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Division 4VWX Redfish

by

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Maritimes

Commercial Data

Preliminary 1977 landings are 16,364 mt. from a TAC of 20,000 mt. Allocations and catches by country are as follows:

	1977	
Country	Allocation	Landings (mt)
Canada	13,000	13,224
U.S.A.	7,000	2,875
USSR		263
Japan		2
Total	20,000	16,364

Landings by ICNAF division are given in Table 1 and the catch per unit effort data for 150-499.9 gt. bottom side trawler are given in Tables 2 & 10.

Sampling of the commercial catch was reported by Canada and USSR. Table 3 shows the length frequencies observed expanded by the ratio of the total landing to the sample weight. Because of the historic similarity of the Canadian and U.S.A. catches the Canadian figures were further enhanced to compensate for the U.S.A. landings. The USSR sample contain generally much smaller fish than the Canadian and represents only about 2% of the total landings. The combined length frequency has a premary mode at 26 cm. and a secondary mode at 35 cm.

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Research Vessel Survey Data

Abundance estimates from Canadian research cruises, Table 4 show an increase from 1976 to a level approximately midway between the oscillatory estimates from 1973 to 1976. Modes are observed at 24, 28 and 37 cm. The first and last of these correspond approximately to those seen in the commercial data. The mode at 24 cm. is probably the mode observed last year at 22 cm and represents age 5 fish. A peak for 5 year olds is also seen in the output of the cohort analysis. Table 5 gives biomass and population estimates and catch rates from the research data.

Age Data and Growth Parameters

From a sample of 718 aged fish (courtesy of D. McKone) an age-length key was constructed and growth parameters estimated for Scotian Shelf redfish. These data are from 1975 research data. The resultant parameters are:

Parameter	Males	Females	Combined
L_∞ (cm.)	42.96	49.07	48.42
K (yr^{-1})	0.061	0.060	0.053
t_0 (yr)	-4.138	-2.774	-4.124
r^2	.95	.94	.96
a (gm/cm)	0.015	0.011	0.012
b	3.038	3.133	3.097
r^2	.98	.98	.98

These results are similar to those reported in Mayo and Miller (1976) having slightly higher L_∞'s but slightly lower growth rates.

The combined age length key was applied to the catch statistics from 1965 to present yielding the catch at age data shown in Table 7 . A cohort analysis with m = .1 was performed on these data and the resultant numbers at age and F are given in Tables 8 and 9 . The F's were averaged over the first ten years and the results are in the right hand side column in Table 9 . These F's were smoothed by eye into the selectivity shown in Figure 3 . This selectivity was input into a yield per recruit projection. The F's were weighted by the estimated numbers at age, see Figure 2 , and regressed against total effort as estimated and reported in Table 10 . The correlation coefficient was .94.

The weighted and fully recruited F's are:

Year	$F_{wt.}$	$F_{F.R.}$	Year	$F_{wt.}$	$F_{F.R.}$
1965	.020	.136	1971	.063	.445
66	.039	.334	72	.050	.257
67	.015	.191	73	.051	.190
68	.006	.202	74	.038	.136
69	.011	.365	75	.042	.189
70	.031	.349	76	.025	.073
			77	.018	.098

The fully recruited F increases from 1976 to 1977 while the weighted F's decrease, reflecting the smaller Russian catch.

The numbers at age show strong 10 and 12 age year classes. The 12 year olds correspond to the mode at 28 cm. observed in the research vessel estimates. The mode at 19 years corresponds to the 35 cm. mode in the catch at length data. The biomass estimates are plotted in Figure 1 . The biomass is seen to roughly follow the catch per unit effort data.

Yield Per Recruit

Yield per recruit estimates were developed from the growth parameters mentioned above, an m of .1 and a selectivity derived from the cohort analysis. The results are shown graphically in Figure 4 . The maximal and 0.1 F levels are:

	Male	Female	Combined
$F_{0.1}$	.245	.217	.221
F_{max}	1.034	.678	.796

Fully recruited F levels have been beneath the F_{max} throughout the period used in the VPA and beneath $F_{0.1}$ since 1973. The stock should therefore be strengthening under the current TAC. This strenghthening may also be inferred from the upward step in CUE from 1976 to 1977, Figure 1 .

Mayo and Miller (1976) estimated MSY at 32,300 and 43,500 mt for lags of 12 and 8 years respectively. The r^2 of these fits was approximately .2. Their data were refit using a method described by Schnute (1977). The r^2 with this method was .12 and the MSY 33,000 tons. The catch and effort data in Table 10 were analysed with Schnute's method. The resultant fit had an r^2 of .05 and an MSY of 36,000 mt. These fits, although dubious, are consistent. The catch and effort data and the equilibrium curve are shown in Figure 5. They do not follow a parabola as reflected by the low r^2. Mayo and Miller's data followed the same linear trend. The effort at MSY is 49,000 hours and 2/3 of this is 32,700 hours. The fully recruited F for this effort approximately .16 with a catch of 19,000 mt. These values were estimated by averaging the 1965 and 1967 fully recruited F's and catches as these years efforts bracket the effort of 2/3 MSY.

