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An assesssment of the Cod Stock in Subdivision 3Ps.*

by

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Nominal catch and catch at age

Cod catches from subdivision 3Ps since 1975 along with corresponding TAC'S are as follows:

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TAC ('000t)	62.4	47.5	32.5	25	25	28	30	33	33	25
Catch('000t)	35	37	32	27	33	38	39	34	38	

Landings by all countries since 1959 are shown in Table 1, while those for Canada in 1983 by month and gear are in Table 2. During the period from 1959 to the mid 1970's catches were mainly from the offshore otter trawl fishery (Fig. 1). Since 1977 only Canada and France have prosecuted this fishery and because of restrictions on offshore allocations, inshore catches have been making up the larger portion of the total. Catches by the major inshore gears over the period 1964 to 1983 are shown in Figure 2. Catches by linetrawl have shown a general increase in recent years while that for codtrap has declined. The catch at age for 1982 was adjusted to a total catch by France of 6964 t as opposed to that used in the 1983 assessment of 5170 t. Catch at age data for the commercial fishery in 1983 (Table 3) were obtained using sampling data as shown in Table 4. An estimate of catch by France of 7000 t was obtained from the Resource Management Division of DFO.

Age frequencies for the major gear components in the Canadian fishery in 1983 along with estimated total catch at age with associates variances are shown in Table 3. Average weights at age were obtained by applying a length weight relationship (log wt = log length × 3.0879 - 5.2106) to the length frequencies and age length keys. The calculated total catch weight was found to be 2% lower than that reported. As indicated in Table 3 and Fig. 3, the 1978 year-class was the most abundant in the commercial catch in 1983.

Survey Data

The estimates of biomass calculated from the stratified random research surveys are shown in Table 5. It can be seen from this table that there are a number of strata that have not been sampled consistently. Table 6 shows estimates of abundance with values for the non-sampled strata estimated using analysis of variance of the ln catch per tow. This approach is similar to that of the multiplicative model developed by Gavaris (1980) for catch rate standardization. The catches were adjusted to the age 4-14 catch using the mean catch per standard tow (Table 7).

The model used is defined by:

$$\ln C_{4\text{-}14} = \mu + \beta_i + \gamma_j + \varepsilon$$

This model takes the ln catch as a function of some mean μ with a strata effect (β_i), a year effect (γ_j) and an error term (ε). To account for the varying levels of precision on the mean catch per tow, each was weighted by the inverse of its ln variance. The ln variance was estimated by:

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* Subsequent to the preparation of this document for the June 1984 Meeting, some additional information became available during the meeting. This resulted in the analysis given in the Appendix (pages 23-27).

ln (standard error) = ln (mean + S.E.) - ln (mean).

The age distribution of survey catches in 1983 and 84 (Fig. 3 and 4) confirm the strength of the 1978 year-class. Abundance and biomass values were much lower in 1984 than that for 1983.

Catch-effort data

Catch rate data for Canada, France (STPM), Spain and Portugal were analysed using a multiplicative model (Gavaris, 1980). Data for 1959-81 were obtained from ICNAF/NAFO Statistical Bulletins while data for 1982-83 were provided by the Statistics and Systems Branch of the Dept. of Fisheries and Oceans Canada. Plots of the residuals indicated that the data were less variable when values of catch and effort were higher. Estimated weights, calculated according to Judge et al. (1980, p. 132), were applied in a weighted regression for the multiplicative model. This procedure was effective in giving weight to data values with large catch and effort. Data with less than 10 t catch and for 10 hr effort were excluded from the analysis to reduce the possible effect of truncation and rounding errors.

A strong seasonal trend was once again indicated (Table 8) with catch rates being highest in the winter months. The annual catch rate indices (Table 9, Fig. 4) show an increasing trend since 1977 to a level in 1982 similar to that in the early 70's. The high catch rate value for 1983 was obtained using only Canadian otter trawl catch rate data. Catch rates from this data set have shown an increasing trend in recent yers along with some large fluctuations (Table 10). The reliability of catch rate data for a restricted (quota) fishery is also questionable as the tendency to fish an allocation when catch rates are traditionally best might introduce bias in a particular year.

The present catch rate series also includes data from France (STPM) OT-5 where data (catch/hr) were available (1978-79, 1981-82). In previous years this data series was not considered long enough for inclusion into the multiplicative model.

Cohort analysis

Catch and weight at age data from the 1983 commercial fishery (Table 3) were added to previously used matrices (Table 11), and these were used in a cohort analysis. Partial recruitment estimates were obtained initially by iteration having first input the value used in the most recent assessment (Bishop and Gavaris 1983) with fishing mortalities at age 14 (F_+) similarly estimated as the fully recruited fishing mortality for ages 7-11. A partial selection determined as appropriate for 1983 was derived as described in NAFO Res. Doc. 84/VI/50 (Gavaris and Bishop, 1984).

The method described provides an estimate of partial selection for each gear used in the fishery. The selectivity for all gears was then obtained by weighting the individual gear selectivities by the catch for that gear (Table 12).

Using this selectivity pattern and data previously described, cohort analyses were obtained using values of fully recruited F ranging from 0.15 to 0.30.

In the most recent assessment, a suitable value for fully recruited F in the current year (1982) was obtained using the relationship of exploitable 'offshore' biomass to catch rate indices. The 'offshore' biomass was obtained by multiplying the fishing mortality from the total fishery by the proportion of the catch taken offshore for 1978-82 to obtain an offshore fishing mortality. 'Offshore' selectivities thus obtained were used to obtain an offshore exploitable biomass.

In the current assessment this approach was considered to be less appropriate as a means of cohort tuning. The rationale for an 'offshore' exploitable biomass approach was that the fishing pattern had changed in recent years (mainly on inshore fishery since 1977) and that it was not appropriate to determine a suitable value for the fully recruited F by using the relationship of exploitable biomass available to the total fishery with catch rate indices from the offshore fishery.,

It is felt that while this concept has theoretical merit, there were sufficient changes in catch rate data currently used, along with known data inadequacies, to question its appropriateness for the present analysis. The current data series uses France (STPM) catch rate data (for which selectivity estimates were not available) as well as that for Can(M). Analysis of 'offshore' selectivities for all years (1959-83) indicated that the change was abrupt beginning in 1978 and that the values for 1983 were very low at age 6. It might also be difficult to determine a precise selectivity pattern when catches by the gear are low as the current case for otter trawl. Selectivities for any one year could be effected substantially.

For these reasons it was decided to use the relationship of catch rate indices to exploitable biomass from the total fishery for the purposes of cohort tuning. Table 13 indicates the results obtained from cohorts at F_t = 0.15, 0.20, 0.25, and 0.30. Data were used for the period 1961-83 because of the inconsistency of the 1959 and low catch rate values with population biomass estimates.

The best'fit' of catch rate indices to exploitable biomass with respect to regression parameters and predictability of values for 1981 to 83 was considered to be with an F_t between 0.20 and 0.25 (Table 13).

The relationship of survey mean number per tow (Age 4-14, Table 6) with cohort population numbers (Age 4-14) was also used to determine a suitable fully recruited F in 1983. Preliminary analysis indicated that the survey values for 1979 and 1981 were high and variable and as such were not included in subsequent analyses. Also, the data values for 1973-80 were clustered (Fig. 6) such that the outlying 1972 value would be the main determinant in a regression analysis. It was, therefore, decided to consider a regression line of mean number per tow data from 1972 to 80 through the origin (no intercept) and subsequently determine a F_t which would estimate the 1982 and 83 population numbers closest to this regression line. Table 14 shows the results of this analysis from cohorts at F_t = 0.15, 0.20, 0.25, and 0.30. The relationship between mean number per tow and population numbers was best at F_t between 0.20 and 0.25.

It was decided that the results from a cohort run at F_t = 0.25 best 'fit' the data available (Fig. 7). The relatively high catch rate value for 1983 may be overestimated and, if so, would tend to produce a lower value for fully recruited F. Tables 15, 16, and 17 show the results in terms of population numbers, population biomass (average), and fishing mortality of a cohort at F_t = 0.25.

Catchabilities over the period 1961-83 in terms ratio of catch rate indices to exploitable biomass are indicated in Fig. 8.

Recruitment

From the relationships of mean number per tow at ages 2 and 3 (F_t = 0.25) estimates of the strengths of the 1979-81 year-classes were obtained (Table 18); Fig. 9 and 10). A comparison of cohort recruitment estimates at age 3, by year, with the geometric mean of cohort recruitment for the period 1959-82 is shown in Fig. 11.

References

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Table 1. Cod landings in metric tons from Subdivision 3Ps.

	Can(N)			France					
Year	Offshore	Inshore	Can(M)	STPM	M	Spain	Portugal	Other	Total
1959	2,726	32,718	4,784	3,078	4,952	7,794	3,647	471	60,170
1960	1,780	40,059	5,095	3,634	2,460	17,223	262	2,123	72,636
1961	2,167	32,506	3,883	4,140	11,490	21,017	4,985	3,434	83,622
1962	1,176	29,888	1,474	2,241	4,138	10,289	1,873	1,560	52,639
1963	1,099	30,447	331	1,757	324	10,826	209	5,058	50,051
1964	2,161	23,887	370	2,097	2,777	15,217	169	7,268	53,956
1965	2,459	25,902	1,203	2,570	1,781	13,404	-	4,081	51,400
1966	5,473	23,785	583	3,207	4,607	23,678	519	3,897	65,749
1967	3,861	26,331	1,258	2,244	3,204	20,852	980	3,663	62,393
1968	6,536	22,940	585	1,880	1,126	26,868	8	18,274	77,217
1969	4,269	20,009	849	2,477	15	28,141	57	7,286	63,103
1970	4,649	23,411	2,166	1,970	35	35,750	143	8,037	76,161
1971	8,657	26,651	731	1,651	2,730	19,169	81	4,297	63,967
1972	3,323	19,276	252	1,436	-	18,550	109	1,379	44,325
1973	3,107	21,349	181	1,165	-	19,952	1,180	5,707	52,641
1974	3,770	15,999	657	948	5,366	14,937	1,246	3,783	46,706
1975	741	14,332	122	775	3,549	12,234	1,350	2,270	35,373
1976	2,013	20,978	317	904	1,501	9,236	177	2,007	37,133
1977	3,333	23,755	2,171	1,252	1,734				32,245
1978	2,082	19,560	700	1,974	2,860			45	27,221
1979	2,381	23,413	863	4,289	2,060				33,006
1980	2,809	29,427	715	1,936	2,681				37,568
1981	2,690	26,075	2,321	4,101	3,706				38,905
1982	2,648	20,886	2,945	4,780	2,184				33,443
1983	2,141	23,495	2,578	7,000					35,214

Table 2. Canadian cod landings in 1983 (t) from NAFO Subdivision 3Ps, by month and gear.

	Can(N)					Can(M)	
Month	OT[a]	Trap	GN	LL	HL	OT	LL
January	362		51	637	9	426	
February	49		76	865	5	200	14
March	451		97	1,064	14	97	14
April	63	56	308	597	29	80	3
May	91	443	787	705	269	226	539
June	51	2,218	1,796	1,298	678	402	348
July	10	921	2,065	660	357	1	97
August	40	2	443	1,377	722	1	90
September	515		121	1,939	329	3	
October	263	1	76	1,318	98	8	28
November	200		42	524	25		
December	46	1	100	358	14	1	
	2,141	3,642	5,962	11,342	2,549	1,445	1,133

[a]Includes pair trawl (52 t) and Danish seine (10 t).

Table 3. Cod catch at age, by gear, from the Canadian fishery in Subdivision 3Ps during 1983, along with an estimate of catch at age for the total fishery.

