

M. Gulf of Maine-Georges Bank Redfish by R.K. Mayo

1.0 Background

Redfish, *Sebastes fasciatus* Storer, are assessed as a unit stock in the Gulf of Maine and Georges Bank region (NAFO Subarea 5). This stock was last assessed *via* survey index at SAW 15 in 1992 (Mayo 1993, NEFSC 1993a, 1993b). At that time, the NEFSC autumn survey biomass index had been gradually increasing at a very slight rate since the mid-1980s, but the index remained well below levels seen in the 1960s and early 1970s. Since landings had also declined to record lows, it was concluded that the exploitation rate was probably quite low, but that the stock remained at a very low level. Recruitment was also found to be extremely poor in recent years and that the population was composed of very few contributing year classes.

The state of this stock was most recently evaluated in 2000 via index assessment (Mayo 2000). At this time, it was noted that biomass indices for Gulf of Maine-Georges Bank redfish, derived from NEFSC autumn bottom trawl surveys, had increased substantially beginning in 1996 and had reached levels approximately equal to those evident in the 1960s. Despite this extremely sharp increase, landings had not increased from the very low levels noted in the early 1990s. The gradual increase in the survey biomass index between 1990 and 1993 was consistent with incremental annual increases in the NEFSC survey abundance index (mean number per tow) observed during the early 1990s, and reflect accumulated recruitment and growth of one or more above-average year classes produced in the mid-1980s. However, the large increase in the survey biomass index in 1996 was supported almost exclusively by fish in the 18-23 cm range at a corresponding age of approximately 5-6 years. It was concluded, therefore, that production of these redfish is likely to have occurred during 1990 and 1991, with reproduction augmented by early-maturing spawners from the mid-1980s year classes. Thus, stock biomass appears to have increased during the mid-1990s through the combined effects of growth and survival of fish from a period of relatively successful reproduction in the early 1990s. Further increases in biomass since 1996 have been supported by a wide range of sizes of fish in the population.

2.0 The Fishery

During the early development phase of the Gulf of Maine redfish fishery, USA landings increased rapidly to a peak level of about 56,000 mt in 1942 followed by a steep decline through the early 1950s (Table M1). Nominal catches then declined at a more gradual rate to less than 10,000 mt during the 1960s. During the 1970s, USA landings increased again, peaking at 16,000 mt in 1971 and again at 15,000 mt in 1979. During the 1970s, additional catches by Canadian and distant water fleets increased the total redfish catch to a maximum of about 17,000 to 20,000 mt per year from 1970 through 1973; catches of redfish by these fleets declined to negligible levels after 1976.

Landings of redfish declined steadily throughout the 1980s, remaining below 1,000 mt per year since 1989, and at less than 500 mt per year since 1994. Total redfish landings in 1999 were 353 mt compared to 320 mt in 1998.

3.0 Research Survey Indices

Indices of relative biomass, derived from NEFSC autumn research vessel bottom trawl surveys, although variable, exhibited a rather steady decline between 1963 and 1982 (Table M2, Figure M1). On average, the biomass index appears to have declined by about 90% over a 20 year period. During this time, only 2 year classes of any significance were produced, 1971 and 1978. Between 1983 and 1993, the biomass index approximately doubled, reflecting the relatively low rate of removals by the fishery and the very slow growth rate of the species. No substantial year classes were detected by the research vessel surveys in the inshore survey strata traditionally used to monitor recruitment until autumn 1995 when a substantial number of fish in the 15-19 cm range were noted, suggesting the possibility of above average reproduction in 1990 and/or 1991. This was followed by a very large increase in the index in the offshore strata in the autumn of 1996, followed by a large decrease in autumn 1997. The autumn biomass index rose sharply in 1996 and has fluctuated between 20 and 30 kg per tow since then, a magnitude comparable to the period between 1963 and the mid-1970s.

During the earlier periods, however, redfish were generally first detected in the inshore strata at relatively small sizes (~ 10 cm or less, age 1 or 2), only to appear in the offshore strata after about 5 or six years (Mayo, 1993). During the 1990s recruitment event, the year class was not detected until fish were close to 20 cm, or about ages 4 or 5, and the numbers appeared to be present in both inshore and offshore strata. In addition, the autumn biomass index increased 4-5 fold between the early 1990s and the mid-1990s, a rate that is inconsistent with the dynamics of this species. The spring index, however, suggests only a very modest change in biomass since the mid-1990s.

