

Assessment of the Cod Stock in 3Pn4RS

by

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Abstract

A catch rate index was obtained using a multiplicative model to combine catch rate data for different month, country, gear and area categories. The coefficient of variation of the commercial catch at age was less than 10% for the dominant ages in the fishery. Cohort analysis using a constant natural mortality of 0.2 was calibrated to the catch rate index and to catch rate series for Quebec based vessels. Best agreement was obtained with a fully recruited fishing mortality of 0.4 in 1981. Partial recruitment (in 1981) for ages 5 and 6 was taken as the average partial recruitment for 1974-80. Partial recruitment for age 4 was determined from the relationship between catch at age 4 per unit effort and population numbers at age 4 from cohort for 1974-79. This resulted in an estimate of 450 million fish at age 4 in 1981. Assuming a catch of 90,000 t in 1982 (the TAC) the projected catch in 1983 corresponding to a fishing mortality of $F_{0.1} = 0.2$ was 91,000 t. The 1977 year-class accounted for 40% of the projected catch biomass. The recent increase in population size, despite fishing mortalities exceeding twice the $F_{0.1}$ level, was attributed to exceptionally high recruitment.

Résumé

Un indice des taux de capture fut généré à l'aide d'un modèle multiplicatif qui permet de combiner des données provenant de mois, de pays, de zones et d'engins différents. Le coefficient de variation pour les prises à l'âge commerciales était inférieur à 10% pour les principales catégories d'âge. Une analyse des cohortes, utilisant un taux de mortalité naturelle constant de 0,2, fut ajustée à l'aide de l'indice des taux de capture et de séries de taux de capture calculés pour les navires québécois. La meilleure concordance fut obtenue avec un taux de mortalité par pêche pour les âges entièrement recrutés égal à 0,4. La moyenne des recrutements partiels pour la période 1974-80 fut utilisée comme indice de recrutement partiel pour les âges 5 et 6 en 1981. Quant à celui pour les individus d'âge 4, il fut estimé à partir d'une relation calculée entre les taux de captures par unité d'effort des poissons de 4 ans et l'abondance de ces mêmes poissons telle que calculée par analyses de cohortes, pour la période 1974-79. C'est ainsi que pour 1981, le nombre de morues de 4 ans fut établi à 450 millions. En supposant que les prises s'élèveront à 90 000 en 1982 (les TPA), on a prévu que les prises, en 1983, pour une mortalité due à la pêche de $F_{0.1} = 0,2$, s'élèveront à 91 000 t, et que la classe d'âge de 1977 représentera 40 % du total des prises. On a déterminé que la récente augmentation des populations observée en dépit d'une mortalité due à la pêche dépassant plus de deux fois le niveau $F_{0.1}$ est attribuable à un recrutement exceptionnellement élevé.

Data Sources

Commercial catch and effort data for 1959-79 were derived from the ICNAF (NAFO) Statistical Bulletin. The NAFO Secretariat supplied an advance release of Canada Maritimes data for 1980. Canada Newfoundland data for 1980-82 and Canada Maritimes data for 1981 were provided by the respective Economics and Statistics Branches of the Department of Fisheries and Oceans. Data are considered finalized only up to 1979. Annual catch rates from the Quebec fishery in Division 4S for 1978-81 were also examined (Lussiaa-Berdou, pers. comm.)

Sampling for lengths and ages in 1981 were obtained from the Commercial Sampling Section for Canadian landings and from the Foreign Observer Program for catches by France. Coverage of the major components of the fishery was fairly complete (Table 1 and 2) with the only obvious deficiencies being the third quarter for otter trawls and the months of June and August for line trawls. Catch and average weight at age for previous years was taken from Gavaris and Bishop (1981).

Data analysis

The catch and effort data were split into two units, from 1959-77 and from 1977-82. The two series are qualitatively different; in recent years the Spanish and Portuguese fleets were absent and the behaviour of the Canadian fleet was influenced by the introduction of new management policies. The multiplicative model (Gavaris 1980) was applied to each series using a weighting factor of $(\text{catch} \times \text{effort})^{0.25}$. The analysis for 1959-77 shows a prominent seasonal pattern with January and February being strong months (Table 3). The post 1977 analysis does not include May to December due to the absence of data but there is an indication that catch rates are highest in January (Table 4). Division 4S does not show as well in the 1977-82 analysis. This may be due to lack of coverage in recent years or to unusually dense concentrations in 3Pn and 4R. The two series were combined by scaling the indices in the 1977-82 series to the 1977 value in the 1959-77 series. Rather than selecting an arbitrary standard for computing an annual series the yearly effect relative to 1959 was estimated (Table 5). It should be noted that the amount of data available for catch rate analysis has been severely reduced limiting the reliability of the index. It is evident, however, that there has been an increasing trend in the catch rate index through the late 70's and early 80's (Fig. 1.).

The catch at age and its variance were computed using the formulae outlined by Gavaris and Gavaris (unpublished). The catch at age for the major components is shown in Table 6. The coefficient of variation for estimates of catch at age between the ages of 4 and 9 was less than 10% (Table 7). The average weight at age was computed by applying a weight length relationship to the length frequencies and age length keys. The discrepancy between reported and calculated total catch weight was about 4%.