Age	OT Can.	LT Can.	GN	Trap	HL	Total Can.
2		3				3
3	8	430	1	193	1	633
4	33	920	32	951	142	2,078
5	472	2,965	554	1,621	954	6,566
6	180	1,185	662	284	302	2,613
7	132	491	379	64	91	1,157
8	187	389	234	21	38	870
9	161	353	280	23	47	864
10	33	92	79	2	7	213
11	16	35	28		2	81
12	1	18	14		1	34
13	1	12	5			18
14		5	2			7
15		5	1			6
16		4				4
17		2				2
18		2	1			3
19		1				1
20		1				1
20+		2				2
Landings	3,586	12,475	5,962	3,642	2,549	

	AVERAGE		CATCH		
AGE	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
3	0.391	35.434	4	1.28	0.33
4	0.583	40.547	790	50.89	0.06
5	0.843	45.745	2594	177.27	0.07
6	1.330	52.949	8195	240.35	0.03
7	1.988	60.266	3261	183.78	0.06
8	2.580	65.513	1444	109.85	0.08
9	3.256	70.302	1086	70.98	0.07
10	3.773	73.654	1078	72.19	0.07
11	5.045	80.736	266	23.78	0.09
12	6.562	88.086	101	12.50	0.12
13	8.448	95.896	43	5.52	0.13
14	10.061	100.818	22	3.47	0.16
15	11.816	107.445	9	2.13	0.23
16	12.633	109.820	7	1.62	0.24
17	13.881	113.116	5	1.38	0.27
18	16.205	118.072	2	0.76	0.32
19	16.542	118.345	3	1.29	0.37
20	14.183	113.756	2	0.77	0.48
21	22.607	132.043	1	0.42	0.41
22	20.472	129.389	1	0.71	0.77
23	11.049	106.000	1	0.68	1.07
24	20.430	129.276	1	0.48	0.74

Table 4. Commercial sampling for NAFO Subdivisions 3Ps cod in 1983

Quarter	Gear	Country	No. aged	Month	No. measured	Landings tons Country/Month	Landings tons Total
1	OT	Can N	184	Jan.	415	362	788
				Mar.	655	451	548
				Other			249
		Can N	(Qtr. 2)				913
							2,498
	LT	Can N	729	Jan.	4,465	637	637
				Feb.	5,526	865	879
							1,516
2	LT	Can N		Mar.	6,260	1,064	1,064
				Apr.	1,026	597	597
				May	6,755	705	705
		Can M	1,452	May	233	539	556
	Trap	Can N		May	972	443	499
	GN			May	3,747	787	1,319
	HL			May	611	269	326
							5,066
3	OT	Can N	307[a]	Sept.	1,252	515	565
		Can M					5
							570
	LT	Can N		June	4,412	1,298	1,298
		Can N		July	889	660	660
		Can N		Aug.	4,247	1,377	1,377
		Can M		June	446	348	563
	Trap	Can N	775	June	4,504	2,218	2,218
		Can N		July	323	921	925
	GN	Can N		June	4,268	1,796	
		Can N		July	1,098	2,065	4,643
	HL	Can N		June	241	678	
		Can N		Aug.	1,748	722	2,223
							13,907
4	OT	Can N	307[a]	Oct.	313	263	509
		Can M					9
							518
	LT	Can N		Sept.	9,031	1,939	1,939
		Can N	1,142	Oct.	4,048	1,318	1,318
		Can N		Nov.	4,844	524	882
							4,139
Totals			4,589		72,329		28,214
Estimated catch by France							7,000
							35,214

[a]Quarter 3 and 4 ALK.

Table 5. Cod biomass (MT) from stratified random cruises in Subdivision 3Ps.

Depth Range(Fm.)	Strata	Area	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0-30	314	974	0	-	1328	-	2357	249	0	-	432	369	2028	13103
	320	1320	-	729	-	-	1335	-	-	-	2946	23087	1920	5618
TOTAL			0	729	1328	-	3692	249	0	-	3378	23456	3948	18721
31-50	308	112	-	181	279	205	193	311	38	125	240	305	490	766
	312	272	210	-	243	355	456	1047	343	151	-	165	766	524
	315	827	1480	0	592		1747	1550	-	1836	235	0	528	2451
	321	1189	1917	0	-	-	1742	-	2037	-	1880	1419	2845	2419
	325	944	-	-	-	-	2	-	180	820	28	1109	85	294
	326	166	-	-	-	-	-	-	0	2	3	0	54	326
TOTAL			3607	181	1114	540	4140	2908	2598	2934	2386	2998	4768	6780
51-100	307	395	2918	6133	3919	884	1127	2097	3222	4105	1763	13723	3028	892
	311	317	3885	590	2432	763	627	411	154	1106	3792	761	1943	3256
	317	193	101	286	589	164	551	491	-	368	536	268	1582	3685
	319	984	4604	662	478	481	3102	2493	-	10637	1652	15068	3548	3799
	322	1567	-	-	-	-	5183	-	491	14	2599	26	3705	4932
	323	696	736	-	-	-	368	63	1652	-	775	491	1215	858
	324	494	-	-	-	-	8	-	-	29	0	-	430	618
TOTAL			12244	7671	7418	2292	10966	5555	5519	16259	11117	30337	15451	18040
101-151	306	419	-	-	376	719	214	161	416	710	457	2652	1211	1250
	309	296	662	975	479	311	178	192	103	1558	863	2983	838	926
	310	170	1008	191	377	2183	-	0	154	119	0	817	608	134
	313	165	371	29	144	242	142	41	50	1036	127	446	283	74
	316	189	271	937	63	58	77	17	-	65	61	25	-	207
	318	123	173	11	4	0	0	6	-	36	790	-	136	11
TOTAL			2485	2143	1443	3513	611	417	723	3524	2298	6923	3076	2602
151-200	705	195	-	-	66	0	0	60	1	91	674	1310	22	27
	706	476	-	-	23	-	-	76	-	356	827	304	30	32
	707	93	-	-	5	0	0	228	-	326	190	-	-	7
	715	132	-	-	-	1	1	31	142	352	499	168	154	338
	716	539	-	-	-	-	-	92	781	303	248	1608	168	147
TOTAL					94	1	1	487	924	1428	2438	3390	374	551
201-300	708	117	-	-	-	0	-	11	-	177	4633	-	-	0
	711	961	-	-	-	-	-	-	-	-	1113	0	0	7
	712	973	-	-	-	-	-	-	-	9077	282	259	353	0
	713	950	-	-	-	0	-	-	-	-	0	850	0	36
	714	1195	-	-	-	-	-	-	-	-	0	161	0	163
TOTAL			-	-	-	0	-	11	-	9254	6028	1270	353	206

	Total Area per Depth Range					
0-30	2294	-	3378	23456	3948	18721
31-50	3510	2934	2386	2998	4768	6780
51-100	4646	16259	11117	30337	15451	18040
101-150	1362	3524	2298	6923	3076	2602
151-200	1435	1428	2438	3390	374	551
201-300	4196	9254	6028	1270	353	206
TOTAL		33399	27645	68374	27970	46900

Table 6. Cod abundance (000's) from stratified-random cruises in Subdivision 3Ps. Numbers in brackets are estimates for non-sampled strata.

Depth range (fath)	Strata	Area	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0-30	314	974	0	(200)	1,170	(374)	1,060	73	0	(669)	279	307	2,237	1,859	91
	320	1,320	(1,246)	545	(988)	(755)	867	(767)	(910)	(1,351)	528	10,354	1,362	1,589	1,870
31-50	308	112	(129)	29	122	65	34	166	21	74	59	46	235	238	395
	312	272	337	(104)	225	221	257	597	378	157	(370)	92	296	347	153
	315	827	186	0	62	(470)	745	1,273	(567)	621	171	0	145	489	410
	321	1,189	223	0	(261)	(199)	312	(203)	179	(356)	196	402	1,227	785	342
	325	944	(165)	(53)	(131)	(100)	35	(102)	567	850	35	190	76	111	63
	326	166	(40)	(13)	(31)	(24)	(32)	(24)	0	12	6	0	69	63	0
51-100	307	395	1,621	2,627	2,609	423	756	1,090	1,186	2,090	949	5,505	2,372	569	193
	311	317	2,261	820	2,847	433	670	119	309	1,124	3,105	690	1,888	1,348	381
	317	193	275	354	742	127	974	196	(262)	309	1,391	623	913	2,062	14
	319	984	1,717	842	1,182	638	4,136	2,958	(2,291)	15,068	2,733	13,000	3,176	2,058	1,637
	322	1,567	(680)	(220)	(538)	(411)	2,235	(418)	706	118	2,641	471	2,632	1,882	509
	323	696	418	(69)	(170)	(130)	78	111	1,097	(233)	261	78	392	383	901
	324	494	(220)	(71)	(174)	(133)	37	(135)	(161)	93	0	(503)	352	593	321
101-150	306	419	(374)	(121)	145	309	110	65	115	440	204	2,810	692	763	47
	309	296	678	141	86	152	89	63	67	870	289	1,811	700	496	56
	310	170	264	51	70	2,038	(204)	0	183	121	0	651	434	72	57
	313	165	121	56	89	215	54	26	17	1,018	81	266	217	37	12
	316	189	60	528	76	43	103	14	(54)	85	35	21	(144)	128	78
	318	123	32	9	5	0	0	5	(41)	503	379	(130)	92	3	0
151-200	705	195	(454)	(147)	55	0	0	48	7	66	432	988	15	5	0
	706	476	(158)	(51)	5	(96)	(128)	46	(115)	202	518	250	9	7	0
	707	93	(25)	(8)	3	0	0	171	(18)	91	122	(57)	(49)	2	0
	715	132	(90)	(29)	(71)	10	30	20	149	221	248	84	45	106	25
	716	539	(148)	(48)	(117)	(89)	(120)	20	587	334	223	1,123	81	91	13
Total		13,247	11,919	7,134	11,974	7,455	13,066	8,710	9,987	27,076	15,255	40,452	19,850	16,086	7,568
Estimated mean no. per tow			11.99	7.18	12.04	7.50	13.14	8.76	10.04	27.23	15.34	40.70	19.97	16.19	7.41

Table 7. Mean number of cod per tow from research trips in Subdivision 3Ps (depths to 200 fath).

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.04	0.03	1.08	0.66	0.22	0.01	0.0	1.47	0.21	0.04	0.68	0.33	0.01
2	1.04	1.40	3.31	1.33	3.14	0.30	0.47	0.61	6.09	0.73	2.60	0.62	0.25
3	1.83	1.64	3.27	3.75	2.05	3.82	0.70	0.89	1.79	4.20	1.33	1.35	0.39
4	3.77	2.50	2.34	3.41	3.77	3.35	2.63	8.24	0.89	6.90	6.53	0.74	0.71
5	2.52	2.79	3.16	2.10	2.35	3.11	1.15	19.77	2.36	7.53	3.01	4.03	0.54
6	1.69	0.78	2.92	1.94	1.07	0.93	0.83	3.12	2.11	9.70	1.41	2.06	2.30
7	2.24	1.56	0.81	1.74	0.65	0.25	0.60	1.04	0.53	9.09	1.89	0.72	0.92
8	1.32	0.61	0.65	0.65	0.60	0.20	0.42	0.55	0.61	1.80	1.95	1.41	0.47
9	0.56	0.82	0.52	0.43	0.14	0.32	0.25	0.22	0.19	1.77	0.53	2.63	0.59
10	0.33	0.19	0.26	0.26	0.11	0.12	0.23	0.19	0.17	0.41	0.14	1.22	0.92
11	0.14	0.05	0.08	0.09	0.08	0.02	0.08	0.04	0.13	0.07	0.10	0.59	0.22
12	0.08	0.05	0.06	0.04	0.08	0.05	0.03	0.02	0.15	0.11	0.04	0.22	0.17
13	0.05		0.04	0.05		0.05	0.03	0.02	0.06	0.11	0.02	0.09	0.07
14	0.09	0.02	0.04			0.01		0.03		0.06	0.02	0.08	0.03
15	0.05	0.01	0.01	0.02	0.03	0.01	0.03		0.03	0.02	0.04	0.06	
16	0.15	0.03	0.02	0.0					0.03	0.02	0.02	0.05	0.04
17	0.11	0.05	0.01	0.02	0.01		0.02		0.02	0.01		0.01	0.0
18	0.07	0.04	0.01			0.01						0.02	0.03
19	0.01		0.01		0.04		0.02					0.02	
20	0.01			0.01		0.02				0.01		0.02	
20+	0.01	0.01	0.01				0.05					0.03	0.01
NK		0.01									0.03		
Total	16.09	12.60	18.62	16.50	14.34	12.57	7.53	36.21	15.40	42.58	20.35	16.30	7.67
Confidence limits													
Upper	25.10	21.58	24.37	23.38	21.20	17.40	11.01	319.07	20.45	115.88	26.63	22.08	10.88
Lower	7.09	3.62	12.87	9.61	7.48	7.74	4.06	-246.66	10.34	-30.71	14.07	10.52	4.46
Sets	44	55	81	56	69	98	44	76	71	53	79	132	84
Survey dates	Mar. 20-30	Mar. 16-23	Apr. 19-30	June 2-13	May 11-21	Apr. 14-26	Feb. 21-28	Feb. 16-Mar. 5	Mar. 19-Apr. 2	Mar. 7-26	May 28-June 9	Apr. 22-May 8	Apr. 9-18

Table 8. Regression coefficients for grouped categories and the analysis of variance from the regression on ln catch rate for cod in Subdivision 3Ps from 1959-83.

Country	Gear	ln power	Month	ln power
Can M	OT 4	0.000	January	0.000
			February	
Can M	OT 5			
France(STPM)	OT 5		March	-0.093
Portugal	OT 6	0.500		
Spain	PT 4		April	
Spain	PT 6		December	-0.252
Can N	OT 4	-0.377	May	
			November	-0.393
Can N	OT 5	-0.245		
			June	
Spain	OT 6	0.136	September	-0.488
			October	
Spain	PT 5	0.869		
			July	-0.565
			August	

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.682
MULTIPLE R SQUARED.....0.465

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.796E1	2.796E1	
REGRESSION	34	1.539E2	4.526E0	17.778
TYPE 1	5	8.564E1	1.713E1	67.283
TYPE 2	5	2.811E1	5.622E0	22.087
TYPE 3	24	5.338E1	2.224E0	8.737
RESIDUALS	696	1.772E2	2.546E-1	
TOTAL	731	3.590E2		

Table 9. Mean catch rate indices of cod in Subdivision 3Ps for the years 1959-83. The proportion of total catch which was used in the analysis for each year is indicated.

