Northeast Fisheries Science Center Reference Document 12-06

Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010

by the Northeast Fisheries Science Center

March 2012

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by the Northeast Fisheries Science Center
NOAA National Marine Fisheries Service
Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

US DEPARTMENT OF COMMERCE
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I. Executive Summary and Introduction

1. Background

The Northeast Multispecies Fishery Management Plan (FMP) of the New England Fishery Management Council (NEFMC) currently comprises twenty groundfish stocks. Nineteen of the stocks were assessed and peer reviewed in 2008 in the GARM III (NEFSC 2008) and one stock, Atlantic wolffish, was reviewed in the Northeast Data Poor Stocks Working Group (DPSWG 2009a, b). Atlantic wolffish was added to the FMP after GARM III took place.

Of the twenty stocks, five were reassessed during 2010-2012, and therefore were not updated for the current report. These five stocks, which were peer reviewed in the SAW/SARC process, include pollock (NEFSC 2010a, b), three stocks of winter flounder (NEFSC 2011a, b), and Gulf of Maine cod (NEFSC 2012).

In addition to the five stocks mentioned above, two other stocks were not updated for the current report because they are scheduled for assessment and peer review in 2012. They are SNE-MidAtlantic yellowtail flounder (SAW/SARC-54) and GB yellowtail flounder (TRAC).

The current report contains updated assessment information on thirteen groundfish stocks (Table 1) from the Multispecies FMP. All are assessment updates, including a status determination, except for white hake which is a more restricted data update. White hake requires significant analytical work, beyond what can be done in an update, and is currently scheduled for a benchmark assessment in late 2012 (SAW/SARC-55).

Table 1. List of stocks, their previous assessment date and review process.

Stock Code	Count	Stock	Previously Assessed	Previous Review Process
A	1	GB cod	2008	GARM III
B	2	GB haddock	2008	GARM III
C	3	GOM haddock	2008	GARM III
D	4	CC-GOM yellowtail flounder	2008	GARM III
E	5	American plaice	2008	GARM III
F	6	witch flounder	2008	GARM III
G	7	Acadian redfish	2008	GARM III
H	8	white hake	2008	GARM III
I	9	GOM-GB windowpane flounder	2008	GARM III
J	10	SNE-MAB windowpane flounder	2008	GARM III
K	11	ocean pout	2008	GARM III
L	12	Atlantic wolffish	2008	DPSWG
M	13	Atlantic halibut	2008	GARM III

2. Assessment and Peer Review Process

A new assessment framework is being developed in the Northeast (NE) region for conducting and peer reviewing operational stock assessments more rapidly and at greater frequency. "Operational" assessments are similar to what are commonly called assessment "updates". This was the first time this process was put into practice in the NE region. The process is described in a white paper (see Appendix 1) that was delivered to the Northeast Regional Coordinating Committee (NRCC) on April 6, 2011.The paper was written by a subcommittee of the NRCC known as the ACL Working Group. See Appendix 1for a flow chart that describes the new process.

The flow chart (in Appendix 1) served as a guide for running the 2012 groundfish assessment update and peer review meeting. Some implementation details follow. At the October 2011 meeting of the NRCC, it was agreed that the NE groundfish stocks would be updated and reviewed according to the new process (Step 1 of flow chart). The lead assessment scientist for each stock planned the analysis (Step 2) and presented the work plan to the Assessment Oversight Panel (AOP) at an open meeting on November 22, 2011 (Step 3). The AOP meeting was attended by representatives of the NEFMC Science and Statistical Committee (SSC) and MAFMC SSC (John Boreman, Jake Kritzer, Mike Sissenwine). The operational stock assessments described in this report were conducted between November 2011 and February 2012 (Step 4). An integrated peer review of the assessments took place during a public meeting at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA from February 13-17, 2012 (Step 5). External reviewers were selected by the NEFMC from their SSC. One external reviewer was selected from another NOAA fisheries science center located on the Pacific coast. The integrated peer review meeting was co-chaired by the chief of the NEFSC Population Dynamics Branch and by the chair of the NEFSC Stock Assessment Workshop (SAW). Each stock assessment was presented at the open meeting by the lead assessment scientist, discussed by the review panel, and comments and questions were taken from the public. The meeting was open to the public and was also accessible over the telephone and web. On the final day of the meeting, the review panel worked with the lead assessment scientists for each stock to write final conclusions about stock status and to summarize the review panel comments. These were reviewed and approved by the entire panel before the meeting ended. Every session had rapporteurs, and their notes were used throughout the meeting, especially during writing sessions. This report, which includes assessment updates and stock status determinations, is available to fishery managers in the NE region (Steps 6 and 7). Appendices 2-4 contain a list of peer reviewers, a list of meeting attendees, and the meeting agenda.

3. Methods

The generic Terms of Reference for the groundfish stock assessment updates were:

1. Update all fishery-dependent data (landings, discards, catch-at-age, etc.) and all fishery-independent data (research survey information) used as inputs in the baseline model or in the last operational assessment.

2. Estimate fishing mortality and stock size for the current year, and update estimates of these parameters in previous years, if these have been revised.

3. Identify and quantify data and model uncertainty that can be considered for setting Acceptable Biological Catch limits.

4. If appropriate, update the values of biological reference points (BRPs).

5. Evaluate stock status with respect to updated status determination criteria.

6. Perform short-term projections; compare results to rebuilding schedules.

7. Comment on whether assessment diagnostics—or the availability of new types of assessment input data—indicate that a new assessment approach is warranted (i.e., referral to the research track).

8. Should the baseline model fail when applied in the operational assessment, provide guidance on how stock status might be evaluated. Should an alternative assessment approach not be readily available, provide guidance on the type of scientific and management advice that can be.

An underlying premise of the assessment updates was to minimize the number of significant changes in methodology that would likely require a more detailed peer review. Slight modifications were necessary depending on the availability of data and model framework. Details on these minor changes are summarized in the individual chapters.

Commercial landings data and discard estimates for 2008 to 2010 were summarized for each stock from appropriate NEFSC databases. All assessments followed the methodologies previously applied in NEFSC (2008).

All recreational landings and discard estimates were obtained from databases developed and maintained by the Marine Recreational Fishing Statistical Survey (MRFSS) program in Silver Spring, MD. The survey methodology for recreational landings data is changing and a new database is being developed under the Marine Recreational Information Program (MRIP). Data from MRIP however, were not used in the groundfish updates because the methodology for converting the historical MRFSS data to MRIP "equivalents" has not been finalized. (A national workshop on the incorporation of MRIP data in stock assessments is planned for late March 2012.) A change in the underlying recreational data for Georges Bank haddock and cod, Gulf of

Maine haddock, and wolffish would have been too large a change to make in this meeting, and merits a more intensive review in a future benchmark assessment.

The NEFSC fall bottom trawl survey indices for 2008-2010 and spring indices for 2008-2011 were included in stock assessments as appropriate. Spring and fall survey indices for the Maine-New Hampshire and Massachusetts Division of Marine Fisheries were updated for 2008 to 2010 and 2011 (spring only). Canadian Department of Fisheries and Oceans survey data for Georges Bank cod and haddock were included in the models for these stocks. All assessments used the same sets of fishery-independent abundance indices as described in GARM III.

New age-length keys for commercial and survey samples were prepared for all age-based assessments except redfish and white hake.

One of the major changes in these assessments was the use of bottom trawl survey data from the relatively new research vessel FSV *Henry B. Bigelow*. All of the NEFSC survey indices for 2009 to 2011 were based on surveys conducted by the *Bigelow*. A large-scale comparative study (Miller et al. 2010) demonstrated that catch rates for the *Bigelow* were generally higher than catch rates for the RV *Albatross IV*, and that there were length specific differences as well. In order to maintain comparability as measures of temporal trend it was necessary to convert survey catches from the *Bigelow* into *Albatross* “equivalents” using either scalar or length-specific adjustment coefficients. The choice was based on recent experience with other stocks for the same species, e.g., Georges Bank yellowtail flounder conversion coefficients were used for Gulf of Maine/Cape Cod yellowtail flounder. For some stocks it was not possible to derive statistically reliable conversion coefficients because of lack of data on those species. For example, no calibration coefficients were estimable for halibut or wolffish. Halibut conversion coefficients were estimated as the average of 4 other flatfish species; wolffish calibration coefficients were assumed to be equal to those of ocean pout, a species with similar body form and habitat.

Owing to its deeper draft, the research survey vessel *Bigelow* cannot sample the same inshore strata as the *Albatross*. This difference was unimportant for all groundfish stocks except Southern New England/Mid-Atlantic Bight windowpane flounder, which is assessed using index methods. For this stock it was necessary to re-estimate all relative fishing mortality rates and survey indices to provide consistency between the assessment and the biological reference points for that stock.

Modeling Issues

By design, there were no changes to the underlying assessment models and there were minimal changes in model configuration. All assessment models used the same sets of survey indices as described in GARM III. Previous assessment models that used split survey abundance time series continued to use them for this update and there were no changes to assumed natural mortality rates or assumptions about discard mortality rates. A summary of the model configurations is provided in Table 2.

Table 2. Summary of model configuration, use of retrospective adjustments and stock recruitment relationships for updated groundfish stocks.

				Retrospective Pattern Adjustment		***Basis for Terminal Year Estimates of:***			***Stock Recruitment Model***			
Stock Code	***Count***	***Stock***	***Model***	***Split Series ?***	***Post hoc adjust-ment?***	***Bio-mass***	***Fish. Mort. Rate***	***Re-cruit-ment***	***Type***	***Fmsy proxy***	***Bmsy Proxy***	***Recruitment Time series used for BRP estimation***
A	1	GB cod	VPA	Yes	No	2010	2010	2004-2008 geo mean	Nonparametric (2 stage)	F40%MSP	SSB/R(F40%MSP)	Recruitment from SSB greater than 50,000 mt
B	2	GB haddock	VPA	No	No	2010	2010	2010	Nonparametric (2 stage)	F40%MSP	SSB/R(F40%MSP)	Recruitment from SSB greater than 75,000 mt. Excluding 1963 and 2003 year classes.
C	3	GOM haddock	VPA	No	No	2010	2010	1977-2010 geo mean	Nonparametric (2 stage)	F40%MSP	SSB/R(F40%MSP)	Recruitment from SSB greater than 3,000 mt
D	4	GOM CC YT	VPA	No	Yes	2010 w/ rho adjust-ment	2010 w/ rho adjust-ment	1985-2008 geom mean	Nonparametric (single stage)	F40%MSP	SSB/R(F40%MSP)	Recruitment from VPA time series 1977-2008
E	5	plaice	VPA	No	Yes	2010 w/ rho adjust-ment	2010 w/ rho adjust-ment	2010	Nonparametric	F40%MSP	SSB/R(F40%MSP)	Recruitment from VPA time series 1980 to 2008
F	6	witch	VPA	Yes	No	2010	2010	2006-2010 geom mean	Nonparametric	F40%MSP	SSB/R(F40%MSP)	Recruitment from VPA time series 1982-2009
G	7	redfish	ASAP	No	No	2010	2010	2004-2008 geo mean	Nonparametric	F50%MSP	SSB/R(F50%MSP)	Recruitment from ASAP time series 1969 to 2010
H	8	white hake	(data update only)	NA	NA	NA	NA	NA	NA	NA	NA	NA
I	9	GOM GB windowpane	Index	NA	NA	2008-2010 ave.	Rel F(2010)	NA	Visual Interpetation	Rel F at Replacement	External	NA
J	10	Southern windowpane	Index	NA	NA	2008-2010 ave.	Rel F(2010)	NA	Visual Interpetation	Rel F at Replacement	External	NA
K	11	ocean pout	Index	NA	NA	2009-2011 ave.	Rel F(2010)	NA	Visual Interpetation	Rel F at Replacement	External	NA
L	12	wolffish	SCALE	NA	NA	2010	2010	2010	Nonparametric	F40%MSP	SSB/R(F40%MSP)	Recruitment from SCALE
M	13	halibut	Replacement yield	NA	NA	2010	Catch/ Biomass (2010)	NA	Implied	F0.1	Internal	NA

Retrospective patterns, whereby a particular variable appears to be consistently under- or overestimated, were important for several stocks. The GARM III precedent of splitting survey abundance series to reduce retrospective patterns was followed for the updates of Georges Bank cod and witch flounder Retrospective patterns were quantified by using a measure known as Mohn's rho. Age-specific measures of Mohn's rho were used to adjust the terminal year abundance estimates for American plaice as in GARM III. The previous assessment of redfish at GARM III used a Mohn's rho adjustment but the retrospective pattern in the current assessment was not significant. Thus, no post hoc adjustment for redfish was made. In contrast the Gulf of Maine/Cape Cod yellowtail flounder stock, which did not have a strong retrospective pattern when last assessed, could not be reduced with a split series approach in this update. As a result, the post hoc Mohn's rho adjustment approach was applied to estimate spawning stock biomass and fishing mortality in 2010.

When spawning stock biomass is consistently overestimated by the model, the use of a split abundance series in the VPA model results in a change in the catchability coefficients and can imply catch efficiencies (q) approaching unity. The change in estimated catchability is an alias for the effects of one or more factors (e.g., missing landings, underestimated discards, increased natural mortality, or true change in catch efficiency) acting individually or collectively to result in overestimation of stock biomass and underestimation of fishing mortality. The GARM III (NEFSC 2008) panel concluded "It is not possible to determine which single factor or combination of factors was responsible for the observed retrospective patterns."

Revision of Biological Reference Points (BRPs)

The bases for biological reference points in age-based assessments were not changed. However, the datasets that are used to estimate the biological reference points were updated which resulted in updated estimates of the BRPs. For example, updated five-year average weights at age, age-specific fishery selectivity and maturity at age were incorporated into estimates of yield per recruit (YPR) and spawning stock biomass (SSB/R) for each stock. Recruitment time series were updated with revised estimates for all years up to 2009. In most cases model based estimates of recruitment for 2010 and 2011 were not included in revising the BRP estimates (Table 2). The terminal year estimates of recruitment, as defined in Table 2, were used for estimation of stock size and served as the initial condition for stock projections. One important change from GARM III was that the estimate of recruitment in the terminal year was not always based on the model. Instead, recruitment was estimated as the geometric mean of multiple years. This method was judged to reduce the reliance of projections on the highly uncertain estimates of recruitment in the terminal year plus one.

No changes were made with respect to the bases for estimating cut points for two-stage stock recruitment relationships nor was the time series of recruitment selectively trimmed to reflect perceived trends in recent low recruitment. Such changes, while supported by some recent observations, were thought to be beyond the scope of the update process.

4. Results

Measures of stock biomass and fishing mortality were computed for 12 of 13 stocks. A composite snapshot of the overall stock status of these stocks (Fig. 1) reveals seven stocks that are overfished and of these, four experience overfishing. Of the five stocks that exceed ½ of the B_{MSY} proxy, one stock (GOM haddock) is experiencing overfishing.

There were no changes in overfished status between the current results and GARM III. Of the 12 assessed stocks two (Acadian redfish and SNE/MAB windowpane flounder) have exceeded their B_{MSY} proxy targets and are therefore newly rebuilt since GARM III (Table 3). Model-based estimates were not derived for white hake because the stock is currently scheduled for a benchmark assessment in December 2012.

Stock biomasses increased for eight of the 12 stocks between 2007 and 2010. Declines in stock biomass for Georges Bank and Gulf of Maine haddock stocks were expected owing to the reduced influence of the strong 2003 year class to the population. Decreases in biomass for American plaice and ocean pout were 12% and 13% respectively.

Comparisons between estimated stock sizes for 2007 from GARM III with the revised estimate for 2007 from the current update results revealed decreases of 46% for Georges Bank cod, 20% for Georges Bank haddock, 57% for Gulf of Maine/Cape Cod yellowtail flounder, and 21% for witch flounder (Fig. 2). Revised biomass estimates for GOM haddock, American plaice, redfish biomasses exceeded those estimated in 2007 at GARM III. The changes in abundance between assessments for the same calendar year estimate are the result of incorporation of more information into the estimate and reduced uncertainty in the stock biomass.

It is important to note that the "best" estimate of stock biomass is not always the terminal year estimate of the model output. Stock status determination for stocks with post hoc retrospective adjustments (plaice and GOM/CC yellowtail flounder) incorporate the effects of retrospective pattern. Index stocks, which rely heavily on the measurement of relative abundance in surveys, typically use a 3-year average to characterize abundance in the terminal year. Three-year averages are used for GOM/GB windowpane flounder, SNE/MAB windowpane flounder and ocean pout.

Estimates of biomass reference points (Table 3) decreased for 8 of the 12 assessed stocks. Such changes reflect a variety of causal factors including reduced recruitment, changes in average weight, changes in selectivity patterns in fisheries, and delayed maturation. It is not possible to ascribe such changes to a single factor.

Changes in fishing mortality and reference points are summarized in Table 4. All of the fishing mortality reference points are based on F_{MSY} proxy values. Changes in the reference points between GARM III and this update were considered negligible. Determinations of overfishing were consistent between 2008 and 2012 with two exceptions (Table 4 and Fig. 3). Overfishing of GOM haddock was not occurring in 2007 (GARM III) but is occurring in 2010. Conversely, overfishing of SNE/MAB windowpane is no longer occurring in 2010. Overfishing was occurring for five of the 12 assessed groundfish stocks in 2010. For most stocks the trend in fishing mortality is downward but GOM haddock constitutes a notable exception. Eight of the 12 stocks demonstrated reduced fishing mortality rates between 2007 and 2010.

Projections of catches for 2012 by stock at various fishing mortality rates (status quo, $F_{rebuild}$, Fmsy and 75% of Fmsy) were typically lower than the ABCs and ACLs currently specified in Framework 47 (Table 5). The increased biomass of redfish resulted in projected catches higher than ACLs for that stock listed in Framework 47 (NEFMC Groundfish FMP). A similar result occurred for the rebuilt stock of SNE-MAB windowpane flounder. Projected catches of GB cod, GOM haddock, GOM/CC yellowtail flounder, plaice and witch flounder consistent with the current control rule of 75% Fmsy were all lower than the Annual Catch limits now set for 2012.

All catch projections is this update should be considered provisional until the NEFMC SSC has received the final report and the NEFMC Multispecies Groundfish PDT has had the opportunity to update the projections with improved or final estimates of catches in 2011. All of the projections herein are based on the assumption that catches in 2011 were equal to 2010. The presentation of alternative F scenarios in Table 5 illustrates the range of likely catches under previously used candidate F scenarios.

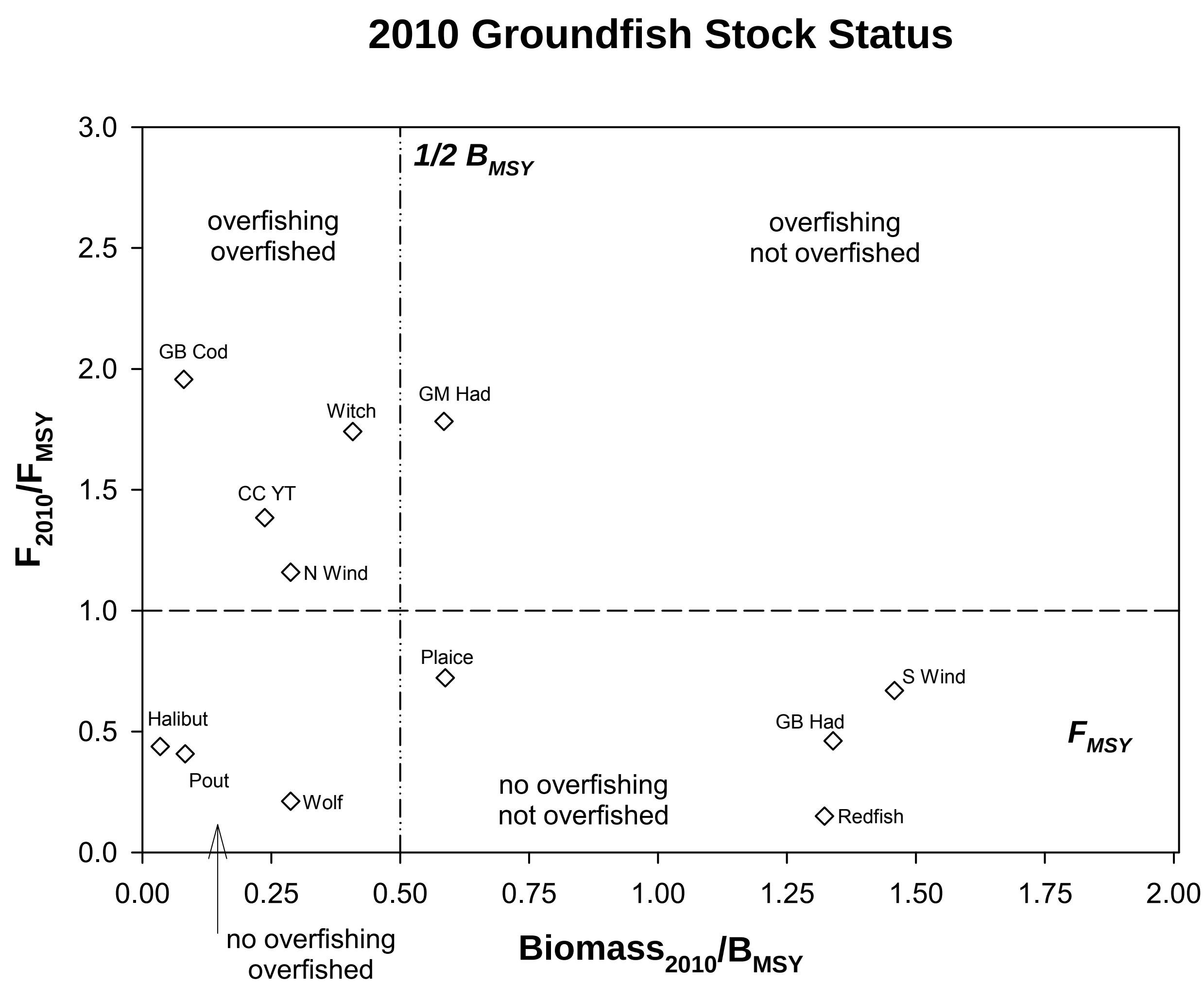
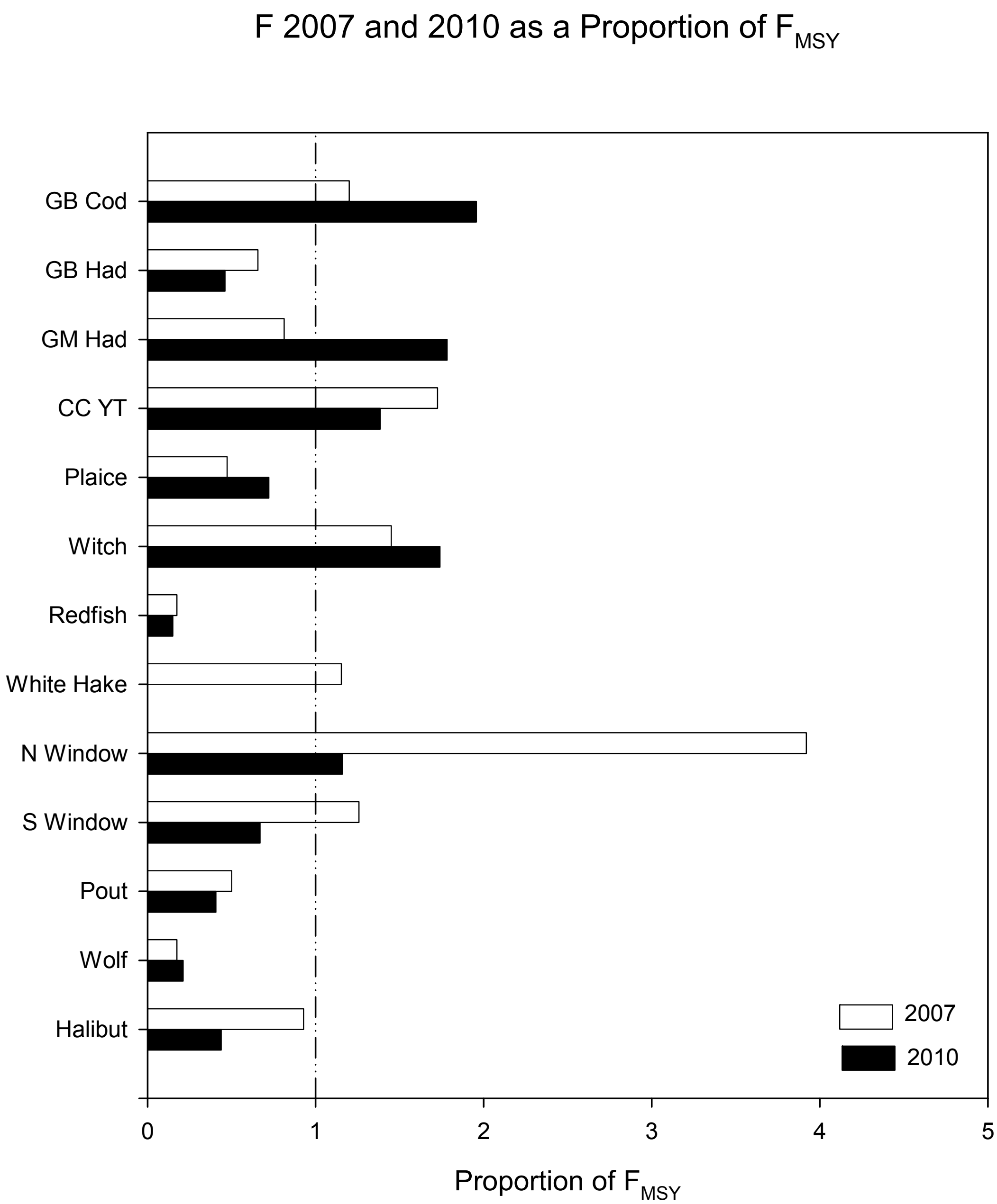
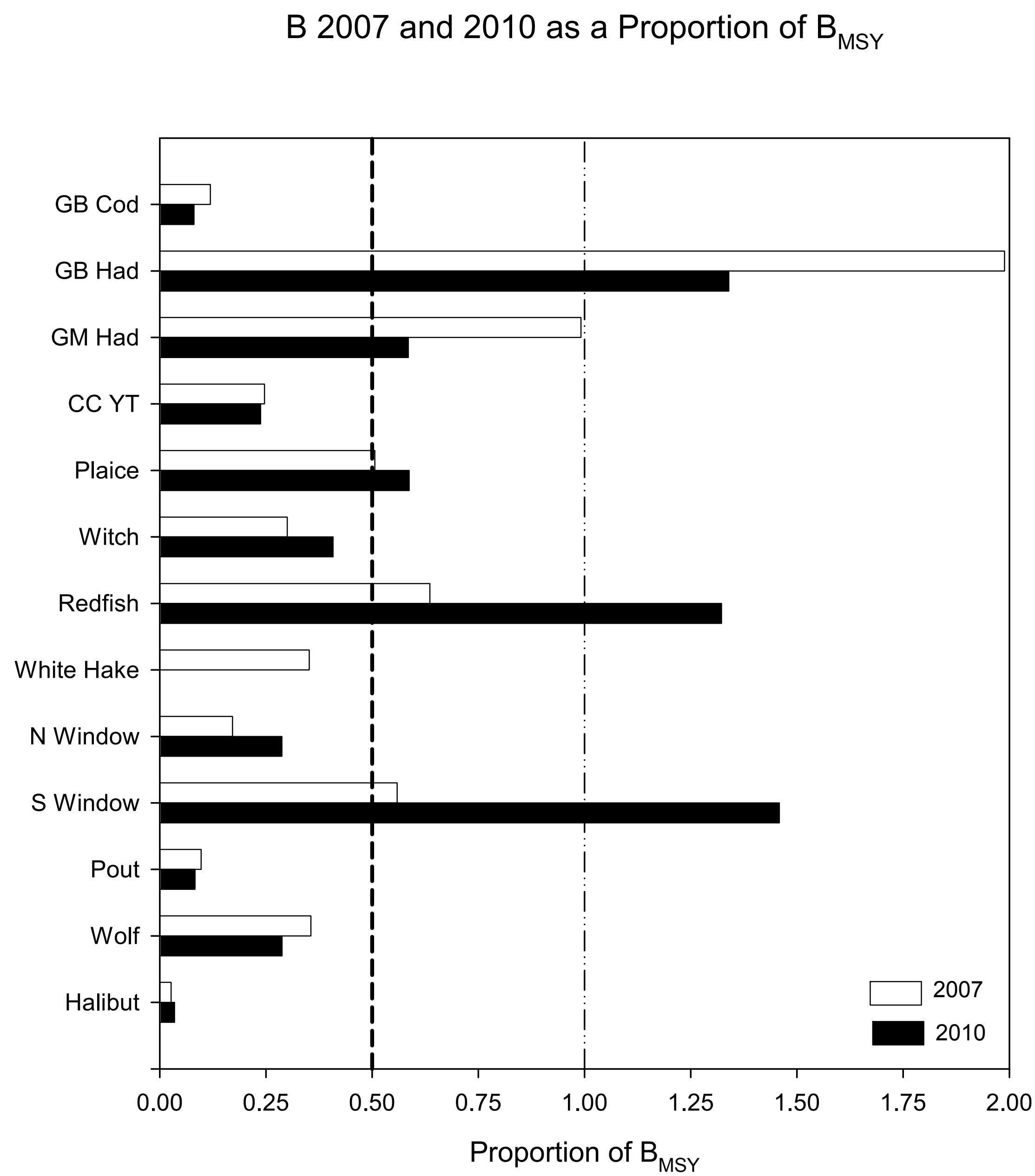


Figure 1. Status of 12 groundfish stocks in 2010 with respect to F_{MSY} and B_{MSY} proxies.



GB = Georges Bank
GOM = Gulf of Maine
CC = Cape Cod
N = Northern stock (Georges Bank/Gulf of Maine)
S = Southern stock (Southern New England/Mid-Atlantic Bight)

Figure 2. Comparisons between 2007 and 2010 fishing mortality with respect to F_{MSY} proxy based on GARM III and the 2012 Groundfish updates.



GB = Georges Bank
GOM = Gulf of Maine
CC = Cape Cod
N = Northern stock (Georges Bank/Gulf of Maine)
S = Southern stock (Southern New England/Mid-Atlantic Bight)

Figure 3. Comparisons between 2007 and 2010 measures of stock biomass with respect to B_{MSY} proxy based on GARM III and the 2012 Groundfish updates.

Table 3. Stock Status summary for **biomass** and comparisons between GARM III and Groundfish Updates Peer Review, Feb 13-17, 2012, for 13 stocks.

Stock Code	Count	Stock	Model	[1]Biomass (mt or kg/tow if noted)					Status	
				2012 Update			GARM III		Overfished?	
				$B_{msy\ proxy}$	B_{2010}	B_{2007}	$B_{msy\ proxy}$	B_{2007}	[2]GARM III	2012 Update
A	1	GB cod	VPA	140,424	11,289	9,494	148,084	17,672	YES	YES
B	2	GB haddock	VPA	124,900	167,279	252,065	158,873	315,975	NO	NO
C	3	GOM haddock	VPA	4,904	2,868	6,796	5,900	5,850	NO	NO
D	4	CC GOM YT flounder	VPA	7,080	1,680	824	7,790	1,922	YES	YES
E	5	American plaice	VPA	18,398	10,805	12,271	21,940	11,106	NO	NO
F	6	witch flounder	VPA	10,051	4,099	2,710	11,447	3,434	YES	YES
G	7	Acadian redfish	SCAA	238,000	314,780	241,090	271,000	172,342	NO	NO
H	8	white hake	(data update)	--	--	--	56,254	19,800	YES	--
I	9	GOM GB windowpane	Index	1.60 kg/tow	0.46 kg/tow	0.242 kg/tow	1.40 kg/tow	0.24 kg/tow	YES	YES
J	10	SNE MAB windowpane	Index	0.24 kg/tow	0.35 kg/tow	0.19 kg/tow	0.34 kg/tow	0.19 kg/tow	NO	NO
K	11	ocean pout	Index	4.94 kg/tow	0.41 kg/tow	0.47 kg/tow	4.94 kg/tow	0.48 kg/tow	YES	YES
L	12	Atlantic wolffish[2]	SCALE	1,756	505	490	2184 - 2202	562 - 998	YES	YES
M	13	Atlantic halibut	Replacement yield	49,000	1,700	1,320	49,000	1,300	YES	YES

Table 4. Stock Status summary for **fishing mortality** and comparisons between GARM III and Groundfish Updates Peer Review, Feb , 2012, for 13 stocks.

Stock Code	Count	Stock	Model	Fishing mortality (instaneous rates or 000 mt landings per survey kg/tow)					Status	
				2012 Update			GARM III		Overfishing?	
				$F_{msy\ proxy}$	F_{2010}	F_{2007}	$F_{msy\ proxy}$	F_{2007}	[2]GARM III	2012
A	1	GB cod	VPA	0.23	0.45	0.88	0.25	0.3	YES	YES
B	2	GB haddock	VPA	0.39	0.18	0.19	0.35	0.23	NO	NO
C	3	GOM haddock	VPA	0.46	0.82	0.23	0.43	0.35	NO	YES
D	4	CC GOM YT flounder	VPA	0.26	0.36	1.02	0.24	0.414	YES	YES
E	5	American plaice	VPA	0.18	0.13	0.08	0.19	0.09	NO	NO
F	6	witch flounder	VPA	0.27	0.47	0.52	0.2	0.29	YES	YES
G	7	Acadian redfish	SCAA	0.04	0.006	0.0049	0.04	0.007	NO	NO
H	8	white hake	(data update)	--	--	--	0.13	0.15	YES	--
I	9	GOM GB windowpane	Index[3]	0.44	0.51	2.082	0.5	1.96	YES	YES
J	10	SNE MAB windowpane	Index[3]	2.09	1.4	1.82	1.47	1.85	YES	NO
K	11	ocean pout	Index[3]	0.76	0.31	0.35	0.76	0.38	NO	NO
L	12	Atlantic wolffish[2]	SCALE	0.33	0.07	0.33	.13 - .32	0.158	UNK	NO
M	13	Atlantic halibut	Replacement yield[4]	0.073	0.032	0.062	0.07	0.065	NO	NO

[1] Column is labelled "Biomass", but for many stocks this refers to spawning stock biomass (SSB). See individual stock chapters.

[2] Wolffish was reviewed in the DPSWG (2009a,b), and not in GARM III (NEFSC 2008)

[3] For Index stocks, this is a relative F based on catch over an abundance index; units= kt/kg/tow

[4]Fishng mortality is approximated as total catch (mt) divided by stock biomass (mt)

Table 5. OFL, ABC and ACL for 2012 by stock, with provisional projected catch in 2012 (mt) under different F scenarios. Projected catches in 2012 assume that 2011 catches equal those in 2010. Estimates may be updated for management purposes. MSY estimates are listed from the 2012 Assessment Updates as well as from GARM III.

		NEFMC SSC Recommendations		Framework 47	Projected catch (mt) for 2012 based on 2012 update				MSY	
Stock Code	Stock	[1]OFL (mt)	[1]ABC (mt)	[2]ACL (mt)	Fmsy proxy	75% Fmsy proxy	Frebuild	F status quo	2012 Update	GARM III
A	GB cod	7,311	5,616	4,861	--	2787	1566	6651	28,774	31,159
B	GB haddock	51,150	39,846	29,260	45,600	--	--	--	28,000	32,746
C	GOM haddock	1,296	1,013	958	327	258	--	--	1,177	1,360
D	CC-GOM yellowtail flounder	1,508	1,159	1,104	723	558		796	1,600	1,720
E	American plaice	4,727	3,632	3,459	--	1636	0	1075	3,385	4,011
F	witch flounder	2,141	1,639	1,563	1,207	919	854	--	2,075	2,352
G	Acadian redfish	12,036	9,224	8,786	13,654	10,286	--	2,196	8,891	10,139
H	white hake	5,306	3,638	3,465	--	--	--	--	--	5,800
I	GOM-GB windowpane flounder	230	173	163	201	--	--	--	700	700
J	SNE-MAB windowpane flounder	515	386	381	729	752	--	--	500	500
K	ocean pout	342	256	240	--	--	--	--	3,754	3,754
L	Atlantic wolffish	92	83	77	--	--	--	--	261	NA
M	Atlantic halibut	143	85	83	--	--	91	--	3,500	3,500

[1]OFL and ABC values are from Science and Statistical Committee memo (page 4) to Paul Howard, for Sept. 26-29, 2011 NEFMC meeting.

[2]2012 ACL values are from Draft Framework Adjustment-47 to the NEFMC Groundfish FMP, Table 10, dated 11/14/11.

"--" = not computed

5. Sources of Uncertainty

Sources of uncertainty were identified for each assessment update (see individual chapters for details). Some of these include (Table 6):

- changes in weights at age, or questions about other life history parameters,
- estimates of catch that depend on available or estimated historical data, and/or assumed discard mortality rate,
- which years in the recruitment time series to include in projections,
- whether the research surveys are representative of stock size/abundance,
- importance of the conversion to a new research survey vessel in 2009,
- retrospective patterns in the VPA model output.

Another source of uncertainty is the ability to accurately project stock size for alternative harvesting scenarios. Appendix 5 compares projected catches and stock sizes from GARM III with the stock assessment updates herein. The Groundfish PDT used updated estimates of catches to project stock size and fishing mortality using the initial stock sizes from GARM III. In general, projected stock sizes exceeded realized values. Resulting fishing mortality estimates associated with recommended catches generally exceeded the projected confidence interval of fishing mortality from GARM III.

Much research has already been done to try to understand causes of retrospective patterns (NEFSC 2008, Legault 2009). There was discussion during the peer review meeting about potential new directions for research related to retrospective patterns. Ideas included performing retrospective analyses to determine how applying retrospective adjustments have (or would have) impacted the probability of overfishing through time. Another idea was to see if there are observable properties in the retrospective patterns that might allow distinction between transient and long-lasting retrospective patterns. There was general consensus that major advances in improving fisheries management advice in the face of retrospective patterns would likely involve extensive simulation testing.

Two research recommendations, applicable to several stocks were suggested: 1) explore the possibility of refining the calibration factors within the assessment model itself (e.g, splitting the survey tuning series and using the results from the calibration experiment as a prior); and 2) continue to examine the trends in mean weights at age and their possible underlying factors.

Table 6. Sources of uncertainty in 2012 assessment updates, by stock. (The white hake row is not filled because the assessment was not updated.)

Stock Code	Stock	Life history	M	Catch data and assumed discard mortality	Historical discards	Survey as tuning index of abundance	Survey selectivity	Bigelow Conversion factor	Low productivity depite low catches	Abundance estimate of of recent year class	Cause of Population Decrease	Projections (Weights at age, or years to include for average recruitment	Retrospective Pattern
A	GB cod	x		x	x							x	x
B	GB haddock	x								x		x	
C	GOM haddock			x								x	
D	CC-GOM yellowtail flounder							x				x	x
E	American plaice			x	x		x					x	x
F	witch flounder	x		x		x							x
G	Acadian redfish						x						
H	white hake												
I	GOM-GB window. flounder			x									
J	SNE-MAB window. flounder							x					
K	ocean pout								x		x		
L	Atlantic wolffish	x				x		x					
M	Atlantic halibut	x	x	x		x							

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II. Species Chapters

A. Georges Bank Atlantic Cod - Loretta O'Brien, Nina Shepherd, and Yanjun Wang

1.0 Background

This stock, Georges Bank (GB) Atlantic cod, was last assessed and peer reviewed in August 2008 (O'Brien et al. 2008). The assessment was conducted using virtual population analysis (VPA) where the catch at age included USA and Canadian commercial landings and discards, and USA recreational landings. Swept area estimates, derived from indices of abundance from three research groundfish trawl surveys (NEFSC spring and autumn, and Department of Fisheries and Oceans (DFO) February) were used to calibrate the VPA, and each of the surveys was split into two time series, between 1994 and 1995.

In the 2008 assessment, total commercial landings were 5,957 mt in 2007 and fully recruited F (ages 5-8, unweighted average) was estimated to be 0.30, the lowest F in the time series (1978-2007). Spawning stock biomass (SSB) was 17,672 mt in 2007. Since 1992, recruiting year classes had all been below the long term average (13.8 million age 1 fish) with the 2000 and 2002 year classes being the lowest in the time series. The 2003 year class, however, was estimated to be near average (11 million age 1 fish) and near the size of the 1998 year class (12 million age 1 fish). The NEFSC spring and autumn bottom trawl survey indices continued to remain near record low values. The last above average autumn recruitment index of survey age 1 fish occurred in 1988, 20 years prior to the terminal year 2007.

In 2008 biological reference points (BRPs) for GB cod were developed by the GARM III BRP Review Panel (O'Boyle 2008) using a non-parametric yield per recruit analysis (YPR) , to determine Fmsy = F40% maximum spawning potential. Stochastic projections, using a 2-stage cumulative distribution function (cdf), with a SSB cut-point for low or high recruitment at 50,000 mt, provided the following BRPs:

F_{MSY} = 0.25,
MSY = 31,159 mt and
SSB_{MSY} = 148,084 mt.

The 2012 assessment presented here is an update of the 2008 assessment model formulation, with the catch at age updated through 2010, and the three groundfish surveys updated through spring of 2011.

2.0 Fishery

GB Atlantic cod is a transboundary stock that is harvested by both USA and Canadian fishing fleets (Table A1). USA cod landings are generally highest in the second calendar quarter (April-June) and are taken predominantly from the western part of Georges Bank (statistical areas (SA) 521-522, 525-526, 537-539, and Subarea 6) throughout the year (Table A2, Fig. A1). SA 537-539 and Subarea 6 landings contribute a small percentage to total landings. The majority of the landings from the eastern part of

Georges Bank (SA 561-562) are taken in the first and second calendar quarter (Table A2). USA landings are taken primarily by otter trawl gear and gill net gear (Table A3). Since 1994, the Canadian fishery for GB cod has been open from June-December, and since 2005, June to the following February. Landings are taken primarily by long line and otter trawl.

Commercial Landings

Total commercial landings and catch of GB cod taken by USA and Canadian fleets, and Distant Water Fleets (DWF) are available from 1893-2010 (Fig. A2a) and total catch is available from 1960-2010 (Table A1, Fig. A2b). USA commercial landings of cod from 1994 to 2010 have been assigned to stock area using the allocation scheme described at the GARM III data meeting (Wigley et al. 2007). Total commercial landings of GB cod were 3,436 mt in 2010, a 28% decrease from 2007. In 2010, the USA accounted for 87% of the total landings and Canada the remaining 13%.

Commercial Discards

Atlantic cod discarded on Georges Bank by the USA otter trawl, gillnet, longline, and scallop fisheries were estimated using the NEFSC Observer data from 1989-2010. A ratio of discarded cod to total kept of all species (d:k) was estimated on a trip basis. Total discards by weight (Table A4) were estimated from the product of d:k and total commercial landings of all species. Discards at age were estimated annually by applying combined survey and commercial age-length keys to observer length frequency data. Estimates of discards from 1978-1988 were hindcasted using a survey filter method (O'Brien and Esteves 2001, Mayo *et al*. 1992, see GARM III BRP WP 4.5). Canadian discards from groundfish and scallop fisheries were estimated from 1978-2010. Discard estimates from the Canadian scallop fishery from 1978 to 1996 are new in this assessment, and were reviewed at the 2009 benchmark for Eastern Georges Bank cod (Wang et al. 2009).

In 2010, the USA fisheries discarded 563 mt and the Canadian fisheries discarded 92 mt. Discards accounted for 17% of the total USA catch and 11% of the total Canadian catch in 2010 (Table A1, Fig. A2b).

Recreational Landings

USA recreational landings of GB cod were estimated using data provided by the NOAA Marine Recreational Fisheries Statistics Survey (MRFSS) from 1981-2010 (Table A5). The number of length samples taken in the recreational fishery is insufficient to be used in estimating the landings at age, however, a review of available samples indicated a length range similar to that in the NEFSC survey. A combined commercial and survey age-length key, and autumn survey length frequencies were applied to the number of fish landed to obtain the landings at age. Recreational landings represent 1%-15% of the total USA catch of cod during 1981-2010. In 2010, recreational landings represented 2% of the total USA cod catch (Table A1, Fig. A2b).

Total Catch

Total combined USA and Canadian catch of GB cod was 4,159 mt in 2010, a 37% decrease from 6,588 mt caught in 2007. USA catches accounted for 80% and Canadian catches accounted for 20% of the total catch. Total discards accounted for 16% of the catch (Table A1, Fig. A2b).

Sampling intensity
The numbers of samples taken to characterize the length and age composition of the USA and Canadian commercial cod landings from Georges Bank are summarized in Tables A6a and A6b. In the USA fishery, sampling intensity by market category has been relatively high since 2003, ranging between one sample per 4 mt to 1 sample per 53 mt (Table A6a). These estimates are biased, however, since samples are usually less than 100 fish, particularly for the large market category. In the Canadian fishery, sampling since 2003 has ranged between one sample per 1 mt to one sample per 6 mt. The average number of fish measured per sample was 49 in the USA fishery and 200 in the Canadian fishery during 2010 (Table A6b).

Catch at age
Numbers (000s), weight (mt), mean weight (kg) and mean length (cm) of fish at age, for the USA commercial landings, USA commercial discards, USA recreational landings, Canadian commercial landings, and Canadian commercial discards at age are presented in Tables A7a-A7e. Total catch at age in numbers (000s), weight (mt), mean weight (kg), and mean length (cm) are presented in Table A7f and Fig.A3. USA landings at age for eastern GB (SA 561-562) and western GB (SA 521,522,525,526,537-539 and SubArea 6) were estimated separately for 1978-2010 and then combined as shown in Table A7a.

3.0 Research Bottom Trawl Surveys

Biomass and abundance indices
NEFSC spring and autumn survey biomass and abundance indices (offshore strata 13-25) generally declined from the mid-1970s to the mid-1990s. Since about 1990 the indices have fluctuated without trend and continue to remain below the long term average (Table A8, Fig. A4-A5). The DFO abundance indices (strata 5Z1-5Z8) show an overall decline since 1990 (Fig.A5). The 2009-2011 NEFSC spring and autumn survey indices were converted from Bigelow units to Albatross IV units to be able to continue the survey time series. For both seasons, a constant calibration coefficient (1.5799) was applied for the weight conversion (Miller et al. 2010) and a length-based calibration coefficient was applied to the number of fish (Brooks et al. 2010, Table A9). Catch at age for NEFSC spring and autumn surveys and DFO spring survey are presented in Tables A10a-10c and Figs.A6-A8.

The recruitment indices for age 1 from the NEFSC autumn bottom trawl survey indicate that the 2008 year class is just above the long term average. This is the first above average year class to occur in 20 years, since the 1988 year class. The 2003, while below average was stronger than the very weak 2000 and 2004 year classes (Fig. A9). The Canadian spring survey indices of abundance indicate that the 2003 year class was above average as both one and two year old fish (Fig. A10).

Age data
Details of the quality assurance and quality control for the aging of Atlantic cod by the Fishery Biology Program at the NEFSC Woods Hole Laboratory can be found at
http://www.nefsc.noaa.gov/fbp/QA-QC/hd-results.html

The precision for aging of cod samples from 2008-2010 ranged between 66.3% - 95.8 % agreement with CVs less than 5.5%.

Maturity ogives
Logistic regression analysis was used to estimate female maturity ogives from NEFSC spring research survey data for 1970- 2011. The number of samples taken each year, by sex, over the time series is not consistently high and does not allow for reliable annual estimates, so the data was smoothed by using a 5-year moving average. For example, the 1990 ogive was estimated by combining data from 1988-1992 and estimating one ogive, and then the 1991 ogive was estimated by combining data from 1989-1993 and so forth, for the time series. This means that the first year, 1970, only as three years of data (1970, 1971, and 1972) and the last year, 2010, has only 4 years of data (2008, 2009, 2010 and 2011). Confidence limits for proportion mature at age were estimated at the 95% level using the approximate variance for large samples (Ashton 1972, O'Brien et al. 1993) and inverse 95% confidence limits for A_{50} (median age at maturity) were estimated within the SAS PROBIT procedure (SAS) (Fig. A11). The maturity ogive for 2010 is presented below.

AGE	1	2	3	4	5	6	7	8	9	10
% mature	0.03	0.30	0.87	0.99	1.00	1.00	1.00	1.00	1.00	1.00

4.0 Assessment

In the 2008 assessment, fully recruited F shifted from age 4, as seen in previous assessments, to fully recruited F at age 5. This was due, in part, to increases in minimum mesh size requirements to 6.5 inch square or diamond mesh that were invoked in May 2002. From 1999 to 2002, mesh requirements had been 6.5 inch square or 6.0 inch diamond mesh.

VPA

Input data and Analyses
The ADAPT calibration method (Parrack 1986, Gavaris 1986, and Conser and Powers 1990) was used to derive estimates of instantaneous fishing mortality in 2010 and beginning year stock sizes in 2011. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality and spawning stock biomass. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

The base ADAPT formulation provided stock size estimates for ages 1-8 in 2011 and corresponding F estimates for ages 1-7 in 2010. Assuming full recruitment at age 5, the F on age 9 in the terminal year was estimated as the average of the F on ages 5-8. The F on age 9 in all years prior to the terminal year was derived from weighted estimates of Z for ages 5-8. For all years, the F on age 9 was applied to the 10+ age group. Spawning stock size estimates were estimated with female maturity ogives derived from NEFSC spring research survey data for 1978- 2011 as described above.

The catch at age (Table A7f, Fig.A3) includes combined USA and Canadian landings and discards, and USA recreational landings from 1978-2010 (Tables A7a-A7e) for age 1-10+. Swept-area estimates used to calibrate the VPA, estimated from indices of abundance, included the NEFSC 1978-2011 spring survey indices for ages 1-8 (Table A10a), the NEFSC 1977-2010 autumn survey indices for ages 0-5 (Table A10b) and the Canadian DFO 1986-1992, and 1995-2011 spring survey indices for ages 1-8 (Table A10c). The NEFSC spring survey was dis-aggregated into two series based on the use of the Yankee #36 or Yankee #41 trawl. The NEFSC employed the #41 trawl during 1973 to 1981. The spring indices were split into a series from 1978-1981 for the #41 trawl and a series from 1982-2011 for the #36 trawl. The survey has been conducted by the Bigelow since 2009 and the survey indices were converted to Albatross IV units as described above. The NEFSC survey time series have also been standardized for door and vessel changes prior to 2008. The autumn survey indices were shifted forward one age and one year to match cohorts in the spring survey in the subsequent year.

The VPA model results presented below are based on the accepted model from GARM III. The model was formulated as described above and in addition the survey times series were split between 1994 and 1995 for all three surveys.

Bridge VPA runs
Several VPAs were conducted to bridge from the 2008 accepted model, to the current 2012 VPA with terminal year 2010. The 2008 VPA (run A) with terminal year 2007 used VPA/ADAPT version 2.8.0. VPA model formulation A was run in VPA/ADAPT version 3.1.1, and the results were exactly the same (Table A12a). Two additional runs were conducted to correct a typo and miscalculation in the survey indices. Run C replaced the age 8 swept area estimates for the DFO February survey, resulting in no change in F and a slight decrease in SSB in 2007. Run D replaced the DFO 2005-2007 swept area estimates, which resulted in a slight increase in F and decrease in SSB in 2007. Run E has a revised catch at age, due primarily to revised Canadian landings and the inclusion of Canadian scallop dredge discards of GB cod from 1978-1996, which had not previously been estimated (Wang et al. 2009). This resulted in the largest change in F and SSB from the GARM III results. This final 2012 update of the GARM III run resulted in a 17% increase in F from 0.3 to 0.35, and a 2% decline in SSB from 17,652 mt to 17, 229 mt. Run E, with all the revisions, was used as the base model to update the catch at age and survey indices through 2010, and is presented as run F (Table A12b).

Diagnostics – 2012 Split VPA
The ADAPT calibration results for estimates of terminal year stock size and catchability (q) estimates, with corresponding standard error and coefficients of variation (CVs) are presented in Table A12b. Stock size estimates were more precise for ages 2-6, (CVs from 27% - 37%) than for age 1 (CV=45%), age 7 (CV=41%), and age 8 (CV=43%). Comparison of precision estimates of catchability at age, pre- and post-split, generally show higher CVs for the post-split indices (Table A12b). The q estimates for post-split indices were higher than pre-split for all surveys. Estimates of q increased with age and approached a ‘flat-top’, with error bars overlapping for the older ages (Fig. A12).

The residuals (observed – predicted) are presented in Fig. A13. The NEFSC spring survey indicated strong year effects in 1978, 2004, and 2010 and the pre-split surveys indicated either no pattern or a pattern of positive to negative residuals over time, however, in the post-split surveys there were no persistent patterns, except for age 2. The DFO survey showed strong year effects in 1990, 1996, and 1998 and the pre-split surveys showed a pattern of negative to positive residuals over time, however, in the post-split surveys there were not persistent patterns. The NEFSC autumn residuals show no persistent pattern in either the pre- or post-split surveys.

VPA Assessment Results – 2012 Split Model

Fully recruited fishing mortality (unweighted, ages 5-8) was estimated at 0.45 in 2010 (Table A13a, Fig. A14), a 37% decline from 2009. Spawning stock biomass (SSB) in 2010 was estimated at 11,289 mt, a 9% increase from 2009 (Table A13b, Fig. A15). SSB was 65% of total stock biomass in 2010 (Table A13c). Recruitment (millions of age 1 fish) of the 2003 year class (7.1 million age 1 fish) is now estimated to be smaller than the 1998 year class (12.4 million age 1 fish) (Table A13a, Fig.A15). The 2002 year class (1.3 million age 1 fish) and the 2004 year class (1.5 million age 1 fish) and are the lowest in the time series. The 2008 year class (7.5 million age 1 fish) is similar in size to the 2003 year class. The last year class (1990-20.6 million age 1 fish) above the time series average (13.7 million age 1 fish, excluding the 2009 and 2010 year classes) occurred over 2 decades ago.

Precision of F and Stock Biomass Estimates

A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the uncertainty associated with the estimate of F and SSB from the final VPA. One thousand bootstrap iterations were performed to estimate standard errors, CVs, and bias for age 1-8 stock size estimates at the start of 2011 and age 1-10+ F estimates in 2010.

The bootstrap results (Table A14a) indicate that stock sizes were well estimated for ages 3-7 with CVs varying between 0.30-0.40, however, age 1 (CV=0.83) ,age 2 (CV=0.46), and age 8 (CV=0.45) were not as well estimated. The fully recruited F for ages 5-8 was well estimated with CVs ranging between 0.19 and 0.37, however, age 1 (CV=0.44) was not as well estimated (Table 14b). There is an 80% probability that the average F in 2010 is between 0.36 and 0.60 (Fig. A16). There is an 80% probability that SSB in 2010 is between 9,884 mt and 13,721 mt (Fig. A16).

Back-calculated partial recruitment

Back-calculated partial recruitment (PR) at age from VPA was averaged over 3 time periods corresponding to changes in management: 1980-1993, 1994-2001, and 2002-2010. Within a time period, the PR was scaled to the highest averaged PR value at age. All three PR vectors appear to be flat topped. The shift from fully recruited F on age 4 during 1980-1993 to age 5 during 1994-2001 and 2002-2010 is evident (Fig. A17).

Retrospective Analysis

A retrospective analysis was performed to evaluate how well the current ADAPT calibration would have estimated F, SSB, and recruits at age 1 for seven years prior to the terminal year, 2010. Mohn's rho, calculated as the average of the 'tips' or terminal year values of each retrospective run, was calculated within each analysis.

Although there is no distinct mechanism (e.g. change in reporting and sampling systems, closed areas, life-history or environmental effect) to motivate splitting the survey time series, when the series are split in the mid-1990s (1994/1995), the result is a weaker retrospective pattern, relative to an un-split survey model. The pattern of estimating F values lower than the terminal year F is stronger than in the previous assessment (rho = -0.4711, Fig. A19a). The corresponding pattern of estimating higher values of SSB relative to the terminal year SSB (rho=0.7059) is also stronger (Fig. A19b). The retrospective analysis of recruits at age 1 indicate that recruits are estimated at higher values relative to the terminal year (rho=1.632), in all years except 2007 (Fig. A19c).

5.0 Biological Reference Points

Yield per Recruit Analysis
A yield per recruit (YPR) analysis was conducted to provide an estimate of $F_{40\%}$ using the methods of Thompson and Bell (1934). Input data for catch and stock weights (ages 1-10+) were derived from an average of the most recent five years (2006-2010). The partial recruitment (PR) was based on a normalized arithmetic mean of 2006-2010 fishing mortality from the VPA and the maturity ogive was estimated from a 5 year moving average analysis as described above, however, the 2010 ogive is based on 4 years: 2008-2011 (Table A15). Non-parametric estimates of MSY and SSB_{MSY} were estimated using the 32-year time series mean recruitment (13.253 million age 1 fish, excludes the 2009-2010 year classes), Y/R (1.3199) and SSB/R (6.4605) (Fig. A20) as:

$F_{40\%}$ = 0.23
MSY = 18,117 mt
SSBmsy = 88,671 mt.

Yield per Recruit Analysis - Stochastic MSY estimates
The GARM III BRP Panel selected the non-parametric YPR analysis as the basis for the estimation of BRPs for GB Atlantic cod. Stochastic projections using the same input data as the YPR were run out to 100 years with F_{MSY} = 0.23. Recruitment was estimated from a 2 stage cumulative distribution function (cdf) based on either 17 low estimates or 14 high estimates of age 1 recruitment. When SSB is < 50,000 mt, recruitment is drawn from the low recruitment cdf, and when SSB > 50,000 mt then recruitment is drawn from the high recruitment cdf. The 100 year projection, as done in GARM III, provided the following non-parametric biomass reference points: F40%= 0.23, MSY = 9,851 mt, and SSB_{MSY} = 48,076 mt, however, the model had not converged. A second 200 year projection also did not converge. This is due to the stock biomass being so low, at such a poor productivity, that it takes many years for the stock to build enough biomass to draw from the > 50,000 mt recruitment bin and then to stabilize at equilibrium. The lack of older spawners contributing to poor productivity is supported by a study of GB cod that indicated age diversity of repeat spawners, spatial distribution of spawned eggs, and bottom temperature all contribute to survival of eggs, and thus successful recruitment (O'Brien et al. 2003). The final model was a 200 year projection, with the F in the first 5 years set to zero and then from year 6 to year 200, F = Fmsy=0.23. The final BRPs were:

2 stage	years		F	SSB	MSY
2012	200	F=0 for 5 yr,	0.23	**140424**	**28,774**

6.0 Projections

Short term stochastic projections were performed to estimate landings and SSB during 2011-2014. The input values for mean catch and stock weights, PR, and maturity are the same as described above for the YPR analysis. Recruitment was estimated from the 2-stage CDF described above and associated with a SSB breakpoint of 50,000 mt. Catch in 2011 was assumed equal to catch in 2010. The projections were run for two F scenarios: 75%F_{MSY}=75%$F_{40\%}$ and Frebuild, for two recruitment assumptions. The first set of projections use the bootstrap distribution of the estimated age 1 recruitment (8.075 million) from terminal year +1 (2011), as estimated by the VPA. The second set of projections use the bootstrap distribution of the 2004-2008 geometric mean of age 1 recruitment (3.797) from the VPA, given that the terminal year+1 estimates are highly uncertain and generally overestimated. The rebuilding plan for GB cod requires that the stock reach SSB_{MSY} by 2026. The $F_{rebuild}$ was estimated in a separate medium term projection out to 2026 using the same input data as above. The stock is projected to rebuild to SSB_{MSY}= 140,424 mt by 2026 with a 50% probability under F= 0.12 for estimated age 1 recruitment or under F=0.09 for the geometric mean recruitment.

The results of the short term projections (Table A16) indicate that under all scenarios catch is projected to decrease and SSB is projected to increase in each year from 2012-2014, relative to 2011, except for year 2014 in the 75% Fmsy , age 1 estimated recruitment scenario.

7.0 Summary

The Georges Bank Atlantic cod stock is overfished and overfishing is occurring (Fig. A21). Fishing mortality (unweighted, ages 5-8) in 2010 was estimated to be about 0.45, however, if the F is adjusted for retrospective bias, F2010 = 0.85. SSB was estimated at 11,289 mt in 2010, 8% of SSB_{MSY} = 140,424 mt. SSB in 2010, adjusted for retrospective bias would be 6,618 mt, about 5% of $SSB_{MSY.}$ The last year class that was above the time series average (13.7 million age 1 fish) occurred almost 2 decades ago in 1990. The 2003 year class, which had been estimated in 2008 to be near the average at 10 million fish is now estimated to be 7 million. The 2008 and 2010 year classes are estimated to be about 8 million age 1 fish, however, with the retrospective bias adjustment, the estimate would only be about 3 million age 1 fish.

Sources of uncertainty include:
1) the estimation of discards, particularly those hindcasted from 1978-1988,
2) the estimation of recreational landings, with very few length samples available, and the lack of sampling during the first 2 months of the year.
3) the presence of substantial retrospective bias for F, SSB and recruitment

Acknowlegdements
The assessment is only possible due to the collection of data on the research surveys, commercial vessels, in the port, and from the fishermen and dealers, and to the auditing and analysis of data, including the aging. The attention to detail and accurate reporting and sampling is essential to the interpretation of the assessment and we thank everyone for their hard work and effort.

8.0 Panel Discussion / Comments

Stock: ***Georges Bank Atlantic Cod***

Conclusions:

Status of Stock

SSB in 2010 is estimated to be 11,289 mt.
F in 2010 is estimated to be 0.45
Revised estimates of the biological reference points are:
SSBmsy proxy= 140,424 mt,
Fmsy proxy = 0.23 and
MSY proxy= 28,774 mt.

Based on these results, the stock of Georges Bank cod is overfished, and overfishing is occurring. The stock is below the biomass target.

The results are based on the same model used in GARM-III (NEFSC 2008), which includes splitting the time series in the mid-90s. However, the recruitment in 2011 was estimated using a geometric mean for years 2004-2008 instead of being estimated directly.

The BRPs are based on the following revisions: updated average selectivity and mean weights and an updated mean maturity ogive that resulted in a decrease in F40% from the 2008 estimate of 0.25 to 0.23.

GB Cod. Summary of Assessment Information

GB Cod	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg	Min	Max	Yr. Range
Landings (mt)	10750	8169	4621	3384	3796	4807	4645	4002	3436		24645	3384	57160	1960-'10
Discards (mt)	399	681	449	1268	914	1774	604	1080	655		682	147	1774	1978-'10
Catch (mt)	11386	9054	5415	4895	4788	6588	5297	5100	4159		25668	4159	61172	1960-'10
Recruits (000s)	3884	1269	7136	1579	3940	4851	3659	7536	3318	8075	13253	1269	46088	1978-'10
F avg 5-8	0.84	0.91	1.03	0.97	0.95	0.88	0.72	0.71	0.45		0.71	0.29	1.19	1978-'10
SSB (mt)	18951	12766	9698	8249	9146	9494	8793	10314	11289		40993	8249	96427	1978-'10

Reviewer's Comments

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

The 2008 GARM recommended using areas swept indices because survey catchability (q) greater than one may indicate that other factors may be contributing to model uncertainty. There was some discussion about whether there is incompatibility between the DFO and NEFSC surveys, given the high q in the DFO. The DFO survey has used 3 different vessels and calibration coefficients are not available. The DFO survey did not sample every stratum across the Bank in 2006, 2007, 2009 and 2010 so that changes in survey indices reflect both changes in population and sampling area. Population changes with sampling changes may confound the interpretation of high q. Despite differences in q, both the spring NEFSC and spring DFO surveys have a long term declining trend.

The panel discussed the stock's recent low productivity and the panel questioned whether this current period represents a new prevailing condition. The Panel discussed how to deal with the low expected recruitment at low stock size. The 2008 GARM assessment modeled the stock recruitment relationship as a two stage stock recruitment relationship with a breakpoint at 50,000 mt (GARM 2008). Although the breakpoint of 50,000 mt in the 2-stanza recruitment model is based on an objective method, the breakpoint is still driven by existing observations. More recruitment events around the breakpoint could potentially influence the reference point estimation, or require a re-estimation of the breakpoint. There was some discussion by the panel about whether the 2-stage approach for recruitment works for long-term projections to estimate MSY and modeling long-term productivity because of the likelihood of staying in the low recruitment stanza due to low stock size. Any revision considered for the stock recruitment relationship is more appropriate for a benchmark assessment.

Current low productivity is related to current age structure, which is truncated compared to age structure in the late 1980's.The last year SSB was above the 50,000 mt threshold was 1991 and the 1990 yearclass was the last above average yearclass. Population recovery will be more likely if the age structure is expanded due to lower fishing mortality, however, achieving rebuilding will be very slow even under a range of low fishing mortality rates if current productivity continues. The estimate of $F_{rebuild}$ decreased in this assessment relative to the one from GARM 2008.

Recommendations were made to investigate the effect of uncertainty in maturity at age in the estimation of SSBmsy. Research into incorporating trends in biological parameters (weights, maturity) into projection methodology is suggested.

Retrospective rho estimates are now higher than in the GARM III split model, i.e. rho-adjusted values are outside of bootstrap CI's. The reviewers discussed whether to rho adjust or not, given the surveys were split to adjust for retrospective bias. An analysis showed large reductions in estimates of age 1 yearclasses as a function of time from the terminal year of the assessment. The panel concluded that the geometric mean of the recruitment time series (2004-2008) be used as an estimate of age 1 in the year t+1. The panel preferred this option over rho-adjusting age 1 terminal year stock sizes. An analysis of rho-adjusting all terminal ages was unavailable.

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Table A1. Commercial catch (metric tons, live) of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1960-2010.

Table

	Country												
	USA				Canada							Total	Total
Year	Landings	Discards	Rec.	Catch	Landings	Discards	Catch	USSR	Spain	Poland	Other	Landings	Catch
1960	10834			10834	19		19	-	-	-	-	10853	10853
1961	14453			14453	223		223	55	-	-	-	14731	14731
1962	15637			15637	2404		2404	5302	-	143	-	23486	23486
1963	14139			14139	7832		7832	5217	-	-	1	27189	27189
1964	12325			12325	7108		7108	5428	18	48	238	25165	25165
1965	11410			11410	10598		10598	14415	59	1851	-	38333	38333
1966	11990			11990	15601		15601	16830	8375	269	69	53134	53134
1967	13157			13157	8232		8232	511	14730	-	122	36752	36752
1968	15279			15279	9127		9127	1459	14622	2611	38	43136	43136
1969	16782			16782	5997		5997	646	13597	798	119	37939	37939
1970	14899			14899	2583		2583	364	6874	784	148	25652	25652
1971	16178			16178	2979		2979	1270	7460	256	36	28179	28179
1972	13406			13406	2545		2545	1878	6704	271	255	25059	25059
1973	16202			16202	3220		3220	2977	5980	430	114	28923	28923
1974	18377			18377	1374		1374	476	6370	566	168	27331	27331
1975	16017			16017	1847		1847	2403	4044	481	216	25008	25008
1976	14906			14906	2328		2328	933	1633	90	36	19926	19926
1977	21138			21138	6173		6173	54	2	-	-	27367	27367
1978	26579	298		26877	8777	98	8875	-	-	-	-	35356	35751
1979	32645	537		33182	5979	103	6082	-	-	-	-	38624	39264
1980	40053	569		40622	8066	83	8149	-	-	-	-	48119	48771
1981	33849	1033	4162	39044	8508	98	8606	-	-	-	-	42357	47649
1982	39333	985	2956	43274	17827	71	17898	-	-	-	-	57160	61172
1983	36756	656	3865	41277	12131	64	12196	-	-	-	-	48887	53473
1984	32915	98	994	34007	5761	68	5829	-	-	-	-	38676	39836
1985	26828	349	4700	31877	10442	103	10545	-	-	-	-	37270	42422
1986	17490	457	425	18372	8504	51	8555	-	-	-	-	25994	26927
1987	19035	266	970	20271	11844	76	11920	-	-	-	-	30879	32191
1988	26310	323	2587	29220	12741	83	12824	-	-	-	-	39051	42044
1989	25056	938	507	26501	7895	76	7971	-	-	-	-	32951	34472
1990	28110	708	1339	30157	14364	70	14435	-	-	-	-	42474	44592
1991	24219	805	657	25682	13467	65	13532	-	-	-	-	37687	39214
1992	16899	1467	350	18716	11667	71	11738	-	-	-	-	28566	30454
1993	14590	489	1127	16206	8526	63	8588	-	-	-	-	23116	24794
1994	9737	236	544	10516	5277	63	5339	-	-	-	-	15013	15855
1995	7026	109	826	7962	1102	38	1140	-	-	-	-	8128	9102
1996	7261	135	367	7763	1924	56	1980	-	-	-	-	9185	9743
1997	7548	139	716	8402	2919	486	3404	-	-	-	-	10467	11807
1998	7041	137	434	7611	1907	365	2272	-	-	-	-	8948	9884
1999	8313	142	387	8842	1818	338	2156	-	-	-	-	10131	10998
2000	7600	220	309	8129	1572	69	1641	-	-	-	-	9172	9770
2001	10749	784	205	11738	2143	143	2286	-	-	-	-	12892	14023
2002	9472	305	237	10014	1278	94	1372	-	-	-	-	10750	11386
2003	6852	481	203	7537	1317	200	1517	-	-	-	-	8169	9054
2004	3509	304	345	4157	1112	145	1258	-	-	-	-	4621	5415
2005	2754	1040	243	4037	630	228	859	-	-	-	-	3384	4895
2006	2700	565	79	3343	1096	349	1445	-	-	-	-	3796	4788
2007	3699	1660	8	5366	1108	114	1221	-	-	-	-	4807	6588
2008	3255	465	47	3767	1390	139	1529	-	-	-	-	4645	5297
2009	2999	873	18	3891	1003	207	1210	-	-	-	-	4002	5100
2010	2688	563	68	3319	748	92	840	-	-	-	-	3436	4159

A2. Distribution of USA commercial Atlantic cod landings by quarter and area (Georges Bank, Georges Bank West, Georges Bank East) in metric tons and percentage of total landings, 1978-2010 (SA=statistical area).

	Landings (metric tons, live)														
	Georges Bank (Division 5Z and Subarea 6)					Georges Bank West SA 521-522, 525-526, 537-539 & Subarea 6					Georges Bank East SA 561-562				
Year	Quarter					Quarter					Quarter				
	1	2	3	4	TOTAL	1	2	3	4	TOTAL	1	2	3	4	TOTAL
1978	5494	8435	5925	5603	25456	3519	6523	5130	4783	19955	1975	1912	795	820	5502
1979	4480	10067	10136	7074	31756	2729	8019	8569	6032	25349	1751	2048	1567	1042	6408
1980	7104	13078	12111	6735	39028	3755	11366	11101	6388	32610	3349	1712	1010	347	6418
1981	7482	11047	9027	5471	33028	4037	9178	7035	4686	24936	3445	1869	1992	785	8091
1982	6801	10936	12204	8502	38443	3500	8768	9691	7918	29877	3301	2168	2513	584	8566
1983	7655	10793	10617	6870	35935	4528	8822	8258	5755	27363	3127	1971	2359	1115	8572
1984	8907	9820	8252	5058	32037	3895	7100	6226	4266	21487	5012	2720	2026	792	10550
1985	6725	8537	5756	5077	26095	3206	7064	4719	4465	19454	3519	1473	1037	612	6641
1986	6234	5526	3207	2309	17275	2625	3759	3012	2184	11580	3609	1767	195	125	5696
1987	4089	6326	4334	4006	18754	2651	4012	3976	3322	13961	1438	2314	358	684	4794
1988	7235	7305	5714	5781	26036	3641	4500	5255	4993	18389	3594	2805	459	788	7646
1989	5653	8814	6218	4369	25056	3707	5683	5809	3405	18604	1907	3084	354	838	6183
1990	6043	9125	7070	5871	28110	3616	5650	6553	5610	21429	2333	3452	459	171	6415
1991	6454	9845	4279	3641	24219	4275	6070	4120	3172	17637	2048	3758	144	403	6353
1992	4562	5561	3282	3494	16899	2574	3340	3068	2711	11693	1954	2174	190	762	5080
1993	3613	5166	2556	3255	14590	2242	3148	2314	2709	10413	1311	1992	233	491	4027
1994	2585	3454	2098	1600	9737	2478	2927	1880	1453	8738	107	527	218	146	998
1995	1438	2365	2102	1122	7026	1316	2023	2058	1086	6483	122	342	43.7	36.1	544
1996	1356	2923	1945	1037	7261	1203	2476	1913	992	6585	153	446	31.7	45.2	676
1997	1159	3449	1856	1084	7548	1067	3024	1842	1066	6999	92.6	425	13.7	17.8	549
1998	1335	2920	1493	1293	7041	1280	2370	1457	1255	6361	54.4	550	36.7	38	679
1999	1675	3807	1770	1061	8313	1463	2893	1743	1019	7118	212	914	26.3	41.8	1195
2000	1716	2798	1695	1391	7600	1502	2307	1665	1355	6829	214	491	29.9	36.2	772
2001	2350	3815	2418	2166	10749	2101	2733	2355	2073	9262	249	1082	63.3	93.1	1488
2002	2841	3834	1621	1175	9472	2408	2761	1513	1102	7784	433	1073	108	73.4	1687.9
2003	1751	2893	1308	900	6852	1304	1717	1234	746	5002	447	1175	74.1	154	1850.5
2004	912.9	1532	524.9	539	3509	679	797	497	529	2503	234	735	27.6	10.1	1006
2005	677.1	1191	528.9	358	2754	659	1072	491	357	2579	18.5	118	37.4	0.77	175
2006	449.4	821	548.5	881	2700	445	714	543	863	2565	4.08	107	5.15	18.4	135
2007	517.6	1255	1020	906	3699	494.1	1068	1014	878.67	3455	13.2	188	5.78	27.2	234
2008	711	1109	722.4	713	3255	706.8	1062	669.1	593.76	3031	4.2	47.6	53.3	119	224
2009	778.9	959.5	723.6	537	2999	702.2	778.5	589.6	480.56	2551	61.9	181	134	56.4	433
2010	642	923.8	411.2	711	2688	589.4	750.1	372.8	618.49	2331	52.6	174	38.5	92.4	357

Table A2 continued . Distribution of USA commercial Atlantic cod landings by quarter and area (Georges Bank, Georges Bank West, Georges Bank East) in metric tons and percentage of total landings, 1978-2010 (SA=statistical area).

	Percentage of Annual Landings														
	Georges Bank (Div. 5Z and 6)					Georges Bank West SA 521-522, 525-526, 537-539 and Div. 6					Georges Bank East SA 561-562				
Year	Quarter					Quarter					Quarter				
	1	2	3	4	TOTAL	1	2	3	4	TOTAL	1	2	3	4	TOTAL
1978	21.6	33.1	23.3	22.0	100.0	13.8	25.6	20.2	18.8	78.4	7.8	7.5	3.1	3.2	21.6
1979	14.1	31.7	31.9	22.3	100.0	8.6	25.3	27.0	19.0	79.8	5.5	6.4	4.9	3.3	20.2
1980	18.2	33.5	31.0	17.3	100.0	9.6	29.1	28.4	16.4	83.6	8.6	4.4	2.6	0.9	16.4
1981	22.7	33.4	27.3	16.6	100.0	12.2	27.8	21.3	14.2	75.5	10.4	5.7	6.0	2.4	24.5
1982	17.7	28.4	31.7	22.1	100.0	9.1	22.8	25.2	20.6	77.7	8.6	5.6	6.5	1.5	22.3
1983	21.3	30.0	29.5	19.1	100.0	12.6	24.6	23.0	16.0	76.1	8.7	5.5	6.6	3.1	23.9
1984	27.8	30.7	25.8	15.8	100.0	12.2	22.2	19.4	13.3	67.1	15.6	8.5	6.3	2.5	32.9
1985	25.8	32.7	22.1	19.5	100.0	12.3	27.1	18.1	17.1	74.6	13.5	5.6	4.0	2.3	25.4
1986	36.1	32.0	18.6	13.4	100.0	15.2	21.8	17.4	12.6	67.0	20.9	10.2	1.1	0.7	33.0
1987	21.8	33.7	23.1	21.4	100.0	14.1	21.4	21.2	17.7	74.4	7.7	12.3	1.9	3.6	25.6
1988	27.8	28.1	21.9	22.2	100.0	14.0	17.3	20.2	19.2	70.6	13.8	10.8	1.8	3.0	29.4
1989	22.6	35.2	24.8	17.4	100.0	14.8	22.7	23.2	13.6	74.3	7.6	12.3	1.4	3.3	24.7
1990	21.5	32.5	25.2	20.9	100.0	12.9	20.1	23.3	20.0	76.2	8.3	12.3	1.6	0.6	22.8
1991	26.6	40.6	17.7	15.0	100.0	17.7	25.1	17.0	13.1	72.8	8.5	15.5	0.6	1.7	26.2
1992	27.0	32.9	19.4	20.7	100.0	15.2	19.8	18.2	16.0	69.2	11.6	12.9	1.1	4.5	30.1
1993	24.8	35.4	17.5	22.3	100.0	15.4	21.6	15.9	18.6	71.4	9.0	13.7	1.6	3.4	27.6
1994	26.6	35.5	21.5	16.4	100.0	25.5	30.1	19.3	14.9	89.7	1.1	5.4	2.2	1.5	10.3
1995	20.5	33.7	29.9	16.0	100.0	18.7	28.8	29.3	15.5	92.3	1.7	4.9	0.6	0.5	7.7
1996	18.7	40.3	26.8	14.3	100.0	16.6	34.1	26.3	13.7	90.7	2.1	6.1	0.4	0.6	9.3
1997	15.4	45.7	24.6	14.4	100.0	14.1	40.1	24.4	14.1	92.7	1.2	5.6	0.2	0.2	7.3
1998	19.0	41.5	21.2	18.4	100.0	18.2	33.7	20.7	17.8	90.4	0.8	7.8	0.5	0.5	9.6
1999	20.2	45.8	21.3	12.8	100.0	17.6	34.8	21.0	12.3	85.6	2.6	11.0	0.3	0.5	14.4
2000	22.6	36.8	22.3	18.3	100.0	19.8	30.3	21.9	17.8	89.8	2.8	6.5	0.4	0.5	10.2
2001	21.9	35.5	22.5	20.2	100.0	19.5	25.4	21.9	19.3	86.2	2.3	10.1	0.6	0.9	13.8
2002	30.0	40.5	17.1	12.4	100.0	25.4	29.2	16.0	11.6	82.2	4.6	11.3	1.1	0.8	17.8
2003	25.6	42.2	19.1	13.1	100.0	19.0	25.1	18.0	10.9	73.0	6.5	17.2	1.1	2.2	27.0
2004	26.0	43.7	15.0	15.4	100.0	19.4	22.7	14.2	15.1	71.3	6.7	20.9	0.8	0.3	28.7
2005	24.6	43.2	19.2	13.0	100.0	23.9	38.9	17.8	13.0	93.6	0.7	4.3	1.4	0.0	6.4
2006	16.6	30.4	20.3	32.6	100.0	16.5	26.4	20.1	31.9	95.0	0.2	4.0	0.2	0.7	5.0
2007	14.0	33.9	27.6	24.5	100.0	13.4	28.9	27.4	23.8	93.4	0.4	5.1	0.2	0.7	6.3
2008	21.8	34.1	22.2	21.9	100.0	21.7	32.6	20.6	18.2	93.1	0.1	1.5	1.6	3.7	6.9
2009	26.0	32.0	24.1	17.9	100.0	23.4	26.0	19.7	16.0	85.1	2.1	6.0	4.5	1.9	14.4
2010	23.9	34.4	15.3	26.4	100.0	21.9	27.9	13.9	23.0	86.7	2.0	6.5	1.4	3.4	13.3

Table A3. Distribution of USA commercial landings (metric tons, live; percentage) of Atlantic cod from Georges Bank (Division 5Z), by gear type, 1965-2010. Data only reflect Georges Bank cod landings that could be identified by gear type.

NOT ALL LANDINGS HAVE A GEAR CODE

	Landings (metric tons,live)						Percentage of Annual Landings					
	Otter trawl	Sink Gill net	Line Trawl	Handline	Other gear	Total	Otter trawl	Sink Gill net	Line Trawl	Handline	Other gear	Total
1965	10251	0	582	505	9	11347	90.3	-	5.1	4.5	0.1	100
1966	10206	0	787	757	19	11769	86.7	-	6.7	6.4	0.2	100
1967	10915	0	894	704	9	12522	87.2	-	7.1	5.6	0.1	100
1968	12084	0	936	524	<1	13544	89.2	-	6.9	3.9	-	100
1969	13194	0	1371	387	<1	14952	88.2	-	9.2	2.6	-	100
1970	11270	0	1676	404	<1	13350	84.4	-	12.6	3	-	100
1971	12436	0	2334	230	2	15002	82.9	-	15.6	1.5	-	100
1972	10179	0	2071	217	10	12477	81.6	-	16.6	1.7	0.1	100
1973	12431	3	2185	206	21	14846	83.7	-	14.7	1.4	0.2	100
1974	14078	3	2548	11	9	16649	84.6	-	15.3	0.1	-	100
1975	12069	0	2435	84	4	14592	82.7	-	16.7	0.6	-	100
1976	12257	4	1519	153	5	13938	88	-	10.9	1.1	-	100
1977	18529	30	912	83	22	19576	94.7	0.2	4.7	0.4	0.1	100
1978	22412	141	1594	1184	126	25456	87.8	0.3	6.6	5	0.3	100
1979	27248	769	2709	870	161	31756	85.9	2	8.8	2.8	0.5	100
1980	33032	4612	1103	6	276	39028	84.7	11.7	2.9	-	0.7	100
1981	28216	3901	122	587	202	33028	86.2	10.9	0.4	1.8	0.6	100
1982	34065	3149	385	627	216	38443	88.9	7.8	1	1.7	0.6	100
1983	32392	2174	833	447	89	35935	90.7	5.3	2.4	1.3	0.3	100
1984	27470	3203	382	755	227	32037	87.1	8.6	1.2	2.5	0.6	100
1985	22070	3094	468	298	165	26095	86.4	10	1.8	1.1	0.7	100
1986	14198	1853	799	329	96	17275	83	10.3	4.2	1.9	0.6	100
1987	14976	1624	1757	293	105	18754	79.9	8.9	9.5	1.3	0.4	100
1988	21333	2053	2158	290	202	26036	83	7.6	8	0.9	0.5	100
1989	19293	3549	1785	160	267	25056	78.4	13.8	6.9	0.5	0.4	100
1990	23162	2701	1360	518	369	28110	84.1	9	4.9	1.5	0.5	100
1991	18836	2614	2003	357	409	24219	79.7	9.7	8.5	1.3	0.8	100
1992	12475	2208	1851	206	158	16899	75.7	11.3	11.1	1.2	0.7	100
1993	11366	1584	1460	79	102	14590	79.7	9.7	9.6	0.4	0.6	100
1994	6900	1375	1193	238	30	9737	70.9	14.1	12.3	2.4	0.3	100
1995	3898	1380	1353	369	25	7026	55.5	19.6	19.3	5.3	0.4	100
1996	4159	1612	1007	463	20	7261	57.3	22.2	13.9	6.4	0.3	100
1997	4483	1652	901	497	15	7548	59.4	21.9	11.9	6.6	0.2	100
1998	4047	959	1374	633	28	7041	57.5	13.6	19.5	9.0	0.4	100
1999	4749	1556	1528	460	19	8313	57.1	18.7	18.4	5.5	0.2	100
2000	4554	1770	830	415	32	7600	59.9	23.3	10.9	5.5	0.4	100
2001	7135	1579	1089	890	56	10749	66.4	14.7	10.1	8.3	0.5	100
2002	6683	1363	773	529	123	9472	70.6	14.4	8.2	5.6	1.3	100
2003	5143	1216	231	233	29	6852	75.1	17.8	3.4	3.4	0.4	100
2004	2771	411	107	154	65	3509	79.0	11.7	3.0	4.4	1.9	100
2005	2273	236	130	53	63	2754	82.5	8.6	4.7	1.9	2.3	100
2006	2130	311	63	65	130	2700	78.9	11.5	2.3	2.4	4.8	100
2007	2982	585	80	34	17	3699	80.6	15.8	2.2	0.9	0.5	100
2008	2568	583	63	25	15	3255	78.9	17.9	1.9	0.8	0.5	100
2009	2379	453	109	38	20	2999	79.3	15.1	3.6	1.3	0.7	100
2010	2293	242	115	18	20	2688	69.3	16.3	9.1	4.4	0.9	100

Otter trawl includes tonnage from pair trawls in 1990 (849 t), 1991 (1068 t), 1992 (1149 t) and 1993 (1352 t).

Table A4. Discards of Atlantic cod in Georges Bank large mesh otter trawl and gill net fisheries, 1989-2010.

Western

	WGB large mesh trawl			WGB small mesh trawl			WGB gillnet, large			WGB longline			WGB Scallop			**Western GB Total**	
Year	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv
1989	607	0.28	25	31.14	0.53	23	0.0			0			0.00			638	0.27
1990	432	0.35	23	1.59	0.49	16	0.0			0			0.00			433	0.35
1991	303	0.48	28	0.79	0.73	13	0.0			55.21	0.84	16	0.00		1	359	0.42
1992	147	0.52	26	0.07	3.94	13	0.0			580.6	0.18	23	33.87	0.84	10	762	0.17
1993	254	0.31	14	12.29	1.09	5	0.0			0			15.91	0.35	11	283	0.29
1994	87	0.86	19	29.05	0.00	2	71.9	0.42	13	0		1	29.97	1.01	6	218	0.39
1995	53	0.48	41	1.34	1.23	4	54.0	0.35	39	0			0.30	0.71	6	109	0.29
1996	17	0.42	16	0.07	0.00	3	89.8	0.71	17	0			24.66	0.48	13	131	0.49
1997	19	0.30	16	0.05	0.00	4	77.0	0.45	13	0			23.55	0.54	10	120	0.31
1998	8	0.56	5	5.99	0.00	1	57.5	0.8	33	0			43.31	0.40	9	115	0.43
1999	35	0.56	11	0.00		4	44.2	0.44	30	0			24.89	0.45	14	104	0.29
2000	67	1.04	20	7.53	0.42	6	77.6	0.3	44	0			3.34	0.15	179	155	0.47
2001	151	0.59	34	7.95	0.42	10	41.9	0.52	27	0			7.30	0.28	17	208	0.44
2002	76	0.33	68	14.99	0.34	17	61.4	0.63	22	113.7	0.56	7	5.08	0.43	11	271	0.29
2003	117	0.21	140	20.12	0.72	21	43.9	0.24	88	6.465	4.68	5	4.53	0.31	12	192	0.22
2004	51	0.19	192	5.24	0.35	32	32.1	0.32	174	12.11	0.36	111	0.37	0.73	25	101	0.15
2005	225	0.12	645	8.00	0.19	88	6.3	0.44	161	37.43	0.51	224	1.95	0.32	81	279	0.12
2006	156	0.18	342	2.53	0.47	23	11.0	0.43	45	15.08	0.60	57	4.25	0.23	102	189	0.16
2007	564	0.11	345	8.18	0.97	16	12.8	0.37	106	5.171	0.61	51	4.35	0.21	177	594	0.11
2008	355	0.10	445	3.08	0.63	8	19.8	0.52	61	4.702	0.46	54	2.10	0.19	210	385	0.09
2009	251	0.13	379	1.90	1.16	26	33.0	0.35	48	3.323	0.23	44	0.68	0.37	59	289	0.12
2010	160	0.11	435	3.96	0.63	32	7.5	0.13	434	2.634	0.29	112	2.36	0.33	93	177	0.10

Eastern

	EGB large mesh trawl			EGB scallop dredge			*EGB small mesh otter*			Eastern GB Total		**Georges Bank Total**	
Year	mt	cv	# trips	mt	cv	# trips	*mt*	*cv*	*# trips*	mt	cv	**mt**	**cv**
1989	100.2	0.45	12				*12.4*	*0*	*3*	100.20	0.45	**738**	**0.24**
1990	91.8	0.38	10				*0*		*1*	91.82	0.38	**525**	**0.29**
1991	148.7	0.74	4				*0*			148.73	0.74	**507**	**0.37**
1992	231.9	0.42	11	3.3445	0	4	*0*			235.29	0.41	**997**	**0.16**
1993	66.6	0.62	13	2.2811	0	6	*0*			68.87	0.60	**352**	**0.26**
1994	5.0	1.17	15	1.2406	0	1	*0*		*1*	6.28	0.94	**224**	**0.38**
1995	0.3	0.61	15	0		3	*0*			0.27	0.61	**109**	**0.29**
1996	1.5	0.38	9	0		4	*0*			1.48	0.38	**132**	**0.49**
1997	0.0			6.402	0	4	*0*			6.40	0.00	**126**	**0.29**
1998	1.6	0.00	2	5.7629	0	3	*0*			7.35	0.00	**122**	**0.41**
1999	11.7	0.00	4	1.2944	0.86	18	*0*			13.00	0.09	**117**	**0.26**
2000	20.9	0.45	9	0.689	0.22	88	*0*		*2*	21.55	0.43	**177**	**0.42**
2001	194.8	0.70	11				*0.537*	*0*	*2*	194.76	0.70	**403**	**0.41**
2002	11.8	0.49	21				*0.498*	*1.37*	*6*	11.80	0.49	**282**	**0.28**
2003	103.8	0.51	68	1.8242		1	*6.393*	*0*	*4*	105.66	0.50	**298**	**0.23**
2004	69.0	0.51	67	0.2753	0.43	22	*7.213*	*0.66*	*7*	69.25	0.51	**170**	**0.23**
2005	253.8	0.13	93	0.5188	0.7	31	*11.03*	*0.6*	*14*	254.36	0.13	**533**	**0.09**
2006	125.0	0.23	40	0.5604	0.59	50	*0*		*5*	125.54	0.23	**314**	**0.13**
2007	354.2	0.31	48	0.97	0.48	11	*17.17*	*1.02*	*11*	355.17	0.31	**950**	**0.13**
2008	25.8	0.19	122	0.9029	0.26	16	*0.223*	*0.76*	*5*	26.67	0.18	**411**	**0.09**
2009	193.7	0.19	116	1.1044	0.43	35	*0.461*	*0.53*	*14*	194.79	0.19	**484**	**0.10**
2010	128.8	0.50	87	0.0977	0	5	*0.254*	*0.77*	*22*	128.94	0.50	**306**	**0.22**

**EGB small mesh otter trawl not included in assessment or tot

Table A5. Estimated numbers (000s) and weight (mt, live) of Atlantic cod caught by marine recreational fishers from the Georges Bank and South stock during 1981-2010.

	Catch		Landed	
Year	Numbers 000s	Weight* mt	Numbers 000s	Weight* mt
1981	1741	3841	1684	3718
1982	1548	6820	1495	6586
1983	1840	5502	1676	5012
1984	483	1294	453	1213
1985	1981	8499	1891	8112
1986	357	924	295	763
1987	503	961	462	881
1988	1362	3993	1132	3318
1989	560	1866	393	1309
1990	584	1438	455	1122
1991	466	1839	373	1473
1992	290	639	204	450
1993	1176	2886	762	1869
1994	603	1880	289	900
1995	799	2033	511	1300
1996	248	803	150	485
1997	544	1379	328	832
1998	582	1633	271	761
1999	233	793	126	429
2000	581	1409	288	699
2001	169	377	99	222
2002	146	442	93	281
2003	162	712	94	413
2004	245	470	130	250
2005	511	1237	142	343
2006	79	317	40	158
2007	25	86	4	13
2008	34	46	23	32
2009	46	104	18	41
2010	125	272	52	112

* Weight as estimated by MRFSS, re-estimated in assessment based on the numbers

Table A6a. USA sampling of commercial Atlantic cod landings, by market category, for the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2010.

	Number of Samples, by Market Category & Quarter															Annual Sampling Intensity			
	Scrod					Market					Large					No. of Tons Landed/Sampled			
Year	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Scrd	Mkt	Lge	∑
1978	17	15	6	3	41	9	12	13	9	43	1	0	1	2	4	69	374	1922	302
1979	2	5	14	8	29	6	19	11	8	44	2	0	4	1	7	88	407	1742	408
1980	7	10	13	4	34	12	14	5	1	32	3	0	0	0	3	136	588	5546	580
1981	4	10	11	3	28	6	9	10	2	27	2	0	0	0	2	149	634	6283	594
1982	5	9	32	9	55	6	20	27	13	66	8	8	9	5	30	156	279	410	260
1983	4	12	17	10	43	12	19	22	14	67	2	15	16	3	36	185	291	259	252
1984	6	8	8	7	29	8	15	8	11	42	18	5	3	3	29	138	441	358	329
1985	6	7	16	5	34	11	11	12	8	42	4	8	7	5	24	201	299	310	268
1986	6	7	7	6	26	8	10	10	11	39	6	5	10	8	29	142	215	186	186
1987	7	8	6	8	29	6	8	9	10	33	6	6	4	2	18	240	220	267	238
1988	8	6	7	5	26	13	7	9	9	38	4	4	3	1	12	283	331	532	346
1989	2	7	9	9	27	7	8	8	7	30	3	4	1	1	9	210	450	660	380
1990	8	9	10	4	31	10	13	9	8	40	4	4	4	0	12	295	315	538	340
1991	6	11	7	5	29	12	13	8	8	41	4	6	3	5	18	158	293	423	275
1992	6	7	7	10	30	8	10	6	9	33	5	5	3	1	14	149	215	377	219
1993	5	16	7	6	34	10	10	7	9	36	6	1	3	2	12	126	173	339	178
1994	3	9	8	2	22	5	11	7	4	27	1	4	3	1	9	92	187	290	167
1995	2	3	13	2	20	2	4	10	2	18	0	1	0	1	2	83	181	880	167
1996	6	2	12	3	23	5	6	11	6	28	0	2	1	1	4	59	143	400	127
1997	3	11	3	10	27	5	16	9	9	39	3	6	0	5	14	50	105	148	94
1998	3	7	23	5	38	10	10	15	3	38	1	2	1	0	3	44	92	573	88
1999	5	3	10	3	21	7	14	10	7	38	2	5	2	0	9	80	118	205	121
2000	21	19	16	27	83	20	14	13	16	63	2	2	2	2	8	18	72	192	49
2001	11	9	13	3	36	9	10	8	10	37	6	12	6	10	34	72	163	55	99
2002	5	7	7	1	20	8	10	11	6	35	14	8	6	3	31	80	153	63	109
2003	4	8	6	10	28	7	16	10	6	39	5	11	10	4	30	21	113	52	70
2004	8	11	4	10	33	14	6	8	13	41	25	13	2	11	51	8	53	20	28
2005	6	12	4	5	27	5	10	12	8	35	7	11	7	11	36	7	52	19	27
2006	11	16	8	14	49	13	15	10	13	51	25	28	7	18	78	6	38	6	15
2007	14	10	10	11	45	22	18	9	10	59	20	27	15	15	77	10	47	6	20
2008	13	11	10	16	50	21	12	9	11	53	40	20	17	18	95	9	44	4	16
2009	15	21	16	13	65	18	20	13	5	56	31	25	11	10	77	5	42	4	15
2010	32	22	15	23	92	32	27	11	19	89	30	12	10	17	69	4	23	4	11

Table A6b. USA and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978 - 2010.

	USA				Canada			
	Length Samples		Age Samples		Length Samples		Age Samples	
Year	No.	# Fish Measured	No.	# Fish Aged	No.	# Fish Measured	No.	# Fish Aged
1978	88	6841	76	1463	28	7684	27	1308
1979	80	6973	79	1647	11	3991	11	656
1980	69	4990	67	1119	10	2784	10	536
1981	57	4304	57	1231	17	4147	16	842
1982	151	11970	147	2579	17	4756	17	858
1983	146	12544	138	2945	15	3822	14	604
1984	100	8721	100	2431	7	1889	7	385
1985	100	8366	100	2321	27	7644	20	1062
1986	94	7515	94	2222	22	5745	19	888
1987	80	6395	79	1704	31	9477	24	1288
1988	76	6483	76	1576	40	11709	36	1984
1989	66	5547	66	1350	32	8716	30	1561
1990	83	7158	83	1700	109	9901	35	2012
1991	88	7708	88	1865	98	10873	37	1782
1992	77	6549	77	1631	89	10878	44	1906
1993	82	6636	82	1598	99	12158	47	2146
1994	58	4688	54	1064	111	25845	27	1268
1995	40	2879	40	778	33	11598	13	548
1996	55	4600	54	1080	125	26663	20	879
1997	80	6638	80	1581	103	31882	29	1244
1998	80	7076	81	1545	115	26549	53	1720
1999	68	5987	67	1503	85	24954	29	918
2000	154	12421	154	3043	97	20782	41	1436
2001	108	8389	108	2421	98	18190	39	1509
2002	86	6400	86	2179	80	18974	32	1264
2003	92	6116	90	2135	94	20199	29	1070
2004	125	8749	107	2755	132	17859	37	1370
2005	98	4705	86	1681	153	21942	42	1483
2006	178	9431	2798	163	307	43259	31	1455
2007	181	9200	171	2697	521	139816	48	1672
2008	198	9747	160	2493	257	63213	48	1729
2009	198	9447	174	2595	188	47206	54	1518
2010	250	12289	239	3549	151	30159	27	1022

Table A7a. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					USA Commercial Landings in Numbers (000's) at Age						
1978	0	291	6012	1767	687	102	185	11	30	4	9088
1979	48	1542	611	3809	903	395	141	295	9	32	7784
1980	102	3091	4760	328	2045	858	386	60	125	4	11758
1981	39	2854	3725	2016	171	902	295	90	134	43	10269
1982	428	7566	2816	1750	1228	130	447	95	50	59	14570
1983	88	3460	5639	1374	881	658	84	155	56	82	12478
1984	70	1342	3275	2865	571	422	374	39	145	84	9186
1985	126	4160	1636	1032	1343	314	191	154	16	75	9046
1986	134	1142	3194	467	375	390	56	51	44	24	5877
1987	19	4873	814	1380	204	163	154	34	21	19	7680
1988	0	1680	5492	695	1059	149	88	90	17	24	9294
1989	0	1649	2633	3291	254	352	49	28	23	3	8283
1990	0	4646	3313	1279	1401	126	122	16	9	8	10920
1991	43	1164	2842	1841	830	562	65	42	12	6	7406
1992	1	2306	1333	761	939	256	177	19	15	3	5810
1993	0	769	3118	608	288	283	83	71	16	3	5239
1994	0	226	1108	1345	201	59	96	29	14	4	3081
1995	0	341	1006	570	310	27	19	19	5	1	2299
1996	0	211	753	947	191	137	8	9	10	0	2267
1997	0	399	539	674	566	75	60	11	6	3	2332
1998	8	692	979	349	258	190	24	8	2	0	2510
1999	0	256	1663	606	211	86	113	15	2	0	2951
2000	9	721	627	865	205	58	30	29	2	0	2547
2001	1	508	2302	616	457	111	34	15	11	1	4056
2002	0	33	1001	1294	310	285	68	13	9	5	3016
2003	0	74	279	650	707	117	94	17	4	2	1944
2004	0	30	272	153	228	158	34	26	6	3	912
2005	0	22	96	358	100	77	55	8	4	2	721
2006	0	12	441	129	185	29	14	13	2	2	827
2007	0	115	168	794	43	65	6	4	3	1	1198
2008	0	162	521	112	301	6	16	0	1	0	1119
2009	0	36	360	355	72	96	4	4	0	0	927
2010	0	21	295	401	102	13	47	1	2	0	881

Table A7a - continued. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2010.

USA Commercial Landings in Weight (Tons) at Age

1978	0	377	14847	6355	2804	546	1229	76	304	41	26579
1979	42	2202	1262	16766	4550	2886	1373	3042	89	435	32645
1980	84	4610	11660	1236	11661	5825	3244	566	1112	54	40053
1981	41	4285	8895	7035	847	6534	2558	893	1960	801	33849
1982	283	10616	7596	6543	6604	864	4299	959	667	902	39333
1983	94	5119	13773	4792	4312	4282	722	1668	645	1350	36756
1984	72	2151	8080	10435	2887	2823	3279	396	1614	1178	32915
1985	118	5857	3475	4051	6910	2009	1563	1603	194	1048	26828
1986	126	1638	7325	1606	2036	2796	508	510	594	351	17490
1987	16	6849	2014	5556	1147	1290	1309	338	240	275	19035
1988	0	2533	12755	2313	5556	1021	733	851	201	347	26310
1989	0	2750	5861	11937	1288	2274	406	262	241	37	25056
1990	0	7087	7638	4488	6723	782	1013	175	101	102	28110
1991	50	1799	6990	6616	4246	3412	498	383	137	88	24219
1992	1	3423	3094	2961	4202	1571	1251	174	165	59	16899
1993	0	1171	6787	2020	1526	1625	638	629	150	43	14590
1994	0	306	2306	4593	965	427	670	261	140	67	9737
1995	0	511	2005	2151	1627	231	175	234	66	27	7026
1996	0	320	1821	3022	910	900	79	94	113	2	7261
1997	0	629	1260	2378	2219	429	447	83	68	34	7548
1998	4	1020	2203	1240	1240	1059	192	57	23	2	7041
1999	0	394	3525	1995	987	503	758	126	22	2	8313
2000	10	1225	1534	3029	977	340	225	242	18	0	7600
2001	0	782	5198	1810	1909	599	220	118	101	13	10749
2002	0	60	2167	3847	1226	1486	439	105	80	63	9472
2003	0	152	663	1944	2783	570	560	123	37	22	6852
2004	0	61	745	507	922	791	196	197	56	34	3509
2005	0	41	246	1226	410	386	313	65	40	29	2754
2006	0	24	1112	465	749	139	89	89	14	18	2700
2007	0	232	419	2515	171	281	31	27	17	5	3699
2008	0	335	1330	344	1107	39	84	5	7	4	3255
2009	0	70	883	1222	300	466	26	26	4	2	2999
2010	0	42	726	1240	393	52	218	6	10	2	2688

Table A7a - continued. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2010.

Year	1	2	3	4	5	6	7	8	9	10+	Mean
					USA Commercial Landings Mean Weight (kg) at Age						
1978	0.582	1.297	2.470	3.597	4.078	5.331	6.651	7.086	10.139	11.218	2.925
1979	0.868	1.428	2.065	4.402	5.041	7.309	9.702	10.310	9.874	13.564	4.194
1980	0.824	1.491	2.450	3.766	5.703	6.789	8.403	9.517	8.918	12.949	3.406
1981	1.071	1.502	2.388	3.489	4.958	7.247	8.662	9.881	14.572	18.588	3.296
1982	0.661	1.403	2.697	3.738	5.378	6.624	9.625	10.108	13.254	15.410	2.700
1983	1.066	1.479	2.442	3.487	4.895	6.506	8.544	10.774	11.586	16.510	2.946
1984	1.026	1.603	2.468	3.643	5.056	6.689	8.759	10.099	11.168	14.096	3.583
1985	0.935	1.408	2.124	3.926	5.147	6.406	8.190	10.423	12.459	14.008	2.966
1986	0.945	1.434	2.293	3.440	5.434	7.160	9.020	10.099	13.347	14.854	2.976
1987	0.857	1.406	2.474	4.027	5.634	7.910	8.507	9.888	11.670	14.841	2.479
1988	0.000	1.508	2.322	3.329	5.245	6.853	8.350	9.452	11.541	14.759	2.831
1989	0.000	1.668	2.226	3.627	5.066	6.454	8.260	9.348	10.640	10.853	3.025
1990	0.000	1.525	2.305	3.509	4.799	6.200	8.317	11.255	11.547	12.582	2.574
1991	1.174	1.546	2.460	3.594	5.116	6.073	7.667	9.080	11.005	14.995	3.270
1992	1.016	1.484	2.321	3.893	4.477	6.127	7.070	9.323	10.818	16.952	2.908
1993	0.866	1.523	2.177	3.323	5.303	5.741	7.671	8.813	9.617	15.446	2.785
1994	0.000	1.354	2.081	3.415	4.809	7.280	6.983	9.174	9.972	18.140	3.160
1995	0.000	1.499	1.992	3.773	5.253	8.397	9.268	12.303	12.152	19.227	3.056
1996	0.896	1.517	2.418	3.192	4.755	6.555	10.069	10.166	11.114	9.348	3.203
1997	0.000	1.577	2.337	3.529	3.919	5.727	7.473	7.856	11.241	11.954	3.236
1998	0.536	1.473	2.250	3.558	4.799	5.581	7.884	7.587	12.382	11.267	2.805
1999	0.000	1.542	2.119	3.291	4.686	5.851	6.739	8.700	10.792	10.671	2.817
2000	1.177	1.699	2.447	3.504	4.755	5.853	7.488	8.271	7.890	10.896	2.985
2001	0.727	1.539	2.258	2.938	4.174	5.407	6.479	7.785	9.334	11.121	2.650
2002	0.000	1.834	2.165	2.974	3.948	5.221	6.510	8.076	9.425	12.169	3.141
2003	0.000	2.048	2.378	2.992	3.937	4.879	5.927	7.079	8.708	11.027	3.524
2004	0.000	2.020	2.735	3.306	4.037	4.998	5.673	7.655	8.668	11.783	3.847
2005	0.000	1.811	2.569	3.426	4.118	5.033	5.737	8.174	9.189	12.225	3.819
2006	0.000	2.080	2.524	3.594	4.048	4.706	6.129	7.039	8.013	10.104	3.264
2007	0.000	2.027	2.495	3.169	3.947	4.299	5.363	7.038	6.646	7.918	3.088
2008	0.000	2.074	2.552	3.075	3.682	6.351	5.387	10.318	8.839	12.675	2.910
2009	0.000	1.924	2.451	3.447	4.158	4.860	7.296	6.649	8.818	12.155	3.234
2010	0.000	2.010	2.463	3.097	3.855	4.155	4.587	5.649	4.890	14.044	3.051

Table A7a - continued. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2010.

USA Commercial Landings Mean Length (cm) at Age

1978	39.0	50.2	61.5	69.2	71.6	78.8	85.3	87.7	97.7	100.5	64.2
1979	44.3	51.9	57.7	74.2	77.9	88.2	97.8	99.6	98.5	108.8	71.0
1980	43.3	52.5	61.3	70.9	81.4	86.6	92.5	95.1	94.5	107.7	66.0
1981	47.4	52.4	60.9	69.0	77.7	88.3	94.0	97.9	111.7	120.7	64.9
1982	39.7	51.6	63.2	70.1	79.6	85.3	97.1	98.5	107.9	113.1	60.5
1983	47.5	52.5	61.4	68.6	77.1	84.9	93.1	100.6	103.0	116.0	63.2
1984	46.9	53.7	61.7	70.1	78.0	86.0	94.0	98.6	102.0	109.5	67.7
1985	45.4	51.6	58.5	72.0	78.7	84.7	91.8	99.7	105.5	109.7	62.5
1986	45.6	51.7	60.2	68.1	79.6	88.0	95.0	98.6	108.1	111.8	63.2
1987	44.2	51.6	61.6	72.5	81.3	91.3	93.1	97.9	103.4	111.7	59.4
1988	0.0	53.0	60.6	67.4	78.9	86.5	92.4	96.4	102.8	111.4	63.1
1989	0.0	54.7	59.8	69.9	77.9	84.2	91.3	96.6	100.6	101.4	64.8
1990	0.0	53.2	60.2	68.9	76.4	83.1	91.8	102.2	103.3	106.0	61.1
1991	49.0	53.3	61.7	69.3	78.1	82.5	89.5	93.3	100.8	111.3	66.1
1992	46.8	52.7	60.9	72.1	75.5	83.5	88.7	96.3	102.8	118.9	63.6
1993	45.0	53.0	59.7	68.5	79.9	82.1	91.7	95.7	98.5	112.6	63.2
1994	0.0	51.3	58.6	69.0	77.7	89.2	89.0	97.6	100.0	121.6	66.0
1995	0.0	52.7	57.9	71.0	80.8	93.3	97.6	106.5	106.8	122.1	64.8
1996	0.0	53.1	61.5	67.5	76.9	87.2	96.9	100.9	103.0	98.3	66.5
1997	0.0	53.6	60.9	69.6	72.2	83.3	91.2	92.5	104.6	105.9	66.7
1998	38.1	52.4	60.3	70.8	78.5	82.9	93.1	92.0	107.8	80.1	63.5
1999	0.0	53.4	59.3	69.0	77.9	83.8	88.3	95.7	102.5	103.6	64.2
2000	48.9	54.8	62.1	70.1	77.6	83.6	90.8	94.6	93.7	0.0	65.2
2001	42.0	53.1	60.3	65.8	74.0	81.2	86.4	91.9	98.4	103.8	62.8
2002	0.0	56.4	59.4	66.4	72.8	80.0	86.3	92.6	97.6	107.3	66.6
2003	0.0	58.3	61.4	66.5	73.1	78.3	84.0	89.1	94.9	103.3	69.7
2004	0.0	58.2	64.0	68.9	73.9	79.5	82.9	92.0	95.5	106.0	71.6
2005	0.0	56.1	63.0	69.6	74.7	79.7	83.1	93.9	96.9	105.8	71.6
2006	0.0	58.7	62.3	70.6	73.8	77.4	85.0	89.0	90.8	97.1	67.6
2007	0.0	58.1	62.5	67.7	72.5	74.7	80.3	87.9	86.2	90.4	66.8
2008	0.0	58.6	63.2	67.4	71.5	85.8	79.7	100.1	95.2	92.3	65.6
2009	0.0	57.6	62.4	70.1	74.6	78.6	89.2	87.4	94.9	88.2	68.0
2010	0.0	58.0	62.4	67.4	72.6	74.0	76.8	80.6	76.5	108.9	66.8

Table A7b. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					USA Commercial Discards in Numbers (000's) at Age						
1978	150	65	120	9	8	0	0	0	0	0	352
1979	231	330	15	13	2	0	0	0	0	0	591
1980	237	371	73	3	0	0	0	0	0	0	683
1981	578	529	62	0	0	0	0	0	0	0	1169
1982	206	676	54	21	0	0	0	0	0	0	957
1983	171	378	103	3	0	0	0	0	0	0	655
1984	58	87	11	0	0	0	0	0	0	0	156
1985	12	289	14	0	0	0	0	0	0	0	315
1986	439	168	35	17	0	0	0	0	0	0	661
1987	16	190	54	5	1	0	0	0	0	0	266
1988	76	206	70	8	0	0	0	0	0	0	360
1989	709	368	192	6	0	0	0	0	0	0	1277
1990	33	457	122	9	3	0	0	0	0	0	626
1991	105	342	83	24	5	3	0	1	0	0	564
1992	140	983	39	13	12	3	3	0	0	0	1193
1993	23	319	58	3	3	2	0	0	0	0	409
1994	75	107	42	12	1	0	0	0	0	0	238
1995	10	67	28	3	0	0	0	0	0	0	109
1996	27	29	15	11	2	1	0	0	0	0	85
1997	114	54	9	4	2	0	0	0	0	0	184
1998	18	19	16	6	3	1	0	0	1	0	64
1999	36	48	26	5	1	0	0	0	0	0	116
2000	25	58	22	16	3	1	0	0	0	0	125
2001	14	207	240	12	9	2	1	0	0	0	484
2002	31	34	122	29	6	0	0	0	0	0	221
2003	2	71	58	52	20	2	1	0	0	0	206
2004	24	46	80	6	5	3	0	0	0	0	164
2005	6	309	99	82	14	6	5	0	0	0	520
2006	23	60	180	13	22	1	0	0	0	0	301
2007	4	467	172	164	8	18	1	1	0	0	834
2008	6	181	109	9	5	0	0	0	0	0	312
2009	30	208	179	16	2	3	0	0	0	0	438
2010	4	125	121	26	4	0	1	0	0	0	281

Table A7b - continued. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					USA Commercial Discards in Weight (Tons) at Age						
1978	86	60	129	12	9	0	0	0	0	0	298
1979	152	349	18	16	3	0	0	0	0	0	537
1980	135	337	93	4	0	0	0	0	0	0	569
1981	374	581	78	0	0	0	0	0	0	0	1033
1982	139	757	64	26	0	0	0	0	0	0	985
1983	116	417	118	5	0	0	0	0	0	0	656
1984	27	61	9	0	0	0	0	0	0	0	98
1985	6	324	20	0	0	0	0	0	0	0	349
1986	285	117	37	18	0	0	0	0	0	0	457
1987	10	186	63	6	2	0	0	0	0	0	266
1988	47	185	83	9	0	0	0	0	0	0	323
1989	302	316	197	19	1	1	0	0	0	0	838
1990	18	429	135	18	14	1	1	0	0	0	617
1991	67	343	113	64	33	18	1	17	0	0	656
1992	101	904	63	49	69	22	21	0	2	0	1231
1993	10	283	72	15	18	14	4	4	1	0	420
1994	29	95	62	34	4	2	2	0	0	0	229
1995	5	60	31	11	2	0	0	0	0	0	109
1996	15	25	33	39	13	8	0	0	0	0	133
1997	63	48	12	6	4	0	0	0	0	0	133
1998	10.8	19	43	24	15	7	1	0	9	0	129
1999	17.5	41	51	17	2	0	0	0	0	0	129
2000	13	62	47	56	15	4	1	0	0	0	198
2001	12	197	269	36	54	13	5	2	1	0	589
2002	19	37	180	47	9	1	0	0	0	0	293
2003	1	83	97	111	67	10	6	1	0	0	377
2004	8	57	116	16	20	13	3	2	0	0	235
2005	1	303	159	219	49	24	26	3	1	0	786
2006	10	62	282	29	48	5	2	1	0	1	439
2007	1	578	256	386	23	53	3	3	1	0	1305
2008	3	238	163	16	16	1	1	0	0	0	438
2009	21	275	314	48	8	11	0	0	0	0	679
2010	2	142	203	65	14	2	6	0	0	0	434

Table A7b - continued. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
				USA Commercial Discards Mean Weight (kg) at Age						
1978	0.577	0.927	1.076	1.386	1.111	0.000	0.000	0.000	0.000	0.000
1979	0.658	1.059	1.185	1.209	1.242	0.000	0.000	0.000	0.000	0.000
1980	0.567	0.910	1.276	1.484	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.648	1.097	1.257	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.675	1.119	1.184	1.261	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.677	1.104	1.148	1.484	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.474	0.699	0.835	1.484	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.474	1.119	1.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.648	0.694	1.049	1.059	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.610	0.980	1.177	1.028	1.484	0.000	0.000	0.000	0.000	0.000
1988	0.615	0.900	1.178	1.093	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.426	0.858	1.026	3.082	5.359	5.533	5.202	6.974	0.000	0.000
1990	0.545	0.938	1.113	1.933	4.053	4.588	4.875	6.273	0.000	0.000
1991	0.639	1.003	1.353	2.678	6.129	6.055	4.652	13.880	0.000	0.000
1992	0.722	0.920	1.617	3.752	5.829	7.293	8.149	6.051	9.199	0.000
1993	0.415	0.888	1.230	4.916	6.806	7.190	8.600	8.656	9.705	0.000
1994	0.390	0.893	1.464	2.866	4.817	6.375	6.325	6.974	0.000	0.000
1995	0.482	0.889	1.087	3.870	4.546	0.000	0.000	0.000	0.000	0.000
1996	0.570	0.872	2.137	3.715	5.519	6.637	0.000	0.000	5.213	0.000
1997	0.552	0.875	1.317	1.576	1.611	0.000	0.000	0.000	0.000	0.000
1998	0.606	1.028	2.665	3.896	4.556	5.106	6.342	7.987	16.634	0.000
1999	0.493	0.854	1.948	3.156	3.626	3.770	4.127	0.000	0.000	0.000
2000	0.527	1.062	2.145	3.546	4.877	5.411	6.186	5.519	0.000	0.000
2001	0.900	0.951	1.122	3.026	5.811	6.912	7.477	7.220	6.822	0.000
2002	0.612	1.102	1.474	1.641	1.650	4.090	4.851	3.780	5.213	0.000
2003	0.303	1.174	1.660	2.161	3.413	4.295	5.737	8.629	9.898	11.339
2004	0.345	1.258	1.453	2.816	3.638	4.785	5.620	8.181	7.602	10.133
2005	0.252	0.981	1.600	2.672	3.592	4.392	5.127	9.867	10.303	10.813
2006	0.442	1.029	1.561	2.189	2.167	3.503	4.972	6.524	4.896	16.102
2007	0.347	1.238	1.489	2.352	2.841	3.016	5.163	5.643	5.611	6.666
2008	0.528	1.310	1.495	1.724	3.063	7.061	5.501	10.712	9.585	10.926
2009	0.699	1.320	1.752	3.071	3.952	4.430	6.867	5.947	5.833	0.000
2010	0.426	1.141	1.680	2.530	3.640	4.081	4.875	3.319	5.056	0.000

Table A7b - continued. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
					USA Commercial Discards Mean Length(cm) at Age					
1978	38.54	44.98	47.49	51.78	47.62	0.00	0.00	0.00	0.00	0.00
1979	40.25	47.14	49.09	49.48	50.00	0.00	0.00	0.00	0.00	0.00
1980	38.33	44.66	50.31	53.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	39.98	47.74	50.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	40.66	48.08	49.11	50.23	0.00	0.00	0.00	0.00	0.00	0.00
1983	40.55	47.78	48.52	53.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	35.70	41.21	43.72	53.00	0.00	0.00	0.00	0.00	0.00	0.00
1985	36.10	48.09	51.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	39.98	40.86	46.97	47.40	0.00	0.00	0.00	0.00	0.00	0.00
1987	38.90	45.83	48.99	47.00	53.00	0.00	0.00	0.00	0.00	0.00
1988	39.30	44.35	48.94	47.65	0.00	0.00	0.00	0.00	0.00	0.00
1989	32.75	42.36	45.76	64.91	79.14	80.64	78.82	89.00	0.00	0.00
1990	36.69	44.20	46.10	54.95	72.16	75.88	77.89	86.00	0.00	0.00
1991	38.24	45.41	49.15	59.41	83.22	82.37	75.96	109.02	0.00	0.00
1992	40.48	44.10	51.87	68.44	81.19	88.16	92.08	83.00	96.57	0.00
1993	33.53	43.61	47.99	76.67	85.94	87.56	93.34	93.86	97.70	0.00
1994	32.33	43.31	51.04	63.24	77.08	85.93	85.67	89.00	0.00	0.00
1995	35.25	43.42	46.01	71.63	75.89	0.00	0.00	0.00	0.00	0.00
1996	37.43	43.28	56.94	69.62	80.18	86.25	0.00	0.00	80.00	0.00
1997	36.86	43.48	49.55	52.15	53.07	0.00	0.00	0.00	0.00	0.00
1998	38.36	45.06	62.39	71.29	75.10	78.26	84.33	92.00	116.00	0.00
1999	35.69	42.80	55.90	66.38	70.01	71.42	73.30	0.00	0.00	0.00
2000	36.45	45.38	57.14	68.56	76.38	79.26	83.65	79.47	0.00	0.00
2001	44.00	44.60	46.48	63.47	81.74	86.69	89.21	87.67	86.36	0.00
2002	38.36	46.56	51.64	53.36	53.31	72.63	78.18	71.00	80.00	0.00
2003	30.17	47.36	53.45	57.46	67.06	72.81	80.48	93.10	97.76	102.88
2004	30.73	48.86	50.96	63.40	68.96	75.62	79.69	91.40	89.02	98.99
2005	28.53	44.36	52.70	62.41	69.21	73.71	77.49	97.28	98.85	100.44
2006	34.13	45.68	52.45	58.51	57.68	68.43	77.02	84.48	74.51	114.02
2007	30.94	48.40	51.45	59.88	63.68	64.60	77.41	80.27	80.33	85.73
2008	36.21	49.38	51.56	53.92	64.83	87.12	78.73	101.97	98.13	102.73
2009	39.96	49.55	54.65	65.50	71.48	74.50	86.81	82.19	83.00	0.00
2010	33.13	47.09	53.92	61.23	69.53	72.20	77.04	68.00	77.94	0.00

Table A7c. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	USA Recreational Landings in Numbers (000's) at Age										
1978	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0
1981	601	382	341	163	12	122	35	22	0	7	1684
1982	136	929	202	109	68	3	38	7	3	0	1495
1983	340	599	507	91	74	34	0	3	0	28	1676
1984	153	92	82	88	12	15	4	1	4	2	453
1985	34	848	387	275	259	44	31	5	3	5	1891
1986	176	46	49	7	6	7	0	1	3	1	295
1987	55	297	46	44	4	8	6	0	1	2	462
1988	239	238	476	51	100	7	3	18	0	0	1132
1989	176	124	29	51	6	5	1	0	0	0	393
1990	22	131	166	54	65	9	6	1	0	2	455
1991	135	59	86	60	23	8	2	0	0	0	373
1992	30	110	32	11	10	4	2	1	0	0	199
1993	277	241	177	21	15	7	3	0	10	3	755
1994	45.8	113	66	43	11	5	3	1	1	0	288
1995	20.6	203	226	32	18	4	1	0	0	0	503
1996	29.1	22	47	36	8	7	0	0	0	0	150
1997	66.5	123	42	48	37	4	5	0	0	0	326
1998	39.2	128	62	18	12	5	0	1	0	0	265
1999	9.0	17	34	36	16	5	5	0	1.9	0.0	124
2000	92	121	29	29	8	2	0	0	0	0	280
2001	4	23	55	6	9	1	0	0	0	0	98
2002	9	11	25	37	5	5	1	0	0	0	93
2003	7	29	16	19	16	2	2	0	0	0	92
2004	30	6	28	22	21	14	3	4	0	0	129
2005	3	76	16	32	7	3	3	0	0	0	141
2006	9	5	14	3	6	1	1	0	0	0	40
2007	1	1	0	1	0	0	0	0	0	0	4
2008	4	8	4	2	5	1	0	0	0	0	24
2009	8	8	2	1	0	0	0	0	0	0	19
2010	9	25	8	6	2	0	1	0	0	0	50

Table A7c - continued. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					USA Recreational Landings in Weight (Tons) at Age						
1978	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0
1981	299	572	879	664	55	1,096	302	206	0	90	4162
1982	73	1,336	436	320	311	16	366	63	35	0	2956
1983	189	822	1,509	333	340	195	0	24	0	454	3865
1984	52	70	249	346	55	106	34	9	44	29	994
1985	15	1,115	833	849	1,164	292	272	56	38	66	4700
1986	93	34	104	23	39	53	1	10	42	25	425
1987	25	463	120	188	22	58	48	0	5	40	970
1988	105	230	1,153	196	593	41	23	246	0	0	2587
1989	96	130	62	157	24	23	9	2	6	0	507
1990	10	165	437	216	358	61	40	10	4	38	1339
1991	61	67	242	184	73	23	8	0	0	0	657
1992	15	140	74	40	42	21	13	4	0	0	350
1993	74	191	432	74	65	48	34	0	175	34	1127
1994	23	109	159	164	46	19	7	8	8	0	544
1995	8	250	375	88	90	12	4	0	0	0	826
1996	13	31	113	112	46	50	1	2	0	0	367
1997	34	159	112	175	170	19	45	1	0	0	716
1998	25	165	130	51	41	20	0	3	0	0	434
1999	5	21	79	145	72	27	21	1	16	0	387
2000	27	105	53	88	31	5	1	0	0	0	309
2001	1	34	115	21	29	4	1	0	0	0	205
2002	3	13	59	113	19	25	4	0	0	0	237
2003	4	31	34	56	59	6	13	1	0	0	203
2004	10	7	55	73	79	65	24	25	3	4	345
2005	2	70	29	82	33	12	14	2	0	0	243
2006	4	4	25	7	19	5	15	2	0	0	79
2007	0	1	0	3	1	2	0	0	0	0	8
2008	1	9	9	3	19	6	0	0	0	0	47
2009	4	6	4	2	1	2	0	0	0	0	18
2010	4	23	14	15	7	1	5	0	0	0	68

Table A7c - continued. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2010.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
					USA Recreational Landings Mean Weight (kg) at Age					
1978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.497	1.497	2.580	4.070	4.608	8.963	8.720	9.583	0.000	12.351
1982	0.537	1.437	2.163	2.921	4.591	5.839	9.512	9.342	10.619	0.000
1983	0.557	1.372	2.973	3.671	4.623	5.701	0.000	7.181	0.000	16.211
1984	0.342	0.756	3.052	3.943	4.600	6.959	8.629	13.780	9.824	13.029
1985	0.453	1.315	2.152	3.081	4.500	6.675	8.684	10.529	11.956	13.730
1986	0.527	0.747	2.134	3.343	7.017	7.701	6.959	11.624	16.623	21.883
1987	0.457	1.558	2.614	4.283	5.587	7.414	7.516	0.000	9.095	26.331
1988	0.440	0.968	2.420	3.802	5.916	6.059	9.095	13.737	0.000	0.000
1989	0.543	1.042	2.119	3.093	4.052	5.052	7.178	8.255	11.590	0.000
1990	0.448	1.267	2.631	4.030	5.515	6.636	7.126	9.990	9.095	17.518
1991	0.451	1.137	2.818	3.063	3.138	3.021	3.780	0.000	0.000	0.000
1992	0.513	1.267	2.356	3.738	4.189	5.595	5.568	7.469	0.000	0.000
1993	0.268	0.794	2.437	3.493	4.289	7.261	9.990	0.000	17.072	9.990
1994	0.495	0.965	2.434	3.832	4.068	4.086	2.405	14.559	14.559	0.000
1995	0.393	1.234	1.659	2.715	5.051	3.274	6.051	0.000	0.000	0.000
1996	0.454	1.399	2.380	3.160	5.936	6.775	2.898	5.415	0.000	0.000
1997	0.509	1.287	2.693	3.630	4.608	4.952	8.582	4.281	0.000	0.000
1998	0.642	1.285	2.074	2.907	3.458	3.954	0.000	4.814	0.000	0.000
1999	0.584	1.203	2.303	4.016	4.568	5.376	4.686	3.780	8.529	0.000
2000	0.291	0.864	1.861	3.023	4.028	2.818	4.826	0.000	0.000	0.000
2001	0.255	1.500	2.090	3.265	3.392	4.348	5.621	0.000	0.000	0.000
2002	0.400	1.189	2.336	3.096	3.942	4.747	5.521	0.000	0.000	0.000
2003	0.557	1.059	2.173	2.876	3.667	2.766	5.486	5.415	0.000	0.000
2004	0.316	1.190	1.988	3.267	3.837	4.637	7.081	5.941	7.469	10.301
2005	0.507	0.918	1.777	2.549	4.452	4.137	4.124	6.735	0.000	0.000
2006	0.397	0.753	1.733	2.431	3.141	3.447	13.837	5.137	4.281	0.000
2007	0.289	0.794	1.400	2.132	4.657	5.329	4.652	6.051	0.000	0.000
2008	0.378	1.172	1.953	2.004	3.561	7.919	3.593	0.000	0.000	0.000
2009	0.480	0.755	1.932	3.035	3.528	4.601	4.826	10.596	7.654	0.000
2010	0.478	0.914	1.703	2.653	4.465	4.259	5.157	0.000	2.898	0.000

Table A7c - continued. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2010.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
					USA Recreational Landings Mean Length (cm) at Age					
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	35.45	51.22	61.41	71.65	73.37	93.68	92.97	96.11	0.00	105.10
1982	36.20	50.58	58.42	63.95	74.60	82.00	96.38	95.90	101.00	0.00
1983	37.06	49.69	64.09	68.54	74.58	80.82	0.00	87.76	0.00	116.25
1984	31.36	40.44	65.53	71.47	74.92	84.39	92.53	110.00	97.34	107.00
1985	34.67	48.86	58.33	64.75	73.30	85.48	93.21	98.55	104.00	108.17
1986	36.41	40.49	56.83	67.90	86.58	88.91	86.33	102.85	115.14	128.00
1987	34.52	51.69	62.40	72.27	80.17	88.59	89.08	0.00	95.00	137.00
1988	33.84	43.79	60.17	69.93	81.10	79.81	95.00	109.57	0.00	0.00
1989	36.83	44.95	57.91	65.19	71.17	77.15	85.87	92.00	102.86	0.00
1990	34.34	47.91	61.66	71.24	79.27	84.42	85.99	98.00	95.00	119.00
1991	34.45	45.68	63.82	65.39	65.94	64.57	71.00	0.00	0.00	0.00
1992	35.46	48.31	59.80	68.79	71.86	79.85	80.43	89.00	0.00	0.00
1993	28.86	41.67	59.92	67.87	74.01	86.36	98.00	0.00	119.00	98.00
1994	35.57	44.05	60.40	70.28	71.56	72.58	61.06	113.00	113.00	0.00
1995	32.66	47.83	53.22	62.77	76.63	66.90	83.00	0.00	0.00	0.00
1996	34.63	49.23	59.68	65.81	81.15	85.37	65.00	80.00	0.00	0.00
1997	35.95	48.47	62.12	68.70	75.09	76.16	91.02	74.00	0.00	0.00
1998	38.57	48.74	57.06	64.09	67.63	71.26	0.00	76.05	0.00	0.00
1999	37.54	47.06	58.77	71.26	74.51	79.07	76.03	71.00	95.00	0.00
2000	29.64	42.42	54.57	64.59	71.88	63.63	77.00	0.00	0.00	0.00
2001	27.89	51.06	57.43	67.20	67.86	74.48	83.00	0.00	0.00	0.00
2002	33.07	47.55	59.58	65.41	70.74	75.27	80.16	0.00	0.00	0.00
2003	37.01	45.30	58.27	63.95	68.98	61.83	79.95	80.00	0.00	0.00
2004	30.44	46.79	55.94	66.93	70.44	75.22	86.09	82.33	89.00	101.00
2005	35.41	43.51	53.93	61.05	74.39	72.39	72.34	86.00	0.00	0.00
2006	33.03	39.79	53.69	60.15	65.71	68.01	109.25	78.54	74.00	0.00
2007	29.72	40.63	49.23	56.94	74.18	77.81	75.51	83.00	0.00	0.00
2008	32.32	46.24	55.64	56.68	66.77	87.87	69.61	0.00	0.00	0.00
2009	35.17	40.54	55.80	64.93	68.68	74.57	77.00	96.02	89.13	0.00
2010	35.20	43.23	54.05	62.30	74.49	73.13	78.87	0.00	65.00	0.00

Table A7d. Canadian commercial landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	Canadian Commercial Landings in Numbers (000's) at Age										
1978	1	71	2341	720	216	76	57	12	11	6	3511
1979	4	553	532	794	267	57	15	12	2	3	2240
1980	1	705	1078	201	499	135	31	14	26	16	2707
1981	3	272	888	637	184	278	93	43	28	11	2437
1982	7	2200	1455	901	689	154	234	105	30	33	5807
1983	15	411	1430	863	290	219	90	127	70	24	3539
1984	0	25	133	380	258	156	95	18	35	28	1129
1985	3	2162	960	403	554	155	46	50	13	12	4358
1986	10	244	1359	396	157	240	38	22	12	4	2480
1987	20	3057	605	764	99	82	116	25	15	7	4789
1988	18	229	2726	345	411	63	72	129	43	28	4064
1989	1	390	340	928	136	200	35	26	41	23	2121
1990	8	429	2108	702	834	88	93	7	9	26	4305
1991	35	688	654	1301	582	481	67	49	15	24	3896
1992	44	1747	918	293	550	204	216	38	28	10	4048
1993	5	269	1159	624	193	247	97	73	19	17	2704
1994	3	149	358	640	229	38	50	25	17	2	1510
1995	1	41	163	62	57	12	5	3	2	0	345
1996	1	28	170	283	55	38	11	3	2	0	590
1997	3	105	148	273	245	61	26	10	3	1	874
1998	0	58	210	102	95	80	16	9	3	2	573
1999	4	41	263	177	48	28	26	7	1	0	597
2000	0	30	59	238	95	23	14	8	2	1	471
2001	0	9	185	114	213	61	18	9	3	0	612
2002	0	3	35	145	42	76	14	5	2	1	323
2003	0	5	56	73	142	28	39	9	2	1	355
2004	0	3	60	64	54	73	18	19	4	2	296
2005	0	6	12	83	24	18	21	8	4	1	178
2006	0	3	112	44	124	32	14	14	2	2	345
2007	0	17	29	236	19	56	10	6	6	0	380
2008	0	18	96	48	201	13	29	4	2	1	411
2009	0	12	87	68	23	92	7	8	1	1	300
2010	0	8	47	130	45	10	20	2	1	0	264

Table A7d - continued. Canadian commercial landings (thousands of fish; metric tons) , mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				Canadian Commercial Landings in Weight (Tons) at Age							
1978	1	88	4998	1908	736	426	337	109	89	85	8777
1979	6	816	814	2590	1118	318	135	125	19	38	5979
1980	0	877	2461	612	2370	844	211	173	294	224	8066
1981	2	347	1841	2037	869	1824	744	388	281	174	8508
1982	4	2972	3101	3323	3491	1038	1993	1041	351	514	17827
1983	14	570	3027	2673	1389	1338	716	1282	801	321	12131
1984	0	37	336	1447	1276	947	775	175	380	389	5761
1985	2	2836	1751	1312	2507	923	351	462	135	163	10442
1986	7	376	3623	1425	810	1621	299	196	110	36	8504
1987	12	4559	1482	3090	553	592	1035	240	178	103	11844
1988	13	261	6024	1154	2040	396	629	1333	495	398	12741
1989	1	452	678	3468	710	1284	247	264	457	335	7895
1990	6	732	5466	2387	3975	541	722	73	109	353	14364
1991	28	1084	1627	4184	2418	2664	497	479	148	337	13467
1992	40	2525	2151	1022	2416	1199	1508	336	319	150	11667
1993	4	389	2512	1797	822	1361	647	624	169	200	8526
1994	2	202	800	2277	1031	245	365	202	130	22	5277
1995	0	55	367	214	295	76	48	25	20	0	1102
1996	1	40	380	888	275	228	70	23	16	3	1924
1997	3	152	314	824	963	336	201	82	33	10	2919
1998	0	82	468	305	381	442	104	71	30	24	1907
1999	3	57	566	580	190	168	175	60	12	7	1818
2000	0	44	126	721	397	115	84	59	19	8	1572
2001	0	13	432	341	852	311	93	70	26	4	2143
2002	0	4	80	451	184	389	96	38	19	16	1278
2003	0	6	124	203	543	125	225	65	16	10	1317
2004	0	4	122	182	182	334	97	138	37	17	1112
2005	0	7	21	210	89	89	108	60	34	12	630
2006	0	3	211	108	436	148	86	81	13	11	1096
2007	0	21	53	579	63	238	63	44	42	4	1108
2008	0	22	204	133	742	67	169	30	15	8	1390
2009	0	14	166	203	79	421	43	58	12	6	1003
2010	0	9	89	323	151	36	109	14	13	4	748

Table A7d - continued. Canadian commercial landings (thousands of fish; metric tons) , mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

					Age						
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Landings Mean Weight (kg) at Age						
1978	0.688	1.237	2.135	2.652	3.403	5.595	5.933	9.311	8.358	13.840	2.500
1979	1.299	1.474	1.530	3.264	4.182	5.543	8.908	10.535	9.766	14.313	2.669
1980	0.552	1.244	2.282	3.049	4.750	6.237	6.717	12.312	11.195	13.581	2.979
1981	0.831	1.275	2.072	3.197	4.727	6.553	7.996	9.118	10.138	16.498	3.492
1982	0.563	1.351	2.131	3.690	5.064	6.742	8.520	9.947	11.734	15.805	3.070
1983	0.912	1.386	2.117	3.097	4.784	6.114	7.979	10.126	11.443	13.292	3.427
1984	0.000	1.457	2.515	3.809	4.949	6.058	8.136	9.675	10.800	13.926	5.103
1985	0.649	1.312	1.824	3.252	4.527	5.950	7.653	9.219	10.438	13.934	2.396
1986	0.742	1.540	2.667	3.602	5.168	6.764	7.933	8.905	9.270	9.952	3.429
1987	0.614	1.491	2.452	4.043	5.588	7.231	8.956	9.697	11.682	15.420	2.473
1988	0.692	1.138	2.209	3.348	4.967	6.319	8.789	10.330	11.429	14.257	3.136
1989	0.802	1.159	1.994	3.738	5.233	6.410	7.050	10.005	11.041	14.282	3.723
1990	0.758	1.705	2.593	3.401	4.766	6.132	7.779	10.437	11.470	13.750	3.337
1991	0.814	1.576	2.487	3.216	4.154	5.545	7.413	9.761	9.621	14.288	3.457
1992	0.923	1.445	2.344	3.484	4.395	5.872	6.973	8.759	11.556	15.243	2.882
1993	0.795	1.443	2.167	2.878	4.263	5.508	6.646	8.523	8.829	11.902	3.153
1994	0.793	1.361	2.237	3.556	4.507	6.500	7.295	8.062	7.666	11.354	3.494
1995	0.435	1.334	2.250	3.430	5.214	6.480	10.218	10.055	10.251	13.004	3.194
1996	0.918	1.464	2.235	3.137	4.963	5.982	6.563	8.874	10.395	11.747	3.259
1997	0.907	1.457	2.123	3.017	3.938	5.492	7.621	8.567	11.644	10.833	3.338
1998	0.693	1.418	2.232	3.003	4.024	5.505	6.656	8.109	10.351	14.082	3.328
1999	0.590	1.383	2.151	3.275	3.938	5.928	6.770	8.084	11.187	15.055	3.044
2000	0.710	1.465	2.119	3.027	4.181	4.900	5.940	7.288	8.921	13.228	3.339
2001	0.000	1.507	2.331	3.001	4.007	5.085	5.128	7.857	9.344	14.642	3.502
2002	0.692	1.361	2.299	3.118	4.359	5.096	6.879	8.092	8.742	11.070	3.953
2003	0.000	1.326	2.227	2.801	3.835	4.397	5.686	7.063	7.698	8.664	3.710
2004	0.704	1.360	2.011	2.827	3.391	4.571	5.527	7.354	9.040	10.328	3.753
2005	0.000	1.248	1.676	2.517	3.766	4.842	5.215	7.114	8.407	9.796	3.539
2006	0.048	1.105	1.886	2.449	3.509	4.579	6.342	5.919	7.278	7.543	3.174
2007	0.175	1.236	1.825	2.459	3.264	4.226	6.321	7.007	7.008	10.101	2.916
2008	0.000	1.276	2.123	2.784	3.691	5.011	5.895	7.955	7.961	9.092	3.381
2009	0.000	1.144	1.908	3.000	3.474	4.588	5.781	6.846	10.220	10.840	3.348
2010	0.551	1.199	1.912	2.490	3.321	3.450	5.321	6.075	9.451	11.284	2.829

Table A7d - continued. Canadian commercial landings (thousands of fish; metric tons) , mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				Canadian Commercial Landings Mean Length (cm) at Age							
1978	39.5	48.1	58.4	62.6	67.9	79.7	80.5	97.1	93.2	110.9	
1979	49.0	51.6	52.7	68.0	74.3	80.8	95.8	101.7	99.4	113.6	
1980	36.7	48.9	59.8	66.3	77.1	83.9	86.3	106.9	103.4	110.7	
1981	42.6	49.2	58.1	67.4	77.2	86.6	92.2	96.4	98.8	112.7	
1982	36.8	49.9	58.1	70.3	78.6	86.8	94.3	98.6	105.4	116.3	
1983	43.7	50.7	58.7	66.8	77.4	84.5	92.7	100.3	104.7	110.3	
1984	0.0	52.1	62.5	72.0	78.3	84.2	92.8	98.5	102.5	111.2	
1985	39.1	49.6	55.5	67.7	75.7	83.5	91.1	96.3	100.2	111.1	
1986	40.8	52.6	63.6	70.5	79.2	86.8	92.3	95.9	96.4	99.6	
1987	38.4	52.0	61.5	72.8	81.5	89.0	95.9	98.6	105.6	115.3	
1988	39.8	47.7	59.6	68.6	78.2	85.0	95.8	101.1	104.6	112.8	
1989	41.6	48.6	57.7	71.2	79.7	85.5	88.0	100.3	103.5	113.2	
1990	41.0	54.3	62.9	68.7	77.0	83.5	91.1	101.8	105.1	111.7	
1991	41.2	53.0	62.0	67.3	73.4	80.5	89.7	99.2	97.7	112.9	
1992	43.7	51.6	60.5	69.2	74.8	82.8	87.3	94.3	104.6	115.7	
1993	41.3	51.1	59.1	65.0	73.6	81.1	86.5	94.6	94.2	106.1	
1994	42.9	50.1	59.5	69.7	75.2	85.0	89.2	91.8	89.4	103.9	
1995	33.0	50.5	59.7	68.5	79.5	85.4	100.6	99.5	99.8	109.1	
1996	43.9	51.2	59.2	66.5	77.5	83.2	84.8	93.4	100.7	105.9	
1997	43.7	51.4	58.6	65.7	72.1	80.7	91.0	94.6	105.4	102.2	
1998	40.0	50.7	59.3	65.4	72.5	80.9	86.3	92.4	101.1	111.8	
1999	37.7	50.4	58.5	67.6	71.6	82.7	87.0	92.1	103.7	114.6	
2000	40.0	51.3	58.4	65.6	73.1	76.9	82.3	88.2	94.6	109.1	
2001	0.0	51.7	59.8	65.2	72.1	78.0	77.9	90.6	96.8	111.4	
2002	40.0	49.8	59.3	66.0	74.2	78.1	86.6	90.9	93.7	101.0	
2003	0.0	48.8	58.9	63.7	71.0	74.4	81.2	87.5	90.3	92.5	
2004	40.1	49.8	56.9	64.1	67.9	75.1	80.3	88.6	95.0	99.3	
2005	0.0	48.4	53.9	61.4	70.5	77.4	78.8	86.6	93.1	97.9	
2006	16.0	46.0	55.7	60.8	68.7	75.4	84.8	82.9	89.2	90.2	
2007	25.0	48.1	55.1	60.9	67.0	73.2	84.2	87.7	87.5	99.4	
2008	0.0	49.0	58.2	63.7	70.0	77.3	82.1	91.1	91.6	95.9	
2009	0.0	46.9	56.2	65.3	68.3	75.2	81.2	86.5	99.9	102.3	
2010	37.0	47.9	56.2	61.3	67.6	68.5	79.5	83.1	97.6	103.9	

Table A7e. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Discards in Numbers (000's) at Age						
1978	6.9	0.2	19.5	3.2	2.4	0.6	2.2	0.1	0.1	0.1	35
1979	8.5	13.0	1.0	12.7	3.5	1.0	0.5	0.6	0.1	0.0	41
1980	5.6	8.5	9.9	0.6	6.2	1.1	0.3	0.3	0.1	0.1	33
1981	22.5	12.6	13.2	5.6	0.2	1.7	0.7	0.2	0.0	0.4	57
1982	8.2	12.4	4.5	4.3	2.6	0.0	1.2	0.3	0.0	0.0	34
1983	1.6	7.0	13.9	1.9	1.3	0.7	0.2	0.4	0.0	0.2	27
1984	9.3	1.5	5.9	8.5	0.8	1.6	0.6	0.1	0.8	0.0	29
1985	5.5	30.0	5.5	2.6	3.1	0.9	0.4	0.4	0.2	0.5	49
1986	29.6	4.3	6.4	0.7	1.2	1.2	0.2	0.2	0.3	0.0	44
1987	2.0	20.5	4.2	5.1	0.4	0.7	0.9	0.3	0.2	0.2	35
1988	4.3	2.2	20.1	2.3	3.3	0.2	0.3	0.6	0.1	0.1	33
1989	3.6	12.9	3.2	9.7	1.4	1.6	0.3	0.2	0.3	0.3	33
1990	2.3	3.4	9.2	2.6	4.1	0.6	0.8	0.2	0.1	0.2	23
1991	12.0	5.7	6.4	3.6	3.0	1.7	0.2	0.2	0.0	0.2	33
1992	4.1	18.3	5.6	0.9	2.4	1.3	0.9	0.2	0.2	0.0	34
1993	2.9	5.6	11.8	2.3	0.6	1.5	0.5	0.5	0.2	0.1	26
1994	1.8	7.3	6.1	6.9	1.7	0.8	1.2	0.1	0.3	0.0	26
1995	0.5	2.1	6.7	2.5	2.2	0.6	0.4	0.1	0.1	0.0	15
1996	3.6	1.8	7.0	8.7	1.8	1.2	0.3	0.1	0.1	0.0	25
1997	3.1	28.6	34.8	49.6	44.9	8.2	2.8	1.1	0.3	0.1	174
1998	2.8	27.8	61.3	23.3	19.1	10.6	1.3	1.2	0.1	0.1	148
1999	2.1	14.0	71.5	37.4	11.1	4.6	3.0	0.7	0.2	0.1	145
2000	1.9	8.3	4.9	9.7	4.2	1.0	0.4	0.2	0.0	0.0	31
2001	3.2	5.5	24.6	4.2	11.4	3.6	1.4	0.7	0.7	0.2	56
2002	0.4	3.2	6.1	18.4	2.6	3.7	1.0	0.2	0.1	0.1	36
2003	0.0	5.2	21.2	22.5	18.9	2.6	3.4	0.6	0.1	0.0	74
2004	19.0	4.4	23.4	12.5	9.6	6.8	0.9	1.3	0.2	0.0	78
2005	0.6	18.2	15.6	55.1	9.0	4.9	4.8	1.0	0.4	0.0	110
2006	2.0	16.0	74.8	20.9	39.4	7.1	1.9	1.8	0.2	0.2	164
2007	0.1	13.6	13.2	44.7	3.5	3.2	0.2	0.1	0.1	0.0	79
2008	0.9	12.8	12.1	5.0	19.6	1.3	3.1	0.4	0.2	0.1	55
2009	0.5	10.2	34.5	17.6	4.9	16.9	1.2	1.1	0.1	0.1	87
2010	1.2	5.8	10.8	20.8	6.0	1.4	1.4	0.1	0.0	0.0	48

Table A7e - continued. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Discards in Weight (Tons) at Age						
1978	3	0	44	12	12	4	18	1	1	1	98
1979	3	17	2	46	17	6	5	7	1	0	103
1980	2	8	22	2	34	7	2	3	1	2	83
1981	6	17	29	20	1	12	6	3	0	4	98
1982	5	18	11	14	11	0	10	2	0	0	71
1983	1	9	33	5	4	4	2	3	0	4	65
1984	2	1	15	27	3	7	3	1	9	0	68
1985	2	41	14	9	12	6	4	4	2	7	102
1986	13	4	12	2	6	7	2	2	3	0	51
1987	1	30	9	14	2	5	7	2	2	4	76
1988	1	2	42	8	17	1	3	7	1	1	83
1989	1	15	6	28	5	11	2	1	3	3	76
1990	1	4	21	8	19	4	6	2	1	4	70
1991	4	8	14	11	11	8	2	2	0	3	65
1992	2	23	12	2	11	9	7	2	3	1	71
1993	1	6	25	7	3	9	4	3	2	1	63
1994	0	6	11	21	7	4	7	1	4	1	63
1995	0	2	13	7	8	2	2	1	1	1	38
1996	1	2	13	23	6	6	1	1	1	0	56
1997	2	41	72	136	161	41	19	9	3	1	486
1998	2	36	125	62	69	52	8	8	1	1	365
1999	1	18	134	101	33	22	18	6	2	2	338
2000	1	10	9	26	14	4	3	2	0	0	69
2001	1	5	41	14	42	17	9	6	6	2	143
2002	0	3	9	47	9	15	5	2	1	1	94
2003	0	6	47	62	56	8	16	4	1	0	200
2004	4	4	38	30	30	25	4	8	2	1	145
2005	0	13	22	117	27	20	20	5	3	0	228
2006	0	8	124	45	119	29	11	10	1	1	349
2007	0	9	14	73	7	9	1	0	0	0	114
2008	0	10	20	12	68	6	18	3	1	1	139
2009	0	8	55	45	15	69	6	7	1	1	207
2010	1	5	17	43	16	4	6	1	0	0	92

Table A7e - continued. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
				Canadian Commercial Discards Mean Weight (kg) at Age						
1978	0.391	1.641	2.275	3.689	5.209	6.783	8.445	8.985	10.222	14.998
1979	0.362	1.276	2.022	3.603	4.811	5.776	10.371	10.937	10.799	0.000
1980	0.360	0.960	2.220	3.667	5.457	6.502	5.894	12.954	11.735	13.451
1981	0.274	1.354	2.181	3.542	5.333	7.018	8.205	12.670	0.000	12.401
1982	0.550	1.489	2.328	3.263	4.163	0.000	8.340	8.842	10.764	0.000
1983	0.413	1.324	2.385	2.491	3.300	5.952	8.174	7.476	0.000	16.207
1984	0.242	0.916	2.483	3.206	3.070	4.394	5.931	8.985	10.471	0.000
1985	0.418	1.367	2.615	3.662	3.933	6.458	8.786	9.867	14.048	15.347
1986	0.445	0.893	1.942	3.217	4.920	5.733	7.439	8.988	10.684	18.000
1987	0.260	1.440	2.188	2.817	5.672	7.487	7.480	6.659	10.100	20.219
1988	0.323	1.057	2.077	3.371	5.062	6.268	9.325	11.369	11.973	17.117
1989	0.360	1.157	1.938	2.837	3.818	6.597	7.615	7.813	11.320	12.723
1990	0.446	1.193	2.316	3.158	4.731	5.903	8.589	10.114	13.493	16.278
1991	0.343	1.441	2.208	3.151	3.614	4.895	7.544	10.059	9.973	14.584
1992	0.548	1.279	2.088	2.672	4.476	6.379	7.420	8.474	11.803	19.671
1993	0.365	1.110	2.117	3.137	5.101	6.191	8.169	7.289	9.450	11.783
1994	0.278	0.853	1.866	2.993	3.786	5.528	5.710	8.661	11.246	17.373
1995	0.159	1.109	1.938	2.628	3.757	4.056	6.801	7.920	11.753	16.693
1996	0.369	1.223	1.782	2.667	3.642	5.412	4.294	12.028	11.920	15.163
1997	0.519	1.421	2.074	2.751	3.578	5.052	6.798	8.328	11.495	12.537
1998	0.794	1.309	2.037	2.673	3.591	4.854	6.070	7.125	9.531	12.366
1999	0.525	1.285	1.875	2.692	3.025	4.807	6.110	8.327	9.672	15.349
2000	0.584	1.271	1.785	2.700	3.322	3.676	6.397	7.722	11.523	13.972
2001	0.208	0.978	1.668	3.334	3.674	4.802	6.142	8.514	8.022	10.533
2002	0.338	1.020	1.542	2.574	3.500	4.114	4.899	8.436	10.001	12.169
2003	0.000	1.190	2.231	2.752	2.971	3.065	4.692	6.014	7.661	0.000
2004	0.230	0.979	1.612	2.411	3.085	3.666	4.207	6.085	8.596	11.353
2005	0.114	0.737	1.437	2.122	3.026	4.090	4.212	5.071	7.578	7.752
2006	0.086	0.518	1.658	2.135	3.023	4.003	5.879	5.605	6.516	8.008
2007	0.161	0.669	1.042	1.628	2.080	2.821	4.670	6.636	5.277	0.000
2008	0.130	0.765	1.679	2.363	3.452	4.999	5.928	7.543	7.758	8.682
2009	0.191	0.764	1.590	2.551	3.009	4.123	5.041	6.413	9.700	11.622
2010	0.418	0.884	1.539	2.077	2.699	2.892	4.080	4.206	6.413	7.901

Table A7e - continued. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

					Age					
Year	1	2	3	4	5	6	7	8	9	10+
					Canadian Commercial Discards Mean Weight (kg) at Age					
1978	34.5	54.9	60.7	71.5	80.6	87.3	94.6	97.0	101.2	115.0
1979	33.2	50.1	58.7	70.8	78.3	83.0	100.9	103.3	100.0	0.0
1980	33.9	45.6	60.5	70.6	81.8	86.8	83.6	106.2	106.0	110.9
1981	30.0	51.2	60.1	70.8	80.8	89.1	94.1	108.7	0.0	104.5
1982	38.7	53.0	61.8	69.0	75.1	0.0	93.8	96.5	103.0	0.0
1983	34.3	51.2	61.7	63.0	69.3	84.4	94.0	89.9	0.0	118.0
1984	29.4	44.5	62.6	67.9	67.3	76.1	84.5	97.0	101.8	0.0
1985	35.5	51.5	63.6	71.3	73.5	86.1	96.3	100.1	112.5	114.4
1986	36.0	44.5	58.1	68.9	81.2	85.2	97.6	97.0	108.3	118.0
1987	30.4	52.1	61.4	68.6	82.0	90.1	92.8	97.5	100.4	121.2
1988	31.3	45.6	59.4	68.8	77.0	79.1	96.7	103.5	103.5	120.6
1989	32.6	48.1	58.1	65.7	71.1	83.6	88.2	96.4	105.2	107.5
1990	35.8	49.2	60.7	67.2	75.9	83.6	92.5	98.0	106.0	111.1
1991	32.4	52.0	60.5	65.3	68.9	78.6	90.8	98.5	94.8	116.6
1992	37.0	49.7	59.4	64.1	75.2	84.7	88.2	92.0	100.9	119.6
1993	33.8	48.0	58.7	67.6	79.8	84.3	91.1	90.7	95.0	103.5
1994	29.1	43.6	56.7	66.4	71.0	80.3	81.0	98.4	101.1	132.6
1995	24.3	47.0	57.6	64.7	72.8	73.5	87.1	86.5	105.4	109.6
1996	33.3	49.3	55.7	63.7	69.3	81.1	73.5	100.8	102.7	109.3
1997	36.9	51.1	58.2	63.9	70.0	78.3	87.5	93.0	104.5	105.9
1998	42.9	49.2	57.8	63.3	70.1	77.6	84.1	89.0	97.8	104.7
1999	36.1	49.2	56.2	63.8	66.4	77.6	84.2	92.1	97.8	114.0
2000	37.3	49.6	55.4	64.2	68.7	70.1	86.0	93.7	101.6	108.4
2001	28.4	46.1	54.7	68.6	72.2	78.7	85.4	94.4	93.4	99.3
2002	32.1	45.3	53.4	62.9	70.7	74.9	80.1	93.4	98.5	103.9
2003	0.0	46.4	60.8	63.9	67.2	67.3	79.6	84.5	91.8	0.0
2004	24.6	44.3	52.7	61.2	66.7	70.7	73.9	84.3	94.6	100.5
2005	22.1	40.2	51.1	58.5	66.1	73.8	73.7	77.8	89.5	91.2
2006	22.0	35.7	52.9	57.7	65.5	71.9	82.2	81.1	86.2	91.7
2007	24.2	40.1	46.9	54.2	58.6	64.9	77.1	87.1	80.7	0.0
2008	22.1	40.8	53.9	60.2	68.6	77.3	82.5	90.0	91.2	95.0
2009	25.8	40.9	53.2	62.1	65.6	73.0	77.9	85.1	99.0	104.6
2010	33.6	43.7	52.9	58.6	64.0	65.7	73.8	74.4	84.9	92.0

Table A7f. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Catch in Numbers (000's) at Age						
1978	158	427	8,493	2,498	914	179	244	23	41	10	12987
1979	292	2,438	1,159	4,628	1,175	453	157	308	11	35	10656
1980	345	4,175	5,921	532	2,550	995	418	74	151	21	15182
1981	1,243	4,050	5,029	2,822	367	1,304	424	155	162	61	15616
1982	784	11,385	4,532	2,785	1,988	287	720	207	84	91	22862
1983	616	4,856	7,693	2,334	1,246	912	174	285	126	134	18376
1984	290	1,548	3,507	3,341	841	595	474	58	185	114	10954
1985	180	7,489	3,003	1,713	2,158	513	268	210	32	92	15659
1986	789	1,605	4,643	888	538	638	94	74	59	28	9356
1987	112	8,438	1,522	2,198	308	253	277	59	37	27	13231
1988	338	2,355	8,785	1,101	1,574	219	162	238	61	52	14883
1989	890	2,544	3,198	4,285	397	559	86	55	65	27	12107
1990	66	5,666	5,718	2,047	2,307	224	221	24	19	36	16328
1991	330	2,258	3,672	3,230	1,444	1,054	134	93	28	30	12272
1992	219	5,165	2,327	1,079	1,513	469	399	58	43	13	11284
1993	309	1,603	4,524	1,259	499	540	185	146	45	23	9133
1994	126	602	1,580	2,047	443	102	151	54	32	6	5143
1995	32	653	1,430	670	387	44	25	22	8	1	3272
1996	61	291	993	1,284	259	185	19	12	12	0	3117
1997	187	709	773	1,049	895	148	94	21	9	4	3890
1998	68	925	1,329	497	387	287	41	18	5	2	3560
1999	51	376	2,058	862	286	124	146	23	5	1	3933
2000	128	939	742	1,157	315	85	45	38	4	1	3454
2001	21	752	2,807	752	699	178	54	25	14	2	5305
2002	40	83	1,189	1,522	366	370	83	18	11	7	3689
2003	9	184	430	816	903	152	141	27	6	3	2671
2004	74	89	463	258	318	255	57	50	11	5	1580
2005	9	431	239	610	153	108	89	18	9	4	1671
2006	35	95	822	210	377	71	31	29	4	4	1678
2007	5	613	383	1,239	74	143	17	11	9	1	2495
2008	11	381	743	176	532	21	48	5	3	1	1920
2009	38	275	663	456	102	208	12	13	2	1	1771
2010	14	184	481	582	159	25	71	4	4	0	1524

Table A7f - continued. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Catch in Weight (Tons) at Age						
1978	90	526	20019	8288	3561	976	1584	186	395	127	35751
1979	203	3383	2095	19418	5687	3209	1513	3174	108	473	39264
1980	221	5832	14236	1854	14065	6677	3457	743	1407	280	48771
1981	723	5801	11720	9756	1773	9466	3609	1490	2241	1,069	47649
1982	503	15699	11207	10225	10417	1918	6668	2066	1053	1,416	61172
1983	414	6937	18459	7808	6045	5819	1440	2977	1446	2,127	53473
1984	154	2320	8689	12255	4220	3882	4092	581	2047	1597	39836
1985	143	10172	6094	6221	10594	3230	2190	2126	369	1283	42421
1986	524	2169	11102	3075	2892	4477	809	718	749	412	26927
1987	64	12087	3689	8855	1726	1945	2398	580	425	422	32191
1988	166	3211	20055	3678	8206	1459	1387	2437	697	747	42044
1989	400	3663	6804	15608	2028	3593	664	529	707	375	34372
1990	35	8417	13697	7118	11090	1389	1782	260	215	497	44500
1991	211	3302	8986	11060	6782	6125	1005	881	285	428	39065
1992	160	7015	5394	4075	6740	2821	2800	515	488	209	30218
1993	89	2040	9828	3913	2434	3058	1327	1261	497	279	24726
1994	55	719	3339	7089	2053	697	1052	473	282	89	15849
1995	14	877	2791	2471	2023	322	229	260	88	28	9102
1996	31	418	2359	4084	1251	1192	151	119	130	5	9742
1997	102	1028	1771	3520	3517	826	712	175	105	46	11800
1998	42.7	1322	2968	1683	1745	1580	305	139	64	28	9876
1999	26.4	531	4355	2837	1285	722	973	193	52	11	10985
2000	52	1446	1769	3920	1434	467	313	303	37	8.1	9749
2001	14	1031	6055	2222	2886	945	327	196	133	19	13829
2002	23	117	2495	4505	1448	1916	545	145	100	81	11374
2003	4	279	965	2377	3508	719	819	193	54	31	8949
2004	22	134	1075	809	1232	1228	323	370	98	55	5346
2005	3	434	477	1853	608	530	482	134	79	41	4642
2006	14	101	1,754	653	1,371	324	202	183	29	32	4663
2007	2	841	743	3,556	265	584	98	74	61	10	6233
2008	5	614	1,727	508	1,951	118	272	38	23	13	5270
2009	25	373	1422	1520	402	970	76	91	17	9	4906
2010	7	221	1049	1686	581	94	342	21	24	6	4030

Table A7f - continued. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Catch Mean Weight (kg) at Age						
1978	0.570	1.231	2.357	3.317	3.894	5.448	6.500	8.256	9.672	12.881	2.753
1979	0.694	1.388	1.808	4.196	4.838	7.082	9.628	10.320	9.861	13.621	3.685
1980	0.639	1.397	2.404	3.484	5.516	6.714	8.275	10.062	9.316	13.453	3.212
1981	0.582	1.433	2.331	3.457	4.831	7.259	8.519	9.633	13.815	17.450	3.051
1982	0.641	1.379	2.473	3.671	5.240	6.680	9.258	10.000	12.605	15.551	2.676
1983	0.672	1.429	2.400	3.346	4.851	6.381	8.253	10.439	11.507	15.867	2.910
1984	0.531	1.498	2.478	3.668	5.015	6.524	8.629	10.006	11.062	14.033	3.637
1985	0.794	1.358	2.029	3.631	4.909	6.291	8.157	10.137	11.596	13.991	2.709
1986	0.665	1.351	2.391	3.465	5.371	7.014	8.578	9.758	12.659	14.506	2.878
1987	0.572	1.432	2.423	4.028	5.604	7.674	8.669	9.791	11.627	15.674	2.433
1988	0.492	1.364	2.283	3.341	5.215	6.675	8.557	10.256	11.462	14.490	2.825
1989	0.449	1.439	2.128	3.642	5.104	6.427	7.746	9.655	10.906	13.839	2.839
1990	0.537	1.485	2.395	3.477	4.806	6.188	8.060	10.946	11.457	13.730	2.725
1991	0.639	1.462	2.447	3.425	4.697	5.809	7.475	9.507	10.241	14.430	3.183
1992	0.732	1.358	2.318	3.777	4.456	6.020	7.016	8.928	11.288	15.699	2.678
1993	0.289	1.273	2.172	3.109	4.878	5.660	7.177	8.662	10.966	12.045	2.707
1994	0.435	1.195	2.113	3.464	4.630	6.827	6.986	8.710	8.835	15.841	3.082
1995	0.419	1.342	1.951	3.686	5.228	7.386	9.332	12.022	11.645	19.016	2.782
1996	0.510	1.438	2.376	3.180	4.835	6.439	7.886	9.795	11.017	10.973	3.125
1997	0.543	1.449	2.291	3.356	3.930	5.572	7.555	8.168	11.373	11.696	3.033
1998	0.626	1.430	2.234	3.384	4.507	5.502	7.357	7.730	11.632	13.689	2.774
1999	0.519	1.412	2.116	3.291	4.487	5.808	6.666	8.437	10.014	13.925	2.793
2000	0.403	1.541	2.385	3.387	4.547	5.501	6.977	8.051	8.401	13.262	2.823
2001	0.673	1.372	2.157	2.954	4.127	5.294	6.032	7.825	9.256	11.667	2.607
2002	0.563	1.405	2.099	2.960	3.957	5.177	6.543	8.085	9.292	11.929	3.083
2003	0.508	1.513	2.246	2.913	3.884	4.719	5.821	7.052	8.373	10.176	3.350
2004	0.304	1.501	2.319	3.129	3.879	4.818	5.689	7.358	8.761	11.188	3.383
2005	0.327	1.006	1.993	3.037	3.969	4.902	5.435	7.509	8.785	11.344	2.778
2006	0.410	1.061	2.133	3.105	3.639	4.533	6.451	6.390	7.518	8.994	2.779
2007	0.335	1.372	1.941	2.869	3.564	4.082	5.927	6.949	6.850	8.758	2.499
2008	0.446	1.611	2.324	2.893	3.670	5.495	5.724	8.158	8.191	10.034	2.744
2009	0.649	1.354	2.144	3.332	3.945	4.674	6.157	6.763	9.757	11.190	2.770
2010	0.457	1.202	2.179	2.896	3.659	3.789	4.799	5.885	6.638	12.049	2.644

Table A7f - continued. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2010.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Catch Mean Length (cm) at Age						
1978	38.4	49.0	60.4	67.2	70.5	79.2	84.2	92.7	96.5	107.1	62.7
1979	40.8	51.2	55.3	73.1	77.0	87.3	97.6	99.7	98.7	109.2	67.6
1980	39.7	51.2	60.9	69.1	80.6	86.2	92.0	97.4	96.1	110.1	64.5
1981	37.8	51.4	60.3	68.8	77.3	88.5	93.5	97.3	109.5	117.4	62.5
1982	39.3	51.0	61.1	69.8	79.1	86.1	96.1	98.4	106.7	114.2	60.1
1983	39.7	51.7	60.9	67.9	77.0	84.7	92.9	100.3	103.9	115.0	62.5
1984	35.9	52.1	61.7	70.3	78.1	85.5	93.7	98.7	102.0	109.9	67.6
1985	42.4	50.6	57.5	69.8	77.3	84.4	91.9	98.8	103.3	109.8	60.5
1986	40.0	50.4	61.1	68.7	79.6	87.6	93.9	97.8	106.1	110.8	62.1
1987	37.4	51.6	61.2	72.5	81.3	90.5	94.2	98.2	104.2	114.1	58.9
1988	35.4	50.8	60.2	67.8	78.9	85.9	93.9	100.0	104.1	112.1	62.4
1989	33.6	51.5	58.7	70.1	78.4	84.6	89.9	98.4	102.5	111.7	62.0
1990	36.4	52.4	60.9	68.8	76.7	83.3	91.4	101.9	104.0	110.9	62.0
1991	38.2	51.8	61.5	68.4	76.0	81.5	89.3	96.6	99.1	112.6	65.1
1992	40.4	50.6	60.6	71.2	75.3	83.2	87.9	94.9	103.9	116.5	60.9
1993	29.5	49.1	59.4	66.8	77.3	81.7	89.1	95.1	101.3	105.7	61.4
1994	33.7	48.1	58.7	69.2	76.3	86.8	88.4	95.0	94.6	115.6	64.6
1995	33.4	50.1	57.1	70.3	80.4	88.6	97.7	105.6	104.9	121.4	62.1
1996	36.0	51.6	60.9	67.2	77.1	86.3	89.2	98.9	102.7	102.9	65.5
1997	36.7	51.5	60.3	68.2	72.1	81.8	91.0	93.3	104.8	105.0	64.3
1998	38.6	51.5	59.9	69.1	76.3	81.9	90.2	91.5	104.7	108.1	62.8
1999	36.2	51.3	59.1	68.5	76.2	83.1	87.6	94.1	99.9	111.6	63.4
2000	32.4	52.5	61.3	69.0	75.9	81.1	88.0	93.2	94.1	106.9	63.0
2001	38.6	50.6	59.0	65.7	73.4	80.1	83.6	91.4	97.7	104.6	61.8
2002	37.2	50.6	58.6	66.0	72.6	79.5	86.2	92.2	96.9	105.8	65.7
2003	35.7	51.4	59.9	65.5	72.4	77.1	83.0	88.4	93.4	99.4	67.8
2004	29.0	51.7	59.8	67.0	72.3	77.7	82.1	89.7	95.0	103.4	66.6
2005	30.4	44.7	56.9	66.1	73.0	78.5	80.9	89.5	94.9	103.0	61.7
2006	33.1	45.3	58.3	66.4	70.2	75.6	85.5	85.5	89.5	94.2	62.6
2007	30.6	50.0	56.4	64.9	69.5	72.7	82.5	87.4	86.9	93.9	60.7
2008	33.8	52.9	60.6	65.3	70.7	80.1	81.3	92.0	92.6	94.8	63.0
2009	38.8	49.9	59.0	68.9	72.7	76.6	83.2	86.6	98.3	99.3	63.0
2010	34.4	47.7	59.3	65.4	70.8	71.2	77.6	82.1	84.6	105.2	62.4

Table A8. Standardized stratified mean catch per tow in numbers and weight (kg)for Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2011. [1,2,3].

