N. Gulf of Maine/Georges Bank Acadian Redfish by **R.K. Mayo, J. Brodziak, M. Traver and L. Col**

1.0 Background

The most recent stock assessment of Acadian redfish in Subarea 5 was completed in 2001 (Mayo *et al.* 2002), and the results were reviewed at the 33rd Northeast Regional Stock Assessment Workshop in June, 2001 (NEFSC 2001a, 2001b). The assessment was based on several analyses including trends in catch/survey biomass exploitation ratios; a yield and biomass per recruit analysis; an age-structured dynamics model which incorporates information on the age composition of the landings, size and age composition of the population, and trends in relative abundance derived from commercial CPUE and research vessel survey biomass indices; and an age-aggregated biomass dynamics model. Surplus production estimates were derived from the age-structured dynamics model. Estimates of current biomass and fishing mortality relative to MSY-based reference points were also provided by the biomass dynamics model.

Based on the most recent assessment, redfish biomass has been increasing in recent years. The NEFSC autumn survey biomass index had increased substantially during the mid-1990s and had remained relatively high through 2000. The rapid increase in abundance and biomass was attributed to recruitment and growth of the 1992 and other early-1990s year classes. The state of this stock was reviewed at the 2002 Groundfish Assessment Review Meeting (Mayo and Col 2002) by examining trends in relative biomass and exploitation ratios based on the NEFSC autumn bottom trawl surveys. At that time exploitation ratios (catch/total survey biomass) suggested that fishing mortality has remained very low since the mid-1980s compared to previous periods. Estimates of fishing mortality derived from the age-structured dynamics model (Mayo *et al.* 2002) also indicated that then current fishing mortality (0.003) was low relative to past decades and less than 10% of F_{MSY}. Stock biomass in 2000 was then estimated to be 119,600 mt or about 33% of B_{MSY} due, in large part, to strong recruitment from the early 1990s

2.0 The Fishery

Exploitation of redfish has changed substantially since the 1930s. 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 N1; Figure N1). 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 the1970s, 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 after1976. Landings of redfish declined steadily throughout the1980s, remaining below 1,000 mt per year since1989, and at less than 500 mt per year since 1994. Total redfish landings in 2004 were 398 mt compared to 360 mt in 2003. Although population biomass has increased sharply since the mid-1990s, most of fish are below the retention size of the current otter trawl regulated minimum mesh size (6.5 in).

The redfish fishery in the Gulf of Maine has traditionally taken very low bycatch of other species. For example, over 70% of the redfish landed during 1964-1978 were taken on trips comprising over 85% redfish (Mayo 1980). Commercial catch per unit effort (CPUE) indices from these trips were considered representative of trends in stock biomass. These indices are available from the

early 1940s through the late1980s but have since been discontinued (Table N1, Figure N2). These indices declined sharply during the 1940s and 1950 as the large accumulated virgin biomass was fished down. The CPUE indices increased during the 1960 following recruitment of several strong year classes from the 1950 (Mayo 1980) but have since shown a steady decline (Figure N2).

As a consequence of the relatively low landings of redfish after the mid 1980s, the level of biological sampling declined and is now extremely low (Table N2). Estimates of catch and mean weight at age were derived up to 1985 (Table N3), but these calculations have since been discontinued.

3.0 Research Survey Indices

Total Biomass Indices

Indices of relative biomass, derived from NEFSC spring (Table N4, Figure N3) and autumn (Table N5, Figure N4) research vessel bottom trawl surveys, although variable, exhibited a rather steady decline between 1963 and 1982. On average, the autumn biomass index appears to have declined by about 90% over a 20 year period.   During this time, only two 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 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 abundance index in the autumn of 1996. The autumn biomass index has fluctuated between 20 and 65 kg per tow since then, a magnitude comparable to the period between 1963 and the mid-1970s. Indices from both surveys are used as relative biomass indices in the age-structured model.

Exploitable Biomass Indices

Indices of exploitable biomass (Table N6) were computed by adjusting the total biomass indices by length-specific retention rates obtained by first fitting mesh selectivity data to a logistic model. Selectivity studies are available for redfish for a range of mesh sizes from 60 to 134 mm (2.36 – 5.28 in) (Clark 1963, Clay 1979, McKone 1979 Nikeshin et al. 1981).   As the regulated mesh size in the groundfish fishery increased to the present 6-6.5 inches, redfish retention rates declined. At present the portion of the total biomass stock that can be exploited is very small compared to the earlier periods.

Survey Age Composition

Age samples from the NEFSC autumn bottom trawl survey are available from 1975 through 2004. As illustrated in Figure Nx abundance estimates at age reveal a series of dominant year classes followed by periods of poor year classes between 1975 and the early 1990s. Several strong year

classes began to appear in the early 1990s and additional year classes have continued to appear in the survey, the annual growth of these fish accounts for the sharp increases in the total biomass indices beginning in the mid-1990s. Both surveys provide age composition information for the age-structured model.

4.0 Assessment Results

The age structured model (RED) employed at the last peer review of this assessment in 2001 (SAW 33) was updated with NEFSC spring and autumn bottom trawl survey biomass indices and NEFSC autumn bottom trawl survey age compositions through 2004. A full description of the age-structured model is provided in Mayo *et al*. 2002.

The age-structured model is based on forward projection of population numbers at age. This modeling approach is based on the principle that population numbers through time are determined by recruitment and total mortality at age through time. The population numbers at age matrix $\mathbf{N}=(N_{y,a})_{Y \times A}$ has dimensions Y by A, where Y is the number of years in the assessment time horizon and A is the number of age classes modeled. The oldest age (A) comprises a plus-group consisting of all fish age-A and older. The time horizon for redfish is 1934-2004 (Y=71). The number of age classes is 26, representing ages 1 through 26+.

Input data to the model includes the total catch 1934-2004), commercial CPUE index (1942-1989), commercial catch at age (1969-1985), NEFSC spring and autumn total biomass indices and the autumn survey age composition (1975-1984).

