B. Georges Bank haddock

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Additional details and supporting information can be found in the Appendix of the GARM-III Report (NEFSC 2008).

1.0 Background

The Georges Bank haddock stock was last assessed as part of the GARM2 (Brodziak et al. 2006). That assessment, which was an update rather than a benchmark, included landings and discards through 2004, and abundance indices through 2005. The model applied was the NMFS Toolbox implementation of VPA, with catch at age extending back to 1963. Reference points had been examined as part of the 2002 working group on biological reference points (NEFSC 2002). Although it was determined that stock size had an effect on recruitment, the parametric fits of stock recruit curves had poor residual diagnostics; thus, a nonparametric approach was taken, with $F_{40\%}$ serving as a proxy for F_{MSY} (Brodziak and Legault 2005). The value of $F_{40\%}$ was 0.26, and the corresponding levels of SSB_{MSY} and MSY were 250,300 mt and 52,900 mt, respectively. These values were derived by taking SSB/R and YPR and multiplying by the mean recruitment for years in the period (1931-1960) where SSB was above its median (75,000 mt). Based on the SSB median criterion, mean recruitment was 75.23 million age-1 recruits (NEFSC 2002).

The current overfished threshold is $SSB_{threshold}=0.5*SSB_{MSY}=125{,}150$ mt, while the current overfishing threshold is $F_{threshold}=F_{MSY}=0.26$ (NEFSC 2002). VPA estimated spawning stock biomass in 2004 was 116,800 mt, or 93% of the $SSB_{threshold}$, and the estimate of F_{2004} was 0.24. Therefore, the stock was slightly overfished, but overfishing was not occurring. Catch in 2004 was estimated to be 16,924 mt—well below the estimated 52,900 mt at MSY.

This document reflects a benchmark assessment for Georges Bank Haddock. Since the GARM2, several different decisions regarding data treatment were made. A standard allocation algorithm to apportion landings to statistical area (Wigley et al. 2007a) was adopted as an improvement over individually determined proration schemes. The apportionment between Georges Bank and Gulf of Maine (Fig. B1) followed the procedure in Palmer (2008). Also, the methodology to estimate discards previously was based on a ratio of discarded to kept of haddock only, whereas currently the ratio is based on discarded haddock to kept of all species; this reflects the methodology accepted at the GARM3-data meeting (Wigley et al. 2007b). Finally, the previous assessment used time-varying stanzas of maturity at age, whereas the current assessment uses a single maturity ogive for all years.

2.0 Fishery

Landings

Total catches of Georges Bank haddock increased from a low of 2,442 mt in 1995 to the recent high of 21,814 mt in 2005 (Table B1, Fig. B2). Historically, the largest catches were taken in the 1960s, peaking at nearly 182,000 mt in 1965. For the years of re-estimated US Georges Bank haddock catches (1989-2007), there was a maximum of 8415 mt in 2004 and a minimum of 309 mt in 1995. US catch increased steadily from the low in 1995 to 2002, and has fluctuated since then. The average US catch for years 2001-2007 is 6032 mt (Table B1). US landings show

the same trend as US catches, with a steady increase since 1995 and fluctuations since 2002. US landings in 2006 and 2007 were 2643 mt and 2930 mt, respectively, which is less than half of the 2001-2005 average landings of 6218 mt (Table B2). Most of the US landings come from trawl gear, with a small amount of landings from hook and line and gillnet. Canadian landings totaled 11,985 mt in 2006 and 11,889 mt in 2007, over four times the US landings in the same years. Estimated landings for the recreational sector were 0 for 2007, and in previous years they were either estimated to be 0 or assumed to be negligible.

Discards

US discards of Georges Bank haddock were re-estimated for years 1989-2007 using at-sea observer sampling data and the discard methodology described in Wigley et al. (2007b). This method uses a ratio of kept haddock to discarded of all species. While the discarded fraction of US catch has typically been low, it has increased in recent years to 33% in 2006 and 40% in 2007 (Table B3). Most of the discards are estimated to be from trawl gear, with a small amount coming from hook/line gear, and negligible amounts from gillnet and scallop dredge (Table B4). Much of the discarding is estimated to be on western Georges Bank, although the number of observed trips on eastern Georges Bank was rather low in the 1990s (Table B5). On eastern Georges Bank, estimated discards in years 2004-2007 averaged 231 mt, while they were 1004 mt on western Georges Bank. The average discarding for the period 2004-2007 is about seven times larger than the average for 2000-2003. Total discard estimates for Georges Bank have reasonable precision for the last 6 years, with CVs generally less than 40%, however the uncertainty for years prior to 2001 is large, with many CVs exceeding 100% (Table B6). Canadian discards generally exceeded 100 mt for the years 1969-1994, but since then have been less than 100 mt (Table B7).

Biological sampling

Sampling of commercial catches by market category for lengths ranged from about 1 to 2 fish per mt of landings, and about one fish or less per mt for age sampling through the mid-1990s (Table B8). Sampling intensity doubled or tripled for the late 1990s to the present. This sampling allowed landings at age to be estimated on a semiannual basis for most years (Table B9). Recently, sampling has been sufficient to estimate quarterly landings, but at the expense of precision; therefore, semiannual landings at age estimates were used for years 1989-2007 (Table B10). Discards at age were estimated from total discards by applying age-length keys from the spring and fall NEFSC groundfish survey (Table B11).

The total catch at age matrix for years 1963-2007 can be found in Table B12.

3.0 Research surveys

Indices

Mean number and mean weight per tow in the spring and fall NEFSC groundfish surveys are down from the peak observed in 2004, which corresponded to the availability of the extraordinary 2003 year class to the survey. Prior to 2004, the indices showed a slow but stable increase in numbers since the early 1990s; the rate of increase in weight was about half the rate of the increase in numbers (Table B13, Fig. B3). Total swept area estimates of abundance at age were calculated for the spring and fall NEFSC groundfish surveys (Table B14). The indices

were generated with the calibration coefficients given in Table B15. Canadian swept area estimates of abundance at age in the spring survey are available for the years 1986-2008 (Table B16).

Length and weight

Both mean length at age and mean weight at age have varied over time, but there was a general trend of smaller, hence, lighter, fish at age in the 1960s and in the early 2000s (Fig. B4). The fact that two extraordinary year classes occurred in 1963 and 2003 suggests the possibility that the declining trend may be due to density effects. This is supported by the fact that weights and lengths increased as those year classes were reduced through fishing and natural mortality. In the fall NEFSC groundfish survey, mean length at the youngest ages has increased in the years 2005-2007, while mean weight at age increased in year 2007 (Fig. B5). In the fall NEFSC groundfish survey, the youngest ages showed an increase in mean length for years 2006-2008 and an increase in mean weight for years 2007-2008. For both spring and fall surveys, the older age classes only increased in the most recent year. Examining the size at age within cohorts, there is evidence that recent cohorts (2005 and 2006) have initial growth rates that are greater than was seen in the 2003 cohort (Fig. B6).

4.0 Assessment

Model

The final GARM3 base model for Georges Bank haddock was performed with the NOAA Fisheries Toolbox (NFT) ADAPT VPA version 2.8.0. Ages one through nine were modeled, with age class nine serving as a plus-group. The first year in the catch at age was 1931 (data from 1931 to 1962 from Clark et al., 1982). The F for the oldest ages is calculated from the F on ages 5 to 7. Previous VPA applications for Georges Bank haddock used ages 4 to 7, but age 4 is not fully selected and including it in the calculation caused the F on the oldest ages to be lower than the preceding ages. The input data file and resulting output from this VPA run can be found in the supporting Appendix (NEFSC 2008).

Maturity

Most haddock are immature at age 1 and almost fully mature by age 3. Previous assessments used time-varying stanzas of maturity at age in VPA analyses. The estimation of maturity at age was revisited for the GARM3-BRP meeting. A series of analyses were performed to estimate maturity at age with a "moving average" type of approach using windows of 3 or 5 years. A single maturity ogive for all years was also estimated (O'Brien 2008). The model estimate of the age at 50% maturity did not appear to differ significantly across years for the 3 or 5 year window, and although the estimated proportion mature at age appeared to differ over time, the trends between ages was not always consistent. For these reasons, a single maturity ogive was used for all years in the VPA (Fig. B7).

Natural Mortality

As in previous assessments for this stock, M=0.2 was assumed for all ages (1-9+) and all years. No alternatives were explored.

Indices

A total of 30 age-specific indices were used: ages 1 through 8 for the NEFSC spring survey, ages 1 through 8 for the NEFSC spring survey with the Yankee-41 net, ages 1 through 8 for the Canadian DFO spring survey, and ages 1 through 6 for the NEFSC fall survey. The NEFSC indices used the conversion coefficients to calibrate for the type of door used and the vessel.

Model selection process

A decision was made by the panel at the GARM3-BRP meeting that the performance of the base VPA was acceptable, with no retrospective patterns of concern being apparent. The alternative model that had been presented (ASAP) was considered preliminary and not recommended as a basis for providing management advice. No additional sensitivity models or alternative VPA configurations were recommended, thus only the base VPA configuration was carried forth to the final GARM3 meeting. The panel at the final GARM3 meeting found the base VPA model and diagnostics to be acceptable and did not recommend any alternative formulation or adjustment for retrospective pattern. The ”final” model is therefore the base model as described.

VPA Results

The base VPA estimated a steady increase in SSB from a low of about 15,000 mt in the early 1990s, to nearly 316,000 mt in 2007 (Table B17, Fig. B8). The dramatic increase in the last three years is due to the exceptionally large 2003 year class reaching maturity. The estimated size of that year class is 494,868,000 age 1 fish, which is slightly larger than the 1963 year class size of 460,816,000 age 1 fish. Excluding these two large year classes, the average recruitment between 1964 and 2007 has been about 17 million age 1 fish. From 1980 to 1994, fishing mortality averaged about 0.4, but dropped to 0.12 in 1995 and remained low for several years (Fig. B9). Since 1998, fishing mortality has steadily increased from 0.15 to 0.23 in 2007.

Uncertainty in model estimates was obtained by performing one thousand bootstrap iterations of the base VPA, where residuals from fits to the indices were randomly resampled with replacement. The estimated precision for stock numbers in 2008 ranged from 23% to 31% for ages three to eight, and was slightly higher at age two (41%). The estimated number of age 1 recruits in 2008 was about 16 million fish, but this value was highly uncertain with a CV of 76%. Spawning stock biomass in 2007 was fairly precise with a CV of 20%. Estimated fishing mortality at age in 2007 was less than 30% for ages three to nine; ages one and two were less precise, with CVs of 43% and 34%, respectively. The estimate of average, unweighted F on ages five to seven was precise with a CV of 16%. Catchabilities for the swept area age-specific indices were generally well estimated, with most CVs less than 20%.

VPA Diagnostics

A combined bootstrap-retrospective analysis was conducted for the base VPA model with 1000 bootstraps for each year from 2000-2007. Bootstrapped distributions of estimated F, SSB, and N were examined for years 2000 and 2004 (Figs. B10 and B11). The years 2000 and 2004 were examined because year 2000 was the last data year considered in the estimate of current BRPs (NEFSC 2002), and because 2004 was the last year of data considered at the GARM2 (Brodziak et al. 2006). There was substantial overlap in the distributions by year in both 2000 and 2004, which does not indicate a retrospective problem.

The relative difference from terminal year estimates of retrospective VPA runs to the full VPA run showed mostly small scale departures (Fig. B12). The large relative difference for age 1 recruits is due to the poor precision associated with terminal year estimated abundance at the youngest age. The average Mohn's rho was calculated for the seven retrospective relative differences in years 2000-2006 (Table B18). These values are very small and suggest that no retrospective problem exists.

Additional heuristic diagnostics considered were the pattern and scale in age-specific q's, and the index-specific standardized residuals. As a null hypothesis, one expects age-specific q's to flatten at ages that are fully selected (unless there is a strong biological phenomenon or gear effect that would induce a dome). The q's estimated in this assessment tended to flatten for the indices of older ages (Fig. B13). Also, with regard to scale, one would typically expect the values to be less than one. For this assessment, the estimated q's ranged from about 0.3 to about 0.9 (Table B19). Finally, to assess the fits to the indices, the standardized log-scale residuals were examined. Although there was some temporal trending, with runs of negatives followed by runs of positives (Fig. B14), the years where this occurred was not consistent between indices at a given age.

5.0 Biological reference points (BRPs)

The NMFS Toolbox program for calculating yield per recruit (YPR) was used to estimate F40% (the current proxy for F_{MSY}). An average of the last 5 years selectivity at age was examined to determine the fully selected age; ages beyond that were assumed to be fully selected as well (Fig. B15). The stock weight, catch weight, SSB weights, and maturity were also based on an average of the last 5 years (2003-2007; Table B20 and Fig. B16). Compared to the selectivity at age that was used to derive the BRPs in 2002, the selectivity ogive in this assessment is shifted towards older ages by about one year (Table B20). The shift of selectivity towards older fish lead to a higher estimate of F40%, while the reduced weights at age lead to lower values for SSB_{MSY} and MSY (Table B21). While reduced average weights at age may be a function of total stock biomass, this relationship is still uncertain and was not incorporated into the biomass projection. For this assessment, F40% was 0.35 compared to the current value of 0.26. Inputs and outputs for the YPR analysis can be found in the supporting appendix (NEFSC 2008).

Following the recommendation in GARM III-BRP-WP4.2 (Legault 2008), the NMFS Toolbox program AGEPRO was used to determine equilibrium, median values for SSB_{MSY} and MSY under the F40% from the YPR analysis. The selectivity ogive and weights used in the determination of F40% (see Table B20) were applied to the population for 100 years and the median, 5^{th}, and 95^{th} percentiles of 1000 bootstraps are reported for SSB and yield (Table B21). The recruitment option employed was to sample from the empirical cdf (Model 14 in AGEPRO). The panel at the GARM III-BRP meeting supported the idea that recruitment tended to be stronger when SSB levels exceeded 75,000 mt. It was therefore recommended that the recruitment estimates to be sampled in the AGEPRO projections should come from the 1931-2007 period for years when SSB>75,000 mt, but excluding the large 1963 and 2003 year classes. Bootstrapped numbers at age from 1000 bootstraps of the base VPA run were also provided to the AGEPRO software. The estimates of equilibrium SSB_{MSY} and MSY are 158,000 mt and 32,700 mt, respectively. There is a 90% probability that SSB_{MSY} is between 96,000 and 230,000 mt, and that MSY is between 19,000 and 49,000 mt.

6.0 Projection

As the Georges Bank haddock stock is now rebuilt, no rebuilding projections were made. However, a projection was made to estimate landings and stock levels in 2009. In this projection, catch in 2008 was assumed to be at the same level as catch in 2007, and fishing mortality was assumed to be F_{MSY} in 2009. Under this mixed harvest scenario, the realized F in 2008 is projected to be 0.07, catch in 2009 is projected to be 87,600 mt, and SSB_{2009} is projected to be 299,900 mt (Table B22).

7.0 Summary

Stock Status

Georges Bank haddock is currently rebuilt ($SSB_{2007}>SSB_{MSY}$) and there is no overfishing ($F_{2007}<F_{MSY}$). Even considering the uncertainty in stock estimates from the VPA bootstraps, there is at least a 90% probability that the stock is not overfished and that there is no overfishing (Table B23, Fig. B17). Comparing the time series of VPA estimated SSB and F, the stock was at its most depleted in the late 1980s and early 1990s, with fishing mortality ranging from 0.36 to 0.44—values that would constitute overfishing if compared to the F40% estimated in this assessment (Table B24). The rate of fishing dropped sharply in 1995 and consequent gains in SSB were realized. By 2006, much of the 2003 year class had matured, and the stock was no longer overfished (SSB_{2006}/SSB_{MSY} = 1.67). It is important to note that it is not appropriate to compare the entire time series of SSB and F values in Table B24 to the reference points derived for this assessment because the BRPs derived herein were based on only the last five years of weights and selectivity (2003-2007). It is clear from comparison with the results in NEFSC (2002) that trends in growth and management regulations affect the reference points.

Sources of Uncertainty

The primary sources of uncertainty for this stock are the age specific mean lengths and weights. Changes in mean size at age, as well as changes in management regulation, have altered the selectivity at age. This, combined with lower weights at age, led to a higher F40% and lower values for SSB_{MSY} and MSY (Table B21). In the future, if these trends are reversed, then the reference points could be expected to shift towards the values estimated by NEFSC (2002).

8.0 GARM Panel Discussion/Comments

Conclusions

The Panel concluded that the VPA model used to assess this stock was Final and sufficient for management purposes. No adjustment was required for any retrospective pattern.