Cohort analysis was conducted using the catch and weight at age matrices in Table 8. The results from a cohort analysis with a fishing mortality of 0.4 in 1981 are shown in Table 9. The fishing mortality for age 15 was estimated to be the fully recruited fishing mortality for ages 7 to 11. This is obtained from the survival rate of fish aged 7 to 10 in one year and 8 to 11 in the

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succeeding year. Population numbers from a cohort analysis with a fishing mortality of 0.4 in 1981 were used for this calculation. The partial recruitment was estimated as the average partial recruitment from 1974-80 (Table 10) where partial recruitment was computed as fishing mortality divided by fully recruited fishing mortality for ages 7 to 11. Figure 2 shows the regression of exploitable biomass versus the catch rate index for the cohort analysis with fishing mortality of 0.4 in 1981.

Results from regression analyses of biomass and exploitable biomass versus the catch rate index are summarized in Table 11 for fishing mortalities of 0.30-0.45 for 1981. Exploitable biomass is calculated by multiplying the mid year biomass by a partial recruitment matrix. Although the discrimination power of the regressions are not that good, a fishing mortality of 0.4 in 1981 results in a relationship between exploitable biomass and the catch rate index which passes closest to the origin. The time series plot of the catch rates from Quebec based vessels (18-25 meters) agrees fairly well with the exploitable biomass (Fig. 3).

Uncertainty about the partial recruitment for age 4 in 1981 makes the large population numbers estimate from cohort suspect. Using the catch at age 4 divided by the effort index as an index of abundance for population numbers at age 4 an estimate for 1981 was obtained (Table 12). It was assumed that the relationship was linear and passed through the origin (Fig. 4). The 1980 point was not used because of the anomalous drop in the catch rate index.

Since changes in the population numbers at age 4 in 1981 do not affect the relationships found between exploitable biomass and the catch rate indices, projections were run using the 4-yr-old population numbers from Table 12 and the 5-15-yr-old population numbers from the cohort analysis (Table 9). The geometric mean of 4-yr-old from 1974-81 (132 million) was used for recruitment in subsequent years. Assuming a catch of 90,000 t (the TAC) in 1982, the catch biomass corresponding to a fishing mortality of $F_{0.1} = 0.2$ in 1983 was 90,823 t (Table 13). Assuming a fishing mortality of $F_{0.1} = 0.2$ in 1982, the catch biomass corresponding to a fishing mortality of $F_{0.1} = 0.2$ in 1983 was 94,629 t (Table 14). In either case it is significant that the 1977 year-class accounts for approximately 40% of the catch biomass in 1983.

The inverse of the slope from the regression of exploitable biomass vs. catch rate index ($F_{1981} = 0.4$) was used as an estimate of q , the coefficient of catchability, in the surplus production model. Although convergence was attained the model was unable to capture the dynamics of the recent increase in population size. The estimates for unfished exploitable biomass, maximum sustainable yield, and for the shape parameter were 202,534 t, 83,813 t, and 9.75 respectively. The non-equilibrium yield at $2/3$ effort $_{MSY}$ for 1983 was 55,564 t. The model consistently underestimated the yield in recent years by substantial amounts.

Corrigendum

The total catch for 1980 in Table 5 should be 94164 instead of 85902 and the proportion decreases accordingly to 0.085 from 0.093.

References

- Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. *Can. J. Fish. Aquat. Sci.* 37: 2272-2275.
- Gavaris, S., and C. A. Bishop. 1981. Assessment of the cod stock in 3Pn4RS. *CAFSAC Res. Doc.* 81/47.

Table 1. Commercial sampling for 3Pn4RS cod in 1981.

Gear	Qtr.	Country	Otoliths	Month	Div.	Length measurements	
OT	1	Can(N)	322	February	3Pn	3648	
		Fra(STPM)	14	February	3Pn	1705	
		Fra(M)	18	February	3Pn	8067	
		Can(N)	380	January	4R	6268	
				February	4R	488	
		Can(M)	100	January	4R	1161	
		Fra(STPM)	6	February	4R	2883	
		Fra(M)	624	January	4R	19137	
				February	4R	11421	
		Can(M)	113	January	4RS	657	
			2	Can(N)	350	May	4R
Can(M)	346			May	4R	1513	
Can(M)	29			May	4S	200	
LT	1	Can(N)	429	February	3Pn	3098	
		2	Can(N)	500	March	3Pn	6221
			Can(N)	669 ^a	March	4R	6374
	Can(M)	44	May	4S	200		
	3	Can(N)	818 ^a	July	4R	1318	
		Can(M)	29	August	4S	200	
	4	Can(N)	487	November	3Pn	4555	
	GN	2	Can(N)	669 ^a	May	4R	483
			Can(N)	818 ^a	June	4R	3112
	TRAP	3	Can(N)	818 ^a	June	4R	2498
ST	2	Can(M)	92	April	4R	400	
		Can(M)		May	4R	200	
		Can(M)	33	June	4S	200	
	3	Can(M)	48	September	4S	400	
	4	Can(M)	150	October	4S	623	
				November	4S	400	
	DS	3	Can(N)	-	July	4R	506

^aTotals represent combined (LT, GN, Trap) quarterly A/L keys from 3Pn4RS.

