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Assessment of the Cod Stock in Subdivision 3Ps

by

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ABSTRACT

Catches of cod from Subdivision 3Ps have increased to approximately 40,000 t in 1980 from a low of 26,000 t in 1978. The 1974 year-class dominated the commercial fishery in 1980 and the 1978 year-class continued to appear strong as 3 year olds in the 1981 survey. Using survey results and cohort runs, the terminal fishing mortality in 1980 was estimated at 0.30. The population numbers at age from the cohort at F_t = 0.30 and estimates of recruitment in 1981 and 82 were used in a projection which indicated a catch of 33,000 t at $F_{0.1}$ in 1982. Catch rate and effort data were used in an asymmetric surplus production model which predicted a nonequilibrium yield of 32,700 t in 1982.

RESUME

Les prises de morue de la division 3Ps ont augmenté, passant d'un creux de 26 000 t en 1978 à environ 40 000 t en 1978. La classe d'âge de 1974 était dominante dans les prises commerciales de 1980 et celle de 1978 semble toujours abondante, à 3 ans, dans le relevé de 1981. D'après les résultats des relevés et de l'analyse de cohortes, nous avons estimé à 0,30 la mortalité par pêche en 1980. Les nombres par âge dans la population, obtenus par analyse des cohortes à F_t = 0,30 et les estimations du recrutement en 1981 et 1982 ont été utilisés pour prédire des prises de 33 000 t à $F_{0,1}$ en 1982. Les données sur les taux de capture et l'effort, utilisées dans un modèle de production excédentaire asymétrique, permettent de prédire un rendement en état de non-équilibre de 32 700 t en 1982.

NOMINAL CATCH AND CATCH AT AGE

Cod catches in Subdivision 3Ps in recent years, along with corresponding TAC's, are shown below:

	1974	1975	1976	1977	1978	1979	1980	1981
TAC ('000 t)	70	62.4	47.5	32.5	25	25	28	30
Catch ('000 t)	44.9	35.4	37.1	32.4	26.3	32.8	40.1*	

*preliminary

Landings for 1980 by Can(N) by month and gear are shown in Table 1. Over 90% of the total catch was obtained by the inshore component. Catch-at-age data for the commercial fishery in 1980 was obtained using sampling as indicated in Table 2. The age compositions by country and gear are shown in Table 3 and Fig. 1. Catches by Can(M) and France were adjusted to numbers at age using Can(N) sampling data. As in 1979 the 1980 catch was dominated by the 1974 year-class (38%) with the '75 and '73 year-classes comprising 23% and 20% respectively.

SURVEY DATA

The results of research surveys in terms of mean number at age per standard tow for the years 1972-81 are shown in Table 4. In contrast to previous years, strata were combined on the basis of depth zone so as to increase the number of sets per zone and reduce variation. In recent years there has been considerable fluctuation in total and for individual ages and year-classes. The 1978 year-class seems to be relatively strong while in the older groups the 1974 and 1975 year-classes were predominant as they had been in previous surveys.

CATCH EFFORT DATA

Catch rate and effort data were updated using data from the Can(N) and Can(M) offshore fisheries. Standardized catch rate and effort values were derived using the multiplicative model as described by Gavaris, S. (1980). Table 5 and Fig. 2 show the historical catch and standardized effort and catch rate as well as the proportions of the total catch that were used in estimating the catch rates. As can be seen this proportion of total catch has been low since 1977, probably coincident with reduced allocations for the offshore component of the fishery. The figures for 1981 were obtained using Can(N) catch rates for the first quarter and assumes a catch for the year equal to the TAC.

The catch effort data of Table 5 were used in an asymmetric surplus production model and produced catch rate, effort and yield values for MSY and 2/3 MSY effort as shown in Table 6. The predicted biomass and nonequilibrium yield for 1982 were 220,619 t and 32,700 t respectively.

Examination of the observed and predicted yield (Fig. 3) shows that there is serial correlation, indicating that variance estimates are unreliable. The large fluctuations in biomass with changes in effort (Fig. 4) imply that the stock is very sensitive to variation of fishing mortality.

PARTIAL SELECTION

Estimates of partial selection were obtained from a comparison of percent commercial catch at age with percent survey abundance at age (Table 7) and by using cohort average F's (ages 6-8) for the period 1974-77 (Table 8). A flat topped recruitment pattern (Table 8) was assumed to have applied in 1980 and the selection pattern from Table 8 was used in a cohort analysis. This selection pattern, along with those used in previous assessments, is shown in Table 9.

COHORT ANALYSIS

Catch at age data from 1959-80 (Table 10), along with average weight at age values (Table 11) and partial selection values for 1980 (Table 8) were used to obtain a series of cohort runs over a range of terminal F's. Table 12 shows the mean population biomasses from cohort runs with terminal F from 0.20 to 0.60 along with the results of regression analyses of the population biomasses with standard catch per unit effort. The best relationship in terms of R^2 and the prediction of 1980 biomass was at $F_t = 0.50$. However, it is evident that the population biomass from other terminal F's (.45-.55) provides an adequate estimate, as well, of 1980 biomass.

A comparison of ages 3+ catch per standard tow from research vessel surveys in 1973-74 with that in 1979-80 (Table 4) shows that there has been some improvement in recent years in terms of average numbers caught per tow. This increase is not reflected in the catch rate data for the same periods (Table 5). The catch rate data for recent years (1977-80) might be suspect as it was obtained from a very small proportion of the total catch (Table 5). A comparison of the ratios of cohort 3+ population numbers from the 1973-74 and 1979-80 periods (F_t ranging from .20 to .60) with survey 3+ catch per tow for the same periods indicated (Table 13) that the cohort run at $F_t = 0.30$ gave the best correspondence. Tables 14-16 show the results of a cohort run at $F_t = 0.30$. Figure 5 shows the relationship between catch rate and population biomass at $F_t = 0.30$.

RECRUITMENT

Estimates of recruitment at age three in 1980, '81 and '82 were obtained (Table 17) from regressions of survey mean numbers per tow at ages two and three by year-class against cohort numbers at age three (F_t 0.30). Recruitment in 1981 and '82 at age three was estimated at 100 million and 50 million respectively.

YIELD PER RECRUIT

In an attempt to determine the "steady state" $F_{0.1}$ for this stock, parameters used in a yield per recruit analysis were those from earlier periods in the fishery when it was considered that the stock was more "lightly exploited". Average weights (Table 18) were those from the period 1946-54 while the partial selection values were those used in the 1972 assessment of the stock which were also very close to the average selection pattern used over the period 1972-80 (Table 9). The calculated $F_{0.1}$ was 0.18 while the F_{max} was 0.32. The figures used in previous assessments were 0.20 ($F_{0.1}$) and 0.30 (F_{max}).