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1959	60170	0.213	0.810	0.096	74299
1960	72636	0.258	0.698	0.083	104081
1961	83620	0.333	1.037	0.111	80610
1962	52639	0.248	0.827	0.094	63615
1963	59051	0.232	1.010	0.119	49580
1964	53956	0.313	0.919	0.107	58735
1965	51400	0.298	0.953	0.111	53946
1966	65749	0.438	1.073	0.113	61255
1967	62393	0.309	0.895	0.103	69731
1968	77217	0.420	1.095	0.111	70489
1969	63103	0.498	1.079	0.114	58467
1970	76161	0.511	0.913	0.095	83397
1971	63967	0.419	0.889	0.088	71968
1972	44323	0.473	0.715	0.070	61972
1973	52641	0.410	0.640	0.061	82315
1974	46712	0.384	0.493	0.050	94814
1975	35373	0.373	0.509	0.063	69519
1976	37133	0.277	0.508	0.058	73056
1977	32245	0.090	0.479	0.056	67358
1978	27221	0.125	0.816	0.107	33351
1979	33006	0.177	0.655	0.075	50360
1980	37568	0.069	0.511	0.068	73561
1981	38905	0.128	0.762	0.092	51082
1982	33443	0.199	0.860	0.097	38891
1983	35214	0.086	1.341	0.181	26264

Table 10. Yearly CPUE (tons/hr) data (catch and effort ≥10) for cod in NAFO Subdivision 3Ps.

	Can N		Can M	
Year	OT 4	OT 5	OT 4	OT 5
1959	1.04			
1960	.78			
1961	.81		.83	
1962	.39			
1963	.55			
1964	.49			
1965	.75	.70		
1966	.81	.87		
1967	.50	.74	.51	.64
1968	.67	.72	.48	.76
1969	.85	.80	.52	.56
1970	.50	.63	.57	.80
1971	.55	.63	.32	.37
1972	.77	.55	.70	.29
1973	.36	.53		
1974	.41	.54	.50	.52
1975	.41	.20	.18	
1976	.38	.30	1.02	
1977	.26	.31	.39	.67
1978	.44	.82	.53	.67
1979	.48	.73	.29	.54
1980	.30	.54	.35	1.04
1981	.38	.98	2.52	1.84
1982	.48	.66	2.56	1.99
1983	.56	.93	1.20	2.18

Table 11. Catch and weight at age data for Subdivision 3Ps cod.

CATCH AT AGE

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	1001	567	450	1245	961	1906	2314	949	2871	1143	774	756	2884	731	945
4	13940	5496	5586	6749	4499	5785	9636	13662	10913	12602	7098	8114	6444	4944	4707
5	7525	23704	10357	9003	7091	5635	5799	13065	12900	13135	11585	12916	8574	4591	11386
6	7265	6714	15960	4533	5275	5179	3609	4621	6392	5853	7178	9763	7266	3552	4010
7	4875	3476	3616	5715	2527	2945	3254	5119	2349	3572	4554	6374	8218	4603	4022
8	942	3484	4680	1367	3030	1881	2055	1586	1364	1308	1757	2456	3131	2636	2201
9	1252	1020	1849	791	898	1891	1218	1833	604	549	792	730	1275	833	2019
10	1260	827	1376	571	292	652	1033	1039	316	425	717	214	541	463	515
11	631	406	446	187	143	339	327	517	380	222	61	178	85	205	172
12	545	407	265	140	99	329	68	389	95	111	120	77	125	117	110
13	44	283	560	135	107	54	122	32	149	5	67	121	62	48	14
14	0	27	58	241	92	27	36	22	3	107	110	14	57	45	29
3+	39280	46411	45203	30677	25014	26623	29471	42834	38336	39032	34813	41713	38662	22768	30130
4+	38279	45844	44753	29432	24053	24717	27157	41885	35465	37889	34039	40957	35778	22037	29185
5+	24339	40348	39167	22683	19554	18932	17521	28223	24552	25287	26941	32843	29334	17093	24478
6+	16814	16644	28810	13680	12463	13297	11722	15158	11652	12152	15356	19927	20760	12502	13092

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	1887	1840	4110	935	218	149	298	1000	110	790
4	6042	7329	12139	9156	4308	2370	1644	2765	5079	2594
5	9987	5397	7923	8326	5391	9777	5096	2864	4114	8195
6	6365	4541	2875	3209	4203	5235	8335	4220	1979	3261
7	2540	5867	1305	920	1791	2588	4387	5187	2806	1444
8	1857	723	495	395	730	884	1420	1573	3101	1086
9	1149	1196	140	265	243	284	349	571	725	1078
10	538	105	53	117	189	82	104	204	297	266
11	249	174	17	57	76	48	54	89	102	101
12	80	52	21	43	26	19	42	37	34	43
13	32	6	4	31	19	11	19	24	15	22
14	17	2	3	11	10	10	25	6	10	9
3+	30743	27232	29085	23465	17204	21457	21773	18540	18372	18889
4+	28856	25392	24975	22530	16986	21308	21475	17540	18262	18099
5+	22814	18063	12836	13374	12678	18938	19831	14775	13183	15505
6+	12827	12666	4913	5048	7287	9161	14735	11911	9069	7310

AVERAGE WEIGHT AT AGE

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	0.28	0.28	0.28	0.28	0.28	0.28	0.29	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
4	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
5	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
6	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
7	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
8	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21
9	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
10	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08
11	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03
12	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
13	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05
14	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16

AGE	1977	1978	1979	1980	1981	1982	1983
3	0.55	0.45	0.41	0.52	0.48	0.45	0.58
4	0.68	0.70	0.65	0.72	0.79	0.77	0.84
5	1.30	1.08	1.01	1.13	1.32	1.17	1.33
6	1.86	1.75	1.65	1.66	1.80	1.78	1.99
7	2.67	2.45	2.55	2.48	2.30	2.36	2.58
8	3.42	2.99	3.68	3.60	3.27	2.88	3.26
9	4.19	4.10	4.30	5.40	4.36	3.91	3.77
10	4.94	5.16	6.49	6.95	5.68	5.28	5.04
11	5.92	5.17	7.00	7.29	7.41	6.18	6.56
12	6.76	7.20	8.20	8.64	9.04	8.62	8.45
13	9.78	7.75	9.53	9.33	8.39	8.64	10.06
14	10.90	8.72	10.84	9.58	9.56	11.41	11.82

Table 12. Average partial selection patterns from the different gears in Subdivision 3Ps cod fishery using catch at age by the gear and fishing mortalities from a cohort at F_t = 0.25.

Age	Otter trawl (1978-81)	Codtrap (1977-80)	Gillnet (1978-81)	Linetrawl (1977-80)	Handline (1978-81)	Weighted average
3	.005	.05		.015	.05	.02
4	.05	.75	.005	.13	.40	.25
5	.25	1.00	.10	.45	1.00	.60
6	.70	.40	.45	.60	.90	.74
7	1.00	.10	.95	.85	.75	1.00
8	1.00	.05	1.00	1.00	.65	1.00
9	.60		1.00	1.00	.35	1.00
10	.50		1.00	1.00	.35	1.00
11	.50		1.00	1.00	.30	1.00
12	.50		1.00	1.00	.30	1.00
13	.50		1.00	1.00	.30	1.00
14	.50		1.00	1.00	.30	1.00
Landings (83)	3,586	3,642	5,962	12,475	2,549	

Table 13. Relationship of standard CPUE indices with exploitable biomass for Subdivision 3Ps cod from cohort analyses at a range of fully recruited fishing mortalities. Residuals (observed-calculated) are indicated for recent years.

		0.15		.20		.25		.30	
Year	CPUE	Observed	Residuals	O.	R.	O.	R.	O.	R.
1961	1.037	134							
1962	.827	134							
1963	1.010	132							
1964	.919	118							
1965	.953	105							
1966	1.073	99							
1967	.895	115							
1968	1.095	112							
1969	1.079	100							
1970	.913	110							
1971	.889	92							
1972	.715	70							
1973	.640	69							
1974	.493	53							
1975	.509	35	-24.0	35	-25.0	34	-25.9	34	-26.4
1976	.508	60	1.09	59	-0.8	57	-2.9	57	-3.6
1977	.479	77	22.0	75	18.3	72	15.5	71	13.9
1978	.816	55	-43.9	53	-41.4	50	-40.9	49	-39.8
1979	.655	80	1.9	75	-1.7	70	-4.4	68	-5.8
1980	.511	90	31.3	81	21.3	75	15.2	72	11.2
1981	.762	118	25.7	100	12.0	89	3.7	82	-1.7
1982	.860	124	19.2	99	0.1	84	-11.5	74	-19.2
1983	1.341	227	58.5	171	17.6	136	-7.7	114	24.1
Intercept			-8.76		2.98		8.30		12.99
Slope			132.29		111.85		101.14		92.96
R^2			0.610		0.664		0.628		0.556

Table 14. Relationship of weighted mean number per tow (ages 4-14) to population numbers (ages 4-14).

F_t	Years in regression	Slope	Difference
0.15	1972-83	13,864	2197
	1972-80	11,667	
0.20	1972-83	11,934	645
	1972-80	11,289	
0.25	1972-83	10,760	-272
	1972-80	11,032	
0.30	1972-83	9,989	-892
	1972-80	10,881	

Table 15. Population numbers (x 10^{-3}) of Subdivision 3Ps cod from a cohort analysis at F_t=0.25.

POPULATION NUMBERS

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	59386	59260	50943	48671	42957	70839	80985	84419	98486	70186	54345	35514	60221
4	107064	47715	48005	41302	38722	34300	56274	64211	68258	78035	56430	43794	28392
5	35820	75043	34093	34249	27708	27632	22848	37354	40210	46010	52487	39778	28514
6	24206	22518	39992	18541	19894	16269	17524	13459	18761	21249	25785	32490	20881
7	16270	13245	12361	18302	11079	11515	8634	11082	6838	9577	12101	14616	17767
8	5812	8910	7699	6849	9813	6784	6763	4125	4441	3473	4609	5787	6199
9	4041	3906	4142	2068	4370	5292	3852	3678	1942	2402	1660	2183	2516
10	3449	2175	2275	1718	978	2766	2622	2052	1352	1043	1470	643	1127
11	3661	1683	1033	618	890	536	1674	1212	740	821	470	555	333
12	1180	2428	1011	442	337	599	132	1075	525	262	472	329	293
13	154	473	1618	588	235	186	193	47	528	344	114	278	200
14	0	86	131	818	359	96	103	48	9	298	277	33	118
3+	261043	237442	203304	174166	157342	176816	201606	222762	242090	233700	210219	175999	166560
4+	201657	178182	152360	125495	114385	105976	120621	138343	143605	163514	155873	140485	106339
5+	94592	130466	104355	84193	75664	71676	64347	74131	75347	85479	99444	96691	77946
6+	58772	55423	70262	49944	47955	44044	41499	36777	35137	39468	46957	56913	49433
7+	34566	32905	30270	31403	28061	27775	23975	23318	16376	18220	21172	24423	28552

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	39496	31374	42610	57153	59866	79605	41905	27054	49542	106079	57759	174748
4	46696	31675	24832	33178	45128	45295	64329	34112	22015	40292	85946	47189
5	17415	33758	21675	14863	20533	25964	28800	48770	25784	16537	30486	65771
6	15587	10104	17336	8709	7286	9642	13724	18701	31083	16499	10948	21237
7	10521	9547	4644	8434	3022	3364	4990	7433	10575	17907	9690	7173
8	7110	4449	4178	1504	1597	1293	1922	2465	3744	4688	9967	5394
9	2242	3436	1651	1740	577	859	701	913	1218	1780	2415	5355
10	906	1082	987	312	342	346	464	354	490	682	941	1321
11	433	323	420	321	160	232	177	209	216	307	374	502
12	195	169	109	119	105	116	139	76	127	128	171	214
13	127	54	39	17	50	67	56	90	45	66	71	109
14	108	60	32	3	8	37	27	29	64	20	33	45
3+	140837	126032	118510	126353	138674	166820	157234	140206	144903	204986	206801	329058
4+	101340	94658	75901	69200	78808	87216	115328	113152	95362	98906	151042	154310
5+	54645	62983	51069	36022	33680	41920	50999	79040	73346	58615	65096	107121
6+	37230	29225	29394	21158	13147	15956	22200	30270	47562	42078	34610	41350
7+	21643	19121	12058	12449	5862	6315	8476	11569	16480	25579	23662	20112

Table 16. Mid-year (average) population biomass (t x 10^{-3}) of Subdivision 3Ps cod from a cohort analysis at F_t=0.25.