Based on results from RED, fishing mortality in 2004 is estimated at 0.00239, a substantial decline from 2001. Spawning stock biomass increased from 124,400 mt in 2001 to 175,800 mt in 2004. The estimate of the 2000 spawning stock biomass based on the present assessment is within 5% of the estimate obtained from the 2001 assessment.

Sensitivity Analyses

The initial version of the age structured forward projection model (RED) was refined after 2001, and is now a component of the NOAA Fisheries Toolbox (NFT) stock assessment software named STATCAM. This version, while identical to RED in most approaches, provides for additional weighting of input data, depending on the length of the time series. Comparative runs of both models were conducted on data sets available at the previous peer review meeting (1934-2000) and at the present meeting (1934-2004) to determine whether differences in modeling approaches produced different estimates of spawning biomass and F.

While both models produce very similar estimates of spawning stock biomass and fishing mortality over time (Figures N6 and N7), the STATCAM model is generating a higher rate of increase in SSB during the past decade than the biomass produced by the original RED model. Although both models produce the same status determination for this stock, because the results from the original RED model were used to derive the biomass reference point, the update from this model is used for current status determination.

5.0 Biological Reference Points

Estimates of recruitment obtained from the age-structured biomass dynamics model reviewed at the 33rd SAW were used to imply the probable recruitment that could be produced by a rebuilt stock as described in NEFSC (2002). Recruitment estimates derived by the model from the 1952-1999 year classes served as the basis for evaluating trends and patterns in recruitment. The stock-recruitment data suggest an increase in the frequency of larger year classes (> 50 million fish) at higher biomass levels. Therefore recruitment estimates corresponding to the upper quartile of the SSB range served as the basis for deriving mean and median recruitment estimates. In accordance with the recommendation of the Stock Assessment Review Committee of the 33rd SAW, the estimate of $F_{50\%}$ (0.04) is taken as a proxy for F_{MSY}. This fishing mortality rate produces 4.1073 kg of spawning stock biomass per recruit and 0.1429 kg of yield per recruit. The resulting mean recruitment of 57.63 million fish results in an SSB_{MSY} estimate of 236,700 mt when multiplied by the SSB per recruit, and an MSY estimate of 8,235 mt when multiplied by the yield per recruit.

Reference points derived from the non parametric approach are:

MSY   8,235mt
B_{MSY} 236,700 mt
F_{MSY} $0.04 = F_{50\%}$ MSP

It was determined (NEFSC 2002) that the stock could not be rebuilt to B_{MSY} by 2009 even at F=0.0. Therefore, the rebuilding scenario invoked a 10 year plus 1 mean generation time (31 years for Acadian redfish) to achieve rebuilding. This results in an Frebuild = 0.013. Based on the results from the present assessment, F in 2004 (0.002) is below Fmsy (and Frebuild), and spawning stock biomass is above ½ Bmsy. Thus overfishing is not occurring and the stock is not in an overfished condition.

6.0 Summary

Spawning stock biomass in 2004 is estimated at 175,800 mt, 74% of Bmsy and F in 2004 is estimated at 0.002, well below Fmsy. Thus, the stock is not overfished and overfishing is not occurring.

7.0 GARM Panel Comments

Exploitable biomass was estimated based on approximate mesh size changes through time. Mesh selection ogives were generated for a set of 5 discrete time periods. These curves were used to estimate exploitable biomass using the NEFSC survey length frequency data. The Panel concluded that this analysis satisfied the research recommendation to evaluate the consequence of changing mesh size on exploitable redfish biomass.

The Panel reviewed results of the updated redfish model (RED) and an alternative statistical catch-at-age mode (STATCAM) applied to provide a sensitivity analysis. The Panel noted that the STATCAM and RED models produce similar results in terms of recent trends in biomass and fishing mortality but had some differences in estimates of the magnitude of strong year classes and survey selectivity. The Panel accepted the updated redfish model (RED).

8.0 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 under-estimate absolute stock size.

9.0 References

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Table N1. Nominal redfish catches (metric tons), actual and standardized catch per unit effort, and calculated standardized USA and total effort for the Gulf of Maine-Georges Bank redfish fishery.

	Nominal Catch (Metric tons)			USA Catch per Unit Effort (tons/day)		Calculated Standard Effort (days fished)	
Year	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 N1 - continued

2000*	319	319	**	**
2001*	360	360	**	**
2002*	368	368	**	**
2003*	361	361	**	**
2004*	398	398	**	**

* Preliminary   **   CPUE and effort not calculated due to sharp reduction in directed redfish trips

Table N2. Commercial length and age sampling summary for Gulf of Maine - Georges Bank Redfish, 1969-2000.

Year	Landings (tons)	Number of Samples	Number of tons/sample	Number of Length Measurements	Number of Ages Collected	Number of Ages Available
1969	12455	14	890	3,200	?	616
1970	16741	18	930	2,300	600	461
1971	20034	34	589	7,796	963	963
1972	19095	16	1193	5,085	?	1,066
1973	17360	23	755	6,246	1,120	1,027
1974	10471	34	308	7,945	2,170	1,011
1975	10572	27	392	6,761	2,912	1,147
1976	10696	24	446	8,094	3,700	1,028
1977	13223	31	427	8,495	3,688	863
1978	14083	30	469	5,493	2,352	1,012
1979	14755	35	422	8,975	3,866	1,122
1980	10183	21	485	4,858	2,210	1,110
1981	7915	21	377	3,718	1,718	851
1982	6903	27	256	4,216	1,734	849
1983	5328	31	172	5,100	2,416	995
1984	4793	26	184	4,603	2,275	1,018
1985	4282	37	116	5,775	2,962	1,464
1986	2929	38	77	6,063	3,102	N/A
1987	1894	29	65	4,633	2,290	N/A
1988	1177	21	56	2,487	1,258	N/A
1989	637	17	37	1,921	958	N/A
1990	601	12	51	1,338	692	N/A
1991	525	10	52	1,136	?225	N/A
1992	849	11	77	1,354	?	N/A
1993	800	5	160	528	?	N/A
1994	440	2	220	226	?	N/A
1995	440	3	147	303	?	N/A
1996	322	1	322	113	?	N/A
1997	251	3	84	343	?	N/A
1998	320	0	-	0	?	N/A
1999	353	1	353	111	?	N/A
2000	319	1	319	110	?	N/A

Table N3. Total catch at age and mean weights at age for Gulf of Maine - Georges Bank redfish, 1969-1985.