PROJECTIONS

Catch projections to 1983 were obtained using the following: catch at age for 1980 (Table 10); the population at age for 1980 from the cohort at $F_t = 0.30$ (Table 5); average weights from the 1980 commercial fishery (Table 11); partial selection values as used in 1980 (Table 9); recruitment estimates of 100 million and 50 million in 1981 and '82 respectively (Table 17) and 50 million in 1983 (geometric mean recruitment from 1968-78 = 52,546 million); catch equal to TAC = 30,000 in 1981 with fishing mortality equal to $F_{0.1}$ (0.20) for 1982 and '83. The results of this projection are shown in Tables 19-20. The projected catch in 1982 is 33,000 t from an average population biomass of 220,000 t.

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.

Table 1. Cod landings for 1980 (metric tons) by Can(N) in Subdivision 3Ps by month and gear.

Months	OT	Trap	GN	LT	HL	Other	Total
Jan.		3	87	343	13		446
Feb.	1338		67	992	42		2439
Mar.	129		42	1248	6		1424
Apr.	84		164	1414	20		1682
May	95	471	380	2388	203		3534
June	27	1068	1655	1748	487		4988
July	19	521	1693	1357	734		4325
Aug.	14	14	829	2479	640	1	3976
Sept.	51		253	2562	324		3191
Oct.	76		133	2379	41		2628
Nov.	226		67	1334	28		1656
Dec.	747		104	530	5		1386
Total	2806	2077	5474	18774	2543	1	31675

NB OT column includes stern and side OT, MWT and DS.

Table 2 Details of sampling and method used to estimate catch at age by the commercial fishery in Subdivision 3Ps during 1980.

Country	Quarter	Gear	No. otoliths	Sampling months	No. of measurements	Ave. wt.	Nom. catch (tons)	Adjusted numbers (000)
Can(N)	1+2	OT	105	1, 2	1242	1.71	1673	978
	3+4	OT	164	11, 12	1816	1.92	1133	590
	1-4					1.79	2806	1868
	3	Trap	862[a]	6, 7, 8	4427	0.95	1603	1681
	1-4					0.95	2077	2186
	1+2	GN	605[a]	4	186	2.08	740	356
	3		862[a]	6, 8	1961	2.63	4177	1588
	4		526[a]	9, 10	226	2.43	557	299
	1-4					2.52	5474	2173
	1	LT	94	2	326	2.49	1335	536
	2		605[a]	3, 4, 5	7117	1.97	5050	2561
	3		862[a]	6, 8	5436	1.98	5584	2820
	4		526[a]	9, 10, 11	4217	2.13	6805	3195
	1-4					2.06	18774	9112
	3	HL	862[a]	6, 7	2428	1.28	1221	957
	1-4					1.28	2543	1987
	1-4	ALL				1.86	31674	17026
Can(M)[b]	1+2	OT	105	1, 2	1242	1.78	348	196
	3+4		164	11, 12	1816	1.96	367	187
	1-4					1.87	715	383
France[c]	1-4	OT	269	1, 2, 11, 12	3058	1.79	7300	4078
	1-4	HL	862	6, 7	2428	1.28	400	313
	1-4	ALL				1.75	7700	4391
ALL	1-4	all	2356		29922	1.84	40089	21800

[a]A/L keys for inshore gears are combined by quarter

[b]Can(N) sampling applied to Can(M) catches

[c]Catches adjusted using Can(N) OT and HL sampling

Table 3. Age composition for cod in Subdivision 3Ps in 1980.

Age	Can(N) OT*	Trap	GN	LT	HL	Total	France	Can(M)	Grand Total
3	16	125		68	37	246	48	4	298
4	65	679	5	357	295	1401	215	28	1644
5	247	959	219	1946	835	4206	773	117	5096
6	542	369	988	4076	668	6643	1515	177	8335
7	558	49	565	1576	125	2873	1470	44	4387
8	119	5	243	704	23	1094	314	12	1420
9	21		68	199	4	292	56	1	349
10			31	73		104			104
11			20	34		54			54
12			13	29		42			42
13			7	12		19			19
14			8	17		25			25
15			3	8		11			11
16			3	6		9			9
17				3		3			3
18				2		2			2
19									
20				1		1			1
>20				1		1			1
Total	1568	2186	2173	9112	1987	17026	4391	383	21800
Av. wt.	1.79	0.95	2.52	2.06	1.28	1.86	1.75	1.87	1.84
Landings	2806	2077	5474	18774	2543	31674	7700	715	40089

*Includes landings by DS, ScS and MWT

Table 4. Mean number of cod per tow from research trips in Subdivision 3Ps (stratification by depth zone).

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.06	.12	1.00	.84	.31	.02	.00	2.69	.24	.06
2	1.64	3.34	5.11	1.53	4.85	.36	.77	1.26	8.94	1.23
3	3.20	2.48	4.30	4.35	2.90	3.92	.70	1.19	2.92	6.29
4	5.16	3.57	3.25	4.29	4.35	3.59	3.28	5.35	1.15	7.02
5	2.89	3.40	4.07	2.49	1.93	4.23	1.85	14.01	3.11	7.41
6	1.88	.93	3.98	2.25	.76	1.24	1.20	3.64	2.73	8.93
7	2.62	1.91	1.15	1.95	.48	.32	.84	1.65	.62	8.62
8	1.50	.75	.91	.67	.49	.27	.63	.89	.64	1.79
9	.69	1.02	.71	.49	.15	.38	.32	.36	.21	1.95
10	.44	.27	.35	.30	.08	.15	.34	.30	.19	.52
11	.20	.10	.10	.11	.09	.03	.15	.08	.14	.14
12	.11	.07	.07	.03	.05	.06	.06	.05	.17	.19
13	.07	.01	.05	.07	.00	.09	.05	.05	.07	.15
14	.14	.03	.10	.00	.00	.02	.00	.06	.00	.12
14+	.55	.26	.14	.06	.10	.08	.16		.07	.16
Total	21.16	18.28	25.31	19.43	16.51	14.77	10.36	31.56	21.19	44.57
Age										
3+	19.46	14.82	19.20	17.06	11.35	14.39	9.59	27.61	12.01	43.28

Table 5. Historical catch and standardized effort and catch rate for cod in Subdivision 3Ps. The proportion of the catch used in estimating the catch rate is indicated.

