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

Cadrin, S.X., J.D. Neilson, S. Gavaris, and P. Perley. 2000. Assessment of the Georges Bank yellowtail flounder stock for 2000. NEFSC Ref. Doc. 00-10. 71 p.

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.

NEFSC (Northeast Fisheries Science Center). 2002. Final report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NEFSC Ref. Doc. 02-04.

Stone, H. 2002. Stock assessment of Georges Bank (5Zjmnh) yellowtail flounder for 2002. Can. Science Advisory Secretariat Res. Doc. 2002. 79 p.

Stone, H., C. Legault, S. Cadrin, S. Gavaris, J. Neilson, and P. Perley. 2001. Stock assessment of Georges Bank (5Zjmnh) yellowtail flounder for 2001. Can. Science Advisory Secretariat Res. Doc. 2001/068. 87 p.

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.

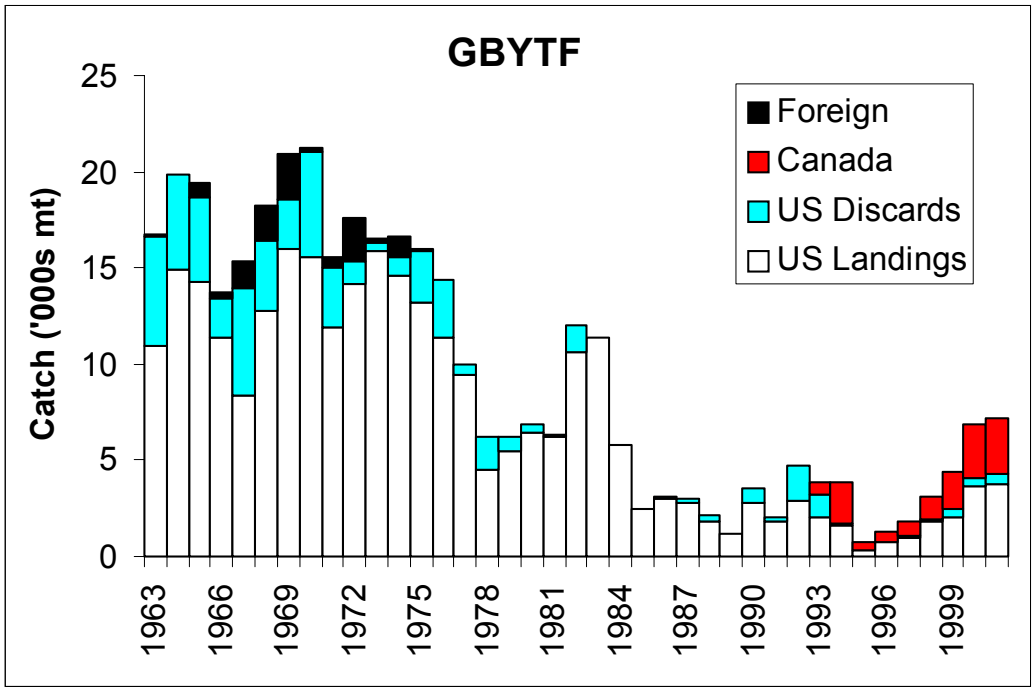


Figure C2. Survey indices of Georges Bank yellowtail flounder biomass.

