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An Assessment of the Redfish in NAFO Division 3P

by

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Abstract

The 1987 catch of over 6000 t was only slightly less than that reported for 1986. Unlike in 1986 however, about twice as much was taken in Subdivision 3Pn than in 3Ps. A non-equilibrium model was again used to assess this stock. It indicated a transient yield, in 1989 at $^2/_3$ effort MEY of about 15,000 t. Catchability continues to be below the long term average, however, and this would suggest that an increase in effort would be necessary if this catch is to be achieved as catch rates will be closer to about 0.7 t/hr rather than the 1.1 t/hr suggested by the model. Catch rates should increase over the next number of years with recruitment, to the fishery, of the relatively strong year-classes of the early 1980's.

Résumé

Les prises de 1987 qui s'élevaient à plus de 6 000 t n'étaient que légèrement inférieures à celles enregistrées en 1986. Toutefois contrairement à la situation en 1986, environ deux fois plus de poissons ont été capturées dans la sous-division 3Pn que dans 3Ps. Une version non équilibrée du modèle a de nouveau été utilisée pour évaluer ce stock. Elle a montré un rendement passager, pour 1989, qui correspond à 2/3 de l'effort du RME d'environ 15 000 t. Toutefois, le potentiel de capture continue d'être inférieur à la moyenne à long terme, et cette situation semblerait indiquer qu'il faudrait une augmentation de l'effort si ces prises doivent être atteintes étant donné que les taux de capture seront plus proches de 0,7 t par heure environ que de 1,1 t par heure établis par le modèle. Les taux de capture devraient augmenter au cours des prochaines années avec le recrutement des classes annuelles relativement fortes du début des années 1980.

Introduction

Nominal catches of redfish in NAFO Division 3P have ranged between about 3000 t and 37,000 t during 1959 to 1987 (Table 1, Figure 1). Only about 4000 t was taken in 1959 but catches gradually increased to the peak of about 37,000 t in 1970. Since then catches have again declined. Over the 1959 to 1987 period, landings from Subdivision 3Pn have remained fairly constant while those from Subdiv. 3Ps have fluctuated.

This stock lies completely within the Canadian 200 mi. fishery zone and this is reflected in the fact that catches have almost all been taken by Canadian vessels in recent years (Table 2). Fishing in both subdivisions is spread over the entire year (Table 3).

The TAC was 18,000 t from 1980 through 1987 based on an $F_{0.1}$ (=0.15) catch estimated from a sequential population analysis (SPA) done in 1979. For 1988, the TAC has been lowered to 15,000 t based on the results of a non-equilibrium production analysis carried out in 1987 (Atkinson and Power MS 1987).

Catches by midwater trawls increased from about 150 t in 1986 to over 2300 t in 1987.

Methods and Results

Catch and effort data for the 1959-1985 period were extracted from ICNAF/NAFO Statistical Bulletins in the usual manner. They were combined with preliminary data from NAFO for 1986 and preliminary data from Canada for 1987. As in the past, only catches where redfish comprised >50% of the total were used. Previously (cf. Atkinson and Power MS 1987) all data for side and stern trawlers was grouped so that separation was based on country, tonnage class and bottom or mid-water trawl only. For this assessment, the side and stern trawlers were kept separate. For those data points that could not be categorized as to side or stern from the ICNAF/NAFO statistics, classification was achieved through ICNAF lists of fishing vessels and/or Lloyd's Registry. Observer program data were used to classify those vessels listed as charters.

The resultant dataset was analysed using a multiplicative model (Gavaris 1980) in order to derive standardized catch rate and effort series. Before analysis, 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. Previous discussions have suggested that there is a potential for biases resulting from the grouping of similar category types *a posteriori*. Similarities between categories in the different category types were examined for the revised data set. Because the suggested groupings were quite different from those used in the past (Atkinson and Power MS 1987), no grouping was done in the present analyses. Again, because of unknown amounts of pro-rating possibly existing in the data, the model was run without weighting.

The analysis of variance from the regression (Tables 4a and 4b) indicate that the model explains only about 52% of the variation in the data. Each of the category types is significant. The residual plots (Figures 2a and 2b) do not reveal any drastic outliers. Boxplots of the residuals (Figures 3a, 3b and 3c) do not show any trends either overall, nor in the two subdivisions.

The results (Table 5, Figures 4 and 5) indicate that standardized catch rates peaked in 1966 at about 1 t/hr while standardized effort peaked in 1975 at about 55,000 hours. Recent catch rates have been about 0.5 t/hr with associated effort levels of about 8000-14,000 hours. Catch rates have increased in the last two years.

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. Atkinson and Power (MS 1987) found that the regression of catch rate (CPUE, C/E) on lagged effort (E) (12 years) ($C/E = a + bE$ (eq'n. 1)) was highly significant, and the equilibrium yield at $^2/_3$ effort MEY was 15,140 t. Because the catch and

effort data were treated differently for this assessment, a similar analysis was carried out using the CPUE and effort derived above. Again the regression (using effort lagged 12 years) was significant (Table 6). The resultant equilibrium yield at $^2/_3$ effort MEY was 15,246 t, not different from that estimated in 1987. Analysis of co-variance to test the null hypothesis that no differences exist in the regression lines derived using the 1987 and 1988 assessment data was carried out. F's of <2 (df1=1, df2=31) confirmed acceptance of the null hypothesis (p=0.05). Thus modifications to the catch/effort database have not had any significant effect on the results of traditional general production analyses.

In 1987, CAFSAC expressed concern about the use of equation 1 above since the possibility of serial correlation exists with the effort term (E) occurring in both X and Y. It was therefore recommended that for Schaefer equilibrium general production analyses, $C = aE + bE^2$ (eq'n 2) be used. The data were analysed using this version of the model incorporating unlagged effort data and effort data lagged 6, 8, and 12 years. The results were compared with those derived using the linear model (equation 1) and are as follows.

	LAG (years)							
	None		6		8		12	
	Eq'n 2	Eq'n 1	Eq'n 2	Eq'n 1	Eq'n 2	Eq'n 1	Eq'n 2	Eq'n 1
corr. coeff. r	0.8649	0.064*	0.4592	0.4428	0.292*	0.5463	0.152*	0.6885
f_{MEY} (hr)	141,834		38,515	57,501		46,094		40,968
MEY yield (t)	48,774		20,113	22,955		19,716		17,152
2/3 f_{MEY} (hr)	94,556		25,677	38,334		30,730		27,312
2/3 f_{MEY} yield (t)	43,355		17,879	20,405		17,525		15,246

* indicates regression is not significant (p=0.05)

These results indicate that the linear model (lag of 8 years) and the quadratic model (lag of 6 years) give approximately the same results. Those from the quadratic model using unlagged data are unrealistic. If the quadratic model was to be used in place of the linear model, the effort data could not be lagged 12 years and thus the procedure would suggest a somewhat higher TAC if equilibrium yield at $^2/_3$ effort MEY was used as the criterion along with the idea that some lagging should occur. The results using the quadratic equation and effort data lagged 6 years are shown in Table 7 and Figures 6a and 6b.

As noted above, the 1988 TAC was established based on the results of analyses using the non-equilibrium form (Rivard and Bledsoe 1978) of the Schaefer model (Atkinson and Power MS 1987). This model was again run, first incorporating all of the data including those for 1987. As was done previously (Atkinson and Power MS 1987), input values for B_∞ and MEY of 270,000 t and 18,000 t respectively and a fixed q-value of 0.000007 were used. Convergence was achieved based on change in RSS<0.00001 (Table 8). The model was again run using, as input, the final estimates of B_∞ and MEY derived above and allowing the model to iterate for q as well. There was

convergence (again based on change in RSS) (Table 9) but the derived estimate of B_{∞} (about 700,000 t) was not only unrealistic, but was also poorly estimated, so this run was rejected.

The annual values of q derived from the initial analysis above were examined (Table 10 and Figure 7). It can be seen that the q-values for the periods 1959-1962 and 1985-1987 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 (Table 11). The model was run one more time, using the derived estimates of B_{∞} and MEY derived immediately above and allowing the model to iterate for q. Convergence was achieved after three iterations (based on change in RSS<0.00001). Because the parameter estimates appeared reasonable (Table 12), this last run was selected for further analysis.

The plot of annual q-values (Figure 8) 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 9). The transient path described by the data (Figure 10) 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. The 1987 point is below the equilibrium curve.

Results of this analysis and the equilibrium analysis above (using the quadratic model) can be summarized as follows:

	Non-equilibrium		Equilibrium	
	MEY	2/3 EFFORT MEY	MEY	2/3 EFFORT MEY
EFFORT	20,716	13,810	38,515	25,677
CATCH RATE	1.097	1.463	0.494	0.696
YIELD	22,735	20,209	20,113	17,879

The equilibrium estimates are only slightly lower than those from the non-equilibrium analysis with regard to yield, but the estimates of effort and CPUE are quite different.

Projection of the results from the non-equilibrium analysis indicated that the catch at $^2/_3$ effort MEY (13,810 hours) in 1989 will be 15,075 t. This corresponds to a catch rate of 1.092 t/hr, twice the actual calculated rate for 1987 (0.545 t/hr). The standardized effort in 1987 (11,097 hours) should have resulted in, according to the model, a catch of 10,522 t. The actual reported catch was only 58% of this.

There are only 3 commercial frequencies (Figure 11) available from the Canadian fishery in 1987. There were none from Maritimes vessels fishing in the area. This situation exists, even though CAFSAC, in 1987, noted the poor sampling and recommended that it be increased, especially for Maritimes vessels. These 3 frequencies 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 as well as their mean length- and weight-at-age (Table 13). The weight/length relationships used to calculate the mean weight-at-age are:

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

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

The one frequency from mid-water trawling in Subdiv. 3Pn shows that relatively large fish were taken (mode at about 30-34 cm). In Subdiv. 3Ps a wide range of sizes were caught. The estimated catch-at-age and fish weight-at-age for 1987 were added to the data available from earlier years (Tables 14a and 14b, Figure 13). Relatively small fish were predominant in 1978-1981. There were also relatively large numbers of small fish caught in the 1985-1987 period. Of interest is the persistence of the 1956 and 1958 year-classes from the early 1970's through to the 1980's. It is well known that these year-classes were relatively strong in the Gulf of St. Lawrence and there was either spill-over into Div. 3P, and/or these year-classes were strong here as well. The high catches in the late 1960's and early 1970's are no doubt due to the presence of these strong year classes.

CAFSAC has previously rejected the use of SPA in situations when there is no convergence. Because 15 years of catch-at-age data are available, trial SPA's were done at 3 input values of terminal F (0.05, 0.10 and 0.15) to check for convergence. Since none was evident, SPA was not carried further.

Stratified random surveys have been conducted in Div. 3P by the Newfoundland Region since 1973 but coverage has been variable and often incomplete. A multiplicative model (Gavaris 1980) was used to derive estimates of mean numbers and weights per standard tow for strata not fished in particular years. Only those strata shown as shaded in Figure 14 were included in the analysis as these strata are were redfish are usually found. Because the number of "zero" catches in this area over the period of the surveys was >10% of the total number of sets, the model was run using stratum averages rather than the raw data (R. Myers, DFO, St. John's, Nfld. pers. comm.) and averages were obtained for the missing strata.

The results (Tables 15 and 16, Figures 15 and 16) show a considerable amount of fluctuation from year to year but overall, there appears to have been a downward trend in both numbers and weights per tow up until 1984. This is probably associated with a decline in the 1956 and 1958 year-classes. Since then, there has been an increase, particularly in mean weight. This recent increase may be attributable to growth of the relatively strong year classes of the early 1980's which are present in both subdivisions (Figures 17, 18 and 19). It is interesting that the year-classes of the early 1970's, known to be relatively strong in the Gulf of St. Lawrence, did not appear to be as strong in Subdiv. 3Ps as those of the early 1980's although the increased commercial catch rates in 1982-1984 was surely because of these early 1970's year-classes. The increasing trend in mean weights per tow seen in recent years is reflected in the commercial catch rates which have gradually increased in 1986 and 1987. The continued increase in mean weight per tow between 1987 and 1988 predicts that commercial catch rates will increase again in 1988.

Conclusions

The research survey data indicate a gradual decrease in the stock from the early 1970's to the early 1980's followed by an increase following recruitment of the relatively strong year-classes of the early 1980's. These trends are generally reflected in the commercial catch rates and the research data suggest that catch rates in the fishery will increase further in 1988.

The results of the equilibrium production analysis using the quadratic equation suggest an equilibrium yield at $^2/_3$ effort MEY of about 18,000 t with effort data lagged 6 years. The non-equilibrium production model indicates only a slightly higher yield at $^2/_3$ effort MEY: about 20,000 t. The two models do suggest different equilibrium effort and catch rates however. This may be due to the fact that there are insufficient data to precisely estimate the location of the downward portion of the equilibrium curve and thus MEY effort and $^2/_3$ effort MEY are not well estimated. The transient yield for 1989 derived from the non-equilibrium model is about 15,000 t, the same level as the 1988 TAC.

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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	1,788	1,854	3,642	18,000
1986*	3,427	3,558	6,985	18,000
1987*	4,076	1,975	6,051	18,000
1988				15,000

* Provisional.

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

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986*	1987*
Canada (M)+	2,735	932	743	37	30	108	311	540	860	391	2,064	2,898
Canada (N)	2,925	1,283	2,266	2,676	2,154	3,749	3,508	2,385	1,536	1,187	1,288	1,178
Canada (Q)	-	-	-	384	165	387	-	-	-	-	75	-
France (M)	8	-	1	1	-	11	-	-	-	-	-	-
France (SP)	236	270	32	62	23	1	1	-	-	-	-	-
France	-	-	-	-	-	-	-	4	-	-	-	-
Ireland	28	-	-	-	-	-	-	-	-	-	-	-
TOTAL	5,932	2,485	3,042	3,160	2,372	4,256	3,820	2,929	2,396	1,578	3,427	4,076

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

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

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986*	1987*
Canada (M)+	3,242	3,730	2,592	970	360	391	515	670	396	313	603	366
Canada (N)	7,948	9,489	9,282	5,119	4,609	4,123	1,553	2,316	1,608	1,429	2,867	1,609
Canada (Q)	-	-	-	248	-	-	-	-	-	-	88	-
France (M)	6	8	14	21	112	124	5	-	-	12	-	-
France (SP)	1,071	1,437	315	101	111	47	17	-	-	-	-	-
France	-	-	-	-	-	-	-	10	1	-	-	-
Japan	8	-	-	-	-	-	-	-	-	-	-	-
Portugal	10	-	-	-	-	-	-	-	-	-	-	-
Spain	13	-	-	-	-	-	-	-	-	-	-	-
USSR	911	14	-	-	-	-	-	-	-	-	-	-
Ireland	26	-	-	-	-	-	-	-	-	-	-	-
TOTAL	13,235	14,678	12,203	6,459	5,192	4,685	2,090	2,996	2,005	1,754	3,558	1,975

* 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
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	18	13	101	3	131	272	527	206	135	122	194	1,788
1986*	-	78	217	1,336	861	68	169	94	84	167	281	72	3,427
1987*	374	675	1,863	128	9	51	78	167	47	4	17	663	4,076

* 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
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	32	27	102	50	126	127	361	413	367	150	63	36	1,854
1986*	12	29	683	278	480	426	736	210	325	105	179	95	3,558
1987*	27	32	99	123	167	254	409	241	186	75	74	288	1,975

* Provisional.

Table 4a: ANOVA from the final multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.723
MULTIPLE R SQUARED..... 0.522

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	3.513E2	3.513E2	
REGRESSION	66	2.405E2	3.644E0	23.144
TYPE 1	26	1.523E2	5.858E0	37.203
TYPE 2	11	1.070E1	9.730E-1	6.179
TYPE 3	1	5.337E0	5.337E0	33.897
TYPE 4	28	7.503E1	2.680E0	17.018
RESIDUALS	1397	2.200E2	1.575E-1	
TOTAL	1464	8.118E2		

Table 4b: Coefficients for the different categories from the final multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3114	INTERCEPT	-0.415	0.129	1464
2	7				
3	37				
4	59				
1	2114	1	0.127	0.046	96
	2124	2	0.204	0.166	6
	2125	3	0.484	0.072	35
	2154	4	0.395	0.070	39
	2155	5	0.937	0.072	36
	3124	6	0.053	0.048	96
	3125	7	0.237	0.036	195
	3144	8	0.554	0.087	25
	3154	9	0.380	0.072	36
	3155	10	0.912	0.068	42
	9114	11	-0.422	0.070	38
	9125	12	0.169	0.072	36
	11115	13	0.274	0.157	7
	11116	14	0.628	0.156	7
	11126	15	0.773	0.139	9
	11127	16	0.909	0.184	5
	14127	17	0.869	0.088	24
	16127	18	0.389	0.166	6
	20114	19	-0.519	0.078	32
	20127	20	1.360	0.082	27
	20157	21	1.711	0.140	9
	27114	22	0.115	0.079	32
	27124	23	0.385	0.091	22
	27125	24	0.417	0.069	44
	27155	25	1.097	0.189	5
	28154	26	0.552	0.139	9
2	1	27	-0.009	0.059	66
	2	28	-0.007	0.055	80
	3	29	-0.076	0.050	105
	4	30	-0.139	0.052	92
	5	31	-0.157	0.056	74
	6	32	0.083	0.045	139
	8	33	-0.052	0.043	173
	9	34	-0.109	0.044	156
	10	35	-0.148	0.045	139
	11	36	-0.208	0.046	138
	12	37	-0.204	0.048	116
3	36	38	0.134	0.023	554
4	60	39	-0.131	0.159	17
	61	40	-0.256	0.155	20
	62	41	-0.158	0.147	28
	63	42	0.056	0.138	52
	64	43	0.074	0.150	24
	65	44	0.250	0.147	28
	66	45	0.334	0.141	41
	67	46	0.245	0.141	50
	68	47	0.183	0.141	42
	69	48	0.103	0.139	54
	70	49	0.031	0.137	63
	71	50	-0.114	0.138	61
	72	51	-0.189	0.137	61
	73	52	-0.227	0.136	79
	74	53	-0.384	0.135	86
	75	54	-0.334	0.134	92

Table 4b: Continued.

