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An Assessment of Redfish in Subarea 2 + Division 3K

by

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ABSTRACT

The status of the redfish stock in Subarea 2 and Div. 3K was evaluated using standardized catch rate data and research survey results. The catch rate series showed an apparent decline between 1977 and 1979. Among possible causes for the decline were a decline in stock biomass, a shift in the composition of the fishing fleet and/or a change in the size selection of redfish. The research surveys did not indicate any trend in the level of abundance. A preliminary cohort analysis was presented but was not used due to too few years of data available. Evidence for a change in the status of the stock was inconclusive.

RESUME

Nous avons évalué l'état du stock de sébastes de la sous-zone 2 et de la division 3K à l'aide des taux de capture standardisés et des résultats de croisières de recherche. La série des taux de capture indique un déclin apparent entre 1977 et 1979. Ce déclin peut être dû à une diminution de biomasse, à des changements de composition de la flottille de pêche et (ou) à une sélection de tailles des sébastes différentes. Les relevés par navires de recherche, pour leur part, ne révèlent aucune tendance d'abondance. Une analyse des cohortes préliminaires a été preparée, mais n'a pas été utilisée, parce que les données ne couvraient pas un nombre suffisant d'années. Les données dont nous disposons ne nous permettent pas d'identifier de changements dans l'état des stocks.

INTRODUCTION

The trend over the last several years in the redfish fishery in Subarea 2 and Div. 3K has been towards the increased participation of Canadian vessels. In 1980 however, the Canadian share of the catch fell off sharply as the market conditions for redfish deteriorated. Only 14,000 t of a quota of 35,000 t was taken, the Canadian catch being 7,700 t compared to 26,600 in 1979.

The data presented in this paper to help determine the status of the stock include trends in CPUE, the age structure of the stock from 1978-1980 as determined by Canadian research surveys and a preliminary cohort analysis based on five years of ageing the commercial catch.

MATERIALS AND METHODS

The large shift in the composition of the redfish fishery (Table 1) has impeded the development of a single standard CPUE series that performs equally well for all years. At several times during the history of the fishery, catches have fallen off drastically, resulting in gaps in the CPUE trend. Another problem has been the reporting of a large proportion of the catch as by-catch (Gavaris, 1979). In this analysis, the catch and effort data for the major participants in the fishery were used to obtain predicted catch rates according to the standardization method described by Gavaris (1980). Catch-rates in the regression were weighted by effort and the variable categories used were country-gear-tonnage class combination, months and years.

Research surveys by the Gadus Atlantica have been conducted in Div. 2J, 3K in the fall of the past three years, 1978-1980. Coverage in 1978 was the most extensive, the number of sets in each of the years being 108, 89 and 84 respectively. Only strata in the 200-1000 m depth zone covered in all three years was included.

The collection of redfish length and otolith samples from Canadian vessels was rather sporadic, reflecting the nature of the fishery (Table 4). The number and seasonal distribution of length frequencies are shown in Table 5, along with the total number of otoliths read.

ESTIMATION OF PARAMETERS

STANDARDIZATION OF CPUE

The results of the multi-linear regression of ℓn (catch rate), weighted by effort, against categories of country-gear-tonnage class, months and years (Type 1, 2 and 3 respectively in Table 3) are shown. The standard chosen was Newfoundland OT, TC 4 and 5, months March and April, based on a lower average coefficient of variation (0.14 over the years 1976-1980) of their predicted catch rates compared to those of other vessel type-month combinations. The trends in catch rates along with the historical catches are shown in Table 2.

PARTIAL SELECTION

An estimate of partial selection was obtained by comparing the commercial to the research catch at age in 1980 and smoothed by the method of cubic splines to obtain the result (Table 10). An "average" selection pattern using the past three years was not attempted as a pronounced change in the selection pattern from 1979 to 1980 was suggested by the commercial catch-at-age matrix (Table 8).

MEAN WEIGHT-AT-AGE

The mean weight-at-age for 1980 was obtained by multiplying the age/length key by the population length frequency and weight-at-length vectors for males and females separately, followed by a weighted average of the males and females. The result of applying this weight vector to the 1980 catch to obtain an estimate of the total 1980 catch biomass did not differ from using the "standard" redfish weight-at-age vector, although the two differed from age to age. One weakness of the age/length key method is its dependence on the age/length key itself which often has very few observations for some ages. The standard age/weight relationship was used for the years 1976-79 (Table 9).

NATURAL AND FISHING MORTALITIES

A natural mortality of 0.1 was assumed for all cohort runs. As only 14,000 t of 35,000 t quota was caught, fishing mortality in 1980 was considered to be low.