POPULATION BIOMASS (AVERAGE)

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	14935	14962	12867	12182	10771	17718	20237	21295	24602	17656	13686	8910	14888
4	62174	27961	28111	23497	22677	19450	31857	35382	38919	44449	32858	24570	15496
5	30949	60147	27575	28539	23202	23972	19161	29159	32106	37721	45028	31667	23116
6	30539	28451	46617	24345	25746	20246	23618	16427	22945	27296	33054	40979	25391
7	29334	24533	22405	32686	21016	21430	14650	17431	11922	16302	20542	23552	27928
8	15396	19981	13752	17710	23502	16630	16258	9301	10651	7885	10421	12604	12490
9	12351	12372	11294	5968	14379	15589	11719	9530	5930	7782	4396	6549	6462
10	12504	7792	6458	6396	3734	11047	9283	6534	5410	3651	4771	2391	3686
11	18097	7952	4197	2792	4433	1741	8156	4950	2775	3801	2384	2473	1555
12	5412	13964	5463	2294	1777	2511	576	5386	2994	1245	2562	1815	1390
13	941	2144	9442	3737	1249	1132	837	188	3235	2487	524	1500	1200
14	0	589	805	5660	2554	668	687	288	64	1960	1768	204	696
3+	232632	220847	188986	165807	155040	152133	157038	155870	161554	172236	171993	157215	134298
4+	217697	205885	176119	153625	144269	134416	136801	134575	136952	154579	158307	148305	119410
5+	155523	177924	148008	130128	121592	114966	104944	99193	98032	110130	125449	123735	103914
6+	124574	117778	120433	101589	98390	90995	85783	70035	65926	72409	80421	92068	80798
7+	94035	89326	73816	77244	72644	70748	62166	53607	42981	45113	47368	51088	55407

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	9924	7833	10555	14253	14628	39433	17044	10024	23274	45917	23533	91640
4	27515	18188	13402	18183	23921	24771	39334	19340	13785	27777	58065	34863
5	14504	26613	15358	11478	15560	24957	25260	39657	23501	17887	29933	73894
6	20700	11800	20757	9026	8525	13136	17953	23519	39661	23029	15891	35078
7	16932	15593	6684	9859	4887	6877	8772	13717	17947	31169	17308	14902
8	16219	9060	8934	3106	3820	3308	4052	6511	9510	11206	21380	14161
9	6529	8048	3295	3525	1852	2687	2083	2923	4991	5740	7091	16256
10	2870	3554	3011	1158	1442	1246	1648	1813	2722	2910	3688	5363
11	1693	1185	1437	1167	826	1074	620	1153	1225	1723	1769	2650
12	770	621	342	556	594	557	811	488	808	875	1188	1453
13	721	337	113	95	349	387	317	725	289	398	492	885
14	676	359	177	14	53	307	168	226	428	143	278	426
3+	119053	103191	84065	72421	76458	118741	118060	120096	138141	168774	180617	291572
4+	109129	95358	73509	58168	61830	79308	101017	110072	114867	122858	157083	199932
5+	81614	77170	60107	39985	37909	54538	61683	90732	101082	95080	99018	165068
6+	67110	50557	44750	28506	22349	29580	36423	51075	77581	77193	69085	91175
7+	46410	38757	23993	19480	13824	16444	18470	27556	37920	54164	53194	56097

Table 17. Fishing mortalities for Subdivision 3Ps cod from a cohort analysis at F_t=0.25.

FISHING MORTALITY

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
3	0.019	0.011	0.010	0.029	0.025	0.030	0.032	0.013	0.033	0.018	0.016	0.024	0.054	0.021	0.034	0.050
4	0.155	0.136	0.138	0.199	0.137	0.206	0.210	0.268	0.194	0.197	0.150	0.229	0.289	0.124	0.179	0.313
5	0.284	0.429	0.409	0.343	0.332	0.255	0.329	0.489	0.438	0.379	0.280	0.444	0.404	0.344	0.466	0.712
6	0.403	0.400	0.582	0.315	0.347	0.434	0.258	0.477	0.472	0.363	0.368	0.404	0.485	0.290	0.577	0.520
7	0.402	0.343	0.391	0.423	0.290	0.332	0.539	0.714	0.477	0.531	0.538	0.658	0.716	0.661	0.627	0.927
8	0.197	0.566	1.114	0.249	0.417	0.366	0.409	0.553	0.415	0.538	0.547	0.633	0.817	0.527	0.791	0.676
9	0.419	0.341	0.680	0.549	0.258	0.502	0.430	0.800	0.421	0.291	0.749	0.461	0.821	0.529	1.048	1.466
10	0.517	0.545	1.104	0.458	0.401	0.302	0.572	0.820	0.299	0.598	0.774	0.459	0.756	0.832	0.746	0.923
11	0.211	0.310	0.649	0.407	0.195	1.199	0.243	0.638	0.838	0.355	0.155	0.438	0.332	0.740	0.889	1.045
12	0.714	0.205	0.342	0.431	0.393	0.933	0.839	0.511	0.223	0.632	0.330	0.299	0.637	1.085	1.268	1.683
13	0.379	1.083	0.482	0.293	0.699	0.387	1.199	1.406	0.374	0.016	1.049	0.657	0.419	0.541	0.337	2.375
14	0.370	0.420	0.660	0.390	0.330	0.370	0.480	0.700	0.430	0.500	0.570	0.630	0.750	0.610	0.740	0.880

AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0.036	0.079	0.013	0.006	0.006	0.007	0.010	0.002	0.005
4	0.280	0.353	0.253	0.077	0.080	0.086	0.079	0.068	0.063
5	0.513	0.556	0.438	0.232	0.250	0.246	0.212	0.162	0.148
6	0.859	0.573	0.459	0.413	0.370	0.351	0.332	0.223	0.185
7	1.464	0.649	0.360	0.505	0.486	0.613	0.386	0.386	0.250
8	0.758	0.420	0.412	0.544	0.505	0.543	0.463	0.421	0.250
9	1.426	0.312	0.417	0.483	0.421	0.381	0.438	0.403	0.250
10	0.465	0.188	0.466	0.599	0.296	0.267	0.401	0.429	0.250
11	0.914	0.125	0.316	0.642	0.293	0.324	0.386	0.359	0.250
12	0.663	0.249	0.527	0.232	0.321	0.453	0.385	0.248	0.250
13	0.513	0.093	0.713	0.469	0.145	0.622	0.511	0.265	0.250
14	1.300	0.520	0.390	0.520	0.480	0.560	0.400	0.410	0.250

Table 18. Relationship of survey mean numbers per tow at ages 2 and 3 with cohort numbers at age (F_T=0.25) for cod in Subdivision 3Ps.

	Age		Cohort No. at age	Predicted cohort Age 3 from survey age		
Year class	2	3	3 (x10^{-3})	2	3	Ave.
1982	0.25			37		
1981	0.62	.39		42	28	35
1980	2.60	1.35		64	41	52.5
1979	0.73	1.33	58			
1978	6.09	4.20	106			
1977	0.60	1.79	50			
1976	0.47	.89	27			
1975	0.30	.70	42			
1974	3.14	3.82	80			
1973	1.33	2.05	60			
1972	3.31	3.75	57			
1971	1.40	3.27	43			
1970	1.04	1.64	31			
1969		1.83	39			
r^2	.76	.54				
int	34.7	22.9				
slope	11.1	13.5				

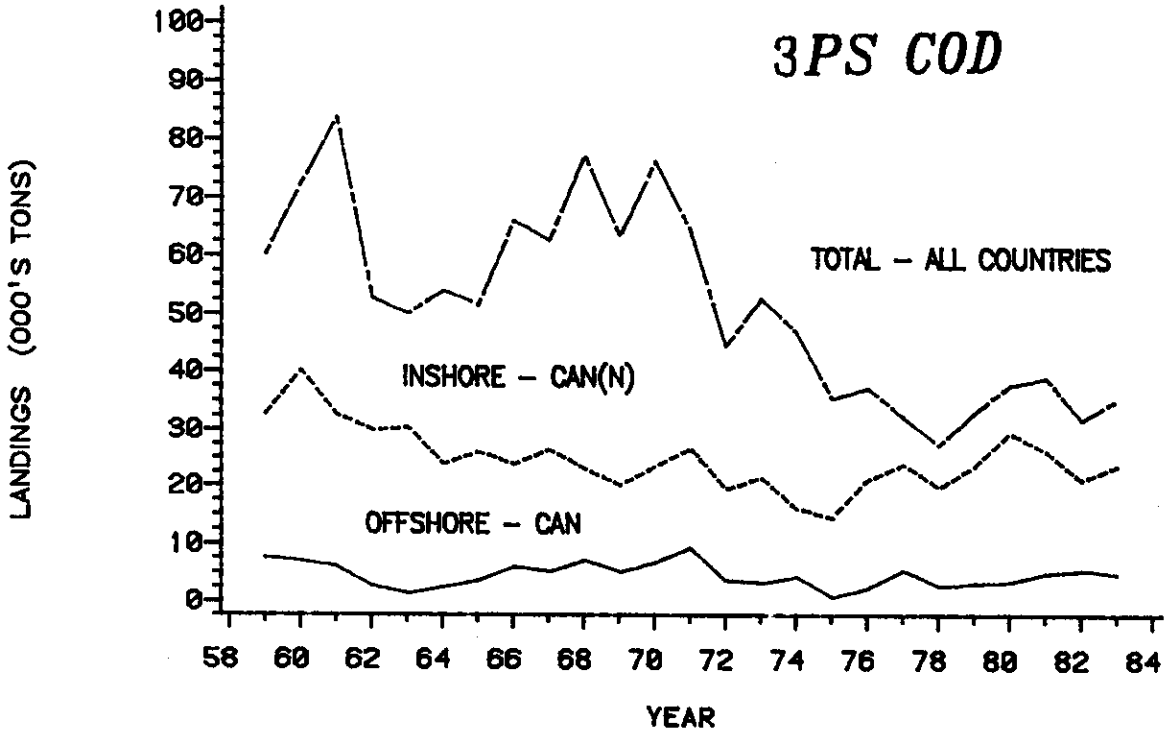

FIG. 1. TOTAL CATCH OF 3PS COD BY ALL COUNTRIES ALONG WITH CANADIAN CATCHES FOR 1959–1983

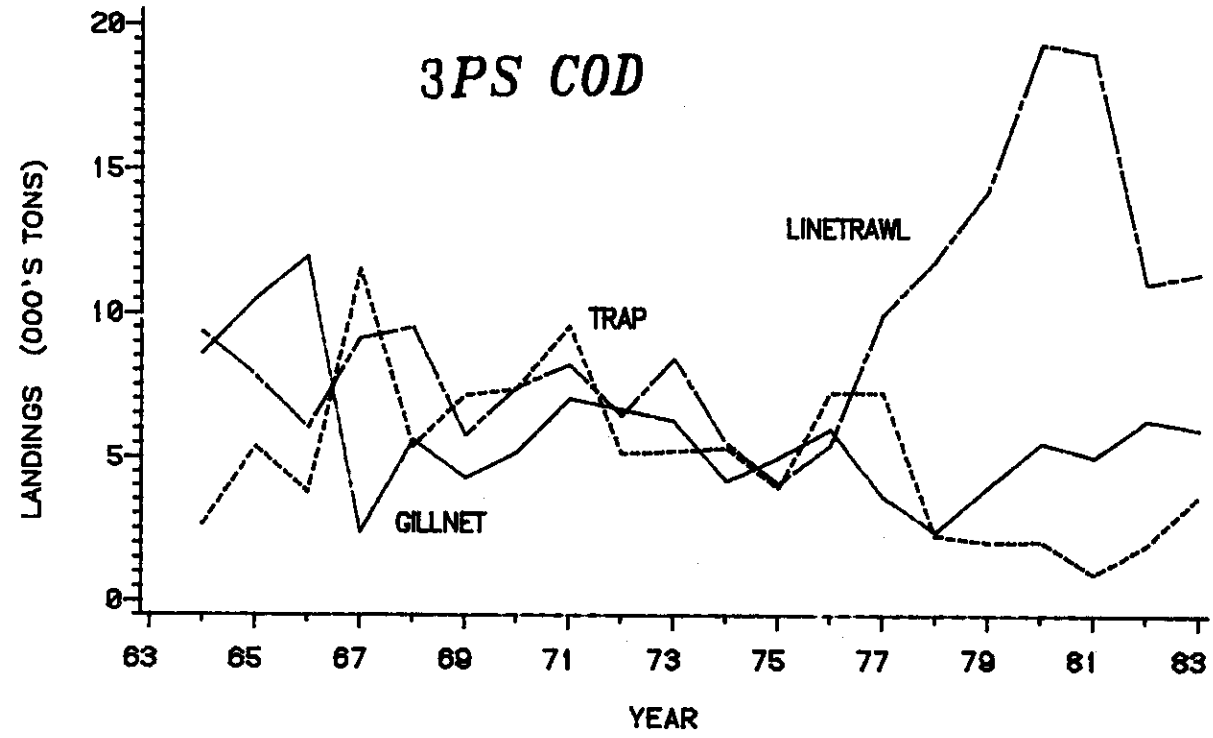

FIG. 2. INSHORE CAN(N) COD CATCH BY GEAR IN SUBDIVISION 3PS FOR THE PERIOD 1964–1983.