Given the continued extremely low landings of redfish relative to the recent increase in the autumn survey biomass index, the exploitation ratio is now extremely low compared to the 1960s and 1970s (Table M3; Figure M2). However, in contrast to this earlier period, where a substantial proportion of the stock persisted in the 30-40 cm range (Mayo, 1993), during the 1990s, almost all of the redfish are less than 25 cm, and almost none are greater than 30 cm. This suggests that, given the present demographics of the stock, only a small fraction of the biomass would be considered exploitable.

4.0 Harvest Control Rule

The Harvest Control Rule proposed for this stock by the Overfishing Definition Review Panel is derived from an estimate of B_{msy} (121, 000) based on the ratio of an MSY estimate (14,000 mt) derived from a Generalized Production Model (Mayo 1980) to a proxy estimate of F_{msy} ($F_{20\%} = 0.116$; Mayo, 1993). Annual biomass estimates which relate to B_{msy} were then derived by expanding NEFSC autumn bottom trawl survey biomass indices to total biomass using swept area calculations.

Given that these two approaches are inconsistent, it would seem prudent that the basis for evaluating the current status of redfish relative to the biomass reference points and the harvest

control rule should be re-examined. Thus, the index assessment presented above provides no basis with which to evaluate the present state of the stock relative to this control rule.

5.0 Sources of Uncertainty

- The sharp increase in the survey biomass index in 1996 is inconsistent with the life history characteristics of this species.
- Given the pelagic diurnal movement and general distribution of redfish, swept area estimates of stock biomass derived from bottom trawl survey data will tend to underestimate absolute stock size.

6.0 References

- Mayo, R.K.. 1980. Exploitation of Redfish, *Sebastes marinus* (L.), in the Gulf of Maine-Georges Bank Region, with particular reference to the 1971 Year-Class, J. Northw. Atl. Fish. Sci., Vol 1: 21-37.
- Mayo, R.K.. 1993. Historic and Recent Trends in the Population Dynamics of Redfish, *Sebastes fasciatus*, Storer, in the Gulf of Maine-Georges Bank Region. NMFS, Northeast Fisheries Science Center Reference Document 93-03, 24 p.
- Mayo, R.K. 2000. Redfish. In: Status of Fishery Resources off the Northeastern United States for 2000. (www.nefsc.nmfs.gov/sos/spsyn/pg/redfish)
- NEFSC 1993a. Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS, Northeast Fisheries Science Center Reference Document 93-06, 108 p.
- NEFSC 1993b. Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW). The Plenary. NMFS, Northeast Fisheries Science Center Reference Document 93-07, 66 p.

Table M1. Nominal catches (metric tons), nominal and standardized catch per unit effort, and calculated standard USA and total effort (days fished) for the Gulf of Maine-Georges Bank redfish fishery.