76	55	-0.569	0.135	85
77	56	-0.517	0.135	80
78	57	-0.516	0.135	78
79	58	-0.611	0.136	80
80	59	-0.417	0.138	58
81	60	-0.566	0.140	48
82	61	-0.362	0.144	39
83	62	-0.158	0.147	35
84	63	-0.334	0.154	24
85	64	-0.478	0.141	50
86	65	-0.372	0.143	40
87	66	-0.267	0.145	39

Table 5: Catch rate and effort derived from the final multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 3114 7 37

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1959	-0.4154	0.0167	0.708	0.091	3783	5341
1960	-0.5459	0.0104	0.624	0.064	9225	14795
1961	-0.6716	0.0093	0.550	0.053	9400	17084
1962	-0.5731	0.0066	0.608	0.049	13438	22101
1963	-0.3594	0.0039	0.754	0.047	13747	18237
1964	-0.3417	0.0076	0.766	0.067	13807	18027
1965	-0.1658	0.0067	0.914	0.075	18733	20506
1966	-0.0815	0.0050	0.995	0.070	20868	20976
1967	-0.1707	0.0049	0.910	0.064	32991	36256
1968	-0.2324	0.0048	0.856	0.059	13884	16228
1969	-0.3122	0.0043	0.790	0.052	32051	40562
1970	-0.3839	0.0038	0.736	0.045	37270	50663
1971	-0.5298	0.0042	0.636	0.041	27500	43264
1972	-0.6044	0.0040	0.590	0.037	26037	44129
1973	-0.6425	0.0035	0.568	0.034	18368	32334
1974	-0.7994	0.0035	0.486	0.029	22158	45631
1975	-0.7499	0.0032	0.510	0.029	28250	55355
1976	-0.9848	0.0034	0.403	0.024	19167	47510
1977	-0.9321	0.0035	0.425	0.025	17163	40359
1978	-0.9314	0.0033	0.426	0.024	15245	35821
1979	-1.0264	0.0034	0.387	0.023	9619	24856
1980	-0.8327	0.0040	0.470	0.030	7564	16108
1981	-0.9812	0.0045	0.405	0.027	8941	22095
1982	-0.7778	0.0056	0.496	0.037	5910	11922
1983	-0.5735	0.0065	0.608	0.049	5925	9749
1984	-0.7493	0.0085	0.509	0.047	4401	8642
1985	-0.8934	0.0048	0.442	0.030	3642	8244
1986	-0.7874	0.0053	0.491	0.036	6985	14225
1987	-0.6823	0.0059	0.545	0.042	6051	11097

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.073

Table 6: ANOVA from general production regressions of standardized commercial catch and effort for redfish in NAFO Division 3P using the linear regression model and effort data lagged 12 years

Variable Name	Coefficient	Std. Err. Estimate	t Statistic	Prob > t
Constant	0.83726406	0.08841589	9.46961117	0.000
Effort lag 12	-0.00001022	0.00000269	-3.79729199	0.002

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Model	0.0694	1	0.0694	14.4194	0.002
Error	0.0770	16	0.0048		
Total	0.1465	17			

Coefficient of Determination	0.4740
Coefficient of Correlation	0.6885
Standard Error of Estimate	0.0694
Durbin-Watson Statistic	1.2315

Table 7: ANOVA from general production regressions of standardized commercial catch and effort for redfish in NAFO Division 3P using the quadratic regression model and effort data lagged 6 years

Variable Name	Coefficient	Std. Err. Estimate	t Statistic	Prob > t
Effort lag 6	1.04445727	0.25948568	4.02510548	0.001
Effort lag 6 ^2	-0.00001356	0.00000687	-1.97442865	0.058

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Model	484114670.5929	1	484114670.5929	5.8783	0.023
Error	1811844619.2404	22	82356573.6018		
Total	2295959289.8333	23			

Coefficient of Determination	0.2109
Coefficient of Correlation	0.4592
Standard Error of Estimate	9288.6121
Durbin-Watson Statistic	0.6351

Table 8: Results of the initial non-equilibrium analysis of catch and effort data for redfish in NAFO Division 3P (all years included, q fixed at 0.000007).

APPROXIMATE STATISTICS FROM LINEAR THEORY

	EST. PAR.	STD. ERR.	T-VALUE
Bo	2.39219E5	2.63890E4	9.06509E0
MSY	1.89203E4	7.08112E2	2.67194E1

CORRELATION MATRIX OF THE ESTIMATED PARAMETERS

1.000000	0.670924
0.670924	1.000000

VARIANCE OF RESIDUALS.....	7327465.503190
R SQUARED.....	0.922590
R-BAR SQUARED.....	0.919723
DURBIN-WATSON STATISTIC.....	0.541890
ORTHOGONALITY OFFSET.....	0.002271

YEAR	BIOMASS	ADJ. LEVEL	YIELD	PRED. YIELD	RESIDUALS
1959	107,240	211,296	3,783	4,283	-500
1960	122,007	161,720	9,225	12,930	-3,705
1961	128,115	149,716	9,400	15,482	-6,082
1962	131,553	123,407	13,438	20,167	-6,729
1963	130,247	143,670	13,747	16,690	-2,943
1964	132,406	144,771	13,807	16,750	-2,943
1965	134,424	131,771	18,733	19,154	-421
1966	133,989	129,306	20,868	19,497	1,371
1967	133,224	49,178	32,991	31,874	1,117
1968	120,175	154,205	13,884	13,853	31
1969	125,320	26,597	32,051	33,204	-1,153
1970	110,954	0	37,270	35,812	1,458
1971	93,508	12,428	27,500	26,660	840
1972	84,444	7,892	26,037	24,599	1,438
1973	76,652	69,745	18,368	17,086	1,282
1974	75,983	15	22,158	22,844	-686
1975	68,988	0	28,250	24,437	3,813
1976	59,181	0	19,167	18,558	609
1977	54,158	27,662	17,163	14,807	2,356
1978	52,341	51,459	15,245	12,897	2,348
1979	52,281	108,960	9,619	9,272	347
1980	56,241	154,834	7,564	6,638	926
1981	63,831	123,438	8,941	10,063	-1,122
1982	68,884	176,786	5,910	6,046	-136
1983	79,022	188,181	5,925	5,675	250
1984	90,710	193,986	4,401	5,752	-1,351
1985	103,251	196,073	3,642	6,207	-2,565
1986	115,884	164,709	6,985	11,694	-4,709
1987	123,085	181,112	6,051	9,758	-3,707
1988	132,181				

Table 9: Results of a non-equilibrium analysis of catch and effort data for redfish in NAFO Division 3P (all years included, model allowed to iterate for q).

APPROXIMATE STATISTICS FROM LINEAR THEORY

	EST. PAR.	STD. ERR.	T-VALUE
B_0	7.07563E5	5.13469E5	1.37800E0
MSY	2.10345E4	7.88949E3	2.66614E0
q	3.92683E-6	5.75529E-7	6.82299E0

CORRELATION MATRIX OF THE ESTIMATED PARAMETERS

1.000000	0.970150	-0.714901
0.970150	1.000000	-0.529071
-0.714901	-0.529071	1.000000

VARIANCE OF RESIDUALS.....	3830407.545408
R SQUARED.....	0.961033
R-BAR SQUARED.....	0.958035
DURBIN-WATSON STATISTIC.....	0.838976
ORTHOGONALITY OFFSET.....	0.000756

YEAR	BIOMASS	ADJ. LEVEL	YIELD	PRED. YIELD	RESIDUALS
1959	189,276	581,502	3,783	4,143	-360
1960	201,959	358,400	9,225	12,006	-2,781
1961	207,247	304,383	9,400	14,160	-4,760
1962	210,599	185,989	13,438	18,435	-4,997
1963	209,745	277,174	13,747	15,273	-1,526
1964	212,093	282,130	13,807	15,274	-1,467
1965	214,560	223,629	18,733	17,493	1,240
1966	214,881	212,537	20,868	17,911	2,957
1967	214,798	0	32,991	30,058	2,933
1968	202,306	324,584	13,884	13,198	686
1969	206,435	0	32,051	32,111	-60
1970	191,448	0	37,270	36,568	702
1971	171,087	0	27,500	28,394	-894
1972	157,886	0	26,037	26,743	-706
1973	145,516	0	18,368	18,518	-150
1974	140,739	0	22,158	24,665	-2,507
1975	129,305	0	28,250	27,043	1,207
1976	114,558	0	19,167	20,935	-1,768
1977	104,913	0	17,163	16,550	613
1978	98,974	0	15,245	14,003	1,242
1979	95,144	120,974	9,619	9,554	65
1980	95,554	327,415	7,564	6,329	1,235
1981	99,320	186,130	8,941	8,917	24
1982	100,767	426,199	5,910	4,982	928
1983	106,382	477,479	5,925	4,317	1,608
1984	113,164	503,603	4,401	4,077	324
1985	120,762	512,995	3,642	4,150	-508
1986	128,904	371,852	6,985	7,546	-561
1987	134,216	445,668	6,051	6,164	-113
1988	141,345				

Table 10: Estimates of annual q and fishing mortality (F) from a non-equilibrium analysis of catch and effort data for redfish in NAFO Division 3P (all years included, q fixed at 0.000007).

YEAR	Q	RESIDUAL	ACTUAL F	AVERAGE F
1959	6.60475E-6	-3.95248E-7	0.04	0.04
1960	5.11055E-6	-1.88945E-6	0.08	0.10
1961	4.29475E-6	-2.70525E-6	0.07	0.12
1962	4.62190E-6	-2.37810E-6	0.10	0.15
1963	5.78742E-6	-1.21258E-6	0.11	0.13
1964	5.78453E-6	-1.21547E-6	0.10	0.13
1965	6.79596E-6	-2.04040E-7	0.14	0.14
1966	7.42490E-6	4.24897E-7	0.16	0.15
1967	6.83021E-6	-1.69794E-7	0.25	0.25
1968	7.11930E-6	1.19299E-7	0.12	0.11
1969	6.30527E-6	-6.94734E-7	0.26	0.28
1970	6.63016E-6	-3.69844E-7	0.34	0.35
1971	6.79762E-6	-2.02376E-7	0.29	0.30
1972	6.98712E-6	-1.28822E-8	0.31	0.31
1973	7.41101E-6	4.11008E-7	0.24	0.23
1974	6.39076E-6	-6.09242E-7	0.29	0.32
1975	7.39760E-6	3.97596E-7	0.41	0.39
1976	6.81693E-6	-1.83070E-7	0.32	0.33
1977	7.85215E-6	8.52151E-7	0.32	0.28
1978	8.13112E-6	1.13112E-6	0.29	0.25
1979	7.40206E-6	4.02064E-7	0.18	0.17
1980	8.34938E-6	1.34938E-6	0.13	0.11
1981	6.33962E-6	-6.60383E-7	0.14	0.15
1982	7.19650E-6	1.96499E-7	0.09	0.08
1983	7.69092E-6	6.90918E-7	0.07	0.07
1984	5.61409E-6	-1.38591E-6	0.05	0.06
1985	4.27867E-6	-2.72133E-6	0.04	0.06
1986	4.23731E-6	-2.76269E-6	0.06	0.10
1987	4.43012E-6	-2.56988E-6	0.05	0.08

Table 11: Results of a non-equilibrium analysis of catch and effort data for redfish in NAFO Division 3P (1963-1984 only, q fixed at 0.000007).

APPROXIMATE STATISTICS FROM LINEAR THEORY

	EST. PAR.	STD. ERR.	T-VALUE
B_{∞}	3.00331E5	3.61424E4	8.30966E0
MSY	2.25321E4	1.33930E3	1.68237E1

CORRELATION MATRIX OF THE ESTIMATED PARAMETERS

1.000000	0.977722
0.977722	1.000000

VARIANCE OF RESIDUALS.....	1805001.795799
R SQUARED.....	0.980792
R-BAR SQUARED.....	0.979831
DURBIN-WATSON STATISTIC.....	1.879596
ORTHOGONALITY OFFSET.....	0.000000

YEAR	BIOMASS	ADJ. LEVEL	YIELD	PRED. YIELD	RESIDUALS
1963	106,820	173,837	13,747	14,078	-331
1964	113,885	175,294	13,807	14,770	-963
1965	120,744	158,099	18,733	17,579	1,154
1966	125,103	154,839	20,868	18,540	2,328
1967	128,678	48,855	32,991	31,234	1,757
1968	119,300	187,772	13,884	13,912	-28
1969	127,315	18,988	32,051	34,044	-1,993
1970	114,876	0	37,270	37,287	-17
1971	98,028	247	27,500	28,032	-532
1972	89,224	0	26,037	26,026	11
1973	81,399	76,059	18,368	18,150	218
1974	80,979	0	22,158	24,338	-2,180
1975	73,694	0	28,250	26,063	2,187
1976	63,222	0	19,167	19,771	-604
1977	57,754	20,396	17,163	15,739	1,424
1978	55,677	51,873	15,245	13,672	1,573
1979	55,469	127,927	9,619	9,804	-185
1980	59,555	188,604	7,564	7,010	554
1981	67,568	147,078	8,941	10,630	-1,689
1982	73,012	217,639	5,910	6,399	-489
1983	84,023	232,711	5,925	6,031	-106
1984	96,995	240,389	4,401	6,154	-1,753
1985	111,297				

Table 12: Results of a non-equilibrium analysis of catch and effort data for redfish in NAFO Division 3P (1963-1984 only, model allowed to iterate for q).

APPROXIMATE STATISTICS FROM LINEAR THEORY

	EST. PAR.	STD. ERR.	T-VALUE
B_∞	3.35941E5	8.05645E4	4.16984E0
MSY	2.27347E4	1.81460E3	1.25288E1
q	6.53371E-6	6.97673E-7	9.36500E0

CORRELATION MATRIX OF THE ESTIMATED PARAMETERS

1.000000	0.802089	-0.788524
0.802089	1.000000	-0.278932
-0.788524	-0.278932	1.000000

VARIANCE OF RESIDUALS.....	1856953.113331
R SQUARED.....	0.981227
R-BAR SQUARED.....	0.979251
DURBIN-WATSON STATISTIC.....	1.866227
ORTHOGONALITY OFFSET.....	0.001057

YEAR	BIOMASS	ADJ. LEVEL	YIELD	PRED. YIELD	RESIDUALS
1963	113,309	186,581	13,747	14,036	-289
1964	119,882	188,301	13,807	14,654	-847
1965	126,345	168,001	18,733	17,387	1,346
1966	130,441	164,152	20,868	18,309	2,559
1967	133,847	39,030	32,991	30,916	2,075
1968	124,483	203,032	13,884	13,774	110
1969	132,203	3,770	32,051	33,760	-1,709
1970	119,820	0	37,270	37,259	11
1971	102,816	0	27,500	28,171	-671
1972	93,607	0	26,037	26,221	-184
1973	85,336	71,146	18,368	18,268	100
1974	84,398	0	22,158	24,474	-2,316
1975	76,729	0	28,250	26,300	1,950
1976	65,916	0	19,167	20,003	-836
1977	60,031	5,432	17,163	15,896	1,267
1978	57,507	42,592	15,245	13,746	1,499
1979	56,835	132,381	9,619	9,780	-161
1980	60,318	204,015	7,564	6,912	652
1981	67,529	154,989	8,941	10,374	-1,433
1982	72,321	238,292	5,910	6,183	-273
1983	82,342	256,086	5,925	5,768	157
1984	94,268	265,151	4,401	5,837	-1,436
1985	107,612				

Table 13: Estimated catch and average weights at age from the commercial fishery for redfish in NAFO Division 3P in 1987.

	average		catch		
age	weight	length	mean	std. err.	c. v.
* 6	0.069	16.690	9	4.13	0.49
* 7	0.112	19.686	216	40.33	0.19
8	0.157	22.034	697	83.49	0.12
9	0.198	23.796	1234	108.83	0.09
10	0.228	24.941	595	85.46	0.14
11	0.282	26.788	285	58.55	0.21
12	0.302	27.456	265	58.98	0.22
13	0.324	28.140	326	66.72	0.20
14	0.348	28.807	421	95.65	0.23
15	0.377	29.625	627	123.31	0.20
16	0.427	30.836	878	158.57	0.18
17	0.464	31.657	1175	192.76	0.16
18	0.496	32.332	866	168.63	0.19
19	0.545	33.341	919	186.84	0.20
20	0.566	33.752	718	166.60	0.23
21	0.548	33.392	657	160.26	0.24
22	0.584	34.118	428	124.13	0.29
23	0.670	35.762	269	100.74	0.37
24	0.665	35.564	365	108.14	0.30
25	0.722	36.633	400	116.18	0.29
26	0.749	37.140	335	96.25	0.29
27	0.850	38.549	237	88.59	0.37
28	0.781	37.533	181	86.14	0.48
29	0.817	38.267	82	45.51	0.55
*30	0.996	40.605	428	95.82	0.22

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 14: Estimates of the numbers of redfish caught at age along with the average weight-at-age during the commercial redfish fishery in NAFO Division 3P.