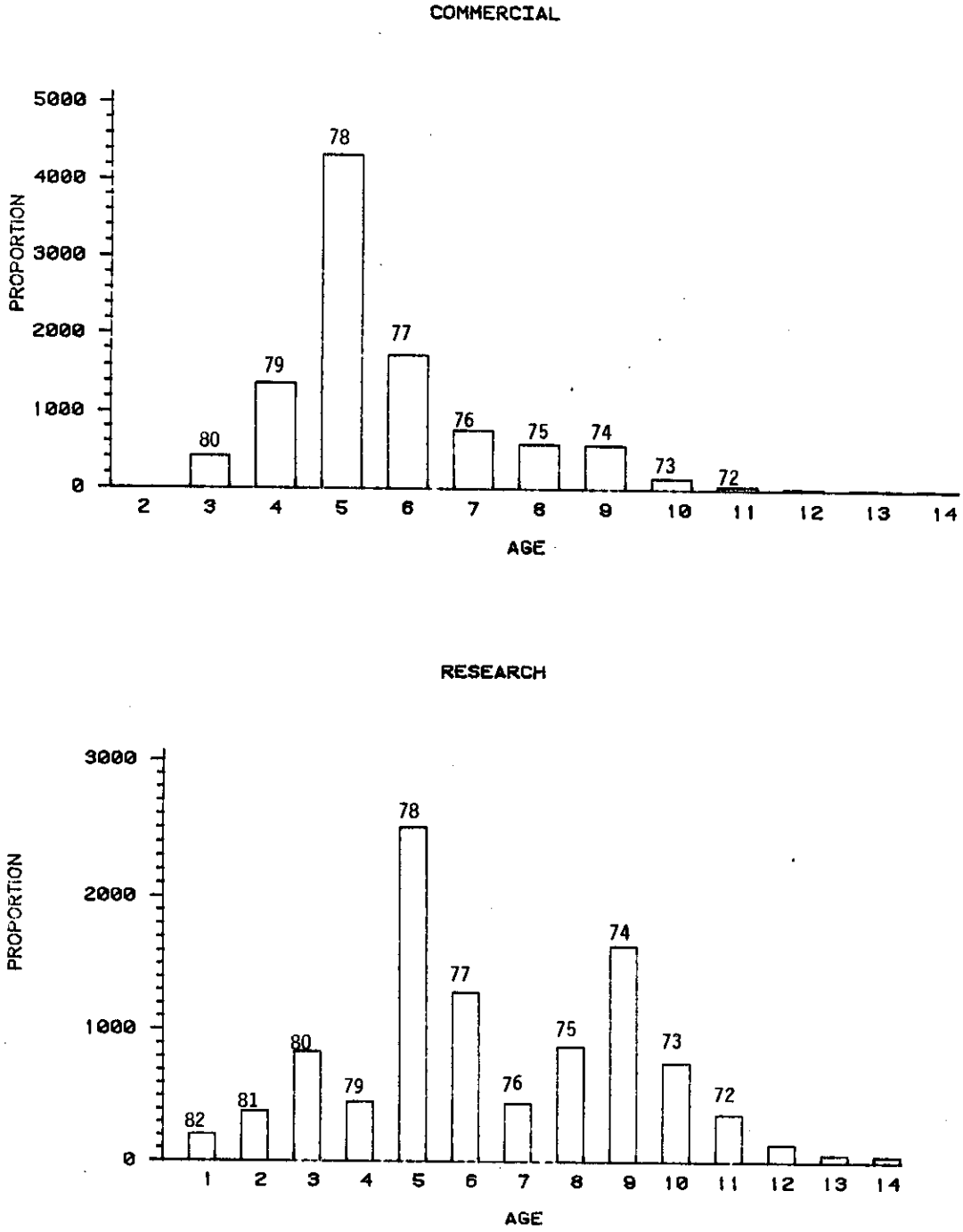

Fig. 3. Proportions at age and by year clsss from the commercial fishery and a research vessel cruise for cod in Subdivision 3Ps during 1983.

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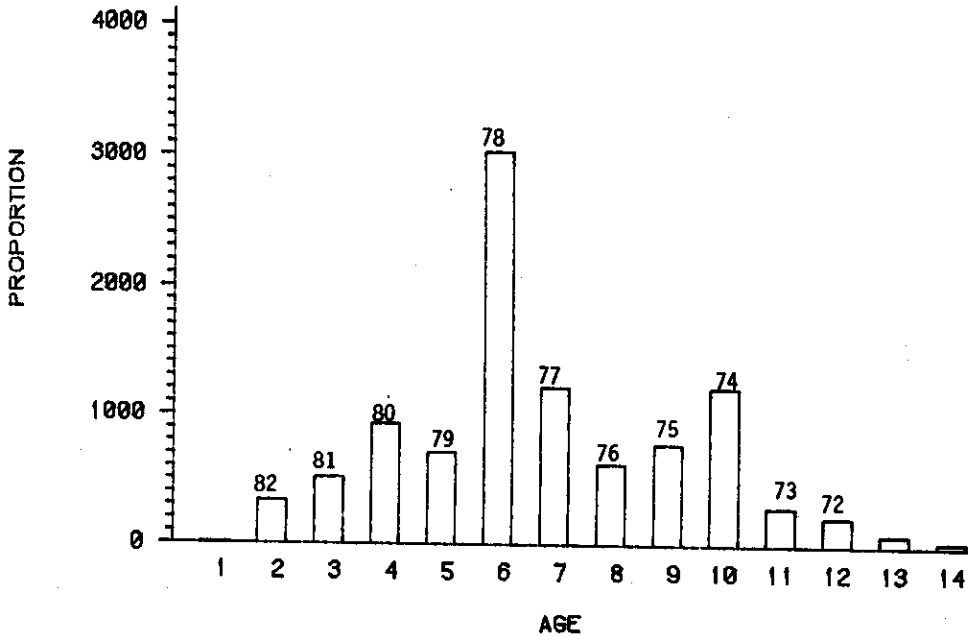

Fig. 4. Proportion of cod at age, and by year class from a research cruise in Subdivision 3Ps during 1984.

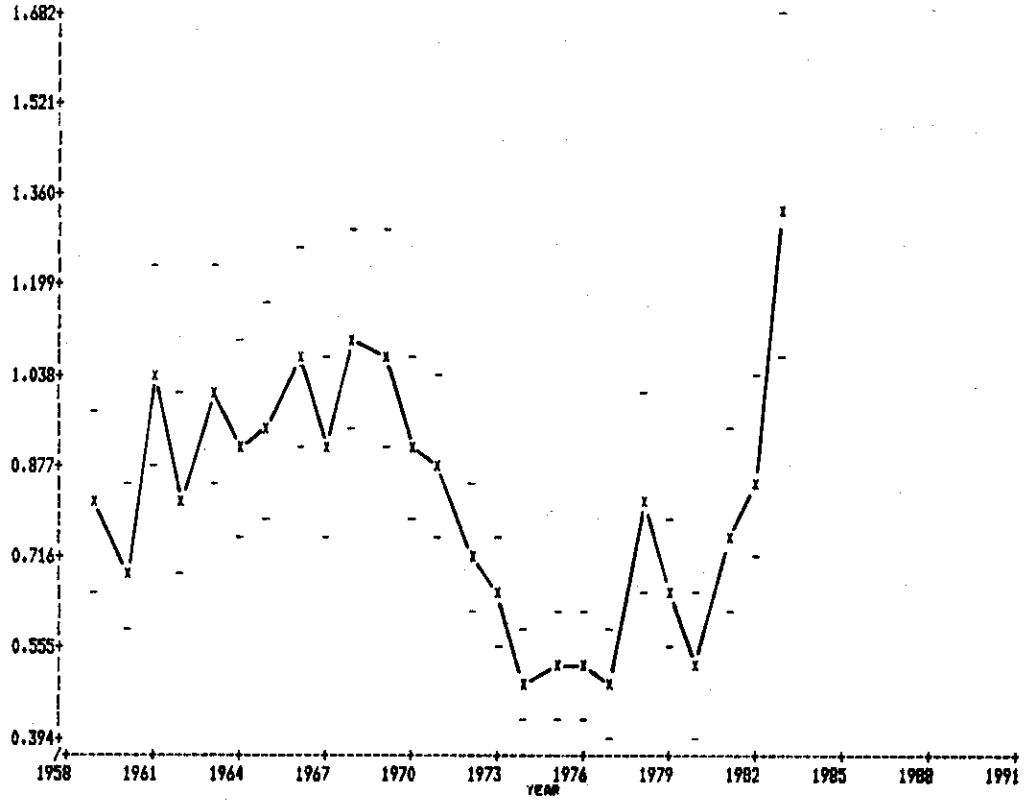

Fig. 5. Historical catch rate indices for cod in Subdivision 3Ps with approximate 90% confidence limits.

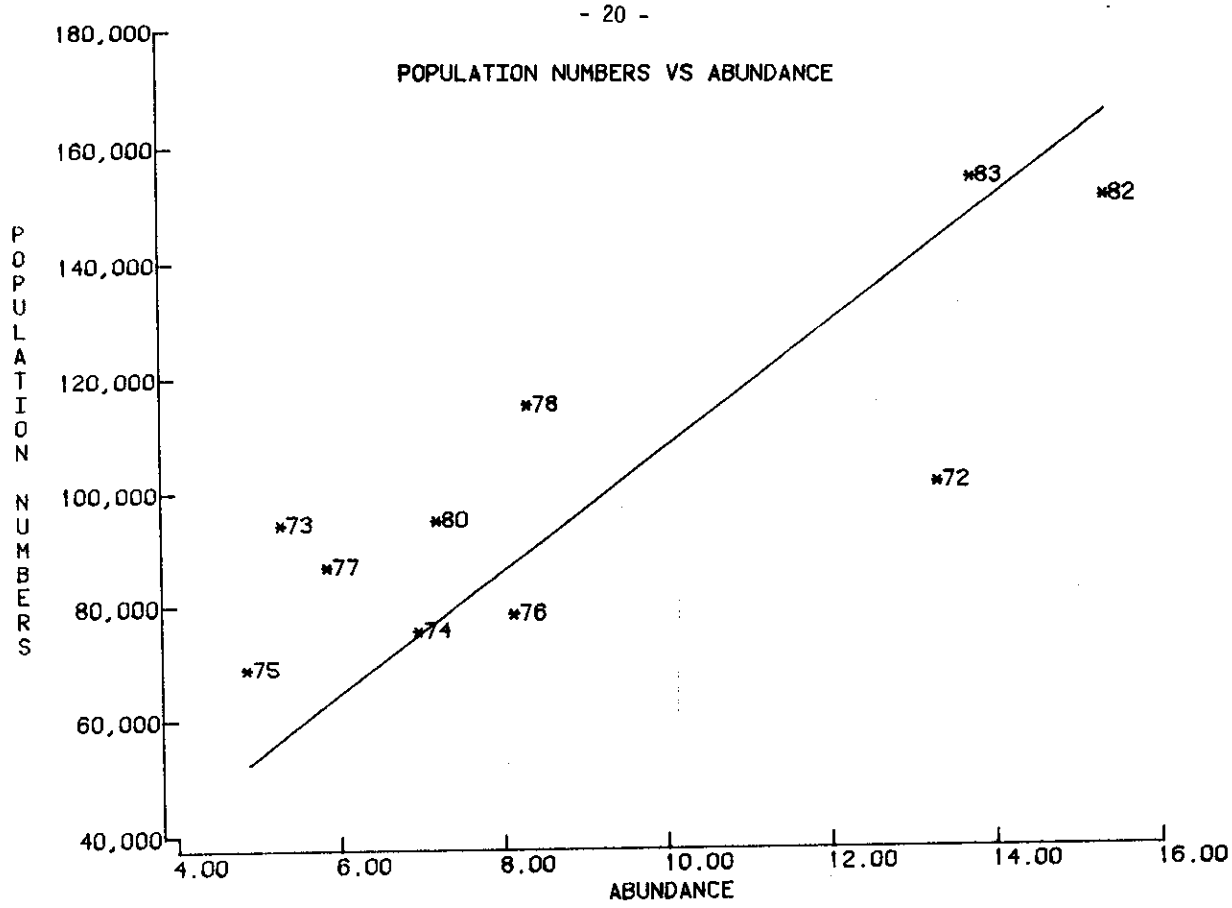

Fig. 6. Relationship of population numbers (ages 4-14) from a cohort at F_t=0.25 with abundance estimates for research vessel surveys.