Age

Number landed (000s)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26+
1969	-	-	-	22	421	439	1008	6065	2513	6717	2660	3975	3287	2221	2820	1348	751	526	606	426	451	345	469	38	100	847
1970	-	-	-	-	146	4055	4048	1060	9692	3221	8351	2734	4702	2672	2302	3489	1778	1640	393	662	368	529	572	488	64	1743
1971	-	-	-	-	-	72	1941	4430	1536	7907	2767	6504	3088	4267	3680	2895	2206	2765	1347	1163	560	1048	559	282	138	2439
1972	-	-	-	-	-	-	933	3296	7401	1712	7580	2782	2884	1994	3531	2449	1205	1276	2245	734	1011	1172	718	538	1280	2874
1973	-	-	-	-	-	-	235	2463	7938	8391	2201	7337	2078	3100	2376	2024	1799	1380	864	933	411	590	426	295	289	1977
1974	-	-	308	105	-	17	8	174	1886	4724	2945	2435	1709	1115	1302	935	1454	910	640	661	589	730	271	285	250	1755
1975	-	-	4	695	72	11	-	30	124	1944	4360	2154	1932	1442	1009	1344	1360	1235	945	1116	608	887	492	294	298	1282
1976	-	-	-	196	8961	439	-	-	21	48	467	2706	3375	1702	1725	1388	1233	1166	1424	608	769	681	323	672	94	2011
1977	-	-	-	-	234	16747	311	-	-	-	81	2127	1262	4012	2948	1748	1310	1190	1064	461	706	541	117	571	1013	2157
1978	-	-	-	-	-	271	24569	215	-	34	33	182	1689	1484	1972	1299	1580	866	899	1283	895	734	500	192	530	2220
1979	-	-	-	-	25	205	849	23729	152	117	48	168	541	1228	830	1221	860	983	845	1008	798	594	532	349	427	2506
1980	-	-	-	-	-	132	175	1110	16900	208	44	46	217	491	317	364	1274	664	564	452	473	370	349	294	265	1308
1981	-	-	23	-	77	40	57	47	223	12380	84	22	317	44	128	185	582	506	534	396	318	381	306	326	350	1540
1982	-	-	3	271	123	60	92	30	-	15	7268	56	32	21	64	42	85	452	840	324	501	484	301	134	104	2270
1983	-	-	-	11	1687	159	46	43	86	49	141	4959	58	106	44	49	34	319	270	551	169	224	314	195	131	1817
1984	-	-	46	11	51	6674	-	20	40	-	35	15	3571	-	-	44	11	92	210	166	324	215	144	157	162	1807
1985	-	-	27	146	33	31	3818	-	28	11	13	40	12	3202	-	25	11	101	116	260	230	187	197	142	107	1489

Mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26+
1969	.010	.020	.052	.113	.115	.142	.169	.195	.219	.260	.320	.339	.366	.404	.425	.473	.495	.457	.589	.497	.515	.594	.589	.705	.708	.591
1970	.010	.020	.052	.092	.172	.168	.170	.189	.221	.236	.290	.339	.356	.367	.340	.418	.427	.438	.523	.579	.505	.450	.464	.476	.345	.541
1971	.010	.020	.052	.092	.135	.172	.242	.244	.265	.304	.333	.369	.399	.437	.445	.468	.435	.449	.541	.553	.514	.544	.581	.481	.473	.540
1972	.010	.020	.052	.092	.135	.171	.197	.240	.257	.289	.334	.367	.399	.427	.451	.472	.490	.515	.509	.562	.581	.565	.604	.489	.560	.668
1973	.010	.020	.052	.092	.135	.171	.162	.213	.257	.281	.343	.341	.384	.402	.482	.454	.500	.492	.523	.525	.529	.641	.633	.568	.653	.620
1974	.010	.020	.064	.080	.135	.195	.150	.233	.270	.326	.331	.378	.399	.427	.449	.442	.503	.527	.540	.565	.525	.578	.585	.641	.633	.642
1975	.010	.020	.039	.098	.161	.221	.195	.383	.349	.317	.342	.394	.399	.420	.405	.469	.533	.527	.522	.550	.600	.547	.595	.607	.663	.662
1976	.010	.020	.052	.076	.199	.173	.195	.245	.345	.278	.296	.347	.395	.389	.405	.427	.511	.517	.542	.517	.518	.552	.645	.577	.628	.630
1977	.010	.020	.052	.092	.090	.173	.288	.245	.277	.297	.350	.413	.412	.408	.433	.454	.462	.534	.537	.610	.466	.595	.611	.544	.552	.605
1978	.010	.020	.052	.092	.135	.135	.209	.300	.277	.311	.383	.468	.402	.433	.423	.458	.551	.504	.526	.547	.523	.537	.633	.551	.606	.641
1979	.010	.020	.052	.092	.135	.200	.191	.251	.304	.295	.248	.402	.508	.472	.474	.564	.526	.543	.551	.617	.664	.597	.567	.605	.567	.647
1980	.010	.020	.052	.092	.135	.108	.175	.188	.283	.371	.421	.362	.424	.454	.506	.478	.499	.518	.554	.595	.647	.664	.629	.599	.681	.695
1981	.010	.020	.080	.092	.117	.150	.143	.195	.247	.318	.374	.466	.404	.532	.592	.543	.528	.499	.537	.550	.594	.617	.560	.633	.653	.650
1982	.010	.020	.052	.142	.203	.256	.242	.252	.277	.383	.395	.491	.563	.383	.544	.475	.540	.504	.564	.583	.592	.563	.621	.499	.535	.699
1983	.010	.020	.052	.107	.172	.198	.249	.329	.252	.368	.396	.425	.381	.471	.504	.595	.494	.579	.639	.580	.614	.647	.622	.630	.589	.682
1984	.010	.020	.110	.092	.206	.197	.195	.311	.252	.297	.333	.297	.377	.403	.420	.497	.569	.499	.519	.499	.610	.547	.568	.630	.517	.619
1985	.010	.020	.092	.146	.154	.177	.239	.245	.279	.345	.421	.362	.595	.443	.441	.591	.494	.545	.599	.552	.603	.635	.605	.699	.624	.692

Table N4   Spring NEFSC bottom trawl survey stratified mean catch per tow indices, average weights and average lengths of redfish in the Gulf of Maine - Georges Bank region.