a) Numbers-at-age

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	13	102	393	39	262	1272	437	198	9	3	9	65	1423	223	9
7	11	867	681	53	500	3939	1501	1014	231	12	12	339	623	1146	216
8	16	1818	1832	249	508	6992	2687	1845	1751	85	9	365	342	1196	697
9	8	1596	866	549	805	7014	2842	2469	2172	262	67	427	332	450	1234
10	20	1481	477	365	850	4944	1597	2004	1905	280	217	1172	49	289	595
11	531	1774	1090	410	791	2240	891	1591	1518	679	267	2149	84	336	285
12	994	1356	611	478	989	1947	1014	1266	1396	959	465	1407	126	371	265
13	3046	3491	996	936	865	814	710	653	1499	1056	693	1197	147	327	326
14	6039	2964	1101	1058	1041	1031	706	833	717	1473	1101	964	178	456	421
15	9222	3075	2163	1013	1465	1104	493	601	585	1167	1225	755	512	605	627
16	5808	7425	3543	1698	808	881	446	325	434	1053	1301	793	910	1099	878
17	7228	2517	8265	1062	1322	752	599	380	393	513	1081	657	973	1025	1175
18	1824	3809	5923	3927	1024	1014	545	320	343	361	1357	688	864	1337	866
19	869	1030	11826	1793	2708	810	528	327	451	261	705	388	415	1133	919
20	1138	1285	2957	5998	1518	1789	651	331	423	169	653	244	433	1315	718
21	583	679	2278	1383	4745	494	1015	445	323	211	556	177	185	657	657
22	381	1507	2040	2256	2323	1458	672	840	576	232	394	138	202	310	428
23	400	2734	1724	1850	2442	988	1256	503	990	217	311	126	118	443	269
24	479	1367	775	1238	2069	1026	727	827	589	338	312	138	212	193	365
25	166	2081	1182	2145	1103	1001	1047	501	1153	440	311	152	174	350	400
26	2	1829	976	1525	630	640	687	509	777	644	251	310	166	364	335
27	2	2	674	820	403	505	451	248	733	432	495	113	319	548	237
28	2	2	2	544	313	322	343	298	508	460	289	142	334	557	181
29	2	2	2	2	294	178	206	178	419	383	306	55	303	412	82

b) Average weights-at-age

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.113	0.060	0.076	0.082	0.066	0.071	0.069
7	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.137	0.098	0.114	0.113	0.088	0.095	0.112
8	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.184	0.164	0.148	0.145	0.125	0.157
9	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.220	0.220	0.214	0.176	0.183	0.209	0.198
10	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.266	0.266	0.258	0.202	0.231	0.249	0.228
11	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.290	0.326	0.269	0.234	0.232	0.276	0.282
12	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.340	0.361	0.318	0.275	0.243	0.287	0.302
13	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.355	0.373	0.347	0.308	0.273	0.328	0.324
14	0.406	0.406	0.406	0.406	0.406	0.406	0.406	0.406	0.417	0.396	0.376	0.346	0.287	0.371	0.348
15	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.426	0.416	0.394	0.350	0.376	0.398	0.377
16	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.465	0.441	0.412	0.404	0.420	0.433	0.427
17	0.516	0.516	0.516	0.516	0.516	0.516	0.516	0.516	0.515	0.514	0.454	0.417	0.476	0.471	0.464
18	0.553	0.553	0.553	0.553	0.553	0.553	0.553	0.553	0.541	0.518	0.464	0.457	0.472	0.536	0.496
19	0.587	0.587	0.587	0.587	0.587	0.587	0.587	0.587	0.621	0.573	0.490	0.519	0.513	0.544	0.545
20	0.621	0.621	0.621	0.621	0.621	0.621	0.621	0.621	0.625	0.599	0.495	0.538	0.553	0.581	0.566
21	0.657	0.657	0.657	0.657	0.657	0.657	0.657	0.657	0.601	0.655	0.533	0.575	0.574	0.650	0.548
22	0.688	0.688	0.688	0.688	0.688	0.688	0.688	0.688	0.650	0.665	0.579	0.544	0.602	0.739	0.584
23	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.652	0.699	0.606	0.627	0.534	0.689	0.670
24	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.707	0.678	0.673	0.598	0.632	0.786	0.665
25	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.726	0.707	0.684	0.638	0.648	0.696	0.722
26	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.784	0.745	0.740	0.673	0.657	0.719	0.749
27	0.913	0.913	0.913	0.913	0.913	0.913	0.913	0.913	0.811	0.850	0.711	0.795	0.686	0.730	0.850
28	0.948	0.948	0.948	0.948	0.948	0.948	0.948	0.948	0.872	0.820	0.820	0.780	0.713	0.765	0.781
29	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.883	0.932	0.845	0.854	0.764	0.800	0.817

Table 15: Mean numbers of redfish caught per standard tow in Division 3P during Canadian research surveys, 1973-1988.
(Numbers in brackets are number of successful sets, • indicates those strata estimated with the multiplicative model)
(STRAP is stratified random estimate; SMA is estimate derived by combining STRAP with multiplicative analysis results)

Stratum	1973 ATC	1974 ATC	1975 ATC	1976 ATC	1977 ATC	1978 ATC	1979 ATC	1980 ATC
302	186.45 •	238.33 •	349.62 •	296.61 •	229.41 •	219.50 •	149.83 •	24.75 •
303	2075.94 •	2653.53 •	3892.72 •	3302.37 •	2554.12 •	2444.04 •	1668.35 •	84.21 (2)
304	2236.44 •	2858.69 •	4193.67 •	3557.68 •	2751.59 •	2633.00 •	1797.33 •	601.22 (2)
305	549.89 •	702.88 •	1031.13 •	874.75 •	676.55 •	647.39 •	441.92 •	36.17 (3)
306	1813.27 •	573.67 (6)	3198.00 (6)	4797.50 (2)	2159.20 (6)	2177.33 (6)	408.40 (5)	165.71 (2)
307	288.80 (5)	200.71 (7)	4067.03 (4)	1861.25 (4)	1252.50 (4)	234.25 (4)	20.50 (4)	12.38 (2)
309	3647.00 (3)	1386.75 (4)	8421.66 (6)	4500.33 (3)	1955.48 (6)	1019.33 (6)	2540.33 (6)	3908.91 (2)
310	95.00 (1)	175.00 (3)	2981.52 (6)	13340.00 (1)	110.50 (6)	622.33 (6)	316.00 (6)	35.64 (2)
311	3.78 (9)	495.00 (8)	7.00 (4)	805.67 (6)	1022.00 (4)	0.00 (4)	19.50 (4)	0.00 (2)
313	1.50 (2)	133.00 (5)	1010.33 (3)	833.33 (3)	78.90 (10)	130.00 (2)	80.00 (5)	15.55 (2)
316	228.33 (3)	150.00 (6)	165.00 (1)	1368.25 (4)	86.42 (6)	119.00 (6)	110.67 (3)	51.30 (2)
317	1.57 (7)	217.62 (8)	558.00 (4)	466.50 (4)	691.37 (4)	3.25 (4)	16.33 (3)	3.40 (2)
318	999.00 (1)	169.50 (2)	2034.29 (4)	1430.00 (2)	228.00 (6)	480.50 (2)	292.50 (2)	94.89 (2)
319	174.20 (5)	411.00 (2)	432.43 (4)	92.25 (4)	83.17 (6)	1241.00 (4)	156.00 (2)	0.79 (4)
705	476.50 (2)	56.75 (4)	154.94 (2)	69.50 (2)	79.50 (4)	251.67 (3)	73.50 (4)	62.65 (2)
706	640.00 (2)	226.57 (7)	175.00 (1)	24.00 (1)	112.28 (4)	71.00 (2)	312.00 (3)	26.33 (2)
707	758.77 •	590.00 (2)	785.25 (4)	596.50 (2)	210.01 (4)	649.50 (2)	740.50 (2)	38.82 (2)
708	653.87 •	835.81 •	185.00 (3)	1040.18 •	364.21 (4)	473.00 (1)	592.50 (2)	15.43 (2)
709	7.45 •	9.52 •	13.95 •	11.84 •	9.16 •	8.76 •	5.98 •	0.99 •
710	11.54 •	14.75 •	21.63 •	18.36 •	14.20 •	13.58 •	9.27 •	1.53 •
711	272.08 •	347.78 •	510.07 •	432.82 •	334.74 •	320.25 •	218.58 •	15.66 (2)
712	294.37 •	376.27 •	551.87 •	468.27 •	362.16 •	346.57 •	104.00 (2)	40.18 (2)
713	202.76 •	259.18 •	39.43 (3)	322.55 •	249.46 •	238.66 •	162.89 •	10.44 (2)
714	310.34 •	396.69 •	581.71 •	493.69 •	381.82 •	127.00 (2)	145.00 (1)	41.09 (2)
715	588.00 (1)	62.75 (4)	318.00 (2)	655.00 (2)	124.00 (4)	343.75 (4)	717.00 (3)	472.84 (2)
716	412.00 (1)	108.00 (3)	648.46 •	18.00 (1)	127.50 (6)	473.50 (4)	173.00 (4)	22.02 (2)
Mean STRAP	563.07	357.37	1561.39	1497.04	585.02	566.71	313.01	906.95
SMA	568.33	514.91	1188.03	1152.42	599.32	598.27	355.72	154.51

Table 15: (cont.)

Stratum	1981 ATC	1982 ATC	1983 Needler	1984 Needler	1985 Templeman	1986 Templeman	1987 Templeman	1988 Templeman
302	126.39 •	89.05 •	42.00 (3)	36.87 •	102.63 •	137.50 (2)	104.50 (2)	47.00 (2)
303	1939.33 (3)	991.66 •	881.25 (4)	410.47 •	1142.96 •	481.00 (4)	1258.67 (3)	274.33 (3)
304	139.00 (2)	1068.33 •	3229.00 (3)	442.20 •	1231.32 •	854.50 (2)	1468.00 (2)	536.00 (2)
305	124.00 (5)	262.68 •	59.83 (6)	108.73 •	302.75 •	125.00 (1)	686.00 (2)	283.67 (6)
306	1830.67 (3)	934.67 (3)	421.50 (4)	15.50 (2)	313.00 (2)	623.67 (3)	231.25 (4)	493.50 (4)
307	924.67 (3)	150.00 (4)	121.25 (4)	127.00 (2)	53.33 (3)	17.00 (3)	36.33 (3)	44.50 (4)
309	7772.50 (2)	522.00 (2)	981.33 (3)	50.50 (2)	453.00 (3)	618.50 (2)	1142.50 (2)	535.00 (3)
310	252.50 (2)	5677.00 (3)	547.00 (3)	70.50 (2)	1225.33 (3)	303.00 (2)	33.50 (2)	801.33 (3)
311	6.50 (2)	7.67 (3)	0.00 (3)	41.00 (2)	11.00 (4)	0.00 (3)	0.00 (3)	1.50 (4)
313	187.00 (2)	4397.00 (2)	829.33 (3)	35.00 (2)	1033.50 (2)	988.00 (2)	150.50 (2)	181.00 (2)
316	175.00 (2)	457.00 (1)	653.75 (4)	127.00 (2)	140.00 (3)	57.50 (2)	313.67 (3)	210.00 (3)
317	1.00 (2)	112.00 (3)	7980.66 (3)	882.50 (2)	0.00 (2)	0.00 (2)	0.00 (3)	2.00 (2)
318	983.88 •	6077.00 (2)	1688.33 (3)	138.00 (2)	799.72 •	958.00 (2)	5547.50 (2)	58.50 (2)
319	8455.00 (2)	260.57 (7)	27.29 (7)	11.67 (6)	0.00 (2)	15.88 (8)	9.11 (9)	98.38 (8)
705	162.00 (2)	644.00 (2)	5.67 (3)	28.50 (2)	78.00 (2)	424.00 (2)	247.50 (2)	121.00 (2)
706	86.00 (2)	118.00 (4)	77.80 (5)	75.00 (2)	465.25 (4)	308.25 (4)	181.92 (5)	429.75 (4)
707	512.19 •	361.39 •	306.33 (3)	226.00 (2)	416.28 •	265.50 (2)	200.50 (2)	634.00 (2)
708	441.83 •	311.66 •	722.00 (2)	113.00 (2)	359.05 •	278.75 (2)	354.50 (2)	432.50 (2)
709	5.04 •	3.55 •	0.50 (2)	4.50 (2)	4.09 •	0.00 (1)	14.00 (1)	7.83 •
710	7.81 •	5.51 •	3.75 (3)	1.00 (2)	8.00 (2)	78.00 (2)	7.24 •	114.50 (2)
711	32.50 (2)	11.50 (2)	68.13 (8)	20.40 (5)	121.75 (8)	280.78 (9)	154.00 (7)	181.43 (7)
712	150.50 (2)	23.00 (3)	67.86 (7)	58.19 •	44.33 (6)	120.78 (9)	117.00 (4)	115.71 (7)
713	65.33 (6)	11.50 (2)	23.71 (7)	40.08 •	55.50 (8)	66.80 (5)	197.00 (4)	954.43 (7)
714	50.50 (8)	39.67 (6)	62.30 (10)	61.34 •	69.00 (1)	89.40 (5)	66.25 (4)	488.33 (9)
715	1015.50 (2)	20.00 (2)	71.33 (3)	43.50 (2)	2448.00 (1)	569.00 (2)	463.00 (2)	307.50 (2)
716	207.75 (4)	122.00 (2)	54.50 (4)	18.67 (3)	84.60 (5)	207.00 (4)	226.00 (3)	240.80 (5)
Mean STRAP	1368.86	432.14	376.57	74.04	164.03	227.89	331.63	323.34
SMA	1297.38	439.73	377.07	90.08	259.57	219.44	328.16	320.89

Table 16: Mean weight of redfish caught per standard tow in Division 3P during Canadian research surveys, 1973-1988.
(Numbers in brackets are number of successful sets, • indicates those strata estimated with the multiplicative model)
(STRAP is stratified random estimate; SMA is estimate derived by combining STRAP with multiplicative analysis results)

Stratum	1973 ATC	1974 ATC	1975 ATC	1976 ATC	1977 ATC	1978 ATC	1979 ATC	1980 ATC
302	21.21 •	25.60 •	36.57 •	27.54 •	21.01 •	27.51 •	18.17 •	9.45 •
303	339.93 •	410.23 •	586.19 •	441.45 •	336.67 •	440.95 •	291.24 •	84.21 (2)
304	507.42 •	612.36 •	875.02 •	658.96 •	502.56 •	658.22 •	434.74 •	601.22 (2)
305	197.94 •	238.87 •	341.33 •	257.05 •	196.04 •	256.76 •	169.58 •	36.17 (3)
306	158.38 •	56.09 (6)	175.99 (6)	322.96 (2)	137.59 (6)	298.47 (6)	48.90 (5)	165.71 (2)
307	12.25 (5)	8.55 (7)	34.34 (4)	58.91 (4)	47.29 (4)	17.69 (4)	3.06 (4)	12.38 (2)
309	541.59 (3)	135.85 (4)	666.33 (6)	666.03 (3)	224.35 (6)	108.48 (6)	337.55 (6)	3908.91 (2)
310	2.27 (1)	34.62 (3)	256.09 (6)	835.36 (1)	29.22 (6)	96.61 (6)	59.35 (6)	35.64 (2)
311	0.30 (9)	30.53 (8)	0.11 (4)	17.69 (6)	61.12 (4)	0.00 (4)	3.69 (4)	0.00 (2)
313	0.90 (2)	16.51 (5)	153.62 (3)	127.61 (3)	12.60 (10)	24.94 (2)	11.25 (5)	15.55 (2)
316	25.71 (3)	20.26 (6)	82.00 (1)	290.30 (4)	13.61 (6)	14.17 (6)	10.89 (3)	51.30 (2)
317	0.52 (7)	16.22 (8)	49.05 (4)	8.16 (4)	41.94 (4)	0.21 (4)	1.74 (3)	3.40 (2)
318	97.16 (1)	23.13 (2)	373.83 (4)	198.90 (2)	32.51 (6)	56.70 (2)	22.46 (2)	94.89 (2)
319	12.91 (5)	64.41 (2)	70.35 (4)	8.96 (4)	5.62 (6)	86.64 (4)	6.58 (2)	0.79 (4)
705	241.31 (2)	19.28 (4)	90.15 (2)	25.40 (2)	22.34 (4)	115.21 (3)	44.03 (4)	62.65 (2)
706	91.17 (2)	53.27 (7)	39.38 (1)	18.16 (1)	31.91 (4)	28.12 (2)	60.18 (3)	26.33 (2)
707	153.71 •	93.89 (2)	237.12 (4)	121.79 (2)	58.59 (4)	100.24 (2)	126.60 (2)	38.82 (2)
708	168.47 •	203.31 •	82.25 (3)	218.79 •	124.44 (4)	87.17 (1)	201.03 (2)	15.43 (2)
709	2.57 •	3.10 •	4.43 •	3.34 •	2.55 •	3.33 •	2.20 •	1.14 •
710	7.81 •	9.43 •	13.47 •	10.15 •	7.74 •	10.13 •	6.69 •	3.48 •
711	86.62 •	104.53 •	149.34 •	112.49 •	85.79 •	112.34 •	74.19 •	15.66 (2)
712	145.66 •	175.78 •	251.14 •	189.15 •	144.26 •	188.94 •	83.91 (2)	40.18 (2)
713	103.04 •	124.35 •	30.50 (3)	133.81 •	102.05 •	133.64 •	88.26 •	10.44 (2)
714	154.15 •	186.03 •	265.74 •	200.18 •	152.67 •	89.36 (2)	110.67 (1)	41.09 (2)
715	201.40 (1)	26.99 (4)	99.79 (2)	159.66 (2)	39.12 (4)	70.31 (4)	383.81 (3)	472.84 (2)
716	258.55 (1)	25.93 (3)	158.26 •	4.99 (1)	32.66 (6)	155.13 (4)	73.26 (4)	22.02 (2)
Mean STRAP	85.21	45.66	125.20	145.52	52.40	89.19	67.64	159.57
SMA	135.63	123.50	193.56	173.56	106.62	136.60	94.74	153.63

Table 16: (cont.)

