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Status of Redfish in NAFO Division 3M

by

D. Power and D. B. Atkinson

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

Introduction

Nominal catches from this stock have been between 14,000 tons and 44,000 tons since 1977 and have been as high as 52,000 tons in 1959 (Table 1, Fig. 1). The present TAC of 20,000 tons has been taken each year since 1983. Provisional statistics indicate nominal catches exceeded the TAC by 9,000 tons in 1986, 24,000 tons in 1987 and 3,000 tons in 1988. The increase from 1986 to 1988 is mostly due to landings by the EEC (primarily Portugal). Up until 1987 the USSR fleet has taken half of the reported landings in each year and in some years as much as 77%.

Catch statistics by month since 1977 indicate that most of the catch is taken from January to September (Table 2). A breakdown of catches by gear since 1976 (Table 3) reveals that midwater trawling is the predominant fishing method.

Lack of catch at age by Canada precludes our doing an analytical type of assessment of this stock and our evaluation of the status of this resource has been based solely on available catch and effort data.

Methods and Results

A catch and effort database was compiled from ICNAF/NAFO Statistical Bulletins for 1959-85. Preliminary NAFO data for 1986 and 1987 were appended to this database. Subsequently, records where redfish comprised more than 50% of the total catch were

selected as these were considered to be redfish directed. These data were utilized in a multiplicative model (Gavaris, 1980) to derive a standardized catch rate index for the period 1959-1987. A new category type, redfish catch as a percentage of total catch, was included to evaluate whether any variation can be explained by such a categorization. Five percentage categories were arbitrarily established for this category type as >50-60, >60-70, >70-80, >80-90 and >90-100. Catch and/or effort data less than 10 units as well as less than five observations of country-gear-tonnage class (CGT), month or percentage categories were deleted before proceeding to run the model. Identification of data in the CGT category type as being attributed to side or stern-type trawlers was consistent with last year's assessment (Power and Atkinson, MS 1988). The regression was run unweighted because of unknown percentages of prorating of effort data prior to 1984.

The regression (Table 4) was highly significant ($P < 0.01$, $r^2 = 0.64$). All category type effects were highly significant ($P < 0.01$ for each effect) except for the month effect which was not significant ($P > 0.25$). The regression coefficients are listed for each category in Table 6. The codes for the composite CGT categories are those used by NAFO (cf. 20127 represents USSR (20) - bottom-trawl stern (12) - tonnage class (7) vessels). It is interesting to note that although there is a significant year effect, only three years (1961, 1970 and 1971) have significantly different regression coefficients from the reference chosen (1959). Residual plots from the regression shown in Fig. 3 and 4 do not indicate any exceptional outliers. Standardized effort from the model (Table 5, Fig. 2) has been in the range of 11,000 hours since 1983 with an increase of around 50% in 1987. The standardized catch rate series (Table 5, Fig. 5) shows a general decline from 1961 to 1967 followed by a sharp increase to the highest rate in the series in 1970. Subsequently, catch rate declined to 1972 and have shown relative stability to 1985. The preliminary data for 1986 and 1987 indicate that catch rate has increased relative to 1985. However, there were about 11,000 tons in 1986 and 22,000 tons in 1987 caught by Portugal for which effort in hours is not available.

In previous assessments of this stock (cf. Power and Atkinson, MS 1987, MS 1988) catch rate and standardized effort were utilized in general production analyses under equilibrium (Schaefer type) conditions using 6, 8 and 10 year lagged effort (Gulland,

1961) as well as a non-equilibrium version (Rivard and Bledsoe, 1978). An equilibrium general production analysis was not attempted this year because there was concern that regressions of CPUE on lagged effort were only significant due to the 1970 and 1971 data points. Subsequently, little confidence was put in parameter estimates from this model. A non-equilibrium general production analysis was attempted but the model would not converge to any sensible parameter estimates and therefore no results are presented.

Estimates of total mortality (Table 8) by the method of Paloheimo (cf. Ricker, 1975) were calculated using a catch-at-age matrix for 1975-1986 (Table 7) available in Vaskov *et al.* (MS 1987) and standardized effort from the multiplicative model. There appears to be wide fluctuations from year to year for Z's calculated for 11+ ages. If we assume a natural mortality rate of 0.1 then fishing mortalities appear to be very much higher than $F_{0.1}$ (generally in the vicinity of 0.15 for redfish) since 1975.

A commercial length frequency for August (Fig. 6) available from the Canadian observer program caught by Cuban vessels indicate a mode of about 28 cm.

