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An Assessment of the Redfish in NAFO Div. 3LN

by

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Introduction

The average catch of redfish from this stock has been about 23,000 t during the 1959-1987 period, with approximately 60% of this being taken in Division 3N (Table 1, Figure 1). The reported landings for 1986 and 1987, above 40,000 t, represent a doubling of the annual catchs compared to those of the 1975-1985 period, and greatly exceed the TAC level of 25,000 t. The 1986 catch in Div. 3L is the second highest on record, being exceeded only in 1959. The increased catch in this division, a result of increased landings by both Portugal and the USSR, accounts for nearly all of the increase in the total for the stock between 1985 and 1986 (Table 2a). Portugal also reported increased catches in Div. 3N in 1986 over those of 1985, but these were counter-balanced by decreased landings from this division by the USSR (Table 2b). Between 1985 and 1986, the USSR shifted their fishing effort from Div. 3N to Div. 3L. It is interesting to note that the total reported USSR catch was identical for in 1985 and 1986, being 10,855 t.

At the time of document preparation, no breakdown of the 1987 provisional landings between divisions was available The provisional data do indicate that total catches by the USSR were about the same as those in 1985 and 1986, while catches by EEC countries were about 28,000 t, an increase of about 5,000 t over the reported catch for 1986.. The fishery is prosecuted throughout the year (Tables 3a and 3b) in both divisions.

Analytical analyses are not possible by the authors at present due to a lack of commercial catch-at-age data within Canada. As a result, only catch and effort data have been employed to monitor the status of this stock.

Methods and Results

Catch and effort data were obtained from ICNAF/NAFO Statistical Bulletins for the 1959-1985 period. These were combined with preliminary NAFO data for 1986 and preliminary Canadian statistics as well as Canadian observer data for 1987. Only those data where redfish comprised >50% of the total catch were used. It was assumed that the proportion of total catch taken in Div. 3L and 3N was the same in 1987 as it was in 1986.

The catch and effort data were analysed using a multiplicative model (Gavaris 1980) to derive a standardized catch rate series. To reduce potential bias due to rounding errors associated with low values, catch and/or effort data comprising <10 units were deleted prior to the multiplicative analysis as were country-gear-tonnage class or month category types with <5 data points. In past assessments (eg. Power and Atkinson MS 1987) side and stern trawler data had been combined prior to analysis. For this assessment, the data were analysed keeping these two gear types separate. No groupings of similar categories within each category type were done this year, and no weighting of the regression was carried out because of unknown levels of pro-rating of the effort data.

It was noted previously (Power and Atkinson MS 1987), that because there were apparent differing trends in the catch rates in Div. 3L and 3N in recent years, it is not appropriate to combine the data from the two divisions in a multiplicative analysis as the assumption of proportionality is violated. Because the input data had been modified, the data from Div. 3LN combined were again analysed as were the separated data from Div. 3L and 3N.

The results of the analysis for Div. 3LN combined (Table 4) indicate that the model explains about 44% of the variation in the data. There are no significant differences between the two divisions (type 3) nor in years (type 4). Boxplots of the residuals (Figure 2) indicate an increasing trend in Div. 3L in recent years but a decreasing trend for Div. 3N. These differences indicate a violation of the assumption of proportionality and thus the two divisions should not be analysed together using the multiplicative analysis. Further analyses with the combined data were therefore not carried out.

Multiplicative analysis of the Div. 3L data explained 52% of the variation (Table 5). There were not significant differences in the catch rates for the different years (type 3) and it can be seen that they have been quite stable over the 1959-1987 period (Table 6, Figure 3). Analysis of the Div. 3N data explained 52% of the variation (Table 6). There were significant differences between years (type 3) but not months (type 2). The resultant catch rate series (Figure 4) does show general stability over the 1959-1987 period with exceptionally high catch rates for 1966 and 1974. These are not thought to be reflective of changes in stock status. There does appear to have been an increase in catch rates during the late 1970's followed by a gradual decline after 1983.

In most years, standardized effort has been greatest in Div. 3N (Figure 5) but this situation has changed in 1986 and presumably in 1987 as well. This increase in effort in Div. 3L is related to the increased catches by Portugal and the USSR noted above.

Multiplicative analysis indicated that there was no contrast in the catch rate series over time in Div. 3L. In this situation, general production analysis is not appropriate. Nonetheless, in a previous assessment (Power and Atkinson MS 1987), a significant relationship ($p<0.05$) was found between catch rate and effort for this division. A similar regression to that done previously (ie effort lagged (moving average) 8 years, 1974 point excluded) was run but was not significant ($p=0.422$). The regression was significant in the previous assessment because of the absence of the 1987 point and the previous location of the 1986 and 1966 points (Figure 6). Atkinson and Power (MS 1987) did point out that the significant relationship was dependent on the 1966 point. Further analyses were not carried out with the Div. 3L catch and effort data.

In general production analyses (Schaefer type), it is usual to regress catch rate on effort ($C/f=\alpha+\beta f$) but the possibility of spurious correlation exists because the effort term (f) occurs in both X and Y. To overcome this, a quadratic relationship ($C=\beta_1 f+\beta_2 f^2$) may be used. Since the quadratic version is forced through the origin, the correlation coefficient is not meaningful and one should examine the p-value for β_1 and β_2.

A series of general production analyses were carried out using the Div. 3N catch and effort data and both the linear and quadratic forms of the model. As has been done previously (Power and Atkinson MS 1987), the 1974 data were included in one set of analyses and excluded in another. When the data for 1974 were excluded, the lagged effort was also recalculated. Because it is felt that relationships using unlagged effort (Gulland 1961) are not meaningful, these were not examined.

With the linear form, regressions with effort lagged 6 and 8 years are significant ($p<0.05$) when the 1974 data are excluded (Table 8). When all data are included, β_1 is significant ($p<0.05$) with all treatments of effort but β_2 is only significant ($p<0.05$) with effort lagged 10 years. The β_2 term is only marginally not significant ($p=0.051$) with effort lagged 8 years however. When the 1974 data are excluded, all β_1's are significant but β_2 is not significant when effort is lagged 6 years.