Discussion

The 2/3 MSY point on the Schaefer curve has a yield of approximately 30,000 mt. Also, when the average recruitment over the VPA, approximately 300 x 10^6, is multiplied by the yield per recruit at $F_{0.1}$, .107, the resultant is 32,000 mt. However, when a projection was run with a TAC of 30,000 the biomass falls steadily and does not recover in 20 years. When the 2/3 MSY effort point is applied to the catch-effort data it is seen to correspond to a catch of approximately 20,000 mt. A projection at a TAC of 20,000 with a constant recruitment of 30 x 10^6 was barely sustainable. The CUE and biomass estimates from both the research cruise and VPA show an increase from 1976 to 1977. On the basis of these findings it is recommended that the TAC remain at 20,000 mt for 1969. Also, it is recommended that another sample be aged from the Shelf in order to upgrade future analyses.

References

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Table 1 . Div. 4VWX Redfish - commercial catch (mt)

Div.	1970	1971	1972	1973	1974	1975	1976	1977
4Vn	4,246	6,954	4,525	7,125	6,985	7,821	5,704	-
4Vs	6,694	23,698	14,580	11,213	8,112	6,772	4,718	-
4W	16,215	19,953	22,223	14,709	11,587	9,487	3,225	-
4X	4,424	11,776	8,972	7,126	6,153	3,903	4,812	-
4VWX	31,579	62,381	50,300	40,173	32,837	27,983	18,459	16,364
TAC	-	-	-	-	40,000	30,000	20,000	20,000

Table 2 Catch rate - commercial catches Canada (M-Q) 150-499.9 gt. side otter trawler. (mt/hr)

	4Vn	4Vs	4W	4X	4VWX
1966	.86	.94	.60	.63	.86
1967	.92	.62	.33	.22	.63
1968	.79	.67	.48	.47	.66
1969	.61	.57	1.03	.39	.59
1970	.45	.45	.79	.43	.58
1971	.69	.79	.66	.47	.63
1972	.55	.76	.72	.27	.59
1973	.49	.61	.65	.28	.54
1974	.41	.54	.52	.39	.47
1975	.35	.58	.54	.35	.47
1976	.34	.52	.47	.44	.45
1977	.58	.69	.45	.41	.59

Table 3 Div 4VWX Redfish - 1977 removals at length by country ($x10^{-3}$).

Length	Canada	Canada-Corrected for USA	Russia	Total
11	-	-	3	3
12	-	-	5	5
13	-	-	7	7
14	-	-	10	10
15	-	-	11	11
16	4	4	6	10
17	4	4	8	12
18	14	17	17	34
19	11	14	23	37
20	49	60	38	98
21	155	189	37	226
22	521	634	37	671
23	1007	1226	41	1267
24	1626	1979	51	2030
25	1869	2275	48	2373
26	1965	2392	49	2441
27	1993	2426	55	2481
28	1638	1994	63	2057
29	1438	1751	55	1806
30	1274	1551	59	1610
31	1177	1433	59	1492
32	1162	1415	63	1478
33	1152	1403	52	1455
34	1271	1547	49	1596
35	1548	1885	31	1916
36	1556	1894	14	1908
37	1158	1410	2	1412
38	1264	1538	-	1538
39	1104	1344	-	1344
40	894	1088	-	1088
41	661	805	-	805
42	427	519	-	519
43	183	222	-	222
44	167	203	-	203
45	89	108	-	108
46	60	74	-	74
47	24	29	-	29
48	10	13	-	13
49	4	5	-	5
50	11	14	-	14
	27490	33465	893	34358

Table 4 Div. 4VWX Redfish - estimated population length frequencies from Canadian research vessel surveys ($x10^{-6}$).

Length Cm.	1970	1971	1972	1973	1974	1975	1976	1977
<10	1.2	1.4	1.5	0.2	0.3	1.0	0.2	.1
11	2.6	0.7	0.3	1.1	1.0	-	0.6	.2
12	2.5	1.6	0.7	1.3	1.5	0.4	0.8	1.5
13	1.8	3.0	1.2	1.6	4.0	0.9	0.8	4.2
14	1.5	3.2	1.9	1.8	11.1	1.3	0.2	7.1
15	3.4	3.5	5.8	3.4	28.8	4.5	0.9	3.6
16	7.5	3.6	6.2	3.5	41.8	4.2	1.1	1.1
17	18.5	15.8	14.1	3.2	46.9	8.9	0.9	1.3
18	33.8	38.3	20.0	7.4	26.9	7.1	6.1	1.1
19	42.3	36.4	26.5	12.1	12.4	10.9	8.6	3.0
20	60.7	53.6	27.5	14.0	7.2	11.8	12.2	5.4
21	67.7	50.9	48.3	24.5	6.4	10.0	10.4	7.7
22	71.7	52.8	53.0	53.4	11.8	17.5	13.0	19.5
23	61.4	52.2	70.7	95.0	10.5	28.6	10.4	33.5
24	47.1	48.1	81.2	93.7	10.1	54.6	6.0	45.4
25	36.2	53.5	64.7	99.3	11.1	72.4	4.5	44.6
26	28.6	42.6	49.0	87.4	10.3	98.0	5.8	41.8
27	24.2	35.3	33.6	65.2	11.7	87.3	7.1	38.8
28	21.9	21.7	29.1	39.2	10.8	98.8	8.2	47.5
29	18.9	19.8	26.4	26.2	11.5	78.6	8.8	44.8
30	19.6	23.6	33.0	19.6	7.4	54.0	10.8	35.4
31	17.1	18.0	27.3	13.0	9.6	43.6	9.6	21.9
32	14.7	16.8	21.4	12.5	9.4	18.0	12.0	17.1
33	12.4	12.3	21.5	9.8	10.5	20.0	11.1	12.4
34	13.0	13.1	14.0	6.4	10.0	4.8	9.2	7.1
35	10.7	14.3	12.2	5.1	7.7	6.1	6.9	4.4
36	6.7	12.6	16.0	6.0	7.1	3.6	6.0	4.3
37	7.3	9.7	13.0	3.8	4.5	5.3	6.5	7.4
38	3.9	4.2	6.0	3.1	4.3	6.1	5.0	2.6
39	2.8	2.9	3.8	1.8	2.9	4.6	4.1	2.0
40	2.1	2.4	1.0	1.6	1.4	3.7	2.1	1.5
41	1.6	1.3	0.3	0.5	0.8	1.5	0.3	.8
42	2.1	1.5	0.4	0.4	1.2	1.1	0.8	.7
43	1.6	1.2	0.1	0.5	0.5	0.6	0.1	.4
44	1.6	0.5	-	-	0.2	1.0	0.1	.2
>45	1.4	0.6	-	0.1	0.1	3.1	0.3	.1
TOTALS	672.1	673.0	731.7	717.7	353.6	774.1	193.7	470.5
<20	115.1	107.5	78.2	35.6	174.7	39.2	22.2	28.6
≥20	557.0	565.5	653.5	682.1	178.9	734.9	171.5	441.9

