D. Cape Cod-Gulf of Maine Yellowtail Flounder

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1.0 Background

The Cape Cod-Gulf of Maine yellowtail flounder stock was most recently assessed at the Groundfish Assessment Review Meeting (GARM III) in 2008 (Legault et al. 2008; NEFSC 2008). That assessment was a benchmark. The previous assessment used virtual population analysis (VPA) to estimate the terminal year fishing mortality rate (F_{2007} = 0.414) and spawning stock biomass (SSB_{2007} = 1,922 mt). Biological reference points were computed using spawning stock biomass per recruit calculations to estimate a proxy for Fmsy (F40%SPR = 0.239) and a projection methodology to estimate the proxies for Bmsy (SSBmsy = 7,790 mt) and MSY (=1,720 mt). Comparison of the terminal year F and SSB with the biological reference points found the stock to be overfished (SSB_{2007} / SSBmsy = 1,922 / 7,790 = 0.25) and undergoing overfishing (F_{2007} / Fmsy = 0.414 / 0.239 = 1.73). This update assessment adds data and makes minor changes to the previous data, but does not change the model formulations for estimating current F and SSB or the biological reference points. The result of this assessment indicates that the Cape Cod yellowtail flounder stock is still overfished and overfishing is occurring. Evidence of an emerging retrospective pattern in this updated assessment is a source of scientific uncertainty.

2.0 Fishery

Landings

Landings of yellowtail flounder from the Cape Cod-Gulf of Maine stock (Figure D1) during 1994-2010 were derived from the trip-based allocation described in the GARM III Data Meeting (GARM 2007; Palmer 2008; Wigley et al. 2007a; Table D1; Figures D2-3). Landings in 2007 changed from 627 mt in the last assessment to 633 mt in this update due to changes in the database. Landings are mostly by trawl and gillnet gear (Tables D2-3; Figures D4-5). Landings at age and mean weight at age were determined by port sampling of small, medium, large, and unclassified market categories (Tables D4-5; Figures D6-7) and pooled age-length keys by half year (Table D6). Sampling intensity has increased in recent years (Table D7) resulting in lower variability in landings at age estimates (Table D8). Recently, the dominant source of landings have come from statistical area 514 (Figures D8-9) and during the first quarter of the calendar year (Figures D10-12).

Discards

Discarded catch for years 1994-2010 was estimated using the Standardized Bycatch Reporting Methodology (SBRM) recommended in the GARM III Data Meeting (GARM 2007; Wigley et al. 2007b). Observed ratios of discarded yellowtail flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, scallop dredge, and gillnet (Table D9) were applied to the total yellowtail landings by gears groupings and by half-year, with uncertainty estimated by the SBRM (Tables D10-11). Discards were approximately 17% of the catch in years 1994-2010 (Table D1; Figure D2). Discards at age and associated mean weights at age were estimated from

sea sampled lengths and pooled age-length keys derived from commercial landings, observer, and survey data.

Total Catch at Age

The landings at age (Table D12; Figure D13) and discards at age (Table D13; Figure D14) were summed to construct the total catch at age (Table D14). Landed (Table D15) and discarded (Table D16) mean weight-at-age were combined by using a numbers weighted average of the individual catch components to derive total catch weight at age (Table D17). Ageing precision has been good (82% - 96% agreement and 0.5 – 3.8 %CV) in recent years (see http://www.nefsc.noaa.gov/fbp/QA-QC/yt-results.html).

3.0 Research Surveys

A total of six research surveys were available for use as tuning indices: spring and fall for the Northeast Fisheries Science Center (NEFSC), Massachusetts Division of Marine Fisheries (MADMF), and Maine-New Hampshire (ME-NH). Conversion factors for the NEFSC surveys are detailed in Tables D18-19. The minimum swept area abundance at age and biomass (with CV) are presented in Tables D20-21 for NEFSC surveys and Tables D22-23 for MADMF surveys. The stratified mean catch per tow at age and biomass (with CV) are presented in Tables D24-25 for ME-NH surveys. Length frequency distributions for the ME-NH surveys were converted to age distributions using appropriate MADMF age-length keys. The MADMF fall indices prior to 1994 used age-length keys from the NEFSC fall surveys. The survey data do not show any strong trends over time (Figures D16-21).

4.0 Assessment

Model Formulation

The VPA was formulated to use catch at ages 1 through 6+ for years 1985 through 2010. The numbers at ages 2-5 were estimated at the start of 2011. The VPA was tuned using the following age-specific time series from the surveys:

	Spring	Fall
NEFSC	1-6+	1-5
MADMF	1-6+	1-5
ME-NH	2-5	2-4

Bridge Building

Catch and survey data have been updated for years in the previous assessment. The NEFSC survey can no longer conduct tows in the inshore strata numbered 58 or 63, so the entire time series was recalculated without these strata. The MADMF and ME-NH surveys did not have full time series (through spring 2008 and fall 2007) at the time of GARM III. Changes in the MADMF age-length keys, and thus in the ME-NH surveys as well, occurred throughout the time series. All of these changes were relatively minor. Replacing the values used in GARM III with the new ones did not result in an appreciable change in the F or SSB estimates (Figures D22-23).

Diagnostics

The VPA was fit with slightly better precision than the GARM III VPA (Table D26). However, the Mohn's rho retrospective statistic (Mohn 1999) deteriorated in this updated assessment (Table D27; Figures D24-25). The GARM III assessment concluded there was not a strong retrospective pattern in that assessment. A retrospective pattern has emerged in this assessment with the three additional years of data. The survey residuals also show a patterning with blocks of large residuals of the same direction in recent years (Figure D26). The estimated catchability coefficients have reasonable magnitudes (<1.0) with the NEFSC surveys exhibiting flat-topped patterns while the two state surveys (MADMF and ME-NH) show domed patterns at ages 5 and 6+ (Table D26; Figure D27).

Assessment Results

The GARM III assessment estimated the 2005 year class to be well above average (10.2 million age-1 fish in 2006). This cohort is now estimated to be 3.9 million age-1 fish, well below the average age-1 abundance of 7.4 million fish (Table D28). The GARM III assessment estimated the 2007 F (ages 4-5) to be 0.41, but the 2007 F (ages 4-5) is now estimated to be 1.02 (Table D29). The GARM III assessment estimated the 2007 SSB to be 1,922 mt, but the 2007 SSB is now estimated to be 824 mt (Table D30). So although this assessment is estimating an increase in population abundance and SSB along with a decrease in F in recent years, if the retrospective pattern continues, these values will cause the stock status to worsen. For example, assuming that the retrospective patterns continue, rho adjusted values can be computed as X/(1+rho) where X denotes the original estimate of F or SSB. Thus, F_{2010} = 0.29 becomes 0.36 (=0.29/(1-0.19) and SSB_{2010} = 2,822 mt becomes 1,680 mt (=2822/(1+0.68). The 2010 estimates of F and SSB were relatively precise (Table D31), with the rho adjusted F remaining within the confidence interval while the rho adjusted SSB is outside the confidence interval. The Review Panel recommended use of the rho adjusted F and SSB values for status determination.

Sensitivity Run

Splitting the survey series between 1994 and 1995 did not appreciably reduce the retrospective pattern (Mohn rho's: F = -8%, SSB = 62%, R = 75%). This was not deemed sufficient to justify estimation of the additional catchability parameters and so was not considered further.

5.0 Biological Reference Points

The GARM III assessment used F40%SPR as a proxy for Fmsy because the estimated stock and recruitment values did not follow a parametric relationship. This approach was continued in this update assessment (Figure D28). The biological and fishery parameters used in estimating F40%SPR are provided in Table D32. The YPR program was used to estimate F40%SPR = 0.26.

The GARM III assessment used hindcast recruitment estimates when computing the biomass related reference points. The hindcast recruitment was estimated based on a simple linear regression between the NEFSC fall survey abundance at age 1 and the VPA estimate at age 1 (Table D33; Figure D29). The most recent two years (2009 and 2010) were not included in the series of values used in AgePro due to high uncertainty in these estimates. A total of 32 recruitment values were used in AgePro: 8 from the hindcast predictions and 24 from the VPA (years 1985-2008). The spawning stock biomass at msy proxy (SSBmsy) was estimated as 7,080 mt and the MSY proxy was estimated as 1,600 mt through the use of a 100 year projection fishing at F40%SPR. The new reference points are compared to those from GARM III in Table D34).

6.0 Projections

Initial Conditions

The recent five year average of partial recruitment, maturity, and weight at age used in the yield per recruit analysis were also used in projections (Table D32). The population abundance at the start of 2011 was derived from the bootstrap results, with the recruitment estimate for 2011 generated as the geometric mean of the estimated recruitments during 1985-2008 from each bootstrap solution. Alternative projections to account for the retrospective pattern used either the Mohn's rho adjustment for SSB applied to all ages or else the Mohn's rho for each age (Table D27). The adjustments were computed by multiplying by 1/(1+rho). Catch in 2011 was assumed equal to the catch in 2010 (633 mt).

$F_{rebuild}$

The Cape Cod-Gulf of Maine yellowtail flounder stock is currently in a rebuilding plan with end date of 2023. The $F_{rebuild}$ was found by iteratively solving for the F which applied in years 2011-2023 resulted in median 2023 SSB equal to SSBmsy. Using the unadjusted initial population abundances, $F_{rebuild}$ was determined to be 0.258. Due to the long rebuilding time frame, using the SSB or age-specific rho adjustments led to only minor change in the estimated $F_{rebuild}$, 0.256 and 0.257, respectively. Note that all three estimates of $F_{rebuild}$ are greater than 75%Fmsy (0.195), the default measure used for catch advice.

Short term projections

Median catch in 2012-2014 was estimated under three scenarios for F in those years: 1) Fstatus quo, meaning F is set equal to F2010 (0.29), 2) Fmsy (0.26), and 3) 75%Fmsy (0.195); and for the three initial population abundance conditions: 1) unadjusted, 2) SSB rho adjusted, and 3) age-specific rho adjusted (Table D35). The projections are presented to demonstrate characteristics of the short term projections and will be modified by the Groundfish Plan Development Team prior to setting the Acceptable Biological Catch for this stock. The Review Panel recommended use of the NAA rho adjusted initial population abundance conditions for determining catch advice.

7.0 Conclusions

Status of Cape Cod-Gulf of Maine Yellowtail Flounder Stock

SSB in 2010 is estimated to be 1,680 mt (with retrospective adjustment).
F in 2010 is estimated to be 0.36 (with retrospective adjustment).
Revised estimates of the biological reference points are:
SSBmsy proxy= 7,080 mt,
Fmsy proxy = 0.26, and
MSY proxy= 1,600 mt.

Based on these results, the stock of Cape Cod-Gulf of Maine yellowtail flounder is overfished and overfishing is occurring. The stock is below the biomass target. This is the same status as reported in GARM-III. This status is the same without the retrospective adjustment to SSB and F as well.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15), which now includes using the posthoc retrospective rho adjustment.

The updated estimates of biological reference points are based on the following revisions: recent five year average partial recruitment and weights at age, estimates of recruitment from the VPA for years 1985-2008 as well as hindcast recruitment from a regression of the VPA age-1 abundance and the NEFSC fall survey age-1 minimum swept area abundances applied to the NEFSC fall survey age-1 values in years 1977-1984. Projections are based on adjusting the 2011 Jan-1 population numbers at age from the bootstrapped VPA according to the age-specific retrospective patterns.

CC-GOM-Yellowtail Flounder. Summary of Assessment Information

CC-GOM-Yellowtail Flounder	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Landings (mt)	2381	2057	1834	913	715	534	492	543	464	546	1616	400	5567	1935-2010
Discards (mt)	239	100	136	273	282	85	141	156	175	87	348	0	1239	1935-2010
Catch (mt)	2620	2157	1970	1186	997	620	633	699	639	633	1964	500	6167	1935-2010
Recruits (000's)	6417	5203	3685	2977	3000	3895	4321	7304	10494	3556	7405	2977	23080	1985-2010
F (4-5)	1.79	1.56	1.47	1.73	1.68	1.47	1.02	1.06	0.61	0.29	1.46	0.29	2.6	1985-2010
SSB (mt)	1712	1795	1351	876	689	677	824	1067	1523	2822	1288	670	2822	1985-2010

8.0 Reviewer Comments

The work that is presented is accepted by the Review Panel for determining stock status and providing catch advice.

The panel recognized that most changes to the input data since the 2008 GARM were minor. Updated landings and discards were relatively well-sampled, and determination of catch at age remained relatively precise. One change to the input data was the addition of NEFSC survey data from the R/V Bigelow using the conversion coefficients accepted and used by the TRAC for Georges Bank yellowtail flounder update assessments. Although the survey conversions add a source of uncertainty, the assessment also benefits from several state surveys of relative abundance.

The updated assessment model produced a retrospective pattern that was not apparent in the GARM assessment. The retrospective pattern was associated with a pattern of mostly positive residuals in recent years, and nearly all negative residuals in the last year. The retrospective pattern resulted in a change in perception of the 2005 yearclass, which was estimated to be strong in the 2008 GARM assessment and is now estimated to be below average. Fully recruited ages in 2007 were also substantially changed, as noted by the estimated F increase from 0.41 in the GARM assessment to 1.02 in this update.

The magnitude of retrospective difference was considerable, and the 7-year average difference was outside the confidence intervals of SSB estimates in the last year, but within the confidence intervals of fishing mortality. The Review Panel used the approach used by the GARM III, which was to apply retrospective adjustments for status determination and projections in such situations. A concern was raised that the retrospective adjustment assumes that the recent retrospective difference will be realized for the terminal year estimates. However, there was a reversal in the of direction retrospective change in 2005/2006. An extended retrospective analysis shows that only two of the 15 years had the opposite direction of retrospective inconsistency (Appendix D1). Recent analysis suggests that applying a retrospective adjustment to the starting conditions for projections will perform better with respect to future SSB than not applying a retrospective adjustment (Augmented PDT 2011).

Several exploratory analyses were presented to investigate potential sources of retrospective inconsistency and their implications for catch advice. A split-survey series modification to the assessment, as applied to other stocks by the 2008 GARM, was attempted but did not remove or substantially reduce the retrospective pattern. All combinations of survey data examined (NEFSC only, MADMF only, ME-NH only, spring only, and fall only) had strong retrospective patterns, suggesting that the recent change in NEFSC survey systems did not produce the retrospective pattern (Appendix D2).

Another exploratory analysis configured the VPA similar to the 'B-ADAPT' model (ICES 2008b) to estimate catch multipliers for 2007-2010. The B-ADAPT-like model had no retrospective pattern, estimated catch multipliers of approximately 2 to 3 (i.e., estimated a doubling or tripling of observed catch), and applying the average catch multiplier to projections produced lower catch advice than the retrospective adjustment (Appendix D3). There is no

evidence for such large underestimation of catch as implied by the B-ADAPT-like results. Most of the recent catch is from statistical area 514 (western Gulf of Maine), which is less influenced by movement of yellowtail from other stock areas, so stock mixing could not explain so much underestimation of catch.

Another exploratory analysis, which assumed natural mortality increased fourfold in years 2007-2010 (from M=0.2 to M=0.8 for all ages), did not have a retrospective pattern, and projections also produced lower catch advice than the retrospective adjustment (Appendix D3). Similar to the lack of evidence for under-reported catch, there is no direct evidence for the recent high natural mortality rate needed to remove the retrospective pattern.

Simulations for Georges Bank yellowtail that assumed changes in survey catchability, catch or natural mortality, suggested that retrospective adjustment performed better than unadjusted catch projections (ICES 2008a). Examination of different approaches to address a retrospective pattern has previously found the same directional change in the catch advice relative to the unadjusted advice as seen in the exploratory analyses (ICES 2008a). After reviewing the exploratory analyses and their implications for projected catch, the Review Panel confirmed that the GARM III approach to applying retrospective adjustments should be used for status determination and catch projections until the underlying source of the retrospective pattern can be understood and corrected. The retrospective adjustment implies an expectation that the retrospective pattern applies to the 2011 abundance at age estimated from the VPA.

9.0 References

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Table D1. Landings, discards, catch (metric tons) and proportion of total catch which is discarded for Cape Cod-Gulf of Maine yellowtail flounder.

Year	Landings	Discards	Catch	% Discard
1935	400	100	500	20%
1936	400	100	500	20%
1937	500	200	700	29%
1938	500	200	700	29%
1939	600	200	800	25%
1940	900	300	1200	25%
1941	1300	400	1700	24%
1942	1512	500	2012	25%
1943	1334	400	1734	23%
1944	1531	500	2031	25%
1945	1214	400	1614	25%
1946	1214	400	1614	25%
1947	1122	300	1422	21%
1948	710	200	910	22%
1949	1221	400	1621	25%
1950	1387	400	1787	22%
1951	862	200	1062	19%
1952	837	200	1037	19%
1953	840	200	1040	19%
1954	1114	300	1414	21%
1955	1320	400	1720	23%
1956	1426	400	1826	22%
1957	2426	700	3126	22%
1958	1639	500	2139	23%
1959	1564	500	2064	24%
1960	1539	500	2039	25%
1961	1822	600	2422	25%
1962	1900	600	2500	24%
1963	3600	1000	4600	22%
1964	1857	600	2457	24%
1965	1506	500	2006	25%
1966	1835	300	2135	14%
1967	1591	800	2391	33%
1968	1581	600	2181	28%

Table D1. Continued

Year	Landings	Discards	Catch	% Discard
1969	1422	300	1722	17%
1970	1310	400	1710	23%
1971	1718	700	2418	29%
1972	1521	300	1821	16%
1973	1724	0	1724	0%
1974	2158	200	2358	8%
1975	2220	0	2220	0%
1976	3845	100	3945	3%
1977	3722	0	3722	0%
1978	4071	400	4471	9%
1979	4439	500	4939	10%
1980	5567	600	6167	10%
1981	3574	600	4174	14%
1982	3635	400	4035	10%
1983	2209	300	2509	12%
1984	1365	20	1385	1%
1985	1171	154	1326	12%
1986	1205	367	1572	23%
1987	1353	271	1624	17%
1988	1275	355	1630	22%
1989	1117	437	1555	28%
1990	3222	1239	4461	28%
1991	1737	515	2251	23%
1992	1031	715	1746	41%
1993	786	145	932	16%
1994	1143	208	1352	15%
1995	1368	147	1515	10%
1996	1176	336	1512	22%
1997	1134	552	1686	33%
1998	1310	311	1621	19%
1999	1303	149	1452	10%
2000	2439	148	2587	6%
2001	2381	239	2620	9%
2002	2057	100	2157	5%

Table D1. Continued

Year	Landings	Discards	Catch	% Discard
2003	1834	136	1970	7%
2004	913	273	1186	23%
2005	715	282	997	28%
2006	534	85	620	14%
2007	492	141	633	22%
2008	543	156	699	22%
2009	464	175	639	27%
2010	546	87	633	14%

Table D2. Cape Cod-Gulf of Maine yellowtail flounder landings (metric tons) by gear and year.

Year	Gillnet	Other/ Unkown	Scallop Dredge	Trawl	Total
1994	156	18	21	948	1143
1995	274	25	11	1059	1369
1996	259	17	13	886	1175
1997	294	10	9	822	1135
1998	399	15	10	886	1310
1999	281	9	3	1010	1303
2000	373	6	3	2057	2439
2001	294	16	2	2070	2382
2002	120	8	1	1928	2057
2003	214	3	1	1616	1834
2004	174	44	1	694	913
2005	142	42	2	529	715
2006	116	21	7	390	534
2007	86	28	1	377	492
2008	109	33	1	399	543
2009	103	33	0	327	464
2010	135	14	0	397	546

Table D3. Cape Cod-Gulf of Maine yellowtail flounder percent landings by gear and year.

Year	Gillnet	Other/ Unkown	Scallop Dredge	Trawl	Total
1994	14%	2%	2%	83%	100%
1995	20%	2%	1%	77%	100%
1996	22%	1%	1%	75%	100%
1997	26%	1%	1%	72%	100%
1998	30%	1%	1%	68%	100%
1999	22%	1%	0%	78%	100%
2000	15%	0%	0%	84%	100%
2001	12%	1%	0%	87%	100%
2002	6%	0%	0%	94%	100%
2003	12%	0%	0%	88%	100%
2004	19%	5%	0%	76%	100%
2005	20%	6%	0%	74%	100%
2006	22%	4%	1%	73%	100%
2007	18%	6%	0%	77%	100%
2008	20%	6%	0%	74%	100%
2009	22%	7%	0%	71%	100%
2010	25%	3%	0%	73%	100%

Table D4. Cape Cod-Gulf of Maine yellowtail flounder landings (metric tons) by market category and half year from 1994-2010.

	Unclassified		Large		Small		Medium		
Year	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Total
1994	77	24	191	351	201	285	8	6	1143
1995	88	18	325	321	346	254	6	9	1368
1996	55	18	270	233	373	205	17	5	1176
1997	46	20	221	338	312	177	11	10	1134
1998	194	50	246	230	333	232	22	3	1310
1999	176	90	160	340	222	284	24	7	1303
2000	343	109	442	471	522	485	50	17	2439
2001	315	159	380	611	382	491	27	18	2381
2002	181	173	322	596	187	542	21	35	2057
2003	349	234	264	390	283	280	15	19	1834
2004	168	73	160	151	143	176	30	12	913
2005	102	88	169	146	116	92	0	2	715
2006	63	57	150	105	96	62	1	0	534
2007	54	45	129	122	57	84	1	0	492
2008	84	41	166	93	69	88	2	0	543
2009	60	61	127	51	95	53	4	13	464
2010	149	33	165	62	78	52	7	0	546

Table D5. Cape Cod-Gulf of Maine yellowtail flounder annual percent or total landings by market category and half year from 1994-2010.

	Unclassified		Large		Small		Medium		
Year	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Total
1994	7%	2%	17%	31%	18%	25%	1%	1%	100%
1995	6%	1%	24%	23%	25%	19%	0%	1%	100%
1996	5%	2%	23%	20%	32%	17%	1%	0%	100%
1997	4%	2%	19%	30%	28%	16%	1%	1%	100%
1998	15%	4%	19%	18%	25%	18%	2%	0%	100%
1999	14%	7%	12%	26%	17%	22%	2%	0%	100%
2000	14%	4%	18%	19%	21%	20%	2%	1%	100%
2001	13%	7%	16%	26%	16%	21%	1%	1%	100%
2002	9%	8%	16%	29%	9%	26%	1%	2%	100%
2003	19%	13%	14%	21%	15%	15%	1%	1%	100%
2004	18%	8%	17%	17%	16%	19%	3%	1%	100%
2005	14%	12%	24%	20%	16%	13%	0%	0%	100%
2006	12%	11%	28%	20%	18%	12%	0%	0%	100%
2007	11%	9%	26%	25%	11%	17%	0%	0%	100%
2008	15%	7%	31%	17%	13%	16%	0%	0%	100%
2009	13%	13%	27%	11%	21%	11%	1%	3%	100%
2010	27%	6%	30%	11%	14%	9%	1%	0%	100%

Table D6. Total number of Cape Cod-Gulf of Maine yellowtail flounder ages sampled from the commercial landings from 1994-2010 by market and half year.

	Unclassified		Large		Small		Medium		
Year	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Total
1994			45	50	50	30			175
1995			107	71	60	89			327
1996		19	30	197		121			367
1997			127	269	70	237			703
1998			32		109	118			259
1999			21	57					78
2000	83		119	186	648	327	60		1423
2001	22	121	64	167	50	206			630
2002	95	42	133	262	204	366		29	1131
2003	142	119	101	348	249	330	29	161	1479
2004	68	28	127	60	226	87	169	29	794
2005	276	160	42	93	142	145			858
2006	30		36	269	144	550			1029
2007	140	56	79	516	173	587			1551
2008	94	51	68	337	211	472			1233
2009	79	19	62	15	166	118			459
2010	50		81	261	250	454			1096

Table D7. Total number of Cape Cod-Gulf of Maine yellowtail flounder lengths sampled from the commercial landings from 1994-2010 by market and half year. Sampling intensity is expressed as lengths per 100 metric tons.

	Unclassified		Large		Small		Medium			
Year	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Half 1	Half 2	Landings (mt)	Lengths/100mt
1994			170	144	261	106			1143	60
1995			491	264	276	407			1368	105
1996		118	87	640		495			1176	114
1997			633	869	388	996			1134	254
1998			67		281	619			1310	74
1999			150	268		116			1303	41
2000	464	102	642	916	2831	1155	231		2439	260
2001	105	534	218	727	344	774			2381	113
2002	304	225	496	1098	764	1646		101	2057	225
2003	565	421	416	1572	1188	1424	133	574	1834	343
2004	263	162	574	267	778	349	679	120	913	350
2005	2007	667	186	409	540	618			715	619
2006	214	93	187	1257	581	1883			534	789
2007	564	350	295	2841	732	2433			492	1465
2008	333	243	356	1577	670	1589			543	879
2009	309	95	275	35	558	364			464	353
2010	165		396	1675	829	1881			546	906

Table D8. Cape Cod-Gulf of Maine coefficient of variation (CV) for landings at age from 1994-2010.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1994		46%	11%	17%	33%	22%
1995		53%	18%	15%	31%	51%
1996		32%	7%	18%	51%	76%
1997		15%	10%	14%	30%	47%
1998		54%	6%	21%	33%	
1999		53%	13%	22%	111%	128%
2000		13%	5%	7%	27%	41%
2001		19%	5%	17%	30%	48%
2002	73%	13%	6%	11%	26%	55%
2003		16%	6%	8%	21%	30%
2004		28%	8%	8%	19%	28%
2005		20%	6%	8%	18%	32%
2006		15%	9%	9%	35%	25%
2007		10%	4%	7%	24%	35%
2008		26%	5%	6%	19%	33%
2009	135%	21%	6%	6%	15%	54%
2010	138%	21%	8%	7%	11%	43%

Table D9. Total number of Cape Cod-Gulf of Maine yellowtail flounder trips observed by gear from 1994-2010. *In 2010, the number of observed trips includes trips observed by both at-sea monitors and observers.*

Year	Otter Trawl Large Mesh	Otter Trawl Small Mesh	Scallop Dredge	Gillnet	Total
1994	14		5	55	74
1995	41	31	5	120	197
1996	15	40	13	67	135
1997	15	3	6	48	72
1998	9		8	117	134
1999	30	11	6	104	151
2000	89	4	29	134	256
2001	135	9	7	89	240
2002	197	49	9	111	366
2003	337	33	12	452	834
2004	315	79	20	1124	1538
2005	734	89	30	962	1815
2006	270	28	35	198	531
2007	362	19	42	252	675
2008	441	13	37	243	734
2009	493	23	19	349	884
2010	729	31	38	1952	2750

Table D10. Cape Cod-Gulf of Maine yellowtail flounder discards by gear and estimated coefficient of variation from 1994-2010.