A summary of the general production results (Table 9) indicates that the linear model gives higher estimates of both MSY and effort at MSY than does the quadratic form because the ratio of slopes is greater than the ratio of intercepts (Figure 7). Given the variance around the catch rates and effort values (from the multiplicative analysis), it is not possible to differentiate between levels of MSY and yield at 2/3 MSY effort indicated by the two versions. The results using the quadratic model including and excluding 1974 are very similar. Results of the general production analyses using effort lagged 8 years are illustrated in Figures 8 - 13.

A few commercial frequencies are available from the fishery in 1987 (Figure 14). Generally, smaller fish were caught in Div. 3N, particularly by Cuba, although this may reflect the fact that fish <25 cm are largely unacceptable to Canadian processors.

Discussion

With multiplicative analysis of the Div. 3LN data combined, an examination of the trends in residuals for Div. 3L and 3N separately indicates differing trends with time. In this situation it is inappropriate to combine these data sets in the multiplicative model as the assumption of a constant relationship is violated. This conclusion is similar to that of Power and Atkinson (MS 1987).

Catch rates in Div. 3L do not show any trends with time. From 1959 to 1986 the average catch of redfish in this division has been about 8,500 t. Catches in this division have however, increased in recent years to almost record highs. In 1986, the reported catch of almost 28,000 t exceeded the quota for Div. 3LN combined. The effect of this increased fishing pressure on catch rates in the future remains to be seen.

Catch rates in Div. 3N show a decrease from 1983 through 1986 (the slight increase indicated in 1987 may be reflective of the relatively few data points available). General production analyses indicate an equilibrium yield at 2/3 effort MSY of about 15,000 - 16,000 t (using a lag of 8 years as has been done previously). Adding this to the average catch for Div. 3L as has been done in the past (Atkinson and Power MS 1986) results in a yield of about 25,000 t, the present TAC level. The MSY for Div. 3N is estimated to be about 17,000 - 18,000 t (again using a lag of 8 years). The yield when average catches for Div. 3L are included, is also about 25,000 t.

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Table 1: Summary of nominal catches (t) of redfish in Divisions 3LN.

Year	3L	3N	Total	TAC
1959	34,107	10,478	44,585	
1960	11,463	16,547	28,010	
1961	8,349	14,826	23,175	
1962	3,425	18,009	21,434	
1963	8,191	12,906	21,097	
1964	3,898	4,206	8,104	
1965	9,451	4,042	13,493	
1966	6,927	10,047	16,974	
1967	7,684	19,504	27,188	
1968	2,348	15,265	17,613	
1969	927	22,142	23,069	
1970	1,029	13,359	14,388	
1971	10,043	24,310	34,353	
1972	3,095	25,838	28,933	
1973	4,709	28,588	33,297	
1974	11,419	10,867	22,286	28,000
1975	3,838	14,033	17,871	20,000
1976	15,971	4,541	20,512	20,000
1977	13,452	3,064	16,516	16,000
1978	6,318	5,725	12,043	16,000
1979	5,584	8,483	14,067	18,000
1980	4,367	11,663	16,030	25,000
1981	9,407	14,873	24,280	25,000
1982	7,870	13,677	21,547	25,000
1983	8,657	11,090	19,747	25,000
1984	2,696	12,065	14,761	25,000
1985	3,677	16,880	20,557	25,000
1986*	27,839	14,350	42,189	25,000
1987*			44,075	25,000
1988				25,000

* Provisional.

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

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986*
Canada (M)	1,671	1,671	18	934	554	1,696	1,003	2,663	52	342	2,595
Canada (N)	4,195	7,686	3,143	4,086	2,412	5,925	5,910	3,800	1,229	1,716	2,243
France (M)	13	6	45	4	3	-	-	-	-	-	-
France (SP)	4	-	8	-	11	-	-	-	-	-	-
FRG	29	-	-	7	-	-	-	-	89	309	54
GDR	744	144	918	168	375	509	12	586	849	672	486
Japan	-	87	522	-	26	128	159	-	105	129	135
Poland	81	-	-	4	2	-	-	2	1	4	-
Portugal	1,534	299	261	265	639	275	125	91	48	4	13,469
Spain	-	141	8	-	-	137	25	347	91	192	199
UK	9	4	-	2	-	-	-	-	-	-	-
USSR	7,691	3,231	1,395	114	345	737	607	1,168	232	309	8,658
Ireland	-	160	-	-	-	-	-	-	-	-	-
Cuba	-	23	-	-	-	-	-	-	-	-	-
Kor-S	-	-	-	-	-	-	29	-	-	-	-
TOTAL	15,971	13,452	6,318	5,584	4,367	9,407	7,870	8,657	2,696	3,677	27,839

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

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

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986*
Canada (M)	307	43	1	198	683	442	-	-	13	311	-
Canada (N)	320	137	18	1,285	367	63	337	1	2	82	16
France (M)	-	-	-	25	-	-	-	-	-	-	-
FRG	-	-	12	-	-	-	-	-	-	-	-
GDR	-	-	11	-	-	58	-	-	-	-	-
Portugal	-	-	-	-	-	-	1	-	365	890	8,273
Japan	-	-	-	-	-	-	-	-	81	-	12
Romania	-	-	-	9	-	-	-	-	-	-	-
Spain	-	59	1	-	14	239	278	875	239	2,881	1,393
UK	-	-	-	-	-	-	-	-	-	-	-
USSR	3,914	2,645	4,532	5,904	8,944	12,762	10,414	7,844	9,045	10,576	2,227
Cuba	-	180	1,150	1,062	1,644	1,309	2,621	2,370	2,320	2,055	2,429
USA	-	-	-	-	11	-	-	-	-	85	-
Kor-S	-	-	-	-	-	-	26	-	-	-	-
TOTAL	4,541	3,064	5,725	8,483	11,663	14,873	13,677	11,090	12,065	16,880	14,350