Consistent with the GARM III 'BRP' review, the stock projections (and BRP estimation) were undertaken using a SSB breakpoint at 75,000 t and excluding the two large 1963 and 2003 year – classes, a decision which the Panel endorsed. As the stock is rebuilt to B_{MSY}, no $F_{REBUILD}$ was estimated. The Panel noted the substantial recent declines in the weights at age due to slower

than average growth, particularly of the 2003 year – class. This is affecting productivity in the short term. The growth of subsequent year – classes is returning to the earlier norm.

Research Recommendations

It was observed that growth appears to be a function of density. As the data to examine this relationship is in the assessment, it should be investigated. Furthermore, if the effect is significant, it should be included in the BRP estimation.

A good correlation was observed between chlorophyll and recruitment strength, especially the strong 2003 year - class. A similar correlation has been observed for other haddock stocks (e.g. Eastern Scotian Shelf haddock; Platt et. al, 2003). The Panel encouraged investigation of other potential covariates of the various aspects of production (growth, recruitment, and natural mortality).

9.0 References

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Table B1. Georges Bank haddock total catch biomass (mt) by country, 1960-2004. US landings and discards were re-estimated for years 1989-2007 following new algorithms for commercial landings allocation (Wigley et al. 2007a), stock apportionment (Palmer 2008), and discard estimation (Wigley et al. 2007b).

Year	USA	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	742	137	1098	20	5866
1973	2777	1661	602	386	3	5429
1974	2396	622	109	764	559	4450
1975	3989	1544	8	61	4	5606
1976	2904	1521	4	46	9	4484
1977	7934	3060	0	0	0	10994
1978	12160	10356	0	0	0	22516
1979	14279	5368	0	0	0	19647
1980	17470	10168	0	0	0	27638
1981	19176	5835	0	0	0	25011
1982	12625	5002	0	0	0	17627
1983	8682	3327	0	0	0	12009
1984	8807	1587	0	0	0	10394
1985	4273	3670	0	0	0	7943
1986	3339	3507	0	0	0	6846
1987	2156	4841	0	0	0	6997
1988	2492	4197	0	0	0	6689
1989	1718	3197	0	0	0	4915
1990	2106	3468	0	0	0	5574
1991	1434	5563	0	0	0	6997
1992	2053	4191	0	0	0	6244
1993	827	3841	0	0	0	4668
1994	2302	2525	0	0	0	4827
1995	309	2133	0	0	0	2442
1996	436	3695	0	0	0	4131
1997	1151	2682	0	0	0	3833
1998	2192	3473	0	0	0	5665
1999	2628	3729	0	0	0	6357
2000	3280	5431	0	0	0	8711
2001	5037	6751	0	0	0	11788
2002	6741	6517	0	0	0	13258
2003	5954	6873	0	0	0	12827

Table B1 (cont.)

2004	8415	9838	0	0	0	18253
2005	7278	14536	0	0	0	21814
2006	3938	12051	0	0	0	15989
2007	4864	11951	0	0	0	16815
Average 1960-2004	12862	5550	3007	232	102	21753
Average 1961-1968	44049	9909	17867	687	440	72952
Average 1969-1984	9328	3649	88	353	87	13505
Average 1985-2000	2044	3759	0	0	0	5802
Average 2001-2007	6032	9788	0	0	0	15821

Table B2. US and Canadian landings (mt) by gear of Georges Bank haddock for years 1989-2007.

	US landings					CAN landings					US + CAN	
YEAR	GILLNET	HOOK/LINE	OTHER	TRAWL	Total US	TRAWL	Longline	Scallop	Other	Total CAN	**TOTAL**	US % of TOTAL
1989	42	25	8	1356	1430	1976	977	12	95	3060	4490	0.32
1990	24	16	12	1953	2005	2411	853	7	69	3340	5345	0.38
1991	19	27	9	1341	1395	4028	1309	8	111	5456	6851	0.20
1992	11	17	3	1974	2005	2583	1384	4	87	4058	6063	0.33
1993	6	16	6	659	687	2489	1143	2	93	3727	4414	0.16
1994	9	35	1	162	207	1597	714	9	91	2411	2618	0.08
1995	14	61	0	156	231	1647	390	7	21	2065	2296	0.10
1996	39	69	0	213	320	2689	947	0	26	3662	3982	0.08
1997	40	68	1	772	880	1991	722	0	36	2749	3629	0.24
1998	80	68	1	1767	1915	2422	921	0	28	3371	5286	0.36
1999	128	35	0	2411	2574	2761	887	0	32	3680	6254	0.41
2000	133	25	1	3044	3203	4146	1186	0	70	5402	8605	0.37
2001	131	49	9	4631	4820	5112	1633	0	29	6774	11594	0.42
2002	186	38	14	6294	6532	4954	1521	0	12	6487	13019	0.50
2003	51	164	4	5541	5760	4985	1776	0	14	6775	12535	0.46
2004	40	783	120	6433	7375	7744	2000	0	1	9745	17120	0.43
2005	29	865	91	5618	6604	12115	2368	0	1	14484	21088	0.31
2006	26	297	56	2265	2643	10088	1896	0	1	11985	14628	0.18
2007	18	233	5	2675	2930	10034	1854	0	1	11889	14819	0.20

Table B3. US landings and discards (mt) of Georges Bank haddock for years 1989-2007. US landings and discards were re-estimated for years 1989-2007 following new algorithms for commercial landings allocation (Wigley et al. 2007a) and discard estimation (Wigley et al. 2007b). Percent discard is computed as the ratio of discards to landings.

YEAR	Landings	Discards	% Discarded
1989	1430	288	20%
1990	2005	102	5%
1991	1395	39	3%
1992	2005	48	2%
1993	687	140	20%
1994	207	2096	1014%
1995	231	78	34%
1996	320	115	36%
1997	880	271	31%
1998	1915	277	14%
1999	2574	54	2%
2000	3203	77	2%
2001	4820	218	5%
2002	6532	209	3%
2003	5760	194	3%
2004	7375	1040	14%
2005	6604	674	10%
2006	2643	1294	49%
2007	2930	1934	66%

Table B4. US discards (mt) by gear, and number of trips sampled (in parentheses), of Georges Bank haddock for years 1989-2007.

YEAR	Hook/Line	Trawl	Gillnet	Scallop	Total
1989	0 (0)	288 (104)	0 (0)	0 (0)	288 (105)
1990	0 (0)	102 (73)	0 (0)	0 (0)	102 (73)
1991	0 (17)	39 (107)	0 (0)	0 (1)	39 (126)
1992	6 (25)	38 (85)	0 (0)	3 (15)	48 (127)
1993	0 (0)	138 (44)	0 (0)	2 (18)	140 (63)
1994	0 (1)	2092 (49)	3 (58)	1 (7)	2096 (115)
1995	0 (0)	71 (86)	6 (76)	0 (9)	78 (171)
1996	0 (0)	94 (58)	16 (30)	5 (19)	115 (107)
1997	0 (0)	269 (47)	1 (34)	1 (14)	271 (96)
1998	0 (0)	276 (20)	1 (49)	0 (12)	277 (81)
1999	0 (0)	50 (34)	3 (48)	0 (33)	54 (115)
2000	0 (0)	74 (59)	3 (70)	0 (273)	77 (402)
2001	0 (0)	215 (82)	1 (43)	1 (18)	218 (143)
2002	35 (8)	165 (141)	3 (49)	6 (11)	209 (211)
2003	2 (5)	185 (288)	4 (169)	3 (15)	194 (477)
2004	17 (113)	1012 (487)	11 (318)	1 (51)	1040 (970)
2005	119 (244)	543 (1198)	1 (299)	11 (118)	674 (1859)
2006	207 (65)	1067 (556)	17 (76)	3 (157)	1294 (855)
2007	64 (58)	1863 (559)	4 (162)	3 (191)	1934 (970)

Table B5. US discards (mt) of haddock for eastern and western Georges Bank, and number of trips sampled (in parentheses), for years 1989-2007.

YEAR	EGB discards	WGB discards	Total GB discards
1989	126 (15)	162 (90)	288 (105)
1990	94 (11)	8 (62)	102 (73)
1991	0 (6)	39 (120)	39 (126)
1992	4 (17)	44 (110)	48 (127)
1993	103 (19)	36 (44)	139 (63)
1994	1065 (17)	1030 (98)	2095 (115)
1995	0 (18)	77 (153)	77 (171)
1996	3 (13)	112 (94)	115 (107)
1997	1 (4)	270 (92)	271 (96)
1998	0 (5)	277 (76)	277 (81)
1999	5 (22)	49 (93)	54 (115)
2000	3 (102)	75 (300)	78 (402)
2001	19 (13)	198 (130)	217 (143)
2002	17 (27)	192 (184)	209 (211)
2003	88 (73)	106 (404)	194 (477)
2004	282 (99)	757 (871)	1039 (970)
2005	75 (161)	599 (1698)	674 (1859)
2006	254 (105)	1040 (750)	1294 (855)
2007	313 (78)	1621 (892)	1934 (970)

Table B6. US discards (mt) of haddock for eastern and western Georges Bank, and coefficient of variation (CV), for years 1989-2007.

YEAR	EGB discards (mt)	CV	WGB discards (mt)	CV	Total GB discards (mt)	CV
1989	126	0.75	162	1.11	288	0.71
1990	94	1.39	8	2.35	102	1.30
1991	0	0.00	39	2.03	39	2.03
1992	4	3.24	44	1.43	48	1.35
1993	103	0.89	36	2.24	140	0.88
1994	1065	2.05	1030	1.47	2096	1.27
1995	0	1.26	77	1.10	78	1.09
1996	3	0.88	112	2.17	115	2.11
1997	1	1.45	270	1.73	271	1.72
1998	0	0.73	277	1.75	277	1.75
1999	5	0.63	49	0.89	54	0.81
2000	3	0.59	75	0.68	77	0.65
2001	19	1.24	198	0.58	218	0.54
2002	17	0.68	192	0.37	209	0.34
2003	88	0.64	106	0.44	194	0.38
2004	282	0.83	757	0.80	1040	0.62
2005	75	0.63	599	0.22	674	0.21
2006	254	0.39	1040	0.34	1294	0.29
2007	313	0.50	1621	0.38	1934	0.33
2000-2003 Average (mt)	32		143		174	
2004-2007 Average (mt)	231		1004		1236	

Table B7. Estimated Canadian discards (mt) of haddock on eastern Georges Bank for years 1969-2007.

Year	Canada
1969	123
1970	116
1971	111
1972	133
1973	98
1974	160
1975	186
1976	160
1977	151
1978	177
1979	186
1980	151
1981	177
1982	130
1983	119
1984	124
1985	186
1986	92
1987	138
1988	151
1989	138
1990	128
1991	117
1992	130
1993	114
1994	114
1995	69
1996	52
1997	60
1998	102
1999	49
2000	29
2001	39
2002	29
2003	98
2004	93
2005	52
2006	67
2007	61

Table B8. US commercial biological sampling by half-year period and by market category for Georges Bank haddock.

Year	Period	Market	Landings (kg)	Length Samples	Sampled Fish	Age Samples	Sampled Fish	Len.Samp/ Landings	Age.Samp/ Landings
1989	1	Large	628399	6	620	6	303	1.0	0.5
	2	Large	182561	1	99	1	38	0.5	0.2
	1	Scrod	388134	6	338	6	256	0.9	0.7
	2	Scrod	226427	9	491	9	259	2.2	1.1
1990	1	Large	792474	8	826	8	235	1.0	0.3
	2	Large	302752	2	218	2	130	0.7	0.4
	1	Scrod	743206	12	669	12	368	0.9	0.5
	2	Scrod	154775	5	288	5	212	1.9	1.4
1991	1	Large	666397	2	206	2	81	0.3	0.1
	2	Large	173355	4	338	4	118	1.9	0.7
	1	Scrod	492017	6	359	6	181	0.7	0.4
	2	Scrod	56409	1	62	1	42	1.1	0.7
1992	1	Large	1122592	14	1325	14	407	1.2	0.4
	2	Large	157002	2	221	2	44	1.4	0.3
	1	Scrod	663373	12	646	12	314	1.0	0.5
	2	Scrod	59310	4	264	4	157	4.5	2.6
1993	1	Large	373746	4	407	4	143	1.1	0.4
	2	Large	81512	2	145	2	74	1.8	0.9
	1	Scrod	172013	9	488	9	267	2.8	1.6
	2	Scrod	55997	2	100	2	49	1.8	0.9
1994	1	Large	51812	3	170	3	94	3.3	1.8
	2	Large	54984	1	76	1	22	1.4	0.4
	1	Scrod	37428	1	66	1	25	1.8	0.7
	2	Scrod	60519	2	141	2	50	2.3	0.8
1995	1	Large	63716	1	104	1	22	1.6	0.3
	2	Large	83844	1	81	1	26	1.0	0.3
	1	Scrod	45166	1	57	1	15	1.3	0.3
	2	Scrod	35270	1	49	1	21	1.4	0.6
1996	1	Large	226244	3	310	3	86	1.4	0.4
	1	Scrod	90409	2	147	2	86	1.6	1.0
	1	Large	170473	2	200	2	42	1.2	0.2
	2	Large	467916	15	1473	15	306	3.1	0.7
1997	1	Scrod	61179	1	50	1	49	0.8	0.8
	2	Scrod	161770	7	555	7	195	3.4	1.2
	1	Large	777823	8	706	7	204	0.9	0.3
	2	Large	735946	4	259	4	129	0.4	0.2
1998	1	Scrod	155305	7	345	8	209	2.2	1.3
	2	Scrod	199221	3	137	3	80	0.7	0.4
	1	Large	863663	8	712	8	190	0.8	0.2
	2	Large	1148341	6	621	6	169	0.5	0.1
1999	1	Scrod	253496	2	183	2	39	0.7	0.2
	2	Scrod	275861	13	761	13	230	2.8	0.8
	1	Large	1538191	10	932	10	313	0.6	0.2
	2	Large	857488	9	934	9	379	1.1	0.4

Table B8 (cont.)

2000	1	Scrod	487740	10	507	10	201	1.0	0.4
	2	Scrod	299435	14	826	14	283	2.8	0.9
	1	Large	1850629	23	2145	23	753	1.2	0.4
	2	Large	1063648	21	2144	21	707	2.0	0.7
2001	1	Scrod	856432	11	647	11	233	0.8	0.3
	2	Scrod	935665	14	874	14	273	0.9	0.3
	1	Large	2506455	11	932	11	362	0.4	0.1
	2	Large	1615059	16	1657	16	493	1.0	0.3
2002	1	Scrod	1428733	7	409	7	169	0.3	0.1
	2	Scrod	806907	9	573	9	197	0.7	0.2
	1	Large	2255111	18	1846	17	517	0.8	0.2
	2	Large	879281	21	2208	19	613	2.5	0.7
2003	1	Scrod	1683556	20	1220	19	384	0.7	0.2
	2	Scrod	809636	13	765	12	204	0.9	0.3
	1	Large	1639086	20	2216	19	545	1.4	0.3
	2	Large	1085046	19	1918	16	353	1.8	0.3
2004	1	Scrod	2542608	16	1156	16	307	0.5	0.1
	2	Scrod	1843139	23	1600	19	282	0.9	0.2
	1	Large	1655434	21	1848	18	383	1.1	0.2
	2	Large	1123669	32	2815	31	1072	2.5	1.0
2005	1	Scrod	2631612	20	1136	19	264	0.4	0.1
	2	Scrod	1122887	25	1390	22	436	1.2	0.4
	1	Large	557172	40	3306	36	1631	5.9	2.9
	2	Large	482089	29	2432	28	1209	5.0	2.5
2006	1	Scrod	1119984	33	1607	32	773	1.4	0.7
	2	Scrod	411924	30	1489	29	676	3.6	1.6
	1	Large	557172	40	3306	36	1631	5.9	2.9
	2	Large	482089	29	2432	28	1209	5.0	2.5
2007	1	Scrod	557172	40	3306	36	1631	5.9	2.9
	2	Scrod	482089	29	2432	28	1209	5.0	2.5
	1	Large	1119984	33	1607	32	773	1.4	0.7
	2	Large	411924	30	1489	29	676	3.6	1.6

Table B9. US landings at age (thousands) of Georges Bank haddock for years 1989-2007.

Year	Age 1	2	3	4	5	6	7	8	9+	**Total**
1989	0	169	19	262	86	146	29	16	12	**739**
1990	0	4	384	138	376	85	53	13	7	**1061**
1991	0	23	30	326	56	127	55	26	4	**648**
1992	0	20	94	69	507	92	110	21	10	**923**
1993	0	49	33	60	33	105	29	16	8	**331**
1994	0	6	56	14	7	8	15	2	1	**107**
1995	0	9	67	45	4	3	4	7	0	**138**
1996	0	11	69	37	16	5	4	4	1	**146**
1997	0	11	138	153	51	13	3	8	9	**387**
1998	0	22	172	269	199	109	53	12	9	**845**
1999	0	1	147	221	357	218	129	63	21	**1156**
2000	0	82	171	317	334	324	165	74	32	**1499**
2001	0	70	644	425	462	372	226	136	89	**2425**
2002	0	2	94	1283	544	442	286	199	271	**3120**
2003	0	1	174	218	1491	258	349	147	251	**2890**
2004	0	0	30	1490	262	1646	273	224	214	**4139**
2005	0	3	6	109	1867	286	988	200	206	**3666**
2006	0	0	104	6	64	911	81	268	64	**1497**
2007	0	7	17	1401	13	37	353	37	140	**2005**

Table B10. Coefficient of variation (CV) for US landings at age for years 1989-2007.