Stratum	1981 ATC	1982 ATC	1983 Needler	1984 Needler	1985 Templeman	1986 Templeman	1987 Templeman	1988 Templeman
302	14.61 •	7.20 •	11.40 (3)	6.53 •	8.46 •	14.75 (2)	10.25 (2)	8.40 (2)
303	178.67 (3)	115.32 •	383.25 (4)	104.59 •	135.55 •	87.00 (4)	184.17 (3)	100.17 (3)
304	42.75 (2)	172.14 •	2265.33 (3)	156.12 •	202.34 •	209.00 (2)	238.25 (2)	112.00 (2)
305	68.00 (5)	67.15 •	48.00 (6)	60.90 •	78.93 •	43.50 (1)	382.65 (2)	155.92 (6)
306	44.93 (3)	54.93 (3)	81.13 (4)	3.51 (2)	37.00 (2)	39.67 (3)	24.63 (4)	190.77 (4)
307	21.17 (3)	4.05 (4)	49.00 (4)	69.25 (2)	3.70 (3)	2.00 (3)	5.67 (3)	3.95 (4)
309	264.50 (2)	42.50 (2)	101.92 (3)	12.25 (2)	85.33 (3)	69.25 (2)	127.00 (2)	86.17 (3)
310	17.50 (2)	529.11 (3)	34.67 (3)	4.75 (2)	95.83 (3)	43.00 (2)	4.00 (2)	46.17 (3)
311	1.50 (2)	0.17 (3)	0.00 (3)	4.00 (2)	1.97 (4)	0.00 (3)	0.00 (3)	0.05 (4)
313	29.00 (2)	158.50 (2)	44.33 (3)	3.50 (2)	89.50 (2)	93.75 (2)	20.25 (2)	31.00 (2)
316	21.00 (2)	36.50 (1)	55.88 (4)	9.75 (2)	12.83 (3)	10.50 (2)	40.50 (3)	24.33 (3)
317	0.25 (2)	1.07 (3)	110.70 (3)	31.25 (2)	0.00 (2)	0.00 (2)	0.00 (3)	0.20 (2)
318	99.39 •	148.50 (2)	88.50 (3)	21.25 (2)	57.58 •	149.75 (2)	671.00 (2)	13.00 (2)
319	46.00 (2)	3.86 (7)	4.79 (7)	2.90 (6)	0.00 (2)	1.45 (8)	1.19 (9)	13.82 (8)
705	49.50 (2)	317.00 (2)	4.33 (3)	13.50 (2)	29.50 (2)	90.50 (2)	102.25 (2)	65.00 (2)
706	17.00 (2)	42.25 (4)	11.50 (5)	8.50 (2)	60.13 (4)	45.88 (4)	35.10 (5)	114.35 (4)
707	105.60 •	52.04 •	80.83 (3)	96.75 (2)	61.17 •	61.50 (2)	69.50 (2)	153.25 (2)
708	115.82 •	57.07 •	358.75 (2)	40.50 (2)	67.08 •	73.25 (2)	101.75 (2)	156.00 (2)
709	1.77 •	0.87 •	0.10 (2)	1.75 (2)	1.02 •	0.00 (1)	5.70 (1)	3.42 •
710	5.38 •	2.65 •	2.27 (3)	0.50 (2)	5.25 (2)	53.50 (2)	5.79 •	68.63 (2)
711	13.50 (2)	5.40 (2)	28.21 (8)	16.10 (5)	31.27 (8)	119.11 (9)	52.71 (7)	84.71 (7)
712	112.00 (2)	15.00 (3)	49.50 (7)	44.81 •	27.97 (6)	70.78 (9)	77.63 (4)	68.00 (7)
713	41.33 (6)	8.25 (2)	16.86 (7)	31.70 •	41.19 (8)	45.10 (5)	110.13 (4)	651.84 (7)
714	32.69 (8)	30.08 (6)	49.85 (10)	47.41 •	31.00 (1)	58.60 (5)	48.38 (4)	312.92 (9)
715	183.84 (2)	11.40 (2)	12.50 (3)	22.00 (2)	1137.00 (1)	97.25 (2)	127.50 (2)	133.00 (2)
716	22.25 (4)	25.25 (2)	15.50 (4)	10.07 (3)	27.50 (5)	71.63 (4)	147.50 (3)	100.06 (5)
Mean STRAP	56.61	39.64	85.29	15.75	30.60	57.20	93.80	154.82
SMA	56.37	45.58	85.29	31.94	54.80	55.77	92.71	153.45

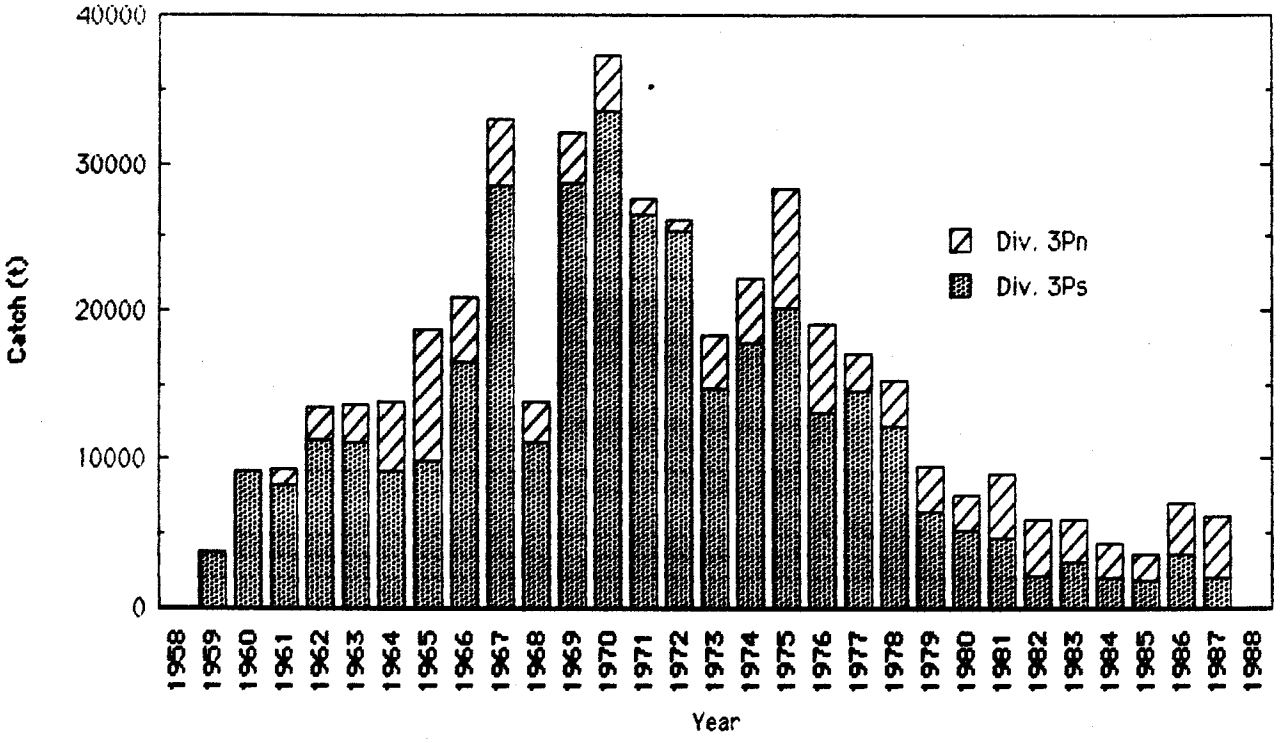

Figure 1: Nominal catches (t) of redfish in NAFO Division 3P, 1959-1987 (1986 and 1987 are provisional).

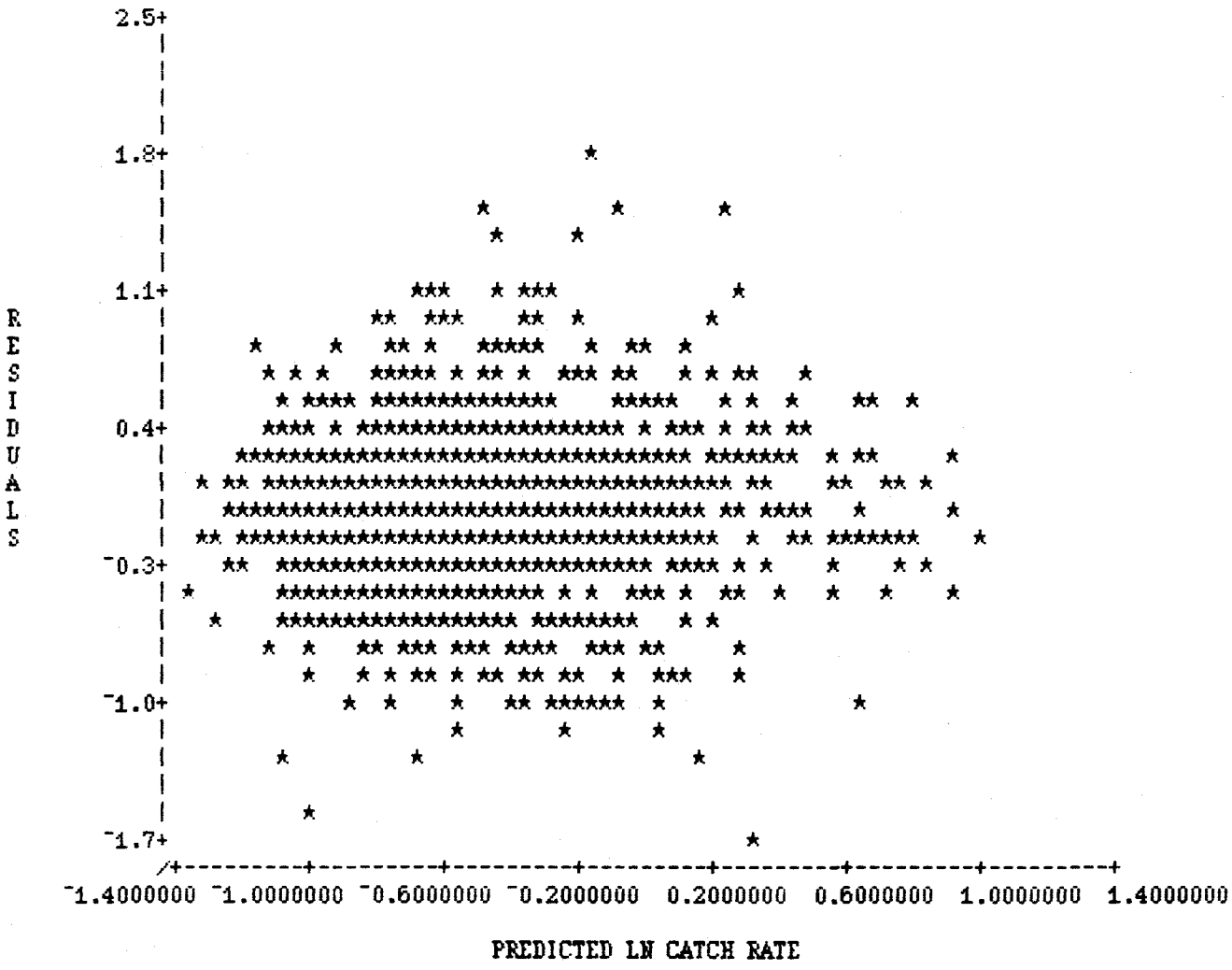

Figure 2a: Residuals vs predicted ln catch rate from multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

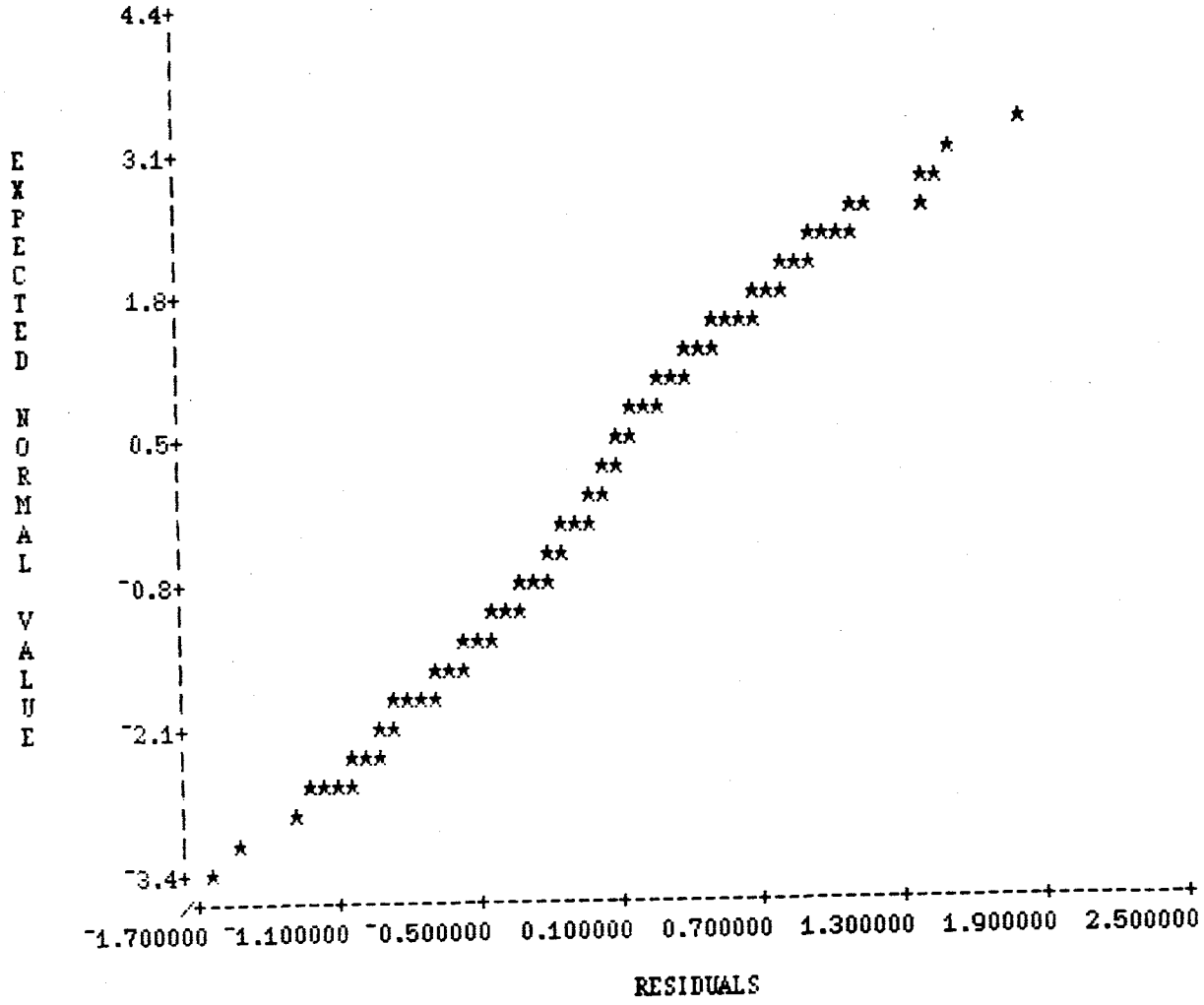

Figure 2b: Expected normal values vs residuals from multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

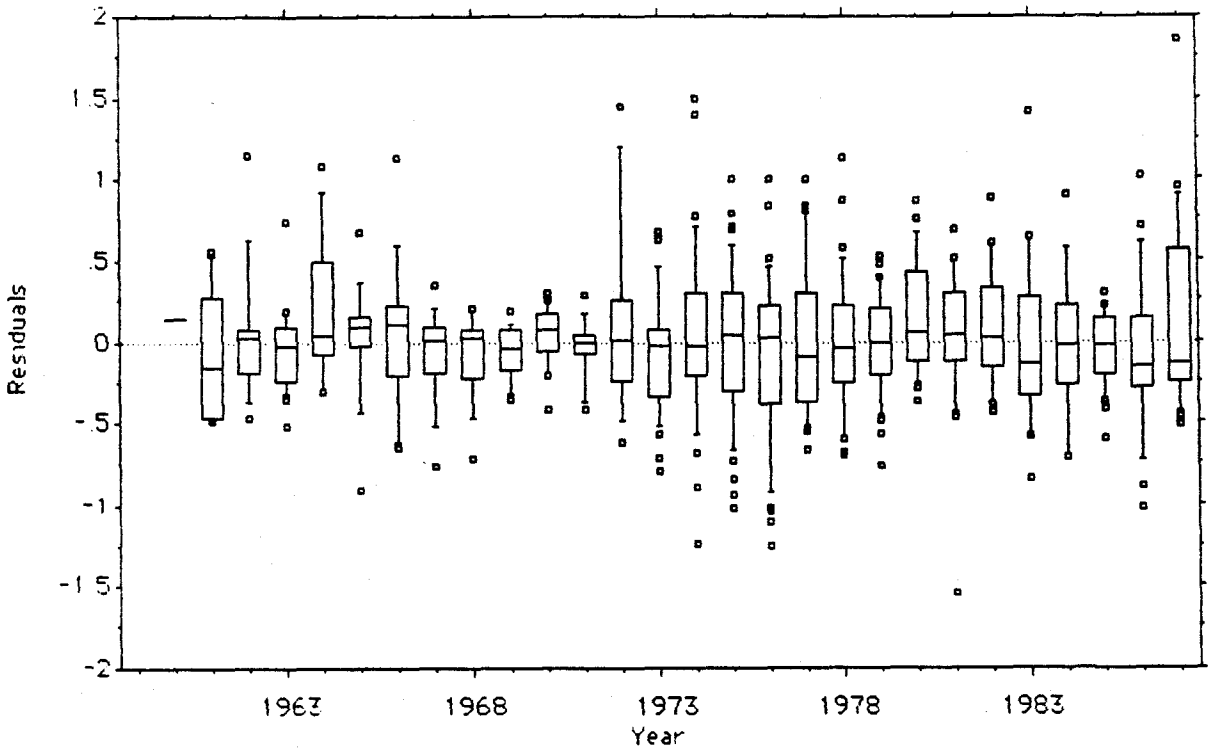

Figure 3a: Boxplots (percentiles) of residuals (Subdiv. 3Pn) from multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

