B. Georges Bank Haddock by **R.W. Brown**

1.0   Background

The Georges Bank haddock stock was last assessed by the United States in 1999 and reviewed by the Northern Demersal Committee of the Northeast Fisheries Science Center's Stock Assessment Workshop (NDWG 2000). The current stock assessment was reviewed at the 3rd Transboundary Resource Assessment Committee in April 2000 (TRAC 2000. Brown 2000). In addition, a Canadian assessment through 1999 was completed in the April 2000 for the 5Zj&m portion of the stock. The 1999 U.S. assessment estimated fully recruited fishing mortality (ages 4-7) in 1999 to be 0.15 (13% exploitation rate), which was above the fishing mortality rate (F_{target} = 0.00) specified by the Sustainable Fisheries Act (SFA) harvest control rule (Brown 2000). Fishing mortality was estimated to have remained between 0.1 and 0.2 between 1995 and 1998. Spawning stock biomass (SSB) was estimated to have increased from 10,900 mt in 1993 to 38,100 mt in 1998. The age structure of the population was continuing to expand and the age 4+ biomass was estimated to be at its highest level since the early 1980s. Preliminary estimates of the 1998 year class indicated an estimated year class size of 61.9 million fish at age 1, the largest year class since 1978. However, there was considerable uncertainty about the size of this year class due to highly variable catches in research vessel surveys available at the time of this assessment.

2.0   2000 Assessment

1999 Fishery

U.S. trip limit regulations for haddock continued to be liberalized, and 1999 regulations were significantly in more liberal in comparison to the 1998 calendar year. The trip limit from January 1 to April 30, 1999 was 3,000 pounds/day up to a maximum of 30,000 pounds/trip, 2,000 pounds/day up to a maximum of 20,000 pounds/trip from May 1 to November 4, 1999, and 5,000 pounds/trip up to a maximum of 50,000 pounds/trip from November 5 to December 31, 1999. As a result of both increased haddock abundance and liberalization of trip limit regulations, U.S. commercial landings of Georges Bank haddock in 1999 were 2,775 mt, a 51% increase from 1998 and an 887% increase over 1996 landings (Table B1, Figure B1). U.S. landings included 2,420 mt of landings from western Georges Bank (statistical areas 521, 522, 525, 526) and 355 mt of landings from eastern Georges Bank (statistical areas 561 & 562). U.S. catch continues to be displaced inshore as a result of Days at Sea regulations and area closures.

U.S. landings at age on western Georges Bank and south were estimated separately by market category using U.S. port sampling data. Sampling was sufficient to characterize western Georges Bank landings, but poor temporal distribution of samples made it necessary to use different temporal pooling for each of the two market categories. For the large haddock, samples were applied separately for quarters 1 and 2 and pooled for quarters 3 and 4. For scrod haddock, samples were pooled for quarters 1 and 2, and estimated separately for quarters 3 and 4.

U.S. port samples were insufficient to characterize U.S. landings from eastern Georges Bank, but landings from this area comprise a relatively small portion of the U.S. and total landings in the assessment. Of the 2,775 mt of U.S. haddock landings from Georges Bank, 355 mt (12.8% of U.S. landings and 5.5% of total landings) occurred in eastern Georges Bank. U.S. landings from eastern Georges Bank were partitioned using U.S. length samples by market category from western Georges Bank and Canadian survey ages (quarter 1) and Canadian commercial ages (quarters 2, 3 & 4). Length samples and landings were pooled identically to the analysis for western Georges Bank.

Discard estimates have been added to the catch at age during the assessment when resource conditions and management actions have resulted in the generation of levels of regulatory discard significantly higher than chronic background levels. In 1974, 1977, 1978, and 1980, discarding increased sharply as three large year classes (1972, 1975, 1978) recruited to the fishery (Overholtz et al. 1983). The catch at age in each of these years was augmented by estimates of associated discard. More recently, the catch at age was also augmented with estimates of discards from 1994 to 1998 to account for discard mortality generated in response to trip limit regulations in the U.S. fishery. Low discard rates reported in the Sea Sample and Vessel Trip Report databases are consistent with liberalized haddock trip limits that were in effect during 1999. These discarding rates are less than the rates reported in the U.S. fishery during the 1994 to 1998 period, and appear to be representative of background discarding rates reported in the Sea Sampling database from 1989 to 1993. Based on these observations and the dearth of information available to characterize the size and age distribution of U.S. discards, estimates of U.S. discards were not included in the 1999 catch at age.

Canadian catch from the Georges Bank haddock stock consisted of 3,680 mt of landings (Table B1), approximately 94% of the allocated 1999 quota of 3,900 mt and 57% of the total haddock landings from the Georges Bank stock. Comparison of observer samples with port samples did not reveal any persistent patterns which would indicate that discarding or high grading was occurring. The size and age composition of the 1999 Canadian fishery was characterized by port and at sea samples from all principal gears and all seasons.

The combined catch at age was dominated by age 3 (1996 year class) haddock, although there were significant contributions by ages 4-6 (1995, 1994, and 1993 year classes). Although 25% of landings by weight from the stock were accounted for by the 1996 year class, age 5 and older fish still comprised 58% of total landings by weight.

Fishery Independent Information

Abundance (stratified mean number/tow) and biomass (stratified mean weight/tow) survey indices in the U.S. Spring survey in 1999 and 2000 remained above levels observed from 1986-1995 (Table B2; Figure B2). The 1999 U.S. Spring survey catch of age 1 haddock (1998 year class) was the highest level observed since 1979 (1978 year class), but the index in the 2000 U.S. Spring survey for this year class was reduced substantially. The abundance and biomass survey indices in the U.S. Autumn survey in 1999 were the highest observed since 1979 (Table B2;

Figure B2). The 1998 U.S. Autumn survey catch of age 0 haddock (1998 year class) was the highest level observed since 1985 (1985 year class), but the index for this year class at age 1 declined sharply in the 1999 survey. Aggregate abundance survey indices in the Canadian Spring survey in 2000 were the highest levels observed since the initiation of the survey in 1986, and three-fold higher than the 1999 index (Figure B2). The majority of this abundance was comprised of large catches of age 1 and 2 haddock (1999 and 1998 year classes, respectively). Each of these indices was 3 fold higher than the next index at age in the Canadian survey time series. A single large tow in the 2000 Canadian survey had a significant effect on the aggregate index value.