Year	Catch(t)	Prop.	Catch Rate Mean(t/hr)	Catch Rate Std. error	Effort(hr)
1959	60,170	0.22	0.723	0.067	83,223
1960	72,636	0.26	0.699	0.061	103,914
1961	83,620	0.36	0.929	0.065	90,011
1962	52,639	0.25	0.720	0.064	73,110
1963	50,051	0.23	0.854	0.080	58,608
1964	53,956	0.31	0.833	0.076	64,773
1965	51,400	0.30	0.880	0.081	58,409
1966	65,749	0.44	0.981	0.078	67,022
1967	62,393	0.34	0.777	0.061	80,300
1968	77,217	0.42	0.962	0.070	80,267
1969	63,103	0.50	0.964	0.074	65,460
1970	76,161	0.53	0.804	0.056	94,728
1971	63,967	0.42	0.736	0.051	86,912
1972	44,323	0.48	0.634	0.046	69,910
1973	52,641	0.41	0.558	0.040	94,339
1974	46,712	0.41	0.429	0.032	108,886
1975	35,373	0.39	0.415	0.038	85,236
1976	37,133	0.28	0.507	0.047	73,241
1977	32,245	0.09	0.549	0.059	58,734
1978	27,221	0.07	0.659	0.090	41,307
1979	33,006	0.06	0.556	0.068	59,363
1980	40,089	0.06	0.519	0.060	77,242
1981	30,000	0.04	0.842	0.185	35,629

Table 6. Management implications for cod in Subdivision 3Ps from the non-equilibrium surplus production analysis.

Unfished biomass		472,662	
Catchability coefficient		0.000003	
Shape parameter		7.0	
	MSY		2/3 Effort MSY
Effort (hrs)	70,390		46,927
Catch rate (t/hr)	1.025		1.231
Yield (t)	72,166		57,778
Biomass 1982 (beginning)		220,619	
Non-equilibrium yield 1982		32,705	

Table 7. Estimation of partial selection at age for cod in 3Ps from a comparison of commercial catch and survey abundance at age in 1980.

Age	Survey abundance ($X\ 10^{-3}$)	% Survey	Commercial catch	% Commercial	% Commercial / % survey	P.S.
3	2377	24.42	298	1.37	.056	.01
4	934	9.59	1644	7.55	.787	.20
5	2531	26.00	5096	23.41	.900	.23
6	2225	22.86	8335	38.28	1.674	.43
7	510	5.24	4387	20.15	3.845	1.00
8	521	5.35	1420	6.52	1.219	.32
9	172	1.77	349	1.60	.904	.24
10	153	1.57	104	.48	.306	.08
11	113	1.16	54	.25	.216	.06
12	141	1.45	42	.19	.131	.03
13	58	.60	19	.09	.150	.04
14	0	0	25	.11		

Table 8. Estimation of partial selection at age for cod in 3Ps based on cohort Ave. F's (ages 6-8) for the period 1974-77.

Age	1974	1975	1976	1977	Ave.	P.S.
3	.071	.031	.100	.026	.057	.05
4	.465	.277	.560	.416	.430	.41
5	1.054	.533	1.005	.875	.867	.83
6	.765	.874	1.108	1.075	.956	.91
7	1.301	1.440	1.189	.941	1.218	1.00
8	.934	.685	.703	.983	.826	
9	2.025	1.184	.484	.890	1.146	
10	1.351	.402	.235	.910	.725	
11	1.574	.898	.192	.499	.791	
12	2.455	.671	.438	1.034	1.150	
Ave F (Ages 6-8)	.659	.931	.489	.351		

Table 9. Partial selection patterns used in previous assessments of cod in Subdivision 3Ps.

Age	1972	1973-76	1977-78	1979	1980	Ave.
3	.04	.05	.07	.09	.05	.06
4	.38	.35	.39	.55	.41	.42
5	.77	.65	.72	.89	.83	.77
6	.85	.63	1.00	1.00	.91	.88
7	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00

Table 10. *CATCH AT AGE COD 3PS* (Numbers X 10^{-3})

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	1001	567	450	1245	961	1906	2314	949	2871	1143	774
4	13940	5496	5586	6749	4499	5785	9636	13662	10913	12602	7098
5	7525	23704	10357	9003	7091	5635	5799	13065	12900	13135	11585
6	7265	6714	15960	4533	5275	5179	3609	4621	6392	5853	7178
7	4875	3476	3616	5715	2527	2945	3254	5119	2349	3572	4554
8	942	3484	4680	1367	3030	1881	2055	1586	1364	1308	1757
9	1252	1020	1849	791	898	1891	1218	1833	604	549	792
10	1260	827	1376	571	292	652	1033	1039	316	425	717
11	631	406	446	187	143	339	327	517	380	222	61
12	545	407	265	140	99	329	68	389	95	111	120
13	44	283	560	135	107	54	122	32	149	5	67
14	0	27	58	241	92	27	36	22	3	107	110

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	756	2884	731	945	1887	1840	4110	935	218	149	298
4	8114	6444	4944	4707	6042	7329	12139	9156	4308	2370	1644
5	12916	8574	4591	11386	9987	5397	7923	8326	5391	9777	5096
6	9763	7266	3552	4010	6365	4541	2875	3209	4203	5235	8335
7	6374	8218	4603	4022	2540	5867	1305	920	1791	2588	4387
8	2456	3131	2636	2201	1857	723	495	395	730	884	1420
9	730	1275	833	2019	1149	1196	140	265	243	284	349
10	214	541	463	515	538	105	53	117	189	82	104
11	178	85	205	172	249	174	17	57	76	48	54
12	77	125	117	110	80	52	21	43	26	19	42
13	121	62	48	14	32	6	4	31	19	11	19
14	14	57	45	29	17	2	3	11	10	10	25

Table 11. WEIGHT AT AGE - 3Ps Cod. (Kg)

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
3	0.28	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
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
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
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
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
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
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
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
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
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
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

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.28	0.28	0.28	0.28	0.28	0.28	0.55	0.45	0.41	0.52
4	0.69	0.69	0.69	0.69	0.69	0.69	0.68	0.70	0.65	0.72
5	1.08	1.08	1.08	1.08	1.08	1.08	1.30	1.08	1.01	1.13
6	1.68	1.68	1.68	1.68	1.68	1.68	1.86	1.75	1.65	1.66
7	2.40	2.40	2.40	2.40	2.40	2.40	2.67	2.45	2.55	2.48
8	3.21	3.21	3.21	3.21	3.21	3.21	3.42	2.99	3.68	3.60
9	4.10	4.10	4.10	4.10	4.10	4.10	4.19	4.10	4.30	5.40
10	5.08	5.08	5.08	5.08	5.08	5.08	4.94	5.16	6.49	6.95
11	6.03	6.03	6.03	6.03	6.03	6.03	5.92	5.17	7.00	7.29
12	7.00	7.00	7.00	7.00	7.00	7.00	6.76	7.20	8.20	8.64
13	8.05	8.05	8.05	8.05	8.05	8.05	8.78	7.75	9.53	9.33
14	9.16	9.16	9.16	9.16	9.16	9.16	10.90	8.72	10.84	9.58

Table 12. Relationship of cohort biomass with standard CPUE from cohort runs at a range of terminal F's.- cod, Subdivision 3Ps.

