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Status of the Cod Stock in Subdivision 3Ps

by

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ABSTRACT

Cod catches from Subdivision 3Ps have increased since the low of 26,000 t in 1978 and have constantly been above the recommended TAC. The catch in 1981 which was mainly by inshore gears was dominated by the 1974 and 1975 year-classes. Using catch rate data and cohort analyses, the terminal fishing mortality in 1981 was estimated at 0.40. A non-equilibrium surplus production analysis suggested past overexploitation as well as a recent trend in stock improvement. The predicted non-equilibrium yield in 1982 at 2/3 effort MSY was 35,000 t.

RESUME

Les prises de morue de la sous-division 3Ps, qui avaient atteint un creux de 26 000 t en 1978, ont augmenté depuis et ont toujours dépassé les TPA recommandés. Les prises de 1981, provenant en grande partie des engins côtiers, ont été dominées par les classes d'âge de 1974 et 1975. Des données sur les taux de capture ainsi que des analyses de cohortes ont donné une mortalité par pêche de dernière année de 0,40 en 1981. Une analyse de production excédentaire en non-équilibre laisse supposer qu'il y eut surexploitation dans le passé, mais aussi que la tendance récente est vers une amélioration du stock. Le rendement en non-équilibre prédit pour 1982 aux 2/3 de l'effort de RMS est de 35 000 t.

Nominal catch and catch-at-age

Cod catches from Subdivision 3Ps since 1974 along with corresponding TAC's are as follows:

	1974	1975	1976	1977	1978	1979	1980	1981	1982
TAC ('000 t)	70	62.4	47.5	32.5	25	25	28	30	33
Catch ('000 t)	47	35	37	32	27	33	38	38[a]	

[a]Preliminary

Landings in 1981 by Canada, by month and gear are shown in Table 1. As in 1980, the inshore gears obtained the majority of the catch (91%) with line trawl (LT) and gillnet (GN) being the most important. Total cod landings for the period 1959-80 are shown in Fig. 1a while a further breakdown of the Can(N) inshore catch by gear for the period 1964-80 is shown in Fig. 1b. The major change in terms of inshore catches (Fig. 1b) has been the decline in the trap catch and the increase in the line trawl catch in recent years. Catch-at-age data for the commercial fishery in 1981 were obtained using sampling data as shown in Table 2. Catch information was not available for France and the total catch was assumed to be equal to the allocation of 4700 t.

Age frequencies for the major gear groupings are shown in Table 3 while the estimated catch-at-age with its variance is indicated in Table 4. Average weights-at-age (Table 4) were derived by applying a length-weight relationship (weight = log length X 3.0879 - 5.2106) to the length frequencies and age length keys. The calculated total catch weight was found to be within 1% of the reported catch weight. As can be seen from Fig. 2, the 1974 and 1975 year-classes predominated in the age composition.

Survey data

The results of stratified random research surveys in terms of mean number per tow for the years 1972-81 are shown in Table 5. Strata were once again combined on the basis of depth zone (50-200 fath) with the exclusion of strata on Burgeo Bank (strata 306-309). The latter were excluded as they were found to cause an unrealistic increase in abundance from 1980 to 1981. It was suspected that the increase in abundance may have been due to an abnormal influx to the area of cod from the 3Pn4RS stock. This phenomenon has been known to occur in the past and, as such, it was felt that the exclusion of strata from this area might give more reliable estimates for St. Pierre Bank. Survey data are not available for 1982.

Catch-effort data

Catch rate and effort data were once again updated using data from the Can(N) and Can(M) offshore fisheries. Data for the period 1959-79 were obtained from ICNAF/NAFO Statistical Bulletins while that for Can(N) for 1980-82 and Can(M) in 1981 were provided by the Economics and Statistics Branch of the Department of Fisheries and Oceans. Data were considered finalized only to 1979.

Since 1979 the cod fishery in Subdivision 3Ps has been conducted mainly by Canada and, to a lesser extent, France. In addition to TAC's, there have also been catch restrictions for the offshore otter trawl component which provides catch/effort information. To minimize the influence of management policy changes, the catch effort data were divided into two groups, 1959-77 and 1977-82. Standardized catch rate and effort values were derived for each group using a multiplicative model with a weighting factor of (catch X effort)$^{0.25}$. Analyses for both groups (Tables 6 and 7) indicate a strong seasonality with highest catch rates in January and February.

Table 8 and Fig. 3 show annual catch rate indices from the combined groups relative to 1959, which indicate an increasing trend since 1975. Once again it can be seen that the amount of data available for catch rate analysis remains small.

Surplus production

The catch and effort series from 1959 to 1982 (Table 8) were used in a non-equilibrium surplus production analysis (Fletcher 1978). First attempts were made with q, the coefficient of catchability, fixed at 0.00001, the inverse of the slope from the regression of exploitable biomass on catch rate index and the shape parameter fixed at 2.0, the symmetric Schaeffer model. With the final estimates of maximum sustainable yield, MSY, and unfished exploitable biomass, B_∞ from this run, the model was applied again allowing q and the shape parameters to be estimated. The final parameter estimates and the management implications are summarized in Table 9. The projected non-equilibrium yield at 2/3 $effort_{MSY}$ in 1983 was estimated at 35,216 t.

To evaluate the validity of the model, the predicted and observed yield are plotted in Fig. 5. There is substantial serial correlation but the model tracks the observed values. The predicted biomass and biomass adjustment levels (Fig. 4) can be used to compare with biomass estimates from the cohort analysis. Equilibrium curves (Fig. 6 and 7) illustrate the relationships between the management parameters.

Partial selection

Estimates of partial selection were obtained from cohort selectivity coefficients (Table 10) from a preliminary run at $F_t = 0.30$. These coefficients were obtained by dividing fishing mortality by the fully recruited fishing mortality for ages 7 to 11. The average of the coefficients for 1978 and 1979 (Table 10) were used as input partial selection values for the 1981 catch-at-age in cohort analyses.

Cohort analysis

Catch-at-age and weight-at-age data for the period 1959-81 are shown in Table 11. These, along with partial recruitment estimates for 1981 (Table 10), were used to compute a series of cohort runs with terminal F's ranging from .30 to 0.50. The fishing mortality used for age 14 (F_t) was that estimated as the fully recruited fishing mortality for ages 7-11 as obtained from a cohort

run at F_t = 0.40. The results of regression analyses of exploitable population biomasses with standard catch per unit effort from cohorts with F_t ranging from .35 to .50 are shown in Table 12. The best relationship in terms of r^2 was at F_t = 0.50 (although the differences were not significant between 0.40 and 0.50) while that for a prediction of 1981 biomass was between .40 and .45. Tables 13-15 present some of the results of a cohort analysis at F_t = 0.40. Figure 8 indicates the results of the relationship between exploitable biomass and CPUE indices at F_t = 0.40.

Recruitment

Mean catch per tow at age data for age 2 and 3 from the surveys (Table 16) was compared with the corresponding year-class strength (population at age 3) as estimated from the cohort (F_t = 0.40). From regression equations the strengths of the 1977-79 year-classes were estimated as shown in Table 16.

REFERENCES

Fletcher, R. I. 1978. Time dependent solutions and efficient parameters for stock-production models. Fish. Bull. 76: 377-388.

Table 1. Cod landings in 1981 (t) from Subdivision 3Ps by month and gear.