Input Data and Analysis

The present assessment represents a one-year update to the previous U.S. assessment (NDWG 2000). The VPA formulation used for the current assessment was identical to the one used in the 1999 U.S. assessment, except for the addition of the terminal year of catch at age (1999) and research survey data (U.S. Spring 1999, U.S. Autumn 1999, Canadian Spring 2000). Very minor revisions were made to 1997 catch at age to incorporate revisions to the estimate of 1997 Canadian catch at age.

Precision of the 2000 stock sizes and 1999 fishing mortality and SSB estimates was derived from 1000 bootstrap simulations of the 1999 VPA formulation. A retrospective analysis of terminal year estimates of stock size, fully recruited fishing mortality and SSB was carried out to 1995.

3.0   Assessment Results

The current assessment continues to consistently estimate the strength of incoming year classes, indicating that the 1992 (15.3 million at age 1), 1993 (12.4 million), and 1996 (19.5 million) were stronger than other year classes since 1988 (Table B3; Figure B3). Based on the consistent strength of age 0+ and 1 survey indices, the 1998 and 1999 year classes are estimated to be 48.8 and 35.2 million fish at age 1, respectively. If these estimates are reliable, the 1998 and 1999 year classes would be the third and fourth largest year class since 1964, although smaller than the 1975 (103.3 million at age 1) and 1978 (84.0 million) year classes (Table B3). There is considerable uncertainty about the relative size of these two year classes due to highly variable results from research vessel surveys conducted to date. The size of these year classes will remain uncertain until additional fishery dependent and independent information is collected and analyzed. The age distribution of the stock continues to show evidence of broadening.

SSB has continued to increase steadily since 1994 and was estimated to be 48,500 mt. Although SSB is threefold higher than was estimated in 1993, it remains less than 50% of the B_{MSY} level of 105,000 mt established by harvest control rules. Fully recruited fishing mortality (ages 4-7) in 1999 is estimated to be 0.16, a slight increase from the fishing mortality estimated for 1998 (Table B3; Figure B4).

VPA Diagnostics

The sums of squares and mean squared residuals from the VPA were within the range of accepted VPAs from the last four U.S. assessments of Georges Bank haddock. The coefficients of variation on estimated age 1-8 stock sizes (range 0.25 - 0.61) were slightly nearly identical to those observed in recent U.S. assessments. Other VPA diagnostics including the range of CV's on survey q estimates, the number of large standardized residuals and the maximum partial variance estimates are consistent with previous U.S. haddock assessments. There were no outstanding residual patterns detected during an analysis of standardized residuals. Residual patterns for the 1998 and 1999 year classes exhibit a general trend reflecting consistently higher Canadian survey indices which are contrasted by consistently lower U.S. Autumn survey indices.

Accounting for precision in the current assessment, there is a 80% probability that fully recruited F in 1999 was between 0.14 and 0.18, and that SSB in 1999 was between 43,800 and 54,500 mt. There was a 14.9% change that SSB in 1999 exceeded the limit threshold (53,000 mt) and a zero percent chance that SSB in 1999 had exceeded the target biomass threshold (68,000 mt).

Retrospective patterns for fishing mortality were similar to those observed in the 1999 assessment of this stock, indicating that terminal year estimates of fishing mortality and SSB are relatively well estimated in the terminal year of the assessment. The alternating pattern of slightly overestimated and slightly underestimated terminal year estimates indicates that there is not a retrospective pattern in the terminal year estimates of these parameters.

Terminal year estimates of age 1 recruitment were more variable with a significant tendency to overestimate age 1 recruitment in some years (1995 year class in 1996, 1998 year class in 1999). The retrospective analysis of age 1 stock sizes reinforces the need for additional survey information on incoming recruitment before firm estimates of year class strength can be made.

Harvest Control Rule

The SFA harvest control rule for Georges Bank haddock is based on MSY-based reference point proxies (Figure B5). When SSB is greater than 105,000 mt, the overfishing limit is $F_{0.1}$ (currently estimated to be 0.26), and the target F is 75% of the F_{MSY} proxy (0.20). The limit F decreases linearly from 0.26 at 105,000 mt of SSB to zero at 53,000 mt SSB, and the target F decreases linearly from 0.20 at 105,000 mt of SSB to zero at 68,000 mt of SSB.

4.0   Consistency of 1999 Projection Forecast with 2000 Assessment Results

Projections conducted during the 1999 assessment (NDWG 2000) were based on the 1999 assessment results, assumed that $F_{1999} = F_{1998} = 0.15$, and estimated that SSB would rise to 44,700 mt in 1999. The 2000 assessment estimated $F_{1999} = 0.16$ and SSB at 48,500 mt (Table B3). The fishing mortality assumption made during the 1999 assessment was reasonable (0.15 vs. realized F of 0.16) and the resulting SSB projection for 1999 (48,500 mt) is within the 80% confidence

interval (40,000 - 49,800 mt) of the 1999 assessment projection. The 2000 assessment resulted in improved SSB estimates for 1997-1999, based on relatively stronger contributions from the 1994 and 1996 year classes.

5.0   Sources of Uncertainty

a)   Sampling of U.S. landings and discards was insufficient to accurately characterize the size and age distribution of the catch. There is a critical need for increased biological sampling for Georges Bank haddock.

b)   There is considerable uncertainty regarding the size of the 1998 and 1999 year classes. Survey indices for these year classes are highly variable and there is conflicting information about the relative size of these year classes from U.S. and Canadian surveys.

6.0   Conclusions

The Georges Bank haddock stock remains in an overexploited condition based on the current low level of biomass in relation to management rebuilding thresholds and pre-collapse stock levels. The assessment indicates that fishing mortality has been reduced from pre-1994 levels, and F_{1999} (0.16 or 13% exploitation) indicates that fishing mortality has remained stable and at relatively low levels since 1994. The age structure of the population is continuing to expand and the age 4+ biomass is at its highest levels since 1982. Recruitment continues to improve and the 1998 and 1999 year classes are currently estimated to be the largest observed since 1978. There is considerable uncertainty about the absolute size of these year classes due to the influence of large tows that have a significant influence on available survey indices. Spawning stock biomass (SSB) in 1998 was estimated to be 48,500 mt, a 3-fold increase over levels estimated in 1993 but less than 50% of the B_{MSY} of 105,000 mt established by U.S. harvest control rules.