Year	INSHORE 1 Stratified Mean Catch per Tow Number	INSHORE 1 Stratified Mean Catch per Tow kg	INSHORE 1 Avg. Wt. kg	INSHORE 1 Avg. Length cm	OFFSHORE 2 Stratified Mean Catch per Tow Number	OFFSHORE 2 Stratified Mean Catch per Tow kg	OFFSHORE 2 Avg. Wt. kg	OFFSHORE 2 Avg. Length cm	COMBINED 3 Stratified Mean Catch per Tow Number	COMBINED 3 Stratified Mean Catch per Tow kg
1968	7.9	1.2	0.152	17.9	51.7	19.8	0.383	26.4	45.2	17.0
1969	59.0	8.3	0.141	20.3	44.2	21.7	0.491	30.6	46.4	19.7
1970	29.7	9.3	0.313	24.4	59.1	20.6	0.349	26.4	54.7	18.9
1971	49.9	13.3	0.267	24.9	176.0	81.7	0.464	29.8	157.2	71.6
1972	23.8	4.6	0.193	18.6	114.7	51.3	0.447	28.9	101.2	44.4
1973	14.4	4.6	0.319	22.0	49.6	28.9	0.583	31.4	44.4	25.3
1974	25.7	6.1	0.237	19.7	35.8	21.0	0.587	31.5	34.3	18.8
1975	50.9	18.9	0.371	25.5	37.4	17.4	0.465	28.5	38.9	17.6
1976	45.9	6.4	0.139	19.8	65.1	29.6	0.455	29.2	62.2	26.2
1977	79.1	24.0	0.303	25.3	15.6	9.4	0.603	32.1	25.1	11.6
1978	33.7	10.4	0.309	25.0	22.3	12.5	0.561	30.2	24.0	12.2
1979	27.5	8.5	0.309	25.4	67.5	36.4	0.539	30.0	61.6	32.3
1980	8.5	2.2	0.259	25.3	33.5	23.5	0.701	32.4	29.8	20.3
1981	3.0	1.0	0.333	22.5	38.9	21.7	0.558	30.5	33.6	18.6
1982	5.0	1.4	0.280	24.7	19.0	10.8	0.568	30.1	16.9	9.4
1983	4.8	0.9	0.188	21.6	10.7	7.0	0.654	31.0	9.9	6.1
1984	5.4	1.6	0.296	25.1	4.9	2.9	0.592	30.2	5.0	2.7
1985	1.2	0.4	0.333	24.8	13.6	7.7	0.566	30.1	11.7	6.6
1986	9.5	5.4	0.568	29.9	4.5	2.8	0.622	31.4	5.3	3.2
1987	5.5	1.4	0.255	23.9	27.8	14.9	0.536	30.5	24.5	12.9
1988	11.7	2.6	0.222	23.0	7.5	3.4	0.453	28.4	8.1	3.3
1989	17.6	2.7	0.153	17.6	6.5	3.0	0.462	27.8	7.6	2.9
1990	0.8	0.2	0.250	23.1	14.4	8.0	0.556	30.2	12.3	6.8
1991	5.5	0.8	0.145	19.4	10.2	4.9	0.480	28.0	9.5	4.3
1992	77.0	15.8	0.205	23.4	31.0	9.8	0.316	26.1	37.9	10.7
1993	12.4	2.3	0.182	22.6	39.5	20.2	0.510	29.7	35.5	17.5
1994	16.6	2.5	0.152	19.6	16.1	4.2	0.259	24.2	16.1	3.9
1995	11.8	2.1	0.176	20.7	6.4	1.9	0.293	23.6	7.2	1.9
1996	16.4	2.2	0.137	20.1	30.9	13.6	0.439	27.9	28.7	11.9
1997	1235.2	175.8	0.142	20.7	33.3	9.3	0.278	24.6	212.0	34.0
1998	13.6	2.0	0.145	20.4	38.4	8.9	0.231	23.6	34.7	7.8
1999	50.8	6.3	0.125	19.9	80.5	21.2	0.264	24.4	76.1	19.0
2000	12.0	2.9	0.238	23.8	209.4	65.3	0.312	25.9	180.1	56.0
2001	103.8	16.7	0.161	21.6	101.2	41.7	0.412	28.7	101.6	40.0
2002	11.6	1.8	0.155	18.4	262.5	71.6	0.273	25.4	225.2	61.2
2003	28.1	2.8	0.100	17.5	123.3	38.7	0.314	26.4	109.1	33.3
2004	72.8	38.2	0.525	27.2	166.2	58.7	0.353	27.1	152.3	55.7
2005	7.7	1	0.130	17.6	169.4	54.2	0.320	26.3	145.3	46.3