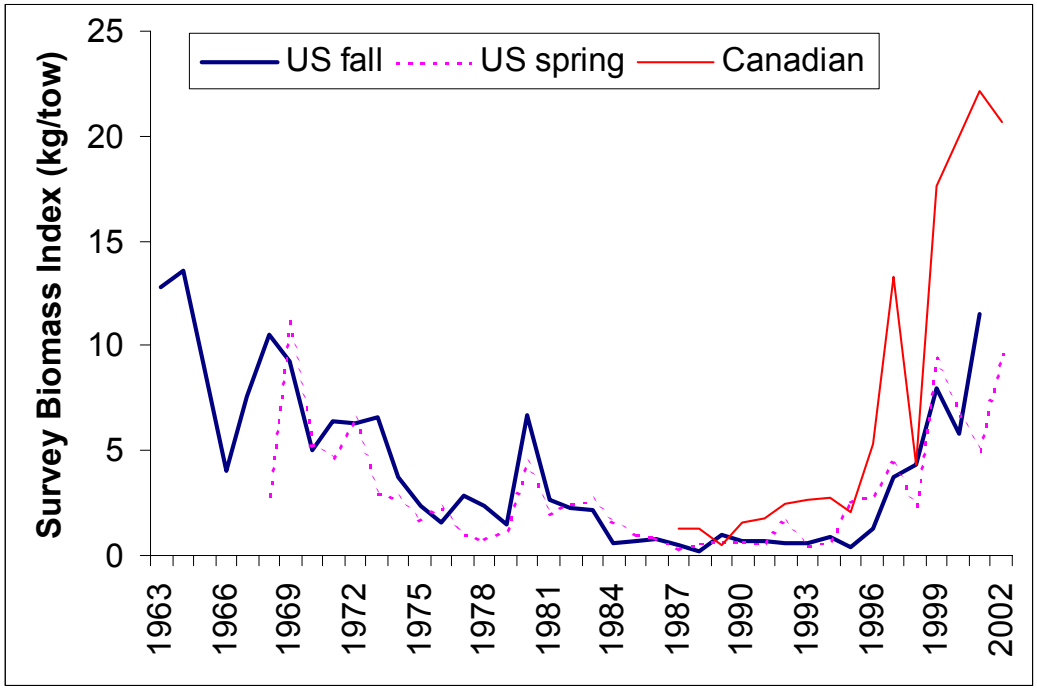


Figure C3. Survey indices of abundance at age. Note that the NEFSC Spring and Fall surveys correspond to the left axes in each plot while the NEFSC scallop and the Canadian surveys correspond to the right axes in each plot.

