Section 2. Stock Assessments

A. Georges Bank Atlantic Cod - L. O'Brien, N. J. Munroe, and L. Col

1.0 Background

This stock was last assessed and peer reviewed in April 2001 (O'Brien and Munroe 2001; Transboundary Resources Assessment Committee 2001). Landings were 9,189 mt in 2000 and fully recruited F (ages 4-8, unweighted average) was estimated to be 0.22 in 2000, the lowest in the time series (1978-2000). Spawning stock biomass was 29,003 mt in 2000 and continued the increasing trend from the record low estimate of 19,233 mt in 1994. Since 1991, recruiting year classes have all been below the long term average and the 1997 and 2000 year classes were the lowest in the time series. The NEFSC spring and autumn bottom trawl survey recruitment indices continued to remain near record low values. Autumn recruitment indices for age 2 fish from the 1994, 1995, 1996, 1997, and 1998 year classes were all below the time series (1963-2000) average. The most recent above-average autumn recruitment index occurred in 1993.

A benchmark assessment review was conducted by the TRAC in February 2002 (NEFSC 2002). Several recommendations were made by the TRAC to rectify the strong retrospective pattern in F. These included estimating the population sizes for ages 1-9 in the terminal year and for age 9 in the three years prior to the terminal year. For the remaining years, F on the oldest age (9) would be estimated as a weighted F of ages 7 and 8. These recommendations will be addressed in the next assessment. The current assessment presented here is considered an update and the methodology has remained the same as used by the Working Group on Re-Evaluation of Biological Reference Points (NEFSC 2002).

2.0 Fishery

Total commercial landings of Georges Bank cod (Table A1, Figure A1) increased 39% in 2001 to 12,769 mt. USA landings increased 40% (10,635 mt) and Canadian landings increased 36% (2,134 mt) in 2001 (Table A1). Recreational landings were estimated at 550 mt in 2001, a decline of about 48% from 2000.

3.0 Research Surveys

NEFSC spring and autumn survey biomass and abundance indices fluctuated slightly during 2000 to 2002, and continue to remain below the long term average (Table A2, Figure A2-A3). The recruitment indices for age 1 and 2 from the 2001 NEFSC autumn bottom trawl survey were well below average (Table A3a). The Canadian spring survey index of abundance increased in 2002 but also is below the time series average (Figure A3, Table A3b).

4.0 Assessment

Input data and Analyses

The current assessment is an update assessment and employs the same VPA formulation as in the 2000 assessment (O'Brien and Munroe 2001). A slight variation from the previous assessment is that the number of surveys available as tuning indices in the terminal year increases from two to three since the USA 2002 spring survey was available at the time the assessment was conducted.

Catch at age (1-10+) has been updated with total 2001 landings (USA and Canadian). The total number of commercial length samples in 2001 was less than in 2000, however, the number of samples collected during these two years was the highest since 1985 (Table A4). The number of quarterly samples was adequate for all market categories except for the fourth quarter scrod samples (Table A5). Spatial coverage was poor for eastern Georges Bank (SA 561, 562), as it has been for several years. As in the last assessment, length samples from western Georges Bank and combined US and Canadian age samples from eastern Georges Bank were applied to characterize the landings from eastern Georges Bank. Landings were dominated in numbers by age 3 fish in both the US and Canadian fisheries and in weight by age 3 fish in the USA fishery and by age 3 and age 5 fish in the Canadian fishery. The total catch at age includes total landings from both the USA and Canadian fisheries (Table A6). No discards at age estimates are derived for stock.

Research survey indices were estimated from the 2002 NEFSC and Canadian Department of Fisheries and Oceans (DFO) spring (ages 1-8) and the NEFSC 2001 autumn (ages 1-6) bottom trawl surveys.

The ADAPT calibration method (Parrack 1986, Gavaris 1988, Conser and Powers 1990) was used to derive estimates of instantaneous fishing mortality and beginning year stock sizes in 2002. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality, spawning stock biomass, and mean biomass estimates. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

Assessment results

Fully recruited fishing mortality (age 4-8) was estimated at 0.38 in 2001 (Figure A4). Spawning stock biomass in 2001 was estimated at 29,170 mt, a 12% increase from 2000 and a 53% increase from the record low in 1994 (Table A7, Figure A5). Recruitment of the 2001 year class (1.7 million age 1 fish) is estimated to be similar to the 2000 year class (1.6 million age 1 fish) and the 1994 year class (3.9 million age 1 fish) (Table A7, Figure A5). The survival ratio of recruit/SSB was above average for the 1996 and 1998 year classes and below average for the more recent year classes.

VPA Diagnostics

Stock size estimates for ages 1-8 were well estimated with CVs ranging from 0.21 to 0.47. The distribution of F estimates from the bootstrap analysis ranged from 0.25 to 0.56 with an 80% probability that F in 2001 was between 0.33 and 0.44. The distribution of SSB estimates from the bootstrap analysis ranged from 21,000 mt to 43,000 mt with an 80% probability that SSB in 2000 was between 25,250 mt and 31,845 mt.

A retrospective pattern exists in this model formulation back to 1994 (Figure A6). The terminal year estimates of fishing mortality are less than converged estimates since 1993, and SSB estimates are greater than converged estimates since 1993. The terminal year estimates of recruits are less than converged estimates from 1992 to 1999 and more than the converged estimates from 2000-2001. The TRAC recommended a different formulation of the ADAPT calibration to address the retrospective pattern and these recommendations will be applied in the next assessment (NEFSC 2002).

Sensitivity Analyses

Analyses were conducted to determine the sensitivity of fishing mortality and spawning stock biomass estimates to changes in the magnitude of the research survey indices used to calibrate the VPA. NEFSC spring and autumn survey indices for 2000-2002 were arbitrarily increased by 10%, 25% and 100% and used to re-calibrate the VPA (Figure A7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

5.0 Projections

Long term forecasts of catch and SSB were conducted with $F_{2002}= 0.85\ F_{2001}$. Input data and results for 2002-2004 are presented in Table A8. The $F_{rebuild}$ that would enable 50% probability of reaching Bmsy by 2019 was 0.15 (Table A8). The current estimate of $F_{rebuild}$ is similar to the previous estimate of 0.17 (NEFSC 2002) which was based on the assessment results from 2000 (O'Brien and Munroe 2001). Median SSB and catch with 80% confidence intervals projected under $F_{rebuild} = 0.15$ are presented in Figure A8.

6.0 Biological Reference Points

Biological reference points were established for Georges Bank cod based on a Beverton-Holt stock recruit model (NEFSC 2002) as :

MSY= 35,236 mt
SSB_{MSY} = 216,780 mt and
F_{MSY}= 0.175

In 2001, spawning stock biomass was estimated at 29,170 mt, about 13% of the target SSB_{MSY}.

The stock is considered to be overfished. F was estimated at 0.38, therefore overfishing is occurring on this stock.

7.0 Summary

Georges Bank Atlantic cod are overfished and overfishing is occurring. Fishing mortality had been steadily declining since 1997, however, F increased about 9% in 2001 to 0.38. Spawning stock continues to slowly increase from the record low in 1994, however, the increase appears to be primarily due to growth.

The 1996 year class accounts for the majority of the US catch and both the 1998 and 1996 year classes account for the majority of the Canadian catch. The 1996 (10.5 million age 1 fish) and 1998 (10.3 million age 1 fish) year classes, while below the long term average (14 million age 1 fish), represent the strongest year classes since the last above-average year class that occurred in 1990 (17.9 million age1 fish). The 1999, 2000, and 2001 year classes are among the lowest in the time series.

The NEFSC and DFO survey biomass and abundance indices fluctuated slightly during 2000 to 2002, however, all the indices continue to remain below the long term average The most recent surveys indicate that the 1999 year class may be similar in size to the 1998 year class.

The lack of strong recruitment in the last decade suggests that recovery of this stock will be largely dependent on reducing fishing mortality.

8. 0 Sources of Uncertainty

Landings data for 1994-2001 are derived by proration and are provisional.

The retrospective analysis indicates a pattern in the estimates of F, SSB, and recruits in the VPA. The terminal year estimates of fishing mortality are less than the converged estimates and SSB estimates are greater than the converged estimates.

There is inadequate data to characterize both the recreational and discarded catch, particularly if these components increase. The TRAC previously rejected using poorly sampled recreational catch since a recreational catch at age with a similar age structure to the commercial catch at age would only be a scaling factor.

9.0 GARM Panel Comments

Sampling of commercial landings is stratified by market category. When evaluating sampling intensity, it may be useful to note the ages that comprise the various market categories to relate sampling to the age structure of the catch.

The residual pattern from the calibrated VPA was discussed at length. It was noted that the residual pattern on the older ages is strongest, and this may lead to the retrospective pattern on F. The retrospective pattern on SSB, however, is not as severe after 1999. A domed-shaped pattern in partial recruitment was again apparent in this assessment. Many factors may be responsible for this pattern which is generally caused by a mismatch between the age composition of the catch and the population as estimated by the survey. This may be influenced by the extensive closed areas on Georges Bank since 1995. The panel reiterated the recommendation of the TRAC that F on the oldest age be estimated directly for several of the most recent years so that a flat-topped PR not be assumed.

10.0 References

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Table A1. Commercial landings (metric tons, live) of Atlantic cod from the Georges Bank and South (NAFO Division 5Z and Subarea 6) stock, 1960 - 2001 (* = Provisional data).

			Country				
Year	USA	Canada	USSR	Spain	Poland	Other	Total
1960	10834	19	-	-	-	-	10853
1961	14453	223	55	-	-	-	14731
1962	15637	2404	5302	-	143	-	23486
1963	14139	7832	5217	-	-	1	27189
1964	12325	7108	5428	18	48	238	25165
1965	11410	10598	14415	59	1851	-	38333
1966	11990	15601	16830	8375	269	69	53134
1967	13157	8232	511	14730	-	122	36752
1968	15279	9127	1459	14622	2611	38	43136
1969	16782	5997	646	13597	798	119	37939
1970	14899	2583	364	6874	784	148	25652
1971	16178	2979	1270	7460	256	36	28179
1972	13406	2545	1878	6704	271	255	25059
1973	16202	3220	2977	5980	430	114	28923
1974	18377	1374	476	6370	566	168	27331
1975	16017	1847	2403	4044	481	216	25008
1976	14906	2328	933	1633	90	36	19926
1977	21138	6173	54	2	-	-	27367
1978	26579	8778	-	-	-	-	35357
1979	32645	5978	-	-	-	-	38623
1980	40053	8063	-	-	-	-	48116
1981	33849	8499	-	-	-	-	42348
1982	39333	17824	-	-	-	-	57157
1983	36756	12130	-	-	-	-	48886
1984	32915	5763	-	-	-	-	38678
1985	26828	10443	-	-	-	-	37271
1986	17490	8411	-	-	-	-	25901
1987	19035	11845	-	-	-	-	30880
1988	26310	12932	-	-	-	-	39242
1989	25097	8001	-	-	-	-	33098
1990	28193	14310	-	-	-	-	42503
1991	24175	13455	-	-	-	-	37630
1992	16855	11712	-	-	-	-	28567
1993	14594	8519	-	-	-	-	23113
1994	9893*	5276	-	-	-	-	15169
1995	6759*	1100	-	-	-	-	7859
1996	7020*	1885	-	-	-	-	8905
1997	7537*	2898	-	-	-	-	10435
1998	6959*	1873	-	-	-	-	8832
1999	8061*	1819	-	-	-	-	9880
2000	7617*	1572	-	-	-	-	9189
2001	10635*	2134	-	-	-	-	12769

Table A2. Standardized stratified mean catch per tow in numbers and weight (kg)for Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2000. [1,2,3]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.79	11.4
1965	-	-	4.25	11.8
1966	-	-	4.90	8.1
1967	-	-	10.33	13.6
1968	4.73	12.7	3.31	8.6
1969	4.63	17.8	2.24	8.0
1970	4.34	15.8	5.12	12.6
1971	3.39	14.3	3.19	9.8
1972	9.16	19.3	13.09	22.9
1973	57.81	94.5	12.28	30.9
1974	14.74	36.4	3.49	8.2
1975	6.89	26.1	6.41	14.1
1976	7.06	18.6	10.43	17.7
1977	6.19	15.3	5.44	12.5
1978	12.31	31.2	8.59	23.3
1979	5.00	16.2	5.95	16.5
1980	7.68	24.1	2.91	6.7
1981	10.44	26.1	9.20	20.3
1982	32.96	101.9	3.34	6.1
1983	7.70	23.5	4.14	6.1
1984	4.08	15.3	4.73	10.0
1985	7.03	21.7	2.31	3.1
1986	5.04	16.7	2.99	3.7
1987	3.24	9.9	2.33	4.4
1988	5.87	13.5	3.07	5.6
1989	4.80	10.9	4.84	4.7
1990	4.79	11.7	4.78	11.5
1991	4.31	8.9	0.96	1.4
1992	2.67	7.4	1.72	3.0
1993	2.40	7.0	2.15	2.2
1994	0.95	1.2	1.82	3.3
1995	3.29	8.4	3.62	5.6
1996	2.70	7.5	1.10	2.7
1997	2.32	5.2	0.87	1.9
1998	4.36	11.7	1.87	2.8
1999	2.15	4.7	1.02	3.0
2000	3.57	8.2	1.31	1.4
2001	1.86	5.5	1.05	2.1
2002	2.08	5.0		
Average	7.50	19.3	4.29	9.2

Table A3a. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2002.

	AGE											
Year	0	1	2	3	4	5	6	7	8	9	10+	No./tow
SPRING												
1968	0.513	0.136	1.615	0.825	0.665	0.385	0.246	0.140	0.083	0.056	0.058	4.722
1969	0.000	0.123	0.546	1.780	0.888	0.451	0.326	0.215	0.128	0.072	0.112	4.641
1970	0.000	0.338	0.804	0.430	1.241	0.162	0.844	0.263	0.058	0.056	0.147	4.342
1971	0.000	0.206	0.860	0.438	0.254	0.570	0.114	0.324	0.365	0.128	0.132	3.391
1972	0.056	3.000	1.838	2.732	0.445	0.166	0.323	0.084	0.285	0.071	0.158	9.159
1973	0.056	0.546	42.258	6.344	6.387	0.657	0.515	0.367	0.058	0.217	0.404	57.808
1974	0.000	0.444	4.558	5.971	0.761	1.988	0.442	0.100	0.265	0.064	0.144	14.735
1975	0.000	0.064	0.327	2.092	2.941	0.377	0.744	0.084	0.115	0.147	0.000	6.890
1976	0.111	1.298	1.955	0.915	0.661	1.607	0.153	0.261	0.029	0.000	0.068	7.058
1977	0.000	0.044	3.389	1.084	0.553	0.267	0.717	0.052	0.066	0.000	0.021	6.193
1978	3.312	0.372	0.192	5.531	0.972	0.778	0.142	0.712	0.065	0.141	0.096	12.312
1979	0.108	0.428	1.298	0.275	1.852	0.547	0.236	0.084	0.139	0.013	0.022	5.000
1980	0.105	0.031	2.217	2.690	0.212	1.705	0.374	0.186	0.031	0.030	0.096	7.676
1981	0.301	2.302	1.852	2.811	1.685	0.106	0.879	0.258	0.132	0.000	0.113	10.438
1982	0.169	0.508	5.435	9.502	8.324	6.208	0.293	1.866	0.369	0.082	0.203	32.958
1983	0.081	0.332	1.952	3.017	0.796	0.697	0.443	0.027	0.219	0.000	0.138	7.701
1984	0.000	0.402	0.431	0.761	1.238	0.422	0.400	0.209	0.000	0.215	0.000	4.078
1985	0.244	0.111	2.653	0.663	1.110	1.412	0.265	0.192	0.180	0.037	0.161	7.029
1986	0.092	0.872	0.409	1.844	0.365	0.540	0.618	0.062	0.125	0.101	0.015	5.044
1987	0.000	0.020	1.613	0.378	0.763	0.062	0.179	0.136	0.033	0.027	0.025	3.235
1988	0.180	0.720	0.609	3.150	0.409	0.644	0.064	0.037	0.049	0.000	0.007	5.868
1989	0.000	0.310	1.410	0.666	1.583	0.235	0.351	0.051	0.040	0.055	0.093	4.794
1990	0.042	0.173	0.922	1.737	0.674	0.912	0.130	0.143	0.013	0.016	0.027	4.790
1991	0.195	1.027	0.528	0.689	0.929	0.479	0.328	0.054	0.041	0.000	0.045	4.313
1992	0.000	0.123	1.252	0.468	0.168	0.273	0.142	0.159	0.020	0.037	0.028	2.670
1993	0.110	0.009	0.399	1.306	0.205	0.090	0.138	0.029	0.034	0.021	0.055	2.396
1994	0.030	0.125	0.272	0.200	0.217	0.033	0.006	0.044	0.000	0.019	0.000	0.945
1995	0.482	0.050	0.382	0.854	0.534	0.599	0.107	0.234	0.028	0.022	0.000	3.290
1996	0.000	0.073	0.214	0.736	1.247	0.174	0.209	0.028	0.018	0.000	0.000	2.699
1997	0.302	0.291	0.437	0.170	0.489	0.422	0.050	0.134	0.020	0.000	0.000	2.315
1998	0.018	0.111	0.665	1.298	0.848	0.755	0.533	0.102	0.031	0.000	0.000	4.360
1999	0.067	0.212	0.291	0.609	0.510	0.238	0.119	0.064	0.031	0.007	0.000	2.148
2000	0.053	0.221	0.807	0.830	1.141	0.370	0.102	0.026	0.020	0.000	0.000	3.569
2001	0.000	0.061	0.235	0.794	0.160	0.383	0.177	0.023	0.018	0.012	0.000	1.862
2002	0.018	0.065	0.093	0.383	0.993	0.239	0.225	0.039	0.000	0.000	0.028	2.083
average	0.301	0.433	2.420	1.828	1.206	0.713	0.312	0.194	0.089	0.047	0.068	7.500

Table A3a continued. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2001.

	AGE											
Year	0	1	2	3	4	5	6	7	8	9	10+	No./tow
AUTUMN												
1963	0.019	0.719	0.778	0.920	0.897	0.354	0.326	0.175	0.103	0.014	0.069	4.374
1964	0.009	0.640	0.699	0.588	0.538	0.145	0.136	0.062	0.050	0.030	0.083	2.980
1965	0.173	1.299	0.998	0.707	0.484	0.167	0.179	0.112	0.081	0.023	0.023	4.246
1966	1.025	1.693	1.000	0.515	0.264	0.100	0.095	0.062	0.039	0.002	0.017	4.812
1967	0.072	7.596	1.334	0.523	0.406	0.133	0.133	0.055	0.051	0.012	0.070	10.385
1968	0.070	0.314	1.611	0.783	0.271	0.073	0.067	0.027	0.023	0.008	0.048	3.295
1969	0.000	0.343	0.622	0.626	0.331	0.094	0.061	0.019	0.023	0.022	0.059	2.200
1970	0.434	1.699	1.361	0.532	0.696	0.153	0.000	0.033	0.055	0.055	0.098	5.116
1971	0.400	0.602	0.617	0.408	0.310	0.478	0.164	0.042	0.090	0.000	0.075	3.186
1972	0.948	7.473	1.191	1.841	0.399	0.241	0.568	0.116	0.204	0.021	0.084	13.085
1973	0.203	1.748	6.060	1.164	2.039	0.210	0.225	0.175	0.062	0.137	0.253	12.276
1974	0.461	0.410	0.667	1.509	0.161	0.089	0.112	0.000	0.059	0.021	0.000	3.489
1975	2.377	0.992	0.421	0.628	1.682	0.111	0.156	0.000	0.000	0.000	0.037	6.406
1976	0.000	6.144	2.073	0.762	0.275	0.738	0.054	0.269	0.037	0.052	0.021	10.425
1977	0.152	0.237	3.434	0.691	0.253	0.173	0.394	0.007	0.027	0.000	0.077	5.444
1978	0.395	1.845	0.391	4.058	0.964	0.336	0.165	0.343	0.050	0.030	0.014	8.590
1979	0.115	1.625	1.677	0.162	1.687	0.321	0.184	0.031	0.113	0.010	0.025	5.948
1980	0.280	0.820	0.564	0.774	0.053	0.265	0.057	0.067	0.027	0.000	0.000	2.905
1981	0.261	3.525	2.250	1.559	0.589	0.054	0.579	0.057	0.064	0.018	0.083	9.039
1982	0.362	0.577	1.910	0.242	0.068	0.115	0.000	0.031	0.033	0.000	0.000	3.337
1983	1.283	0.850	1.089	0.740	0.069	0.033	0.004	0.010	0.015	0.000	0.044	4.136
1984	0.179	1.909	0.682	0.929	0.825	0.024	0.059	0.039	0.000	0.039	0.044	4.728
1985	1.002	0.181	0.843	0.067	0.106	0.077	0.028	0.000	0.000	0.000	0.003	2.306
1986	0.076	2.279	0.129	0.329	0.008	0.049	0.073	0.016	0.000	0.007	0.022	2.987
1987	0.204	0.414	1.353	0.108	0.200	0.028	0.012	0.000	0.000	0.000	0.007	2.325
1988	0.550	0.875	0.437	0.904	0.060	0.194	0.000	0.011	0.039	0.000	0.000	3.069
1989	0.251	2.798	1.046	0.161	0.507	0.055	0.015	0.007	0.000	0.000	0.000	4.841
1990	0.157	0.364	1.624	1.814	0.412	0.286	0.069	0.022	0.011	0.000	0.022	4.781
1991	0.041	0.408	0.175	0.274	0.031	0.029	0.000	0.000	0.000	0.000	0.000	0.957
1992	0.035	0.412	0.949	0.174	0.100	0.044	0.010	0.000	0.000	0.000	0.000	1.724
1993	0.178	0.970	0.532	0.383	0.017	0.025	0.022	0.000	0.000	0.022	0.000	2.149
1994	0.067	0.406	0.664	0.433	0.153	0.068	0.021	0.000	0.006	0.000	0.000	1.819
1995	0.160	0.245	1.811	1.249	0.087	0.054	0.011	0.000	0.000	0.000	0.000	3.616
1996	0.022	0.240	0.196	0.414	0.143	0.060	0.027	0.000	0.000	0.000	0.000	1.101
1997	0.006	0.236	0.321	0.109	0.129	0.049	0.009	0.007	0.000	0.000	0.000	0.867
1998	0.070	0.336	1.026	0.352	0.041	0.035	0.004	0.000	0.004	0.000	0.000	1.867
1999	0.070	0.140	0.154	0.310	0.255	0.087	0.000	0.000	0.000	0.000	0.000	1.016
2000	0.020	0.571	0.538	0.071	0.079	0.031	0.000	0.000	0.000	0.000	0.000	1.308
2001	0.028	0.047	0.381	0.459	0.059	0.055	0.008	0.008	0.000	0.000	0.000	1.045

Table A3b. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian spring bottom trawl survey on Georges Bank, 1986 - 2002.

					AGE						
Year	1	2	3	4	5	6	7	8	9	10+	0+
SPRING											
1986	0.60	2.27	2.81	0.37	0.65	0.44	0.26	0.04	0.07	0.03	7.54
1987	0.25	2.13	0.93	1.09	0.34	0.12	0.22	0.08	0.03	0.07	5.26
1988	0.28	1.01	4.66	0.58	1.02	0.13	0.08	0.17	0.04	0.07	8.04
1989	1.63	2.78	1.38	2.85	0.36	0.42	0.05	0.10	0.12	0.06	9.75
1990	0.42	2.44	3.78	2.08	3.87	0.42	0.93	0.12	0.12	0.35	14.53
1991	1.18	1.16	1.84	2.15	1.05	1.31	0.16	0.22	0.03	0.09	9.19
1992	0.11	2.86	1.77	0.80	0.98	0.60	0.43	0.12	0.07	0.02	7.76
*1993	0.05	0.60	2.83	1.04	0.62	1.23	0.44	0.42	0.07	0.12	7.42
*1994	0.02	0.80	0.89	1.65	0.60	0.23	0.45	0.11	0.15	0.04	4.94
1995	0.07	0.67	1.50	0.86	0.60	0.19	0.04	0.05	0.02	0.02	4.02
1996	0.14	0.49	2.31	4.02	1.09	0.79	0.33	0.08	0.11	0.03	9.39
1997	0.32	0.53	0.55	1.25	1.23	0.27	0.06	0.03	0.02	0.01	4.27
1998	0.01	0.67	0.95	0.35	0.35	0.28	0.07	0.02	0.00	0.02	2.72
1999	0.33	0.32	1.49	1.09	0.41	0.26	0.15	0.01	0.02	0.01	4.09
2000	0.10	0.44	1.05	3.92	1.71	0.78	0.40	0.24	0.01	0.03	8.68
2001	0.00	0.06	0.64	0.42	1.11	0.52	0.26	0.17	0.16	0.06	3.40
2002	0.01	0.09	0.57	2.05	0.68	1.22	0.40	0.17	0.05	0.08	5.32
											6.84

* indices not included in VPA calibration

Table A4. USA and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 2001.

	USA				Canada			
	Length Samples		Age Samples		Length Samples		Age Samples	
Year	No.	# Fish Measured	No.	# Fish Aged	No.	# Fish Measured	No.	# Fish Aged
1978	88	6841	76	1463	29	7684	29	1308
1979	80	6973	79	1647	13	3991	12	656
1980	69	4990	67	1119	10	2784	10	536
1981	57	4304	57	1231	17	4147	16	842
1982	151	11970	147	2579	17	4756	8	858
1983	146	12544	138	2945	15	3822	14	604
1984	100	8721	100	2431	7	1889	7	385
1985	100	8366	100	2321	29	7644	20	1062
1986	94	7515	94	2222	19	5745	19	888
1987	80	6395	79	1704	33	9477	33	1288
1988	76	6483	76	1576	40	11709	40	1984
1989	66	5547	66	1350	32	8716	32	1561
1990	83	7158	83	1700	40	9901	40	2012
1991	88	7708	88	1865	45	10873	45	1782
1992	77	6549	77	1631	48	10878	48	1906
1993	82	6636	82	1598	51	12158	51	2146
1994	58	4688	54	1064	104	25845	101	1268
1995	40	2879	40	778	36	11598	36	548
1996	55	4600	54	1080	129	26663	129	879
1997	80	6638	80	1581	118	31882	38	1244
1998	80	7076	81	1545	139	26549	139	1720
1999	68	5987	67	1503	84	24954	84	918
2000	155	12219	154	2951	107	20782	107	1436
2001	108	8389	108	2389	108	18190	108	1509

Table A5. USA sampling of commercial Atlantic cod landings, by market category, for the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 2001.

	Number of Samples, by Market Category & Quarter															Annual Sampling Intensity			
	Scrod					Market					Large					No. of Tons Landed/Sample			
Year	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Scrd	Mkt	Lge	∑
1978	17	15	6	3	41	9	12	13	9	43	1	0	1	2	4	69	374	1922	302
1979	2	5	14	8	29	6	19	11	8	44	2	0	4	1	7	88	407	1742	408
1980	7	10	13	4	34	12	14	5	1	32	3	0	0	0	3	136	588	5546	580
1981	4	10	11	3	28	6	9	10	2	27	2	0	0	0	2	149	634	6283	594
1982	5	9	32	9	55	6	20	27	13	66	8	8	9	5	30	156	279	410	260
1983	4	12	17	10	43	12	19	22	14	67	2	15	16	3	36	185	291	259	252
1984	6	8	8	7	29	8	15	8	11	42	18	5	3	3	29	138	441	358	329
1985	6	7	16	5	34	11	11	12	8	42	4	8	7	5	24	201	299	310	268
1986	6	7	7	6	26	8	10	10	11	39	6	5	10	8	29	142	215	186	186
1987	7	8	6	8	29	6	8	9	10	33	6	6	4	2	18	240	220	267	238
1988	8	6	7	5	26	13	7	9	9	38	4	4	3	1	12	283	331	532	346
1989	2	7	9	9	27	7	8	8	7	30	3	4	1	1	9	210	450	660	380
1990	8	9	10	4	31	10	13	9	8	40	4	4	4	0	12	295	315	538	340
1991	6	11	7	5	29	12	13	8	8	41	4	6	3	5	18	158	293	423	275
1992	6	7	7	10	30	8	10	6	9	33	5	5	3	1	14	149	215	377	219
1993	5	16	7	6	34	10	10	7	9	36	6	1	3	2	12	126	173	339	178
1994	3	9	8	2	22	5	11	7	4	27	1	4	3	1	9	92	187	290	167
1995	2	3	13	2	20	2	4	10	2	18	0	1	0	1	2	83	181	880	167
1996	6	2	12	3	23	5	6	11	6	28	0	2	1	1	4	59	143	400	127
1997	3	11	3	10	27	5	16	9	9	39	3	6	0	5	14	50	105	148	94
1998	3	7	23	5	38	10	10	15	3	38	1	2	1	0	3	44	92	573	88
1999	5	3	10	1	21	7	13	10	5	38	2	4	2	0	9	80	118	205	118
2000	22	20	16	27	85	19	14	13	18	64	2	1	2	2	7	18	71	219	49
2001	11	9	13	3	36	9	10	8	10	37	6	12	6	10	34	72	163	55	98

Table A6. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2000.

	Age											% of Total Landings	
Year	1	2	3	4	5	6	7	8	9	10+	Total	USA	Canada
					Total Commercial Landings in Numbers (000's) at Age								
1978	2	393	7748	2303	830	131	345	47	40	15	11854	73.7	26.3
1979	34	1989	900	4870	1212	458	77	253	4	48	9845	81.2	18.8
1980	89	3777	5828	500	2308	1076	445	87	167	10	14287	80.9	19.1
1981	27	3205	4221	2464	235	1406	417	123	130	62	12290	84.1	15.9
1982	331	9138	3824	2787	2000	281	673	213	71	83	19401	74.1	25.9
1983	108	4286	8063	2456	1055	776	95	235	100	65	17239	72.2	27.8
1984	81	1307	3423	3336	840	516	458	44	171	121	10297	89.0	11.0
1985	134	6426	2443	1368	1885	412	218	203	21	97	13207	68.4	31.6
1986	156	1326	4573	797	480	627	87	72	47	29	8194	71.7	28.3
1987	26	7473	1406	2121	279	252	270	63	38	24	11952	64.2	35.8
1988	10	1577	8022	1012	1497	244	161	197	50	47	12817	71.6	28.4
1989	-	2088	2922	4155	331	541	82	43	50	18	10230	81.1	18.9
1990	7	4942	5042	1882	2264	229	245	36	17	38	14702	74.3	25.7
1991	52	1525	3243	3281	1458	1088	126	70	23	23	10889	67.7	32.3
1992	70	4177	2170	1038	1482	404	309	34	33	10	9727	58.7	41.3
1993	4	1033	4246	1115	440	472	159	143	32	17	7661	67.0	33.0
1994	2	398	1526	1825	394	96	137	46	38	6	4468	68.5	31.5
1995	0.1	392	1058	692	290	44	26	15	2	1	2520	86.9	13.1
1996	0.7	207	903	1234	241	123	15	3	5	0.2	2731	80.0	20.0
1997	3	517	639	881	794	131	84	16	9	4	3078	74.2	25.8
1998	0.2	739	1188	423	324	237	39	14	6	4	2975	81.9	18.1
1999	2	285	1927	706	201	97	119	16	2	3	3359	83.7	16.3
2000	6	811	710	1024	306	72	38	25	2	1	2994	84.5	15.5
2001	-	682	2381	647	595	163	46	22	11	2	4548	86.6	13.4
					Total Commercial Landings in Weight (Tons) at Age								
1978	1	515	18890	7990	3597	757	2549	395	465	198	35357	75.2	24.8
1979	30	2970	1936	20504	5923	3288	711	2611	44	606	38623	84.5	15.5
1980	75	5516	14382	1833	13036	7184	3735	793	1408	154	48116	83.2	16.8
1981	24	4789	9953	8416	1224	10156	3575	1212	1848	1151	42348	79.9	20.1
1982	253	12812	10187	10681	10705	1827	6303	2110	891	1388	57157	68.8	31.2
1983	105	6387	19167	8126	4891	4963	763	2418	1120	946	48886	75.2	24.8
1984	85	2137	8389	12074	4271	3401	4078	447	1938	1858	38678	85.1	14.9
1985	121	9111	5095	5319	9588	2644	1765	2073	246	1309	37271	72.0	28.0
1986	145	1955	11189	2917	2692	4505	776	717	596	409	25901	67.5	32.5
1987	19	11071	3509	8882	1619	1945	2416	633	426	360	30880	61.6	38.4
1988	8	2399	18923	3552	8085	1618	1412	1960	566	719	39242	67.0	33.0
1989	-	3375	6633	15673	1783	3625	669	455	588	298	33098	75.8	24.2
1990	5	7709	12412	6629	11075	1448	2069	382	222	552	42503	66.3	33.7
1991	59	2481	8265	11221	6955	6411	933	736	223	346	37630	64.2	35.8
1992	80	6441	5348	3991	6971	2486	2322	334	402	192	28567	59.0	41.0
1993	3	1585	9566	3717	2184	3012	1195	1315	316	220	23113	63.1	36.9
1994	2	581	3308	6673	1892	716	1095	430	364	103	15165	65.2	34.8
1995	0.1	577	2215	2649	1595	327	273	174	20	20	7851	86.1	13.9
1996	0.6	311	2199	4178	1183	817	127	21	59	2	8898	78.9	21.1
1997	3	816	1483	3114	3256	790	674	135	111	53	10435	72.2	27.8
1998	0.1	1096	2735	1477	1532	1408	323	117	82	61	8832	78.8	21.2
1999	1	446	4283	2437	985	622	874	159	27	45	9880	81.6	18.4
2000	6	1386	1731	3644	1478	424	283	213	14	9	9189	82.9	17.1
2001	-	1034	5627	2038	2582	899	283	180	110	20	12772	83.3	16.7

Table A6 continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2001.

Total Commercial Landings Mean Weight (kg) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10+	Mean
1978	0.707	1.310	2.461	3.469	4.336	5.787	7.374	8.492	11.785	13.200	2.983
1979	0.889	1.494	2.149	4.211	4.888	7.178	9.183	10.313	11.699	12.625	3.923
1980	0.836	1.460	2.468	3.668	5.647	6.676	8.390	9.089	8.432	15.400	3.368
1981	0.882	1.495	2.358	3.415	5.213	7.222	8.565	9.888	14.170	18.565	3.446
1982	0.765	1.402	2.664	3.834	5.352	6.511	9.363	9.897	12.503	16.723	2.946
1983	0.971	1.490	2.377	3.309	4.637	6.393	7.964	10.286	11.227	14.554	2.836
1984	1.053	1.635	2.451	3.619	5.083	6.582	8.909	10.104	11.303	15.356	3.756
1985	0.907	1.418	2.086	3.887	5.087	6.412	8.097	10.236	11.418	13.494	2.822
1986	0.929	1.475	2.447	3.660	5.603	7.191	8.915	9.955	12.687	14.104	3.161
1987	0.726	1.481	2.495	4.187	5.810	7.726	8.949	10.013	11.414	15.000	2.584
1988	0.786	1.520	2.359	3.511	5.401	6.647	8.776	9.987	11.143	15.298	3.062
1989	-	1.617	2.269	3.772	5.396	6.694	8.222	10.718	11.665	17.111	3.235
1990	0.831	1.560	2.462	3.522	4.892	6.333	8.456	10.648	12.580	14.526	2.891
1991	1.114	1.627	2.548	3.420	4.769	5.891	7.410	10.520	9.686	15.373	3.456
1992	1.148	1.542	2.464	3.843	4.704	6.156	7.509	9.846	12.059	19.025	2.937
1993	0.872	1.534	2.253	3.333	4.967	6.379	7.510	9.217	9.699	13.236	3.017
1994	0.906	1.459	2.168	3.657	4.804	7.432	8.013	9.368	9.698	16.659	3.394
1995	0.906	1.471	2.095	3.830	5.492	7.384	10.715	11.617	10.383	14.953	3.087
1996	0.882	1.507	2.435	3.387	4.912	6.622	8.369	8.438	12.883	12.002	3.212
1997	0.954	1.577	2.321	3.532	4.103	6.019	8.050	8.631	11.870	12.795	3.390
1998	0.579	1.483	2.302	3.497	4.735	5.934	8.185	8.610	12.684	14.606	2.969
1999	0.830	1.565	2.223	3.452	4.891	6.422	7.341	9.685	12.153	13.735	2.941
2000	1.055	1.710	2.437	3.558	4.836	5.923	7.406	8.498	8.267	10.594	3.069
2001	0.880	1.517	2.363	3.152	4.337	5.510	6.217	8.230	9.818	12.477	2.808
1978-2000	0.888	1.514	2.361	3.634	5.028	6.589	8.338	9.747	11.365	14.434	
1996-2000	0.879	1.565	2.346	3.487	4.712	6.191	7.890	8.797	11.570	12.735	

Total Commercial Landings Mean Length (cm) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10+	Mean
1978	39.5	50.0	60.8	67.9	72.7	80.4	80.2	93.1	103.4	106.5	64.1
1979	44.7	52.2	57.7	73.2	76.8	87.5	95.3	99.5	103.4	106.4	69.6
1980	43.8	51.8	61.2	69.7	80.9	86.0	92.4	93.8	92.4	114.6	65.6
1981	44.4	52.2	60.2	68.4	78.2	88.0	93.5	97.5	110.3	119.5	65.6
1982	42.2	51.2	62.4	70.5	79.1	84.3	96.0	97.4	105.8	115.0	61.9
1983	45.5	52.3	60.4	67.0	75.3	84.4	90.7	99.1	101.9	111.4	62.4
1984	47.2	54.0	61.5	69.8	77.8	85.5	94.4	98.6	102.3	112.8	68.6
1985	44.9	51.1	57.5	71.4	78.0	84.3	91.3	98.8	102.3	108.2	61.1
1986	45.0	51.9	61.1	69.2	80.7	87.7	94.4	98.0	105.9	108.4	64.3
1987	40.7	51.8	61.2	73.0	81.8	90.1	94.5	98.2	102.5	111.2	59.7
1988	40.8	52.8	60.4	68.5	79.5	85.3	93.6	97.7	101.5	111.2	64.1
1989	-	53.8	60.0	70.4	79.2	85.2	91.7	100.3	103.2	113.3	65.7
1990	41.7	53.5	61.0	68.7	76.6	83.2	92.1	100.2	106.0	110.8	62.9
1991	47.7	53.6	62.2	67.7	75.8	80.9	87.8	99.4	95.9	113.9	67.0
1992	46.2	52.4	60.8	70.6	75.1	82.2	87.9	96.0	104.3	116.0	62.4
1993	42.2	52.7	59.6	67.0	76.3	83.6	88.2	95.1	95.9	107.0	63.0
1994	43.1	51.7	58.9	69.6	75.8	88.2	90.7	95.3	95.9	115.8	65.8
1995	43.0	50.6	58.2	70.9	80.5	88.5	100.9	103.8	99.1	113.0	64.6
1996	45.1	52.7	61.2	68.0	76.9	85.5	90.7	91.0	106.9	104.6	66.4
1997	43.7	53.4	60.2	68.8	72.1	82.3	91.2	93.1	104.2	106.5	66.7
1998	37.8	52.4	60.1	68.8	76.0	82.2	91.4	93.1	106.4	111.9	61.7
1999	41.5	53.4	59.6	68.6	76.9	84.1	88.5	96.6	103.4	109.0	64.0
2000	47.3	55.1	61.6	69.6	76.9	82.2	88.6	93.1	92.5	107.9	65.2
2001	43.0	53.1	60.9	66.7	74.0	80.2	83.0	91.6	97.7	102.2	63.4

Table A7. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), mean biomass (mt), spawning stock biomass (mt), and percent mature of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2001.

Stock Numbers (Jan 1) in thousands

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	27711	23512	20109	41393	17470	9614	27389	8671	42749	16376	23445	15674	9196	17857	6619	8175	5335	3940	6884	10464	4307	10259	4969	1556	1651
2	4270	22686	19219	16383	33865	14004	7774	22351	6978	34859	13384	19186	12833	7523	14573	5356	6690	4366	3226	5636	8565	3526	8398	4063	1274
3	25527	3140	16774	12318	10513	19458	7587	5182	12485	4513	21778	9531	13819	6035	4779	8152	3450	5117	3220	2454	4146	6344	2629	6142	2709
4	7933	13889	1756	8460	6266	5148	8635	3115	2032	6084	2423	10572	5159	6752	2006	1949	2832	1444	3232	1819	1431	2320	3450	1510	2874
5	2877	4411	6965	986	4697	2608	1992	4051	1312	943	3062	1068	4896	2521	2559	703	587	667	556	1530	692	789	1260	1898	651
6	1127	1604	2515	3614	594	2036	1181	871	1611	640	519	1152	575	1960	745	754	178	124	284	237	534	273	464	755	1016
7	1414	804	899	1085	1687	232	965	500	340	752	296	204	454	263	620	244	191	59	62	121	76	223	136	315	471
8	67	846	588	334	511	772	104	375	212	200	371	97	93	150	102	228	56	32	25	37	23	27	75	77	216
9	147	12	463	403	162	226	419	46	124	108	107	126	40	44	60	52	57	4	13	17	16	6	7	39	43
10+	55	148	27	191	187	145	293	208	76	68	99	45	89	43	18	27	9	2	1	1	10	9	4	7	25
1 +	71127	71052	69317	85166	75953	54244	56341	45370	67920	64543	65484	57655	47154	43147	32080	25642	19384	15755	17501	22317	19800	23776	21392	16361	10931

Fishing Mortality

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0.02	0.01	0	0.02	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0
2	0.11	0.1	0.24	0.24	0.35	0.41	0.21	0.38	0.24	0.27	0.14	0.13	0.55	0.25	0.38	0.24	0.07	0.1	0.07	0.11	0.1	0.09	0.11	0.21
3	0.41	0.38	0.48	0.48	0.51	0.61	0.69	0.74	0.52	0.42	0.52	0.41	0.52	0.9	0.7	0.86	0.67	0.26	0.37	0.34	0.38	0.41	0.35	0.56
4	0.39	0.49	0.38	0.39	0.68	0.75	0.56	0.66	0.57	0.49	0.62	0.57	0.52	0.77	0.85	1	1.25	0.75	0.55	0.77	0.4	0.41	0.4	0.64
5	0.38	0.36	0.46	0.31	0.64	0.59	0.63	0.72	0.52	0.4	0.78	0.42	0.72	1.02	1.02	1.18	1.35	0.65	0.65	0.85	0.73	0.33	0.31	0.43
6	0.14	0.38	0.64	0.56	0.74	0.55	0.66	0.74	0.56	0.57	0.73	0.73	0.58	0.95	0.91	1.18	0.91	0.5	0.65	0.94	0.67	0.5	0.19	0.27
7	0.31	0.11	0.79	0.55	0.58	0.6	0.74	0.66	0.33	0.51	0.92	0.59	0.91	0.75	0.8	1.27	1.58	0.67	0.31	1.45	0.84	0.89	0.37	0.18
8	1.49	0.4	0.18	0.52	0.62	0.41	0.63	0.91	0.47	0.43	0.88	0.68	0.56	0.72	0.46	1.18	2.37	0.73	0.15	0.65	1.1	1.09	0.46	0.38
9	0.36	0.44	0.51	0.44	0.66	0.67	0.6	0.71	0.54	0.49	0.73	0.58	0.63	0.87	0.95	1.12	1.31	0.72	0.57	0.85	0.54	0.43	0.36	0.38
10+	0.36	0.44	0.51	0.44	0.66	0.67	0.6	0.71	0.54	0.49	0.73	0.58	0.63	0.87	0.95	1.12	1.31	0.72	0.57	0.85	0.54	0.43	0.36	0.38
mn4-8,u	0.542	0.348	0.49	0.466	0.652	0.58	0.644	0.738	0.49	0.48	0.786	0.598	0.658	0.842	0.808	1.162	1.492	0.66	0.462	0.932	0.748	0.644	0.346	0.38

Table A7 continued. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), mean biomass (mt), spawning stock biomass (mt), and percent mature of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2001.

Mean biomass (mt)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	17756	18930	15201	33078	11990	8411	26099	7069	35925	10766	16698	11493	6923	18001	6848	6460	4380	3235	5503	9047	2260	7717	4749	1241
2	4816	29255	22650	19782	36452	15600	10449	24024	8343	41183	17250	26448	14056	9839	17044	6647	8562	5536	4253	7653	10972	4782	12331	5068
3	47057	5118	29978	21112	20017	31666	12313	7019	21789	8384	36579	16162	24293	9321	7775	11337	4993	8595	5973	4402	7240	10561	4918	10168
4	20817	42243	4894	21839	16000	10999	21920	8106	5191	18429	5806	27812	12975	14781	4777	3783	5477	3563	7708	4119	3770	5995	9241	3217
5	9449	16495	28841	4033	17037	8352	6888	13463	5247	4126	10555	4295	15689	6947	6950	1899	1431	2464	1838	3882	2135	2993	4770	6120
6	5533	8742	11357	18264	2510	9170	5214	3621	8109	3448	2245	5019	2527	6859	2764	2614	799	660	1266	851	2112	1265	2277	3316
7	8154	6341	4785	6532	10957	1273	5563	2718	2353	4828	1564	1164	2322	1259	2944	961	713	420	405	478	384	995	769	1630
8	275	6555	4453	2347	3458	5943	717	2321	1538	1486	2266	691	696	1030	732	1141	189	243	175	216	112	145	464	482
9	1326	107	2801	4217	1355	1693	3264	341	1107	894	774	1020	345	260	427	282	287	29	114	128	142	58	46	287
10+	553	1376	303	2611	2091	1408	3101	1838	751	735	985	532	880	406	201	201	76	21	4	11	108	97	30	66
Total	115735	135163	125262	133816	121866	94514	95527	70520	90352	94279	94721	94636	80706	68704	50461	35323	26906	24767	27239	30784	29235	34605	39593	31595

SSB at the start of the spawning season - males and females (mt)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	912	1104	850	1962	1200	902	3122	773	8515	2226	3479	2475	634	1962	761	639	73	54	88	1006	191	746	127	28
2	1411	7540	6911	5784	16138	6347	4303	11650	5030	25330	8897	13716	6608	4218	9018	3434	2814	1868	1404	3598	5521	1822	4177	2114
3	33839	3730	22412	15924	15649	26065	10500	6878	18776	7101	32836	14539	22020	9014	7415	11466	5170	7871	5264	3858	6596	9575	4447	10333
4	20179	38255	4300	21375	15792	12655	21656	8075	4841	17022	6131	27183	12814	16502	5219	4528	6388	3549	7601	4541	3691	5907	8782	3637
5	8796	16541	30441	3962	17468	9635	7117	14908	5434	3936	12372	4192	18056	8431	8374	2444	1813	2594	2092	4785	2425	2985	4728	6718
6	4892	8127	12487	20324	2961	10514	5653	4251	8583	3704	2763	5933	2950	8685	3351	3286	898	658	1486	1066	2277	1342	2340	3602
7	8094	5563	5914	7240	12174	1464	6221	3163	2355	5363	2023	1326	2841	1539	3492	1299	1012	453	446	672	446	1225	854	1793
8	366	6672	5047	2693	4108	6842	815	2980	1702	1701	2931	811	769	1213	777	1508	307	265	220	273	156	191	528	546
9	1339	111	3841	4111	1557	2059	3957	420	1245	1030	965	1192	408	372	554	411	422	36	136	146	147	59	60	320
10+	657	1674	376	3178	2704	1825	3942	2407	941	907	1296	673	1126	554	279	290	115	27	5	15	135	117	35	79
Total	80484	89318	92581	86551	89751	78309	67286	55506	57423	68318	73693	72041	68226	52488	39239	29305	19012	17375	18744	19961	21585	23970	26078	29170

Percent Mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	7	7	7	7	13	13	13	13	28	28	28	28	12	12	12	12	2	2	2	13	13	13	3	3
2	34	34	34	34	47	47	47	47	67	67	67	67	52	52	52	52	39	39	39	57	57	57	44	44
3	78	78	78	78	84	84	84	84	91	91	91	91	90	90	90	90	95	95	95	92	92	92	95	95
4	96	96	96	96	97	97	97	97	98	98	98	98	99	99	99	99	100	100	100	100	100	100	100	100
5-10+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table A8. Input parameters and results of stochastic projection analysis using a Beverton-Holt stock recruit model for Georges Bank Atlantic cod for 2002-2019 for F2002 =0.85 F2001.

Input for Projections:

Age	Fishing Mortality(PR)	% Mature	Average Weight Stock	Average Weight Landed
1	0.00	0.03	0.677	0.884
2	0.15	0.44	1.151	1.515
3	0.60	0.95	1.887	2.361
4	1.00	1.00	2.920	3.614
5	1.00	1.00	4.232	4.996
6	1.00	1.00	5.693	6.543
7	1.00	1.00	7.332	8.245
8	1.00	1.00	8.914	9.679
9	1.00	1.00	10.432	11.301
10+	1.00	1.00	15.231	14.642

Projection results for 2002-2004

Year	Recruitment (000 fish)	F	Median Landings (000 mt)	Median SSB (000 mt)
F2002= 0.85 F2001				
2002	7295	0.32	8.083	27.031
2003	6994	0.15	3.787	25.250
2004	7626	0.15	3.979	28.781

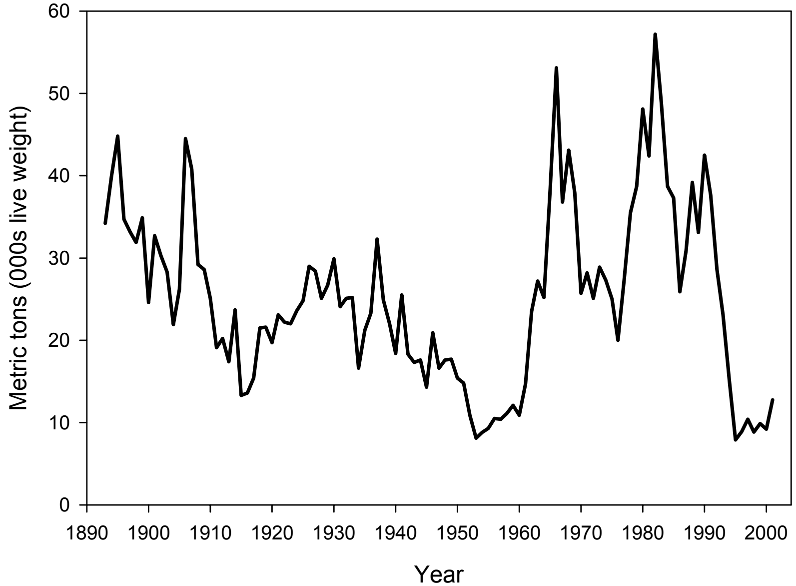


Figure A1a. Total commercial landings of Georges Bank cod (NAFO Division 5Z and Subarea 6), 1893-2001.

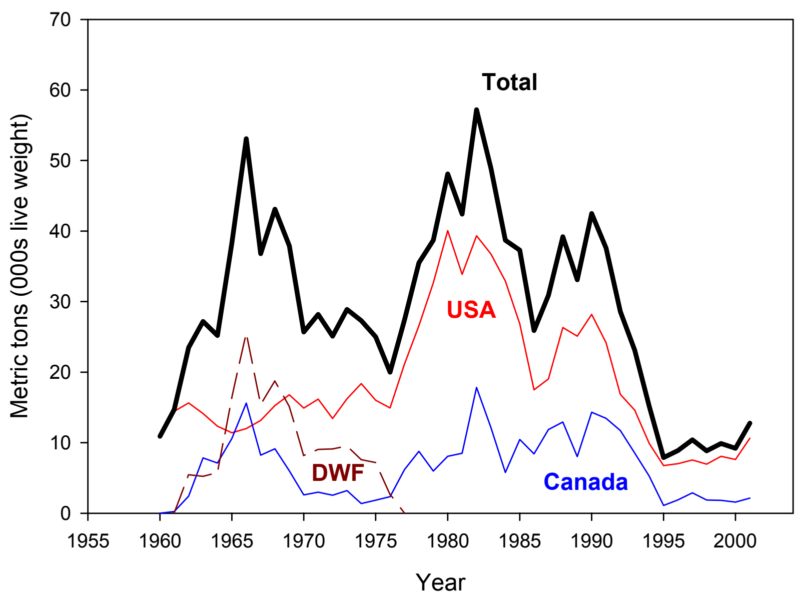


Figure A1b. Total commercial landings of Georges Bank cod (NAFO Division 5Z and Subarea 6), 1960-2001.

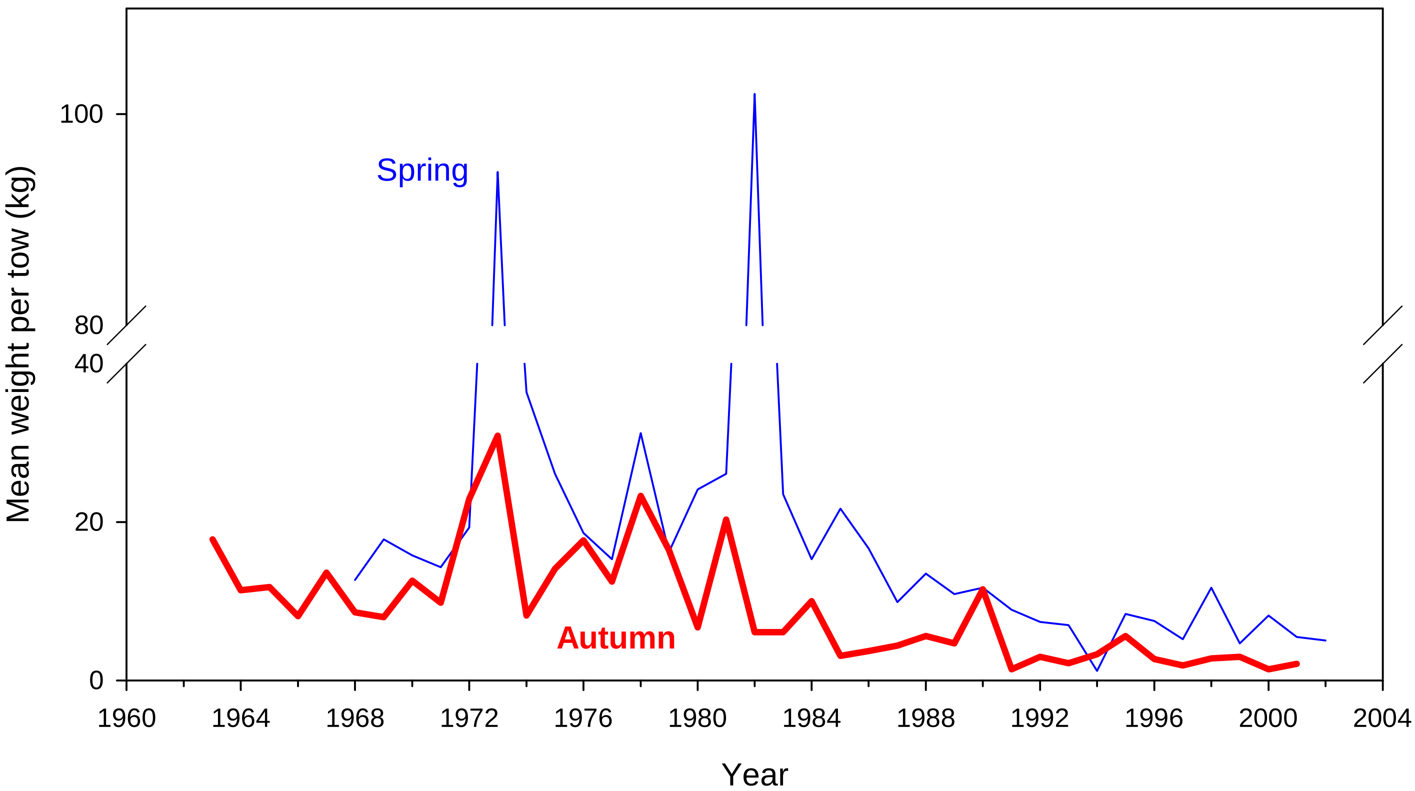


Figure A2. Standardized stratified mean catch per tow (kg) of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963-2001.

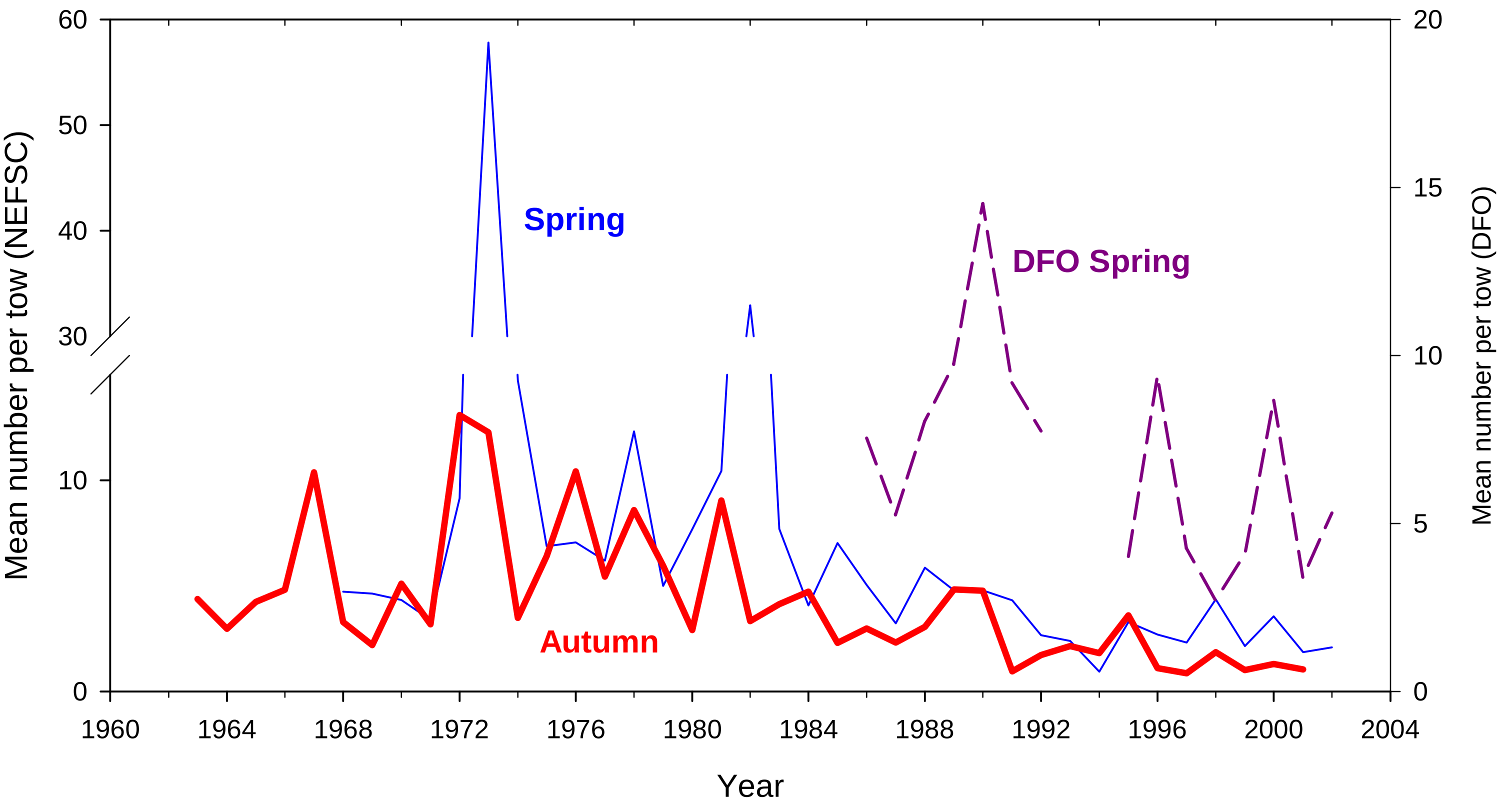


Figure A3. Standardized stratified mean number per tow of Atlantic cod in NEFSC and DFO spring and NEFSC autumn research vessel bottom trawl surveys on Georges Bank, 1963-2002.

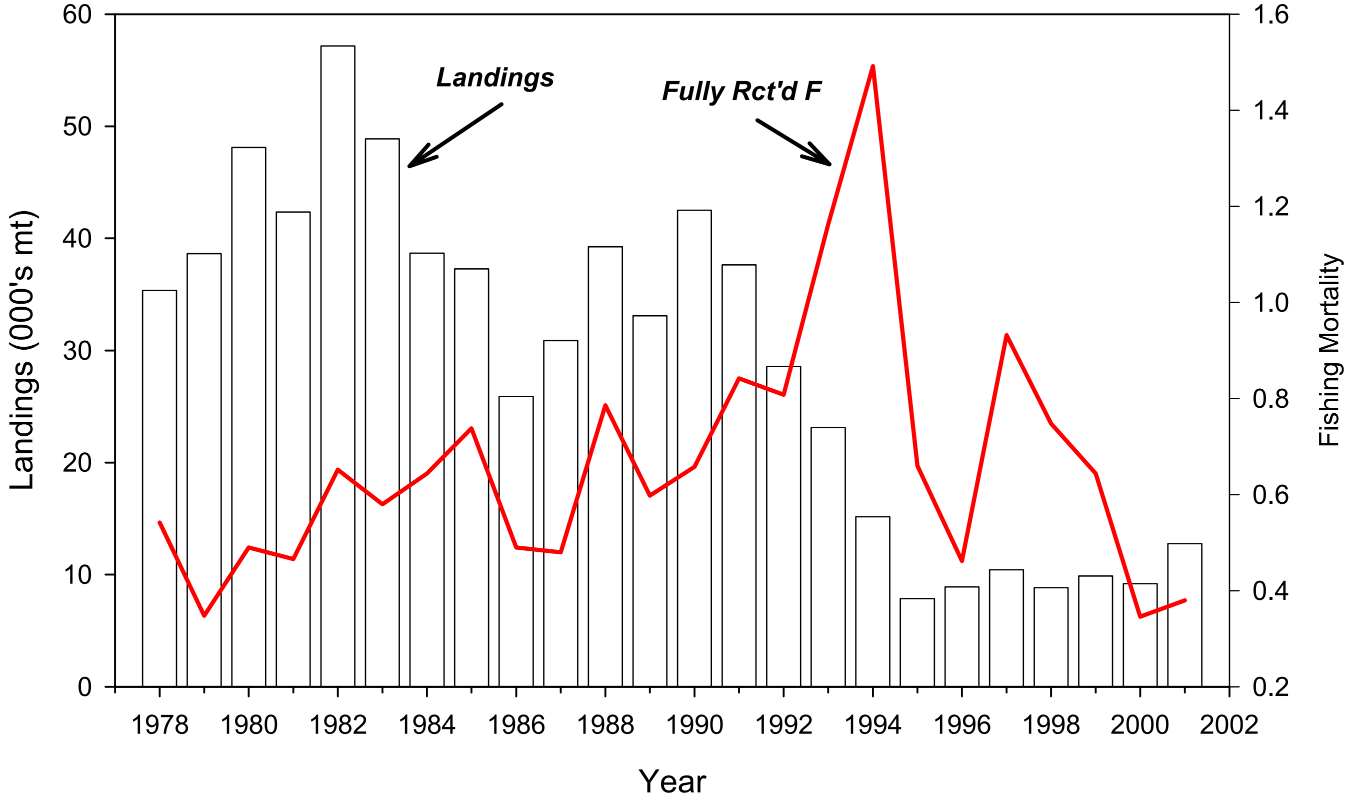


Figure A4. Trends in total commercial landings and fishing mortality for Georges Bank cod, 1978-2001.

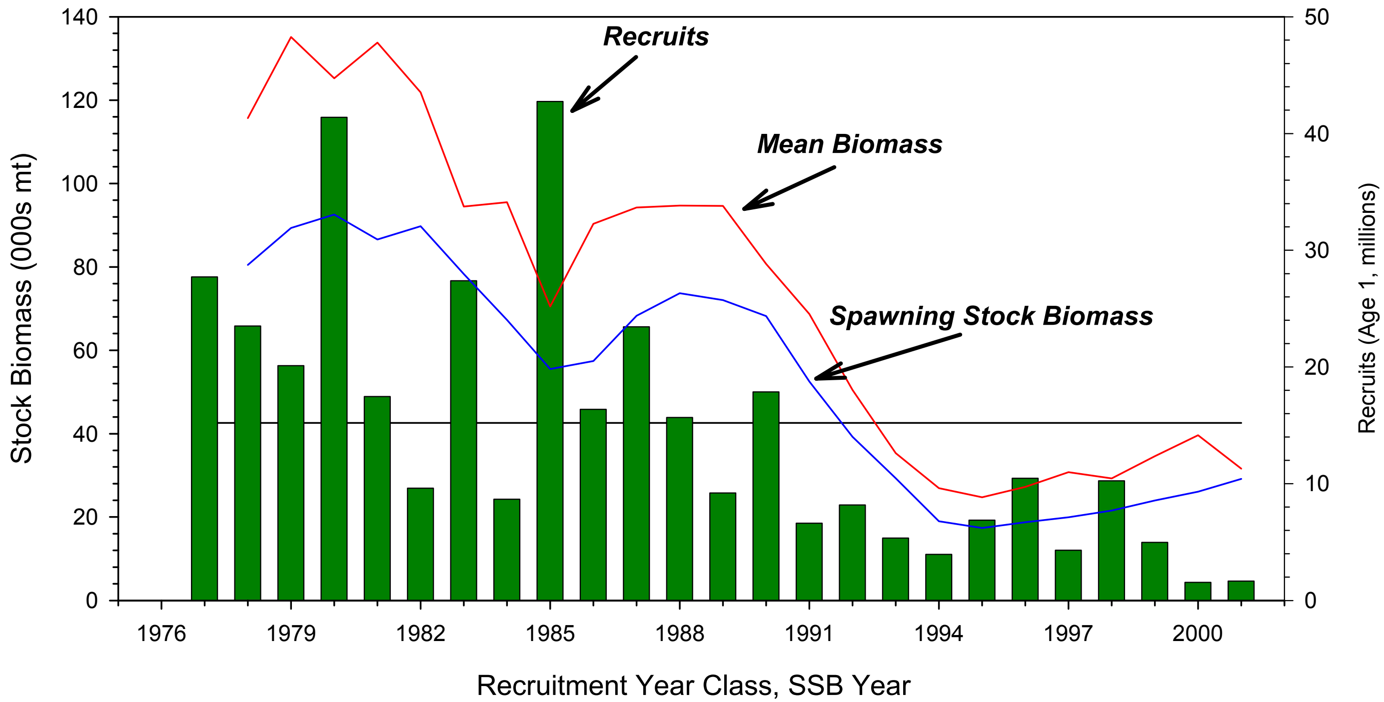


Figure A5. Trends in stock biomass and recruitment for Georges Bank Atlantic cod, 1978-2001. Horizontal line is the average recruitment for the time serioes.

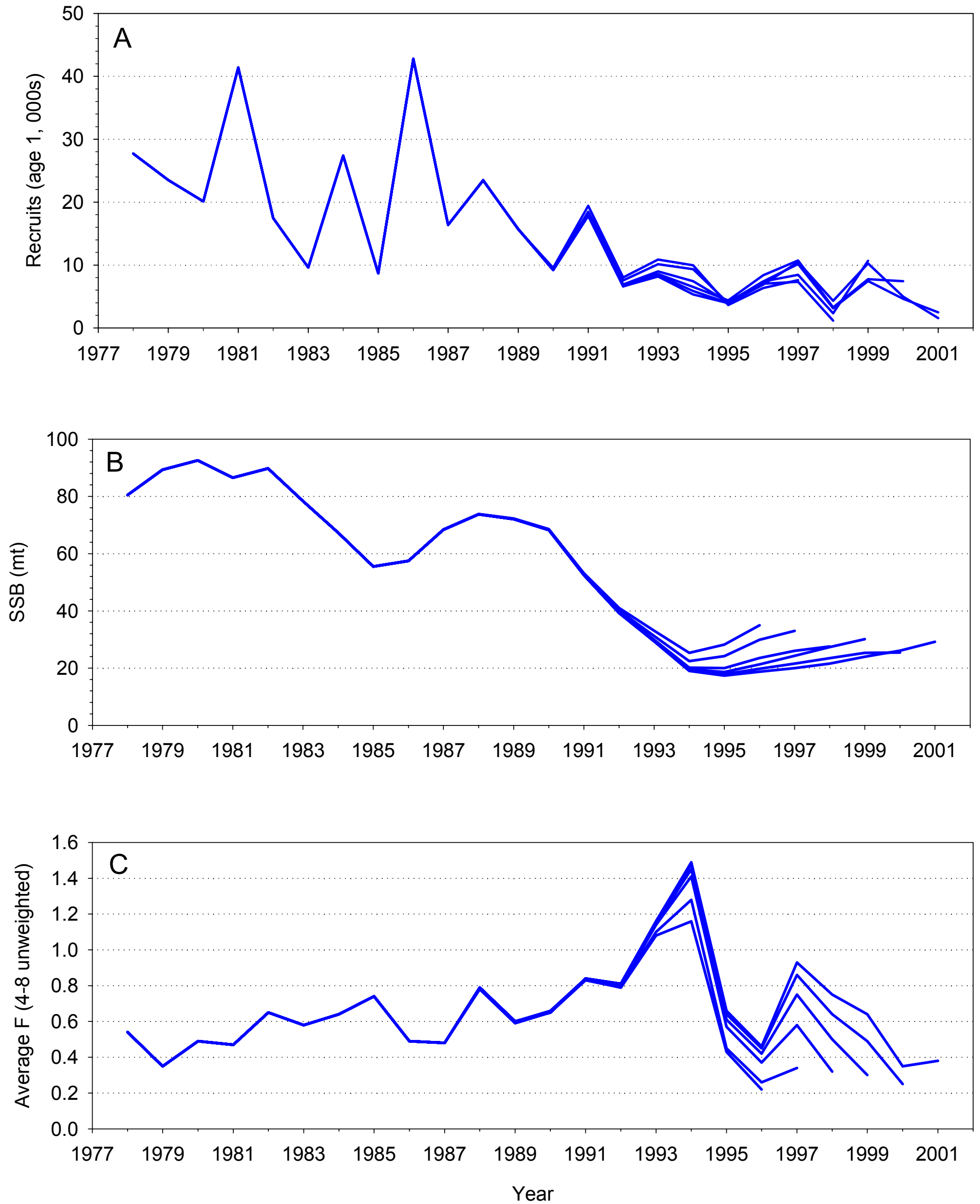


Figure A6. Retrospective analysis of Georges Bank cod recruits at age 1(A), spawning stock biomass (B), and fishing mortality (C) (average F, aged 4-8, unweighted), based on the final ADAPT VPA formulation, 2001-1996.

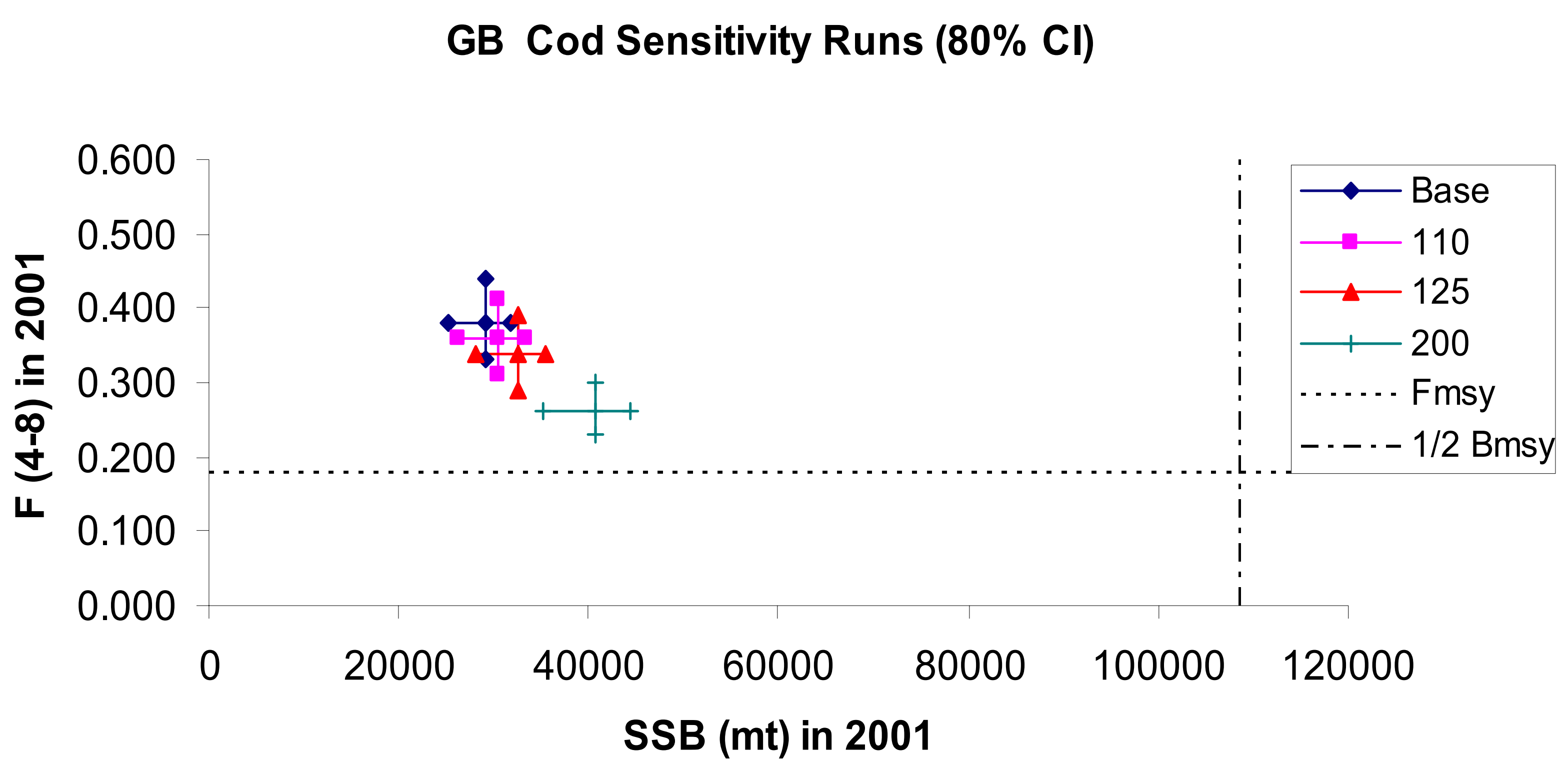


Figure A7. Fishing mortality and spawning stock biomass estimates from VPA calibrated using survey indices increased by 0% (base), 10% (110), 25% (125), and 100 %(200).

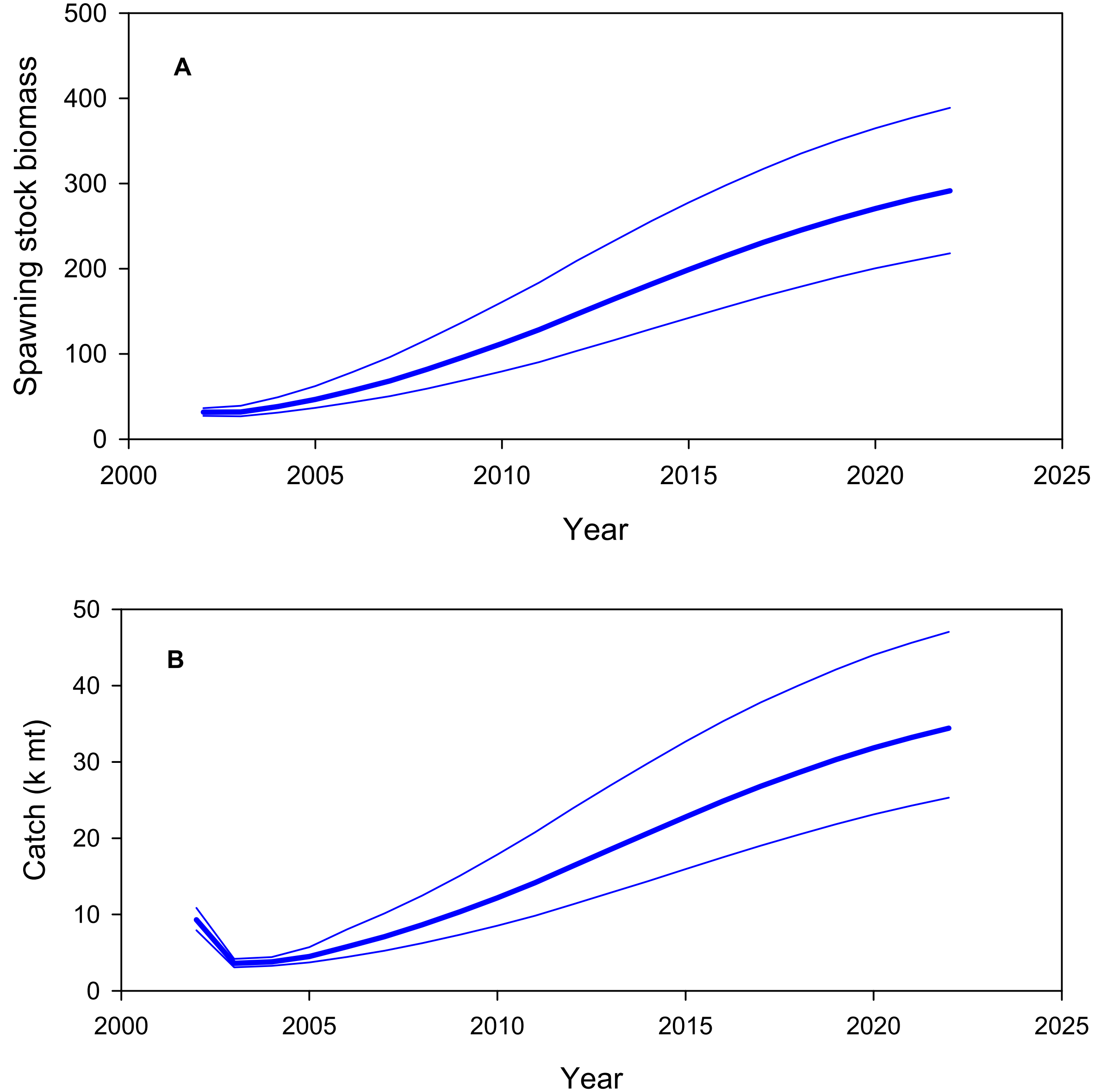


Figure A8. Median and 80% confidence intervals of predicted spawning stock biomass (panel A) and predicted catch (panel B) for Georges Bank Atlantic cod under Frebuild = 0.10.

B. Georges Bank Haddock by **Jon Brodziak, Michele Thompson and Russell Brown**

1.0 Background

The Georges Bank haddock stock was last assessed at the Transboundary Resources Assessment Committee Meeting in 2001. Based on the 2001 assessment, spawning biomass was increasing (59,700 mt in 2000) from a near-record low of 11,400 mt in 1993 and fishing mortality was relatively low (F=0.19 in 2000). In this report, we update the Georges Bank haddock assessment using fishery data for 2001 and available survey data for 2001-2002. Updated estimates of spawning biomass and fishing mortality are used for stock status determination. Sensitivity of assessment results to survey trawl warp marking discrepancies during 2000-2002 is evaluated. An updated estimate of the fishing mortality required to rebuild the spawning biomass to B_{MSY} by 2009 ($F_{REBUILD}$) is provided.

2.0 Assessment for 2002

2.1 2001 Landings

US haddock landings were prorated into Georges Bank and Gulf of Maine stock components using a standard algorithm. US Georges Bank haddock landings totaled 4,637 mt in 2001, a 38% increase over 2000 (Table B1, Figure B1). Canadian landings totaled 6,712 mt in 2001, a 24% increase over 2000. US sea sampling data indicated discard rates of 0-5% in 2001 for primary fishing gears. There were no changes in regulatory measures which might have increased discarding. As a result, discards were assumed to be negligible as in the 2000 and 2001 assessments (Brown and Munroe 2000).

US Commercial fishery sampling increased in 2001 (Table B2) for total number of samples (+41%), fish lengths (+43%), and fish ages (+58%) over 2000 sampling. Commercial fishery sampling on western Georges Bank was adequate to compute US catch-at-age on a quarterly basis (Table B2). Sampling was not adequate on eastern Georges Bank to characterize fishery length compositions due to a lack of large and scrod haddock sampling in the second half of the year (Table B2). US Landings are relatively low on eastern Georges Bank (608 mt in 2001) versus western Georges Bank (4,028 mt in 2001). Fisheries in both areas use otter trawl gear and length selectivity is similar. As a result, US catch-at-age data for eastern Georges Bank was computed on a quarterly basis using the commercial fishery length composition of western Georges Bank landings with the addition of all US length samples from eastern Georges Bank (Table B2). Canadian commercial fishery age-length keys from eastern Georges Bank were used for quarters 2, 3, and 4, while the Canadian spring survey age-length key was used for quarter 1. Canadian commercial fishery length sampling (n=67,905 fish) was over 10-fold greater than US fishery length sampling (n=5,276 fish). Canadian commercial fishery age sampling (n=1,393 fish) was comparable to US fishery length sampling (n=1,985 fish). The US fishery catch-at-age data was combined with the Canadian fishery catch-at-age data to compute total catch at age (Table B3).

2.2 Survey Indices

US spring survey indices were computed for 2001-2002 (Table B4) and US autumn survey indices were computed for 2001 (Table B5) using standardized data. Canadian survey indices for 2001-2002 (Table B6) were provided by DFO, Canada (Stratis Gavaris, personal communication). Canadian survey indices in 2001-2002 were lower than the record high 2000 index which included unusually large catches in stratum 5Z8. Survey maturity-at-age analyses from the 2001 assessment were used for computing spawning biomass.

3.0 Assessment Results

3.1 VPA Results

An updated VPA analysis for Georges Bank haddock was conducted. The VPA formulation was identical to that used for the 2001 assessment, with the exception that the US spring survey was used for tuning in the terminal year. The updated VPA had a total of 30 new survey index values for calibration. VPA diagnostics indicated a good fit to the survey data with maximal coefficients of variation of catchability ranging from 0.14 to 0.34 across surveys.

VPA results indicate that total stock size increased (Table B7) from 80.5 million fish in 2000 to 111.4 million fish in 2002 (+38%). Spawning biomass increased (Table B8, Figure B3) from 59,000 mt in 2000 to 74,400 mt in 2001 (+26%). Fishing mortality (average ages 4-7, unweighted) increased from 0.19 in 2000 to 0.22 in 2001 (+16%; Table B9, Figure B4). Results indicate that the 1998 (39.5 million) and 2000 (75.1) year classes are the strongest since 1978. Preliminary indications are that the 2001 year class may be well below average. Retrospective analysis suggests a random pattern of retrospective estimation errors (Figure B5). Bootstrap analysis indicates that estimates of spawning biomass and F in 2001 are relatively precise with coefficients of variation of 9-10%.

3.2 Sensitivity Analyses

3.2.1 Potential Survey Trawl Warp Inconsistencies during 2000-2002

Measurements of NEFSC survey trawl warps in autumn 2002 suggested that right and left warps may have been offset by up to several feet during winter 2000 through spring 2002 surveys. To evaluate the sensitivity of VPA results to potential undercapture of fish, NEFSC spring and autumn survey indices were arbitrarily adjusted upwards by 10%, 25%, and 100% for spring 2000 through spring 2002 (Figure B6). Results are summarized in Section 5.2 (Summary of Assessment Advice).

3.2.2 Influence of Survey Index Time Series Selection

VPA analysis for Georges Bank haddock includes three survey index time series (US spring, US fall, and Canadian spring). To evaluate sensitivity of baseline results to selection of survey index time series, VPA analyses were conducted using only one index for calibration. Results indicate that the baseline results are closely matched by one-index results for US spring and US fall indices while one-index results for the Canadian spring index produce higher spawning biomass and lower F estimates than the baseline.

4.0 Sources of Uncertainty

- US catch-at-age data for eastern Georges Bank haddock landings are less certain than for western Georges Bank haddock. Improved sampling of US landings from eastern Georges Bank haddock would improve precision of US catch-at-age data.

- Proration of landings are based on preliminary logbook data and are subject to change.

5.0 Summary Stock Status

5.1 Biological Reference Points

For Georges Bank haddock, spawning biomass (B_{MSY}) and the proxy fishing mortality (F_{MSY}) to produce MSY are B_{MSY} = 250,300 mt and F_{MSY} = 0.263 (NEFSC 2002). The overfished threshold ($B_{THRESHOLD}$) for Georges Bank haddock is $B_{THRESHOLD}$ = ½ B_{MSY} = 125,200 mt. The overfishing threshold ($F_{THRESHOLD}$) for Georges Bank haddock is $F_{THRESHOLD}$ = F_{MSY} = 0.26.

5.2 Stock Status in 2001

In 2001, spawning biomass was 74,400 mt (59% of $B_{THRESHOLD}$ and 30% of B_{MSY}). Therefore, the Georges Bank haddock stock was overfished in 2001. In 2001, the fishing mortality was 0.22 (85% of $F_{THRESHOLD}$). Therefore, overfishing was not occurring on the Georges Bank haddock stock in 2001.

5.3 Projections

Age-structured projections were conducted to compute $F_{REBUILD}$ for 2003-2009. A two-stage resampling model using the cumulative distribution function of observed recruitment with a cutoff spawning biomass value of 75,000 mt was updated using recruitment results from the baseline VPA and updated mean weights at age and selectivities based on 1999-2001 averages. The assumed value of fishing mortality in 2002 was $F_{2002} = 0.85*F_{2001} = 0.19$. The assumed 15% reduction in F from 2001 to 2002 is based on environmental impact analyses of the probable impacts of implementing the Settlement Agreement for the Amendment 9 groundfish lawsuit during fishing year 2002.

Projection results indicate that $F_{REBUILD}$ = 0.197 (Table B10, Figure B7). Median projected spawning biomass and landings in 2009 under $F_{REBUILD}$ are 250,300 mt and 38,300 mt. Median projected landings in 2002, 2003, and 2004 are 12,500 , 17,800 , and 19,400 mt, respectively. Average projected landings for fishing years 2002-2003 and 2003-2004 are 15,000 and 18,600 mt.

6.0 References

Brown, R. W., and N. J. Munroe. 2000. Stock assessment of Georges Bank haddock, 1931-1999. Northeast Fisheries Science Center Ref. Doc. 00-12, NEFSC, Woods Hole, MA 02543.

Northeast Fisheries Science Center [NEFSC]. 2002. Final Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NEFSC Reference Document 02-04, Woods Hole, MA, 02543.

Table B1. Commercial landings (mt) of haddock from Georges Bank and south (NAFO Division 5Z and Subarea 6), 1960-2001.[1]

Year	U.S.	Canada	USSR	Spain	Other	Total
1960	40800	77	0	0	0	40877
1961	46384	266	0	0	0	46650
1962	49409	3461	1134	0	0	54004
1963	44150	8379	2317	0	0	54846
1964	46512	11625	5483	2	464	64086
1965	52823	14889	81882	10	758	150362
1966	52918	18292	48409	1111	544	121274
1967	34728	13040	2316	1355	30	51469
1968	25469	9323	1397	3014	1720	40923
1969	16456	3990	65	1201	540	22252
1970	8415	1978	103	782	22	11300
1971	7306	1630	374	1310	242	10862
1972	3869	609	137	1098	20	5733
1973	2777	1563	602	386	3	5331
1974	2396	462	109	764	559	4290
1975	3989	1358	8	61	4	5420
1976	2904	1361	4	46	9	4324
1977	7934	2909	0	0	0	10843
1978	12160	10179	0	0	0	22339
1979	14279	5182	0	0	0	19461
1980	17470	10017	0	0	0	27487
1981	19176	5658	0	0	0	24834
1982	12625	4872	0	0	0	17497
1983	8682	3208	0	0	0	11890
1984	8807	1463	0	0	0	10270
1985	4273	3484	0	0	0	7757
1986	3339	3415	0	0	0	6754
1987	2156	4703	0	0	0	6859
1988	2492	4046[2]	0	0	0	6538
1989	1430	3059	0	0	0	4489
1990	2001	3340	0	0	0	5341
1991	1395	5446	0	0	0	6841
1992	2005	4061	0	0	0	6066
1993	687	3727	0	0	0	4414
1994	218[3]	2411	0	0	0	2629
1995	218[3]	2064	0	0	0	2282
1996	313[3]	3643	0	0	0	3956
1997	888[3]	2622	0	0	0	3510
1998	1841[3]	3371	0	0	0	5212
1999	2775[3]	3680	0	0	0	6455
2000	3366[3]	5402	0	0	0	8768
2001	4637[3]	6712	0	0	0	11349

[1]All landings 1960-1979 are from Clark et al. (1982); U.S. landings 1980-1981 are from Overholtz et al. (1983); U.S. landings 1982-1993 are from NMFS, NEFSC Detailed Weighout Files and Canvas data; Canadian landings 1980-1998 from Gavaris and Van Eeckhaute (1999); Canadian landings in 1999-2001 from S. Gavaris (Personal Communication).
[2]1895 tons were excluded because of suspected misreporting (Gavaris and Van Eeckhaute 1995).
[3]U.S. landings from 1994-1999 are prorated using Vessel Trip Report data and are considered provisional.

Table B2. U.S. sampling of commercial haddock landings for length and age composition from Georges Bank and south (NAFO Division 5Z and Subarea 6), 1982-2001. Eastern Georges (statistical areas 561, 562, 523 and 524), Western Georges (521, 522, 525, 526, 537, 538, 539 and Subarea 6). Q1, Q2, Q3, Q4, denote quarters 1, 2, 3, and 4, respectively.

Number of Samples				Number of Samples by Market Category, Area, and Quarter																				Annual Sampling Intensity: No. of Tons Landed/Sample			
				Scrod										Large										Scrod		Large	
				Eastern Georges					Western Georges					Eastern Georges					Western Georges					East	West	East	West
Year	No.	# Fish Meas.	# Fish Aged	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑				
1982	89	7851	1788	6	7	6	3	22	1	4	15	4	24	3	9	8	4	24	1	4	7	7	19	96	54	172	264
1983	104	8955	2000	3	9	4	4	20	2	5	8	2	17	7	9	6	5	27	2	12	17	5	38	54	35	139	95
1984	57	4762	1142	11	4	2	1	18	0	1	2	3	6	9	7	1	5	22	3	3	2	3	11	56	65	122	299
1985	32	2528	627	7	4	2	0	13	0	1	2	1	4	7	1	1	0	9	1	0	4	1	6	18	136	161	338
1986	30	2276	571	2	3	1	0	6	0	1	2	1	4	4	2	3	2	11	1	2	3	3	9	186	77	98	92
1987	36	2573	837	2	7	0	1	10	0	0	3	1	4	3	4	1	3	11	2	1	6	2	11	51	41	168	52
1988	34	2542	1096	2	4	2	4	12	1	2	2	0	5	5	4	1	4	14	1	1	1	0	3	61	47	69	186
1989	23	1548	856	4	1	1	1	7	0	1	7	1	9	2	2	0	1	5	1	1	0	0	2	50	29	87	189
1990	27	2001	945	5	5	1	2	13	1	1	1	1	4	1	5	0	1	7	2	0	1	0	3	46	77	84	167
1991	32	1065	439	3	3	0	3	9	0	0	7	0	7	0	9	0	3	12	4	0	0	0	4	56	48	35	31
1992	54	2456	922	7	10	5	0	22	3	4	0	0	7	3	8	2	0	11	3	4	5	0	12	46	38	56	9
1993	31	1140	533	3	3	0	0	6	2	3	3	2	10	0	11	0	0	11	0	0	2	2	4	30	27	13	20
1994	8	546	212	0	0	1	0	1	0	1	0	1	2	0	0	1	0	1	2	1	0	1	4	11	46	22	23
1995	3	198	58	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	∞	25	∞	∞
1996	6	524	191	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	3	4	6	30	∞	50
1997	34	3203	848	0	0	0	0	0	0	1	7	3	10	0	1	0	0	1	1	1	7	13	22	∞	22	33	10
1998	24	1692	686	0	0	0	0	0	7	2	1	2	12	1	0	0	0	1	3	3	3	2	11	∞	26	271	111
1999	28	2268	595	0	0	0	0	0	1	0	5	6	12	0	1	1	0	2	4	4	1	5	14	∞	60	131	122
2000	51	3699	1256	1	3	1	4	9	5	2	6	8	21	0	0	1	0	1	7	5	2	6	20	6	37	54	114
2001	72	5276	1985	1	1	1	0	3	6	4	9	6	25	2	3	0	0	5	7	10	13	9	39	99	56	62	67

Table B3. Total catch at age (000's) and mean weight (kg) at age of commercial landings and discards of haddock from Georges Bank and south (NAFO Division 5Z and Statistical Area 6), 1982-2001.

Year	1	2	3	4	5	6	7	8	9+	TOTAL
					Total Commercial Catch in Numbers (000's) at Age					
1963	2910	4047	7418	11152	8198	2205	1405	721	1096	39152
1964	10101	15935	4554	4776	8722	5794	2082	1028	1332	54324
1965	9601	125818	44496	5356	4391	6690	3772	1094	1366	202584
1966	114	6843	100810	19167	2768	2591	2332	1268	867	136760
1967	1150	168	2891	20667	10338	1209	993	917	698	39031
1968	8	2994	709	1921	14519	3499	667	453	842	25612
1969	2	11	1698	448	654	5954	1574	225	570	11136
1970	46	158	16	570	186	214	2308	746	464	4708
1971	1	1375	223	40	289	246	285	1469	928	4856
1972	156	2	450	81	32	120	78	66	1236	2221
1973	2560	2075	3	386	53	30	77	15	447	5646
1974[2]	46	4320[2]	657	2	70	2	2	53	249	5401
1975	192	1034	1864	375	4	42	4	4	88	3607
1976	144	473	550	880	216	0	23	4	112	2402
1977[3]	1	19585[3]	187	680	515	357	4	39	111	21479
1978[4]	1	761	14395[4]	305	567	517	139	14	67	16766
1979	1	26	1726	7169	525	410	315	96	46	10314
1980[5]	8	31000[5]	347	975	6054	594	546	153	81	39758
1981	1	1743	10998	831	937	2572	331	158	94	17665
1982	1	1165	1633	3733	391	569	1119	106	110	8827
1983	0	214	813	690	2239	272	186	800	76	5290
1984	0	93	297	727	397	1482	234	267	543	4041
1985	0	2406	550	194	461	228	526	78	152	4596
1986	6	54	2810	223	146	173	150	266	60	3888
1987	0	1995	129	1613	122	73	89	106	135	4262
1988	4	52	2384	134	931	149	55	64	106	3879
1989	0	1263	86	877	143	358	46	28	45	2846
1990	2	11	1445	172	868	98	177	46	44	2863
1991	6	448	91	2149	102	410	73	154	72	3505
1992	7	247	320	132	1527	111	323	27	94	2788
1993	7	290	350	299	104	659	38	159	76	1980
1994[6]	1.2	268.9	810.4	170.3	65.6	69.3	150.8	43.4	42.7	1623
1995[6]	9.2	89.4	596.5	457.2	59.9	31.5	8.2	56.6	18.0	1327
1996[6]	5.1	53.6	569.6	946.0	463.6	68.2	21.9	5.4	7.9	2141
1997[6]	29.6	174.7	285.3	755.0	547.0	212.1	18.8	15.8	39.6	2078
1998[6]	1.0	198.9	414.6	501.1	691.6	526.0	148.5	21.1	41.0	2544
1999	0.9	39.7	1062.2	582.3	497.8	509.9	335.2	142.8	40.9	3211
2000	0.1	390.3	618.3	1578.2	555.9	494.9	361.1	245.6	85.3	4249
2001	2.1	193.8	2684.2	1128.5	1632.7	883.2	580.2	436.6	345.9	7887

Table B3. Continued.

Total Commercial Landings Mean Weight[1](kg) at Age

Year	1	2	3	4	5	6	7	8	9+
1963	0.57	0.87	1.18	1.47	1.68	2.15	2.35	3.04	3.10
1964	0.50	0.83	1.12	1.43	1.64	2.01	2.40	2.64	2.97
1965	0.58	0.69	1.03	1.35	1.67	1.99	2.26	2.66	3.11
1966	0.58	0.73	0.89	1.26	1.70	2.07	2.28	2.87	3.18
1967	0.66	0.70	0.95	1.18	1.42	2.05	2.31	2.66	3.10
1968	0.59	0.81	1.05	1.32	1.57	2.10	2.32	2.62	2.86
1969	0.52	0.78	1.10	1.69	1.75	1.99	2.52	2.99	3.63
1970	0.71	1.27	1.22	1.93	2.19	2.39	2.58	3.23	3.75
1971	(0.67)	1.03	1.31	1.74	2.39	2.81	2.92	3.10	3.72
1972	0.62	1.03	1.74	2.04	2.42	2.92	3.06	3.44	3.66
1973	0.60	1.03	1.58	2.13	2.41	3.29	3.42	3.86	3.94
1974	0.72	1.06	1.82	2.32	2.83	3.76	4.05	3.92	4.26
1975	0.62	0.98	1.63	2.21	2.20	2.94	4.00	4.05	4.33
1976	0.50	0.99	1.39	1.99	2.66	(3.08)	3.69	4.67	4.94
1977	(0.53)	1.07	1.44	2.17	2.73	3.21	4.15	4.00	4.99
1978	(0.53)	0.94	1.50	2.04	2.79	3.19	3.37	3.61	5.11
1979	(0.53)	1.00	1.28	2.02	2.51	3.14	3.78	3.79	4.87
1980	0.55	0.94	1.21	1.73	2.17	2.82	3.60	3.56	3.87
1981	0.39	0.87	1.24	1.83	2.30	2.72	3.71	4.04	4.44
1982	0.22	0.97	1.45	1.88	2.37	2.76	3.24	3.96	4.09
1983	(0.33)	1.02	1.37	1.83	2.21	2.65	3.25	3.36	4.27
1984	(0.33)	0.92	1.32	1.83	2.20	2.67	2.96	3.41	3.72
1985	(0.33)	0.99	1.39	1.98	2.46	2.72	3.06	3.72	3.80
1986	0.45	0.94	1.36	1.83	2.56	2.83	2.96	3.46	3.78
1987	(0.43)	0.83	1.43	2.00	2.25	2.63	3.02	3.77	4.29
1988	0.42	0.98	1.34	1.68	2.06	2.45	2.97	3.49	3.96
1989	(0.53)	0.89	1.48	1.79	2.21	2.57	3.24	3.56	3.82
1990	0.64	0.97	1.48	1.78	2.12	2.55	2.81	2.99	4.16
1991	0.581	1.201	1.311	1.817	2.183	2.645	2.852	3.048	4.337
1992	0.538	1.175	1.639	1.768	2.186	2.519	2.967	3.365	4.267
1993	0.659	1.169	1.728	2.171	2.119	2.628	2.649	3.123	4.014
1994	0.447	1.093	1.643	2.209	2.628	2.728	2.902	3.783	4.546
1995	0.429	0.967	1.489	2.025	2.542	2.815	3.275	3.091	3.981
1996	0.456	1.098	1.497	1.838	2.325	2.543	3.423	3.516	3.712
1997	0.416	0.998	1.690	1.891	2.213	2.547	3.1.4	3.380	3.655
1998	0.511	0.968	1.485	1.917	2.333	2.688	3.027	3.038	4.070
1999	0.678	1.101	1.527	1.830	2.111	2.339	2.697	2.973	3.682
2000	0.664	1.133	1.464	1.893	2.252	2.372	2.732	2.991	3.298
2001	0.394	1.228	1.465	1.761	2.159	2.527	2.622	2.736	3.395

[1]Data 1963-1979 from Clark et al. (1982); Data 1980-1981 from Overholtz et al. (1983); Data 1982-1990 from Hayes and Buxton (1992); data from 1991-1994 from O'Brien and Brown (1996); data from 1995-2001 from current assessment, Gavaris and Van Eekhaute (1999), and S. Gavaris (personal communication).
[2]Of this total, approximately 1.0 million fish were added to the catch at age to account for high discards in 1974.
[3]Of this total, approximately 12.8 million fish were added to the catch at age to account for high discards in 1977.
[4]Of this total, approximately 5.0 million fish were added to the catch at age to account for high discards in 1978.
[5]Of this total, approximately 20.0 million fish were added to the catch at age to account for high discards in 1980.
[6]Total includes discards resulting from trip limit regulations for most year classes.

Table B4. Stratified mean catch per tow (numbers) for haddock in NEFSC offshore spring research vessel bottom trawl surveys on Georges Bank (Strata 01130-01250, 01290-01300), 1968-2002. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1968	0.40	2.83	0.46	0.70	6.72	1.68	0.25	0.45	0.34	13.83
1969	0.00	0.07	0.58	0.25	0.42	4.23	1.03	0.28	0.46	7.32
1970	0.67	0.25	0.00	0.33	0.46	0.46	2.00	0.98	0.85	6.00
1971	0.00	1.16	0.25	0.00	0.12	0.12	0.09	0.82	0.22	2.78
1972	4.02	0.09	0.61	0.12	0.03	0.04	0.13	0.03	1.30	6.37
1973	30.68	4.84	0.00	0.54	0.09	0.00	0.18	0.01	1.28	37.62
1974	2.13	13.29	2.86	0.00	0.24	0.00	0.01	0.10	0.37	19.00
1975	0.94	0.97	3.32	0.63	0.00	0.13	0.09	0.01	0.15	6.24
1976	80.79	0.30	0.60	0.92	0.43	0.00	0.04	0.00	0.10	83.18
1977	0.61	33.41	0.42	1.22	0.60	0.45	0.00	0.04	0.12	36.87
1978	0.07	0.97	15.93	0.36	0.94	0.82	0.16	0.06	0.10	19.41
1979	36.12	1.58	1.13	5.71	0.33	0.16	0.37	0.06	0.04	45.50
1980	5.20	46.70	0.51	1.04	4.87	0.67	0.37	0.46	0.24	60.06
1981	3.30	3.29	19.49	2.19	0.76	1.78	0.24	0.11	0.05	31.21
1982	0.76	1.53	0.94	4.07	0.42	0.28	0.61	0.00	0.00	8.61
1983	0.43	0.55	0.58	0.22	2.41	0.01	0.04	1.16	0.18	5.58
1984	2.09	1.18	0.64	0.63	0.58	0.72	0.07	0.04	0.30	6.25
1985	0.00	4.96	0.76	0.40	0.87	0.34	1.17	0.10	0.25	8.85
1986	2.49	0.18	2.06	0.24	0.11	0.21	0.12	0.33	0.11	5.85
1987	0.00	3.62	0.06	0.81	0.08	0.10	0.05	0.22	0.01	4.95
1988	1.55	0.04	0.99	0.13	0.32	0.12	0.11	0.12	0.00	3.38
1989	0.02	3.49	0.45	0.71	0.14	0.41	0.06	0.05	0.01	5.34
1990	0.86	0.00	5.72	0.33	0.58	0.06	0.13	0.00	0.01	7.69
1991	0.54	1.07	0.24	1.85	0.09	0.10	0.02	0.04	0.02	3.97
1992	0.40	0.18	0.11	0.07	0.33	0.03	0.03	0.03	0.00	1.18
1993	1.17	0.65	0.18	0.14	0.12	0.37	0.06	0.02	0.02	2.73
1994	0.70	2.68	1.00	0.15	0.10	0.07	0.16	0.02	0.05	4.92
1995	0.50	1.29	2.32	0.91	0.17	0.11	0.03	0.18	0.11	5.61
1996	1.09	4.59	8.86	5.21	2.62	0.35	0.07	0.08	0.00	22.86
1997	1.79	1.02	3.35	3.66	2.01	0.89	0.13	0.07	0.00	12.92
1998	0.82	2.95	1.25	1.06	0.85	0.21	0.06	0.01	0.06	7.28
1999	10.21	2.03	2.14	0.72	0.64	0.51	0.20	0.20	0.02	16.67
2000	1.83	2.37	4.10	2.01	1.11	1.11	1.01	0.48	0.27	14.29
2001	10.01	0.86	2.44	0.83	0.30	0.21	0.12	0.08	0.07	14.92
2002	0.18	19.25	6.72	3.22	1.09	0.48	0.61	0.17	0.53	32.25

Table B5. Stratified mean catch per tow (numbers) for haddock in NEFSC offshore autumn research vessel bottom trawl surveys on Georges Bank (Strata 01130-01250, 01290-01300), 1963-2001. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1963	83.93	25.39	9.22	6.81	8.34	5.95	2.04	1.68	1.18	0.46	145.01
1964	2.37	112.87	63.74	5.83	1.79	3.81	1.56	0.69	0.25	0.33	193.24
1965	0.33	10.16	77.39	9.70	1.07	0.80	0.91	0.80	0.25	0.27	101.69
1966	6.14	0.95	2.89	18.39	3.35	0.52	0.49	0.33	0.12	0.07	33.26
1967	0.03	6.72	0.36	1.00	6.76	1.62	0.49	0.21	0.33	0.18	17.70
1968	0.09	0.06	0.95	0.13	0.33	3.86	1.27	0.27	0.16	0.39	7.51
1969	0.39	0.03	0.00	0.28	0.13	0.16	1.52	0.51	0.09	0.27	3.38
1970	0.04	4.13	0.21	0.01	0.28	0.27	0.51	1.37	0.48	0.40	7.70
1971	2.43	0.00	0.31	0.07	0.01	0.22	0.03	0.09	0.75	0.28	4.20
1972	6.75	2.52	0.00	0.52	0.09	0.00	0.09	0.06	0.03	1.30	11.35
1973	3.23	9.00	1.61	0.00	0.19	0.04	0.00	0.07	0.01	0.72	14.89
1974	0.75	1.77	0.98	0.31	0.00	0.01	0.00	0.00	0.00	0.22	4.05
1975	23.48	0.63	0.72	4.86	0.92	0.00	0.03	0.00	0.01	0.30	30.95
1976	4.32	64.17	0.52	0.54	0.82	0.30	0.00	0.04	0.10	0.25	71.07
1977	0.13	2.14	18.73	0.56	0.57	0.64	0.34	0.04	0.01	0.09	23.25
1978	13.22	0.84	1.04	9.27	0.18	0.26	0.45	0.01	0.00	0.01	25.30
1979	1.32	45.57	0.04	0.90	3.81	0.26	0.28	0.05	0.01	0.00	52.24
1980	11.68	2.71	12.72	0.45	0.18	1.70	0.48	0.46	0.09	0.06	30.54
1981	0.38	6.13	2.08	3.70	0.21	0.42	0.53	0.00	0.00	0.01	13.45
1982	1.36	0.00	1.33	0.34	1.40	0.13	0.07	0.21	0.01	0.10	4.96
1983	5.80	0.24	0.21	0.27	0.30	0.94	0.12	0.00	0.10	0.01	7.99
1984	0.03	3.32	0.88	0.24	0.28	0.06	0.45	0.00	0.00	0.12	5.38
1985	11.35	0.65	1.53	0.22	0.05	0.10	0.07	0.17	0.00	0.05	14.19
1986	0.00	5.11	0.09	1.21	0.06	0.13	0.13	0.02	0.03	0.03	6.81
1987	1.80	0.00	0.79	0.10	0.77	0.06	0.06	0.02	0.02	0.00	3.62
1988	0.07	3.02	0.18	1.30	0.12	0.40	0.12	0.11	0.00	0.03	5.35
1989	0.47	0.05	2.71	0.20	0.66	0.09	0.13	0.02	0.02	0.00	4.34
1990	0.77	0.67	0.02	1.19	0.05	0.17	0.04	0.00	0.00	0.00	2.92
1991	2.16	0.21	0.24	0.05	0.22	0.02	0.02	0.00	0.00	0.02	2.92
1992	2.85	2.08	0.23	0.24	0.00	0.47	0.02	0.08	0.03	0.06	6.06
1993	1.52	4.04	2.01	0.30	0.00	0.06	0.15	0.02	0.00	0.00	8.09
1994	0.91	0.77	0.81	0.67	0.12	0.05	0.02	0.17	0.06	0.00	3.58
1995	2.27	7.14	4.90	2.32	0.38	0.01	0.00	0.07	0.02	0.00	17.11
1996	1.31	0.54	0.93	1.04	0.49	0.14	0.01	0.01	0.00	0.01	4.47
1997	0.32	2.47	1.47	0.75	0.55	0.33	0.13	0.00	0.07	0.08	6.16
1998	4.32	2.79	2.47	0.72	0.41	0.18	0.16	0.02	0.00	0.01	11.07
1999	1.82	0.84	3.37	8.05	3.52	2.32	0.82	1.32	0.75	0.31	23.13
2000	4.14	2.82	5.48	3.10	1.10	0.66	0.13	0.27	0.09	0.19	17.99
2001	0.85	8.77	1.68	7.44	2.12	1.16	0.36	0.22	0.13	0.01	22.74

Table B6. Stratified mean catch per tow (numbers) for haddock in Canadian offshore research vessel bottom trawl surveys on Georges Bank, 1986-2002.[1] The Georges Bank strata set includes strata 5Z1-5Z8.