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

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

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1976	33	833	3,916	2,324	578	1,290	2,205	537	815	2,122	954	364	15,971
1977	170	275	1,764	1,034	498	920	2,016	1,339	820	2,069	1,406	981	13,452 a
1978	41	535	301	356	466	669	272	48	19	224	933	2,454	6,318
1979	76	1	1,084	1,391	116	132	492	466	5	22	1,290	509	5,584
1980	271	112	396	119	373	261	80	10	718	311	22	1,694	4,367
1981	280	61	137	1,120	2,286	532	73	90	404	161	1,980	2,283	9,407
1982	1,126	672	1,232	1,225	295	289	459	37	643	1,367	173	352	7,870
1983	1,304	496	672	1,080	934	708	274	642	562	1,070	799	116	8,657
1984	243	135	168	360	76	161	49	57	1,002	318	46	81	2,696
1985	481	120	177	331	215	165	41	78	354	866	441	408	3,677
1986*	423	845	3,468	7,272	3,662	503	976	2,196	545	3,964	2,166	1,819	27,839

* Provisional.
a includes a catch of 160 t in month 'unknown'.

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

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1976	645	721	475	828	755	301	298	27	146	284	61	-	4,541
1977	454	91	1,383	305	47	135	390	217	22	1	19	-	3,064
1978	1	1,230	1,806	875	390	794	32	343	-	12	23	219	5,725
1979	3,693	1,177	562	1	1,091	21	563	804	248	98	155	70	8,483
1980	3,561	2,798	2,269	121	368	833	81	422	1,085	122	2	1	11,663
1981	6,293	3,657	877	78	77	145	1,035	1,577	413	273	208	240	14,873
1982	3,042	1,970	2,919	1,141	243	100	581	3,156	485	21	12	7	13,677
1983	869	609	2,029	2,186	1,226	675	1,121	1,266	303	376	208	222	11,090
1984	4,562	1,763	1,821	676	67	74	1,694	1,014	156	93	131	14	12,065
1985	1,110	2,169	2,181	4,212	1,668	420	1,665	676	784	541	230	1,223	16,880 a
1986*	392	665	406	533	454	911	4,392	81	1,196	110	3,768	1,442	14,350

* Provisional.
a includes a catch of 1 t in month 'unknown'.

Table 4: Results of the multiplicative analysis of commercial catch and effort data for redfish in Divisions 3L and 3N combined.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.659
MULTIPLE R SQUARED..... 0.435

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	4.909E1	4.909E1	
REGRESSION	66	1.178E2	1.785E0	7.885
TYPE 1	26	6.004E1	2.309E0	10.200
TYPE 2	11	5.269E0	4.790E-1	2.116
TYPE 3	1	7.032E-2	7.032E-2	0.311
TYPE 4	28	1.246E1	4.450E-1	1.966
RESIDUALS	677	1.533E2	2.264E-1	
TOTAL	744	3.202E2		

Table 5: Results of the multiplicative analysis of commercial catch and effort data for redfish in Division 3L.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.718
MULTIPLE R SQUARED..... 0.515

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.364E1	2.364E1	
REGRESSION	62	8.524E1	1.375E0	6.089
TYPE 1	23	4.242E1	1.844E0	8.168
TYPE 2	11	8.429E0	7.663E-1	3.394
TYPE 4	28	8.890E0	3.175E-1	1.406
RESIDUALS	355	8.015E1	2.258E-1	
TOTAL	418	1.890E2		

Table 6: Results of the multiplicative analysis of commercial catch and effort data for redfish in Division 3N.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.722
MULTIPLE R SQUARED..... 0.522

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.273E1	2.273E1	
REGRESSION	49	5.102E1	1.041E0	5.525
TYPE 1	10	1.449E1	1.449E0	7.691
TYPE 2	11	9.222E-1	8.383E-2	0.445
TYPE 4	28	1.595E1	5.698E-1	3.024
RESIDUALS	248	4.673E1	1.884E-1	
TOTAL	298	1.205E2		

Table 7: Standardized CPUE and effort from the multiplicative analysis of catch and effort data for redfish in NAFO Division 3L.

	LN TRANSFORM		RETRANSFORMED			
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT
1959	0.0234	0.0334	1.127	0.205	34107	30255
1960	-0.0363	0.0373	1.060	0.203	11463	10814
1961	0.2723	0.0681	1.421	0.365	8349	5876
1962	0.0393	0.0555	1.133	0.264	3425	3024
1963	0.1600	0.0614	1.274	0.311	8191	6428
1964	0.4799	0.1103	1.712	0.554	3898	2276
1965	0.1999	0.0792	1.315	0.363	9451	7190
1966	-0.2762	0.0790	0.817	0.225	6927	8482
1967	0.2498	0.0404	1.409	0.281	7684	5454
1968	-0.0512	0.0579	1.034	0.245	2348	2272
1969	0.0622	0.0433	1.166	0.240	927	795
1970	0.1806	0.0623	1.300	0.320	1029	791
1971	0.1032	0.0524	1.209	0.274	10043	8304
1972	0.0322	0.0588	1.123	0.269	3095	2756
1973	0.2678	0.1334	1.369	0.484	4709	3440
1974	-0.6401	0.1009	0.561	0.174	11419	20344
1975	0.0723	0.0552	1.171	0.272	3838	3278
1976	0.0242	0.0174	1.137	0.150	15971	14042
1977	-0.0939	0.0174	1.011	0.133	13452	13310
1978	-0.3000	0.0179	0.822	0.110	6318	7684
1979	0.0423	0.0220	1.155	0.171	5584	4833
1980	0.0384	0.0203	1.152	0.164	4367	3791
1981	0.0392	0.0192	1.153	0.159	9407	8156
1982	0.1906	0.0165	1.344	0.172	7870	5857
1983	0.2738	0.0186	1.459	0.198	8657	5934
1984	-0.0456	0.0232	1.058	0.160	2696	2549
1985	0.2177	0.0196	1.379	0.192	3677	2667
1986	0.2525	-0.0191	1.428	0.197	27839	19499
1987	0.1656	0.0251	1.305	0.206	29076	22280

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.204

Table 8: Standardized CPUE and effort from the multiplicative analysis of catch and effort data for redfish in NAFO Division 3N.