	Otter Trawl Large		Otter Trawl Small		Scallop Dredge		Gillnet		Total
Year	D(mt)	CV	D(mt)	CV	D(mt)	CV	D(mt)	CV	D(mt)
1994	3	58%	13	0%	163	15%	30	141%	209
1995	32	91%	7	47%	32	11%	76	56%	147
1996	121	98%	2	51%	148	40%	64	70%	335
1997	27	35%	9	3%	354	29%	162	47%	552
1998	33	67%	3	0%	228	9%	48	51%	312
1999	91	36%	0	27%	27	19%	31	43%	149
2000	53	48%	2	44%	27	12%	67	58%	149
2001	127	30%	1	43%	98	7%	13	41%	239
2002	70	20%	6	53%	13	10%	11	40%	100
2003	88	28%	1	95%	24	7%	22	58%	135
2004	220	28%	5	47%	17	3%	32	17%	274
2005	225	24%	1	36%	4	43%	51	56%	281
2006	68	29%	3	21%	4	18%	9	89%	84
2007	77	19%	9	21%	40	59%	15	50%	141
2008	141	20%	1	46%	4	59%	10	62%	156
2009	136	19%	6	30%	23	120%	11	19%	176
2010	48	14%	22	35%	9	58%	8	23%	87

Table D11. Cape Cod-Gulf of Maine yellowtail flounder annual percent of total discards by gear.

Year	Otter Trawl Large Mesh	Otter Trawl Small Mesh	Scallop Dredge	Gillnet	Total
1994	1%	6%	78%	14%	100%
1995	22%	5%	22%	52%	100%
1996	36%	1%	44%	19%	100%
1997	5%	2%	64%	29%	100%
1998	11%	1%	73%	15%	100%
1999	61%	0%	18%	21%	100%
2000	36%	1%	18%	45%	100%
2001	53%	0%	41%	5%	100%
2002	70%	6%	13%	11%	100%
2003	65%	1%	18%	16%	100%
2004	80%	2%	6%	12%	100%
2005	80%	0%	1%	18%	100%
2006	81%	4%	5%	11%	100%
2007	55%	6%	28%	11%	100%
2008	90%	1%	3%	6%	100%
2009	77%	3%	13%	6%	100%
2010	55%	25%	10%	9%	100%

Table D12. Cape Cod-Gulf of Maine yellowtail landings at age (thousand of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	Total
1985	6	876	839	635	329	121	2806
1986	0	2232	695	273	40	8	3248
1987	0	684	2101	309	116	53	3263
1988	1	918	1281	744	199	41	3184
1989	0	838	1284	287	38	9	2456
1990	0	717	6663	472	35	28	7915
1991	0	361	1065	1718	291	74	3509
1992	0	410	1030	644	188	14	2286
1993	0	34	868	723	110	54	1789
1994	0	107	1365	668	198	108	2446
1995	0	379	1442	1136	176	170	3303
1996	0	448	1911	426	49	8	2842
1997	0	630	1175	632	119	13	2569
1998	0	51	1896	575	134	0	2656
1999	0	511	2028	379	26	7	2951
2000	0	925	2773	1355	127	30	5210
2001	0	942	3317	822	144	24	5249
2002	20	997	2338	885	107	34	4381
2003	0	614	1930	1151	148	70	3913
2004	0	86	1182	453	227	66	2014
2005	0	100	759	523	80	45	1507
2006	0	106	506	351	76	53	1092
2007	0	115	512	341	54	14	1036
2008	0	32	521	436	110	20	1119
2009	1	48	406	426	89	7	977
2010	0	51	487	398	137	37	1110

Table D13. Cape Cod-Gulf of Maine yellowtail discards at age (thousand of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	Total
1985	681	369	68	0	0	0	1118
1986	95	1993	90	32	0	0	2210
1987	19	1201	230	0	0	0	1450
1988	451	1664	221	0	0	0	2336
1989	118	1459	528	11	0	0	2116
1990	84	2180	2738	21	0	0	5023
1991	465	1011	700	234	7	0	2417
1992	1709	3569	930	87	3	0	6298
1993	159	391	206	72	0	0	828
1994	19	710	332	47	11	1	1120
1995	37	147	335	52	3	0	574
1996	26	339	516	219	55	0	1155
1997	8	850	831	215	61	7	1972
1998	38	443	616	75	18	3	1193
1999	9	231	265	18	6	0	529
2000	2	189	209	52	6	5	463
2001	20	400	404	27	0	0	851
2002	37	207	111	21	1	0	377
2003	10	245	193	49	4	0	501
2004	13	389	412	118	15	9	956
2005	15	394	502	63	2	3	979
2006	7	84	156	39	7	0	293
2007	14	158	221	69	18	0	480
2008	2	72	305	59	9	6	453
2009	8	213	251	71	8	1	552
2010	3	82	157	37	5	1	285

Table D14. Cape Cod-Gulf of Maine yellowtail total catch (landings and discards) at age in thousand of fish.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	Total
1985	687	1245	907	635	329	121	3924
1986	95	4225	785	305	40	8	5458
1987	19	1885	2331	309	116	53	4713
1988	452	2582	1502	744	199	41	5520
1989	118	2297	1812	298	38	9	4572
1990	84	2897	9401	493	35	28	12938
1991	465	1372	1765	1952	298	74	5926
1992	1709	3979	1960	731	191	14	8584
1993	159	425	1074	795	110	54	2617
1994	19	817	1697	715	209	109	3566
1995	37	526	1777	1188	179	170	3877
1996	26	787	2427	645	104	8	3997
1997	8	1480	2006	847	180	20	4541
1998	38	494	2512	650	152	3	3849
1999	9	742	2293	397	32	7	3480
2000	2	1114	2982	1407	133	35	5673
2001	20	1342	3721	849	144	24	6100
2002	57	1204	2449	906	108	34	4758
2003	10	859	2123	1200	152	70	4414
2004	13	475	1594	571	242	75	2970
2005	15	494	1261	586	82	48	2486
2006	7	190	662	390	83	53	1385
2007	14	273	733	410	72	14	1516
2008	2	104	826	495	119	26	1572
2009	9	261	657	497	97	8	1529
2010	3	133	644	435	142	38	1395

Table D15. Mean weights at age (kg) of landed Cape Cod-Gulf of Maine yellowtail.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	0.188	0.315	0.373	0.489	0.600	0.786
1986		0.323	0.459	0.575	0.730	0.996
1987		0.309	0.415	0.548	0.652	0.916
1988	0.113	0.303	0.361	0.523	0.696	0.841
1989		0.381	0.440	0.661	0.928	1.317
1990		0.310	0.410	0.560	0.824	0.970
1991		0.345	0.385	0.541	0.742	1.021
1992		0.323	0.406	0.522	0.606	1.169
1993		0.309	0.379	0.428	0.737	0.999
1994		0.315	0.383	0.527	0.688	0.909
1995		0.333	0.354	0.427	0.645	0.790
1996		0.311	0.408	0.502	0.681	1.283
1997		0.388	0.414	0.499	0.637	0.943
1998		0.303	0.427	0.632	0.907	**0.985**
1999		0.387	0.420	0.613	0.577	0.810
2000		0.368	0.441	0.568	0.626	0.853
2001		0.376	0.427	0.581	0.766	0.898
2002	0.378	0.384	0.447	0.569	0.777	1.046
2003		0.359	0.426	0.542	0.677	0.946
2004		0.345	0.398	0.485	0.607	0.832
2005		0.353	0.414	0.514	0.690	0.918
2006		0.368	0.423	0.491	0.782	0.926
2007		0.354	0.434	0.514	0.610	0.875
2008		0.365	0.433	0.509	0.611	0.842
2009	0.271	0.387	0.437	0.494	0.576	0.887
2010	0.113	0.408	0.432	0.515	0.597	0.757

Table D16. Mean weights at age (kg) of discarded Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	0.132	0.147	0.150			
1986	0.103	0.168	0.190	0.180		
1987	0.056	0.187	0.195			
1988	0.123	0.153	0.203			
1989	0.129	0.207	0.244	0.383		
1990	0.079	0.236	0.274	0.338		
1991	0.124	0.197	0.277	0.343	0.542	
1992	0.053	0.113	0.234	0.316	0.364	
1993	0.089	0.148	0.269	0.315	0.632	
1994	0.089	0.153	0.236	0.306	0.422	0.333
1995	0.055	0.240	0.278	0.302	0.528	
1996	0.109	0.207	0.289	0.383	0.545	0.899
1997	0.145	0.196	0.306	0.415	0.571	0.732
1998	0.079	0.198	0.288	0.429	0.485	0.707
1999	0.148	0.248	0.296	0.416	0.708	0.544
2000	0.101	0.255	0.318	0.512	0.558	0.713
2001	0.226	0.270	0.291	0.312	0.435	
2002	0.130	0.256	0.299	0.376	0.575	0.693
2003	0.087	0.228	0.305	0.375	0.485	0.793
2004	0.077	0.230	0.298	0.363	0.640	0.825
2005	0.062	0.238	0.300	0.512	0.850	0.966
2006	0.106	0.224	0.292	0.366	0.776	0.951
2007	0.036	0.229	0.311	0.382	0.690	
2008	0.046	0.234	0.323	0.449	0.657	0.810
2009	0.120	0.245	0.323	0.471	0.681	0.935
2010	0.144	0.271	0.316	0.426	0.700	0.932

Table D17. Mean weights at age (kg) of caught (landed + discarded) Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	0.132	0.266	0.357	0.489	0.600	0.786
1986	0.103	0.250	0.428	0.534	0.730	0.996
1987	0.056	0.232	0.393	0.548	0.652	0.916
1988	0.123	0.206	0.338	0.523	0.696	0.841
1989	0.129	0.270	0.383	0.650	0.928	1.317
1990	0.079	0.254	0.370	0.550	0.824	0.970
1991	0.124	0.236	0.342	0.517	0.737	1.021
1992	0.053	0.135	0.325	0.498	0.602	1.169
1993	0.089	0.160	0.358	0.418	0.737	0.999
1994	0.089	0.174	0.354	0.512	0.674	0.904
1995	0.055	0.307	0.340	0.422	0.643	0.790
1996	0.109	0.266	0.383	0.462	0.609	1.266
1997	0.145	0.278	0.369	0.478	0.615	0.865
1998	0.079	0.209	0.393	0.609	0.856	0.707
1999	0.148	0.344	0.406	0.604	0.601	0.801
2000	0.101	0.349	0.432	0.566	0.623	0.835
2001	0.226	0.344	0.412	0.573	0.765	0.898
2002	0.218	0.362	0.440	0.565	0.774	1.042
2003	0.087	0.322	0.415	0.535	0.672	0.945
2004	0.077	0.251	0.372	0.460	0.609	0.831
2005	0.062	0.261	0.369	0.514	0.694	0.921
2006	0.106	0.305	0.392	0.478	0.781	0.926
2007	0.036	0.282	0.397	0.492	0.630	0.875
2008	0.120	0.282	0.392	0.504	0.616	0.863
2009	0.153	0.292	0.391	0.484	0.586	0.895
2010	0.131	0.323	0.401	0.504	0.595	0.756

Table D18. Conversion factors applied to NEFSC surveys for years 1985-2008. The standard tow used the polyvalent doors, the Yankee 36 gear, and the Albatross IV vessel. Tows which did not use this combination were converted to the standard by multiplying by the door factor when BMV oval doors were used, dividing by the gear factor when the Yankee 41 gear was used, and multiplying by the vessel factor when the Delaware II vessel was used. These conversion factors were derived from Byrne and Forrester (1991) and Rago et al. (1994).

Factor	Weight	Number
Door	1.28	1.22
Gear	1.73	1.76
Vessel	0.85	0.85

Table D19. Conversion factors applied to NEFSC surveys for years 2009 onward. In 2009, the Albatross IV was decommissioned and replaced by the Henry B. Bigelow. A new net, fishing system, and standard operating procedures were implemented with the change. During 2008, one of the largest marine survey vessel comparative experiments was conducted of 636 side-by-side comparison tows. These data were used to estimate the following length specific calibrations (Bigelow/Albatross) for yellowtail flounder as part of the TRAC (Transboundary Resources Assessment Committee) stock assessment of Georges Bank flounder (Brooks et al. 2011). Miller et al. (2010) also estimated seasonal conversion factors for biomass (Bigelow/Albatross) as 2.244 (CV=15.6%) and 2.402 (CV=9.2%) for the spring and fall, respectively.

Length	Calibration	CV (%)
≥18	3.857302	21.0
19	3.857302	21.0
20	3.857302	21.0
21	3.621597	19.6
22	3.385892	17.9
23	3.150187	16.0
24	2.914482	13.8
25	2.678777	11.3
26	2.443072	8.4
27	2.207367	5.2
28	1.971662	3.7
29	1.971657	3.7
≥30	1.971657	3.7

Table D20. Minimum swept area numbers (000s) at age, biomass (mt), and coefficient of variation for the **NEFSC spring survey**. These values were computed from offshore strata 25, 26, 27, 39, 40 and inshore strata 56, 59, 60, 61, 64, 65, 66, which combined have an area of 4157 square nautical miles. To convert these values to catch/tow in numbers or biomass divide by 371.1607 (=1000*4157/0.0112, where 1000 is the units used in the VPA, 4157 is the survey area, and 0.0112 is the area swept by a single tow). Calibration factors for years 1985-2008 are presented in Table D18 and for years 2009-2011 in Table D19. The CV for years 2009-2011 incorporates the uncertainty of the Bigelow calibration factor (the CV without the calibration factor is 46.0, 39.0, and 33.2 for years 2009-2011, respectively).

Year	age-1	age-2	age-3	age-4	age-5	age-6+	Biomass (mt)	CV (%)
1985	17.779	297.522	328.069	79.280	49.030	12.508	232.3	15.7
1986	6.161	680.523	75.123	51.888	37.747	0.000	178.4	34.4
1987	19.672	504.370	743.806	200.835	170.214	468.516	938.0	60.9
1988	324.098	1411.487	342.247	190.220	99.620	57.122	399.7	8.3
1989	55.934	687.390	455.043	117.435	122.372	0.000	272.2	39.8
1990	0.000	715.004	1990.498	80.282	0.000	32.068	628.2	36.9
1991	136.921	1169.045	948.501	300.974	68.590	15.477	572.9	26.9
1992	18.855	357.725	688.949	186.211	7.015	0.000	288.1	40.8
1993	24.571	253.243	403.749	210.374	0.000	0.000	190.7	37.8
1994	113.835	863.023	517.695	310.402	192.892	71.671	393.9	29.5
1995	69.110	393.987	1507.766	1124.543	172.590	18.113	771.7	23.0
1996	5.716	213.380	543.157	775.689	129.312	0.000	426.5	28.9
1997	8.166	334.230	727.661	571.291	65.361	0.000	459.6	25.8
1998	0.000	274.733	1115.449	341.728	54.412	0.000	437.8	36.3
1999	6.792	301.234	1081.785	524.599	106.078	80.727	601.1	33.2
2000	26.909	3720.292	6645.930	789.756	82.769	32.180	3663.3	37.4
2001	0.000	442.498	1854.059	390.350	81.841	0.000	865.5	28.6
2002	5.753	603.804	2731.632	1262.837	72.413	19.968	1422.9	27.0
2003	36.114	338.387	927.308	663.079	304.092	9.799	733.5	51.7
2004	141.783	230.454	971.290	151.285	52.445	0.000	404.8	12.8
2005	26.427	224.701	1474.584	495.648	0.000	0.000	546.0	30.6
2006	52.000	429.433	1319.662	465.955	36.634	12.916	489.8	29.1
2007	11.617	871.931	2401.892	1587.157	82.472	0.000	1325.9	40.5
2008	66.475	679.855	3048.529	601.911	59.311	17.779	1141.4	29.1
2009	144.270	1091.472	2951.470	1840.178	143.157	0.000	1442.2	48.1
2010	35.631	1073.248	3895.295	1813.937	279.336	23.272	1778.5	41.5
2011	68.479	78.575	2207.293	1712.387	255.952	31.140	1026.6	36.4

Table D21. Minimum swept area numbers (000s) at age, biomass (mt), and coefficient of variation for the **NEFSC fall survey**. These values were computed from offshore strata 25, 26, 39, 40 and inshore strata 56, 59, 60, 61, 64, 65, 66, which combined have an area of 3437 square nautical miles. To convert these values to catch/tow in numbers or biomass divide by 321.6964 (=1000*3437/0.0112, where 1000 is the units used in the VPA, 3437 is the survey area, and 0.0112 is the area swept by a single tow). Calibration factors for years 1985-2008 are presented in Table D18 and for years 2009-2010 in Table D19. The CV for years 2009-2010 incorporates the uncertainty of the Bigelow calibration factor (the CV without the calibration factor is 40.0 and 59.1 for years 2009-2010, respectively).

Year	age-1	age-2	age-3	age-4	age-5	age-6+	Biomass (mt)	CV (%)
1985	1413.927	568.854	428.029	36.825	0.000	0.000	483.4	27.7
1986	380.126	1057.062	92.983	0.000	0.000	0.000	278.4	54.3
1987	151.013	414.251	168.444	14.607	5.493	0.000	166.7	17.6
1988	944.009	1429.240	139.505	42.287	0.000	0.000	351.3	18.0
1989	452.180	1343.683	581.191	79.910	55.237	0.000	574.3	45.5
1990	912.922	1617.600	749.604	11.876	2.547	0.000	611.6	31.1
1991	492.105	439.445	438.524	88.810	0.000	0.000	321.7	8.4
1992	802.938	913.321	576.557	308.348	45.172	49.192	613.8	39.7
1993	1151.180	1204.362	160.741	26.483	0.000	0.000	294.0	67.4
1994	795.942	2398.443	794.407	265.293	114.096	0.000	865.7	24.9
1995	158.255	220.981	329.768	86.907	52.537	0.000	240.2	19.1
1996	340.478	935.079	1585.194	379.359	42.901	0.000	841.0	27.4
1997	330.412	782.961	930.476	394.641	183.726	36.273	717.2	49.3
1998	328.632	951.865	384.023	312.123	75.215	0.000	521.7	34.4
1999	1321.189	2600.643	1777.758	543.967	228.131	8.715	1922.5	30.1
2000	281.742	2137.507	1412.699	71.993	0.000	0.000	1093.2	39.0
2001	42.410	1201.876	714.558	29.767	0.000	0.000	595.4	31.1
2002	128.765	445.337	180.995	43.423	6.076	0.000	222.8	35.2
2003	183.174	2692.767	566.583	133.184	77.486	0.000	1056.9	34.6
2004	74.632	363.739	197.934	7.703	0.000	0.000	154.7	40.0
2005	497.782	424.562	185.230	17.124	0.000	0.000	197.1	19.8
2006	747.701	476.700	267.902	21.512	0.000	0.000	252.9	17.8
2007	119.865	2033.078	1562.116	461.110	40.139	0.000	1089.6	21.9
2008	445.490	1803.013	2712.284	858.237	18.106	0.000	1505.6	44.3
2009	647.690	4283.760	2716.918	194.896	21.635	0.000	1827.8	40.9
2010	969.878	4539.602	2576.185	302.579	14.546	0.000	1652.7	59.5

Table D22. Minimum swept area numbers (000s) at age, biomass (mt), and coefficient of variation for the **MADMF spring survey**. These values were computed from strata 17-36, which combined have an area of 1055 square nautical miles. To convert these values to catch/tow in numbers or biomass divide by 274.2961 (=1000*1055/0.003846, where 1000 is the units used in the VPA, 1055 is the survey area, and 0.003846 is the area swept by a single tow).

Year	age-1	age-2	age-3	age-4	age-5	age-6+	Biomass (mt)	CV (%)
1985	497.025	2103.632	1910.253	411.883	120.197	92.191	1330.9	23.6
1986	501.852	4329.545	464.109	68.492	22.575	18.625	1208.0	21.5
1987	680.968	1275.203	1350.771	268.316	69.342	40.678	937.3	14.7
1988	826.262	3476.237	664.400	183.778	11.191	0.000	960.3	21.3
1989	203.391	4955.845	907.756	252.106	12.042	0.000	1190.9	18.5
1990	260.033	2761.284	4097.024	179.061	35.576	11.383	1734.3	17.8
1991	15.717	1207.945	819.679	511.946	112.215	36.865	781.6	17.7
1992	323.724	2204.189	2112.492	558.001	361.111	20.737	1467.0	19.7
1993	188.249	1625.232	1489.071	495.461	62.156	79.902	1088.6	22.5
1994	610.583	5578.251	1899.172	390.159	88.351	29.130	1530.1	15.6
1995	1659.053	2801.770	5042.386	624.298	265.436	5.733	2123.2	13.1
1996	291.083	3229.864	2758.706	1418.989	393.615	14.647	1805.8	12.4
1997	133.088	2997.837	2082.401	724.224	87.226	0.000	1298.3	26.7
1998	157.748	841.102	2369.425	228.626	38.676	4.416	916.7	22.6
1999	65.063	1290.618	2134.189	239.762	17.829	0.000	1006.2	22.5
2000	159.393	3767.019	5794.890	1946.433	240.119	82.700	3556.0	15.6
2001	32.175	1681.243	6305.245	1739.257	280.303	0.000	3220.4	13.4
2002	115.780	296.350	3236.091	1244.838	58.507	40.706	1728.3	18.0
2003	12.672	1873.415	1796.064	1977.895	301.671	11.904	1712.2	19.5
2004	42.351	608.169	1987.879	978.524	124.146	5.074	1093.3	24.8
2005	92.136	1537.732	3878.136	1018.297	19.009	6.364	1748.1	28.7
2006	167.266	1648.876	5099.961	1370.384	60.482	25.153	2249.5	26.7
2007	128.261	3236.036	4743.184	1731.220	182.709	0.000	2527.2	23.9
2008	12.974	2064.764	7819.031	2715.038	284.994	0.000	3551.3	22.5
2009	85.526	2261.078	5276.169	2753.001	205.695	16.101	2805.0	22.4
2010	62.567	1499.906	6217.114	2342.215	444.853	30.392	2838.4	15.5
2011	74.828	622.076	5650.775	4028.889	381.162	5.458	2928.0	29.7

Table D23. Minimum swept area numbers (000s) at age, biomass (mt), and coefficient of variation for the **MADMF fall survey**. These values were computed from strata 17-36, which combined have an area of 1055 square nautical miles. To convert these values to catch/tow in numbers or biomass divide by 274.2961 (=1000*1055/0.003846, where 1000 is the units used in the VPA, 1055 is the survey area, and 0.003846 is the area swept by a single tow).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	Biomass (mt)	CV (%)
1985	1564.311	447.514	282.690	0.000	0.000	4.882	358.8	34.6
1986	712.457	1357.080	55.545	9.107	1.975	0.000	375.5	30.9
1987	1605.894	629.592	135.118	19.393	5.458	0.000	289.3	25.7
1988	2457.529	3083.308	622.680	41.282	0.000	0.000	1074.2	54.3
1989	723.360	1431.186	263.352	28.335	0.000	0.000	400.9	10.5
1990	1425.325	3273.587	1327.758	1.591	0.000	0.000	942.1	24.2
1991	1030.969	1409.608	1379.051	235.127	0.000	0.000	629.9	31.8
1992	1968.596	993.473	569.549	129.331	55.572	0.000	524.7	25.6
1993	2301.783	1998.659	1591.370	393.012	0.000	0.000	831.3	23.0
1994	562.170	2375.295	349.234	36.070	0.000	0.000	650.0	16.1
1995	2356.231	3484.548	1235.512	0.000	0.000	0.000	1278.4	20.4
1996	468.306	815.510	463.423	32.833	0.000	0.000	325.1	13.5
1997	274.708	1410.266	171.271	21.697	12.590	0.000	378.5	9.1
1998	1617.771	1438.848	464.027	0.000	0.000	0.000	570.5	18.5
1999	1296.735	2669.889	846.478	134.789	16.513	0.000	1025.8	20.5
2000	317.086	1825.249	808.515	56.148	23.864	8.585	784.8	25.5
2001	188.359	1638.261	868.586	29.679	0.000	0.000	733.4	20.0
2002	427.271	178.869	626.355	250.734	9.930	0.000	349.2	23.2
2003	151.082	1612.422	856.737	655.815	15.991	0.000	893.0	37.5
2004	638.177	2381.741	1743.591	522.562	2.524	0.000	1198.3	45.0
2005	242.094	1165.045	1046.988	56.231	0.000	0.000	545.0	41.4
2006	343.254	1370.384	1044.437	111.995	0.000	0.000	691.5	26.7
2007	105.055	1206.464	931.784	155.718	0.000	0.000	611.0	30.7
2008	745.125	1481.995	1547.387	183.778	16.513	0.000	866.1	27.5
2009	939.135	2279.181	693.805	61.771	1.755	0.000	781.6	20.3
2010	362.674	2800.564	1858.027	228.077	6.830	0.000	1338.8	20.8

Table D24. Stratified mean catch per tow (number of fish) at age, mean catch per tow (kg), and coefficient of variation for the **ME-NH spring survey**. These values were computed from all strata. Conversion to minimum swept area was not possible. Length frequencies collected by this survey were converted to age frequencies by applying annual age-length keys from the MADMF survey in the same year and season.

Year	age-1	age-2	age-3	age-4	age-5	age-6+	B (kg/tow)	CV (%)
2001	0.000	0.836	1.997	0.435	0.085	0.000	1.20	68.1
2002	0.000	0.358	2.011	0.707	0.034	0.031	0.95	23.4
2003	0.000	0.523	0.772	0.653	0.061	0.000	0.52	20.9
2004	0.000	0.246	1.138	0.409	0.010	0.000	0.43	25.6
2005	0.016	0.401	1.151	0.197	0.002	0.000	0.40	28.4
2006	0.000	0.231	0.642	0.137	0.003	0.003	0.23	20.9
2007	0.004	1.088	2.435	0.779	0.072	0.000	1.05	25.9
2008	0.155	0.490	1.342	0.355	0.031	0.000	0.53	27.8
2009	0.012	0.562	1.335	0.558	0.035	0.000	0.58	26.2
2010	0.007	0.913	2.601	0.681	0.113	0.016	1.01	26.3
2011	0.051	0.255	0.887	0.477	0.032	0.000	0.36	26.2

Table D25. Stratified mean catch per tow (number of fish) at age, mean catch per tow (kg), and coefficient of variation for the **ME-NH fall survey**. These values were computed from all strata. Conversion to minimum swept area was not possible. Length frequencies collected by this survey were converted to age frequencies by applying annual age-length keys from the MADMF survey in the same year and season.

Year	age-1	age-2	age-3	age-4	age-5	age-6+	B (kg/tow)	CV (%)
2000	0.053	1.799	0.640	0.030	0.010	0.000	0.61	51.1
2001	0.062	0.907	0.419	0.011	0.000	0.000	0.35	49.4
2002	0.000	0.202	0.560	0.177	0.005	0.000	0.27	26.1
2003	0.000	0.396	0.421	0.370	0.000	0.000	0.37	3.4
2004	0.010	0.507	0.476	0.135	0.000	0.000	0.28	22.0
2005	0.000	0.162	0.183	0.012	0.000	0.000	0.09	69.5
2006	0.000	0.093	0.092	0.002	0.000	0.000	0.05	74.9
2007	0.017	0.955	0.929	0.140	0.000	0.000	0.52	51.6
2008	0.119	0.539	0.541	0.045	0.003	0.000	0.28	41.1
2009	0.021	0.562	0.253	0.038	0.000	0.000	0.22	37.1
2010	0.170	0.663	0.347	0.001	0.000	0.000	0.26	62.3

Table D26. Statistical properties of estimates for population abundance and survey catchability coefficients for Cape Cod-Gulf of Maine yellowtail flounder VPA.