1. Strata Set: 26, 27, 39, 40
2. Strata Set: 24, 28-30, 36-38
3. Strata Set: 24, 26-30, 36-40

Table N5   Autumn NEFSC bottom trawl survey stratified mean catch per tow indices, average weights and average lengths of redfish in the Gulf of Maine - Georges Bank region.
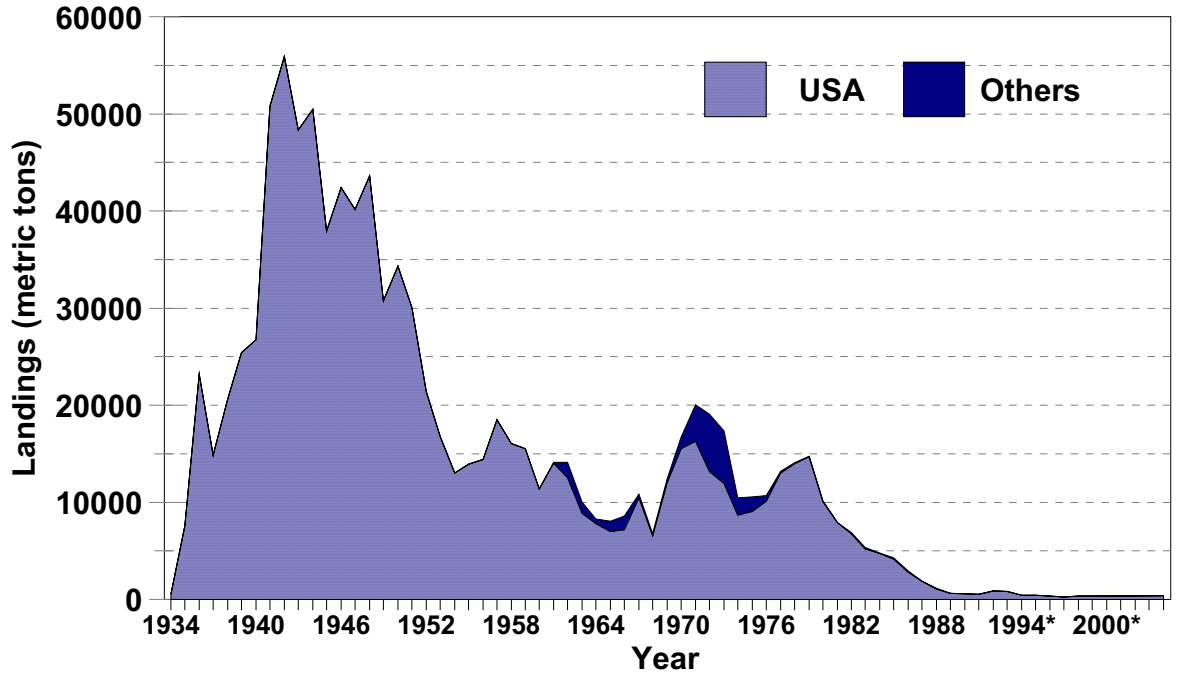
Year	INSHORE 1 Stratified Mean Catch per Tow Number	kg	Avg. Wt. kg	Avg. Length cm	OFFSHORE 2 Stratified Mean Catch per Tow Number	kg	Avg. Wt. kg	Avg. Length cm	COMBINED 3 Stratified Mean Catch per Tow Number	kg
1963	86.3	7.6	0.088	17.4	87.5	27.0	0.309	26.4	87.3	24.1
1964	81.3	13.5	0.166	20.2	122.3	61.8	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
2000	133.3	21.8	0.164	21.6	99.4	26.9	0.271	24.8	104.4	26.2
2001	144.4	28.9	0.200	22.8	80.2	28.0	0.349	27.3	89.8	28.2
2002	217.7	31.6	0.145	20.7	179.5	43.7	0.243	24.4	185.2	41.9
2003	664.0	153.1	0.231	25.0	178.8	50.2	0.281	25.6	250.9	65.5
2004	61.2	7.0	0.114	15.3	138.8	41.8	0.301	25.6	127.3	36.6

1. Strata Set: 26, 27, 39, 40
2. Strata Set: 24, 28-30, 36-38
3. Strata Set: 24, 26-30, 36-40

Table N6. Commercial landings (mt), NEFSC autumn survey biomass index
(kg/tow), and index of exploitation for Gulf of Maine redfish.

Year	Commercial landings (mt)	Biomass Index		Exploitation Ratio	Exp Biomass Index		Exploitation Ratio
1963	10046	24.1		0.0417	23.841		0.0421
1964	8313	54.6		0.0152	54.487		0.0153
1965	8057	13.1		0.0615	12.708		0.0634
1966	8569	29.1		0.0294	28.553		0.0300
1967	10864	24.3		0.0447	23.826		0.0456
1968	6777	40.4		0.0168	40.05		0.0169
1969	12455	23.5		0.0530	23.361		0.0533
1970	16741	32.9		0.0509	32.807		0.0510
1971	20034	23.4		0.0856	22.098		0.0907
1972	19095	24.6		0.0776	23.077		0.0827
1973	17360	17.0		0.1021	16.209		0.1071
1974	10471	24.2		0.0433	22.833		0.0459
1975	10572	39.9		0.0265	37.828		0.0279
1976	10696	15.3		0.0699	14.42		0.0742
1977	13223	17.3		0.0764	15.494		0.0853
1978	14083	20.7		0.0680	19.231		0.0732
1979	14755	16.0		0.0922	15.341		0.0962
1980	10183	12.6		0.0808	12.195		0.0835
1981	7915	12.2		0.0649	11.953		0.0662
1982	6903	3.4		0.2030	2.062		0.3348
1983	5328	4.1		0.1300	2.294		0.2323
1984	4793	3.9		0.1229	2.542		0.1886
1985	4282	5.7		0.0751	3.121		0.1372
1986	2929	8.0		0.0366	2.951		0.0993
1987	1894	5.5		0.0344	2.6		0.0728
1988	1177	6.3		0.0187	2.896		0.0406
1989	637	6.8		0.0094	2.676		0.0238
1990	601	12.2		0.0049	4.535		0.0133
1991	525	8.4		0.0063	3.521		0.0149
1992	849	8.1		0.0105	3.071		0.0276
1993	800	11.2		0.0071	3.742		0.0214
1994	440	5.9		0.0074	1.432		0.0307
1995	440	4.7		0.0095	0.566		0.0777
1996	322	30.6		0.0011	3.387		0.0095
1997	251	18.9		0.0013	4.393		0.0057
1998	320	31.7		0.0010	4.37		0.0073
1999	353	22.9		0.0015	3.753		0.0094
2000	319	26.2		0.0012	3.938		0.0081
2001	360	28.2		0.0013	5.554		0.0065
2002	368	41.9		0.0009	5.848		0.0063
2003	416	65.5		0.0006	11.688		0.0036
2004	398	36.6		0.0011	6.954		0.0057