	LN TRANSFORM		RETRANSFORMED			
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT
1959	0.1287	0.0272	1.233	0.202	10478	8497
1960	0.1515	0.0607	1.241	0.302	16547	13338
1961	0.0381	0.0408	1.119	0.224	14826	13252
1962	0.2661	0.0313	1.411	0.248	18009	12767
1963	-0.0061	0.0411	1.070	0.215	12906	12060
1964	-0.1841	0.0542	0.890	0.205	4206	4727
1965	0.1201	0.0542	1.206	0.277	4042	3351
1966	0.4755	0.0254	1.746	0.277	10047	5754
1967	0.0598	0.0843	1.119	0.319	19504	17436
1968	-0.6677	0.0633	0.546	0.136	15265	27950
1969	-0.2380	0.0387	0.850	0.166	22142	26059
1970	-0.0393	0.0436	1.034	0.214	13359	12919
1971	-0.2683	0.0854	0.805	0.231	24310	30189
1972	-0.0442	0.0377	1.032	0.199	25838	25037
1973	-0.0286	0.0524	1.041	0.235	28588	27475
1974	0.5522	0.0521	1.860	0.420	10867	5842
1975	-0.0623	0.0499	1.007	0.223	14033	13932
1976	-0.4397	0.0439	0.693	0.144	4541	6556
1977	-0.0761	0.0554	0.991	0.230	3064	3093
1978	-0.1252	0.0402	0.950	0.189	5725	6023
1979	-0.0824	0.0282	0.998	0.167	8483	8500
1980	0.4402	0.0279	1.683	0.280	11663	6928
1981	0.1612	0.0280	1.274	0.212	14873	11679
1982	0.3376	0.0262	1.520	0.245	13677	8995
1983	0.1419	0.0304	1.248	0.216	11090	8889
1984	-0.0795	0.0353	0.997	0.186	12065	12097
1985	-0.1451	0.0345	0.934	0.172	16880	18064
1986	-0.1385	0.0388	0.939	0.183	14350	15289
1987	0.0273	0.1118	1.068	0.348	14987	14033

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.209

Table 9: Summary of regression results relating catch and effort for redfish in NAFO Division 3N (* denotes those relationships selected for further analysis).

a) Linear regressions of CPUE on effort ($C/f=\alpha+\beta f$) including all years.

LAG	α	β	r^2	p
6	1.262	1.225×10^{-5}	0.041	0.340
8	1.268	1.212×10^{-5}	0.028	0.457
10	1.134	0.437×10^{-5}	0.003	0.831
12	1.100	0.109×10^{-5}	0.000	0.967

b) Linear regressions of CPUE on effort ($C/f=\alpha+\beta f$) excluding 1974.

LAG	α	β	r^2	p
6	1.384	2.402×10^{-5}	0.214	0.026 *
8	1.454	2.870×10^{-5}	0.210	0.037 *
10	1.255	1.598×10^{-5}	0.059	0.317
12	1.227	1.085×10^{-5}	0.019	0.594

c) Quadratic regressions of CPUE on effort ($C=\beta_1 f+\beta_2 f^2$) including all years.

LAG	β_1	β_2	$p\beta_1$	$p\beta_2$
6	1.210	1.368×10^{-5}	0.001	0.420
8	1.767	4.743×10^{-5}	0.000	0.051 *
10	2.303	8.590×10^{-5}	0.000	0.017 *
12	2.388	9.635×10^{-5}	0.006	0.067

d) Quadratic regressions of CPUE on effort ($C=\beta_1 f+\beta_2 f^2$) excluding 1974.

LAG	β_1	β_2	$p\beta_1$	$p\beta_2$
6	1.285	1.778×10^{-5}	0.001	0.308
8	1.840	5.121×10^{-5}	0.000	0.034 *
10	2.405	9.067×10^{-5}	0.000	0.006 *
12	2.641	11.105×10^{-5}	0.002	0.024

Table 10: Summary of equilibrium general production results derived from the selected relationships described in Table x.

Relationship	MSY		2/3 f_{MSY}	
	Effort (hour)	Yield (t)	Effort (hour)	Yield (t)
linear, lag 6, no 1974	28,808	19,932	19,205	17,717
linear, lag 8, no 1974	25,338	18,427	16,892	16,380
quadratic, lag 8, all years	18,622	16,448	12,415	14,621
quadratic, lag 10, all years	13,405	15,436	8,937	13,721
quadratic, lag 8, no 1974	17,960	16,520	11,974	14,684
quadratic, lag 10, no 1974	13,263	15,950	8,842	14,178

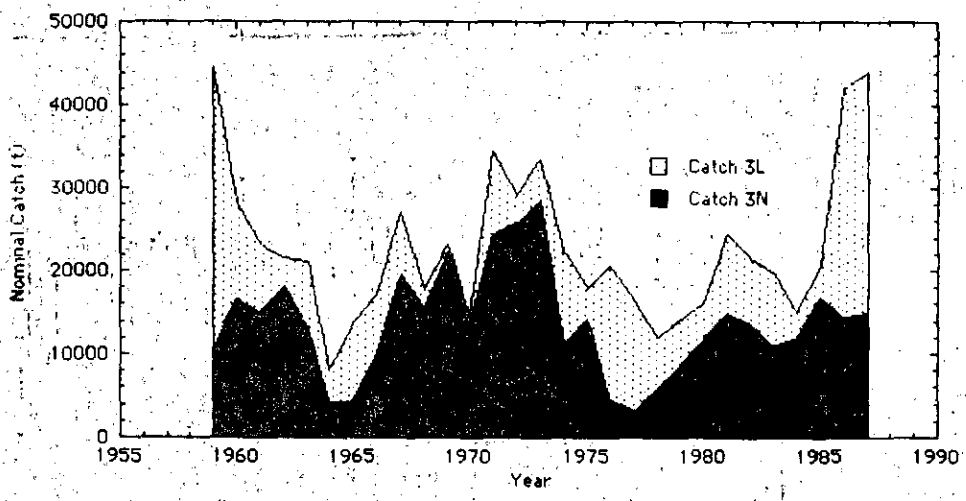

Figure 1: Nominal catches of redfish in NAFO Divisions 3LN, 1959-1987 (1986 and 1987 are provisional).