Year	0	1	2	3	4	Age group 5	6	7	8	9+	Total
1986	0.00	4.06	0.22	6.05	1.07	0.19	0.29	0.34	0.37	0.42	13.01
1987	0.00	0.03	3.04	0.69	2.51	0.67	0.08	0.30	0.10	0.86	8.28
1988	0.00	1.47	0.05	8.53	0.17	2.85	0.18	0.17	0.11	0.50	14.03
1989	0.00	0.03	5.34	0.72	2.12	0.19	0.42	0.03	0.03	0.23	9.11
1990	0.00	0.93	0.11	9.87	0.13	3.36	0.23	1.09	0.13	0.34	16.19
1991	0.00	0.75	1.67	0.14	8.99	0.11	1.60	0.09	0.44	0.21	14.00
1992	0.00	3.30	2.95	1.13	0.17	3.82	0.03	1.06	0.04	0.58	13.08
1993	0.00	3.96	2.16	0.55	0.45	0.04	1.28	0.02	0.32	0.16	8.94
1994	0.00	3.32	11.52	4.08	0.42	0.24	0.02	0.70	0.01	0.27	20.59
1995	0.00	1.94	2.62	4.30	2.22	0.56	0.28	0.00	0.48	0.66	13.06
1996	0.00	5.37	2.54	4.25	4.43	2.57	0.23	0.21	0.03	0.50	20.14
1997	0.00	1.74	1.15	0.81	2.36	2.47	1.77	0.24	0.09	0.59	11.22
1998	0.00	2.41	8.18	3.08	2.57	3.76	3.67	1.98	0.24	0.48	26.37
1999	0.00	19.75	3.41	7.16	2.21	1.40	1.35	1.26	0.33	0.13	37.00
2000	0.00	18.33	68.60	9.32	8.91	2.11	1.55	1.94	1.14	0.59	112.50
2001	0.00	22.28	2.83	10.88	3.09	4.13	1.29	1.15	1.41	1.65	48.71
2002	0.00	1.98	31.70	6.65	15.36	4.32	5.32	1.59	1.32	7.73	75.97

[1] S. Gavaris Personal communication.

Table B7. Beginning year stock size (000s) of Georges Bank haddock estimated from the VPA, 1963 to 2002.

Age	1963	1964	1965	1966	1967	1968	1969
1	192405	486215	32602	4081	13172	420	984
2	32188	154895	388939	18005	3238	9744	336
3	33117	22691	112399	204592	8549	2499	5268
4	46437	20401	14458	51763	76289	4384	1405
5	29224	27929	12382	6991	25037	43760	1851
6	9696	16509	14974	6164	3219	11144	22690
7	6014	5943	8274	6207	2702	1541	5958
8	2799	3652	2982	3361	2971	1314	658
9	4224	4695	3685	2274	2242	2419	1652
1+	356105	742932	590695	303437	137420	77225	40804

Age	1970	1971	1972	1973	1974	1975	1976
1	4773	473	8507	19485	10792	7623	102890
2	804	3866	387	6824	13636	8794	6067
3	265	515	1921	315	3709	7256	6265
4	2777	203	220	1166	255	2443	4254
5	745	1758	130	107	605	207	1660
6	924	441	1178	77	40	432	166
7	13190	562	139	856	36	31	316
8	3454	8710	203	43	631	28	21
9	2135	5475	3761	1271	2954	610	598
1+	29066	22004	16444	30143	32659	27422	122237

Age	1977	1978	1979	1980	1981	1982	1983
1	14364	5984	84420	10102	7221	2502	3099
2	84109	11760	4898	69116	8264	5911	2048
3	4540	51141	8939	3987	28537	5189	3786
4	4631	3548	28846	5757	2950	13413	2770
5	2686	3177	2628	17130	3831	1663	7604
6	1164	1733	2088	1677	8547	2289	1008
7	136	630	951	1338	836	4670	1359
8	238	107	390	494	602	385	2811
9	673	512	186	259	355	396	265
1+	112541	78592	133346	109861	61143	36419	24750

Table B7. Continued.

	1984	1985	1986	1987	1988	1989	1990
1	17284	1752	14732	2199	16921	1081	2653
2	2537	14151	1434	12056	1800	13850	885
3	1483	1993	9409	1125	8065	1427	10197
4	2364	945	1134	5161	805	4446	1091
5	1644	1277	598	727	2766	538	2847
6	4200	987	629	358	485	1422	311
7	579	2097	602	358	227	262	840
8	945	263	1241	357	213	136	173
9	1906	507	278	451	349	217	164
1+	32941	23973	30057	22791	31631	23379	19160

	1991	1992	1993	1994	1995	1996	1997
1	2419	9903	13861	14240	9802	10908	19940
2	2171	1975	8102	11342	11658	8017	8926
3	715	1372	1393	6371	9043	9464	6515
4	7041	503	834	824	4483	6864	7233
5	737	3820	292	412	521	3256	4764
6	1545	511	1746	145	278	372	2247
7	166	894	318	833	56	199	243
8	528	70	440	226	546	39	143
9	245	240	208	221	173	56	362
1+	15565	19287	27193	34614	36559	39175	50373

	1998	1999	2000	2001	2002
1	14198	39479	17692	75115	4453
2	16299	11623	32322	14485	61497
3	7147	13164	9480	26110	11745
4	5074	5476	9817	7202	19432
5	5218	3700	3957	6609	5169
6	3387	3647	2579	2737	4334
7	1640	2297	2524	1664	1741
8	181	1208	1578	1740	1020
9	351	345	545	1358	2028
1+	53495	80941	80495	137020	111419

Table B8. Spawning stock biomass (mt) of Georges Bank haddock estimated from the VPA, 1963 to 2001.

Age	1963	1964	1965	1966	1967	1968	1969
1	00	00	00	00	00	00	00
2	00	00	00	00	00	1710	60
3	24532	15607	66805	97767	4700	1409	3221
4	56925	23391	14829	49168	68052	3958	1597
5	38916	37115	16069	8724	27362	50539	2364
6	17459	25531	21711	9324	4999	16457	35028
7	11770	11365	14076	10997	4935	2718	11957
8	6545	7884	6294	7116	6272	2727	1465
9	11456	12085	9574	6011	5958	5837	5067
1+	167603	132978	149358	189106	122279	85355	60760

	1970	1971	1972	1973	1974	1975	1976
1	00	00	00	00	00	00	00
2	164	777	85	1592	3156	2307	1502
3	184	409	1725	350	4208	7675	6237
4	3609	264	301	1904	463	4449	6829
5	1257	3416	234	185	1365	442	3684
6	1668	820	2873	181	112	1152	410
7	26943	1151	304	2506	124	109	969
8	8755	22254	546	125	2144	103	83
9	7114	18399	11711	4218	11683	2405	2652
1+	49694	47490	17779	11061	23256	18642	22367

	1977	1978	1979	1980	1981	1982	1983
1	00	00	00	00	00	00	00
2	17917	2558	1118	12908	1680	1073	295
3	4128	45484	7116	3295	20671	4034	3143
4	7321	5641	44086	7738	3804	17772	3961
5	5612	7039	5316	30147	6720	3057	13359
6	2917	4403	5529	3748	17850	5064	2200
7	458	1838	2804	3684	2226	12214	3717
8	826	381	1225	1552	2003	1280	8028
9	3039	2395	794	859	1377	1407	979
1+	42218	69739	67988	63931	56331	45902	35682

Table B8. Continued.

	1984	1985	1986	1987	1988	1989	1990
1	377	78	1113	143	1116	97	118
2	434	4751	489	4330	717	5095	337
3	1445	1782	8547	1091	6672	1462	10030
4	3208	1336	1586	7136	1105	6037	1588
5	2903	2271	1184	1333	4754	903	4757
6	8576	2133	1442	829	976	2869	631
7	1331	5258	1498	919	558	665	2009
8	2724	750	3591	1026	594	394	469
9	6141	1660	935	1665	1190	740	595
1+	27139	20018	20385	18472	17682	18263	20534

	1991	1992	1993	1994	1995	1996	1997
1	94	344	472	288	50	64	98
2	950	837	1815	2730	2472	1775	1938
3	694	1597	1236	5742	10124	10006	7842
4	9811	662	1239	1349	7548	10362	11219
5	1325	6260	475	892	1134	6440	8819
6	3189	1065	3478	275	695	850	5052
7	360	2097	755	2070	153	569	634
8	1332	178	1121	642	1508	119	448
9	916	846	699	901	635	190	1216
1+	18672	13886	11291	14889	24319	30376	37266

	1998	1999	2000	2001
1	94	394	164	246
2	3530	2817	9127	4220
3	7939	14799	10566	29361
4	8299	8639	15117	10647
5	9552	6685	7325	12026
6	7098	7408	5173	5831
7	4185	5333	5814	3672
8	569	3302	4065	4279
9	1253	1166	1632	4146
1+	42518	50541	58984	74429

Table B9. Fishing mortality (F) at age and average F (ages 4-7, unweighted) for Georges Bank haddock estimated from VPA, 1963 to 2001.

Age	1963	1964	1965	1966	1967	1968	1969
1	0.02	0.02	0.39	0.03	0.10	0.02	0.00
2	0.15	0.12	0.44	0.54	0.06	0.41	0.04
3	0.28	0.25	0.58	0.79	0.47	0.38	0.44
4	0.31	0.30	0.53	0.53	0.36	0.66	0.43
5	0.37	0.42	0.50	0.58	0.61	0.46	0.50
6	0.29	0.49	0.68	0.62	0.54	0.43	0.34
7	0.30	0.49	0.70	0.54	0.52	0.65	0.35
8	0.34	0.37	0.52	0.54	0.42	0.48	0.47
9	0.34	0.37	0.52	0.54	0.42	0.48	0.47
4-7	0.32	0.43	0.60	0.57	0.51	0.55	0.40

	1970	1971	1972	1973	1974	1975	1976
1	0.01	0.00	0.02	0.16	0.00	0.03	0.00
2	0.24	0.50	0.01	0.41	0.43	0.14	0.09
3	0.07	0.65	0.30	0.01	0.22	0.33	0.10
4	0.26	0.25	0.52	0.46	0.01	0.19	0.26
5	0.32	0.20	0.32	0.79	0.14	0.02	0.16
6	0.30	0.96	0.12	0.56	0.06	0.11	0.00
7	0.21	0.82	0.97	0.10	0.06	0.16	0.08
8	0.27	0.21	0.45	0.49	0.10	0.17	0.23
9	0.27	0.21	0.45	0.49	0.10	0.17	0.23
4-7	0.27	0.56	0.48	0.48	0.07	0.12	0.12

	1977	1978	1979	1980	1981	1982	1983
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.30	0.07	0.01	0.68	0.27	0.25	0.12
3	0.05	0.37	0.24	0.10	0.55	0.43	0.27
4	0.18	0.10	0.32	0.21	0.37	0.37	0.32
5	0.24	0.22	0.25	0.50	0.32	0.30	0.39
6	0.41	0.40	0.24	0.50	0.40	0.32	0.35
7	0.03	0.28	0.46	0.60	0.58	0.31	0.16
8	0.20	0.16	0.32	0.42	0.34	0.36	0.38
9	0.20	0.16	0.32	0.42	0.34	0.36	0.38
4-7	0.22	0.25	0.32	0.45	0.42	0.32	0.31

Table B9. Continued.

	1984	1985	1986	1987	1988	1989	1990
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.21	0.04	0.20	0.03	0.11	0.01
3	0.25	0.36	0.40	0.14	0.40	0.07	0.17
4	0.42	0.26	0.25	0.42	0.20	0.25	0.19
5	0.31	0.51	0.31	0.21	0.47	0.35	0.41
6	0.49	0.29	0.36	0.26	0.42	0.33	0.43
7	0.59	0.32	0.32	0.32	0.31	0.22	0.26
8	0.37	0.40	0.27	0.40	0.40	0.26	0.35
9	0.37	0.40	0.27	0.40	0.40	0.26	0.35
4-7	0.45	0.35	0.31	0.30	0.35	0.28	0.32

	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.26	0.15	0.04	0.03	0.01	0.01	0.02
3	0.15	0.30	0.33	0.15	0.08	0.07	0.05
4	0.41	0.34	0.50	0.26	0.12	0.17	0.13
5	0.17	0.58	0.50	0.19	0.14	0.17	0.14
6	0.35	0.27	0.54	0.75	0.13	0.23	0.11
7	0.67	0.51	0.14	0.22	0.18	0.13	0.09
8	0.39	0.56	0.51	0.24	0.12	0.17	0.13
9	0.39	0.56	0.51	0.24	0.12	0.17	0.13
4-7	0.40	0.43	0.42	0.36	0.14	0.17	0.12

	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00
2	0.01	0.00	0.01	0.01
3	0.07	0.09	0.07	0.10
4	0.12	0.13	0.20	0.13
5	0.16	0.16	0.17	0.22
6	0.19	0.17	0.24	0.25
7	0.11	0.18	0.17	0.29
8	0.14	0.14	0.19	0.22
9	0.14	0.14	0.19	0.22
4-7	0.14	0.16	0.19	0.22

Table B10. Input data and results for short-term (2002-2005) stochastic stock biomass and catch projections for Georges Bank haddock.

```
Input for Projections:
----------------------
Number of Years:  3; Initial Year: 2002; Final Year: 2005
Number of Ages : 9; Age at Recruitment: 1; Last Age: 9
Natural Mortality is assumed Constant over time at:  .200
Proportion of F before spawning:  .25
Proportion of M before spawning:  .25
Last age is a PLUS group;
```

Age-specific Input data for Projection # 1

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0010	1.0000	.0400	0.579	0.395
2	.0460	1.0000	.4900	1.154	0.843
3	.4880	1.0000	.9500	1.485	1.282
4	.8290	1.0000	1.0000	1.828	1.672
5	1.0000	1.0000	1.0000	2.174	2.010
6	1.0000	1.0000	1.0000	2.413	2.284
7	1.0000	1.0000	1.0000	2.684	2.524
8	1.0000	1.0000	1.0000	2.900	2.850
9+	1.0000	1.0000	1.0000	3.458	3.458

Projections for 2002-2005; F(2002)=0.19; Basis: 85% of 2001 point estimate. Recruitment (age 1) 2002-2004 year classes derived from two-stage resampling of 1931-2001 stock-recruitment data excluding the 1963 year class with a 75,000 mt spawning biomass cutoff.

SSB was estimated to be 74,400 mt in 2001.

2002 F	2002 Catch	2002 SSB	2003 F	2003 Catch	2003 SSB
0.19	12462	99737	$F_{rebuild}$ =0.197	17840	122264
0.19	12462	99737	F_{SQ} =0.190	17252	122415

2004 F	2004 Catch	2004 SSB	2005 F	2005 Catch	2005 SSB
0.197	19432	131712	0.197	22488	158330
0.190	18887	132413	0.190	21929	159533

Figure B1. Total commercial landings (thousand mt) of haddock from Georges Bank and south, 1904-2001.

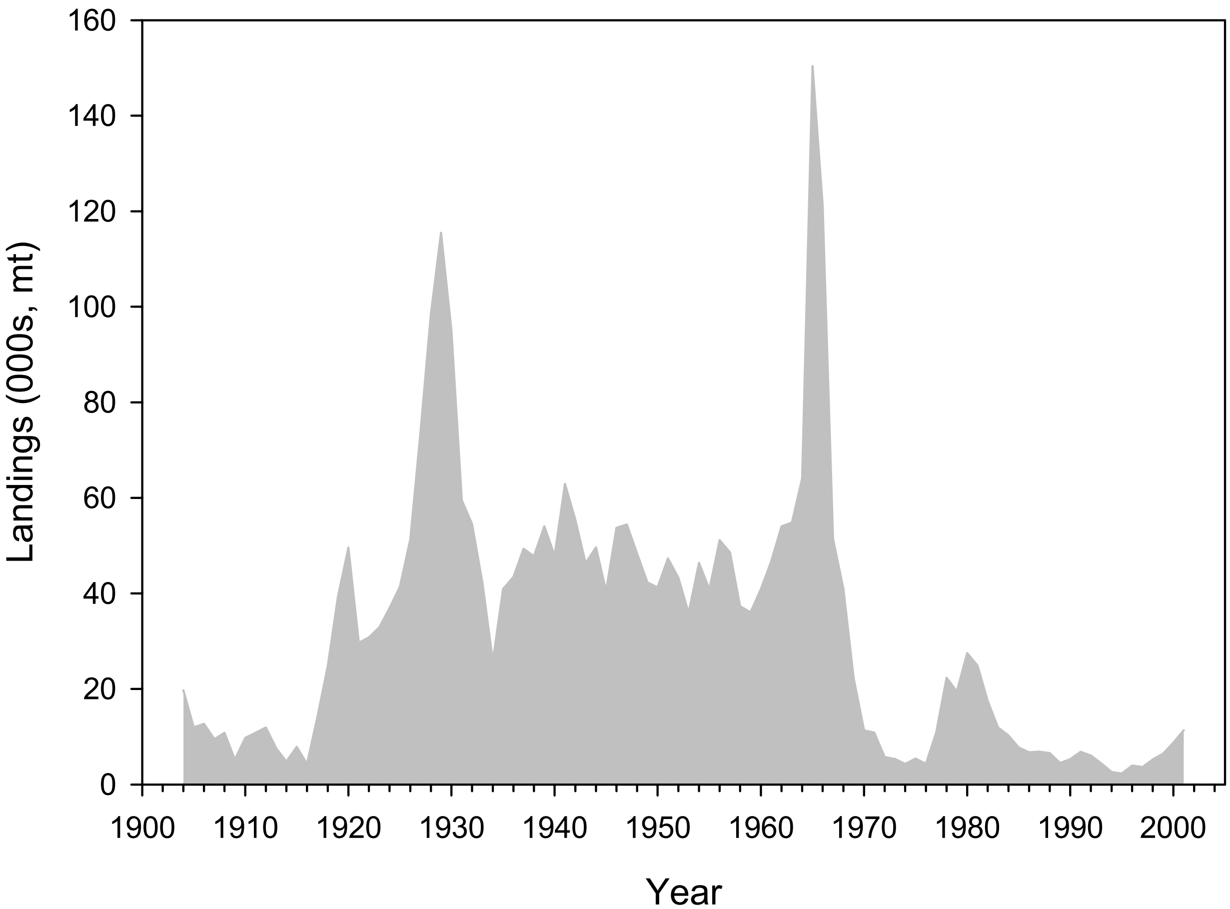


Figure B2. Georges Bank haddock research survey indices, 1963-2002.

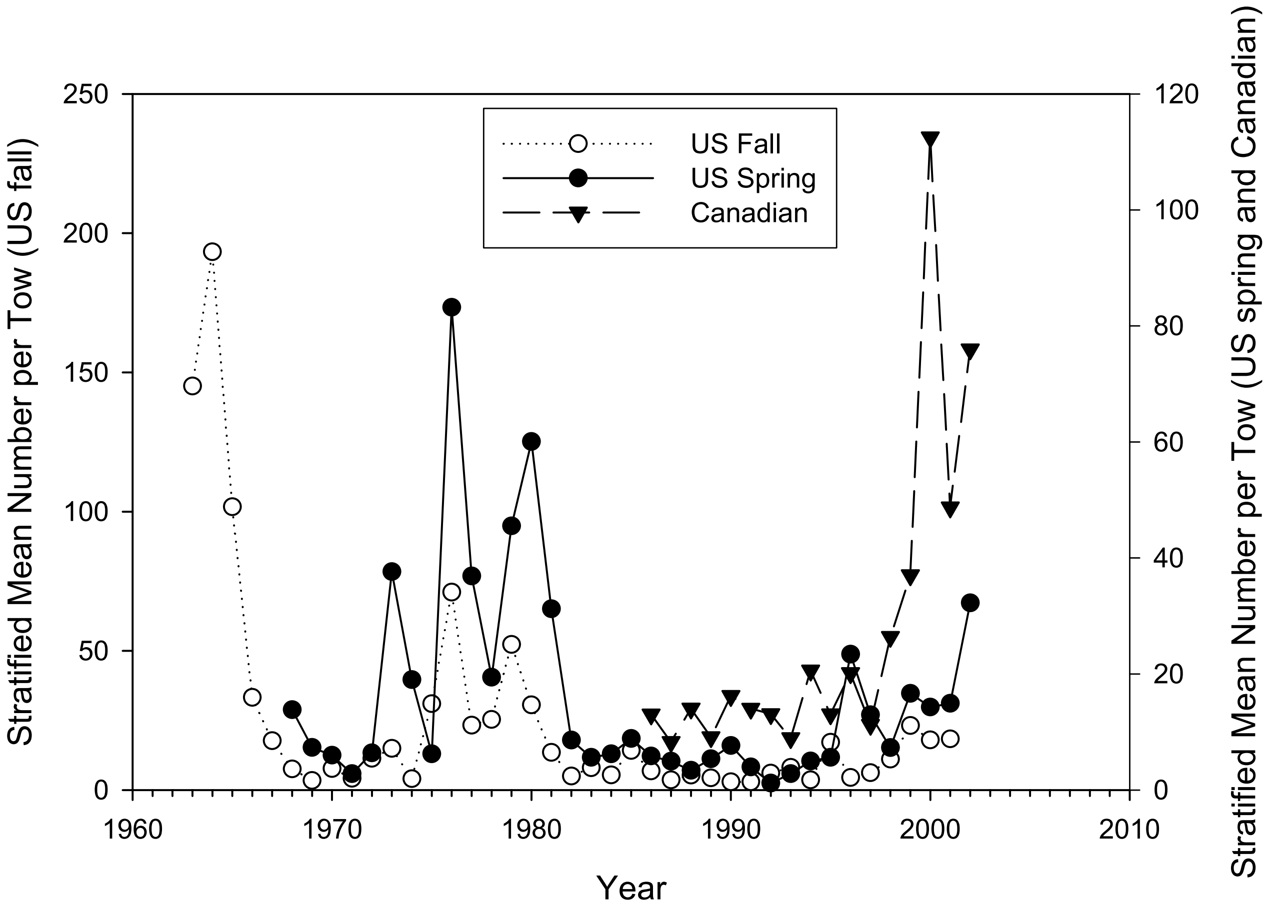


Figure B3. Trends in spawning stock biomass (line) and recruitment (bars) for Georges Bank haddock from 1931-2001.

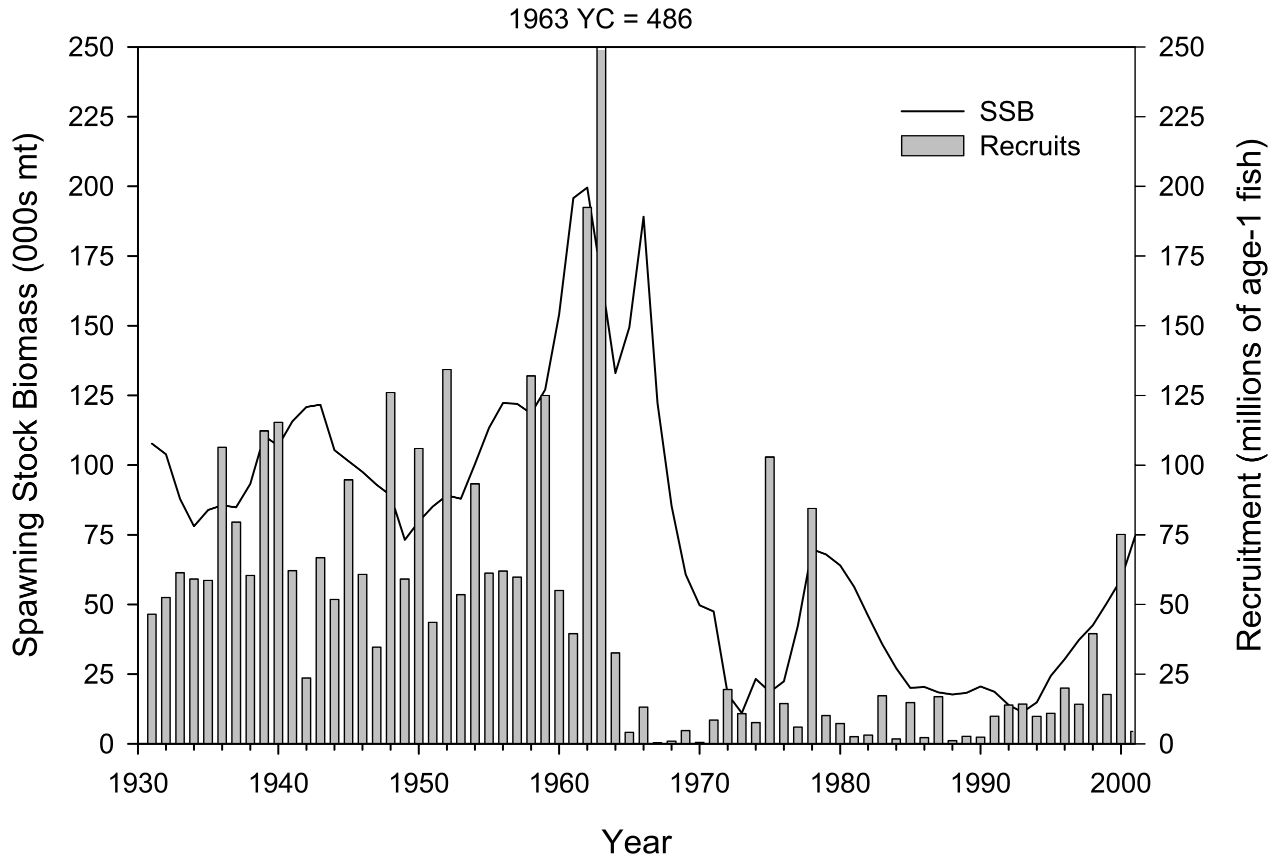
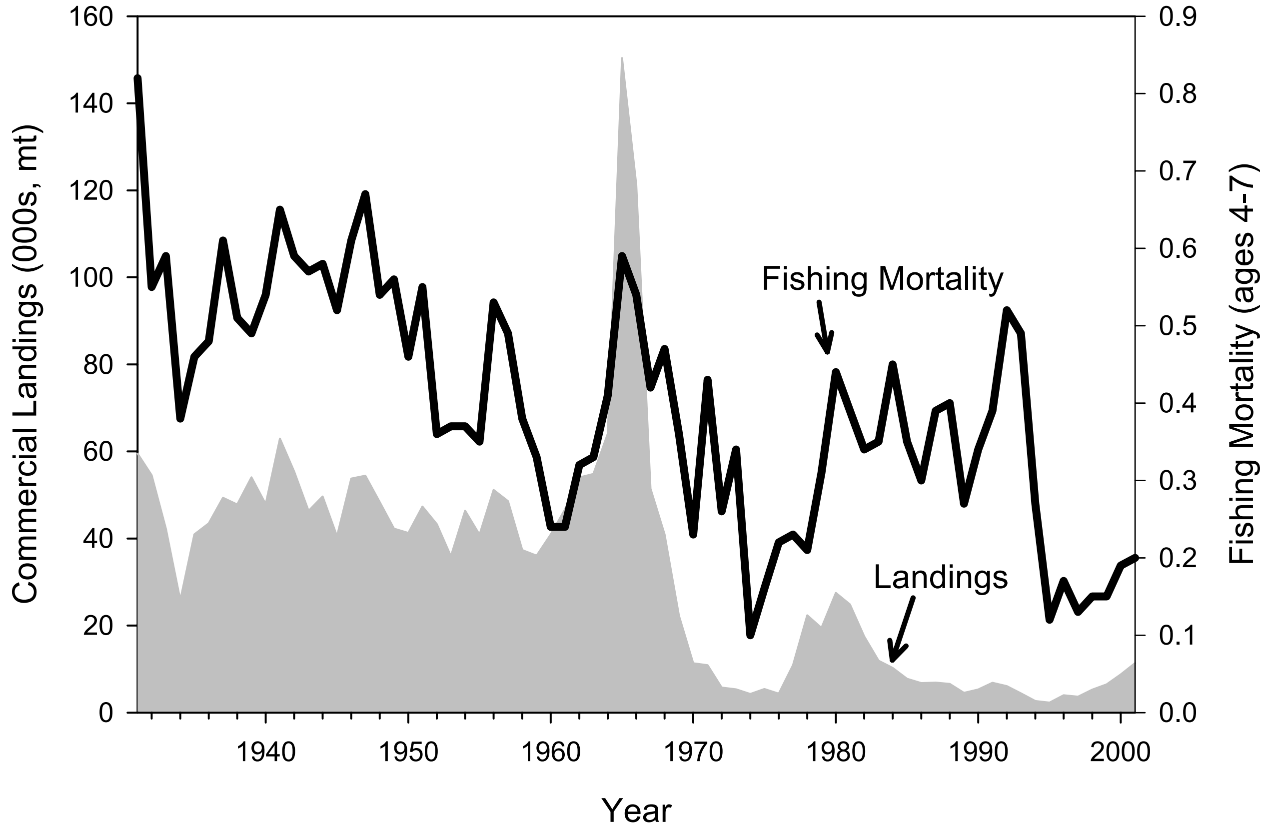


Figure B4. Trends in commercial landings (thousand mt, live weight) and fishing mortality (unweighted mean, ages 4-7) for Georges Bank haddock from 1931-2001.



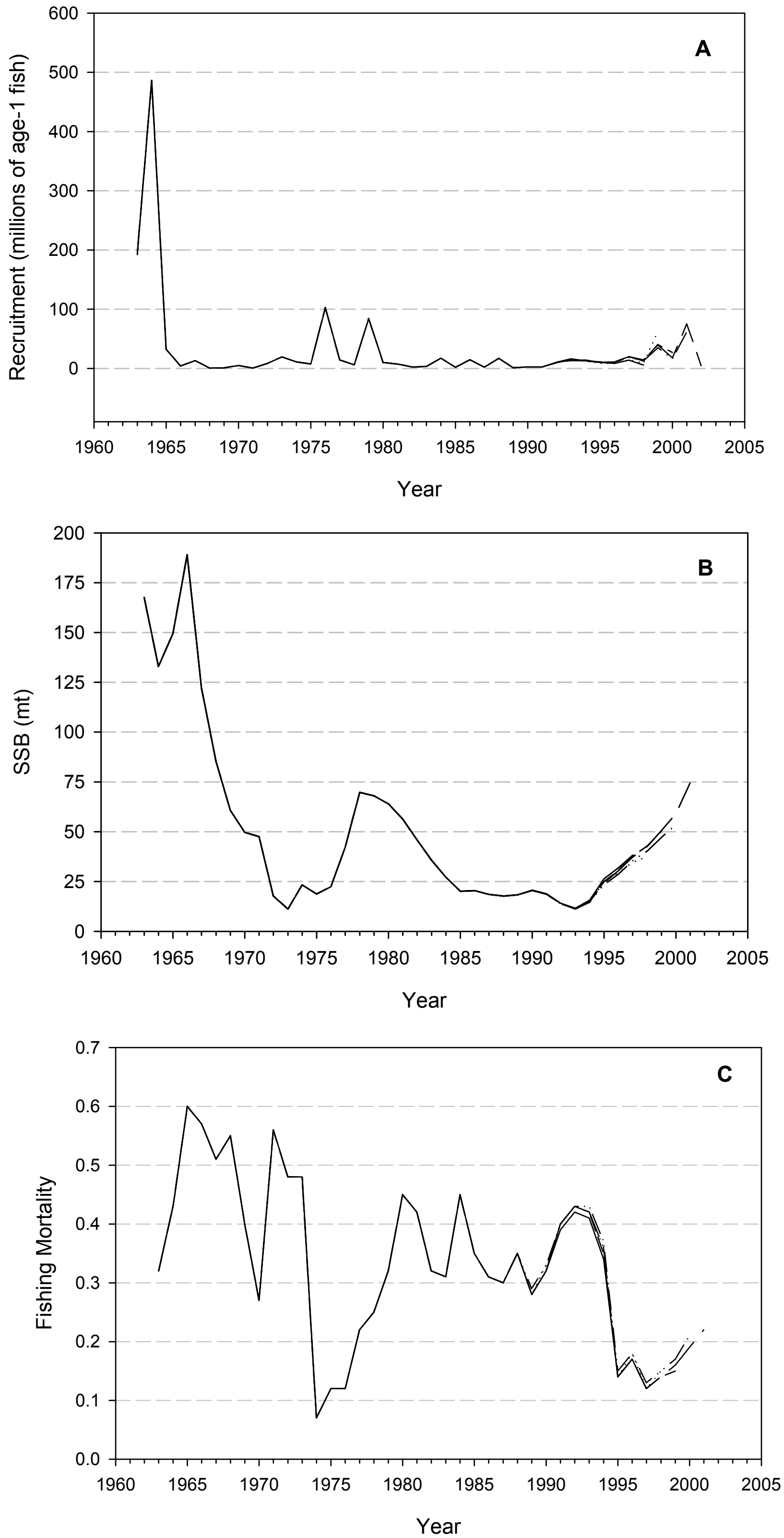


Figure B5. Retrospective analysis of Georges Bank haddock recruitment (A), spawning stock biomass (B) and fishing mortality (C).

Figure B6. Georges Bank haddock sensitivity to hypothetical NEFSC survey index adjustments due to trawl warp offsets during 2000-2002.

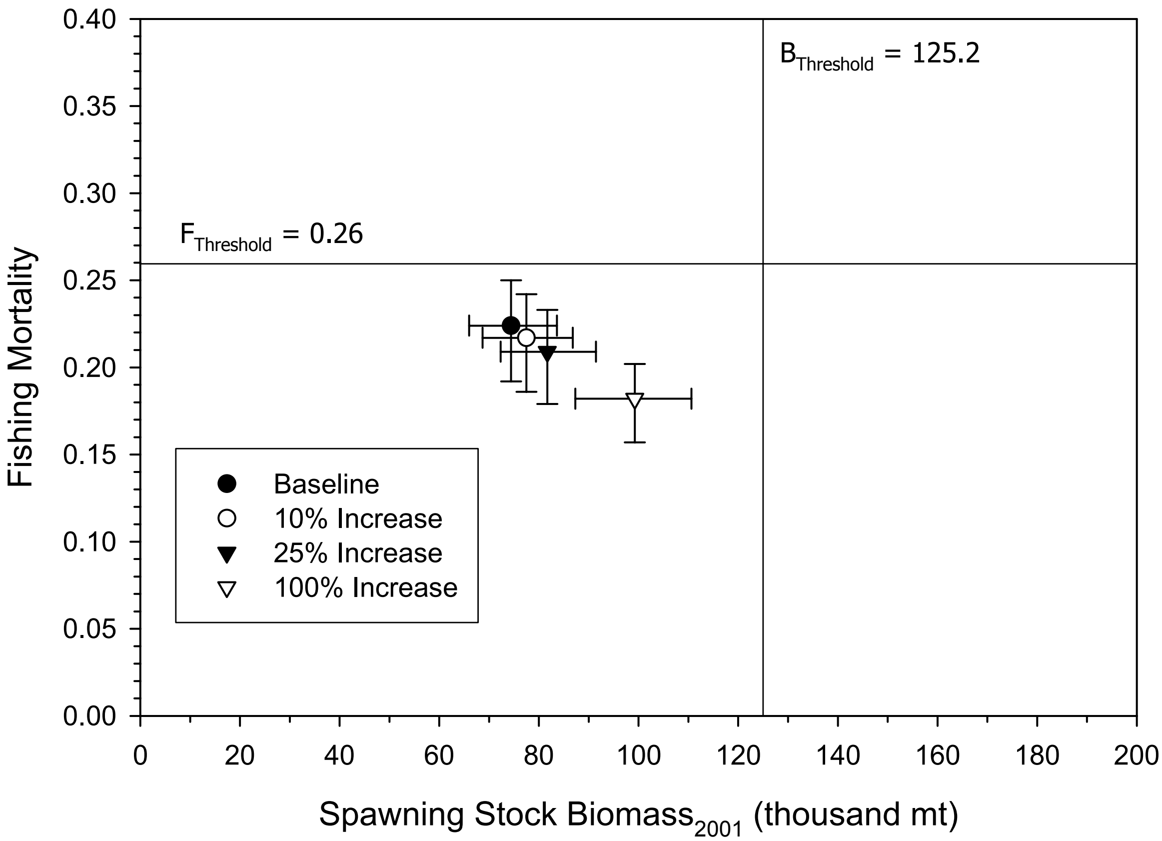
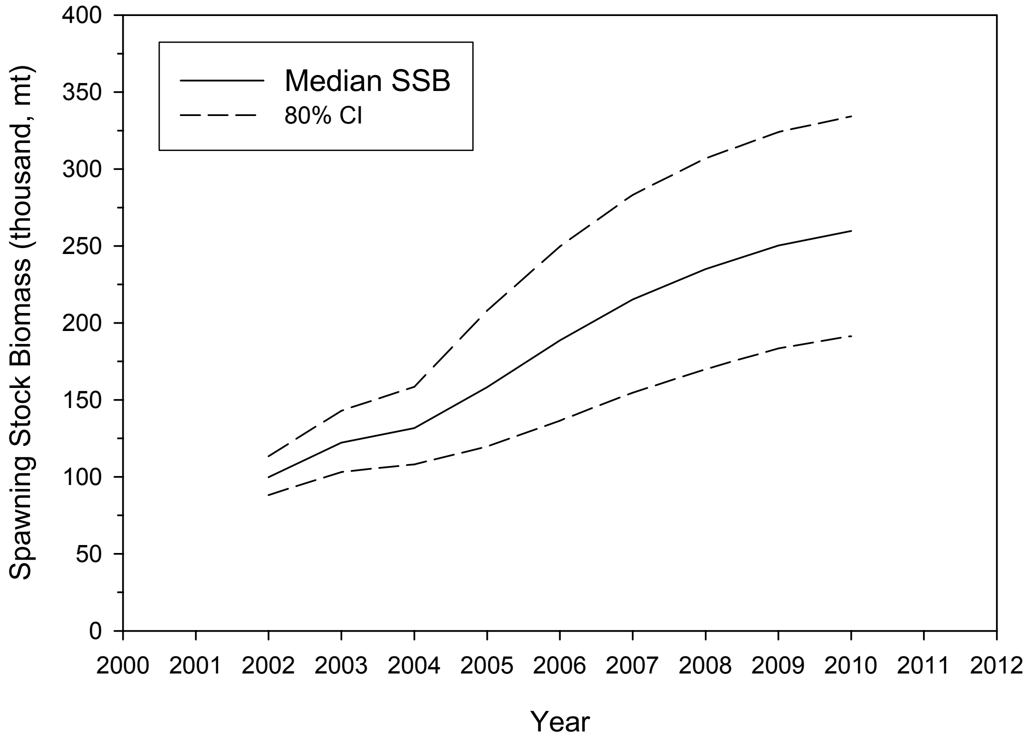
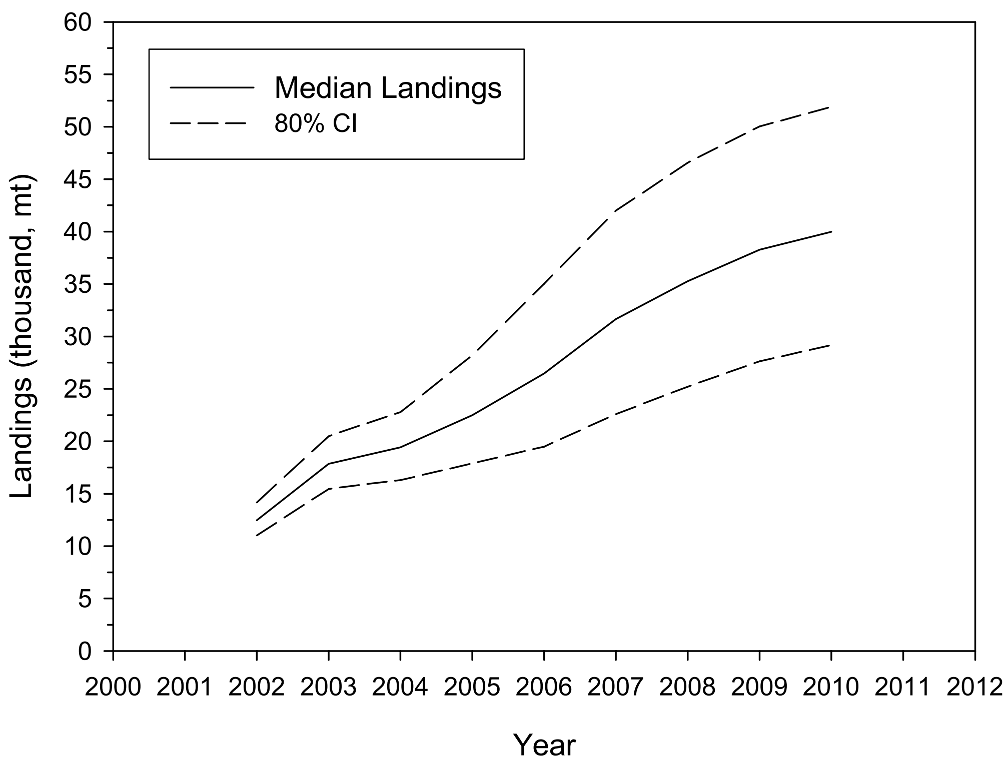


Figure B7. Georges Bank haddock projection results for $F=F_{REBUILD}$.





C. Georges Bank Yellowtail Flounder by C.M. Legault

1.0 Background
Spawning stock biomass of Georges Bank yellowtail flounder in 2000 approached SSB_{msy} and fishing mortality was low (SSB was 43,000 mt and fully recruited F was 0.14; Stone et al. 2001). This report updates catch and survey indices and estimates 2001 fishing mortality and 2002 stock size.

2.0 Assessment Data

2.1 US 2001 Landings
U.S. landings were prorated as described in Cadrin et al. (1998; Table C1; Figure C1). US landings from Georges Bank in 2001 increased only slightly from 2000 (2% increase). Sampling intensity of landings in 2001 was comparable to that in 2000 (Table C2). Both the large and small categories were sampled in both halves of the year. Half year-specific age-length keys were applied to landings at length by half year and market category to estimate landings and mean weights at age.

2.2 US 2001 Discards
US discarded catch was estimated from logbook information on discard: kept ratios by half-year for trawl gear and by whole year for dredge gear (due to fewer observations for dredge gear), (Cadrin et al. 2000; Table C1). US discards were 13% of US landings by weight in 2001. Discards at age and associated mean weights at age were estimated from sea sampled lengths and pooled commercial-survey age-length keys. However, length distributions of trawl discards were only sampled in the first half of 2001; those samples were used to characterize all 2001 trawl discards. No dredge length frequencies were collected in 2001. Average length distributions for dredge gear by half year for 1998 through 2000 were used to age the dredge discards. It should be noted that the US discard estimate of 505 mt is substantially higher than the estimate used in the recent Canadian assessment (60 mt; Stone 2002) due to differences in the dredge discard estimate.

2.3 Canadian Landings
The Canadian landings contain a proration of flatfish landed as "unspecified" which were prorated as described in Stone et al. (2001). Canadian 2001 landings were provided by H. Stone (DFO, pers. comm.) and increased slightly relative to those in 2000 (2%; Table C1; Figure C1). Length frequencies collected by Canadian samplers were used with sex specific age-length keys provided from US landings to generate the Canadian landings by age and associated average weight at age (Stone et al. 2001; Table C2).

2.4 Total Catch at Age
Total catch at age was formed by adding the US landings, US discards and Canadian landings (Table C3a). Average weight at age was computed as the catch weighted average of the weights at age from these three sources (Table C3b).

2.5 Research Vessel Survey Indices

Survey abundance and biomass indices are reported in Table C4. Estimates from research vessel surveys are from valid tows on Georges Bank (NEFSC offshore strata 13-21; Canadian strata 5Z1-5Z4; NEFSC scallop strata 54, 55, 58-72, 74) standardized according to net, vessel, and door changes (Stone et al. 2001). All survey indices of total abundance and total biomass are either high, increasing, or both in recent years (Figure C2). This trend is also seen in numbers by age (Figure C3).

3.0 Assessment Results

3.1 Age-Based Analysis

An updated VPA calibration of Georges Bank yellowtail flounder is summarized in Table C4. This analysis updates the assessment reported by Stone et al. (2001) by including 2001 landings and discards, 2001 NEFSC fall and scallop survey indices, 2001 Canadian survey indices, and 2001-2002 NEFSC spring survey indices. Results indicate that the fully recruited fishing mortality rate remains low in 2001 at 0.13 (Figure C4). Spawning biomass has increased every year since 1995 and recruitment remains high (Figure C4). The age structure of the stock has improved and is approaching levels corresponding to those expected in equilibrium when the stock is at MSY (Figure C5). However, this analysis found a strong retrospective pattern of underestimating F and overestimating SSB in the terminal year, as seen in previous assessments (Figure C6). The estimate of F for 2000 increased from 0.14 in the 2001 assessment (Stone et al. 2001) to 0.24. Thus, the value of F for 2001 may be underestimated. The 2001 SSB estimate of 39,000 t is less than the 2000 SSB estimate from the Stone et al. 2001 stock assessment (43,000 t), again reflecting the retrospective pattern found in previous assessments. Bootstrap analysis indicates that abundance was estimated with moderate precision (CV=14%-43%). These results cannot be directly compared to the most recent Canadian stock assessment (Stone 2002) because the Canadian VPA results are all bias-corrected while these are not. However, trends are similar between these two assessments.

3.2 Sensitivity Analyses

Sensitivity analyses of the VPA assessment were conducted to examine hypothetical changes in the recent NEFSC spring and fall survey values due to warp misalignment (Figure C7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

3.3 Stock Status

Proxies for MSY reference points were derived from yield and SSB per recruit analyses and the assumption of constant recruitment (NEFSC 2002). Long-term average recruitment is 53.8 million at age-1.

MSY = 12,900 mt

SSBmsy = 58,800 mt.

Fmsy = 0.25 fully recruited (derived from $F_{40\%}$)

Therefore, according to VPA results, the stock is not overfished and overfishing is not occurring, e.g. SSB_{2001}=39,000 mt > 29,400 mt = ½ $SSB_{Threshold}$ of 58,800 and F_{2001}=0.13 < 0.25 = Fmsy.

3.4 Projection
A projection assuming F in 2002 is 15% lower than in 2001, with recruitment similar to that observed when SSB was greater than 5,000 mt, suggests that $F_{rebuild}$ remains at 0.22, just below the Fmsy value of 0.25 (Figure C8). The total catch, F and SSB that occur in the short term under these projections are presented along with the input in Table C6.

3.5 Biomass-Based Analysis
For comparative purposes, surplus production analysis (ASPIC) was updated to provide alternative perspectives on stock status. Biomass and F estimates are generally similar to estimates from VPA, but biomass estimates in recent years are higher from ASPIC than from VPA (Figure C9). The surplus production model estimates of Bmsy and Fmsy also produce the conclusion as the VPA, viz., the Georges Bank yellowtail flounder stock is not overfished and overfishing is not occurring (B_{2001}/Bmsy = 1.38; F_{2001}/Fmsy = 0.37).

4.0 Sources of Uncertainty

- Dredge discards were insufficiently sampled both in magnitude as well as length composition in 2001.
- Retrospective patterns continue in the VPA for this assessment. Updated VPAs may indicate higher F and lower SSB in 2001 than the values reported here.
- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.

5.0 GARM Panel Comments
The use of logbook data to estimate discards was questioned. It was noted that there were very few observer samples from the trawl fishery, and none from the scallop dredge fishery. Discards accounted for approximately 7% of the total catch by weight, and is not considered to be a major component of the catch. Discard ratios from recent years were less than those for 2001, but the GARM concluded that increased discard ratios may result from increasing stock sizes and constant trip limits.

Information on discard reason (e.g., sublegal size, regulatory trip limit, quality) is needed to evaluate the general size structure of discards. Observer information from recent years indicates that trawl discards are primarily undersized, but the reasons for dredge discards are a combination of undersized fish, regulations, and poor quality.

The GARM noted the importance of appropriately scaling survey indices in overlaying NEFSC and Canadian data. The short time series and greater catchability of the Canadian survey suggests a greater rate of increase in recent years when overlayed with NEFSC data.

Strong year classes did not appear consistently in all surveys and could not be followed clearly over time within survey series. Similar discrepancies exist in both Canadian and NEFSC survey data and may stem from use of NEFSC age data to derive abundance at age indices from the Canadian survey.

The GARM questioned if survey data adjusted for presumed warp effects improves the retrospective pattern or makes it worse. Retrospective analyses of sensitivity runs showed that the retrospective pattern persisted in all runs, but was slightly less with survey adjustments.

The sensitivity of results to the NEFSC spring survey was discussed. Presumably the higher F and lower SSB result from decreased catches of the 2001 spring survey at all ages. The influence of the relatively short Canadian series was discussed. Further sensitivity analyses truncated the spring and fall series and showed high sensitivity of results when survey indices were used one at a time.

The GARM noted that the current ADAPT configuration is slightly different than that used in previous assessments, because the spring survey data had not been available in previous spring assessments. A sensitivity analysis without the current year NEFSC spring survey had very a similar retrospective pattern.

The issue of undeclared landings was raised. The GARM felt that U.S. dealer records were among the most reliable sources of information in the assessment, however proration of total yellowtail catch to stock area imposes some uncertainty to the estimate of catch. There was also some discussion of the possibility of unreported yellowtail landings in Canadian fisheries (e.g., from the scallop fishery).

The GARM requested information on current size structure compared to historical size structure. Survey length frequencies indicate that the size structure is now similar to that observed in the 1960s. Furthermore, the age structure is similar to that expected under $F_{40\%}$ over the lifetime of a cohort with long-term median abundance, with the exception of fewer fish older that 6. Given the recent reduction in F and increase in recruitment, abundance of age-6+ fish is expected to increase.

6.0 References

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Table C1. Catch of Georges Bank yellowtail flounder (thousand mt).

Year	US Landings	US Discards	Canada	Foreign	Total Catch
1963	11.0	5.6	0.0	0.1	16.7
1964	14.9	4.9	0.0	0.0	19.8
1965	14.2	4.4	0.0	0.8	19.4
1966	11.3	2.1	0.0	0.3	13.7
1967	8.4	5.5	0.0	1.4	15.3
1968	12.8	3.6	0.0	1.8	18.2
1969	15.9	2.6	0.0	2.4	20.9
1970	15.5	5.5	0.0	0.3	21.3
1971	11.9	3.1	0.0	0.5	15.5
1972	14.2	1.2	0.0	2.2	17.6
1973	15.9	0.4	0.0	0.3	16.5
1974	14.6	1.0	0.0	1.0	16.6
1975	13.2	2.7	0.0	0.1	16.0
1976	11.3	3.0	0.0	0.0	14.4
1977	9.4	0.6	0.0	0.0	10.0
1978	4.5	1.7	0.0	0.0	6.2
1979	5.5	0.7	0.0	0.0	6.2
1980	6.5	0.4	0.0	0.0	6.9
1981	6.2	0.1	0.0	0.0	6.3
1982	10.6	1.4	0.0	0.0	12.0
1983	11.4	0.1	0.0	0.0	11.4
1984	5.8	0.0	0.0	0.0	5.8
1985	2.5	0.0	0.0	0.0	2.5
1986	3.0	0.0	0.0	0.0	3.1
1987	2.7	0.2	0.0	0.0	3.0
1988	1.9	0.3	0.0	0.0	2.1
1989	1.1	0.1	0.0	0.0	1.2
1990	2.8	0.8	0.0	0.0	3.6
1991	1.8	0.2	0.0	0.0	2.0
1992	2.9	1.9	0.0	0.0	4.7
1993	2.1	1.1	0.7	0.0	3.9
1994	1.6	0.1	2.1	0.0	3.9
1995	0.3	0.0	0.5	0.0	0.8
1996	0.8	0.0	0.5	0.0	1.3
1997	1.0	0.1	0.8	0.0	1.8
1998	1.8	0.1	1.2	0.0	3.1
1999	2.0	0.5	2.0	0.0	4.4
2000	3.7	0.4	2.9	0.0	6.9
2001	3.8	0.5	2.9	0.0	7.2
mean	7.2	1.5	0.3	0.3	9.3

Table C2. Sampling history of the Georges Bank yellowtail flounder fishery.

		US					Canada		
			Length Samples						
Year	Half	Trips	Small	Large	Ages	Landings	Trips	Lengths	Landings
1991	1		227	352	173	1011			
	2		627	438	295	724			
	All		854	790	468	1735			
1992	1		401	308	204	1162			
	2		716	517	331	1631			
	All		1117	825	535	2793			
1993	1		468	326	227	1199			
	2		632	774	387	857			
	All		1100	1100	614	2056			
1994	1	1	95	93	53	198			
	2	7	847	596	353	1391			
	All	8	942	689	406	1589			
1995	1	4	235	345	166	161			
	2	1	0	81	23	132			
	All	5	235	426	189	292			
1996	1	3	250	254	146	521			
	2	3	382	274	173	230			
	All	6	632	528	319	751			
1997	1	11	957	726	516	654	3	600	100
	2	1	0	103	63	312	10	2308	709
	All	12	957	829	579	966	13	2908	810
1998	1	7	453	490	231	578	1	2380	36
	2	2	199	284	62	1245	16	3741	1123
	All	9	652	774	293	1823	17	6121	1159
1999	1	7	451	266	195	1160	0	0	
	2	4	251	574	105	906	22	4944	
	All	11	702	840	300	2066	22	4944	1971
2000	1		94	782	200	2223	5	1120	92
	2		598	1288	405	1455	53	13048	2767
	All	11	692	2070	605	3678	58	14168	2859
2001	1	15	696	1055	433	2779			
	2	15	1073	576	381	989			
	All	30	1769	1631	814	3768			

Table C3a. Total catch (thousands) at age of Georges Bank yellowtail flounder.

	Age						
Year	1	2	3	4	5	6+	Total
1973	347	4890	13243	9276	3743	1618	33117
1974	2143	8971	7904	7398	3544	1477	31437
1975	4372	25284	7057	3392	2084	1148	43337
1976	615	31012	5146	1347	532	868	39520
1977	330	8580	9917	1721	394	474	21416
1978	9659	3105	4034	1660	459	174	19091
1979	233	9505	3445	1242	550	272	15247
1980	309	3572	8821	1419	321	99	14541
1981	55	729	5351	4556	796	126	11613
1982	2063	17491	7122	3246	1031	84	31037
1983	696	7689	16016	2316	625	127	27469
1984	428	1917	4266	4734	1592	321	13258
1985	650	3345	816	652	410	65	5938
1986	158	5771	978	347	161	76	7491
1987	140	2653	2751	761	132	112	6549
1988	483	2367	1191	624	165	38	4868
1989	185	1516	668	262	68	19	2718
1990	219	1931	6123	800	107	20	9200
1991	412	54	1222	2430	293	60	4471
1992	2389	8359	2527	1269	510	27	15081
1993	5194	1009	2777	2392	318	75	11765
1994	71	861	5742	2571	910	136	10291
1995	14	157	895	715	137	27	1944
1996	50	383	1509	716	167	15	2841
1997	16	595	1258	1502	341	90	3802
1998	26	971	2792	1824	624	103	6338
1999	21	3287	3209	1498	651	162	8829
2000	100	3731	5747	2824	798	324	13524
2001	217	2754	6866	2585	1007	478	13907
mean	1089	5603	4807	2279	775	297	14850

Table C3b. Total weight (kg) at age of George Bank yellowtail flounder from US and Canadian commercial samples.

	Age						
Year	1	2	3	4	5	6+	mean wt
1973	0.100	0.352	0.462	0.527	0.603	0.776	0.492
1974	0.108	0.345	0.498	0.609	0.680	0.842	0.491
1975	0.111	0.316	0.489	0.554	0.618	0.682	0.366
1976	0.106	0.312	0.542	0.636	0.741	0.835	0.367
1977	0.109	0.342	0.525	0.634	0.782	0.950	0.468
1978	0.100	0.315	0.510	0.684	0.793	0.915	0.297
1979	0.103	0.331	0.460	0.649	0.728	0.893	0.407
1980	0.100	0.325	0.493	0.656	0.813	1.078	0.470
1981	0.099	0.347	0.490	0.603	0.707	0.799	0.542
1982	0.112	0.301	0.486	0.650	0.748	1.055	0.384
1983	0.139	0.296	0.440	0.604	0.736	0.959	0.415
1984	0.162	0.240	0.378	0.500	0.642	0.785	0.436
1985	0.178	0.363	0.497	0.647	0.733	0.812	0.423
1986	0.176	0.342	0.540	0.664	0.823	0.912	0.396
1987	0.112	0.316	0.522	0.666	0.680	0.842	0.455
1988	0.100	0.325	0.555	0.688	0.855	0.985	0.429
1989	0.100	0.345	0.542	0.725	0.883	1.122	0.432
1990	0.100	0.293	0.397	0.577	0.697	0.870	0.388
1991	0.100	0.268	0.368	0.481	0.726	0.852	0.434
1992	0.100	0.295	0.369	0.522	0.647	1.183	0.309
1993	0.100	0.288	0.377	0.507	0.562	0.882	0.282
1994	0.150	0.256	0.350	0.472	0.628	0.863	0.402
1995	0.155	0.249	0.365	0.462	0.582	0.712	0.410
1996	0.137	0.298	0.405	0.568	0.725	0.975	0.449
1997	0.155	0.310	0.410	0.523	0.668	0.968	0.474
1998	0.185	0.333	0.453	0.542	0.670	0.840	0.487
1999	0.210	0.374	0.506	0.637	0.748	0.877	0.503
2000	0.185	0.379	0.480	0.612	0.756	0.962	0.506
2001	0.108	0.287	0.435	0.610	0.812	1.016	0.480
mean	0.128	0.316	0.461	0.593	0.713	0.901	0.425

Table C4a. Survey indices of Georges Bank yellowtail abundance and biomass.

Stratified Mean Number per tow at Age

NEFSC Spring Survey				Age						
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1968	0.149	3.364	3.579	0.316	0.084	0.160	0.127	0.000	7.779	2.813
1969	1.015	9.406	11.119	3.096	1.423	0.454	0.188	0.057	26.758	11.170
1970	0.093	4.485	6.030	2.422	0.570	0.121	0.190	0.000	13.911	5.312
1971	0.791	3.335	4.620	3.754	0.759	0.227	0.050	0.029	13.564	4.607
1972	0.138	7.136	7.198	3.514	1.094	0.046	0.122	0.000	19.247	6.450
1973	1.931	3.266	2.368	1.063	0.410	0.173	0.023	0.020	9.254	2.938
1974	0.316	2.224	1.842	1.256	0.346	0.187	0.085	0.009	6.265	2.719
1975	0.420	2.939	0.860	0.298	0.208	0.068	0.000	0.013	4.806	1.676
1976	1.034	4.368	1.247	0.311	0.196	0.026	0.048	0.037	7.268	2.273
1977	0.000	0.671	1.125	0.384	0.074	0.013	0.000	0.000	2.267	0.999
1978	0.936	0.798	0.507	0.219	0.026	0.000	0.008	0.000	2.494	0.742
1979	0.279	1.933	0.385	0.328	0.059	0.046	0.041	0.000	3.072	1.227
1980	0.057	4.644	5.761	0.473	0.057	0.037	0.000	0.000	11.030	4.456
1981	0.012	1.027	1.779	0.721	0.205	0.061	0.000	0.026	3.830	1.960
1982	0.045	3.742	1.122	1.016	0.455	0.065	0.000	0.026	6.472	2.500
1983	0.000	1.865	2.728	0.531	0.123	0.092	0.061	0.092	5.492	2.642
1984	0.000	0.093	0.809	0.885	0.834	0.244	0.000	0.000	2.865	1.646
1985	0.110	2.198	0.262	0.282	0.148	0.000	0.000	0.000	3.000	0.988
1986	0.027	1.806	0.291	0.056	0.137	0.055	0.000	0.000	2.372	0.847
1987	0.000	0.128	0.112	0.133	0.053	0.055	0.000	0.000	0.480	0.329
1988	0.078	0.275	0.366	0.242	0.199	0.027	0.000	0.000	1.187	0.566
1989	0.047	0.424	0.740	0.290	0.061	0.022	0.022	0.000	1.605	0.729
1990	0.000	0.065	1.108	0.393	0.139	0.012	0.045	0.000	1.762	0.699
1991	0.435	0.000	0.254	0.675	0.274	0.020	0.000	0.000	1.659	0.631
1992	0.000	2.010	1.945	0.598	0.189	0.000	0.000	0.000	4.742	1.566
1993	0.046	0.290	0.500	0.317	0.027	0.000	0.000	0.000	1.180	0.482
1994	0.000	0.621	0.638	0.357	0.145	0.043	0.000	0.000	1.804	0.660
1995	0.040	1.180	4.810	1.490	0.640	0.010	0.000	0.000	8.170	2.579
1996	0.030	0.990	2.630	2.700	0.610	0.060	0.000	0.000	7.020	2.853
1997	0.019	1.169	3.733	4.081	0.703	0.134	0.000	0.000	9.837	4.359
1998	0.000	2.081	1.053	1.157	0.759	0.323	0.027	0.000	5.400	2.324
1999	0.050	4.746	10.820	2.720	1.623	0.426	0.329	0.024	20.738	9.307
2000	0.183	4.819	7.666	2.914	0.813	0.422	0.102	0.000	16.919	6.696
2001	0.000	2.315	6.563	2.411	0.483	0.352	0.101	0.000	12.225	5.008
2002	0.188	2.412	12.333	4.078	1.742	0.378	0.408	0.086	21.624	9.566
mean	0.242	2.366	3.111	1.299	0.448	0.125	0.056	0.012	7.660	3.038

Table C4b. Survey indices of Georges Bank yellowtail abundance and biomass.

Stratified Mean Number per tow at Age										
NEFSC Fall Survey					Age					
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1963	14.722	7.896	11.226	1.858	0.495	0.281	0.034	0.233	36.746	12.791
1964	1.721	9.723	7.370	5.998	2.690	0.383	0.095	0.028	28.007	13.625
1965	1.138	5.579	5.466	3.860	1.803	0.162	0.284	0.038	18.345	9.104
1966	8.772	4.776	2.070	0.837	0.092	0.051	0.000	0.000	17.775	3.989
1967	9.137	9.313	2.699	1.007	0.309	0.076	0.061	0.000	22.708	7.577
1968	11.782	11.946	5.758	0.766	0.944	0.059	0.000	0.000	31.254	10.535
1969	8.106	10.381	5.855	1.662	0.553	0.149	0.182	0.000	27.023	9.278
1970	4.610	5.133	3.144	1.952	0.451	0.063	0.017	0.000	16.417	4.978
1971	3.627	6.949	4.904	2.248	0.551	0.234	0.024	0.024	18.586	6.362
1972	2.424	6.525	4.824	2.095	0.672	0.279	0.000	0.000	17.604	6.328
1973	2.494	5.497	5.104	2.944	1.216	0.416	0.171	0.031	17.967	6.600
1974	4.623	2.854	1.524	1.060	0.460	0.249	0.131	0.000	11.931	3.734
1975	4.625	2.511	0.877	0.572	0.334	0.033	0.000	0.031	9.344	2.365
1976	0.336	1.929	0.475	0.117	0.122	0.033	0.000	0.067	3.079	1.533
1977	0.928	2.161	1.649	0.618	0.113	0.056	0.036	0.016	5.577	2.828
1978	4.729	1.272	0.773	0.406	0.139	0.011	0.000	0.024	7.391	2.383
1979	1.312	1.999	0.316	0.122	0.138	0.038	0.064	0.007	4.014	1.520
1980	0.761	5.086	6.050	0.678	0.217	0.162	0.006	0.033	13.071	6.722
1981	1.584	2.333	1.630	0.500	0.121	0.083	0.013	0.000	6.264	2.621
1982	2.424	2.185	1.590	0.423	0.089	0.000	0.000	0.000	6.711	2.271
1983	0.109	2.284	1.914	0.473	0.068	0.012	0.000	0.038	4.898	2.131
1984	0.661	0.400	0.306	2.428	0.090	0.029	0.000	0.018	3.944	0.593
1985	1.350	0.560	0.160	0.040	0.080	0.000	0.000	0.000	2.200	0.709
1986	0.280	1.110	0.350	0.070	0.000	0.000	0.000	0.000	1.810	0.820
1987	0.113	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031	0.509
1988	0.019	0.213	0.102	0.031	0.000	0.000	0.000	0.000	0.376	0.171
1989	0.248	1.992	0.774	0.069	0.066	0.000	0.000	0.000	3.176	0.977
1990	0.000	0.326	1.517	0.280	0.014	0.000	0.000	0.000	2.284	0.725
1991	2.100	0.275	0.439	0.358	0.000	0.000	0.000	0.000	3.172	0.730
1992	0.151	0.396	0.712	0.162	0.144	0.027	0.000	0.000	1.592	0.576
1993	0.842	0.136	0.587	0.536	0.000	0.000	0.000	0.000	2.101	0.545
1994	1.200	0.220	0.980	0.710	0.260	0.030	0.030	0.000	3.440	0.897
1995	0.280	0.120	0.350	0.280	0.050	0.010	0.000	0.000	1.160	0.354
1996	0.140	0.350	1.870	0.450	0.070	0.000	0.000	0.000	2.880	1.303
1997	1.392	0.533	3.442	2.090	1.071	0.082	0.000	0.000	8.611	3.781
1998	1.900	4.817	4.202	1.190	0.298	0.055	0.019	0.000	12.531	4.347
1999	3.090	8.423	5.727	1.432	1.436	0.260	0.000	0.000	20.394	7.973
2000	0.629	1.697	4.814	2.421	0.948	0.800	0.027	0.000	11.355	5.838
2001	3.518	6.268	8.091	2.601	1.718	0.714	1.334	0.000	24.282	11.553
mean	2.766	3.501	2.821	1.164	0.459	0.124	0.065	0.015	11.053	4.146

Table C4c. Survey indices of Georges Bank yellowtail abundance and biomass.

Stratified Mean Number per tow at Age

Canadian Survey	Age							
Year	1	2	3	4	5	6+	Total	kg/tow
1987	0.12	0.68	2.00	1.09	0.06	0.00	3.95	1.26
1988	0.00	0.66	1.89	0.80	0.59	0.01	3.96	1.24
1989	0.11	0.78	0.80	0.32	0.10	0.02	2.13	0.47
1990	0.00	1.27	4.62	1.12	0.43	0.01	7.45	1.58
1991	0.02	0.59	1.72	2.91	0.99	0.00	6.24	1.76
1992	0.22	10.04	4.52	1.21	0.16	0.00	16.14	2.48
1993	0.33	2.16	5.04	3.47	0.62	0.00	11.63	2.64
1994	0.00	6.03	3.33	3.08	0.75	0.33	13.51	2.75
1995	0.21	1.31	4.07	2.22	1.14	0.11	9.07	2.03
1996	0.45	5.54	8.44	7.49	1.37	0.16	23.45	5.30
1997	0.10	9.48	15.16	19.09	3.11	0.54	47.49	13.29
1998	0.92	3.10	3.81	5.15	2.44	0.59	16.01	4.29
1999	0.22	13.05	24.78	9.07	6.85	3.10	57.07	17.67
2000	0.06	9.18	31.22	18.56	5.77	4.42	69.22	19.95
2001	0.29	5.97	51.67	16.65	4.41	3.61	82.62	22.16
2002							63.49	20.62
mean	0.20	4.66	10.87	6.15	1.92	0.86	27.09	7.47

Scallop Survey	
Year	age 1
1982	0.313
1983	0.140
1984	0.233
1985	0.549
1986	0.103
1987	0.047
1988	0.116
1989	0.195
1990	0.100
1991	2.117
1992	0.167
1993	1.129
1994	1.503
1995	0.609
1996	0.508
1997	1.062
1998	1.872
1999	1.038
2000	0.912
2001	0.789
2002	1.005
mean	0.691

Table C5a. Estimates of stock size from virtual population analysis.

STOCK NUMBERS (Jan 1) in thousands

Age	1973	1974	1975	1976	1977	1978	1979
1	28290	50265	68516	22919	15760	50823	23375
2	23279	22848	39214	52140	18208	12605	32871
3	28937	14635	10589	9228	14628	7144	7510
4	16960	11709	4830	2284	2899	3003	2199
5	6729	5492	2893	885	651	816	957
6	2859	2240	1551	1417	768	304	465
1+	107055	107189	127593	88873	52914	74695	67376

Age	1980	1981	1982	1983	1984	1985	1986
1	22099	61066	21627	5818	8620	14594	6660
2	18927	17814	49947	15840	4134	6670	11361
3	18312	12264	13925	25067	6011	1650	2434
4	3032	7011	5199	4957	6031	1062	613
5	677	1198	1618	1319	1962	654	279
6	206	185	129	264	382	102	129
1+	63252	99538	92445	53266	27141	24732	21476

Age	1987	1988	1989	1990	1991	1992	1993
1	7023	19349	8528	11685	22048	15873	11798
2	5310	5623	15405	6815	9369	17679	10834
3	4079	1947	2462	11241	3832	7622	6910
4	1108	851	516	1411	3663	2032	3954
5	188	219	132	185	432	800	515
6	155	49	36	34	86	41	119
1+	17863	28037	27079	31372	39430	44047	34131

Age	1994	1995	1996	1997	1998	1999	2000
1	9988	12714	17661	33375	58222	53641	48490
2	4960	8113	10397	14414	27311	47645	43898
3	7957	3282	6500	8165	11263	21482	36034
4	3145	1319	1877	3957	5547	6695	14684
5	1073	249	433	889	1880	2891	4126
6	154	48	38	232	308	715	1666
1+	27276	25724	36906	61032	104531	133068	148898

Age	2001	2002
1	50544	00
2	39609	41186
3	32565	29938
4	24302	20449
5	9467	17558
6	4477	10074
1+	160964	119205

Table C5b. Estimates of fishing mortality from VPA.

FISHING MORTALITY

	1973	1974	1975	1976	1977	1978	1979
1	0.01	0.05	0.07	0.03	0.02	0.24	0.01
2	0.26	0.57	1.25	1.07	0.74	0.32	0.39
3	0.70	0.91	1.33	0.96	1.38	0.98	0.71
4	0.93	1.20	1.50	1.05	1.07	0.94	0.98
5	0.95	1.25	1.59	1.09	1.10	0.97	1.01
6	0.95	1.25	1.59	1.09	1.10	0.97	1.01

	1980	1981	1982	1983	1984	1985	1986
1	0.02	0.00	0.11	0.14	0.06	0.05	0.03
2	0.23	0.05	0.49	0.77	0.72	0.81	0.82
3	0.76	0.66	0.83	1.22	1.53	0.79	0.59
4	0.73	1.27	1.17	0.73	2.02	1.14	0.98
5	0.74	1.33	1.22	0.74	2.27	1.18	1.01
6	0.74	1.33	1.22	0.74	2.27	1.18	1.01

	1987	1988	1989	1990	1991	1992	1993
1	0.02	0.03	0.02	0.02	0.02	0.18	0.67
2	0.80	0.63	0.12	0.38	0.01	0.74	0.11
3	1.37	1.13	0.36	0.92	0.43	0.46	0.59
4	1.42	1.66	0.82	0.98	1.32	1.17	1.10
5	1.50	1.79	0.84	1.02	1.39	1.22	1.15
6	1.50	1.79	0.84	1.02	1.39	1.22	1.15

	1994	1995	1996	1997	1998	1999	2000
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.21	0.02	0.04	0.05	0.04	0.08	0.10
3	1.60	0.36	0.30	0.19	0.32	0.18	0.19
4	2.34	0.91	0.55	0.54	0.45	0.28	0.24
5	2.77	0.94	0.56	0.55	0.46	0.29	0.24
6	2.77	0.94	0.56	0.55	0.46	0.29	0.24

	2001
1	0.00
2	0.08
3	0.27
4	0.13
5	0.13
6	0.13

Table C5c. Estimates of spawning biomass from VPA.

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1973	1974	1975	1976	1977	1978	1979
1	00	00	00	00	00	00	00
2	2836	2575	3052	4310	1898	1440	3837
3	8895	4500	2678	3026	3891	2185	2320
4	5531	3982	1319	861	1084	1275	873
5	2509	2042	848	383	296	397	421
6	1372	1031	502	691	424	171	251
1+	21143	14130	8398	9271	7592	5469	7702

	1980	1981	1982	1983	1984	1985	1986
1	00	00	00	00	00	00	00
2	2310	2733	5527	1534	629	1480	2358
3	5930	4161	4356	6031	1103	543	947
4	1351	2295	1908	2035	1195	394	248
5	371	449	670	656	450	270	139
6	150	78	75	171	107	46	71
1+	10112	9716	12537	10427	3485	2732	3763

	1987	1988	1989	1990	1991	1992	1993
1	00	00	00	00	00	00	00
2	1027	1205	4334	1461	2143	1834	1422
3	1108	621	1058	2797	1083	2139	1610
4	375	269	244	497	935	599	1164
5	63	82	75	78	162	286	165
6	64	21	26	18	38	27	60
1+	2638	2198	5739	4850	4360	4885	4421

	1994	1995	1996	1997	1998	1999	2000
1	00	00	00	00	00	00	00
2	556	958	1457	2097	4279	8248	7639
3	1133	816	1841	2451	3533	7978	12623
4	516	383	781	1518	2292	3486	7484
5	195	90	229	434	958	1766	2596
6	38	21	27	164	196	512	1334
1+	2438	2268	4335	6663	11258	21989	31677

	2001
1	00
2	5260
3	10035
4	12946
5	6713
6	3976
1+	38932

Table C6. Projection input and short term output from the age based assessment. The fishing mortality rate in 2003 and 2004 is $F_{rebuild.}$

M = 0.2

Age	Weight (kg)	Maturity	Selectivity
1	0.181	0	0.006
2	0.349	0.52	0.315
3	0.462	0.86	0.648
4	0.578	0.98	1
5	0.710	1	1
6+	0.948	1	1

Year	F	SSB	Catch
2002	0.11	47.73	4.60
2003	0.22	50.87	10.10
2004	0.22	50.71	10.11

Figure C1. Total catch of Georges Bank yellowtail flounder.

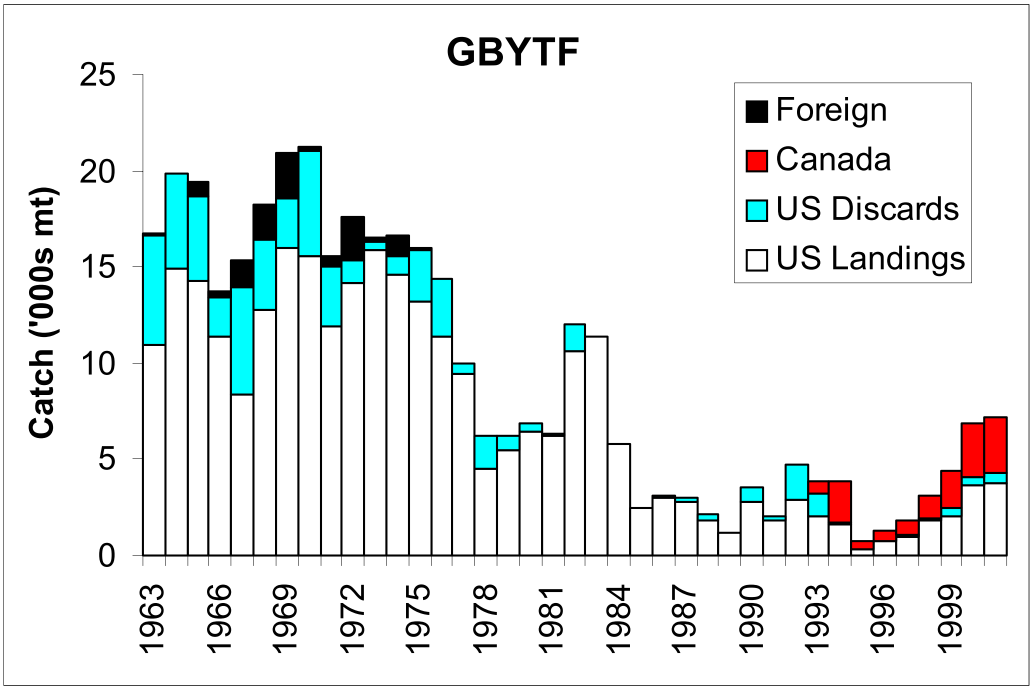


Figure C2. Survey indices of Georges Bank yellowtail flounder biomass.

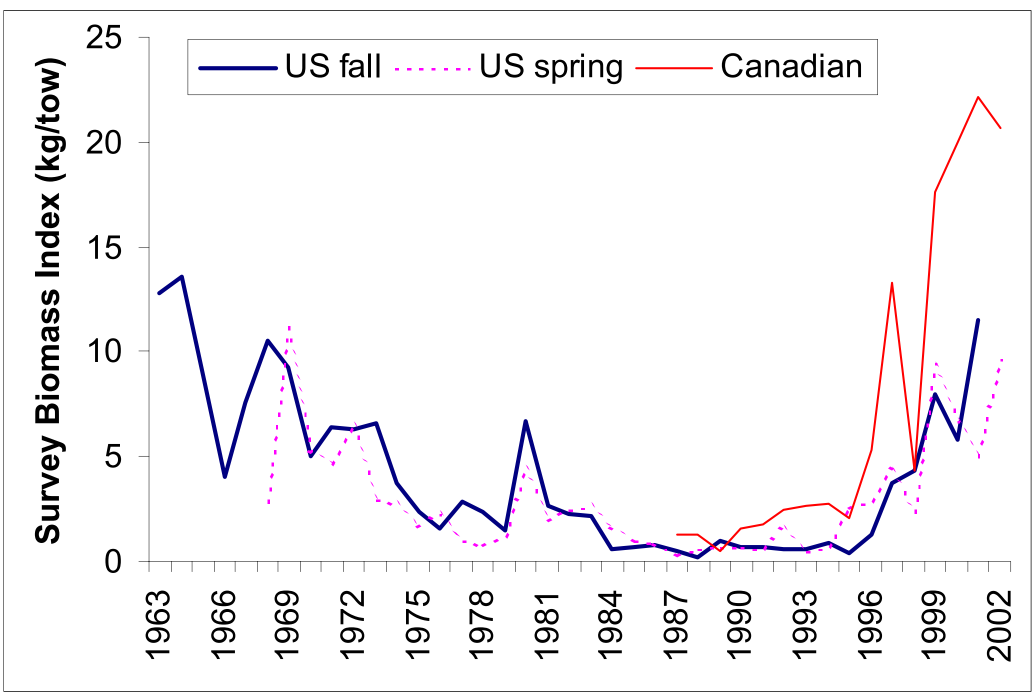


Figure C3. Survey indices of abundance at age. Note that the NEFSC Spring and Fall surveys correspond to the left axes in each plot while the NEFSC scallop and the Canadian surveys correspond to the right axes in each plot.

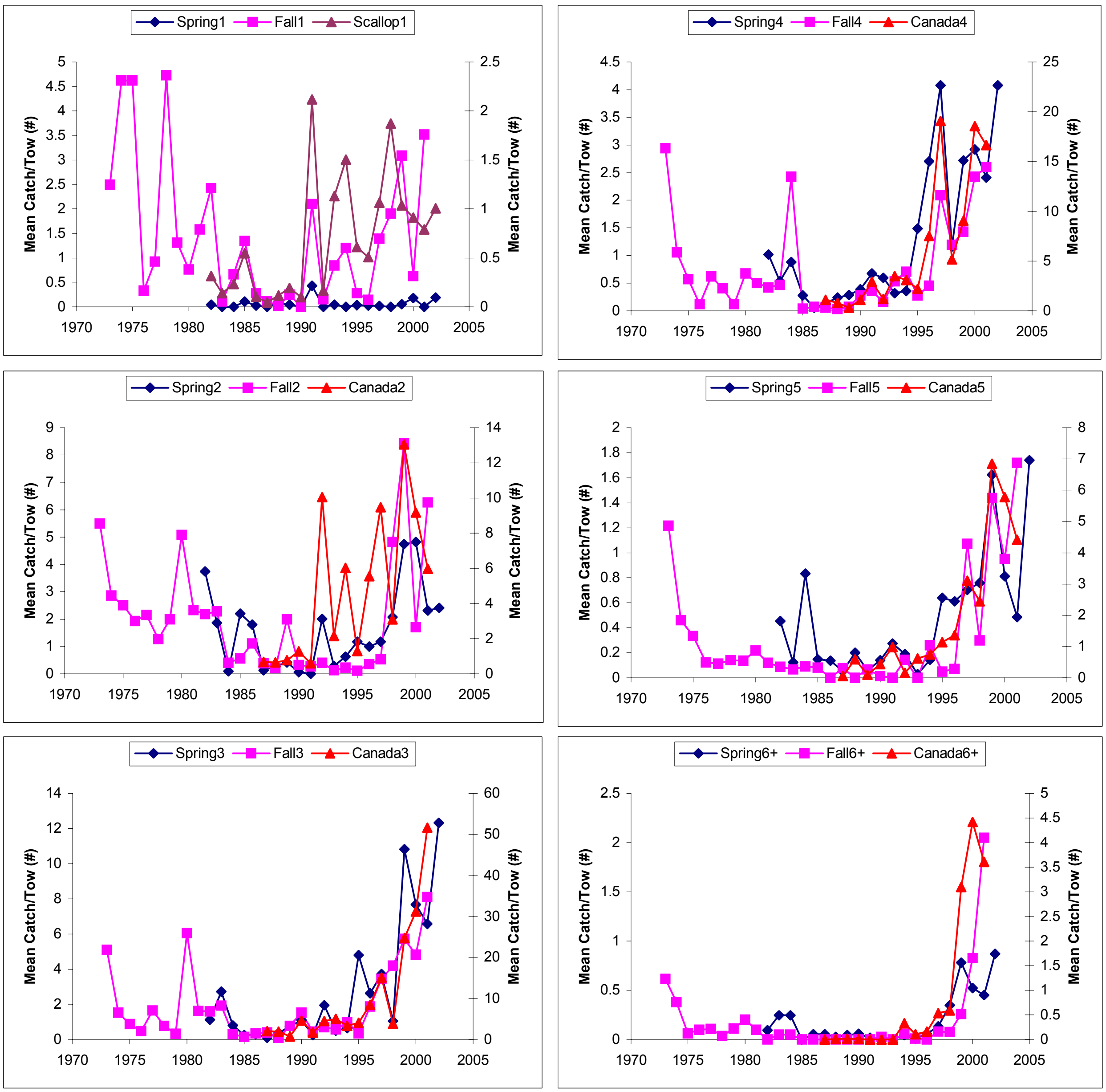


Figure C4. Summary of Georges Bank yellowtail flounder VPA results.

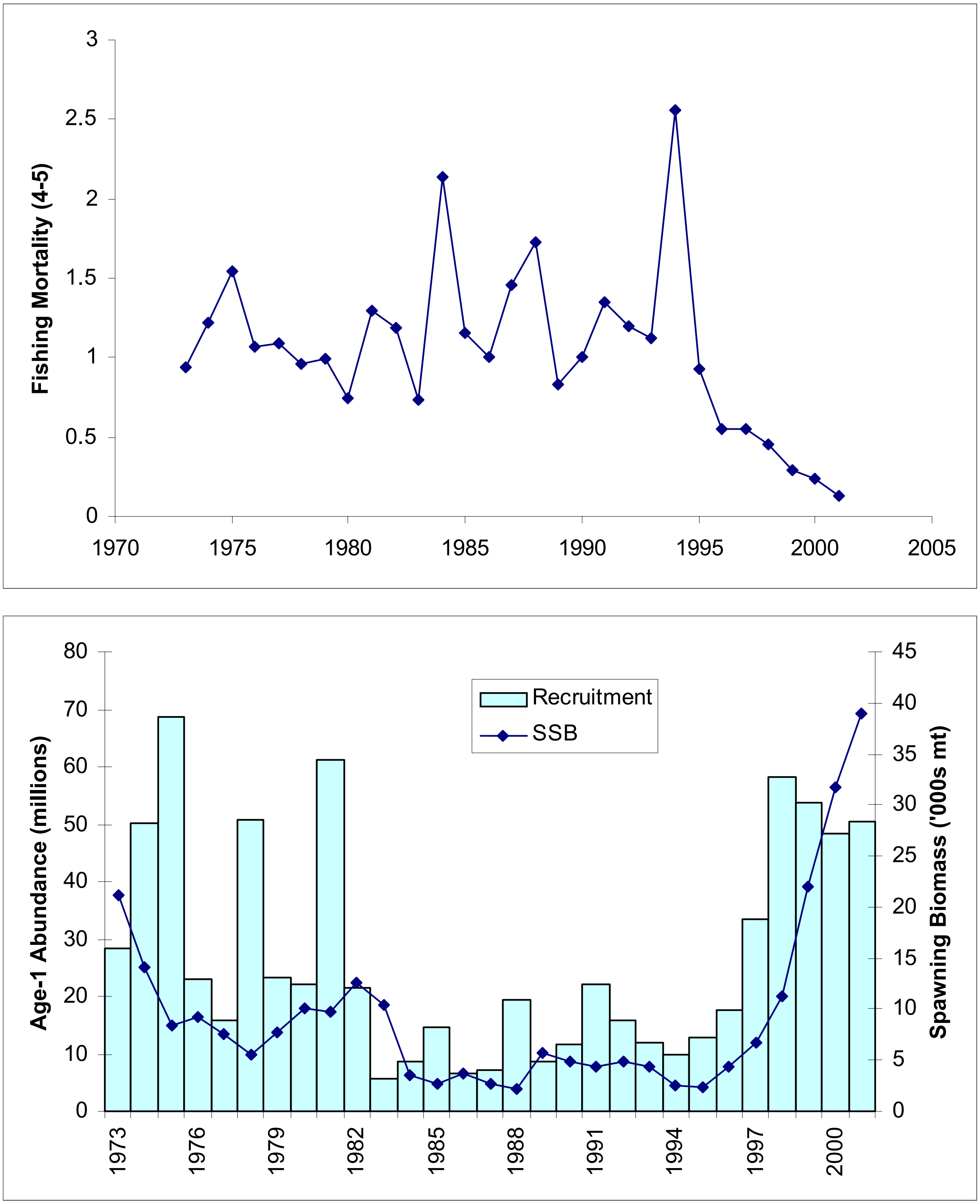


Figure C5. Population abundance at age from VPA compared to equilibrium levels at MSY.

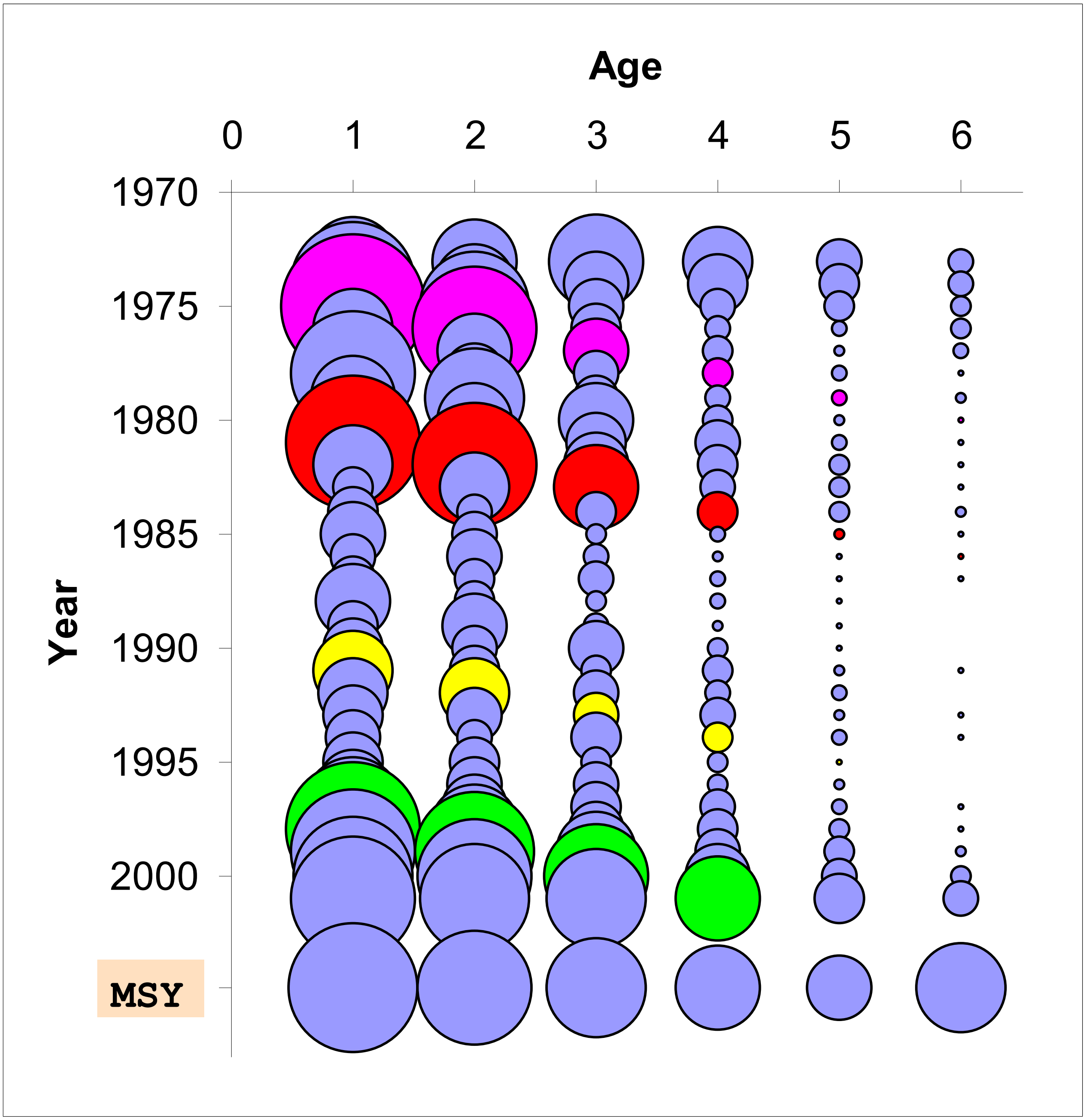


Figure C6. Retrospective patterns in Georges Bank yellowtail flounder VPA.

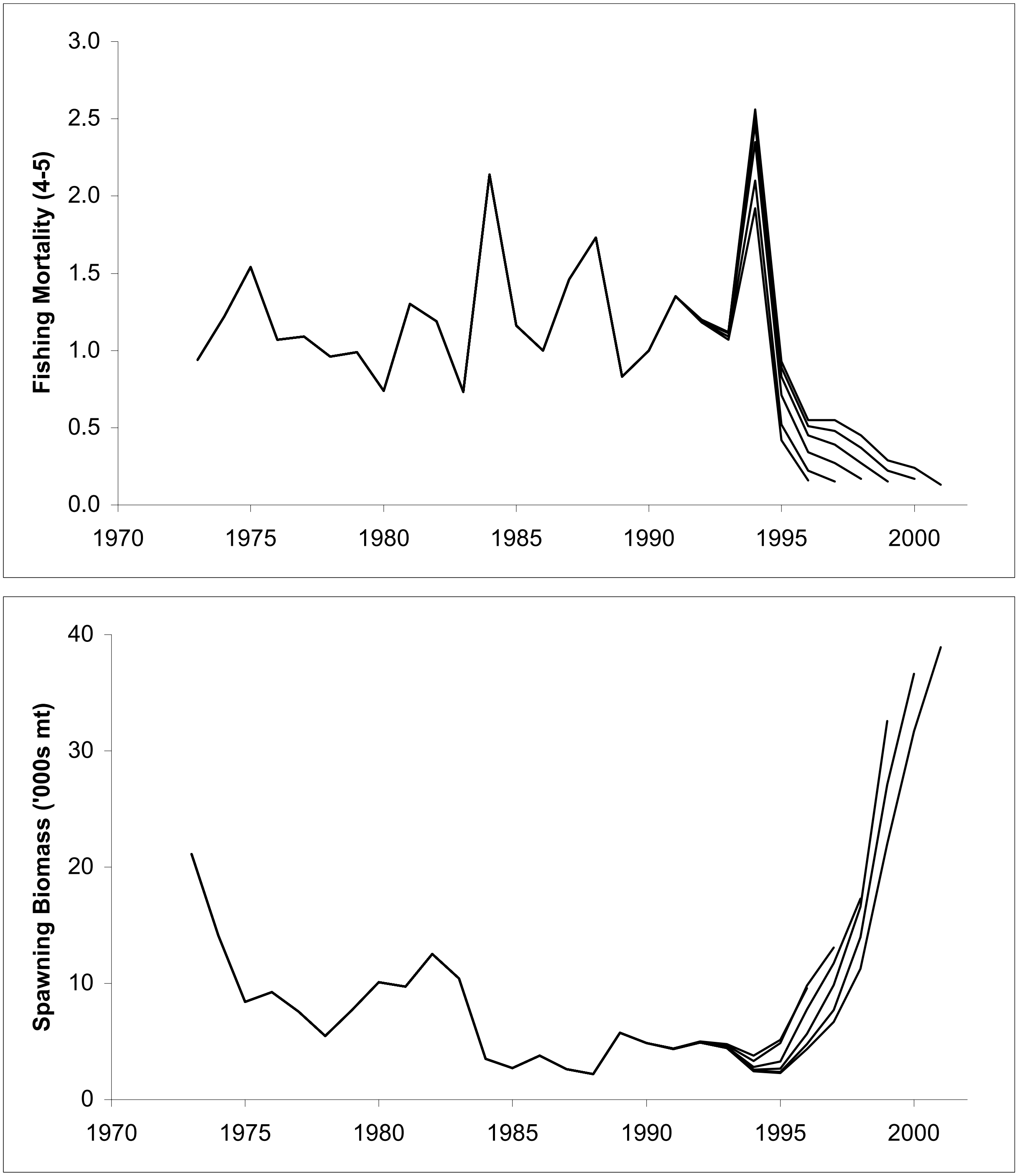


Figure C7. Point estimate (center symbol) and 80% confidence intervals (end symbols) for F and SSB in 2001 for the base run and three sensitivity analyses which increased the impacted survey catches.

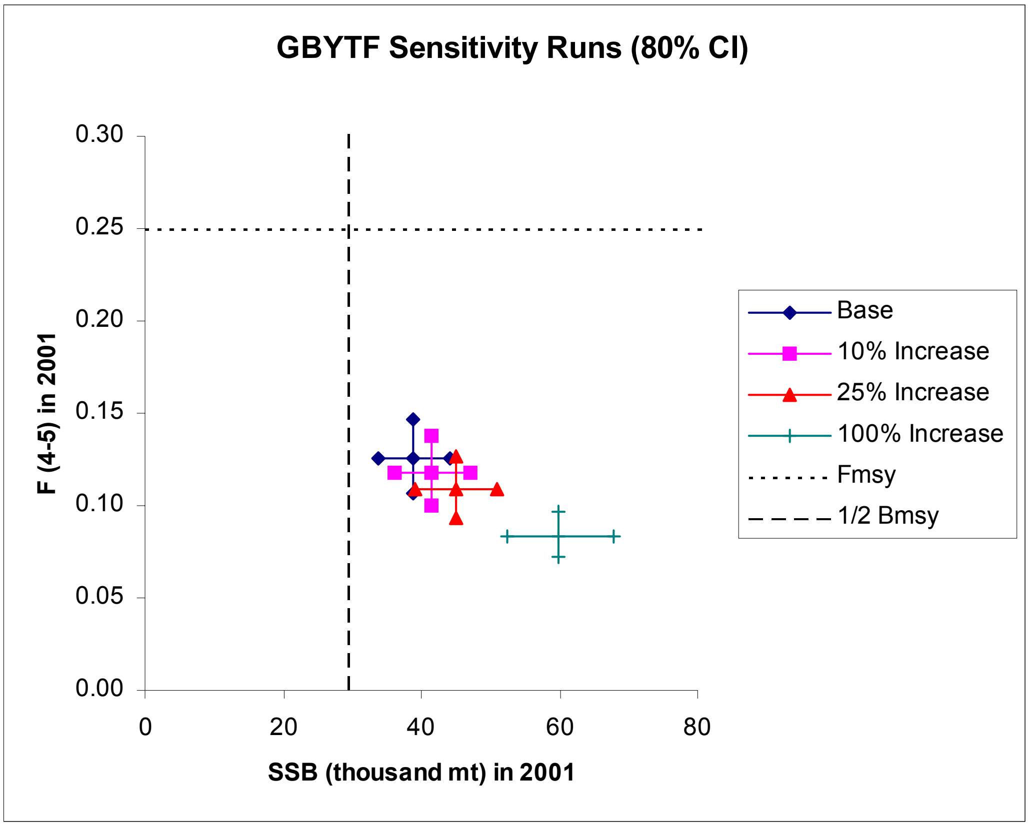


Figure C8. Projected spawning stock biomass under $F_{Rebuild}$=0.22 in years 2003 through 2009 to achieve a 50% probability of Bmsy in 2009.

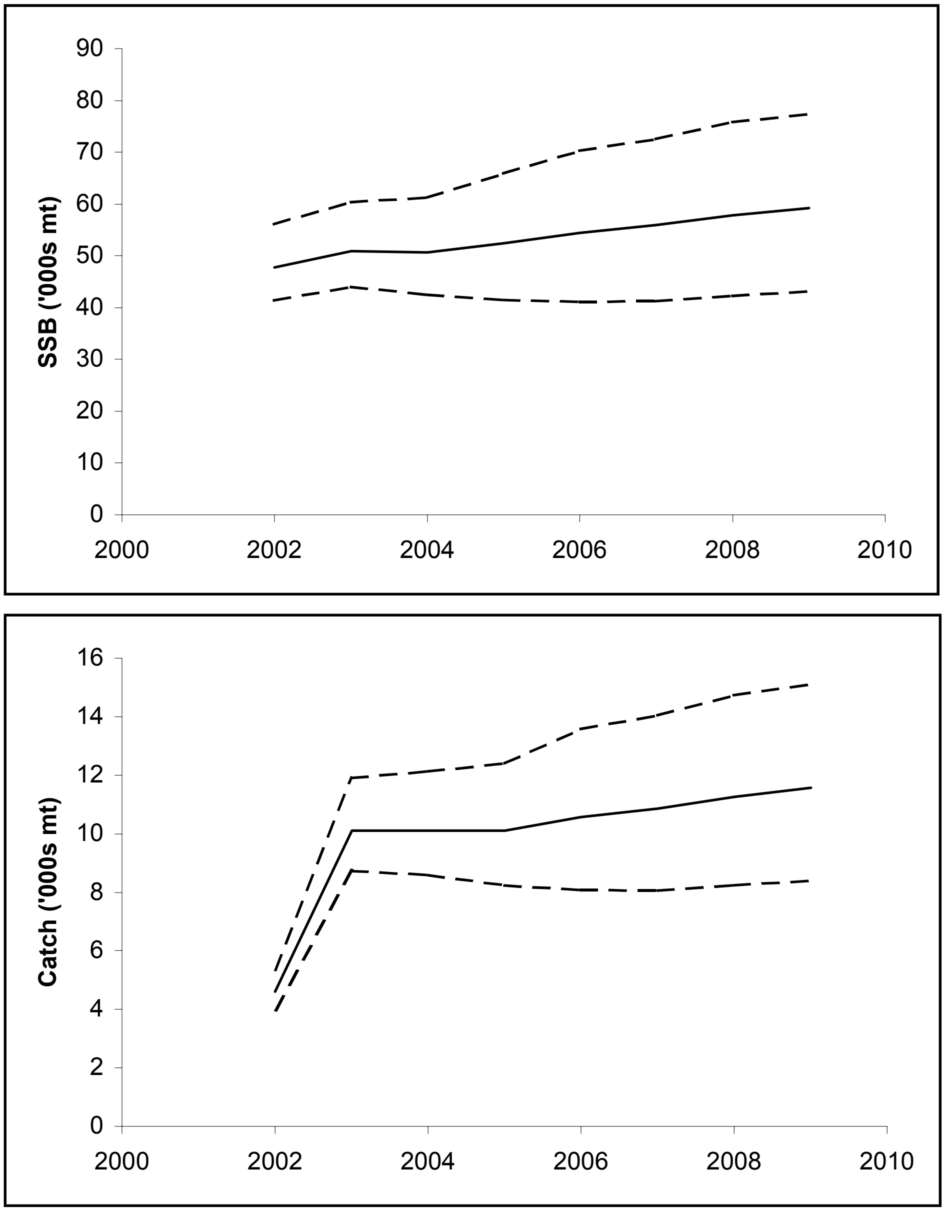
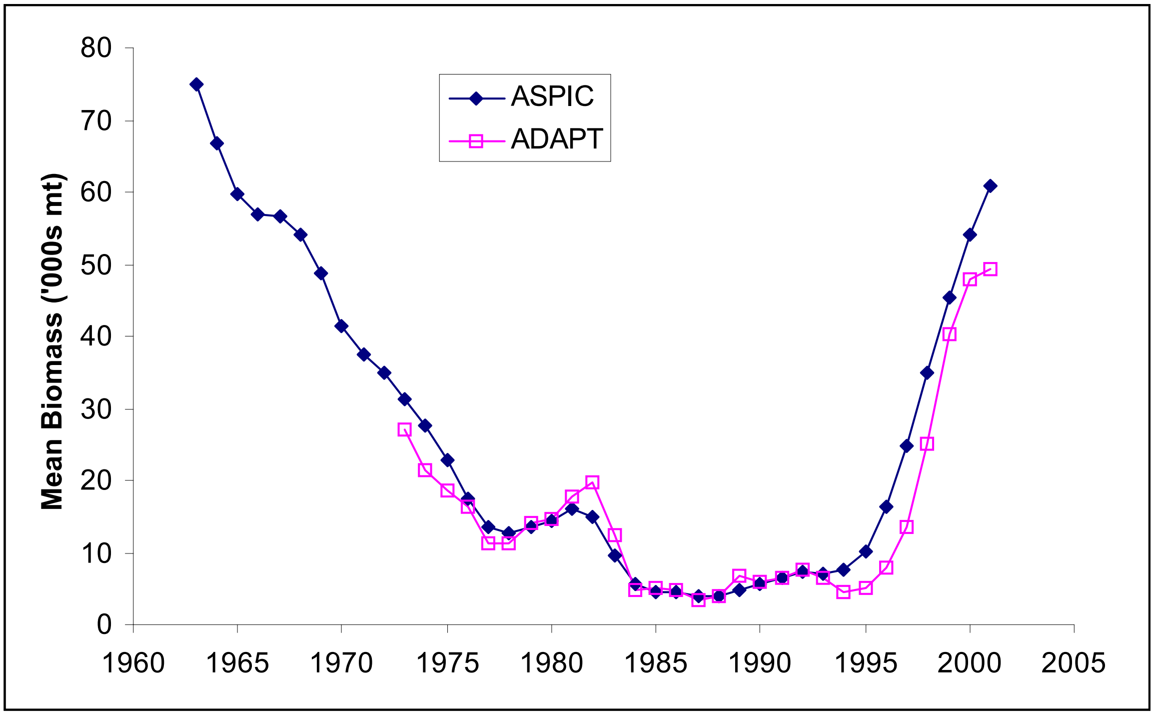
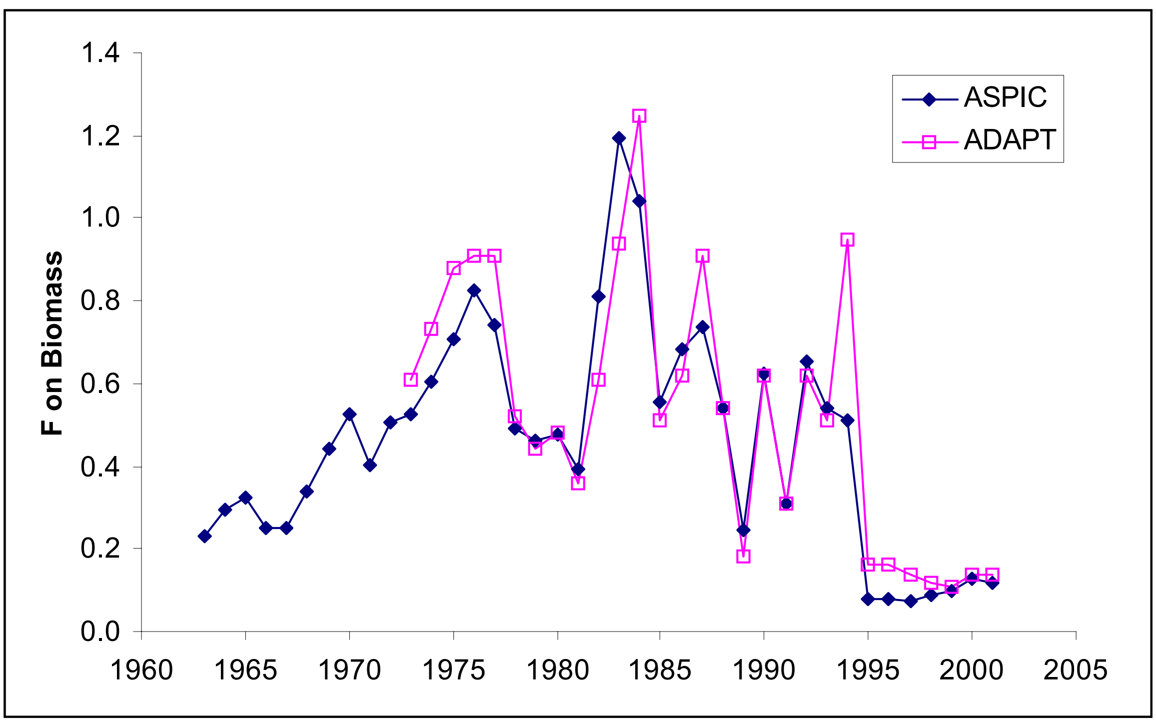


Figure C9. Mean biomass of Georges Bank yellowtail flounder and fishing mortality on biomass.





D. Southern New England Yellowtail Flounder by S.X. Cadrin

1.0 Background

The southern New England yellowtail stock was at low biomass and relatively low F in 1999 (SSB was 5,400 mt and fully recruited F was 0.3; Cadrin 2001). This report updates catch and survey indices, and estimates 2001 fishing mortality and 2002 stock size. In August 2002, the Southern Demersal Working Group concluded that southern New England and Mid Atlantic yellowtail flounder should be assessed and managed as a single unit stock, and is concurrently preparing an assessment of the southern New England- Mid Atlantic yellowtail resource (Cadrin 2002). In September 2002, the Working Group reviewed input data, analyses and projections in this report.

2.0 2002 Assessment

2.1 2000-2001 Landings

U.S. landings were prorated as described in NEFSC (1998; Table D1; Figure D1). Landings from southern New England have steadily increased since 1999 (a 9% increase in 2000 and an 11% increase in 2001). Sampling in 2000 and 2001 improved from that in 1999 (Table D2). Although all classified market categories were sampled in each half-year period, the overall number of samples was low. Landings at length for 2001 and 2002 were estimated by half-year and market category. Landings at age for 1999 were revised by assuming the average age distribution for July to December in 1998, 2000 and 2001 for landings in the second half of 1999.

2.2 2000-2001 Discards

Discarded catch was estimated from logbook information on discard to kept ratios by half-year and gear (NEFSC 1998). Discards were 5% of landings by weight in 2000 and 2001. Discards at age were estimated from observer lengths and survey age-length keys, however length distribution of scallop dredge discards were only sampled in the second half of 2000. Those samples were used to characterize all 2000-2001 dredge discards. Total catch at age and mean weights at age are reported in Table D3.

2.3 2000-2002 Survey Indices

Survey abundance and biomass indices are reported in Table D4. Estimates are from valid tows in southern New England (offshore strata 5, 6, 9, 10; scallop strata 33, 34, 35, 46), standardized according to net, vessel, and door changes (NEFSC 1998). All survey indices of total abundance and total biomass remained low in recent years (Figure D2).

3.0 Assessment Results

3.1 Age-Based Analysis

Results of an updated VPA calibration of southern New England yellowtail are summarized in Table D5. This update uses existing stock definitions, i.e., Southern New England yellowtail flounder is a single stock. This analysis updates the assessment reported by Cadrin (2000) by including 1999-2001 landings and discards, 1999-2000 scallop and fall indices, and 2000-2002 winter and spring indices. Note that a VPA was updated in 2000, but was rejected because of inadequate sampling of catch at age in 1999 (see Cadrin 2000 for details). Results indicate that fishing mortality increased to 1.58 in 1999, and decreased to 0.54 and 0.46 in 2000 and 2001 (Figure D3). Spawning biomass increased from extremely low levels in the middle 1990s to 1,400 mt in 1999 and 2,000 mt in 2000, but slightly decreased to 1,900 mt in 2001. Retrospective analysis indicates a strong pattern of underestimating F, and overestimating SSB in recent years, but the estimates of 2000 F and SSB were much more consistent than those from 1994-1999 (Figure D4). Bootstrap analysis indicates that abundance was estimated with moderate precision (CV=38-47%). Sensitivity to recent NEFSC survey observations was evaluated by arbitrarily increasing recent NEFSC survey observations by 10%, 25%, and 100% (Figure D7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

Proxies for MSY reference points were derived from yield and SSB per recruit analyses and the assumption of constant recruitment (NEFSC 2002). Assuming that F_{MSY} is approximately $F_{40\%}$ (0.27 on fully-recruited ages) and long-term average recruitment (40.7 million at age-1), MSY=9,000 mt and SSB_{MSY}=45,200 mt. Therefore, despite uncertainty in the assessment, the stock is clearly overfished (2001 SSB= 1,900mt, 4%SSB_{MSY}) and overfishing is occurring (2001 F=0.46, =1.7 · F_{MSY}).

Stochastic projections that assume a 15% reduction in F from 2001 to 2002 and recruitment similar to that experienced in the last decade suggest that the stock cannot rebuild to B_{MSY} by 2009 even if F in 2003-2010 is zero. If the same hindcast recruitment values used to derive the reference points (NEFSC 2002) are assumed for projections, therefore stock is expected to have approximately a 50% chance of rebuilding to SSB_{MSY} by 2009 with an F of 0.10 (Figure D5, Table D6). However, long-term recruitment levels are not likely in the short-term, because SSB is extremely low, and retrospective patterns indicate that projections may be overly optimistic.