RESULTS AND DISCUSSION

CPUE

Several values were missing from the catch rate series during years when redfish-directed effort was very low or non-existent. The catch rate for 1980 was based on preliminary data for Newfoundland vessels only representing 6% of the total catch and may not be representative of the entire fishery.

While significant results were obtained from the standardization procedure, the regression explained only 57 percent of the variation in the catch rates. Given the lack of catch and effort data for this stock combined with the abrupt changes in the composition of the fleet that have occurred, this result was not surprising. Canadian participation in the fishery increased in 1978 while the USSR decreased its involvement substantially. At the same time, a decline was observed in the catch rate which persisted up to the 1980 preliminary catch rate figure. The apparent change in catch rate level may describe two components of the fishery rather than a change in the abundance of the stock.

RESEARCH SURVEYS

The research survey results have been very variable. The 1980 abundance indices were intermediate between the relatively high values of 1978 and the low values of 1979 (Table 7). Each survey has produced a different picture of the age structure of the population as well, with fewer young fish being sampled in the last two surveys than in 1978 (Table 6). No very large pre-recruit year-class was evident in any of the surveys. There would appear to be a generally even distribution of age-classes in the redfish stock in Div. 2J and 3K.

CATCH-AT-AGE

The age structure of the catch changed markedly between 1979 and 1980 (Table 8). The shift to older fish in 1980 may have been influenced by the poor market conditions for redfish or of learning by the Canadian fleet rather than to poor recruitment.

COHORT ANALYSIS

In an effort to determine fishing mortality in 1980, the relationships between CPUE and mean biomass of ages 14+ at various levels of F were investigated (Table 11). All relationships at F's of 0.07, 0.10, 0.15 and 0.20 were about equally good. This method was clearly inadequate given the dubious value of the CPUE series and the lack of convergence in the cohort table. A change in the partial recruitment vector might also have produced high correlations between CPUE and mean biomass for a wide range of F values. Tables from cohort runs for F values of 0.07 and 0.10 are presented in Tables 12 and 13 for completeness. This method of analysis may become useful as more years of data are accumulated.

CONCLUSIONS

A decline in catch rates which occurred between 1977 and 1979 was not interpreted to mean that a corresponding decline had necessarily occurred in the stock biomass. A shift in the composition of the fleet and a change in the size selection of redfish were confounding factors. The research surveys did not indicate any trend in the abundance level. A preliminary cohort analysis was presented but was not used to determine the status of the stock.

REFERENCES

Gavaris, C. A. 1979. An assessment of Subarea 2 and Division 3K redfish. CAFSAC Res. Doc. 79/33.

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

Table 1. Nominal catches of redfish, SA2+Division 3K, 1979-80 (t)

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Bulgaria	0	0	0	20	0	0	0	0	0	0	0
Canada	63	153	49	374	153	445	3,894	3,498	22,052	26,587	7,752
Cuba	0	0	0	0	0	0	0	0	0	43	0
Faroes	0	0	0	9	0	0	0	0	0	0	0
GDR	4,827	2,662	2,400	2,484	2,465	2,447	1,729	1,305	2,909	543	1,014
Iceland	0	209	296	0	0	0	2	0	0	0	0
Japan	10	48	0	0	0	0	0	4	255	0	0
Norway	175	53	4	30	13	0	9	0	0	0	0
Poland	5,229	6,184	2,136	4,489	3,646	4,219	3,950	2,269	625	302	874
Portugal	0	0	620	2,784	4,820	2,971	823	845	378	544	272
Romania	845	168	329	305	0	0	0	312	0	0	0
Spain	0	0	3	0	0	26	0	134	37	0	45
USSR	10,379	9,785	13,481	24,230	11,898	13,575	14,881	8,014	2,685	2,578	4,029
Denmark	0	0	0	51	9	0	0	0	0	0	0
France	0	0	19	4	48	4	11	110	22	3	0
FRG	439	94	470	3,349	6,593	1,837	647	803	157	68	121
UK	11	0	226	836	500	35	19	245	26	62	45
Others	0	0	0	0	0	0	0	0	0	0	172
Total	21,970	19,356	20,033	38,965	30,145	25,559	25,965	17,539	29,146	30,730	14,324

Table 2. Historical catches and CPUE of the standard (Can N OT. TC 4 and 5, months March and April).