Discussion

Insufficient contrast in the catch-rate data makes the use of general production models inappropriate in the calculation of sustainable yields from this stock.

The standardized catch-rate series indicates a fairly stable period from 1972 to 1985. Preliminary data indicate a rise in catch rate from the 1985 rate. At the same time, catches have increased by 9,000 tons in 1986 and 24,000 tons in 1987 from an average of 20,000 tons for 1983-1985.

Paloheimo Z's suggest that since 1977 catches ranging from 14,000 tons to 20,000 tons have generated fishing mortalities very much higher than $F_{0.1}$ and it is expected that these would affect catch rates. This appears inconsistent with the apparent stability of the catch-rate index since 1972.

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Table 1: Nominal catches (t) of redfish in Division 3M by country and year.

Country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986*	1987*	1988*
Canada (M)+	1,402	486	443	218	12	-	-	-	-	-	-	-
Canada (N)	3,392	3,861	4,686	60	517	2	-	-	-	-	-	-
France (M)	546	242	67	15	7	-	-	-	-	-	-	-
France (SP)	25	-	-	-	-	-	-	-	-	-	-	-
FRG	10	300	-	73	-	41	-	769	848	145	-	-
GDR	-	-	-	1,290	15	-	40	98	-	88	-	-
Japan	138	321	636	976	386	392	390	389	313	400	131	145
Poland	11	83	13	292	-	-	-	-	-	-	-	-
Portugal	854	455	666	985	659	1,408	1,667	2,123	1,306	10,783	21,823	-
Romania	-	24	4	-	-	-	-	-	-	-	-	-
Spain	52	31	13	29	488	31	589	282	281	643	825	-
UK	376	20	-	-	-	3	-	-	-	-	-	-
USSR	9,507	9,251	10,441	10,430	10,434	10,916	14,517	15,005	15,703	15,045	19,875	13,501
Iceland	-	-	-	-	-	-	-	-	-	5	-	-
Ireland	2,503	767	-	-	-	-	-	-	-	-	-	-
Cuba	1,451	863	1,527	1,549	1,373	1,853	2,324	1,562	1,831	1,764	1,757	1,735
Bulgaria	-	58	1,578	50	-	-	-	-	-	-	-	-
Kor-S	-	-	-	-	-	38	-	-	-	-	-	-
EEC (Un.Sp.)	-	-	-	-	-	-	-	-	-	-	-	7,180
TOTAL	20,267	16,762	20,074	15,967	13,891	14,684	19,527	20,228	20,282	28,873	44,411	22,561

* Provisional

Table 2: Nominal catches (t) of redfish in Division 3M by month and year.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1977	417	532	2,786	1,847	1,821	3,649	4,284	1,416	590	243	81	98	20,267 a
1978	394	354	963	1,156	1,026	4,017	1,004	1,650	1,301	2,996	1,067	834	16,762
1979	790	1,560	896	4,237	5,147	2,394	1,393	56	111	1,486	1,369	635	20,074
1980	1,212	1,341	4,751	2,852	1,377	735	-	1,083	1,126	471	293	726	15,967
1981	198	849	2,671	5,120	1,615	711	698	952	847	7	149	74	13,891
1982	987	295	2,222	2,825	2,328	1,484	1,292	2,209	543	241	125	133	14,684
1983	2,393	1,014	1,128	2,260	2,395	3,099	3,384	1,529	1,500	691	51	83	19,527
1984	159	1,725	2,465	4,283	3,773	3,679	1,148	912	900	419	449	316	20,228
1985	267	422	445	656	2,172	79	3,135	7,308	1,046	614	2,051	2,087	20,282
1986*	3,892	3,563	2,852	1,844	4,176	117	2,582	5,842	2,501	742	322	440	28,873
1987*	2,053	3,496	4,763	9,756	10,198	2,637	2,604	2,582	1,762	1,398	1,647	1,515	44,411
1988*	6,053	3,694	3,867	1,727	835	953	945	1,762	637	901	232	955	22,561

* Provisional.

a includes a catch of 2,503 t from month 'unknown'.

Table 3: Breakdown of catches by gear type for redfish in Div. 3M.