Stock Numbers Predicted in Terminal Year Plus One (2011)

Age	Estimate	Std. Error	CV (%)
2	2909	1031	35
3	6908	1624	24
4	3235	714	22
5	1001	250	25

Catchability Coefficients for Each Survey Used

Index	Estimate	Std. Error	CV (%)
NEFSC_S_1	0.005	0.001	25
NEFSC_S_2	0.095	0.012	13
NEFSC_S_3	0.329	0.053	16
NEFSC_S_4	0.403	0.070	17
NEFSC_S_5	0.438	0.082	19
NEFSC_S_6+	0.362	0.143	40
NEFSC_F_1	0.065	0.011	16
NEFSC_F_2	0.250	0.036	15
NEFSC_F_3	0.287	0.051	18
NEFSC_F_4	0.189	0.054	29
NEFSC_F_5	0.384	0.167	43
MADMF_S_1	0.022	0.005	25
MADMF_S_2	0.361	0.044	12
MADMF_S_3	0.791	0.112	14
MADMF_S_4	0.723	0.124	17
MADMF_S_5	0.515	0.091	18
MADMF_S_6+	0.315	0.103	33
MADMF_F_1	0.114	0.016	14
MADMF_F_2	0.343	0.044	13
MADMF_F_3	0.339	0.056	16
MADMF_F_4	0.147	0.044	30
MADMF_F_5	0.086	0.036	42
MENH_S_2	1.16E-04	1.66E-05	14
MENH_S_3	4.31E-04	7.40E-05	17
MENH_S_4	4.01E-04	6.70E-05	17
MENH_S_5	1.16E-04	4.78E-05	41
MENH_F_2	9.47E-06	3.24E-06	34
MENH_F_3	2.42E-04	5.40E-05	22
MENH_F_4	7.13E-04	1.46E-04	20

Table D27. Mohn's rho retrospective statistic for F, SSB, and numbers at ages 1 through 6+.

Peel	F	SSB	N1	N2	N3	N4	N5	N6+
2009	-57%	67%	-3%	15%	45%	87%	83%	116%
2008	-70%	157%	-10%	47%	133%	117%	108%	178%
2007	-64%	151%	-6%	146%	115%	92%	84%	133%
2006	-41%	100%	161%	105%	94%	18%	1%	59%
2005	11%	24%	67%	78%	22%	-9%	-29%	5%
2004	55%	0%	61%	5%	15%	-16%	-41%	-6%
2003	30%	-20%	-34%	8%	-10%	-12%	-19%	-8%
mean	-19%	68%	34%	58%	59%	39%	27%	68%

Table D28. Estimated population abundance at age (000s).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1985	11698	3324	1736	777	403	148	18086
1986	5778	8959	1607	613	81	16	17053
1987	8201	4645	3563	615	231	106	17360
1988	23080	6697	2116	853	228	47	33021
1989	8673	18488	3172	406	52	12	30803
1990	7361	6994	13067	985	70	56	28534
1991	9443	5951	3135	2407	367	91	21394
1992	7880	7311	3639	997	261	19	20107
1993	5956	4915	2444	1233	172	84	14804
1994	6707	4733	3640	1041	305	158	16585
1995	5709	5474	3139	1465	220	210	16217
1996	7197	4641	4007	990	160	14	17008
1997	7558	5869	3091	1125	239	27	17909
1998	7841	6181	3475	753	176	3	18429
1999	9754	6386	4614	630	51	11	21445
2000	8843	7977	4558	1733	164	43	23319
2001	6417	7238	5528	1092	187	31	20493
2002	5203	5236	4718	1234	149	46	16587
2003	3685	4208	3205	1681	213	98	13089
2004	2977	3008	2672	745	317	98	9818
2005	3000	2426	2035	772	108	63	8404
2006	3895	2442	1542	546	118	76	8618
2007	4321	3182	1829	670	103	30	10137
2008	7304	3533	2365	818	197	43	14259
2009	10494	5979	2798	1196	231	19	20717
2010	3556	8584	4659	1701	535	186	19220

Table D29. Estimated fishing mortality at age. Note the 2010 value is rho adjusted to 0.36 for status determination.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	F(4-5)
1985	0.07	0.53	0.84	2.07	2.07	2.07	2.07
1986	0.02	0.72	0.76	0.78	0.78	0.78	0.78
1987	0.00	0.59	1.23	0.79	0.79	0.79	0.79
1988	0.02	0.55	1.45	2.60	2.60	2.60	2.60
1989	0.02	0.15	0.97	1.56	1.56	1.56	1.56
1990	0.01	0.60	1.49	0.79	0.79	0.79	0.79
1991	0.06	0.29	0.95	2.02	2.02	2.02	2.02
1992	0.27	0.90	0.88	1.56	1.56	1.56	1.56
1993	0.03	0.10	0.65	1.20	1.20	1.20	1.20
1994	0.00	0.21	0.71	1.36	1.36	1.36	1.36
1995	0.01	0.11	0.95	2.02	2.02	2.02	2.02
1996	0.00	0.21	1.07	1.22	1.22	1.22	1.22
1997	0.00	0.32	1.21	1.66	1.66	1.66	1.66
1998	0.01	0.09	1.51	2.50	2.50	2.50	2.50
1999	0.00	0.14	0.78	1.15	1.15	1.15	1.15
2000	0.00	0.17	1.23	2.03	2.03	2.03	2.03
2001	0.00	0.23	1.30	1.79	1.79	1.79	1.79
2002	0.01	0.29	0.83	1.56	1.56	1.56	1.56
2003	0.00	0.25	1.26	1.47	1.47	1.47	1.47
2004	0.00	0.19	1.04	1.73	1.73	1.73	1.73
2005	0.01	0.25	1.11	1.68	1.68	1.68	1.68
2006	0.00	0.09	0.63	1.47	1.47	1.47	1.47
2007	0.00	0.10	0.60	1.02	1.02	1.02	1.02
2008	0.00	0.03	0.48	1.06	1.06	1.06	1.06
2009	0.00	0.05	0.30	0.61	0.61	0.61	0.61
2010	0.00	0.02	0.16	0.33	0.25	0.25	0.29

Table D30. Estimated spawning stock biomass (mt). Note the 2010 value is rho adjusted to 1,680 mt for status determination.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1985	0	112	335	144	94	45	730
1986	0	261	384	213	39	11	908
1987	0	133	643	218	100	64	1157
1988	0	173	300	136	49	12	670
1989	0	739	622	124	23	8	1515
1990	0	217	1990	351	38	36	2633
1991	0	196	554	481	107	37	1375
1992	0	107	628	233	75	11	1054
1993	0	119	511	282	71	47	1029
1994	0	119	735	272	108	75	1308
1995	0	252	550	240	56	66	1164
1996	0	178	753	247	54	10	1242
1997	0	224	527	243	68	11	1073
1998	0	196	558	146	49	1	949
1999	0	326	1038	212	17	5	1599
2000	0	409	904	379	40	14	1746
2001	0	356	1016	266	62	12	1712
2002	0	264	1125	328	55	23	1795
2003	0	192	603	438	71	46	1351
2004	0	110	494	150	86	36	876
2005	0	90	362	177	34	27	689
2006	0	113	356	127	46	35	677
2007	0	138	434	199	38	16	824
2008	0	155	581	238	72	22	1067
2009	0	269	741	404	97	12	1523
2010	0	433	1337	672	264	116	2822

Table D31. Bootstrap estimates of uncertainty in 2010 F at age and SSB.

	Point	10th%ile	90th%ile
F 2010			
age 1	0.001	0.001	0.001
age 2	0.017	0.013	0.023
age 3	0.165	0.128	0.216
age 4	0.330	0.253	0.435
age 5	0.247	0.205	0.310
age 6+	0.247	0.205	0.310
Avg F 4-5	0.288	0.230	0.371
SSB	2822	2407	3379

Table D32. Values for partial recruitment (PR), maturity, and weights at age (kg, same values used for catch and SSB) used in yield per recruit calculations and age-based projections. Natural mortality is 0.2 for all ages and the fraction of both F and M before spawning is 0.4167.

Age	PR	Maturity	WAA
1	0.001	0	0.111
2	0.064	0.171	0.298
3	0.486	0.833	0.395
4	1	0.977	0.495
5	1	1	0.639
6+	1	1	0.859

Table D33. Hindcast estimates of recruitment based on the NEFSC fall age 1 survey estimates and the VPA estimates of age-1 abundance.

Year	Survey	VPA	Predicted
1977	1628		11616
1978	118		5758
1979	1426		10829
1980	3400		18486
1981	1195		9936
1982	200		6074
1983	128		5798
1984	129		5800
1985	1414	11698	10783
1986	380	5778	6774
1987	151	8201	5885
1988	944	23080	8961
1989	452	8673	7053
1990	913	7361	8840
1991	492	9443	7208
1992	803	7880	8414
1993	1151	5956	9764
1994	796	6707	8387
1995	158	5709	5913
1996	340	7197	6620
1997	330	7558	6581
1998	329	7841	6574
1999	1321	9754	10424
2000	282	8843	6392
2001	42	6417	5464
2002	129	5203	5799
2003	183	3685	6010
2004	75	2977	5589
2005	498	3000	7230
2006	748	3895	8199
2007	120	4321	5764
2008	445	7304	7027
2009	648	10494	7812
2010	970	3556	9061

Table D34. Biological reference points from the GARM III assessment and this update assessment for Cape Cod-Gulf of Maine yellowtail flounder.

	GARM III	This Assessment
Fmsy	0.239	0.26
SSBmsy (mt)	7790	7080
MSY (mt)	1720	1600

Table D35. Median catch and spawning stock biomass for three fishing mortality rate projections and three initial abundances. The median F in 2011 for the unadjusted, SSB rho adjusted, and age-specific (NAA) rho adjusted initial abundances are 0.184, 0.326, and 0.278, respectively. The Review Panel recommended the use of the NAA rho adjusted projections for setting overfishing limits (Fmsy) and acceptable biological catch (75%Fmsy).

	Fstatus quo = 0.29			Fmsy = 0.26			75%Fmsy = 0.195		
		rho adjusted			rho adjusted			rho adjusted	
	Unadj.	SSB	NAA	Unadj.	SSB	**NAA**	Unadj.	SSB	**NAA**
Median Catch (mt)									
Year									
2011	633	633	633	633	633	**633**	633	633	**633**
2012	1264	687	796	1148	624	**723**	886	481	**558**
2013	1302	738	853	1209	684	**791**	979	552	**639**
2014	1406	905	1017	1324	848	**953**	1107	701	**790**
Median Spawning Stock Biomass (mt)									
Year									
2011	4417	2517	2895	4417	2517	2895	4417	2517	2895
2012	4898	2683	3115	4952	2712	3149	5072	2777	3223
2013	5316	3101	3591	5479	3189	3694	5854	3395	3932
2014	5712	3934	4328	5963	4080	4494	6562	4425	4889

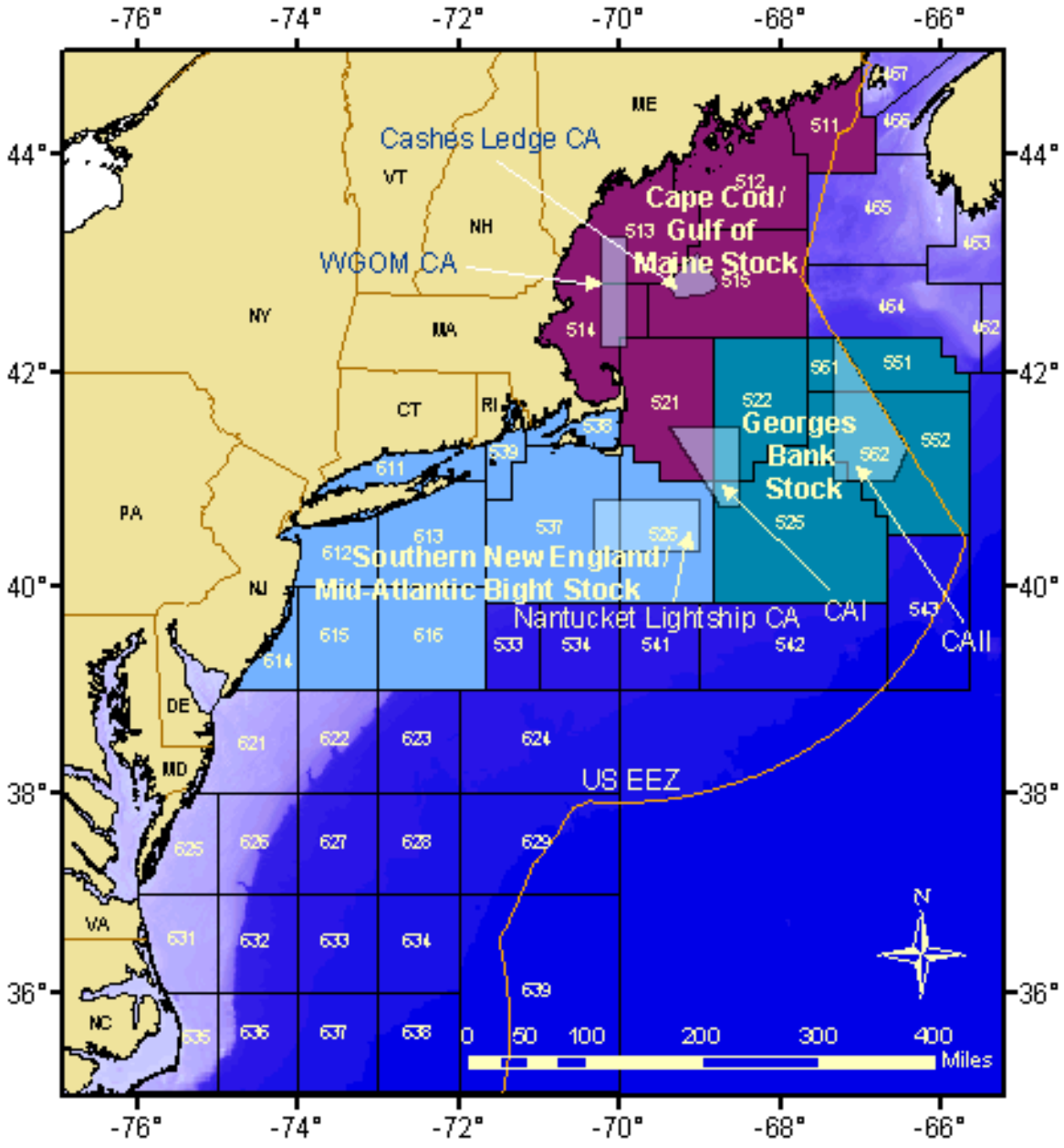

Figure D1. Stock area map for yellowtail flounder from Status of Stocks website (http://www.nefsc.noaa.gov/sos/).

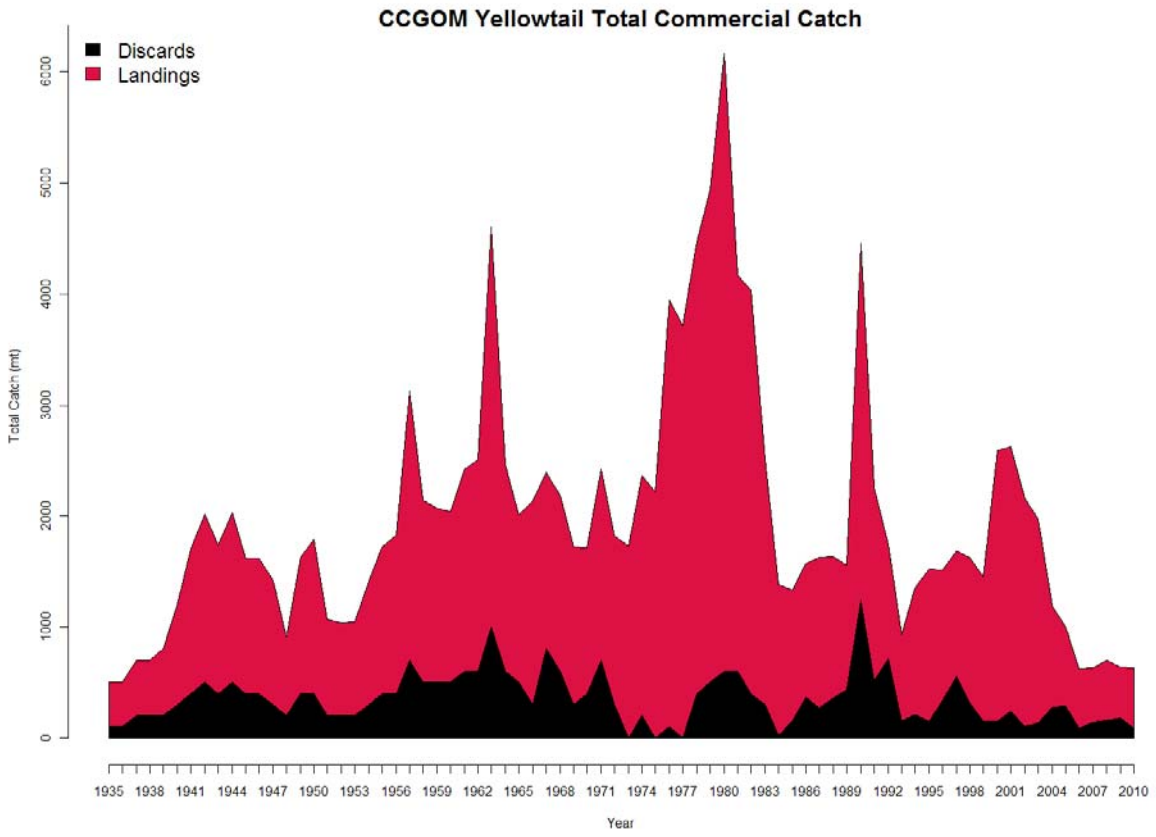

Figure D2. Total catch of Cape Cod-Gulf of Maine yellowtail flounder from 1935-2010 by disposition (landings and discards).

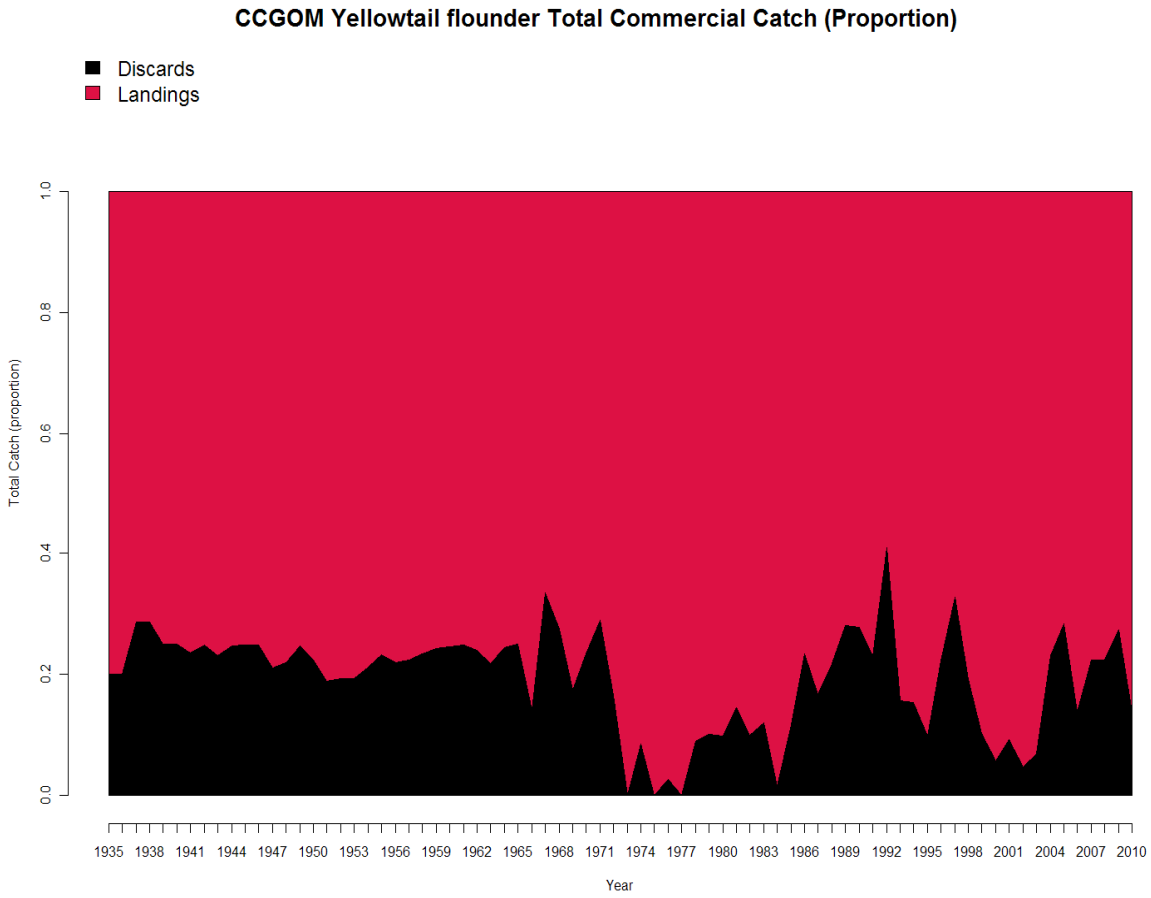

Figure D3. Total catch of Cape Cod-Gulf of Maine yellowtail flounder from 1935-2010 by disposition (landings and discards) expressed as proportions.

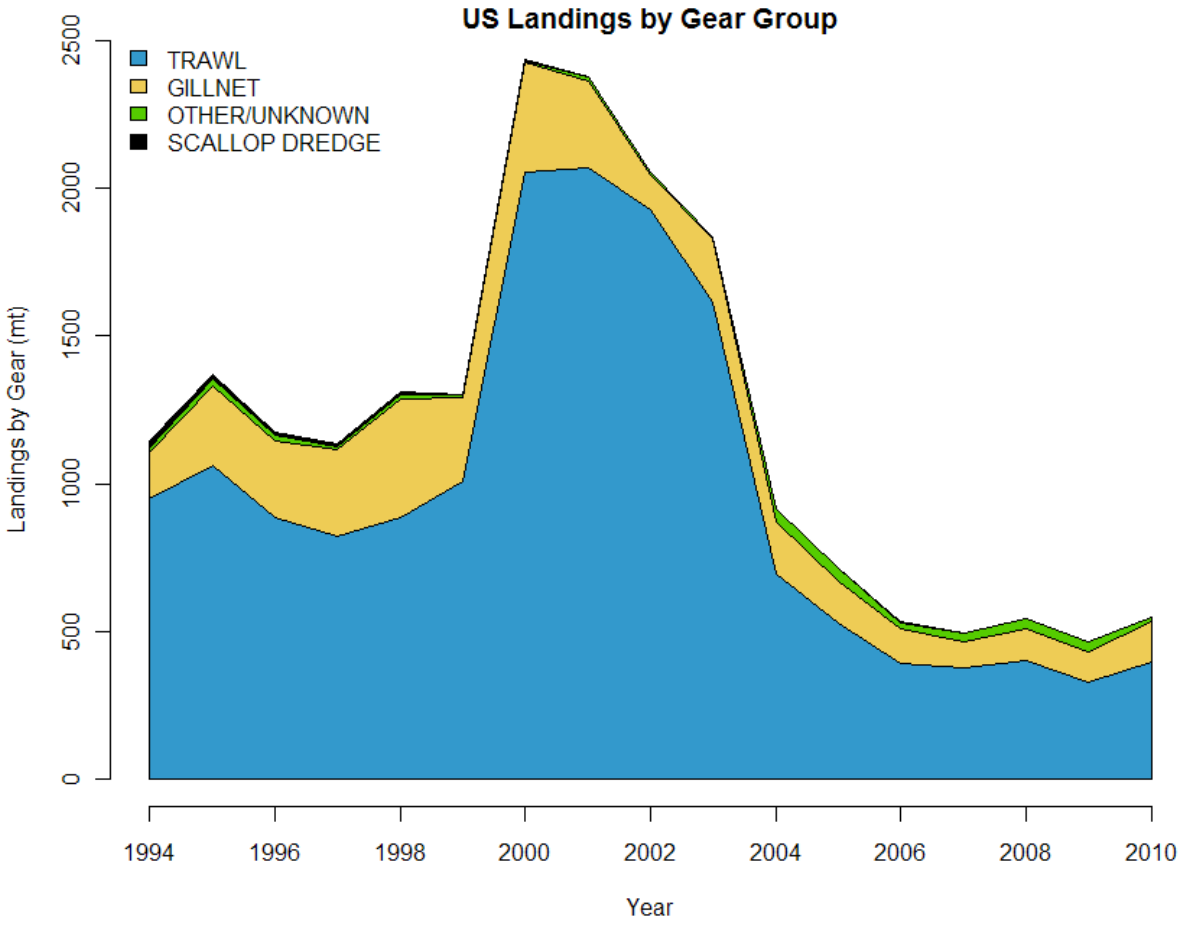

Figure D4. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by gear groupings.

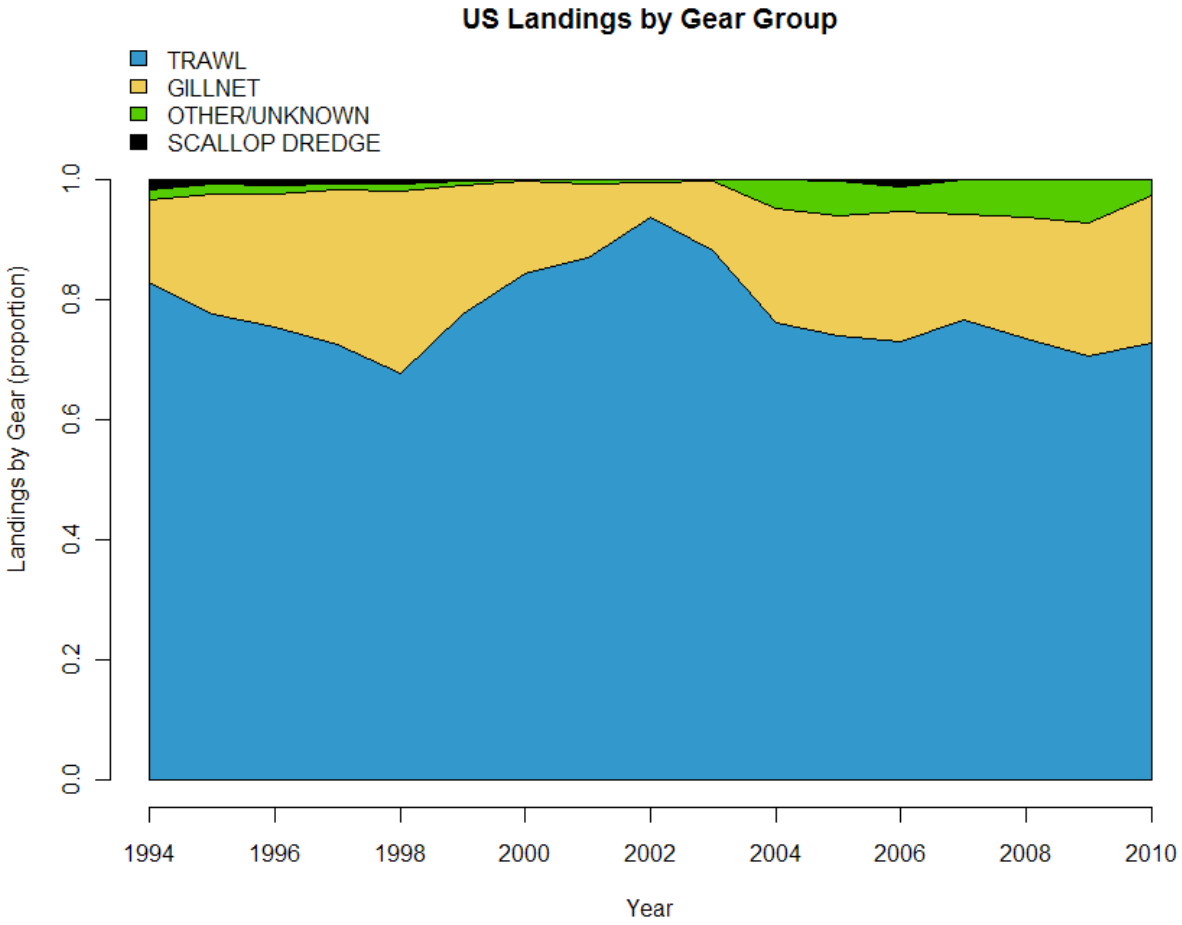

Figure D5. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by gear groupings expressed as proportions.