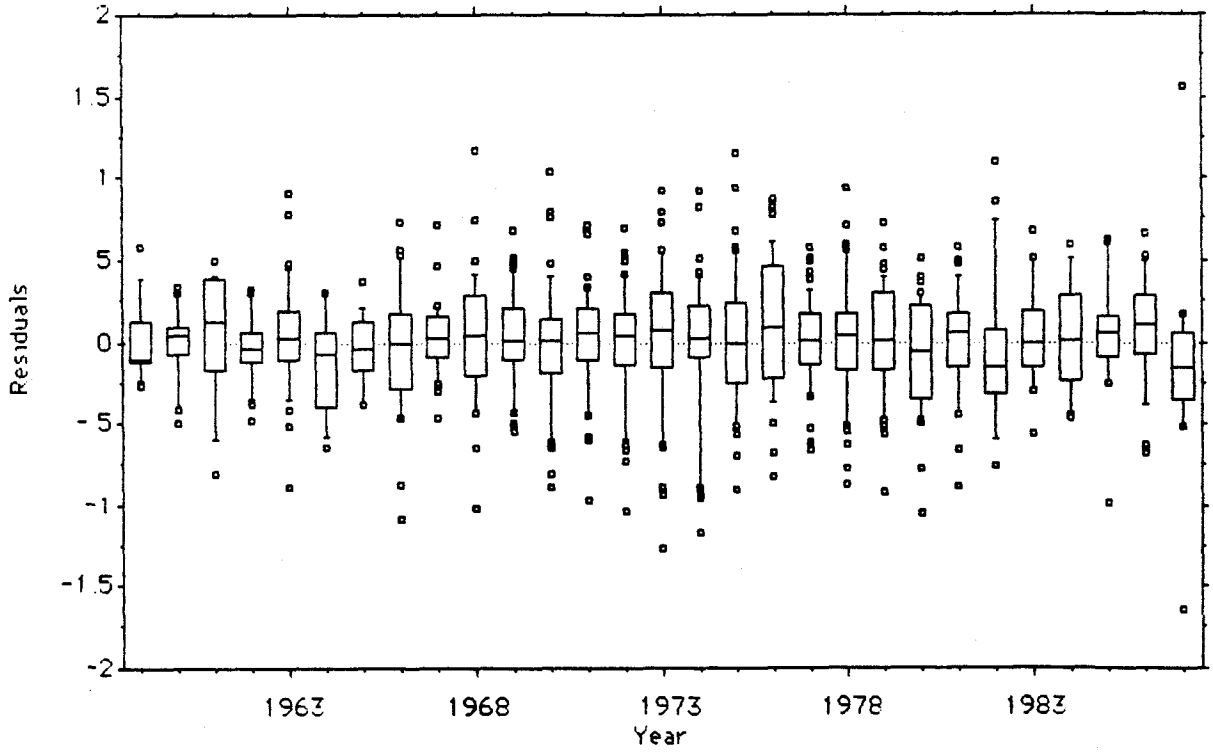

Figure 3b: Boxplots (percentiles) of residuals (Subdiv. 3Ps) from multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

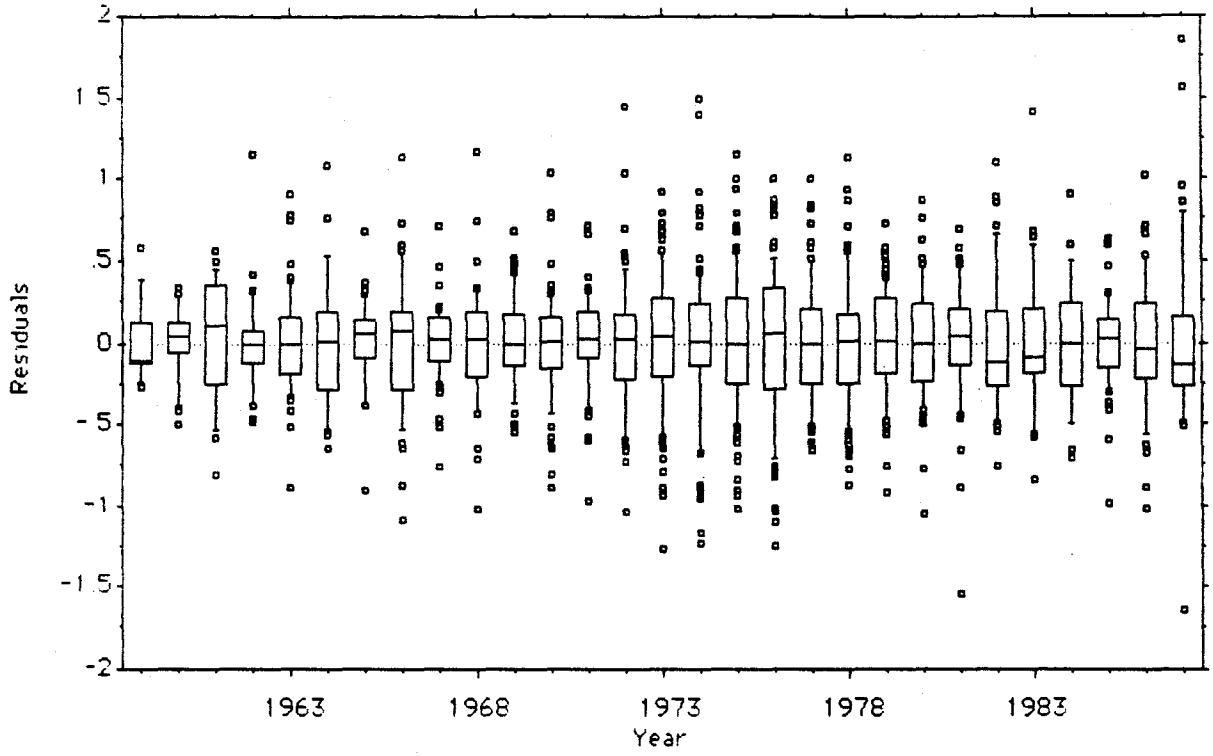

Figure 3c: Boxplots (percentiles) of residuals (Subdiv. 3Pn and 3Ps combined) from multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

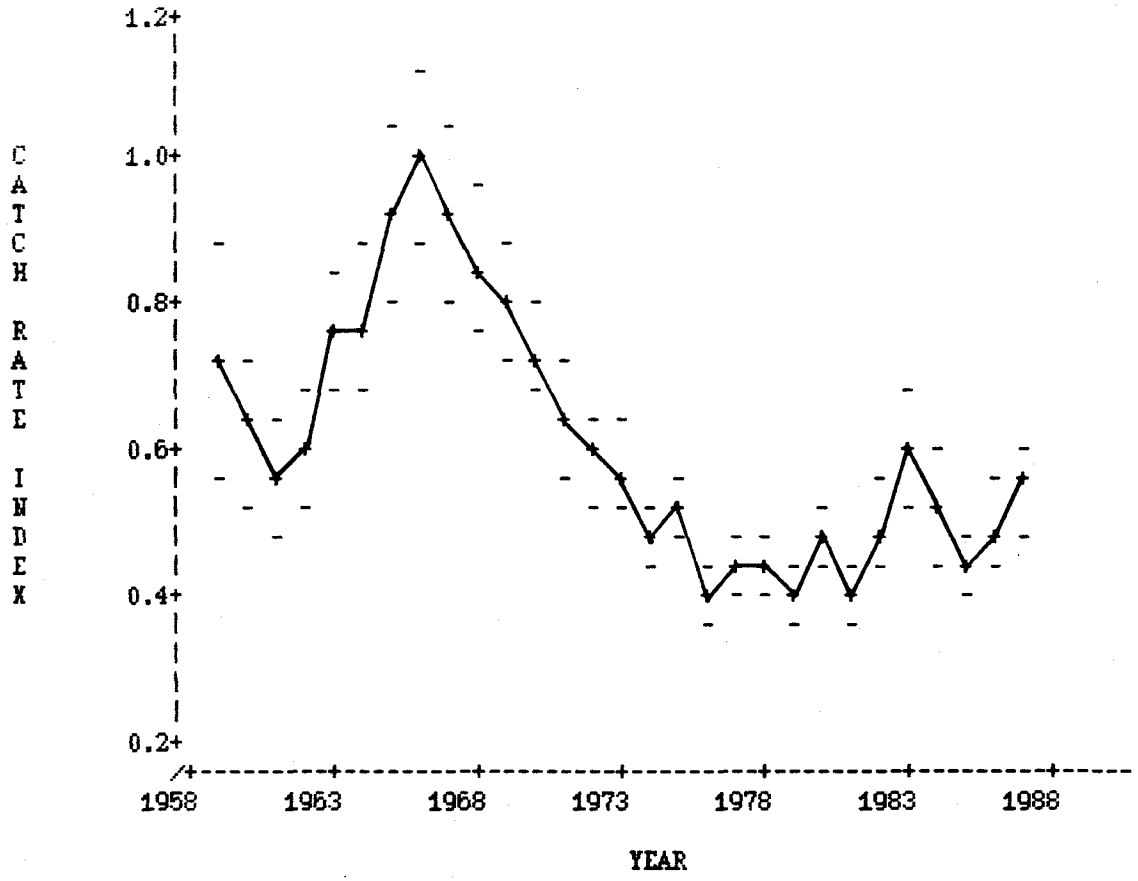

Figure 4: Standardized catch rates (t/hr) derived from the multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3P.

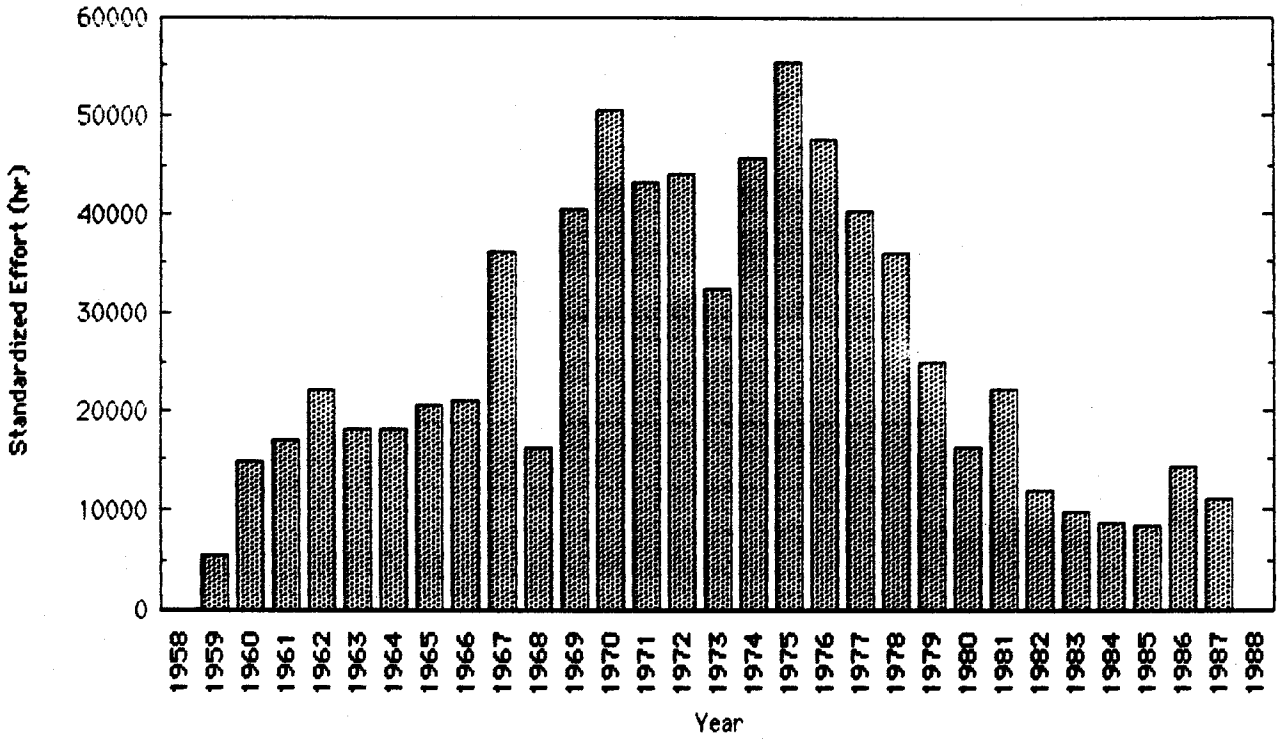

Figure 5: Standardized effort (hr) for redfish in NAFO Division 3P, 1959-1987 (1986 and 1987 are provisional).

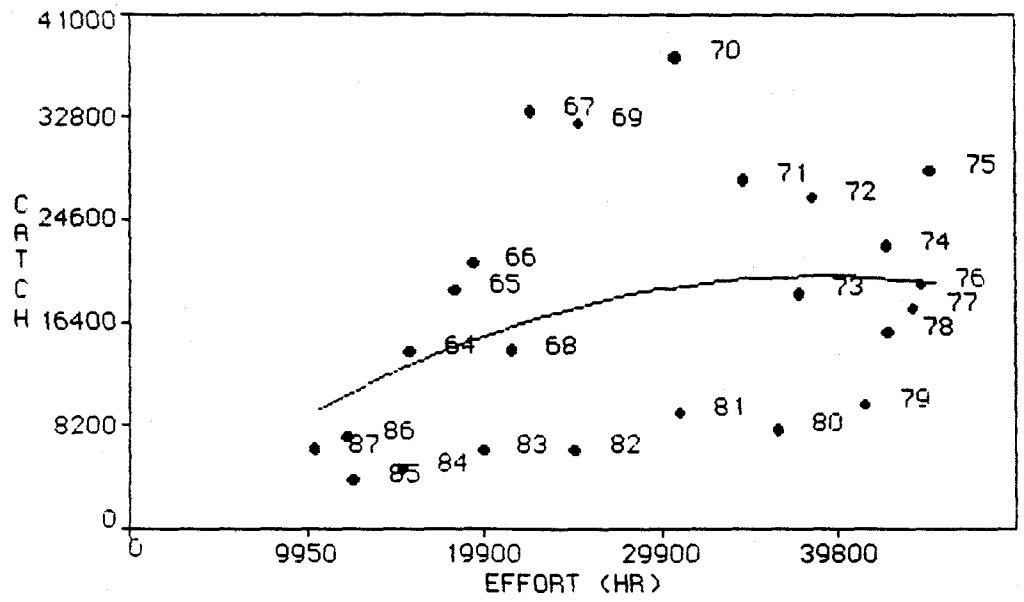

Figure 6a: Results of regression of catch of redfish in NAFO Div. 3P on standardized fishing effort (lagged 6 years) using the quadratic model.

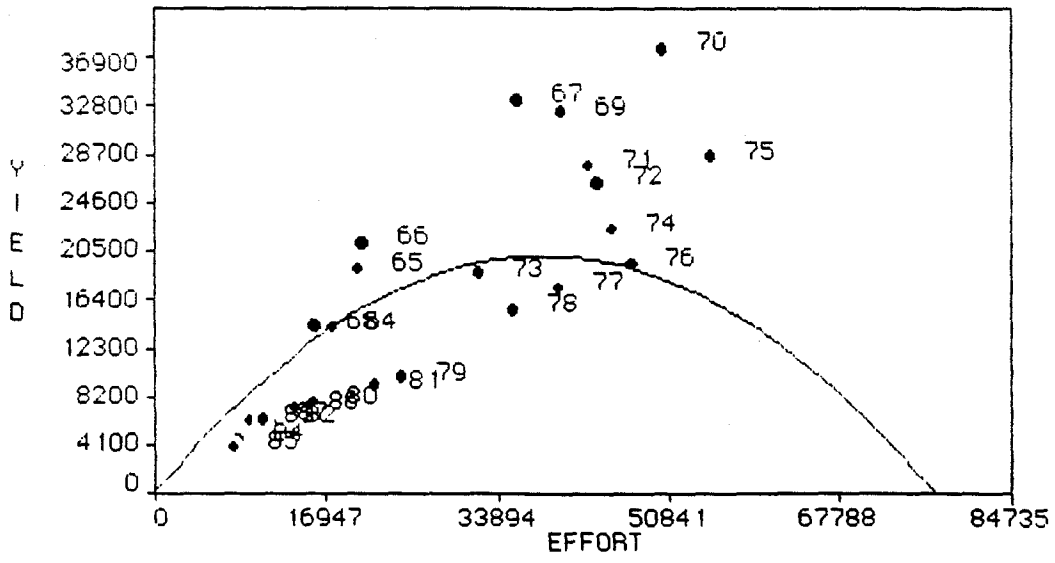

Figure 6b: Equilibrium general production curve for redfish in NAFO Div. 3P from the quadratic model above.

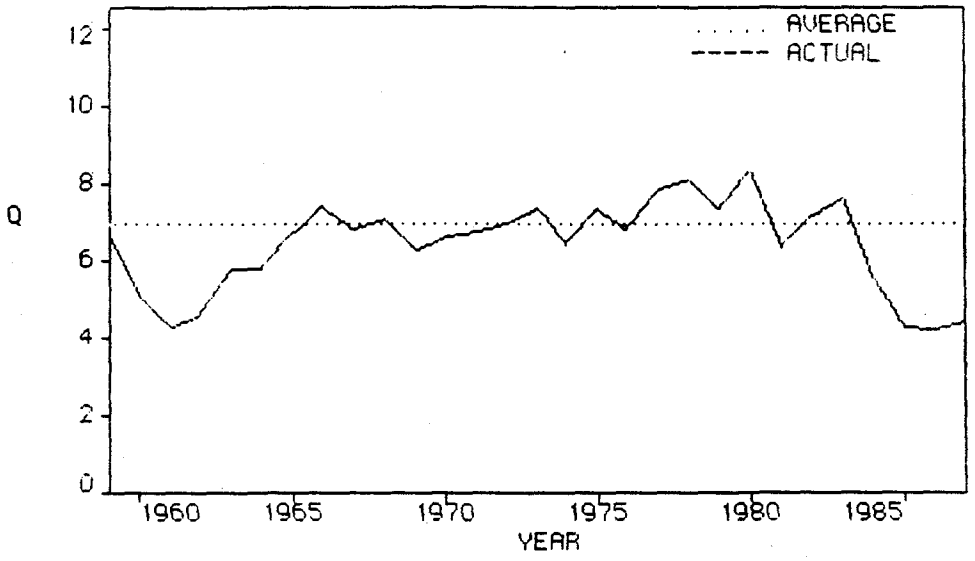

Figure 7: Annual values of q (x1E-6) from the initial run of the non-equilibrium model for redfish in NAFO Div. 3P.