	3M				
	Bottom	MW	Gillnets	Misc.	Total
Year	Trawl	Trawl			
1977	8,259	12,008	-	-	20,267
1978	5,671	11,091	-	-	16,762
1979	7,118	12,937	19	-	20,074
1980	4,959	11,008	-	-	15,967
1981	3,008	10,823	60	-	13,891
1982	2,921	11,763	-	-	14,684
1983	6,811	12,716	-	-	19,527
1984	4,150	16,078	-	-	20,228
1985	2,799	17,483	-	-	20,282
1986*	11,482	16,572	-	639	28,873
1987*	22,699	21,601	-	111	44,411

* Provisional

Table 4. Analysis of variance results from the multiplicative model to derive a standardized catch rate for redfish in NAFO Division 3M.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.798
MULTIPLE R SQUARED..... 0.638

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.572E1	2.572E1	
REGRESSION	62	1.885E2	3.040E0	11.264
TYPE 1	19	1.190E2	6.261E0	23.197
TYPE 2	11	2.850E0	2.591E-1	0.960
TYPE 3	1	5.491E0	1.373E0	5.086
TYPE 4	28	1.858E1	6.634E-1	2.458
RESIDUALS	397	1.071E2	2.699E-1	
TOTAL	460	3.214E2		

Table 5. Predicted standardized catch rate series. (1986 and 1987 are based on preliminary data)

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1959	0.6678	0.0295	2.200	0.375	51977	23630
1960	1.2194	0.1744	3.551	1.422	8388	2362
1961	1.4069	0.0999	4.446	1.373	15517	3490
1962	1.0418	0.0986	3.088	0.948	6958	2253
1963	1.0390	0.0870	3.098	0.895	7035	2271
1964	0.7680	0.3193	2.103	1.101	17647	8392
1965	0.8780	0.0810	2.645	0.739	33427	12637
1966	0.4393	0.3278	1.507	0.798	7241	4804
1967	0.4038	0.3265	1.456	0.769	729	501
1968	0.9532	0.0826	2.849	0.803	4963	1742
1969	0.8019	0.1118	2.414	0.786	2801	1160
1970	1.6682	0.0607	5.889	1.431	3168	538
1971	1.3247	0.0328	4.236	0.761	8033	1896
1972	0.8127	0.0230	2.551	0.385	41946	16444
1973	0.6659	0.0404	2.184	0.435	22352	10236
1974	0.8420	0.0243	2.625	0.407	34671	13207
1975	0.7767	0.0229	2.461	0.371	16075	6532
1976	0.5856	0.0269	2.029	0.331	16998	8379
1977	0.4803	0.0226	1.830	0.274	20267	11075
1978	0.6473	0.0220	2.163	0.320	16762	7749
1979	0.3292	0.0170	1.578	0.205	20074	12724
1980	0.6019	0.0188	2.070	0.283	15957	7707
1981	0.6444	0.0200	2.159	0.304	13891	6434
1982	0.6442	0.0196	2.159	0.301	14684	6801
1983	0.4638	0.0205	1.802	0.257	19527	10837
1984	0.4552	0.0243	1.783	0.277	20228	11345
1985	0.5134	0.0286	1.886	0.317	20282	10755
1986	0.8810	0.0373	2.712	0.519	28873	10647
1987	0.8974	0.0334	2.762	0.501	44411	16080

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.237

Table 6. Regression coefficients from the multiplicative model for catch rate standardization.

			REGRESSION COEFFICIENTS		
CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	20127	INTERCEPT	0.668	0.172	460
2	4				
4	95				
5	59				
1	2125	1	-0.062	0.197	10
	2155	2	0.187	0.265	5
	3125	3	-0.835	0.174	12
	3154	4	-0.009	0.210	8
	3155	5	0.334	0.150	21
	4127	6	-0.126	0.164	14
	4157	7	0.371	0.145	22
	10127	8	-0.030	0.207	8
	14125	9	-1.247	0.173	12
	14126	10	-0.992	0.144	20
	14127	11	-0.680	0.123	33
	14156	12	-1.040	0.235	6
	16127	13	-0.886	0.188	13
	17127	14	-0.412	0.190	10
	20114	15	-1.837	0.161	35
	20116	16	-0.581	0.214	12
	20156	17	0.305	0.241	7
	20157	18	0.453	0.087	110
	27125	19	0.261	0.232	6
2	1	20	-0.286	0.135	23
	2	21	-0.131	0.125	28
	3	22	-0.237	0.108	43
	5	23	-0.110	0.109	42
	6	24	-0.191	0.108	47
	7	25	-0.117	0.106	53
	8	26	-0.112	0.108	49
	9	27	-0.272	0.115	37
	10	28	-0.235	0.125	30
	11	29	-0.181	0.126	28
	12	30	-0.148	0.141	21
4	55	31	-0.322	0.129	29
	65	32	-0.388	0.095	43
	75	33	-0.137	0.100	41
	85	34	-0.061	0.074	80
5	60	35	0.552	0.422	2
	61	36	0.739	0.322	4
	62	37	0.374	0.324	4
	63	38	0.371	0.300	5
	64	39	0.100	0.573	1
	65	40	0.210	0.293	5
	66	41	-0.229	0.579	1
	67	42	-0.264	0.579	1
	68	43	0.285	0.295	5
	69	44	0.134	0.343	3
	70	45	1.000	0.258	7
	71	46	0.657	0.209	14
	72	47	0.145	0.196	17
	73	48	-0.002	0.239	8
	74	49	0.174	0.196	21
	75	50	0.109	0.193	22
	76	51	-0.082	0.207	22
	77	52	-0.187	0.197	26
	78	53	-0.020	0.191	32
	79	54	-0.339	0.182	43
	80	55	-0.066	0.187	30
	81	56	-0.023	0.189	28
	82	57	-0.024	0.188	28
	83	58	-0.204	0.190	29
	84	59	-0.213	0.196	24
	85	60	-0.154	0.206	20
	86	61	0.213	0.220	14
	87	62	0.230	0.215	19