Month	Can(N) OT	Trap	GN	LT	HL	DS	PT	Total
January	1,329	1	65	1,323	6			2,724
February	580		62	1,451	7	1		2,101
March	309		128	1,402	6	3	1	1,849
April	87	2	370	618	26	3	3	1,109
May	28	111	1,420	1,391	159		10	3,119
June	8	729	1,424	2,344	304		2	4,811
July	6	101	826	2,897	305	2	2	4,139
August	22	1	332	3,017	211	3	1	3,587
September	76		188	1,625	57			1,946
October	24		104	1,460	32	4		1,624
November	46		37	820	22	1		926
December	139		40	644	7			830
Total	2,654	945	4,996	18,992	1,142	17	19	28,765

Month	CanM OT	LL	Total
January	683		683
February	2		2
March	1	1	2
April	7	14	21
May	13	1	14
June	5	102	107
July	2	230	232
August		313	313
September	39	126	165
October	8	427	435
November	1	188	189
December		157	157
Total	761	1559	2320

France - No catch information available.
Allocation of 4700 (t) assumed to be total catch.

Table 2. Commercial sampling for 3Ps cod in 1981.

Gear	Qtr.	Country	Otoliths	Month	Length measurements
OT	1	Can(N)	293	January	1104
		Fra(STPM)	-	February	448
	4	Can(N)	89	November	178
LT	1	Can(N)	509	January	1192
		Can(N)		February	3017
	2	Can(N)	698[a]	March	1219
		Can(N)		May	3546
	3	Can(N)	583[a]	June	166
		Can(N)		July	2200
		Can(N)		August	2372
		Can(M)	63	July	240
	4	Can(N)	665[a]	September	4531
				October	1287
TRAP	2	Can(N)	698	May	463
	3	Can(N)	583	June	969
		Can(N)		July	407
GN	2	Can(N)	698	April	231
		Can(N)		May	4055
	3	Can(N)	583	June	687
				July	567
HL	3	Can(N)	583	July	136
				August	1437

[a]Totals represent combined (LT, GN, TRAP, HL) quarterly A/L keys from 3Ps.

Table 3. Age composition of the commercial catch for cod in Subdivision 3Ps in 1981 grouped by gear and quarter.

GEAR/QTR.	OT/1	OT/4	IN/1	IN/2	IN/3	IN/4
AGE						
3	0	5	5	32	597	229
4	1	11	67	219	1777	323
5	30	15	198	246	1667	319
6	237	21	592	452	1741	549
7	239	30	551	1062	1780	767
8	138	10	55	359	553	210
9	22	6	15	202	194	49
10	5	2	5	38	108	17
11	1	3	3	9	55	6
12	1	3	2	8	13	3
13	0	0	2	7	10	2
14	0	0	1	1	3	1
NO. LENGTHS	1104	178	4209	9514	8941	5818
NO. OTOLITHS	293	89	509	698	583	665
CATCH WEIGHT	2364	326	2774	5570	14741	4549

OT = Other Trawl
IN = Inshore

Table 4. Estimates of catch and weight-at-age of Subdivision 3Ps cod from the commercial fishery in 1981.

AGE	WEIGHT(kg)	CATCH (Nos. x 10^{-3})	VAR(CATCH)	STD.ERROR	COEF.VAR
2	0.248	1	0.635	0.80	1.02
3	0.478	1000	5813.877	76.25	0.08
4	0.787	2765	23451.869	153.14	0.06
5	1.322	2864	43579.471	208.76	0.07
6	1.803	4220	54861.743	234.23	0.06
7	2.298	5187	47948.618	218.97	0.04
8	3.266	1573	14668.426	121.11	0.08
9	4.359	571	3606.430	60.05	0.11
10	5.676	204	1131.038	33.63	0.17
11	7.410	89	262.040	16.19	0.18
12	9.037	37	48.418	6.96	0.19
13	8.392	24	51.507	7.18	0.30
14	9.558	6	7.970	2.82	0.48
15	11.528	5	3.095	1.76	0.34
16					
17	17.191	5	5.508	2.35	0.49
18	11.624	1	0.494	0.70	0.79
19					
20					
21					
22					
23	13.095	1	0.759	0.87	1.12

Table 5. Mean number of cod per tow from research trips in Subdivision 3Ps (stratification by depth zone - 50 to 200 fath and excluding strata on Burgeo Bank - 306 to 309).

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.07	.15	1.33	1.06	0.31	.03	0.0	3.60	.23	.08
2	1.83	3.96	6.45	1.72	5.35	.26	1.06	1.89	9.57	1.50
3	3.35	2.39	4.70	5.18	3.30	4.57	.88	1.40	3.22	5.94
4	4.86	3.13	2.04	4.93	4.97	4.26	3.46	6.15	1.09	5.35
5	2.41	1.54	2.36	2.42	2.07	3.82	1.51	13.84	3.06	5.79
6	1.38	.21	2.79	2.07	.79	.93	.76	1.98	2.51	4.63
7	1.97	.28	.93	1.70	.50	.24	.44	.72	.57	3.11
8	1.37	.08	.73	.53	.50	.25	.35	.49	.62	.46
9	.67	.10	.63	.40	.12	.40	.20	.26	.21	.58
10	.47	.06	.26	.21	.07	.16	.21	.20	.17	.15
11	.21	.02	.12	.06	.05	.01	.07	.07	.12	.06
12	.12	.02	.07	.02	.05	.06	.02	.05	.14	.08
13	.07	.02	.06	.06		.05	.02	.02	.05	.07
14	.15		.06			.02	.00	.04	.00	.06
15	.07			.02	.05	.03	.02		.03	
16	.17	.02	.01						.02	
17	.17	.04	.01	.04					.02	
18	.08	.06	.01							
19	.02				.03					
20	.02			.01		.03				
>20	.01	.03	.01				.04			
Total	19.48	12.11	22.57	20.43	18.18	15.11	9.04	30.70	21.63	27.85

Table 6. Regression coefficients for grouped categories and the analysis of variance from the regression of ln catch rate for cod in NAFO Subdivision 3Ps from 1959-77.

Country-gear	ln power	Month	ln power
Can(N) OT-4	-0.131		
Can(N) OT-5			
		June	-0.584
Can (M) OT-4	0.000	July	
Can (M) OT-5	0.224	August	-0.551
Span OT-6	0.409	May	
		September	-0.481
Port OT-6		October	
Span PT-4	0.787		
Span PT-6		November	-0.334
Span PT-5	1.133	December	-0.247
		April	-0.149
		March	-0.090
		January	0.000
		February	

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.715
MULTIPLE R SQUARED.....0.511

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.468E1	1.468E1	
REGRESSION	30	1.682E2	5.607E0	25.672
TYPE 1	5	9.650E1	1.930E1	88.378
TYPE 2	7	5.331E1	7.616E0	34.873
TYPE 3	18	4.618E1	2.566E0	11.748
RESIDUALS	736	1.607E2	2.184E-1	
TOTAL	767	3.436E2		

Table 7. Regression coefficients for grouped categories and the analysis of variance from the regression of ln catch rate for cod in NAFO Subdivision 3Ps from 1977-82.

Country-gear	ln power	Month	ln power
Can (N) OT-4	-0.359	April	-1.279
Can (M) OT-4	0.000	May	-0.874
Can (N) OT-5	0.052		
Can (M) OT-5	0.460		
		October November	-0.740
		August September December	-0.633
		March June July	-0.581
		February	-0.385
		January	0.000

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.636
MULTIPLE R SQUARED.....0.405

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.115E2	1.115E2	
REGRESSION	14	3.235E1	2.311E0	7.245
TYPE 1	3	1.414E1	4.715E0	14.783
TYPE 2	6	1.396E1	2.327E0	7.297
TYPE 3	5	9.200E0	1.840E0	5.769
RESIDUALS	149	4.752E1	3.189E-1	
TOTAL	164	1.914E2		

Table 8. Mean catch rate indices of cod in NAFO Subdivision 3Ps 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 is also indicated.