	Spring				Autumn			
Year	No/Tow	No. CV	Wt/Tow	Wt CV	No/Tow	No. CV	Wt/Tow	Wt. CV
1963	-		-		4.4	28.3	17.8	27.2
1964	-		-		2.8	22.1	11.4	29.5
1965	-		-		4.3	29.3	11.8	31.6
1966	-		-		4.9	25.2	8.1	23.0
1967	-		-		10.3	25.6	13.6	22.7
1968	4.7	21.1	12.7	19.7	3.3	24.1	8.6	25.1
1969	4.6	15.6	17.8	15.2	2.2	18.3	8.0	20.1
1970	4.3	19.0	15.8	19.8	5.1	17.0	12.6	18.7
1971	3.4	16.0	14.3	22.4	3.2	21.4	9.8	25.5
1972	9.2	16.1	19.3	13.6	13.1	23.6	22.9	36.2
1973	57.8	67.5	94.5	57.9	12.3	23.7	30.9	29.2
1974	14.7	18.0	36.4	16.6	3.5	21.3	8.2	21.2
1975	6.9	36.8	26.1	34.1	6.4	50.2	14.1	41.0
1976	7.1	18.8	18.6	14.6	10.4	31.1	17.7	23.9
1977	6.2	12.6	15.3	13.7	5.4	16.1	12.5	14.0
1978	12.3	17.3	31.2	15.4	8.6	15.3	23.3	15.2
1979	5.0	14.1	16.2	14.0	6.0	19.3	16.5	12.9
1980	7.7	24.8	24.1	21.1	2.9	18.1	6.7	24.5
1981	10.4	17.0	26.1	15.6	9.2	41.8	20.3	43.5
1982	33.0	75.2	101.9	84.2	3.3	40.4	6.1	41.5
1983	7.7	23.6	23.5	18.1	4.1	34.8	6.1	30.2
1984	4.1	16.6	15.3	20.4	4.7	29.9	10.0	31.7
1985	7.0	22.2	21.7	19.2	2.3	40.0	3.1	45.8
1986	5.0	13.9	16.7	15.3	3.0	43.6	3.7	27.4
1987	3.2	15.7	9.9	16.7	2.3	28.5	4.4	30.2
1988	5.9	19.2	13.5	18.2	3.1	28.5	5.6	34.4
1989	4.8	20.0	10.9	18.2	4.8	39.7	4.7	29.1
1990	4.8	21.9	11.7	18.4	4.8	31.4	11.5	41.6
1991	4.3	11.2	8.9	13.8	1.0	25.2	1.4	30.3
1992	2.7	18.0	7.4	20.7	1.7	25.5	3.0	31.7
1993	2.4	26.4	7.0	25.4	2.2	64.2	2.2	34.3
1994	1.0	26.9	1.2	27.6	1.8	27.1	3.3	33.3
1995	3.3	26.1	8.4	38.5	3.6	48.4	5.6	47.4
1996	2.7	25.1	7.5	23.2	1.1	27.3	2.7	27.6
1997	2.3	17.4	5.2	26.7	0.9	44.6	1.9	48.4
1998	4.4	34.3	11.7	36.0	1.9	23.6	2.8	21.3
1999	2.2	16.0	4.7	19.4	1.0	31.8	3.0	42.9
2000	3.6	25.6	8.2	23.9	1.3	65.4	1.4	36.7
2001	1.9	26.0	5.5	33.1	1.1	33.2	2.1	34.6
2002	2.1	23.4	5.0	19.8	4.7	37.1	11.3	44.8
2003	2.0	36.9	4.2	39.7	1.3	42.7	2.1	32.3
2004	5.4	50.1	14.3	59.1	4.2	41.5	5.9	70.3
2005	2.0	17.6	4.5	19.4	1.0	30.7	1.6	30.1
2006	3.2	26.9	6.1	24.3	1.4	43.0	2.7	45.2
2007	3.4	25.1	5.1	24.2	0.6	29.4	1.1	37.1
2008	3.6	31.6	4.3	22.5	3.6	74.6	2.9	34.1
2009	2.3	29.8	3.5	25.3	2.5	54.6	4.2	39.6
2010	1.9	25.4	3.8	22.8	1.6	42.7	2.5	34.7
2011	1.0	23.9	1.9	26.4				

Table A9. Length based calibration coefficients and coefficient of variation (CV) used to calibrate Atlantic cod captured by the Bigelow to Albatross IV units, applied to both spring and autumn data, in the Gulf of Maine and Georges Bank area.

cm	calibration coefficient	CV
1 to 20	5.7237	16.2%
21	5.6002	16.0%
22	5.4767	15.8%
23	5.3532	15.5%
24	5.2297	15.3%
25	5.1062	15.0%
26	4.9827	14.7%
27	4.8592	14.5%
28	4.7357	14.2%
29	4.6122	13.9%
30	4.4887	13.5%
31	4.3652	13.2%
32	4.2417	12.9%
33	4.1182	12.5%
34	3.9947	12.2%
35	3.8712	11.8%
36	3.7477	11.4%
37	3.6242	11.0%
38	3.5007	10.6%
39	3.3772	10.3%
40	3.2537	9.9%
41	3.1302	9.5%
42	3.0067	9.2%
43	2.8832	9.0%
44	2.7597	8.9%
45	2.6362	8.9%
46	2.5127	9.0%
47	2.3892	9.4%
48	2.2657	10.1%
49	2.1422	11.0%
50	2.0187	12.3%
51	1.8952	13.9%
52	1.7717	16.0%
53	1.6482	18.5%
54	1.6016	19.6%
55 etc,	1.6016	20.0%

Table A10a. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2011.

	AGE											
Year	0	1	2	3	4	5	6	7	8	9	10+	No./tow
SPRING												
1968	0.513	0.136	1.615	0.825	0.665	0.385	0.246	0.140	0.083	0.056	0.058	4.722
1969	0.000	0.123	0.546	1.780	0.888	0.451	0.326	0.215	0.128	0.072	0.112	4.641
1970	0.000	0.338	0.804	0.430	1.241	0.162	0.844	0.263	0.058	0.056	0.147	4.342
1971	0.000	0.206	0.860	0.438	0.254	0.570	0.114	0.324	0.365	0.128	0.132	3.391
1972	0.056	3.000	1.838	2.732	0.445	0.166	0.323	0.084	0.285	0.071	0.158	9.159
1973	0.056	0.546	42.258	6.344	6.387	0.657	0.515	0.367	0.058	0.217	0.404	57.808
1974	0.000	0.444	4.558	5.971	0.761	1.988	0.442	0.100	0.265	0.064	0.144	14.735
1975	0.000	0.064	0.327	2.092	2.941	0.377	0.744	0.084	0.115	0.147	0.000	6.890
1976	0.111	1.298	1.955	0.915	0.661	1.607	0.153	0.261	0.029	0.000	0.068	7.058
1977	0.000	0.044	3.389	1.084	0.553	0.267	0.717	0.052	0.066	0.000	0.021	6.193
1978	3.312	0.372	0.192	5.531	0.972	0.778	0.142	0.712	0.065	0.141	0.096	12.312
1979	0.108	0.428	1.298	0.275	1.852	0.547	0.236	0.084	0.139	0.013	0.022	5.000
1980	0.105	0.031	2.217	2.690	0.212	1.705	0.374	0.186	0.031	0.030	0.096	7.676
1981	0.301	2.302	1.852	2.811	1.685	0.106	0.879	0.258	0.132	0.000	0.113	10.438
1982	0.169	0.508	5.435	9.502	8.324	6.208	0.293	1.866	0.369	0.082	0.203	32.958
1983	0.081	0.332	1.952	3.017	0.796	0.697	0.443	0.027	0.219	0.000	0.138	7.701
1984	0.000	0.402	0.431	0.761	1.238	0.422	0.400	0.209	0.000	0.215	0.000	4.078
1985	0.244	0.111	2.653	0.663	1.110	1.412	0.265	0.192	0.180	0.037	0.161	7.029
1986	0.092	0.872	0.409	1.844	0.365	0.540	0.618	0.062	0.125	0.101	0.015	5.044
1987	0.000	0.020	1.613	0.378	0.763	0.062	0.179	0.136	0.033	0.027	0.025	3.235
1988	0.180	0.720	0.609	3.150	0.409	0.644	0.064	0.037	0.049	0.000	0.007	5.868
1989	0.000	0.310	1.410	0.666	1.583	0.235	0.351	0.051	0.040	0.055	0.093	4.794
1990	0.042	0.173	0.922	1.737	0.674	0.912	0.130	0.143	0.013	0.016	0.027	4.790
1991	0.195	1.027	0.528	0.689	0.929	0.479	0.328	0.054	0.041	0.000	0.045	4.313
1992	0.000	0.123	1.252	0.468	0.168	0.273	0.142	0.159	0.020	0.037	0.028	2.670
1993	0.110	0.009	0.399	1.306	0.205	0.090	0.138	0.029	0.034	0.021	0.055	2.396
1994	0.030	0.125	0.272	0.200	0.217	0.033	0.006	0.044	0.000	0.019	0.000	0.945
1995	0.482	0.050	0.382	0.854	0.534	0.599	0.107	0.234	0.028	0.022	0.000	3.290
1996	0.000	0.073	0.214	0.736	1.247	0.174	0.209	0.028	0.018	0.000	0.000	2.699
1997	0.302	0.291	0.437	0.170	0.489	0.422	0.050	0.134	0.020	0.000	0.000	2.315
1998	0.018	0.111	0.665	1.298	0.848	0.755	0.533	0.102	0.031	0.000	0.000	4.360
1999	0.067	0.212	0.291	0.609	0.510	0.238	0.119	0.064	0.031	0.007	0.000	2.148
2000	0.053	0.221	0.807	0.830	1.141	0.370	0.102	0.026	0.020	0.000	0.000	3.569
2001	0.000	0.061	0.235	0.794	0.160	0.383	0.177	0.023	0.018	0.012	0.000	1.862
2002	0.018	0.065	0.093	0.383	0.993	0.239	0.225	0.039	0.000	0.000	0.028	2.083
2003	0.000	0.016	0.213	0.271	0.623	0.696	0.064	0.080	0.012	0.000	0.000	1.975
2004	0.000	0.637	0.058	0.579	1.407	1.354	0.893	0.179	0.261	0.013	0.000	5.380
2005	0.061	0.012	0.484	0.138	0.631	0.274	0.205	0.127	0.030	0.000	0.000	1.963
2006	0.013	0.179	0.231	1.306	0.332	0.723	0.213	0.121	0.054	0.000	0.000	3.172
2007	0.000	0.125	0.639	0.376	1.794	0.181	0.209	0.031	0.018	0.000	0.000	3.372
2008	0.131	0.633	0.832	0.579	0.351	0.961	0.038	0.045	0.000	0.000	0.000	3.569
2009	0.000	0.617	0.349	0.576	0.281	0.149	0.248	0.017	0.009	0.010	0.000	2.256
2010	0.000	0.103	0.582	0.366	0.580	0.142	0.033	0.124	0.000	0.009	0.000	1.939
2011	0.000	0.077	0.259	0.181	0.283	0.140	0.051	0.008	0.018	0.000	0.000	1.016
average	0.267	0.399	2.008	1.553	1.102	0.672	0.293	0.171	0.090	0.066	0.096	6.526

Table A10b. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2010.

					AGE							
Year	0	1	2	3	4	5	6	7	8	9	10+	No./tow
AUTUMN												
1963	0.019	0.719	0.778	0.920	0.897	0.354	0.326	0.175	0.103	0.014	0.069	4.374
1964	0.009	0.640	0.699	0.588	0.538	0.145	0.136	0.062	0.050	0.030	0.083	2.980
1965	0.173	1.299	0.998	0.707	0.484	0.167	0.179	0.112	0.081	0.023	0.023	4.246
1966	1.025	1.693	1.000	0.515	0.264	0.100	0.095	0.062	0.039	0.002	0.017	4.812
1967	0.072	7.596	1.334	0.523	0.406	0.133	0.133	0.055	0.051	0.012	0.070	10.385
1968	0.070	0.314	1.611	0.783	0.271	0.073	0.067	0.027	0.023	0.008	0.048	3.295
1969	0.000	0.343	0.622	0.626	0.331	0.094	0.061	0.019	0.023	0.022	0.059	2.200
1970	0.434	1.699	1.361	0.532	0.696	0.153	0.000	0.033	0.055	0.055	0.098	5.116
1971	0.400	0.602	0.617	0.408	0.310	0.478	0.164	0.042	0.090	0.000	0.075	3.186
1972	0.948	7.473	1.191	1.841	0.399	0.241	0.568	0.116	0.204	0.021	0.084	13.085
1973	0.203	1.748	6.060	1.164	2.039	0.210	0.225	0.175	0.062	0.137	0.253	12.276
1974	0.461	0.410	0.667	1.509	0.161	0.089	0.112	0.000	0.059	0.021	0.000	3.489
1975	2.377	0.992	0.421	0.628	1.682	0.111	0.156	0.000	0.000	0.000	0.037	6.406
1976	0.000	6.144	2.073	0.762	0.275	0.738	0.054	0.269	0.037	0.052	0.021	10.425
1977	0.152	0.237	3.434	0.691	0.253	0.173	0.394	0.007	0.027	0.000	0.077	5.444
1978	0.395	1.845	0.391	4.058	0.964	0.336	0.165	0.343	0.050	0.030	0.014	8.590
1979	0.115	1.625	1.677	0.162	1.687	0.321	0.184	0.031	0.113	0.010	0.025	5.948
1980	0.280	0.820	0.564	0.774	0.053	0.265	0.057	0.067	0.027	0.000	0.000	2.905
1981	0.261	3.525	2.250	1.559	0.589	0.054	0.579	0.057	0.064	0.018	0.083	9.039
1982	0.362	0.577	1.910	0.242	0.068	0.115	0.000	0.031	0.033	0.000	0.000	3.337
1983	1.283	0.850	1.089	0.740	0.069	0.033	0.004	0.010	0.015	0.000	0.044	4.136
1984	0.179	1.909	0.682	0.929	0.825	0.024	0.059	0.039	0.000	0.039	0.044	4.728
1985	1.002	0.181	0.843	0.067	0.106	0.077	0.028	0.000	0.000	0.000	0.003	2.306
1986	0.076	2.279	0.129	0.329	0.008	0.049	0.073	0.016	0.000	0.007	0.022	2.987
1987	0.204	0.414	1.353	0.108	0.200	0.028	0.012	0.000	0.000	0.000	0.007	2.325
1988	0.550	0.875	0.437	0.904	0.060	0.194	0.000	0.011	0.039	0.000	0.000	3.069
1989	0.251	2.798	1.046	0.161	0.507	0.055	0.015	0.007	0.000	0.000	0.000	4.841
1990	0.157	0.364	1.624	1.814	0.412	0.286	0.069	0.022	0.011	0.000	0.022	4.781
1991	0.041	0.408	0.175	0.274	0.031	0.029	0.000	0.000	0.000	0.000	0.000	0.957
1992	0.035	0.412	0.949	0.174	0.100	0.044	0.010	0.000	0.000	0.000	0.000	1.724
1993	0.178	0.970	0.532	0.383	0.017	0.025	0.022	0.000	0.000	0.022	0.000	2.149
1994	0.067	0.406	0.664	0.433	0.153	0.068	0.021	0.000	0.006	0.000	0.000	1.819
1995	0.160	0.245	1.811	1.249	0.087	0.054	0.011	0.000	0.000	0.000	0.000	3.616
1996	0.022	0.240	0.196	0.414	0.143	0.060	0.027	0.000	0.000	0.000	0.000	1.101
1997	0.006	0.236	0.321	0.109	0.129	0.049	0.009	0.007	0.000	0.000	0.000	0.867
1998	0.070	0.336	1.026	0.352	0.041	0.035	0.004	0.000	0.004	0.000	0.000	1.867
1999	0.070	0.140	0.154	0.310	0.255	0.087	0.000	0.000	0.000	0.000	0.000	1.016
2000	0.020	0.571	0.538	0.071	0.079	0.031	0.000	0.000	0.000	0.000	0.000	1.308
2001	0.028	0.047	0.381	0.459	0.059	0.055	0.008	0.008	0.000	0.000	0.000	1.045
2002	0.234	0.478	0.707	1.396	1.627	0.118	0.131	0.012	0.000	0.000	0.000	4.703
2003	0.327	0.166	0.309	0.201	0.156	0.082	0.000	0.007	0.000	0.000	0.000	1.248
2004	1.685	0.745	0.136	0.710	0.252	0.322	0.252	0.065	0.020	0.000	0.000	4.210
2005	0.052	0.055	0.579	0.129	0.176	0.026	0.000	0.007	0.000	0.000	0.000	1.024
2006	0.099	0.433	0.162	0.514	0.034	0.125	0.015	0.038	0.010	0.010	0.000	1.438
2007	0.075	0.115	0.207	0.050	0.130	0.006	0.007	0.000	0.000	0.000	0.000	0.590
2008	2.217	0.390	0.621	0.177	0.011	0.111	0.036	0.008	0.000	0.000	0.000	3.571
2009	0.117	1.287	0.644	0.357	0.073	0.025	0.036	0.000	0.008	0.000	0.000	2.547
2010	0.312	0.384	0.587	0.130	0.135	0.063	0.000	0.000	0.000	0.000	0.000	1.611
average	0.375	1.209	0.998	0.672	0.387	0.138	0.115	0.059	0.048	0.028	0.056	4.109

Table A10c. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian February bottom trawl survey, 1986-2011.

	AGE										
Year	1	2	3	4	5	6	7	8	9	10+	No./ tow
SPRING											
1986	0.60	2.27	2.81	0.37	0.65	0.44	0.26	0.04	0.07	0.03	7.54
1987	0.25	2.13	0.93	1.09	0.34	0.12	0.22	0.08	0.03	0.07	5.26
1988	0.28	1.01	4.66	0.58	1.02	0.13	0.08	0.17	0.04	0.07	8.04
1989	1.63	2.78	1.38	2.85	0.36	0.42	0.05	0.10	0.12	0.06	9.75
1990	0.42	2.44	3.78	2.08	3.87	0.42	0.93	0.12	0.12	0.35	14.53
1991	1.18	1.16	1.84	2.15	1.05	1.31	0.16	0.22	0.03	0.09	9.19
1992	0.11	2.86	1.77	0.80	0.98	0.60	0.43	0.12	0.07	0.02	7.76
*1993	0.05	0.60	2.83	1.04	0.62	1.23	0.44	0.42	0.07	0.12	7.42
*1994	0.02	0.80	0.89	1.65	0.60	0.23	0.45	0.11	0.15	0.04	4.94
1995	0.07	0.67	1.50	0.86	0.60	0.19	0.04	0.05	0.02	0.02	4.02
1996	0.14	0.49	2.31	4.02	1.09	0.79	0.33	0.08	0.11	0.03	9.39
1997	0.32	0.53	0.55	1.25	1.23	0.27	0.06	0.03	0.02	0.01	4.27
1998	0.01	0.67	0.95	0.35	0.35	0.28	0.07	0.02	0.00	0.02	2.72
1999	0.33	0.32	1.49	1.09	0.41	0.26	0.15	0.01	0.02	0.01	4.09
2000	0.10	0.44	1.05	3.92	1.71	0.78	0.40	0.24	0.01	0.03	8.68
2001	0.00	0.06	0.64	0.42	1.11	0.52	0.26	0.17	0.16	0.06	3.40
2002	0.01	0.09	0.57	2.05	0.68	1.22	0.40	0.17	0.05	0.08	5.32
2003	0.00	0.02	0.30	0.65	1.21	0.32	0.34	0.16	0.01	0.00	3.01
2004	0.54	0.10	0.39	0.42	0.45	0.39	0.07	0.12	0.02	0.01	2.50
**2005	0.02	1.43	0.62	2.69	1.21	0.53	0.32	0.03	0.01	0.00	6.86
2006	0.00	0.04	1.40	0.62	1.59	0.66	0.19	0.19	0.07	0.05	4.81
2007	0.14	0.52	0.94	2.94	0.39	0.60	0.10	0.08	0.04	0.00	5.75
2008	0.01	0.32	0.90	0.59	2.18	0.14	0.28	0.03	0.00	0.01	4.47
2009	0.03	0.27	2.24	1.99	0.42	2.38	0.00	0.07	0.00	0.01	7.40
2010	0.00	0.14	1.10	4.68	2.07	0.82	2.12	0.07	0.10	0.00	11.12
2011	0.13	0.44	0.67	0.78	1.00	0.19	0.05	0.08	0.01	0.00	3.34
average	0.27	0.87	1.48	1.61	1.05	0.59	0.32	0.11	0.06	0.05	6.37

Table A11. Model configuration of Virtual Population Analysis (VPA) for Georges Bank Atlantic cod assessment update.

VPA

Years	1978-2010
Catch at age	ages 1-10+ USA commercial landings and discards, recreational landings CA commercial landings and discards
Surveys: Split 1994/1995	NEFSC spring Yankee 41, 1978-1981 NEFSC spring Yankee 36, 1982-2011 NEFSC autumn, 1977-2010, lagged forward, one year, one age DFO winter/spring, 1986-2011
Fully recruited F	ages 5-8
Natural Mortality	0.2 all ages

Table A12a. VPA model comparisons: A = 2008 GARM accepted split survey, B=2012 rerun with updated software, C=correction to DFO age 8 survey indices, D=correction to 2005-2007 swept area estimates, E=revised catch at age.

	A = B: A 2008 GARM III Split Survey; B 2012 GARM III rerun				C: 2012 GARM III - correct DFO age 8 sv					D: 2012 GARM III correct DFO SV 2005-06-07					E: 2012 GARM III all revised caa				
	RSS 323.85					RSS 323.112					RSS 321.52					RSS 321.396			
age	stk	std err	cv	F	age	stk	std err	cv	F2007	age	stk	std err	cv	F2007	age	stk	std err	cv	F2012
1	4875	2187	0.45	0.00	1	4874	2183.8	0.45	0.00	1	4850	2167.7	0.45	0.00	1	4929	2202.3	0.45	0.00
2	5752	1828	0.32	0.12	2	5751	1825.2	0.32	0.12	2	5607	1775.0	0.32	0.12	2	5700	1803.0	0.32	0.14
3	3852	1134	0.29	0.31	3	3851	1132.5	0.29	0.31	3	3761	1104.7	0.29	0.32	3	3766	1117.3	0.30	0.31
4	970	274	0.28	0.31	4	970	273.7	0.28	0.31	4	935	264.7	0.28	0.32	4	950	268.1	0.28	0.33
5	2930	804	0.27	0.34	5	2929	802.4	0.27	0.34	5	2854	784.2	0.27	0.36	5	2829	785.5	0.28	0.39
6	157	50	0.32	0.40	6	157	49.7	0.32	0.40	6	149	47.7	0.32	0.41	6	142	46.4	0.33	0.47
7	238	87	0.36	0.17	7	239	86.8	0.36	0.17	7	226	83.2	0.37	0.18	7	216	82.0	0.38	0.19
8	81	31	0.39	0.30	8	80	31.0	0.39	0.30	8	73	29.0	0.40	0.32	8	70	28.4	0.40	0.35
F 5-8				0.30	**F 5-8**				0.30	**F 5-8**				0.32	**F 5-8**				0.35
SSB				17652	**SSB**				17665	**SSB**				17209	**SSB**				17229

Catchability

		A=B q	Std. Err	CV	C q	Std. Err	CV	D q	Std. Err	CV	E q	Std. Err	CV
spr_36_us_1	1	0.02	0.01	0.34	0.02	0.01	0.34	0.02	0.01	0.34	0.02	0.01	0.34
spr_36_us_2	2	0.09	0.01	0.12	0.09	0.01	0.12	0.09	0.01	0.12	0.09	0.01	0.12
spr_36_us_3	3	0.17	0.03	0.18	0.17	0.03	0.18	0.17	0.03	0.18	0.17	0.03	0.18
spr_36_us_4	4	0.22	0.04	0.20	0.22	0.04	0.20	0.22	0.04	0.20	0.21	0.04	0.20
spr_36_us_5	5	0.26	0.06	0.22	0.26	0.06	0.22	0.26	0.06	0.22	0.26	0.06	0.22
spr_36_us_6	6	0.28	0.05	0.19	0.28	0.05	0.19	0.28	0.05	0.19	0.27	0.05	0.18
spr_36_us_7	7	0.30	0.05	0.18	0.30	0.05	0.18	0.30	0.05	0.18	0.27	0.05	0.18
spr_36_us_8	8	0.36	0.07	0.20	0.36	0.07	0.20	0.36	0.07	0.20	0.33	0.06	0.19
post-spr_36_us_1	9	0.03	0.01	0.21	0.03	0.01	0.21	0.03	0.01	0.21	0.03	0.01	0.21
post-spr_36_us_2	10	0.10	0.01	0.09	0.10	0.01	0.09	0.10	0.01	0.09	0.10	0.01	0.09
post-spr_36_us_3	11	0.23	0.03	0.11	0.23	0.03	0.11	0.23	0.03	0.11	0.22	0.03	0.12
post-spr_36_us_4	12	0.51	0.09	0.17	0.51	0.09	0.17	0.51	0.09	0.17	0.51	0.09	0.17
post-spr_36_us_5	13	0.69	0.11	0.17	0.69	0.11	0.17	0.70	0.12	0.17	0.70	0.12	0.17
post-spr_36_us_6	14	0.70	0.12	0.17	0.70	0.12	0.17	0.71	0.12	0.17	0.71	0.12	0.17
post-spr_36_us_7	15	0.72	0.18	0.25	0.72	0.18	0.25	0.73	0.18	0.25	0.73	0.18	0.25
post-spr_36_us_8	16	0.82	0.17	0.21	0.82	0.17	0.21	0.82	0.18	0.21	0.82	0.17	0.21
spr_41_us_1	17	0.01	0.01	0.76	0.01	0.01	0.76	0.01	0.01	0.76	0.01	0.01	0.75
spr_41_us_2	18	0.09	0.02	0.23	0.09	0.02	0.23	0.09	0.02	0.23	0.09	0.02	0.26
spr_41_us_3	19	0.20	0.05	0.24	0.20	0.05	0.24	0.20	0.05	0.24	0.19	0.05	0.26
spr_41_us_4	20	0.18	0.02	0.13	0.18	0.02	0.13	0.18	0.02	0.13	0.17	0.02	0.14
spr_41_us_5	21	0.22	0.05	0.25	0.22	0.05	0.25	0.22	0.05	0.25	0.20	0.06	0.28
spr_41_us_6	22	0.21	0.04	0.17	0.21	0.04	0.17	0.21	0.04	0.17	0.19	0.03	0.18
spr_41_us_7	23	0.30	0.11	0.37	0.30	0.11	0.37	0.30	0.11	0.37	0.27	0.10	0.38
spr_41_us_8	24	0.29	0.17	0.57	0.29	0.17	0.57	0.29	0.17	0.57	0.27	0.16	0.60
spr_dfo_1	25	0.04	0.01	0.32	0.04	0.01	0.32	0.04	0.01	0.32	0.03	0.01	0.32
spr_dfo_2	26	0.19	0.04	0.21	0.19	0.04	0.21	0.19	0.04	0.21	0.18	0.04	0.21
spr_dfo_3	27	0.32	0.04	0.11	0.32	0.04	0.11	0.32	0.04	0.11	0.32	0.04	0.11
spr_dfo_4	28	0.37	0.05	0.13	0.37	0.05	0.13	0.37	0.05	0.13	0.36	0.05	0.13
spr_dfo_5	29	0.58	0.07	0.12	0.58	0.07	0.12	0.58	0.07	0.12	0.57	0.07	0.12
spr_dfo_6	30	0.56	0.11	0.21	0.56	0.11	0.21	0.56	0.11	0.21	0.54	0.11	0.21
spr_dfo_7	31	0.73	0.21	0.29	0.73	0.21	0.29	0.73	0.21	0.29	0.69	0.20	0.28
spr_dfo_8	32	0.00	0.00	0.27	0.91	0.24	0.27	0.91	0.24	0.27	0.84	0.23	0.27
post-spr_dfo_1	33	0.02	0.01	0.36	0.02	0.01	0.36	0.02	0.01	0.36	0.02	0.01	0.36
post-spr_dfo_2	34	0.08	0.02	0.26	0.08	0.02	0.26	0.08	0.02	0.26	0.08	0.02	0.26
post-spr_dfo_3	35	0.36	0.05	0.15	0.36	0.05	0.15	0.37	0.06	0.15	0.36	0.06	0.15
post-spr_dfo_4	36	0.89	0.13	0.15	0.89	0.13	0.15	0.87	0.12	0.14	0.86	0.12	0.14
post-spr_dfo_5	37	1.41	0.20	0.14	1.41	0.20	0.14	1.40	0.20	0.14	1.40	0.20	0.14
post-spr_dfo_6	38	1.93	0.29	0.15	1.94	0.29	0.15	1.91	0.28	0.15	1.92	0.28	0.15
post-spr_dfo_7	39	1.90	0.39	0.21	1.90	0.39	0.21	1.85	0.37	0.20	1.85	0.37	0.20
post-spr_dfo_8	40	0.00	0.00	0.25	1.83	0.44	0.24	1.91	0.43	0.22	1.92	0.44	0.23
aut_1	41	0.02	0.00	0.20	0.02	0.00	0.20	0.02	0.00	0.20	0.02	0.00	0.20
aut_2	42	0.08	0.01	0.14	0.08	0.01	0.14	0.08	0.01	0.14	0.08	0.01	0.14
aut_3	43	0.12	0.02	0.15	0.12	0.02	0.15	0.12	0.02	0.15	0.12	0.02	0.15
aut_4	44	0.13	0.02	0.18	0.13	0.02	0.18	0.13	0.02	0.18	0.12	0.02	0.18
aut_5	45	0.09	0.02	0.24	0.09	0.02	0.24	0.09	0.02	0.24	0.09	0.02	0.24
aut_6	46	0.10	0.02	0.16	0.10	0.02	0.16	0.10	0.02	0.16	0.10	0.02	0.16
post-aut_1	47	0.02	0.01	0.43	0.02	0.01	0.43	0.02	0.01	0.43	0.02	0.01	0.43
post-aut_2	48	0.07	0.02	0.21	0.07	0.02	0.21	0.07	0.02	0.20	0.07	0.01	0.20
post-aut_3	49	0.16	0.03	0.19	0.16	0.03	0.19	0.16	0.03	0.18	0.16	0.03	0.18
post-aut_4	50	0.23	0.05	0.22	0.23	0.05	0.22	0.24	0.05	0.22	0.23	0.05	0.22
post-aut_5	51	0.21	0.05	0.24	0.21	0.05	0.24	0.21	0.05	0.24	0.21	0.05	0.24
post-aut_6	52	0.25	0.06	0.26	0.25	0.06	0.26	0.26	0.07	0.25	0.26	0.06	0.25

Table A12b. Selected VPA diagnostics, including predicted beginning year stock numbers for ages 1-8, standard error and CV, and catchability estimates of each survey index, with standard error and CV for the Georges Bank Atlantic cod stock for the **2012 updated VPA.**

2012 revised caa TY 2010

RSS 384.38

age	stk	std err	cv	F2012
1	8075	3711.7	0.46	0.00
2	2704	881.2	0.33	0.03
3	4857	1320.6	0.27	0.28
4	1366	396.2	0.29	0.44
5	937	302.5	0.32	0.52
6	211	77.3	0.37	0.41
7	44	17.8	0.41	0.42
8	122	52.5	0.43	0.45
F 5-8				0.45
SSB				11289

Survey Index	**Catchability**		
	q	**Std. Err**	**CV**
spr_36_us_1	0.02	0.01	0.34
spr_36_us_2	0.09	0.01	0.12
spr_36_us_3	0.17	0.03	0.18
spr_36_us_4	0.21	0.04	0.20
spr_36_us_5	0.26	0.06	0.22
spr_36_us_6	0.27	0.05	0.18
spr_36_us_7	0.27	0.05	0.18
spr_36_us_8	0.33	0.06	0.19
post-spr_36_us_1	0.04	0.01	0.21
post-spr_36_us_2	0.12	0.01	0.11
post-spr_36_us_3	0.23	0.03	0.15
post-spr_36_us_4	0.54	0.09	0.17
post-spr_36_us_5	0.73	0.13	0.17
post-spr_36_us_6	0.76	0.12	0.16
post-spr_36_us_7	0.82	0.17	0.21
post-spr_36_us_8	0.77	0.17	0.22
spr_41_us_1	0.01	0.01	0.75
spr_41_us_2	0.09	0.02	0.26
spr_41_us_3	0.19	0.05	0.26
spr_41_us_4	0.17	0.02	0.14
spr_41_us_5	0.20	0.06	0.28
spr_41_us_6	0.19	0.03	0.18
spr_41_us_7	0.27	0.10	0.38
spr_41_us_8	0.27	0.16	0.60
spr_dfo_1	0.03	0.01	0.32
spr_dfo_2	0.18	0.04	0.21
spr_dfo_3	0.32	0.04	0.11
spr_dfo_4	0.36	0.05	0.13
spr_dfo_5	0.57	0.07	0.12
spr_dfo_6	0.54	0.11	0.21
spr_dfo_7	0.69	0.20	0.28
spr_dfo_8	0.84	0.23	0.27
post-spr_dfo_1	0.01	0.00	0.34
post-spr_dfo_2	0.09	0.02	0.24
post-spr_dfo_3	0.42	0.07	0.16
post-spr_dfo_4	1.09	0.17	0.15
post-spr_dfo_5	1.76	0.27	0.15
post-spr_dfo_6	2.52	0.45	0.18
post-spr_dfo_7	2.41	0.51	0.21
post-spr_dfo_8	2.45	0.50	0.21
aut_1	0.02	0.00	0.20
aut_2	0.08	0.01	0.14
aut_3	0.12	0.02	0.15
aut_4	0.12	0.02	0.18
aut_5	0.09	0.02	0.24
aut_6	0.10	0.02	0.16
post-aut_1	0.03	0.01	0.41
post-aut_2	0.10	0.02	0.19
post-aut_3	0.20	0.03	0.15
post-aut_4	0.26	0.05	0.18
post-aut_5	0.23	0.05	0.21
post-aut_6	0.31	0.06	0.20

Table A13a. Beginning year stock size (thousands of fish) and instantaneous fishing mortality (F) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using split survey swept area estimates for the commercial catch at age ADAPT formulation, 1978-2010.

Stock Numbers (Jan 1) in thousands

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	29757	26299	22627	45810	19573	11479	29373	9770	46088	18464	25552	18372	10790	20623	7669	9928	6407
2	5319	24220	21268	18214	36384	15317	8842	23787	7837	37022	15016	20615	14238	8775	16587	6081	7850
3	26308	3970	17632	13656	11271	19576	8185	5845	12757	4972	22725	10174	14586	6587	5156	8947	3539
4	8104	13923	2210	9128	6677	5173	9143	3567	2109	6285	2705	10741	5461	6824	2126	2143	3292
5	3065	4394	7250	1331	4941	2976	2151	4493	1391	933	3176	1230	4960	2638	2704	779	636
6	1400	1689	2542	3651	760	2267	1322	1008	1753	657	488	1197	651	2001	875	869	196
7	1291	985	976	1191	1821	365	1040	551	367	863	311	204	481	331	699	299	232
8	78	838	665	425	595	846	143	428	211	216	458	110	90	196	151	217	81
9	176	44	410	478	210	302	437	65	163	107	124	164	41	53	78	72	49
10+	43	137	57	181	229	322	269	189	78	79	105	68	80	56	24	37	9
Total	75541	76498	75635	94064	82461	58623	60905	49702	72755	69599	70660	62876	51378	48084	36068	29370	22288

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	3956	6724	10725	4947	12390	5990	2034	3884	1269	7136	1579	3940	4851	3659	7536	3318	8075
2	5132	3210	5450	8612	3989	10098	4789	1646	3143	1031	5776	1285	3195	3968	2986	6135	2704
3	5883	3613	2366	3823	6218	2927	7421	3244	1272	2407	764	4340	966	2064	2904	2197	4857
4	1486	3531	2066	1244	1939	3245	1730	3563	1591	657	1554	411	2813	448	1024	1782	1366
5	879	618	1741	757	574	817	1620	744	1556	575	306	726	149	1196	210	431	937
6	129	374	274	627	274	214	387	701	283	472	188	114	259	56	504	81	211
7	69	66	141	93	257	114	100	157	244	96	159	58	30	85	26	227	44
8	57	35	37	32	39	81	53	33	55	75	28	51	20	10	27	11	122
9	18	27	17	11	10	11	33	21	11	20	17	7	17	6	4	10	6
10+	4	1	7	4	2	2	4	13	5	9	7	7	2	3	2	2	6
Total	17613	18199	22825	20150	25691	23499	18169	14006	9430	12478	10379	10939	12301	11494	15224	14193	18326

Fishing Mortality

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.01	0.01	0.02	0.03	0.05	0.06	0.01	0.02	0.02	0.01	0.01	0.05	0.01	0.02	0.03	0.03	0.02
2	0.09	0.12	0.24	0.28	0.42	0.43	0.21	0.42	0.25	0.29	0.19	0.15	0.57	0.33	0.42	0.34	0.09
3	0.44	0.39	0.46	0.52	0.58	0.56	0.63	0.82	0.51	0.41	0.55	0.42	0.56	0.93	0.68	0.80	0.67
4	0.41	0.45	0.31	0.41	0.61	0.68	0.51	0.74	0.62	0.48	0.59	0.57	0.53	0.73	0.80	1.02	1.12
5	0.40	0.35	0.49	0.36	0.58	0.61	0.56	0.74	0.55	0.45	0.78	0.44	0.71	0.90	0.94	1.18	1.40
6	0.15	0.35	0.56	0.50	0.53	0.58	0.68	0.81	0.51	0.55	0.67	0.71	0.47	0.85	0.87	1.12	0.84
7	0.23	0.19	0.63	0.49	0.57	0.74	0.69	0.76	0.33	0.43	0.84	0.61	0.70	0.59	0.97	1.11	1.21
8	0.38	0.51	0.13	0.51	0.48	0.46	0.58	0.76	0.48	0.36	0.83	0.78	0.34	0.72	0.54	1.29	1.30
9	0.29	0.32	0.52	0.46	0.57	0.61	0.62	0.75	0.50	0.47	0.77	0.57	0.68	0.86	0.93	1.14	1.23
10+	0.29	0.32	0.52	0.46	0.57	0.61	0.62	0.75	0.50	0.47	0.77	0.57	0.68	0.86	0.93	1.14	1.23
F 5-8	0.29	0.35	0.45	0.46	0.54	0.60	0.63	0.77	0.47	0.45	0.78	0.64	0.55	0.77	0.83	1.18	1.19

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.01	0.01	0.02	0.02	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00
2	0.15	0.11	0.15	0.13	0.11	0.11	0.19	0.06	0.07	0.10	0.09	0.09	0.24	0.11	0.11	0.03
3	0.31	0.36	0.44	0.48	0.45	0.33	0.53	0.51	0.46	0.24	0.42	0.23	0.57	0.50	0.29	0.28
4	0.68	0.51	0.80	0.57	0.66	0.49	0.64	0.63	0.82	0.56	0.56	0.81	0.66	0.56	0.67	0.44
5	0.65	0.61	0.82	0.81	0.78	0.55	0.64	0.77	0.99	0.92	0.79	0.83	0.78	0.66	0.76	0.52
6	0.46	0.77	0.89	0.69	0.68	0.57	0.70	0.85	0.88	0.89	0.98	1.14	0.92	0.55	0.60	0.41
7	0.49	0.38	1.28	0.67	0.96	0.56	0.90	0.86	0.98	1.03	0.93	0.89	0.92	0.94	0.71	0.42
8	0.54	0.49	0.98	0.94	1.03	0.71	0.73	0.89	0.79	1.29	1.17	0.93	0.91	0.72	0.79	0.45
9	0.62	0.65	0.85	0.75	0.79	0.55	0.66	0.81	0.98	0.91	0.87	0.87	0.87	0.67	0.64	0.45
10+	0.62	0.65	0.85	0.75	0.79	0.55	0.66	0.81	0.98	0.91	0.87	0.87	0.87	0.67	0.64	0.45
F 5-8	0.54	0.56	0.99	0.78	0.86	0.60	0.74	0.84	0.91	1.03	0.97	0.95	0.88	0.72	0.71	0.45

Table A13b. Spawning stock biomass (mt) and female percent mature (5-year moving window) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using split survey swept area estimates for the commercial catch at age ADAPT formulation, 1978-2010.

SSB at start of spawning season

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	840	869	839	1499	646	395	1224	1032	3221	1321	1772	870	407	1133	369	54
2	1699	6946	7390	6114	10581	5414	4056	10742	4365	19651	7953	9988	4706	3770	6552	2306
3	31351	4190	22799	17276	14718	26660	11666	7825	18592	7236	32643	14217	20283	9257	7297	12098
4	19097	37701	4894	22805	16387	12598	23613	9053	4832	17060	6615	26685	12762	16416	5414	4697
5	7934	15906	30796	4925	18283	10969	7764	16296	5422	3691	12370	4567	17837	8869	8742	2656
6	5413	8094	12765	20570	3823	11511	6427	4784	9138	3724	2581	5951	3267	8870	3889	3500
7	6195	6683	6504	8023	13134	2321	6655	3425	2470	6057	2120	1282	2979	1978	3670	1579
8	534	6091	6196	3375	4907	7449	1144	3408	1684	1804	3641	851	761	1472	1091	1320
9	1446	360	3572	5045	2032	2834	4096	601	1645	1021	1115	1523	376	467	668	570
10+	506	1714	675	2822	3128	4473	3290	2253	1012	1104	1294	833	950	678	311	354
Total	75014	88554	96427	92455	87639	84626	69934	59419	52382	62668	72105	66768	64329	52911	38001	29133

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	61	35	98	346	179	252	88	73	90	14	80	17	43	29	36	104	23
2	1802	1850	1137	2518	4023	1816	4374	1669	659	916	325	1096	252	824	968	684	1564
3	4620	7919	5584	3626	5772	9024	4624	11134	4301	1700	3479	989	4969	1073	2820	4329	3033
4	7246	3583	7818	4886	3045	4507	7737	3949	7763	3254	1502	3560	846	5976	926	2442	3949
5	1848	3245	2277	5191	2485	1897	2791	5267	2165	4325	1605	915	2032	421	3361	604	1336
6	949	674	1846	1187	2514	1212	937	1634	2718	1020	1702	675	387	828	217	1828	282
7	1153	492	460	770	512	1284	637	478	777	1101	405	675	272	129	338	132	970
8	497	458	296	244	203	248	508	335	193	315	382	146	251	109	58	142	57
9	337	158	269	154	94	77	84	243	151	75	133	113	45	92	42	30	60
10+	107	59	9	73	48	19	18	37	134	45	84	64	49	15	25	18	16
Total	18619	18473	19793	18994	18878	20337	21799	24818	18951	12766	9698	8249	9146	9494	8793	10314	11289

Percent mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.08	0.07	0.09	0.09	0.08	0.08	0.13	0.18	0.16	0.20	0.25	0.20	0.12	0.13	0.09	0.04
2	0.33	0.34	0.38	0.38	0.36	0.41	0.49	0.59	0.58	0.59	0.64	0.61	0.46	0.53	0.47	0.43
3	0.75	0.78	0.79	0.79	0.79	0.85	0.87	0.91	0.91	0.89	0.90	0.91	0.85	0.89	0.89	0.93
4	0.95	0.96	0.96	0.96	0.96	0.98	0.98	0.99	0.99	0.98	0.98	0.98	0.97	0.98	0.99	1.00
5	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.04	0.04	0.05	0.10	0.09	0.07	0.07	0.08	0.07	0.04	0.07	0.06	0.05	0.04	0.04	0.03	0.03
2	0.41	0.50	0.48	0.57	0.56	0.51	0.51	0.50	0.43	0.33	0.38	0.36	0.35	0.37	0.35	0.31	0.30
3	0.92	0.96	0.95	0.94	0.94	0.93	0.94	0.93	0.88	0.84	0.83	0.83	0.84	0.88	0.86	0.87	0.87
4	1.00	1.00	1.00	0.99	1.00	0.99	1.00	0.99	0.99	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A13c. Stock biomass (mt), at the beginning of the year, of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using split survey swept area estimates for the commercial catch at age ADAPT formulation, 1978-2010.

January 1 Biomass

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	10867	12863	9664	17312	8409	5162	9752	5948	20878	6835	7346	4540	3509	9035	4258	1411	1589
2	5404	21539	20938	17430	32589	14660	8869	20200	8119	36130	13261	17346	11633	7773	15451	5870	4611
3	46479	5923	32207	24639	21213	35609	15401	10191	22989	8999	41096	17331	27084	12559	9491	15368	5804
4	22261	43785	5547	26314	19531	14880	27124	10698	5592	19506	7697	30973	14854	19546	6465	5751	9029
5	8851	17602	34876	5462	21030	12558	8810	19065	6144	4112	14556	5079	20751	10661	10564	3344	2412
6	5739	8869	14485	23100	4320	13108	7437	5660	10284	4219	2984	6928	3656	10571	4651	4362	1129
7	6658	7135	7469	9006	14924	2713	7717	4018	2699	6730	2521	1468	3460	2255	4460	1965	1458
8	589	6860	6546	3798	5495	8316	1303	4002	1886	1979	4323	1002	833	1717	1234	1692	638
9	1570	393	4024	5636	2311	3242	4696	705	1850	1141	1310	1731	435	558	806	713	428
10+	549	1871	760	3153	3558	5116	3772	2641	1138	1234	1521	947	1100	809	375	442	136
Total	108970	126840	136516	135848	133378	115365	94882	83129	81579	90886	96614	87344	87314	75482	57755	40917	27232

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	896	2038	3584	2063	3731	1311	946	1334	374	1190	286	882	741	937	3596	783	2173
2	3923	2493	4686	7585	3750	9028	3563	1600	2901	900	3192	756	2395	2914	2321	5420	2019
3	8982	6452	4294	6877	10814	5370	13530	5504	2260	4509	1321	6358	1385	3685	5398	3773	8025
4	4147	8796	5835	3464	5258	8687	4591	9003	3934	1740	4124	1022	6961	1062	2850	4440	3443
5	3742	2607	6153	2943	2235	3161	6056	2544	5277	1934	1079	2414	496	3881	708	1505	3140
6	753	2171	1423	2918	1404	1065	1898	3240	1222	2040	821	483	997	246	2088	312	865
7	552	506	985	592	1558	724	574	927	1341	497	815	326	155	409	153	1076	229
8	518	331	298	246	305	592	391	232	371	490	183	303	131	68	168	64	775
9	181	310	184	111	91	95	281	178	92	160	135	53	110	49	35	67	41
10+	68	10	86	56	22	20	42	159	55	102	76	59	18	29	21	18	62
Total	23763	25715	27528	26855	29167	30053	31872	24720	17827	13562	12033	12657	13389	13281	17338	17458	20773

Table A14a. Uncertainty measures of predicted stock size in 2011 (A) and fishing mortality in 2010 (B) for ages 1-10 from 1000 bootstrap replications.

A. Stock Size 2011

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 1	8075.	10919.	9117.	0.8350
N 2	2704.	2965.	1352.	0.4562
N 3	4857.	5086.	1677.	0.3297
N 4	1366.	1443.	443.	0.3069
N 5	937.	975.	320.	0.3283
N 6	211.	221.	77.	0.3486
N 7	44.	46.	18.	0.3988
N 8	122.	131.	59.	0.4469

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 1	2844.	302.	35.2163	5232.	1.7427
N 2	261.	44.	9.6346	2443.	0.5534
N 3	229.	54.	4.7138	4628.	0.3623
N 4	77.	14.	5.6627	1288.	0.3438
N 5	39.	10.	4.1205	898.	0.3565
N 6	11.	2.	5.0514	200.	0.3857
N 7	2.	1.	5.6836	41.	0.4468
N 8	9.	2.	7.6797	113.	0.5213

	LOWER 80. % CI	UPPER 80. % CI
N 1	3149.	21239.
N 2	1551.	4687.
N 3	3336.	7145.
N 4	947.	2030.
N 5	607.	1389.
N 6	129.	323.
N 7	25.	70.
N 8	66.	211.

Table A14a - continued. Uncertainty measures of predicted stock size in 2011 (A) and fishing mortality in 2010 (B) for ages 1-10 from 1000 bootstrap replications.

B. Fishing Mortality (2010)

Bootstrap Output Variable: Fishing Mortality (2010)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0048	0.0052	0.002310	0.4422
AGE 2	0.0336	0.0352	0.010536	0.2993
AGE 3	0.2753	0.2807	0.072295	0.2575
AGE 4	0.4431	0.4598	0.121917	0.2652
AGE 5	0.5156	0.5340	0.144402	0.2704
AGE 6	0.4123	0.4387	0.148882	0.3394
AGE 7	0.4215	0.4524	0.165367	0.3655
AGE 8	0.4498	0.4750	0.091657	0.1929
AGE 9	0.4498	0.4750	0.091657	0.1929
AGE 10	0.4498	0.4750	0.091657	0.1929

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000464	0.000075	9.7586	0.0043	0.5378
AGE 2	0.001611	0.000337	4.7939	0.0320	0.3294
AGE 3	0.005388	0.002293	1.9570	0.2699	0.2678
AGE 4	0.016654	0.003891	3.7582	0.4265	0.2859
AGE 5	0.018417	0.004603	3.5718	0.4972	0.2904
AGE 6	0.026403	0.004782	6.4041	0.3859	0.3858
AGE 7	0.030876	0.005320	7.3247	0.3907	0.4233
AGE 8	0.025232	0.003006	5.6094	0.4246	0.2159
AGE 9	0.025232	0.003006	5.6094	0.4246	0.2159
AGE 10	0.025232	0.003006	5.6094	0.4246	0.2159

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.002747	0.008272
AGE 2	0.022947	0.048435
AGE 3	0.193545	0.374870
AGE 4	0.319741	0.619384
AGE 5	0.365280	0.740702
AGE 6	0.277160	0.639278
AGE 7	0.264936	0.674031
AGE 8	0.364467	0.598939
AGE 9	0.364467	0.598939
AGE 10	0.364467	0.598939

Table A15. Input data for yield-per-recruit and projection analysis. Selectivity and mean weight estimated as an average of 2006-2010 data, and proportion mature estimated from a four year average, 2008-2011.

Age	VPA selectivity	Stock weight	Catch weight	Spawning stock weight	Discard weight	Proportion mature
1	0.01	0.269	0.459	0.269	0.47	0.03
2	0.15	0.747	1.320	0.747	1.168	0.30
3	0.50	1.652	2.144	1.652	1.591	0.87
4	0.85	2.521	3.019	2.521	2.284	0.99
5	1.00	3.353	3.695	3.353	3.011	1.00
6	1.00	4.106	4.515	4.106	3.872	1.00
7	1.00	5.239	5.812	5.239	5.245	1.00
8	1.00	6.357	6.829	6.357	5.921	1.00
9	1.00	7.459	7.791	7.459	7.024	1.00
10	1.00	10.205	10.205	10.205	8.962	1.00

Table A16. Projection results of catch and spawning stock biomass in 2011 using catch in 2010=2011 for 3 fishing mortality (F) scenarios: F status quo, 75%Fmsy, and Frebuild.

	Year	Discards	Landings	Catch	SSB	F
75%Fmsy	2011	673	3,486	4,159	15,436	0.35
0.17	2012	423	2,339	2,787	19,023	0.17
	2013	505	3,242	3,757	26,178	0.17
	2014	567	4,092	4,657	31,254	0.17
Frebuild	2011	673	3,486	4,159	15,436	0.35
0.12	2012	305	1,698	2,020	19,148	0.12
SSBmsy= 140,424 mt	2013	372	2,436	2,814	27,145	0.12
	2014	427	3,162	3,587	33,249	0.12

GEOMEAN RCT	Year	Discards	Landings	Catch	SSB	F
75%Fmsy	2011	694	3,465	4,159	10,245	0.54
0.17	2012	251	1,427	1,683	11,840	0.17
	2013	346	2,042	2,358	15,964	0.17
					21,605	0.17
Frebuild	2011	694	3,465	4,159	10,245	0.35
0.09	2012	133	765	900	11,963	0.09
SSBmsy= 140,424 mt	2013	190	1,153	1,336	16,957	0.09
	2014	235	1,581	1,825	23,711	0.09

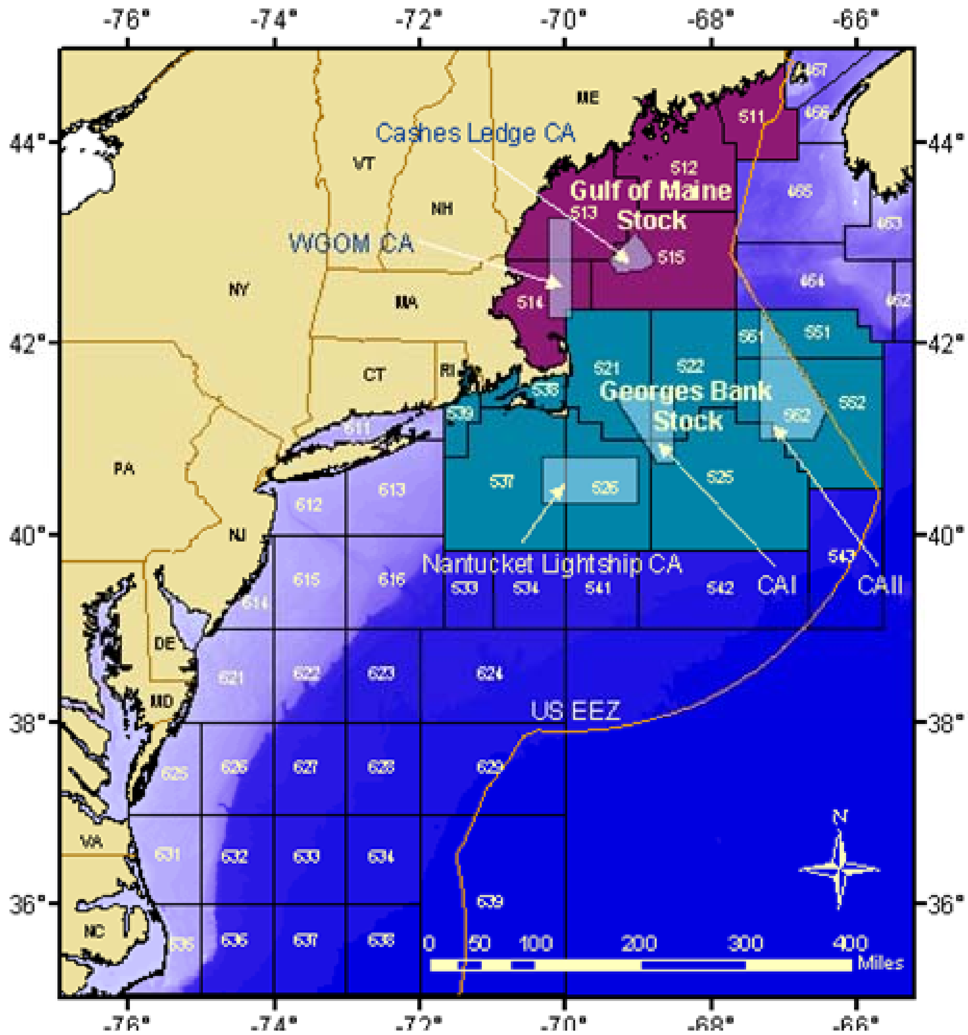


Figure A1. Stock area of Georges Bank cod as defined by Northwest Atlantic Fisheries Organization (NAFO) statistical areas: 521-526, 551-552, 561-562, 537-539, and Subarea 6.

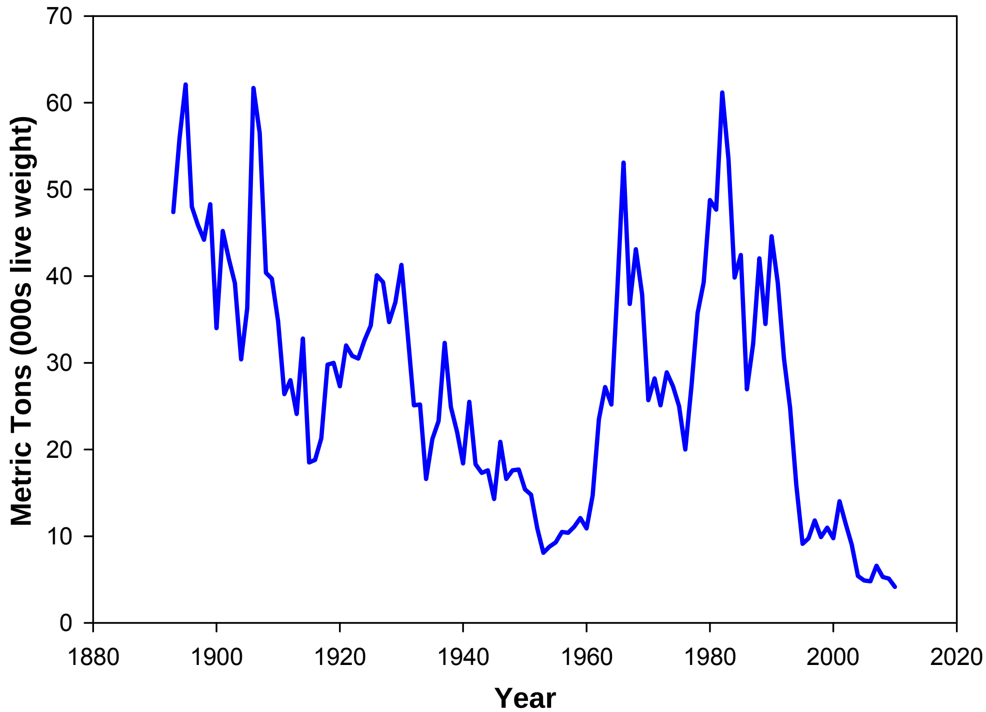


Figure A2a. Total commercial landings (1893-1977) and catch (1978-2010) of Georges Bank Atlantic cod (NAFO Div. 5Z and SubArea 6).

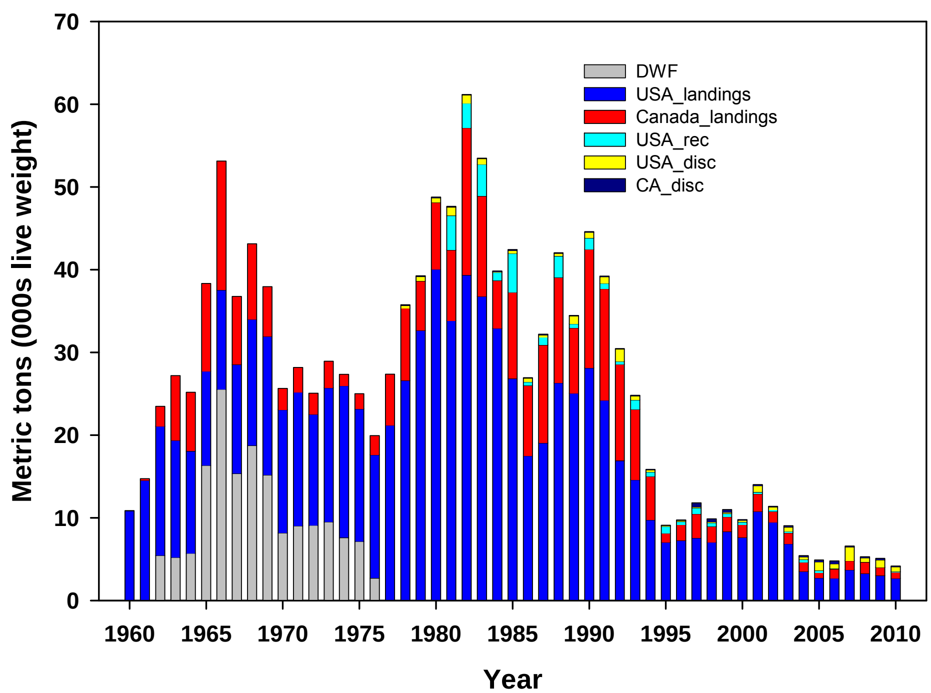


Figure A2b. Total catch of Georges Bank Atlantic cod including USA commercial landings, discards, and recreational landings, and Canadian landings and discards, 1960-2010.

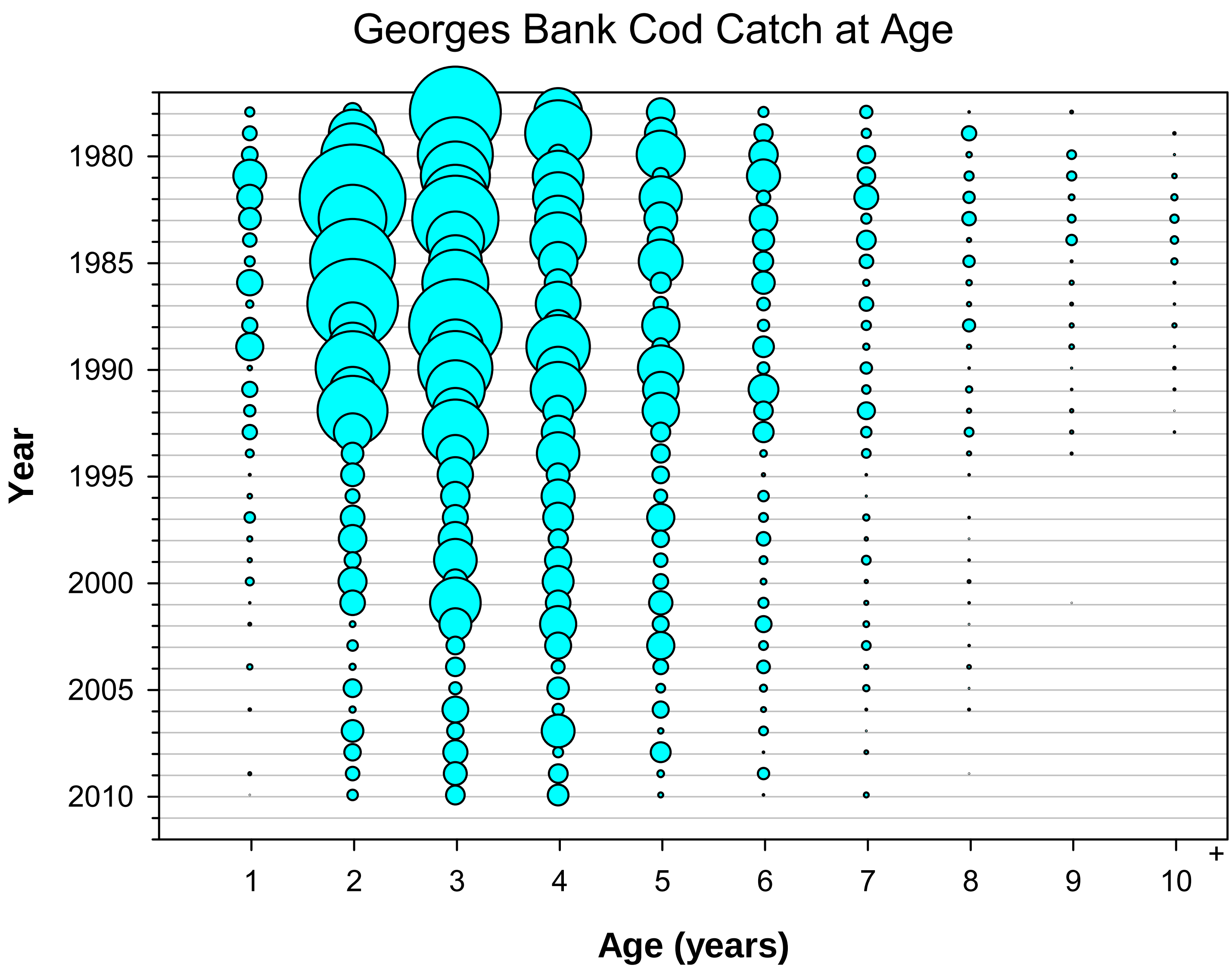


Figure A3. Total catch at age (000s of fish) of combined USA and Canadian commercial landings and discards and USA recreational landings for Georges Bank cod, 1978-2010.

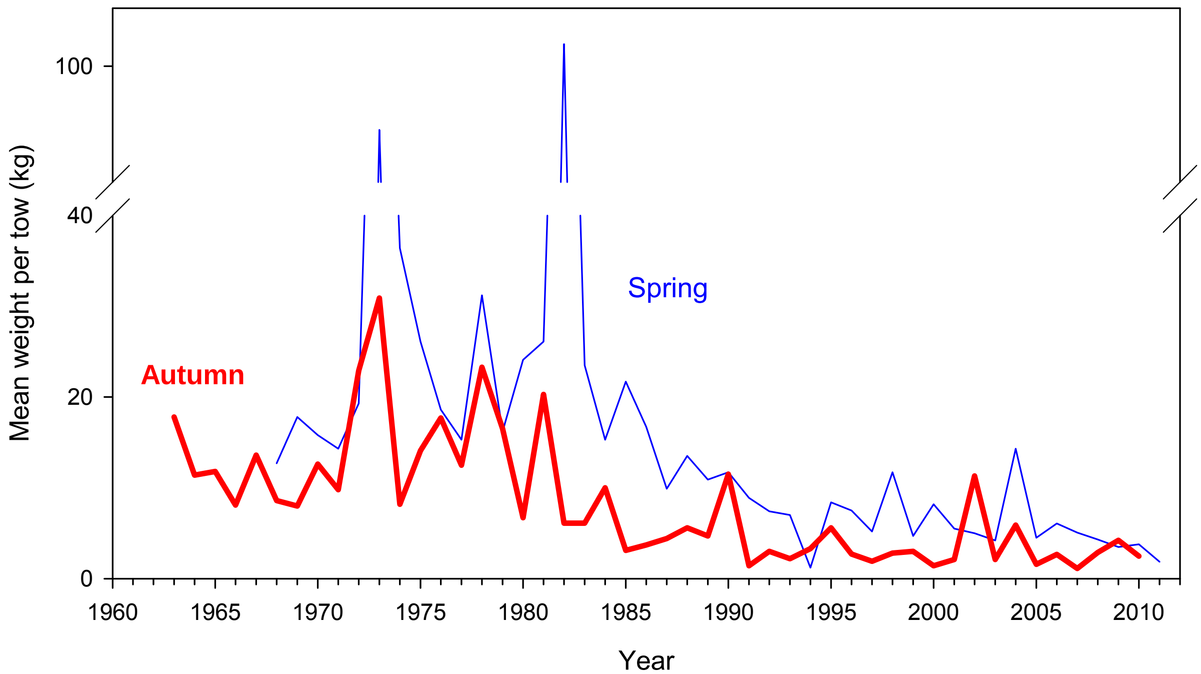


Figure A4. Standardized stratified mean catch per tow (kg) of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys (strata 13-25) on Georges Bank, 1963-2011.

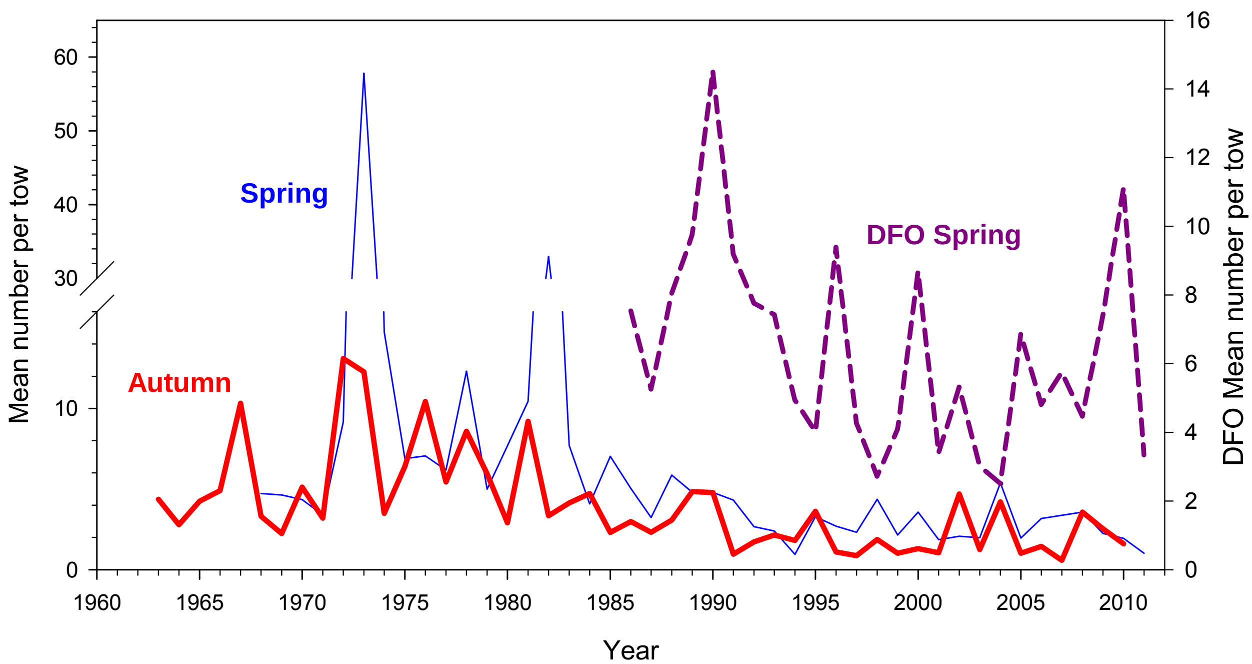


Figure A5. Standardized stratified mean number per tow of Atlantic cod in NEFSC and DFO spring and NEFSC autumn research vessel bottom trawl surveys on Georges Bank, 1963-2011.

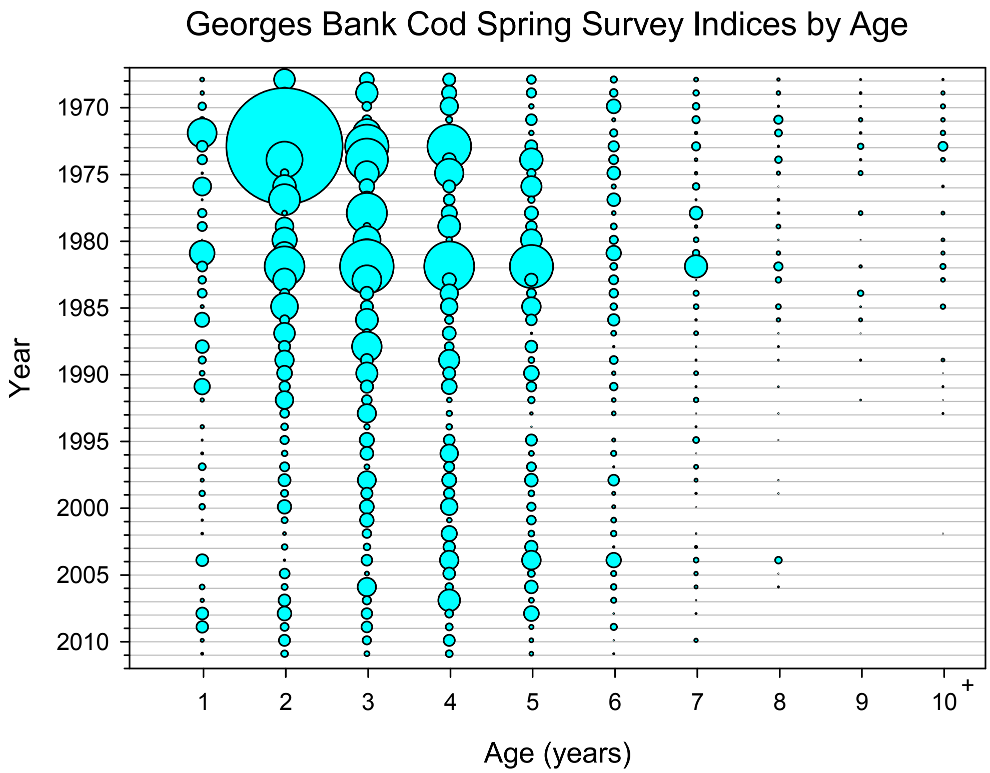


Figure A6. Standardized stratified mean catch per tow at age (numbers) of Georges Bank cod in NEFSC spring bottom trawl surveys, 1968-2011.

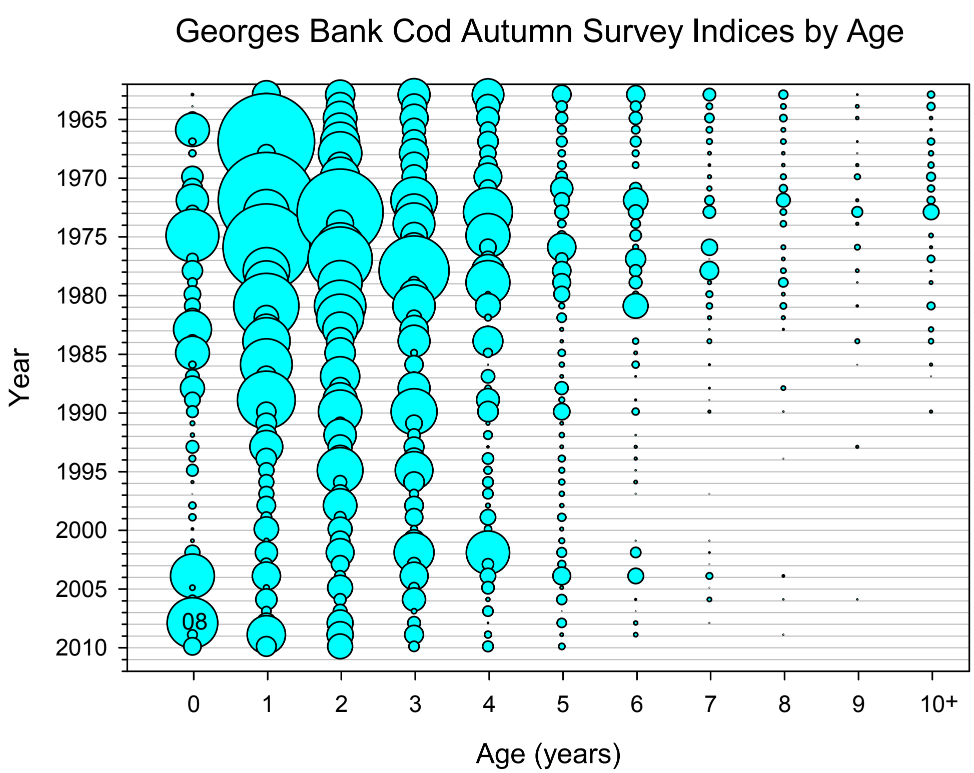


Figure A7. Standardized stratified mean catch per tow at age (numbers) of Georges Bank cod in NEFSC autumn bottom trawl surveys, 1963-2010.

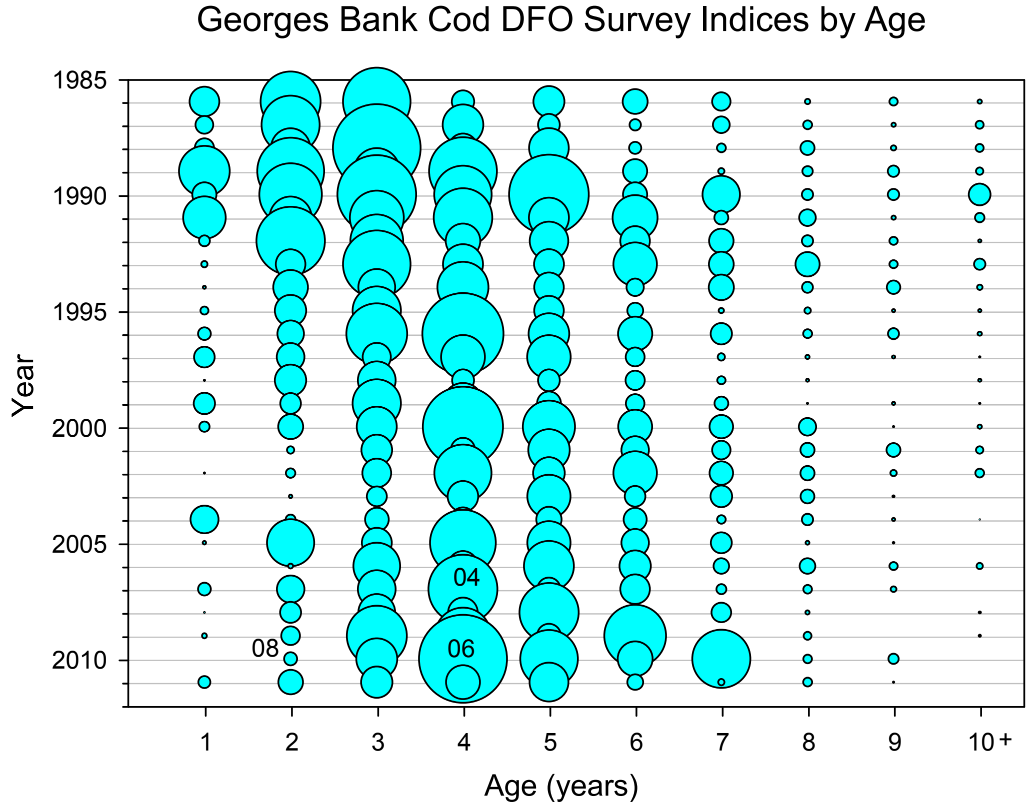
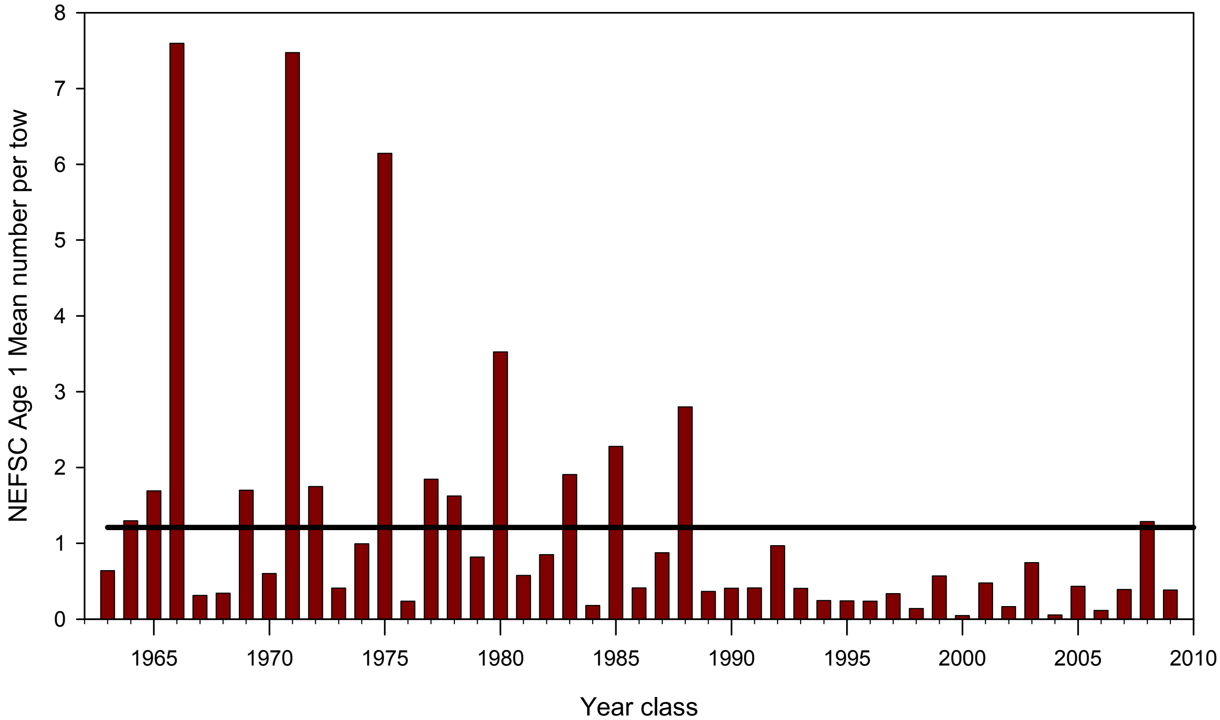


Figure A8. Standardized stratified mean catch per tow at age (numbers) of Georges Bank cod in the DFO spring bottom trawl surveys, 1986-2011.



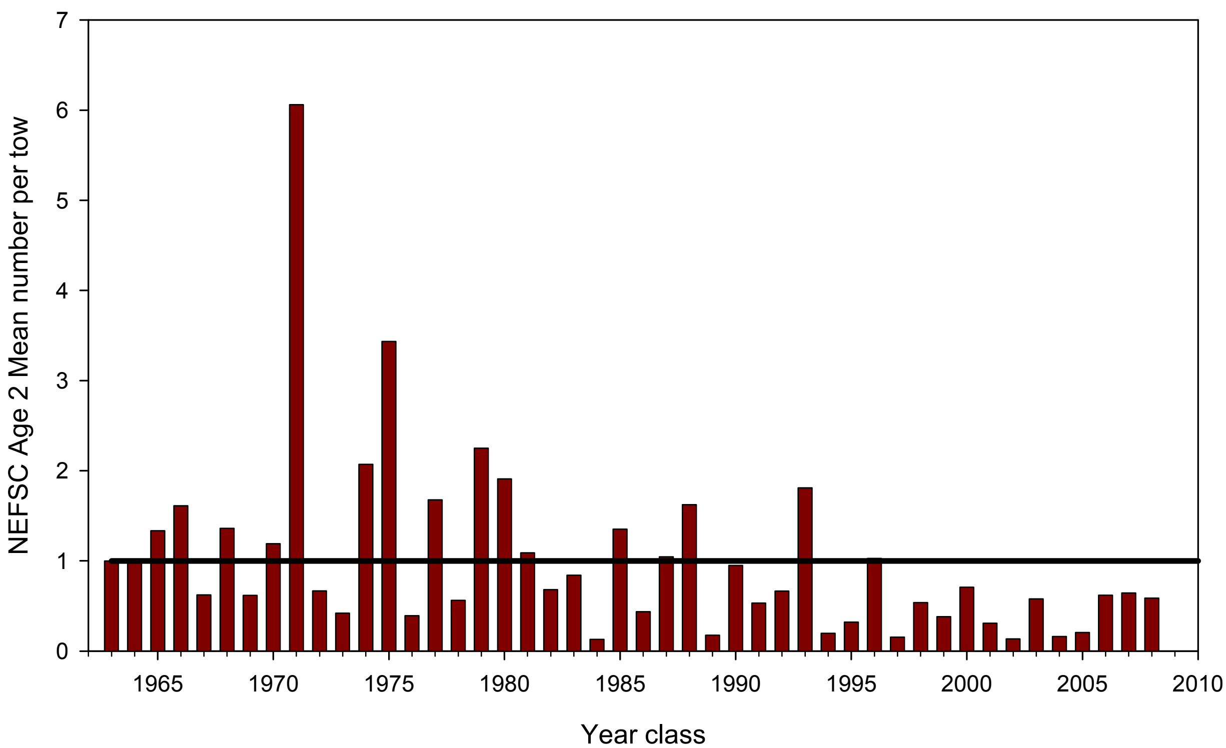


Figure A9. Relative year class strength of age 1 and age 2 Georges Bank cod based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1963-2010. Horizontal line represents the time series average.

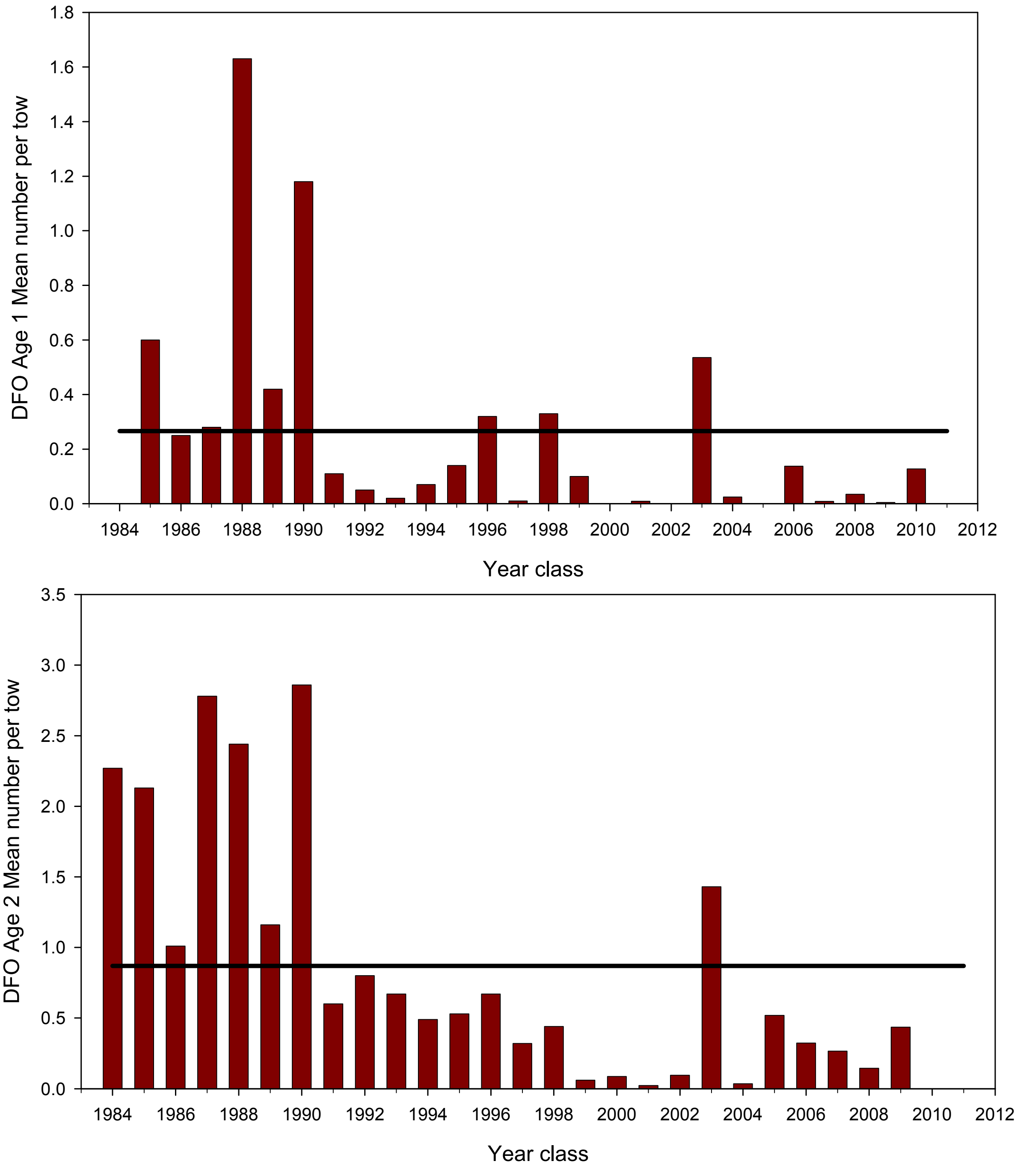


Figure A10. Relative year class strength of age 1 and age 2 Georges Bank cod based on catch (number) per tow indices from DFO spring research vessel bottom trawl surveys, 1986-2011. Horizontal line represents the time series average.

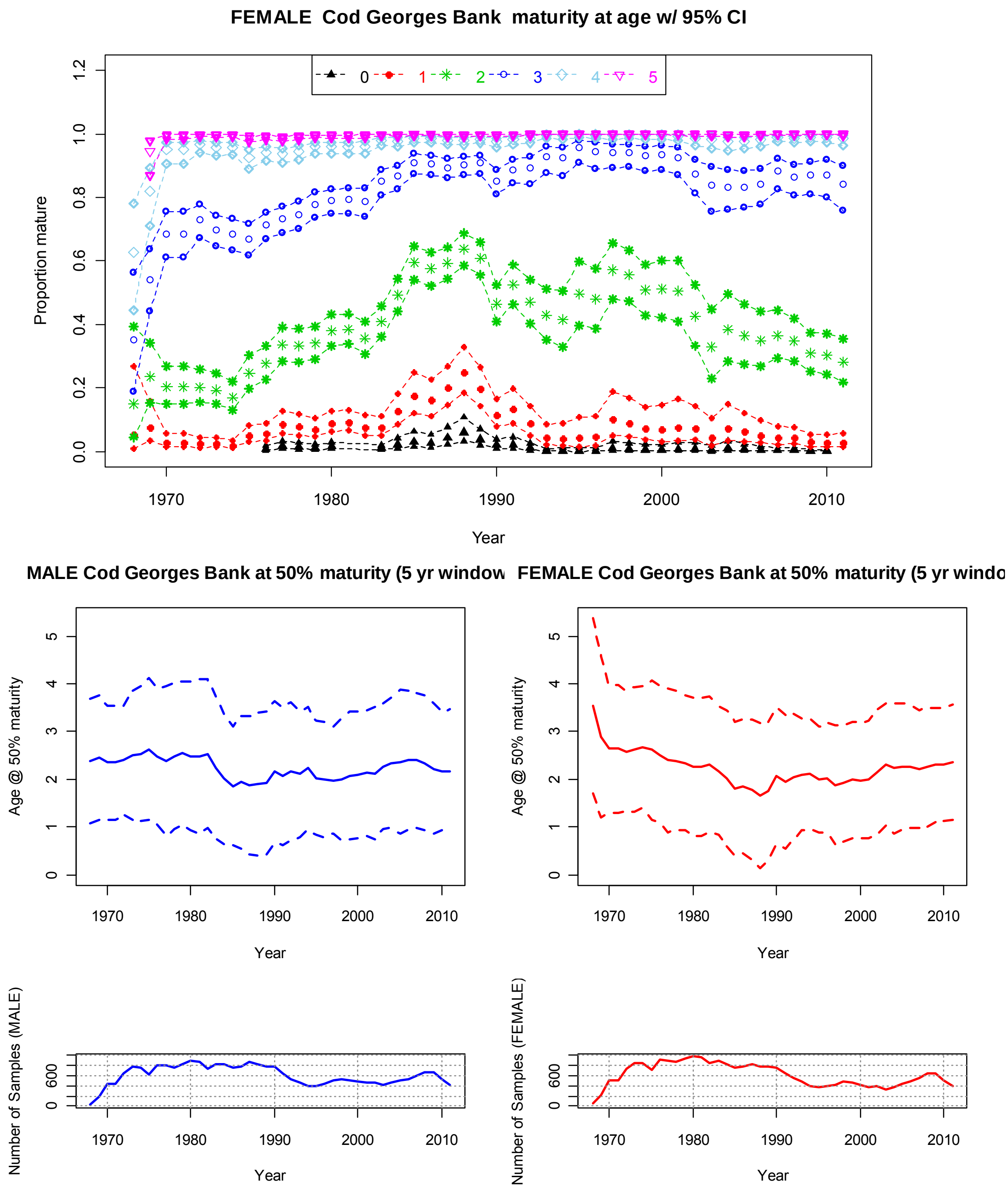


Figure A11. Proportion mature at age with 95% confidence intervals for female Georges Bank cod using a 5-year moving window for ages 1-5 (upper panel), median age at maturity (A50) for males (middle left panel) and females (middle right panel) with 95% confidence intervals, and number of samples in the combined 5-year moving average for males (lower left panel) and females (lower right panel).

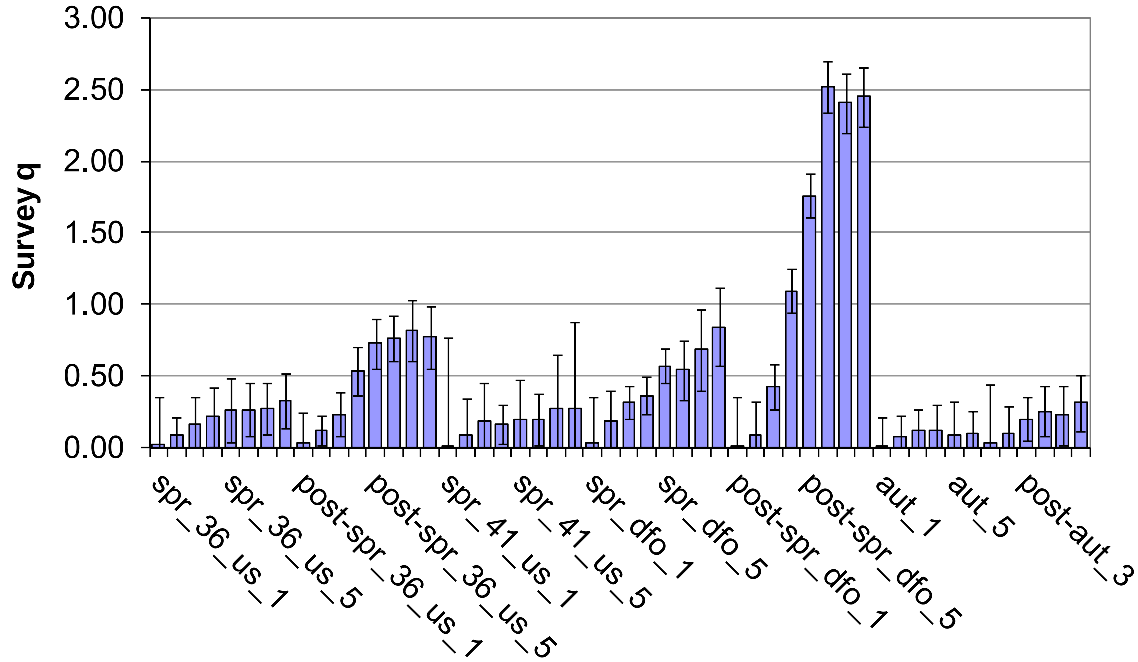
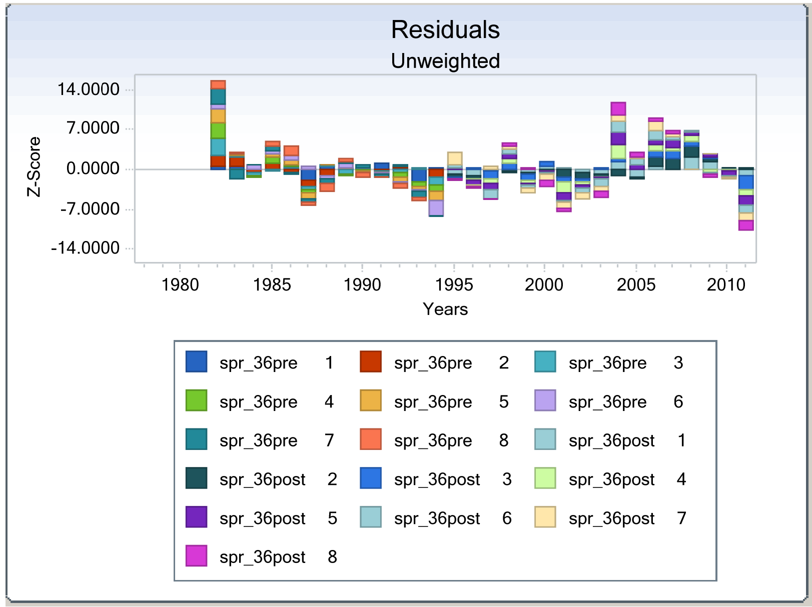
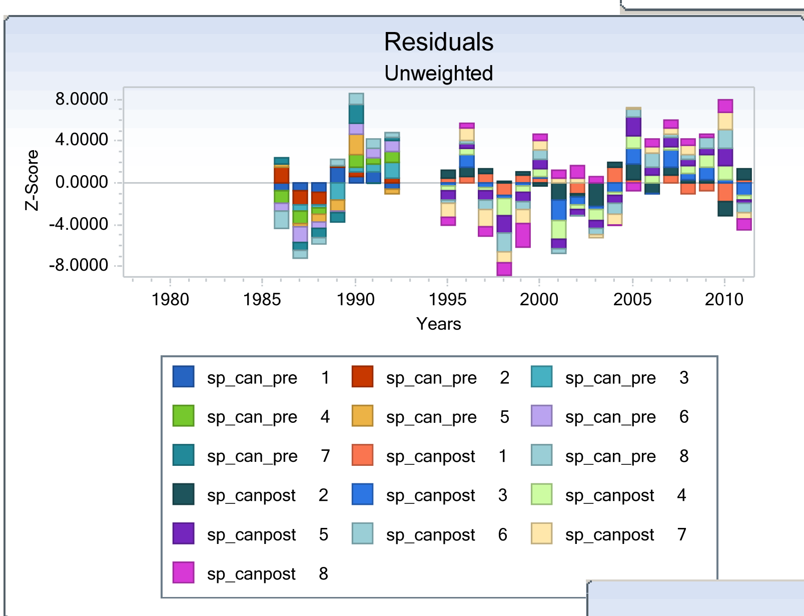
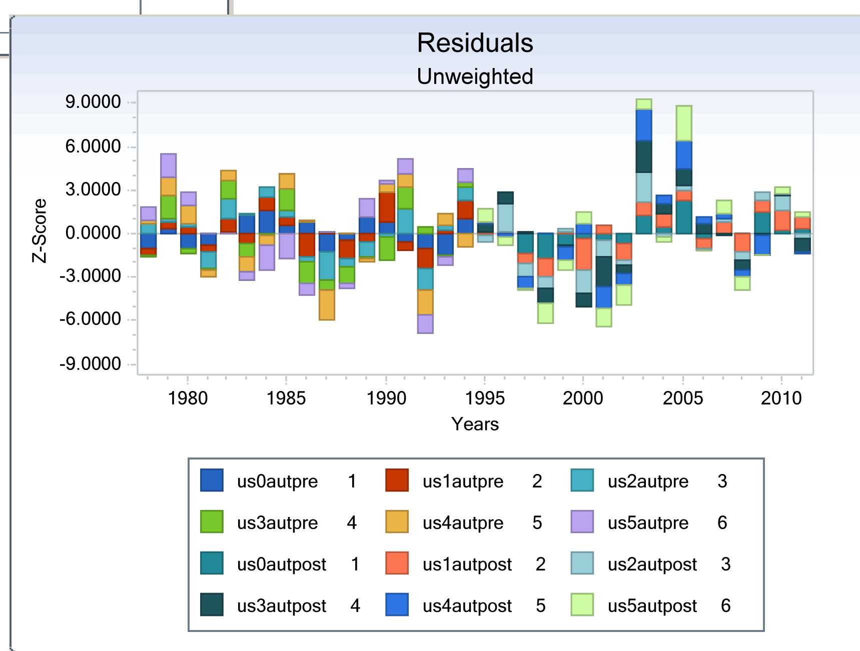


Figure A12. Survey catchability (q) estimates based on swept area estimates of Georges Bank cod in NEFSC and DFO spring and autumn research bottom trawl surveys as estimated in the 2012 VPA update**.**

Figure A13.
Residuals for NEFSC spring, DFO February, and NEFSC autumn surveys from VPA.







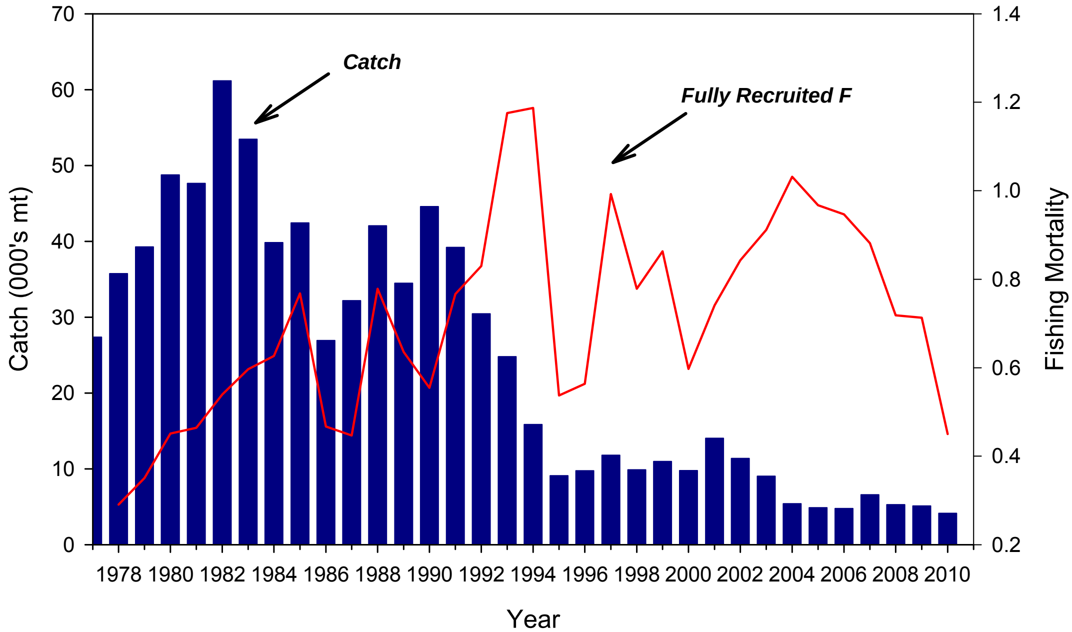


Figure A14. Trends in total catch and fishing mortality (ages 5-8) for Georges Bank cod, 1978-2010.

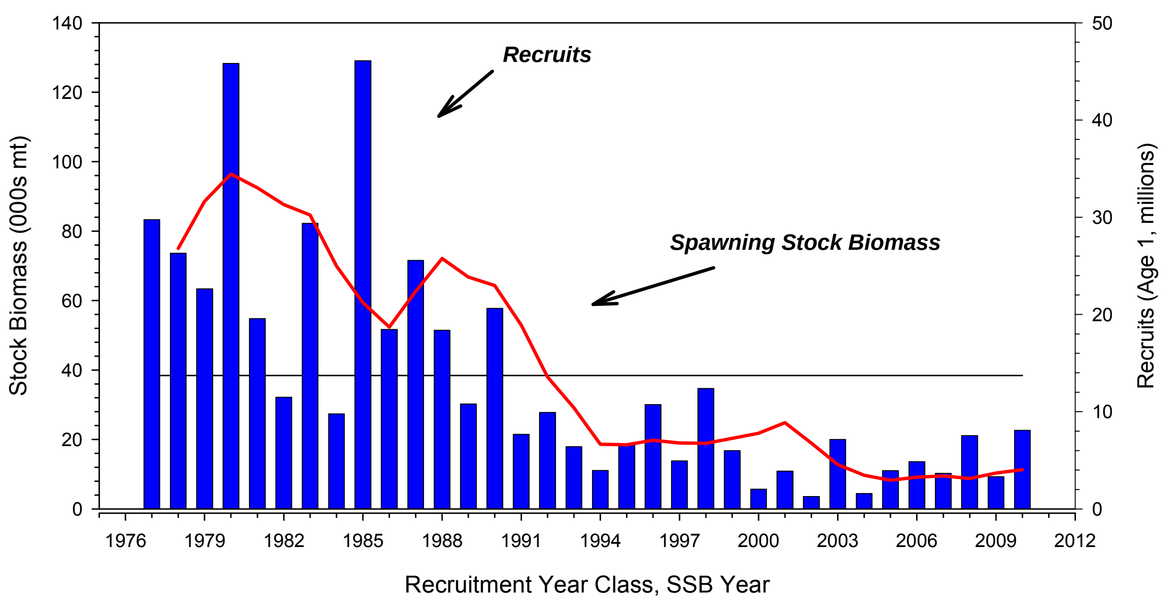


Figure A15. Trends in stock biomass and recruitment for Georges Bank Atlantic cod, 1978-2010. Horizontal line is the average recruitment for the time series.

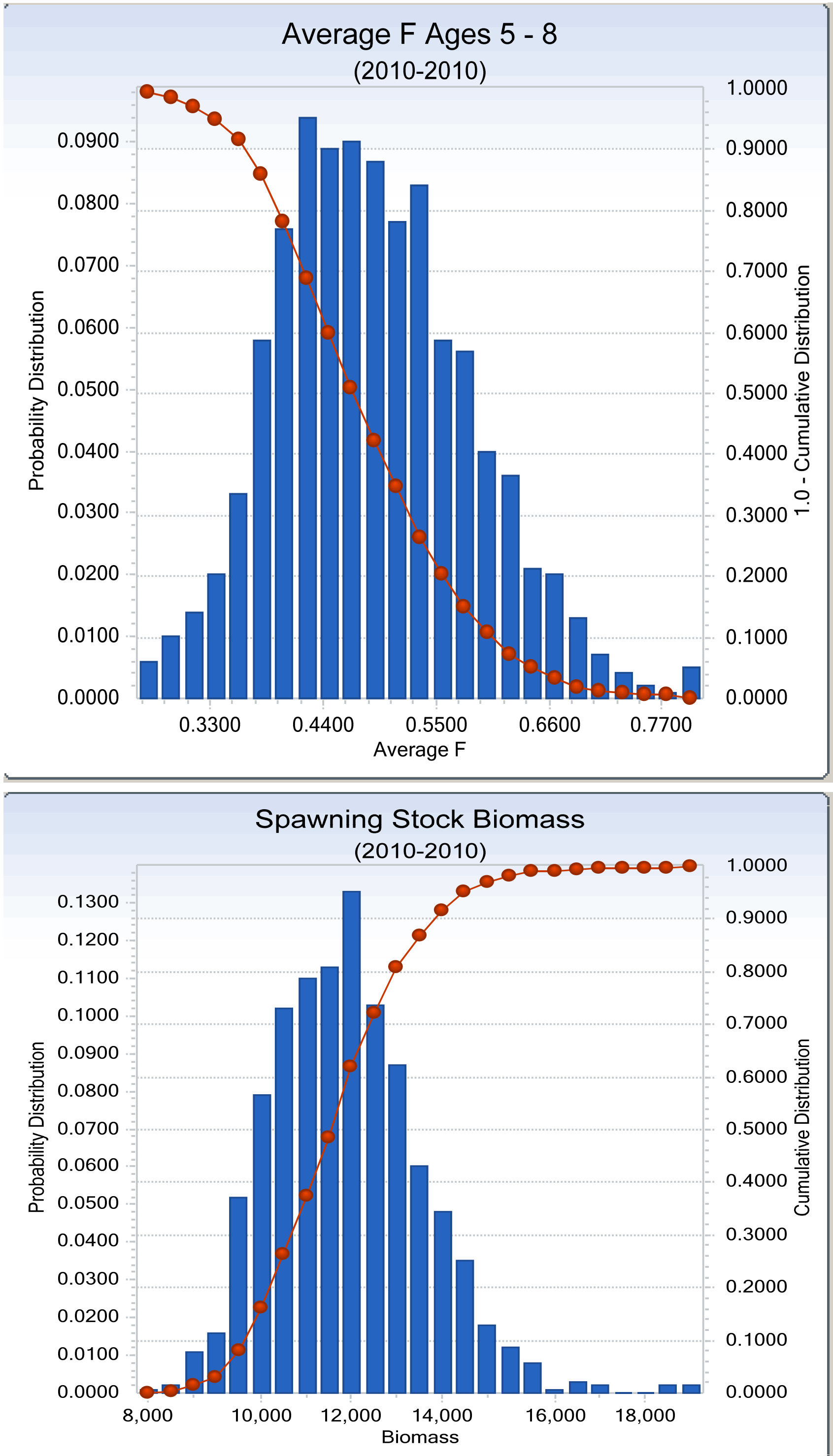


Figure A16. Precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages(5-8) and spawning stock biomass at the beginning of the spawning season for Georges Bank Atlantic cod, 2010. Bar height indicates the frequency of values within that range. The solid line is the cumulative probability that F is greater than, or SSB is less than, any selected value on X- axis.

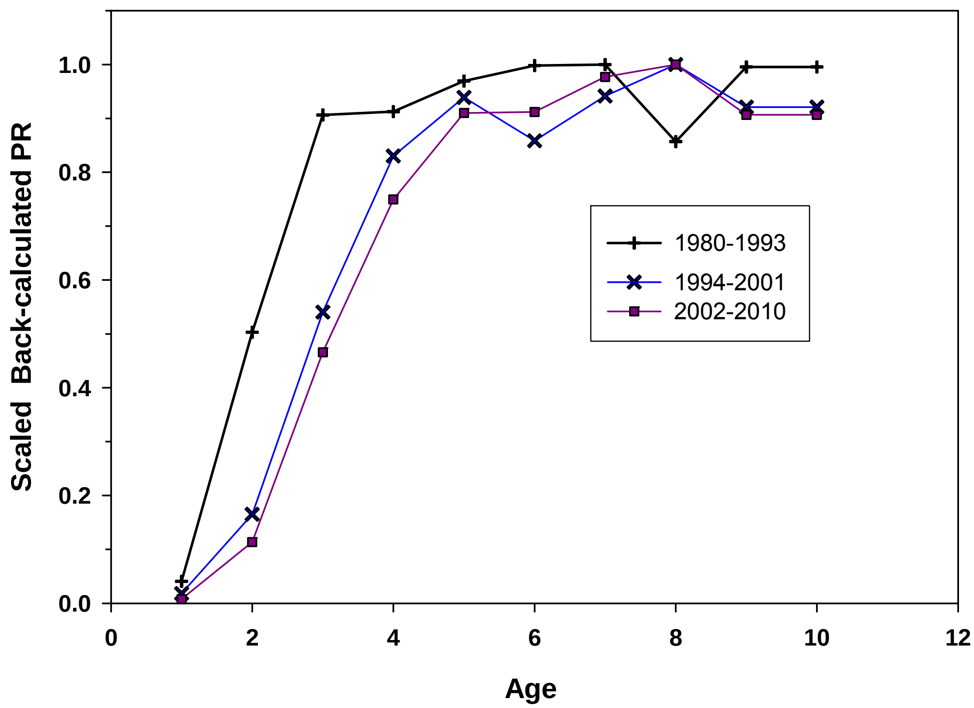


Figure A17. Scaled back-calculated partial recruitment (PR) from VPA for time periods 1980-1993, 1994-2001, and 2002-2010 for Georges Bank Atlantic cod.

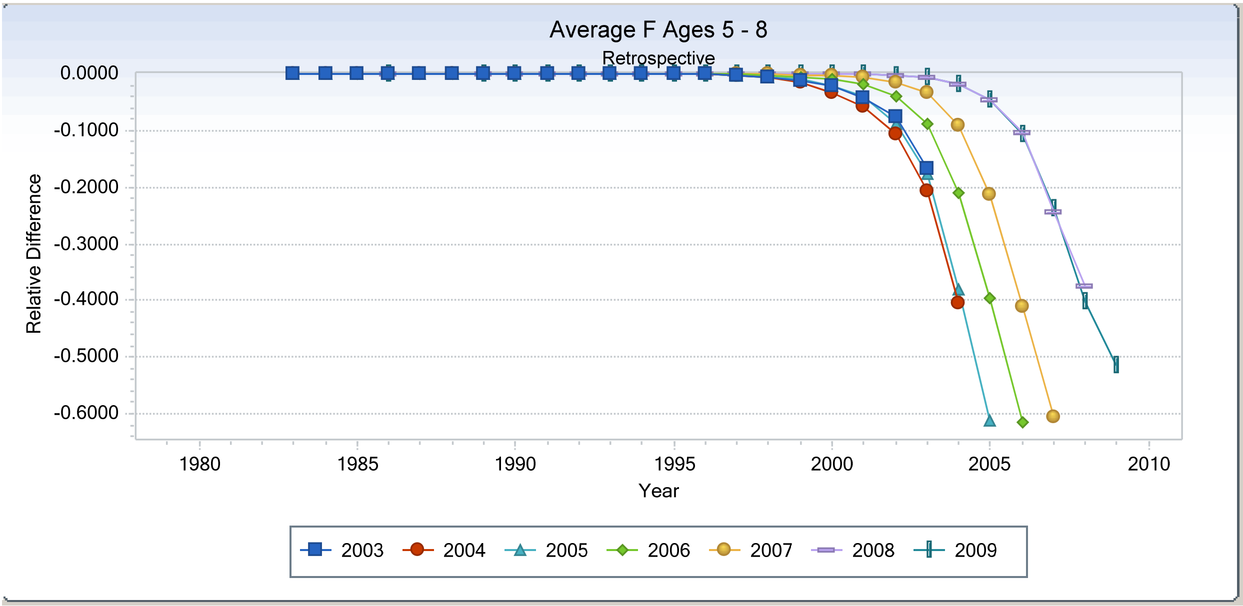


Figure A19a. Retrospective analysis of relative difference to terminal year 2010 (rho = -0.4711) of Georges Bank Atlantic cod fishing mortality (ages 5-8, unweighted), based on ADAPT VPA, 2000-2010.

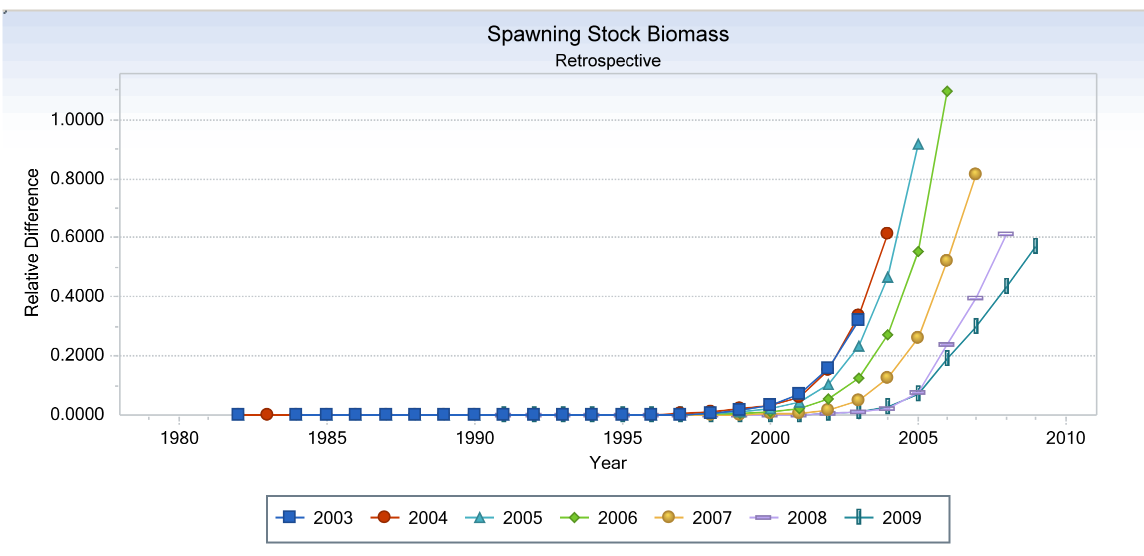


Figure A19b. Retrospective analysis of relative difference to terminal year 2010 (rho = 0.7059) of Georges Bank Atlantic cod spawning stock biomass based on ADAPT VPA, 2000-2010.

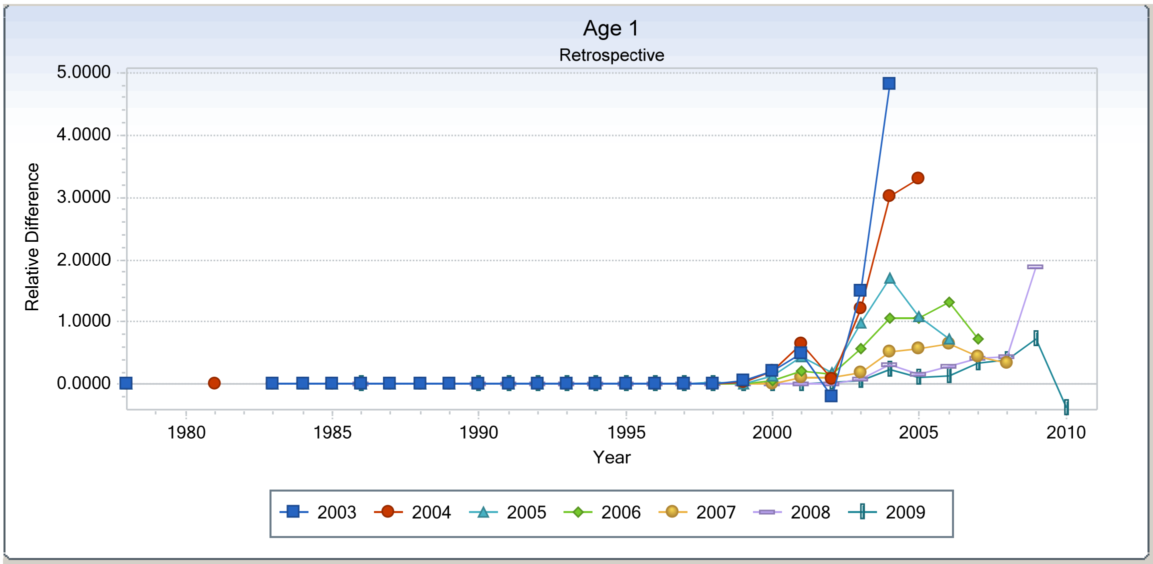


Figure A19c. Retrospective analysis of relative difference to terminal year 2007 (rho = 1.6320) of Georges Bank Atlantic cod age 1 recruitment based on ADAPT VPA , 2000-2010.

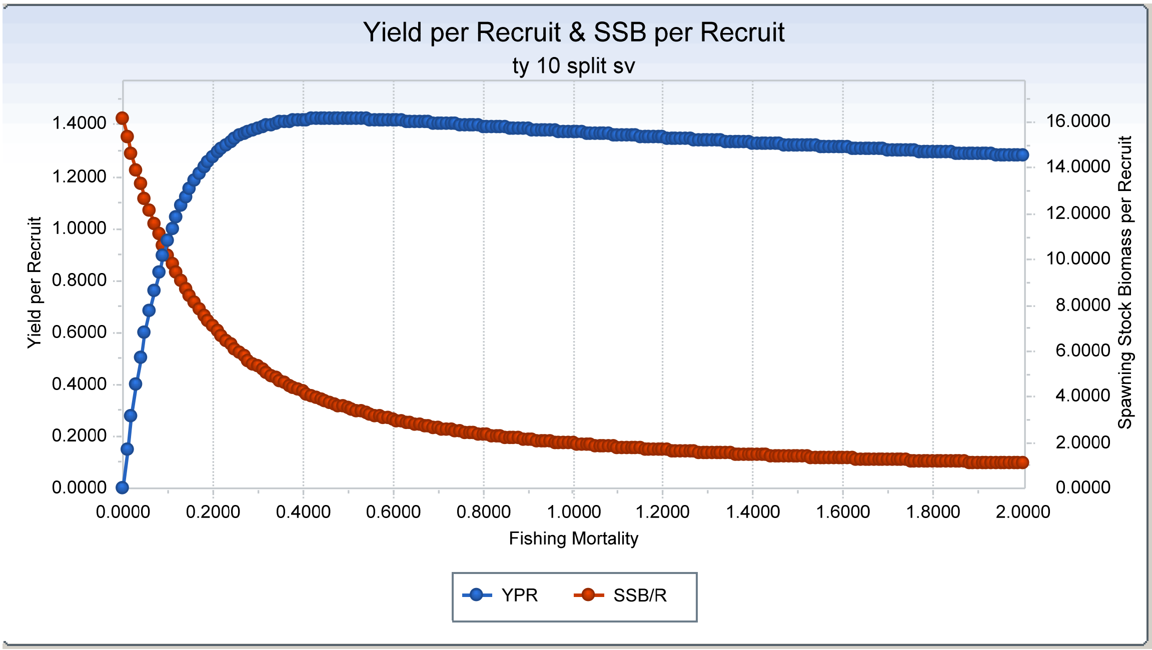


Figure A20. Yield- and Spawning Stock Biomass per-recruit analysis for Georges Bank Atlantic cod . $F_{0.1}$ =0.21 , F_{max} = 0.47 and $F_{40\%}$= 0.23.

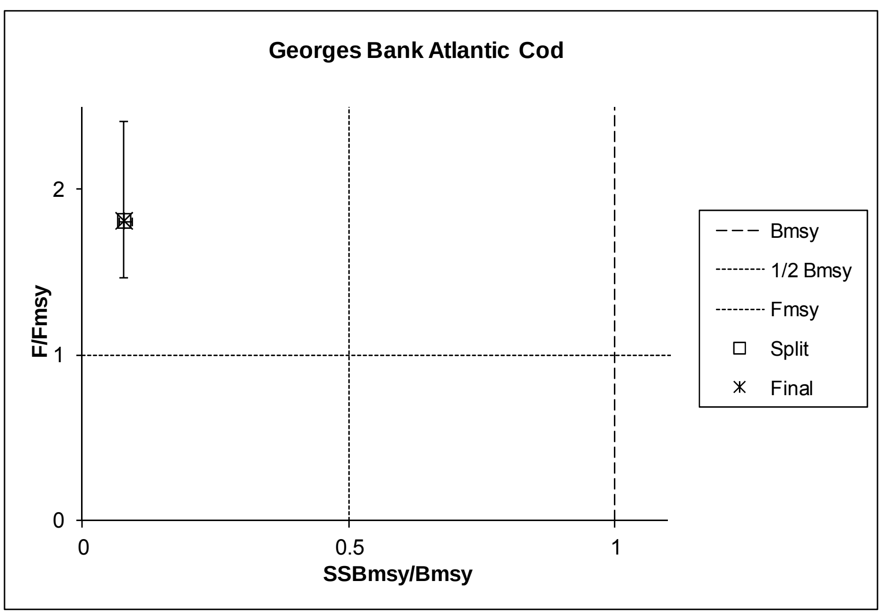


Figure A21. Status of 2010 fishing mortality (F) and spawning stock biomass (SSB) of Georges Bank Atlantic cod relative to F_{MSY} and SSB_{MSY}.

B. Georges Bank Haddock
Melanogrammus aegelfinus

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B. Georges Bank Haddock

A. Background

The Georges Bank haddock stock was last assessed as part of the GARM-III (Brooks et al. 2008). That assessment was a benchmark, and all methods that were accepted by the GARM-III review panel were used in this update. Three additional years of catch and index data are incorporated.

B. Fishery

Total catches of Georges Bank haddock have steadily increased in the past decade, from 8711 mt in 2000 to 25903 mt in 2010 (Table B1; Fig. 1). Catch exceeded 20000 mt for the last three years (2008-2010). On average, the US fraction of recent catch has been 30% with Canada accounting for the remaining catch.

US catch has been dominated by landings the last three years, with over 90% of the landings due to otter trawl gear (Table B2). Longline and gillnet account for most of the remaining landings.

In 2007, about 40% of the US catch was due to discarding (Table B3), primarily undersized fish from the 2003 boomer year class. Since then, discard estimates have decreased dramatically, accounting for 1-6% of the total catch. The number of trips observed for discard estimation has been high, with over 1000 trips in each of the last three years (Table B4). All of the US catch of Georges Bank haddock is due to the commercial fleet, as recreational discards are estimated to be zero or near-zero (Table B5).

Recent sampling of commercial landings by market category for lengths ranged from 1 to 10 fish per mt of landings and about 0.5 to 5 fish for age sampling per mt landed (Table B6).

Ageing of samples

Precision age testing for haddock is conducted six times a year, once for each cruise (spring & autumn) and for each quarter of the commercial samples. The precision tests are for both Georges Bank and Gulf of Maine stocks combined. Each precision test includes a subsample of about 100 fish, and measures the repeatability of age assignment by the age reader. Two accuracy tests for Georges Bank haddock are conducted each year, using the reference collection of Georges Bank samples (N ≈ 60; one prior to and one after the production ageing). In addition to these tests, an annual exchange of Georges Bank age samples is conducted with DFO staff in Canada to compare age assignments between the age readers (2-4 separate precision tests each year representing a range of sample sources/seasons; N ≈ 50 within each test).

For the period 2008 to 2010, the precision levels for all haddock (Georges Bank and Gulf of Maine) had an average agreement of 97% and an average CV of 0.5%. The best results showed complete agreement (100%, 0.0% CV) between the ages for each fish; the worst results were 92% agreement and a CV of 1.3%, both on tests of the autumn survey. No bias occurred in any of the tests. All of these results exceed our standards for adequate ages (>80% agreement, <5% CV, and no bias).

Accuracy tests on Georges Bank haddock resulted in an average 94% agreement (1.6% CV). The best result was 96.7% (0.3% CV) for the January 2009 test; the worst result was 88% agreement (4.1% CV) in October 2010. Full testing results and an explanation of the statistics listed above can be found at http://www.nefsc.noaa.gov/fbp/QA-QC/hd-results.html.

Landings at age were estimated from an age-length key derived from the commercially sampled fish. Discards at age were estimated from total discards by applying age-length keys from the spring and fall NEFSC groundfish survey. Age specific components of landings, discards, and total catch can be found in Tables B7-B9, and Figure B2. The 2003 year class continues to dominate both the landed and discarded fraction of the catch.

The weights at age for the catch are a weighted mean of the age-specific weights from the various components of the catch (US landings, US discards, Canadian landings, Canadian discards). In recent years, weight at age declined for all ages, coincident with the extraordinarily large 2003 year class (Table B10; Fig. B3). Consistent with previous assessments, spawning weights have been calculated from the catch weights by the Rivard method.

C. Research surveys

For the NEFSC spring and fall groundfish surveys, the trends in mean number per tow and mean kg per tow for the last decade have tracked the 2003 year class (Table B11; Fig. B4). Both the spring and fall surveys peaked in 2004; there was some noise but mean number per tow declined sharply through 2010 while mean kg/tow declined more gradually as declines in numbers was somewhat offset by gains in weight with age. The fall 2010 mean number/tow and the spring 2011 mean number per tow are quite large. These two observations provide the first glimpse of the incoming 2010 year class, which may be the first strong year class since 2003.

The indices at age have been scaled and reflect minimum swept area estimates for the two NEFSC surveys and for the DFO spring survey on Georges Bank (Tables B12-B14; Fig. B5). The NEFSC fall survey is lagged forward an age and a year, while the two spring surveys (NEFSC and DFO) reflect true ages. The spring 2011 estimates for age 1 are large for both NEFSC and DFO.

The fall and spring NEFSC surveys for 2009-2010 were conducted from the R/V Henry Bigelow, and are expressed in units that are consistent with the R/V Albatross IV. A large scale calibration study between vessels was conducted, and initial estimates for constant calibration factors were calculated by Miller et al. (2010). Additional analyses were done to estimate length specific calibration factors and are reported in Brooks et al. (2010). Length specific calibration factors and CV are given in Table B15. The calibration factors are estimated to be very precise, with CVs ranging from 3% to 7%.

D. Assessment

Model

The final GARM-III base model for Georges Bank haddock was performed with the NOAA Fisheries Toolbox (NFT) ADAPT VPA version 2.8.0. That input file was then run in ADAPT VPA version 3.1.1 to confirm that the results were identical. The additional data were then added and run with the same configuration as for GARM-III. 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.

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. A single ogive for all years was adopted at GARM-III based on the age at 50% maturity not appearing to differ significantly across years for the 3 or 5 year window. Data from 2008-2010 provided no evidence to deviate from the existing maturity ogive (Fig. B6).

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.

VPA Results

The VPA estimated a steady increase in SSB from a low of about 15,000 mt in the early 1990s, to about 252,000 mt in 2007 (Table B16, Fig. B7). The dramatic increase 2005-2007 is due to the exceptionally large 2003 year class reaching maturity. From 2007 to 2010, SSB decreased 35% as that 2003 year class decreased in number from both natural and fishing mortality.

The estimated size of the 2003 year class is 412,386,000 age-1 fish, which is slightly less than the 1963 year class size of 460,816,000 age-1 fish (Table B17; Fig. B8). 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, average fishing mortality on ages 5 to 7 was about 0.4, but dropped to 0.12 in 1995 and remained low for several years (Table B18; Fig. B9). Since 1998, fishing mortality steadily increased from 0.15 to 0.26 in 2006, but has since been close to or below 0.2.

The catchabilities (q's) estimated in this assessment tended to flatten for the indices of older ages (Fig. B10). The model estimates of q's ranged from about 0.3 to about 0.7 for the NEFSC and DFO surveys (Table B19). The years 1973-1981 in the spring NEFSC spring survey are modeled as a separate index, and have catchabilities in the range of 0.72-0.91.

Uncertainty in model estimates was obtained by performing one thousand bootstrap iterations of the base VPA. The estimated precision for stock numbers in 2011 ranged from 23% to 32% for ages three to eight, and was slightly higher at age two (42%). The estimated number of age 1 recruits in 2011 was nearly 750 million age-1 fish, but this value was highly uncertain with a CV of 84%.

Spawning stock biomass in 2010 was estimated at 167,266 mt and was fairly precise with a CV of 17%. Estimated average fishing mortality on ages 5 to 7 in 2010 was 0.18 with a CV of 13%.

VPA Diagnostics

Plots of standardized residuals for the indices did not show any strong patterning (Fig. B11). The average Mohn's rho was calculated for the seven retrospective relative differences in years 2003-2009 (Fig 12). The values for Mohn's rho were 0.2 for SSB, -0.15 for F, and 0.14 for age-1 recruitment. Retrospective plots of catchability estimates showed very little sensitivity to years being removed from the model (Fig. B13).

E. Biological reference points (BRPs)

The NMFS Toolbox program for calculating yield per recruit 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. B14). The stock weight, catch weight, SSB weights, and maturity were also based on an average of the last 5 years (2006-2010; Table B20 and Fig. B15). Compared to the selectivity at age that was used to derive the BRPs in GARM-III, the selectivity ogive in this assessment shows age 6 to be fully selected and age 5 to have a selectivity of about 0.71 (Table B20). For this assessment, the updated estimate of F40% was 0.39 compared to the current GARM-III value of 0.35 (Table B20).

As was done for GARM-III, 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). At the GARM-III-BRP meeting, it was noted that recruitment tended to be stronger when SSB levels exceeded 75,000 mt (Fig. B16). The panel therefore recommended that the recruitment estimates to be sampled in the AGEPRO projections should come from the model estimates when SSB>75,000 mt, but excluding the large 1963 and 2003 year classes. Both the 1963 and 2003 year classes were excluded, as were the final two model estimates (2009 and 2010 recruitment). The long-term median recruitment from this projection is 54.2 million age-1 fish, with 90% CI ranging from 4 million to 130 million fish. The estimates of equilibrium SSB_{MSY} and MSY are 124,900 mt and 28,000 mt, respectively. There is a 90% probability that SSB_{MSY} is between 71,800 and 187,800 mt, and that MSY is between 16,300 and 41,900 mt.

F. Projection

As the Georges Bank haddock stock is still considered rebuilt, no rebuilding projections were made. However, a projection was made to estimate catch and stock levels from 2011-2015. In this projection, catch in 2011 was assumed to be at the same level as catch in 2010 (25,903 mt), and fishing mortality was assumed to be F_{MSY} in 2012-2015 (F=0.39). Under this mixed harvest scenario, the realized F in 2011 is projected to be 0.20, and catch in years 2012-2015 is projected to increase from 45,600 mt to 98,200 mt. SSB from 2011 to 2015 is projected to range from 313,300 mt to 466,300 mt (Table B22; Fig. B17).

Sensitivity projection

The estimate of the 2010 year class is uncertain, but the high initial estimate has a large influence on projected short-term catch (Table B23). As this initial estimate is only based on data from the spring 2011 survey indices of age-1 fish, there are no corroborating observations in the catch. A sensitivity projection was done where the estimated size of the 2010 year class is reduced by half. This 50% reduction was motivated by examining the direction and magnitude of change between initial estimates of two recent above average year classes (2003 and 1998). Specifically, the relative change in estimates of year class size was compared between an estimate based on one year of data and model runs that added one additional year of data. Rather than computing this relative change from the terminal point (as in Mohn's rho), the relative change was calculated from the initial model estimate. This more closely replicates the present scenario: survey observations from one year are all that is being used to estimate the 2010 year class. In future years, the estimate will become less certain as data are added to the model. The question is how biased is the initial 2010 year class estimate, and what is the best way to address this in projections? Figure B18 shows the relative change in estimated year class size as additional years of data are added to the model. In general, estimates of year classes tended to stabilize with three to five years of data. Over the range of years considered, the current estimates of two recent large year classes (1998 and 2003) were about half of the initial estimate based on one year of data.

Results from this sensitivity projection lead to catches that range from 40,700 mt in 2012 to 56,500 mt in 2015. From 2011 to 2015, SSB ranged from 147,700 mt to 240,200 (Fig. B17).

G. Summary

Stock Status

The estimate of SSB_{2010} is 167,278 mt, which is greater than the median estimate of SSB_{MSY} (124,900 mt). Therefore, the Georges Bank haddock stock is not overfished. The estimate of F on fully selected fish in 2010 is 0.24, which is less than the F_{MSY} proxy (0.39), therefore overfishing is not occurring. Applying Mohn's rho for 7 years did not cause the stocks status to differ from the calculated confidence interval, therefore the retrospective pattern was not considered for additional sensitivity configurations (Fig. B19).

Sources of Uncertainty

The primary source of uncertainty for this stock is the estimate of the 2010 year class. It is hypothesized that there is less uncertainty in age specific mean lengths and weights, compared to the GARM-III assessment, because the patterns have stabilized somewhat over the period of years used to estimate the reference points and for making projections. If the 2010 year class materializes and is indeed large, the current slower growth may persist.

The catch projections for 2011-2015 used the same series of recruitment estimates as were used to estimate reference points, i.e. values of recruitment that corresponded to SSB greater than 75,000 mt. There were 39 recruitments that matched this criterion, and the mean recruitment was 58 million fish. If all estimated recruitments had been sampled (excluding the final two years, and excluding the two extraordinary 1963 and 2003 year classes), then the mean recruitment would have been somewhat lower at 41.7 million fish. Recent recruitment since 2000 (excluding 2003) has averaged about 19 million fish. It can be expected that projected catch advice will be sensitive to the recruitment values that are sampled from.

H. Panel Conclusions and Comments

Status of Georges Bank Haddock Stock

SSB in 2010 is estimated to be 167,279 mt.
Status determination is based on average $F_{5\text{-}7}$, which is estimated to be 0.18.
(F on fully selected fish in 2010 is estimated to be 0.24.)
Revised estimates of the biological reference points are:

SSBmsy proxy= 124,900 mt,
Fmsy proxy = 0.39, and
MSY proxy= 28,000 mt.

Based on these results, the stock of Georges Bank haddock is not overfished and overfishing is not occurring. The stock is above the biomass target.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15). Short-term projection methodology adopted a new approach to reduce the influence of a potentially large but uncertain 2010 year class. The initial estimate of the 2010 year class is nearly 750 million age-1 fish, although the CV on this estimate is 84%. Recruitment estimate for 2010 was reduced by multiplying it by 0.41 for the short-term projections, which is the magnitude of reduction observed between the initial and final estimate for the large 2003 year class at age 1.

The BRPs are based on the following updates: average of the most recent 5 years of weights and selectivity at age, the same approach used in GARM 2008.

GB Haddock. Summary of Assessment Information

GB Haddock	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg	Min	Max	YrRange
Landings (mt)	13019	12535	17121	21087	14629	14837	20632	22930	25759		10635	2296	25759	1989-2010
Discards (mt)	239	292	1132	727	1360	1968	389	196	144		508	103	2209	1989-2010
Catch (mt)	13258	12827	18253	21814	15989	16815	21021	23126	25903		21847	2442	150362	1960-'10
SSB	100258	119310	108126	126290	225173	252065	238744	210557	167279		82400	14836	252065	1960-'10
Recruits	5551	2870	412375	7985	28833	7123	9365	4773	7605	748016	53074	267	748016	1960-'11
F avg 5-7	0.24	0.22	0.31	0.33	0.26	0.19	0.13	0.14	0.18		0.32	0.07	0.68	1960-'10

Reviewer Comments

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

The 2010 yearclass appears to be large. The panel asked about the impact of slow growth, selectivity and how a tendency for initial year class strength to be overestimated could impact projections. This concern arose because of experience with overestimatiion of projected catch as the 2003 year class recruited to the fishery. Currently growth is similar to that observed for the 2003 yearclass. Fishery selectivity is different, but management has altered size limits several times so that year class effects and management effects on selectivity are confounded.

The panel expressed concern that weights and selectivity could be misspecified in short term projections for the 2010 year class. To address these concerns, three additional projections were conducted and are included in GB haddock Appendix: i) the 2010 year class was multiplied by 0.41, which was the most recent calculation for rescaling of the 2003 year class (Appendix Tables B1-B2); ii) in addition to (i), realized weights for the 2003 year class were used as projected weights for the 2010 year class (Appendix Table B3, Appendix Figs B1-B2); iii) in addition to (i) and (ii), realized selectivity for the 2003 year class were used as projected selectivity for the 2010 year class (Appendix Table B3; Appendix Fig. B3). It should be noted that for the third projection, the realized selectivities for the 2003 year class at ages 1-3, and 7.5 months for age 4 were based on a higher minimum size regulation.

Neither projected catches nor projected SSB for the additional sensitivity scenarios differed markedly between the three additional projections (Appendix Fig. B4). Given the difference in minimum size (it is now lower than what the 2003 year class experienced in its first 4 years), the panel decided to select sensitivity run (i) as the most appropriate for management advice.

I. References

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Miller TJ, Das C, Politis PJ, Miller AS, Lucey SM, Legault CM, Brown RW, Rago PJ. 2010. Estimation of Albatross IV to Henry B. Bigelow calibration factors. Northeast Fish Sci Cent Ref Doc. 10-05. 233 p.

Table B1. Georges Bank haddock total catch biomass (mt) by country, 1960-2010.

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	4855	11951	0	0	0	16815
2008	6207	14814	0	0	0	21021
2009	5477	17648	0	0	0	23126
2010	9310	16592	0	0	0	25903

Table B2. US and Canadian landings (mt) by gear of Georges Bank haddock for years 1989-2010.

	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	0.2
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	0.1
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	0.5
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	9	240	5	2695	2930	10034	1854	0	1	11889	14819	0.2
2008	27	402	25	5397	2695	12615	2164	0	2	14781	17475	0.15
2009	41	415	0	4879	5397	15407	2185	0	3	17595	22992	0.23
2010	28	361	43	8748	4879	14100	2476	0	2	16578	21457	0.23

Table B3. US discards (mt) by gear, and CV (in parentheses), of Georges Bank haddock for years 2007-2010.

Year	Hook/Line		OT-lg		OT-sm		GN-lg		GN-xlg		Scallop	
2007	74	*0.33*	1812	*0.17*	9	*0.39*	3	*0.51*	0		3	*0.22*
2008	43	*0.14*	303	*0.23*	3	*1.26*	3	*0.33*	0.1	*0.70*	2	*0.23*
2009	27	*0.17*	108	*0.22*	3	*0.70*	4	*0.45*	0.1	*0.80*	1	*0.32*
2010	13	*0.28*	74	*0.11*	37	*0.85*	4	*0.22*	0.2	*0.46*	2	*0.88*

Table B4. Number of observed trips by gear for US discards of haddock on Georges Bank for years 1989-2010.

YEAR	Hook/Line	Trawl	Gillnet	Scallop	Total
1989	0	104	0	0	105
1990	0	73	0	0	73
1991	17	107	0	1	126
1992	25	85	0	15	127
1993	0	44	0	18	63
1994	1	49	58	7	115
1995	0	86	76	9	171
1996	0	58	30	19	107
1997	0	47	34	14	96
1998	0	20	49	12	81
1999	0	34	48	33	115
2000	0	59	70	273	402
2001	0	82	43	18	143
2002	8	141	49	11	211
2003	5	288	169	15	477
2004	113	487	318	51	970
2005	244	1198	299	118	1859
2006	65	556	76	157	855
2007	58	554	162	191	965
2008	63	694	109	231	1097
2009	59	839	94	97	1089
2010	126	876	626	100	1728

Table B5. Recreational landings and discards of Georges Bank haddock.

There are none.

Table B6. 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 B6 (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	994414	29	1449	29	618	1.5	0.6
	2	Scrod	1240913	40	1997	37	849	1.6	0.7
	1	Large	327839	27	1873	27	1046	5.7	3.2
	2	Large	336784	38	2671	35	1335	7.9	4.0
2008	1	Scrod	2541463	42	2049	42	981	0.8	0.4
	2	Scrod	2190639	36	1876	35	862	0.9	0.4
	1	Large	369581	47	3450	45	1653	9.3	4.5
	2	Large	693611	32	2852	32	1456	4.1	2.1
2009	1	Scrod	2393773	44	2188	40	975	0.9	0.4
	2	Scrod	2022335	46	2346	46	1085	1.2	0.5
	1	Large	374001	30	2542	28	1169	6.8	3.1
	2	Large	515613	31	2615	30	1283	5.1	2.5
2010	1	Scrod	4662461	68	3391	62	1550	0.7	0.3
	2	Scrod	2445521	51	2659	47	1148	1.1	0.5
	1	Large	1130560	56	5465	53	2611	4.8	2.3
	2	Large	813924	46	4027	44	2042	4.9	2.5

Table B7. Total landings at age (thousands) of Georges Bank haddock for years 1989-2010.

Year	1	2	3	4	5	6	7	8	9	**Total**
1989	0	1322	97	997	215	466	60	36	56	3248
1990	2	11	1648	264	1119	153	217	55	49	3518
1991	6	464	120	2366	144	517	128	171	65	3981
1992	7	250	405	196	1952	181	426	47	100	3563
1993	7	295	376	338	118	739	63	169	82	2188
1994	1	247	793	162	61	55	140	30	40	1529
1995	2	70	592	459	57	28	7	58	15	1288
1996	1	39	550	899	435	65	22	7	73	2092
1997	3	92	219	695	534	207	17	16	43	1826
1998	1	185	455	527	738	555	167	23	44	2694
1999	1	36	884	536	602	562	382	160	46	3207
2000	0	391	608	1563	583	525	374	256	97	4395
2001	2	130	2319	969	1266	649	433	356	259	6382
2002	1	288	299	3137	915	1101	397	304	549	6992
2003	2	8	1849	446	2644	597	711	210	385	6851
2004	178	3	67	4677	671	2861	675	546	399	10077
2005	2	114	34	319	8373	763	1815	311	341	12072
2006	6	4	2205	43	341	5233	301	802	215	9150
2007	1	29	186	8350	158	191	1708	162	304	11089
2008	2	28	378	298	12491	112	106	912	226	14552
2009	12	117	188	860	283	12864	83	75	513	14994
2010	2	51	409	380	1432	443	13373	58	335	16483

Table B8. Total discard at age (thousands) of Georges Bank haddock for years 1989-2010.

	Age								
Year	1	2	3	4	5	6	7	8	9	**Total**
1989	2	140	26	22	2	12	2	1	1	**208**
1990	61	1	49	5	5	1	1	0	0	**123**
1991	1	22	3	4	0	1	0	1	0	**32**
1992	77	15	3	1	8	0	0	0	0	**104**
1993	26	68	63	2	2	2	0	0	0	**163**
1994	26	291	399	80	81	18	173	25	70	**1163**
1995	15	24	22	12	2	1	2	3	1	**82**
1996	6	17	16	20	15	1	0	0	5	**80**
1997	12	51	54	50	27	11	1	2	6	**214**
1998	5	45	16	31	29	16	2	0	5	**149**
1999	2	7	22	5	4	4	2	3	2	**51**
2000	2	16	18	8	5	3	3	2	2	**59**
2001	12	15	74	27	15	7	5	3	3	**161**
2002	2	109	46	40	11	4	5	2	2	**221**
2003	3	10	94	15	42	8	8	2	4	**186**
2004	468	30	55	439	58	74	12	17	9	**1162**
2005	18	498	8	20	132	15	28	4	2	**725**
2006	158	14	959	28	34	185	26	40	13	**1457**
2007	19	151	45	1703	19	26	127	15	50	**2156**
2008	6	13	58	6	285	3	2	7	5	**387**
2009	6	16	12	25	3	99	1	1	2	**165**
2010	33	9	11	5	9	2	65	0	3	**136**

Table B9. Total catch at age (thousands) for Georges Bank haddock, 1989-2010.

Year	1	2	3	4	5	6	7	8	9+	Total
1989	2	1462	123	1019	217	478	62	37	57	**3456**
1990	63	12	1697	269	1124	154	218	55	49	**3641**
1991	7	486	123	2370	144	518	128	172	65	**4013**
1992	84	265	408	197	1960	181	426	47	100	**3667**
1993	33	363	439	340	120	741	63	169	82	**2351**
1994	27	538	1192	242	142	73	313	55	110	**2692**
1995	17	94	614	471	59	29	9	61	16	**1370**
1996	7	56	566	919	450	66	22	7	78	**2172**
1997	15	143	273	745	561	218	18	18	49	**2040**
1998	6	230	471	558	767	571	169	23	49	**2843**
1999	3	43	906	541	606	566	384	163	48	**3258**
2000	2	407	626	1571	588	528	377	258	99	**4454**
2001	14	145	2393	996	1281	656	438	359	262	**6543**
2002	3	397	345	3177	926	1105	402	306	551	**7213**
2003	5	18	1943	461	2686	605	719	212	389	**7037**
2004	646	33	122	5116	729	2935	687	563	408	**11239**
2005	20	612	42	339	8505	778	1843	315	343	**12797**
2006	164	18	3164	71	375	5418	327	842	228	**10607**
2007	19	181	232	10054	176	217	1835	177	353	**13244**
2008	8	41	436	304	12776	116	108	919	232	**14939**
2009	18	133	199	885	286	12962	84	76	515	**15159**
2010	35	60	420	384	1442	444	13438	58	338	**16618**

Table B10. Weights at age for the catch and SSB for Georges Bank haddock.

Catch weights at age

Year	1	2	3	4	5	6	7	8	9+
1989	0.53	0.89	1.48	1.79	2.21	2.57	3.24	3.56	3.82
1990	0.64	0.97	1.48	1.78	2.12	2.55	2.81	2.99	4.16
1991	0.58	1.20	1.31	1.82	2.18	2.65	2.85	3.05	4.34
1992	0.54	1.18	1.64	1.77	2.19	2.52	2.97	3.37	4.27
1993	0.66	1.17	1.73	2.17	2.12	2.63	2.65	3.12	4.01
1994	0.45	1.09	1.64	2.21	2.63	2.73	2.90	3.78	4.55
1995	0.43	0.97	1.49	2.03	2.54	2.82	3.28	3.09	3.98
1996	0.46	1.10	1.50	1.84	2.33	2.54	3.42	3.52	3.71
1997	0.42	1.00	1.69	1.89	2.21	2.55	3.14	3.38	3.66
1998	0.51	0.97	1.49	1.92	2.33	2.69	3.03	3.04	4.07
1999	0.68	1.10	1.53	1.83	2.11	2.34	2.70	2.97	3.68
2000	0.66	1.13	1.46	1.89	2.25	2.37	2.73	2.99	3.30
2001	0.36	1.17	1.46	1.75	2.16	2.53	2.63	2.73	3.41
2002	0.31	0.91	1.34	1.74	1.95	2.47	3.13	3.07	3.34
2003	0.26	0.65	1.36	1.61	1.86	2.05	2.52	3.09	3.17
2004	0.21	0.39	1.00	1.50	1.67	1.95	2.07	2.47	2.91
2005	0.18	0.57	1.05	1.45	1.67	1.83	2.03	2.13	2.63
2006	0.19	0.48	0.95	1.06	1.61	1.78	1.89	2.06	2.31
2007	0.19	0.41	0.94	1.15	1.36	1.64	1.83	1.70	2.11
2008	0.36	0.75	1.00	1.22	1.37	1.58	1.70	1.94	2.14
2009	0.53	0.84	1.00	1.24	1.40	1.54	1.66	2.12	2.13
2010	0.23	0.71	1.06	1.22	1.36	1.51	1.60	1.73	2.19

SSB weights at age

	1	2	3	4	5	6	7	8	9+
1989	0.39	0.61	1.20	1.55	1.93	2.30	2.82	3.25	3.82
1990	0.47	0.72	1.15	1.62	1.95	2.37	2.69	3.11	4.16
1991	0.41	0.88	1.13	1.64	1.97	2.37	2.70	2.93	4.34
1992	0.37	0.83	1.40	1.52	1.99	2.35	2.80	3.10	4.27
1993	0.51	0.79	1.42	1.89	1.94	2.40	2.58	3.04	4.01
1994	0.30	0.85	1.39	1.95	2.39	2.40	2.76	3.17	4.55
1995	0.27	0.66	1.28	1.82	2.37	2.72	2.99	3.00	3.98
1996	0.31	0.69	1.20	1.65	2.17	2.54	3.10	3.39	3.71
1997	0.27	0.67	1.36	1.68	2.02	2.43	2.83	3.40	3.66
1998	0.35	0.63	1.22	1.80	2.10	2.44	2.78	3.09	4.07
1999	0.52	0.75	1.22	1.65	2.01	2.34	2.69	3.00	3.68
2000	0.50	0.88	1.27	1.70	2.03	2.24	2.53	2.84	3.30
2001	0.22	0.88	1.29	1.60	2.02	2.39	2.50	2.73	3.41

2002	0.21	0.57	1.25	1.59	1.85	2.31	2.81	2.84	3.34
2003	0.21	0.44	1.11	1.47	1.79	2.00	2.50	3.11	3.17
2004	0.13	0.32	0.80	1.43	1.64	1.90	2.06	2.49	2.91
2005	0.11	0.35	0.64	1.21	1.58	1.75	1.99	2.10	2.63
2006	0.13	0.29	0.73	1.06	1.53	1.72	1.86	2.05	2.31
2007	0.09	0.28	0.67	1.04	1.20	1.62	1.80	1.79	2.11
2008	0.24	0.37	0.64	1.07	1.25	1.47	1.67	1.88	2.14
2009	0.46	0.55	0.87	1.11	1.31	1.45	1.62	1.89	2.13
2010	0.08	0.61	0.95	1.11	1.30	1.45	1.57	1.70	2.19

Table B11. Mean number/tow and mean kg/tow from the NEFSC spring (left) and fall (right) bottom trawl survey.

YEAR	Mean Num/tow	CV %	Mean kg/tow	CV %
1963	---	---	---	---
1964	---	---	---	---
1965	---	---	---	---
1966	---	---	---	---
1967	---	---	---	---
1968	13.6	27	20.6	22
1969	7.2	25	16.9	29
1970	5.9	55	17.1	69
1971	2.9	28	5.0	24
1972	6.5	40	7.5	20
1973	37.5	69	15.4	34
1974	19.0	36	17.7	34
1975	6.2	41	8.2	43
1976	83.2	48	15.7	33
1977	36.9	38	26.6	36
1978	19.4	28	31.3	28
1979	49.7	28	20.3	19
1980	59.8	37	53.8	35
1981	31.2	23	38.1	23
1982	8.9	22	13.1	20
1983	5.6	18	13.2	26
1984	6.3	29	7.4	26
1985	8.9	34	11.1	32
1986	5.9	23	5.9	27
1987	5.0	53	5.6	49
1988	3.4	20	3.4	17
1989	5.3	26	4.7	20
1990	7.7	51	7.6	36
1991	4.0	44	4.4	42
1992	1.2	26	1.4	28
1993	2.7	29	2.5	44
1994	4.9	64	3.6	63
1995	5.6	45	5.7	44
1996	23.4	73	25.7	70
1997	12.9	68	18.5	79
1998	7.3	44	6.1	40
1999	16.6	45	7.7	43

YEAR	Mean Num/tow	CV %	Mean kg/tow	CV %
1963	144.9	16	79.8	17
1964	193.2	19	96.6	18
1965	101.7	15	72.8	15
1966	34.0	19	30.4	19
1967	17.0	29	24.9	21
1968	7.5	33	16.8	32
1969	3.0	26	8.5	27
1970	7.6	52	13.2	38
1971	3.6	25	5.6	30
1972	10.8	21	8.5	20
1973	14.8	35	9.8	27
1974	3.8	26	4.0	27
1975	29.9	25	15.1	52
1976	70.8	48	35.8	43
1977	23.2	33	27.6	34
1978	25.1	21	18.1	19
1979	52.2	57	32.1	46
1980	30.4	22	22.0	22
1981	13.4	31	14.3	21
1982	5.4	32	7.3	22
1983	8.0	38	5.8	23
1984	5.4	39	4.5	30
1985	13.2	33	3.7	18
1986	6.8	45	5.0	26
1987	3.6	38	2.6	42
1988	5.3	24	5.3	27
1989	4.3	33	4.5	33
1990	2.9	30	2.6	35
1991	2.9	38	0.9	23
1992	5.9	37	3.2	35
1993	8.0	40	4.3	38
1994	3.5	39	2.9	45
1995	17.1	39	10.7	37
1996	4.4	23	4.1	36
1997	6.1	57	6.5	42
1998	10.8	22	5.8	26
1999	23.1	43	33.1	46

2000	14.3	*49*	17.9	*62*
2001	14.9	*23*	6.1	*30*
2002	32.2	*36*	22.3	*32*
2003	14.8	*37*	15.6	*38*
2004	140.5	*63*	41.4	*30*
2005	59.8	*34*	17.7	*24*
2006	37.3	*29*	17.3	*28*
2007	57.3	*34*	34.6	*36*
2008	27.7	*45*	23.8	*53*
2009	19.1	*23*	28.5	*24*
2010	25.0	*19*	41.9	*21*
2011	65.2	*31*	20.4	*20*

2000	18.0	*40*	15.4	*45*
2001	22.7	*35*	20.0	*43*
2002	42.1	*35*	36.3	*34*
2003	169.5	*30*	23.0	*37*
2004	187.0	*36*	55.8	*29*
2005	90.5	*23*	39.4	*24*
2006	57.0	*25*	37.4	*26*
2007	53.9	*45*	43.9	*45*
2008	16.0	*36*	18.0	*37*
2009	30.7	*28*	34.2	*31*
2010	130.3	*44*	19.9	*21*

Table B12. Minimum swept area abundance indices at age for NEFSC spring survey.