Table 7. Catch at age data taken from Vascov et al (1987, NAFO SCR Doc. 87/20).

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
5	2658	16	39	1160	618	123	321	14	13	1027	8200	2571
6	2735	135	99	1104	2118	818	1194	233	155	875	3870	6350
7	3667	462	308	1228	3571	2708	2925	1137	837	1536	670	3973
8	3937	1342	706	1140	3665	3672	4533	3050	3320	2621	350	1353
9	4537	2827	1581	1718	3146	4399	5877	5119	6031	3857	1310	1163
10	6449	5794	3445	3690	3020	3855	6412	7334	9792	6044	2520	2272
11	5967	7025	4736	4913	3364	2827	4855	6387	9095	6204	2630	2718
12	3811	5323	4238	4467	3632	2280	2699	3569	5291	4335	3440	3793
13	2558	4533	4662	4550	4492	2838	2223	2350	3643	3612	4050	3495
14	1623	3093	4014	3611	3985	2740	1666	1600	2323	2599	3300	2861
15	1062	2016	3483	2609	3316	2409	1235	1187	1783	1799	1700	1622
16	789	1410	2929	1799	2508	1867	850	963	1281	1233	1670	1383
17	482	703	1671	936	1364	1134	454	615	684	573	570	482
18	371	449	1263	623	986	853	311	454	457	351	460	426
19	370	333	982	437	795	658	237	383	356	250	180	231
20	258	211	705	259	558	471	164	264	229	158	280	281
21	241	136	491	165	376	324	108	170	154	99	210	171
22	176	61	210	57	143	133	41	50	48	25	70	60
23	145	17	61	49	68	37	14	7	5	4	40	28

Table 8. Estimates of total mortality (Z) as calculated by the method of Paloheimo (see text for details) utilizing data from Table 7 and estimated standardized effort from Table 5 for 1975 to 1986.

ESTIMATES OF TOTAL MORTALITIES (Z)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
11	0.363	0.784	-0.299	0.798	-0.112	-0.134	0.363	0.654	0.787	0.536	-0.376
12	0.076	0.412	-0.428	0.490	-0.255	-0.155	0.194	0.445	0.428	0.015	-0.026
13	0.059	0.401	-0.102	0.629	-0.007	0.352	0.384	0.395	0.383	0.037	0.337
14	0.032	0.160	0.074	0.581	0.002	0.616	0.394	0.358	0.384	0.371	0.700
15	-0.034	-0.095	0.304	0.535	0.073	0.861	0.304	0.390	0.415	0.021	0.196
16	0.364	0.109	0.784	0.773	0.292	1.233	0.379	0.808	0.850	0.718	1.233
17	0.320	-0.307	0.630	0.444	-0.032	1.113	0.055	0.763	0.713	0.166	0.281
18	0.357	-0.504	0.704	0.252	-0.097	1.100	-0.153	0.709	0.649	0.614	0.679
19	0.811	-0.471	0.976	0.252	0.022	1.209	-0.052	0.980	0.858	-0.167	-0.155
20	0.889	-0.566	1.095	0.123	0.042	1.292	0.020	1.005	0.884	-0.338	0.483
21	1.623	-0.155	1.796	0.639	0.538	1.887	0.826	1.730	1.864	0.293	1.243
22	2.586	0.279	1.098	0.319	0.851	2.071	1.823	2.768	2.531	-0.523	0.906
11+	0.621	0.004	0.553	0.486	0.110	0.954	0.378	0.917	0.896	0.145	0.433

