Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 87/43

CSCPCA Document de recherche 87/43

Redfish in NAFO Division 3P

by

D.B. Atkinson and D. Power
Science Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland A1C 5X1

Abstract

Catches, while remaining well below the present TAC, doubled between 1985 and 1986 to about 6,600 t in 1986. These were split fairly evenly between Subdiv. 3Pn and 3Ps. Maritime vessels took most of the catch in Subdiv. 3Pn while Newfoundland vessels took the most in Subdiv. 3Ps. A non-equilibrium model was used for the first time to assess this stock. It indicated a yield, in 1988 at ⅔ effort MEY of about 15,000 t. Catchability has been below the long term average in recent years, however, and this would suggest that an increase in effort would be necessary if this catch is to be achieved. There is evidence, from research surveys, that recruitment to this fishery will increase in the next few years.

Résumé

Même si elles restent encore inférieures au TPA, les prises ont doublé en 1985 à 1986 pour atteindre 6 600 t. Ces prises se répartissent assez également entre les subdivisions 3Pn et 3Ps. Les bateaux des Maritimes ont effectué la plus grande partie des prises dans la subdivision 3Pn et les bateaux de Terre-Neuve dans les subdivisions 3Ps. Pour la première fois un modèle de production non-équilibre a été utilisé pour l'évaluation de ce stock. Ce modèle indique pour 1988 un rendement de 15 000 t pour un effort équivalent aux 2/3 du RME. Les possibilités de captures ont été inférieures à la moyenne à long terme au cours des dernières années toutefois, ce qui suggérerait qu'un accroissement de l'effort serait nécessaire pour que ce total soit atteint. Les relevés de recherche donnent à penser que dans le cas de cette pêche le recrutement augmentera au cours des quelques prochaines années.

Introduction

Nominal catches of redfish from Division 3P rose fairly steadily from about 4000 t in 1959 to a peak of about 37,000 t in 1970 and have declined since then to less than 10,000 t annually (Table 1, Figure 1). Before the declaration of Canada's 200 mile fishery zone, catches were much greater in Subdivision 3Ps than 3Pn, a reflection of foreign participation in this fishery. In recent years, the catches have been fairly evenly divided between the two subdivisions. In 1986, Canada (Maritimes) vessels accounted for about 60% of the landings in 3Pn while Canada (Newfoundland) vessels took over 80% of the total in 3Ps (Tables 2a and 2b). The fishery in both subdivisions is spread out over the entire year (Tables 3a and 3b). The present TAC level of 18,000 t has been in place from 1976 to the present (with the exception of 1979 when it was lowered to 16,000 t for one year) but was only achieved in 1976 and 1977. This level was established based on the results of a sequential population analysis (SPA) carried out at that time. Because of low fishing mortalities, it has not been possible to update that SPA.

Methods and Results

Catch and effort data extracted from ICNAF/NAFO Statistical Bulletins for the period 1959 to 1984 were combined with preliminary data from NAFO for 1985 and preliminary data from Canada for 1986. These were analysed using a multiplicative model (Gavaris 1980) to derive a standardized catch rate series (STANDAR v.1, Anon. MS 1986). Only those catches where redfish comprised >50% of the total were used. In addition, all country-gear-TC and months with <5 data points were deleted as were all catches and effort of <10 units. This was done in order to reduce potential biases. Because of discussions concerning potential biases resulting from the grouping of similar category types *a posteriori*, the same groupings as used in the 1986 assessment (Atkinson and Power MS 1986) were used. In addition, because of unknown amounts of pro-rating possibly existing in the data, the model was run without weighting, unlike in the past. The parameter estimates and final combinations are shown in Table 4, and the regression results are in Tables 5 and 6. Standardized effort peaked in 1975 at about 50,000 hours, then declined to current levels of 5000-10,000 hours (Figure 2). The standardized effort in 1986 was only slightly less than double that in 1985. Catch rates peaked in 1966 then declined fairly steadily until around 1980 when they increased again (Figure 3). After dropping in 1984 and 1985, catch rates again increased in 1986.

It was determined previously (Atkinson and Power MS 1986) that a lag of 12 years was most appropriate for equilibrium general production analysis since with this lag, serial correlation disappeared from the relationship of CPUE on effort. This same situation existed after incorporation of the 1986 data so the equilibrium version of the Schaefer general production model was run with a lag of 12 years only (Gulland 1961). The results (Figures 4 and 5) indicate that the regression of CPUE on lagged effort is highly significant, and the equilibrium yield at ⅔ effort maximum exploitable yield (MEY) is 15,140 t, about 3000 t less than the present TAC level.

The non-equilibrium form (Rivard and Bledsoe 1978) of the Schaefer model was run, first incorporating all of the data including those for 1986. Input values for virgin stock biomass (B_∞) and maximum equilibrium yield (MEY) of 270,000 t and 18,000 t respectively and a fixed catchability coefficient (q) of 0.000007 resulted in convergence (based on change in the residual sum of squares (RSS)<0.00001). The model was again run using, as input, the final estimates of B_∞ and MEY derived above and allowing the model to estimate q as well. There was convergence (again based on change in RSS) but the derived estimate of B_∞ (about 900,000 t) seemed to be unrealistic so this run was rejected.

The annual values of q derived from the initial analysis above were examined (Figure 6). It can be seen that the q-values for the periods 1959-1962 and 1984-1986 are all well below the overall average. Because of this, these years were eliminated from the

analyses and the model re-run using, as input, the values derived from the first analysis above and q fixed at 0.000007. The model converged very quickly with the orthogonality offset <0.001, the change in RSS <0.00001 and the relative change in each parameter <0.00001. The model was run one more time, using the derived estimates of B_{∞} and MEY derived immediately above and allowing the model to estimate q. Again convergence was very quick with regard to the three tests above. Because the parameter estimates appeared reasonable with B_{∞} of about 320,000 t and MEY of about 23,000 t (Table 7), this last run was selected for further analysis. It should be noted that the data are insufficient to predict well the downward side of the equilibrium curve.

The plot of annual q-values (Figure 7) indicates very little variation, meaning that these data are explained quite well by the stock dynamics described by the model. Similarly, the model does a very good job of predicting the annual yields (Figure 8). The transient path described by the data (Figure 9) is generally what would be expected in a stock production analysis although there are some deviations from this (eg. 1973 point). Good recruitment, probably in the late 1950's, pushed the stock above equilibrium but a gradual depletion of this year class(es) resulted in a return below the equilibrium curve.

Results of this analysis and the equilibrium analysis above can be summarized as follows:

	Non-equilibrium		Equilibrium	
	MEY	2/3 EFFORT MEY	MEY	2/3 EFFORT MEY
EFFORT	19,898	13,265	34,494	22,996
CATCH RATE	1.169	1.558	0.494	0.658
YIELD	23,254	20,670	17,035	15,140

The results from the non-equilibrium analysis were projected from the beginning of 1984 through 1988. The projections for the 1984-1986 period were done iteratively (ie. adjusting input effort) in order to arrive at a non-equilibrium yield equal to the actual catch taken in these years. Projections for 1987 and 1988 were done with ⅔ effort MEY as input. This resulted in yields for 1987 and 1988 of 14,496 t and 15,300 t respectively. The corresponding F (based on F=qf) is 0.093, approximately 0.1, while the predicted catch rates are 1.093 t/hr and 1.153 t/hr respectively.

The available commercial frequencies (Figures 10 and 11) were combined (Figure 12) then applied to a commercial age-length key (Gavaris and Gavaris 1983) to derive an estimate of the numbers of redfish caught at age in the 1986 fishery (Table 8). The weight/length relationships used to calculate the mean weight at age are:

$$WT(males)=0.01659FL^{2.9548}$$

$$WT(females)=0.01372FL^{3.0210}$$

Again in 1986, a relatively large number of small fish was taken in this fishery.

In 1986, questions were raised within CAFSAC concerning the validity of conducting SPA analyses on stocks were there is no convergence. It was concluded that this process is not appropriate, particularly for redfish. Because of this, no SPA was attempted. The catch at age and weights at age for the 1973-1986 period are shown in Tables 9 and 10 respectively.

A Canadian research cruise was again conducted in Division 3P in the spring of 1987. The mean numbers caught at age per standard tow in the 1986 survey as well as the mean numbers caught per tow at length in the 1987 survey are shown in Figures 13 and 14 respectively. The modes in the two figures correspond to the same year class(es) and these are also present in the commercial numbers at age for 1985 and 1986 (Table 9). These fish should be fully recruited to the fishery in the next few years.