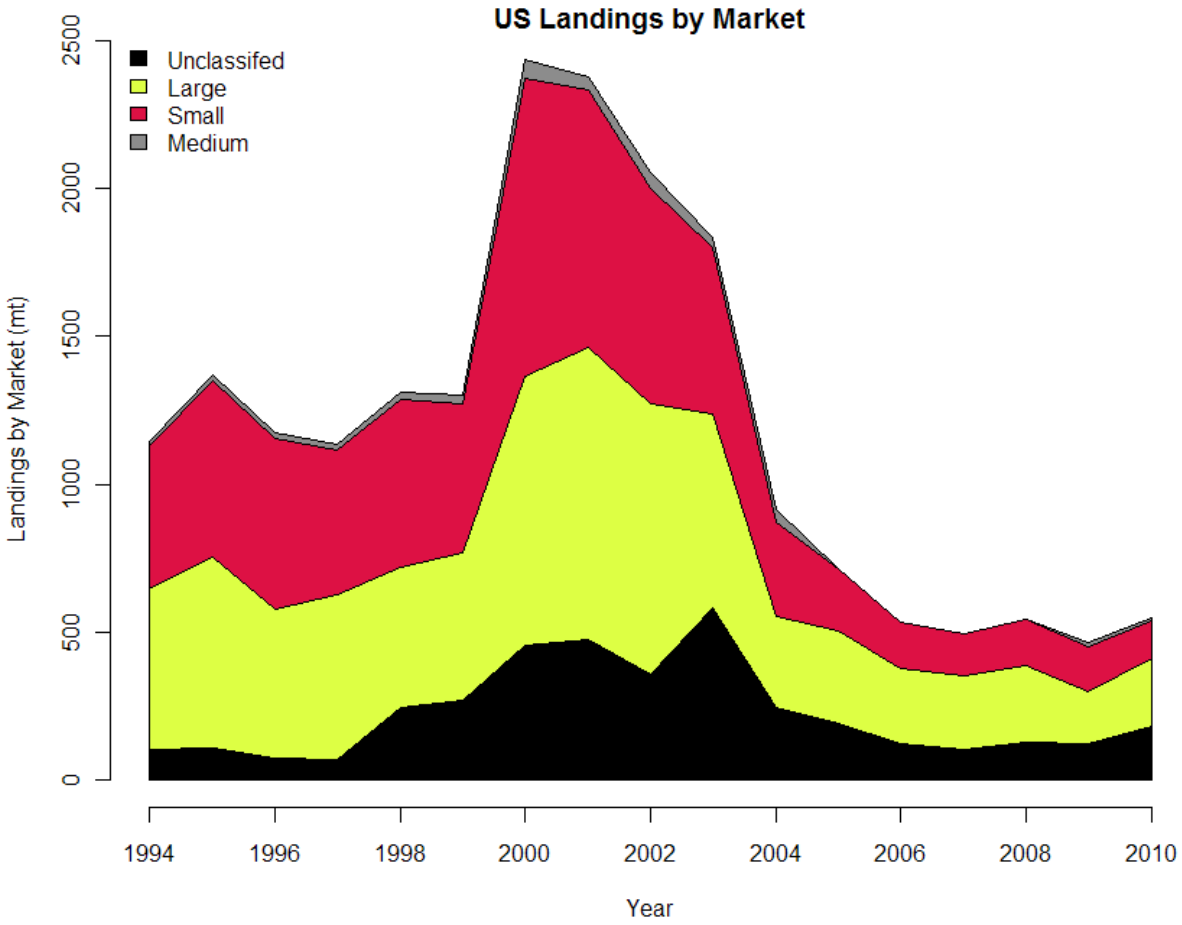

Figure D6. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by market category.

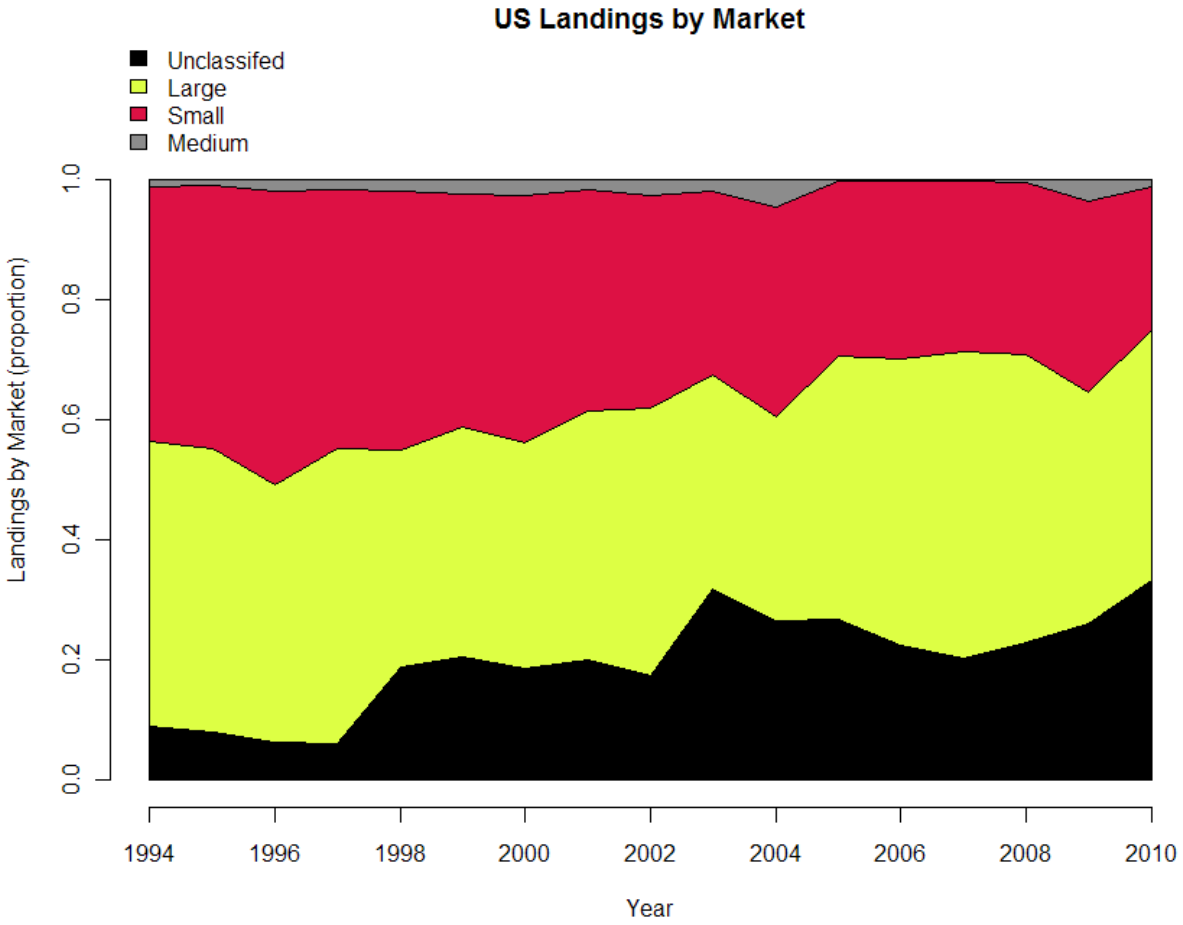

Figure D7. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by market category expressed as proportions.

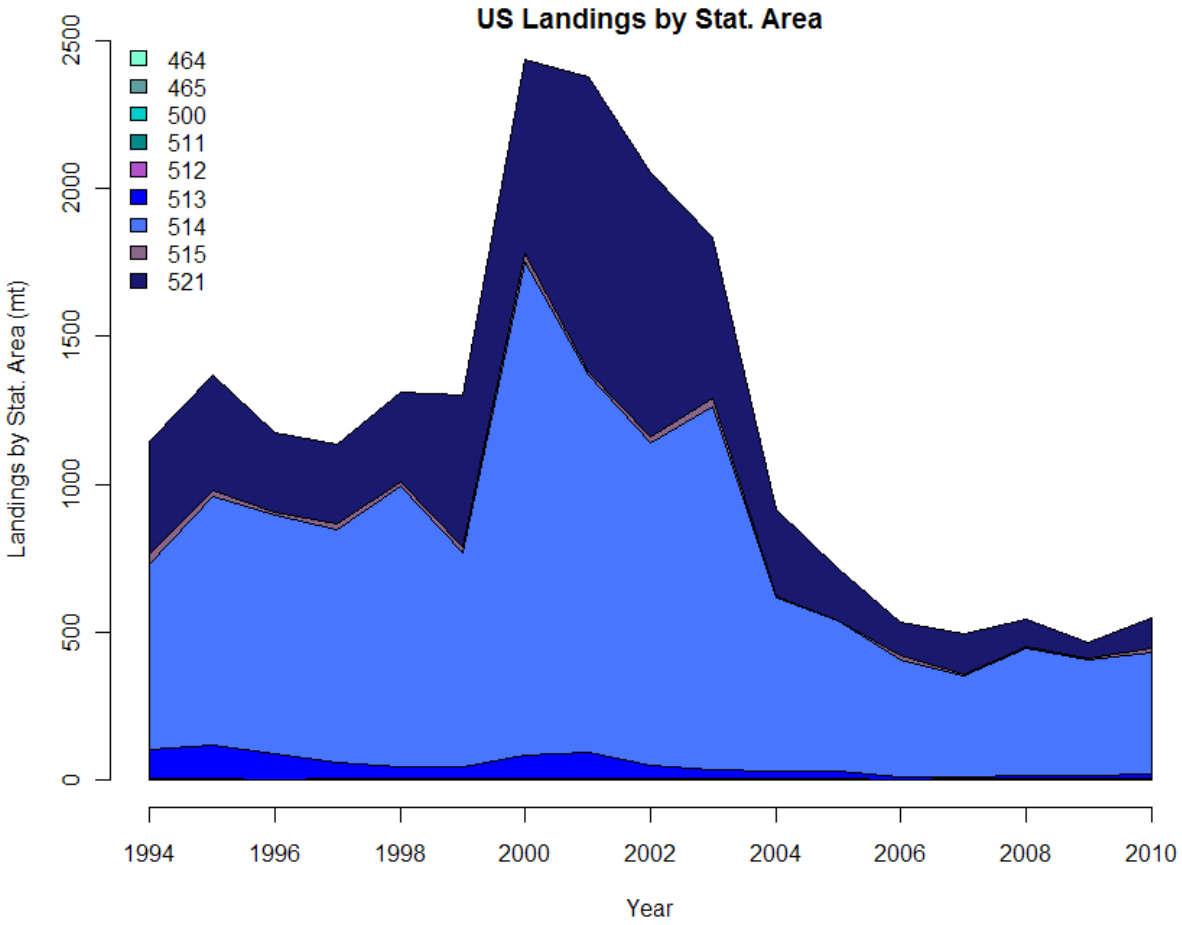

Figure D8. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by statistical area.

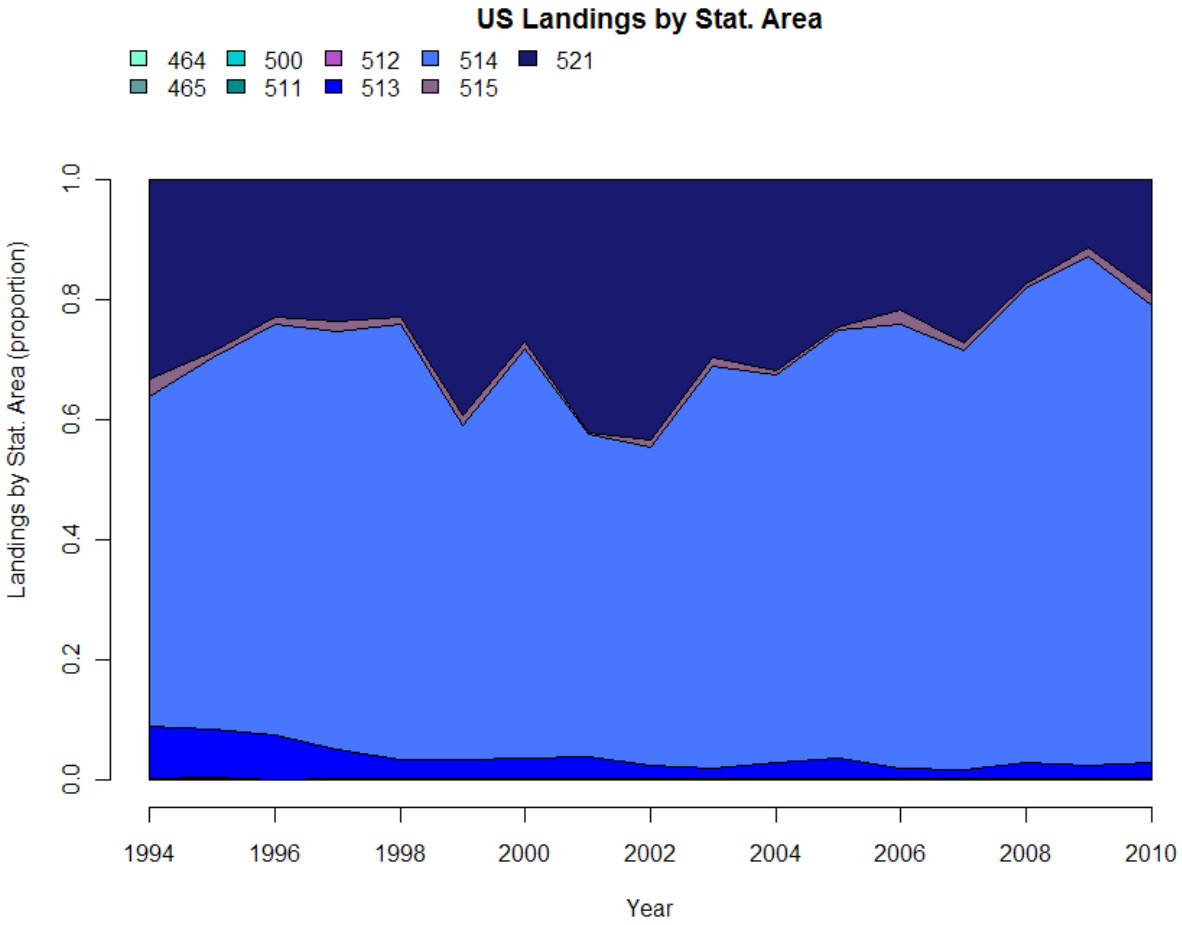

Figure D9. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by statistical area expressed as proportions.

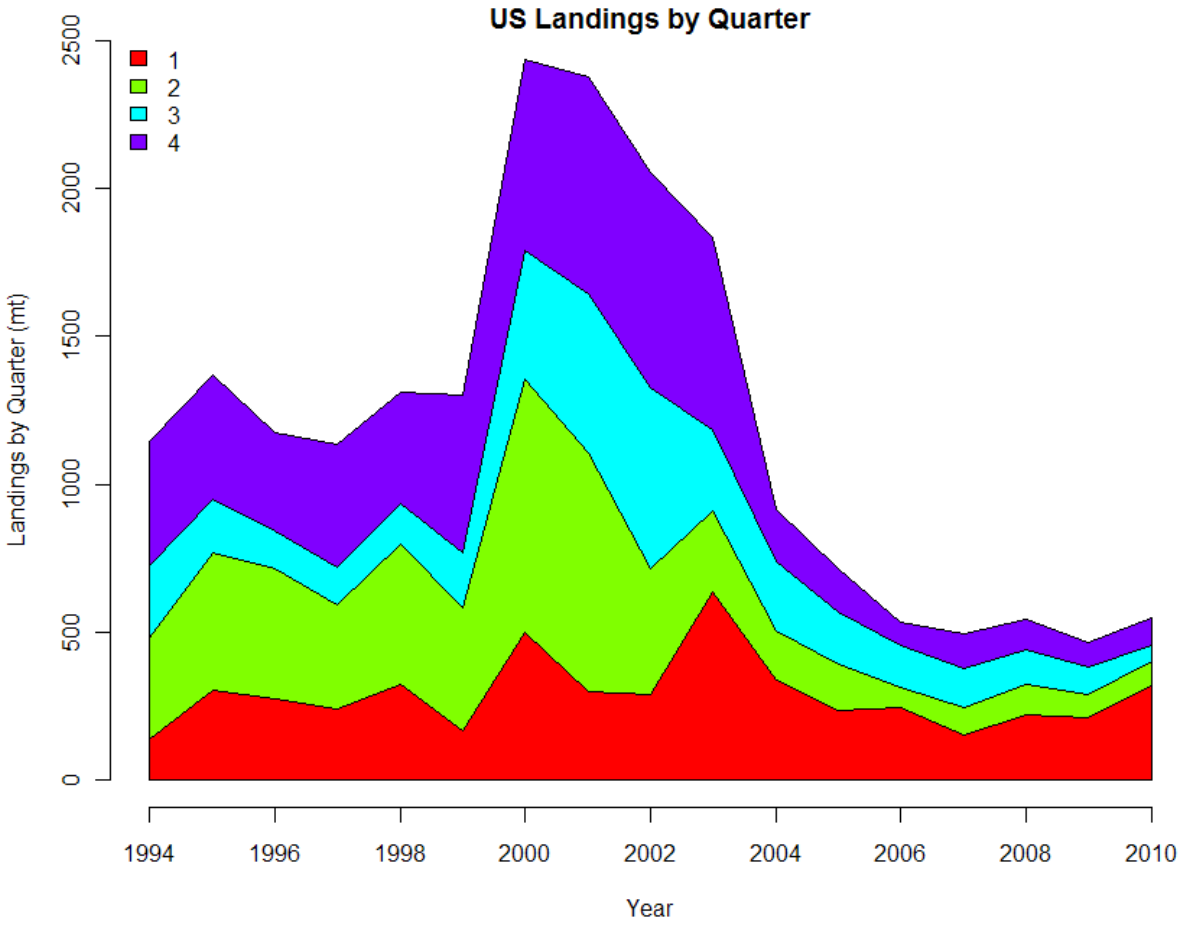

Figure D10. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by quarter.

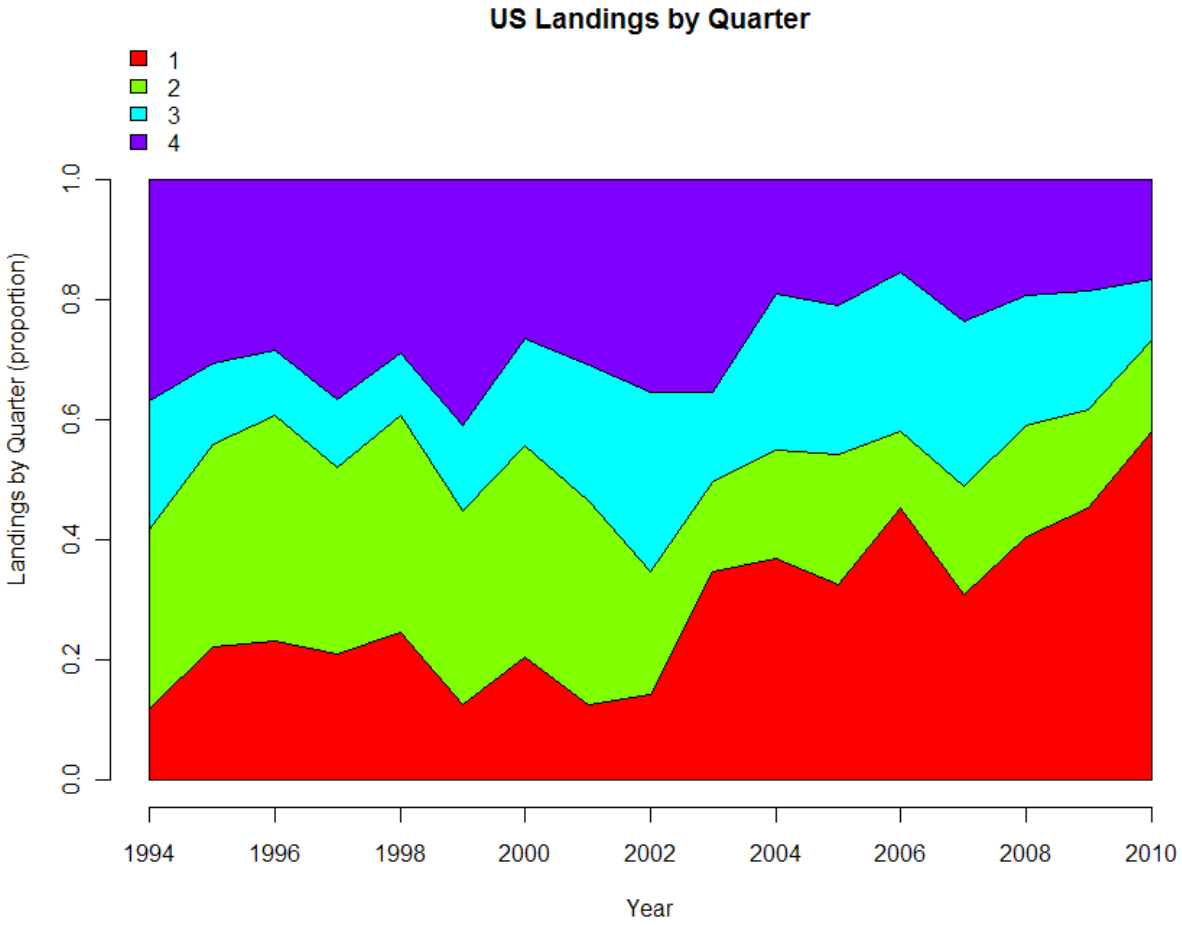

Figure D11. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by quarter expressed as proportions.

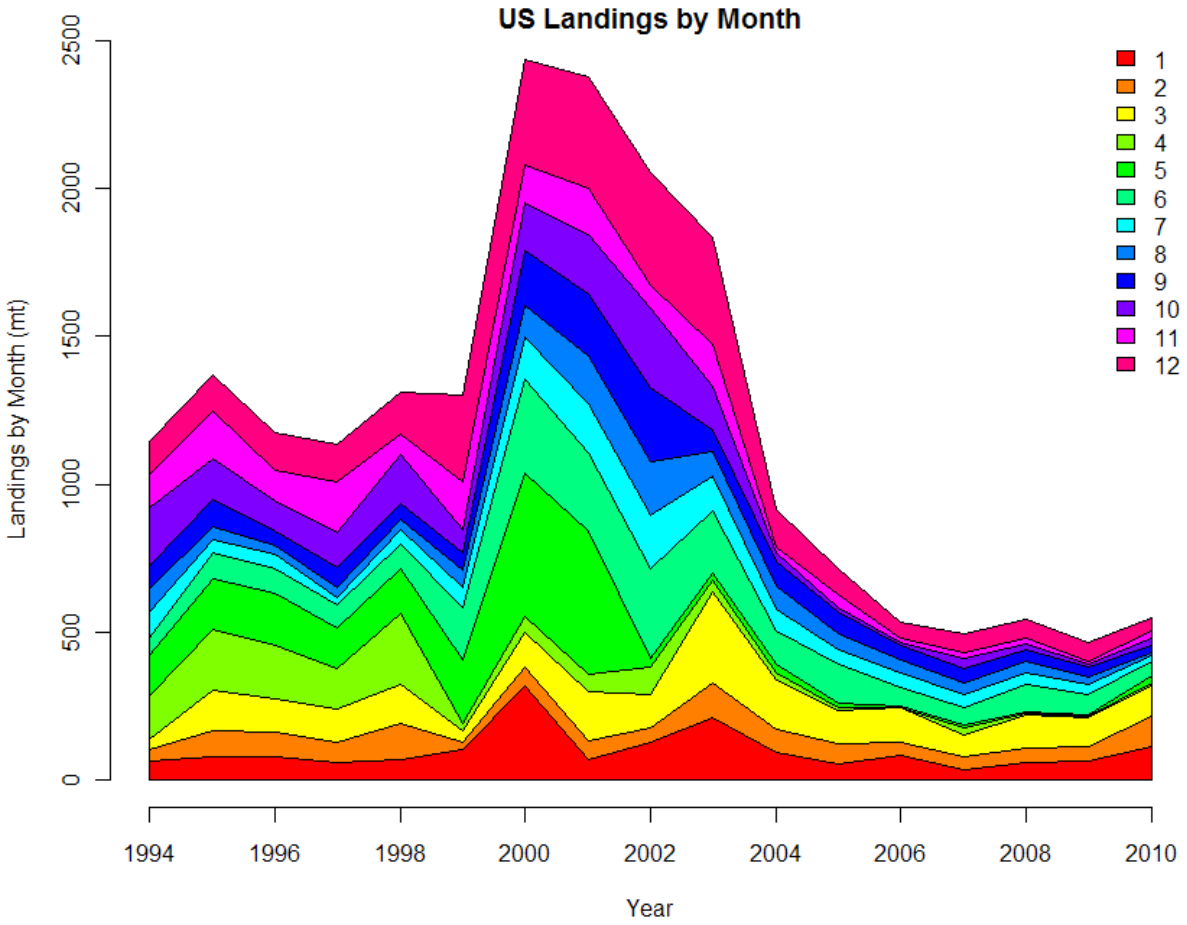

Figure D12. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by month.