Table 5 Div. 4VWX Redfish - Canadian survey results

Div.	1970	1971	1972	1973	1974	1975	1976	1977
A. Biomass estimates (mt)								
4V	53,540	71,750	27,710	29,100	37,370	25,540	52,500	38,160
4W	99,620	45,680	33,530	27,060	11,950	178,250	7,800	87,856
4X	19,180	68,830	168,010	140,360	40,270	41,630	23,150	35,614
4VWX	172,340	186,260	229,250	196,520	89,590	245,420	83,450	161,630
B. Population number estimates ($x10^{-6}$)								
4V	131.5	152.0	115.2	95.4	95.2	101.4	119.1	81.2
4W	481.4	152.3	122.1	94.6	48.6	609.8	18.7	273.3
4X	58.9	369.7	494.5	527.7	209.8	62.9	55.9	116.2
4VWX	671.8	674.0	731.8	717.7	353.6	774.1	193.7	470.6
C. Catch rates (Kg/tow)								
4V	37.98	50.92	19.66	20.64	26.52	18.12	37.26	52.65
4W	58.10	26.64	19.55	15.78	6.97	103.95	4.55	26.91
4X	10.42	37.36	91.21	76.20	2186	22.60	12.58	24.32
4VWX	34.70	37.51	46.16	39.57	18.04	49.42	16.81	33.56

Table 6. Length frequencies from commercial sampling.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
10	0	0	0	0	0	67	0	0	0	0	43	0	0
11	0	0	0	0	0	143	0	0	28	18	129	0	3
12	0	0	0	0	0	150	0	24	61	39	429	0	5
13	0	0	0	0	0	544	259	8	188	114	1268	0	7
14	31	21	0	0	0	1309	786	0	388	245	2343	0	10
15	68	66	90	0	0	2211	918	0	238	150	2858	0	11
16	233	161	0	0	0	3210	2787	76	475	239	3396	0	10
17	354	568	162	7	0	4956	8007	61	1028	545	5029	5	12
18	377	1296	374	27	0	8913	11916	262	2032	896	6788	15	34
19	726	1445	350	40	8	9286	12948	439	3697	1577	6254	115	37
20	975	2936	1235	81	19	11106	10707	1037	6736	3307	4211	321	98
21	2212	4018	2106	79	17	9368	9259	2967	10489	5248	2623	625	226
22	3342	6729	2198	108	91	8513	9664	6682	13412	6500	2220	3462	671
23	5273	8583	2489	131	231	6565	13194	10354	13870	7860	3114	4763	1267
24	7494	12238	3369	157	316	5423	14978	14707	12716	8231	4493	5439	2030
25	7050	13660	3300	219	496	3979	15753	17502	13244	8773	6231	6781	2323
26	5976	12625	2556	307	563	3007	14941	17195	10852	7688	6550	5212	2441
27	5904	10484	3060	507	627	2919	12215	14652	9580	7453	5263	4304	2481
28	5240	9518	2785	662	1688	2681	10473	12894	7399	6175	5210	3161	2057
29	4662	7951	2780	1065	2556	2792	9352	10218	5556	5059	4049	3784	1806
30	3365	8002	3271	1515	3776	2892	8376	8416	5290	4960	3728	2831	1610
31	2414	5468	3419	1868	3570	2881	6677	5890	3618	3936	3215	2414	1492
32	1436	3595	3238	2164	3937	3098	6182	5141	3444	3271	3031	1707	1478
33	1474	3065	3063	1922	3566	2683	5852	4150	3388	2614	2188	1623	1455
34	1072	1908	1856	1972	3437	3004	6016	3677	2790	2230	2245	1651	1596
35	991	2381	1154	1514	2615	2739	5281	2640	2113	1910	2150	1084	1916
36	996	1480	1007	1478	2213	2465	4324	2694	1940	1887	2265	1323	1908
37	639	1612	1114	1200	2385	1857	3486	2036	1694	1652	1818	1077	1412
38	459	1015	1048	1061	1982	1990	2263	1736	1356	1356	1468	734	1538
39	340	1359	469	793	1103	1271	1358	1024	735	775	1055	340	1344
40	292	1210	503	577	1419	1077	997	701	587	417	797	223	1088
41	240	1021	145	482	682	729	632	491	273	264	385	91	805
42	183	587	323	389	568	500	297	345	175	144	326	35	519
43	140	518	108	207	316	206	216	172	153	69	185	18	222
44	37	232	108	131	136	142	129	92	82	29	75	0	203
45	28	77	107	64	133	66	37	117	37	32	84	0	108
46	0	24	36	31	51	44	68	0	97	0	49	0	74
47	9	9	0	22	51	26	0	0	60	7	61	0	29
48	0	16	0	0	25	13	7	0	0	8	51	0	13
49	0	0	0	19	0	0	3	0	56	0	0	0	5
50	0	3	0	0	49	0	0	0	0	0	16	0	14
	64032	125881	47823	20799	38626	114825	210358	148400	139877	95678	97693	53138	34358