Table 2. Cod landings (t) in 1981 by country and gear from Divisions 4R and 4S and Subdivision 3Pn.

Country	Gear	3Pn	4R	4S	Total
CanN	OT	3573	26868	28	30469
	GN	5	5826	288	6119
	LT	7516	8833	17	16366
	HL	72	2087		2159
	TRAP	4	4889	2	4895
	D. S.	18	380		398
		<u>11188</u>	<u>48883</u>	<u>335</u>	<u>60406</u>
CanM	OT	50	2076	52	2178
	ST		160	140	300
	LL	12	55	6	73
	D. S.			30	30
		<u>62</u>	<u>2291</u>	<u>228</u>	<u>2581</u>
CanQ	OT		645	10947	11592
	ST			1615	1615
	GN			7806	7806
	LL			182	182
	HL			551	551
				<u>645</u>	<u>21101</u>
France ^a	OT	3482	9266		12748
All	All	14732	61085	21664	97481

^aLandings obtained from NAFO Circular letters for 1981.

Table 3. Regression coefficients for grouped categories and the analysis of variance from the regression of ln catch rate for cod in NAFO area 3Pn4RS from 1959-77.

Country gear	ln power	Months	ln power
CanN OT-4	-0.085	October	-0.931
CanM OT-4	0.000	November December	-0.734
CanN OT-5	0.225	June	
CanM OT-5	0.424	July September	-0.586
Port OT-6		May	
Span OT-6	0.711	August	-0.429
Span PT-4			
Port OT-7	0.992	April	-0.334
		May	-0.153
Div.	ln power	January	0.000
		February	0.123
3Pn	0.000		
4S	0.111		
4R	0.248		

MULTIPLE R.....0.806
 MULTIPLE R SQUARED.....0.649

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.293E1	1.293E1	
REGRESSION	32	2.723E2	8.509E0	45.531
TYPE 1	5	6.534E1	1.307E1	69.921
TYPE 2	7	9.650E1	1.379E1	73.759
TYPE 3	2	1.898E1	9.491E0	50.782
TYPE 4	18	3.396E1	1.887E0	10.095
Residuals	787	1.471E2	1.869E-1	
Total	820	4.323E2		

Table 4. Regression coefficients for grouped categories and the analysis of variance from the regression of ln catch rate for cod in NAFO area 3Pn4RS from 1977-82

Country gear	ln power	Months	ln power
CanN OT-4	-0.562	February	
CanN OT-5	-0.231	March	-0.238
CanM OT-4	0.000	April	
CanM OT-5	0.218	May	
		January	0.000
		Div.	ln power
		4S	-0.149
		3Pn	
		4R	0.000

MULTIPLE R.....0.678
 MULTIPLE R SQUARED.....0.459

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.353E0	1.353E0	
Regression	10	3.054E1	3.054E0	13.687
TYPE 1	3	1.365E1	4.549E0	20.383
TYPE 2	1	7.126E-1	7.126E-1	3.193
TYPE 3	1	1.267E0	1.267E0	5.679
TYPE 4	5	6.225E0	1.245E0	5.578
Residuals	161	3.593E1	2.232E-1	
Total	172	6.783E1		

Table 5. Mean catch rate indices of cod in NAFO area 3Pn4RS for years 1960-82 relative to 1959 with their respective standard errors. The proportion of total catch which was used in the analysis for each year is also indicated.

YEAR	TOTAL CATCH	PROP.	RELATIVE POWER		EFFORT
			MEAN	S.E.	
1959	58060	0.034	1.000	0.000	58060
1960	94350	0.251	1.015	0.170	92942
1961	100010	0.363	1.401	0.228	71399
1962	91682	0.314	1.231	0.201	74499
1963	76151	0.278	1.525	0.253	49949
1964	84234	0.283	1.406	0.234	59920
1965	68929	0.276	1.280	0.209	53839
1966	65085	0.312	1.141	0.185	57053
1967	79312	0.237	1.003	0.159	79095
1968	89671	0.235	1.181	0.188	75949
1969	71140	0.204	1.021	0.164	69671
1970	106736	0.393	1.012	0.159	105514
1971	84310	0.351	0.692	0.112	121756
1972	57062	0.308	0.778	0.125	73328
1973	66489	0.260	0.673	0.111	98864
1974	66428	0.304	0.957	0.154	69392
1975	60215	0.263	0.759	0.125	79349
1976	76981	0.119	0.756	0.124	101792
1977	73566	0.239	0.704	0.115	104444
1978	78506	0.152	0.968	0.114	81101
1979	82677	0.116	1.127	0.156	73353
1980	85902	0.093	0.895	0.095	95928
1981	97501	0.133	1.219	0.158	79963
1982	90000	0.042	1.069	0.184	84217

AVERAGE C.V. FOR THE MEAN: 0.150

Table 6. Age compositions of the commercial catch for cod in 3Pn4RS grouped by gear and quarter.