Observed increases in SSB of Georges Bank haddock have resulted from conservation of a series of relatively weak year classes. This was a necessary first step in the stock rebuilding process. Spawning stock has been rebuilt and age structure has been restored to the point where recruitment appears to be improving significantly. If incoming recruitment from the 1998 and 1999 year classes is conserved, growth and maturation of these year classes will result in significant increases in SSB. Based on historical stock recruitment relationships for this stock, as SSB increases, the probability of additional strong recruitment events will be significantly enhanced. Maintenance of low fishing mortality rates to promote continuous rebuilding of SSB is essential to achieving biomass rebuilding targets for this stock. Given the potential growth trajectories for this stock, maintenance of current low fishing mortality rates should still allow for significant increases in available landings to both the U.S. and Canadian fisheries over the next several years.

7.0 References

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Table B1.　Commercial landings (mt) of haddock from Georges Bank and south (NAFO Division 5Z and Subarea 6), 1960-1999.[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

[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, NEFC Detailed Weighout Files and Canvas data; Canadian landings 1980-1998 from Gavaris and Van Eeckhaute (1999); Canadian landings 1999 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.   Mean number and mean weight (kg) per tow of haddock caught in the U.S. spring and autumn bottom trawl surveys from 1963-1999.

Year	Spring Survey		Autumn Survey	
	Number/Tow	Weight (kg)/tow	Number/tow	Weight (kg)/tow
1963			145.01	79.77
1964			193.24	96.75
1965			101.69	72.78
1966			33.26	29.87
1967	*Spring survey initiated in 1968*		17.70	25.47
1968	13.84	20.55	7.51	15.40
1969	7.33	16.93	3.38	8.44
1970	6.00	17.12	7.70	13.50
1971	2.79	5.00	4.20	5.59
1972	6.38	7.37	11.35	8.47
1973	37.62	15.37	14.89	9.78
1974	19.01	17.70	4.05	3.99
1975	6.24	8.21	30.95	15.10
1976	83.19	15.72	71.07	35.76
1977	36.86	26.58	23.25	27.52
1978	19.41	31.27	25.29	18.06
1979	45.50	19.77	52.24	31.98
1980	60.06	53.92	30.54	21.98
1981	31.21	38.02	13.45	14.01
1982	8.60	13.11	4.96	7.34
1983	5.60	13.21	7.99	5.75
1984	6.24	7.45	5.38	4.48
1985	8.85	11.14	14.19	3.86
1986	5.85	5.86	6.81	5.10
1987	4.95	5.60	3.62	2.56
1988	3.38	3.43	5.35	5.57
1989	5.35	4.70	4.34	4.70
1990	7.68	7.57	2.92	2.62
1991	3.97	4.38	2.92	0.94
1992	1.18	1.41	6.06	3.17
1993	2.79	2.48	8.09	4.33
1994	4.99	3.63	3.58	2.93
1995	5.61	5.72	17.11	10.66
1996	23.40	25.73	4.47	4.11
1997	12.95	18.50	6.16	6.51
1998	7.28	6.12	11.07	5.75
1999	16.66	7.74	33.09	23.13

Table B3.   Beginning year stock size (000s) of Georges Bank haddock estimated from VPA,
               1963 - 1999.

	1963	1964	1965	1966	1967	1968	1969
1	190706	471885	33154	4137	12954	422	988
2	32266	153504	377207	18457	3284	9565	338
3	32743	22756	111260	194986	8920	2536	5122
4	45821	20096	14510	50830	68425	4687	1435
5	29031	27424	12131	7034	24273	37321	2099
6	9186	16351	14561	5959	3254	10519	17419
7	5595	5526	8144	5868	2535	1570	5446
8	2795	3309	2640	3255	2694	1177	682
9	4217	4251	3258	2201	2031	2163	1712
1+	352360	725101	576867	292727	128369	69961	35241

	1970	1971	1972	1973	1974	1975	1976
1	4661	369	8517	19418	10547	7661	103305
2	807	3774	301	6832	13582	8594	6098
3	267	518	1846	245	3716	7211	6100
4	2657	204	222	1104	198	2448	4217
5	770	1660	131	109	555	160	1665
6	1127	462	1097	78	41	391	127
7	8874	729	156	790	37	32	282
8	3035	5177	339	57	577	28	22
9	1875	3245	6311	1679	2702	622	623
1+	24071	16137	18919	30311	31954	27146	122441

	1977	1978	1979	1980	1981	1982	1983
1	13810	6073	83984	10137	7225	2480	3108
2	84449	11306	4971	68760	8292	5915	2029
3	4565	51420	8568	4046	28246	5212	3788
4	4497	3568	29074	5453	2999	13174	2789
5	2657	3066	2645	17317	3582	1703	7408
6	1168	1709	1997	1691	8700	2085	1041
7	104	633	931	1264	847	4796	1192
8	210	82	392	478	541	394	2914
9	594	390	187	251	319	406	275
1+	112054	78246	132750	109396	60751	36164	24545

	1984	1985	1986	1987	1988	1989	1990
1	17265	1761	14746	2103	16757	1087	2644
2	2544	14136	1442	12068	1722	13716	890
3	1468	1999	9396	1131	8075	1363	10087
4	2366	933	1139	5150	810	4454	1038
5	1659	1279	588	731	2757	542	2853
6	4039	999	630	350	488	1415	314
7	606	1966	612	360	220	265	835
8	808	284	1134	365	214	130	175
9	1628	550	254	461	351	208	166
1+	32384	23908	29941	22719	31393	23180	19002

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Table B3 (Cont).   Beginning year stock size (000s) of Georges Bank haddock estimated
                       from VPA, 1963 - 1999.