	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	2813	22645	5946	146829	1139	829	4489	367

2008	5956	2817	8334	895	65429	1385	478	3342
2009	4863	3591	2757	8761	1357	37154	993	633
2010	1309	1180	5915	3262	10623	1299	55782	0
2011	185638	2371	1590	1612	1259	2185	696	15799

Table B13. Minimum swept area abundance indices at age for NEFSC fall survey.

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
2008	2744	4196	22493	3596	137796	1067
2009	3140	2947	1811	5933	789	35977
2010	3676	1411	2866	3057	10448	1149

Table B14. Minimum swept area abundance indices at age for 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
2009	2466	4439	2981	7907	891	49461	696	140
2010	7002	1078	4770	3913	10468	2852	66009	490
2011	315264	2127	1708	3104	1332	2987	735	29975

Table B15. Calibration factors at length applied to 2009 and 2010 NEFSC surveys.

Length (cm)	Estimate	CV
1-18	2.626169	0.070962
19	2.580551	0.069482
20	2.534933	0.067956
21	2.489315	0.066384
22	2.443697	0.064765
23	2.398079	0.063096
24	2.352461	0.061376
25	2.306843	0.059606
26	2.261226	0.057785
27	2.215608	0.055912
28	2.16999	0.053989
29	2.124372	0.052019
30	2.078754	0.050004
31	2.033136	0.047951
32	1.987518	0.045868
33	1.9419	0.043767
34	1.896282	0.041668
35	1.850664	0.039594
36	1.805047	0.037583
37	1.759429	0.035684
38	1.713811	0.033963
39	1.668193	0.032508
40	1.622575	0.031427
41	1.576957	0.030848
42	1.531339	0.030902
43	1.485721	0.031704
44	1.440103	0.033337
45	1.394485	0.035839
46	1.348868	0.039209
47	1.30325	0.043428
48	1.257632	0.048471
49	1.212014	0.054326
50	1.166396	0.060995
>=51	1.16399	0.06137

Table B16. Estimates of spawning stock biomass (SSB) and January 1 biomass.

Year	SSB	January 1 Biomass
1960	137525	261928
1961	171975	266177
1962	179431	246772
1963	163737	290348
1964	167402	447882
1965	217565	427380
1966	186839	265251
1967	106435	137889
1968	71846	91654
1969	47766	57663
1970	34913	43090
1971	24771	31422
1972	23222	30466
1973	15889	29102
1974	29695	44728
1975	22061	32703
1976	28598	68128
1977	49855	94994
1978	76793	99301
1979	72409	116118
1980	71227	115195
1981	61538	79618
1982	49505	59318
1983	38684	45588
1984	26978	35613
1985	20041	27942
1986	21010	30619
1987	20829	28831
1988	19764	29506
1989	20525	28873
1990	24361	30422
1991	22019	27778
1992	16501	24534
1993	14836	28319
1994	20257	33497
1995	26749	37379
1996	35643	46797
1997	43585	57313
1998	50807	67047

1999	59528	94876
2000	73600	105017
2001	87872	122822
2002	100258	134118
2003	119310	136169
2004	108126	170384
2005	126290	202093
2006	225173	262027
2007	252065	275473
2008	238744	260918
2009	210557	232338
2010	167279	185601
2011		301991.05

Table B17. Estimated number at age for Georges Bank haddock for ages 1-9+.

Year	1	2	3	4	5	6	7	8	9+
1960	122245	106224	34088	21407	13203	10239	3725	1965	1685
1961	54312	99853	72550	22399	13424	8053	6770	2342	3182
1962	39050	44411	72117	45973	14561	8367	4925	4403	3337
1963	188241	31905	32344	44439	28253	8822	4974	2627	3994
1964	460816	151491	22475	19812	26363	15773	5242	2811	3642
1965	32513	368163	109665	14304	11929	13764	7724	2428	3032
1966	4155	18003	188650	49979	6915	5833	5300	2959	2023
1967	14013	3299	8612	64678	23760	3185	2461	2256	1717
1968	542	10436	2549	4459	34417	10213	1525	1126	2094
1969	1111	437	5856	1451	1934	15196	5225	652	1653
1970	4616	908	348	3271	786	997	7112	2866	1782
1971	267	3737	601	270	2165	476	624	3753	2371
1972	8526	217	1828	292	185	1512	171	256	4801
1973	19498	6836	176	1083	165	122	1127	68	2036
1974	10577	13615	3701	141	535	87	73	852	4002
1975	7930	8617	7129	2417	114	372	69	57	1276
1976	105348	6313	6091	4105	1630	90	266	53	1495
1977	13983	86117	4726	4473	2540	1132	73	196	558
1978	6125	11447	52655	3698	3041	1610	602	56	270
1979	83888	5014	8680	30082	2751	1975	851	367	176
1980	10934	68674	4081	5539	18124	1775	1245	412	218
1981	7364	8945	28384	3027	3653	9382	918	529	315
1982	2581	6028	5744	13325	1727	2143	5355	453	470
1983	3284	2112	3879	3226	7533	1060	1240	3370	320
1984	18080	2688	1534	2438	2015	4138	621	846	1720
1985	2518	14801	2116	986	1335	1288	2044	296	577
1986	16786	2061	9900	1227	628	670	844	1190	268
1987	2614	13738	1638	5549	801	381	391	555	706
1988	19995	2140	9414	1223	3066	544	245	239	395
1989	1364	16366	1704	5517	877	1656	308	150	230
1990	3406	1115	12081	1285	3600	523	927	197	174
1991	2716	2732	902	8362	810	1939	290	563	213
1992	10741	2217	1799	628	4719	533	1123	123	263
1993	15568	8718	1576	1107	337	2110	274	538	261
1994	15420	12716	6810	896	601	169	1063	168	334
1995	12687	12601	9926	4503	517	364	72	589	156
1996	11778	10372	10232	7572	3262	370	271	52	586
1997	23451	9637	8441	7866	5372	2265	244	202	537
1998	14637	19187	7760	6664	5768	3892	1658	184	382
1999	49156	11979	15501	5929	4953	4032	2673	1205	352

2000	11668	40242	9768	11874	4366	3510	2791	1843	703
2001	90866	9551	32580	7433	8306	3045	2398	1946	1422
2002	5551	74382	7689	24515	5188	5647	1903	1570	2824
2003	2870	4542	60540	5983	17209	3414	3629	1197	2192
2004	412375	2345	3703	47812	4483	11670	2251	2324	1685
2005	7985	337041	1890	2922	34534	3014	6917	1227	1336
2006	28833	6520	275392	1510	2086	20631	1769	4008	1084
2007	7123	23458	5322	222615	1172	1371	12024	1154	2296
2008	9365	5814	19042	4148	173187	801	927	8192	2065
2009	4773	7660	4723	15197	3122	130269	552	661	4480
2010	7605	3891	6152	3687	11644	2298	94968	376	2206
2011	748016	6195	3132	4658	2672	8234	1481	65649	300

Table B18. Estimated fishing mortality at age, F on fully selected fish (Full F) and the average F on ages 5-7 (F5-7).

Year	1	2	3	4	5	6	7	8	9+	Full F	F5-7
1960	0.00	0.18	0.22	0.27	0.29	0.21	0.26	0.26	0.26	0.29	0.26
1961	0.00	0.13	0.26	0.23	0.27	0.29	0.23	0.26	0.26	0.29	0.26
1962	0.00	0.12	0.28	0.29	0.30	0.32	0.43	0.35	0.35	0.43	0.35
1963	0.02	0.15	0.29	0.32	0.38	0.32	0.37	0.36	0.36	0.38	0.36
1964	0.02	0.12	0.25	0.31	0.45	0.51	0.57	0.51	0.51	0.57	0.51
1965	0.39	0.47	0.59	0.53	0.52	0.75	0.76	0.68	0.68	0.76	0.68
1966	0.03	0.54	0.87	0.54	0.58	0.66	0.65	0.63	0.63	0.87	0.63
1967	0.09	0.06	0.46	0.43	0.64	0.54	0.58	0.59	0.59	0.64	0.59
1968	0.02	0.38	0.36	0.64	0.62	0.47	0.65	0.58	0.58	0.65	0.58
1969	0.00	0.03	0.38	0.41	0.46	0.56	0.40	0.47	0.47	0.56	0.47
1970	0.01	0.21	0.05	0.21	0.30	0.27	0.44	0.34	0.34	0.44	0.34
1971	0.00	0.51	0.52	0.18	0.16	0.83	0.69	0.56	0.56	0.83	0.56
1972	0.02	0.01	0.32	0.37	0.22	0.09	0.71	0.34	0.34	0.71	0.34
1973	0.16	0.41	0.02	0.51	0.44	0.32	0.08	0.28	0.28	0.51	0.28
1974	0.00	0.45	0.23	0.02	0.16	0.03	0.03	0.07	0.07	0.45	0.07
1975	0.03	0.15	0.35	0.19	0.04	0.14	0.07	0.08	0.08	0.35	0.08
1976	0.00	0.09	0.11	0.28	0.16	0.00	0.10	0.09	0.09	0.28	0.09
1977	0.00	0.29	0.05	0.19	0.26	0.43	0.06	0.25	0.25	0.43	0.25
1978	0.00	0.08	0.36	0.10	0.23	0.44	0.29	0.32	0.32	0.44	0.32
1979	0.00	0.01	0.25	0.31	0.24	0.26	0.53	0.34	0.34	0.53	0.34
1980	0.00	0.68	0.10	0.22	0.46	0.46	0.66	0.52	0.52	0.68	0.52
1981	0.00	0.24	0.56	0.36	0.33	0.36	0.51	0.40	0.40	0.56	0.40
1982	0.00	0.24	0.38	0.37	0.29	0.35	0.26	0.30	0.30	0.38	0.30
1983	0.00	0.12	0.26	0.27	0.40	0.33	0.18	0.31	0.31	0.40	0.31
1984	0.00	0.04	0.24	0.40	0.25	0.51	0.54	0.43	0.43	0.54	0.43
1985	0.00	0.20	0.35	0.25	0.49	0.22	0.34	0.35	0.35	0.49	0.35
1986	0.00	0.03	0.38	0.23	0.30	0.34	0.22	0.29	0.29	0.38	0.29
1987	0.00	0.18	0.09	0.39	0.19	0.24	0.29	0.24	0.24	0.39	0.24
1988	0.00	0.03	0.33	0.13	0.42	0.37	0.29	0.36	0.36	0.42	0.36
1989	0.00	0.10	0.08	0.23	0.32	0.38	0.25	0.32	0.32	0.38	0.32
1990	0.02	0.01	0.17	0.26	0.42	0.39	0.30	0.37	0.37	0.42	0.37
1991	0.00	0.22	0.16	0.37	0.22	0.35	0.66	0.41	0.41	0.66	0.41
1992	0.01	0.14	0.29	0.42	0.60	0.47	0.54	0.54	0.54	0.60	0.54
1993	0.00	0.05	0.36	0.41	0.49	0.49	0.29	0.42	0.42	0.49	0.42
1994	0.00	0.05	0.21	0.35	0.30	0.64	0.39	0.45	0.45	0.64	0.45
1995	0.00	0.01	0.07	0.12	0.13	0.09	0.14	0.12	0.12	0.14	0.12
1996	0.00	0.01	0.06	0.14	0.16	0.22	0.09	0.16	0.16	0.22	0.16
1997	0.00	0.02	0.04	0.11	0.12	0.11	0.08	0.11	0.11	0.12	0.11
1998	0.00	0.01	0.07	0.10	0.16	0.18	0.12	0.15	0.15	0.18	0.15

1999	0.00	0.00	0.07	0.11	0.14	0.17	0.17	0.16	0.16	0.17	0.16
2000	0.00	0.01	0.07	0.16	0.16	0.18	0.16	0.17	0.17	0.18	0.17
2001	0.00	0.02	0.08	0.16	0.19	0.27	0.22	0.23	0.23	0.27	0.23
2002	0.00	0.01	0.05	0.15	0.22	0.24	0.26	0.24	0.24	0.26	0.24
2003	0.00	0.00	0.04	0.09	0.19	0.22	0.25	0.22	0.22	0.25	0.22
2004	0.00	0.02	0.04	0.13	0.20	0.32	0.41	0.31	0.31	0.41	0.31
2005	0.00	0.00	0.02	0.14	0.32	0.33	0.35	0.33	0.33	0.35	0.33
2006	0.01	0.00	0.01	0.05	0.22	0.34	0.23	0.26	0.26	0.34	0.26
2007	0.00	0.01	0.05	0.05	0.18	0.19	0.18	0.19	0.19	0.19	0.19
2008	0.00	0.01	0.03	0.08	0.08	0.17	0.14	0.13	0.13	0.17	0.13
2009	0.00	0.02	0.05	0.07	0.11	0.12	0.18	0.14	0.14	0.18	0.14
2010	0.01	0.02	0.08	0.12	0.15	0.24	0.17	0.18	0.18	0.24	0.18

Table B19. Estimates of catchability for indices used in the model. NEFSC_S41 is the NEFSC spring index for years 1973-1981, which was treated as a separate index.

Index	**Estimate**	***CV***
NEFSC_Spring_1	0.32	*0.19*
NEFSC_Spring_2	0.55	*0.13*
NEFSC_Spring_3	0.64	*0.13*
NEFSC_Spring_4	0.58	*0.09*
NEFSC_Spring_5	0.64	*0.11*
NEFSC_Spring_6	0.53	*0.15*
NEFSC_Spring_7	0.56	*0.14*
NEFSC_Spring_8	0.62	*0.16*
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_Fall_1	0.44	*0.13*
NEFSC_Fall_2	0.68	*0.14*
NEFSC_Fall_3	0.58	*0.12*
NEFSC_Fall_4	0.66	*0.09*
NEFSC_Fall_5	0.58	*0.10*
NEFSC_Fall_6	0.57	*0.11*
DFO_Spring_1	0.32	*0.21*
DFO_Spring_2	0.40	*0.18*
DFO_Spring_3	0.66	*0.11*
DFO_Spring_4	0.64	*0.12*
DFO_Spring_5	0.69	*0.13*
DFO_Spring_6	0.53	*0.17*
DFO_Spring_7	0.70	*0.16*
DFO_Spring_8	0.61	*0.15*

Table B20. Input and output for the yield per recruit analysis.

2012 update

Age	Stock wt	Catch wt	SSB wt	Selectivity	M	Maturity
1	0.20	0.30	0.20	0.02	0.20	0.06
2	0.42	0.64	0.42	0.06	0.20	0.47
3	0.77	0.99	0.77	0.22	0.20	0.92
4	1.08	1.18	1.08	0.38	0.20	0.99
5	1.32	1.42	1.32	0.71	0.20	1.00
6	1.54	1.61	1.54	1.00	0.20	1.00
7	1.70	1.73	1.70	1.00	0.20	1.00
8	1.86	1.91	1.86	1.00	0.20	1.00
9+	2.17	2.17	2.17	1.00	0.20	1.00

	F	YPR	SSB/R
F40%	0.39	0.49	2.21

GARM-III

Age	Stock wt	Catch wt	SSB wt	Selectivity	M	Maturity
1	0.11	0.20	0.11	0.01	0.20	0.06
2	0.36	0.59	0.36	0.03	0.20	0.47
3	0.80	1.09	0.80	0.15	0.20	0.92
4	1.25	1.38	1.25	0.40	0.20	0.99
5	1.56	1.66	1.56	1.00	0.20	1.00
6	1.82	1.89	1.82	1.00	0.20	1.00
7	2.05	2.09	2.05	1.00	0.20	1.00
8	2.34	2.35	2.34	1.00	0.20	1.00
9+	2.64	2.64	2.64	1.00	0.20	1.00

	F	YPR	SSB/R
F40%	0.35	0.57	2.60

Table B21. Updated reference point estimates compared to GARM-III estimates for Georges Bank haddock. SSBmsy and MSY are in thousands of metric tons; recruitment is in millions of age-1 fish.

	2012 update		
	Median	**5th**	**95th**
SSBmsy	124.9	71.8	187.8
MSY	28	16.3	41.9
Recruitment	54.2	4	130

	GARM-III		
	Median	**5th**	**95th**
SSBmsy	158,873	96,350	229,744
MSY	32,746	19,538	48,865
Recruitment	59	4	130

Table B22. Short term projections at F_{MSY} for Georges Bank haddock. Catch in 2011 was assumed to be the same as catch in 2010.

No down weighting applied to age-1 recruits in 2011

	Catch (000 mt)				**SSB (mt)**		
Year	**5%**	**Median**	**95%**	**Year**	**5%**	**Median**	**95%**
2011	25.9	25.9	25.9	2011	188.3	313.4	665.8
2012	29.9	45.6	68.2	2012	203.8	400.7	1014.7
2013	31.2	58.9	146.3	2013	206.8	492.3	1371.3
2014	31.0	72.4	200.1	2014	209.2	510.8	1427.4
2015	37.1	98.3	285.0	2015	202.3	466.4	1254.7

Age-1 recruits decreased by 50% in 2011

	Catch (000 mt)				**SSB (mt)**		
Year	**5%**	**Median**	**95%**	**Year**	**5%**	**Median**	**95%**
2011	25.9	25.9	25.9	2011	104.7	147.5	201.6
2012	27.6	40.7	59.4	2012	108.8	172.6	309.0
2013	24.7	40.9	84.2	2013	116.2	238.3	619.9
2014	23.0	44.2	108.7	2014	116.6	256.7	675.4
2015	25.5	56.6	150.2	2015	114.5	240.2	589.2

Table B23. Influence of 2010 year class on short term projections for Georges Bank haddock.

No down weighting of age-1 fish in 2011

Proportion of CAA

Year	1	2	3	4	5	6	7	8	9
2011	0.17	0.00	0.01	0.02	0.02	0.09	0.01	0.65	0.02
2012	0.01	0.45	0.01	0.01	0.03	0.02	0.05	0.01	0.41
2013	0.01	0.02	0.78	0.01	0.01	0.01	0.01	0.02	0.14
2014	0.01	0.02	0.05	0.83	0.01	0.01	0.01	0.00	0.07
2015	0.00	0.01	0.04	0.05	0.85	0.01	0.00	0.00	0.04

Proportion of CAA in biomass

Year	1	2	3	4	5	6	7	8	9
2011	0.03	0.00	0.01	0.02	0.02	0.09	0.02	0.79	0.02
2012	0.00	0.21	0.01	0.01	0.03	0.02	0.06	0.01	0.65
2013	0.00	0.01	0.66	0.01	0.01	0.02	0.01	0.03	0.26
2014	0.00	0.01	0.04	0.79	0.01	0.01	0.01	0.00	0.13
2015	0.00	0.01	0.03	0.04	0.86	0.01	0.00	0.00	0.05

Age-1 recruits decreased by 50% in 2011

Proportion of CAA

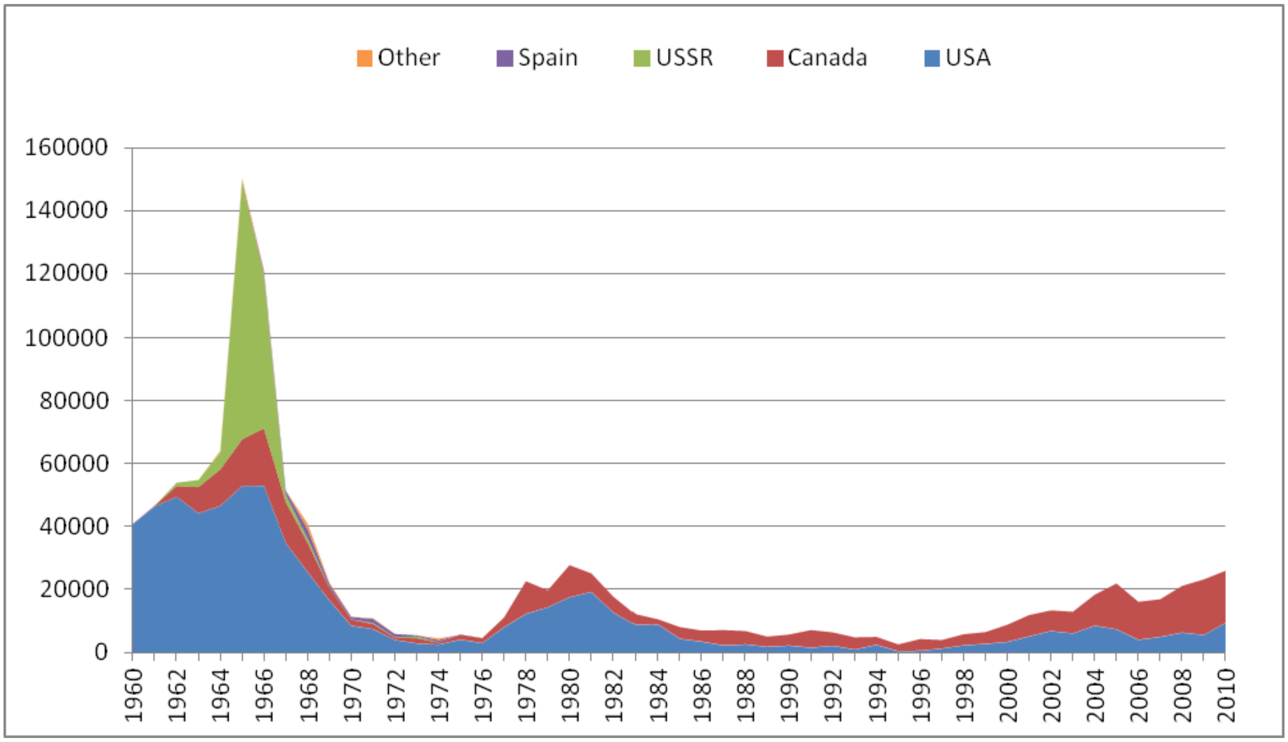
Year	1	2	3	4	5	6	7	8	9
2011	0.09	0.00	0.01	0.02	0.02	0.10	0.02	0.71	0.02
2012	0.02	0.29	0.02	0.01	0.03	0.02	0.06	0.01	0.53
2013	0.01	0.03	0.64	0.02	0.01	0.02	0.01	0.03	0.23
2014	0.01	0.03	0.08	0.72	0.02	0.01	0.01	0.00	0.13
2015	0.01	0.02	0.07	0.08	0.74	0.01	0.00	0.00	0.06

Proportion of CAA in biomass

Year	1	2	3	4	5	6	7	8	9
2011	0.02	0.00	0.01	0.02	0.02	0.10	0.02	0.80	0.02
2012	0.00	0.12	0.01	0.01	0.03	0.02	0.07	0.01	0.72
2013	0.00	0.02	0.49	0.01	0.01	0.03	0.01	0.04	0.38
2014	0.00	0.01	0.06	0.66	0.02	0.01	0.01	0.01	0.21
2015	0.00	0.01	0.05	0.07	0.75	0.01	0.00	0.01	0.09

Figure B1. Catch of Georges Bank haddock by country; (a) in mt; (b) as a proportion.

(a)



(b)

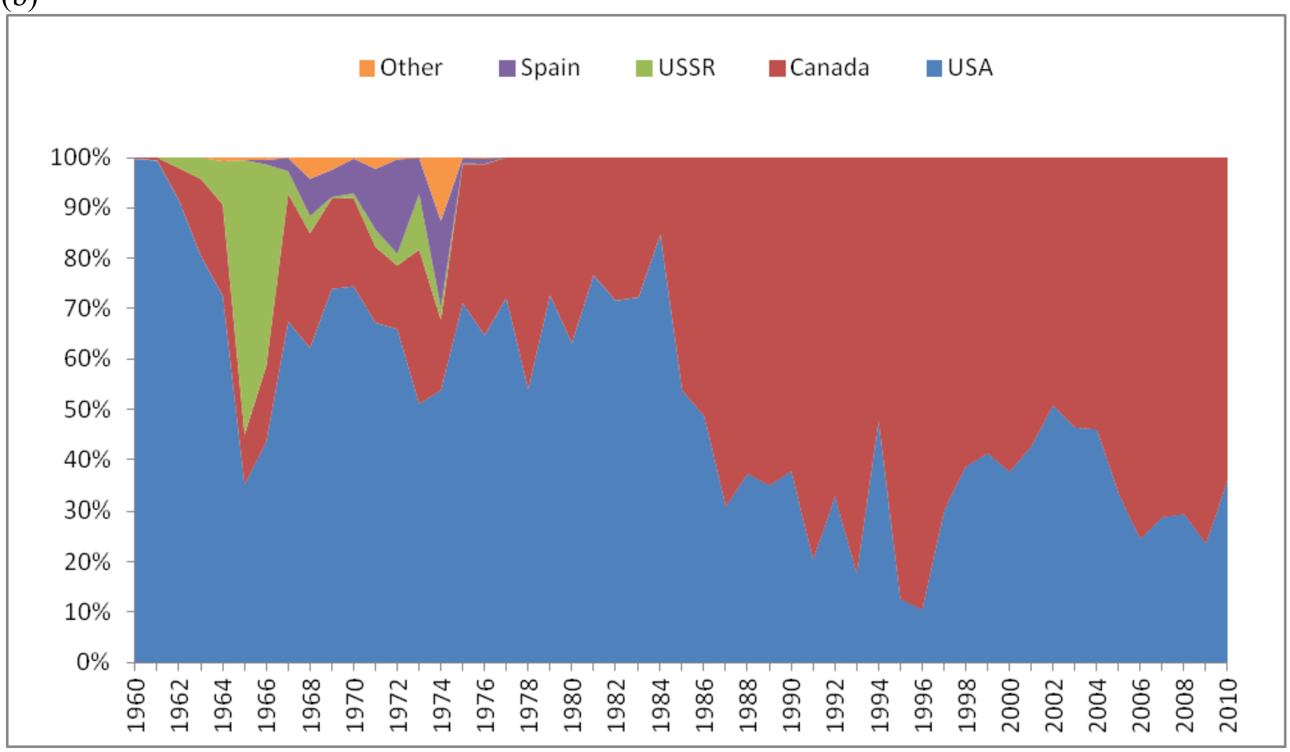


Figure B2a. Bubble plots of **landings** at age for Georges Bank haddock, plotted as proportion within year.

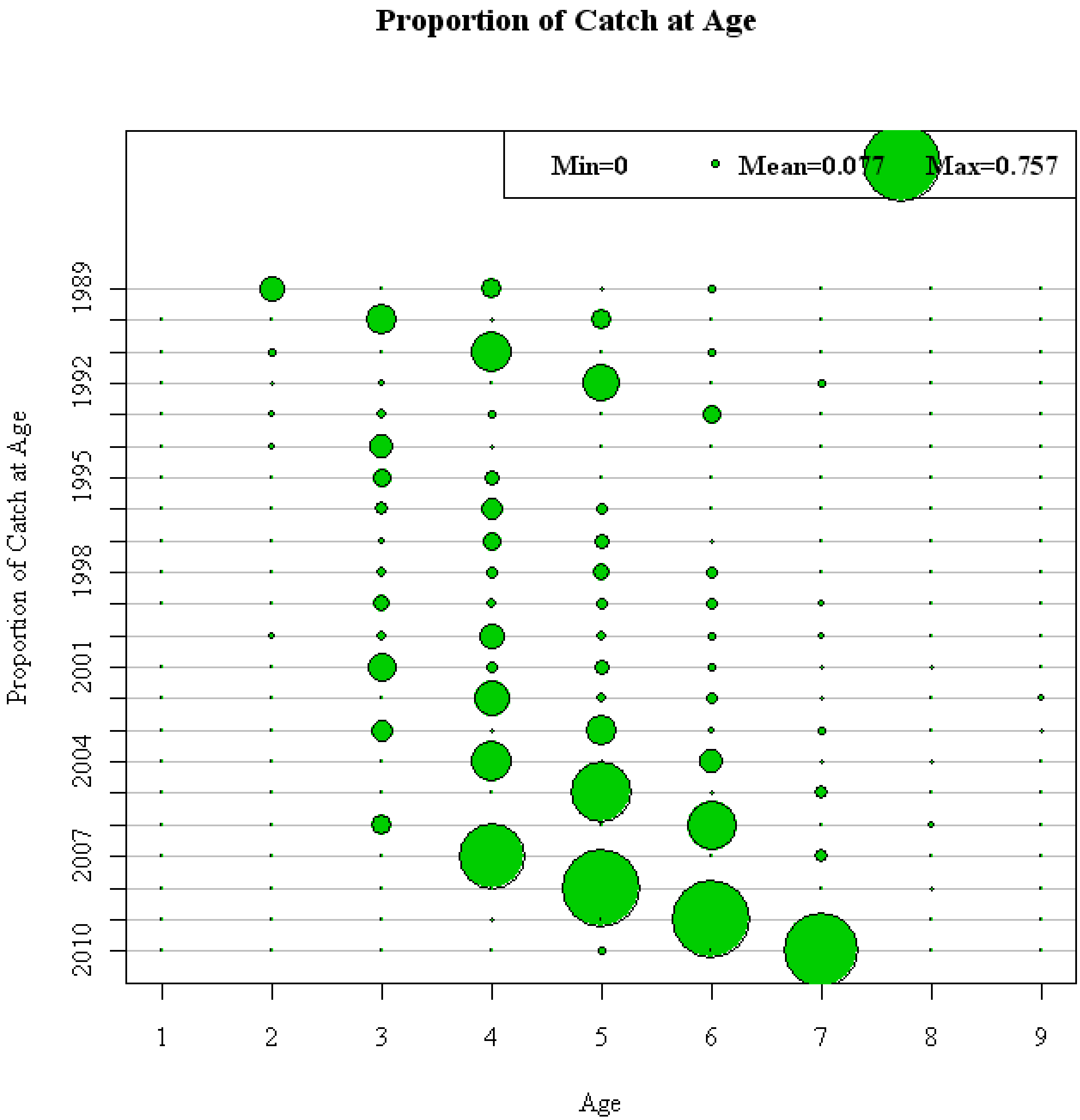


Figure B2b. Bubble plots of **discards** at age for Georges Bank haddock, plotted as proportion within year.

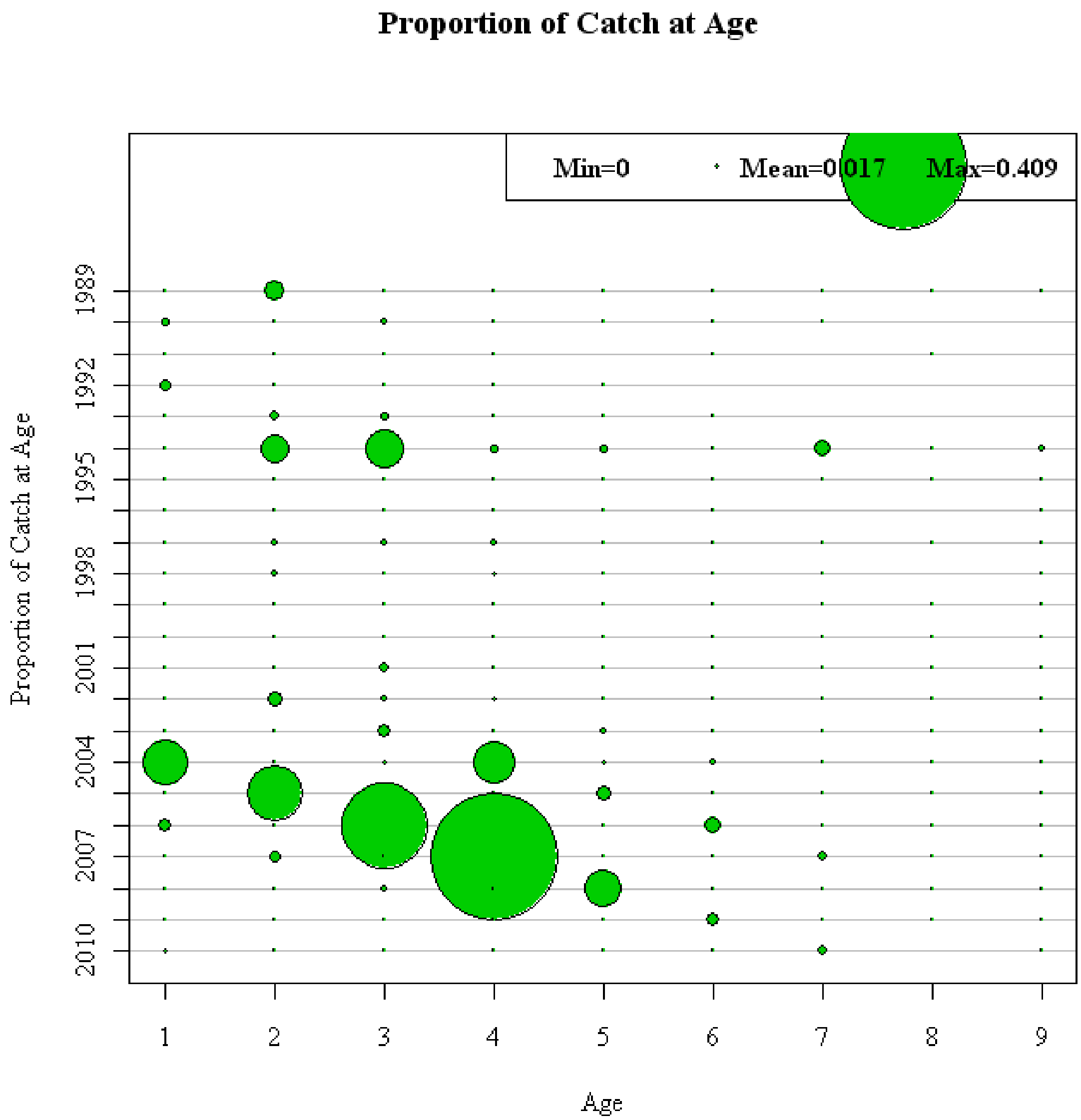


Figure B2c. Bubble plots of **catch** at age for Georges Bank haddock, plotted as proportion within year.

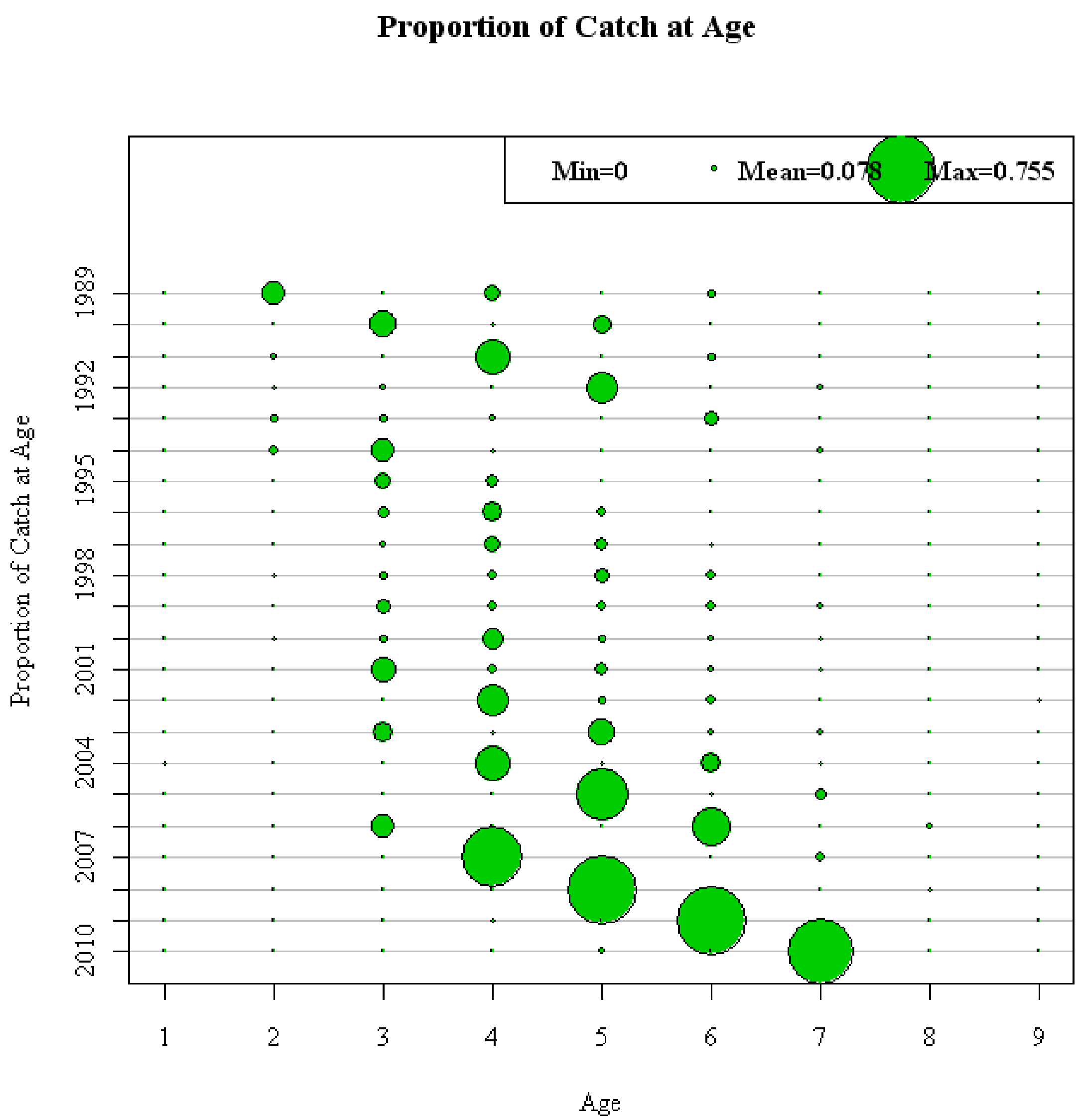


Figure B3a. Normalized weight at age trends for catch for Georges Bank haddock.

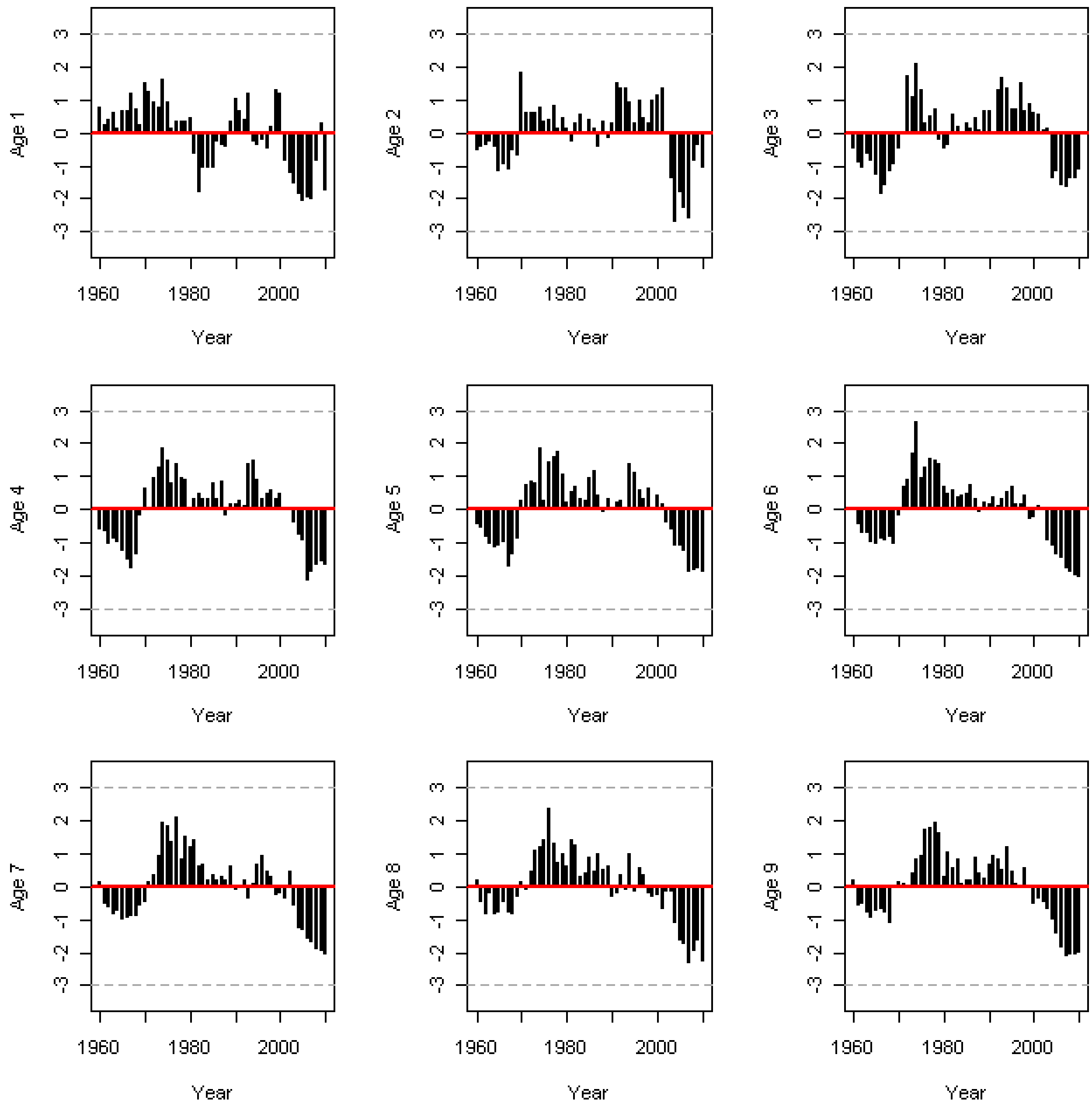


Figure B3b. Normalized weight at age trends for SSB for Georges Bank haddock.

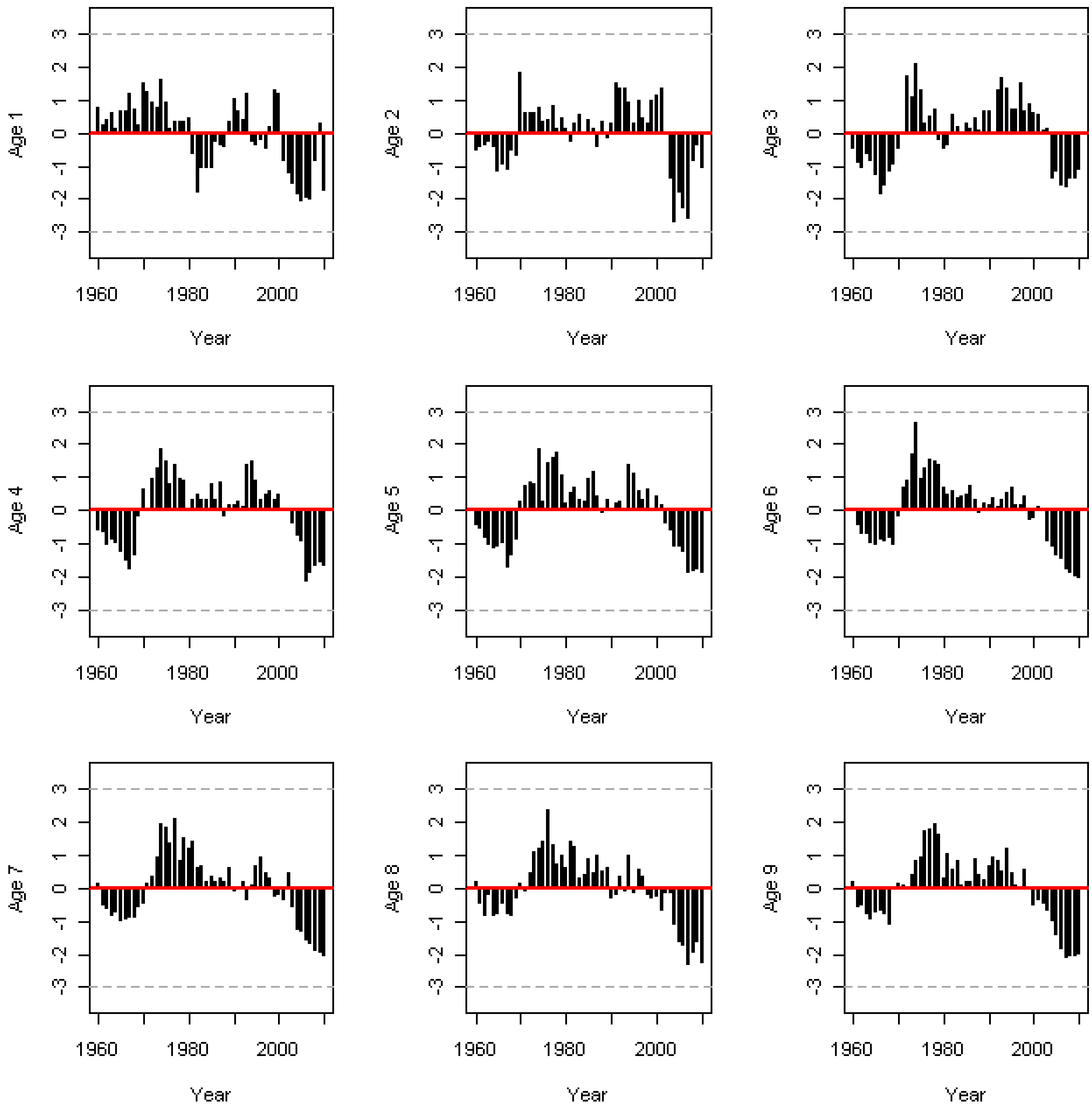


Figure B4a. NEFSC Spring and Fall mean number per tow.

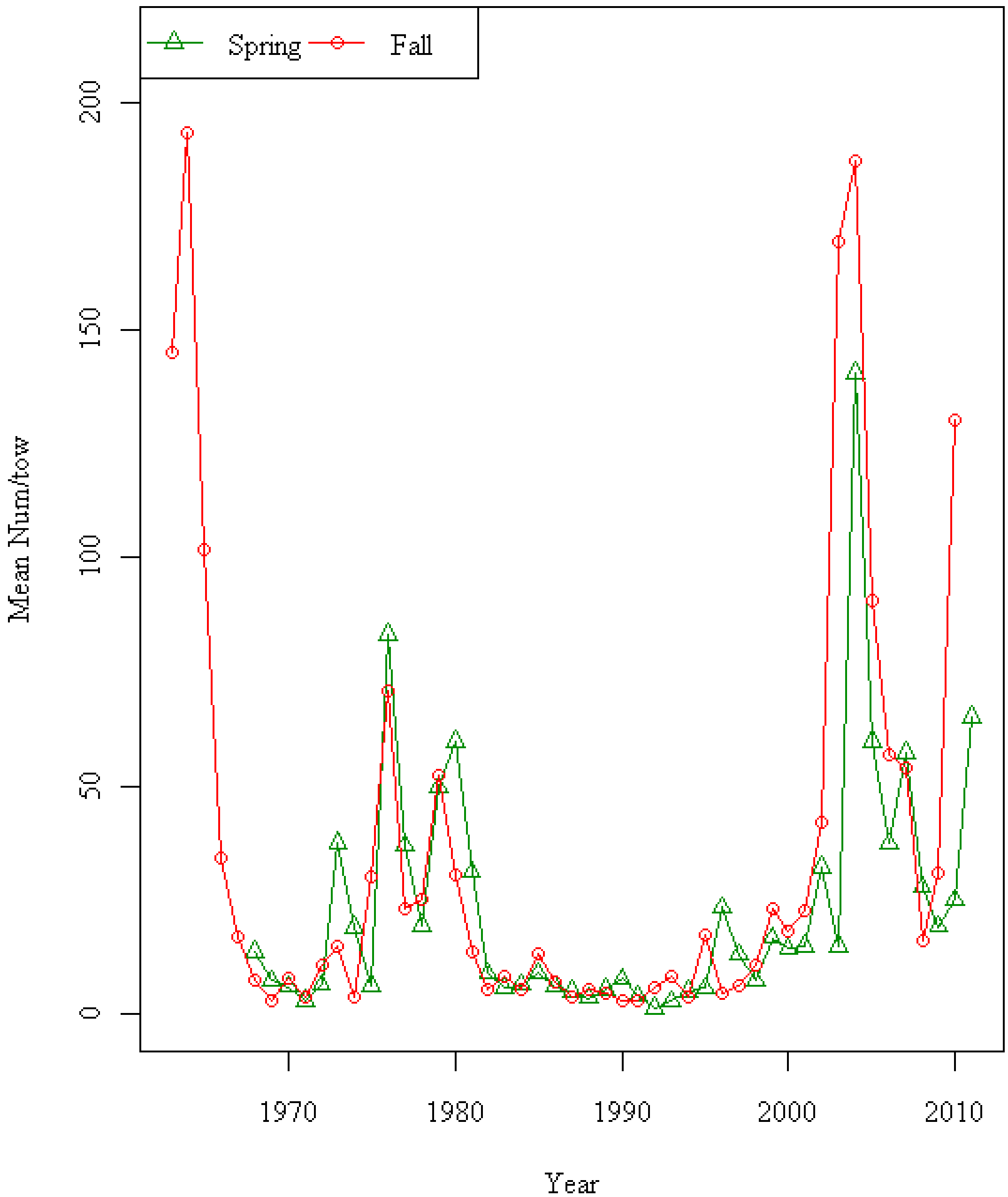


Figure B4b. NEFSC Spring and Fall mean kg per tow.

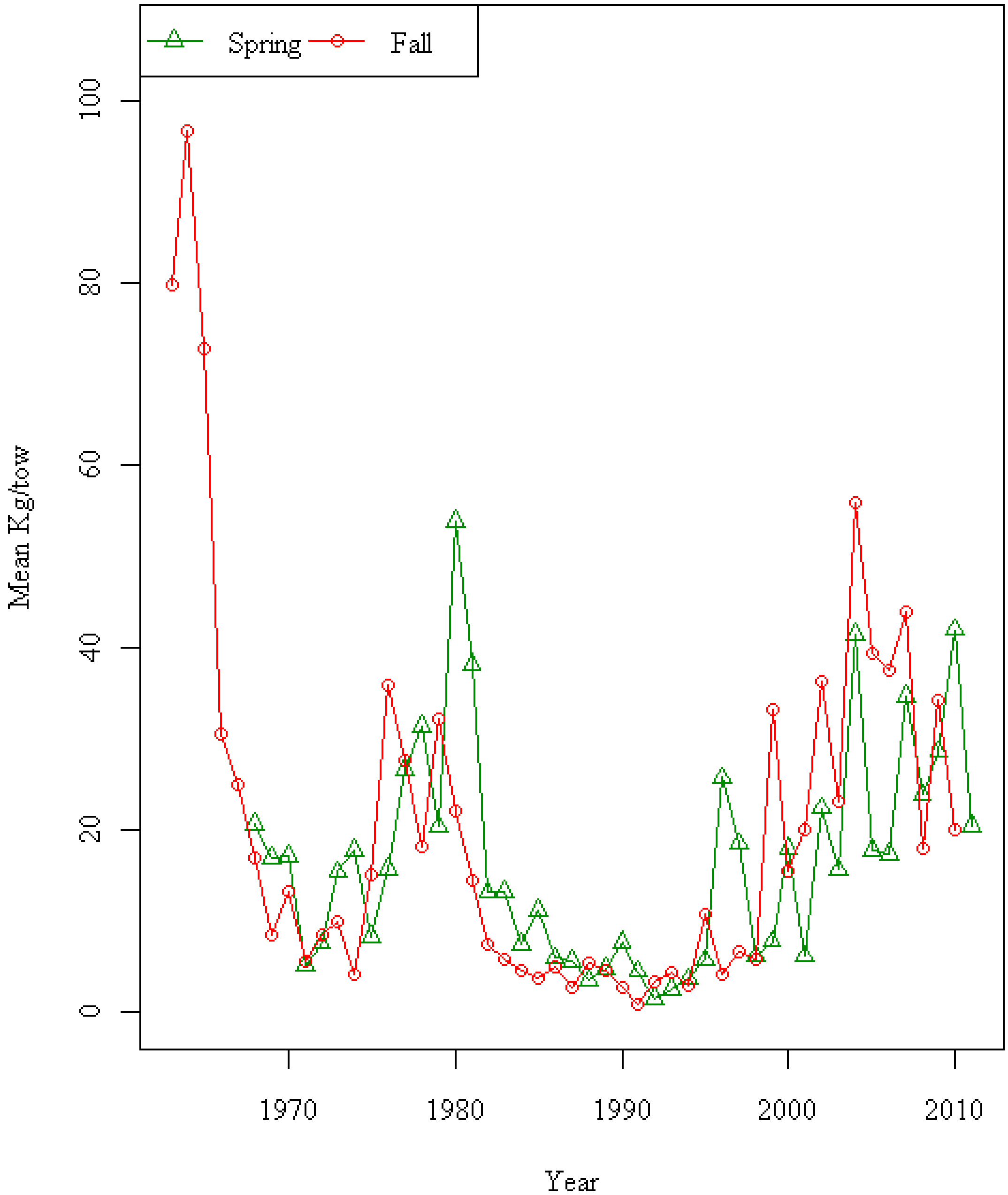


Figure B5a. Bubble plots of abundance at age in the NEFSC spring survey, plotted as proportion in each year. The orange bubbles are the years when the Yankee 41 was used and were treated as a separate series in the VPA

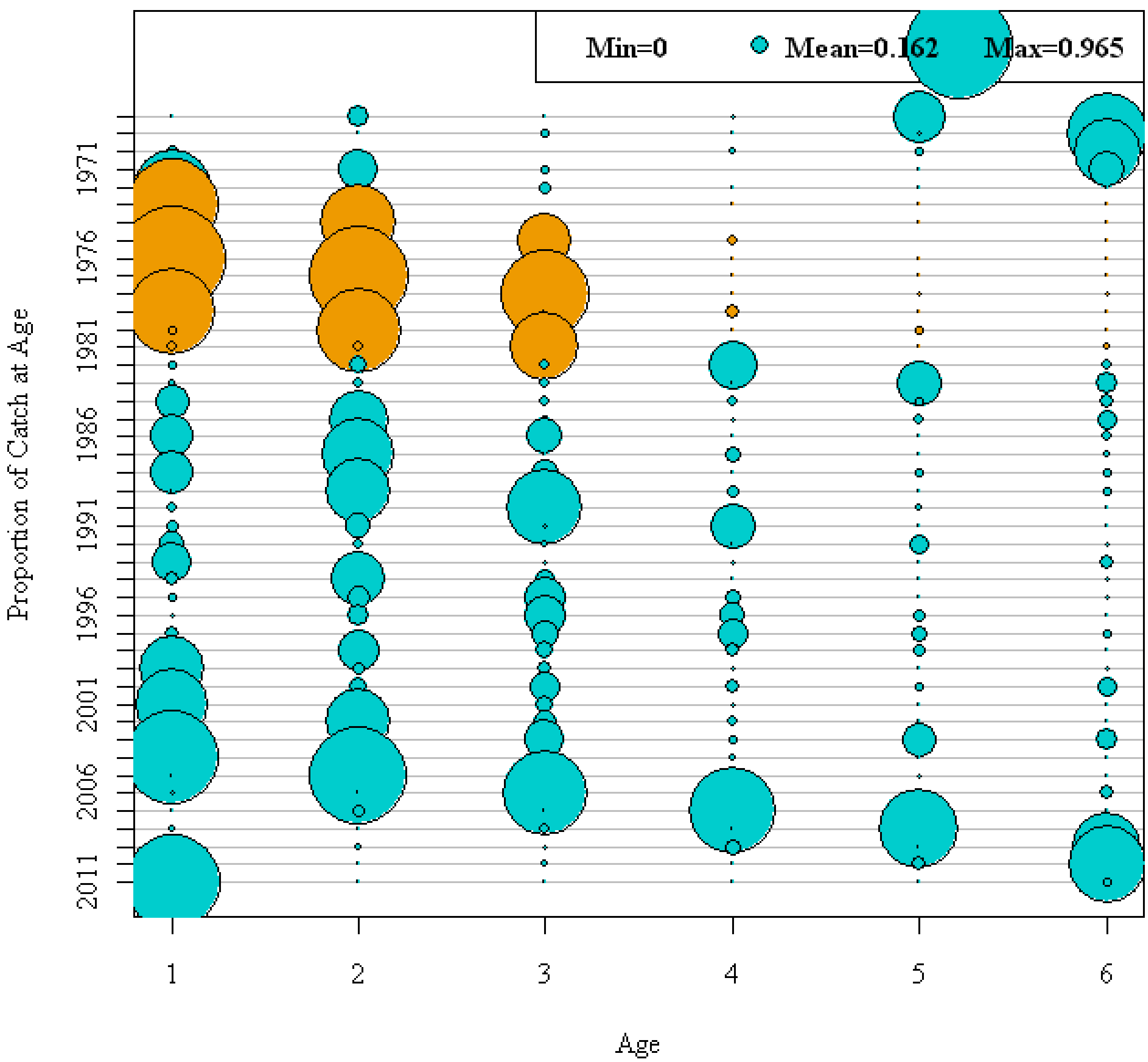


Figure B5b. Bubble plots of abundance at age in the NEFSC fall survey, plotted as proportion in each year.

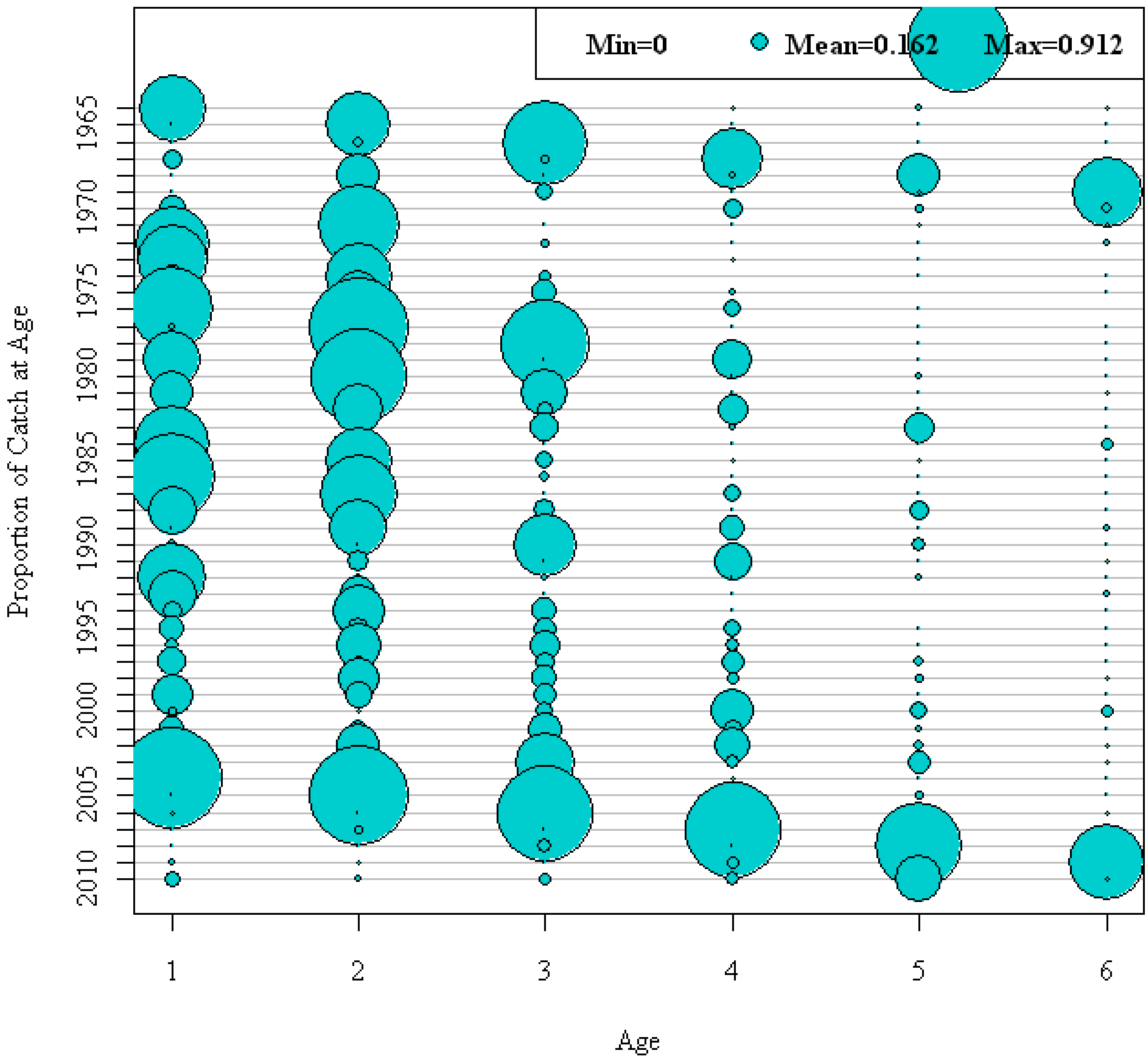


Figure B5c. Bubble plots of abundance at age in the DFO spring survey, plotted as proportion in each year.

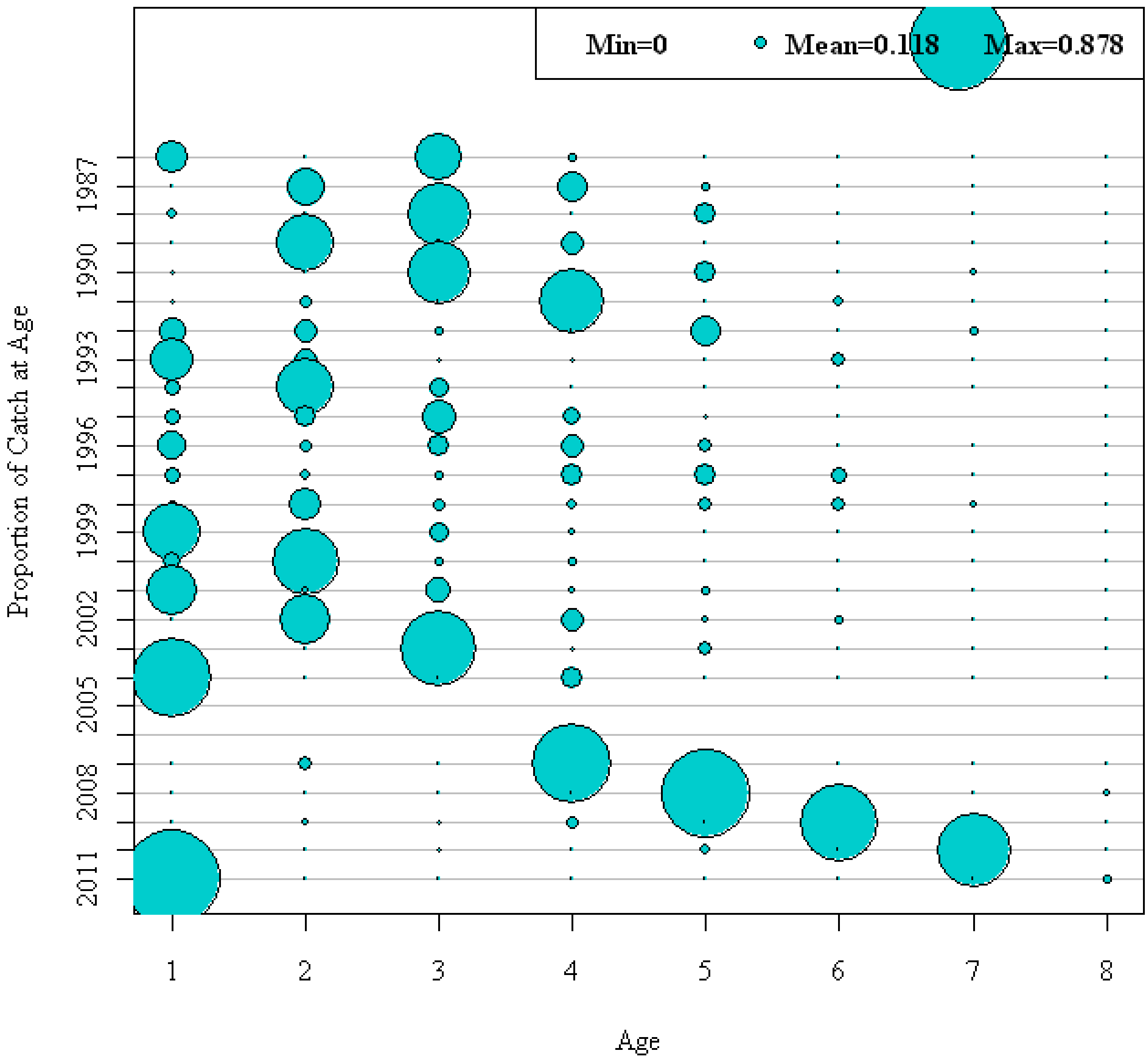


Figure B6. Maturity at age in Georges Bank haddock.

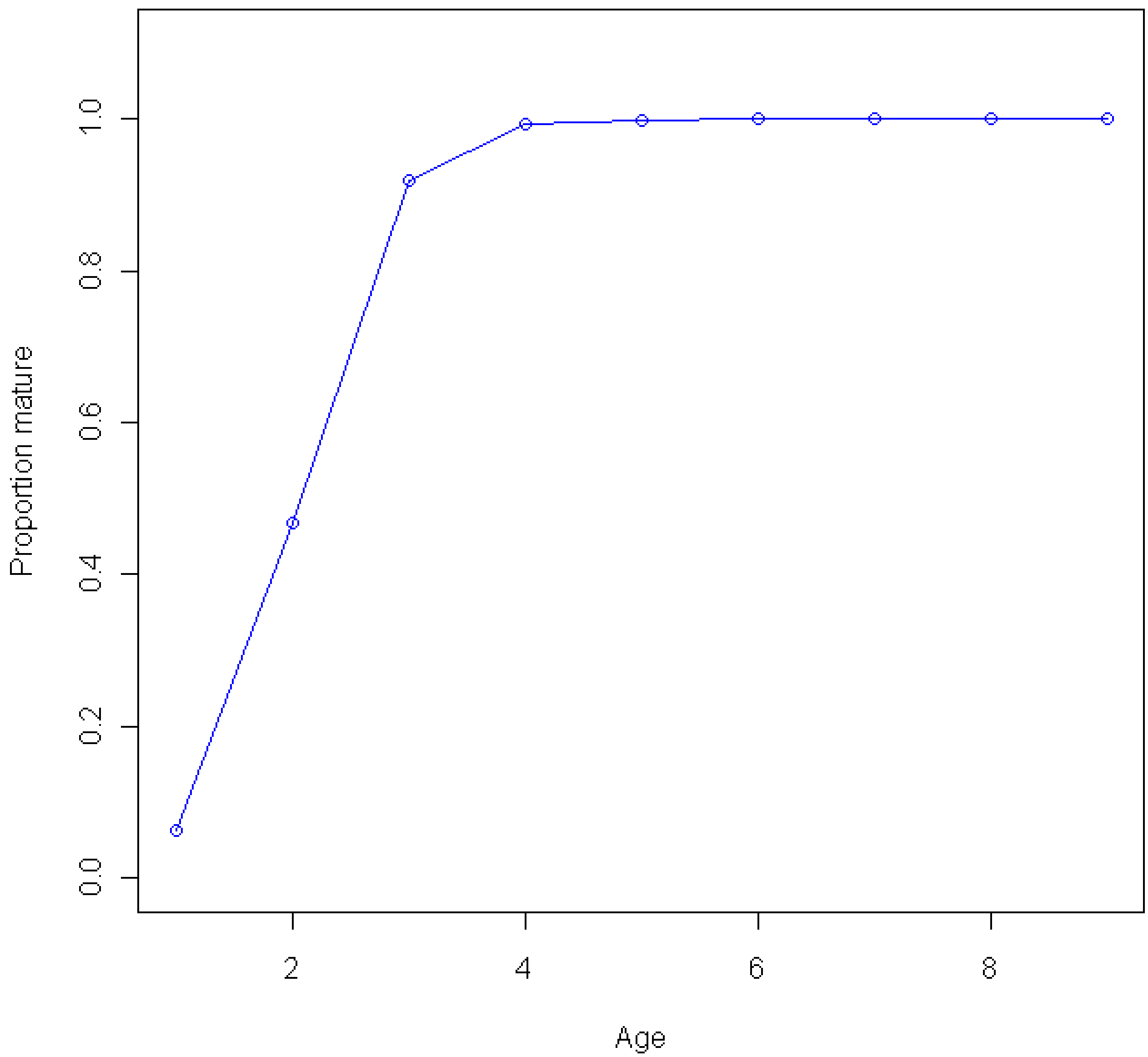


Figure B7. Spawning stock biomass (SSB) for Georges Bank haddock.

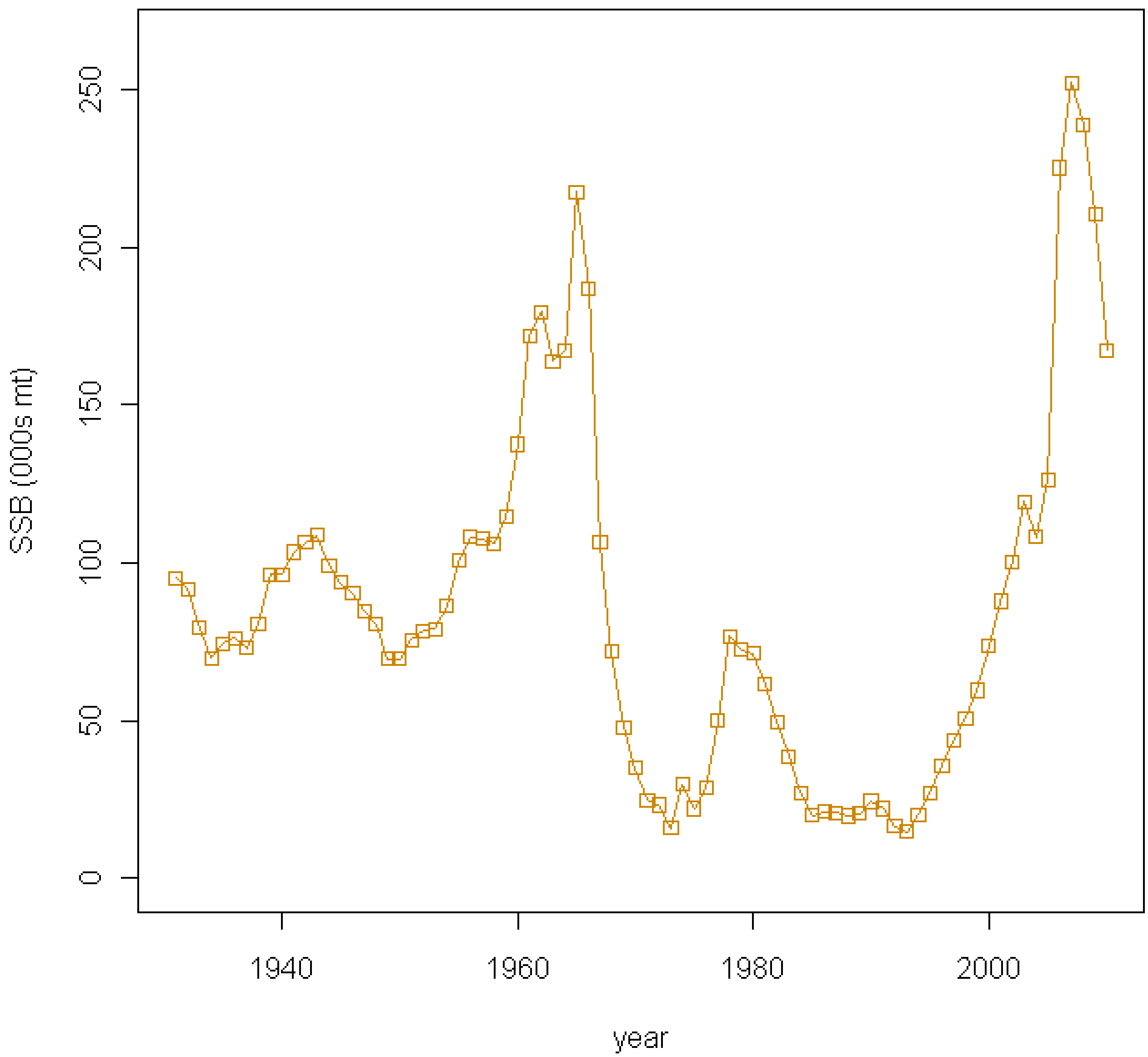


Figure B8. Recruitment of age-1 fish for Georges Bank haddock.

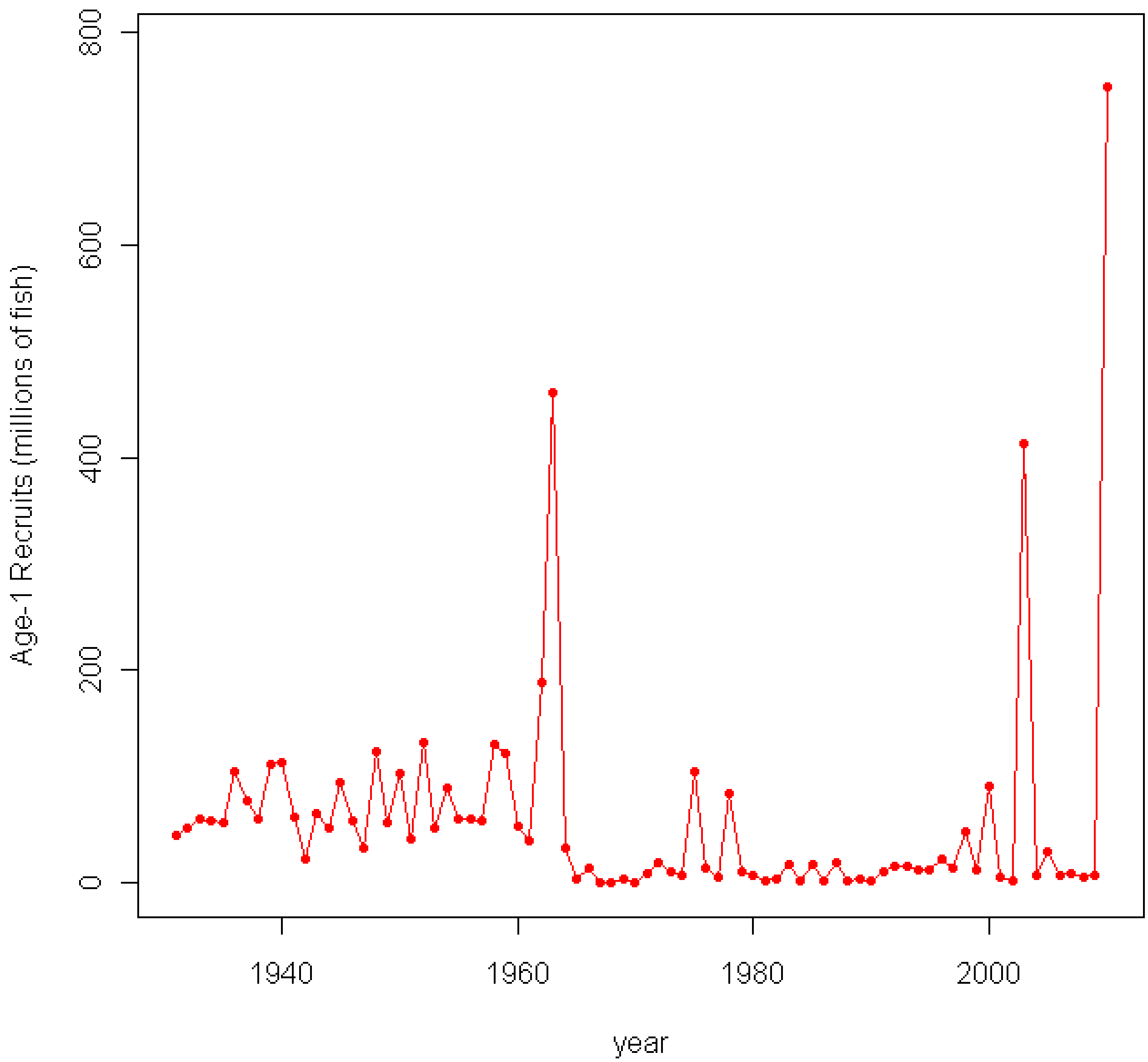


Figure B9. Fishing mortality for Georges Bank haddock, expressed as the F on fully selected fish ("F Full") and the average F on ages 5-7 ("F5-7").

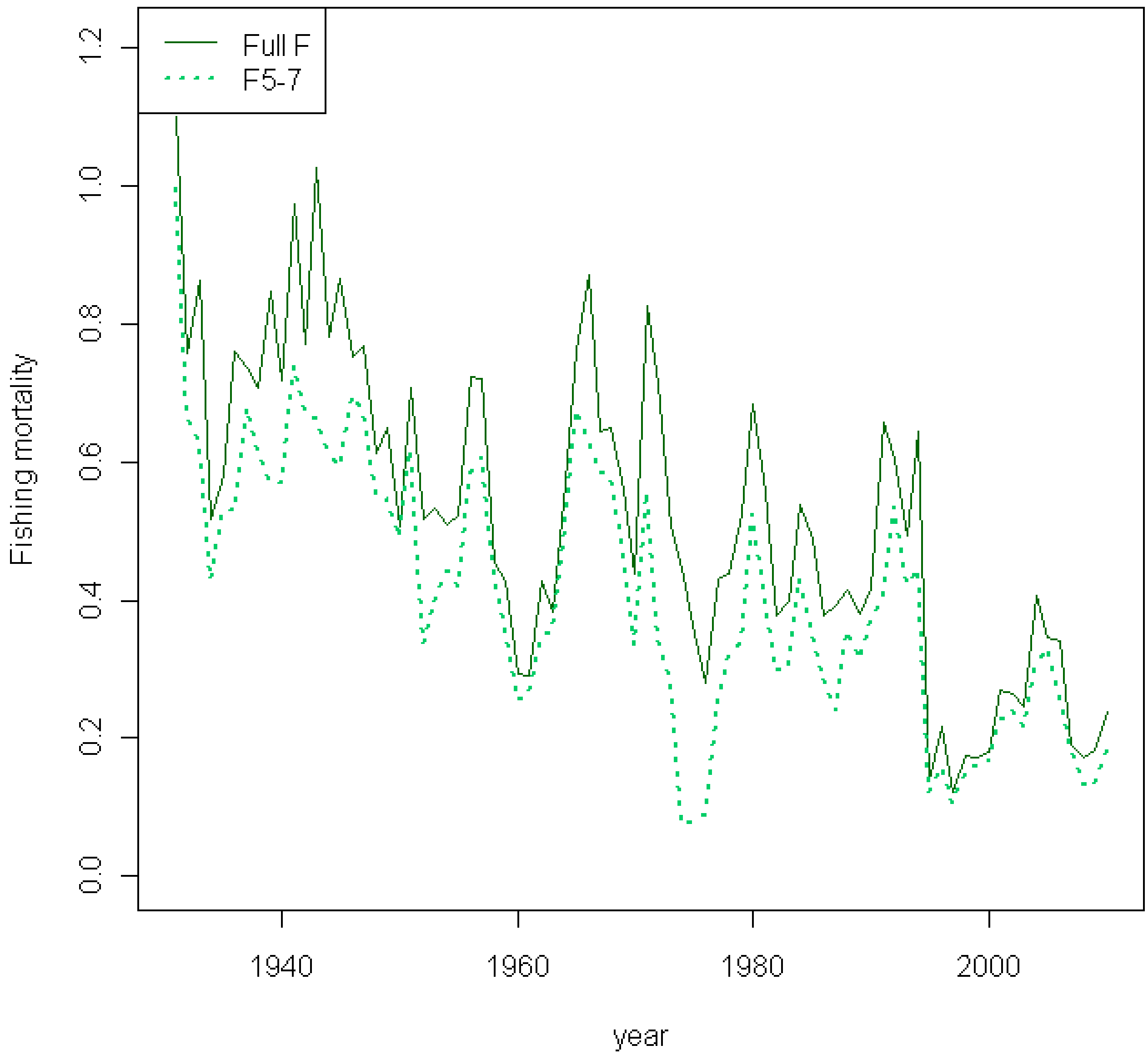


Figure B10. Estimated catchabilities for each index in the Georges Bank haddock assessment. See Table B19 for name of each index.

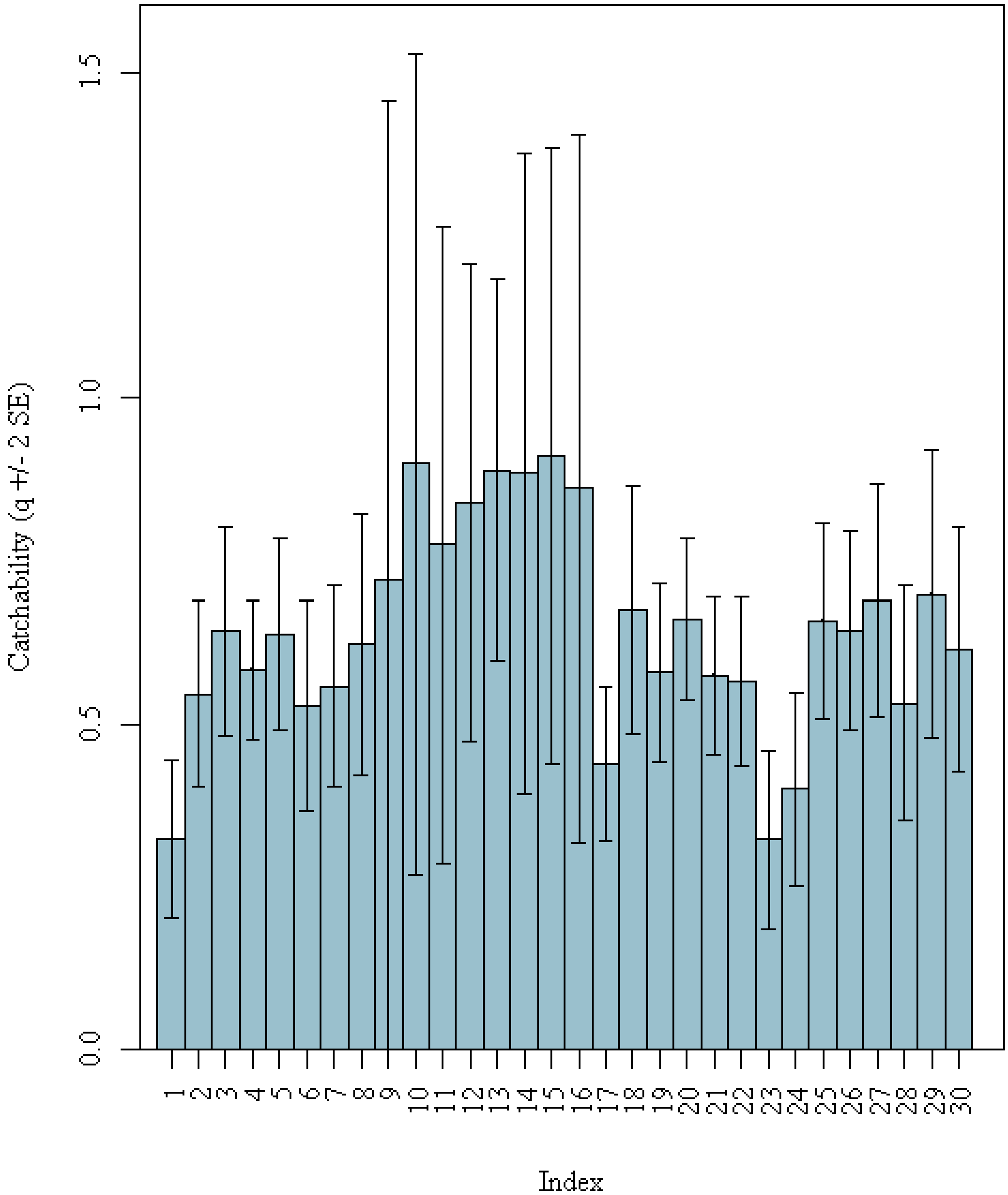


Figure B11. Standardized residuals for the indices in the Georges Bank haddock assessment.

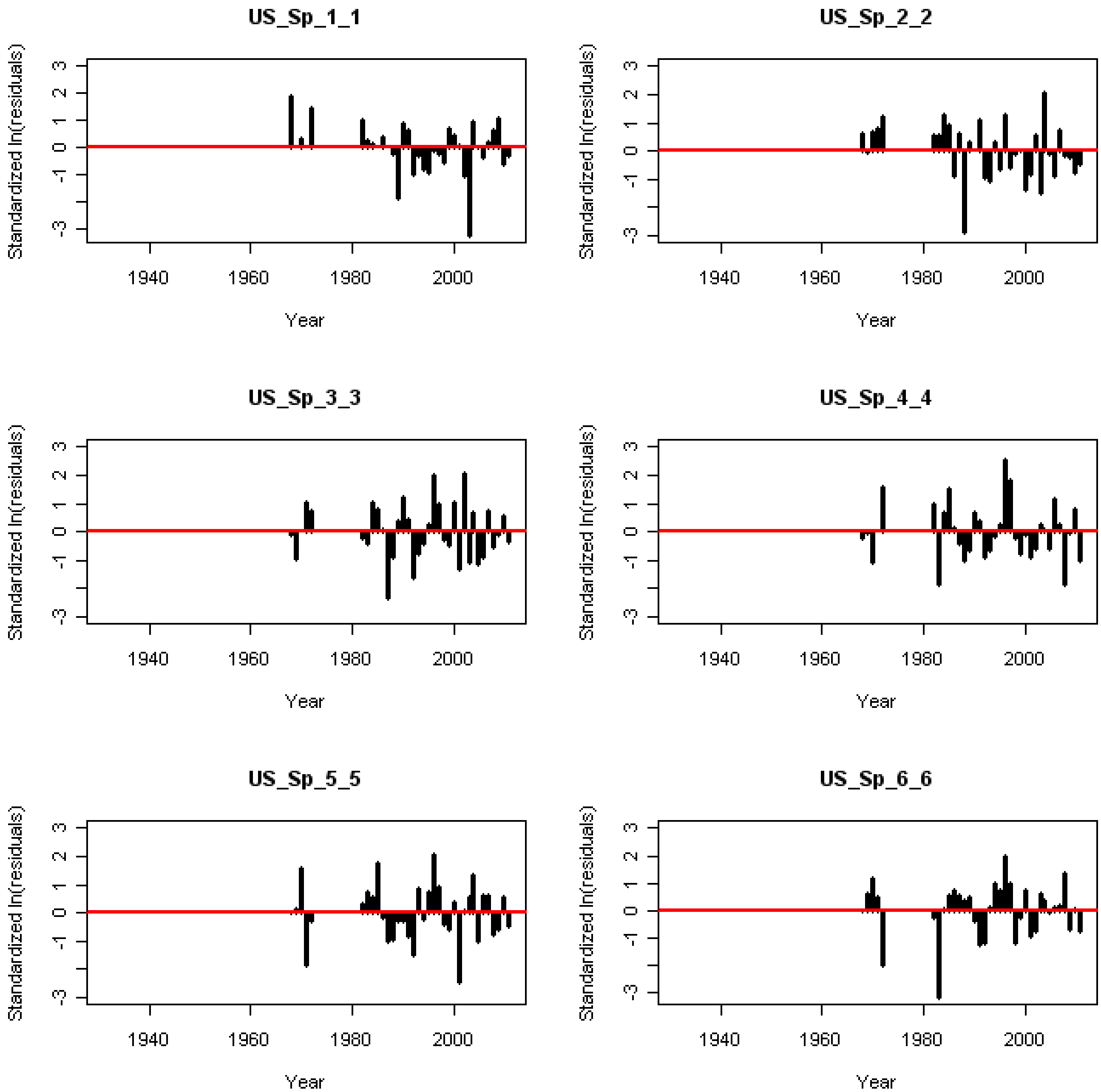


Fig. B11 (cont)

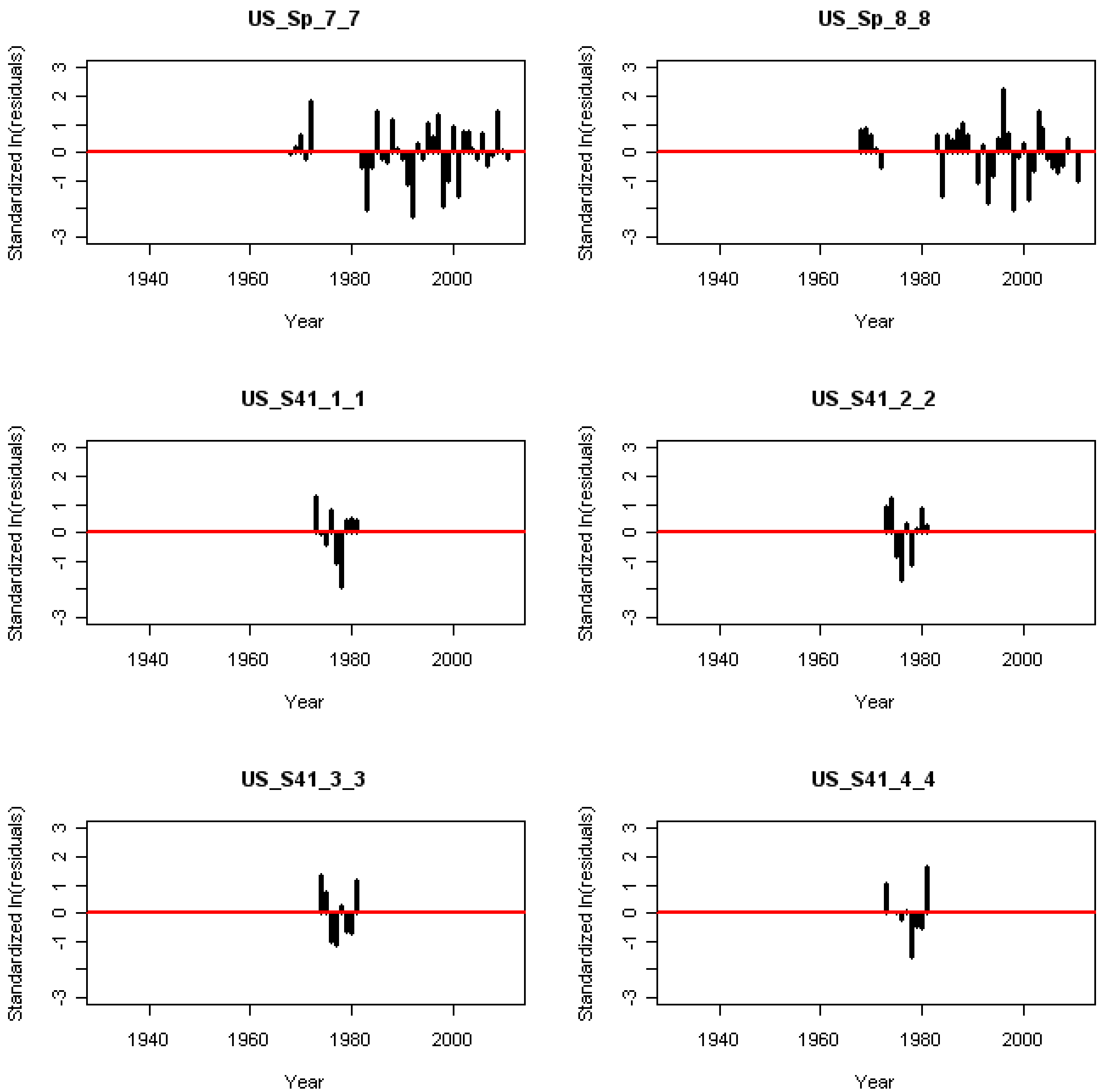
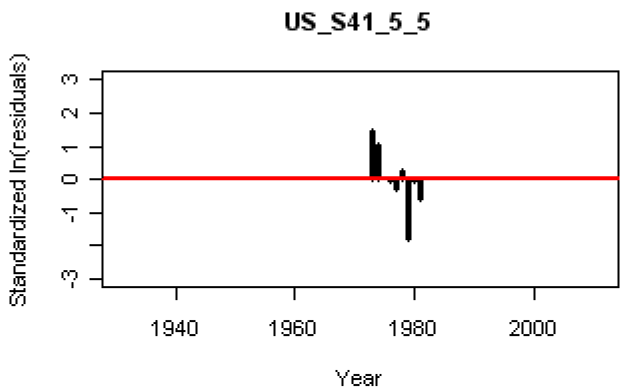
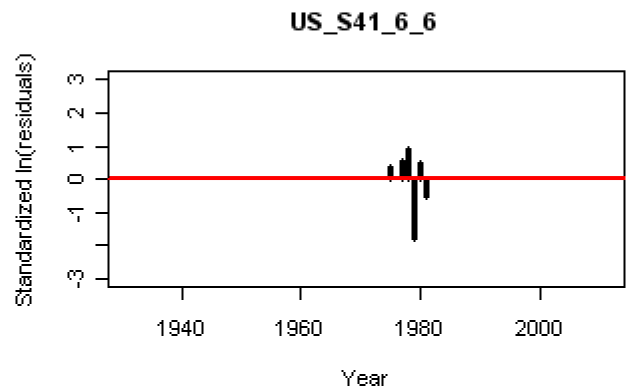

US_Sp_7_7
US_Sp_8_8
US_S41_1_1
US_S41_2_2
US_S41_3_3
US_S41_4_4
Standardized ln(residuals)
Year
1940
1960
1980
2000
3
2
1
0
-1
-3

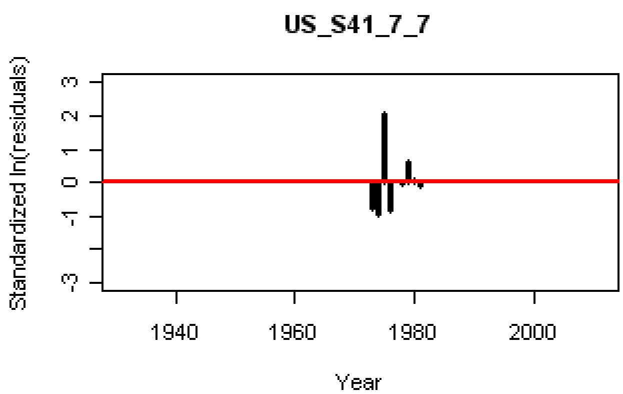
Fig. B11 (cont.)



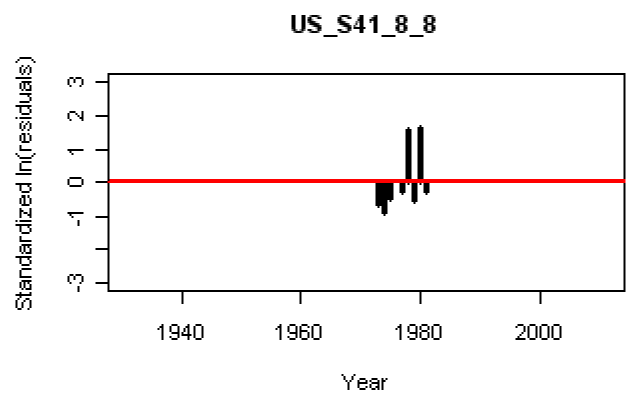
US_S41_5_5
Standardized ln(residuals)
3
2
1
0
-1
-3
1940
1960
1980
2000
Year



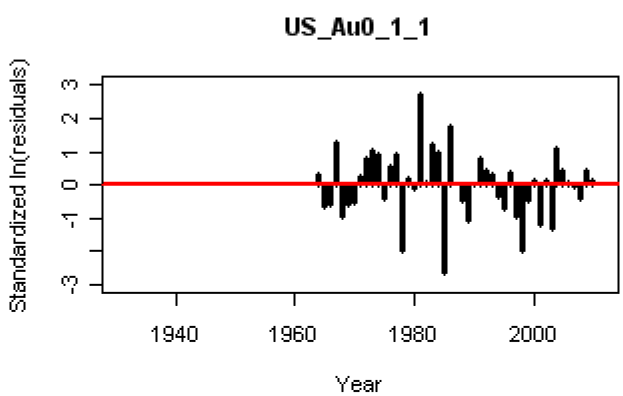
US_S41_6_6
Standardized ln(residuals)
3
2
1
0
-1
-3
1940
1960
1980
2000
Year



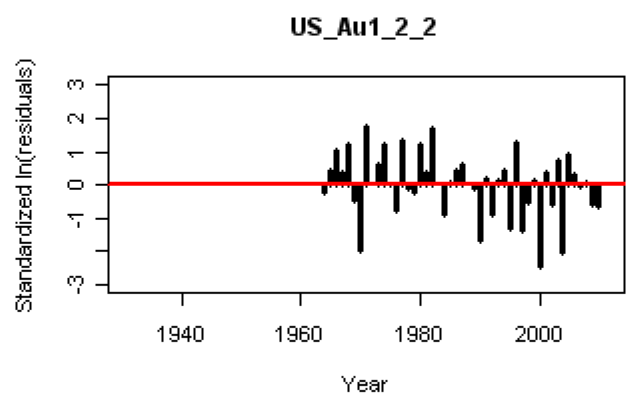
US_S41_7_7
Standardized ln(residuals)
3
2
1
0
-1
-3
1940
1960
1980
2000
Year



US_S41_8_8
Standardized ln(residuals)
3
2
1
0
-1
-3
1940
1960
1980
2000
Year



US_Au0_1_1
Standardized ln(residuals)
3
2
1
0
-1
-3
1940
1960
1980
2000
Year



US_Au1_2_2
Standardized ln(residuals)
3
2
1
0
-1
-3
1940
1960
1980
2000
Year

Fig. B11 (cont.)

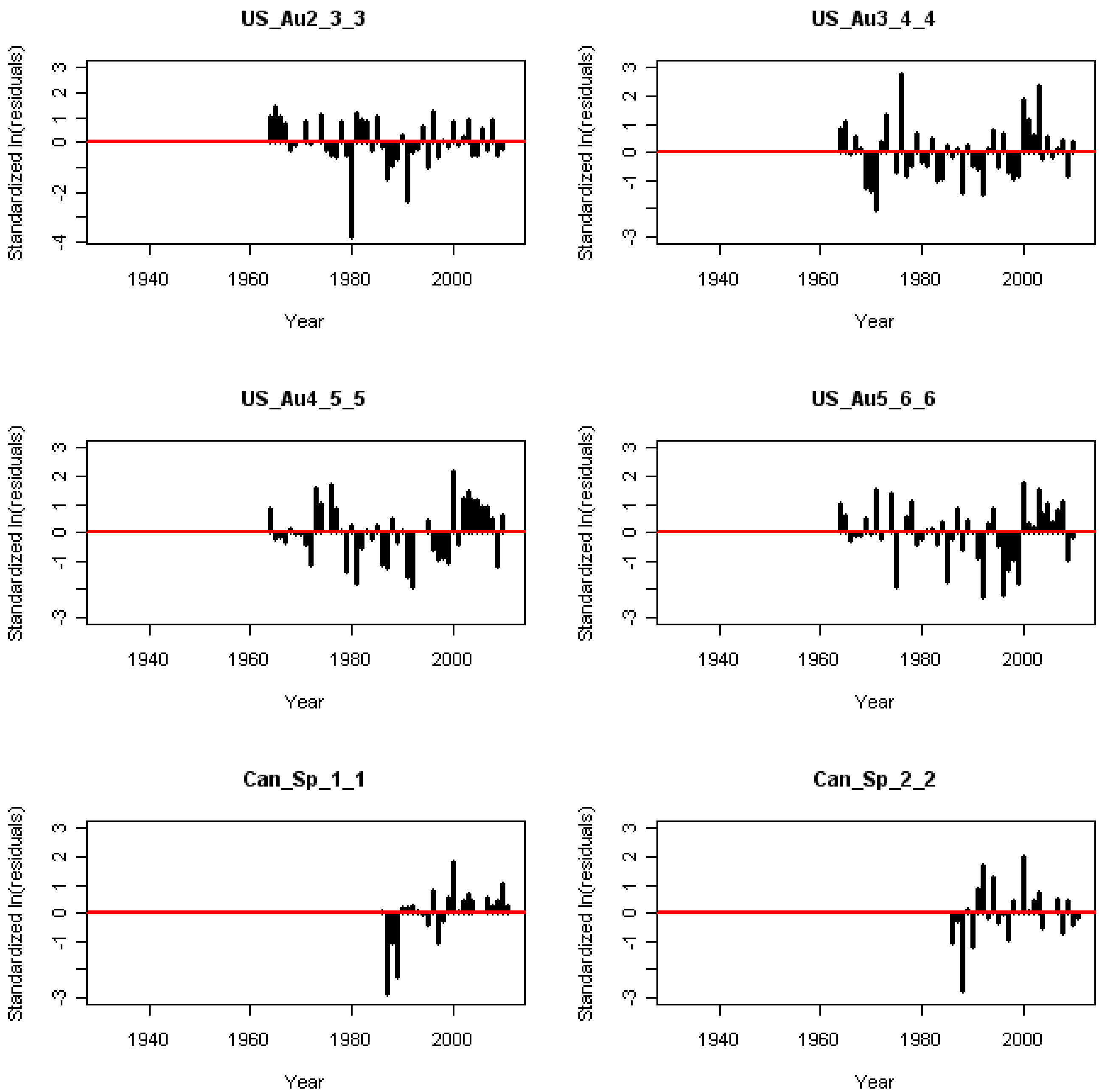
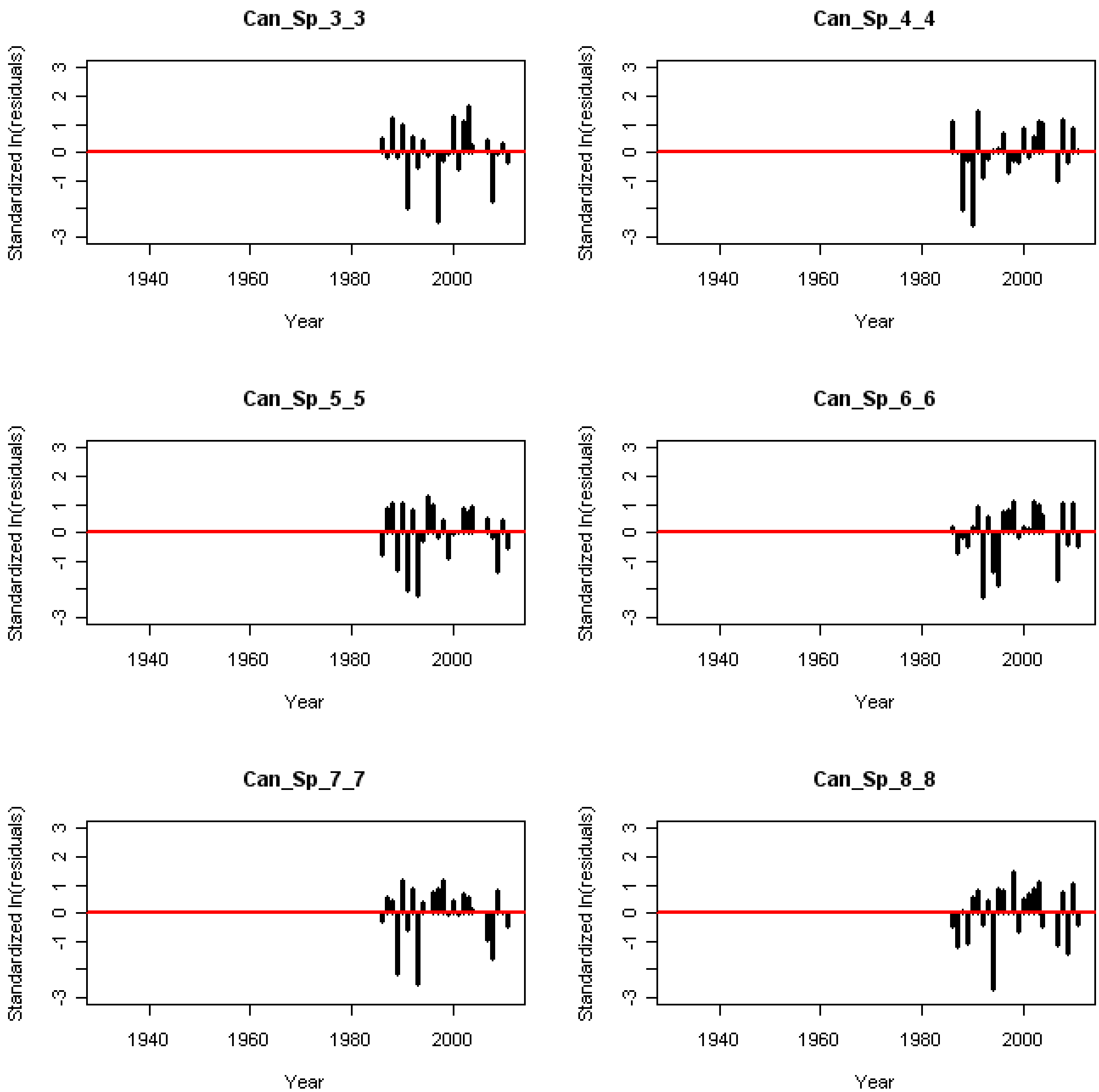

US_Au2_3_3
US_Au3_4_4
US_Au4_5_5
US_Au5_6_6
Can_Sp_1_1
Can_Sp_2_2
Standardized ln(residuals)
Year
1940
1960
1980
2000

Fig. B11 (cont.)



Can_Sp_3_3
Can_Sp_4_4
Can_Sp_5_5
Can_Sp_6_6
Can_Sp_7_7
Can_Sp_8_8
Standardized ln(residuals)
Year
1940
1960
1980
2000

Figure B12a. Mohn's rho for spawning stock biomass (expressed on relative scale).

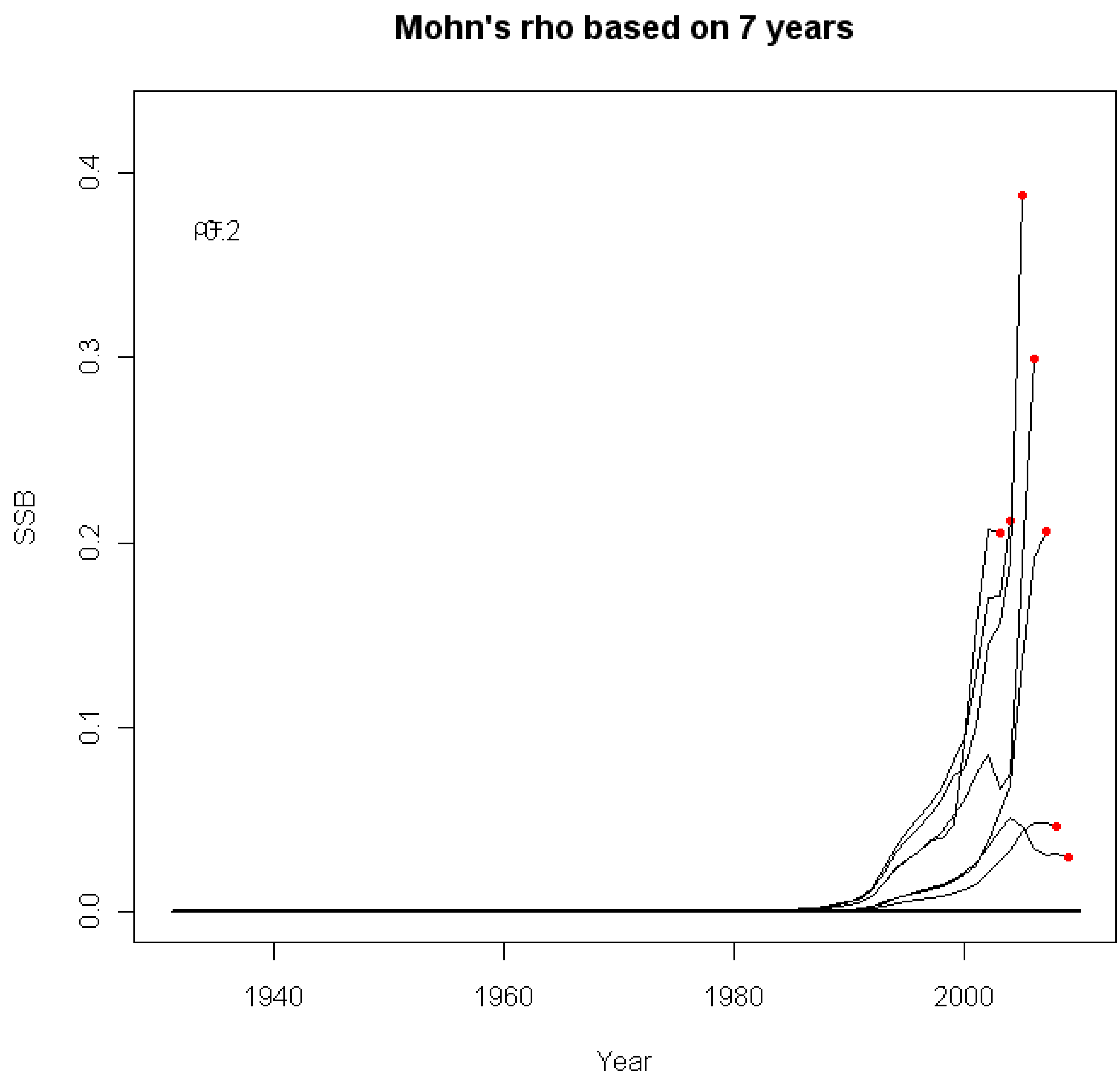


Figure B12b. Mohn’s rho for F (expressed on relative scale).

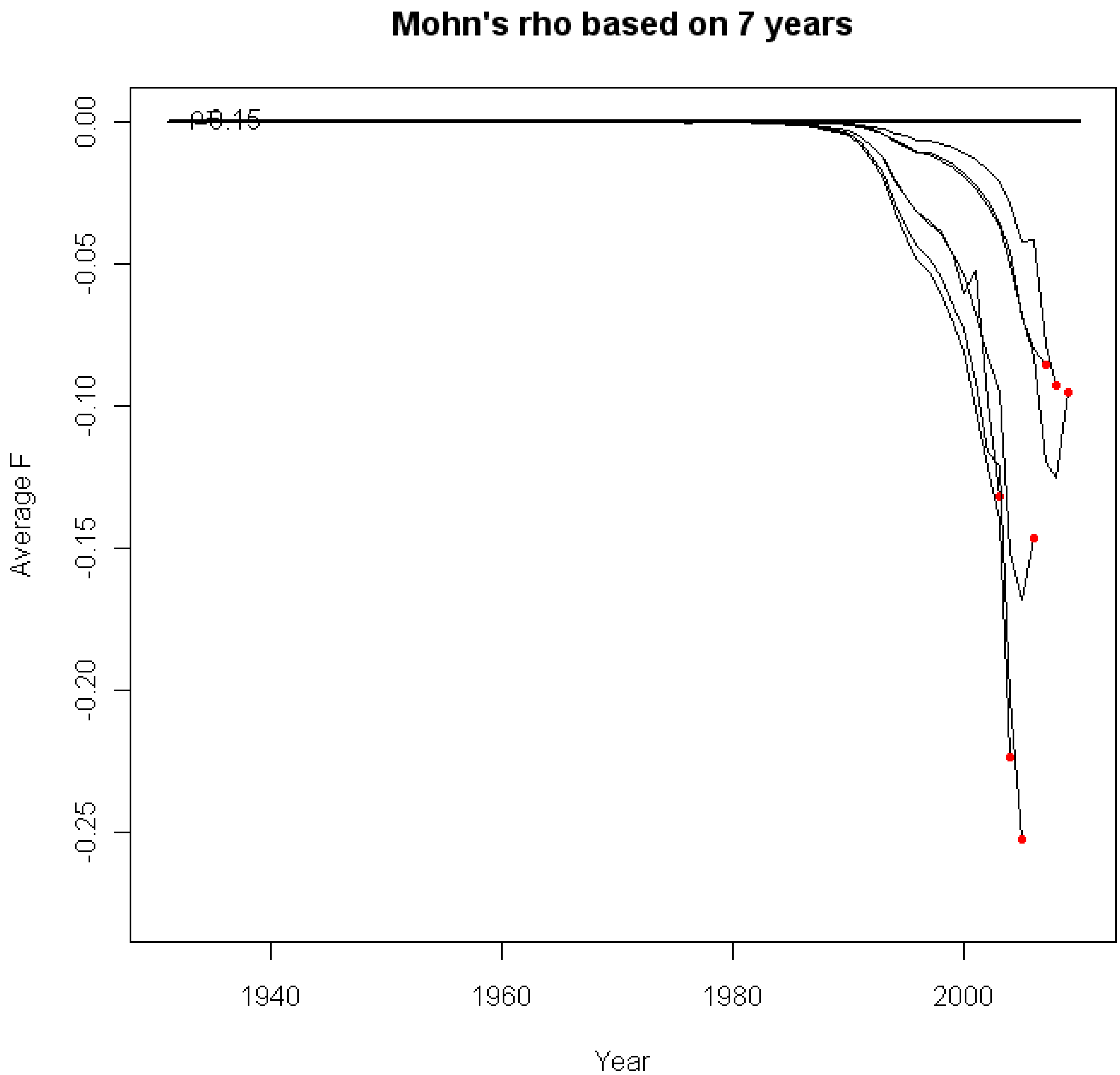


Figure B12c. Mohn's rho for recruitment (expressed on relative scale).

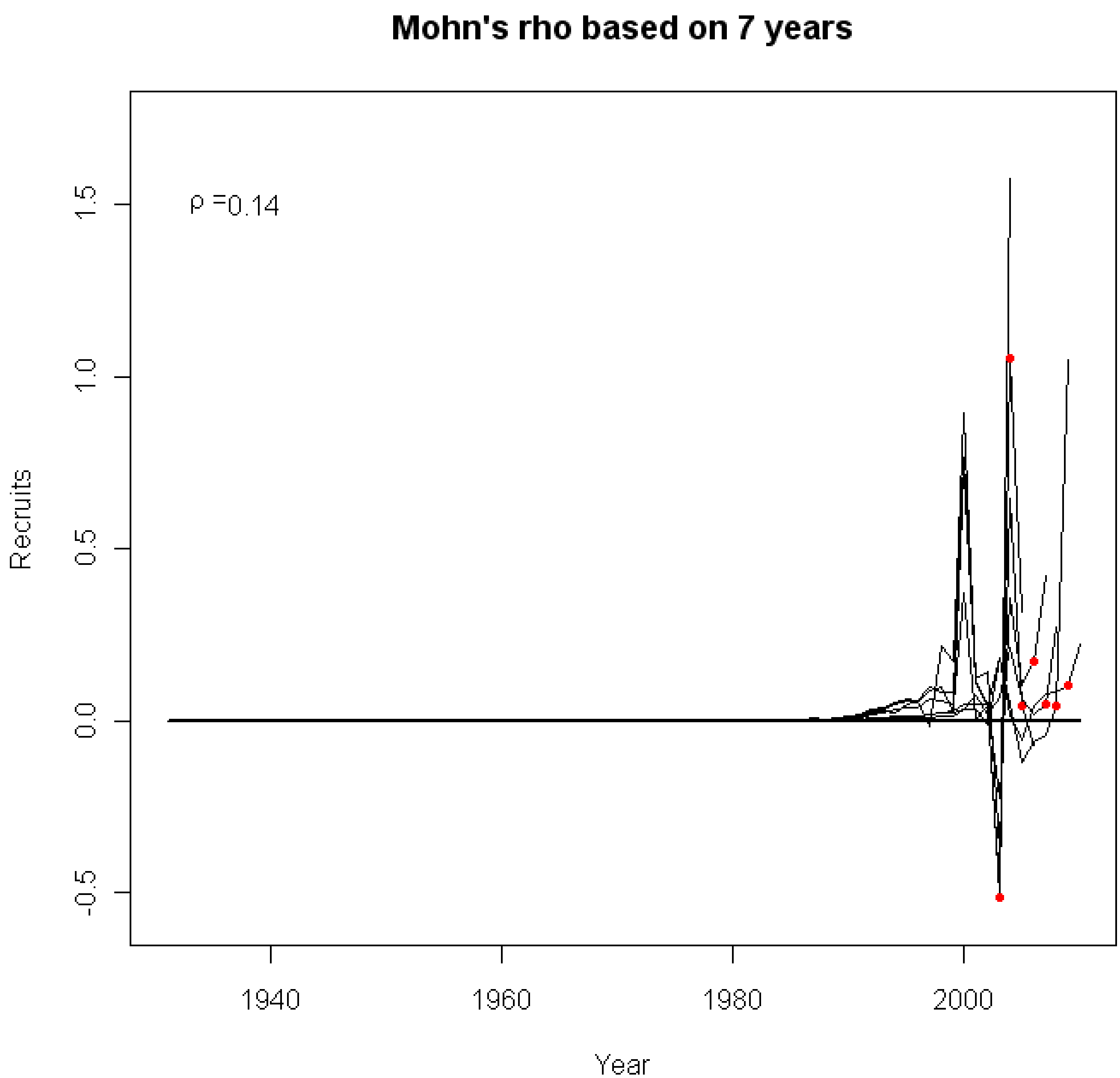
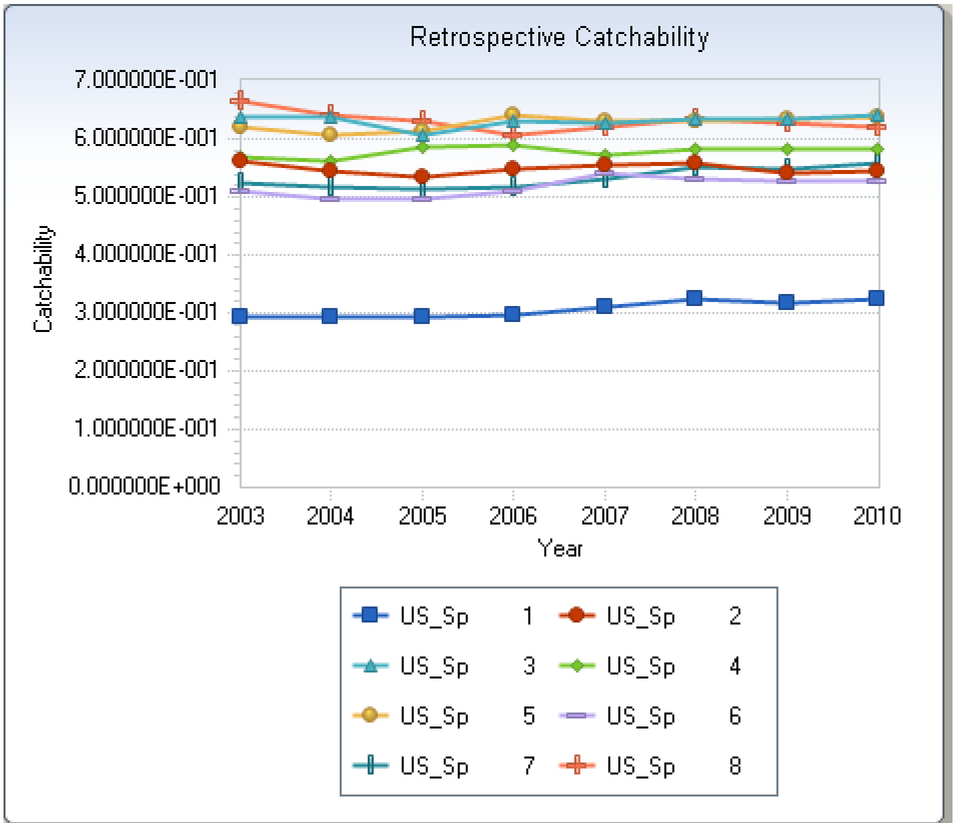


Figure B13a. Retrospective estimates of q for the NEFSC spring survey (top) and for the years 1973-1981 when the Yankee 41 was used.



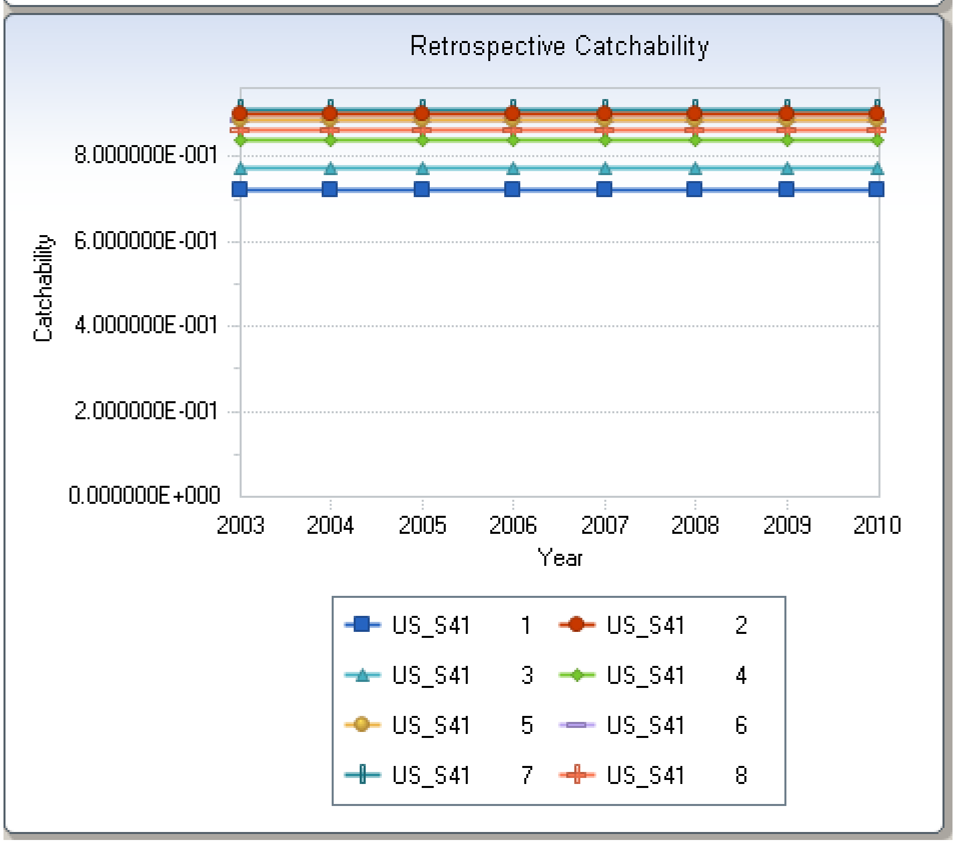


Figure B13b. Retrospective estimates of q for the NEFSC fall survey (top) and for the DFO spring survey (bottom).

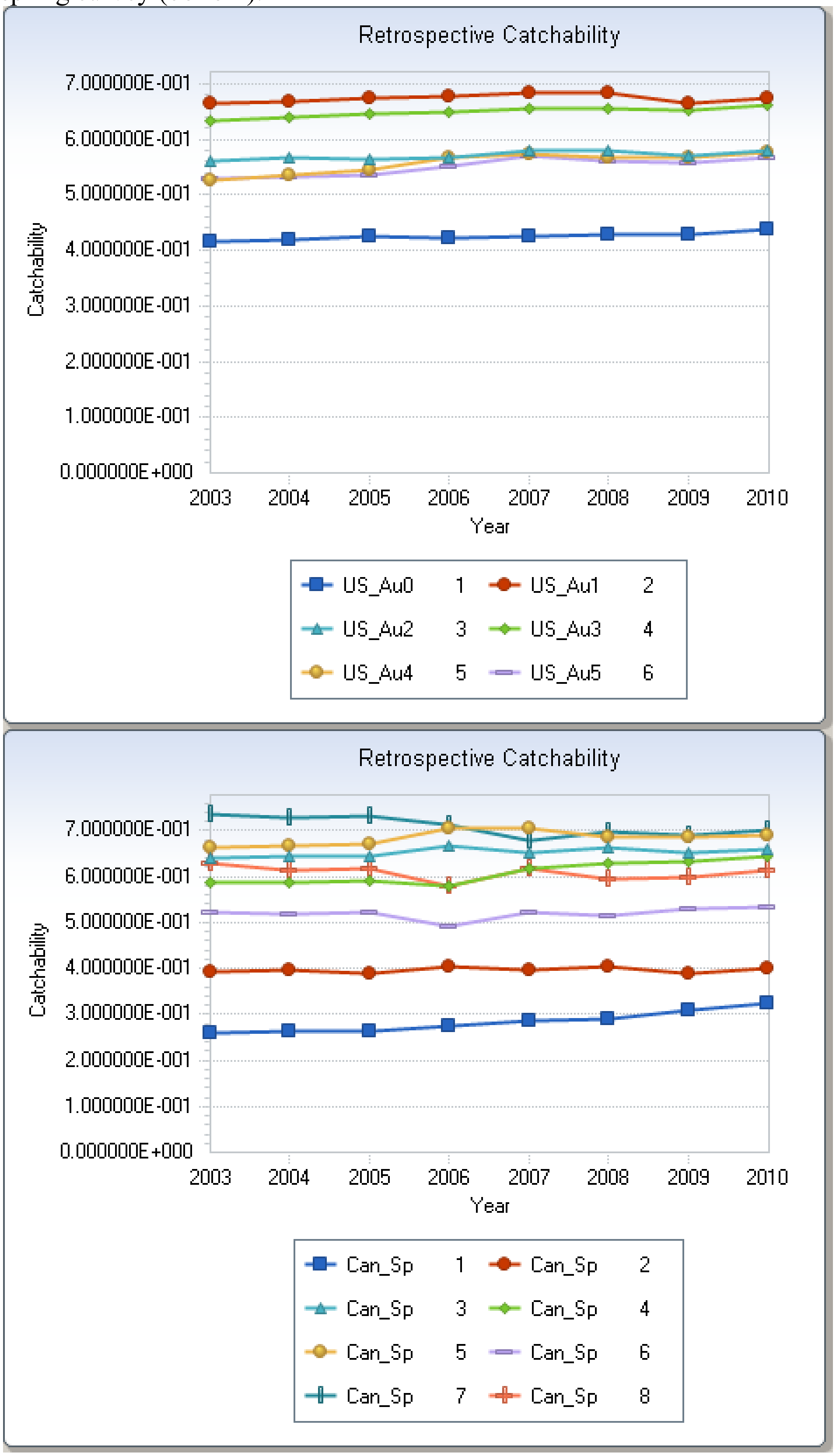


Figure B14. Mean selectivity at age vector used in YPR analysis. The mean of years 2006-2010 is plotted.

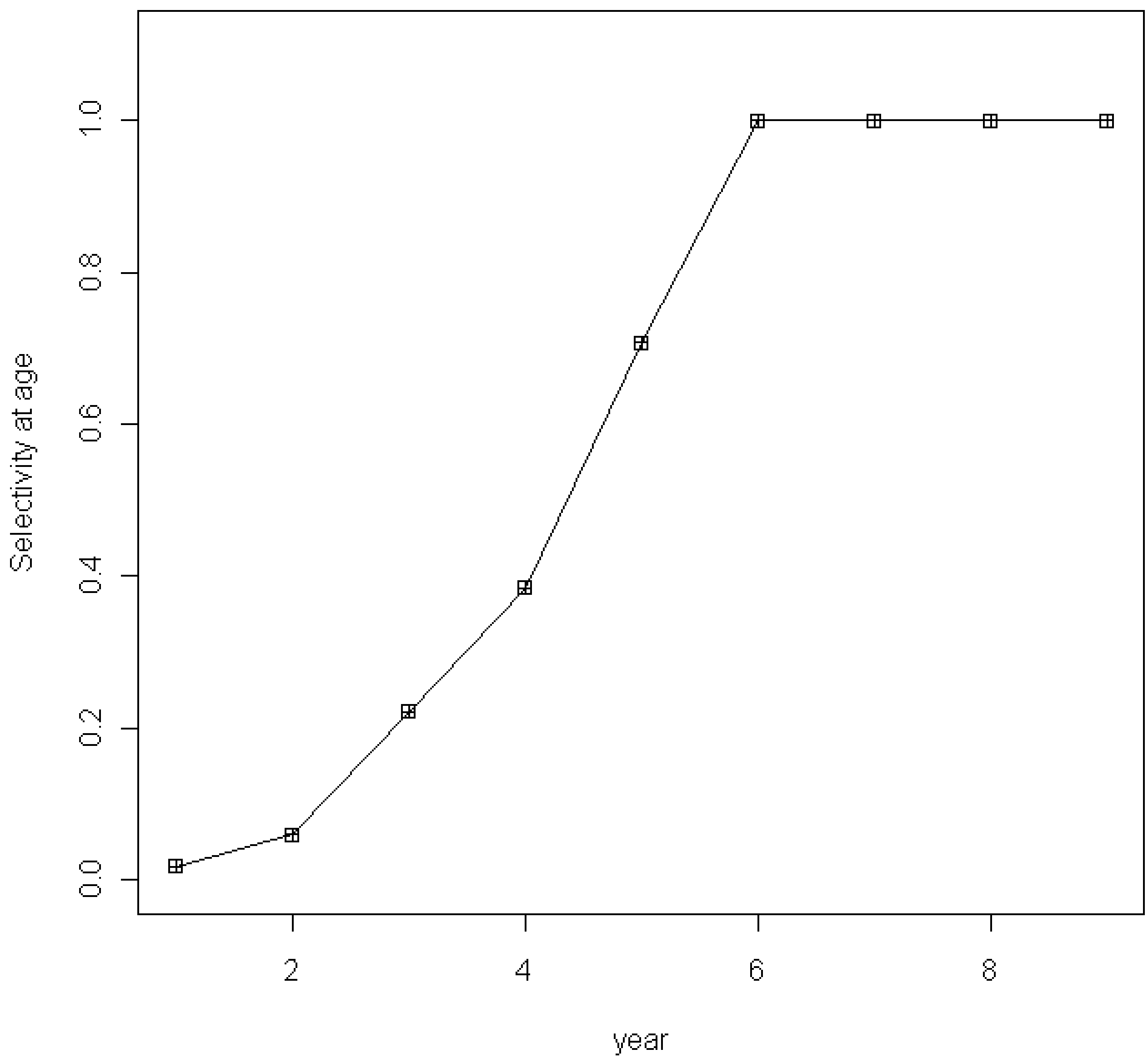


Figure B15. Mean weight at age vectors (catch and ssb) used in yield per recruit analysis. The mean of years 2006-2010 is plotted.

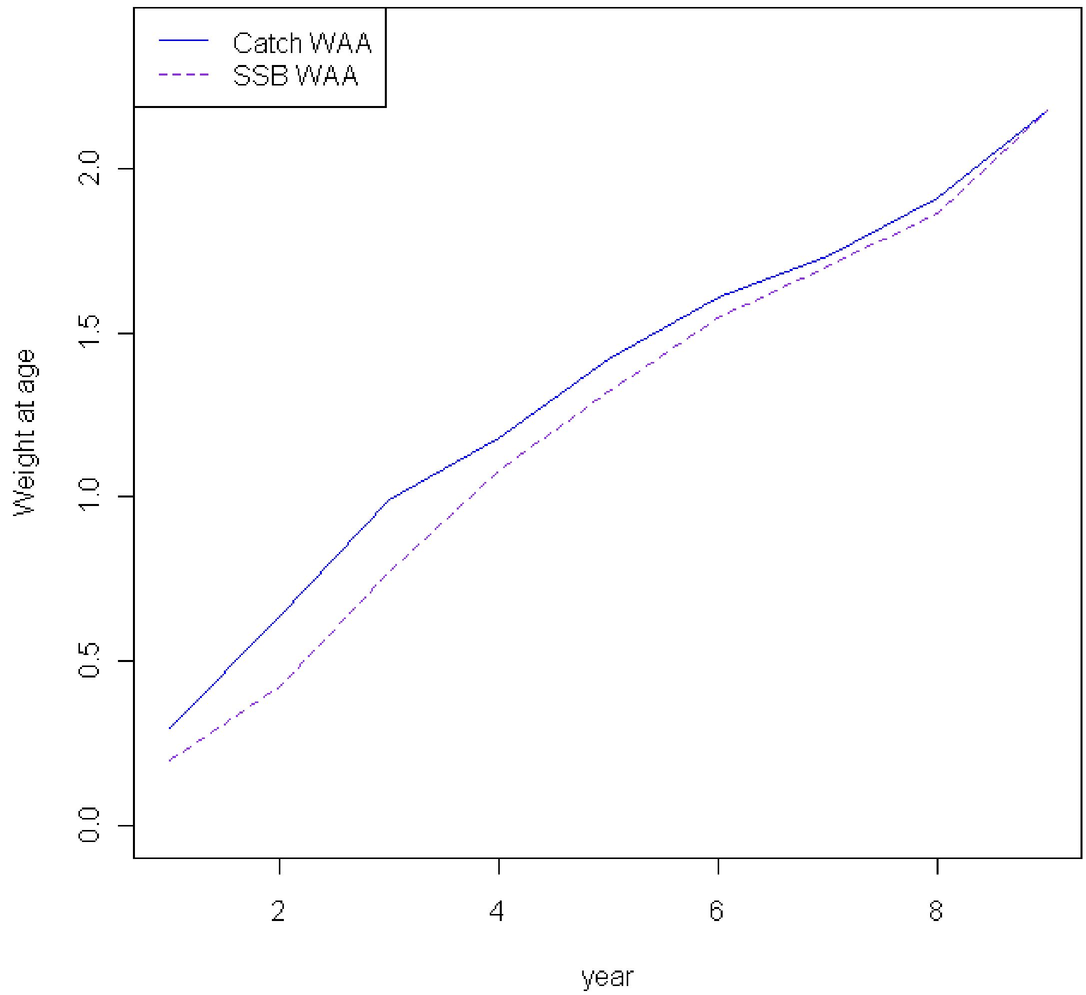


Figure B16. Overlay of age-1 recruitment (bars) and SSB (solid line) for Georges Bank haddock.

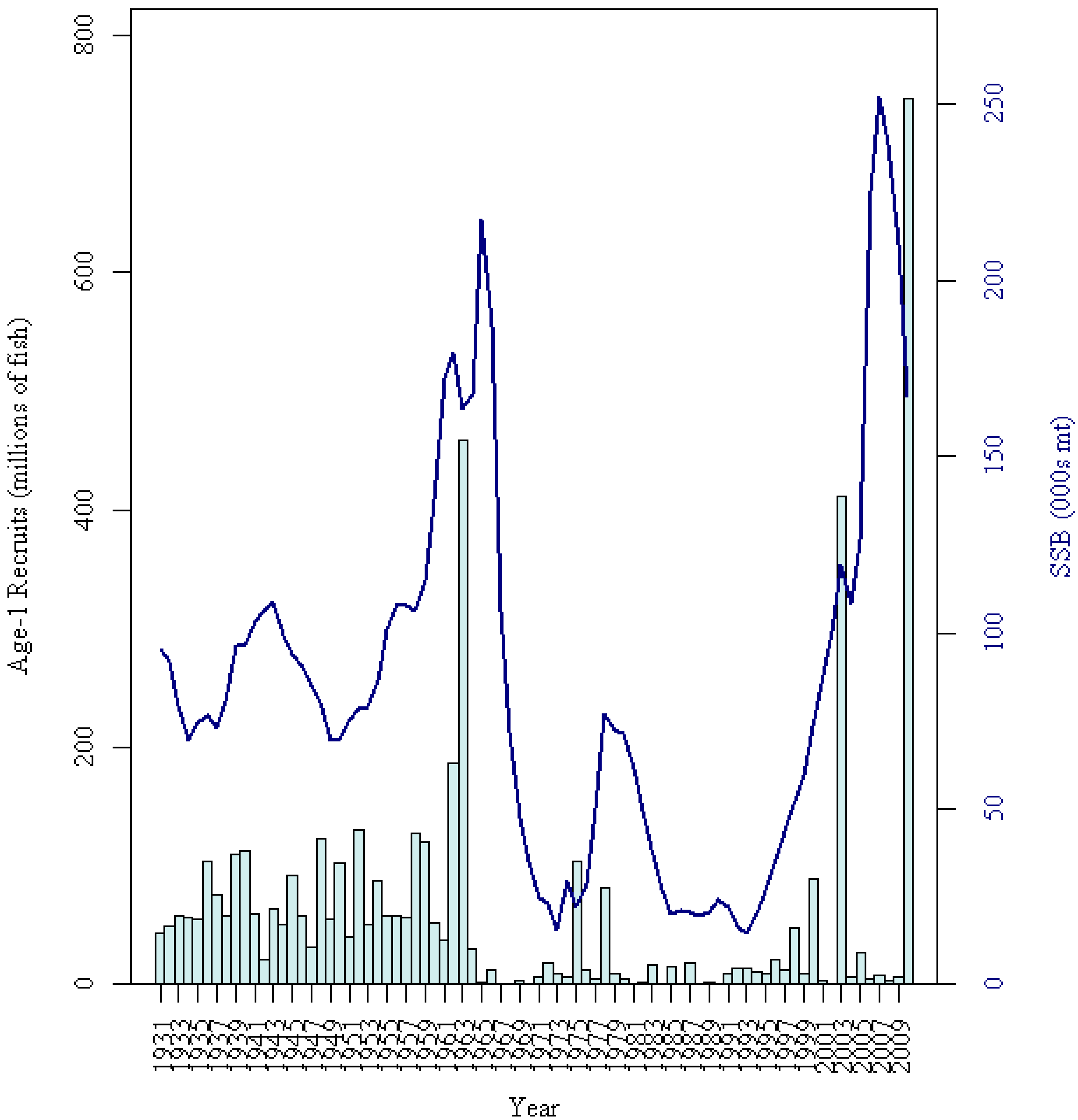


Figure B17a. Projections assuming a catch in 2011 of 25,903 mt, and fishing at F=0.39 in years 2012-2015. On the left, no adjustment is made to the uncertain 2010 year class. On the right, that year class is decreased by 50% before making the projections.

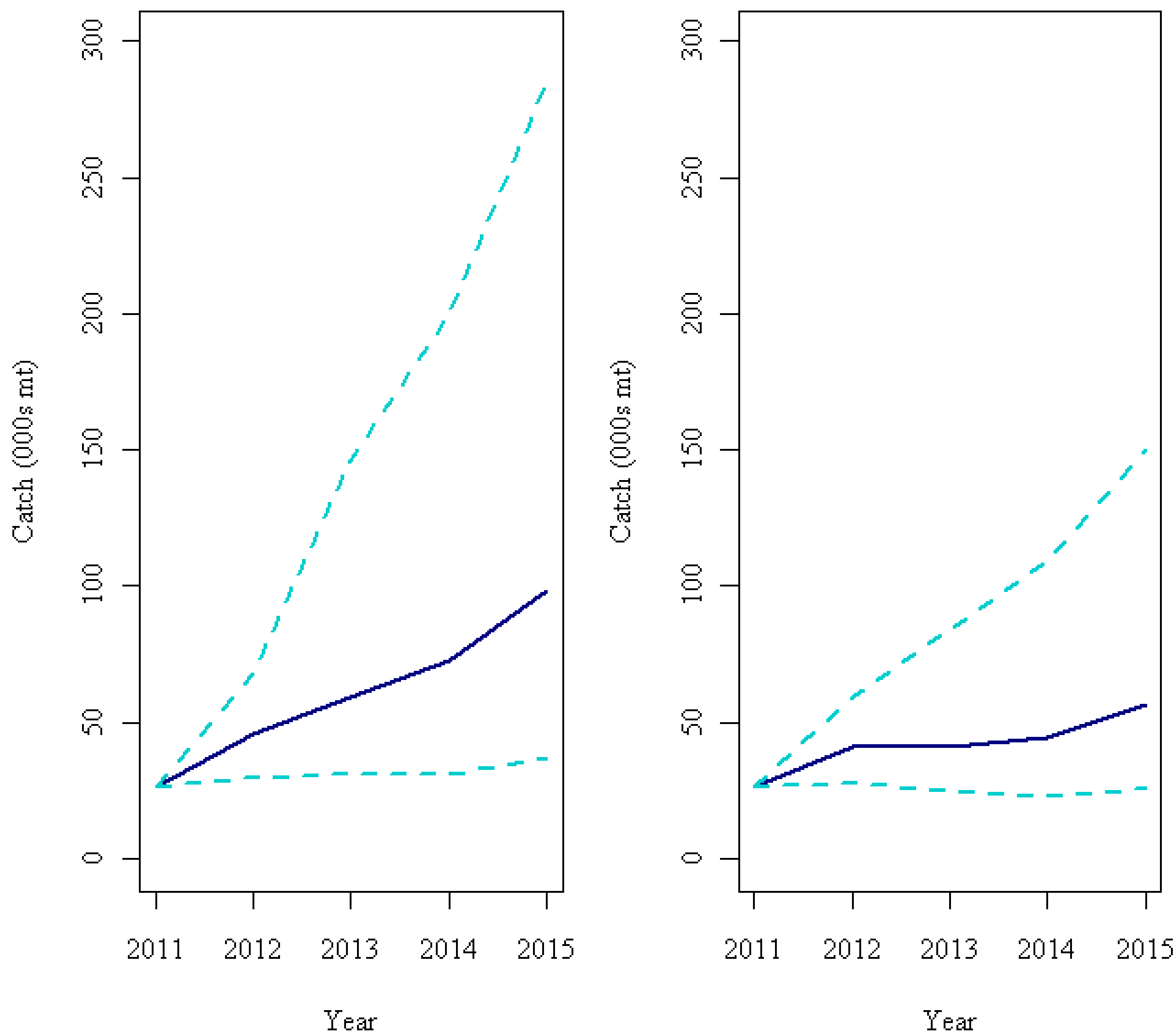


Figure B17b. Projected spawning stock biomass, assuming a catch in 2011 of 25,903 mt, and fishing at F=0.39 in years 2012-2015. On the left, no adjustment is made to the uncertain 2010 year class. On the right, that year class is decreased by 50% before making the projections.

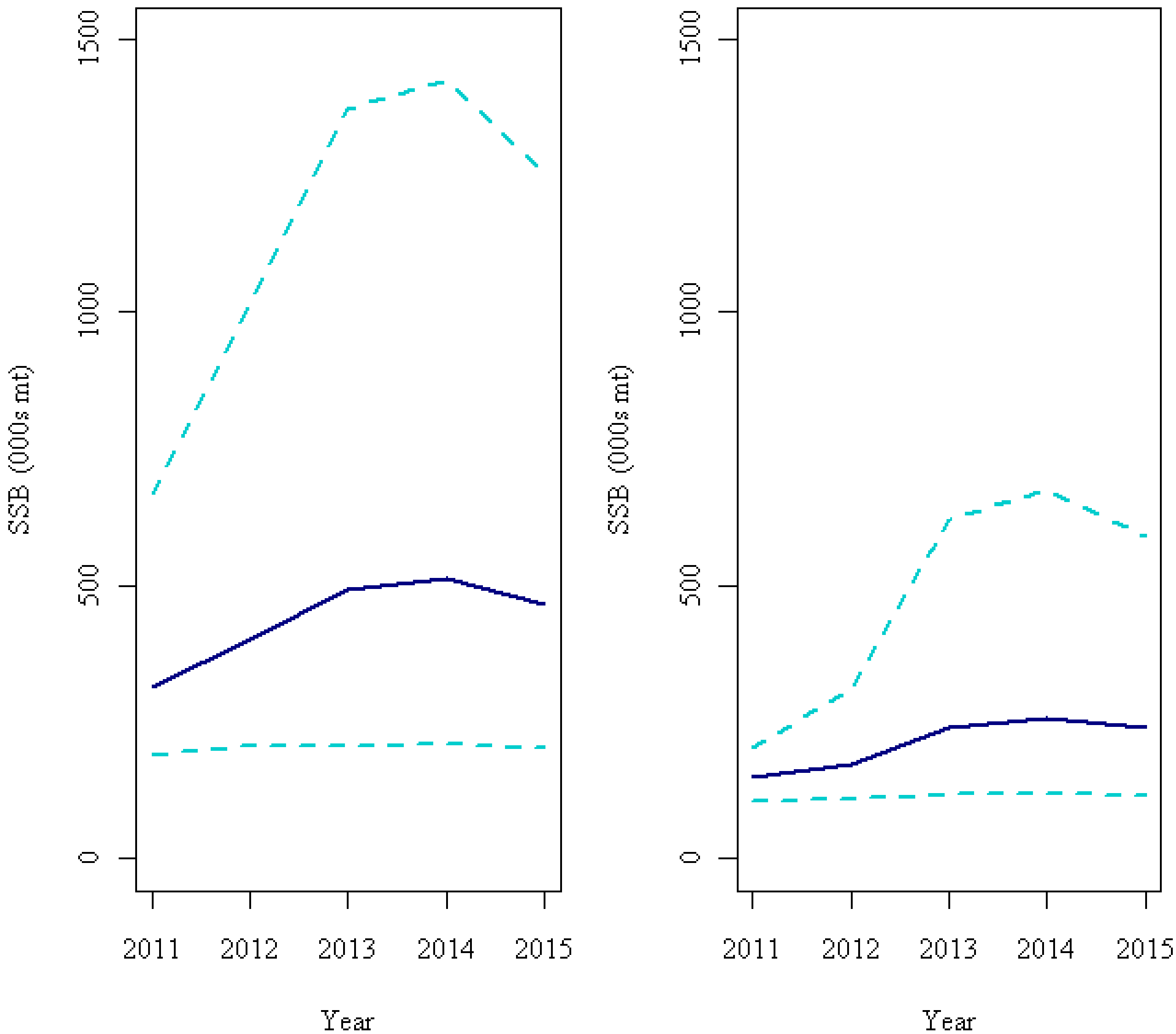


Figure B18. Relative change in estimated year class strength between the first estimate with one year of data (on the horizontal line y=1), and subsequent model runs with additional years of data.

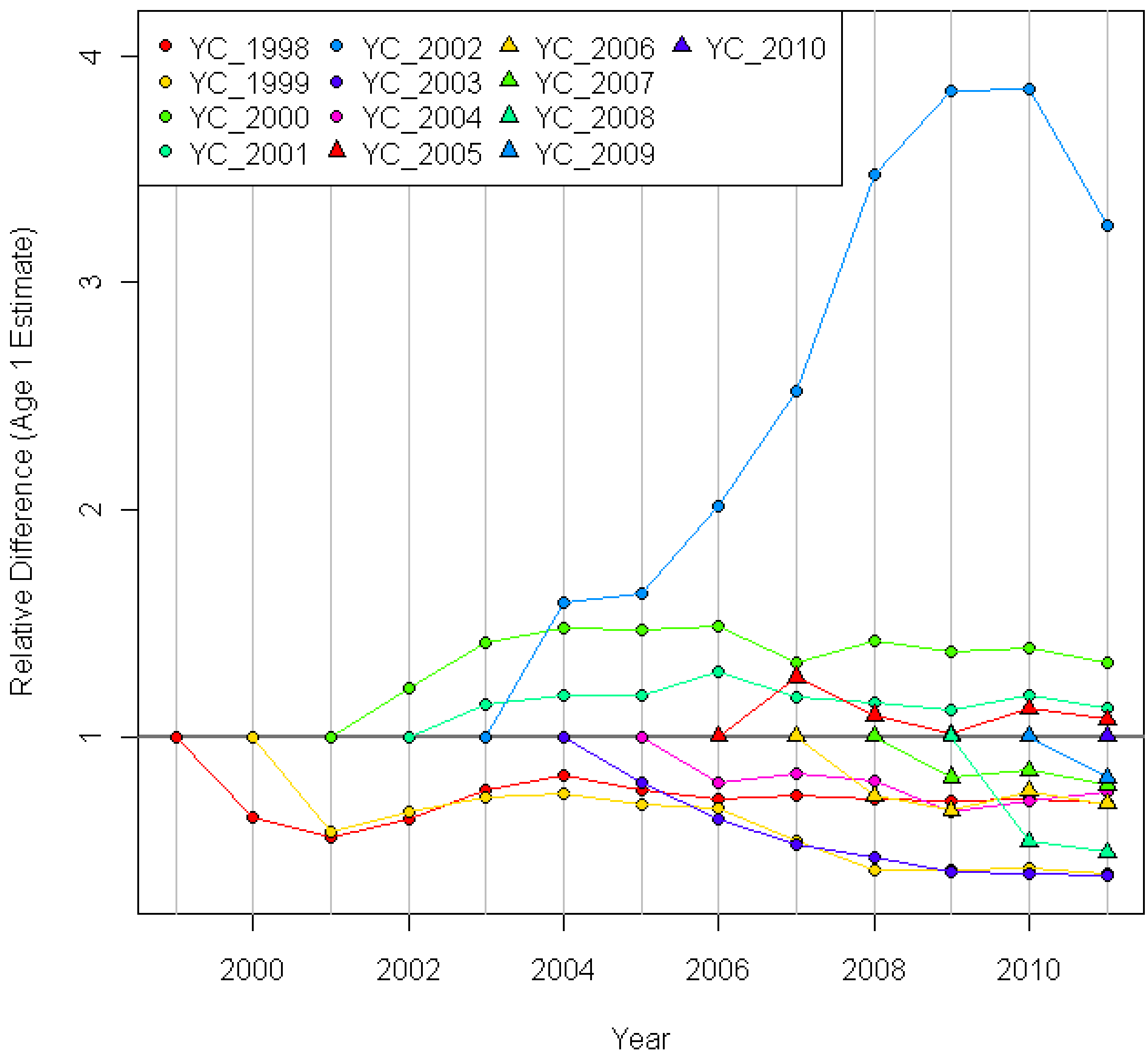
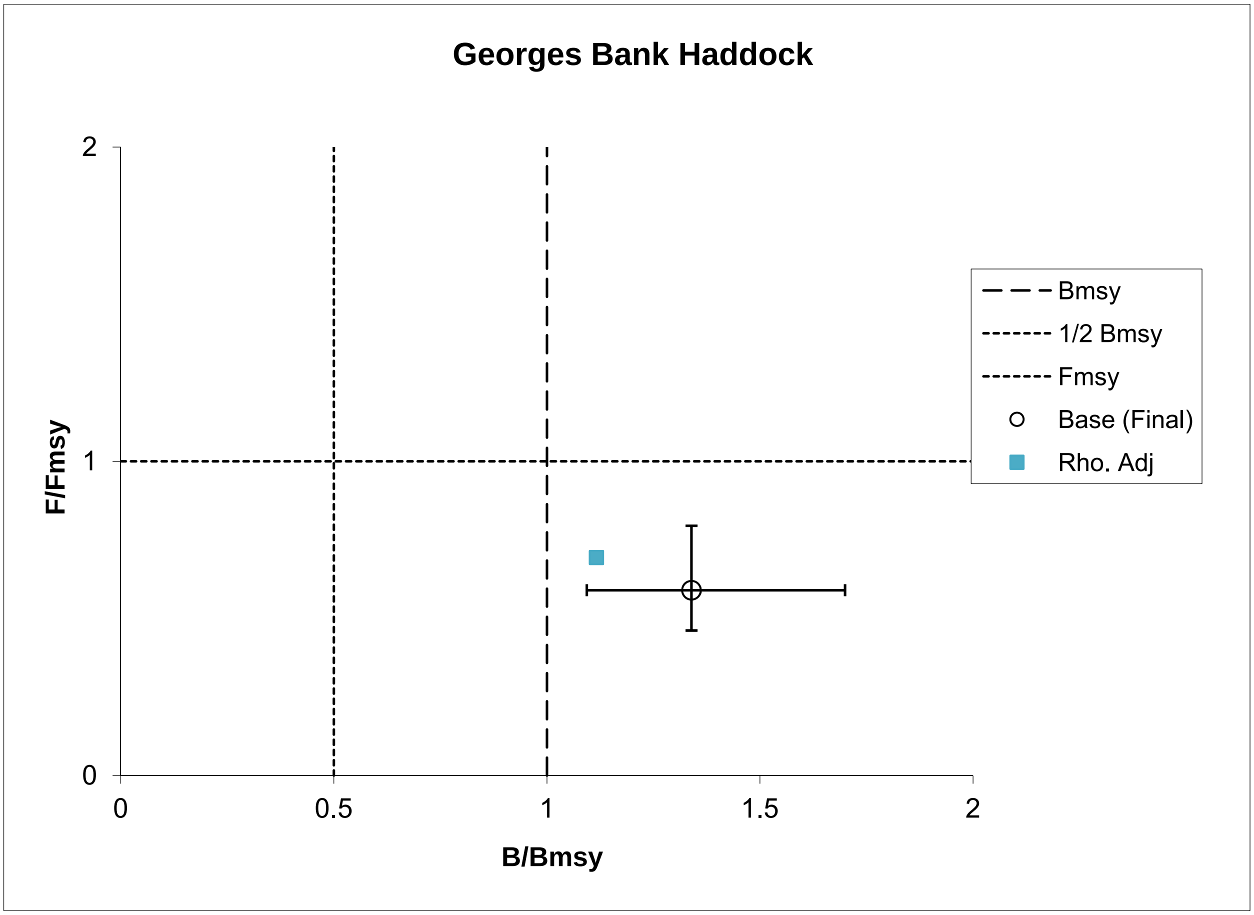


Figure B19. Stock status for Georges Bank haddock. The base model with 90% confidence interval is plotted as well as a point (blue square) demonstrating the effect of the calculated Mohn's rho statistic on stock status.



GB haddock Appendix : Panel Requests related to projections, and dependency on the uncertain incoming 2010 year class, which was estimated to be nearly 750 million age-1 fish (CV=84%).

Appendix Table B1. Initial estimates of incoming year classes (thousands) with only 1 year of data (spring surveys only) and subsequent estimates of year class size as additional years of data are added.

Number of years data	Yearclass 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	**108,072**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	70,808	44,253	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	37,900	17,310	**104,255**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	41,384	20,317	91,788	4,274	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	48,811	19,462	87,321	4,787	849	NA	NA	NA	NA	NA	NA	NA	NA
6	56,414	21,811	103,281	6,136	1,798	**1,008,802**	NA	NA	NA	NA	NA	NA	NA
7	53,136	20,343	93,972	5,568	1,365	811,522	8,664	NA	NA	NA	NA	NA	NA
8	50,515	20,140	100,401	6,017	1,684	677,830	7,678	21,766	NA	NA	NA	NA	NA
9	51,342	15,991	91,319	5,523	2,045	572,982	9,303	35,825	12,077	NA	NA	NA	NA
10	50,319	11,970	97,522	5,646	2,912	493,885	8,251	26,402	7,416	16,325	NA	NA	NA
11	49,884	12,062	94,638	5,498	3,396	457,050	7,466	28,530	7,224	11,218	11,516	NA	NA
12	50,467	12,259	95,391	5,821	3,403	420,443	7,544	29,111	7,582	10,515	6,084	9,787	NA
13	**49,157**	11,668	**90,867**	5,551	2,870	**412,386**	7,986	28,833	7,123	9,365	4,773	7,605	*748,020*

Appendix Table B2. Relative adjustment between initial estimates of incoming year classes with only 1 year of data (spring surveys only) and subsequent estimates of year class size as additional years of data are added.

Number of years data	Yearclass 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	**1.00**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	0.66	1.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	0.35	0.39	**1.00**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	0.38	0.46	0.88	1.00	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.45	0.44	0.84	1.12	1.00	NA	NA	NA	NA	NA	NA	NA	NA
6	0.52	0.49	0.99	1.44	2.12	**1.00**	NA	NA	NA	NA	NA	NA	NA
7	0.49	0.46	0.90	1.30	1.61	0.80	1.00	NA	NA	NA	NA	NA	NA
8	0.47	0.46	0.96	1.41	1.98	0.67	0.89	1.00	NA	NA	NA	NA	NA
9	0.48	0.36	0.88	1.29	2.41	0.57	1.07	1.65	1.00	NA	NA	NA	NA
10	0.47	0.27	0.94	1.32	3.43	0.49	0.95	1.21	0.61	1.00	NA	NA	NA
11	0.46	0.27	0.91	1.29	4.00	0.45	0.86	1.31	0.60	0.69	1.00	NA	NA
12	0.47	0.28	0.91	1.36	4.01	0.42	0.87	1.34	0.63	0.64	0.53	1.00	NA
13	**0.45**	0.26	**0.87**	1.30	3.38	**0.41**	0.92	1.32	0.59	0.57	0.41	0.78	*1.00*

Appendix Table B3. Comparison of five year averages for catch weight at age (Catch WAA), spawning stock biomass weights at age (SSB WAA), and selectivity at age versus the realized values for the 2003 year class. Projections for 2011-2015 substituted the yellow highlighted values for the 2003 year class instead of the 5 year average values.

Catch WAA	age1	age2	age3	age4	age5	age6	age7	age8	age9
5 year average	0.30	0.64	0.99	1.18	1.42	1.61	1.73	1.91	2.17
2003-yc	0.21	0.57	0.95	1.15	1.37	1.56	1.69	1.87	2.14

SSB WAA	age1	age2	age3	age4	age5	age6	age7	age8	age9
5 year average	0.20	0.42	0.77	1.08	1.32	1.54	1.70	1.86	2.17
2003-yc	0.13	0.35	0.73	1.04	1.25	1.50	1.66	1.82	2.14

Selectivity	age1	age2	age3	age4	age5	age6	age7	age8	age9
5 year average	0.02	0.06	0.22	0.38	0.71	1.00	1.00	1.00	1.00
2003-yc	0.004	0.006	0.04	0.27	0.49	1.00	1.00	1.00	1.00

Appendix Table B4. Short term catch (000s mt) projections for Georges Bank haddock. The base run, using the estimated size of 2010 year class with no adjustment is compared with three sensitivities: i) the magnitude of the 2010 year class is multiplied by 0.41; ii) in addition to (i), the estimated weights at age for the 2003 year class were used for the 2010 year class; iii) in addition to (i) and (ii), the estimated selectivities for the 2003 year class were used for the 2010 year class.

CATCH (000s mt)

No Adjustment

Year	1%	5%	10%	25%	50%	75%	90%	95%	99%
2011	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
2012	25.5	29.9	33.0	38.8	45.6	54.3	63.8	68.2	85.5
2013	25.3	31.2	34.4	44.8	58.9	84.5	116.4	146.3	238.9
2014	23.3	31.0	36.3	49.5	72.4	109.4	156.3	200.1	340.6
2015	26.4	37.1	45.0	63.7	98.3	152.2	220.7	285.0	493.2

Rescale by 59%

Year	1%	5%	10%	25%	50%	75%	90%	95%	99%
2011	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
2012	23.0	27.2	29.5	34.4	40.0	46.7	53.1	57.5	64.1
2013	19.5	23.3	25.9	30.9	37.8	48.8	61.6	72.9	112.8
2014	17.3	21.4	23.9	30.0	39.3	55.0	74.7	92.0	151.7
2015	18.0	23.3	27.0	35.2	49.2	71.6	100.2	126.0	212.5

Rescale by 59%, use 2003 WAA

Year	1%	5%	10%	25%	50%	75%	90%	95%	99%
2011	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
2012	22.7	26.8	29.1	34.0	39.5	46.2	52.5	57.0	63.2
2013	19.3	23.1	25.7	30.5	37.2	47.8	60.1	70.8	109.5
2014	17.3	21.2	23.7	29.7	38.7	54.1	73.3	90.2	148.2
2015	17.8	22.9	26.4	34.4	48.0	69.6	97.2	122.2	205.2

Rescale by 59%, use 2003 WAA and selectivity

2011	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
2012	20.1	24.2	26.6	30.4	36.1	42.2	48.1	51.9	58.7
2013	15.0	17.5	19.0	21.8	25.2	29.3	33.2	36.1	41.3
2014	16.1	19.6	21.8	26.6	33.8	46.0	61.0	74.0	119.1
2015	16.7	21.2	24.3	31.1	42.4	60.4	83.5	104.0	172.6

Appendix Table B5. Short term SSB (000s mt) projections for Georges Bank haddock. The base run, using the estimated size of 2010 year class with no adjustment is compared with three sensitivities: i) the magnitude of the 2010 year class is multiplied by 0.41; ii) in addition to (i), the estimated weights at age for the 2003 year class were used for the 2010 year class; iii) in addition to (i) and (ii), the estimated selectivities for the 2003 year class were used for the 2010 year class.