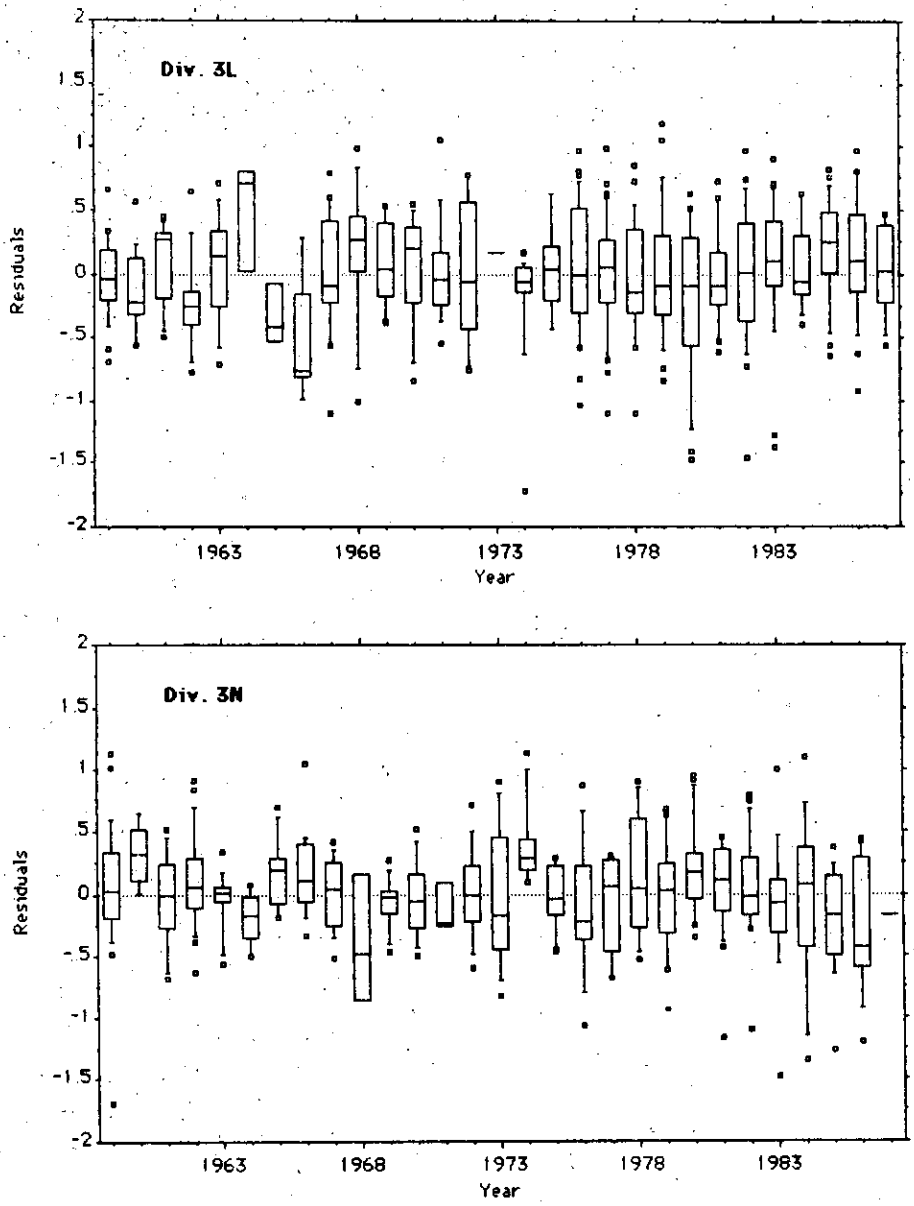

Figure 2: Boxplots (percentiles) of residuals by year for catch rates in divisions 3L and 3N from the multiplicative analysis of data for the two divisions combined.

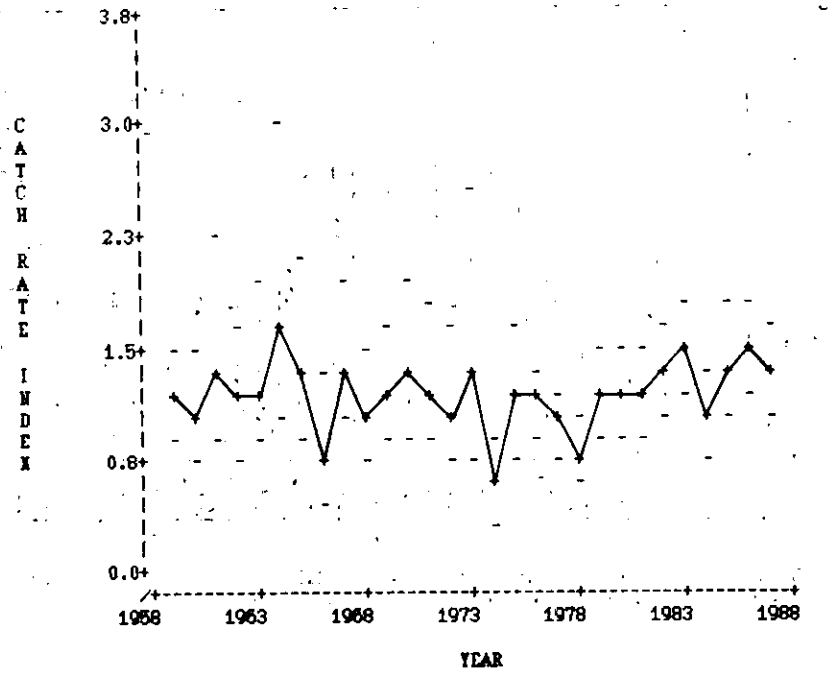

Figure 3: Standardized catch rates (t/hr) derived from the multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3L.