Figure N1

Gulf of Maine-Georges Bank Redfish
Commercial Landings

Gulf of Maine - Georges Bank Redfish
Catch, Effort and CPUE
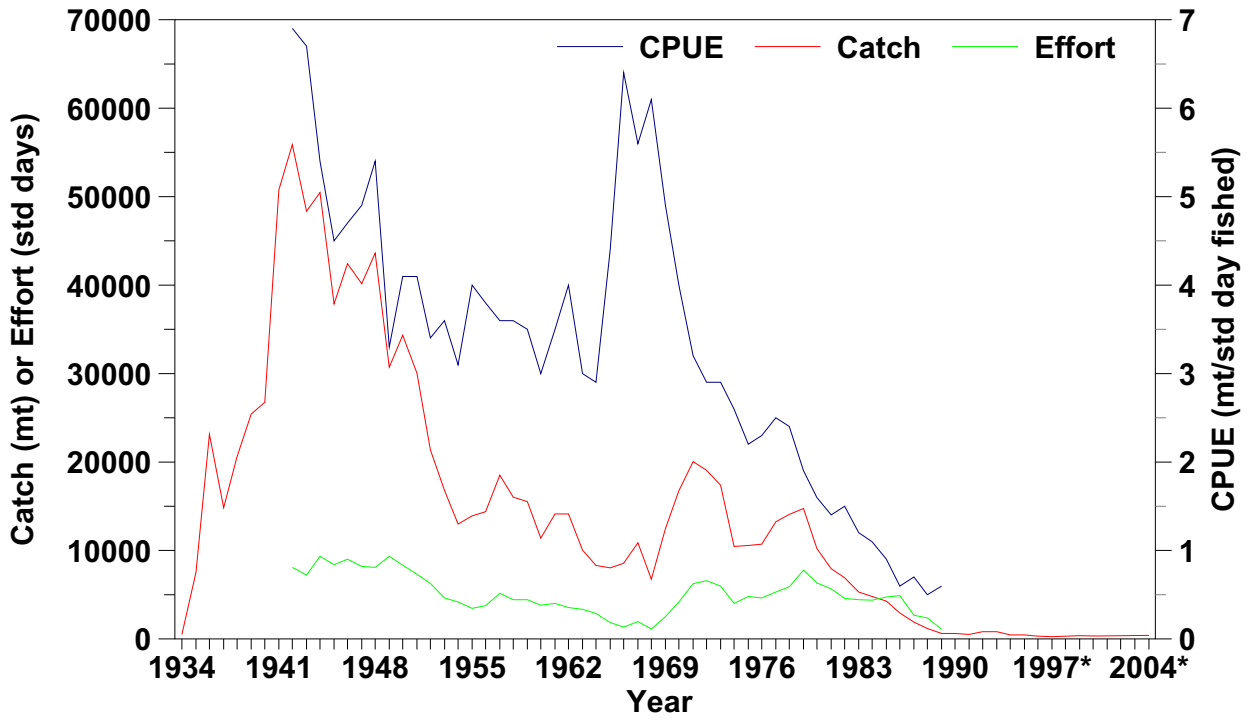
Redfish Stratified Mean Catch per Tow
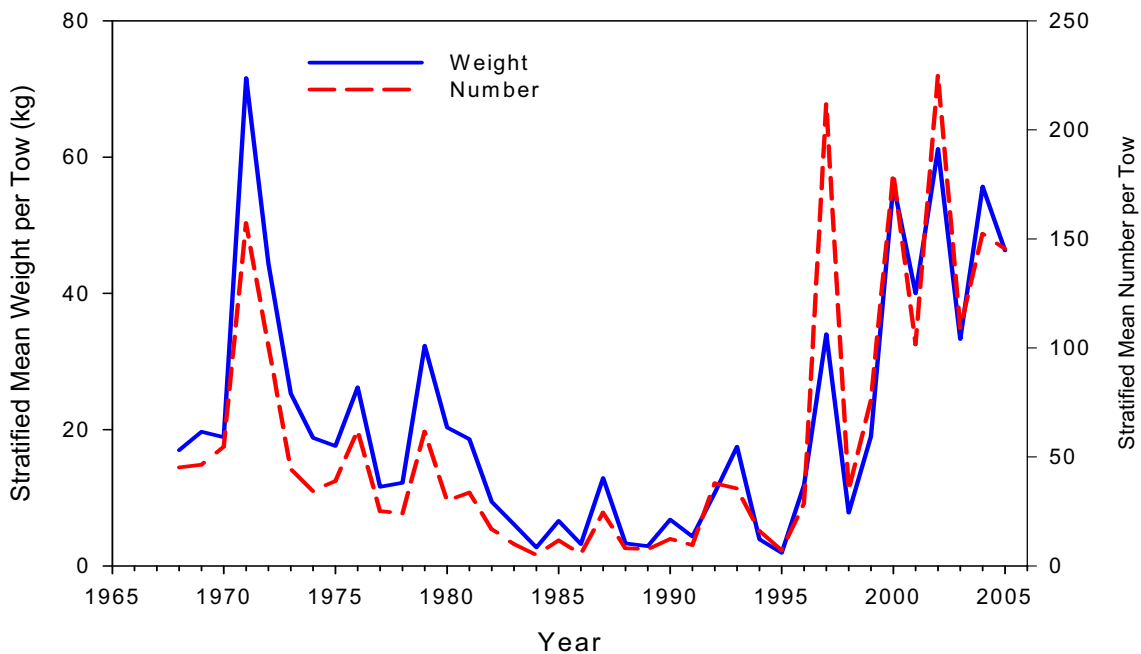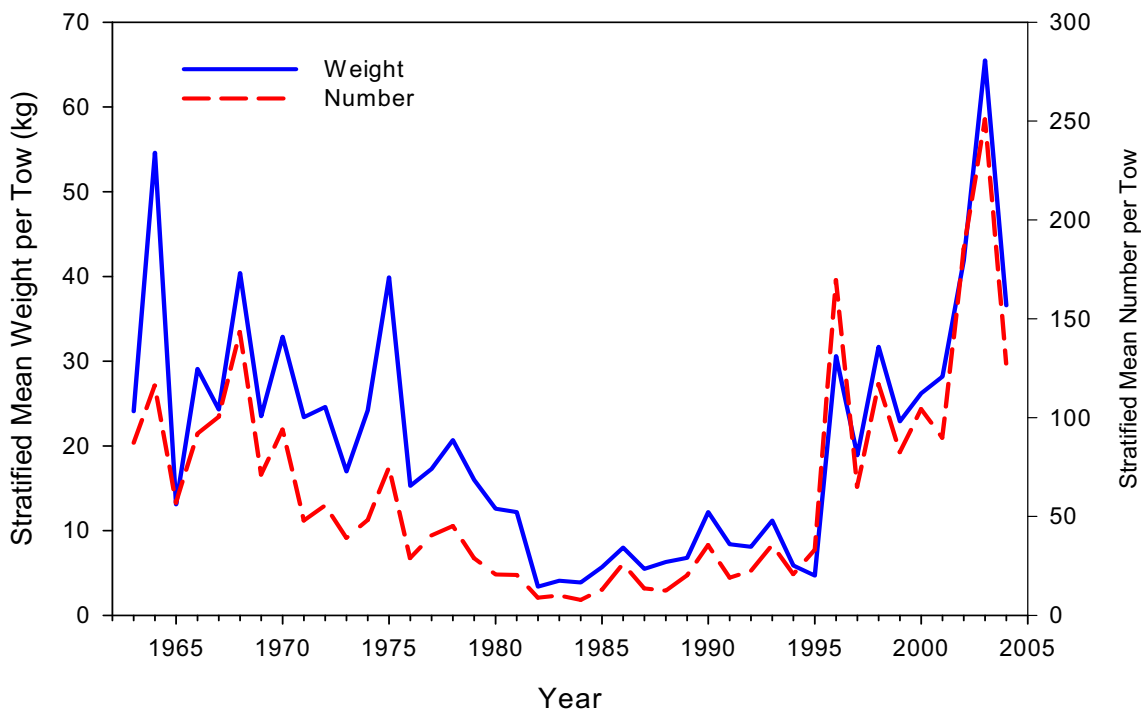NMFS Spring Bottom Trawl Survey