GEAR/QUA.	OT/1	OT/2	OT/4	IN/1	IN/2	IN/3	IN/4
AGE							
4	1217	1267	64	17	72	4574	578
5	2617	3692	28	41	249	1583	339
6	6528	7722	86	296	912	2151	302
7	4278	3246	30	394	1015	1919	312
8	1466	1088	12	121	490	555	77
9	467	285	2	64	284	338	31
10	135	114	1	14	76	151	12
11	15	14	0	4	18	60	3
12	20	5	0	4	12	33	0
13	6	6	0	4	12	30	0
14	3	1	0	2	8	15	0
15	10	6	0	1	4	8	0
NO. LENGTHS	55435	5755	1023	3098	13278	7634	4555
NO. OTOLITHS	1557	850	150	429	1213	847	487
CATCH WEIGHT	23295	22120	280	1821	5540	17080	3012

Table 7 . . Estimated average weight, catch and variance of the catch from commercial statistics for cod in NAFO area 3Pn4RS during 1981.

AGE	WEIGHT	CATCH	VAR(CATCH)	STD. ERROR	COEF. VAR
2	0.300	3	2.995	1.73	0.52
3	0.502	540	11606.632	107.73	0.20
4	0.679	10382	137175.408	370.37	0.04
5	0.921	11398	319840.245	565.54	0.05
6	1.267	23991	495013.547	703.57	0.03
7	1.707	14921	316126.749	562.25	0.04
8	2.160	5076	93073.574	305.08	0.06
9	2.696	1961	24922.313	157.87	0.08
10	3.812	670	6716.025	81.95	0.12
11	5.400	152	512.089	22.63	0.15
12	7.302	98	204.374	14.30	0.15
13	6.429	78	157.611	12.55	0.16
14	7.742	38	73.375	8.57	0.22
15	4.505	38	132.811	11.52	0.31
16	11.439	19	14.397	3.79	0.20
17	12.597	16	13.350	3.65	0.23
18	10.023	4	17.367	4.17	0.98
19	8.400		0.051	0.23	1.03
20	7.429	1	0.283	0.53	0.74

Table 8 . Catch and average weight matrices used for sequential population analysis of cod in NAFO area 3Pn4RS.

AGE	CATCH							
	1974	1975	1976	1977	1978	1979	1980	1981
4	1471	2924	1984	3141	3134	4110	2620	10382
5	5121	4380	14724	10292	11159	16209	15975	11398
6	11537	6446	7570	15321	17601	13751	20475	23991
7	7353	9048	3775	7653	10346	12890	10821	14921
8	10987	3392	5867	2882	2432	4669	6029	5076
9	3902	5808	2016	3041	1164	1416	1262	1961
10	2722	1647	2584	949	1188	643	398	670
11	704	815	1717	612	460	473	217	152
12	273	870	600	292	382	252	268	98
13	147	64	196	171	194	112	68	78
14	48	52	90	49	106	83	88	38
15	40	150	27	11	17	28	24	38

AGE	AVERAGE WEIGHT							
	1974	1975	1976	1977	1978	1979	1980	1981
4	0.57	0.57	0.57	0.57	0.68	0.55	0.52	0.68
5	0.86	0.86	0.86	0.86	0.87	0.89	0.82	0.92
6	1.30	1.30	1.30	1.30	1.30	1.32	1.29	1.27
7	1.79	1.79	1.79	1.79	1.84	1.78	1.76	1.71
8	2.43	2.43	2.43	2.43	2.56	2.41	2.37	2.16
9	3.06	3.06	3.06	3.06	3.01	3.15	3.42	2.70
10	3.60	3.60	3.60	3.60	2.88	3.57	4.17	3.81
11	4.06	4.06	4.06	4.06	3.23	3.79	4.43	5.40
12	4.48	4.48	4.48	4.48	3.96	4.51	3.78	7.30
13	4.89	4.89	4.89	4.89	4.12	5.23	4.98	6.43
14	5.30	5.30	5.30	5.30	5.84	4.74	3.93	7.74
15	5.71	5.71	5.71	5.71	9.33	5.43	7.00	4.51

Table 9. Results from cohort analysis for cod in NAFO area 3Pn4RS using a fishing mortality of 0.4 in 1981 for fully recruited ages.

POPULATION NUMBERS								
AGE	1974	1975	1976	1977	1978	1979	1980	1981
4	49175	91872	103612	100554	149488	201655	142868	614650
5	33300	38930	72572	83036	79484	119555	161382	114600
6	47139	22630	27910	46094	58671	54979	83217	117674
7	20590	28155	12696	16001	23876	32110	32571	49606
8	27586	10205	14864	6979	6176	10187	14626	16875
9	10903	12644	5286	6861	3106	2856	4115	6519
10	5881	5396	5097	2503	2866	1490	1057	2227
11	2464	2352	2927	1835	1191	1271	638	505
12	580	1380	1188	843	949	559	613	326
13	340	228	343	430	426	431	229	259
14	571	145	129	103	197	173	252	126
15	103	424	72	24	40	65	67	126
4+	198632	214361	246696	265263	326470	425331	441635	923695
5+	149457	122489	143084	164709	176982	223676	298767	308845
6+	116156	83558	70511	81674	97498	104121	137384	194245
7+	69018	60928	42601	35579	38826	49142	54168	76571