SSB (000s mt)

No Adjustment

Year	1%	5%	10%	25%	50%	75%	90%	95%	99%
2011	96.0	109.6	117.9	134.6	153.6	176.0	196.5	211.6	231.0
2012	106.9	131.4	144.6	179.9	228.4	311.8	412.2	499.4	801.9
2013	118.2	160.9	192.6	269.8	404.4	622.6	895.5	1153.5	1969.0
2014	120.7	169.0	204.5	288.6	442.5	683.7	989.7	1276.2	2215.2
2015	116.7	161.5	193.4	265.3	394.6	598.0	856.0	1093.7	1879.6

Rescale by 59%

Year	1%	5%	10%	25%	50%	75%	90%	95%	99%
2011	90.4	104.3	113.2	127.8	146.3	167.9	188.9	200.1	222.9
2012	87.1	104.6	114.4	135.3	162.7	199.6	243.2	274.7	391.5
2013	85.7	107.5	120.4	155.7	208.8	300.4	416.4	521.8	870.6
2014	81.5	106.6	123.5	161.2	223.7	324.2	452.9	567.1	956.3
2015	79.2	105.2	122.3	157.8	212.7	296.9	405.8	498.6	822.3

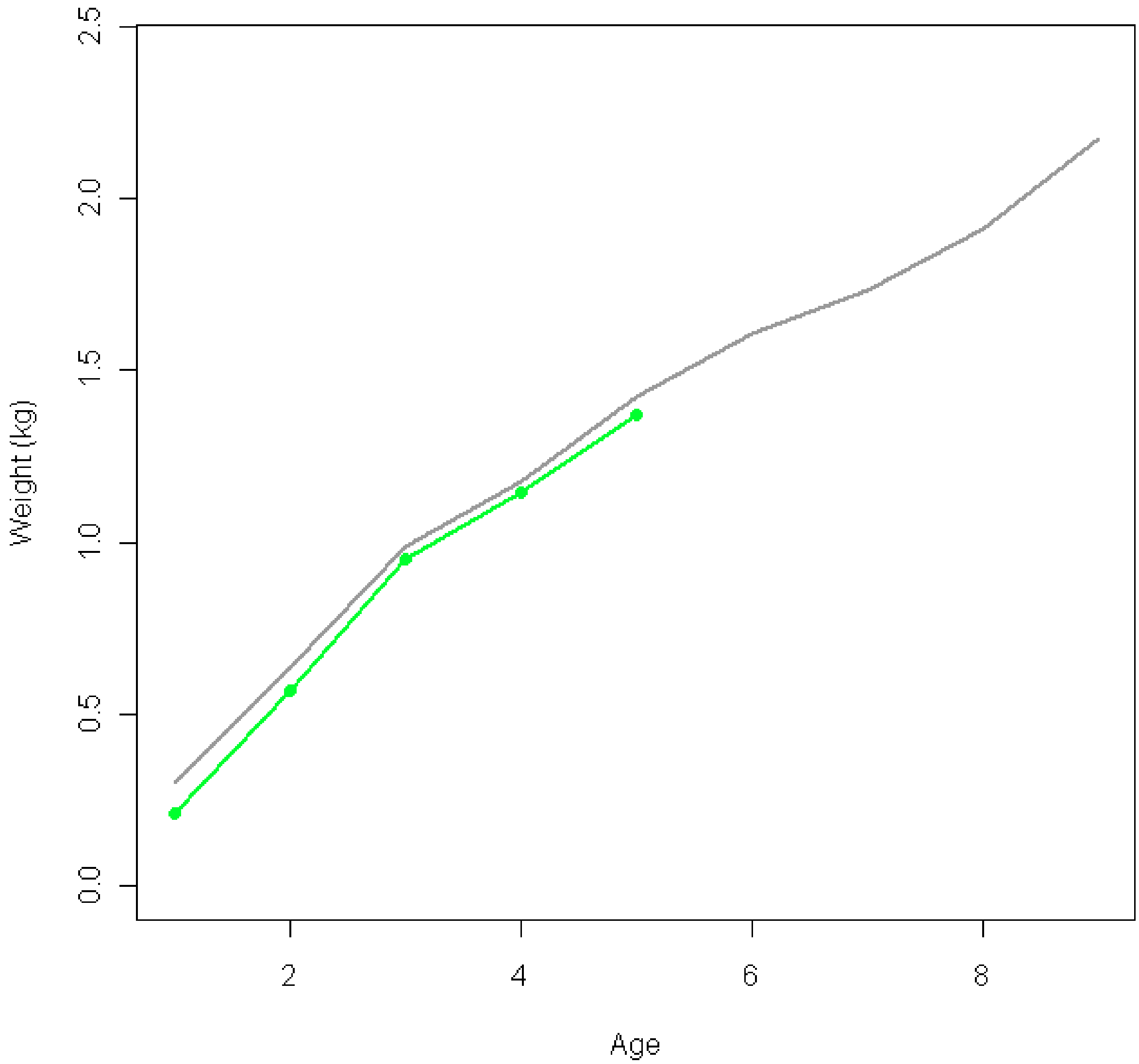
Rescale by 59%, use 2003 WAA

Year	1%	5%	10%	25%	50%	75%	90%	95%	99%
2011	89.0	103.5	111.9	125.9	144.6	165.8	186.0	197.7	221.6
2012	84.6	100.8	109.5	129.2	153.7	187.4	223.6	246.8	337.0
2013	84.4	105.2	117.5	151.4	201.6	288.6	398.7	498.0	826.3
2014	81.0	104.6	121.4	158.1	218.2	315.6	439.3	550.0	921.5
2015	77.7	102.7	119.3	153.7	206.1	286.5	388.9	477.8	779.9

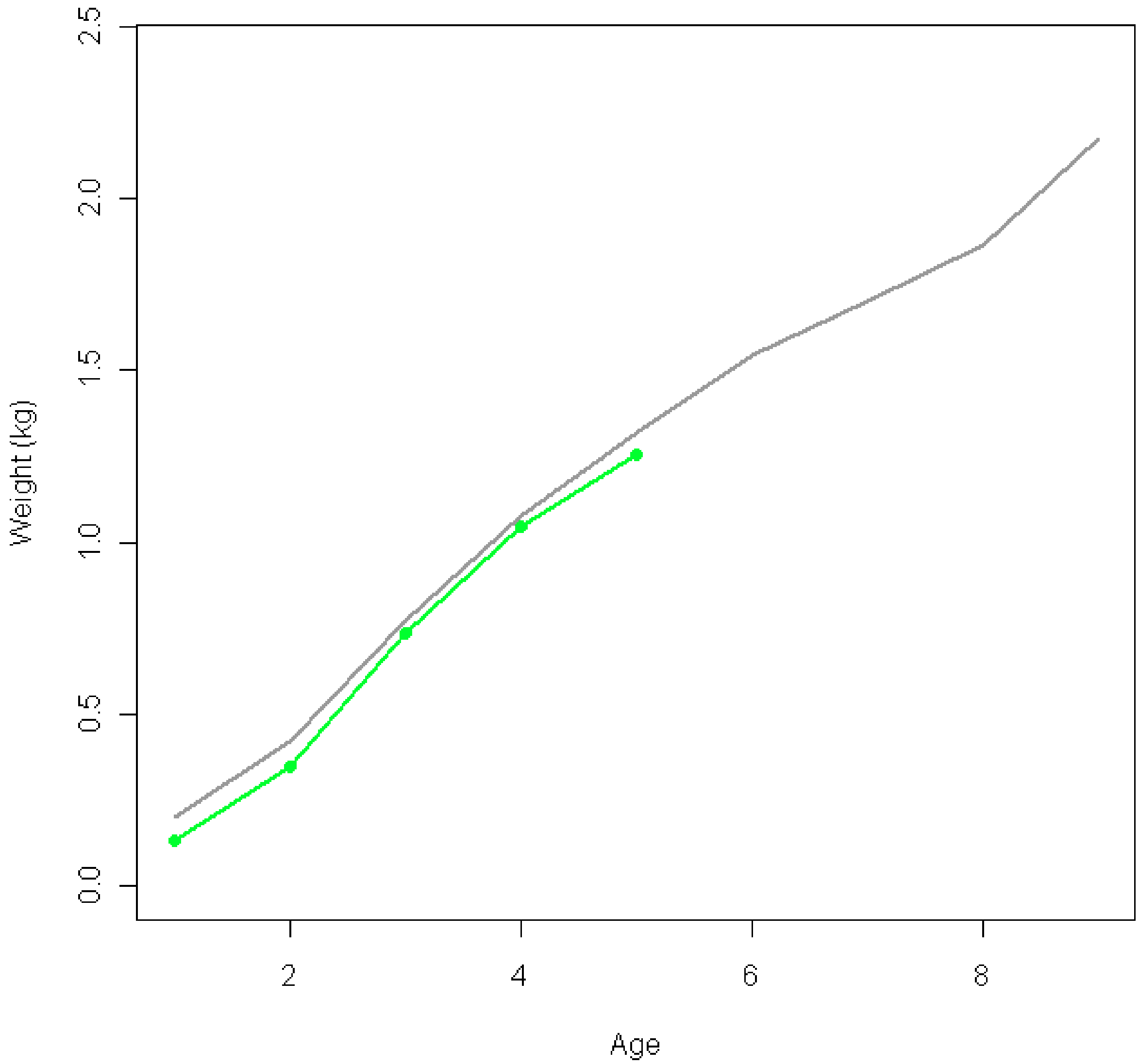
Rescale by 59%, use 2003 WAA and selectivity

2011	88.9	103.5	111.8	125.9	144.6	165.7	186.0	197.6	221.5
2012	84.5	100.9	109.6	129.3	153.8	187.7	224.1	247.4	338.1
2013	85.4	107.0	119.6	154.6	206.8	297.1	412.1	515.6	855.7
2014	84.5	109.8	127.7	167.5	234.3	341.9	480.0	603.7	1015.4
2015	83.0	110.0	128.2	166.1	226.7	320.9	441.2	546.7	904.7

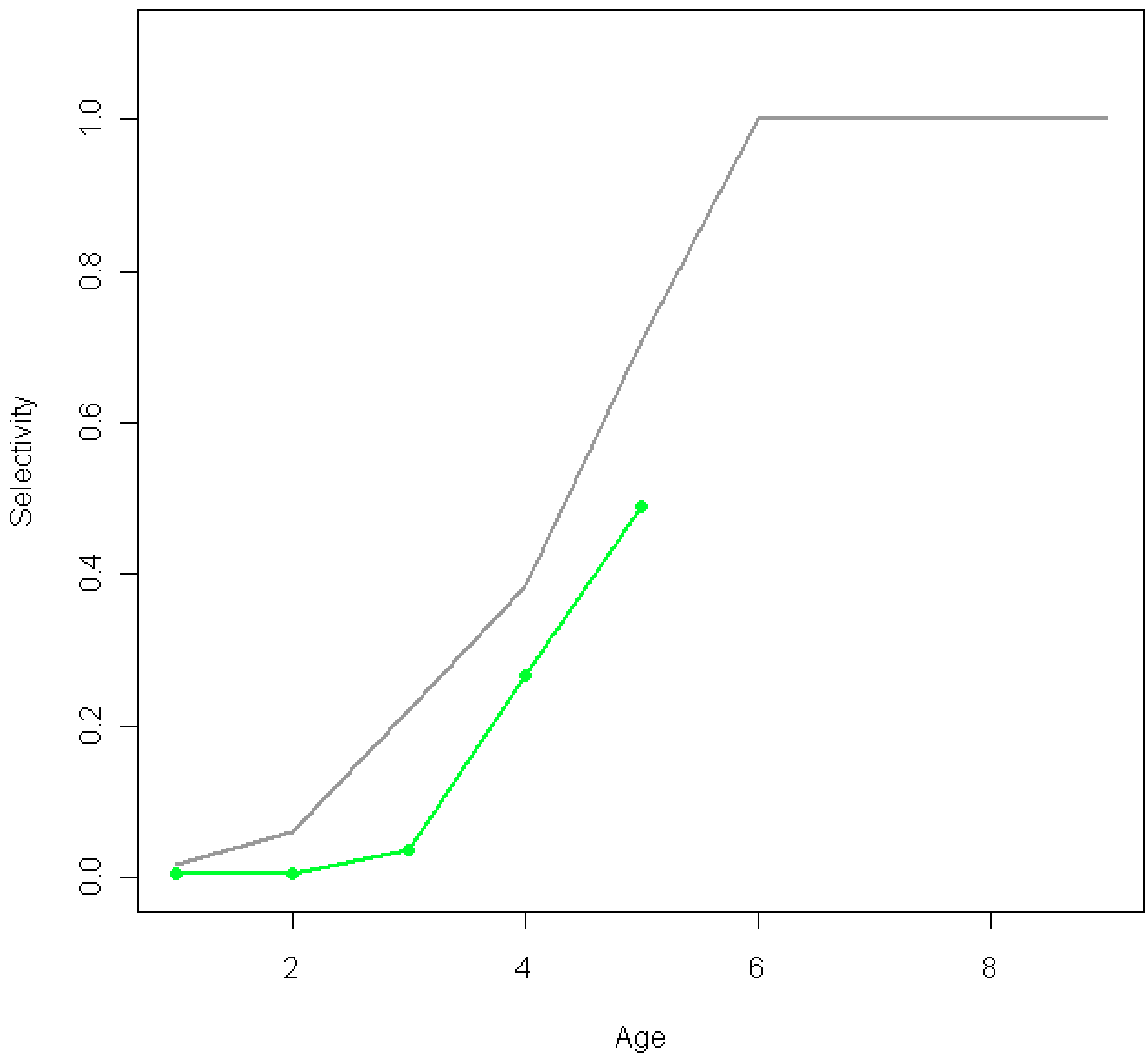
Appendix Figure B1. Comparison of 5-year average catch weight at age (solid grey) and realized catch weight at age (ages 1-5) for 2003 year class.



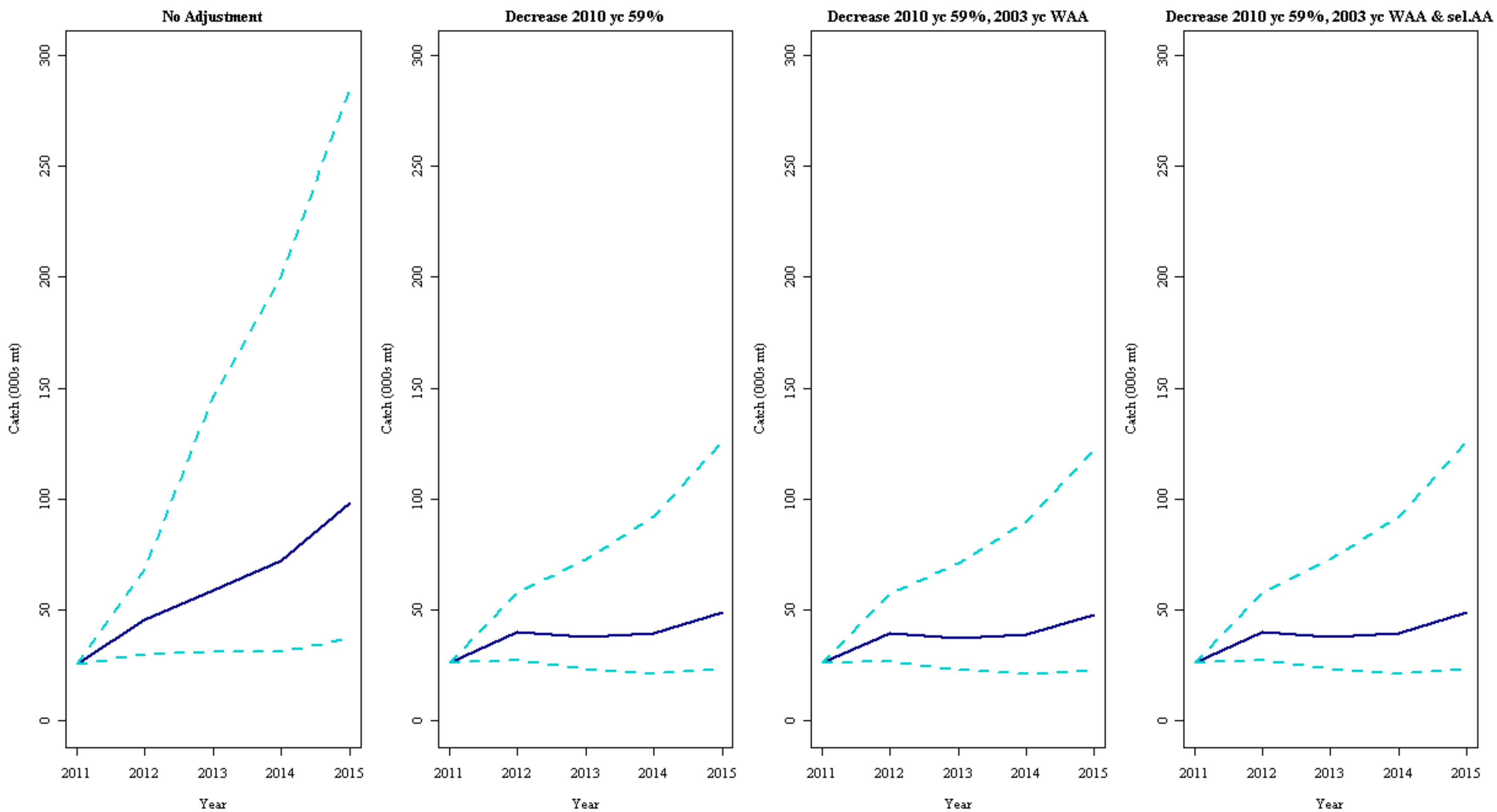
Appendix Figure B2. Comparison of 5-year average SSB weight at age (solid grey) and realized SSB weight at age (ages 1-5) for 2003 year class.



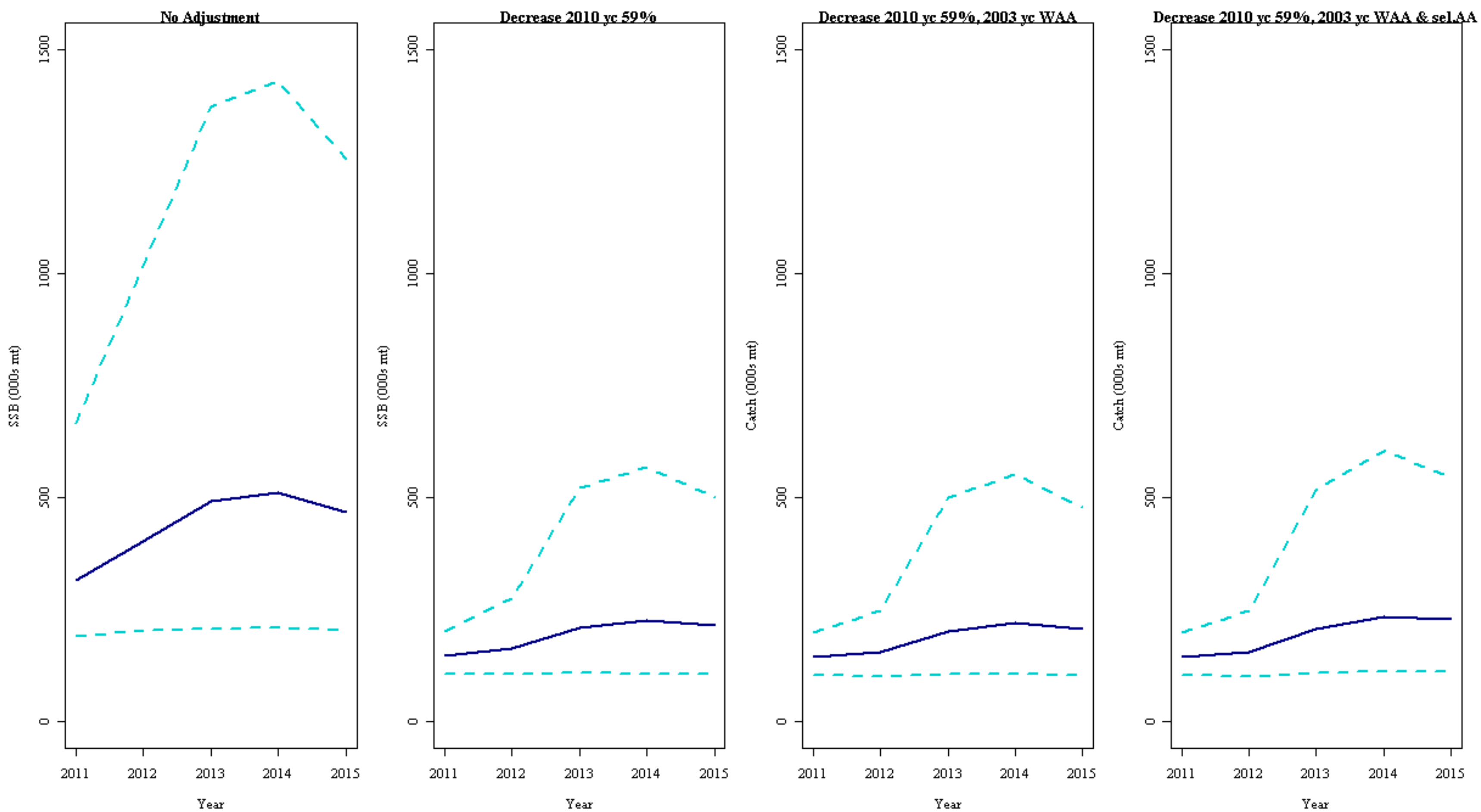
Appendix Figure B3. Comparison of 5-year average selectivity at age (solid grey) and realized selectivity at age (ages 1-5) for 2003 year class.



Appendix Figure B4. Influence on catch advice of different adjustments to 2010 year class in short-term projections.



Appendix Figure B5. Influence on ssb of different adjustments to 2010 year class in short-term projections.



C. 2012 Update of the Gulf of Maine haddock (*Melanogrammus aeglefinus*) stock assessment: an update of the resource through calendar year 2010.

Gulf of Maine haddock (*Melanogrammus aeglefinus*)

Michael C. Palmer, Sandra Sutherland, Elizabeth N. Brooks

1. Background

The Gulf of Maine haddock stock was last assessed at the 3rd Groundfish Assessment Review Meeting (GARM III) in 2008 (NEFSC 2008). That assessment was conducted using the ADAPT-VPA model covering the years 1977 to 2007. In prior assessments the stock was assessed using index-based methods (e.g., NEFSC 2005). At GARM III, 2007 spawning stock biomass was estimated at 5,850 mt and average fishing mortality on ages 6-8 was estimated at 0.35. GARM III reference points were based on a yield per recruit analysis proxy of F_{MSY}=F40%=0.43and use of long-term stochastic projections to estimate SSB_{MSY} and MSY. The corresponding values were 5,900 mt (1/2 B_{MSY}=$B_{threshold}$=2,950 mt) and 1,360 mt, respectively. As of GARM III, the stock was not overfished and overfishing was not occurring. Based on the GARM III assessment, the stock was considered fully rebuilt due to the fact that the GARM III assessment indicated that spawning stock biomass had exceeded the biomass threshold in 2000.

This current assessment represents an operational update of the 2008 GARM III benchmark assessment through calendar year 2010. Three additional years of data have been prepared using methods identical to those used in the previous assessment and incorporated into the existing model configuration. The 2007 catch has been re-estimated to account for revisions made to the 2007 commercial seafood dealer landings which has impacts both commercial landings and discards.

2. Biology

The Gulf of Maine haddock stock assessment region is defined as statistical areas 511 – 515 (NAFO area 5Y; fig. C.1). the stock complex extends from the north side of Cape Cod, Massachusetts northeast to the Canadian border. The other haddock stock in United States (US) waters is the Georges Bank haddock stock which occupies the region directly to the south of the Gulf of Maine haddock stock complex. The delineation of the two stocks is supported by differences in growth rates, and general distribution patterns (Begg et al., 1999), though tagging studies do indicate some degree of mixing between the stocks as well as with those stocks in Canadian waters (reviewed in Begg 1998).

Growth curves estimated using Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey data for Gulf of Maine haddock are shown in figure C.2. The majority of growth occurs between ages 0 and 5, with limited growth beyond age 6; L_∞ is estimated at 62.6 cm and 66.0 cm for the spring and fall respectively. The oldest age observed in the NEFSC bottom trawl survey is 18. Assuming natural mortality (M) is proportional to the oldest observed age using the relationship of Hewitt and Hoenig (2005; $M=4.22/t_{max}$), M is estimated at 0.23. This suggests that the assumed M used in the previous assessment is a reasonable approximation of true natural mortality.

In the GARM III assessment, a time invariant maturity ogive based on the maturity stage of female haddock observed in the NEFSC spring bottom trawl survey was used to estimate maturity-at-age. The decision was based on the temporal stability of age-at-50% maturity (A_{50}). The maturity schedule was re-evaluated as part of this update. Using a three-year moving average, the temporal stability of the age-at-50% maturity was examined. It should be noted that there were insufficient maturity observations to support examination of single year calculations of A_{50}; pooling of maturity observations using 3-year averages was still not sufficient to estimate A_{50} during the late 1980's to mid 1990's when samples were limited. For the periods where A_{50} could be estimated, there was little evidence of any temporal trends suggesting that the approach applied in GARM III is still reasonable (fig. C.3). The resulting maturity ogive is presented in figure C.4; this maturity ogive has been updated from the one used in GARM III to incorporate three years of additional maturity data.

The same length-weight relationships used in GARM III have been used in this assessment update (fig. C.5; **note the fall LW equation was erroneously reported in the GARM III assessment document*). The length-weight relationships are based on data collected by the NEFSC surveys between 1992 and 2007. Length-weight relationships were not recalculated for this update because it would mean that the conversion of catch weights to fish numbers would be performed on a different basis for the more recent catch series relative to the older catch series from GARM III. In general Gulf of Maine haddock are slightly heavier at length in the fall relative to their condition in the spring (fig. C.6). Length-weight relationships are provided below:

(1) Spring: $W_{live\ (kg)} = 0.000007690 \cdot L_{(fork\ cm)}^{3.0622}$ ($p < 0.0001$, n=2502)

(2) Fall: $W_{live\ (kg)} = 0.000009870 \cdot L_{(fork\ cm)}^{3.0090}$ ($p < 0.0001$, n=4890)

(3) Annual: $W_{live\ (kg)} = 0.000009298 \cdot L_{(fork\ cm)}^{3.0205}$ ($p < 0.0001$, n=4890)

3. Ageing precision

Precision age testing for haddock is conducted six times a year, once for each season of the bottom trawl survey (spring and fall) and for each quarter of the commercial samples. The precision tests are for both Georges Bank and Gulf of Maine stocks combined. Each precision test includes a subsample of about 100 fish, and measures the repeatability of age assignment by the age reader. Two accuracy tests for Georges Bank haddock are conducted each year, using the reference collection of Georges Bank samples ($n \approx 60$; one prior to and one after the production ageing). In addition to these tests, an annual exchange of Georges Bank age samples is conducted with Fisheries and Oceans Canada (DFO) staff to compare age assignments between the age readers (2-4 separate precision tests each year representing a range of sample sources/seasons; $n \approx 50$ within each test).

For the period 2008 to 2010, the precision levels for all haddock (Georges Bank and Gulf of Maine) had an average agreement of 97% and an average CV of 0.5%. The best results showed complete agreement (100%, 0.0% CV) between the ages for each fish; the worst results were 92% agreement and a CV of 1.3%, both on tests of the autumn survey. No bias occurred in any of the tests. All of these results exceed our standards for adequate ages (>80% agreement, <5% CV, and no bias).

Accuracy tests on Georges Bank haddock resulted in an average 94% agreement (1.6% CV). The best result was 96.7% (0.3% CV) for the January 2009 test; the worst result was 88% agreement (4.1% CV) in October 2010.

Exchange results on Georges Bank samples were more variable, in part due to a change in the Canadian age reader between 2009 and 2010. Average precision levels in the exchange were 95% (1.0% CV) for 2009, followed by 78% (3.3% CV) in 2010 and 89% (2.4% CV) in 2011. The best result among the three years was 98.1% (0.5% CV) for survey samples in the 2009 exchange. The worst results were 63% agreement and 4.1% CV, both in 2010 tests of commercial samples. The tests did not reveal the presence of any bias.

The 2003 year class still dominates age samples, but it is unlikely to present issues in the quality of age data. All QA/QC testing has demonstrated that the ages are accurate (as compared with the reference collection) and consistent (both by the NEFSC age reader and in comparison with the DFO age reader). It is unlikely that confusion between the 2003 year-class and neighboring year-classes has occurred.

Full testing results and an explanation of the statistics listed above can be found at http://www.nefsc.noaa.gov/fbp/QA-QC/hd-results.html.

4. Fishery

Commercial landings

Commercial landings of haddock in the region have ranged from a low of 120.1 mt in 1993 to a high of 6317.6 mt in 1980. Between 2006 and 2010, commercial landings have averaged approximately 570 mt annually (table C.1). The commercial fishery has been largely dominated by the US domestic fleet; there have been no foreign landings since 1986. Commercial landings of haddock are dominated by the trawl fleet, though the longline and gillnet fleets land small amounts (table C.2). Gillnet landings contributed a larger proportion of the total landings during the 1980s when minimum mesh sizes ranged from 5 1/8" to 5 1/2". Handline, beam trawl, pot and scallop dredge gear account for the remaining landings.

Length and age samples of US commercial landings were collected through the Northeast Region Port Sampling Program. Sampling of landings are stratified by market category (scrod and large) and quarter. To the extent possible catches-at-age were estimated using the same stratification used to collect the port samples (i.e., by quarter and market category), however in years where available length/age data were insufficient to characterize the catch, quarters were grouped to achieve full length frequency distributions. Prior to 1977 port sampling intensity was low with limited, or no sampling of many markets and quarters. From 1977 on, sampling remained relatively high until the late-1980s when landings began to decline (table C.3). Sampling remained low until 1997 when haddock trip limit restrictions were relaxed and landings increased. Sampling of commercial ages has followed similar trends (table C.4). Commercial age-length keys were supplemented with survey age data as necessary when the number of ages per year was less than 100. This practice was limited to the extent possible.

Commercial landings-at-age were estimated from 1977 to 2010 using the Commercial Data Biostatistical Analysis Program (BioStat) software (NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov/). The length-weight equations presented in equations 1-3 were used. In situations where biological sampling was limited and samples had to be aggregated across semesters, the annual length-weight equation was applied. Resulting commercial landings-at-age and weights at age are presented in tables C.5 and C.6, respectively. A bubble plot of landing-at-age is shown in figure C.8. Uncertainty in the landings-at-age was evaluated through a bootstrap analysis of 1000 realizations (e.g., Legault and Seaver 2007). The catch-at-age coefficients of variation (CV) were generally less than the informal standard of 0.3 for age 4-8. Fish age 4-8 make up the majority of the landings (table C.7). Prior to 1984 individual sampling events can not be identified which precludes estimation of CVs using a bootstrap approach.

Commercial discards

Gulf of Maine haddock are primarily discarded in the commercial fishery because they are below the minimum retention size (table C.8). For the commercial fishery, the minimum size has ranged from 16” to 19” between 1977 and 2010 (table C.9). During the period from 1994 to 1997 when possession limits ranged from 500 to 1,000 lb/day regulatory discards were responsible for >10% of the total discards.

Commercial discards were estimated for four commercial fleets: the large mesh bottom otter trawl (≥ 5.5”), small mesh bottom otter trawl (< 5.5”), benthic longline, sink gillnet, midwater trawl (includes both paired midwater and midwater trawls). For years where direct observations of commercial discards were made by at-sea observers (1989 – present) estimates of commercial discards were calculated using the combined-ratio method (Wigley et al. 2007). For years 1977 to 1989, discards were estimated using the survey-scaling method (Palmer et al. 2008). Prior to 1983, the large mesh otter trawl fishery did not exist due to minimum mesh sizes below the existing large-mesh definition. It was assumed that the primary reason for discards in the period before 1994 was similar to the most recent period, i.e., below minimum size. It is unknown whether groundfish quotas in place in the late 1970’s to early 1980’s resulted in significant discarding of legal sized fish.

Commercial discards average less than 100 mt per year (table C.10). There are two predominant peaks in discards, the first between 1977 and 1978 when there was an abundance of undersized fish and a second from 1994 to 1997 when restrictive trip limits were in place. Discards constitute a minor fraction of total fishery removals with the exception of the 1994 to 1997 period (fig. C.7).

Length and age samples of commercial discards are collected by the Northeast Fisheries Observer Program. The number of individual lengths sampled annually has varied from zero in 1990 to over 900 in 2005 (table C.11). Because of the relative sparseness of discard sampling, a non-fleet specific annual discard length frequency was used to characterize the length distribution of the discarded catch. An examination of the length frequencies by gear type indicates that the gears have similar selectivities, with the exception of the small mesh otter trawl which catches a large proportion of haddock below 25 cm (fig. C.9). Length distributions by gear type over time have been highly variable, reflective of the sparse sampling in many years (fig. C.10). In years where the total number of sampled fish was less than 100, discard length frequencies were supplemented by the length frequency distribution of fish from the NEFSC surveys that were below the minimum size. Age-length keys were supplemented with survey age data in all years. Discards-at-age were estimated from 1977 to the present using the BioStat software (table C.12, fig. C.11). Because of the combined nature of the discard biosampling sources (i.e., discards and survey) analyses of the uncertainty in the discards at age could not be assessed. Commercial weights-at-age are presented in table C.13.

Recreational landings

Gulf of Maine haddock recreational landings (types A and B1 catch) were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS). MRFSS data are available from 1981 onward. Estimation of the numbers-at-age of recreational live releases (B2) was not possible due to very limited sampling of the recreational releases. For this reason type B2 catch could not be fully accounted for and are not included in the assessment. Landings were partitioned among stock complexes using a standard algorithm (S. Steinback pers. comm.). Historically, recreational landings have been a minor component of overall fishery removals, though between 2006 and 2010 they were of a similar magnitude to commercial landings, averaging approximately 603 mt (table C.14). Type B2 recreational catch is has ranged from 19% to 59% of recreational landings in terms of numbers over the last five years.

Recreational length samples were extremely limited prior to 2002 (table C.14). The size distribution of haddock landed by the recreational fishery is similar to those of the commercial longline fishery and from those fish captured in the bottom trawl survey above the recreational minimum size (fig. C.12). Length samples before 2002 were supplemented with length frequency data from these sources. Because no ages were sampled from the recreational fishery, age-length keys were obtained from survey age data for all years. Recreational landings-at-age were estimated from 1981 to the present using the BioStat software (table C.15, fig. C.13). Because of the combined nature of the recreational landings biosampling sources (i.e., MRFSS survey, commercial longline and survey) analyses of the uncertainty in the recreational catch at age could not be assessed nor were weights-at-age calculated.

Total fishery catch at age are presented in table C.16 and figure C.14. Per the convention used in GARM III, the age composition utilizes an age 9 plus group. This decision was based on the increasing imprecision of landings-at-age beyond the age 9 group. The mean catch weights-at-age were calculated using a numbers-weighted average of the commercial landings and discards (table C.17). Minor imputation of the weights-at-age was required for the youngest and oldest age classes. This was performed using a 5-year centered moving average. January 1 stock and spawning stock weights-at-age were estimated from the catch weights-at-age using the Rivard method (table C.18). The method adjusts the catch weights-at-age, which are generally presumed to represent mid-year weights, back to January 1. Mean weights at the beginning of the year for a given age class are calculated as the geometric mean of the weight in the same year and of the same cohort in the previous year. No adjustments are made for the plus group calculation. Calculations for the initial and final years and ages are described in Rivard (1980, 1982). Overall mean weights have declined over the last decade and are currently below their long-term averages (fig. C.15).

5. Research surveys

Survey indices of abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) were estimated from both the NEFSC spring and autumn bottom trawl surveys between 1963 and 2010/11 (spring survey commenced in 1968). The indices include catch data from stations within the NEFSC offshore survey strata 01260 – 01280 and 01360 – 01400 (fig. C.16). Survey indices were adjusted for catchability differences over time due to the effects of changing vessels, trawl doors and survey protocols. The NEFSC bottom trawl survey has utilized three different vessels and three different door configurations throughout the time series of the survey (table C.19). In an effort to maintain a consistent survey time series, survey indices are converted to 'Albatross IV/Polyvalent door' equivalents using several different conversion factors (table C.20). The largest change in the survey time series occurred in 2009 when the FSV Albatross IV was decommissioned and replaced by the FSV Henry B. Bigelow. This resulted in changes not only to the vessel and doors, but also to the overall trawl gear and survey protocols (summarized in table C.21). Calibration experiments to estimate survey differences were conducted in the spring and fall of 2008 (Brown 2009). The results of those experiments were peer reviewed by a panel of external (non-NMFS) experts and are summarized in Miller et al. (2010). These results provided annual calibration coefficients both in terms of abundance (numbers) and biomass (weight). Further work by Brooks et al. (2010) developed length-specific abundance calibration coefficients for haddock. This method uses a segmented regression model where a constant conversion factor is applied to fish ≤ 18 cm and ≥ 51 cm, and a constantly decreasing linear regression is fit to fish between 19 and 50 cm (table C.20).

Indices declined from highs in the mid-1960's to lows in the early 1970's before again increasing during the late 1970's and early 1980's. The period from 1987 to 1992 experienced historically low indices. Increases have been observed between the mid 1990s through the early 2000s due to the contribution of the large 1998 year class. Survey indices have slowly declined since the recent highs in the early 2000s and are currently in the range of survey values observed during the early 1980s (table C.21, figures C.17 and C.18). Survey CVs average between 0.33 and 0.43, with the fall survey generally having higher survey indices and a higher degree of precision (table C.22). The spring 2011 age 1 index provides some indication of a moderately strong year class in 2010, though there is insufficient information available to determine its absolute strength (tables C.23 and C.24, figures C.19 and C.20).

6. Assessment

Model Selection

The ADAPT-VPA model configuration applied at GARM III included catch, survey and biological data for years 1977 through 2007 with a maximum age of 9^+ calibrated using the ADAPT-VPA software, version 2.8.0 (NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov/). Backward computation of fishing mortality on the plus group was employed. The decision to start the VPA at 1977 and plus the ages at 9^+ was made based on the availability of biological sampling and high CVs in the catch at age estimates for the older age classes, respectively. During GARM III several calibration runs were undertaken to assess the sensitivity of the VPA results to inclusion/exclusion of the survey indices at age. The final model configuration included catch at age estimates of ages 1 to 9^+ and survey abundance at age (age 1 and above), however, the spring survey and autumn surveys plus groups began at age-6 and age-8 respectively because of the predominance of zero values in the survey indices of the older age classes (tables C.23 and C.24). The VPA configuration of ages 1-9+ is a departure from the GARM III configuration. There was an inconsistency in the GARM III VPA formulation (ages 0-9^+) and biological reference point/projections (ages 1-9^+). This inconsistency was resolved in this update. The change in configuration had no impact on the overall assessment results. The comparison of an age 0-9^+ configuration to the base model is presented in Appendix C1.

The NEFSC spring and autumn survey series were converted to area swept equivalents prior to inclusion in the model. The area swept conversion assumes a trawl area of 0.0112 nm^2/tow and a total strata area of 14,028 nm^2. Comparatively, the total stock area shown in figure C.1 is 15,708 nm^2. These calculations assume 100% trawl efficiency.

For the 2012 update of the Gulf of Maine haddock assessment all model configuration details were kept identical to the configuration used in GARM III with the exception of the age 1-9^+ formulation noted above.

Model diagnostics and results

Age-specific survey residual plots for the BASE run do not exhibit any evidence of systematic patterning (fig. C.21a-c). BASE run survey catchability coefficients (*q*) were < 1.0 for all but the NEFSC fall ages 6-8^+ indices (fig. C.22; *note the fall ages were lagged forward an age an a year in the model). While the *q* estimates exceed 1 for these older ages, suggestive of > 100% efficiency of the survey, the CVs on these estimates are moderately large (table C.25).

A variant of the retrospective statistic, Mohn's rho (Mohn 1999; equation 4) was used to quantify the relative retrospective bias in terminal year estimates of fishing mortality (F), spawning stock biomass (SSB) and age-1 recruitment. There is a moderate retrospective pattern observable in the terminal year F, SSB and recruitment estimates (fig. C.23-25), however there is no separation of the bootstrap distributions (1000 iterations; fig. C.26) suggesting absence of a strong retrospective pattern (Legault 2009). There is a tendency for the model to underestimate SSB, overestimate F, with recruitment patterns being variable. Annual values of relative differences and Mohn's rho values are reported in table C.26. There is some evidence of a dampening of the retrospective patterns in the most recent years with respect to SSB and F.

$$(4) \qquad \rho = \frac{\left(\sum_{y} \frac{x_{y,tip} - x_{y,ref}}{x_{y,ref}} \right)}{y}$$

The precision of the 2011 (terminal year + 1) stock size at age, SSB in 2010, and F at age in 2010 was evaluated by resampling the errors from 1000 bootstrap realizations. Bootstrapped CVs of the stock size at age are moderately large (>30%) for all ages, notably for age 2 and the 9^+ group (table C.27). The 2010 SSB was estimated at 2,868 mt with a 90% probability of the SSB being between 2,140 mt and 4,233 mt (fig. C.27).

Bootstrapped CVs of F-at-age ranged from 0.34 at age 8 and 9 to 0.69 at age 1 (table C.27). The 2003 year class which is estimated to have been moderately strong (4.2 million fish at age 1) is experiencing high fishing mortality. In the GARM III assessment there was the presence of a weak year class (2000) with a high, but highly uncertain estimate of fishing mortality. The high fishing mortality on this year class inflated the estimates of average F on the full recruited age classes ($F_{6\text{-}8}$) leading to highly unstable estimates of the average $F_{6\text{-}8}$ relative to the numbers-weighted $F_{6\text{-}8}$ (fig. C.28). For this reason, the use of a numbers-weighted average $F_{6\text{-}8}$ was applied in the GARM III assessment. The situation in this current assessment update is exactly the opposite, with a moderately strong year class experiencing high fishing mortality (table C.28). This argues for a return to the use of a straight average $F_{6\text{-}8}$ consistent with other groundfish stocks in the Northeast Region. The 2012 Groundfish Update Integrated Peer Review Panel supported the move to the average $F_{6\text{-}8}$ for the basis of stock status determination. The 2010 average $F_{6\text{-}8}$ was estimated at 0.82 with a 90% probability of being between 0.42 and 1.63 (table C.32, fig. C.29); comparatively, the 2010 numbers-weighted average $F_{6\text{-}8}$ was estimated at 1.04.

Partial recruitment patterns over the past five years have been highly variable (fig. C.31). The patterns are suggestive of a slight doming in fishery selectivity with decreasing selectivity beyond age 7. Fish age 5 and older are at least 50% selected by the fishery. Selectivity patterns have changed over time, with a general decrease in overall selectivity for fish age 3 and younger over time in response to changes in mesh size and minimum retention size (table C.29).

The VPA model results indicate the stock numbers were around 25.5 million fish during the late 1970s and declined to 1.3 million fish by 1991 (table C.30). The high abundances in the late 1970s were driven by the strong year class of 1975 and moderate year classes of 1978 and 1979. Two back-to-back moderate strength year classes in 1993 and 1994 contributed to an increase in population numbers following the lows observed in the late 1980s and early 1990s. A very strong year class developed in 1998. This 1998 year class increased stock numbers above 20 million for the first time since 1980. Stock size declined after the high in 1999, though the contribution of the 2003 year class led to a slight increase in 2004. Since 2004 stock size has declined. With the exception of the 2003 year class, recruitment over the past decade has been poor. Based on the NEFSC spring bottom trawl survey there is some indication of a moderate 2010 year class, though existing information does not suggest it will be a strong year class. Current stock size in 2010 is estimated around 3.5 million fish.

SSB was estimated at approximately 15,000 mt during the early 1980s, declining to a low of approximately 550 mt by 1989 (table C.31). Moderate recruitment during the mid-1990s combined with the strong 1998 year class led to a recent peak in the SSB in 2002 at around 16,700 mt. SSB has since declined as the 1998 year class has been removed from the population. The 2003 year class should have reached near 100% maturity in 2007. 2010 spawning stock biomass is estimated at 2,868 mt, just under the GARM III overfished threshold of 2,950 mt (1/2 B_{MSY}). Fishing mortality rates have been generally increasing over the last decade in response near constant harvest and declining stock numbers (table C.32, fig. C.32). Fishing mortality in 2010 is estimated to have exceed the GARM III overfishing definition of 0.43 (F_{MSY}=$F_{40\%}$)

7. Biological Reference Points

GARM III biological reference points (BRPs) were determined from yield per recruit (YPR) and SSB per recruit (SSBPR) analyses based on mean weight and partial recruitment vectors calculated from an un-weighted average of the most recent five years in the assessment (2003 – 2007; NEFSC 2008). Similar to the treatment in GARM III, fishery selectivity was forced to be ‘flat-topped’ beyond the fully selected age (age 7). All other inputs were time invariant. Given the continued decline in haddock weights-at-age and updates to the maturity ogive and recruitment estimates, BRPs should be updated. It should be noted that applying averages of the recent weights-at-age for the purposes of yield projections could be cause for concern when used for long-term projection. However, without better understanding the underlying cause(s), the current biological parameters are the best indicator of future parameters. Yield per recruit input vectors are presented in table C.33. Results of the YPR/SSBPR analysis are presented in table C.34. Using the same F_{MSY} basis as used in GARM III of $F_{40\%}$, the revised estimate of F_{MSY} is 0.46. This compares to the GARM III estimate of 0.43. Current levels of fishing mortality exceed the revised F-threshold of $F_{40\%}$ regardless of whether the average or numbers-weight $F_{6\text{-}8}$ are used (fig. C.35).
Maximum sustainable yield and SSB_{MSY} were derived from the median values of long-term projections (100 years) of the Age Structured Model Projections (AGEPRO, NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov/) model run at a constant harvest of $F_{40\%}$ = 0.46. Input vectors for the AGEPRO runs are the same as those used for the YPR/SSBR analyses (table C.33). Following on the methods employed in the GARM III assessment, projected recruitment was determined using the cumulative density function (CDF) of a recruitment series that included both VPA-estimated age-1 recruitment and hindcasted recruitment estimates based on NEFSC fall bottom trawl survey age-1 indices. A linear regression was fit to VPA estimates of age 1 recruitment and NEFSC autumn bottom trawl survey indices of abundance of age 1 fish (fig. C.33). Using the regression relationship, recruitment was estimated back to the 1962 year class (fig. C.34). The 2008 GARM BRP Panel recommended a recruitment series that includes VPA estimated recruitment excluding recruitment estimates for years when SSB was less than 3,000 mt in addition to hindcasted recruitment from 1962 to 1976 with the large 1962 year class removed (considered a “bonanza” outlier). The resulting BRP estimates were: SSB_{MSY} = 4,904 mt (90% confidence interval of 2,272 – 10,604 mt), and MSY = 1,117 mt (90% confidence

interval of 553 – 2,563 mt). For comparison, GARM III SSB_{MSY} was estimated at 5,900 mt and MSY was estimated at 1,360 mt. Current SSB is above the revised $B_{threshold}$ value of 2,452 mt (1/2 B_{MSY}; fig. C.36).

Based on the updated 2012 assessment and revised reference points, the stock is not currently overfished, but overfishing is occurring (table C.35, fig. C.37). The 2012 Groundfish Update Integrated Peer Review Panel supported the move to the average $F_{6\text{-}8}$ for the basis of stock status determination for the reasons noted earlier. Accounting for the observed retrospective bias does change stock status with respect to the overfishing definition. However, the revised stock status point does not fall outside the confidence intervals of the un-adjusted point (fig. C.37). The GARM III precedence was to not adjust stock status or projection inputs when the F and SSB estimates revised for retrospective bias do not fall outside the confidence intervals of the model.

8. Projections

Short term projections of future stock status were conducted based on the current assessment results without accounting for retrospective bias. This rationale was identical to that of stock status determination. Numbers-at-age in 2011 were derived from 1000 different bootstrap iterations of the VPA model. Short term projections have assumed catch in 2011 to be equal to the catch in 2010 (i.e., 1,309 mt). This is a reasonable assumption given that the 2011 ABC is nearly identical to the 2010 ABC (Δ=51 mt). Recruitment was sampled from a cumulative density function (CDF) of the same recruitment inputs used in BRP determination. This recruitment series omits recruitment estimates when SSB < 3,000 mt. While 2010 SSB is estimated at 2,928 mt, below the <3,000 mt threshold, the 2012 Groundfish Update Integrated Peer Review Panel felt that it was important to retain consistency between the recruitment stream used in reference points and that used for short term projections. Projections were run under two different F assumptions: $F_{MSYproxy} = F_{40\%} = 0.47$, and $F_{75\%FMSY} = 0.35$. Projection results are summarized in terms of median SSB and fishery catch (yield) under both scenarios outlined above in table C.36. Under all scenarios SSB is projected to drop below $B_{threshold}$ from 2011-2014.

9. Conclusions

Gulf of Maine haddock stock status
SSB in 2010 is estimated to be 2,868 mt.
F in 2010 is estimated to be 0.82.

Revised estimates of the biological reference points are:
SSBmsy proxy= 4,904 mt,
Fmsy proxy = 0.46, and
MSY proxy= 1,177 mt.

Based on these results, the Gulf of Maine haddock stock is not overfished and overfishing is occurring. The stock is below the biomass target. This represents a change from GARM III status when the stock was not experiencing overfishing.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15) with the exception that the model was configured with ages 1-9^+ rather than the age 0-9^+ configuration used in GARM III. A sensitivity run was examined showing that the change in configuration had no impact on assessment results.

The BRPs are based on the following updates: average of the most recent 5 years of weights, maturity, and selectivity at age, the same approach used in GARM 2008

Sources of Uncertainty

Sources of uncertainty in the current assessment include: 1) assumption of 100% survival in the recreational released live catch (type B2); 2) use of the weights-at-age from the recent five years for long term projections, 3) expectation of median recruitment in the near future, and 4) differences between MRFSS-based recreational landings and recreational landings re-estimated using the new Marine Recreational Information Program (MRIP) statistical design. With respect to the last area of uncertainty, the 2012 Groundfish Update Integrated Peer Review Panel recommended that a sensitivity of the assessment results to the MRIP-based recreational landings estimates be conducted. These sensitivity analyses are presented in Appendix C2. In general, use of MRIP recreational landings does not alter stock status determination and has negligible influence on estimates of spawning stock biomass and recruitment. There is a slight decrease in the 2010 fishing mortality estimate compared to the BASE assessment results, but the 2010 $F_{6\text{-}8}$ based on the MRIP sensitivity run is still above the overfishing threshold.

GOM Haddock. Summary of Assessment Information

GOM Haddock	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Rec Landings (mt)	190	166	192	430	717	504	628	611	531	743	181	0	743	1981-'10
Comm Landings (mt)	929	977	1023	946	962	618	674	508	486	561	1871	120	6318	1964-'10
Discards (mt)	27	24	23	27	37	49	50	12	14	5	40	1	368	1977-'10
Catch (mt)	1147	1166	1237	1403	1716	1172	1352	1132	1031	1309	2015	217	6339	1964-'10
F avg 6-8	0.19	0.18	0.15	0.14	0.19	0.19	0.23	0.26	0.53	0.82	0.53	0.14	3	1977-'10
SSB (mt)	12525	16757	14741	12545	10125	7958	6796	4481	3864	2868	6940	543	16757	1977-'10
Recruits (000's)	1197	1070	82	4193	482	1236	2130	287	289	433	2237	82	15112	1977-'10

10. Panel discussion/comments

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

At GARM III a numbers-weighted F was recommended. The basis for this recommendation was there was a single age group in the fully recruited ages which had an unusually high mortality rate. This situation is not present in the current assessment and the Panel supported adoption of an average F, rather than the numbers-weighted F used in the previous assessment. This is consistent with the calculation of fully recruited fishing mortality in other NE groundfish stocks.

Recreational landings are a large portion of the landings. Differences exist between the MRFSS and preliminary MRIP estimates, although the differences are not systematic. A sensitivity run using preliminary MRIP estimates of recreational landings (although same proportion at age) indicated no change to stock status.

Based on the projections, the stock SSB has declined below the threshold and is overfished in 2011. Estimates of the 2006 and 2005 yearclasses were revised downward from the GARM III assessment and the 2007-2009 yearclasses are well below the median. The panel discussed the episodic nature of recruitment in this stock and the implications for rebuilding.

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Tables

Table C.1. Total catch of Gulf of Maine haddock between 1977 and 2010.

Year	Foreign landings (mt)	US recreational landings (mt)	US commercial discards (mt)	US commercial landings (mt)	Total (mt)
1964	70.0			5378.8	5378.8
1965	159.0			4154.7	4154.7
1966	1125.0			4524.0	4524.0
1967	589.0			4852.2	4852.2
1968	120.0			3417.3	3417.3
1969	290.0			2404.6	2404.6
1970	105.0			1435.8	1435.8
1971	112.0			1190.2	1190.2
1972	27.0			912.3	912.3
1973	49.0			526.0	526.0
1974	207.0			628.8	628.8
1975	83.0			1180.2	1180.2
1976	91.0			1834.5	1834.5
1977	26.0		78.7	3230.1	3308.8
1978	641.0		47.6	4382.5	4430.1
1979	257.0		18.0	4130.6	4148.6
1980	203.0		21.7	6317.6	6339.3
1981	513.0	36.3	19.4	5720.4	5776.1
1982	1278.0	30.9	15.3	5637.0	5683.2
1983	2003.0	57.6	17.9	5593.4	5668.9
1984	1245.0	49.4	21.4	2792.8	2863.6
1985	791.0	30.7	17.3	2234.3	2282.3
1986	225.0	55.0	8.0	1590.4	1653.3
1987		29.7	1.2	829.2	860.0
1988		12.1	1.5	416.2	429.8
1989		9.5	8.7	263.8	282.0
1990		2.9	2.4	433.3	438.6
1991		0.4	4.1	430.9	435.4
1992		0.0	19.1	311.8	330.9
1993		0.5	29.7	193.0	223.2
1994		3.8	93.5	120.1	217.4
1995		175.1	127.6	173.0	475.7
1996		6.6	106.5	246.6	359.7
1997		31.6	368.2	588.6	988.4
1998		44.5	24.1	885.2	953.8
1999		19.2	2.9	542.5	564.6
2000		127.6	37.9	737.9	903.4
2001		190.3	27.1	929.1	1146.5
2002		165.9	23.6	976.9	1166.4
2003		191.8	22.6	1023.0	1237.4
2004		429.6	26.6	946.5	1402.7
2005		717.1	37.4	961.5	1716.0
2006		503.9	49.4	618.2	1171.5
2007		627.9	50.2	673.7	1351.8
2008		611.4	12.4	508.5	1132.3
2009		531.0	13.8	486.0	1030.8
2010		743.2	4.6	561.1	1308.9

Table C.2. United States commercial landings of Gulf of Maine haddock by primary gear type between 1964 and 2010.

Year	Otter trawl (mt)	Benthic longline (mt)	Sink gillnet (mt)	Other (mt)	Total landings (mt)
1964	4690	528	156	6	5379
1965	3309	687	147	12	4155
1966	4107	335	79	3	4524
1967	4621	161	64	6	4852
1968	3285	94	33	5	3417
1969	2227	104	74	1	2405
1970	1155	211	68	2	1436
1971	850	260	77	4	1190
1972	440	375	95	2	912
1973	235	205	85	1	526
1974	456	127	45	1	629
1975	1016	90	74	0	1180
1976	1552	38	244	1	1835
1977	2576	102	552	1	3230
1978	3564	84	734	1	4382
1979	3362	52	715	1	4131
1980	4836	72	1387	23	6318
1981	4560	75	1085	0	5720
1982	5293	7	332	5	5637
1983	4906	16	654	17	5593
1984	2360	12	410	11	2793
1985	1885	9	247	93	2234
1986	1361	9	184	37	1590
1987	653	11	159	6	829
1988	252	14	145	5	416
1989	150	2	101	10	264
1990	333	10	85	5	433
1991	357	7	62	4	431
1992	257	13	40	1	312
1993	160	6	26	0	193
1994	84	9	27	0	120
1995	93	37	38	5	173
1996	162	43	39	3	247
1997	464	69	55	1	589
1998	705	81	68	31	885
1999	438	22	79	4	543
2000	588	21	123	6	738
2001	813	8	104	3	929
2002	690	30	242	15	977
2003	810	87	82	45	1023
2004	707	81	128	30	946
2005	592	144	93	132	962
2006	384	138	79	18	618
2007	410	180	67	17	674
2008	394	49	51	14	508
2009	346	38	73	28	486
2010	446	37	41	38	561

Table C.3. Number of lengths sampled from commercially landed Gulf of Maine haddock by market category and quarter between 1977 and 2010. The blue and grey shaded cells indicate where quarterly samples have been aggregated when length sampling was insufficient to support quarterly stratification.

Year	Large				Scrod				Total lengths	Commercial landings (mt)	Metric tons/100 lengths
	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4			
1977		197	358		382	511	481	569	2498	3230.1	129.3
1978	149	35	200		223	322	179	203	1311	4382.5	334.3
1979	195		124	100	114			66	599	4130.6	689.6
1980		319	102		51	175	257	201	1105	6317.6	571.7
1981		52	257	638	53	358	514	381	2253	5720.4	253.9
1982	103		1361	104	473	53	273	154	2521	5637.0	223.6
1983	249	868	1317	496	312	308	340	203	4093	5593.4	136.7
1984		79	828	391	187	94	139	113	1831	2792.8	152.5
1985	347	597	573	536	353	202	298	84	2990	2234.3	74.7
1986	283	234	789	271	181	242	207	204	2411	1590.4	66.0
1987	214	102	515	405	162	79	75	136	1688	829.2	49.1
1988	91		100	202	261	50	42		746	416.2	55.8
1989			65	118	99			129	411	263.8	64.2
1990	34			100	41	50		50	275	433.3	157.6
1991		146	216	213	57		179	212	1023	430.9	42.1
1992	121			19	107		53	111	411	311.8	75.9
1993	combined 1992 & 1994 and ran annual				103	56	125		284	193.0	68.0
1994		100	52	297				219	668	120.1	18.0
1995	62				194				256	173.0	67.6
1996	77			427		92		100	696	246.6	35.4
1997	120	255	497	355		124	358	147	1856	588.6	31.7
1998	309	111	78	313	689	49	156	35	1740	885.2	50.9
1999	117		300	211			214	102	944	542.5	57.5
2000	488	313	339	107	414	259	105	287	2312	737.9	31.9
2001	528	93	207	579	353	108	66	847	2781	929.1	33.4
2002	729	210		262	348	143	247	161	2100	976.9	46.5
2003	792	348	1282	1043	485	216	716	513	5395	1023.0	19.0
2004	1898	942	101	601	1021	1085	262	451	6361	946.5	14.9
2005	1313	325	573	752	661	449	733	769	5575	961.5	17.2
2006	1193	687	453	617	928	535	569	514	5496	618.2	11.2
2007	817	348	1016	616	781	360	768	400	5106	673.7	13.2
2008	789	472	351	141	566	466	348	295	3428	508.5	14.8
2009	1248	409	142	181	568	306	135	119	3108	486.0	15.6
2010	1018	214	187	614	600	239	135	156	3163	561.1	17.7

Table C.4. Number of ages sampled from commercially landed Gulf of Maine haddock by market category and quarter between 1977 and 2010. Italicized ‘combined’ cells indicate where age-length-keys were augmented with age information from NEFSC bottom trawl surveys.

	Large				Scrod				Combined				Total ages	Commercial landings (mt)	Metric tons/100 ages
Year	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4			
1977		40	57		112	155	175	220	112	195	232	220	1421	3230.1	227.3
1978	40	20	39		80	115	50	49	120	135	89	49	687	4382.5	637.9
1979	48		25	45	30			16	*78*		*25*	*61*	210	4130.6	1966.9
1980		58	20		17	39	68	46	17	97	88	46	418	6317.6	1511.4
1981		15	61	147	14	105	124	80	14	120	185	227	869	5720.4	658.3
1982	20		284	21	103	14	75	45	123	14	359	66	799	5637.0	705.5
1983	65	214	225	110	90	90	77	43	155	304	302	153	1214	5593.4	460.7
1984		21	229	94	47	31	47	31	*47*	*52*	276	125	656	2792.8	425.7
1985	95	140	135	148	95	64	95	10	190	204	230	158	1046	2234.3	213.6
1986	49	61	149	55	54	75	58	61	103	136	207	116	810	1590.4	196.3
1987	36	24	125	105	40	14	28	45	76	38	153	150	544	829.2	152.4
1988	18		17	39	86		15		104		*32*	*39*	276	416.2	150.8
1989			16	15	58			27	*58*		*16*	*42*	201	263.8	131.3
1990	28			22	15	16		15	*43*	*16*		*37*	142	433.3	305.2
1991		32	37	40	16		80	47	*16*	*32*	117	87	395	430.9	109.1
1992	20			18	20		15	65	*40*		*15*	*83*	238	311.8	131.0
1993					20	23	49		*20*	*23*	*49*		184	193.0	104.9
1994		26	21	124				72		*26*	21	196	315	120.1	38.1
1995	28				58				*86*				144	173.0	120.2
1996	25			91		13		18	*25*	*13*		109	178	246.6	138.6
1997	23	79	130	81		22	69	56	23	101	199	137	607	588.6	97.0
1998	45	24	23	145	82	21	41	21	127	45	64	166	567	885.2	156.1
1999	13		76	70	20		67	35	*33*		143	105	403	542.5	134.6
2000	136	88	98	38	148	93	57	91	284	181	155	129	1138	737.9	64.8
2001	143	33	71	177	99	39	18	197	242	72	89	374	1130	929.1	82.2
2002	264	71		92	159	47	24	66	423	118	24	158	1019	976.9	95.9
2003	250	88	431	274	161	90	308	199	411	178	739	473	2559	1023.0	40.0
2004	500	142		41	283	206	33	41	783	348	33	82	1809	946.5	52.3
2005	251	48	211	314	157	122	274	246	408	170	485	560	2422	961.5	39.7
2006	634	165	287	255	444	268	294	225	1078	433	581	480	3803	618.2	16.3
2007	392	166	501	322	391	172	387	193	783	338	888	515	3667	673.7	18.4
2008	424	309	205	69	261	226	168	149	685	535	373	218	2615	508.5	19.4
2009	720	293	141	106	273	150	77	70	993	443	218	176	2400	486.0	20.3
2010	619	117	133	292	322	75	51	47	941	192	184	339	2151	561.1	26.1

Table C.5. Gulf of Maine haddock commercial landings-at-age between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9^{+}	Total
1977	0.0	43.8	1747.2	51.1	365.0	215.0	143.6	4.8	1.6	6.3	2578.4
1978	0.0	0.0	337.7	1958.4	181.2	320.3	154.6	32.0	0.0	4.6	2988.8
1979	0.0	7.5	81.4	613.5	1348.8	200.5	105.5	32.4	23.8	0.0	2413.4
1980	0.0	0.0	861.6	109.8	754.9	1235.8	165.4	134.1	11.5	25.3	3298.4
1981	0.0	0.0	1458.3	641.3	266.8	356.8	498.2	69.1	96.8	12.1	3399.4
1982	0.0	67.0	440.7	1245.1	510.4	80.5	225.1	400.0	89.6	59.6	3118.0
1983	0.0	0.0	6.4	595.4	712.7	588.9	109.1	184.0	251.0	86.8	2534.3
1984	0.0	0.0	44.7	32.0	409.8	173.1	247.3	43.1	48.9	99.7	1098.8
1985	0.0	0.0	16.6	236.1	62.2	267.1	107.9	173.4	34.7	37.6	935.4
1986	0.0	0.0	0.0	153.7	287.7	63.4	97.5	73.8	88.0	11.4	775.4
1987	0.0	0.0	2.3	16.2	90.4	48.9	33.1	51.9	37.5	17.1	297.4
1988	0.0	0.0	0.0	12.7	9.8	52.9	38.2	9.0	20.5	4.3	147.5
1989	0.0	0.0	15.7	3.4	48.5	16.5	21.2	16.1	1.7	0.8	124.0
1990	0.0	0.0	1.9	133.3	1.8	24.1	17.7	28.2	3.4	0.0	210.4
1991	0.0	0.0	26.6	47.7	61.6	17.7	19.2	13.0	2.7	2.2	190.7
1992	0.0	0.0	7.4	88.9	36.3	23.3	2.4	2.3	0.0	1.1	161.8
1993	0.0	0.0	11.7	25.4	29.8	17.6	5.9	6.4	0.0	0.0	96.7
1994	0.0	0.0	5.3	29.5	9.4	1.7	6.9	4.5	1.0	0.6	58.9
1995	0.0	0.0	1.8	5.7	30.8	9.4	5.0	5.0	3.0	2.8	63.5
1996	0.0	0.0	2.4	53.3	53.0	14.0	4.3	6.1	5.3	0.8	139.2
1997	0.0	0.0	2.4	82.7	104.6	53.4	12.7	4.2	1.0	1.2	262.3
1998	0.0	0.0	11.8	20.0	111.3	171.5	50.3	16.4	7.3	7.2	395.7
1999	0.0	0.0	0.3	41.4	60.5	89.8	60.5	30.6	6.7	6.0	295.8
2000	0.0	0.0	3.6	27.9	84.2	53.3	114.7	49.8	26.3	13.9	373.7
2001	0.0	0.0	7.8	148.0	101.3	72.4	67.6	64.4	31.8	20.7	513.9
2002	0.0	0.0	0.0	11.0	176.5	89.9	90.8	28.5	53.3	56.7	506.8
2003	0.0	0.0	0.0	2.3	29.8	344.9	70.2	51.5	18.0	60.4	577.1
2004	0.0	0.0	0.0	2.1	19.8	42.9	344.7	52.6	24.6	40.9	527.6
2005	0.0	0.0	0.0	1.4	18.3	41.9	68.7	310.7	35.8	53.8	530.6
2006	0.0	0.0	0.0	8.0	0.3	20.5	35.4	39.7	200.7	40.9	345.5
2007	0.0	0.0	0.1	1.5	97.1	5.4	26.4	21.6	47.6	216.6	416.3
2008	0.0	0.0	0.6	18.9	8.3	173.3	1.7	18.4	13.0	99.5	333.8
2009	0.0	0.0	0.0	2.2	14.6	5.6	142.0	2.6	16.6	85.6	269.3
2010	0.0	0.0	0.5	0.5	16.9	26.5	9.2	168.7	2.2	84.6	309.0

Table C.6. Gulf of Maine haddock average weights-at-age of commercial landings between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
1977		0.124	0.760	1.142	2.014	2.624	3.302	4.664	5.980			7.291		4.778	1.253	
1978			0.783	1.220	1.776	2.423	2.950	4.135				5.980				
1979		0.596	0.806	1.223	1.797	2.247	2.535	2.829	3.293							
1980			0.760	1.253	1.873	2.389	3.288	3.376	3.989			4.359				
1981			0.681	1.489	1.970	2.520	3.280	3.840	4.188	3.482				4.074	4.017	
1982		0.351	0.644	0.998	2.142	2.560	3.102	3.648	4.260	4.296	3.838	4.153	4.311		3.269	
1983			0.878	1.200	1.732	2.375	2.963	3.379	3.719	4.185	4.266	4.456	3.653			
1984			0.959	1.243	1.804	2.303	3.158	3.948	4.414	4.118	4.074	5.221	2.549	4.695		
1985			1.142	1.103	1.909	2.356	2.655	3.573	4.116	4.495	3.949	6.339	5.073			
1986				1.221	1.456	2.281	2.495	3.051	3.632	4.636	4.158					
1987			1.059	1.299	1.995	2.431	2.618	3.364	4.186	4.991	5.572	5.559				
1988				1.231	1.494	2.654	2.337	3.649	4.894	4.811	6.089					
1989			1.269	1.850	1.667	2.507	2.304	3.378	4.474	4.331						
1990			0.800	1.523	3.361	2.361	2.962	3.628	3.506							
1991			1.347	1.485	2.490	2.960	2.964	3.307	4.245	3.372						
1992			1.401	1.711	1.916	2.679	2.936	2.918		2.803						
1993			1.092	1.399	1.919	2.521	3.165	3.907								
1994			1.155	1.659	2.175	2.624	2.814	3.350	3.545	2.795	4.897	3.989				
1995			1.565	1.777	2.056	2.610	3.725	4.575	5.150	4.692	4.331	6.312				
1996			1.605	1.399	1.802	2.224	3.128	2.396	2.120	3.190						
1997			1.240	2.135	2.019	2.526	3.203	3.417	3.937	4.020	4.311	2.549				
1998			1.236	1.530	1.890	2.254	2.857	3.378	3.124	2.861	2.880	4.778				
1999			0.919	1.324	1.704	1.717	1.935	2.349	3.103	3.295		3.442	3.229	4.416		
2000			1.301	1.223	1.543	1.843	2.068	2.374	2.611	2.959	3.493		3.309	4.426	3.390	
2001			1.151	1.388	1.518	1.814	2.251	2.276	2.457	2.454	2.771	2.369				3.442
2002				1.231	1.411	1.682	2.206	2.668	2.457	2.617	2.943	3.471	5.895			
2003				1.022	1.361	1.554	1.868	2.194	2.537	2.582	2.577	2.345	2.826	2.149	3.989	
2004				1.038	1.391	1.441	1.736	2.111	2.167	2.298	2.156	2.284	2.326	3.500		
2005				1.060	1.232	1.586	1.552	1.813	2.024	2.194	2.592	2.334	2.860	2.456	2.549	
2006				1.143	1.365	1.494	1.778	1.636	1.809	2.001	2.174	2.673	2.275	2.396	2.350	2.549
2007			0.812	1.163	1.236	1.238	1.626	1.682	1.672	1.755	1.864	2.124	3.029	2.401	2.109	3.004
2008			1.061	1.162	1.232	1.384	1.496	1.793	1.778	1.662	1.795	1.950	1.913	2.990		
2009				1.131	1.235	1.381	1.730	1.677	2.021	2.151	1.985	2.020	2.339	1.775	2.133	
2010			1.130	0.994	1.155	1.433	1.663	1.785	2.172	2.183	2.273	2.103	2.113	2.265	3.511	2.488

Table C.7. Coefficients of variation (CV) associated with the estimates of Gulf of Maine haddock commercial landings-at-age of between 1984 and 2010. CVs could not be estimated prior to 1984 due to the inability to uniquely identify biological samples of commercial landings.

Year	Age0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1984			0.23	0.09	0.09	0.11	0.03	0.09	0.12	0.09	0.27	0.53	0.17	0.25		
1985			0.18	0.10	0.16	0.08	0.11	0.05	0.11	0.16	0.18	1.28	0.79			
1986				0.07	0.06	0.05	0.04	0.04	0.08	0.17	0.24					
1987			0.41	0.19	0.07	0.05	0.07	0.05	0.08	0.10	0.19	0.46				
1988				0.34	0.23	0.31	0.46	0.31	0.45	0.55	0.65					
1989			0.79	1.02	0.43	0.41	0.38	0.32	0.93	1.13						
1990			0.85	0.24	1.07	0.50	0.48	0.52	1.04							
1991			0.54	0.26	0.13	0.25	0.23	0.24	0.52	0.85						
1992			0.89	0.19	0.40	0.57	0.73	1.01		1.43						
1993			0.18	0.18	0.19	0.25	0.28	0.49								
1994			0.17	0.10	0.27	0.38	0.31	0.23	0.47	1.09	1.13	0.88				
1995				0.74	0.14	0.44	0.42	0.35	0.44	8.11	0.99	0.61				
1996			0.85	0.26	0.24	0.34	0.31	0.45	0.76	1.06						
1997			0.99	0.12	0.14	0.13	0.26	0.24	0.37	0.35	0.77	1.15				
1998			0.83	0.30	0.14	0.11	0.19	0.36	0.37	0.61	1.24	1.38				
1999				0.28	0.21	0.20	0.23	0.22	0.37	0.55		1.12	0.97	1.43		
2000			0.54	0.24	0.16	0.12	0.11	0.17	0.26	0.52	0.65		0.87	0.70	0.77	
2001			0.45	0.10	0.10	0.16	0.11	0.15	0.22	0.37	0.53	0.92				1.10
2002				0.44	0.08	0.15	0.13	0.24	0.17	0.21	0.28	0.48	1.36			
2003				0.81	0.19	0.05	0.11	0.14	0.19	0.15	0.18	0.46	0.40	0.75	1.28	
2004				0.68	0.47	0.17	0.04	0.12	0.19	0.26	0.28	0.31	0.46	0.99		
2005				0.73	0.27	0.15	0.10	0.03	0.15	0.17	0.27	0.29	0.27	0.73	1.21	
2006				0.25	0.76	0.16	0.13	0.09	0.04	0.12	0.18	0.30	0.22	0.33	0.55	1.34
2007			1.33	0.52	0.08	0.35	0.14	0.14	0.10	0.04	0.18	0.25	0.50	0.59	0.59	1.36
2008			1.22	0.33	0.30	0.07	0.44	0.15	0.18	0.17	0.09	0.26	0.46	0.97		
2009				0.59	0.24	0.31	0.05	0.38	0.12	0.19	0.15	0.09	0.32	0.47	1.06	
2010			1.21	1.08	0.20	0.16	0.26	0.06	0.37	0.18	0.18	0.21	0.13	0.40	0.64	1.43
Average			0.69	0.38	0.25	0.22	0.23	0.25	0.32	0.74	0.43	0.61	0.53	0.69	0.87	1.31

Table C.8. Discard reason by year described as the fractional occurrence of the total observed hauls with discard reasons recorded by observers and at-sea monitors between 1989 and 2010. The predominant discard reason for each year is highlighted in bold.

Year	Other/unknown	No Market	Poor quality	Regulatory, other	Regulatory, below minimum size	High grading	Count of observed hauls with discard reason available
1989	**0.625**	0.000	0.375	0.000	0.000	0.000	16
1990	**0.800**	0.000	0.200	0.000	0.000	0.000	10
1991	**0.841**	0.000	0.159	0.000	0.000	0.000	44
1992	**0.837**	0.000	0.163	0.000	0.000	0.000	49
1993	**0.848**	0.030	0.121	0.000	0.000	0.000	66
1994	**0.425**	0.050	0.000	0.200	0.325	0.000	40
1995	0.015	0.067	0.030	0.336	**0.552**	0.000	134
1996	0.000	0.025	0.058	0.133	**0.725**	0.058	120
1997	0.000	0.132	0.019	0.170	**0.679**	0.000	53
1998	0.118	0.000	0.118	0.000	**0.765**	0.000	17
1999	0.000	0.059	**0.471**	0.294	0.176	0.000	17
2000	0.022	0.156	0.244	0.000	**0.578**	0.000	45
2001	0.000	0.014	0.056	0.000	**0.931**	0.000	72
2002	0.000	0.088	0.165	0.077	**0.670**	0.000	91
2003	0.004	0.063	0.091	0.012	**0.831**	0.000	254
2004	0.000	0.037	0.137	0.097	**0.730**	0.000	300
2005	0.005	0.016	0.143	0.040	**0.795**	0.000	552
2006	0.006	0.000	0.078	0.028	**0.888**	0.000	179
2007	0.000	0.034	0.087	0.034	**0.846**	0.000	208
2008	0.000	0.014	0.096	0.089	**0.801**	0.000	146
2009	0.000	0.006	0.256	0.028	**0.711**	0.000	180
2010	0.000	0.023	0.128	0.174	**0.674**	0.000	86

Table C.9. Gulf of Maine haddock minimum size limits for the commercial and recreational fishery from 1977 to 2010. Prior to 1977 there were no federal minimum size limits for either fishery. Values in italics are assumed pending clarification of regulations under the initial Groundfish Fishery Management Plan.

Year	Commercial minimum size limit (total length, inches)	Recreational minimum size limit (total length, inches)	Management action
1977	16	*15*	Groundfish Fishery Management Plan
1978	16	*15*	
1979	16	*15*	
1980	16	*15*	
1981	16	*15*	
1982	16	*15*	
1983	17	15	Interim' Groundfish Fishery Management Plan
1984	17	15	
1985	17	15	
1986	17	15	
1987	19	17	Amendment 1
1988	19	17	
1989	19	19	
1990	19	19	
1991	19	19	
1992	19	19	
1993	19	19	
1994	19	19	Amendment 5
1995	19	19	
1996	19	19	
1997	19	19	
1998	19	19	
1999	19	19	
2000	19	19	
2001	19	19	
2002	19	23	Framework 33
2003	19	21	Framework 22
2004	19	19	Amendment 13
2005	19	19	
2006	19	19	
2007	18	19	Emergency action (August 10, 2007 through August 10, 2008)
2008	18	19	
2009	18	18	Amendment 16

Table C.10. Commercial discards of Gulf of Maine haddock by primary gear type between 1977 and 2010. Values prior to 1989 were estimated using a hindcasting procedure. Coefficients of variation (CVs) are provided in italics.

Year	Large mesh otter trawl (≥ 5.5" mesh)			Small mesh otter trawl (< 5.5" mesh)			Sink gillnet			Benthic longline			Midwater trawl			Total	
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	CV
1977	0.0			39.0			14.3			25.3			0.1			78.7	
1978	0.0			25.8			11.8			9.9			0.0			47.6	
1979	0.0			11.2			3.3			3.4			0.0			18.0	
1980	0.0			14.5			4.4			2.8			0.0			21.7	
1981	0.0			11.9			4.7			2.9			0.0			19.4	
1982	8.5			3.1			2.7			1.0			0.0			15.3	
1983	10.4			3.5			3.1			0.9			0.0			17.9	
1984	12.4			3.7			4.7			0.6			0.0			21.4	
1985	10.9			2.5			3.3			0.7			0.0			17.3	
1986	4.7			1.0			1.8			0.5			0.0			8.0	
1987	0.7			0.1			0.3			0.1			0.0			1.2	
1988	0.8			0.1			0.5			0.1			0.0			1.5	
1989	5.8	37	*0.91*	0.0	23	*0.97*	2.9	84	*0.50*							8.7	*0.62*
1990	0.5	26	*1.10*	0.0	8		1.9	120	*0.43*							2.4	*0.41*
1991	2.3	48	*0.62*	0.0	29		1.4	801	*0.31*	0.4	2	*1.20*				4.1	*0.38*
1992	18.0	44	*0.66*	0.0	15		1.0	896	*0.25*	0.0	9					19.1	*0.62*
1993	26.3	17	*0.53*	0.0	6		3.4	560	*0.34*	0.0	2					29.7	*0.47*
1994	85.8	6	*0.56*				7.6	85	*0.44*							93.5	*0.52*
1995	121.4	25	*0.37*	0.5	30	*0.34*	5.7	69	*0.39*				0.0	4		127.6	*0.36*
1996	85.9	11	*0.69*	2.4	40	*0.19*	18.3	46	*0.50*							106.5	*0.57*
1997	368.0	5	*1.65*	0.0	3		0.3	33	*1.08*							368.2	*1.65*
1998	20.9	6	*0.42*				3.2	78	*0.64*							24.1	*0.37*
1999	1.3	21	*1.47*	0.2	11	*0.47*	1.3	73	*0.53*				0.0	2		2.9	*0.70*
2000	30.0	79	*0.59*				7.9	81	*0.44*				0.0	3		37.9	*0.47*
2001	13.1	113	*0.51*	8.3	4	*0.71*	5.7	47	*0.31*							27.1	*0.34*
2002	11.1	149	*0.32*	0.8	35	*0.53*	11.8	80	*0.36*	0.0	1		0.0	1		23.6	*0.24*
2003	11.2	253	*0.20*	0.3	19	*0.56*	5.8	295	*0.19*	5.3	14	*0.46*	0.0	28		22.6	*0.16*
2004	20.1	258	*0.30*	0.7	67	*0.89*	3.9	775	*0.20*	0.5	8	*0.37*	1.5	68	*0.55*	26.6	*0.23*
2005	14.5	498	*0.21*	0.1	69	*0.54*	4.5	651	*0.14*	17.0	58	*0.26*	1.2	70	*0.34*	37.4	*0.15*
2006	38.8	206	*0.50*	0.2	24	*0.43*	3.2	128	*0.23*	7.1	36	*0.35*	0.0	10	*1.07*	49.4	*0.40*
2007	4.8	234	*0.28*	0.5	19	*0.37*	25.1	118	*0.78*	18.5	36	*0.39*	1.3	7	*1.02*	50.2	*0.42*
2008	5.3	260	*0.40*	0.7	15	*0.16*	2.7	150	*0.28*	3.7	20	*0.47*	0.0	14		12.4	*0.23*
2009	3.0	428	*0.34*	0.4	27.5	*0.74*	6.4	276	*0.27*	4.0	35	*0.81*	0.0	32		13.8	*0.28*
2010	2.6	685	*0.27*	0.4	36.5	*0.62*	1.2	1239	*0.17*	0.3	52	*0.40*	0.0	35	*0.82*	4.6	*0.17*

Table C.11. Summary of Gulf of Maine length sampling (number of lengths) of commercial discards by observers and at-sea monitors between 1989 and 2010 by gear type and semester.

Year	Longline		Large mesh otter trawl		Small mesh otter trawl		Sink gillnet		Midwater trawl		Total		Annual
	1	2	1	2	1	2	1	2	1	2	1	2	
1989			1	8							1	8	9
1990													0
1991								1			0	1	1
1992			10	12				1			10	13	23
1993			8	44			2	1			10	45	55
1994			7	12			1	18			8	30	38
1995			210	201		16	7	6			217	223	440
1996			46	13	21	3	25	12			92	28	120
1997			737	3			1	2			738	5	743
1998			10				2	1			12	1	13
1999				5		6		18			0	29	29
2000				10			6	2			6	12	18
2001			24	16	1		5				30	16	46
2002			4	49		40	35	3			39	92	131
2003	105		96	116		22	45	56			246	194	440
2004	23		39	194		121	58	64		35	120	414	534
2005	207	7	202	228		18	14	87	19	128	442	468	910
2006	140		219	81	4	3		5			363	89	452
2007	299		118	91		8	14	10	32		463	109	572
2008	63		32	185			3	3			98	188	286
2009	127		79	17		10	91	1			297	28	325
2010	11		25	55		3	3	35			39	93	132

Table C.12. Gulf of Maine haddock commercial discards-at-age between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+	Total
1977	8.2	504.6	44.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	557.0
1978	9.9	3.1	95.8	1.2	0.0	0.0	0.0	0.0	0.0	1.0	110.9
1979	46.5	62.0	6.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	115.7
1980	76.6	121.9	3.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	202.4
1981	3.8	164.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	170.7
1982	178.9	10.8	15.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	206.0
1983	2.5	76.1	10.0	7.3	0.1	0.0	0.0	0.0	0.0	0.0	96.0
1984	0.0	11.4	43.2	1.0	1.9	0.0	0.0	0.0	0.0	0.0	57.4
1985	0.2	3.1	8.3	21.4	0.0	0.0	0.0	0.0	0.0	0.0	33.0
1986	10.0	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9
1987	14.6	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.8
1988	0.0	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5
1989	0.0	3.4	7.1	0.8	1.7	0.0	0.0	0.0	0.0	0.0	13.0
1990	4.5	4.5	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	10.8
1991	9.2	7.9	2.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	19.8
1992	4.8	20.4	11.0	4.8	0.1	0.0	0.0	0.0	0.0	0.0	41.0
1993	15.7	12.4	17.8	3.1	1.8	0.2	0.6	0.1	0.4	0.6	52.7
1994	60.4	89.9	17.8	21.4	3.9	1.5	3.2	2.0	0.3	0.4	200.8
1995	0.9	50.1	58.5	42.0	14.5	1.6	0.9	0.6	0.0	0.0	169.1
1996	47.7	9.9	32.4	85.8	10.3	1.7	0.4	0.4	0.2	0.0	189.0
1997	0.2	2.9	5.7	87.4	123.1	23.9	4.4	1.5	0.5	0.2	249.8
1998	107.6	13.3	13.8	1.5	4.7	5.0	0.0	0.0	0.0	0.0	145.9
1999	1.1	8.4	0.7	0.2	0.1	0.1	0.1	0.0	0.0	0.0	10.8
2000	1.1	5.4	47.0	14.2	1.7	0.2	0.4	0.1	0.0	0.0	70.1
2001	1.2	1.6	11.2	21.1	2.3	0.4	0.4	0.3	0.0	0.0	38.6
2002	0.0	2.1	1.3	6.6	17.3	1.8	0.3	0.0	0.1	0.1	29.5
2003	0.0	0.1	3.9	1.0	3.6	14.3	1.5	0.3	0.2	0.1	25.0
2004	0.3	7.8	0.4	4.9	1.1	2.9	12.1	1.0	0.4	0.5	31.4
2005	0.0	0.3	15.6	1.0	5.1	4.3	4.1	10.1	0.6	0.5	41.5
2006	5.2	9.4	1.6	35.9	3.8	3.7	1.6	2.8	9.2	0.4	73.6
2007	0.0	1.8	13.4	4.6	30.7	0.3	2.1	0.5	1.5	5.4	60.3
2008	0.0	0.0	4.4	3.1	0.6	6.5	0.2	0.4	0.0	0.9	16.0
2009	0.4	0.1	0.7	6.8	3.4	0.5	3.3	0.1	0.2	0.5	15.9
2010	0.1	1.6	0.8	0.9	1.7	0.4	0.1	0.7	0.0	0.1	6.3

Table C.13. Gulf of Maine haddock average weights-at-age of commercial discards between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
1977	0.023	0.145	0.115													
1978	0.022	0.116	0.483	0.459											0.262	
1979	0.016	0.207	0.598	0.726												
1980	0.019	0.153	0.390	0.453												
1981	0.032	0.114	0.207													
1982	0.036	0.196	0.410	0.455												
1983	0.034	0.123	0.368	0.644	0.723											
1984		0.237	0.397	0.452	0.581											
1985	0.053	0.327	0.461	0.583												
1986	0.072	0.365														
1987	0.027	0.100														
1988		0.081														
1989		0.254	0.788	0.830	0.942											
1990	0.025	0.231		0.698												
1991	0.014	0.235	0.766	0.969												
1992	0.036	0.206	0.872	1.061	1.239											
1993	0.029	0.185	0.702	1.066	1.848	2.227	4.426	1.949	4.172	4.446				4.812	4.446	
1994	0.034	0.065	0.756	1.641	2.347	3.275	3.333	4.786	3.466		4.105	4.105				
1995	0.015	0.068	0.760	1.109	1.649	2.837	3.096	3.378								
1996	0.070	0.238	0.479	0.748	1.483	2.067	2.373	1.943	2.171							
1997	0.069	0.148	0.801	1.484	1.395	1.879	2.350	2.619	3.587	3.617	3.779	2.639				
1998	0.023	0.220	0.707	0.757	0.821	0.784	1.759			1.759						
1999	0.047	0.168	0.511	0.730	1.271	1.744	2.809	2.922	4.441	3.850	3.828		3.452	4.448		
2000	0.039	0.190	0.531	0.629	0.943	1.242	1.554	2.940	3.365						2.891	
2001	0.020	0.200	0.626	0.786	0.895	1.010	0.837	0.874	1.702							
2002	0.074	0.178	0.374	0.721	0.902	1.080	1.202	1.395	1.312	1.360						
2003		0.130	0.516	0.767	0.829	1.004	1.041	1.469	1.172	1.847	2.218	2.088	2.452			
2004	0.024	0.164	0.581	0.742	1.164	1.074	1.165	1.378	1.676	1.852	1.575	2.602	2.505	3.764		
2005	0.099	0.154	0.503	0.723	0.900	0.991	1.174	1.314	1.624	1.819	2.057	1.948	2.192	2.165	2.637	
2006	0.035	0.085	0.452	0.740	0.635	0.956	1.152	1.103	1.063	1.216	1.367		1.455	1.565		
2007		0.223	0.601	0.754	0.892	1.099	0.957	1.321	1.150	1.131	1.543	1.636	2.814	1.912	2.214	
2008			0.536	0.735	0.957	0.900	0.873	0.906	1.132	1.017	0.987					
2009	0.058	0.123	0.599	0.785	0.954	1.014	1.041	1.116	1.144	1.548	1.141	1.229	2.013	1.552		
2010	0.090	0.282	0.541	0.824	0.874	1.032	1.120	1.154	2.685	2.175	2.281	1.681	1.750	2.848	2.685	

Table C.14. Recreational harvest of Gulf of Maine haddock by type (A, B1 and B2) in numbers and weight.

Year	Annual length samples (numbers)	Estimated recreational landings, A + B1 (numbers)	Estimated recreational releases, B2 (numbers)	Recreational landings (mt)	Metric tons/100 lengths
1981	13	22,990	0	*36.3*	279.4
1982	2	19,531	122	*30.9*	1543.1
1983	10	36,455	0	*57.6*	576.0
1984	16	31,277	1,687	*49.4*	308.9
1985	7	19,417	92	*30.7*	438.3
1986	0	34,777	432	*55.0*	
1987	6	18,765	0	*29.7*	494.2
1988	2	7,630	2,970	*12.1*	602.8
1989	3	5,995	5,134	*9.5*	315.7
1990	0	1,836	278	*2.9*	
1991	0	242	0	*0.4*	
1992	0	0	0	0.0	
1993	0	336	0	*0.5*	
1994	4	2,385	1,720	*3.8*	94.2
1995	153	110,818	43,469	175.1	114.4
1996	25	4,190	8,597	6.6	26.5
1997	21	20,022	15,733	31.6	150.7
1998	62	28,161	9,550	44.5	71.8
1999	32	12,128	16,673	19.2	59.9
2000	34	80,735	101,016	127.6	375.2
2001	25	120,422	112,326	190.3	761.1
2002	119	83,283	171,955	165.9	139.4
2003	210	119,788	260,881	191.8	91.3
2004	928	278,497	142,426	429.6	46.3
2005	1,711	444,739	116,168	717.1	41.9
2006	1,171	277,858	164,196	503.9	43.0
2007	1,068	398,229	105,432	627.9	58.8
2008	1,151	358,480	124,259	611.4	53.1
2009	1,188	311,584	71,984	531.0	44.7
2010	723	391,482	72,595	743.2	102.8

Table C.15. Gulf of Maine haddock recreational landings-at-age between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9^{+}	Total
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.0	0.0	5.3	4.2	2.1	3.2	5.0	1.0	1.6	0.6	23.0
1982	0.0	0.0	2.4	10.6	3.5	0.6	0.6	1.3	0.2	0.3	19.5
1983	0.0	0.0	0.6	9.8	11.4	7.5	1.2	1.7	3.1	1.2	36.5
1984	0.0	0.0	8.4	1.2	8.3	3.1	6.4	0.9	0.8	2.3	31.3
1985	0.0	0.0	0.7	8.8	1.1	3.4	1.4	2.6	0.7	0.8	19.4
1986	0.0	1.2	0.0	5.9	16.3	2.8	4.2	1.9	2.0	0.4	34.8
1987	0.0	0.0	1.3	1.9	6.3	2.6	1.9	2.2	1.2	1.3	18.8
1988	0.0	0.0	0.0	0.3	0.3	2.1	1.8	0.4	2.1	0.5	7.6
1989	0.0	0.0	1.1	0.3	1.0	1.2	1.2	1.1	0.1	0.1	6.0
1990	0.0	0.0	0.0	0.9	0.0	0.2	0.1	0.4	0.3	0.0	1.8
1991	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3
1994	0.0	0.0	0.3	1.3	0.2	0.2	0.2	0.1	0.0	0.0	2.4
1995	0.0	0.0	18.3	51.7	37.9	1.1	0.7	0.5	0.3	0.3	110.8
1996	0.0	0.0	0.1	1.8	1.5	0.3	0.1	0.2	0.1	0.0	4.2
1997	0.0	0.0	0.1	6.9	8.3	2.8	1.0	0.4	0.2	0.3	20.0
1998	0.0	0.0	1.1	2.2	10.0	11.5	2.1	0.5	0.3	0.4	28.2
1999	0.0	0.0	0.0	1.7	1.9	3.6	3.0	1.5	0.3	0.2	12.1
2000	0.0	0.0	0.6	5.8	20.7	12.8	23.5	11.3	4.6	1.4	80.7
2001	0.0	0.0	4.4	44.4	26.4	15.8	10.9	10.0	5.5	3.0	120.4
2002	0.0	0.0	0.0	0.4	23.6	16.4	16.4	4.5	10.2	11.8	83.3
2003	0.0	0.0	0.0	0.2	5.2	71.6	16.2	10.3	3.9	12.2	119.8
2004	0.0	0.3	0.1	1.4	14.1	33.5	189.1	15.5	11.4	13.1	278.5
2005	0.0	0.3	1.2	1.7	25.6	40.8	74.5	248.2	23.7	28.7	444.7
2006	0.0	0.0	0.0	25.9	0.8	21.0	33.5	34.8	141.6	20.2	277.9
2007	0.0	0.0	0.3	2.7	159.4	4.8	25.1	21.1	37.4	147.6	398.2
2008	0.0	0.0	0.7	15.7	4.7	180.1	0.0	33.8	19.9	103.6	358.5
2009	0.0	0.0	0.3	15.8	37.2	15.8	162.0	2.2	22.2	56.1	311.6
2010	0.0	0.0	0.0	3.0	44.2	69.2	21.0	176.3	0.0	77.8	391.5

Table C.16. Gulf of Maine haddock total catch numbers-at-age between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1977	8.2	548.4	1791.5	51.1	365.0	215.0	143.6	4.8	1.6	6.3
1978	9.9	3.1	433.5	1959.5	181.2	320.3	154.6	32.0	0.0	5.6
1979	46.5	69.5	87.4	614.6	1348.8	200.5	105.5	32.4	23.8	0.0
1980	76.6	121.9	865.2	110.0	754.9	1235.8	165.4	134.1	11.5	25.3
1981	3.8	164.0	1466.5	645.6	268.9	360.0	503.2	70.1	98.3	12.7
1982	178.9	77.9	458.6	1256.6	513.9	81.2	225.7	401.3	89.8	59.8
1983	2.5	76.1	17.0	612.5	724.2	596.3	110.3	185.7	254.1	88.0
1984	0.0	11.4	96.4	34.1	420.0	176.2	253.7	44.0	49.8	102.1
1985	0.2	3.1	25.5	266.2	63.3	270.5	109.3	176.0	35.3	38.3
1986	10.0	21.1	0.0	159.6	304.0	66.2	101.7	75.8	90.0	11.8
1987	14.6	8.1	3.6	18.1	96.7	51.5	35.0	54.2	38.7	18.4
1988	0.0	18.5	0.0	13.0	10.1	55.0	40.1	9.4	22.7	4.8
1989	0.0	3.4	23.9	4.4	51.2	17.7	22.4	17.2	1.8	0.9
1990	4.5	4.5	1.9	136.0	1.8	24.2	17.8	28.6	3.7	0.0
1991	9.2	7.9	28.9	48.3	61.7	17.7	19.2	13.0	2.7	2.2
1992	4.8	20.4	18.3	93.7	36.4	23.3	2.4	2.3	0.0	1.1
1993	15.7	12.4	29.6	28.7	31.7	17.8	6.5	6.4	0.4	0.6
1994	60.4	89.9	23.4	52.2	13.5	3.4	10.3	6.7	1.3	1.0
1995	0.9	50.1	78.5	99.4	83.2	12.1	6.5	6.1	3.4	3.1
1996	47.7	9.9	35.0	141.0	64.8	16.1	4.8	6.6	5.6	0.8
1997	0.2	2.9	8.3	177.0	235.9	80.1	18.1	6.1	1.8	1.8
1998	107.6	13.3	26.6	23.7	126.1	188.0	52.4	16.9	7.6	7.6
1999	1.1	8.4	0.9	43.4	62.4	93.5	63.6	32.1	7.1	6.2
2000	1.1	5.4	51.2	47.8	106.6	66.3	138.6	61.2	31.0	15.3
2001	1.2	1.6	23.4	213.5	130.0	88.5	79.0	74.7	37.3	23.7
2002	0.0	2.1	1.3	18.0	217.4	108.0	107.5	33.1	63.5	68.6
2003	0.0	0.1	3.9	3.6	38.6	430.8	87.9	62.1	22.2	72.7
2004	0.3	8.1	0.5	8.4	34.9	79.3	546.0	69.1	36.4	54.5
2005	0.0	0.6	16.7	4.1	49.0	87.0	147.4	569.0	60.1	83.1
2006	5.2	9.4	1.6	69.9	4.9	45.2	70.5	77.3	351.5	61.5
2007	0.0	1.8	13.9	8.8	287.1	10.5	53.6	43.2	86.4	369.6
2008	0.0	0.0	5.7	37.7	13.5	359.9	1.9	52.6	32.9	204.0
2009	0.4	0.1	1.0	24.8	55.2	21.9	307.3	4.9	39.0	142.2
2010	0.1	1.6	1.3	4.3	62.8	96.1	30.2	345.7	2.2	162.5

Table C.17. Gulf of Maine haddock average catch weights-at-age between 1977 and 2010. Grey shaded cells were imputed using a 5-year centered moving average.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1977	0.023	0.143	0.744	1.142	2.014	2.624	3.302	4.664	5.980	5.702
1978	0.022	0.116	0.717	1.220	1.776	2.423	2.950	4.135	4.421	4.999
1979	0.016	0.249	0.792	1.222	1.797	2.247	2.535	2.829	3.293	4.712
1980	0.019	0.153	0.758	1.251	1.873	2.389	3.288	3.376	3.989	4.359
1981	0.032	0.114	0.680	1.489	1.970	2.520	3.280	3.840	4.188	3.786
1982	0.036	0.329	0.636	0.998	2.142	2.560	3.102	3.648	4.260	4.086
1983	0.034	0.123	0.566	1.193	1.732	2.375	2.963	3.379	3.719	4.226
1984	0.049	0.237	0.683	1.220	1.798	2.303	3.158	3.948	4.414	4.091
1985	0.053	0.327	0.914	1.060	1.909	2.356	2.655	3.573	4.116	4.205
1986	0.072	0.365	0.885	1.221	1.456	2.281	2.495	3.051	3.632	4.505
1987	0.027	0.100	1.059	1.299	1.995	2.431	2.618	3.364	4.186	5.181
1988	0.041	0.081	0.993	1.231	1.494	2.654	2.337	3.649	4.894	5.353
1989	0.022	0.254	1.119	1.666	1.642	2.507	2.304	3.378	4.474	4.331
1990	0.025	0.231	0.800	1.512	3.361	2.361	2.962	3.628	3.506	3.965
1991	0.014	0.235	1.303	1.480	2.490	2.960	2.964	3.307	4.245	3.372
1992	0.036	0.206	1.085	1.678	1.914	2.679	2.936	2.918	3.863	2.803
1993	0.029	0.185	0.857	1.363	1.915	2.517	3.289	3.888	4.172	4.603
1994	0.034	0.065	0.848	1.651	2.226	2.931	2.976	3.795	3.529	3.990
1995	0.015	0.068	0.784	1.189	1.926	2.643	3.630	4.451	5.150	5.563
1996	0.070	0.238	0.557	0.997	1.750	2.207	3.066	2.369	2.122	3.190
1997	0.069	0.148	0.931	1.801	1.682	2.326	2.983	3.209	3.816	3.735
1998	0.023	0.220	0.951	1.475	1.847	2.213	2.856	3.378	3.124	3.003
1999	0.047	0.168	0.624	1.320	1.704	1.717	1.937	2.350	3.110	3.343
2000	0.039	0.190	0.586	1.022	1.531	1.840	2.066	2.375	2.612	3.387
2001	0.020	0.200	0.841	1.313	1.504	1.809	2.242	2.270	2.457	2.575
2002	0.074	0.178	0.374	1.040	1.366	1.670	2.203	2.667	2.456	2.753
2003	0.054	0.130	0.516	0.945	1.304	1.532	1.851	2.190	2.520	2.566
2004	0.024	0.164	0.581	0.829	1.379	1.418	1.717	2.097	2.159	2.244
2005	0.099	0.154	0.503	0.919	1.159	1.531	1.531	1.797	2.018	2.381
2006	0.035	0.085	0.452	0.814	0.693	1.411	1.752	1.601	1.776	2.121
2007	0.064	0.223	0.603	0.855	1.153	1.231	1.577	1.675	1.656	1.769
2008	0.061	0.178	0.601	1.102	1.215	1.367	1.441	1.775	1.777	1.771
2009	0.058	0.123	0.599	0.871	1.183	1.351	1.714	1.663	2.013	2.029
2010	0.090	0.282	0.762	0.883	1.129	1.427	1.659	1.782	2.172	2.144
2006-2010 average	0.062	0.178	0.603	0.905	1.075	1.357	1.629	1.699	1.879	1.967

Table C.18. Gulf of Maine haddock average stock/spawning stock weights-at-age between 1977 and 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1977	0.010	0.064	0.581	0.916	1.836	2.475	2.951	4.791	5.281	5.702
1978	0.007	0.052	0.320	0.953	1.424	2.209	2.782	3.695	4.541	4.999
1979	0.005	0.074	0.303	0.936	1.481	1.998	2.478	2.889	3.690	4.712
1980	0.008	0.050	0.434	0.995	1.513	2.072	2.718	2.925	3.359	4.359
1981	0.010	0.047	0.323	1.062	1.570	2.173	2.799	3.553	3.760	3.786
1982	0.020	0.103	0.269	0.824	1.786	2.246	2.796	3.459	4.045	4.086
1983	0.013	0.067	0.432	0.871	1.315	2.256	2.754	3.238	3.683	4.226
1984	0.019	0.090	0.290	0.831	1.465	1.997	2.739	3.420	3.862	4.091
1985	0.020	0.127	0.465	0.851	1.526	2.058	2.473	3.359	4.031	4.205
1986	0.061	0.139	0.538	1.056	1.242	2.087	2.425	2.846	3.602	4.505
1987	0.016	0.085	0.622	1.072	1.561	1.881	2.444	2.897	3.574	5.181
1988	0.017	0.047	0.315	1.142	1.393	2.301	2.384	3.091	4.058	5.353
1989	0.007	0.102	0.301	1.286	1.422	1.935	2.473	2.810	4.041	4.331
1990	0.008	0.071	0.451	1.301	2.366	1.969	2.725	2.891	3.441	3.965
1991	0.004	0.077	0.549	1.088	1.940	3.154	2.645	3.130	3.924	3.372
1992	0.016	0.054	0.505	1.479	1.683	2.583	2.948	2.941	3.574	2.803
1993	0.019	0.082	0.420	1.216	1.793	2.195	2.968	3.379	3.489	4.603
1994	0.024	0.043	0.396	1.190	1.742	2.369	2.737	3.533	3.704	3.990
1995	0.004	0.048	0.226	1.004	1.783	2.426	3.262	3.640	4.421	5.563
1996	0.048	0.060	0.195	0.884	1.443	2.062	2.847	2.933	3.073	3.190
1997	0.039	0.102	0.471	1.002	1.295	2.018	2.566	3.137	3.007	3.735
1998	0.009	0.123	0.375	1.172	1.824	1.929	2.577	3.174	3.166	3.003
1999	0.023	0.062	0.371	1.120	1.585	1.781	2.070	2.591	3.241	3.343
2000	0.017	0.095	0.314	0.799	1.422	1.771	1.883	2.145	2.478	3.387
2001	0.007	0.088	0.400	0.877	1.240	1.664	2.031	2.166	2.416	2.575
2002	0.056	0.060	0.274	0.935	1.339	1.585	1.996	2.445	2.361	2.753
2003	0.031	0.098	0.303	0.595	1.165	1.447	1.758	2.197	2.593	2.566
2004	0.010	0.094	0.275	0.654	1.142	1.360	1.622	1.970	2.174	2.244
2005	0.107	0.061	0.287	0.731	0.980	1.453	1.473	1.757	2.057	2.381
2006	0.014	0.092	0.264	0.640	0.798	1.279	1.638	1.566	1.787	2.121
2007	0.038	0.088	0.226	0.622	0.969	0.924	1.492	1.713	1.628	1.769
2008	0.043	0.107	0.366	0.815	1.019	1.255	1.332	1.673	1.725	1.771
2009	0.026	0.087	0.327	0.724	1.142	1.281	1.531	1.548	1.890	2.029
2010	0.063	0.128	0.306	0.727	0.992	1.299	1.497	1.748	1.901	2.144
2006-2010 average	0.037	0.100	0.298	0.706	0.984	1.208	1.498	1.650	1.786	1.967

Table C.19. Vessel and door types used in the Northeast Fisheries Science Center's bottom trawl survey.

Year	Spring	Autumn	Door
1963		Albatross IV	BMV
1964		Albatross IV	BMV
1965		Albatross IV	BMV
1966		Albatross IV	BMV
1967		Albatross IV	BMV
1968	Albatross IV	Albatross IV	BMV
1969	Albatross IV	Albatross IV	BMV
1970	Albatross IV	Albatross IV	BMV
1971	Albatross IV	Albatross IV	BMV
1972	Albatross IV	Albatross IV	BMV
1973	Albatross IV	Albatross IV	BMV
1974	Albatross IV	Albatross IV	BMV
1975	Albatross IV	Albatross IV	BMV
1976	Albatross IV	Albatross IV	BMV
1977	Albatross IV	Delaware II	BMV
1978	Albatross IV	Delaware II	BMV
1979	Albatross IV/Delaware II	Albatross IV/Delaware II	BMV
1980	Albatross IV/Delaware II	Delaware II	BMV
1981	Delaware II	Albatross IV/Delaware II	BMV
1982	Delaware II	Albatross IV	BMV
1983	Albatross IV	Albatross IV	BMV
1984	Albatross IV	Albatross IV	BMV
1985	Albatross IV	Albatross IV	Polyvalent
1986	Albatross IV	Albatross IV	Polyvalent
1987	Albatross IV/Delaware II	Albatross IV	Polyvalent
1988	Albatross IV	Albatross IV/Delaware II	Polyvalent
1989	Delaware II	Delaware II	Polyvalent
1990	Delaware II	Delaware II	Polyvalent
1991	Delaware II	Delaware II	Polyvalent
1992	Albatross IV	Albatross IV	Polyvalent
1993	Albatross IV	Delaware II	Polyvalent
1994	Delaware II	Albatross IV	Polyvalent
1995	Albatross IV	Albatross IV	Polyvalent
1996	Albatross IV	Albatross IV	Polyvalent
1997	Albatross IV	Albatross IV	Polyvalent
1998	Albatross IV	Albatross IV	Polyvalent
1999	Albatross IV	Albatross IV	Polyvalent
2000	Albatross IV	Albatross IV	Polyvalent
2001	Albatross IV	Albatross IV	Polyvalent
2002	Albatross IV	Albatross IV	Polyvalent
2003	Delaware II	Albatross IV	Polyvalent
2004	Albatross IV	Albatross IV	Polyvalent
2005	Albatross IV	Albatross IV	Polyvalent
2006	Albatross IV	Albatross IV	Polyvalent
2007	Albatross IV	Albatross IV	Polyvalent
2008	Albatross IV	Albatross IV	Polyvalent
2009	Henry B. Bigelow	Henry B. Bigelow	PolyIce oval
2010	Henry B. Bigelow	Henry B. Bigelow	PolyIce oval
2011	Henry B. Bigelow		PolyIce oval

Table C.20. Summary of the calibration factors applied to the Northeast Fisheries Science Center bottom trawl survey and corresponding coefficients of variation (CV) where available.

Calibration type	**Index**	**Length (cm)**	**Calibration coefficient**	**CV**	**Source**
Deleware II to Albatross IV	Biomass (weight)	*NA*	0.790	*NA*	Forrester et al., 1997
	Abundance (numbers)	*NA*	0.820	*NA*	
BMV door to Polyvalent door	Biomass (weight)	*NA*	1.510	*NA*	
	Abundance (numbers)	*NA*	1.490	*NA*	
Bigelow to Albatross IV	Biomass (weight), spring	*NA*	0.878	*NA*	Miller et al. 2010
	Biomass (weight), fall	*NA*	1.489	*NA*	
	Abundance (numbers)	≤ 18	2.626	0.07	Brooks et al. 2010
		19	2.581	0.07	
		20	2.535	0.07	
		21	2.489	0.07	
		22	2.444	0.06	
		23	2.398	0.06	
		24	2.352	0.06	
		25	2.307	0.06	
		26	2.261	0.06	
		27	2.216	0.06	
		28	2.170	0.05	
		29	2.124	0.05	
		30	2.079	0.05	
		31	2.033	0.05	
		32	1.988	0.05	
		33	1.942	0.04	
		34	1.896	0.04	
		35	1.851	0.04	
		36	1.805	0.04	
		37	1.759	0.04	
		38	1.714	0.03	
		39	1.668	0.03	
		40	1.623	0.03	
		41	1.577	0.03	
		42	1.531	0.03	
		43	1.486	0.03	
		44	1.440	0.03	
		45	1.394	0.04	
		46	1.349	0.04	
		47	1.303	0.04	
		48	1.258	0.05	
		49	1.212	0.05	
		50	1.166	0.06	
		≥ 51	1.164	0.06	

Table C.21. Summary of differences in survey protocol from the FSV Albatross IV survey (2008 and earlier) and FSV Henry B. Bigelow (2009 - present). Adapted from Brooks et al. (2010).

Measure	FSV Henry B Bigelow	FSV Albatross IV
Tow speed	3.0 knots SOG	3.8 knots SOG
Tow duration	20min	30 mins
Headrope height	3.5-4m	1-2m
Ground gear	Rockhopper Sweep	Roller Sweep
(cookies, rock hoppers, etc.)	Total Length-25.5m	Total Length-24.5m
	Center- 8.9m length, 16" rockhoppers.	Center-5m length, 16" rollers.
	Wings- 8.2m each	Wings- 9.75m each, 4" cookies.
	14" rockhoppers	
Mesh	Poly webbing	Nylon webbing
	Forward Portion of trawl (jibs, upper and lower wing ends, 1st&2nd side panels, 1st bottom belly)12cm,4mm	Body of trawl= 12.7cm
	Square aft to codend:6cm, 2.5mm	Codend- 11.5cm
	Codend: 12cm, 4mm dbl.	Liner (codend and aft portion of top belly)-1.27cm knotless
	Codend Liner: 2.54cm, knotless	
Net design	4 Seam, 3 Bridle	Yankee 36 (recent years)
Door type	550 kg PolyIce oval	450 kg polyvalent
Other comments	Wing End to Door distance= 36.5m	Wing End to Door Distance= 9m

Table C.21. Gulf of Maine haddock Northeast Fisheries Science Center bottom trawl survey stratified mean indices in terms of both abundance (numbers/tow) and biomass (weight (kg)/tow).

Year	Spring		Fall	
	Mean number/tow	Mean weight (kg)/tow	Mean number/tow	Mean weight (kg)/tow
1963			69.549	50.697
1964			14.176	18.386
1965			17.434	17.731
1966			10.742	13.103
1967			12.186	16.871
1968	6.066	8.107	8.564	17.307
1969	3.719	6.607	5.451	12.721
1970	0.906	1.784	2.918	7.354
1971	0.878	2.523	2.880	8.159
1972	0.862	0.867	1.984	3.036
1973	1.312	1.598	4.165	8.583
1974	1.437	1.059	2.687	3.347
1975	2.770	3.482	5.533	8.616
1976	8.326	6.350	6.035	8.040
1977	6.799	6.725	8.296	8.752
1978	1.356	1.434	9.775	21.658
1979	2.890	3.948	6.174	15.567
1980	2.212	2.673	7.152	9.835
1981	3.613	3.545	4.456	10.874
1982	2.047	2.555	2.627	4.164
1983	3.678	3.567	2.598	5.219
1984	1.095	1.144	1.697	3.893
1985	1.773	1.882	4.079	6.149
1986	0.707	1.284	0.623	1.392
1987	0.092	0.063	1.035	2.645
1988	0.187	0.301	0.335	1.476
1989	0.083	0.125	0.283	0.631
1990	0.024	0.000	0.145	0.432
1991	0.074	0.066	0.142	0.120
1992	0.193	0.271	0.211	0.091
1993	0.450	0.200	0.866	0.472
1994	0.402	0.253	0.325	0.217
1995	0.806	0.350	0.977	1.099
1996	0.305	0.338	2.407	3.543
1997	1.935	1.222	2.688	2.424
1998	0.197	0.112	3.130	2.917
1999	4.267	1.108	6.730	4.910
2000	3.610	1.815	16.589	14.032
2001	2.364	3.205	9.960	11.981
2002	5.704	2.793	3.920	4.835
2003	3.191	3.908	4.733	5.359
2004	1.061	1.199	5.704	7.171
2005	0.862	0.971	4.132	3.932
2006	3.151	2.661	3.910	3.945
2007	0.771	0.675	5.153	4.393
2008	1.848	1.510	2.266	3.147
2009	1.531	2.573	2.017	1.203
2010	1.630	3.713	2.662	1.339
2011	1.233	1.259		

Table C.22. Coefficients of variation (CV) associated with the Gulf of Maine haddock Northeast Fisheries Science Center bottom trawl survey indices.

Year	Abundance (num/tow)		Biomass (kg/tow)	
	Spring	Fall	Spring	Fall
1963		0.26		0.15
1964		0.34		0.17
1965		0.32		0.19
1966		0.33		0.27
1967		0.22		0.24
1968	0.29	0.15	0.23	0.15
1969	0.19	0.23	0.21	0.21
1970	0.24	0.22	0.24	0.20
1971	0.44	0.31	0.42	0.32
1972	0.35	0.23	0.54	0.34
1973	0.22	0.20	0.35	0.30
1974	0.37	0.55	0.42	0.31
1975	0.27	0.26	0.44	0.30
1976	0.35	0.23	0.34	0.27
1977	0.31	0.32	0.38	0.27
1978	0.41	0.18	0.28	0.19
1979	0.21	0.20	0.21	0.22
1980	0.38	0.33	0.43	0.24
1981	0.23	0.19	0.22	0.24
1982	0.32	0.34	0.32	0.28
1983	0.41	0.28	0.42	0.27
1984	0.39	0.27	0.42	0.27
1985	0.37	0.40	0.30	0.28
1986	0.45	0.43	0.49	0.38
1987	0.37	0.32	0.49	0.28
1988	0.53	0.64	0.59	0.73
1989	0.77	0.38	0.88	0.49
1990	0.56	0.37	0.89	0.35
1991	0.53	0.59	0.61	0.72
1992	0.58	0.52	0.94	0.60
1993	0.45	0.71	0.68	0.81
1994	0.34	0.41	0.37	0.89
1995	0.47	0.57	0.44	0.40
1996	0.31	0.39	0.35	0.44
1997	0.38	0.36	0.48	0.27
1998	0.40	0.48	0.44	0.43
1999	0.40	0.30	0.35	0.25
2000	0.39	0.45	0.40	0.39
2001	0.58	0.27	0.66	0.26
2002	0.51	0.34	0.31	0.32
2003	0.23	0.22	0.27	0.24
2004	0.33	0.25	0.38	0.29
2005	0.39	0.19	0.46	0.16
2006	0.45	0.24	0.42	0.20
2007	0.35	0.29	0.34	0.24
2008	0.51	0.32	0.33	0.30
2009	0.37	0.35	0.36	0.27
2010	0.35	0.46	0.38	0.61
2011	0.35		0.38	
Average	**0.39**	**0.34**	**0.43**	**0.33**

Table C.23. Northeast Fisheries Science Center spring bottom trawl survey indices-at-age for Gulf of Maine haddock.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1968	0.0	0.0	0.0	63.9	377.0	5552.3	1118.5	167.8	140.3	177.9
1969	0.0	0.0	0.0	67.6	23.8	329.4	3163.8	983.2	36.3	53.9
1970	0.0	0.0	0.0	0.0	0.0	0.0	179.1	766.5	115.2	73.9
1971	0.0	0.0	0.0	0.0	0.0	0.0	32.6	32.6	797.8	236.7
1972	0.0	731.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	348.2
1973	0.0	161.6	982.0	0.0	67.6	0.0	0.0	0.0	0.0	432.1
1974	0.0	1127.3	110.2	417.1	0.0	0.0	0.0	0.0	20.0	126.5
1975	0.0	37.6	2452.4	190.4	476.0	0.0	254.3	0.0	0.0	60.1
1976	0.0	6405.3	155.3	2171.8	220.4	1179.9	83.9	41.3	0.0	170.3
1977	0.0	1450.4	4093.2	61.4	1677.1	509.8	723.9	0.0	0.0	0.0
1978	0.0	106.5	896.8	417.1	37.6	240.5	0.0	0.0	0.0	0.0
1979	0.0	464.7	393.3	501.0	1727.2	291.8	243.0	0.0	0.0	0.0
1980	0.0	1318.9	190.4	214.2	569.9	398.3	31.3	0.0	0.0	46.3
1981	0.0	1479.2	1243.7	760.3	266.8	445.9	200.4	31.3	47.6	47.6
1982	0.0	56.4	542.3	1117.2	582.4	184.1	82.7	0.0	0.0	0.0
1983	179.1	1693.4	171.6	1548.1	399.5	383.3	0.0	204.2	0.0	27.6
1984	0.0	23.8	713.9	67.6	374.5	135.3	0.0	0.0	56.4	0.0
1985	0.0	52.6	350.7	1371.5	72.6	212.9	73.9	62.6	25.1	0.0
1986	0.0	63.9	0.0	151.6	504.8	0.0	45.1	91.4	28.8	0.0
1987	0.0	45.1	31.3	38.8	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	53.9	0.0	0.0	18.8	149.0	12.5	0.0	0.0	0.0
1989	0.0	0.0	45.1	15.0	0.0	15.0	15.0	15.0	0.0	0.0
1990	15.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	17.5	8.8	65.1	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	106.5	0.0	0.0	136.5	0.0	0.0	0.0	0.0	0.0
1993	0.0	326.9	182.9	0.0	0.0	36.3	18.8	0.0	0.0	0.0
1994	0.0	92.7	228.0	152.8	30.1	0.0	0.0	0.0	0.0	0.0
1995	0.0	552.4	300.6	91.4	37.6	0.0	0.0	0.0	28.8	0.0
1996	0.0	0.0	46.3	182.9	154.1	0.0	0.0	0.0	0.0	0.0
1997	0.0	970.7	289.3	299.3	741.5	95.2	27.6	0.0	0.0	0.0
1998	0.0	100.2	57.6	0.0	77.7	11.3	0.0	0.0	0.0	0.0
1999	0.0	4664.3	109.0	202.9	36.3	284.3	48.8	0.0	0.0	0.0
2000	0.0	1298.8	1488.0	1212.4	181.6	105.2	66.4	170.3	0.0	0.0
2001	0.0	91.4	164.1	1302.6	657.6	209.2	284.3	81.4	60.1	112.7
2002	0.0	4132.0	259.3	757.8	1776.0	101.5	45.1	27.6	45.1	0.0
2003	0.0	449.6	254.3	116.5	136.5	2492.5	255.5	180.4	45.1	67.6
2004	0.0	144.0	0.0	192.9	41.3	119.0	777.8	36.3	0.0	18.8
2005	0.0	12.5	215.4	0.0	87.7	104.0	281.8	343.2	0.0	36.3
2006	0.0	224.2	115.2	2101.7	340.7	130.3	27.6	264.3	686.4	58.9
2007	0.0	195.4	106.5	35.1	315.6	0.0	35.1	36.3	42.6	199.1
2008	0.0	45.1	825.4	514.8	0.0	418.3	0.0	35.1	71.4	405.8
2009	0.0	40.2	111.5	527.1	274.5	49.8	685.7	0.0	16.9	211.5
2010	0.0	129.0	15.8	9.9	163.8	161.7	63.3	985.2	0.0	512.8
2011	0.0	694.6	248.6	12.1	0.0	31.1	218.3	0.0	203.0	136.4

Table C.24. Northeast Fisheries Science Center fall bottom trawl survey indices-at-age for Gulf of Maine haddock.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1963	44591.5	15259.2	2134.3	3772.5	8694.9	6184.8	2090.4	1650.8	1303.9	1430.4
1964	101.5	7394.8	2314.6	884.3	1221.2	2279.6	2196.9	1232.5	0.0	129.0
1965	67.6	459.7	10008.7	6342.7	316.9	1816.1	1509.3	830.4	417.1	67.6
1966	23.8	0.0	657.6	8262.7	2731.7	355.7	771.5	504.8	104.0	42.6
1967	0.0	0.0	0.0	1931.4	10013.7	2255.8	661.3	156.6	186.6	57.6
1968	0.0	0.0	0.0	0.0	241.7	7846.9	1818.6	271.8	399.5	146.5
1969	0.0	0.0	0.0	46.3	35.1	46.3	5159.0	1166.1	172.8	201.7
1970	0.0	60.1	0.0	0.0	0.0	157.8	170.3	2437.4	759.0	71.4
1971	335.7	0.0	0.0	0.0	20.0	0.0	152.8	211.7	2541.3	345.7
1972	0.0	1490.5	0.0	30.1	0.0	0.0	0.0	0.0	0.0	964.4
1973	1414.1	27.6	1202.4	0.0	445.9	32.6	27.6	47.6	27.6	1994.0
1974	27.6	2079.2	261.8	537.3	0.0	0.0	0.0	0.0	0.0	460.9
1975	1112.2	284.3	2399.8	698.9	1738.5	0.0	56.4	56.4	0.0	583.7
1976	2045.3	2247.0	96.4	1596.9	186.6	1129.8	0.0	236.7	0.0	20.0
1977	130.3	3864.0	4259.8	171.6	1287.6	240.5	319.4	0.0	0.0	117.7
1978	217.9	109.0	2149.3	6917.6	251.8	801.6	1508.0	157.8	0.0	130.3
1979	978.2	527.3	105.2	1406.6	3574.6	637.5	408.3	78.9	0.0	16.3
1980	4951.1	637.5	400.8	0.0	373.2	1337.7	814.1	196.6	131.5	116.5
1981	0.0	769.0	703.9	1268.8	393.3	1070.9	853.0	212.9	229.2	80.2
1982	483.5	70.1	854.2	1070.9	383.3	68.9	0.0	140.3	60.1	160.3
1983	0.0	697.6	66.4	799.1	755.3	390.8	215.4	85.2	201.7	42.6
1984	0.0	253.0	677.6	0.0	353.2	0.0	511.0	0.0	42.6	285.6
1985	0.0	111.5	589.9	3413.1	21.3	228.0	187.9	494.7	0.0	63.9
1986	0.0	18.8	0.0	86.4	439.6	106.5	22.5	31.3	73.9	0.0
1987	36.3	0.0	159.1	142.8	238.0	76.4	298.1	182.9	0.0	162.8
1988	0.0	0.0	0.0	40.1	28.8	126.5	0.0	51.4	171.6	0.0
1989	0.0	73.9	73.9	23.8	15.0	38.8	65.1	65.1	0.0	0.0
1990	11.3	30.1	0.0	70.1	0.0	0.0	0.0	47.6	23.8	0.0
1991	66.4	58.9	0.0	0.0	52.6	0.0	0.0	0.0	0.0	0.0
1992	53.9	181.6	0.0	28.8	0.0	0.0	0.0	0.0	0.0	0.0
1993	124.0	584.9	274.3	46.3	37.6	18.8	0.0	0.0	0.0	0.0
1994	258.0	58.9	0.0	0.0	0.0	0.0	0.0	45.1	0.0	45.1
1995	0.0	117.7	756.5	231.7	45.1	45.1	0.0	0.0	0.0	28.8
1996	53.9	144.0	284.3	1306.4	774.0	85.2	142.8	87.7	45.1	91.4
1997	268.0	1663.3	31.3	473.4	731.5	104.0	93.9	0.0	0.0	0.0
1998	1836.2	301.9	539.8	164.1	529.8	372.0	87.7	60.1	31.3	0.0
1999	678.9	4046.8	776.6	1023.3	348.2	597.4	657.6	164.1	63.9	72.6
2000	417.1	1009.5	14039.3	2009.0	1584.4	558.6	774.0	278.1	110.2	0.0
2001	245.5	300.6	2865.7	6038.3	946.9	1084.7	359.5	240.5	339.4	56.4
2002	17.5	151.6	17.5	603.7	3157.6	457.2	169.1	0.0	256.8	81.4
2003	1068.4	0.0	350.7	91.4	608.7	3123.7	438.4	60.1	0.0	187.9
2004	91.4	435.9	36.3	700.1	328.2	1017.0	4026.8	155.3	210.4	145.3
2005	235.5	137.8	1977.7	110.2	179.1	393.3	534.8	1399.0	95.2	114.0
2006	288.1	353.2	110.2	2206.9	35.1	274.3	134.0	357.0	1053.4	85.2
2007	18.8	1305.1	1064.6	276.8	2701.6	82.7	17.5	202.9	152.8	631.3
2008	0.0	0.0	505.4	138.7	0.0	1308.7	0.0	201.9	142.7	541.1
2009	1112.7	323.5	115.0	235.2	14.4	50.6	435.4	0.0	64.6	174.6
2010	2035.2	43.1	26.6	62.2	210.5	363.9	139.7	301.1	0.0	151.4

Table C.25. VPA estimates of NEFSC bottom trawl survey catchability (q).

Survey ID	Survey	q	CV
1	NEFSC spring age1	0.16	0.23
2	NEFSC spring age2	0.15	0.18
3	NEFSC spring age3	0.21	0.17
4	NEFSC spring age4	0.23	0.21
5	NEFSC spring age5	0.21	0.16
6	NEFSC spring age6+	0.18	0.19
7	NEFSC fall age1 (modeled age2)	0.22	0.17
8	NEFSC fall age2 (modeled age3)	0.33	0.20
9	NEFSC fall age3 (modeled age4)	0.55	0.16
10	NEFSC fall age4 (modeled age5)	0.56	0.16
11	NEFSC fall age5 (modeled age6)	0.88	0.13
12	NEFSC fall age6 (modeled age7)	1.09	0.22
13	NEFSC fall age7 (modeled age8)	1.48	0.27
14	NEFSC fall age8+ (modeled age9+)	2.28	0.39

Table C.26. ADAPT-VPA retrospective Mohn's rho statistics for Gulf of Maine haddock using the average of a 7-year peel from 2003 to 2010.

Year	**SSB**	**$F_{6\text{-}8}$**	**Age-1 recruitment**
2003	-0.03	1.89	31.39
2004	-0.42	1.07	-0.67
2005	-0.34	0.95	-0.52
2006	-0.33	1.27	0.34
2007	-0.26	1.04	0.39
2008	0.04	0.52	0.02
2009	-0.17	-0.06	1.39
Mohn's Rho (7 year)	**-0.21**	**0.95**	**4.62**

Table C.27. VPA model uncertainty measures in terminal year + 1 (2011) Gulf of Maine haddock stock numbers-at-age.

Age	NLLS estimate	Bootstrap mean	Bootstrap standard error	CV for NLLS solution	Bias estimate	Bias standard error	Percent bias	NLLS estimated corrected for bias	CV for corrected estimate	Lower 80% CI	Upper 80% CI
Age2	590	735	613	0.83	145	20	24.6	445	1.38	220	1683
Age3	150	166	83	0.50	16	3	10.6	134	0.62	68	313
Age4	153	171	86	0.50	18	3	12.1	134	0.64	71	336
Age5	695	734	269	0.37	39	9	5.7	656	0.41	373	1235
Age6	346	355	144	0.41	9	5	2.6	337	0.43	169	610
Age7	94	102	47	0.46	8	2	8.3	86	0.55	42	187
Age8	122	154	131	0.85	32	4	26.3	90	1.46	13	400
Age9	81	483	2149	4.45	402	69	497.6	-321	-6.69	2	1538

Age	NLLS estimate	Bootstrap mean	Bootstrap standard error	CV for NLLS solution	Bias estimate	Bias standard error	Percent bias	NLLS estimated corrected for bias	CV for corrected estimate	Lower 80% CI	Upper 80% CI
Age1	0.00	0.00	0.00	0.69	0.00	0.00	19.8	0.00	1.03	0.00	0.01
Age2	0.01	0.01	0.00	0.47	0.00	0.00	11.7	0.01	0.60	0.00	0.02
Age3	0.03	0.03	0.01	0.48	0.00	0.00	10.5	0.02	0.60	0.01	0.05
Age4	0.08	0.08	0.03	0.36	0.01	0.00	6.8	0.07	0.41	0.04	0.14
Age5	0.22	0.25	0.09	0.35	0.02	0.00	10.3	0.20	0.44	0.13	0.41
Age6	0.25	0.28	0.14	0.50	0.03	0.00	10.3	0.23	0.61	0.14	0.50
Age7	1.26	1.48	0.84	0.57	0.22	0.03	17.7	1.04	0.81	0.57	3.14
Age8	0.93	0.95	0.32	0.34	0.01	0.01	1.5	0.92	0.35	0.48	1.51
Age9	0.93	0.95	0.32	0.34	0.01	0.01	1.5	0.92	0.35	0.48	1.51

Table C.28. VPA model estimates of average fishing mortality-at-age on Gulf of Maine haddock between 1977 and 2010. *The model estimates of fishing mortality hit a bound of 5.0 in several instances which are highlighted by italicized text.*

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1977	0.10	0.15	0.03	0.20	0.51	0.42	*5.00*	0.42	0.42
1978	0.00	0.10	0.25	0.14	0.27	0.87	0.15	0.47	0.47
1979	0.01	0.06	0.21	0.28	0.23	0.13	0.45	0.16	0.16
1980	0.02	0.18	0.11	0.42	0.44	0.30	0.25	0.28	0.28
1981	0.05	0.34	0.20	0.40	0.36	0.32	0.20	0.30	0.30
1982	0.15	0.18	0.56	0.25	0.20	0.41	0.45	0.44	0.44
1983	0.05	0.05	0.38	0.74	0.50	0.47	0.69	0.59	0.59
1984	0.02	0.09	0.12	0.49	0.39	0.41	0.34	0.40	0.40
1985	0.02	0.04	0.39	0.34	0.69	0.45	0.56	0.51	0.51
1986	0.08	0.00	0.41	1.05	0.71	0.61	0.67	0.63	0.63
1987	0.07	0.02	0.22	0.47	0.49	1.11	0.79	0.89	0.89
1988	0.03	0.00	0.09	0.19	0.55	0.91	1.10	0.94	0.94
1989	0.01	0.05	0.06	0.57	0.57	0.45	1.48	0.64	0.64
1990	0.01	0.01	0.49	0.03	0.58	2.54	2.02	2.18	2.18
1991	0.02	0.11	0.18	0.43	0.44	1.38	*5.00*	1.43	1.43
1992	0.03	0.07	0.63	0.20	0.29	0.10	0.58	0.16	0.16
1993	0.01	0.06	0.14	0.45	0.14	0.12	0.40	0.19	0.19
1994	0.04	0.02	0.14	0.09	0.08	0.11	0.18	0.13	0.13
1995	0.02	0.04	0.11	0.35	0.11	0.21	0.09	0.13	0.13
1996	0.01	0.01	0.09	0.10	0.11	0.06	0.34	0.11	0.11
1997	0.00	0.01	0.10	0.23	0.17	0.17	0.10	0.14	0.14
1998	0.01	0.02	0.03	0.09	0.28	0.16	0.23	0.17	0.17
1999	0.00	0.00	0.03	0.10	0.09	0.15	0.14	0.14	0.14
2000	0.00	0.00	0.03	0.10	0.14	0.19	0.21	0.19	0.19
2001	0.00	0.01	0.02	0.11	0.11	0.25	0.15	0.19	0.19
2002	0.00	0.00	0.01	0.03	0.12	0.19	0.15	0.18	0.18
2003	0.00	0.00	0.00	0.03	0.08	0.14	0.16	0.15	0.15
2004	0.00	0.01	0.01	0.06	0.07	0.13	0.15	0.13	0.13
2005	0.00	0.01	0.09	0.10	0.21	0.18	0.20	0.19	0.19
2006	0.01	0.00	0.03	0.14	0.12	0.26	0.14	0.18	0.18
2007	0.00	0.01	0.03	0.15	0.50	0.21	0.25	0.23	0.23
2008	0.00	0.00	0.05	0.06	0.29	0.16	0.33	0.31	0.31
2009	0.00	0.00	0.02	0.09	0.13	0.42	0.75	0.43	0.43
2010	0.00	0.01	0.03	0.08	0.22	0.25	1.26	0.93	0.93

Table C.29. VPA model estimates of partial recruitment of Gulf of Maine haddock between 1977 and 2010.

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1977	0.02	0.03	0.01	0.04	0.10	0.08	1.00	0.08	0.08
1978	0.00	0.12	0.29	0.16	0.31	1.00	0.17	0.54	0.54
1979	0.02	0.14	0.46	0.62	0.52	0.30	1.00	0.36	0.36
1980	0.05	0.42	0.24	0.96	1.00	0.70	0.58	0.64	0.64
1981	0.12	0.85	0.50	1.00	0.89	0.79	0.50	0.74	0.74
1982	0.27	0.32	1.00	0.44	0.37	0.73	0.82	0.78	0.78
1983	0.07	0.06	0.52	1.00	0.68	0.64	0.94	0.80	0.80
1984	0.03	0.19	0.24	1.00	0.80	0.83	0.70	0.81	0.81
1985	0.03	0.06	0.56	0.49	1.00	0.66	0.81	0.75	0.75
1986	0.08	0.00	0.39	1.00	0.68	0.58	0.63	0.60	0.60
1987	0.06	0.02	0.20	0.43	0.44	1.00	0.71	0.80	0.80
1988	0.03	0.00	0.08	0.17	0.50	0.83	1.00	0.86	0.86
1989	0.01	0.04	0.04	0.38	0.39	0.30	1.00	0.43	0.43
1990	0.01	0.00	0.19	0.01	0.23	1.00	0.79	0.86	0.86
1991	0.00	0.02	0.04	0.09	0.09	0.28	1.00	0.29	0.29
1992	0.05	0.11	1.00	0.32	0.46	0.16	0.93	0.26	0.26
1993	0.02	0.13	0.32	1.00	0.32	0.27	0.90	0.41	0.41
1994	0.21	0.11	0.81	0.52	0.44	0.64	1.00	0.75	0.75
1995	0.05	0.11	0.31	1.00	0.32	0.58	0.26	0.36	0.36
1996	0.02	0.04	0.28	0.29	0.32	0.18	1.00	0.34	0.34
1997	0.01	0.03	0.42	1.00	0.75	0.74	0.44	0.63	0.63
1998	0.02	0.05	0.10	0.32	1.00	0.56	0.82	0.61	0.61
1999	0.00	0.00	0.21	0.65	0.62	1.00	0.95	0.98	0.98
2000	0.01	0.02	0.15	0.48	0.68	0.92	1.00	0.95	0.95
2001	0.01	0.04	0.10	0.44	0.45	1.00	0.60	0.76	0.76
2002	0.01	0.01	0.05	0.16	0.64	1.00	0.81	0.95	0.95
2003	0.01	0.03	0.03	0.17	0.48	0.86	1.00	0.91	0.91
2004	0.01	0.05	0.08	0.39	0.47	0.86	1.00	0.87	0.87
2005	0.01	0.03	0.41	0.46	1.00	0.88	0.94	0.92	0.92
2006	0.03	0.02	0.11	0.54	0.47	1.00	0.53	0.68	0.68
2007	0.00	0.03	0.06	0.30	1.00	0.42	0.51	0.45	0.45
2008	0.00	0.01	0.14	0.18	0.88	0.48	1.00	0.96	0.96
2009	0.00	0.01	0.03	0.12	0.17	0.57	1.00	0.57	0.57
2010	0.00	0.01	0.02	0.06	0.18	0.20	1.00	0.74	0.74
2006-2010 Average	0.01	0.01	0.07	0.24	0.54	0.53	0.81	0.68	0.68
5yr-standardized	0.01	0.02	0.09	0.30	0.67	0.66	1.00	0.85	0.85
5yr-standardized flat topped	0.01	0.02	0.09	0.30	0.67	0.66	1.00	1.00	1.00

Table C.30. VPA model estimates of Gulf of Maine haddock numbers-at-age between 1977 and 2010.

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+	Total
1977	6,599	13,777	1,888	2,204	588	463	1	5	20	25,545
1978	1,916	4,908	9,666	1,500	1,476	289	250	0	16	20,021
1979	7,024	1,565	3,627	6,151	1,065	920	99	176	0	20,627
1980	6,908	5,688	1,203	2,417	3,823	691	658	52	114	21,554
1981	3,955	5,545	3,878	886	1,301	2,022	417	418	54	18,476
1982	606	3,090	3,223	2,594	484	742	1,203	279	186	12,407
1983	1,573	426	2,117	1,514	1,661	323	405	625	217	8,861
1984	818	1,219	333	1,183	593	826	166	166	340	5,644
1985	152	660	911	242	592	328	449	96	104	3,534
1986	286	122	517	507	141	244	170	210	28	2,225
1987	140	215	100	280	145	57	108	72	34	1,151
1988	625	108	173	65	143	73	15	40	9	1,251
1989	489	495	88	130	44	68	24	4	2	1,344
1990	372	398	384	68	60	21	35	4	0	1,342
1991	387	300	324	192	54	28	1	4	3	1,293
1992	706	310	220	222	102	28	6	0	8	1,602
1993	1,593	559	237	96	149	63	21	3	4	2,725
1994	2,763	1,293	431	168	50	106	45	12	9	4,877
1995	3,277	2,181	1,037	306	126	38	77	31	28	7,101
1996	1,432	2,637	1,715	760	176	92	25	58	8	6,903
1997	2,391	1,163	2,128	1,277	564	129	71	15	15	7,753
1998	2,658	1,955	945	1,582	833	389	90	53	53	8,558
1999	15,211	2,164	1,577	752	1,182	513	271	58	51	21,779
2000	2,961	12,446	1,771	1,252	560	883	363	193	95	20,524
2001	1,205	2,419	10,144	1,407	929	398	598	242	154	17,496
2002	1,081	985	1,960	8,112	1,035	680	255	423	456	14,987
2003	82	883	805	1,588	6,445	750	460	179	586	11,778
2004	4,251	67	720	656	1,265	4,888	535	321	480	13,183
2005	501	3,473	55	582	506	964	3,510	375	519	10,485
2006	1,378	410	2,828	41	432	336	657	2,361	413	8,856
2007	1,723	1,120	334	2,253	29	313	212	468	2,003	8,455
2008	287	1,409	904	265	1,586	14	208	134	833	5,640
2009	226	235	1,149	706	205	975	10	123	449	4,078
2010	722	185	191	918	528	148	522	4	291	3,509
2011	1,124	590	150	153	695	346	94	122	81	3,355
1977-2010 mean	2,244									
1977-2010 median	1,292									
1977-2010 geometric mean	1,124									

Table C.31. VPA model estimates of Gulf of Maine haddock January 1 and spawning stock biomass between 1977 and 2010.

Year	January 1 total stock biomass (mt)	Spawning stock biomass (mt)
1977	17,169	9,077
1978	18,086	13,036
1979	18,841	15,207
1980	20,064	15,158
1981	19,233	14,750
1982	17,391	13,822
1983	13,292	10,396
1984	8,483	6,902
1985	5,833	4,500
1986	3,531	2,648
1987	1,848	1,369
1988	1,111	826
1989	843	543
1990	1,158	706
1991	1,194	807
1992	1,280	914
1993	1,437	959
1994	2,084	1,343
1995	3,243	2,249
1996	4,115	3,031
1997	6,370	4,743
1998	8,273	6,483
1999	8,933	6,474
2000	11,619	7,373
2001	16,345	12,525
2002	18,905	16,757
2003	16,230	14,741
2004	14,117	12,545
2005	11,967	10,125
2006	9,305	7,958
2007	7,956	6,796
2008	5,618	4,481
2009	4,648	3,864
2010	3,651	2,868
2011	2,575	

Table C.32. VPA model estimates of average Gulf of Maine haddock fishing mortality on ages 6 through 8 between 1977 and 2010.

Year	Average F_{6-8}	N-weighted F_{6-8}	Biomass weighted F_{6-8}	Catch weighted F_{6-8}
1977	1.94	0.42	0.42	0.56
1978	0.50	0.54	0.49	0.75
1979	0.25	0.16	0.17	0.20
1980	0.28	0.28	0.28	0.28
1981	0.27	0.30	0.30	0.30
1982	0.43	0.44	0.44	0.44
1983	0.58	0.59	0.59	0.60
1984	0.38	0.40	0.40	0.40
1985	0.51	0.52	0.52	0.52
1986	0.64	0.63	0.63	0.63
1987	0.93	0.89	0.89	0.90
1988	0.98	0.94	0.95	0.95
1989	0.86	0.72	0.74	0.89
1990	2.25	2.21	2.20	2.22
1991	2.60	1.53	1.55	2.73
1992	0.28	0.18	0.18	0.34
1993	0.24	0.19	0.20	0.26
1994	0.14	0.13	0.14	0.14
1995	0.14	0.13	0.13	0.15
1996	0.17	0.12	0.12	0.18
1997	0.14	0.14	0.14	0.15
1998	0.19	0.17	0.18	0.18
1999	0.14	0.14	0.14	0.14
2000	0.20	0.19	0.19	0.19
2001	0.19	0.19	0.19	0.20
2002	0.18	0.18	0.18	0.18
2003	0.15	0.15	0.15	0.15
2004	0.14	0.13	0.13	0.13
2005	0.19	0.19	0.19	0.19
2006	0.19	0.18	0.18	0.18
2007	0.23	0.23	0.23	0.23
2008	0.26	0.31	0.32	0.32
2009	0.53	0.43	0.43	0.43
2010	0.82	1.04	1.06	1.18

Table C.33. Summary of the inputs to the Gulf of Maine haddock yield per recruit analysis.

Age	Fishery selectivity	Natural mortality	Catch weights (kg)	Stock weights (kg)	Spawning stock weights (kg)	Proportion mature
Age1	0.009	0.200	0.178	0.100	0.100	0.027
Age2	0.017	0.200	0.603	0.298	0.298	0.236
Age3	0.091	0.200	0.905	0.706	0.706	0.773
Age4	0.297	0.200	1.075	0.984	0.984	0.974
Age5	0.672	0.200	1.357	1.208	1.208	0.998
Age6	0.660	0.200	1.629	1.498	1.498	1.000
Age7	1.000	0.200	1.699	1.650	1.650	1.000
Age8	1.000	0.200	1.879	1.786	1.786	1.000
Age9^{+}	1.000	0.200	1.967	1.967	1.967	1.000

Table C.34. Yield per recruit results for Gulf of Maine haddock.

Reference point	**F**	**YPR**	**SSB/R**	**Mean age**
F_0	0.00	0.000	4.921	5.5
$F_{0.1}$	0.34	0.435	2.258	3.3
F_{max}	2.11	0.539	0.900	2.4
$F_{40\%}$	0.46	0.470	1.968	3.1

Table C.35. Biological reference points for Gulf of Maine haddock and the ratio of 2010 model estimates of fishing mortality and spawning stock biomass used for stock status determination.

Reference point		90% confidence interval
F_{MSY} ($F_{40\%}$)	0.46	
SSB_{MSY} (mt)	4,904	(2,272 - 10,604)
MSY (mt)	1,177	(553 - 2,563)

VPA base model			Ratio 2010/reference point		Retrospective adjusted	
2010 point estimate		90% confidence interval	Ratio	90% confidence interval	Point estimate	Ratio
$F_{6\text{-}8}$ (average)	0.82	(0.42 - 1.63)	1.78	(0.91 - 3.54)	0.42	0.91
SSB	2,868	(2,140 - 4,233)	0.58	(0.44 - 0.86)	3,630	0.74

Table C.36. Short-term projections of Gulf of Maine haddock fishery yield (catch) and spawning stock biomass conducted at both F_{MSY} (0.46) and 75% F_{MSY} (0.35) harvest scenarios in the years 2011 – 2020. Projections have not been adjusted to account for retrospective bias.

Year	**1964-2010 recruitment series (SSB ≥ 3 kmt)**	
	75% F_{MSY} (0.35)	**F_{MSY} ($F_{40\%}$ = 0.46)**
	Total fishery yield (mt)	
2011	1,309	1,309
2012	258	327
2013	270	322
2014	331	387
2015	428	498
2016	584	679
2017	739	853
2018	885	996
2019	976	1,085
2020	1,034	1,129
	Spawning stock biomass (mt)	
2011	1,904	1,904
2012	1,317	1,296
2013	1,607	1,532
2014	2,154	2,021
2015	2,956	2,771
2016	3,800	3,558
2017	4,426	4,093
2018	4,902	4,464
2019	5,174	4,635
2020	5,379	4,783

Figures

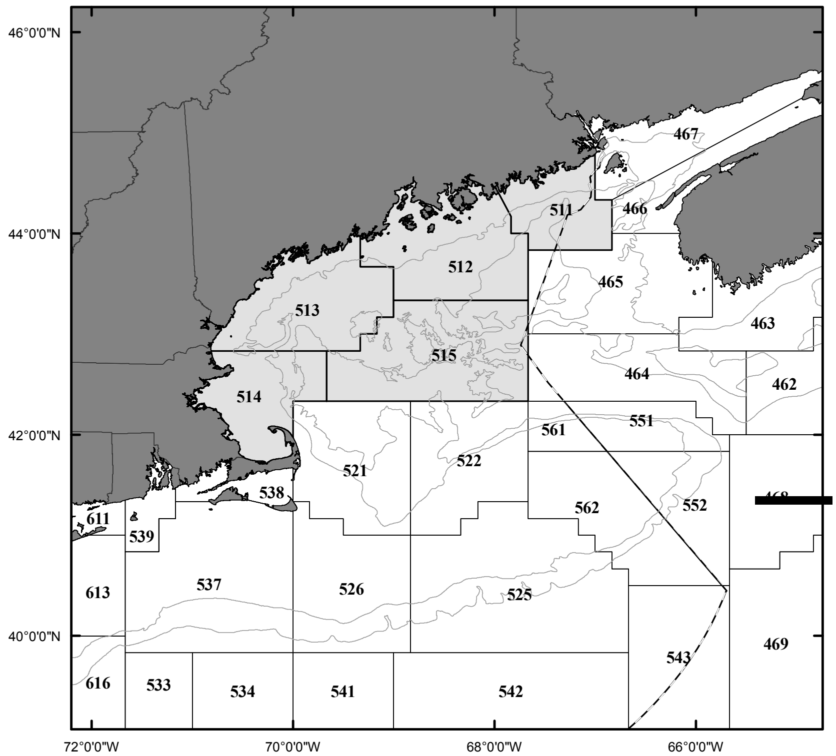
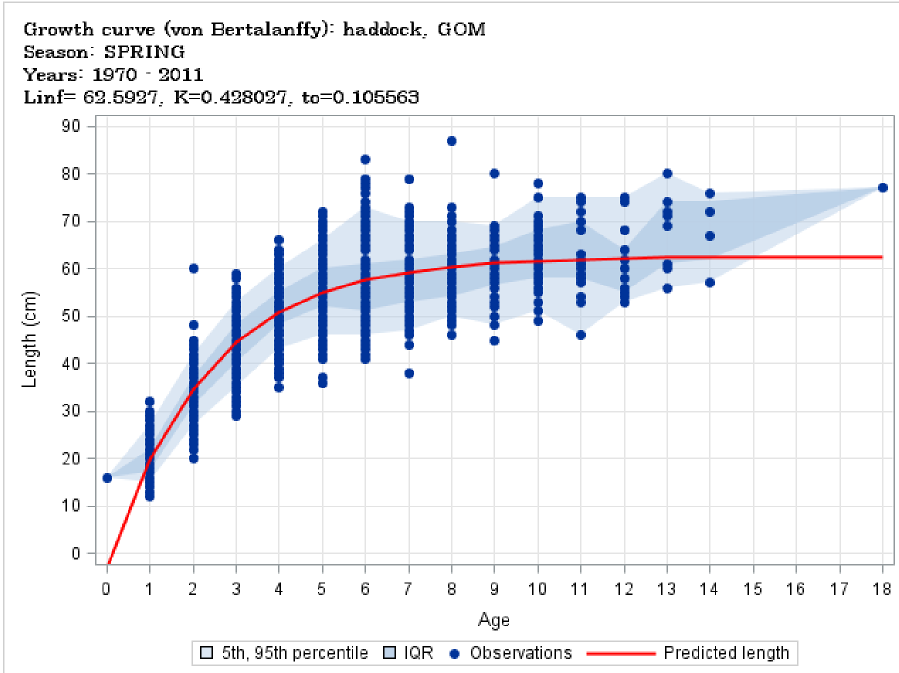


Figure C.1. Map of the Gulf of Maine haddock assessment area (shaded grey). The United States exclusive econic zone (EEZ) is defined by the dashed line. Within the Gulf of Maine region, this line is informally referred to as the “Hague Line”.



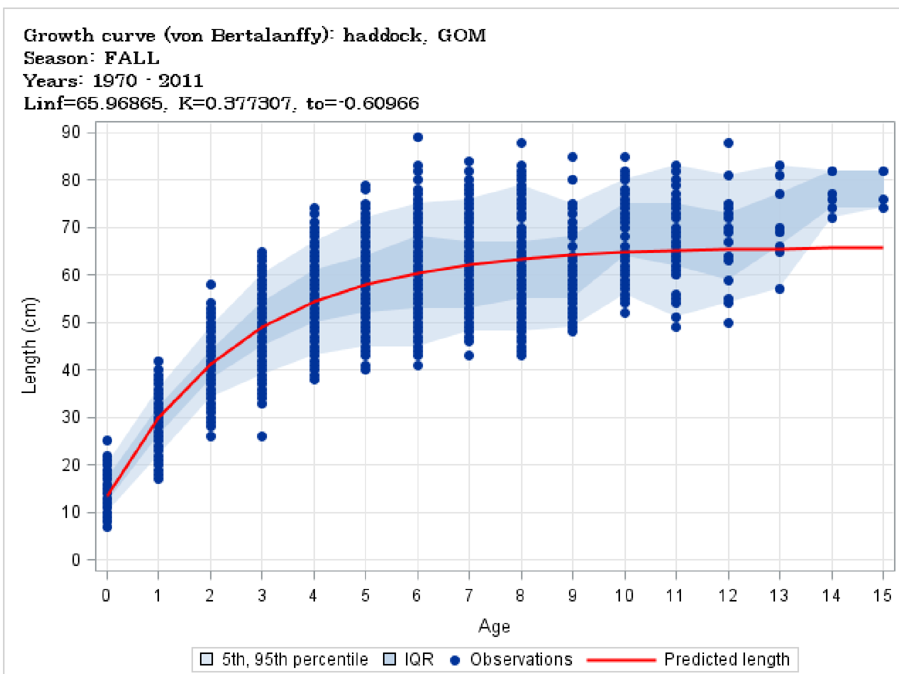


Figure C.2. Comparison of von Bertalanffy growth curves for the Gulf of Maine haddock stocks as estimated from data collected from the Northeast Fisheries Science Center spring (top) and fall (bottom) bottom trawl surveys between 1970 and 2011.

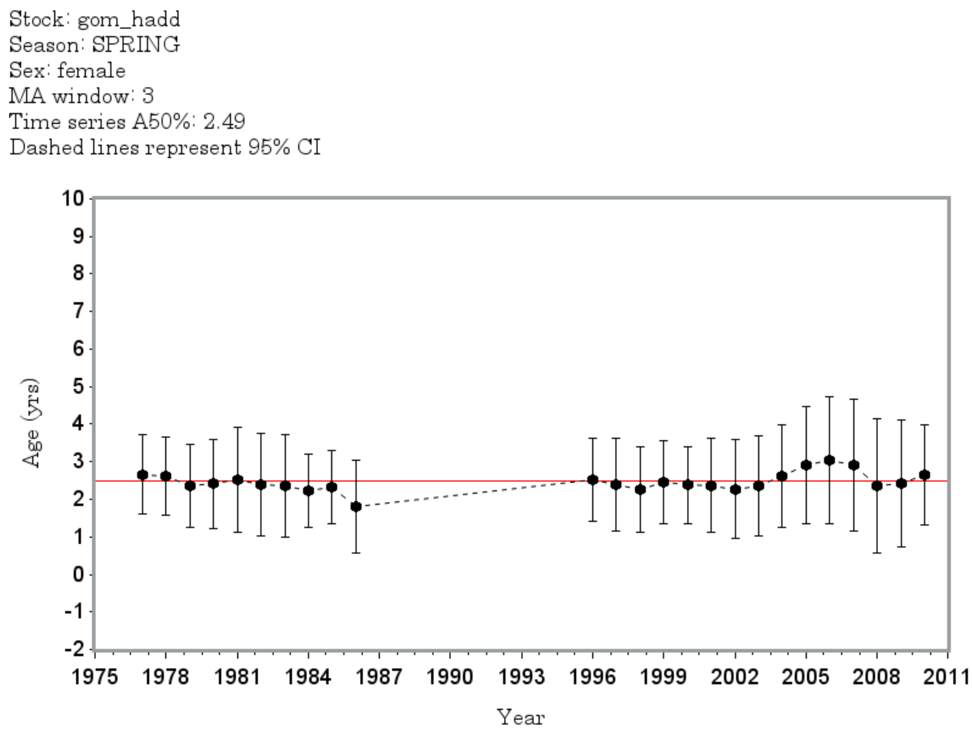


Figure C.3. Three-year moving averages of the average age-at-50% maturity (A50) and corresponding 95% confidence intervals for female Gulf of Maine haddock from 1977 to 2011. Average maturity has been estimated from data collected from the Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey. Years in which maturity ogives could not be estimated are omitted from the top panel.

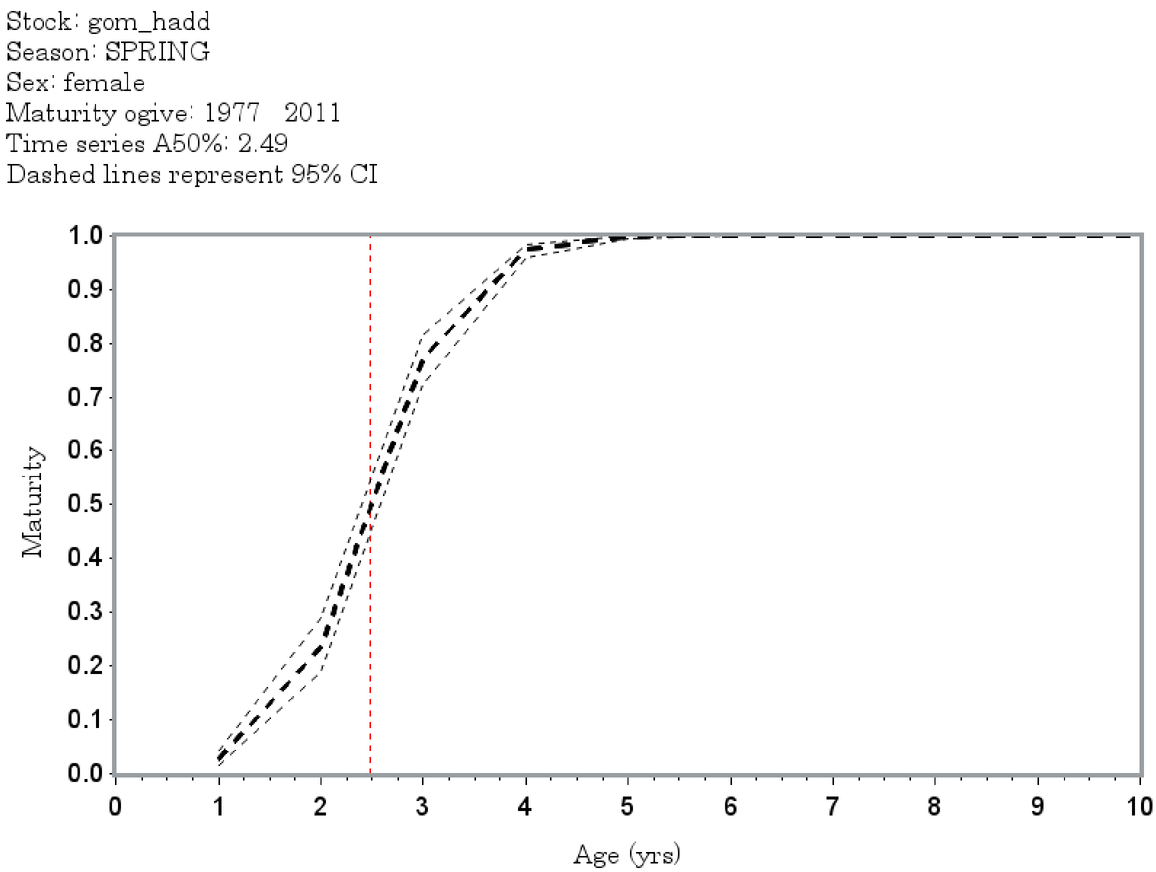


Figure C.4. Maturity ogive for female Gulf of Maine haddock based on time series averages of maturity and age information collected from the Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey from 1977 to 2011.

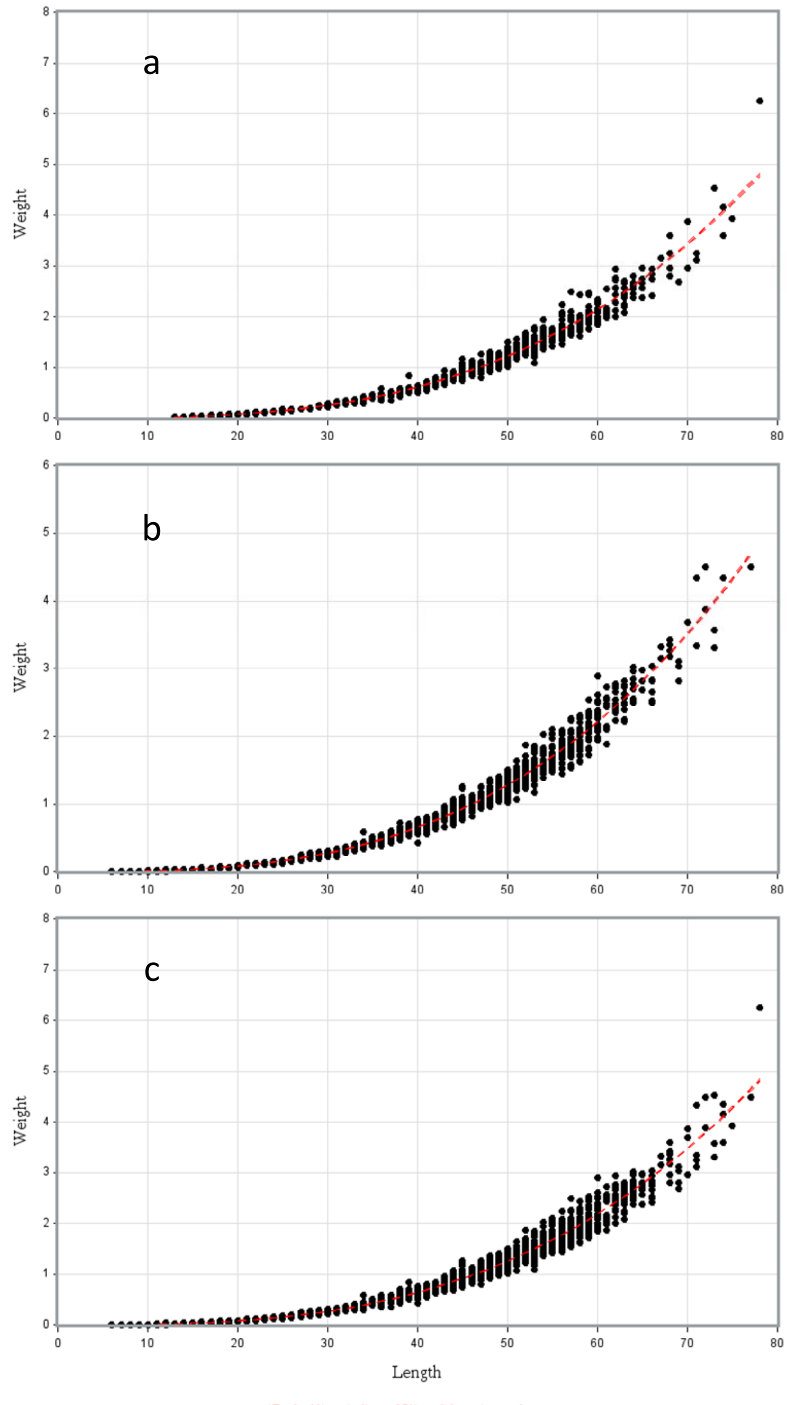


Figure C.5. Gulf of Maine haddock length-weight relationships for spring (a), fall (b) and annual (c; combined spring and fall). Length-weight relationships were estimated from Northeast Fisheries Science center bottom trawl survey data.