Year	Age 1	2	3	4	5	6	7	8	9
1989	-----	0.12	0.4	0.2	0.19	0.19	0.26	0.36	0.58
1990	-----	0.64	0.19	0.18	0.1	0.21	0.24	0.28	0.62
1991	-----	0.39	0.43	0.08	0.31	0.29	0.36	0.46	0.79
1992	-----	0.54	0.19	0.28	0.07	0.15	0.13	0.3	0.43
1993	-----	0.04	0.26	0.22	0.26	0.15	0.23	0.28	0.5
1994	-----	0.5	0.09	0.28	0.41	0.37	0.14	0.47	0.48
1995	-----	0.46	0.11	0.13	0.51	0.48	0.37	0.26	-----
1996	-----	0.32	0.17	0.35	0.43	0.86	0.69	0.65	0.86
1997	-----	0.56	0.09	0.18	0.15	0.35	0.72	0.71	0.72
1998	-----	0.4	0.19	0.11	0.14	0.23	0.32	0.51	0.75
1999	-----	1.32	0.25	0.15	0.12	0.13	0.23	0.32	0.39
2000	-----	0.26	0.13	0.13	0.1	0.11	0.15	0.22	0.38
2001	-----	0.35	0.1	0.11	0.1	0.08	0.1	0.14	0.18
2002	-----	1.31	0.29	0.09	0.1	0.12	0.13	0.15	0.19
2003	-----	1.34	0.25	0.17	0.05	0.13	0.09	0.13	0.12
2004	-----	-----	0.54	0.11	0.17	0.07	0.15	0.14	0.12
2005	-----	0.76	0.6	0.21	0.07	0.15	0.09	0.16	0.13
2006	-----	-----	0.14	0.38	0.14	0.04	0.12	0.11	0.14
2007	-----	0.61	0.39	0.04	0.40	0.18	0.08	0.25	0.16

Table B11. US discard at age (thousands) of Georges Bank haddock for years 1989-2007.

	Age									
Year	0	1	2	3	4	5	6	7	8	9
1989	0	2	140	26	22	2	12	2	1	1
1990	0	61	1	49	5	5	1	1	0	0
1991	0	1	22	3	4	0	1	0	1	0
1992	0	77	15	3	1	8	0	0	0	0
1993	0	26	68	63	2	2	2	0	0	0
1994	0	26	291	399	80	81	18	173	25	70
1995	8	15	24	22	12	2	1	2	3	1
1996	21	6	17	16	20	15	1	0	0	5
1997	0	12	51	54	50	27	11	1	2	6
1998	19	5	45	16	31	29	16	2	0	5
1999	0	2	7	22	5	4	4	2	3	2
2000	5	2	16	18	8	5	3	3	2	2
2001	0	12	15	74	27	15	7	5	3	3
2002	0	2	109	46	40	11	4	5	2	2
2003	13	3	10	94	15	42	8	8	2	4
2004	1	468	30	55	439	58	74	12	17	9
2005	35	18	498	8	20	132	15	28	4	2
2006	0	158	14	959	28	34	185	26	40	13
2007	1	12	143	48	2843	40	119	810	64	253

Table B12. Total catch at age (thousands) for Georges Bank haddock, 1931-2007.

Year	1	2	3	4	5	6	7	8	9
1931	1755	8801	2041	5785	9100	6045	3380	1794	559
1932	118	2084	25871	2421	3676	2894	1320	664	391
1933	244	8476	6023	10046	2092	1579	1210	538	647
1934	341	4454	5414	3734	3149	1051	619	250	168
1935	1197	11872	8819	3706	2944	2458	499	442	109
1936	880	12327	11486	5431	2141	1377	1362	259	124
1937	1288	11034	10910	5629	4143	1875	952	481	222
1938	1030	20199	7755	3755	2113	1600	945	327	173
1939	607	13937	19617	5163	2152	967	837	326	239
1940	2040	7254	12317	8253	2510	1479	752	222	136
1941	780	23464	9808	8033	5764	1781	941	307	384
1942	310	14307	16348	6531	3996	2331	1036	227	176
1943	19	4191	17738	8364	3102	2693	790	354	178
1944	64	761	8437	14843	5689	2281	497	469	108
1945	121	8522	2029	6386	5795	2315	914	265	205
1946	209	7466	15213	2738	5785	3840	1827	272	23
1947	90	16621	10334	7181	2127	2739	1501	745	457
1948	80	11227	19237	5116	2744	1157	780	450	369
1949	328	6472	12479	9608	2347	1061	624	409	353
1950	88	28971	4107	4272	3315	1131	520	225	250
1951	645	8266	26472	2177	2448	2138	740	297	215
1952	0	25120	8892	8485	1361	944	530	182	107
1953	1083	1807	17588	5726	3757	1012	542	337	152
1954	108	31858	5107	5611	2315	2131	720	353	98
1955	90	3941	19251	3316	3278	1649	1068	320	173
1956	52	11948	6698	12066	3405	3378	1348	563	201
1957	35	6594	14046	4523	5822	2357	1630	473	366
1958	125	5571	7088	6665	3784	2366	903	442	142
1959	94	5716	7994	5169	3934	1758	1172	424	334
1960	258	16010	6122	4562	3067	1792	787	406	348
1961	62	10689	14927	4198	2917	1856	1266	496	674
1962	74	4455	16245	10440	3448	2089	1566	1185	898
1963	2910	4047	7418	11152	8198	2205	1405	721	1096
1964	10101	15935	4554	4776	8722	5794	2082	1028	1332
1965	9601	125818	44496	5356	4391	6690	3772	1094	1366
1966	114	6843	100810	19167	2768	2591	2332	1268	867
1967	1150	168	2891	20667	10338	1209	993	917	698
1968	8	2994	709	1921	14519	3499	667	453	842
1969	2	11	1698	448	654	5954	1574	225	570
1970	46	158	16	570	186	214	2308	746	464
1971	1	1375	223	40	289	246	285	1469	928
1972	160	2	460	83	33	123	80	68	1265
1973	2607	2113	3	393	54	31	78	15	455
1974	48	4481	682	2	73	2	2	55	258
1975	199	1070	1928	388	4	43	4	4	91
1976	149	491	570	913	224	0	24	4	116
1977	1	19858	190	690	522	362	4	40	113

Table B12 (cont.)

1978	1	767	14509	307	572	521	140	14	68
1979	1	26	1743	7238	530	414	318	97	46
1980	8	31170	349	980	6087	597	549	154	81
1981	1	1755	11076	837	944	2590	333	159	95
1982	1	1174	1645	3761	394	573	1127	107	111
1983	0	216	821	697	2261	275	188	808	77
1984	0	94	301	736	402	1500	237	270	550
1985	0	2464	563	199	472	234	539	80	156
1986	6	55	2848	226	148	175	152	270	61
1987	0	2035	132	1646	125	75	91	108	138
1988	4	53	2439	137	953	152	56	66	108
1989	2	1462	123	1019	217	478	62	37	57
1990	63	12	1697	269	1124	154	218	55	49
1991	7	486	123	2370	144	518	128	172	65
1992	84	265	408	197	1960	181	426	47	100
1993	33	363	439	340	120	741	63	169	82
1994	27	538	1192	242	142	73	313	55	110
1995	17	94	614	471	59	29	9	61	16
1996	7	56	566	919	450	66	22	7	78
1997	15	143	273	745	561	218	18	18	49
1998	6	230	471	558	767	571	169	23	49
1999	3	43	906	541	606	566	384	163	48
2000	2	407	626	1571	588	528	377	258	99
2001	14	145	2393	996	1281	656	438	359	262
2002	3	397	345	3177	926	1105	402	306	551
2003	5	18	1943	461	2686	605	719	212	389
2004	646	33	122	5116	729	2935	687	563	408
2005	20	612	42	339	8505	778	1843	315	343
2006	164	18	3164	71	375	5418	327	842	228
2007	13	175	240	11216	194	311	2512	229	564

Table B13. NEFSC spring and autumn bottom-trawl survey indices (number and weight) for Georges Bank haddock. Conversion factors were applied for door and vessel.

	Spring Survey		Autumn Survey	
Year	Number/ Tow	Weight (kg)/ Tow	Number/ Tow	Weight (kg)/ Tow
1963	------	------	145	79.8
1964	------	------	193.2	96.8
1965	------	------	101.7	72.8
1966	------	------	33.3	29.9
1967	------	------	17.7	25.5
1968	13.8	20.6	7.5	15.4
1969	7.3	16.9	3.4	8.4
1970	6	17.1	7.7	13.5
1971	2.8	5	4.2	5.6
1972	6.4	7.4	11.4	8.5
1973	37.6	15.4	14.9	9.8
1974	19	17.7	4.1	4
1975	6.2	8.2	31	15.1
1976	83.2	15.7	71.1	35.8
1977	36.9	26.6	23.3	27.5
1978	19.4	31.3	25.3	18.1
1979	45.5	19.8	52.2	32
1980	60.1	53.9	30.5	22
1981	31.2	38	13.5	14
1982	8.6	13.1	5	7.3
1983	5.6	13.2	8	5.8
1984	6.2	7.5	5.4	4.5
1985	8.9	11.1	14.2	3.9
1986	5.9	5.9	6.8	5.1
1987	5	5.6	3.6	2.6
1988	3.4	3.4	5.4	5.6
1989	5.4	4.7	4.3	4.7
1990	7.7	7.6	2.9	2.6
1991	4	4.4	2.9	0.9
1992	1.2	1.4	6.1	3.2
1993	2.8	2.5	8.1	4.3
1994	5	3.6	3.6	2.9
1995	5.6	5.7	17.1	10.7
1996	23.4	25.7	4.5	4.1
1997	13	18.5	6.2	6.5
1998	7.3	6.1	11.1	5.8
1999	16.7	7.7	23.1	33.1
2000	14.3	17.9	18	15.4
2001	14.9	6.1	22.7	20
2002	32.3	22.3	42.1	36.3
2003	14.8	15.6	169.5	23
2004	140.5	41.4	187	55.8
2005	59.8	17.7	90.5	39.4
2006	37.3	17.3	57	37.4
2007	57.3	34.6	53.9	43.9
2008	27.7	23.8		

Table B14a. Total swept area estimates of abundance at age (numbers in thousands) for Georges Bank haddock NEFSC spring survey, 1968-2007. Years 1973-1981 were conducted with the Yankee-41 net, while all other years used the Yankee-36 net. Conversion factors were applied for door and vessel effects.

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8
1968	1298	9185	1493	2272	21811	5453	811	1461
1969	0	227	1883	811	1363	13729	3343	909
1970	2175	811	0	1071	1493	1493	6491	3181
1971	0	3765	811	0	389	389	292	2661
1972	13048	292	1980	389	97	130	422	97
1973	99579	15709	0	1753	292	0	584	32
1974	6913	43136	9283	0	779	0	32	325
1975	3051	3148	10776	2045	0	422	292	32
1976	262221	974	1947	2986	1396	0	130	0
1977	1980	108439	1363	3960	1947	1461	0	130
1978	227	3148	51704	1168	3051	2661	519	195
1979	117235	5128	3668	18533	1071	519	1201	195
1980	16878	151575	1655	3376	15807	2175	1201	1493
1981	10711	10678	63259	7108	2467	5777	779	357
1982	2467	4966	3051	13210	1363	909	1980	0
1983	1396	1785	1883	714	7822	32	130	3765
1984	6784	3830	2077	2045	1883	2337	227	130
1985	0	16099	2467	1298	2824	1104	3797	325
1986	8082	584	6686	779	357	682	389	1071
1987	0	11749	195	2629	260	325	162	714
1988	5031	130	3213	422	1039	389	357	389
1989	65	11328	1461	2304	454	1331	195	162
1990	2791	0	18565	1071	1883	195	422	0
1991	1753	3473	779	6005	292	325	65	130
1992	1298	584	357	227	1071	97	97	97
1993	3797	2110	584	454	389	1201	195	65
1994	2269	8708	3254	481	330	214	503	49
1995	1627	4172	7528	2969	536	370	93	578
1996	3525	14908	28744	16894	8497	1133	237	243
1997	5826	3319	10885	11871	6522	2887	409	228
1998	2673	9582	4049	3437	2773	696	196	18
1999	33135	6581	6950	2328	2085	1646	663	652
2000	5937	7692	13322	6521	3604	3591	3292	1543
2001	32502	2789	7910	2707	977	682	374	265
2002	593	62469	21807	10459	3546	1548	1969	552
2003	32	811	17689	3927	15742	3116	3700	2791
2004	363974	6005	3895	29406	7076	8666	1396	3116
2005	2597	173126	519	1233	10873	1461	3278	617
2006	6532	1850	93249	1644	2058	12006	1684	1537
2007	2789	22744	5937	146687	1113	792	4528	431
2008	5979	2842	8374	712	65850	1275	553	2920

Table B14b. Total swept area estimates of abundance at age (numbers in thousands) for Georges Bank haddock NEFSC fall survey, 1964-2007. Conversion factors were applied for door and vessel effects.

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
1964	272418	82407	29936	22101	27082	19296
1965	7689	366336	206889	18909	5803	12380
1966	1064	32982	251188	31483	3482	2612
1967	19925	3095	9382	59678	10881	1693
1968	97	21811	1161	3240	21956	5271
1969	290	193	3095	435	1064	12526
1970	1257	97	0	919	435	532
1971	145	13396	677	48	919	871
1972	7883	0	1016	242	48	725
1973	21908	8173	0	1693	290	0
1974	10494	29210	5223	0	629	145
1975	2418	5755	3192	1016	0	48
1976	76217	2031	2321	15766	2998	0
1977	14025	208291	1693	1741	2660	967
1978	436	6941	60803	1824	1864	2062
1979	42915	2737	3371	30104	595	833
1980	4284	147902	119	2935	12375	833
1981	37917	8805	41289	1467	595	5513
1982	1229	19911	6743	12018	674	1349
1983	4401	0	4304	1112	4546	435
1984	18812	774	677	871	967	3047
1985	97	10785	2853	774	919	193
1986	36839	2110	4966	714	162	325
1987	0	16586	292	3927	195	422
1988	5842	0	2564	325	2499	195
1989	227	9802	584	4219	389	1298
1990	1517	160	8783	639	2156	293
1991	2502	2182	80	3859	160	559
1992	7000	665	772	160	719	53
1993	9250	6751	747	779	0	1525
1994	4924	13121	6521	985	0	186
1995	2955	2506	2622	2166	402	147
1996	7377	23168	15917	7519	1222	39
1997	4256	1765	3005	3370	1583	463
1998	1049	8003	4762	2431	1777	1056
1999	14008	9050	8028	2348	1338	571
2000	5922	2728	10934	26130	11429	7536
2001	13433	9161	17791	10077	3562	2143
2002	2774	28471	5459	24147	6877	3774
2003	377	6203	72276	17673	27709	6075
2004	501602	231	1464	27761	5759	10893
2005	5288	531168	711	2741	44206	3814
2006	13818	5745	250707	904	2260	15370
2007	3051	14742	2374	156979	1282	1404

Table B15. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys during 1968-2005.

Year	Door	Spring Vessel	Conversion	Fall Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1	Albatross IV	1
2006	Polyvalent	Albatross IV	1	Albatross IV	1
2007	Polyvalent	Albatross IV	1	Albatross IV	1
2008	Polyvalent	Albatross IV	1		

Table B16. Swept area estimates of abundance at age (thousands) from the Canadian DFO spring survey.