Year	Stand. CPUE	Pop^n biomass (Age 3+) at F_t .20	.25	.30	.35	.40	.45	.50	.55	.60
1959	.723	232								
1960	.699	221								
1961	.929	189								
1962	.720	166								
1963	.854	155								
1964	.833	152								
1965	.880	157								
1966	.981	156								
1967	.777	162								
1968	.962	173								
1969	.964	173	172	172	172	172	172	172	172	172
1970	.804	158	158	158	158	158	158	158	158	158
1971	.736	136	136	135	135	135	135	135	135	135
1972	.634	121	121	120	120	120	120	119	119	119
1973	.558	106	105	104	104	104	103	103	103	103
1974	.429	88	87	86	85	84	84	84	83	83
1975	.415	81	78	76	74	73	72	72	71	71
1976	.507	98	91	86	83	80	78	76	75	74
1977	.549	176	155	141	131	124	118	114	110	107
1978	.659	182	162	144	131	121	114	108	103	99
1979	.556	207	172	149	132	120	110	102	96	91
1980	.519	240	192	160	137	120	106	96	87	80
1981	.842									
Predicted	1980 biomass	139	125	116	109	104	100	97	100	107
r^2		.08	35	.60	.75	.82	.85	.86	.86	.85
m		77.35	110.89	134.23	151.07	163.45	173.45	180.61	187.36	192.06
int		98.62	67.85	46.30	30.84	19.46	10.28	3.62	2.55	6.89

Table 13. Ratios of the age 3+ population numbers from the 1973-74 period to the 1979-80 period from cohort runs at different terminal F's and survey mean number per tow - cod, Subdivision 3Ps.

	Terminal F								
	.20	.25	.30	.35	.40	.45	.50	.55	.60
Cohort	.63	.76	.87	.98	1.08	1.18	1.27	1.36	1.44
Survey	.86	.86	.86	.86	.86	.86	.86	.86	.86

Table 14. Population numbers from a cohort run at F_t = 0.30 - cod, Subdivision 3Ps.

POPULATION NUMBERS (X 10^{-3})

	1959	1960	1961	1962	1963	1964	1965	1966	1967
3	59422	59386	51101	48671	42968	70844	80995	84451	98562
4	106918	47745	48108	41431	38722	34309	56277	64220	68284
5	35879	74924	34117	34333	27814	27632	22856	37357	40217
6	24201	22566	39894	18561	19963	16356	17524	13466	18764
7	16266	13240	12401	18222	11095	11572	8705	11082	6843
8	5844	8907	7695	6881	9747	6797	6809	4183	4441
9	4010	3932	4140	2066	4397	5239	3863	3715	1990
10	3410	2151	2296	1716	975	2787	2578	2061	1383
11	3661	1652	1013	635	888	534	1692	1176	747
12	1182	2426	985	425	351	598	131	1089	495
13	158	475	1618	567	222	198	192	46	540
14	0	90	132	818	342	85	113	47	8
3+	260951	237492	203500	174326	157484	176951	201736	222892	242274
4+	201529	178107	152399	125655	114516	106107	120741	138441	143712
5+	94611	130362	104291	84223	75794	71797	64463	74222	75429
6+	58732	55438	70174	49890	47980	44165	41607	36865	35212

	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	70346	54726	35774	60527	39560	31172	43472	63326	77688
4	78098	56560	44105	28605	46946	31728	24667	33885	50182
5	46031	52538	39885	28769	17589	33962	21718	14728	21111
6	21254	25802	32532	20968	15796	10246	17504	8744	7175
7	9579	12106	14630	17801	10593	9718	4761	8571	3050
8	3477	4610	5791	6211	7139	4508	4317	1599	1709
9	2402	1664	2185	2519	2252	3459	1699	1855	655
10	1082	1470	645	1128	908	1090	1005	351	436
11	847	502	555	335	434	325	426	336	193
12	268	492	355	293	197	170	110	124	118
13	319	119	295	221	127	56	40	18	54
14	307	257	37	132	125	60	33	3	9
3+	234012	210846	176789	167508	141666	126495	119752	133542	162381
4+	163666	156120	141015	106982	102105	95323	76280	70216	84693
5+	85568	99560	96910	78377	55160	63595	51613	36331	34511
6+	39536	47021	57025	49608	37571	29633	29895	21603	13400

	1977	1978	1979	1980
3	92790	41337	19268	22079
4	59887	75124	33647	15640
5	30102	40746	57608	25403
6	10115	17112	28482	38319
7	3273	5378	10207	18583
8	1317	1847	2783	6015
9	951	720	852	1478
10	410	539	370	441
11	309	230	270	229
12	142	202	119	178
13	78	78	141	80
14	41	35	46	106
3+	199414	183348	153794	128551
4+	106625	142011	134526	106472
5+	46738	66887	100879	90831
6+	16636	26141	43271	65428

Table 15. Mean population biomasses from a cohort run at F_t = 0.30 - cod, Subdivision 3Ps.

MEAN POPULATION BIOMASS (MT)

	1959	1960	1961	1962	1963	1964	1965	1966	1967
3	14944	14994	12907	12182	10773	17719	20239	21303	24621
4	62083	27979	28175	23578	22677	19455	31859	35387	38935
5	31007	60028	27599	28622	23307	23972	19168	29162	32113
6	30531	28525	46464	24376	25852	20380	23618	16437	22949
7	29326	24524	22491	32509	21051	21554	14808	17431	11933
8	15487	19972	13740	17804	23309	16669	16394	9475	10651
9	12237	12469	11285	5957	14477	15385	11760	9678	6110
10	12321	7675	6565	6387	3723	11146	9075	6577	5553
11	18097	7777	4083	2887	4424	1729	8253	4746	2817
12	5426	13964	5296	2188	1868	2501	566	5479	2806
13	972	2158	9442	3580	1146	1218	827	176	3322
14	0	618	817	5660	2408	575	767	280	55
3+	232432	220683	188865	165731	155015	152304	157334	156131	161867
4+	217488	205689	175958	153549	144241	134585	137095	134828	137245
5+	155406	177709	147782	129970	121564	115130	105235	99441	98310
6+	124399	117681	120183	101348	98257	91158	86067	70279	66196

	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	17697	13783	8976	14966	9940	7782	10774	15820	19152
4	44488	32940	24766	15630	27672	18221	13298	18627	27110
5	37742	45078	31774	23369	14676	26817	15401	11343	16141
6	27305	33081	41044	25527	21020	12023	21018	9083	8352
7	16306	20552	23584	28006	17093	15976	6956	10214	4952
8	7897	10426	12616	12526	16303	9240	9356	3397	4152
9	7782	4409	6555	6474	6565	8142	3506	4018	2144
10	3836	4771	2404	3692	2883	3592	3104	1342	1875
11	3941	2559	2473	1567	1699	1198	1476	1257	1003
12	1284	2695	1982	1390	782	627	356	591	674
13	2311	563	1628	1358	721	348	120	105	381
14	2042	1599	237	816	824	359	188	19	62
3+	172631	172455	158038	135321	120179	104324	85552	75815	85999
4+	154935	158673	149063	120355	110239	96542	74778	59995	66846
5+	110446	125733	124297	104725	82567	78321	61480	41368	39736
6+	72704	80655	92523	81356	67891	51504	46079	30025	23596