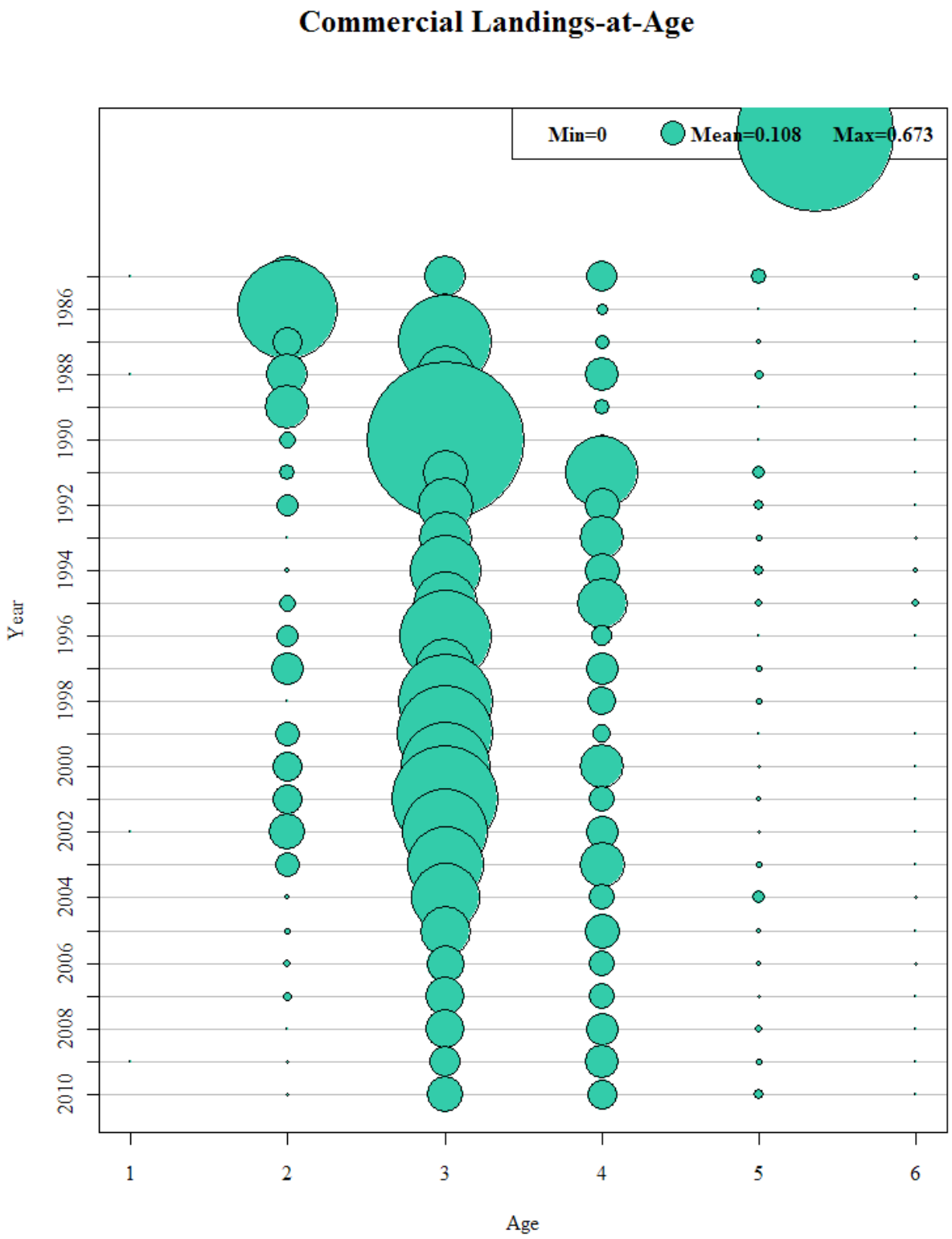

Figure D13. Landings-at-age of Cape Cod-Gulf of Maine yellowtail flounder from 1985-2010. *Note age 6 is a plus group.*

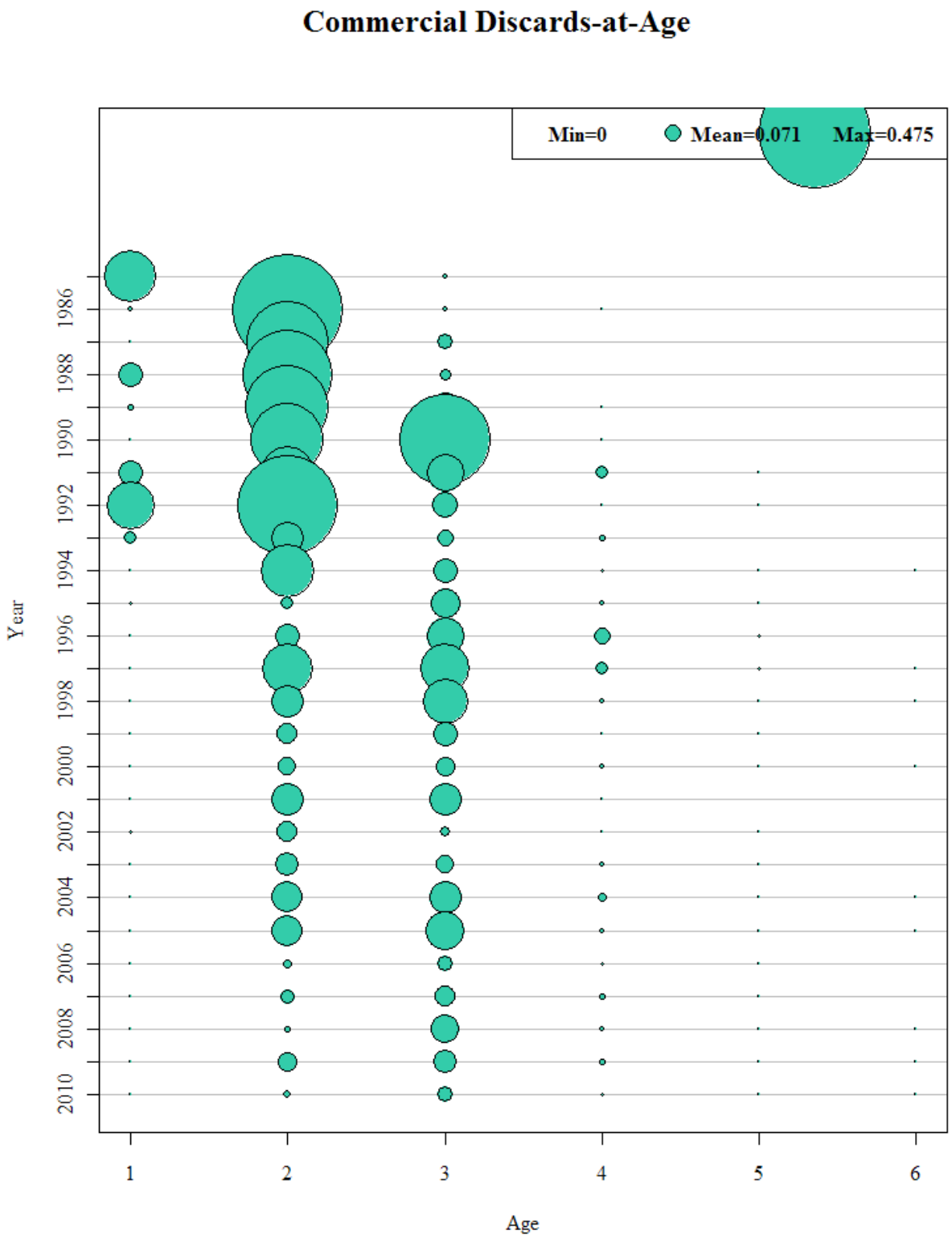

Figure D14. Discards-at-age of Cape Cod-Gulf of Maine yellowtail flounder from 1985-2010. *Note age 6 is a plus group.*

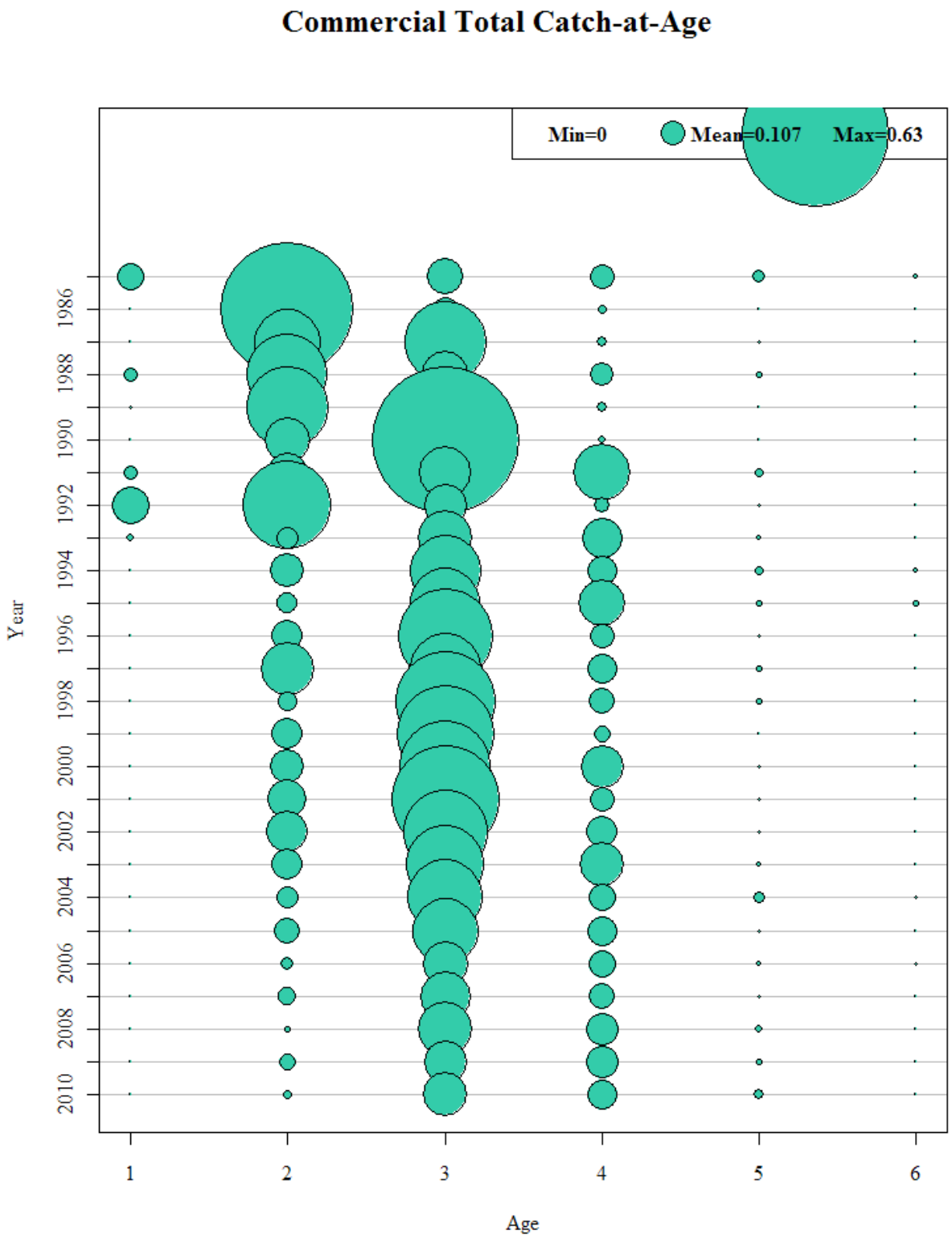

Figure D15. Total catch-at-age of Cape Cod-Gulf of Maine yellowtail flounder from 1985-2010. *Note age 6 is a plus group.*

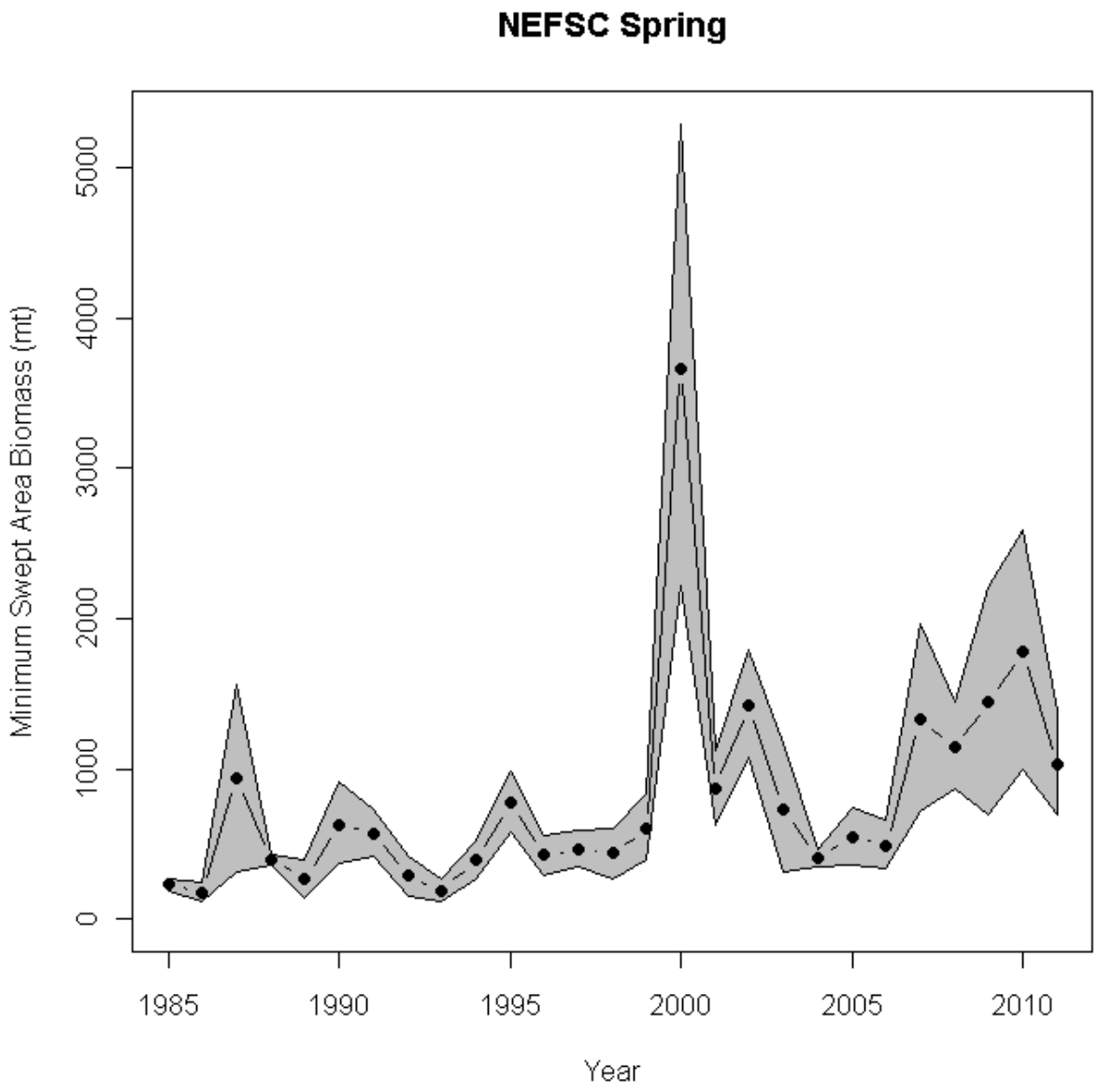

Figure D16. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the NEFSC spring survey.

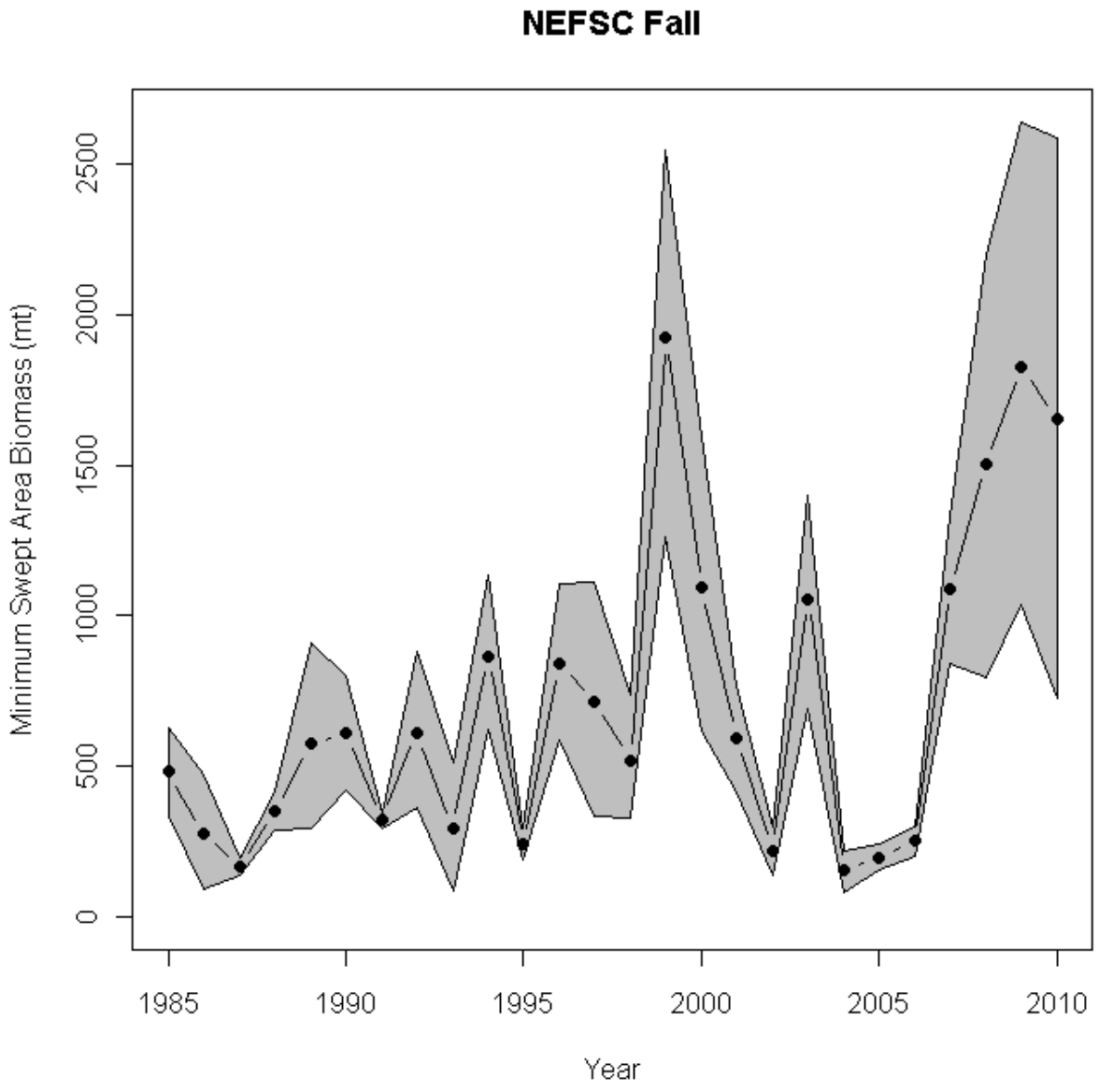

Figure D17. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the NEFSC fall survey.

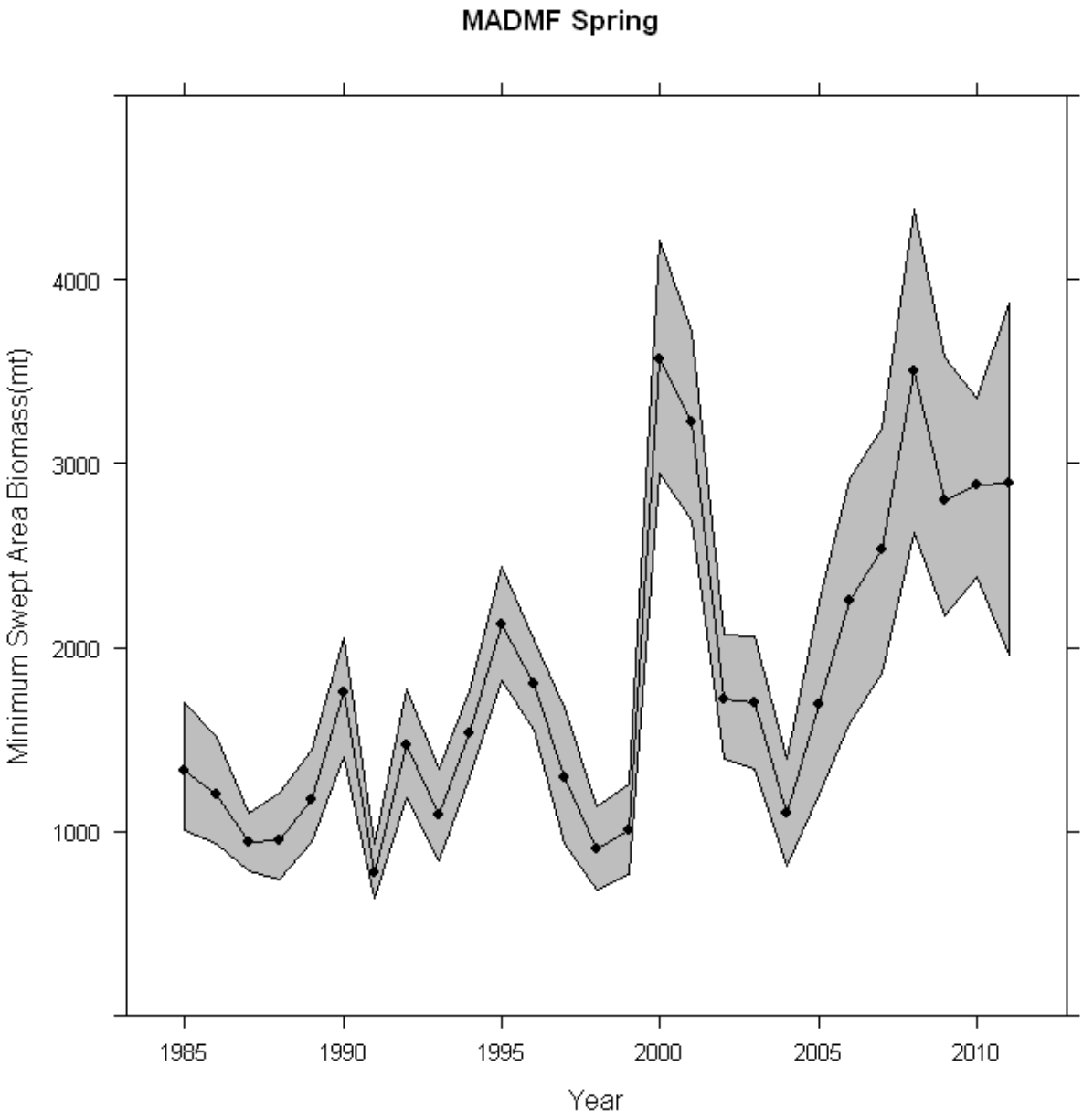

Figure D18. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the MADMF spring survey.

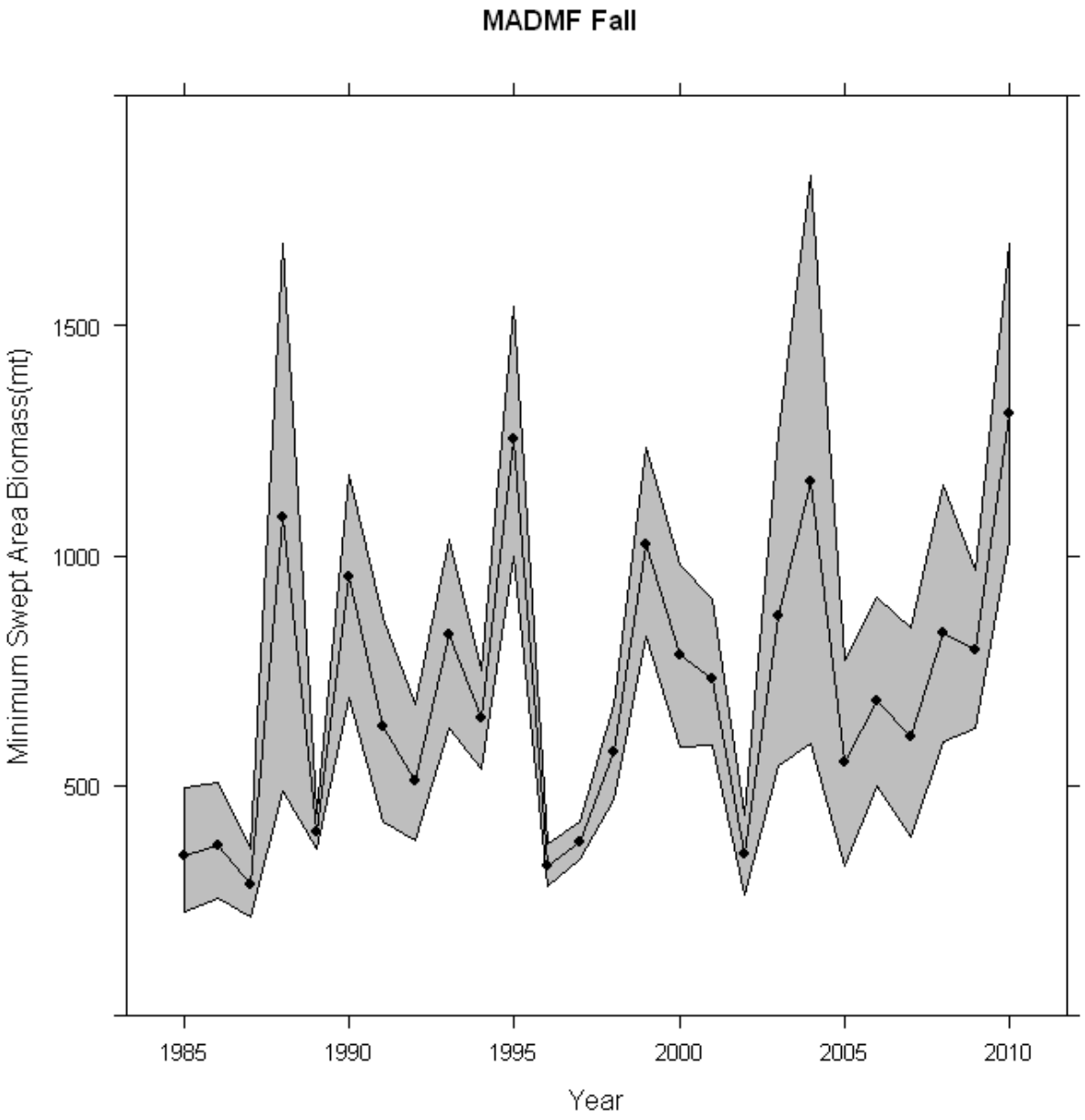

Figure D19. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the MADMF fall survey.