Table 7. Age frequencies

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	61.	70.	27.	1.	0.	2012.	1318.	35.	467.	283.	3108.	0.	18.
4	1198.	2537.	973.	54.	15.	12738.	13548.	1258.	5963.	2948.	9759.	416.	132.
5	2841.	5983.	2146.	118.	55.	20188.	23886.	4080.	12690.	6183.	12380.	1681.	414.
6	3333.	6260.	2197.	119.	83.	17089.	22036.	5001.	12630.	6385.	9882.	1910.	548.
7	2877.	5369.	1663.	169.	278.	5894.	9207.	6035.	8149.	4614.	3314.	2392.	796.
8	1765.	3343.	929.	60.	90.	2738.	4688.	3871.	4728.	2666.	1582.	1553.	489.
9	1734.	3302.	981.	175.	414.	1530.	4044.	4022.	3292.	2267.	1577.	1313.	588.
10	11365.	20559.	5834.	722.	1439.	10394.	26606.	25453.	23498.	15022.	9068.	9365.	3580.
11	3871.	7200.	2164.	531.	1023.	3505.	9340.	9034.	7512.	5101.	3497.	3251.	1495.
12	7499.	13796.	4533.	1315.	2663.	5230.	16830.	17881.	12531.	9403.	6874.	5969.	3073.
13	3993.	7636.	2241.	561.	1193.	2457.	8969.	9984.	6654.	5019.	3825.	3188.	1594.
14	3421.	6620.	2193.	884.	1677.	2662.	8445.	8671.	5892.	4529.	3556.	2903.	1732.
15	3572.	7089.	2389.	1154.	2164.	2964.	9186.	9303.	6117.	4801.	4060.	3186.	2021.
16	2417.	4525.	1877.	935.	1763.	2120.	6077.	6022.	3937.	3264.	2666.	2124.	1390.
17	1277.	2450.	1145.	872.	1574.	1628.	3679.	3201.	2097.	1834.	1728.	1158.	1190.
18	1845.	3629.	1787.	1098.	2034.	2064.	5176.	4753.	3103.	2755.	2394.	1643.	1370.
19	2213.	4640.	2421.	1738.	3245.	3057.	7038.	5941.	3907.	3510.	3250.	2175.	1986.
20	1708.	3678.	1975.	1454.	2668.	2456.	5232.	4335.	2932.	2570.	2349.	1589.	1715.
21	1461.	3266.	1840.	1394.	2619.	2300.	4483.	3820.	2492.	2365.	2275.	1447.	1626.
22	886.	2192.	1455.	1255.	2304.	2017.	3515.	2581.	1882.	1722.	1760.	997.	1423.
23	1438.	3472.	2090.	1654.	3058.	2672.	5002.	4088.	2821.	2583.	2489.	1501.	1863.
24	657.	1630.	1284.	1039.	1929.	1625.	2900.	2126.	1564.	1426.	1456.	801.	1030.
25	856.	2118.	1068.	839.	1618.	1408.	2639.	2251.	1544.	1394.	1369.	797.	1093.
26	598.	1381.	974.	821.	1490.	1249.	2323.	1715.	1242.	1094.	1101.	681.	839.
27	295.	755.	437.	486.	863.	813.	1252.	806.	620.	548.	643.	317.	649.
28	314.	831.	463.	389.	728.	594.	996.	810.	540.	539.	571.	312.	477.
29	193.	448.	264.	339.	570.	583.	939.	566.	436.	421.	489.	250.	461.
30	38.	145.	40.	82.	125.	111.	87.	85.	68.	41.	80.	11.	130.
31	12.	29.	28.	29.	78.	54.	61.	47.	37.	37.	48.	20.	49.
32	52.	126.	90.	102.	190.	159.	263.	165.	139.	100.	118.	70.	110.
33	52.	110.	111.	84.	150.	126.	220.	159.	139.	107.	99.	64.	82.
34	26.	89.	46.	59.	89.	76.	45.	49.	36.	23.	64.	5.	79.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	26.	85.	52.	56.	121.	105.	109.	80.	65.	57.	78.	30.	93.
	63892.	125363.	47715.	20592.	38310.	114619.	210142.	148228.	139724.	95609.	97508.	53120.	34136.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
3	529928.	439347.	394149.	677244.	363465.	688534.	139040.	124248.	194146.	143653.	127510.	51016.	63970.
4	380019.	479441.	397471.	356615.	612795.	328877.	621097.	124555.	112390.	175227.	129714.	112420.	46161.
5	315090.	342716.	431403.	358721.	322627.	554466.	285463.	549105.	111505.	96023.	155748.	108087.	101326.
6	289770.	282403.	304411.	388309.	324472.	291872.	482499.	235577.	492970.	88823.	81004.	129150.	96202.
7	322642.	259024.	249574.	273353.	351243.	293515.	247841.	415621.	208401.	434043.	74296.	63896.	115043.
8	270195.	289202.	229268.	224243.	247179.	317553.	259977.	215498.	370329.	180817.	388350.	64074.	55539.
9	245614.	242804.	258501.	206567.	202846.	223572.	284730.	230777.	191308.	330590.	161074.	349889.	56499.
10	198687.	220592.	216557.	232968.	186743.	183149.	200841.	253787.	204991.	169971.	296973.	144246.	315344.
11	207043.	168969.	180043.	190400.	210111.	167603.	155833.	156419.	205425.	163131.	139507.	260087.	121611.
12	136867.	183658.	146040.	160851.	171776.	189144.	148319.	132119.	132941.	178730.	142755.	122904.	232245.
13	127314.	116709.	153058.	127831.	144293.	152896.	166169.	118195.	102537.	108369.	152778.	122631.	105530.
14	101974.	111401.	98340.	136361.	115133.	129427.	136009.	141824.	97450.	86450.	93282.	134600.	107928.
15	82319.	89016.	94503.	86896.	122544.	102581.	114579.	115033.	120079.	82572.	73915.	81023.	119030.
16	63852.	71088.	73802.	83237.	77528.	108824.	89999.	94937.	95236.	102833.	70148.	63019.	70281.
17	59055.	55476.	60018.	64993.	74427.	68474.	96452.	75654.	80174.	82429.	89943.	60936.	55002.
18	41930.	52221.	47867.	53218.	57979.	65846.	60409.	83773.	65410.	70550.	72840.	79740.	54036.
19	33097.	36185.	43800.	41612.	47109.	50526.	57617.	49737.	71280.	56233.	61216.	63631.	70589.
20	28094.	27842.	28328.	37328.	35999.	39539.	42810.	45439.	39352.	60780.	47543.	52299.	55507.
21	21540.	23795.	21694.	23754.	32393.	30036.	33440.	33759.	36991.	32819.	52551.	40784.	45810.
22	18359.	18100.	18425.	17879.	20167.	26819.	24990.	25993.	26913.	31100.	27446.	45386.	35526.
23	12655.	15770.	14292.	15287.	14984.	16056.	22348.	19268.	21064.	22562.	26502.	23160.	40119.
24	8653.	10083.	10966.	10944.	12259.	10649.	11986.	15463.	13546.	16376.	17958.	21612.	19529.
25	5757.	7205.	7573.	8701.	8914.	9258.	8090.	8087.	11970.	10769.	13462.	14864.	18794.
26	4063.	4395.	4504.	5836.	7075.	6527.	7037.	4810.	5176.	9362.	8418.	10878.	12691.
27	2857.	3107.	2663.	3149.	4500.	4985.	4718.	4157.	2721.	3503.	7431.	6570.	9195.
28	1755.	2304.	2093.	1994.	2387.	3251.	3737.	3077.	2995.	1873.	2648.	6112.	5643.
29	1149.	1289.	1295.	1453.	1435.	1467.	2376.	2434.	2014.	2196.	1182.	1853.	5234.
30	675.	856.	740.	921.	992.	756.	773.	1257.	1664.	1408.	1587.	604.	1440.
31	609.	575.	636.	632.	755.	779.	579.	616.	1057.	1441.	1235.	1360.	536.
32	404.	539.	492.	549.	545.	609.	654.	465.	513.	921.	1269.	1072.	1212.
33	249.	316.	368.	360.	400.	312.	400.	342.	265.	332.	739.	1036.	904.
34	124.	176.	181.	228.	245.	219.	162.	153.	158.	107.	199.	575.	877.
35	74.	87.	74.	120.	149.	137.	126.	103.	91.	108.	74.	119.	515.
36	22.	54.	39.	42.	81.	78.	74.	62.	55.	52.	71.	30.	93.