Year	Catch (t)	CPUE (t/hr)	Std. error	Effort (hrs)
1959	186,837	1.015	0.170	184,076
1960	129,773	0.665	0.116	195,147
1961	55,455	-		
1962	19,657	0.976	0.367	20,140
1963	23,671	1.709	0.442	13,851
1964	56,178	1.621	0.407	34,656
1965	42,653	1.686	0.422	25,298
1966	32,730	1.197	0.310	27,343
1967	26,162	1.232	0.393	21,235
1968	18,913	-		
1969	24,786	-		
1970	21,970	0.712	0.398	30,857
1971	19,356	0.769	0.211	25,170
1972	20,033	-		
1973	38,965	0.819	0.162	47,576
1974	30,145	-		
1975	25,559	0.597	0.265	42,812
1976	25,965	1.024	0.178	25,356
1977	17,539	1.086	0.182	16,150
1978	28,896	0.890	0.072	32,467
1979	30,730	0.706	0.076	43,527
1980	14,324	0.517	0.086	27,706

Table 3. Anova results from the multiplicative model. Type 1, 2 and 3 variables represent country-tonnage class-gear categories, months and years.

Multiple R.............0.755
Multiple R Squared.....0.570

Analysis of Variance

Source of variation	DF	Sums of squares	Mean squares	F-value
Type 1	5	$9.87384E^{0}$	$1.97477E^{0}$	15.641
Type 2	8	$7.62018E^{0}$	$9.52522E^{-1}$	7.544
Type 3	16	$8.91699E^{0}$	$5.57312E^{-1}$	4.414
Regression	29	$3.98920E^{1}$	$1.37559E^{0}$	10.895
Residuals	238	$3.00488E^{1}$	$1.26255E^{-1}$	
Total	267	$6.99408E^{1}$		

Table 4. Catches of redfish in Divisions 2J-3K , 1980, by country and month.

Month	Division 2J				Division 3K				Grand Total
	Can N	Can M	Other	Total	Can N	Can M	Other	Total	
Jan.			23	23			120	120	143
Feb.	170	9	107	286	122		24	146	432
Mar.	35		15	50	980	124	85	1189	1239
Apr.	6	13		18	1196	435	13	1644	1662
May	77	85		162	812	196	38	1046	1208
June			1	1	93		15	108	109
July	13			13	33		165	198	211
Aug.		426		426	16	111	633	760	1186
Sept.	156	2616		2772	6		1060	1066	3838
Oct.	9		362	371	5		127	132	503
Nov.			63	63			1486	1486	1549
Dec.			66	66	8		1405	1413	1479
Total	466	3149	637	4251	3271	866	5171	9308	13,559

Table 5. Number of commercial length frequency samples by month and division and the number of otoliths in age/length key from Canadian (Nfld. and Maritime) OT vessels, redfish, SA2+Division 3K, 1980.

Month	Division 2J	Division 3K
Jan		
Feb		3
Mar		4
Apr	1	9
May	2	2
June		
July		
Aug		
Sept	4	
Oct		
Nov		
Dec		

Number of females aged: 542

Number of males aged: 430

Table 6. Estimates of abundance at age, in thousands of individuals, from research surveys in Divisions 2J-3K, 1978-80.

	1978	1979	1980
1	1844	28	0
2	6962	231	108
3	22230	1380	1003
4	40073	9235	679
5	103961	17299	7149
6	88083	28339	19475
7	81465	37140	46813
8	181965	48701	66260
9	289594	73479	87098
10	224923	50775	50564
11	232678	43011	67318
12	110416	41985	68180
13	138400	62204	74392
14	99762	47006	49179
15	104211	29645	61714
16	78728	20047	87243
17	39526	25754	46176
18	22295	15743	58174
19	26230	15001	29501
20	38878	5373	39792
21	37440	7294	13405
22	19517	6133	14590
23	18292	3551	14297
24	14806	4361	12659
25	30708	5348	3286
26	21951	5458	7281
27	11399	5681	8163
28	13770	3944	8720
29	5752	3432	1800
30	41757	21156	43908

Table 7. Estimates of total abundance and mean catch per tow, in numbers and weights, from research surveys in Divisions 2J-3K, 1978-80.

Year	Total abundance Numbers X 10^{-3}	Total abundance Weight (kg) X 10^{-3}	Mean weight (kg)
1978	2,148,272	648,792	0.30
1979	638,600	284,884	0.45
1980	988,860	509,912	0.52

Year	Mean catch per tow Numbers	Mean catch per tow Weights (kg)
1978	735.73	222.20
1979	219.72	98.02
1980	332.25	171.33

Table 8. Catch at age for redfish in Divisions 2J, 3K, 1976-80.