Year	Nominal Catch (metric tons)			USA Catch per Unit Effort (Tons per Day Fished)		Calculated Standard Effort (Days Fished)	
	USA	Others	Total	Actual	Standard	USA	Total
1934	519		519				
1935	7549		7549				
1936	23162		23162				
1937	14823		14823				
1938	20640		20640				
1939	25406		25406				
1940	26762		26762				
1941	50796		50796				
1942	55892		55892	6.9	6.9	8100	8100
1943	48348		48348	6.7	6.7	7216	7216
1944	50439		50439	5.4	5.4	9341	9341
1945	37912		37912	4.5	4.5	8425	8425
1946	42423		42423	4.7	4.7	9026	9026
1947	40160		40160	4.9	4.9	8196	8196
1948	43631		43631	5.4	5.4	8080	8080
1949	30743		30743	3.3	3.3	9316	9316
1950	34307		34307	4.1	4.1	8368	8368
1951	30077		30077	4.1	4.1	7336	7336
1952	21377		21377	3.5	3.4	6287	6287
1953	16791		16791	3.8	3.6	4664	4664
1954	12988		12988	3.4	3.1	4190	4190
1955	13914		13914	4.5	4.0	3479	3479
1956	14388		14388	4.4	3.8	3786	3786
1957	18490		18490	4.3	3.6	5136	5136
1958	16043	4	16047	4.4	3.6	4456	4458
1959	15521		15521	4.3	3.5	4435	4435
1960	11373	2	11375	3.8	3.0	3791	3792
1961	14040	61	14101	4.6	3.5	4011	4029
1962	12541	1593	14134	5.4	4.0	3135	3534
1963	8871	1175	10046	4.1	3.0	2957	3349
1964	7812	501	8313	4.3	2.9	2694	2867
1965	6986	1071	8057	7.0	4.4	1588	1831
1966	7204	1365	8569	11.7	6.4	1126	1339
1967	10442	422	10864	12.4	5.6	1865	1940
1968	6578	199	6777	14.7	6.1	1078	1111
1969	12041	414	12455	11.4	4.9	2457	2542
1970	15534	1207	16741	9.0	4.0	3884	4185
1971	16267	3767	20034	7.0	3.2	5083	6261
1972	13157	5938	19095	5.7	2.9	4537	6584
1973	11954	5406	17360	5.3	2.9	4122	5986
1974	8677	1794	10471	5.0	2.6	3337	4027
1975	9075	1497	10572	4.0	2.2	4125	4805
1976	10131	565	10696	4.6	2.3	4405	4650
1977	13012	211	13223	4.9	2.5	5205	5289
1978	13991	92	14083	4.8	2.4	5830	5868
1979	14722	33	14755	3.6	1.9	7748	7766
1980	10085	98	10183	3.2	1.6	6303	6364
1981	7896	19	7915	2.7	1.4	5640	5654
1982	6735	168	6903	2.7	1.5	4490	4602
1983	5215	113	5328	2.1	1.2	4346	4440
1984	4722	71	4793	1.9	1.1	4293	4357
1985	4164	118	4282	1.4	0.9	4627	4758
1986	2790	139	2929	1.0	0.6	4650	4882
1987	1859	35	1894	1.1	0.7	2656	2706
1988	1076	101	1177	0.9	0.5	2152	2354
1989	628	9	637	1.1	0.6	1047	1062
1990	588	13	601				
1991	525		525				
1992	849		849				
1993	800		800				
1994*	440		440				
1995*	440		440				
1996*	322		322				
1997*	251		251				
1998*	320		320				
1999*	353		353				

Table M2. NEFSC autumn bottom trawl survey stratified mean catch per tow indices, average weights (kg), and average lengths (cm) of redfish in the Gulf of Maine-Georges Bank region, 1963-1999.

	<u>Inshore</u>				<u>Offshore</u>				<u>Combined</u>	
	Stratified Mean		Avg.	Avg.	Stratified Mean		Avg.	Avg.	Stratified Mean	
	Catch per Tow		Weight	Length	Catch per Tow		Weight	Length	Catch per Tow	
	No.	Kg	Kg	Cm	No.	Kg	Kg	Cm	No.	Kg
1963	86.3	7.6	0.088	17.4	87.5	27.0	0.309	26.4	87.3	24.1
1964	81.3	13.5	0.166	20.2	122.3	61.8	0.505	30.8	116.3	54.6
1965	189.5	22.3	0.118	17.7	33.9	11.5	0.339	25.3	57.0	13.1
1966	172.8	17.0	0.098	16.2	77.8	31.2	0.401	27.4	91.9	29.1
1967	62.9	5.3	0.084	17.7	107.1	27.6	0.258	23.6	100.5	24.3
1968	41.1	4.7	0.114	18.3	161.3	46.6	0.289	25.1	143.4	40.4
1969	105.9	16.0	0.151	20.7	65.2	24.8	0.380	27.4	71.2	23.5
1970	18.2	2.8	0.154	20.3	107.2	38.2	0.356	26.3	94.0	32.9
1971	20.7	4.7	0.227	21.8	52.8	26.7	0.506	29.7	48.0	23.4
1972	36.4	6.6	0.181	20.8	58.9	27.8	0.472	29.2	55.6	24.6
1973	26.2	2.1	0.080	15.6	41.4	19.7	0.476	29.7	39.2	17.0
1974	44.4	4.7	0.106	18.0	49.0	27.6	0.563	30.1	48.3	24.2
1975	45.7	6.0	0.131	19.6	79.9	45.9	0.574	30.6	74.8	39.9
1976	11.6	2.5	0.216	22.6	31.9	17.5	0.549	30.2	28.9	15.3
1977	54.6	12.3	0.225	23.4	37.9	18.1	0.478	28.5	40.4	17.3
1978	20.4	5.5	0.270	24.6	49.5	23.4	0.473	29.0	45.2	20.7
1979	6.2	2.1	0.339	26.5	32.8	18.4	0.561	30.5	28.9	16.0
1980	20.6	6.2	0.301	24.6	20.6	13.8	0.670	31.8	20.6	12.6
1981	6.8	1.9	0.279	24.9	22.7	14.0	0.617	31.8	20.4	12.2
1982	28.2	4.6	0.163	21.2	5.6	3.2	0.571	31.5	9.0	3.4
1983	30.2	8.7	0.288	24.8	6.5	3.3	0.508	29.1	10.0	4.1
1984	7.7	3.2	0.416	27.9	7.8	4.1	0.526	29.0	7.8	3.9
1985	7.2	2.1	0.292	24.8	14.0	6.3	0.450	28.0	13.0	5.7
1986	67.6	15.3	0.226	23.3	18.8	6.7	0.356	26.1	26.1	8.0
1987	26.5	4.8	0.181	21.9	11.5	5.6	0.487	29.2	13.7	5.5
1988	18.5	5.1	0.276	21.9	11.4	6.5	0.570	29.1	12.4	6.3
1989	14.0	2.9	0.207	22.6	21.3	7.5	0.352	25.9	20.3	6.8
1990	57.6	14.5	0.252	23.8	31.7	11.7	0.369	26.7	35.5	12.2
1991	7.2	1.1	0.153	20.4	21.1	9.6	0.455	28.5	19.1	8.4
1992	7.8	1.2	0.147	20.0	24.9	9.3	0.374	27.3	22.4	8.1
1993	53.7	7.4	0.137	20.0	32.5	11.9	0.366	26.3	35.6	11.2
1994	31.5	5.4	0.171	21.7	19.0	6.0	0.317	25.0	20.9	5.9
1995	109.7	11.1	0.102	18.5	19.9	3.5	0.177	21.3	33.2	4.7
1996	53.8	9.1	0.169	21.5	189.9	34.4	0.181	21.9	169.6	30.6
1997	105.6	15.7	0.149	20.3	57.9	19.5	0.337	26.0	65.0	18.9
1998	48.7	10.7	0.219	20.4	128.9	35.4	0.275	23.6	117.0	31.7
1999	164.2	35.1	0.214	23.2	68.2	20.7	0.304	25.6	82.5	22.9