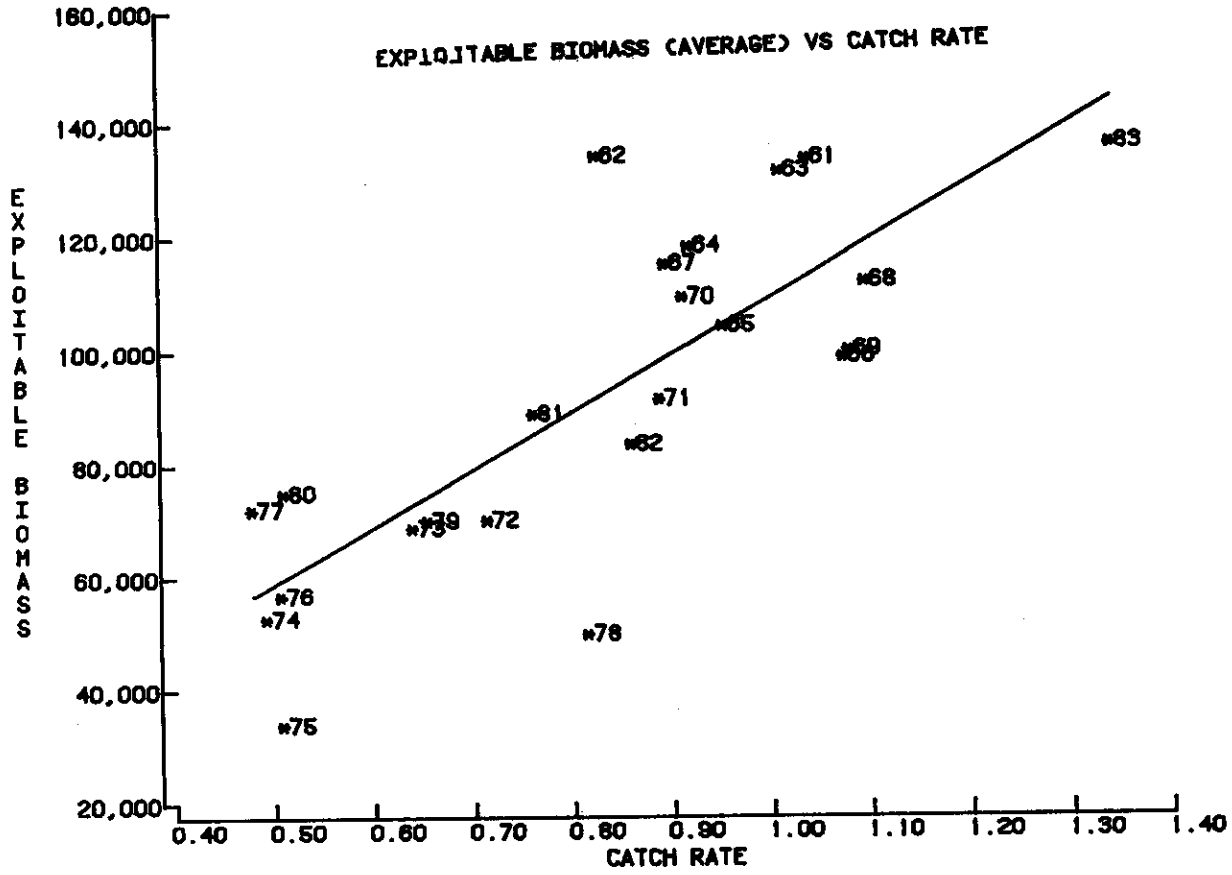

Fig. 7. Relationship of cohort exploitable biomass (F_t=0.25) with standard CPUE for the period 1961-83 for Subdivision 3Ps cod.

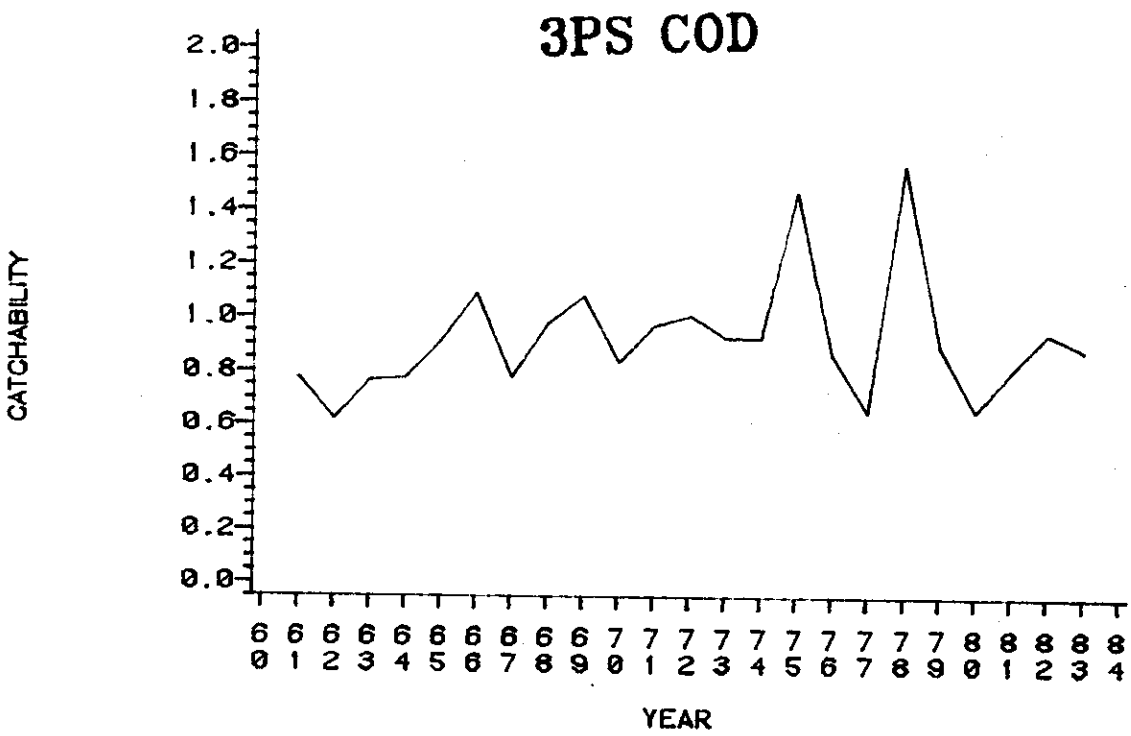

Fig. 8. Catchabilities (CPUE/Ave. expl. biomass) by year for cod in Subdivision 3Ps using cohort biomass estimates at F_t=0.25.

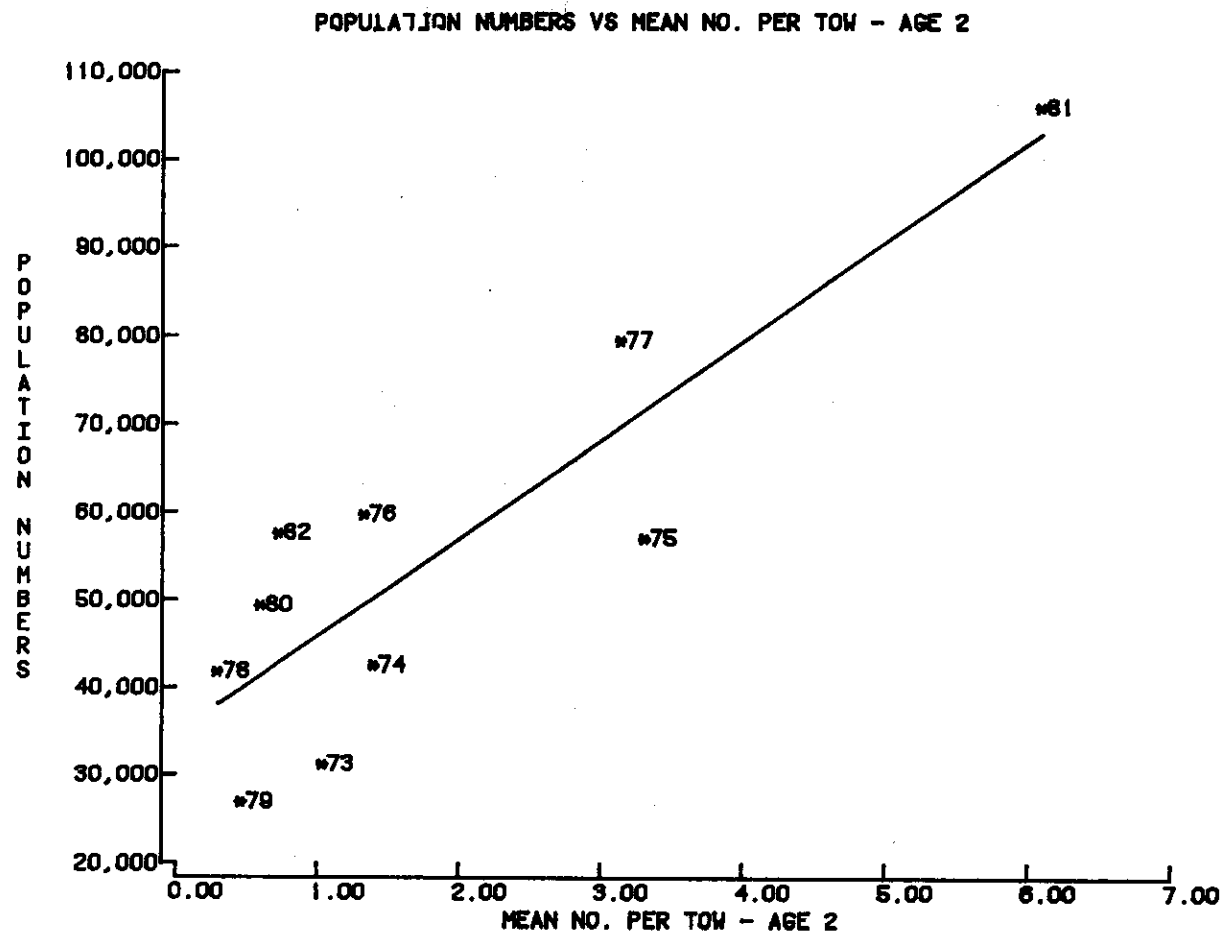

Fig. 9. Comparis on of survey mean number per tow at age 2 with cohort population numbers at age 3 of the same year class (F_t =0.25).

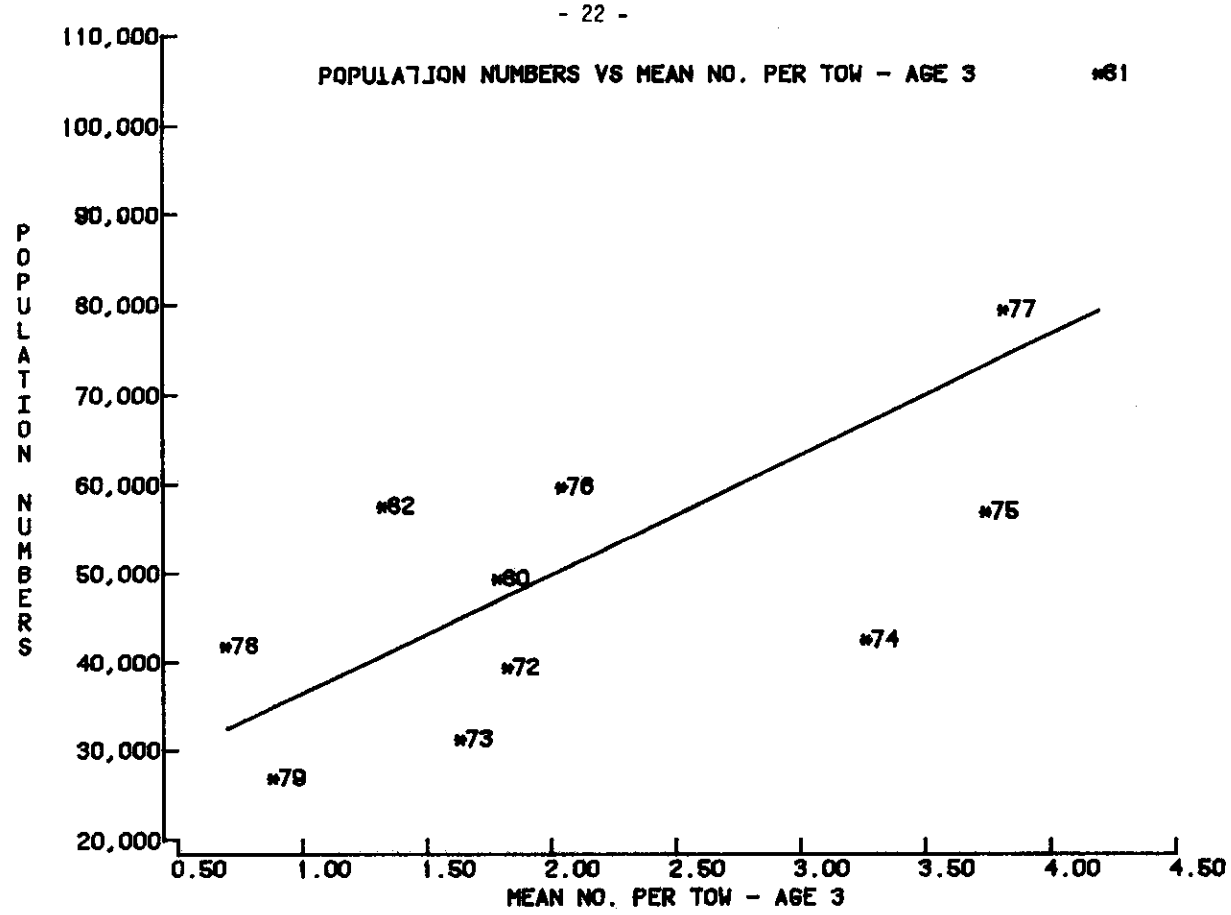

Fig. 10. Comparison of survey mean number per tow at age 3 with cohort population numbers at age 3 of the same year class (F_t=0.25)