CATCH MATRIX $(X10^{-3})$

	1976	1977	1978	1979	1980
6	7	22	4	240	28
7	30	102	403	2159	294
8	136	219	1252	5678	1629
9	1265	612	3326	8798	972
10	2067	843	4106	9251	848
11	3866	1569	4534	6700	819
12	5580	1930	5856	4011	1006
13	7818	2241	6261	7374	1511
14	8652	3315	6321	6646	1844
15	5615	3162	5311	6571	2000
16	2700	2776	5377	6075	1685
17	1826	2504	4003	5544	1710
18	946	1812	2269	1796	1007
19	757	1778	1501	1241	773
20	1128	1638	1508	1391	1033
21	968	895	1093	1412	653
22	885	940	958	789	519
23	1100	555	596	573	491
24	1005	618	891	599	730
25	684	598	835	930	508
26	678	514	752	569	511
27	512	435	513	590	493
28	632	418	540	589	380
29	284	200	140	283	405

Table 9. Weight (Kg) at age. Values for 1976-79 are the "standard" while 1980 is calculated from the age/length key and length frequency.

	1976	1977	1978	1979	1980
6	0.103	0.103	0.103	0.103	0.110
7	0.135	0.135	0.135	0.135	0.170
8	0.169	0.169	0.169	0.169	0.184
9	0.205	0.205	0.205	0.205	0.217
10	0.243	0.243	0.243	0.243	0.240
11	0.282	0.282	0.282	0.282	0.279
12	0.322	0.322	0.322	0.322	0.287
13	0.362	0.362	0.362	0.362	0.314
14	0.403	0.403	0.403	0.403	0.361
15	0.443	0.443	0.443	0.443	0.418
16	0.482	0.482	0.482	0.482	0.463
17	0.521	0.521	0.521	0.521	0.534
18	0.559	0.559	0.559	0.559	0.566
19	0.596	0.596	0.596	0.596	0.596
20	0.631	0.631	0.631	0.631	0.674
21	0.665	0.665	0.665	0.665	0.651
22	0.698	0.698	0.698	0.698	0.747
23	0.730	0.730	0.730	0.730	0.788
24	0.759	0.759	0.759	0.759	0.754
25	0.788	0.788	0.788	0.788	0.769
26	0.815	0.815	0.815	0.815	0.946
27	0.841	0.841	0.841	0.841	0.931
28	0.866	0.866	0.866	0.866	0.922
29	0.889	0.889	0.889	0.889	0.999

Table 10. The ratio of commercial to research numbers at age (C/R) was smoothed (C/R-S) to obtain an estimate of partial selection.

Age	C/R	C/R-S
6	0.038	0.097
7	0.167	0.261
8	0.656	0.383
9	0.298	0.405
10	0.447	0.389
11	0.324	0.386
12	0.393	0.452
13	0.542	0.613
14	1.000	0.845

Table 11. Trends in catch rate and mean biomass of the fully recruited age-classes from cohort for different F values. Regression results are listed below.

		Mean biomass of ages 14+				
Year	CPUE	F = 0.05	0.07	0.10	0.15	0.20
1976	1.024	176,547	139,946	112,492	91,141	80,472
1977	1.086	181,906	141,426	111,065	87,454	75,656
1978	0.890	182,402	138,730	105,962	80,460	67,704
1979	0.706	178,248	131,190	95,863	68,337	54,538
1980	0.517	177,642	126,887	88,821	59,214	44,411
	r^2		0.96	0.96	0.95	0.94
	T-value	ns	9.84	10.60	8.60	7.99
Predicted biomass for 1980			126,972	88,755	59,008	44,118

Table 12. The population numbers and fishing mortality at age from cohort when terminal F in 1980 is 0.07.

POPULATION NUMBERS ($X10^{-3}$)

	1976	1977	1978	1979	1980
6	63695	57097	81531	19109	4348
7	65836	57627	51642	73769	17062
8	66257	59542	52046	46344	64695
9	70198	59823	53667	45902	36533
10	72286	62314	53548	45397	33165
11	70126	63441	55583	44546	32277
12	64960	59775	55911	45980	33934
13	67139	53470	52251	45020	37789
14	50878	53313	46250	41323	33722
15	34731	37806	45087	35836	31069
16	34362	26084	31200	35744	26175
17	23059	28523	20962	23117	26564
18	19028	19128	23427	15159	15643
19	16601	16317	15584	19039	12008
20	21186	14301	13073	12673	16047
21	15498	18097	11382	10395	10144
22	15881	13102	15524	9259	8062
23	15179	13528	10961	13135	7627
24	12360	12688	11713	9351	11340
25	12196	10228	10893	9751	7891
26	2797	10385	8686	9062	7938
27	1420	1886	8908	7144	7658
28	1367	798	1293	7572	5903
29	658	635	324	656	6291
6+	817698	749910	731446	625284	493887
7+	754003	692814	649915	606175	489539
8+	688167	635187	598272	532406	472477
9+	621910	575645	546226	486062	407782