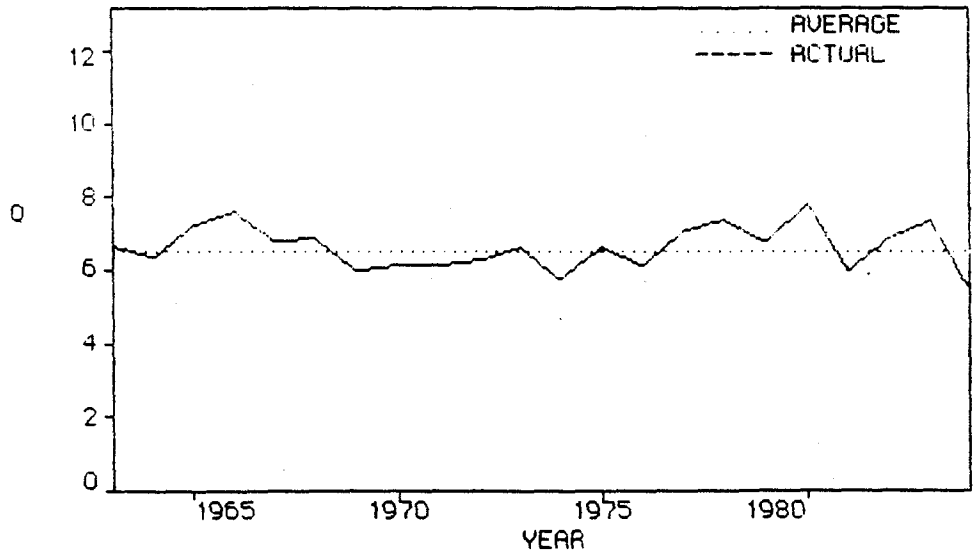

Figure 8: Annual values of q (x1E-6) from the final run of the non-equilibrium model for redfish in NAFO Div. 3P.

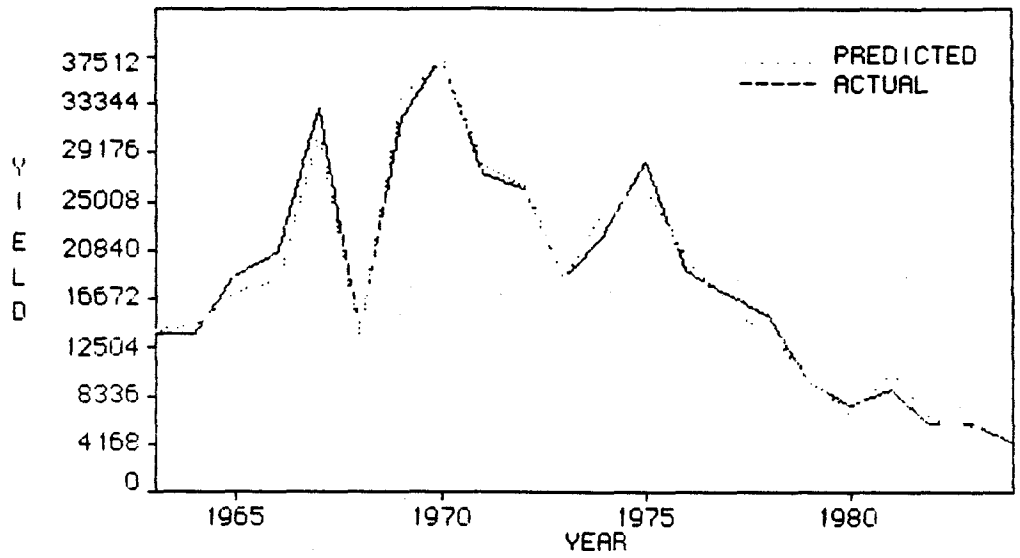

Figure 9: Actual annual yields of redfish from NAFO Div. 3P compared with those predicted from the final run of the non-equilibrium model.

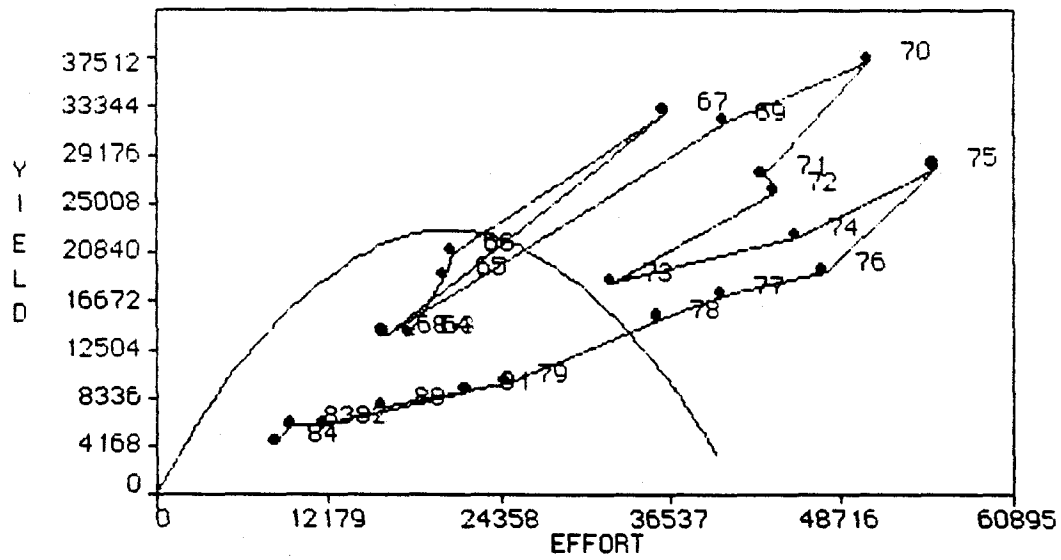

Figure 10: Equilibrium curve and transient levels of yield vs standardized effort from the final run of the non-equilibrium model for redfish in NAFO Div. 3P.

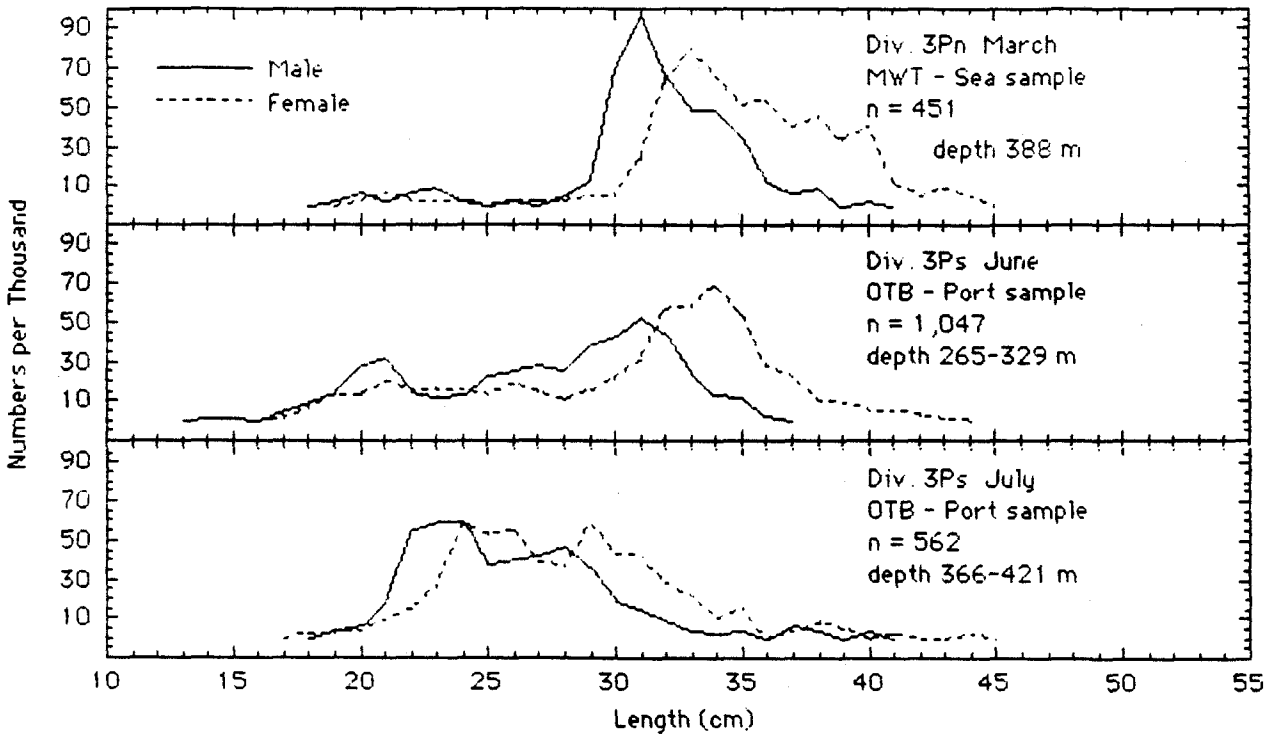

Figure 11 Length frequencies available from the commercial redfish fishery by Canada (Nfld.) in NAFO Division 3P in 1987.

Frequency	Wt.		Frequency	Wt.		Frequency	Wt.
			Sea3PnMarCNMWT	4076 |			
Port3PsJunCNOT	254 |--		CanOT3Ps	1975 |--		Can3P	6051
Port3PsJulCNOT	409 |						

Figure 12: Commercial frequencies used and the process followed to deive the estimate of the number of redfish caught at age in NAFO Division 3P in 1987.

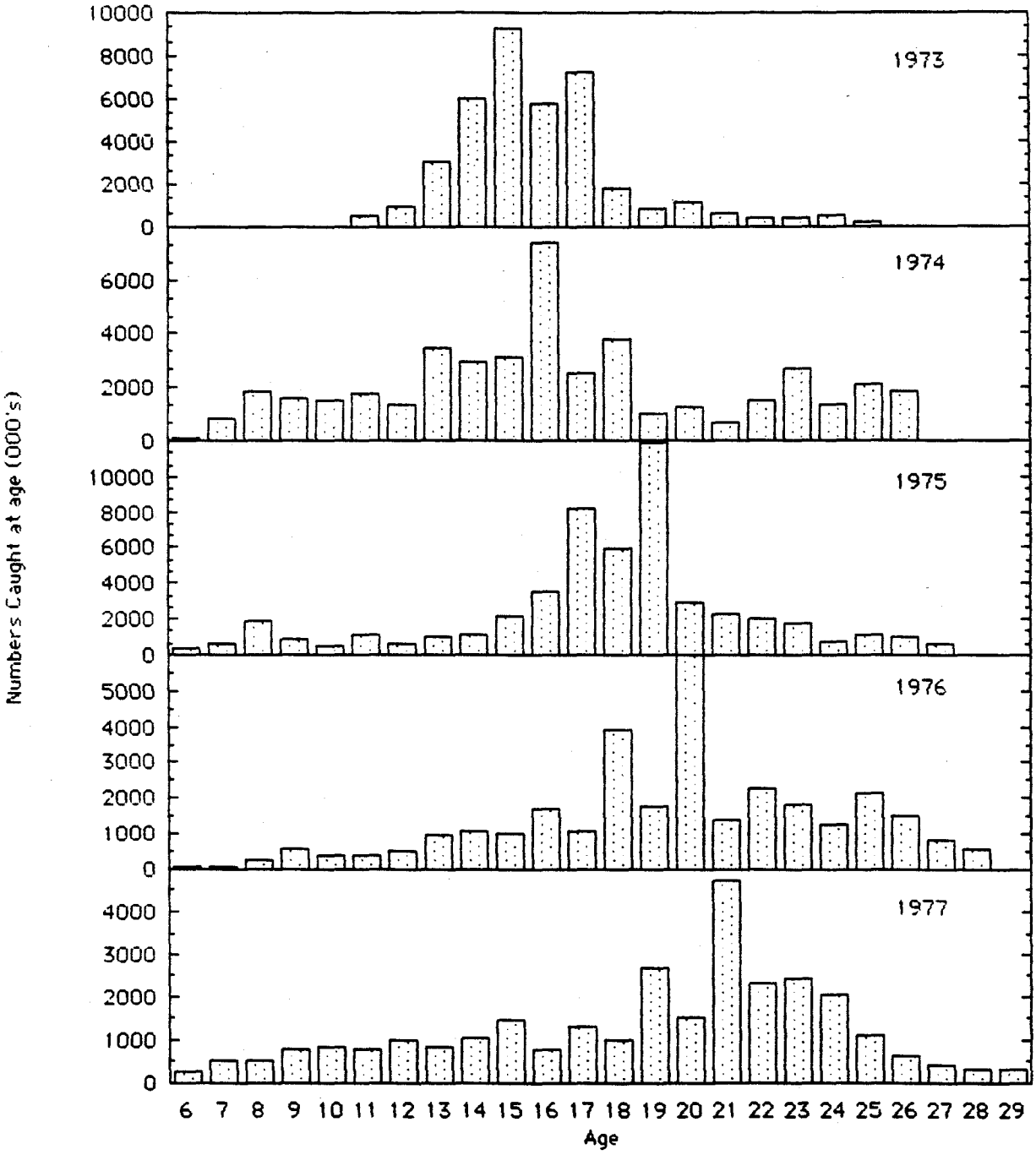

Figure 13: Estimated numbers of redfish caught at age in the commercial fishery in NAFO Division 3P.

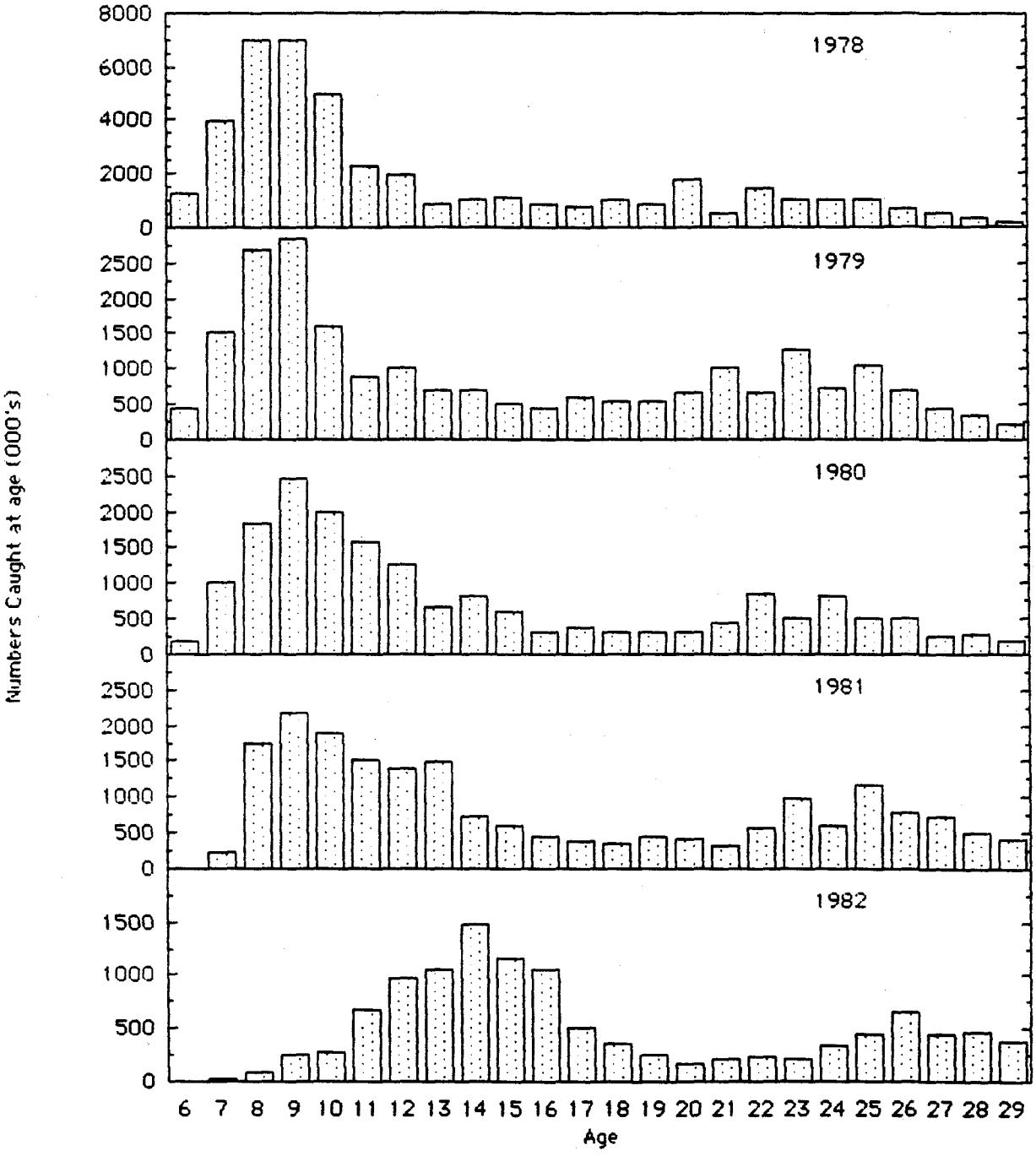

Figure 13 : Continued.