	1977	1978	1979	1980
3	46005	16812	7130	10331
4	33799	46185	19066	9623
5	29898	36989	47783	23126
6	13948	23386	38249	50682
7	6655	9650	20214	36266
8	3381	3845	7589	17040
9	3041	2156	2682	6282
10	1537	2009	1906	2409
11	1489	871	1546	1312
12	722	1222	809	1210
13	472	471	1171	591
14	343	236	401	798
3+	141291	143832	148546	159670
4+	95285	127020	141416	149340
5+	61487	80835	122350	139716
6+	31589	43846	74567	116590

Table 16. Fishing mortalities from a cohort run at F_t = 0.30 - cod, Subdivision 3Ps.

FISHING MORTALITY

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	0.019	0.011	0.010	0.029	0.025	0.030	0.032	0.012	0.033	0.018	0.016
4	0.156	0.136	0.137	0.198	0.137	0.206	0.210	0.268	0.194	0.196	0.149
5	0.264	0.430	0.409	0.342	0.331	0.255	0.329	0.489	0.438	0.379	0.279
6	0.403	0.399	0.584	0.315	0.345	0.431	0.258	0.477	0.472	0.363	0.367
7	0.402	0.343	0.389	0.426	0.290	0.330	0.533	0.714	0.477	0.531	0.537
8	0.196	0.566	1.115	0.248	0.421	0.365	0.406	0.543	0.415	0.537	0.547
9	0.423	0.338	0.680	0.550	0.256	0.509	0.428	0.788	0.409	0.291	0.747
10	0.525	0.553	1.085	0.458	0.402	0.299	0.585	0.815	0.291	0.569	0.774
11	0.211	0.317	0.667	0.394	0.196	1.208	0.240	0.665	0.826	0.342	0.144
12	0.713	0.205	0.353	0.452	0.374	0.937	0.855	0.502	0.238	0.612	0.314
13	0.367	1.076	0.482	0.306	0.763	0.360	1.213	1.498	0.364	0.017	0.975
14	0.350	0.400	0.650	0.390	0.350	0.430	0.430	0.720	0.500	0.480	0.630
7+	0.372	0.416	0.680	0.393	0.337	0.400	0.472	0.693	0.441	0.486	0.561

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.024	0.054	0.021	0.034	0.049	0.033	0.060	0.011	0.006	0.009	0.015
4	0.227	0.286	0.124	0.179	0.316	0.273	0.311	0.185	0.065	0.081	0.123
5	0.443	0.400	0.340	0.463	0.710	0.519	0.536	0.365	0.158	0.208	0.249
6	0.403	0.483	0.286	0.567	0.514	0.853	0.585	0.432	0.317	0.227	0.273
7	0.657	0.714	0.654	0.611	0.891	1.413	0.640	0.372	0.459	0.329	0.300
8	0.633	0.815	0.524	0.776	0.645	0.692	0.386	0.403	0.574	0.432	0.300
9	0.461	0.820	0.526	1.036	1.376	1.247	0.269	0.368	0.466	0.460	0.300
10	0.456	0.755	0.828	0.738	0.895	0.401	0.144	0.379	0.490	0.281	0.300
11	0.438	0.329	0.738	0.880	1.037	0.848	0.103	0.228	0.455	0.218	0.300
12	0.274	0.637	1.067	1.256	1.618	0.624	0.219	0.406	0.154	0.194	0.300
13	0.605	0.370	0.541	0.326	2.228	0.463	0.085	0.583	0.315	0.090	0.300
14	0.540	0.640	0.500	0.740	0.830	0.970	0.440	0.350	0.370	0.270	0.300
7+	0.617	0.738	0.610	0.742	0.888	1.248	0.467	0.374	0.476	0.349	0.300

Table 17. Relationship of survey mean numbers per tow at ages 2 and 3 with cohort numbers at age 3 (F_t = .30) - cod, Subdivision 3Ps.

Year class	Age 2	Age 3	Cohort numbers at age 3 ($X\ 10^{-3}$)
1979	1.23		
1978	8.94	6.29	
1977	1.26	2.92	
1976	.77	1.19	19
1975	.36	.70	41
1974	4.85	3.92	93
1973	1.53	2.90	78
1972	5.11	4.35	63
1971	3.34	4.30	43
1970	1.64	2.48	31
1969		3.20	40
r^2	.39	.30	
slope	8.56	9.97	
int.	31.04	22.30	
t	1.78	1.60	
DF.	5	6	
	Predicted numbers at age 3		Ave.
1979	42		42
1978	108	85	96
1977	42	51	46

Table 18. YIELD PER RECRUIT ANALYSIS
- cod, Subdivision 3Ps.

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.1000	0.231	0.614	2.660	1.000
F0.1---	0.1791	0.331	0.766	2.312	0.696
	0.2000	0.351	0.785	2.234	0.640
	0.3000	0.426	0.823	1.933	0.447
FMAX---	0.3250	0.440	0.824	1.872	0.413
	0.4000	0.476	0.817	1.716	0.333
	0.5000	0.514	0.799	1.554	0.260
	0.6000	0.543	0.777	1.432	0.211
	0.7000	0.566	0.756	1.335	0.176
	0.8000	0.586	0.737	1.258	0.150
	0.9000	0.602	0.719	1.195	0.130
	1.0000	0.616	0.704	1.142	0.115
	1.1000	0.628	0.690	1.098	0.102
	1.2000	0.639	0.677	1.060	0.092
	1.3000	0.649	0.666	1.027	0.083
	1.4000	0.657	0.656	0.998	0.076
	1.5000	0.665	0.647	0.973	0.070
	1.6000	0.672	0.639	0.950	0.065
	1.7000	0.679	0.631	0.930	0.060
	1.8000	0.685	0.624	0.911	0.056
	1.9000	0.691	0.618	0.895	0.053
	2.0000	0.696	0.612	0.880	0.050

Age	Ave. wts. (Kg)	Partial selection
3	.36	.04
4	.71	.38
5	1.15	.77
6	1.66	.85
7	2.48	1
8	3.16	1
9	3.47	1
10	5.09	1
11	5.54	1
12	5.66	1
13	5.74	1
14	6.09	1
15	6.17	1
16	6.00	1
17	6.22	1
18	6.67	1
19	7.00	1
20	7.00	1

(Ave. wts. from 1946-54)

Table 19. Population numbers and average population biomass from a projection of 3Ps cod at F_t = 0.20.