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8
1986	5714	310	8515	1506	267	408	479	521
1987	42	4278	971	3533	943	113	422	141
1988	2069	70	12005	239	4011	253	239	155
1989	42	7515	1013	2984	267	591	42	42
1990	1309	155	13891	183	4729	324	1534	183
1991	1056	2350	197	12652	155	2252	127	619
1992	4644	4152	1590	239	5376	42	1492	56
1993	5573	3040	774	633	56	1801	28	450
1994	4673	16213	5742	591	338	28	985	14
1995	2730	3687	6052	3124	788	42	0	676
1996	8599	4067	6812	7093	4110	366	338	56
1997	2449	1633	1393	3293	3336	2393	324	127
1998	3392	11512	4335	3617	5292	5165	2787	338
1999	27796	4799	10077	3110	1970	1900	1773	464
2000	25797	96547	13117	12540	2970	2181	2730	1604
2001	31357	3983	15312	4349	5813	1816	1618	1984
2002	2787	44614	9359	21617	6080	7487	2238	1858
2003	1922	3582	97567	7229	18640	4133	3779	1697
2004	207872	580	2807	55692	5541	10384	1739	1023
2005	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0
2007	4215	15001	4419	80460	1121	178	4177	299
2008	3923	1248	4813	5204	109124	1009	195	8595

Table B17. VPA estimates of spawning stock biomass (SSB) and average fishing mortality on ages 5-7 in 2007, and number at age in 2008. Precision estimates came from 1000 bootstraps that randomly resampled residuals from the indices.

Parameter	Estimate	CV
SSB_{2007}	315976	0.20
F_{2007}	0.23	0.16
$N1_{2008}$	16376	0.76
$N2_{2008}$	6064	0.41
$N3_{2008}$	17450	0.31
$N4_{2008}$	4175	0.27
$N5_{2008}$	209204	0.23
$N6_{2008}$	790	0.26
$N7_{2008}$	911	0.29
$N8_{2008}$	9299	0.31

Table B18. To compute Mohn's Rho (Mohn 1999), the relative differences from terminal year estimates of average fishing mortality on ages 5-7 (F), spawning stock biomass (SSB) and the number of age-1 recruits, and the average of those values for years 2000-2006 for Georges Bank haddock.

Year	F	SSB	Recr(age1)
2000	0.08	-0.14	-0.30
2001	0.08	-0.05	-0.15
2002	-0.07	0.11	-0.69
2003	-0.10	0.14	1.15
2004	-0.19	0.13	0.31
2005	-0.20	0.23	0.01
2006	-0.07	0.10	0.36
AVERAGE	**-0.07**	**0.07**	**0.10**

Table B19. VPA estimate of catchability (q) and CV for swept-area age-specific abundance indices for Georges Bank haddock.

Index	q	CV
NEFSC spr 1	0.31	0.20
NEFSC spr 2	0.56	0.14
NEFSC spr 3	0.63	0.14
NEFSC spr 4	0.57	0.10
NEFSC spr 5	0.63	0.13
NEFSC spr 6	0.54	0.16
NEFSC spr 7	0.54	0.15
NEFSC spr 8	0.62	0.17
NEFSC S41 1	0.72	0.51
NEFSC S41 2	0.90	0.35
NEFSC S41 3	0.78	0.31
NEFSC S41 4	0.84	0.22
NEFSC S41 5	0.89	0.16
NEFSC S41 6	0.88	0.28
NEFSC S41 7	0.91	0.26
NEFSC S41 8	0.86	0.32
NEFSC aut 1	0.43	0.14
NEFSC aut 2	0.69	0.15
NEFSC aut 3	0.57	0.12
NEFSC aut 4	0.65	0.10
NEFSC aut 5	0.57	0.11
NEFSC aut 6	0.56	0.12
CAN spr 1	0.28	0.23
CAN spr 2	0.40	0.21
CAN spr 3	0.66	0.13
CAN spr 4	0.62	0.13
CAN spr 5	0.71	0.14
CAN spr 6	0.52	0.19
CAN spr 7	0.68	0.18
CAN spr 8	0.62	0.16

Table B20. Inputs to the NMFS Toolbox YPR module for this assessment (GARM3) and for the previous assessment (GARM2). Vectors of selectivity, catch weight, and SSB weight are averages for the years 2003-2007. Maturity at age was assumed constant over all years.

	GARM3 Final meeting				*GARM2 (2005)*			
Age	Selectivity	Catch wt	SSB wt	Maturity	*Selectivity*	*Catch wt*	*SSB wt*	*Maturity*
1	0.01	0.20	0.11	0.06	*0.00*	*0.36*	*0.26*	*0.01*
2	0.03	0.59	0.36	0.47	*0.09*	*0.85*	*0.62*	*0.55*
3	0.15	1.09	0.80	0.92	*0.47*	*1.32*	*1.15*	*0.95*
4	0.40	1.38	1.25	0.99	*0.92*	*1.70*	*1.56*	*0.99*
5	1.00	1.66	1.56	1.00	*1.00*	*1.98*	*1.87*	*1.00*
6	1.00	1.89	1.82	1.00	*1.00*	*2.27*	*2.17*	*1.00*
7	1.00	2.09	2.05	1.00	*1.00*	*2.62*	*2.48*	*1.00*
8	1.00	2.35	2.34	1.00	*1.00*	*2.87*	*2.80*	*1.00*
9+	1.00	2.64	2.64	1.00	*1.00*	*3.23*	*3.23*	*1.00*

Table B21. Biological reference points (BRPs) for Georges Bank haddock from this assessment, and the point estimates estimated by NEFSC (2002). SSB_{MSY} and MSY were estimated from stochastic bootstrapped projections in AGEPRO, while F40% is a deterministic point estimate from the NMFS YPR Toolbox module.

BRP	5th percentile	Median	95th percentile	*NEFSC (2002)*
F40%	0.35	0.35	0.35	*0.26*
SSB_{MSY}	96,350	158,873	229,744	*250,300*
MSY	19,538	32,746	48,865	*52,900*

Table B22. Stock estimates in 2007 from the VPA, and projected estimates for 2008 and 2009 from AGEPRO. The bold values in outlined boxes were fixed values in the AGEPRO projections.

Year	SSB (mt)	Catch (mt)	F
2007	315,976	21,929	0.23
2008	*346,216*	***21,929***	*0.071*
2009	*299,871*	*87,587*	***0.35***

Table B23. Estimated stock status with 10th and 90th percentiles from the VPA bootstraps (for year 2007) and from the AGEPRO projections (2008 and 2009).

Year	SSB(10%)/ SSB_{MSY}	SSB(50%)/ SSB_{MSY}	SSB(90%)/ SSB_{MSY}	F(10%)/ F_{MSY}	F(50%)/ F_{MSY}	F(90%)/ F_{MSY}
2007	1.53	1.99	2.59	0.55	0.66	0.82
2008	1.64	2.18	2.89	0.15	0.20	0.27
2009	1.42	1.89	2.51	1.00	1.00	1.00

Table B24. Estimates of fully selected F (average F on ages 5 to 7) and spawning stock biomass (SSB) as estimated from VPA.

Year	**$F_{5 \text{ to } 7}$**	**SSB**			
1931	1.00	95,164	1969	0.47	47,765
1932	0.66	91,793	1970	0.34	34,914
1933	0.63	79,341	1971	0.56	24,773
1934	0.43	69,708	1972	0.34	23,221
1935	0.53	74,432	1973	0.28	15,890
1936	0.53	76,206	1974	0.07	29,695
1937	0.68	73,040	1975	0.08	22,062
1938	0.61	80,664	1976	0.09	28,598
1939	0.57	96,442	1977	0.25	49,855
1940	0.57	96,421	1978	0.32	76,795
1941	0.74	103,393	1979	0.34	72,413
1942	0.67	106,387	1980	0.52	71,230
1943	0.66	108,848	1981	0.40	61,542
1944	0.61	99,289	1982	0.30	49,509
1945	0.60	93,728	1983	0.31	38,688
1946	0.70	90,348	1984	0.43	26,982
1947	0.67	84,819	1985	0.35	20,046
1948	0.55	80,575	1986	0.29	21,016
1949	0.55	69,510	1987	0.24	20,838
1950	0.49	69,498	1988	0.36	19,775
1951	0.62	75,572	1989	0.32	20,543
1952	0.34	78,393	1990	0.37	24,388
1953	0.40	79,120	1991	0.41	22,054
1954	0.44	86,183	1992	0.53	16,546
1955	0.42	100,705	1993	0.42	14,907
1956	0.59	108,320	1994	0.44	20,406
1957	0.61	107,600	1995	0.12	26,991
1958	0.43	106,201	1996	0.16	36,012
1959	0.36	114,615	1997	0.10	44,106
1960	0.26	137,525	1998	0.15	51,502
1961	0.26	171,975	1999	0.16	60,500
1962	0.35	179,431	2000	0.16	75,111
1963	0.36	168,999	2001	0.22	90,118
1964	0.51	181,244	2002	0.23	104,085
1965	0.68	238,377	2003	0.21	126,003
1966	0.63	193,543	2004	0.30	115,770
1967	0.59	107,237	2005	0.31	142,954
1968	0.58	71,845	2006	0.24	265,994
			2007	0.23	315,975

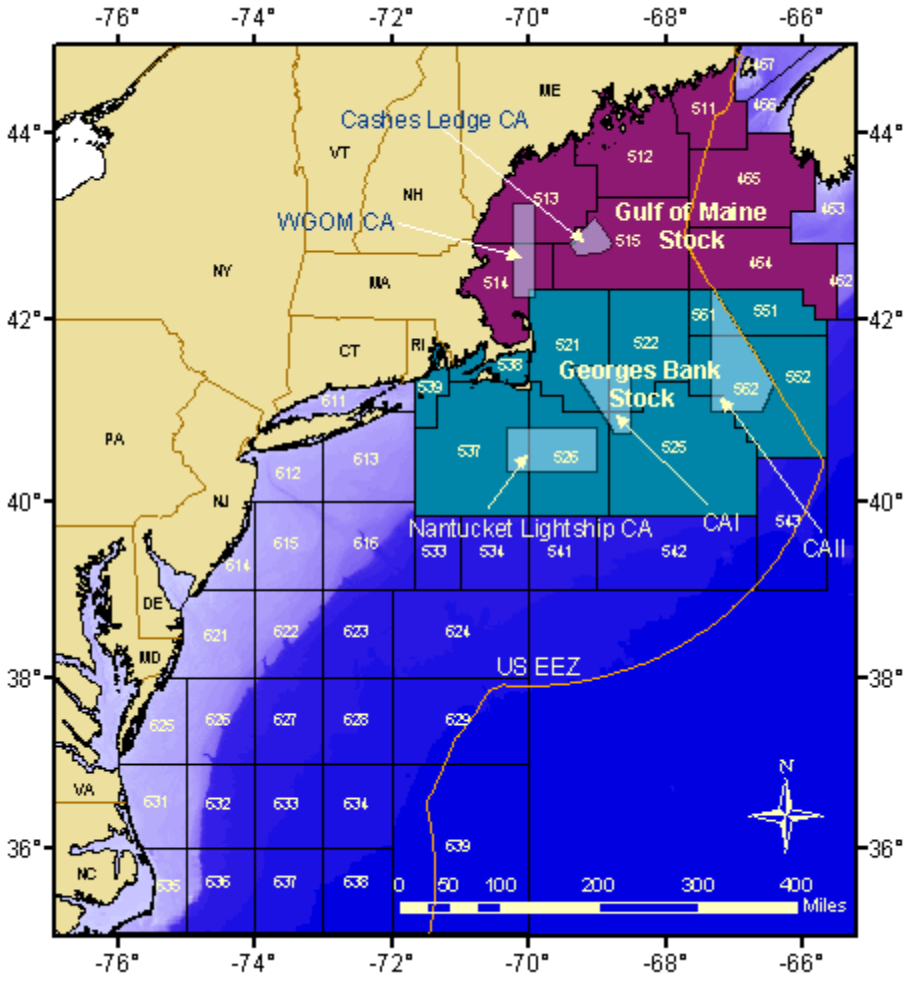


Figure B1. Statistical areas used to define the Gulf of Maine and Georges Bank haddock stocks.

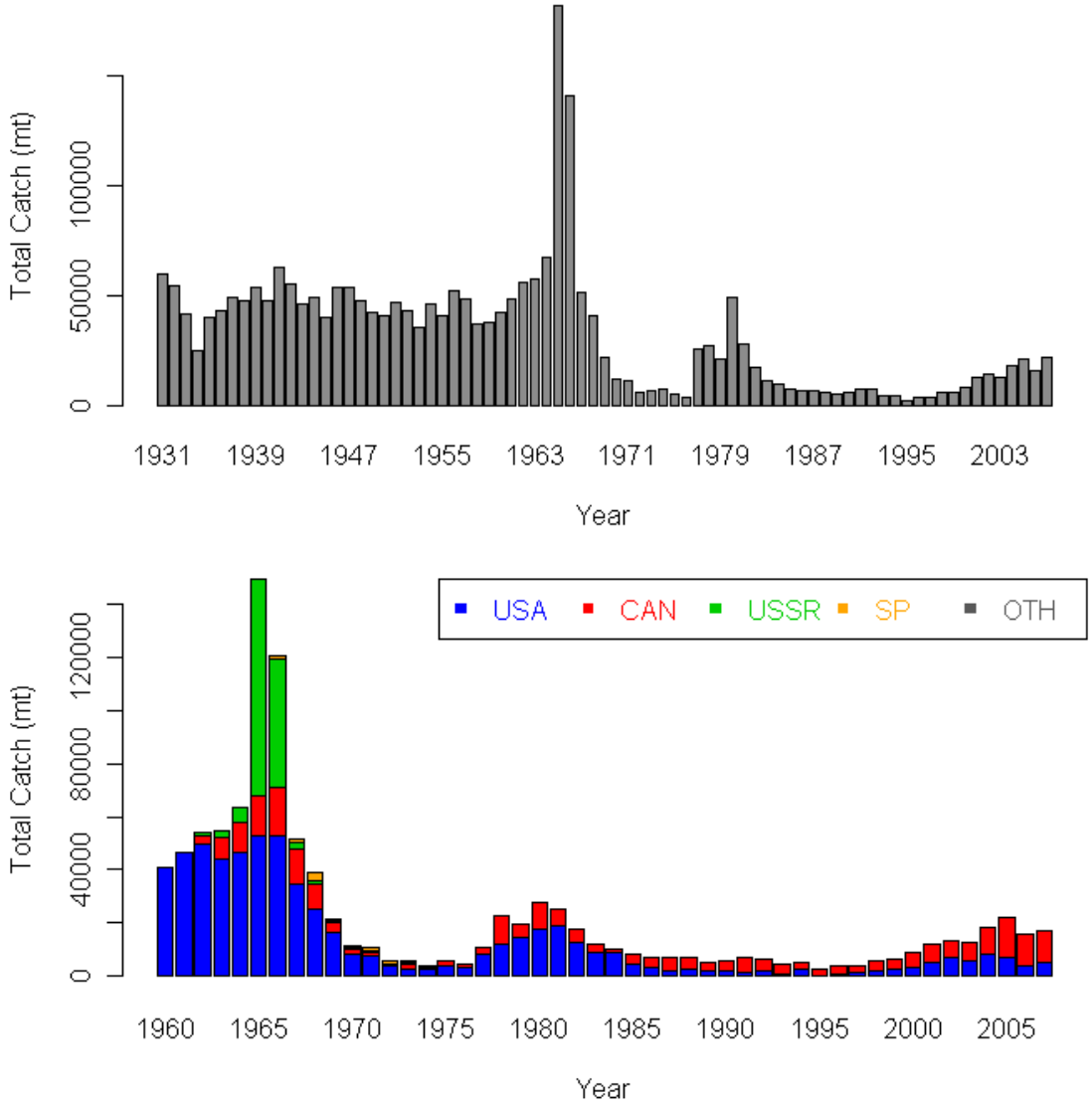


Figure B2. Historical total catch (1931-2007) and total catch by country (1960-2007) for Georges Bank haddock.