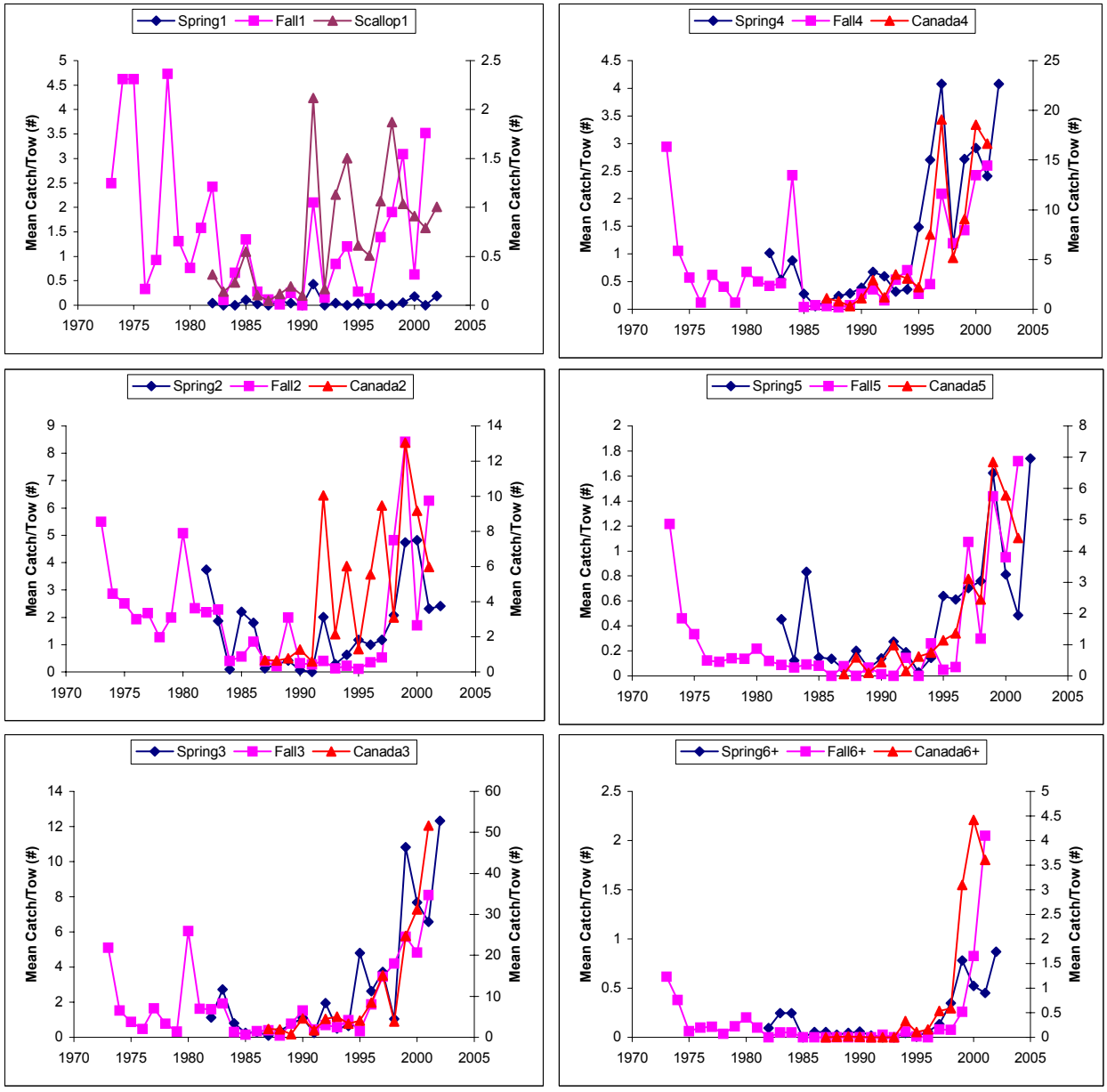
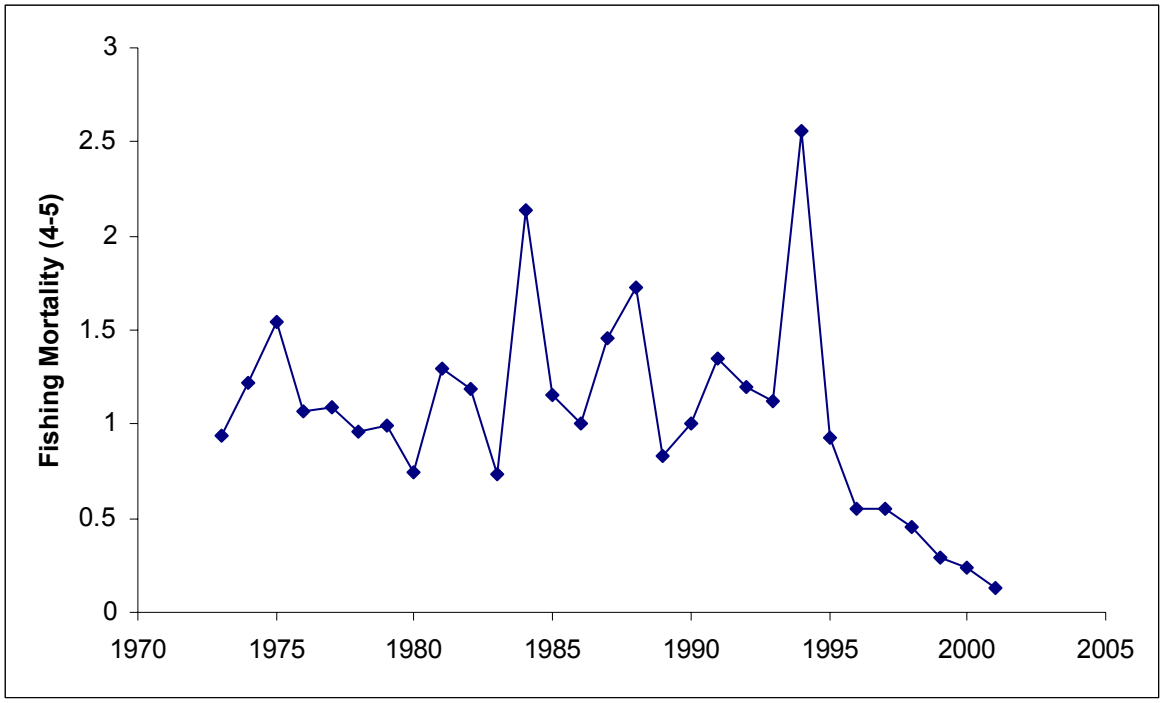


Figure C4. Summary of Georges Bank yellowtail flounder VPA results.