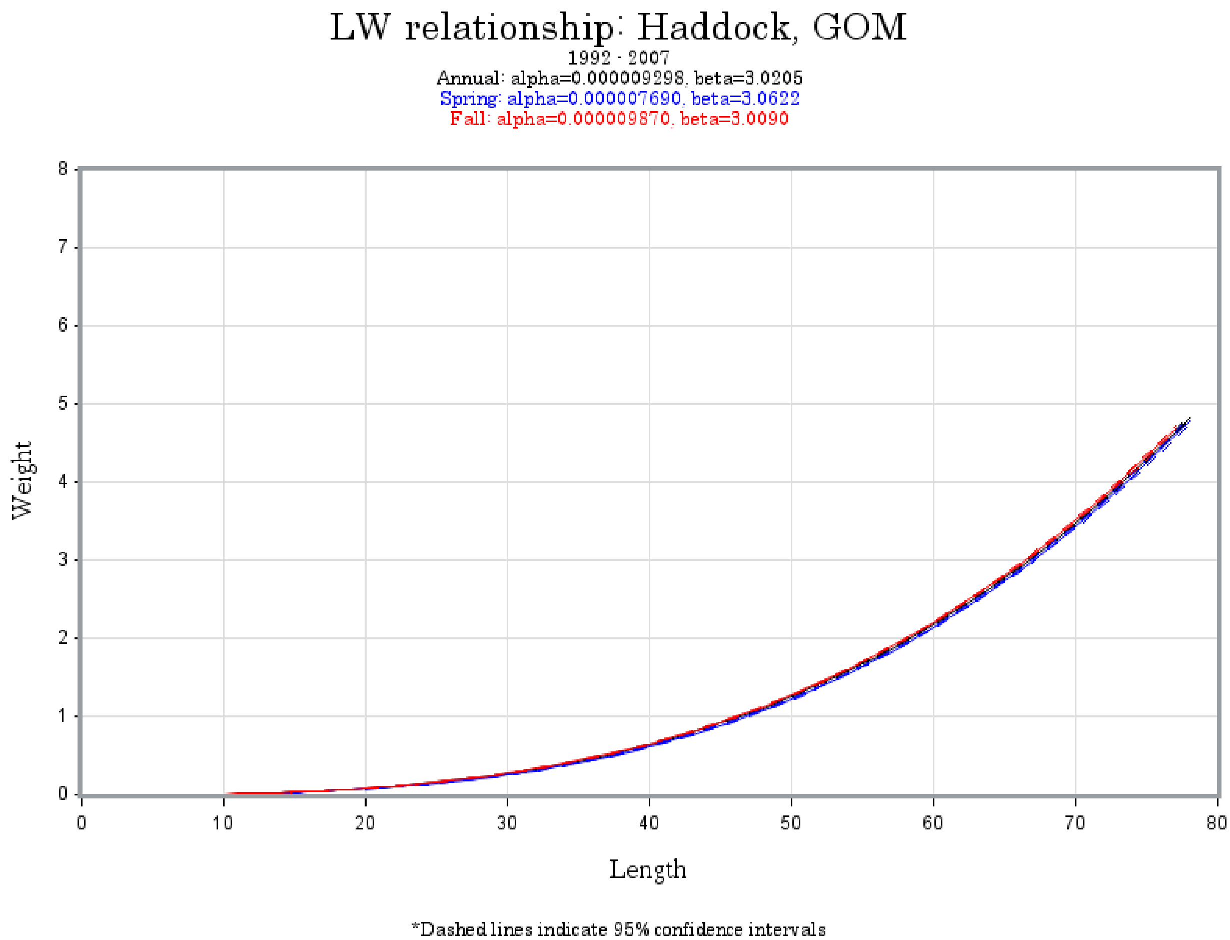


Figure C.6. Comparison of the Gulf of Maine haddock seasonal and annual length-weight equations estimated from Northeast Fisheries Science center bottom trawl survey data.

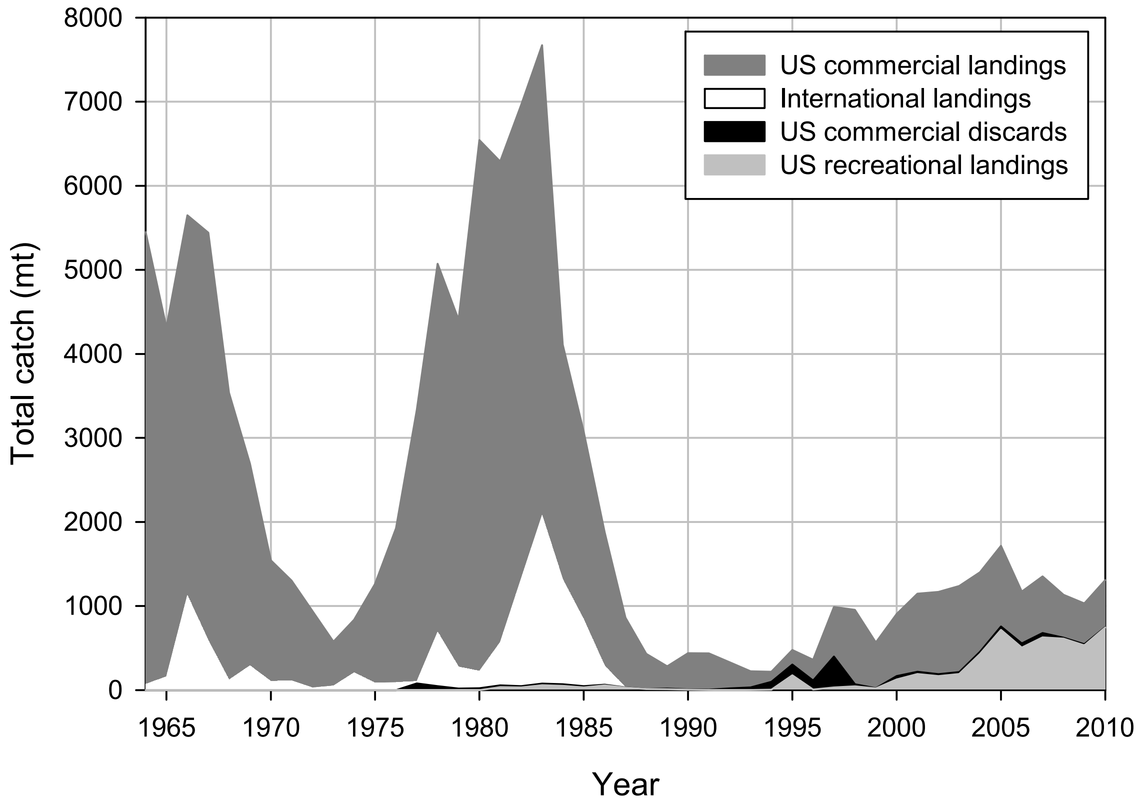


Figure C.7. Total catch (mt) of Gulf of Maine haddock by fishery and disposition from 1964 to 2010.

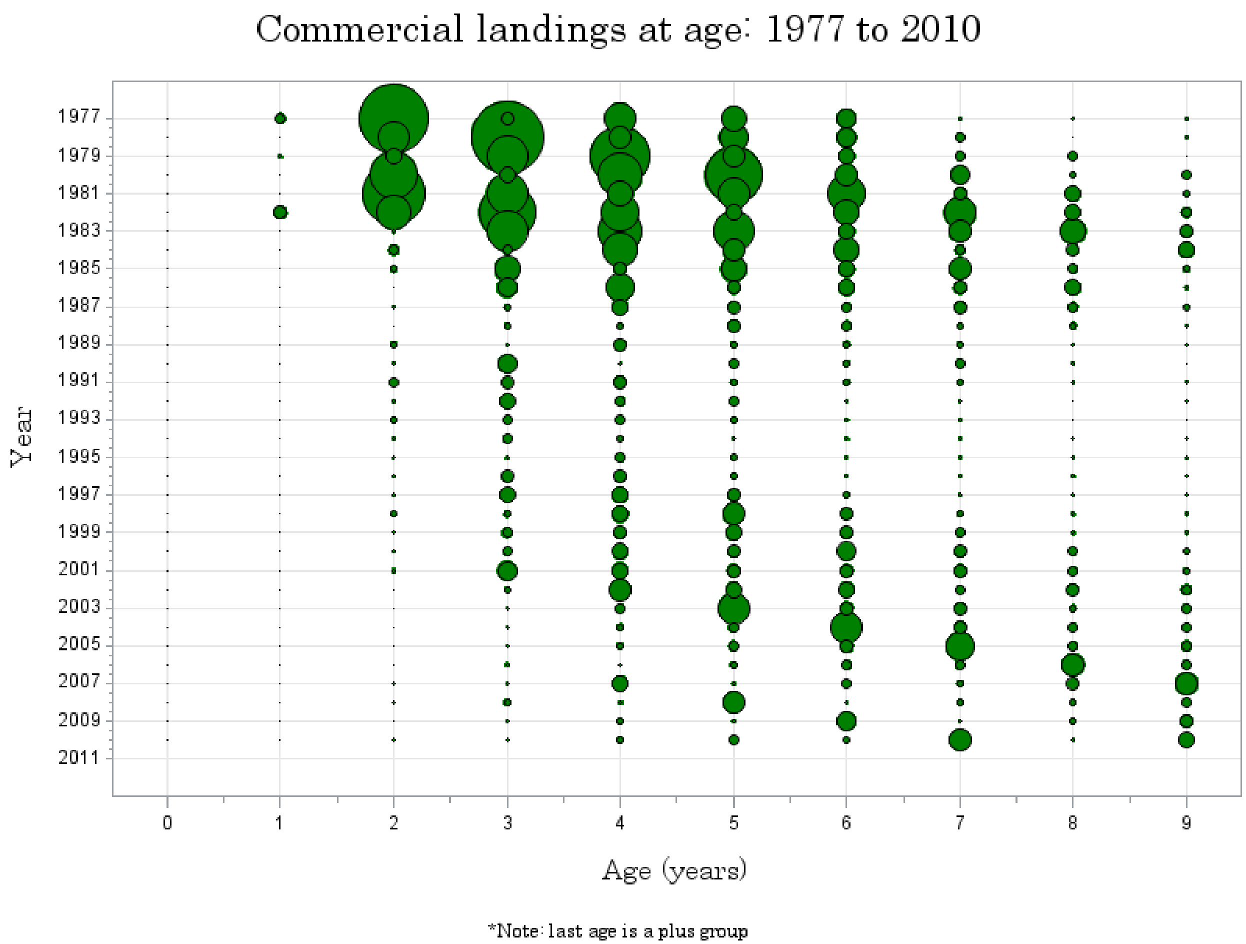


Figure C.8. Commercial landings-at-age of Gulf of Maine haddock from 1977 to 2010. **Note that age 9 is a plus group.*

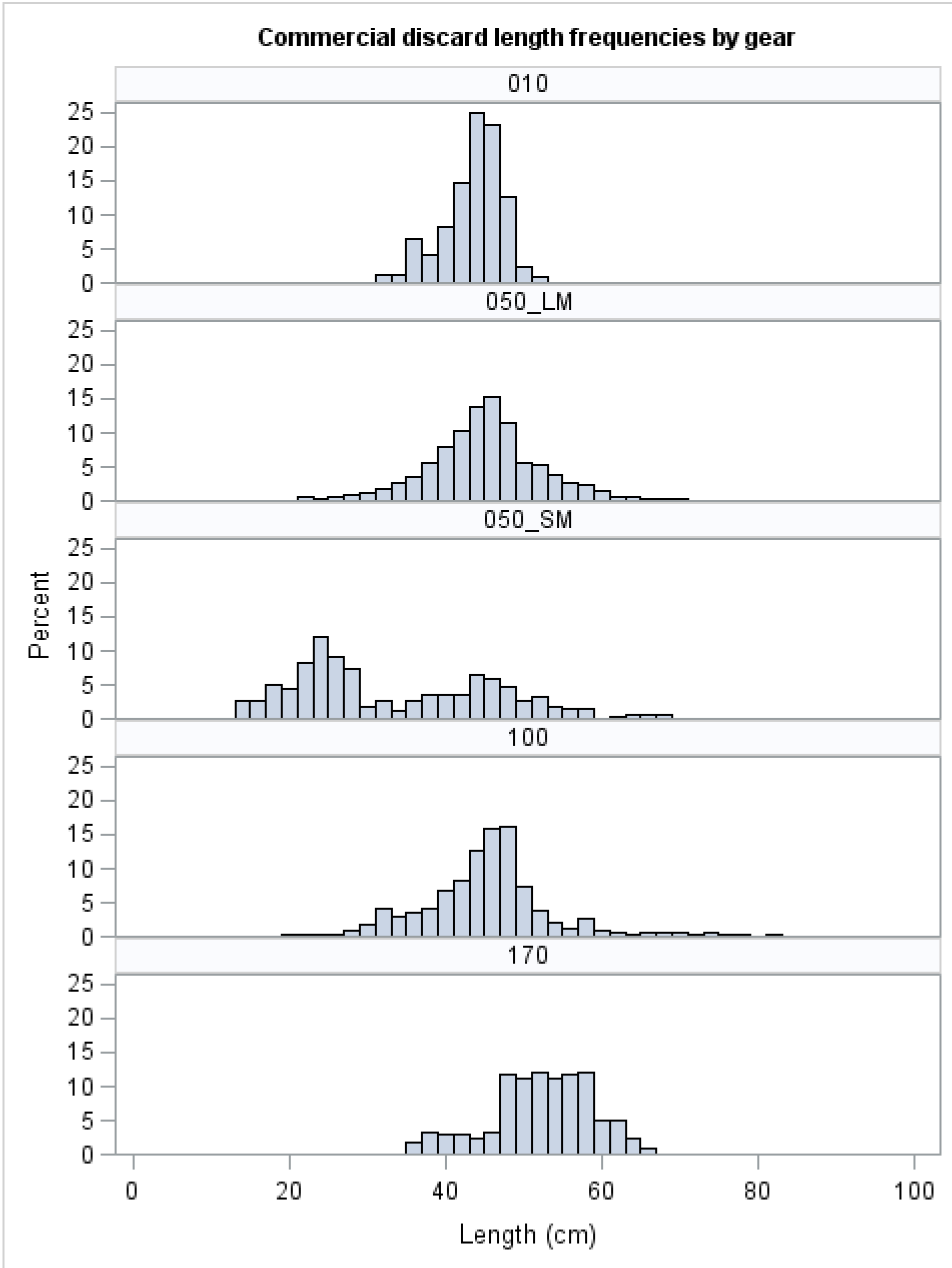


Figure C.9. Aggregate length frequency distributions, by gear type, of Gulf of Maine haddock discarded in the commercial fishery between 1989 and 2010. Gear types shown include: longline (010), large mesh otter trawl (050_LM), small mesh otter trawl (050_SM), sink gillnet (100) and midwater trawl (170).

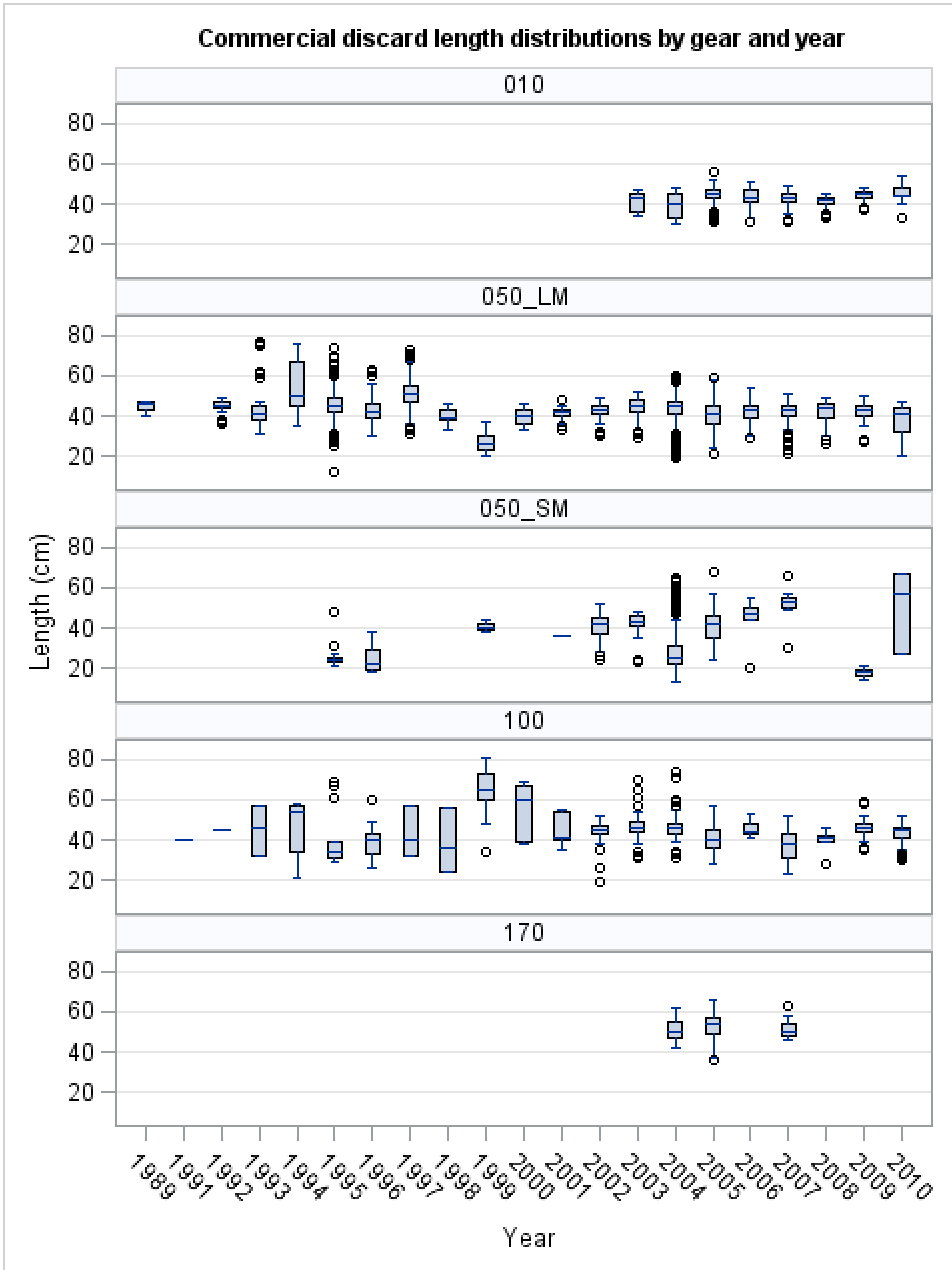


Figure C.10. Box plots showing the length distributions of Gulf of Maine haddock discarded by the commercial fishery between 1989 and 2010. Gear types shown include: longline (010), large mesh otter trawl (050_LM), small mesh otter trawl (050_SM), sink gillnet (100) and midwater trawl (170). Missing years indicate that there were either no observed trips in the Gulf of Maine or no haddock were observed to have been discarded.

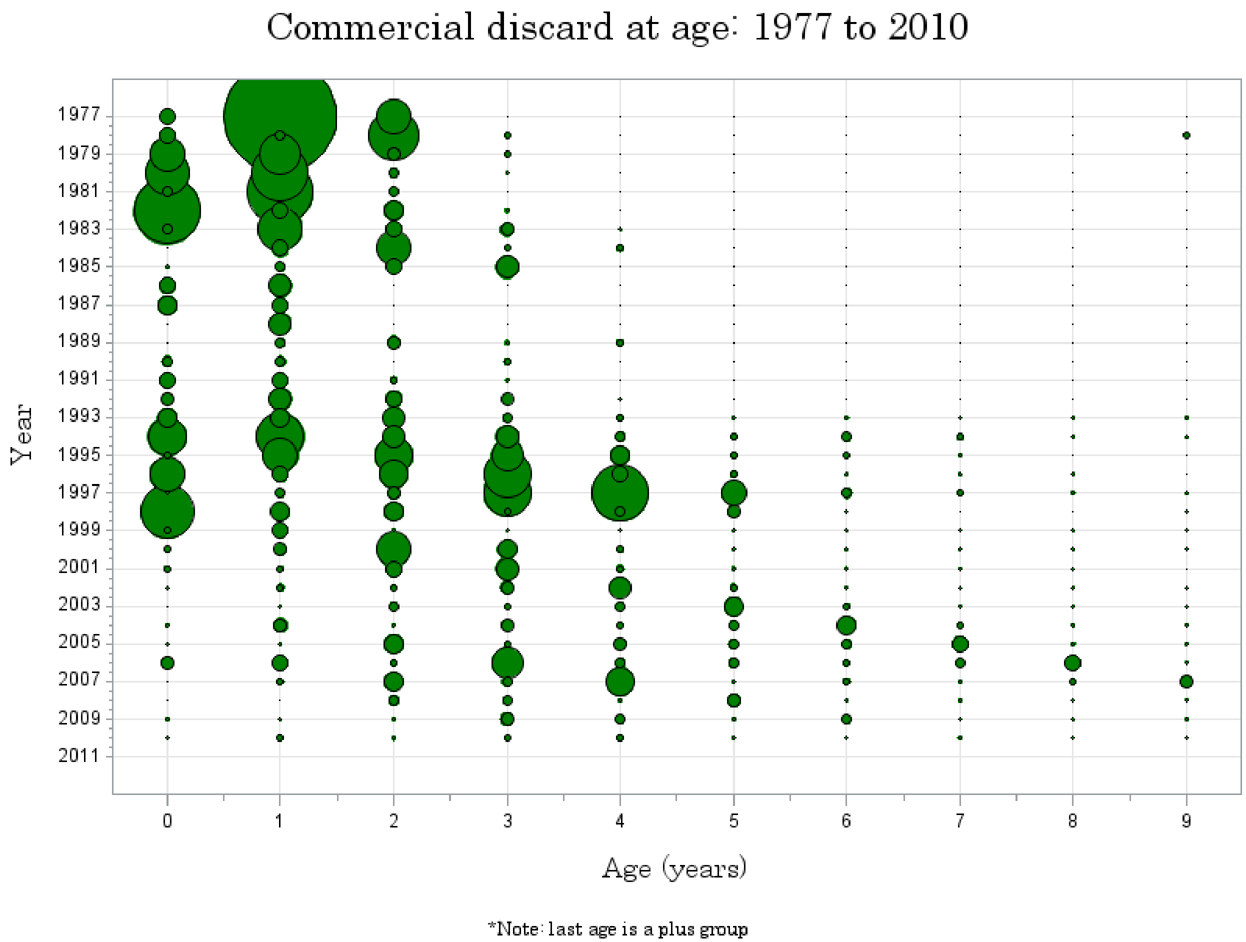


Figure C.11. Commercial discards-at-age of Gulf of Maine haddock from 1977 to 2010. **Note that age 9 is a plus group.*

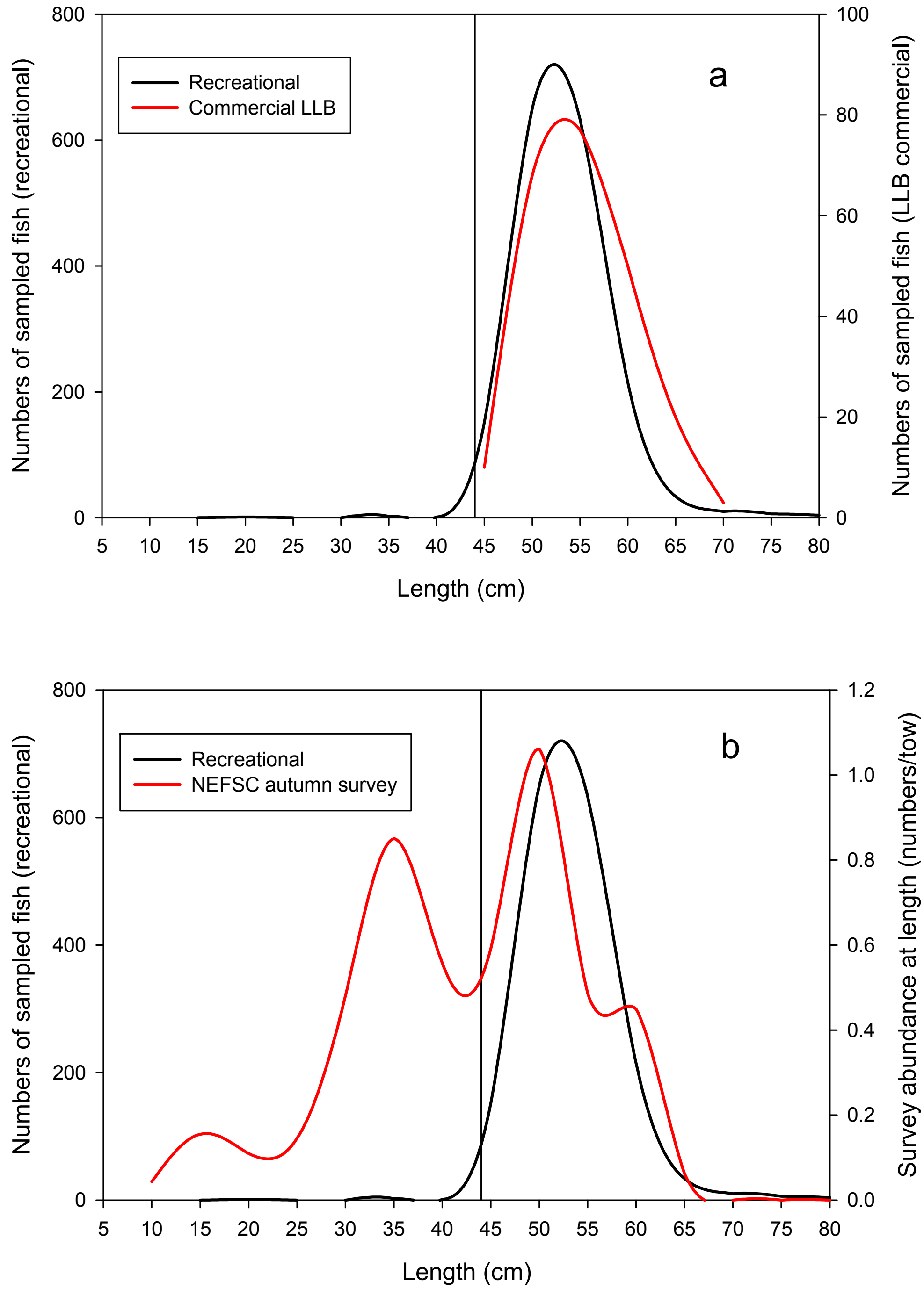


Figure C.12. Selectivity of the recreational fishery relative to the commercial longline fishery (a) and Northeast Fisheries Science Center bottom trawl survey (b). Solid vertical lines indicate minimum legal size for recreational fishery. Data shown are from 2005.

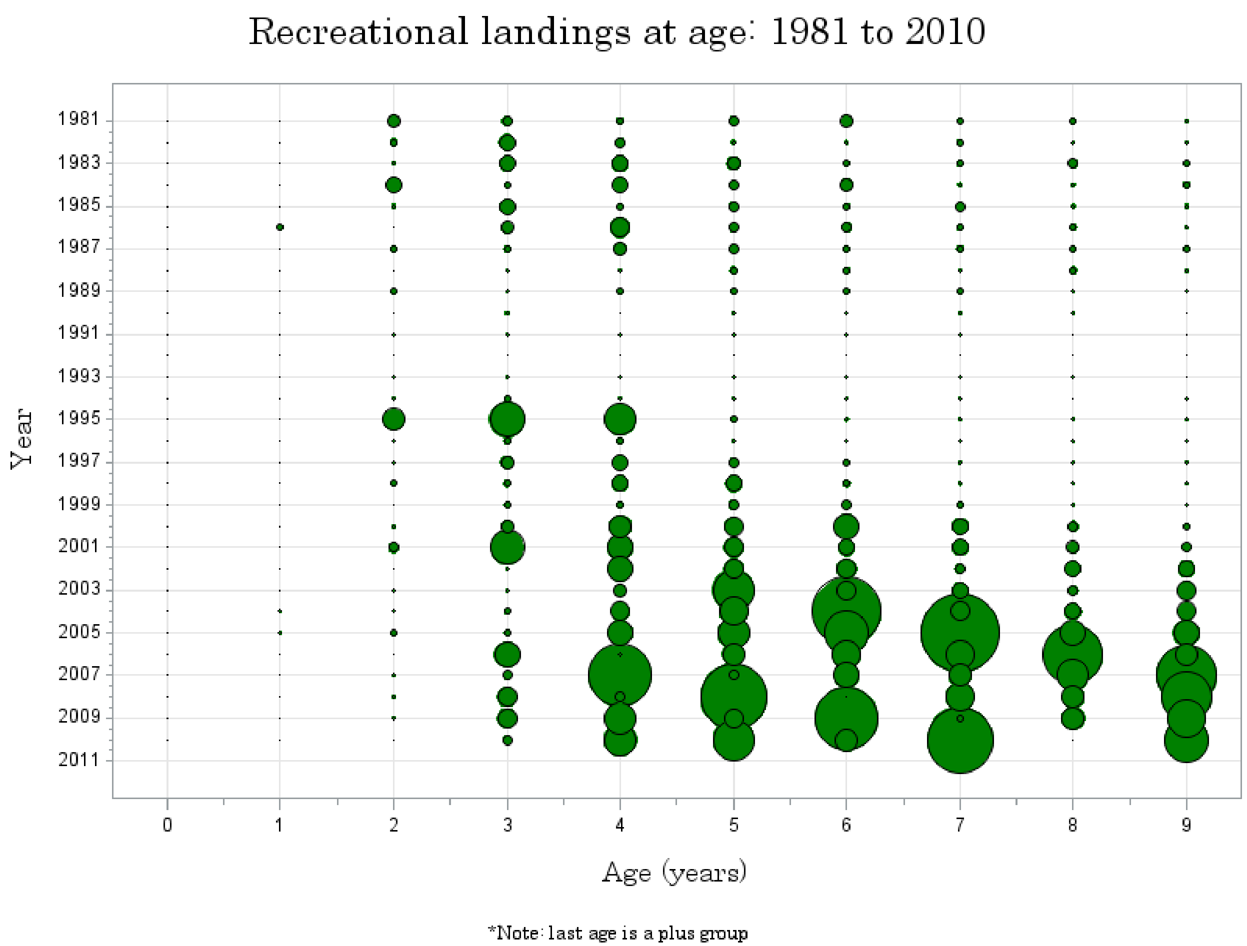


Figure C.13. Recreational landings-at-age of Gulf of Maine haddock from 1981 to 2010. **Note that age 9 is a plus group.*

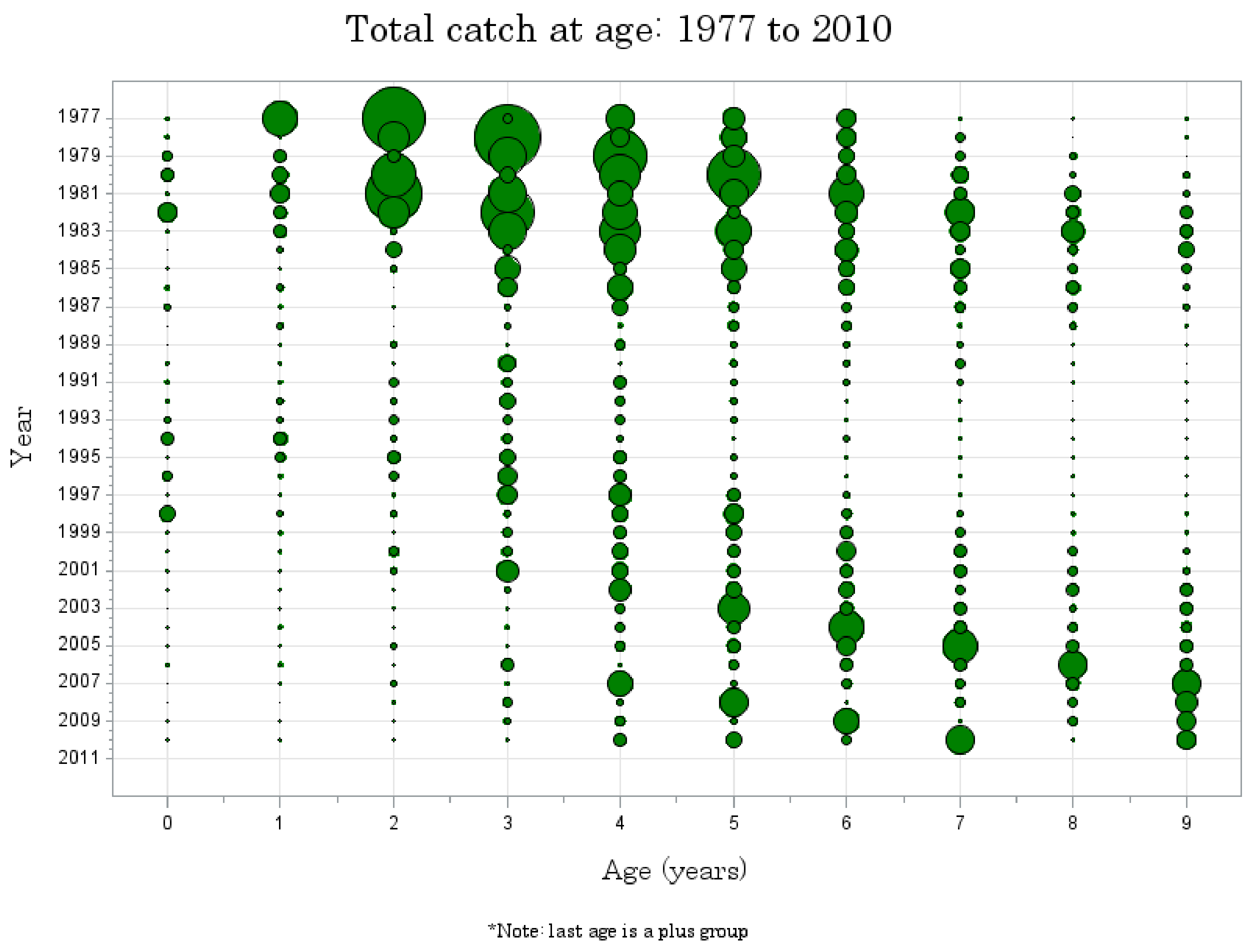


Figure C.14. Total fishery catch-at-age of Gulf of Maine haddock from 1977 to 2010. **Note that age 9 is a plus group.*

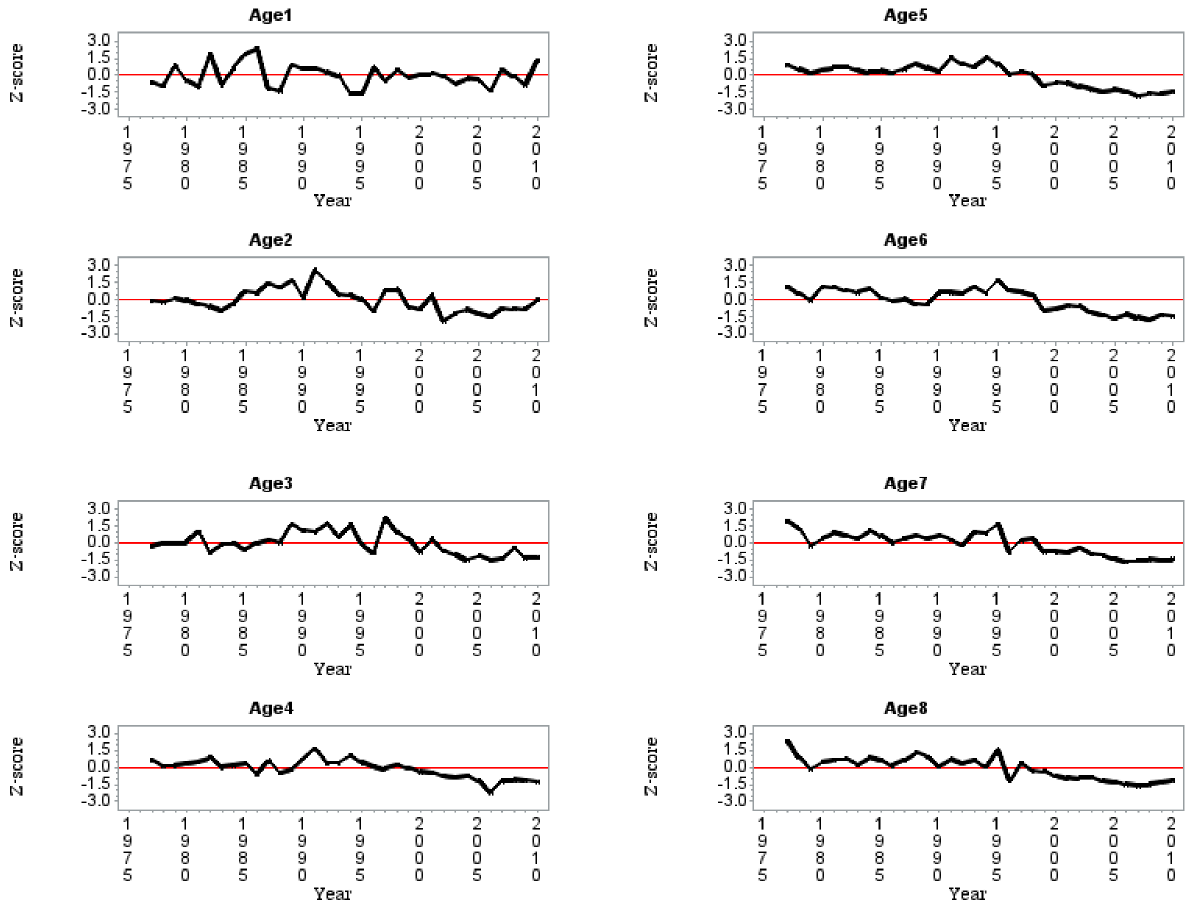


Figure C.15. Average catch weights-at-age of age 1 through age 8 Gulf of Maine haddock from 1977 to 2010. Weights-at-age were estimated using a number weighted average of commercial landing and commercial discard weights-at-age. Average weights are presented as z-scores ([*x*-μ]/σ).

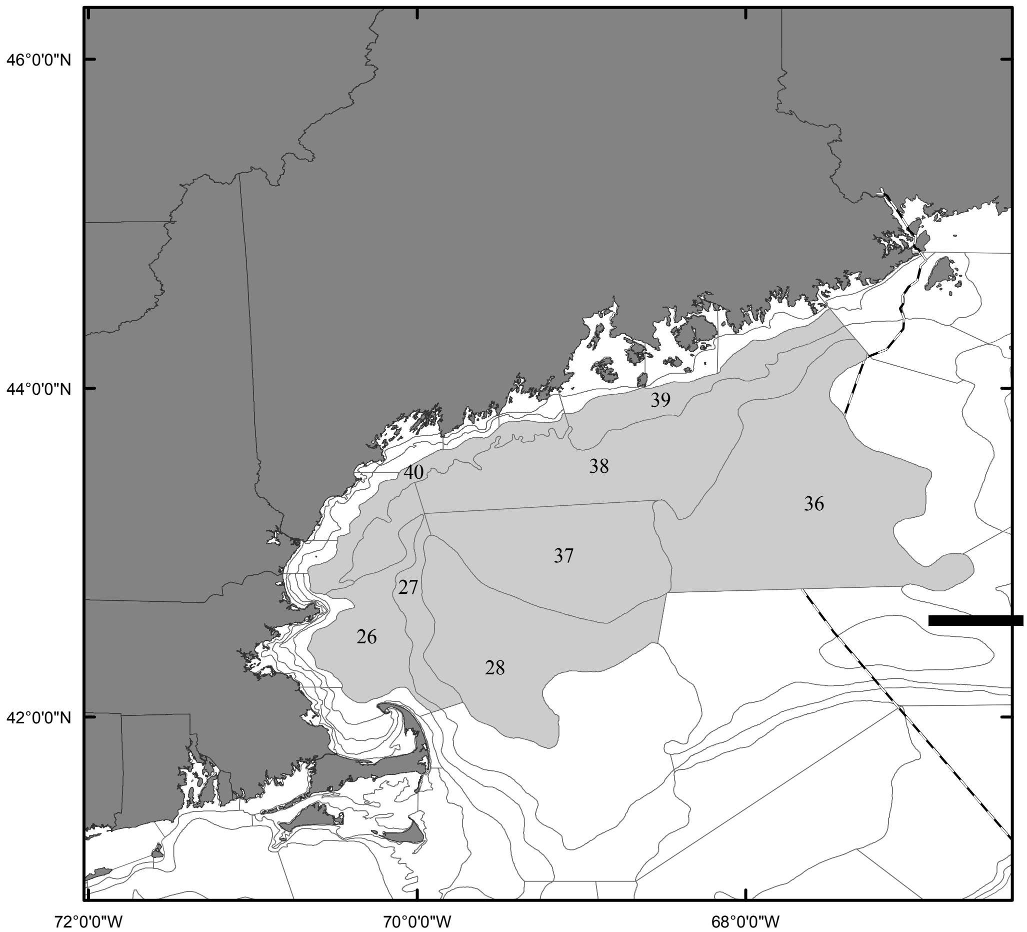
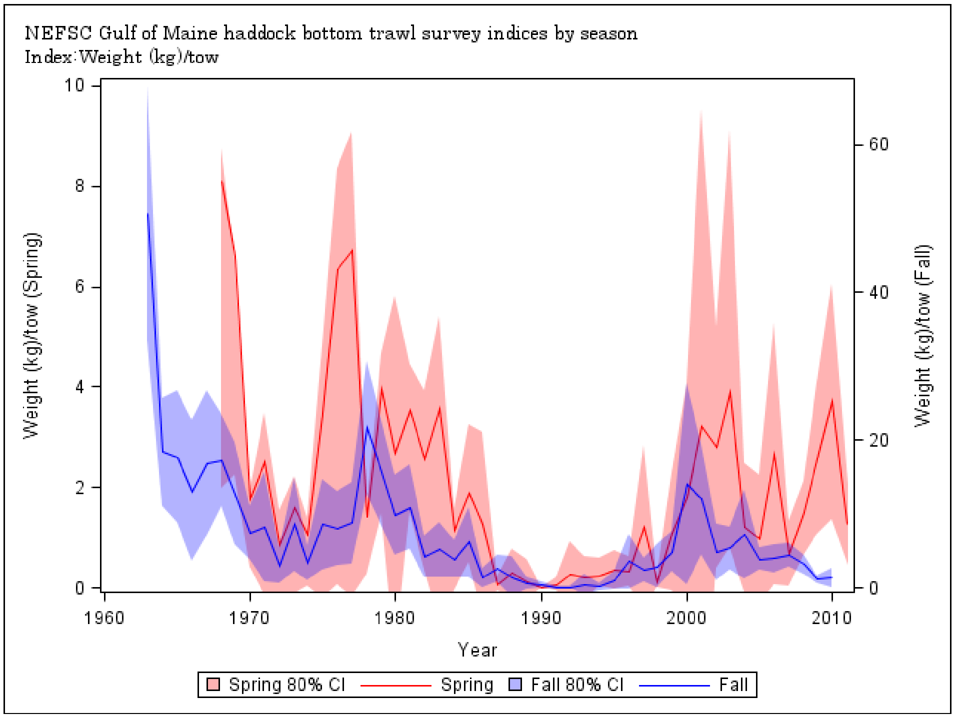


Figure C.16. Map of the Northeast Fisheries Science Center (NEFSC) bottom trawl offshore survey strata included in the Gulf of Maine haddock stock assessment (shaded grey).



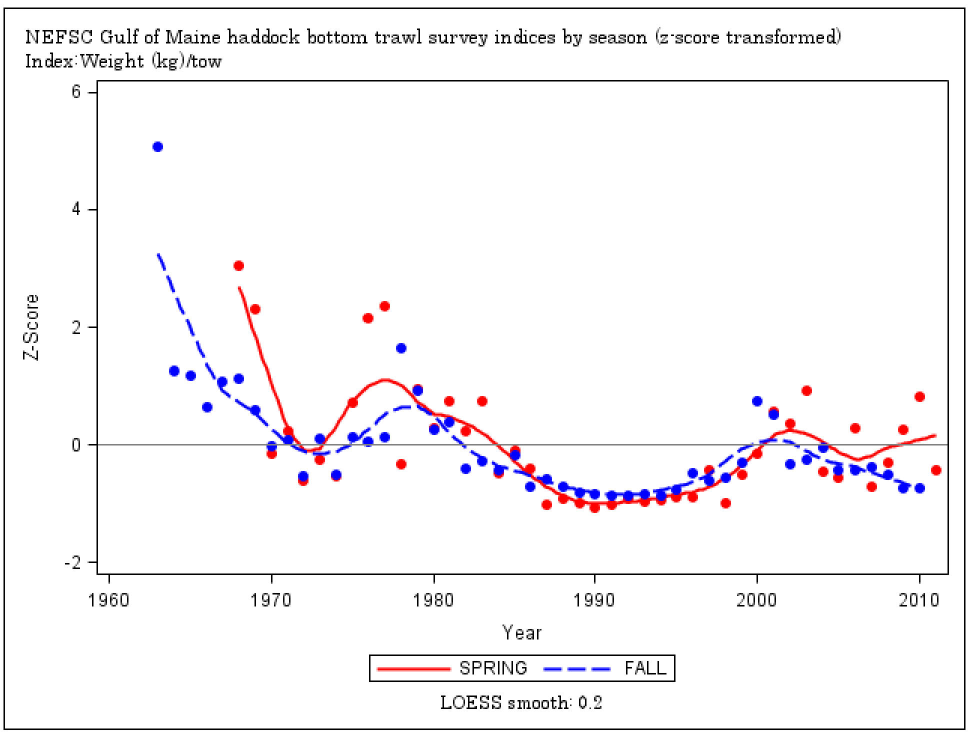


Figure C.17. Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey biomass (weight/tow) indices from 1963 to 2011 for Gulf of Maine haddock. The bottom plot shows the survey indices plotted as z-scores with a Loess smooth fit to the data. **Spring survey did not begin until 1968, 2011 fall survey data are not available at the time of this report.*

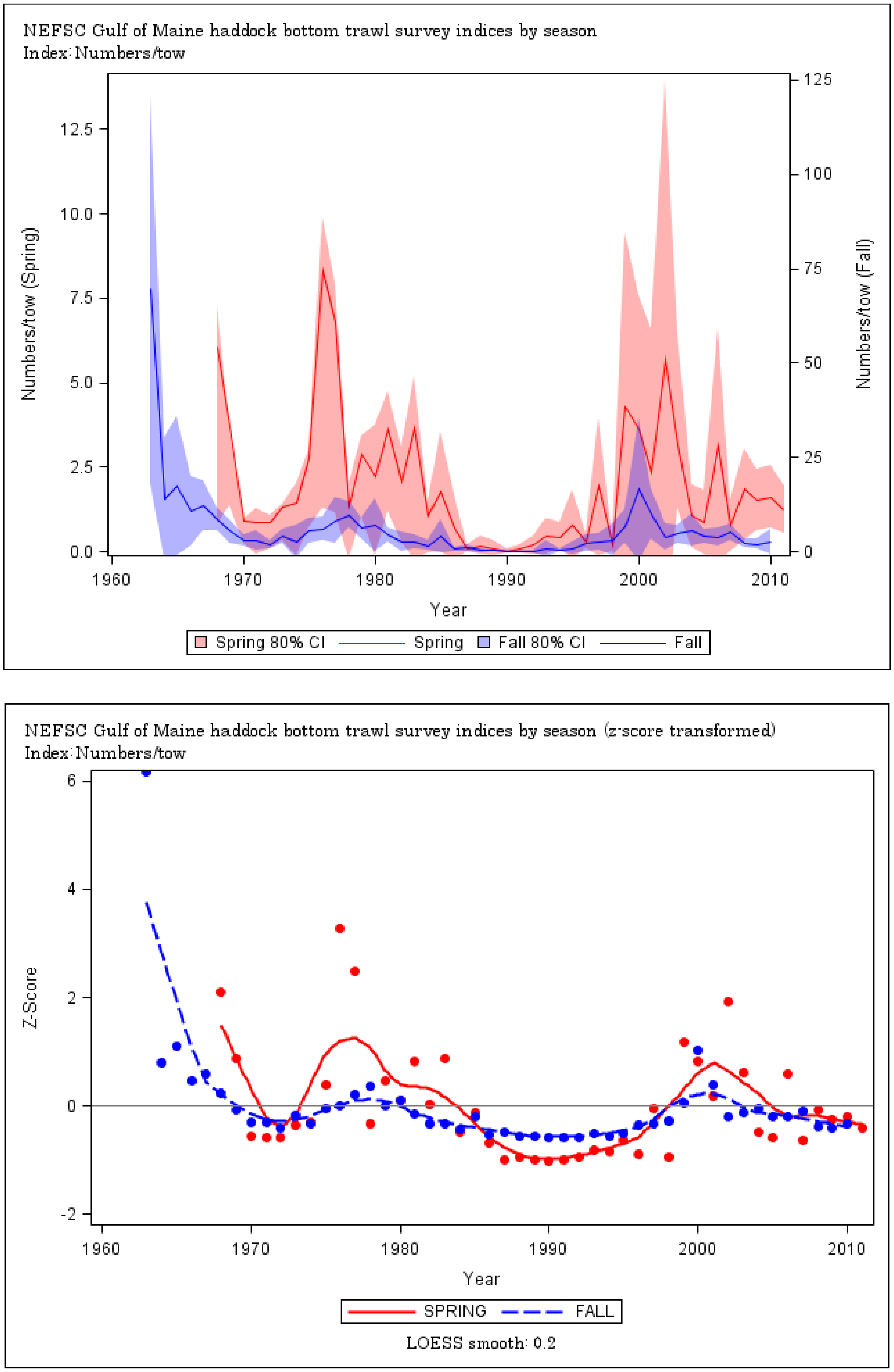


Figure C.18. Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey abundance (numbers/tow) indices from 1963 to 2011 for Gulf of Maine haddock. The bottom plot shows the survey indices plotted as z-scores with a Loess smooth fit to the data. **Spring survey did not begin until 1968, 2011 fall survey data are not available at the time of this report.*

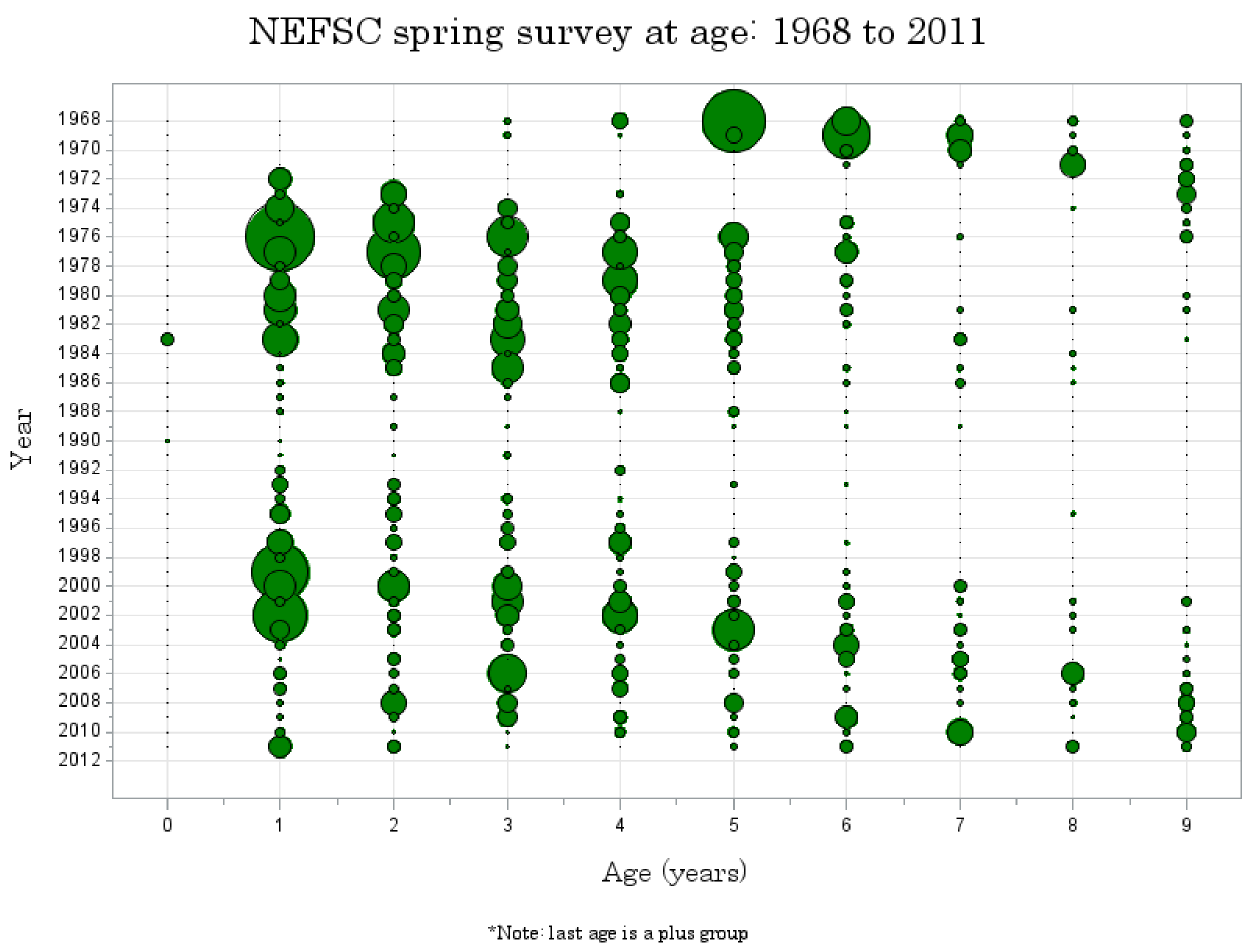


Figure C.19. Gulf of Maine haddock numbers-at-age from the NEFSC spring bottom trawl survey, 1968-2011. **Note that age 9 is a plus group.*

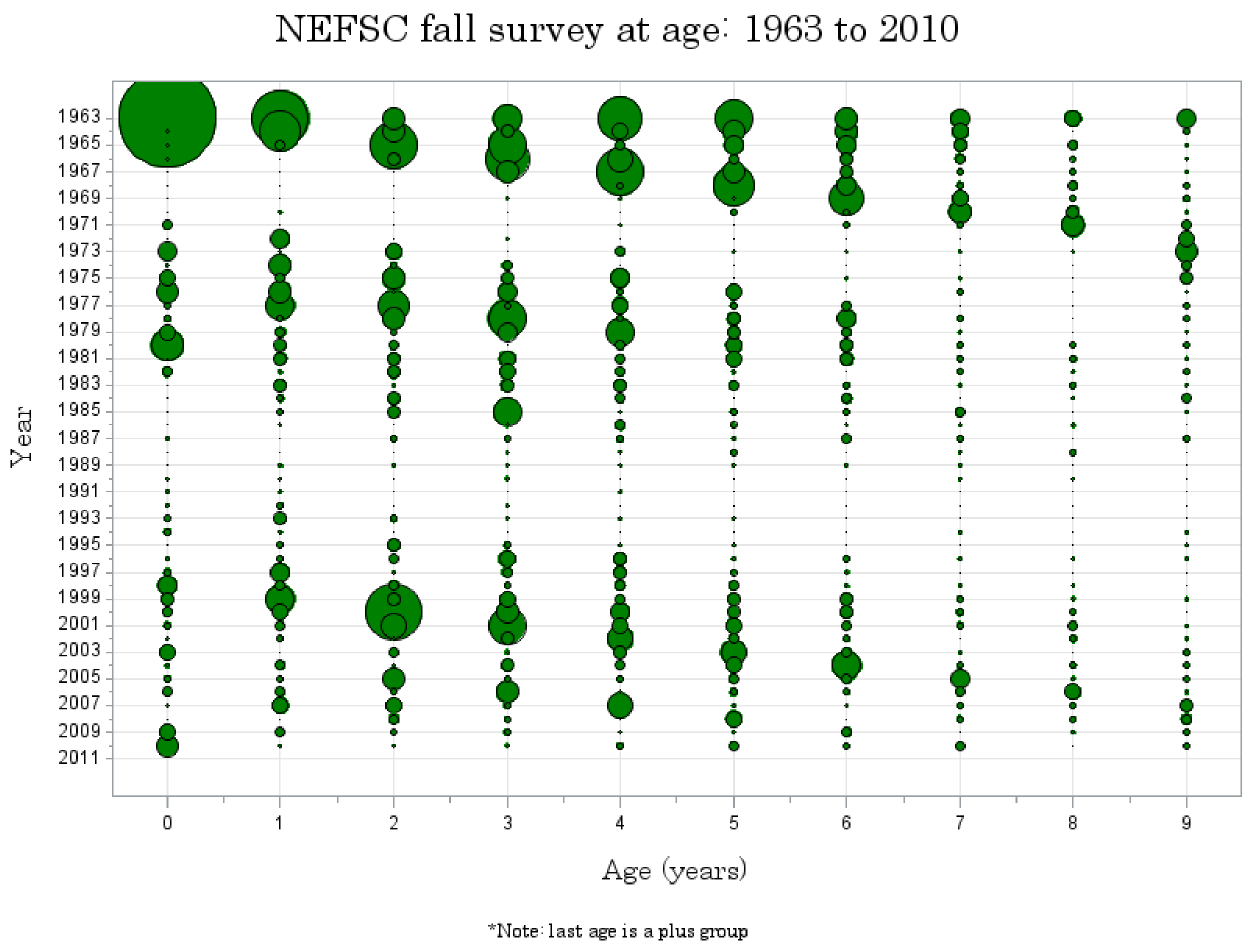


Figure C.20. Gulf of Maine haddock numbers-at-age from the NEFSC fall bottom trawl survey, 1963-2010. **Note that age 9 is a plus group.*

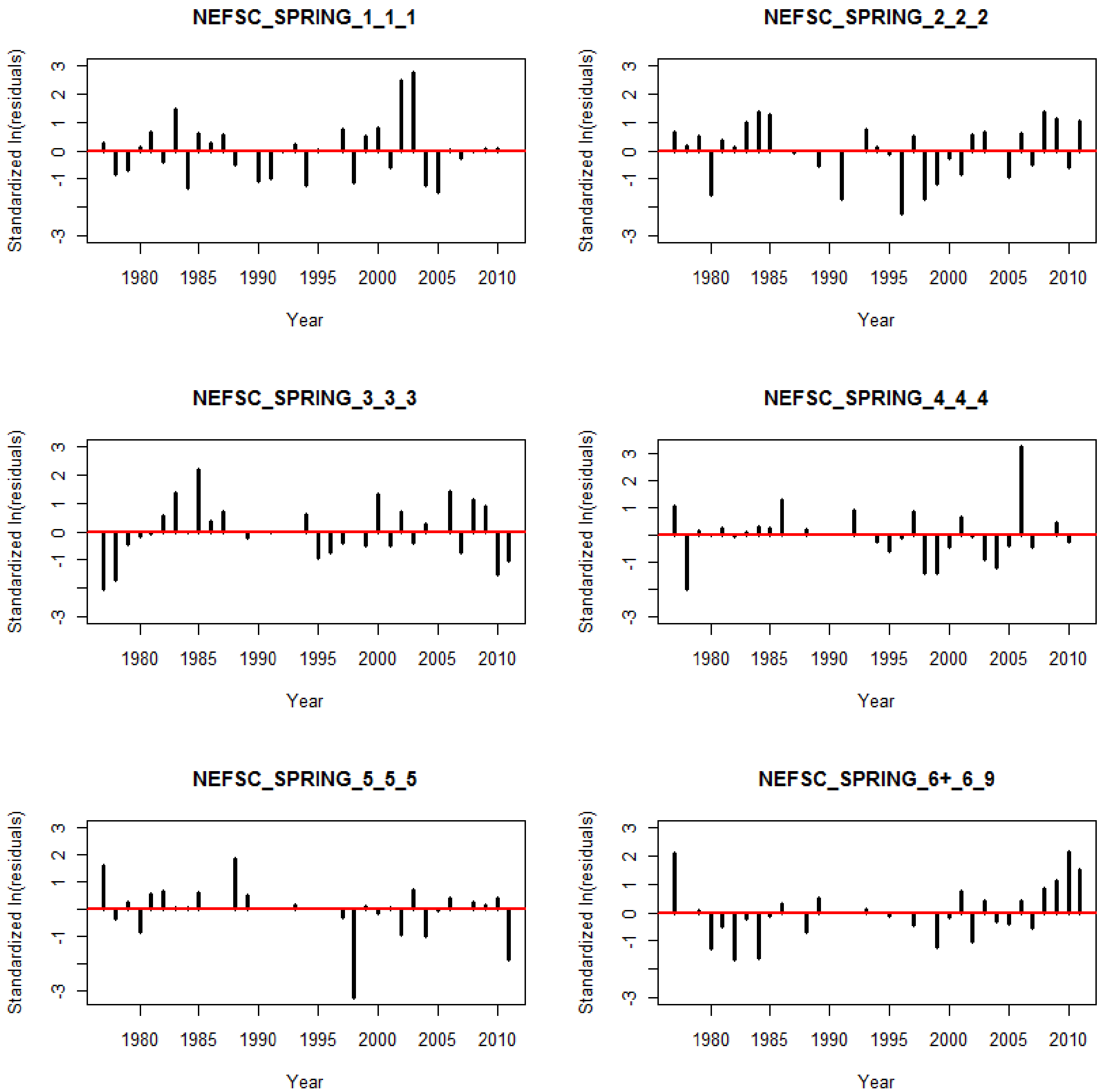


Figure C.21a. ADAPT-VPA model residuals to the survey fits of the Northeast Fisheries Science Center spring Gulf of Maine haddock survey ages 1 (NEFSC_SPRING_1_1_1) through 6^+ (NEFSC_SPRING_6+_6_9).

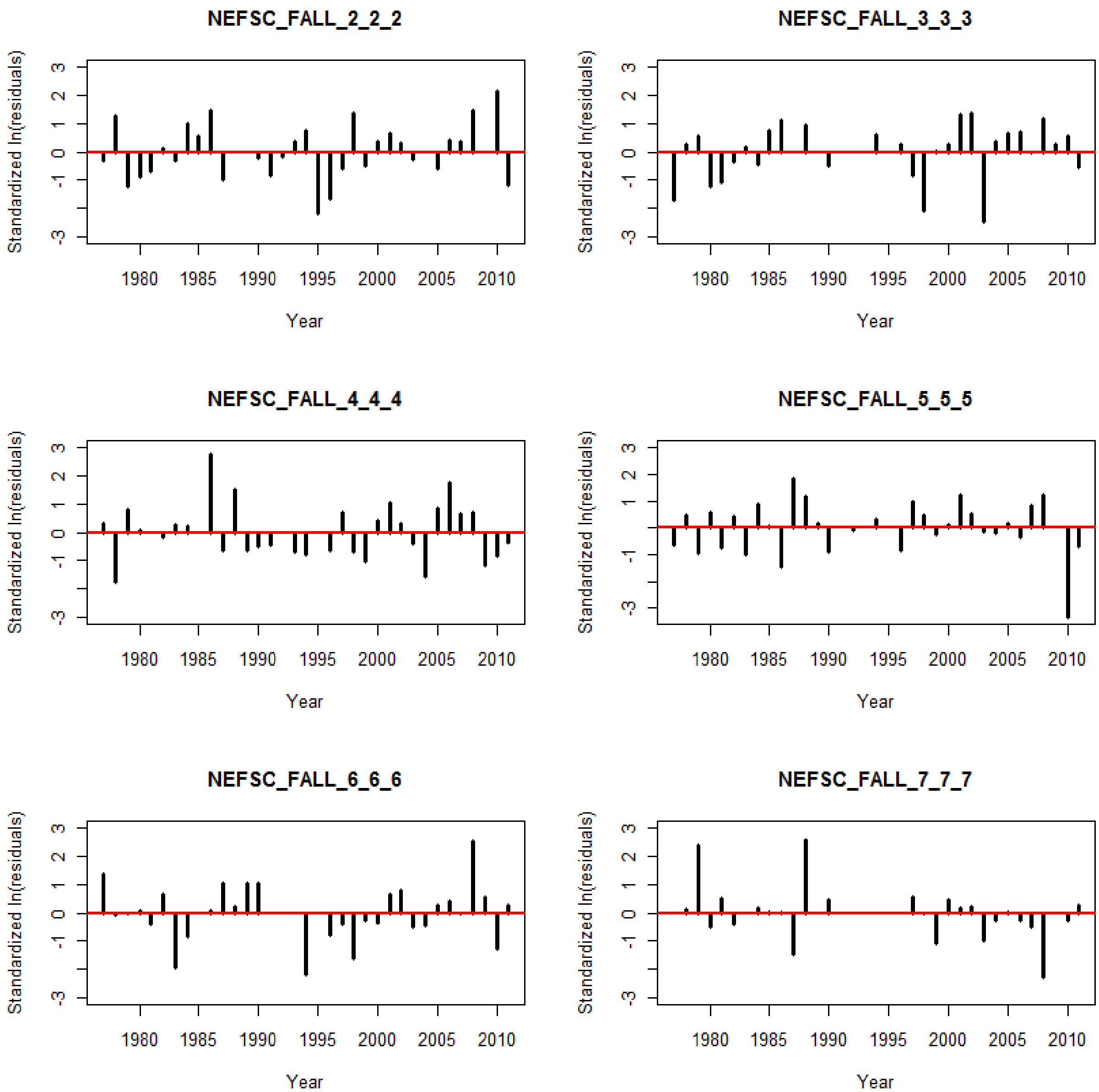


Figure C.21b. ADAPT-VPA model residuals to the survey fits of the Northeast Fisheries Science Center spring Gulf of Maine haddock survey ages 1 (NEFSC_FALL_2_2_2) through 6 (NEFSC_FALL_7_7_7). **Note: fall surveys have been lagged forward a year and an age (e.g., 2008 age 1 index was modeled as 2009 age 2).*

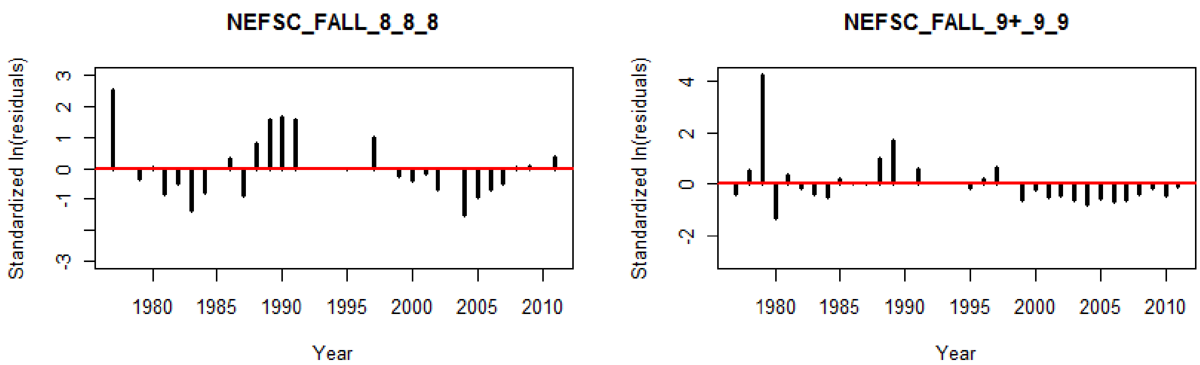


Figure C.21c. ADAPT-VPA model residuals to the survey fits of the Northeast Fisheries Science Center spring Gulf of Maine haddock survey ages 7 (NEFSC_FALL_8_8_8) through 8^+ (NEFSC_FALL_9_9_9). **Note: fall surveys have been lagged forward a year and an age (e.g., 2008 age 1 index was modeled as 2009 age 2).*

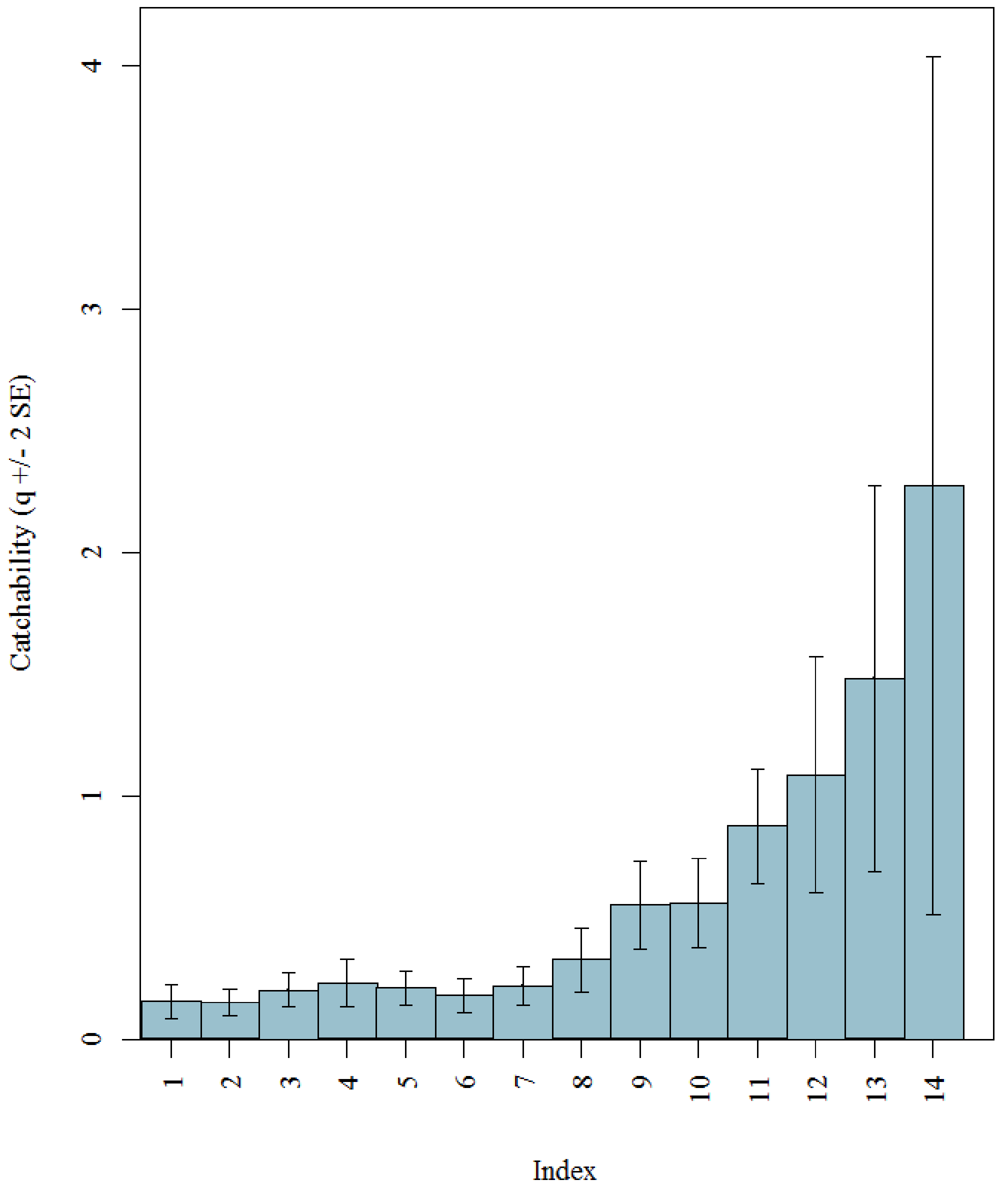


Figure C.22. ADAPT-VPA estimated survey catchability (*q*) for the Northeast Fisheries Science Center spring (index 1-7) and fall (index 8-14) bottom trawl surveys.

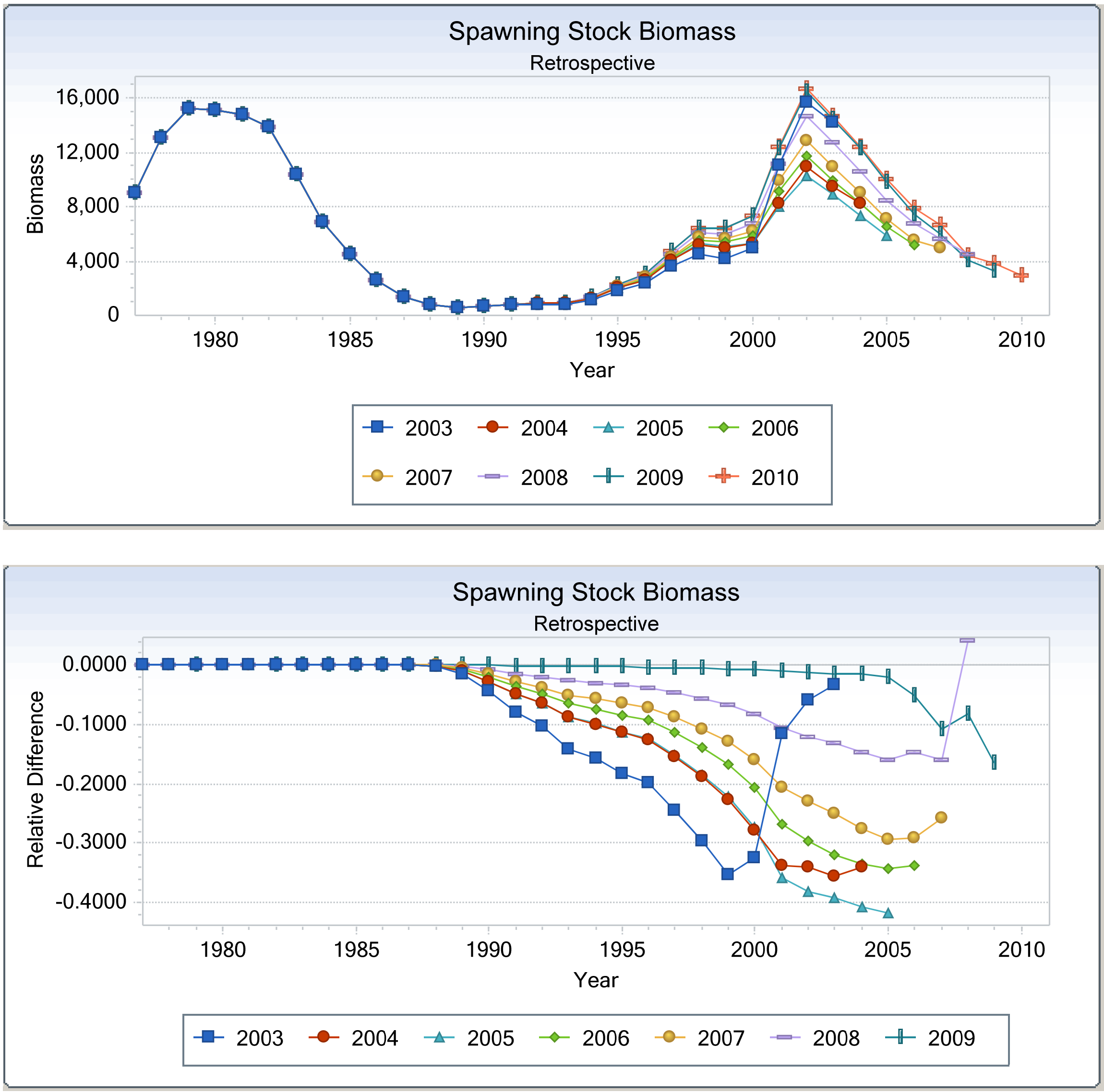
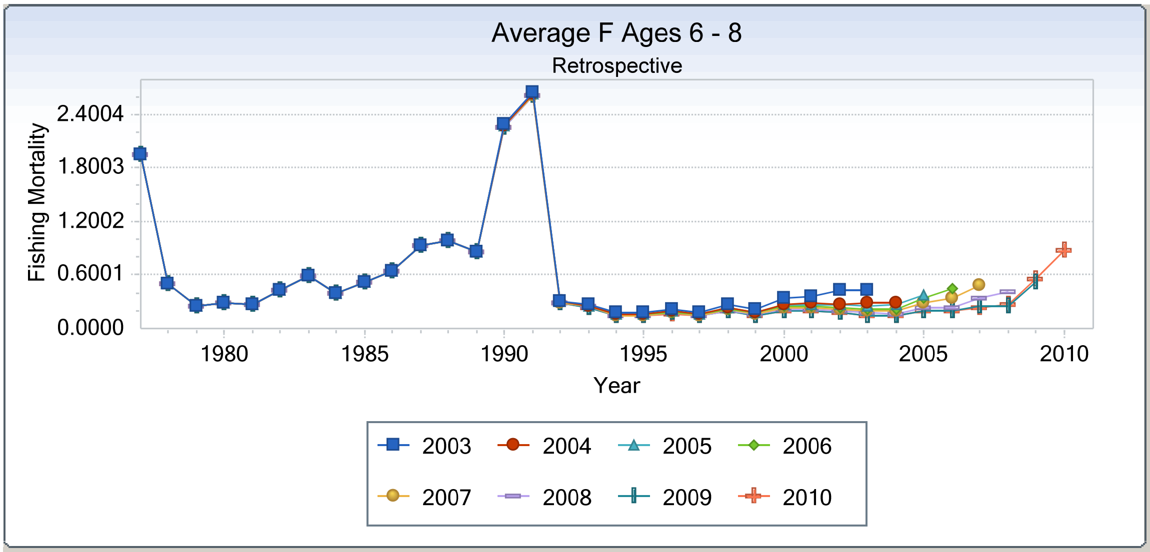


Figure C.23. ADAPT-VPA model retrospective patterns for Gulf of Maine haddock spawning stock biomass (mt) in absolute (top) and relative (bottom) terms.



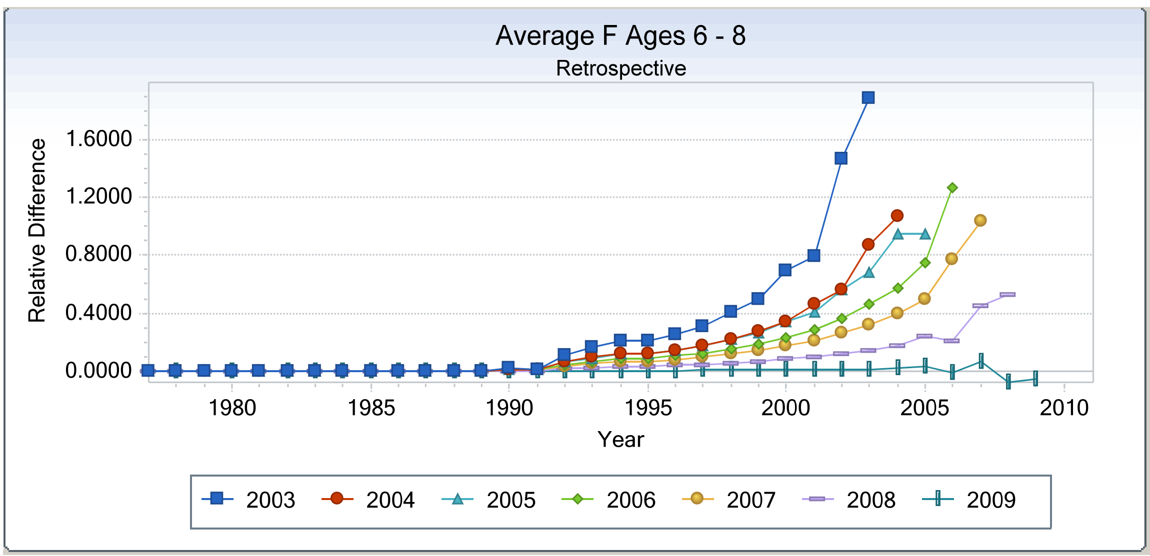
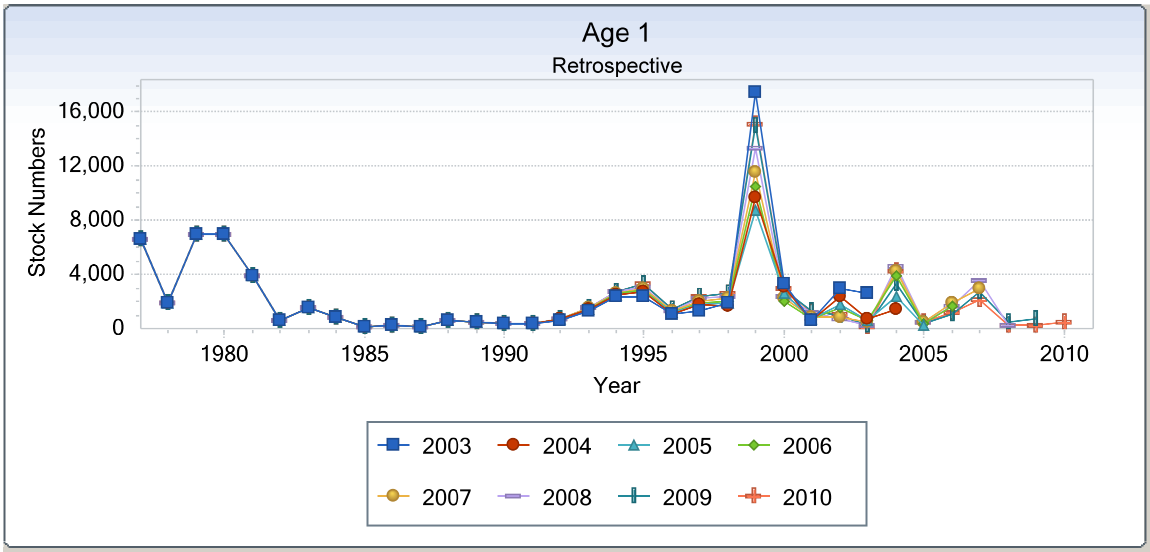


Figure C.24. ADAPT-VPA model retrospective patterns for Gulf of Maine haddock average fishing mortality in absolute (top) and relative (bottom) terms.



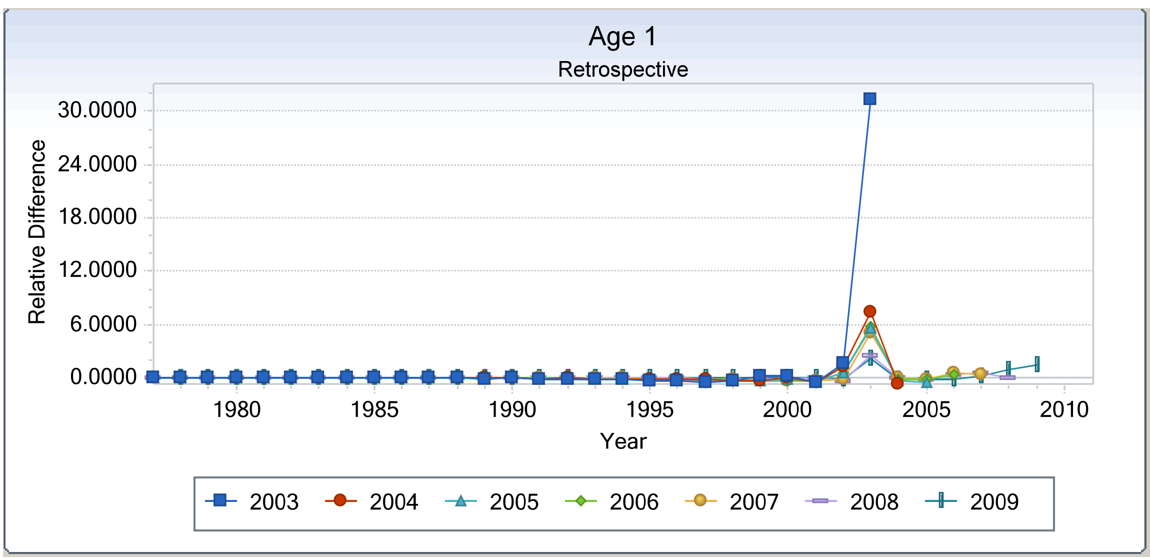
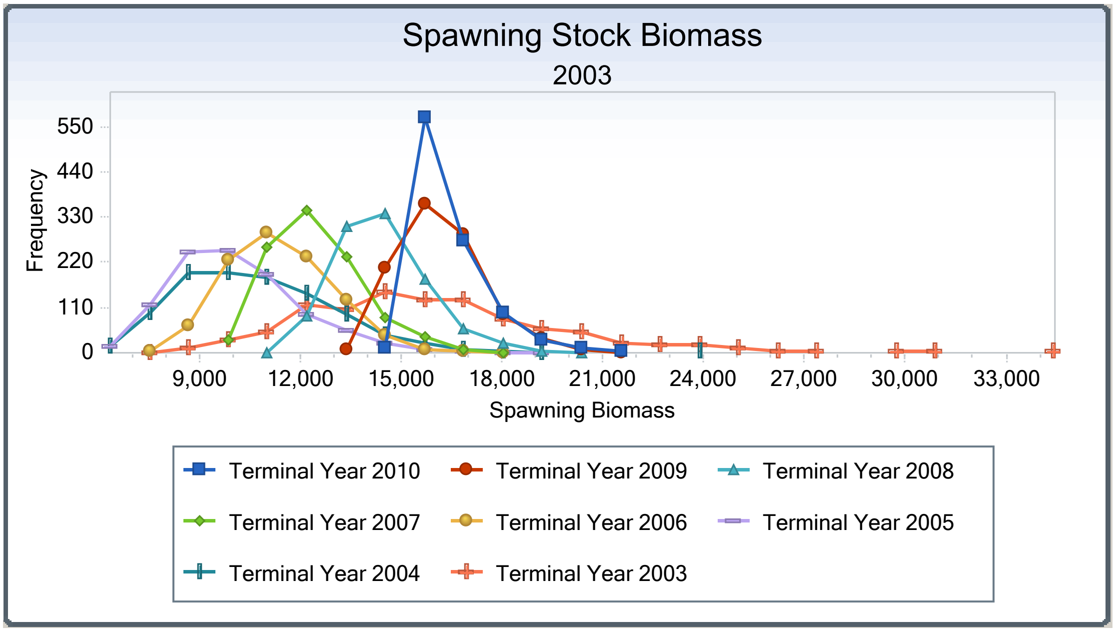


Figure C.25. ADAPT-VPA model retrospective patterns for Gulf of Maine haddock age-1 recruitment in absolute (top) and relative (bottom) terms.



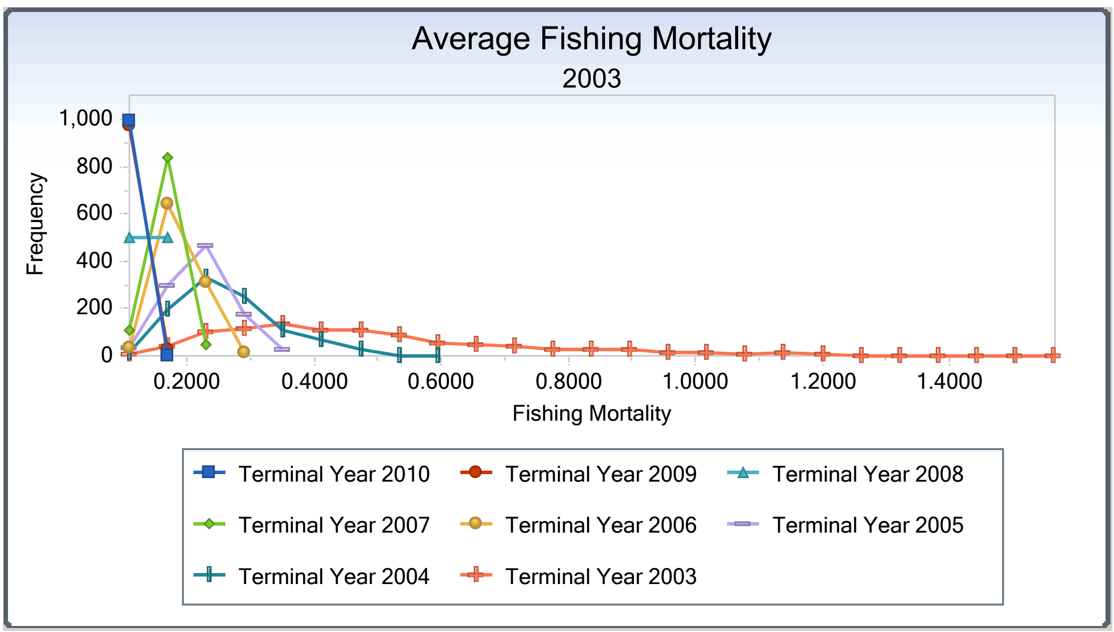
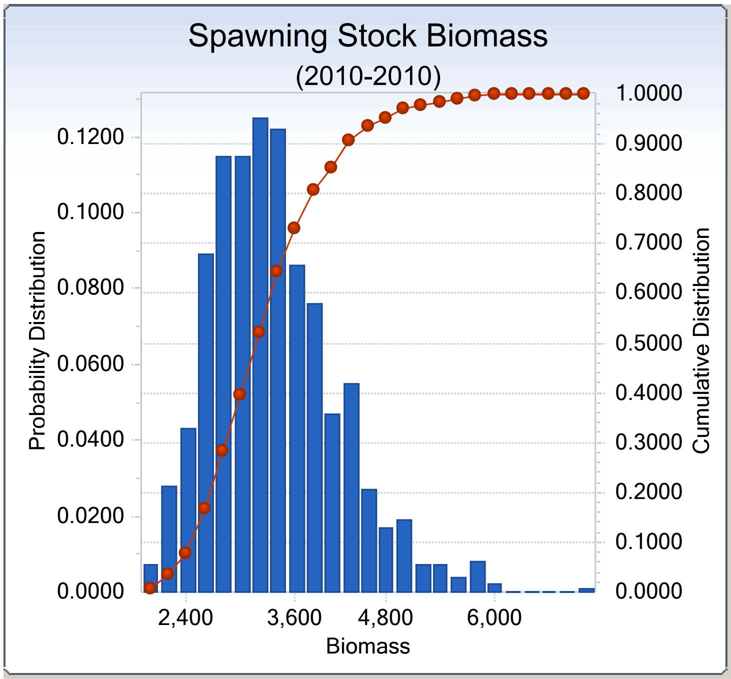


Figure C.26. Distribution of 2003 spawning stock biomass (top) and average fishing mortality (bottom) estimates from 1000 bootstrap iterations of a 7-year peel (2003-2010) of the ADAPT-VPA model.



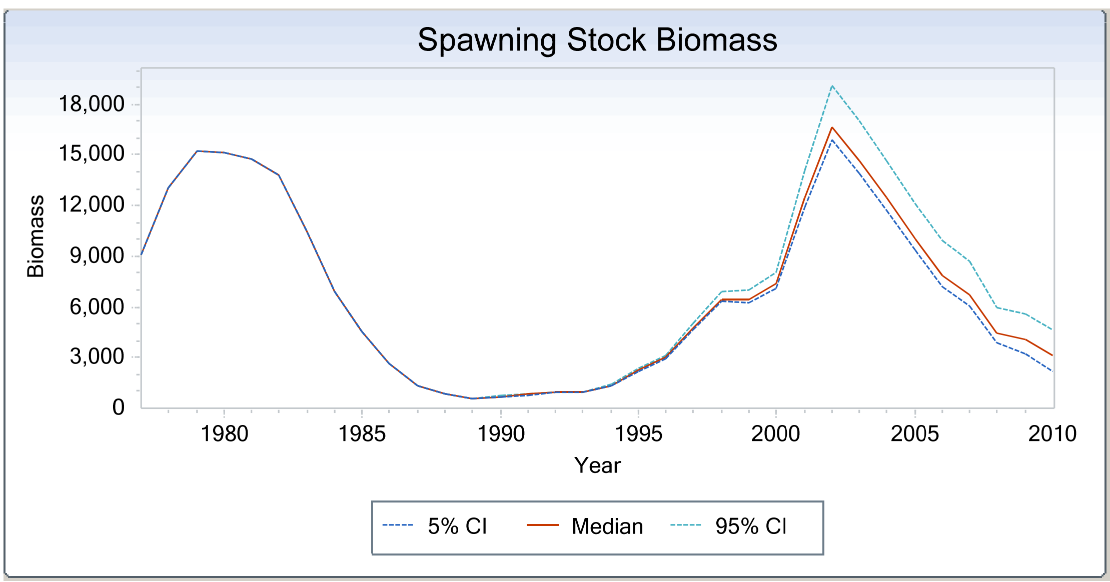
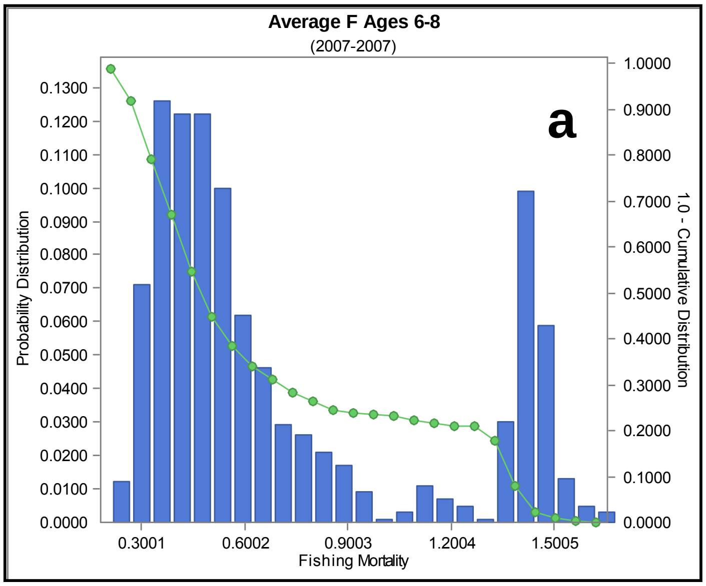


Figure C.27. Top: bootstrap distribution of 2010 Gulf of Maine haddock spawning stock biomass. Bottom: time series of Gulf of Maine haddock spawning stock biomass and the associated 90% confidence interval for Gulf of Maine from the ADAPT-VPA model from 1977 to 2010.



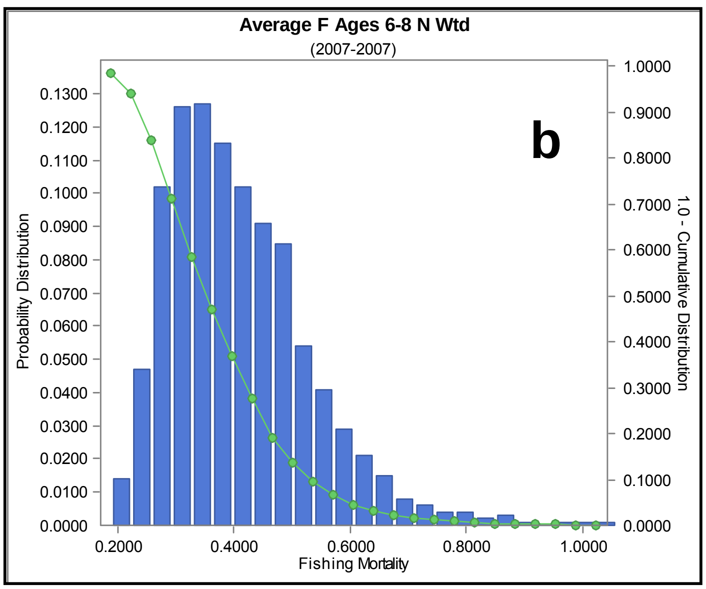


Figure C.28. Bootstrap distribution of 2007 fishing mortality (F) on Gulf of Maine haddock from the GARM III assessment. Bootstrap distributions are shown for both un-weighted average $F_{6\text{-}8}$ (a), and numbers weighted average $F_{6\text{-}8}$ (b). The vertical bars provide the probability distribution of values of $F_{6\text{-}8}$ from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.

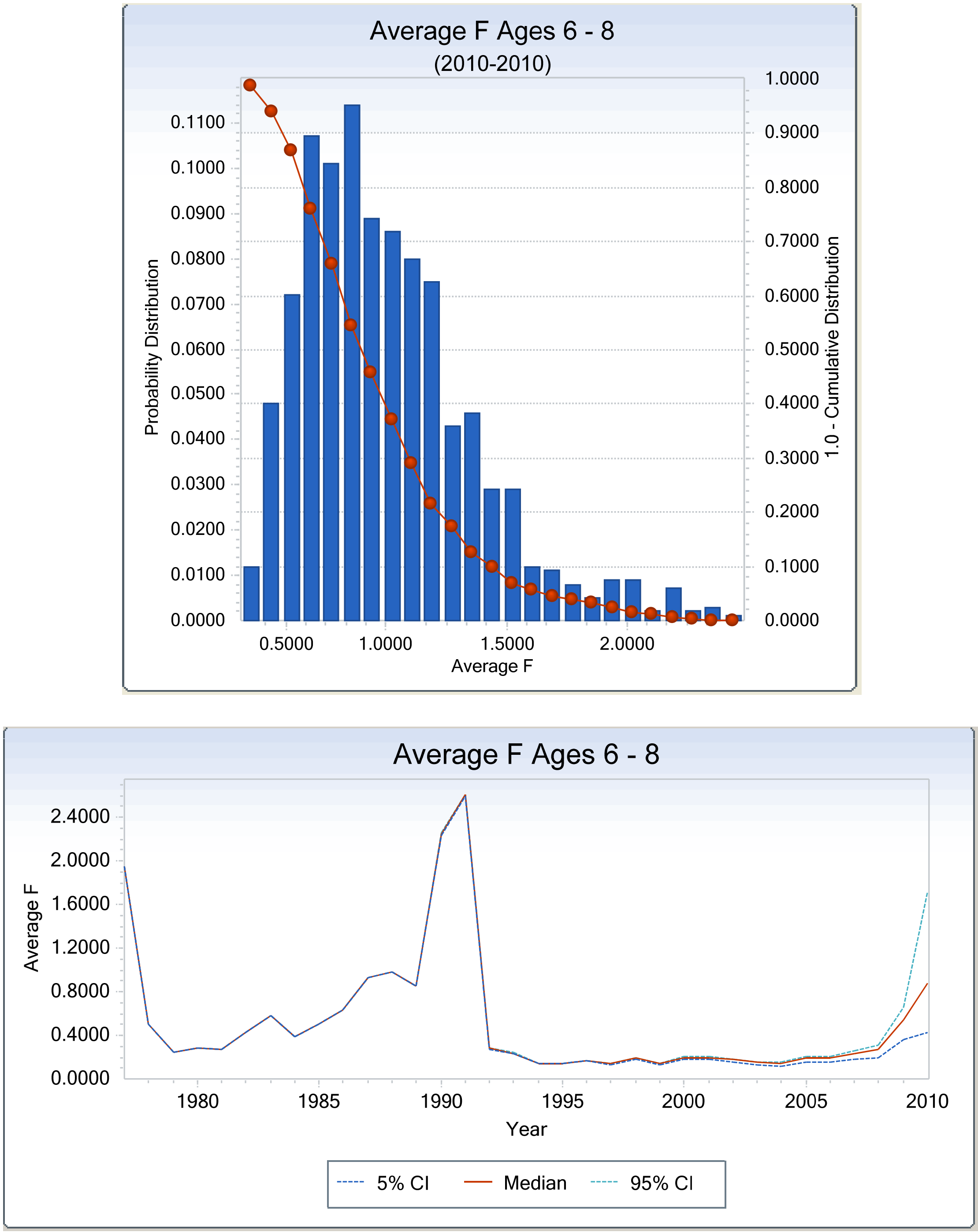
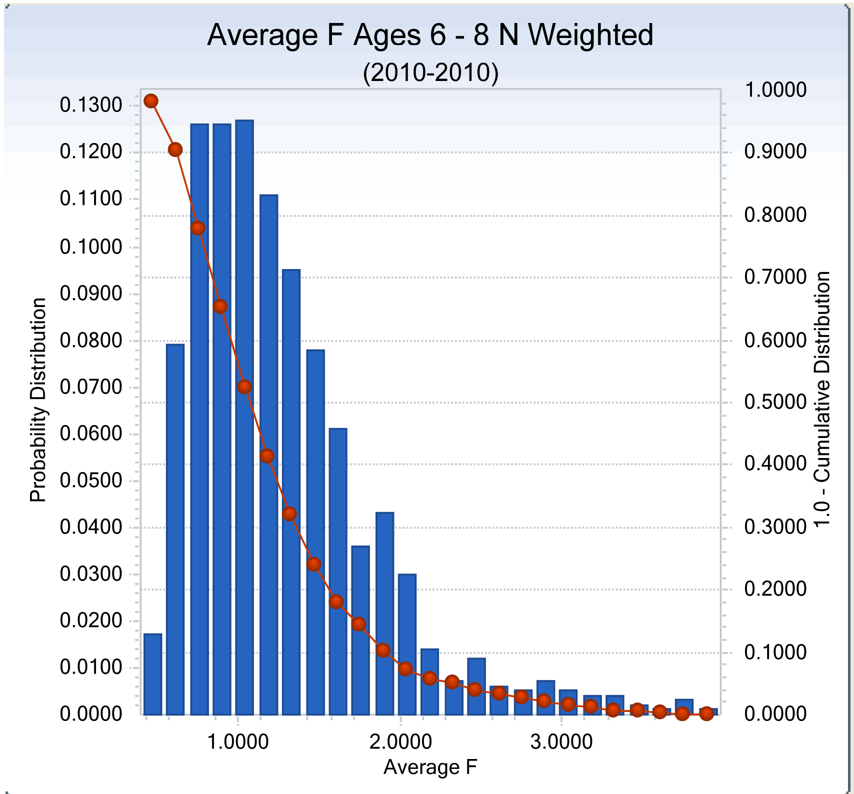


Figure C.29. Top: bootstrap distribution of 2010 Gulf of Maine haddock of average fishing mortality on ages 6-8. Bottom: time series of Gulf of Maine haddock average fishing mortality on ages 6-8 and the associated 90% confidence interval for Gulf of Maine from the ADAPT-VPA model from 1977 to 2010. The vertical bars provide the probability distribution of values of $F_{6\text{-}8}$ from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.



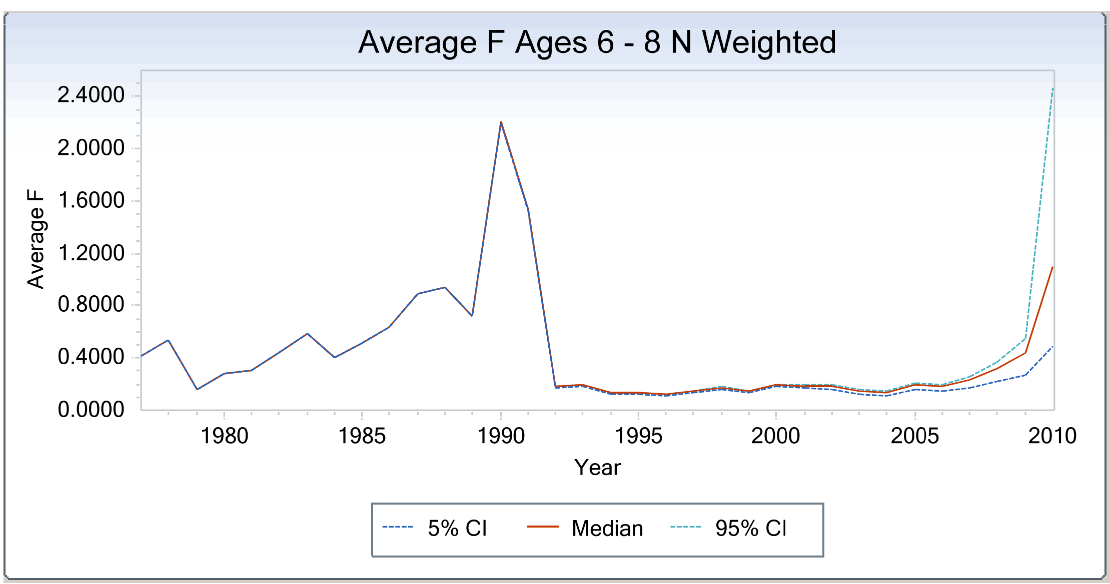


Figure C.30. Top: bootstrap distribution of 2010 Gulf of Maine haddock numbers-weighted average fishing mortality on ages 6-8. Bottom: time series of Gulf of Maine haddock numbers-weighted average fishing mortality on ages 6-8 and the associated 90% confidence interval for Gulf of Maine from the ADAPT-VPA model from 1977 to 2010. The vertical bars provide the probability distribution of values of $F_{6\text{-}8}$ from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.

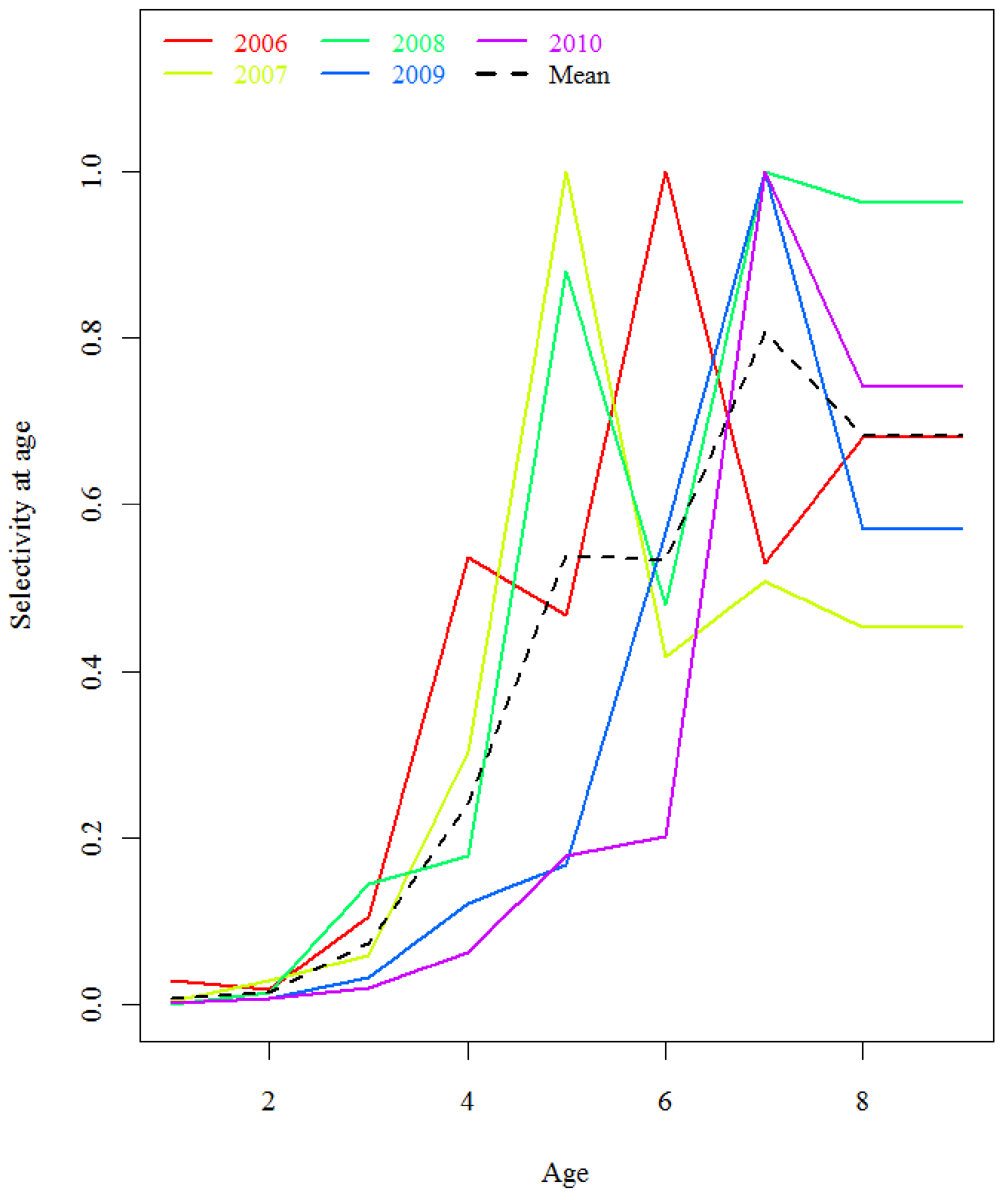


Figure C.31. ADAPT-VPA model catch selectivity patterns for Gulf of Maine haddock over the last five years of the model (2006- 2010).

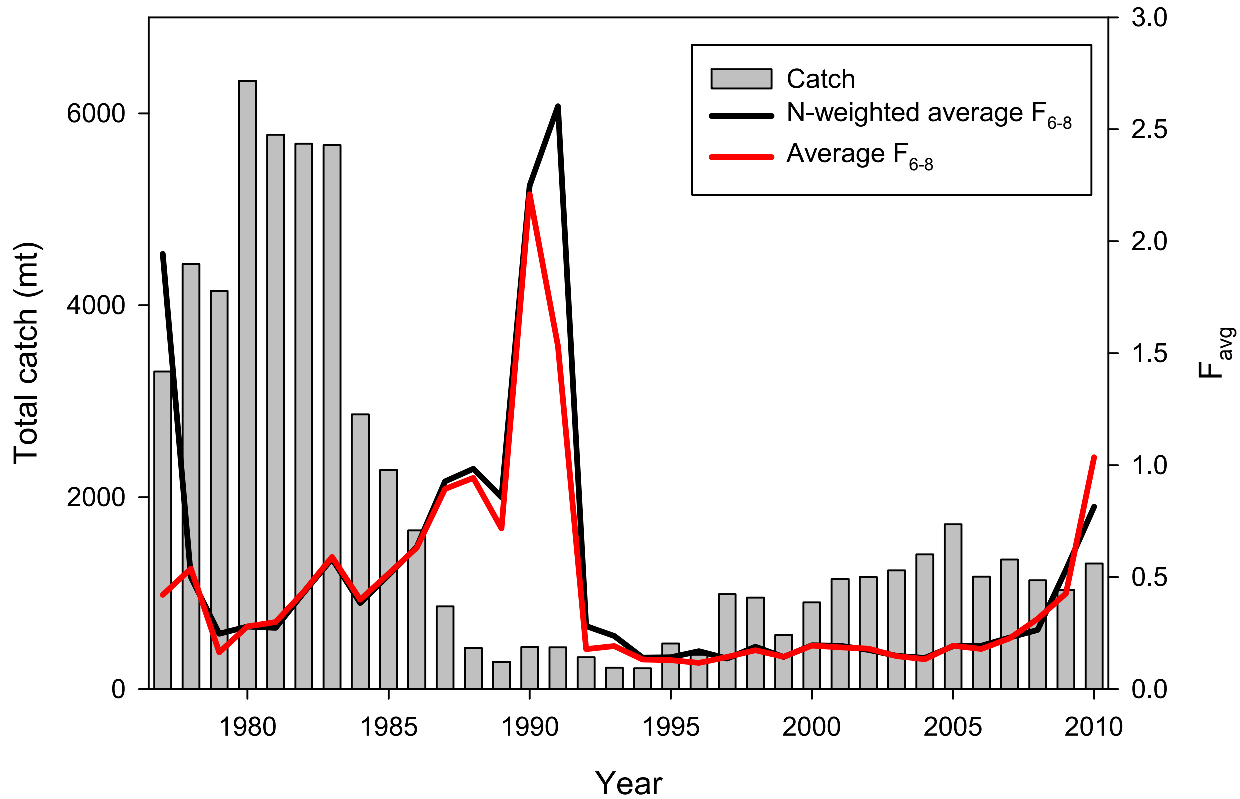


Figure C.32. Trends in total catch (commercial landings, commercial discards and recreational landings), average F on ages 6-8 and numbers-weighted average fishing mortality between 1982 and 2010.

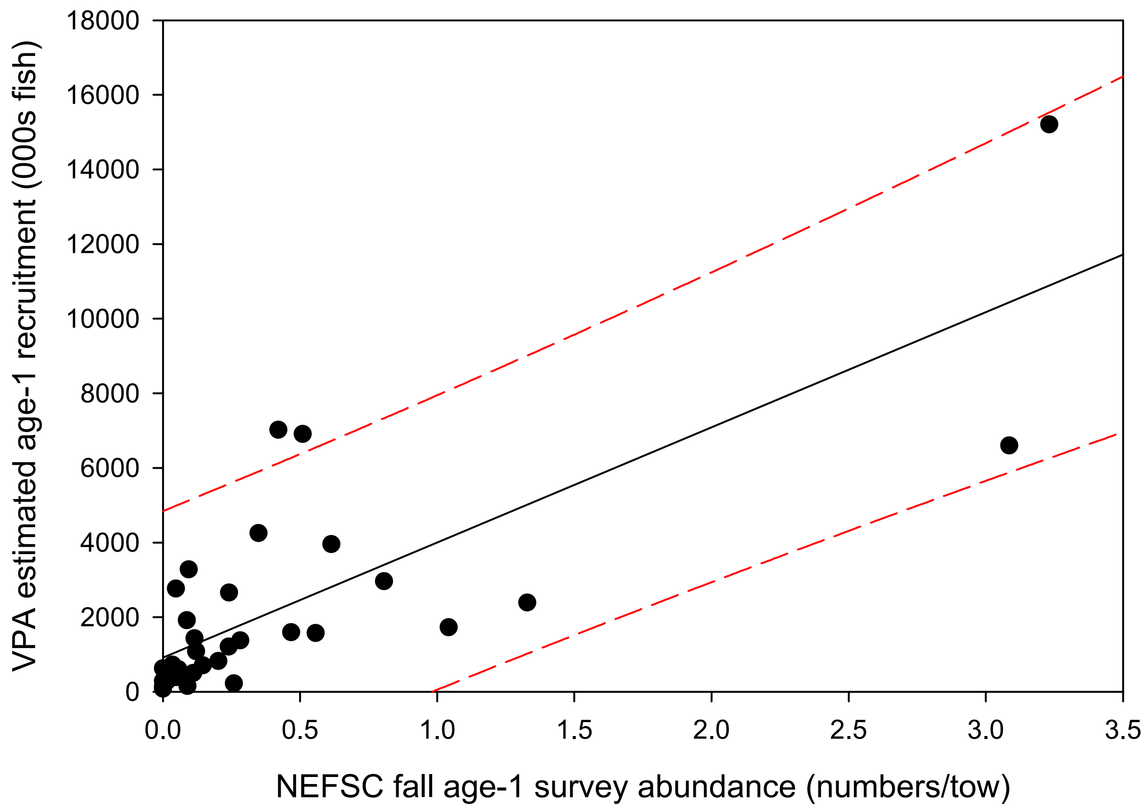


Figure C.33. Regression of ADAPT-VPA model estimates of age-1 numbers on age-1NEFSC fall survey abundance index.

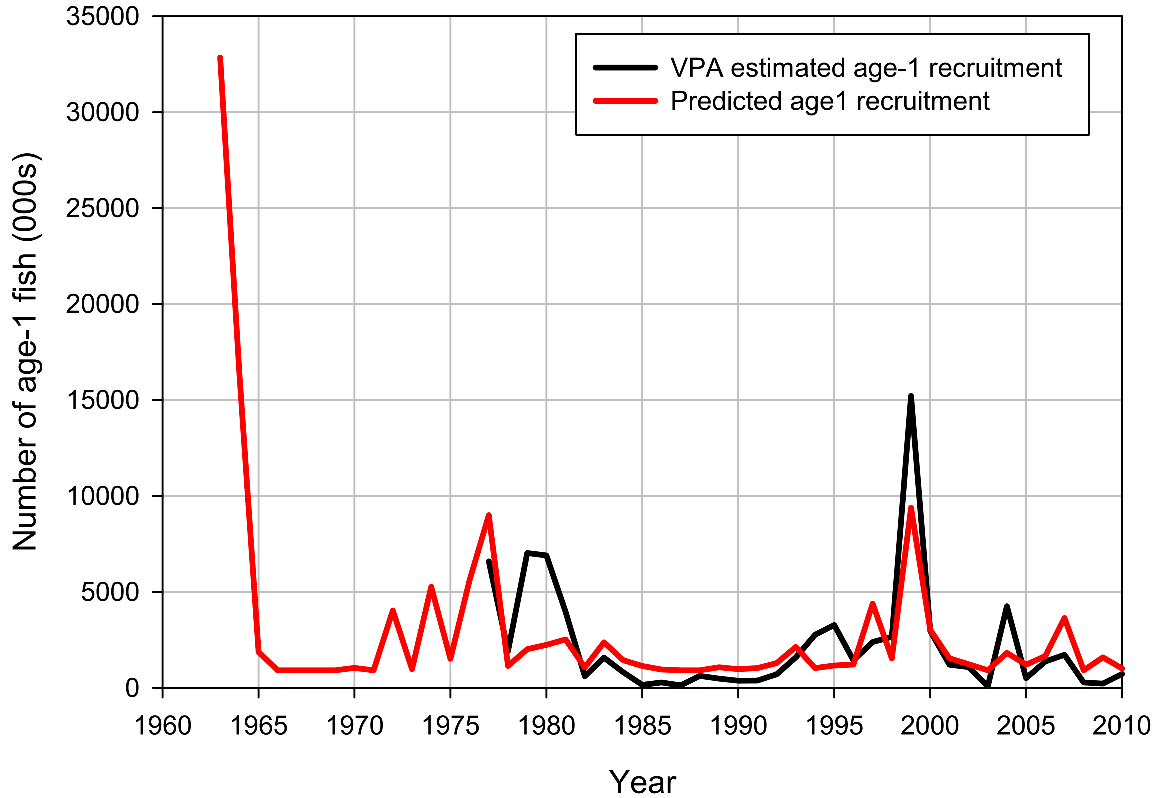


Figure C.34. Comparison of estimated age-1 numbers from survey regression model to age-1 numbers estimated by the ADAPT-VPA model.

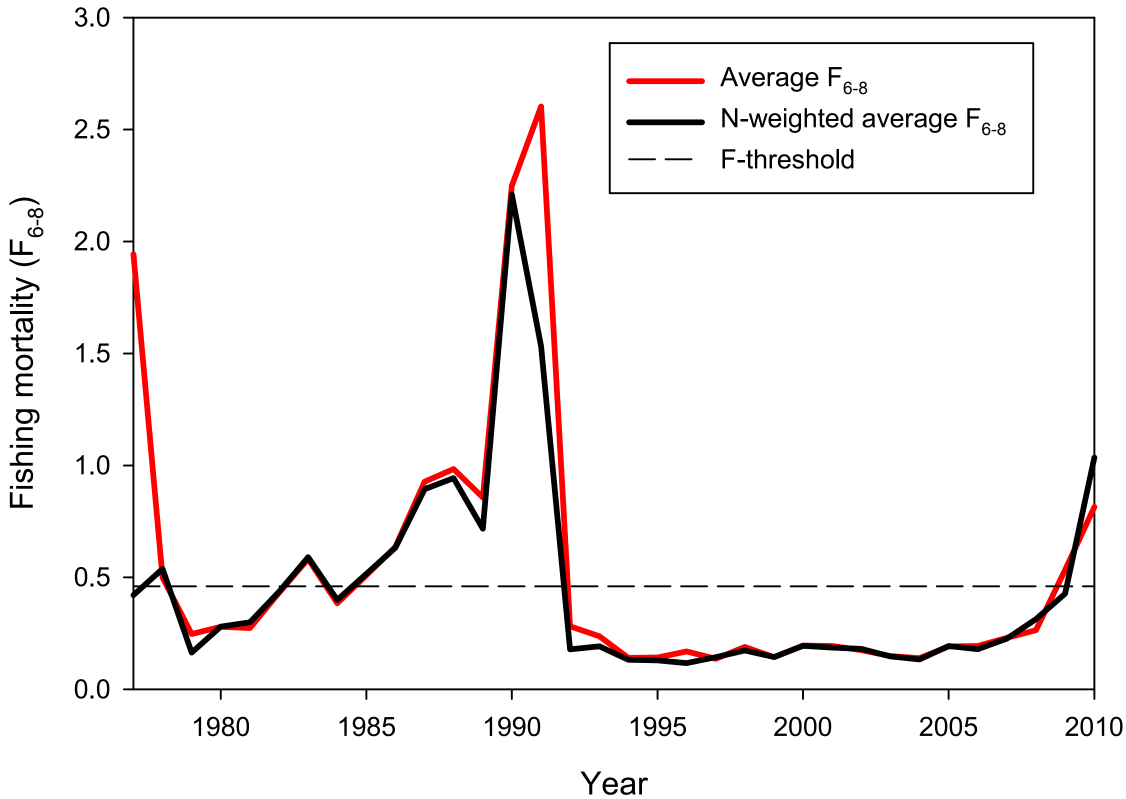


Figure C.35. Trends in total fully recruited average fishing mortality (F) on ages 6-8 and numbers-weighted average between 1982 and 2010. The fishing threshold corresponding to $F_{MSY}=F_{40\%}=0.46$ is shown by a dashed line.

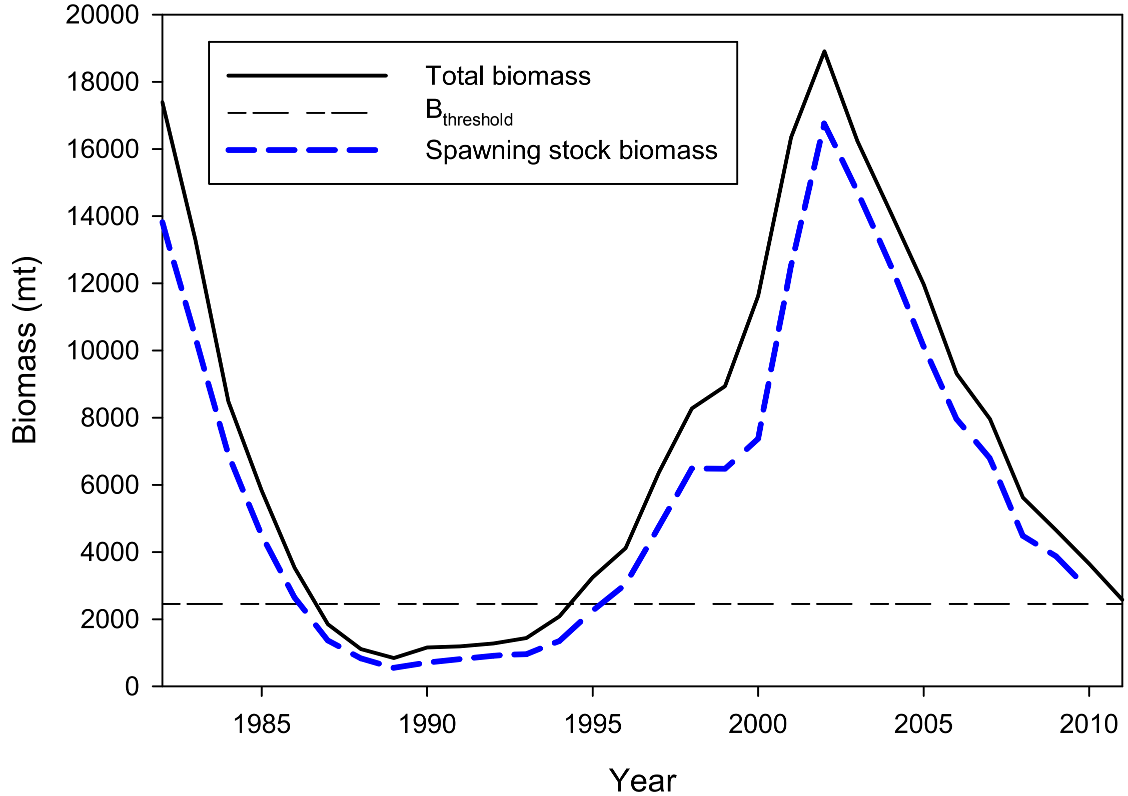


Figure C.36. Trends in total biomass and spawning stock biomass between 1982 and 2010. The biomass threshold corresponding to ½ B_{MSY}=2,452 mt is shown by a dashed line.

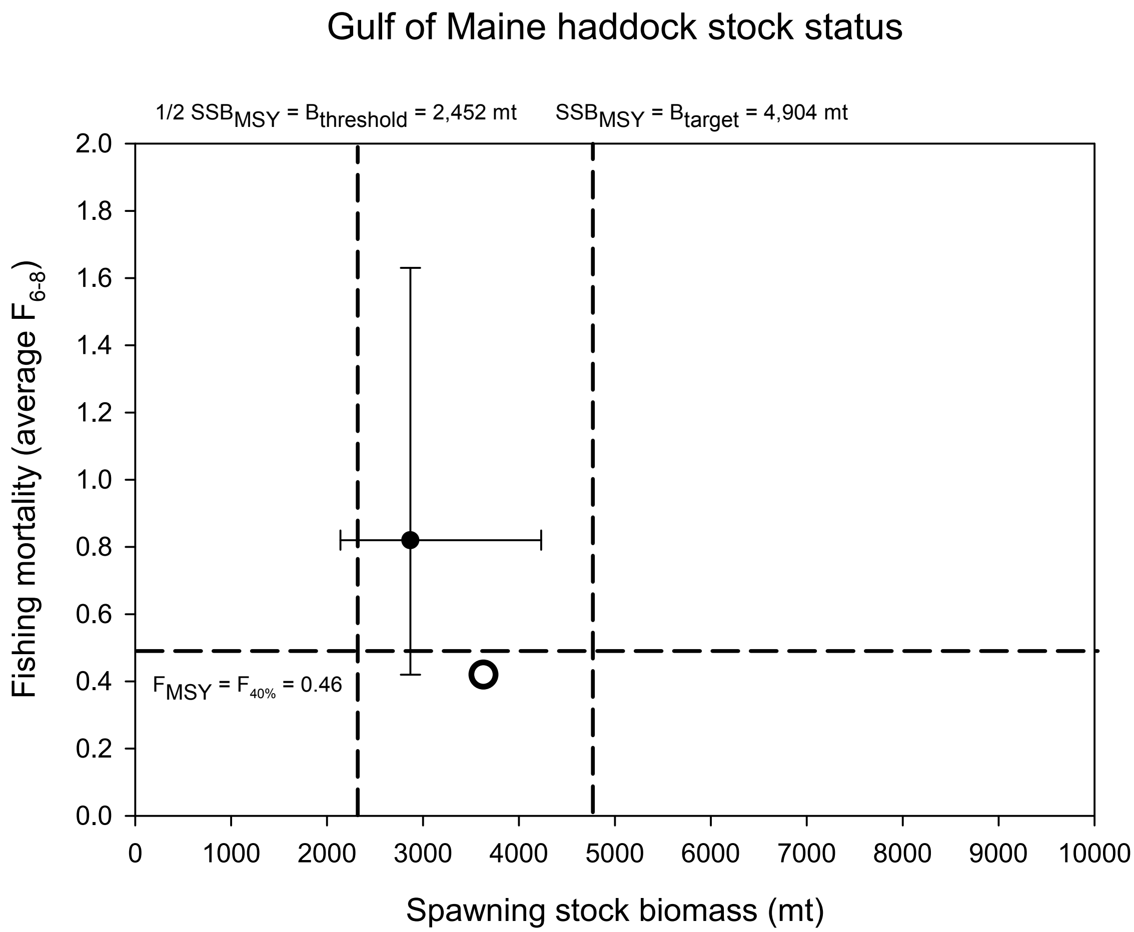


Figure C.37. Gulf of Maine haddock stock status in 2010 with respect to updated biological reference points using average $F_{6\text{-}8}$. Error bars represent the 90% confidence intervals.

Appendix C1. Comparison of Gulf of Maine haddock BASE VPA results to results achieved using an age $0\text{-}9^{+}$ VPA configuration as was done in GARM III.

The GARM III VPA configuration used an age $0\text{-}9^{+}$ configuration, but only considered ages $1\text{-}9^{+}$ in the biological reference point determinations. To resolve this consistency, an age 1-9+ configuration was applied in the 2012 update of the Gulf of Maine haddock assessment. A sensitivity run was conducted on the 2012 VPA assessment to quantify the impacts of the change in formulation between the GARM III and the 2012 VPA model in terms of spawning stock biomass, average fishing mortality and age-1 recruitment. Results are shown in figures C1.1 – C1.3. There are no discernable differences between the two model configurations. The use of an age $1\text{-}9^{+}$ configuration in the 2012 assessment will have no impacts on assessment results and will resolved the inconsistency between the assessment and biological reference point/projections.

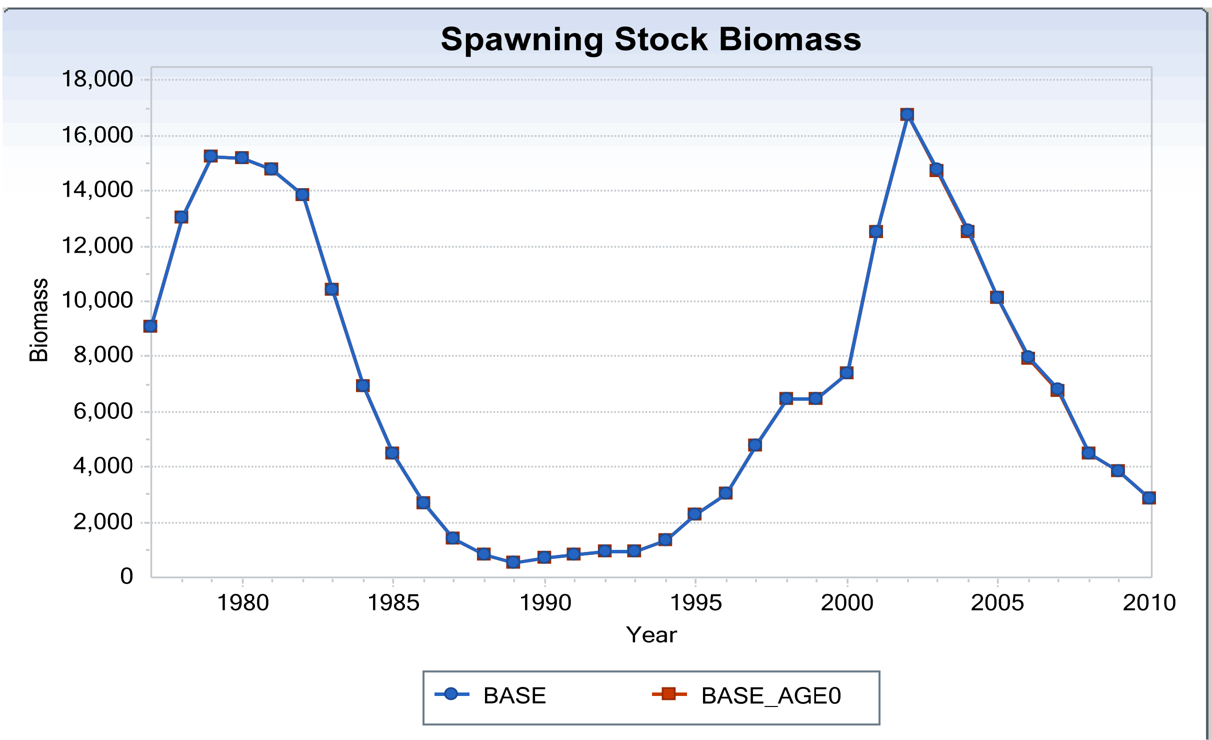


Figure C1.1. Comparison of Gulf of Maine haddock spawning stock biomass from the 2012 updated BASE VPA age $1\text{-}9^{+}$ configuration to a sensitivity configuration applying an age $0\text{-}9^{+}$ configuration (BASE_AGE0) as was used in GARM III.

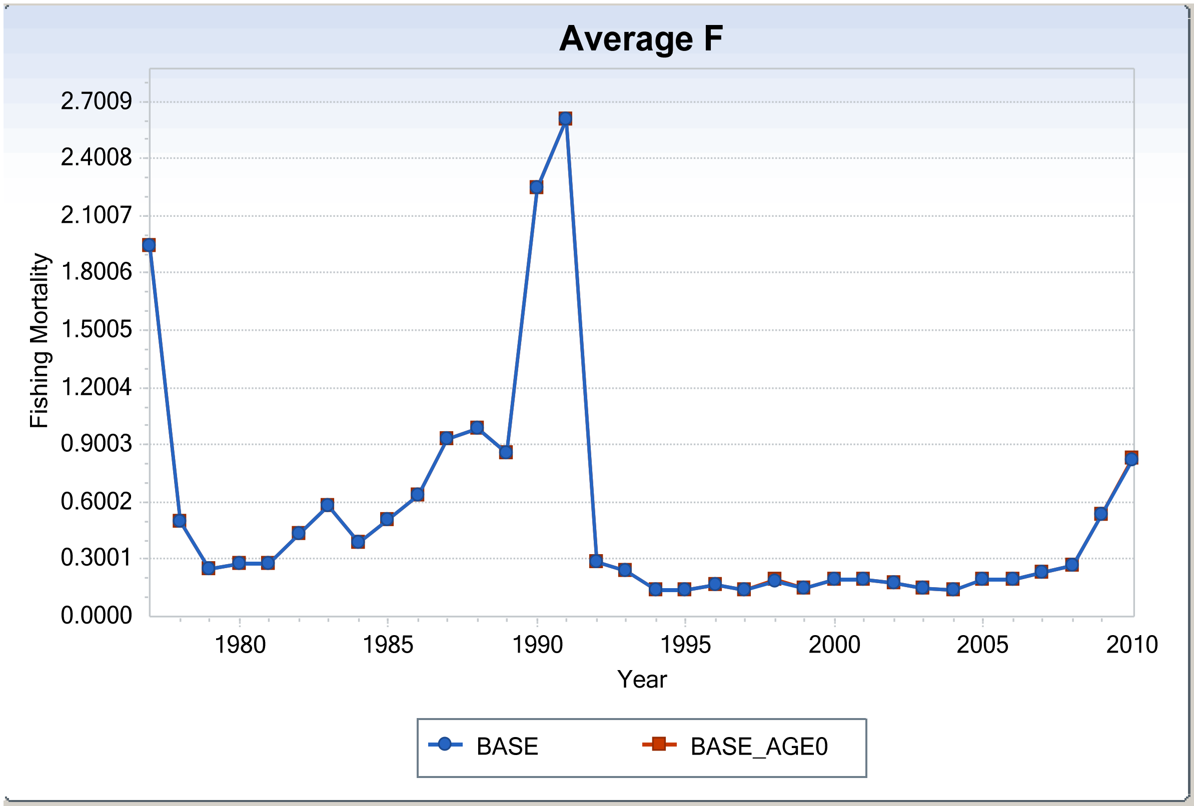


Figure C1.2. Comparison of Gulf of Maine haddock average fishing mortality on ages 6-8 ($F_{6\text{-}8}$) from the 2012 updated BASE VPA age 1-9$^+$ configuration to a sensitivity configuration applying an age 0-9$^+$ configuration (BASE_AGE0) as was used in GARM III.

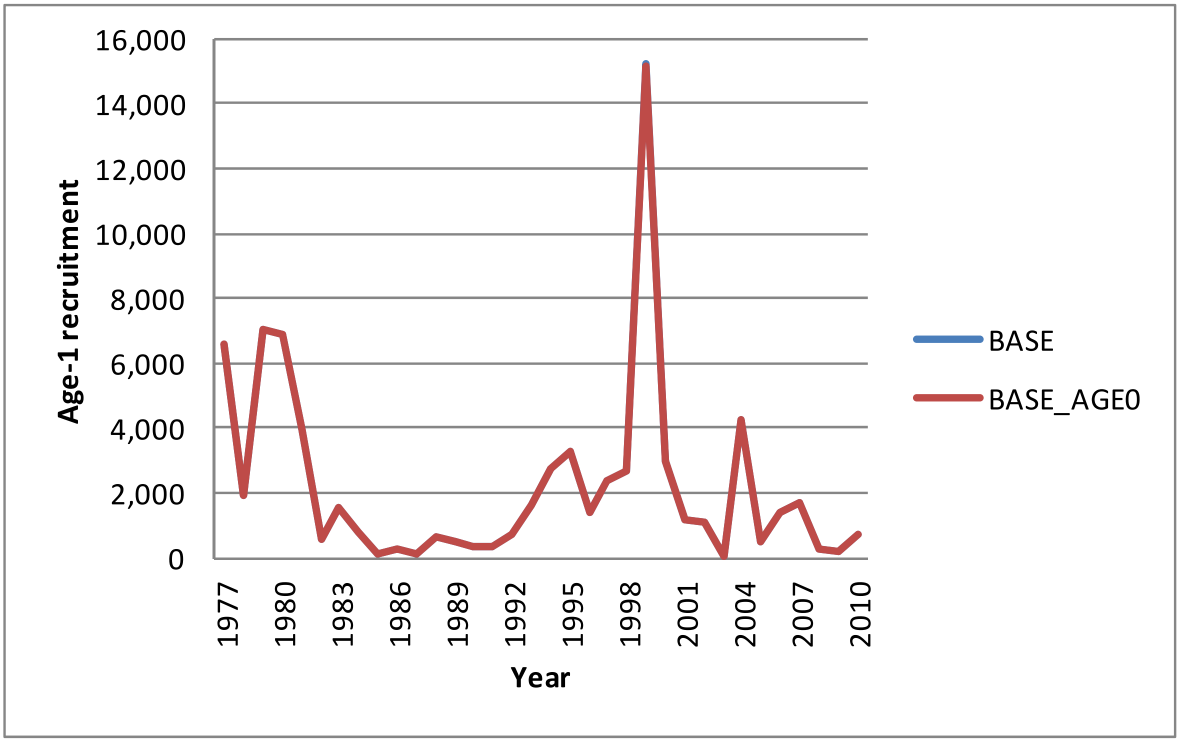


Figure C1.3. Comparison of Gulf of Maine haddock age-1 recruitment from the 2012 updated BASE VPA age 1-9^{+} configuration to a sensitivity configuration applying an age 0-9^{+} configuration (BASE_AGE0) as was used in GARM III.

Appendix C2. Sensitivity of the Gulf of Maine haddock assessment to Marine Recreational Information Program (MRIP) estimates of recreational landings.

In January, 2012 revised estimates of recreational catch were released which reflected a new treatment of the recreational catch statistics collected under the MRFSS system. These new catch estimates were released under the new name of the Marine Recreational Information Program (MRIP). There were several issues that precluded the incorporation of MRIP data into the 2012 Groundfish Assessment Updates, most notably was the late release of the data. Other issues include the partial time series of revised recreational catch that is currently available (only 2004-present recreational catch have been revised) and the fact that adjustments had not been made to the length sampling data to account for the revised MRIP statistical design. Despite these issues, the 2012 Groundfish Update Integrated Peer Review Panel recommended that a sensitivity analysis of the Gulf of Maine haddock assessment to revised MRIP-based recreational landings estimates be conducted.

Estimates of Gulf of Maine haddock MRIP recreational landings were approximated from the total haddock MRIP landings. Since there are virtually no recreational landings of Georges Bank haddock during this period, the total haddock landings provide a reasonable proxy of Gulf of Maine haddock landings. Estimates of stock-specific Gulf of Maine haddock MRIP landings were available, but measures of precision were not readily available for the stock-specific estimates. The ratios of the stock-specific landings to the total haddock landings ranged from 0.97 to 1.01, with an average of 1.0; ratios higher than 1.0 are indicative of some estimation error in the stock-specific landings. The comparison supports the use of the total haddock landings as a proxy for stock-specific Gulf of Maine haddock landings. MRFSS landings are greater than MRIP landing estimates in two out of the seven years, but within the 95% confidence intervals of the MRIP landing estimates in all years except 2010 (fig. C2.1). The ratio of MRIP landings to the MRFSS landings used in the assessment ranged from 0.50 (2010) to 1.07 (2006).

To evaluate the sensitivity of the Gulf of Maine haddock assessment to the revised MRIP landings, the total recreational catch was adjusted using the MRIP:MRFSS ratio for the years 2004 to 2010. Given that there was no consistent bias to the MRFSS data and because there is no information on MRIP prior to 2004, no adjustments were made to recreational landings between 1981 and 2003. Since no information was available on modifications to the length-frequency distributions, it was assumed that there was no change to the landings-at-age proportions. Correspondingly, the recreational landings-at-age were adjusted by the MRIP:MRFSS ratio in the corresponding year. Total catch-at-age was recalculated following the adjustment to the recreational landings-at-age.

The ADAPT-VPA was rerun using the revised catch-at-age matrix. No other changes were made to the VPA formulation. Overall, the revised MRIP VPA run was consistent with the results of the BASE VPA run. There were minor changes to the spawning stock biomass (SSB) from 1999 to 2010, with the MRIP run tending to estimate slightly lower SSB in all but the terminal year (fig. C2.2). The 2010 SSB was estimated at 2,868 mt in the BASE run and 2,886 mt in the MRIP run. Estimates of average fishing mortality were nearly identical between the two runs, with the exception of 2009 and 2010 when the MRIP run estimated lower fishing mortality (fig. C2.3). The 2010 average $F_{6\text{-}8}$ was estimated at 0.82 in the BASE run and 0.56 in the MRIP run. The

MRIP run resulted in minor downward rescaling of the 1998 year class (-3%) and a slight positive rescaling of the 2003 year class (4%; fig. C2.4). Overall, the impacts of the revised MRIP landings on the assessment were minor.

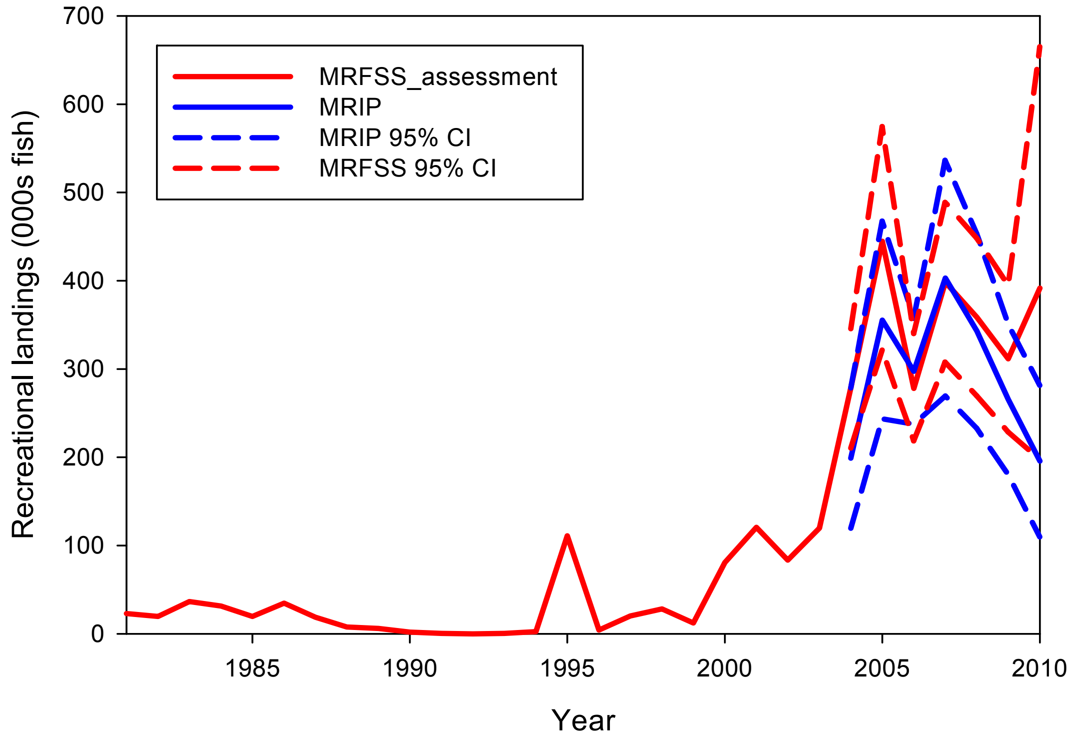


Figure C2.1. Comparison of Gulf of Maine haddock recreational landings used in the BASE assessment (MRFSS) and Marine Recreational Information Program (MRIP) estimates of recreational landings. The associated 95% confidence intervals for both time series are shown between 2004 and 2010.

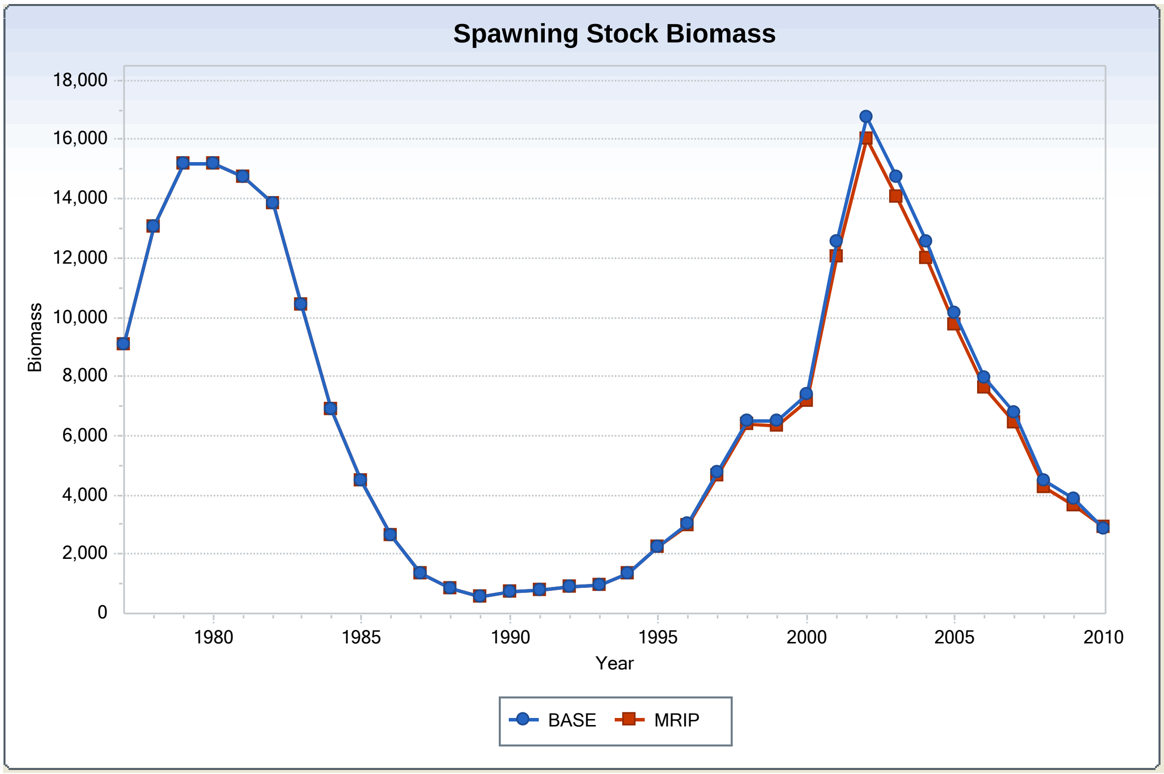


Figure C2.2. Comparison of Gulf of Maine haddock spawning stock biomass from the 2012 updated BASE assessment to an assessment using MRIP estimates of recreation landings between 2004 and 2010 (MRIP).

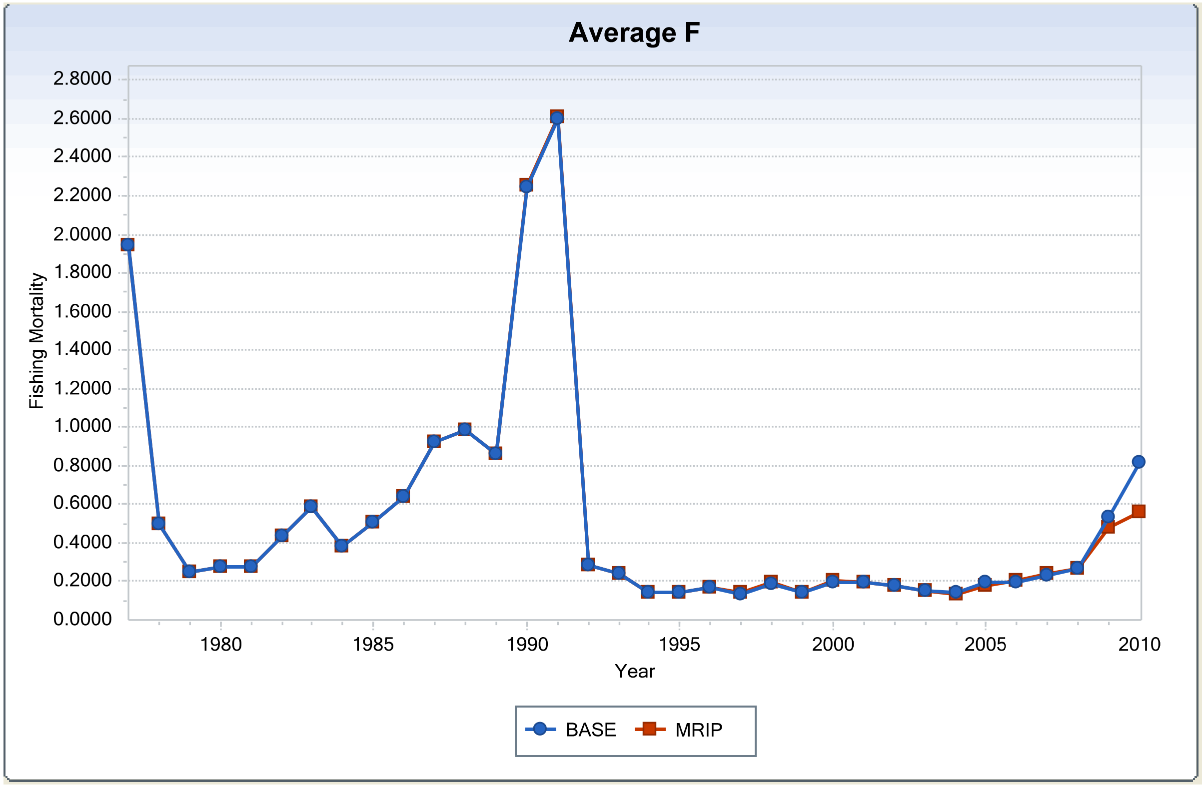


Figure C2.3. Comparison of Gulf of Maine haddock average fishing mortality on ages 6-8 ($F_{6\text{-}8}$) from the 2012 updated BASE assessment to an assessment using MRIP estimates of recreation landings between 2004 and 2010 (MRIP).

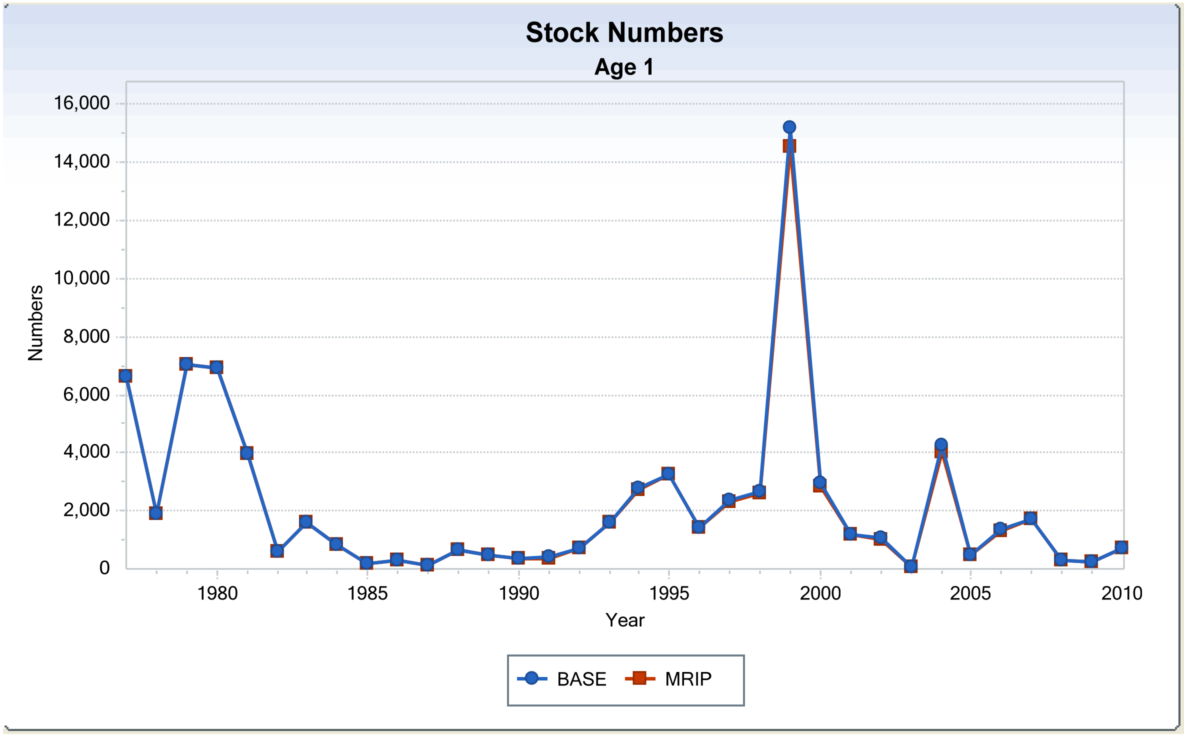


Figure C2.4. Comparison of Gulf of Maine haddock age-1 recruitment from the 2012 updated BASE assessment to an assessment using MRIP estimates of recreation landings between 2004 and 2010 (MRIP).

D. Cape Cod-Gulf of Maine Yellowtail Flounder
by Chris Legault, Larry Alade, Sarah Emery, Jeremy King, and Sally Sherman

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

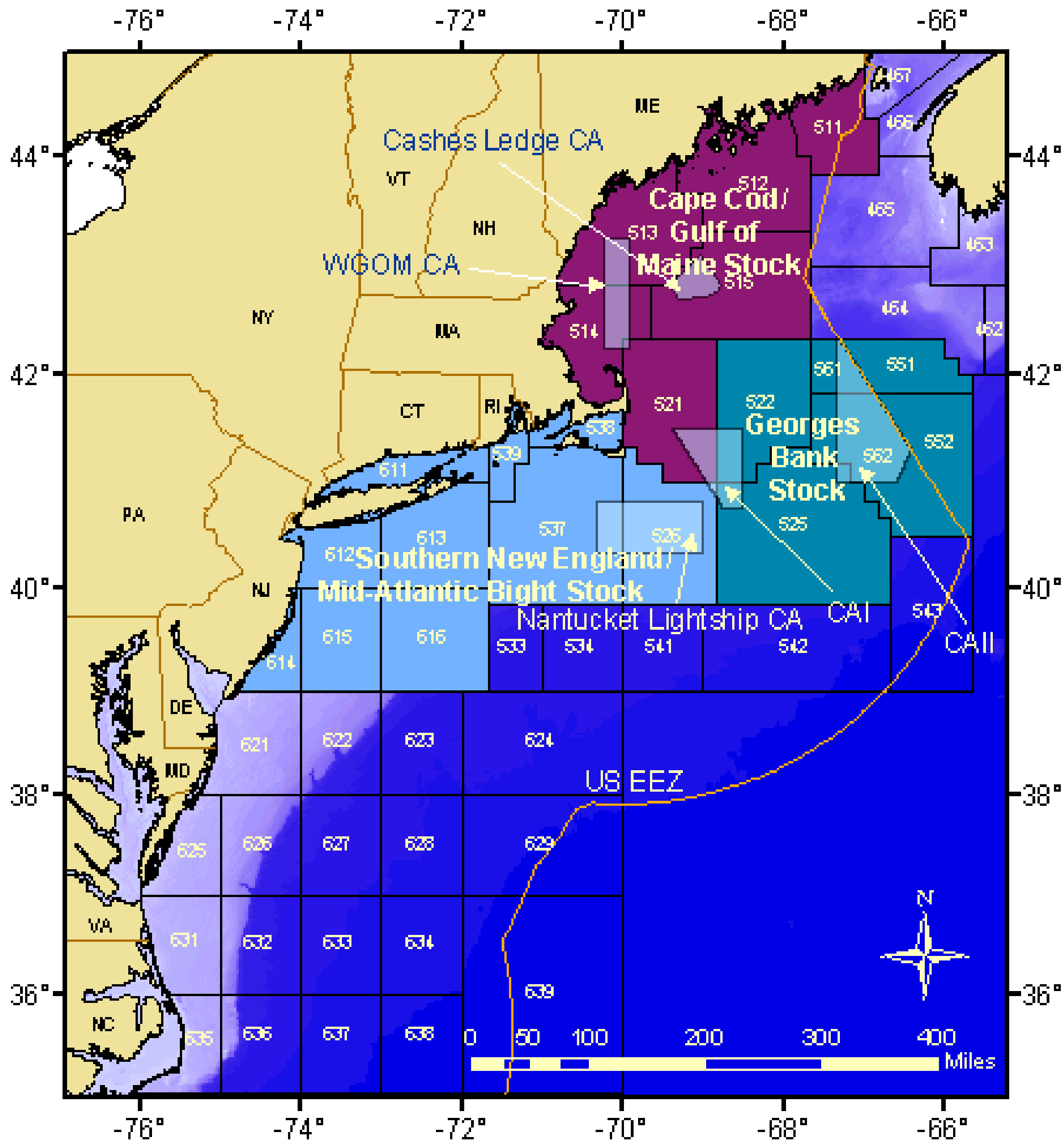

Figure D1. Stock area map for yellowtail flounder from Status of Stocks website (http://www.nefsc.noaa.gov/sos/).

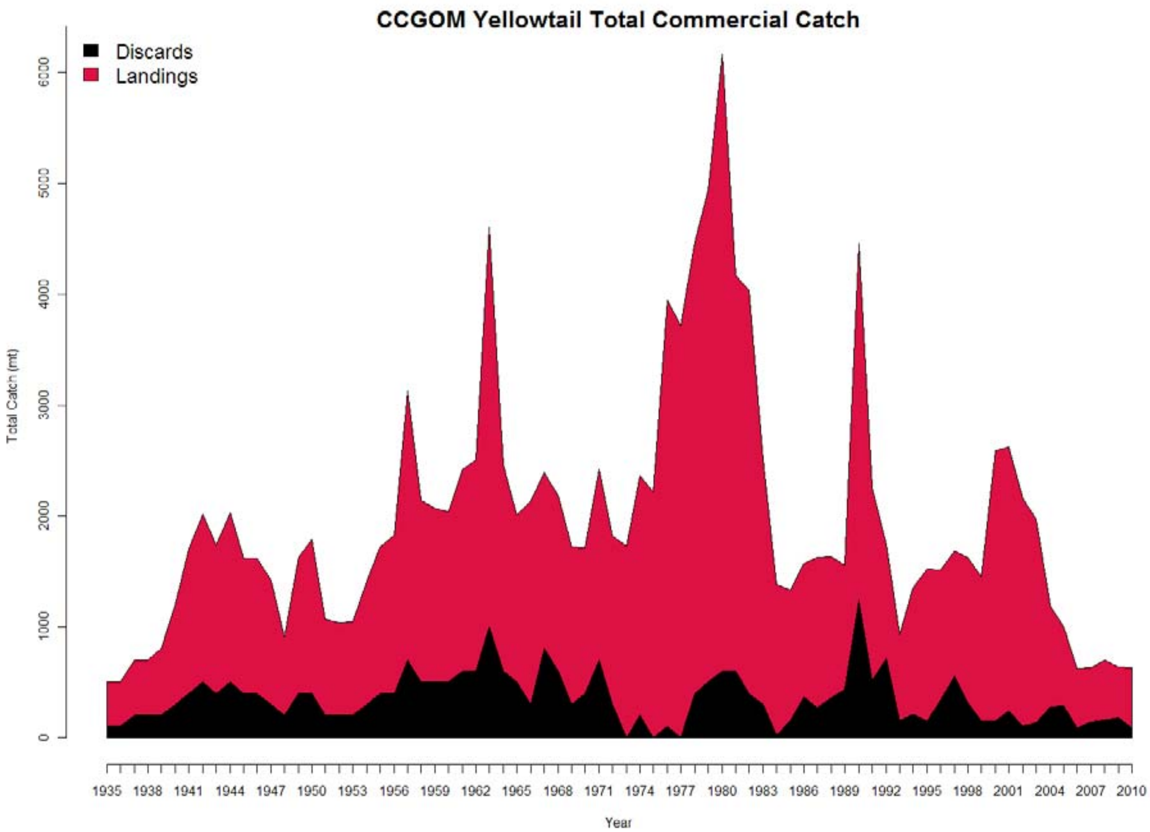

Figure D2. Total catch of Cape Cod-Gulf of Maine yellowtail flounder from 1935-2010 by disposition (landings and discards).