In the past, estimates of biomass from the spring research cruises have not been used because the estimates fluctuated widely from year to year. In an attempt to resolve this, the data from the surveys were analysed using a multiplicative model (Gavaris 1980) to fill in the missing strata in each year. Weighting was based on the annual variances. The results (Figure 15) indicate that the procedure did not result in more reasonable inter-annual variability in the biomass estimates. Because of the considerable fluctuations noted, Paloheimo Z's were not calculated using the research data. Over the entire period of the surveys, the average estimated minimum trawlable biomass was about 40,000 t. The estimate from the 1987 survey is 74,000 t.

Conclusions

Research data indicate that the year-classes of the early 1980's are relatively strong and should be recruiting to the fishery in increasing numbers over the next few years. This should be reflected in an increase in catch rates.

The results of the equilibrium production analysis suggest an equilibrium yield at ⅔ effort MEY of about 15,000 t. The 1986 point is below the equilibrium curve suggesting a yield in 1987 below the ⅔ effort MEY yield.

The non-equilibrium production model indicates a higher yield at ⅔ effort MEY, probably because the equilibrium model incorporated lagged effort data. The data for the most recent years are only poorly described by the model as indicated by the apparent drop in the value of q in the 1984-1986 period. Nonetheless, the non-equilibrium yield for 1988 as determined by the model (15,300 t) is very close to yield at ⅔ effort MEY suggested by the equilibrium model. Given that the present TAC of 18,000 t was established based upon an SPA analysis using only 6 years of catch-at-age data, and given that CAFSAC has concluded that the use of SPA is inappropriate for redfish at present because SPA does not converge even with 12 years of data, then it would seem reasonable to lower the TAC for this stock in 1988 to 15,000 t based on the best data presently available. With the equilibrium model alone, this is the ⅔ effort MEY level of yield, the level at which TAC's have been traditionally set from this model. The non-equilibrium model indicates a non-equilibrium yield, based on the estimate of transient biomass, of 15,300 t. It should be noted, however, that according to the non-equilibrium model, catchability has been below normal during the most recent time period. Given this, it is anticipated that unless catchability returns to normal, an increase in effort would be required if a catch in the range of 15,000 t is taken.

References

Anon. Ms 1986. CAFSAC Assessment Software Catalogue. CAFSAC Res. Doc. 86/96.

Atkinson, D.B. and D. Power. MS 1986. The NAFO Division 3P Redfish. CAFSAC Res. Doc. 86/53.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37: 2272-2275.

Gavaris, S. and C.A. Gavaris 1983. Estimation of catch at age and its variance for groundfish stocks in the Newfoundland Region. In Sampling Commercial Catches of Marine Fish and Invertebrates. W.G. Doubleday and D. Rivard ed. Can. Spec. Pub. Fish. Aquat. Sci. 66pp 178-182.

Gulland, J.A. 1961. Fishing and stocks of fish at Iceland. U.K. Min. Agric. Fish. Food, Fish. Invest. (Ser. 2) 23(4): 52 p.

Rivard, D. and L.J. Bledsoe. 1978. Parameter Estimation for the Pella-Tomlinson Stock Production Model under Nonequilibrium Conditions. Fish. Bull. 76 (3): 523-534.

Table 1: Summary of nominal catches (t) of redfish in Division 3P.

Year	3Pn	3Ps	Total	TAC
1959	9	3,774	3,783	
1960	14	9,211	9,225	
1961	1,060	8,340	9,400	
1962	2,132	11,306	13,438	
1963	2,597	11,150	13,747	
1964	4,688	9,119	13,807	
1965	8,802	9,931	18,733	
1966	4,325	16,543	20,868	
1967	4,526	28,465	32,991	
1968	2,642	11,242	13,884	
1969	3,324	28,727	32,051	
1970	3,689	33,581	37,270	
1971	966	26,534	27,500	
1972	639	25,398	26,037	
1973	3,654	14,714	18,368	
1974	4,264	17,894	22,158	25,000
1975	8,100	20,150	28,250	25,000
1976	5,932	13,235	19,167	18,000
1977	2,485	14,678	17,163	18,000
1978	3,042	12,203	15,245	18,000
1979	3,160	6,459	9,619	16,000
1980	2,372	5,192	7,564	18,000
1981	4,256	4,685	8,941	18,000
1982	3,820	2,090	5,910	18,000
1983	2,929	2,996	5,925	18,000
1984	2,396	2,005	4,401	18,000
1985*	1,578	1,754	3,332	18,000
1986*	3,466	3,416	6,882	18,000
1987				18,000

* Provisional.

Table 2a: Nominal catches (t) of redfish in Division 3Pn by country and year.

Country	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985*	1986*
Canada (M)+	3,941	2,735	932	743	37	30	108	311	540	860	391	2,064
Canada (N)	3,505	2,925	1,283	2,266	2,676	2,154	3,749	3,508	2,385	1,536	1,187	1,240
Canada (Q)	-	-	-	-	384	165	387	-	-	-	-	162
France (M)	27	8	-	1	1	-	11	-	-	-	-	-
France (SP)	571	236	270	32	62	23	1	1	-	-	-	-
France	-	-	-	-	-	-	-	-	4	-	-	-
Japan	6	-	-	-	-	-	-	-	-	-	-	-
Portugal	50	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	28	-	-	-	-	-	-	-	-	-	-
TOTAL	8,100	5,932	2,485	3,042	3,160	2,372	4,256	3,820	2,929	2,396	1,578	3,466

* Provisional.
\+ Maritimes and Quebec were combined prior to 1979.

Table 2b: Nominal catches (t) of redfish in Division 3Ps by country and year.

Country	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985*	1986*
Canada (M)+	2,549	3,242	3,730	2,592	970	360	391	515	670	396	313	602
Canada (N)	8,744	7,948	9,489	9,282	5,119	4,609	4,123	1,553	2,316	1,608	1,429	2,814
Canada (Q)	-	-	-	-	248	-	-	-	-	-	-	-
France (M)	60	6	8	14	21	112	124	5	-	-	12	-
France (SP)	571	1,071	1,437	315	101	111	47	17	-	-		-
France	-	-	-	-	-	-	-	-	10	1	-	-
Japan	-	8	-	-	-	-	-	-	-	-	-	-
Portugal	101	10	-	-	-	-	-	-	-	-	-	-
Spain	10	13	-	-	-	-	-	-	-	-	-	-
UK	3	-	-	-	-	-	-	-	-	-	-	-
USSR	8,112	911	14	-	-	-	-	-	-	-	-	-
Ireland	-	26	-	-	-	-	-	-	-	-	-	-
TOTAL	20,150	13,235	14,678	12,203	6,459	5,192	4,685	2,090	2,996	2,005	1,754	3,416

* Provisional.
\+ Maritimes and Quebec were combined prior to 1979.

Table 3a: Nominal catches (t) of redfish in Division 3Pn by month and year.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1975	1,944	445	224	744	21	61	273	1,146	2,764	340	104	34	8,100
1976	281	511	1,370	1,892	469	281	509	371	130	91	19	8	5,932
1977	146	108	373	74	71	291	102	459	613	89	71	88	2,485
1978	6	339	674	38	10	77	160	549	392	55	491	251	3,042
1979	17	142	598	354	74	92	210	168	167	372	570	396	3,160
1980	5	38	279	193	12	155	388	196	173	192	360	381	2,372
1981	9	432	100	315	117	160	969	540	498	753	272	91	4,256
1982	-	1	39	13	10	153	502	288	923	652	959	280	3,820
1983	21	63	30	207	1	217	294	622	791	144	356	183	2,929
1984	3	534	223	119	57	87	305	258	173	435	130	72	2,396
1985*	66	-	7	-	1	86	241	521	206	135	121	194	1,578
1986*	-	78	217	1,336	948	68	169	94	84	149	251	72	3,466

* Provisional.

Table 3b: Nominal catches (t) of redfish in Division 3Ps by month and year.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1975	911	357	657	847	2,546	1,846	3,072	3,527	2,589	1,731	1,104	963	20,150
1976	363	371	1,729	1,272	714	2,414	2,970	2,282	822	211	66	21	13,235
1977	80	388	1,348	694	506	2,408	1,848	1,782	1,846	2,010	1,307	461	14,678
1978	31	301	899	396	148	903	1,625	2,029	1,892	2,178	1,066	735	12,203
1979	30	53	459	881	140	886	951	1,005	690	587	618	159	6,459
1980	6	72	347	469	174	257	978	1,130	706	335	339	379	5,192
1981	21	537	763	157	217	897	465	937	134	150	224	183	4,685
1982	4	5	27	127	154	133	220	580	193	398	205	44	2,090
1983	8	11	25	28	82	61	133	462	667	957	168	394	2,996
1984	9	126	179	39	114	470	804	141	40	37	22	24	2,005
1985*	30	27	101	32	106	123	361	412	339	125	62	36	1,754
1986*	12	29	683	274	391	418	726	210	316	102	160	95	3,416

* Provisional.