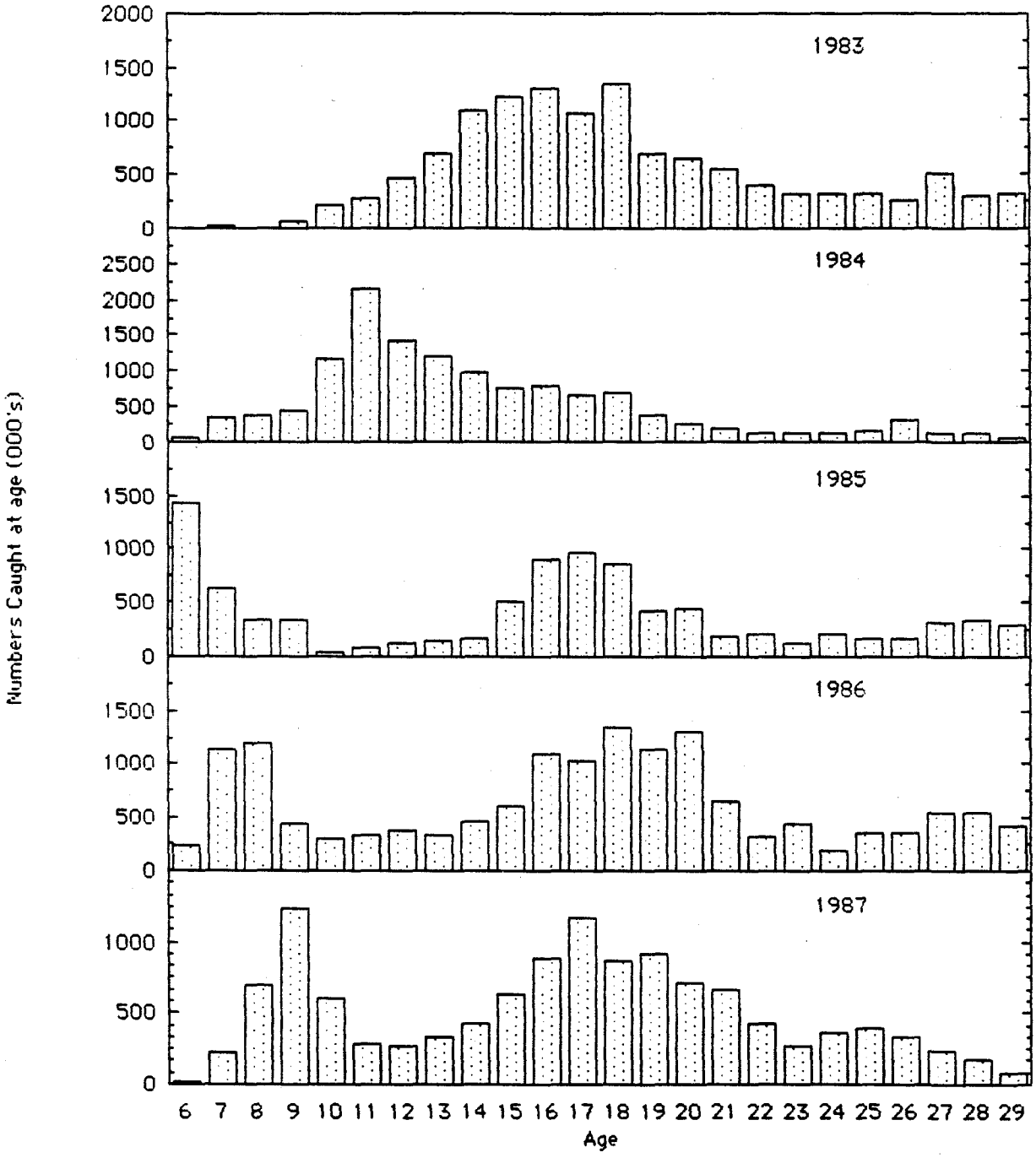

Figure 13: Continued.

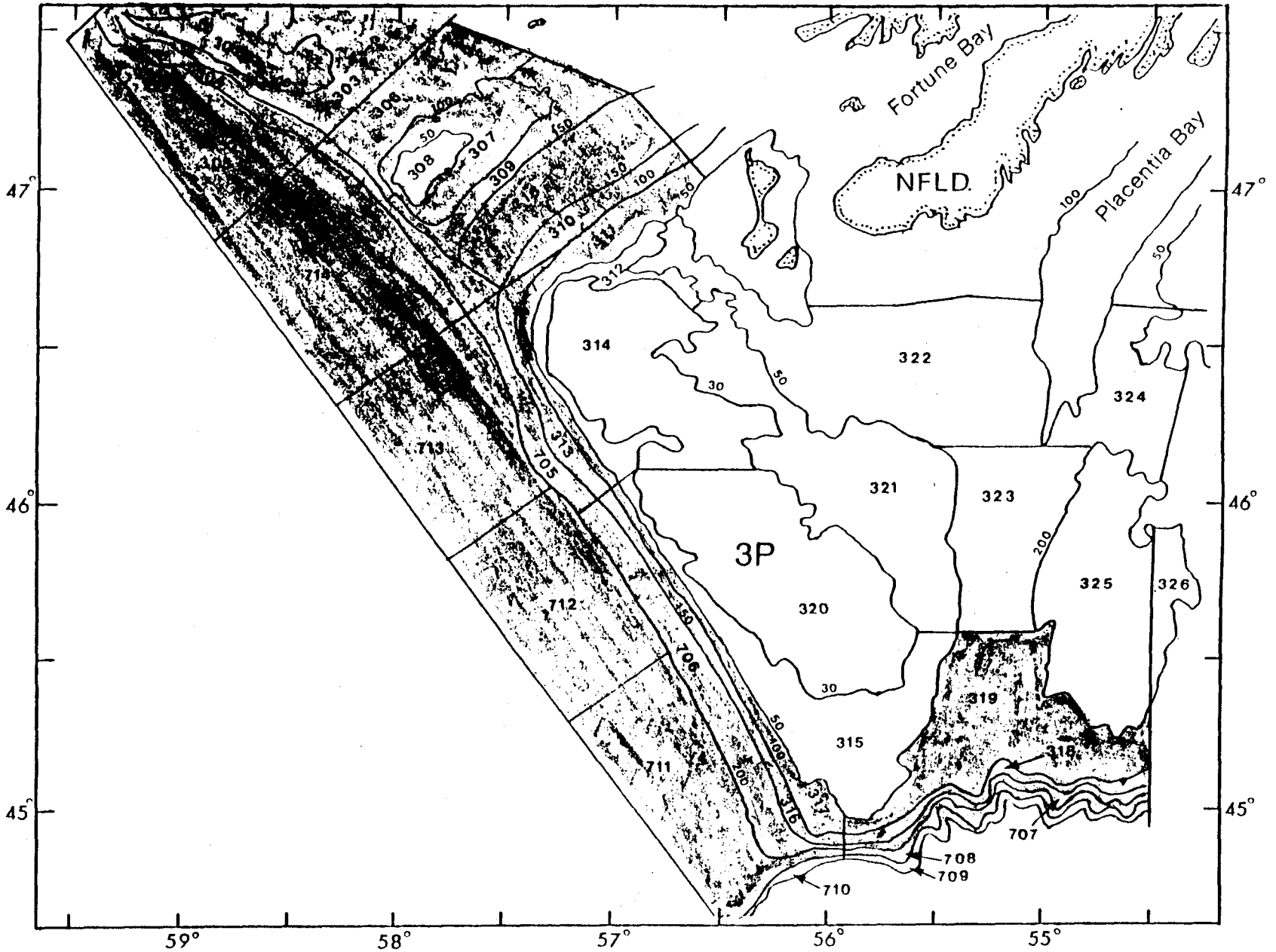

Figure 14 Stata in NAFO Div. 3P The shaded area indicates those strata used for the estimates of mean quantities of of redfish caught during standard tow during research cruises to the area

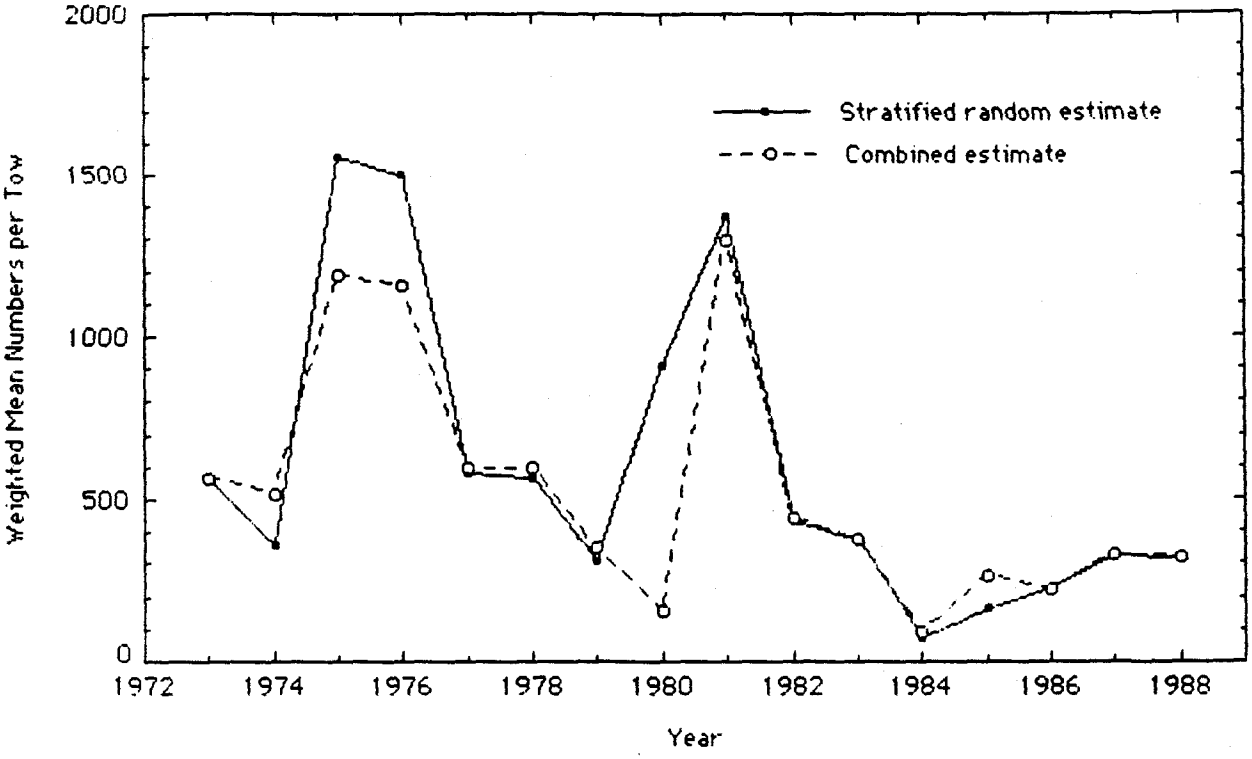

Figure 15. Trend in mean numbers caught per tow in Div. 3P from 1973-1988 based on stratified random estimates alone and including estimates for missing strata using a multiplicative analysis.

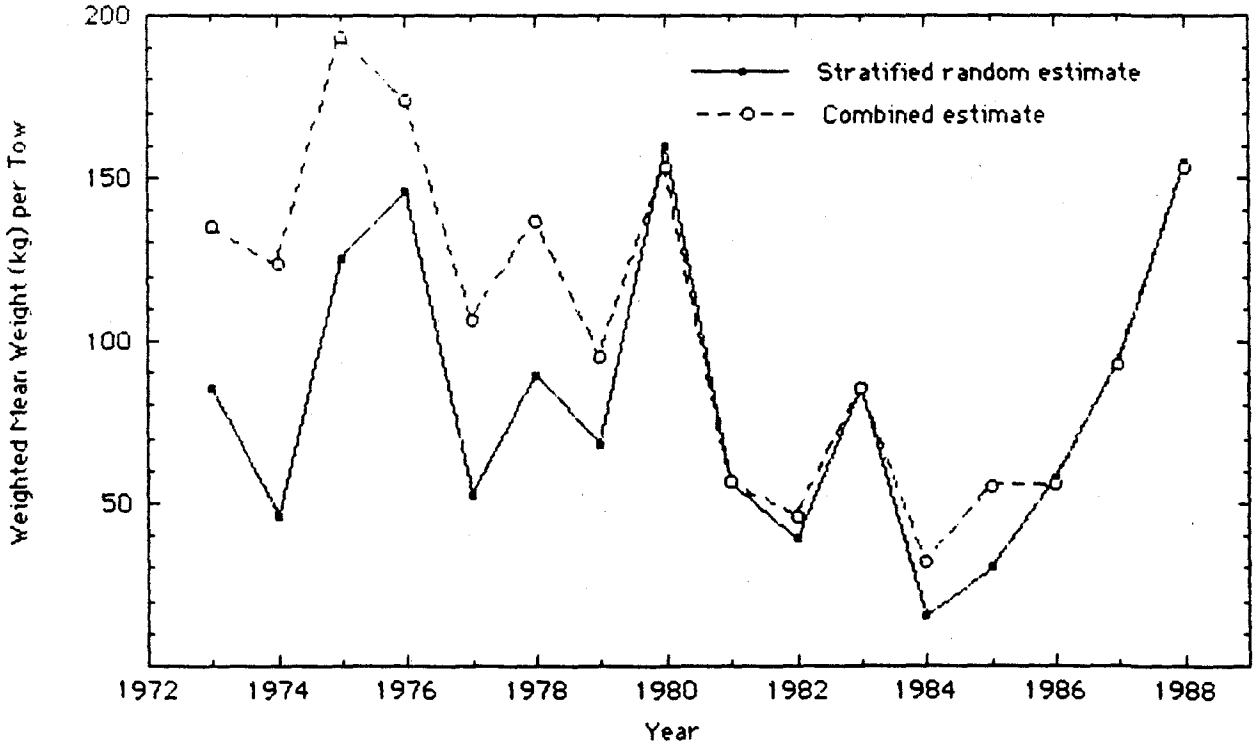

Figure 16. Trend in mean weights caught per tow in Div. 3P from 1973-1988 based on stratified random estimates alone and including estimates for missing strata using a multiplicative analysis.

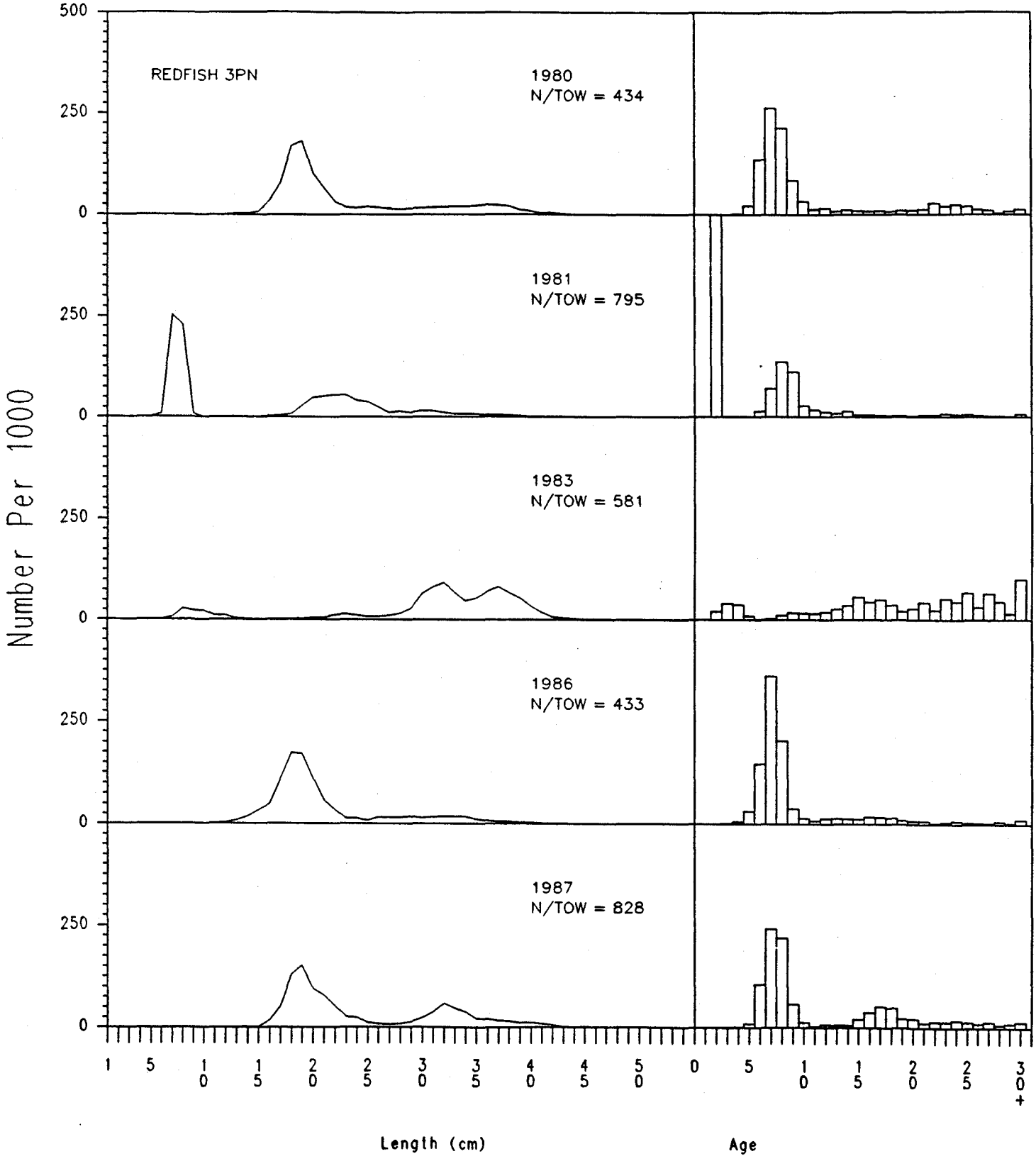

Figure 17: Mean numbers of redfish caught at length and age per thousand during research cruises to NAFO Subdiv. 3Pn.