Table 8. Numbers at age estimated by cohort analysis.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	
3	.000	.000	.000	.000	.000	.003	.010	.000	.003	.002	.026	.000	.000	.003
4	.003	.006	.003	.000	.000	.042	.023	.011	.057	.018	.082	.004	.003	.019
5	.010	.019	.005	.000	.000	.039	.092	.008	.127	.070	.087	.016	.004	.037
6	.012	.024	.008	.000	.000	.064	.049	.023	.027	.079	.137	.016	.006	.034
7	.009	.022	.007	.001	.001	.021	.040	.015	.042	.011	.048	.040	.007	.020
8	.007	.012	.004	.000	.000	.009	.019	.019	.014	.016	.004	.026	.009	.011
9	.007	.014	.004	.001	.002	.007	.015	.018	.018	.007	.010	.004	.011	.009
10	.062	.103	.029	.003	.008	.062	.150	.111	.128	.098	.033	.071	.012	.067
11	.020	.046	.013	.003	.005	.022	.065	.063	.039	.033	.027	.013	.013	.028
12	.059	.082	.033	.009	.016	.030	.127	.153	.104	.057	.052	.052	.014	.061
13	.034	.071	.016	.005	.009	.017	.058	.093	.071	.050	.027	.028	.016	.038
14	.036	.065	.024	.007	.015	.022	.068	.066	.066	.057	.041	.023	.017	.039
15	.047	.087	.027	.014	.019	.031	.088	.089	.055	.063	.059	.042	.018	.049
16	.041	.069	.027	.012	.024	.021	.074	.069	.044	.034	.041	.036	.021	.039
17	.023	.048	.020	.014	.022	.025	.041	.046	.028	.024	.020	.020	.023	.027
18	.047	.076	.040	.022	.038	.034	.094	.062	.051	.042	.035	.022	.027	.045
19	.073	.145	.060	.045	.075	.066	.137	.134	.059	.068	.057	.037	.030	.076
20	.066	.150	.076	.042	.081	.068	.138	.106	.082	.045	.053	.032	.033	.075
21	.074	.156	.093	.064	.089	.084	.152	.127	.073	.079	.047	.038	.038	.086
22	.052	.136	.087	.077	.128	.082	.160	.110	.076	.060	.070	.023	.043	.085
23	.127	.263	.167	.121	.242	.192	.268	.252	.152	.128	.104	.071	.050	.164
24	.083	.186	.131	.105	.181	.175	.294	.156	.129	.096	.089	.040	.057	.132
25	.170	.370	.160	.107	.212	.174	.420	.346	.146	.146	.113	.058	.063	.191
26	.168	.401	.258	.160	.250	.225	.426	.470	.291	.131	.148	.068	.072	.236
27	.115	.295	.189	.177	.225	.188	.327	.228	.274	.180	.095	.052	.077	.186
28	.208	.477	.265	.229	.387	.213	.329	.324	.210	.361	.257	.055	.093	.262
29	.195	.455	.241	.282	.540	.541	.537	.280	.258	.225	.571	.153	.097	.337
30	.061	.197	.058	.099	.142	.167	.126	.074	.044	.031	.055	.020	.100	.090
31	.022	.054	.048	.049	.115	.075	.118	.083	.037	.027	.041	.015	.100	.060
32	.146	.281	.214	.217	.458	.320	.549	.465	.335	.121	.103	.071	.100	.260
33	.249	.458	.382	.283	.501	.555	.863	.672	.808	.415	.152	.067	.100	.423
34	.250	.764	.313	.321	.484	.452	.349	.415	.276	.260	.410	.009	.100	.339
35	.207	.717	.464	.284	.556	.518	.603	.525	.466	.320	.794	.144	.100	.438
36	.150	.360	.210	.200	.290	.210	.280	.180	.140	.120	.120	.100	.100	.189
AVE	.020	.039	.015	.006	.011	.030	.063	.050	.051	.038	.042	.025	.018	