Figure N4

Redfish Stratified Mean Catch per Tow
NMFS Autumn Bottom Trawl Survey
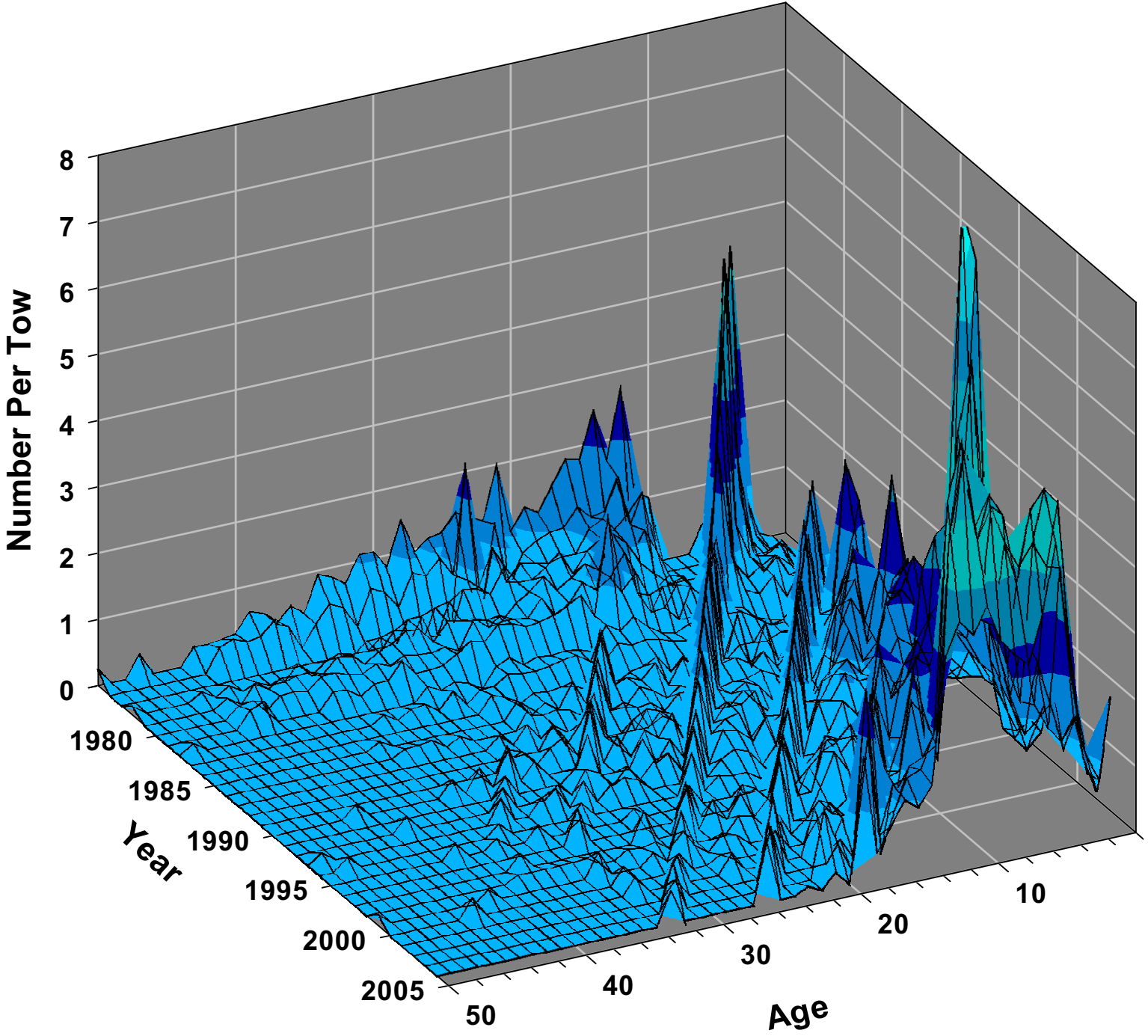
Autumn Survey Redfish Age Composition