POPULATION BIOMASS (MID-YEAR)								
AGE	1974	1975	1976	1977	1978	1979	1980	1981
4	25172	46978	53350	51434	90962	99424	66159	374967
5	23728	28446	50110	60258	57506	89259	113194	90496
6	47885	22343	27829	43909	57239	56498	83680	119860
7	26483	37244	17101	18474	29571	39576	42034	63675
8	46544	18170	25156	11624	11016	16143	23727	27410
9	23956	25420	11392	14004	6616	5701	10527	13217
10	13861	14531	11495	6360	5650	3585	3114	6385
11	7592	6918	6798	5454	2697	3420	2057	2052
12	1690	3336	3340	2737	2599	1669	1552	1789
13	1119	850	976	1459	1158	1743	860	1254
14	2616	552	331	354	697	529	715	735
15	415	1748	291	91	256	241	336	428
4+	221061	206537	208168	216159	265967	317790	347955	702270
5+	195889	159559	154818	164725	175005	218366	281796	327303
6+	172161	131113	104708	104467	117499	129107	168601	236807
7+	124275	108769	76879	60558	60260	72609	84922	116946

FISHING MORTALITY								
AGE	1974	1975	1976	1977	1978	1979	1980	1981
4	0.034	0.036	0.021	0.035	0.023	0.023	0.020	0.019
5	0.186	0.133	0.254	0.147	0.169	0.162	0.116	0.116
6	0.315	0.378	0.356	0.458	0.403	0.324	0.317	0.254
7	0.502	0.439	0.398	0.752	0.652	0.586	0.458	0.400
8	0.580	0.458	0.573	0.610	0.571	0.706	0.608	0.400
9	0.503	0.709	0.547	0.673	0.535	0.794	0.414	0.400
10	0.717	0.412	0.822	0.543	0.613	0.648	0.538	0.400
11	0.380	0.483	1.045	0.460	0.557	0.530	0.472	0.400
12	0.734	1.193	0.817	0.483	0.589	0.690	0.660	0.400
13	0.650	0.371	1.000	0.580	0.700	0.339	0.397	0.400
14	0.098	0.504	1.478	0.744	0.903	0.754	0.489	0.400
15	0.550	0.490	0.530	0.690	0.620	0.630	0.500	0.400

Table 10. Historical partial selection estimate for age 4-6 cod in NAFO Area 3Pn4RS

Age	Year							Average
	1974	1975	1976	1977	1978	1979	1980	
4	0.06	0.07	0.04	0.05	0.04	0.04	0.04	0.05
5	0.34	0.27	0.47	0.21	0.27	0.26	0.23	0.29
6	0.57	0.77	0.66	0.67	0.65	0.52	0.64	0.64

Table 11. Results from regression analyses of biomass and exploitable biomass versus catch rate for cod in NAFO Area 3Pn4RS using years 1974-81.

	F_{1981}			
	0.30	0.35	0.40	0.45
<u>Biomass</u>				
Corrected R^2	0.52	0.53	0.53	0.55
Intercept	-550343	-415679	-339350	-236121
1981 residual	252255	206187	183168	144715
<u>Exploitable biomass</u>				
Corrected R^2	0.40	0.39	0.39	0.31
Intercept	-73590	-29062	4340	30324
1981 residual	74722	57391	44394	34284

Table 12. A linear relationship passing through the origin between the abundance index and population numbers at age 4 was used to estimate the numbers at age 4 in 1981.

Year	Catch at age 4/effort	Population numbers at age 4
1974	0.021198	49175
1975	0.036850	91872
1976	0.019491	103612
1977	0.030074	100554
1978	0.038643	149488
1979	0.056030	201655
Sum	0.202286	696356
1981	0.129835	446948*

*Predicted.

Table 13. Projection for cod in NAFO area 3Pn4RS assuming a catch of 90,000 t in 1982.

POPULATION NUMBERS				CATCH NUMBERS			
AGE	1981	1982	1983	AGE	1981	1982	1983
4	446948	132000	132000	4	10382	1605	1191
5	114600	356556	106623	5	11398	24376	5451
6	117674	83550	269932	6	23991	12054	29457
7	49606	74763	57547	7	14921	16109	9486
8	16875	27224	46724	8	5076	5866	7702
9	6519	9261	17014	9	1961	1995	2805
10	2227	3578	5788	10	670	771	954
11	505	1222	2236	11	152	263	369
12	326	277	764	12	98	60	126
13	259	179	173	13	78	39	29
14	126	142	112	14	38	31	18
15	126	69	89	15	38	15	15
16	0	69	43	16	0	15	7
17	0	0	43	17	0	0	7
4+	755791	688890	639088	4+	68803	63199	57615
5+	308843	556890	507088	5+	58421	61594	56425
6+	194243	200334	400465	6+	47023	37218	50974
7+	76569	116784	130533	7+	23032	25163	21517