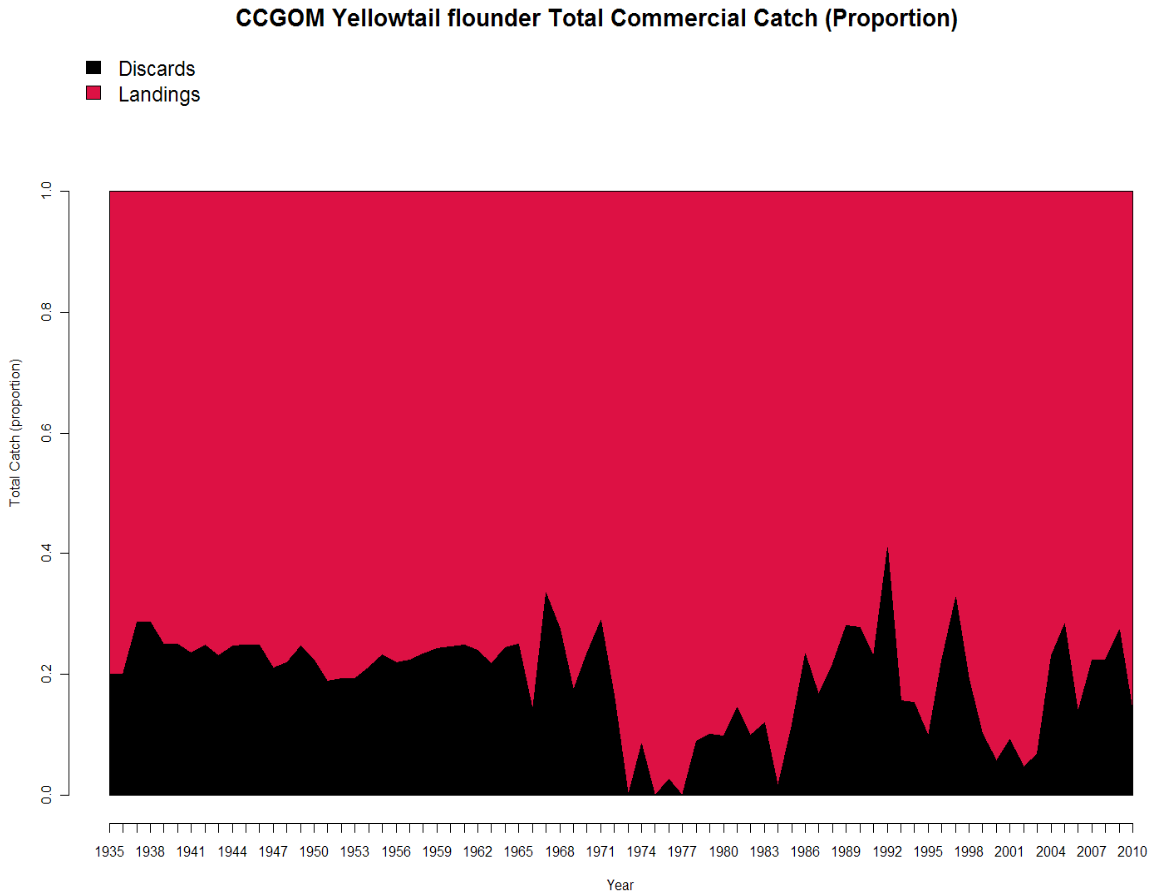

Figure D3. Total catch of Cape Cod-Gulf of Maine yellowtail flounder from 1935-2010 by disposition (landings and discards) expressed as proportions.

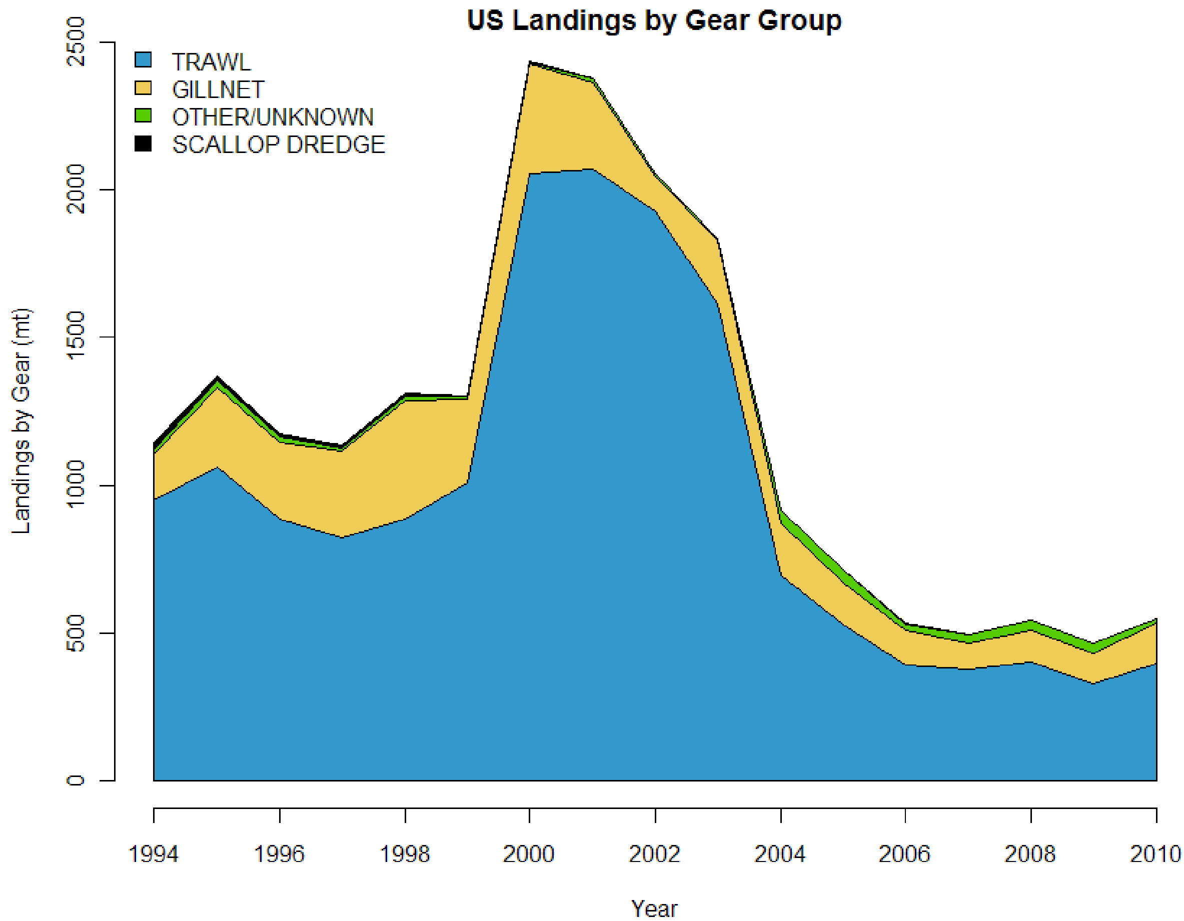

Figure D4. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by gear groupings.

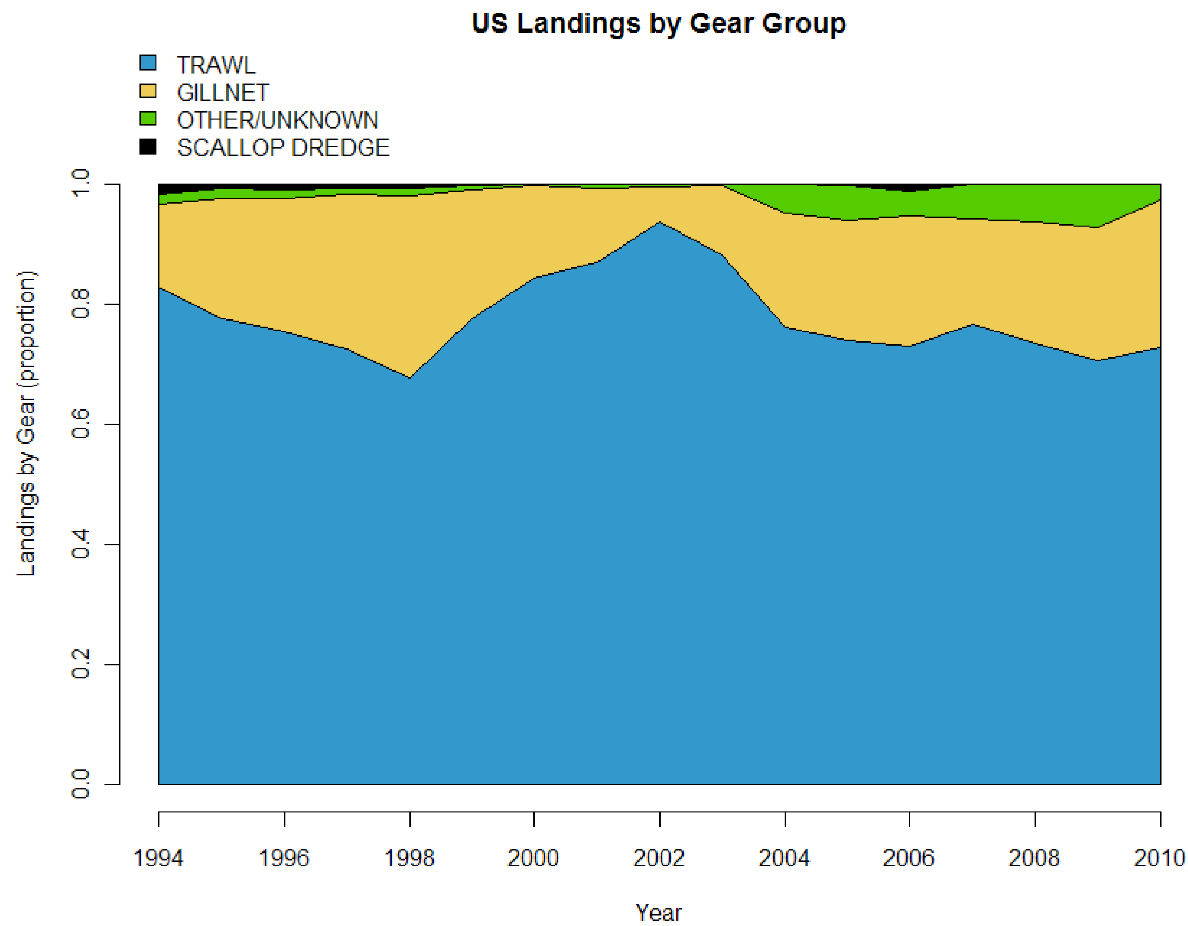

Figure D5. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by gear groupings expressed as proportions.

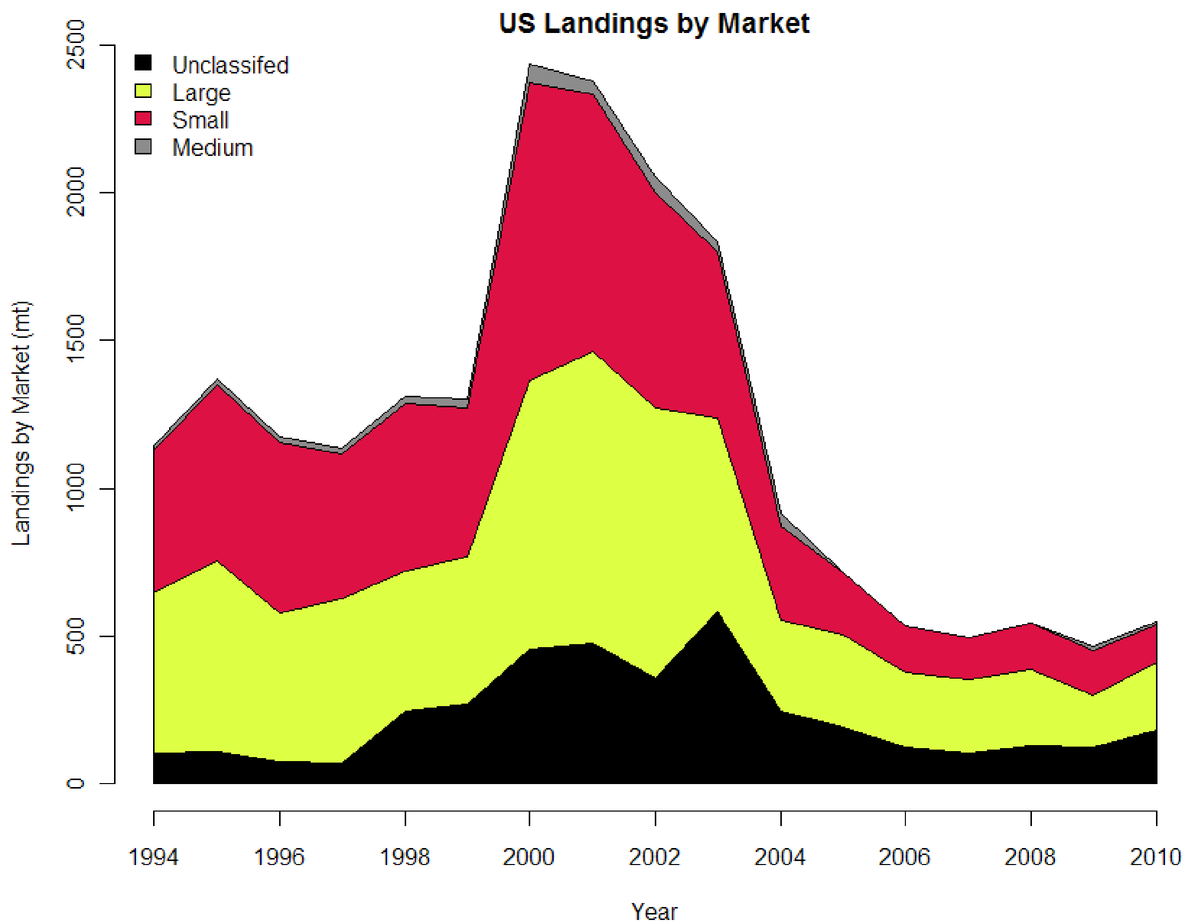

Figure D6. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by market category.

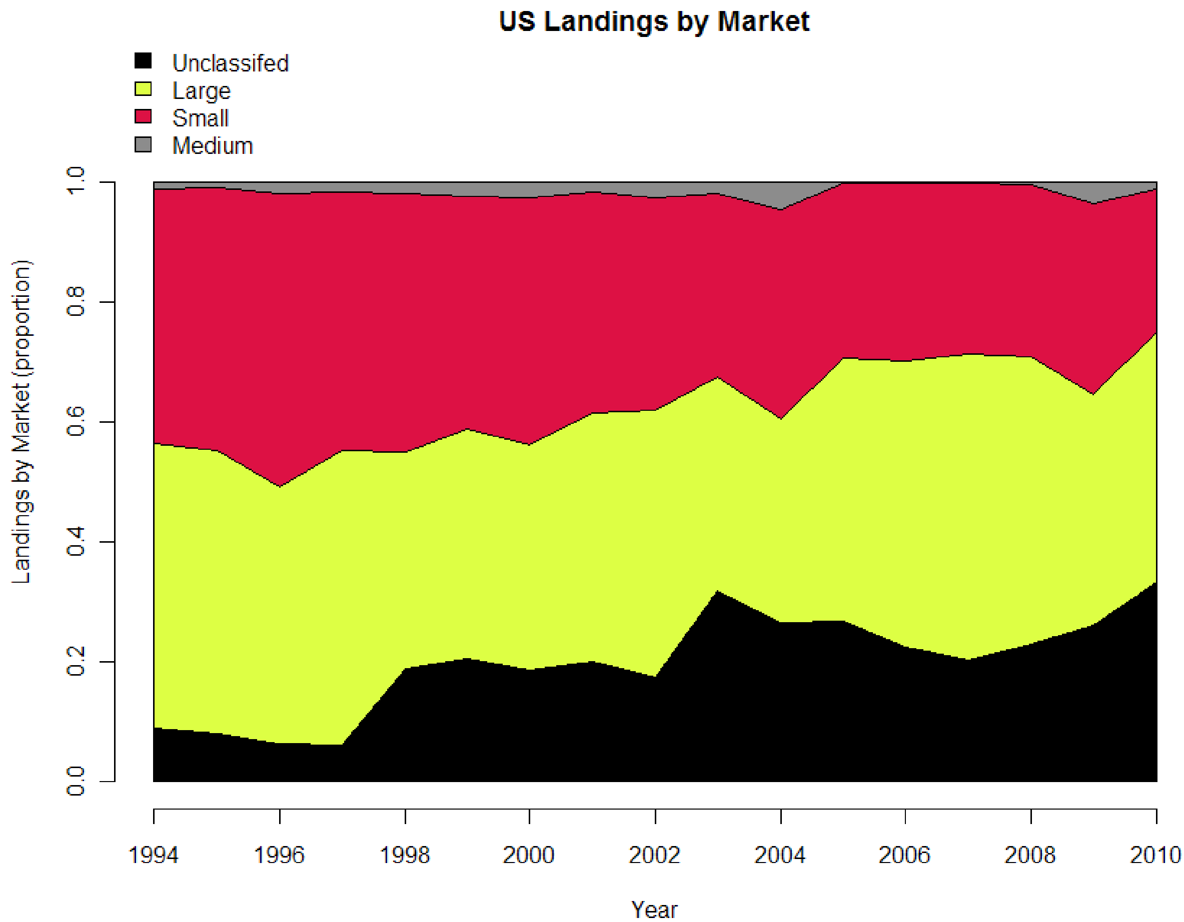

Figure D7. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by market category expressed as proportions.

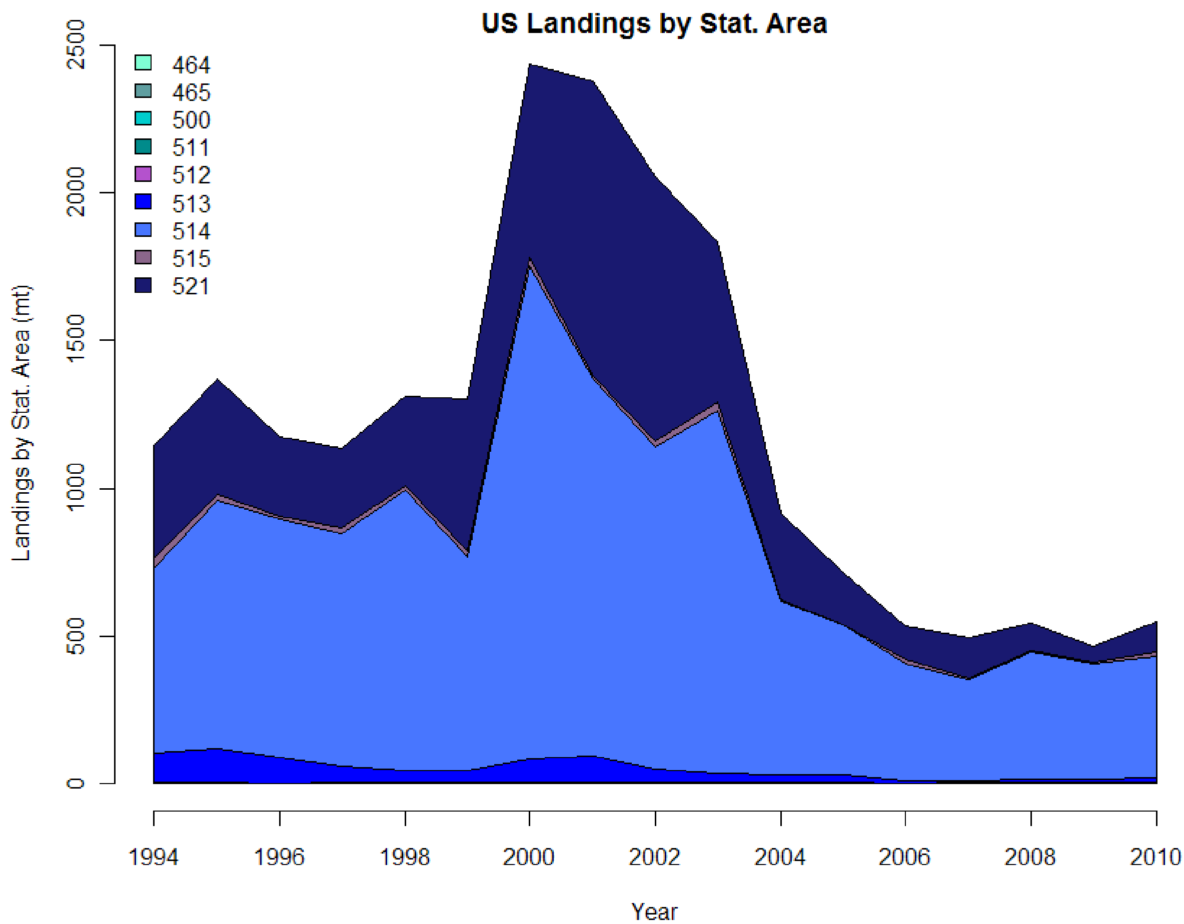

Figure D8. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by statistical area.

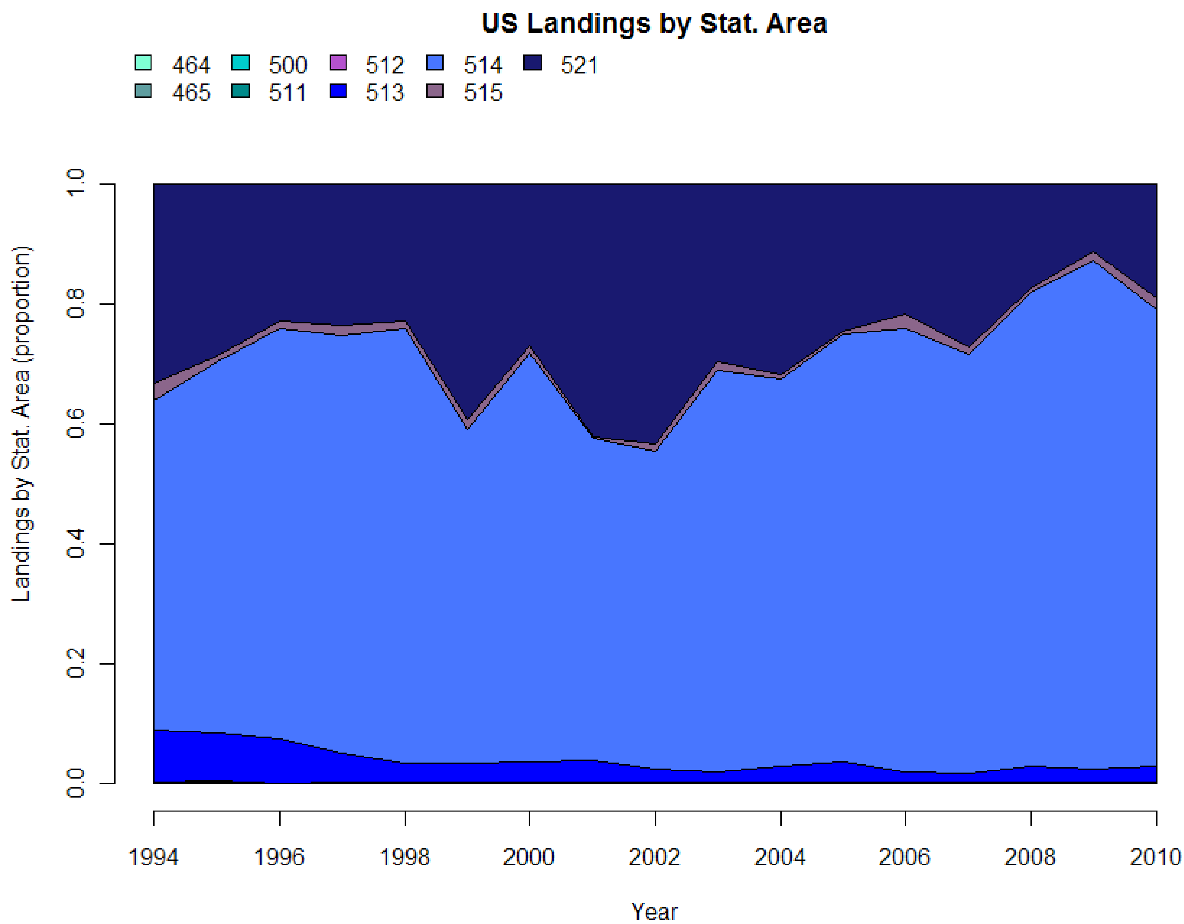

Figure D9. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by statistical area expressed as proportions.

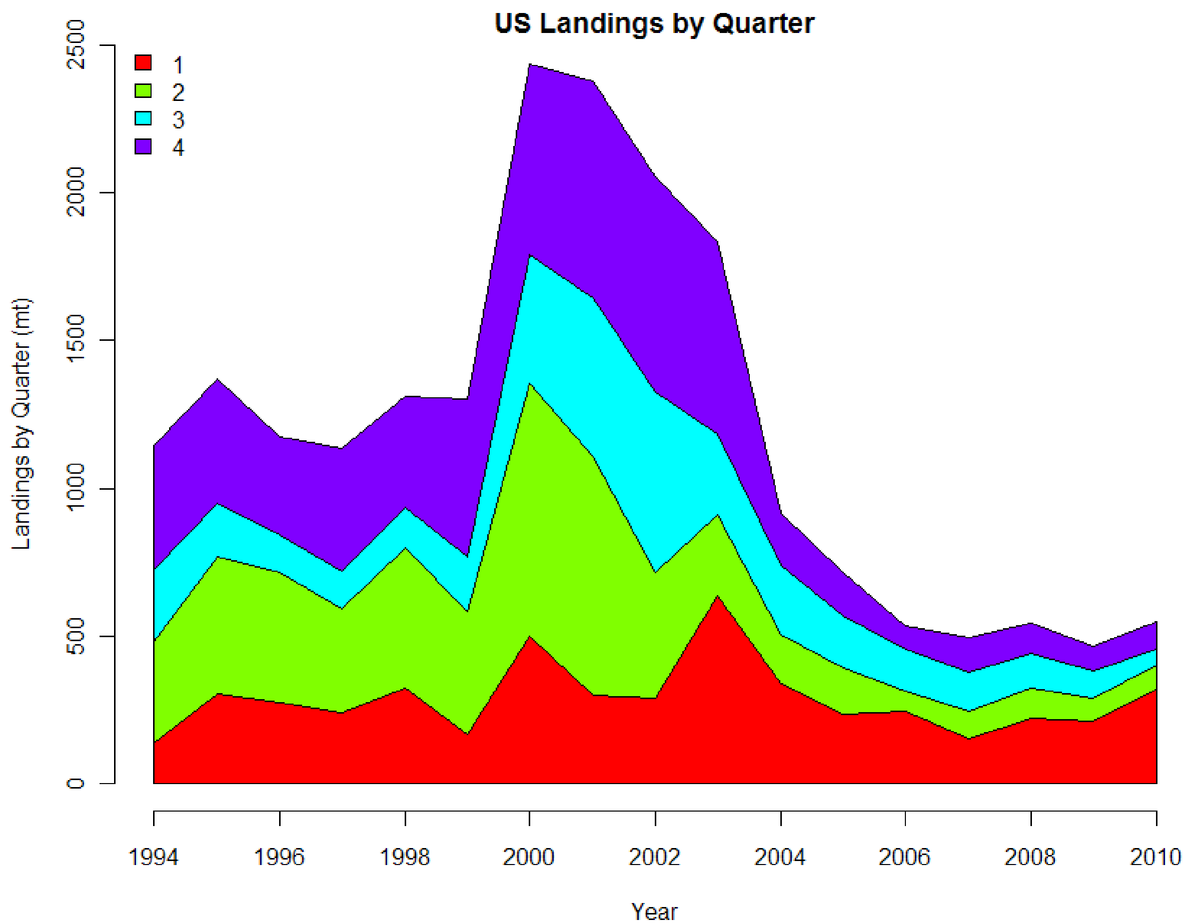

Figure D10. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by quarter.

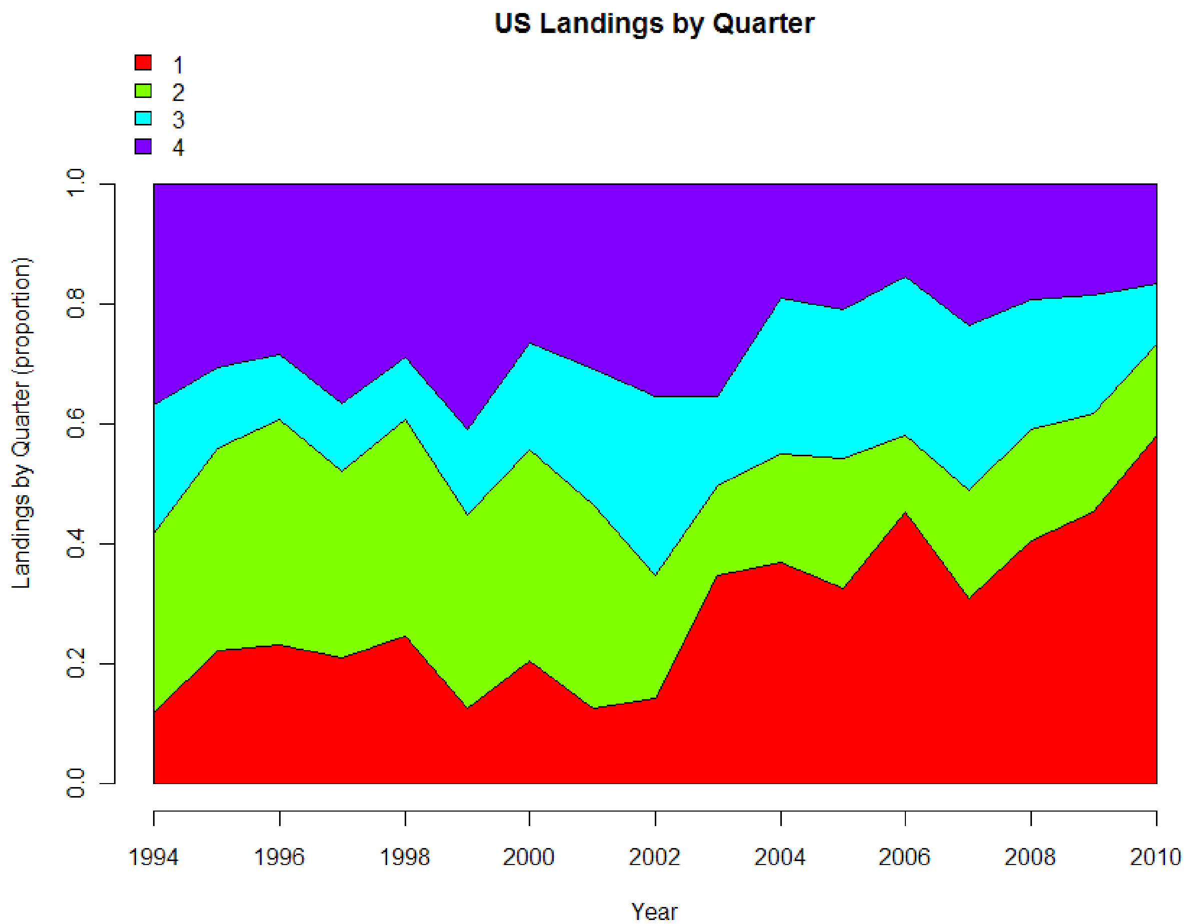

Figure D11. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by quarter expressed as proportions.

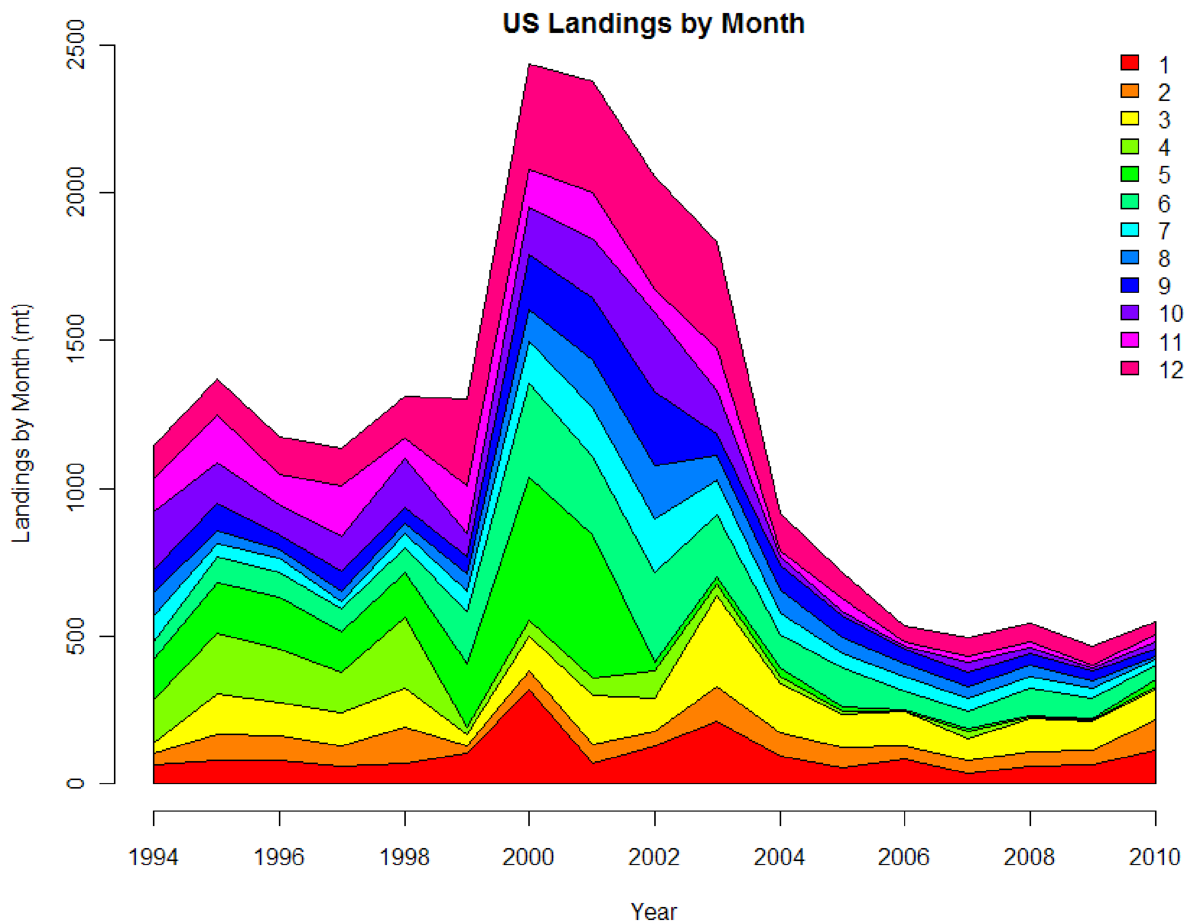

Figure D12. Landings of Cape Cod-Gulf of Maine yellowtail flounder from 1994-2010 by month.

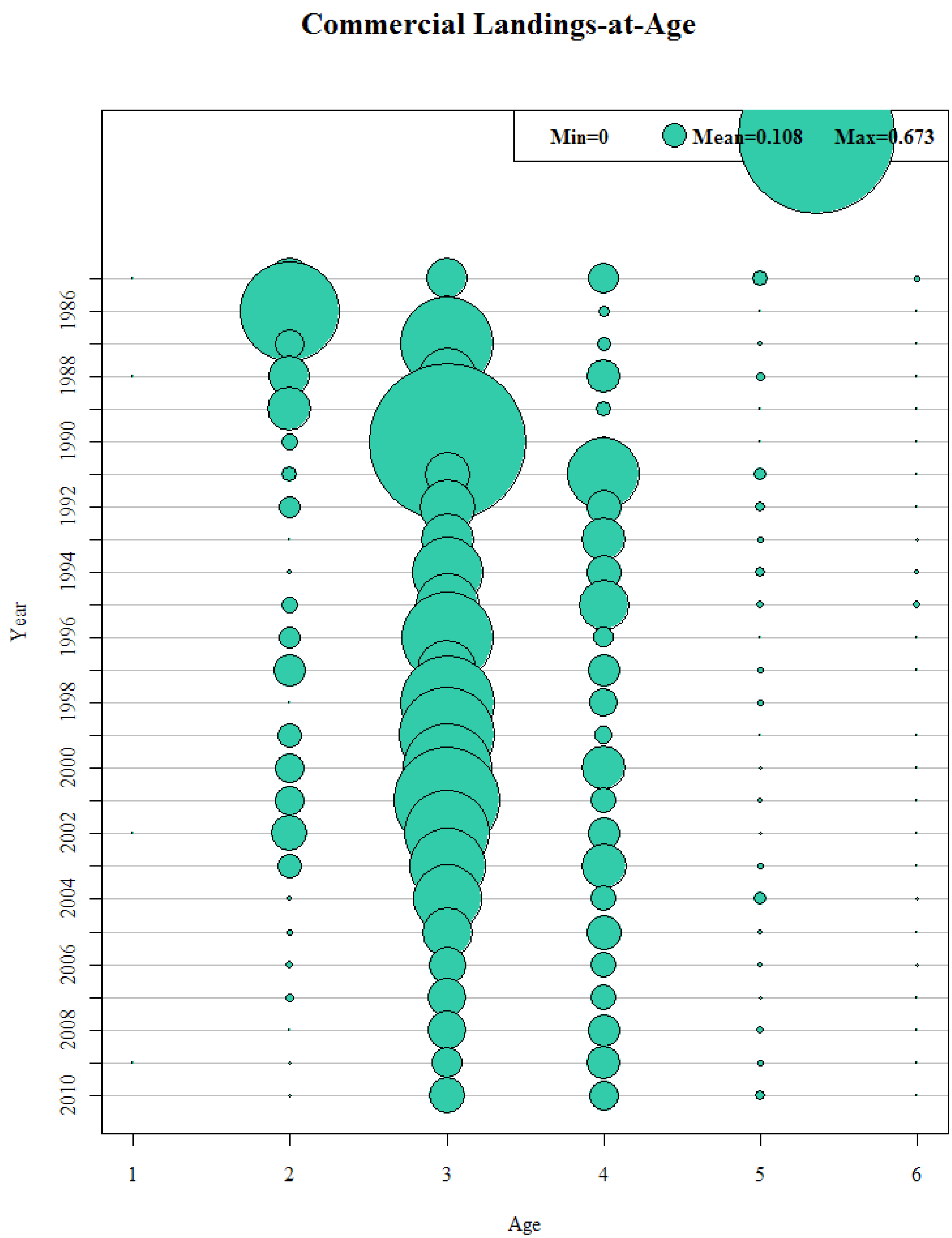

Figure D13. Landings-at-age of Cape Cod-Gulf of Maine yellowtail flounder from 1985-2010. *Note age 6 is a plus group.*

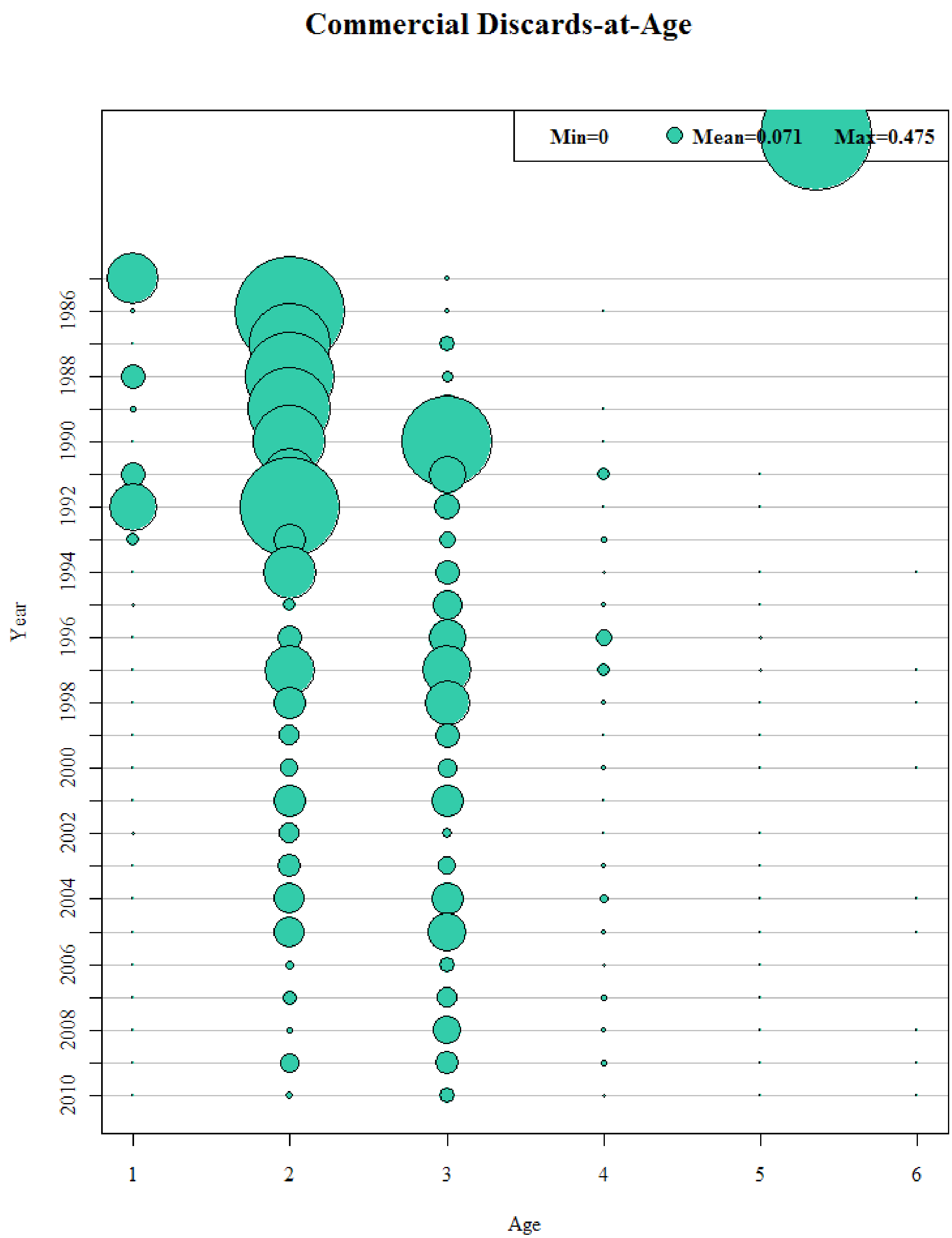

Figure D14. Discards-at-age of Cape Cod-Gulf of Maine yellowtail flounder from 1985-2010. *Note age 6 is a plus group.*

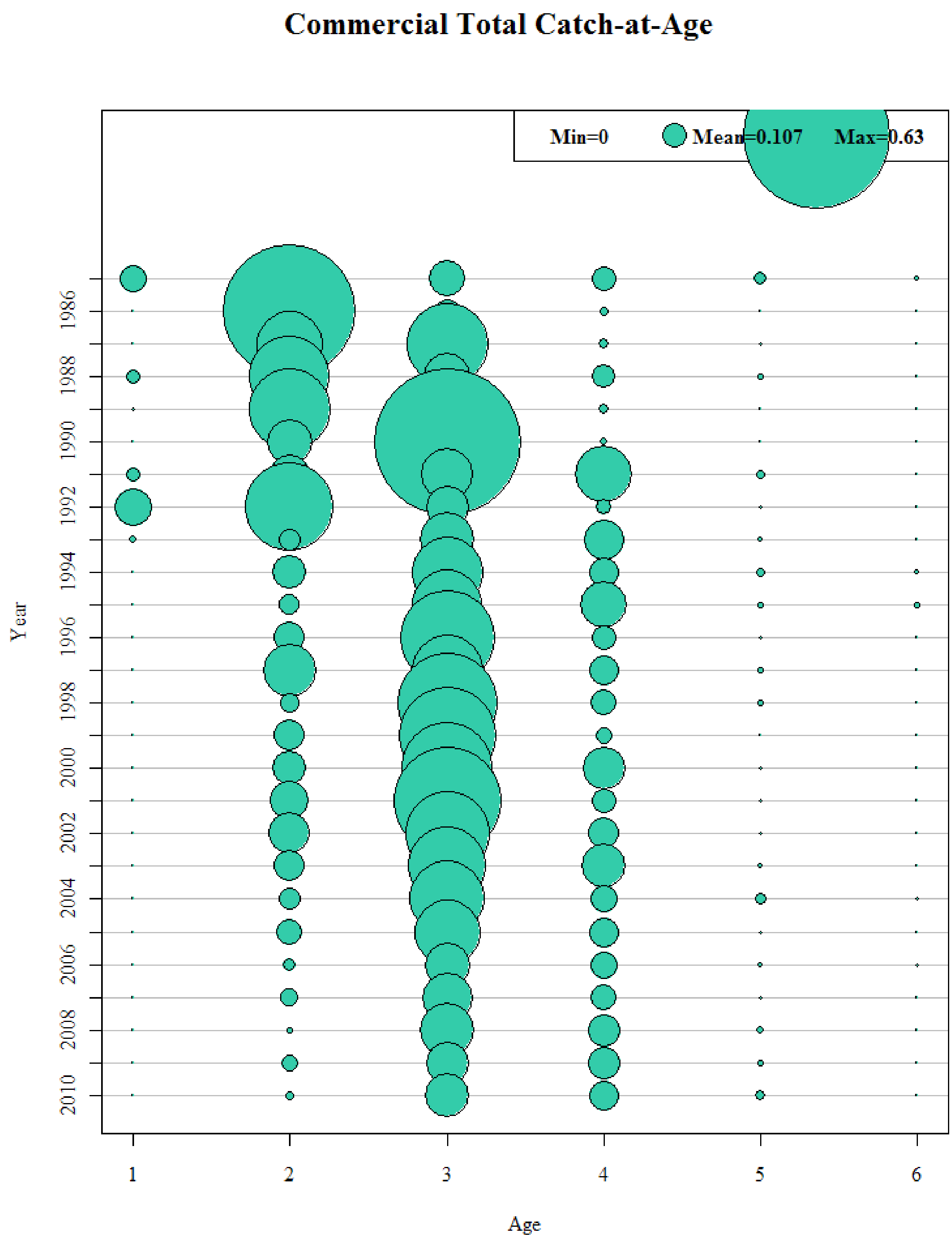

Figure D15. Total catch-at-age of Cape Cod-Gulf of Maine yellowtail flounder from 1985-2010. *Note age 6 is a plus group.*

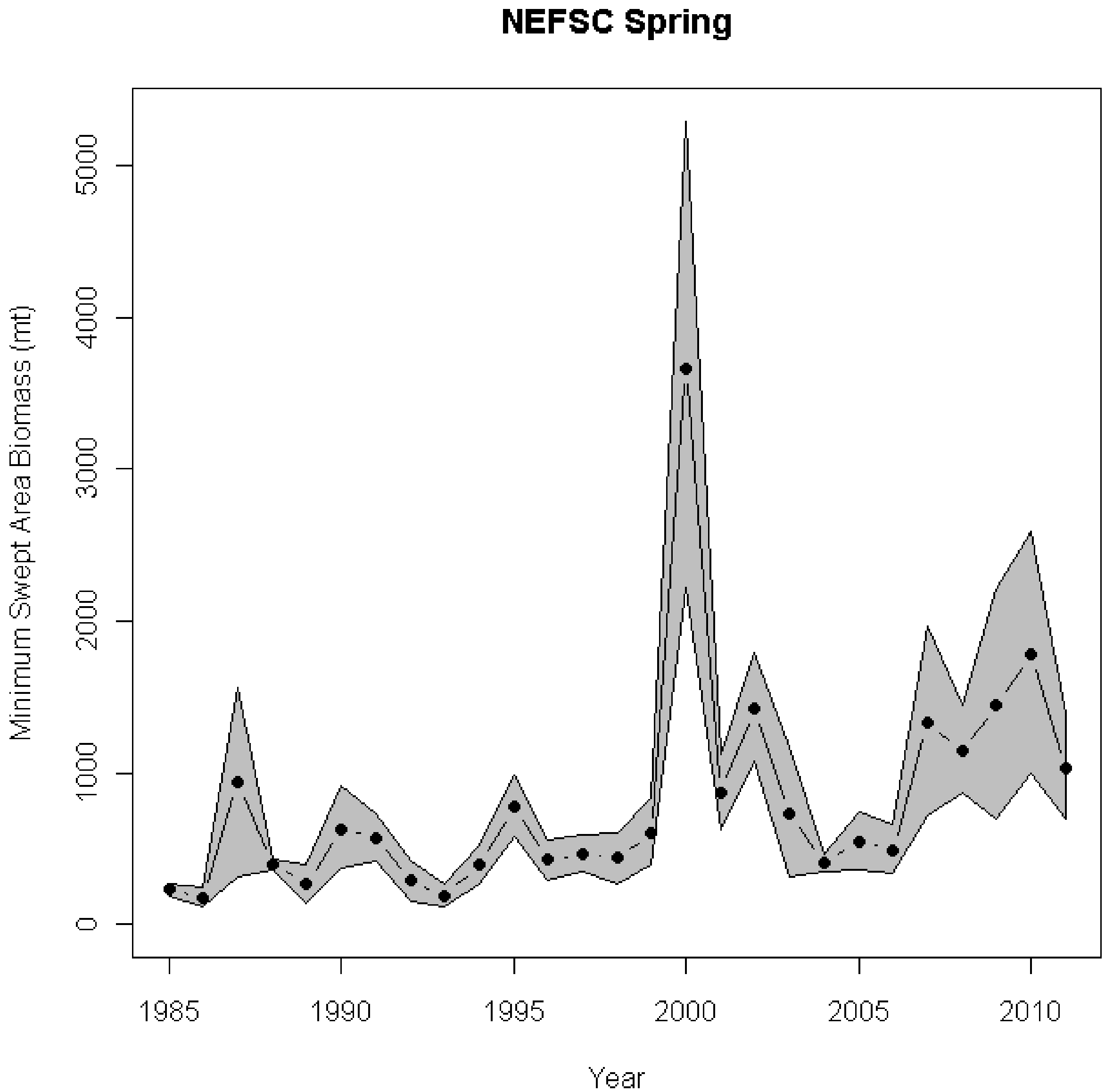

Figure D16. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the NEFSC spring survey.

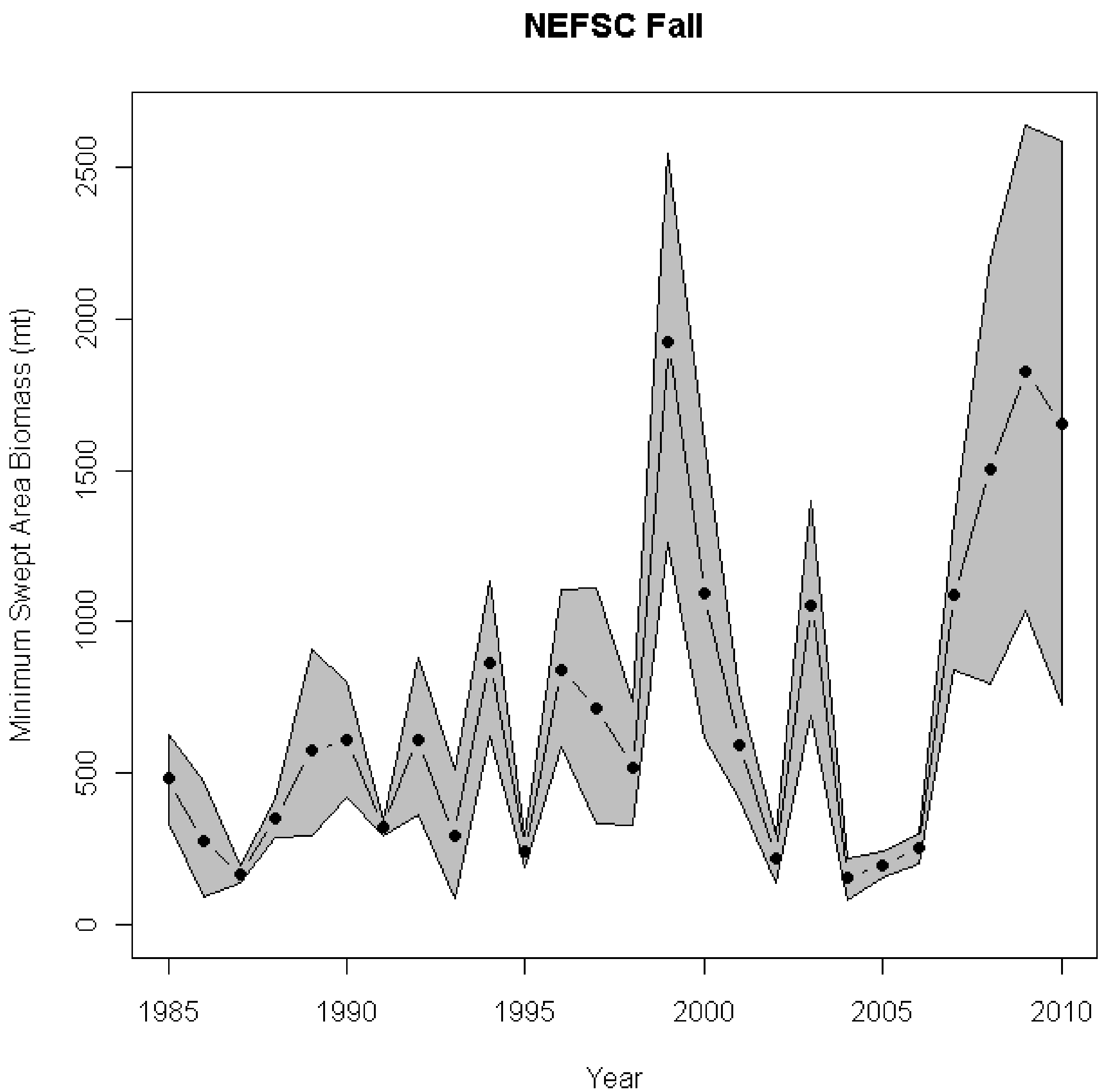

Figure D17. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the NEFSC fall survey.

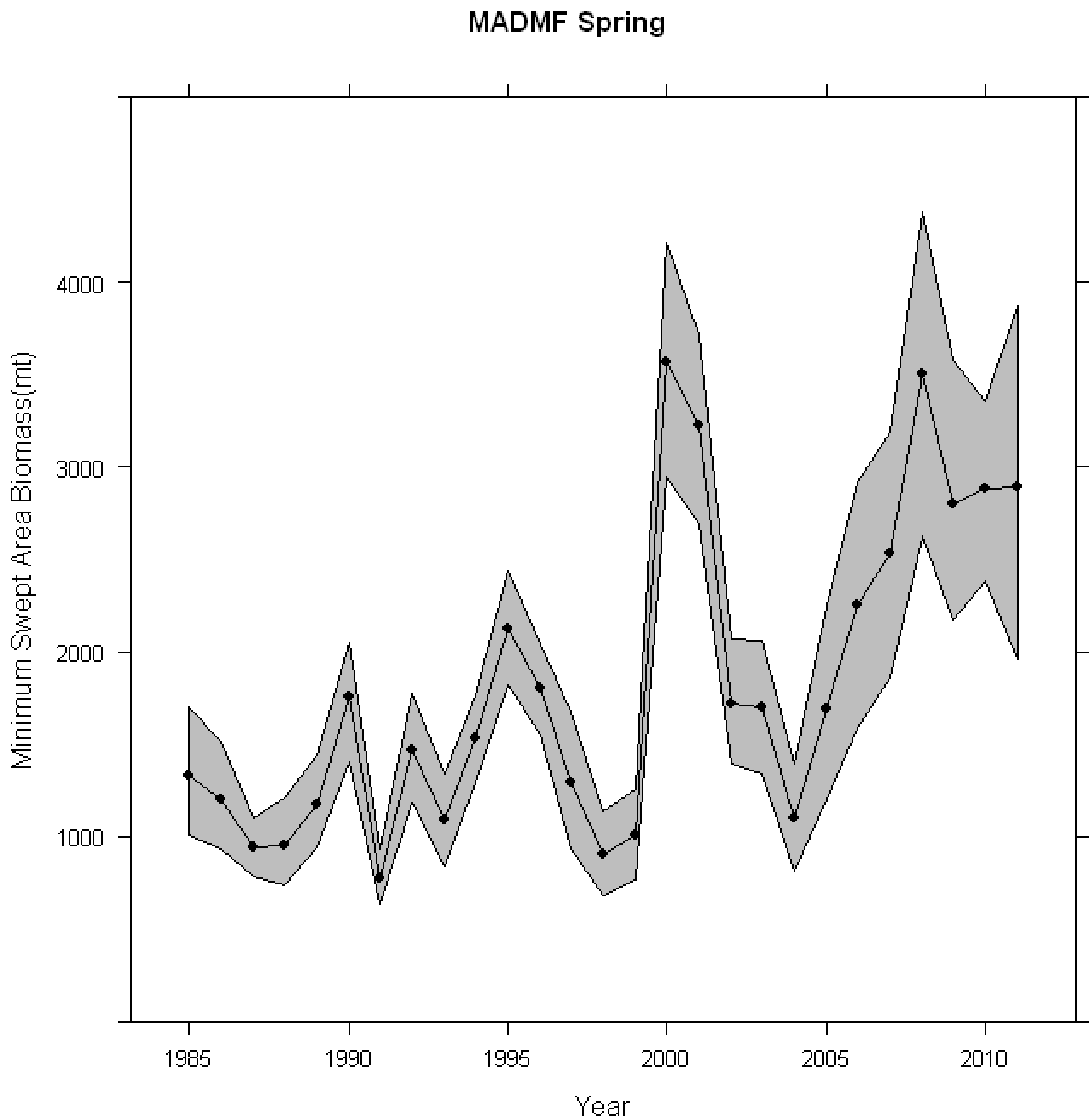

Figure D18. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the MADMF spring survey.

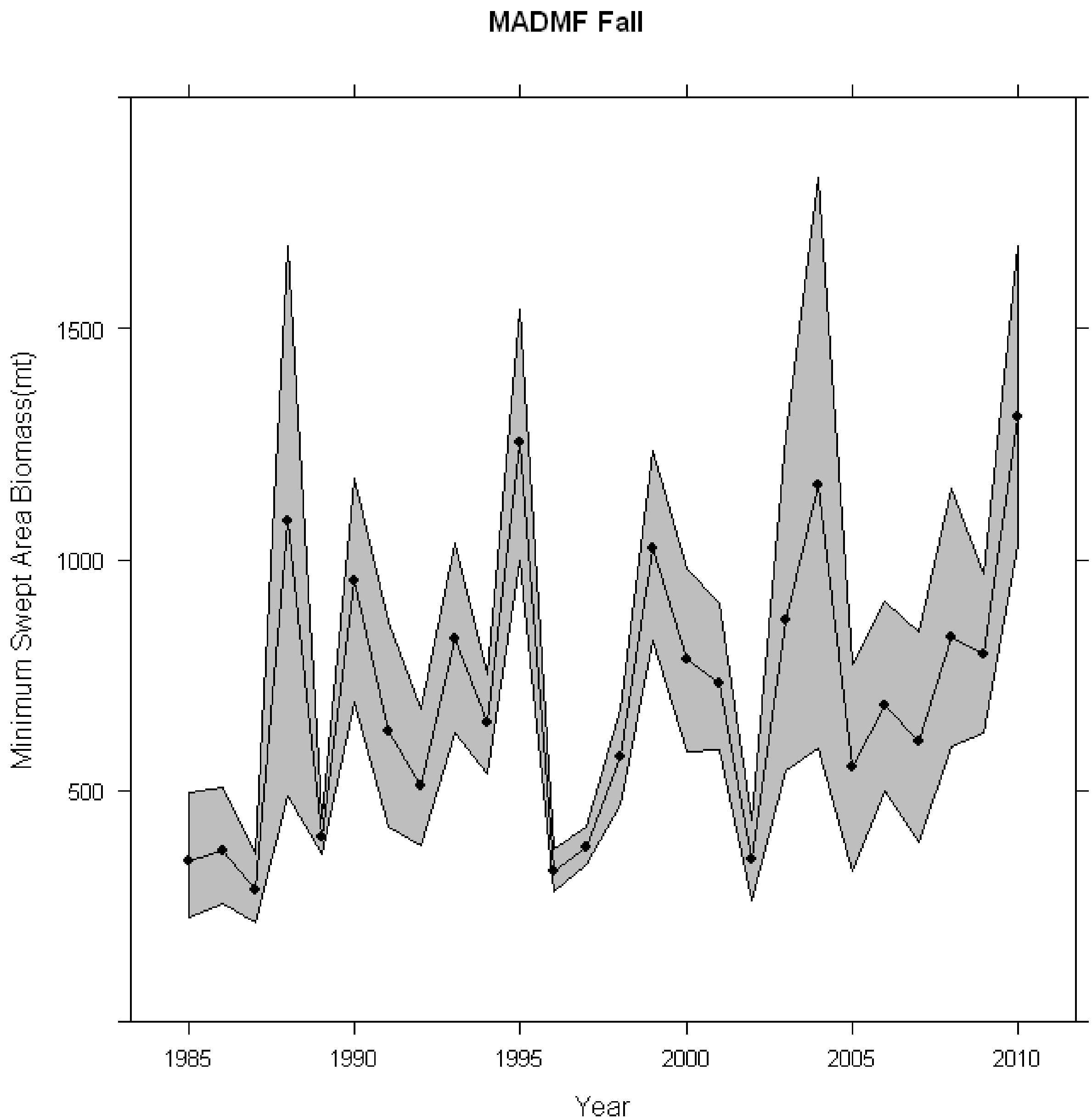

Figure D19. Minimum swept area biomass (mt) with 80% confidence intervals from bootstrapping for the MADMF fall survey.

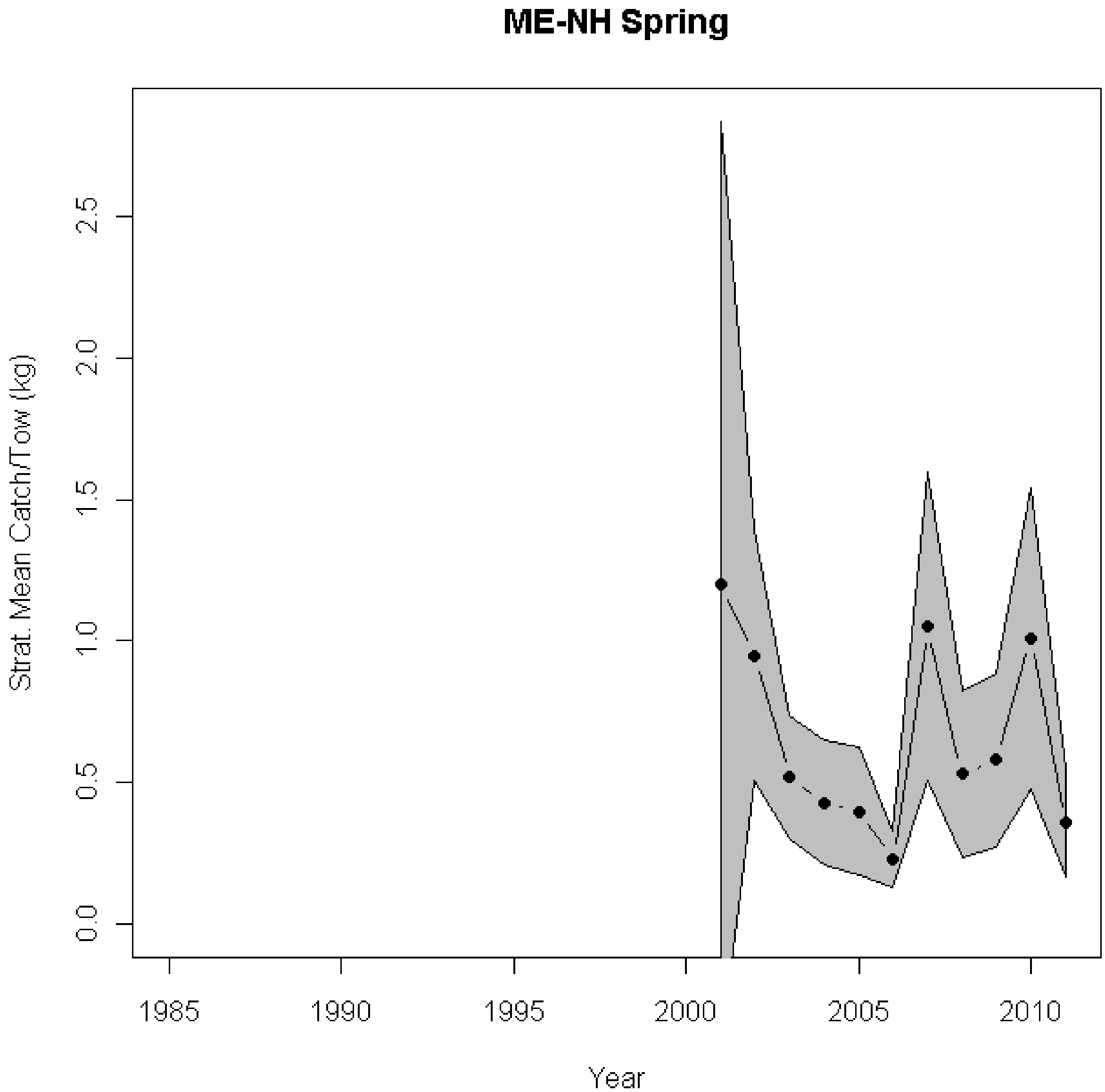

Figure D20. Stratified mean catch per tow (kg) with two standard errors for the ME-NH spring survey.

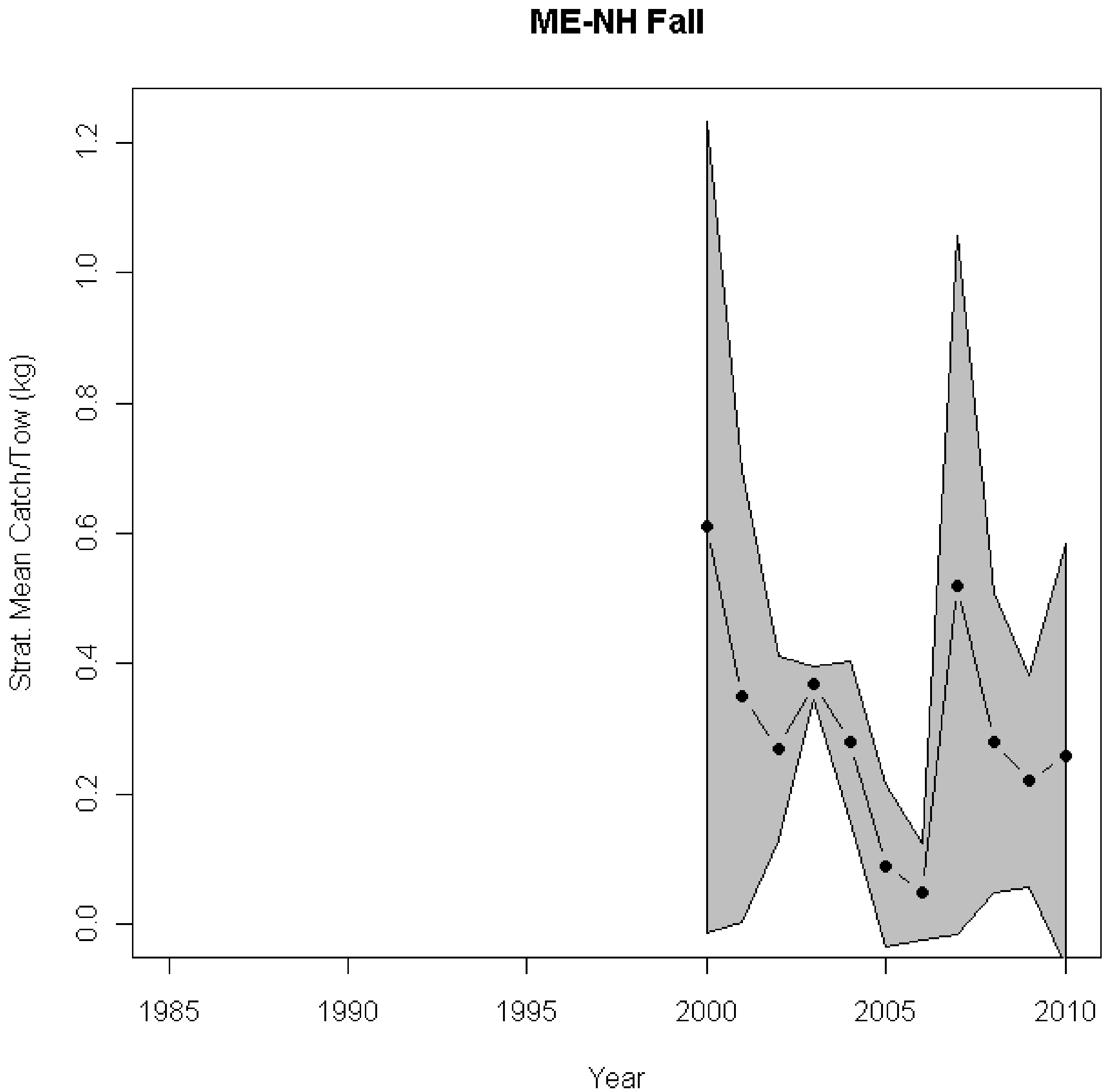

Figure D21. Stratified mean catch per tow (kg) with two standard errors for the ME-NH fall survey.

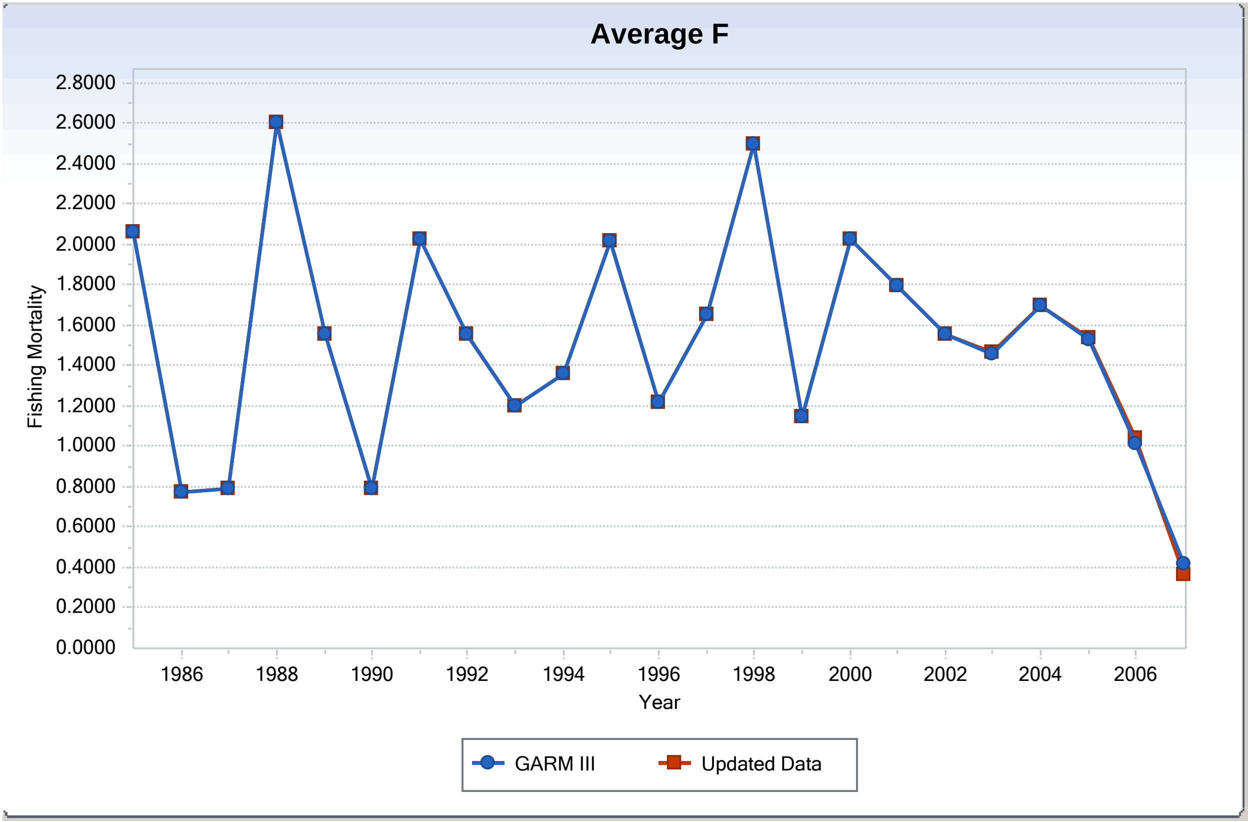

Figure D22. Comparison of average F (ages 4-5) from the GARM III VPA and the VPA with updated data.

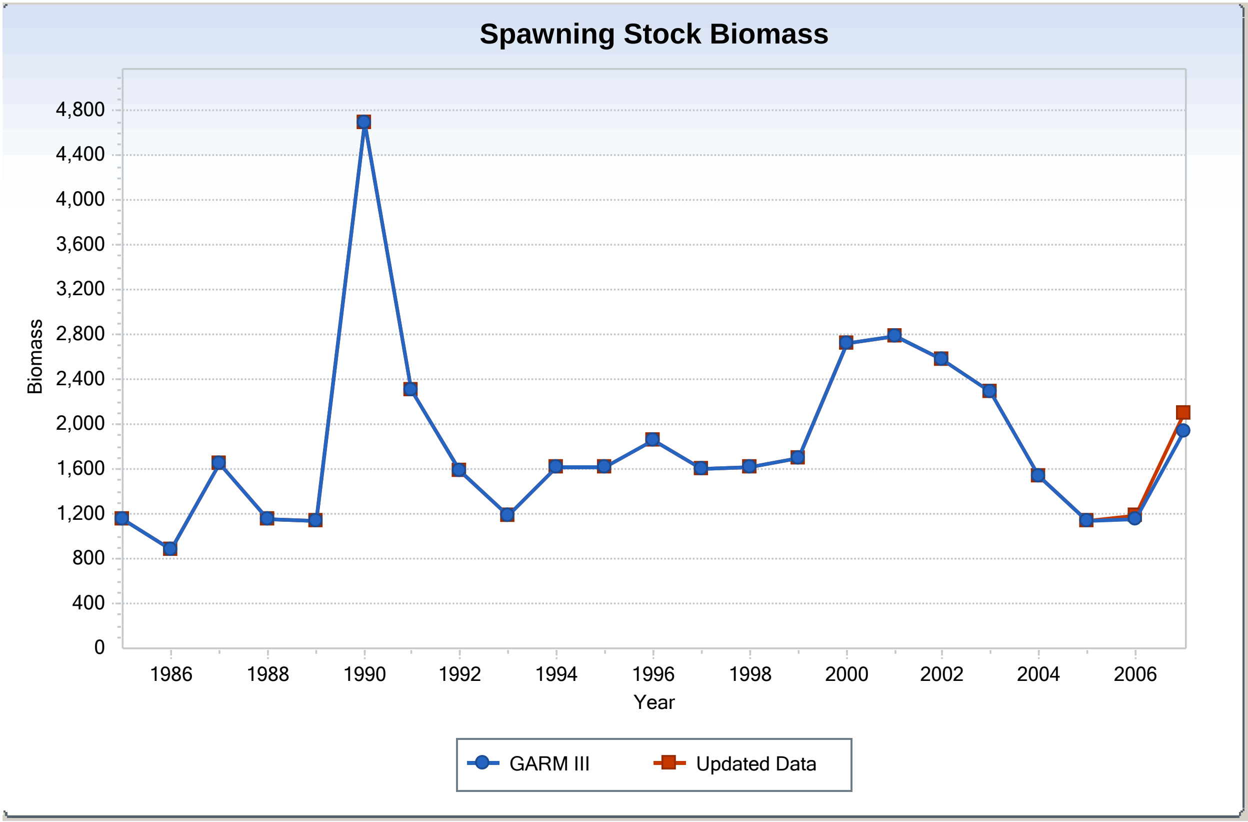

Figure D23. Comparison of spawning stock biomass from the GARM III VPA and the VPA with updated data.

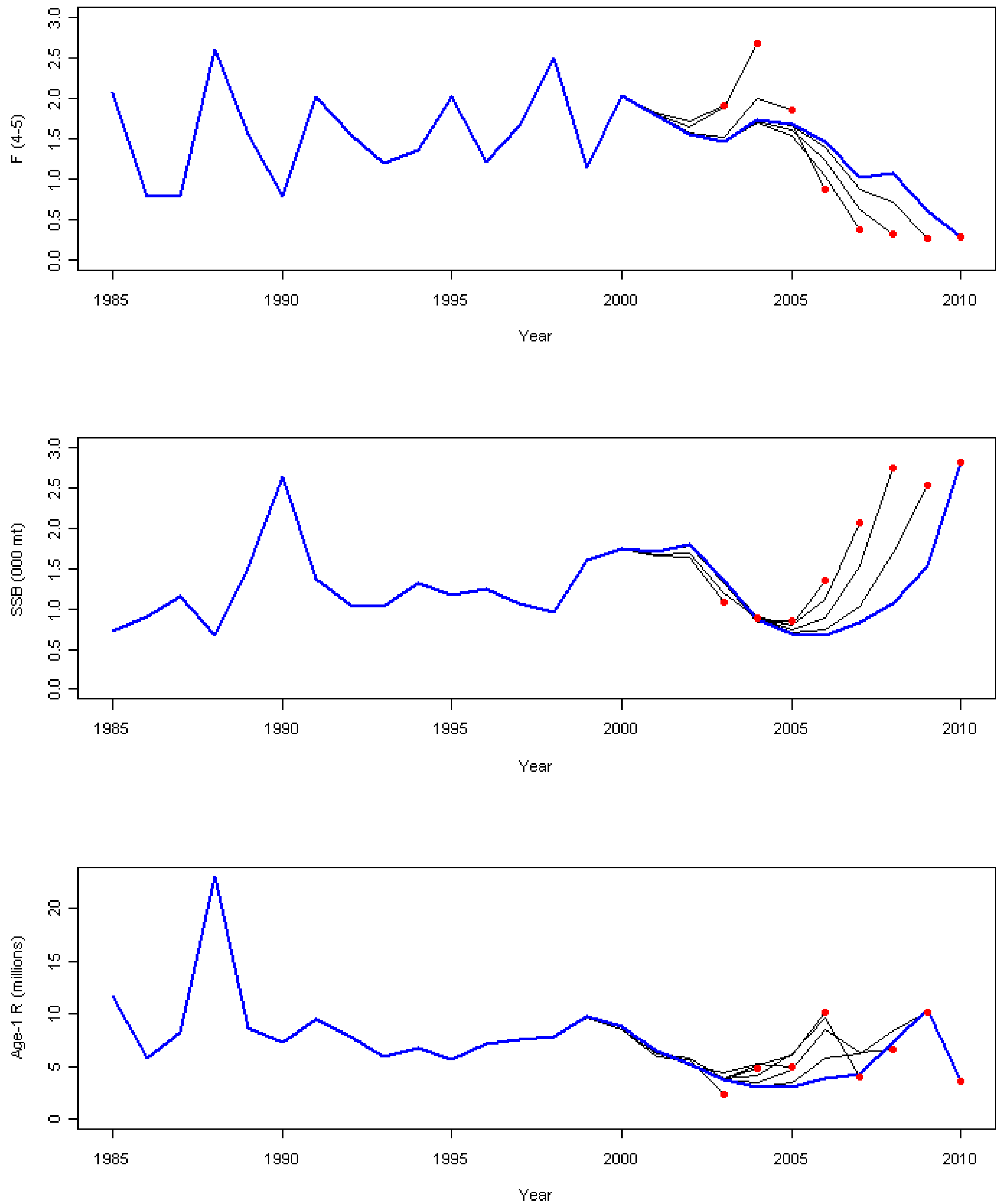

Figure D24. Retrospective plots for F, SSB, and recruitment.

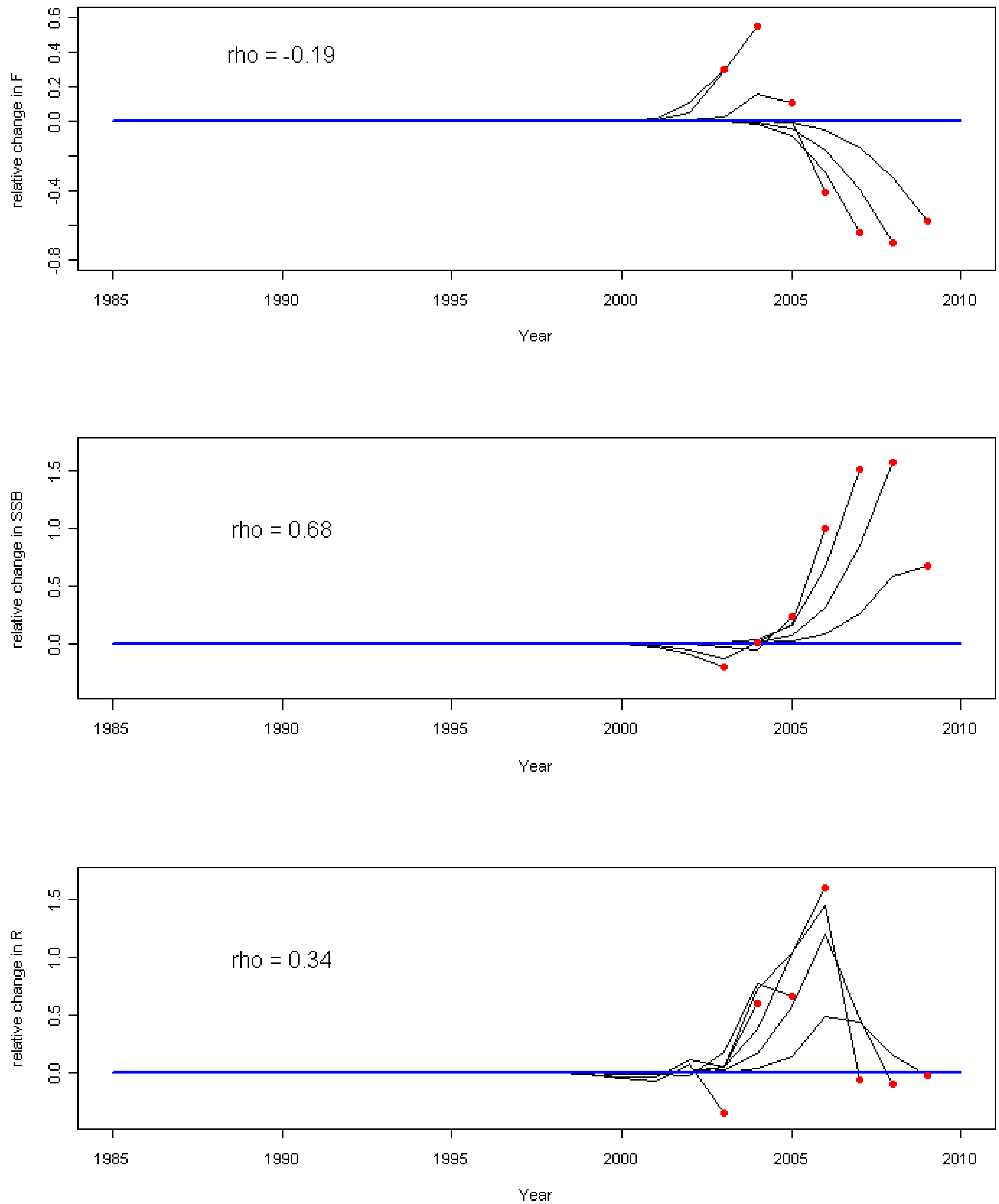

Figure D25. Relative retrospective plots for F, SSB, and recruitment.

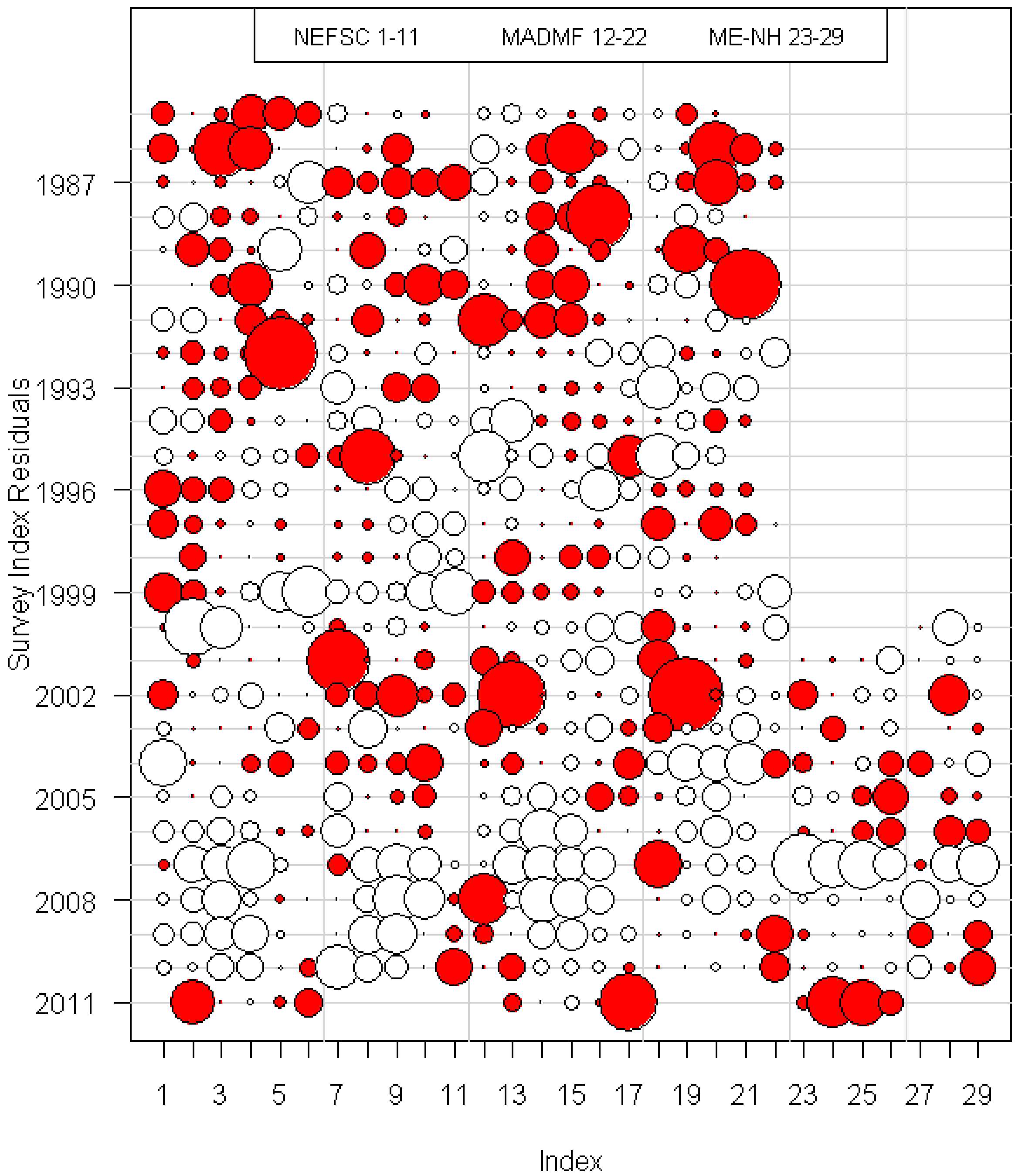

Figure D26. Residuals for indices of abundance in VPA grouped by survey: columns 1-6 are NEFSC spring ages 1-6+, columns 7-11 are NEFSC fall ages 1-5, columns 12-17 are MADMF spring ages 1-6+, columns 18-22 are MADMF fall ages 1-5, columns 23-26 are ME-NH spring ages 2-5, and columns 27-29 are ME-NH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

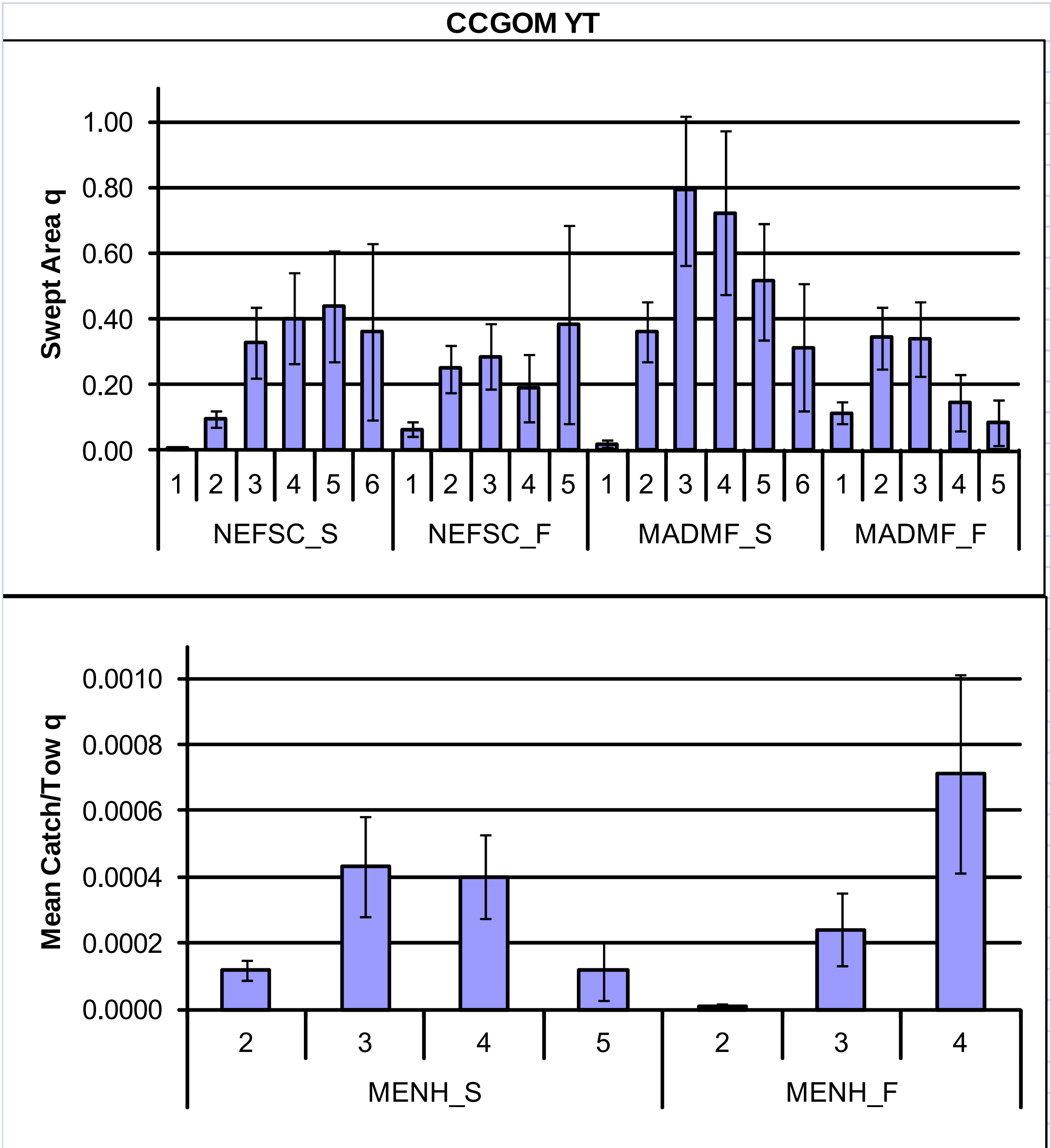

Figure D27. Catchability estimates with plus and minus two standard deviations for swept area indices (top panel) and mean catch per tow (bottom panel).

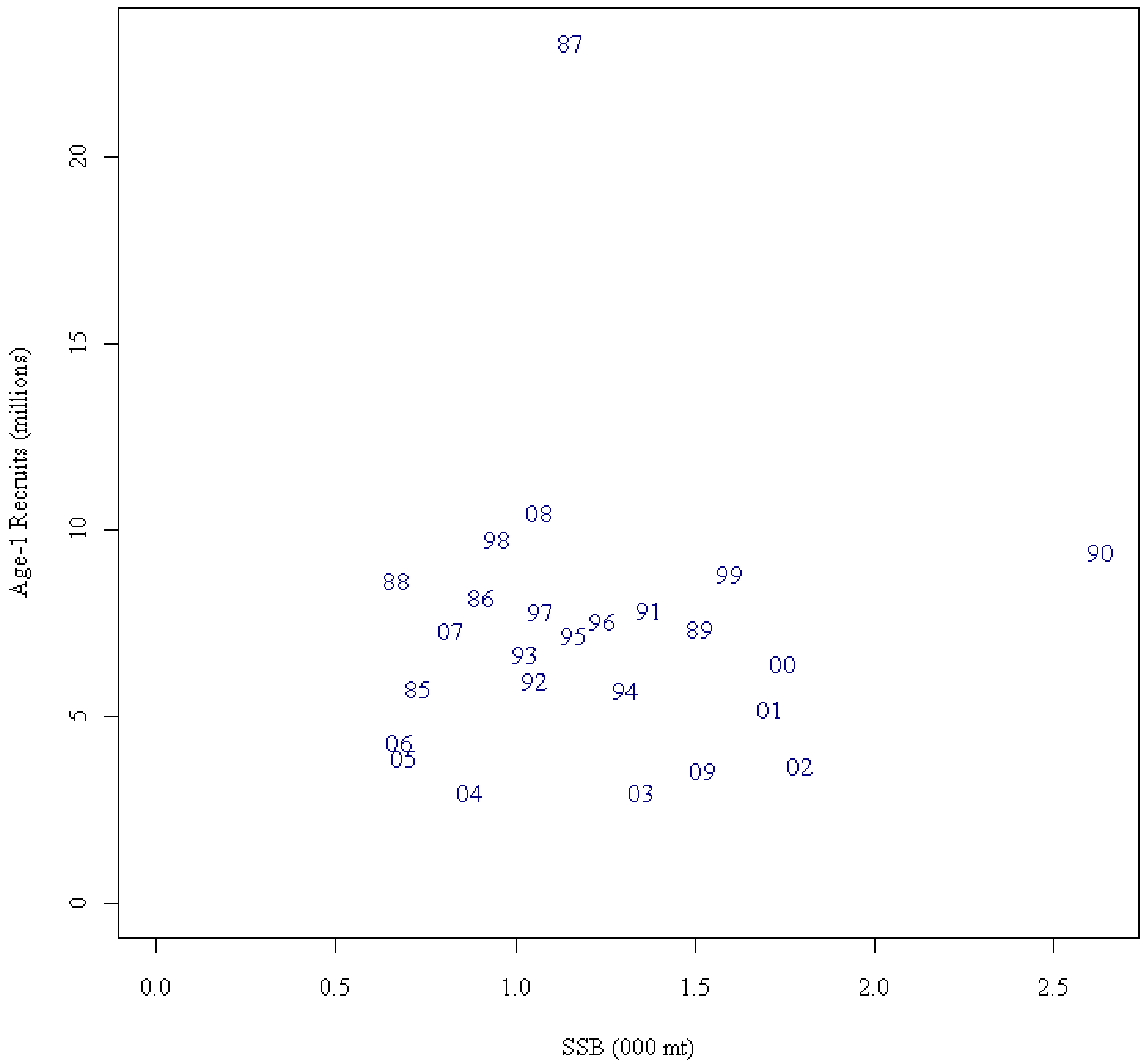

Figure D28. Stock recruitment relationship, plotted values denote the last two digits of the year associated with spawning stock biomass.

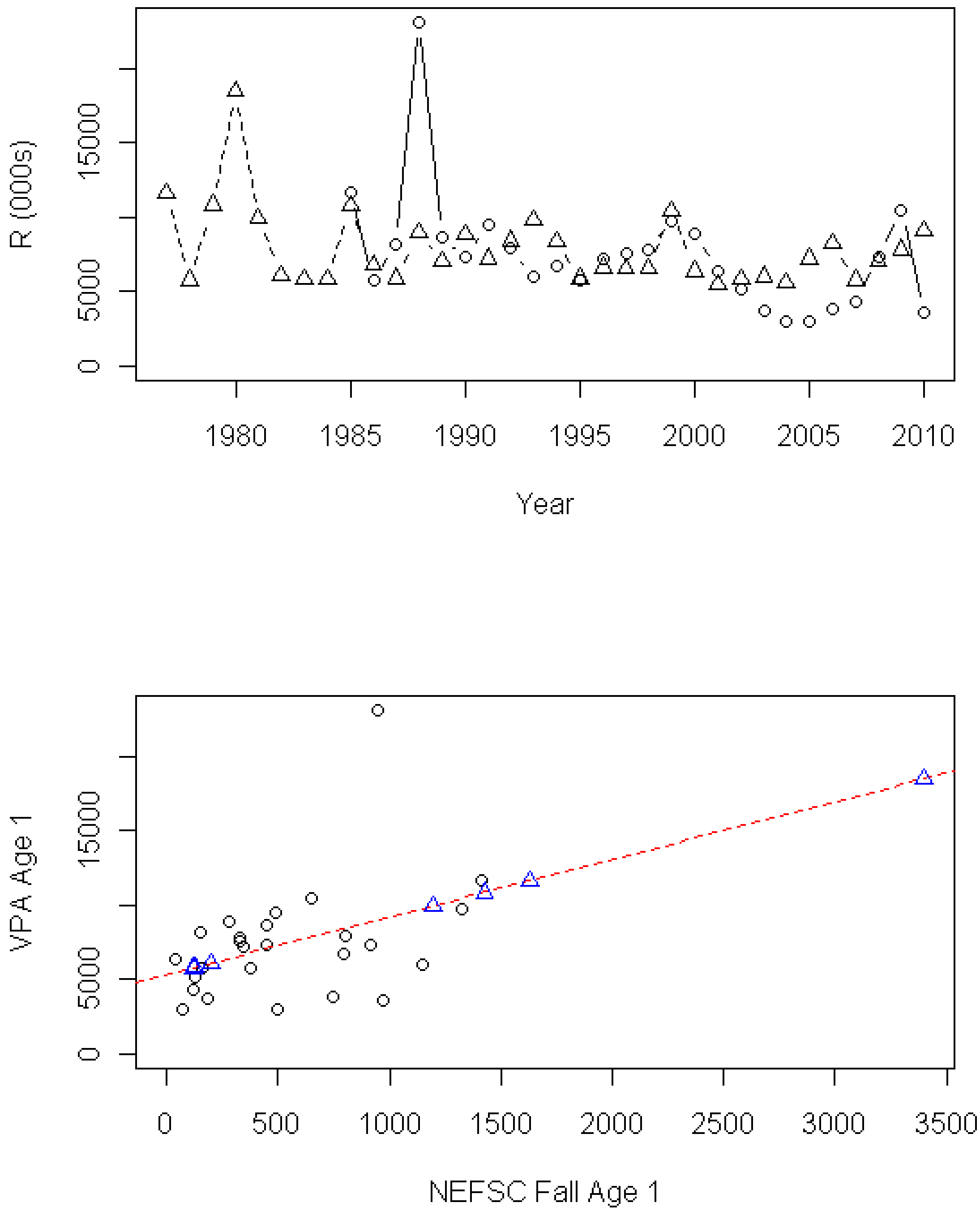

Figure D29. Hindcast estimates of recruitment using the NEFSC Fall survey at age 1.

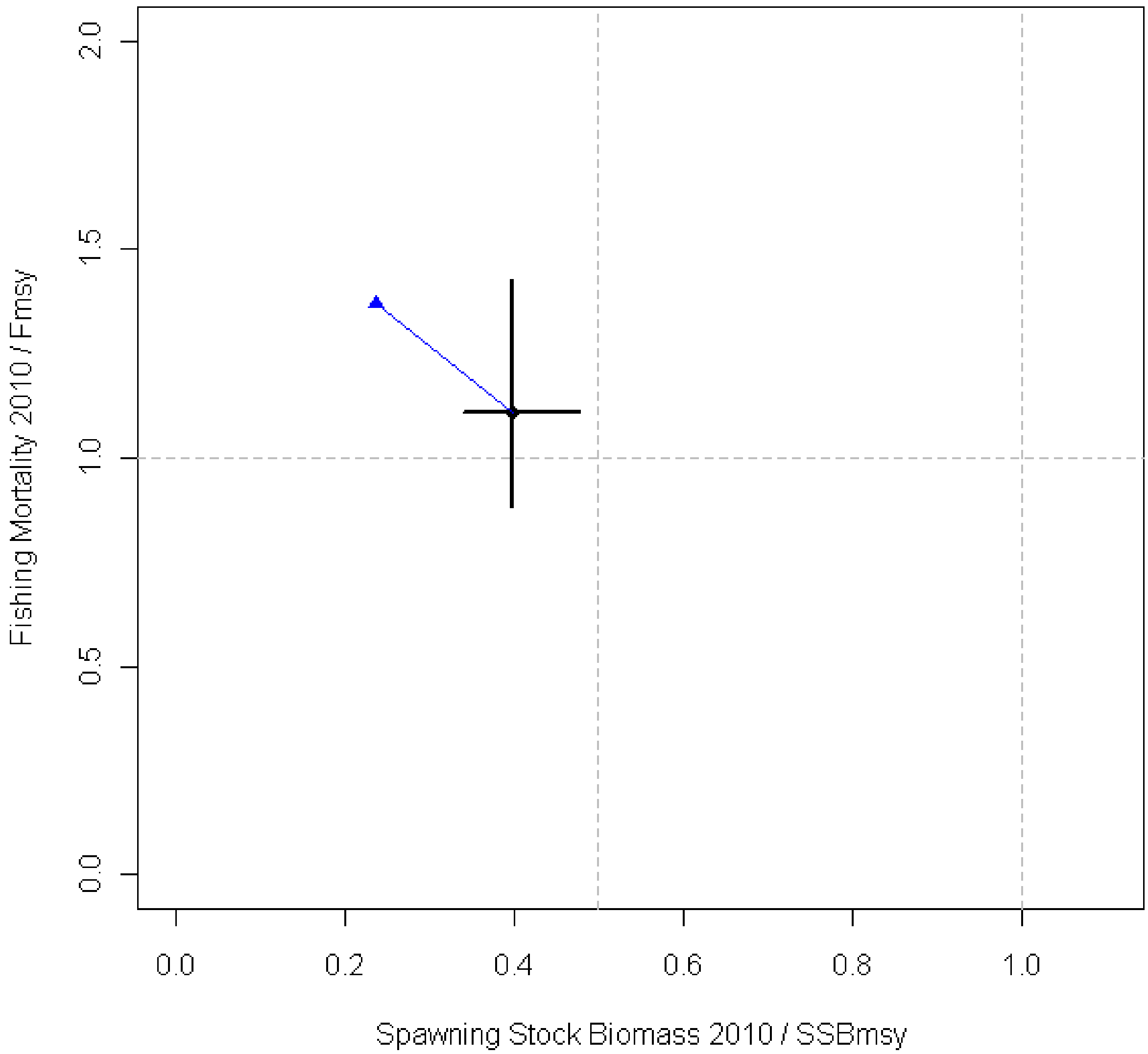

Figure D30. Current status of Cape Cod-Gulf of Maine yellowtail flounder. The black lines denote the 80% confidence interval for the 2010 F and SSB ratios. The blue triangle denotes the change in the ratios when F and SSB are adjusted to account for the retrospective pattern. The Review Panel recommended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

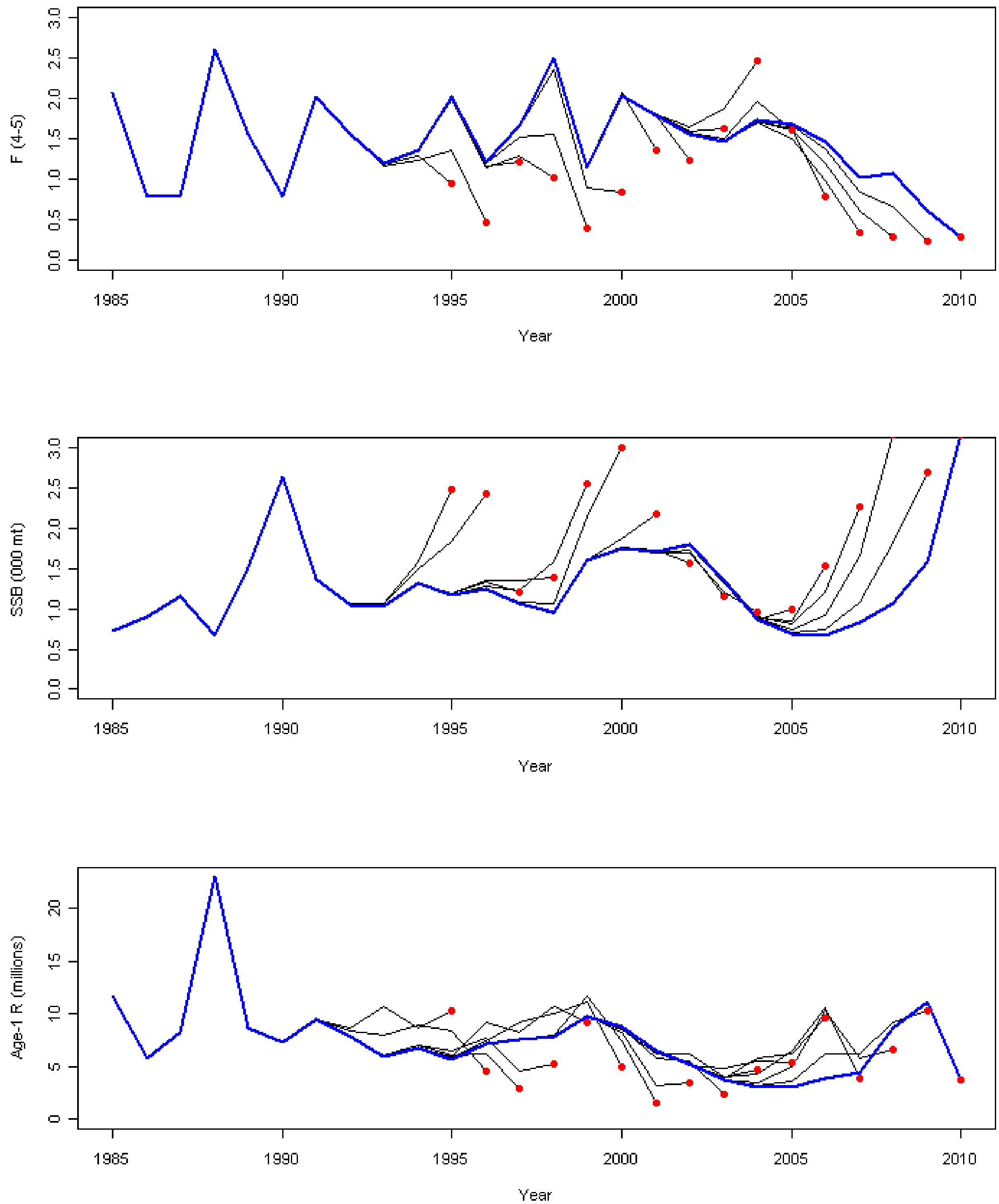

Figure AppendD1. Retrospective plots for F, SSB, and recruitment for the extended retrospective analysis.

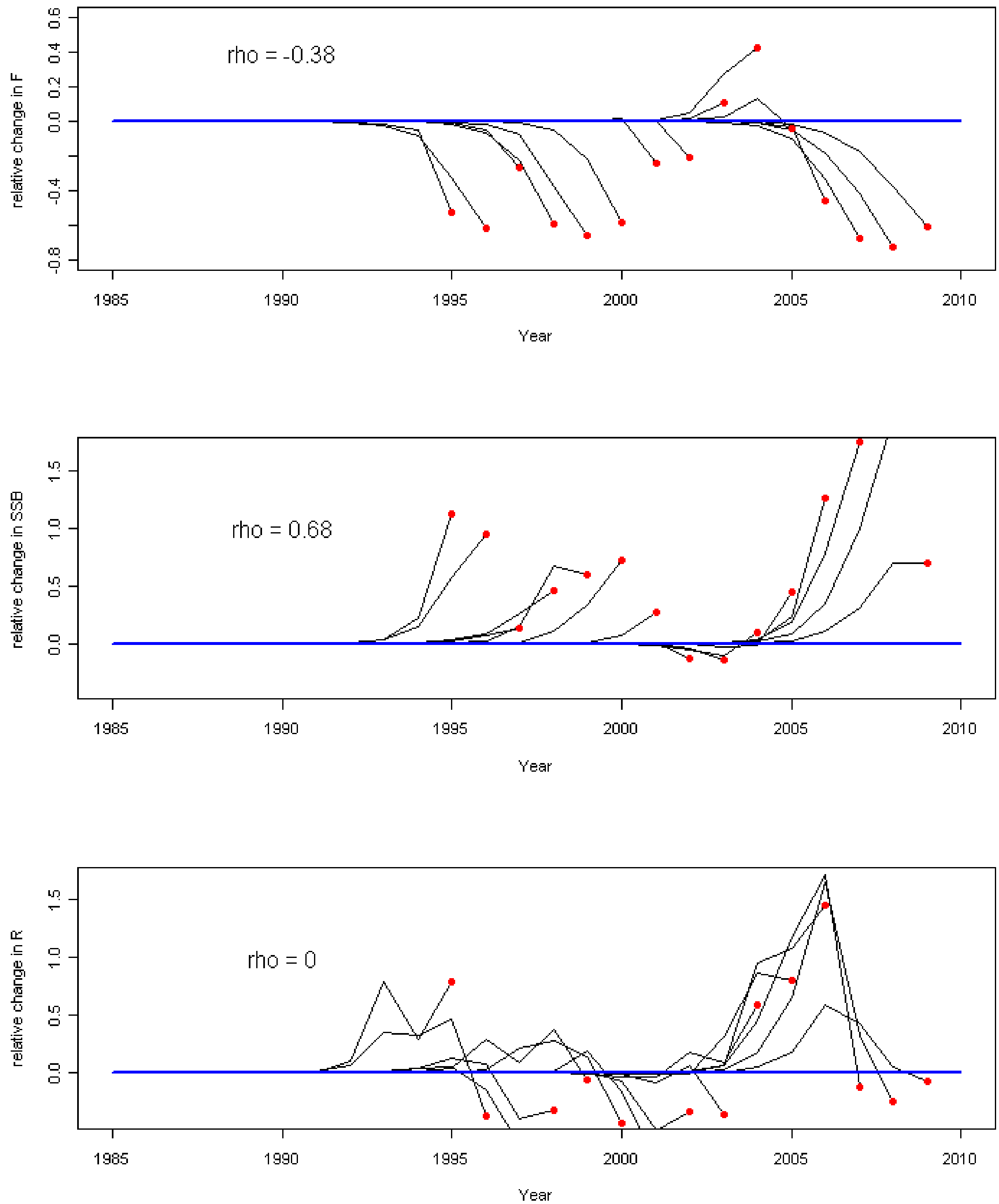

Figure AppendD2. Relative retrospective plots for F, SSB, and recruitment for the extended retrospective analysis.

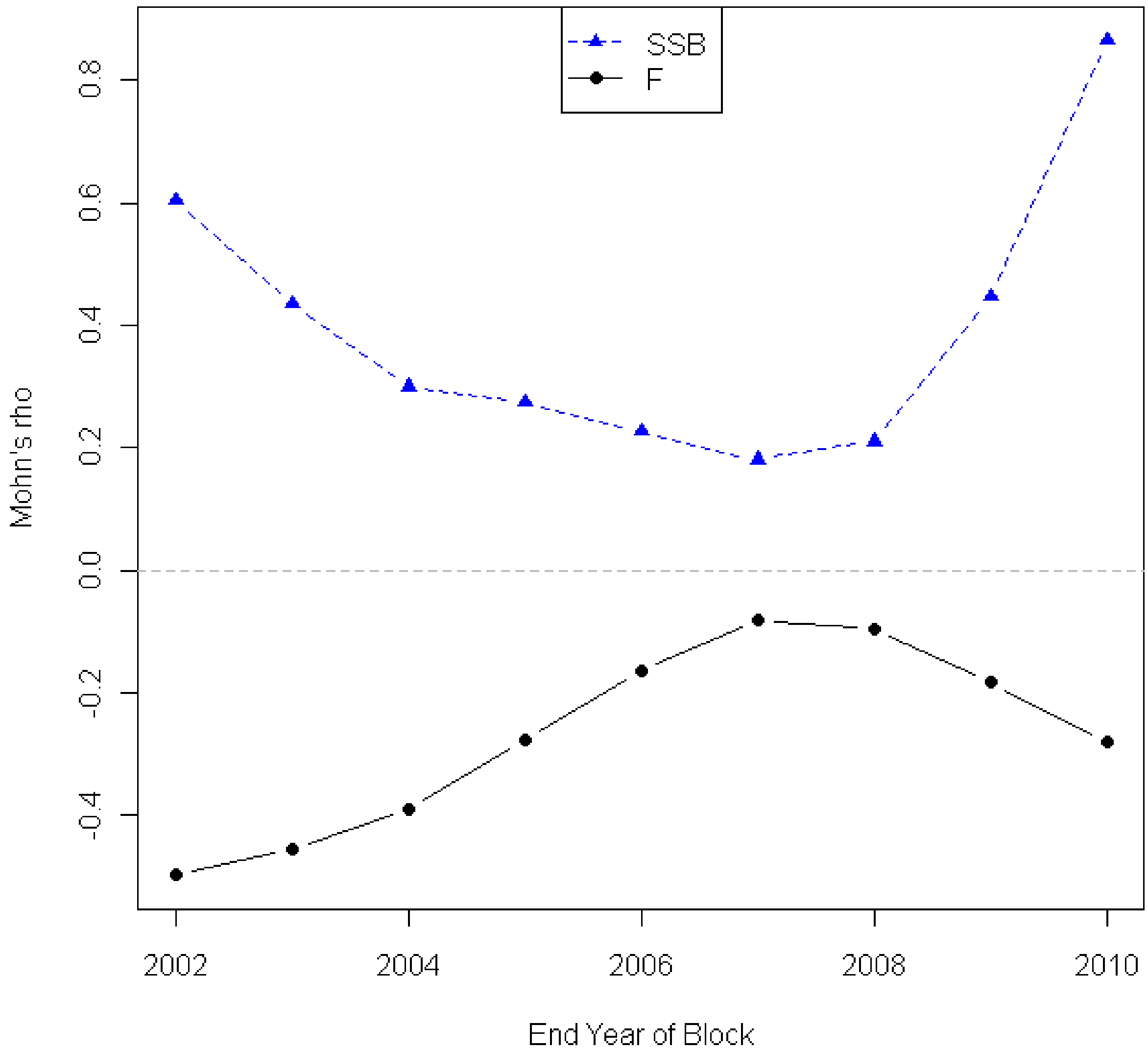

Figure AppendD3. Mohn's rho retrospective statistic for blocks of seven year peels from the extended retrospective analysis.

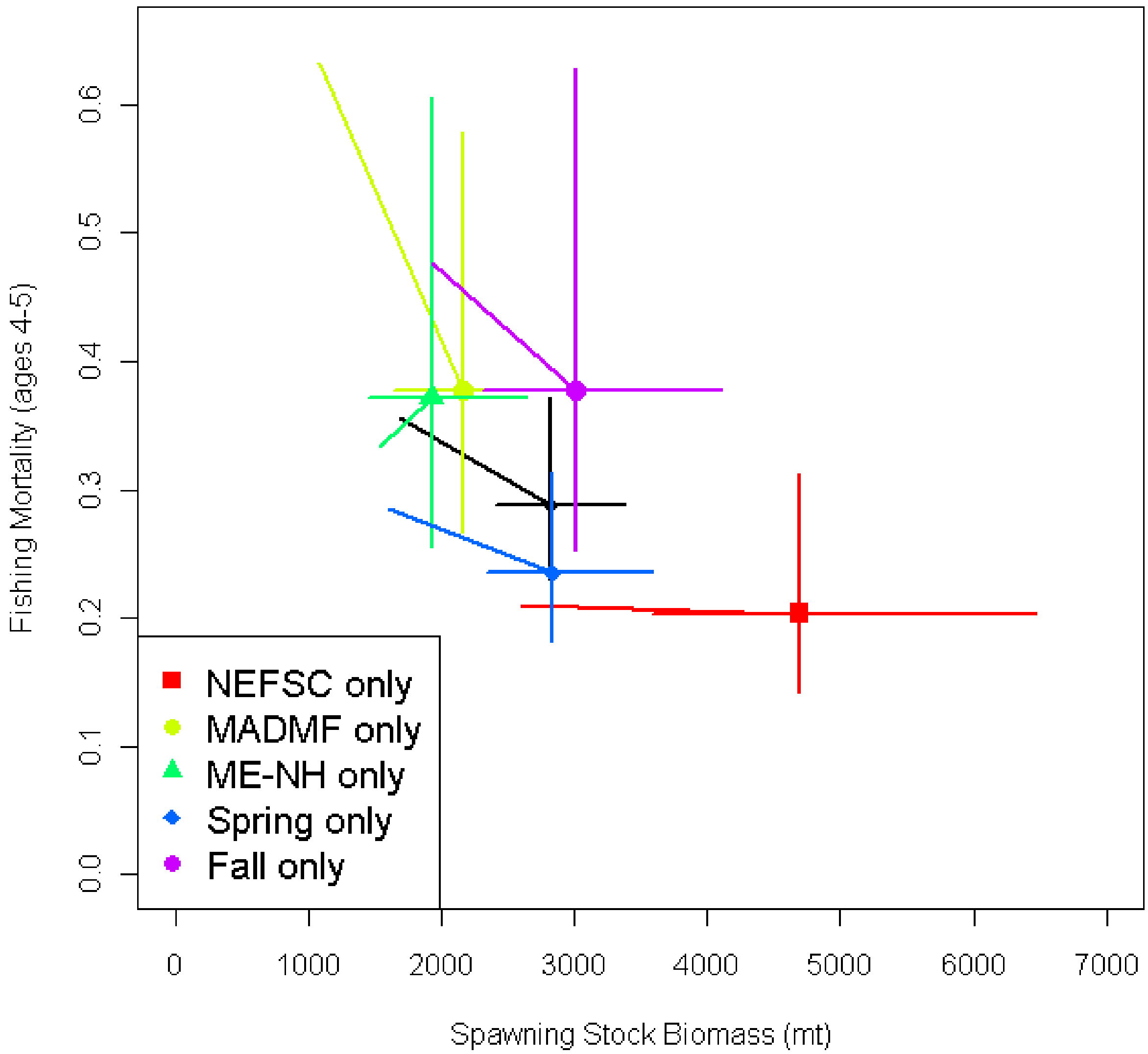

Figure AppendD4. The base case estimates of 2010 F and SSB with 80% confidence intervals and rho adjusted values (black lines) compared with the same plots for the five sensitivity analyses using subsets of the surveys as tuning indices.

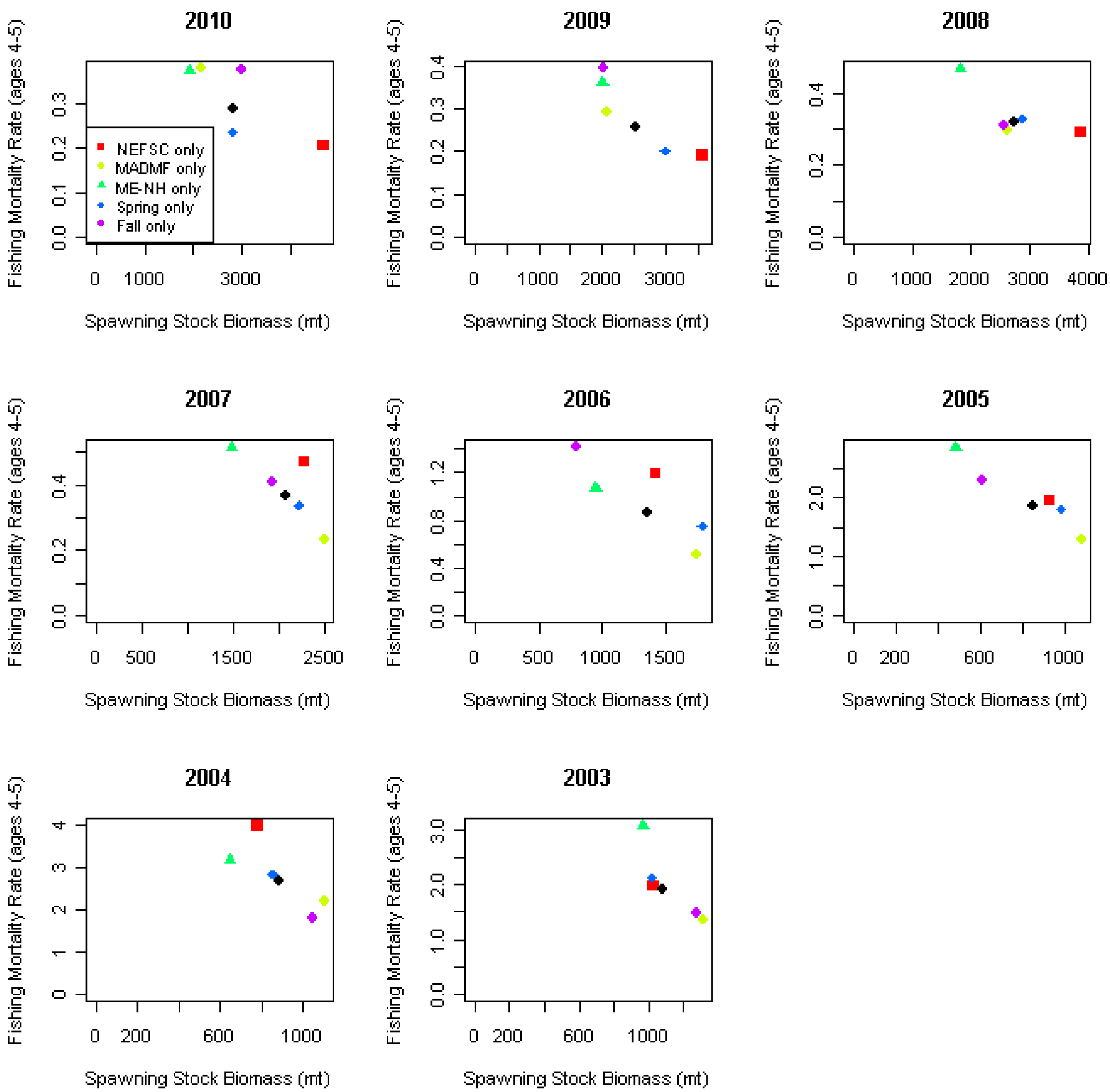

Figure AppendD5. Base terminal year F and SSB values (black) compared to the five sensitivity analyses using subsets of the surveys as tuning indices for the seven year retrospective analysis.

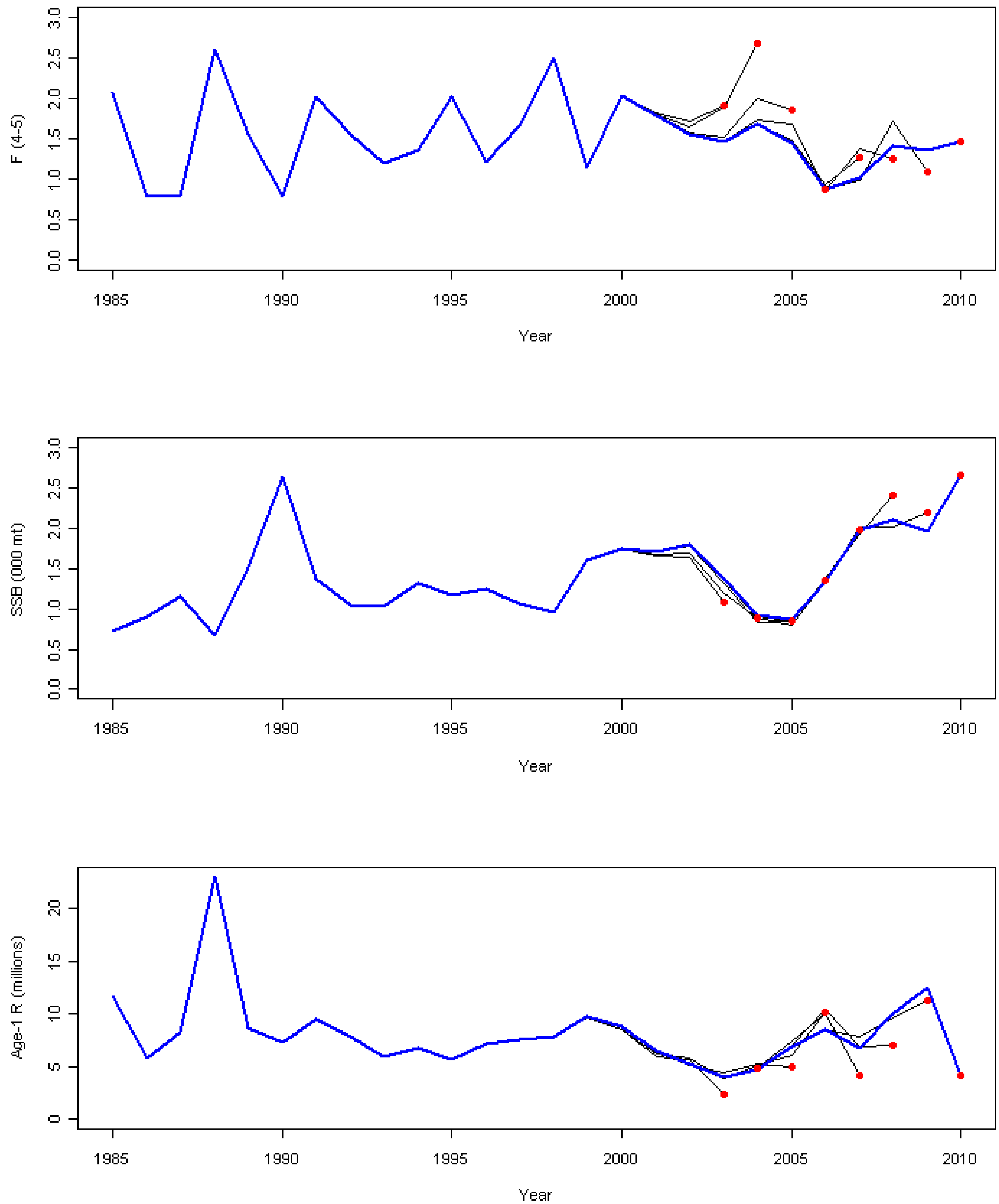

Figure AppendD6. Retrospective plots for F, SSB, and recruitment for the catch multiplier analysis.

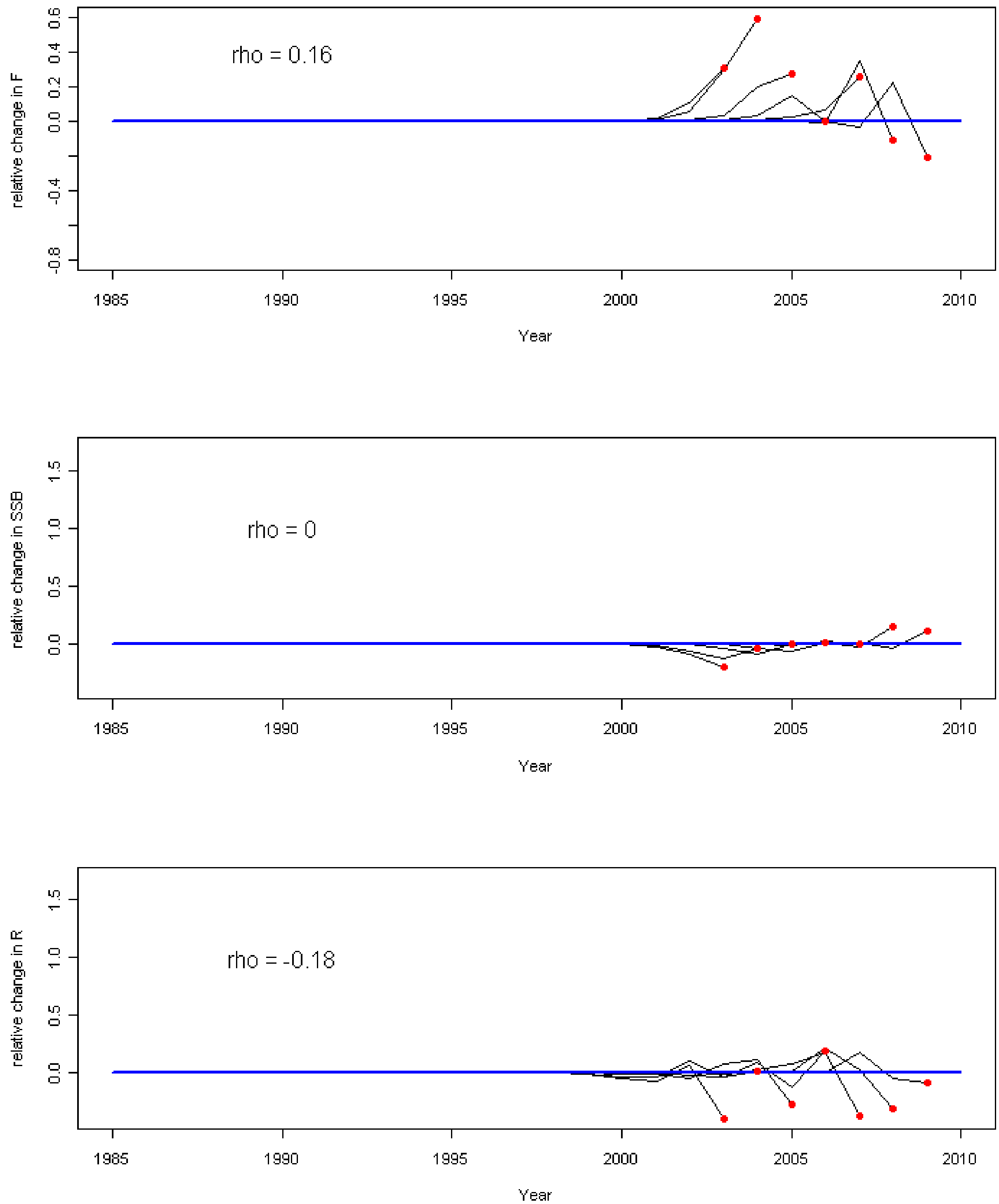

Figure AppendD7. Relative retrospective plots for F, SSB, and recruitment for the catch multiplier analysis.

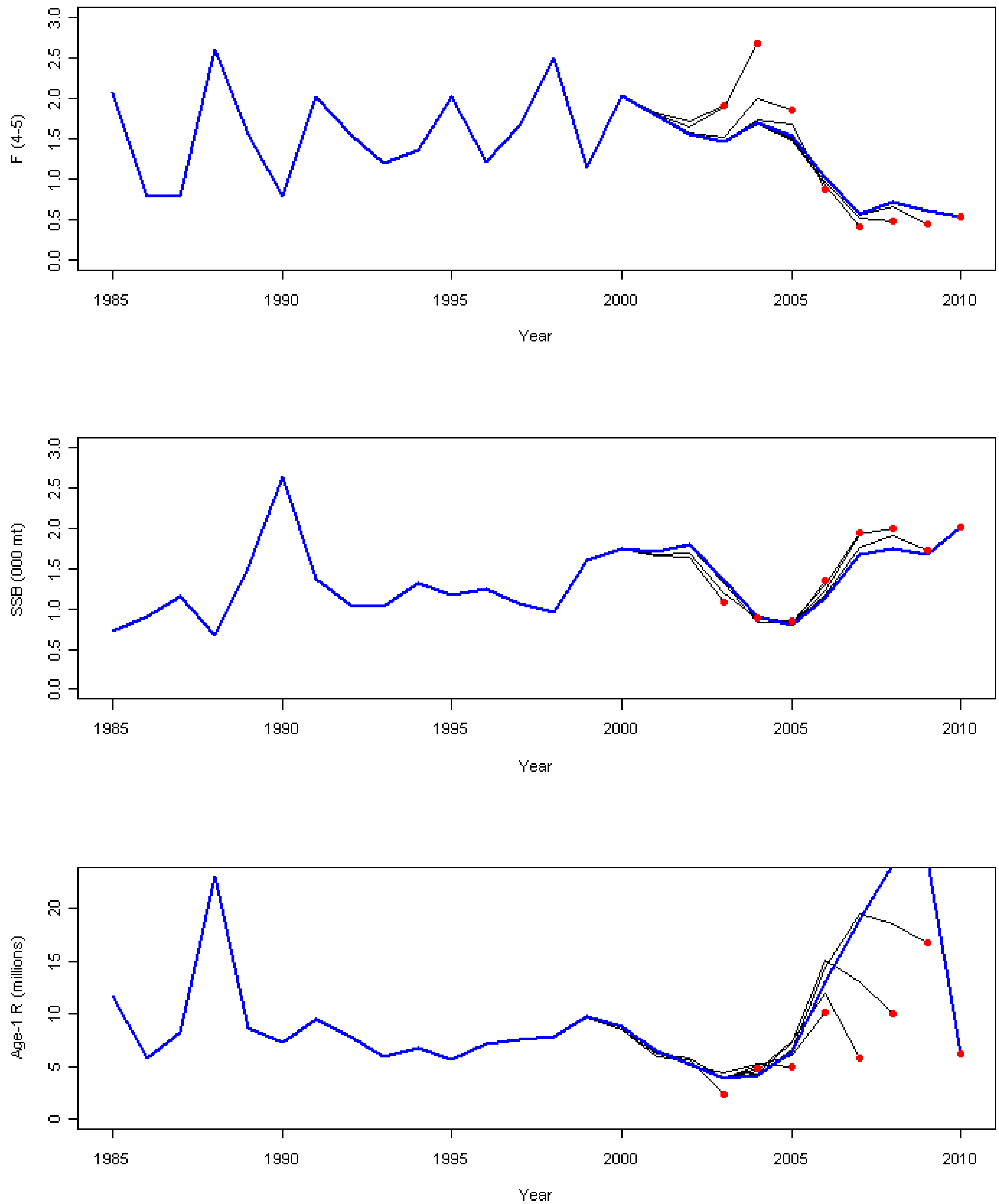

Figure AppendD8. Retrospective plots for F, SSB, and recruitment for the increase natural mortality analysis.

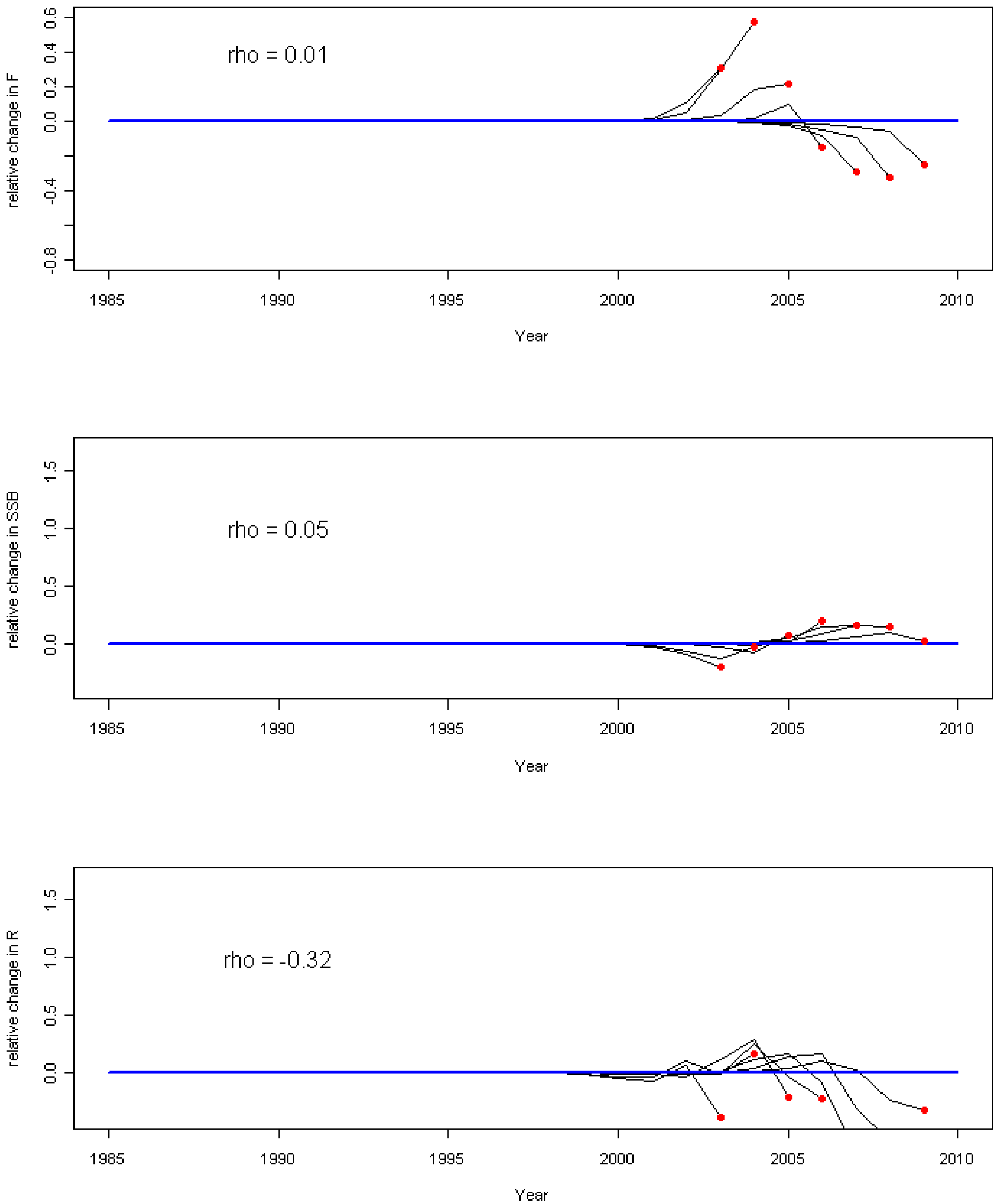

Figure AppendD9. Relative retrospective plots for F, SSB, and recruitment for the increase natural mortality analysis.

E. Gulf of Maine – Georges Bank American plaice Assessment for 2012
by Loretta O'Brien and Josh Dayton

1.0 Background

American plaice is distributed along the Northwest Atlantic continental shelf from southern Labrador to Rhode Island in relatively deep waters (Collette and Klein-MacPhee 2002). Off the U.S. coast, American plaice are managed as a single stock in the Gulf of Maine-Georges Bank region (Figure E1) where the greatest commercial concentrations exist between 90 and 182 m (50 and 100 fathoms).

This stock was last assessed and peer reviewed in August 2008 at the GARM-II meeting (O'Brien *et al.* 2008). The assessment was conducted using VPA with total catch including commercial landings, large mesh discards, and shrimp trawl discards for ages 1-11+. For terminal year 2007, total commercial landings were 988 mt and fully recruited F (ages 5-8, unweighted average) was estimated to be 0.06. Spawning stock biomass was 15,659 mt in 2007. The 2003, 2004, 2005, and 2007 year classes were all estimated to be above the long term average (28.8 million age 1 fish). The spring and autumn research survey indices of abundance did not indicate strong trends since 2000. Recruitment indices of age 1 fish from NEFSC autumn surveys indicated that both the 1997, 1998, 2005 and 2006 year classes were above average. The 1997, 2001, 2003, and 2004 year classes were above average in the autumn Massachusetts state survey.

In 2008, biological reference points (BRPs) were developed by the GARM III BRP Review Panel (O'Boyle 2008) for Gulf of Maine - Georges Bank American plaice using a non-parametric yield-pre-recruit (YPR) analysis to determine Fmsy=F40%. Stochastic projections using an empirical cumulative distribution function of recruitment at age 1 provided the following BRPs:

F_{MSY} = 0.19,
MSY = 4,011 mt and
SSB_{MSY} = 21,940 mt.

2.0 Fishery

Total commercial landings of Gulf of Maine-Georges Bank (GM-GB) American plaice were 1,401 mt in 2010, a 2% increase from 2009 and a 27% increase from revised 2007 landings (Table E1-E2, Fig. E2). USA fisheries have accounted for about 95-100% of the landings since the mid-1970s and Canadian fisheries account for the remainder. The otter trawl fleet accounts for more than 95% of the landings in recent years (Table E3) and the fishery is prosecuted primarily during the 2nd and 3rd calendar quarter of the year. Since the mid-1990s the largest proportion of the landings are in the small market category (Table E4). Sampling intensity (metric tons landed per sample) has increased since the late 1990s (Table E5). During 2000-2010, sampling intensity ranged between 5 mt -92 mt per sample for the three market categories : small, medium and large.

The age composition for 1980-1984 landings was estimated using the NEFSC bottom trawl survey age-length relationship (O'Brien et al. 1992). Age data is now available for 1982-1984 and will be incorporated into the next benchmark assessment. Landings at age were estimated separately for the Gulf of Maine and Georges Bank and then combined for the years 1985-1993 and 2003-2010, however, for 1994-2002, landings at age were estimated by pooling Gulf of Maine and Georges Bank samples. Samples were generally applied on a quarterly basis but were pooled by half year or annually if sampling was not adequate (Table E5).

Discards were estimated from 1980-1988 for large mesh otter trawl and northern shrimp fisheries using a survey method described in O'Brien and Esteves (2001) and WP4.5 from the GARM 2008 BRP meeting. The survey method applies the survey abundance indices at length, filtered by a mesh selectivity ogive and a culling ogive, and a measure of effort to derive discard length frequencies. Survey age-length keys were then applied to estimate the discards at age. Discards of American plaice were estimated for large and small mesh otter trawl, and gill net fisheries in each area, and in the GM northern shrimp fishery and the GB scallop fishery from 1989-2010 using the Standardized Bycatch Reporting Methodology recommended in the GARM III Data meeting (GARM 2007, Wigley et al. 2007). The small mesh, gillnet and scallop discards had not been included in the previous assessment (O'Brien et al. 2008). The NEFSC Observer Data Base was used to estimate discard to kept ratios (d:k) of discarded American plaice to total kept of all species, on a trip basis. Total biomass of American plaice discards were then estimated by applying the d:k to total commercial landings (Table E6). Observer length frequencies, and both research survey and commercial age-length keys were applied to estimate discards at age for the large mesh fishery. The biomass estimates from the small mesh otter trawl, gillnet and scallop fishery were included as part of the large mesh discard at age analysis as sufficient data samples are not available for these other fisheries.

Discarding of small fish historically occurred in the northern shrimp fishery during the 1st and 4th calendar quarter, however, in recent years the discards are minimal. Discards in the large mesh fishery occur year-round. Total discards ranged between 2% -40% of the catch during 1978-2010 and accounted for about 20% of the total catch during 2005-2010.

Total catch, including landings and discards are presented in Table E7. Commercial landings, shrimp, and large mesh fishery discards (including small mesh otter trawl, gillnet, and scallop), and total catch, at age, for abundance, biomass, mean weight, and mean length are presented in Tables E8a-E8d. Total catch at age is dominated by ages 4-7, with a recent increase in age 2 (Fig. E3).

3.0 Research Bottom Trawl Surveys

Biomass and abundance indices

The NEFSC survey indices of abundance and biomass (offshore strata 13-30,36-40) peaked around 1980, declined until the late 1980s, and have since fluctuated with no strong trend (Table E9, Figs. E4-E5). The Massachusetts Division of Marine Fisheries (MADMF) spring and autumn surveys (strata 25-36) indicate a peak in abundance in the late 1980s, with a generally declining trend until about 2000, then generally increasing, however, since 2006 the autumn indices show a decline, with an increase in 2011 (Fig. E6).

Catch at age for NEFSC and MADMF spring and autumn surveys is presented in Tables E10a-E10c and Figs. E7-E10. NEFSC autumn age 1 recruitment indices indicate that the 1997, 1998, 2005, 2006, and 2007 year classes are the most recent above average year classes (Table E10b,Fig. E11a). The autumn MADMF age 1 recruitment indices indicate the most recent above average year classes are the 1997, 2001, 2003, and 2004 (Table E13, Fig. E11b).

Maturity ogives

Logistic regression analysis was used to estimate female maturity ogives from NEFSC spring research survey data for 1980 - 2011. The number of samples taken each year, by sex, over the time series is not consistently high and does not allow for reliable annual estimates, so the data were smoothed by using a 5-year moving average. For example, the 1990 ogive was estimated by combining data from 1988-1992, and then the 1991 ogive was estimated by combining data from 1989-1993 and so forth, for the time series. This means that the first year, 1980, only as three years of data (1980, 1981, and 1982) and the last year, 2010, has only 4 years of data (2008, 2009, 2010, and 2011). Confidence limits for proportion mature at age were estimated at the 95% level using the approximate variance for large samples (Ashton 1972, O'Brien et al. 1993) and inverse 95% confidence limits for A_{50} (median age at maturity) were estimated within the SAS PROBIT procedure (SAS) (Fig. E12).

4.0 Assessment

VPA

Input data and Analyses

The ADAPT calibration method (Parrack, 1986, Gavaris 1988, Conser and Powers 1990) was used to derive estimates of instantaneous fishing mortality (F) in 2010 and beginning year stock sizes in 2010. The catch at age used in the VPA includes commercial landings and discards from 1980-2010 for ages 1 to 11+. Research survey indices used for calibration include spring NEFSC abundance indices for ages 1-8, 9+, spring MADMF abundance indices for ages 1-5, autumn NEFSC abundance indices for ages 0-7, 8+, and autumn MADMF abundance indices for ages 1-5. The autumn indices were lagged forward an age and a year to match cohorts in the spring surveys. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of F and spawning stock biomass (SSB). A retrospective analysis was performed for terminal year F, SSB, and age 1 recruitment.

Bridge VPA runs

Several VPAs were conducted to bridge from the 2008 accepted model, to the current 2012 VPA with terminal year 2010. The 2008 VPA (run A) with terminal year 2007 used VPA/ADAPT version 2.8.0. VPA model formulation A was run in VPA/ADAPT version 3.1.1, (run B) and the results were exactly the same (Table E11). An additional run (C) was conduct to include a correction in the maturity analysis (extra strata excluded), revised landing estimates in the dealer data (Table E2), and the re-calculation of discards from 1989-2010 that now includes small mesh otter trawl, gill net, and scallop fishery discards. The difference between run B and C is minimal, with no change in F2007 and a minor decline in SSB. Model formulation and catch at age from run C was the basis for updating the assessment to terminal year 2010. The 2012 assessment run is presented as run D (Table E11).

2012 Assessment results

The ADAPT calibration results for estimates of terminal year stock size and catchability (q) estimates, with corresponding standard error and coefficients of variation (CVs) are presented in Table E11. Stock size estimates are more precise for ages 4-10, (CVs ranging from 16%-19%) than for ages 1-3 (CVs between 23%-48%). Catchability estimates at age for the NEFSC surveys were more precise for ages 2-7 (7%-13%), than for age 1, age 8+ and age 9+ (14%-21%). The MADMF autumn survey q estimates at age were more precise for ages 1 and 2 (11%,17%) then the spring survey estimates for ages 1-2 (14%,22%), however, for the older ages the reverse is true; autumn survey q is less precise for ages 3-5 (10%-19%) than the spring q estimates of ages (7%-10%, Table E11). There appears to be a dome in the survey q's where the youngest and oldest fish have relatively low catchability (Fig. E13a).

The residuals (observed – predicted) indicated a pattern of negative residuals in the early years of the time series and positive residuals in the latter part of the time series for most ages in NEFSC spring and fall surveys (Fig. E13b). The MADMR autumn survey shows strong negative residuals in recent years. Average fully recruited F (ages 6-9) in 2010 was estimated as 0.09 (Table E12, Fig. E14). The 2010 estimate of SSB was 17642 mt, a 44% increase from 2007, and the highest SSB since 1984 (Table E12, Fig. E15). Since 1980, recruitment has ranged from 8 million to 50 million age 1 fish with a time series average of 27 million age 1 fish. The 2003 (33.4 million fish), 2004 (36.7 million), and 2005 (38.9 million) year classes are all above average, and are the first to appear since the 1994 (28.0 million fish) year class (Table E12, Fig. E15).

Precision estimates of F and SSB

A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the uncertainty associated with the estimate of F and SSB from the final VPA. One thousand bootstrap iterations were performed to estimate standard errors, CVs, and bias for age 1-10 stock size estimates at the start of 2010 and age 1-11+ F estimates in 2010. The bootstrap results indicate that stock sizes were well estimated for ages 4-10 with CVs varying between 15%-20%, however, age 1(CV=99%) and age 2 (CV=38%) were not as well estimated. The fully recruited F for ages 6-9 was well estimated with CVs ranging between 15% and 19%. There is an 80% probability that the average F in 2010 is between 0.0780 and 0.0975 (Fig. E16). The bootstrap results indicate that SSB was well estimated (CV=0.07) and slightly lower than the bootstrap mean. There is an 80% probability that SSB in 2010 is between 16,064 mt and 19,326 mt (Fig. E16).

Back-calculated partial recruitment

Back-calculated partial recruitment (PR) at age from VPA was averaged over 3 time periods corresponding to changes in management: 1980-1993, 1994-2001, and 2002-2010. Within a time period, the PR was scaled to the highest averaged PR value at age. All three PRs vectors appear to be flat topped. The shift from fully recruited F on age 5 during 1980-1993 to age 6 during 2002-2010 is apparent (Fig. E17).

Retrospective analysis

A retrospective analysis was performed to evaluate how well the current ADAPT calibration would have estimated F, SSB, and recruits at age 1 for seven years prior to the terminal year, 2010. Mohn's rho, calculated as the average of the 'tips' or terminal year values of each retrospective run, was calculated within each analysis. There is a retrospective bias of estimating F values lower than the terminal year F (rho = -0.35, Fig. E18a) and a corresponding pattern of estimating higher values of SSB relative to the terminal year SSB (rho=0.62, Fig. E18b). The retrospective analysis in recruits at age 1 indicate that recruits are estimated at higher values relative to the terminal year (rho=1.24, Fig. E18c).

5.0 Biological Reference Points

Yield per Recruit Analysis

A yield per recruit (YPR) analysis was conducted to provide an estimate of $F_{40\%}$ using the methods of Thompson and Bell (1934). Input data (Table E13) for catch weights and stock weights (ages 1-11+) were estimated as an average of the most recent 5 years (2006-2010). The PR was based on a normalized geometric mean of the 2006-2010 Fs from the VPA and the maturity ogive was estimated annually as a 5 year moving average as described above, although there are only 4 years in the average for 2010 (2008-2011). The YPR and spawning stock biomass/recruit (SSB/R) plot is presented in Fig. E19.

Non-parametric estimates of MSY and SSB_{MSY} were estimated using the 30-year time series mean recruitment (27.868 million age 1 fish, excludes the 2009-2010 year classes), Y/R (0.124) and SSB/R (0.687) (Fig. E19) as:

$F_{40\%}$ = 0.18
MSY = 3,452 mt
SSBmsy = 19,133 mt.

These estimates are similar to the 2008 GARM III results: Fmsy=0.19, MSY = 4,059 mt, and SSBmsy = 22,243 mt (O'Brien et al. 2008).

Yield per Recruit Analysis - Stochastic MSY estimates

The GARM III BRP Panel selected the non-parametric YPR analysis as the basis for the estimation of BRPs for Gulf of Maine - Georges Bank American plaice. Stochastic projections using the same input data as the YPR were run out to 100 years with F_{MSY} = 0.18. Recruitment was estimated from an empirical cumulative distribution function (CDF) based on 30 estimates of age 1 recruitment from the 2012 VPA, i.e. the 2009 and 2010 year classes were not included. The projection provided the following non-parametric biomass reference points:

F40% = 0.18
MSY = 3,385 mt,
SSB_{MSY} = 18,398 mt.

These values are lower than those estimated in the 2008 assessment: MSY = 4,011 mt SSB_{MSY} = 21,940 mt (O'Brien et al. 2008).

6.0. Projections

Short term stochastic projections were performed to estimate landings and SSB during 2011-2014. The input values for mean catch and stock weights, PR, and maturity are the same as described above for the YPR analysis. The bootstrapped numbers at age were adjusted for retrospective bias using the 7-year average rho values. Catch in 2011 was assumed equal to catch in 2010. The projections were run under three F scenarios: F_{2010}, F_{MSY}=75%$F_{MSY,}$ and $F_{rebuild}$. Recruitment was projected from a CDF of 30 recruitments from the 2012 VPA. The rebuilding plan for American plaice requires that the stock reach SSB_{MSY} by 2014. The results (Table E14) indicate that under all three F scenarios both landings and SSB are projected to increase in 2014. The stock will not rebuild to 18,398 mt by 2014, even at F=0.0.

7.0 Summary

The Gulf of Maine – Georges Bank American plaice stock is not overfished and overfishing is not occurring (Fig. E20), as determined by the retrospective bias-adjusted model output. Commercial catch has declined since 2003. Fishing mortality in 2010 (0.09) rho-adjusted to 0.13 is among the lowest estimates in the time series. Biomass has been increasing since 2004 and the 2010 SSB (17,642 mt), rho-adjusted to 10,805 mt is 59% of SSB_{MSY}. Research survey indices indicate that the stock is below the long term average biomass in recent years, however, the 2004 and 2005 year classes are above average.

Sources of uncertainty include:

-Age composition of landings 1980-1984; estimated using NEFSC age keys
-Historical discards, prior to 1989.
-Discard estimation of small mesh fishery catch at age, given the lack of length frequency samples.
-Retrospective pattern of F,SSB and recruitment

Acknowledgements

The assessment is only possible due to the collection of data on the research surveys, commerical vessels, in the port, and from the fishermen and dealers, and to the auditing and analysis of data, including the aging. The attention to detail and accurate reporting and sampling is essential to the interpretation of the assessment and we thank everyone for their hard work and effort.

8.0 Panel Discussion / Comments

Stock: *Gulf of Maine – Georges Bank American plaice*

Conclusions:

Status of Stock

SSB in 2010 is estimated to be 10,805 mt, retrospective rho-adjusted.
F in 2010 is estimated to be 0.13, retrospective rho-adjusted.

Revised estimates of the biological reference points are:
SSBmsy proxy= 18,398 mt,
Fmsy proxy = 0.18 and
MSY proxy= 3,385 mt.

Based on these results, the American plaice stock is not overfished and overfishing is not occurring. The stock is not above the biomass target. The stock status remained unchanged since the 2008 assessment.

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

The BRPs are based on the following updates: updated recruitment, average selectivity and mean weights and an updated mean maturity ogive.

American Plaice. Summary of Assessment Information

American Plaice	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Landings (mt)	4451	3498	2487	1713	1343	1105	990	1100	1380	1404	4562	990	15156	1960-2010
Discards (mt)	484	296	320	356	299	286	247	258	390	393	660	247	1863	1989-2010
Catch (mt)	4935	3795	2806	2069	1641	1391	1237	1358	1771	1798	4847	1237	15156	1960-2010
Recruits (000's)	14785	27477	21577	33402	36719	38879	16890	21564	18368	7623	27215	7623	63586	1980-2010
F age 6-9	0.62	0.56	0.57	0.45	0.25	0.2	0.08	0.11	0.12	0.09	0.49	0.08	0.91	1980-2010
SSB (mt)	10036	8216	7028	6210	6875	9194	12271	15963	16919	17642	12735	6210	37995	1980-2010

Panel Comments

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

Survey estimates using constant conversion coefficients for the Bigelow and Albatross were used in the assessment. Length-based conversion coefficients require a fuller consideration than can be performed in an update assessment.

It was noted that the age specific catchabilities in the surveys appear to be dome shaped. The younger fish are inshore, as seen in the state surveys, and potentially more available to the surveys than the older, larger fish that are more offshore in deeper waters and less available to the surveys. Biological justification for the survey dome catchability relative to the catch selectivity requires further investigation.

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Table E1. Commercial landings (metric tons, live weight) of American plaice from Gulf of Maine, Georges Bank, Southern New England, and the Mid-Atlantic regions, 1960-2010 (NAFO Div. 5Y, 5Z and 6).

Year	Gulf of Maine			Georges Bank					Southern New England				Mid - Atlantic			Grand Total		
	USA	Can	Total	USA	Can	USSR	Other	Total	USA	USSR	Other	Total	USA	Other	Total	USA	Other	Total
1960	620	1	621	689				689	-	-	-	-	0	-	0	1309	1	1310
1961	692		692	830				830	-	-	-	-	0	-	0	1522	-	1522
1962	694		694	1233	44			1277	-	-	-	-	0	-	0	1927	44	1971
1963	693		693	1489	127	24		1640	-	-	-	-	0	-	0	2182	151	2333
1964	811		811	2800	177		11	2988	-	-	-	-	0	-	0	3611	188	3799
1965	967		967	2376	180	112		2668	-	-	-	-	0	-	0	3343	292	3635
1966	955	2.0	957	2388	242	279	1	2910	-	-	-	-	0	-	0	3343	524	3867
1967	1066	6.0	1,072	2166	203	1018	10	3397	-	-	-	-	4	-	4	3236	1,237	4473
1968	904	5.0	909	1695	173	193	5	2066	637	145		782	18	2	20	3254	523	3777
1969	1059	7.0	1,066	1738	71	63	17	1889	505	349		854	130	0	130	3432	507	3939
1970	895		895	1603	92	927	658	3280	88	18	40	146	8	0	8	2594	1,735	4329
1971	648	5.0	653	1511	38	228	296	2073	11	112	206	329	6	2	8	2176	887	3063
1972	569		569	1222	22	358		1602	3	71		74	0	-	0	1794	451	2245
1973	687		687	910	38	289		1237	5	158		163	0	-	0	1602	485	2087
1974	945	2.0	947	1039	27	16	2	1084	92	4		96	0	-	0	2076	51	2127
1975	1507		1,507	913	25	148		1086	3			3	0	-	0	2423	173	2596
1976	2550		2,550	948	24	3		975	10			10	1	-	1	3509	27	3536
1977	5647		5,647	1408	35	50		1493	6	78		84	7	-	7	7068	163	7231
1978	7287	30.0	7,317	2193	77			2270	15			15	8	-	8	9503	107	9610
1979	8835		8,835	2478	23			2501	13		7	20	4	-	4	11330	30	11360
1980	11139		11,139	2399	43		5	2447	10			10	1	-	1	13549	48	13597
1981	10327	1.0	10,328	2482	15		2	2499	26		2	28	46	-	46	12881	20	12901
1982	11147		11,147	3935	27		1	3963	35		2	37	9	-	9	15126	30	15156
1983	9142	7.0	9,149	3955	30			3985	40			40	4	-	4	13141	37	13178
1984	6833	2.0	6,835	3277	6			3283	17			17	7	-	7	10134	8	10142
1985	4766	1.0	4,767	2249	40			2289	12			12	2	-	2	7029	41	7070
1986	3319		3,319	1146	34			1180	4			4	3	-	3	4472	34	4506
1987	2766		2,766	1032	48			1080	2			2	1	-	1	3801	48	3849
1988	2271		2,271	1097	108			1205	13			13	1	-	1	3382	108	3490
1989	1646		1,646	703	68			771	1			1	3	-	3	2353	68	2421
1990	1802		1,802	639	52			691	2			2	2	-	2	2445	52	2497
1991	2936		2,936	1310	26			1336	15			15	0	-	0	4261	26	4287
1992	4564		4,564	1838	3			1841	10			10	4	-	4	6416	3	6419
1993	3866		3,866	1839				1839	11			11	4	-	4	5720	-	5720
1994	3553		3,553	1388	30			1418	29			29	7.9	-	7.93	4977	30	5007
1995	3132		3,132	1443	2			1445	34			34	8.1	-	8.13	4617	2	4619
1996	3018		3,018	1310	2			1312	31			31	3.7	-	3.67	4363	2	4365
1997	2306		2,306	1546	65			1611	37			37	0.7	-	0.72	3890	65	3955
1998	2290		2,290	1317	20			1337	20			20	3.9	-	3.9	3631	20	3651
1999	1631		1,631	1449	123			1572	23			23	4.6	-	4.57	3108	123	3231
2000	2594		2,594	1572	143			1715	22			22	8.7	-	8.66	4196	143	4339
2001	2736	0.38	2,736	1618	50			1668	44			44	2.4	-	2.39	4400	50	4451
2002	2005	0.52	2,006	1374	98.7			1472	15			15	5.1	-	5.12	3399	99	3498
2003	1520	0.12	1,520	874	**60.2**			934	29			29	3.1	-	3.11	2426	60	2487
2004	1045	0.1	1,046	633	2.87			636	28			28	3.9	-	3.86	1710	3.0	1713
2005	752.4	0.28	753	569	4.95			574	13			13	2.4	-	2.38	1337	5.2	1343
2006	583.1	0.02	583	494	10.7			504	17			17	0.8	-	0.79	1094	10.7	1105
2007	601.1	0.06	601	375	2.03			377	6			6	5.9	-	5.94	988	2.1	990
2008	702.8	0.23	703	388	0.09			388	4			4	5	-	4.97	1100	0.3	1100
2009	865.8	0.02	866	501	0.17			501	6			6	7.1	-	7.15	1380	0.2	1380
2010	901.5	0.16	902	492	0.29			492	8			8	2.4	-	2.4	1404	0.5	1404

Table E2. Difference in 2008 assessment landings and revised landings retrieved in 2012 from the Commercial Fisheries Data Base (CFDBS).