YEAR	TOTAL CATCH	PROP.	RELATIVE POWER MEAN	S.E.	EFFORT
1959	60170	0.213	1.000	0.000	60170
1960	72536	0.258	0.979	0.114	74203
1961	83620	0.364	1.307	0.140	63960
1962	52639	0.248	1.026	0.123	51316
1963	50051	0.232	1.225	0.149	40853
1964	53956	0.313	1.194	0.145	45172
1965	51400	0.299	1.274	0.156	40353
1966	65749	0.438	1.407	0.161	46727
1967	62393	0.322	1.140	0.132	54717
1968	77217	0.424	1.371	0.153	56335
1969	63103	0.504	1.375	0.155	45885
1970	76161	0.531	1.142	0.123	66680
1971	63967	0.425	1.051	0.115	60861
1972	44323	0.475	0.904	0.099	49026
1973	52641	0.411	0.807	0.088	65201
1974	46712	0.395	0.600	0.066	77808
1975	35373	0.375	0.587	0.073	60308
1976	37133	0.284	0.722	0.090	51419
1977	32245	0.091	0.783	0.110	41169
1978	27221	0.068	0.871	0.139	31235
1979	33006	0.064	0.880	0.126	37503
1980	40069	0.066	0.827	0.108	48484
1981	35785	0.044	0.949	0.168	37708
1982	33000	0.010	1.037	0.284	31832

AVERAGE C.V. FOR THE MEAN: 0.124

Table 9. Management implications for cod in Subdivision 3Ps from a non-equilibrium surplus production analysis.

Unfished exploitable biomass	545762	
Catchability coefficient	.000005	
Shape parameter	1.9	
	MSY	2/3 Effort MSY
Effort	40339	26893
Catch rate index	1.432	1.917
Yield	57769	51547
Biomass 1983 (beginning)	233311	
Non-equilibrium yield (1983)	35216	

Table 10. Selectivity coefficients from a cohort analysis on 3Ps cod at F_t=0.30.

1974	1975	1976	1977	1978	1979	1980	1981	Average 1978-79
0.06	0.03	0.15	0.03	0.01	0.02	0.02	0.02	.01
0.35	0.22	0.70	0.63	0.15	0.18	0.22	0.31	.17
0.81	0.40	1.11	1.13	0.43	0.54	0.49	0.78	.49
0.59	0.67	1.15	1.20	0.79	0.75	0.68	0.91	.77
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 11. Catch and weight-at-age data for 3Ps cod. Weights-at-age prior to 1975 were the same as those presented for 1975 and 1976.

CATCH 3PS (Nos. x 10^{-3})

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

AGE	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
3	1143	774	756	2884	731	945	1887	1840	4110	935
4	12602	7098	8114	6444	4944	4707	6042	7329	12139	9156
5	13135	11585	12916	8574	4591	11386	9987	5397	7923	8326
6	5853	7178	9763	7266	3552	4010	6365	4541	2875	3209
7	3572	4554	6374	8218	4603	4022	2540	5867	1305	920
8	1308	1757	2456	3131	2636	2201	1857	723	495	395
9	549	792	730	1275	833	2019	1149	1196	140	265
10	425	717	214	541	463	515	538	105	53	117
11	222	61	178	85	205	172	249	174	17	57
12	111	120	77	125	117	110	80	52	21	43
13	5	67	121	62	48	14	32	6	4	31
14	107	110	14	57	45	29	17	2	3	11

AGE	1978	1979	1980	1981
3	218	149	298	1000
4	4308	2370	1644	2765
5	5391	9777	5096	2864
6	4203	5235	8335	4220
7	1791	2588	4387	5187
8	730	884	1420	1573
9	243	284	349	571
10	189	82	104	204
11	76	48	54	89
12	26	19	42	37
13	19	11	19	24
14	10	10	25	6

WEIGHT-AT-AGE (Kg)

AGE	1975	1976	1977	1978	1979	1980	1981
3	0.28	0.28	0.55	0.45	0.41	0.52	0.48
4	0.69	0.69	0.68	0.70	0.65	0.72	0.79
5	1.08	1.08	1.30	1.08	1.01	1.13	1.32
6	1.68	1.68	1.86	1.75	1.65	1.66	1.80
7	2.40	2.40	2.67	2.45	2.55	2.48	2.30
8	3.21	3.21	3.42	2.99	3.68	3.60	3.27
9	4.10	4.10	4.19	4.10	4.30	5.40	4.36
10	5.08	5.08	4.94	5.16	6.49	6.95	5.68
11	6.03	6.03	5.92	5.17	7.00	7.29	7.41
12	7.00	7.00	6.76	7.20	8.20	8.64	9.04
13	8.05	8.05	8.78	7.75	9.53	9.33	8.39
14	9.16	9.16	10.90	8.72	10.84	9.58	9.56

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

Year	CPUE	Exploitable biomass ($x10^{-3}$ t) at F_t .35	.40	.45	.50
1961	1.307	138			
1962	1.026	135			
1963	1.225	133			
1964	1.194	123			
1965	1.274	103			
1966	1.407	99			
1967	1.140	120			
1968	1.371	112			
1969	1.375	100			
1970	1.142	109			
1971	1.051	91			
1972	.904	71			
1973	.807	70			
1974	.600	54			
1975	.587	35			
1976	.722	61	60	59	
1977	.783	80	78	77	75
1978	.871	52	50	49	47
1979	.880	75	71	68	65
1980	.827	87	80	74	70
1981	.949	103	90	80	72
1982	1.037				
Predicted 1981 exploitable biomass		86	85	84	83
Int.		1.46	-3.07	-6.60	-9.41
Slope		89.58	92.66	95.06	96.97
'r^2'		.610	.635	.645	.647

Table 13. Population numbers($\times 10^{-3}$) of Subdivision 3Ps cod from a cohort run at F_t=0.40.

POPULATION NUMBERS

AGE	1959	1960	1961	1962	1963	1964	1965	1966
3	59387	59262	50953	48678	42961	70840	80988	84422
4	107059	47716	48007	41310	38728	34304	56274	64214
5	35832	75039	34094	34250	27715	27637	22851	37354
6	24206	22528	39989	18542	19895	16275	17528	13462
7	16270	13245	12369	18299	11079	11516	8638	11085
8	5813	8910	7699	6855	9811	6785	6764	4123
9	4041	3907	4142	2068	4375	5291	3853	3678
10	3439	2176	2276	1718	978	2770	2620	2052
11	3661	1675	1033	618	890	536	1678	1211
12	1181	2426	1004	442	337	599	132	1078
13	158	474	1618	582	235	186	193	47
14	0	90	132	818	355	96	104	48
3+	261047	237447	203315	174181	157360	176834	201624	222779
4+	201660	178185	152362	125503	114398	105994	120636	138357
5+	94600	130469	104355	84194	75670	71690	64362	74143
6+	58769	55429	70261	49943	47956	44053	41510	36789
7+	34563	32902	30273	31401	28060	27779	23982	23327

AGE	1967	1968	1969	1970	1971	1972	1973	1974
3	98486	70191	54370	35514	60321	39467	31318	42595
4	68260	78036	56433	43814	28392	46777	31652	24786
5	40212	46012	52487	39781	28530	17415	33624	21655
6	18761	21250	25787	32491	20883	15600	10104	17391
7	6841	9577	12102	14617	17767	10523	9558	4644
8	4444	3475	4609	5788	6200	7110	4451	4187
9	1945	2404	1662	2183	2516	2243	3436	1652
10	1353	1046	1472	644	1127	907	1083	987
11	740	822	472	556	333	433	323	421
12	523	262	472	331	294	196	169	109
13	530	343	114	278	201	128	55	39
14	9	299	276	33	118	109	61	32
3+	242105	233717	210255	176030	166684	140909	126034	118497
4+	143619	163526	155885	140516	106363	101442	94717	75902
5+	75359	85490	99452	96702	77971	54665	63065	51116
6+	35147	39478	46965	56921	49441	37250	29241	29461
7+	16386	18228	21178	24430	28558	21649	19137	12070

AGE	1975	1976	1977	1978	1979	1980	1981
3	57545	61337	78131	43683	28783	60369	276366
4	33167	45449	46500	63122	35568	23431	49157
5	14826	20523	26226	29786	47782	26976	17696
6	8693	7255	9634	13939	19509	30274	17475
7	8479	3008	3338	4984	7609	11236	17244
8	1504	1633	1282	1901	2460	3888	5230
9	1747	577	889	692	896	1214	1898
10	313	348	346	488	347	476	678
11	321	161	237	177	229	210	296
12	119	105	117	143	76	144	123
13	17	50	67	57	93	45	80
14	3	8	38	27	29	66	20
3+	126733	140457	166806	158999	143381	158330	386263
4+	69189	79119	88675	115316	114598	97960	109896
5+	36022	33671	42175	52194	79030	74529	60740
6+	21196	13148	15948	22408	31248	47554	43044
7+	12503	5893	6315	8469	11739	17280	25348

Table 14 . Mid-year population biomass ($x10^{-3}$ T) of Subdivision 3Ps cod from a cohort run at F_t=0.40.