3.2 Biomass-Based Analysis

Due to continued low intensity of sampling and resulting problems estimating catch at age, a surplus production analysis (ASPIC) was updated to provide alternative perspectives on stock status. Biomass and F estimates are generally similar to the VPA, but biomass estimates in recent years are substantially greater than those from VPA (Figure D6). Despite the more optimistic perspective from ASPIC, stock biomass in 2001 remains only 15% of the ASPIC estimate of B_{MSY}. Therefore, ASPIC results also suggest that the stock is overfished. Stochastic projections at status quo F in 2002 and F=0 for 2003-2009 indicate a 25% probability of rebuilding to the ASPIC estimate of B_{MSY} by 2009.

4.0 Sources of Uncertainty

- Estimates of recent catch at age may not be reliable due to poor sampling intensity. Therefore VPA and age-based projections may be misleading. Retrospective patterns may indicate inadequate sampling and mis-allocation of catch at age.
- Retrospective patterns indicate that VPA estimates of biomass and F may be overly optimistic. Updated VPAs may indicate that 2001 biomass levels were lower, and 2001 F greater than reported here.

- Although historical perspective from production models are valuable, current biomass levels may not be reliable, because recruitment is implicitly assumed to be a function of stock biomass.
- Inappropriate stock delineation may result in underestimated removals (e.g., from adjacent areas in the Mid Atlantic Bight).
- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.

5.0 GARM Discussion

The GARM noted that the Nantucket Lightship Closure does not appear to be helping recovery of this species. Abundance and size structure within the closed area does not appear to be significantly different from outside the area.

The question of what recruitment is appropriate for projections was raised. Using only the recent ten years of recruitment results in zero probability of rebuilding to SSB_{MSY} because these recruitment values are so low. Using the entire time series of recruitment for projections does allow for rebuilding with F greater than zero. The GARM suggested that an interim rebuilding target may be derived from short-term recruitment (average=2.4 million) and 40% maximum SSB per recruit. The expected biomass at $F_{40\%}$ and short term recruitment is 2,700mt SSB, and current SSB is approximately 70% of the proposed interim target.

It was suggested that a jackknife approach be used to quantify the uncertainty in the generation of the catch at age.

6.0 References

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NEFSC (Northeast Fisheries Science Center). 1998. Southern New England yellowtail flounder. NEFSC Ref. Doc. 98-15: 328-350.

NEFSC (Northeast Fisheries Science Center). 2002. Final report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. 19 March, 2002.

Table D1. Landings and catch of southern New England yellowtail flounder (thousand mt).

	US Landings	US discards	Industrial landings	Foreign landings	total catch
1960	7.8	3.2	0.5		11.5
1961	11.6	4.7	0.7		17.0
1962	13.1	5.3	0.2		18.6
1963	22.0	5.9	0.3	0.2	27.9
1964	19.0	10.0	0.5		29.0
1965	18.4	9.4	1.0	1.4	27.8
1966	14.9	8.7	2.7	0.7	23.6
1967	10.8	15.0	4.5	2.8	25.8
1968	14.3	13.7	3.9	3.5	28.0
1969	11.4	24.2	4.2	17.6	35.6
1970	13.1	9.3	2.1	2.5	22.4
1971	8.2	4.0	0.4	0.3	12.2
1972	8.2	5.0	0.3	3.0	13.2
1973	6.9	1.5	0.3	0.2	8.4
1974	6.4	8.7		0.1	15.1
1975	3.2	1.9			5.1
1976	1.6	1.6			3.2
1977	2.8	1.9			4.7
1978	2.3	5.0			7.3
1979	5.3	4.4			9.7
1980	6.0	1.7			7.7
1981	4.7	1.2			5.9
1982	10.3	5.0			15.3
1983	17.0	3.5			20.5
1984	7.9	1.1			9.0
1985	2.7	1.2			3.9
1986	3.3	1.1			4.4
1987	1.6	0.9			2.5
1988	0.9	1.8			2.7
1989	2.5	5.5			8.0
1990	8.0	9.7			17.7
1991	3.9	2.3			6.2
1992	1.4	1.1			2.5
1993	0.5	0.1			0.6
1994	0.2	0.1			0.3
1995	0.2	0.1			0.2
1996	0.3	0.1			0.4
1997	0.2	0.0			0.3
1998	0.4	0.1			0.5
1999	0.7	0.1			0.8
2000	0.7	0.0			0.8
2001	0.8	0.0			0.9

Table D2. Samples of southern New England yellowtail flounder (italics indicate observer lengths).

Number of Fish Sampled

year	half year	unclassified length	large lengths	small lengths	ages	# of observer trips
1993	1	0	347	625	189	11
	2	0	72	234	73	3
1994	1	0	102	133	52	4
	2	0	252	254	143	6
1995	1	0	234	240	121	6
	2	0	94	146	50	3
1996	1	0	0	0	0	0
	2	0	469	691	226	13
1997	1	0	813	803	317	18
	2	0	328	679	133	11
1998	1	49	283	596	202	8
	2	80	0	126	37	2
1999	1	*154*	272	408	333	9
	2	*0*	0	0	0	0
2000	1	*170*	304	103	621	11
	2	*178*	214	177	363	17
2001	1	*249*	191	263	710	9
	2	*263*	175	313	514	9

Table D3a. Catch at age (thousands) of southern New England yellowtail flounder.

	age 1	age 2	age 3	age 4	age 5	age 6	age 7+
1973	188	5056	8299	4673	1716	1517	312
1974	858	28334	4715	5098	2500	950	1217
1975	8840	3779	1497	983	1257	549	471
1976	214	6599	912	245	337	391	355
1977	5442	4771	3973	392	205	253	283
1978	8698	13311	1495	1025	165	34	72
1979	204	19225	8371	1033	428	96	24
1980	988	9998	6342	3619	472	117	31
1981	38	6745	6737	2449	884	128	14
1982	169	35130	13693	1744	404	78	7
1983	2526	18430	38615	3364	376	129	42
1984	510	5731	14843	6661	740	244	21
1985	2230	7015	1516	1312	774	135	31
1986	462	9680	2921	561	324	119	22
1987	1590	3404	2033	803	139	47	9
1988	5899	2050	508	407	101	17	6
1989	24	19215	3103	411	47	3	0
1990	192	2048	42185	2025	79	5	0
1991	445	1607	5050	9489	93	1	17
1992	477	1453	1982	2347	279	11	3
1993	13	423	376	426	124	40	0
1994	9	150	222	165	132	49	1
1995	7	248	163	210	30	4	3
1996	21	305	496	151	29	13	6
1997	1	56	351	150	15	2	3
1998	0	388	478	179	34	5	1
1999	3	72	1446	180	56	13	5
2000	31	456	834	336	12	2	2
2001	1	235	1161	300	84	18	9

Table D3b. Mean weight at age (kg) of southern New England yellowtail flounder catch.

	age 1	age 2	age 3	age 4	age 5	age 6	age 7+
1973	0.210	0.298	0.381	0.420	0.430	0.506	0.611
1974	0.203	0.308	0.359	0.429	0.477	0.476	0.518
1975	0.218	0.290	0.385	0.439	0.436	0.469	0.515
1976	0.228	0.303	0.427	0.528	0.533	0.568	0.603
1977	0.215	0.284	0.385	0.521	0.529	0.484	0.612
1978	0.234	0.296	0.402	0.543	0.710	0.791	0.677
1979	0.189	0.301	0.366	0.476	0.590	0.684	0.679
1980	0.206	0.281	0.384	0.499	0.690	0.891	1.182
1981	0.140	0.262	0.343	0.484	0.619	0.664	0.476
1982	0.226	0.263	0.354	0.502	0.661	0.821	0.956
1983	0.175	0.262	0.341	0.499	0.671	0.829	0.838
1984	0.182	0.239	0.298	0.388	0.497	0.652	0.724
1985	0.183	0.264	0.370	0.428	0.541	0.62	0.867
1986	0.186	0.285	0.335	0.470	0.598	0.617	0.804
1987	0.247	0.268	0.361	0.412	0.542	0.595	0.905
1988	0.270	0.293	0.398	0.501	0.664	0.936	0.937
1989	0.311	0.337	0.389	0.546	0.736	0.959	1.046
1990	0.301	0.327	0.378	0.461	0.800	0.884	0.781
1991	0.206	0.262	0.336	0.414	0.676	0.874	0.594
1992	0.167	0.316	0.367	0.430	0.597	0.779	1.409
1993	0.122	0.358	0.430	0.471	0.645	1.040	0.901
1994	0.108	0.320	0.349	0.416	0.556	0.717	0.949
1995	0.123	0.317	0.410	0.460	0.668	0.883	0.863
1996	0.147	0.374	0.409	0.466	0.585	0.665	0.804
1997	0.143	0.295	0.425	0.495	0.680	0.871	0.926
1998	0.130	0.284	0.399	0.528	0.694	0.790	0.707
1999	0.210	0.320	0.428	0.574	0.806	1.177	1.128
2000	0.020	0.367	0.493	0.587	0.774	0.860	0.904
2001	0.153	0.335	0.412	0.610	0.729	0.919	0.948

Table D4a. Survey indices of southern New England yellowtail abundance and biomass.

Mean Number per Tow at Age

NEFSC Spring Survey				Age						
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1968	1.662	31.719	31.913	19.002	0.886	0.168	0.067	0.000	85.416	18.624
1969	5.102	19.866	27.261	14.675	2.540	0.285	0.000	0.000	69.730	13.340
1970	1.486	10.669	19.964	14.136	4.066	1.096	0.235	0.096	51.749	11.721
1971	1.066	11.323	8.519	23.664	6.065	0.967	0.011	0.011	51.627	10.693
1972	0.492	21.844	14.735	4.596	8.813	1.360	0.257	0.000	52.098	10.728
1973	1.301	7.270	12.713	6.276	4.261	6.595	0.820	0.456	39.693	14.678
1974	0.742	2.972	2.326	2.530	1.647	0.593	0.964	0.193	11.967	5.040
1975	0.561	1.556	0.500	0.769	0.810	0.471	0.033	0.146	4.845	1.984
1976	0.026	3.259	0.528	0.250	0.302	0.250	0.157	0.051	4.823	2.452
1977	0.205	1.251	1.556	0.166	0.173	0.080	0.024	0.103	3.557	1.993
1978	2.963	9.783	2.027	0.715	0.187	0.036	0.047	0.138	15.897	5.146
1979	1.542	3.357	1.741	0.354	0.110	0.000	0.000	0.008	7.112	2.147
1980	0.370	4.303	3.278	2.711	0.291	0.116	0.006	0.039	11.115	5.949
1981	0.203	8.622	3.089	1.279	0.464	0.047	0.000	0.000	13.704	6.846
1982	0.333	14.049	7.459	1.860	0.605	0.186	0.020	0.000	24.512	6.001
1983	0.090	3.900	12.916	1.059	0.312	0.000	0.000	0.000	18.278	4.641
1984	0.000	0.500	1.648	2.612	0.665	0.223	0.000	0.000	5.649	1.625
1985	0.561	0.744	0.417	0.201	0.454	0.093	0.000	0.000	2.470	0.666
1986	0.037	4.083	1.492	0.308	0.073	0.036	0.000	0.000	6.029	1.605
1987	0.000	0.198	0.919	0.144	0.000	0.000	0.000	0.000	1.261	0.402
1988	0.327	0.692	0.177	0.245	0.127	0.000	0.000	0.000	1.568	0.399
1989	0.151	10.308	0.604	0.066	0.000	0.000	0.000	0.000	11.129	2.433
1990	0.091	0.368	18.994	3.794	0.031	0.000	0.000	0.000	23.278	7.828
1991	0.438	0.340	1.573	4.484	0.510	0.111	0.000	0.000	7.455	2.786
1992	0.081	0.269	0.275	1.196	0.112	0.000	0.000	0.000	1.933	0.653
1993	0.037	0.533	0.221	0.517	0.097	0.000	0.000	0.000	1.405	0.506
1994	0.031	0.494	0.040	0.019	0.045	0.015	0.000	0.000	0.643	0.219
1995	0.054	0.944	0.284	0.072	0.030	0.011	0.018	0.000	1.413	0.360
1996	0.000	0.528	2.442	0.314	0.063	0.000	0.000	0.000	3.347	1.054
1997	0.119	1.816	1.735	0.274	0.081	0.000	0.000	0.000	4.025	1.183
1998	0.154	3.696	0.433	0.231	0.077	0.000	0.000	0.000	4.590	0.973
1999	0.037	1.426	3.265	0.243	0.036	0.000	0.000	0.000	5.006	1.763
2000	0.000	2.016	1.680	0.672	0.168	0.000	0.000	0.000	4.537	1.444
2001	0.000	0.109	2.535	0.471	0.077	0.000	0.000	0.000	3.192	1.267
2002	0.292	1.750	0.680	0.583	0.097	0.000	0.000	0.000	3.402	0.939
mean	0.587	5.330	5.427	3.157	0.979	0.364	0.076	0.035	15.956	4.288

Table D4b. Survey indices of southern New England yellowtail abundance and biomass.

Mean Number per Tow at Age

NEFSC Fall Survey					Age					
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1963	19.798	20.168	14.960	5.830	0.660	0.151	0.000	0.100	61.667	16.842
1964	22.529	31.952	5.861	8.701	3.983	1.108	0.000	0.000	74.133	19.03
1965	13.231	21.390	7.771	2.140	2.167	0.155	0.000	0.090	46.944	12.675
1966	43.305	13.066	2.375	1.247	0.231	0.000	0.000	0.000	60.224	9.431
1967	22.497	31.159	13.716	1.936	0.472	0.079	0.160	0.000	70.019	14.057
1968	11.285	13.352	22.860	1.443	0.115	0.000	0.000	0.000	49.055	10.062
1969	14.481	11.884	33.861	6.351	0.113	0.050	0.050	0.000	66.791	14.401
1970	5.157	6.736	19.936	12.961	3.067	0.520	0.089	0.000	48.466	10.965
1971	7.748	13.298	7.618	18.468	3.287	0.264	0.196	0.000	50.879	11.632
1972	5.135	20.125	24.054	22.993	14.991	2.050	0.054	0.000	89.402	20.114
1973	1.726	1.590	2.224	1.640	1.241	1.057	0.212	0.000	9.689	2.264
1974	1.216	2.047	0.676	2.776	1.166	0.489	0.238	0.093	8.701	2.141
1975	1.981	0.516	0.266	0.329	0.334	0.000	0.104	0.000	3.531	0.715
1976	3.632	7.331	0.877	0.088	0.139	0.361	0.423	0.189	13.041	2.962
1977	1.759	2.275	0.828	0.053	0.046	0.113	0.078	0.000	5.151	1.501
1978	3.247	7.599	0.450	0.392	0.043	0.009	0.079	0.032	11.851	3.057
1979	1.794	4.533	2.537	0.388	0.043	0.041	0.000	0.000	9.335	2.565
1980	1.463	4.506	1.202	0.426	0.000	0.000	0.000	0.000	7.597	1.957
1981	4.704	8.944	1.404	0.334	0.080	0.061	0.000	0.000	15.527	3.789
1982	2.610	29.372	8.673	1.025	0.409	0.000	0.000	0.000	42.088	8.126
1983	4.582	17.956	10.078	0.876	0.073	0.000	0.050	0.000	33.616	6.515
1984	0.719	2.217	2.400	0.659	0.000	0.000	0.000	0.000	5.994	1.365
1985	1.018	0.447	0.161	0.122	0.000	0.000	0.000	0.000	1.748	0.438
1986	0.826	1.685	0.365	0.088	0.000	0.000	0.000	0.000	2.963	0.883
1987	1.515	0.674	0.558	0.047	0.037	0.000	0.037	0.000	2.868	0.607
1988	1.261	0.388	0.173	0.195	0.048	0.000	0.000	0.000	2.065	0.496
1989	0.000	8.004	1.400	0.065	0.000	0.000	0.000	0.000	9.469	2.359
1990	0.000	0.097	2.395	0.270	0.000	0.000	0.000	0.000	2.763	0.974
1991	0.865	0.219	1.709	0.453	0.000	0.000	0.000	0.000	3.247	1.013
1992	0.261	0.062	0.180	0.337	0.012	0.000	0.000	0.000	0.852	0.229
1993	0.070	0.015	0.028	0.020	0.000	0.000	0.000	0.000	0.133	0.053
1994	0.754	0.553	0.198	0.192	0.085	0.011	0.000	0.000	1.793	0.374
1995	0.180	1.306	0.171	0.095	0.000	0.000	0.000	0.000	1.752	0.432
1996	0.653	0.290	0.258	0.025	0.000	0.000	0.000	0.000	1.226	0.266
1997	0.889	0.716	1.687	0.373	0.037	0.000	0.000	0.000	3.702	1.041
1998	1.384	2.141	0.188	0.076	0.000	0.036	0.000	0.000	3.824	0.899
1999	0.189	0.119	0.116	0.000	0.000	0.000	0.000	0.000	0.424	0.101
2000	0.223	1.675	0.670	0.335	0.000	0.000	0.112	0.000	3.015	0.988
2001	0.607	0.946	0.207	0.110	0.000	0.000	0.000	0.000	1.870	0.630
mean	5.264	7.471	5.002	2.407	0.843	0.168	0.048	0.013	21.216	4.819

Table D4c. Survey indices of southern New England yellowtail abundance and biomass.

Mean Number per Tow at Age

NEFSC Winter Survey

Year	Age 1	2	3	4	5	6	7	8+	Total	kg/tow
1992	0.000	2.884	1.881	6.418	1.295	0.000	0.000	0.000	12.478	4.402
1993	1.349	3.853	0.711	1.841	0.306	0.000	0.000	0.000	8.060	1.968
1994	0.586	17.778	1.363	2.917	1.258	0.199	0.000	0.000	24.101	6.809
1995	0.368	7.615	4.474	1.317	0.493	0.123	0.036	0.000	14.426	4.059
1996	0.092	2.304	11.703	1.552	0.207	0.109	0.033	0.000	16.000	5.159
1997	0.301	3.976	9.141	2.625	0.508	0.000	0.000	0.000	16.551	5.831
1998	0.267	3.160	1.210	0.365	0.000	0.000	0.041	0.000	5.043	1.281
1999	0.550	10.699	14.210	0.528	0.176	0.000	0.000	0.000	26.163	8.874
2000	0.246	4.540	4.341	1.296	0.000	0.000	0.000	0.000	10.422	3.330
2001	0.026	1.963	14.025	2.848	0.370	0.160	0.027	0.000	19.418	7.944
2002	0.057	4.477	4.024	3.627	0.227	0.057	0.000	0.000	12.467	4.077
mean	0.349	5.750	6.098	2.303	0.440	0.059	0.013	0.000	15.012	4.885

Scallop Survey

Mean Number per Tow at Age

Year	age-1	all
1982	0.406	8.129
1983	0.736	2.435
1984	0.193	0.612
1985	0.783	1.214
1986	0.020	0.581
1987	0.243	0.564
1988	6.133	6.613
1989	0.578	6.468
1990	0.077	0.647
1991	0.680	0.933
1992	0.456	0.653
1993	0.468	0.479
1994	1.020	1.664
1995	0.319	1.828
1996	0.213	1.570
1997	1.383	1.737
1998	1.121	2.383
1999	0.752	1.160
2000	0.360	1.855
2001	0.282	0.451
2002	0.088	0.605
average	0.760	1.939

Table D5a. Stock numbers from VPA for southern New England yellowtail flounder.

STOCK NUMBERS (Jan 1) in thousands -

	1973	1974	1975	1976	1977	1978	1979
1	42144	9234	28866	12910	47571	52422	30090
2	15230	34335	6784	15635	10376	34024	35049
3	19877	7894	2473	2135	6829	4179	15812
4	10100	8765	2197	670	922	1997	2068
5	3810	4041	2563	909	327	400	707
6	3446	1567	1046	961	439	82	179
7	700	1968	883	863	483	172	44
1+	95307	67803	44812	34082	66949	93276	83950

	1980	1981	1982	1983	1984	1985	1986
1	41943	126925	53147	14583	16730	19837	6969
2	24451	33446	103883	43360	9654	13236	14223
3	11300	10973	21280	53266	18824	2719	4489
4	5371	3513	2888	5033	8670	1982	854
5	759	1123	661	786	1077	1071	435
6	192	194	120	175	303	212	177
7	50	21	11	55	25	48	32
1+	84066	176195	181989	117259	55284	39104	27179

	1987	1988	1989	1990	1991	1992	1993
1	13987	121992	16399	6852	3535	1969	850
2	5287	10013	94541	13405	5436	2491	1180
3	2886	1249	6343	60017	9122	2997	725
4	1032	524	563	2385	10967	2899	660
5	192	119	60	89	121	393	250
6	63	31	06	07	01	15	69
7	12	11	00	00	22	04	00
1+	23459	133937	117911	82754	29203	10767	3735

	1994	1995	1996	1997	1998	1999	2000
1	1606	1509	1425	4145	3108	4887	2319
2	684	1306	1229	1148	3393	2545	3998
3	584	425	845	730	889	2427	2018
4	253	277	200	243	280	295	678
5	155	58	37	27	63	68	79
6	92	07	20	04	09	21	05
7	02	05	09	06	02	08	05
1+	3376	3588	3766	6303	7744	10250	9102

	2001	2002
1	2542	00
2	1871	2080
3	2861	1319
4	898	1292
5	251	464
6	54	130
7	27	42
1+	8503	5326

Table D5b. Fishing mortality estimates from VPA for southern New England yellowtail flounder.

FISHING MORTALITY -

	1973	1974	1975	1976	1977	1978	1979
1	0.00	0.11	0.41	0.02	0.14	0.20	0.01
2	0.46	2.43	0.96	0.63	0.71	0.57	0.93
3	0.62	1.08	1.11	0.64	1.03	0.50	0.88
4	0.72	1.03	0.68	0.52	0.63	0.84	0.80
5	0.69	1.15	0.78	0.53	1.18	0.61	1.11
6	0.67	1.11	0.87	0.60	1.01	0.61	0.90
7	0.67	1.11	0.87	0.60	1.01	0.61	0.90
4,6	0.69	1.10	0.78	0.55	0.94	0.69	0.94

	1980	1981	1982	1983	1984	1985	1986
1	0.03	0.00	0.00	0.21	0.03	0.13	0.08
2	0.60	0.25	0.47	0.63	1.07	0.88	1.39
3	0.97	1.13	1.24	1.62	2.05	0.96	1.27
4	1.36	1.47	1.10	1.34	1.89	1.32	1.29
5	1.16	2.04	1.13	0.75	1.43	1.60	1.73
6	1.12	1.30	1.27	1.68	2.19	1.22	1.36
7	1.12	1.30	1.27	1.68	2.19	1.22	1.36
4,6	1.22	1.61	1.17	1.26	1.84	1.38	1.46

	1987	1988	1989	1990	1991	1992	1993
1	0.13	0.05	0.00	0.03	0.15	0.31	0.02
2	1.24	0.26	0.25	0.18	0.40	1.03	0.50
3	1.51	0.60	0.78	1.50	0.95	1.31	0.85
4	1.96	1.96	1.64	2.78	3.13	2.25	1.25
5	1.62	2.82	1.97	3.99	1.91	1.53	0.80
6	1.73	0.93	0.85	1.63	1.73	1.79	1.01
7	1.73	0.93	0.85	1.63	1.73	1.79	1.01
4,6	1.77	1.90	1.49	2.80	2.26	1.86	1.02

	1994	1995	1996	1997	1998	1999	2000
1	0.01	0.01	0.02	0.00	0.00	0.00	0.01
2	0.28	0.24	0.32	0.06	0.14	0.03	0.13
3	0.55	0.55	1.05	0.76	0.90	1.07	0.61
4	1.27	1.82	1.79	1.14	1.22	1.12	0.79
5	2.84	0.85	2.06	0.94	0.90	2.48	0.18
6	0.89	0.91	1.22	0.86	1.00	1.14	0.65
7	0.89	0.91	1.22	0.86	1.00	1.14	0.65
4,6	1.67	1.19	1.69	0.98	1.04	1.58	0.54

	2001
1	0.00
2	0.15
3	0.60
4	0.46
5	0.46
6	0.46
7	0.46
4,6	0.46

Table D5c. Spawning stock biomass estimates from VPA for southern New England yellowtail flounder.

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1973	1974	1975	1976	1977	1978	1979
1	1056	214	634	349	1156	1348	678
2	2554	2615	899	2482	1493	5415	4871
3	5276	1630	542	630	1544	1228	3617
4	2896	2253	668	262	339	703	648
5	1131	1098	743	358	97	203	242
6	1215	432	315	392	128	46	77
7	298	591	292	373	178	83	19
1+	14427	8832	4091	4846	4936	9028	10152

	1980	1981	1982	1983	1984	1985	1986
1	1022	2125	1435	279	359	411	150
2	3641	5371	15306	5938	1007	1648	1543
3	2613	2115	4048	8354	2152	608	799
4	1396	847	843	1321	1407	451	215
5	297	273	251	355	272	273	116
6	98	69	53	66	73	73	57
7	34	05	05	21	07	23	13
1+	9102	10806	21941	16334	5276	3487	2894

	1987	1988	1989	1990	1991	1992	1993
1	391	3850	610	243	82	35	12
2	575	1795	19510	2763	822	348	233
3	501	349	1609	10949	1863	574	197
4	173	107	142	317	1134	449	170
5	49	22	18	12	34	114	106
6	17	18	04	03	01	05	43
7	05	06	00	00	06	02	00
1+	1710	6148	21892	14288	3941	1526	762

	1994	1995	1996	1997	1998	1999	2000
1	21	22	25	71	48	123	06
2	133	256	274	225	620	547	944
3	146	125	202	204	220	598	696
4	57	55	41	69	82	98	263
5	24	25	08	12	28	18	52
6	42	04	08	02	04	14	03
7	01	03	04	03	01	05	03
1+	424	490	561	586	1003	1403	1967

	2001
1	47
2	401
3	829
4	416
5	139
6	38
7	19
1+	1888

Table D6. Short-term projections of southern New England yellowtail flounder.

Input Assumptions	age 1	age 2	age 3	age 4	age 5	age 6	age 7+
stock weight (kg)	0.129	0.327	0.416	0.517	0.685	0.852	0.887
landed weight (kg)	0.129	0.341	0.419	0.521	0.674	0.858	0.891
discard weight (kg)	0.037	0.309	0.375	0.511	0.667	0.840	0.891
maturity	0.130	0.740	0.980	1.000	1.000	1.000	1.000
partial recruitment	0.010	0.130	0.580	1.000	1.000	1.000	1.000
proportion discarded	1.000	0.330	0.180	0.180	0.180	0.180	0.180

Results

Year	F	Landings (mt)	Discards (mt)	SSB (mt)
2002	0.39	405	92	1931
2003	0.10*	131	30	2647
2004	0.10*	214	54	5482

* assumes long-term recruitment pattern

Figure D1. Total catch of southern New England yellowtail flounder.

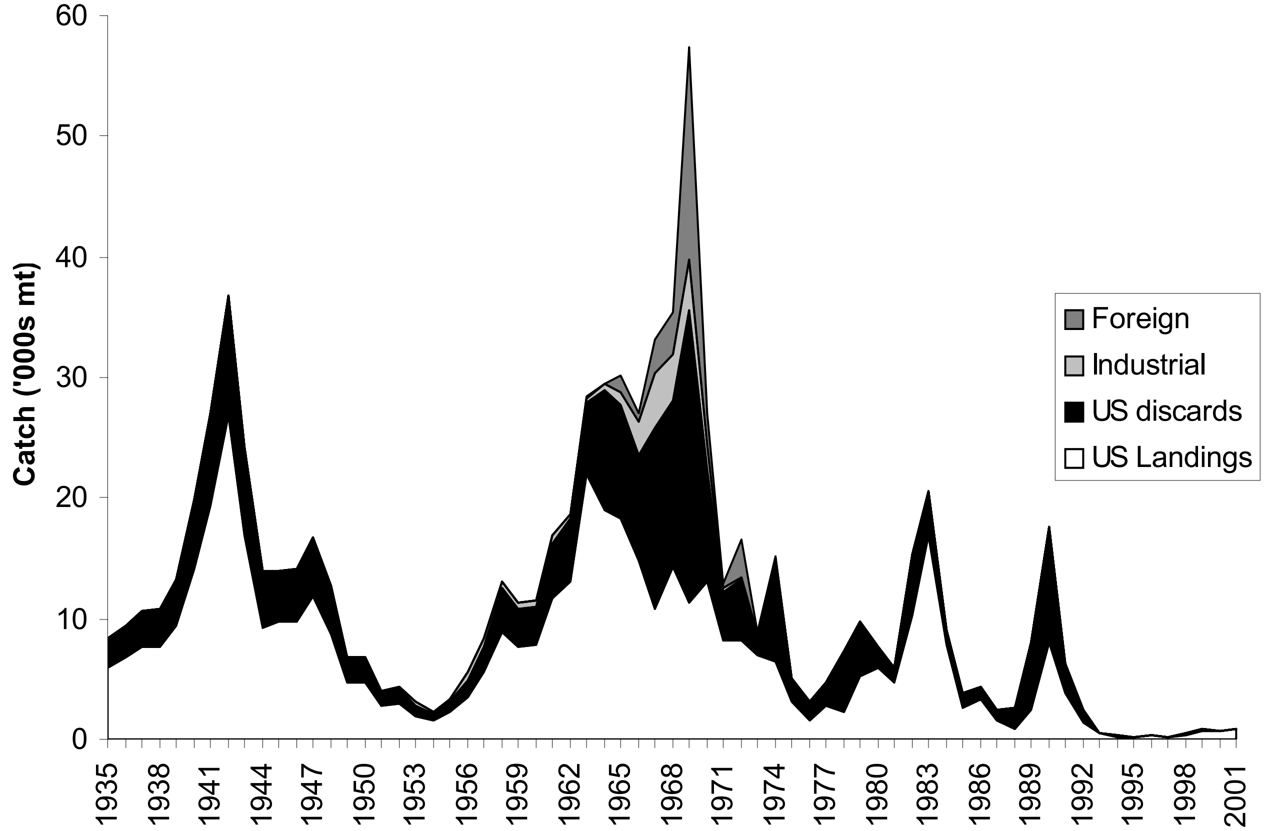


Figure D2. Survey indices of southern New England yellowtail flounder biomass.

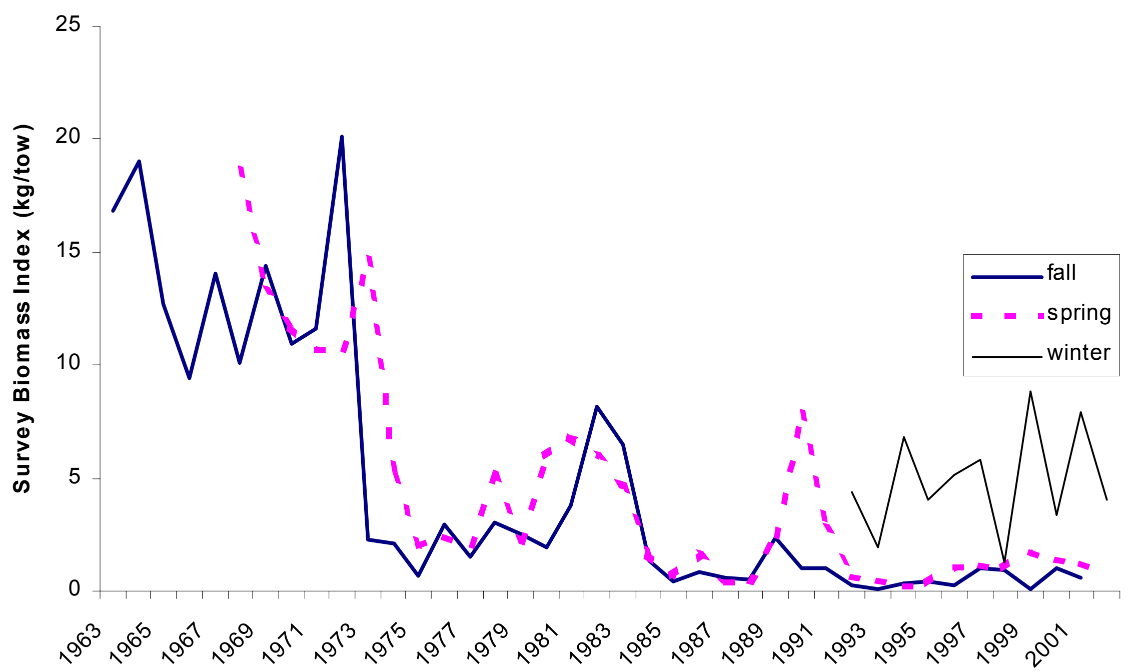


Figure D3a. Estimates of fishing mortality, recruitment and spawning stock biomass for southern New England yellowtail flounder from VPA.

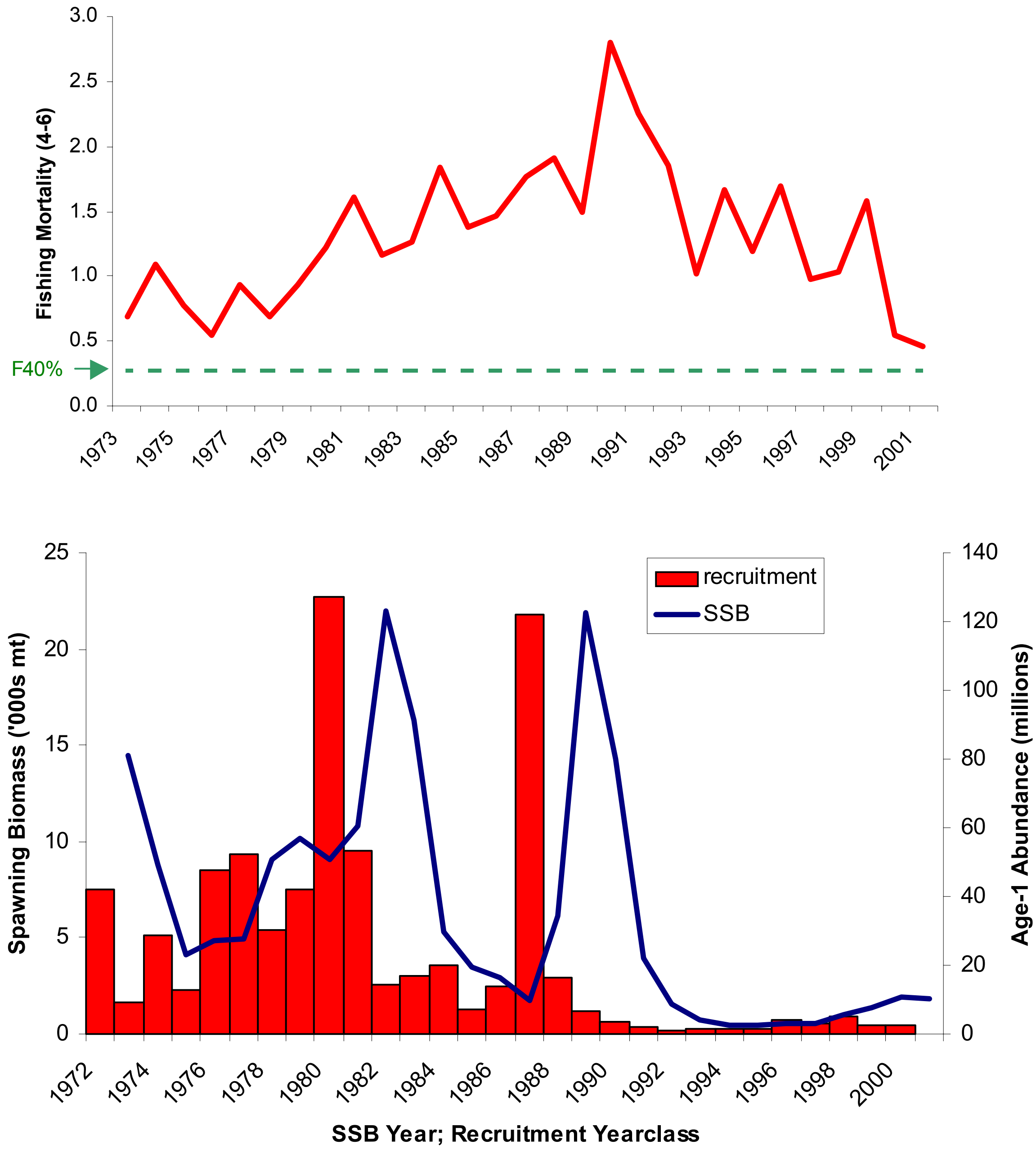


Figure D3b. Abundance at age of southern New England yellowtail flounder.

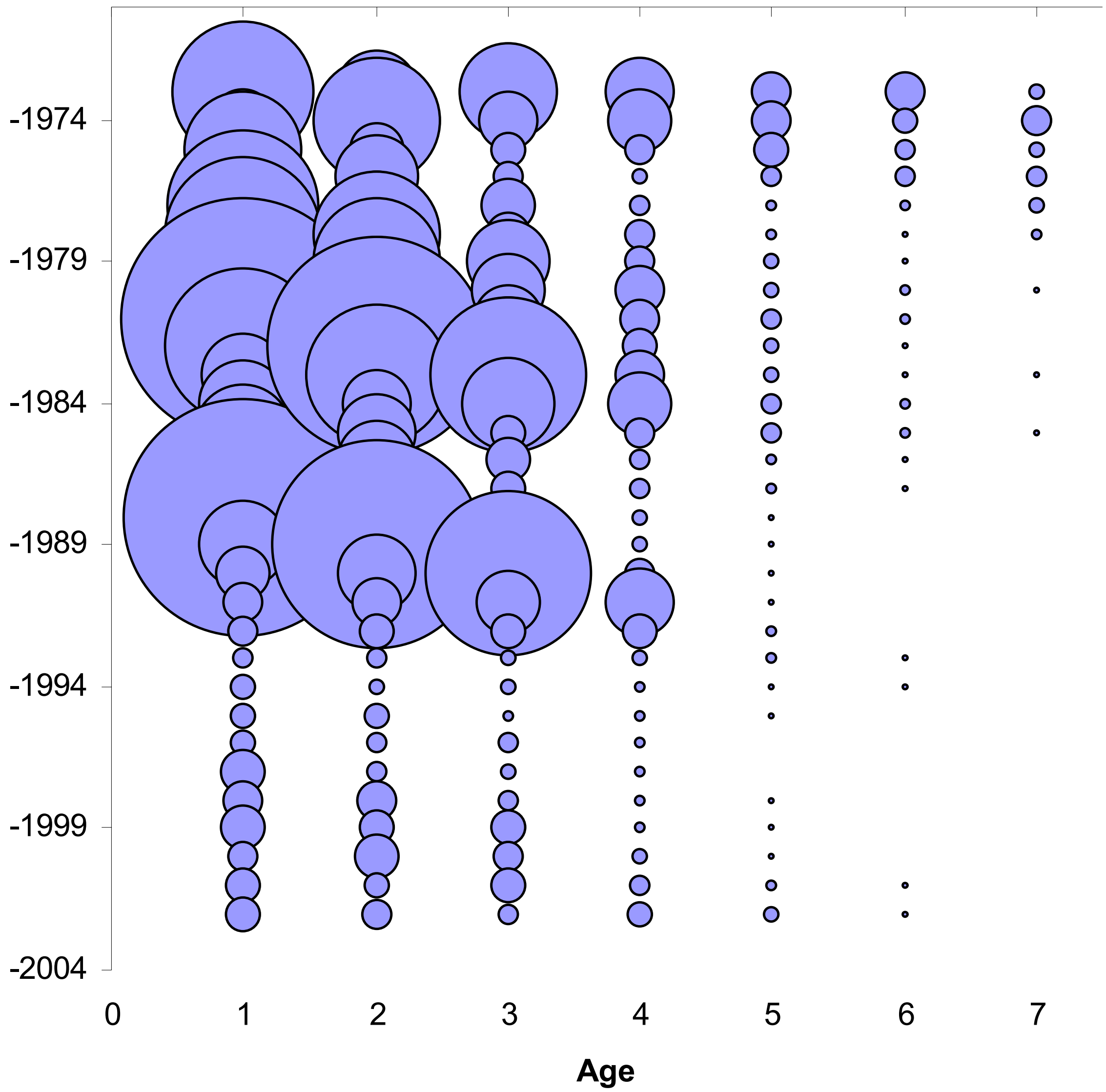


Figure D4. Retrospective analysis of the southern New England yellowtail flounder VPA.

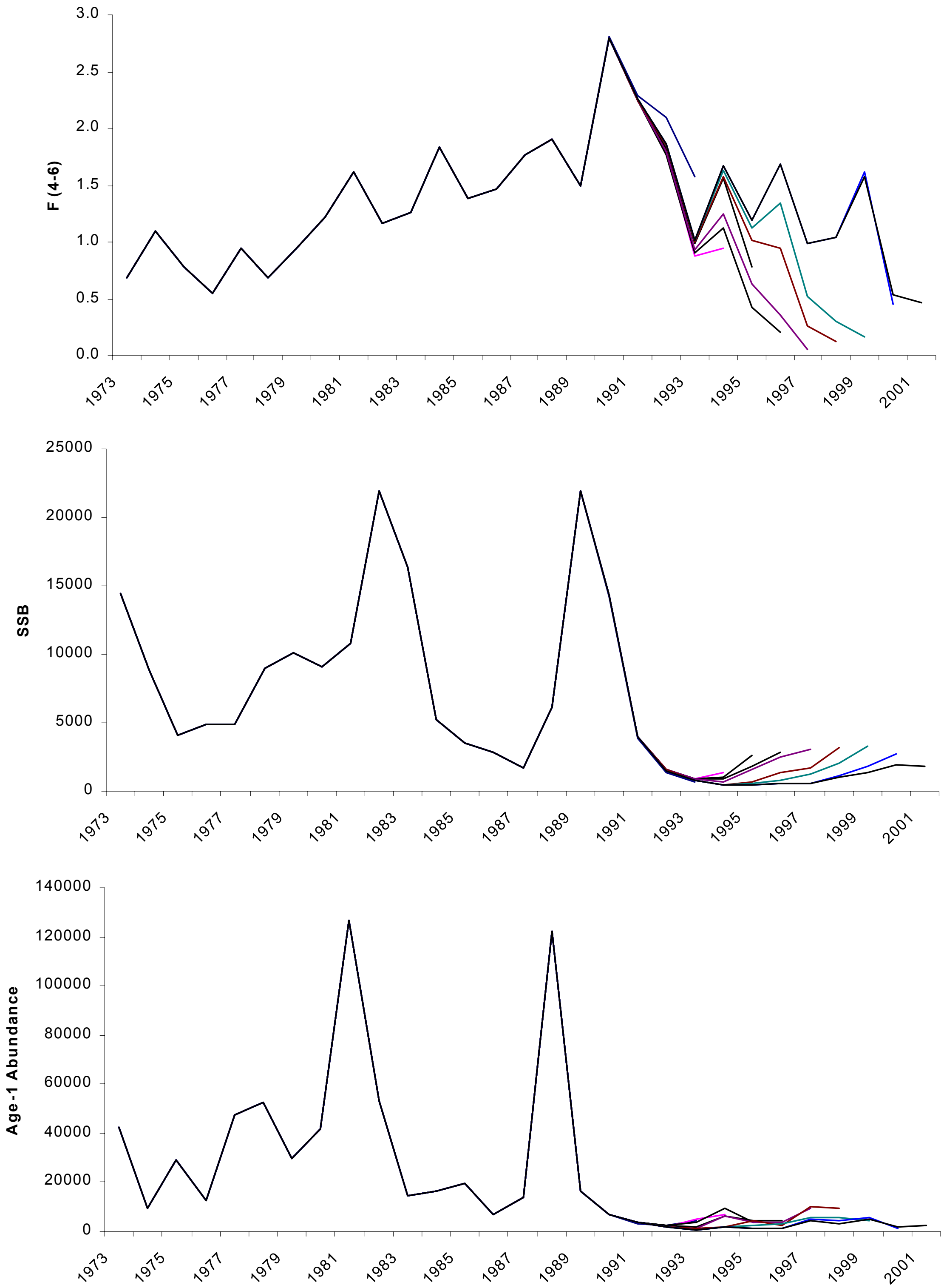


Figure D5. Stochastic projection of spawning biomass and total catch under two scenarios of recruitment and a constant F of $F_{rebuild} = 0.10$

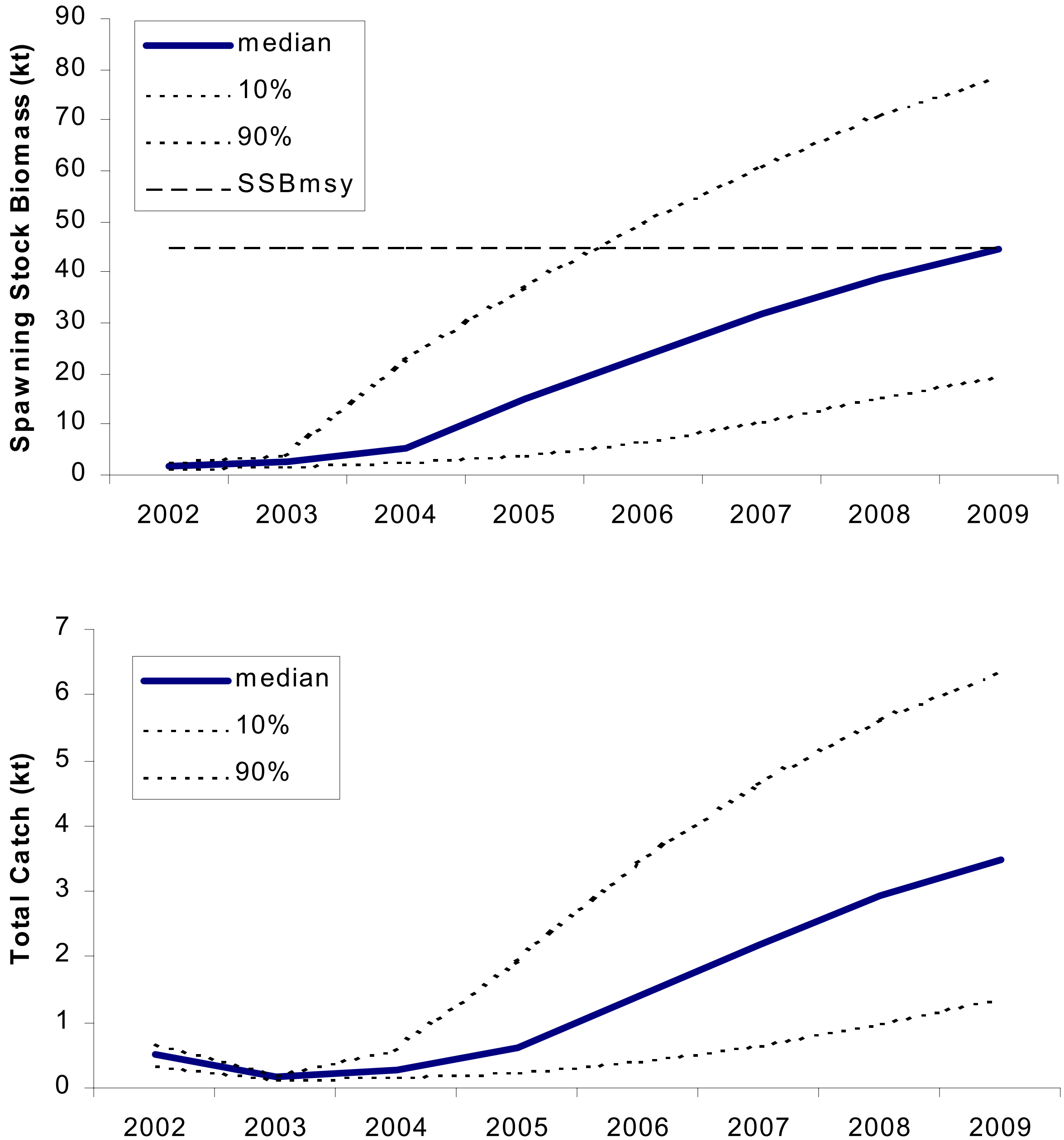


Figure D6. Mean biomass of southern New England yellowtail flounder and fishing mortality on biomass.

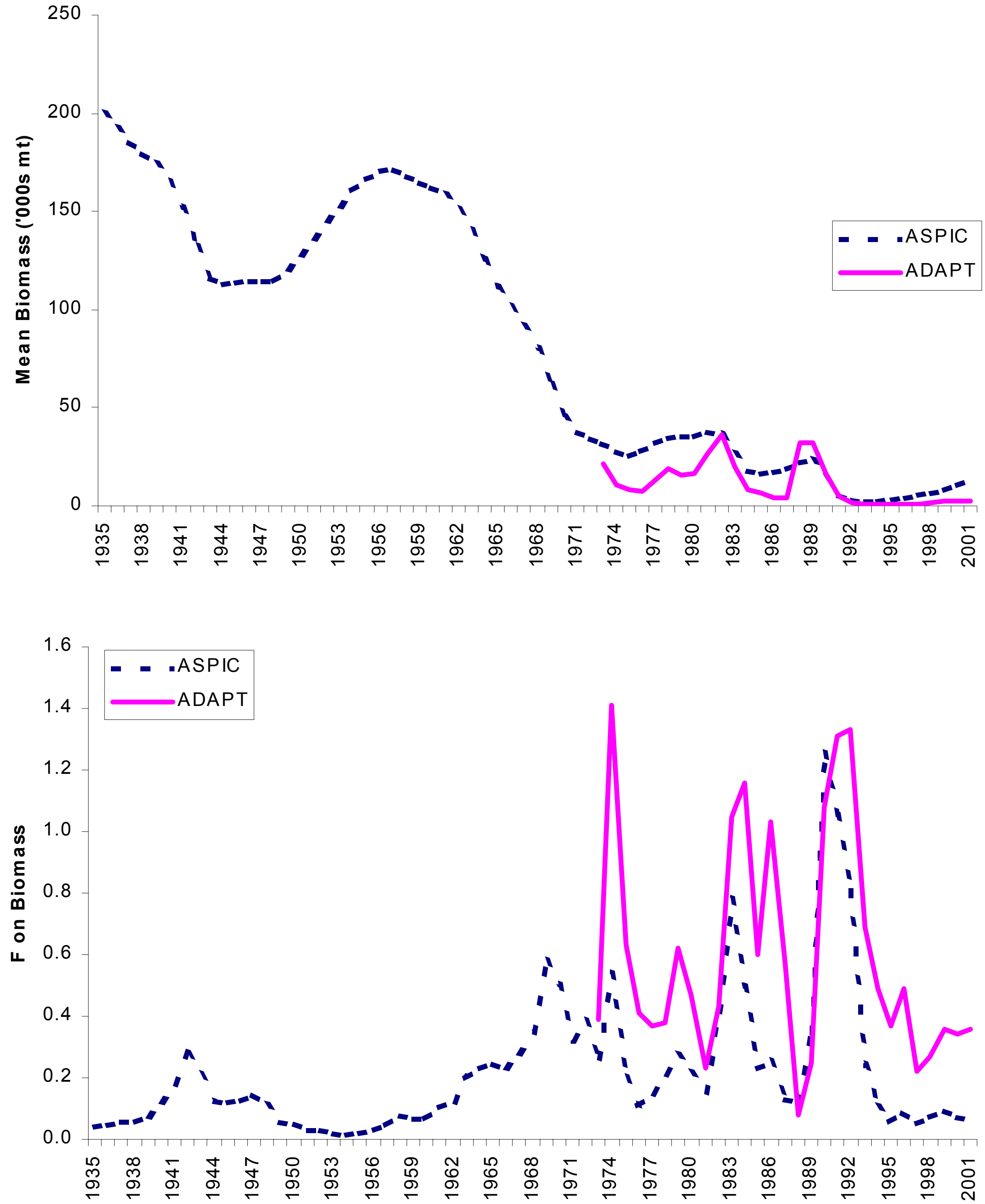
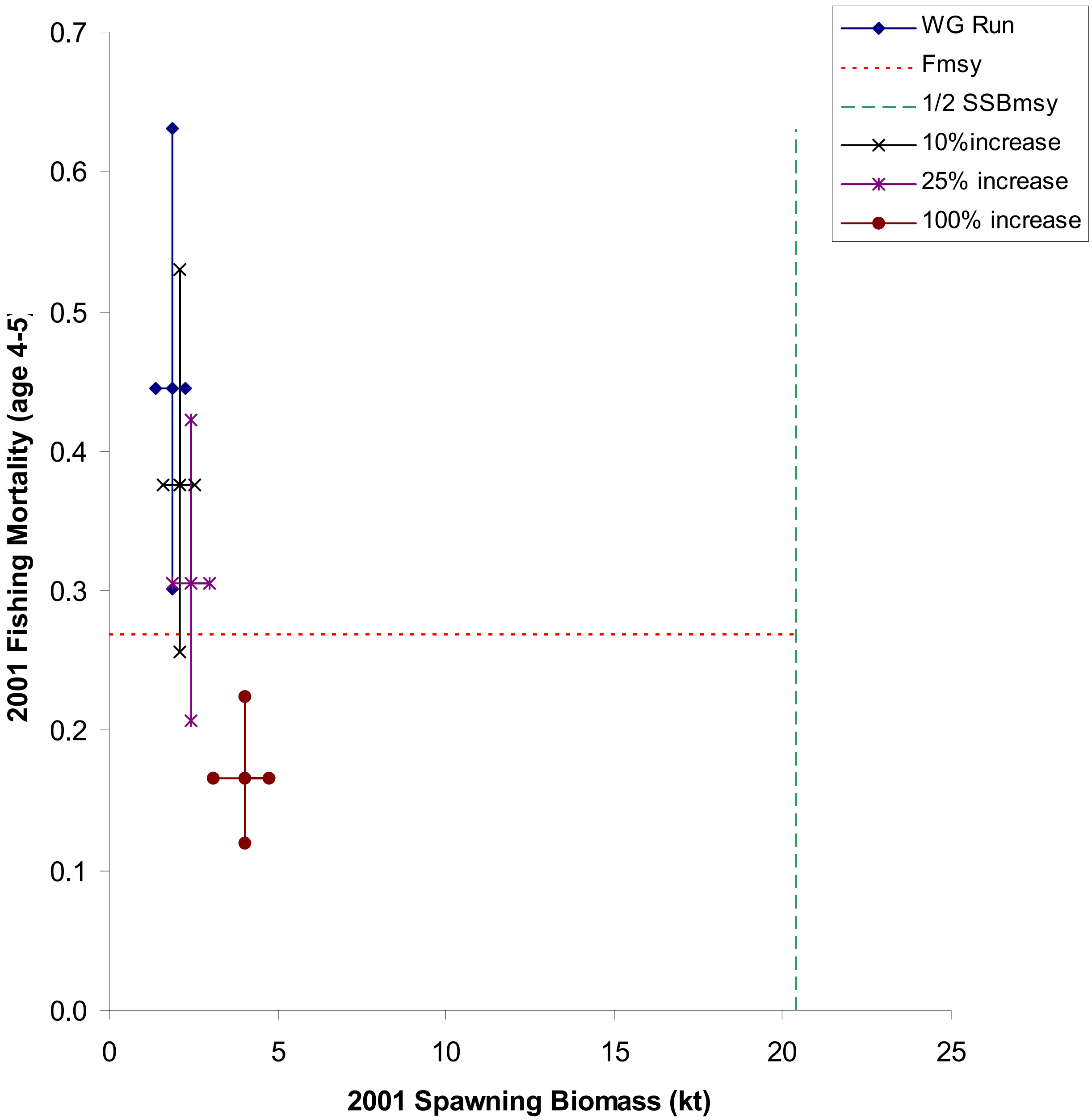


Figure D7. Sensitivity of results to increasing NEFSC indices since 2000 by 10%, 25% and 100% (with 80% confidence intervals). Results accepted by the working group ("WG Run") are shown for comparison.



E. Cape Cod Yellowtail Flounder by **S.X. Cadrin** and **J. King**

1.0 Background

The Cape Cod yellowtail flounder stock was at low biomass and was overexploited in 1999 (SSB was 1,900 mt and fully recruited F was 0.31; Cadrin and King 2001). This report updates catch and survey indices and estimates 2001 fishing mortality and 2002 stock size. In August 2002, the Southern Demersal Working Group concluded that Cape Cod and northern Gulf of Maine yellowtail flounder should be assessed and managed as a single unit stock, and is concurrently preparing an assessment of the Cape Cod - Gulf of Maine yellowtail resource (Cadrin and King 2002). In September 2002, the Working Group reviewed input data, analyses and projections in this report.

2.0 2002 Assessment

<u>2.1 2000-2001 Landings</u>

U.S. landings were prorated as described in Cadrin et al. (1999; Table E1; Figure E1). Landings from the Cape Cod stock increased from 1,100 mt in 1999 to 2,300 mt in 2000 and to 2,400 mt in 2001. Sampling intensity of landings in 2000 and 2001 improved from recent years. Although all classified market categories were sampled in each half-year period, the overall number of samples was low (Table E2).

<u>2.2 2000-2001 Discards</u>

Estimates of discarded catch for 1998-1999 were revised from those derived from logbook information (Cadrin and King 2001) using observer data by fishery as described by Cadrin et al. (1999). Estimates of 2000-2001 discards were also based on observer data. Discard rates varied between 7% and 19% of total catch for 1998-2001. Discards at age were estimated from sea-sampled lengths and survey age-length keys. Total catch at age and mean weights at age are reported in Table E3.

<u>2.3 2000-2002 Survey Indices</u>

Survey abundance and biomass indices are reported in Table E4. Estimates are from valid tows on the Cape Cod grounds (offshore strata 25, 26; inshore strata 56-66; Massachusetts strata 17-36) standardized according to net, vessel, and door changes (NEFSC 1998). Three of the four survey series indicate a substantial increase in biomass during 1999 and 2000, but only the Massachusetts spring survey remained high in 2001 and that index sharply decreased in 2002 (Figure E2).

3.0 Assessment Results

Results of an updated VPA calibration of Cape Cod yellowtail flounder (using the existing stock definition) are summarized in Table E5. This analysis updates the assessment reported in Cadrin and King (2001) by including 2000-2001 landings and discards, 2000 fall indices, all 2001 indices, and 2002 spring indices. The Working Group recommended a revised calibration configuration that includes all survey indices for older yellowtail to reduce the bias in estimates of age-5 abundance. Although parameter estimates in Cadrin et al. (1999) were not substantially biased, the positive bias in age-5 abundance increased in the updated assessments. The 2002 updated assessment initially had a 17% bias, when indices of older ages were excluded, but the bias decreased to 4% when the indices of older ages were included. Therefore, the revised calibration is used as the basis for this assessment. Results indicate that F increased to nearly 2.0 in 2000 and 2001, and SSB increased to 1,900mt in 2001 (Figure E3). Retrospective analysis indicates a tendency toward greatly underestimate F in the most recent years (Figure E4). Bootstrap analysis indicates that abundance was estimated with moderate to low precision (CV=33-43%). Sensitivity to recent NEFSC survey observations was evaluated using sensitivity analyses (Figure E6). Results are summarized in Section 5.2 (Summary of Assessment Advice).

Proxies for MSY reference points were derived from yield and SSB per recruit analyses and the assumption of constant recruitment (NEFSC 2002). Assuming that F_{MSY} is approximately $F_{40\%}$ (0.21 on fully-recruited ages) and average recruitment (7.89 million at age-1), MSY=1,700 mt and SSB_{MSY}=8,400 mt. Therefore, despite uncertainty in the assessment, the stock is clearly overfished (2001 SSB= 1,900 mt=23%SSB_{MSY}) and overfishing is occurring (2001 F=2.0, = F>9 · F_{MSY}).

Stochastic projections at 85% of status quo F in 2002 and $F_{rebuild}$=0.12 for 2003-2009 indicate there is a 50% probability of rebuilding to SSB_{MSY} by 2009 (Table E6, Figure E5). However, retrospective patterns indicate that projections may be overly optimistic.

5.0 Sources of Uncertainty

- Retrospective patterns indicate that VPA estimates of biomass and F may be overly optimistic. Updated VPAs may indicate that 2002 biomass levels were substantially lower, and 1999 F substantially greater than reported here. For example, previous assessments concluded that SSB rapidly increased in the late 1990s, but this updated assessment indicates much less rebuilding.
- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.
- The limited number of observer samples in small mesh and scallop dredge fisheries imposes considerable uncertainty in discard estimates.

6.0 GARM Discussion

The GARM noted that the high F seems inconsistent with level or increasing SSB and increasing survey indices. Discussion centered on how this could be possible, without the GARM reaching a consensus conclusion. The panel recommends that a cooperative tagging study be conducted to estimate F and evaluate the possibility of movement patterns out of the stock area that could be causing the estimates of F to be mis-representative.

It was suggested that the high F means that the tuning is actually only working on the oldest age group. The estimated catchabilities increase without reaching an asymptote with increasing age.

Ageing does not seem to be a problem with this stock, especially for the young ages in the catch. However, inadequate sampling of the catch could be causing a problem.

The short time series may not be sufficient to adequately estimate stock sizes. The time series is short due to extremely low sampling of catch prior to 1985 and because inshore strata were not sampled in the NEFSC surveys prior to 1979.

The possibility of contributions from the Georges Bank and/or Southern New England stocks of yellowtail flounder to the Cape Cod stock was discussed in terms of both adult movement and recruitment impacts. Given the relative sizes of the stocks, especially the Georges Bank and Cape Cod stocks, any transfer among stocks could overwhelm the signal from Cape Cod.

7.0 References

Cadrin, S.X. and J. King 2001. Cape Cod yellowtail flounder. In Assessment of 19 Northeast Groundfish Stocks through 2000. NEFSC Ref. Doc. 01-20: 67-79.

Cadrin, S.X. and J. King 2002. Stock Assessment of yellowtail flounder in the Cape Cod - Gulf of Maine area. SAW36 WPA7.

Cadrin, S.X., J. King, and L.E. Suslowicz. 1999. Status of the Cape Cod yellowtail flounder stock for 1998. NEFSC Ref. Doc. 99-04.

NEFSC (Northeast Fisheries Science Center). 2002. Final report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. 19 March, 2002.

Table E1. Landings of Cape Cod yellowtail flounder (mt).

	Landings (mt)	Discards (mt)	Percent Discard	Total Catch (mt)
1960	1,500	500	33	2,000
1961	1,800	600	33	2,400
1962	1,900	600	32	2,500
1963	3,600	1,000	28	4,600
1964	1,851	600	32	2,451
1965	1,498	500	33	1,998
1966	1,808	300	17	2,108
1967	1,542	800	52	2,342
1968	1,569	600	38	2,169
1969	1,346	300	22	1,646
1970	1,185	400	34	1,585
1971	1,662	700	42	2,362
1972	1,364	300	22	1,664
1973	1,662	0	0	1,662
1974	2,054	200	10	2,254
1975	2,027	0	0	2,027
1976	3,587	100	3	3,687
1977	3,469	0	0	3,469
1978	3,683	400	11	4,083
1979	4,163	500	12	4,663
1980	5,106	600	12	5,706
1981	3,149	600	19	3,749
1982	3,150	400	13	3,550
1983	1,884	300	16	2,184
1984	1,121	20	2	1,141
1985	967	77	8	1,044
1986	1,041	305	29	1,346
1987	1,159	198	17	1,357
1988	1,085	283	26	1,368
1989	909	390	43	1,299
1990	2,984	1,141	38	4,125
1991	1,472	405	28	1,877
1992	828	637	77	1,465
1993	628	90	14	718
1994	978	192	20	1,170
1995	1,207	233	19	1,440
1996	1,064	182	17	1,246
1997	1,040	257	25	1,297
1998	1,169	259	22	1,428
1999	1,089	107	10	1,196
2000	2,279	163	7	2,443
2001	2,362	447	19	2,810

Table E2. Samples of Cape Cod yellowtail flounder.

Number of Fish Sampled

year	half year	trips	unclass. lengths	small lengths	large lengths	ages
1985	1	5	109	304	196	292
	2	12	0	825	543	357
1986	1	4	0	608	206	217
	2	6	0	321	172	240
1987	1	6	0	300	352	353
	2	5	0	284	269	207
1988	1	6	0	477	267	286
	2	5	0	291	364	252
1989	1	6	10	261	314	305
	2	4	97	262	173	200
1990	1	8	536	532	374	339
	2	6	636	429	276	137
1991	1	8	811	501	332	610
	2	7	109	531	242	277
1992	1	4	707	126	254	339
	2	7	136	262	457	268
1993	1	3	170	145	182	177
	2	3	273	244	74	114
1994	1	4	100	261	170	273
	2	3	0	106	144	149
1995	1	4	39	276	201	196
	2	6	998	392	275	157
1996	1	1	2560	0	87	196
	2	12	118	495	640	485
1997	1	7	343	388	483	556
	2	17	317	996	869	634
1998	1	7	4781	0	508	195
	2	6	165	0	600	165
1999	1	4	2501	278	60	49
	2	4	1024	268	116	57
2000	1	46	521	723	2775	903
	2	15	0	566	1057	395
2001	1	8	3502	251	570	192
	2	16	1950	393	774	436

Table E3. Catch at age (above) and mean weights at age (below) of Cape Cod yellowtail flounder.

Total catch at age (thousands)				age		
	age 1	age 2	age 3	age 4	age 5	age 6+
1985	344	922	734	522	268	99
1986	79	3655	654	250	32	7
1987	14	1486	1954	268	100	46
1988	361	2130	1219	625	172	36
1989	114	2131	1385	233	31	8
1990	81	2738	8692	435	32	26
1991	460	1206	1464	1555	256	61
1992	1688	3881	1538	543	153	12
1993	138	349	857	602	91	46
1994	60	471	1301	699	240	113
1995	453	702	2382	858	154	83
1996	7	547	1425	892	298	18
1997	1	880	1437	819	182	14
1998	56	650	2101	518	151	44
1999	11	481	1321	668	109	48
2000	3	1024	2844	1228	153	38
2001	19	1644	3633	1083	155	39

weight at age (kg)				age		
	age 1	age 2	age 3	age 4	age 5	age 6+
1985	0.13	0.28	0.36	0.49	0.60	0.79
1986	0.10	0.25	0.43	0.53	0.73	0.99
1987	0.06	0.24	0.40	0.55	0.65	0.91
1988	0.12	0.21	0.34	0.53	0.70	0.85
1989	0.13	0.27	0.39	0.65	0.92	1.31
1990	0.08	0.26	0.37	0.55	0.82	0.96
1991	0.12	0.23	0.34	0.53	0.73	1.02
1992	0.05	0.13	0.32	0.52	0.61	1.15
1993	0.09	0.16	0.36	0.43	0.74	1.00
1994	0.08	0.22	0.36	0.49	0.62	0.83
1995	0.07	0.22	0.33	0.42	0.61	0.80
1996	0.04	0.19	0.39	0.49	0.53	1.02
1997	0.03	0.31	0.38	0.46	0.57	0.81
1998	0.03	0.27	0.40	0.53	0.62	1.04
1999	0.03	0.33	0.42	0.56	0.57	0.91
2000	0.03	0.37	0.44	0.56	0.61	0.87
2001	0.03	0.32	0.41	0.58	0.74	1.05

Table E4a. Survey indices of Cape Cod yellowtail abundance and biomass.
Mean Number per Tow at Age

MADMF Spring Survey					Age					
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1978	2.71	20.69	11.82	1.60	0.63	0.54	0.10	0.13	38.22	10.16
1979	2.63	22.58	13.85	3.68	0.86	0.00	0.17	0.00	43.77	11.38
1980	2.68	17.62	10.10	2.30	0.15	0.00	0.00	0.00	32.85	10.03
1981	5.61	58.83	9.00	2.26	1.59	0.27	0.00	0.00	77.56	16.35
1982	0.69	17.06	17.04	4.45	0.94	0.06	0.04	0.00	40.28	12.85
1983	3.13	8.50	11.51	4.28	0.04	0.17	0.03	0.00	27.66	9.00
1984	0.43	18.13	7.56	2.29	0.85	0.00	0.00	0.00	29.26	7.37
1985	1.97	8.27	7.15	1.52	0.59	0.39	0.05	0.05	19.99	5.21
1986	1.73	15.39	1.74	0.24	0.21	0.04	0.00	0.00	19.36	4.52
1987	2.53	4.95	5.31	0.97	0.27	0.11	0.08	0.00	14.22	3.67
1988	3.10	14.46	2.52	0.60	0.05	0.02	0.00	0.00	20.74	3.83
1989	0.67	22.26	3.18	1.08	0.06	0.00	0.00	0.00	27.25	4.73
1990	0.63	11.77	15.57	0.63	0.14	0.01	0.02	0.01	28.77	6.60
1991	0.06	5.34	3.31	2.15	0.48	0.12	0.05	0.00	11.50	3.32
1992	1.30	11.03	9.71	2.38	1.45	0.03	0.03	0.00	25.94	6.54
1993	0.63	7.99	6.31	1.94	0.23	0.06	0.20	0.03	17.38	4.60
1994	2.67	24.02	7.53	1.49	0.33	0.12	0.00	0.00	36.15	6.23
1995	7.51	14.64	24.96	2.88	1.20	0.02	0.02	0.00	51.22	10.38
1996	1.17	18.03	14.70	6.78	1.74	0.00	0.04	0.00	42.46	9.25
1997	0.52	16.94	12.22	4.04	0.54	0.00	0.00	0.00	34.26	7.55
1998	0.55	4.96	13.50	1.25	0.19	0.02	0.00	0.00	20.46	5.17
1999	0.10	6.34	10.90	1.28	0.08	0.00	0.00	0.00	18.70	5.08
2000	0.83	21.92	33.29	11.28	1.30	0.52	0.00	0.00	69.14	20.37
2001	0.22	10.21	38.20	10.39	1.68	0.00	0.00	0.00	60.71	19.34
2002	0.36	1.29	13.84	5.34	0.26	0.17	0.00	0.00	21.27	7.43
mean	1.91	16.16	10.99	2.67	0.60	0.11	0.04	0.01	32.48	8.44

Table E4b. Survey indices of Cape Cod yellowtail abundance and biomass.

Mean Number per Tow at Age

MADMF Fall Survey					Age					
year	0	1	2	3	4	5	6	7	8+	sum	kg/tow
1978	0.04	7.13	7.74	1.45	0.11	0.00	0.01	0.00	0.00	16.48	2.80
1979	0.03	24.11	22.82	1.78	0.06	0.00	0.00	0.00	0.00	48.80	7.33
1980	0.03	26.54	12.38	2.70	0.35	0.00	0.00	0.00	0.00	42.00	5.90
1981	0.00	2.93	6.54	1.54	0.23	0.17	0.00	0.00	0.00	11.41	2.76
1982	0.00	9.58	3.36	5.54	0.30	0.08	0.00	0.00	0.00	18.86	4.20
1983	0.00	9.68	6.68	1.60	0.13	0.00	0.00	0.00	0.00	18.09	3.39
1984	0.04	1.91	3.00	0.86	0.39	0.10	0.02	0.00	0.04	6.37	1.18
1985	0.04	5.70	1.63	1.03	0.00	0.00	0.00	0.00	0.02	8.42	1.17
1986	0.01	2.60	4.95	0.20	0.03	0.01	0.00	0.00	0.00	7.80	1.36
1987	0.44	5.85	2.30	0.49	0.07	0.02	0.00	0.00	0.00	9.17	1.09
1988	0.00	8.96	11.24	2.27	0.15	0.00	0.00	0.00	0.00	22.62	3.71
1989	0.00	2.64	5.22	0.96	0.10	0.00	0.00	0.00	0.00	8.92	1.52
1990	0.00	5.20	11.93	4.84	0.01	0.00	0.00	0.00	0.00	21.98	4.16
1991	0.00	3.76	5.14	5.03	0.86	0.00	0.00	0.00	0.00	14.78	3.23
1992	0.20	7.18	3.62	2.08	0.47	0.20	0.00	0.00	0.00	13.75	2.00
1993	0.00	8.39	7.29	5.80	1.43	0.00	0.00	0.00	0.00	22.91	3.99
1994	0.00	2.36	11.79	1.79	0.15	0.00	0.00	0.00	0.00	16.09	3.27
1995	0.00	8.38	15.16	5.85	0.00	0.00	0.00	0.00	0.00	29.40	5.75
1996	0.01	1.87	3.94	2.18	0.17	0.00	0.00	0.00	0.00	8.17	1.56
1997	0.00	1.01	7.38	1.14	0.16	0.10	0.00	0.00	0.00	9.79	2.10
1998	0.00	7.05	6.74	2.25	0.00	0.00	0.00	0.00	0.00	16.05	2.68
1999	0.15	4.73	11.94	4.10	0.65	0.08	0.00	0.00	0.00	21.66	4.71
2000	0.00	1.36	8.25	3.53	0.22	0.10	0.00	0.03	0.00	13.48	3.46
2001	0.00	0.57	8.06	4.23	0.14	0.00	0.00	0.00	0.00	13.00	3.55
mean	0.04	6.65	7.88	2.63	0.26	0.04	0.00	0.00	0.00	17.50	3.20

Table E4c. Survey indices of Cape Cod yellowtail abundance and biomass.

Mean Number per Tow at Age

NEFSC Spring Survey				Age						
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1979	0.36	0.47	0.88	0.56	0.03	0.02	0.00	0.00	2.32	0.76
1980	0.00	4.76	2.72	0.95	0.19	0.00	0.00	0.00	8.62	3.11
1981	0.07	4.31	2.92	0.64	0.73	0.35	0.45	0.00	9.46	2.93
1982	0.05	1.86	4.82	2.47	0.67	0.38	0.42	0.11	10.78	4.57
1983	2.01	5.39	4.33	1.78	0.19	0.13	0.00	0.00	13.82	4.09
1984	0.06	1.72	1.02	0.66	0.43	0.04	0.05	0.12	4.10	1.37
1985	0.13	1.85	1.80	0.43	0.25	0.10	0.00	0.00	4.56	1.39
1986	0.03	2.99	0.26	0.07	0.17	0.00	0.00	0.00	3.51	0.68
1987	0.11	2.41	3.61	0.59	0.91	0.92	1.07	0.52	10.13	4.75
1988	1.48	6.31	1.30	0.85	0.33	0.12	0.06	0.00	10.43	1.68
1989	0.32	3.83	2.35	0.21	0.10	0.00	0.00	0.00	6.82	1.11
1990	0.00	3.66	8.87	0.23	0.00	0.16	0.00	0.00	12.93	2.78
1991	0.66	5.64	3.89	1.23	0.29	0.00	0.08	0.00	11.79	2.51
1992	0.25	1.50	2.34	0.65	0.03	0.00	0.00	0.00	4.77	1.06
1993	0.10	1.01	1.17	0.58	0.00	0.00	0.00	0.00	2.87	0.59
1994	0.54	3.81	1.57	0.61	0.22	0.13	0.00	0.00	6.88	1.15
1995	0.22	1.41	4.94	3.19	0.31	0.07	0.00	0.00	10.14	2.35
1996	0.02	0.57	0.79	0.42	0.00	0.00	0.00	0.00	1.81	0.40
1997	0.03	1.33	2.12	1.71	0.38	0.00	0.00	0.00	5.56	1.56
1998	0.00	1.14	3.35	1.22	0.28	0.00	0.00	0.00	5.99	1.47
1999	0.03	1.07	3.44	2.45	0.48	0.18	0.00	0.00	7.65	2.34
2000	0.48	5.56	21.74	7.49	1.21	1.45	0.00	0.00	37.93	12.39
2001	0.00	1.92	6.50	1.11	0.34	0.00	0.00	0.00	9.87	3.15
2002	0.02	2.66	8.15	3.60	0.28	0.04	0.00	0.04	14.80	4.58
mean	0.29	2.80	3.95	1.41	0.33	0.17	0.09	0.03	9.06	2.61

Table E4d. Survey indices of Cape Cod yellowtail abundance and biomass.

Mean Number per Tow at Age

NEFSC Fall Survey					Age					
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1979	5.73	5.84	1.75	0.44	0.08	0.02	0.00	0.00	13.86	3.88
1980	14.13	12.04	5.46	2.08	0.46	0.00	0.05	0.00	34.21	8.95
1981	4.20	6.38	1.15	0.30	0.19	0.00	0.00	0.00	12.22	2.60
1982	0.77	3.67	3.53	0.43	0.48	0.04	0.00	0.00	8.92	2.84
1983	0.59	0.79	0.50	0.04	0.00	0.00	0.00	0.00	1.92	0.46
1984	0.43	1.50	0.69	0.87	0.62	0.20	0.10	0.10	4.51	1.77
1985	6.60	2.54	1.94	0.29	0.00	0.00	0.00	0.00	11.37	2.52
1986	1.73	4.71	0.40	0.00	0.00	0.00	0.00	0.00	6.83	1.25
1987	0.73	1.75	0.61	0.07	0.06	0.00	0.00	0.00	3.23	0.72
1988	4.13	6.04	0.60	0.11	0.00	0.00	0.00	0.00	10.88	1.49
1989	2.32	7.47	2.75	0.49	0.00	0.00	0.00	0.09	13.12	2.95
1990	4.67	7.93	3.72	0.06	0.01	0.00	0.00	0.00	16.38	3.05
1991	2.39	2.23	1.93	0.40	0.00	0.00	0.00	0.00	6.95	1.49
1992	3.32	3.65	2.54	1.05	0.25	0.19	0.00	0.00	10.99	2.49
1993	5.86	5.75	0.68	0.10	0.00	0.00	0.00	0.00	12.39	1.38
1994	3.23	9.64	3.47	0.95	0.29	0.00	0.00	0.00	17.57	3.46
1995	0.79	1.09	1.05	0.23	0.05	0.00	0.00	0.00	3.21	0.93
1996	1.41	3.64	5.96	1.57	0.18	0.00	0.00	0.00	12.75	3.31
1997	1.39	3.23	3.67	1.66	0.90	0.15	0.00	0.00	11.00	2.96
1998	1.58	4.51	1.90	1.38	0.39	0.00	0.00	0.00	9.76	2.27
1999	5.27	10.55	6.88	2.12	0.94	0.04	0.00	0.00	25.80	7.64
2000	1.30	8.81	5.87	0.34	0.00	0.00	0.00	0.00	16.33	4.53
2001	0.29	4.93	2.92	0.12	0.03	0.03	0.00	0.00	8.31	2.47
mean	3.17	5.16	2.61	0.66	0.21	0.03	0.01	0.01	11.85	2.84

Table E5a. Stock numbers of Cape Cod yellowtail flounder from VPA.

STOCK NUMBERS (Jan 1) in thousands -

	1985	1986	1987	1988	1989	1990	1991
1	9891	4712	6755	21229	7697	6279	9142
2	2702	7787	3786	5518	17054	6199	5067
3	1443	1378	3068	1756	2590	12034	2597
4	657	517	536	744	334	868	1988
5	326	65	197	196	43	63	317
6	116	14	89	39	11	50	73
1+	15133	14473	14432	29482	27730	25492	19184

	1992	1993	1994	1995	1996	1997	1998
1	7149	7076	5495	4997	6435	5972	7932
2	7068	4326	5668	4445	3681	5262	4889
3	3057	2275	3226	4215	3004	2519	3512
4	802	1112	1088	1464	1295	1170	762
5	221	165	365	258	422	253	217
6	17	82	168	136	25	19	62
1+	18315	15036	16011	15514	14862	15195	17373

	1999	2000	2001	2002
1	11269	7444	1645	00
2	6444	9216	6092	1329
3	3414	4841	6619	3500
4	974	1600	1390	2132
5	155	193	199	158
6	67	46	48	28
1+	22323	23341	15993	7148

Table E5b. Fishing mortality estimates for Cape Cod yellowtail flounder from VPA.

FISHING MORTALITY -

	1985	1986	1987	1988	1989	1990	1991
1	0.04	0.02	0.00	0.02	0.02	0.01	0.06
2	0.47	0.73	0.57	0.56	0.15	0.67	0.31
3	0.83	0.74	1.22	1.46	0.89	1.60	0.98
4	2.11	0.76	0.80	2.64	1.47	0.81	2.00
5	2.40	0.78	0.82	3.43	1.56	0.83	2.24
6	2.40	0.78	0.82	3.43	1.56	0.83	2.24
4,5	2.25	0.77	0.81	3.03	1.52	0.82	2.12

	1992	1993	1994	1995	1996	1997	1998
1	0.30	0.02	0.01	0.11	0.00	0.00	0.01
2	0.93	0.09	0.10	0.19	0.18	0.20	0.16
3	0.81	0.54	0.59	0.98	0.74	1.00	1.08
4	1.38	0.91	1.24	1.04	1.43	1.49	1.39
5	1.45	0.94	1.29	1.08	1.51	1.58	1.47
6	1.45	0.94	1.29	1.08	1.51	1.58	1.47
4,5	1.42	0.93	1.27	1.06	1.47	1.53	1.43

	1999	2000	2001
1	0.00	0.00	0.01
2	0.09	0.13	0.35
3	0.56	1.05	0.93
4	1.42	1.89	1.97
5	1.50	2.08	1.97
6	1.50	2.08	1.97
4,5	1.46	1.98	1.97

Table E5c. Spawning stock biomass estimates for Cape Cod yellowtail flounder from VPA.

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT)

	1985	1986	1987	1988	1989	1990	1991
1	00	00	00	00	00	00	00
2	46	106	53	68	319	90	76
3	274	324	551	242	519	1703	438
4	123	183	194	121	108	314	422
5	66	32	84	30	19	34	84
6	31	09	53	07	07	31	27
1+	540	654	934	468	972	2172	1046

	1992	1993	1994	1995	1996	1997	1998
1	00	00	00	00	00	00	00
2	46	49	88	66	48	110	91
3	520	488	677	689	641	471	667
4	216	301	293	366	322	267	208
5	68	76	122	92	110	69	67
6	10	51	75	64	12	07	32
1+	859	965	1254	1278	1132	924	1065

	1999	2000	2001
1	00	00	00
2	151	238	124
3	847	1026	1371
4	278	376	326
5	44	46	59
6	30	16	21
1+	1349	1700	1901

Table E6. Short term projections of Cape Cod yellowtail flounder.

Input Assumptions	age 1	age 2	age 3	age 4	age 5	age 6+
stock weight (kg)	0.04	0.28	0.39	0.51	0.61	0.92
landed weight (kg)	0.15	0.35	0.41	0.52	0.61	0.92
discard weight (kg)	0.15	0.22	0.30	0.41	0.53	0.75
maturity	0.00	0.08	0.81	1.00	1.00	1.00
partial recruitment	0.01	0.11	0.55	1.00	1.00	1.00
proportion discarded	1.00	0.52	0.20	0.07	0.05	0.04

Results

Year	F	Landings (mt)	Discards (mt)	SSB (mt)
2002	1.67	1651	224	1368
2003	0.12	117	17	1179
2004	0.12	217	31	2463

Figure E1. Total catch of Cape Cod yellowtail flounder.

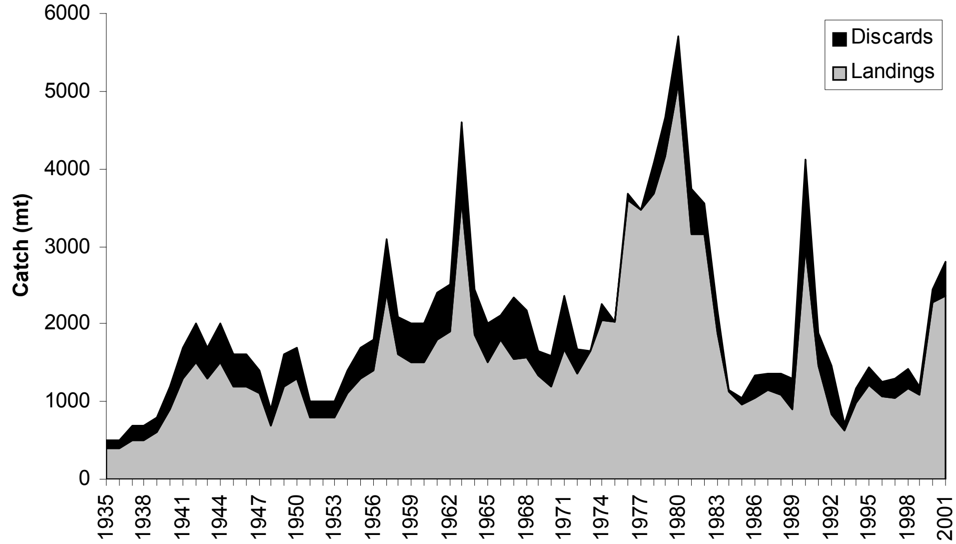


Figure E2. Survey indices of Cape Cod yellowtail flounder biomass.

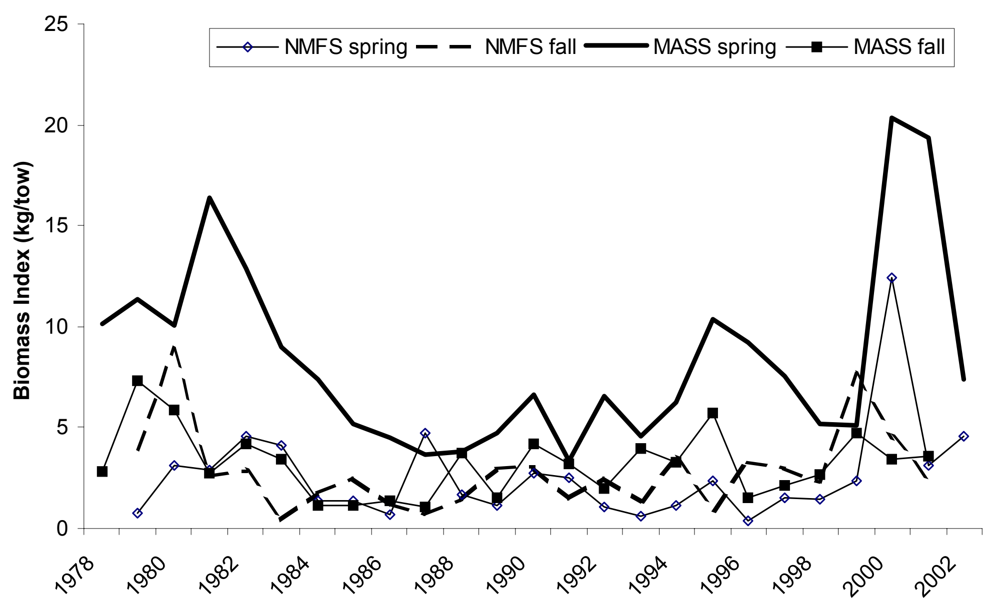
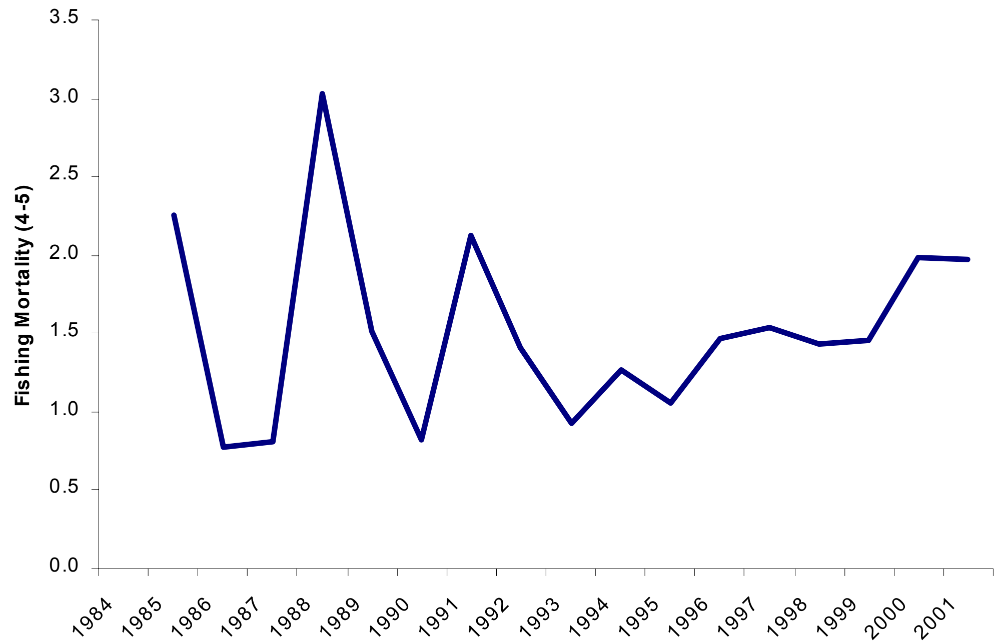


Figure E3. Cape Cod yellowtail flounder VPA results.



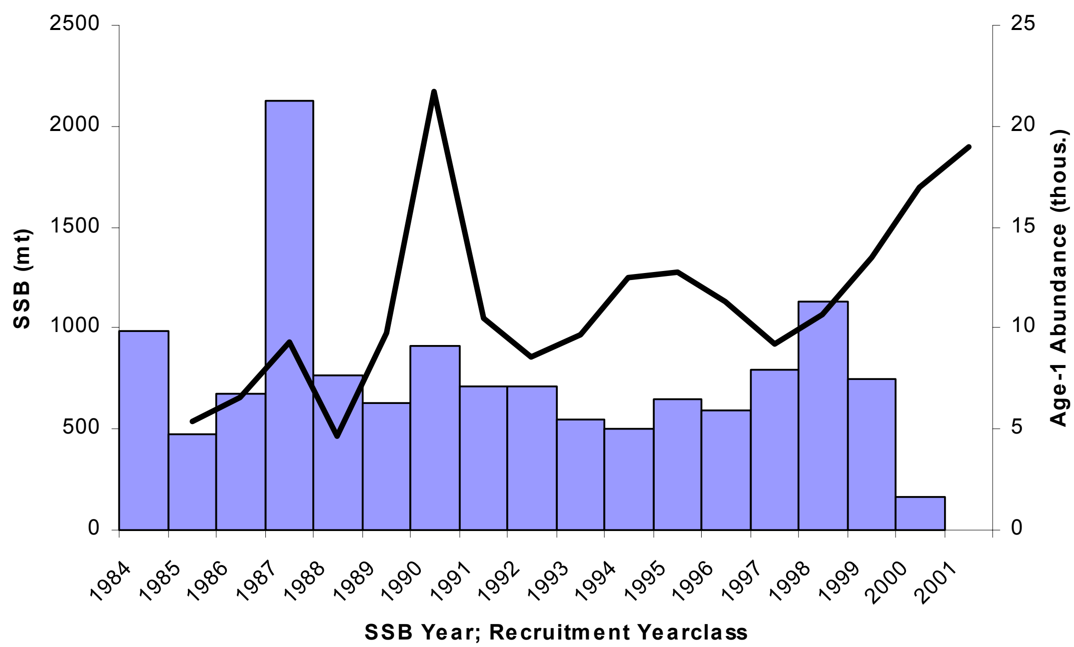


Figure E4. Retrospective analysis of the Cape Cod yellowtail flounder VPA.

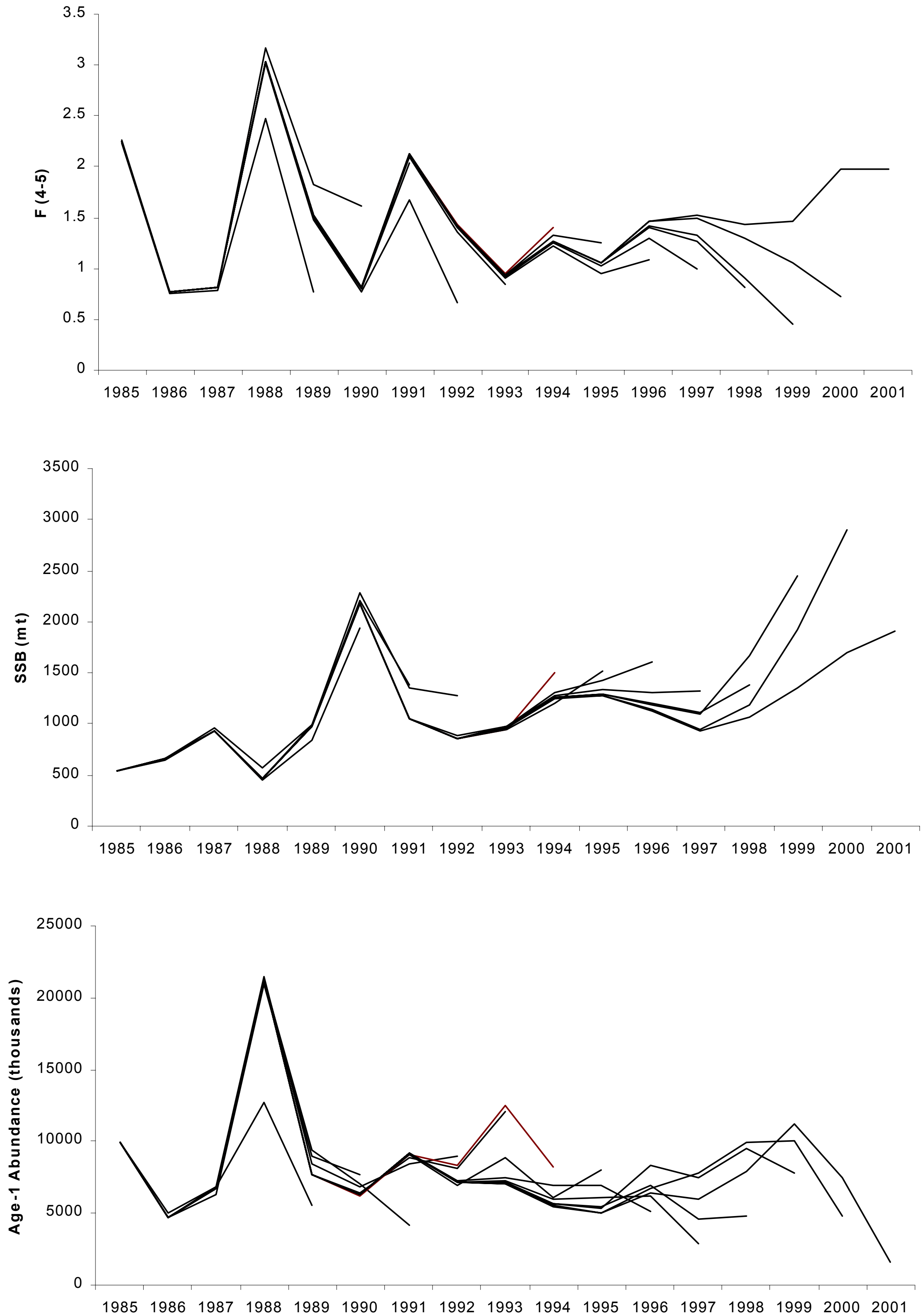
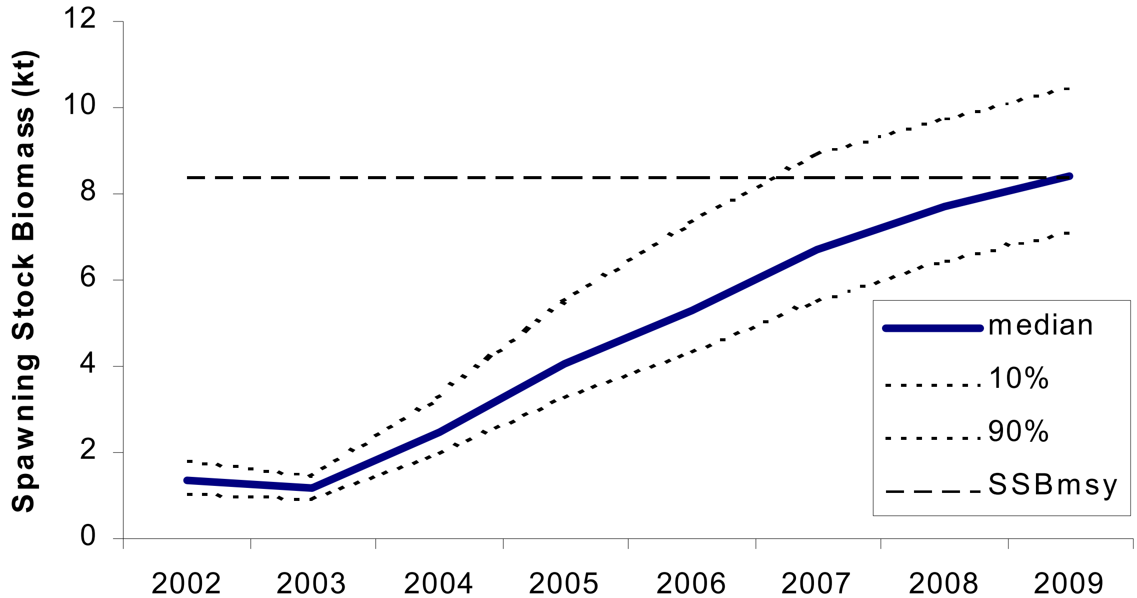


Figure E5. Stochastic projection of Cape Cod yellowtail flounder for $F_{rebuild}$=0.12.



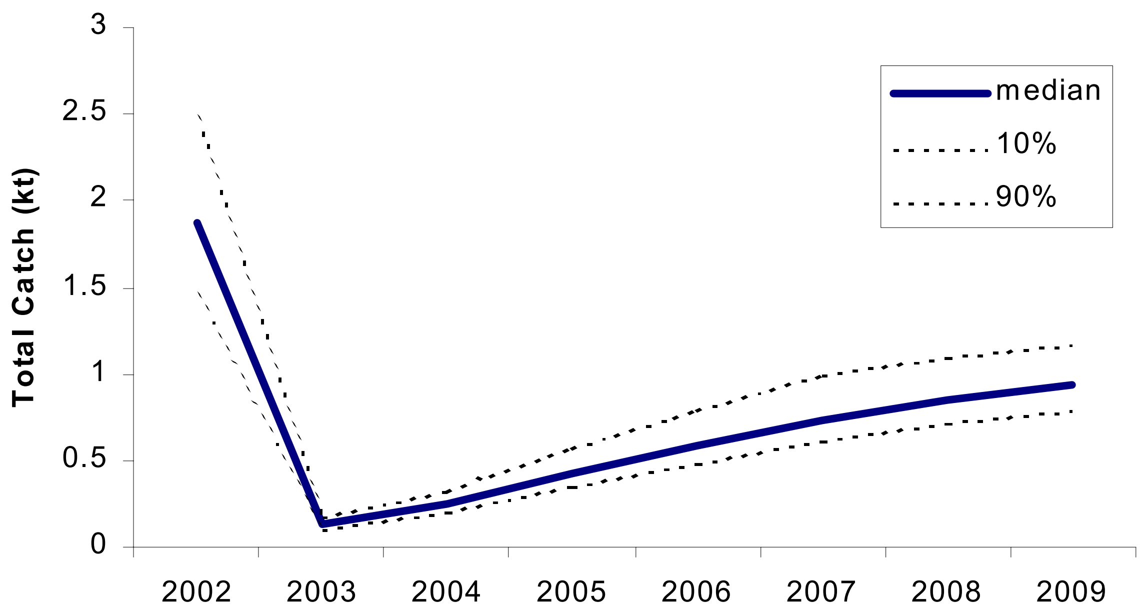
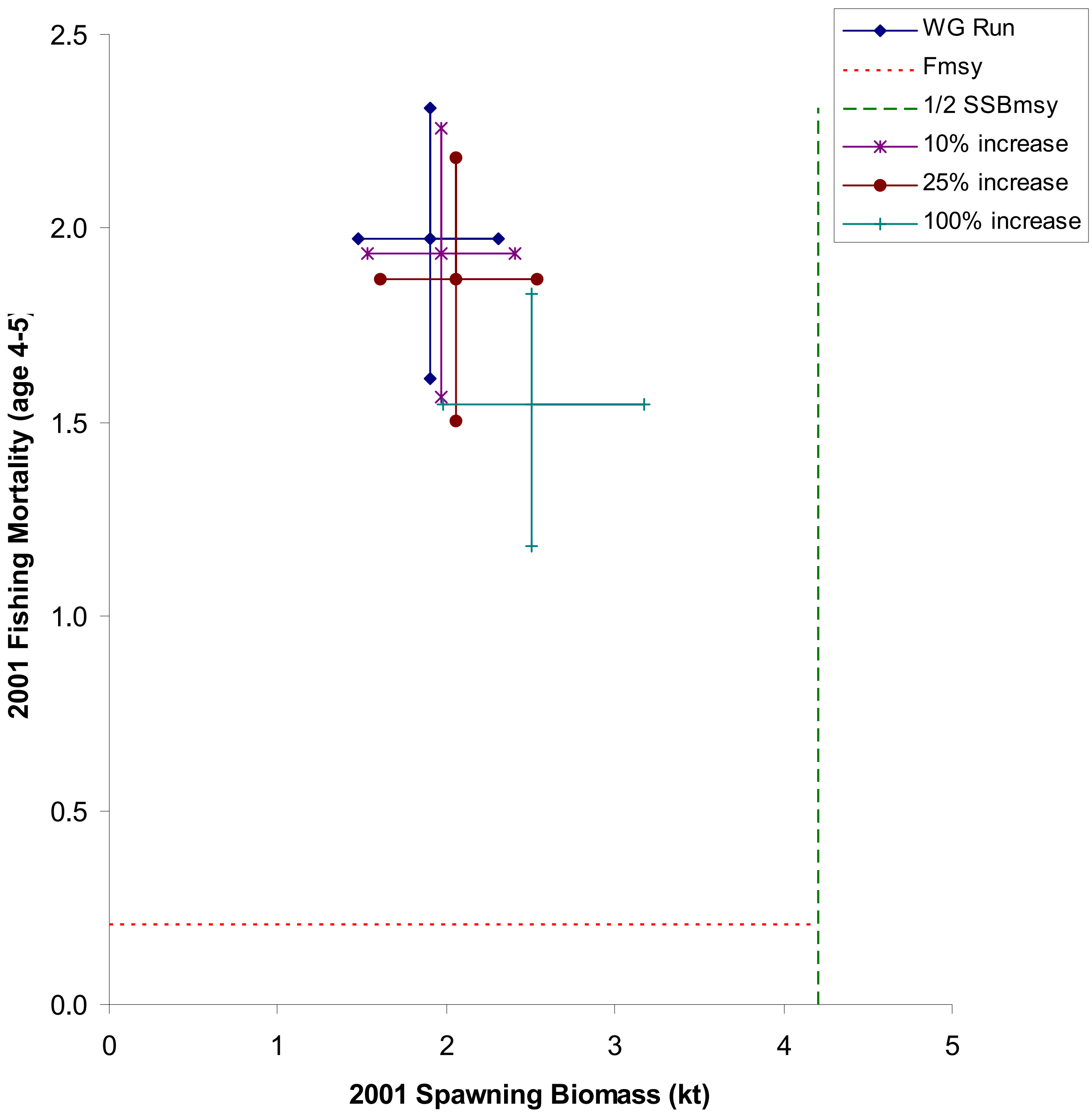


Figure E6. Sensitivity of results to excluding NEFSC survey indices and increasing NEFSC indices since 2000 by 10%, 25% and 100% (with 80% confidence intervals). Results accepted by the working group ("WG Run") are shown for comparison.



F. Gulf of Maine Cod by **R.K. Mayo and L. Col**

1.0 Background

The Gulf of Maine Atlantic cod stock was last assessed in 2001 (Mayo *et al.* 2002; NEFSC 2001). All of the methodology applied in the present assessment is the same as in the 2001 assessment as described in Mayo *et al.* (2002). In the 2001 assessment, fully recruited fishing mortality (ages 4+) in 2000 was estimated to be 0.73, and the 1999 F was estimated to be 0.77. Spawning stock biomass was estimated to have declined to 11,100 mt in 1999, a decline from a recent high of 14,600 mt in 1995 and a series high of 24,200 mt in 1990. The strength of the most recent recruiting year classes was estimated to be very low. The 1993, 1994 and 1995 year classes continue to be estimated as the lowest in the VPA series dating back to 1982 (1981 year class). The recruit/SSB survival ratios for these most recent year classes were also estimated to be very low compared to previous year classes. NEFSC spring and autumn research vessel bottom trawl survey indices for Gulf of Maine cod had declined to record low levels in the mid-1990s; indices from both surveys fluctuated at relatively low levels but have been increasing in 2001 and 2002. The 1994-1996 year classes derived from the NEFSC and Commonwealth of Massachusetts surveys were also among the lowest in the respective series, but the Mass. DMF survey and the 2001 and 2002 NEFSC surveys indicate that the 1998 year class may be larger than the recent average.

2.0 The Fishery

Commercial landings of Gulf of Maine cod declined to 1,636 metric tons (mt) in 1999, a 61 % decline from 1998 (Table F1; Figure F1). Commercial landings have since increased to 3,730 mt in 2000 and 4,416 mt in 2001. Discard estimates have been derived on a gear-quarter basis from 1989 through 2001 based on NEFSC Observer Program data; these results indicate a substantial increase in the overall discard /kept ratio in 1999 compared to previous years. Ratios calculated for 2000 and 2001 are lower than the 1999 ratio, but substantially greater than the pre-1999 ratios. Discards estimated from the Observer Program data equaled 2,600, 1,200 and 1,600 mt in 1999, 2000 and 2001, respectively. Discards have also been estimated based on Vessel Trip Reports, filtered to exclude vessels which do not report discards. Discards based on these data have been estimated to be 2,800, 2,200 and 1,600 mt in 1999, 2000, and 2001, respectively.

During the review of the 2001 assessment at SAW33, it was agreed that the discard estimates from both Sea Sample and VTR data could be accepted with reservation. It was then concluded that only approximations of the actual estimates in 500 mt increments were considered. For the purposes of the present assessment, the procedure agreed at SAW33 was employed for the 2001 data. Full details are given in Mayo *et al.* (2002). Discards as derived in this manner are given below:

Year	Landings	Discard Estimates SS	VTR	SARC 33 As Used	Commercial Catch
1999	1,636	2,630	2,822	2,500	4,136
2000	3,730	1,170	2,246	1,000	4,730
2001	4,416	1,619	1,600	1,500*	5,916

* SARC approach carried forward for 2001

The estimated recreational catch of Gulf of Maine cod (retained component only) remained the same in 1999 as in 1998 at approximately 822-824 mt, but increased to 1,100 mt in 2000 and 2,600 mt in 2001. For input to VPA, the landings at age were raised by the ratio of total catch (including discards) to landings under the assumption that high discarding in 1999-2001 was due to trip limits, resulting in discarding of all sizes in the same proportion as landings.

The number of commercial port samples for this stock declined from 78 in 1997 to 46 in 1998 to 15 in 1999. Port sampling has since improved, increasing to 61 samples in 2000 and 113 samples in 2001 (Table F2). Sampling was not well distributed among quarters and market categories in 1999 and 2000, as only 1 biological sample was taken in the 3rd and 4th quarter of 1999, requiring substantial pooling over quarter. In 1999 and 2000 samples from each market category were pooled on an annual basis, but improved sampling in 2001 allowed a return to the traditional quarterly pooling of samples within each market category. In 2001, sampling was approximately proportional to the distribution of the landings by market category (Table F3). As has generally been the case, the landings at age in 1999-2001 were dominated by age 3 and 4 cod (Table F4).

3.0 Research Vessel Surveys

NEFSC research vessel bottom trawl survey abundance and biomass indices for Gulf of Maine cod remained relatively low through autumn 1999 and spring 2000 (Table F5; Figure F2). The autumn 1999 indices increased slightly over 1998, while the spring 2000 indices decreased slightly from the 1999 values. However, biomass indices increased substantially in 2001 and spring 2002 over the 1999-2000 values.

Autumn biomass indices were also partitioned into inshore (strata 26 and 27; area 1,734 square miles) and offshore (strata 28-30, 36-40; 16,158 square miles) Gulf of Maine regions. When expressed in this manner, stratified mean weight per tow indices may be seen to represent comparative biomass density rather than indices of absolute biomass.

However, when appropriate weighting by area is applied to the respective inshore and offshore indices to allow comparison of absolute biomass between regions, the weighted indices provide a perspective on trends in absolute biomass. These results suggest that biomass has declined more precipitously in the offshore regions of the Gulf of Maine, while biomass in the inner region has declined at a lesser rate. Both inshore and offshore biomass indices have been increasing in recent years, consistent with an expansion of the population to the offshore area. Recruitment indices for the 1994-1997 year classes derived from the NEFSC and Mass. DMF bottom trawl surveys are among the lowest in the respective series, although indices for the 1998 and 1999 year classes appear to be above the recent average. The 2000 year class appears to be the extremely weak.

4.0 Assessment

Input Data and Analyses

The present assessment represents a one-year update to the previous assessment (Mayo *et al.* 2002; NEFSC 2001). The same VPA formulation used in the previous assessment was employed in the present update, except that current year (2002) spring survey data were available. Catch at age data were updated for 2001 with the inclusion of commercial discards (1,500 mt in 2001) and recreational catch at age. NEFSC and Mass. DMF survey abundance indices (stratified mean number per tow at age) were updated through spring 2002. As in recent VPAs, commercial CPUE indices were included only through 1993.

Precision of the 2001 spawning stock biomass and fully recruited fishing mortality was derived from 1,000 bootstrap replicates of the VPA based on resampling of survey residuals. A retrospective analysis of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB were also carried out. Projections through 2009 were also completed.

Assessment Results

Fully recruited fishing mortality (ages 4+) in 2001 is estimated at 0.47 (Table F6; Figure F3), and spawning stock biomass is estimated to have increased to 22,000 mt in 2001 (Table F6; Figure F4). The 1998 year class is estimated to be equivalent to the 1992 year class (approximately 9-10 million fish), while all intervening year classes are below the long term geometric mean (5.9 million fish). The 1999 year class is slightly below average, the 2000 year class (< 1 million fish) is by far the poorest of those estimated by the VPA, and the 1993-1995 year classes are about ½ the long term average.