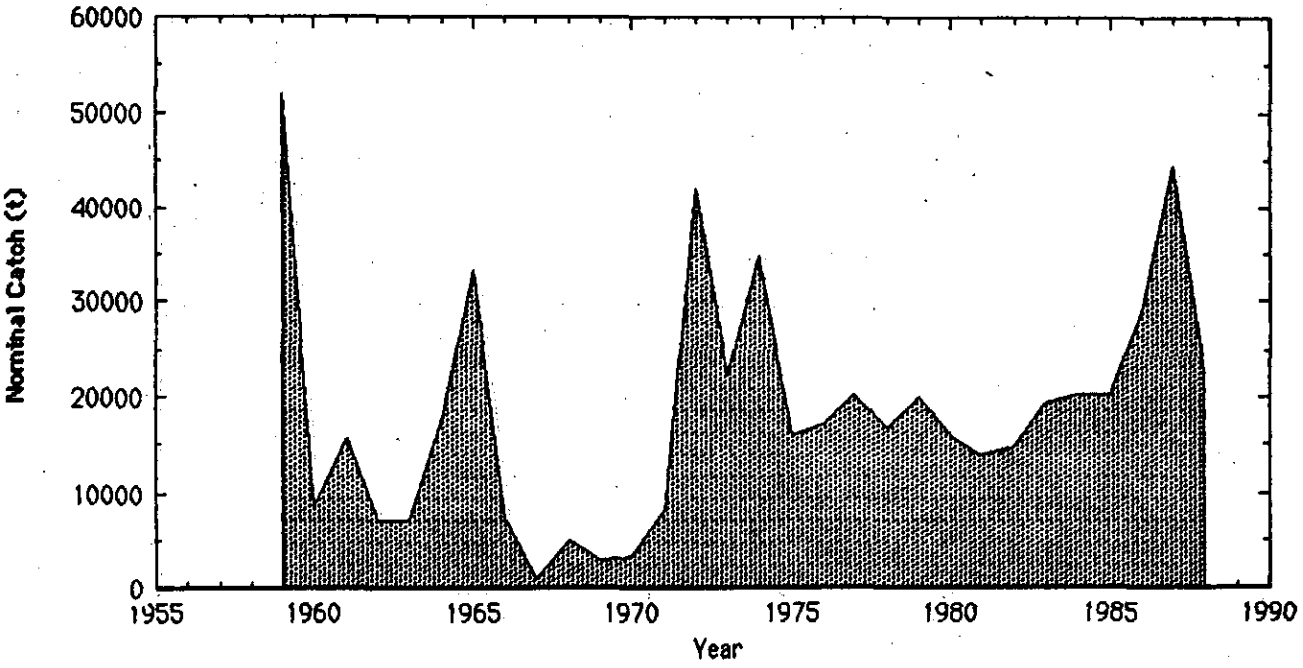

Figure 1: Nominal catches of redfish in NAFO Div. 3M (1986-1988 are provisional).