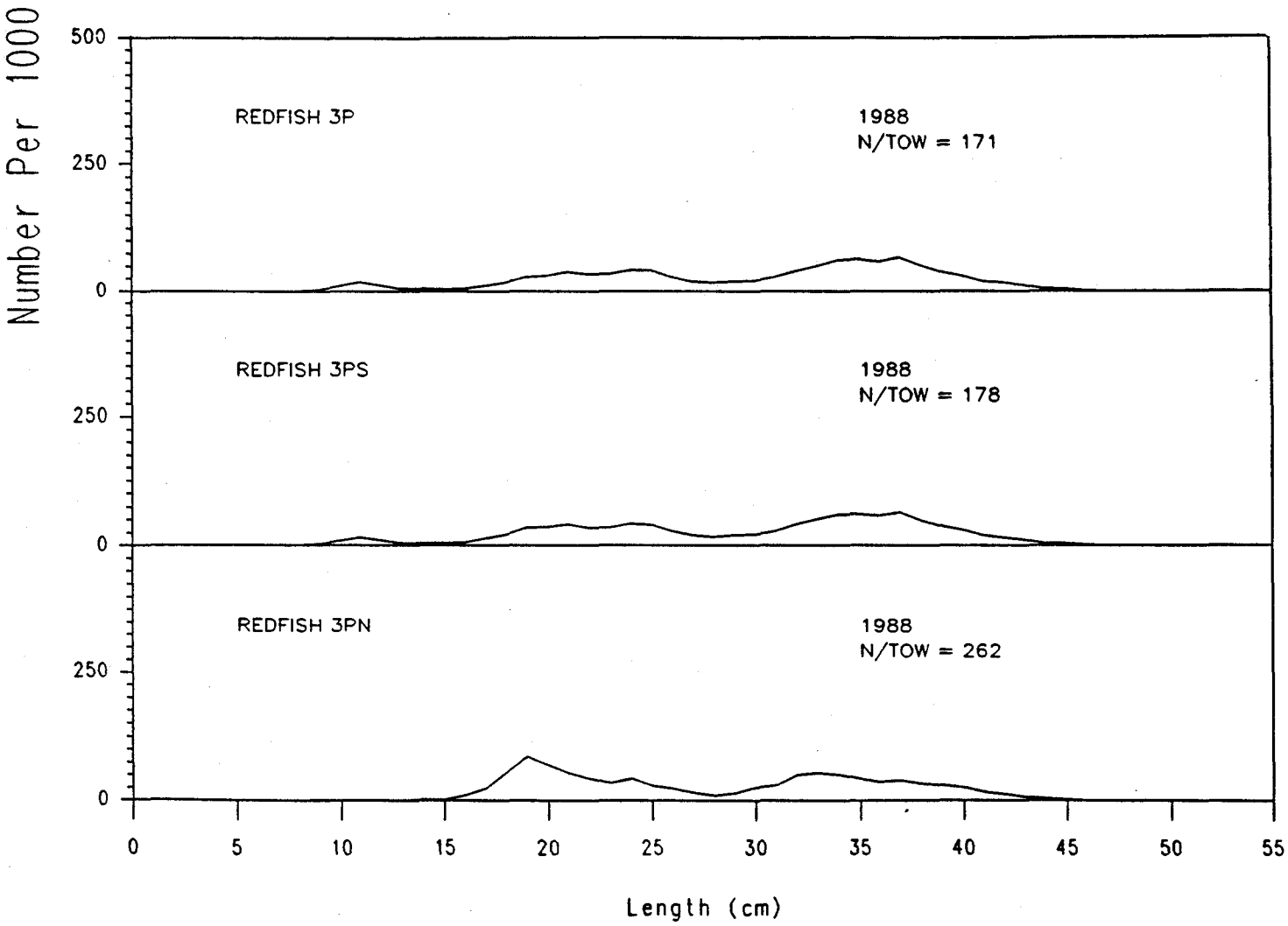

Figure 17: Continued.

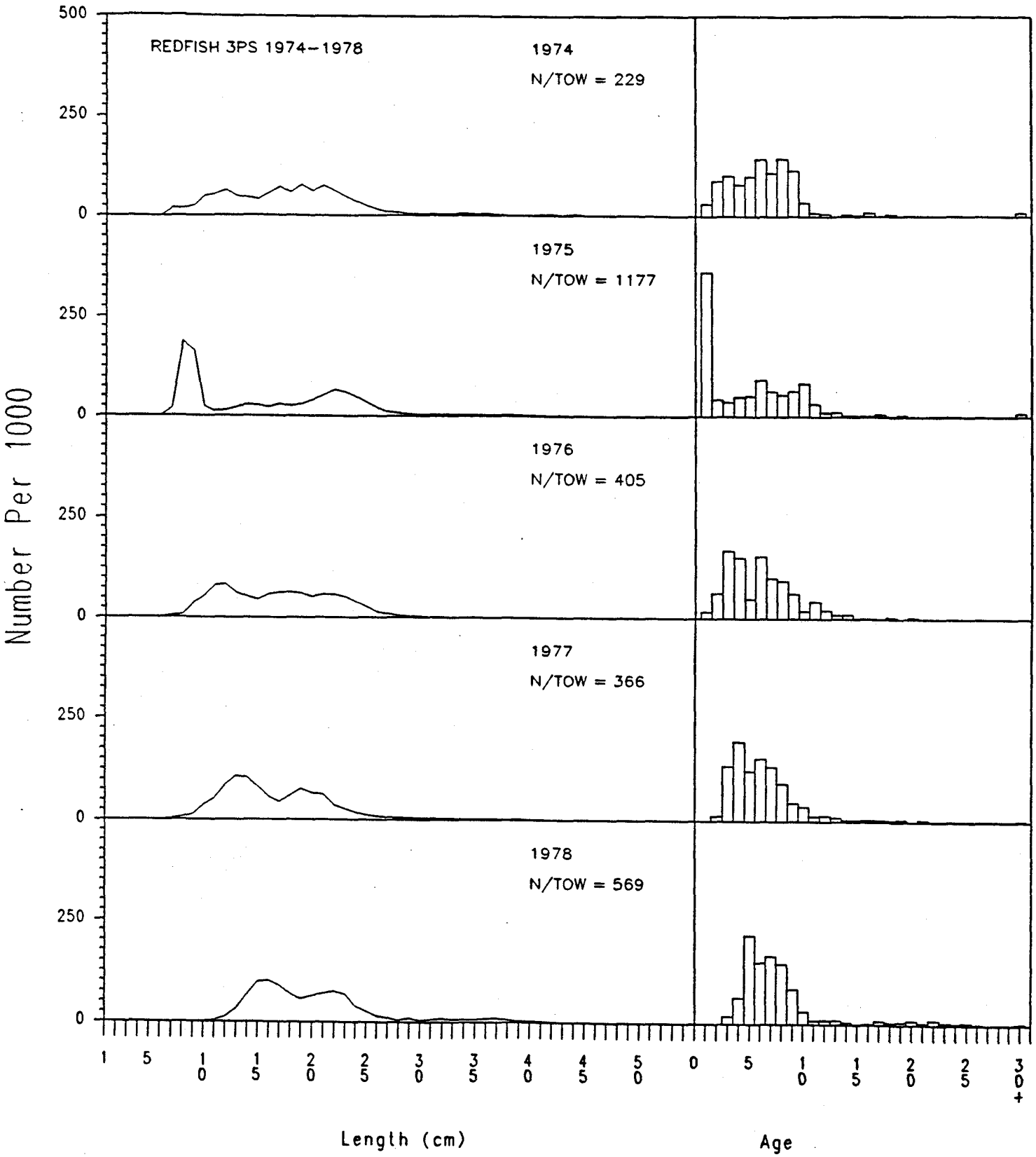

Figure 18: Mean numbers of redfish caught at length and age per thousand during research cruises to NAFO Subdiv. 3Ps.

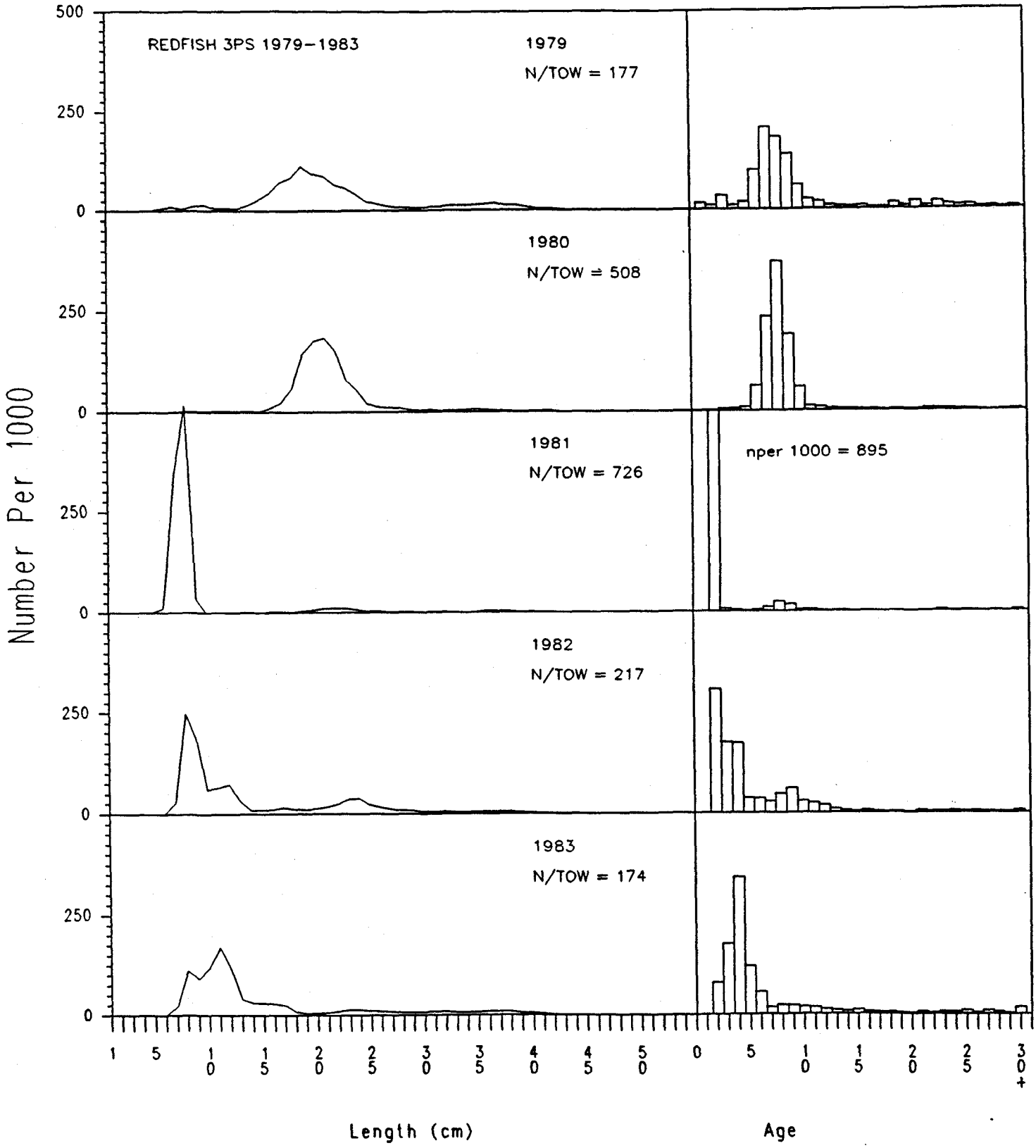

Figure 18: Continued.

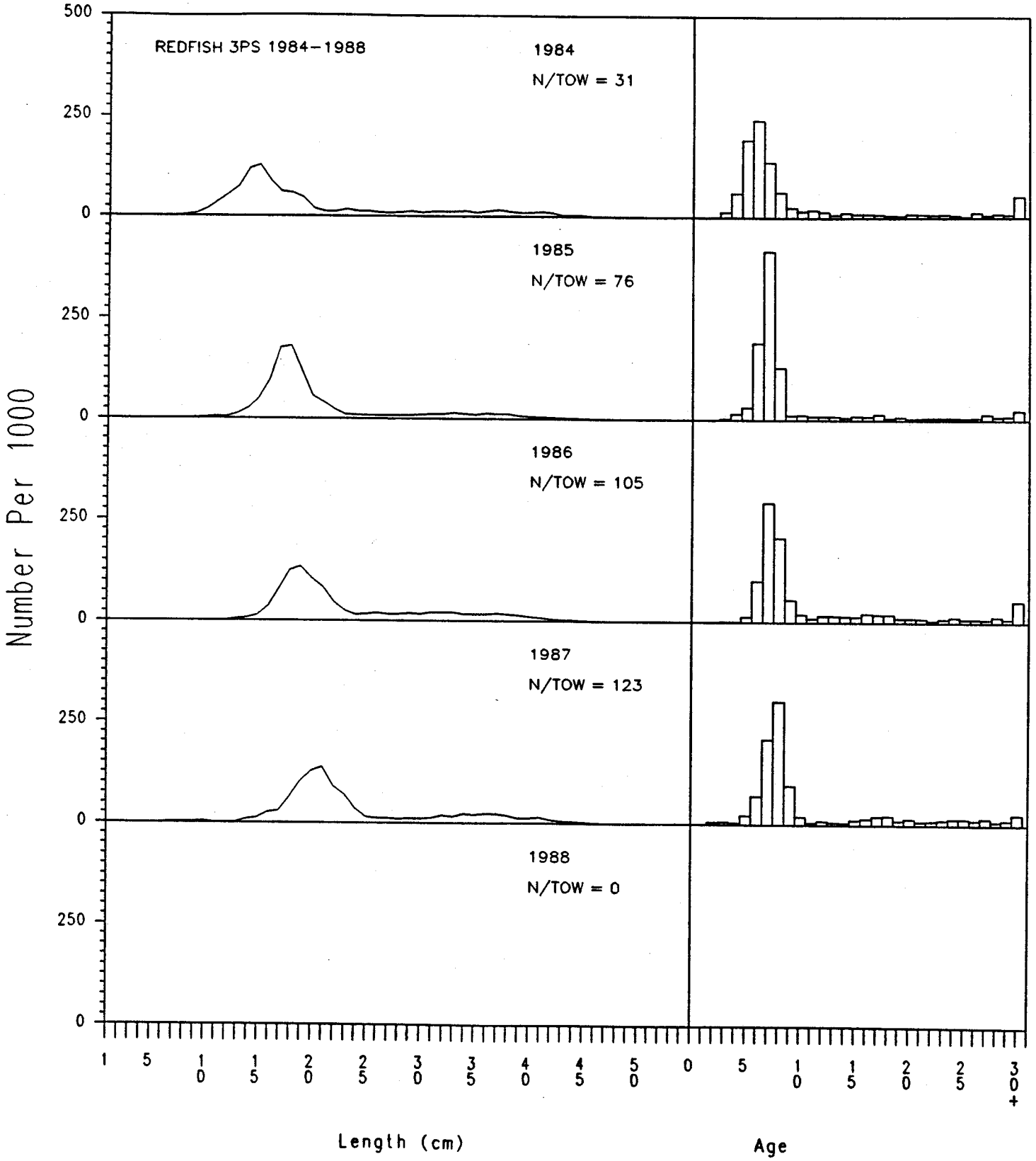

Figure 18: Continued.

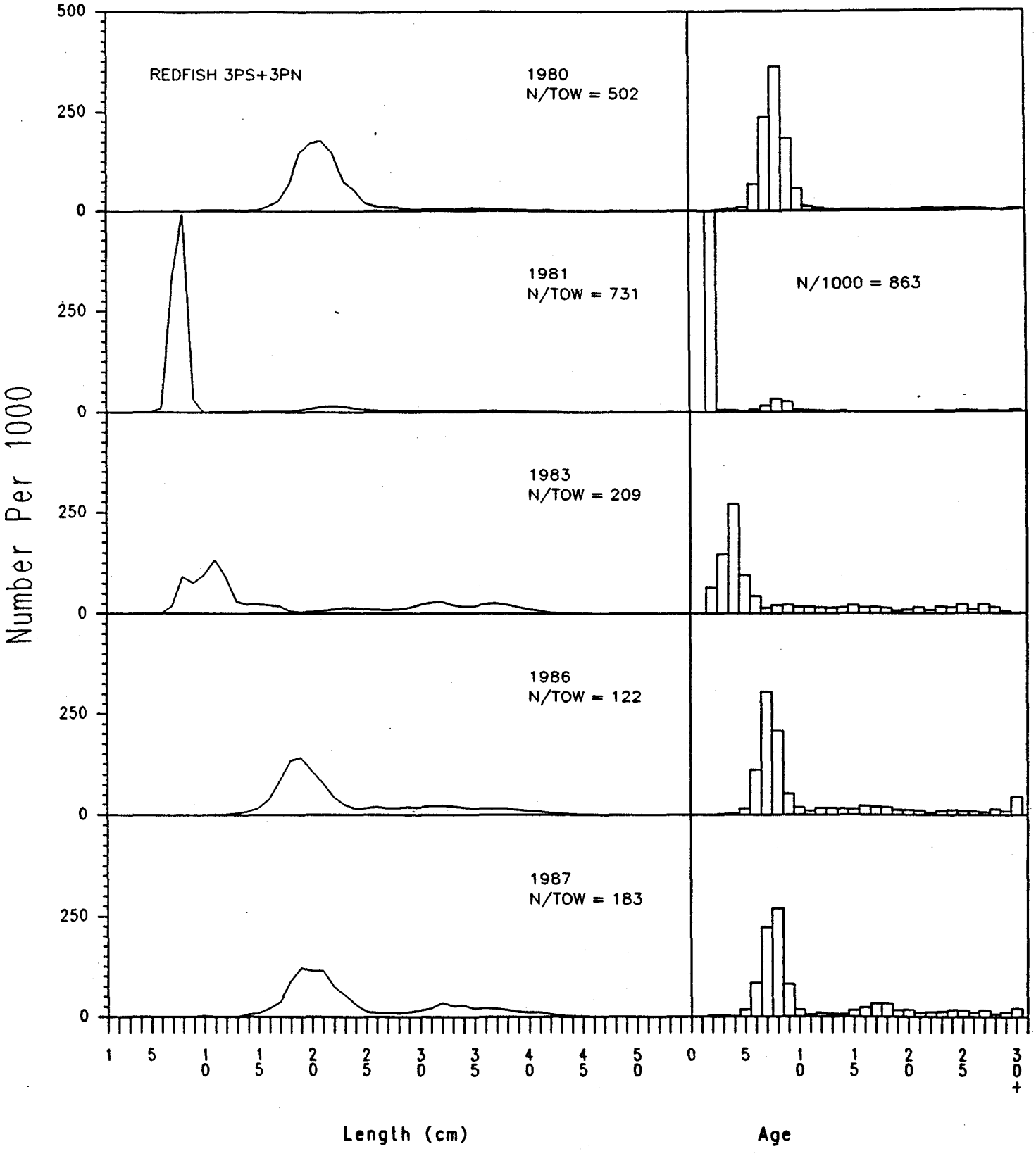

Figure 19: Mean numbers of redfish caught at length and age per thousand during research cruises to NAFO Subdiv. 3Pn and 3Ps combined.