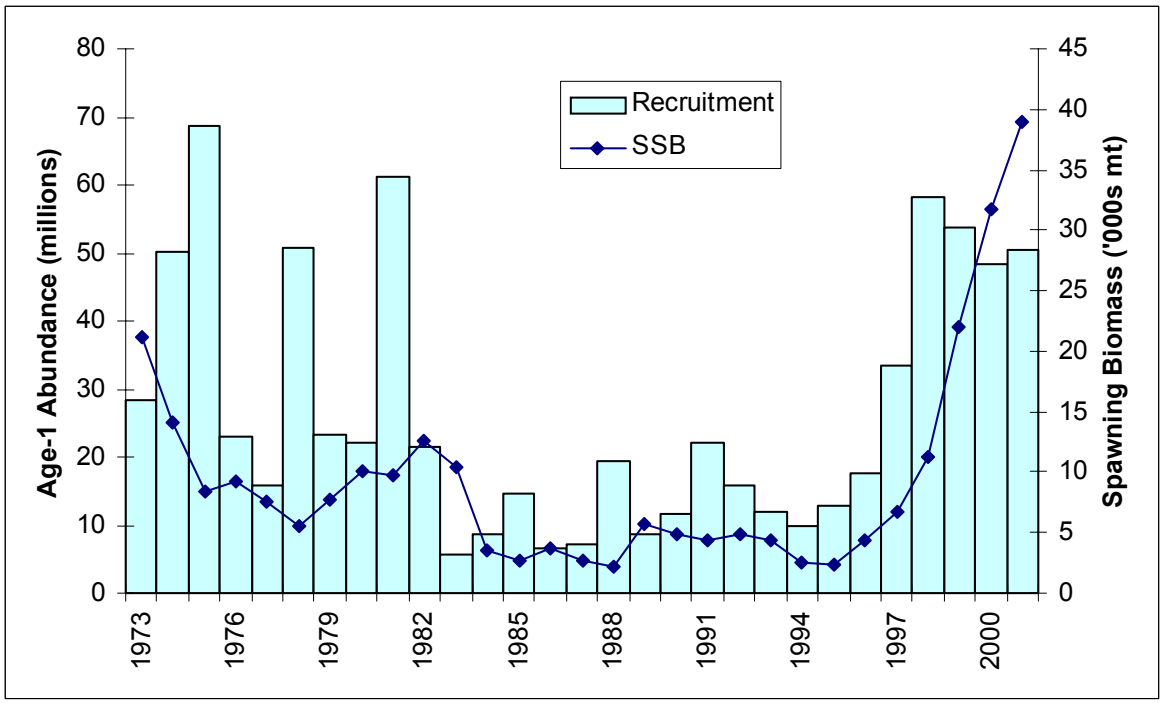


Figure C5. Population abundance at age from VPA compared to equilibrium levels at MSY.