	1991	1992	1993	1994	1995	1996	1997
1	2377	9306	15272	12448	10425	9908	19530
2	2163	1940	7613	12497	10190	8527	8107
3	719	1365	1365	5970	9989	8262	6933
4	6951	506	828	801	4155	7638	6249
5	694	3746	295	408	502	2988	5398
6	1551	476	1686	147	274	357	2027
7	168	899	289	784	58	196	230
8	523	72	443	202	505	40	141
9	243	247	210	198	160	58	356
1+	15388	18558	28001	33456	36258	37974	48971

	1998	1999	2000
1	11294	48760	35243
2	15963	9245	39921
3	6477	12890	7534
4	5415	4927	9592
5	4413	3980	3507
6	3906	2987	2808
7	1460	2722	1984
8	171	1061	1926
9	331	303	951
1+	49430	86877	103466

Table B3 (Cont). Spawning stock biomass (mt) of Georges Bank haddock estimated from the VPA, 1963-1999.

	1963	1964	1965	1966	1967	1968	1969
1	00	00	00	00	00	00	00
2	00	00	00	00	00	1675	61
3	24233	15655	65996	91773	4934	1433	3119
4	56101	23010	14892	48128	60273	4294	1636
5	38629	36355	15691	8788	26351	41983	2731
6	16464	25247	20964	8946	5063	15410	26018
7	10877	10439	13799	10289	4575	2780	10823
8	6533	7059	5446	6850	5610	2397	1526
9	11435	10811	8271	5784	5324	5124	5278
1+	164273	128575	145060	180559	112131	75096	51190

	1970	1971	1972	1973	1974	1975	1976
1	00	00	00	00	00	00	00
2	164	756	67	1594	3142	2253	1510
3	185	411	1652	273	4216	7623	6069
4	3442	266	304	1789	359	4459	6767
5	1303	3215	236	189	1248	342	3694
6	2067	873	2671	183	116	1039	316
7	17573	1590	354	2308	126	113	863
8	7609	12676	962	170	1956	105	87
9	6177	10450	20679	5770	10659	2455	2771
1+	38520	30237	26924	12276	21822	18389	22076

	1977	1978	1979	1980	1981	1982	1983
1	00	00	00	00	00	00	00
2	17995	2458	1134	12825	1686	1074	293
3	4151	45760	6800	3345	20420	4055	3145
4	7098	5675	44468	7305	3874	17421	3991
5	5546	6779	5353	30529	6242	3137	12974
6	2927	4333	5274	3784	18209	4569	2279
7	351	1847	2737	3438	2262	12571	3240
8	725	286	1233	1494	1781	1315	8354
9	2664	1797	799	827	1224	1445	1019
1+	41458	68935	67797	63547	55698	45586	35294

	1984	1985	1986	1987	1988	1989	1990
1	376	79	1114	137	1105	97	117
2	436	4746	491	4335	685	5044	339
3	1429	1787	8534	1097	6681	1395	9917
4	3212	1317	1593	7119	1112	6049	1507
5	2933	2274	1163	1340	4738	911	4770
6	8196	2162	1446	808	983	2853	638
7	1405	4897	1526	923	540	672	1994
8	2283	820	3256	1054	597	377	476
9	5141	1817	848	1710	1197	708	603
1+	25411	19900	19971	18523	17638	18106	20361