VPA Diagnostics

Based on the variability indicated by the survey residuals, the bootstrap analysis suggests that there is a 90% probability that 2001 fully recruited fishing mortality is greater than 0.38, and 2001 SSB is less than 25,600 mt. With the current VPA formulation, a retrospective pattern is evident in the estimates of terminal F whereby fully recruited F appears to have been overestimated in 1999 and 2000 and underestimated from 1994-1997 (Figure F5). The opposite pattern is evident for SSB, although to a lesser extent. Terminal year estimates of the strength of the 1994-1996 year classes in 1995-1997 were considerably lower than the retrospective estimates, but recent year classes appear to have been well estimated in the terminal year

VPA Sensitivity Runs

The sensitivity of the VPA calibration process to various assumptions of changes in survey catchability during 2000 to 2002 was examined. Specifically, the 2000-2002 NEFSC spring and autumn age-specific indices were arbitrarily raised by 10%, 25%, and 100%, and the VPA calibration process was repeated. Bootstrapping each of the VPAs provided a series of overlap plots based on the 80% confidence intervals (80% CI). These results suggest considerable overlap between the 10% and 25% adjustment VPAs and the base VPA, with the 100% adjustment VPA exhibiting considerable distance from all others (Figure F6). Further details are presented in section 4.2 of this report.

5.0 Projections

Catch and stock size projections were performed with F_{2002} assumed equal to 85% of F_{2001} (0.40), and $F_{2003\text{-}2009}$ determined by iterating a revised estimate of $F_{rebuild}$ until there was a 50% probability that SSB was equal to SSB_{MSY} in 2009. The estimate of $F_{rebuild}$ based on the present VPA results is 0.114. Input data and projection results are given in Table F7 and Figure F7.

Medium term projections suggest that SSB will increase to SSBmsy (82,830 mt) by 2009 with at least a 50% probability if F is held at Frebuild (0.114) between 2003 and 2009 (Figure F7). Short term projections of catch for 2003 indicate that total catch (including commercial landings and discard, and recreational landings) should not exceed 2,479 mt if the revised estimate of $F_{rebuild}$ (0.114) is to be achieved in 2003.

6.0 Biological Reference Points

The following biological reference points were obtained from an age-structured production model (NEFSC 2002) performed on yield and SSB/recruit analyses and the VPA estimates of SSB and age 1 recruitment obtained from the 2001 assessment (Mayo *et al.* 2002):

MSY	16,600 mt
SSB_{MSY}	82,830 mt
F_{MSY}	0.225 (fully recruited)

At that time, the fishing mortality required to rebuild SSB to SSB_{MSY} by 2009 was determined to be 0.165, based on starting conditions in 2001. The fishing mortality to rebuild to the same SSB_{MSY} was re-estimated from the results of the present assessment as 0.114, based on starting conditions in 2002. The differences are primarily due to the use of 85% of F_{2001} (0.40) in 2002 in the present analysis versus an assumption of F_{max} (0.258) in 2002 in the previous analysis, and the inclusion of the weak 2000 year class as part of the starting stock sizes in 2002 versus the geometric mean in the previous analysis. In addition the geometric mean recruitment applied in 2002 (5.9 million fish at age 1) is somewhat lower than the previous estimate (6.6 million) applied in 2001.

7.0 Conclusions

In 2001, SSB was less than ½ SSB_{MSY} and fully recruited fishing mortality was about 2 times F_{MSY}. Therefore the stock is overfished and overfishing is occurring.

8.0 Summary

Fishing mortality appears to have declined considerably in 2001 compared to earlier years, and spawning biomass is continuing to increase. The SSB estimate for 2001 (22,000 mt) is close to the high values of 1982 and 1989-1991. However, the apparent improvement in the condition of the stock is dependent to a large extent on the incoming 1998 year class. The strength of subsequent year classes, however, is either just below average (1999 year class) or extremely low (2000 year class).

Although recent surveys have indicated a marked increase in biomass, especially spring 2001 and 2002 and autumn 2001, there appears to have been a catchability effect associated with the spring 2002 survey in which abundance indices at age for most cohorts increased over the previous year.

Overall, there is accumulating evidence that the biomass of Gulf of Maine cod has been increasing in 2001 and 2002. Further increases in biomass may occur if fishing mortality is reduced to maximize the contribution of the 1998 year class to the spawning stock. Based on the current maturity ogive, this year class will be fully mature at age 4 in 2002. However, given the expected relatively poor strength of the 1999 and 2000 year classes, rebuilding of the stock may plateau unless additional average or above average year classes recruit in the next several years.

9.0 GARM Panel Comments

The Panel commented that the stock distribution had collapsed into a small area within Massachusetts Bay; however, there is now some evidence that the stock is starting to expand towards the outer Gulf of Maine. The Panel observed that the 2000 year class was estimated to be the weakest in the time series but, at this time, it is premature to draw final conclusions regarding the strength of this year class given the retrospective pattern in recruitment estimates (i.e. in future assessments, the 2000 year class may not be as low as currently estimated). The Panel noted that the 2000 fishing morality rate is lower than the estimate in the last assessment and this result is consistent with the retrospective pattern for fishing mortality which revealed a tendency to overestimate F in 2000.

Similarly, the Panel noted that the tuned 2001 F in the present assessment is considerably lower than the 2001 projected F (NEFSC 2002). This is due to several factors. The Projected 2001 F was based on stock conditions obtained from the 2001 VPA which was calibrated with research vessel survey data collected through autumn 2000. The present assessment utilizes 3 additional NEFSC surveys (2001 and 2002 spring and 2001 autumn), all of which indicated year over year increases in stock abundance, as well as corresponding Massachusetts surveys used to calibrate stock size estimates of recruiting ages.

Sources of Uncertainty

- Discard estimates included in the assessment in 1999-2001 based on the approach recommended by the 33rd SAW are likely to have underestimated the actual discards because they were rounded down to the nearest lower 500 ton bin.

- The estimate of the size of the incoming 2000 year class in 2001 is uncertain, but its influence on the projections is substantial. In the past, estimates of low recruitment were revised upward as data from the fishery were included, but the final estimates still indicated that they were lowest in the VPA series. Subsequent estimates of the strength of the 2000 year class may also increase.

10.0 Research Recommendations

- Explore a VPA formulation where autumn tuning indices are adjusted back to Jan 1, instead of shifted forward one year and one age.

- Explore the use of the state of Maine survey as a tuning indices.

- Given the overall truncation in the age composition, investigate possible trends in size/age composition of the inshore versus offshore areas.

- Request the Methods Working Group to investigate means of deriving an appropriate sampling intensity for commercial landings.

11.0 References

Mayo, R.K., E.M. Thunberg, S.E. Wigley and S.X. Cadrin. 2002. The 2001 Assessment of the Gulf of Maine Atlantic Cod Stock. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 02-02.

NEFSC. 2001. 33rd Northeast Regional Stock Assessment Workshop (33rd SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS/NEFSC, Reference Document 01-18.

NEFSC 2002. Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NMFS/NEFSC, Reference Document 02-04, 254p.

Table F1. Commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (NAFO Division 5Y), 1960 - 2001.[1]

Year	Gulf of Maine				
	USA	Canada	USSR	Other	Total
1960	3448	129	-	-	3577
1961	3216	18	-	-	3234
1962	2989	83	-	-	3072
1963	2595	3	133	-	2731
1964	3226	25	-	-	3251
1965	3780	148	-	-	3928
1966	4008	384	-	-	4392
1967	5676	297	-	-	5973
1968	6360	61	-	-	6421
1969	8157	59	-	268	8484
1970	7812	26	-	423	8261
1971	7380	119	-	163	7662
1972	6776	53	11	77	6917
1973	6069	68	-	9	6146
1974	7639	120	-	5	7764
1975	8903	86	-	26	9015
1976	10172	16	-	-	10188
1977	12426	-	-	-	12426
1978	12426	-	-	-	12426
1979	11680	-	-	-	11680
1980	13528	-	-	-	13528
1981	12534	-	-	-	12534
1982	13582	-	-	-	13582
1983	13981	-	-	-	13981
1984	10806	-	-	-	10806
1985	10693	-	-	-	10693
1986	9664	-	-	-	9664
1987	7527	-	-	-	7527
1988	7958	-	-	-	7958
1989	10397	-	-	-	10397
1990	15154	-	-	-	15154
1991	17781	-	-	-	17781
1992	10891	-	-	-	10891
1993	8287	-	-	-	8287
1994*	7877	-	-	-	7877
1995*	6798	-	-	-	6798
1996*	7194	-	-	-	7194
1997*	5421	-	-	-	5421
1998*	4156	-	-	-	4156
1999*	1636	-	-	-	1636
2000*	3730	-	-	-	3730
2001*	4416	-	-	-	4416

* Provisional

[1] USA 1960-1993 landings from NMFS, NEFSC Detailed Weighout Files and Canvass data.
[2] USA 1994-2001 landings estimated by prorating NMFS, NEFSC Detailed Weighout data by Vessel Trip Reports.

Table F2. USA sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 2001.

Year	Number of Samples				Number of Samples, by Market Category & Quarter															Annual Sampling Intensity			
	Length Samples		Age Samples		Scrod					Market					Large					No. of Tons Landed/Sample			
	No.	No. Fish Measured	No.	No. Fish Aged	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Scrod	Market	Large	∑
1982	48	3848	48	866	6	7	6	6	25	4	3	7	4	18	0	2	1	2	5	134	348	792	266
1983	71	5241	67	1348	14	10	10	4	38	4	10	6	2	22	1	3	5	2	11	106	294	318	197
1984	55	3925	55	1224	7	5	6	7	25	4	3	5	6	18	1	6	3	2	12	85	319	245	193
1985	69	5426	66	1546	5	6	7	5	23	8	6	7	4	25	7	5	3	6	21	95	229	132	155
1986	53	3970	51	1160	5	5	6	3	19	5	6	8	2	21	1	5	4	3	13	124	242	170	182
1987	43	3184	42	939	4	4	3	4	15	5	5	3	5	18	4	2	3	1	10	83	224	225	175
1988	34	2669	33	741	4	3	4	4	15	1	5	3	5	14	1	2	2	0	5	147	271	391	234
1989	32	2668	32	714	3	3	3	3	12	4	1	5	4	14	2	2	1	1	6	209	430	311	325
1990	39	2982	38	789	3	7	3	5	18	4	7	4	3	18	0	2	1	0	3	300	378	966	387
1991	56	4519	56	1152	2	10	4	3	19	5	11	11	3	30	0	3	3	1	7	250	313	519	318
1992	51	4086	51	1002	2	8	6	3	19	6	7	7	3	23	3	1	1	4	9	104	232	375	214
1993	23	1753	23	447	3	3	3	1	10	1	2	4	1	8	1	1	2	1	5	177	453	527	360
1994	30	2696	33	665	0	2	2	4	8	1	4	4	6	15	0	2	3	2	7	180	284	272	263
1995	31	2568	32	662	4	2	2	4	12	2	7	1	2	12	0	5	0	2	7	133	300	202	219
1996	77	7027	71	1483	6	5	7	9	27	7	9	10	12	38	1	3	3	5	12	62	116	79	93
1997	78	6657	74	1521	7	10	3	9	29	11	9	9	7	36	1	8	2	2	13	37	91	71	69
1998	46	4205	46	912	4	7	0	3	14	8	9	9	3	29	0	0	2	1	3	53	81	321	90
1999	15	1305	16	350	6	0	1	0	7	4	2	0	0	6	2	0	0	0	2	36	144	245	109
2000	61	4687	57	1300	12	5	3	4	24	12	14	4	6	36	0	0	0	1	1	14	62	1131	61
2001	113	7326	105	2436	4	4	4	7	19	7	9	8	15	39	3	16	18	18	55	18	58	32	39

Source: 1982-1985 from Serchuk and Wigley (1986); 1986-2001 from NEFSC files.

Table F3. Percentage (by weight) of USA commercial Atlantic cod landings from the Gulf of Maine (NAFO Division 5Y), by market category, 1964 - 2001.

	Gulf of Maine			
Year	Large	Market	Scrod	Total [a]
1964	29	59	12	100
1965	39	54	7	100
1966	42	48	10	100
1967	41	41	17	100
1968	47	43	9	100
1969	35	55	9	100
1970	43	52	6	100
1971	52	42	6	100
1972	58	35	7	100
1973	52	36	11	100
1974	39	33	28	100
1975	32	42	26	100
1976	29	45	20	100
1977	33	42	22	100
1978	38	44	17	100
1979	37	49	14	100
1980	36	45	19	100
1981	29	45	22	100
1982	29	45	24	100
1983	25	45	28	100
1984	26	51	19	100
1985	25	51	20	100
1986	22	51	23	100
1987	29	52	16	100
1988	26	45	23	100
1989	17	55	23	100
1990	34	43	19	100
1991	26	51	20	100
1992	31	49	18	100
1993	32	44	21	100
1994	24	54	18	100
1995	21	53	23	100
1996	13	61	23	100
1997	17	60	20	100
1998	23	57	18	100
1999	29	53	16	100
2000	30	59	9	100
2001	40	51	8	100

[a] Includes landings of 'mixed' cod.

Table F4a. Total (commercial and recreational)landings at age (thousands of fish; metric tons) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2001. (Input data for Virtual Population Analysis)

Year	Age 1	2	3	4	5	6	7+	Total
			Total Landings at Age in Numbers (000's)					
1982	88	1995	2350	1386	717	75	242	6853
1983	14	1337	2896	1184	685	448	169	6733
1984	24	813	1572	1636	469	205	142	4861
1985	49	989	2111	1122	665	133	137	5206
1986	26	208	2750	929	275	197	190	4575
1987	41	907	1418	1525	330	79	97	4397
1988	6	520	2140	1149	434	51	34	4334
1989	5	530	2284	1698	485	91	61	5154
1990	7	294	4195	2373	488	167	105	7629
1991	5	447	1349	4948	946	151	85	7931
1992	-	350	600	526	2184	218	86	3962
1993	1	152	1998	787	140	481	39	3597
1994	1	57	1380	1228	315	74	88	3143
1995	-	279	1152	1324	204	14	34	3007
1996	-	86	688	1943	368	46	10	3141
1997	-	61	494	466	894	72	8	1995
1998	-	110	485	616	180	211	11	1614
1999[1]	1	8	563	566	267	78	104	1586
2000[2]	-	97	485	934	211	96	25	1849
2000[3]	-	56	1000	666	370	104	87	2281
			Total Landings at Age in Weight (Tons)					
1982	50	2151	3735	3719	3392	494	2738	16279
1983	6	1421	4664	2891	2568	2691	1680	15921
1984	12	820	2551	4412	1710	1192	1462	12169
1985	18	1007	3442	3121	2929	725	1327	12549
1986	11	213	4946	2679	1252	1186	2225	12512
1987	13	917	2185	4752	1564	547	998	10976
1988	1	513	3764	2736	2204	321	363	9902
1989	3	628	3922	4979	1861	386	726	12575
1990	1	299	6941	5414	2046	1266	1424	17391
1991	1	507	2045	12204	3807	1093	944	20601
1992	-	536	1149	1432	6684	1080	911	11793
1993	1	172	3650	1903	594	2927	428	9675
1994	-	78	2568	3790	1047	449	868	8799
1995	-	452	2132	3531	1033	100	455	7703
1996	-	142	1440	4537	1321	340	109	7889
1997	-	105	1088	1382	2807	328	71	5781
1998	-	147	1023	1809	744	871	109	4701
1999[1]	-	10	1036	1573	1093	449	801	4963
2000[2]	-	156	1103	3090	905	559	181	5996
2000[3]	-	104	2387	2143	1784	661	705	7780

1. Includes 2,500 mt of estimated discards.
2. Includes 1,000 mt of estimated discards.
3. Includes 1,500 mt of estimated disaards.

Table F4b. Mean weight (kg) and mean length (cm) at age of total landings (commercial and recreational) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2001. (Input data for Virtual Population Analysis)

Total Landings Mean Weight (kg) at Age

Year	Age 1	2	3	4	5	6	7+	Average
1982	0.568	1.078	1.589	2.683	4.731	6.587	11.314	2.375
1983	0.429	1.063	1.610	2.442	3.749	6.007	9.941	2.365
1984	0.500	1.009	1.623	2.697	3.646	5.815	10.296	2.503
1985	0.367	1.018	1.621	2.782	4.405	5.451	9.686	2.410
1986	0.423	1.024	1.799	2.884	4.553	6.020	11.711	2.735
1987	0.317	1.011	1.541	3.116	4.739	6.924	10.289	2.496
1988	0.167	0.987	1.759	2.381	5.078	6.294	10.676	2.285
1989	0.600	1.185	1.717	2.932	3.837	4.242	11.902	2.440
1990	0.143	1.017	1.655	2.282	4.193	7.581	13.562	2.280
1991	0.171	1.134	1.516	2.466	4.024	7.238	11.106	2.598
1992	0.468	1.531	1.915	2.722	3.060	5.000	10.593	2.977
1993	1.000	1.132	1.627	2.418	4.243	6.085	10.974	2.690
1994	0.418	1.368	1.861	3.086	3.324	6.068	9.864	2.800
1995	0.418	1.620	1.851	2.667	5.064	7.143	13.382	2.562
1996	0.418	1.651	2.093	2.335	3.590	7.391	10.900	2.512
1997	0.418	1.721	2.202	2.966	3.140	4.556	8.875	2.898
1998	0.466	1.336	2.109	2.937	4.133	4.128	9.909	2.913
1999	0.331	1.250	1.841	2.776	4.100	5.736	7.702	3.129
2000	0.418	1.600	2.274	3.310	4.291	5.811	7.307	3.243
2001	0.418	1.868	2.388	3.215	4.817	6.370	8.103	3.411

Total Landings Mean Length (cm) at Age

Year	Age 1	2	3	4	5	6	7+	Average
1982	37.1	46.6	52.7	62.6	76.5	85.6	101.4	57.4
1983	33.5	46.6	53.1	61.0	70.5	82.5	95.6	58.0
1984	28.5	45.5	53.3	63.1	69.5	81.2	98.1	59.3
1985	32.0	45.4	53.3	64.1	74.5	79.9	96.6	58.5
1986	33.7	45.1	55.3	64.6	75.0	82.4	105.9	61.1
1987	26.4	45.1	52.1	66.4	76.2	86.4	98.4	58.8
1988	26.2	45.0	54.7	60.6	78.1	83.2	100.5	58.1
1989	38.4	48.5	54.6	65.1	71.2	77.5	103.1	60.0
1990	23.7	46.2	54.1	60.0	73.2	89.7	108.9	58.3
1991	24.9	47.5	51.9	61.3	71.8	88.1	100.7	61.1
1992	31.3	52.9	56.4	62.9	65.5	76.9	100.1	64.1
1993	38.0	47.4	55.9	60.8	73.5	83.2	101.7	61.4
1994	26.3	50.3	56.1	66.0	67.2	82.4	97.5	62.8
1995	31.2	53.8	56.0	62.4	78.0	87.2	107.1	60.9
1996	31.2	54.0	58.3	60.3	68.9	88.9	103.5	61.2
1997	31.2	54.6	59.4	65.0	66.3	74.8	104.6	64.4
1998	35.0	50.7	58.4	64.8	72.4	72.1	95.1	63.9
1999	33.0	47.4	56.0	63.9	72.1	80.7	89.9	64.9
2000	31.2	53.4	59.4	65.6	73.7	82.3	88.1	66.4
2001	31.2	56.3	60.9	66.8	76.9	84.5	91.3	66.9

Table F5. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1963 - 2002 [a,b,c]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	5.92	17.9
1964	-	-	4.00	22.8
1965	-	-	4.49	12.0
1966	-	-	3.78	12.9
1967	-	-	2.56	9.2
1968	5.44	17.9	4.39	19.4
1969	3.25	13.2	2.76	15.4
1970	2.21	11.1	4.90	16.4
1971	1.43	7.0	4.37	16.5
1972	2.06	8.0	9.31	13.0
1973	7.54	18.8	4.46	8.7
1974	2.91	7.4	4.33	9.0
1975	2.51	6.0	6.15	8.6
1976	2.78	7.6	2.15	6.7
1977	3.88	8.5	3.08	10.2
1978	2.06	7.7	5.75	12.9
1979	4.27	9.5	3.49	17.5
1980	2.15	6.2	7.04	14.2
1981	4.86	10.8	2.42	8.1
1982	3.75	8.6	7.77	16.1
1983	3.91	10.5	4.22	8.8
1984	3.40	5.8	2.42	8.8
1985	2.52	7.7	2.92	8.5
1986	1.96	3.6	1.95	5.1
1987	1.68	3.0	2.98	3.4
1988	3.13	3.3	5.90	6.6
1989	2.26	2.5	4.65	4.6
1990	2.36	3.1	2.99	4.9
1991	2.39	2.9	1.25	2.8
1992	2.41	8.7	1.43	2.4
1993	2.50	5.9	1.23	1.0
1994	1.27	2.4	2.14	2.7
1995	1.91	2.4	2.01	3.7
1996	2.46	5.4	1.32	2.4
1997	2.19	5.6	0.87	1.9
1998	1.71	4.2	0.84	1.5
1999	2.30	5.1	1.81	3.5
2000	3.08	3.2	2.60	4.7
2001	2.15	6.2	1.98	7.3
2002	3.72	10.9		

[a] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFSC 1991).

[b] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these differences.

[c] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1978, 1980, 1989-1991 and 1993 were accomplished with the R/V DELAWARE II; in all other years, the surveys were accomplished using the R/V ALBATROSS IV. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBTATROSS IV equivalents. Conversion coefficients 0.79 (number) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Table F6. Final VPA Results for Gulf of Maine Cod, 1982-2002

STOCK NUMBERS (Jan 1) in thousands -

	1982	1983	1984	1985	1986	1987	1988
1	7769	7539	10464	7004	10161	12538	25198
2	10891	6281	6160	8545	5690	8296	10228
3	5359	7112	3933	4307	6101	4471	5971
4	3026	2262	3202	1797	1616	2507	2377
5	1796	1223	780	1142	456	483	673
6	170	822	382	214	333	125	97
7	541	305	260	216	315	150	63
1+	29552	25543	25180	23227	24674	28569	44607

	1989	1990	1991	1992	1993	1994	1995
1	4302	4021	6994	6419	9373	3383	3457
2	20625	3518	3286	5721	5255	7673	2769
3	7903	16407	2614	2286	4368	4165	6231
4	2953	4404	9637	920	1328	1768	2161
5	907	881	1459	3413	277	376	336
6	158	303	280	338	818	100	22
7	104	188	155	132	65	116	53
1+	36952	29721	24423	19228	21485	17581	15030

	1996	1997	1998	1999	2000	2001	2002
1	3377	5055	5183	10078	4564	566	00
2	2830	2765	4138	4243	8250	3737	463
3	2014	2239	2208	3289	3467	6667	3009
4	4059	1027	1386	1369	2183	2399	4554
5	572	1565	419	578	609	942	1362
6	91	135	473	180	231	308	437
7	19	15	24	237	60	255	289
1+	12962	12800	13832	19974	19364	14874	10113

FISHING MORTALITY -

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.01	0.00	0.00	0.00
2	0.23	0.27	0.16	0.14	0.04	0.13	0.06
3	0.66	0.60	0.58	0.78	0.69	0.43	0.50
4	0.71	0.86	0.83	1.17	1.01	1.12	0.76
5	0.58	0.96	1.09	1.03	1.10	1.41	1.25
6	0.67	0.92	0.90	1.16	1.06	1.20	0.87
7	0.67	0.92	0.90	1.16	1.06	1.20	0.87
4-5,u	0.64	0.91	0.96	1.10	1.05	1.26	1.01

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.03	0.10	0.16	0.07	0.03	0.01	0.12
3	0.38	0.33	0.84	0.34	0.70	0.46	0.23
4	1.01	0.91	0.84	1.00	1.06	1.46	1.13
5	0.89	0.95	1.26	1.23	0.82	2.62	1.11
6	1.01	0.94	0.91	1.22	1.05	1.70	1.17
7	1.01	0.94	0.91	1.22	1.05	1.70	1.17
4-5,u	0.95	0.93	1.05	1.11	0.94	2.04	1.12

Table F6 (Continued).

	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.03	0.02	0.03	0.00	0.01	0.02
3	0.47	0.28	0.28	0.21	0.17	0.18
4	0.75	0.70	0.68	0.61	0.64	0.37
5	1.24	1.00	0.64	0.71	0.48	0.57
6	0.82	0.89	0.68	0.65	0.61	0.47
7	0.82	0.89	0.68	0.65	0.61	0.47
4-5,u	1.00	0.85	0.66	0.66	0.56	0.47

Jan 1 BIOMASS (using Jan 1 mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	3224	2111	3662	1541	2784	2257	1588
2	9606	4880	4053	6093	3488	5426	5717
3	6871	9367	5164	5509	8255	5615	7966
4	6869	4455	6674	3819	3495	5937	4552
5	7542	3880	2328	3935	1624	1785	2676
6	948	4381	1782	956	1715	701	528
7	6122	3030	2678	2097	3690	1543	678
1+	41181	32104	26341	23950	25051	23263	23705

	1989	1990	1991	1992	1993	1994	1995
1	1983	205	399	1630	8014	717	726
2	9178	2747	1324	2929	3616	8978	2279
3	10290	22969	3247	3369	7303	6044	9913
4	6705	8716	19466	1868	2859	4197	4816
5	2741	3089	4420	9375	941	1065	1330
6	734	1636	1541	1517	3530	508	109
7	1238	2544	1720	1396	714	1141	714
1+	32869	41906	32116	22085	26976	22649	19887

	1996	1997	1998	1999	2000	2001
1	696	1183	1254	1522	1114	138
2	2352	2345	3091	3068	6006	2679
3	3708	4270	4207	5157	5845	11261
4	8439	2558	3526	3314	5390	5939
5	1769	4238	1467	2005	2102	3467
6	556	546	1701	877	1129	1565
7	212	131	241	1827	435	2066
1+	17731	15272	15487	17768	22021	27114

Table F6 (Continued).

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	218	143	248	60	108	87	61
2	2326	1174	993	2765	1608	2465	2629
3	3630	5002	2764	4445	6762	4801	6729
4	5197	3283	4945	3039	2857	4768	3877
5	6421	3100	1821	3204	1308	1365	2102
6	820	3633	1483	763	1390	554	442
7	5296	2513	2229	1672	2991	1221	567
1+	23908	18848	14484	15947	17024	15262	16406

	1989	1990	1991	1992	1993	1994	1995
1	77	22	42	173	853	28	28
2	4241	732	349	784	974	3295	821
3	8868	11771	1528	1724	3517	4822	8214
4	5481	5872	13262	1239	1876	3151	3820
5	2284	2372	3221	6871	739	666	1069
6	599	1327	1255	1173	2809	370	87
7	1012	2104	1430	1101	580	831	568
1+	22561	24200	21088	13065	11347	13163	14608

	1996	1997	1998	1999	2000	2001
1	27	46	49	59	43	05
2	859	858	1131	1127	2203	982
3	2950	3509	3458	4286	4892	9405
4	7127	2181	3016	2866	4639	5350
5	1391	3471	1274	1721	1875	3049
6	469	455	1469	761	986	1400
7	179	109	208	1585	380	1848
1+	13001	10630	10604	12405	15019	22040

Table F7a. Starting conditions and input data for short-term (2002-2004) stochastic stock biomass and catch projections for Gulf of Maine cod.

Input for Projections:

Number of Years: 3; Initial Year: 2002; Final Year: 2004
Number of Ages : 7; Age at Recruitment: 1; Last Age: 7
Natural Mortality is assumed Constant over time at: .200
Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Last age is a PLUS group;

Age-specific Input data for Projection # 1

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0010	1.0000	.0400	0.441	0.283
2	.0134	1.0000	.3800	1.229	0.725
3	.2867	1.0000	.8900	1.782	1.466
4	1.0000	1.0000	.9900	2.694	2.180
5	1.0000	1.0000	1.0000	4.089	3.343
6	1.0000	1.0000	1.0000	6.031	4.960
7+	1.0000	1.0000	1.0000	10.881	10.881

Table F7b. Results of short-term stochastic stock biomass and catch projections for Gulf of Maine cod.

Projections for 2002-2004;

F2002=0.40 Basis: 85% of Status quo 2001 point estimate.

Recruitment (age 1) 2002 and 2003 year classes derived from Beverton-Holts spawning stock-recruitment relationship based on 1981-1999 year classes.

SSB was estimated to be 22,000 mt in 2001.

2002			2003			2004	
F	Catch	SSB	F	Catch	SSB	Catch	SSB
0.40	7786	23616	$F_{rebuild}$ =0.114	2479	22831	2916	31544

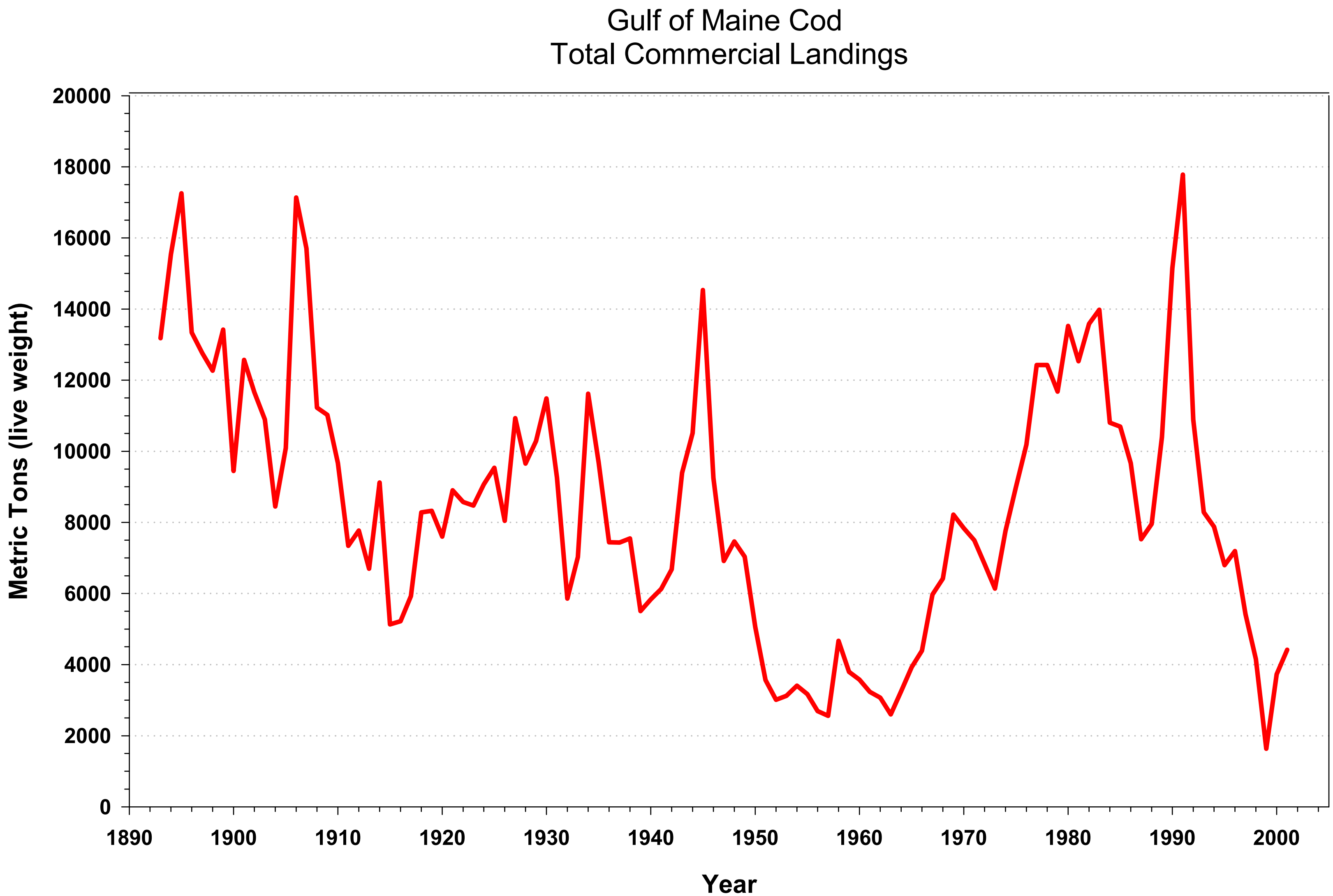


Figure F1. Total commercial landings of Gulf of Maine cod (NAFO Div. 5Y), 1893-2001.

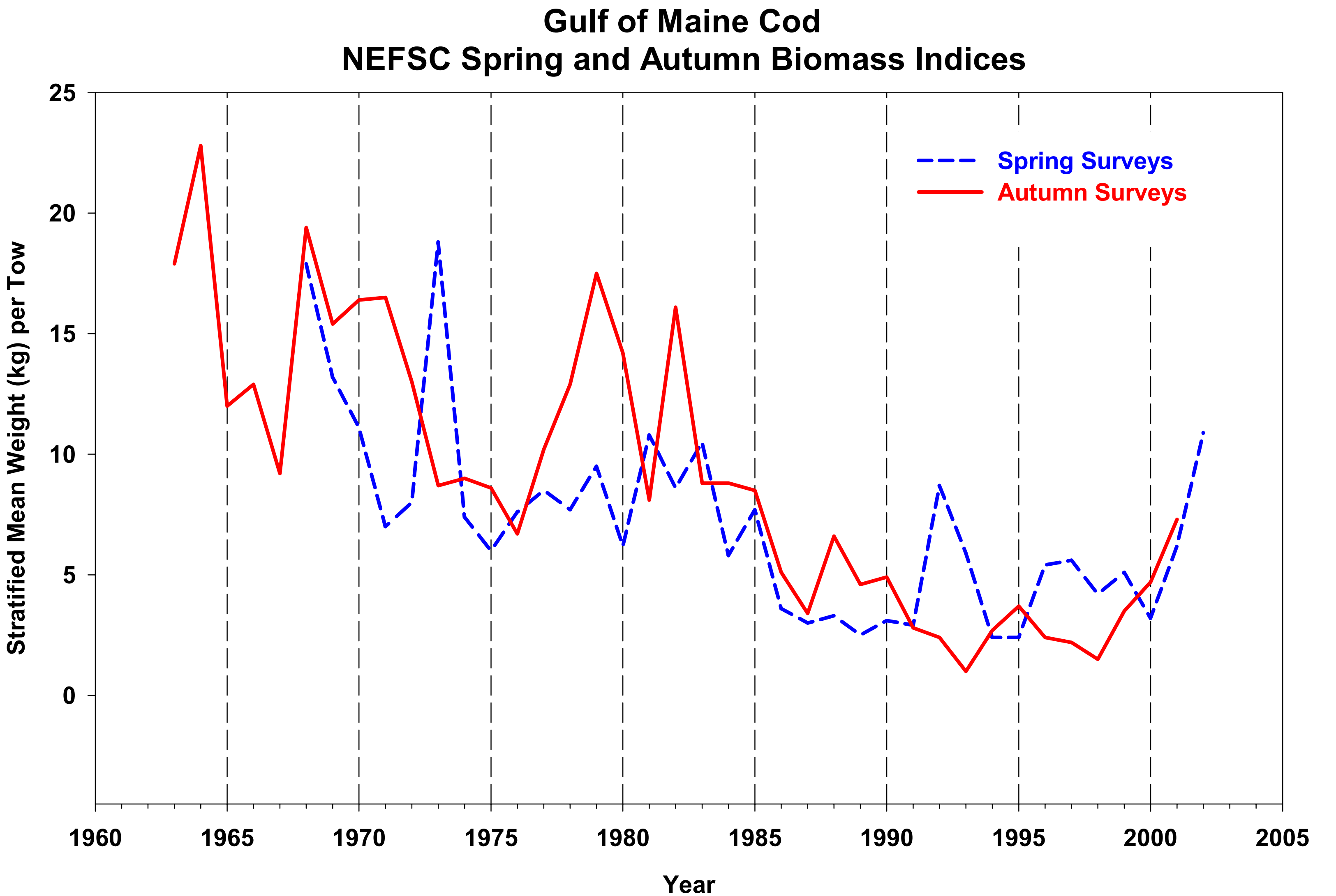


Figure F2. Biomass indices (stratified mean weight per tow) for Gulf of Maine cod from NEFSC autumn bottom trawl surveys.

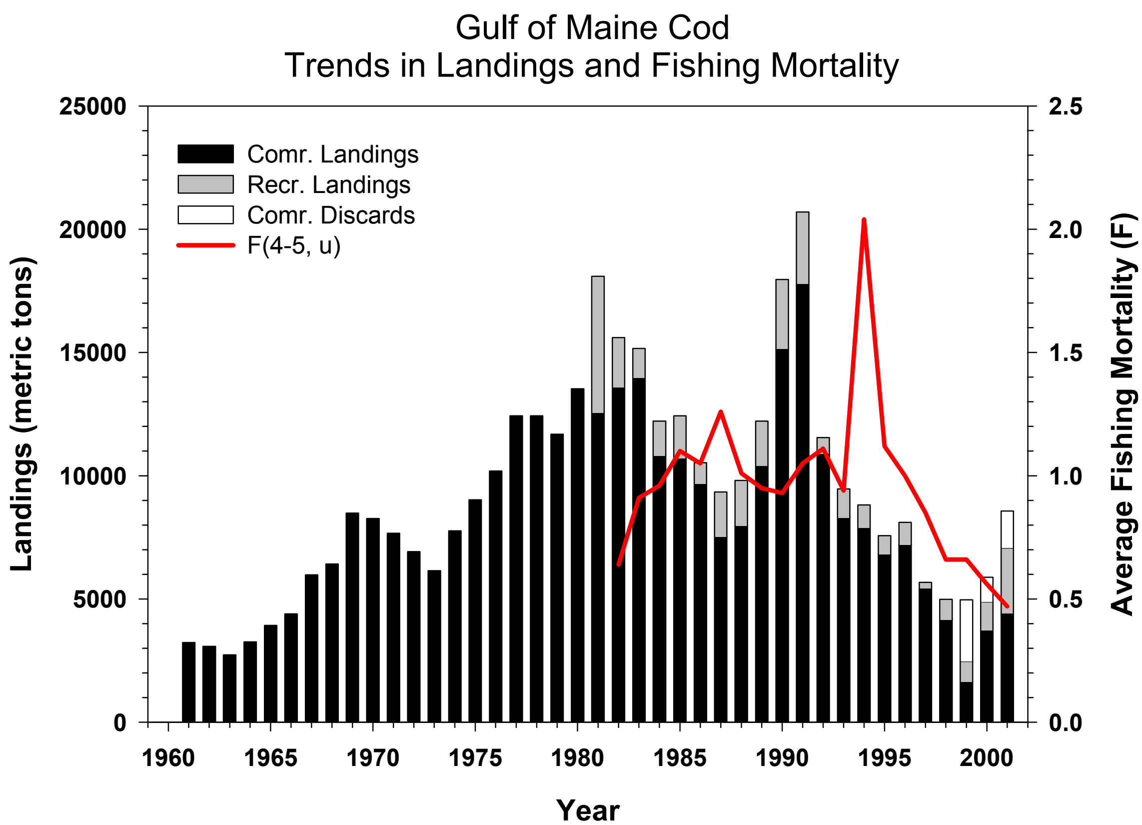


Figure F3. Trends in landings and fishing mortality for Gulf of Maine cod.

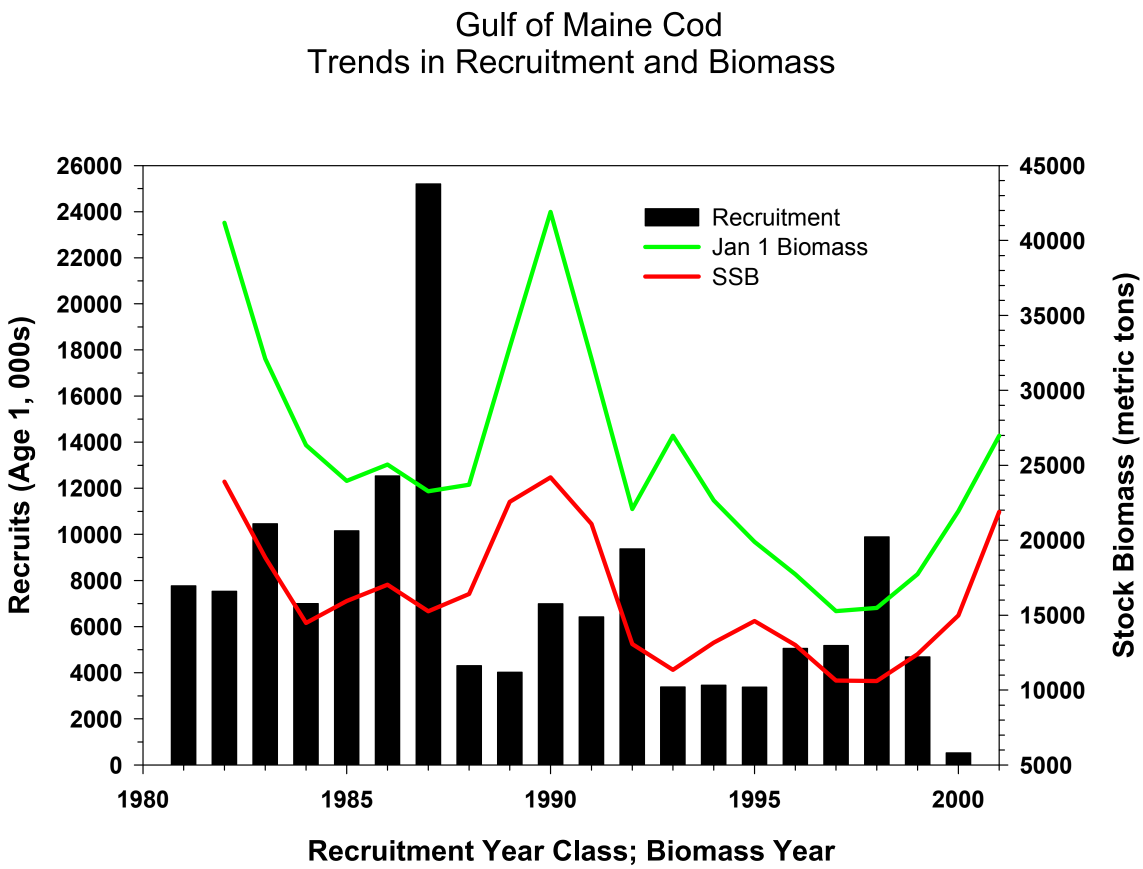
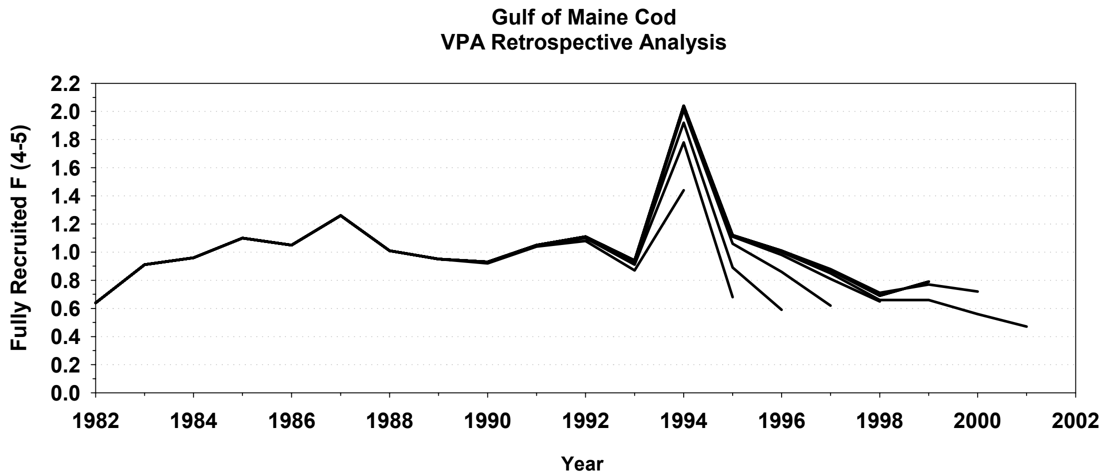
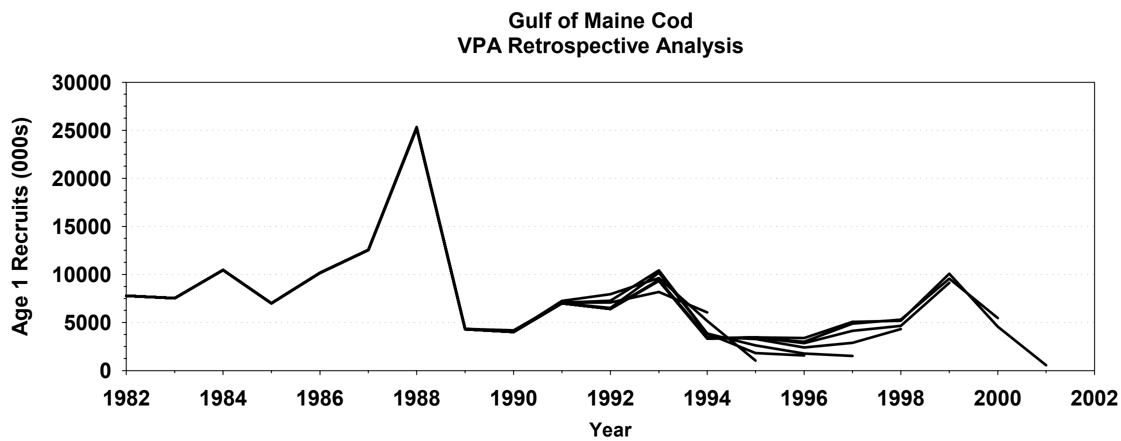


Figure F4. Trends in recruitment (age 1) and biomass for Gulf of Maine cod.





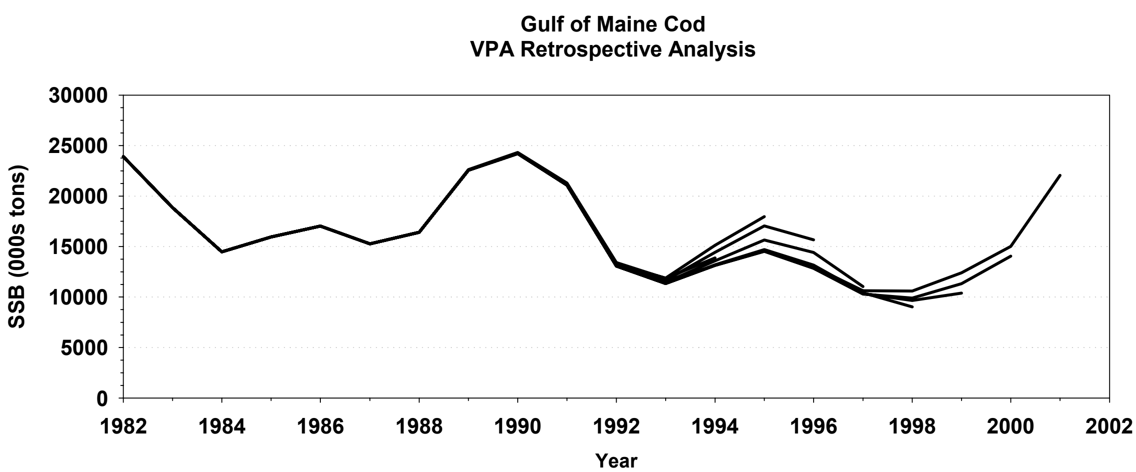


Figure F5. Retrospective analysis of estimates of terminal year F, recruitment and SSB from the VPA for Gulf of Maine Cod.

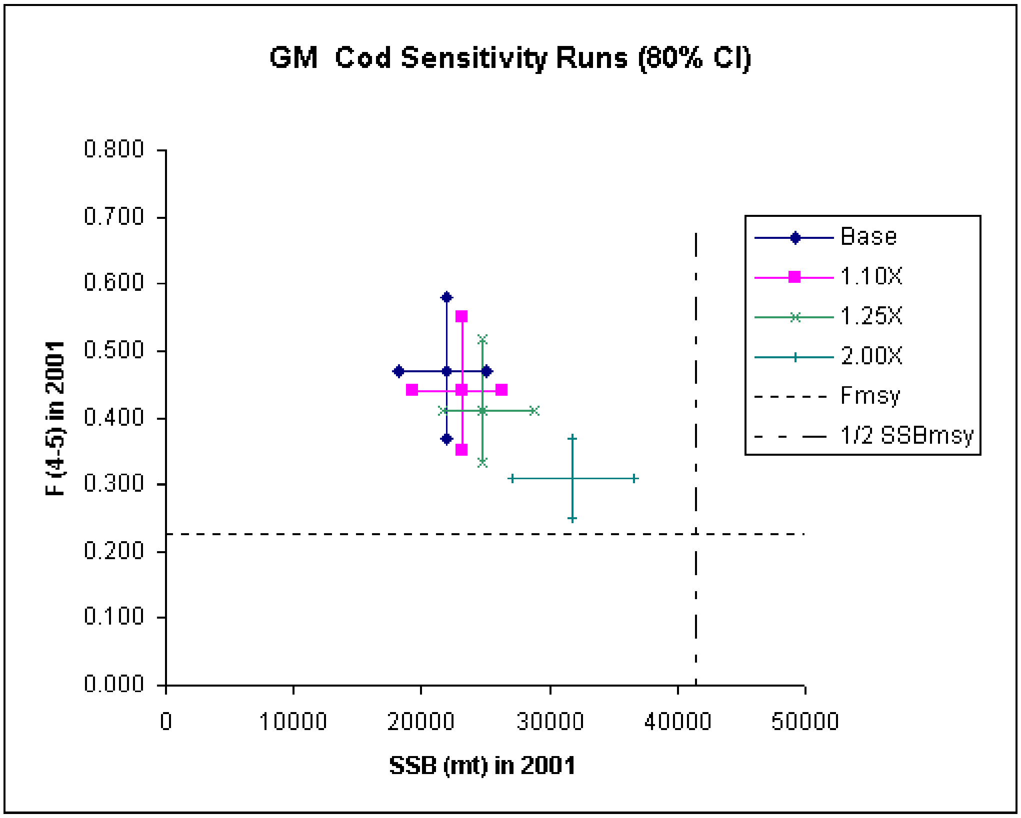
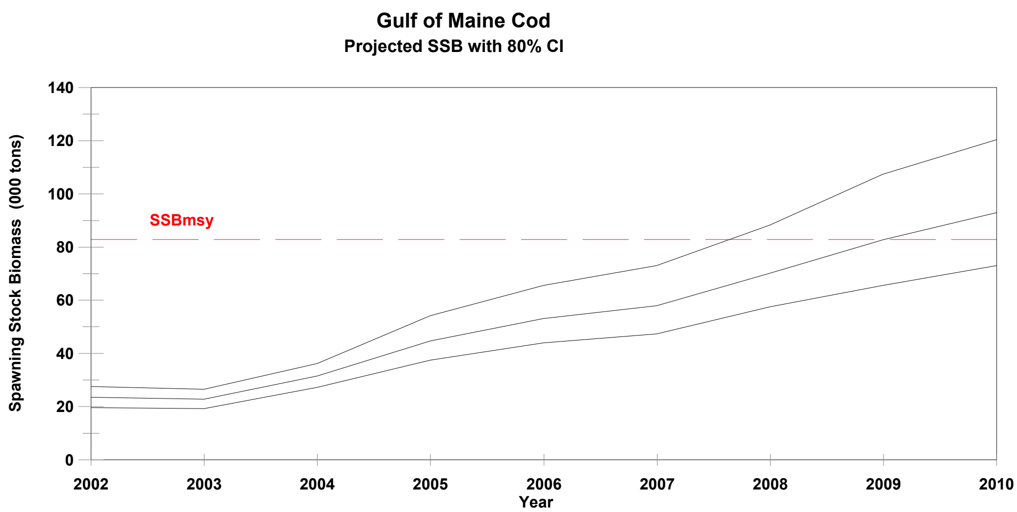
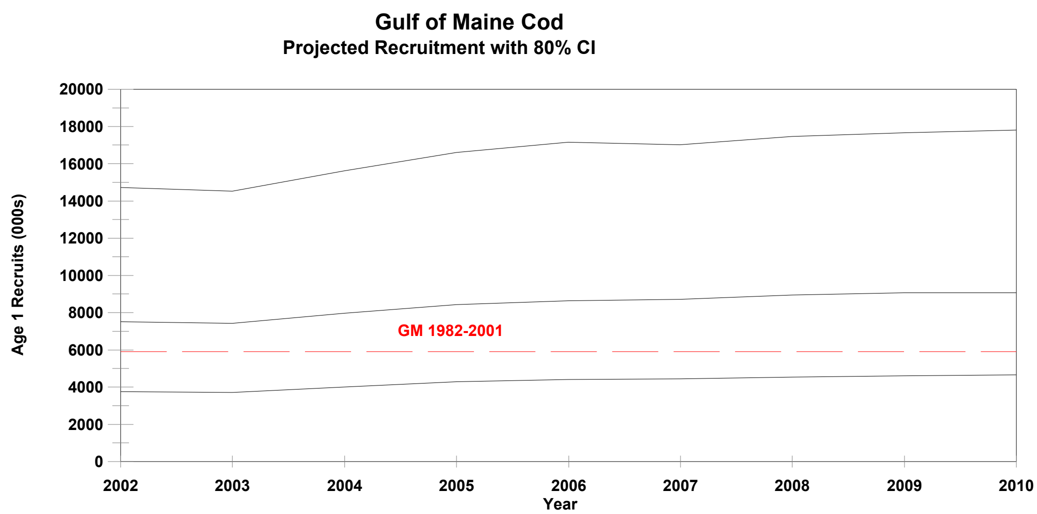


Figure F6. Sensitivity of VPA estimates of F and SSB in 2001 to presumed differences in survey catchability during 2000-2002 based on 1000 bootstrap replications (median and 80% CI) of the base VPA.





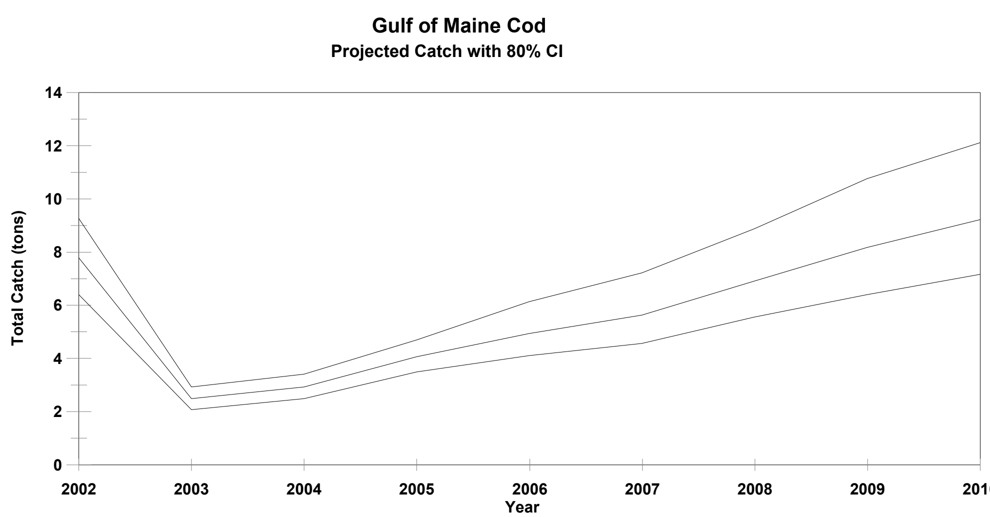


Figure F7. Projected SSB, recruitment and catch for Gulf of Maine cod. Frebuild=0.115

G. Witch Flounder by S. E. Wigley

1.0 Background

Witch flounder, *Glyptocephalus cynoglossus*, are assessed as a unit stock from the Gulf of Maine southward. An analytical assessment was last conducted for this species in 1999 (Wigley et al.1999) and reviewed at SAW 29 (NEFSC 1999). The SAW 29 assessment indicated average fishing mortality (ages 7-9, unweighted) increased from 0.21 in 1982 to 0.59 in 1985, declined to 0.24 in 1990, increased to 0.86 in 1996, then declined to 0.37 in 1998. Mean 3+ biomass declined steadily from 27,930 mt in 1982 to 7,742 mt in 1994, then sharply increased to 18,934 mt by 1998. Spawning stock biomass declined from 18,000 tons in 1982 to about 4,000 tons in 1993 and then increased sharply to 8,600 mt in 1998. Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 38 million fish (1996 year class) with a mean of 14 million fish.

This report updates catch in 1999-2001, survey indices through spring 2002, estimates 2001 fishing mortality and 2002 spawning stock biomass, and provides projections of median landings and spawning stock biomass for two fishing mortality scenarios. Sensitivity analyses of assessment results were conducted to evaluate the impact of mis-marked survey trawl wires and the selection of survey tuning indices.

2.0 2002 Assessment

The Fishery

The U.S. nominal catch is taken from both the Georges Bank and Gulf of Maine regions. Canadian landings from both areas have been minor (not more than 68 mt annually). Landings for 1991-2000 averaged 2,200 mt annually but increased to over 3,000 mt in 2001 (Table G1 and Figure G1).

Sampling intensity of landings during 1999 and 2001 was comparable to that of the previous decade, i.e., an average of 43 samples annually. Sampling intensity in 2000 increased to 110 samples; however 100 of these were from the small market category (Table G2). As in previous years, it was necessary to pool some quarters for some market categories. To estimate landings at age and mean weights at age, quarter, semi-annual or annual age-length keys were applied to corresponding commercial landings length frequency data by market category. Landed weights-at-age in 1999-2001 continue to decline as observed in recent years (Table G2).

Discard estimation

Discards-at-age were updated using the same estimation methods used in the 1999 assessment. The estimation of large-mesh otter trawl discards is based upon a method which filters survey length frequency data through a commercial gear retention ogive and then through a culling ogive. A semi-annual ratio estimator of survey-filtered 'kept' index to semi-annual numbers landed was used to expand the estimated 'discard' survey index to numbers of fish discarded at length. Semi-annual numbers of fished discarded were apportioned to age using the corresponding seasonal NEFSC survey age/length key. Witch flounder discarded in the large mesh otter trawl fishery range in age from 0 to 6, with the majority at ages 4 to 5. Estimated numbers of fish discarded at sea in 2000-2001 comprised as much as 65% of witch flounder landed, similar to that estimated for 1996 (Figure G2).

Discards in the small mesh trawl fishery for northern shrimp during 1999-2001 were estimated from the relationship between age 3 fish in the autumn NEFSC survey and discard rate during 1993-1997. This method was used to estimate 1998 discards in the 1999 assessment due to lack of sea sampling in the shrimp fishery. For each year, the total discard weight was estimated by expanding the discard rates (mt/day fished) for 1998-2001 by the number of days fished estimated from the Vessel Trip Reports. Discarded numbers at age were derived by apportioning discard weight by the average age composition of discards in 1993-1997 and then dividing by the average 1993-1997 discard mean weights at age. Witch flounder discarded in the shrimp fishery range in age from 0 to 6, with the majority at ages 1-3. During 1999-2001, the number of fish discarded in the shrimp fishery averaged 8% of witch flounder landed (Figure G2).

The total catch at age is presented in Tables G3 and G4, and Figure G2 .

Research Vessel Survey Indices

NEFSC bottom trawl survey indices have increased since the late 1990's (Table G5, Figures G3a-b). Witch flounder abundance has reached near-record and record high levels in the spring and autumn surveys, respectively. The biomass indices have increased to levels observed in the mid-1980's. Survey age compositions are presented in Table G6. The survey mean weights and mean lengths at age show a similar decline as reported in the commercial landings. Survey maturity-at-age has decrease in 2000-2002.

3.0 Assessment Results

The VPA formulation is the same as the 1999 assessment and uses catch (landings plus discards) through 2001 and NEFSC spring and autumn survey indices through 2002 and 2001, respectively, to estimate stock sizes for ages 4 to 10. The VPA had a mean square residual of 0.76, the coefficients of variation (CVs) for estimated ages ranged between 32% and 45%, and the CVs for survey catchability coeffiecients (q) were consistent, ranging from 19% to 22%.

VPA results indicate average fishing mortality (ages 7-9, unweighted) increased from 0.21 in 1982 to 0.59 in 1985, declined to 0.24 in 1990, increased to 0.96 in 1996, then declined to 0.37 in 1999, and increased to 0.45 in 2001 (Table G7, Figure G4). Spawning stock biomass declined steadily from 18,000 mt in 1982 to 4,000 mt in 1995, and has increased to 11,300 mt in 2001 (Table G7, Figure G5). Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 84 million fish (1997 year class) with a mean of 22 million fish (median of 14 million; Table G7, Figure G5). The addition of the 1995 to 1999 year classes to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment.

The retrospective analysis indicates that average F was overestimated in the early to mid-1990's and underestimated in the late 1990s, but the 2000 F estimate was initially overestimated (Figure G6a). Spawning stock biomass was consistently overestimated since 1994 (Figure G6b). The retrospective analysis indicated a pattern of relatively consistent estimates of the number of age 3 recruits, with the notable exception of the 1992, 1993 and 1996 year classes, which were overestimated (Figure G6c).

Bootstrap results suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 19% and 13%, respectively. The 80% confidence interval for F_{2001}=0.45 was 0.38 and 0.59, and for SSB_{2001} = 11,300 mt the 80% confidence interval was 9,784 mt and 13,584 mt (Figure G7).

Biological Reference Points

Based on yield and spawning stock biomass per recruit analyses and the arithmetic mean of the VPA age 3 recruitment (NEFSC 2002):

SSBmsy = 19,900 mt
Fmsy = F40% = 0.164
MSY = 2,990 mt.

In 2001, spawning stock biomass was slightly above ½ SSBmsy (9,950 mt), the overfished threshold, and fishing mortality (F = 0.45) was three times higher than Fmsy, the overfishing threshold; therefore, witch flounder was not overfished but overfishing was occurring in 2001 (Figure G7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

Sensitivity Analyses

NEFSC survey tuning indices from spring 2000-2002 and autumn 2000-2001 are arbitrarily adjusted by 1.1, 1.25, and 2.0 to evaluate the sensitivity of the VPA results to the potential gear effect of the differences in survey trawl wires during these years (Figure G7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

4.0 Projections

Since the stock is currently above the SSB_{MSY} target, age-structured projections used Fmsy = F40% fishing mortality rate to evaluate the trajectories of spawning biomass and catch. The projection analyses used stock and landings mean weights at age and selectivity pattern from 1998-2001, the maturity at age from 2000-2002, and recruitment re-sampled from the cumulative distribution function based on the VPA age 3 recruitment from 1982 - 1998 year classes. Initial stock sizes in 2002 were derived from 1000 bootstrap iterations of the VPA. Fishing mortality in 2002 was set to fishing mortality in 2001 with a 15% reduction (e.g. $F_{2002} = F_{2001} * 0.85$). The fishing mortality in 2003 - 2009 was set to Fmsy = F40% = 0.164.

The median catch (median landings + median discards) in 2003 is projected to be 4,370 mt and 6,260 mt in 2004. The median SSB in 2003 is projected to be 25,410 mt and 34,700 mt in 2004 (Table G8) The projected median catch and SSB in 2009 under Fmsy are 5,764 mt and 36,807 mt, respectively (Figure G8).

5.0 Panel Comments

The GARM noted the block of positive residuals in the younger ages beginning in 1991, and suggested that the survey tuning series for the younger ages could be split into two series. The GARM noted that the SSB will reach SSBmsy within a year, yet current SSB is barely above ½ SSBmsy. A yield per recruit analysis with current mean weights, maturity ogive and partial recruitment was compared with the yield per recruit analysis used to estimate biological reference points. The results of this comparison indicated that the increase in mean recruitment was a contributing factor. The mean recruitment used to calculate the biological reference points was 12.42 million fish using the 1982 to 1994 year classes. However, with the assessment update, four additional year classes are estimated. The mean recruitment increases to 22.1 million fish (median 14.5 million) when the 1982-1998 year classes are used. The GARM pointed out that the recent above-average year classes may be poorly determined, and based on the retrospective pattern for recruitment, these year classes may be overestimated. The Panel concluded that the biological reference points are appropriate; however, the projections of SSB may be overly optimistic because future assessment updates may reveal that these year class are not as strong as they appear at this time.

6.0 Sources of Uncertainty

- Low frequency of samples across market category and quarter results in imprecise mean weights at age and estimates of numbers at age.

- Confounding of survey-based estimates of discards and use of same survey as tuning indices for VPA calibration may be a problem.

- Lack of data to support direct estimates of discards at age requires use of various surrogate survey-based methods.

- Retrospective patterns suggest that estimates of 2002 SSB may be overestimated (e.g. updated assessments may have lower estimated 2002 SSB).

7.0 Research recommendations for witch flounder

- Explore alternative VPA analyses with the survey tuning indices split into two series for the younger age groups.

8.0 References

Lange, A.M.T. and F.E. Lux. 1978. Review of the other flounder stocks (winter flounder, American plaice, witch flounder, and windowpane flounder) off the northeast United States. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 78-44, 53 pp.

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Northeast Fisheries Science Center. 1999. Report of the 29th Northeast Regional Stock Assessment Workshop (29th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 99-14, 347 p.

Wigley, S.E., J. K.T. Brodziak, and S.X. Cadrin. 1999. Assessment of the witch flounder stock in Subareas 5 and 6 for 1999. Northeast Fish. Sci. Cent. Ref. Doc. 99-16, 153 p.

Table G1. Witch flounder landings, discards and catch (mt, live) from Subareas 5 and 6 1960-2001.

	Landings					
Year	Canada	USA [2]	Other[1]	Total	Discard	Total USA Catch (used in VPA)
1960	-	1255	-	1255		
1961	2	1022	-	1024		
1962	1	976	-	977		
1963	27	1226	121	1374		
1964	37	1381	-	1418		
1965	22	2140	502	2664		
1966	68	2935	311	3314		
1967	63	3370	249	3682		
1968	56	2807	191	3054		
1969	-	2542	1310	3852		
1970	19	3112	130	3261		
1971	35	3220	2860	6115		
1972	13	2934	2568	5515		
1973	10	2523	629	3162		
1974	9	1839	292	2140		
1975	13	2127	217	2357		
1976	5	1871	6	1882		
1977	11	2469	13	2493		
1978	18	3501	6	3525		
1979	17	2878	-	2895		
1980	18	3128	1	3147		
1981	7	3422	-	3449		
1982	9	4906	-	4915	48	4953
1983	45	6000	-	6045	162	6162
1984	15	6660	-	6675	100	6760
1985	46	6130	-	6431	61	6191
1986	67	4610	-	5216	25	4635
1987	23	3450	-	3819	47	3497
1988	45	3262	-	3665	60	3322
1989	13	2074	-	2384	133	2207
1990	12	1478	-	1492	184	1662
1991	7	1798	-	1805	95	1893
1992	7	2246	-	2253	171	2417
1993	10	2605	-	2615	376	2981
1994	34	2670	-	2704	422	3092
1995	11	2212	-	2223	265	2477
1996	10	2088	-	2098	454	2542
1997	7	1775	-	1782	393	2168
1998	10	1849	-	1859	335	2184
1999	19	2121	-	2140	354	2475
2000	53	2439	-	2492	547	2986
2001	32	3024	-	3047	705	3729

[1] Includes West Germany, East Germany, Poland, Spain, Japan, & the former USSR.
[2] excluding landings from Grand Banks (subarea 3).

Table G2. Summary of USA commercial witch flounder landings (mt), number of length samples(n), number of fish measured (len)and number of age samples (age) by market category and quarter for all gear types, 1981 - 2001. The sampling ratio represents the amount of landings per length sample.

Year		Quarter 1 Small	Quarter 1 Med.	Quarter 1 Large	Quarter 2 Small	Quarter 2 Med.	Quarter 2 Large	Quarter 3 Small	Quarter 3 Med.	Quarter 3 Large	Quarter 4 Small	Quarter 4 Med.	Quarter 4 Large	All	Sampling Ratio
1981	mt	260	7	517	269	32	694	242	13	607	230	0	453	3324	
	n	.	.	.	.	1	1	.	1	.	1	.	1	5	
	len	.	.	.	.	101	103	.	89	.	105	.	100	498	
	age	.	.	.	.	.	26	.	25	.	25	.	25	101	
1982	mt	348	1	726	342	73	886	287	170	739	278	201	669	4720	
	n	5	2	6	1	2	2	2	2	6	3	4	2	37	128
	len	527	194	626	126	209	216	189	210	514	307	393	189	3700	
	age	128	55	150	30	55	50	50	50	150	81	105	50	954	
1983	mt	475	250	910	471	286	1037	298	154	758	257	169	613	5678	
	n	5	2	3	5	1	5	8	3	8	6	3	.	49	116
	len	680	232	265	685	96	520	1008	123	981	677	344	.	5611	
	age	135	30	55	131	16	125	152	0	159	180	75	.	1058	
1984	mt	462	322	1036	513	393	1000	403	248	653	429	286	586	6331	
	n	5	9	4	7	1	7	8	1	2	4	2	1	51	124
	len	804	1112	400	970	117	775	1045	106	191	615	243	91	6469	
	age	154	250	76	186	25	180	210	28	53	105	44	25	1336	
1985	mt	465	377	613	697	453	850	526	291	553	433	310	408	5976	
	n	12	1	2	5	4	7	7	7	6	8	2	4	65	92
	len	1530	105	229	657	426	698	795	800	684	824	264	349	7361	
	age	319	29	50	106	77	153	97	138	113	161	25	29	1297	
1986	mt	384	309	356	654	421	595	375	238	354	312	212	238	4448	
	n	6	3	5	5	4	5	4	3	4	5	3	2	49	90
	len	662	307	515	558	410	413	302	364	406	416	337	233	4923	
	age	123	60	89	106	97	129	63	75	100	87	75	52	1056	
1987	mt	349	211	228	432	317	387	296	203	247	298	203	202	3373	
	n	1	1	2	4	2	3	5	5	4	2	3	2	34	69
	len	85	145	200	323	228	316	354	583	400	204	261	178	3277	
	age	25	25	50	77	47	76	78	113	95	48	64	51	749	

Table G2 continued.

Year		Quarter 1 Small	Med.	Large	Quarter 2 Small	Med.	Large	Quarter 3 Small	Med.	Large	Quarter 4 Small	Med.	Large	All	Sampling Ratio
1988	mt	424	304	271	436	393	389	184	176	208	140	140	131	3196	
	n	5	4	5	5	5	3	5	4	3	3	4	3	49	65
	len	335	407	465	344	544	429	396	359	295	229	402	356	4561	
	age	70	89	106	71	110	77	70	100	75	61	95	69	993	
1989	mt	230	174	148	255	264	251	98	145	156	85	107	103	2016	
	n	1	2	2	2	2	1	2	2	1	1	2	.	18	112
	len	94	201	222	230	236	27	150	206	100	125	202	.	1793	
	age	25	50	49	50	46	25	40	51	25	25	47	.	433	
1990	mt	113	125	107	147	168	147	100	119	129	84	79	85	1403	
	n	1	2	3	6	3	1	6	2	2	7	2	.	35	40
	len	134	199	199	335	296	100	349	247	145	381	201	.	2586	
	age	15	40	45	81	70	25	69	41	50	103	48	.	587	
1991	mt	71	56	58	219	151	167	192	142	184	168	108	121	1637	
	n	5	2	3	7	2	1	4	2	3	5	4	3	41	40
	len	262	224	401	537	239	125	212	165	249	300	410	274	3398	
	age	53	50	80	93	45	25	49	49	52	66	97	58	717	
1992	mt	180	86	82	466	163	174	205	115	138	212	97	116	2034	
	n	4	2	2	7	1	2	7	1	1	2	.	1	30	68
	len	259	241	185	501	125	235	477	121	117	129	.	46	2436	
	age	42	46	52	78	25	25	86	25	25	27	.	23	454	
1993	mt	350	112	110	442	192	161	263	122	150	331	96	106	2435	
	n	7	1	.	7	1	1	9	1	5	.	.	.	32	76
	len	830	100	.	741	107	100	728	85	499	.	.	.	3190	
	age	55	25	.	56	27	26	74	.	73	.	.	.	336	
1994	mt	403	143	98	505	183	154	390	122	117	383	91	80	2670	
	n	.	.	.	3	5	6	5	5	1	5	3	4	37	72
	len	.	.	.	560	532	749	356	648	105	342	368	407	4067	
	age	.	.	.	59	104	134	44	113	26	56	60	82	678	

Table G2 continued.

Year	Quarter 1 Small	Quarter 1 Med.	Quarter 1 Large	Quarter 2 Small	Quarter 2 Med.	Quarter 2 Large	Quarter 3 Small	Quarter 3 Med.	Quarter 3 Large	Quarter 4 Small	Quarter 4 Med.	Quarter 4 Large	All	Sampling Ratio
1995 mt	336	91	77	586	117	100	399	61	70	304	48	40	2212	
n	3	3	3	6	3	5	.	.	.	2	.	1	26	85
len	208	348	347	459	367	517	.	.	.	217	.	94	2557	
age	53	84	89	81	75	135	.	.	.	27	.	25	569	
1996 mt	313	57	36	545	86	60	458	56	44	363	42	28	2088	
n	5	2	3	5	2	1	5	4	4	5	3	3	42	50
len	504	218	292	331	240	127	494	464	468	343	277	348	4106	
age	59	45	78	53	50	26	59	86	101	60	70	69	756	
1997 mt	313	40	25	478	86	41	398	55	27	265	31	16	1775	
n	6	3	3	9	4	3	9	3	1	9	1	1	52	34
len	557	350	351	812	418	309	783	308	107	505	128	50	4678	
age	77	68	70	108	73	77	98	81	20	73	18	23	786	
1998 mt	372	39	19	587	79	31	380	40	20	239	26	14	1849	80
n	5	2	1	4	1	1	5	3	1	.	.	.	23	
len	339	206	128	238	88	135	484	186	100	.	.	.	1904	
age	45	50	19	30	.	29	47	22	.	.	.	.	242	
1999 mt	386	48	19	616	79	31	436	67	30	353	38	18	2121	51
n	3	.	.	4	.	.	17	2	3	11	1	.	41	
len	282	.	.	308	.	.	1110	201	306	775	109	.	3091	
age	15	.	.	62	.	.	143	.	32	91	16	.	359	
2000 mt	477	53	17	583	93	27	555	89	28	451	50	16	2439	21
n	31	2	.	47	.	.	17	1	.	5	5	2	110	
len	2253	91	.	2445	.	.	994	105	.	308	558	217	6971	
age	390	10	.	460	.	.	224	20	.	67	92	51	1314	
2001 mt	584	71	17	828	99	30	699	98	28	507	50	13	3024	70
n	8	4	2	3	3	2	8	2	3	5	3	.	43	
len	744	422	134	237	352	159	594	209	213	313	232	.	3609	
age	125	63	42	47	48	64	126	34	46	61	48	.	704	

Table G3. Numbers ('000) at age of witch flounder in the total catch, 1982-2001.

	Age												
Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
					Total Catch in Numbers (1000's) at Age								
1982	0.03	0.06	1.72	190.49	1064.47	1207.67	1475.40	665.20	656.00	399.50	239.40	1578.40	7478.4
1983	0.00	0.02	4.28	337.11	1346.17	1520.76	1575.12	1590.20	977.80	737.70	510.40	1675.50	10275.1
1984	0.00	0.33	0.88	146.61	1466.31	2002.70	1739.59	1486.50	1497.50	696.70	375.10	1718.80	11131.0
1985	0.00	0.34	3.47	123.58	1176.12	2118.21	1936.24	1524.90	1247.90	606.00	400.40	1359.20	10496.4
1986	0.00	0.53	3.86	22.95	377.07	1516.79	2775.35	1566.90	834.90	412.70	222.80	758.20	8492.1
1987	2.08	18.92	79.93	22.25	181.26	467.06	1280.06	1574.70	870.90	480.60	252.40	489.40	5719.6
1988	0.42	14.66	130.29	600.27	139.91	264.30	658.27	1382.70	1154.10	401.50	266.70	597.50	5610.6
1989	0.85	10.69	50.32	447.05	436.26	65.27	315.20	761.60	884.70	350.70	123.80	349.00	3795.4
1990	1.46	6.29	95.30	343.93	635.77	1108.23	257.90	276.30	475.30	336.90	82.10	179.10	3798.6
1991	3.06	17.90	23.26	441.77	407.92	872.56	581.70	238.60	247.50	295.60	317.30	260.80	3708.0
1992	2.84	44.35	159.43	399.46	1259.95	866.37	943.97	723.10	203.40	179.40	121.10	380.20	5283.6
1993	113.76	85.80	129.59	417.23	1807.93	1420.56	919.56	598.10	586.50	219.10	279.00	391.10	6968.2
1994	8.06	1368.48	496.44	41.97	1002.18	2762.60	1290.40	828.40	197.06	540.16	113.70	324.90	8974.4
1995	2.68	49.96	635.31	641.30	617.50	1197.11	1722.49	849.85	267.81	97.35	269.86	157.06	6508.3
1996	5.21	32.68	51.06	119.38	952.15	1978.27	1322.45	1431.51	263.42	215.63	57.09	113.69	6542.5
1997	8.68	74.92	104.10	104.87	1022.81	1467.20	1386.54	1016.31	592.64	83.33	49.90	70.24	5981.5
1998	49.78	391.45	268.05	219.73	619.38	1284.18	1483.99	1583.87	370.71	141.42	15.54	70.34	6498.4
1999	32.11	252.53	173.52	243.71	1079.28	1482.74	1395.00	1178.30	763.15	251.27	31.57	54.36	6937.6
2000	21.61	169.95	118.24	148.73	1395.59	1722.99	1187.30	1611.14	1027.62	623.71	94.82	212.81	8334.5
2001	12.33	96.96	65.98	160.66	1352.04	2348.48	1344.47	1671.77	1461.88	635.35	426.14	307.17	9883.2

Table G4. Mean weight (kg) at age of witch flounder in the total catch, 1982-2001.

	Age												
Year	0	1	2	3	4	5	6	7	8	9	10	11+	Total
	Total Catch Mean Weight (kg) at age												
1982	0.000	0.002	0.038	0.152	0.242	0.329	0.421	0.550	0.727	0.886	0.983	1.406	0.662
1983	-	0.009	0.038	0.149	0.202	0.270	0.409	0.518	0.613	0.795	0.977	1.357	0.600
1984	-	0.017	0.040	0.151	0.229	0.328	0.421	0.539	0.664	0.817	0.922	1.339	0.607
1985	-	0.017	0.023	0.128	0.237	0.305	0.429	0.565	0.691	0.842	0.964	1.326	0.590
1986	0.000	0.017	0.026	0.089	0.206	0.299	0.408	0.533	0.676	0.853	0.975	1.321	0.546
1987	0.006	0.015	0.033	0.081	0.191	0.298	0.433	0.561	0.686	0.828	0.980	1.303	0.611
1988	0.004	0.006	0.017	0.045	0.203	0.311	0.434	0.538	0.668	0.819	0.980	1.326	0.592
1989	0.009	0.012	0.034	0.122	0.170	0.321	0.425	0.574	0.682	0.818	0.968	1.358	0.582
1990	0.004	0.012	0.029	0.062	0.187	0.257	0.438	0.586	0.688	0.849	1.049	1.454	0.438
1991	0.004	0.014	0.035	0.062	0.199	0.344	0.421	0.578	0.702	0.836	0.974	1.420	0.510
1992	0.003	0.007	0.026	0.103	0.230	0.379	0.459	0.614	0.739	0.822	0.882	1.243	0.458
1993	0.003	0.009	0.027	0.122	0.202	0.318	0.432	0.535	0.666	0.882	1.023	1.335	0.428
1994	0.005	0.004	0.019	0.070	0.202	0.280	0.430	0.534	0.691	0.832	0.909	1.266	0.345
1995	0.005	0.007	0.023	0.058	0.171	0.308	0.431	0.561	0.690	0.911	0.974	1.243	0.381
1996	0.004	0.019	0.031	0.061	0.155	0.234	0.425	0.554	0.708	0.856	0.974	1.232	0.389
1997	0.004	0.023	0.034	0.059	0.196	0.251	0.359	0.495	0.628	0.871	1.037	1.293	0.362
1998	0.003	0.006	0.023	0.065	0.169	0.249	0.349	0.492	0.585	0.871	0.978	1.206	0.339
1999	0.003	0.006	0.023	0.089	0.191	0.261	0.406	0.516	0.584	0.628	0.917	0.872	0.358
2000	0.003	0.006	0.024	0.083	0.185	0.207	0.359	0.450	0.533	0.633	0.677	0.925	0.359
2001	0.003	0.006	0.023	0.119	0.168	0.215	0.330	0.469	0.550	0.646	0.647	0.840	0.378
mean	0.004	0.011	0.028	0.094	0.197	0.288	0.411	0.538	0.659	0.815	0.940	1.253	0.477

Table G5. Stratified mean number per tow at age of witch flounder in NEFSC offshore spring and autumn bottom trawl surveys in Gulf of Maine-Georges Bank region (strata 22-30,36-40), 1963-2002.

	SPRING		AUTUMN	
Year	Number per tow	Weight per tow	Number per tow	Weight per tow
1963	-	-	5.52	3.46
1964	-	-	2.89	2.00
1965	-	-	3.94	2.27
1966	-	-	7.80	4.56
1967	-	-	3.01	2.02
1968	4.83	3.35	4.82	3.49
1969	3.74	2.53	5.81	4.40
1970	6.39	4.49	4.89	3.71
1971	2.70	2.04	4.32	2.95
1972	5.35	4.01	3.24	2.42
1973	8.20	6.21	3.18	2.05
1974	6.23	3.62	2.38	1.58
1975	3.72	2.75	1.66	1.03
1976	5.50	3.70	1.34	0.94
1977	4.20	1.96	5.06	3.38
1978	3.87	2.56	4.04	2.94
1979	2.91	1.71	1.94	1.62
1980	8.46	3.89	2.62	2.04
1981	8.14	4.05	3.66	2.19
1982	3.64	1.87	0.99	0.83
1983	6.41	2.74	4.72	2.12
1984	3.00	1.66	4.37	2.34
1985	5.18	2.75	2.76	1.59
1986	2.07	1.35	1.59	1.09
1987	1.01	0.65	0.48	0.37
1988	1.43	0.85	1.38	0.57
1989	1.95	0.74	0.89	0.38
1990	0.63	0.24	2.00	0.40
1991	1.68	0.57	2.08	0.54
1992	1.26	0.48	0.94	0.24
1993	1.47	0.36	5.15	0.54
1994	3.13	0.53	2.21	0.42
1995	1.88	0.47	4.74	0.62
1996	1.36	0.28	5.38	1.02
1997	2.22	0.43	5.11	0.77
1998	4.27	0.77	3.70	0.47
1999	3.15	0.48	5.91	0.88
2000	3.45	0.52	6.63	1.11
2001	4.41	0.75	7.94	1.71
2002	8.10	1.62		

Note: During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No significant differences in catchability were found for witch flounder, therefore no adjustments have been made (Byrne and Forrester, 1991). No significant differences were found between research vessels, and no adjustment have been made (Byrne and Forrester, 1991).

Spring surveys during 1973-1981 were accomplished with a 41 Yankee trawl; in all other years, a 36 Yankee trawl was used. No adjustments have been made.

Table G6. Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys (Strata 22-30, 36-40), 1980-2002.

	AGE															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
Spring																
1980	0.00	0.06	0.23	0.95	1.52	0.72	1.20	1.02	0.38	0.40	0.31	0.30	0.12	0.16	1.10	8.46
1981	0.00	0.00	0.05	0.82	0.93	2.00	1.02	0.76	0.67	0.42	0.13	0.20	0.24	0.22	0.90	8.40
1982	0.00	0.04	0.01	0.56	0.57	0.34	0.21	0.64	0.41	0.08	0.26	0.15	0.03	0.03	0.30	3.64
1983	0.00	0.00	0.03	0.58	1.25	1.33	0.55	0.64	0.67	0.48	0.20	0.09	0.08	0.11	0.41	6.41
1984	0.00	0.00	0.01	0.10	0.33	0.73	0.42	0.26	0.28	0.24	0.11	0.12	0.09	0.02	0.29	3.00
1985	0.00	0.00	0.00	0.02	0.43	1.11	1.19	0.86	0.45	0.13	0.06	0.14	0.09	0.04	0.67	5.18
1986	0.00	0.00	0.00	0.00	0.04	0.24	0.53	0.43	0.17	0.18	0.07	0.04	0.08	0.05	0.25	2.07
1987	0.00	0.00	0.00	0.00	0.06	0.12	0.12	0.26	0.17	0.03	0.06	0.03	0.00	0.00	0.15	1.01
1988	0.00	0.02	0.02	0.06	0.00	0.07	0.31	0.38	0.25	0.16	0.08	0.04	0.02	0.00	0.02	1.43
1989	0.00	0.02	0.01	0.04	0.98	0.12	0.07	0.10	0.31	0.07	0.03	0.05	0.05	0.02	0.06	1.95
1990	0.00	0.01	0.00	0.04	0.09	0.32	0.02	0.02	0.02	0.06	0.01	0.00	0.01	0.00	0.03	0.63
1991	0.00	0.04	0.00	0.78	0.11	0.11	0.19	0.02	0.09	0.10	0.14	0.02	0.02	0.00	0.07	1.68
1992	0.00	0.05	0.01	0.19	0.37	0.08	0.12	0.15	0.05	0.14	0.02	0.01	0.05	0.00	0.02	1.26
1993	0.00	0.15	0.11	0.14	0.46	0.33	0.06	0.08	0.00	0.02	0.02	0.00	0.06	0.00	0.04	1.47
1994	0.00	0.10	0.71	0.53	0.64	0.83	0.16	0.03	0.02	0.06	0.01	0.00	0.00	0.02	0.02	3.13
1995	0.00	0.04	0.12	0.58	0.32	0.18	0.31	0.11	0.12	0.04	0.00	0.04	0.03	0.00	0.00	1.88
1996	0.00	0.02	0.04	0.24	0.41	0.33	0.22	0.07	0.00	0.00	0.00	0.03	0.00	0.00	0.00	1.36
1997	0.00	0.07	0.07	0.15	0.71	0.58	0.46	0.08	0.10	0.00	0.00	0.00	0.00	0.00	0.00	2.22
1998	0.00	0.11	1.06	0.73	0.41	0.79	0.70	0.21	0.15	0.08	0.00	0.00	0.00	0.03	0.00	4.27
1999	0.00	0.11	0.40	0.98	0.77	0.49	0.17	0.18	0.03	0.01	0.02	0.00	0.00	0.00	0.00	3.15
2000	0.00	0.01	0.27	1.17	0.70	0.67	0.24	0.25	0.11	0.00	0.04	0.00	0.00	0.00	0.00	3.45
2001	0.00	0.11	0.09	0.72	1.47	1.02	0.41	0.30	0.15	0.11	0.04	0.00	0.00	0.00	0.00	4.41
2002	0.00	0.02	0.06	0.87	2.69	2.23	0.81	0.70	0.35	0.20	0.10	0.02	0.00	0.03	0.04	8.10

Table G6 continued. Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys (Strata 22-30, 36-40), 1980-2002.

	AGE														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
Autumn																
1980	0.04	0.00	0.02	0.00	0.20	0.26	0.28	0.36	0.17	0.15	0.27	0.04	0.16	0.12	0.57	2.62
1981	0.03	0.07	0.03	0.24	0.44	0.61	0.46	0.27	0.26	0.18	0.21	0.17	0.04	0.13	0.48	3.66
1982	0.02	0.00	0.00	0.06	0.01	0.02	0.08	0.25	0.13	0.01	0.03	0.03	0.00	0.06	0.29	0.99
1983	0.00	0.01	0.01	0.49	1.60	0.78	0.51	0.47	0.11	0.10	0.12	0.09	0.02	0.00	0.42	4.72
1984	0.00	0.00	0.00	0.08	0.97	1.01	0.58	0.54	0.32	0.14	0.12	0.06	0.04	0.14	0.38	4.37
1985	0.00	0.00	0.01	0.07	0.06	0.60	0.62	0.58	0.24	0.13	0.09	0.01	0.03	0.10	0.22	2.76
1986	0.01	0.00	0.00	0.01	0.04	0.27	0.36	0.31	0.15	0.11	0.02	0.02	0.01	0.05	0.23	1.59
1987	0.00	0.00	0.02	0.01	0.00	0.02	0.05	0.18	0.07	0.00	0.01	0.00	0.02	0.00	0.08	0.48
1988	0.00	0.00	0.00	0.71	0.07	0.00	0.03	0.22	0.06	0.05	0.03	0.06	0.02	0.03	0.08	1.38
1989	0.17	0.02	0.02	0.08	0.30	0.01	0.02	0.04	0.05	0.09	0.01	0.00	0.03	0.00	0.04	0.89
1990	0.48	0.12	0.11	0.39	0.52	0.17	0.05	0.02	0.02	0.05	0.00	0.00	0.01	0.04	0.03	2.00
1991	0.22	0.02	0.17	0.67	0.35	0.27	0.15	0.09	0.06	0.02	0.04	0.03	0.00	0.00	0.00	2.08
1992	0.09	0.03	0.11	0.27	0.22	0.06	0.05	0.00	0.00	0.02	0.01	0.02	0.00	0.01	0.04	0.94
1993	2.54	0.67	0.11	0.55	0.76	0.23	0.06	0.03	0.08	0.00	0.02	0.04	0.00	0.01	0.01	5.15
1994	0.42	0.17	0.28	0.50	0.20	0.39	0.04	0.11	0.00	0.04	0.01	0.00	0.01	0.00	0.04	2.21
1995	0.51	0.21	0.80	1.57	0.86	0.49	0.22	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.01	4.74
1996	0.23	0.09	0.27	0.74	2.02	1.40	0.45	0.06	0.06	0.03	0.00	0.04	0.00	0.00	0.00	5.38
1997	0.89	0.34	1.00	0.53	0.86	0.77	0.40	0.32	0.00	0.00	0.00	0.00	0.02	0.00	0.00	5.10
1998	0.64	0.08	0.54	1.33	0.48	0.31	0.17	0.10	0.04	0.02	0.00	0.00	0.00	0.00	0.00	3.70
1999	0.32	0.53	1.17	1.51	1.06	0.58	0.36	0.28	0.06	0.03	0.01	0.00	0.00	0.00	0.00	5.91
2000	0.94	0.10	0.71	1.43	1.75	0.68	0.59	0.22	0.14	0.05	0.00	0.00	0.03	0.00	0.00	6.63
2001	0.00	0.04	0.21	0.92	3.13	1.93	0.81	0.62	0.16	0.06	0.05	0.00	0.00	0.00	0.00	7.94

Table G7. Estimates of beginning year stock size ('000 of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt)for witch flounder estimated from virtual population analysis, 1982-2001.

Stock Size Jan 1 ('000)

Age	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
3	15430	17856	15839	7315	4853	2936	9470	6322	6805	8941
4	12802	13104	15056	13497	6182	4155	2506	7594	5026	5538
5	9764	10032	10030	11598	10526	4971	3408	2028	6131	3736
6	7902	7284	7223	6775	8018	7652	3845	2688	1685	4249
7	4565	5433	4808	4603	4035	4326	5399	2699	2022	1211
8	2990	3312	3201	2759	2547	2019	2263	3364	1616	1484
9	2340	1965	1943	1365	1217	1418	930	877	2075	950
10	1372	1644	1007	1026	613	665	775	428	429	1473
11+	9013	5364	4580	3458	2071	1279	1724	1199	933	1206
3+	66178	65994	63687	52396	40062	29421	30320	27199	26722	28788

	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
3	14538	10112	16169	15902	15982	18357	36749	51092	83904	67123	22643
4	7286	12142	8316	13878	13092	13645	15703	31427	43749	72079	57625
5	4388	5102	8774	6228	11372	10385	10795	12941	26048	36361	60784
6	2407	2973	3074	4988	4250	7953	7578	8100	9763	20821	29117
7	3118	1196	1706	1448	2696	2431	5559	5145	5678	7301	16673
8	821	2012	474	700	458	992	1150	3315	3335	3392	4733
9	1047	518	1188	225	354	150	304	646	2145	1917	1563
10	544	735	242	521	104	104	52	130	322	1268	1061
11+	1699	1023	686	300	204	145	233	224	720	908	1194
3+	35848	35813	40629	44190	48512	54162	78123	113020	175664	211170	195393

Table G7 continued.

Fishing Mortality

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0.01	0.02	0.01	0.01	0
3	0.01	0.02	0.01	0.02	0.01	0.01	0.07	0.08	0.06	0.05
4	0.09	0.12	0.11	0.10	0.07	0.05	0.06	0.06	0.15	0.08
5	0.14	0.18	0.24	0.22	0.17	0.11	0.09	0.04	0.22	0.29
6	0.22	0.27	0.30	0.37	0.47	0.20	0.20	0.14	0.18	0.16
7	0.17	0.38	0.41	0.44	0.54	0.50	0.32	0.36	0.16	0.24
8	0.27	0.38	0.70	0.67	0.44	0.63	0.80	0.33	0.38	0.20
9	0.20	0.52	0.49	0.65	0.45	0.45	0.63	0.56	0.19	0.41
10	0.21	0.41	0.51	0.55	0.50	0.53	0.46	0.37	0.23	0.26
11+	0.21	0.41	0.51	0.55	0.50	0.53	0.46	0.37	0.23	0.26
7-9,u	0.21	0.43	0.53	0.59	0.48	0.53	0.58	0.42	0.24	0.28

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0.06	0	0	0	0	0	0.01	0
2	0.01	0.01	0.03	0.04	0	0	0	0	0	0
3	0.03	0.05	0.00	0.04	0.01	0.01	0.01	0.01	0	0
4	0.21	0.17	0.14	0.05	0.08	0.08	0.04	0.04	0.03	0.02
5	0.24	0.36	0.41	0.23	0.21	0.17	0.14	0.13	0.07	0.07
6	0.55	0.41	0.60	0.47	0.41	0.21	0.24	0.21	0.14	0.07
7	0.29	0.77	0.74	1.00	0.85	0.60	0.37	0.28	0.37	0.28
8	0.31	0.38	0.59	0.53	0.97	1.03	0.43	0.29	0.40	0.62
9	0.20	0.61	0.67	0.63	1.07	0.91	0.70	0.54	0.38	0.44
10	0.27	0.53	0.70	0.82	0.90	0.72	0.39	0.30	0.38	0.45
11+	0.27	0.53	0.70	0.82	0.90	0.72	0.39	0.30	0.38	0.45
7-9,u	0.27	0.59	0.67	0.72	0.96	0.85	0.50	0.37	0.38	0.45

Table G7 continued.

Spawning Stock biomass ('000 mt)

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	5	2	1	4	3	3	0
4	0	88	107	367	145	78	46	96	108	6
5	55	486	483	1871	1726	768	520	326	784	88
6	423	1297	1174	2237	2451	2495	1253	896	574	531
7	1105	1858	1648	2035	1718	1856	2410	1236	958	457
8	1589	1708	1578	1468	1428	1073	1182	1881	929	870
9	1806	1336	1237	894	845	959	613	575	1491	656
10	1206	1393	772	811	499	543	630	349	373	1250
11+	11938	6632	5491	4083	2457	1489	2063	1492	1273	1598
1+	18121	14798	12490	13772	11271	9263	8721	6854	6493	5456

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	72	69
4	8	17	87	102	84	100	106	237	489	744
5	113	127	893	684	1007	912	1069	1219	1248	1743
6	340	439	903	1406	1262	1955	1893	2185	1537	2828
7	1178	407	706	587	1116	985	2142	2030	1735	2172
8	482	1142	255	379	240	481	562	1652	1482	1378
9	750	368	770	157	222	99	195	348	1183	1010
10	435	602	188	399	82	85	44	108	192	734
11+	1968	1220	753	318	211	163	256	181	609	690
1+	5274	4321	4555	4032	4222	4779	6267	7960	8548	11368

Table G8. Summary of projection input and results for witch flounder. Projected median estimates of catch (median landings + median discards), landings, discards and spawning stock biomass are provided for fishing mortality with a 15% reduction in current F ($F_{2002} = F_{2001}$ * .85 = 0.38).

Projection input:

Age	Fish Mort. Pattern	Proportion Mature	Discard Fraction	Average Weights Landings	Stock	Discards
3	0.0090	0.020	1.00	0.116	0.047	0.089
4	0.0960	0.090	0.93	0.293	0.114	0.168
5	0.2500	0.250	0.75	0.335	0.207	0.194
6	0.4150	0.540	0.15	0.387	0.295	0.219
7	1.0000	0.780	0.00	0.482	0.420	0.219
8	1.0000	0.930	0.00	0.563	0.524	0.219
9	1.0000	0.990	0.00	0.695	0.635	0.219
10	1.0000	1.000	0.00	0.805	0.777	0.219
11+	1.0000	1.000	0.00	0.961	0.961	0.219

Projection results (weight reported in '000 mt)

Scenario	Year	F full	Median Catch	Median Landings	Median Discards	Median SSB
85% of F2001	2002	0.38	7.11	5.96	1.15	18.31
FMSY	2003	0.164	4.37	3.98	0.39	25.41
FMSY	2004	0.164	6.26	6.06	0.20	34.70

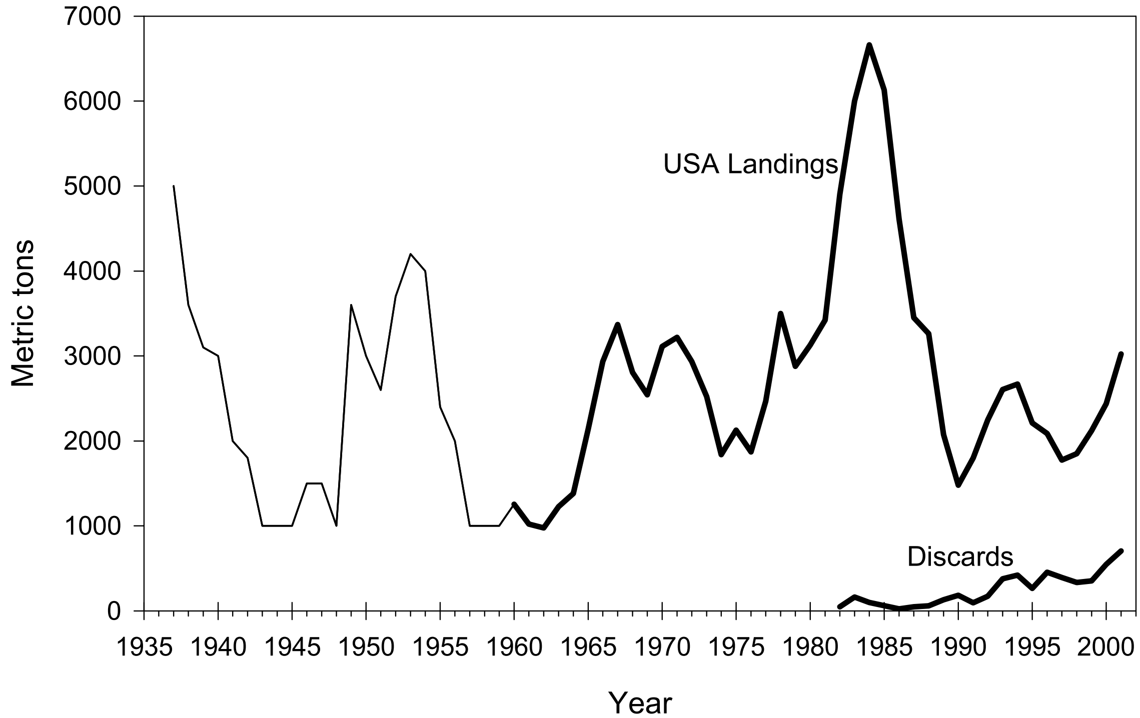


Figure G1. Historical USA witch flounder landings (mt), excluding USA landings from the Grand Banks in the mid-1980's. The thin line represents provisional landings data taken from Lange and Lux (1978). Discards are from the shrimp and large-mesh otter trawl fisheries.

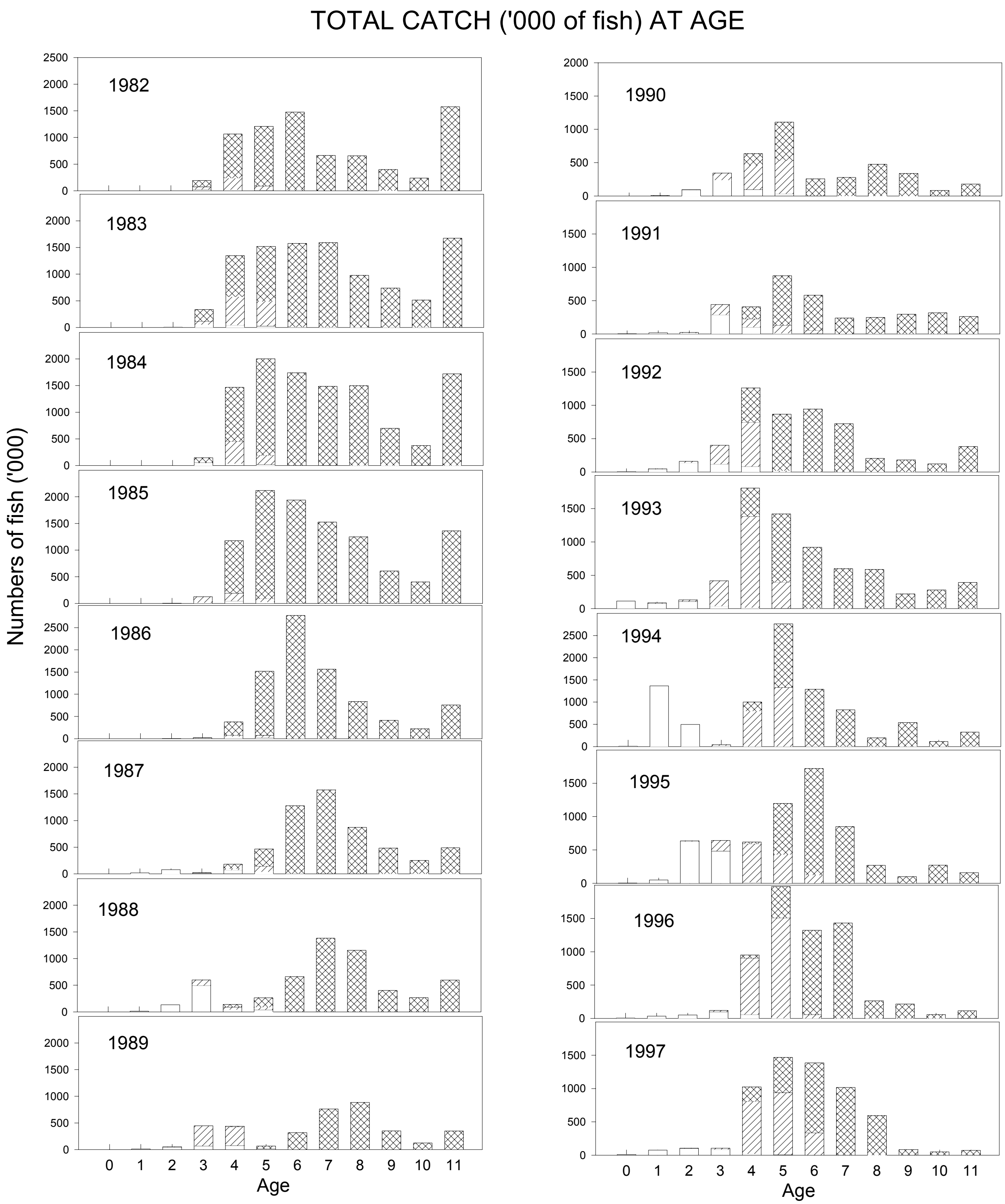


Figure G2. Number of witch flounder ('000 of fish) at age in the total catch, by fishery, 1982-2001. Open bar represents discards in the shrimp fishery, diagonal bar represents discards in large-mesh fishery and hatched bar represents landings.

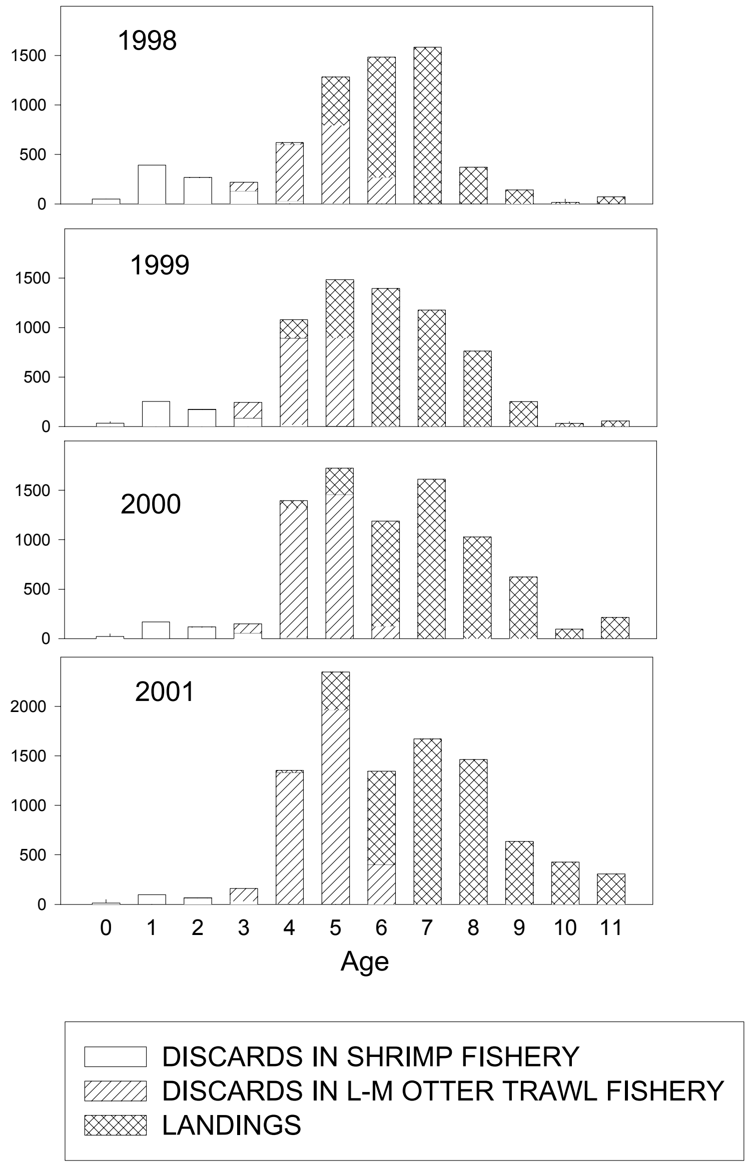
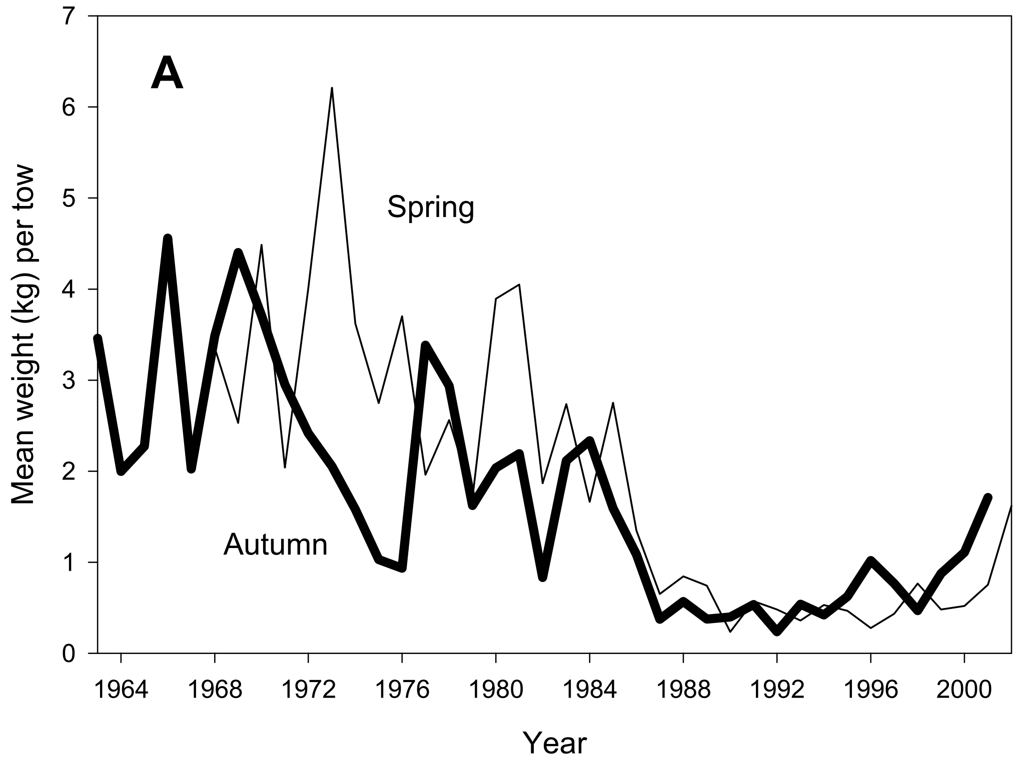


Figure G2 continued.