Table 4: Parameter estimates from the analysis of catch/effort for redfis
Division 3P using a multiplicative model.

Country-Gear-TC	Estimate	Month	Estimate
USSR OTB 4	-0.557	Apr.	
		May	
FR(SP) OTB 4	-0.453	Oct.	-0.132
		Nov.	
CAN(N) OTB 4	0.000	Dec.	
CAN(M) OTB 4		Jan.	
CAN(MQ) OTB 4		Feb.	
CAN(N) OTB 5	0.178	Mar.	0.000
FR(SP) OTB 5		Jul.	
GDR OTB 5		Aug.	
		Sep.	
CAN(MQ) OTM 4			
CAN(N) OTM 4		Jun.	0.110
CAN(M) OTB 5	0.413		
CAN(MQ) OTB 5			
POL OTB 7			
CAN(Q) OTM 4	0.560		
		Div.	
GDR OTB 6	0.689		
CAN(MQ) OTM 5			
CAN(N) OTM 5	0.894	3Pn	-0.065
JPN OTB 7			
GDR OTB 7		3Ps	0.000
USSR OTB 7	1.321		
USSR OTM 7	1.675		

Table 5: Regression of multiplicative model for redfish in Division 3P.

multiple r..... 0.714
multiple r squared..... 0.509

analysis of variance

source of variation	df	sums of squares	mean squares	f-value
intercept	1	3.449e2	3.449e2	
regression	39	2.276e2	5.837e0	37.150
type 1	9	1.459e2	1.621e1	103.186
type 2	2	8.691e0	4.345e0	27.657
type 3	1	1.317e0	1.317e0	8.383
type 4	27	8.460e1	3.133e0	19.943
residuals	1396	2.193e2	1.571e⁻1	
total	1436	7.919e2		

Table 6: The predicted catch rate for redfish in Division 3P.

	ln transform		retransformed			
year	mean	s.e.	mean	s.e.	catch	effort
1959	⁻0.4605	0.0159	0.677	0.085	3783	5586
1960	⁻0.6041	0.0095	0.588	0.057	9225	15676
1961	⁻0.6899	0.0082	0.540	0.049	9400	17394
1962	⁻0.5378	0.0059	0.630	0.048	13438	21333
1963	⁻0.3193	0.0032	0.785	0.044	13747	17515
1964	⁻0.3005	0.0068	0.798	0.066	13807	17296
1965	⁻0.1069	0.0059	0.969	0.074	18733	19327
1966	⁻0.0495	0.0042	1.027	0.066	20868	20312
1967	⁻0.1258	0.0037	0.952	0.058	32991	34648
1968	⁻0.1720	0.0042	0.909	0.059	13884	15275
1969	⁻0.2503	0.0036	0.841	0.050	32051	38121
1970	⁻0.3194	0.0030	0.785	0.043	37270	47487
1971	⁻0.4829	0.0033	0.666	0.038	27500	41270
1972	⁻0.5405	0.0032	0.629	0.036	26037	41390
1973	⁻0.5652	0.0026	0.614	0.031	18368	29920
1974	⁻0.7196	0.0026	0.526	0.027	22158	42119
1975	⁻0.6829	0.0022	0.546	0.026	28250	51752
1976	⁻0.9092	0.0024	0.435	0.021	19167	44034
1977	⁻0.8722	0.0025	0.452	0.022	17163	37998
1978	⁻0.8716	0.0025	0.452	0.023	15245	33732
1979	⁻0.9650	0.0025	0.412	0.021	9619	23369
1980	⁻0.7554	0.0031	0.507	0.028	7564	14906
1981	⁻0.9107	0.0037	0.434	0.026	8941	20584
1982	⁻0.6988	0.0046	0.537	0.036	5910	11013
1983	⁻0.5173	0.0048	0.643	0.045	5925	9210
1984	⁻0.6371	0.0071	0.570	0.048	4401	7720
1985	⁻0.8156	0.0036	0.478	0.029	3332	6975
1986	⁻0.6453	0.0035	0.566	0.034	6882	12151

Table 7: Results of non-equilibrium analysis of catch and effort data, 1963-1983

APPROXIMATE STATISTICS FROM LINEAR THEORY

EST. PAR.	STD. ERR.	T-VALUE
3.20333E5	7.29232E4	4.39275E0
2.32540E4	1.73253E3	1.34220E1
7.29646E-6	7.43276E-7	9.81662E0

CORRELATION MATRIX OF THE ESTIMATED PARAMETERS

1.000000	0.821239	-0.809359
0.821239	1.000000	-0.342125
-0.809359	-0.342125	1.000000

VARIANCE OF RESIDUALS.....	1606498.899303
R SQUARED.....	0.982797
R-BAR SQUARED.....	0.980886
DURBIN-WATSON STATISTIC.....	2.077777
ORTHOGONALITY OFFSET.....	0.000000

YEAR	BIOMASS	ADJ. LEVEL	YIELD	PRED. YIELD	RESIDUALS
1963	105,594	177,940	13,747	14,074	-327
1964	112,401	179,720	13,807	14,763	-956
1965	119,109	163,209	18,733	17,306	1,427
1966	123,705	155,201	20,868	18,790	2,078
1967	127,090	38,652	32,991	31,278	1,713
1968	117,809	196,150	13,884	13,755	129
1969	126,007	10,417	32,051	33,759	-1,708
1970	114,107	0	37,270	37,103	167
1971	97,697	0	27,500	28,461	-961
1972	88,572	0	26,037	26,009	28
1973	80,841	77,090	18,368	17,958	410
1974	80,576	0	22,158	24,155	-1,997
1975	73,653	0	28,250	26,350	1,900
1976	63,212	0	19,167	19,904	-737
1977	57,833	11,417	17,163	16,122	1,041
1978	55,509	46,099	15,245	13,981	1,264
1979	55,049	130,348	9,619	9,984	-365
1980	58,837	199,150	7,564	7,008	556
1981	66,586	152,989	8,941	10,683	-1,742
1982	71,840	230,800	5,910	6,367	-457
1983	82,576	245,458	5,925	6,122	-197
1984	95,175				

Table 8: Estimated numbers of redfish caught at age (000's) (including their average weight and length) in the commercial fishery in Division 3P in 1986.

	average		catch		
age	weight	length	mean	std. err.	c. v.
5	0.049	15.000	6	6.51	1.03
* 6	0.071	16.831	190	40.52	0.21
7	0.095	18.620	975	79.42	0.08
8	0.125	20.279	1018	78.05	0.08
9	0.209	24.270	383	41.97	0.11
10	0.249	25.741	246	40.26	0.16
11	0.276	26.685	286	45.84	0.16
12	0.287	26.977	316	47.35	0.15
13	0.328	28.223	278	53.10	0.19
14	0.371	29.415	388	74.86	0.19
15	0.398	30.210	515	93.49	0.18
16	0.433	31.048	935	130.88	0.14
17	0.471	31.832	872	126.69	0.15
18	0.536	33.153	1138	160.64	0.14
19	0.544	33.282	964	145.84	0.15
20	0.581	34.041	1119	150.27	0.13
21	0.650	35.232	559	114.97	0.21
22	0.739	36.769	264	74.22	0.28
23	0.689	35.901	377	91.62	0.24
24	0.786	37.528	164	56.73	0.35
25	0.696	35.995	298	72.48	0.24
26	0.719	36.468	310	73.27	0.24
27	0.730	36.595	466	95.75	0.21
28	0.765	37.312	474	82.48	0.17
29	0.800	37.855	351	73.39	0.21
*30	0.907	39.380	1122	99.80	0.09

* for the ages flagged by * there was an age length key with only one age determination for some length. Since the variance formula has n_1 in the denominator it cannot be evaluated for this length. Consequently this variance component is not included in the variance for the flagged ages. This is generally not a serious problem since it occurs when few fish are caught at that length.

Table 9. Estimated numbers of redfish caught at age (000's) in Division 3P, 1973-1986.

