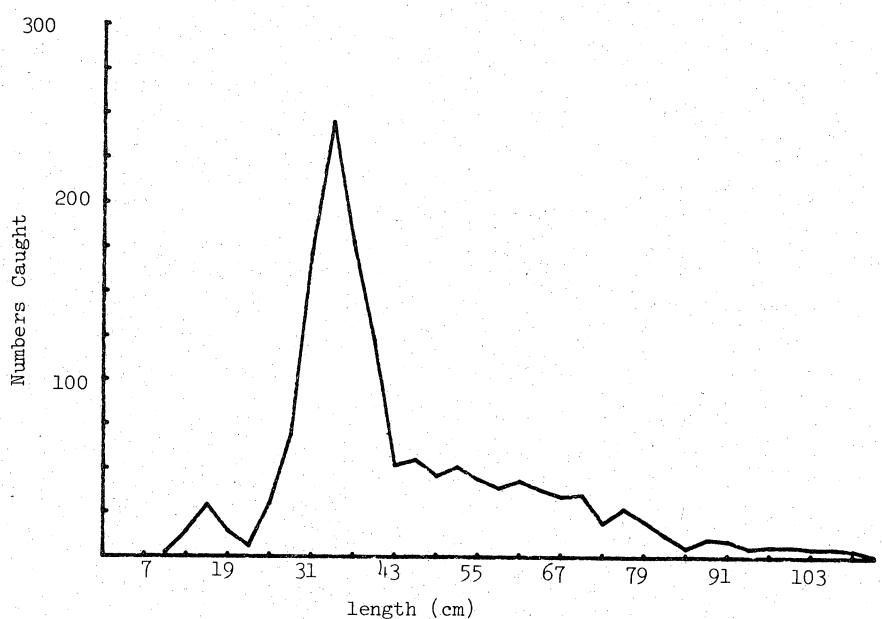


Fig. 3. Length frequency of the research vessel survey catch of cod in 3NO during 1981.

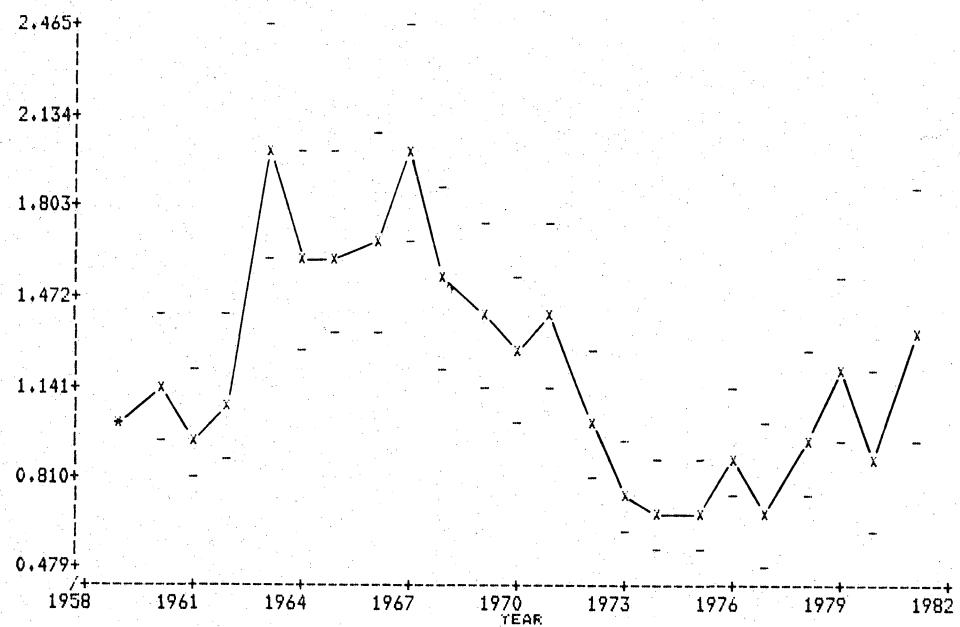


Fig. 4. Relative catch rate index with approximate 90% confidence interval for cod in NAFO Divisions 3NO.