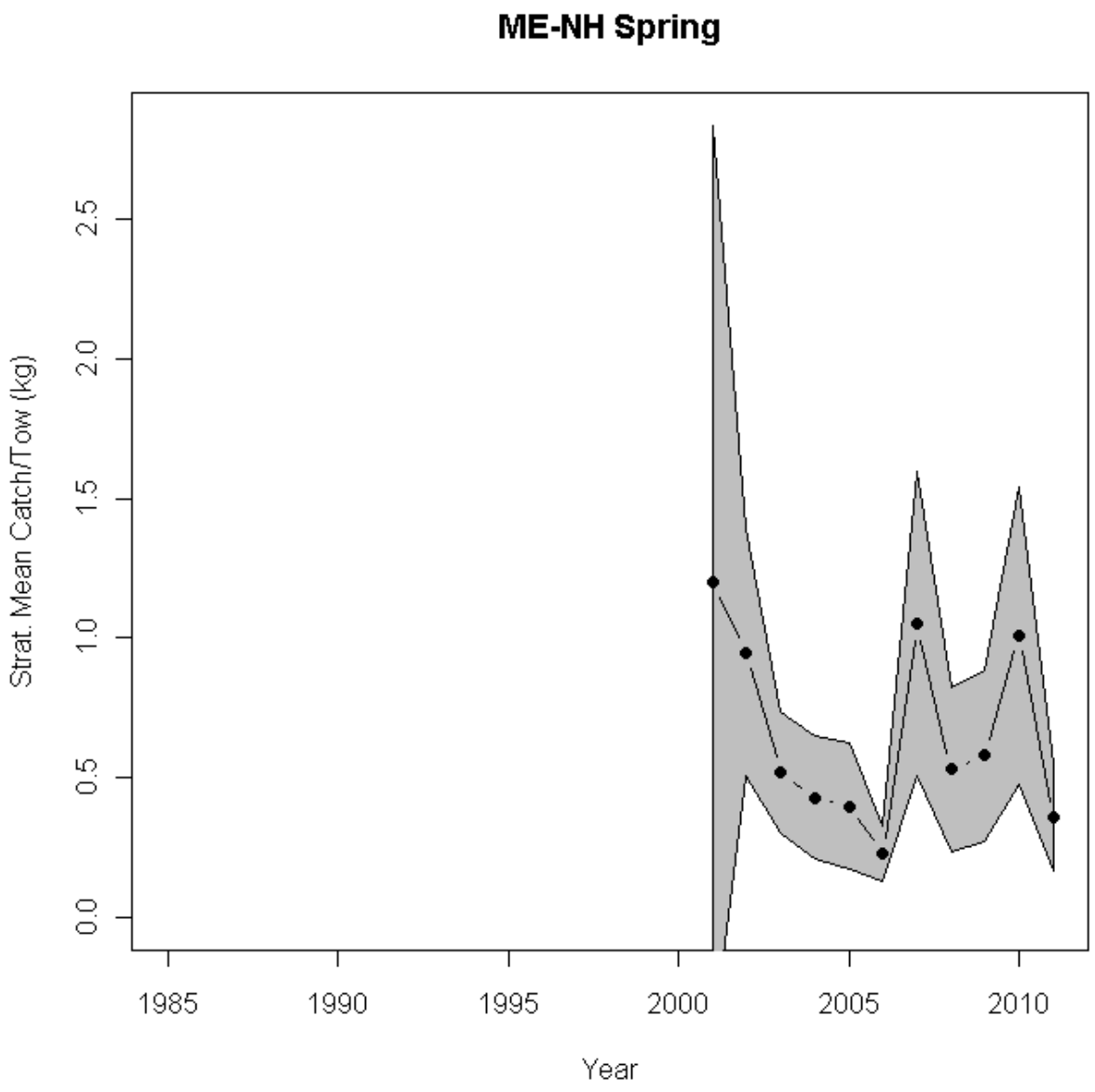

Figure D20. Stratified mean catch per tow (kg) with two standard errors for the ME-NH spring survey.

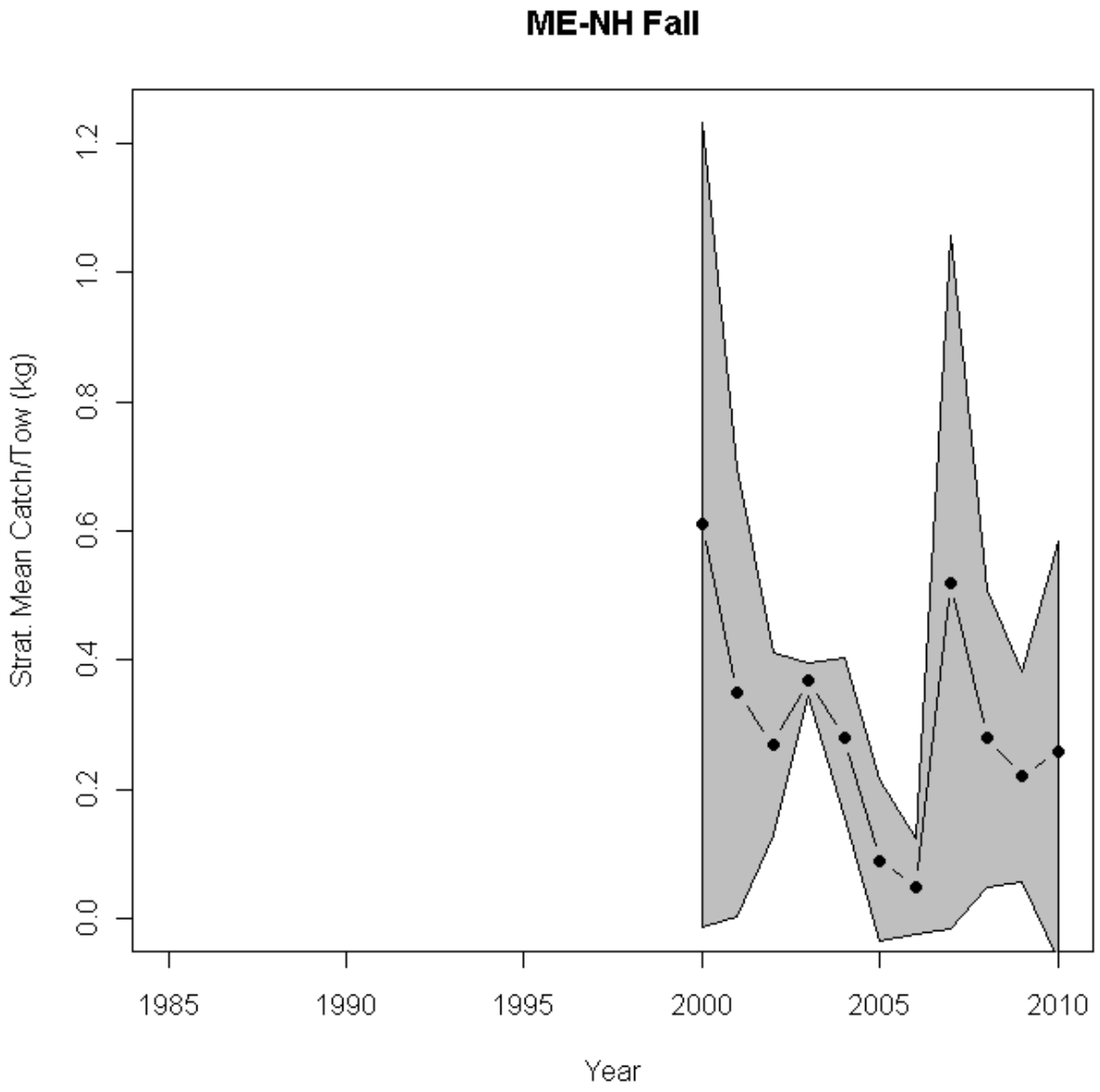

Figure D21. Stratified mean catch per tow (kg) with two standard errors for the ME-NH fall survey.

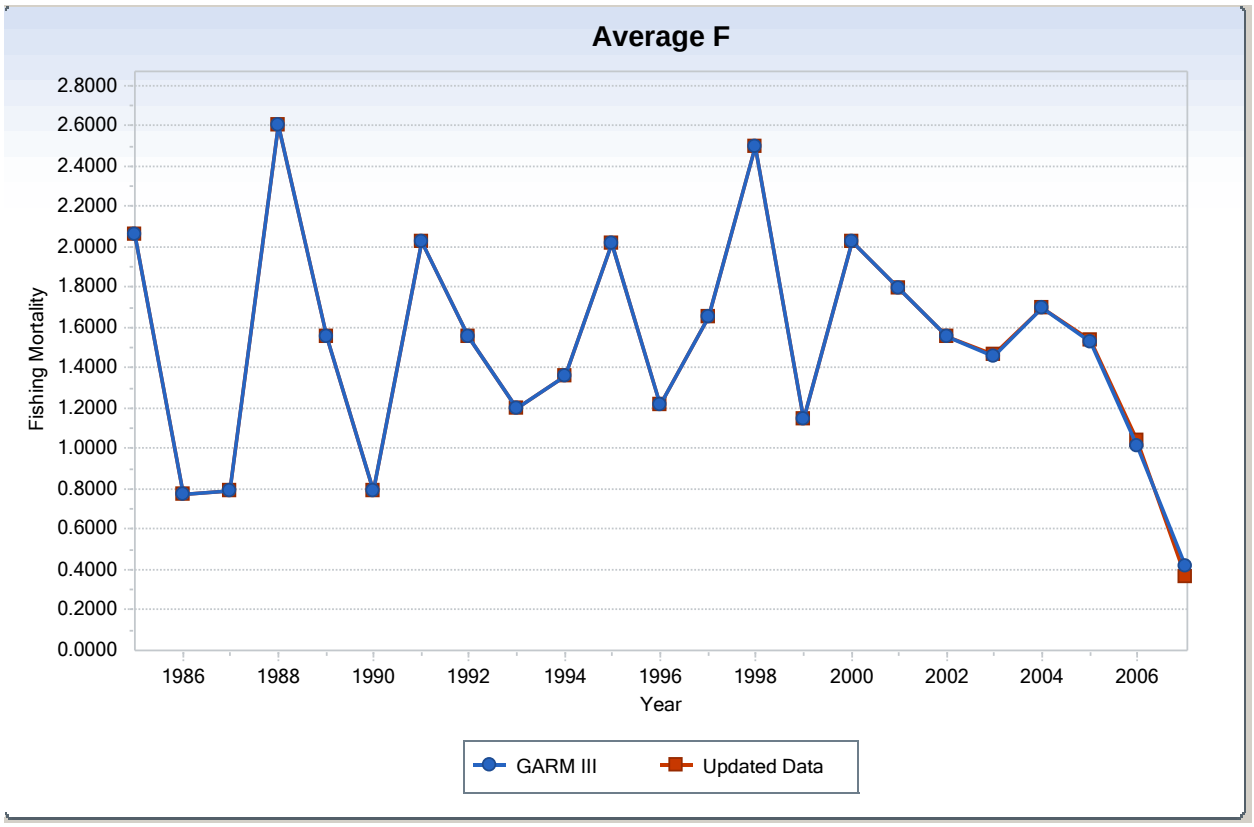

Figure D22. Comparison of average F (ages 4-5) from the GARM III VPA and the VPA with updated data.

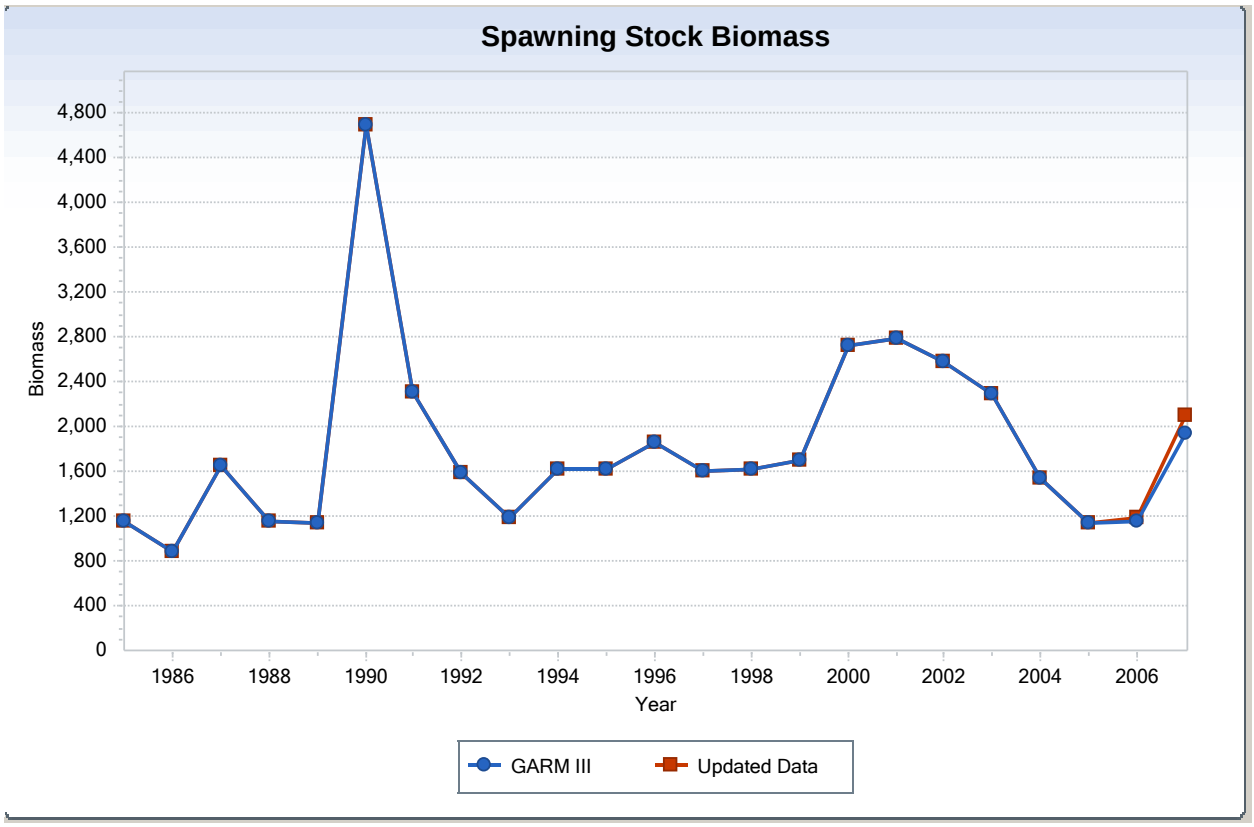

Figure D23. Comparison of spawning stock biomass from the GARM III VPA and the VPA with updated data.

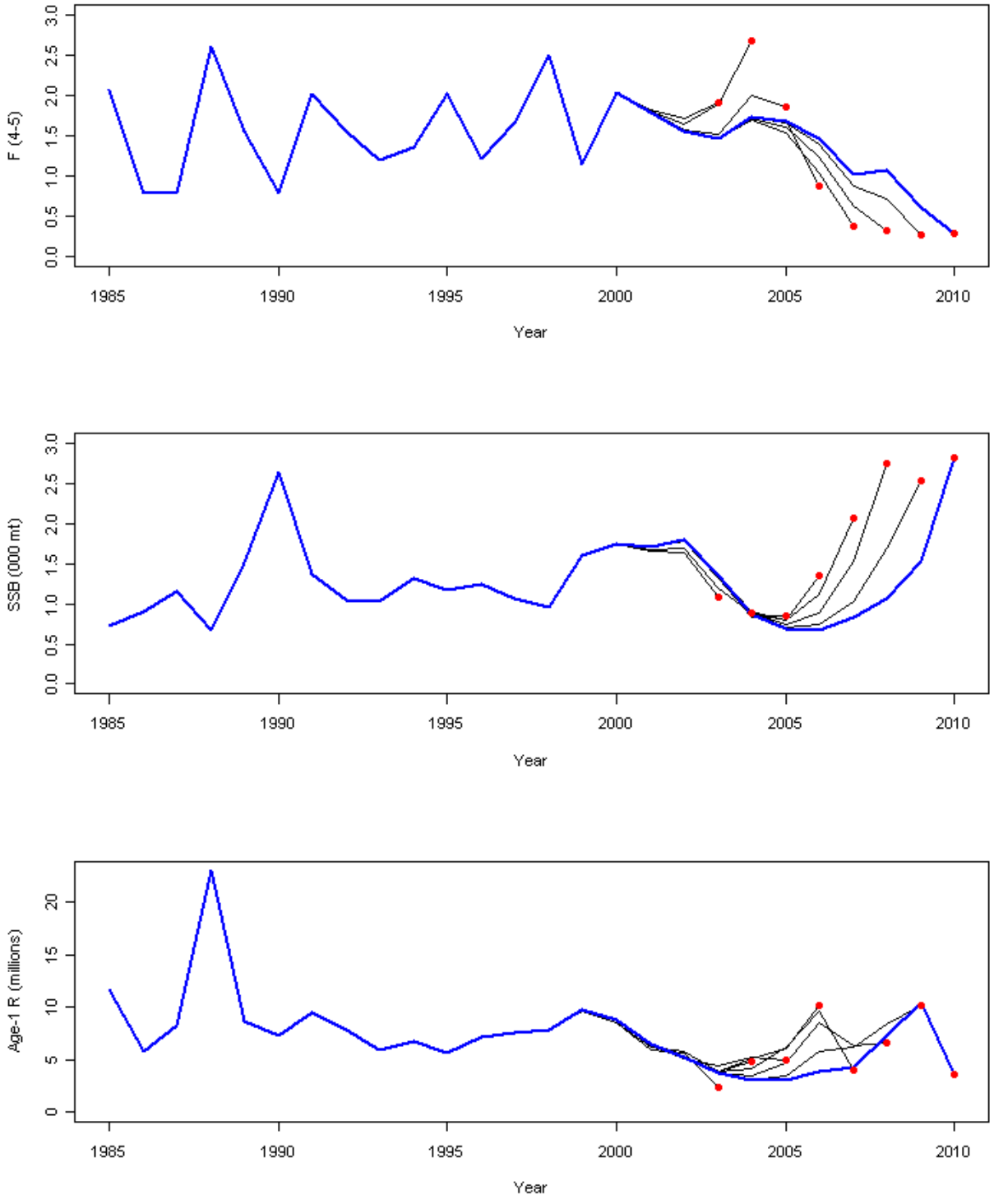

Figure D24. Retrospective plots for F, SSB, and recruitment.

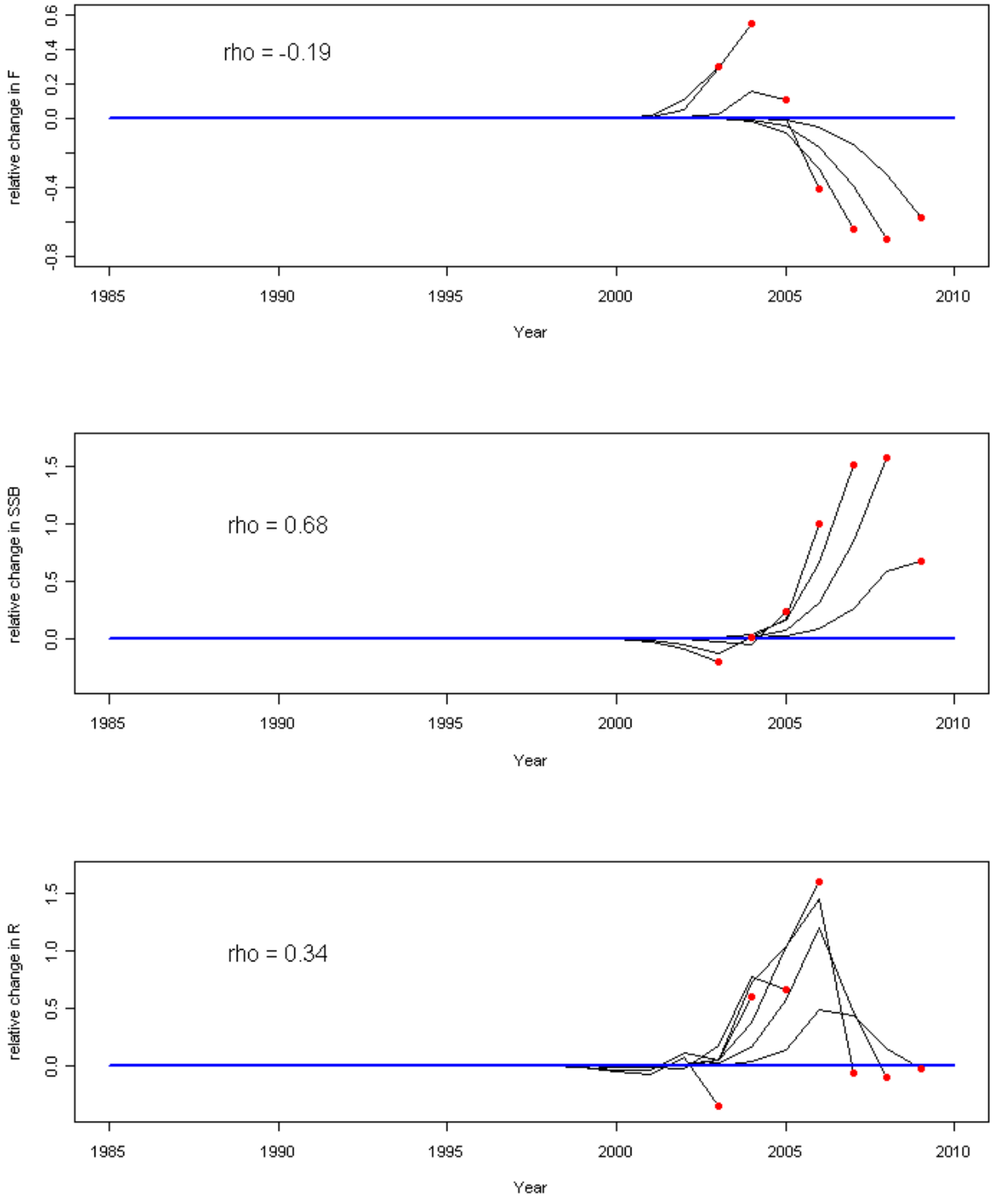

Figure D25. Relative retrospective plots for F, SSB, and recruitment.

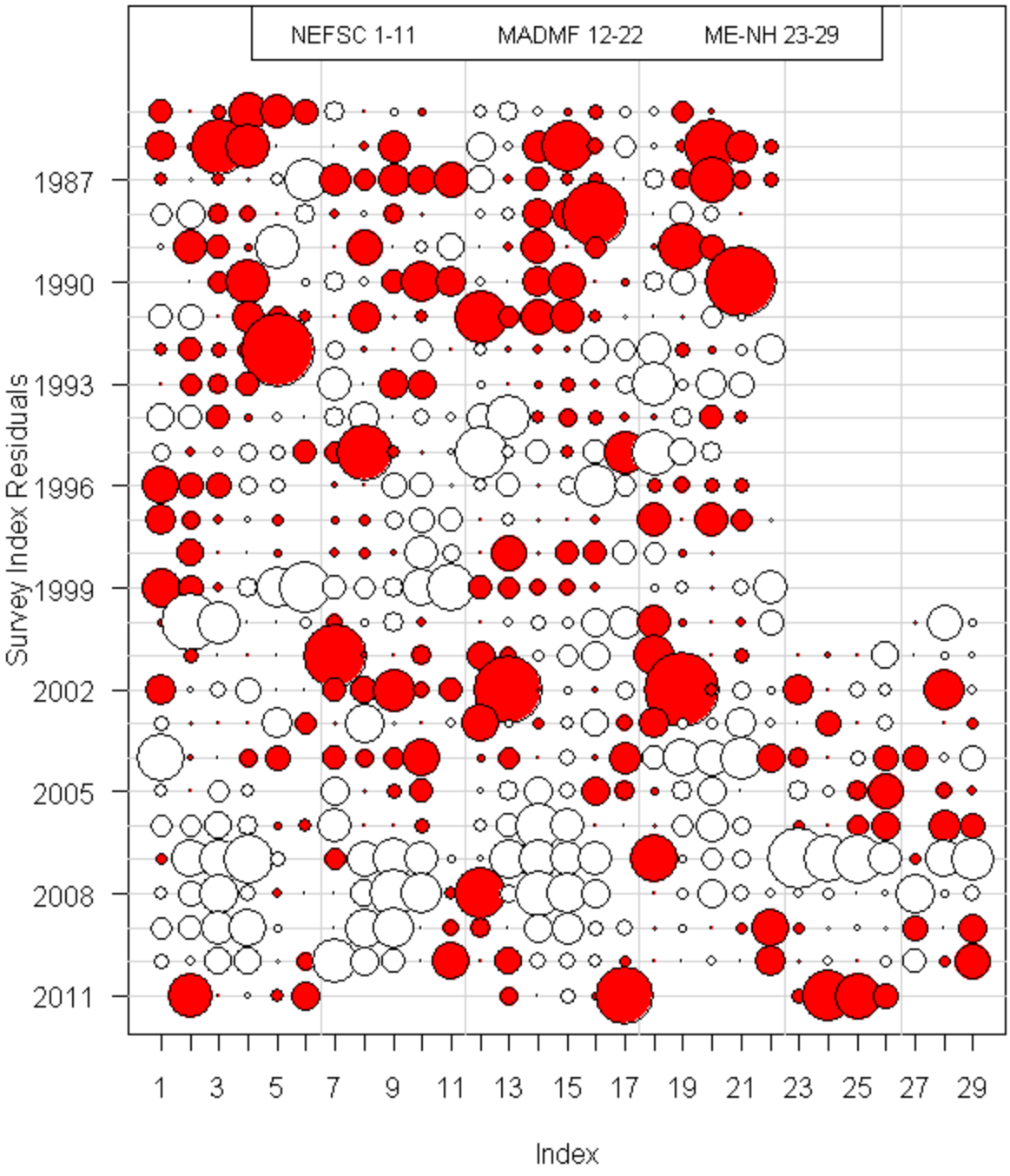

Figure D26. Residuals for indices of abundance in VPA grouped by survey: columns 1-6 are NEFSC spring ages 1-6+, columns 7-11 are NEFSC fall ages 1-5, columns 12-17 are MADMF spring ages 1-6+, columns 18-22 are MADMF fall ages 1-5, columns 23-26 are ME-NH spring ages 2-5, and columns 27-29 are ME-NH fall ages 2-4.

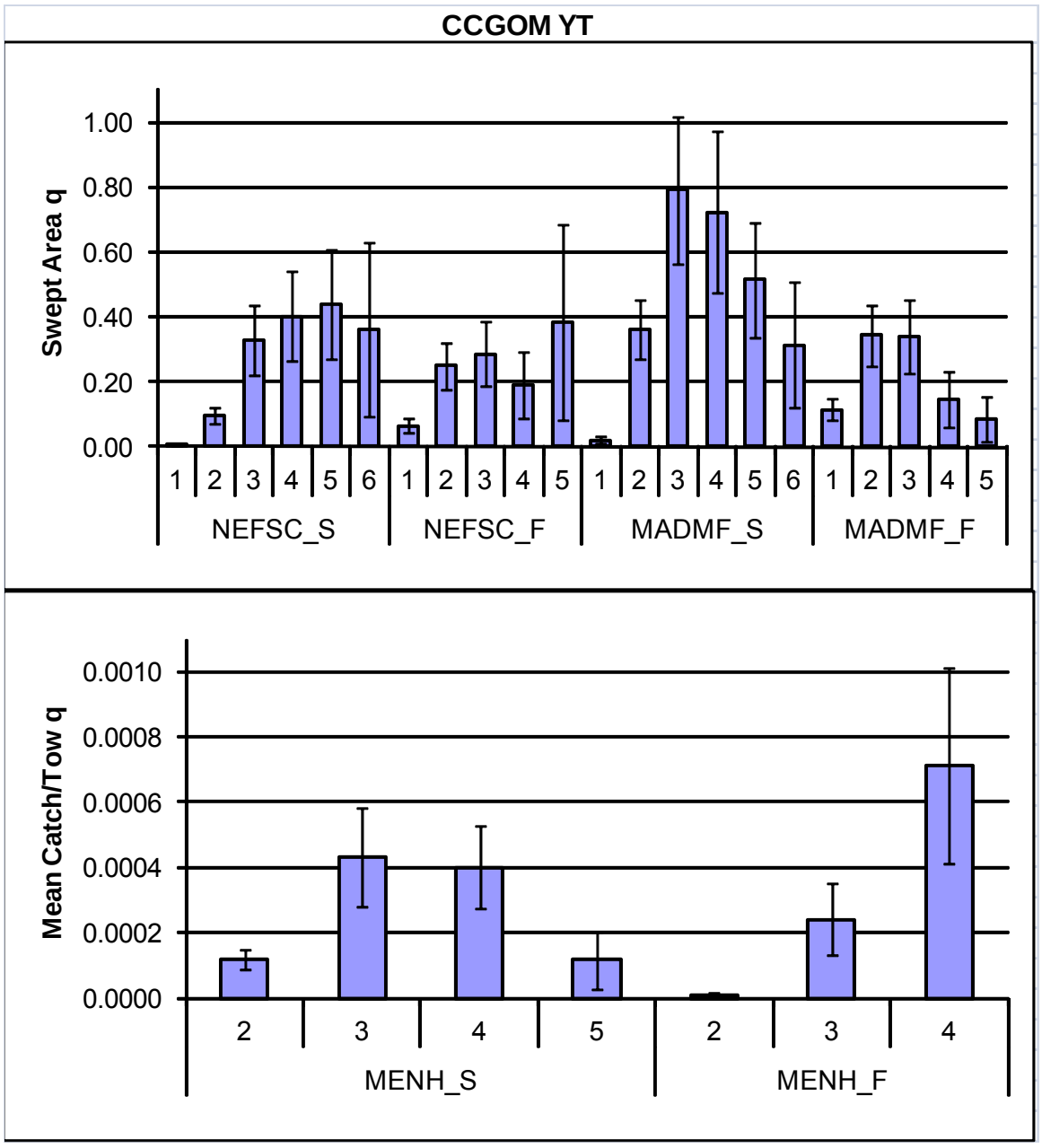

Figure D27. Catchability estimates with plus and minus two standard deviations for swept area indices (top panel) and mean catch per tow (bottom panel).