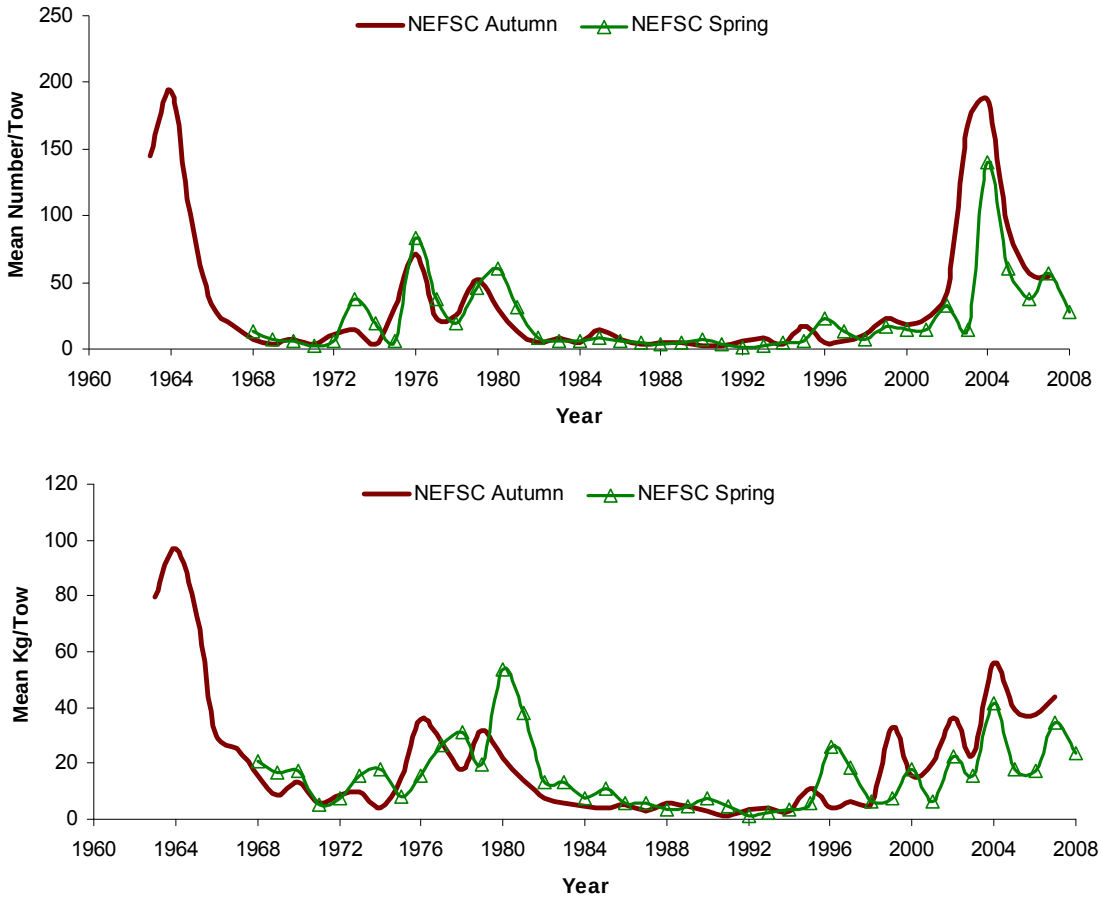


Figure B3. NEFSC spring and autumn bottom-trawl surveys in mean number per tow (top) and mean kg per tow (bottom) of Georges Bank haddock.

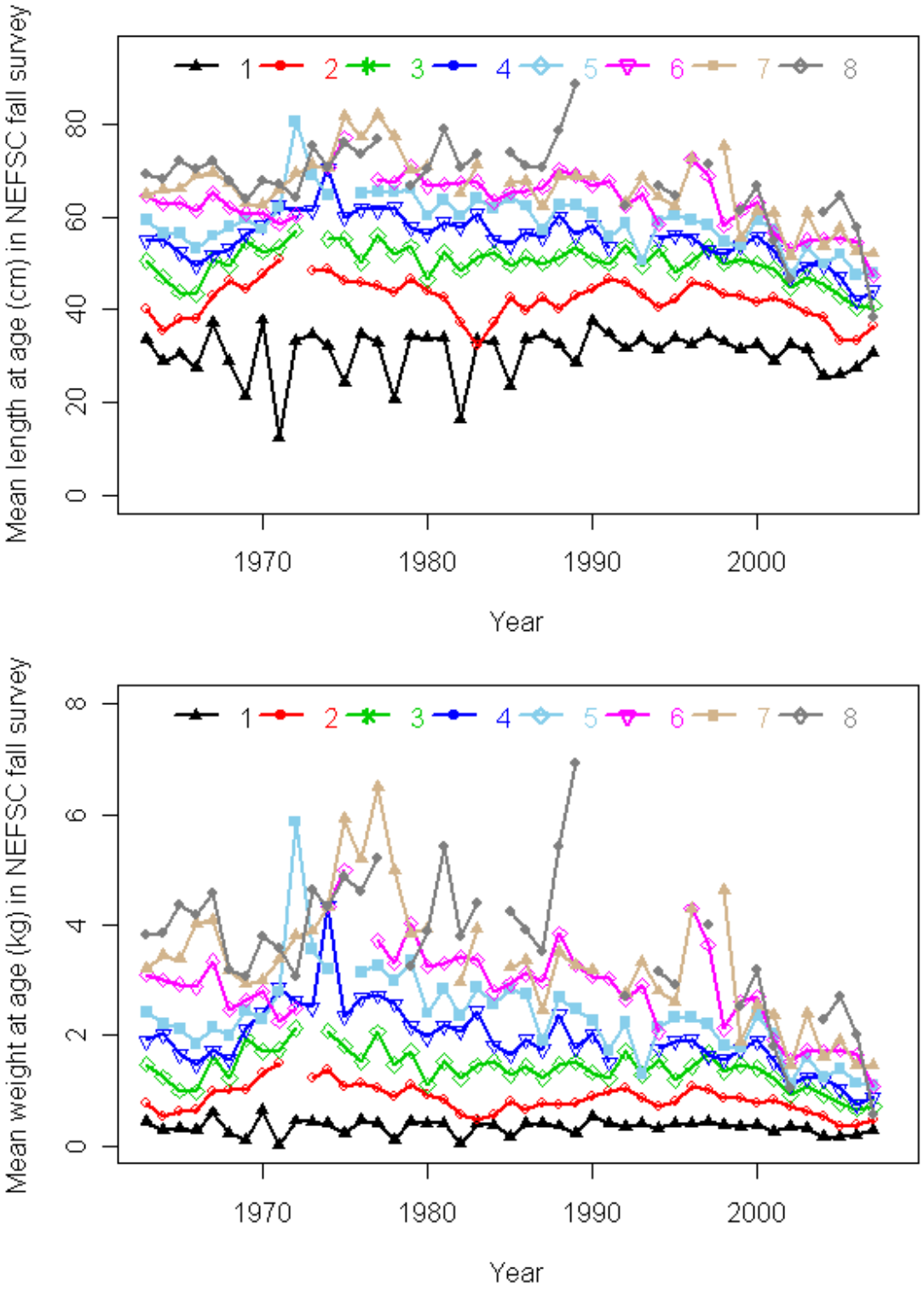


Figure B4a. Mean length and mean weight at age of Georges Bank haddock in the fall NEFSC bottom-trawl survey (1963-2007).

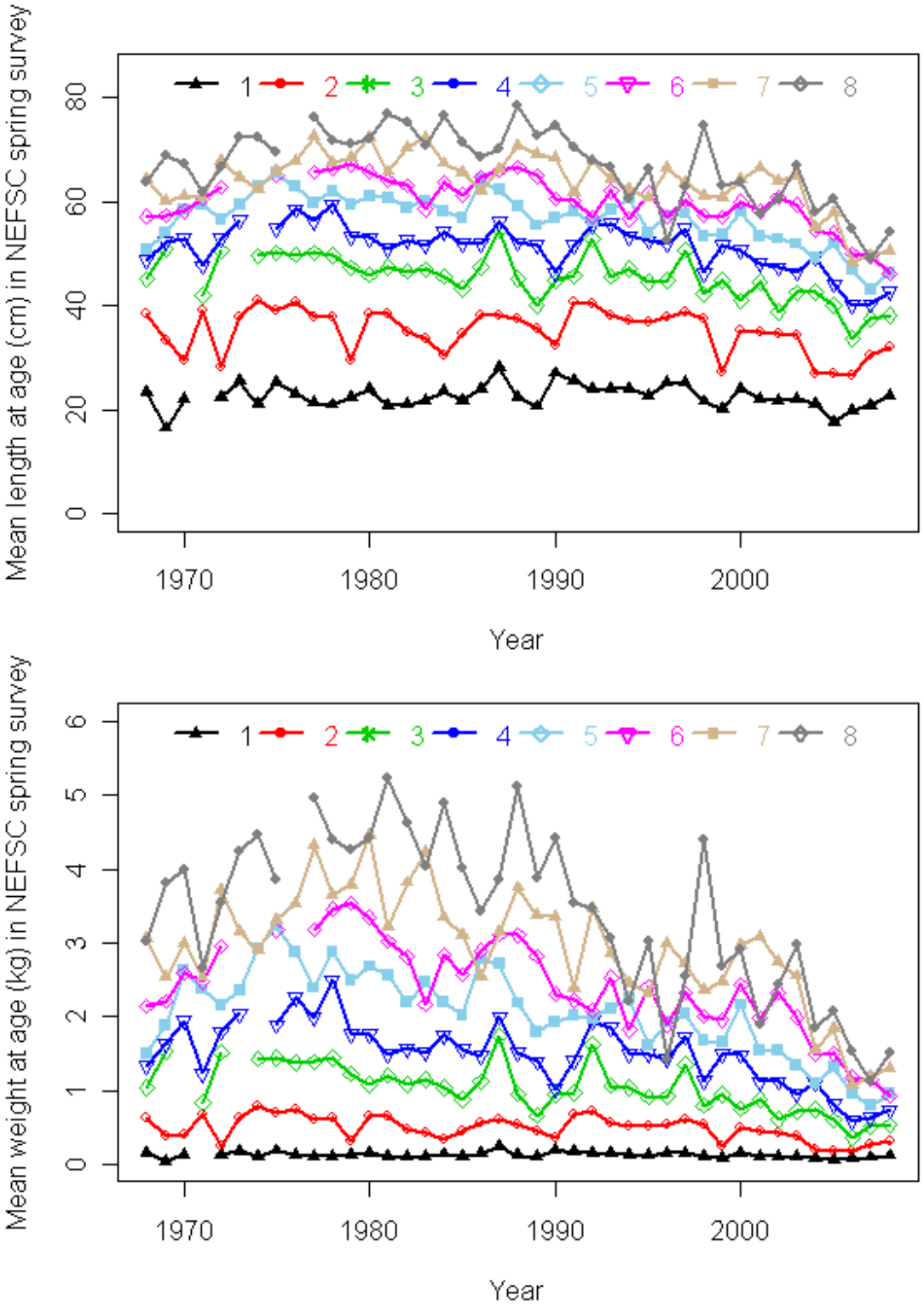


Figure B4b. Mean length (cm) and mean weight (kg) at age of Georges Bank haddock in the spring NEFSC bottom-trawl survey (1968-2007).

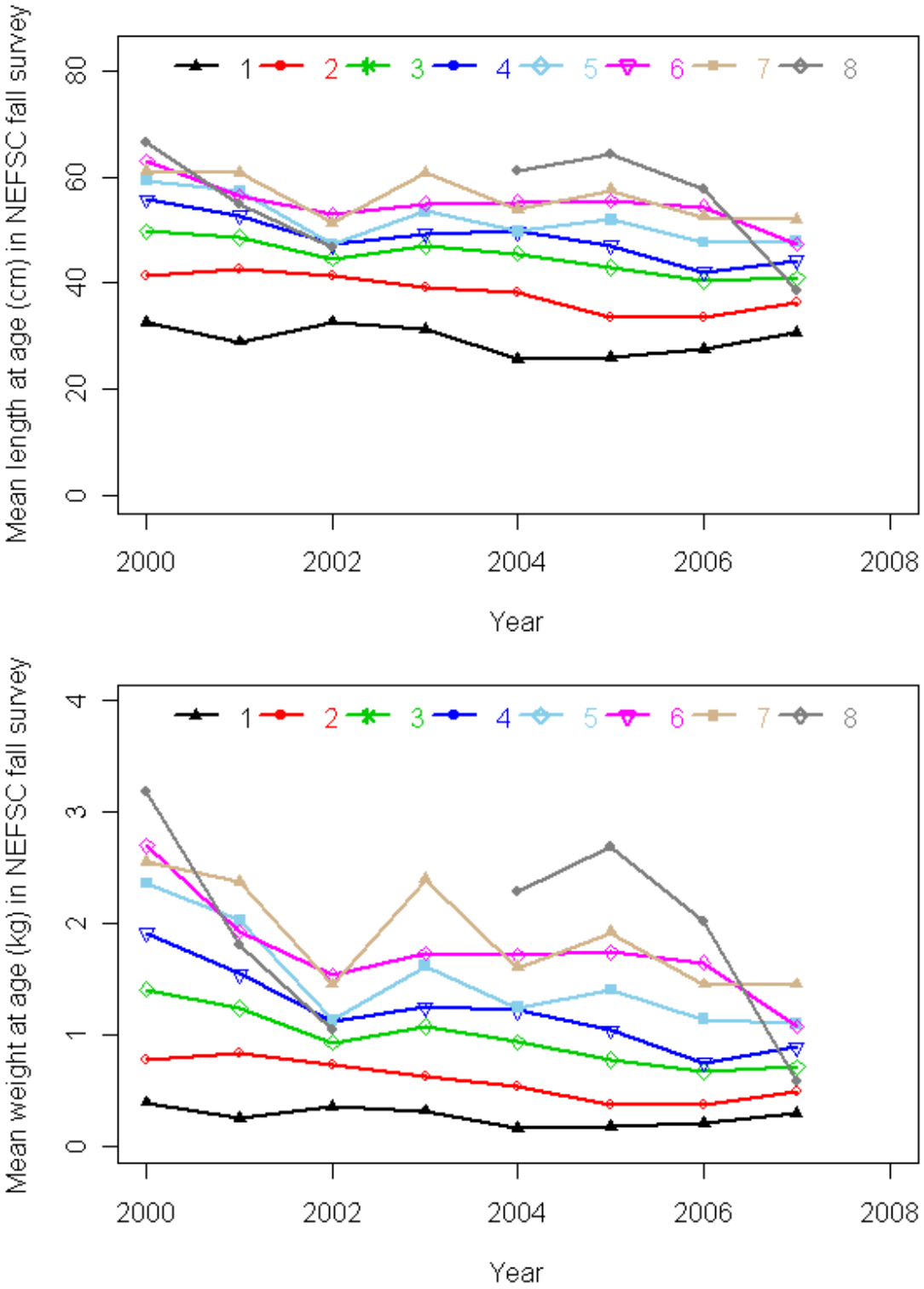


Figure B5a. Mean length and mean weight at age of Georges Bank haddock in the fall NEFSC bottom-trawl survey (2000-2007).