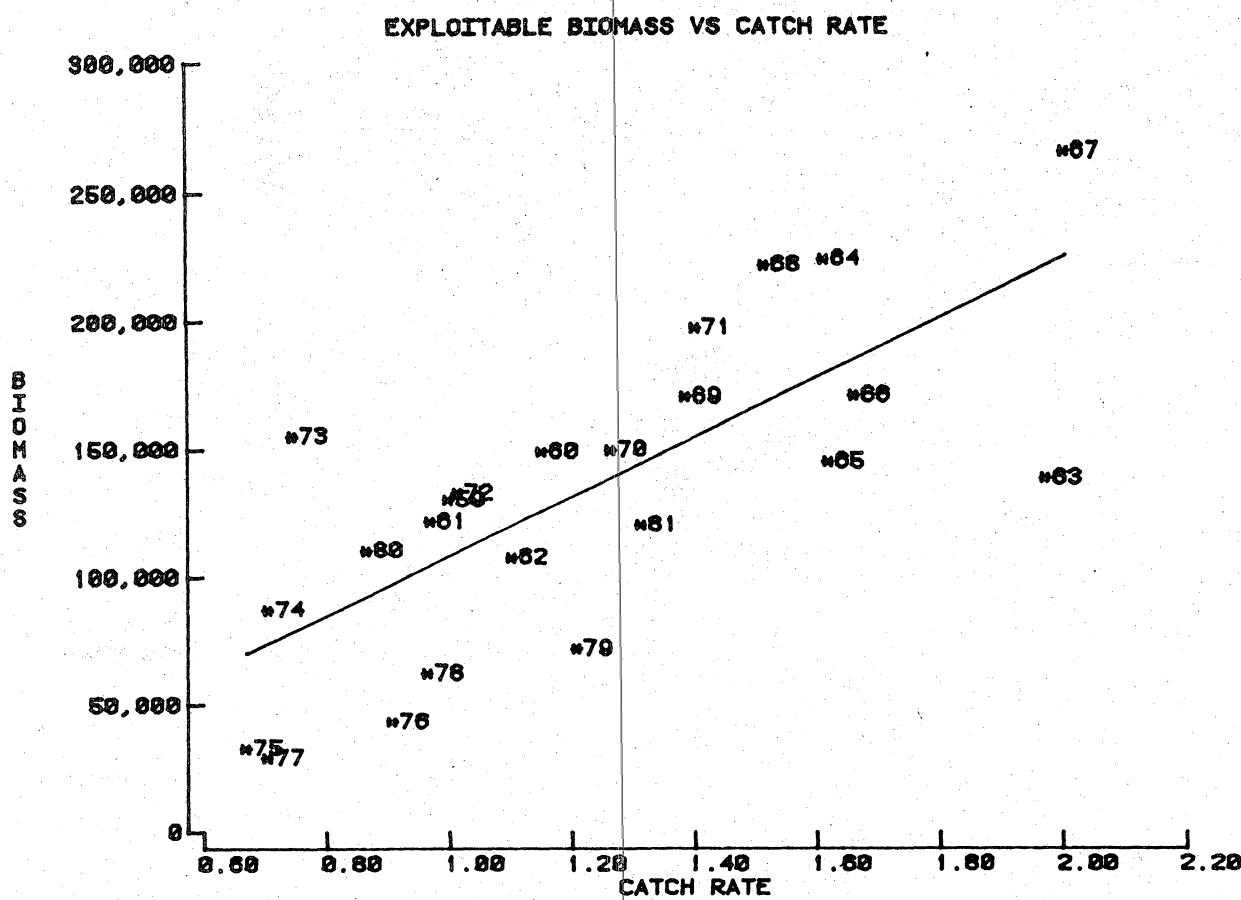


Fig. 5. Plot of the regression of exploitable biomass vs catch rate index for cod in NAFO Divisions 3NO using a fishing mortality of 0.18 for fully recruited ages in 1981.