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
6	13	105	401	41	257	1339	440	191	8	3
7	11	895	694	56	491	4146	1510	976	204	11
8	16	1876	1868	263	499	7359	2703	1776	1550	76
9	8	1647	883	581	790	7382	2859	2377	1923	234
10	20	1528	486	386	835	5203	1606	1929	1686	250
11	536	1830	1112	434	777	2358	896	1532	1344	606
12	1004	1399	623	506	971	2049	1020	1219	1236	856
13	3076	3602	1016	990	849	857	714	629	1327	943
14	6099	3058	1123	1119	1022	1085	710	802	635	1315
15	9314	3173	2206	1072	1438	1162	496	579	518	1042
16	5866	7661	3613	1796	793	927	449	313	384	940
17	7300	2597	8428	1124	1298	791	603	366	348	458
18	1842	3930	6040	4154	1005	1067	548	308	304	322
19	878	1063	12060	1897	2659	852	531	315	399	233
20	1149	1326	3015	6345	1490	1883	655	319	374	151
21	589	701	2323	1463	4659	520	1021	428	286	188
22	385	1555	2080	2387	2281	1534	676	809	510	207
23	404	2821	1758	1957	2398	1040	1263	484	876	194
24	484	1410	790	1310	2031	1080	731	796	521	302
25	168	2147	1205	2269	1083	1053	1053	482	1021	393
26	2	1887	995	1613	619	674	691	490	688	575
27	2	2	687	868	396	532	454	239	649	386
28	2	2	2	575	307	339	345	287	450	411
29	2	2	2	2	289	187	207	171	371	342

age	1983	1984	1985	1986
6	8	96	1049	190
7	10	496	459	975
8	8	535	252	1018
9	58	625	245	383
10	188	1717	36	246
11	232	3147	62	286
12	404	2060	93	316
13	602	1753	108	278
14	956	1412	131	388
15	1064	1106	377	515
16	1130	1161	671	935
17	939	962	717	872
18	1178	1008	637	1138
19	612	569	306	964
20	567	358	319	1119
21	483	260	136	559
22	342	202	149	264
23	270	185	87	377
24	271	203	156	164
25	270	223	128	298
26	218	454	122	310
27	430	165	235	466
28	251	208	246	474
29	266	81	223	351

Table 10: Estimated weight at age (kg) of redfish caught in Division 3P, 1973-1986.

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.06	0.08	0.08	0.07	0.07
7	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.10	0.11	0.11	0.09	0.10
8	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.16	0.15	0.15	0.13
9	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.21	0.18	0.18	0.21
10	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.27	0.27	0.26	0.20	0.23	0.25
11	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.33	0.27	0.23	0.23	0.28
12	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.34	0.36	0.32	0.28	0.24	0.29
13	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.36	0.37	0.35	0.31	0.27	0.33
14	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.42	0.40	0.38	0.35	0.29	0.37
15	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.43	0.42	0.39	0.35	0.38	0.40
16	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.47	0.44	0.41	0.40	0.42	0.43
17	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.51	0.45	0.42	0.48	0.47
18	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.52	0.46	0.46	0.47	0.54
19	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.62	0.57	0.49	0.52	0.51	0.54
20	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.63	0.60	0.50	0.54	0.55	0.58
21	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.60	0.66	0.53	0.58	0.57	0.65
22	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.65	0.67	0.58	0.54	0.60	0.74
23	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.65	0.70	0.61	0.63	0.53	0.69
24	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.71	0.68	0.67	0.60	0.63	0.79
25	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.73	0.71	0.68	0.64	0.65	0.70
26	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.78	0.75	0.74	0.67	0.66	0.72
27	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.81	0.85	0.71	0.80	0.69	0.73
28	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.87	0.82	0.82	0.78	0.71	0.77
29	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.88	0.93	0.85	0.85	0.76	0.80

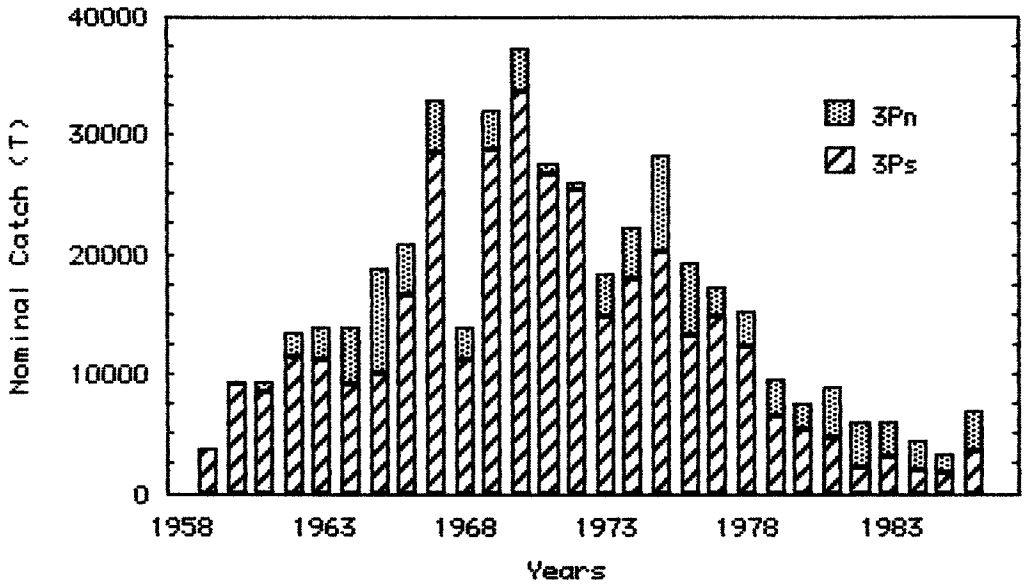


Fig. 1: Nominal catches of redfish from Division 3P, 1959-1986
(1985 and 1986 are provisional)

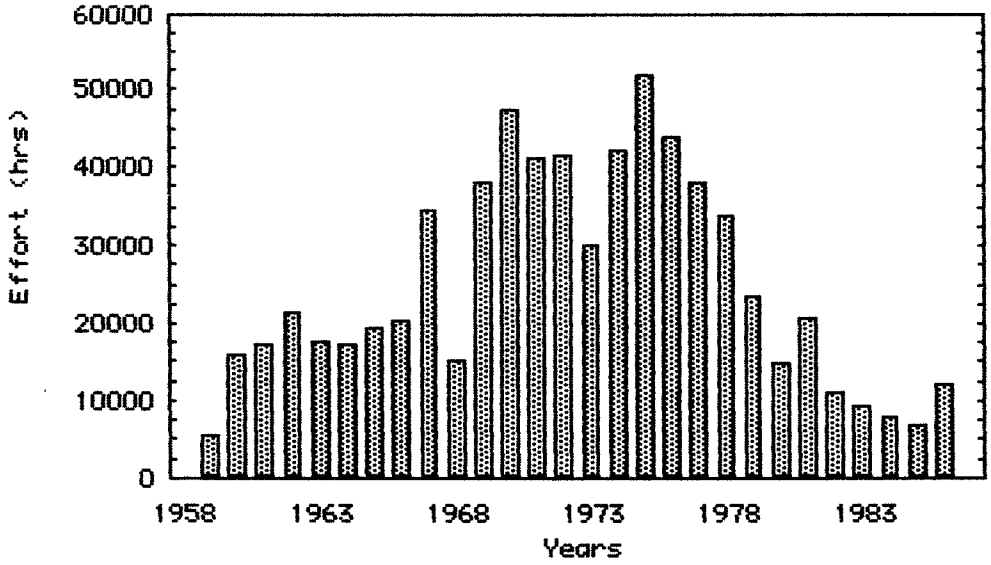


Fig. 2: Standardized effort for redfish in Division 3P, 1959-1986
(1985 and 1986 are provisional)