Table 9. Fishing mortalities from cohort analysis.

Table 10. Redfish commercial catch (metric tons) and effort data (hrs) for ICNAF Div. 4VWX.

Year	Catch *	Effort*	C/E	4VXW Total Catch	Estimated Total Effort
1965	1019	1919	.5310	19578	36870
1966	4507	5266	.8559	40836	47711
1967	2554	4077	.6264	18244	29125
1968	3213	4898	.6560	13103	19974
1969	5074	8575	.5917	22742	38435
1970	7154	12306	.5813	31579	54325
1971	15396	24565	.6267	62381	99539
1972	9473	16175	.5857	50300	85880
1973	6695	12332	.5429	40173	73997
1974	6916	14786	.4677	32819	70170
1975	4782	10222	.4678	27983	59818
1976	3934	8680	.4532	18459	40730
1977	4007	6771	.5918	16362	27648

* Data for Canada (MQ) 150-499.9 gt side otter trawl.

Figure 1. Biomass estimates and catch per unit effort versus time.

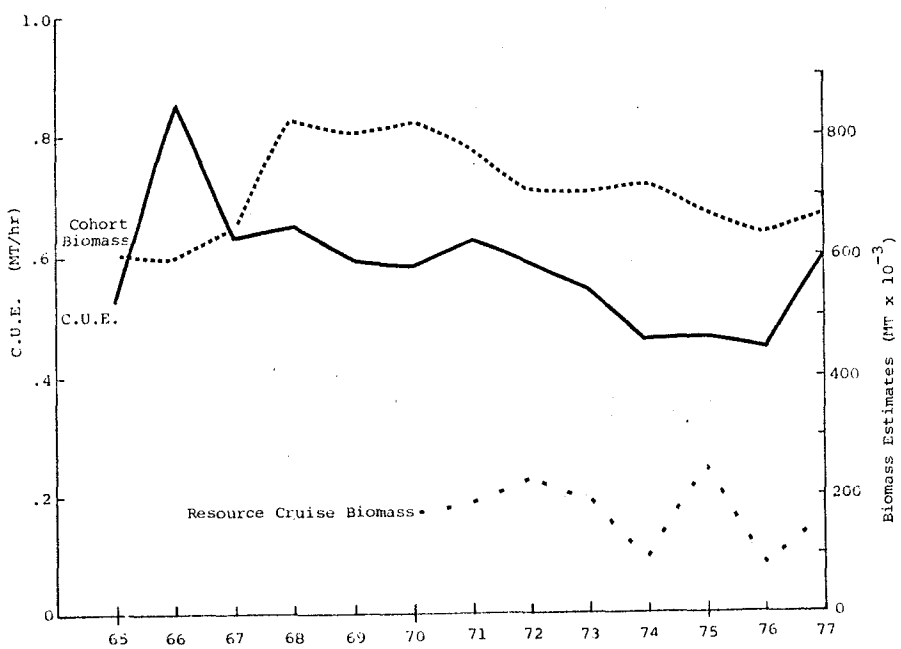


Figure 2. Catch and weighted fishing mortality versus estimated effort in hours.