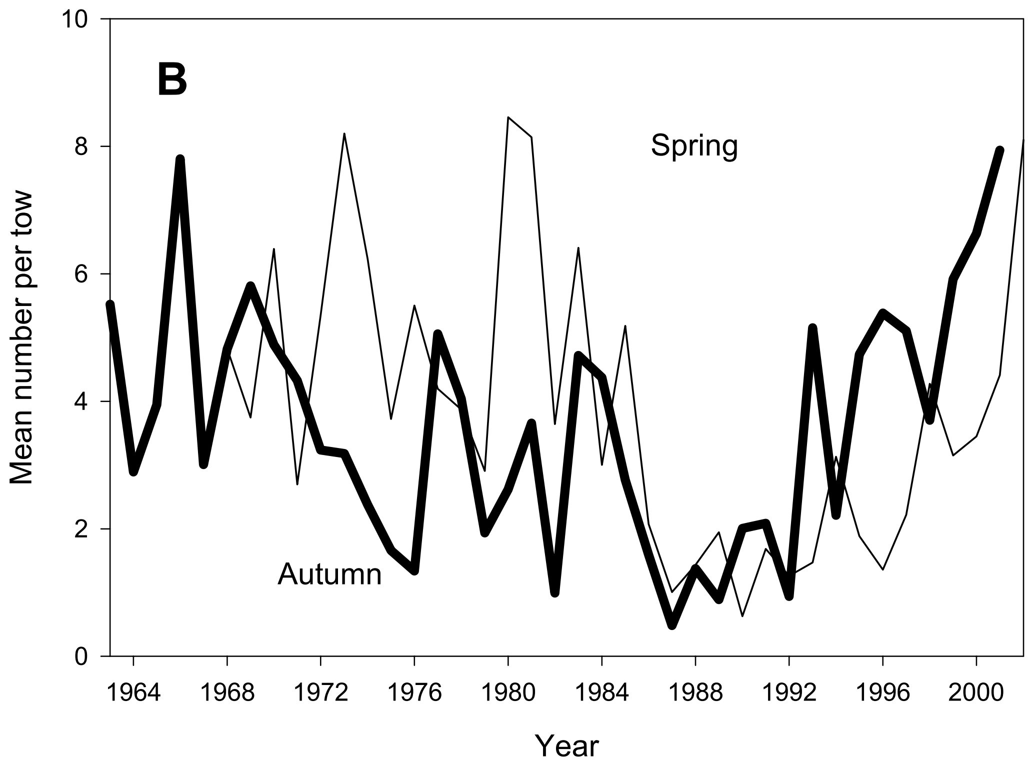


Figure G3. Stratified mean weight (kg) per tow (A) and mean number per tow (B) of witch flounder in the NEFSC spring and autumn bottom trawl surveys, 1963-2002.

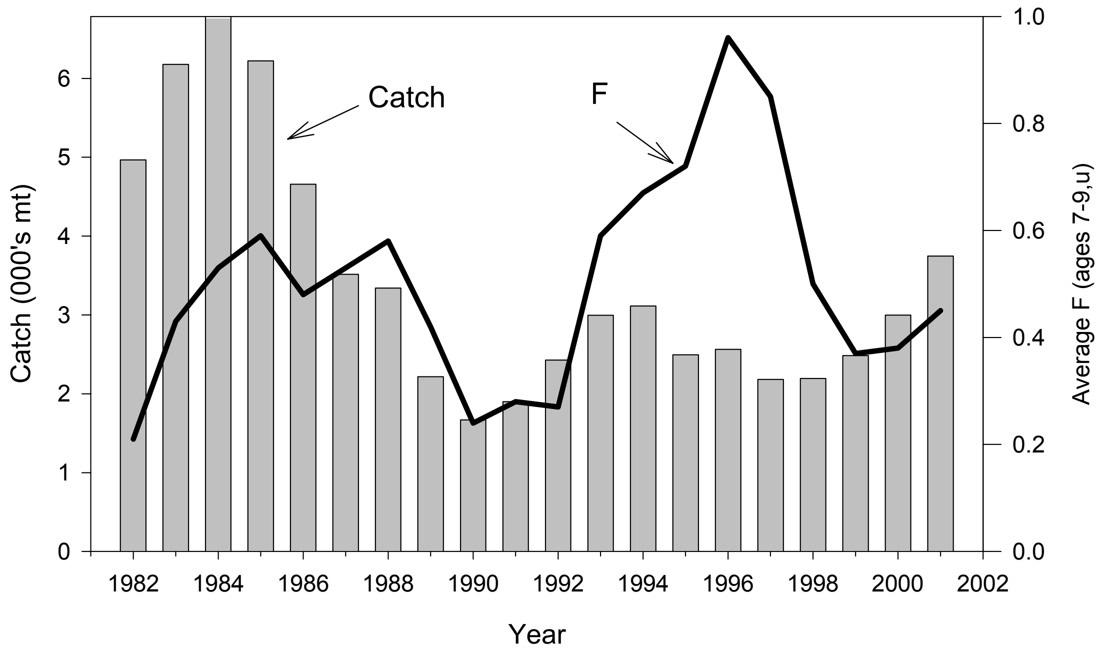


Figure G4. Trends in total catch and fishing mortality for witch flounder, 1982-2001.

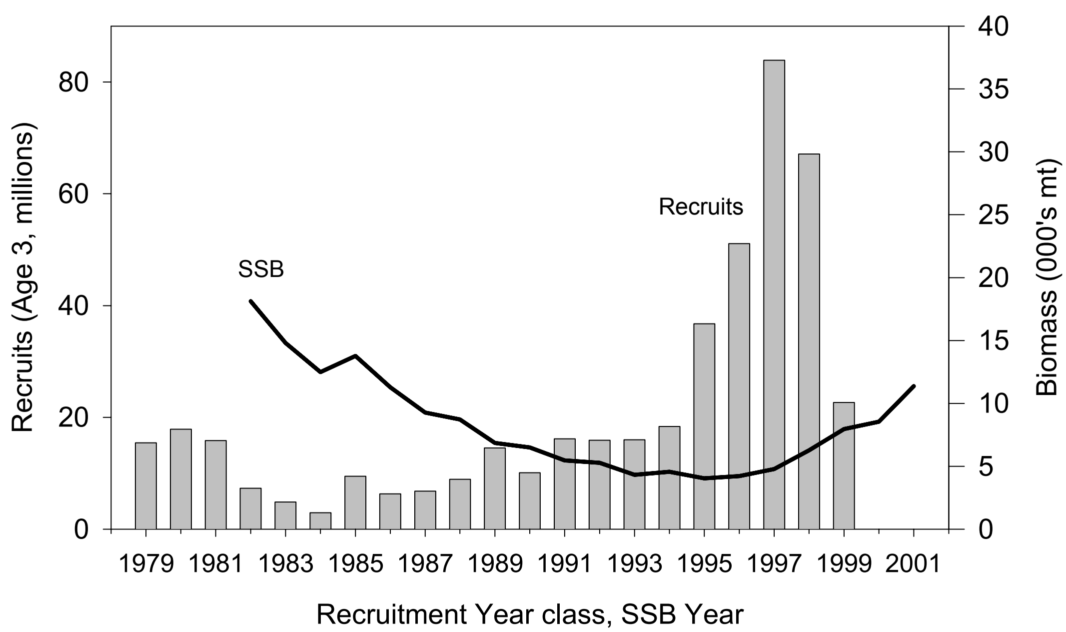


Figure G5. Trends in spawning stock biomass and recruitment (age 3) for witch flounder.

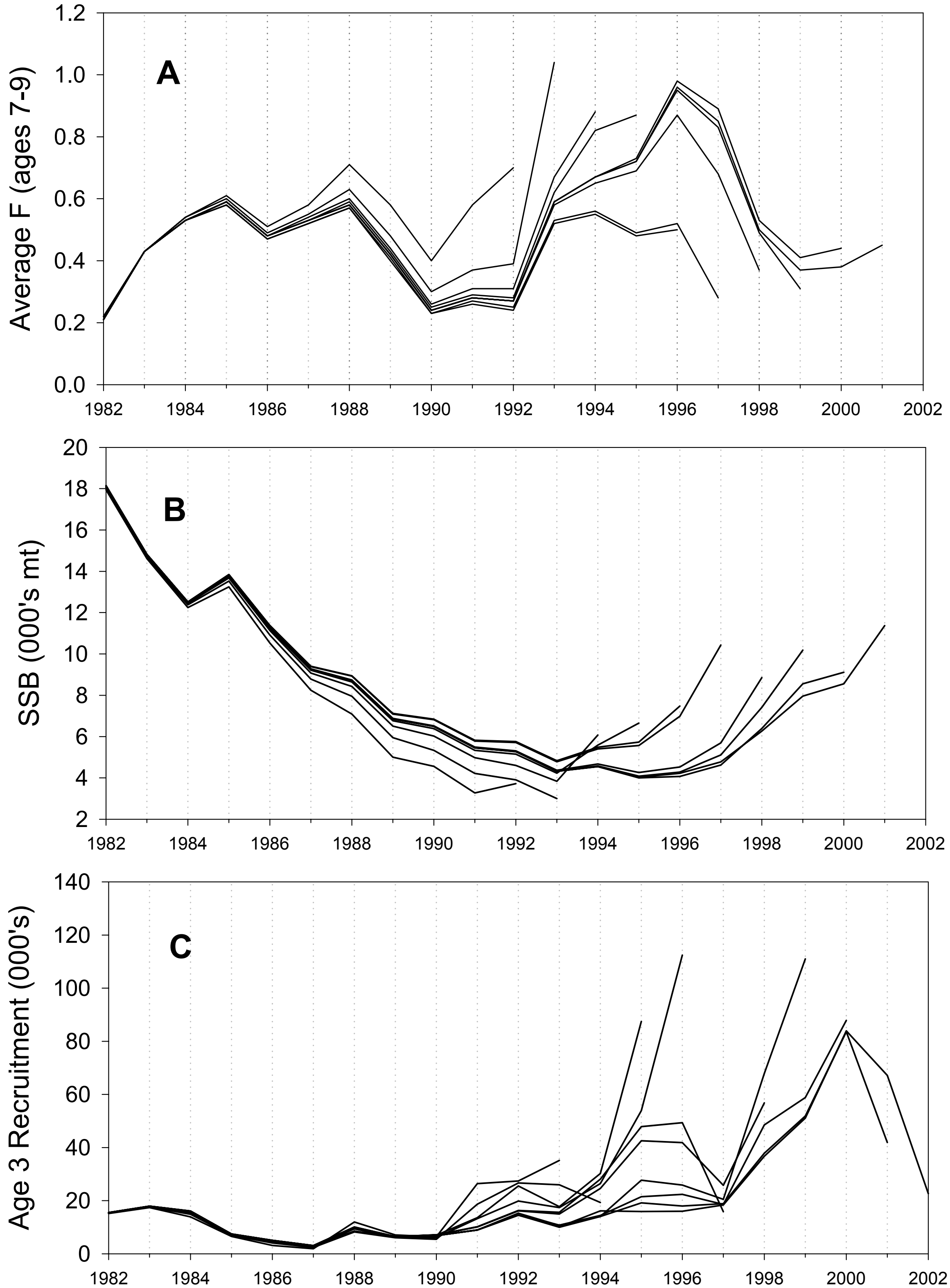


Figure G6. Retrospective analysis results of fishing mortality(A), spawning stock biomass (B), and age 3 recruitment(C).

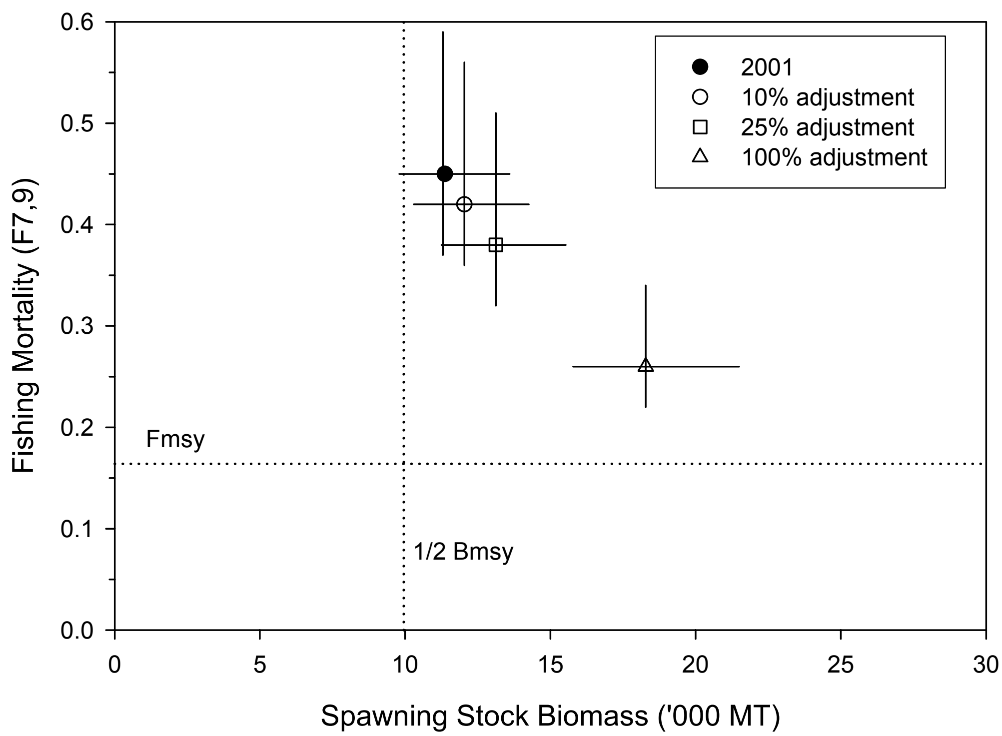


Figure G7. Stock status of witch flounder in 2001 (solid circle with 80% confidence intervals) and three sensitivity analyses: the open circle represents stock status when the 2000-2002 survey tuning indices were arbitrarily adjusted upward by 1.1; open square represents results when 2000-2002 survey tuning indices were arbitrarily adjusted by 1.25; open triangle represents results when 2002-2002 survey tuning indices were arbitrarily adjusted by 2.0.

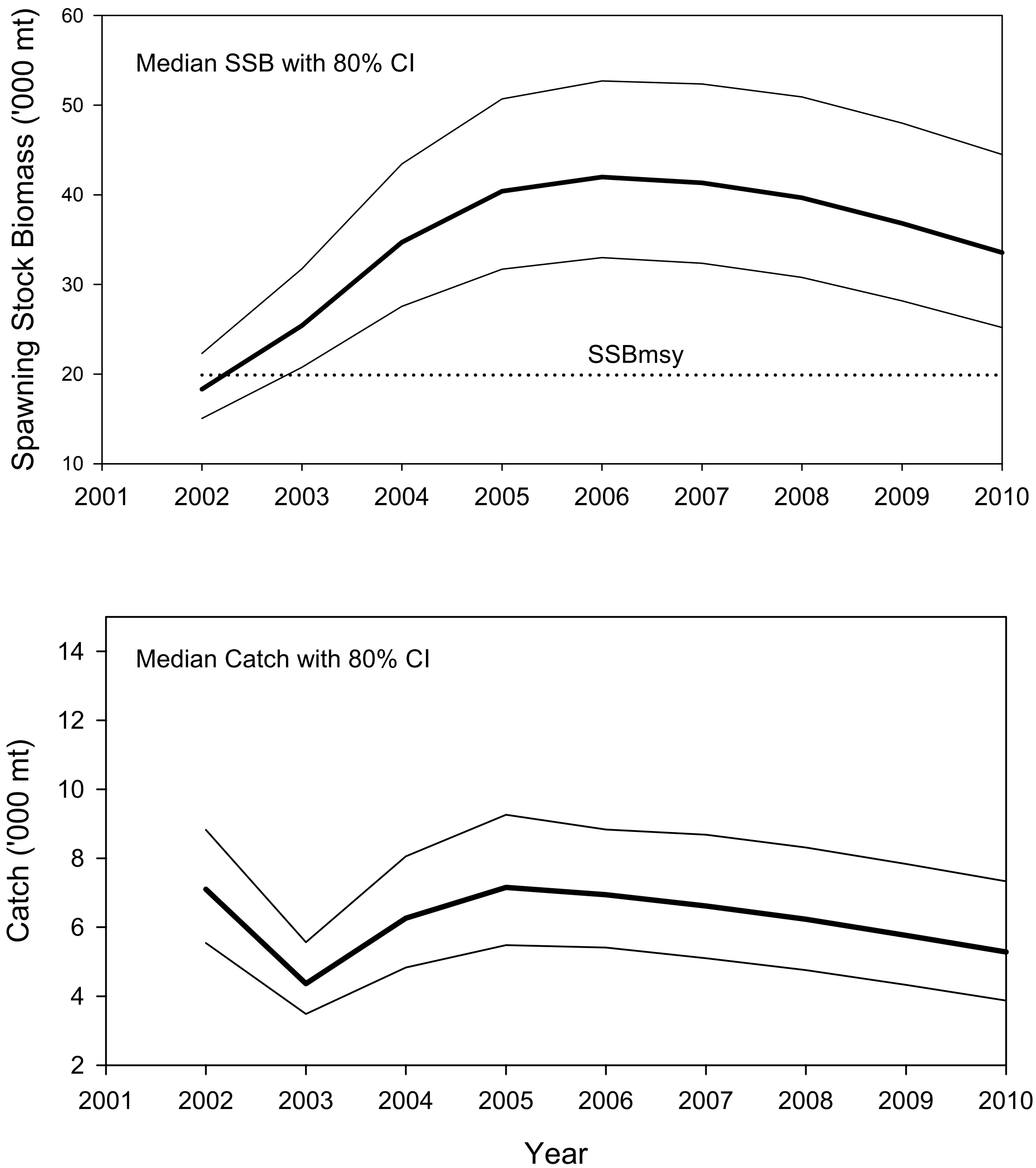


Figure G8. Projected median spawning stock biomass ('000 mt) and median catch ('000 mt) with 80% confidence intervals.

H. Gulf of Maine-Georges Bank American Plaice by L. O'Brien, C. Esteves, and L. Col

1.0 Background

This stock was last assessed in 2000 (O'Brien and Esteves 2001) and reviewed by the 32nd Northeast Regional SAW (NEFSC 2001). Fully recruited F (ages 5-8, unweighted average) in 1999 was estimated to be 0.27, a decrease of 10% from 1998. Spawning stock biomass was 14,056 mt in 1999, a decrease of 9% from 1998. The most recent strong recruitment since 1993 was the above- average 1998 year class with an average recruit/SSB survival ratio.

2.0 Fishery

Total commercial landings of Gulf of Maine-Georges Bank American plaice were 4,479 mt in 2001, a 3% increase from 2000 and a 38% increase from 1999 (Table H1, Figure H1). Canadian fisheries landed 46 mt in 2001, and 143 mt in 2000, accounting for about 1%-3% of the total landings. The otter trawl fleet accounts for more than 90% of the landings. The fishery is prosecuted primarily during the 2^{nd} and 3^{rd} calendar quarter of the year.

Discarding of small fish occurs in the northern shrimp fishery during the 1^{st} and 4^{th} calendar quarter, and year-round by the large mesh fishery. Discarded catch in the Northern shrimp fishery is estimated directly from sea-sampled trips (1989-1997) and indirectly using survey data (1980-1988,1998-2001). Discards in the large mesh fishery are also estimated based on survey data. Since 1998 discards in the shrimp fishery account for about 5% of the total catch (in numbers) and discards in the large mesh fishery account for about 20-30% of the total catch (in numbers) (Figure H2).

3.0 Research Surveys

The NEFSC survey indices of abundance and biomass have generally been increasing since 1988. The most recent spring and autumn indices, however, both indicate a decreasing trend (Table H2, Figure H3 and H4). Recruitment indices of age 1 fish from NEFSC autumn surveys indicate that both the 1997 and 1998 year classes are above average and similar in size to the 1992 year class (Table 3a). These same year classes in the autumn Massachusetts state survey are just below the time series average (Table 3b) .

4.0 Assessment

Input data and Analyses

The current assessment is an update and employs the same ADAPT formulation as in the 2000 assessment (O'Brien and Esteves 2001). Landings at age has been updated with total 2000 and 2001 landings, and discards have been estimated for the Northern shrimp fishery and the large mesh fishery. Number of samples obtained for characterizing the catch at age have improved since 1995 and samples were adequate for 2000-2001 (Table H4). The total catch at age includes estimates of discarded fish from both the Northern shrimp fishery and the large mesh fishery and landings from the commercial fishery (Table H5, Figure H2).

Research survey indices have been estimated for the spring NEFSC (ages 1-8) and MADMF (ages 1-5) surveys and the autumn NEFSC (ages1-6) and MADMF (ages 1-5) surveys for 2000-2001. The ADAPT calibration method (Parrack 1986, Gavaris 1988, Conser and Powers 1990) was used to derive estimates of instantaneous fishing mortality and beginning year stock sizes in 2002. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality, spawning stock biomass, and mean biomass estimates. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

Assessment results

Fully recruited fishing mortality (age 5-8) was estimated to be 0.43 in 2001 (Table H6, Figure H5). Spawning stock biomass in 2001 was estimated to be 13,822 mt, a 3% decrease from 2000 and a 5% decrease from 1999 (Table H6, Figure H6). Recruitment of the 2001 year class (39.3 million age 1 fish) is estimated to be similar to the above average 1998 year class (40 million age 1 fish) (Table H6, Figure H6).

VPA Diagnostics

Stock size estimates for ages 1-8 were well estimated with CVs ranging from 0.16 to 0.48. The distribution of F estimates from the bootstrap analysis ranged from 0.32 to 0.75 with an 80% probability that F in 2001 was between 0.37 and 0.50. The distribution of SSB estimates from the bootstrap analysis ranged from 10,500 mt to 18,500 mt with an 80% probability that SSB in 2000 was between 12,250 mt to 15,390 mt.

There is not a strong retrospective pattern in this model formulation (Figure H7). The terminal year estimates of fishing mortality exhibit a pattern of being more than the converged estimates prior to 1997. The SSB estimates do not have a retrospective pattern. The terminal year estimates of recruits are less than converged estimates from 1993. These patterns are similar to the previous assessment (O'Brien and Esteves 2001).

Sensitivity Analyses

Analyses were conducted to determine the sensitivity of fishing mortality and spawning stock biomass estimates to changes in the magnitude of the research survey indices used to calibrate the VPA. NEFSC spring and autumn survey indices for 2000-2002 were arbitrarily increased by 10%, 25% and 100% and used to re-calibrate the VPA (Figure H8). Results are summarized in Section 5.2 (Summary of Assessment Advice).

5.0 Projections

Long term forecasts of catch (landings plus discards) and SSB were conducted with F_{2002}= 0.85* F_{2001}. Input data and results for 2002-2004 are presented in Table H7. The $F_{rebuild}$ that would enable 50% probability of reaching SSBmsy by 2009 was 0.10. The current estimate of $F_{rebuild}$ is similar to the previous estimate of 0.13 (NEFSC 2002) which was based on the assessment results from 2000 (O'Brien and Esteves 2001). Landings are projected to be 1,336 mt in 2003 and 1,562 mt in 2004, and discards are projected to be 161 mt in 2003 and 128 mt in 2004 (Figure H9). SSB is projected to be 15,938 mt in 2003 and 17,038 mt in 2004 (Figure H9).

6.0 Biological Reference Points

Biological reference points were established for Gulf of Maine -Georges Bank American plaice based on yield per recruit analyses using $F_{40\%}$ as a proxy for F_{MSY} (NEFSC 2002) as :

MSY= 4,900 mt
SSB_{MSY} = 28,600 mt and
F_{MSY}= 0.166

In 2001, spawning stock biomass was estimated at 13,822 mt, about 48% of the target SSB_{MSY}. The stock is considered to be overfished, although the upper 80% confidence interval includes biomass >50% SSB_{MSY} Overfishing is occurring on this stock because 2001 F= 0.43 > F_{MSY} . The 80% confidence intervals about F_{2001} were also above F_{MSY}.

7.0 Summary

American plaice in the Gulf of Maine-Georges Bank region are overfished and overfishing is occurring. Fishing mortality on this stock declined during 1996-1999, but then increased in 2000-2001 as the 1996 and 1997 year classes recruited to the fishery. Spawning stock biomass increased from 1995 to 1998 and has been decreasing since 1998. Spawning stock biomass was 13,822 mt in 2001. The 1998 and 2001 year classes appear to be above average, whereas the 2000 year class is the lowest on record. The survey biomass indices generally show an increasing trend during the last decade and the 1997 and 1998 year classes appear to be near or above average. The recent strong year classes represent an opportunity to rebuild the stock with lower fishing mortality rates.

8.0 Sources of Uncertainty

- Lack of direct estimates of discards from sea sampled trips for large mesh fishery and shrimp fishery.

- Projections of SSB are likely to be underestimated if recruits are underestimated as indicated by the strong retrospective pattern of age 1 recruits.

9.0 GARM Panel Comments

Discards are estimated with a method that uses survey indices for 2001-2002. The sensitivity analyses of the impact of the offset trawl warp on survey catches could also include the impact on discard estimates. The working group asked to see one year's discard estimates bumped up to reflect a 100% increase in survey catch in order to see the magnitude of discards.

The GARM concluded that it is inappropriate to use the MADMF indices in sensitivity analyses of the influence of a single survey series on estimates of F and SSB because of the limited geographic coverage of the survey.

Discards are an important part of the catch at age. Sea sampling of small mesh fisheries has been incomplete in recent years e.g., no sampling of the northern shrimp fishery since 1997. It was recommended that improved sea sampling for the northern shrimp fishery and other small mesh fisheries (e.g. the whiting fishery), and the scallop fishery be implemented (this is also a general recommendation since these fisheries generate discards for many stocks (e.g., Cape Cod yellowtail, SNE yellowtail, witch, American plaice).

The GARM noted a strong pattern in residuals for the age 1 survey index. This is most likely because the catch at age 1 consists solely of discards that were, in some periods, estimated using the same survey indices that have the residual pattern.

10. Research Recommendations

The GARM panel recommended that sensitivity analyses be conducted to evaluate effects of uncertainty in discard estimates on assessment results.

The survey time series could be split into two tuning indices based on time periods corresponding to changes in methods for estimating discards

11.0 References

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Table H1. Commercial landings (metric tons, live weight) of American plaice from the Gulf of Maine, Georges Bank, Southern New England and the Mid-Atlantic, 1960-2001.

Year	Gulf of Maine			Georges Bank					Southern New England				Mid - Atlantic			Grand Total		
	USA	Can	Total	USA	Can	USSR	Other	Total	USA	USSR	Other	Total	USA	Other	Total	USA	Other	Total
1960	620	1	621	689	-	-	-	689	-	-	-	0	-	-	0	1309	1	1310
1961	692	-	692	830	-	-	-	830	-	-	-	0	-	-	0	1522	0	1522
1962	694	-	694	1233	44	-	-	1277	-	-	-	0	-	-	0	1927	44	1971
1963	693	-	693	1489	127	24	-	1640	-	-	-	0	-	-	0	2182	151	2333
1964	811	-	811	2800	177	-	11	2988	-	-	-	0	-	-	0	3611	188	3799
1965	967	-	967	2376	180	112	-	2668	-	-	-	0	-	-	0	3343	292	3635
1966	955	2	957	2388	242	279	1	2910	-	-	-	0	-	-	0	3343	524	3867
1967	1066	6	1072	2166	203	1018	10	3397	-	-	-	0	4	-	4	3236	1237	4473
1968	904	5	909	1695	173	193	5	2066	637	145	-	782	18	2	20	3254	523	3777
1969	1059	7	1066	1738	71	63	17	1889	505	349	-	854	130	-	130	3432	507	3939
1970	895	-	895	1603	92	927	658	3280	88	18	40	146	8	-	8	2594	1735	4329
1971	648	5	653	1511	38	228	296	2071	11	112	206	329	6	2	8	2176	887	3063
1972	569	-	569	1222	22	358	-	1602	3	71	-	74	-	-	0	1794	451	2245
1973	687	-	687	910	38	289	-	1237	5	158	-	163	-	-	0	1602	485	2087
1974	945	2	947	1039	27	16	2	1084	92	4	-	96	-	-	0	2076	51	2127
1975	1507	-	1507	913	25	148	-	1086	3	-	-	3	-	-	0	2423	173	2596
1976	2550	-	2550	948	24	3	-	975	10	-	-	10	1	-	1	3509	27	3536
1977	5647	-	5647	1408	35	50	-	1493	6	78	-	84	7	-	7	7068	163	7231
1978	7287	30	7317	2193	77	-	-	2270	15	-	-	15	8	-	8	9503	107	9610
1979	8835	-	8835	2478	23	-	-	2501	13	-	7	20	4	-	4	11330	30	11360
1980	11139	-	11139	2399	43	-	5	2447	10	-	-	10	1	-	1	13549	48	13597
1981	10327	1	10328	2482	15	-	2	2499	26	-	2	28	46	-	46	12881	20	12901
1982	11147	-	11147	3935	27	-	1	3963	35	-	2	37	9	-	9	15126	30	15156
1983	9142	7	9149	3955	30	-	-	3985	40	-	-	40	4	-	4	13141	37	13178
1984	6833	2	6835	3277	6	-	-	3283	17	-	-	17	7	-	7	10134	8	10142
1985	4766	1	4767	2249	40	-	-	2289	12	-	-	12	2	-	2	7029	41	7070
1986	3319	-	3319	1146	34	-	-	1180	4	-	-	4	3	-	3	4472	34	4506
1987	2766	-	2766	1032	48	-	-	1080	2	-	-	2	1	-	1	3801	48	3849
1988	2271	-	2271	1097	108	-	-	1205	13	-	-	13	1	-	1	3382	108	3490
1989	1646	-	1646	703	68	-	-	771	1	-	-	1	3	-	3	2353	68	2421
1990	1802	-	1802	639	52	-	-	690	2	-	-	2	2	-	2	2445	52	2497
1991	2936	-	2936	1310	26	-	-	1310	15	-	-	15	0	-	0	4261	26	4287
1992	4564	-	4566	1838	3	-	-	1838	10	-	-	10	4	-	4	6416	3	6419
1993	3865	-	3865	1838	-	-	-	1838	11	-	-	11	4	-	4	5718	-	5718
1994	***3357***	-	3431	***1683***	30	-	-	1562	***22***	-	-	22	***4***	-	4	5066	30	5096
1995	***3105***	-	3126	***1505***	2	-	-	1486	***15***	-	-	15	***20***	-	20	4645	2	4647
1996	***2912***	-	2922	***1430***	2	-	-	1423	***40***	-	-	40	***15***	-	15	4396	2	4398
1997	***2312***	-	2396	***1576***	65	-	-	1560	***23***	-	-	23	***26***	-	26	3937	65	4002
1998	***2234***	-	2234.4	***1385***	20	-	-	1405	***23***			23	***20***		20	3663	20	3683
1999	***1718***	-	1717.7	***1384***	123	-	-	1507	***11***			11	***21***		21	3134	123	3257
2000	***2497***	-	2497.5	***1687***	143	-	-	1830	***10***			10	***19***		19	4213	143	4356
2001	***2602***	-	2601.7	***1814***	46	-	-	1860	***7***			7	***10***		10	4433	46	4479

** 1994-2001 data are provisional and spatially distributed based on proportions of landings recorded by area in the VTR database

Table H2. Standardized stratified mean number and mean weight per tow (kg) of American plaice in NEFSC spring and autumn bottom trawl surveys in the Gulf of Maine - Georges Bank area, 1963 -2002 (Offshore strata 26-30,36-40,13-25)

	SPRING		AUTUMN	
	Number	Weight	Number	Weight
1963	—	—	14.17	5.87
1964	—	—	8.20	2.84
1965	—	—	11.95	3.80
1966	—	—	17.78	4.90
1967	—	—	11.05	2.69
1968	11.36	3.40	8.61	2.91
1969	8.59	2.68	7.51	2.36
1970	5.43	1.81	6.46	2.01
1971	3.80	1.26	7.47	1.96
1972	4.28	1.32	7.44	1.60
1973	7.18	1.85	6.19	1.94
1974	8.34	1.94	6.89	1.42
1975	5.78	1.72	8.12	2.43
1976	11.85	3.37	9.98	2.99
1977	14.57	5.11	11.80	3.52
1978	10.61	3.82	15.13	4.66
1979	9.23	3.62	9.96	4.00
1980	18.34	4.78	14.24	5.12
1981	18.75	5.88	13.04	5.62
1982	11.61	3.80	5.88	2.49
1983	16.94	4.60	9.34	3.45
1984	4.10	1.42	7.12	2.02
1985	4.94	1.88	6.95	2.00
1986	3.09	0.92	5.61	1.56
1987	3.50	0.81	4.38	1.09
1988	3.58	0.84	9.69	1.46
1989	4.81	0.75	9.21	1.17
1990	5.09	0.75	15.46	2.90
1991	5.91	1.05	7.71	1.56
1992	4.11	1.36	6.31	1.78
1993	5.29	1.39	11.89	2.39
1994	4.89	0.85	18.07	2.67
1995	9.43	1.94	11.84	2.58
1996	7.83	1.69	7.58	2.23
1997	7.62	1.62	6.27	1.94
1998	4.52	1.11	9.29	2.22
1999	4.18	1.20	11.03	2.57
2000	9.96	2.30	12.23	2.80
2001	10.65	2.19	10.40	2.63
2002	6.70	1.76		

Table H3a . Standardized stratified mean number per tow by age and mean weight per tow (kg) of American plaice in NEFSC spring and autumn bottom trawl surveys in the Gulf of Maine - Georges Bank[1] area, 1980-2002.

	AGE GROUP																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	#/tow	kg/tow
Spring																	
1980	0.00	0.57	3.55	4.49	3.00	2.89	1.60	1.12	0.25	0.31	0.23	0.04	0.02	0.02	0.04	18.34	4.78
1981	0.00	0.13	3.49	4.31	3.55	2.67	1.74	1.45	0.79	0.41	0.34	0.07	0.09	0.07	0.09	18.75	5.88
1982	0.00	0.06	1.04	1.79	3.17	2.13	1.34	0.92	0.49	0.35	0.19	0.07	0.01	0.04	0.02	11.601	3.80
1983	0.00	0.20	3.68	3.33	4.48	2.64	1.18	0.58	0.32	0.15	0.15	0.11	0.05	0.02	0.04	16.94	4.60
1984	0.00	0.02	0.35	0.57	0.90	1.30	0.58	0.22	0.10	0.01	0.02	0.01	0.01	0.00	0.03	4.10	1.42
1985	0.00	0.03	0.32	0.98	0.86	0.73	0.86	0.46	0.42	0.12	0.07	0.04	0.02	0.02	0.02	4.94	1.88
1986	0.00	0.01	0.46	0.34	1.01	0.59	0.29	0.21	0.10	0.04	0.04	0.00	0.00	0.00	0.00	3.09	0.92
1987	0.00	0.09	0.61	0.99	0.69	0.51	0.25	0.17	0.07	0.03	0.03	0.03	0.01	0.00	0.00	3.50	0.81
1988	0.00	0.20	0.99	0.84	0.76	0.31	0.23	0.12	0.01	0.09	0.01	0.01	0.00	0.00	0.00	3.58	0.84
1989	0.00	0.05	1.59	1.27	0.86	0.49	0.29	0.16	0.03	0.07	0.01	0.01	0.00	0.00	0.00	4.81	0.75
1990	0.00	0.00	0.57	2.65	1.02	0.54	0.17	0.06	0.04	0.05	0.00	0.00	0.00	0.00	0.00	5.09	0.75
1991	0.00	0.03	0.71	1.63	2.33	0.92	0.15	0.07	0.04	0.02	0.00	0.02	0.00	0.00	0.01	5.91	1.05
1992	0.00	0.06	0.34	1.15	0.88	1.07	0.43	0.11	0.04	0.02	0.01	0.00	0.01	0.00	0.00	4.11	1.36
1993	0.00	0.33	0.84	1.16	1.58	0.61	0.45	0.17	0.08	0.02	0.01	0.02	0.03	0.00	0.00	5.29	1.39
1994	0.00	0.03	1.43	1.14	1.12	0.75	0.23	0.10	0.03	0.01	0.00	0.01	0.01	0.01	0.01	4.88	0.85
1995	0.00	0.31	1.97	3.21	2.31	1.11	0.44	0.22	0.03	0.03	0.03	0.01	0.02	0.01	0.01	9.43	1.94
1996	0.00	0.02	0.47	1.94	3.30	1.31	0.53	0.20	0.05	0.02	0.00	0.00	0.00	0.00	0.00	7.83	1.69
1997	0.00	0.01	0.85	1.66	2.52	2.05	0.39	0.09	0.01	0.00	0.01	0.00	0.02	0.00	0.00	7.62	1.62
1998	0.00	0.06	0.19	1.02	1.12	1.22	0.68	0.16	0.06	0.01	0.01	0.003	0.01	0.00	0.00	4.52	1.11
1999	0.00	0.08	0.41	0.52	1.13	0.79	0.64	0.41	0.17	0.02	0.02	0.00	0.00	0.00	0.00	4.18	1.20
2000	0.00	0.03	1.91	2.48	2.22	1.60	0.86	0.60	0.15	0.07	0.02	0.003	0.01	0.00	0.00	9.96	2.30
2001	0.00	0.00	0.71	3.67	3.37	1.45	0.75	0.37	0.17	0.09	0.05	0.02	0.00	0.00	0.00	10.65	2.19
2002	0.00	0.10	0.35	0.98	2.35	1.66	0.51	0.33	0.20	0.14	0.07	0.01	0.00	0.00	0.00	6.70	1.76

Table H3a (continued). Standardized stratified mean number per tow by age and mean weight per tow (kg) of American plaice in NEFSC spring and autumn bottom trawl surveys in the Gulf of Maine - Georges Bank[1] area, 1980-2002.

	AGE GROUP																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	#/tow	kg/tow
Autumn																	
1980	0.00	1.58	2.22	2.72	2.85	1.53	1.03	0.93	0.57	0.31	0.20	0.11	0.04	0.07	0.08	14.24	5.12
1981	0.00	0.43	2.79	2.22	2.62	2.30	1.55	0.63	0.58	0.07	0.20	0.20	0.02	0.02	0.12	13.04	5.62
1982	0.00	0.20	0.91	1.65	1.27	0.57	0.48	0.30	0.17	0.19	0.08	0.03	0.00	0.00	0.02	5.88	2.49
1983	0.06	0.50	1.01	2.02	2.92	1.36	0.68	0.34	0.17	0.10	0.03	0.05	0.06	0.01	0.03	9.34	3.45
1984	0.02	0.22	2.24	1.56	1.21	1.07	0.51	0.12	0.10	0.00	0.03	0.01	0.02	0.00	0.01	7.12	2.02
1985	0.02	0.91	0.83	2.64	1.05	0.79	0.41	0.19	0.05	0.03	0.02	0.00	0.00	0.01	0.00	6.95	2.00
1986	0.10	0.51	1.48	0.89	1.45	0.47	0.43	0.16	0.12	0.04	0.01	0.02	0.01	0.00	0.00	5.61	1.56
1987	0.01	0.53	1.27	0.99	0.43	0.69	0.25	0.10	0.04	0.04	0.01	0.02	0.00	0.00	0.00	4.38	1.09
1988	0.00	2.84	2.97	2.39	0.78	0.47	0.10	0.07	0.00	0.03	0.00	0.02	0.00	0.00	0.00	9.69	1.46
1989	0.05	0.48	4.45	2.86	0.98	0.19	0.10	0.02	0.02	0.02	0.02	0.00	0.01	0.02	0.00	9.21	1.17
1990	0.01	1.52	2.26	7.49	2.89	0.59	0.25	0.11	0.07	0.02	0.02	0.01	0.01	0.00	0.01	15.46	2.90
1991	0.02	0.47	2.48	2.03	1.59	0.73	0.30	0.04	0.07	0.00	0.01	0.00	0.00	0.00	0.01	7.71	1.56
1992	0.02	0.65	1.23	1.85	1.28	0.78	0.30	0.07	0.05	0.03	0.02	0.00	0.02	0.00	0.00	6.31	1.78
1993	0.01	1.71	2.35	3.47	2.28	1.05	0.80	0.11	0.04	0.04	0.04	0.00	0.00	0.00	0.00	11.89	2.39
1994	0.04	3.83	7.53	2.81	1.71	1.30	0.04	0.25	0.13	0.01	0.03	0.02	0.00	0.00	0.00	18.07	2.67
1995	0.01	0.50	3.80	3.82	2.50	0.90	0.22	0.04	0.03	0.00	0.00	0.00	0.02	0.00	0.00	11.84	2.58
1996	0.01	0.54	0.81	2.00	2.74	0.93	0.39	0.07	0.04	0.03	0.00	0.00	0.02	0.00	0.02	7.58	2.23
1997	0.01	0.36	1.06	1.55	1.86	1.04	0.32	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.02	6.27	1.94
1998	0.01	1.73	0.60	1.88	2.01	1.78	1.08	0.12	0.05	0.01	0.01	0.00	0.01	0.00	0.00	9.29	2.22
1999	0.02	2.00	2.20	2.05	2.13	1.60	0.81	0.20	0.03	0.00	0.00	0.00	0.00	0.00	0.00	11.03	2.57
2000	0.03	0.47	2.90	3.91	2.28	1.35	0.75	0.33	0.14	0.03	0.03	0.00	0.00	0.00	0.00	12.23	2.79
2001	0.02	0.40	1.22	3.31	2.64	1.46	0.53	0.41	0.20	0.17	0.02	0.00	0.01	0.00	0.00	10.40	2.63

[1] Offshore strata 13-30, 36-40

Table H3b. Stratified mean number per tow by age of American plaice in Massachusetts spring and autumn bottom trawl surveys in Massachusetts Bay and Cape Cod Bay (Regions 4+5), 1982-2002.

	Age												Total
Year	0	1	2	3	4	5	6	7	8	9	10	11	#/tow
Spring													
1982	0.00	7.18	49.25	33.35	17.14	5.00	2.42	1.12	0.26	0.15	0.03	0.07	115.97
1983	0.00	1.93	18.76	22.42	21.46	10.22	2.37	0.73	0.20	0.19	0.06	0.10	78.44
1984	0.00	2.15	27.44	21.32	10.57	4.64	1.21	0.18	0.09	0.01	0.03	0.07	67.71
1985	0.00	21.56	17.16	24.22	9.50	3.77	2.24	0.65	0.76	0.12	0.04	0.03	80.05
1986	0.00	27.06	110.27	26.91	14.43	2.84	0.61	0.05	0.08	0.06	0.00	0.16	182.47
1987	0.00	34.36	17.26	15.79	3.90	1.76	0.51	0.10	0.02	0.00	0.00	0.00	73.70
1988	0.00	81.47	63.57	17.85	8.72	1.54	0.47	0.09	0.00	0.00	0.00	0.00	173.71
1989	0.00	8.07	127.26	44.97	11.99	3.03	1.31	0.20	0.03	0.03	0.00	0.05	196.94
1990	0.00	7.73	25.37	56.71	16.48	3.43	0.53	0.11	0.10	0.13	0.00	0.00	110.59
1991	0.00	2.10	19.98	34.77	18.98	3.24	0.18	0.07	0.01	0.00	0.00	0.00	79.33
1992	0.00	8.20	11.06	33.98	14.99	7.42	1.11	0.45	0.00	0.00	0.00	0.00	77.21
1993	0.00	11.60	18.98	16.08	9.16	3.45	0.81	0.04	0.02	0.00	0.00	0.00	60.14
1994	0.00	11.60	52.57	22.12	7.13	3.88	1.03	0.31	0.00	0.00	0.00	0.00	98.64
1995	0.00	0.54	34.65	49.64	10.32	3.16	0.62	0.17	0.03	0.05	0.02	0.00	99.20
1996	0.00	2.29	4.14	14.92	31.39	6.33	1.01	0.77	0.01	0.00	0.00	0.00	60.86
1997	0.00	1.55	7.96	13.95	17.24	12.21	2.41	0.21	0.00	0.00	0.00	0.00	55.52
1998	0.00	2.83	4.33	11.45	7.53	8.93	3.95	0.49	0.00	0.03	0.00	0.00	39.54
1999	0.00	1.35	11.65	11.65	15.11	7.57	3.96	1.62	0.35	0.01	0.00	0.00	53.27
2000	0.00	3.45	56.51	34.86	19.98	13.29	4.95	3.64	0.17	0.03	0.00	0.00	136.88
2001	0.00	0.07	4.75	23.71	17.03	4.74	2.18	0.95	0.48	0.15	0.10	0.03	54.19
2002	0.00	6.26	4.15	10.77	18.59	5.93	1.49	0.78	0.38	0.21	0.07	0.00	48.63
Autumn													
1982	0.17	13.24	15.46	10.22	5.11	1.14	0.56	0.14	0.05	0.05	0.01	0.08	46.23
1983	1.29	52.17	18.98	10.02	8.30	1.39	0.32	0.15	0.05	0.06	0.00	0.01	92.74
1984	0.11	3.14	13.24	4.27	1.83	0.77	0.24	0.04	0.05	0.00	0.00	0.00	23.69
1985	0.00	60.97	9.45	14.21	1.56	0.14	0.03	0.02	0.00	0.00	0.00	0.00	86.38
1986	0.23	41.27	40.08	12.07	5.30	0.39	0.13	0.01	0.00	0.00	0.00	0.00	99.48
1987	0.24	46.36	14.60	3.00	0.52	0.23	0.07	0.01	0.04	0.00	0.00	0.00	65.07
1988	0.00	85.63	41.28	13.98	1.34	0.45	0.08	0.00	0.00	0.00	0.00	0.00	142.76
1989	0.03	57.56	122.25	31.03	2.33	0.13	0.01	0.01	0.00	0.00	0.00	0.00	213.35
1990	0.08	31.99	14.20	20.12	3.93	0.21	0.03	0.00	0.00	0.00	0.00	0.00	70.56
1991	0.04	24.07	90.36	40.05	11.51	1.17	0.14	0.00	0.00	0.00	0.00	0.00	167.34
1992	0.00	46.33	12.99	29.79	11.04	1.38	0.00	0.00	0.12	0.00	0.00	0.00	101.66
1993	0.00	76.21	36.80	17.59	6.85	1.71	0.69	0.00	0.00	0.00	0.00	0.00	139.84
1994	0.00	36.71	79.31	10.76	2.91	1.56	0.23	0.14	0.00	0.00	0.00	0.00	131.62
1995	0.00	11.84	44.22	24.93	4.21	0.91	0.08	0.00	0.00	0.00	0.00	0.00	86.19
1996	0.09	16.25	19.25	27.55	13.96	1.39	0.28	0.00	0.00	0.00	0.00	0.00	78.78
1997	0.00	13.61	28.08	17.91	10.29	1.46	0.19	0.01	0.00	0.00	0.00	0.00	71.55
1998	0.16	34.56	6.12	13.80	7.10	3.76	0.62	0.01	0.00	0.00	0.00	0.00	66.13
1999	0.00	29.23	32.57	20.61	10.58	2.85	1.2	0.41	0.00	0.00	0.00	0.00	97.45
2000	0.03	6.26	25.67	19.42	6.01	2.99	1.07	0.35	0.03	0.02	0.00	0.00	61.85
2001	0.00	3.01	14.71	30.81	9.07	2.67	0.26	0.36	0.15	0.02	0.00	0.00	61.06

Table H4. Sampling of commercial American plaice landings, by market category, for the Gulf of Maine and Georges Bank areas (NAFO Division 5Y and 5Z), 1985-2001.

		Small				Medium				Large				Total Number	Number of tons landed / sample			Total Lengths	Total Numbers
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Samples	Sm.	Med.	Lrg.	Measured	Aged
1985	GB	2	4	14	3	---	2	2	2	---	3	7	1	40				537	828
	GM	2	5	5	5	3	1	9	5	1	10	6	5	57				1885	1321
	total	4	9	19	8	3	3	11	7	1	13	13	6	97	49	55	116	2422	2149
1986	GB	3	6	5	3	2	4	3	2	1	4	3	2	38				908	716
	GM	9	5	3	5	3	4	5	1	10	10	7	4	66				1199	1420
	total	12	11	8	8	5	8	8	3	11	14	10	6	104	33	35	56	2107	2136
1987	GB	4	5	5	1	---	2	3	2	2	4	4	1	33				715	633
	GM	2	6	5	3	1	5	2	3	3	3	6	5	44				1226	885
	total	6	11	10	4	1	7	5	5	5	7	10	6	77	39	40	63	1941	1518
1988	GB	3	7	4	2	1	3	4	2	4	5	2	4	41				1023	505
	GM	4	7	4	5	6	6	4	3	6	5	3	2	55				2166	803
	total	7	14	8	7	7	9	8	5	10	10	5	6	96	34	21	40	3189	1308
1989	GB	2	5	5	---	1	1	6	1	5	3	3	---	32				869	600
	GM	1	3	3	3	1	---	4	3	2	1	---	1	22				863	432
	total	3	8	8	3	2	1	10	4	7	4	3	1	54	35	29	63	1732	1032
1990	GB	---	5	6	---	2	1	2	2	---	2	5	---	25				698	494
	GM	5	5	3	3	1	6	3	5	1	5	3	5	45				1558	938
	total	5	10	9	3	3	7	5	7	1	7	8	5	70	33	26	42	2256	1432
1991	GB	---	3	1	---	3	1	1	---	3	3	2	---	17				494	123
	GM	5	3	7	6	3	1	4	3	---	1	5	2	40				1211	736
	total	5	6	8	6	6	2	5	3	3	4	7	2	57	78	67	67	1705	859
1992	GB	---	4	1	---	---	1	1	---	---	2	2	1	12				200	158
	GM	1	5	2	2	1	4	3	2	2	2	3	2	29				1148	684
	total	1	9	3	2	1	5	4	2	2	4	5	3	41	168	143	155	1348	842
1993	GB	---	2	1	1	---	1	---	---	---	3	2	1	11				69	190
	GM	2	4	4	1	---	2	2	---	---	1	2	---	18				445	251
	total	2	6	5	2	0	3	2	0	0	4	4	1	29	133	260	253	514	441
1994	GB	---	---	---	---	---	---	1	1	---	1	---	1	4				204	52
	GM	---	2	5	3	---	4	3	3	---	2	3	3	28				1307	458
	total	0	2	5	3	0	4	4	4	0	3	3	4	32	205	97	181	1511	510
1995	GB	1	---	---	---	1	---	---	---	1	---	---	---	3				149	44
	GM	1	3	---	2	---	2	---	---	---	2	---	1	11				276	149
	total	2	3	0	2	1	2	0	0	1	2	0	1	14	323	336	332	425	193
1996	GB	---	2	2	1	---	1	4	---	---	2	1	1	14				852	222
	GM	2	3	2	1	2	1	3	5	3	1	4	2	29				1582	435
	total	2	5	4	2	2	2	7	5	3	3	5	3	43	189	53	75	2434	657
1997	GB	2	4	2	3	---	2	3	1	---	2	---	---	19				460	231
	GM	4	4	3	1	2	3	3	---	1	5	3	2	31				1138	489
	total	6	8	5	4	2	5	6	1	1	7	3	2	50	82	77	69	1598	720
1998	GB	1	4	1	---	2	1	1	1	1	1	1	1	15				1440	247
	GM	2	3	1	1	6	3	7	7	2	2	2	2	38				3994	577
	total	3	7	2	1	8	4	8	8	3	3	3	3	53	111	41	87	5434	824
1999	GB	4	4	---	1	5	2	1	---	---	4	1	---	22				2356	308
	GM	6	8	6	9	7	4	5	7	1	6	3	2	64				6428	967
	total	10	12	6	10	12	6	6	7	1	10	4	2	86	31	29	61	8784	1275
2000	GB	14	11	3	1	1	2	---	1	2	2	2	2	41				2546	412
	GM	14	28	4	1	2	7	3	---	---	4	1	3	67				4567	743
	total	28	39	7	2	3	9	3	1	2	6	3	5	108	22	79	78	7113	1155
2001	GB	4	2	1	2	---	2	2	3	---	3	2	1	22				2143	228
	GM	4	3	4	---	3	2	2	2	4	2	1	4	31				3089	435
	total	8	5	5	2	3	4	4	5	4	5	3	5	53	87	79	81	5232	663

Table H5. Catch at age (thousands of fish; metric tons) and mean weight (kg), of commercial landings, large mesh and northern shrimp fishery discards of American plaice, ages 1-9+, from Gulf of Maine - Georges Bank, and South, 1980-2001.

Year	0	1	2	3	4	5	6	7	8	9+	Total
					Catch in Numbers (000's) at Age						
1980	0	5	99	1072	2672	3939	3933	3632	1185	3369	19906
1981	0	5	982	2192	5055	5337	3648	2401	1582	1706	22907
1982	0	10	603	3348	4574	4503	3599	3297	2038	2710	24681
1983	0	15	663	1478	5177	4918	3913	2270	1272	2062	21768
1984	0	3	370	991	2422	6031	3244	1936	580	1350	16927
1985	0	65	158	1217	1336	2405	2872	2228	1081	887	12250
1986	0	59	639	738	2284	1700	1476	1307	631	460	9295
1987	0	38	590	1840	1439	2282	1337	895	543	309	9274
1988	0	314	786	1840	1833	1597	1444	553	270	321	8957
1989	0	132	1653	1831	1125	829	536	753	471	411	7740
1990	0	68	676	3389	2664	1369	531	291	349	450	9787
1991	0	13	323	1001	4410	3403	1123	321	164	402	11161
1992	0	37	231	1083	2222	6810	2724	819	198	342	14467
1993	0	107	426	2032	4141	3583	3139	1403	265	563	15658
1994	1	288	506	623	2627	4459	1703	1288	608	688	12791
1995	1	518	1488	2285	6503	4826	2001	654	584	315	19174
1996	0	195	936	1418	4443	2958	1471	549	250	224	12444
1997	0	158	1375	803	2739	3919	1701	718	230	335	11978
1998	0	37	63	281	883	2607	2476	1044	320	272	7983
1999	0	4	202	205	985	1713	2073	1273	463	261	7180
2000	0	3	320	744	1229	1838	2354	1676	560	220	8944
2001	0	0	85	520	1322	2470	2063	1649	935	439	9485

Table H5. (continued) Catch at age (thousands of fish; metric tons) and mean weight (kg), of commercial landings, large mesh and northern shrimp fishery continued discards of American plaice, ages 1-9+, from Gulf of Maine - Georges Bank, and South, 1980-2001.

Year	0	1	2	3	4	5	6	7	8	9+	Average
					Mean Weight at age (kg)						
1980	0.000	0.030	0.076	0.154	0.267	0.409	0.653	0.829	1.039	1.523	0.725
1981	0.000	0.032	0.108	0.168	0.316	0.442	0.778	0.885	0.978	1.315	0.576
1982	0.000	0.018	0.115	0.230	0.290	0.418	0.564	0.960	1.138	1.479	0.631
1983	0.002	0.013	0.033	0.185	0.378	0.530	0.670	0.823	1.042	1.479	0.630
1984	0.000	0.004	0.045	0.161	0.303	0.524	0.630	0.888	1.187	1.657	0.636
1985	0.000	0.018	0.058	0.084	0.209	0.331	0.534	0.847	1.167	1.618	0.596
1986	0.001	0.016	0.042	0.138	0.229	0.384	0.587	0.842	1.174	1.702	0.516
1987	0.000	0.013	0.046	0.131	0.234	0.409	0.609	0.892	1.173	1.688	0.465
1988	0.000	0.016	0.046	0.159	0.284	0.449	0.641	0.880	1.231	1.630	0.429
1989	0.000	0.012	0.041	0.135	0.275	0.446	0.566	0.736	0.857	1.537	0.373
1990	0.000	0.021	0.058	0.138	0.265	0.455	0.639	0.824	0.968	1.352	0.344
1991	0.000	0.015	0.053	0.120	0.330	0.498	0.710	0.960	1.161	1.479	0.464
1992	0.000	0.028	0.065	0.159	0.315	0.485	0.717	0.948	1.202	1.617	0.533
1993	0.000	0.016	0.078	0.212	0.304	0.434	0.590	0.936	1.234	1.647	0.492
1994	0.001	0.014	0.028	0.194	0.328	0.418	0.564	0.763	1.083	1.807	0.525
1995	0.001	0.012	0.027	0.203	0.322	0.453	0.646	0.909	1.166	1.399	0.407
1996	0.000	0.014	0.038	0.110	0.338	0.474	0.637	0.902	1.172	1.657	0.418
1997	0.000	0.014	0.021	0.111	0.316	0.402	0.605	0.746	0.951	1.565	0.407
1998	0.001	0.013	0.030	0.165	0.281	0.371	0.518	0.805	1.031	2.482	0.550
1999	0.000	0.008	0.018	0.198	0.324	0.417	0.535	0.702	0.879	1.401	0.537
2000	0.000	0.013	0.031	0.221	0.314	0.436	0.538	0.732	1.002	1.234	0.524
2001	0.000	0.000	0.018	0.131	0.297	0.418	0.518	0.681	0.823	1.130	0.522
1980-2001	0.001	0.016	0.049	0.159	0.296	0.437	0.611	0.841	1.075	1.564	0.514
1997-2001	0.001	0.012	0.024	0.165	0.306	0.409	0.543	0.733	0.937	1.562	0.508

Table H6. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt) of Gulf of Maine-Georges Bank American plaice, estimated from virtual population analysis (VPA) and calibrated using the commercial catch at age ADAPT formulation, 1980-2001.

Stock Numbers (Jan 1) in thousands

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	52640	25117	21944	25115	13179	14379	18433	36791	53241	27075	33006	33292	40176	44722	40917	31176	29111	21210	34525	39965	14071	4015	39260
2	42215	43094	20559	17957	20548	10787	11714	15038	30088	43306	22048	26961	27245	32860	36518	33240	25056	23658	17223	28233	32717	11517	3287
3	35914	34473	34394	16287	14102	16489	8689	9012	11778	23923	33961	17440	21782	22097	26518	29441	25868	19667	18125	14044	22932	26497	9353
4	24231	28434	26241	25130	11997	10649	12399	6446	5714	7978	17929	24738	13373	16853	16253	21148	22037	19896	15376	14585	11313	18102	21223
5	21550	17421	18706	17345	15890	7631	7510	8085	3976	3020	5514	12269	16263	8938	10052	10930	11430	14022	13811	11790	11050	8150	13625
6	17203	14080	9434	11240	9751	7553	4072	4610	4554	1810	1722	3276	6966	7153	4076	4195	4582	6682	7934	8949	8102	7384	4438
7	11092	10526	8227	4467	5662	5048	3585	1998	2565	2422	997	929	1666	3238	3016	1796	1624	2420	3931	4255	5451	4504	4179
8	5101	5795	6445	3752	1603	2884	2117	1752	826	1600	1302	553	471	623	1382	1304	879	833	1332	2274	2332	2946	2195
9+	14407	6202	8496	6025	3694	2342	1531	989	973	1384	1666	1344	803	1307	1544	694	781	1204	1125	1274	910	1371	2295
1 +	224352	185140	154444	127318	96428	77763	70049	84722	113716	112518	118145	120802	128745	137793	140277	133924	121368	109592	113381	125369	108878	84486	99854

Fishing Mortality

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0.01	0	0	0.01	0.01	0	0	0	0	0.01	0.02	0.01	0.01	0	0	0	0
2	0	0.03	0.03	0.04	0.02	0.02	0.06	0.04	0.03	0.04	0.03	0.01	0.01	0.01	0.02	0.05	0.04	0.07	0	0.01	0.01	0.01
3	0.03	0.07	0.11	0.11	0.08	0.09	0.1	0.26	0.19	0.09	0.12	0.07	0.06	0.11	0.03	0.09	0.06	0.05	0.02	0.02	0.04	0.02
4	0.13	0.22	0.21	0.26	0.25	0.15	0.23	0.28	0.44	0.17	0.18	0.22	0.2	0.32	0.2	0.42	0.25	0.17	0.07	0.08	0.13	0.08
5	0.23	0.41	0.31	0.38	0.54	0.43	0.29	0.37	0.59	0.36	0.32	0.37	0.62	0.59	0.67	0.67	0.34	0.37	0.23	0.18	0.2	0.41
6	0.29	0.34	0.55	0.49	0.46	0.55	0.51	0.39	0.43	0.4	0.42	0.48	0.57	0.66	0.62	0.75	0.44	0.33	0.42	0.3	0.39	0.37
7	0.45	0.29	0.59	0.82	0.47	0.67	0.52	0.68	0.27	0.42	0.39	0.48	0.78	0.65	0.64	0.51	0.47	0.4	0.35	0.4	0.42	0.52
8	0.3	0.36	0.43	0.47	0.51	0.53	0.4	0.42	0.45	0.39	0.35	0.4	0.63	0.64	0.67	0.68	0.38	0.36	0.31	0.25	0.31	0.43
9+	0.3	0.36	0.43	0.47	0.51	0.53	0.4	0.42	0.45	0.39	0.35	0.4	0.63	0.64	0.67	0.68	0.38	0.36	0.31	0.25	0.31	0.43
mn 5-8,u	0.32	0.35	0.47	0.54	0.50	0.55	0.43	0.47	0.44	0.39	0.37	0.43	0.65	0.64	0.65	0.65	0.41	0.37	0.33	0.28	0.33	0.43

Table H6 continued.

SSB at the start of the spawning season - males and females (mt)

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	24	12	8	5	0	5	11	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	164	186	95	32	37	12	71	92	14	21	11	17	16	15	7	6	5	4	10	12	15	5
3	878	873	1206	529	230	225	395	327	156	299	400	230	320	287	370	246	157	144	182	184	245	289
4	2413	2943	2719	3438	1320	929	1285	853	611	988	2003	3084	1525	1955	2331	2720	3094	2027	1553	1917	1583	2633
5	4546	4061	4723	4651	4638	1633	1787	2036	995	878	1611	3634	4980	2555	2704	3183	3673	4218	3899	3377	3456	2332
6	7938	6457	3632	4659	4446	3084	1488	1908	1971	778	780	1556	3405	3053	1627	1703	2077	3105	3065	3491	3283	3012
7	7051	6935	5724	2308	3614	2906	2011	1160	1668	1425	588	614	1068	2144	1641	1076	1048	1436	2393	2208	2926	2277
8	4181	4535	5528	3174	1326	2443	1817	1492	736	1197	957	466	411	547	1121	986	785	670	1029	1707	1723	1952
9+	19379	7092	10734	7538	5125	3153	2243	1430	1349	1834	1962	1712	1056	1748	2247	779	1120	1636	2458	1593	989	1323
Total	46575	33094	34369	26333	20739	14391	11108	9315	7501	7420	8312	11313	12781	12303	12048	10699	11960	13240	14589	14490	14220	13822

Percent Mature (females)

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	3	3	3	3	3	3	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	8	8	8	8	8	8	24	24	2	2	2	2	2	1	1	1	1	1	3	3	3	3
3	24	24	24	24	24	24	55	55	17	17	17	17	17	12	12	12	12	12	18	18	18	18
4	52	52	52	52	52	52	83	83	65	65	65	65	65	60	60	60	60	60	61	61	61	61
5	79	79	79	79	79	79	95	95	94	94	94	94	94	94	94	94	94	94	92	92	92	92
6	93	93	93	93	93	93	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
7	98	98	98	98	98	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table H7. Input parameters and results of stochastic projection analysis using an empirical resampling model for Gulf of Maine-Georges Bank American plaice for 2002-2009 for $F_{2002}= 0.85F_{2001}$.

Input for Projections:

Age	Fishing Mortality(PR)	Discard Fraction	% Mature	Average Weight Stock	Average Weight Landed	Average Weight Discarded
1	0.02	1.00	0.00	0.001	0.009	0.011
2	0.03	1.00	0.03	0.172	0.015	0.022
3	0.07	0.92	0.18	0.391	0.068	0.165
4	0.28	0.70	0.61	0.432	0.246	0.260
5	0.72	0.29	0.92	0.478	0.360	0.287
6	1.00	0.14	0.99	0.568	0.465	0.297
7	1.00	0.07	1.00	0.735	0.612	0.297
8	1.00	0.03	1.00	0.919	0.819	0.334
9	1.00	0.02	1.00	1.268	1.255	0.415

Projection results for 2002-2004

Year	Recruitment (000 fish)		F	Median Landings (000 mt)	Median Discards (000 mt)	Median SSB (000 mt)
F2002= 0.85 F2001						
2002	30174		0.37	4.030	0.711	15.269
2003	30121	$F_{rebuild}$	0.10	1.336	0.161	15.938
2004	30101		0.10	1.562	0.128	17.038

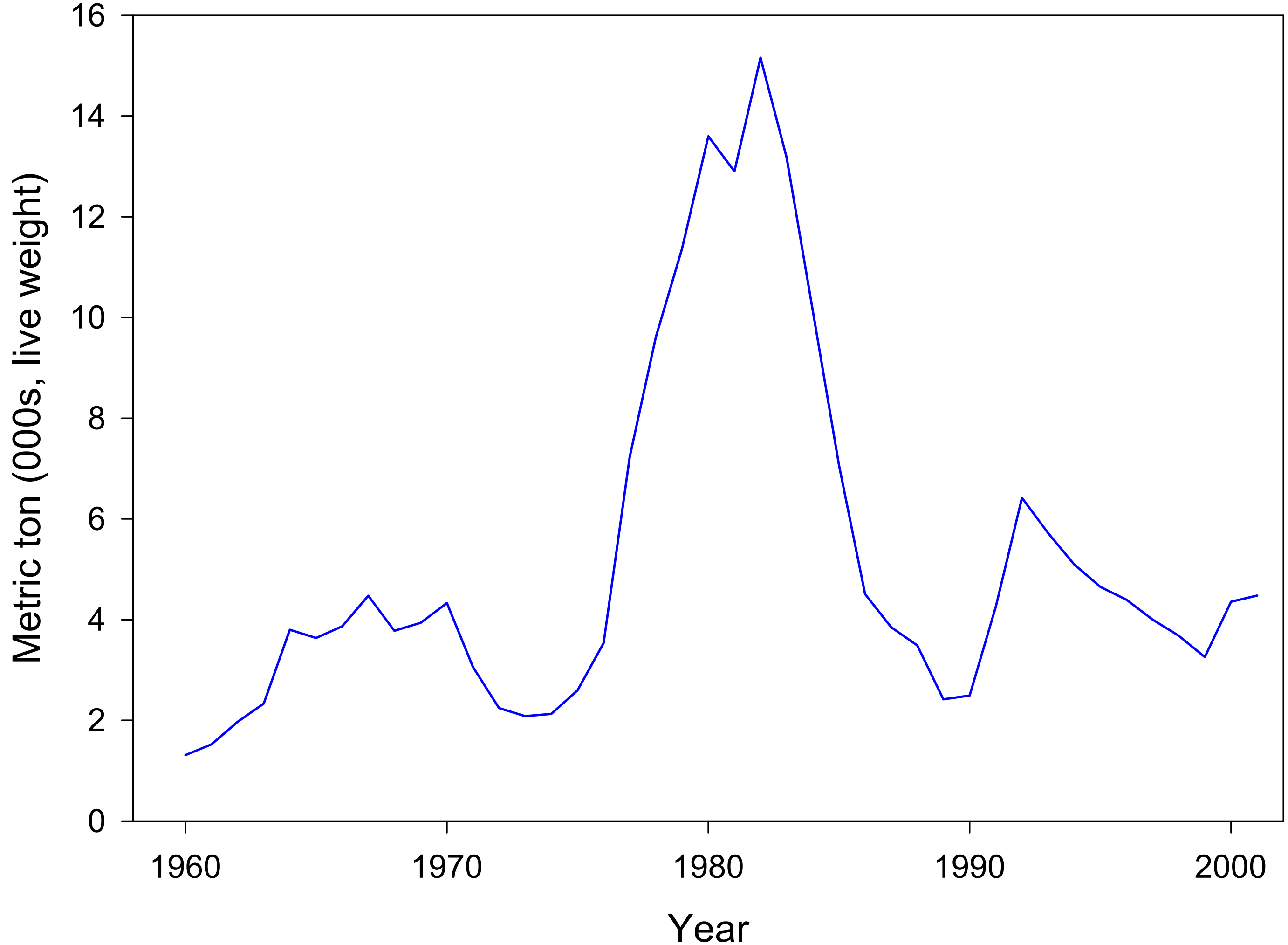

Figure H1. Total commercial landings of Gulf of Maine-Georges Bank American plaice (Division 5Z and 6), 1960-2001.

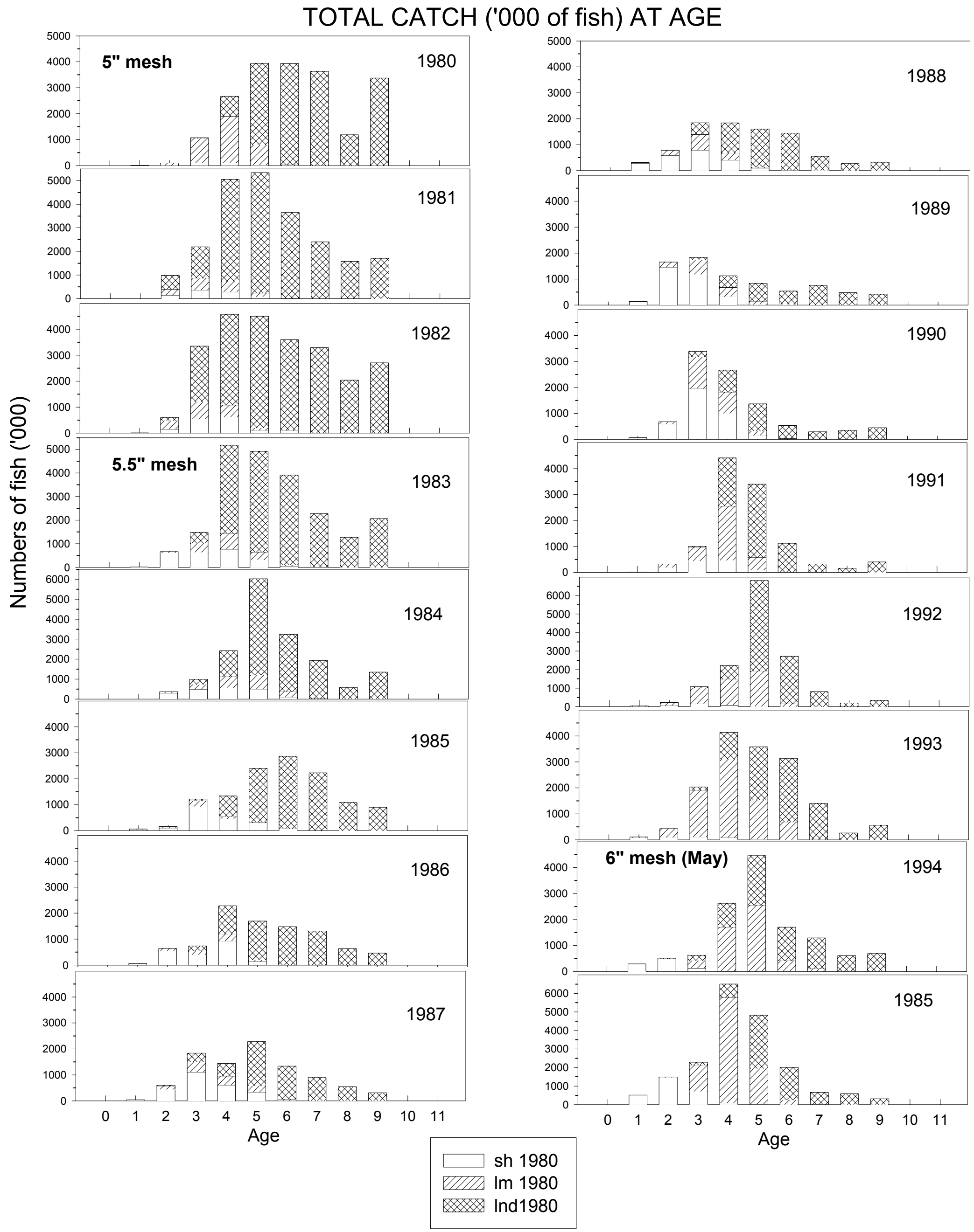

Figure H2. Number of American plaice ('000 of fish) at age in the total catch (discards from shrimp and large mesh fisheries, and landings), 1980 - 2001.

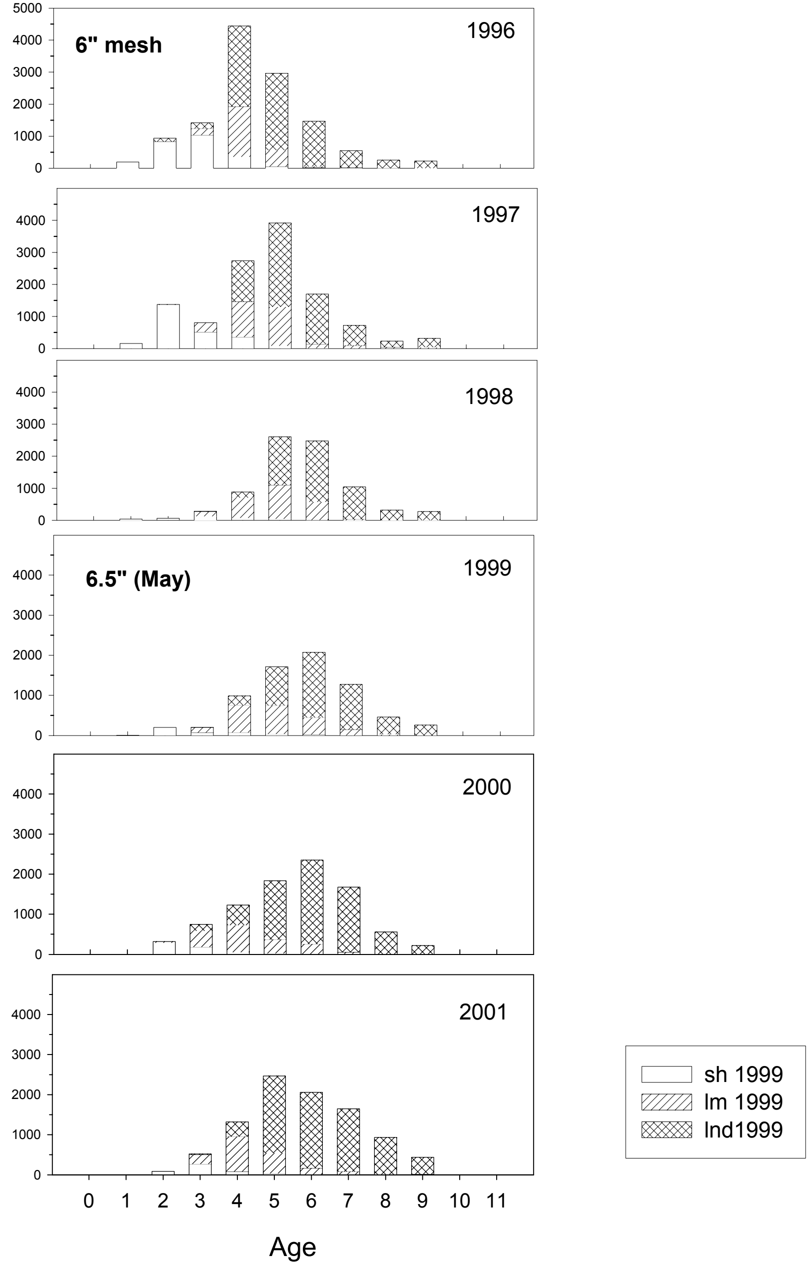

Figure H2 continued.

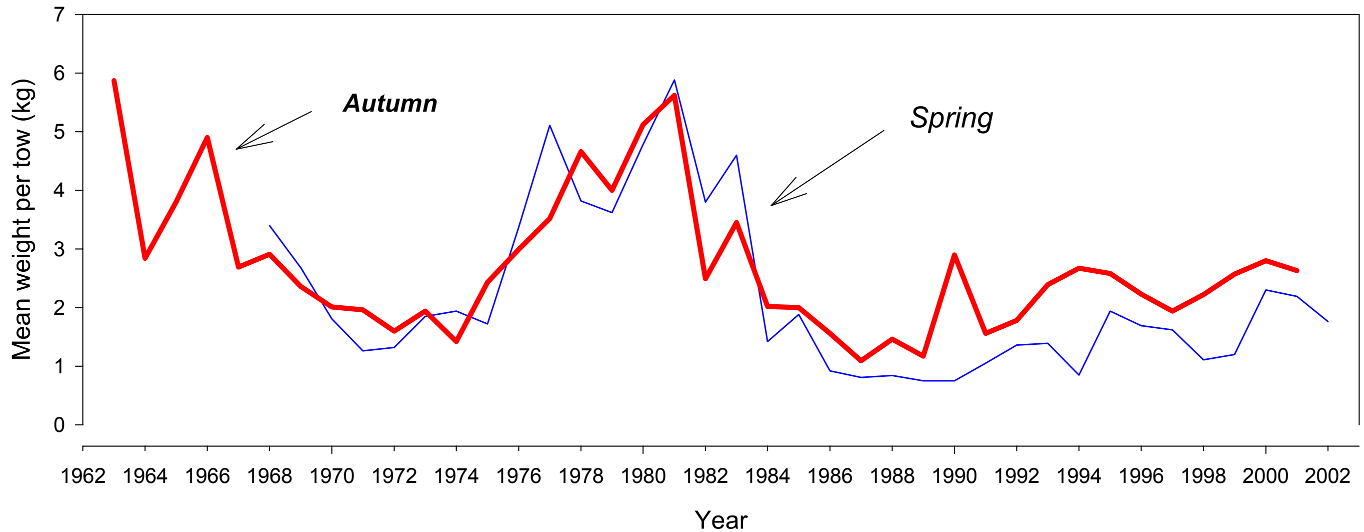

Figure H3. Standardized stratified mean weight per tow (kg) of American plaice in NEFSC spring and autumn research vessel bottom trawl survey in the Gulf of Maine-Georges Bank region, 1963-2002.

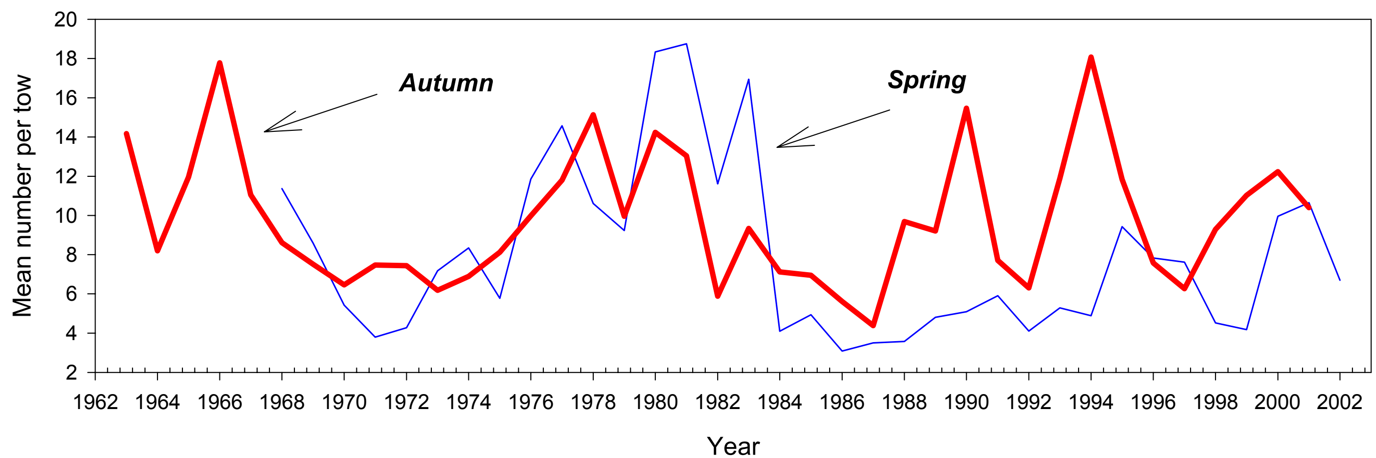

Figure H4. Standardized stratified mean number per tow of American plaice in NEFSC spring and autumn research vessel bottom trawl survey in the Gulf of Maine-Georges Bank region, 1963-2002.

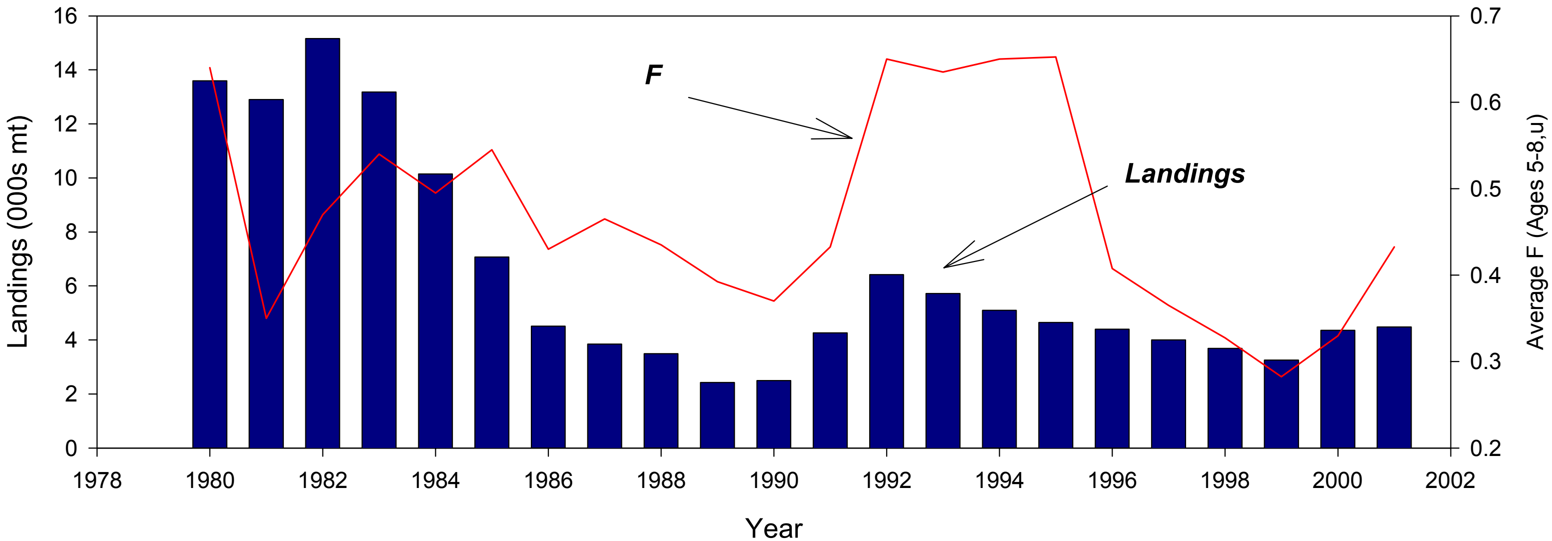

Figure H5. Trends in total commercial landings and fishing mortality for Gulf of Maine-Georges Bank American plaice, 1980-2001

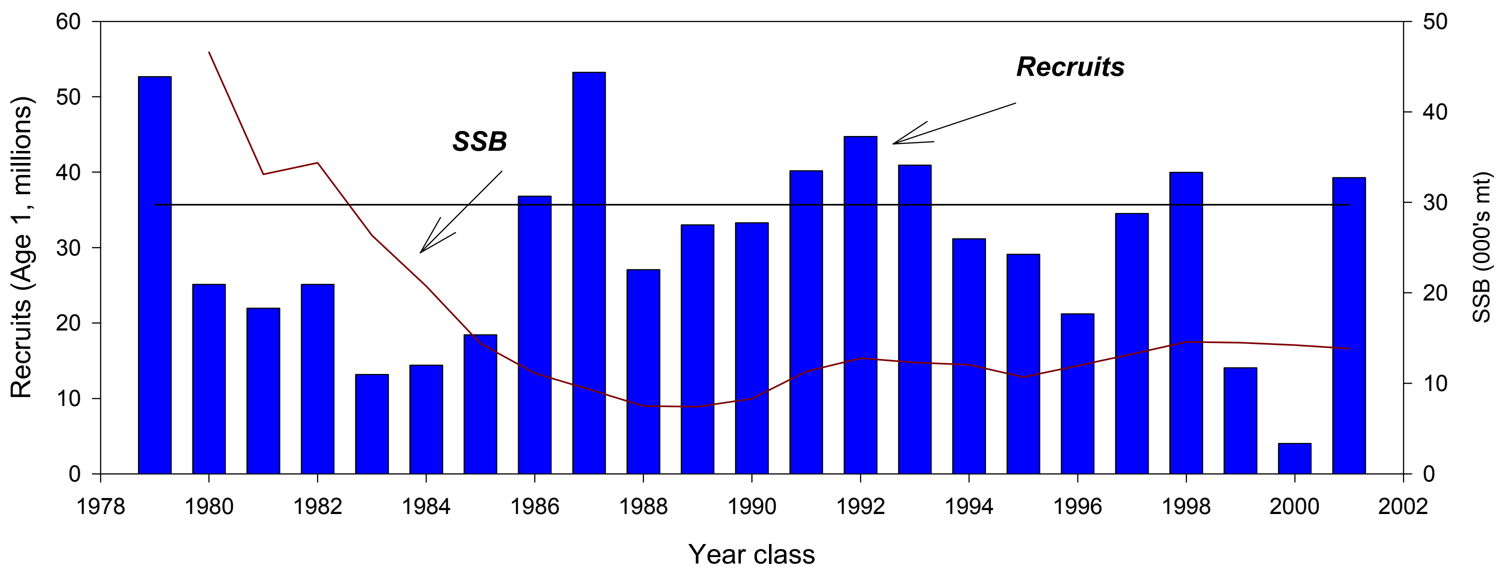

Figure H6. Trends in recruitment and spawning stock biomass for Gulf of Maine-Georges Bank American plaice, 1980-2001.

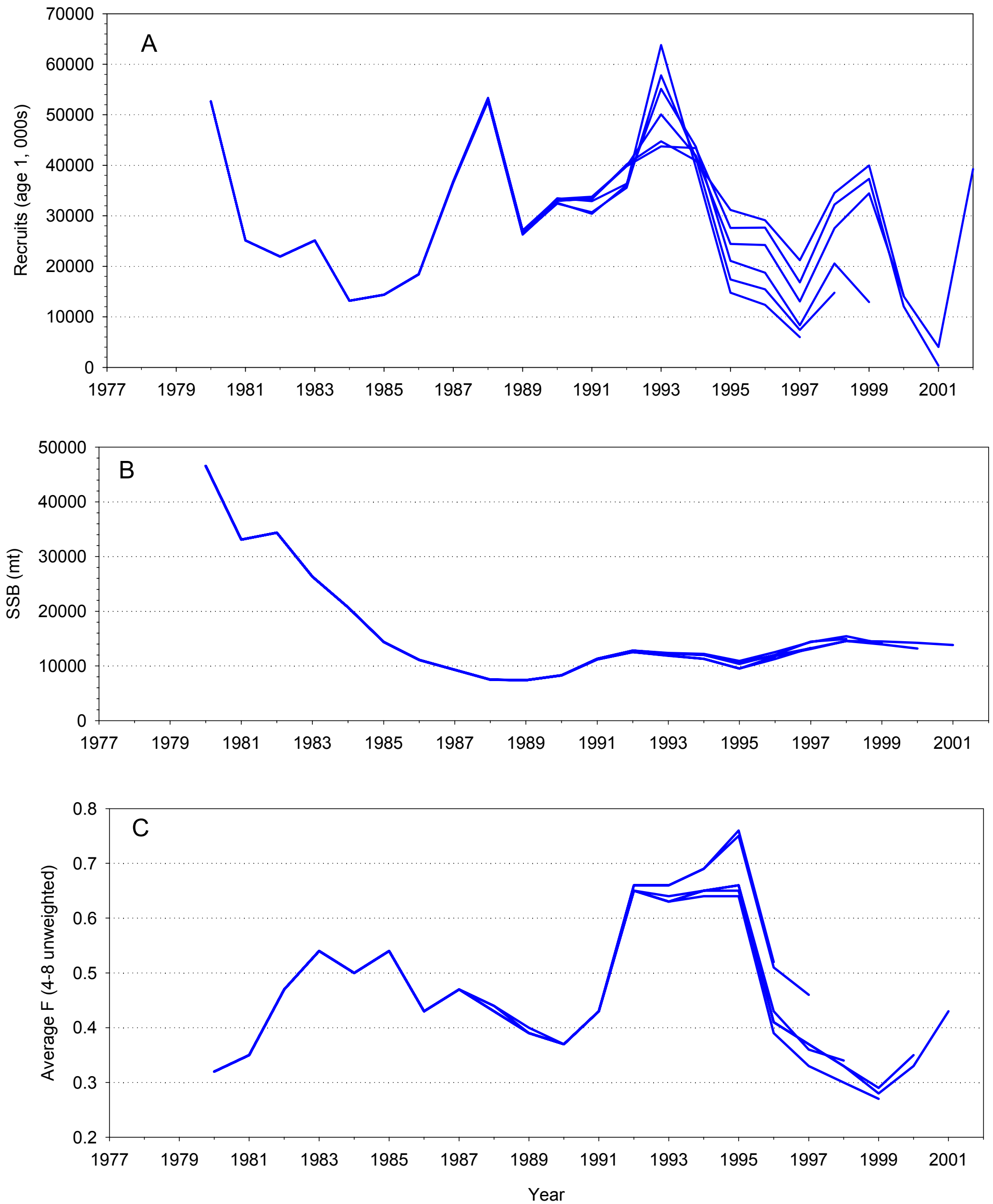

Figure H7. Retrospective analysis of Gulf of Maine-Georges Bank American plaice recruits at age 1(A), spawning stock biomass (B), and fishing mortality (C) (average F, aged 5-8, unweighted), based on the final ADAPT VPA formulation, 2001-1996.

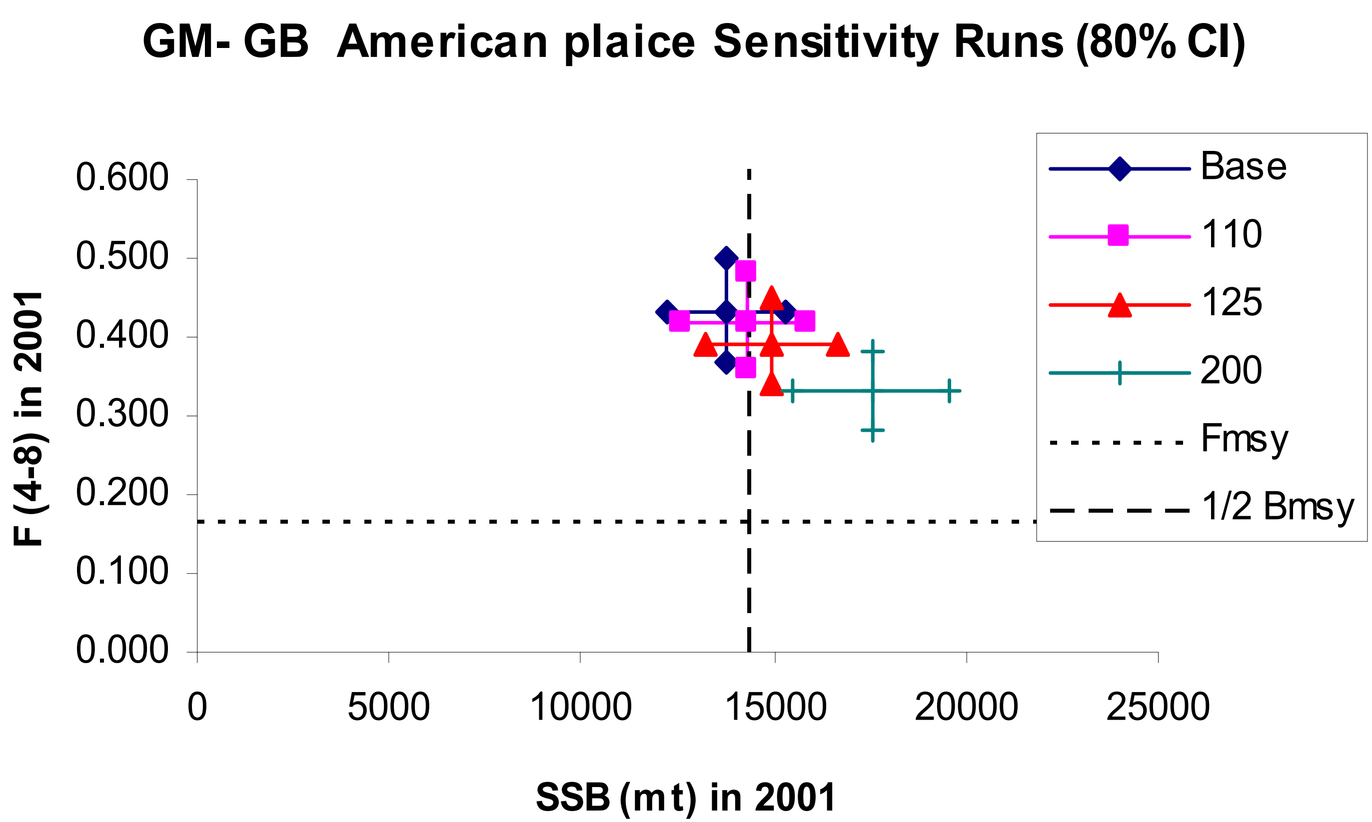

Figure H8. Fishing mortality and spaw ning stock biomass estimates from VPA calibrated using survey indices increased by 0% (base), 10% (110), 25% (125), and 100 %(200).

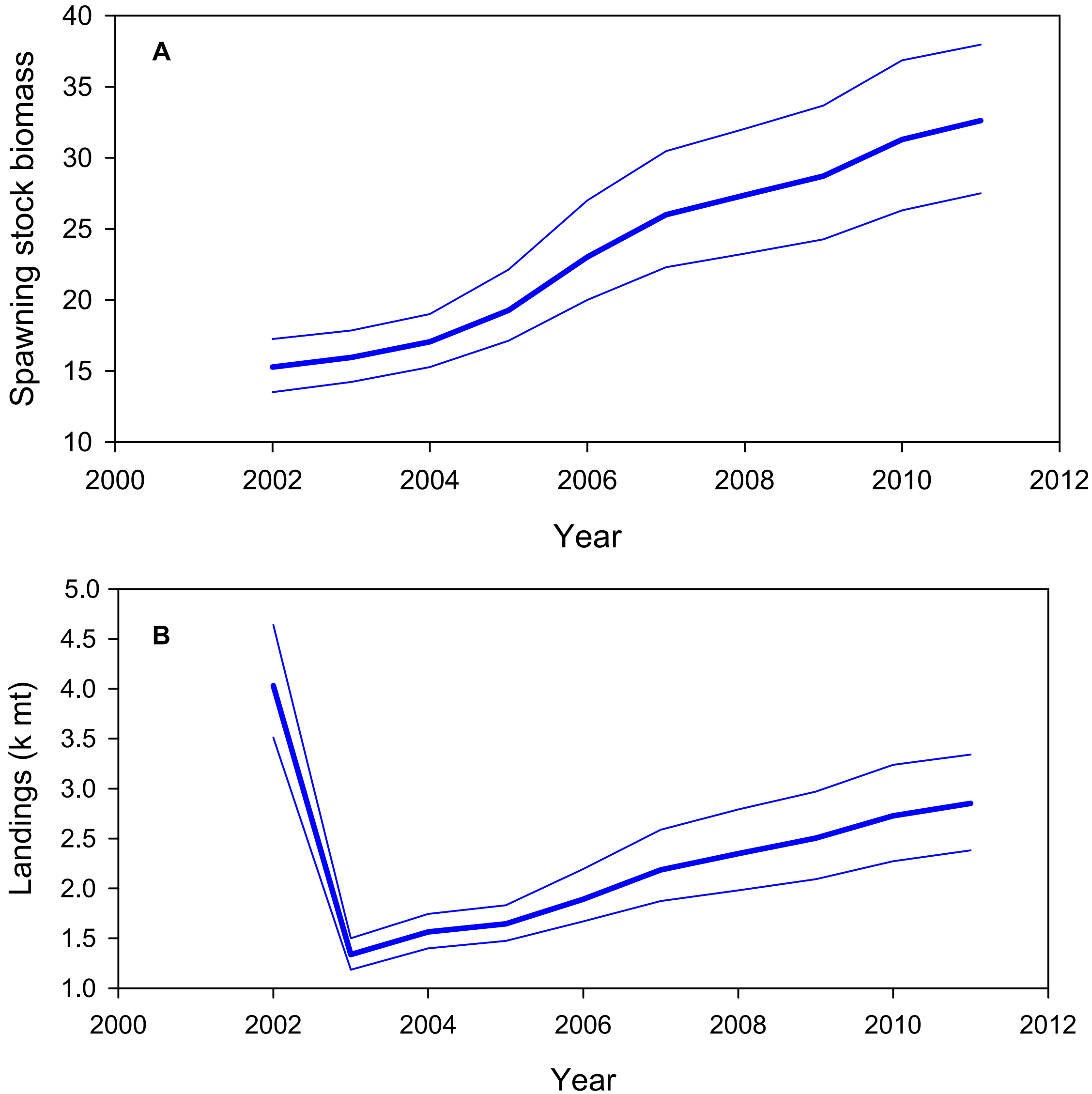

Figure H9. Median and 80% confidence intervals of predicted spawning stock biomass (panel A) and predicted landings (panel B) for American plaice under Frebuild = 0.10.

I. Georges Bank Winter Flounder by Lisa Hendrickson

1.0 Background

The Georges Bank winter flounder stock was last assessed in November, 2001 at SAW/SARC 34 (NEFSC 2002a). The assessment was based on a biomass dynamics model (ASPIC) (Prager 1995) which incorporated catch (1964-2000) and biomass indices from the NEFSC autumn (1963-2000) and spring (1968-2001) bottom trawl surveys. Model results indicated a reasonable fit to the input data and that yield has been below surplus production since 1994. Relative estimates of mean biomass (B_t/B_{MSY}) declined sharply during 1977-1994, then increased to B_{MSY} in 2000. Relative fishing mortality rates (F_t/F_{MSY}) have been at or below F_{MSY} since 1994. During 2000, the stock was not overfished and overfishing was not occurring.

In 2002, the biological reference points adopted at SAW34 were re-examined and use of the absolute estimates of F_{MSY} and B_{MSY}, rather than survey-based equivalents, were recommended (NEFSC 2002b). In addition, medium term stochastic projections (Prager 1995) were generated for 2002-2008 using bootstrap distributions of stock biomass in 2001 generated from the SAW 34 ASPIC model and assuming $F_{2002}=F_{2001}$ and $F_{2003\text{-}2008}=F_{MSY}$. Projected biomass was maintained at B_{MSY} throughout the projected time series with high probability. Projected catch increased to 3,000 mt and was also maintained throughout the projected time series.

2.0 Assessment Results

Stock status was assessed from the results of an updated run of the SAW 34 ASPIC model. Data updates included the addition of NEFSC survey biomass indices from autumn of 2001 and spring of 2002, as well as total landings in 2001.

The sensitivity of catch rate underestimation, due to trawl warp length offsets, during NEFSC surveys conducted between the spring of 2000 and 2002 was also assessed.

2.1 The Fishery

Total commercial landings of Georges Bank winter flounder are predominately from the U.S., but prior to 1977 also included landings from Canadian and distant water fleets. Since 1994, the Canadian proportion of total landings has increased to 5-10%. Total landings peaked at 4,500 mt in 1972 then declined between 1984 and 1995 from 3,900 mt to 800 mt, respectively (Table I1 and Figure I1). Landings have been increasing since 1995 and reached 2,500 mt in 2001.

Discarding of winter flounder occurs in the multi-species otter trawl fishery and the scallop dredge fishery. However, existing data are insufficient to produce reliable estimates of the magnitude or size and age composition of these discards (NEFSC 2002a).

2.2 Research Survey Indices

Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices from the NEFSC spring (April 1968-2002) and autumn (October 1963-2001) bottom trawl surveys, as well the Canadian spring bottom trawl surveys (March 1987-2002) are presented in Table I2. Biomass indices from all three surveys are presented in Figure I2. Canadian survey indices were not included in the current assessment because not all winter flounder habitat on Georges Bank is sampled during that survey (NEFSC 2001). Despite considerable variability, both NEFSC series of biomass indices indicate a declining trend during the 1980s and an increasing trend since the early 1990s. The Canadian biomass indices also indicate an increasing trend since 1992. In 2001, biomass indices from all three surveys were above their time series averages.

2.3 Biological Reference Points

The biological reference points for Georges Bank winter flounder are the absolute estimates of F_{MSY} and B_{MSY} from the SAW 34 ASPIC model (NEFSC 2002b). A maximum sustainable yield of 3,020 mt was estimated to be produced by a biomass (B_{MSY}) of 9,355 mt at a F_{MSY} value of 0.32. Threshold F is defined as F_{MSY} (= 0.32) when biomass is greater than B_{MSY} (= 9,355 mt) then declines linearly to zero at 1/2 B_{MSY} (= 4,677 mt). The target fishing mortality rate is defined as 75% of F_{MSY} (= 0.24) when biomass is greater than 9,355 mt then declines linearly to zero at a threshold biomass of 4,677 mt.

2.4 ASPIC Model Results and Stock Status

Fishing mortality rates declined sharply during 1993 and 1999, from 0.71 to 0.14, (Table I3 and Figure I3) and were at or below F_{MSY} (= 0.32) during 1995-2001. Average total biomass has been increasing since 1994 and was slightly above B_{MSY} during 2001 (Figure I4). There was no retrospective pattern in the ASPIC-derived estimates of fishing mortality rates or total biomass (Figure I5). The 2001 fishing mortality rate estimate is 0.25 and the 2001 total biomass estimate is 9,805 mt. Therefore, in 2001 the stock was not overfished and overfishing was not occurring.

2.5 Sensitivity Analyses

Autumn and spring survey biomass indices from 2000-2002 were increased by 10%, 25% and 100% and included in a sensitivity analysis using the updated ASPIC model configuration (Table I4). Relative total biomass and fishing mortality rate point estimates for 2001 and their respective 80% confidence intervals, generated from 1,000 bootstrap iterations, are shown for the nominal run and the three sets of increased survey indices (Figure I6). The ASPIC model produces new reference point estimates with each run, so a solid line is used in Figure I6 to indicate a ratio of the current F_{MSY} and B_{MSY} reference points in relation to those re-estimated for comparison of the sensitivity analysis results (dashed line). Relative fishing mortality rates decreased and relative total biomass increased with increases in the survey biomass indices. However, overlapping confidence intervals indicate there was no significant difference between the nominal run and the three runs that incorporated increased survey biomass indices.

3.0 Projections

Short-term (2002-2005) and long-term (2002-2010) stochastic projections (Figure I7) were performed under a scenario where F_{2002}=15% reduction in F_{2001} and fishing mortality rates for the following years were set at F_{MSY} (= 0.32). Biomass levels above B_{MSY} were projected for 2003-2005 and yields of about 3,000 mt (MSY) were projected for the same time period (Table I5).

4.0 Sources of Uncertainty

1. Exclusion of the discards from the U.S. otter trawl and scallop dredge fisheries results in an underestimation of fishery removals of the younger age classes (ages 0 to 3).

2. Current biomass levels estimated from the ASPIC model may not be reliable because recruitment is implicitly assumed to be a function of stock biomass.

3. U.S. landings are based on prorations of preliminary logbook data which are subject to change.

4. There is some uncertainty about the accuracy of reported Canadian landings because of the non-targeted nature of the Canadian fishery and the tendency to report landings of some flatfish species, including winter flounder, as unclassified flounders.

5.0 Literature Cited

Northeast Fisheries Science Center. 2002a. Report of the 34th Northeast Regional Stock Assessment Workshop (34th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. *Northeast Fish. Sci. Cent. Ref. Doc.* 02-06; 346 p.

Northeast Fisheries Science Center. 2002b. Final report of the working group on re-evaluation of biological reference points for New England groundfish. 231 p.

Prager, M.H. 1995. User's manual for ASPIC: a stock production model incorporating covariates. SEFSC Lab. Doc. MIA

Table I1. Landings (mt) of Georges Bank winter flounder, by statistical area and country, during 1964-2001.

	522-525 561-562	5Ze[2] (521-526 and 541-562)		5Z (521-562)		
YEAR	USA[1]	CANADA	USSR	CANADA	USSR	TOTAL
1964	1,371			146		1,517
1965	1,176			199	312	1,687
1966	1,877			164	156	2,197
1967	1,917			83	349	2,349
1968	1,570	57	372			1,999
1969	2,167	116	235			2,518
1970	2,615	61	40			2,716
1971	3,092	62	1,029			4,183
1972	2,805	8	1,699			4,512
1973	2,269	14	693			2,976
1974	2,124	12	82			2,218
1975	2,409	13	515			2,937
1976	1,877	15	1			1,893
1977	3,572	15	7			3,594
1978	3,185	65				3,250
1979	3,045	19				3,064
1980	3,931	44				3,975
1981	3,993	19				4,012
1982	2,961	19				2,980
1983	3,894	14				3,908
1984	3,927	4				3,931
1985	2,151	12				2,163
1986	1,762	25				1,787
1987	2,637	32				2,669
1988	2,804	55				2,859
1989	1,880	11				1,891
1990	1,898	55				1,953
1991	1,814	14				1,828
1992	1,822	27				1,849
1993	1,662	21				1,683
1994	907	65				972
1995	706	54				760
1996	1,265	71				1,336
1997	1,287	143				1,430
1998	1,243	93				1,336
1999	938	104				1,042
2000	1,677	161				1,838
2001	1,945	529				2,474

[1] USA landings prior to 1985 include those from Statistical Areas 551 and 552 and landings during 1994-2001 were prorated from Vessel Trip Reports based on gear, month and state.

[2] Includes landings from statistical areas 521 and 526; outside of the Georges Bank winter flounder stock area.

Table I2. Standardized, stratified abundance (numbers) and biomass (weight) indices for Georges Bank winter flounder from the U.S. NEFSC spring and autumn, and Canadian spring research vessel bottom trawl surveys. U.S. offshore survey strata 13-22; Canadian survey strata (5Z1-5Z4). Trawl door standardization coefficients of 1.46 (numbers) and 1.39 (weight) were applied to indices from U.S. survey indices conducted prior to 1985 to account for differences in catchability between survey doors.

	U.S. Spring Survey		**U.S. Autumn Survey**		**Canada Spring Survey**	
	Number/tow	kg/tow	Number/tow	kg/tow	Number/tow	kg/tow
1963			1.20	1.82		
1964			1.30	1.82		
1965			2.15	2.05		
1966			5.16	5.66		
1967	*Spring Survey initiated in 1968*		1.79	2.07		
1968	2.70	3.11	1.31	1.07		
1969	3.14	4.29	2.37	2.39		
1970	1.86	2.29	5.62	6.49		
1971	1.84	2.17	1.32	1.26		
1972	4.95	5.32	1.26	1.58		
1973	2.95	3.51	1.22	1.20		
1974	6.05	5.78	1.19	1.46		
1975	1.96	1.41	3.79	2.06		
1976	4.67	3.01	5.99	3.93		
1977	3.79	1.58	4.86	3.99		
1978	7.07	5.06	4.06	3.10		
1979	1.74	2.21	5.07	3.83		
1980	3.22	2.80	1.66	1.87		
1981	3.73	3.75	3.83	2.43		
1982	2.30	1.52	5.30	2.69		
1983	8.41	7.11	2.73	2.36		
1984	5.53	5.60	3.93	2.45		
1985	3.84	2.65	1.98	1.12		
1986	2.00	1.21	3.58	2.18	*Iinitiated in 1987*	
1987	2.80	1.25	0.76	0.89	1.24	1.74
1988	2.93	1.65	4.08	1.27	4.31	2.75
1989	1.30	0.76	1.56	1.05	4.05	1.95
1990	2.80	1.57	0.50	0.35	4.93	2.64
1991	2.40	1.32	0.27	0.14	1.98	1.38
1992	1.42	0.90	0.68	0.38	0.51	0.59
1993	1.02	0.57	1.17	0.66	3.53	1.76
1994	1.29	0.58	0.87	0.58	5.10	2.01
1995	2.61	1.49	2.36	1.34	5.63	1.96
1996	2.31	1.50	1.54	1.76	4.12	2.30
1997	1.61	1.19	1.74	1.53	4.58	3.09
1998	0.76	0.72	1.78	1.57	1.14	1.21
1999	3.83	3.48	1.54	1.76	1.25	1.89
2000	4.42	3.69	2.16	2.66	1.48	2.22
2001	1.29	1.22	2.45	2.51	2.28	2.54
2002	5.05	5.16			3.17	3.85

Table I3. Fishing mortality rates and average total biomass (mt) estimates for Georges Bank winter flounder during 1964-2001.

Year	Fishing Mortality	Total Biomass (mt)
1964	0.26	5,752
1965	0.25	6,883
1966	0.28	7,850
1967	0.27	8,569
1968	0.21	9,420
1969	0.25	10,160
1970	0.26	10,510
1971	0.42	9,978
1972	0.52	8,622
1973	0.38	7,933
1974	0.27	8,340
1975	0.34	8,765
1976	0.20	9,393
1977	0.37	9,630
1978	0.35	9,243
1979	0.34	9,120
1980	0.46	8,589
1981	0.53	7,567
1982	0.43	7,007
1983	0.62	6,327
1984	0.80	4,945
1985	0.51	4,232
1986	0.40	4,454
1987	0.60	4,446
1988	0.76	3,771
1989	0.57	3,313
1990	0.62	3,154
1991	0.62	2,949
1992	0.69	2,688
1993	0.71	2,365
1994	0.40	2,420
1995	0.25	3,089
1996	0.34	3,927
1997	0.30	4,730
1998	0.23	5,823
1999	0.14	7,407
2000	0.21	8,950
2001	0.25	9,805

Table I4. Summary of results from a sensitivity analysis of increases in survey biomass indices using an ASPIC biomass dynamics model for the assessment of Georges Bank winter flounder.