POPULATION BIOMASS (MID-YEAR)

AGE	1959	1960	1961	1962	1963	1964	1965	1966
3	14935	14962	12870	12184	10772	17718	20238	21295
4	62171	27962	28112	23502	22681	19452	31857	35383
5	30960	60142	27576	28540	23209	23976	19164	29159
6	30539	28466	46611	24347	25747	20254	23624	16431
7	29335	24533	22422	32680	21017	21432	14660	17438
8	15397	19981	13752	17728	23495	16631	16260	9312
9	12353	12374	11295	5968	14398	15582	11720	9532
10	12456	7794	6460	6397	3734	11066	9275	6536
11	18097	7906	4200	2793	4434	1741	8175	4942
12	5421	13964	5419	2297	1778	2511	576	5404
13	972	2152	9442	3696	1251	1134	837	188
14	0	618	812	5660	2516	670	688	288
3+	232637	220855	188970	165791	155032	152168	157074	155909
4+	217702	205893	176101	153608	144260	134450	136837	134614
5+	155531	177931	147989	130106	121579	114998	104980	99230
6+	124571	117789	120412	101565	98371	91022	85815	70071
7+	94032	89323	73801	77219	72623	70767	62192	53640

AGE	1967	1968	1969	1970	1971	1972	1973	1974
3	24602	17657	13693	8910	14913	9916	7819	10552
4	38921	44449	32860	24583	15496	27566	18173	13373
5	32109	37723	45028	31670	23132	14504	26679	15338
6	22946	27299	33056	40980	25395	20721	11800	20842
7	11926	16302	20545	23555	27928	16936	15617	6684
8	10659	7890	10421	12608	12494	16219	9065	8961
9	5941	7790	4401	6550	6465	6532	8049	3301
10	5412	3663	4780	2396	3687	2874	3558	3011
11	2777	3803	2395	2481	1560	1694	1189	1441
12	2987	1246	2564	1825	1398	775	622	346
13	3252	2480	526	1502	1210	729	341	113
14	64	1976	1762	205	698	685	366	181
3+	161595	172279	172030	157264	134376	119151	103278	84143
4+	136993	154622	158337	148355	119462	109235	95459	73592
5+	98072	110173	125478	123772	103966	81669	77286	60219
6+	65964	72450	80450	92102	80834	67165	50607	44881
7+	43018	45151	47393	51122	55439	46444	38807	24039

AGE	1975	1976	1977	1978	1979	1980	1981
3	14352	15001	38698	17769	10666	28377	120000
4	18175	24123	25517	38568	20198	14709	34130
5	11441	15550	25271	26229	38748	24727	19288
6	9000	8477	13123	18299	24740	38431	24662
7	9975	4858	6815	8758	14132	19477	29823
8	3106	3928	3274	3994	6492	9991	12859
9	3557	1852	2803	2050	2856	4970	6224
10	1163	1470	1246	1766	1770	2634	2897
11	1167	831	1101	620	1281	1185	1649
12	559	594	562	837	488	939	836
13	98	352	387	321	754	289	503
14	15	56	311	168	231	452	143
3+	72609	77093	119108	119378	122356	146181	253018
4+	58257	62092	80410	101609	111690	117804	133018
5+	40082	37969	54893	63042	91492	103095	98887
6+	28641	22418	29621	36812	52744	78368	79599
7+	19641	13941	16499	18514	28004	39936	54937

Table 15. Fishing mortalities from a cohort run at F_t=0.40 for Subdivision 3Ps cod.

FISHING MORTALITY

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
3	0.019	0.011	0.010	0.029	0.025	0.030	0.032	0.013	0.033	0.018
4	0.155	0.136	0.138	0.199	0.137	0.206	0.210	0.268	0.194	0.197
5	0.264	0.429	0.409	0.343	0.332	0.255	0.329	0.489	0.438	0.379
6	0.403	0.400	0.582	0.315	0.347	0.433	0.258	0.477	0.472	0.363
7	0.402	0.343	0.390	0.423	0.290	0.332	0.538	0.714	0.477	0.531
8	0.197	0.566	1.114	0.249	0.418	0.366	0.409	0.553	0.414	0.538
9	0.419	0.340	0.680	0.549	0.257	0.503	0.430	0.800	0.420	0.291
10	0.519	0.545	1.103	0.458	0.401	0.301	0.572	0.820	0.299	0.596
11	0.211	0.312	0.648	0.407	0.195	1.199	0.243	0.639	0.838	0.355
12	0.713	0.205	0.345	0.430	0.393	0.933	0.839	0.509	0.224	0.631
13	0.367	1.079	0.482	0.296	0.698	0.387	1.198	1.406	0.372	0.016
14	0.350	0.400	0.654	0.390	0.335	0.369	0.479	0.699	0.430	0.496

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	0.016	0.024	0.054	0.021	0.034	0.050	0.036	0.077	0.013	0.006
4	0.150	0.229	0.289	0.124	0.180	0.314	0.280	0.350	0.245	0.078
5	0.280	0.444	0.404	0.344	0.465	0.713	0.515	0.556	0.432	0.223
6	0.368	0.404	0.485	0.290	0.577	0.518	0.861	0.576	0.459	0.405
7	0.538	0.658	0.716	0.661	0.626	0.927	1.447	0.653	0.363	0.506
8	0.547	0.633	0.817	0.527	0.791	0.674	0.758	0.408	0.416	0.552
9	0.748	0.461	0.821	0.528	1.048	1.463	1.412	0.312	0.399	0.491
10	0.773	0.458	0.756	0.831	0.746	0.923	0.463	0.184	0.468	0.553
11	0.154	0.436	0.331	0.740	0.886	1.062	0.914	0.124	0.308	0.642
12	0.330	0.297	0.634	1.077	1.266	1.663	0.659	0.249	0.523	0.225
13	1.046	0.657	0.416	0.536	0.333	2.358	0.497	0.092	0.712	0.463
14	0.572	0.626	0.748	0.602	0.726	0.858	1.255	0.493	0.386	0.519

AGE	1979	1980	1981
3	0.006	0.005	0.004
4	0.076	0.081	0.064
5	0.256	0.234	0.196
6	0.352	0.363	0.308
7	0.471	0.565	0.400
8	0.506	0.517	0.400
9	0.431	0.382	0.400
10	0.303	0.276	0.400
11	0.264	0.334	0.400
12	0.321	0.390	0.400
13	0.140	0.622	0.400
14	0.470	0.530	0.400

Table 16. Relationship of survey mean numbers per tow at ages 2 and 3 with cohort numbers at age (F_t = 0.40) - cod, Subdivision 3Ps.