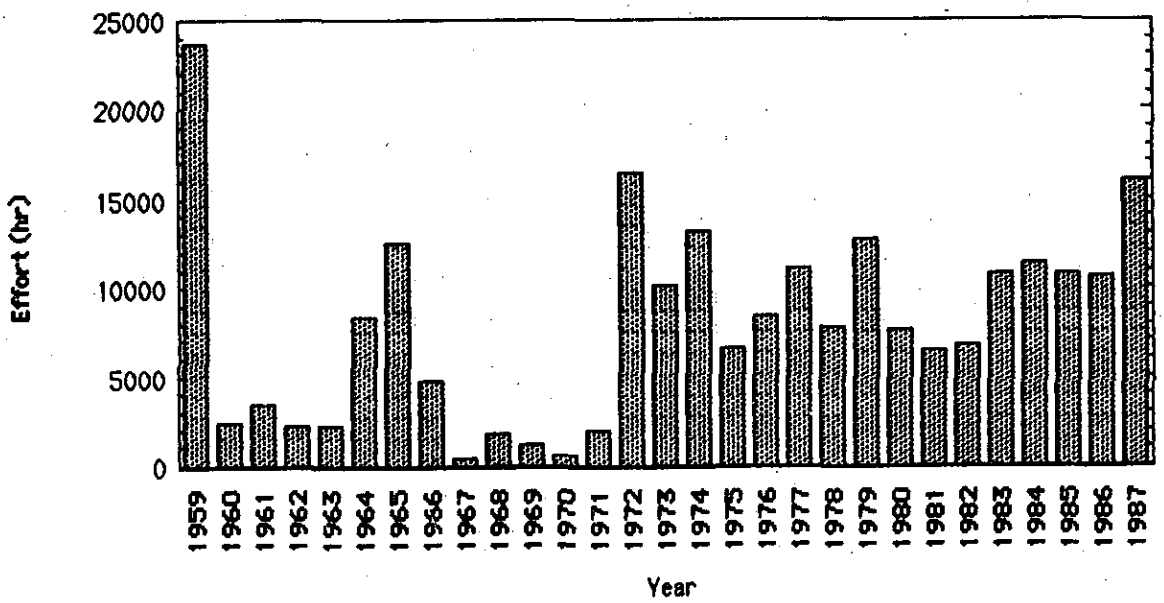

Figure 2: Standardized effort (hr) for redfish in NAFO Div. 3M.

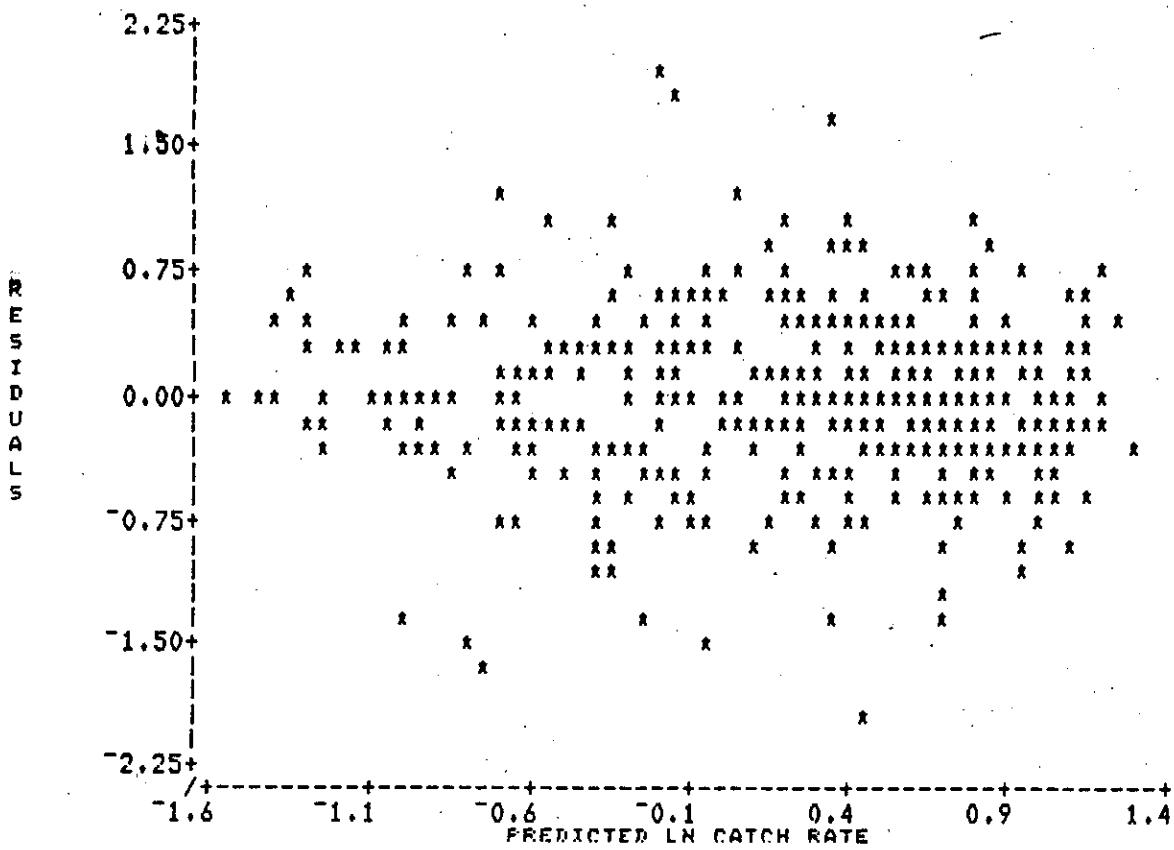

Figure 3. Plot of residuals versus ln(predicted catch rate) from the multiplicative model.