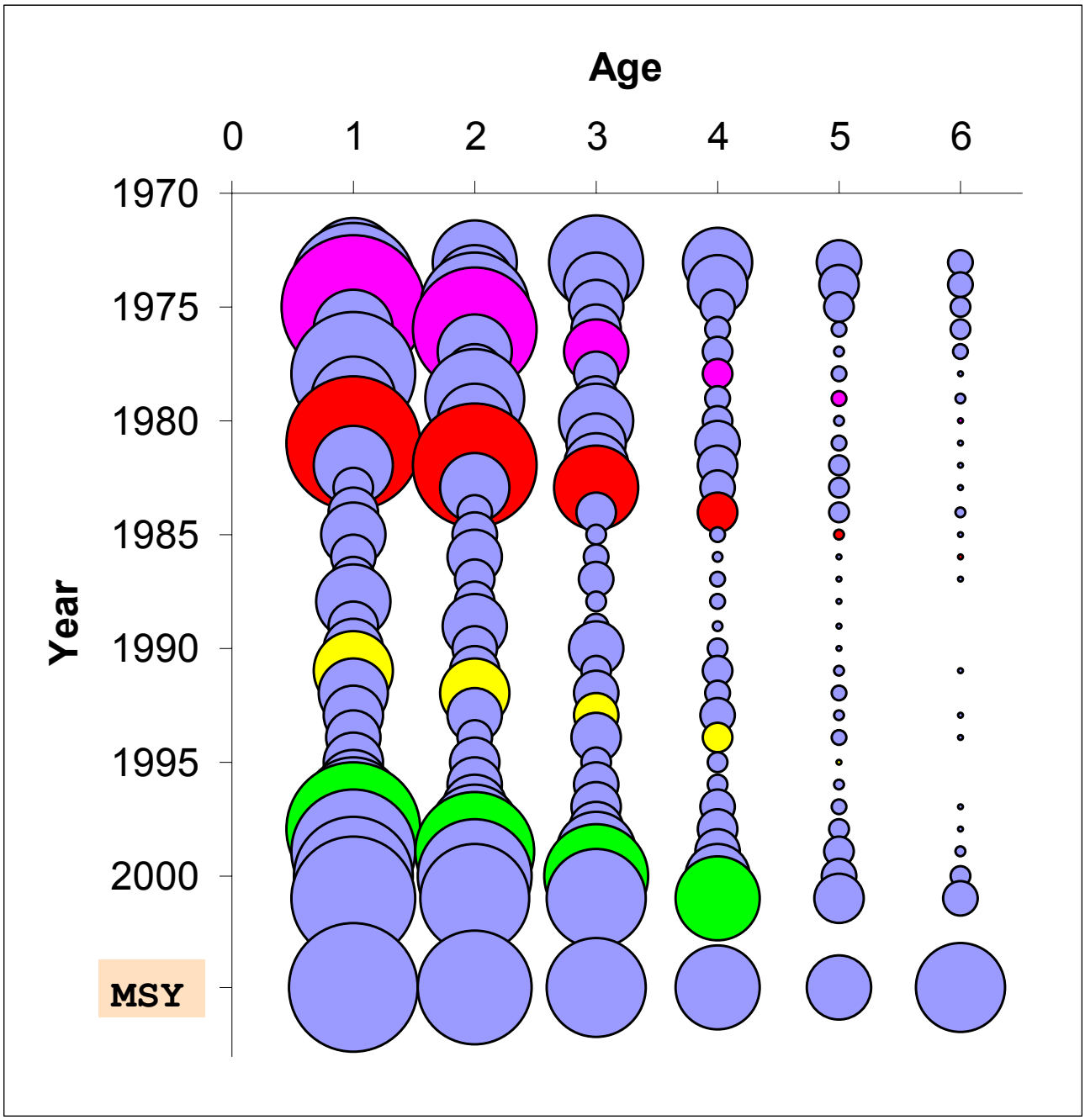


Figure C6. Retrospective patterns in Georges Bank yellowtail flounder VPA.