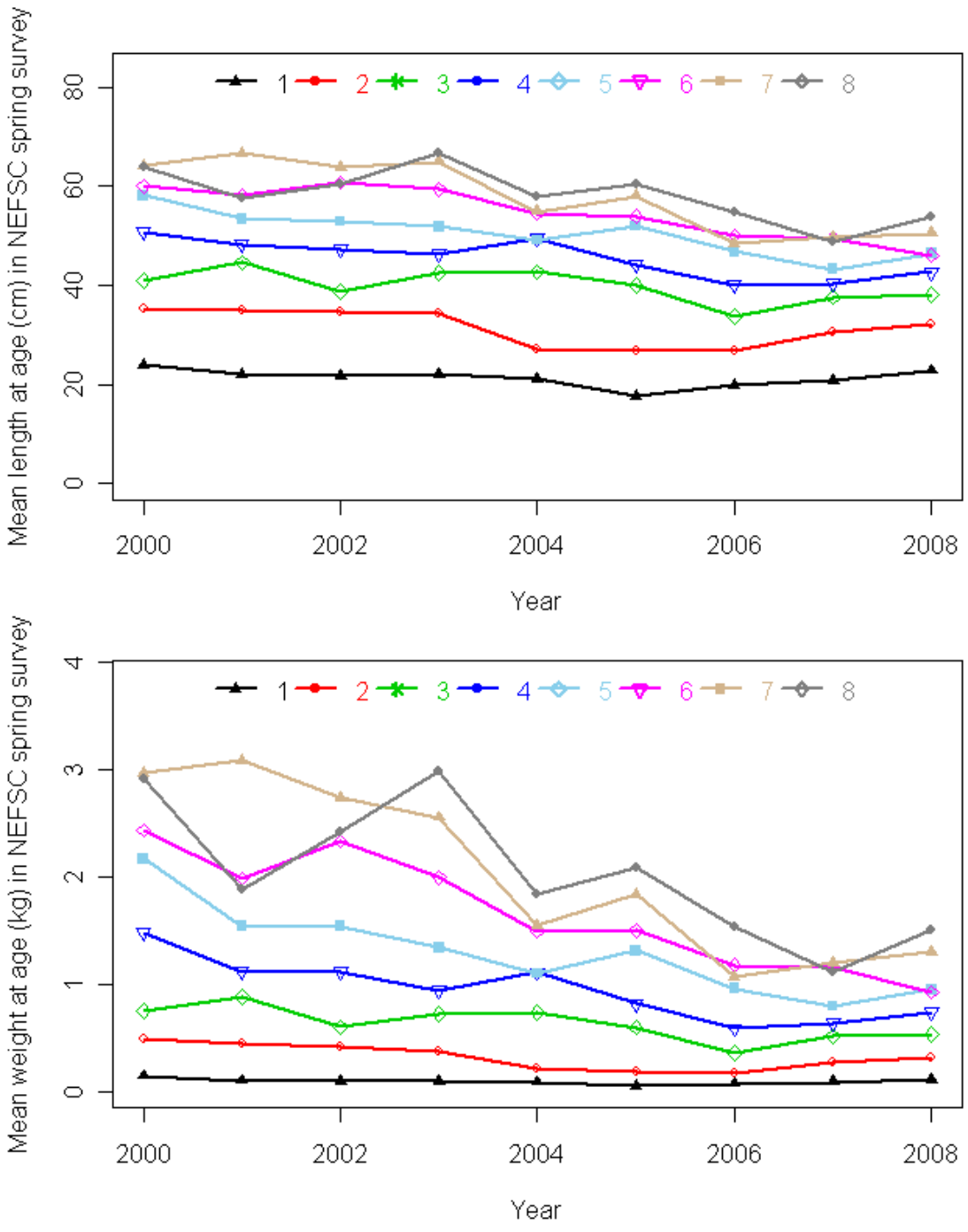
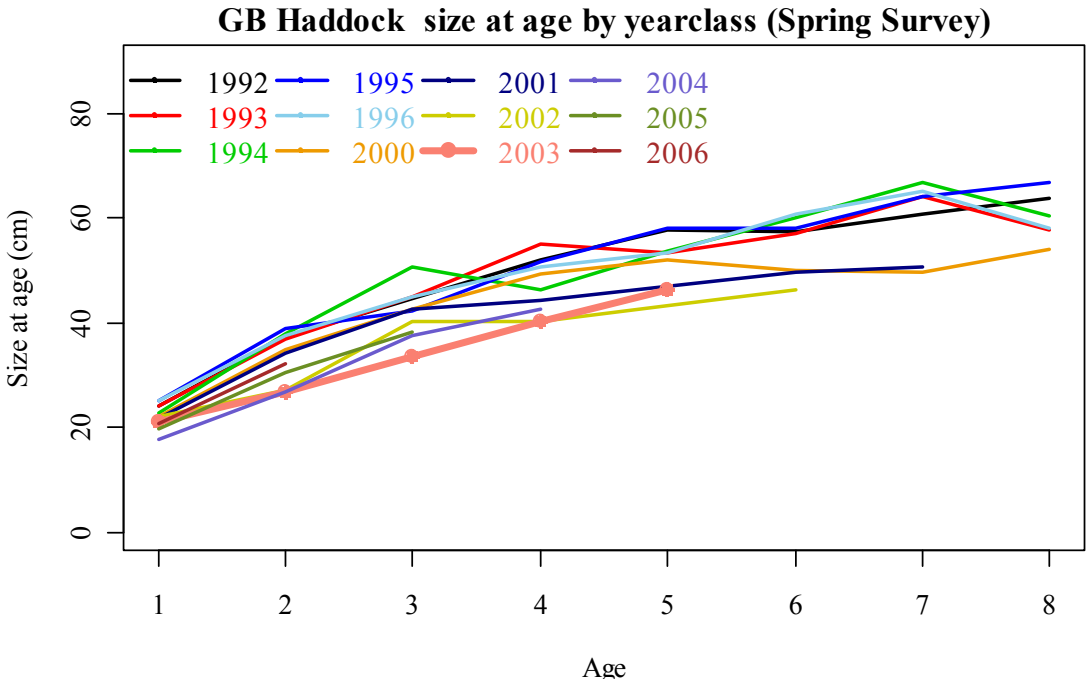


Figure B5b. Mean length and mean weight at age of Georges Bank haddock in the fall NEFSC bottom-trawl survey (2000-2007).



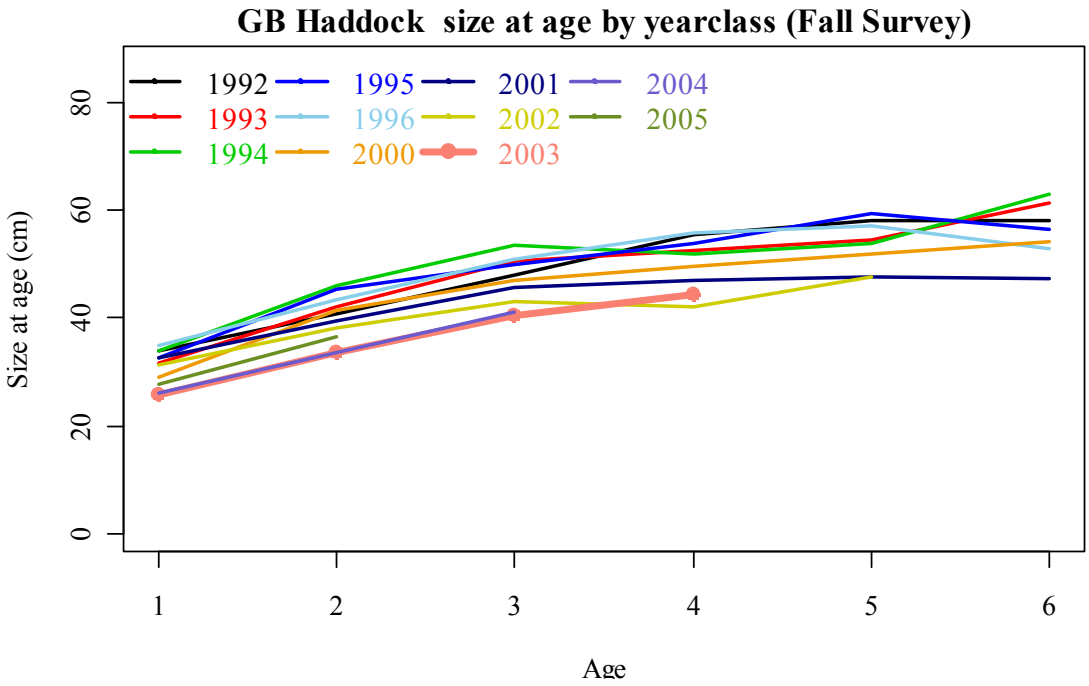


Figure B6. Mean size at age (cm) by year class of Georges Bank haddock in the spring and fall NEFSC surveys. The strong 2003 year class is indicated by a bold line with filled circles.

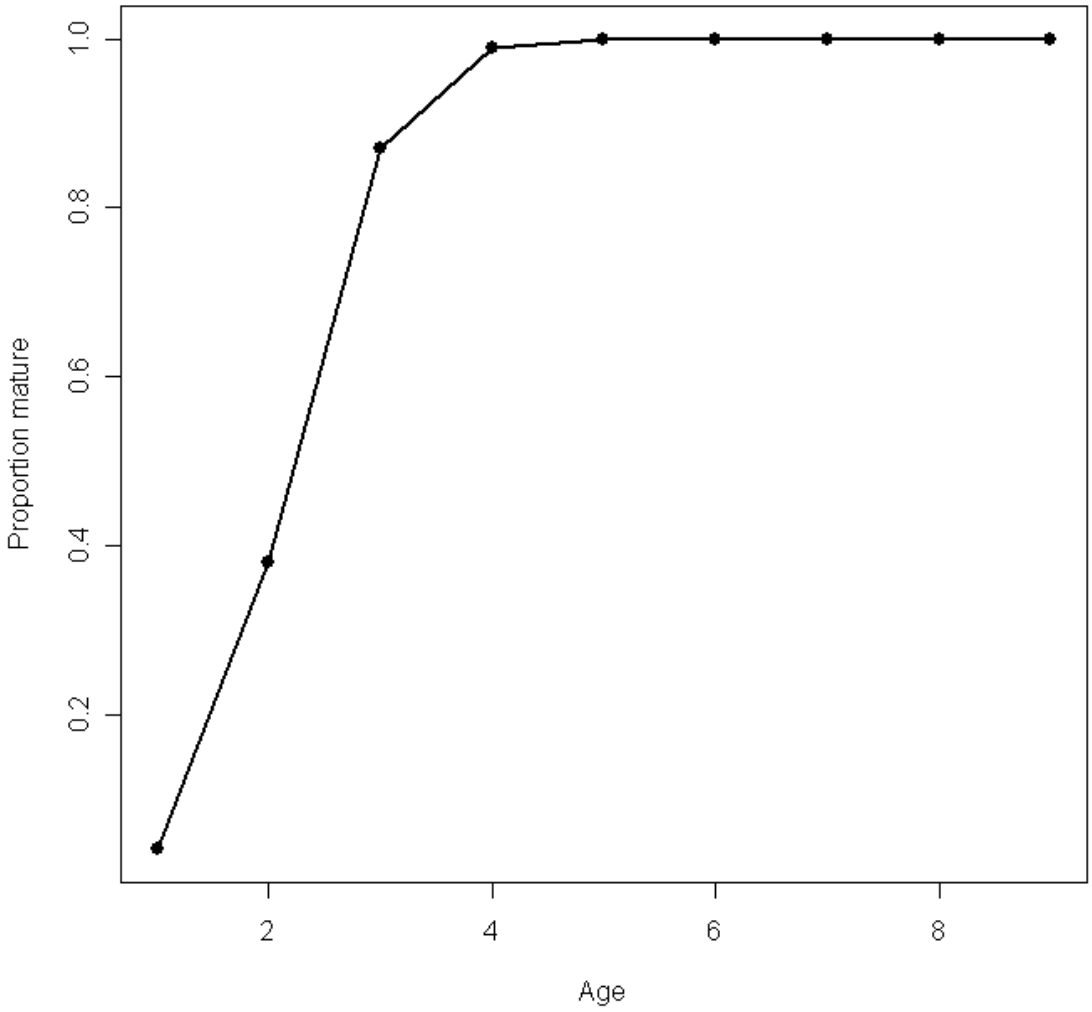


Figure B7. Proportion mature at age for Georges Bank haddock.

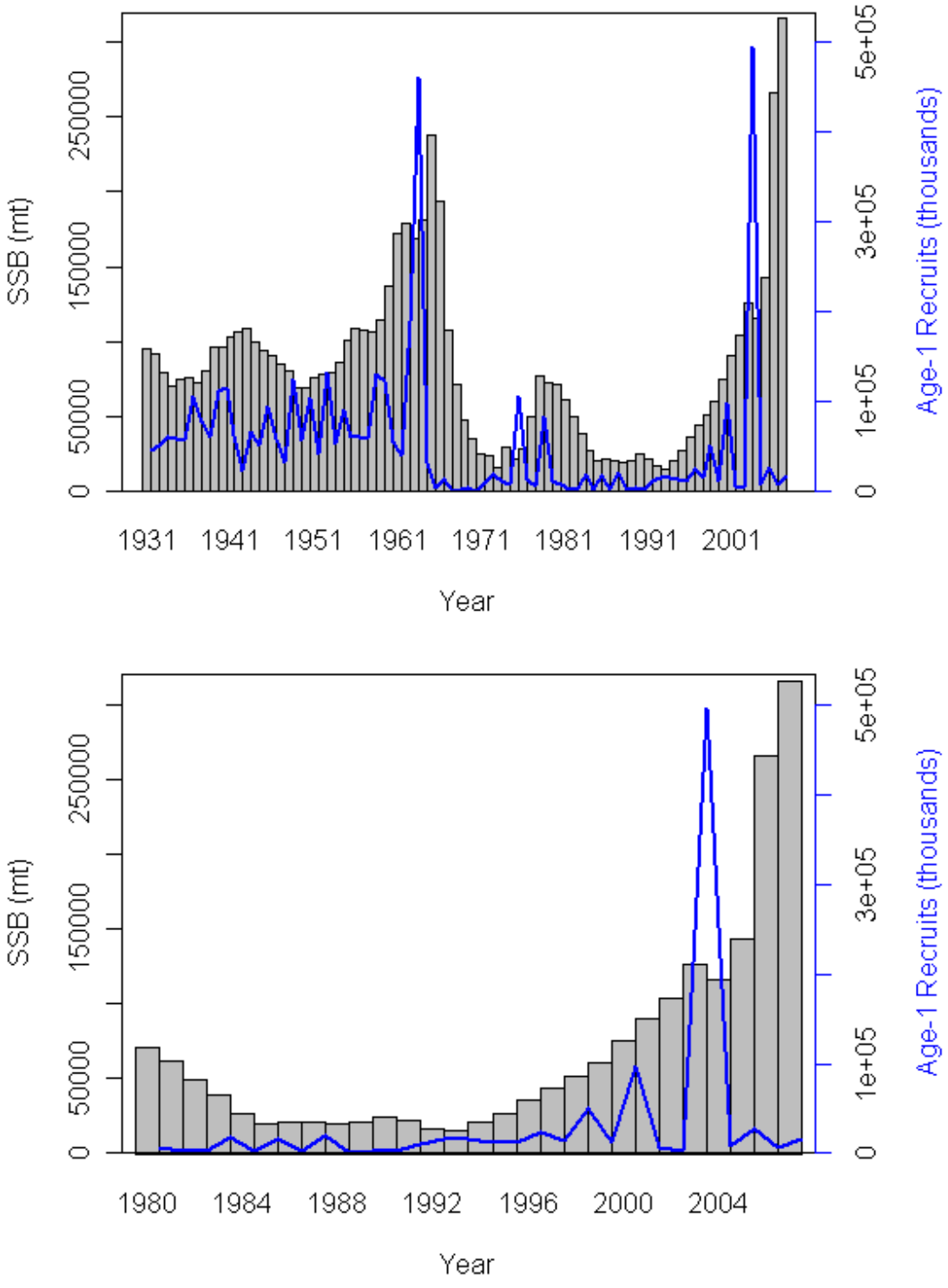


Figure B8. VPA estimates of spawning stock biomass (SSB, mt) and age-1 recruits (thousands) for Georges Bank haddock.

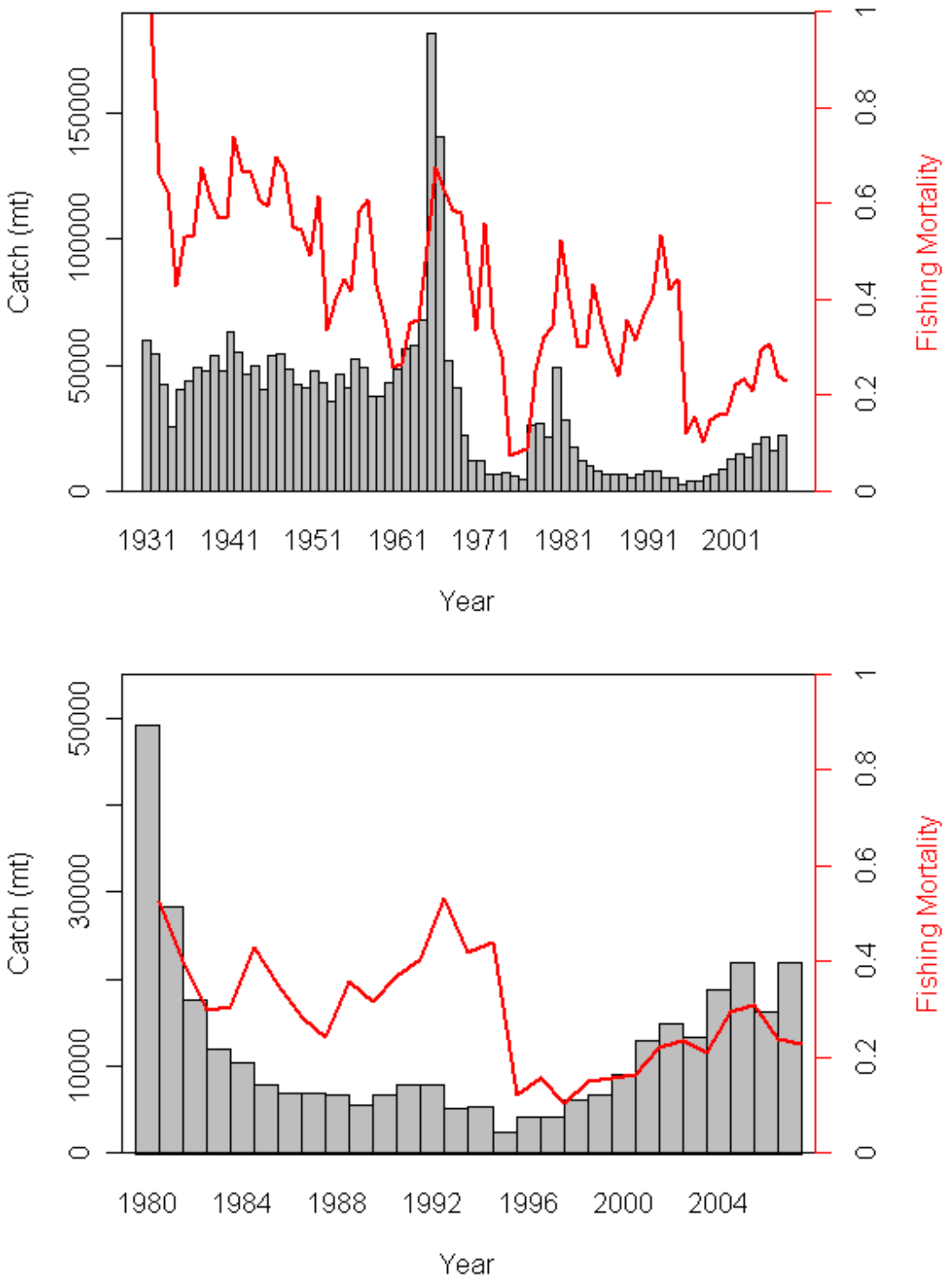


Figure B9. Total catch (mt) and VPA estimates of average fishing mortality on ages 5-7 for Georges Bank haddock.