Table B3 (Cont).   Spawning stock biomass (mt) of Georges Bank haddock estimated from
                       the VPA, 1963 - 1999.

```
             1991      1992      1993      1994      1995      1996      1997
     ----------------------------------------------------------------------------
     1          92       323       521       252        53        58        96
     2         947       822      1704      3010      2160      1888      1759
     3         698      1589      1209      5366     11204      8713      8350
     4        9669       666      1230      1309      6979     11583      9641
     5        1244      6115       480       882      1092      5885     10037
     6        3201       985      3336       281       686       812      4543
     7         367      2109       683      1940       158       560       601
     8        1319       185      1132       570      1392       124       440
     9         907       878       706       800       586       198      1196
     ----------------------------------------------------------------------------
     1+      18445     13674     11001     14409     24311     29823     36663

                1998      1999
        --------------------------
        1         75       569
        2       3457      2240
        3       7181     14483
        4       8875      7744
        5       8013      7212
        6       8241      6006
        7       3713      6366
        8        535      2885
        9       1178      1018
        --------------------------
        1+     41270     48522
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Table B3 (Cont).   Estimated mean biomass (mt) for the Georges Bank haddock estimated from VPA, 1963 - 1999.

	1963	1964	1965	1966	1967	1968	1969
1	97717	211391	14554	2142	7375	223	465
2	23694	108938	190543	9574	2026	5762	235