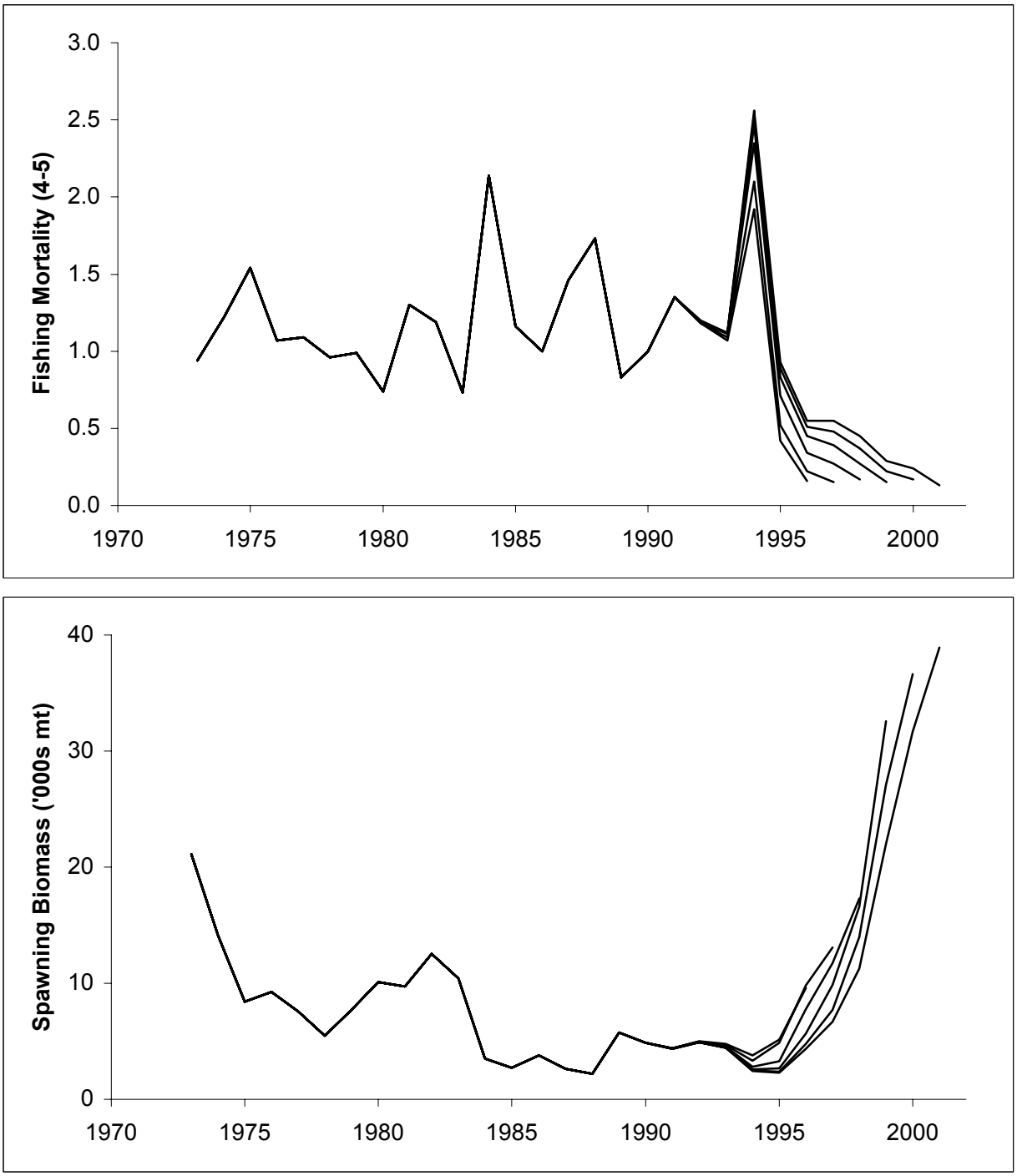


Figure C7. Point estimate (center symbol) and 80% confidence intervals (end symbols) for F and SSB in 2001 for the base run and three sensitivity analyses which increased the impacted survey catches.

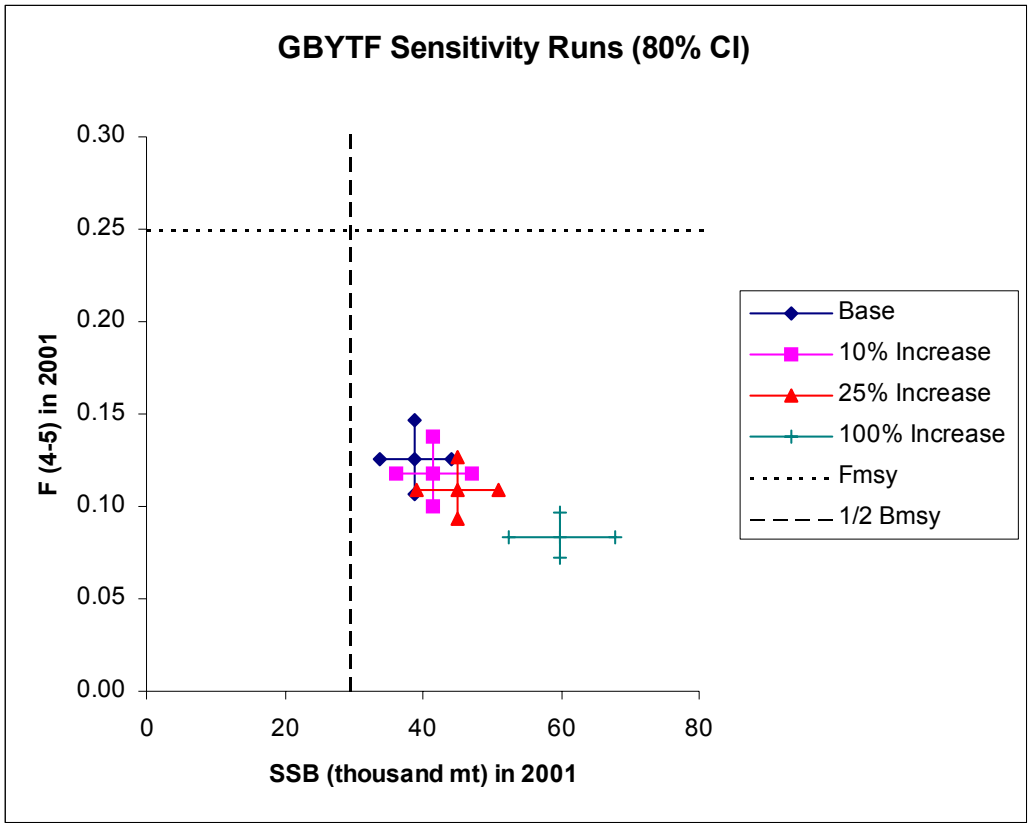


Figure C8. Projected spawning stock biomass under $F_{REBUILD}$=0.22 in years 2003 through 2009 to achieve a 50% probability of B_{msy} in 2009.