Table M3. Commercial landings (mt), NEFSC autumn survey biomass index (kg/tow),
And index of exploitation for Gulf of Maine redfish.

Year	Commercial Landings (mt)	NEFSC Autumn Biomass Index (kg/tow)	Exploitation Ratio
1963	10046	24.1	0.4168
1964	8313	54.6	0.1523
1965	8057	13.1	0.6150
1966	8569	29.1	0.2945
1967	10864	24.3	0.4471
1968	6777	40.4	0.1677
1969	12455	23.5	0.5300
1970	16741	32.9	0.5088
1971	20034	23.4	0.8562
1972	19095	24.6	0.7762
1973	17360	17.0	1.0212
1974	10471	24.2	0.4327
1975	10572	39.9	0.2650
1976	10696	15.3	0.6991
1977	13223	17.3	0.7643
1978	14083	20.7	0.6803
1979	14755	16.0	0.9222
1980	10183	12.6	0.8082
1981	7915	12.2	0.6488
1982	6903	3.4	2.0303
1983	5328	4.1	1.2995
1984	4793	3.9	1.2290
1985	4282	5.7	0.7512
1986	2929	8.0	0.3661
1987	1894	5.5	0.3444
1988	1177	6.3	0.1868
1989	637	6.8	0.0937
1990	601	12.2	0.0493
1991	525	8.4	0.0625
1992	849	8.1	0.1049
1993	800	11.2	0.0714
1994	440	5.9	0.0741
1995	440	4.7	0.0946
1996	322	30.6	0.0105
1997	251	18.9	0.0133
1998	320	31.7	0.0101
1999	353	22.9	0.0154