Year-class	Age 2	Age 3	Cohort numbers at age 3 ($\times 10^{-3}$)	Predicted cohort age 3 from survey age 2	Predicted cohort age 3 from survey age 3	Average
1979	1.50			34		34
1978	9.57	5.94		197	140	168
1977	1.89	3.22	60	42	64	53
1976	1.06	1.40	29			
1975	.26	.88	44			
1974	5.35	4.57	78			
1973	1.72	3.30	61			
1972	6.45	5.18	58			
1971	3.96	4.70	43			
1970	1.83	2.39	31			
1969		3.35	39			
r^2	.64	.38				
Slope	20.17	27.72				
Int.	3.63	-24.93				

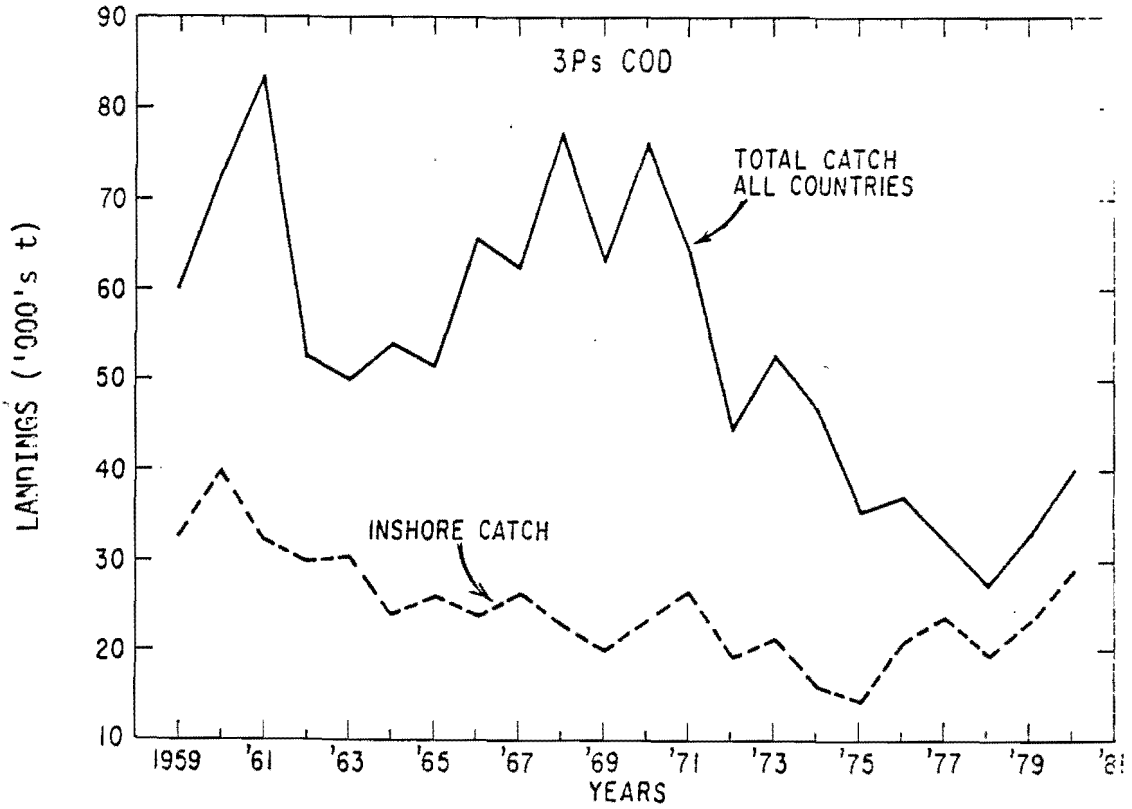

Fig. 1a. Total catch of 3Ps cod by all countries along with the inshore catch for Can(N) for the period 1959-80.

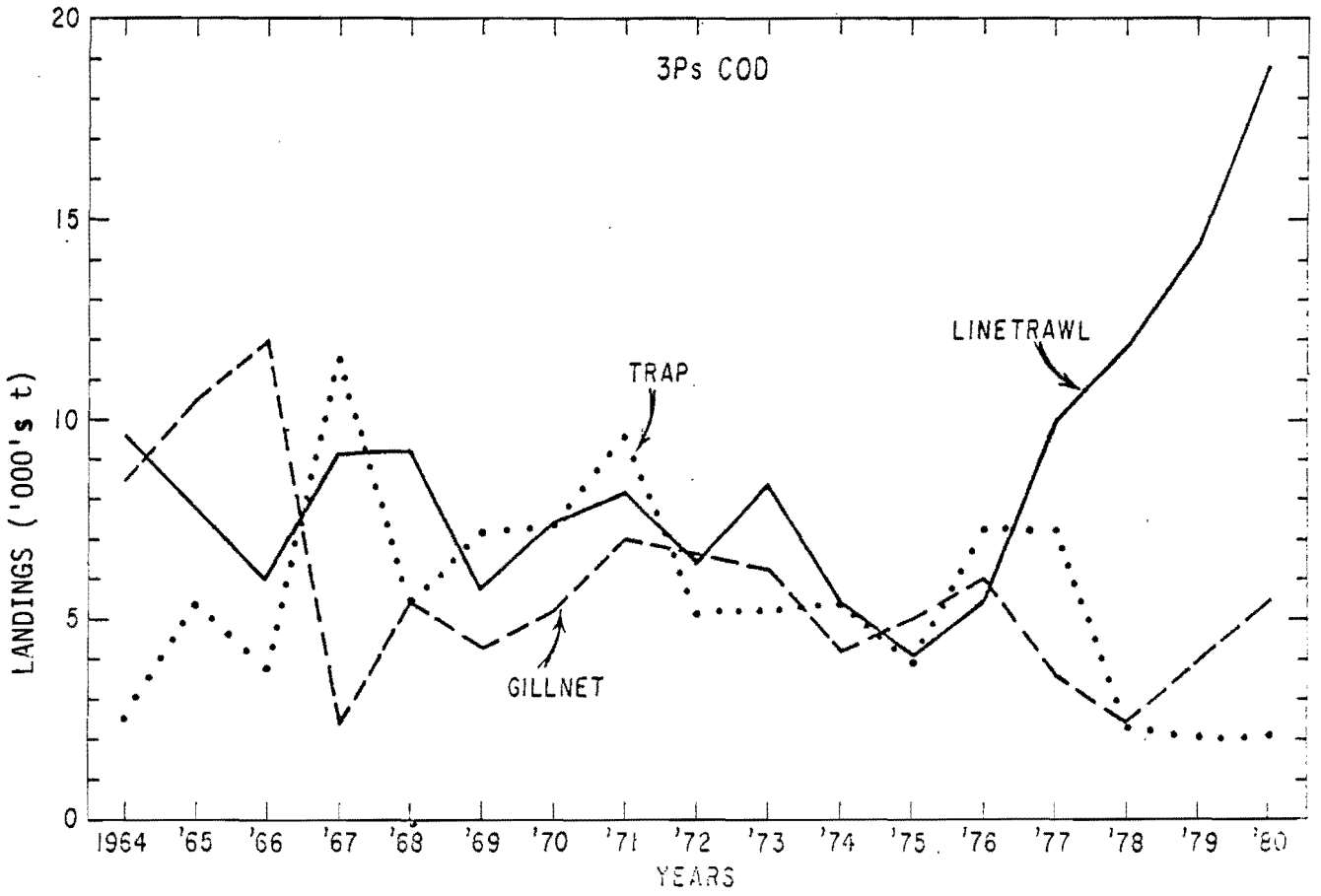

Fig. 1b. Inshore cod catch in 3Ps by Can(N) for the period 1964-80.