Input Data	U.S. autumn survey, 1964-2001 U.S. spring survey, 1968-2002 Total landings, 1964-2001 (Nominal run)	Nominal run with 10% increase in 2000-2002 survey indices	Nominal run with 25% increase in 2000-2002 survey indices	Nominal run with 100% increase in 2000-2002 survey indices
Total Objective Function	1.959	1.954	1.956	2.055
B coverage	0.923	0.938	0.945	1.130
B nearness	1.000	1.000	1.000	1.000
R^2 in CPUE				
U.S. Autumn Survey	0.34	0.35	0.36	0.41
U.S. Spring Survey	0.23	0.24	0.25	0.29
B1 Ratio	0.57	0.56	0.54	0.47
r	0.66	0.69	0.72	0.86
F_{msy}	0.33	0.35	0.36	0.43
B_{msy} (mt)	9,119	8,742	8,429	7,193
MSY (mt)	3,028	3,036	3,047	3,097
B_{2002}/B_{MSY}	1.10	1.16	1.22	1.38
F_{2001}/F_{MSY}	0.76	0.72	0.68	0.58

Table I5. Short-term stochastic projections of yield (mt) and total biomass (mt), during 2002-2005, for Georges Bank winter flounder assuming F2002=15% reduction in F2001 and F2003-2005 = FMSY.

Year	Yield (mt)	Total Biomass (mt)
2002	2,250	10,250
2003	3,433	11,020
2004	3,323	10,590
2005	3,253	10,310

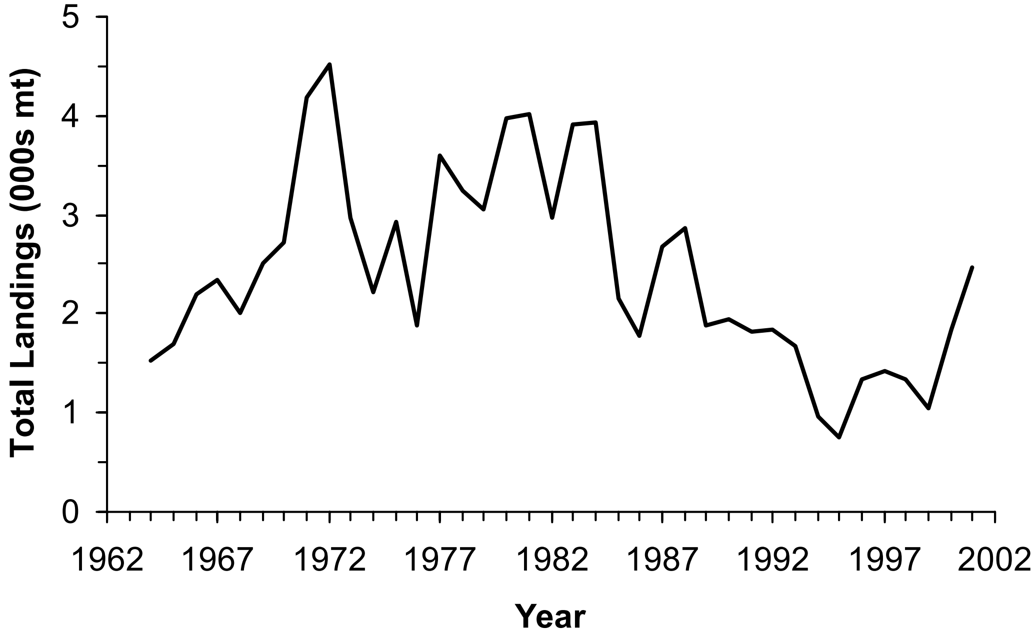

Figure I1. Total commercial landings of Georges Bank winter flounder during 1964-2001.

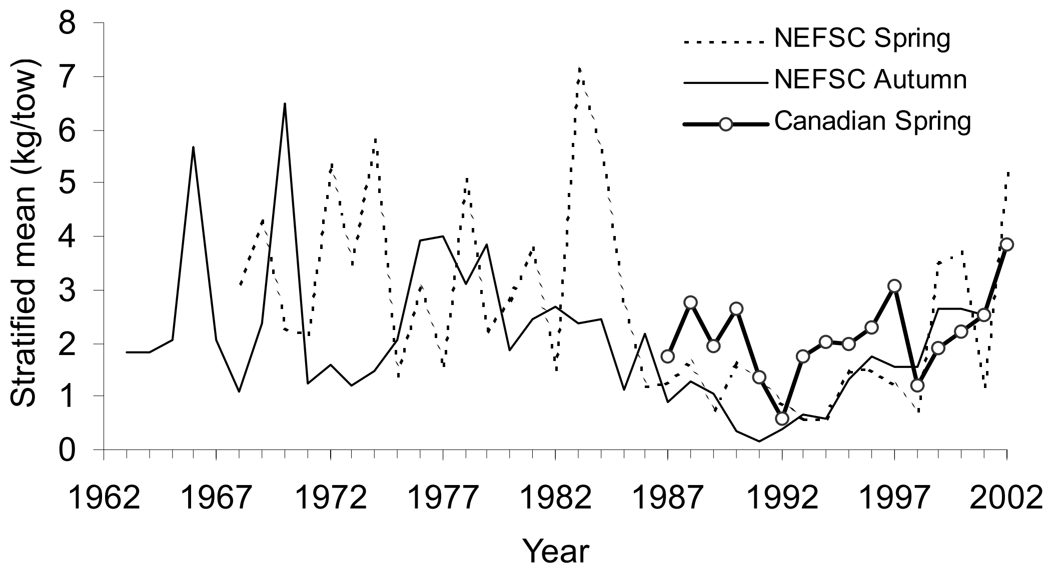

Figure I2. Relative biomass indices (stratified mean kg per tow) of Georges Bank winter flounder from NEFSC spring (1968-2002) and autumn (1963-2001) bottom trawl surveys and the Canadian spring (1987-2002) bottom trawl survey.

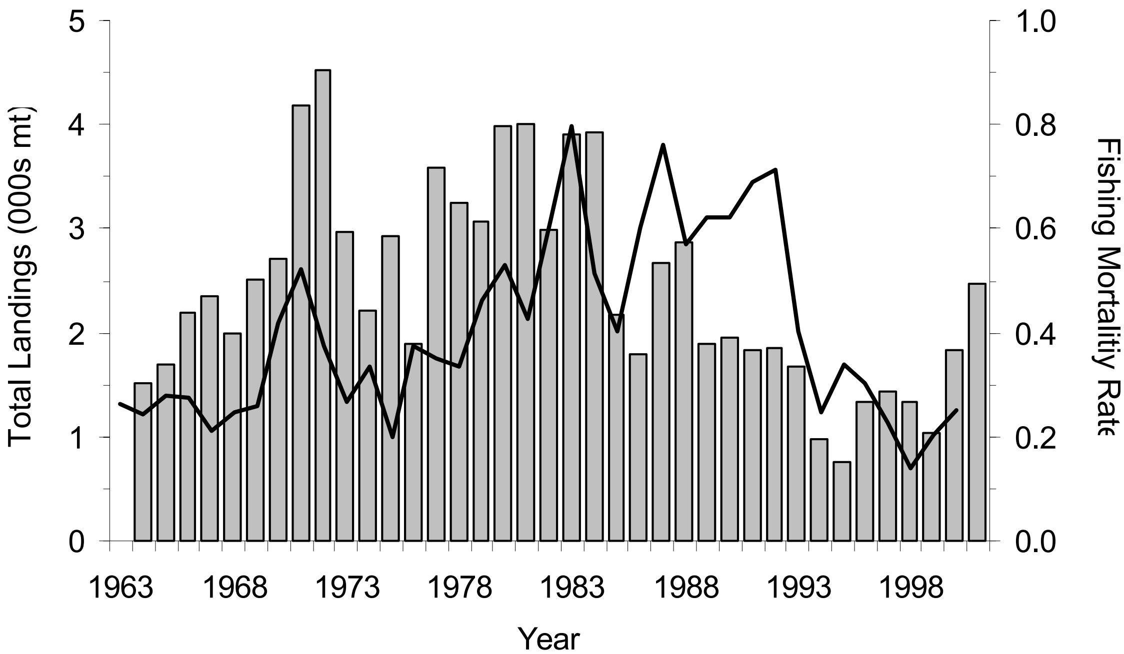

Figure I3. Trends in total landings and fishing mortality rates for Georges Bank winter flounder during 1964-2001.

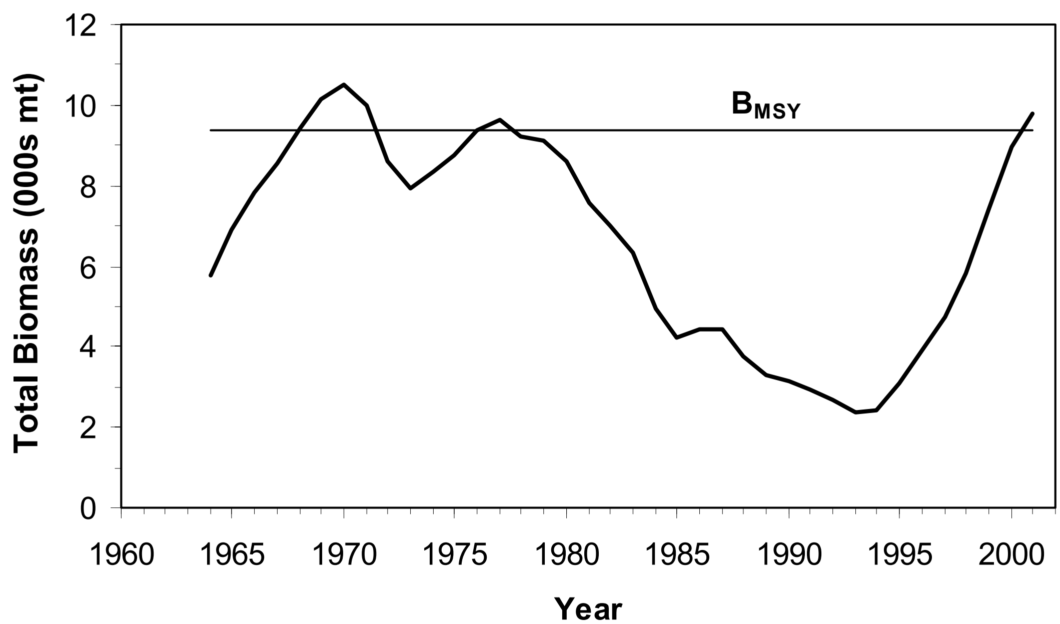

Figure I4. Trends in Georges Bank winter flounder total biomass, estimated from an ASPIC biomass dynamics model, during 1964-2001 in relation to B_{MSY} (9,355 mt).

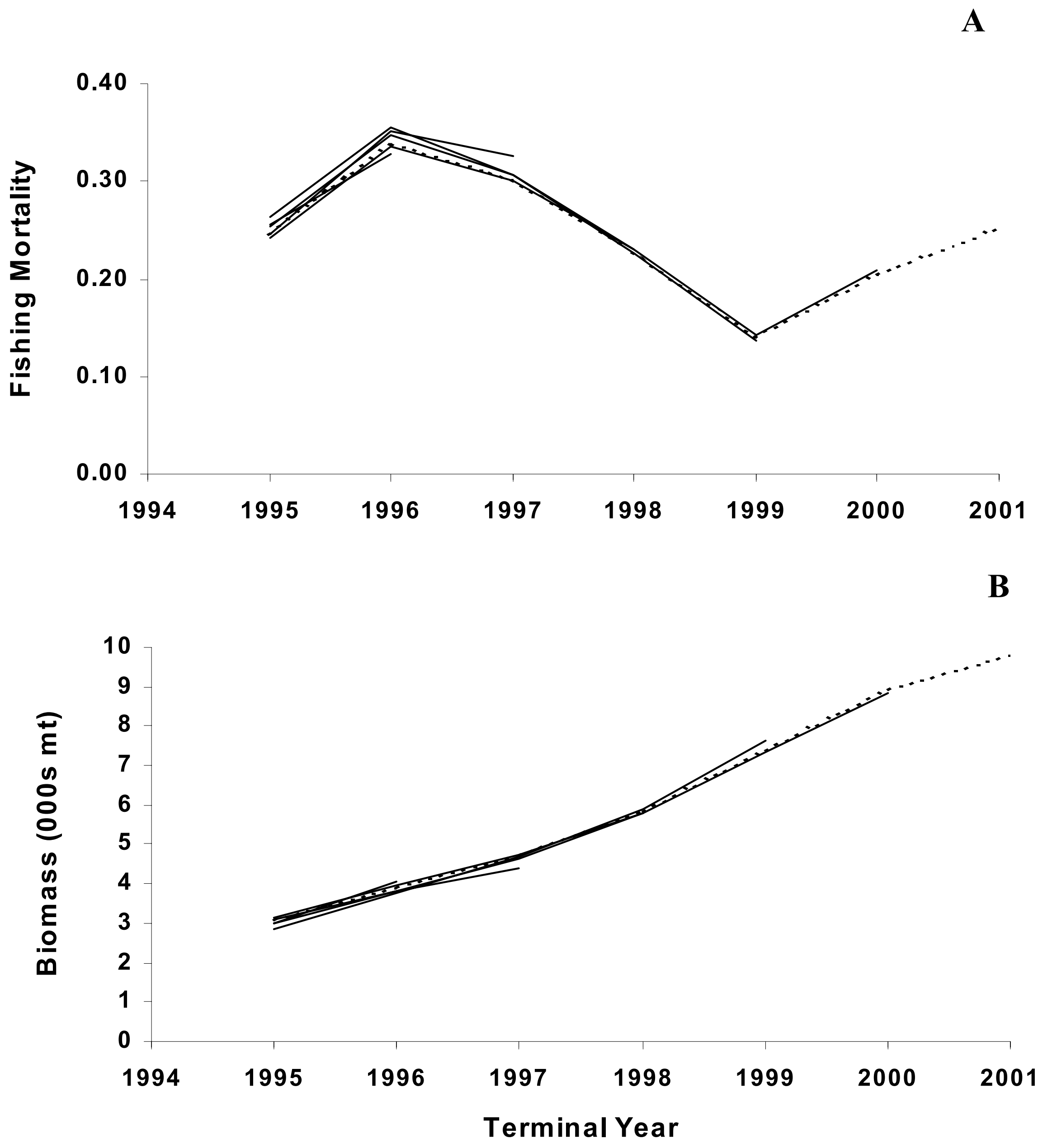

Figure I5. Retrospective analysis of ASPIC-derived estimates of (A) fishing mortality rates and (B) total biomass for Georges Bank winter flounder during 1995-2001.

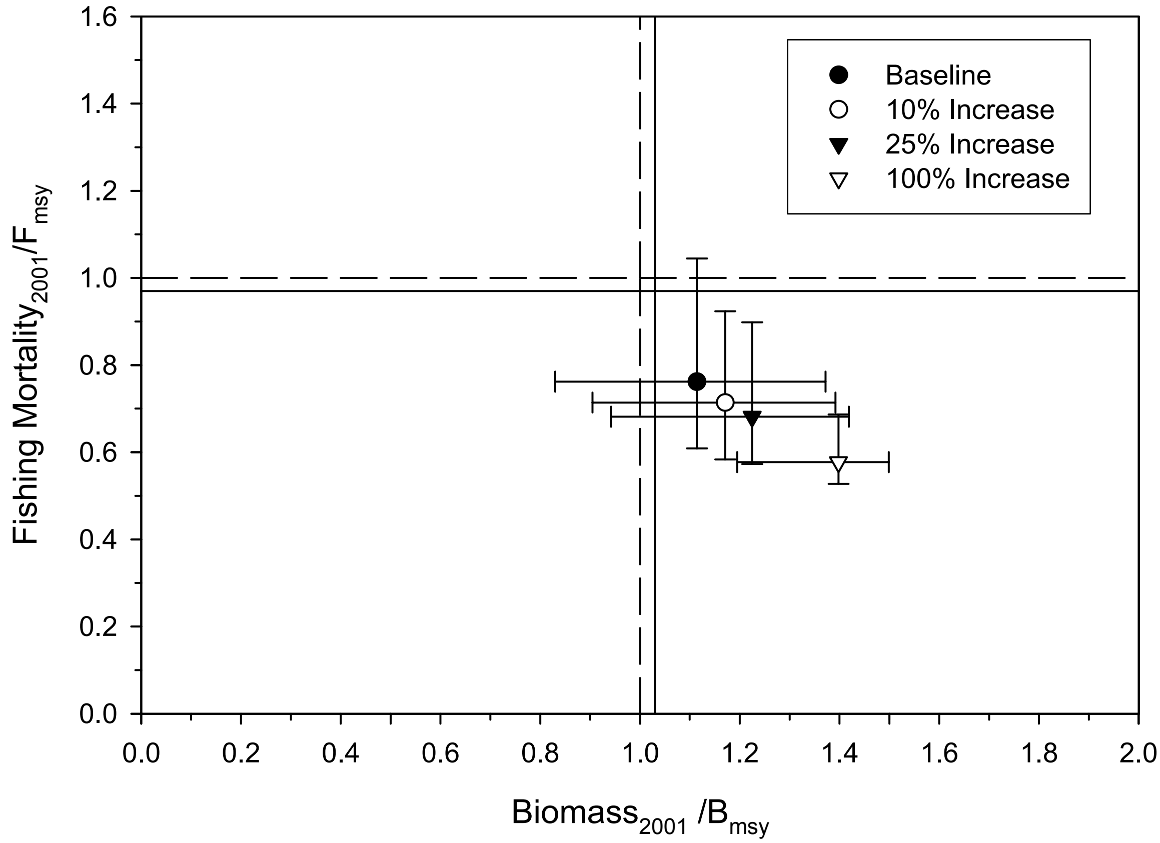

Figure I6. Point estimates and 80% confidence intervals of relative total biomass and fishing mortality rates during 2001 generated from a bootstrapped nominal run of an ASPIC biomass dynamics model and three sensitivity runs, including increased NEFSC survey biomass indices during spring 2000-2002, for the Georges Bank winter flounder stock. Solid lines represent ratios of the current B_{MSY} and F_{MSY} reference points in relation to those re-estimated from the sensitivity analysis (dashed line).

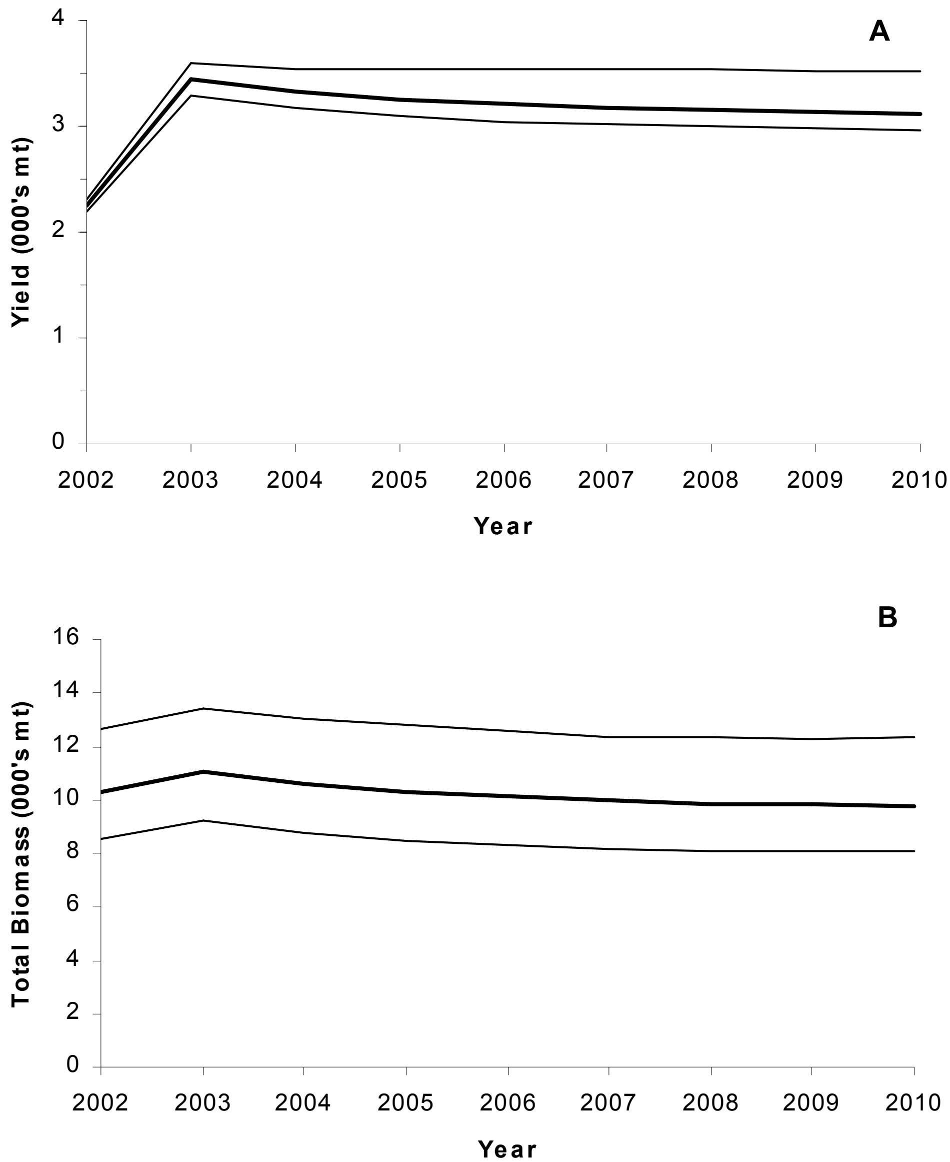

Figure I7. Median and 80% confidence intervals of projected (A) yield (mt) and (B) total biomass (mt) of Georges Bank winter flounder under F_{MSY} fishing mortality rates (F=0.32) during 2003-2010 and assuming F_{2002}=15% reduction in F_{2001}.

J. Southern New England/Mid-Atlantic (SNE/MA) winter flounder by Mark Terceiro

1.0 Background

The current assessment of the SNE/MA stock complex of winter flounder is an update of the previous assessments completed in 1998 at SARC 28 (NEFSC 1999). The SARC 28 assessment included catch through 1997, research survey abundance indices through 1998, catch-at-age analyzed by virtual population analysis (VPA) for 1981-1997, and biological reference points based on a production model conditioned on VPA results. The SARC 28 assessment concluded that the stock complex was fully exploited and at a medium level of biomass. Total biomass in 1997 was estimated to be 17,900 mt, spawning stock biomass was estimated to be 8,600 mt, and the fully recruited fishing mortality rate was estimated to be F = 0.31 Subsequent to the SARC 28 assessment, the status of SNE/MA winter flounder has been evaluated annually by projection methods to provide advice to the New England Fishery Management Council (NEFMC). The last such status update was provided in 2001, and projected total biomass to be 25,300 mt, spawning stock biomass to be 13,800 mt, and fully recruited F = 0.29, in 1999 (NEFSC 2001). The current assessment, conducted by the ASMFC Winter Flounder Technical Committee in September 2002, updates landings and discard estimates, research survey abundance indices, and assessment models through 2001-2002, as applicable.

2.0 2002 Assessment

The Fishery

After reaching an historical peak of 11,977 metric tons (mt) in 1966, then declining through the 1970s, total U.S. commercial landings of winter flounder again peaked at 11,176 mt in 1981, and then steadily declined to a record low of 2,159 mt in 1994. Landings have increased since 1994 to 4,448 mt in 2001 (Table J1, Figure J1). The primary gear in the fishery is the otter trawl which accounts for an average of 95% of landings since 1989. Scallop dredges account for 4%, with such gears as handlines, pound nets, fyke nets, and gill nets each accounting for about 1% of total landings.

Recreational landings reached a peak in 1984 of 5,772 mt but declined substantially thereafter (Table J2, Figure J1). Recreational landings have been less than 1,000 mt since 1991, with the lowest estimated landings in 1998 of 290 mt. Recreational landings in 2001 from the Southern New England/Mid Atlantic stock complex were 552 mt. The principal mode of fishing is private/rental boats, with most recreational landings occurring during January to June.

Input data and analyses

Length samples of winter flounder are available from both the commercial and recreational landings. In the commercial fishery, annual sampling intensity varied from 59 to 264 mt landed per 100 lengths measured during 1981-2001 (Table J3). Since 1997, port sampling has been adequate to develop the commercial fishery landings at age on a half-year, market category basis across all statistical areas.

In the recreational fishery, annual sampling intensity varied from 36 to 231 mt landed per 100 lengths measured during 1981-1997. Ages were determined using NEFSC survey spring and fall age-length keys.

Since 1995, the ASMFC Winter Flounder Technical Committee has considered NEFSC Fishery Observer data (OB), and NER vessel trip report (VTR) data as sources of information to use in the estimation of commercial fishery discards. The Committee concluded that the VTR mean discard to landed ratio aggregated over all trips in annual half-year season strata provided the most reliable data from which to estimate commercial fishery discards. VTR trawl gear fishery discards to landings ratios on a half-year basis were applied to corresponding commercial fishery landings to estimate discards in weight (Table J4, Figure J1). The Fishery Observer length frequency samples were judged adequate to directly characterize the proportion discarded at length. A discard mortality rate of 50% (Howell et al., 1992) was applied to trawl discards to produce the number of fish discarded dead at length. For 1998, discard estimates at length were made by half-year; for 1999-2001, sample lengths were applied on an annual basis due to low sample sizes. Ages were determined using NEFSC survey spring and fall age-length keys.

A discard mortality of 15% was assumed for recreational discards (B2 category from MRFSS data), as assumed in Howell et al. (1992). Discard losses peaked in 1984-1985 at 0.7 million fish. Discards have since declined, reaching a low in 1999 of 62,000 fish. In 2001, 81,000 fish were estimated to have been discarded (Table J4, Figure J1). Since 1997, irregular sampling of the recreational fisheries by state fisheries agencies has indicated that the discard is usually of fish below the minimum landing size of 12 inches (30 cm). For 1998-2001, the recreational discard has been assumed to have the same length frequency as the landed portion of the catch below 12 inches, and so is predominantly ages 1, 2, and 3 fish. The recreational discard for 1998-2001 is aged using NEFSC survey spring and fall age-length keys.

The virtual population analysis (VPA) was calibrated using the NEFSC Woods Hole Fisheries Assessment Compilation Toolbox (FACT) version 1.50 of the ADAPT VPA (Conser and Powers 1990). Abundance indices at age were available from several research surveys: NEFSC spring bottom trawl ages 1-7+, NEFSC fall ages 1-5 (advanced to tune January 1 abundance of ages 2-6), NEFSC winter ages 1-5, Massachusetts spring ages 1-7+, Rhode Island fall age 0 (advanced to tune age-1), Rhode Island spring ages 1-7+, Connecticut spring ages 1-7+, New York age 0 (advanced to tune age-1) and age-1, Massachusetts summer seine index of age-0 (advanced to tune age-1), Delaware juvenile trawl survey age-0 (advanced to tune age-1), New Jersey Ocean trawl survey ages 1-7+, and New Jersey River trawl survey ages 1-7+. Survey indices were selected for inclusion in VPA tuning based on consideration of the partial variance in a VPA trial run including all indices, residual error patterns from the trial runs, and on the significance of the correlation among indices and with VPA abundance estimates from the trial run including all indices. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality and spawning stock biomass. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

3.0 Assessment results

Research surveys

Mean weight per tow and number per tow indices for the NEFSC spring, fall, and winter time series are presented in Table J5. Indices dropped from the beginning of the time series in the 1960s to a low point in the early to mid- 1970s, then rose to a peak by the early 1980s. Following several years of high indices, abundance once again declined to below the low levels of the 1970s. NEFSC survey indices reached near- or record low levels for the time series in the late 1980s- 1990s. Indices from the three survey series generally increased during 1993-1998/1999, but have since declined (Figure J2).

Several state survey indices were available to characterize abundance of winter flounder. The Massachusetts Division of Marine Fisheries (MADMF) spring and fall survey (1978-2001), Rhode Island Division of Fish and Wildlife (RIDFW) spring and fall survey (1979-2001), Connecticut Department of Environmental Protection (CTDEP), Long Island Sound Trawl Survey (1984-2001), and the New Jersey Division of Fish, Game and Wildlife (NJDFW) ocean survey trends are summarized in Table J6 and Figure J2. The numerous state recruitment surveys (MADMF, RIDFW, CTDEP, New York Department of Environmental Conservation (NYDEP), NJDFW, Delaware Division of Fish and Game (DEDFG)) are summarized in Table J7 and Figure J3.

Virtual Population Analysis

During 1981-1993, fishing mortality (fully recruited F, ages 4-5) varied between 0.4 (1982) and 1.4 (1988), and was as high as 1.2 as recently as 1997. Fishing mortality has been in the range of 0.5-0.6 during 1999-2001 ($F_{2001} = 0.51$; Table J8, Figure J4). SSB declined from 14,800 mt in 1983 to a record low of 2,700 mt in 1994. SSB has increased since 1994 to 7,600 mt in 2001 (Table J8, Figure J5). Recruitment declined continuously from 62.9 million age-1 fish in 1981 to 7.8 million in 1992. Recruitment then averaged 14.7 million fish during 1993-2001, below the VPA time series average of 23.9 million. The 2002 year class is estimated to be the smallest on record, at only 5.7 million fish (Table J8, Figure J5).

VPA diagnostics

The Technical Committee considered six different configurations of tuning indices. In general, tuning indices were excluded if they exhibited high partial variance (indicating a lack of fit within the VPA model) and low correlation with other indices with similar spatial and temporal characteristics and with the VPA estimates of 2002 stock size. Run W36ALL was the initial trial including all indices. Run W36_1 excluded eight indices with high partial variance within the VPA and low correlation with other indices and/or the VPA estimates of stock size, resulting in improvements both in overall fit (mean square residual (MSR) reduced by 14%) and in the precision of the stock size estimates. Run W36_2 dropped an additional seven indices from the W36_1 configuration, resulting in further improvements in fit (21% improvement over run W36_1) and precision. This was the run adopted as final by the Technical Committee, and is the basis for all further analyses.

The precision of the 2002 stock size, fishing mortality at age in 2001, and SSB estimates from VPA was evaluated using bootstrap techniques (Efron 1982). Five hundred bootstrap iterations were realized in which errors (differences between predicted and observed survey values) were resampled. Bootstrap estimates of stock size at age indicate low bias (<6%) for ages 2-7+ and bootstrap standard errors provide stock size CVs ranging from 18% at age 3 to 34% at age 1. Bootstrapped estimates of spawning stock biomass indicate a CV of 9%, with low bias (bootstrap mean estimate of spawning stock biomass of 7,705 mt compared with VPA estimate of 7,643 mt). There is an 80% probability that spawning stock in 2001 was between 6,800 mt and 8,400 mt. The bootstrap estimates of standard error associated with fishing mortality rates at age indicate good precision. Coefficients of variation for F estimates ranged from 16% at age 3 to 21% at ages 1, 6 and 7+. There is an 80% probability that fully recruited F for ages 4-5 in 2001 was between 0.44 and 0.58.

A retrospective analysis of the VPA was conducted back to a terminal catch year of 1997 (Figure J6). The SNE/MA winter flounder VPA exhibits a severe retrospective pattern of underestimation of F and overestimation of SSB during the late 1990s. The most likely cause of this pattern is the underestimation of the total catch. The analysis indicated a tendency for the significant underestimation of fully recruited F for the terminal years 1993-1999. In that period, underestimation of F ranged from 232% for 1997 to 14% for 1993. The pattern reversed for 2000 (i.e., F was overestimated), indicating that survey variability may also contribute to the retrospective pattern of the SNE/MA winter flounder VPA. Fishing mortality appears to have been overestimated for 2000 by 7%. The retrospective pattern for spawning stock biomass has been a tendency for overestimation since 1991. The overestimation of SSB was most severe for the 1997 and 1998 terminal years (115% and 198% overestimation). The retrospective estimation of age-1 recruits indicated a tendency for overestimation during 1993-2000, with recruitment apparently underestimated for 2001 (2000 year class).

Sensitivity of VPA estimates to hypothetical NEFSC survey adjustments

Sensitivity analyses of the VPA results to hypothetical changes in the recent NEFSC spring and fall survey values were conducted (Figure J7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

4.0 Biological reference points

The Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (RPWG; NEFSC 2002) re-estimated the biological reference points for SNE/MA winter flounder in 2002 using yield and SSB per recruit (Thompson and Bell 1936) and Beverton-Holt stock-recruitment models (Beverton and Holt 1957, Brodziak et al. 2001, Mace and Doonan 1988) based on the SARC 28 assessment (NEFSC 1999). The yield and SSB per recruit analyses indicate that $F_{40\%} = 0.21$ and $F_{0.1} = 0.25$. The stock-recruitment model indicated that MSY = 10,600 mt, $F_{msy} = 0.32$, and $B_{msy} = 30{,}100$ mt.

Biological reference points estimated by the RPWG (NEFSC 2002) were updated by the Technical Committee with partial recruitment pattern and mean weights at age for 1998-2000 (the 2001 estimates were not included in the averages due to the retrospective variability of the partial recruitment pattern in the terminal year of the VPA). Given the stability of the input data to these analyses and the consistency of the results with the previous work, the Technical Committee elected to retain the RPWG (NEFSC 2002) estimates of biological reference points for this assessment. The assessment indicates that the stock complex is overfished and overfishing is occurring.

5.0 GARM comments

The discussion focused on 2 major issues. The first involved the research vessel surveys, and the apparent lack of consistency between the total biomass and young-of-the-year indices derived from the individual state and NEFSC time series. Several reasons for the inconsistency were discussed, however the major issue is spatial and temporal discontinuity. Each of the surveys covers different portions of the population and they are not conducted concurrently. Each of the state surveys samples a relatively small portion of the inshore range of the species while the NEFSC survey samples the broad offshore area. Due to the migratory behavior of the species, environmental variability in the inshore waters may have a strong influence on the species availability to the survey gear. The GARM recommended that the subcommittee explore methods to weight the surveys based on their area of coverage of the population.

The second major issue discussed at the GARM was the problematic retrospective pattern of underestimation of F and overestimation of SSB during the late 1990s exhibited in the VPA. The pattern in the late 1990s may have been due to a low level of samples from the commercial fishery. The GARM agreed that the VPA provides information on stock status, i.e. the stock complex is overfished and overfishing is occurring, however projections based on the current VPA should not be conducted for this assessment.

6.0 Sources of uncertainty

1) Landings data for 1994 and later years are derived by proration and are considered provisional.

2) Length frequency sampling intensity of the recreational fishery landings has been low in some recent years.

3) Length frequency sampling intensity of the commercial fishery discards has been low in some recent years.

4) Commercial fishery discard estimates are based on rates provided by fishermen in the vessel trip reports, due to inadequate fishery observer sampling.

5) The SNE/MA winter flounder VPA exhibits a severe retrospective pattern of underestimation of F and overestimation of SSB during the late 1990s.

7.0 Summary

The Southern New England/Mid-Atlantic winter flounder stock complex is overfished and overfishing is occurring. Fully recruited fishing mortality in 2001 was 0.51 (exploitation rate = 37%), about 60% above the RPWG (NEFSC 2002) re-estimate of Fmsy = 0.32. There is an 80% chance that the 2001 F was between 0.44 and 0.58. Spawning stock biomass was estimated to be 7,600 mt in 2001, about 25% of the re-estimate of Bmsy = 30,100 mt. There is an 80% chance that the spawning stock biomass was between 6,800 mt and 8,400 mt in 2001.

Spawning stock biomass declined substantially from 13,000-14,000 mt during the early 1980s to only 2,700 mt during 1994-1996, but has increased since the mid 1990s to about 7,600 mt in 2001 due to reduced fishing mortality rates since 1997. The arithmetic average recruitment from 1981 to 2001 is 23.9 million age-1 fish, with a median of 18.9 million fish. Recent recruitment to the stock has been below average since 1989. The 2001 year class, at only 5.6 million fish, is the smallest in the 22-year time series.

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Table J1. Winter flounder commercial landings (metric tons) for southern New England/Mid-Atlantic stock complex area (U.S. statistical reporting areas 521, 526, divisions 53, 61-63) as reported by NEFSC weighout, state bulletin and general canvass data.

Year	Metric Tons
1964	7,474
1965	8,678
1966	11,977
1967	9,478
1968	7,070
1969	8,107
1970	8,603
1971	7,367
1972	5,190
1973	5,573
1974	4,259
1975	3,982
1976	3,265
1977	4,413
1978	6,327
1979	6,543
1980	10,627
1981	11,176
1982	9,438
1983	8,659
1984	8,882
1985	7,052
1986	4,929
1987	5,172
1988	4,312
1989	3,670
1990	4,232
1991	4,823
1992	3,816
1993	3,010
1994	2,159
1995	2,634
1996	2,781
1997	3,441
1998	3,208
1999	3,444
2000	3,783
2001	4,448

Table J2. Estimated number (000's) and weight (mt) of winter flounder caught, landed, and discarded in the recreational fishery, Southern New England/Mid-Atlantic stock complex.

	Number (000's)				Metric tons
	Catch A+B1+B2	Landed A+B1	Released B2	15% Release Mortality	Landed A+B1
1981	11006	8089	2916	437	3050
1982	10665	8392	2273	341	2457
1983	11010	8365	2645	397	2524
1984	17723	12756	4967	745	5772
1985	18056	13297	4759	714	5198
1986	9368	6995	2374	356	2940
1987	9213	6900	2313	347	3141
1988	10134	7358	2775	416	3423
1989	5919	3682	2236	335	1802
1990	3827	2486	1340	201	1063
1991	4325	2795	1530	230	1214
1992	1360	806	555	83	393
1993	2211	1180	1031	155	543
1994	1829	1209	620	93	598
1995	1850	1390	461	69	661
1996	2679	1554	1125	169	689
1997	1901	1207	694	104	621
1998	1008	584	425	64	290
1999	1071	658	412	62	320
2000	2043	1346	697	105	831
2001	1441	901	540	81	552

Table J3. The total number of commercial lengths sampled by market category for Southern New England/Mid-Atlantic winter flounder. The landing (mt) and metric tons per 100 lengths are also shown.

year	number of lengths					landing (mt)	mt/100 lengths
	unclass	small	medium	large	total		
1981	1,904	1,542	-	784	4,230	11,176	264
1982	513	2,425	657	2,201	5,796	9,438	163
1983	927	1,790	1,044	1,840	5,601	8,659	155
1984	551	1,171	637	1,338	3,697	8,882	240
1985	716	2,632	1,663	1,396	6,407	7,052	110
1986	799	2,206	1,024	1,091	5,120	4,929	96
1987	99	2,524	670	1,978	5,271	5,172	98
1988	269	1,731	958	1,250	4,208	4,312	102
1989	106	1,224	1,220	975	3,525	3,670	104
1990	102	1,473	1,180	1,333	4,088	4,232	104
1991	-	1,220	921	917	3,058	4,823	158
1992	402	1,343	1,259	1,159	4,163	3,816	92
1993	62	1,249	401	642	2,354	3,010	128
1994	142	1,092	816	543	2,593	2,159	83
1995	79	1,182	290	325	1,876	2,634	140
1996	480	854	521	109	1,964	2,781	142
1997	201	1,327	1,176	1,301	4,005	3,441	86
1998	942	899	1,325	415	3,581	3,208	90
1999	2,381	798	607	821	4,607	3,444	75
2000	1,653	942	2,893	965	6,453	3,783	59
2001	760	897	2,301	2,297	6,255	4,448	71

Table J4. Total winter flounder recreational and commercial catch for the Southern New England/Mid-Atlantic stock complex in weight
(mt) and numbers (000s).

Year	Commercial Landings		Commercial Discards		Recreational Landings		Recreational Discards		Total Catch		% Discards/Total	
	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s
1981	11,176	20,705	1,343	5,123	3,050	8,089	88	437	15,657	34,354	9.1	16.2
1982	9,438	19,016	1,149	4,271	2,457	8,392	66	341	13,110	32,020	9.3	14.4
1983	8,659	16,312	1,311	5,251	2,524	8,365	125	399	12,619	30,327	11.4	18.6
1984	8,882	17,116	986	3,936	5,772	12,756	148	745	15,788	34,553	7.2	13.5
1985	7,052	14,211	1,534	4,531	5,198	13,297	230	714	14,014	32,753	12.6	16.0
1986	4,929	9,460	1,273	4,902	2,940	6,994	66	356	9,208	21,712	14.5	24.2
1987	5,172	10,524	950	3,545	3,141	6,899	61	347	9,324	21,315	10.8	18.3
1988	4,312	8,377	904	3,728	3,423	7,359	69	416	8,708	19,880	11.2	20.8
1989	3,670	7,888	1,404	5,761	1,802	3,684	49	335	6,925	17,668	21.0	34.5
1990	4,232	7,202	673	2,567	1,063	2,485	31	201	5,999	12,455	11.7	22.2
1991	4,823	9,063	784	2,701	1,214	2,794	51	230	6,872	14,788	12.2	19.8
1992	3,816	6,759	511	1,811	393	802	15	83	4,735	9,455	11.1	20.0
1993	3,010	5,336	457	1,580	543	1,180	31	155	4,041	8,251	12.1	21.0
1994	2,159	1,948	304	344	598	1,210	34	93	3,095	3,595	10.9	12.2
1995	2,634	2,321	121	107	661	1,390	23	69	3,439	3,887	4.2	4.5
1996	2,781	2,372	173	149	689	1,555	64	168	3,707	4,244	6.4	7.5
1997	3,441	5,834	267	1,200	618	1,204	26	85	4,352	8,323	6.7	15.4
1998	3,208	6,224	456	1,503	290	584	13	64	3,967	8,375	11.8	18.7
1999	3,444	7,356	329	1,074	320	658	14	62	4,107	9,150	8.4	12.4
2000	3,783	6,590	148	534	831	1,346	30	105	4,792	8,575	3.7	7.5
2001	4,448	7,690	83	285	552	901	19	81	5,102	8,957	2.0	4.1

Table J5. Winter flounder NEFSC survey index stratified mean number and mean weight (kg) per tow for the Southern New England- Mid-Atlantic stock complex. Spring and fall strata set (offshore 1-12, 25, 69-76 ; inshore 1-29, 45-56); winter strata set (offshore 1-2, 5-6,9-10,69,73).

	Spring				Fall			
Year	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)
1963					8.554	33.2	3.284	41.4
1964					13.673	22.1	4.894	19.4
1965					15.537	32.5	4.435	28.7
1966					9.843	31.5	3.275	27.3
1967					9.109	20.6	2.745	18.7
1968	2.444	26.7	0.734	37.2	8.105	21.0	2.190	18.7
1969	5.640	34.3	3.414	53.7	6.841	34.9	1.939	29.7
1970	2.729	30.9	1.326	35.6	5.110	36.1	2.375	47.8
1971	2.035	32.9	0.756	36.2	3.861	17.5	1.231	19.1
1972	1.865	28.1	0.656	32.1	7.687	39.4	3.053	44.6
1973	7.458	19.9	2.013	20.6	2.691	26.9	0.775	25.8
1974	3.362	21.9	1.043	19.3	2.032	31.1	0.822	29.4
1975	1.135	22.6	0.354	20.8	2.196	20.3	0.688	22.1
1976	3.085	16.3	0.804	17.2	2.376	32.2	1.251	42.9
1977	4.209	17.2	1.189	18.6	4.722	22.5	1.735	25.2
1978	6.695	11.1	1.758	13.3	3.743	17.6	1.430	22.6
1979	2.966	16.8	1.069	25.0	10.058	18.4	2.606	15.4
1980	15.250	17.5	3.551	13.6	9.964	31.0	3.216	29.5
1981	18.234	20.9	4.762	16.9	10.206	20.3	3.110	19.9
1982	6.986	20.1	1.918	15.8	4.927	22.8	1.683	25.9
1983	6.262	18.4	2.469	28.0	8.757	37.6	2.690	31.7
1984	5.524	19.0	2.072	28.4	2.681	21.1	0.887	21.0
1985	5.360	17.4	1.983	16.5	2.727	21.5	0.991	21.5
1986	2.266	23.9	0.766	23.4	1.538	21.9	0.487	19.1
1987	1.763	21.3	0.568	17.9	1.167	28.9	0.419	37.8
1988	2.126	19.6	0.730	19.3	1.246	22.4	0.530	27.5
1989	2.485	33.5	0.582	29.6	1.435	40.7	0.341	30.4
1990	1.992	36.8	0.472	33.1	1.979	29.6	0.546	25.8
1991	2.473	15.6	0.692	14.7	1.950	23.6	0.708	25.6

Table J5 continued.

	Spring				Fall				Winter			
Year	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)
1992	1.579	23.4	0.435	22.1	2.963	32.4	0.829	31.8	3.680	27.3	0.928	26.0
1993	0.961	19.1	0.219	14.8	1.382	25.0	0.392	25.9	2.590	29.4	0.456	21.5
1994	1.510	26.4	0.329	21.9	4.134	24.8	1.482	27.3	3.797	30.8	1.183	35.5
1995	2.097	23.4	0.592	19.1	2.253	20.7	0.626	17.3	2.221	26.1	0.697	29.1
1996	1.517	14.3	0.428	15.2	3.186	39.8	1.063	45.3	3.778	28.4	0.734	25.2
1997	1.436	22.1	0.399	20.0	7.893	32.6	2.583	26.7	3.906	19.7	1.043	21.6
1998	2.774	20.6	0.845	22.1	6.597	13.6	2.232	9.9	7.169	21.6	1.830	24.1
1999	4.171	16.2	1.245	16.4	3.596	17.0	1.549	16.5	10.328	31.8	3.100	32.3
2000	3.172	26.6	1.123	31.9	6.168	25.5	2.143	26.2	5.571	32.9	1.525	29.5
2001	1.568	14.3	0.581	13.3	4.877	28.1	2.030	28.5	3.096	31.6	0.873	29.0
2002	2.043	15.7	0.782	16.3					2.901	27.7	1.188	38.3

NOTE: 1968-1972 spring index does not include inshore strata ; 1963-1971 fall index does not include inshore strata. All indices calculated with trawl door conversion factors where appropriate. Winter trawl survey began in 1992.

Table J6. SNE/MA winter flounder mean weight per tow for annual state surveys.

Year	MADMF spring	RIDFW spring	RIDFW fall	CTDEP	NJDFW Ocean (April)
1978	18.12				
1979	18.17	7.72	7.24		
1980	15.18	13.57	4.88		
1981	15.77	12.13	2.12		
1982	14.82	5.23	1.30		
1983	19.67	9.52	2.28		
1984	14.68	8.43	3.38	15.68	
1985	11.60	5.93	3.01	13.82	
1986	10.36	6.47	3.12	10.33	
1987	9.57	8.14	2.25	11.76	
1988	6.64	6.02	1.45	18.29	
1989	8.46	3.09	0.79	22.62	5.86
1990	5.38	3.07	0.71	29.02	4.78
1991	2.91	7.38	0.18	24.59	5.32
1992	7.99	0.95	0.42	12.29	2.48
1993	8.16	0.22	0.50	10.26	3.87
1994	12.59	1.67	0.33	12.20	3.25
1995	7.98	6.04	0.89	7.72	8.06
1996	9.78	4.45	0.91	20.41	3.73
1997	10.02	4.57	0.64	15.53	6.52
1998	7.99	5.00	0.32	14.66	4.17
1999	4.44	3.66	0.57	10.29	6.83
2000	6.52	4.52	0.56	12.63	5.24
2001	3.73	3.56	0.28	14.02	6.36
2002				10.90	8.80

Table J7. State survey indices (stratified mean number per tow or haul) for young-of-year winter flounder in Southern New England/Mid-Atlantic stock complex.

Year	CTDEP	RIDFW	DEDFG	MADMF	NYDEC
1975				0.30	
1976				0.32	
1977				0.60	
1978				0.34	
1979				0.49	
1980				0.40	
1981				0.32	
1982				0.37	
1983				0.23	
1984				0.32	
1985				0.34	0.75
1986		29.00	0.17	0.32	
1987		11.60	0.09	0.27	0.97
1988	15.50	8.90	0.02	0.18	0.69
1989	1.90	18.90	0.29	0.42	1.67
1990	3.10	22.10	0.63	0.33	2.71
1991	5.80	12.00	0.03	0.27	2.57
1992	13.70	33.20	0.27	0.29	11.49
1993	6.00	5.50	0.04	0.07	4.73
1994	16.60	2.60	0.31	0.15	2.44
1995	12.50	5.30	0.10	0.16	0.91
1996	19.20	2.80	0.04	0.22	3.80
1997	7.47	4.40		0.39	4.42
1998	9.38	2.50		0.16	3.11
1999	8.70	14.60		0.19	7.49
2000	4.30	52.90		0.33	0.90
2001	1.30	12.90		0.21	2.31
2002				0.10	

Table J8. Virtual Population Analysis for SNE/MA winter flounder, 1981-2001.

STOCK NUMBERS (Jan 1) in thousands

	1981	1982	1983	1984	1985	1986	1987
1	62859	52020	56503	35617	34615	32795	25973
2	52566	50232	42060	45703	28708	28090	26656
3	27768	30289	28226	27884	26945	16839	17273
4	7146	9748	13560	11068	10077	10446	5551
5	1468	2600	4606	5559	4603	2773	4738
6	363	600	1577	2148	2944	1096	1317
7	218	564	1219	1949	2228	876	730
1+	152388	146054	147751	129927	110120	92914	82238

	1988	1989	1990	1991	1992	1993	1994
1	26726	23113	17366	11355	7808	8844	8315
2	21199	21806	18504	14185	9249	6370	6993
3	17057	13790	13106	13242	8875	6212	3350
4	6000	5458	4798	5053	4381	3233	2074
5	1748	1325	1299	1276	1111	1251	1084
6	1433	339	317	369	268	300	495
7	433	312	223	165	86	218	300
1+	74596	66142	55613	45645	31778	26429	22611

	1995	1996	1997	1998	1999	2000	2001
1	12647	17632	21154	18793	13372	12710	19011
2	6753	10333	14407	16971	15341	10889	10343
3	4733	5352	7658	9864	11966	10076	7610
4	1700	2190	3070	3284	4761	6170	5082
5	1053	588	791	875	1063	2320	2830
6	606	487	171	159	254	456	1120
7	433	312	73	228	83	168	512
1+	27925	36893	47324	50174	46840	42788	46509

	2002
1	5665
2	15553
3	6671
4	2912
5	2179
6	1602
7	1057
1+	35639

Table J8 continued.

FISHING MORTALITY

	1981	1982	1983	1984	1985	1986	1987
1	0.02	0.01	0.01	0.02	0.01	0.01	0.00
2	0.35	0.38	0.21	0.33	0.33	0.29	0.25
3	0.85	0.60	0.74	0.82	0.75	0.91	0.86
4	0.81	0.55	0.69	0.68	1.09	0.59	0.96
5	0.69	0.30	0.56	0.44	1.23	0.54	1.00
6	0.81	0.50	0.67	0.60	1.18	0.59	1.00
7	0.81	0.50	0.67	0.60	1.18	0.59	1.00

	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.02	0.00	0.01	0.00	0.03	0.01
2	0.23	0.31	0.13	0.27	0.20	0.44	0.19
3	0.94	0.86	0.75	0.91	0.81	0.90	0.48
4	1.31	1.24	1.12	1.31	1.05	0.89	0.48
5	1.44	1.23	1.06	1.36	1.11	0.73	0.38
6	1.41	1.29	1.15	1.39	1.10	0.86	0.45
7	1.41	1.29	1.15	1.39	1.10	0.86	0.45

	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.02	0.00	0.01	0.01	0.00
2	0.03	0.10	0.18	0.15	0.22	0.16	0.24
3	0.57	0.36	0.65	0.53	0.46	0.48	0.76
4	0.86	0.82	1.06	0.93	0.52	0.58	0.65
5	0.57	1.04	1.40	1.04	0.65	0.53	0.37
6	0.76	0.88	1.16	0.98	0.55	0.57	0.23
7	0.76	0.88	1.16	0.98	0.55	0.57	0.23

Average F for 4,5

	1981	1982	1983	1984	1985	1986	1987
4,5	0.75	0.42	0.63	0.56	1.16	0.57	0.98

	1988	1989	1990	1991	1992	1993	1994
4,5	1.38	1.23	1.09	1.34	1.08	0.81	0.43

	1995	1996	1997	1998	1999	2000	2001
4,5	0.72	0.93	1.23	0.98	0.58	0.55	0.51

Table J8 continued.

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1981	1982	1983	1984	1985	1986	1987
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	4739	4757	3771	3557	3615	2395	2482
4	3893	4592	5119	3855	3106	3541	1958
5	1205	2157	2899	2927	1838	1374	1779
6	341	603	1387	1540	1272	634	644
7	214	900	1590	2129	1037	718	489
1+	10393	13009	14766	14008	10869	8662	7353

	1988	1989	1990	1991	1992	1993	1994
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	2282	1923	1831	1980	1414	960	600
4	1863	1642	1556	1627	1626	1242	902
5	744	576	590	526	559	667	639
6	516	169	177	200	156	203	300
7	260	248	169	140	93	206	215
1+	5663	4559	4323	4474	3848	3278	2656

	1995	1996	1997	1998	1999	2000	2001
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	849	1028	1563	1817	2128	1756	2579
4	665	857	1311	1354	1990	2548	2103
5	589	293	389	452	563	1251	1692
6	376	301	113	107	170	296	715
7	279	214	84	224	73	169	553
1+	2759	2693	3459	3954	4923	6021	7643

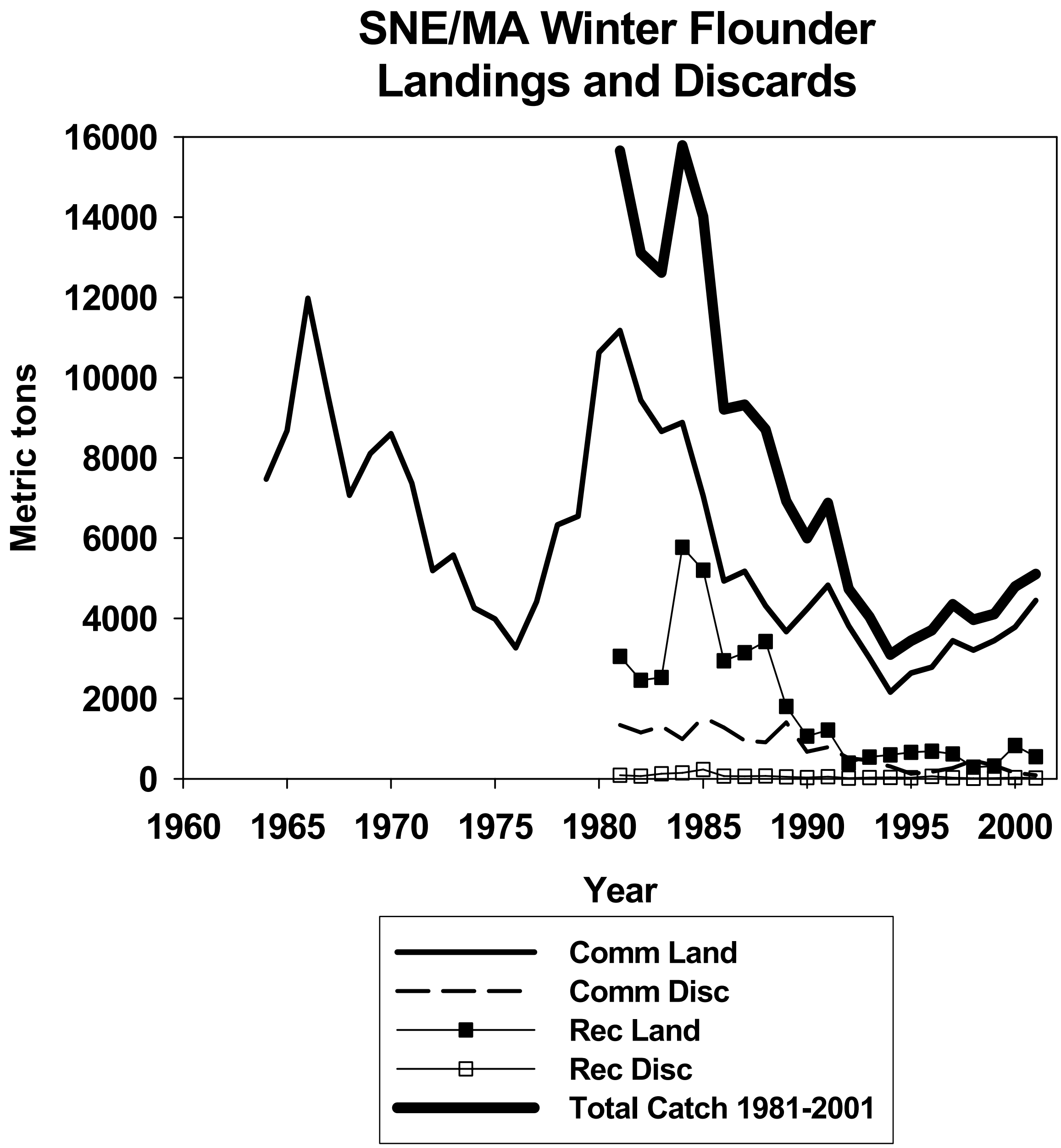

Figure J1. Commercial landings (1964-2001), commercial discards (1981-2001) recreational landings (1981-2001), recreational discards (1981-2001) and total fishery catch (198-2001) for the SNE/MA winter flounder stock complex.

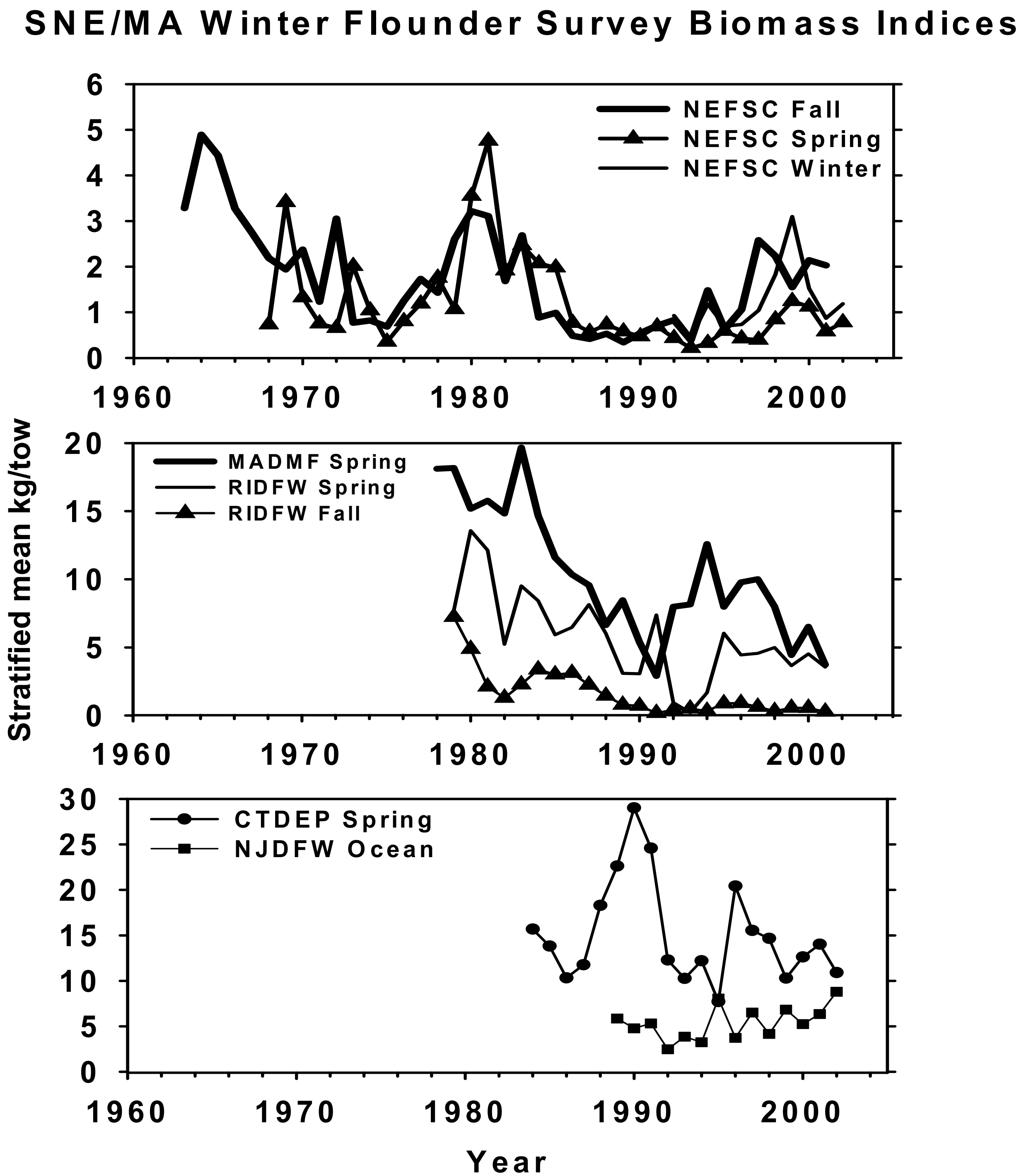

Figure J2. Trends in research survey biomass indices for SNE/MA winter flounder.

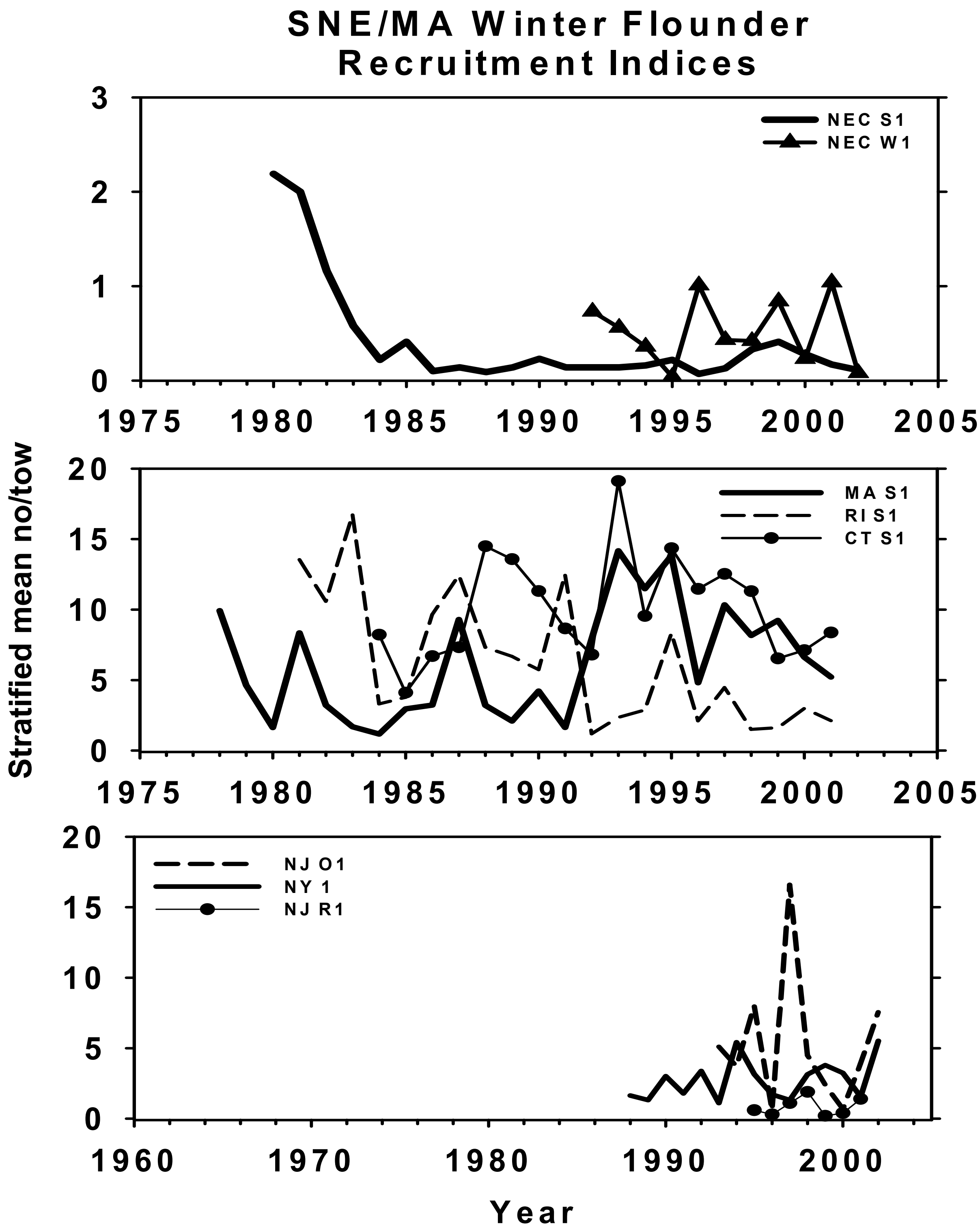

Figure J3. Trends in research survey recruitment indices for SNE/MA winter flounder. Includes spring survey age-1 indices and fall YOY indices advanced one year

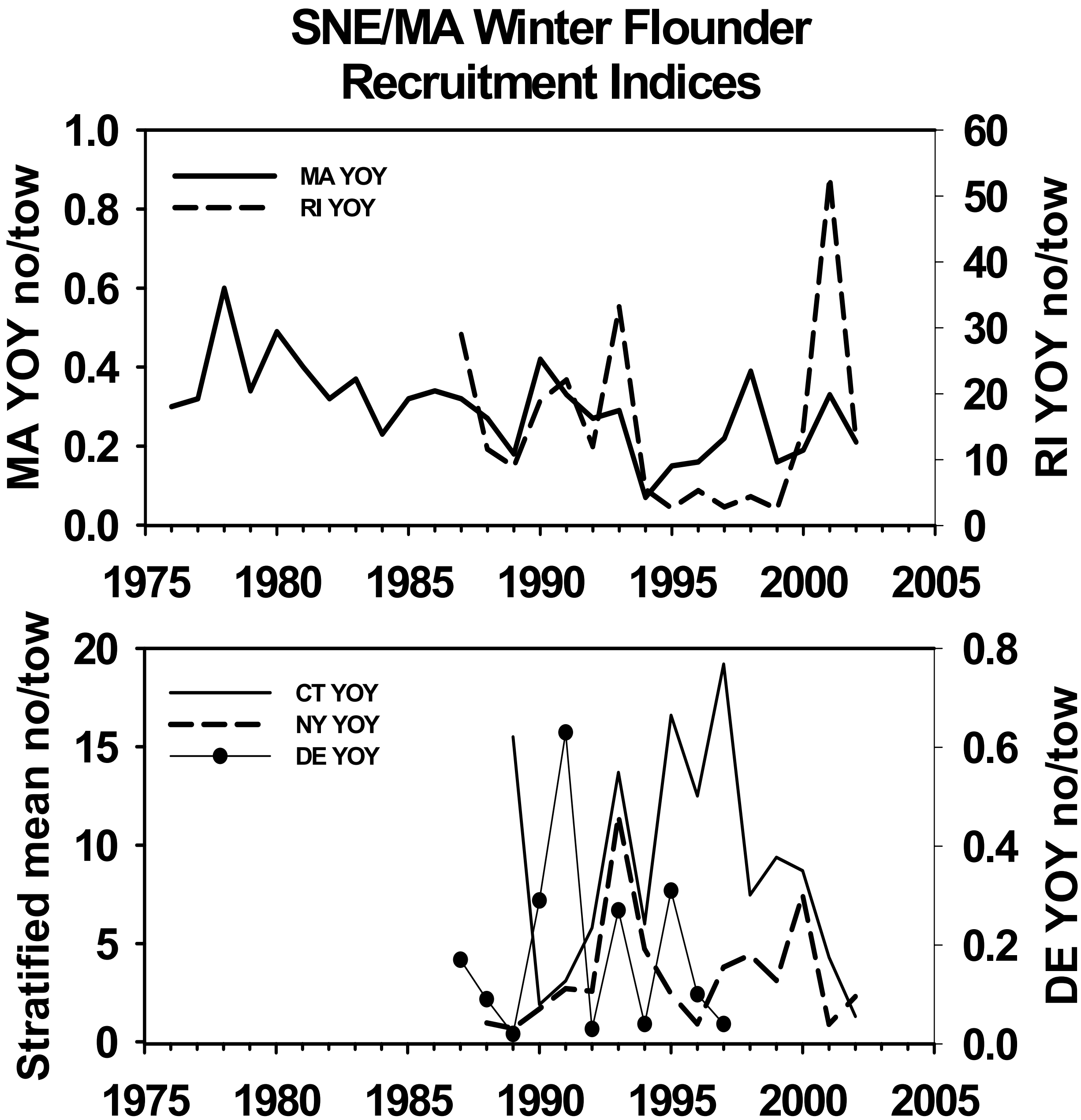

Figure J3 continued.

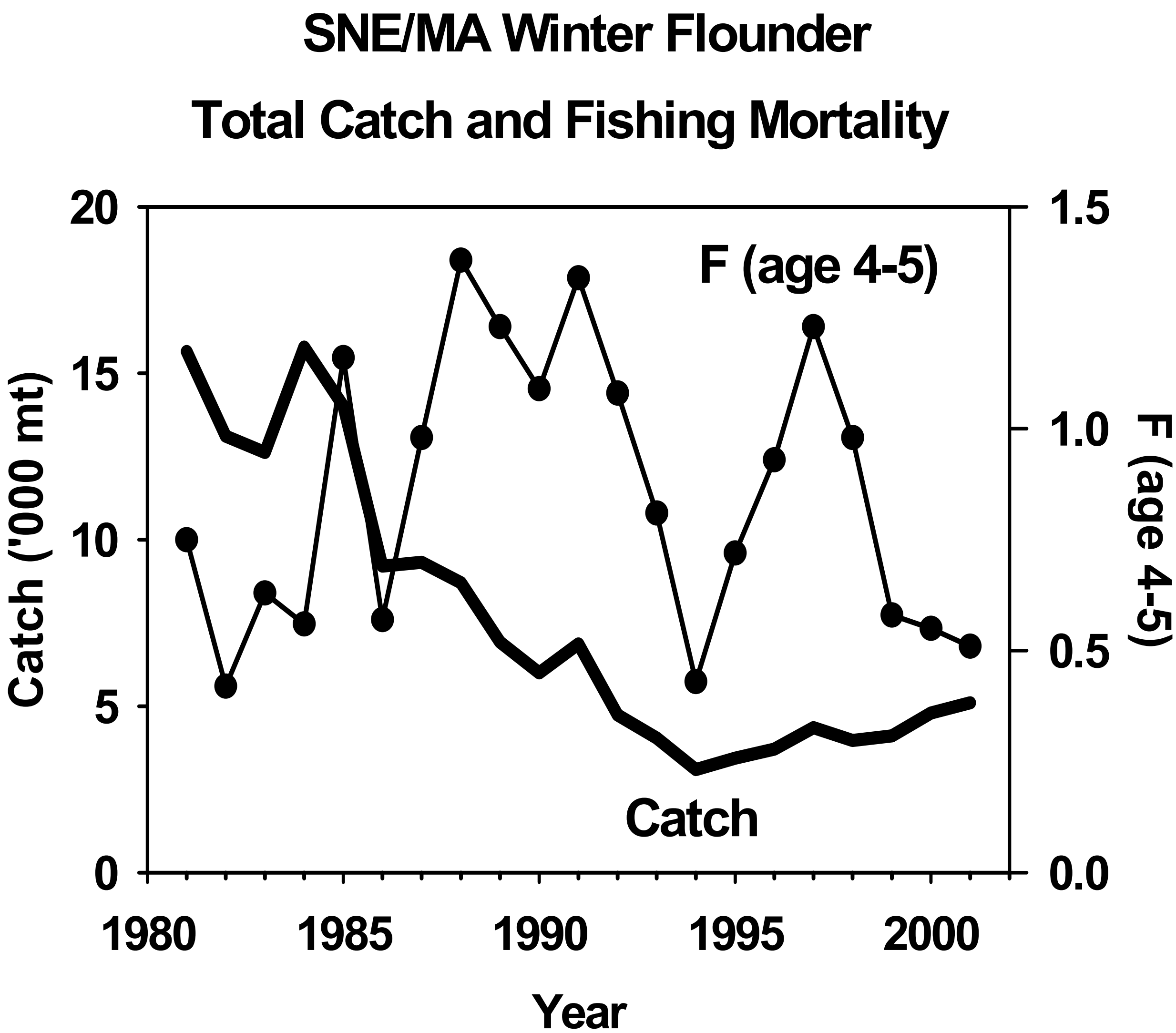

Figure J4. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (F, ages 4-5, unweighted) for SNE/MA winter flounder.

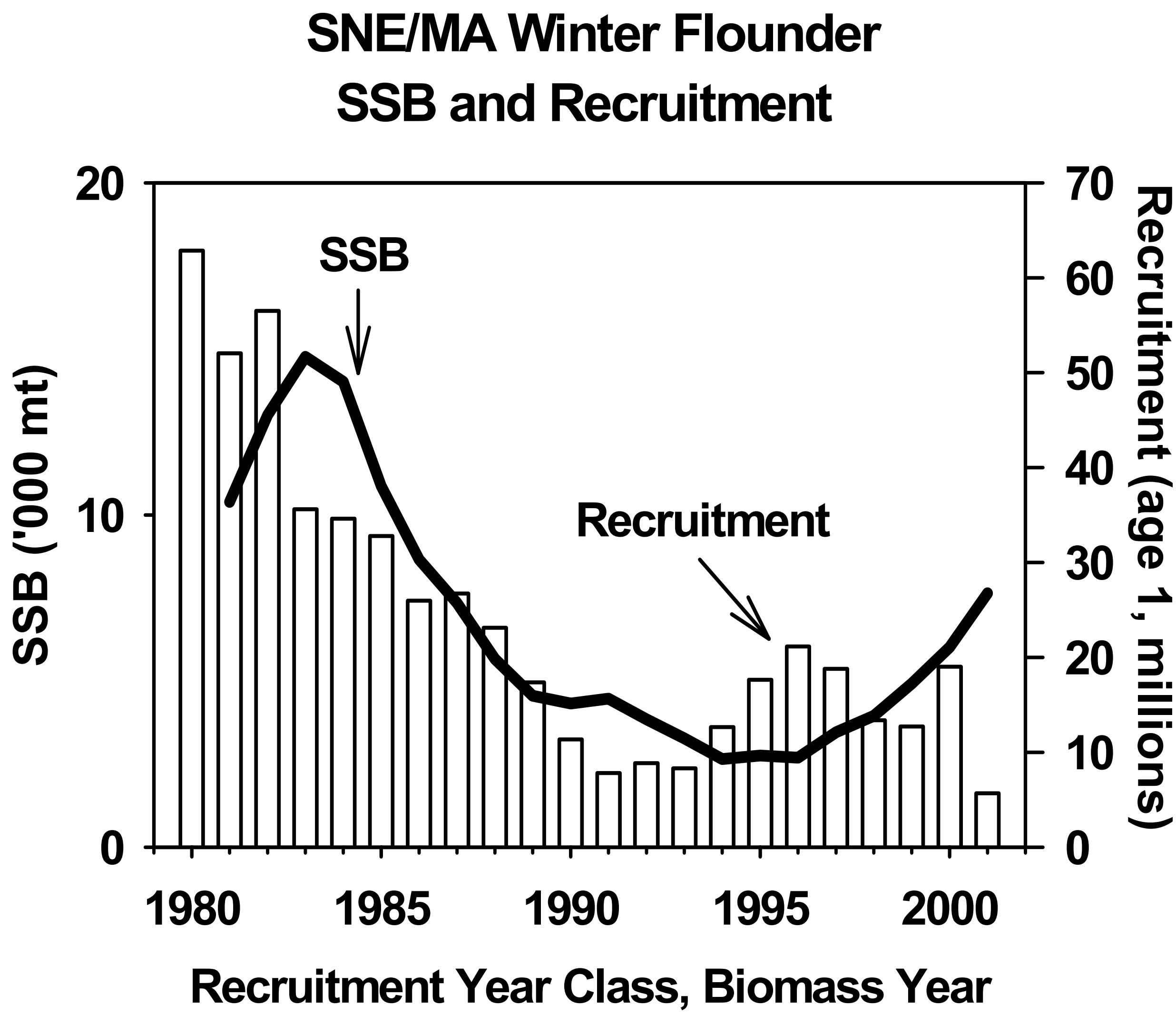

Figure J5. Spawning stock biomass (SSB, ages 3-7+, '000 mt) and recruitment (millions of fish at age-1) for SNE/MA winter flounder.

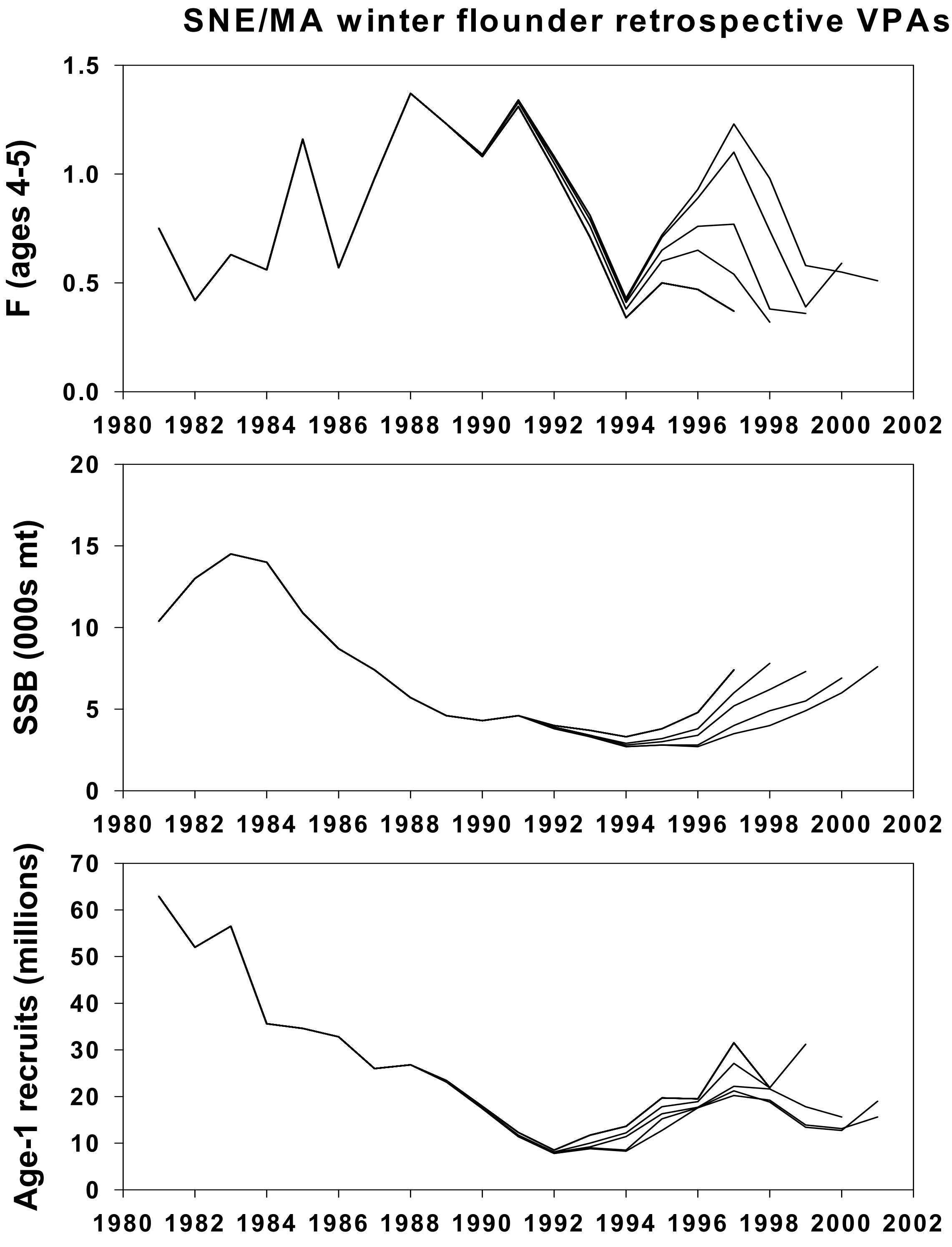

Figure J6. Retrospective VPAs for SNE/MA winter flounder.

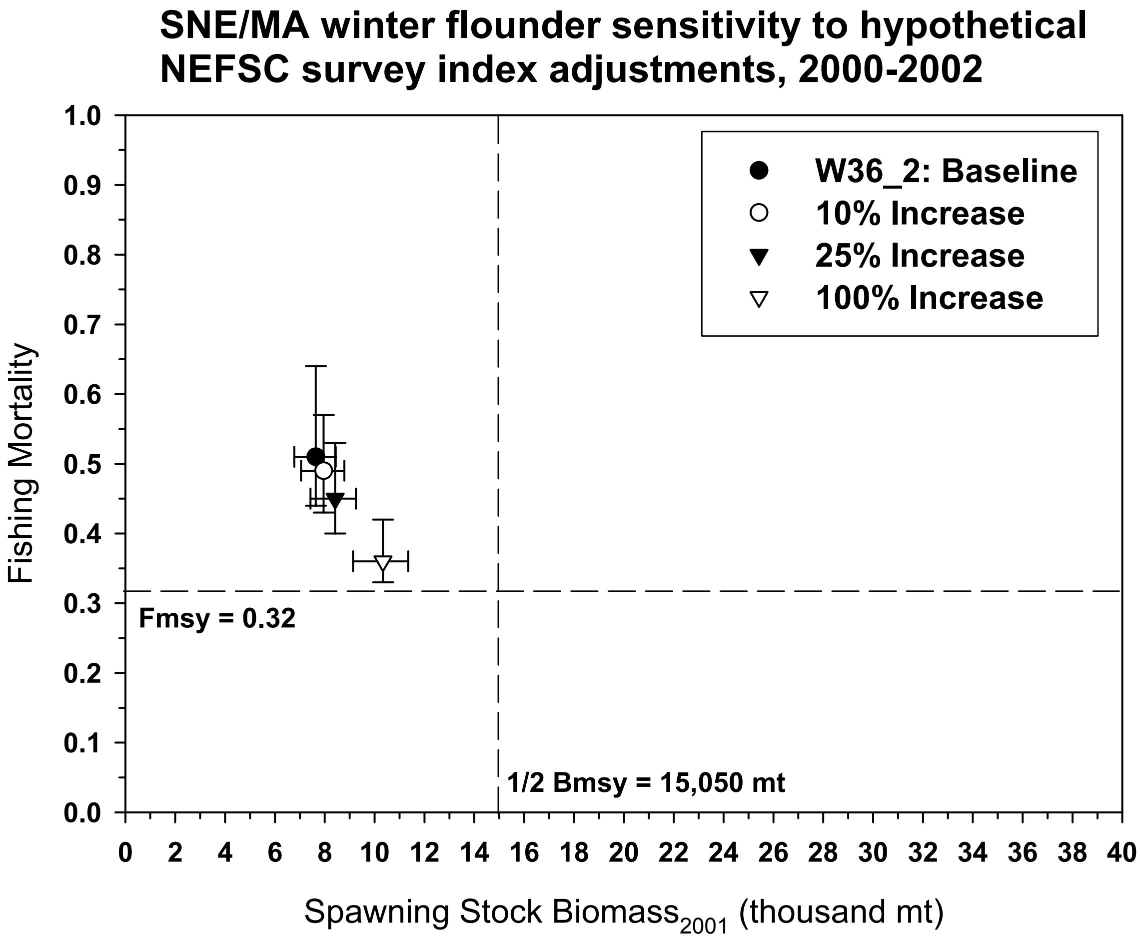

Figure J7. SNE/MA winter flounder VPA sensitivity to hypothetical NEFSC winter, spring, and fall survey index adjustments.

K. Georges Bank/Gulf of Maine White Hake by K.A. Sosebee

1.0 Background

This stock was last assessed in 2001 and reviewed at SAW 33. An ASPIC model was used to estimate stock sizes and fishing mortality. Only fish > 60 cm were included to eliminate species identification as a source of uncertainty. Landings and discards were used in the model, which was tuned with spring and autumn survey biomass indices. Fishing mortality in 2000 was estimated to be more than twice the value for F_{msy}. Biomass estimates were less than 1/4 B_{msy}. NEFSC spring and autumn research vessel bottom trawl survey indices had declined to near record low levels in 1999 but increased in 2000.

2.0 The Fishery

United States commercial landings of white hake increased to 3,364 metric tons (mt) in 2001, a 16% increase from 2000 (Table K1; Figure K1). Canadian landings declined to 228 mt (9% decline). Discard estimates were derived for 2001 using the same method as in the previous assessment. Discards increased 38% to 439 mt overall (Figure K1). Only otter trawl discards are used in the assessment. Such discards increased to 334 mt (34%).

3.0 2002 Assessment

Landings-at-length were estimated using port samples collected in 2001. The sampling intensity (Table K2) and coverage were adequate, except for the unclassified market category. As in the previous assessment, unclassified landings were low and were raised with the total at the end.

Discards-at-length were estimated using length samples from 2000 and 2001. The otter trawl sampling in the observer program was very low (one sample in the first half) in 2001 so pooling was necessary (Table K3). The possible mis-identification of species is a problem, particularly for estimation of discards. The length compositions of both the landings and discards were broken out into fish <= 60 cm and fish > 60 cm (Table K4, Figure K2). This length cutoff ensures that most of the fish > 60 cm are white hake since red hake do not reach this size. For years prior to 1985, an average proportion of fish > 60 cm for 1985-2000 was used to split the landings into two parts (75% > 60 cm). All discards prior to 1989 were assumed to be <= 60 cm. The NEFSC surveys were also split into two parts as in the commercial length compositions (Figure K2, Table K6). The rate of decline for the > 60 cm portion of the stock is apparently greater than that for the stock as a whole.

The ASPIC model from the previous assessment using catch of white hake greater than 60 cm was updated .

4.0 Assessment Results

NEFSC research vessel bottom trawl survey abundance and biomass indices for white hake remained relatively low through autumn 1999 (Table K5, Figure K3). Autumn indices increased sharply in 2000 and 2001.

Estimates of F_{msy} and B_{msy} from the > 60 cm ASPIC model changed significantly with the addition of one year of data. The estimated value for r, the intrinsic rate of increase, also changed (from 0.58 to 0.73). This value of r appears to be implausibly high for a gadid species which lives to be 20 years old. Therefore, the GARM did not accept the ASPIC model results.

Since the ASPIC model was not accepted, an alternative was developed. An index of relative exploitation (catch/survey biomass index) corresponding to a replacement ratio of 1.0, as described in NEFSC (2002) was developed for biomass indices and catches of white hake > 60 cm. Autumn NEFSC survey biomass indices from 1963 through 2001 (Figure K2) were used to calculate the replacement ratios, defined as the biomass index in the current year divided by the average biomass indices from the previous 5 years. The biomass indices and total catch (Figure K2) were used to compute the relative exploitation rates, defined as the catch in the current year divided by the 3 year average survey biomass index for the previous 2 years and the current year (Figure K4). These relative exploitation rates (or relative F) may be considered a proxy for F for white hake.

Prior to the 1980s, a high proportion of the replacement ratios equaled or exceeded 1.0 (Figure K4). During the 1980s and early 1990s, most of the replacement ratios were less than 1.0, with ratios greater than 1.0 appearing sporadically. The values for the last two years were greater than 1.0 due to the large increase in the survey biomass index in the last two years.

The relationship between replacement ratios and relative F was evaluated by a linear regression of the $\log_e$ replacement ratio on $\log_e$ relative F (NEFSC 2002) and the results were used to derive an estimate of relative F corresponding to a replacement ratio of 1.0 (Figure K4). Results for white hake were highly significant (NEFSC 2002). The regression indicates that, on average, when the relative F is greater than 0.55, the stock is not likely to replace itself.

The GARM decided to use the value of MSY estimated from the last accepted ASPIC model run at SAW 33. In evaluating this number, the GARM also looked at the relationship between the catches and survey indices. It appears that when catches exceeded 4,200 mt, the survey indices of biomass declined, and when catches dropped below this value, the indices either stabilized or increased. The value of 4,234 mt can then be used to derive B_{MSY} by dividing it by F_{MSY}. This gives a value of 7.70 kg/tow for B_{msy}.

The current value for biomass of 2.35 kg/tow is below that of ½ B_{msy} and indicates that this stock is overfished. Likewise, the relative F value of 1.36 is above F_{msy} indicating that overfishing is occurring.

5.0 Biological Reference Points

The following biological reference point proxies were obtained from an index-based model of replacement ratios (NEFSC 2002) derived from indices of relative exploitation:

MSY	4,234 mt
B_{MSY}	7.70 kg/tow
F_{MSY}	0.55 (Relative F)

6.0 Trawl Warp Analyses

Analyses were conducted to determine the effects of increasing the survey biomass indices for 2000 and 2001 to account for possible trawl warp problems. Results are summarized in section 5.2 (Summary of Assessment Advice).

7.0 GARM comments

The GARM reviewed the ASPIC results for white hake and noted a significant change in the estimate of r from the last assessment. The GARM concluded that the ASPIC model does not provide reliable results for determining stock status and that stock status should be determined directly from the surveys.

8.0 Sources of Uncertainty

- Catch at age and length are not well characterized due to possible mis-identification of species in the commercial and sea sampling data, low sampling of commercial landings, and sparse discard data.

- Catchability of older ages and larger fish in the survey may be low.

9.0 References

NEFSC. 2001. 33rd Northeast Regional Stock Assessment Workshop (33rd SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 01-18.

NEFSC. 2002. Final Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 02-04.

Table K1. Total Landings (mt,live) of white hake by country from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1964-2001.

	Canada	USA	Other	Grand Total
1964	29	3016	0	3045
1965	0	2617	0	2617
1966	0	1563	0	1563
1967	16	1126	0	1142
1968	85	1210	0	1295
1969	34	1343	6	1383
1970	46	1807	280	2133
1971	100	2583	214	2897
1972	40	2946	159	3145
1973	117	3279	5	3401
1974	232	3773	0	4005
1975	146	3672	0	3818
1976	195	4104	0	4299
1977	170	4976	338	5484
1978	155	4869	29	5053
1979	251	4044	4	4299
1980	305	4746	2	5053
1981	454	5969	0	6423
1982	764	6179	2	6945
1983	810	6408	0	7218
1984	1013	6757	0	7770
1985	953	7353	0	8306
1986	956	6109	0	7065
1987	555	5818	0	6373
1988	534	4783	0	5317
1989	583	4548	0	5131
1990	547	4927	0	5474
1991	552	5607	0	6159
1992	1138	8444	0	9582
1993	1681	7466	0	9147
1994	955	4737	0	5692
1995	481	4333	0	4814
1996	372	3287	0	3659
1997	290	2225	0	2515
1998	228	2364	0	2592
1999	174	2624	0	2798
2000	224	2990	0	3214
2001	203	3482	0	3685

Table K2. Summary of US commercial white hake landings (mt), number of length samples (n), and number of fish measured(len) by market category and quarter from the Gulf of Maine to the Mid-Atlantic (SA 464,465, 511-515,521-526,533-539,611-626) for all gear types, 1985-2001.

		small					medium					large					unclassified					All	Sampling Intensity mt/
Year		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	sample
1985	mt	129	162	235	167	694	63	78	181	124	446	237	433	1135	623	2428	367	737	1690	988	3782	7349	272
	N	-	2	4	3	9	-	-	-	-	-	-	5	5	3	13	-	1	3	1	5	27	
	#fish	-	233	323	317	873	-	-	-	-	-	-	632	519	271	1422	-	101	293	104	498	2793	
1986	mt	59	134	105	100	398	86	89	55	54	284	274	422	835	417	1948	455	752	1578	694	3478	6107	235
	N	1	3	2	1	7	1	1	-	2	4	1	3	2	1	7	2	2	3	1	8	26	
	#fish	102	263	215	101	681	94	122	-	229	445	122	315	248	96	781	215	206	292	106	819	2726	
1987	mt	98	300	641	576	1616	13	49	122	123	306	171	326	943	372	1813	262	482	1035	301	2080	5814	194
	N	-	2	4	5	11	-	2	1	1	4	-	1	6	3	10	2	1	1	1	5	30	
	#fish	-	240	291	507	1038	-	203	91	109	403	-	111	518	236	865	218	140	112	125	595	2901	
1988	mt	181	549	893	397	2020	26	82	262	120	489	136	330	695	325	1486	73	137	437	134	782	4776	165
	N	5	6	3	5	19	1	1	1	-	3	1	1	2	1	5	-	1	-	1	2	29	
	#fish	558	764	240	478	2040	100	92	105	-	297	112	121	214	85	532	-	100	-	41	141	3010	
1989	mt	149	221	404	358	1132	41	54	124	68	287	188	473	904	470	2035	33	190	774	96	1092	4547	350
	N	1	1	2	2	6	-	-	1	-	1	-	-	2	2	4	1	-	1	-	2	13	
	#fish	91	94	213	195	593	-	-	103	-	103	-	-	206	204	410	100	-	106	-	206	1312	
1990	mt	207	411	885	450	1953	43	108	303	171	625	167	300	596	320	1382	24	182	580	176	962	4922	234
	N	3	4	4	2	13	-	-	2	1	3	2	-	1	1	4	-	-	-	1	1	21	
	#fish	309	408	399	151	1267	-	-	302	99	401	214	-	101	103	418	-	-	-	101	101	2087	
1991	mt	150	366	1215	612	2342	88	160	381	129	758	126	241	533	338	1238	52	358	714	138	1262	5601	156
	N	2	5	6	4	17	1	1	3	1	6	4	1	1	4	10	-	2	1	-	3	36	
	#fish	151	471	485	244	1351	103	100	382	100	685	375	99	96	539	1109	-	207	94	-	301	3446	
1992	mt	424	626	1735	848	3633	102	202	766	358	1428	231	351	699	371	1651	60	280	1246	141	1727	8439	211
	N	4	4	8	3	19	1	4	3	3	11	-	2	3	2	7	1	-	2	-	3	40	
	#fish	329	432	655	240	1656	80	388	266	317	1051	-	194	325	297	816	97	-	237	-	334	3857	
1993	mt	331	502	453	214	1500	161	397	1117	461	2136	173	476	795	416	1860	94	463	975	433	1965	7462	191
	N	2	5	4	1	12	2	3	2	1	8	2	3	7	2	14	-	2	2	1	5	39	
	#fish	150	504	275	50	979	184	309	196	95	784	199	262	676	175	1312	-	214	196	97	507	3582	
1994	mt	63	82	116	56	317	154	374	593	265	1386	206	481	687	407	1782	193	352	457	251	1252	4737	144
	N	-	2	4	1	7	-	2	3	3	8	-	3	4	2	9	-	2	4	3	9	33	
	#fish	-	167	386	100	653	-	230	305	272	807	-	303	363	304	970	-	236	431	372	1039	3469	

Table K2.cont.

1995	mt	39	43	98	56	245	140	238	616	399	1393	197	398	595	374	1564	134	225	504	268	1130	4333	361
	N	-	1	1	1	3	-	2	2	1	5	-	2	-	1	3	-	1	-	-	1	12	
	#fish	-	107	97	105	309	-	191	222	111	524	-	221	-	103	324	-	100	-	-	100	1257	
1996	mt	23	34	80	43	181	96	207	531	269	1103	208	331	416	280	1234	110	152	339	169	769	3287	122
	N	-	-	-	-	-	1	-	4	4	9	-	2	4	5	11	1	1	3	2	7	27	
	#fish	-	-	-	-	-	101	-	435	541	1077	-	202	451	759	1412	127	72	326	220	745	3234	
1997	mt	31	58	124	83	295	76	113	369	193	751	146	146	438	335	1065	34	28	26	26	113	2225	32
	N	4	2	4	2	12	3	7	6	13	29	5	7	7	9	28	-	-	-	1	1	70	
	#fish	458	206	430	261	1355	276	694	564	1200	2734	541	720	678	896	2835	-	-	-	58	58	6982	
1998	mt	31	54	128	105	318	55	77	218	152	502	159	311	571	407	1449	28	23	34	14	100	2370	74
	N	1	2	1	1	5	3	-	3	2	8	7	2	8	1	18	-	-	1	-	1	32	
	#fish	53	220	120	59	452	327	-	402	305	1034	684	213	1311	110	2318	-	-	118	-	118	3922	
1999	mt	50	76	103	87	317	85	110	236	149	580	303	468	633	257	1661	11	14	25	16	66	2624	119
	N	-	-	1	-	1	1	1	3	4	9	1	6	2	3	12	-	-	-	-	-	22	
	#fish	-	-	119	-	119	111	102	315	313	841	166	665	202	327	1360	-	-	-	-	-	2320	
2000	mt	55	70	81	81	286	118	202	289	201	811	293	497	596	446	1833	14	15	20	12	60	2990	120
	N	4	-	-	1	5	5	1	5	4	15	1	1	-	3	5	-	-	-	-	-	25	
	#fish	428	-	-	123	551	527	106	573	450	1656	103	126	-	336	565	-	-	-	-	-	2772	
2001	mt	59	122	167	177	525	131	155	219	310	815	413	497	697	434	2041	10	22	57	12	101	3482	97
	N	2	3	2	2	9	2	1	2	2	7	3	4	7	6	20	-	-	-	-	-	36	
	# fish	231	329	213	224	997	221	100	235	215	771	328	456	797	660	2241	-	-	-	-	-	4009	

Table K3. Summary of Domestic Observer number of number of trips (trips) and number of age samples taken (age) by gear type, half year, and catch disposition, 1989-2001.

		Sink Gill Net						Otter Trawl						Grand	
		Half 1		Half 2		Total		Half 1		Half 2		Total		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips			14	1	14	1	4	10	3	19	7	29	21	30
	len			512	2	512	2	123	916	154	1734	277	2650	789	2652
1990	trips	6		8	1	14	1	3	4	1	5	4	9	18	10
	len	206		1197	32	1403	32	69	53	138	312	207	365	1610	397
1991	trips	20	1	89	7	109	8	2	1	3	2	5	3	114	11
	len	2526	135	9973	30	12499	165	53	180	413	45	466	225	12965	390
1992	trips	34	1	182	4	216	5	7	6	2	4	9	10	225	15
	len	1620	1	8473	4	10093	5	265	17	59	144	324	161	10417	166
1993	trips	26	1	129	10	155	11	8	20	5	2	13	22	168	33
	len	1276	1	4001	13	5277	14	681	333	658	44	1339	377	6616	391
1994	trips	10		81	3	91	3	12	37	8	7	20	44	111	47
	len	44		1835	12	1879	12	247	570	489	294	736	864	2615	876
1995	trips	9	1	117	7	126	8	12	49	9	10	21	59	147	67
	len	167	1	2638	30	2805	31	1111	1375	697	372	1808	1747	4613	1778
1996	trips	11	2	78	2	89	4	8	16	6	13	14	29	103	33
	len	70	13	826	3	896	16	284	526	331	381	615	907	1511	923
1997	trips	8		24	2	32	2	5	9	6	6	11	15	43	17
	len	85		427	4	512	4	117	93	110	64	227	157	739	161
1998	trips	8		31	1	39	1	3	2	1	1	4	3	43	4
	len	36		411	1	447	1	39	17	12	2	51	19	498	20
1999	trips	6		17	3	23	3	1		7	17	8	17	31	20
	len	79		218	20	297	20	23		113	287	136	287	433	307
2000	trips	7	2	5		12	2	7	5	15	10	22	15	34	17
	len	47	9	143		190	9	421	119	475	76	896	195	1086	204
2001	trips	1	1	6	1	7	2	1	1	4		5	1	12	3
	len	15	3	4501	2	4516	5	46	43	2217		2263	43	6779	48

Table K4. Commercial catch of white hake by size group.

	> 60 cm			<= 60 cm		
Year	Landings	Discards	Total	Landings	Discards	Total
1964	2284	0	2284	761	664	1425
1965	1963	0	1963	654	408	1062
1966	1173	0	1173	391	298	689
1967	857	0	857	286	288	574
1968	971	0	971	324	325	649
1969	1037	0	1037	346	370	716
1970	1600	0	1600	533	582	1115
1971	2173	0	2173	724	760	1484
1972	2359	0	2359	786	678	1464
1973	2551	0	2551	850	767	1617
1974	3004	0	3004	1001	731	1732
1975	2864	0	2864	954	536	1490
1976	3224	0	3224	1075	634	1709
1977	4113	0	4113	1371	914	2285
1978	3790	0	3790	1263	862	2125
1979	3224	0	3224	1075	813	1888
1980	3790	0	3790	1263	1049	2312
1981	4817	0	4817	1606	1372	2978
1982	5209	0	5209	1736	1525	3261
1983	5414	0	5414	1805	1923	3728
1984	5828	0	5828	1943	2037	3980
1985	6306	0	6306	1987	2176	4163
1986	6405	0	6405	654	1845	2499
1987	5025	0	5025	1353	1895	3248
1988	3295	0	3295	2041	1444	3485
1989	3944	0	3944	1186	2050	3236
1990	3156	0	3156	2330	4297	6627
1991	3824	0	3824	2347	1350	3697
1992	6147	0	6147	3434	715	4149
1993	5576	0	5576	3583	603	4186
1994	3985	55	4040	1706	177	1883
1995	2185	2	2187	2625	133	2758
1996	2850	0	2850	806	517	1323
1997	2248	75	2323	270	147	417
1998	2421	78	2499	173	160	333
1999	2530	565	3095	269	1509	1778
2000	2999	17	3016	215	263	478
2001	3093	107	3200	593	264	857

Table K5. Stratified mean catch per tow in numbers and weight (kg) for white hake from NEFSC offshore spring and autumn research vessel bottom trawl surveys (strata 21-30,33-40), 1963-2002.

	Spring			Autumn		
Year	No/Tow	Wt/Tow	Length	No/Tow	Wt/Tow	Length
1963				5.00	6.31	46.2
1964				1.77	4.14	56.3
1965				4.39	6.86	50.4
1966				6.79	7.67	45.1
1967				3.92	3.64	42.6
1968	1.60	1.74	44.1	4.24	4.54	44.9
1969	3.76	5.09	46.3	9.24	13.09	46.8
1970	5.84	11.86	52.9	8.05	12.82	51.3
1971	3.31	5.14	51.3	10.38	12.10	43.6
1972	10.18	12.66	47.3	12.52	13.10	45.2
1973	9.24	12.22	49.9	9.05	13.46	51.7
1974	8.08	13.99	55.0	5.35	11.00	54.5
1975	9.32	11.22	44.7	5.28	7.23	48.5
1976	9.98	17.01	52.7	6.04	10.56	54.7
1977	6.13	11.01	55.5	9.78	13.74	47.8
1978	3.22	6.14	51.8	7.87	12.54	50.2
1979	5.26	4.97	43.0	5.62	10.31	53.1
1980	10.38	13.96	49.7	10.86	16.66	48.8
1981	17.09	19.92	45.9	8.70	12.16	49.9
1982	6.06	8.91	51.0	1.96	2.11	46.7
1983	3.23	3.12	43.7	8.22	10.79	48.8
1984	2.75	4.17	51.4	5.32	8.23	51.9
1985	4.33	5.38	48.5	9.37	9.74	42.9
1986	8.24	5.61	40.0	14.42	11.56	41.9
1987	7.15	6.44	45.3	7.59	9.62	49.2
1988	4.52	3.69	41.9	8.12	9.88	46.1
1989	3.65	3.22	43.0	11.76	9.23	40.5
1990	11.11	18.37	53.3	13.09	10.58	41.5
1991	8.42	6.14	41.6	13.22	12.20	44.6
1992	7.59	7.11	45.1	10.16	11.24	47.7
1993	7.93	6.84	45.1	11.35	11.66	45.2
1994	4.59	3.17	40.1	8.44	7.02	42.3
1995	4.38	4.02	44.1	9.54	8.20	40.8
1996	2.87	3.07	45.9	4.52	6.35	51.2
1997	1.88	0.89	38.4	4.69	4.55	41.5
1998	2.25	1.09	37.7	4.41	4.27	44.5
1999	3.32	2.97	44.6	5.68	3.44	36.3
2000	5.19	3.33	40.4	7.57	6.72	43.8
2001	4.81	5.18	48.4	5.74	7.97	52.7
2002	5.13	6.32	49.0			

Table K6. NEFSC autumn and spring survey indices by size group.

	Autumn		Spring	
Year	> 60	<= 60	> 60	<= 60
1964	3.25	0.89		
1965	4.60	2.26		
1966	4.00	3.67		
1967	1.77	1.85		
1968	2.20	2.34	0.98	0.76
1969	8.38	4.71	3.58	1.52
1970	7.76	5.07	9.12	2.74
1971	8.00	4.10	3.62	1.52
1972	7.04	6.05	8.95	3.71
1973	8.22	5.23	7.01	5.21
1974	8.19	2.80	10.34	3.65
1975	4.46	2.77	7.48	3.74
1976	6.83	3.73	12.90	4.10
1977	9.07	4.67	7.97	3.04
1978	8.46	4.08	4.97	1.17
1979	6.97	3.34	2.83	2.14
1980	11.60	5.06	8.73	5.23
1981	8.44	3.72	13.47	6.45
1982			6.15	2.76
1983	6.06	4.73	1.54	1.58
1984	5.05	3.18	2.68	1.49
1985	5.49	4.24	3.06	2.32
1986	4.38	7.18	2.29	3.32
1987	4.56	5.06	2.56	3.88
1988	5.41	4.48	1.90	1.80
1989	3.84	5.39	1.80	1.42
1990	3.79	6.79	12.14	6.22
1991	4.83	7.37	2.76	3.38
1992	4.14	7.10	2.30	4.81
1993	4.90	6.76	2.68	4.16
1994	2.46	4.56	1.23	1.94
1995	2.96	5.23	1.96	2.06
1996	3.34	3.01	1.77	1.30
1997	2.60	1.95	0.14	0.75
1998	1.64	2.64	0.26	0.84
1999	1.26	2.17	1.43	1.53
2000	2.91	3.81	1.08	2.26
2001	2.89	5.08	2.16	3.02
2002			3.44	1.73

Table K7. Three-year moving average of the NEFSC autumn survey index and the relative F values used in the index-based model of replacement ratios.

Year	Survey Index	Relative F
1965	3.92	0.50
1966	3.95	0.30
1967	3.46	0.25
1968	2.66	0.36
1969	4.12	0.25
1970	6.11	0.26
1971	8.05	0.27
1972	7.60	0.31
1973	7.75	0.33
1974	7.82	0.38
1975	6.96	0.41
1976	6.49	0.50
1977	6.79	0.61
1978	8.12	0.47
1979	8.17	0.39
1980	9.01	0.42
1981	9.00	0.54
1982	9.09	0.57
1983	7.25	0.75
1984	6.12	0.95
1985	5.53	1.14
1986	4.97	1.29
1987	4.81	1.04
1988	4.78	0.69
1989	4.60	0.86
1990	4.35	0.73
1991	4.15	0.92
1992	4.25	1.44
1993	4.63	1.21
1994	3.84	1.05
1995	3.44	0.64
1996	2.92	0.98
1997	2.97	0.78
1998	2.52	0.99
1999	1.83	1.69
2000	1.94	1.56
2001	2.35	1.36

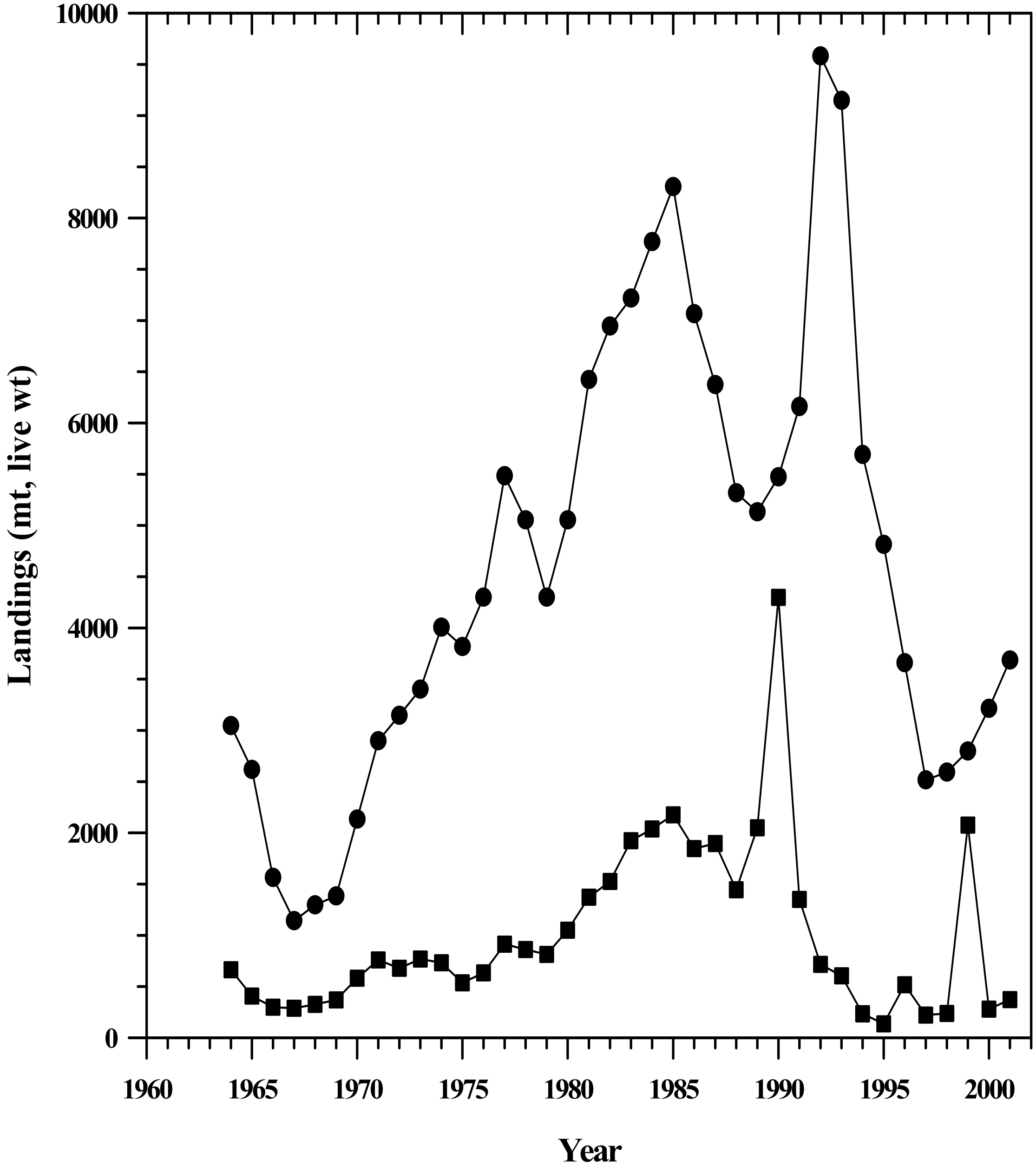

Figure K1. Total landings (circle) and discards (squares) of white hake from the Gulf of Maine to Mid-Atlantic region, 1964-2001.