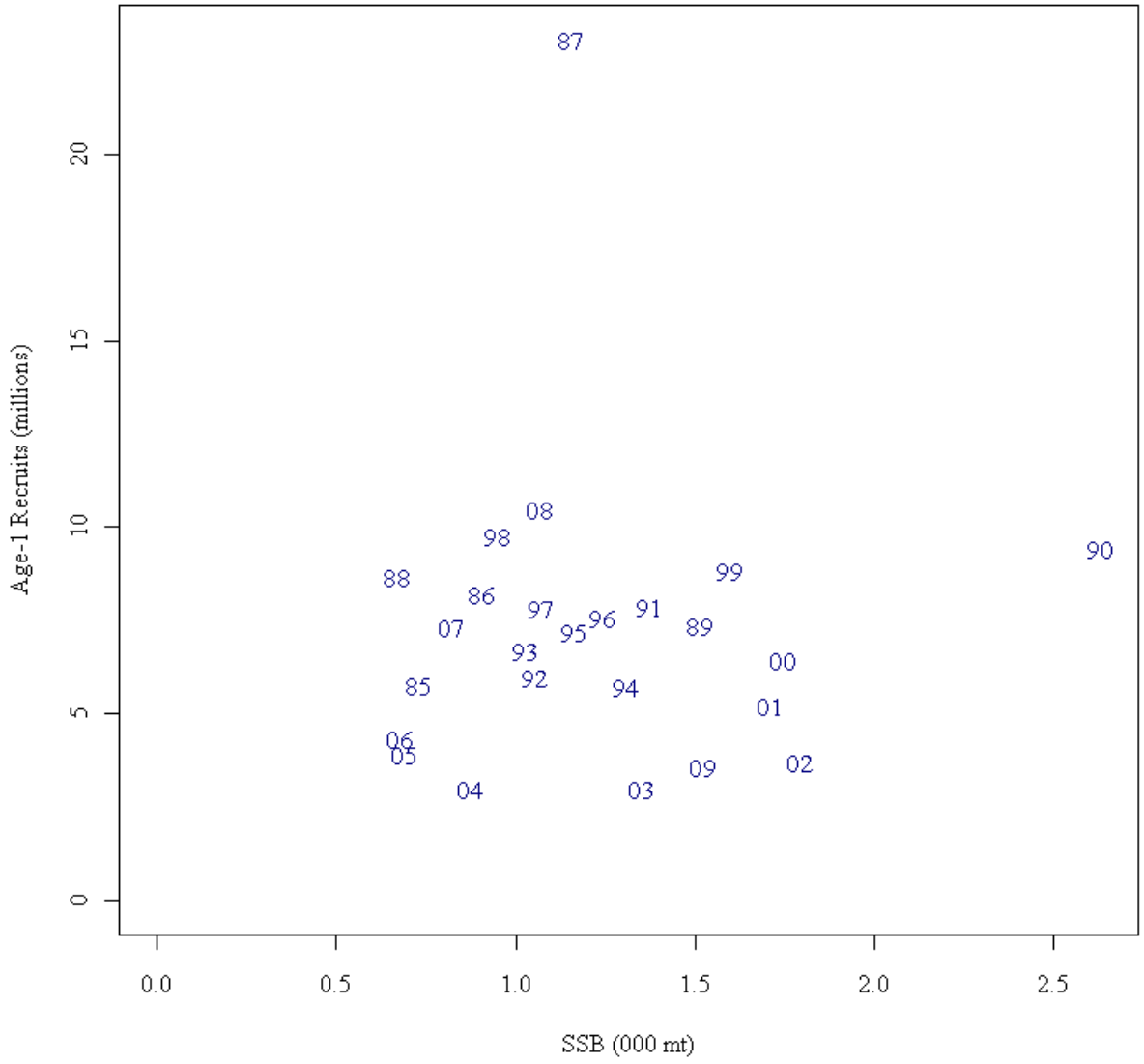

Figure D28. Stock recruitment relationship, plotted values denote the last two digits of the year associated with spawning stock biomass.

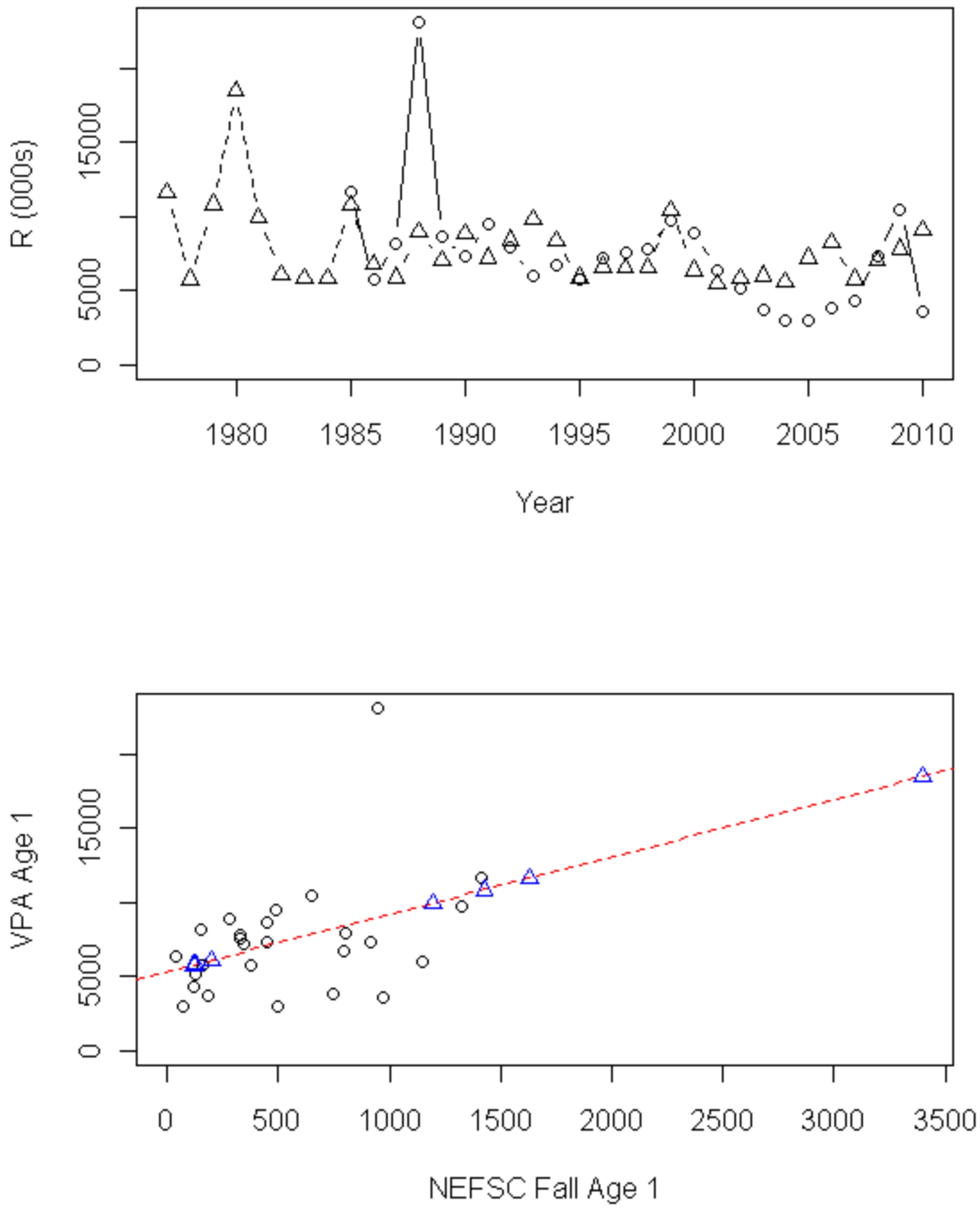

Figure D29. Hindcast estimates of recruitment using the NEFSC Fall survey at age 1.

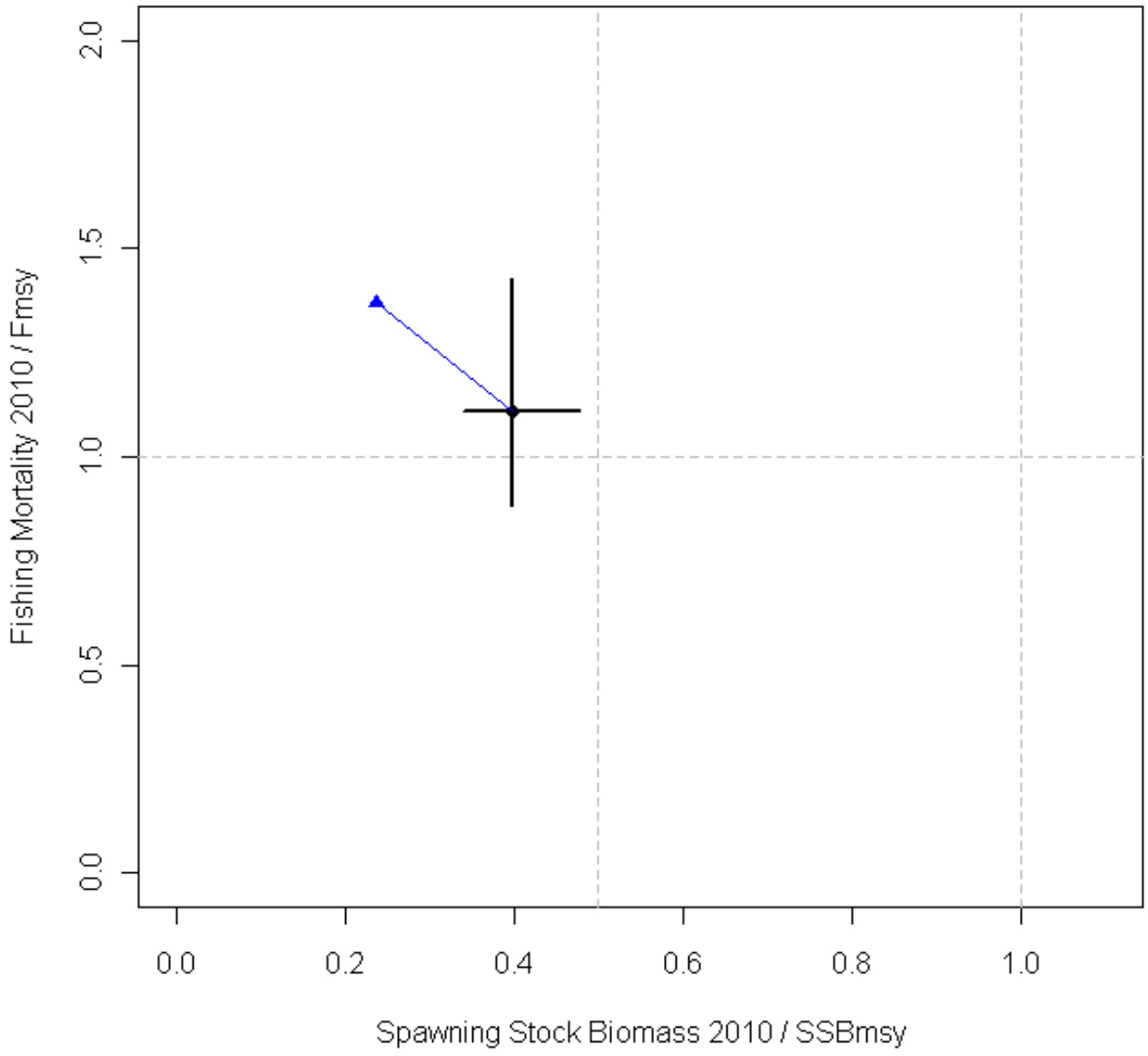

Figure D30. Current status of Cape Cod-Gulf of Maine yellowtail flounder. The black lines denote the 80% confidence interval for the 2010 F and SSB ratios. The blue triangle denotes the change in the ratios when F and SSB are adjusted to account for the retrospective pattern. The Review Panel recommended using the blue triangle for status determination.

Appendices for Section D: Cape Cod Gulf of Maine Yellowtail Flounder

Appendix D1. Extended retrospective analysis

An extended retrospective analysis was conducted which examined dropping years back to 1995 to look for changes in the direction of the estimates. Since the Maine-New Hampshire survey begins in 2000 and 2001, it was excluded from this analysis. Thirteen of the fifteen retrospective peels for F and SSB had the same directional bias, with all the additional peels (prior to 2003) occurring in the same direction (Figures AppendD1-2). Computing the Mohn's rho retrospective statistic for successive blocks of seven years demonstrates that the retrospective pattern is consistent and persistent (Figure AppendD3).

Appendix D2. Tune to subsets of surveys

Subsets of surveys were used to tune the VPA as a sensitivity analysis. The subsets were the two NEFSC surveys only, the two MADMF surveys only, the two ME-NH surveys only, the three spring surveys only, and the three fall surveys only. The uncertainty in the 2010 estimates of F and SSB for each subset was estimated through the standard bootstrapping approach and retrospective analysis was conducted to allow calculation of rho adjusted values. All five sensitivity runs resulted in higher uncertainty in the 2010 estimates of F and SSB, as seen by the larger 80% confidence intervals, and had strong retrospective patterns (Figure Append D4). The location of the subset analysis estimates of F and SSB relative to the base model change in each of the retrospective peels, but the base case which uses all the tuning indices is always located near the center of the distribution of estimates from the sensitivity analyses (Figure AppendD5). This indicates that care should be taken before drawing conclusions regarding the directional change associated with a given subset of tuning indices, because it can change over time.

Appendix D3. Catch advice from alternative approaches to address the retrospective problem

Retrospective patterns can be addressed by methods other than splitting the survey time series or adjusting the terminal year results. One approach is to estimate catch multipliers in recent years to allow the model to find the amount of catch most consistent with the survey observations. This approach is called B-Adapt in the ICES literature (ICES 2008a). A second approach is to change the natural mortality rate in recent years. Both approaches were examined for Cape Cod-Gulf of Maine yellowtail flounder and followed through to catch advice to compare with the catch advice from the unadjusted and Mohn's rho adjusted VPA results.

Catch multipliers were estimated for years 2007 through 2010. These years were selected based on the retrospective pattern observed in the original assessment. The catch multipliers were bounded at 0.2 and 5 and were applied equally to catch for all ages in each year. The catch multiplier for each year was estimated independently of the other years. The resulting catch multiplier estimates ranged from 2.4 to 3.1 with relatively good precision of 36-37% CVs (Table AppendD1). This means, for example, that the observed catch at each age for year 2010 in Table D14 was more than tripled. The retrospective patterns were substantially reduced relative to the original assessment (Figures AppendD6-7). The Fmsy proxy of F40%SPR was recalculated to be 0.27 using the mean of the recent five year selectivity from this run. For projections, the catch in

2011 was set equal to the catch in 2010 multiplied by the average multiplier 2.82 (633 mt * 2.82 = 1785.06 mt). Hindcast recruitment was estimated from the relationship between the NEFSC fall age-1 survey and the age-1 abundance estimated from this model. Projections for years 2012-2014 were conducted for the Fmsy proxy and compared to the Base and rho adjusted projections (Table AppendD2). Since the reduction of the retrospective pattern required the use of catch multipliers in recent years, it would be expected that this would continue in the future. Thus, the catches from the AgePro run should be divided by the average of the catch multipliers (2.82) in order to produce the catch that would be used in setting the OFL or ABC. These catches are approximately half of those produced by the NAA rho adjusted projections, but in the same direction as the NAA rho adjusted catches are from the Base catch advice (lower).

The natural mortality rate at all ages for years 2007 through 2010 was increased from 0.2 to 0.8, with all other ages and years left at 0.2. These years were selected based on the retrospective pattern observed in the original assessment. This fourfold increase was determined iteratively, a threefold increase did not remove the retrospective pattern while a fivefold increase changed the direction of the retrospective pattern for F and SSB. The retrospective patterns were substantially reduced relative to the original assessment (Figures AppendD8-9). The Fmsy proxy of F40%SPR was recalculated to be 1.90 using the mean of the recent five year selectivity from this run and the M=0.8 for all ages. For projections, the catch in 2011 was set equal to the catch in 2010 (633 mt). Hindcast recruitment was estimated from the relationship between the NEFSC fall age-1 survey and the age-1 abundance estimated from this model. Projections for years 2012-2014 were conducted for the Fmsy proxy and compared to the Base and rho adjusted projections (Table AppendD3). The catches in 2013 and 2014 are approximately half of those produced by the NAA rho adjusted projections, but in the same direction as the NAA rho adjusted catches are from the Base catch advice (lower).

Thus, under both approaches to address the retrospective problem, use of catch multipliers or increasing natural mortality rate in recent years, catch advice for 2013 and 2014 is lower than the Base or NAA rho adjusted projections.

Table AppendD1. Catch multipliers for years 2007 through 2010 and associated coefficient of variation.

Year	Multiplier	CV
2007	2.4087	37%
2008	2.8558	36%
2009	2.9212	37%
2010	3.1037	36%

Table AppendD2. Median catch and spawning stock biomass for Fmsy proxy projections. The label CM denotes the catch multiplier results. Note that the CM/2.82 would be the catch advice associated with the catch multiplier analysis. The Base, SSB rho, and NAA rho values are repeated from Table D35 for ease of comparison.

Median Catch (mt)

Year	CM	**CM/2.82**	Base	SSB rho	NAA rho
2011	1786	**633**	633	633	633
2012	833	**295**	1148	624	723
2013	1001	**355**	1209	684	791
2014	1240	**440**	1324	848	953

Median Spawning Stock Biomass (mt)

Year	CM	Base	SSB rho	NAA rho
2011	3530	4417	2516	2895
2012	3715	4952	2712	3149
2013	4714	5479	3189	3694
2014	5646	5963	4080	4494

Table AppendD3. Median catch and spawning stock biomass for Fmsy proxy projections. The label Inc M denotes the increase natural mortality results. The Base, SSB rho, and NAA rho values are repeated from Table D35 for ease of comparison.

Median Catch (mt)

Year	Inc M	Base	SSB rho	NAA rho
2011	**633**	633	633	633
2012	**1096**	1148	624	723
2013	**454**	1209	684	791
2014	**424**	1324	848	953

Median Spawning Stock Biomass (mt)

Year	Inc M	Base	SSB rho	NAA rho
2011	1824	4417	2516	2895
2012	750	4952	2712	3149
2013	460	5479	3189	3694
2014	464	5963	4080	4494

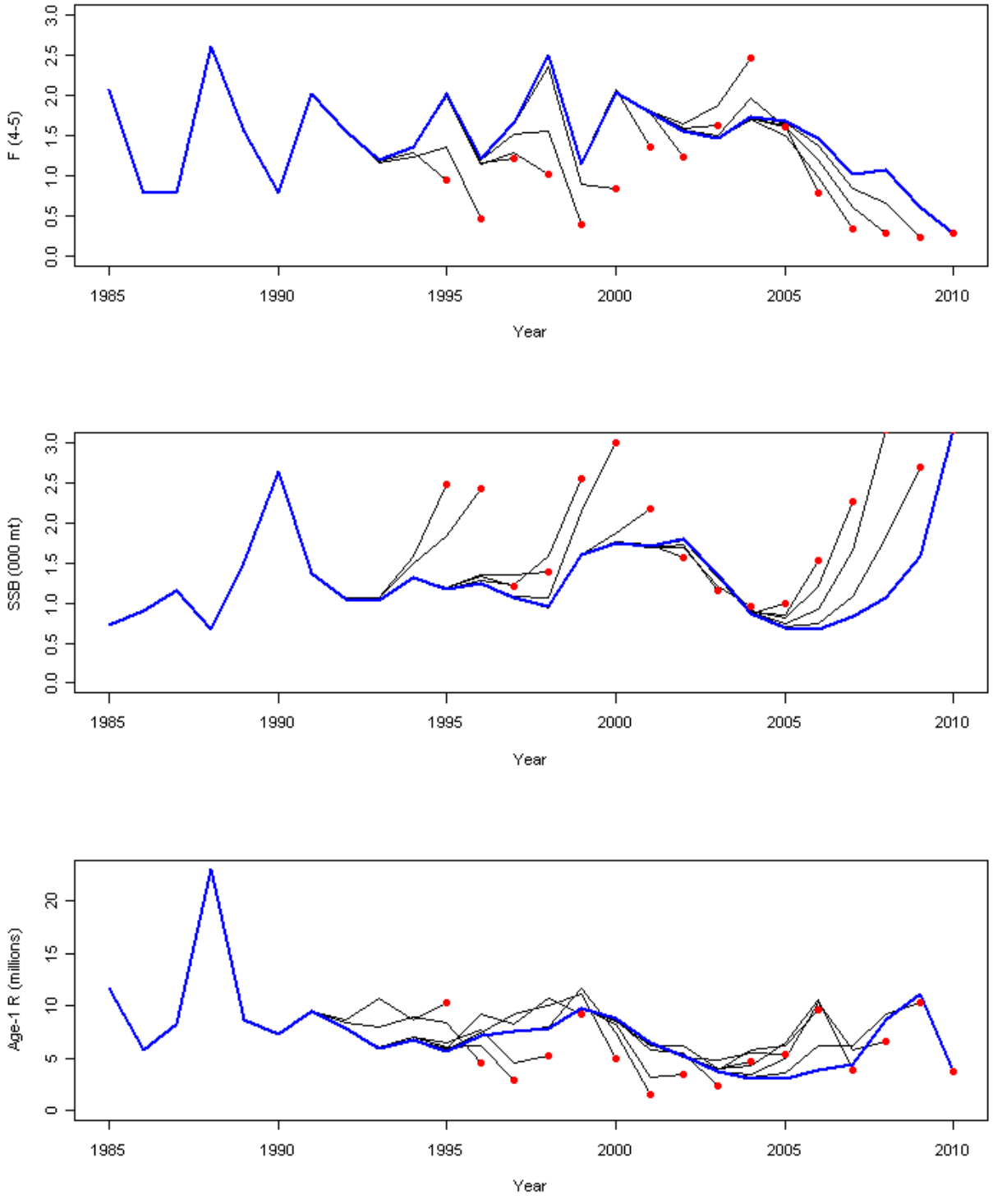

Figure AppendD1. Retrospective plots for F, SSB, and recruitment for the extended retrospective analysis.

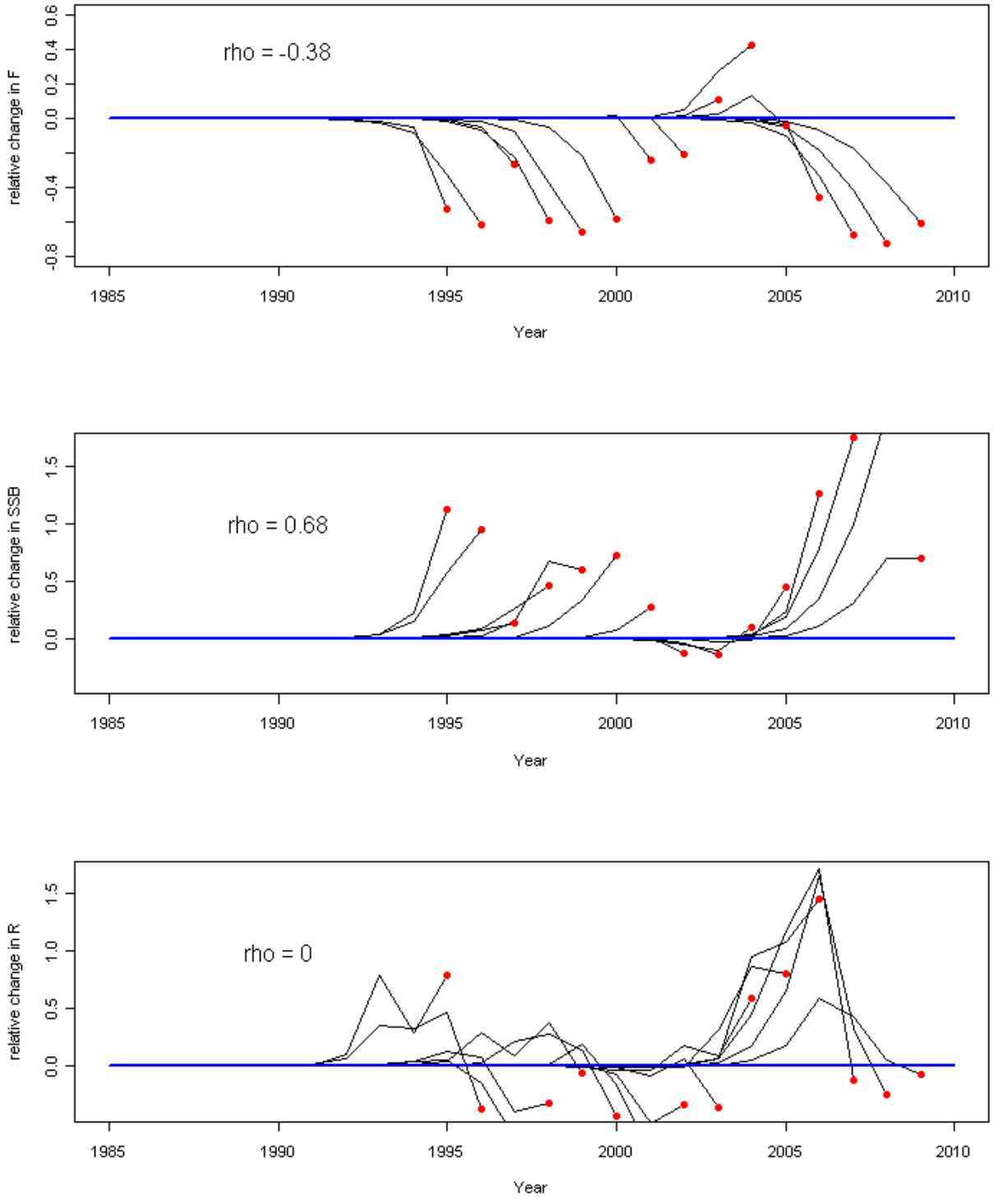

Figure AppendD2. Relative retrospective plots for F, SSB, and recruitment for the extended retrospective analysis.