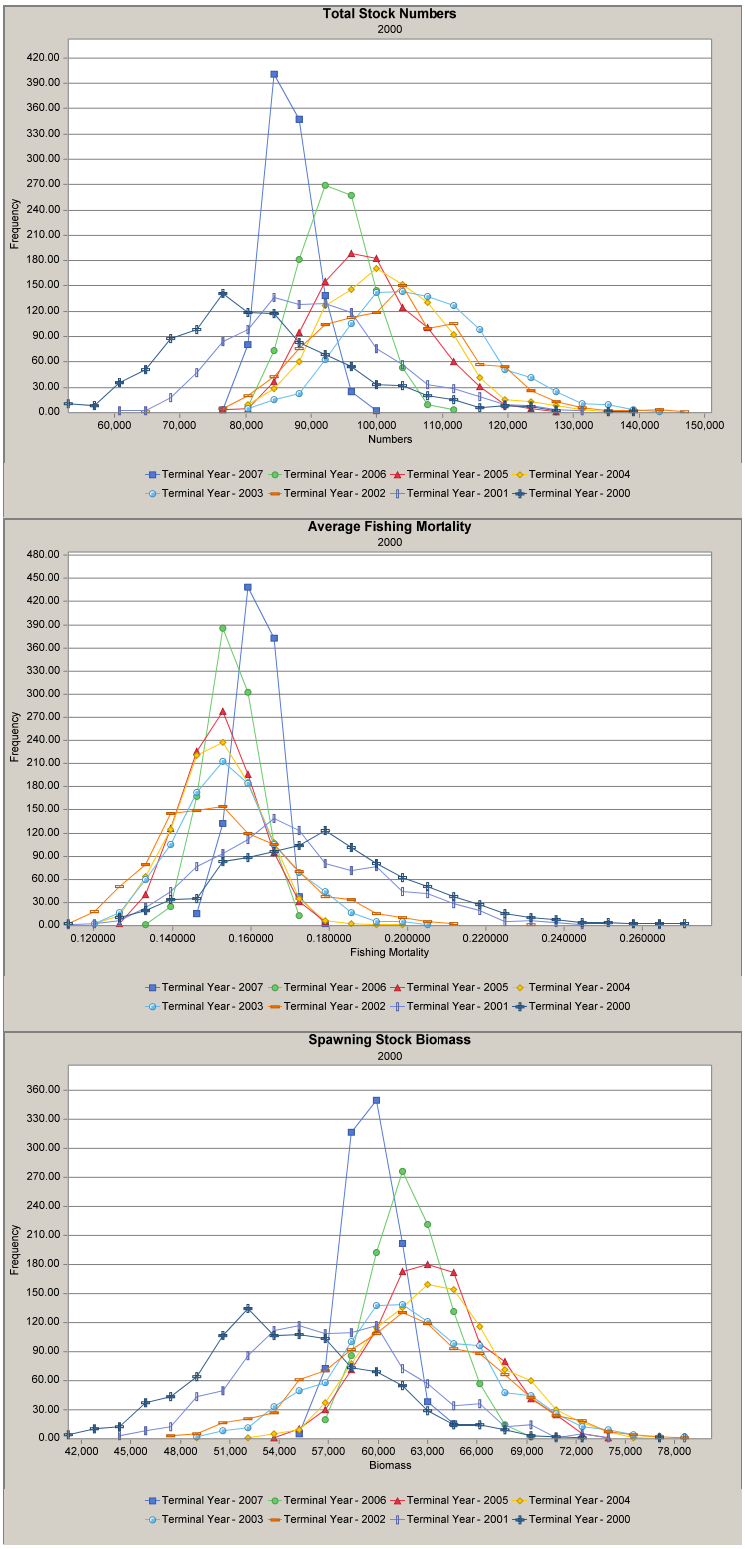


Figure B10. Bootstrapped retrospective distributions of total numbers (top), fishing mortality (middle) and spawning stock biomass (bottom) in year 2000 for Georges Bank haddock.

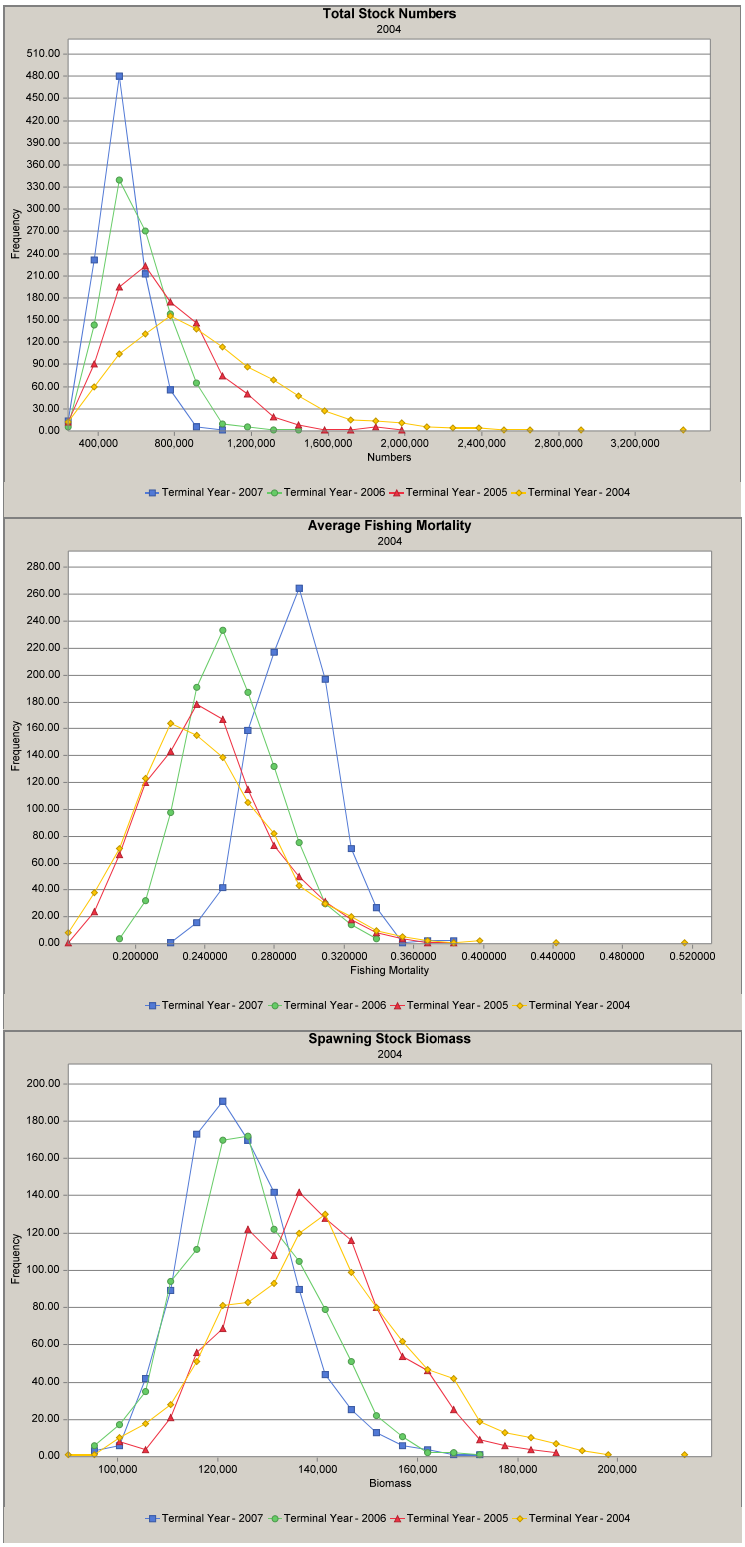


Figure B11. Bootstrapped retrospective distributions of total numbers (top), fishing mortality (middle) and spawning stock biomass (bottom) in year 2004 for Georges Bank haddock.

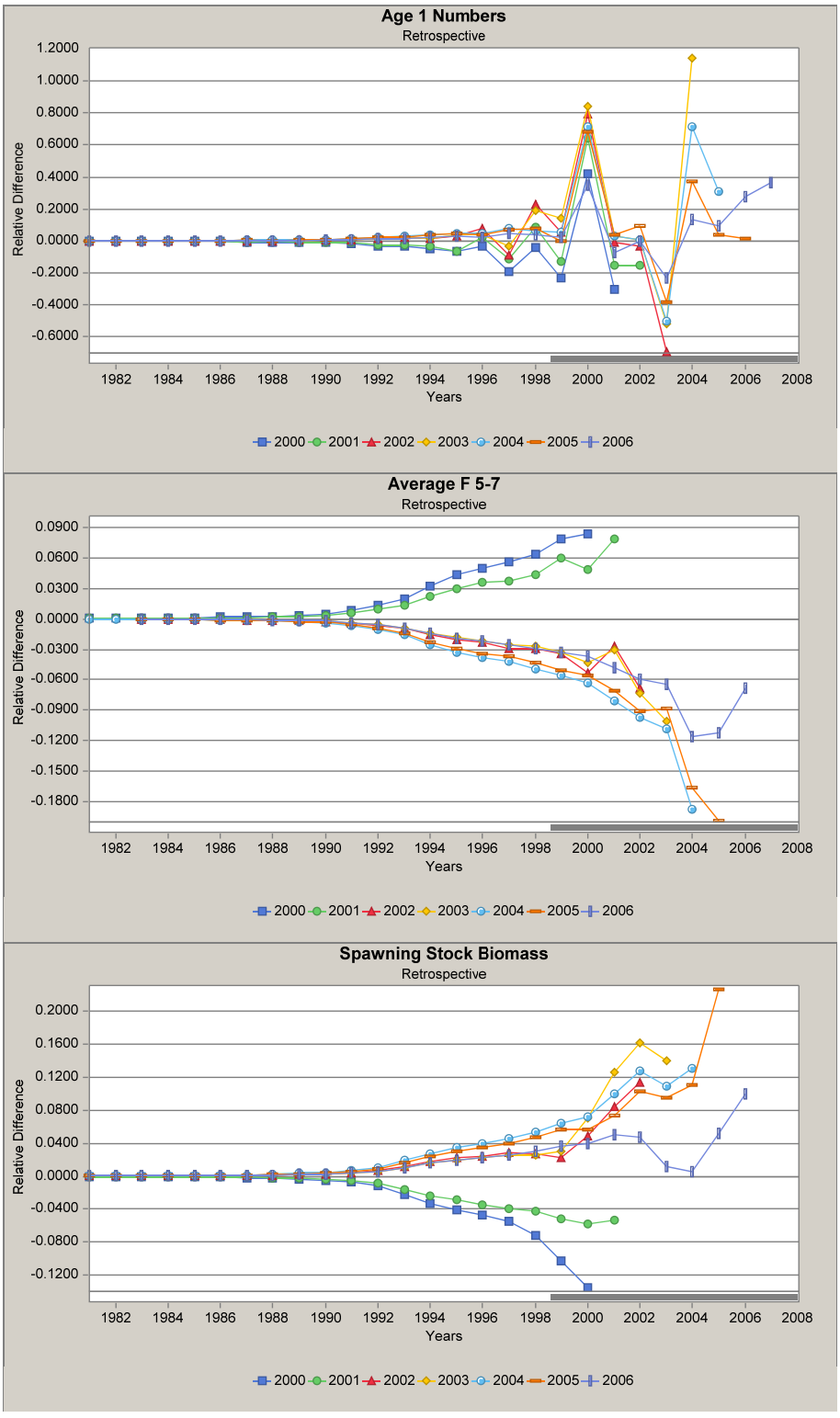


Figure B12. Retrospective analysis of relative differences from terminal year estimates of age-1 recruits (top), fishing mortality (middle) and spawning stock biomass (bottom) for Georges Bank haddock.

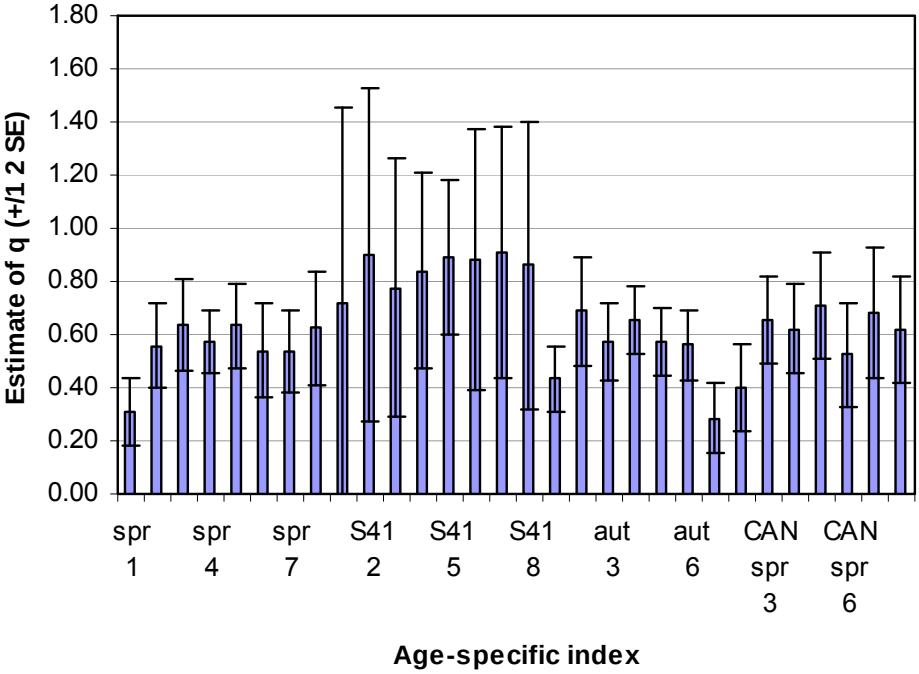


Figure B13. VPA estimates of catchability (q), +/- 2 standard errors, for swept area age-specific abundance indices of Georges Bank haddock.

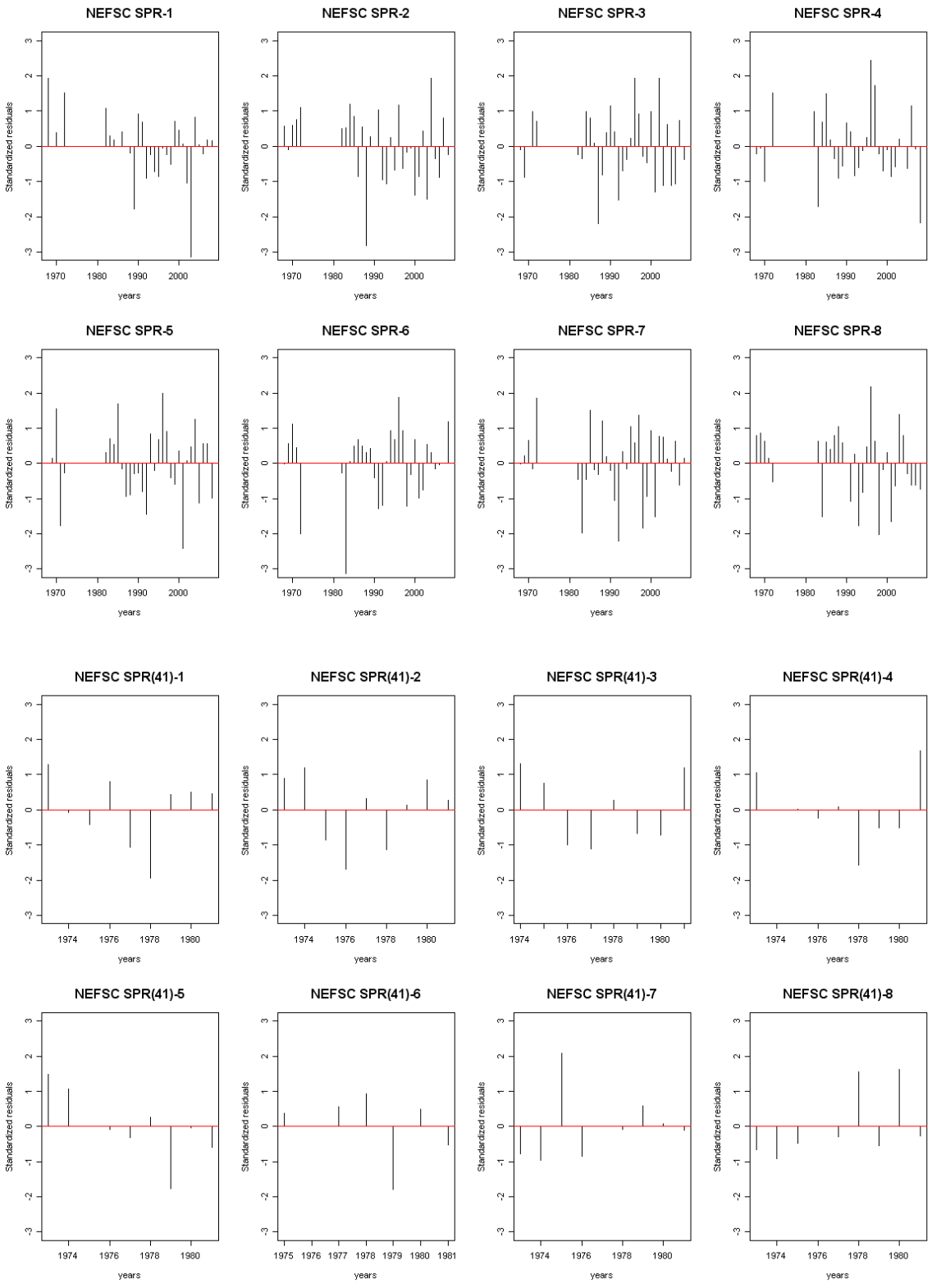


Figure B14a. Residuals from fitting to NEFSC spring swept area indices of abundance at age for Georges Bank haddock.