POPULATION NUMBERS (X 10^{-3})

	1980	1981	1982	1983
3	22079	100000	50000	50000
4	15640	17808	81019	40529
5	25403	11323	13378	61110
6	38319	16214	7789	9278
7	18583	23878	10968	5316
8	6015	11271	15850	7352
9	1478	3648	7482	10624
10	441	896	2422	5015
11	229	268	595	1623
12	178	139	178	399
13	80	108	92	119
14	106	48	72	62
3+	128551	185601	189842	191427
4+	106472	85601	139842	141427
5+	90832	67793	58824	100898
6+	65429	56470	45446	39788

POPULATION BIOMASS (AVERAGE - MT)

	1980	1981	1982	1983
3	10330.76	46891.86	23451.47	23451.47
4	9623.13	11150.89	50830.02	25427.47
5	23126.29	10673.91	12659.40	57827.99
6	50681.89	22277.60	10746.50	12800.67
7	36266.87	48583.84	22417.90	10865.65
8	17040.43	33290.59	47027.56	21813.63
9	6280.51	16163.38	33298.34	47285.27
10	2412.34	5111.26	13871.81	28727.37
11	1313.97	1600.40	3575.04	9753.45
12	1210.35	984.97	1264.81	2840.20
13	586.81	826.57	709.25	915.53
14	799.25	380.58	565.95	488.17
3+	159672.60	197935.85	220418.05	242196.87
4+	149341.84	151043.99	196966.58	218745.39
5+	139718.72	139893.10	146136.55	193317.92
6+	116592.42	129219.19	133477.15	135489.93

Table 20. Catch numbers and biomass from a projection of 3Ps cod at $F_t = 0.20$.

CATCH NUMBERS (X 10^{-3})

	1980	1981	1982	1983
3	298	946	451	451
4	1644	1332	5789	2896
5	5096	1645	1860	8495
6	8335	2562	1178	1403
7	4387	4110	1808	876
8	1420	1940	2613	1212
9	349	628	1233	1751
10	104	154	399	827
11	54	46	98	268
12	42	24	29	66
13	19	19	15	20
14	25	8	12	10
3+	21773	13415	15485	18275
4+	21475	12469	15034	17824
5+	19831	11137	9245	14928
6+	14735	9492	7386	6433

CATCH BIOMASS (MT)

	1980	1981	1982	1983
3	155	492	235	235
4	1184	959	4168	2085
5	5758	1859	2101	9599
6	13836	4253	1956	2330
7	10880	10193	4484	2173
8	5112	6985	9406	4363
9	1885	3391	6660	9457
10	723	1072	2774	5745
11	394	336	715	1951
12	363	207	253	568
13	177	173	142	183
14	240	80	113	98
3+	40706	30000	33006	38787
4+	40551	29508	32772	38552
5+	39367	28549	28603	36467
6+	33609	26690	26502	26868

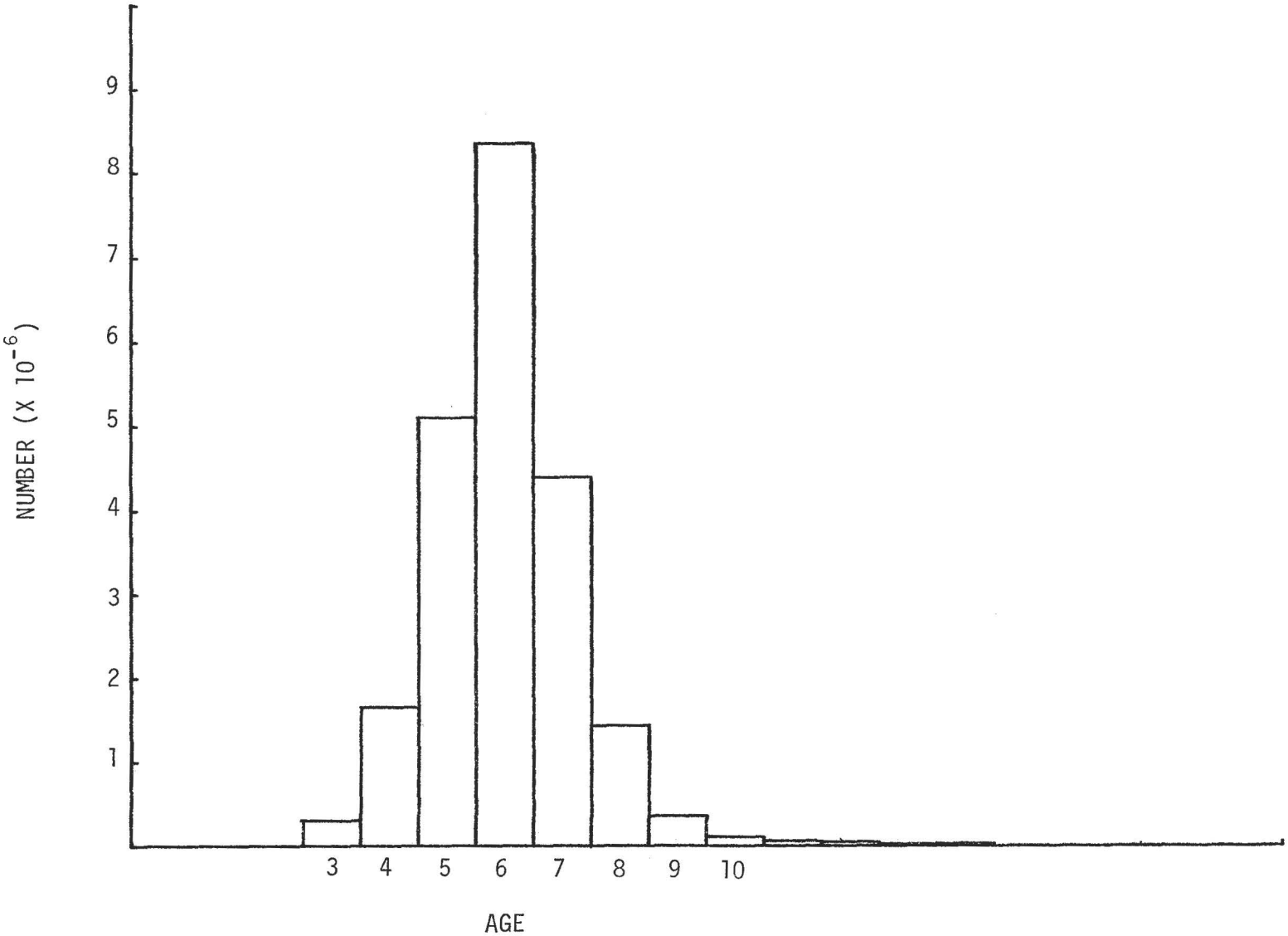

Fig. 1. Per mille age composition from the commercial cod fishery in 3Ps in 1980.