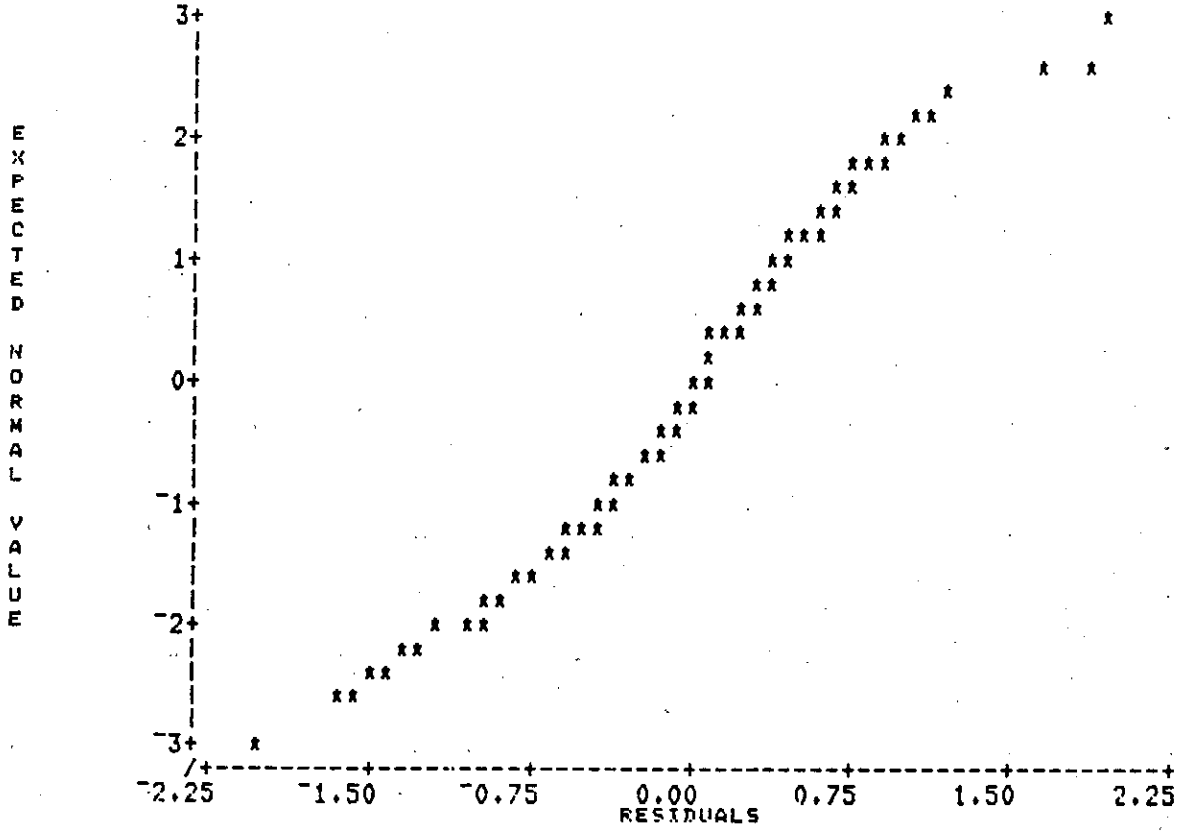

Figure 4. Plot of expected normal versus residuals from the multiplicative model for catch rate standardization.