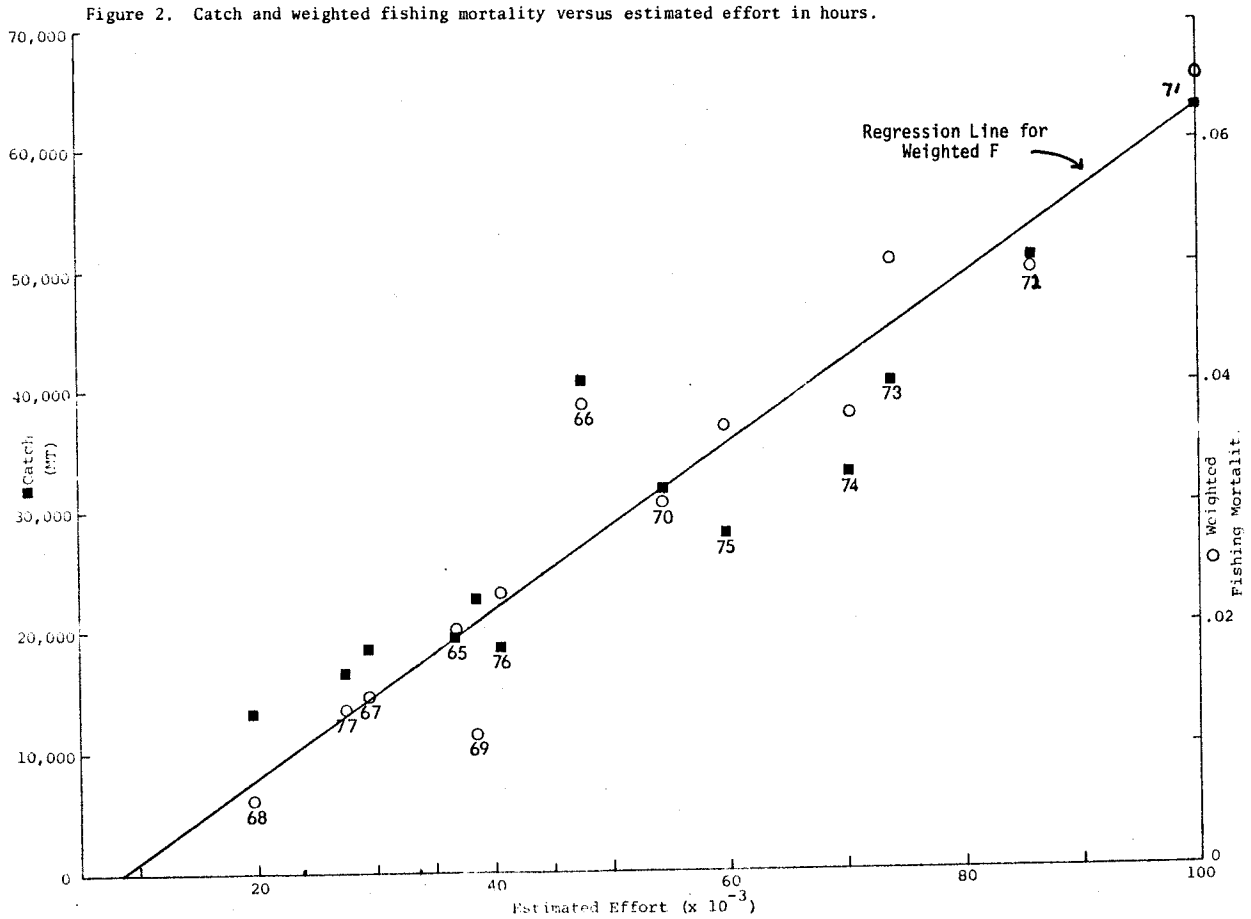
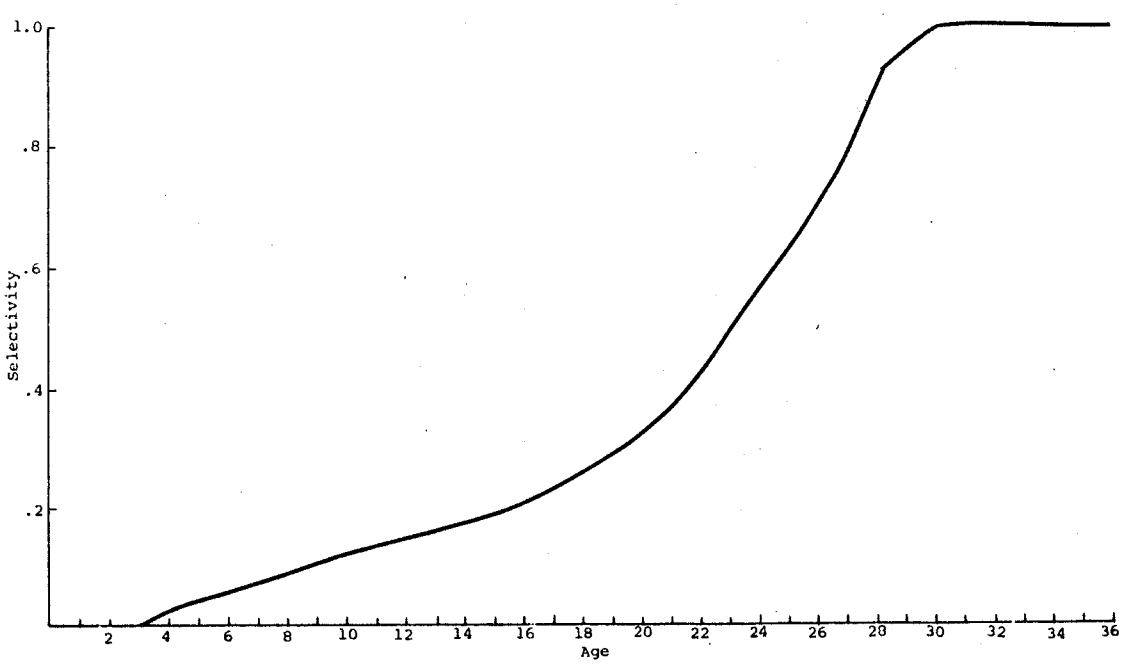


Figure 3. Selectivity from cohort analysis.