3	30570	20524	79454	107563	6249	2031	4131
4	52683	22565	13938	45273	60547	4252	1805
5	37107	33322	14500	8336	23357	41005	2735
6	15484	23667	19034	8292	4737	16183	25212
7	10228	9378	12048	9296	4088	2471	10392
8	6577	6509	4809	6534	5219	2165	1497
9	10122	9407	6938	4896	4586	4345	4563
1+	284182	445700	355818	201907	118183	78438	51035

	1970	1971	1972	1973	1974	1975	1976
1	2983	224	4739	9796	6867	4247	46780
2	828	2777	280	5270	10666	7130	5242
3	286	458	2511	348	5529	9097	7308
4	4091	287	324	1700	414	4489	6720
5	1320	3249	248	167	1324	315	3728
6	2183	791	2731	181	136	980	356
7	17699	1487	300	2318	132	107	901
8	7654	12198	942	169	1948	96	85
9	5489	9174	18665	5098	9910	2252	2513
1+	42532	30643	30740	25047	36925	28713	73634

	1977	1978	1979	1980	1981	1982	1983
1	6634	2917	40343	5051	2554	494	930
2	71235	9281	4493	42806	5771	4630	1768
3	5826	58786	8824	4231	24504	5619	4140
4	8107	6291	45834	7702	4192	18830	3982
5	5864	6958	5353	27164	6363	3188	12276
6	2803	4087	5034	3442	17830	4408	2131
7	384	1695	2568	3068	2195	12237	3210
8	683	242	1162	1257	1652	1198	7491
9	2411	1633	711	717	1071	1275	898
1+	103947	91891	114321	95439	66131	51880	36824

	1984	1985	1986	1987	1988	1989	1990
1	5164	527	6013	820	6378	522	1533
2	2080	11489	1203	8249	1505	10509	778
3	1558	2125	9604	1375	8155	1765	12464
4	3234	1480	1683	7660	1120	6434	1519
5	2864	2256	1174	1353	4145	923	4522
6	7688	2149	1365	736	894	2826	596
7	1259	4627	1415	847	509	702	1871
8	2021	810	3087	1042	561	370	404
9	4444	1600	756	1498	1045	635	533
1+	30312	27062	26301	23578	24312	24687	24221

Table B3 (Cont). Estimated mean biomass (mt) for the Georges Bank haddock estimated from VPA, 1963 - 1999.

	1991	1992	1993	1994	1995	1996	1997
1	1250	4536	9120	5043	4052	4094	7358
2	2082	1922	7901	12238	8889	8457	7247
3	795	1761	1828	8228	13045	10792	10387
4	9420	692	1288	1413	7168	11861	9980