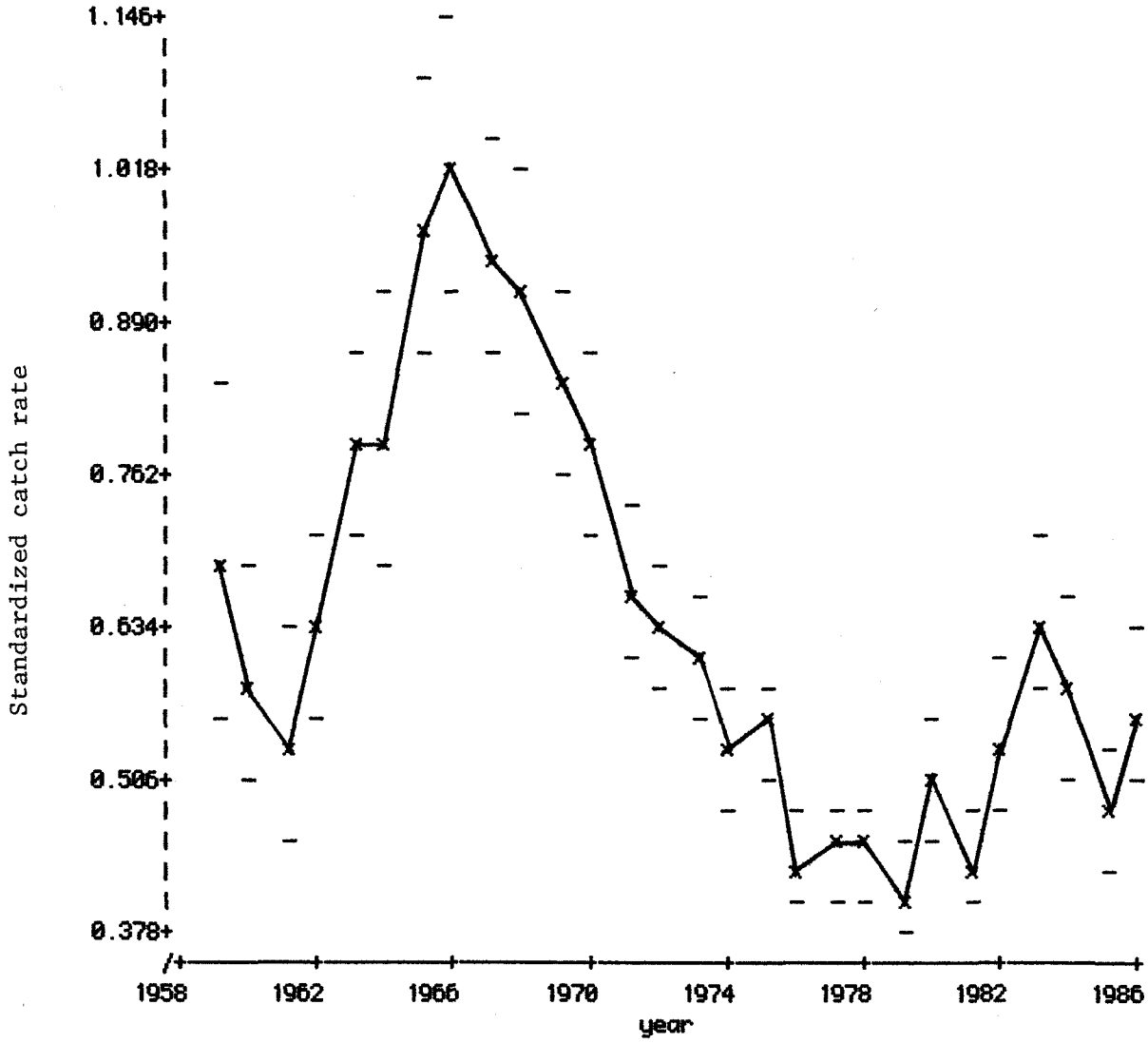


Figure 3: Plot of catch rates for redfish in NAFO Division 3P in the period 1959-1986 as derived using a multiplicative model (1985 and 1986 are preliminary).

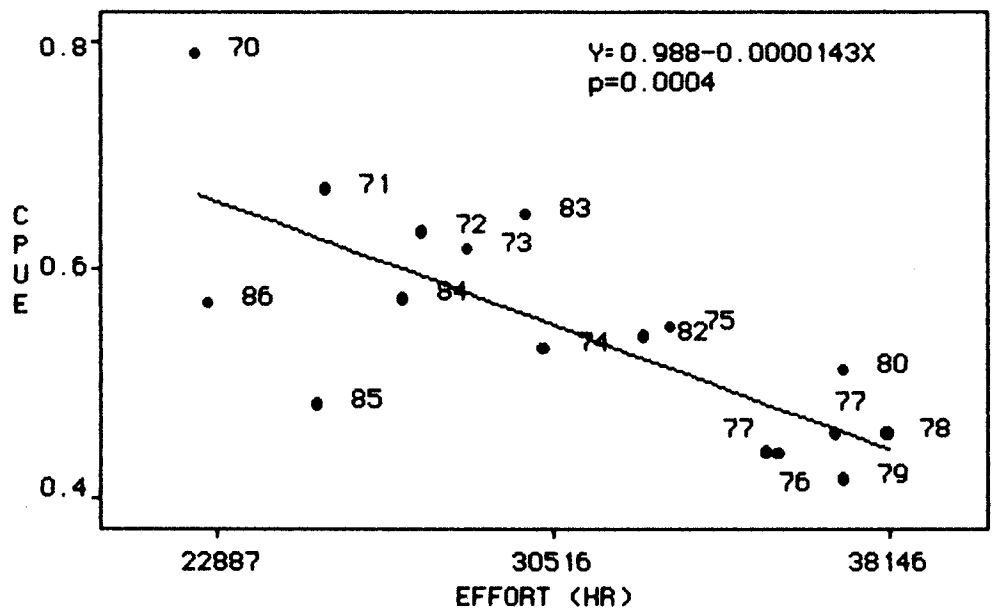


Figure 4: Regression of standardized CPUE on standardized effort for redfish in NAFO Division 3P using data lagged 12 years.

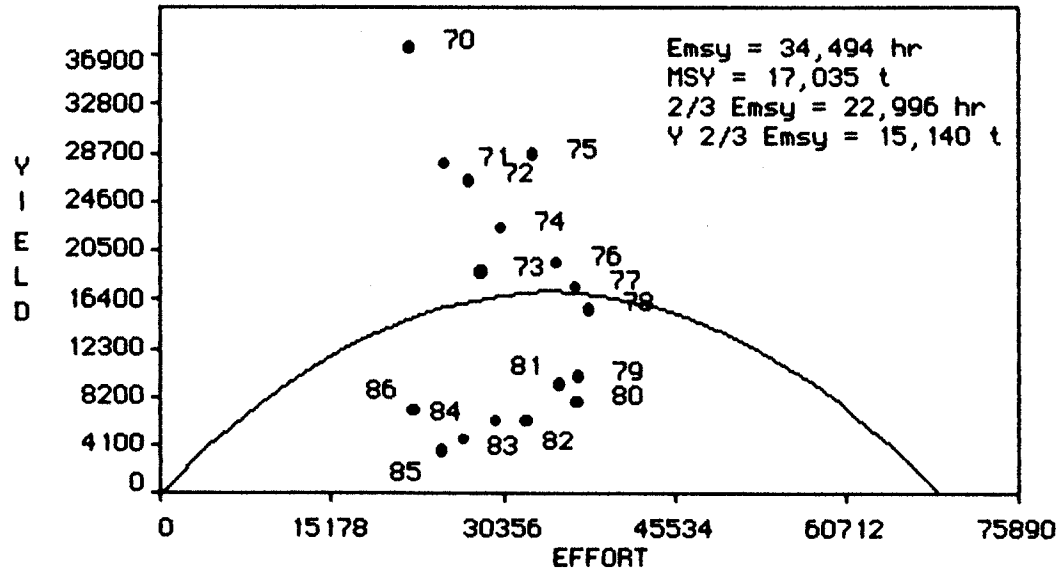


Figure 5: Schaefer general production curve derived from the regression above.

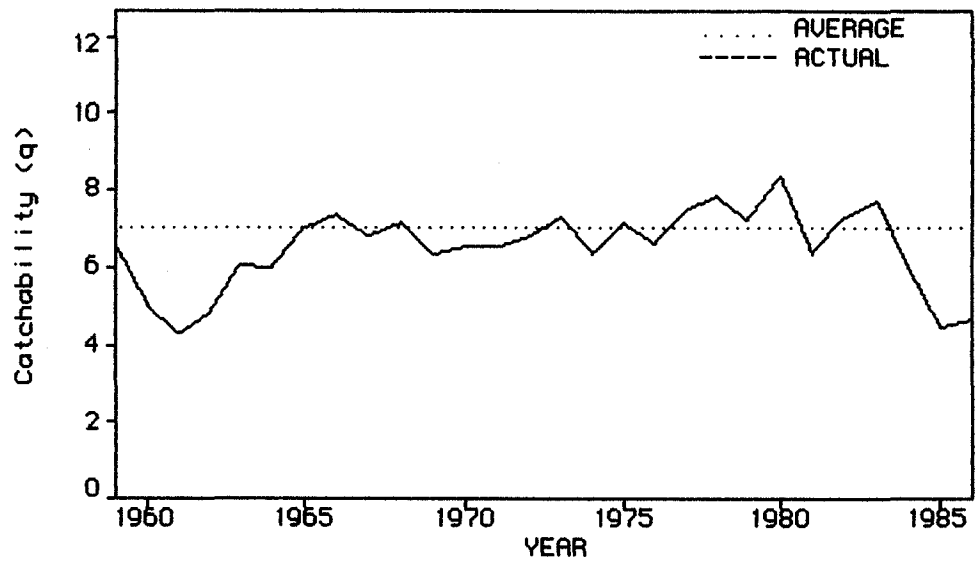


Fig. 6: Average and actual annual catchability (q) values determined from the non-equilibrium production model run with data for 1959-1986 inclusive for redfish in NAFO Div. 3P (the values shown are q x million).