	2008 Landings					Revised landings					Difference: Revised - 2008 mt				
Year	**GOM**	**GB**	**SNE**	**MAB**	**Total**	**GOM**	**GB**	**SNE**	**MAB**	**Total**	**GOM**	**GB**	**SNE**	**MAB**	**Total**
1994	3545.0	1387.0	29.0	8.0	4969.0	3552.6	1387.6	28.8	7.9	4977.0	7.6	0.6	-0.2	-0.1	8.0
1995	3125.0	1437.0	34.0	8.0	4604.0	3132.3	1442.7	33.7	8.1	4616.8	7.3	5.7	-0.3	0.1	**12.8**
1996	3014.0	1309.0	31.0	4.0	4358.0	3018.0	1309.6	31.4	3.7	4362.7	4.0	0.6	0.4	-0.3	4.7
1997	2305.0	1544.0	37.0	1.0	3887.0	2306.4	1546.4	37.0	0.7	3890.5	1.4	2.4	0.0	-0.3	3.5
1998	2287.0	1312.0	20.0	4.0	3623.0	2290.0	1316.5	20.3	3.9	3630.7	3.0	4.5	0.3	-0.1	7.7
1999	1629.0	1444.0	23.0	4.0	3100.0	1631.3	1449.4	23.0	4.6	3108.3	2.3	5.4	0.0	0.6	8.3
2000	2590.0	1571.0	22.0	9.0	4192.0	2593.6	1571.7	22.4	8.7	4196.3	3.6	0.7	0.4	-0.3	4.3
2001	2718.0	1610.0	44.0	2.0	4374.0	2735.6	1618.3	44.1	2.4	4400.4	**17.6**	**8.3**	0.1	0.4	**26.4**
2002	2003.0	1355.0	15.0	5.0	3378.0	2005.2	1373.7	14.9	5.1	3399.0	2.2	**18.7**	-0.1	0.1	**21.0**
2003	1517.0	873.0	29.0	3.0	2422.0	1519.9	874.0	29.2	3.1	2426.2	2.9	1.0	0.2	0.1	4.2
2004	1014.0	622.0	28.0	4.0	1668.0	1045.5	632.7	28.3	3.9	1710.3	**31.5**	**10.7**	0.3	-0.1	**42.3**
2005	733.0	537.0	13.0	2.0	1285.0	752.4	569.1	13.5	2.4	1337.4	**19.4**	**32.1**	0.5	0.4	**52.4**
2006	577.0	481.0	17.0	1.0	1076.0	583.1	493.6	16.8	0.8	1094.3	6.1	**12.6**	-0.2	-0.2	**18.3**
2007	607.0	366.0	6.0	6.0	985.0	601.1	374.6	6.2	5.9	987.8	-5.9	8.6	0.2	-0.1	2.8

Table E3. Percentage of landings of American plaice by gear type, 1980-2010.

	GEAR TYPE			
YEAR	Otter Trawl	Shrimp Trawl	Sink Gill Net	OTHER
1980	96.8	0.7	0.8	1.8
1981	96.5	2.2	0.7	0.6
1982	96.3	2.0	0.8	0.9
1983	96.3	1.7	0.3	1.7
1984	97.2	1.0	0.2	1.6
1985	96.9	1.6	0.1	1.4
1986	96.1	2.5	0.3	1.1
1987	95.5	2.6	0.6	1.5
1988	96.2	1.7	0.6	1.6
1989	95.5	1.4	1.2	2.0
1990	93.4	2.2	2.0	2.5
1991	94.8	0.9	0.9	3.3
1992	96.1	1.3	0.1	2.5
1993	95.9	1.2	0.1	2.8
1994	95.8	0.0	3.2	1.0
1995	95.1	0.1	3.8	1.0
1996	95.7	0.1	3.3	0.9
1997	96.1	0.1	3.0	0.8
1998	91.6	0.1	7.3	1.0
1999	97.5	0.1	2.0	0.4
2000	98.4	0.1	1.1	0.4
2001	98.4	0.1	1.3	0.2
2002	98.8	0.0	0.6	0.6
2003	96.9	0.2	0.9	2.0
2004	96.2	0.0	1.0	2.8
2005	94.4	0.0	2.2	3.4
2006	96.2	0.0	1.3	2.5
2007	98.3	0.0	1.0	0.7
2008	98.8	0.2	0.9	0.2
2009	94.8	0.0	2.1	3.2
2010	98.8	0.0	0.8	0.4

Table E4. Landings by market category (Sm = small + peewee; Md=medium; Lg=large+jumbo; Un=unclassified) for statistical areas 511-515, 521-522, 525-526, 561-562 for American plaice, 1980-2010.

	Quarter 1				Quarter 2				Quarter 3				Quarter 4				Total			
YEAR	Sm	Md	Lg	Un	Sm	Md	Lg	Un	Sm	Md	Lg	Un	Sm	Md	Lg	Un	Sm	Md	Lg	Un
1980	565	0	1527	3	1398	0	3667	100	1026	0	2399	16	479	0	1488	1	3468	0	9081	120
1981	730	0	1775	26	1233	0	3557	253	993	0	2209	34	457	0	1532	2	3413	0	9073	315
1982	581	0	1468	11	1353	5	4350	318	1191	524	2643	131	571	299	1570	40	3696	827	10031	500
1983	580	356	1624	5	1488	713	3148	57	1027	497	1816	18	399	276	1090	3	3494	1843	7678	83
1984	431	247	1071	10	954	649	2355	27	812	479	1444	19	372	309	909	13	2568	1684	5779	70
1985	512	253	708	14	709	511	1548	22	503	369	1046	13	239	188	521	9	1963	1321	3823	59
1986	187	132	409	13	539	350	1014	33	342	201	536	11	202	146	349	6	1269	829	2308	63
1987	169	108	304	20	460	275	744	43	367	203	475	20	199	126	246	35	1195	711	1768	117
1988	203	94	279	39	447	244	529	75	433	186	303	47	155	88	143	36	1238	612	1254	197
1989	117	76	158	25	300	208	423	68	222	126	222	29	139	81	135	21	778	491	938	142
1990	101	66	142	19	269	194	317	49	323	196	273	20	190	118	146	19	883	573	879	107
1991	138	78	116	20	594	347	367	61	773	378	353	40	435	263	241	41	1939	1066	1077	162
1992	302	174	291	35	902	634	805	112	887	624	674	80	426	278	394	17	2517	1710	2164	244
1993	277	183	413	17	706	516	868	81	589	371	602	27	423	232	401	14	1995	1302	2284	139
1994	236	120	243	22	660	434	702	15	653	386	492	8	435	216	343	6	1984	1155	1780	50
1995	212	116	196	9	806	422	579	28	793	286	323	9	433	175	212	4	2245	998	1310	50
1996	236	105	173	4	804	340	431	22	910	240	250	10	490	158	182	3	2439	844	1036	40
1997	321	98	157	2	692	389	359	56	538	399	238	15	314	172	133	2	1866	1059	887	75
1998	172	145	150	2	635	475	388	28	401	333	261	3	219	176	229	6	1427	1130	1029	38
1999	160	161	221	4	392	328	365	13	349	231	239	2	260	177	197	3	1161	897	1021	21
2000	182	179	221	1	426	388	371	14	655	388	325	8	395	307	321	10	1658	1263	1238	33
2001	236	218	328	17	525	429	437	21	586	356	320	4	369	248	276	3	1717	1251	1361	45
2002	308	232	300	2	341	269	259	18	508	241	215	3	312	184	183	2	1470	927	956	24
2003	209	136	175	2	246	209	151	11	389	216	151	3	223	158	143	0	1068	718	620	16
2004	155	89	107	3	147	101	94	4	292	181	114	1	170	112	97	0	764	483	412	9
2005	139	86	94	2	134	100	69	3	192	84	66	7	156	80	73	1	622	350	302	13
2006	134	70	81	1	92	85	57	6	135	82	67	1	129	55	78	2	491	292	282	10
2007	99	40	55	2	117	59	43	9	207	65	44	2	139	57	56	2	562	221	198	15
2008	118	52	66	5	115	45	29	5	230	65	40	3	205	58	71	2	668	220	206	15
2009	220	55	92	0	163	38	25	3	291	76	48	4	241	57	81	3	914	226	245	10
2010	233	68	101	16	133	38	23	14	245	68	34	43	230	59	43	63	841	234	202	137

Table E5. Sampling of American plaice commercial landings, by market category, for the Gulf of Maine and Georges Bank areas (NAFO Division 5Y and 5Z), 1985-2010. Outline indicates samples pooled to estimate landings at age.

Year	Area	Small Q1	Small Q2	Small Q3	Small Q4	Medium Q1	Medium Q2	Medium Q3	Medium Q4	Large Q1	Large Q2	Large Q3	Large Q4	Number of tons landed / sample Sm.	Med.	Lrg.
1985	GB	2	4	14	3	---	2	2	2	---	3	7	1			
	GM	2	5	5	5	3	1	9	5	1	10	6	5			
	total	4	9	19	8	3	3	11	7	1	13	13	6	49	55	116
1986	GB	3	6	5	3	2	4	3	2	1	4	3	2			
	GM	9	5	3	5	3	4	5	1	10	10	7	4			
	total	12	11	8	8	5	8	8	3	11	14	10	6	33	35	56
1987	GB	4	5	5	1	---	2	3	2	2	4	4	1			
	GM	2	6	5	3	1	5	2	3	3	3	6	5			
	total	6	11	10	4	1	7	5	5	5	7	10	6	39	40	63
1988	GB	3	7	4	2	1	3	4	2	4	5	2	4			
	GM	4	7	4	5	6	6	4	3	6	5	3	2			
	total	7	14	8	7	7	9	8	5	10	10	5	6	34	21	40
1989	GB	2	5	5	---	1	1	6	1	5	3	3	---			
	GM	1	3	3	3	1	---	4	3	2	1	---	1			
	total	3	8	8	3	2	1	10	4	7	4	3	1	35	29	63
1990	GB	---	5	6	---	2	1	2	2	---	2	5	---			
	GM	5	5	3	3	1	6	3	5	1	5	3	5			
	total	5	10	9	3	3	7	5	7	1	7	8	5	33	26	42
1991	GB	---	3	1	---	3	1	1	---	3	3	2	---			
	GM	5	3	7	6	3	1	4	3	---	1	5	2			
	total	5	6	8	6	6	2	5	3	3	4	7	2	78	67	67
1992	GB	---	4	1	---	---	1	1	---	---	2	2	1			
	GM	1	5	2	2	1	4	3	2	2	2	3	2			
	total	1	9	3	2	1	5	4	2	2	4	5	3	168	143	155
1993	GB	---	2	1	1	---	1	---	---	---	3	2	1			
	GM	2	4	4	1	---	2	2	---	---	1	2	---			
	total	2	6	5	2	0	3	2	0	0	4	4	1	133	260	254
1994	GB	---	---	---	---	---	---	1	1	---	1	---	1			
	GM	---	2	5	3	---	4	3	3	---	2	3	3			
	total	0	2	5	3	0	4	4	4	0	3	3	4	198	96	178
1995	GB	1	---	---	---	1	---	---	---	1	---	---	---			
	GM	1	3	---	2	---	2	---	---	---	2	---	1			
	total	2	3	0	2	1	2	0	0	1	2	0	1	321	333	328
1996	GB	---	2	2	1	---	1	4	---	---	2	1	1			
	GM	2	3	2	1	2	1	3	5	3	1	4	2			
	total	2	5	4	2	2	2	7	5	3	3	5	3	188	53	74
1997	GB	2	4	2	3	---	2	3	1	---	2	---	---			
	GM	4	4	3	1	2	3	3	---	1	5	3	2			
	total	6	8	5	4	2	5	6	1	1	7	3	2	81	76	68
1998	GB	1	4	1	---	2	1	1	1	1	1	1	1			
	GM	2	3	1	1	6	3	7	7	2	2	2	2			
	total	3	7	2	1	8	4	8	8	3	3	3	3	110	40	86

Table E5 – continued. Sampling of American plaice commercial landings, by market category, for the Gulf of Maine and Georges Bank areas (NAFO Division 5Y and 5Z), 1985-2010. Outline indicates samples pooled to estimate landings at age.

Year	Area	Small Q1	Small Q2	Small Q3	Small Q4	Medium Q1	Medium Q2	Medium Q3	Medium Q4	Large Q1	Large Q2	Large Q3	Large Q4	Number of tons landed / sample Sm.	Med.	Lrg.
1999	GB	4	4	---	1	5	2	1	---	---	4	1	---			
	GM	6	8	6	9	7	4	5	7	1	6	3	2			
	total	10	12	6	10	12	6	6	7	1	10	4	2	31	29	60
2000	GB	14	11	3	1	1	2	---	1	2	2	2	2			
	GM	15	29	4	1	2	6	3	---	---	4	1	3			
	total	29	40	7	2	3	8	3	1	2	6	3	5	21	84	77
2001	GB	4	2	1	2	---	2	2	4	---	3	2	1			
	GM	5	5	4	---	3	3	2	2	4	2	1	4			
	total	9	7	5	2	3	5	4	6	4	5	3	5	75	70	80
2002	GB	1	2	2	1	2	1	2	---	4	3	2	---			
	GM	2	3	2	3	2	1	3	---	1	3	3	2			
	total	3	5	4	4	4	2	5	0	5	6	5	2	92	84	53
2003	GB	1	3	---	---	2	---	---	---	---	3	2	---			
	GM	2	8	6	5	1	6	6	5	6	7	11	7			
	total	3	11	6	5	3	6	6	5	6	10	13	7	43	36	17
2004	GB	1	1	1	4	3	---	2	4	1	---	3	1			
	GM	5	4	7	2	2	6	4	3	12	12	2	8			
	total	6	5	8	6	5	6	6	7	13	12	5	9	31	20	11
2005	GB	3	2	2	3	1	3	---	2	7	2	2	4			
	GM	2	5	6	4	4	1	6	2	6	6	3	2			
	total	5	7	8	7	5	7	6	4	13	8	5	6	23	16	9
2006	GB	2	2	---	2	3	2	1	1	4	5	2	2			
	GM	3	3	9	2	3	3	2	4	2	4	4	3			
	total	5	5	9	4	6	5	3	5	6	9	6	5	21	15	11
2007	GB	3	3	2	3	2	1	4	3	3	4	1	3			
	GM	4	4	6	2	3	2	3	2	5	1	6	5			
	total	7	7	8	5	5	3	7	5	8	5	7	8	21	11	7
2008	GB	5	7	3	4	4	6	3	3	5	6	1	3			
	GM	0	2	3	3	2	3	4	6	3	5	7	4			
	total	5	9	6	7	6	9	7	9	8	11	8	7	25	7	6
2009	GB	4	8	8	3	6	6	6	6	2	7	4	5			
	GM	2	2	1	2	1	4	3	4	4	4	4	5			
	total	6	10	9	5	7	10	9	10	6	11	8	10	30	6	7
2010	GB	4	4	2	2	4	2	2	1	6	4	4	4			
	GM	2	4	5	5	3	6	6	3	5	9	6	6			
	total	6	8	7	7	7	8	8	4	11	13	10	10	30	9	5

Table E6. Discards of American plaice for Gulf of Maine and Georges Bank large and small mesh otter trawl, gillnet, shrimp and scallop fisheries, 1989-2010. Estimated using SBRM method.

Gulf of Maine

	GM large mesh trawl			GM small mesh trawl			GM gillnet			GM shrimp			TOTAL Gulf of Maine		
Year	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips
1989	628.1	0.31	37	52.1	0.37	23	4.8	0.21	84	381.6	0.22	40	1066.7	0.20	184
1990	813.1	0.64	26	152.8	1.12	8	56.0	0.44	120	535.0	0.18	31	1556.8	0.36	185
1991	1382.7	0.36	48	9.4	0.31	29	23.3	0.19	801	216.1	0.13	52	1631.4	0.31	930
1992	567.4	0.36	44	22.7	0.53	15	29.9	0.12	896	126.8	0.19	82	746.8	0.28	1037
1993	317.4	0.42	17	0.0		6	50.3	0.14	560	30.9	0.23	81	398.6	0.33	664
1994	559.5	0.91	6	0.0			37.6	0.68	85	33.7	0.22	77	630.8	0.81	168
1995	389.5	0.47	24	38.6	0.18	30	144.3	0.31	69	109.5	0.18	73	682.0	0.28	196
1996	209.3	0.79	11	53.0	0.13	40	63.9	0.49	46	141.2	0.28	35	467.5	0.37	132
1997	404.5	0.56	5	95.1	0.00	3	72.6	0.49	33	44.8	0.21	16	617.0	0.37	57
1998	613.1	0.79	6	0.0			14.3	0.37	78	*28.7**			627.4	0.77	84
1999	573.7	0.38	22	6.2	0.63	11	9.0	0.62	73	*26.0**			588.9	0.37	106
2000	65.1	0.33	80	0.0			23.3	0.33	81	*32.9**			88.4	0.26	161
2001	196.4	0.39	111	24.1	0.00	4	20.1	0.54	47	*29.5**		3	248.0	0.31	165
2002	170.4	0.46	149	15.1	0.28	34	4.1	0.31	80	*3.0**			189.7	0.41	263
2003	180.2	0.14	251	8.4	0.31	19	5.8	0.37	295	22.0	0.27	15	216.5	0.12	580
2004	252.6	0.31	250	7.7	0.26	68	3.5	0.28	775	6.1	0.32	12	270.0	0.29	1105
2005	204.6	0.15	499	7.4	0.37	69	2.5	0.27	651	8.0	0.19	17	222.4	0.14	1236
2006	122.0	0.37	203	12.9	0.37	24	1.0	0.69	128	6.5	0.43	20	142.3	0.32	375
2007	61.8	0.14	225	6.0	0.23	16	1.6	0.43	118	13.0	0.29	14	82.4	0.12	373
2008	95.1	0.14	254	4.5	0.40	12	3.0	0.23	150	11.3	0.29	19	113.8	0.12	435
2009	83.2	0.18	410	17.5	0.42	22	4.1	0.35	276	11.1	0.34	12	115.9	0.15	720
2010	141.5	0.08	609	54.6	0.45	30	3.2	0.11	1239	39.9	0.30	15	239.2	0.12	1893

Georges Bank

	GB large mesh trawl			GB small mesh trawl			GB gill net			GB scallop,limited			TOTAL Georges Bank			TOTAL Gulf of Maine - Georges Bank		
Year	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	**mt**	**cv**	**# trips**
1989	122.5	0.46	26	11.1	0.62	24	0.00		23	0.0			133.7	0.43	73.0	1200	0.18	257
1990	69.2	0.69	25	5.8	0.69	16	0.08	0.72	29	0.0			75.0	0.64	70.0	1632	0.34	255
1991	211.3	0.60	28	4.8	1.10	13	0.43	0.67	161	14.5	0.00	1	231.1	0.55	203.0	1863	0.28	1133
1992	60.2	0.50	29	1.9	1.39	13	0.07	0.91	137	3.1	0.44	10	65.2	0.46	189.0	812	0.26	1226
1993	96.5	0.64	20	0.3	1.47	5	0.04	2.56	62	113.6	0.47	11	210.5	0.39	98.0	609	0.26	762
1994	47.7	1.13	25	0.0		2	0.01	2.63	38	2.4	1.11	7	50.1	1.08	72.0	681	0.75	240
1995	353.7	0.35	41	13.5	0.95	4	0.37	0.61	59	14.5	0.87	6	382.0	0.33	110.0	1064	0.21	306
1996	117.4	0.87	17	4.4	0.00	3	1.02	0.96	29	1.5	0.38	13	124.4	0.82	62.0	592	0.34	194
1997	232.2	0.47	16	0.1	0.00	4	1.93	1.01	15	44.9	0.56	11	279.2	0.40	46.0	896	0.29	103
1998	77.6	2.60	5	0.0		1	0.36	1.48	43	48.4	0.61	9	126.3	1.62	58.0	754	0.70	142
1999	103.7	0.55	11	0.2	0.00	4	0.26	0.64	30	65.1	0.56	22	169.2	0.40	67.0	758	0.30	173
2000	164.7	0.31	20	40.0	1.06	6	0.74	0.98	44	39.6	0.25	227	245.0	0.28	297.0	333	0.21	458
2001	145.0	0.17	34	56.5	0.77	10	0.18	0.91	27	34.7	0.42	17	236.5	0.22	88.0	484	0.19	253
2002	101.4	0.24	69	2.5	0.81	17	0.00		22	2.9	1.19	11	106.8	0.23	119.0	296	0.28	382
2003	55.3	0.21	148	28.7	0.35	22	0.25	0.59	93	19.1	0.79	11	103.4	0.21	274.0	320	0.11	854
2004	75.3	0.15	210	7.8	0.59	32	0.39	0.39	180	2.6	0.67	41	86.0	0.14	463.0	356	0.23	1568
2005	54.6	0.09	706	9.2	0.23	95	0.08	1.84	167	12.2	0.55	80	76.1	0.11	1048.0	299	0.11	2284
2006	122.7	0.12	362	15.6	0.98	23	0.00		47	5.4	0.65	110	143.6	0.15	542.0	286	0.18	917
2007	149.9	0.12	371	6.7	0.57	16	1.24	1.95	115	6.4	0.47	106	164.2	0.12	608.0	247	0.09	981
2008	130.4	0.10	488	3.4	0.76	9	0.12	0.54	70	10.0	0.30	100	144.0	0.09	667.0	258	0.07	1102
2009	243.3	0.14	397	6.3	0.82	29	0.51	0.53	52	24.3	0.20	73	274.3	0.13	551.0	390	0.10	1271
2010	120.3	0.12	395	33.3	0.90	39	0.22	0.27	441	0.4	0.90	55	154.2	0.22	930.0	393	0.11	2823

* as estimated by direct method (O'Brien and Esteves 2001, O'Brien et al. 2005), not included in total mt or # trips

* scallop limited trips

Table E7. Total catch (commercial landings (metric tons, live weight) and discards) of American plaice from the Gulf of Maine, Georges Bank, Southern New England, and the Mid-Atlantic, 1960-2010 (NAFO Div. 5Y, 5Z and 6).

Year	Gulf of Maine			Georges Bank			Southern New England			Mid-Atlantic			Grand Total		
	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Discards	Catch
1960	621		621	689		689	-		0	0		0	1310	0	1310
1961	692		692	830		830	-		0	0		0	1522	0	1522
1962	694		694	1277		1277	-		0	0		0	1971	0	1971
1963	693		693	1640		1640	-		0	0		0	2333	0	2333
1964	811		811	2988		2988	-		0	0		0	3799	0	3799
1965	967		967	2668		2668	-		0	0		0	3635	0	3635
1966	957		957	2910		2910	-		0	0		0	3867	0	3867
1967	1072		1072	3397		3397	-		0	4		4	4473	0	4473
1968	909		909	2066		2066	782		782	20		20	3777	0	3777
1969	1066		1066	1889		1889	854		854	130		130	3939	0	3939
1970	895		895	3280		3280	146		146	8		8	4329	0	4329
1971	653		653	2073		2073	329		329	8		8	3063	0	3063
1972	569		569	1602		1602	74		74	0		0	2245	0	2245
1973	687		687	1237		1237	163		163	0		0	2087	0	2087
1974	947		947	1084		1084	96		96	0		0	2127	0	2127
1975	1507		1507	1086		1086	3		3	0		0	2596	0	2596
1976	2550		2550	975		975	10		10	1		1	3536	0	3536
1977	5647		5647	1493		1493	84		84	7		7	7231	0	7231
1978	7317		7317	2270		2270	15		15	8		8	9610	0	9610
1979	8835		8835	2501		2501	20		20	4		4	11360	0	11360
1980	11139		11139	2447		2447	10		10	1		1	13597	0	13597
1981	10328		10328	2499		2499	28		28	46		46	12901	0	12901
1982	11147		11147	3963		3963	37		37	9		9	15156	0	15156
1983	9149		9149	3985		3985	40		40	4		4	13178	0	13178
1984	6835		6835	3283		3283	17		17	7		7	10142	0	10142
1985	4767		4767	2289		2289	12		12	2		2	7070	0	7070
1986	3319		3319	1180		1180	4		4	3		3	4506	0	4506
1987	2766		2766	1080		1080	2		2	1		1	3849	0	3849
1988	2271		2271	1205		1205	13		13	1		1	3490	0	3490
1989	1646	1066.71	2713	771	134	905	1		1	3		3	2421	1200	3621
1990	1802	1556.83	3359	691	75	766	2		2	2		2	2497	1632	4129
1991	2936	1631.4	4567	1336	231	1567	15		15	0		0	4287	1863	6150
1992	4564	746.793	5311	1841	65	1906	10		10	4		4	6419	812	7231
1993	3866	398.558	4265	1839	210	2049	11		11	4		4	5720	609	6329
1994	3553	630.838	4183	1418	50	1468	29		29	7.9318		8	5007	681	5688
1995	3132	681.969	3814	1445	382	1827	34		34	8.1328		8	4619	1064	5683
1996	3018	467.521	3485	1312	124	1436	31		31	3.6744		4	4365	592	4957
1997	2306	617.001	2923	1611	279	1891	37		37	0.7154		1	3955	896	4852
1998	2290	627.446	2917	1337	126	1463	20		20	3.9025		4	3651	754	4405
1999	1631	588.927	2220	1572	169	1742	23		23	4.574		5	3231	758	3989
2000	2594	88.395	2682	1715	245	1960	22		22	8.6562		9	4339	333	4673
2001	2736	247.961	2984	1668	236	1905	44		44	2.3946		2	4451	484	4935
2002	2006	189.696	2195	1472	107	1579	15		15	5.1248		5	3498	296	3795
2003	1520	216.453	1736	934	103	1038	29		29	3.1068		3	2487	320	2806
2004	1046	270.043	1316	636	86	722	28		28	3.8646		4	1713	356	2069
2005	753	222.446	975	574	76	650	13		13	2.3835		2	1343	299	1641
2006	583	142.315	725	504	144	648	17		17	0.7936		1	1105	286	1391
2007	601	82.4384	684	377	164	541	6		6	5.9419		6	990	247	1237
2008	703	113.832	817	388	144	532	4		4	4.9692		5	1100	258	1358
2009	866	115.862	982	501	274	776	6		6	7.1466		7	1380	390	1771
2010	902	239.236	1141	492	154	646	8		8	2.4028		2	1404	393	1798

Table E8a. Commercial landings (thousands of fish; metric tons), mean weight (kg),and mean length (cm), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Landings in Numbers (000's) at Age

Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0	0	22	770	3129	3903	3629	1185	1139	850	1380	16007
1981	0	587	1332	4332	5101	3619	2381	1574	645	440	621	20632
1982	0	113	2134	3495	4296	3482	3293	2038	1256	737	718	21563
1983	0	1	437	3732	4267	3807	2251	1270	697	449	911	17822
1984	0	3	253	1298	4819	2865	1913	577	274	307	769	13078
1985	0	0	60	786	2066	2787	2213	1081	438	267	182	9881
1986	0	1	198	1082	1502	1462	1307	631	255	105	100	6644
1987	0	15	343	486	1703	1271	891	541	187	62	60	5557
1988	0	1	446	1148	1456	1427	543	270	177	88	55	5612
1989	0	0	76	451	686	504	749	469	193	103	116	3346
1990	0	0	202	846	1049	500	290	349	193	96	161	3687
1991	0	0	23	1862	2835	1112	321	165	202	98	105	6723
1992	0	0	46	739	4872	2563	813	191	131	118	93	9566
1993	0	0	123	1029	2037	2452	1382	265	287	151	125	7851
1994	0	23	196	898	1869	1264	1157	598	235	150	291	6680
1995	0	0	141	713	2862	1734	642	579	210	53	50	6983
1996	0	100	174	2496	2378	1401	529	240	124	35	64	7540
1997	0	0	2	1260	2584	1540	613	182	85	66	116	6449
1998	0	0	6	174	1497	1893	999	318	60	57	155	5158
1999	0	0	2	224	988	1668	1160	443	148	42	79	4753
2000	0	0	113	417	1432	2120	1715	566	138	70	20	6591
2001	0	0	0	394	1912	2003	1523	899	289	57	46	7123
2002	0	0	3	330	1079	1674	1162	504	275	158	177	5362
2003	0	0	0	127	767	1076	700	513	262	150	106	3701
2004	0	0	7	126	468	857	448	358	195	78	74	2610
2005	0	0	3	195	604	595	400	173	100	44	50	2163
2006	0	0	2	170	496	405	296	178	98	56	43	1744
2007	0	0	24	309	594	411	210	96	58	23	24	1749
2008	0	0	36	191	549	474	306	153	91	87	60	1946
2009	0	0	0	136	604	637	433	362	126	45	89	2433
2010	0	0	44	280	319	773	535	214	106	104	78	2451

Landings in Weight (Tons) at Age

Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0	0	6	271	1387	2562	3008	1232	1347	1168	2616	13597
1981	0	78	276	1485	2318	2832	2122	1545	729	552	963	12901
1982	0	23	620	1166	1845	2007	3164	2320	1502	1144	1364	15156
1983	0	0	149	1718	2482	2594	1863	1325	867	650	1530	13178
1984	0	1	84	549	2913	1957	1713	688	310	421	1506	10142
1985	0	0	13	212	747	1516	1884	1263	603	445	387	7070
1986	0	0	53	349	616	864	1101	741	380	183	219	4506
1987	0	3	97	187	809	797	797	636	278	107	137	3849
1988	0	0	126	413	689	922	484	333	247	151	124	3490
1989	0	0	26	177	335	295	553	403	257	150	224	2421
1990	0	0	78	355	548	330	240	338	210	125	273	2497
1991	0	0	8	844	1541	795	309	192	258	150	190	4287
1992	0	0	22	314	2624	1896	774	237	173	193	188	6419
1993	0	0	51	463	1055	1591	1306	327	400	238	289	5720
1994	0	3	47	384	991	793	921	647	303	213	705	5007
1995	0	0	50	299	1472	1134	527	648	281	111	96	4619
1996	0	17	59	1009	1226	911	487	288	171	55	142	4365
1997	0	0	0	535	1230	980	504	205	114	104	282	3955
1998	0	0	2	69	654	1099	825	328	80	83	510	3651
1999	0	0	0	98	484	989	873	410	164	61	151	3231
2000	0	0	46	173	703	1236	1323	571	151	99	37	4339
2001	0	0	0	174	878	1088	1084	760	306	82	78	4451
2002	0	0	1	134	498	876	790	454	293	197	255	3498
2003	0	0	0	51	341	606	488	439	255	166	141	2487
2004	0	0	2	56	222	479	310	284	191	79	90	1713
2005	0	0	1	81	292	337	275	152	95	47	64	1343
2006	0	0	1	73	239	237	200	152	90	57	56	1105
2007	0	0	9	125	280	233	141	80	58	28	34	990
2008	0	0	14	83	268	250	189	101	70	63	62	1100
2009	0	0	0	60	284	346	251	216	92	39	94	1380
2010	0	0	15	130	158	410	328	148	78	63	75	1404

Table E8a continued. Commercial landings, (thousands of fish; metric tons), mean weight (kg), and mean length (cm), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Landings Mean Weight (kg) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Mean
1980	0.000	0.000	0.285	0.352	0.443	0.656	0.829	1.039	1.183	1.374	1.895	0.849
1981	0.000	0.133	0.207	0.343	0.454	0.783	0.891	0.982	1.130	1.254	1.551	0.625
1982	0.000	0.200	0.291	0.334	0.429	0.577	0.961	1.138	1.196	1.552	1.901	0.703
1983	0.000	0.184	0.341	0.460	0.582	0.682	0.828	1.043	1.244	1.446	1.680	0.740
1984	0.000	0.180	0.331	0.423	0.605	0.683	0.895	1.192	1.133	1.369	1.958	0.775
1985	0.000	0.000	0.221	0.270	0.362	0.544	0.852	1.167	1.377	1.665	2.128	0.716
1986	0.000	0.191	0.267	0.322	0.410	0.591	0.842	1.174	1.491	1.747	2.194	0.678
1987	0.000	0.201	0.284	0.386	0.475	0.627	0.895	1.177	1.483	1.732	2.284	0.693
1988	0.000	0.151	0.282	0.360	0.473	0.646	0.893	1.231	1.396	1.717	2.238	0.622
1989	0.000	0.000	0.339	0.393	0.489	0.586	0.739	0.858	1.334	1.463	1.940	0.724
1990	0.000	0.000	0.384	0.420	0.522	0.660	0.826	0.968	1.089	1.305	1.696	0.677
1991	0.000	0.000	0.333	0.453	0.543	0.715	0.963	1.161	1.276	1.541	1.813	0.638
1992	0.000	0.000	0.473	0.424	0.538	0.739	0.953	1.240	1.319	1.640	2.007	0.671
1993	0.000	0.000	0.416	0.451	0.518	0.649	0.945	1.234	1.394	1.577	2.313	0.729
1994	0.000	0.138	0.239	0.427	0.530	0.627	0.796	1.083	1.289	1.424	2.424	0.749
1995	0.000	0.000	0.359	0.420	0.517	0.685	0.914	1.168	1.099	2.105	1.921	0.676
1996	0.000	0.166	0.339	0.404	0.516	0.650	0.919	1.202	1.383	1.565	2.242	0.579
1997	0.000	0.000	0.214	0.424	0.476	0.636	0.822	1.127	1.336	1.570	2.425	0.613
1998	0.000	0.000	0.343	0.395	0.437	0.581	0.826	1.031	1.350	1.463	3.293	0.708
1999	0.000	0.000	0.255	0.437	0.490	0.593	0.753	0.925	1.113	1.462	1.908	0.680
2000	0.000	0.000	0.409	0.416	0.491	0.583	0.772	1.008	1.094	1.411	1.864	0.658
2001	0.000	0.000	0.000	0.443	0.459	0.543	0.712	0.845	1.059	1.455	1.684	0.625
2002	0.000	0.000	0.295	0.407	0.462	0.523	0.679	0.901	1.067	1.246	1.443	0.652
2003	0.000	0.000	0.000	0.402	0.445	0.563	0.697	0.855	0.976	1.105	1.322	0.672
2004	0.000	0.000	0.339	0.447	0.474	0.559	0.692	0.793	0.980	1.015	1.211	0.656
2005	0.000	0.000	0.432	0.414	0.483	0.566	0.688	0.876	0.947	1.074	1.277	0.621
2006	0.000	0.000	0.326	0.431	0.482	0.585	0.677	0.850	0.923	1.028	1.301	0.634
2007	0.000	0.000	0.387	0.407	0.472	0.566	0.673	0.838	1.003	1.196	1.450	0.566
2008	0.000	0.000	0.378	0.434	0.489	0.528	0.616	0.662	0.770	0.730	1.035	0.565
2009	0.000	0.000	0.367	0.437	0.469	0.543	0.579	0.596	0.726	0.861	1.050	0.567
2010	0.000	0.000	0.355	0.464	0.496	0.530	0.613	0.691	0.731	0.609	0.965	0.573

Landings Mean Length (cm) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Mean
1980	0.0	0.0	32.6	34.7	37.1	41.7	44.8	47.9	49.9	52.2	57.3	44.1
1981	0.0	25.8	28.8	34.0	36.9	43.3	45.2	46.7	48.8	50.3	53.8	39.4
1982	0.0	29.0	32.4	33.7	36.4	39.5	46.3	48.8	49.9	53.9	57.3	40.8
1983	0.0	28.7	34.2	37.2	39.8	41.9	44.2	47.5	50.2	52.9	54.9	42.2
1984	0.0	28.5	33.9	36.3	40.3	41.8	45.3	49.9	49.3	52.2	59.0	42.8
1985	0.0	0.0	30.0	31.9	34.6	39.1	45.0	49.6	52.0	55.2	59.3	41.4
1986	0.0	29.0	31.9	33.6	36.0	40.1	44.6	49.5	53.3	56.0	59.9	40.7
1987	0.0	29.4	32.5	35.5	37.8	41.0	45.6	49.5	53.3	55.8	60.7	41.3
1988	0.0	27.0	32.4	34.8	37.6	41.4	45.6	50.4	52.3	55.7	60.2	39.9
1989	0.0	0.0	34.3	35.8	38.2	40.2	43.0	44.6	51.5	52.9	57.6	41.9
1990	0.0	0.0	35.6	36.5	38.9	41.6	44.5	46.7	48.3	51.1	55.3	41.3
1991	0.0	0.0	34.2	37.4	39.4	42.6	46.6	49.3	50.6	53.9	56.3	40.8
1992	0.0	0.0	38.0	36.7	39.2	43.1	46.4	50.5	51.4	54.9	58.3	41.5
1993	0.0	0.0	36.5	37.3	38.8	41.4	46.6	50.5	52.4	54.4	60.4	42.3
1994	0.0	26.2	30.4	36.7	39.2	41.2	44.2	48.6	51.2	52.6	61.4	42.3
1995	0.0	0.0	35.0	36.6	38.8	41.6	44.6	49.0	51.7	59.4	57.7	41.3
1996	0.0	27.7	34.1	36.2	38.8	41.4	46.1	50.0	52.1	54.3	60.3	39.5
1997	0.0	0.0	30.0	36.7	37.9	41.3	44.5	49.0	51.7	54.2	61.1	40.2
1998	0.0	0.0	34.5	35.9	37.0	40.1	44.7	47.8	51.8	53.0	67.1	41.5
1999	0.0	0.0	31.6	36.9	38.2	40.4	43.4	46.2	48.9	52.9	57.3	41.7
2000	0.0	0.0	36.4	36.4	38.2	40.1	43.5	47.2	48.6	52.5	57.1	41.3
2001	0.0	0.0	0.0	37.1	37.5	39.3	42.6	44.7	47.8	53.1	55.3	40.6
2002	0.0	0.0	33.0	36.3	37.6	39.0	42.1	45.9	48.3	50.6	52.8	41.1
2003	0.0	0.0		36.1	37.2	39.8	42.4	45.1	46.7	48.4	51.1	41.5
2004	0.0	0.0	34.4	37.3	37.9	39.7	42.2	43.8	46.7	47.3	49.7	41.3
2005	0.0	0.0	37.0	36.4	38.1	39.8	42.1	45.4	46.3	48.0	50.8	40.6
2006	0.0	0.0	34.0	36.9	38.1	40.2	42.0	44.9	45.9	47.5	50.9	40.9
2007	0.0	0.0	35.8	36.2	37.9	39.8	41.8	44.7	46.9	49.9	52.8	39.5
2008	0.0	0.0	35.5	36.9	38.2	39.1	40.9	41.6	43.5	42.6	47.6	39.7
2009	0.0	0.0		37.0	37.8	39.3	40.1	40.4	42.9	45.1	47.9	39.7
2010	0.0	0.0	34.9	37.7	38.3	39.1	40.9	42.1	42.7	40.4	46.4	39.8

Table E8b. Northern shrimp fishery discards, (thousands of fish; metric tons) mean weight (kg), and mean length (cm), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Shrimp Discards in Numbers (000's) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0	0	114	115	29	0	0	0	0	0	0	258
1981	1	148	364	287	80	0	0	3	0	0	0	883
1982	7	155	546	633	106	96	4	0	0	0	0	1546
1983	14	614	641	761	320	51	6	0	1	0	0	2408
1984	3	302	488	575	495	98	6	3	0	0	0	1969
1985	54	103	931	465	308	79	15	0	0	0	0	1955
1986	54	552	400	933	132	10	0	0	0	0	0	2081
1987	31	439	1108	610	338	13	1	0	0	0	0	2540
1988	283	587	786	408	91	12	10	0	0	0	0	2178
1989	15	1576	1377	727	224	99	22	7	0	0	0	4047
1990	0	899	2946	989	208	33	13	11	0	0	0	5099
1991	0	209	567	623	134	6	0	0	0	0	0	1540
1992	10	247	662	218	90	3	4	0	0	0	0	1233
1993	22	275	124	36	9	2	0	0	0	0	0	467
1994	58	858	99	23	6	2	2	0	0	0	0	1048
1995	42	2081	571	49	13	3	0	0	0	0	0	2761
1996	12	783	542	508	85	24	8	0	0	0	0	1962
1997	15	627	128	120	55	9	0	0	0	0	0	954
1998	37	61	127	78	49	7	1	0	0	0	0	361
1999	4	200	74	79	41	26	7	1	0	0	0	432
2000	3	292	192	58	37	11	6	0	0	0	0	599
2001	0	85	274	83	39	12	5	0	0	0	0	498
2002	1	3	16	16	4	1	0	0	0	0	0	41
2003	10	667	12	11	5	1	0	1	0	0	1	709
2004	4	110	36	7	2	1	0	0	0	0	0	162
2005	34	270	34	4	1	0	0	0	0	0	0	343
2006	24	55	18	6	3	1	1	0	0	0	0	109
2007	160	212	35	9	4	1	0	0	0	0	0	422
2008	14	48	45	29	10	3	1	0	0	0	0	150
2009	0	36	47	55	15	2	1	0	0	0	0	154
2010	0	483	310	32	37	17	2	0	0	0	0	880

Shrimp Discards in Weight (Tons) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0	0	12	20	6	0	0	0	0	0	0	37
1981	0	6	32	43	15	0	0	1	0	0	0	97
1982	0	5	49	88	21	17	1	0	0	0	0	181
1983	0	18	58	103	53	10	1	0	0	0	0	244
1984	0	10	35	73	73	17	1	1	0	0	0	211
1985	1	4	63	56	44	17	3	0	0	0	0	189
1986	1	21	31	130	24	2	0	0	0	0	0	208
1987	0	13	83	80	66	3	0	0	0	0	0	246
1988	4	22	67	55	16	3	2	0	0	0	0	169
1989	0	51	122	130	51	20	5	2	0	0	0	381
1990	0	36	272	161	50	9	4	3	0	0	0	535
1991	0	5	51	119	38	2	0	0	0	0	0	216
1992	0	8	53	39	24	1	1	0	0	0	0	127
1993	0	8	12	7	2	1	0	0	0	0	0	31
1994	0	19	8	3	1	0	0	0	0	0	0	34
1995	0	53	42	9	4	1	0	0	0	0	0	109
1996	0	18	30	62	21	7	2	0	0	0	0	140
1997	0	12	8	13	9	2	0	0	0	0	0	45
1998	1	2	8	8	8	2	0	0	0	0	0	29
1999	0	3	3	8	5	4	2	0	0	0	0	26
2000	0	5	11	7	6	3	2	0	0	0	0	33
2001	0	1	11	9	5	2	1	0	0	0	0	29
2002	0	0	1	1	1	0	0	0	0	0	0	3
2003	0	16	1	1	1	0	0	0	0	1	2	22
2004	0	2	2	1	0	0	0	0	0	0	0	6
2005	0	5	2	0	0	0	0	0	0	0	1	8
2006	0	2	1	1	1	0	0	0	1	0	0	6
2007	1	6	3	1	1	0	0	0	0	0	0	13
2008	0	1	3	4	2	1	0	0	0	0	0	11
2009	0	1	3	5	2	0	0	0	0	0	0	11
2010	0	15	15	4	4	2	0	0	0	0	0	40

Table E8b.-continued. Northern shrimp fishery discards, (thousands of fish; metric tons) mean weight (kg), and mean length (cm), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Shrimp Discards Mean Weight (kg) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Mean
1980	0.000	0.000	0.104	0.170	0.210	0.359	0.000	0.000	0.000	0.000	0.000	0.145
1981	0.007	0.040	0.087	0.151	0.192	0.320	0.000	0.239	0.000	0.000	0.000	0.110
1982	0.014	0.030	0.091	0.139	0.197	0.180	0.239	0.000	0.000	0.000	0.000	0.117
1983	0.013	0.029	0.091	0.136	0.167	0.193	0.177	0.359	0.295	0.000	0.000	0.101
1984	0.004	0.032	0.072	0.127	0.148	0.178	0.198	0.239	0.000	0.000	0.000	0.107
1985	0.015	0.043	0.068	0.121	0.144	0.211	0.196	0.000	0.000	0.000	0.000	0.096
1986	0.014	0.037	0.078	0.139	0.183	0.204	0.000	0.359	0.000	0.000	0.000	0.100
1987	0.011	0.029	0.075	0.132	0.195	0.247	0.307	0.000	0.000	0.000	0.000	0.097
1988	0.016	0.038	0.085	0.134	0.175	0.253	0.209	0.000	0.000	0.000	0.000	0.078
1989	0.009	0.032	0.089	0.179	0.226	0.203	0.228	0.348	0.432	0.000	0.000	0.094
1990	0.000	0.040	0.092	0.162	0.242	0.272	0.275	0.261	0.472	0.000	0.000	0.105
1991	0.004	0.026	0.090	0.191	0.283	0.391	0.701	0.000	0.515	0.000	0.000	0.140
1992	0.006	0.032	0.080	0.181	0.263	0.443	0.323	0.000	0.962	0.000	0.000	0.103
1993	0.003	0.031	0.101	0.188	0.255	0.412	0.670	0.000	0.000	0.000	0.000	0.066
1994	0.004	0.023	0.083	0.152	0.207	0.151	0.133	1.349	1.349	0.000	0.000	0.032
1995	0.006	0.025	0.074	0.188	0.280	0.356	0.396	0.327	0.000	0.000	0.000	0.039
1996	0.003	0.023	0.056	0.122	0.246	0.306	0.252	0.000	0.609	0.000	0.000	0.072
1997	0.006	0.020	0.066	0.107	0.169	0.189	0.432	0.000	0.000	0.000	0.000	0.047
1998	0.013	0.027	0.062	0.106	0.168	0.248	0.258	0.604	0.714	0.000	0.000	0.079
1999	0.008	0.017	0.044	0.100	0.124	0.171	0.259	0.295	0.533	0.000	0.000	0.060
2000	0.013	0.018	0.059	0.113	0.152	0.223	0.241	0.454	0.000	0.000	0.000	0.055
2001	0.000	0.018	0.040	0.103	0.129	0.169	0.246	0.411	0.431	0.000	0.000	0.059
2002	0.000	0.022	0.046	0.085	0.163	0.223	0.222	0.318	0.432	0.000	0.000	0.074
2003	0.030	0.024	0.078	0.102	0.141	0.161	0.283	0.137	0.326	1.776	1.725	0.034
2004	0.004	0.018	0.051	0.119	0.251	0.316	0.402	0.705	1.049	1.141	1.148	0.038
2005	0.009	0.017	0.049	0.118	0.151	0.191	0.191	0.000	0.000	0.000	1.628	0.026
2006	0.010	0.029	0.066	0.134	0.229	0.265	0.253	1.001	1.183	1.110	1.183	0.063
2007	0.008	0.029	0.081	0.162	0.243	0.299	0.319	0.266	0.000	0.000	0.000	0.031
2008	0.003	0.029	0.059	0.142	0.202	0.244	0.275	0.330	0.000	0.000	0.000	0.074
2009	0.000	0.036	0.068	0.086	0.110	0.133	0.133	0.000	0.000	0.000	0.000	0.072
2010	0.000	0.031	0.048	0.114	0.113	0.122	0.117	0.000	0.000	0.000	0.000	0.045

Shrimp Discards Mean Length (cm) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Mean
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989	11.5	16.5	22.7	28.2	30.4	29.2	30.2	34.6	37.0	0.0	0.0	21.9
1990	0.0	17.9	22.9	27.1	30.9	32.1	32.2	31.7	38.0	0.0	0.0	23.3
1991	9.0	15.7	22.9	28.7	32.4	35.8	42.8	0.0	38.9	0.0	0.0	25.1
1992	10.0	16.8	21.9	28.1	31.7	36.7	33.5	0.0	47.0	0.0	0.0	22.7
1993	8.3	16.3	23.7	28.6	31.0	35.7	42.1	0.0	0.0	0.0	0.0	19.2
1994	9.1	15.0	22.1	26.8	29.3	26.7	26.0	52.0	52.0	0.0	0.0	15.7
1995	10.1	15.4	21.5	28.5	32.0	34.7	35.9	33.9	0.0	0.0	0.0	16.9
1996	8.6	15.1	19.7	24.8	30.7	33.1	31.1	0.0	41.0	0.0	0.0	19.8
1997	10.3	14.5	20.6	24.0	27.5	28.6	37.0	0.0	0.0	0.0	0.0	17.3
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	16.3	15.4	22.0	23.8	26.2	27.0	32.5	26.2	34.0	56.4	55.3	15.8
2004	8.8	14.1	19.2	24.9	31.0	33.2	34.9	41.8	48.0	49.4	49.1	16.1
2005	11.2	13.9	19.1	24.8	26.7	29.0	29.0	0.0	0.0	0.0	55.0	14.4
2006	11.9	16.2	20.9	25.6	30.4	31.8	31.5	46.3	50.0	48.6	50.0	17.6
2007	10.6	16.2	22.1	27.1	30.7	33.0	33.5	32.0	0.0	0.0	0.0	15.0
2008	8.0	16.3	19.9	26.0	29.2	31.0	32.2	34.1	0.0	0.0	0.0	19.7
2009	0.0	17.5	20.9	22.6	24.5	26.0	26.0	0.0	0.0	0.0	0.0	21.1
2010	0.0	16.4	18.8	24.5	24.5	25.0	25.0	0.0	0.0	0.0	0.0	18.1

Table E8c. Large mesh fishery discards (including small mesh otter trawl, gillnet, and scallop) (thousands of fish; metric tons) mean weight (kg), and mean length (cm), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Large Mesh Discards in Numbers (000's) at Age

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1980	5	99	936	1787	781	30	3	0	0	0	0	3641
1981	4	247	496	437	158	30	20	5	0	0	0	1396
1982	3	335	669	447	102	22	0	0	0	0	0	1577
1983	1	48	400	681	328	53	12	1	3	0	0	1527
1984	0	65	249	549	718	282	16	0	0	0	0	1880
1985	11	55	227	86	31	6	0	0	0	0	0	415
1986	6	86	140	268	66	4	0	0	0	0	0	570
1987	7	136	390	344	241	53	4	2	0	0	0	1177
1988	30	197	607	277	50	6	0	0	0	0	0	1167
1989	15	2342	2662	2218	906	347	94	71	3	1	3	8663
1990	0	1074	4698	3154	1100	238	94	67	0	0	0	10425
1991	0	240	988	4272	2131	163	7	1	1	0	0	7804
1992	10	250	887	1117	1276	119	50	0	0	0	0	3708
1993	22	278	418	1144	531	196	4	0	0	0	0	2593
1994	58	860	213	881	1068	85	3	0	0	0	0	3169
1995	46	2565	1748	2026	610	179	18	16	0	0	0	7209
1996	12	1192	1367	1615	435	142	51	4	3	2	5	4829
1997	15	638	388	1354	1389	247	27	0	0	0	0	4058
1998	0	29	227	686	1391	709	79	1	0	0	0	3121
1999	0	16	112	943	691	780	227	46	2	0	0	2819
2000	0	17	210	495	280	144	54	2	0	0	0	1202
2001	0	8	193	665	485	269	81	22	7	0	7	1739
2002	0	10	94	445	389	152	38	16	10	4	1	1159
2003	12	690	49	202	560	217	33	35	12	1	10	1822
2004	6	138	218	317	473	370	72	15	5	2	1	1616
2005	34	284	107	270	450	213	60	11	1	0	1	1433
2006	29	88	130	365	327	158	71	17	3	6	1	1194
2007	161	238	202	339	221	94	19	5	1	3	0	1284
2008	15	55	109	353	350	110	41	24	2	3	1	1063
2009	1	52	92	324	410	378	159	72	22	1	1	1513
2010	0	496	382	236	425	362	158	31	34	3	0	2126

Large Mesh Discards in Weight (Tons) at Age

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0	8	147	424	218	9	1	0	0	0	0	808
1981	0	22	62	70	27	6	3	1	0	0	0	191
1982	0	42	99	69	19	4	0	0	0	0	0	233
1983	0	4	66	135	70	12	3	0	1	0	0	290
1984	0	7	40	112	173	71	5	0	0	0	0	409
1985	0	5	25	11	5	1	0	0	0	0	0	48
1986	0	6	18	45	12	1	0	0	0	0	0	82
1987	0	11	60	69	59	15	1	0	0	0	0	217
1988	1	13	100	53	11	1	0	0	0	0	0	181
1989	0	84	263	465	235	87	32	28	2	1	3	1200
1990	0	41	525	657	292	68	29	20	0	0	0	1632
1991	0	7	105	1013	662	68	5	1	1	0	0	1862
1992	0	8	86	260	395	43	15	0	0	0	0	807
1993	0	9	68	294	169	68	2	0	0	0	0	609
1994	0	19	30	255	349	26	0	0	0	0	0	681
1995	0	72	187	517	189	68	8	7	0	0	0	1048
1996	0	30	83	228	145	60	20	5	5	4	10	590
1997	0	13	59	351	388	74	10	0	0	0	0	896
1998	0	1	27	152	352	200	21	1	0	0	0	754
1999	0	1	14	207	189	247	79	17	2	0	0	755
2000	0	1	37	121	89	55	23	2	0	0	0	329
2001	0	0	28	169	151	89	28	7	3	0	2	477
2002	0	0	14	97	111	48	12	6	4	2	3	296
2003	0	17	5	39	156	70	12	10	5	1	4	319
2004	0	3	15	51	130	116	27	7	3	1	1	355
2005	0	5	7	54	125	70	20	4	1	0	1	288
2006	0	3	14	80	98	52	25	8	2	3	1	286
2007	1	8	30	85	72	34	10	3	1	1	0	247
2008	0	2	13	78	100	35	15	9	1	2	1	257
2009	0	2	10	64	111	114	53	25	9	1	1	389
2010	0	16	27	54	114	109	50	10	12	1	0	393

Table E8c.-continued. . Large mesh fishery discards (including small mesh otter trawl, gillnet, and scallop) (thousands of fish; metric tons) mean weight (kg), and mean length (cm), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Large Mesh Discards Mean Weight (kg) at Age

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Mean
1980	0.030	0.076	0.157	0.237	0.279	0.311	0.392	0.000	0.000	0.000	0.000	0.222
1981	0.037	0.089	0.124	0.160	0.169	0.189	0.171	0.209	0.000	0.000	0.000	0.136
1982	0.029	0.126	0.148	0.155	0.182	0.173	0.000	0.000	0.000	0.000	0.000	0.147
1983	0.024	0.083	0.165	0.197	0.213	0.228	0.234	0.308	0.229	0.000	0.000	0.190
1984	0.000	0.103	0.162	0.205	0.241	0.253	0.317	0.432	0.000	0.000	0.000	0.217
1985	0.030	0.088	0.112	0.132	0.155	0.168	0.000	0.000	0.000	0.000	0.000	0.115
1986	0.035	0.072	0.128	0.167	0.189	0.171	0.295	0.000	0.000	0.000	0.000	0.144
1987	0.020	0.084	0.154	0.202	0.246	0.286	0.295	0.116	0.000	0.000	0.000	0.184
1988	0.019	0.068	0.165	0.193	0.226	0.262	0.359	0.000	0.000	0.000	0.000	0.155
1989	0.009	0.036	0.099	0.210	0.260	0.250	0.341	0.390	0.822	1.350	1.242	0.139
1990	0.000	0.038	0.111	0.208	0.266	0.284	0.308	0.294	0.472	0.000	0.000	0.156
1991	0.004	0.027	0.106	0.237	0.311	0.415	0.731	0.660	0.666	0.000	0.000	0.238
1992	0.006	0.032	0.097	0.233	0.309	0.365	0.294	0.000	0.962	0.000	0.000	0.218
1993	0.003	0.032	0.162	0.257	0.319	0.345	0.414	0.000	0.000	0.000	0.000	0.235
1994	0.004	0.023	0.142	0.289	0.327	0.307	0.133	1.349	1.349	0.000	0.000	0.215
1995	0.006	0.028	0.107	0.255	0.311	0.376	0.447	0.445	1.258	0.000	0.000	0.145
1996	0.003	0.026	0.061	0.141	0.333	0.423	0.386	1.271	1.661	1.867	2.036	0.122
1997	0.006	0.021	0.152	0.259	0.280	0.301	0.375	0.561	0.000	0.000	0.000	0.221
1998	0.000	0.037	0.120	0.221	0.253	0.282	0.270	0.772	0.000	0.000	0.000	0.242
1999	0.000	0.041	0.120	0.219	0.273	0.317	0.348	0.369	0.855	1.106	0.000	0.268
2000	0.000	0.051	0.178	0.244	0.318	0.381	0.431	0.802	0.714	0.000	0.000	0.273
2001	0.000	0.036	0.145	0.254	0.312	0.329	0.344	0.330	0.370	0.432	0.326	0.274
2002	0.007	0.039	0.148	0.219	0.285	0.315	0.329	0.341	0.370	0.402	1.815	0.256
2003	0.027	0.024	0.096	0.193	0.279	0.322	0.357	0.298	0.379	1.357	0.422	0.175
2004	0.005	0.019	0.067	0.162	0.276	0.315	0.368	0.508	0.690	0.687	0.932	0.220
2005	0.009	0.017	0.061	0.199	0.279	0.329	0.331	0.402	0.823	1.012	1.465	0.201
2006	0.010	0.033	0.108	0.219	0.299	0.331	0.346	0.491	0.859	0.459	1.051	0.240
2007	0.008	0.033	0.151	0.252	0.327	0.362	0.523	0.604	0.738	0.360	1.057	0.192
2008	0.003	0.032	0.124	0.220	0.286	0.320	0.370	0.380	0.793	0.526	1.241	0.242
2009	0.010	0.041	0.105	0.196	0.271	0.301	0.332	0.349	0.400	0.751	0.739	0.257
2010	0.000	0.032	0.070	0.228	0.269	0.300	0.317	0.323	0.355	0.442	1.107	0.185

Large Mesh Discards Mean Length (cm) at Age

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Mean
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989	11.5	17.1	23.4	29.5	31.6	31.0	33.6	35.5	43.9	51.8	50.1	24.6
1990	0.0	17.6	24.1	29.3	31.8	32.5	33.3	32.8	38.0	0.0	0.0	26.2
1991	9.0	15.9	23.9	30.7	33.4	36.2	43.3	42.0	42.0	0.0	0.0	30.2
1992	10.0	16.8	23.1	30.5	33.3	35.1	32.9	0.0	47.0	0.0	0.0	28.9
1993	8.3	16.4	27.2	31.5	33.7	34.5	36.5	0.0	0.0	0.0	0.0	29.7
1994	9.1	15.0	25.7	32.6	34.0	33.2	26.0	52.0	52.0	0.0	0.0	27.4
1995	10.2	15.8	23.8	31.4	33.2	35.2	37.0	36.5	50.8	0.0	0.0	24.2
1996	8.6	15.6	20.1	25.7	33.1	35.9	34.3	50.7	54.8	57.3	58.8	22.7
1997	10.3	14.6	26.1	31.3	32.2	33.1	35.4	40.0	0.0	0.0	0.0	28.6
1998	0.0	17.6	24.6	29.9	31.3	32.3	31.5	44.0	0.0	0.0	0.0	30.6
1999	0.0	18.2	24.5	29.8	31.9	33.3	34.2	34.5	45.0	49.0	0.0	31.5
2000	0.0	19.4	28.1	31.0	33.3	35.2	35.9	44.2	43.0	0.0	0.0	31.6
2001	0.0	17.3	26.1	31.3	33.4	34.0	34.5	34.0	35.3	37.0	34.0	31.9
2002	11.0	17.3	26.2	29.7	32.4	33.4	33.6	33.8	34.7	35.0	56.7	31.0
2003	15.5	15.4	23.3	28.6	32.2	33.7	34.5	32.6	35.2	51.2	34.6	25.4
2004	9.1	14.4	20.8	27.3	32.2	33.4	34.7	38.1	42.2	41.9	45.9	28.6
2005	11.2	14.0	20.4	28.9	32.2	33.9	33.6	35.7	44.5	46.9	52.7	27.0
2006	11.9	16.9	24.0	29.8	33.0	34.0	34.2	37.5	45.2	36.8	48.0	29.7
2007	10.6	16.7	26.5	31.2	33.8	34.8	38.6	40.0	43.2	34.5	48.3	26.1
2008	8.1	16.6	24.1	29.8	32.4	33.6	35.0	35.3	43.8	38.6	50.1	29.9
2009	11.7	17.9	23.4	28.5	31.8	33.0	33.9	34.5	35.9	43.3	43.2	30.8
2010	0.0	16.6	20.3	30.1	31.7	32.9	33.5	33.7	34.8	37.1	47.5	26.4

Table E8d. Total catch (thousands of fish; metric tons) and mean weight (kg), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

Catch in Numbers (000's) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1980	5	99	1072	2672	3939	3933	3632	1185	1139	850	1380	19906
1981	5	982	2192	5056	5338	3649	2401	1582	645	440	621	22912
1982	10	603	3349	4575	4504	3599	3298	2038	1256	737	718	24686
1983	15	663	1478	5174	4915	3910	2269	1271	701	449	911	21756
1984	3	370	991	2422	6031	3244	1936	580	274	307	769	16927
1985	65	158	1217	1336	2405	2872	2228	1081	438	267	182	12250
1986	59	639	738	2284	1700	1476	1307	631	255	105	100	9295
1987	38	590	1840	1439	2282	1337	895	543	187	62	60	9274
1988	314	786	1840	1833	1597	1444	553	270	177	88	55	8957
1989	30	3918	4116	3396	1816	950	865	547	196	104	118	16055
1990	0	1973	7846	4989	2357	771	398	426	193	96	161	19212
1991	1	450	1577	6758	5100	1281	329	167	203	98	105	16068
1992	20	497	1595	2074	6237	2685	866	191	131	118	93	14506
1993	43	554	664	2208	2576	2651	1387	265	287	151	125	10911
1994	116	1741	508	1801	2944	1351	1162	598	235	150	291	10897
1995	88	4646	2459	2788	3486	1917	661	595	211	53	50	16953
1996	25	2075	2082	4619	2898	1567	589	243	127	37	69	14331
1997	29	1265	518	2735	4029	1795	640	182	85	66	116	11461
1998	37	90	359	938	2936	2610	1079	319	60	57	155	8640
1999	4	216	187	1247	1721	2474	1393	490	150	42	79	8004
2000	3	309	515	969	1748	2275	1775	569	138	70	20	8391
2001	0	93	467	1142	2437	2285	1609	922	296	57	53	9360
2002	1	13	112	791	1471	1827	1200	520	285	163	178	6562
2003	22	1356	60	341	1332	1294	733	549	274	151	118	6231
2004	11	248	261	449	943	1228	520	373	200	79	76	4388
2005	68	554	144	469	1055	809	460	184	101	44	51	3938
2006	53	143	150	540	826	565	368	196	101	61	44	3046
2007	321	450	261	657	819	506	230	101	59	26	24	3454
2008	29	104	190	573	909	586	348	177	93	90	61	3159
2009	1	87	139	516	1028	1017	593	434	148	47	90	4100
2010	0	979	735	548	780	1152	694	246	140	107	78	5458

Catch in Weight (Tons) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0	8	165	715	1611	2571	3009	1232	1347	1168	2616	14442
1981	0	106	370	1599	2360	2838	2125	1547	729	552	963	13189
1982	0	69	768	1323	1884	2028	3165	2320	1502	1144	1364	15570
1983	0	22	273	1956	2605	2616	1867	1325	868	650	1530	13712
1984	0	17	160	735	3159	2046	1720	689	310	421	1506	10761
1985	1	9	102	279	796	1534	1887	1263	603	445	387	7306
1986	1	27	102	523	652	867	1101	741	380	183	219	4796
1987	0	27	241	337	934	815	799	637	278	107	137	4312
1988	5	36	293	521	716	927	486	333	247	151	124	3839
1989	0	134	410	773	621	402	590	433	260	152	227	4003
1990	0	77	875	1173	890	407	272	360	210	125	273	4664
1991	0	12	164	1977	2241	865	315	193	258	150	190	6365
1992	0	16	161	613	3042	1940	790	237	173	193	188	7353
1993	0	17	131	764	1226	1660	1308	327	400	238	289	6360
1994	1	42	85	642	1341	820	922	648	303	213	705	5721
1995	1	124	279	825	1666	1202	536	655	281	111	96	5776
1996	0	65	172	1300	1392	978	509	293	176	59	153	5095
1997	0	25	68	899	1628	1056	515	205	114	104	282	4896
1998	1	3	37	229	1015	1301	846	329	80	83	510	4433
1999	0	4	17	312	678	1241	953	427	166	62	151	4013
2000	0	6	95	301	798	1293	1348	572	151	99	37	4701
2001	0	2	39	352	1034	1179	1113	767	309	82	80	4957
2002	0	0	15	233	610	924	802	459	297	199	258	3798
2003	1	32	6	91	498	676	499	449	260	168	147	2828
2004	0	5	19	109	353	596	337	291	194	80	92	2074
2005	1	10	9	135	417	407	295	156	95	47	66	1638
2006	1	5	16	154	338	290	225	160	93	60	57	1398
2007	2	14	43	212	354	267	152	84	59	29	34	1249
2008	0	3	30	165	370	286	204	110	72	65	63	1368
2009	0	3	13	128	396	460	304	241	100	40	95	1781
2010	0	31	57	187	277	520	378	158	90	64	75	1838

Table E8d – continued. Total catch (thousands of fish; metric tons) and mean weight (kg), at age, of American plaice from the Gulf of Maine and Georges Bank stock, 1980-2010. (NAFO Division 5Y and 5Z).

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Mean
						Catch Mean Weight (kg) at Age						
1980	0.030	0.076	0.154	0.267	0.409	0.653	0.829	1.039	1.183	1.374	1.895	0.857
1981	0.032	0.108	0.168	0.316	0.442	0.778	0.885	0.978	1.130	1.254	1.551	0.618
1982	0.018	0.115	0.230	0.290	0.418	0.564	0.960	1.138	1.196	1.552	1.901	0.686
1983	0.013	0.033	0.185	0.378	0.530	0.670	0.823	1.042	1.238	1.446	1.680	0.701
1984	0.004	0.045	0.161	0.303	0.524	0.630	0.888	1.187	1.133	1.369	1.958	0.725
1985	0.018	0.058	0.084	0.209	0.331	0.534	0.847	1.167	1.377	1.665	2.128	0.628
1986	0.016	0.042	0.138	0.229	0.384	0.587	0.842	1.174	1.491	1.747	2.194	0.540
1987	0.013	0.046	0.131	0.234	0.409	0.609	0.892	1.173	1.483	1.732	2.284	0.480
1988	0.016	0.046	0.159	0.284	0.449	0.641	0.880	1.231	1.396	1.717	2.238	0.442
1989	0.009	0.034	0.100	0.227	0.342	0.423	0.682	0.791	1.326	1.462	1.925	0.264
1990	0.000	0.039	0.111	0.235	0.378	0.528	0.685	0.845	1.088	1.305	1.696	0.257
1991	0.004	0.027	0.104	0.292	0.439	0.675	0.958	1.157	1.274	1.541	1.813	0.408
1992	0.006	0.032	0.101	0.296	0.488	0.722	0.912	1.240	1.319	1.640	2.007	0.520
1993	0.003	0.031	0.198	0.346	0.476	0.626	0.943	1.234	1.394	1.577	2.313	0.609
1994	0.004	0.025	0.168	0.356	0.455	0.606	0.793	1.083	1.289	1.424	2.424	0.590
1995	0.006	0.026	0.114	0.296	0.480	0.656	0.901	1.149	1.100	2.105	1.921	0.352
1996	0.003	0.031	0.083	0.281	0.481	0.624	0.863	1.203	1.389	1.582	2.227	0.366
1997	0.006	0.020	0.131	0.329	0.404	0.588	0.803	1.126	1.336	1.570	2.425	0.452
1998	0.013	0.030	0.103	0.244	0.346	0.499	0.785	1.031	1.350	1.463	3.293	0.572
1999	0.008	0.019	0.091	0.250	0.394	0.501	0.685	0.872	1.109	1.458	1.908	0.520
2000	0.013	0.020	0.184	0.310	0.456	0.568	0.760	1.007	1.094	1.411	1.864	0.565
2001	0.000	0.019	0.083	0.308	0.425	0.516	0.692	0.833	1.042	1.454	1.501	0.538
2002	0.002	0.035	0.137	0.294	0.414	0.505	0.668	0.883	1.042	1.223	1.446	0.618
2003	0.029	0.024	0.092	0.268	0.374	0.522	0.682	0.819	0.949	1.108	1.246	0.477
2004	0.004	0.019	0.072	0.242	0.374	0.485	0.647	0.782	0.973	1.009	1.207	0.493
2005	0.009	0.017	0.065	0.288	0.396	0.504	0.641	0.848	0.946	1.073	1.283	0.433
2006	0.010	0.032	0.105	0.284	0.409	0.513	0.612	0.819	0.923	0.977	1.295	0.478
2007	0.008	0.031	0.163	0.324	0.432	0.528	0.660	0.825	0.999	1.104	1.449	0.372
2008	0.003	0.030	0.156	0.287	0.408	0.488	0.586	0.624	0.770	0.722	1.039	0.453
2009	0.010	0.039	0.093	0.248	0.385	0.452	0.512	0.555	0.678	0.858	1.046	0.457
2010	0.000	0.032	0.078	0.342	0.355	0.452	0.544	0.644	0.641	0.605	0.966	0.351

Table E9. Standardized stratified mean catch per tow in numbers and weight (kg) and coefficient of variation (CV) for American plaice in NEFSC offshore spring and autumn and Massachusetts Division of Marine Fisheries inshore spring and autumn research vessel bottom trawl surveys, 1963 - 2011.

	NEFSC Spring				NEFSC Autumn				MADMF			
									Spring		Autumn	
Year	No/Tow	No. CV	Wt/Tow	Wt CV	No/Tow	No. CV	Wt/Tow	Wt. CV	No/Tow	No. CV	No/Tow	Wt. CV
1963	-		-		14.2	15.2	5.7	14.8				
1964	-		-		8.2	14.7	2.8	13.2				
1965	-		-		11.9	14.0	3.8	11.9				
1966	-		-		18.3	16.1	4.9	13.3				
1967	-		-		11.0	23.2	2.7	20.5				
1968	11.2	19.9	3.3	18.0	8.6	16.5	2.9	15.9				
1969	8.3	14.5	2.6	13.7	7.5	17.4	2.2	13.4				
1970	5.4	12.3	1.8	12.6	6.5	14.6	2.0	13.3				
1971	3.8	14.1	1.3	16.4	7.5	17.7	2.0	18.9				
1972	4.3	11.0	1.3	12.7	7.4	15.3	1.6	12.6				
1973	7.2	12.7	1.9	13.5	6.2	10.4	1.9	14.5				
1974	8.3	26.7	1.9	19.0	6.9	25.6	1.4	21.1				
1975	5.8	14.9	1.7	13.7	8.1	11.0	2.4	10.2				
1976	11.9	13.8	3.4	11.2	10.0	18.9	3.0	13.1				
1977	14.6	11.9	5.1	19.9	11.8	9.6	3.5	9.4				
1978	10.6	10.7	3.8	10.7	15.1	9.2	4.7	10.4				
1979	9.2	8.5	3.5	10.7	10.0	8.4	4.0	9.8				
1980	18.3	16.5	4.8	10.4	14.2	10.8	5.1	11.7				
1981	18.7	11.5	5.9	12.0	13.0	11.8	5.6	13.2				
1982	11.6	16.8	3.8	14.4	5.9	16.0	2.5	16.4	116.0	17.4	46.2	25.1
1983	16.9	27.1	4.6	14.9	9.3	14.3	3.4	14.2	78.4	35.3	92.7	20.7
1984	4.1	18.1	1.4	11.8	7.1	20.8	2.0	13.6	67.7	23.4	23.7	35.0
1985	4.9	11.4	1.9	11.3	6.9	14.7	2.0	12.7	80.1	35.2	86.4	16.4
1986	3.1	20.6	0.9	15.9	5.6	24.6	1.6	15.7	182.5	31.5	99.5	27.9
1987	3.5	15.8	0.8	14.1	4.4	13.4	1.1	12.3	73.7	28.6	65.6	30.3
1988	3.6	19.9	0.8	15.1	9.7	32.0	1.5	18.1	173.7	33.3	161.6	27.6
1989	4.8	16.8	0.7	15.1	9.2	22.2	1.2	16.7	200.4	33.4	213.4	27.0
1990	5.1	22.6	0.8	13.4	15.5	17.2	2.9	13.3	110.6	20.6	70.6	21.4
1991	5.9	18.7	1.0	15.2	7.7	13.3	1.6	9.7	79.3	22.5	167.7	32.5
1992	4.1	12.9	1.4	12.7	6.3	19.8	1.8	16.2	77.2	37.0	101.7	17.7
1993	5.3	14.7	1.4	12.8	11.9	18.5	2.4	14.6	60.1	22.0	139.8	24.2
1994	4.9	17.1	0.9	13.0	18.1	23.4	2.7	16.1	118.5	39.1	131.6	15.5
1995	9.4	19.5	1.9	12.3	11.8	15.5	2.6	14.5	99.2	22.7	86.2	21.5
1996	7.8	16.7	1.7	12.1	7.6	15.2	2.2	19.4	61.0	21.0	78.9	15.7
1997	7.6	37.7	1.6	22.9	6.3	15.2	1.9	16.0	55.8	34.0	71.5	16.5
1998	4.5	13.6	1.1	10.8	9.3	16.7	2.2	13.7	39.5	30.6	66.1	23.9
1999	4.2	16.6	1.2	15.7	11.0	18.8	2.6	18.7	53.3	53.0	97.1	23.3
2000	10.0	20.6	2.3	17.1	12.2	25.2	2.8	21.9	136.9	28.8	61.8	17.9
2001	10.6	17.4	2.2	13.3	10.4	22.5	2.6	20.0	54.2	22.7	61.1	8.0
2002	6.7	10.5	1.8	11.0	9.7	20.8	2.2	21.3	48.6	22.5	80.9	19.2
2003	4.2	13.8	0.9	11.5	9.3	22.7	2.3	32.1	106.0	20.7	84.0	25.1
2004	8.2	28.4	1.4	22.3	5.4	12.1	1.0	17.2	86.0	26.8	99.5	26.5
2005	5.0	34.9	0.8	36.6	5.8	17.4	1.0	21.1	67.0	30.6	128.4	21.1
2006	7.4	18.4	1.0	15.8	12.5	20.9	1.7	15.3	116.6	23.3	98.1	27.3
2007	10.0	15.0	1.3	14.4	11.0	22.4	1.4	19.1	119.9	31.1	67.6	23.9
2008	8.1	14.5	1.5	12.8	14.4	16.2	2.1	14.2	71.5	18.9	52.6	18.7
2009	6.6	16.3	1.0	14.4	8.0	19.9	1.4	18.1	119.8	39.3	52.0	17.9
2010	7.1	18.9	1.2	18.0	7.2	16.4	1.5	17.0	53.3	16.3	51.7	15.1
2011	5.6	15.7	1.0	17.4					49.0	37.1	82.4	25.5
1963-201	7.7	17.3	2.0	14.8	9.7	17.3	2.5	15.6	91.9	28.6	90.7	22.3

Table E10a. Standardized stratified mean number per tow by age and mean weight per tow (kg) of American plaice in the NEFSC spring research bottom trawl survey in the Gulf of Maine and Georges Bank area (offshore strata 13-30, 36-40) , 1980-2011.

Spring

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	no/tow
1980	0	0.45	3.69	4.55	3.05	2.93	1.61	1.14	0.26	0.31	0.23	0.04	0.04	0.03	0.01	18.34
1981	0	0.13	3.43	4.21	3.46	2.61	1.69	1.41	0.77	0.40	0.32	0.07	0.09	0.07	0.09	18.75
1982	0	0.03	1.05	1.79	3.17	2.13	1.33	0.92	0.50	0.35	0.19	0.07	0.02	0.05	0.01	11.61
1983	0	0.20	3.68	3.33	4.48	2.64	1.18	0.58	0.32	0.15	0.15	0.11	0.05	0.02	0.04	16.93
1984	0	0.01	0.35	0.56	0.90	1.29	0.58	0.22	0.10	0.01	0.02	0.01	0.01	0.00	0.04	4.10
1985	0	0.03	0.32	0.98	0.86	0.73	0.86	0.46	0.42	0.12	0.07	0.04	0.02	0.02	0.02	4.95
1986	0	0.01	0.46	0.34	1.01	0.59	0.29	0.21	0.10	0.04	0.04	0	0	0	0	3.09
1987	0	0.09	0.61	0.99	0.69	0.51	0.25	0.17	0.07	0.03	0.03	0.03	0.01	0	0	3.48
1988	0	0.20	0.99	0.84	0.76	0.31	0.23	0.12	0.01	0.09	0.01	0.01	0	0	0	3.57
1989	0	0.05	1.59	1.27	0.86	0.49	0.29	0.16	0.03	0.07	0.01	0.01	0	0	0	4.83
1990	0	0.00	0.57	2.65	1.02	0.54	0.17	0.06	0.04	0.05	0	0	0	0	0	5.10
1991	0	0.03	0.71	1.63	2.33	0.92	0.15	0.07	0.04	0.02	0	0.02	0	0	0.01	5.93
1992	0	0.06	0.34	1.15	0.88	1.07	0.43	0.11	0.04	0.02	0.01	0	0.01	0	0.00	4.12
1993	0	0.33	0.84	1.16	1.58	0.61	0.45	0.17	0.08	0.02	0.01	0.02	0.03	0	0.00	5.30
1994	0	0.03	1.43	1.14	1.12	0.75	0.23	0.10	0.03	0.01	0	0.01	0.01	0.01	0.01	4.88
1995	0	0.03	1.97	3.21	2.30	1.11	0.44	0.22	0.03	0.04	0.03	0.01	0.02	0.01	0.01	9.43
1996	0	0.02	0.47	1.94	3.30	1.31	0.53	0.20	0.05	0.02	0	0	0.00	0	0	7.84
1997	0	0.01	0.85	1.66	2.52	2.05	0.39	0.09	0.01	0	0.01	0	0.02	0	0	7.61
1998	0	0.06	0.19	1.02	1.12	1.22	0.68	0.16	0.06	0.01	0.01	0	0.01	0	0	4.54
1999	0	0.08	0.41	0.52	1.13	0.79	0.64	0.41	0.17	0.02	0.02	0	0.00	0	0	4.19
2000	0	0.03	1.91	2.48	2.22	1.60	0.86	0.60	0.15	0.07	0.02	0	0.01	0	0	9.95
2001	0	0.00	0.71	3.67	3.37	1.45	0.75	0.37	0.17	0.09	0.05	0.02	0	0	0	10.65
2002	0	0.10	0.35	0.98	2.35	1.66	0.51	0.33	0.20	0.14	0.07	0.01	0	0	0	6.70
2003	0	0.04	0.76	0.27	0.70	1.24	0.64	0.22	0.10	0.09	0.04	0.03	0.01	0.02	0	4.17
2004	0	0.36	0.87	2.03	1.79	1.33	1.14	0.34	0.10	0.18	0	0.01	0.02	0	0	8.16
2005	0	0.20	0.78	1.04	1.23	0.91	0.50	0.24	0.12	0	0.02	0	0	0	0	5.02
2006	0	0.76	1.62	1.71	1.70	0.84	0.32	0.30	0.11	0.02	0.02	0.01	0	0.01	0	7.42
2007	0	0.25	3.74	2.78	1.61	1.02	0.33	0.14	0.07	0.01	0.02	0.01	0	0	0	9.97
2008	0	0.11	0.58	2.04	2.85	1.41	0.65	0.22	0.09	0.06	0.04	0.02	0.00	0.00	0.01	8.06
2009	0	0.35	1.81	0.52	1.65	1.37	0.69	0.34	0.12	0.03	0.01	0.02	0.00	0.00	0.00	6.90
2010	0	0.13	1.49	1.75	0.93	1.34	0.90	0.34	0.13	0.09	0.03	0.00	0.01	0.00	0.00	7.14
2011	0	0.28	0.63	1.12	0.80	0.88	0.63	0.59	0.35	0.19	0.09	0.02	0.00	0.00	0.00	5.59
Average 1980-2011	0.00	0.15	0.98	1.48	1.56	1.05	0.52	0.25	0.11	0.09	0.06	0.03	0.02	0.02	0.02	7.45

Table E10b. Standardized stratified mean number per tow by age and mean weight per tow (kg) of American plaice in the NEFSC autumn research bottom trawl survey in the Gulf of Maine and Georges Bank area (offshore strata 13-30, 36-40) , 1980-2010..

Autumn

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	no/tow
1980	0.00	1.58	2.23	2.72	2.84	1.53	1.02	0.93	0.57	0.30	0.19	0.11	0.04	0.09	0.09	14.24
1981	0.00	0.44	2.64	2.16	2.48	2.16	1.44	0.59	0.53	0.06	0.16	0.15	0.02	0.02	0.16	13.04
1982	0.00	0.20	0.91	1.65	1.27	0.57	0.48	0.30	0.17	0.19	0.08	0.03	0.00	0.00	0.02	5.87
1983	0.06	0.50	1.01	2.02	2.92	1.36	0.68	0.34	0.17	0.10	0.03	0.05	0.06	0.01	0.03	9.34
1984	0.02	0.22	2.24	1.56	1.21	1.07	0.51	0.12	0.10	0.00	0.03	0.01	0.02	0.00	0.01	7.12
1985	0.02	0.91	0.83	2.64	1.05	0.79	0.41	0.19	0.05	0.03	0.02	0.00	0.00	0.01	0.00	6.95
1986	0.10	0.51	1.46	0.87	1.43	0.47	0.42	0.16	0.11	0.04	0.01	0.02	0.01	0.00	0.00	5.61
1987	0.01	0.53	1.27	0.99	0.43	0.69	0.25	0.10	0.04	0.04	0.01	0.02	0.00	0.00	0.00	4.38
1988	0.00	2.84	2.97	2.39	0.78	0.47	0.10	0.07	0.00	0.03	0.00	0.02	0.00	0.00	0.00	9.67
1989	0.05	0.48	4.45	2.86	0.98	0.19	0.10	0.02	0.02	0.02	0.02	0.00	0.01	0.02	0.00	9.22
1990	0.01	1.71	2.26	7.49	2.89	0.59	0.25	0.12	0.07	0.02	0.02	0.01	0.01	0.01	0.00	15.46
1991	0.01	0.47	2.47	2.02	1.59	0.73	0.29	0.04	0.06	0.00	0.01	0.00	0.00	0.00	0.01	7.70
1992	0.02	0.65	1.23	1.85	1.28	0.78	0.30	0.07	0.05	0.03	0.02	0.00	0.02	0.00	0.00	6.30
1993	0.01	1.70	2.34	3.47	2.28	1.05	0.80	0.11	0.04	0.04	0.04	0.00	0.00	0.00	0.00	11.88
1994	0.04	3.83	7.53	2.81	1.71	1.30	0.40	0.25	0.13	0.01	0.03	0.02	0.00	0.00	0.00	18.06
1995	0.01	0.50	3.80	3.82	2.50	0.90	0.22	0.04	0.03	0.00	0.00	0.00	0.02	0.00	0.00	11.84
1996	0.01	0.54	0.81	2.00	2.74	0.93	0.39	0.07	0.04	0.03	0.00	0.00	0.02	0.00	0.02	7.60
1997	0.01	0.36	1.06	1.55	1.86	1.04	0.32	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.02	6.28
1998	0.01	1.73	0.60	1.88	2.01	1.78	1.08	0.12	0.05	0.01	0.01	0.00	0.01	0.00	0.00	9.29
1999	0.02	2.00	2.20	2.05	2.13	1.60	0.81	0.20	0.03	0.00	0.00	0.00	0.00	0.00	0.00	11.04
2000	0.03	0.47	2.90	3.91	2.28	1.35	0.75	0.33	0.14	0.03	0.03	0.00	0.00	0.00	0.00	12.22
2001	0.02	0.40	1.22	3.31	2.64	1.46	0.53	0.41	0.20	0.17	0.02	0.00	0.01	0.00	0.00	10.39
2002	0.05	1.00	0.77	1.30	3.36	1.73	0.53	0.39	0.29	0.17	0.06	0.02	0.02	0.00	0.00	9.69
2003	0.03	0.70	2.26	1.26	1.76	1.74	0.88	0.35	0.13	0.06	0.08	0.01	0.00	0.03	0.00	9.29
2004	0.01	0.70	0.96	1.19	0.98	0.73	0.50	0.19	0.09	0.03	0.00	0.02	0.00	0.00	0.00	5.42
2005	0.00	0.69	1.65	0.72	1.17	0.75	0.43	0.15	0.10	0.08	0.04	0.00	0.01	0.00	0.00	5.77
2006	0.03	2.04	2.54	2.61	2.57	1.41	0.57	0.44	0.16	0.03	0.04	0.00	0.00	0.01	0.00	12.46
2007	0.02	1.08	3.45	2.83	2.19	0.85	0.42	0.15	0.02	0.02	0.00	0.00	0.00	0.00	0.00	11.02
2008	0.03	2.02	1.74	4.78	2.92	1.46	0.88	0.43	0.06	0.07	0.02	0.03	0.00	0.00	0.00	14.44
2009	0.03	1.64	2.16	1.21	1.42	1.15	0.38	0.10	0.04	0.03	0.03	0.00	0.00	0.00	0.00	8.18
2010	0.11	1.00	1.65	1.12	0.87	1.22	0.72	0.35	0.09	0.05	0.06	0.00	0.02	0.00	0.00	7.25
Average	0.02	1.08	2.12	2.36	1.89	1.09	0.54	0.23	0.12	0.06	0.04	0.04	0.02	0.02	0.05	9.58

Table 10c. Stratified mean number per tow by age of American plaice in Massachusetts DMR spring and autumn bottom trawl surveys in Massachusetts Bay and Cape Cod Bay (Regions 4+5), 1982-2011.

					Age								Total
Year	0	1	2	3	4	5	6	7	8	9	10	11	#/tow
Spring													
1982	0.00	7.18	49.25	33.35	17.14	5.00	2.42	1.12	0.26	0.15	0.03	0.07	115.97
1983	0.00	1.93	18.76	22.42	21.46	10.22	2.37	0.73	0.20	0.19	0.06	0.10	78.44
1984	0.00	2.15	27.44	21.32	10.57	4.64	1.21	0.18	0.09	0.01	0.03	0.07	67.71
1985	0.00	21.56	17.16	24.22	9.50	3.77	2.24	0.65	0.76	0.12	0.04	0.03	80.05
1986	0.00	27.06	110.27	26.91	14.43	2.84	0.61	0.05	0.08	0.06	0.00	0.16	182.47
1987	0.00	34.36	17.26	15.79	3.90	1.76	0.51	0.10	0.02	0.00	0.00	0.00	73.70
1988	0.00	81.47	63.57	17.85	8.72	1.54	0.47	0.09	0.00	0.00	0.00	0.00	173.71
1989	0.00	8.07	127.26	44.97	11.99	3.03	1.31	0.20	0.03	0.03	0.00	0.05	196.94
1990	0.00	7.73	25.37	56.71	16.48	3.43	0.53	0.11	0.10	0.13	0.00	0.00	110.59
1991	0.00	2.10	19.98	34.77	18.98	3.24	0.18	0.07	0.01	0.00	0.00	0.00	79.33
1992	0.00	8.20	11.06	33.98	14.99	7.42	1.11	0.45	0.00	0.00	0.00	0.00	77.21
1993	0.00	11.60	18.98	16.08	9.16	3.45	0.81	0.04	0.02	0.00	0.00	0.00	60.14
1994	0.00	11.60	52.57	22.12	7.13	3.88	1.03	0.31	0.00	0.00	0.00	0.00	98.64
1995	0.00	0.54	34.65	49.64	10.32	3.16	0.62	0.17	0.03	0.05	0.02	0.00	99.20
1996	0.00	2.29	4.14	14.92	31.39	6.33	1.01	0.77	0.01	0.00	0.00	0.00	60.86
1997	0.00	1.55	7.96	13.95	17.24	12.21	2.41	0.21	0.00	0.00	0.00	0.00	55.52
1998	0.00	2.83	4.33	11.45	7.53	8.93	3.95	0.49	0.00	0.03	0.00	0.00	39.54
1999	0.00	1.35	11.65	11.65	15.11	7.57	3.96	1.62	0.35	0.01	0.00	0.00	53.27
2000	0.00	3.45	56.51	34.86	19.98	13.29	4.95	3.64	0.17	0.03	0.00	0.00	136.88
2001	0.00	0.07	4.75	23.71	17.03	4.74	2.18	0.95	0.48	0.15	0.10	0.03	54.19
2002	0.00	6.26	4.15	10.77	18.59	5.93	1.49	0.78	0.38	0.21	0.07	0.00	48.63
2003	0.00	5.15	44.88	12.38	18.27	17.82	4.37	0.95	1.64	0.25	0.01	0.28	106.02
2004	0.00	16.50	11.84	33.91	13.07	5.67	3.67	0.88	0.18	0.19	0.06	0.00	85.95
2005	0.00	6.66	21.04	22.93	8.24	4.80	1.98	0.98	0.35	0.00	0.00	0.02	66.99
2006	0.00	4.74	54.23	35.00	14.21	4.94	1.90	1.25	0.25	0.00	0.03	0.00	116.55
2007	0.00	2.53	48.78	42.88	15.77	7.45	1.39	0.73	0.18	0.01	0.14	0.04	119.89
2008	0.00	2.64	6.86	24.85	23.84	8.28	2.89	0.89	0.24	0.07	0.01	0.05	70.62
2009	0.00	2.25	31.79	15.77	17.06	14.95	4.21	1.68	0.68	0.13	0.01	0.11	88.64
2010	0.00	0.26	9.86	16.02	5.51	8.34	4.00	1.25	0.40	0.18	0.05	0.01	45.87
2011	0.00	0.82	4.31	8.70	8.33	5.64	4.75	3.60	1.59	0.36	0.35	0.10	38.53
Autumn													
1982	0.17	13.24	15.46	10.22	5.11	1.14	0.56	0.14	0.05	0.05	0.01	0.08	46.23
1983	1.29	52.17	18.98	10.02	8.30	1.39	0.32	0.15	0.05	0.06	0.00	0.01	92.74
1984	0.11	3.14	13.24	4.27	1.83	0.77	0.24	0.04	0.05	0.00	0.00	0.00	23.69
1985	0.00	60.97	9.45	14.21	1.56	0.14	0.03	0.02	0.00	0.00	0.00	0.00	86.38
1986	0.23	41.27	40.08	12.07	5.30	0.39	0.13	0.01	0.00	0.00	0.00	0.00	99.48
1987	0.24	46.36	14.60	3.00	0.52	0.23	0.07	0.01	0.04	0.00	0.00	0.00	65.07
1988	0.00	85.63	41.28	13.98	1.34	0.45	0.08	0.00	0.00	0.00	0.00	0.00	142.76
1989	0.03	57.56	122.25	31.03	2.33	0.13	0.01	0.01	0.00	0.00	0.00	0.00	213.35
1990	0.08	31.99	14.20	20.12	3.93	0.21	0.03	0.00	0.00	0.00	0.00	0.00	70.56
1991	0.04	24.07	90.36	40.05	11.51	1.17	0.14	0.00	0.00	0.00	0.00	0.00	167.34
1992	0.00	46.33	12.99	29.79	11.04	1.38	0.00	0.00	0.12	0.00	0.00	0.00	101.66
1993	0.00	76.21	36.80	17.59	6.85	1.71	0.69	0.00	0.00	0.00	0.00	0.00	139.84
1994	0.00	36.71	79.31	10.76	2.91	1.56	0.23	0.14	0.00	0.00	0.00	0.00	131.62
1995	0.00	11.84	44.22	24.93	4.21	0.91	0.08	0.00	0.00	0.00	0.00	0.00	86.19
1996	0.09	16.25	19.25	27.55	13.96	1.39	0.28	0.00	0.00	0.00	0.00	0.00	78.78
1997	0.00	13.61	28.08	17.91	10.29	1.46	0.19	0.01	0.00	0.00	0.00	0.00	71.55
1998	0.16	34.56	6.12	13.80	7.10	3.76	0.62	0.01	0.00	0.00	0.00	0.00	66.13
1999	0.00	29.23	32.57	20.61	10.58	2.85	1.20	0.41	0.00	0.00	0.00	0.00	97.45
2000	0.03	6.26	25.67	19.42	6.01	2.99	1.07	0.35	0.03	0.02	0.00	0.00	61.85
2001	0.00	3.01	14.71	30.81	9.07	2.67	0.26	0.36	0.15	0.02	0.00	0.00	61.06
2002	0.17	39.31	9.37	11.78	14.88	3.72	0.78	0.41	0.28	0.10	0.02	0.00	80.87
2003	0.00	23.98	33.08	14.24	7.58	4.00	0.39	0.58	0.07	0.04	0.01	0.00	83.98
2004	0.00	60.02	19.10	9.96	6.31	2.74	1.03	0.18	0.08	0.00	0.00	0.08	99.50
2005	0.00	41.42	54.52	14.74	11.65	4.22	1.43	0.20	0.18	0.06	0.00	0.03	128.44
2006	0.00	14.51	45.14	20.80	10.88	4.13	1.38	1.03	0.14	0.04	0.08	0.00	98.14
2007	0.07	7.95	24.53	19.24	10.82	2.79	1.61	0.43	0.08	0.06	0.00	0.02	67.60
2008	0.00	4.72	10.22	13.48	16.33	7.06	2.36	0.81	0.21	0.05	0.00	0.00	55.24
2009	0.00	1.96	11.32	10.57	16.34	8.12	1.88	0.75	0.37	0.02	0.00	0.00	51.33
2010	0.00	0.88	7.82	11.61	5.17	7.75	3.88	1.03	0.38	0.19	0.04	0.01	38.76

Table E11. Results of VPA bridge runs A) from the GARM III accepted model, B) GARM III formulation run in the latest version of VPA/ADAPT, C) run B updated with terminal year 2007 revised catch at age, and D) run C updated catch at age and surveys to terminal year 2011 .

	A	B	C	D
	GARM III Accepted no split	2012 GARM III rerun	2012 GARM III run revised input	2012 TY 2010
RSS	383.74	300.043	300.49	368.625

age	A stk pred	A std err	A cv	A F	B stk pred	B std err	B cv	B F2007	C stk pred	C std err	C cv	C F2007	D stk pred	D std err	D cv	D F2010
1	42084	27453	0.65	0.01	42084	27453	0.65	0.01	26216	12067	0.46	0.02	20748	10020	0.48	0.00
2	19085	5593	0.29	0.01	19085	5593	0.29	0.01	16955	4537	0.27	0.01	6241	1742	0.28	0.07
3	34216	7492	0.22	0.01	34216	7492	0.22	0.01	33863	7038	0.21	0.01	11428	2583	0.23	0.06
4	23148	4236	0.18	0.03	23148	4236	0.18	0.03	24454	4305	0.18	0.04	11089	2120	0.19	0.07
5	15759	2590	0.16	0.10	15759	2590	0.16	0.10	16371	2616	0.16	0.10	6771	1169	0.17	0.05
6	7052	1133	0.16	0.07	7052	1133	0.16	0.07	7343	1181	0.16	0.06	12858	2067	0.16	0.11
7	6866	1058	0.15	0.11	6866	1058	0.15	0.11	7020	1096	0.16	0.12	8705	1426	0.16	0.10
8	1632	331	0.20	0.05	1632	331	0.20	0.05	1675	342	0.20	0.05	5738	985	0.17	0.08
9	1801	358	0.20	0.03	1801	358	0.20	0.03	1859	368	0.20	0.02	2598	505	0.19	0.04
10	2375	444	0.19	0.06	2375	444	0.19	0.06	2436	452	0.19	0.06	2770	503	0.18	0.09

	A			B			C			D		
	2007 F6-9	SSB		2007 F6-9	SSB		2007 F6-9	SSB		2012 F6-9	SSB	Age1
	0.06	15659		0.06	15659		0.06	15471		0.09	17642	
Mohn's Rho	-0.31	0.41								-0.35	0.63	1.24
										1.54	0.61	0.45

INDEX	A Catchabilit	A Std. Err	A CV	B Catchability	B Std. Err	B CV	C Catchabilit	C Std. Err	C CV	D Catchabilit	D Std. Err	D CV
spr_us_1	0.008	0.001	0.19	0.008	0.001	0.19	0.007	0.001	0.19	0.009	0.002	0.21
spr_us_2	0.118	0.013	0.11	0.118	0.013	0.11	0.112	0.013	0.11	0.129	0.016	0.12
spr_us_3	0.237	0.023	0.10	0.237	0.023	0.10	0.226	0.022	0.10	0.239	0.023	0.10
spr_us_4	0.345	0.028	0.08	0.345	0.028	0.08	0.332	0.027	0.08	0.338	0.026	0.08
spr_us_5	0.332	0.023	0.07	0.332	0.023	0.07	0.324	0.023	0.07	0.333	0.024	0.07
spr_us_6	0.271	0.020	0.07	0.271	0.020	0.07	0.267	0.020	0.07	0.269	0.021	0.08
spr_us_7	0.239	0.022	0.09	0.239	0.022	0.09	0.238	0.023	0.09	0.244	0.022	0.09
spr_us_8	0.178	0.024	0.14	0.178	0.024	0.14	0.179	0.025	0.14	0.182	0.023	0.13
spr_us_9+	0.183	0.028	0.15	0.183	0.028	0.15	0.185	0.028	0.15	0.184	0.025	0.14
us1aut	0.107	0.012	0.12	0.107	0.012	0.12	0.101	0.012	0.12	0.121	0.016	0.13
us2aut	0.300	0.026	0.09	0.300	0.026	0.09	0.285	0.024	0.08	0.314	0.026	0.08
us3aut	0.455	0.040	0.09	0.455	0.040	0.09	0.437	0.038	0.09	0.456	0.037	0.08
us4aut	0.545	0.041	0.07	0.545	0.041	0.07	0.532	0.040	0.08	0.535	0.043	0.08
us5aut	0.521	0.045	0.09	0.521	0.045	0.09	0.515	0.045	0.09	0.512	0.045	0.09
us6aut	0.461	0.045	0.10	0.461	0.045	0.10	0.459	0.046	0.10	0.458	0.046	0.10
us7aut	0.328	0.042	0.13	0.328	0.042	0.13	0.329	0.042	0.13	0.328	0.044	0.13
us8paut	0.310	0.044	0.14	0.310	0.044	0.14	0.313	0.044	0.14	0.301	0.043	0.14
spr_ma_1	0.042	0.010	0.24	0.042	0.010	0.24	0.039	0.009	0.23	0.037	0.008	0.22
spr_ma_2	0.234	0.037	0.16	0.234	0.037	0.16	0.212	0.033	0.15	0.225	0.032	0.14
spr_ma_3	0.319	0.025	0.08	0.319	0.025	0.08	0.295	0.023	0.08	0.305	0.022	0.07
spr_ma_4	0.229	0.018	0.08	0.229	0.018	0.08	0.220	0.017	0.08	0.223	0.018	0.08
spr_ma_5	0.128	0.013	0.10	0.128	0.013	0.10	0.125	0.012	0.09	0.134	0.013	0.10
ma1aut	0.266	0.040	0.15	0.266	0.040	0.15	0.250	0.036	0.15	0.219	0.037	0.17
ma2aut	0.341	0.039	0.12	0.341	0.039	0.12	0.323	0.036	0.11	0.322	0.035	0.11
ma3aut	0.271	0.030	0.11	0.271	0.030	0.11	0.260	0.029	0.11	0.266	0.028	0.10
ma4aut	0.140	0.019	0.14	0.140	0.019	0.14	0.137	0.019	0.14	0.149	0.020	0.13
ma5aut	0.054	0.010	0.19	0.054	0.010	0.19	0.053	0.010	0.19	0.062	0.012	0.19

Table E12. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and percent mature of Gulf of Maine-Georges Bank American plaice, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1980-2010.

Stock Numbers (Jan 1) in thousands

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	50232	25903	20906	24864	15983	19961	26410	47524	63586	24530	24478	24216	27203	44903	44324
2	39485	41122	21203	17108	20344	13084	16284	21570	38875	51776	20056	20039	19824	22254	36724
3	32630	32238	32781	16815	13409	16322	10570	12756	17127	31119	38857	14642	16000	15782	17720
4	24058	25748	24417	23820	12434	10084	12265	7988	8786	12364	21770	24755	10566	11662	12322
5	19252	17289	16531	15874	14849	8001	7052	7986	5245	5544	7074	13338	14199	6785	7561
6	13956	12219	9366	9490	8587	6762	4393	4246	4490	2861	2911	3679	6355	6051	3248
7	9946	7895	6729	4446	4272	4125	2968	2273	2277	2381	1490	1690	1863	2802	2585
8	4677	4890	4309	2568	1618	1769	1394	1262	1060	1368	1175	863	1088	752	1058
9	3005	2764	2585	1709	969	805	488	577	548	625	630	580	556	719	378
10	2776	1441	1683	995	772	547	269	173	304	290	336	342	293	338	332
11+	4509	2034	1639	2018	1933	373	256	168	191	331	563	367	233	279	644
Total	204526	173543	142149	119707	95169	81832	82349	106522	142488	133188	119339	104510	98179	112327	126897

AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	28017	24976	21205	16448	19906	10803	14785	27477	21577	33402	36719	38879	16890	21564	18368	7623
2	36185	22859	20426	17335	13433	16294	8843	12104	22494	17645	27338	30001	31783	13538	17629	15037
3	28496	25439	16844	15582	14111	10802	13061	7156	9898	17193	14223	21882	24434	25616	10990	14355
4	14050	21113	18950	13323	12433	11384	8379	10272	5757	8049	13840	11515	17780	19769	20801	8873
5	8466	8995	13132	13052	10062	9055	8446	5832	7697	4406	6184	10909	8940	13965	15668	16565
6	3555	3814	4765	7137	8046	6689	5841	4728	3453	5102	2760	4114	8186	6581	10613	11900
7	1451	1204	1721	2294	3506	4368	3437	2737	2235	1668	3074	1534	2859	6245	4859	7773
8	1079	597	460	835	915	1623	1988	1377	1169	1173	899	2103	925	2134	4800	3444
9	334	354	271	214	399	313	820	805	662	467	626	570	1545	666	1588	3538
10	101	87	176	146	121	192	133	405	403	297	204	422	376	1212	461	1166
11+	95	161	309	397	227	54	125	445	314	283	238	304	339	820	897	1047
Total	121829	109598	98259	86762	83158	71578	65857	73338	75659	89686	106104	122232	114059	112111	106676	91322

Fishing Mortality

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.03	0.03	0.04	0.02	0.01	0.04	0.03	0.02	0.09	0.11	0.03	0.03	0.03	0.05
3	0.04	0.08	0.12	0.10	0.08	0.09	0.08	0.17	0.13	0.16	0.25	0.13	0.12	0.05	0.03
4	0.13	0.24	0.23	0.27	0.24	0.16	0.23	0.22	0.26	0.36	0.29	0.36	0.24	0.23	0.18
5	0.25	0.41	0.36	0.41	0.59	0.40	0.31	0.38	0.41	0.44	0.45	0.54	0.65	0.54	0.55
6	0.37	0.40	0.55	0.60	0.53	0.62	0.46	0.42	0.43	0.45	0.34	0.48	0.62	0.65	0.61
7	0.51	0.41	0.76	0.81	0.68	0.89	0.66	0.56	0.31	0.51	0.35	0.24	0.71	0.77	0.67
8	0.33	0.44	0.72	0.78	0.50	1.09	0.68	0.63	0.33	0.58	0.51	0.24	0.21	0.49	0.95
9	0.53	0.30	0.75	0.59	0.37	0.90	0.84	0.44	0.44	0.42	0.41	0.48	0.30	0.57	1.12
10	0.41	0.41	0.65	0.68	0.57	0.76	0.56	0.49	0.38	0.50	0.38	0.37	0.58	0.67	0.68
11+	0.41	0.41	0.65	0.68	0.57	0.76	0.56	0.49	0.38	0.50	0.38	0.37	0.58	0.67	0.68
F6-9	0.44	0.38	0.70	0.69	0.52	0.87	0.66	0.51	0.38	0.49	0.40	0.36	0.46	0.62	0.84

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
2	0.15	0.11	0.07	0.01	0.02	0.02	0.01	0.00	0.07	0.02	0.02	0.01	0.02	0.01	0.01	0.07
3	0.10	0.09	0.03	0.03	0.01	0.05	0.04	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.06
4	0.25	0.27	0.17	0.08	0.12	0.10	0.16	0.09	0.07	0.06	0.04	0.05	0.04	0.03	0.03	0.07
5	0.60	0.44	0.41	0.28	0.21	0.24	0.38	0.32	0.21	0.27	0.21	0.09	0.11	0.07	0.08	0.05
6	0.88	0.60	0.53	0.51	0.41	0.47	0.56	0.55	0.53	0.31	0.39	0.16	0.07	0.10	0.11	0.11
7	0.69	0.76	0.52	0.72	0.57	0.59	0.71	0.65	0.44	0.42	0.18	0.31	0.09	0.06	0.14	0.10
8	0.91	0.59	0.57	0.54	0.87	0.48	0.70	0.53	0.72	0.43	0.25	0.11	0.13	0.10	0.10	0.08
9	1.15	0.50	0.42	0.37	0.53	0.66	0.50	0.49	0.60	0.63	0.19	0.22	0.04	0.17	0.11	0.04
10	0.84	0.63	0.53	0.56	0.48	0.51	0.63	0.58	0.53	0.35	0.27	0.17	0.08	0.09	0.12	0.09
11+	0.84	0.63	0.53	0.56	0.48	0.51	0.63	0.58	0.53	0.35	0.27	0.17	0.08	0.09	0.12	0.09
F6-9	0.91	0.61	0.51	0.53	0.60	0.55	0.62	0.56	0.57	0.45	0.25	0.20	0.08	0.11	0.12	0.09

Table E12- continued. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and percent mature of Gulf of Maine-Georges Bank American plaice, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1980-2010.

SSB at start of spawning season

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	4	5	2	0	9	5	3	7	1	0	0	0	0	0
2	38	111	73	20	37	23	29	28	36	45	7	6	4	3	3
3	496	646	859	410	218	271	212	216	351	425	298	120	108	142	145
4	2528	2593	2226	2934	1398	964	871	892	1088	1389	1890	2404	996	1134	1728
5	4585	4178	3974	4162	4343	1767	1496	1989	1388	1383	1672	3346	4028	1970	2310
6	6653	5641	3571	3867	3842	2708	1577	1740	1942	1049	1069	1552	2886	2677	1412
7	6356	5107	4479	2305	2590	2252	1591	1359	1468	1319	700	1077	1165	1812	1464
8	4085	3754	3397	2013	1329	1292	1115	1018	973	940	747	688	1069	672	801
9	2874	2646	2202	1663	912	782	497	649	598	684	502	507	607	779	343
10	3040	1508	1802	1051	829	591	345	233	420	348	383	384	348	392	376
11+	7339	2711	2519	2722	3121	624	465	323	369	535	827	577	384	518	1254
Total	37995	28898	25109	21148	18621	11282	8203	8449	8639	8117	8093	10661	11596	10100	9836

AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0	0	0	0	0	0	0	0	7	0	2	2	1	0	3	1
2	3	6	1	4	4	6	3	5	4	8	8	19	32	14	16	20
3	169	143	121	94	112	102	85	55	91	95	90	167	368	406	138	178
4	1682	1947	1683	1332	1069	1083	1166	926	578	630	1108	867	1728	2219	2087	754
5	2695	2693	3533	3668	2564	2520	2493	1699	2050	1129	1556	3136	2466	3935	3890	3552
6	1467	1694	2090	2656	2846	2652	2321	1798	1312	1895	1014	1659	3413	2661	3921	4224
7	859	712	1017	1239	1691	2214	1714	1299	1117	830	1559	751	1531	3220	2184	3466
8	779	510	374	632	579	1136	1262	896	687	732	594	1411	605	1272	2511	1825
9	260	376	294	229	355	247	704	631	496	339	488	455	1315	484	956	1985
10	128	93	217	169	144	201	136	377	361	253	185	369	354	959	346	696
11+	141	291	623	1081	365	85	152	530	326	298	271	359	458	794	867	941
Total	8184	8464	9954	11103	9728	10246	10036	8216	7028	6210	6875	9194	12271	15963	16919	17642

Percent mature (females)

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.01	0.02	0.01	0.02	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2	0.02	0.05	0.06	0.05	0.08	0.12	0.07	0.05	0.04	0.04	0.02	0.02	0.02	0.01	0.01
3	0.15	0.19	0.18	0.18	0.24	0.29	0.24	0.25	0.26	0.22	0.14	0.14	0.14	0.12	0.12
4	0.55	0.51	0.46	0.47	0.53	0.57	0.57	0.69	0.72	0.68	0.64	0.62	0.60	0.58	0.58
5	0.90	0.82	0.76	0.78	0.80	0.81	0.85	0.94	0.95	0.94	0.95	0.94	0.93	0.93	0.93
6	0.98	0.95	0.92	0.94	0.93	0.93	0.96	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	1.00	0.99	0.98	0.98	0.98	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	0.99	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.03	0.03
2	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.04	0.04	0.06	0.07	0.09	0.08
3	0.12	0.13	0.12	0.14	0.16	0.17	0.17	0.16	0.17	0.14	0.19	0.19	0.22	0.24	0.25	0.24
4	0.60	0.58	0.59	0.60	0.58	0.61	0.64	0.62	0.56	0.56	0.59	0.59	0.56	0.55	0.54	0.51
5	0.94	0.93	0.93	0.94	0.91	0.92	0.94	0.93	0.89	0.91	0.90	0.90	0.85	0.83	0.80	0.77
6	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.98	0.98	0.96	0.95	0.93	0.92
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98	0.97
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E13. Input data for yield-per-recruit and projection analysis. Selectivity and mean weight estimated as an average of 2006-2010 data, and proportion mature estimated as an average of four years of data, 2008-2011.

Age	VPA selectivity	Natrual Mortality	Stock weight	Catch weight	Spawning stock weight	Discard weight	Proportion mature
1	0.01	0.2	0.004	0.008	0.004	0.006	0.03
2	0.12	0.2	0.016	0.033	0.016	0.034	0.08
3	0.13	0.2	0.058	0.119	0.058	0.111	0.24
4	0.40	0.2	0.182	0.297	0.182	0.223	0.51
5	0.72	0.2	0.337	0.398	0.337	0.291	0.77
6	1.00	0.2	0.444	0.487	0.444	0.323	0.92
7	1.00	0.2	0.538	0.583	0.538	0.378	0.97
8	1.00	0.2	0.644	0.693	0.644	0.429	0.99
9	1.00	0.2	0.767	0.802	0.767	0.629	1.00
10	1.00	0.2	0.855	0.853	0.855	0.508	1.00
11+	1.00	0.2	1.159	1.159	1.159	1.039	1.00

Table E14. Projection results of catch and biomass (mt) in 2011-2014 where 2011 catch = 2010 catch for 3 fishing mortality scenarios: Fstatus quo, 75%Fmsy, and $F_{rebuild}$ for the base run, adjusted for retrospective bias by applying a 7-year average rho.

BASE Model with retrospective adjustment

	Year	Discards	Landings	Catch	SSB	F
F status quo	2011	343	1455	1798	11588	0.16
0.09	2012	181	893	1075	12213	0.09
	2013	161	952	1114	12703	0.09
	2014	151	968	1122	12822	0.09
75%Fmsy	2011	343	1455	1798	11588	0.16
0.14	2012	276	1359	1636	12073	0.14
	2013	237	1385	1624	12034	0.14
	2014	217	1351	1573	11667	0.14
Frebuild	2011	343	1455	1798	11588	0.16
0.0	2012	0	0	0	12469	0.0
	2013	0	0	0	14015	0.0
	2014	0	0	0	15231	0.0

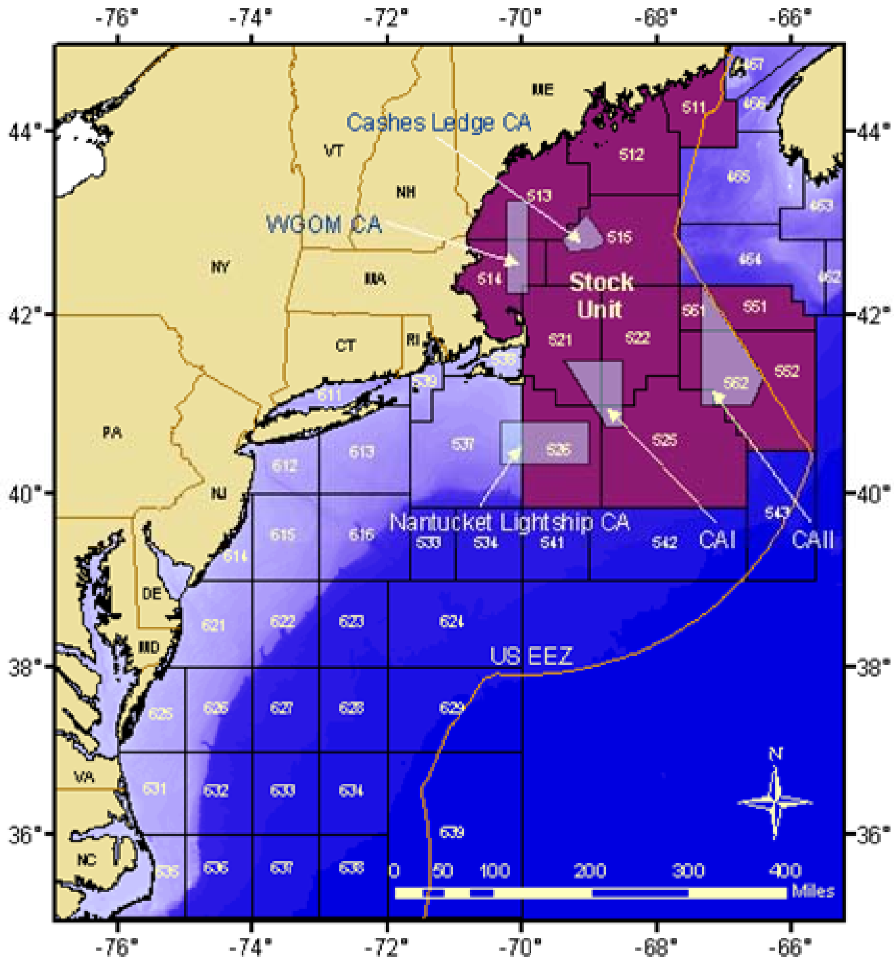


Figure E1. Stock area of American plaice as defined by Northwest Atlantic Fisheries Organization (NAFO) statistical areas: 511-515, 521-526, 551-552, and 561-562.

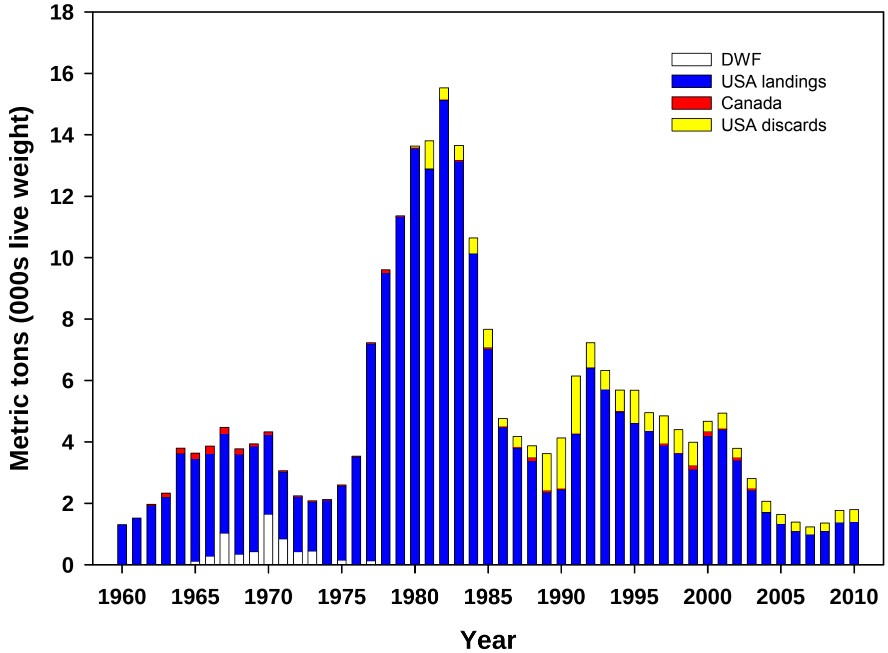


Figure E2. Total catch of Gulf of Maine-Georges Bank American plaice including USA commercial landings and discards, and Canadian landings, 1960-2010.

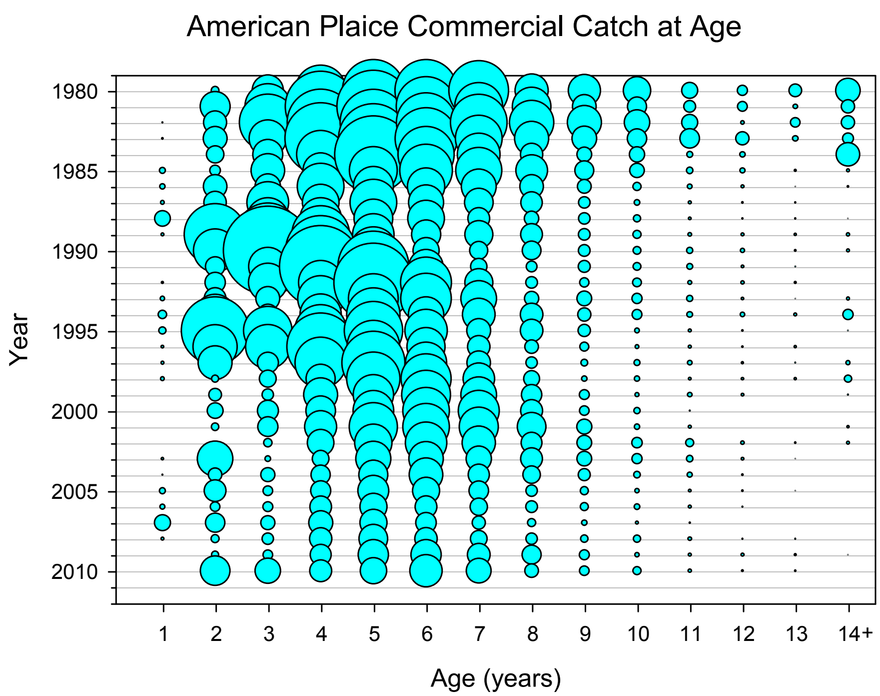


Figure E3. Catch at age (thousands of fish) of Gulf of Maine-Georges Bank American plaice, 1980-2010.

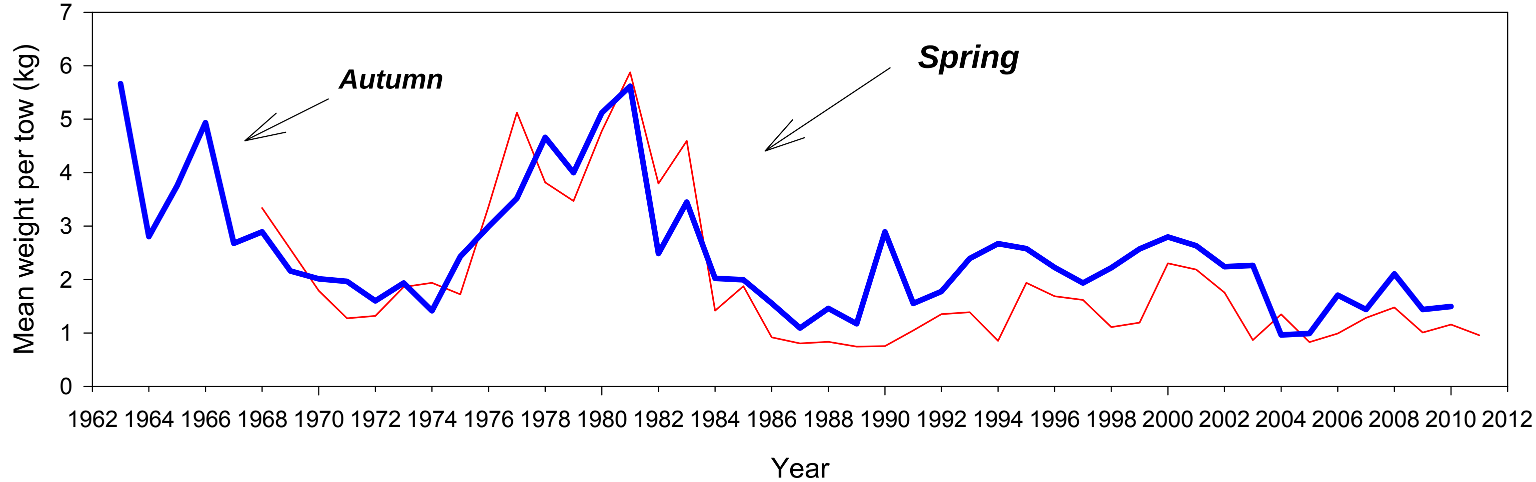


Figure E4. Standardized stratified mean weight per tow (kg) of American plaice in NEFSC and spring and autumn and spring DFO research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963-2011.

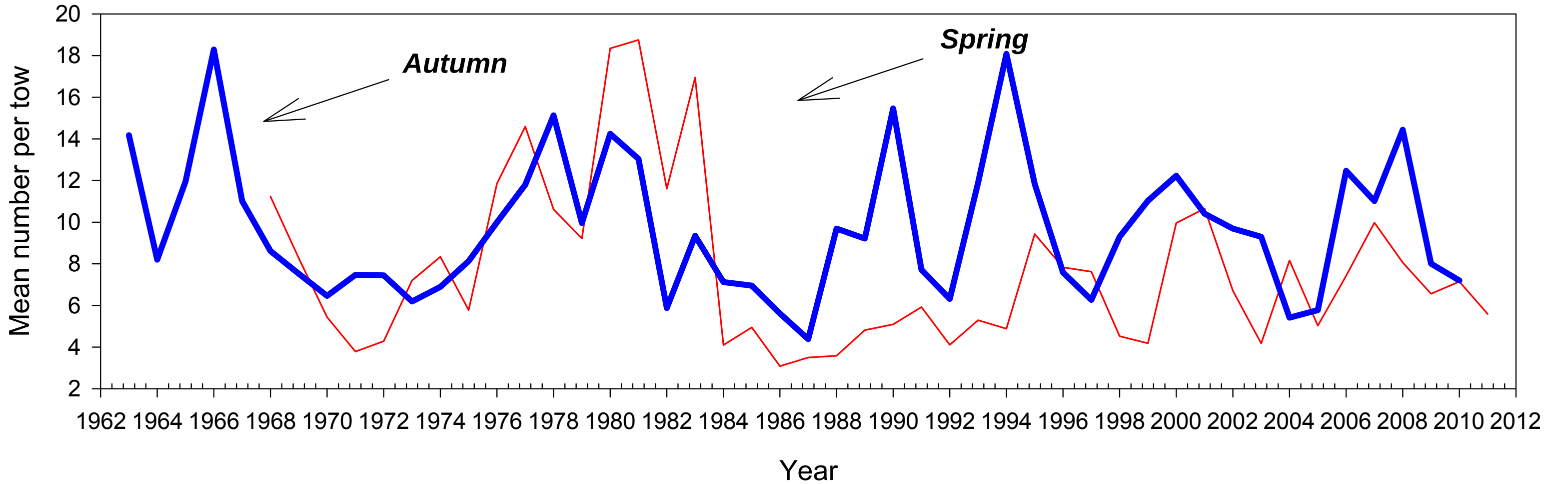


Figure E5. Standardized stratified mean number per tow (kg) of American plaice in NEFSC spring and autumn research and spring DFO research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963-2011.

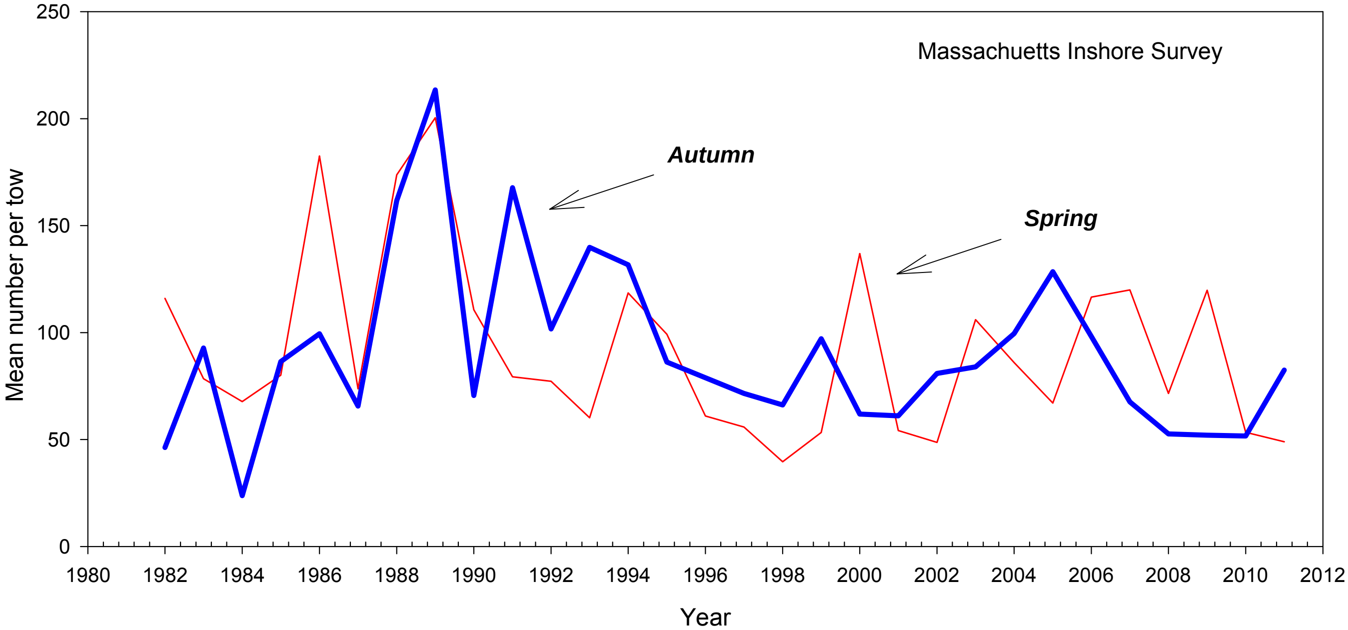


Figure E6. Standardized stratified mean number per tow (kg) of American plaice in MADMF spring and autumn research research vessel bottom trawl surveys region, 1982-2011.

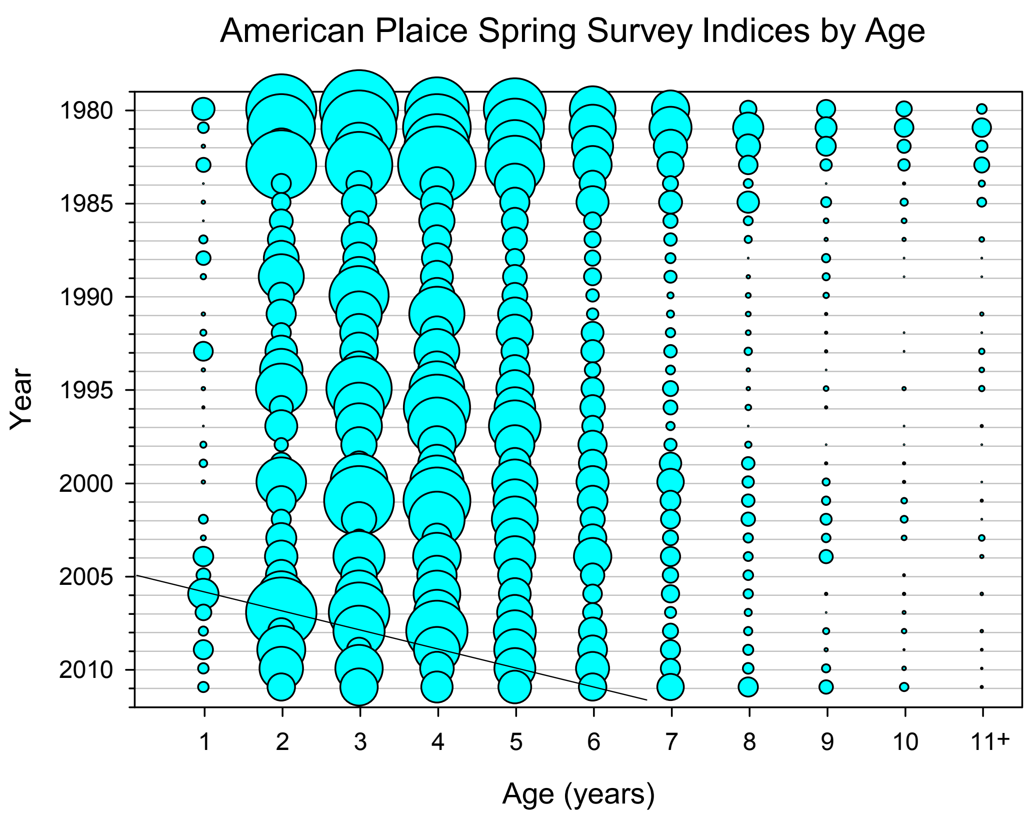


Figure E7. Standardized stratified mean catch per tow at age (numbers) of American plaice in the NEFSC spring bottom trawl survey, 1980-2011.

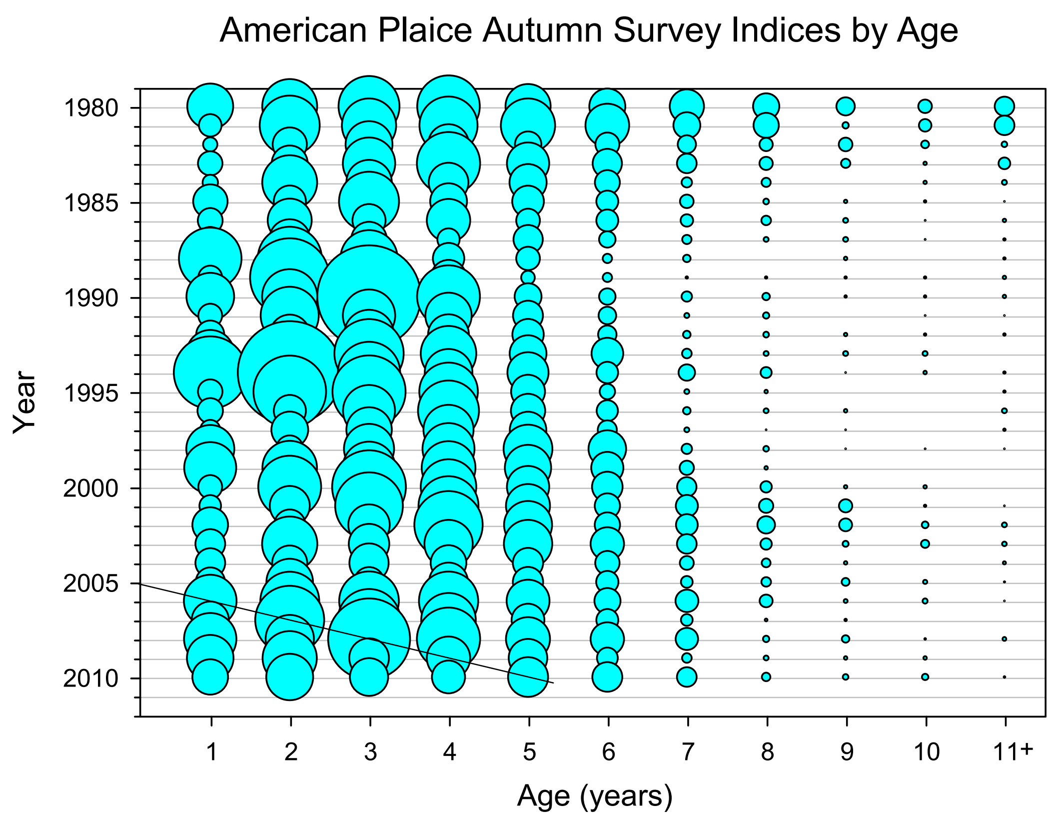


Figure E8. Standardized stratified mean catch per tow at age (numbers) of American plaice in the NEFSC autumn bottom trawl survey, 1980-2010.

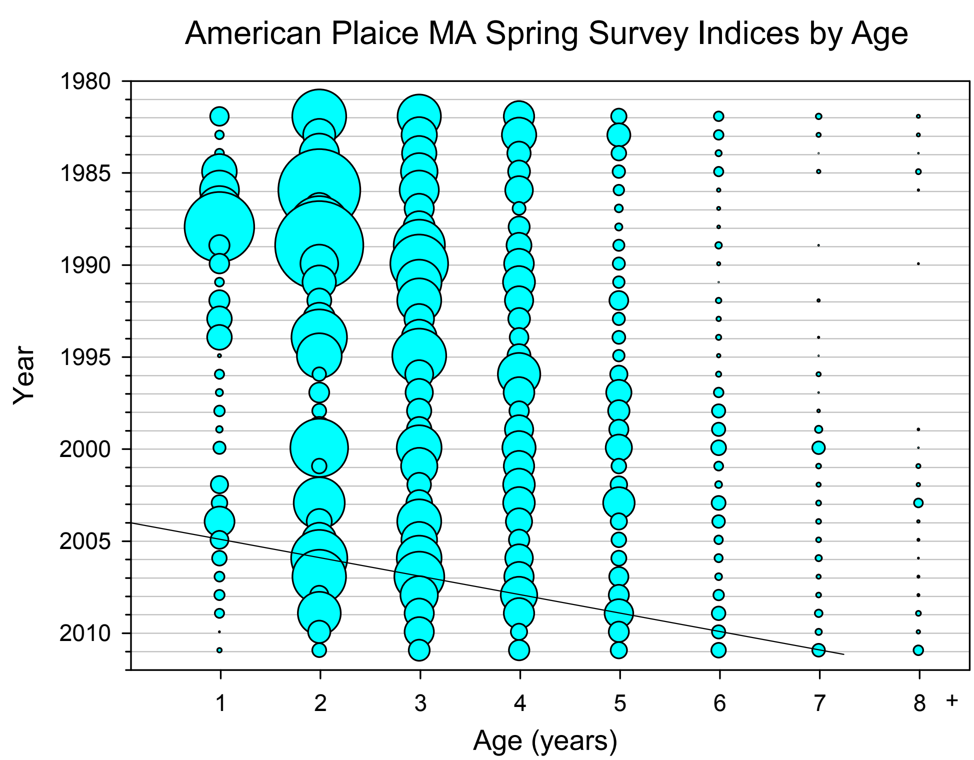


Figure E9. Standardized stratified mean catch per tow at age (numbers) of American plaice in the Massachusetts DMR spring bottom trawl survey, 1982-2011.

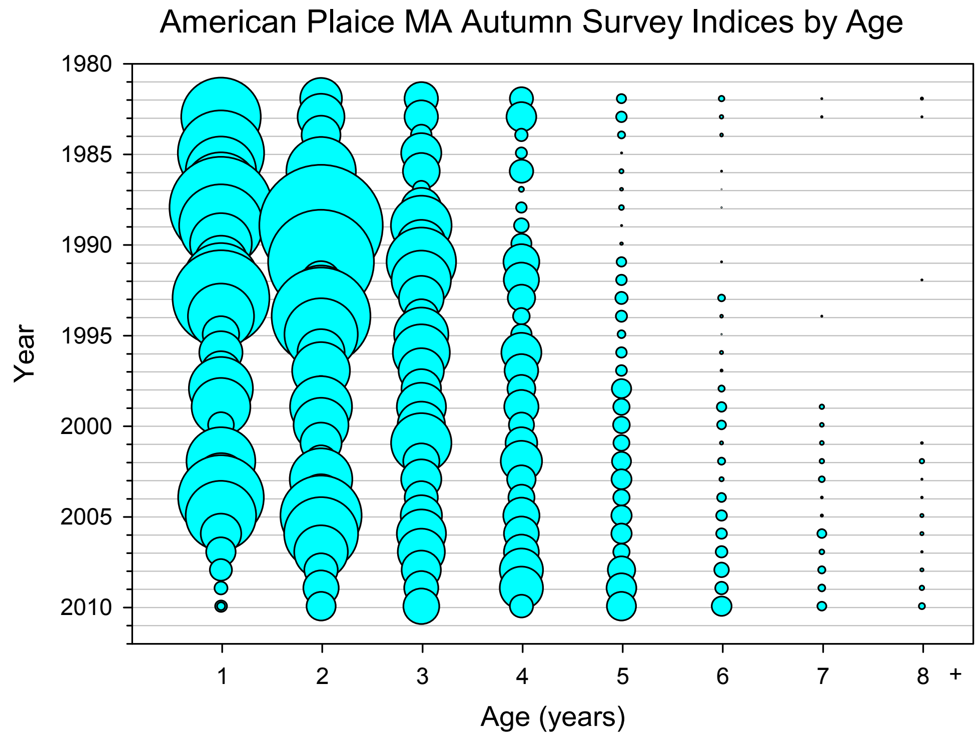


Figure E10. Standardized stratified mean catch per tow at age (numbers) of American plaice in the Massachusetts DMR autumn bottom trawl survey, 1982-2010.

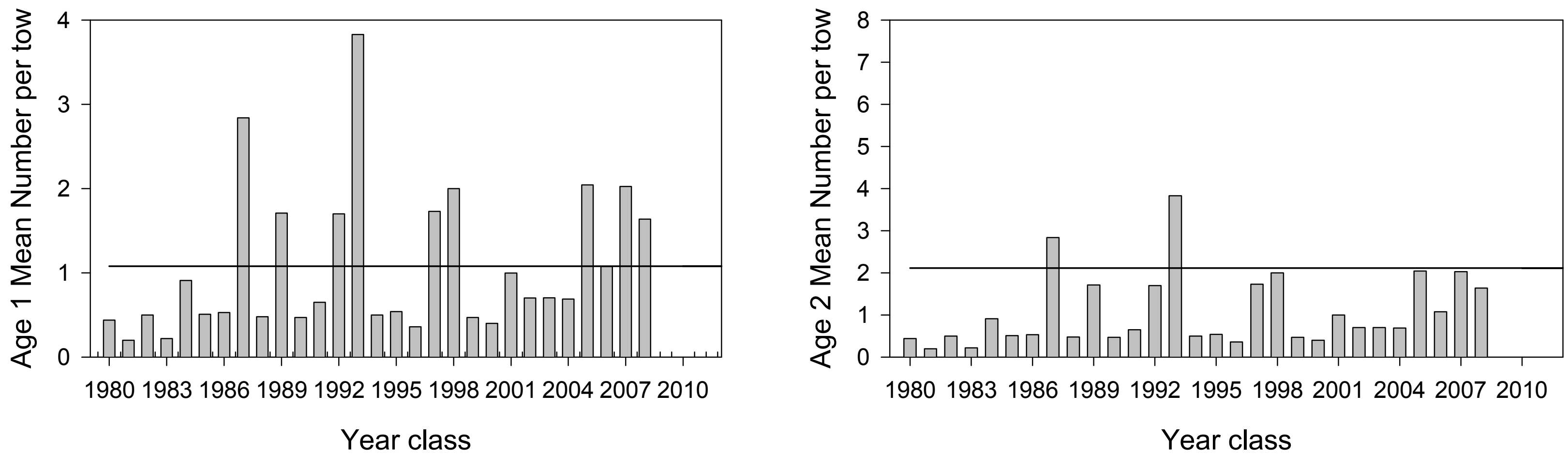


Figure E11a. Relative year class strength of age 1 and age 2 Gulf of Maine-George Bank American plaice from standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1980-2010.

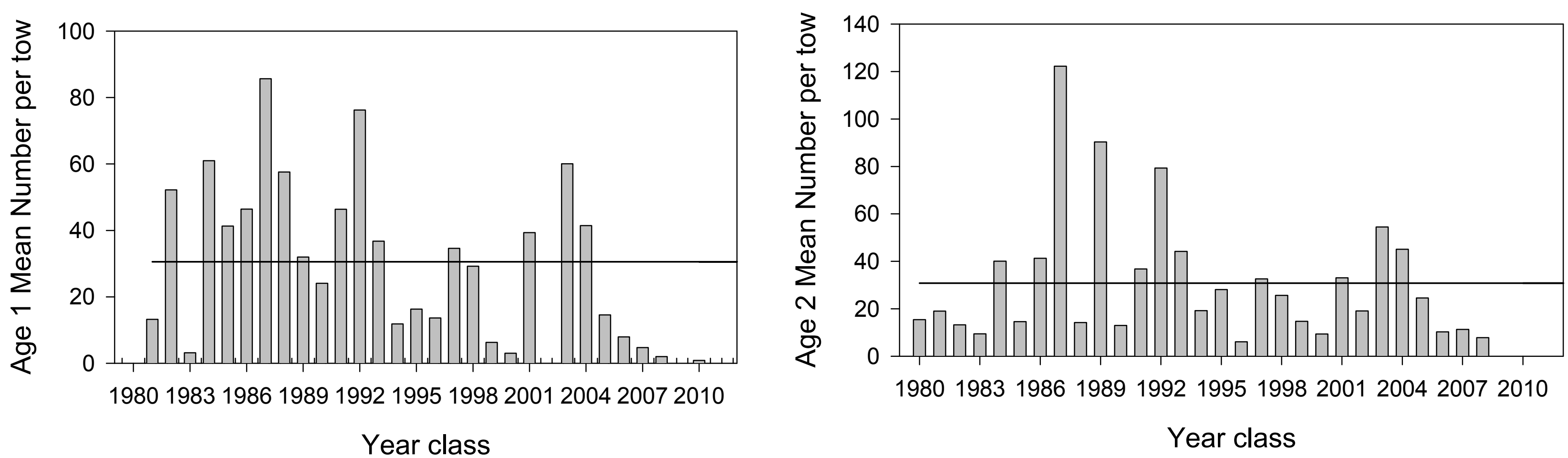
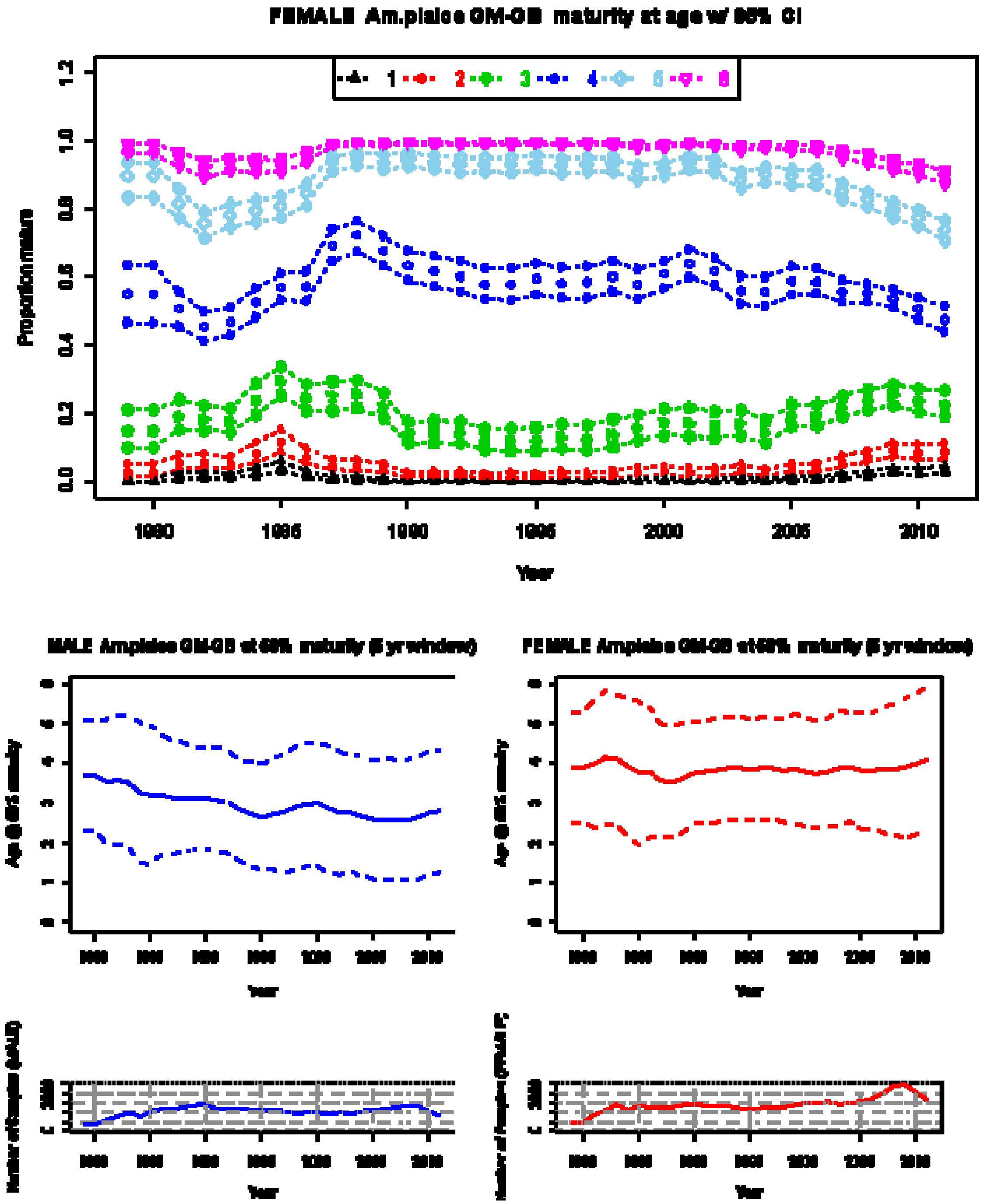


Figure E11b. Relative year class strength of age 1 and age 2 Gulf of Maine-George Bank American plaice from standardized catch (number) per tow indices from MADMF autumn research vessel bottom trawl surveys, 1982-2010.



E12. Proportion mature at age with 95% confidence intervals for female Gulf of Maine-Georges Bank American plaice using a 5-year moving window for ages 1-5 (upper panel), median age at maturity (A50) for males (middle left panel) and females (middle right panel) with 95% confidence intervals, and number of samples in the combined 5-year moving average for males (lower left panel) and females (lower right panel).

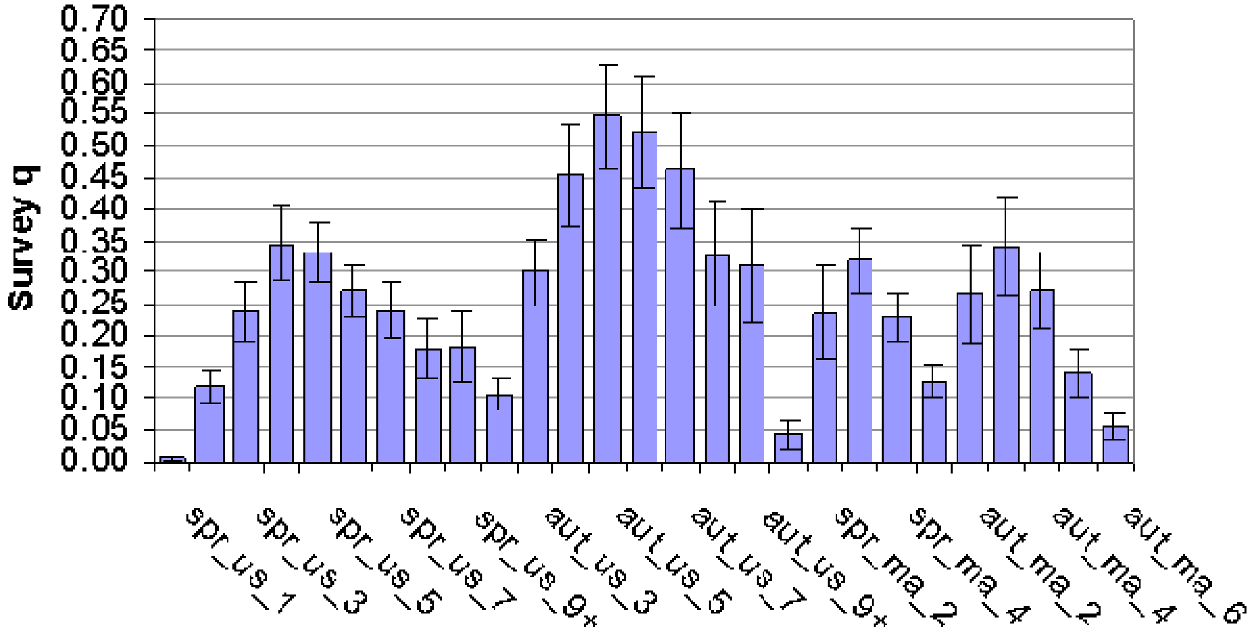


Figure E13a. Survey catchability (q) estimates based on swept area estimates of American plaice in NMFS and MADMF spring and autumn research bottom trawl surveys.

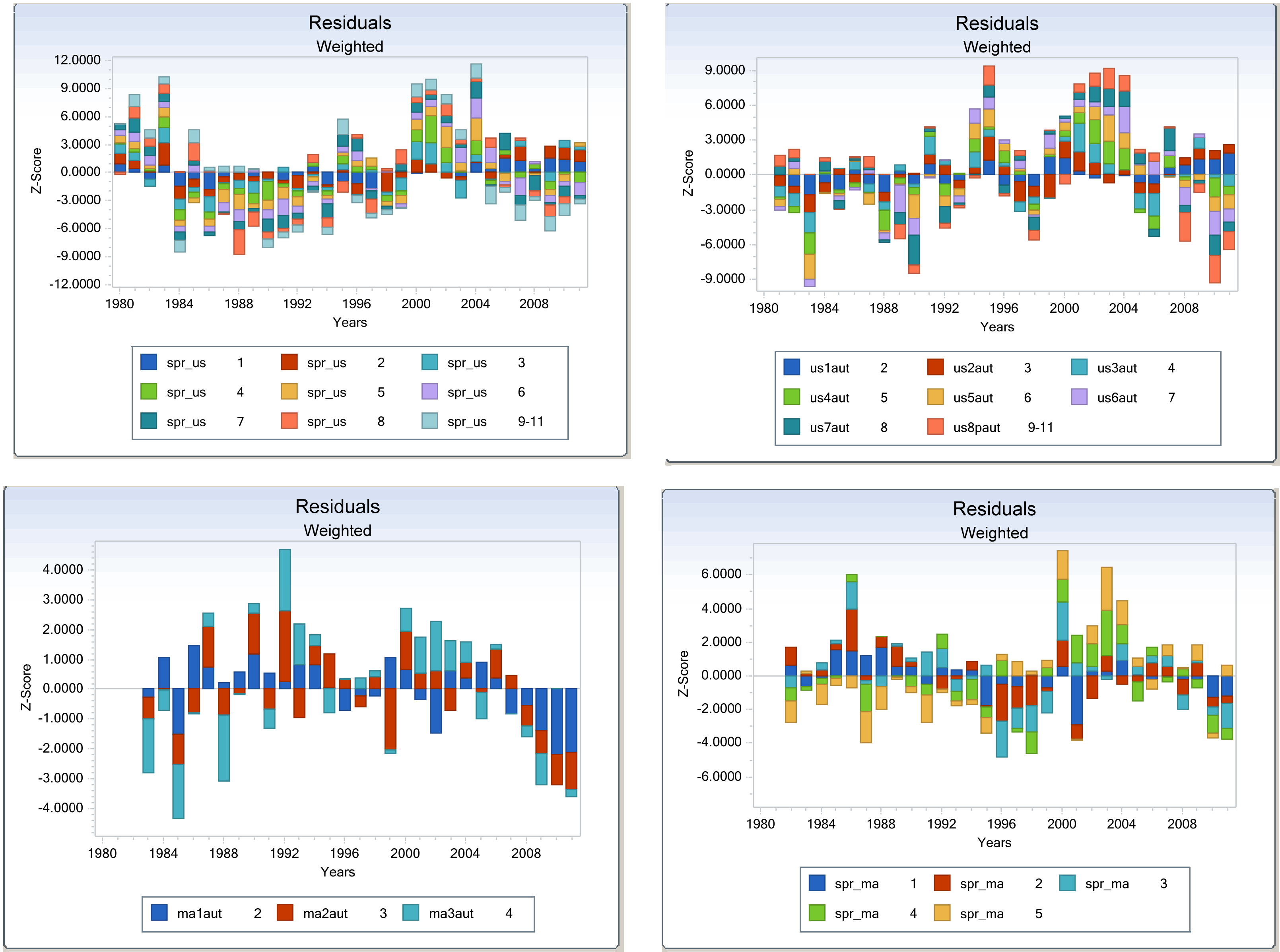


Figure E13b. Residuals for NEFSC spring and autumn and MADMR spring and autumn surveys from VPA.

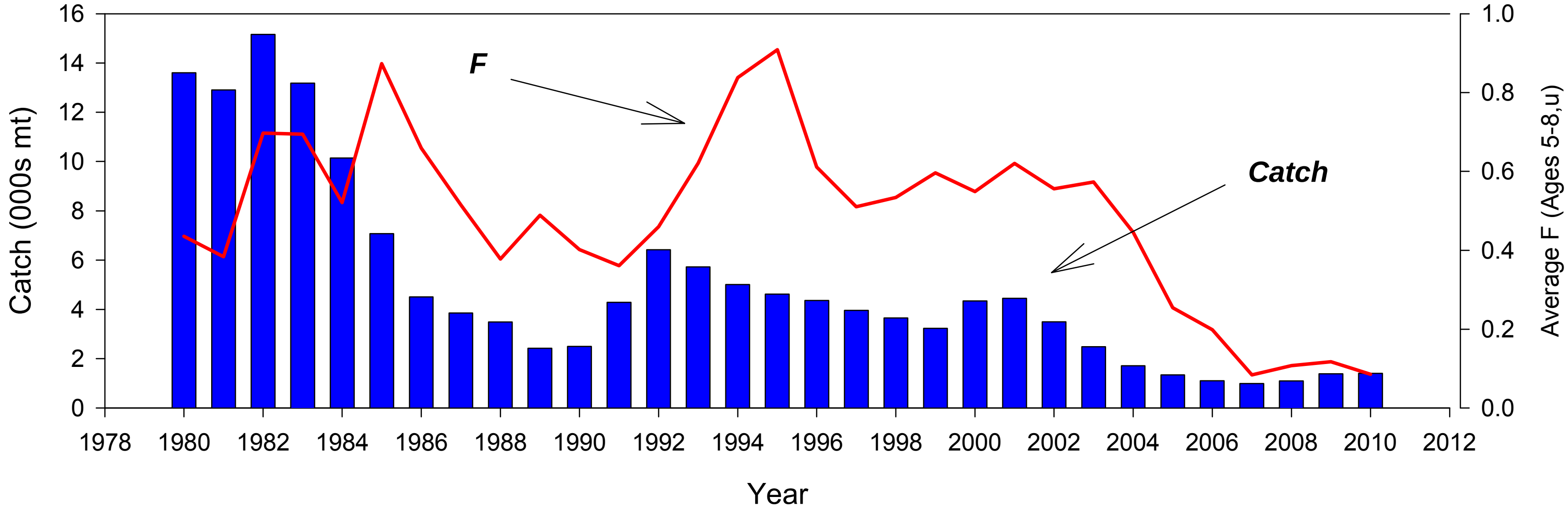


Figure E14. Trends in total commercial catch and fishing mortality for Gulf of Maine-Georges Bank American plaice, 1980-2010

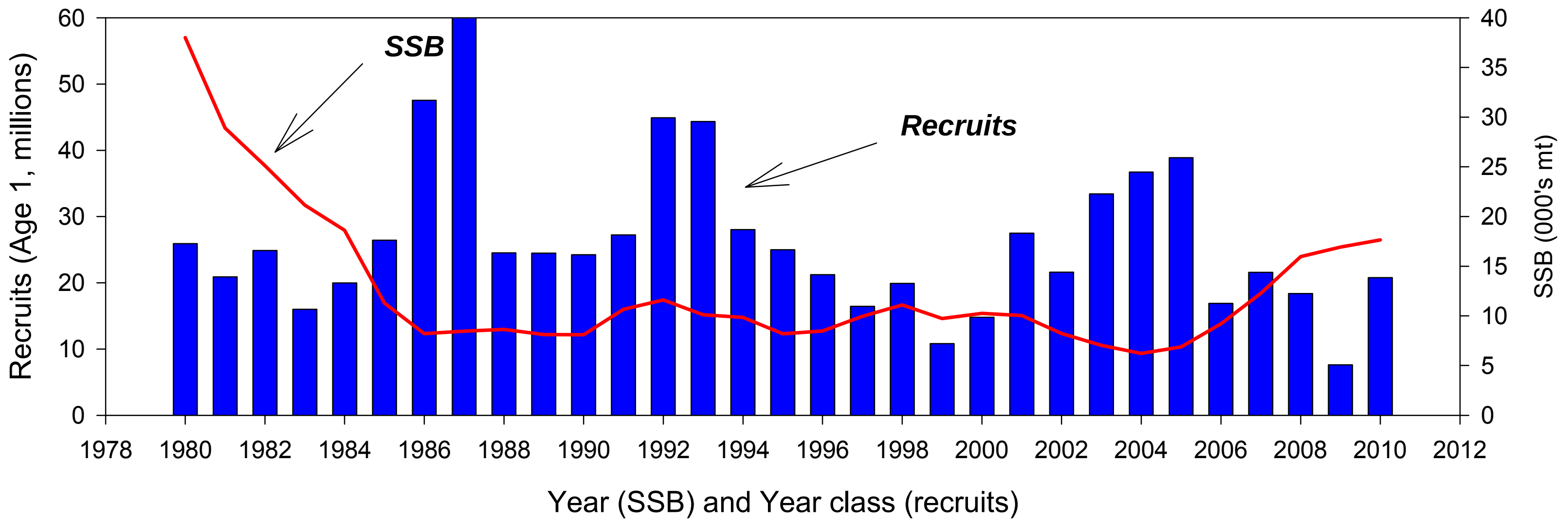
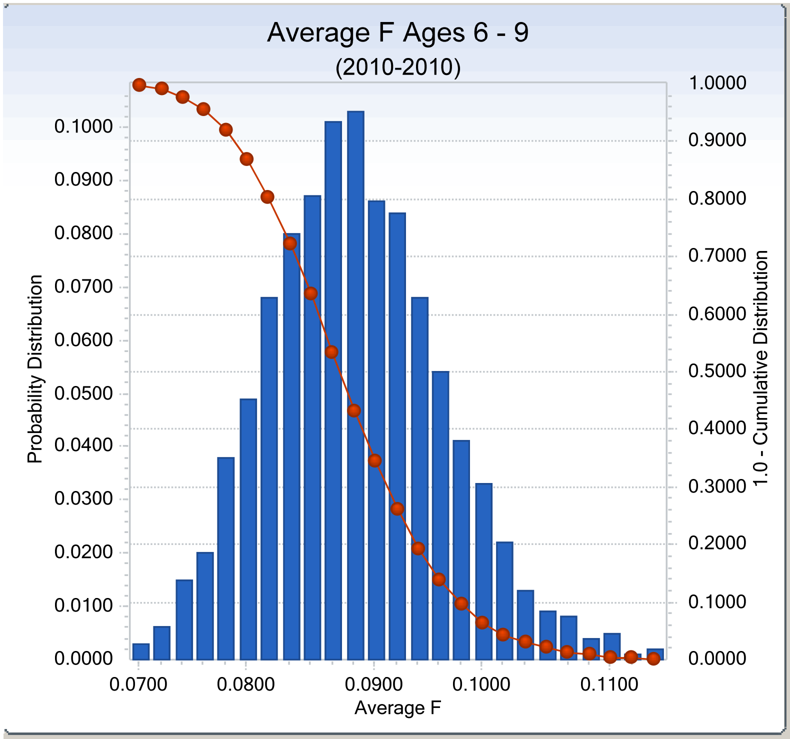


Figure E15. Trends in recruitment and spawning stock biomass for Gulf of Maine-Georges Bank American plaice, 1980 - 2010.