Figure N5

Figure N6
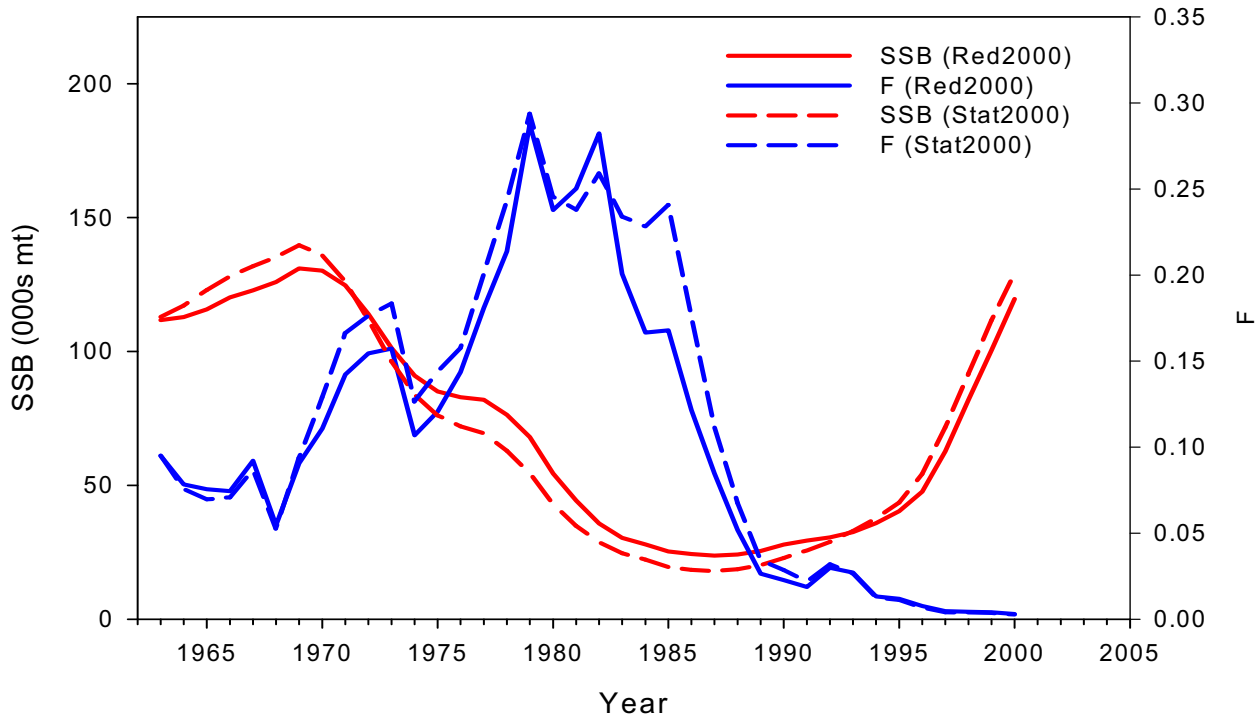
Redfish Red2000 and Stat2000 Models

Figure N7
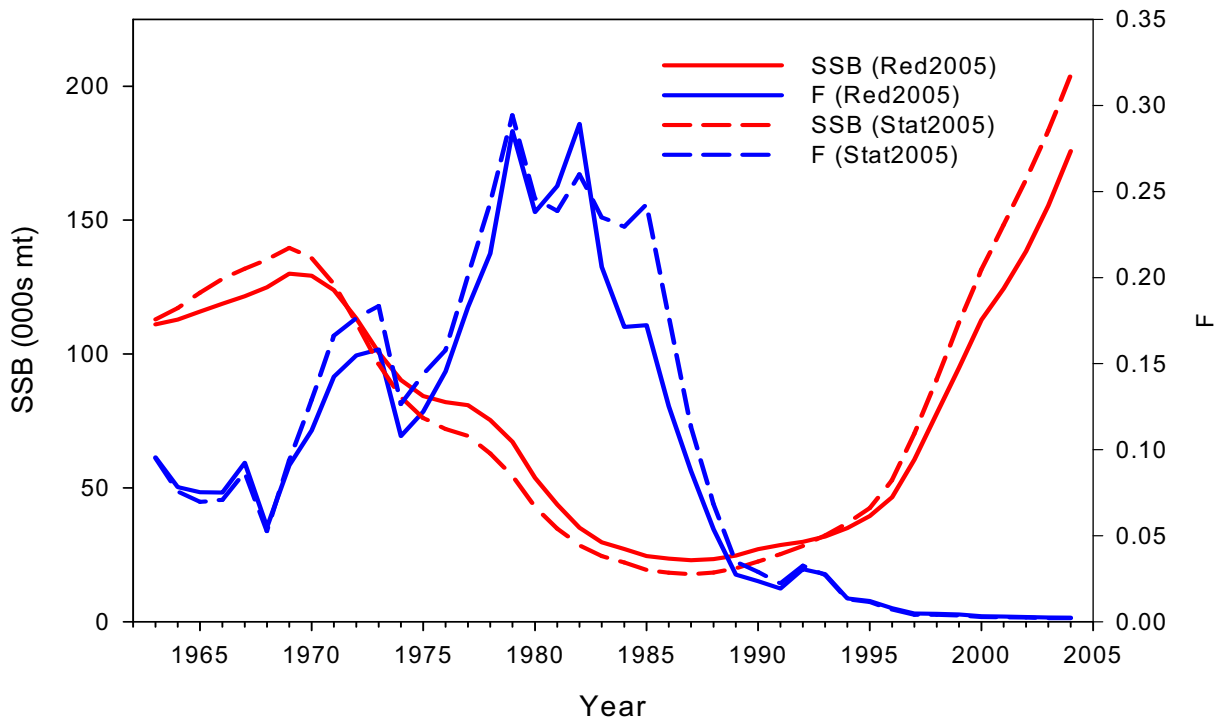
Redfish Red2005 and Stat2005 Models

Figure N8

Acadian Redfish

Acadian Redfish