5	1262	5640	451	885	1080	5758	10202
6	3161	944	3095	262	656	734	4402
7	323	1912	644	1841	159	572	618
8	1203	171	994	611	1329	118	404
9	794	747	605	718	542	182	1105
1+	20290	18326	25925	31237	36919	42567	51703

	1998	1999
1	5230	29963
2	15579	9205
3	9061	17041
4	8632	7644
5	7746	7093
6	7905	5734
7	3723	6206
8	542	2648
9	1086	935
1+	59505	86470

Table B3 (Cont).   Estimated fishing mortality (F) for the Georges Bank haddock estimated from VPA, 1963 - 1999.

	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	0.46	0.53	0.06	0.42	0.04
3	0.29	0.25	0.58	0.85	0.44	0.37	0.46
4	0.31	0.30	0.52	0.54	0.41	0.60	0.42
5	0.37	0.43	0.51	0.57	0.64	0.56	0.42
6	0.31	0.50	0.71	0.65	0.53	0.46	0.47
7	0.33	0.54	0.72	0.58	0.57	0.63	0.38
8	0.34	0.42	0.61	0.56	0.47	0.55	0.45
9	0.34	0.42	0.61	0.56	0.47	0.55	0.45
4-7	0.33	0.44	0.62	0.59	0.53	0.56	0.43

	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	0.52	0.01	0.41	0.43	0.14	0.09
3	0.07	0.65	0.31	0.01	0.22	0.34	0.10
4	0.27	0.24	0.52	0.49	0.01	0.19	0.26
5	0.31	0.21	0.31	0.77	0.15	0.03	0.15
6	0.24	0.89	0.13	0.55	0.06	0.13	0.00
7	0.34	0.57	0.81	0.11	0.06	0.15	0.09
8	0.32	0.38	0.24	0.35	0.11	0.17	0.22
9	0.32	0.38	0.24	0.35	0.11	0.17	0.22
4-7	0.29	0.48	0.44	0.48	0.07	0.12	0.13

	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	0.08	0.01	0.69	0.26	0.25	0.12
3	0.05	0.37	0.25	0.10	0.56	0.43	0.27
4	0.18	0.10	0.32	0.22	0.37	0.38	0.32
5	0.24	0.23	0.25	0.49	0.34	0.29	0.41
6	0.41	0.41	0.26	0.49	0.40	0.36	0.34
7	0.04	0.28	0.47	0.65	0.57	0.30	0.19
8	0.23	0.21	0.32	0.44	0.39	0.35	0.36
9	0.23	0.21	0.32	0.44	0.39	0.35	0.36
4-7	0.22	0.25	0.32	0.46	0.42	0.33	0.31

	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	0.13	0.39	0.07	0.17
4	0.41	0.26	0.24	0.42	0.20	0.25	0.20
5	0.31	0.51	0.32	0.20	0.47	0.35	0.41
6	0.52	0.29	0.36	0.26	0.41	0.33	0.42
7	0.56	0.35	0.32	0.32	0.32	0.21	0.27
8	0.45	0.36	0.30	0.39	0.40	0.27	0.34