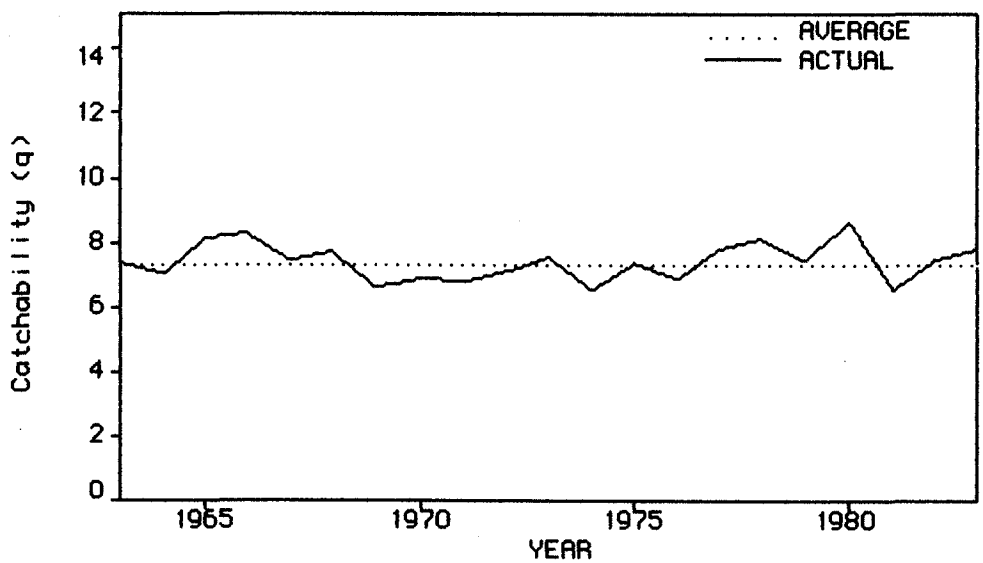


Fig. 7: Average and actual annual catchability (q) values determined from the non-equilibrium production model run with data for 1963-1983 inclusive for redfish in NAFO Div. 3P (the values shown are q x million).

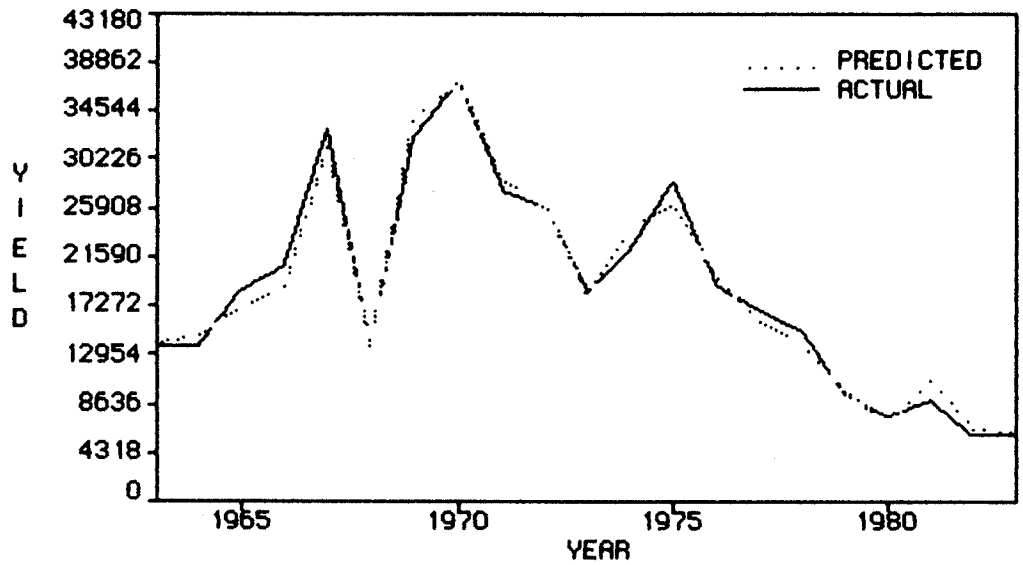


Fig. 8: Actual annual yields for redfish in NAFO Div. 3P compared with those predicted by the non-equilibrium production model using years 1963-1983.

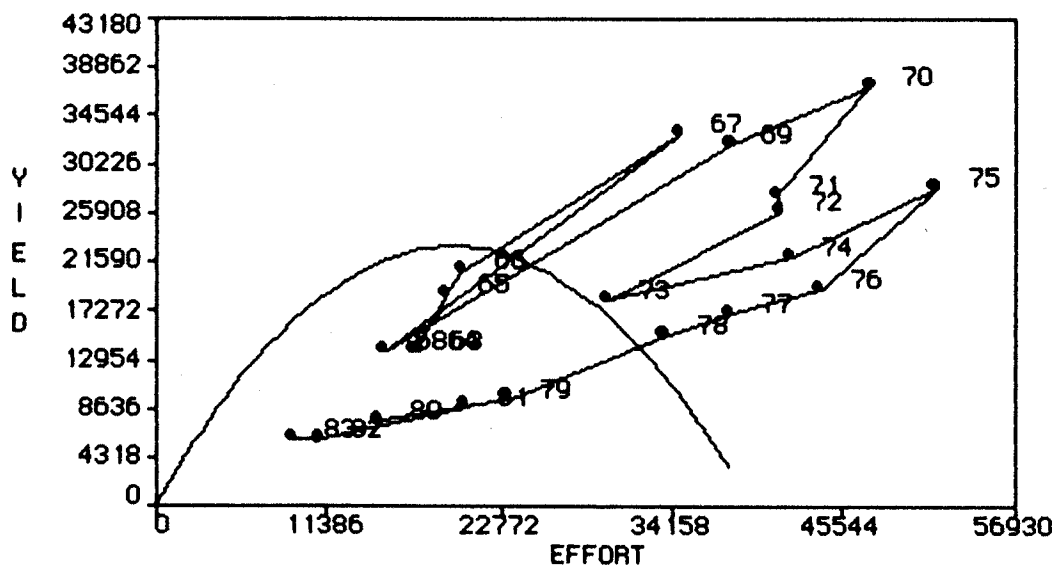


Fig. 9: Equilibrium yield curve and actual transient levels of yield and effort derived from the non-equilibrium model run using 1963-1983 only for redfish in NAFO Div. 3P.