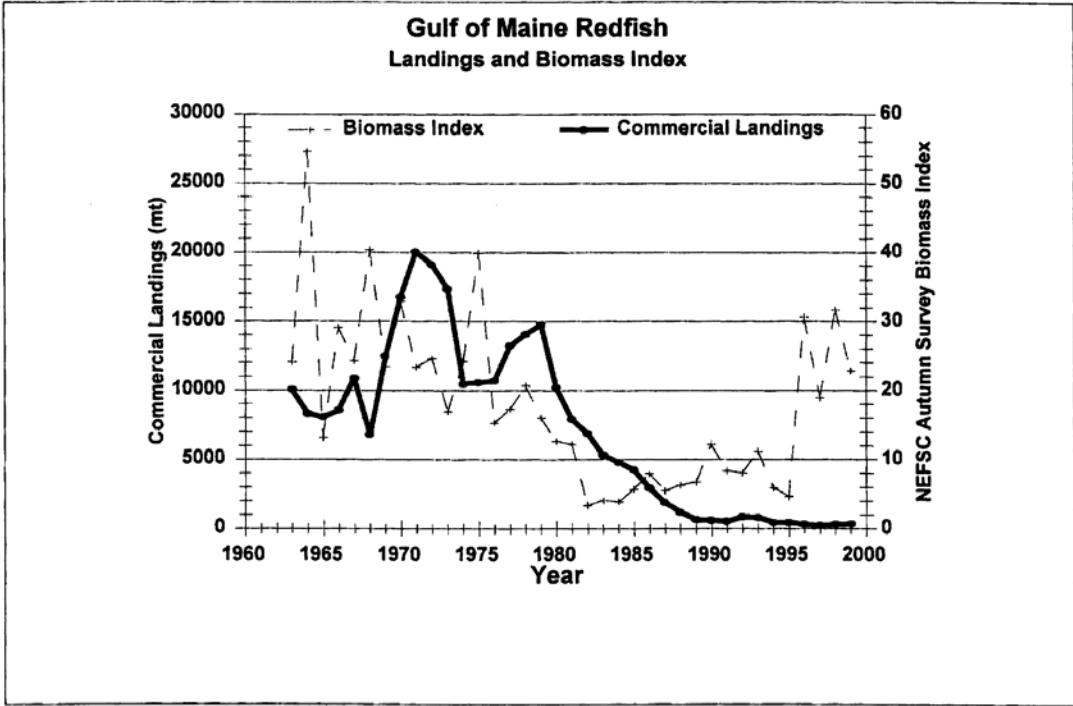


Figure M1. Commercial landings and biomass index derived from NEFSC autumn survey biomass indices for Gulf of Maine redfish.

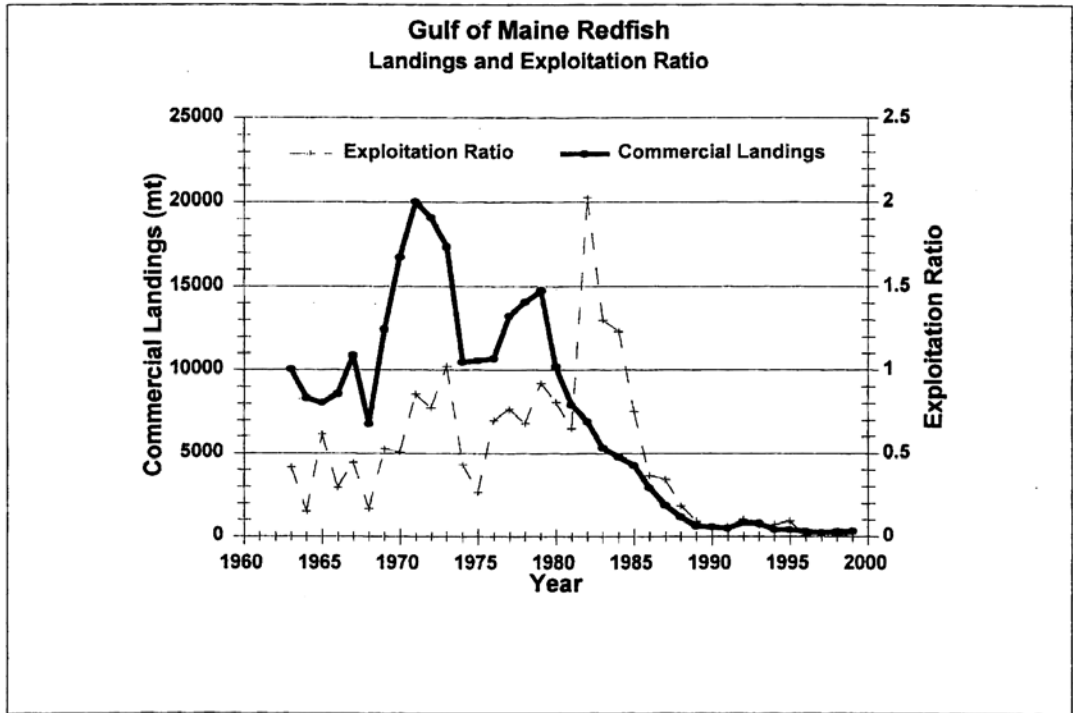


Figure M2. Commercial landings and exploitation ratio derived from NEFSC autumn survey biomass indices for Gulf of Maine redfish.