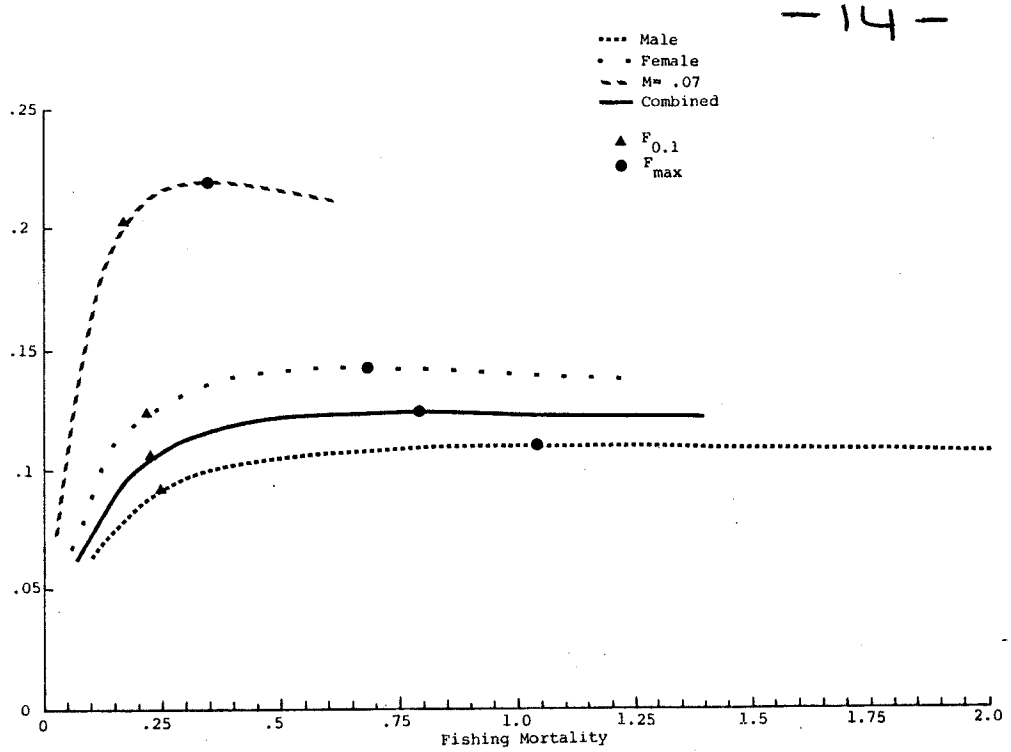


Figure 4. Yield per recruit estimates.

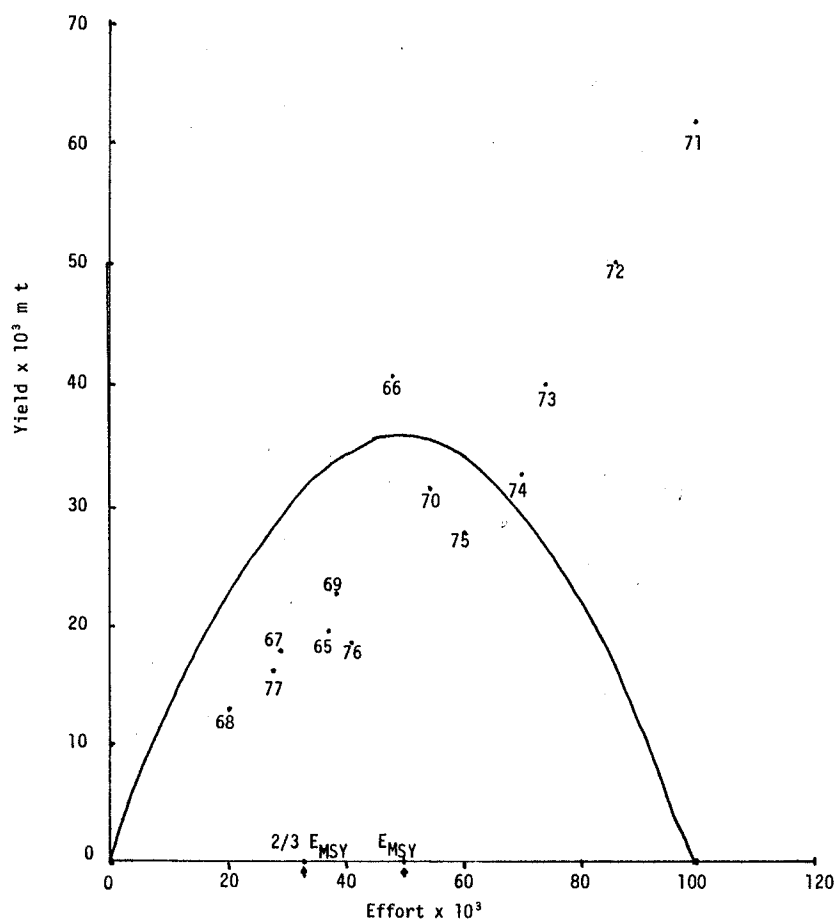



Figure 5. Redfish commercial catch and effort data and yield curve.