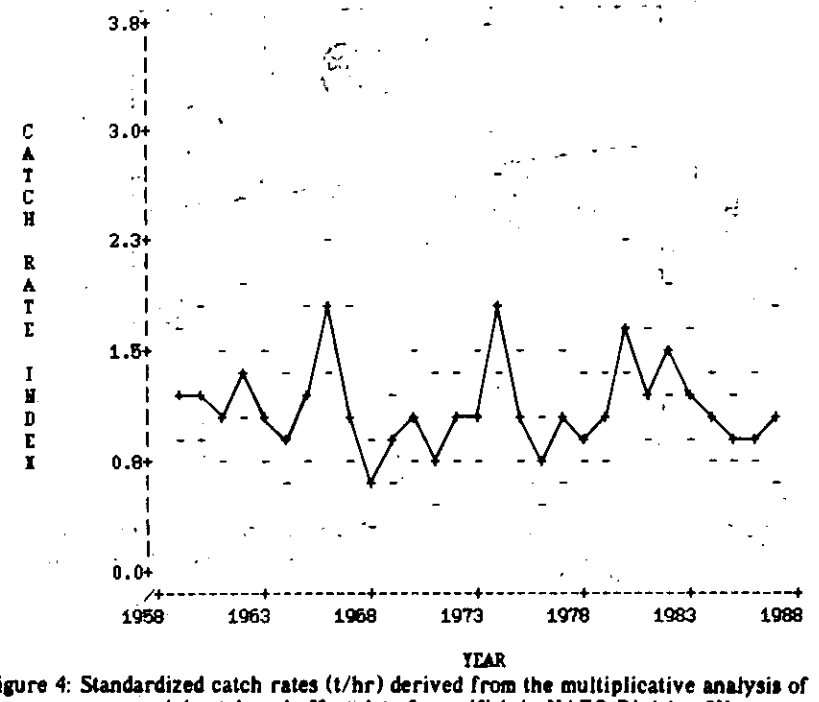

Figure 4: Standardized catch rates (t/hr) derived from the multiplicative analysis of commercial catch and effort data for redfish in NAFO Division 3N.

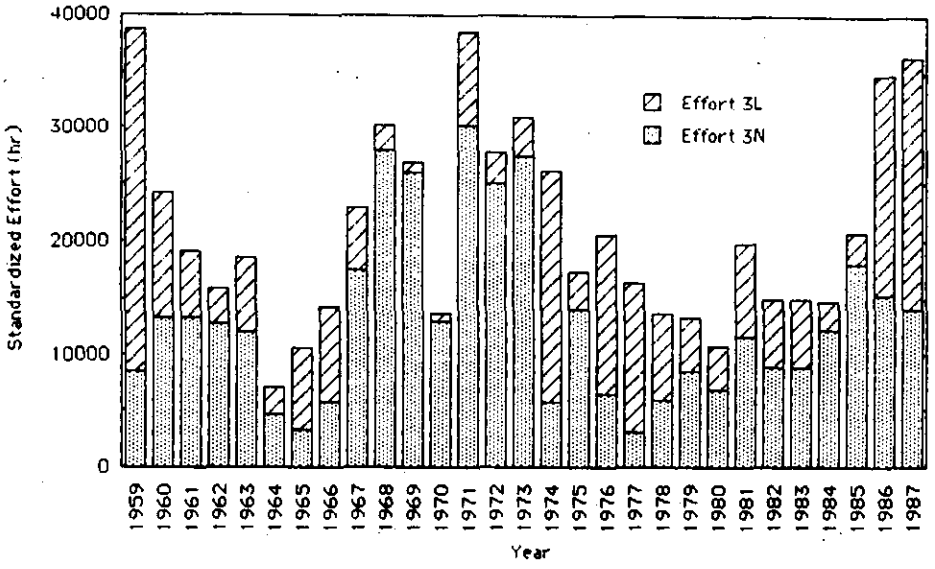

Figure 5: Standardized effort for redfish in NAFO Divisions 3LN derived from the multiplicative model (1986 and 1987 are preliminary).

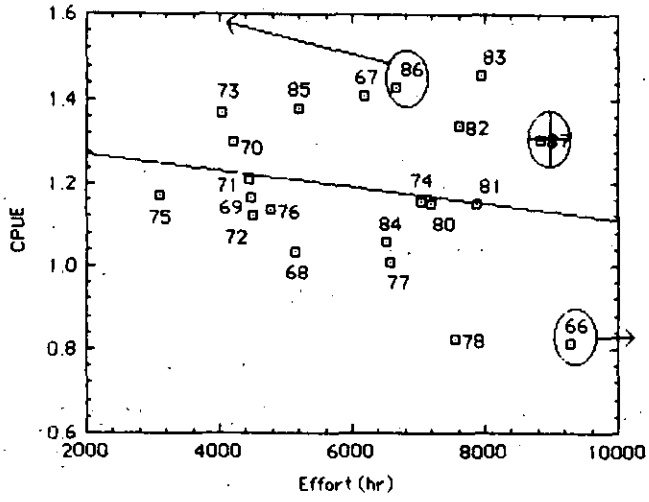

Figure 6 : Linear regression of standardized CPUE on standardized effort for redfish in NAFO Division 3L illustrating the differences that resulted in a significant relationship in 1987.