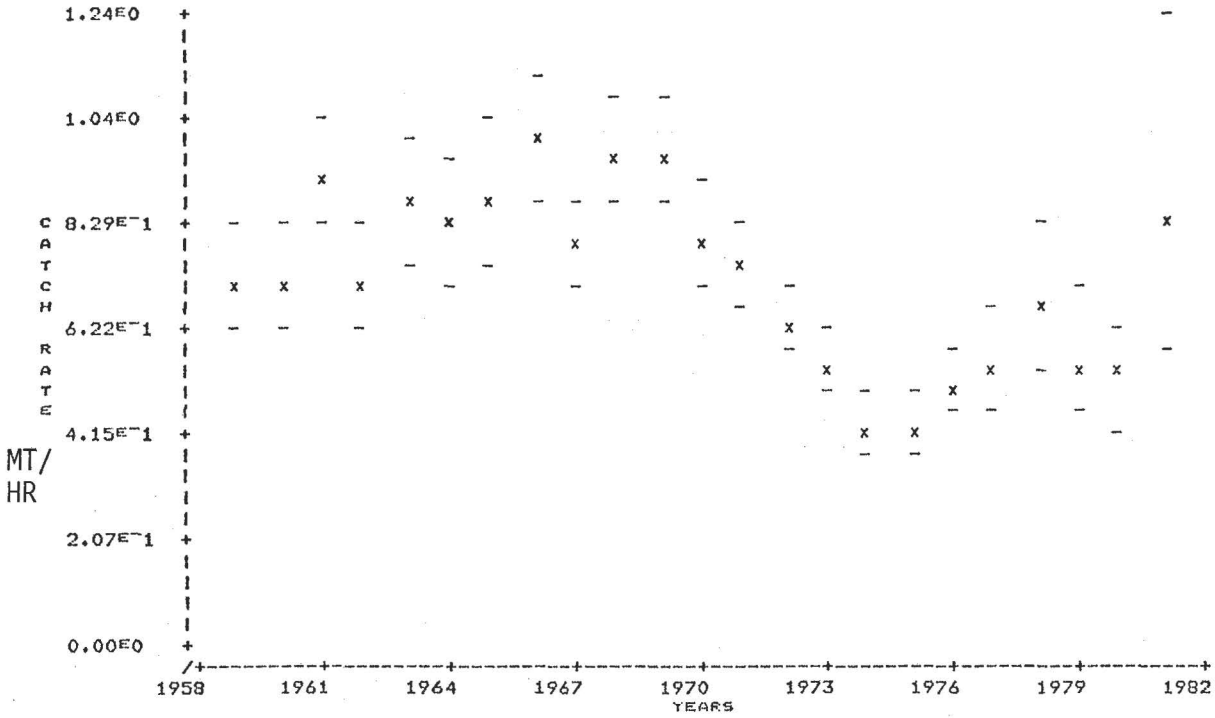

Fig.2.Historical catch rates for cod in Subdivision 3Ps.

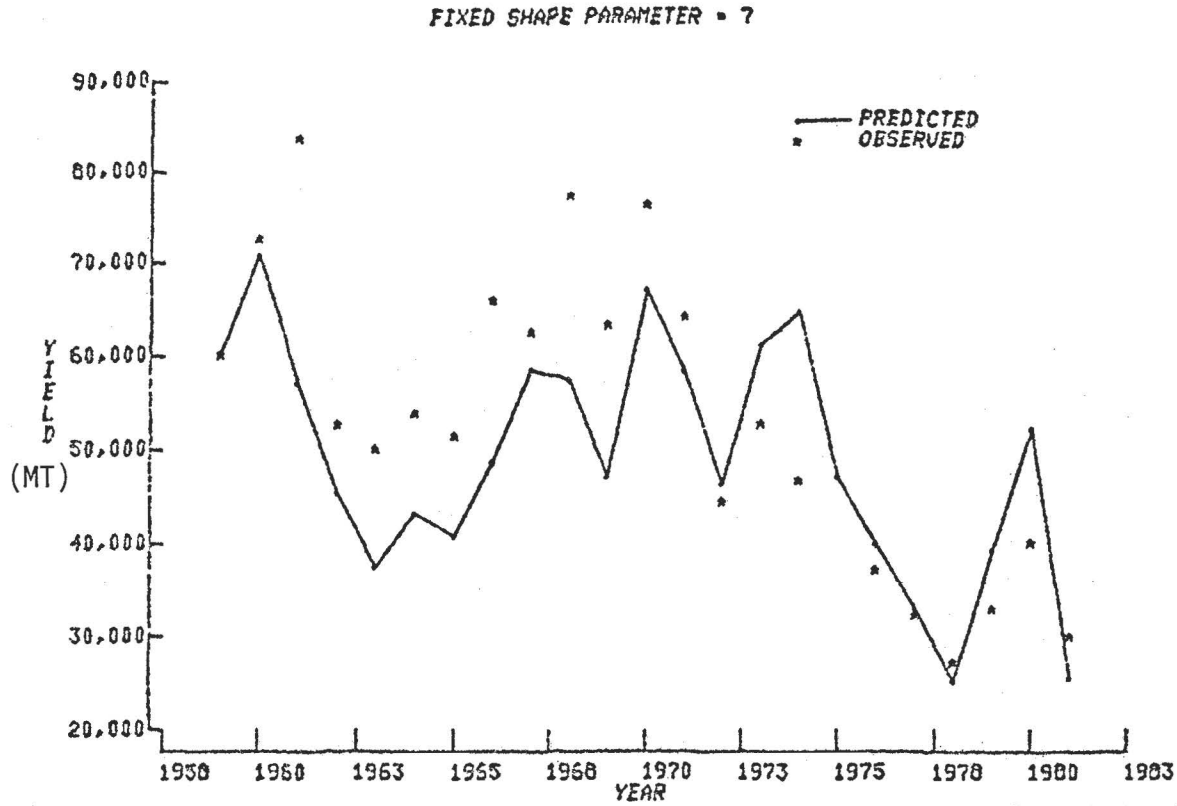

Fig. 3. Plot of predicted and observed yield shows that there is substantial serial correlation - cod, Subdivision 3Ps.