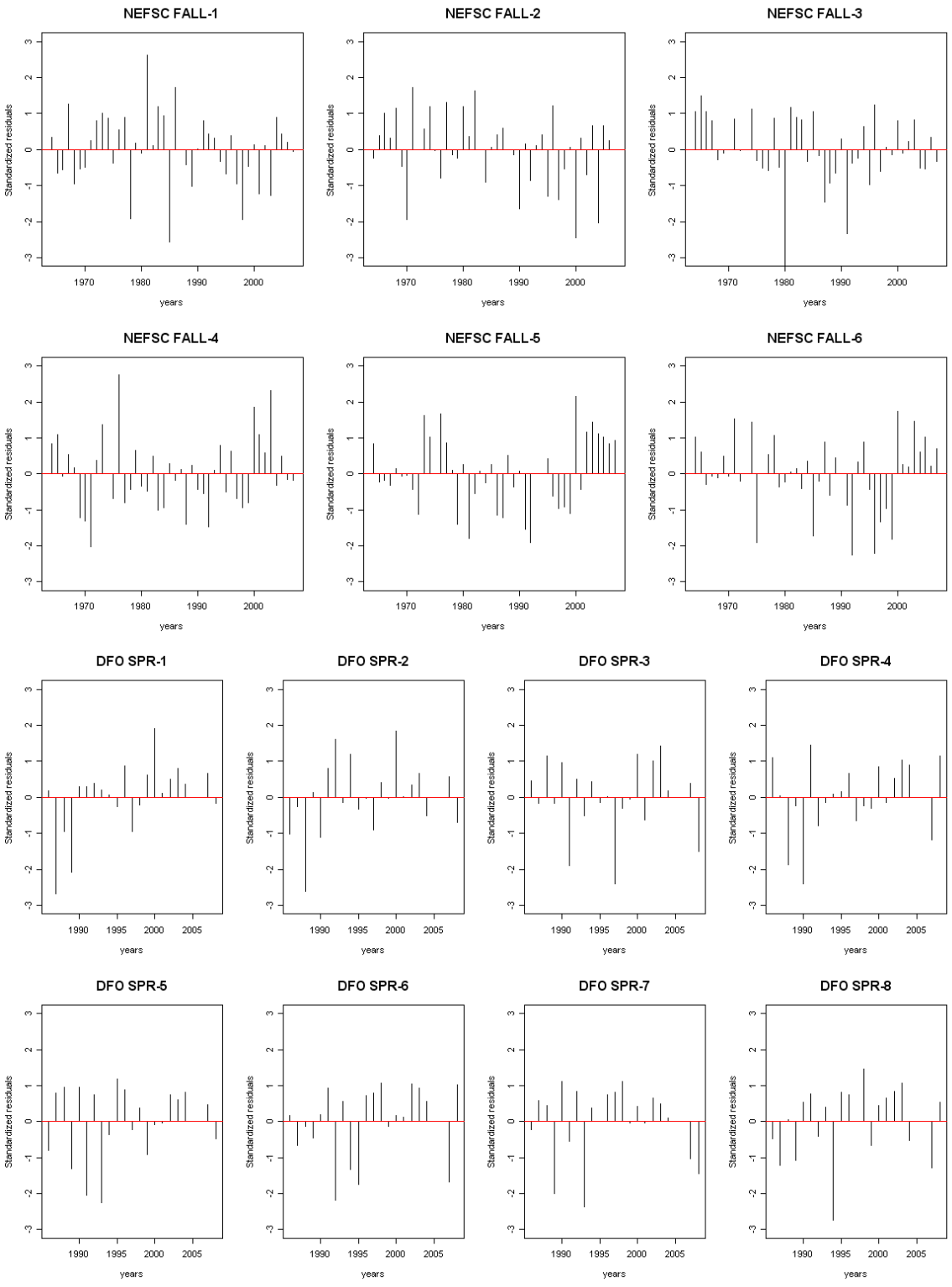


Figure B14b. Residuals from fitting to NEFSC fall and Canadian DFO spring swept area indices of abundance at age for Georges Bank haddock.

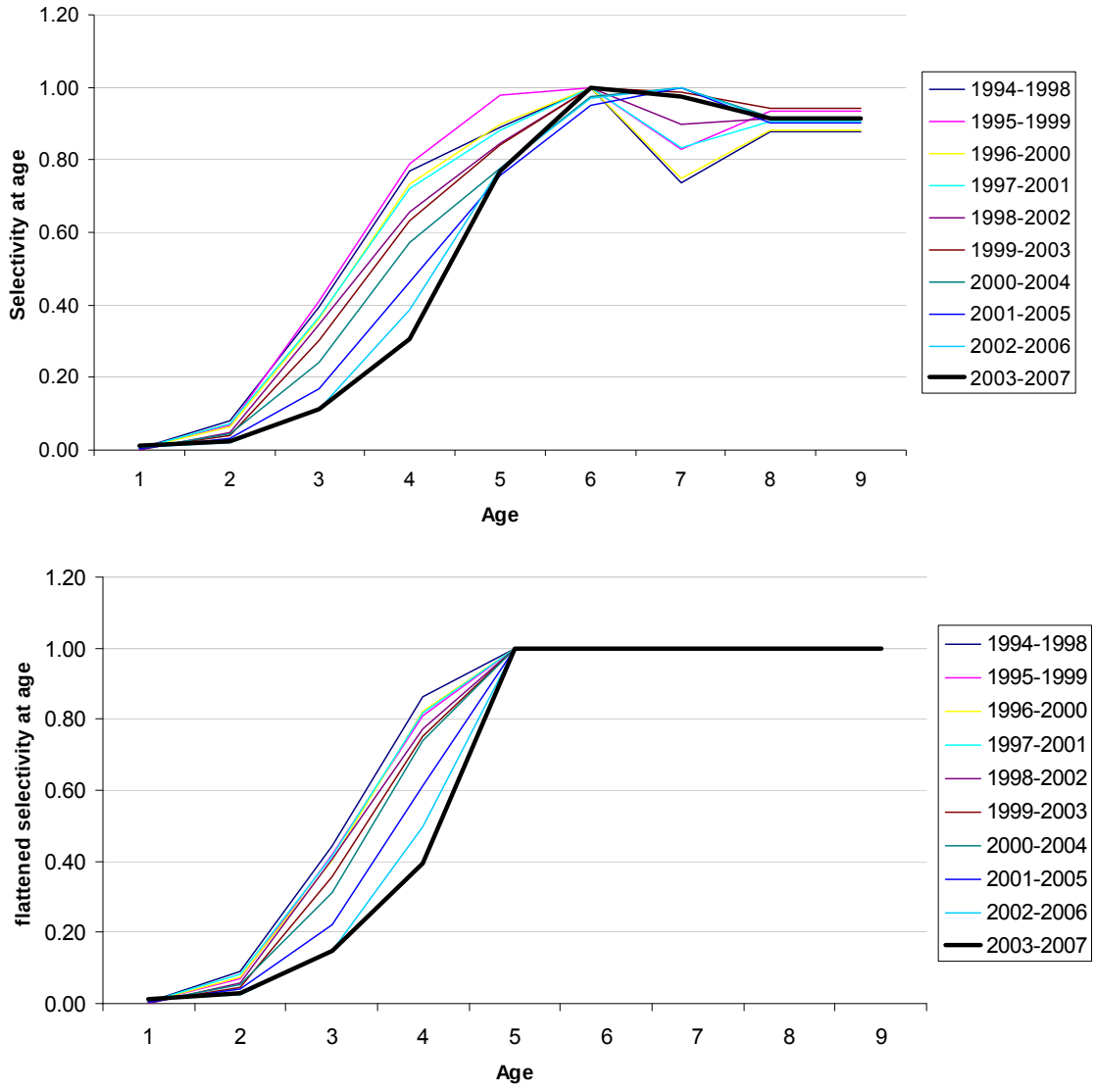


Figure B15. Five-year average selectivity at age for Georges Bank haddock as estimated in the VPA (top), and rescaled to asymptote at age 5 (bottom).

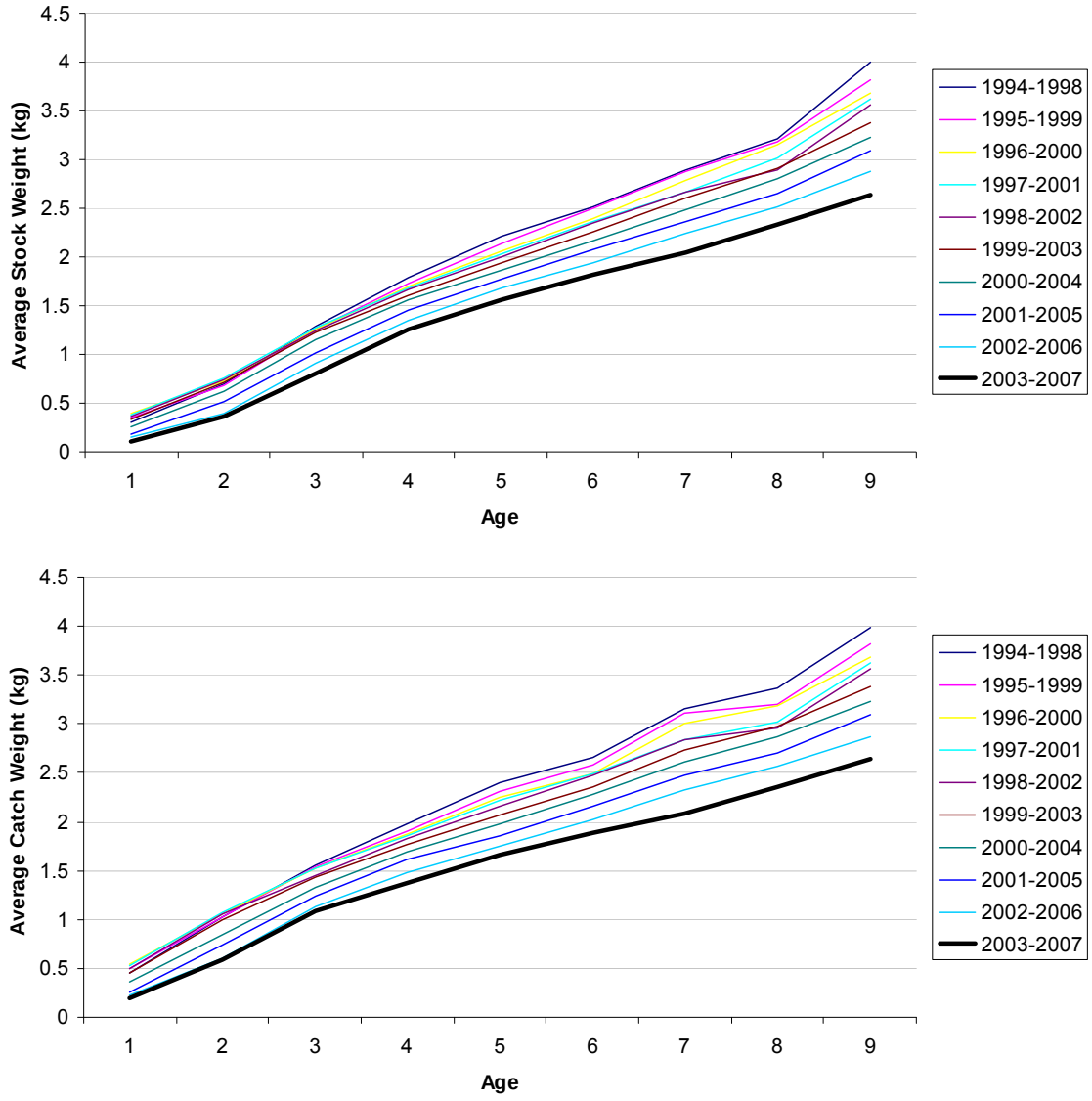


Figure B16. Five-year average weights at age for Georges Bank haddock.

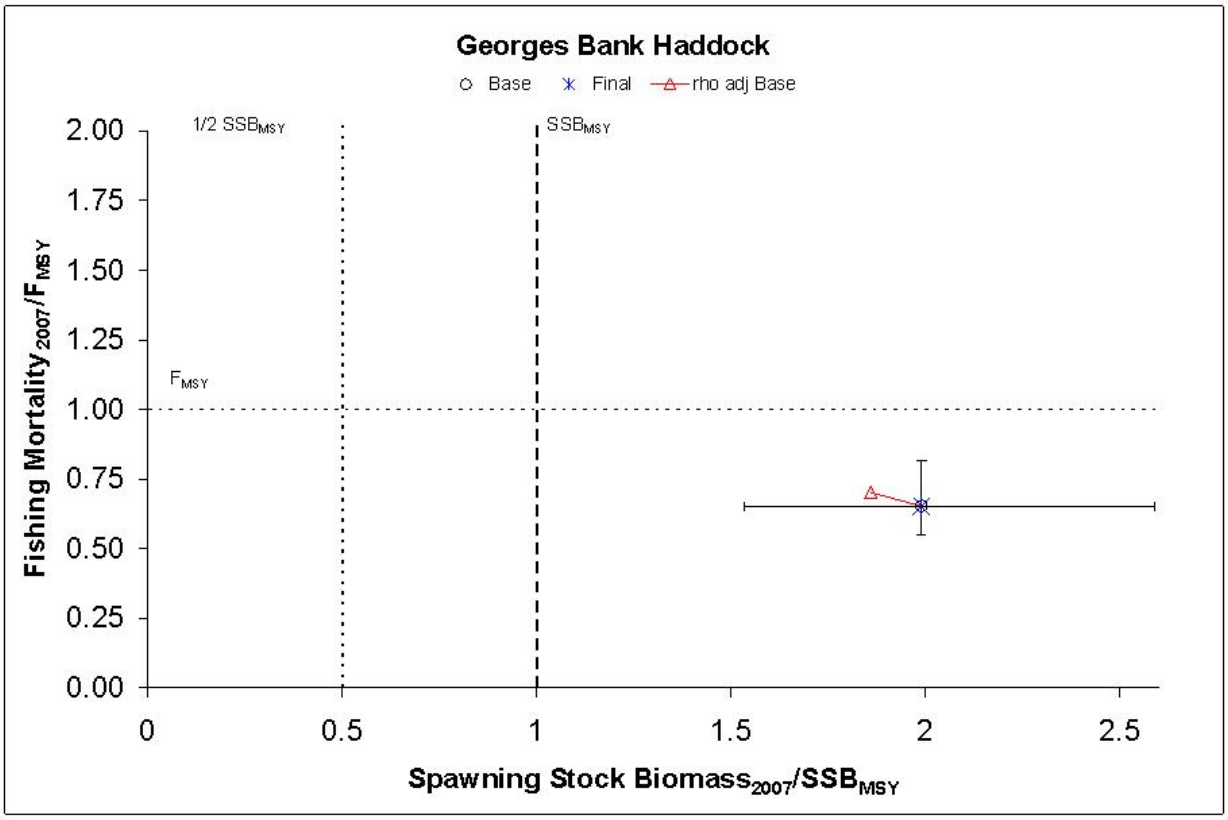


Figure B17. Estimated stock status of Georges Bank haddock, with 10^th and 90^th percentiles for 2007. Stock status after applying a correction for Mohn's rho ('rho adj Base') is shown for comparison, although management advice is based on the Base (Final) unadjusted stock status.