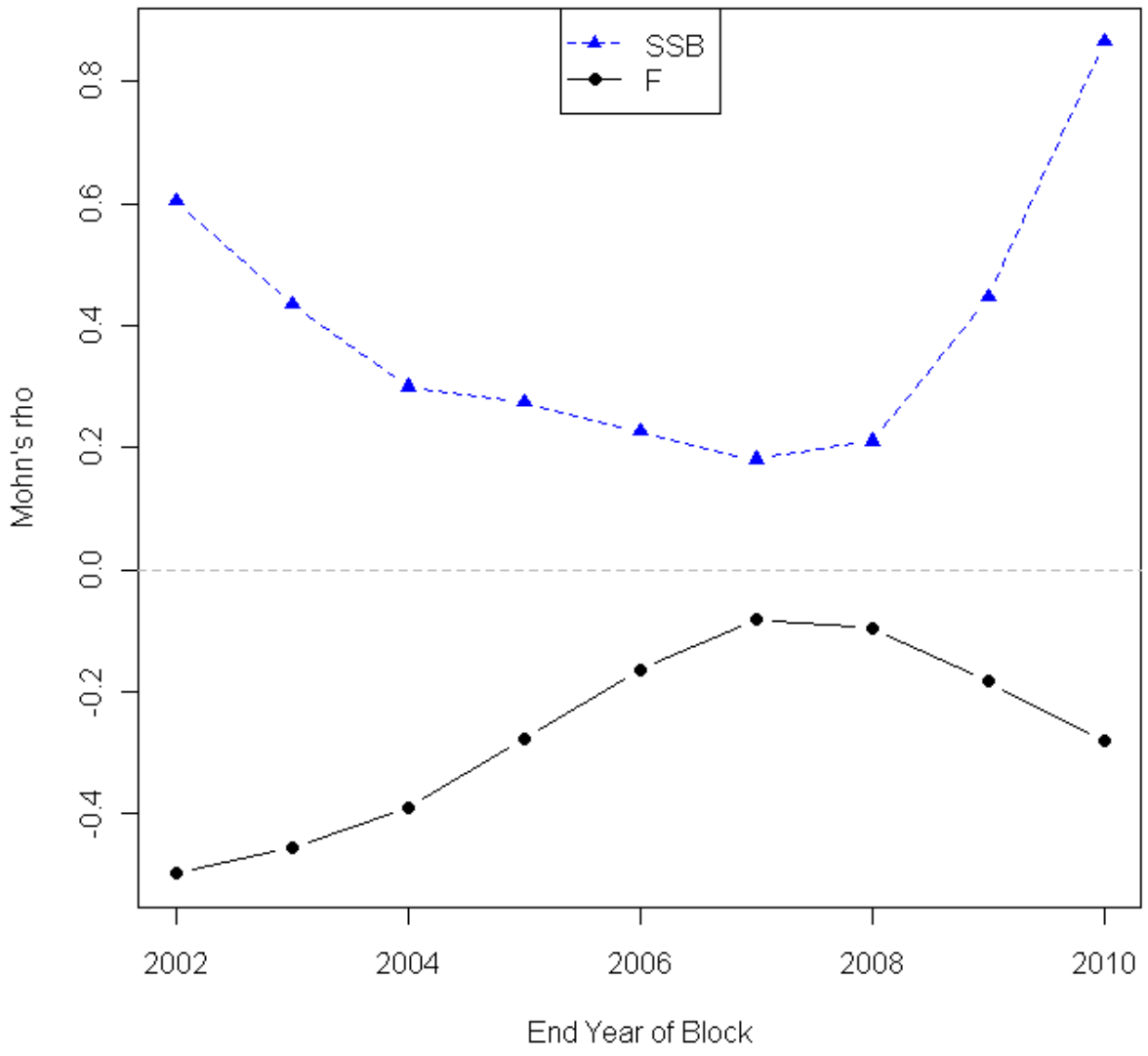

Figure AppendD3. Mohn's rho retrospective statistic for blocks of seven year peels from the extended retrospective analysis.

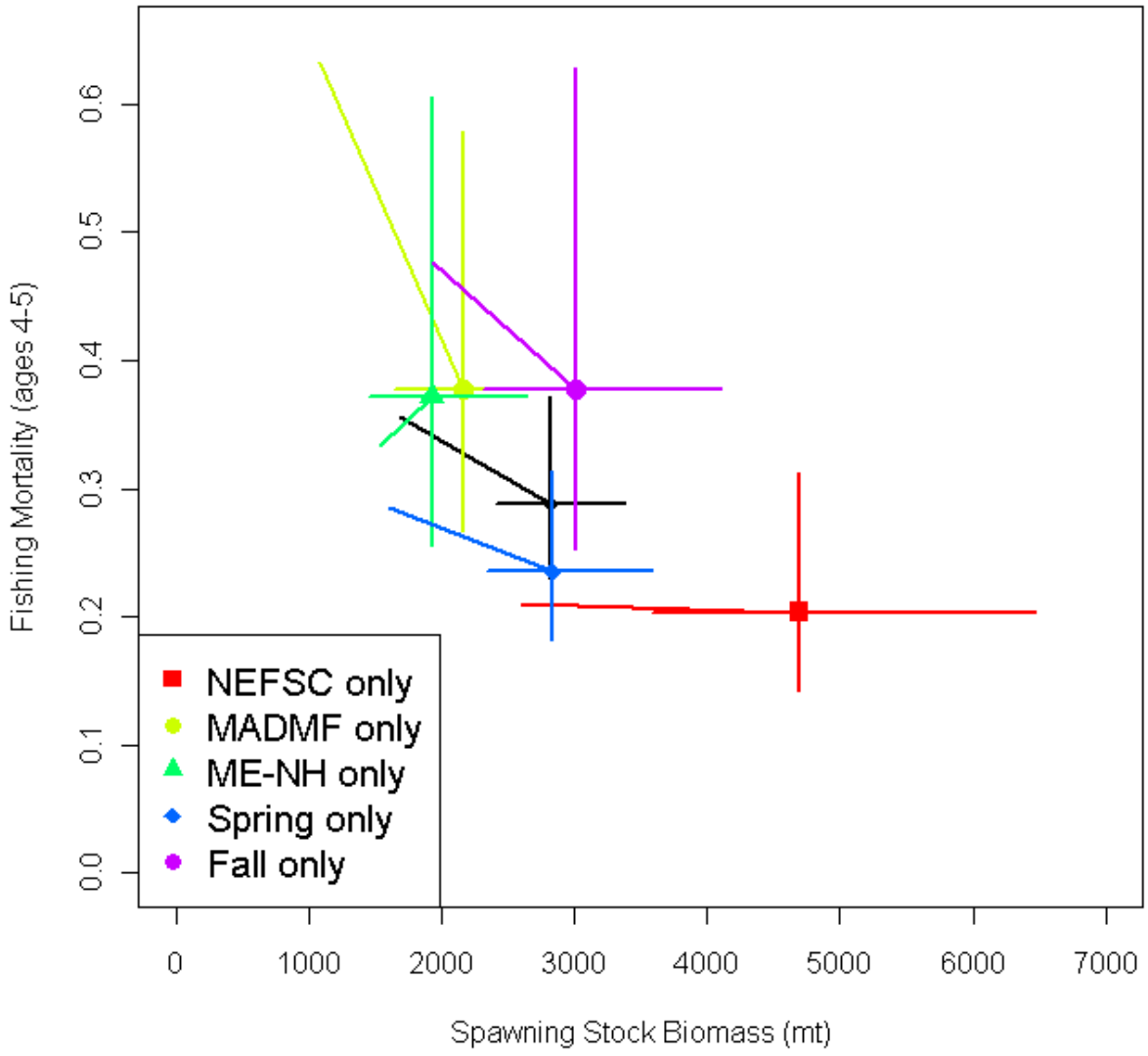

Figure AppendD4. The base case estimates of 2010 F and SSB with 80% confidence intervals and rho adjusted values (black lines) compared with the same plots for the five sensitivity analyses using subsets of the surveys as tuning indices.

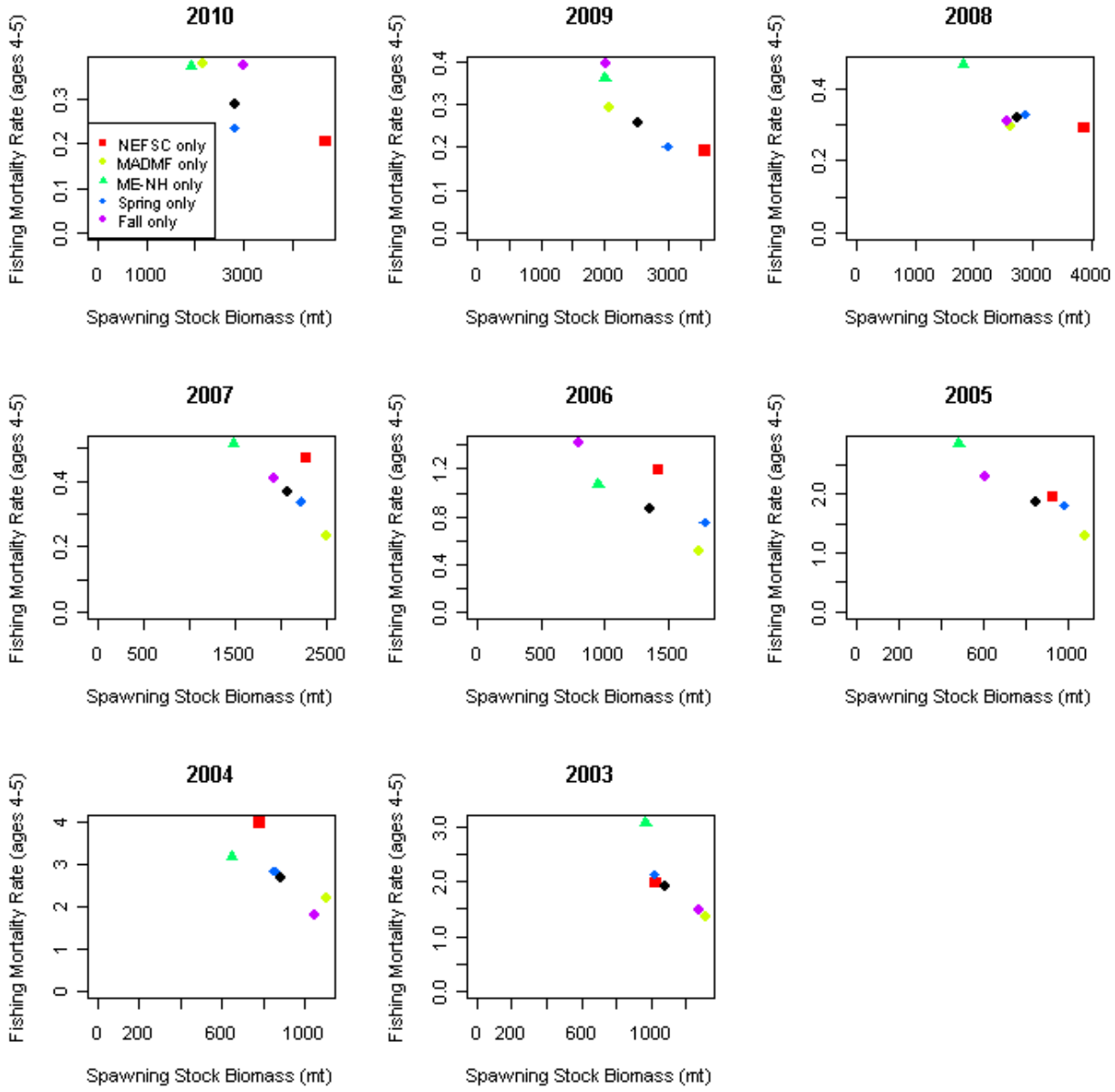

Figure AppendD5. Base terminal year F and SSB values (black) compared to the five sensitivity analyses using subsets of the surveys as tuning indices for the seven year retrospective analysis.

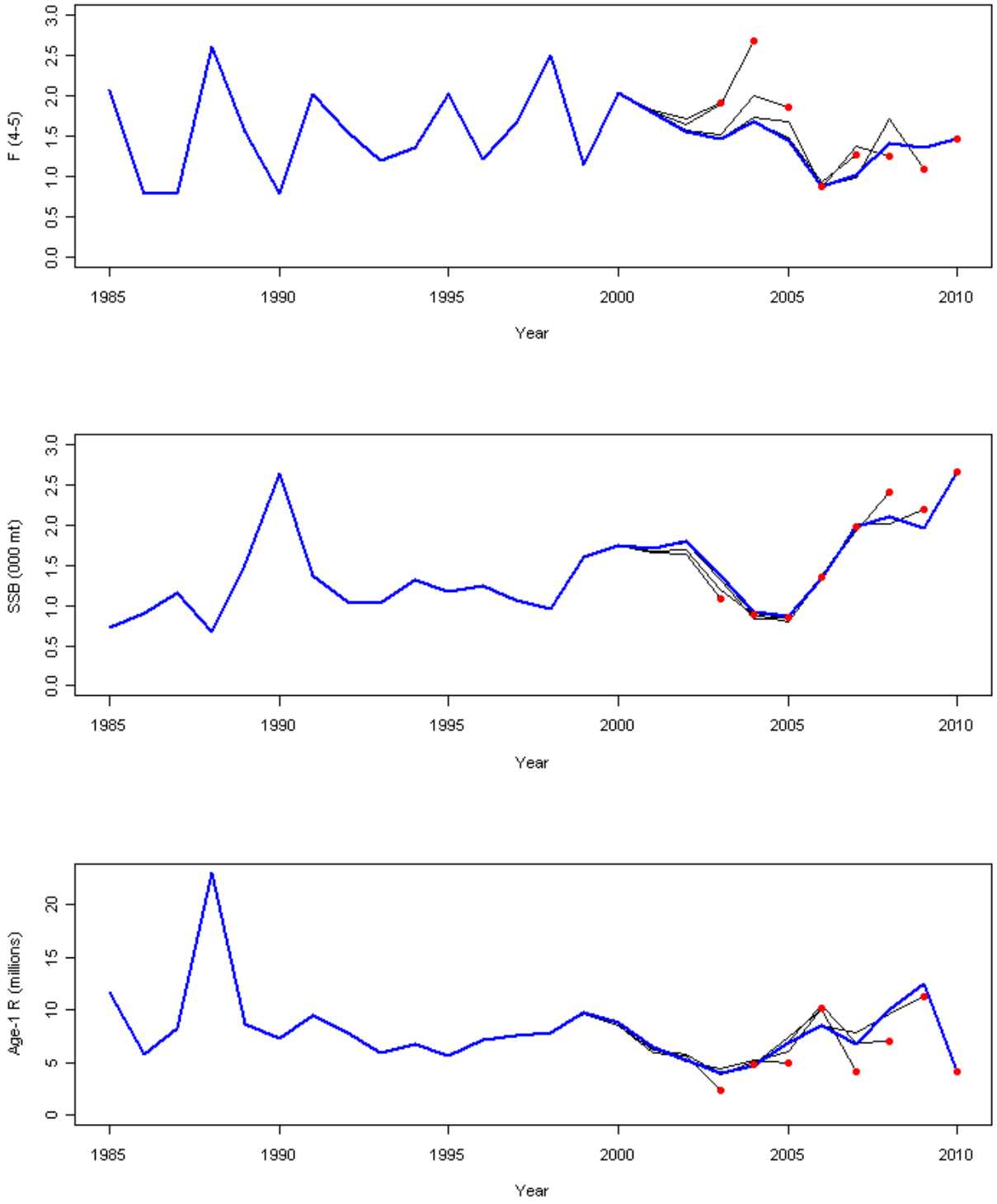

Figure AppendD6. Retrospective plots for F, SSB, and recruitment for the catch multiplier analysis.

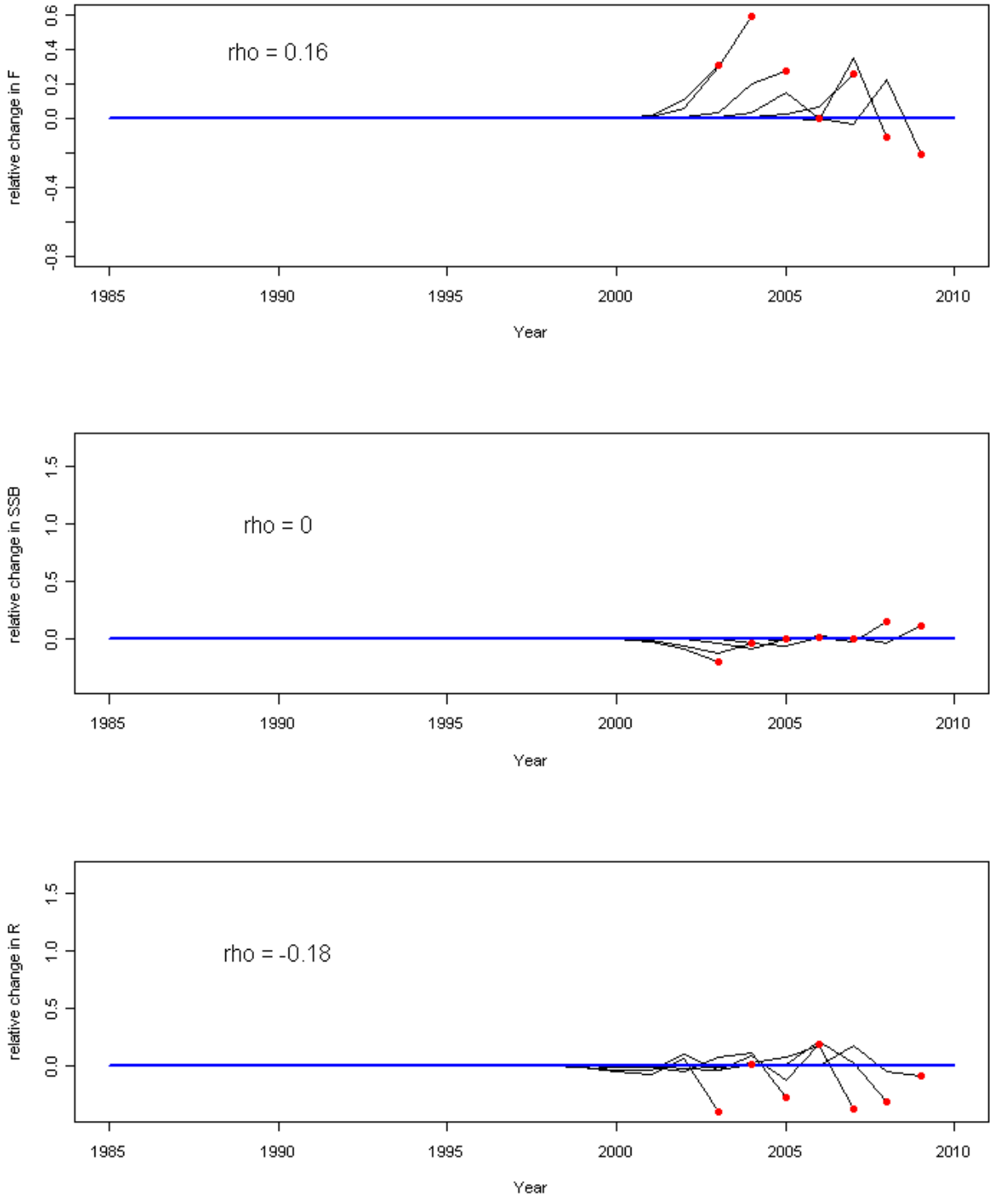

Figure AppendD7. Relative retrospective plots for F, SSB, and recruitment for the catch multiplier analysis.

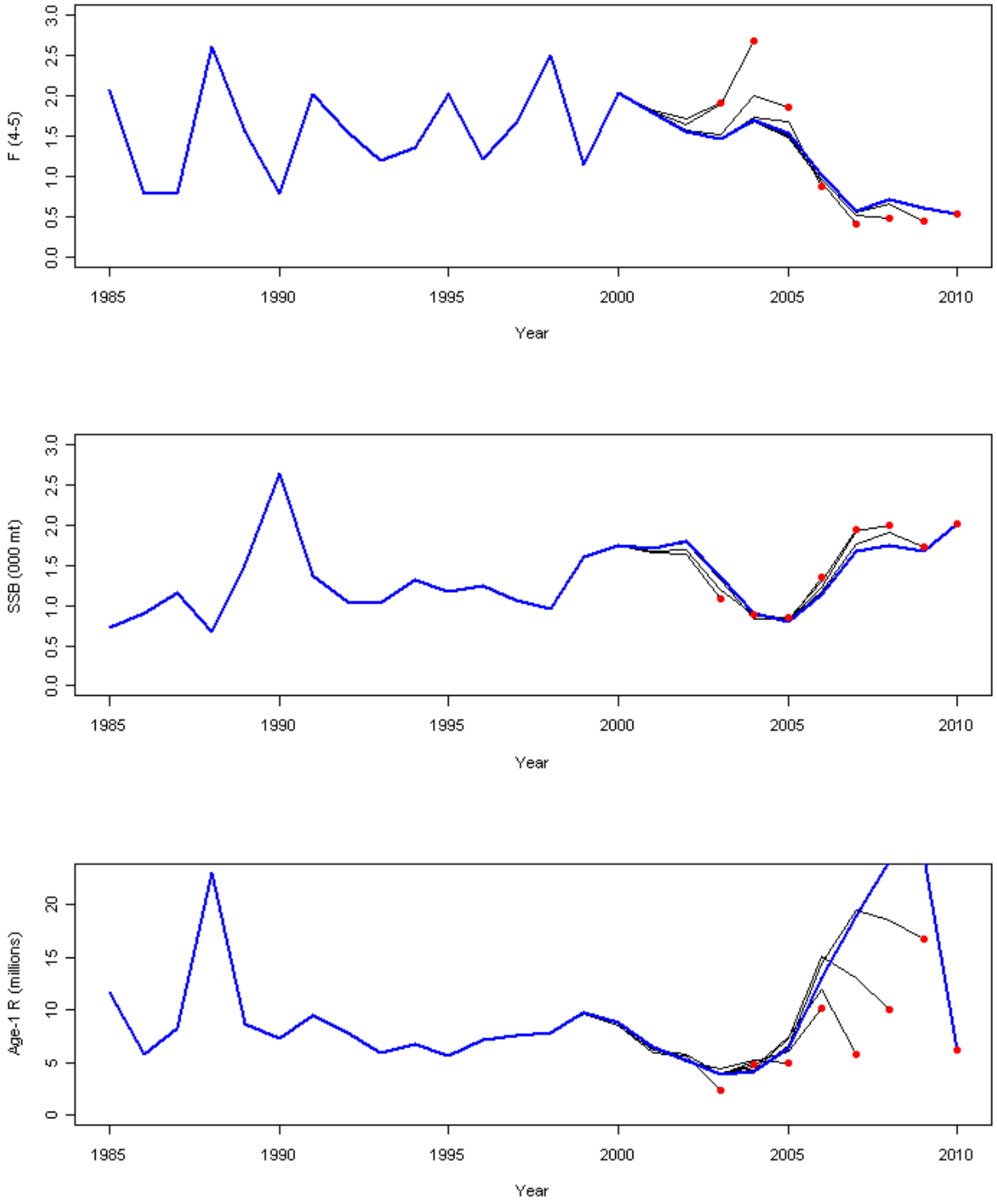

Figure AppendD8. Retrospective plots for F, SSB, and recruitment for the increase natural mortality analysis.

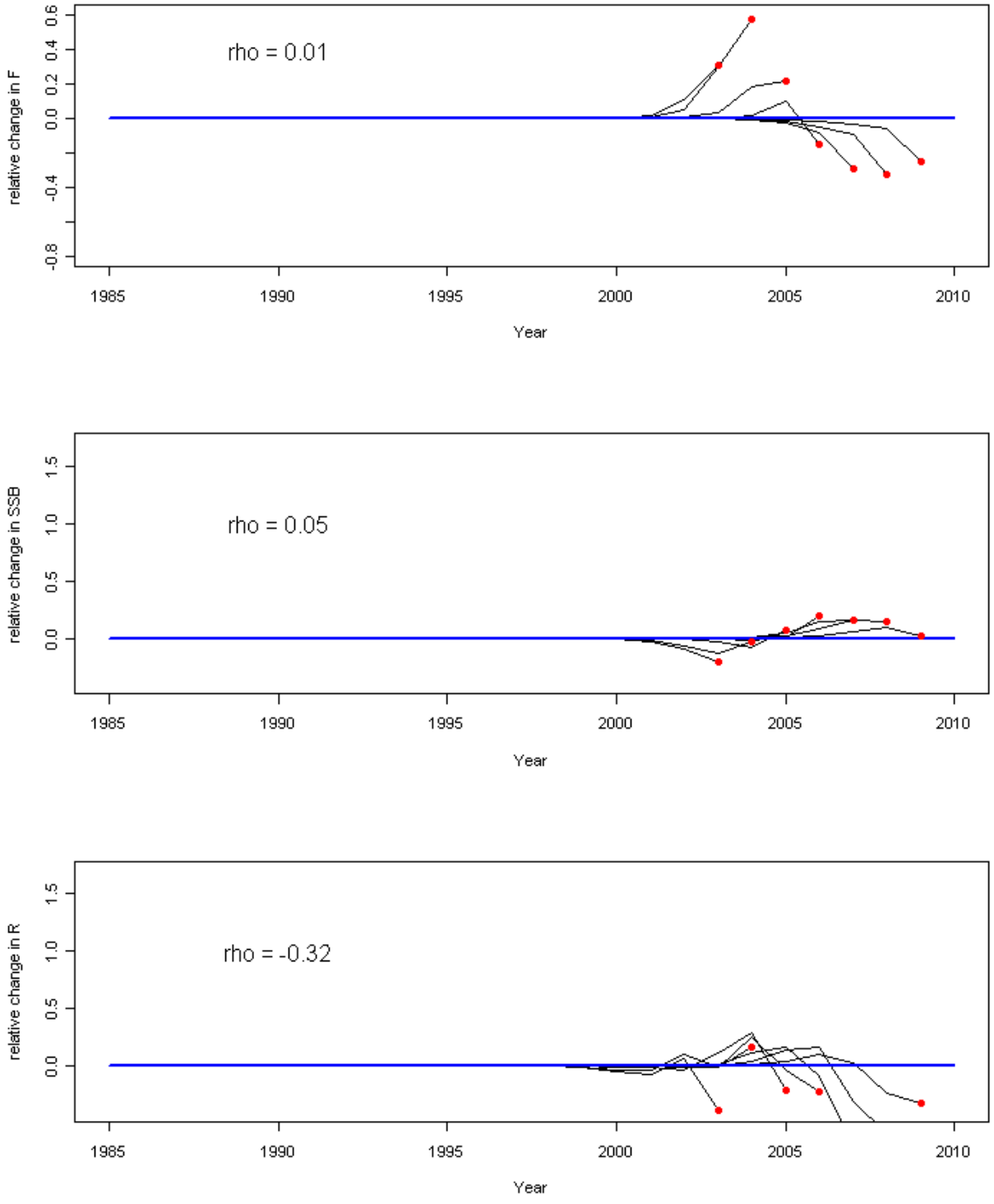

Figure AppendD9. Relative retrospective plots for F, SSB, and recruitment for the increase natural mortality analysis.