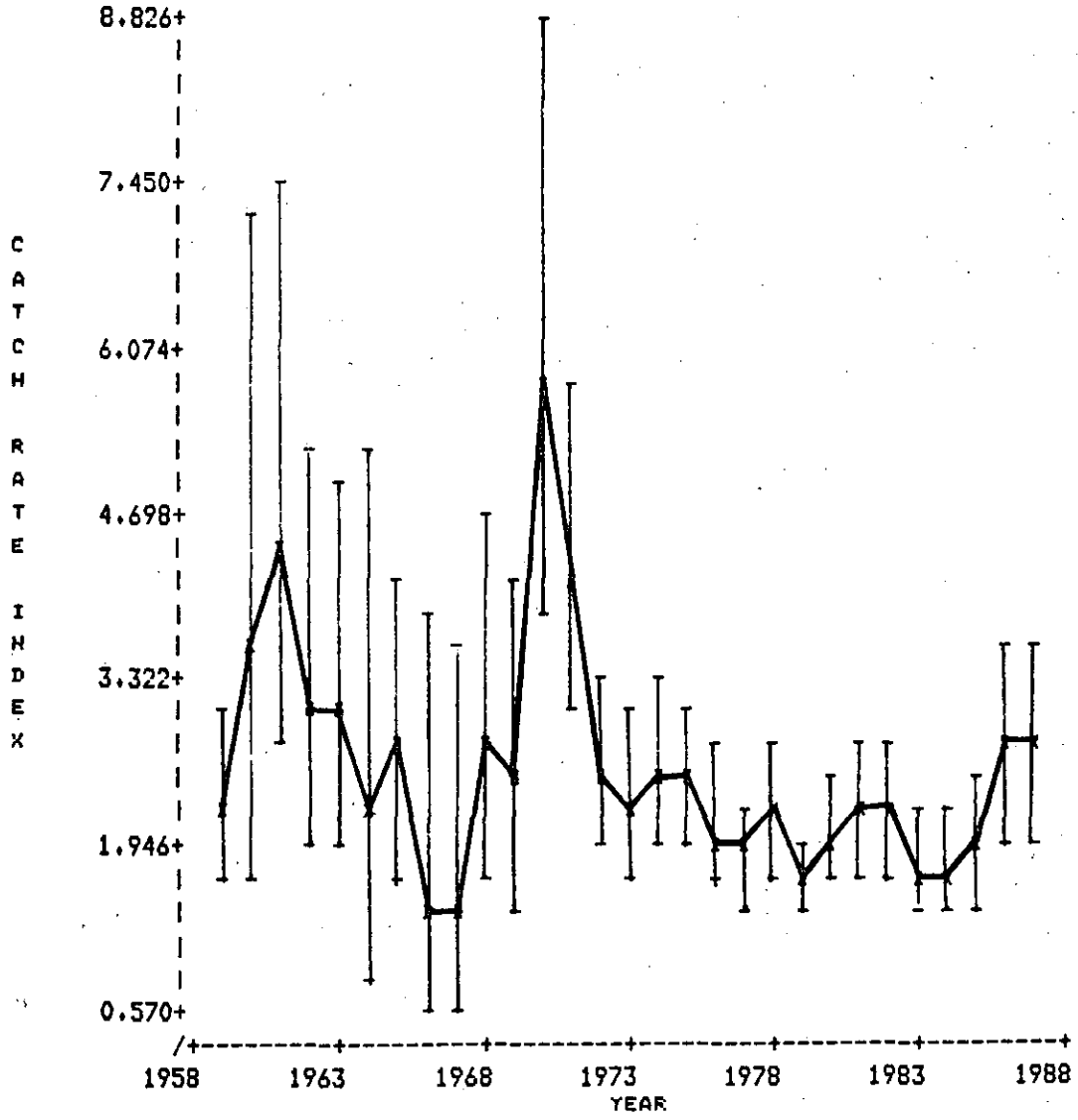

Figure 5. Plot of predicted standardized catch rates for redfish in NAFO Division 3M for the period 1959 to 1987 as derived using a multiplicative model (1986 and 1987 are preliminary).

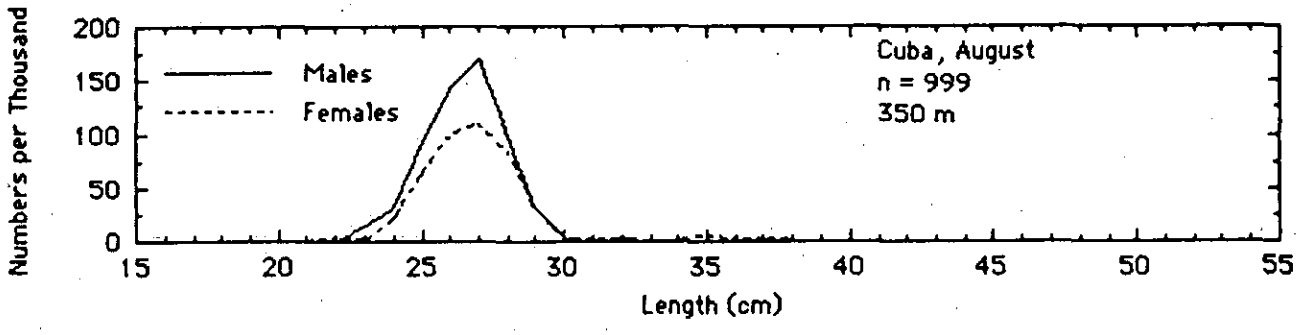

Figure 6 : Commercial frequency of redfish caught by Cuba in NAFO Division 3M in 1988 as collected by Canadian Observers.