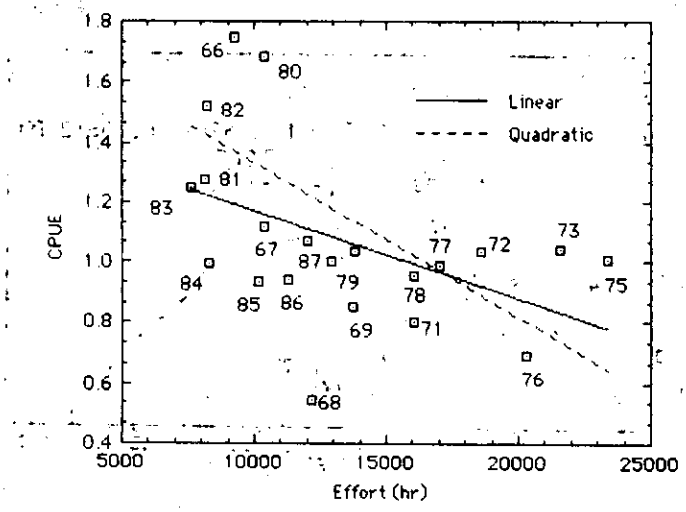

Figure 7 : Comparison of relationship between CPUE and effort as derived from the linear relationship (C/f=a+bf) and the quadratic one (C=af+bf*f) for NAFO Division 3N redfish (1974 excluded).

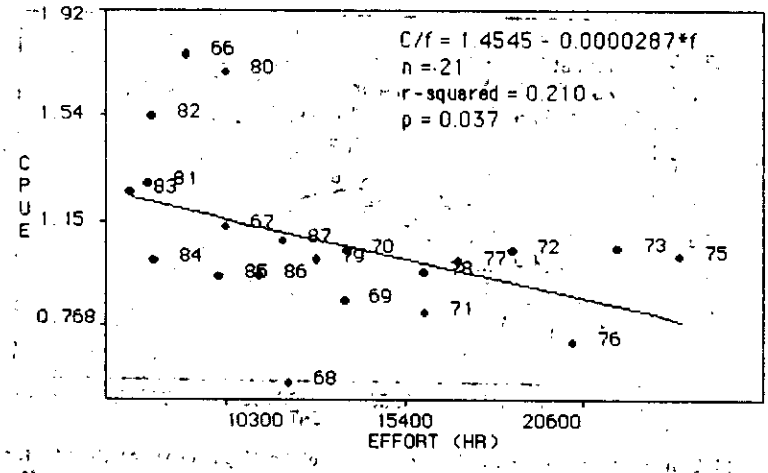

Figure 8 : Linear relationship between catch and effort (lagged 8 years) for redfish in NAFO Division 3N. The labelled points are the lagged effort values.

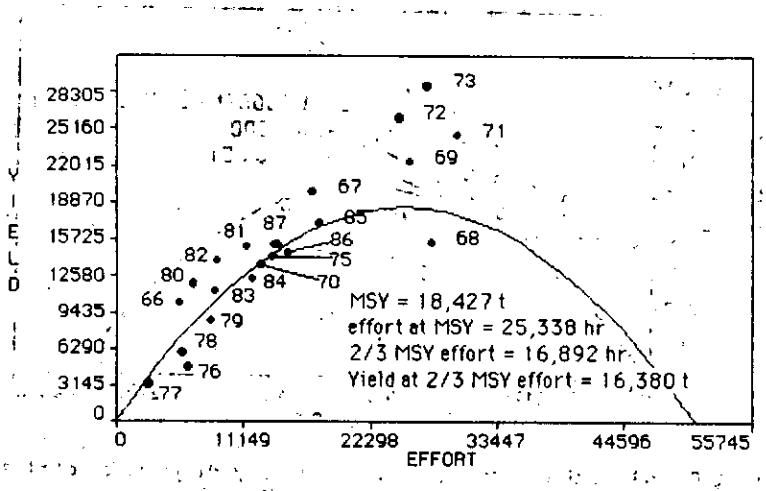

Figure 9 : Equilibrium curve derived from the linear relationship between catch and effort (lagged 8 years) for redfish in NAFO Division 3N (the labelled points are the actual effort values derived for each year).

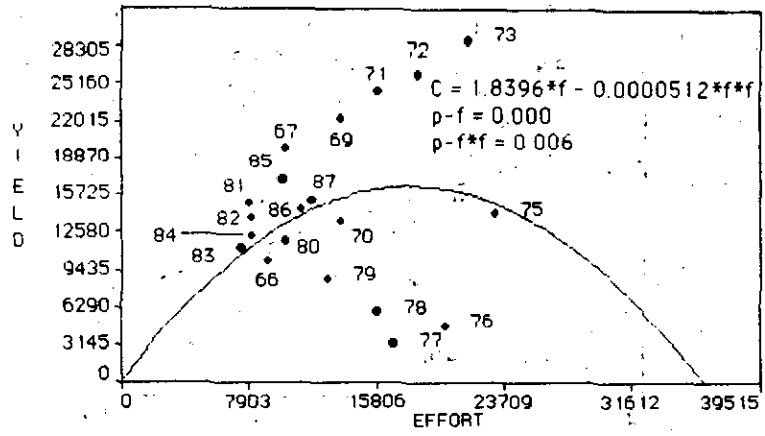

Figure 10 :Quadratic relationship between catch and effort (lagged 8 years) for redfish in NAFO Division 3N. The labelled points are the lagged effort values (1974 deleted).

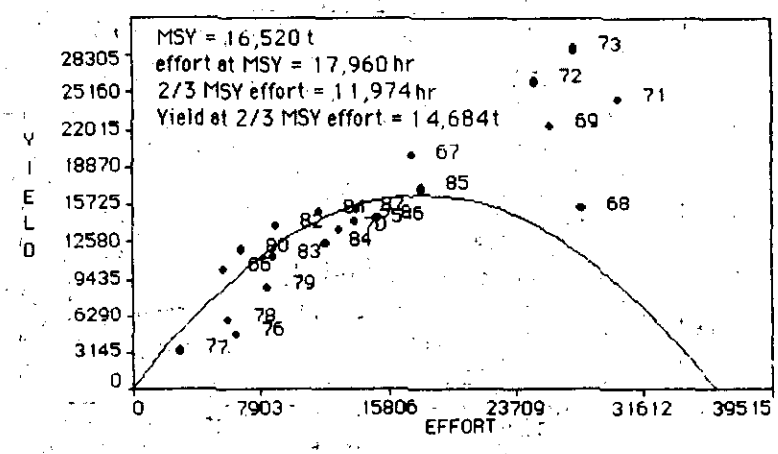

Figure 11 :Equilibrium curve derived from quadratic relationship between catch and effort (lagged 8 years) for redfish in NAFO Division 3N (the labelled points are the actual effort values derived for each year, 1974 is deleted).