CATCH BIOMASS				FISHING MORTALITY			
AGE	1981	1982	1983	AGE	1981	1982	1983
4	7060	1091	810	4	0.026	0.014	0.010
5	10486	22426	5015	5	0.116	0.078	0.058
6	30469	15309	37410	6	0.254	0.173	0.128
7	25515	27547	16221	7	0.400	0.270	0.200
8	10964	12671	16636	8	0.400	0.270	0.200
9	5295	5388	7572	9	0.400	0.270	0.200
10	2553	2937	3635	10	0.400	0.270	0.200
11	821	1422	1990	11	0.400	0.270	0.200
12	715	436	919	12	0.400	0.270	0.200
13	502	248	184	13	0.401	0.270	0.200
14	294	237	143	14	0.401	0.270	0.200
15	304	119	117	15	0.401	0.270	0.200
16	0	170	81	16	0.000	0.270	0.200
17	0	0	89	17	0.000	0.000	0.200
4+	94977	90000	90823				
5+	87917	88909	90013				
6+	77431	66483	84999				
7+	46962	51174	47588				

Table 14. Projection for cod in NAFO area 3Pn4RS assuming a fishing mortality of 0.2 in 1982.

POPULATION NUMBERS			
AGE	1981	1982	1983
4	446948	132000	132000
5	114600	356556	106997
6	117674	83550	275473
7	49606	74763	60186
8	16875	27224	50115
9	6519	9261	18249
10	2227	3578	6208
11	505	1222	2378
12	326	277	819
13	259	179	186
14	126	142	120
15	126	69	95
16	0	69	46
17	0	0	46
4+	755791	688890	652940
5+	308843	556890	520940
6+	194243	200334	413942
7+	76569	116784	138469

CATCH NUMBERS			
AGE	1981	1982	1983
4	10382	1191	1191
5	11398	18228	5470
6	23991	9118	30061
7	14921	12324	9921
8	5076	4488	8261
9	1961	1527	3008
10	670	590	1023
11	152	201	395
12	98	46	135
13	78	30	31
14	38	23	20
15	38	11	16
16	0	11	8
17	0	0	8
4+	68803	47787	59547
5+	58421	46596	58357
6+	47023	28368	52887
7+	23032	19251	22825

CATCH BIOMASS			
AGE	1981	1982	1983
4	7060	810	810
5	10486	16770	5032
6	30469	11579	38178
7	25515	21074	16965
8	10964	9693	17844
9	5295	4122	8122
10	2553	2247	3899
11	821	1088	2135
12	715	333	986
13	502	190	197
14	294	181	153
15	304	91	126
16	0	130	87
17	0	0	96
4+	94977	68308	94629
5+	87917	67498	93819
6+	77431	50729	88787
7+	46962	39149	50609

FISHING MORTALITY			
AGE	1981	1982	1983
4	0.026	0.010	0.010
5	0.116	0.058	0.058
6	0.254	0.128	0.128
7	0.400	0.200	0.200
8	0.400	0.200	0.200
9	0.400	0.200	0.200
10	0.400	0.200	0.200
11	0.400	0.200	0.200
12	0.400	0.200	0.200
13	0.401	0.200	0.200
14	0.401	0.200	0.200
15	0.401	0.200	0.200
16	0.000	0.200	0.200
17	0.000	0.000	0.200