9	0.45	0.36	0.30	0.39	0.40	0.27	0.34
4-7	0.45	0.35	0.31	0.30	0.35	0.28	0.33

Table B3 (Cont).   Estimated fishing mortality (F) for the Georges Bank haddock estimated from VPA, 1963 - 1999.

	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	0.02	0.01	0.01	0.02
3	0.15	0.30	0.33	0.16	0.07	0.08	0.05
4	0.42	0.34	0.51	0.27	0.13	0.15	0.15
5	0.18	0.60	0.49	0.20	0.14	0.19	0.12
6	0.35	0.30	0.57	0.73	0.14	0.24	0.13
7	0.65	0.51	0.16	0.24	0.17	0.13	0.10
8	0.39	0.54	0.50	0.27	0.13	0.16	0.14
9	0.39	0.54	0.50	0.27	0.13	0.16	0.14
4-7	0.40	0.44	0.43	0.36	0.14	0.18	0.12

	1998	1999
1	0.00	0.00
2	0.01	0.00
3	0.07	0.10
4	0.11	0.14
5	0.19	0.15
6	0.16	0.21
7	0.12	0.15
8	0.15	0.16
9	0.15	0.16
4-7	0.14	0.16
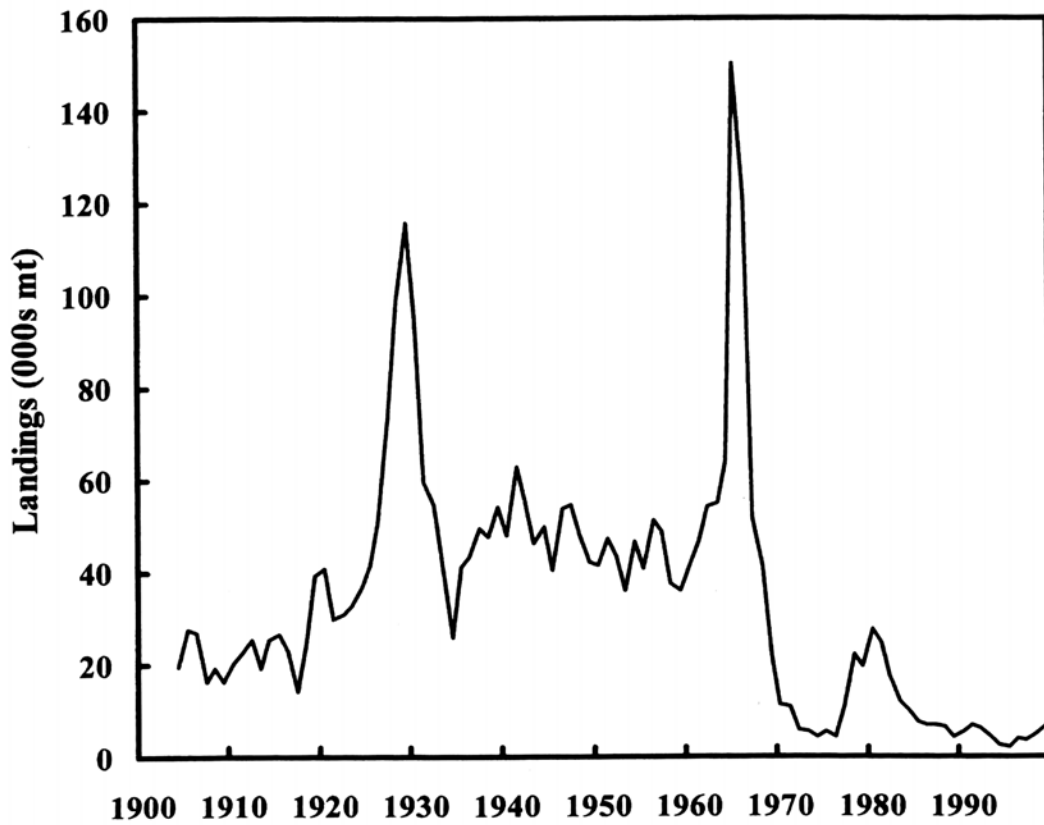
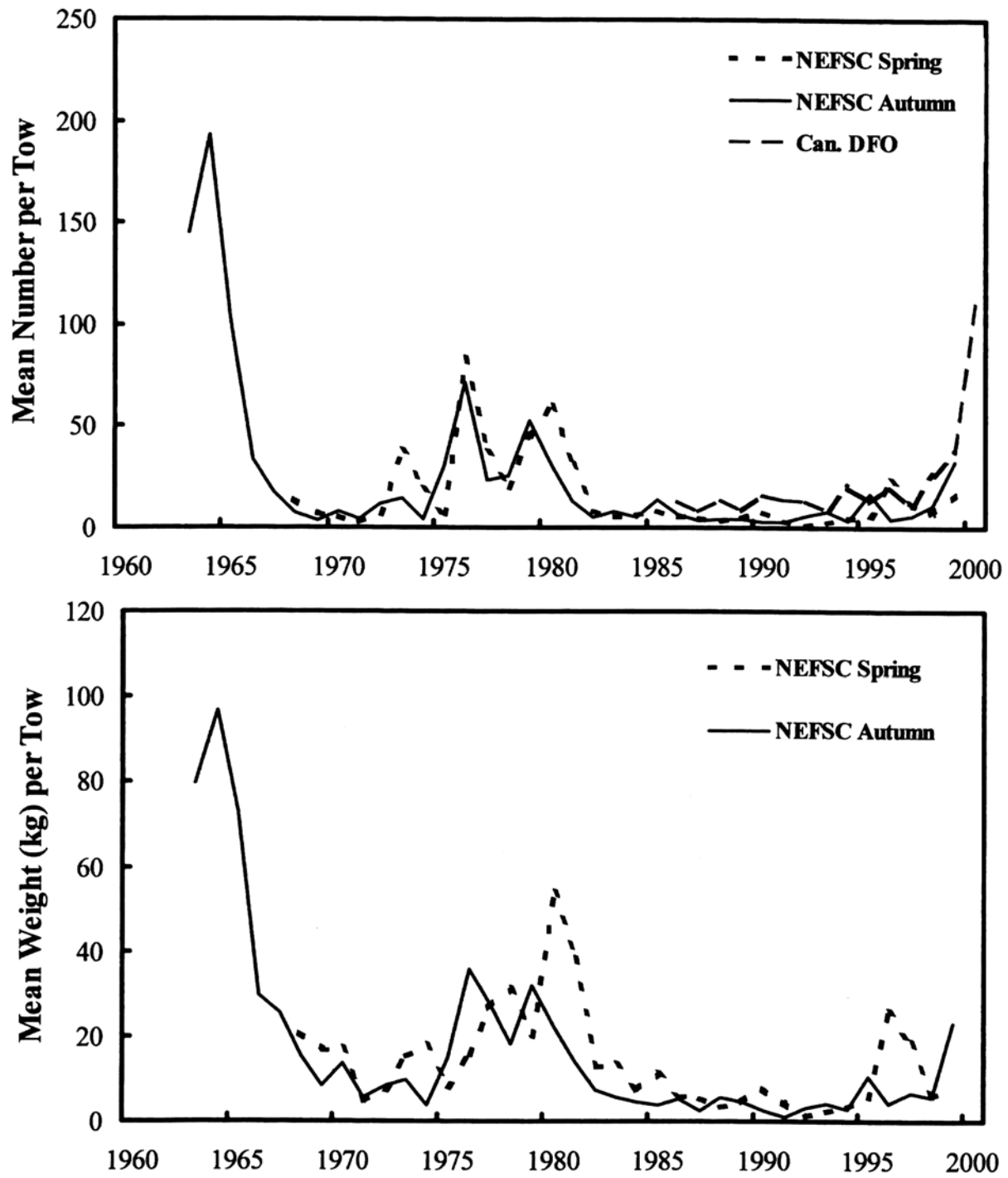Figure B1. Total commercial landings (000s mt) of haddock from Georges Bank and south, 1904-1999.

Figure B2. U.S. and Canadian research vessel survey abundance (stratified and standardized mean number/tow, Top Panel) and biomass (kg per tow, Bottom Panel) indices for Georges Bank haddock from 1963-1999. U.S. survey includes strata 01130-01250 and 01290-01300; Canadian survey indices include strata 5Z1-5Z8. Surveys have not been adjusted for catchabilities.
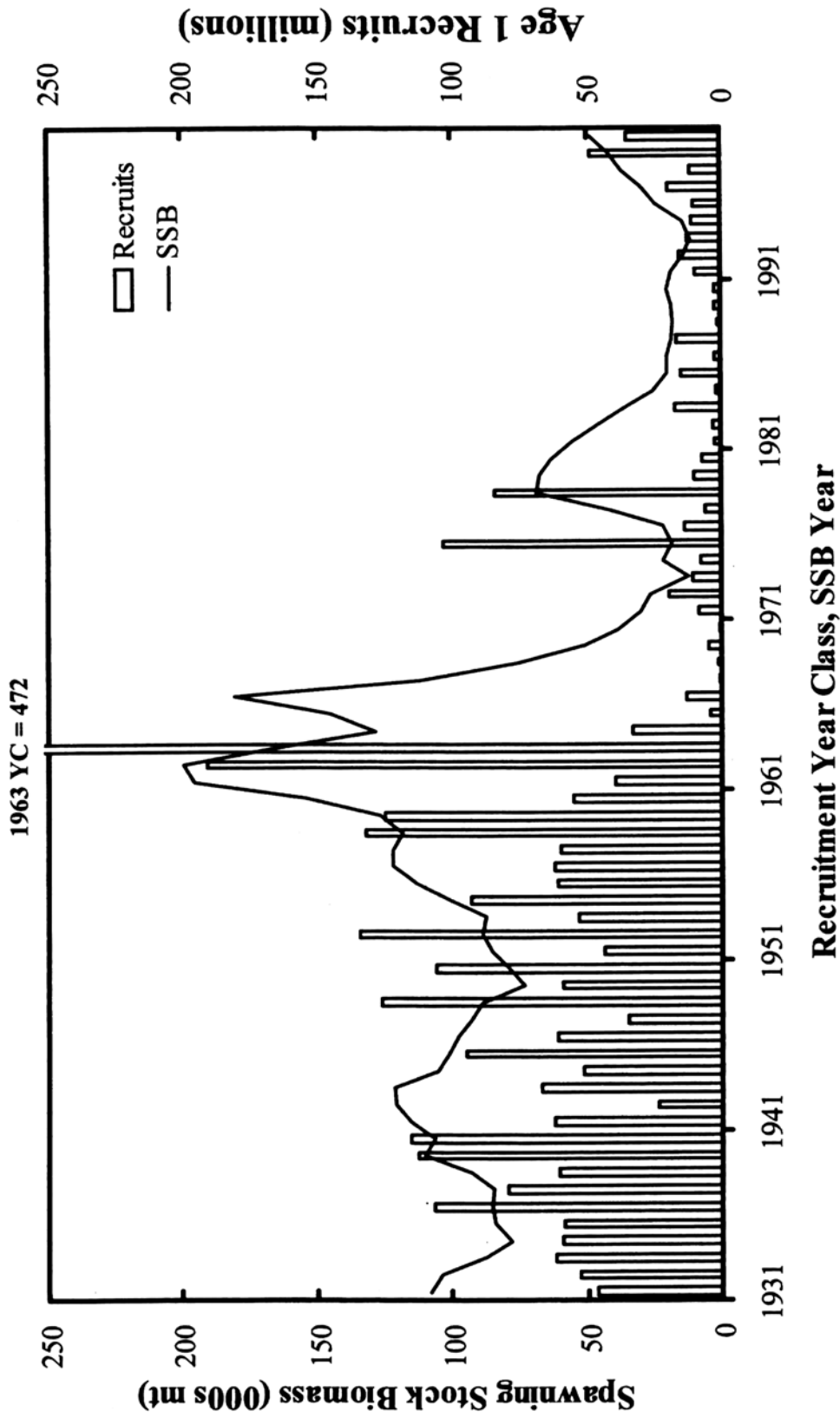
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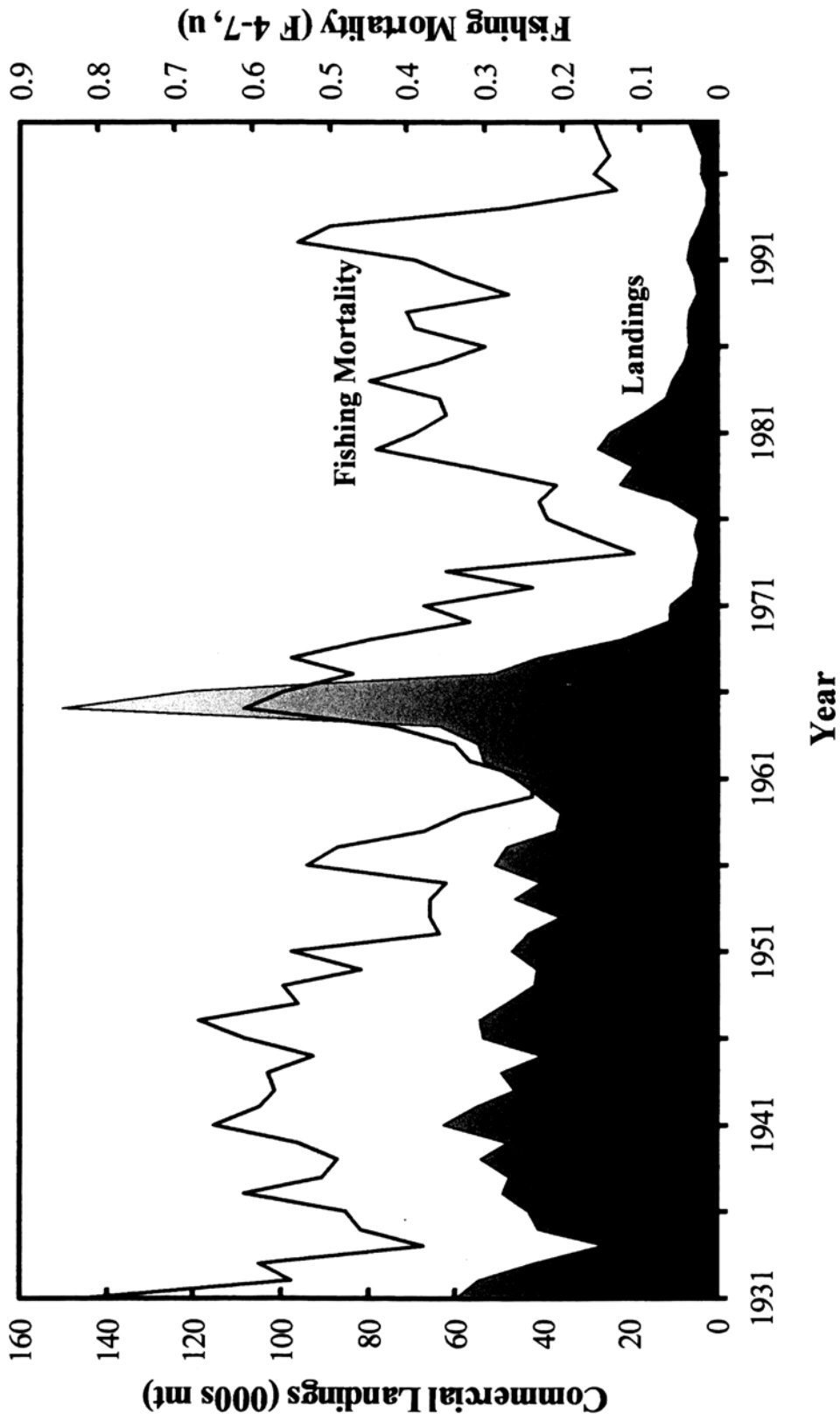Figure B3. Trends in spawning stock biomass (line) and age 1 recruitment (bars) for Georges Bank haddock from 1931-1999.

Figure B4.   Trends in commercial landings (mt, live weight) and fully recruited fishing mortality (mean F, ages 4-7, unweighted) for Georges Bank haddock from 1931-1999.
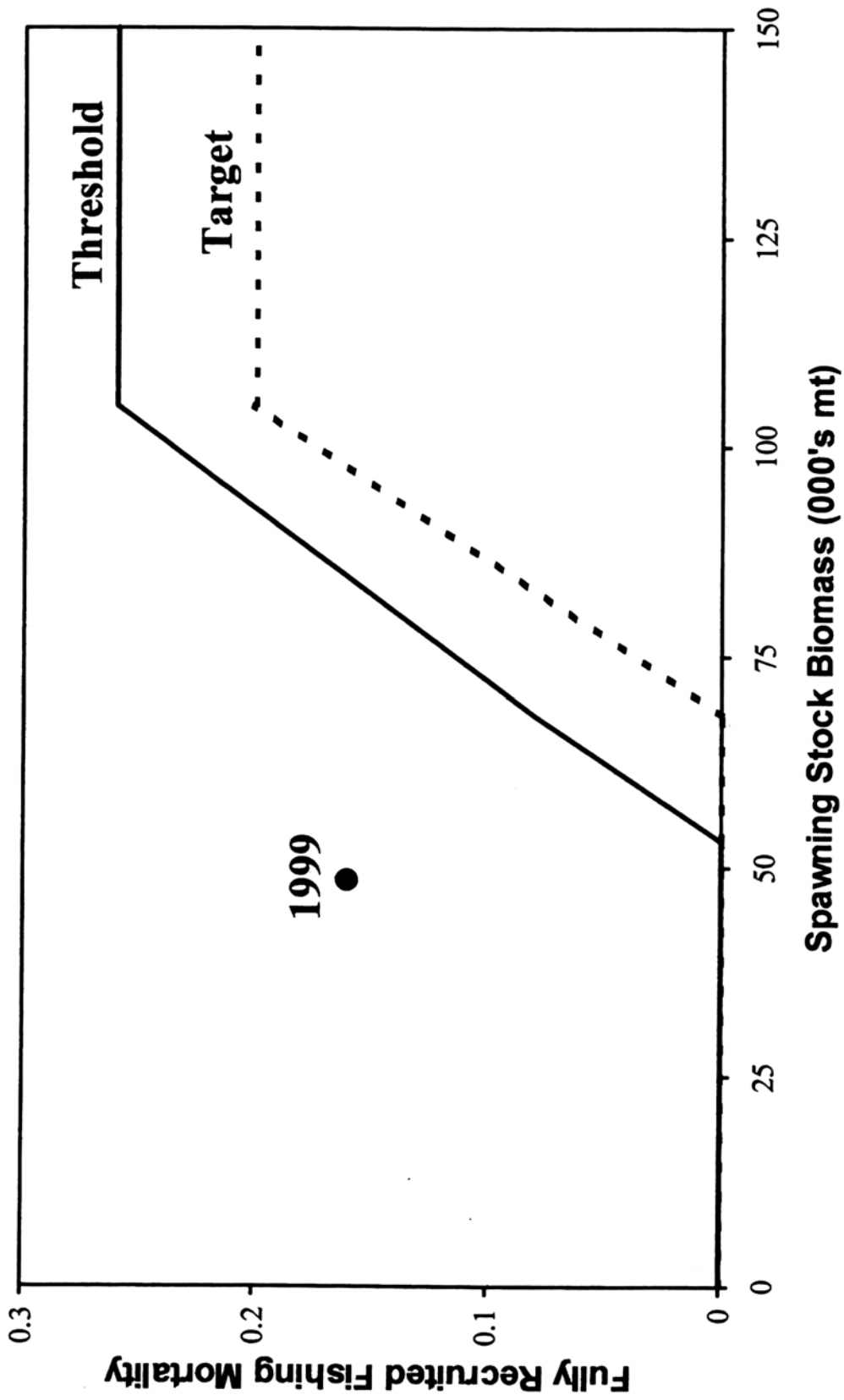
Figure B5. SFA harvest control rule for Georges Bank haddock based on proxies of MSY-based reference points and minimum biomass thresholds.