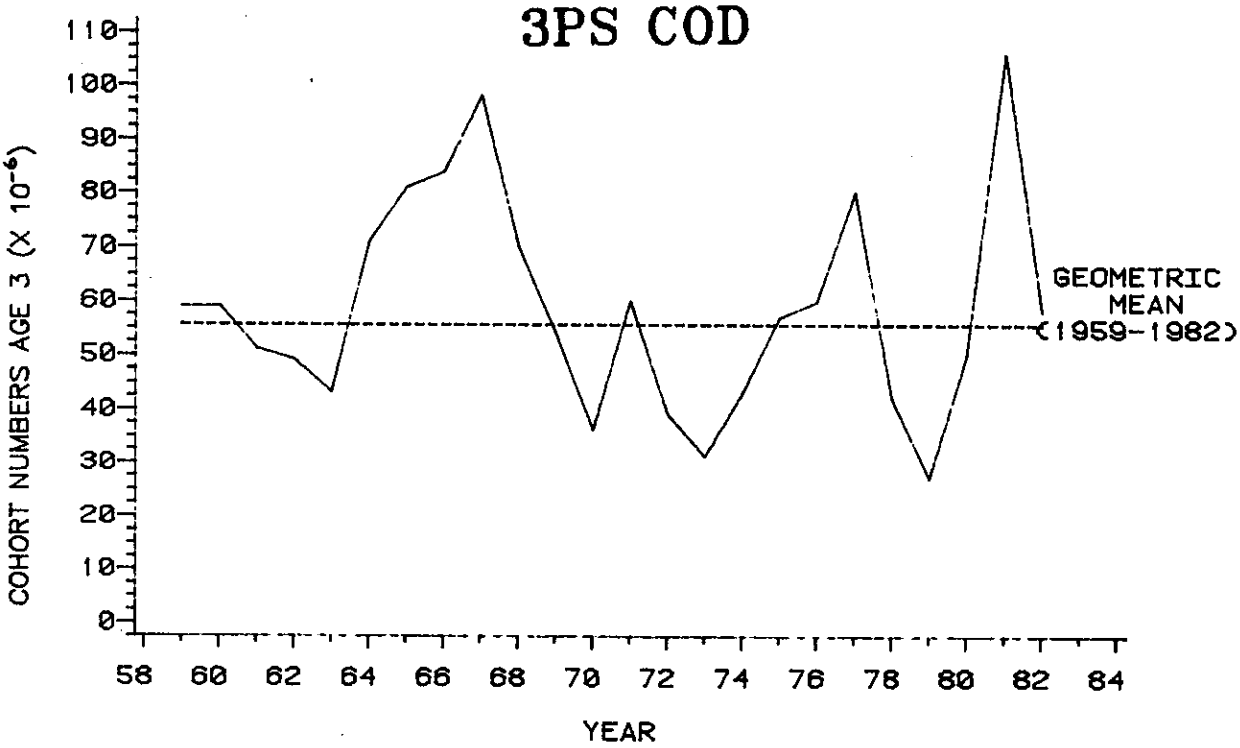

Fig. 11. Comparison of Subdivision 3Ps cod cohort recruitment estimates at age 3 with their geometric mean from 1959-1982.

APPENDIX

Further Assessment of the Cod Stock in Subdivision 3Ps

Catch information for 1983 provided during the June 1984 NAFO Scientific Council meeting was included with that previously used and is shown in Table 1. The existing catch at age matrix was adjusted to include sampling data available from French catches (Table 2).

A cohort analysis having a fully recruited fishing mortality of 0.25 was considered appropriate to the fishery in 1983. The results of this analysis in terms of population numbers, midyear population biomass, and fishing mortality are shown in Tables 3-5.

Table 6 shows the results of regression analysis of total exploitable biomass and catch rate index for a range of values of fully recruited fishing mortality. Figure 1 shows the results of this relationship from a cohort having F_t=0.25. The relationship of the combined (French and Canadian) survey mean number per tow estimates (age 4+) with cohort age 4+abundance (F_t=0.20) is shown in Figure 2.

Table 1. Cod landings in metric tons from Subdivision 3Ps.

	Can(N)			France					
Year	Offshore	Inshore	Can(M)	STPM	M	Spain	Portugal	Other	Total
1959	2,726	32,718	4,784	3,078	4,952	7,794	3,647	471	60,170
1960	1,780	40,059	5,095	3,634	2,460	17,223	262	2,123	72,636
1961	2,167	32,506	3,883	4,140	11,490	21,017	4,985	3,434	83,622
1962	1,176	29,888	1,474	2,241	4,138	10,289	1,873	1,560	52,639
1963	1,099	30,447	331	1,757	324	10,826	209	5,058	50,051
1964	2,161	23,887	370	2,097	2,777	15,217	169	7,268	53,956
1965	2,459	25,902	1,203	2,570	1,781	13,404	-	4,081	51,400
1966	5,473	23,785	583	3,207	4,607	23,678	519	3,897	65,749
1967	3,861	26,331	1,258	2,244	3,204	20,852	980	3,663	62,393
1968	6,536	22,940	585	1,880	1,126	26,868	8	18,274	77,217
1969	4,269	20,009	849	2,477	15	28,141	57	7,286	63,103
1970	4,649	23,411	2,166	1,970	35	35,750	143	8,037	76,161
1971	8,657	26,651	731	1,651	2,730	19,169	81	4,297	63,967
1972	3,323	19,276	252	1,436	-	18,550	109	1,379	44,325
1973	3,107	21,349	181	1,165	-	19,952	1,180	5,707	52,641
1974	3,770	15,999	657	948	5,366	14,937	1,246	3,783	46,706
1975	741	14,332	122	775	3,549	12,234	1,350	2,270	35,373
1976	2,013	20,978	317	904	1,501	9,236	177	2,007	37,133
1977	3,333	23,755	2,171	1,252	1,734				32,245
1978	2,082	19,560	700	1,974	2,860			45	27,221
1979	2,381	23,413	863	4,289	2,060				33,006
1980	2,809	29,427	715	1,936	2,681				37,568
1981	2,690	26,075	2,321	4,101	3,706				38,905
1982	2,648	20,886	2,945	4,780	2,184				33,443
1983	2,141	23,495	2,578	4,478	5,372				38,064

Table 2. Catch at age from the commercial cod fishery in Subdivision 3Ps.

CATCH AT AGE

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	1001	567	450	1245	961	1906	2314	949	2871	1143	724	756	2884
4	13940	5496	3086	6749	4499	5785	9636	13662	10913	12602	7098	8114	6444
5	7525	23704	10357	9003	7091	5635	5799	13065	12900	13136	11585	12916	9574
6	7265	6714	15960	4533	5225	5179	3609	4621	6592	5893	7179	9263	7266
7	4875	3476	3618	5515	2527	2945	3254	5119	2349	3572	4554	6374	8219
8	942	3484	4680	1367	3030	1881	2055	1586	1364	1308	1757	2456	3131
9	1253	1020	1849	791	898	1991	1218	1833	604	547	792	730	1275
10	1260	897	1374	571	292	652	1033	1039	316	425	717	214	541
11	631	406	446	187	143	339	327	517	380	223	61	178	85
12	545	407	265	140	99	329	68	389	95	111	126	77	128
13	44	283	566	135	107	54	122	32	149	5	67	121	62
14	0	27	58	241	92	27	36	22	3	107	110	14	57
3+	39280	46411	45203	30677	25014	26623	29471	42834	38336	39032	34813	41713	38662
4+	38279	45844	44753	29432	24053	24717	27157	41885	35465	37889	34039	40957	35778
5+	24339	40348	39167	22683	19554	18932	17521	28223	24552	25287	26941	32843	29334
6+	16814	16644	38810	13680	12463	13297	11722	15158	11652	12152	15356	19927	20760

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	731	945	1887	1840	4110	935	218	149	298	1000	110	783
4	4944	4707	6042	7329	12139	9156	4308	2370	1644	2765	5079	2623
5	4591	11386	9987	8397	7923	8326	5391	9777	5096	2864	4114	9106
6	3552	4010	6365	4541	2875	3209	4203	5235	8335	4220	1979	3984
7	4603	4022	2540	5867	1305	920	1791	2588	4387	5187	3806	1705
8	2636	2201	1857	723	495	395	730	884	1420	1573	3101	1140
9	833	2019	1149	1196	140	265	243	284	349	571	725	1029
10	463	515	938	105	53	117	189	83	104	204	297	237
11	205	172	249	174	17	57	76	48	54	89	102	90
12	117	110	80	52	21	43	26	19	42	37	34	35
13	49	14	33	6	4	31	19	11	19	24	15	18
14	45	29	17	2	3	11	10	10	25	6	10	8
3+	22768	30130	30748	27232	29085	23465	17204	21457	21773	18540	18372	20758
4+	22037	29185	28856	25392	24975	22530	16986	21308	21475	17540	18262	19975
5+	17093	24478	22814	18063	12836	13374	12678	18938	19831	14775	13183	17352
6+	12502	13092	12827	12666	4913	5048	7287	9161	14735	11911	9069	8246

Table 3. Population numbers ($\times 10^{-3}$) of Subdivision 3Ps cod from a cohort analysis at F_t = 0.25.

POPULATION NUMBERS

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	59386	59260	50943	48671	42957	70339	80985	84419	96486	70186	54345	35514	60221	37531
4	162964	47715	48005	41302	38721	34300	56274	64211	68258	78035	56430	43794	28392	46696
5	35820	75043	34093	34249	27708	27632	22648	32354	40210	46010	52487	39778	28514	17415
6	24206	22516	39992	16541	19894	16269	17524	13459	19761	31249	25785	32490	20681	15567
7	16370	13245	12361	18303	11079	11513	8634	11082	8838	9537	12101	14616	17767	10521
8	5812	8910	7695	6349	9313	6784	6753	4125	4441	3473	4809	5787	6199	7119
9	4041	3906	4142	2868	4370	5292	3853	3678	1942	2402	1660	2183	2516	2242
10	3449	2178	2275	1718	978	2766	2622	2052	1353	1643	1470	643	1127	906
11	3661	1682	1033	618	690	536	1674	1212	740	821	470	555	333	433
12	1180	2426	1011	442	337	599	132	1075	525	382	472	329	293	195
13	154	473	1618	589	225	186	193	47	529	344	114	278	200	137
14	0	86	131	818	359	96	103	48	9	298	277	33	118	108
3+	261043	237442	203304	174166	157342	176816	201606	222762	242090	233700	210219	175999	166560	140971
4+	201657	178182	152360	125495	114385	105976	120621	138343	143605	163514	155873	140495	106339	101340
5+	94692	130466	104355	84193	75664	71676	64347	74131	75347	85479	99444	96691	77946	54645
6+	58872	55423	70262	49944	47956	44044	41499	41777	35137	39468	46957	56913	49433	37230

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	31227	42369	56882	59282	78797	42631	29540	58121	107624	48980	173200
4	34704	24712	32552	44906	44817	63667	34709	24378	47316	87210	40002
5	33756	21698	14765	20372	25782	28408	46228	26273	18471	36237	66806
6	10104	17336	8728	7205	9510	13575	19391	30639	16899	12521	25944
7	9547	4644	8434	3637	3298	4882	7311	10312	17544	10018	6469
8	4449	4178	1504	1577	1306	1567	2877	3644	4473	9670	5663
9	3428	1651	1740	577	859	712	868	1146	1699	2239	5111
10	1082	987	812	342	346	464	363	454	623	874	1177
11	333	420	321	160	332	177	299	227	276	326	447
12	169	109	119	105	116	139	76	127	134	147	174
13	54	39	17	50	67	56	90	45	66	76	89
14	60	32	3	8	37	27	29	64	20	32	49
3+	125914	118173	125906	137642	165168	156610	142581	155427	215146	208341	327133
4+	94687	75804	69024	78360	86371	113979	112041	97306	107522	159360	153934
5+	59983	51092	36472	33454	41554	50308	77332	72928	60206	72150	113931
6+	29226	29394	21177	13082	15771	21899	29704	46655	41735	35913	47125

Table 4. Mid-year (average) population biomass ($t \times 10^{-3}$) of Subdivision 3Ps cod from a cohort analysis at F_t = 0.25.