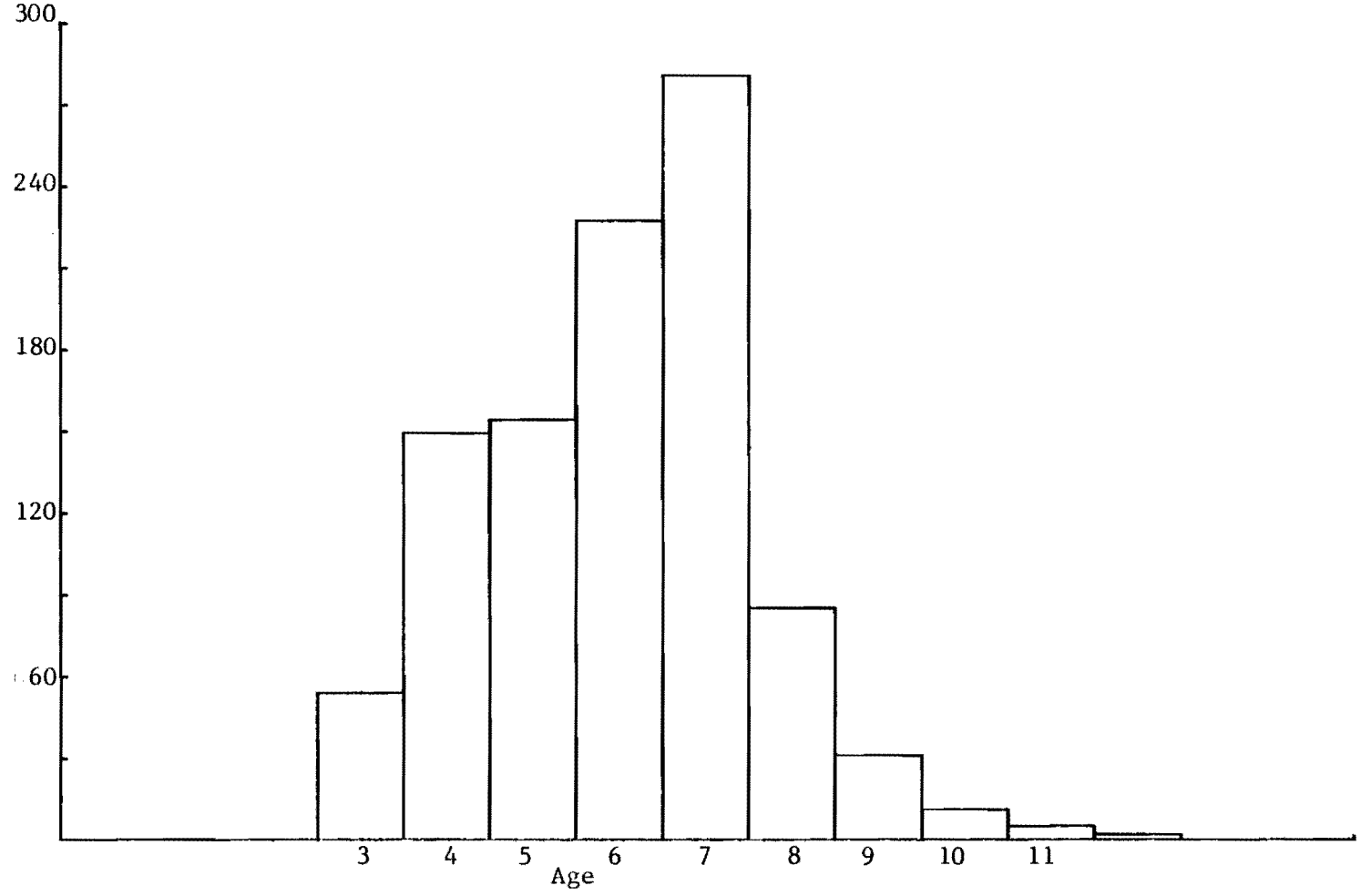

Fig. 2. Per mille age conposition from the commercial cod fishery in Subdivision 3Ps in 1981.

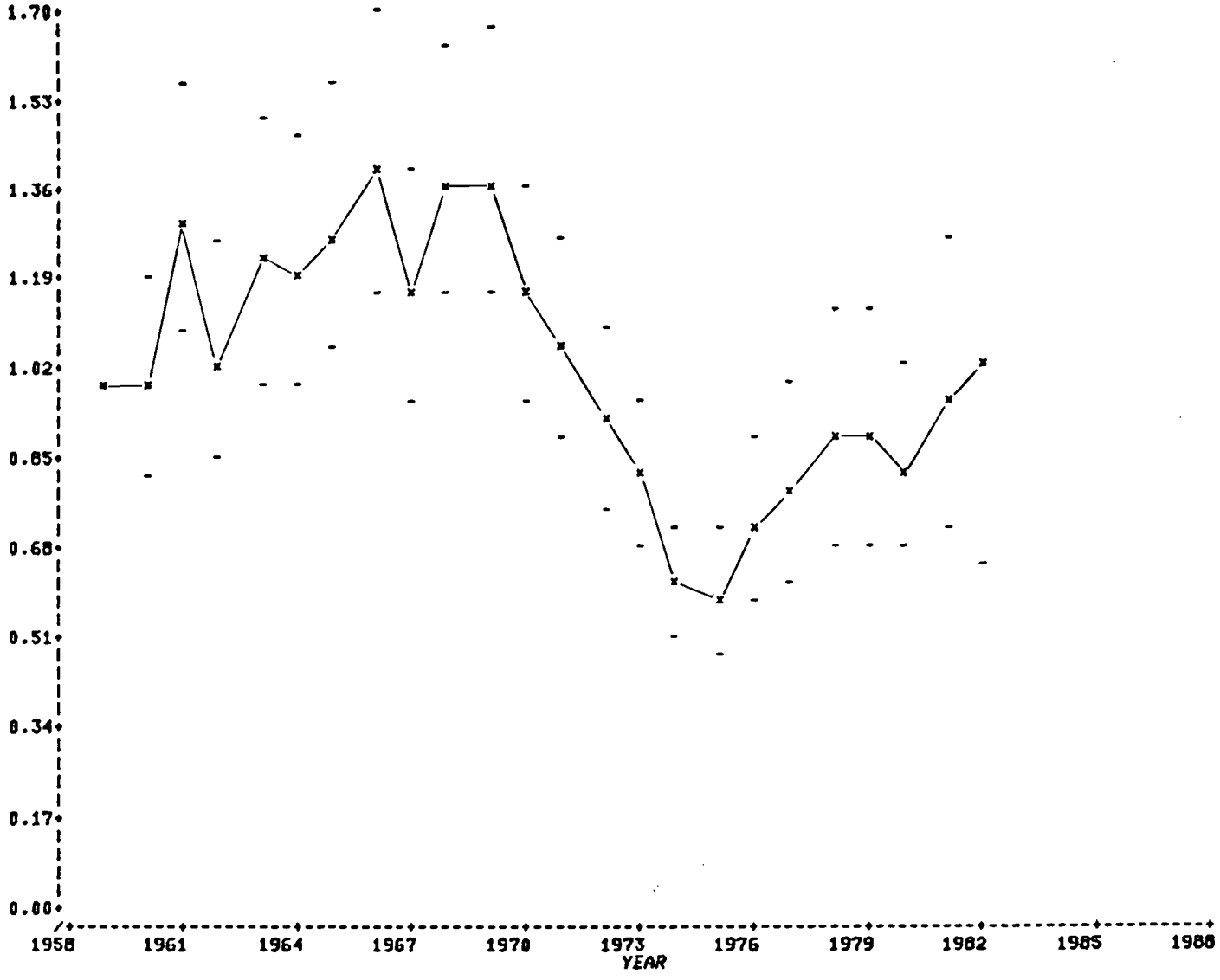

Fig. 3. Historical catch rate indices for cod in Subdivision 3Ps and their respective confidence limits.