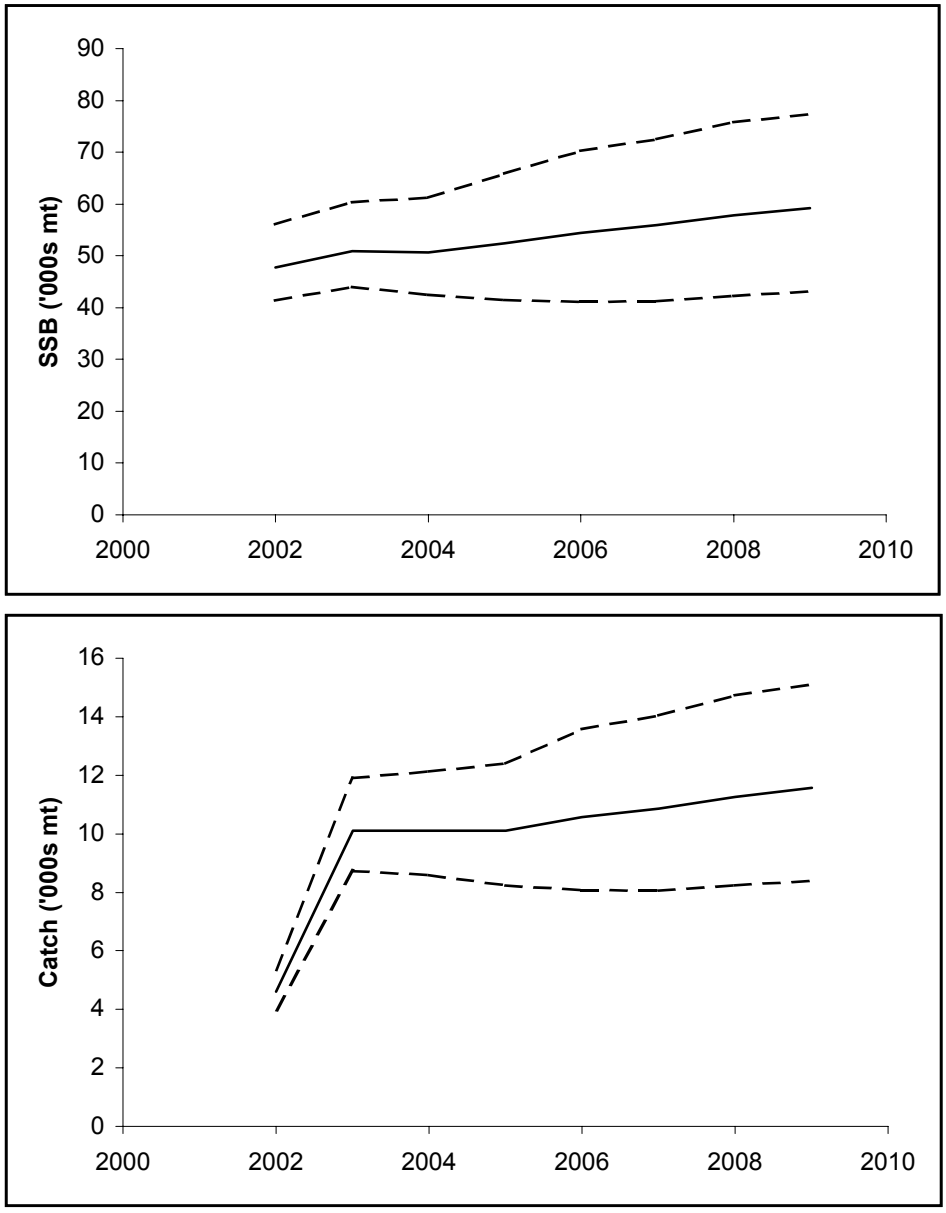


Figure C9. Mean biomass of Georges Bank yellowtail flounder and fishing mortality on biomass.