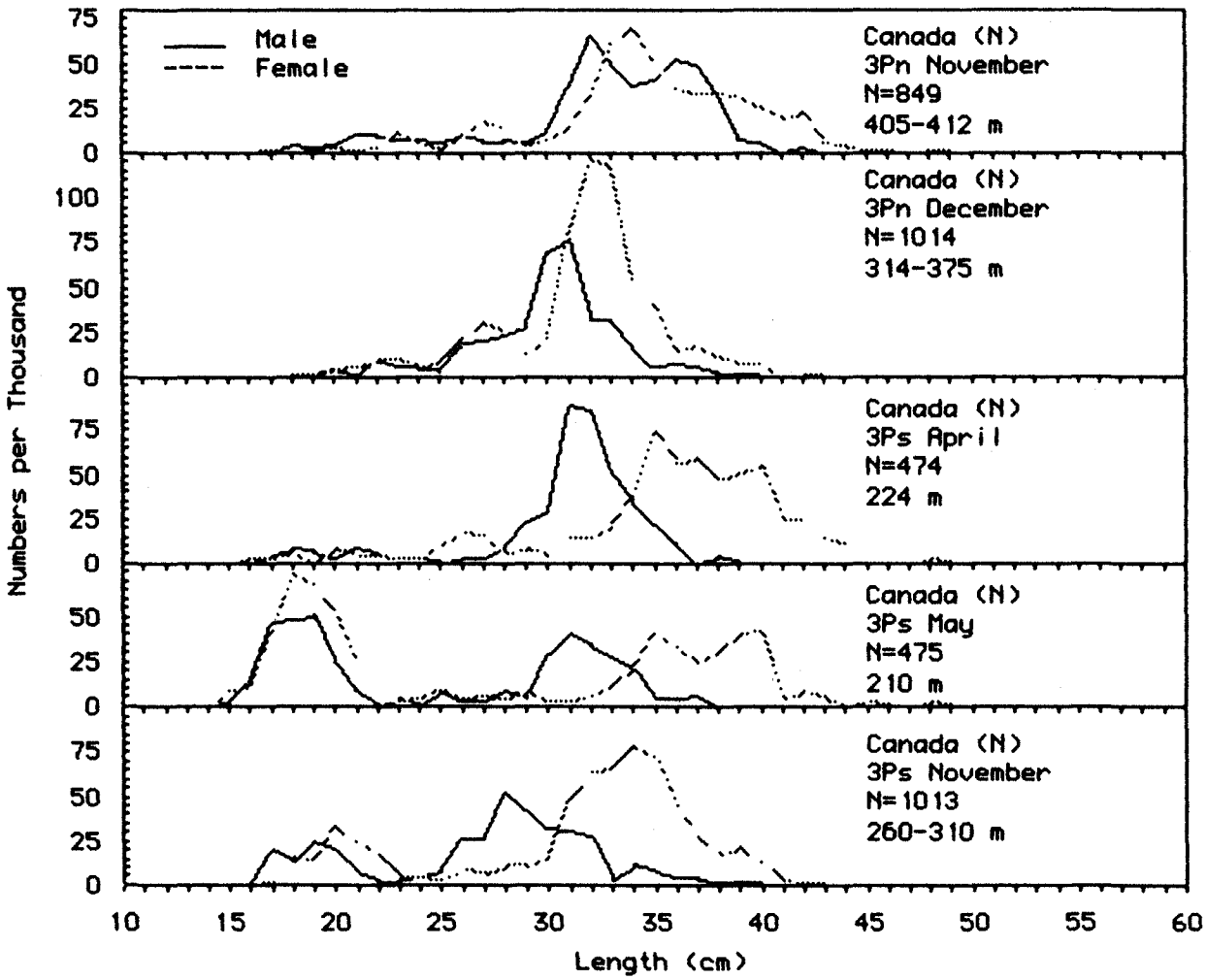


Fig. 10: Commercial length frequencies of redfish caught by Canada in NAFO Division 3P in 1986 (port sampling).

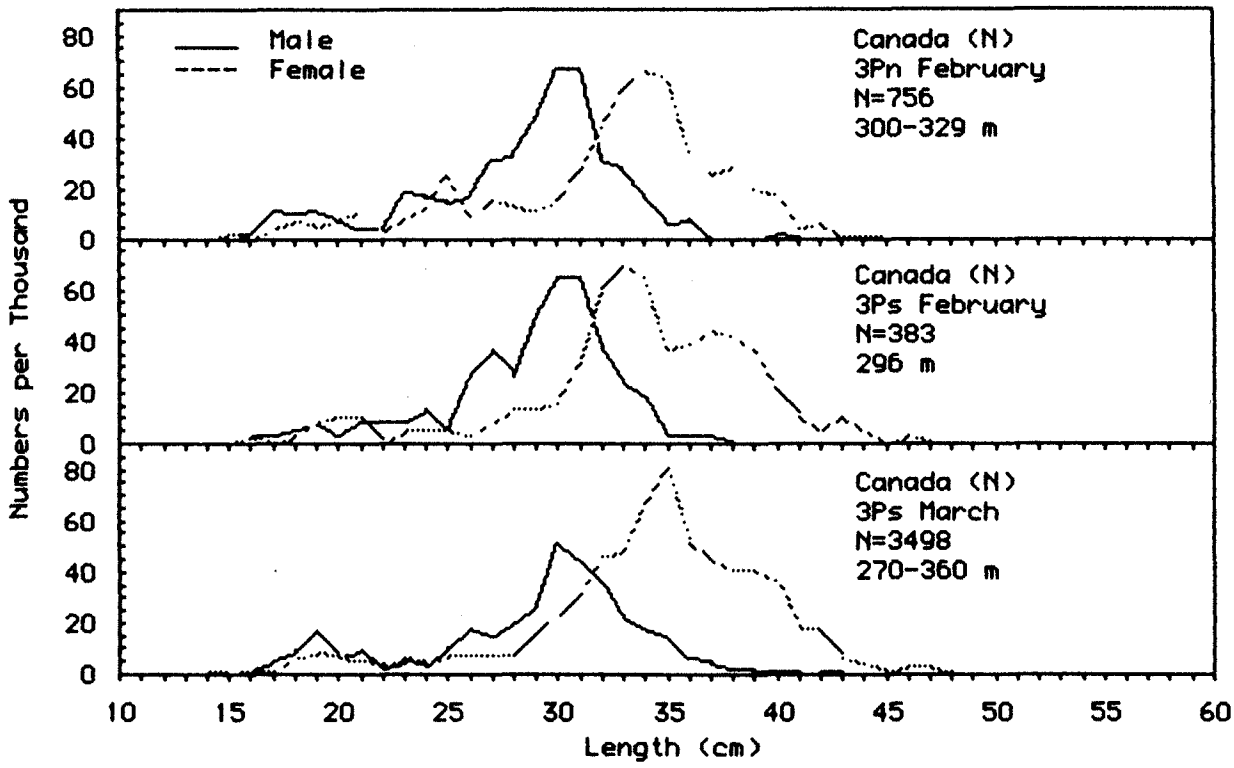


Fig. 11: Commercial length frequencies of redfish caught by Canada in NAFO Division 3P in 1986 (sea sampling).

Frequency	Wt.	Frequency	Wt.	Frequency	Wt.
Sea3PnFebCNOT	108				
Port3PnNovCNOT	208	CanOT3Pn	3466		
Port3PnDecCNOT	40				
				CanOT3P	6882
Sea3PsFebCNOT	683				
Sea3PsMarCNOT	29				
Port3PsAprCNOT	274	CanOT3Ps	3416		
Port3PsMayCNOT	391				
Port3PsNovCNOT	160				

Figure 12: Commercial frequencies used and the process followed to derive the estimate of the number of redfish caught at age in NAFO Division 3P in 1986.

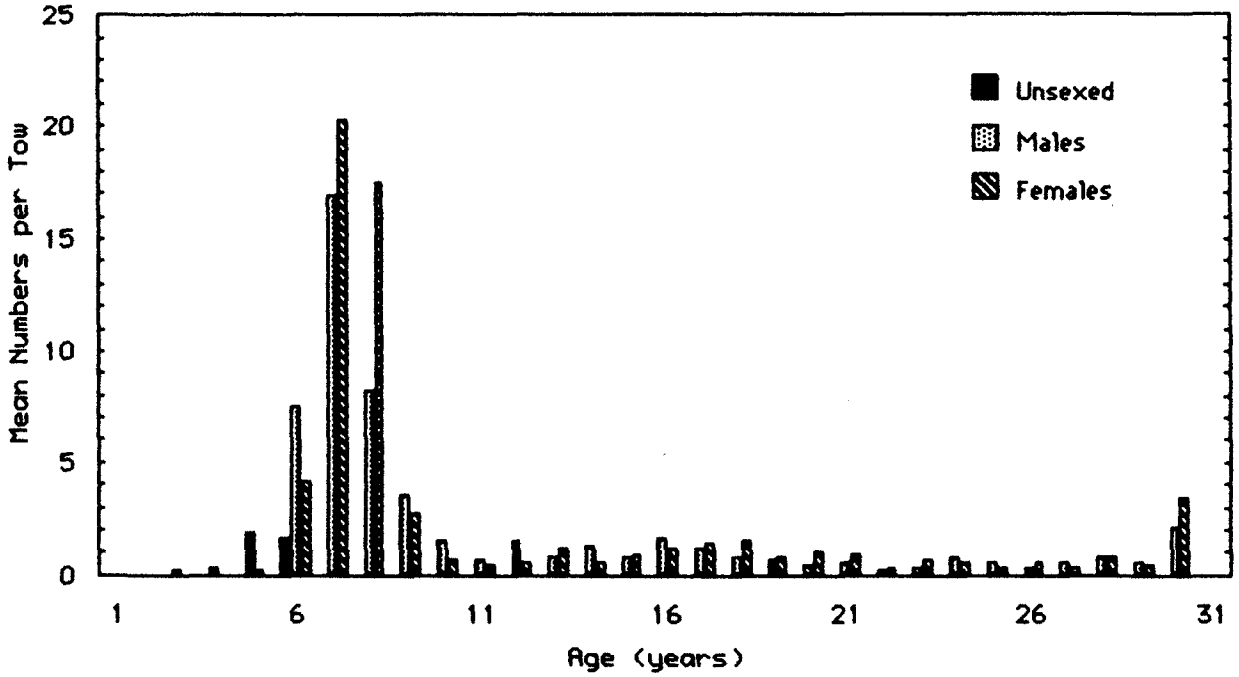


Fig. 13: Mean Numbers of redfish caught per tow at age during a Canadian research cruise to NAFO Division 3P in the spring of 1986.