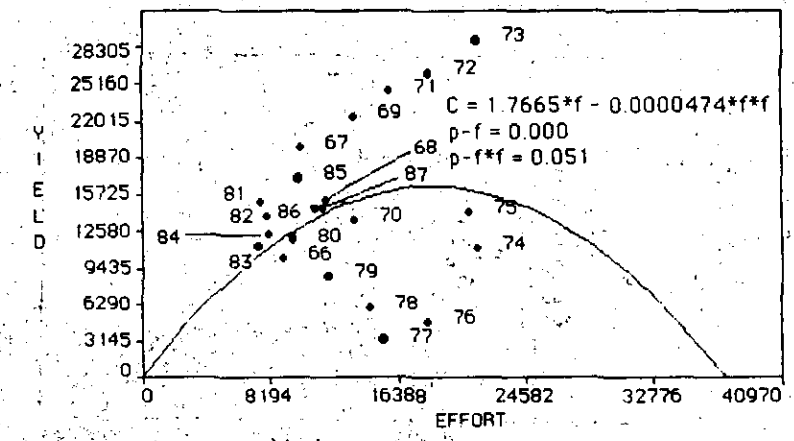

Figure 12 :Quadratic relationship between catch and effort (lagged 8 years) for redfish in NAFO Division 3N. The labelled points are the lagged effort values.

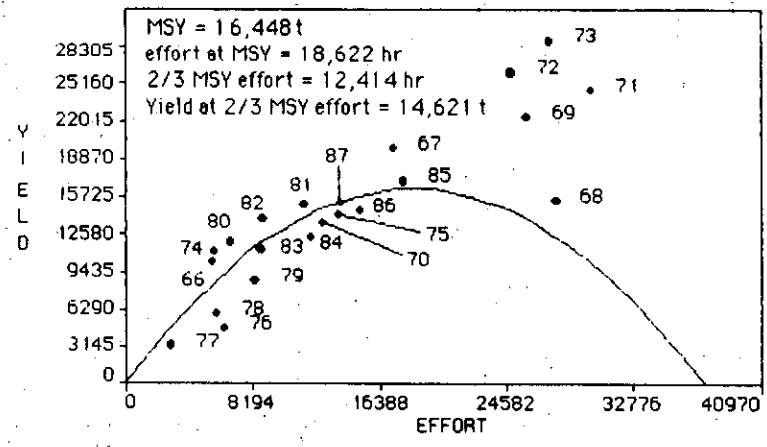

Figure 13 : Equilibrium curve derived from quadratic relationship between catch and effort (lagged 8 years) for redfish in NAFO Division 3N (the labelled points are the actual effort values derived for each year).

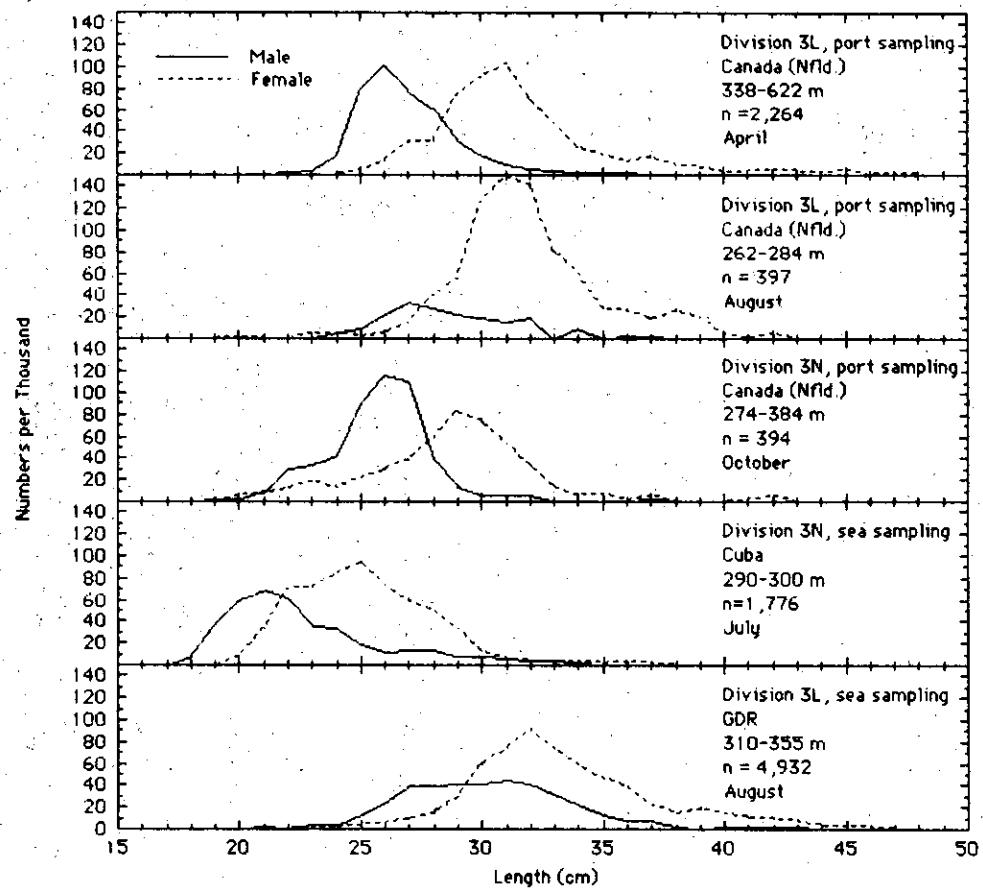

Figure 14 : Commercial frequencies of redfish caught in NAFO Divisions 3LN in 1987 as collected by Canadian port samplers and observers.