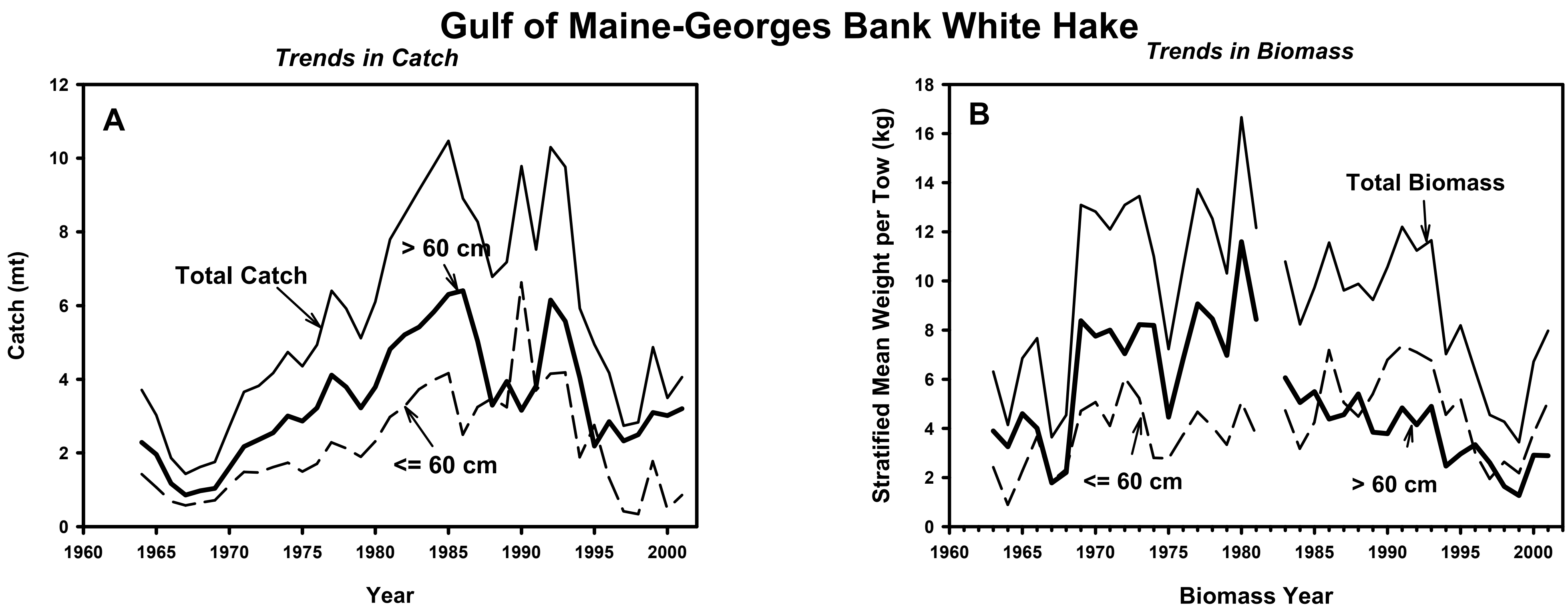

Figure K2. Trends in catch (Panel A) and survey indices of biomass (Panel B) by size class.

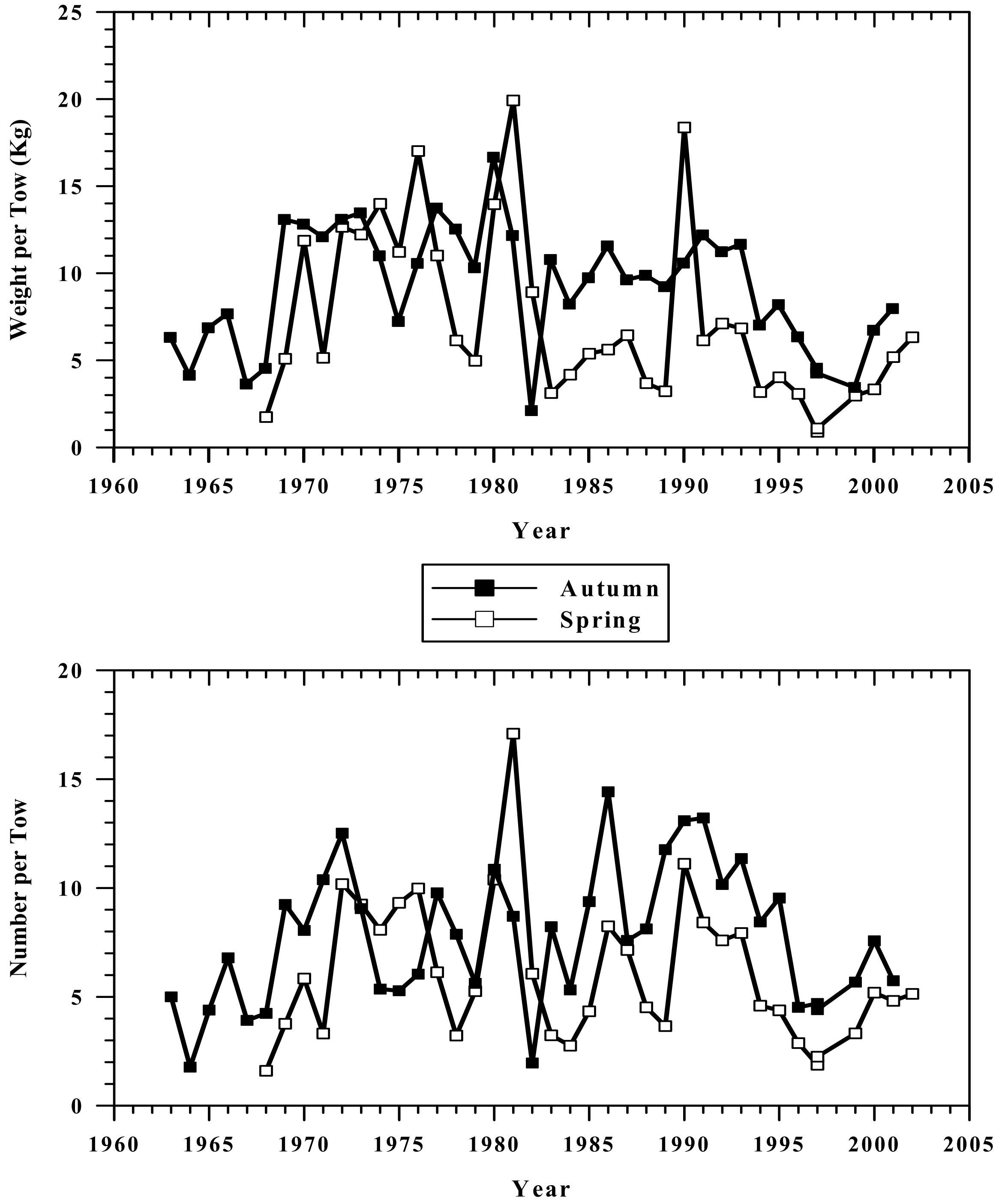

Figure K3. White hake indices of biomass (top panel) and abundance (bottom panel) from the NEFSC bottom trawl spring (solid line) and autumn (dashed line) surveys in the Gulf of Maine to Northern Georges Bank region (offshore strata 21-30, 33-40), 1963-2002.

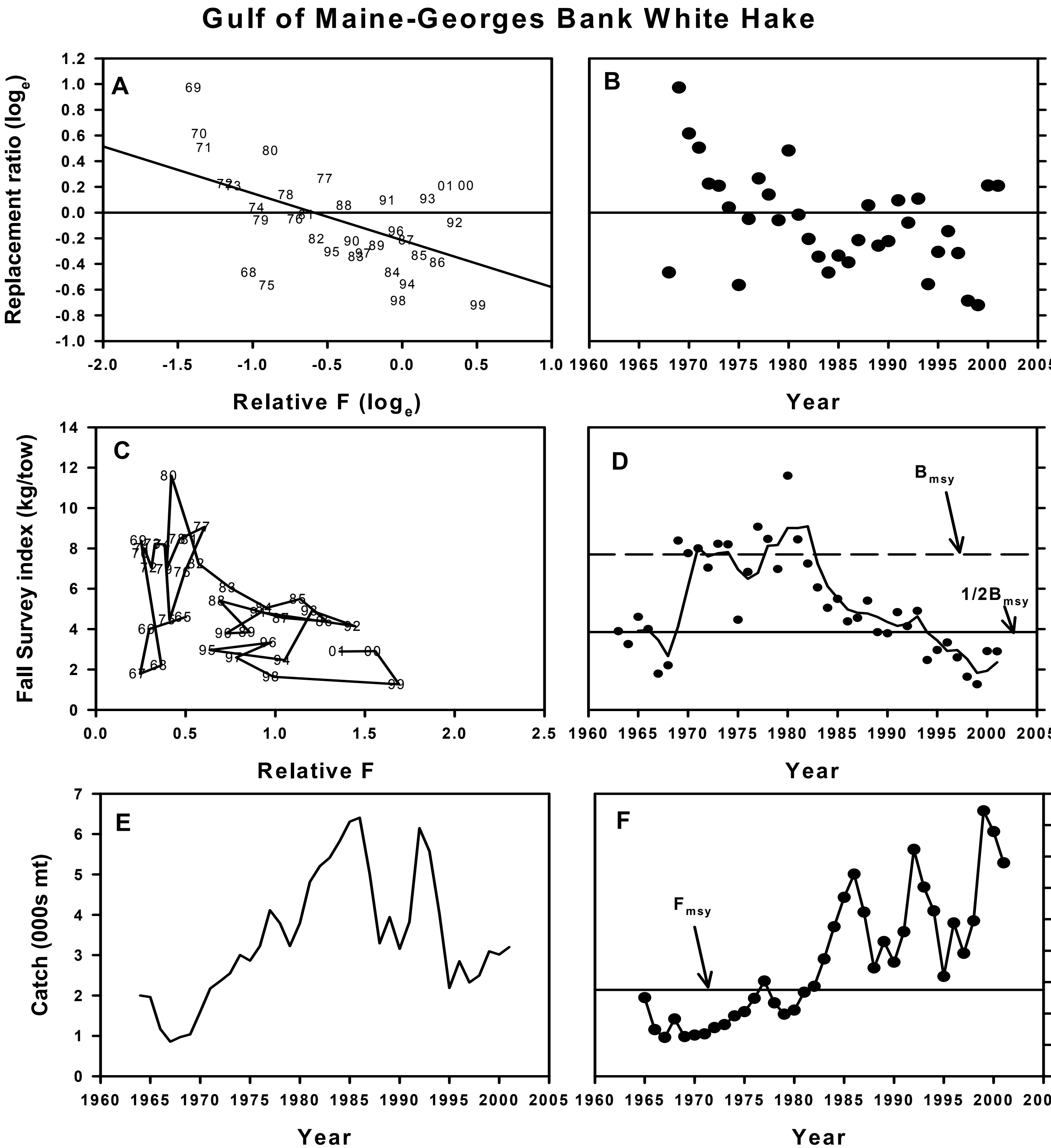

Figure K4. Six-panel plot depicting relatioship between relative F and replacement ratio (A), trend in replacement ratio (B), relationship between biomass and relative F (C), trend in biomass (D), trend in catch (E), and trend in relative F (F).

L. Scotian Shelf-Georges Bank-Gulf of Maine Pollock by R.K. Mayo and L. Col

1.0 Background

Pollock, *Pollachius virens* (L.) Are assessed as a unit stock from the eastern Scotian Shelf (NAFO Division 4V) to Georges Bank, the Gulf of Maine and portions of the Mid-Atlantic region (Subareas 5 and 6). This stock was last assessed over its range via VPA at SAW 16 in 1993 (Mayo and Figuerido 1993, NEFSC 1993a, 1993b). At that time, spawning stock biomass had been declining since the mid-1980s, and was expected to reach its long-term average (144,000 mt). Fishing mortality was estimated to be 0.72 in 1992, above $F_{20\%}$ (0.65) and well above Fmed (0.47). The stock was then considered to be fully exploited and at a medium biomass level.

The state of this stock was most recently evaluated in 2000 via index assessment (Mayo 2001). At that time, it was noted that biomass indices for the Gulf of Maine-Georges Bank portion of the stock, derived from NEFSC autumn bottom trawl surveys, had increased during the mid-1970s, declined sharply during the 1980s, but have been generally increasing since the mid-1990s. Indices derived from Canadian bottom trawl surveys, conducted on the Scotian Shelf, increased during the 1980s, but declined sharply during the early 1990s. The index assessment provided no basis with which to evaluate the state of the stock relative to the control rule as determined by the Overfishing Definition Review Panel (Anon. 1998).

An assessment of this stock over the major portion of its range (NAFO Divisions 4VWX and Subdivision 5Zc) has been conducted by Canada since 1989. The most recent full stock assessment was conducted in 1999 (Neilson et al. 1999) and the most recent update was performed in 2001. In 1999, it was noted that age 5+ population biomass reached a maximum in 1985 and then declined steadily to a minimum in 1995. Biomass had increased slightly after 1995 due to recruitment from the 1992 year class. Recent recruitment has been declining, and it was concluded that most indicators of stock status suggest that the resource remains depleted. The 2001 update indicated a further decline in the relative biomass indices and a reduction in the size structure of the population.

2.0 The Fishery

2.1 Divisions 4VWX and Subareas 5&6

Nominal commercial catches from the Scotian Shelf, Gulf of Maine, and Georges Bank region increased from an annual average of 38,200 mt during 1972-76 to 68,800 mt in 1986 (Table L1, Figure L1). Canadian landings increased steadily from 24,700 mt in 1977 to an annual average of 43,900 mt during 1985-87, while U.S. landings increased from an average of 9,700 mt during 1973-77 to more than 19,000 mt annually from 1985-1987, peaking at 24,500 mt in 1986. Landings by distant-water fleets declined from an annual average of 9,800 mt during 1970-73 to less than 1,100 mt per year during 1981-88. Distant-water fleet landings increased to 3,300 mt in 1991, but have since declined to negligible levels. Over time, most of the distant water fleet catch has been taken by the USSR/Russian fleet on the Scotian Shelf (Table L1).

By 1996, USA and Canadian landings had declined to 2,963 mt and 9,145 mt, respectively, the lowest landings by either country in over 3 decades. Landings by distant water fleets fishing on the Scotian Shelf remained almost negligible. Since 1996, USA and Canadian landings have increased slightly but remain low relative to past levels. From 1999 to 2001, USA landings fluctuated between 4,111 and 4,600 mt, and Canadian landings ranged from 5,700 to 7,700 mt (Table L1).

Since 1984, the USA fishery has been restricted to areas of the Gulf of Maine and Georges Bank west of the line delimiting the USA and Canadian fishery zones. The Canadian fishery occurs primarily on the Scotian Shelf and additional landings are obtained from Georges Bank east of the line delimiting the USA and Canadian fishery zones. This fishery on the Scotian Shelf has shifted westward over time, and the contribution to the total catch from larger, mobile gear vessels has steadily diminished since 1981.

2.2 Subareas 5&6

The commercial fishery in Subareas 5&6 is dominated by United States landings with additional catches taken by some distant water fleets primarily during the 1970s and by Canada. The total landings increased steadily from less than 10,000 mt during the 1960s to a maximum of over 26,000 mt in 1986 (Figure L2). Landings declined sharply during the late 1980s and have remained below 10,000 mt throughout most of the 1990s. Landings since 1999 have fluctuated between 5,000 and 6,000 mt.

3.0 Research Survey Indices

Indices of relative biomass (ln re-transformed), derived from NEFSC autumn bottom trawl surveys have varied considerably since 1963 (Table L2, Figure L2). Indices generally fluctuated between 2 and 5 kg per tow throughout most of the 1960s and 1970s, peaking at over 5-7 kg per tow during the mid-to-late 1970s, reflecting recruitment of several moderate-to strong year classes from the early 1970s. Strong year classes were also produced in 1979 and 1980, after which recruitment began to diminish.

Biomass indices declined rapidly during the early 1980s, and continued to decline steadily through the early 1990s, remaining below 1 kg per tow and reaching a minimum in 1994. Since 1994, biomass indices from the Gulf of Maine-Georges Bank region have generally increased, reaching 1.5 kg per tow in 1999 and 2.45 kg/tow in 2001 (Table L2, Figure L2). On the Scotian Shelf, Canadian biomass indices, derived from commercial fishery catch rates, declined rapidly after 1985, following the recruitment of the 1979 year class. After increasing slightly from 1994 to 1996, catch rate indices have continued to decline (Neilson et al. 1999).

4.0 Assessment Results

4.1 Divisions 4VWX and Subareas 5&6

As evident from recent trends in total landings from the entire stock and NEFSC autumn biomass indices calculated for the Gulf of Maine-Georges Bank region, exploitation ratios (total landings/NEFSC autumn biomass index) peaked in the mid-to-late 1980s after which they steadily declined (Table L3, Figure L3). Biomass indices from the Gulf of Maine-Georges Bank region have been increasing since the late 1990s, and now indicate that biomass may have returned to levels evident during the early 1980s. Measures of stock biomass on the Scotian Shelf, however, remain extremely low relative to past levels.

4.2 Subareas 5&6

As evident from recent trends in total landings from Subareas 5 and 6 and NEFSC autumn biomass indices calculated for the Gulf of Maine-Georges Bank region, exploitation ratios (Subarea 5&6 landings/NEFSC autumn biomass index) peaked in the mid-to-late 1980s after which they steadily declined (Table L3, Figure L4). Biomass indices from the Gulf of Maine-Georges Bank region have been increasing during the late 1990s and now indicate that biomass may have returned to levels evident during the early 1980s.

Relative Exploitation Rate Analyses

An index of relative exploitation (catch/survey biomass index) corresponding to a replacement ratio of 1.0, as described in NEFSC (2002) was developed for the portion of the unit stock of pollock within the USA EEZ (NAFO Subareas 5&6). Autumn NEFSC survey biomass indices from the Gulf of Maine and Georges Bank region from 1963 through 2001 (Figure L5) were used to calculate the replacement ratios, defined as the biomass index in the current year divided by the average biomass indices from the previous 5 years. The biomass indices and total landings (Figure L6) from the same region were used to compute the relative exploitation rates, defined as the catch in the current year divided by the 3 year average survey biomass index for the current year and the previous 2 years (Figure L7). These relative exploitation rates (or relative F) may be considered a proxy for F for that portion of the pollock stock considered in this analysis.

Prior to the 1980s, a high proportion of the replacement ratios equaled or exceeded 1.0 (Figure L8). During the 1980s and early 1990s, most of the replacement ratios were less than 1.0, with ratios greater than 1.0 appearing again by the late 1990s as the biomass indices began to gradually increase from the very low levels of the mid-1990s.

The relationship between replacement ratios and relative F was evaluated by a linear regression of the Log_e replacement ratio on Log_e relative F (NEFSC 2002) and the results were used to derive an estimate of relative F corresponding to a replacement ratio of 1.0 (Figure L9). Results for pollock were highly significant (NEFSC 2002), and the estimate of the relative replacement F (F rel rep) has a low standard error compared to the point estimate (5.88). The regression indicates that, on average, when the relative F is greater than 5.88, the stock is not likely to replace itself in the long-term.

The data displayed in Figures L5, L8 and L10 also provide a means to derive a biomass index which relates to the replacement ratios. In this case, it is evident that most of the replacement ratios below 1.0 occurred during the 1980s when the biomass index was less than about 3.0. This index may be considered as the biomass proxy for Bmsy that corresponds to the relative F proxy for Fmsy.

5.0 Biological Reference Points

Since the relative F relates the catch directly to survey biomass, the catch corresponding to the Bmsy proxy can be estimated from the relative F and the biomass index of Bmsy. For pollock, this computes to 3.0 * 5.88 = 17.64, or 17,640 mt as a proxy for MSY.

The following biological reference point proxies were obtained from an index-based model of replacement ratios (NEFSC 2002) derived from indices of relative exploitation (Table L3):

MSY	17,640 mt
B_{MSY}	3.00 kg/tow
F_{MSY}	5.88 (Relative F)

Since the mid-1990s, the NEFSC autumn survey biomass has been increasing towards the 3.0 kg/tow Bmsy proxy, and the replacement ratio has remained at or above 1.0. Since 1999 the relative F has remained below the 5.88 Fmsy proxy.

Short term projections indicate total commercial landings (including Canadian) of 5,500 mt from Subareas 5&6 in 2003 based on a relative F which will allow the biomass to increase by 10% annually.

6.0 Sensitivity Analysis

Clearly, analyses that are directly linked to survey indices will be more sensitive to changes in survey catchability than model-based analyses such as VPA. The sensitivity of estimates of relative F and replacement ratios to presumed changes in survey catchability during autumn 2000 and 2001 were evaluated and the results are presented in Section 4.2. Results are summarized in Section 5.2 (Summary of Assessment Advice).

7.0 Summary

In 2001, the 3-year average biomass index for pollock was 1.60, approximately 58% of the 3.00 Bmsy proxy. Thus, current biomass is estimated to be between ½ Bmsy and Bmsy. In 2001, the 3-year average relative F was 3.55, approximately 60% of the 5.88 Fmsy proxy. Thus, current F is estimated to be below Fmsy. Accordingly, in 2001 the stock was not overfished and overfishing was not occurring.

8.0 GARM Panel Comments

After the survey proxy reference point analyses were described, the GARM panel suggested that performance of the method should be verified by comparing results from the proxy method with estimates of absolute values of the same reference points derived from VPA-based results.

The projections of catch based on a 10% growth in biomass should be updated in the present analysis using 2001 starting conditions.

The survey biomass indices which form the basis of the estimates of the biomass and F proxy reference points are based on a set of survey strata that have been incompletely sampled over the 1963-2001 time period. The Panel recommends that the survey data be re-evaluated with a goal of achieving a consistent strata set over the entire time period.

9.0 Sources of Uncertainty

- Survey indices for pollock exhibit considerable inter-annual variability

- Movement of pollock among the NAFO Divisions comprising the stock unit is likely to vary over time, contributing to the year effects noted in the surveys

10.0 References

Anon. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. Final Report. Overfishing Definition Review Panel. June 17, 1998.

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NEFSC 2002. Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish, . NMFS/NEFSC, Reference Document 02-04, 254p.

Table L1. Pollock landings (metric tons, live) from Divisions 4VWX and Subareas 5 and 6 by country, 1960-2001.

Year	Canada	USA	FRG	GDR	Japan	Spain	USSR	Cuba	Others	Total DWF	Total
1960	29470	10132	0	0	0	783	0	0	1	784	40386
1961	26323	10265	0	0	0	982	0	0	1	983	37571
1962	31721	7391	0	0	0	0	0	0	0	0	39112
1963	28999	6650	126	0	0	0	793	0	28	947	36596
1964	30007	6006	208	0	0	0	4603	0	429	5240	41253
1965	27316	5303	71	0	0	1361	2667	0	11	4110	36729
1966	18271	3791	0	0	0	2384	9865	0	12	12261	34323
1967	17567	3312	0	0	0	1779	644	0	15	2438	23317
1968	18062	3276	0	0	0	1128	372	0	7	1507	22845
1969	15968	3943	1188	2195	0	1515	227	0	7	5132	25043
1970	10753	3976	3233	4710	40	532	527	0	0	9042	23771
1971	11757	4890	633	6849	15	912	2216	0	3	10628	27275
1972	18022	5729	475	4816	8	616	3495	0	58	9468	33219
1973	26990	6303	1124	948	1570	3113	3092	0	36	9883	43176
1974	24975	8726	149	2	40	1500	2301	0	62	4054	37755
1975	26548	9318	236	95	0	708	2004	0	124	3167	39033
1976	23568	10863	994	24	0	303	1466	0	390	3177	37608
1977	24654	13056	368	0	1	2	182	0	53	606	38316
1978	26801	17714	0	0	110	0	502	141	39	792	45307
1979	29967	15541	7	0	19	0	1025	50	23	1124	46632
1980	35986	18280	0	0	81	0	950	32	99	1162	55428
1981	40270	18171	0	0	15	0	358	0	90	463	58904
1982	38029	14357	0	0	3	0	297	84	44	428	52814
1983	32749	13967	0	0	6	0	226	261	22	515	47231
1984	33465	17903	0	1	1	0	97	123	46	268	51636
1985	43300	19457	0	0	17	0	336	66	77	496	63253
1986	42845	24542	0	0	51	0	564	387	81	1083	68470
1987	45407	20353	0	0	82	0	314	343	28	767	66527
1988	41690	14960	0	0	1	0	1054	225	0	1280	57930
1989	41093	10553	0	0	1	0	1782	99	478	2360	54006
1990	36178	9645	0	0	0	0	1040	261	3	1304	47127
1991	37931	7950	0	0	38	0	1117	459	167	1781	47662
1992	32002	7183	0	0	72	0	1006	1015	9	2102	41287
1993	20253	5629	0	0	0	0	176	644	0	820	26702
1994	15240	3768	0	0	0	0	0	10	0	10	19018
1995	9781	3358	0	0	0	0	0	58	0	58	13197
1996	9145	2963	0	0	0	0	6	129	0	135	12243
1997	11927	4267	0	0	0	0	0	64	0	64	16258
1998	14371	5583	0	0	0	0	1	9	0	10	19964
1999	7737	4594	0	0	0	0	0	6	0	6	12337
2000	5676	4043	0	0	0	0	0	0	0	0	9719
2001	6306	4111	0	0	0	0	0	0	0	0	10417

1996-1999 Canadian Data Preliminary
1994-2001 USA Data Preliminary
1999 DWF Data Preliminary

Table L2. Stratified mean catch per tow in numbers and weight (kg) for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in **NEFSC offshore spring[1], summer[2], and autumn[1] bottom trawl surveys**, 1963-2001.

	Spring[3]				Summer				Autumn			
	Weight		Numbers		Weight		Numbers		Weight		Numbers	
Year	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed
1963	-	-	-	-	10.28	3.45	2.31	1.07	5.79	4.96	1.46	1.32
1964	-	-	-	-	5.27	2.32	2.06	0.96	4.35	2.42	1.63	1.04
1965	-	-	-	-	2.56	1.05	1.72	0.63	2.75	2.12	0.83	0.77
1966	-	-	-	-	-	-	-	-	2.35	1.61	0.97	0.58
1967	-	-	-	-	-	-	-	-	1.80	1.16	0.52	0.44
1968	4.50	2.90	1.10	0.93	-	-	-	-	3.17	2.30	0.69	0.62
1969	2.66	2.53	1.12	0.99	1.75	1.19	0.70	0.47	6.59	3.01	1.31	0.85
1970	4.91	3.53	1.67	1.47	-	-	-	-	2.59	2.00	0.64	0.62
1971	4.39	3.30	1.18	1.05	-	-	-	-	3.96	1.90	1.09	0.69
1972	5.67	4.07	4.43	2.62	-	-	-	-	4.37	3.13	1.41	1.16
1973	4.82	3.77	4.00	1.61	-	-	-	-	4.71	4.04	1.64	1.25
1974	4.10	4.43	1.39	1.24	-	-	-	-	3.18	1.52	0.90	0.56
1975	5.90	5.37	1.67	1.32	-	-	-	-	2.04	1.50	0.70	0.50
1976	6.84	7.02	1.59	1.48	-	-	-	-	16.66	7.32	3.69	1.70
1977	3.38	3.04	1.61	1.23	9.98	8.35	2.07	1.67	8.78	5.26	2.14	1.25
1978	6.56	3.71	2.48	1.06	4.05	3.80	1.29	0.92	5.83	3.56	0.98	0.67
1979	4.75	4.07	1.06	0.97	17.57	4.14	2.96	1.19	5.81	4.67	1.28	0.91
1980	4.40	3.92	1.52	1.17	9.83	6.61	12.21	2.25	4.63	3.32	0.83	0.68
1981	6.17	5.42	1.95	1.40	-	-	-	-	7.75	1.56	5.24	0.63
1982	6.62	3.68	3.98	2.02	-	-	-	-	3.14	1.63	1.40	0.78
1983	1.83	1.20	0.90	0.69	-	-	-	-	3.03	1.41	0.98	0.61
1984	2.87	2.06	1.00	0.84	-	-	-	-	1.10	0.70	0.43	0.38
1985	26.81	7.85	13.70	3.05	-	-	-	-	2.43	1.97	1.12	0.77
1986	7.69	4.10	1.84	1.25	-	-	-	-	1.83	1.20	0.88	0.58
1987	13.17	2.50	6.94	1.14	-	-	-	-	2.01	1.20	0.60	0.51
1988	1.98	1.36	0.89	0.74	-	-	-	-	12.83	1.75	3.71	0.86
1989	5.17	2.18	1.98	1.02	-	-	-	-	1.20	0.61	1.86	0.76
1990	1.79	1.14	0.75	0.55	-	-	-	-	2.11	1.05	0.83	0.60
1991	5.14	2.96	2.32	1.44	-	-	-	-	1.04	0.64	0.72	0.54
1992	3.35	2.17	1.79	1.24	-	-	-	-	1.69	0.92	1.05	0.65
1993	1.63	1.29	1.64	1.16	-	-	-	-	0.76	0.56	1.03	0.56
1994	1.17	0.94	0.59	0.54	-	-	-	-	0.72	0.41	0.50	0.37
1995	3.89	1.48	3.46	0.89	-	-	-	-	1.38	0.67	0.93	0.54
1996	1.07	0.75	0.65	0.51	-	-	-	-	1.10	0.70	1.02	0.69
1997	4.51	2.01	3.33	1.78	-	-	-	-	1.49	0.98	1.74	0.90
1998	2.69	1.65	2.64	1.56	-	-	-	-	1.29	0.76	2.07	0.74
1999	1.07	0.86	2.16	1.02	-	-	-	-	3.07	1.52	2.40	1.40
2000	1.35	0.98	1.49	0.98	-	-	-	-	1.42	0.83	2.74	1.33
2001	2.03	1.28	1.69	1.27	-	-	-	-	3.57	2.45	2.38	1.81

[1] Strata 13-40 (See Figure 3).
[2] Strata 21-28 and 37-40 (See Figure 3).
[3] The "36 Yankee" trawl was used from 1968-1972, and 1982-1999; the "41 Yankee" trawl was used from 1973-1981. No gear conversion factors are available to adjust for differences in fishing power.

Table L3. Total commercial landings (mt), NEFSC autumn survey biomass index (kg/tow,Ln, retransformed), replacement index and exploitation ratio for pollock in NAFO Subareas 5&6.

Year	Total Landings (mt)	NEFSC Autumn Survey Biomass Index (kg/tow) Annual	3-yr Avg	Relative F Ratio Annual	3-yr Avg	Replacement Ratio 5-yr Avg
1963	6241	4.960		1.258		
1964	9008	2.420		3.722		
1965	9000	2.120	3.167	4.245	2.842	
1966	9847	1.610	2.050	6.116	4.803	
1967	8534	1.160	1.630	7.357	5.236	
1968	5222	2.300	1.690	2.270	3.090	0.937
1969	9822	3.010	2.157	3.263	4.554	1.566
1970	11976	2.000	2.437	5.988	4.915	0.980
1971	15203	1.900	2.303	8.002	6.600	0.942
1972	13013	3.130	2.343	4.158	5.553	1.509
1973	13076	4.040	3.023	3.237	4.325	1.637
1974	12393	1.520	2.897	8.153	4.278	0.540
1975	13871	1.500	2.353	9.247	5.894	0.596
1976	13382	7.320	3.447	1.828	3.883	3.027
1977	16273	5.260	4.693	3.094	3.467	1.502
1978	22305	3.560	5.380	6.265	4.146	0.906
1979	18452	4.670	4.497	3.951	4.103	1.219
1980	23539	3.320	3.850	7.090	6.114	0.744
1981	22068	1.560	3.183	14.146	6.932	0.323
1982	19466	1.629	2.170	11.950	8.972	0.443
1983	17816	1.414	1.534	12.600	11.612	0.480
1984	20633	0.700	1.248	29.476	16.537	0.278
1985	21069	1.967	1.360	10.711	15.488	1.141
1986	26507	1.205	1.291	21.998	20.537	0.829
1987	22347	1.202	1.458	18.592	15.327	0.869
1988	17304	1.753	1.387	9.871	12.479	1.351
1989	11903	0.608	1.188	19.577	10.022	0.445
1990	11201	1.054	1.138	10.627	9.840	0.782
1991	9600	0.640	0.767	15.000	12.511	0.550
1992	10225	0.920	0.871	11.114	11.735	0.875
1993	9873	0.496	0.685	19.905	14.406	0.498
1994	7099	0.409	0.608	17.357	11.670	0.550
1995	4362	0.667	0.524	6.540	8.324	0.948
1996	4164	0.704	0.593	5.915	7.018	1.124
1997	5483	0.984	0.785	5.572	6.985	1.539
1998	7441	0.758	0.815	9.817	9.126	1.163
1999	5591	1.522	1.088	3.673	5.139	2.161
2000	5240	0.833	1.038	6.291	5.050	0.899
2001	5680	2.448	1.601	2.320	3.548	2.549

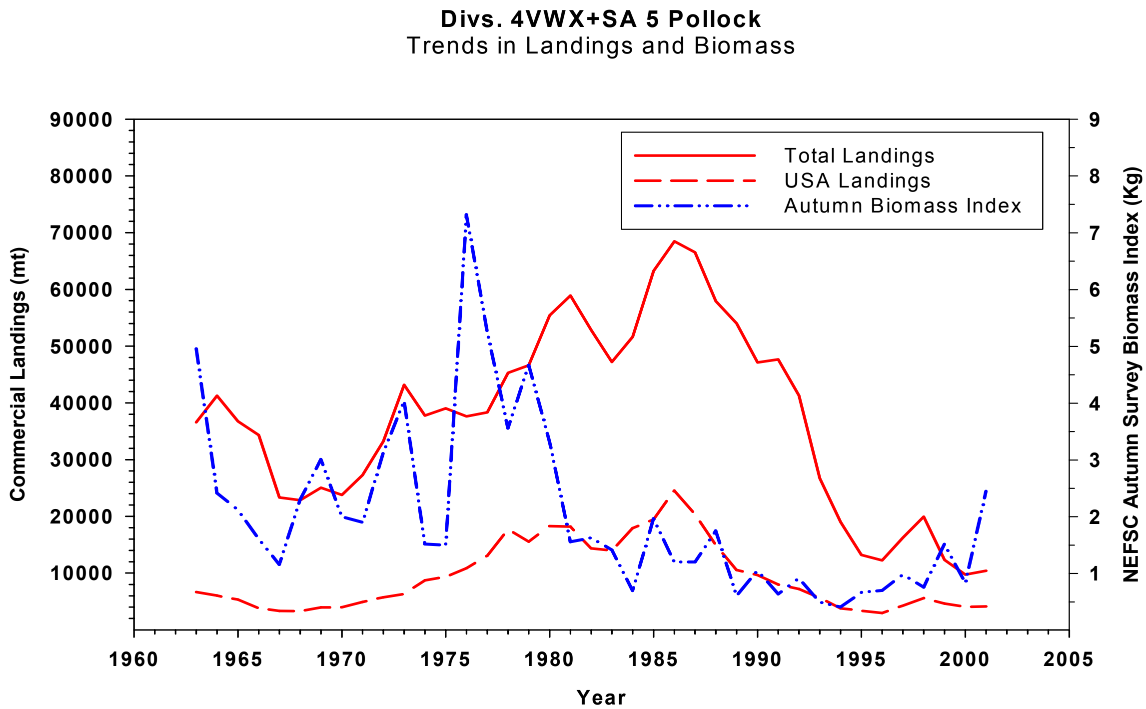

Figure L1. Trends in total and USA landings of pollock from Divisions 4VWX and Subareas 5 and 6, and NEFSC autumn survey biomass index (kg/tow), 1963-2001.

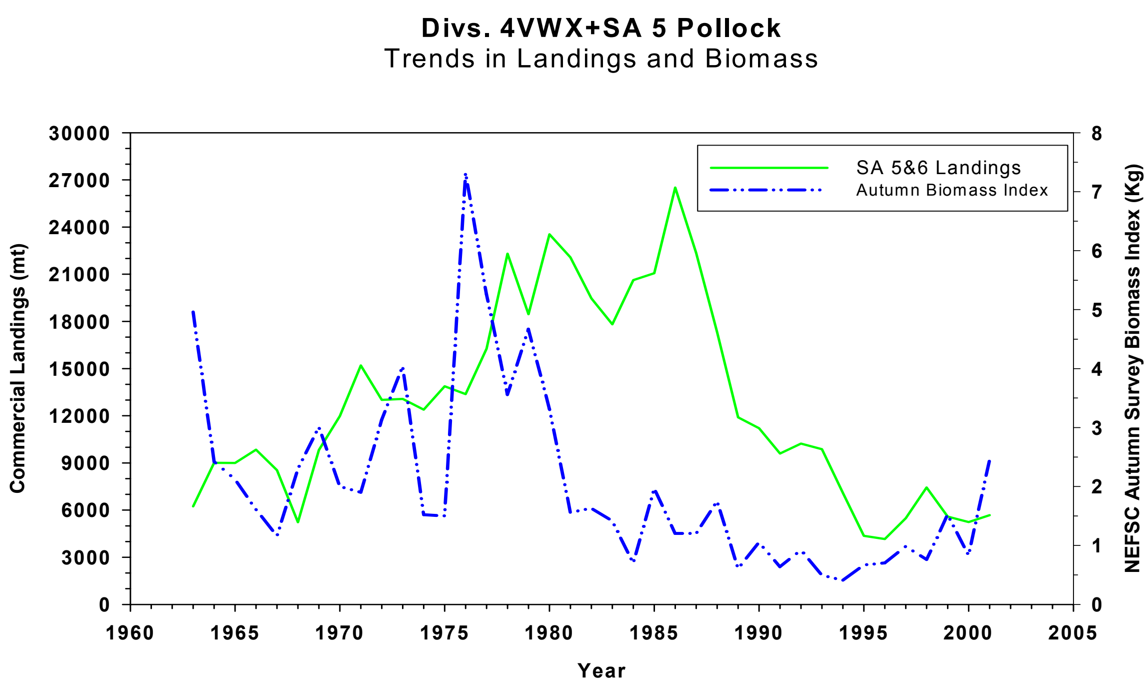

Figure L2. Trends in total landings of pollock from Divisions 4VWX and from Subareas 5 and 6, and NEFSC autumn survey biomass index (kg/tow), 1963-2001.

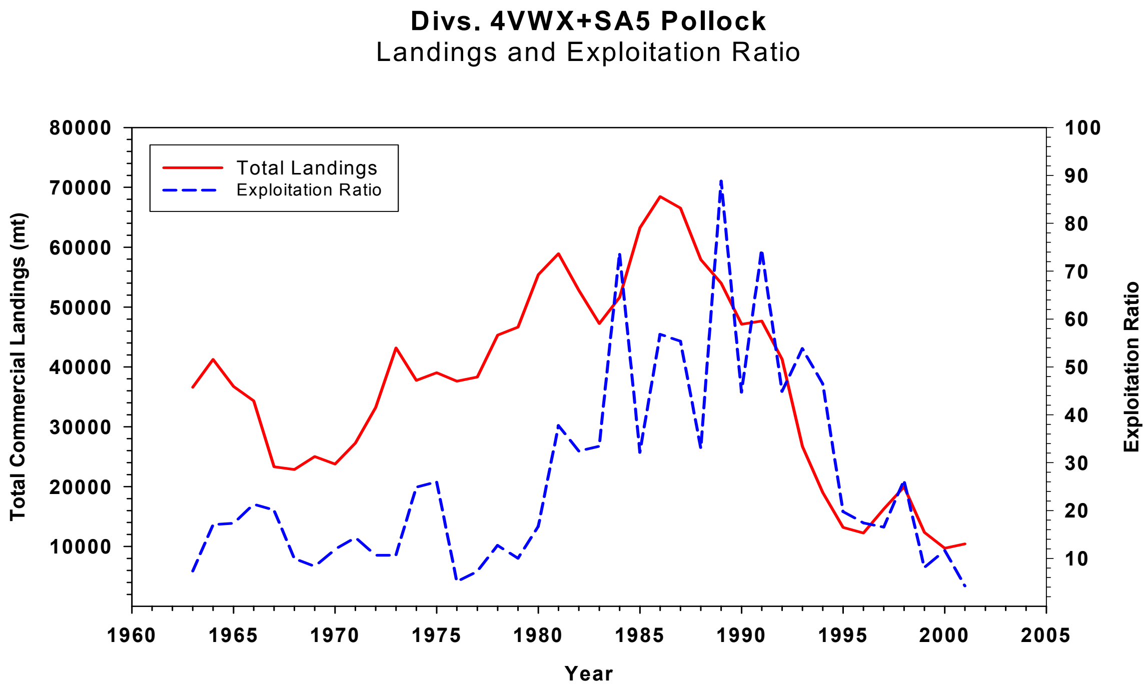

Figure L3. Trends in total landings of pollock from Divisions 4VWX and Subareas 5 and 6, and indices of relative exploitation (landings/survey biomass), 1963-2001.

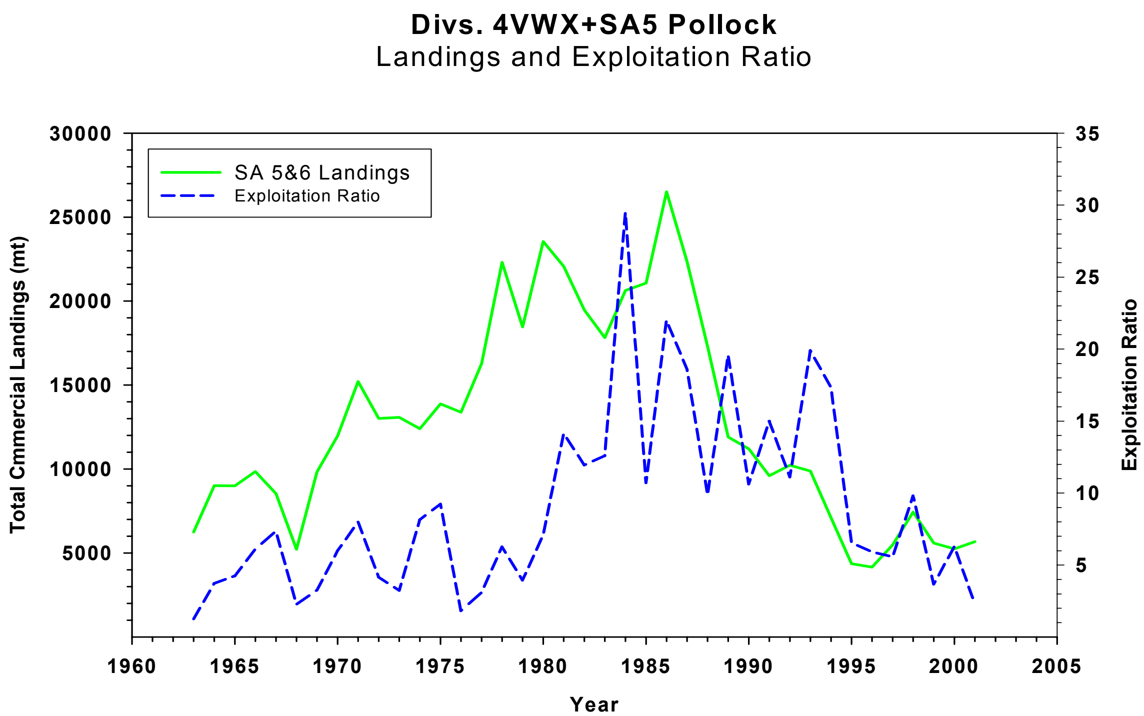

Figure L4. Trends in total landings of pollock from Subareas 5 and 6, and indices of relative exploitation (landings/survey biomass), 1963-2001.

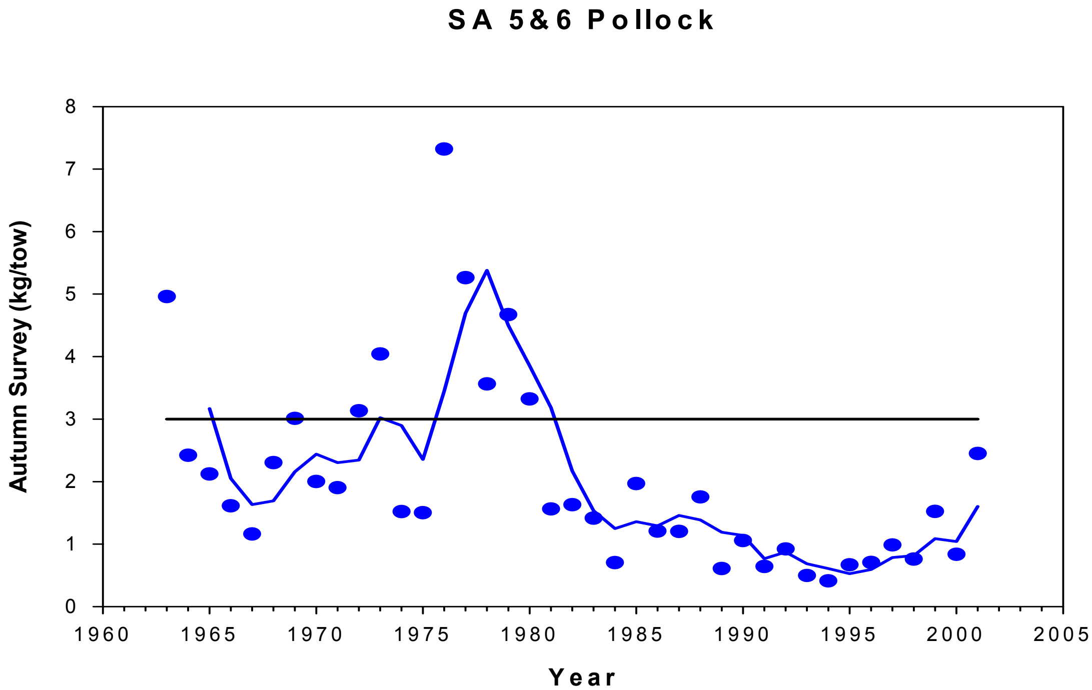

Figure L5. Trends in the NEFSC autumn survey biomass index for pollock from Subareas 5 and 6, 1963-2001.

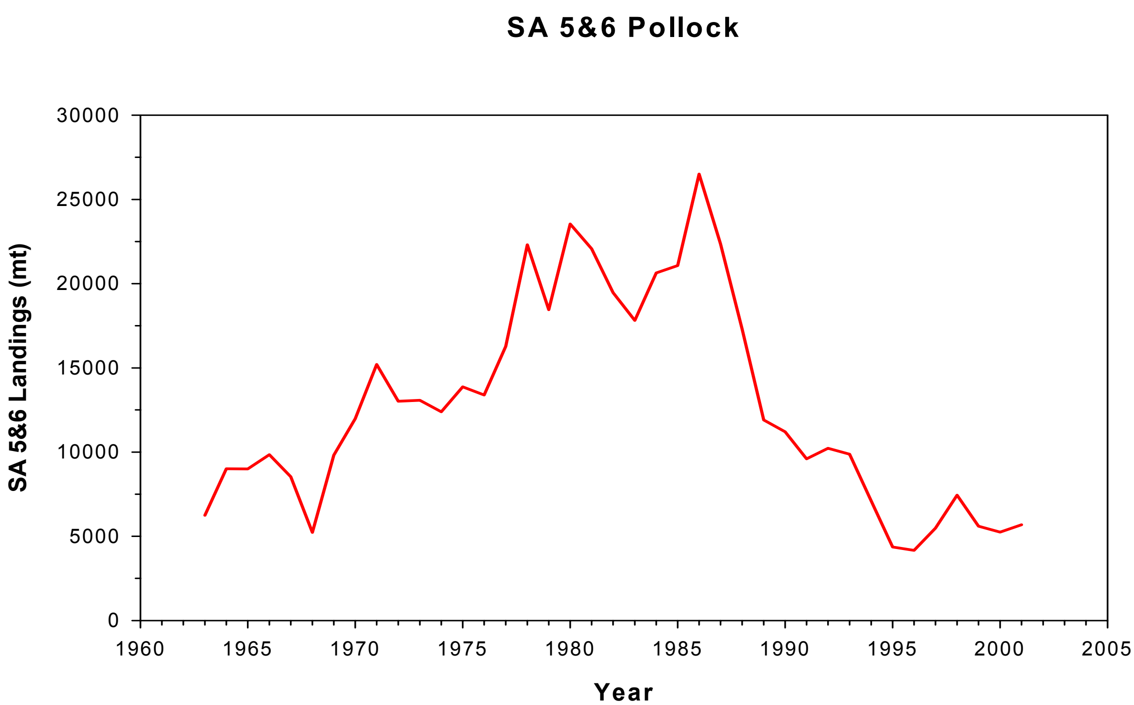

Figure L6. Trends in total landings of pollock from Subareas 5 and 6, 1963-2001.

SA 5&6 Pollock

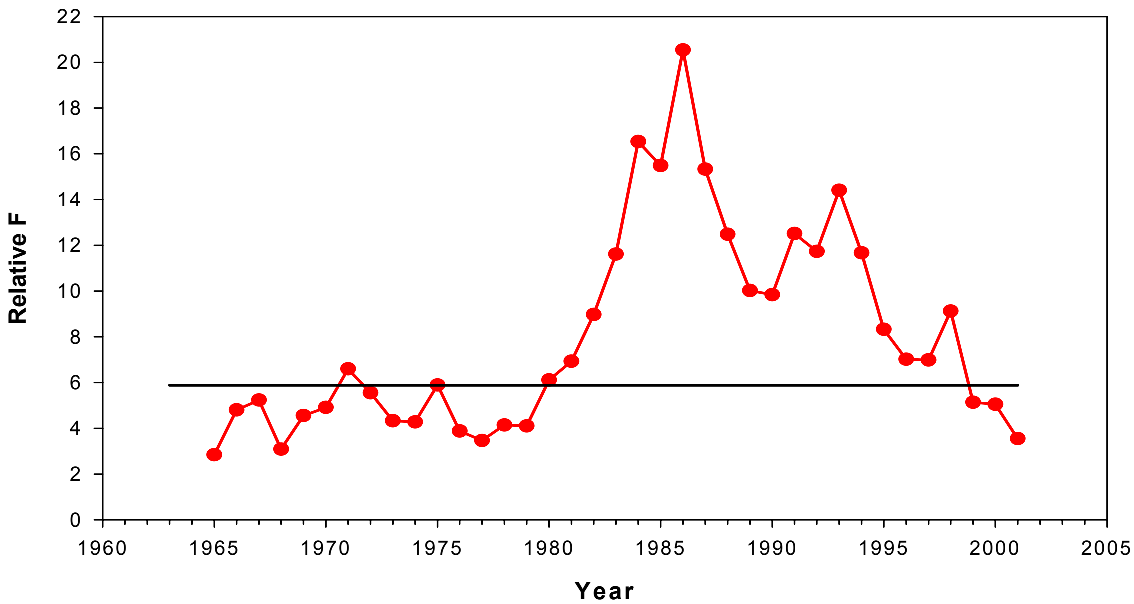

Figure L7. Trends in relative F for pollock in Subareas 5 and 6, 1963-2001.

SA 5&6 Pollock

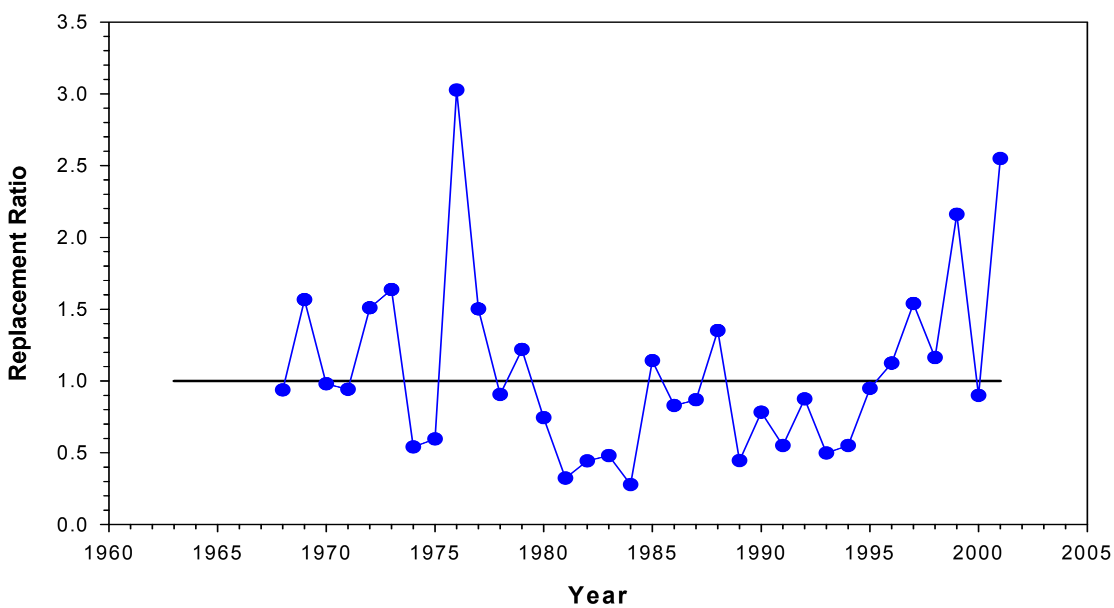

Figure L8. Trends in replacement ratio for pollock in Subareas 5 and 6, 1963-2001.

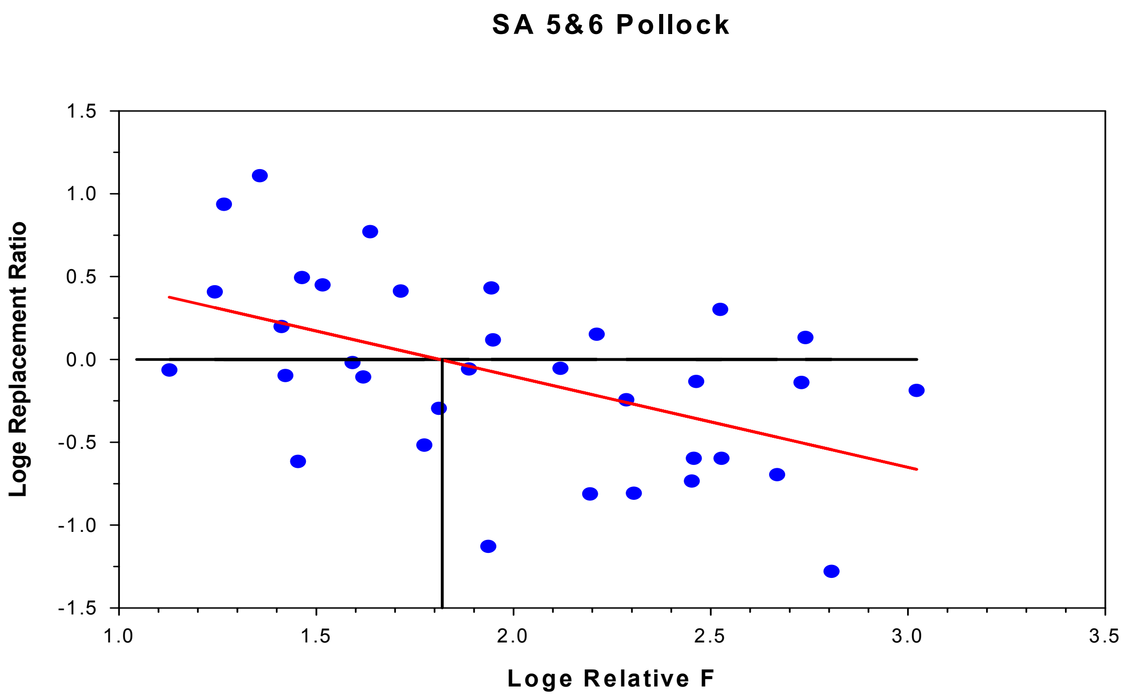

Figure L9. Relationship between the replacement ratio and relative F for pollock in Subareas 5 and 6, 1963-2001.

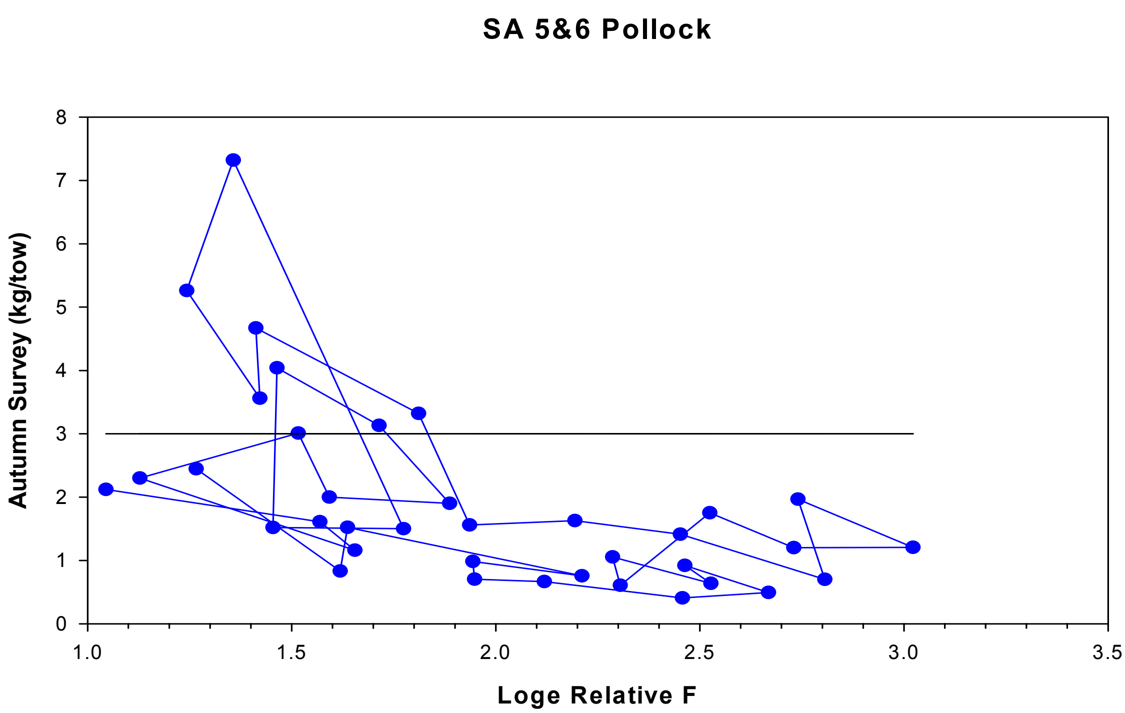

Figure L10. Relationship between the NEFSC autumn survey biomass index and relative F for pollock in Subareas 5 and 6, 1963-2001.

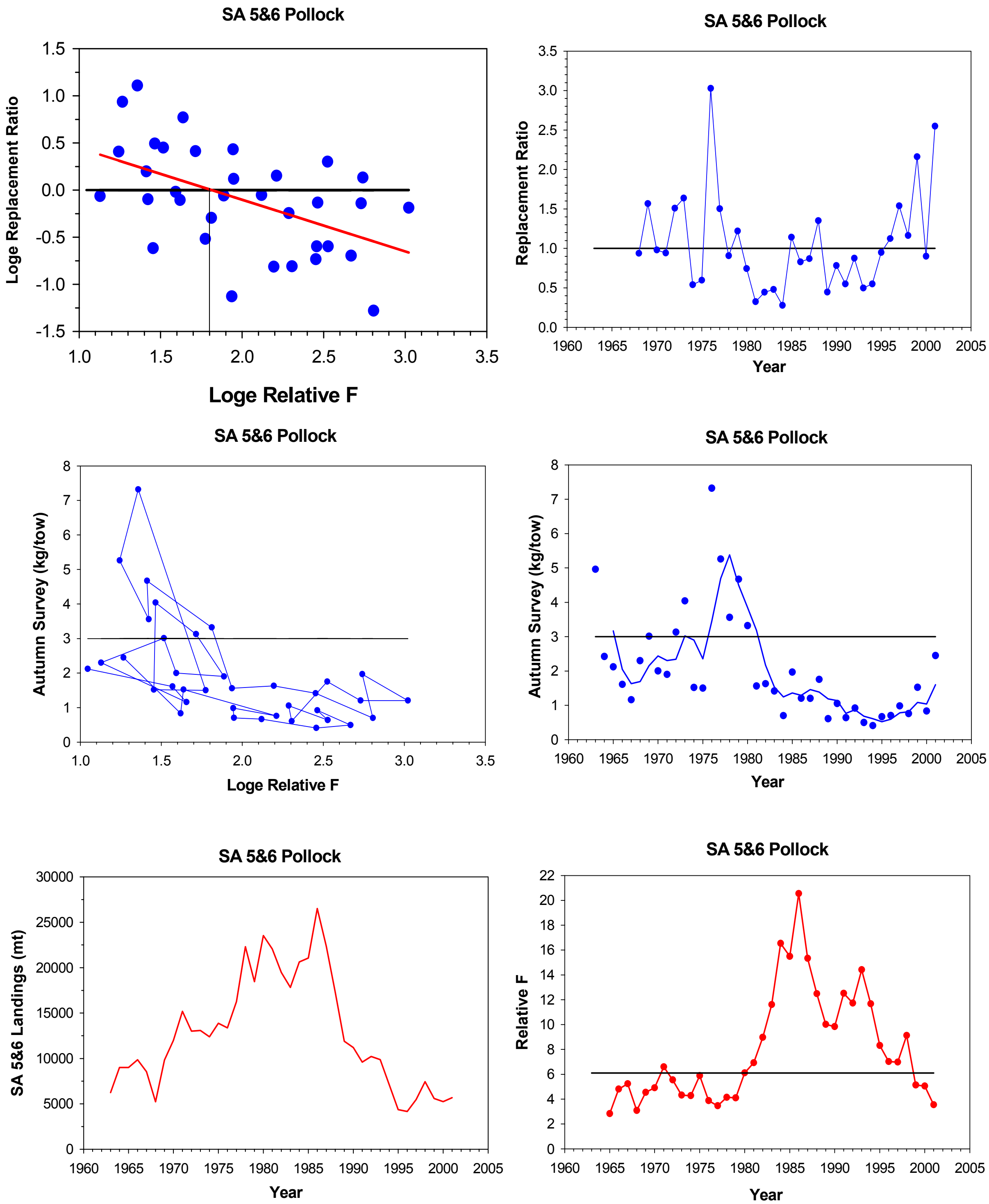

Figure L11. Six-panel plot illustrating relationships between landings, survey biomass indices, relative F, and replacement ratios for pollock in Subareas 5 and 6, 1963-2001.

M. Gulf of Maine-Georges Bank Acadian Redfish by **R.K. Mayo 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, and information on current biomass and fishing mortality relative to MSY-based reference points were also provided by the biomass dynamics model.

At that time, 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 assessment conducted in 2001 provided no basis with which to evaluate the state of the stock relative to the control rule as determined by the Overfishing Definition Review Panel (Anon. 1998).

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; Figure 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 the1980s, remaining below 1,000 mt per year since 1989, and at less than 500 mt per year since 1994. Total redfish landings in 2001 were 360 mt compared to 319 mt in 2000.

3.0 Research Survey Indices

Indices of relative biomass, derived from NEFSC autumn research vessel bottom trawl surveys, although variable, exhibited a steady decline between 1963 and 1982 (Table M2, Figure M2). 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 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. The autumn biomass index 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. 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.

4.0 Assessment Results

Since the assessment reviewed at SAW 33 was completed, no additional aging data have become available to allow an assessment update. Landings remained very low in 2001 and the 2001 NEFSC autumn survey biomass index remained similar to that of 2000, indicating no appreciable change in the exploitation rate since 2000. Therefore, the results from the 2001 assessment serve as the basis for the present assessment report.

Exploitation ratios (catch/survey biomass) suggest that fishing mortality has been very low since the mid-1980s compared to previous periods (Table M3; Figure M3). Estimates of fishing mortality derived from the age-structured dynamics model and the age-aggregated biomass model were similar (Mayo *et al.* 2002), both indicating that current fishing mortality is low relative to past decades and less than 5% of F_{MSY}. Spawning stock biomass has increased since the mid-1990s, and was estimated to be 119,600 mt in 2000 (Mayo *et al*. 2002) due, in large part, to strong recruitment from the early 1990s. When measured against the estimates of F_{MSY} and SSB_{MSY} provided in NEFSC (2002), the stock is not overfished, and overfishing is not occurring.

Given the continued extremely low landings of redfish relative to the recent increase in biomass, exploitation is now extremely low compared to the 1960s and 1970s (Table M3; Figure M3). 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 were 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.

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 yearclasses 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 20 year plus 1 mean generation time (31 years for Acadian redfish) to achieve rebuilding. This results in an $F_{rebuild}$ = 0.01.

6.0 GARM Panel Comments

A question was raised as to why the catches have not followed the increase in the survey biomass. The current mesh size is too large for the size of the fish which make up the bulk of the biomass. The fishery for redfish from the 1950s to the 1980s used a smaller mesh size for redfish trips (3"). Some fishers claim to be discarding but there do not appear to be any large discarding events in the data. There is no evidence of targeting at present. The market was lost when the stock declined.

The change in mesh size used in the fishery was a concern in the interpretation of exploitation ratios. Ratios of catch to total biomass indices may not be comparable under different mesh regimes because the change in the amount of exploitable biomass would produce different q's. This is probably not a direct concern because exploitation ratios are not the basis for the assessment and the overall conclusion would not change. For species in which larger fish make up the major portion of the catch, this may not be a problem, but it may be for smaller-sized species such as redfish.

There was a question as to whether the year classes from the 1990s may have been inshore of the survey at younger ages. This had not been the case in the past for other large year classes. The Massachusetts survey does occasionally catch small redfish.

Recommendations

- Compute survey biomass indices of exploitable biomass and utilize these for calculating exploitation ratios.
- Perform a more systematic analysis of the data to determine discard rates.

7.0 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.

8.0 References

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Table M1 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				
2000*	319		319				
2001*	360		360				

* Preliminary
CPUE and effort not calculated after 1989 due to sharp reduction in directed redfish trips .

Table M2 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. Wgt. (kg)	Avg. Length (cm)	OFFSHORE 2 Stratified Mean Catch per Tow Number	(kg)	Avg. Wgt. (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

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

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)	Biomass Index	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
2000	319	26.2	0.0122
2001	360	28.2	0.0128

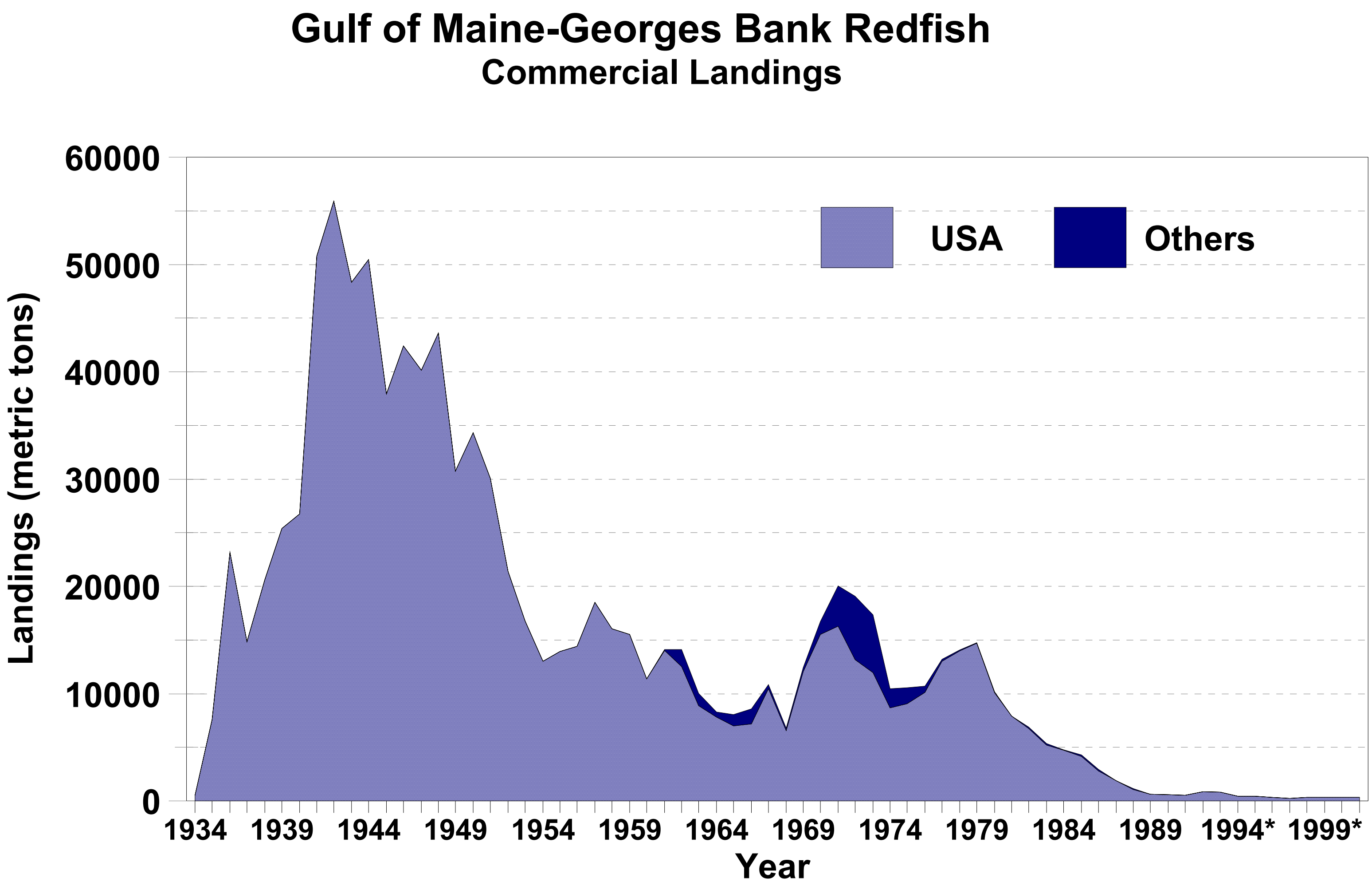

Figure M1. Total commercial landings of Acadian redfish from the Gulf of Maine-Georges Bank region, 1934-2001

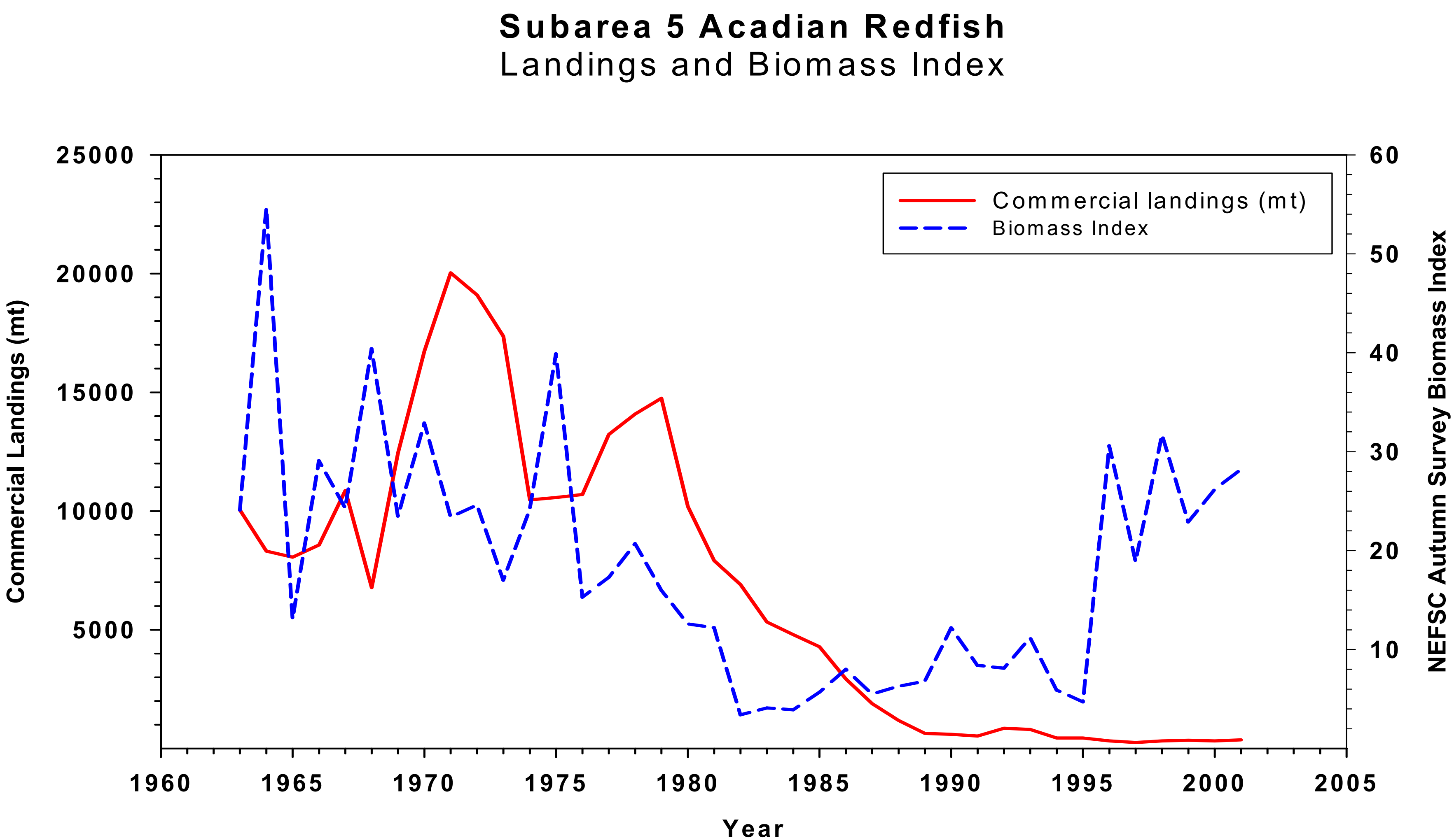

Figure M2. Commercial landings and biomass index derived from NEFSC autumn survey biomass indices for Acadian redfish, 1963-2001.

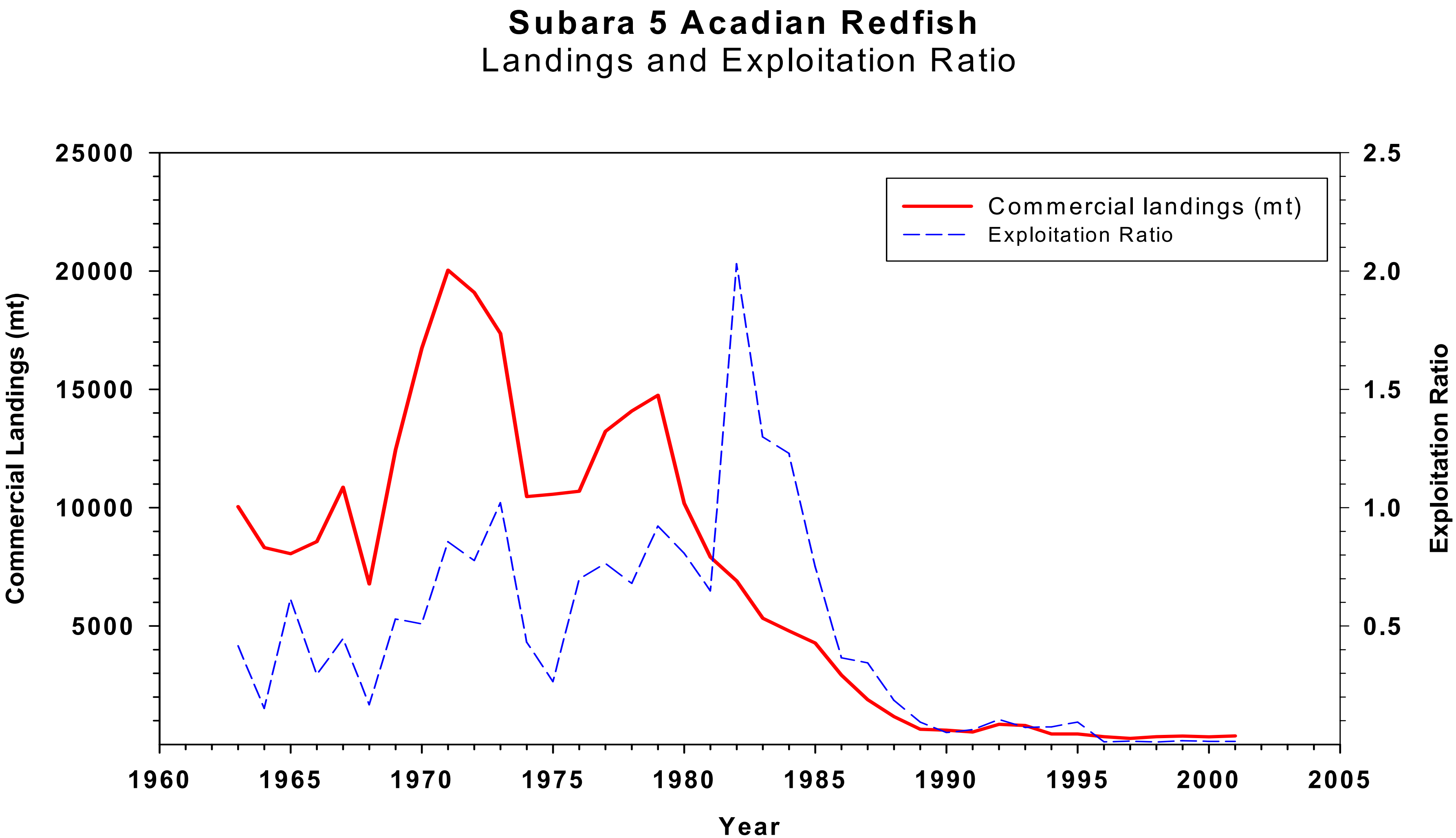

Figure M3. Commercial landings and exploitation ratios derived from NEFSC autumn survey biomass indices for Acadian redfish.

N. Ocean Pout by S.E. Wigley

1.0 Background

Ocean pout, *Macrozoarces americanus*, are assessed as a unit stock from Cape Cod Bay south to Delaware. An index assessment for this species was last reviewed at SAW 11 in 1990 (NEFSC 1990). The status of this stock was most recently evaluated in 2000 (NEFSC 2001). At that time, the three year average spring biomass index (1997-1999 average = 1.98 kg/tow) was approximately 40% of the current B_{msy} proxy (1980-1991 median = 4.9 kg/tow) and below the biomass threshold (½ Bmsy = 2.4 kg/tow). Ocean pout are included in the New England Fishery Management Council's Multispecies Fishery Management Plan under the "nonregulated multispecies" category.

2.0 The Fishery

From 1964 to 1974, an industrial fishery developed for ocean pout, and nominal catches by the U.S. fleet averaged 4,700 mt. Distant-water fleets began harvesting ocean pout in large quantities in 1966, and total nominal catches peaked at 27,000 mt in 1969. Foreign catches declined substantially afterward, and none have been reported since 1974 (Table N1, Figure N1). United States landings declined to an average of 600 mt annually during 1975 to 1983. Catches increased in 1984 and 1985 to 1,300 mt and 1,500 mt respectively, due to the development of a small directed fishery in Cape Cod Bay supplying the fresh fillet market. Landings have declined more or less continually since 1987. In recent years, landings from the southern New England/Mid-Atlantic area have continued to dominate the catch, reversing landing patterns observed in 1986-1987, when the Cape Cod Bay fishery was dominant. The shift in landings is attributed to the changes in management (gear/mesh) regulations. Total landings in 2001 were only 18 mt, a near-record low in the time series (Table N1, Figure N1).

3.0 Research Survey Indices

Commercial landings and the NEFSC spring research vessel survey biomass index followed similar trends during 1968 to 1975 (encompassing peak levels of foreign fishing and the domestic industrial fishery); both declined from very high values in 1968-1969 to lows of 300 mt and 1.3 kg per tow, respectively, in 1975. Between 1975 and 1985, survey indices increased to record high levels, peaking in 1981 and 1985. Since 1985, survey catch per tow indices have generally declined, and are presently below than the long-term survey average (3.5 kg per tow); the 2001 spring survey index was 2.8 kg per tow (Table N2, Figure N1). Both NEFSC winter survey and the Massachusetts Division of Marine Fisheries inshore research vessel surveys confirm the declining trend observed in the NEFSC spring survey.

4.0 Exploitation Indices

Annual relative exploitation ratios (landings/NEFSC spring survey biomass index) have declined sharply from a peak in 1973 to low levels in the early 1980s then increased slightly in the late-1980s, after which they declined to record low levels (Table N3, Figure N2). The 2001 exploitation index (0.007) was the lowest in the time series and well below the Fmsy proxy (0.31), derived as the MSY proxy (1,500 mt) divided by the Bmsy proxy. Since discards have not been estimated, and landings, not total catch, were used to derive exploitation ratios, the exploitation ratios may be under estimated.

5.0 Assessment Results

The index assessment presented above reveals that landings, survey and exploitation ratios trends have remained stable. No substantial change in stock status has occurred since the last assessment.

For ocean pout, the replacement ratio and relative F analyses were not sufficiently informative for estimating Bmsy, Fmsy, and MSY (NEFSC 2002). Thus, the biological reference points for ocean pout remain based upon research vessel survey biomass trends and the exploitation history (Applegate et al. 1998). MSY was chosen to be 1,500 mt and the Bmsy proxy was determined as the median survey index from 1980-1991 (4.9 kg/tow). The minimum biomass threshold is ½ of the Bmsy proxy (2.4 kg/tow). Given these proxies, the threshold Fmsy is 0.31 (1.5/4.9).

To evaluate stock conditions, the three year average of NEFSC spring survey indices and the exploitation ratio (2001 landings/ average of 1999, 2000, 2001 spring survey biomass indices) were used as proxies for biomass and fishing mortality, respectively. In 2001, the three year average survey index (2.46 kg/tow) indicates that biomass is slightly above 1/2Bmsy and the exploitation ratio (0.007) indicates F is below the F threshold (Figure N3). Thus, the ocean pout population was not overfished and overfishing did not occur in 2001.

Since the ocean pout fishery occurs primarily in the spring it is possible to evaluate the stock condition for 2002. Using the NEFSC 2002 spring survey (2.026 kg/tow), the 3 year average spring biomass index (2.28 kg/tow) is below ½ Bmsy. Using preliminary 2002 landings (9 mt), the 2002 exploitation ratio (0.004) remains below the F threshold. Thus, the preliminary evaluation for 2002 is that the ocean pout population is overfished and overfishing is not occurring.

Sensitivity analyses

Sensitivity analyses were conducted by deriving exploitation ratios from NEFSC spring biomass indices which were arbitrarily increased by 10%, 25% and 100% (Figure N3). Results are summarized in Section 5.2 (Summary of Assessment Advice).

6.0 GARM Comments

The discussion centered around the conclusion that the stock was defined as overfished despite minimal landings for two decades. Although landings have been low perhaps due to mesh size regulations, the possibility exists that significant numbers are discarded in other fisheries. The panel noted that the landings to survey ratio has not accounted for the changes in commercial catchability which has occurred over time due to changes in mesh regulation. Declining trends in the NEFSC spring biomass correspond with the declining biomass trends observed in the Massachusetts inshore survey. It was noted that any inflation of the NEFSC index to account for potential gear problems would only create a mis-match between these series.

A preliminary examination of length frequency data from the NEFSC spring survey series revealed little change in the minimum and maximum size over time. The GARM suggested further exploration of the size distribution for evidence of changing stock demographics given the stock decline over time.

7.0 Sources of Uncertainty

- The size composition of the commercial landings could not be characterized, due to the lack of commercial length samples.

- Discards have not been estimated, only landings were used to derive exploitation ratios instead of total catch. Therefore, exploitation ratios may be underestimated.

Research Recommendations

- Explore various data sources to estimate the magnitude of discarding in fisheries which may impact the ocean pout population (e.g. scallop fishery).

- Explore computing survey biomass indices of exploitable biomass and utilize these for calculating exploitation ratios.

- Examine demographic data for changes over time.

- Initiate biological studies to update basic life history information.

8.0 References

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Table N1. Commercial landings (mt, live) of ocean pout from the Gulf of Maine-Mid-Atlantic region (NAFO Subarea 5 and 6), 1962-2002.

	USA				
Year	5	6	Total	Other	Total
1962	0	0	0	0	0
1963	20	0	20	0	20
1964	2123	0	2123	0	2123
1965	877	0	877	0	877
1966	7149	0	7149	6231	13380
1967	7090	0	7090	271	7361
1968	8373	364	8737	4324	13061
1969	5571	966	6537	20435	26972
1970	5851	426	6277	895	7172
1971	2678	1448	4126	1784	5910
1972	1927	358	2285	1066	3351
1973	2810	285	3095	2275	5370
1974	2790	459	3249	483	3732
1975	209	65	274	3	277
1976	341	337	678	0	678
1977	809	250	1059	0	1059
1978	715	320	1035	0	1035
1979	658	14	672	0	672
1980	339	11	350	0	350
1981	234	17	251	0	251
1982	317	4	321	0	321
1983	408	0	408	0	408
1984	1324	0	1324	0	1324
1985	1450	54	1504	0	1504
1986	801	1	802	0	802
1987	2111	74	2185	0	2185
1988	1765	46	1811	0	1811
1989	1308	6	1314	0	1314
1990	1299	13	1312	0	1312
1991	1361	63	1424	0	1424
1992	406	68	474	0	474
1993	217	15	232	0	232
1994	137	59	196	0	196
1995	51	14	65	0	65
1996	22	29	51	0	51
1997	8	25	33	0	33
1998	8	9	17	0	17
1999	8	10	18	0	18
2000	8	11	19	0	19
2001	9	9	18	0	18
2002*	2	7	9	0	9

1994-1999 spatial patterns are based upon Vessel Trip Report data.
* preliminary.

Table N2. Stratified mean catch per tow in weight and numbers, mean length and individual average fish weight of ocean pout in NEFSC spring surveys, in the Gulf of Maine-Mid-Atlantic region (strata 1-26,73-76), 1968-2002.

Year	Mean weight (kg) per tow	Mean number per tow	Mean Length (cm)	Individual average weight (kg)
1968	5.366	6.766	51.1	0.793
1969	6.154	8.629	49.3	0.713
1970	5.180	6.133	51.9	0.845
1971	2.183	3.135	50.2	0.696
1972	4.453	5.090	51.6	0.875
1973	3.373	4.591	48.8	0.735
1974	1.479	2.310	47.0	0.640
1975	1.293	1.358	53.4	0.952
1976	1.400	2.440	46.5	0.574
1977	3.605	6.366	44.8	0.566
1978	3.371	11.831	31.6	0.285
1979	1.493	5.197	34.7	0.287
1980	5.729	11.837	42.6	0.484
1981	7.605	14.131	42.7	0.538
1982	4.743	8.690	44.0	0.546
1983	4.236	5.076	50.5	0.835
1984	5.540	7.275	50.0	0.762
1985	6.494	9.011	48.7	0.721
1986	6.345	6.995	53.0	0.907
1987	2.705	3.076	51.7	0.879
1988	3.244	5.405	45.0	0.600
1989	2.792	5.323	44.0	0.525
1990	5.074	6.369	50.3	0.797
1991	3.783	5.596	49.7	0.676
1992	2.257	2.639	52.9	0.855
1993	3.084	3.546	53.4	0.870
1994	2.309	2.639	54.3	0.875
1995	1.916	2.525	50.5	0.759
1996	2.058	3.127	47.6	0.658
1997	1.632	2.069	52.4	0.789
1998	1.733	2.957	46.1	0.586
1999	2.561	3.340	50.2	0.767
2000	2.016	3.113	48.2	0.648
2001	2.801	3.748	51.6	0.747
2002	2.026	2.809	51.3	0.721

Table N3. Annual relative exploitation ratios (annual landings /spring survey biomass indices) and relative exploitation ratios used in stock status (annual landings/ 3year average spring biomass indices) for ocean pout, 1968-2002.

Year	Annual relative exploitation rate (landings/spring index)	Relative exploitation ratio (landings/ 3 yr avg spring index)
1968	2.434	
1969	4.383	
1970	1.385	1.2884
1971	2.249	1.0897
1972	0.753	0.8508
1973	1.592	1.6096
1974	2.523	1.2032
1975	0.214	0.1352
1976	0.484	0.4875
1977	0.294	0.5044
1978	0.307	0.3707
1979	0.450	0.2380
1980	0.061	0.0991
1981	0.033	0.0508
1982	0.068	0.0533
1983	0.096	0.0738
1984	0.239	0.2736
1985	0.232	0.2773
1986	0.126	0.1309
1987	0.808	0.4217
1988	0.558	0.4419
1989	0.468	0.4482
1990	0.259	0.3543
1991	0.376	0.3667
1992	0.210	0.1280
1993	0.075	0.0763
1994	0.085	0.0770
1995	0.034	0.0268
1996	0.025	0.0244
1997	0.021	0.0180
1998	0.010	0.0097
1999	0.007	0.0086
2000	0.009	0.0089
2001	0.006	0.0071
2002	0.004	0.0039

Note: preliminary 2002 landings used.

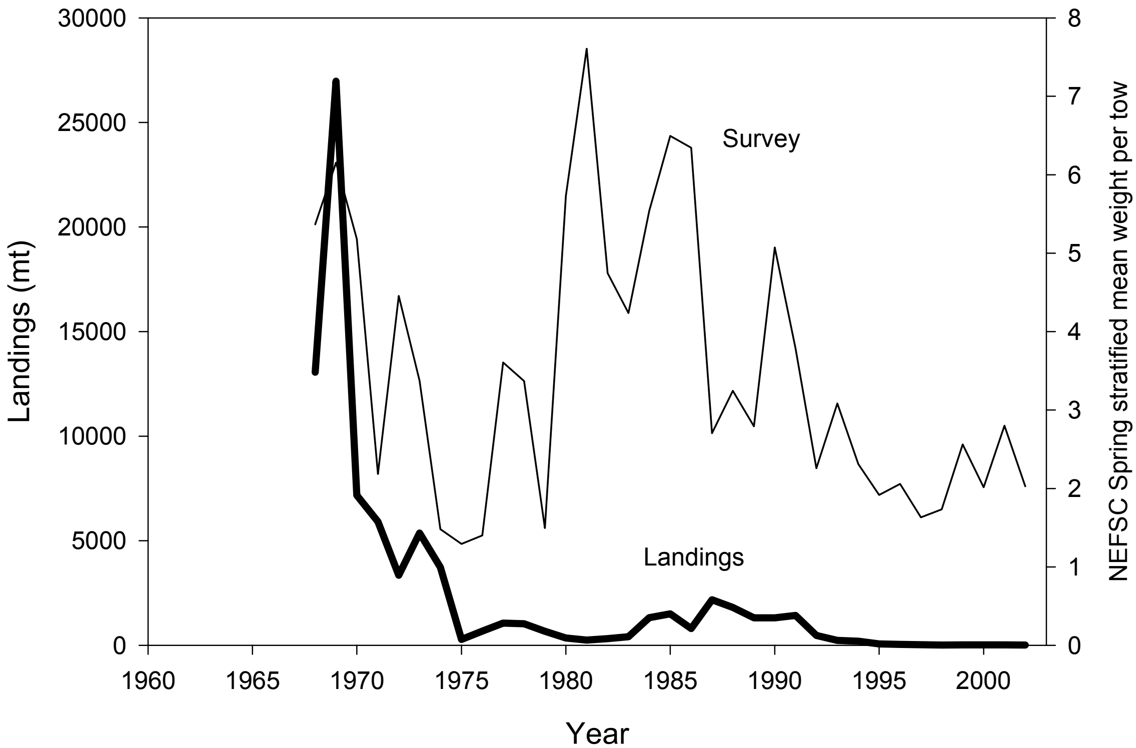


Figure N1. Trends in landings (mt) and NEFSC spring survey biomass (kg/tow) for ocean pout, 1968 - 2002.

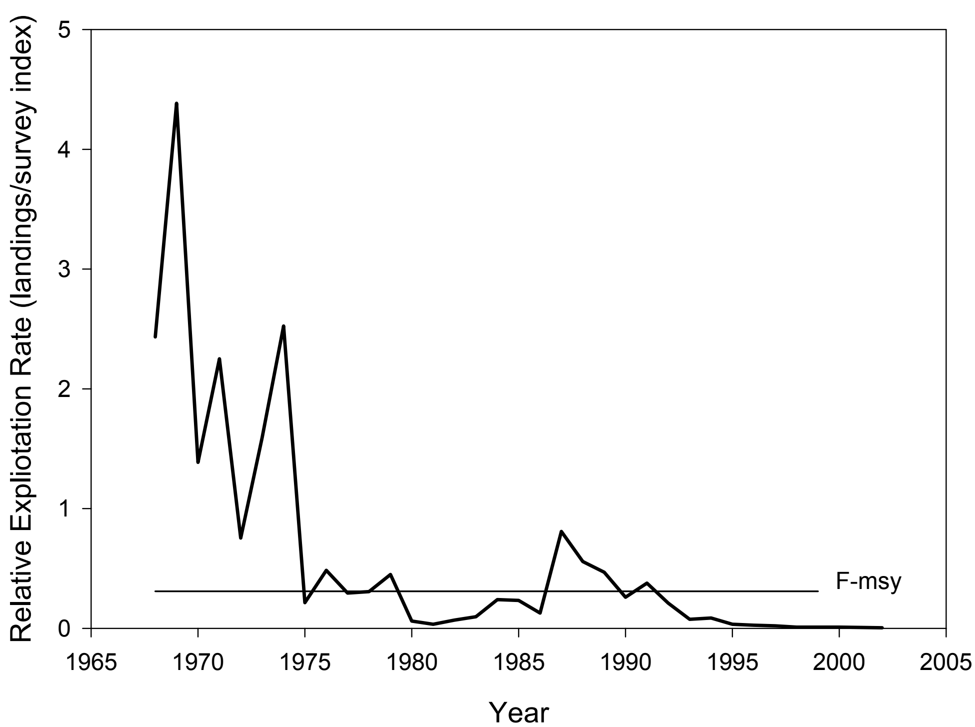


Figure N2.
Exploitation indices (landings/spring biomass index) for ocean pout, 1970 - 2002.

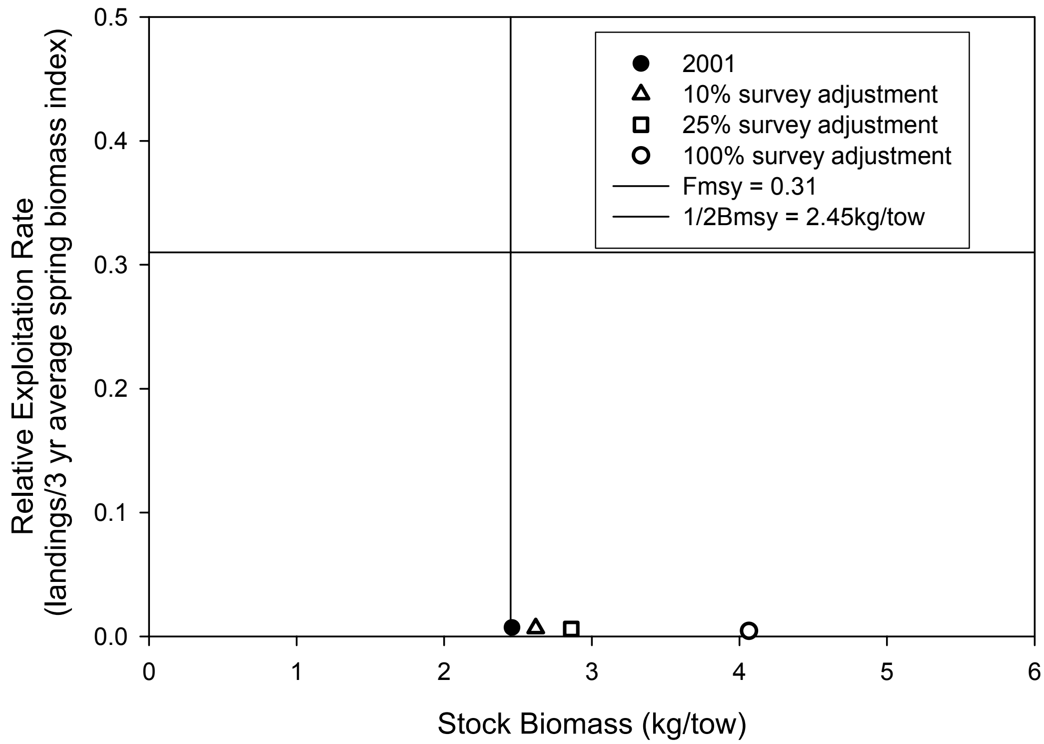


Figure N3. Ocean pout stock status in 2001 and three sensitivity analyses in which NEFSC spring survey biomass was arbitrarily adjusted by 10%, 25% and 100%.

O. Windowpane Flounder (Gulf of Maine-Georges Bank) by Lisa Hendrickson

1.0 Background

No stock structure information is available for windowpane flounder. However, the assessment assumes two stock areas (Georges Bank and Southern New England) based on apparent differences in growth, sexual maturity, and abundance trends. Landings from the Gulf of Maine are low, so that area is combined with Georges Bank.

The northern windowpane flounder stock, which includes the Gulf of Maine and Georges Bank regions (GOM-GB), has never been formally assessed as part of the SAW/SARC process. The following index-based assessment is an update of the last report on stock status (NEFSC 2001) and a re-evaluation of the overfishing definition (NEFSC 2002).

2.0 Assessment Results

2.1 The Fishery

Windowpane landings were first recorded in 1975. During most years, the GOM-GB stock has comprised a higher proportion of the total landings than the SNE-MAB stock. Following a 1991 record high of 2,900 mt, landings declined sharply to 300 mt in 1994 (Table O1 and Figure O1). High landings during the early 1990s probably reflected an expansion of the fishery to offshore areas, as well as the targeting of windowpane flounder as an alternative to depleted groundfish stocks. Landings declined from 700 mt in 1996 to a record low of 44 mt in 2001.

Discarding of windowpane has not been quantified, so discards were not included in the calculation of exploitation indices.

2.2 Research Survey Indices

Biomass indices of GOM-GB windowpane flounder from the NEFSC autumn bottom trawl surveys (1963-2001) are presented in Table O1 and Figure O2. Survey biomass indices are highly variable, but indicate a declining trend following a time series peak in 1984 and an increasing trend after 1991. The large increase in the 1998 survey index is primarily attributable to a large catch of windowpane at one station.

2.3 Biological Reference Points

Biological reference points for GOM-GB windowpane flounder were derived from survey-based proxies of biomass and exploitation rates and are based on an ASPIC-based MSY estimate of 1,000 mt. The threshold F is defined as an F_{MSY} proxy (= 1.11) when the NEFSC autumn survey index is greater than 0.94 kg/tow (equal to a B_{MSY} proxy) and declines linearly to zero at 50% of the B_{MSY} proxy (= 0.47 kg/tow). The target exploitation index is defined as 60% of the F_{MSY} proxy (= 0.67) when the autumn survey index is greater than 0.94 kg/tow and declines linearly to zero at 0.47 kg/tow.

2.4 Relative Exploitation Rates and Stock Status

Relative exploitation rates (landings/NEFSC autumn survey biomass index) have been declining since reaching a peak in 1991 (Table O1 and Figure O3) and were below the F_{MSY} proxy (=1.11) during 1997-2001. The 1999-2001 autumn survey mean biomass index equals 0.79 kg/tow and the 1999-2001 mean exploitation index (landings/NEFSC autumn survey biomass index) equals 0.10 (Table O3 and Figure O2). Overfishing was not occurring and the stock was not overfished in 2001.

3.0 Sources of Uncertainty

* Stock structure is uncertain.

* Discarding is not quantified and may represent a sizable fraction of the multi-species catches given recent groundfish retention restrictions.

* Vessel trip reports have been used to prorate the landings since 1995, and a fraction of the landings from Southern New England may have been reported as Georges Bank landings or vice versa.

4.0 Literature Cited

NEFSC (Northeast Fisheries Science Center). 2002. Final report of the working group on reevaluation of biological reference points for New England groundfish. 231 p.

NEFSC (Northeast Fisheries Science Center). 2001. Assessment of 19 Northeast groundfish stocks through 2000; a report to the New England Fishery Management Council's Multi-species Monitoring Committee. Northern and Southern Demersal Working Groups, Northeast Stock Assessment Workshop. *Northeast Fish. Sci. Cent. Ref. Doc.* 01-20;
217 p.

Table O1. Landings (mt), NEFSC autumn survey biomass indices (stratified mean kg per tow, offshore strata 13-29 and 37-40), and exploitation indices (landings/autumn survey biomass index) for Gulf of Maine-Georges Bank windowpane flounder during 1963-2001. Landings include Statistical Areas beginning with 51 and 52, with the exception of 526, 530-539 and 541.

Year	Landings[1] (mt)	Biomass Indices (kg per tow)	Exploitation Indices (landings/biomass index)
1963		0.24	
1964		0.10	
1965		0.17	
1966		0.48	
1967		0.52	
1968		0.26	
1969		0.64	
1970		0.19	
1971		0.16	
1972		0.57	
1973		1.53	
1974		0.82	
1975	1,300	0.39	3.38
1976	1,516	1.17	1.30
1977	1,099	1.56	0.71
1978	923	1.15	0.80
1979	856	0.73	1.18
1980	408	0.63	0.65
1981	413	0.79	0.52
1982	411	0.49	0.83
1983	460	0.55	0.84
1984	743	2.14	0.35
1985	2,141	0.94	2.29
1986	1,842	1.11	1.67
1987	1,396	0.65	2.16
1988	1,377	0.65	2.12
1989	1,577	0.41	3.81
1990	1,078	1.13	0.96
1991	2,862	0.17	16.74
1992	1,519	0.38	4.01
1993	1,212	0.62	1.96
1994	300	0.31	0.97
1995	700	0.80	0.87
1996	700	0.50	1.40
1997	418	0.43	0.96
1998	396	1.66	0.24
1999	46	0.73	0.06
2000	142	0.73	0.20
2001	44	0.92	0.05

[1] Landings from 1995-2001were prorated based on Vessel Trip Reports.

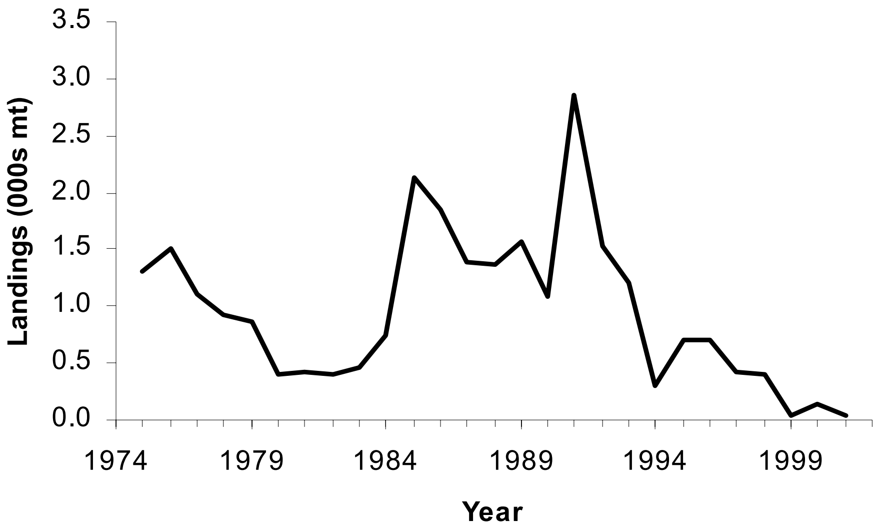


Figure O1. Commercial landings of Gulf of Maine-Georges Bank windowpane flounder during 1975-2001.

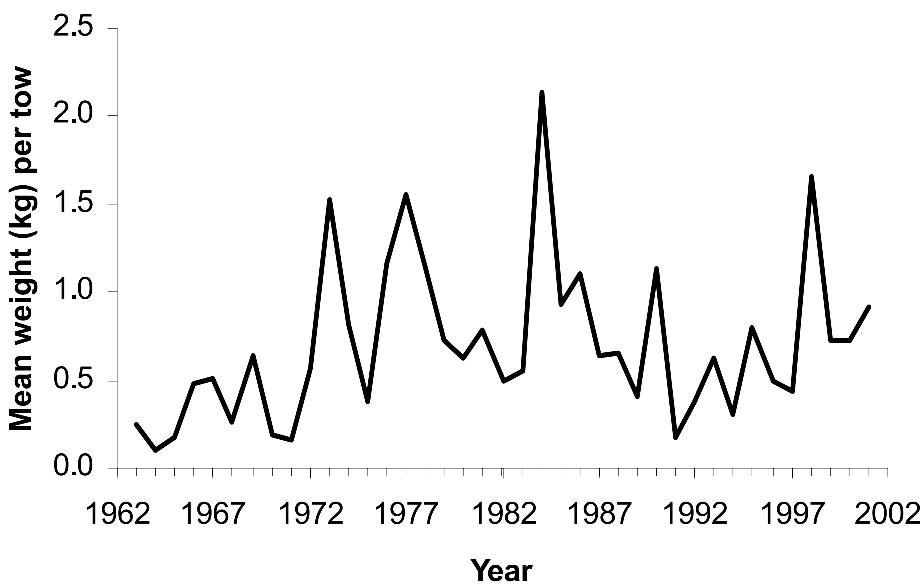


Figure O2. Relative biomass indices (stratified mean kg per tow) for Gulf of Maine-Georges Bank windowpane flounder from the NEFSC autumn bottom trawl surveys during 1963-2001.

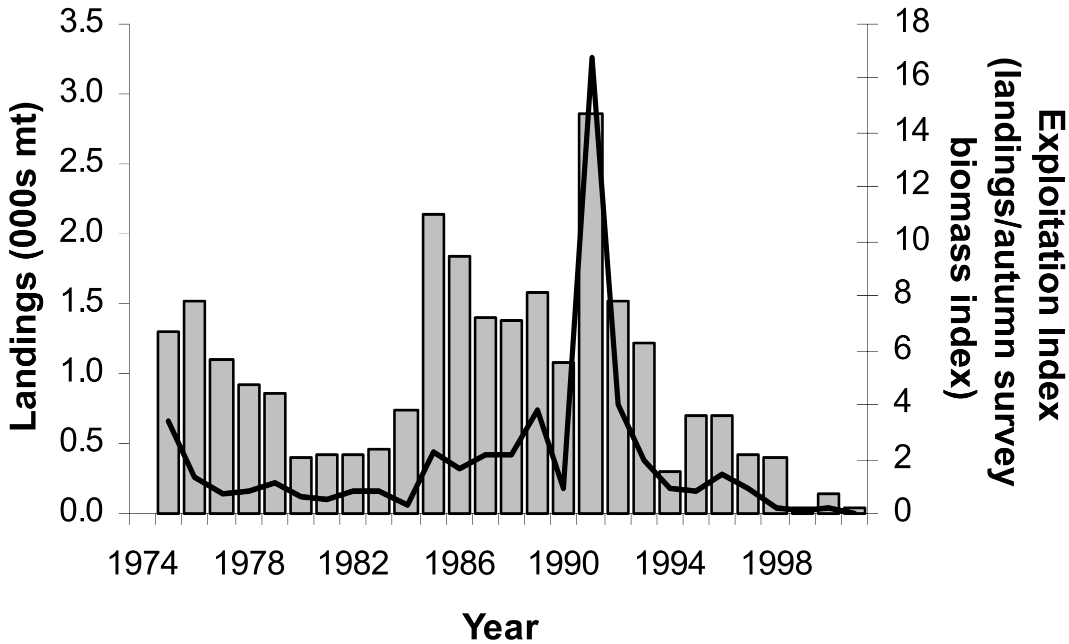


Figure O3. Relative exploitation indices (landings/autumn survey biomass indices) and landings (mt) of Gulf of Maine-Georges Bank windowpane flounder during 1975-2001.

P. Windowpane Flounder (Southern New England-Mid-Atlantic Bight)
by Lisa Hendrickson

1.0 Background

No stock structure information is available. Therefore, a provisional arrangement has been adopted that recognizes two stock areas based on apparent differences in growth, sexual maturity, and abundance trends between fish from Georges Bank and from Southern New England. The proportion of total landings contributed by the Mid-Atlantic area is low, so data from that area are combined with those from Southern New England.

The southern windowpane flounder stock, which includes the southern New England and Mid-Atlantic Bight regions (SNE-MAB), has never been formally assessed as part of the SAW/SARC process. The following index-based assessment is an update of the last report on stock status (NEFSC 2001) and a re-evaluation of the overfishing definition (NEFSC 2002).