POPULATION BIOMASS (AVERAGE)

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	14735	14962	12367	12182	10771	17718	20237	21295	24602	17656	13666	9510	14888	9533
4	62174	27961	28111	23497	22677	19450	31557	35392	38919	34449	32858	24570	15496	27515
5	30949	60147	27575	28537	23202	23972	19161	29159	32106	37721	45023	31667	23116	14504
6	30539	28451	46617	24345	25746	20246	23518	16427	22945	27296	33054	40979	25391	20700
7	29334	24533	22405	32666	21016	21430	14650	17431	11922	16302	20542	23552	27926	16932
8	15396	19981	13752	17710	23902	16630	16258	9301	10651	7585	10421	12604	12490	16219
9	12351	12372	11294	5968	14379	15597	11719	9530	5930	7782	4376	6549	6462	6529
10	12564	7772	6458	6356	3734	11047	9283	6534	5410	3651	4771	2391	3696	2970
11	18097	7952	4197	2772	4433	1741	8156	4950	2775	3801	2384	2473	1555	1693
12	5412	13964	5463	2294	1777	2511	576	5386	2994	1245	2562	1815	1390	770
13	941	2144	9442	3737	1249	1132	937	188	3235	2487	524	1500	1200	721
14	0	589	805	5660	2554	668	687	288	64	1960	1768	204	696	676
3+	232632	220847	188986	165607	155040	152133	157038	155870	161554	172236	171993	157215	134258	119062
4+	217697	205885	176119	153625	144269	134416	136801	134575	136952	154579	158307	148305	119410	109129
5+	155523	177924	148008	130128	121592	114966	104944	99193	98032	110130	125449	123735	103914	81614
6+	124574	117778	120433	101589	98370	90995	85783	70035	65926	72409	80421	92069	80795	67110

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	7796	10494	14184	14420	39630	17341	11096	27317	46589	19953	90823
4	18206	13326	18059	23731	24474	38914	19692	15327	32805	58946	29373
5	26613	15381	11380	15398	24740	24874	39159	24004	20209	36043	74529
6	11800	20757	9057	6399	12910	17714	23034	38987	23686	18455	42955
7	15592	6684	9859	4922	6716	9527	13430	17338	30402	15017	17596
8	9060	8934	3106	3920	3347	3901	6209	9177	10557	20591	14966
9	8048	3295	3525	1552	2687	2123	2748	4632	5412	6458	15517
10	3554	3011	1156	1442	1246	1649	1363	2493	2600	3361	4778
11	1185	1437	1167	826	1074	620	1153	1271	1521	1493	2362
12	621	342	556	574	557	811	488	808	922	995	1133
13	337	113	75	349	387	317	725	289	398	529	724
14	359	177	14	53	307	168	226	428	143	278	462
3+	103172	83951	72160	75916	117477	116959	119924	142071	175251	185126	295077
4+	95376	73457	57976	61437	78447	99617	108729	114753	128662	165173	204349
5+	77170	60131	39917	37656	53973	60703	89036	99426	95853	106226	174871
6+	50557	44750	28537	22256	29233	35928	49877	75422	75644	70183	100342

Table 5. Fishing mortalities for Subdivision 3Ps cod from a cohort analysis at F_t = 0.25.

FISHING MORTALITY

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.019	0.011	0.010	0.039	0.025	0.030	0.032	0.013	0.033	0.018	0.016	0.024	0.054	0.021	0.034	0.050	0.036
4	0.155	0.136	0.138	0.199	0.137	0.206	0.210	0.268	0.194	0.197	0.150	0.229	0.289	0.124	0.179	0.315	0.282
5	0.264	0.429	0.409	0.343	0.332	0.255	0.329	0.469	0.438	0.379	0.280	0.444	0.404	0.344	0.466	0.711	0.517
6	0.403	0.400	0.582	0.315	0.347	0.434	0.259	0.477	0.472	0.363	0.368	0.404	0.485	0.290	0.577	0.520	0.856
7	0.402	0.343	0.371	0.423	0.290	0.332	0.539	0.714	0.477	0.331	0.538	0.658	0.716	0.661	0.627	0.727	1.464
8	0.197	0.566	1.114	0.249	0.417	0.366	0.409	0.553	0.415	0.538	0.547	0.633	0.917	0.527	0.791	0.676	0.759
9	0.419	0.341	0.680	0.549	0.259	0.302	0.430	0.800	0.421	0.291	0.749	0.461	0.921	0.529	1.048	1.466	1.426
10	0.517	0.545	1.104	0.458	0.401	0.302	0.572	0.820	0.299	0.598	0.774	0.459	0.756	0.832	0.746	0.923	0.465
11	0.211	0.310	0.649	0.407	0.195	1.199	0.243	0.638	0.938	0.355	0.155	0.438	0.332	0.740	0.989	1.065	0.914
12	0.714	0.205	0.342	0.431	0.393	0.933	0.839	0.511	0.223	0.632	0.330	0.299	0.637	1.055	1.268	1.563	0.663
13	0.379	1.083	0.482	0.273	0.699	0.387	1.199	1.406	0.374	0.016	1.049	0.657	0.419	0.541	0.337	2.375	0.513
14	0.370	0.420	0.660	0.390	0.330	0.370	0.480	0.700	0.430	0.500	0.570	0.670	0.750	0.610	0.740	0.880	1.300

AGE	1976	1977	1978	1979	1980	1981	1982	1983
3	0.030	0.013	0.006	0.066	0.006	0.010	0.002	0.003
4	0.355	0.256	0.078	0.078	0.077	0.067	0.067	0.075
5	0.562	0.441	0.235	0.254	0.241	0.188	0.134	0.163
6	0.582	0.467	0.419	0.378	0.258	0.322	0.192	0.180
7	0.644	0.369	0.330	0.496	0.635	0.396	0.370	0.250
8	0.420	0.407	0.566	0.529	0.563	0.492	0.438	0.250
9	0.312	0.417	0.474	0.448	0.410	0.464	0.448	0.250
10	0.188	0.466	0.399	0.287	0.252	0.450	0.471	0.250
11	0.129	0.316	0.642	0.293	0.312	0.437	0.426	0.250
12	0.349	0.527	0.332	0.321	0.357	0.366	0.256	0.250
13	0.073	0.713	0.469	0.145	0.622	0.511	0.247	0.250
14	0.520	0.370	0.520	0.480	0.560	0.400	0.410	0.250

Table 6. Results of regressions used for tuning cohort.

F_T	0.20	0.25	0.30
Total exploitable biomass vs catch rate index			
Slope	118,476	103,117	92,872
Intercept	-2,030	7,481	13,824
R^2	0.68	0.63	0.55
81 residual	396	-6,261	-10,704
82 residual	-27,064	-34,895	-40,135
83 residual	30,051	3,958	-13,437

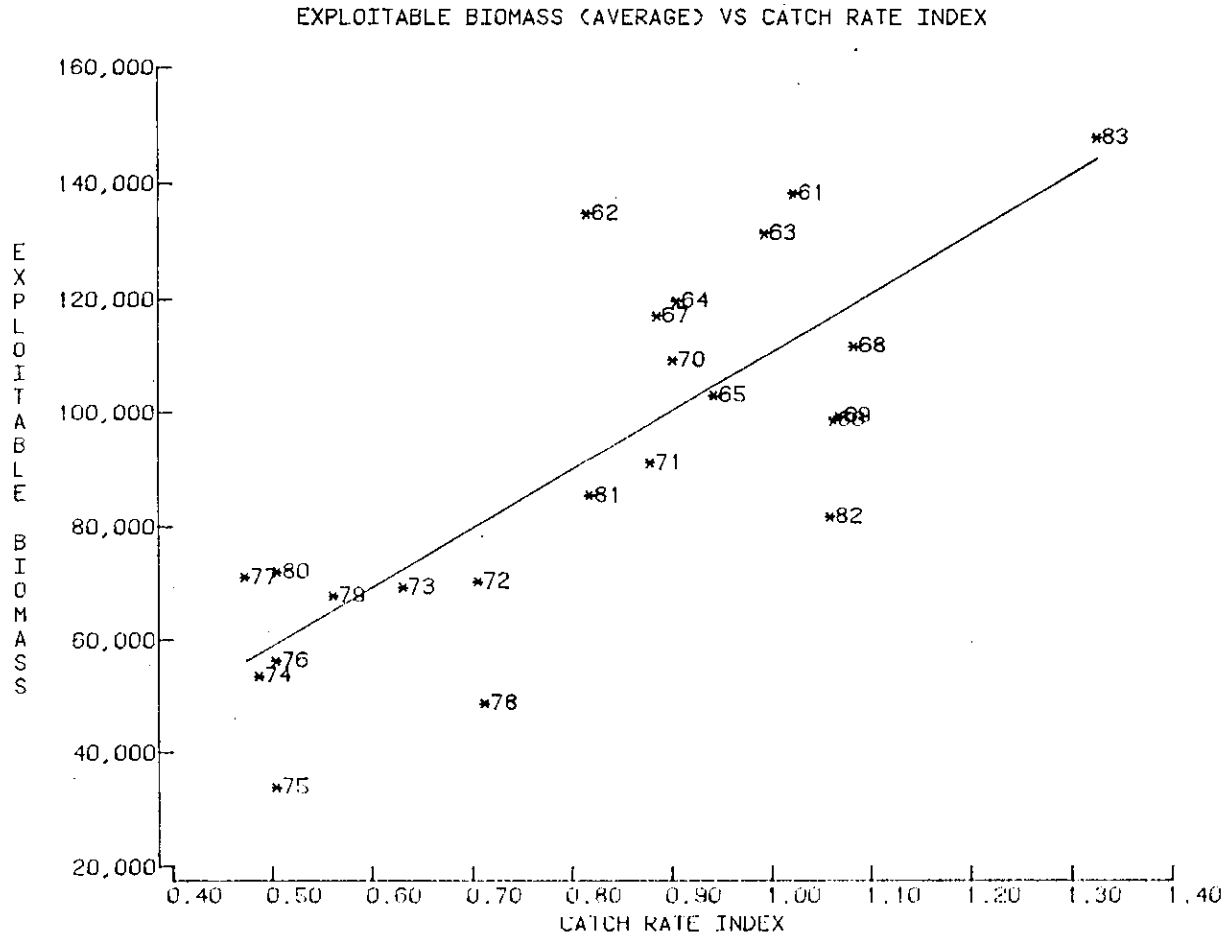

Fig. 1. Relationship of cohort exploitable biomass (F_t = 0.25) with standard CPUE for the period 1961-83 for Subdivision 3Ps cod.

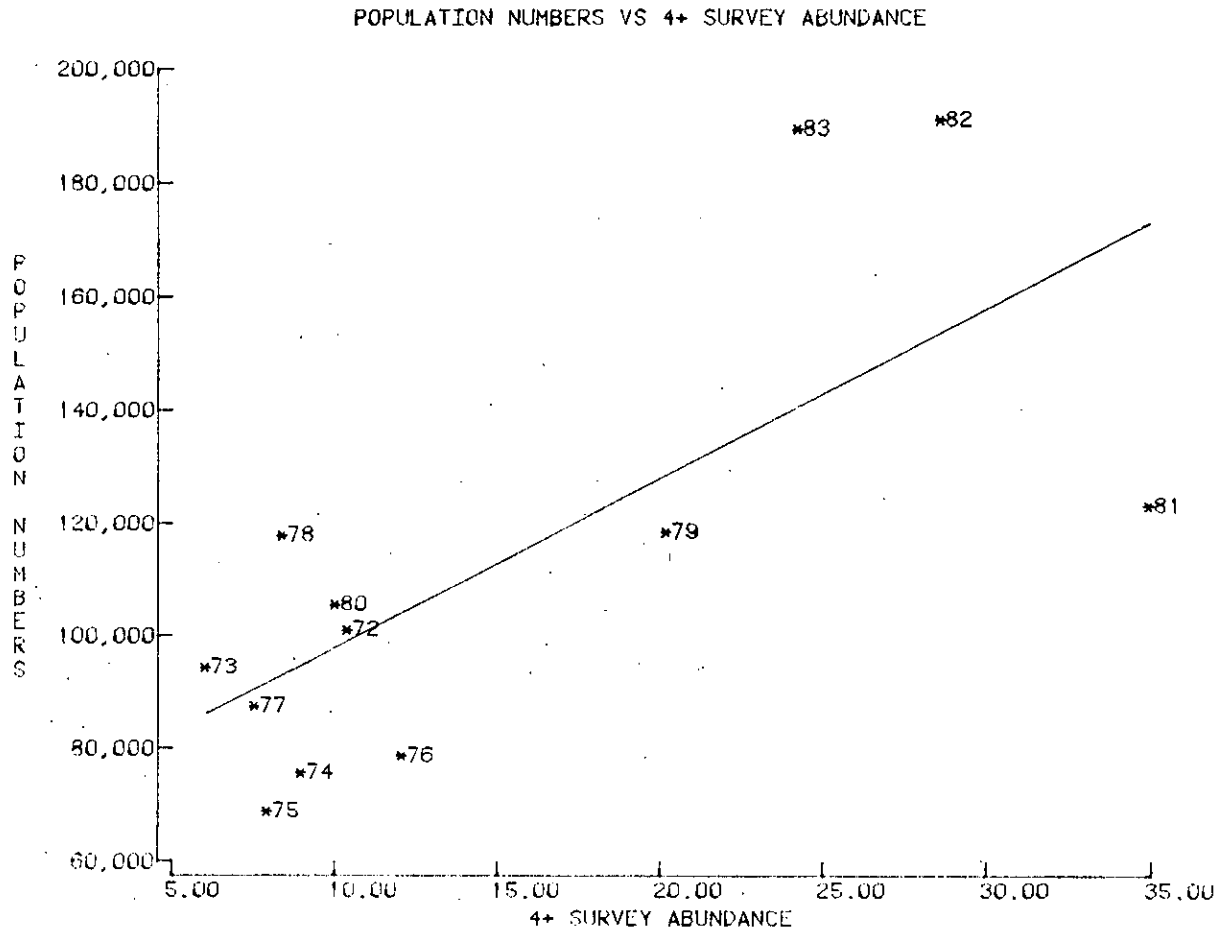

Fig. 2. Cohort 4+ abundance vs. survey 4+ abundance for the period 1972-83 (F_t = 0.20).