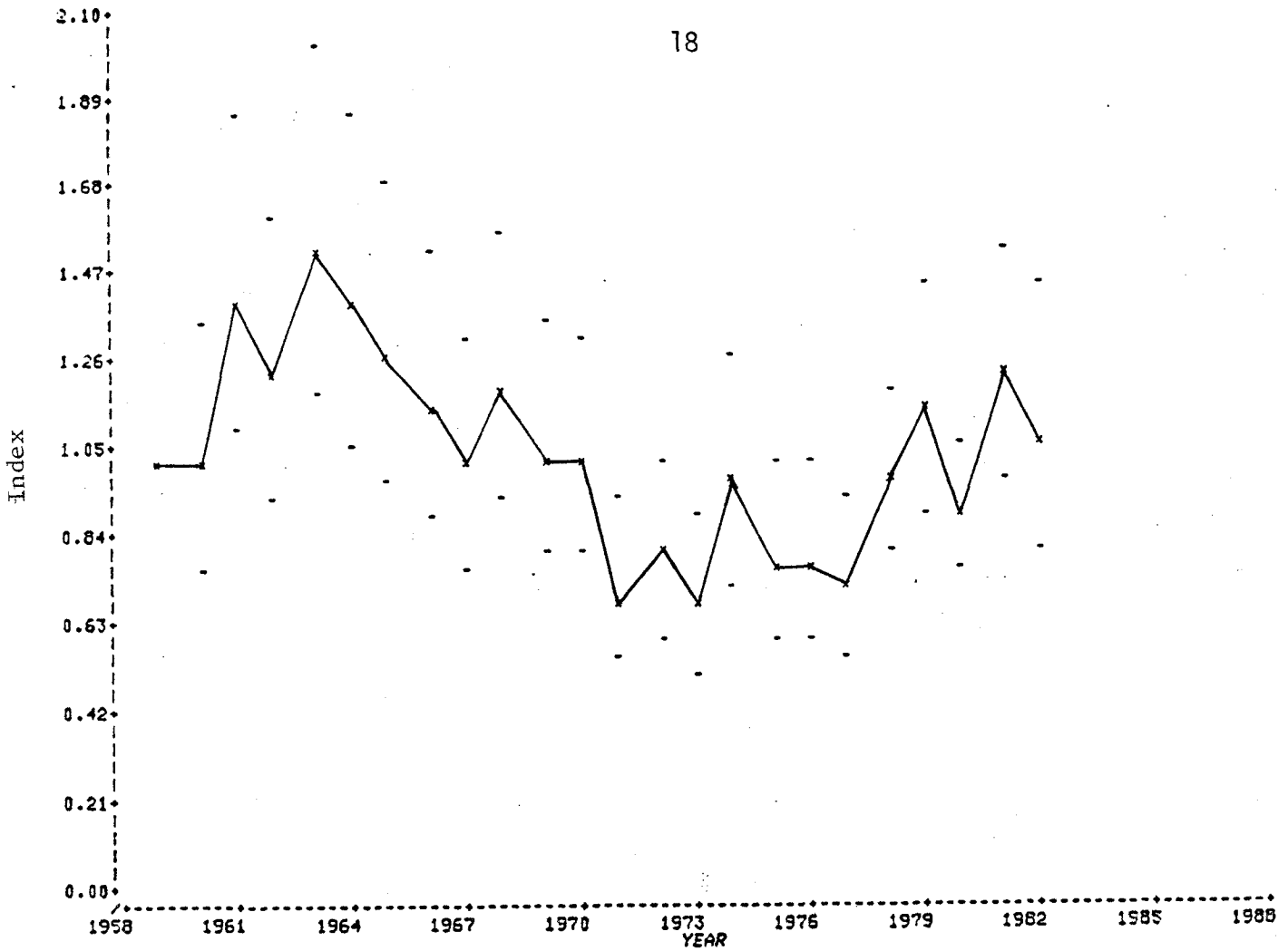


Fig. 1. . Relative catch rate indices with approximate 90% confidence intervals for cod in NAFO area 3Pn4RS.

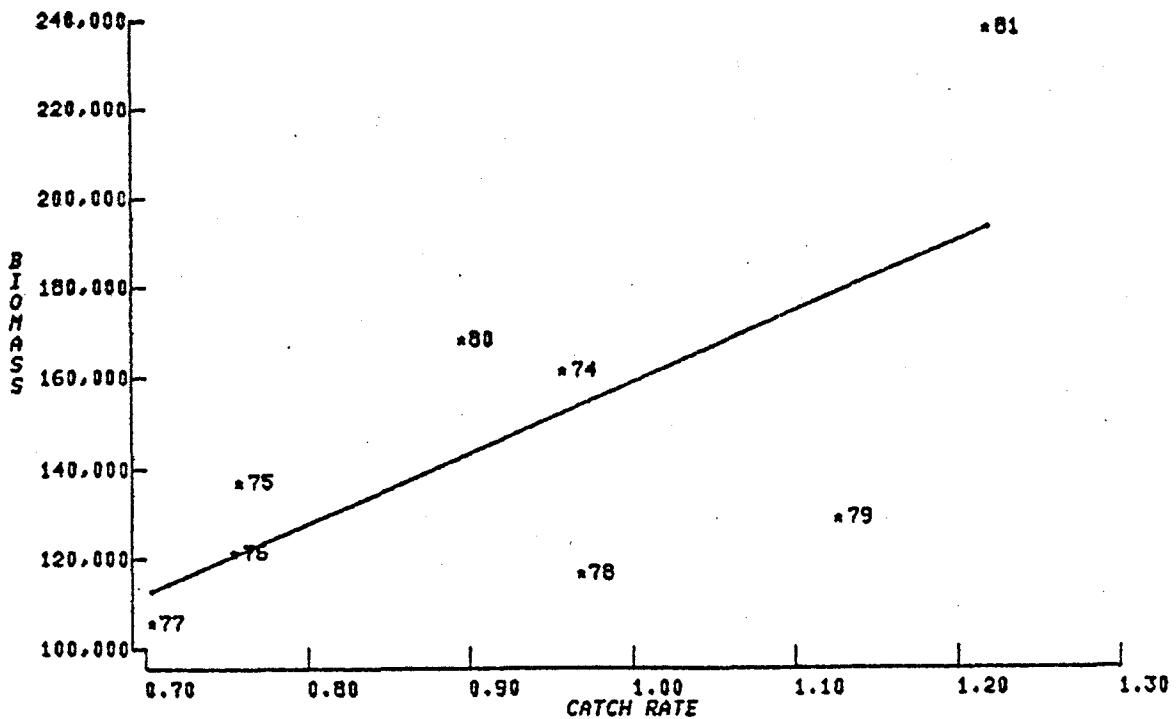


Fig. 2. Plot of the regression of exploitable biomass versus catch rate index for a fishing mortality of 0.4 in 1981.