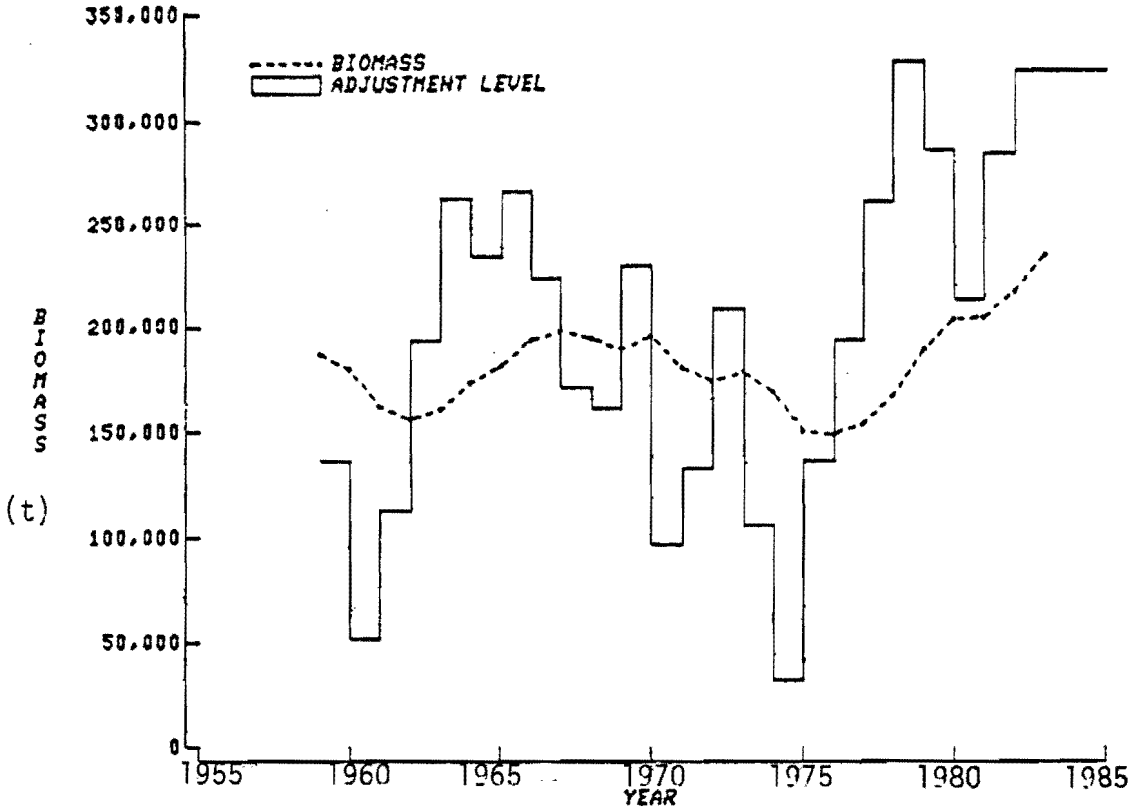

Fig. 4. Biomass at the beginning of each year along with the equilibrium adjusted biomass level for the fishing effort applied during that year for 3Ps cod.

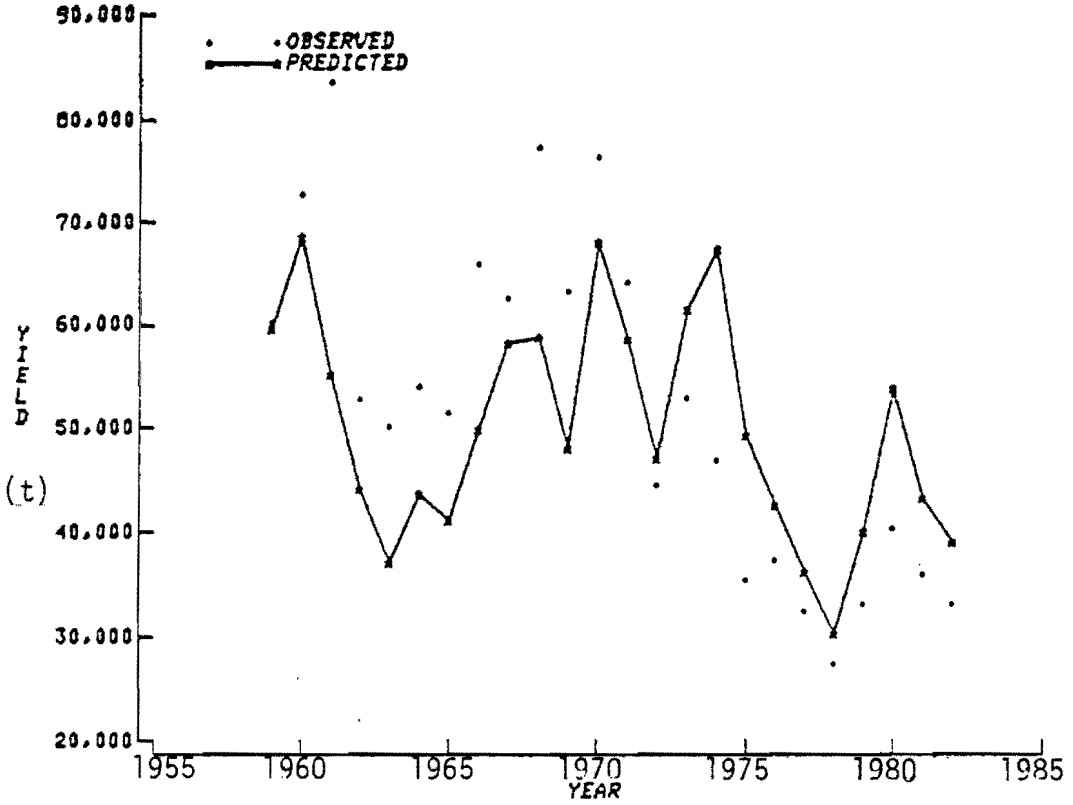

Fig. 5. Observed and predicted yield values by the non-equilibrium model for 3Ps cod.