2.0 Assessment Results

2.1 The Fishery

Windowpane landings were first recorded in 1975. During most years, the GOM-GB stock has comprised a higher proportion of the total landings than the SNE-MAB stock. However, SNE-MAB landings exceeded those from the Gulf of Maine-Georges Bank stock during 1980-1984, 1999 and 2001 (Table P1 and Figure P1). Landings declined rapidly during 1985-1995, from a peak of 2,100 mt to a record low of 100 mt, respectively. During 1996-2000, landings stabilized at the lowest levels observed in the time series, ranging between 100 mt and 200 mt. Landings in 2001 were 112 mt.

Discarding of windowpane has not been quantified, so discards were not included in the calculation of exploitation indices.

2.2 Research Survey Indices

Relative biomass indices, stratified mean weight (kg) per tow, of SNE-MAB windowpane flounder from the NEFSC autumn (1963-2001) bottom trawl surveys are presented in Table P1 and Figure P2. Biomass indices are highly variable, but indicate a declining trend during 1982-1993 followed by stable, but low biomass levels during 1994-2000 and a slight increase in 2001.

2.3 Biological Reference Points

Biological reference points for SNE-MAB windowpane flounder that were adopted in Amendment 9 were derived from survey-based proxies of biomass and exploitation and based on an ASPIC-based MSY estimate of 900 mt. The overfishing definition was subsequently revised based on a stock replacement ratio analysis, but target reference points were not revised (NEFSC 2002). The threshold F is defined as an F_{MSY} proxy (= 0.98) when the NEFSC autumn survey index is greater than 0.92 kg/tow (equal to a B_{MSY} proxy) and declines linearly to zero at 50% of the B_{MSY} proxy (= 0.46 kg/tow).

2.4 Relative Exploitation Rates and Stock Status

Relative exploitation rates (landings/NEFSC autumn survey biomass index) declined sharply after reaching a peak in 1993 (Table P1 and Figure P3) and were below the F_{MSY} proxy (= 0.98) during 1994-2001. The 1999-2001 autumn survey mean biomass index equals 0.21 kg/tow and the 1999-2001 mean exploitation index (landings/NEFSC autumn survey biomass index) equals 0.69. Based on the biological reference points, overfishing is not occurring, but the stock is overfished. However, exploitation rates are based only on landings, and if unaccounted discarding is substantial, then the 1999-2001 average exploitation rate is underestimated.

3.0 Sources of Uncertainty

3.1 Stock structure is uncertain.

3.2 Discarding is not quantified and may represent a sizable fraction of the multi-species and sea scallop catches.

3.3 Vessel trip reports have been used to prorate the landings, since 1995, and a fraction of the landings from Southern New England may have been reported as Georges Bank landings or visa versa.

4.0 Literature Cited

Northeast Fisheries Science Center. 2002. Final report of the working group on re-evaluation of biological reference points for New England groundfish. 231 p.

Northeast Fisheries Science Center. 2001. Assessment of 19 Northeast groundfish stocks through 2000; a report to the New England Fishery Management Council's Multi-species Monitoring Committee. Northern and Southern Demersal Working Groups, Northeast Stock Assessment Workshop. *Northeast Fish. Sci. Cent. Ref. Doc.* 01-20; 217 p.

Table P1. Landings (mt), NEFSC autumn survey biomass indices (stratified mean kg per tow, offshore strata 1-12 and 61-76), and exploitation indices (landings/autumn survey biomass index) for Southern New England-Mid-Atlantic Bight windowpane flounder during 1963-2001. Landings include Statistical Areas beginning with 6, 526, 530-539 and 541.

Year	Landings[1] (mt)	Biomass Indices (kg per tow)	Exploitation Indices (landings/biomass index)
1963		1.99	
1964		0.87	
1965		0.78	
1966		1.11	
1967		0.81	
1968		0.90	
1969		0.37	
1970		0.31	
1971		0.40	
1972		0.57	
1973		0.58	
1974		0.26	
1975	681	0.14	4.76
1976	568	0.36	1.58
1977	647	0.54	1.21
1978	898	0.54	1.67
1979	633	0.76	0.83
1980	532	0.26	2.08
1981	883	0.52	1.70
1982	651	0.87	0.75
1983	798	0.37	2.17
1984	1,088	0.25	4.40
1985	2,065	0.62	3.34
1986	1,381	0.56	2.45
1987	887	0.44	2.02
1988	1,172	0.42	2.76
1989	1,121	0.09	12.18
1990	890	0.18	4.92
1991	817	0.41	2.02
1992	584	0.18	3.24
1993	469	0.03	15.14
1994	200	0.23	0.89
1995	100	0.20	0.50
1996	200	0.26	0.76
1997	7,107	0.13	0.84
1998	123	0.18	0.68
1999	116	0.12	1.00
2000	126	0.17	0.75
2001	112	0.34	0.33

[1] Landings from 1995-2001were prorated based on Vessel Trip Reports.

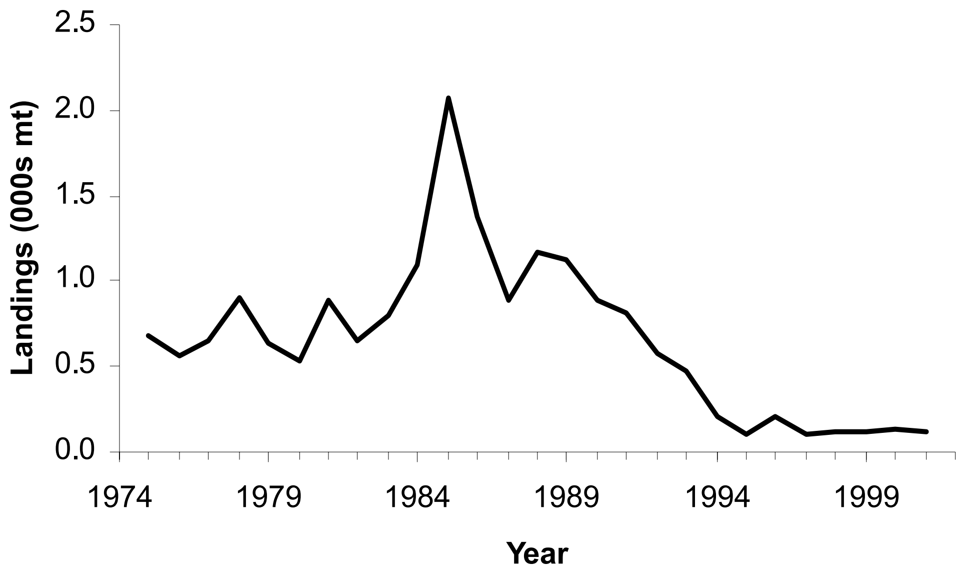


Figure P1. Landings of Southern New England-Mid-Atlantic Bight windowpane flounder during 1963-2001.

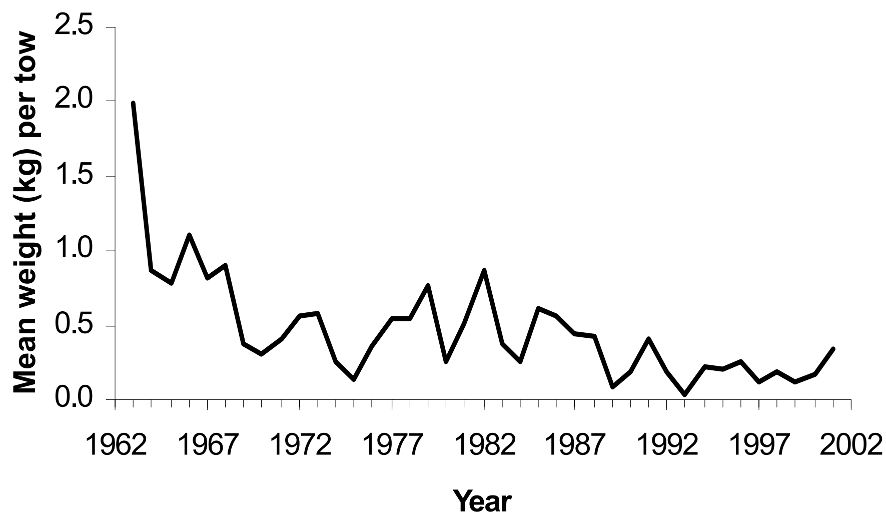


Figure P2. Relative biomass indices (stratified mean kg per tow) for Southern New England-Mid-Atlantic Bight windowpane flounder from the NEFSC autumn research vessel bottom trawl surveys (offshore strata 1-12 and 61-76) during 1963-2001.

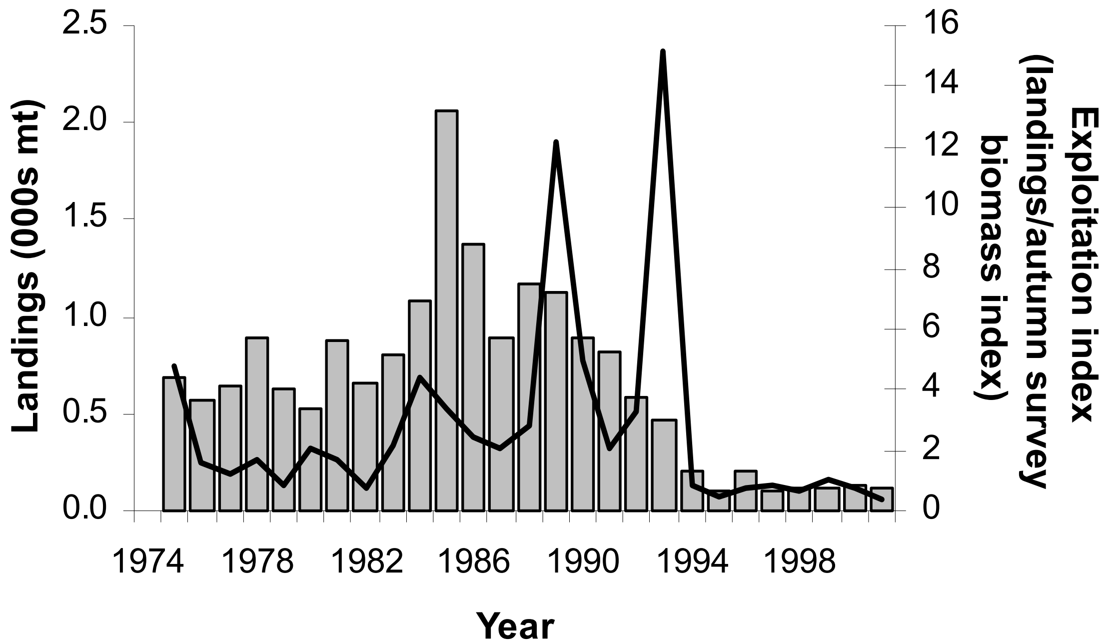


Figure P3. Relative exploitation indices (landings/autumn survey biomass indices) and landings (mt) of Southern New England-Mid-Atlantic Bight windowpane flounder during 1975-2001.

Q. MID ATLANTIC YELLOWTAIL FLOUNDER by Steve Cadrin

1.0 Background

The stock has been at relatively low abundance in recent years (Overholtz and Cadrin 1999, Cadrin 2001). This report updates catch through 2001 and survey indices through 2002. In August 2002, the Southern Demersal Working Group concluded that southern New England and Mid Atlantic yellowtail flounder should be assessed and managed as a single unit stock, and is concurrently preparing an assessment of the southern New England- Mid Atlantic yellowtail resource (SAW36 WP A6). In September 2002, the Working Group reviewed input data, analyses and projections in this report.

2.0 2002 Assessment

2.1 2000-2001 Landings

Recent landings (1994-1999) were prorated as described in the Georges Bank assessment (Cadrin et al. 1998; Table Q1; Figure Q1). Landings from Mid Atlantic yellowtail in 2001 (230 mt) was similar to landings in 2000.

2.3 1999-2002 Survey Indices

Survey abundance and biomass indices are reported in Table Q1. Estimates are from valid tows in the Mid-Atlantic area (offshore strata 1, 2, 69, 70, 73, 74), standardized according to net, vessel, and door changes (Cadrin et al. 1998). All survey indices of total biomass remained low (Figure Q2).

3.0 Assessment Results

The average fall biomass index for the last three years (1999-2001 average=0.21 kg/tow) is 2% of the B_{MSY} proxy (12.91 kg/tow) and well below the biomass threshold ($B_{MSY}/2$=6.46 kg/tow). The average exploitation index (landings/fall survey biomass index) for the last three years (2.17) is almost seven times greater than the F_{MSY} proxy (0.33).

Sensitivity to recent NEFSC survey observations was evaluated by increasing recent NEFSC survey observations by 10%, 25%, and 100% (Figure Q3). Results are summarized in Section 5.2 (Summary of Assessment Advice).

4.0 Sources of Uncertainty

- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.
- The Mid Atlantic yellowtail resource may not be self-sustaining and may be an extension of the southern New England stock.

5.0 GARM Discussion

The GARM agreed that the stock appears to be more overfished than the Southern New England stock. Results from combining the two stocks gives the same impression as the two parts separately.

The GARM recommends that ichthyoplankton surveys be processed. This data could be used in meta-population analysis with movement of recruits among stocks.

6.0 References

Cadrin, S.X. 2001. Mid-Atlantic yellowtail flounder. In Assessment of 19 Northeast Groundfish Stocks through 2000. Northeast Fisheries Science Center Reference Document 01-20: 190-194.

Cadrin, S.X., W.J. Overholtz, J.D. Neilson, S. Gavaris, and S. Wigley. 1998. Stock assessment of Georges Bank yellowtail flounder for 1997. NEFSC Ref. Doc. 98-06.

Overholtz, W. and S. Cadrin. 1998. Yellowtail flounder. In Status of the Fishery Resources off the Northeastern United States for 1998, S.H. Clark, editor. NOAA Tech. Mem. NMFS-NE-115: 70-74.

Table Q1. Survey indices, landings and exploitation indices of Mid-Atlantic yellowtail flounder.

	NEFSC fall		NEFSC spring		NEFSC winter		Landings	Exploitation
	#/tow	kg/tow	#/tow	kg/tow	#/tow	kg/tow	(k mt)	Index
1963*	35.17	11.45						
1964*	20.01	6.22					1.80	0.29
1965*	59.84	7.45					2.10	0.28
1966*	58.89	11.33					2.40	0.21
1967	67.81	11.93					5.30	0.44
1968	99.21	17.26	106.06	21.78			3.30	0.19
1969	55.33	12.61	83.69	17.67			4.60	0.36
1970	55.16	13.20	58.05	14.41			4.20	0.32
1971	32.91	4.84	44.54	10.10			7.90	1.63
1972	105.21	26.82	46.71	12.69			8.90	0.33
1973	10.05	2.40	39.16	11.76			5.10	2.13
1974	0.80	0.24	16.33	5.62			1.90	7.85
1975	1.06	0.21	2.20	0.90			0.70	3.41
1976	0.46	0.08	5.22	1.22			0.30	3.80
1977	1.75	0.23	8.91	2.26			0.60	2.58
1978	1.45	0.29	12.12	2.59			0.40	1.39
1979	1.27	0.26	2.94	0.77			0.50	1.95
1980	0.97	0.19	14.53	4.60			0.30	1.55
1981	22.81	3.04	34.13	8.16			0.70	0.23
1982	12.47	2.18	29.23	6.71			0.43	0.20
1983	2.31	0.47	16.56	4.27			0.59	1.26
1984	2.05	0.23	4.13	1.22			1.04	4.48
1985	1.71	0.19	5.06	1.37			0.15	0.79
1986	0.97	0.21	2.51	0.56			0.25	1.18
1987	0.15	0.01	0.65	0.23			0.17	11.52
1988	3.93	0.23	0.93	0.33			0.09	0.42
1989	7.16	1.16	10.18	1.65			0.40	0.34
1990	4.23	0.81	9.94	2.62			0.24	0.29
1991	0.37	0.13	6.90	2.08			0.21	1.67
1992	0.00	0.00	2.29	0.83	12.86	4.96	0.24	---
1993	0.58	0.09	0.45	0.19	4.19	1.87	0.17	1.90
1994	2.26	0.23	0.09	0.06	3.45	1.42	0.24	1.02
1995	0.08	0.03	1.30	0.28	13.50	2.73	0.02	0.71
1996	0.25	0.06	1.40	0.46	5.84	1.74	0.15	2.77
1997	0.83	0.21	1.14	0.43	12.26	4.52	0.54	2.59
1998	0.30	0.09	2.71	0.68	14.06	3.61	0.22	2.50
1999	2.03	0.50	1.39	0.59	1.75	3.74	0.47	0.95
2000	0.37	0.11	1.42	0.57	7.76	2.53	0.22	1.94
2001	0.07	0.02	0.26	0.16	4.72	2.08	0.23	14.64
Mean	17.24	3.51	16.86	4.11	8.04	2.92	1.50	2.17
3y mean		0.21		0.44		2.78		5.84

* not all strata sampled.

Figure Q1. Landings and exploitation index of Mid Atlantic yellowtail flounder.

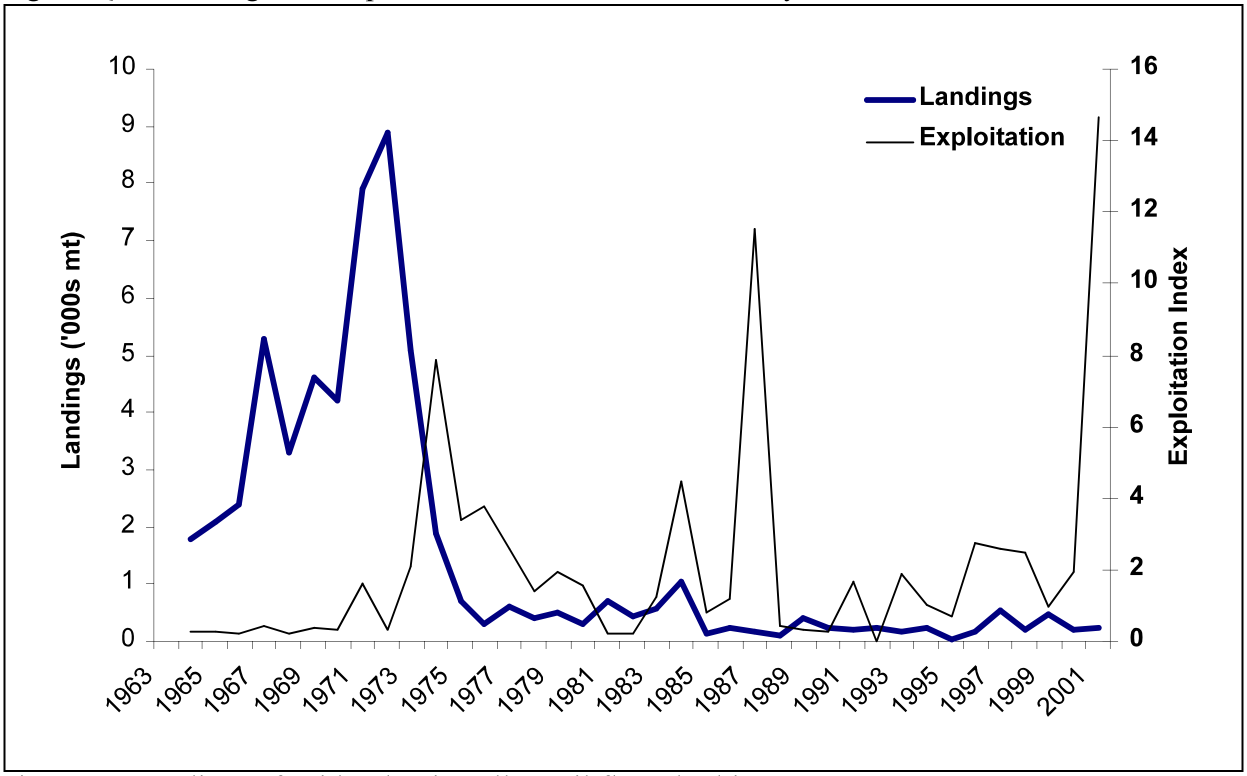


Figure Q2. Indices of Mid Atlantic yellowtail flounder biomass.

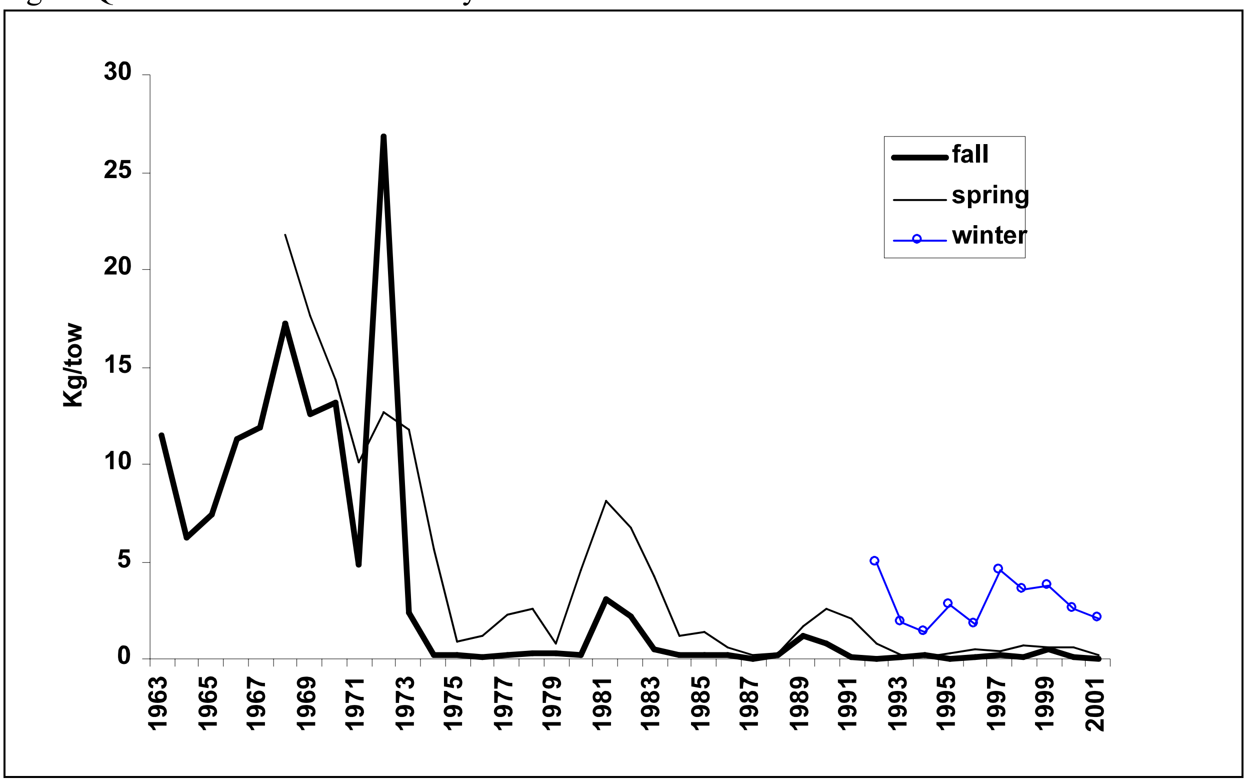
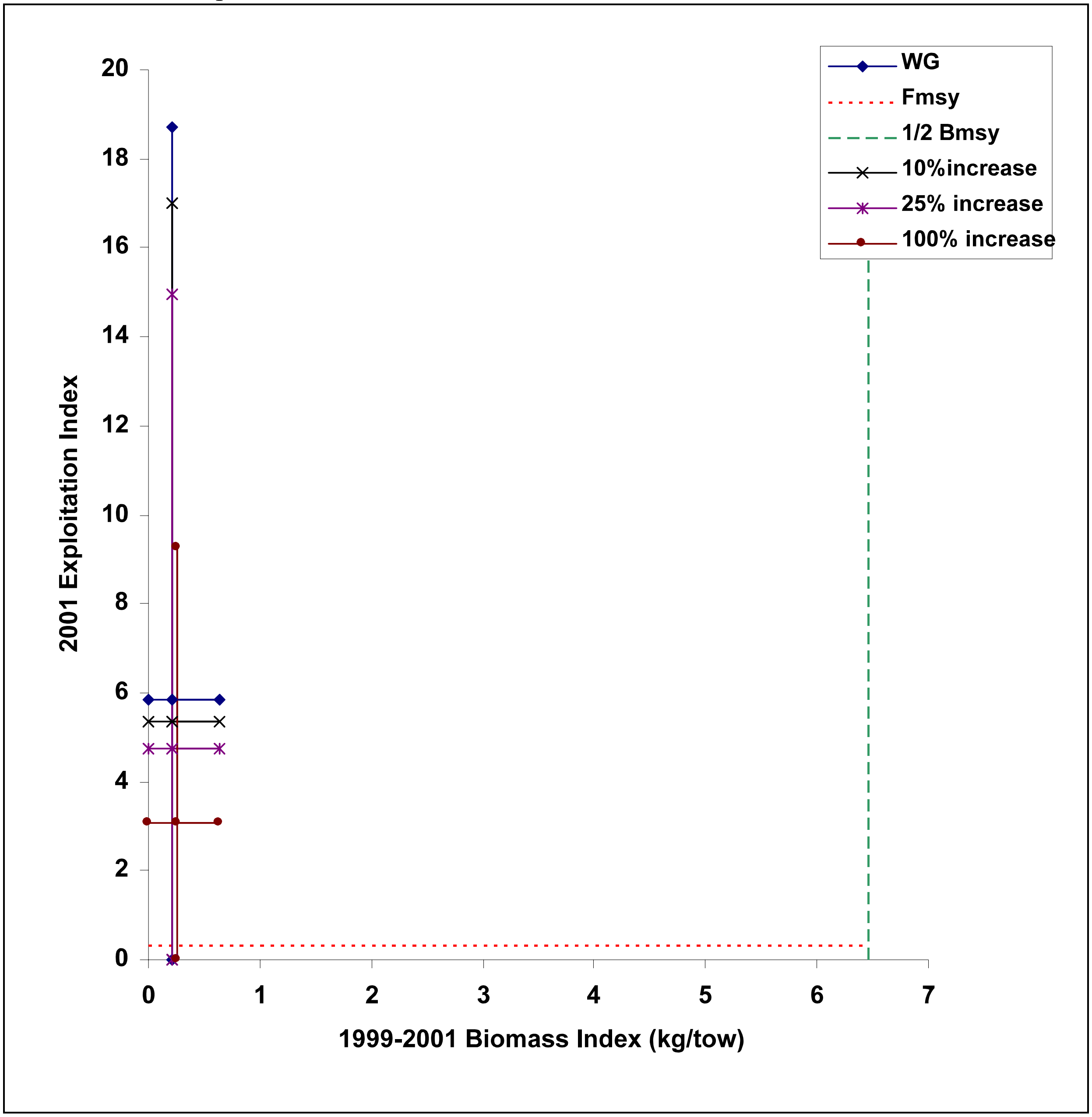


Figure Q3. Sensitivity of results to increasing NEFSC indices since 2000 by 10%, 25% and 100% (with 80% confidence intervals). Results accepted by the working group ("WG") are shown for comparison.



R. Gulf of Maine Haddock by Jon Brodziak and Michele Thompson

1.0 Background

The Gulf of Maine haddock stock was last assessed in 2001 by the Northern Demersal Working Group (NEFSC 2001). Research survey indices indicated that stock biomass was increasing. In this report, we update the Gulf of Maine haddock assessment using fishery data for 2001 and available survey data for 2001-2002. Updated survey biomass and exploitation rate indices are used for stock status determination.

2.0 Assessment for 2002

2.1 2001 Landings

US haddock landings were prorated into Georges Bank and Gulf of Maine stock components using a standard algorithm. US Gulf of Maine haddock commercial fishery landings totaled 1,190 mt in 2001, a 72% increase over 2000 (Table R1, Figure R1) and over 2.5 times the 1992-2000 average (451 mt). Despite the substantial increase, commercial landings in 2001 were still less than half of average landings during 1982-1991 (2,564 mt).

Provisional US recreational landings of Gulf of Maine haddock were extracted from MRFSS databases in 2001 (Scott Steinback, NEFSC, personal communication). Recreational landings totaled 203 mt in 2001, a 7% increase over 2000 landings and over three times average recreational landings since 1992 (Figure R1).

2.2 Survey Indices

US spring survey indices were computed for 2001-2002 (Table B2, Figure B2) and US autumn survey indices were computed for 2001 (Table B2, Figure B2) using standardized data.

3.0 Assessment Results

3.1 Index-Based Results

An updated index-based assessment was conducted. The 3-year average of the NEFSC autumn survey biomass constituted the stock biomass index, except for 1963-1964 where one- and two-year averages were used (Table R3). Commercial fishery landings were used as the catch (Table R3). Observed exploitation rate indices were computed as the catch divided by the observed survey biomass index in each year. Smoothed exploitation rate indices used for stock status determination were computed as the catch divided by the 3-year average stock biomass index (Table R3, Figure R3). The smoothed exploitation rate index in 2001 was 0.115, an increase of roughly 20% over the 2000 index (0.095) and one-half of the F_{MSY} proxy (0.23).

3.2 Sensitivity to Potential Trawl Warp Inconsistencies during 2000-2002

Measurements of NEFSC survey trawl warps in autumn 2002 suggested that right and left warps may have been offset by up to several feet during winter 2000 through spring 2002 surveys. To evaluate the sensitivity of index-based results to potential undercapture of fish, NEFSC autumn survey indices were arbitrarily adjusted upwards by 10%, 25%, and 100% for autumn 2000 and 2001. Results are summarized in Section 5.2 (Summary of Assessment Advice).

4.0 Sources of Uncertainty

- Recruitment dynamics of the Gulf of Maine and Georges Bank haddock stocks may be linked. The amount of interchange between stocks is a source of uncertainty.

5.0 Summary Stock Status

<u>Biological Reference Points</u>
For Gulf of Maine haddock, the stock biomass index (B_{MSY}) and the proxy exploitation rate index (F_{MSY}) to produce MSY are B_{MSY} = 22.17 kg/tow and F_{MSY} = 0.23 (NEFSC 2002). The overfished threshold ($B_{THRESHOLD}$) for Gulf of Maine haddock is $B_{THRESHOLD}$ = ½ B_{MSY} = 11.08 kg/tow. The overfishing threshold ($F_{THRESHOLD}$) for Gulf of Maine haddock is $F_{THRESHOLD}$ = F_{MSY} = 0.23.

<u>Stock Status in 2001</u>
In 2001, the stock biomass index was 10.31 kg/tow (93% of $B_{THRESHOLD}$ and 47% of B_{MSY}) with a standard error of 4.08 kg/tow. Based on the point estimate of the biomass index, the Gulf of Maine haddock stock was overfished in 2001. In 2001, the exploitation rate index was 0.115 (50% of $F_{THRESHOLD}$). Therefore, overfishing was not occurring on the Gulf of Maine haddock stock in 2001.

<u>Projections</u>
Projected catches to rebuild the Gulf of Maine stock were evaluated in spring 2002 (NEFSC 2002, Table 4.1.2). Projected catches for 2002-2009 were updated assuming a 10% annual increase in biomass from 2001 onwards with a constant exploitation rate index. Projected catches (rounded to the nearest 100 mt) were: 1,500 mt in 2002 and 2003; 1,700 mt in 2004; 1,800 mt in 2005; 2,000 mt in 2006; 2,200 mt in 2007; 2,500 mt in 2008; and 2,700 mt in 2009.

6.0 References

Northeast Fisheries Science Center. 2001. Assessment of 19 Northeast groundfish stocks through 2000. NEFSC Reference Document 01-20, Woods Hole, MA, 02543.

Northeast Fisheries Science Center. 2002. Final Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NEFSC Reference Document 02-04, Woods Hole, MA, 02543.

Table R1. Commercial landings (mt, live weight) of haddock from the Gulf of Maine (NAFO Division 5Y; U.S. statistical areas 511-515) from 1956-2001.

Year	United States	Canada	USSR	Other	Total
1956	7278	29	--	--	7307
1957	6141	25	--	--	6166
1958	7082	285	--	--	7367
1959	4497	163	--	--	4660
1960	4541	383	--	--	4924
1961	5297	112	--	--	5409
1962	5003	107	--	--	5110
1963	4742	3	44	--	4789
1964	5383	70	--	--	5453
1965	4204	159	--	--	4363
1966	4579	1125	--	--	5704
1967	4907	589	--	–	5496
1968	3437	120	--	--	3557
1969	2423	59	--	231	2713
1970	1457	38	--	67	1562
1971	1194	85	--	27	1306
1972	909	23	4	--	936
1973	509	49	--	--	558
1974	622	198	--	9	829
1975	1180	79	--	4	1263
1976	1865	91	--	--	1956
1977	3296	26	--	--	3322
1978	4538	641	--	--	5179
1979	4622	257	--	--	4879
1980	7270	203	--	--	7473
1981	5726	513	--	--	6239
1982	5645	1278	--	--	6923
1983	5594	2003	--	--	7597
1984	2793	1245	--	--	4038
1985	2234	781	--	--	3015
1986	1443	225	--	--	1668
1987	829	--	--	--	829
1988	436	--	--	--	436
1989	264	--	--	--	264
1990	433	--	--	--	433
1991	431	--	--	--	431
1992	312	--	--	--	312
1993	193	--	--	--	193
1994 [1]	112	--	--	--	112
1995 [1]	192	--	--	--	192
1996 [1]	257	--	--	--	257
1997 [1]	616	--	--	--	616
1998 [1]	1018	--	--	--	1018
1999 [1]	668	--	--	--	668
2000 [1]	691	–	–	–	691
2001 [1]	1190	–	–	–	1190

[1] U.S. landings from 1994-2001 are provisional.

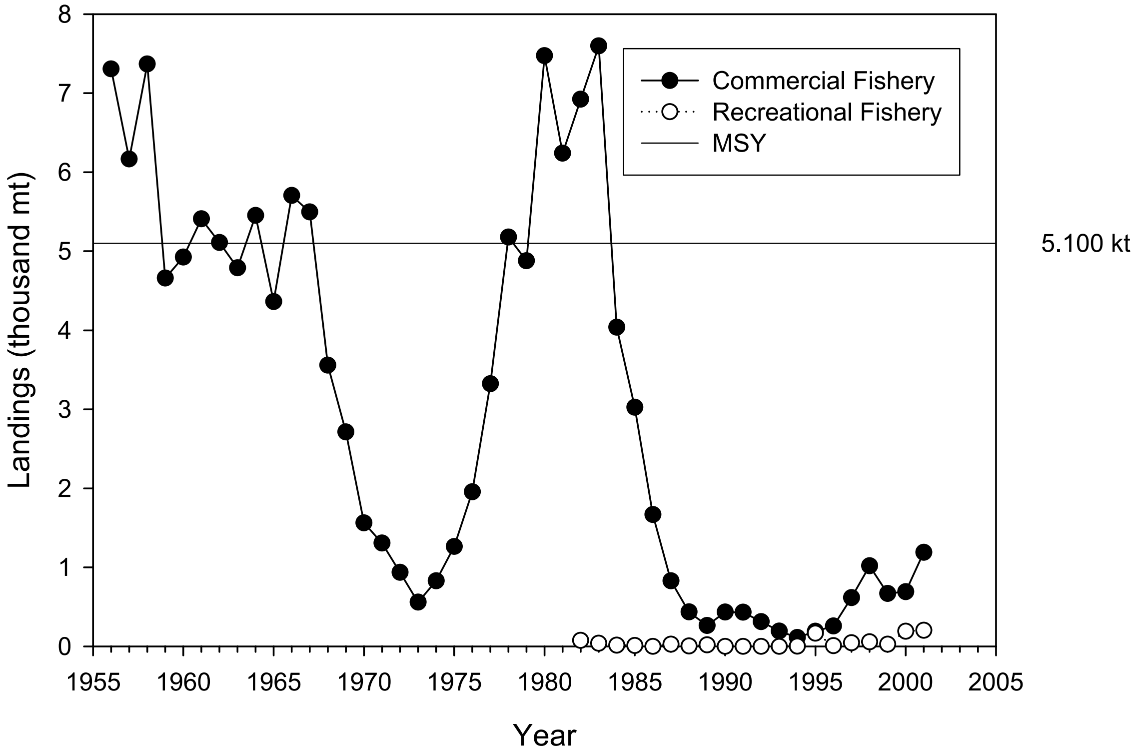
Table R2. Stratified mean catch number and weight (kg) per tow for haddock in NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 01260-01280, 01360-01400), 1963-2002.

Year	Spring Number per Tow	Spring Weight per Tow		Autumn Number per Tow	Autumn Weight per Tow
1963				69.549	50.697
1964				14.176	18.829
1965				17.434	17.644
1966				11.652	13.859
1967				12.186	16.853
1968	6.008	7.887		7.648	15.484
1969	3.783	7.376		5.451	12.854
1970	0.906	1.725		2.918	7.354
1971	0.878	2.523		2.879	8.137
1972	0.862	0.867		1.984	3.036
1973	1.204	1.578		4.165	8.583
1974	1.437	1.059		2.687	3.347
1975	2.770	3.482		5.533	8.616
1976	8.326	6.350		6.035	8.040
1977	6.799	6.725		8.296	8.752
1978	1.356	1.434		9.163	20.932
1979	3.330	4.633		5.528	13.723
1980	2.697	3.383		7.152	9.835
1981	4.405	4.488		3.869	9.344
1982	2.047	2.555		2.627	4.164
1983	3.678	3.567		2.598	5.219
1984	1.095	1.144		1.696	3.893
1985	1.773	1.882		4.079	6.149
1986	0.707	1.284		0.623	1.392
1987	0.092	0.062		1.035	2.645
1988	0.187	0.301		0.335	1.476
1989	0.083	0.124		0.283	0.631
1990	0.024	0.000		0.145	0.432
1991	0.074	0.066		0.142	0.120
1992	0.193	0.271		0.211	0.091
1993	0.450	0.200		0.866	0.472
1994	0.402	0.253		0.325	0.217
1995	0.806	0.350		0.977	1.099
1996	0.305	0.338		2.407	3.543
1997	1.935	1.222		2.688	2.424
1998	0.197	0.112		3.130	2.917
1999	4.267	1.108		6.730	4.910
2000	3.610	1.815		16.589	14.032
2001	2.364	3.215		9.960	11.983
2002	5.704	2.794			

Table R3. Exploitation rate index for Gulf of Maine haddock based on autumn NEFSC survey biomass index and (3-year average, except for 1963-1964) and annual commercial landings, 1963-2001.

Year	Landings	Survey Index	3-Year Average Survey Index	Annual Exploitation Rate Index Based on 3-Year Survey Index
1963	4.789	50.697	50.697	0.094
1964	5.453	18.829	34.763	0.157
1965	4.363	17.644	29.057	0.150
1966	5.704	13.859	16.777	0.340
1967	5.496	16.853	16.119	0.341
1968	3.557	15.484	15.399	0.231
1969	2.713	12.854	15.064	0.180
1970	1.562	7.354	11.897	0.131
1971	1.306	8.137	9.448	0.138
1972	0.936	3.036	6.176	0.152
1973	0.558	8.583	6.585	0.085
1974	0.829	3.347	4.989	0.166
1975	1.263	8.616	6.849	0.184
1976	1.956	8.04	6.668	0.293
1977	3.322	8.752	8.469	0.392
1978	5.179	20.932	12.575	0.412
1979	4.879	13.723	14.469	0.337
1980	7.473	9.835	14.830	0.504
1981	6.239	9.344	10.967	0.569
1982	6.923	4.164	7.781	0.890
1983	7.597	5.219	6.242	1.217
1984	4.038	3.893	4.425	0.912
1985	3.025	6.149	5.087	0.595
1986	1.668	1.392	3.811	0.438
1987	0.829	2.645	3.395	0.244
1988	0.436	1.476	1.838	0.237
1989	0.264	0.631	1.584	0.167
1990	0.433	0.432	0.846	0.512
1991	0.431	0.12	0.394	1.093
1992	0.312	0.091	0.214	1.456
1993	0.193	0.472	0.228	0.848
1994	0.112	0.217	0.260	0.431
1995	0.192	1.099	0.596	0.322
1996	0.257	3.543	1.620	0.159
1997	0.616	2.424	2.355	0.262
1998	1.018	2.917	2.961	0.344
1999	0.668	4.910	3.417	0.195
2000	0.691	14.032	7.286	0.095
2001	1.190	11.983	10.308	0.115
Average 1963-2001	2.525	8.301	9.140	0.395

Figure R1. Gulf of Maine haddock commercial landings during 1956-2001 and provisional recreational landings during 1982-2001.



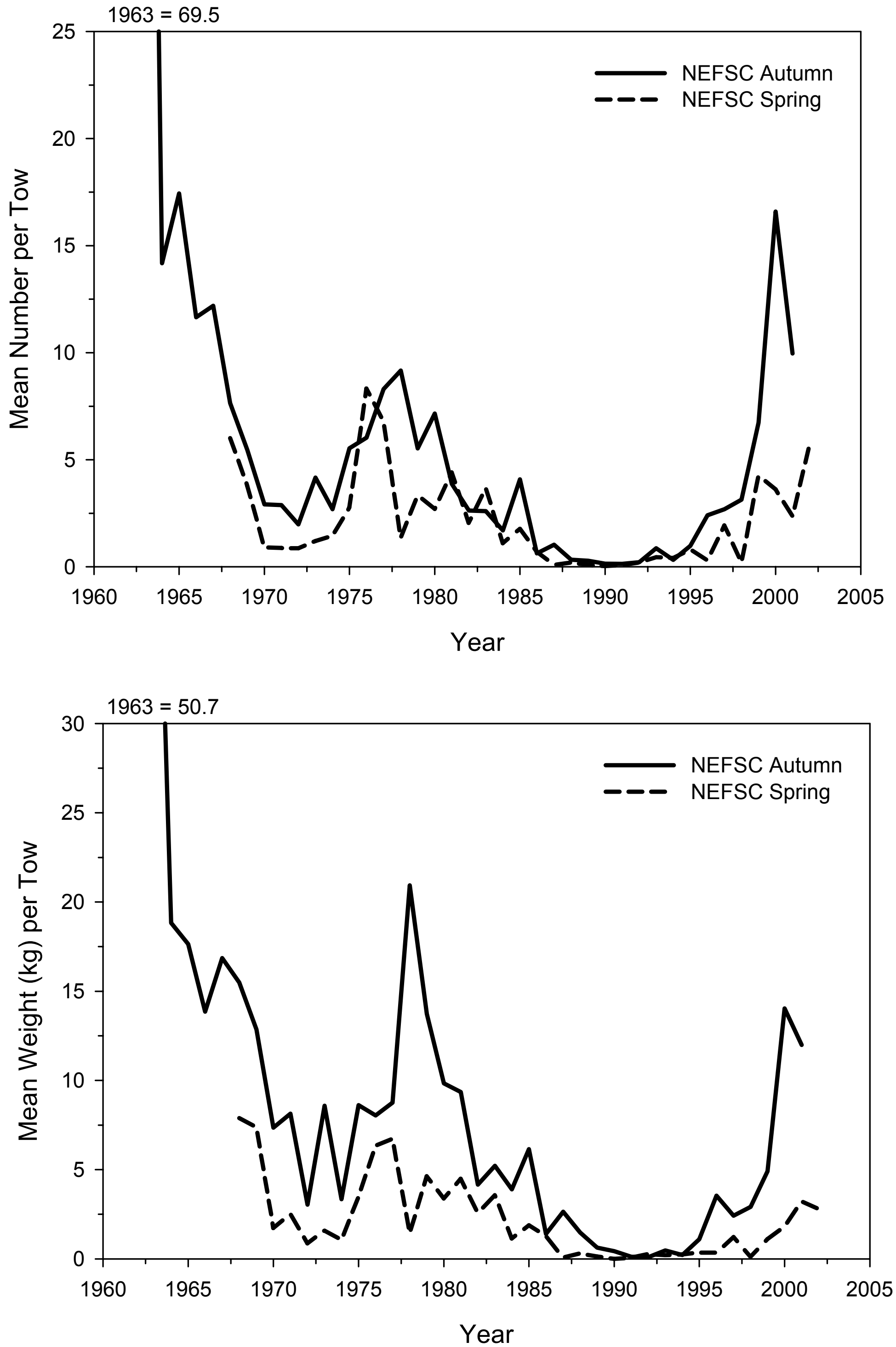
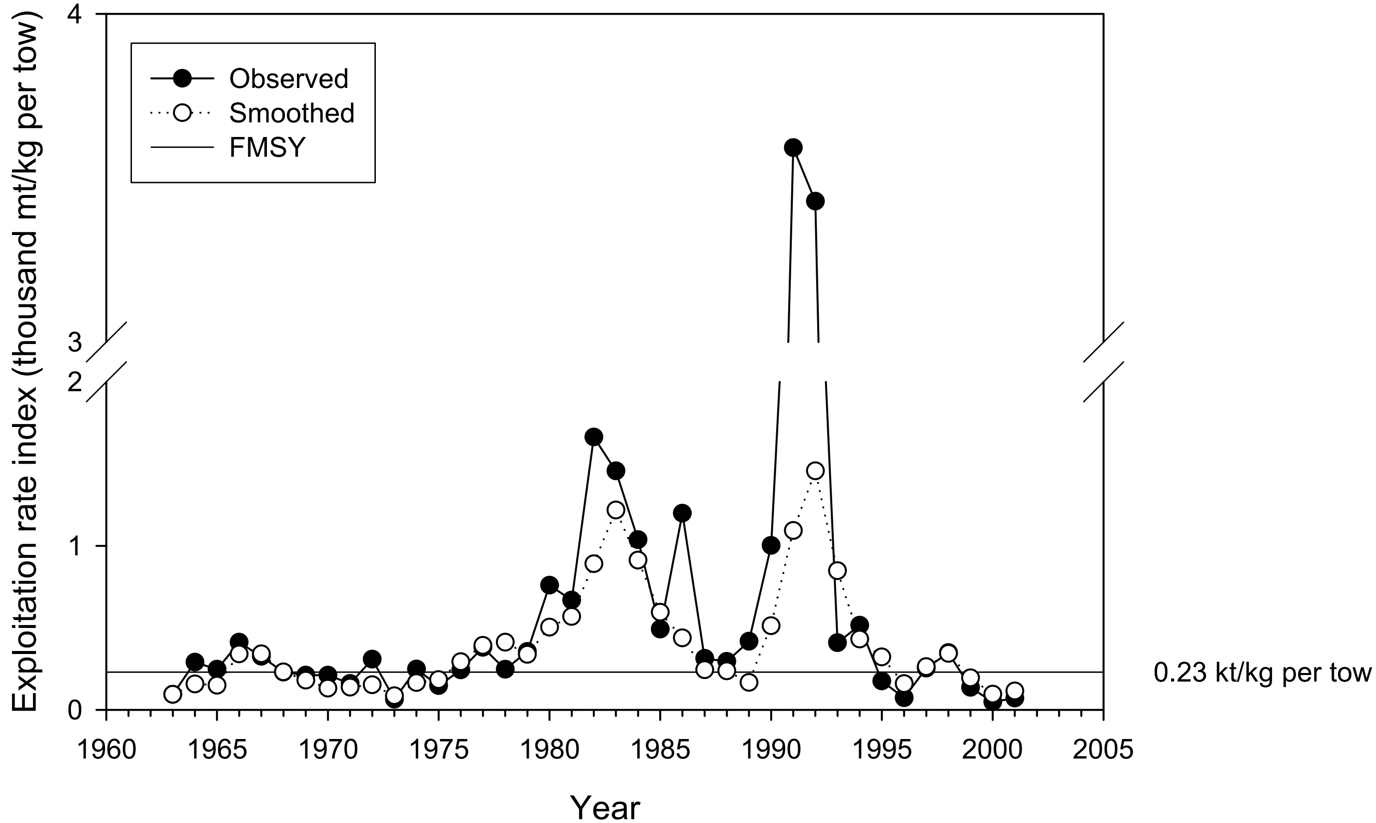


Figure R2. Northeast Fisheries Science Center research standardized and stratified survey abundance (mean number per tow; top panel) and biomass (kg per tow; bottom panel) indices for Gulf of Maine haddock from 1963-2002. U.S. survey includes strata 01260-01280 and 01360-01400.

Figure R3. Observed and smoothed exploitation rate indices for Gulf of Maine haddock, 1963-2001.



S. Atlantic Halibut by Jon Brodziak

1.0 Background

The Atlantic halibut (*Hippoglossus hippoglossus*) is distributed from Labrador to southern New England in the northwest Atlantic (Bigelow and Schroeder 1953). The Atlantic halibut stock within Gulf of Maine-Georges Bank waters (NAFO Subarea 5) has been exploited since the 1830s. The Gulf of Maine-Georges Bank Atlantic halibut stock was last assessed in 2001 by the Northern Demersal Working Group (NEFSC 2001). The stock was overfished based on research survey indices and is not expected to rebuild in the near future. In this report, we update the Atlantic halibut assessment using fishery data for 2001 and available survey data for 2001-2002. Updated survey biomass indices are used for stock status determination.

2.0 Assessment for 2002

2.1 2001 Landings

Records of Atlantic halibut landings from the Gulf of Maine and Georges Bank begin in 1893 (Table S1, Figure S1). Substantial landings occurred prior to this, however, as the halibut fishery declined in the late 1800s (Hennemuth and Rockwell 1987). Landings have decreased since the 1890s as components of the resource have been sequentially depleted. Annual landings averaged 662 mt during 1893-1940 and declined to an average of 144 mt during 1941-1976. During 1977-2000, landings have averaged 89 $mt \cdot yr^{-1}$. Reported landings in 2001 were 22 mt. Of these, 11 mt (50%) were landed by domestic fishermen with the remainder landed by Canadian fishermen (Division 5Zc).

2.2 Survey Indices

The Northeast Fisheries Science Center spring and autumn bottom trawl surveys provide measures of the relative abundance of Atlantic halibut within the Gulf of Maine and Georges Bank region (offshore survey strata 13-30 and 36-40, Table S2). Both indices have high inter-annual variability since relatively few halibut are captured during these surveys; in some years, no halibut are caught. The survey indices suggest that relative abundance increased during the 1970s to early 1980s and subsequently declined in the 1990s. It is unknown whether abundance trends in the Gulf of Maine and Georges Bank region have been influenced by changes in the seasonal distribution and availability of Atlantic halibut, however. US spring survey indices were computed for 2001-2002 (Table S2, Figure S2) and US autumn survey indices were computed for 2001 (Table S2, Figure S2) using standardized data.

3.0 Assessment Results

Based on updated spring and autumn survey data, Atlantic halibut biomass within the Gulf of Maine and Georges Bank region remains low. Swept-area biomass indices in spring 2001 and 2002 were 544 and 425 mt with a 5-year average of 312 mt in 2001 (Figure S3). Autumn swept-area biomass in 2000 was 123 mt with a 5-year average of 232 mt in 2001 (Figure S3). Thus, stock biomass, as indexed by the 5-year moving average of autumn swept-area biomass, was below the biomass threshold of 2,700 mt (Figure S3). Although no estimates of fishing mortality are available, exploitation rate indices (annual landings/5-year moving average of survey index) suggest that exploitation rates have probably been stable since the 1970s, and may have declined during the 1990s (Figure 4). Thus, the Atlantic halibut stock in the Gulf of Maine and Georges Bank region remains depleted and exploitation rates do not appear to have increased since the 1970s.

4.0 Sources of Uncertainty

- Fishery-dependent information on the size and age composition of Atlantic halibut landings is limited, although an experimental fishery in the Gulf of Maine during 2000-2002 has provided some valuable fishery-dependent data (Sigourney 2002).

- Stock structure of Atlantic halibut within the Gulf of Maine and Georges Bank region is uncertain. Wise and Jensen (1959) documented movements of tagged Atlantic halibut between Georges Bank and Browns Bank, but it is difficult to draw any definite conclusions about movement rates from their study. Recently, one halibut released near Stonington, Maine in April 2000 during the Gulf of Maine experimental fishery was recaptured off Port au Basque, Newfoundland in May 2002 after growing from 32 to 40 inches in total length (Kohl Kanwit, Maine DMF, personal communication). To date, preliminary data indicate three recaptures of fish tagged in the experimental fishery during 2000-2002 within Canadian waters.

- The portion of the Atlantic halibut population within Gulf of Maine and Georges Bank region is a transboundary stock. Conservation measures for both USA and Canadian fisheries may be needed to rebuild this stock.

5.0 Summary Stock Status

Biological Reference Points

For Gulf of Maine-Georges Bank Atlantic halibut, the stock biomass index (B_{MSY}) and the proxy exploitation rate index (F_{MSY}) to produce MSY are B_{MSY} = 5,400 mt and F_{MSY} = 0.06 (NEFMC 1998, NEFSC 2002). The overfished threshold ($B_{THRESHOLD}$) for Atlantic halibut is $B_{THRESHOLD}$ = ½ B_{MSY} = 2,700 mt. The overfishing threshold ($F_{THRESHOLD}$) for Atlantic halibut is $F_{THRESHOLD}$ = F_{MSY} = 0.06.

Stock Status in 2001

In 2001, the stock biomass index was 232 mt (9% of $B_{THRESHOLD}$ and 4% of B_{MSY}) with a standard error of 50 mt. Based on the point estimate of the biomass index, the Gulf of Maine-Georges Bank Atlantic halibut stock was overfished in 2001. In 2001, no estimate of fishing mortality was available and overfishing status was unknown.

6.0 References

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Table S1. Reported landings (mt) of Atlantic halibut from the Gulf of Maine and Georges Bank, 1893-2001.									
Year	USA	Canada	Other	Total	Year	USA	Canada	Other	Total
1893	634	0	0	634	1947	196	0	0	196
1894	843	0	0	843	1948	156	0	0	156
1895	4200	0	0	4200	1949	157	0	0	157
1896	4908	0	0	4908	1950	116	0	0	116
1897	733	0	0	733	1951	154	0	0	154
1898	564	0	0	564	1952	123	0	0	123
1899	407	0	0	407	1953	104	0	0	104
1900	311	0	0	311	1954	125	0	0	125
1901	287	0	0	287	1955	74	0	0	74
1902	367	0	0	367	1956	62	0	0	62
1903	502	0	0	502	1957	80	0	0	80
1904	332	0	0	332	1958	73	0	0	73
1905	580	0	0	580	1959	59	0	0	59
1906	542	0	0	542	1960	63	0	0	63
1907	447	0	0	447	1961	79	5	0	84
1908	891	0	0	891	1962	86	35	25	146
1909	193	0	0	193	1963	94	88	1	183
1910	329	0	0	329	1964	115	120	1	236
1911	389	0	0	389	1965	128	153	18	299
1912	460	0	0	460	1966	110	110	62	282
1913	402	0	0	402	1967	102	386	26	514
1914	329	0	0	329	1968	74	193	3	270
1915	336	0	0	336	1969	63	96	9	168
1916	478	0	0	478	1970	52	67	19	138
1917	293	0	0	293	1971	81	38	0	119
1918	375	0	0	375	1972	63	37	8	108
1919	496	0	0	496	1973	51	38	0	89
1920	896	0	0	896	1974	46	29	1	76
1921	689	0	0	689	1975	70	36	0	106
1922	694	0	0	694	1976	58	33	0	91
1923	508	0	0	508	1977	50	31	0	81
1924	616	0	0	616	1978	84	50	0	134
1925	843	0	0	843	1979	125	29	0	154
1926	944	0	0	944	1980	80	88	0	168
1927	831	0	0	831	1981	80	118	0	198
1928	781	0	0	781	1982	85	116	0	201
1929	570	0	0	570	1983	72	131	0	203
1930	716	0	0	716	1984	75	62	0	137
1931	511	0	0	511	1985	61	57	0	118
1932	443	0	0	443	1986	44	32	0	76
1933	279	0	0	279	1987	27	23	0	50
1934	192	0	0	192	1988	47	81	0	128
1935	292	0	0	292	1989	13	65	0	78
1936	374	0	0	374	1990	16	58	0	74
1937	187	0	0	187	1991	30	58	0	88
1938	146	0	0	146	1992	22	47	0	69
1939	124	0	0	124	1993	15	50	0	65
1940	497	0	0	497	1994	22	24	0	46
1941	145	0	0	145	1995	11	8	0	19
1942	250	0	0	250	1996	13	12	0	25
1943	76	0	0	76	1997	14	14	0	28
1944	77	0	0	77	1998	8	9	0	17
1945	55	0	0	55	1999	12	8	0	20
1946	124	0	0	124	2000	11	6	0	17
					2001	11	11	0	22

Table S2. Stratified mean weight (kg) per tow of Atlantic halibut from NEFSC spring[1] and autumn surveys (offshore strata 13-30, 36-40) and exploitation rate indices calculated as annual landings divided by the 5-year moving average of swept-area biomass indices.

Year	Spring Survey Index	Autumn Survey Index	Spring Explotiation Rate Index	Autumn Explotiation Rate Index
1963		0.085		
1964		0.067		
1965		0.032		
1966		0.004		
1967		0.009		3.93
1968	0.129	0.000		3.63
1969	0.236	0.494		0.47
1970	0.105	0.000		0.41
1971	0.033	0.091		0.30
1972	0.005	0.018	0.32	0.27
1973	0.113	0.131	0.27	0.18
1974	0.112	0.014	0.31	0.45
1975	0.000	0.095	0.61	0.46
1976	0.644	0.378	0.16	0.22
1977	0.142	0.059	0.12	0.18
1978	0.163	0.294	0.19	0.24
1979	0.357	0.040	0.18	0.27
1980	0.563	0.010	0.14	0.32
1981	0.066	0.321	0.23	0.41
1982	0.082	0.115	0.25	0.39
1983	0.611	0.000	0.18	0.63
1984	0.022	0.124	0.15	0.36
1985	0.063	0.106	0.21	0.27
1986	0.000	0.313	0.15	0.17
1987	0.287	0.033	0.08	0.13
1988	0.023	0.004	0.49	0.33
1989	0.000	0.066	0.32	0.23
1990	0.064	0.060	0.30	0.23
1991	0.062	0.243	0.30	0.33
1992	0.037	0.201	0.56	0.18
1993	0.006	0.046	0.58	0.16
1994	0.017	0.000	0.37	0.13
1995	0.005	0.066	0.23	0.05
1996	0.013	0.053	0.48	0.10
1997	0.063	0.174	0.41	0.12
1998	0.017	0.103	0.22	0.06
1999	0.239	0.015	0.09	0.07
2000	0.000	0.021	0.08	0.07
2001	0.164	0.037	0.07	0.09
2002	0.128			

Figure S1. Atlantic halibut landings from the Gulf of Maine-Georges Bank region during 1893-2001.

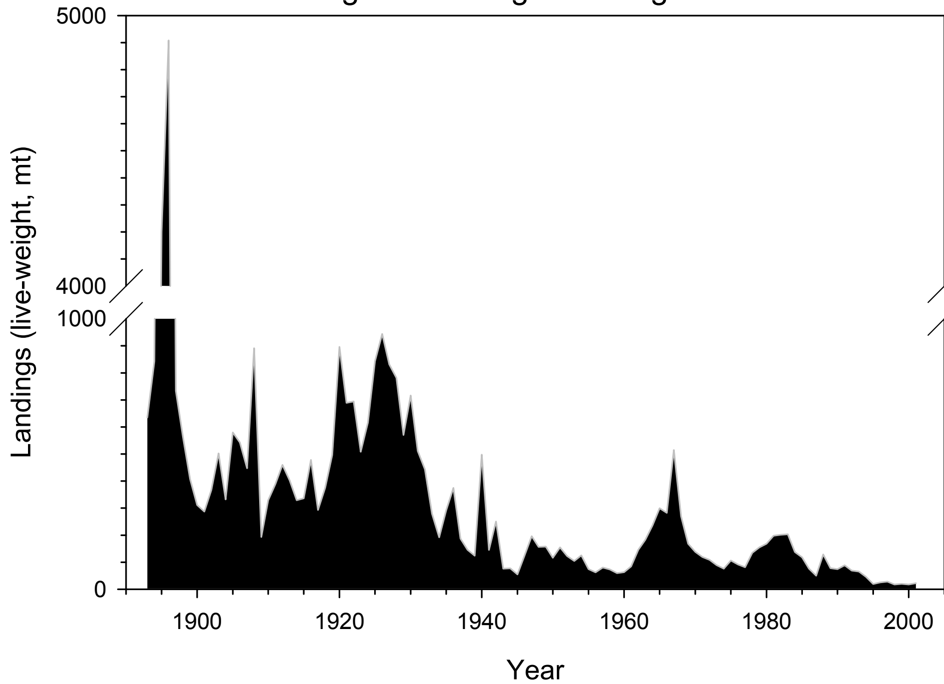


Figure S2. Trends in swept-area biomass indices (mt) of Atlantic halibut from NEFSC spring and autumn bottom trawl surveys.

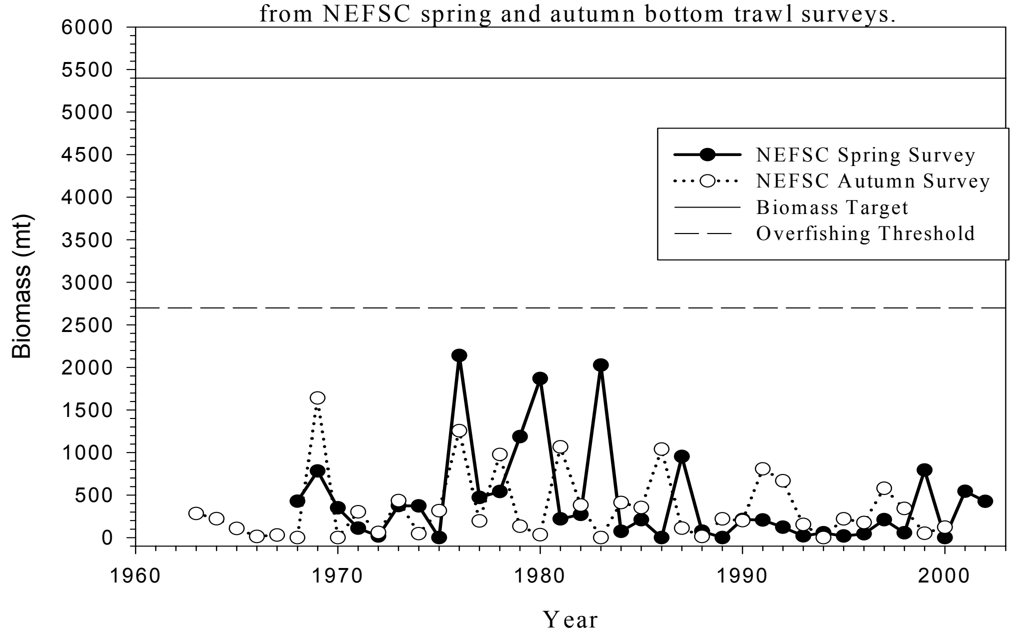


Figure S3. Trends in Atlantic halibut landings from the Gulf of Maine and Georges Bank in comparison to 5-year moving averages of spring and autumn survey indices, 1967-2001.

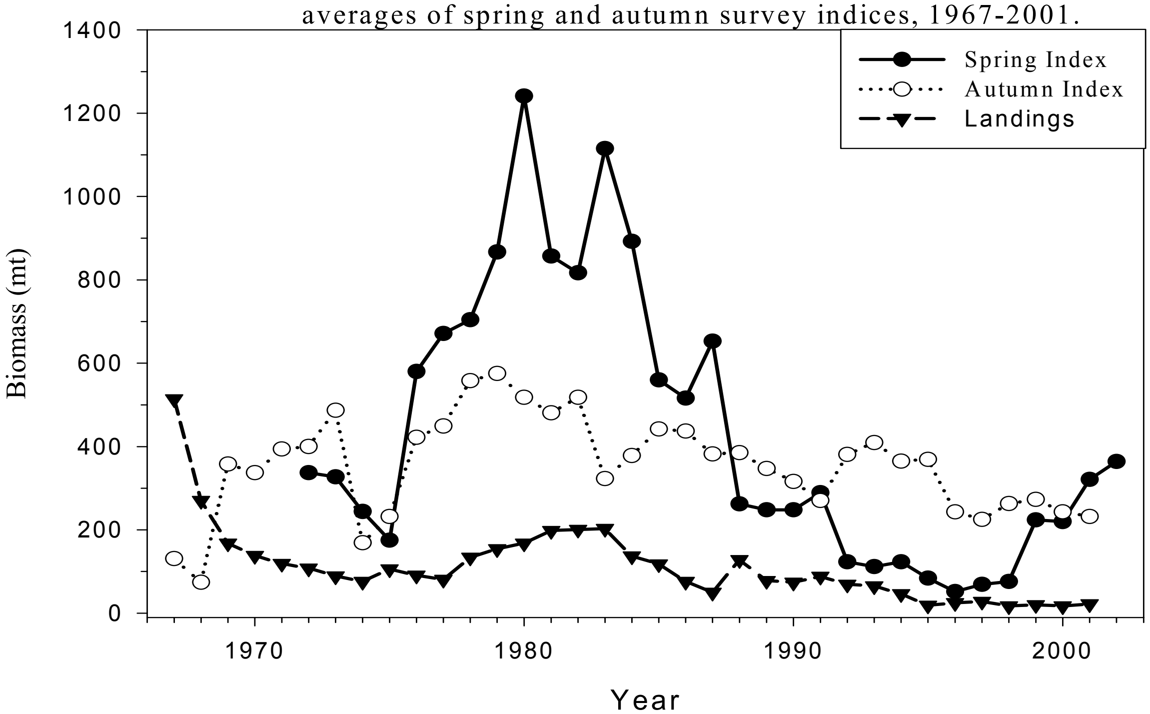
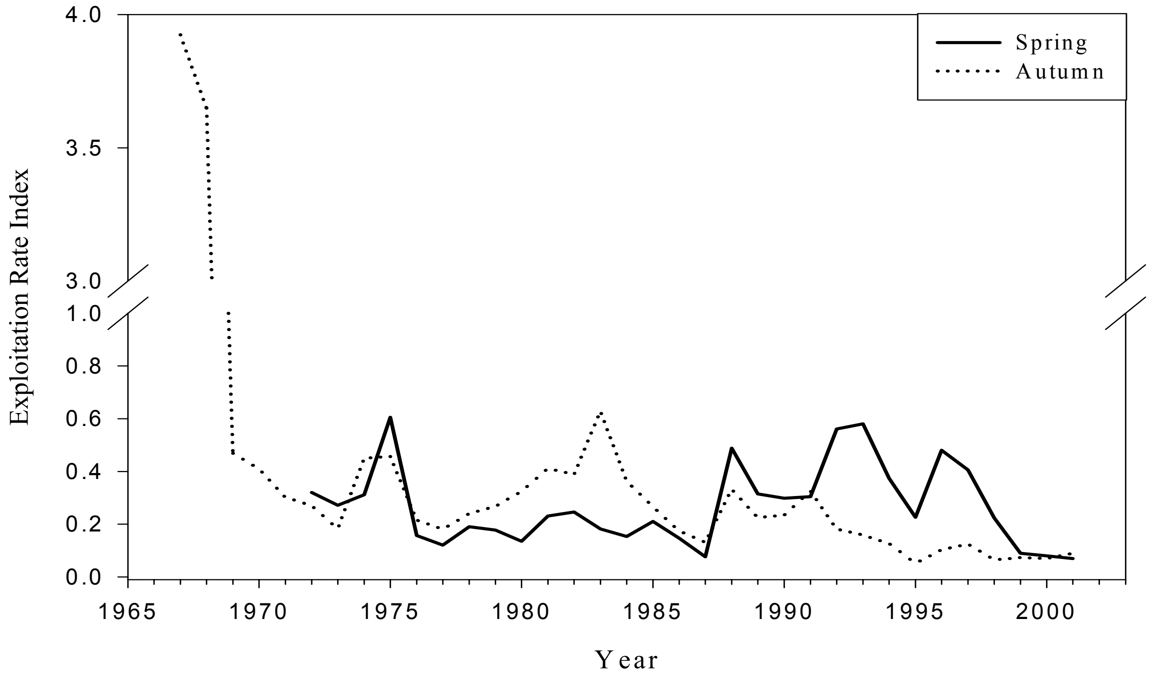


Figure S4. Trends in exploitation rate indices for Atlantic halibut from the Gulf of Maine and Georges Bank based on 5-year moving averages of NEFSC spring and autumn survey indices, 1967-2001



T. **Gulf of Maine (GM) winter flounder** by Paul Nitschke

1.0 Background

The last assessment for Gulf of Maine winter flounder was an index-based assessment reviewed at SARC 21 (NEFSC 1996). Low indices and the absence of large fish in the survey led SARC 21 to conclude that the stock was overexploited in the mid 1990s. The ASMFC Winter Flounder Technical Committee has constructed a benchmark virtual population analysis (VPA) in September 2002 which will be reviewed at SARC 36 (December 2002). Since this is a new benchmark assessment, full VPA output is not included here, but will be available in draft form to the council.

2.0 Fishery

Commercial landings were near 1,000 mt from 1964 to the mid 1970s. Thereafter commercial landings increased to a peak of 2,793 mt in 1982, and then steadily declined to a record low of 253 mt in 1999. Landings have remained near 500 mt since 1999 (Table T1, Figure T1). Otter trawl was the primary gear used during 1964-1985 (>95% of the landings). Since 1985 the proportion of landings coming from gill nets has increased, and has averaged 25% since1990.

Recreational landings reached a peak in 1981 (2,554 mt) but declined substantially thereafter (Table T2, Figure T2). Landings have been less than 1000 mt since 1995, with the lowest estimated landings in 1998 (30 mt). Landings in 2001 for Gulf of Maine winter flounder were 43 mt.

In the commercial fishery, annual sampling intensity varied during 1982-2001 from 4 to 310 mt landed per sample. Overall sampling intensity was adequate, however temporal and market category coverage in some years was poor (Table T3). Samples were pooled by halfyear when possible. Lengths of kept fish from observer data were used to supplement length data of unclassified fish. Lengths taken from gillnet trips in the observer data were used to characterize the gillnet proportion of the landings.

Discards were estimated for the large mesh trawl (1982-2001), gillnet (1986-2001), and northern shrimp fishery (1982-2001). The survey method was used in estimating both the discard and discard length composition for the large mesh trawl fishery from 1982-1993 (Mayo et al. 1992). VTR large mesh otter trawl discards to landings ratios were applied to corresponding commercial fishery landings to estimate discards in weight from 1994 to 2001. Fishery observer discard-to-landings ratios were used for estimating gillnet discard rates. Observer discard-to-days fished ratios were used for the northern shrimp fishery since landing of winter flounder in the shrimp fishery is prohibited. The observer length frequency data for gillnet and the northern shrimp fishery were used to characterize the proportion discarded at length. The sample proportion at length, converted to weight, was used to convert the discard estimate in weight to numbers at length. As for the southern New England stock (NEFSC 1999), a 50% mortality rate was applied to all commercial discard data (Howell et al., 1992). Numbers at ages were determined using NEFSC/MDMF spring and NEFSC fall survey age-length keys (Table T5).

A discard mortality of 15% was assumed for recreational discards (B2 category from MRFSS data), as assumed in Howell et al. (1992). Discard losses peaked at 140,000 fish in 1982. Discards have since declined reaching a low of 7,000 fish in 1999. In 2001, 15,000 fish were estimated to have been discarded (Table T2, Figure T2). Since 1997, irregular sampling of recreational fisheries has indicated that discards are usually fish below the minimum landing size of 12 inches (30 cm). For 1982-2001, the recreational discard has been assumed to have the same length frequency as the catch in the MDMF survey below the legal size and above an assumed hookable fish size (13 cm). The recreational discard for 1982-2001 is aged using NEFSC/MDMF spring and NEFSC fall survey age-length keys.

3.0 Research Surveys

Mean number per tow indices for the NEFSC and the Massachusetts Division of Marine Fisheries (MDMF) spring and fall time series are presented in Table T4 and Figures T3 through T6. All of the indices generally show a decrease in the population in the late 1980s from a high in the early 1980s with low abundance remaining through the early 1990s. All of the indices show signs of increased abundance starting in 1998 and 1999.

The Seabrook Nuclear Power Plant in New Hampshire has conducted a monthly bottom trawl survey since 1985. This survey also shows an increase in the number of fish in the late 1990s (Figure T7).

4.0 2001 Assessment

The VPA for Gulf of Maine winter flounder will be reviewed at SARC 36 (December 2002), therefore, results are not presented here. Estimates of Bmsy and Fmsy are not currently available.

5.0 Sources of uncertainty

* Landings data for 1994 and later years are derived by proration and are considered provisional.

* The lack of survey coverage in inshore New Hampshire and Maine where winter flounder are abundant is a source of uncertainty. Low number of tows taken per strata in inshore Massachusetts strata in the NEFSC survey is a source of variability in the index.

* Length frequency sampling coverage of the commercial fishery has been poor in some years.

* Observer sampling intensity of the commercial large mesh fishery has been low. Shrimp fishery discard sampling has been dropped in recent years. Commercial fishery discard

estimates are based on rates provided by fishermen in the vessel trip reports, due to inadequate fishery observer sampling.

6.0 GARM comments

The benchmark VPA assessment for Gulf of Maine winter flounder was presented to the GARM. However the GARM did not comment on the VPA assessment since a review has not been made on this assessment and a formal review will be conducted in the upcoming SARC. VPA results will be verbally presented to the council. The GARM also noted that all the surveys showed similar trends.

7.0 Summary

Stock summary information will be finalized at SARC 36.

References

Howell, P., A. Howe, M. Gibson and S. Ayvasian. 1992. Fishery management plan for inshore stocks of winter flounder. Atlantic States Marine Fisheries Commission. Fisheries Management Report No. 21. May, 1992.

Mayo, R.K., L. O'Brien, and N. Buxton. 1992. Discard estimates of American plaice, *Hippoglossoides platessoides*, in the Gulf of Maine northern shrimp fishery and the Gulf of Maine-Georges Bank large-mesh otter trawl fishery. SAW 14 Res. Doc. 14/3. 40 pp.

NEFSC. 1996. Report of the 21th Northeast Regional Stock Assessment Workshop (21st SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. [By Northeast Regional Stock Assessment Workshop No. 21.] June 1996.

Table T1. Winter flounder commercial landings (metric tons) for Gulf of Maine stock (U.S. statistical reporting areas 512 to 515).

Year	metric tons
1964	1,081
1965	665
1966	785
1967	803
1968	864
1969	975
1970	1,092
1971	1,113
1972	1,085
1973	1,080
1974	885
1975	1,181
1976	1,465
1977	2,161
1978	2,194
1979	2,021
1980	2,437
1981	2,406
1982	2,793
1983	2,096
1984	1,699
1985	1,582
1986	1,188
1987	1,140
1988	1,250
1989	1,253
1990	1,116
1991	1,008
1992	825
1993	611
1994	552
1995	796
1996	600
1997	618
1998	637
1999	253
2000	382
2001	571

Table T2. Estimated number (000's) and weight (mt) of winter flounder caught, landed, and discarded in the recreational fishery, Gulf of Maine stock.

	Number (000's)				Metric tons
	Catch A+B1+B2	Landed A+B1	Released B2	15% Release Mortality	Landed A+B1
1981	6,200	5,433	767	115	2,554
1982	8,207	7,274	933	140	1,876
1983	2,169	1,988	181	27	868
1984	2,477	2,285	191	29	1,300
1985	3,694	3,220	474	71	1,896
1986	946	691	255	38	523
1987	3,070	2,391	679	102	1,809
1988	953	841	111	17	345
1989	1,971	1,678	294	44	620
1990	786	652	134	20	370
1991	213	154	59	9	91
1992	186	137	48	7	90
1993	396	249	147	22	140
1994	232	145	87	13	83
1995	150	82	68	10	39
1996	184	98	86	13	56
1997	192	64	129	19	43
1998	109	65	44	7	30
1999	115	67	48	7	34
2000	177	75	102	15	42
2001	172	72	100	15	43

Table T3. Number of samples, lengths, ages, and sampling intensity for Gulf of Maine winter flounder. Number of samples and calculations of metric tons per sample is done on a halfyear basis and does not include observer data or gillnet landings from 1990-2001. Lengths in bold font are from observer trawl data.

		Number of lengths					Ages	Number of samples					mt/samples				
year	qtr	lg	sm	md	un	total	total	lg	sm	md	un	total	lg	sm	md	un	total
1982	1	-	-	-	296			-	-	-	3						
	2	102	101	-	159			1	1	-	1		838	453	-	46	
	3	84	81	-	106			1	1	-	1						
	4	-	-	-	-	929	483	-	-	-	-	9	396	691	-	231	310
1983	1	80	-	99	-			1	-	1	-						
	2	300	100	-	407			3	1	-	4		120	510	-	53	
	3	108	388	-	-			1	3	-	-						
	4	107	956	-	106	2651	1182	1	8	-	1	24	125	44	64	95	87
1984	1	201	209	-	-			2	2	-	-						
	2	237	294	-	221			3	2	-	2		74	95	-	-	
	3	-	123	-	-			-	1	-	-						
	4	126	690	100	-	2201	908	1	5	1	-	19	189	67	114	124	89
1985	1	273	565	-	-			3	3	-	-						
	2	392	170	-	-			3	2	-	-		54	-	-	-	
	3	105	-	-	-			1	-	-	-						
	4	116	-	-	80	1701	318	1	-	-	1	14	87	-	182	176	113
1986	1	-	-	-	266			-	-	-	3						
	2	237	109	109	-			3	1	1	-		-	242	126	48	
	3	-	111	86	-			-	1	1	-						
	4	-	389	107	89	1503	344	-	5	1	1	17	113	37	31	56	70
1987	1	-	-	-	113			-	-	-	1						
	2	-	-	-	-			-	-	-	-		-	-	-	-	
	3	-	95	-	-			-	1	-	-						
	4	47	156	272	-	683	130	1	2	3	-	8	257	137	75	249	143
1988	1	-	258	311	-			-	3	3	-						
	2	102	-	395	-			1	-	4	-		-	108	23	-	
	3	-	-	-	-			-	-	-	-						
	4	-	169	107	-	1342	249	-	2	1	-	14	340	164	96	-	89
1989	1	-	-	-	100			-	-	-	1						
	2	113	-	91	**134**			1	-	1	-		-	-	168	-	
	3	-	95	120	**32**			-	1	1	-						
	4	-	-	100	-	785	148	-	-	1	-	6	313	435	42	254	209
1990	1	328	301	-	-			3	4	-	-						
	2	-	-	-	102			-	-	-	1		64	48	-	-	
	3	-	-	-	-			-	-	-	-						
	4	117	197	97	-	1142	241	1	2	1	-	12	83	90	138	118	75

Table T3. Continued.

		Number of lengths					Ages	Number of samples					mt/samples				
year	qtr	lg	sm	md	un	total	total	lg	sm	md	un	total	lg	sm	md	un	total
1991	1	100	51	105	101			1	1	1	1						
	2	88	203	100	**42**			1	2	1	-		92	72	-	-	
	3	-	95	-	-			-	1	-	-						
	4	236	254	-	-	1375	262	3	3	-	-	15	32	47	95	115	65
1992	1	110	-	-	**107**			1	-	-	-						
	2	136	100	93	-			2	1	1	-		47	119	84	-	
	3	-	-	-	-			-	-	-	-						
	4	57	74	253	-	930	270	1	1	3	-	10	75	134	19	-	67
1993	1	100	-	-	-			1	-	-	-						
	2	-	-	288	-			-	-	3	-		83	-	16	-	
	3	-	55	-	**91**			-	1	-	-						
	4	80	-	157	**51**	822	183	1	-	2	-	8	47	177	30	-	59
1994	1	-	-	-	-			-	-	-	-						
	2	-	71	92	102			-	1	1	1		-	-	75	-	
	3	-	-	-	-			-	-	-	-						
	4	94	-	235	-	594	139	1	-	3	-	7	112	143	15	60	62
1995	1	101	-	175	**63**			1	-	2	-						
	2	-	-	299	-			-	-	3	-		-	-	37	-	
	3	-	-	414	-			-	-	4	-						
	4	-	-	-	**609**	1661	248	-	-	-	-	10	134	-	42	-	55
1996	1	-	77	-	-			-	1	-	-						
	2	-	231	-	-			-	2	-	-		-	44	-	-	
	3	-	355	252	-			-	2	3	-						
	4	84	440	86	**112**	1637	246	1	5	1	-	15	80	16	18		29
1997	1	-	204	-	-			-	2	-	-						
	2	-	127	75	-			-	2	1	-		-	28	66	-	
	3	-	220	218	-			-	2	3	-						
	4	307	502	56	-	1709	295	4	8	1	-	23	25	11	14	-	19
1998	1	-	148	79	-			-	2	1	-						
	2	-	151	201	-			-	3	2	-		-	34	29	-	
	3	-	583	-	-			-	7		-						
	4	69	163	110	-	1504	341	1	2	1	-	19	65	14	30	-	25
1999	1	-	173	104	-			-	2	1	-						
	2	-		171	-			-	-	2	-		-	17	-	-	
	3	-	28	-	-			-	1	-	-						
	4	-	152	-	**408**	1036	149	-	3	-	-	9	-	5	10	-	19
2000	1	-	866	143	**480**			-	12	2	-						
	2	-	3441	51	**554**			-	45	1	-		-	1	-	-	
	3	-	102	-	**50**			-	2	-	-						
	4	-	114	-	**26**	5827	883	-	2	-	-	64	-	12	13	-	4
2001	1	-	-	187	**172**			-	-	2	-						
	2	99	157	189	**630**			1	2	3	-		-	37	10	-	
	3	-	100	52	**399**			-	1	1	-						
	4	-	154	198	**1307**	3644	246	-	2	2	-	14	26	21	24	-	32

Table T4. NEFSC and MA DMF survey indices of abundance for Gulf of Maine winter flounder. Indices are stratified mean number and mean weight (kg) per tow. NEFSC indices are for inshore strata (58,59,60,61,65,66) and offshore strata (26,27,38,39,40). NEFSC indices are calculated with trawl door conversion factors where appropriate. MA DMF uses strata 25-36.

	NEFSC spring		NEFSC fall		MDMF spring		MDMF fall	
year	number	weight	number	weight	number	weight	number	weight
1978					86.805	18.373	43.360	9.887
1979	9.063	3.218	6.003	2.602	64.952	14.407	119.506	28.978
1980	11.284	4.447	13.141	6.553	66.231	17.494	74.684	15.940
1981	13.051	3.946	4.179	3.029	100.569	28.370	47.342	13.228
1982	7.670	3.022	4.201	1.924	60.719	14.687	106.053	23.635
1983	12.367	5.653	10.304	3.519	108.508	27.233	88.143	15.772
1984	5.155	1.979	7.732	3.106	66.271	15.977	35.956	10.817
1985	3.469	1.418	7.638	2.324	48.651	13.594	44.564	7.381
1986	2.343	0.998	2.502	0.938	62.356	14.724	41.914	6.603
1987	5.609	1.503	1.605	0.488	83.171	17.648	50.426	7.227
1988	6.897	1.649	3.000	1.031	52.733	10.617	33.063	7.173
1989	3.717	1.316	6.402	2.013	63.595	13.317	33.983	7.462
1990	5.415	2.252	3.527	1.177	74.131	12.966	67.874	13.452
1991	4.517	1.436	7.035	1.467	49.265	11.587	88.777	15.473
1992	3.933	1.160	10.447	3.096	74.146	13.938	77.350	13.471
1993	1.556	0.353	7.559	1.859	80.133	12.390	92.476	14.996
1994	3.481	0.891	4.870	1.319	71.710	10.036	67.351	13.560
1995	12.185	3.149	4.765	1.446	87.848	14.560	84.768	17.250
1996	2.736	0.732	10.099	3.116	77.249	12.823	74.295	13.031
1997	2.806	0.664	10.008	2.950	95.918	14.796	74.347	14.316
1998	2.001	0.528	3.218	0.987	91.466	15.756	93.889	14.934
1999	6.510	1.982	10.921	3.269	77.941	14.198	117.648	22.672
2000	10.383	2.885	12.705	5.065	169.291	35.453	101.633	25.693
2001	5.242	1.666	8.845	3.143	90.153	23.891	80.978	18.367
2002	12.066	3.693			87.376	21.404		

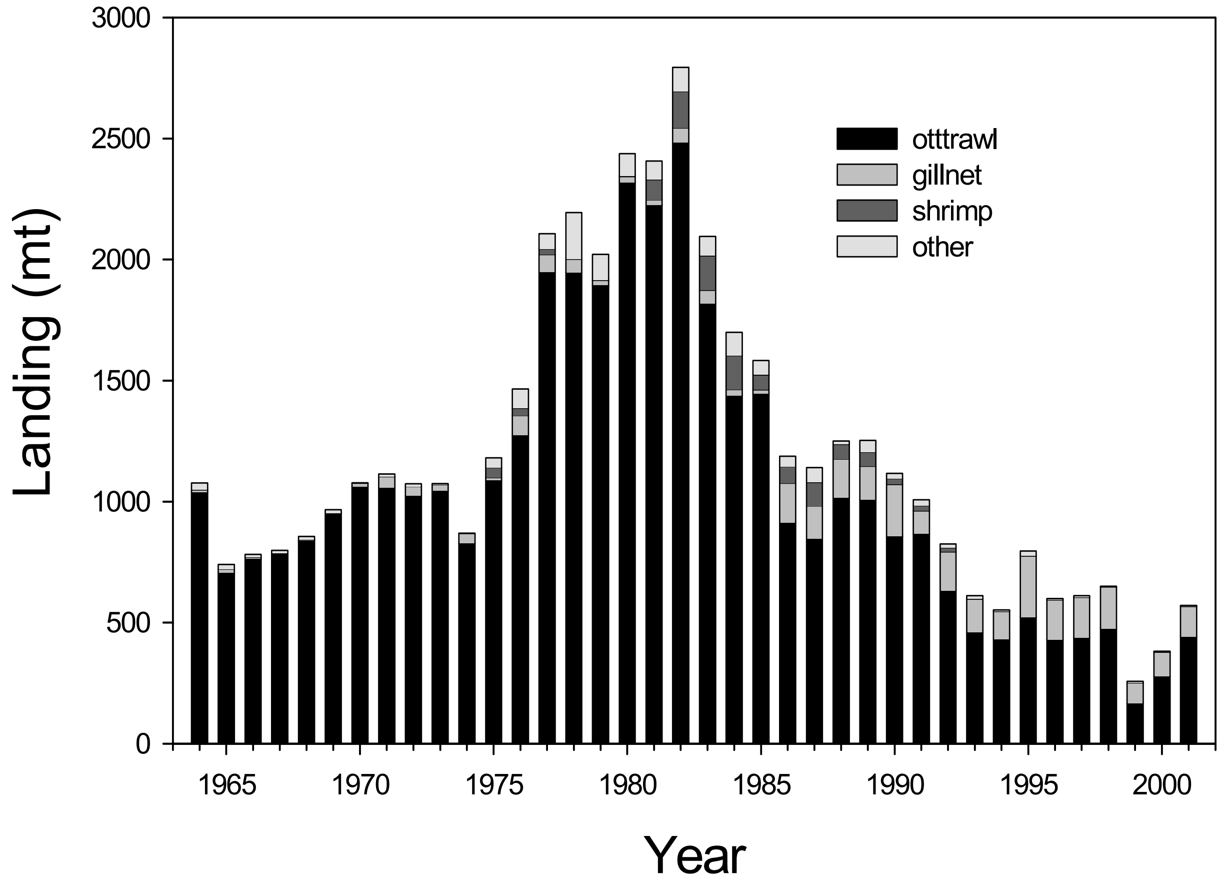


Figure T1. Gulf of Maine winter flounder landings (mt) by gear.

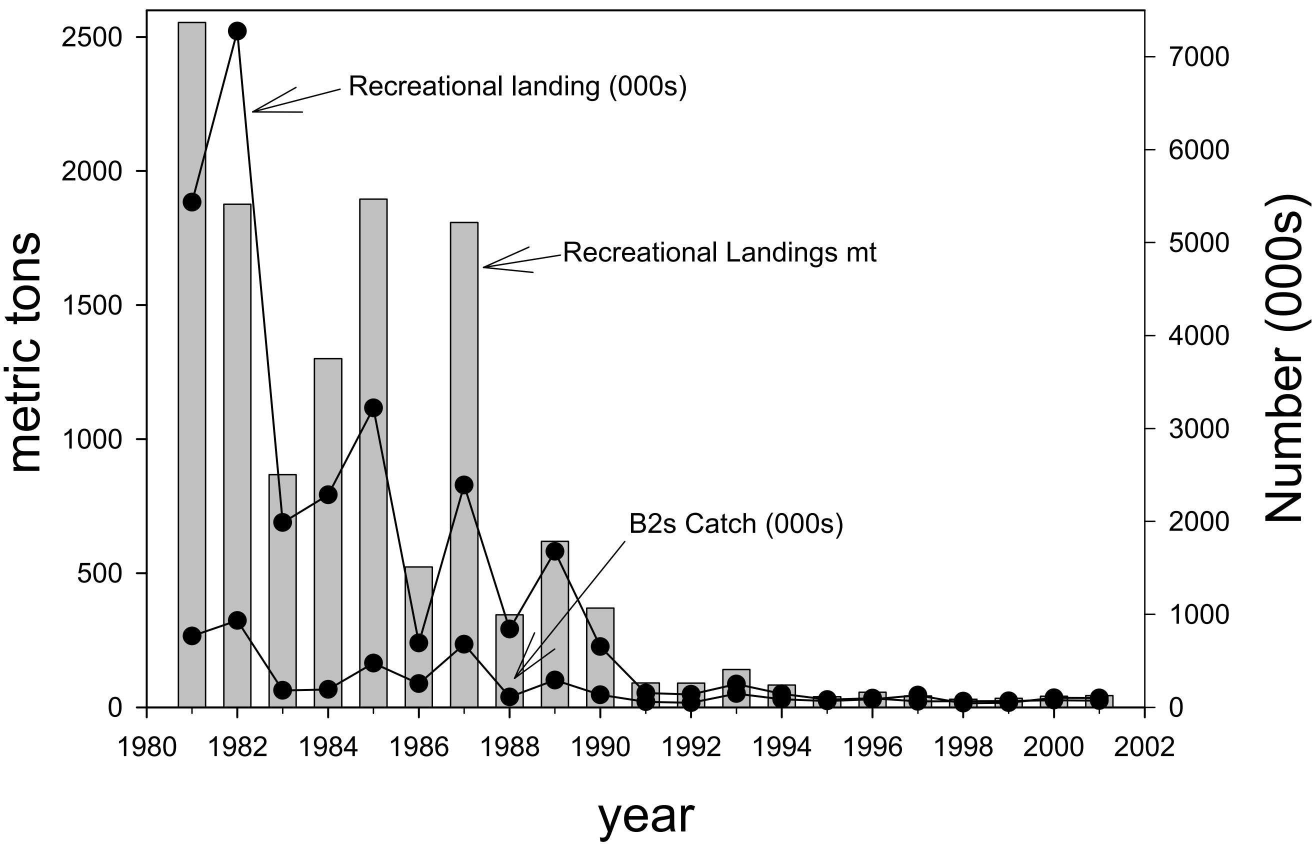


Figure T2. Recreational landings in numbers and metric tons for Gulf of Maine winter flounder. B2 catch is fished released alive.

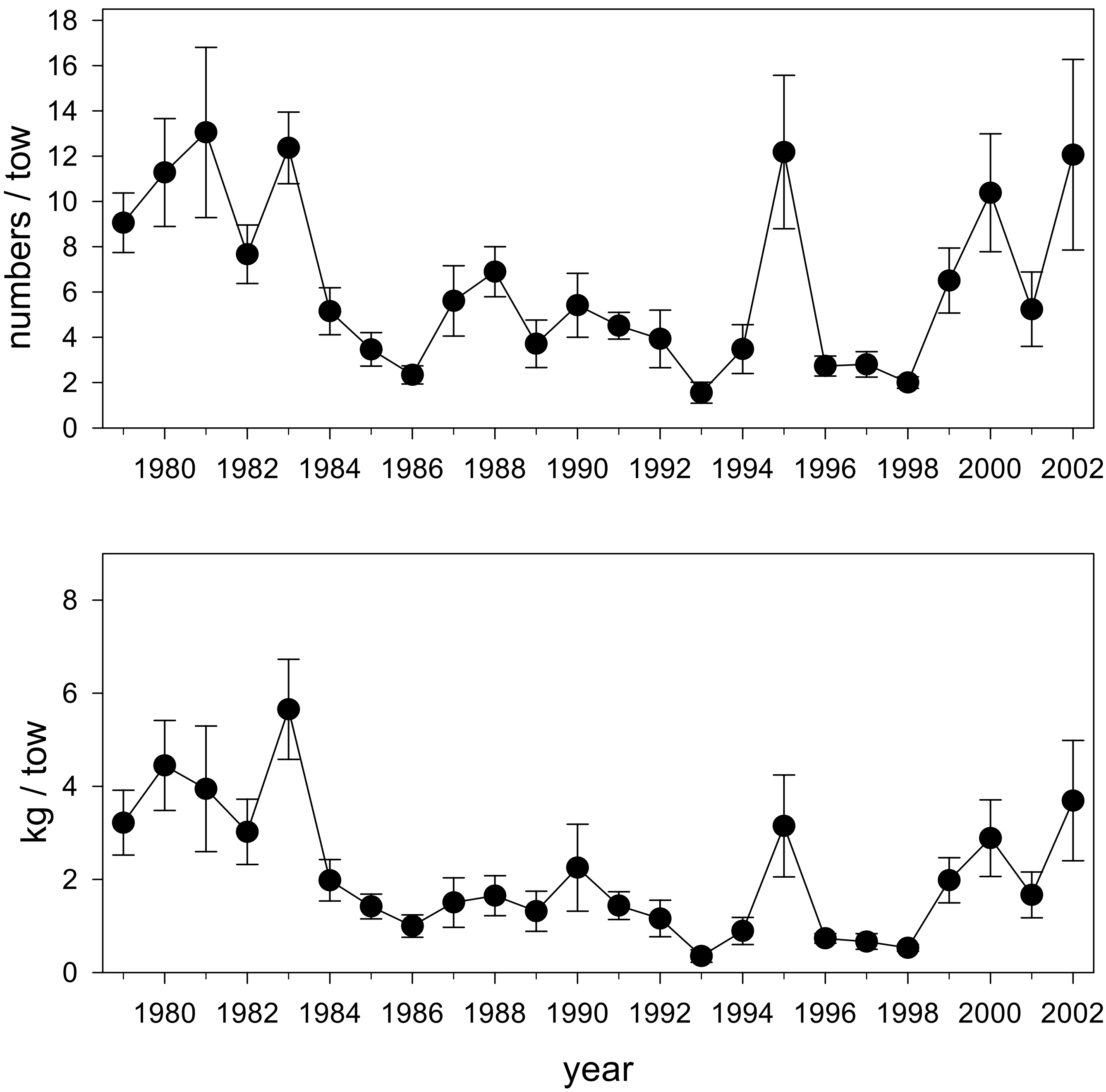


Figure T3. NEFSC Spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are used where appropriate.

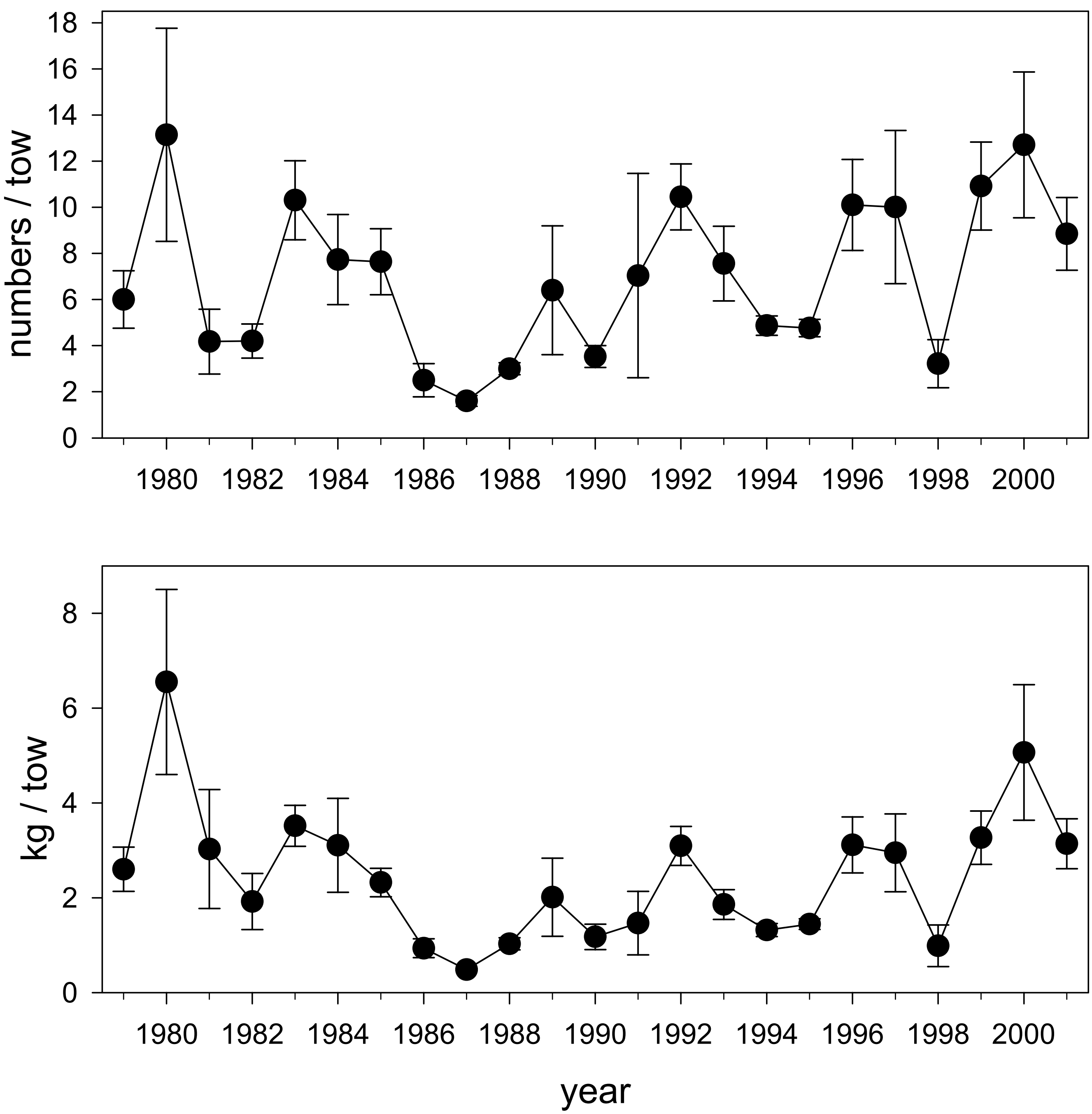


Figure T4. NEFSC Fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are used where appropriate.

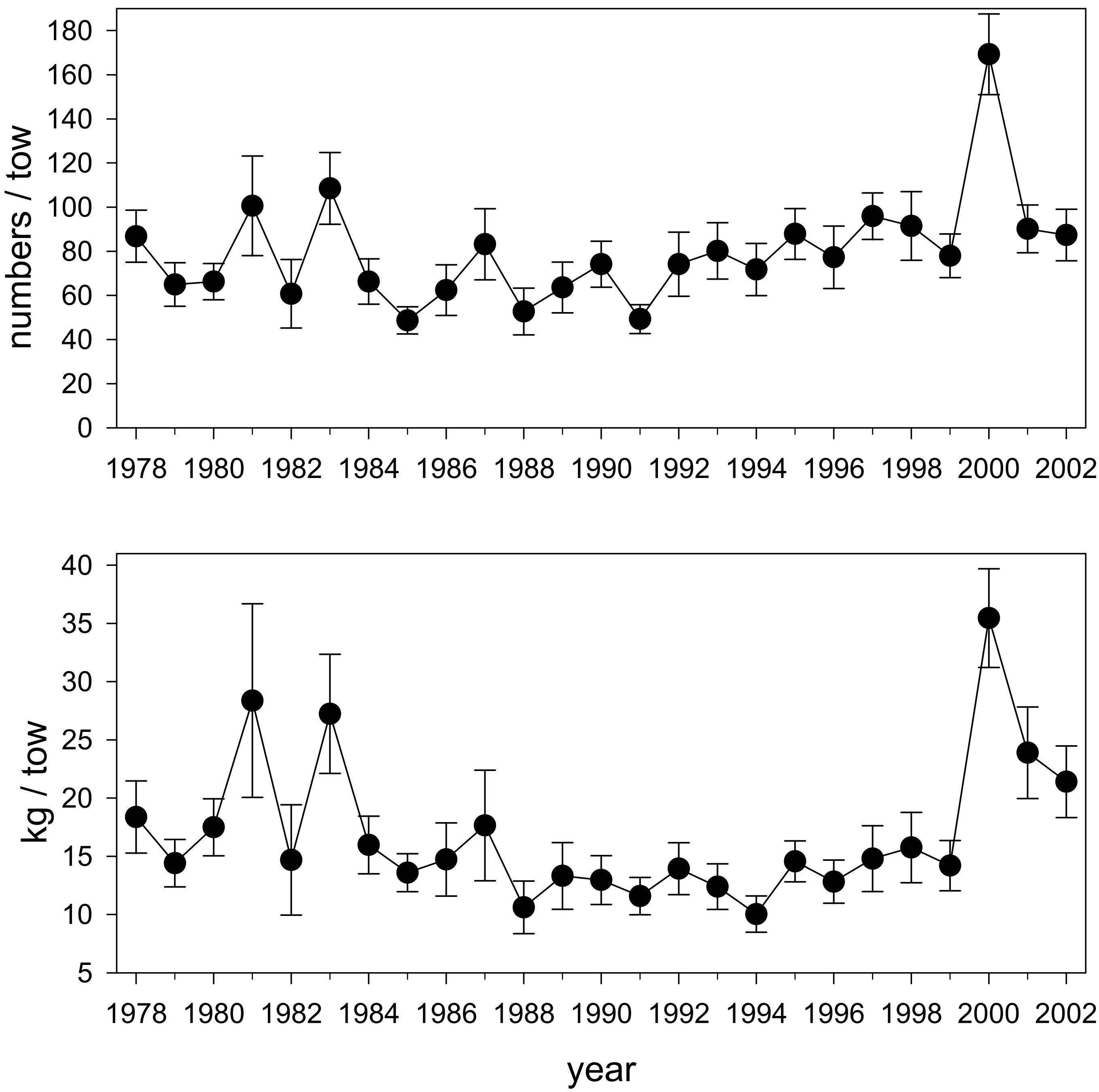


Figure T5. Massachusetts Division of Marine Fisheries (MA DMF) spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

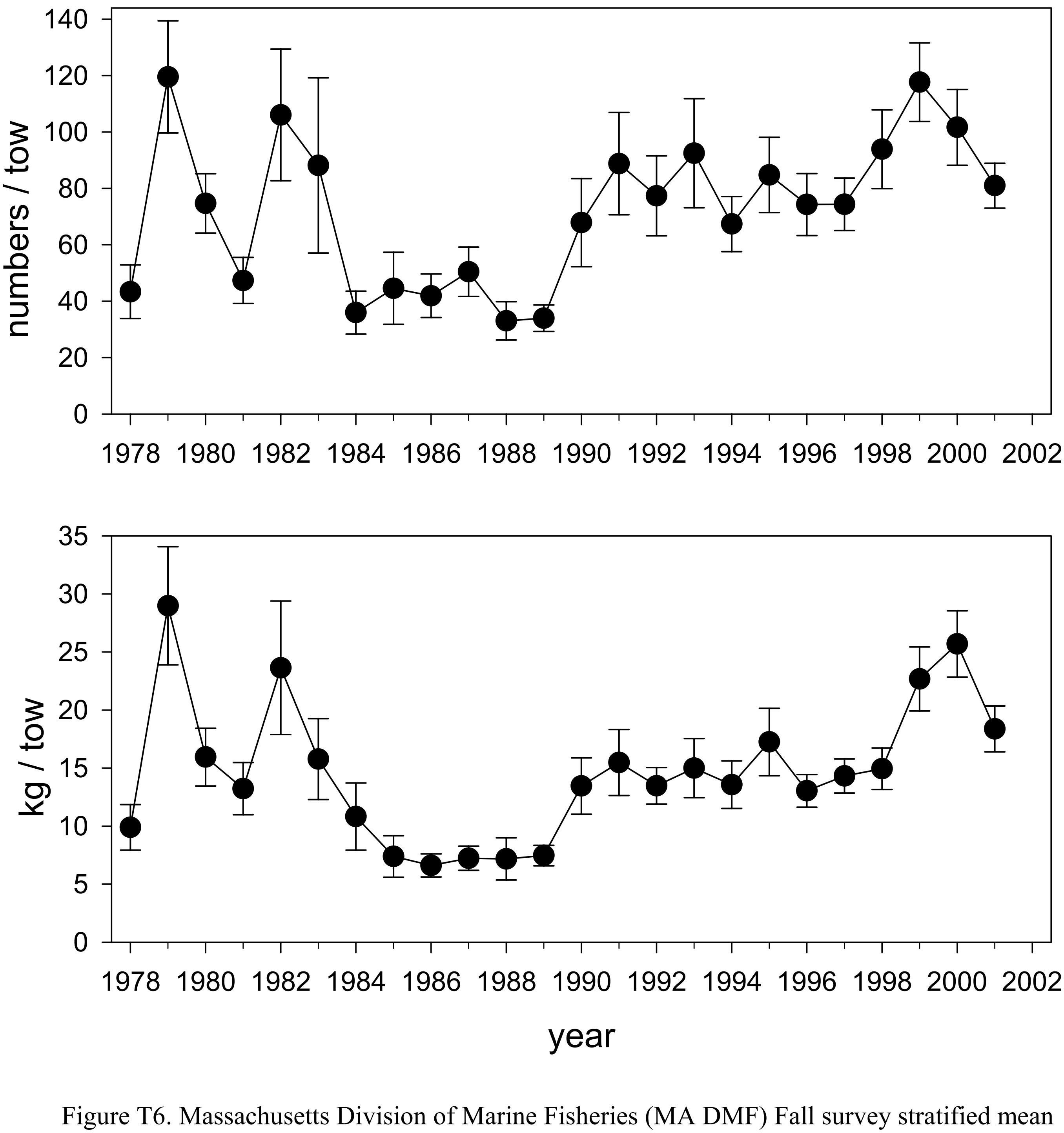


Figure T6. Massachusetts Division of Marine Fisheries (MA DMF) Fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

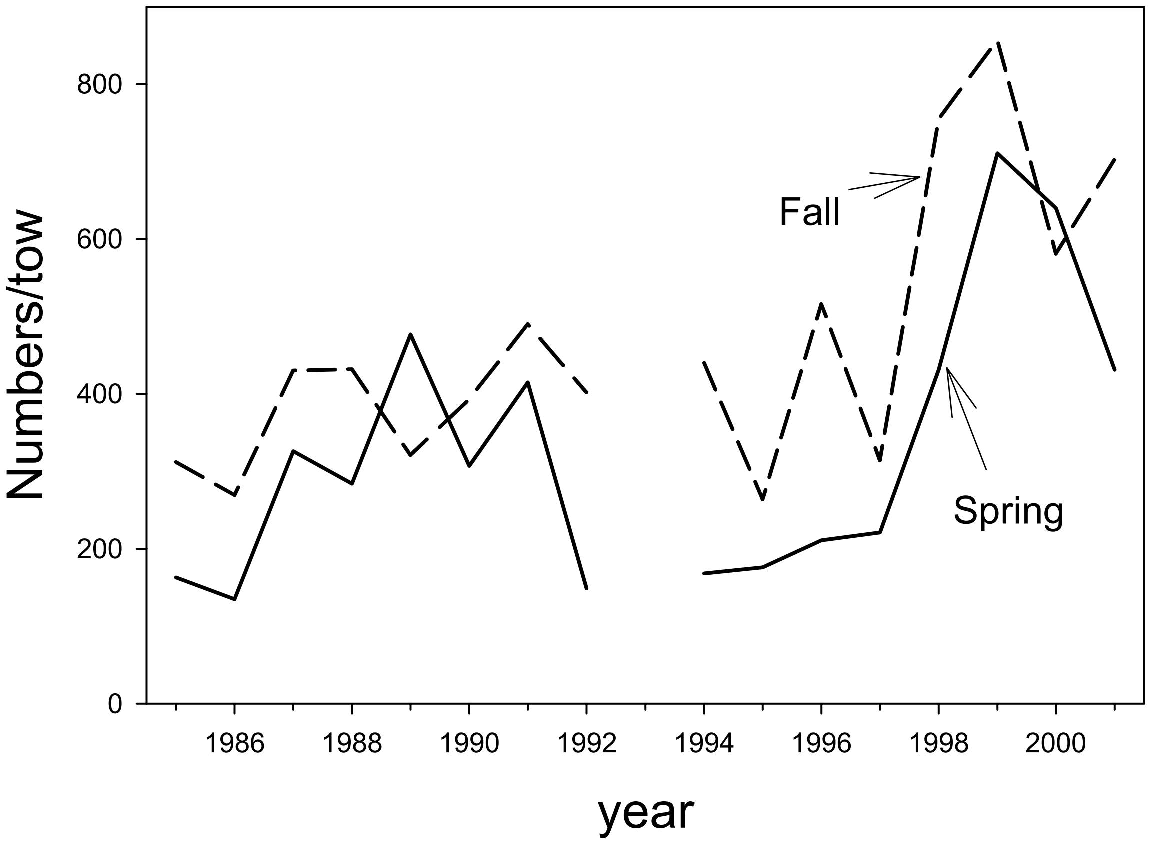


Figure T7. Seabrook Nuclear Power Plant in (New Hampshire) spring and fall survey mean numbers per tow for Gulf of Maine winter flounder. No survey was done in 1993.