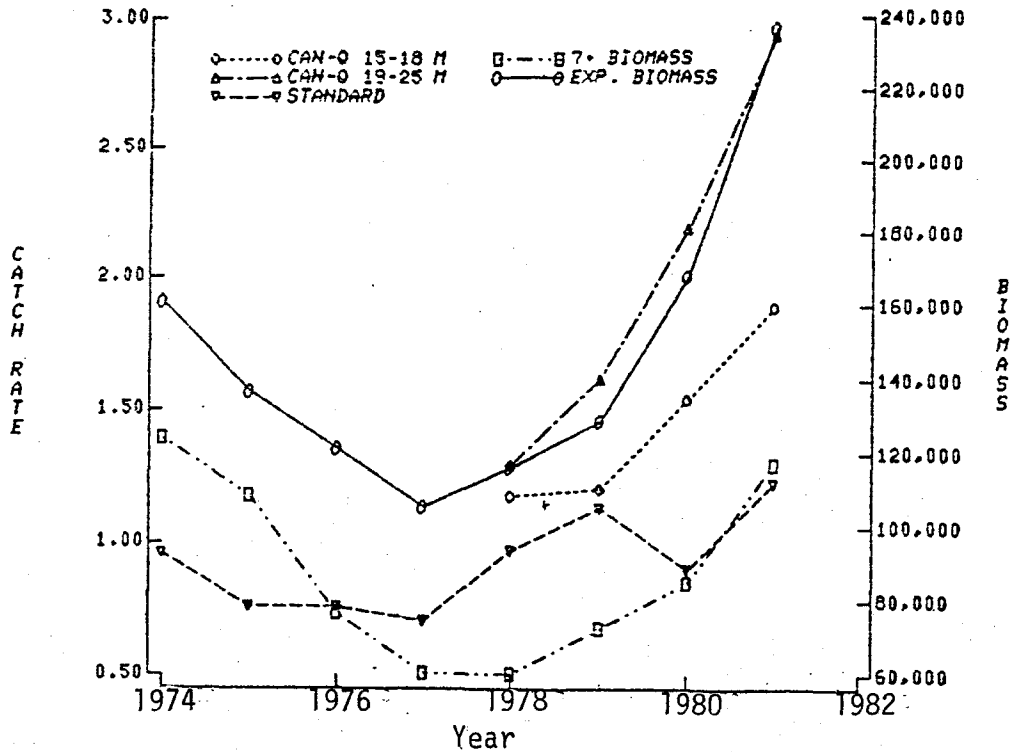


Fig. 3. Comparison of some catch rate indices with biomass from cohort analysis with a fishing mortality of 0.40 in 1981 for cod in NAFO area 3Pn4RS.

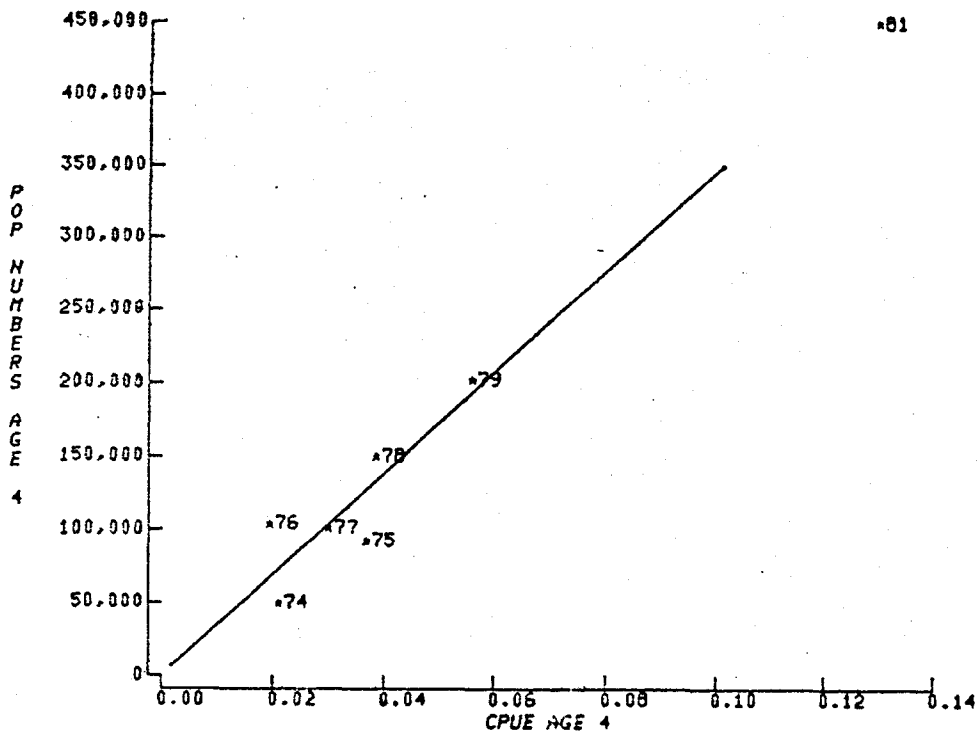


Fig. 4. Relationship of population numbers and catch rate index at age 4 used to estimate the numbers at age 4 in 1981 for cod in NAFO area 3Pn4RS.