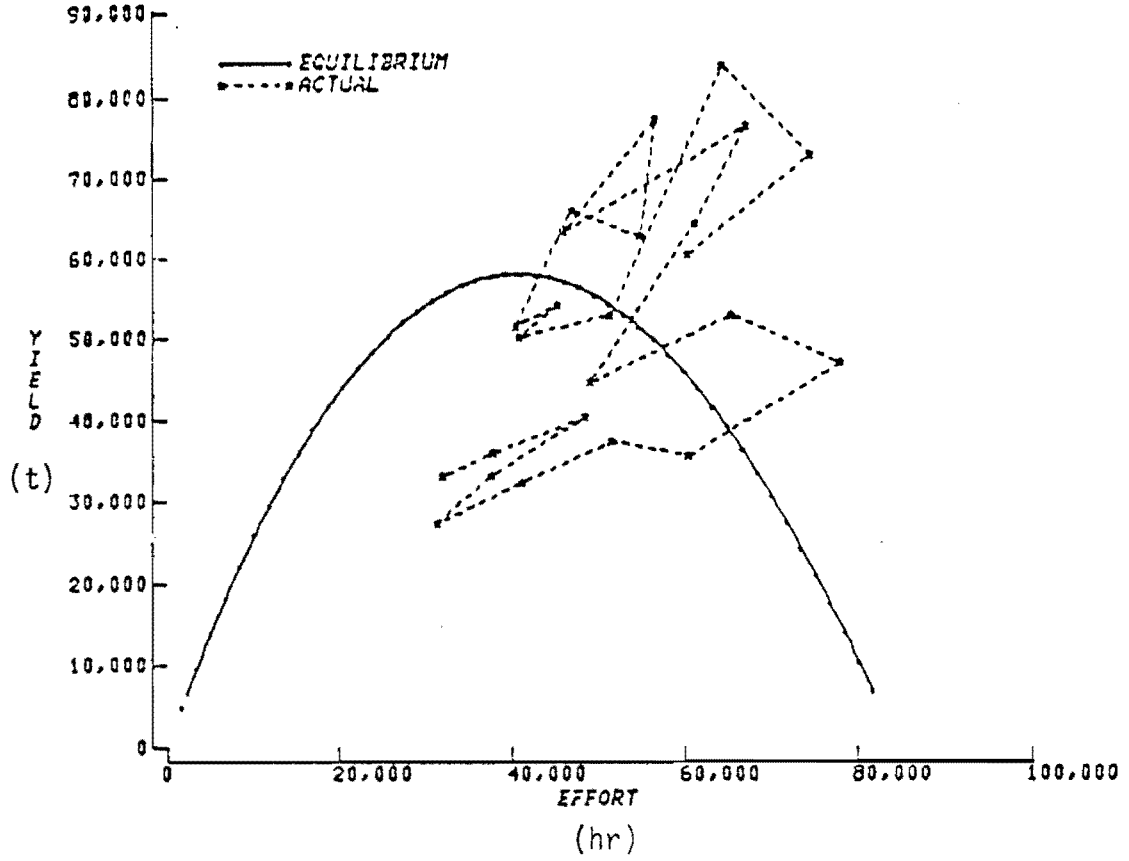

Fig. 6. Equilibrium yield (T) vs. effort (hr) for 3Ps cod.

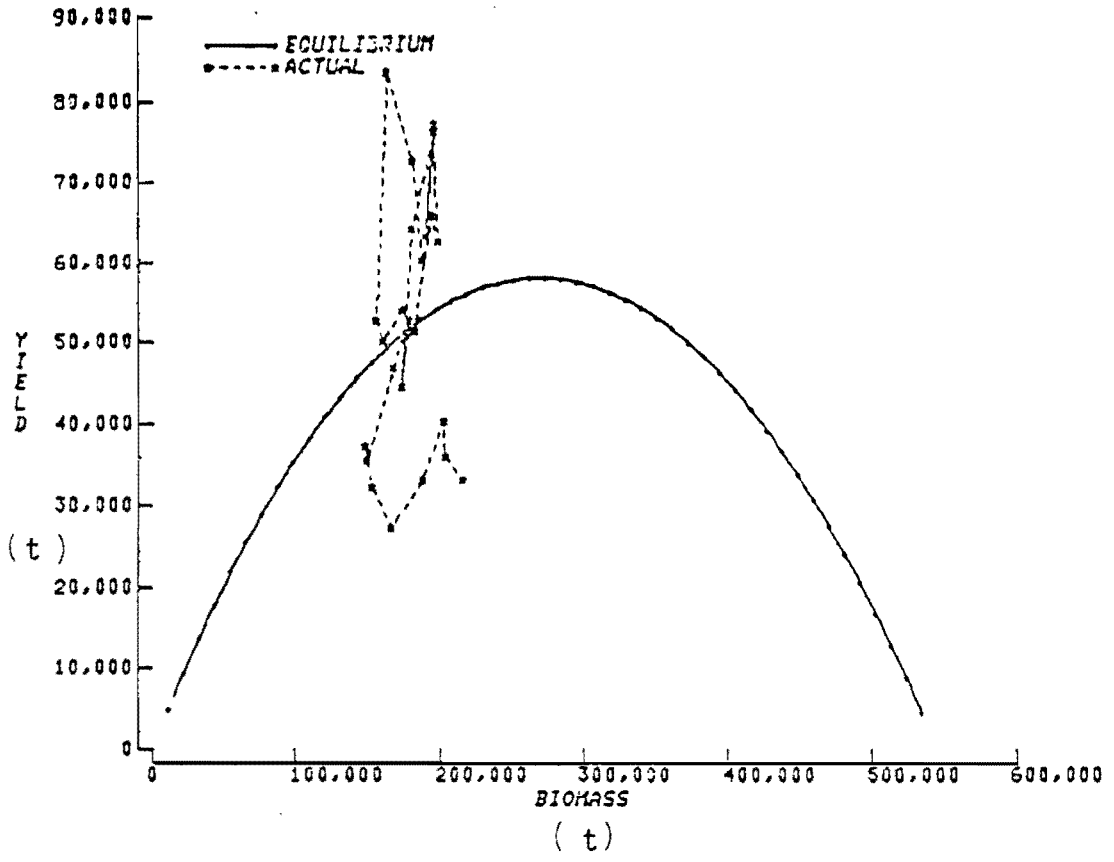

Fig. 7. Equilbrium yield (t) vs. biomass (t) for 3Ps cod.

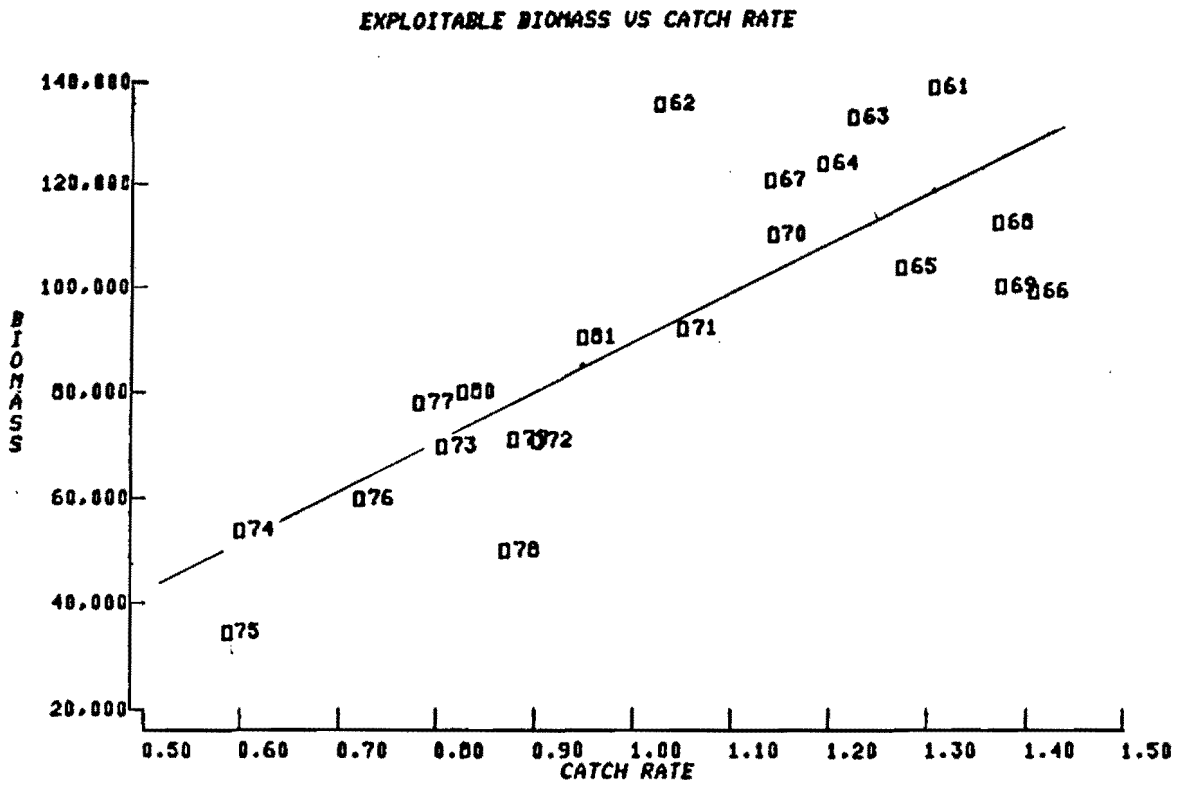

Fig. 8. Relationship of cohort exploitable biomass (F_t=0.40) with standard CPUE indices for the period 1961-81 for Subdivision 3Ps cod.