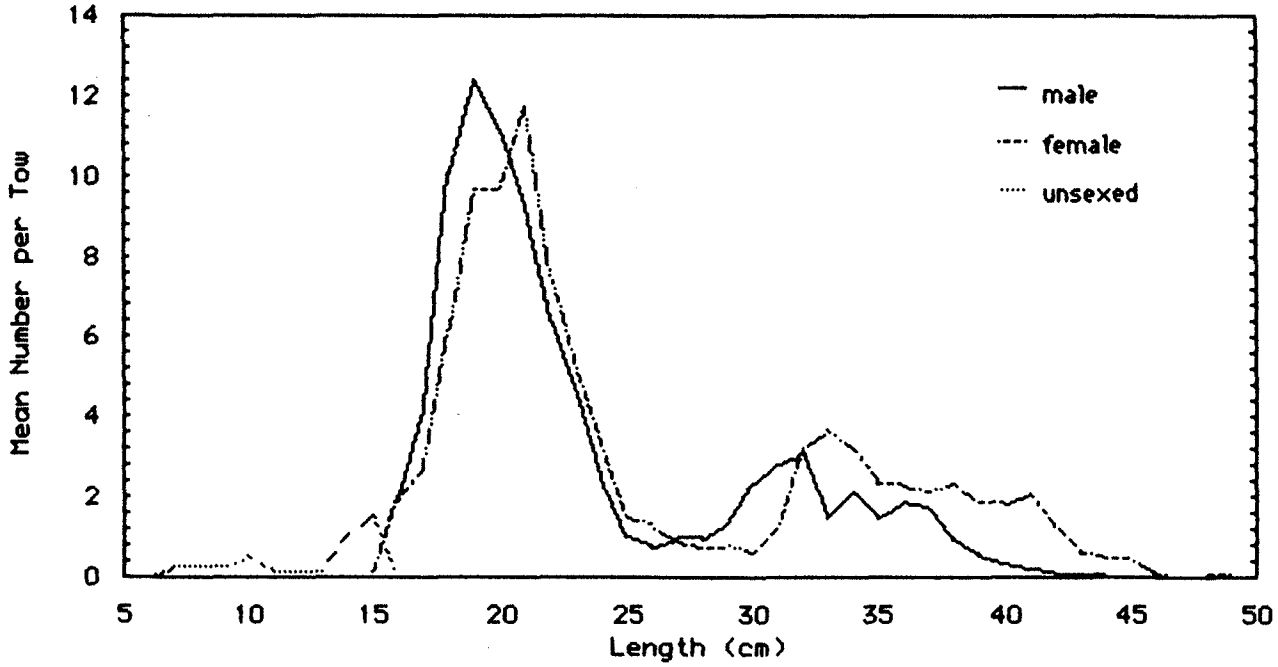
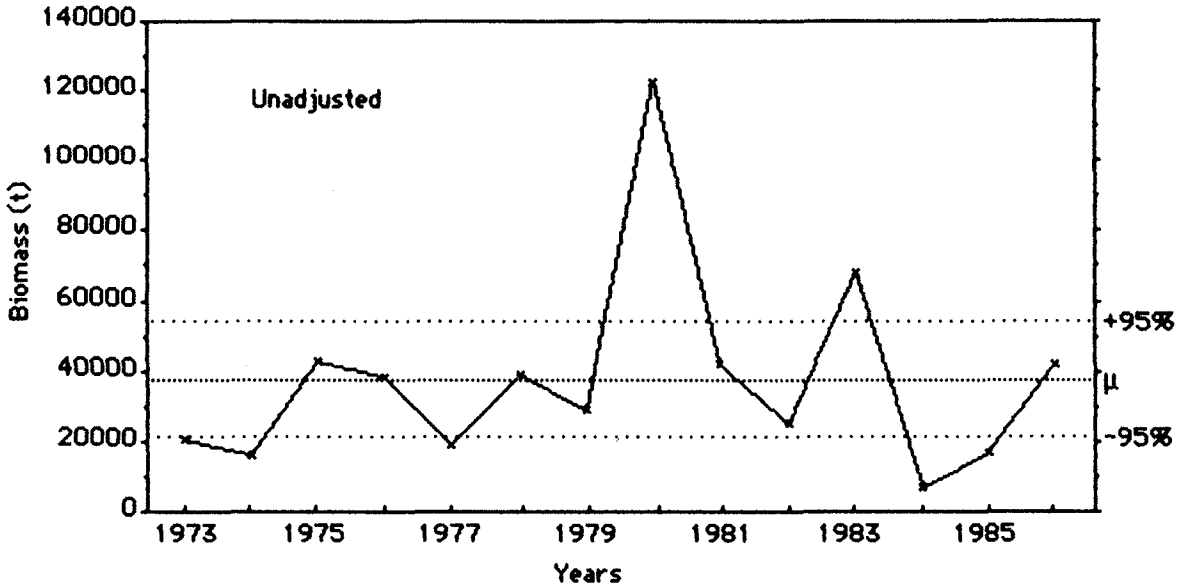


Fig. 14: Mean Numbers of redfish caught per tow at length during a Canadian research cruise to NAFO Division 3P in the spring of 1987.



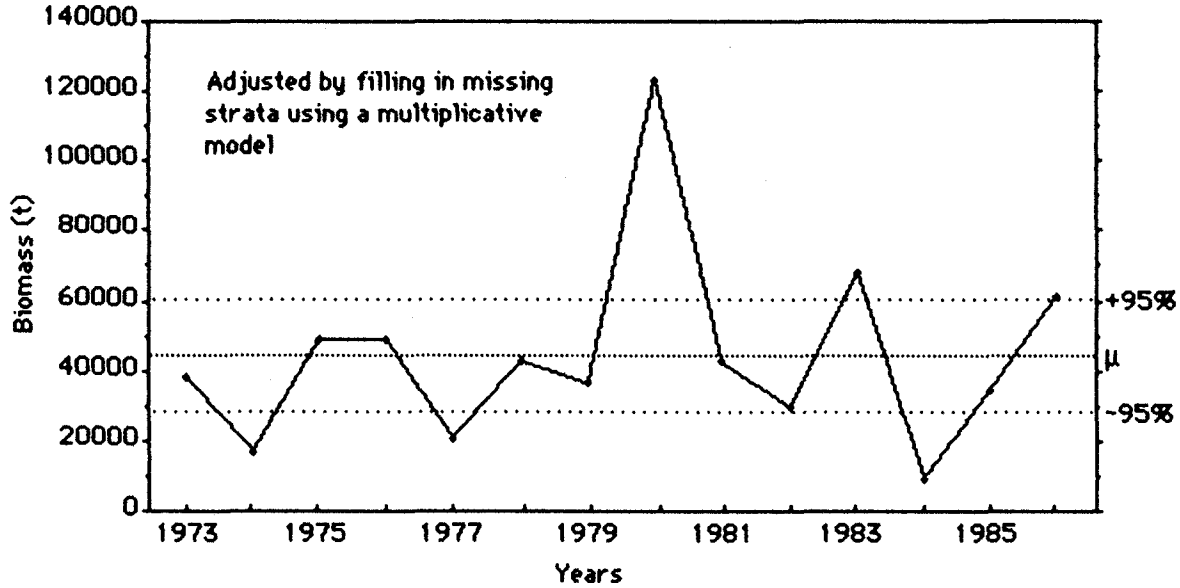


Fig. 15: Annual biomass estimates of redfish in NAFO Div. 3P from Canadian research surveys conducted in the spring.