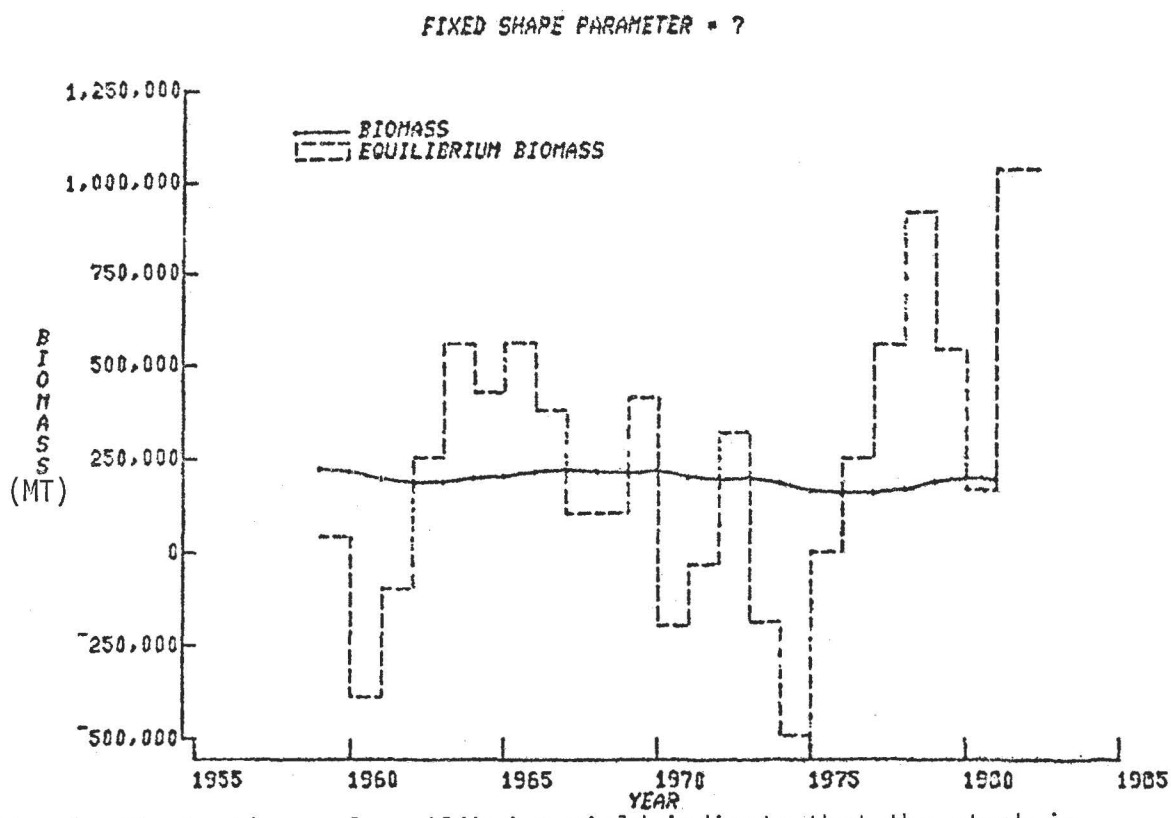

Fig. 4. Fluctuations of equilibrium yield indicate that the stock is sensitive to variations in effort - cod, Subdivision 3Ps.

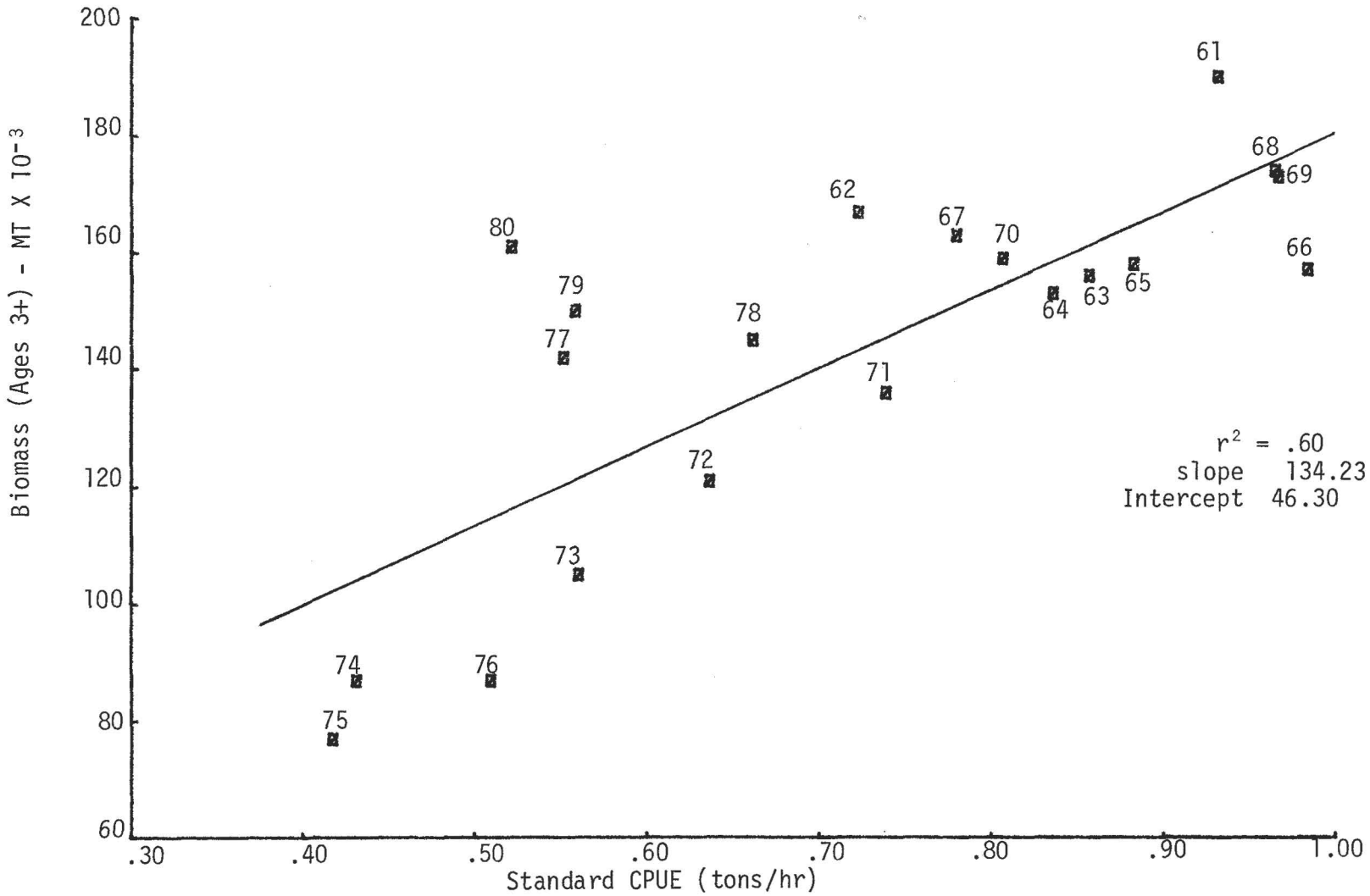

Fig. 5. Relationship of cohort biomass with standard CPUE from a cohort run at F_t = 0.30 for the period 1961-80 - cod, Subdivision 3Ps.