FISHING MORTALITY

	1976	1977	1978	1979	1980
6	0.000	0.000	0.000	0.013	0.007
7	0.000	0.002	0.008	0.031	0.018
8	0.002	0.004	0.026	0.138	0.027
9	0.019	0.011	0.067	0.225	0.028
10	0.031	0.014	0.084	0.241	0.027
11	0.060	0.026	0.090	0.172	0.027
12	0.095	0.035	0.117	0.096	0.032
13	0.131	0.045	0.135	0.189	0.043
14	0.197	0.068	0.155	0.185	0.059
15	0.186	0.092	0.132	0.214	0.070
16	0.086	0.119	0.200	0.197	0.070
17	0.087	0.097	0.224	0.291	0.070
18	0.054	0.105	0.107	0.133	0.070
19	0.049	0.122	0.107	0.071	0.070
20	0.058	0.128	0.129	0.123	0.070
21	0.068	0.053	0.106	0.154	0.070
22	0.060	0.078	0.067	0.094	0.070
23	0.079	0.044	0.059	0.047	0.070
24	0.089	0.053	0.083	0.070	0.070
25	0.061	0.063	0.084	0.106	0.070
26	0.294	0.053	0.095	0.068	0.070
27	0.476	0.278	0.062	0.091	0.070
28	0.666	0.800	0.578	0.085	0.070
29	0.600	0.400	0.600	0.600	0.070
15+	0.099	0.094	0.130	0.153	0.070

Table 13. The population numbers and fishing mortality at age from cohort when terminal F in 1980 is 0.10.

POPULATION NUMBERS $(X10^{-3})$

	1976	1977	1978	1979	1980
6	49050	42508	58137	13503	3048
7	51582	44376	38442	52601	11990
8	51306	46644	40056	34400	45542
9	53641	46294	41997	35053	25725
10	57630	47333	41306	34837	23348
11	56696	50180	42027	33470	22722
12	53645	47624	43912	33714	23912
13	55657	43233	41256	34163	26691
14	44116	42924	36987	31374	23897
15	29540	31688	35686	27454	22067
16	27425	21388	25664	27238	18591
17	18674	22247	16712	18107	18867
18	15543	15160	17748	11314	11111
19	13304	13164	11994	13901	8529
20	16285	11318	10220	9425	11397
21	12087	13662	8682	7813	7205
22	12450	10016	11510	6817	5726
23	11869	10423	8168	9504	5417
24	9809	9693	8903	6824	8054
25	9477	7919	8183	7209	5605
26	2797	7924	6597	6610	5638
27	1420	1886	6681	5254	5439
28	1367	798	1293	5558	4193
29	658	635	324	656	4468
6+	656027	589036	562486	466797	349182
7+	606977	546528	504349	453294	346134
8+	555395	502152	465907	400693	334145
9+	504089	455508	425852	366293	288603

FISHING MORTALITY

	1976	1977	1978	1979	1980
6	0.000	0.001	0.000	0.019	0.010
7	0.001	0.002	0.011	0.044	0.026
8	0.003	0.005	0.033	0.191	0.038
9	0.025	0.014	0.087	0.306	0.041
10	0.038	0.019	0.110	0.327	0.039
11	0.074	0.033	0.120	0.236	0.039
12	0.116	0.044	0.151	0.134	0.045
13	0.160	0.056	0.174	0.257	0.061
14	0.231	0.085	0.198	0.252	0.084
15	0.223	0.111	0.170	0.290	0.100
16	0.109	0.147	0.249	0.267	0.100
17	0.108	0.126	0.290	0.388	0.100
18	0.066	0.134	0.144	0.183	0.100
19	0.062	0.153	0.141	0.099	0.100
20	0.076	0.165	0.169	0.169	0.100
21	0.088	0.071	0.142	0.211	0.100
22	0.078	0.104	0.092	0.130	0.100
23	0.103	0.058	0.080	0.065	0.100
24	0.114	0.069	0.111	0.097	0.100
25	0.079	0.083	0.113	0.146	0.100
26	0.294	0.071	0.128	0.095	0.100
27	0.476	0.278	0.084	0.126	0.100
28	0.666	0.800	0.578	0.118	0.100
29	0.600	0.400	0.600	0.600	0.100
15+	0.124	0.120	0.171	0.211	0.100