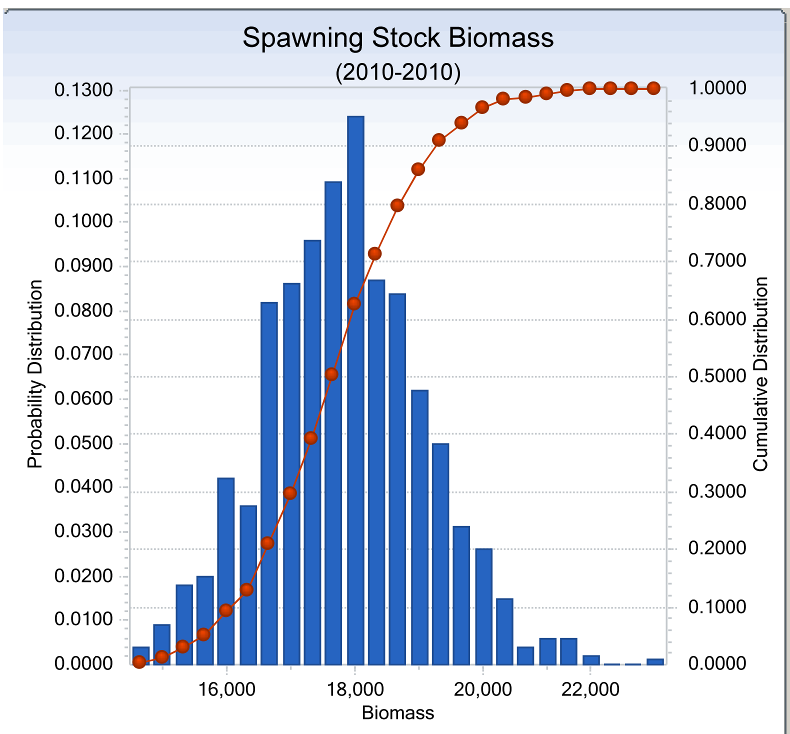


Figure E16. Precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages (6-9) and spawning stock biomass at the beginning of the spawning season for Gulf of Maine – Georges Bank American plaice, 2010. Bar height indicates the frequency of values within that range. The solid line is the cumulative probability that F is greater than or SSB is less than any selected value on X- axis.

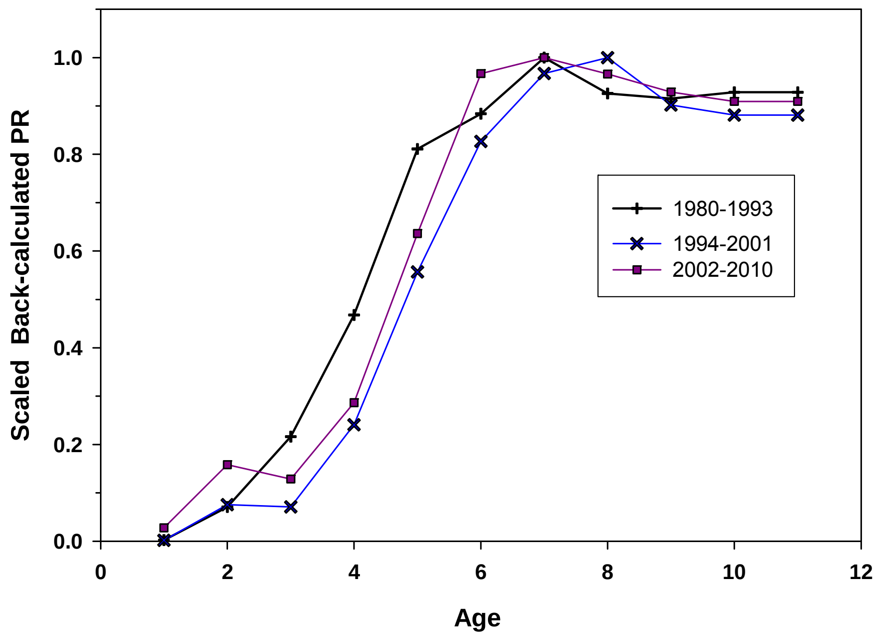


Figure E17. Scaled back-calculated partial recruitment (PR) from VPA for time periods 1980-1993, 1994-2001, and 2002-2010 for Gulf of Maine-Georges Bank American plaice.

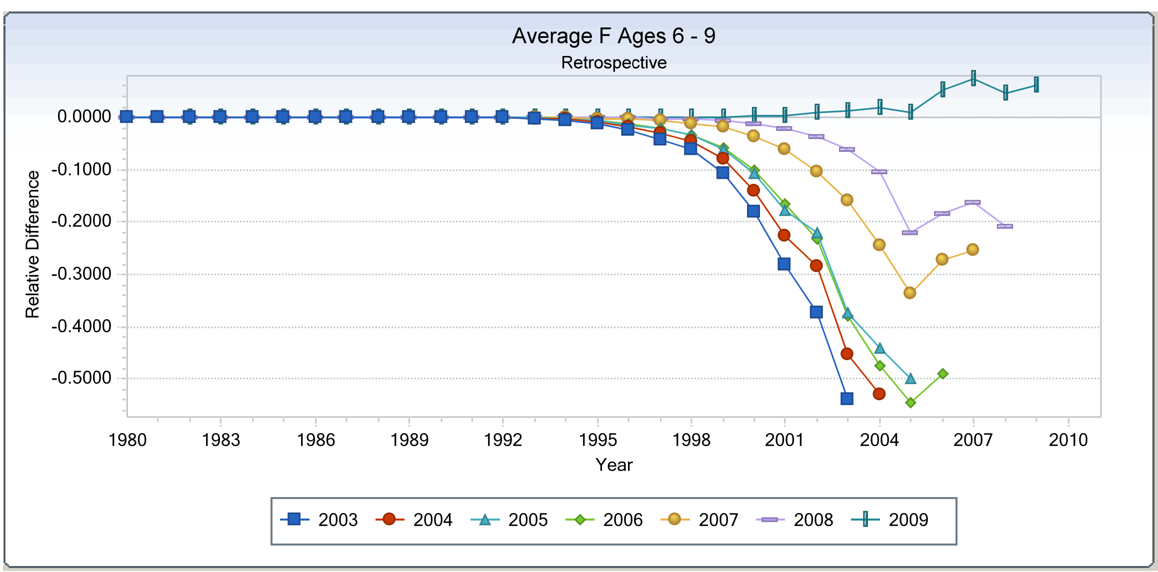


Figure E18a. Retrospective analysis of relative difference to terminal year 2010 of Gulf of Maine-Georges Bank American plaice fishing mortality (ages 6-9, unweighted), based on ADAPT VPA, 2003-2010.

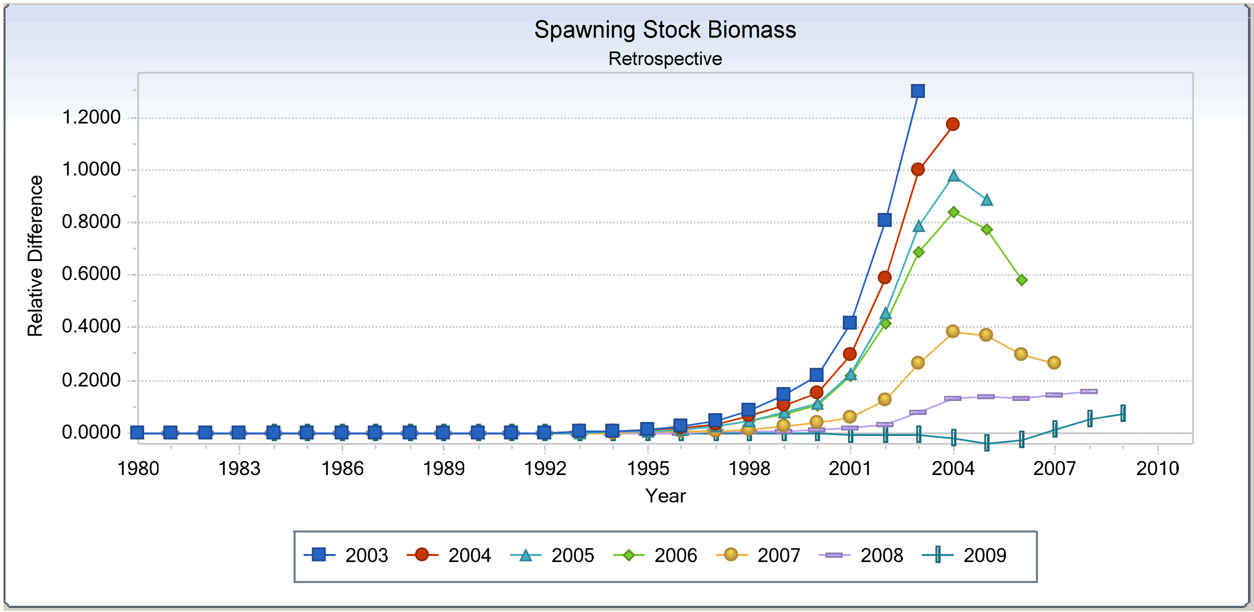


Figure E18b. Retrospective analysis of relative difference to terminal year 2010 of Gulf of Maine-Georges Bank American plaice spawning stock biomass based on ADAPT VPA, 2003-2010.

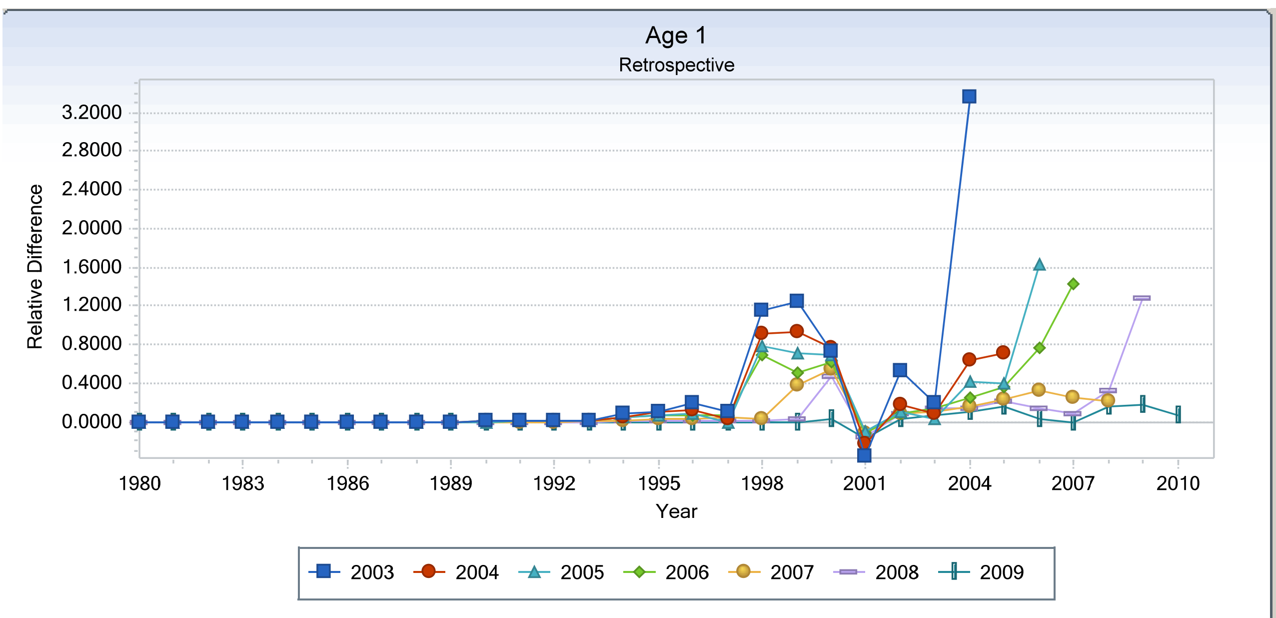


Figure E18c. Retrospective analysis of relative difference to terminal year 2010 of Gulf of Maine-Georges Bank American plaice age 1 recruits based on ADAPT VPA, 2003-2010.

Figure E19. Yield- and Spawning Stock Biomass per-recruit analysis for Gulf of Maine – Georges Bank American plaice. $F_{0.1}$ =0.20 , F_{max} = 0.46 and $F_{40\%}$= 0.18.

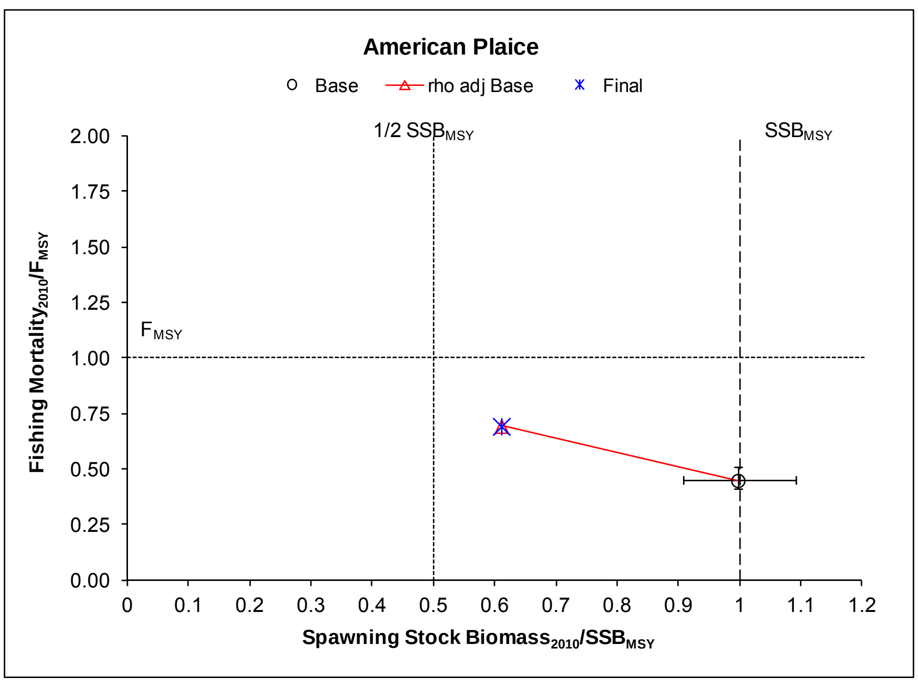


Figure E20. Status of 2010 fishing mortality (F) and spawning stock biomass (SSB) of Gulf of Maine-Georges Bank American plaice relative to F_{MSY} and SSB_{MSY} .

F. **Witch Flounder** by S.E. Wigley and S. Emery

1.0 Background

Witch flounder, *Glyptocephalus cynoglossus*, is assessed as a unit stock from the Gulf of Maine southward (Figure F1). An analytical assessment was last conducted for this species in 2008 at the Groundfish Assessment Review Meeting (GARM 2008; Wigley and Col 2008). Witch flounder was overfished and overfishing occurred in 2007. The 2008 assessment indicated average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.70 in 1988, declined to 0.23 in 1992, increased to 1.14 in 1996, then declined to 0.29 in 2007. Spawning stock biomass declined steadily from 16,903 mt in 1982 to 3,877 mt in 1996 and then increased to 6,874 mt in 2000 and declined to 3,434 mt in 2007. Since 1982, recruitment at age 3 has ranged from approximately 2 million fish (2002 year class) to 26 million fish (2004 year class) with a mean (1979 – 2005 year classes) of 11.1 million fish. The retrospective analysis indicates a pattern of overestimation of average F prior to 2003 and then underestimation for average F from 2003 onward. A similar 'flip' pattern was also evident for spawning stock biomass. Spawning stock biomass was underestimated prior to 2001 and then overestimated from 2001 onward. The retrospective analysis for Age 3 recruits indicated an overestimation prior to 2001 and then an underestimation from 2002 onward. NEFSC bottom trawl survey indices generally declined from the early 1960s to record low levels in the late 1980s and early 1990s. Since then survey indices increased but have exhibited a declining trend since 2001. Biological reference points were estimated. A yield and spawning stock per recruit analysis was performed using 5-year (2003-2007) averages for partial recruitment, stock weights, catch weights and maturity (2004-2008). Based on yield and SBB per recruit analysis, a proxy of Fmsy was F40%MSP = 0.20. A long-term stochastic projection estimated SSBmsy = 11,447 mt and MSY = 2,352 mt. The long-term projections used a constant F scenario (F= Fmsy =0.20), estimates of Age 3 recruitment derived by re-sampling the cumulative density functions based on empirical observations during 1982 to 2008 (1997 to 2005 year classes), proportions of F and M which occur before spawning (0.1667; March 1) and M = 0.15 (Wigley and Col 2008).

This report includes catch through 2010, survey indices through spring 2011, and estimates 2010 fishing mortality and spawning stock biomass. Biological reference points are updated. Commercial witch flounder catch was updated for 2007, with negligible changes occurring for this unit stock species.

2.0 Fishery

Commercial landings

USA landings generally increased from the early 1960s, peaking in 1984 at 6,660 mt (Table F1 and Figure F1). Subsequently, landings declined and have fluctuated about 2,300 mt until the early-2000s and have declined since. In 2010, landings were 759 mt (Table F1 and Figure F2). Significant proportions of the U.S. nominal catch have been taken from both the Georges Bank and Gulf of Maine regions. The majority of the landings are taken by otter trawl gear (Table F2). Canadian landings from both areas have been minor (not more than 68 mt annually). The proportion of landings by market category has changed over time (Figure F3). From the mid-

1970's to 1990, the percentage of 'peewee' and 'small' market category fish was about 35%, but rose sharply to over 80% by 1995 and has remained at that level.

Sampling of landings has increased in recent years (Table F3). When sampling was low, it was necessary to pool some quarters for some market categories. To estimate landings at age and mean weights at age, quarter, semi-annual or annual age-length keys were applied to corresponding commercial landings length frequency data by market category. Number of fish landed at age and mean weights at age of landed fish are presented in Tables F4 and F5, respectively.

Tests to evaluate ageing precision are conducted by the NEFSC Fishery Biology Program on a regular basis (survey cruise or commercial quarter). There was a change in age reader following the GARM 2008 witch flounder assessment. An extensive age reader comparison (N=251) was performed, resulting in 89% agreement between readers, with a low CV and no bias. Precision levels for the current age reader are quite similar to those of the previous age reader, ranging between 85% and 90% for survey samples, and 76% to 83% from commercial samples. Test results and statistical methods used are given at:
http://www.nefsc.noaa.gov/fbp/QA-QC/index.html .

Discard estimation

Discards have been estimated for three fleets: northern shrimp trawl, large-mesh (>=5.5 inch) otter trawl, and small-mesh (<5.5 inch) otter trawl (Table F6 and Figure F4). The majority of discards occur between ages 1 to 6, and the discards are a small component of total catch (Figure F2). The methods used to estimate fleet specific discards are given below.

Discards from the northern shrimp fishery were estimated using two methods used in a previous assessment (Wigley et al. 2003): when no Northeast Fisheries Observer Program (NEFOP) observer data were available (1982-1988, 1998-2002), a regression of age 3 fish in the autumn NEFSC survey and observed discard rates was used to estimate ratios of discard weight to days fished (d/df) ratios. When observer data were available (1989-1997, 2003-2010), d/df ratios were calculated by fishing zone (a surrogate for depth). To estimate discard weight, the mean discard ratio (weighted by days fished in each fishing zone) was expanded by the days fished in the northern shrimp fishery. For 2003 to 2005, witch flounder discards in the northern shrimp fishery were estimated to be near zero. This is attributed to the short duration of the northern shrimp season in 2003-2004, the shift in effort to near-shore waters inshore of witch flounder distribution, and the relative low abundance of juvenile witch flounder in these years. For 2006 through 2010, witch flounder discards were estimated to be very small and are associated primarily with the 2004 year class. Witch flounder discarded in the northern shrimp fishery range in age from 0 to 6, with the majority at ages 1-3. The estimated discard weight of witch flounder from the shrimp fishery is small compared to the other trawl fleets (Table F6).

The estimation of large-mesh otter trawl discards is based upon two methods. For 1982 to 1988, a method which filters survey length frequency data through a commercial gear retention ogive and a culling ogive was used and then a semi-annual ratio estimator of survey-filtered 'kept' index to semi-annual numbers landed was used to expand the estimated 'discard' survey index to numbers of fish discarded at length (Wigley et al. 2003). For 1989 to 2010[1], an annual combined ratio of witch flounder discard weight to kept weight of all species ratios (d/k_{all}) was calculated from observer data. Total discard weight was derived by multiplying the d/k_{all} ratio by the commercial large-mesh otter trawl landings. Observed discard length frequencies are used to estimate discarded fish at length. Semi-annual numbers of fish discarded were apportioned to age using the corresponding seasonal NEFSC survey age/length key. Discards from the large-mesh otter trawl fishery account for the majority of total discards (Table F6). Witch flounder discarded in the large-mesh otter trawl fishery range in age from 0 to 6, with the majority at ages 4 to 5. Discards at age and mean weights at age from the large-mesh otter trawl and northern shrimp trawl fleets are presented in Tables F7 and F8 and Figure F4.

Witch flounder discards from the small-mesh otter trawl fisheries were also estimated using an annual combined ratio for this fleet and expanded to total discards by commercial landings of small-mesh otter trawls (Table F6). The small-mesh otter trawl discard length frequencies for 1989 to 2010 were too sparse to estimate discarded fish at length. Given the possession regulations for this fleet, the commercial catch at age was used to apportion the small-mesh otter trawl discard weight to discards at age.

The total catch (landings + large-mesh otter trawl discards + shrimp trawl discards+ small-mesh discards) at age and mean weight at age are presented in Tables F9 and F10, and Figure F5. Strong year classes of note were: 1979-1981, 1989 and 1993. The age composition data also reveal a truncated age-structure in the late-1990's and again in the late-2000s. For fish age 6 and older, mean weights at age declined between 1992 and 2003 and have since fluctuated at lower levels below the time series average (Table F10 and Figure F6).

3.0 Research Vessel Surveys

The NEFSC bottom trawl survey indices generally declined from the early 1960s to record low levels in the late 1980s and early 1990s. There was a slight increasing trend in the late 1990s to early 2000s followed by a declining trend (Table F11, Figures F7 and F8). Survey age compositions (mean number per tow at age) are presented in Table F12, Figure F9. The survey mean weights at age show a similar pattern of decline as reported for the commercial landings (Appendix Figure F1). A 5-year moving window of pooled maturity data from the NEFSC spring survey is used to estimate median age at maturity. The survey maturity-at-age has remained generally stable, with a median A50 between ages 5 and 6. The most recent median A50 is approximately age 5 (Figure F10) for females.

Both the Massachusetts inshore survey (Howe et al. 1981; Appendix Table F1 and Appendix Figure F2) and the Atlantic States Marine Fisheries Commission summer shrimp survey (Northern Shrimp Technical Committee 1981; Appendix Table F2 and Appendix Figure F3) show similar trends in abundance and biomass to the NEFSC surveys. However, the MA inshore survey exhibits a slight increasing trend in abundance and biomass in recent years. The ME-NH

[1] In 2010, NEFOP At-Sea Monitoring (ASM) data were pooled with NEFOP observer (OB) data for the large-mesh otter trawl discard estimation. A comparison of the discard rates using ASM and OB indicated no statistical differences for witch flounder in otter trawl gear by quarter (Wigley et al. 2011).

inshore survey indices (Sherman et al. 2005; S. Sherman pers.com)[2] are presented in Appendix Table F3 and Appendix Figure F4. The abundance and biomass trends in the ME-NH inshore survey appear stable since 2002. The spring and fall witch flounder length frequency data identify strong 2004 and 2008 year classes, consistent with the length frequency data in NESFC and ASFMC shrimp surveys.

NEFSC Survey conversion factors: 1963 to 2008

There are no significant vessel, door, or net conversion factors for witch flounder in the NEFSC bottom trawl survey. No conversion factors have been applied to the survey indices for the 1963 through 2008 period.

NEFSC Survey conversion factors: 2009 - 2011

There are significant vessel conversion factors between the *FS/V Bigelow* and the *R/V Albatross IV* for witch flounder (Miller et al. 2010) in the NEFSC bottom trawl survey. The vessel conversion factor for numbers and weight (spring and autumn) is 3.2572 and has been applied to the 2009 through 2011 NEFSC bottom trawl surveys. The *FS/V Bigelow* survey indices were divided by the conversion factor to obtain indices consistent with the *R/V Albatross IV*. Length-based conversion factors have not been established for witch flounder. A small working group was convened to discuss candidate models and the application of length-based conversion factors for witch flounder. The group concluded that further work was needed before length-based factors were applied; however, the group agreed that a sensitivity run should be conducted using survey indices adjusted with length-based conversion factors derived from a second order polynomial (the candidate model).

4.0 Assessment

Input Data and analysis

The Virtual Population Analysis (VPA) is calibrated using the NOAA Fisheries Toolbox (NFT) ADAPT VPA version 3.1.1. Since the last assessment, only minor changes in software have occurred, 2007 catch was revised and three years of data were added. The VPA formulation is the same as the previous assessment and uses USA total catch (landings and discards for ages 3 to 11+) through 2010 and NEFSC spring and autumn survey abundance indices (ages 3 to 11+) through 2011 and 2010, respectively, to estimate stock sizes for ages 3 to 10. All indices are given equal weighting. Autumn survey indices are lagged forward one year and one age to calibrate with beginning year population sizes of the subsequent year. A flat-top partial recruitment vector is assumed, with full fishing mortality on ages 8 and older. The F on ages 10 and 11+ in all years prior to the terminal year is derived from the weighted estimates of Z on ages 8 and 9. Instantaneous rate of natural mortality (M) is assumed to be 0.15. Spawning stock

[2] ME-NH inshore survey indices were provided by S. Sherman, Maine Department of Marine Resources, West Boothbay Harbor, ME. Some of the data are summarized in Annual Report on the Maine-New Hampshire Inshore Trawl Survey, January 1, 2010-December 31, 2010, Contract # NA07NMF4720357, submitted to the NOAA Fisheries Northeast Region Cooperative Research Partners Program, December 2011.

biomass (SSB) is calculated at time of spawning (March) and mean weights at age calculated by the Rivard method. Annual maturity ogives are estimated using NEFSC spring maturity at age data through 2011, pooled by 5-year moving time blocks.

During the GARM 2008 Assessment Model Meeting, the panel concluded that there was sufficient data for an age-structured model that assumes negligible error in the catch-at-age. The panel also recommended exploring the retrospective pattern that has been present in previous assessments. Similar to the GARM 2008 accepted VPA analysis, a VPA analysis was performed for a SPLIT case, where the survey time series was split between 1994 and 1995. This time split corresponds to changes in the commercial reporting methods as well as other regulatory management changes. Summary statistics of the SPLIT case (Run D), referred to hereafter as the SPLIT RUN, are given in Table F13. Table F13 also presents summary statistics for six other VPA runs, including the accepted VPA from the GARM 2008 assessment (Run A), two ‘bridge runs’ conducted to evaluate the impact of new software and the revised 2007 catch (Runs B and C, respectively), and three sensitivity runs. A sensitivity run was conducted where survey indices were not split (NO SPLIT, Run E), and two sensitivity runs (Runs F and G) of the SPLIT RUN were performed where length-based conversion factors from the second order polynomial (the candidate model) were applied to the 2009 through 2011 survey indices. For Run F, length-specific conversion factors were applied to the entire length range while Run G applied length-specific conversion factors to lengths between 20 and 40 cm and held the conversion factor constant for lengths less than 20 cm and greater than 40 cm (i.e. all lengths less than 20 cm used the 20 cm conversion factor and all lengths greater than 40 cm used the 40 cm conversion factor).

For all VPA runs, NEFSC spring and autumn relative abundance indices at age were transformed into swept area absolute abundance indices and used as tuning indices to explore changes in survey catchabilities (q). Appendix Table F4 summarizes the NEFSC survey strata area used in the swept area calculations. Survey catchabilities from the SPLIT RUN are given in Figure F11 and were very similar to those for GARM 2008. In the SPLIT RUN, the 1982-1994 series q ranged between 0.01 and 0.23 and the 1995-2011 q ranged between 0.05 and 0.34. The magnitude and pattern of increasing survey catchabilities at age for younger fish and a general level pattern at older ages appear reasonable. The causes of the increased q between the 1982-1994 and 1995-2011 series in the SPLIT RUN remain unknown.

Selection of a final VPA run

The precision of the stock size estimates are similar between all the formulations. Among the four VPA runs (Runs D, E, F and G), the SPLIT RUN had best model fit with the lowest values of residual sums of squares and mean square residual and the least retrospective pattern (Table F13). The VPA runs had similar retrospective patterns indicating that average F was underestimated, SSB was overestimated and Age 3 recruitment exhibited a ‘flip’ (change in direction) pattern (overestimated than underestimated). The Mohn rho statistics (described below) of the VPA SPLIT run indicate that the retrospective pattern is less severe than the other model formulations (Table F14) for average F, SSB and Age 3. In addition to the summary of terminal year estimates (Table F13), comparisons of trends in F, SSB and Age 3 recruit from the GARM 2008 (Run A), SPLIT RUN (Run D), and NO SPLIT (Run E) are given in Appendix Figure F5 and from the SPLIT RUN (Run D), SPLIT LCF1 (Run F) and SPLIT LCF2 (Run G) are given in Appendix Figure F6. The combination of: 1) the contraction of the age structure observed in the survey indices at age and the commercial catch at age; 2) the low NEFSC survey abundance and biomass indices in recent years; and 3) the magnitude of the 2004 year class at age 3 relative to the age 3 abundance indices over the entire time series (Appendix Figure F4), indicating a strong 2004 cohort but not exceptional year class, all seem to suggest that the VPA SPLIT RUN more accurately characterizes the witch flounder population. The VPA SPLIT RUN is used for biological reference point calculations and for stock status determination.

VPA SPLIT RUN results

The VPA SPLIT RUN (Run D) had a mean square residual of 0.700, the coefficients of variation (CVs) for estimated stock size at age ranged between 30% and 61% (Table F13), and the CVs for survey catchability coefficients (q) were consistent, ranging from 14% to 43%. Residual patterns from the NEFSC survey tuning indices from the SPLIT RUN are given in Figure F12. The patterns appear random for most ages; however, for ages 7 and 10 there appear to be blocks of positive and negative residuals.

Results indicate average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.70 in 1988, declined to 0.23 in 1992, increased to 1.14 in 1996, then declined to 0.47 in 2010 (Tables F15 and F16; Figure F13). Spawning stock biomass declined from 16,903 mt in 1982 to 3,871 mt in 1996, increased to 6,794 mt in 2000 and then declined to 4,099 mt in 2010 (Tables F15 and F16; Figure F13). Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 17 million fish (1980 year class) with a mean of 9.8 million fish (Tables F15 and F16; Figure F13). The addition of the 2008 year class to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment (Figure F17). As in previous assessments, the Age 3 stock size in terminal year + 1 (2008 year class) is poorly estimated (61% CV; Table F13).

Mohn rho statistic (Mohn 1999; GARM 2008) was derived by taking the average of seven (2003 – 2009) relative differences between the quantity (e.g. F, SSB and Age 3) from the reduced time series assessment and the same quantity from the full assessment. The SPLIT RUN Mohn rho statistics for F, SSB and Age 3 was -0.33, 0.61 and 0.06, respectively (Table F14).

The precision of the 2011 stock size at age, F at age in 2010, and SSB in 2010 from the VPA SPLIT RUN was evaluated using bootstrap techniques (Efron 1982). Bootstrap results of the SPLIT RUN suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 19% and 12%, respectively. The 80% confidence interval for F_{2010}=0.47 was 0.38 and 0.61, and for SSB_{2010} = 4,099 mt the 80% confidence interval was 3,614 mt and 4,874 mt. The range of the bootstrap estimates and the probability of the individual values are presented in Figure F17.

5.0 Biological Reference Points

For this assessment, yield and spawning stock per recruit analyses (YPR v2.7) were updated using 5-year (2006-2010) averages for partial recruitment, stock weights, catch weights and maturity (2007-2011; Table F17). Based on yield and SSB per recruit analyses, a proxy of

Fmsy is F40%MSP = 0.27 for the SPLIT Run (Table F18).

A long-term (100 year) stochastic projection (AGEPRO v4.2) was performed to estimate spawning stock biomass and MSY under equilibrium conditions. The same partial recruitment, mean weights at age and maturity vectors used in the yield and SSB per recruit analysis were also used in the projections. A constant F scenario was used (F = Fmsy = 0.27). Estimates of Age 3 recruitment used in the projections were derived by re-sampling the cumulative density function based on the empirical observations during 1982 to 2009 (1979 to 2006 year classes) from the SPLIT RUN (Table F17). The proportions of F and M which occurs before spawning equals 0.1667 (March 1); M equals 0.15. Comparisons of GARM 2008 and updated biological references points are given in Table F18.

Trends of the age structure of the spawning stock biomass and the age structure under MSY conditions are given in Figure F18. As reported above, SSB in 2010 is well below SSBmsy, and the distribution of spawning biomass at age is concentrated at younger ages in 2010, indicating a truncated age structure.

6.0 Projections

Short term projections of catch and spawning stock biomass in 2011 through 2017 were conducted under four F scenarios using the bootstrapped VPA SPLIT RUN calibrated stock sizes in 2011. The partial recruitment, maturity ogive, and mean weights at age (Table F19) are the same as described for biological reference points (using 5 year average mean weight and the 1982 – 2009 series (1979 – 2006 year classes) of Age 3 recruitment and an assumed natural mortality of 0.15.

Short-term median estimates of catch and spawning stock biomass for 2011 through 2017 are given in Table F19. If 2010 fishing mortality is held at F status quo (F=0.47), then 2017 catch is forecast to be 2,323mt and spawning stock biomass is forecast to be 5,212 mt. If fishing mortality is held at Fmsy (F=0.27), then 2017 catch is forecast to be 1,991 mt and spawning stock biomass is forecast to be 9,653 mt. If fishing mortality is held at F75%msy (F= 0.20), then 2017 catch is forecast to be 1,770 and spawning stock biomass is forecast to be 10,921 mt. Projections to estimate $F_{rebuild}$ in 2011- 2017 that will rebuild the spawning biomass to SSBmsy = 10,051 mt by 2017 indicate that $F_{rebuild}$ = 0.18 (attaining 11,233 mt with a 75% confidence; Table F19).

When the 2006-2010 geometric mean is used to estimate Age 3 in 2011 then the estimated stock size is 6.079 million fish rather than 16.044 million fish (61% CV) estimated via the survey tuning indices (Run D, SPLIT RUN; Table F16). If the fishing mortality is held at F75%msy (F= 0.20) and 2011 stock sizes with the 2006-2010 geometric mean for Age 3 is used, then the 2012 to 2017 median catches and SSB are lower than the median catches and SSB from the projection using the 2011 stock sizes with Age 3 estimated via the survey tuning indices (Table F19).

7.0 Summary

Based on the VPA SPLIT RUN, witch flounder fishing mortality and spawning stock biomass in 2010 are summarized relative to the biological reference points (Figure F19). The 2010 spawning stock biomass was 4,099 mt, 41% below SSBmsy (10,051 mt) and 2010 fishing mortality was 0.47, 173% above Fmsy (F=0.27); therefore, witch flounder was overfished and overfishing occurred in 2010 (Figure F19).

The 2010 witch flounder assessment reveals that discards continue to be a minor component of the total catch. Total catch has declined in recent years and is below the time series average. Fishing mortality has declined substantially since 1996; however, F in 2010 is about twice as high as the estimated fishing mortality in the early 1990s. Spawning stock biomass has shown a general declining trend over the time series. Age 3 recruits have averaged 9.8 million fish over the time series. The 2004 year class appears strong (above the time series average) while the 2005 – 2007 year classes are below the time series average.

Based on yield per recruit analyses, Fmsy = F40%MSP = 0.27. SSBmsy and MSY were estimated using a long-term stochastic projection. SSBmsy = 10,051 mt and MSY = 2,075 mt. The 2010 spawning stock biomass age structure remains truncated compared to the conditions under MSY (Figure F18).

Changes from last assessment

Changes from the last assessment were: minor revisions to 2007 catches, software updates and three additional years for data.

Sources of Uncertainty

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

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

- The research bottom trawl survey catches very few witch flounder; in many years, the stratified mean number per tow of witch flounder is less than 5 fish. Abundance of witch flounder in the late 1980s and early 1990's may have gone below levels that provide reliable estimates of trends in abundance and biomass.

8.0 Conclusions:

Status of Stock for Witch flounder

SSB in 2010 is estimated to be 4,099 mt.
F in 2010 is estimated to be 0.47.
<u>Updated</u> estimates of the biological reference points are:

SSBmsy proxy = 10,051 mt,
Fmsy proxy = 0.27, and
MSY proxy = 2,075 mt.

Based on these results, witch flounder is overfished and overfishing is occurring. The stock is below the biomass target. This is the same status as reported in GARM-III.

The results are based on the same model (ADAPT VPA) used in GARM-III (NEFSC 2008, CRD#08-15), which includes splitting the time series between 1994 and 1995.

The BRPs are based on the following updates: average of the recent five year partial recruitment, mean weights at age, and maturity, as well as estimates of recruitment from the VPA for years 1982 to 2009.

Witch Flounder. Summary of Assessment Information

Witch Flounder	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg	Min	Max	YrRange
Landings (mt)	3227	3162	2935	2662	1871	1086	1012	963	765		2700	765	6675	1937-2010
Discards(mt)	225	334	309	150	87	97	63	104	89		162	25	339	1982-2010
Catch (mt)	3413	3458	3226	2802	1950	1173	1071	1058	848		2951	848	6760	1982-2010
SSB (mt)	6168	5504	4221	3756	2757	2710	3194	3900	4099	-	6555	2710	16903	1982-2010
F age 8-9	0.54	0.75	0.93	0.84	0.85	0.521	0.55	0.41	0.47	-	0.60	0.23	1.14	1982-2010
Recruitment, Age 3 millions	11.213	8.476	5.106	3.702	4.521	2.438	7.277	3.962	5.119	16.044	9.390	2.438	17.706	1982-2011

Panel Comments

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

The GARM III assessment used the split series model to reduce the retrospective pattern, but it did not eliminate the retrospective pattern. This update assessment also uses the split series model to reduce but not remove the retrospective pattern. The remaining retrospective pattern in this assessment is larger than in the GARM III assessment. Although the split leads to a reduction in retrospective bias, it does not identify the underlying causes or imply its persistence. This situation is similar to other stocks for which the split was used to remove a retrospective pattern.

The sensitivity run that used a 5 year geometric mean in stock projections indicated that recruitment in terminal year of current assessment is likely to be substantially overestimated. When the 2006-2010 geometric mean is used to estimate Age 3 in 2011, the estimated stock size is 6.079 million fish rather than 16.044 million fish estimated via the survey tuning indices. The projected SSB and median catches are substantially lower when the 5-year geometric mean recruitment is used compared to the estimates using terminal year estimates of recruitment.

The Panel discussed the declining trends in mean weights at age for the middle and older ages. Possible causes of the declines are the imprecise estimation of mean weights at age in the earlier time series, selective fishery removals, or an actual decline in growth rates of older fish. The issue of changing weights in age has been noted in a number of groundfish stocks, and research into its cause should be continued. This has been identified as a source of uncertainty. Concern was expressed that if there is a difference in the weight at age in commercial samples and survey samples, using only the commercial catch mean weights at age as population mean weights could lead to the overestimation of population biomass.

Survey estimates using constant conversion coefficients for the *Bigelow* were used in the assessment. Length-based conversion coefficients require a fuller consideration than can be performed in an update assessment.

Two research recommendations, applicable to several stocks were suggested: 1) explore the possibility of refining the calibration factors within the assessment model itself (e.g, splitting the survey tuning series and using the results from the calibration experiment as a prior); and 2) continue to examine the trends in mean weights at age and their possible underlying factors.

9.0 Acknowledgments

We thank all those who diligently collected data from the commercial fisheries (dock-side and at-sea) and the research vessel surveys. We thank Sally Sherman of Maine DMR for providing the ME-NH survey indices of abundance and biomass. We thank all the members of the Groundfish Assessment Review Meetings for their review and helpful comments.

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Table F1. Witch flounder landings, discards and catch (metric tons, live) by country, 1937-2010 [1937-1959 provisional landings reported in Lange and Lux, 1978; 1960-1963 reported to ICNAF/NAFO (Burnett and Clark, 1983)].

	LANDINGS							
Year	USA Subarea 4, 5 & 6	USA Subarea 3	USA Total	CAN	Other	Total	USA Discards	USA Catch
1937			*5000*			*5000*		
1938			*3600*			*3600*		
1939			*3100*			*3100*		
1940			*3000*			*3000*		
1941			*2000*			*2000*		
1942			*1800*			*1800*		
1943			*1000*			*1000*		
1944			*1000*			*1000*		
1945			*1000*			*1000*		
1946			*1500*			*1500*		
1947			*1500*			*1500*		
1948			*1000*			*1000*		
1949			*3600*			*3600*		
1950			*3000*			*3000*		
1951			*2600*			*2600*		
1952			*3700*			*3700*		
1953			*4200*			*4200*		
1954			*4000*			*4000*		
1955			*2400*			*2400*		
1956			*2000*			*2000*		
1957			*1000*			*1000*		
1958			*1000*			*1000*		
1959			*1000*			*1000*		
1960	1255		1255			1255		
1961	1022		1022	2		1024		
1962	976		976	1		977		
1963	1226		1226	27	121	1374		
1964	1381		1381	37		1418		
1965	2140		2140	22	502	2664		
1966	2935		2935	68	311	3314		
1967	3370		3370	63	249	3682		
1968	2807		2807	56	191	3054		
1969	2542		2542		1310	3852		
1970	3112		3112	19	130	3261		
1971	3220		3220	35	2860	6115		
1972	2934		2934	13	2568	5515		
1973	2523		2523	10	629	3162		
1974	1839		1839	9	292	2140		
1975	2127		2127	13	217	2357		
1976	1871		1871	5	6	1882		
1977	2469		2469	11	13	2493		
1978	3501		3501	18	6	3525		
1979	2878		2878	17		2895		
1980	3128		3128	18	1	3147		
1981	3442		3442	7		3449		

continued.

Table F1 continued. Witch flounder landings, discards and catch (metric tons, live).

	LANDINGS							
Year	USA Subarea 4, 5 & 6	USA Subarea 3	USA Total	CAN	Other	Total	USA Discards	USA Total Catch
1982	4906		4906	9		4915	48	4954
1983	6000		6000	45		6045	162	6162
1984	6660		6660	15		6675	100	6760
1985	6130	255	6385	46		6431	61	6191
1986	4610	539	5149	67		5216	25	4635
1987	3450	346	3796	23		3819	47	3497
1988	3262	358	3620	45		3665	60	3322
1989	2068	297	2365	13		2378	76	2144
1990	1465	2	1467	12		1479	96	1561
1991	1777		1777	7		1784	217	1994
1992	2227		2227	7		2234	212	2439
1993	2601		2601	10		2611	224	2825
1994	2670		2670	34		2704	339	3009
1995	2209		2209	11		2220	203	2412
1996	2087		2087	10		2097	207	2294
1997	1772		1772	7		1779	209	1981
1998	1848		1848	10		1858	198	2046
1999	2121		2121	19		2140	277	2398
2000	2439		2439	53		2492	178	2617
2001	3020		3020	32		3052	307	3327
2002	3188		3188	39		3227	225	3413
2003	3124		3124	38		3162	334	3458
2004	2917		2917	18		2935	309	3226
2005	2652		2652	10		2662	150	2802
2006	1863		1863	8		1871	87	1950
2007	1076		1076	11		1086	97	1173
2008	1009		1009	3		1012	63	1071
2009	954		954	9		963	104	1058
2010	759		759	6		765	89	848

Table F2. Percentage of witch flounder landings (metric tons, live) by gear type, 1964-2010.

YEAR	Otterl Trawl	Shrimp Trawl	Gillnet	Unknown	Other	Total
1964	99.9	.	.	.	0.1	100.0
1965	99.8	.	.	.	0.2	100.0
1966	99.7	.	.	.	0.3	100.0
1967	100.0	.	.	.	0.0	100.0
1968	99.9	.	.	.	0.1	100.0
1969	100.0	.	.	.	0.0	100.0
1970	100.0	.	0.0	.	0.0	100.0
1971	97.7	.	0.0	.	2.3	100.0
1972	97.4	.	0.0	.	2.6	100.0
1973	98.6	.	0.0	.	1.3	100.0
1974	99.7	.	0.0	.	0.3	100.0
1975	97.0	2.5	0.1	.	0.4	100.0
1976	98.8	0.8	0.1	.	0.3	100.0
1977	97.2	1.5	0.1	.	1.3	100.0
1978	98.0	.	0.1	.	1.8	100.0
1979	97.8	0.2	0.4	.	1.7	100.0
1980	96.6	0.6	0.2	.	2.6	100.0
1981	97.2	0.8	0.2	.	1.8	100.0
1982	96.8	0.8	0.4	.	2.0	100.0
1983	95.9	0.6	0.1	.	3.4	100.0
1984	96.1	0.4	0.0	.	3.4	100.0
1985	95.0	1.1	0.1	.	3.8	100.0
1986	95.4	1.1	0.2	.	3.3	100.0
1987	95.4	1.1	0.8	.	2.8	100.0
1988	96.0	0.8	0.6	.	2.6	100.0
1989	95.3	0.4	1.4	.	2.9	100.0
1990	92.8	0.6	2.5	.	4.1	100.0
1991	94.9	0.4	1.0	.	3.7	100.0
1992	96.1	0.1	0.9	.	2.9	100.0
1993	94.1	0.0	2.9	.	3.0	100.0
1994	96.1	0.0	2.6	0.2	1.1	100.0
1995	96.5	0.0	2.1	0.5	1.0	100.0
1996	97.1	0.0	2.0	0.2	0.8	100.0
1997	96.9	0.3	1.4	0.0	1.4	100.0
1998	97.1	0.1	1.5	0.0	1.3	100.0
1999	97.3	0.1	2.1	0.1	0.4	100.0
2000	97.7	0.0	1.6	0.0	0.7	100.0
2001	98.3	0.0	1.2	0.1	0.3	100.0
2002	97.4	0.0	1.2	0.8	0.6	100.0
2003	97.6	0.0	1.3	0.0	1.1	100.0
2004	95.2	0.0	1.0	2.0	1.8	100.0
2005	90.4	0.0	1.7	5.3	2.6	100.0
2006	94.1	0.1	1.5	1.9	2.3	100.0
2007	97.0	0.1	1.7	1.0	0.3	100.0
2008	95.0	0.6	3.2	1.0	0.2	100.0
2009	94.0	0.1	3.7	1.7	0.6	100.0
2010	95.3	0.0	3.0	0.7	1.0	100.0

Dealer Electronic Reporting (DER) was implemented in 2004;
For 2010, Otter Trawl (95.3%) includes Haddock Separator Trawl (3.1%) and Ruhle Trawl (0.1%).

Table F3. Summary of USA commercial witch flounder landings (mt), number of length samples (n), number of fish measured (len) and number of age samples (age) by market category and quarter for all gear types, 1981 - 2010. The sampling ratio represents the amount of landings per length sample.

		Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total	Sampling
Year		Small	Med.	Large	Small	Med.	Large	Small	Med.	Large	Small	Med.	Large	All	Ratio
1981	mt	260	7	517	269	32	694	242	13	607	230	0	453	3324	
	n	.	.	.	.	1	1	.	1	.	1	.	1	5	665
	len	.	.	.	.	101	103	.	89	.	105	.	100	498	
	age	.	.	.	.	.	26	.	25	.	25	.	25	101	
1982	mt	348	1	726	342	73	886	287	170	739	278	201	669	4720	
	n	5	2	6	1	2	2	2	2	6	3	4	2	37	128
	len	527	194	626	126	209	216	189	210	514	307	393	189	3700	
	age	128	55	150	30	55	50	50	50	150	81	105	50	954	
1983	mt	475	250	910	471	286	1037	298	154	758	257	169	613	5678	
	n	5	2	3	5	1	5	8	3	8	6	3	.	49	116
	len	680	232	265	685	96	520	1008	123	981	677	344	.	5611	
	age	135	30	55	131	16	125	152	0	159	180	75	.	1058	
1984	mt	462	322	1036	513	393	1000	403	248	653	429	286	586	6331	
	n	5	9	4	7	1	7	8	1	2	4	2	1	51	124
	len	804	1112	400	970	117	775	1045	106	191	615	243	91	6469	
	age	154	250	76	186	25	180	210	28	53	105	44	25	1336	
1985	mt	465	377	613	697	453	850	526	291	553	433	310	408	5976	
	n	12	1	2	5	4	7	7	7	6	8	2	4	65	92
	len	1530	105	229	657	426	698	795	800	684	824	264	349	7361	
	age	319	29	50	106	77	153	97	138	113	161	25	29	1297	
1986	mt	384	309	356	654	421	595	375	238	354	312	212	238	4448	
	n	6	3	5	5	4	5	4	3	4	5	3	2	49	90
	len	662	307	515	558	410	413	302	364	406	416	337	233	4923	
	age	123	60	89	106	97	129	63	75	100	87	75	52	1056	
1987	mt	349	211	228	432	317	387	296	203	247	298	203	202	3373	
	n	1	1	2	4	2	3	5	5	4	2	3	2	34	69
	len	85	145	200	323	228	316	354	583	400	204	261	178	3277	
	age	25	25	50	77	47	76	78	113	95	48	64	51	749	
1988	mt	424	304	271	436	393	389	184	176	208	140	140	131	3196	
	n	5	4	5	5	5	3	5	4	3	3	4	3	49	65
	len	335	407	465	344	544	429	396	359	295	229	402	356	4561	
	age	70	89	106	71	110	77	70	100	75	61	95	69	993	
1989	mt	230	174	148	255	264	251	98	145	156	85	107	103	2016	
	n	1	2	2	2	2	1	2	2	1	1	2	.	18	112
	len	94	201	222	230	236	27	150	206	100	125	202	.	1793	
	age	25	50	49	50	46	25	40	51	25	25	47	.	433	

Table F3 continued. Summary of commercial sampling for witch flounder.

		Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total	Sampling
Year		Small	Med.	Large	Small	Med.	Large	Small	Med.	Large	Small	Med.	Large	All	Ratio
1990	mt	113	125	107	147	168	147	100	119	129	84	79	85	1403	
	n	1	2	3	6	3	1	6	2	2	7	2	.	35	40
	len	134	199	199	335	296	100	349	247	145	381	201	.	2586	
	age	15	40	45	81	70	25	69	41	50	103	48	.	587	
1991	mt	71	56	58	219	151	167	192	142	184	168	108	121	1637	
	n	5	2	3	7	2	1	4	2	3	5	4	3	41	40
	len	262	224	401	537	239	125	212	165	249	300	410	274	3398	
	age	53	50	80	93	45	25	49	49	52	66	97	58	717	
1992	mt	180	86	82	466	163	174	205	115	138	212	97	116	2034	
	n	4	2	2	7	1	2	7	1	1	2	.	1	30	68
	len	259	241	185	501	125	235	477	121	117	129	.	46	2436	
	age	42	46	52	78	25	25	86	25	25	27	.	23	454	
1993	mt	350	112	110	442	192	161	263	122	150	331	96	106	2435	
	n	7	1	.	7	1	1	9	1	5	.	.	.	32	76
	len	830	100	.	741	107	100	728	85	499	.	.	.	3190	
	age	55	25	.	56	27	26	74	.	73	.	.	.	336	
1994	mt	403	143	98	505	183	154	390	122	117	383	91	80	2669	
	n	.	.	.	3	5	6	5	5	1	5	3	4	37	72
	len	.	.	.	560	532	749	356	648	105	342	368	407	4067	
	age	.	.	.	59	104	134	44	113	26	56	60	82	678	
1995	mt	336	91	77	586	117	100	399	61	70	304	48	40	2229	
	n	3	3	3	6	3	5	.	.	.	2	.	1	26	85
	len	208	348	347	459	367	517	.	.	.	217	.	94	2557	
	age	53	84	89	81	75	135	.	.	.	27	.	25	569	
1996	mt	313	57	36	545	86	60	458	56	44	363	42	28	2088	
	n	5	2	3	5	2	1	5	4	4	5	3	3	42	50
	len	504	218	292	331	240	127	494	464	468	343	277	348	4106	
	age	59	45	78	53	50	26	59	86	101	60	70	69	756	
1997	mt	313	40	25	478	86	41	398	55	27	265	31	16	1775	
	n	6	3	3	9	4	3	9	3	1	9	1	1	52	34
	len	557	350	351	812	418	309	783	308	107	505	128	50	4678	
	age	77	68	70	108	73	77	98	81	20	73	18	23	786	
1998	mt	372	39	19	587	79	31	380	40	20	239	26	14	1846	
	n	5	2	1	4	1	1	5	3	1	.	.	.	23	80
	len	339	206	128	238	88	135	484	186	100	.	.	.	1904	
	age	45	50	19	30	.	29	47	22	.	.	.	.	242	
1999	mt	386	48	19	616	79	31	436	67	30	353	38	18	2121	
	n	3	.	.	4	.	.	17	2	3	11	1	.	41	51
	len	282	.	.	308	.	.	1110	201	306	775	109	.	3091	
	age	15	.	.	62	.	.	143	.	32	91	16	.	359	

Table F3 continued. Summary of commercial sampling for witch flounder.

Year		Quarter 1 Small	Med.	Large	Quarter 2 Small	Med.	Large	Quarter 3 Small	Med.	Large	Quarter 4 Small	Med.	Large	Total All	Sampling Ratio
2000	mt	477	53	17	583	93	27	555	89	28	451	50	16	2439	
	n	31	2	.	47	.	.	17	1	.	5	5	2	110	22
	len	2253	91	.	2445	.	.	994	105	.	308	558	217	6971	
	age	393	10	.	463	.	.	224	20	.	67	92	51	1320	
2001	mt	583	71	17	824	99	30	699	98	28	507	50	13	3019	
	n	8	4	2	3	3	2	8	2	3	5	3	.	43	70
	len	744	422	134	237	352	159	594	209	213	313	232	.	3609	
	age	125	64	42	48	48	64	126	34	46	61	49	.	707	
2002	mt	740	79	18	774	103	26	849	114	29	400	45	9	3186	
	n	5	1	2	3	5	3	5	2	3	3	2	2	36	89
	len	363	121	107	212	518	209	389	150	194	262	226	115	2866	
	age	75	16	50	65	73	64	88	34	62	49	30	49	655	
2003	mt	603	70	17	684	108	30	865	125	36	533	43	10	3124	
	n	4	6	6	10	5	10	11	6	16	7	7	13	101	31
	len	324	423	162	881	482	433	943	531	552	654	632	525	6542	
	age	57	93	60	131	64	174	172	91	246	99	120	191	1498	
2004	mt	609	76	16	598	90	23	758	113	30	546	45	13	2917	
	n	5	13	23	8	5	8	5	5	2	19	5	15	113	26
	len	480	1244	1813	675	549	576	541	356	48	1838	420	83	8623	
	age	73	226	505	151	96	169	58	95	10	49	72	.	1504	
2005	mt	603	69	14	639	101	18	618	96	21	433	34	6	2652	
	n	15	8	11	10	7	9	8	8	12	9	8	15	120	22
	len	727	525	309	798	523	288	542	369	329	512	422	445	5789	
	age	78	65	104	117	113	93	130	92	165	92	99	229	1377	
2006	mt	619	67	14	418	52	8	367	46	12	232	24	4	1863	
	n	9	6	14	11	5	16	11	5	26	11	5	29	148	13
	len	501	538	765	837	433	255	584	268	392	577	444	334	5928	
	age	90	114	246	146	118	119	129	75	282	119	106	238	1782	
2007	mt	264	27	5	267	37	7	227	40	8	173	19	3	1076	
	n	10	6	40	12	2	12	11	15	24	10	5	19	166	6
	len	516	480	400	653	203	304	605	279	237	605	232	177	4691	
	age	106	144	343	132	51	172	136	133	189	107	76	159	1748	

Table F3 continued. Summary of commercial sampling for witch flounder.

Year		Quarter 1 Small	Quarter 1 Med.	Quarter 1 Large	Quarter 2 Small	Quarter 2 Med.	Quarter 2 Large	Quarter 3 Small	Quarter 3 Med.	Quarter 3 Large	Quarter 4 Small	Quarter 4 Med.	Quarter 4 Large	Total All	Sampling Ratio
2008	mt	274.8	33.9	7.2	233	28.1	5.1	216.6	32.9	7.2	148.2	18.1	3.7	1009	
	n	13	4	22	13	10	24	13	7	12	13	8	16	155	7
	len	649	243	410	819	329	237	578	417	104	749	459	166	5160	
	age	152	83	229	155	190	236	130	69	95	153	178	159	1829	
2009	mt	271.1	31.1	5.2	207.8	23.4	3.9	224.7	32.1	8	126.6	16.2	4	954	
	n	12	8	15	14	10	20	10	4	18	10	5	4	130	7
	len	642	393	269	722	299	123	575	246	193	572	317	17	4368	
	age	150	163	136	151	139	83	113	100	150	127	74	11	1397	
2010	mt	256.7	30.6	5.1	151.5	16.5	2.8	136.9	18.5	6	118.3	13.9	2.6	759	
	n	10	6	18	12	15	28	12	7	15	13	4	9	149	5
	len	537	355	147	656	376	197	685	221	129	672	200	132	4307	
	age	114	106	119	147	178	157	146	134	117	147	77	105	1547	

Table F4. USA commercial landings at age (thousands of fish), of witch flounder, 1982 – 2010.

		USA Commercial Landings in Numbers (1000's) at Age										
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1982	0.000	0.000	0.000	117.900	826.600	1119.900	1454.300	665.200	656.000	399.500	239.400	1578.400
1983	0.000	0.000	0.000	219.800	768.600	1033.700	1567.300	1590.200	977.800	737.700	510.400	1675.500
1984	0.000	0.000	0.000	90.600	1012.400	1808.700	1734.300	1486.500	1497.500	696.700	375.100	1718.800
1985	0.000	0.000	0.000	0.000	985.100	2026.800	1933.800	1524.900	1247.900	606.000	400.400	1359.200
1986	0.000	0.000	0.000	6.300	298.500	1441.600	2772.600	1566.900	834.900	412.700	222.800	758.200
1987	0.000	0.000	0.000	0.000	81.500	321.600	1276.000	1574.700	870.900	480.600	252.400	489.400
1988	0.000	0.000	0.000	0.000	50.800	176.000	654.700	1382.700	1154.100	401.500	266.700	597.500
1989	0.000	0.000	0.000	0.000	7.290	49.690	314.330	759.350	882.120	349.650	123.390	348.000
1990	0.000	0.000	0.000	0.000	181.570	574.320	255.610	273.860	471.070	333.930	81.350	177.490
1991	0.000	0.000	0.000	0.000	179.540	732.880	519.430	235.770	244.550	292.110	313.560	257.770
1992	0.000	0.000	0.000	0.000	509.310	839.430	935.490	716.980	201.640	177.880	120.040	377.010
1993	0.000	0.000	0.000	0.000	422.170	1022.890	917.660	597.190	585.560	218.770	278.530	390.480
1994	0.000	0.000	0.000	0.000	201.639	1431.828	1288.414	828.243	197.021	540.057	113.680	324.838
1995	0.000	0.000	0.000	0.000	23.690	763.000	1597.430	848.700	267.450	97.220	269.490	156.840
1996	0.000	0.000	0.000	0.000	45.790	467.720	1263.830	1430.480	263.230	215.480	57.050	113.620
1997	0.000	0.000	0.000	0.000	212.263	528.139	1049.873	1014.449	591.550	83.179	49.808	70.112
1998	0.000	0.000	0.000	0.000	18.090	487.960	1213.510	1583.010	370.510	141.350	15.540	70.300
1999	0.000	0.000	0.000	0.000	185.149	585.733	1391.764	1178.302	763.150	251.266	31.571	54.361
2000	0.000	0.000	0.000	0.000	75.400	261.550	1072.960	1671.410	1004.050	558.090	93.130	234.600
2001	0.000	0.000	0.000	0.000	18.818	379.952	931.284	1683.679	1455.521	632.495	427.485	309.590
2002	0.000	0.000	0.000	0.000	169.070	648.660	1233.240	2107.400	1269.990	640.020	94.100	201.150
2003	0.000	0.000	0.000	0.000	56.790	517.680	1222.550	1760.820	1535.500	741.010	433.590	347.010
2004	0.000	0.000	0.000	0.000	188.530	696.460	1221.100	1403.550	1122.510	785.000	313.390	285.050
2005	0.000	0.000	0.000	0.000	75.118	637.827	1702.245	1746.227	818.771	408.738	234.635	132.335
2006	0.000	0.000	0.000	0.000	36.197	177.392	571.614	1519.138	869.397	355.919	132.599	73.028
2007	0.000	0.000	0.000	0.000	15.084	48.668	220.213	852.105	594.940	167.497	96.950	42.708
2008	0.000	0.000	0.000	4.215	58.171	84.173	270.632	578.017	449.391	312.074	111.419	66.505
2009	0.000	0.000	0.000	0.000	35.417	223.433	246.701	476.561	436.345	320.804	73.851	76.973
2010	0.000	0.000	0.000	0.000	0.000	111.778	304.427	275.523	394.735	176.211	231.944	45.576

Table F5. USA commercial landings mean weight (kg) at age of witch flounder, 1982 – 2010.

	USA Commercial Landings Mean Weight (kg) at Age											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1982	-	-	-	0.216	0.275	0.345	0.424	0.550	0.727	0.886	0.983	1.406
1983	-	-	-	0.195	0.257	0.322	0.410	0.518	0.613	0.795	0.977	1.357
1984	-	-	-	0.212	0.268	0.346	0.422	0.539	0.664	0.817	0.922	1.339
1985	-	-	-	-	0.253	0.311	0.429	0.565	0.691	0.842	0.964	1.326
1986	-	-	-	-	0.227	0.306	0.408	0.533	0.676	0.853	0.975	1.321
1987	-	-	-	-	0.272	0.342	0.434	0.561	0.686	0.828	0.980	1.303
1988	-	-	-	-	0.310	0.367	0.435	0.538	0.668	0.819	0.980	1.326
1989	-	-	-	-	0.260	0.344	0.425	0.574	0.682	0.818	0.968	1.358
1990	-	-	-	-	0.308	0.323	0.438	0.586	0.688	0.849	1.049	1.454
1991	-	-	-	-	0.286	0.371	0.443	0.578	0.702	0.836	0.974	1.420
1992	-	-	-	-	0.328	0.383	0.459	0.614	0.739	0.822	0.882	1.243
1993	-	-	-	-	0.292	0.364	0.432	0.535	0.666	0.882	1.023	1.335
1994	-	-	-	-	0.308	0.357	0.430	0.534	0.691	0.832	0.909	1.266
1995	-	-	-	-	0.284	0.367	0.448	0.561	0.690	0.911	0.974	1.243
1996	-	-	-	-	0.260	0.355	0.435	0.554	0.708	0.856	0.974	1.232
1997	-	-	-	-	0.318	0.357	0.407	0.495	0.628	0.871	1.037	1.293
1998	-	-	-	-	0.235	0.331	0.382	0.492	0.585	0.871	0.978	1.206
1999	-	-	-	-	0.325	0.355	0.406	0.516	0.584	0.628	0.917	0.872
2000	-	-	-	-	0.319	0.326	0.376	0.455	0.535	0.624	0.704	0.915
2001	-	-	-	-	0.291	0.325	0.384	0.468	0.550	0.645	0.647	0.840
2002	-	-	-	-	0.355	0.344	0.416	0.477	0.553	0.652	0.826	0.941
2003	-	-	-	-	0.275	0.315	0.355	0.433	0.507	0.567	0.621	0.810
2004	-	-	-	-	0.288	0.317	0.369	0.451	0.543	0.613	0.698	0.873
2005	-	-	-	-	0.291	0.327	0.371	0.449	0.558	0.634	0.725	0.909
2006	-	-	-	-	0.290	0.327	0.372	0.465	0.551	0.655	0.719	0.932
2007	-	-	-	-	0.292	0.323	0.394	0.480	0.564	0.679	0.742	0.906
2008	-	-	-	0.304	0.313	0.383	0.436	0.485	0.544	0.599	0.649	0.823
2009	-	-	-	-	0.284	0.330	0.402	0.462	0.562	0.622	0.727	0.677
2010	-	-	-	-	-	0.313	0.353	0.442	0.502	0.658	0.620	0.821
Mean												
2006-2010	-	-	-	-	0.294	0.338	0.395	0.468	0.556	0.638	0.712	0.849
1982-2010	-	-	-	-	0.288	0.341	0.410	0.514	0.623	0.757	0.867	1.129

Table F6. The number of observed trips, witch flounder discards (in metric tons) and coefficient of variation (CV) by the large-mesh otter trawl, small-mesh otter trawl and northern shrimp trawl fleets, 1982 – 2010.

used in VPA

	Large-mesh Otter Trawl			Small-mesh Otter Trawl			Shrimp Trawl		Total	
YEAR	trips	mt	CV	trips	mt	CV	trips	mt	mt	CV
1982		42						6	48	
1983		149						13	162	
1984		89						11	100	
1985		49						12	61	
1986		12						13	25	
1987		26						22	47	
1988		26						34	60	
1989	55	56	0.46	45	2	0.44	36	19	76	0.45
1990	46	55	0.41	22	12	0.92	47	29	96	0.37
1991	72	184	0.42	41	3	0.87	62	29	217	0.41
1992	62	193	0.31	28	1	5.29	110	18	212	0.31
1993	29	215	0.39	11	0	3.41	104	9	224	0.39
1994	25	318	0.50	2	*5*		98	16	339	0.49
1995	48	159	0.16	34	10	0.25	88	34	203	0.15
1996	23	144	0.56	44	50	0.38	50	14	207	0.43
1997	19	191	0.38	7	5	13.15	28	13	209	0.49
1998	9	117	1.51	1	*62*			18	198	0.99
1999	32	146	0.53	16	120	0.67		12	277	0.42
2000	93	126	0.24	7	44	0.61		8	178	0.24
2001	139	239	0.17	14	63	0.37		4	307	0.16
2002	205	211	0.18	51	13	0.84		1	225	0.18
2003	372	281	0.12	43	53	0.22	15	0	334	0.11
2004	425	288	0.12	96	20	0.39	12	0	309	0.11
2005	1097	126	0.07	157	24	0.18	17	0	150	0.07
2006	519	72	0.09	48	15	0.34	20	1	87	0.10
2007	527	48	0.14	32	43	0.31	14	2	97	0.16
2008	678	61	0.10	20	1.57	0.92	16	0	63	0.10
2009	731	100	0.13	50	3.75	0.91	7	1	104	0.13
2010	877	80	0.09	68	8.54	0.32	11	1	89	0.08

Due to small sample sizes in 1994 and 1998 in the small-mesh otter trawl fleet, the boxed values represent an average discard weight of the preceding and following years.

Table F7. Witch flounder discards at age (thousands of fish) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2010.

	Discards in Numbers (1000's) at Age											
Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.030	0.060	1.719	72.590	237.874	87.770	21.102	0.000	0.000	0.000	0.000	0.000
1983	0.000	0.020	4.283	117.310	577.567	487.062	7.822	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.334	0.884	56.013	453.907	194.004	5.286	0.000	0.000	0.000	0.000	0.000
1985	0.000	0.338	3.470	123.580	191.020	91.412	2.437	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.532	3.859	16.649	78.567	75.193	2.745	0.000	0.000	0.000	0.000	0.000
1987	2.084	18.918	79.933	22.250	99.755	145.459	4.060	0.000	0.000	0.000	0.000	0.000
1988	0.417	14.659	130.291	600.271	89.115	88.302	3.567	0.000	0.000	0.000	0.000	0.000
1989	0.737	11.107	52.609	89.660	303.471	104.106	0.000	0.000	0.396	0.000	0.000	0.000
1990	1.187	5.176	116.983	303.232	200.684	200.585	0.000	0.000	0.000	0.000	0.000	0.000
1991	2.958	17.794	78.958	496.264	450.987	348.944	129.780	0.000	0.000	0.000	0.000	0.000
1992	2.706	43.408	136.916	161.856	460.095	273.947	130.037	12.009	0.000	0.000	0.000	0.000
1993	112.060	78.837	108.179	86.473	584.190	395.440	5.872	2.206	0.000	0.000	0.000	0.000
1994	8.058	1368.463	498.455	67.221	439.211	629.888	59.437	119.237	2.287	2.786	0.000	7.859
1995	2.680	49.949	658.585	640.868	354.387	278.294	108.050	2.413	0.993	0.284	0.000	0.000
1996	5.206	32.683	51.477	141.832	327.193	418.024	61.442	0.000	0.000	0.000	0.000	0.000
1997	8.683	74.911	106.806	124.289	485.868	366.753	155.794	5.404	1.367	0.781	0.000	0.248
1998	49.780	392.321	278.498	220.996	283.455	240.982	70.956	10.156	0.318	0.238	0.000	0.000
1999	32.110	253.018	188.874	146.512	275.888	340.571	51.780	15.455	1.912	0.804	0.000	0.000
2000	21.610	169.950	121.192	122.168	291.153	297.891	74.732	17.516	2.878	0.000	0.000	0.000
2001	12.330	96.960	66.280	65.071	310.455	645.812	176.741	43.068	0.143	0.143	0.000	0.000
2002	2.320	19.121	15.755	32.539	406.974	471.164	125.103	34.891	5.906	2.781	1.127	1.068
2003	0.000	1.429	6.686	31.990	226.211	585.743	379.425	120.428	23.726	6.433	1.328	1.408
2004	0.000	0.148	9.622	32.951	169.061	476.762	383.720	116.846	31.664	15.111	13.510	7.967
2005	0.000	5.920	14.598	15.318	109.137	196.146	158.955	53.816	9.365	4.596	1.313	0.854
2006	0.000	2.524	18.810	45.398	35.729	61.004	136.814	36.592	9.802	3.726	2.121	1.770
2007	0.000	2.076	20.100	71.185	70.247	53.408	37.778	18.282	2.009	1.905	0.000	0.543
2008	0.000	0.100	4.907	25.718	131.668	89.504	42.413	15.279	4.267	0.284	0.103	0.793
2009	0.000	0.367	17.170	26.611	129.873	214.695	53.182	20.865	17.681	2.291	0.542	0.334
2010	0.000	3.393	50.873	28.559	63.017	117.131	138.653	16.523	3.624	1.710	0.359	1.113

Table F8. Witch flounder discard mean weight (kg) at age in the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2010.

					Discards Mean Weight (kg) at Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1982	0.000	0.002	0.038	0.048	0.126	0.127	0.181					
1983		0.009	0.038	0.064	0.130	0.158	0.248					
1984		0.017	0.040	0.053	0.141	0.162	0.253					
1985		0.017	0.023	0.128	0.153	0.166	0.231					
1986		0.017	0.026	0.090	0.125	0.173	0.229					
1987	0.006	0.015	0.033	0.081	0.125	0.201	0.232					
1988	0.004	0.006	0.017	0.045	0.142	0.200	0.276					
1989	0.010	0.012	0.032	0.058	0.145	0.225						
1990	0.004	0.010	0.032	0.049	0.134	0.191						
1991	0.004	0.014	0.038	0.057	0.154	0.235	0.239					
1992	0.003	0.007	0.021	0.067	0.178	0.264	0.292					
1993	0.003	0.009	0.022	0.096	0.199	0.235	0.316					
1994	0.005	0.004	0.019	0.083	0.179	0.226	0.364					
1995	0.005	0.007	0.025	0.052	0.151	0.222	0.253	0.473	0.595	0.702		
1996	0.004	0.019	0.031	0.064	0.134	0.208	0.251					
1997	0.004	0.023	0.034	0.065	0.157	0.197	0.245	0.498	0.471	0.702		
1998	0.003	0.006	0.024	0.061	0.161	0.203	0.222	0.230	0.355	0.370		
1999	0.003	0.006	0.024	0.067	0.162	0.219	0.283	0.407	0.423	0.495		
2000	0.003	0.006	0.025	0.070	0.146	0.185	0.253	0.238	0.256			
2001	0.003	0.006	0.023	0.084	0.166	0.207	0.227	0.257	0.309	0.309		
2002	0.003	0.007	0.030	0.099	0.172	0.201	0.231	0.259	0.427	0.556	0.566	0.404
2003		0.008	0.039	0.069	0.136	0.195	0.237	0.263	0.317	0.416	0.422	0.681
2004		0.009	0.053	0.099	0.156	0.205	0.241	0.289	0.407	0.527	0.510	0.776
2005		0.020	0.065	0.114	0.171	0.211	0.251	0.299	0.390	0.486	0.504	0.754
2006		0.012	0.052	0.098	0.164	0.203	0.232	0.271	0.343	0.351	0.523	0.694
2007		0.015	0.037	0.108	0.177	0.220	0.245	0.304	0.449	0.607		0.815
2008	0.000	0.004	0.049	0.115	0.171	0.208	0.237	0.288	0.390	0.616	0.570	0.966
2009		0.042	0.044	0.102	0.187	0.218	0.252	0.299	0.300	0.490	0.427	0.798
2010	0.000	0.010	0.026	0.115	0.180	0.218	0.233	0.263	0.367	0.416	0.598	0.579
mean												
2006-2010		0.017	0.042	0.108	0.176	0.213	0.240	0.285	0.370	0.496	0.529	0.770
1982-2010	0.004	0.012	0.033	0.079	0.156	0.203	0.250	0.309	0.387	0.503	0.515	0.718

Table F9. Total USA commercial catch [landings + shrimp trawl discards + small-mesh otter trawl discards + large-mesh otter trawl discards] in numbers (thousands of fish) at age of witch flounder, 1982 - 2010.

USA Commercial Catch in Numbers (1000's) at Age

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.030	0.060	1.719	190.490	1064.474	1207.670	1475.402	665.200	656.000	399.500	239.400	1578.400
1983	0.000	0.020	4.283	337.110	1346.167	1520.762	1575.122	1590.200	977.800	737.700	510.400	1675.500
1984	0.000	0.334	0.884	146.613	1466.307	2002.704	1739.586	1486.500	1497.500	696.700	375.100	1718.800
1985	0.000	0.338	3.470	123.580	1176.120	2118.212	1936.237	1524.900	1247.900	606.000	400.400	1359.200
1986	0.000	0.532	3.859	22.949	377.067	1516.793	2775.345	1566.900	834.900	412.700	222.800	758.200
1987	2.084	18.918	79.933	22.250	181.255	467.059	1280.060	1574.700	870.900	480.600	252.400	489.400
1988	0.417	14.659	130.291	600.271	139.915	264.302	658.267	1382.700	1154.100	401.500	266.700	597.500
1989	0.738	11.117	52.657	89.743	311.047	153.938	314.619	760.049	883.329	349.972	123.504	348.320
1990	1.196	5.217	117.916	305.651	385.304	781.087	257.649	276.045	474.828	336.594	81.999	178.906
1991	2.963	17.822	79.083	497.048	631.523	1083.533	650.236	236.142	244.936	292.571	314.055	258.177
1992	2.707	43.434	137.000	161.955	970.000	1114.061	1066.182	729.437	201.764	177.989	120.114	377.241
1993	112.072	78.845	108.190	86.482	1006.466	1418.479	923.630	599.459	585.622	218.793	278.559	390.521
1994	8.071	1370.806	499.308	67.336	641.947	2065.247	1350.159	949.103	199.650	543.772	113.875	333.267
1995	2.691	50.156	661.314	643.523	379.643	1045.609	1712.546	854.639	269.556	97.908	270.607	157.490
1996	5.321	33.404	52.613	144.961	381.212	905.284	1354.510	1462.038	269.037	220.234	58.309	116.127
1997	8.704	75.092	107.065	124.590	699.825	897.063	1208.592	1022.328	594.355	84.164	49.929	70.531
1998	51.345	404.651	287.250	227.941	311.022	751.852	1324.834	1643.237	382.483	146.038	16.028	72.509
1999	33.799	266.329	198.811	154.220	485.292	975.036	1519.487	1256.558	805.310	265.331	33.232	57.221
2000	21.975	172.823	123.241	124.233	372.750	568.899	1167.096	1717.480	1023.952	567.525	94.705	238.566
2001	12.569	98.839	67.565	66.332	335.655	1045.644	1129.500	1760.213	1483.876	644.900	435.770	315.590
2002	2.329	19.195	15.816	32.664	578.257	1124.127	1363.562	2150.523	1280.799	645.271	95.593	202.995
2003	0.000	1.451	6.790	32.491	287.431	1120.695	1627.050	1910.694	1583.632	759.142	441.725	353.872
2004	0.000	0.000	9.684	33.162	359.881	1180.736	1615.099	1530.134	1161.566	805.236	328.994	294.894
2005	0.000	5.972	14.727	15.452	185.874	841.300	1877.554	1815.860	835.412	416.966	238.021	134.359
2006	0.000	2.544	18.956	45.751	72.486	240.250	713.937	1567.829	886.037	362.442	135.768	75.379
2007	0.00	2.16	20.87	73.91	88.60	105.98	267.86	903.70	619.79	175.88	100.66	44.91
2008	0.00	0.10	4.91	29.98	190.12	173.93	313.51	594.17	454.33	312.82	111.69	67.40
2009	0.00	0.37	17.23	26.71	165.88	439.68	300.95	499.19	455.64	324.24	74.66	77.58
2010	0.00	3.43	51.39	28.85	63.66	231.23	447.58	295.01	402.41	179.73	234.66	47.16

Table F10. USA commercial catch mean weight (kg) at age of witch flounder, 1982 - 2010.

USA Commerical Catch Mean Weight (kg) at Age												
Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.002	0.038	0.152	0.242	0.329	0.421	0.550	0.727	0.886	0.983	1.406
1983		0.009	0.038	0.149	0.202	0.270	0.409	0.518	0.613	0.795	0.977	1.357
1984		0.017	0.040	0.151	0.229	0.328	0.421	0.539	0.664	0.817	0.922	1.339
1985		0.017	0.023	0.128	0.237	0.305	0.429	0.565	0.691	0.842	0.964	1.326
1986		0.017	0.026	0.089	0.206	0.299	0.408	0.533	0.676	0.853	0.975	1.321
1987	0.006	0.015	0.033	0.081	0.191	0.298	0.433	0.561	0.686	0.828	0.980	1.303
1988	0.004	0.006	0.017	0.045	0.203	0.311	0.434	0.538	0.668	0.819	0.980	1.326
1989	0.010	0.012	0.032	0.058	0.147	0.263	0.425	0.574	0.682	0.818	0.968	1.358
1990	0.004	0.010	0.032	0.049	0.217	0.289	0.438	0.586	0.688	0.849	1.049	1.454
1991	0.004	0.014	0.038	0.057	0.192	0.327	0.402	0.578	0.702	0.836	0.974	1.420
1992	0.003	0.007	0.021	0.067	0.257	0.354	0.439	0.610	0.739	0.822	0.882	1.243
1993	0.003	0.009	0.022	0.096	0.238	0.328	0.431	0.534	0.666	0.882	1.023	1.335
1994	0.005	0.004	0.019	0.083	0.219	0.317	0.427	0.527	0.690	0.833	0.909	1.264
1995	0.005	0.007	0.025	0.052	0.160	0.328	0.436	0.561	0.690	0.910	0.974	1.243
1996	0.004	0.019	0.031	0.064	0.149	0.286	0.426	0.554	0.708	0.856	0.974	1.232
1997	0.004	0.023	0.034	0.065	0.206	0.291	0.386	0.495	0.628	0.869	1.037	1.291
1998	0.003	0.006	0.024	0.061	0.165	0.289	0.373	0.490	0.585	0.870	0.978	1.206
1999	0.003	0.006	0.024	0.067	0.228	0.305	0.402	0.515	0.584	0.628	0.917	0.872
2000	0.003	0.006	0.025	0.070	0.182	0.251	0.368	0.453	0.534	0.624	0.704	0.915
2001	0.003	0.006	0.023	0.084	0.173	0.250	0.359	0.463	0.550	0.645	0.647	0.840
2002	0.003	0.007	0.030	0.099	0.226	0.284	0.399	0.473	0.552	0.652	0.823	0.938
2003		0.008	0.039	0.069	0.164	0.251	0.327	0.422	0.504	0.566	0.620	0.809
2004			0.053	0.099	0.226	0.272	0.338	0.439	0.539	0.611	0.690	0.870
2005		0.020	0.065	0.114	0.220	0.300	0.361	0.445	0.556	0.632	0.724	0.908
2006		0.012	0.052	0.098	0.227	0.295	0.345	0.460	0.549	0.652	0.716	0.927
2007		0.015	0.037	0.108	0.198	0.269	0.372	0.476	0.564	0.678	0.742	0.905
2008		0.004	0.049	0.141	0.214	0.293	0.409	0.480	0.543	0.599	0.649	0.824
2009		0.042	0.044	0.102	0.208	0.275	0.375	0.455	0.552	0.621	0.725	0.677
2010		0.010	0.026	0.115	0.180	0.264	0.316	0.432	0.501	0.656	0.620	0.815
mean												
2006-2010		0.017	0.042	0.113	0.206	0.279	0.363	0.461	0.541	0.641	0.690	0.830
1982-2010	0.004	0.012	0.033	0.090	0.204	0.294	0.397	0.511	0.622	0.757	0.866	1.128

Table F11. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in **NEFSC offshore spring and autumn bottom trawl surveys** in Gulf of Maine-Georges Bank region (strata 22-30,36-40), 1963-2011.

	SPRING						AUTUMN					
	Number		Weight		Length	Avg. wt.	Number		Weight		Length	Avg. wt.
Year	per tow	CV	per tow	CV	per tow	per tow	per tow	CV	per tow	CV	per tow	per tow
1963	-		-		-	-	5.52	18.6	3.46	17.2	39.7	0.627
1964	-		-		-	-	2.89	13.6	2.09	17.2	44.2	0.724
1965	-		-		-	-	3.94	14.8	2.29	17.0	40.6	0.580
1966	-		-		-	-	7.89	17.0	4.61	16.2	41.2	0.585
1967	-		-		-	-	3.00	18.0	1.99	27.4	43.7	0.666
1968	4.71	17.8	3.27	21.1	42.3	0.693	4.82	18.2	3.52	19.0	44.8	0.731
1969	3.73	22.1	2.59	22.5	45.3	0.695	5.81	29.2	4.21	19.7	43.5	0.725
1970	6.39	14.3	4.50	13.5	44.7	0.705	4.89	10.7	3.68	12.8	45.0	0.753
1971	2.74	22.0	2.04	26.6	46.5	0.747	4.32	14.6	2.96	14.7	42.1	0.686
1972	5.35	20.1	4.01	21.3	45.8	0.749	3.24	15.3	2.42	16.7	43.9	0.747
1973	8.20	11.8	6.21	14.5	44.8	0.758	3.18	23.4	2.05	23.7	43.6	0.646
1974	6.23	17.9	3.62	18.3	39.3	0.581	2.38	16.7	1.58	19.9	41.0	0.666
1975	3.72	26.2	2.75	32.8	43.9	0.739	1.66	19.1	1.03	25.8	39.8	0.621
1976	5.50	16.8	3.70	22.0	42.3	0.673	1.34	23.6	0.94	21.1	41.9	0.699
1977	4.20	25.6	1.96	20.8	37.2	0.467	5.05	21.3	3.38	15.3	42.0	0.669
1978	3.87	21.4	2.56	18.5	41.7	0.662	4.04	12.3	2.94	10.6	42.8	0.727
1979	2.91	20.7	1.71	17.4	38.2	0.587	1.94	10.3	1.62	11.4	45.2	0.838
1980	8.46	29.8	3.89	15.9	36.0	0.460	2.62	13.8	2.04	16.4	43.7	0.777
1981	8.14	14.5	4.05	19.3	38.0	0.497	3.66	28.5	2.19	20.9	40.4	0.600
1982	3.64	22.2	1.87	17.2	37.2	0.513	0.99	40.5	0.83	40.5	44.7	0.842
1983	6.41	27.0	2.74	22.0	36.3	0.427	4.72	14.2	2.12	13.4	36.7	0.448
1984	3.00	16.1	1.66	17.0	39.9	0.554	4.37	13.9	2.33	16.1	39.7	0.534
1985	5.18	19.3	2.75	19.2	40.3	0.531	2.76	19.7	1.59	23.1	41.9	0.577
1986	2.07	15.8	1.35	17.0	44.1	0.650	1.59	15.5	1.09	14.7	43.3	0.683
1987	1.01	23.2	0.65	25.1	43.4	0.646	0.48	33.0	0.37	27.3	43.9	0.774
1988	1.43	23.3	0.85	27.5	42.3	0.590	1.38	17.3	0.57	19.6	35.2	0.414
1989	1.95	21.7	0.74	20.0	35.8	0.382	0.89	19.6	0.38	26.6	31.4	0.423
1990	0.63	30.3	0.24	30.6	35.2	0.378	2.00	16.4	0.40	18.4	24.7	0.200
1991	1.68	25.0	0.57	21.9	31.5	0.341	2.08	27.6	0.54	27.3	29.2	0.258
1992	1.26	18.2	0.48	23.1	34.8	0.383	0.94	30.0	0.24	37.6	29.5	0.254
1993	1.47	17.7	0.36	20.9	30.3	0.245	5.15	25.0	0.54	22.8	17.0	0.105
1994	3.13	22.6	0.53	28.5	27.4	0.170	2.21	16.4	0.42	26.5	24.9	0.191
1995	1.88	16.9	0.47	19.9	30.6	0.248	4.74	19.6	0.62	20.7	25.7	0.132
1996	1.36	16.9	0.28	19.4	30.5	0.204	5.38	19.1	1.02	21.1	29.7	0.189
1997	2.22	26.7	0.43	28.1	31.0	0.195	5.10	19.6	0.77	21.9	24.9	0.150
1998	4.27	17.5	0.77	18.8	29.0	0.179	3.70	20.1	0.47	23.2	24.2	0.127
1999	3.15	20.5	0.48	20.0	28.1	0.153	5.91	21.9	0.88	21.3	26.3	0.148
2000	3.45	14.0	0.52	12.4	27.3	0.151	6.63	15.2	1.11	17.3	27.1	0.167
2001	4.41	16.3	0.75	13.0	29.5	0.170	7.94	16.2	1.71	16.5	32.3	0.216
2002	8.10	20.3	1.61	16.5	31.4	0.199	4.31	19.0	1.06	20.0	33.2	0.246
2003	5.20	16.1	1.30	14.5	34.2	0.250	2.66	19.0	0.79	18.8	35.4	0.298
2004	3.80	12.6	1.08	13.5	35.5	0.283	3.82	31.8	1.03	31.9	33.3	0.271
2005	3.36	20.3	0.89	22.1	34.6	0.265	1.93	18.5	0.38	16.7	27.8	0.197
2006	3.09	13.9	0.72	11.0	32.2	0.235	2.03	19.3	0.46	20.7	30.5	0.226
2007	2.37	16.5	0.58	14.9	32.9	0.245	2.74	22.8	0.57	23.2	31.6	0.208
2008	7.45	25.0	1.40	21.7	31.28	0.188	2.78	17.1	0.64	19.5	31.2	0.233
*2009	2.20	18.5	0.50	18.6	31.74	0.227	2.08	19.0	0.45	21.0	29.6	0.217
*2010	2.49	17.8	0.54	18.1	30.44	0.218	1.99	16.9	0.36	20.9	28.4	0.182
*2011	2.72	16.0	0.55	17.0	30.21	0.201						

**For 2009 through 2011, constant conversion factors were applied (3.257177 for numbers and 3.257201 for weight). For 1963 through 2008, there are no significant survey conversion factors for witch flounder.*

Table F12. Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys (Strata 22-30, 36-40), 1980 – 2011.

	AGE															
SPRING	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**	**Total**
1980	0.000	0.060	0.230	0.950	1.520	0.720	1.200	1.020	0.380	0.400	0.310	0.300	0.120	0.160	1.100	8.460
1981	0.000	0.000	0.050	0.820	0.930	2.000	1.020	0.760	0.670	0.420	0.130	0.200	0.240	0.220	0.900	8.400
1982	0.000	0.044	0.042	0.610	0.484	0.377	0.237	0.609	0.362	0.093	0.259	0.175	0.026	0.033	0.292	3.642
1983	0.000	0.000	0.071	0.531	1.262	1.293	0.541	0.716	0.632	0.475	0.214	0.166	0.075	0.054	0.376	6.407
1984	0.000	0.000	0.103	0.012	0.307	0.778	0.401	0.310	0.202	0.196	0.115	0.173	0.117	0.023	0.266	3.001
1985	0.000	0.000	0.000	0.017	0.459	1.057	1.199	0.908	0.412	0.148	0.149	0.044	0.072	0.027	0.691	5.182
1986	0.000	0.000	0.000	0.000	0.044	0.240	0.529	0.412	0.172	0.194	0.079	0.038	0.063	0.055	0.248	2.073
1987	0.000	0.000	0.000	0.000	0.059	0.114	0.133	0.259	0.185	0.009	0.061	0.023	0.000	0.000	0.163	1.007
1988	0.000	0.023	0.023	0.062	0.000	0.072	0.300	0.379	0.239	0.137	0.086	0.084	0.029	0.000	0.000	1.434
1989	0.000	0.023	0.013	0.036	1.004	0.105	0.073	0.081	0.327	0.081	0.015	0.056	0.056	0.019	0.056	1.945
1990	0.000	0.008	0.000	0.038	0.091	0.319	0.000	0.042	0.009	0.050	0.018	0.009	0.011	0.000	0.030	0.626
1991	0.000	0.042	0.000	0.781	0.108	0.087	0.209	0.033	0.101	0.083	0.138	0.018	0.022	0.000	0.064	1.684
1992	0.000	0.054	0.009	0.187	0.373	0.085	0.111	0.152	0.045	0.149	0.015	0.016	0.046	0.000	0.019	1.260
1993	0.000	0.149	0.112	0.137	0.472	0.320	0.058	0.085	0.000	0.015	0.015	0.000	0.068	0.000	0.037	1.469
1994	0.000	0.107	0.698	0.541	0.644	0.810	0.164	0.027	0.028	0.070	0.008	0.000	0.000	0.016	0.016	3.129
1995	0.000	0.041	0.120	0.581	0.316	0.179	0.312	0.116	0.110	0.042	0.000	0.038	0.028	0.000	0.000	1.883
1996	0.000	0.017	0.036	0.244	0.394	0.346	0.218	0.073	0.000	0.000	0.000	0.032	0.000	0.000	0.000	1.359
1997	0.000	0.072	0.066	0.152	0.693	0.617	0.437	0.084	0.083	0.014	0.000	0.000	0.000	0.000	0.000	2.219
1998	0.000	0.112	1.079	0.712	0.388	0.798	0.713	0.214	0.154	0.076	0.000	0.000	0.000	0.028	0.000	4.274
1999	0.000	0.106	0.376	0.974	0.797	0.482	0.164	0.182	0.031	0.014	0.023	0.000	0.000	0.000	0.000	3.149
2000	0.000	0.007	0.250	1.194	0.692	0.660	0.239	0.253	0.116	0.000	0.035	0.000	0.000	0.000	0.000	3.446
2001	0.000	0.105	0.099	0.713	1.476	1.020	0.401	0.293	0.163	0.113	0.028	0.000	0.000	0.000	0.000	4.409
2002	0.000	0.023	0.060	0.897	2.627	2.263	0.822	0.683	0.351	0.192	0.103	0.014	0.000	0.029	0.037	8.101
2003	0.000	0.000	0.000	0.150	0.808	1.646	1.017	0.869	0.387	0.197	0.046	0.060	0.000	0.016	0.009	5.204
2004	0.000	0.009	0.060	0.074	0.428	0.648	0.809	0.883	0.368	0.158	0.161	0.135	0.000	0.000	0.067	3.799
2005	0.000	0.011	0.160	0.146	0.220	0.737	0.760	0.574	0.383	0.245	0.086	0.018	0.000	0.021	0.000	3.362
2006	0.000	0.043	0.460	0.347	0.138	0.207	0.683	0.568	0.410	0.145	0.069	0.015	0.000	0.000	0.000	3.087
2007	0.000	0.000	0.178	0.571	0.263	0.241	0.228	0.546	0.154	0.158	0.000	0.031	0.000	0.000	0.000	2.370
2008	0.000	0.011	0.372	0.847	2.833	1.341	0.646	0.724	0.550	0.088	0.036	0.000	0.000	0.000	0.000	7.448
*2009	0.000	0.116	0.126	0.278	0.407	0.540	0.195	0.147	0.211	0.112	0.053	0.009	0.003	0.004	0.000	2.202
*2010	0.000	0.139	0.457	0.267	0.163	0.426	0.498	0.143	0.097	0.179	0.064	0.031	0.016	0.004	0.009	2.494
*2011	0.000	0.035	0.369	0.692	0.251	0.276	0.432	0.270	0.114	0.087	0.118	0.045	0.008	0.010	0.010	2.716

**Survey conversion factors applied.*

Table F12 continued.   Stratified mean number per tow at age of witch flounder.

						AGE										
AUTUMN	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**	**Total**
1980	0.040	0.000	0.020	0.000	0.200	0.260	0.280	0.360	0.170	0.150	0.270	0.040	0.160	0.120	0.570	2.620
1981	0.030	0.070	0.030	0.240	0.440	0.610	0.460	0.270	0.260	0.180	0.210	0.170	0.040	0.130	0.480	3.660
1982	0.020	0.000	0.000	0.058	0.013	0.027	0.076	0.241	0.132	0.015	0.027	0.032	0.009	0.039	0.301	0.991
1983	0.000	0.008	0.011	0.507	1.596	0.758	0.548	0.444	0.084	0.137	0.073	0.114	0.025	0.000	0.415	4.718
1984	0.000	0.000	0.000	0.093	0.943	0.991	0.605	0.535	0.310	0.149	0.126	0.073	0.041	0.132	0.375	4.373
1985	0.000	0.000	0.009	0.059	0.076	0.610	0.684	0.482	0.270	0.103	0.122	0.029	0.015	0.089	0.217	2.763
1986	0.009	0.000	0.000	0.000	0.051	0.266	0.353	0.309	0.160	0.112	0.009	0.010	0.021	0.052	0.237	1.590
1987	0.000	0.000	0.023	0.000	0.011	0.023	0.046	0.192	0.071	0.000	0.009	0.000	0.000	0.023	0.085	0.482
1988	0.000	0.007	0.000	0.725	0.055	0.012	0.036	0.215	0.048	0.046	0.045	0.079	0.011	0.043	0.055	1.376
1989	0.174	0.018	0.018	0.082	0.301	0.009	0.021	0.017	0.084	0.078	0.024	0.000	0.026	0.000	0.037	0.888
1990	0.481	0.088	0.137	0.380	0.507	0.219	0.024	0.023	0.023	0.025	0.000	0.000	0.009	0.055	0.034	2.005
1991	0.224	0.021	0.177	0.661	0.329	0.290	0.145	0.067	0.059	0.030	0.052	0.028	0.000	0.000	0.000	2.083
1992	0.097	0.029	0.109	0.259	0.224	0.054	0.061	0.000	0.000	0.019	0.009	0.019	0.000	0.019	0.042	0.940
1993	2.541	0.672	0.154	0.544	0.777	0.219	0.058	0.022	0.081	0.000	0.019	0.042	0.000	0.011	0.014	5.154
1994	0.432	0.156	0.287	0.532	0.165	0.395	0.037	0.106	0.000	0.043	0.009	0.000	0.005	0.000	0.042	2.209
1995	0.512	0.203	0.764	1.624	0.858	0.472	0.229	0.000	0.000	0.011	0.054	0.000	0.000	0.000	0.009	4.736
1996	0.232	0.092	0.261	0.785	1.988	1.386	0.441	0.066	0.065	0.037	0.000	0.033	0.000	0.000	0.000	5.384
1997	0.892	0.339	0.979	0.522	0.871	0.770	0.383	0.329	0.000	0.000	0.000	0.000	0.020	0.000	0.000	5.105
1998	0.639	0.082	0.520	1.363	0.465	0.303	0.165	0.110	0.043	0.012	0.000	0.000	0.000	0.000	0.000	3.701
1999	0.323	0.521	1.178	1.514	1.044	0.600	0.364	0.275	0.050	0.037	0.009	0.000	0.000	0.000	0.000	5.915
2000	0.943	0.096	0.719	1.408	1.746	0.674	0.589	0.229	0.152	0.049	0.000	0.000	0.026	0.000	0.000	6.630
2001	0.000	0.039	0.210	0.952	3.156	1.886	0.813	0.612	0.159	0.058	0.056	0.000	0.000	0.000	0.000	7.940
2002	0.000	0.000	0.275	0.431	1.475	0.997	0.532	0.331	0.148	0.071	0.000	0.046	0.005	0.000	0.000	4.311
2003	0.018	0.000	0.038	0.075	0.307	0.580	0.770	0.315	0.129	0.222	0.083	0.021	0.046	0.019	0.038	2.660
2004	0.276	0.072	0.014	0.086	0.453	0.987	0.826	0.498	0.355	0.054	0.105	0.072	0.000	0.000	0.019	3.816
2005	0.132	0.635	0.087	0.023	0.131	0.181	0.269	0.340	0.055	0.052	0.012	0.000	0.000	0.016	0.000	1.933
2006	0.066	0.103	0.540	0.322	0.046	0.104	0.298	0.286	0.138	0.071	0.042	0.014	0.000	0.000	0.000	2.030
2007	0.000	0.065	0.162	1.206	0.478	0.188	0.220	0.261	0.069	0.078	0.000	0.000	0.014	0.000	0.000	2.740
2008	0.275	0.021	0.095	0.422	0.794	0.273	0.254	0.235	0.302	0.014	0.057	0.000	0.000	0.008	0.000	2.748
*2009	0.092	0.391	0.178	0.189	0.349	0.420	0.146	0.133	0.111	0.065	0.004	0.008	0.000	0.000	0.000	2.084
*2010	0.037	0.377	0.453	0.190	0.218	0.176	0.265	0.050	0.115	0.061	0.019	0.021	0.002	0.000	0.000	1.986

**Survey conversion factors applied.*

Table F13. Parameter estimates (with coefficient of variation), stock size (N) in '000 of fish, and estimates of terminal F from ADAPT VPA formulations for witch flounder. *Note: SPLIT survey indices are: 1982-1994 and 1995 - onward.*

RUN	A	B	C	D	E	F	G
	GARM 2008 SPLIT RUN	Update 2012 SPLIT RUN	Update 2012 SPLIT RUN	**Update 2012 SPLIT RUN**	Update 2012 NO SPLIT RUN	Update 2012 SPLIT RUN LCF1	Update 2012 SPLIT RUN LCF2
Software	NFT VPA 2.7.7	NFT VPA 3.1.1	NFT VPA 3.1.1	**NFT VPA 3.1.1**	NFT VPA 3.1.1	NFT VPA 3.1.1	NFT VPA 3.1.1
Catch-At-Age	1982-2007 3-11+	1982-2007 3-11+	1982-2007 w/ revised 2007 3-11+	1982-2010 3-11+	1982-2010 3-11+	1982-2010 3-11+	1982-2010 3-11+
Est.Ages	3-10	3-10	3-10	3-10	3-10	3-10	3-10
NMFS-s	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+
NMFS-a	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+
Residual Sum Sq.	324.1	324.1	324.1	348.4	423.0	356.9	351.9
Mean Sq.Residual	0.730	0.730	0.730	0.700	0.849	0.716	0.706
N3 (cv)	11,992 (.63)	11,992 (.63)	11,992 (.63)	16,044 (.61)	33,879 (.67)	6,749 (.62)	6,891 (.61)
N4 (cv)	22,123 (.45)	22,123 (.45)	22,121 (.45)	4,380 (.44)	7,837 (.47)	2,207 (.44)	2,264 (.44)
N5 (cv)	5,433 (.37)	5,433 (.37)	5,432 (.37)	2,855 (.36)	4,966 (.39)	2,002 (.37)	2,036 (.36)
N6 (cv)	1,220 (.34)	1,220 (.34)	1,220 (.34)	4,273 (.32)	7,371 (.34)	3,476 (.33)	3,540 (.33)
N7 (cv)	1,442 (.35)	1,442 (.35)	1,442 (.35)	5,887 (.30)	10,022 (.31)	4,864 (.31)	4,973 (.31)
N8 (cv)	2,074 (.39)	2,074 (.39)	2,076 (.39)	1,427 (.32)	2,535 (.32)	1,070 (.35)	1,137 (.34)
N9 (cv)	957 (.44)	957 (.44)	959 (.44)	418 (.42)	813 (.37)	218 (.49)	292 (.46)
N10 (cv)	1,354 (.36)	1,354 (.36)	1,356 (.36)	479 (.38)	1,113 (.30)	225 (.46)	330 (.42)
F 3	0.003	0.003	0.003	0.006	0.003	0.012	0.012
F 4	0.015	0.015	0.015	0.021	0.012	0.029	0.029
F 5	0.077	0.077	0.077	0.049	0.029	0.060	0.059
F 6	0.159	0.159	0.159	0.068	0.041	0.082	0.080
F 7	0.339	0.339	0.338	0.175	0.102	0.227	0.215
F 8	0.470	0.470	0.467	0.635	0.374	0.990	0.818
F 9	0.114	0.114	0.113	0.297	0.139	0.551	0.407
F10	0.292	0.292	0.290	0.466	0.257	0.771	0.612
F11+	0.292	0.292	0.290	0.466	0.257	0.771	0.612
2007 Avg F 8-9	**0.292 (.27)**	0.292	0.290	0.52	0.43	0.58	0.55
2007 SSB (mt)	**3,434 (.15)**	3,434	3,750	2,710	3,476	2,392	2,513
2007 Age 3 in yr t	**25,781**	25,781	25,780	12,438	19,973	10,573	10,773
2010 Avg F 8-9				**0.47 (.20)**	0.26 (.35)	0.77	0.61
2010 SSB (mt)				**4,099 (.12)**	7,033 (.15)	3,108	3,350
2010 Age 3 in yr t				**5,119**	9,136	2,596	2,662
Mohn's rho F8-9	-0.02			-0.33	-0.55	-0.29	-0.33
Mohn's rho SSB	0.43			0.61	1.38	0.67	0.65
Mohn's rho Age 3	-0.13			0.06	0.52	0.16	0.13
Notes:	GARM 2008 accepted run	'Bridge Run' with updated software	'Bridge Run' with revised 2007 values	2008 thru 2010 added; constant conversion factors for surveys 2009+	Sensitivity run; no split in survey tuning indices	Sensitivity run: length-based CF for surveys 2009+	Sensitivity run: length-based CF 20-40 cm then constant for surveys 2009+

Table F14. Mohn rho statistic (average of relative differences of 7 'peels') for fishing mortality (F 8-9), spawning stock biomass (SSB), and recruits (Age 3) for the SPLIT RUN and three sensitivity runs.

SPLIT RUN

Run D	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	Mean
F 8-9	-0.23	-0.43	-0.61	-0.71	-0.44	0.02	0.07	**-0.33**
SSB	0.90	1.30	0.74	0.76	0.38	0.11	0.06	**0.61**
Age 3	-0.67	-0.59	0.13	0.33	0.65	0.27	0.26	**0.06**

NO SPLIT

Run E	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	Mean
F 8-9	-0.53	-0.64	-0.80	-0.84	-0.67	-0.33	-0.03	**-0.55**
SSB	2.09	2.64	1.98	1.92	1.28	-0.42	0.20	**1.38**
Age 3	-0.36	-0.20	0.89	1.01	1.21	0.60	0.52	**0.52**

SPLIT LCF1

Run F	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	Mean
F 8-9	-0.23	-0.44	-0.62	-0.73	-0.50	0.13	0.33	**-0.29**
SSB	0.92	1.33	0.80	0.89	0.56	0.19	0.03	**0.67**
Age 3	-0.61	-0.52	0.35	0.57	0.99	0.32	-0.01	**0.16**

SPLIT LCF2

Run G	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	Mean
F 8-9	-0.23	-0.44	-0.62	-0.72	-0.47	0.06	0.12	**-0.33**
SSB	0.91	1.32	0.77	0.84	0.48	0.17	0.06	**0.65**
Age 3	-0.64	-0.55	0.30	0.54	0.96	0.31	0.01	**0.13**

Table F15. Summary of witch flounder spawning stock biomass (mt), fully recruited fishing mortality (F8-9), recruitment (Age 3, millions fish), and year class from VPA **SPLIT RUN**, 1982 to 2010, with Age 3 recruits predicted in 2011.

Year	SSB (mt)	Avg F8-9	Recruits Age 3	Year Class
1982	16,903	0.26	15.409	1979
1983	13,439	0.50	17.706	1980
1984	11,542	0.63	16.371	1981
1985	10,433	0.68	7.670	1982
1986	9,550	0.50	5.437	1983
1987	8,950	0.60	3.137	1984
1988	8,312	0.70	9.301	1985
1989	7,360	0.44	6.070	1986
1990	6,334	0.25	7.541	1987
1991	6,950	0.25	8.659	1988
1992	7,052	0.23	12.156	1989
1993	5,833	0.45	8.905	1990
1994	4,350	0.60	13.104	1991
1995	4,068	0.62	11.837	1992
1996	3,871	1.14	15.676	1993
1997	4,141	1.08	13.896	1994
1998	5,160	0.66	14.774	1995
1999	6,070	0.54	12.596	1996
2000	6,794	0.56	11.448	1997
2001	6,688	0.91	12.134	1998
2002	6,168	0.54	11.213	1999
2003	5,504	0.75	8.476	2000
2004	4,221	0.93	5.106	2001
2005	3,756	0.84	3.702	2002
2006	2,757	0.85	4.521	2003
2007	2,710	0.52	12.438	2004
2008	3,194	0.55	7.277	2005
2009	3,900	0.41	3.962	2006
2010	4,099	0.47	5.119	2007
2011			16.044	2008

Min	2,710	0.23	3.137
Max	16,903	1.14	17.706
Mean	6,556	0.60	9.850
Geomean			8.865
Median			9.301
Mean (1979 to 2006 year classes)			10.019

Summary statistics for Recruits Age 3 exclude the 2011 estimate.

Table F16. Estimates of beginning year stock size ('000 of fish), instantaneous fishing mortality and spawning stock biomass (mt) for witch flounder estimated from the virtual population analysis, 1982-2010 **SPLIT RUN**.

Jan 1 Population Numbers

AGE	1982	1983	1984	1985	1986
3	15409.	17706.	16371.	7670.	5437.
4	12176.	13086.	14927.	13954.	6487.
5	9564.	9495.	10017.	11491.	10922.
6	7830.	7115.	6766.	6771.	7932.
7	4290.	5376.	4669.	4218.	4041.
8	2752.	3077.	3160.	2648.	2225.
9	2102.	1763.	1747.	1344.	1132.
10	1101.	1440.	839.	862.	600.
11	7260.	4728.	3844.	2927.	2040.
Total	62485.	63786.	62339.	51884.	40817.

AGE	1987	1988	1989	1990	1991
3	3137.	9301.	6070.	7541.	8659.
4	4659.	2680.	7449.	5141.	6208.
5	5234.	3842.	2177.	6123.	4069.
6	7998.	4073.	3062.	1731.	4548.
7	4270.	5700.	2897.	2344.	1252.
8	2036.	2225.	3629.	1792.	1762.
9	1146.	951.	856.	2308.	1104.
10	594.	545.	449.	414.	1675.
11	1152.	1220.	1267.	904.	1377.
Total	30226.	30535.	27856.	28300.	30653.

AGE	1992	1993	1994	1995	1996
3	12156.	8905.	13104.	11837.	15676.
4	6992.	10313.	7584.	11216.	9592.
5	4759.	5121.	7945.	5934.	9302.
6	2502.	3067.	3099.	4932.	4140.
7	3313.	1172.	1788.	1425.	2667.
8	859.	2178.	459.	668.	445.
9	1290.	553.	1334.	211.	327.
10	680.	946.	275.	648.	92.
11	2136.	1326.	804.	377.	183.
Total	34686.	33581.	36391.	37248.	42424.

Table F16 continued.

AGE	1997	1998	1999	2000	2001
3	13896.	14774.	12596.	11448.	12134.
4	13358.	11845.	12505.	10698.	9738.
5	7903.	10849.	9907.	10314.	8863.
6	7169.	5972.	8642.	7624.	8350.
7	2315.	5053.	3916.	6033.	5483.
8	954.	1052.	2834.	2212.	3608.
9	136.	278.	553.	1696.	963.
10	80.	40.	105.	233.	937.
11	113.	183.	181.	586.	678.
Total	45925.	50046.	51239.	50845.	50754.

AGE	2002	2003	2004	2005	2006
3	11213.	8476.	5106.	3702.	4521.
4	10382.	9621.	7266.	4364.	3172.
5	8071.	8400.	8014.	5920.	3584.
6	6661.	5907.	6194.	5806.	4317.
7	6142.	4473.	3583.	3840.	3266.
8	3096.	3305.	2092.	1676.	1637.
9	1740.	1486.	1390.	736.	675.
10	240.	903.	582.	458.	251.
11	510.	724.	522.	259.	140.
Total	48055.	43296.	34749.	26762.	21564.

AGE	2007	2008	2009	2010	2011
3	12438.	7277.	3962.	5119.	16044.
4	3847.	10637.	6236.	3385.	4380.
5	2663.	3229.	8979.	5213.	2855.
6	2862.	2194.	2618.	7321.	4273.
7	3056.	2216.	1598.	1975.	5887.
8	1371.	1797.	1359.	915.	1427.
9	596.	610.	1127.	750.	418.
10	249.	351.	238.	671.	479.
11	111.	212.	247.	136.	435.
Total	27193.	28521.	26364.	25485.	36197.

Table F16 continued.

Fishing Mortality

AGE	1982	1983	1984	1985	1986
3	0.0134	0.0207	0.0097	0.0175	0.0046
4	0.0987	0.1172	0.1116	0.0950	0.0646
5	0.1459	0.1888	0.2416	0.2206	0.1616
6	0.2261	0.2713	0.3226	0.3661	0.4693
7	0.1823	0.3813	0.4172	0.4894	0.5357
8	0.2953	0.4162	0.7050	0.6995	0.5132
9	0.2282	0.5928	0.5561	0.6571	0.4945
10	0.2657	0.4770	0.6494	0.6850	0.5069
11	0.2657	0.4770	0.6494	0.6850	0.5069

AGE	1987	1988	1989	1990	1991
3	0.0077	0.0720	0.0160	0.0446	0.0638
4	0.0428	0.0578	0.0460	0.0841	0.1159
5	0.1009	0.0769	0.0791	0.1475	0.3363
6	0.1887	0.1907	0.1171	0.1743	0.1668
7	0.5020	0.3014	0.3305	0.1354	0.2264
8	0.6110	0.8055	0.3026	0.3344	0.1618
9	0.5944	0.6000	0.5750	0.1705	0.3344
10	0.6050	0.7394	0.3492	0.2388	0.2248
11	0.6050	0.7394	0.3492	0.2388	0.2248

AGE	1992	1993	1994	1995	1996
3	0.0144	0.0105	0.0055	0.0603	0.0100
4	0.1614	0.1109	0.0955	0.0371	0.0437
5	0.2893	0.3524	0.3268	0.2098	0.1105
6	0.6079	0.3897	0.6266	0.4649	0.4314
7	0.2696	0.7880	0.8344	1.0153	0.8773
8	0.2904	0.3402	0.6253	0.5648	1.0317
9	0.1605	0.5501	0.5725	0.6825	1.2541
10	0.2104	0.3793	0.5858	0.5918	1.1200
11	0.2104	0.3793	0.5858	0.5918	1.1200

AGE	1997	1998	1999	2000	2001
3	0.0097	0.0168	0.0133	0.0118	0.0059
4	0.0580	0.0287	0.0427	0.0382	0.0378
5	0.1302	0.0775	0.1119	0.0612	0.1356
6	0.1998	0.2719	0.2093	0.1797	0.1571
7	0.6383	0.4283	0.4212	0.3641	0.4215
8	1.0840	0.4926	0.3633	0.6817	0.5793
9	1.0673	0.8215	0.7168	0.4437	1.2393
10	1.0819	0.5529	0.4132	0.5714	0.6866
11	1.0819	0.5529	0.4132	0.5714	0.6866

Table F16 continued.

AGE	2002	2003	2004	2005	2006
3	0.0031	0.0041	0.0070	0.0045	0.0114
4	0.0618	0.0327	0.0548	0.0469	0.0251
5	0.1621	0.1548	0.1723	0.1657	0.0749
6	0.2482	0.3500	0.3280	0.4253	0.1956
7	0.4698	0.6098	0.6097	0.7028	0.7182
8	0.5839	0.7163	0.8947	0.7588	0.8601
9	0.5055	0.7868	0.9589	0.9242	0.8482
10	0.5550	0.7377	0.9199	0.8064	0.8566
11	0.5550	0.7377	0.9199	0.8064	0.8566

AGE	2007	2008	2009	2010
3	0.0064	0.0044	0.0073	0.0061
4	0.0251	0.0194	0.0291	0.0205
5	0.0438	0.0597	0.0541	0.0489
6	0.1061	0.1667	0.1319	0.0680
7	0.3812	0.3390	0.4075	0.1750
8	0.6596	0.3164	0.4449	0.6345
9	0.3802	0.7915	0.3688	0.2974
10	0.5664	0.4172	0.4097	0.4660
11	0.5664	0.4172	0.4097	0.4660

Table F16 continued.

Average Fishing Mortality For Ages 8-9

Year	Average F	N Weighted	Biomass Wtd	Catch Wtd
1982	0.2618	0.2663	0.2630	0.2699
1983	0.5045	0.4805	0.4919	0.4921
1984	0.6306	0.6520	0.6454	0.6577
1985	0.6783	0.6852	0.6833	0.6857
1986	0.5039	0.5069	0.5060	0.5071
1987	0.6027	0.6050	0.6042	0.6051
1988	0.7028	0.7439	0.7349	0.7525
1989	0.4388	0.3546	0.3635	0.3799
1990	0.2524	0.2421	0.2345	0.2664
1991	0.2481	0.2283	0.2353	0.2558
1992	0.2254	0.2124	0.2078	0.2295
1993	0.4452	0.3827	0.3913	0.3973
1994	0.5989	0.5860	0.5841	0.5867
1995	0.6236	0.5931	0.5994	0.5962
1996	1.1429	1.1259	1.1368	1.1318
1997	1.0756	1.0819	1.0813	1.0819
1998	0.6571	0.5613	0.5802	0.5835
1999	0.5400	0.4211	0.4274	0.4509
2000	0.5627	0.5784	0.5701	0.5968
2001	0.9093	0.7183	0.7369	0.7792
2002	0.5447	0.5557	0.5526	0.5576
2003	0.7516	0.7382	0.7403	0.7392
2004	0.9268	0.9203	0.9227	0.9210
2005	0.8415	0.8093	0.8153	0.8138
2006	0.8542	0.8566	0.8561	0.8566
2007	0.5199	0.5749	0.5639	0.5978
2008	0.5539	0.4369	0.4493	0.5101
2009	0.4069	0.4104	0.4081	0.4133
2010	0.4660	0.4828	0.4633	0.5305

Table F16 continued.

Spawning Stock Biomass

AGE	1982	1983	1984	1985	1986
3	20.	21.	38.	8.	6.
4	107.	132.	185.	127.	91.
5	376.	459.	580.	685.	994.
6	1116.	1241.	1244.	1585.	1918.
7	1544.	1884.	1715.	1720.	1638.
8	1634.	1544.	1559.	1388.	1219.
9	1632.	1172.	1088.	878.	781.
10	949.	1207.	629.	666.	487.
11	9525.	5779.	4505.	3376.	2416.
Total	16903.	13439.	11542.	10433.	9550.

AGE	1987	1988	1989	1990	1991
3	13.	31.	16.	13.	16.
4	176.	143.	188.	111.	98.
5	846.	703.	329.	552.	380.
6	2475.	1301.	969.	406.	941.
7	1796.	2526.	1308.	1004.	497.
8	1084.	1161.	2038.	1007.	1009.
9	758.	629.	561.	1648.	757.
10	479.	423.	368.	360.	1417.
11	1324.	1395.	1583.	1232.	1837.
Total	8950.	8312.	7360.	6334.	6950.

AGE	1992	1993	1994	1995	1996
3	25.	22.	31.	11.	11.
4	137.	162.	137.	163.	98.
5	473.	479.	685.	629.	857.
6	585.	712.	652.	1291.	1166.
7	1361.	422.	622.	546.	1060.
8	501.	1228.	235.	354.	228.
9	921.	393.	872.	146.	199.
10	550.	794.	217.	515.	70.
11	2500.	1621.	899.	414.	183.
Total	7052.	5833.	4350.	4068.	3871.

AGE	1997	1998	1999	2000	2001
3	6.	18.	20.	25.	36.
4	104.	155.	200.	160.	156.
5	581.	969.	766.	786.	595.
6	1820.	1302.	1859.	1426.	1381.
7	904.	1816.	1373.	1938.	1626.
8	458.	499.	1336.	939.	1451.
9	87.	173.	287.	909.	435.
10	62.	33.	86.	136.	513.
11	119.	196.	144.	475.	496.
Total	4141.	5160.	6070.	6794.	6688.

Table F16 continued.

AGE	2002	2003	2004	2005	2006
3	67.	28.	36.	35.	27.
4	235.	202.	167.	137.	79.
5	544.	590.	513.	512.	255.
6	1043.	811.	816.	860.	590.
7	1644.	1100.	789.	878.	726.
8	1191.	1145.	662.	569.	533.
9	869.	647.	570.	320.	303.
10	151.	476.	286.	244.	134.
11	425.	505.	380.	200.	109.
Total	6168.	5504.	4221.	3756.	2757.

AGE	2007	2008	2009	2010
3	74.	66.	33.	54.
4	88.	299.	259.	111.
5	204.	278.	990.	555.
6	473.	421.	588.	1478.
7	805.	690.	547.	655.
8	519.	777.	602.	364.
9	310.	294.	588.	410.
10	149.	210.	141.	372.
11	89.	159.	152.	100.
Total	2710.	3194.	3900.	4099.

Table F17. Witch flounder input vectors for biological reference points (yield and spawning biomass per recruit analyses and long-term stochastic projections).

Age	Partial recruitment	Sel. on M	Mean Stock wts	Mean Catch wts	Mean SpStock wts	Maturity
3	0.011	1	0.087	0.113	0.087	0.11
4	0.039	1	0.152	0.206	0.152	0.25
5	0.091	1	0.244	0.279	0.244	0.47
6	0.427	1	0.322	0.363	0.322	0.71
7	0.603	1	0.414	0.461	0.414	0.87
8	1.000	1	0.501	0.541	0.501	0.95
9	1.000	1	0.595	0.641	0.595	0.98
10	1.000	1	0.662	0.690	0.662	0.99
11+	1.000	1	0.830	0.830	0.830	1.00

Year	Age 3 ('000 fish)
1982	15,409
1983	17,706
1984	16,371
1985	7,670
1986	5,437
1987	3,137
1988	9,301
1989	6,070
1990	7,541
1991	8,659
1992	12,156
1993	8,905
1994	13,104
1995	11,837
1996	15,676
1997	13,896
1998	14,774
1999	12,596
2000	11,448
2001	12,134
2002	11,213
2003	8,476
2004	5,106
2005	3,702
2006	4,521
2007	12,438
2008	7,277
2009	3,962
Mean	10,019

Table F18. Witch flounder yield and spawning stock biomass per recruit results and corresponding biological reference points estimated in GARM 2008 and Update 2012. The Fmsy = F40%MSP is based on yield per recruit analyses, while the SSBmsy and MSY estimates are based on long-term stochastic projections using the VPA SPLIT RUN. (*Note: mean Age 3 recruitment values are not used in the calculations of Update 2012 SSBmsy and MSY estimates*).

				Mean Age 3	Agepro Projections	
	Fmsy F40%	Y/R (kg)	SSB/R (kg)	Recruitment (fish,millions)	SSBmsy (mt)	MSY (mt)
GARM 2008						
SPLIT RUN	0.20	0.1943	0.9346	11.1	11,447	2,352
Update 2012						
SPLIT RUN	0.27	0.2069	0.9970	10.0	10,051	2,075

Table F19. Short-term projected median estimates of catch (mt) and spawning stock biomass (mt) of witch flounder in 2011 through 2017 under four fishing mortality scenarios: F status quo, Fmsy, F75%msy [with Age 3 stock size estimated via survey tuning indices and via 2006-2010 geometric mean (GM)], and F-rebuild based on the VPA **SPLIT RUN**. Projections assumed 2011 catches = 2010 catches; initial 2011 stock sizes for ages 3 to 11+ are from the calibrated VPA, average 2006-2010 partial recruitment, average 2006-2010 mean weights and maturation ogive representing 2007-2011 maturities are given below.

Projection input vectors:

Age	Partial recruitment	Sel. on M	Mean Stock wts	Mean Catch wts	Mean SpStock wts	Maturity
3	0.011	1	0.087	0.113	0.087	0.11
4	0.039	1	0.152	0.206	0.152	0.25
5	0.091	1	0.244	0.279	0.244	0.47
6	0.427	1	0.322	0.363	0.322	0.71
7	0.603	1	0.414	0.461	0.414	0.87
8	1.000	1	0.501	0.541	0.501	0.95
9	1.000	1	0.595	0.641	0.595	0.98
10	1.000	1	0.662	0.690	0.662	0.99
11+	1.000	1	0.830	0.830	0.830	1.00

Projection results based on SPLIT RUN:

	Fsq (0.47)	Fmsy (0.27)	F75%msy (0.20)	GM Age 3 t+1 F75%msy (0.20)	Frebuild (0.18)
Catch (mt)					
Year					
2011	848	848	848	848	848
2012	1,946	1,207	919	902	854
2013	1,800	1,273	1,017	976	955
2014	1,947	1,465	1,205	1,007	1,140
2015	2,105	1,660	1,393	1,129	1,324
2016	2,328	1,909	1,630	1,258	1,556
2017	2,323	1,991	1,734	1,414	1,663
Spawning Stock Biomass (mt)					
Year					
2011	5,212	5,212	5,212	5,103	5,212
2012	5,860	5,995	6,044	5,695	6,054
2013	6,016	6,819	7,135	6,160	7,207
2014	6,477	7,741	8,298	6,769	8,427
2015	7,002	8,719	9,527	7,668	9,722
2016	7,236	9,343	10,387	8,511	10,641
2017	7,211	9,653	10,921	9,260	11,233

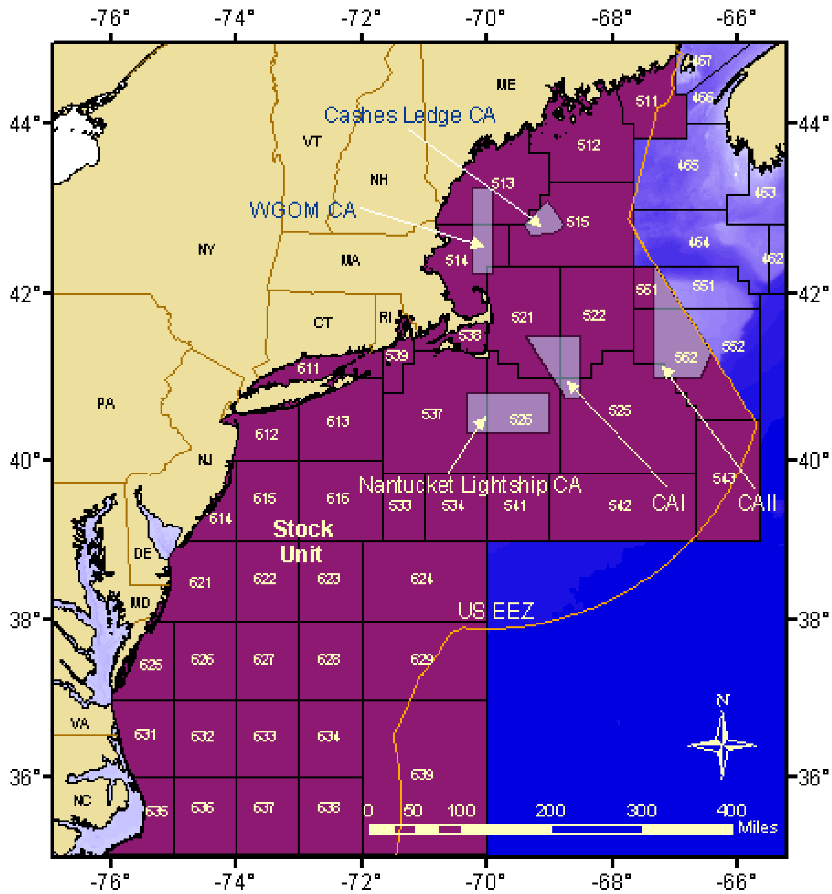


Figure 10.1. Statistical areas used to define the witch flounder stock.

Figure F1. Statistical areas used to define the witch flounder stock.

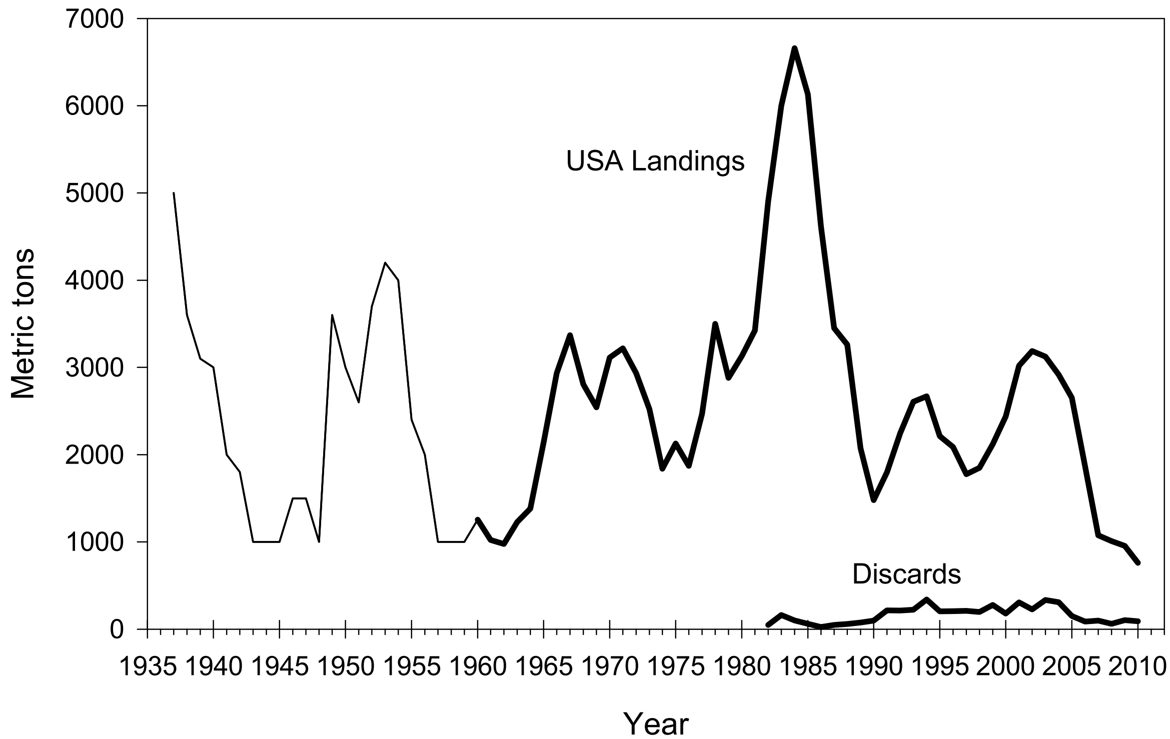


Figure F2. Historical USA witch flounder landings (mt), excluding USA landings from the Grand Banks in the mid-1980's. The thin line represents provisional landings data taken from Lange and Lux (1978). Discards are from the northern shrimp, small-mesh (<5.5 inch) otter trawl and large-mesh (>5.5 inch) otter trawl fisheries.

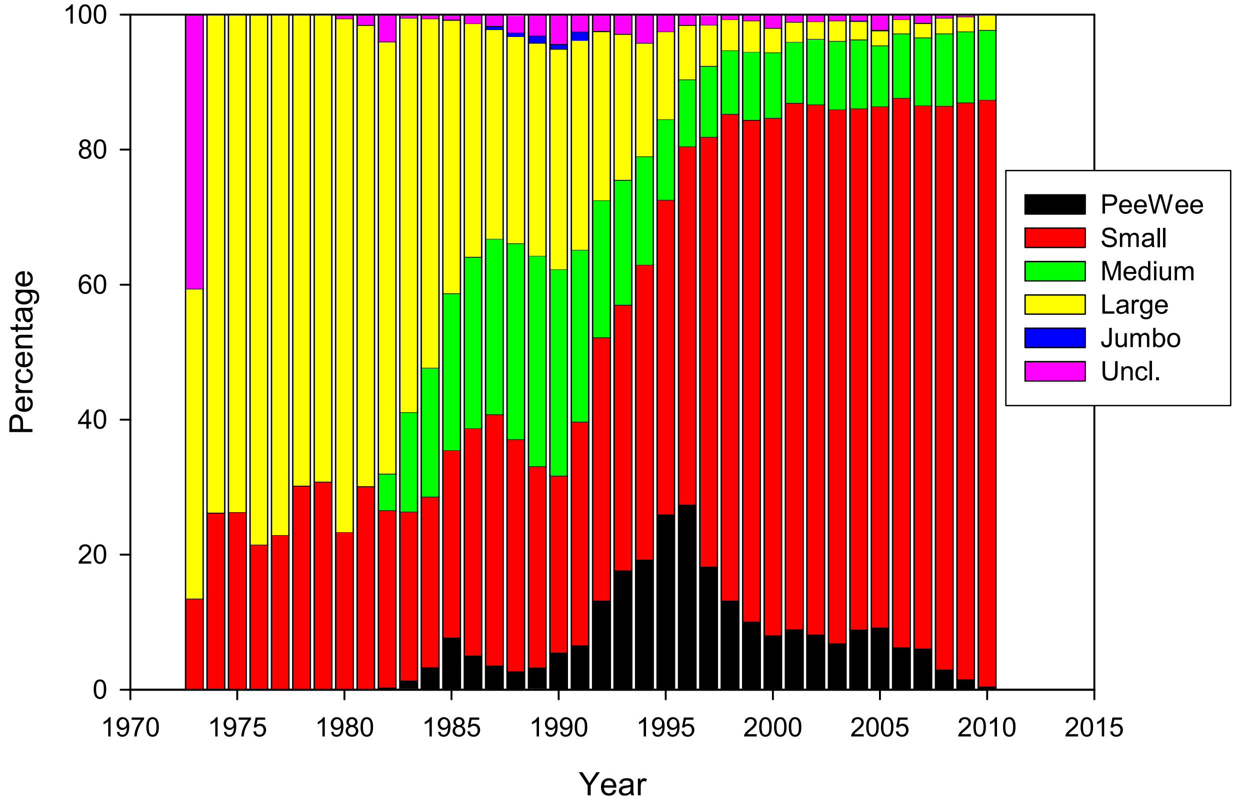


Figure F3. Percentage of witch flounder landings by market category for 1973 to 2010.

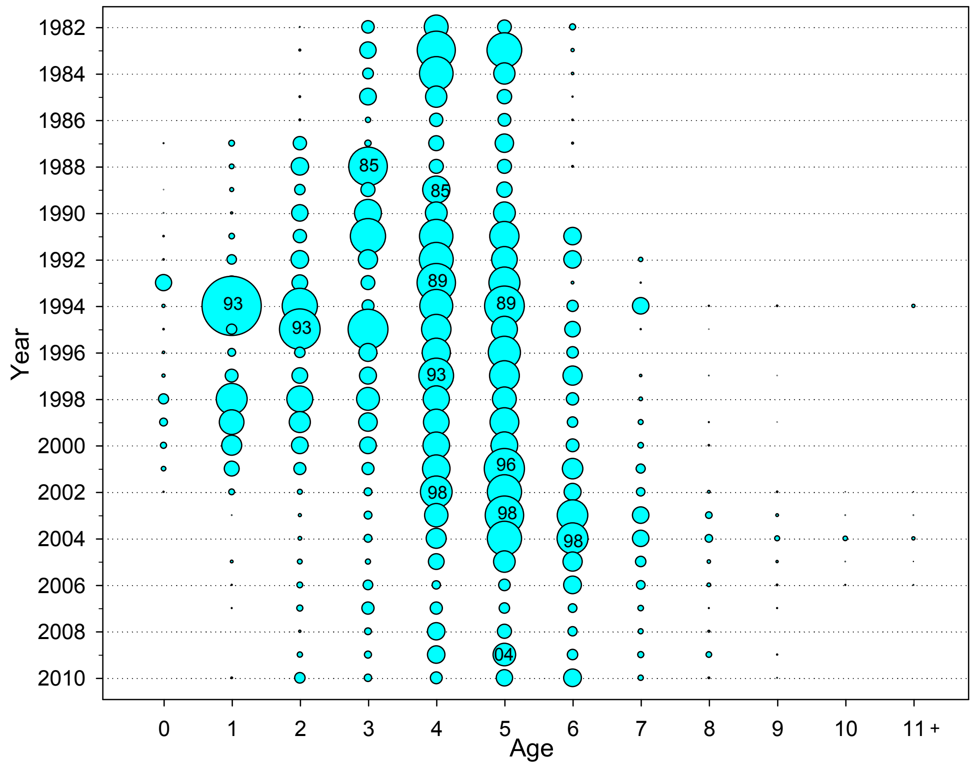


Figure F4. Witch flounder discards at age (in numbers) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 to 2010; selected cohorts are labeled.

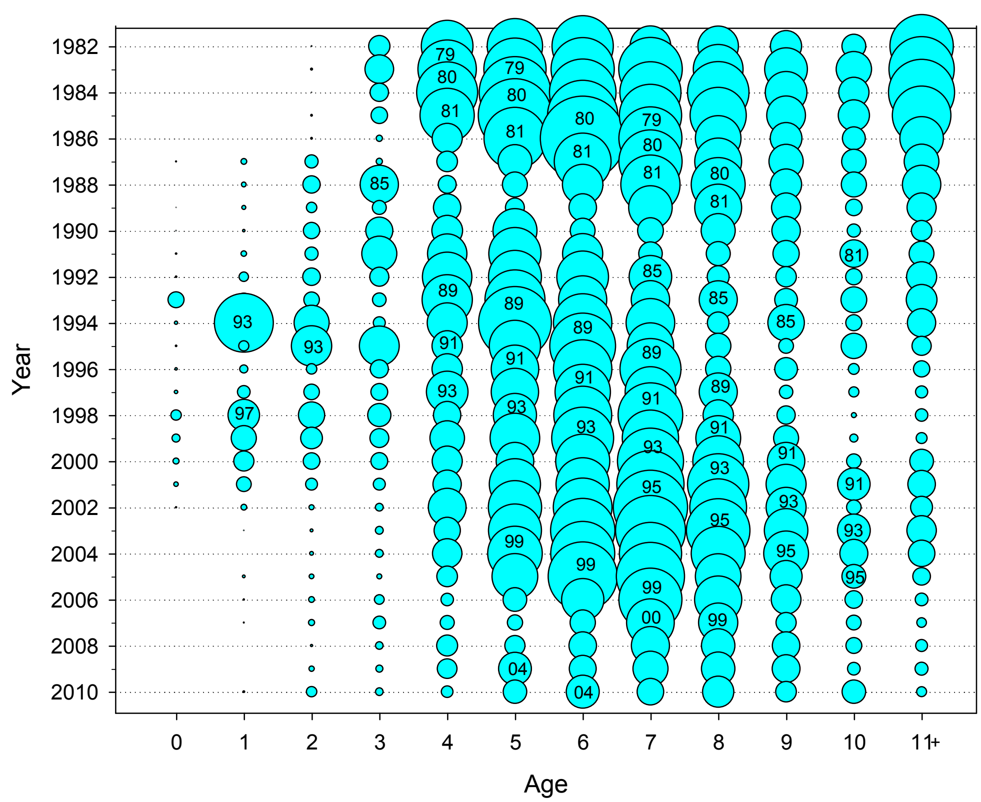


Figure F5. Witch flounder catch at age (in numbers), 1982-2010; selected cohorts are labeled.

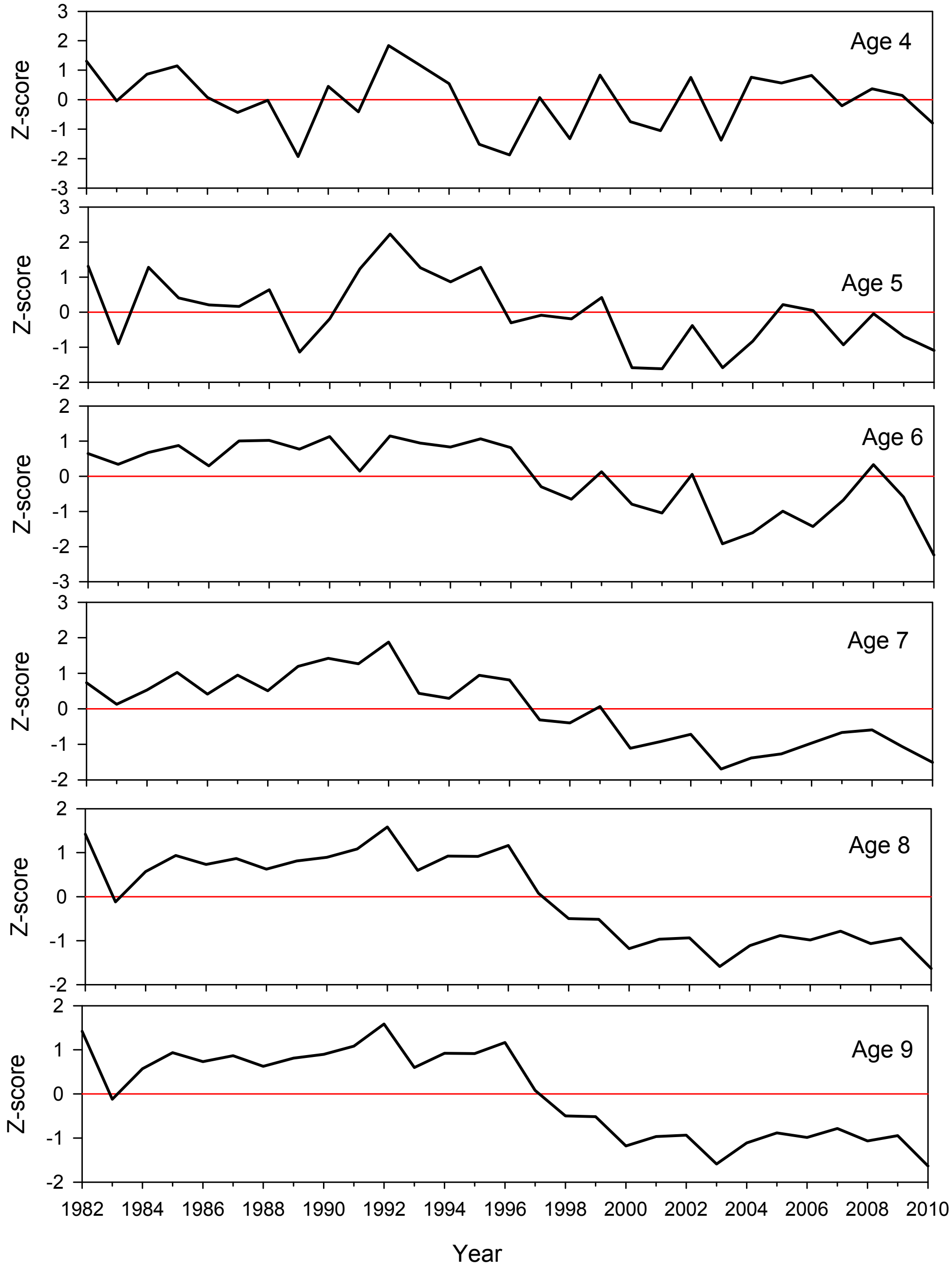


Figure F6. Z-scores of witch flounder mean weight at age in the catch for ages 4 to 9, 1982 - 2010.

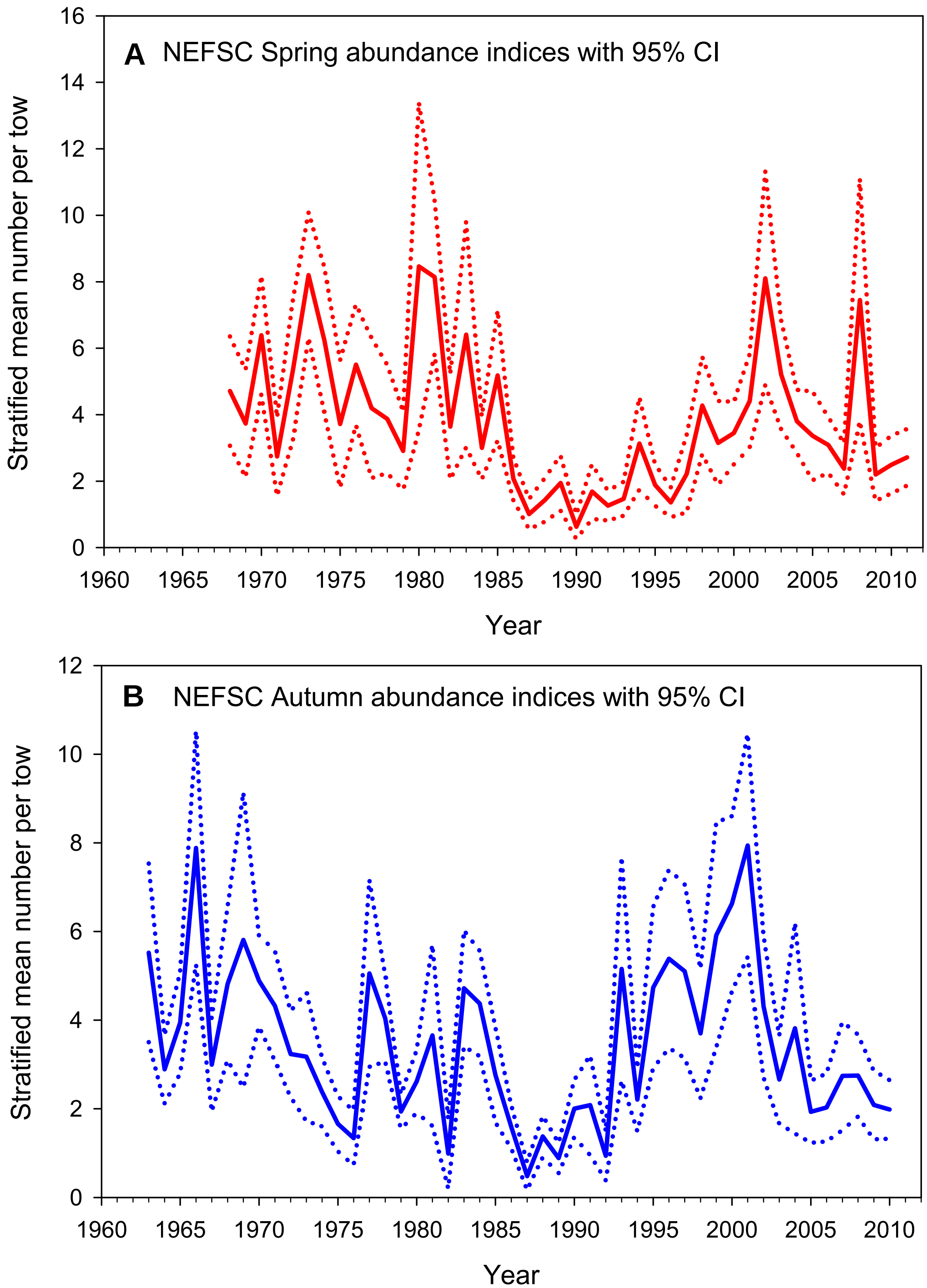


Figure F7. Stratified mean number per tow of witch flounder in the NEFSC spring (A) and autumn (B) bottom trawl surveys, 1963-2010, spring 2011.

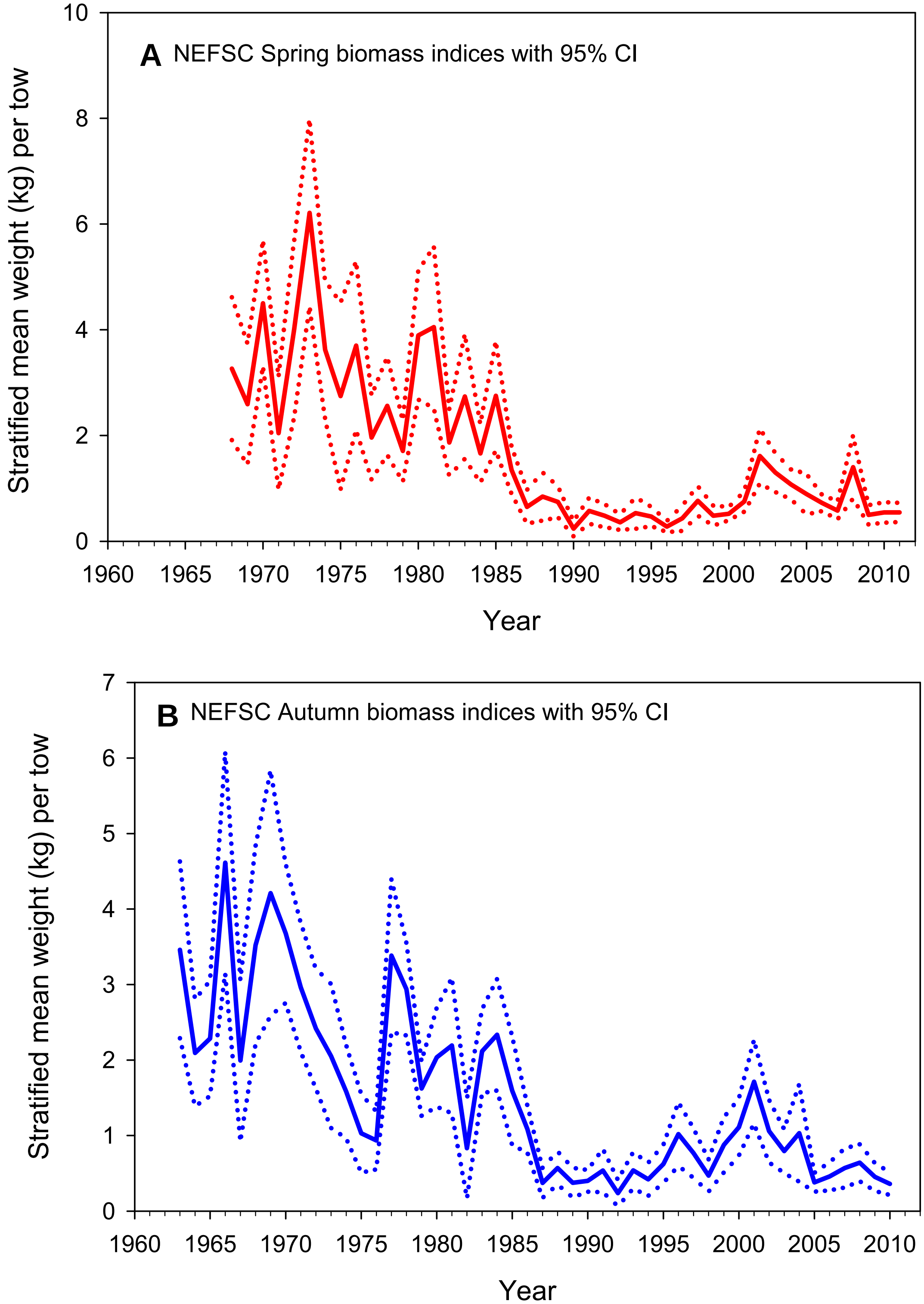


Figure F8. Stratified mean weight (kg) per tow of witch flounder in the NEFSC spring (A) and autumn (B) bottom trawl surveys, 1963-2010 and spring 2011.

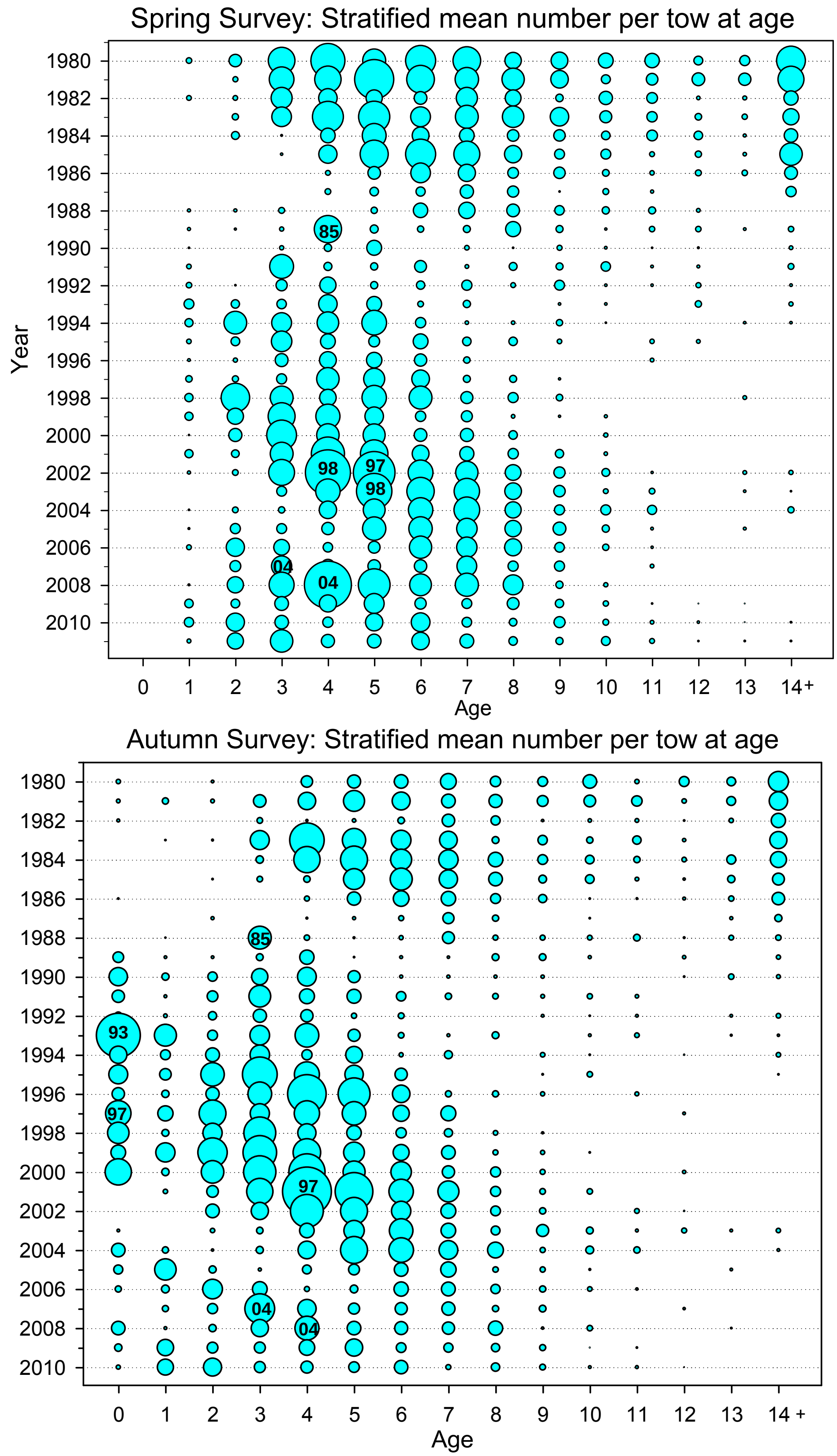


Figure F9. Stratified mean number of witch flounder per tow at age from NEFSC spring (top) and autumn (bottom) surveys, 1980 – 2011.

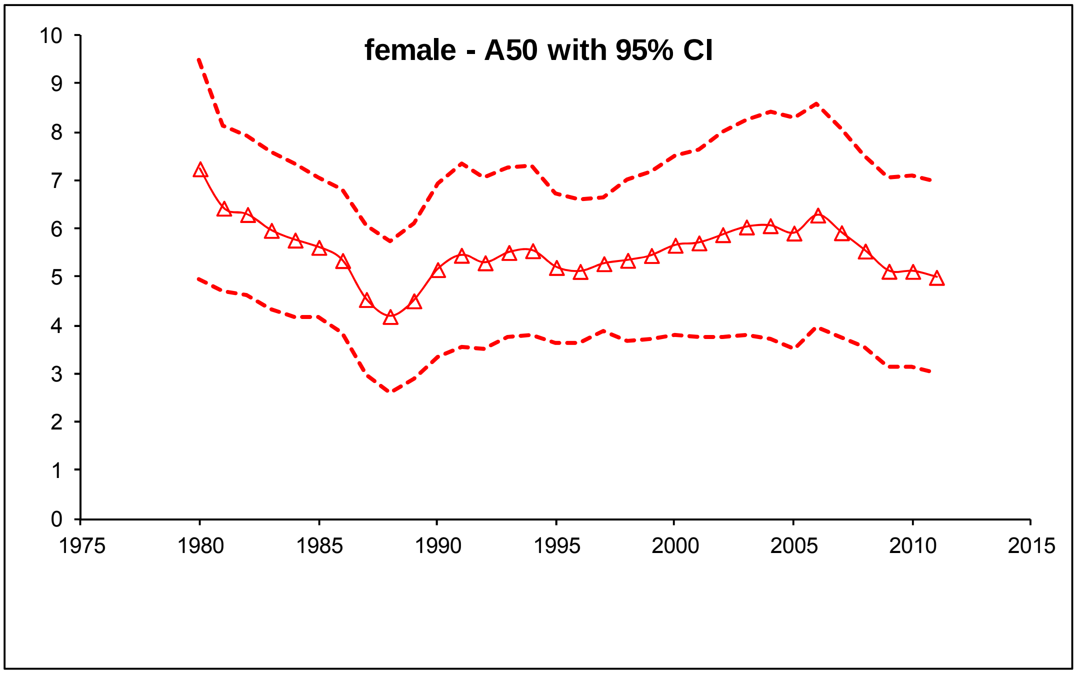


Figure F10. Annual estimates of median age (A50) of female witch flounder maturity derived from a five-year moving time block of maturity observations collected during the NEFSC spring survey, 1980 – 2011.

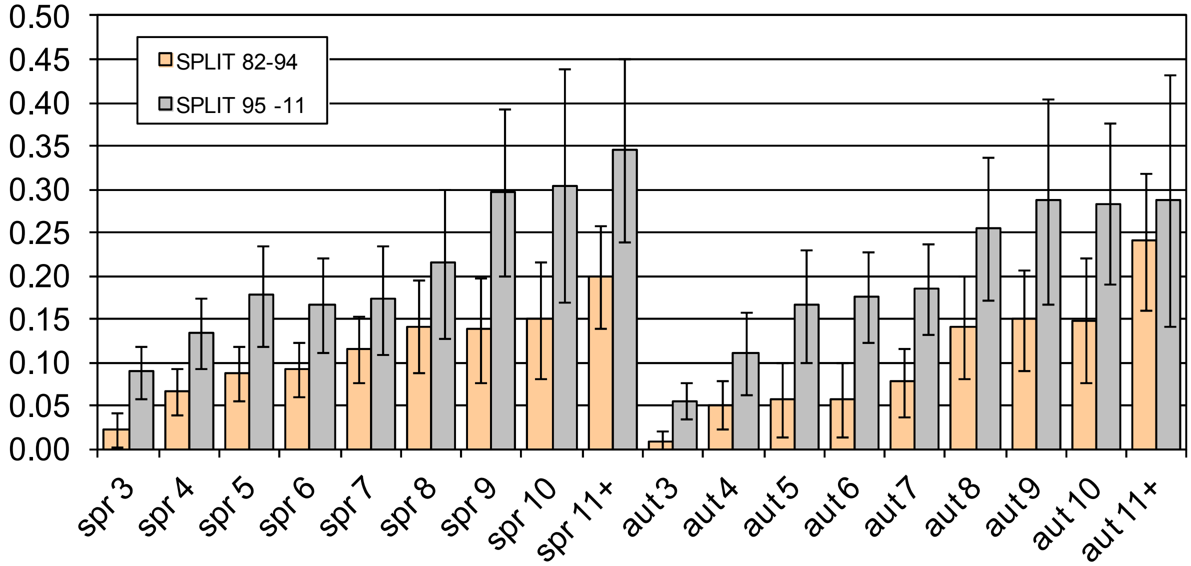


Figure F11. NEFSC swept-area survey catchabilities (q) by age (3 to 11+) and season (spring and autumn) from the VPA SPLIT RUN (survey tuning indices split between 1994 and 1995).

SPLIT RUN

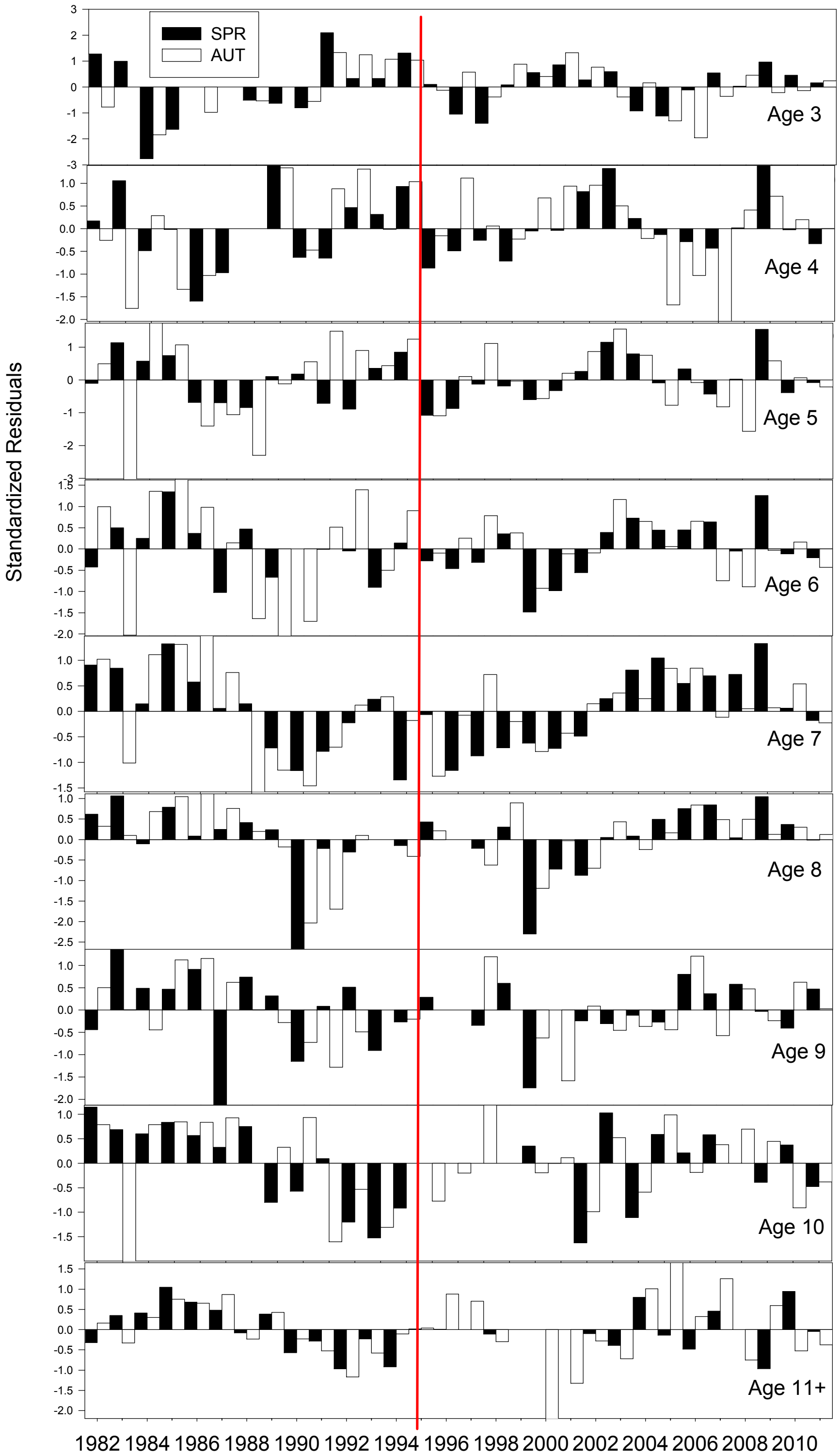


Figure F12. Witch flounder standardized residuals for NEFSC survey indices (spring solid bar and autumn open bar) at age from the VPA SPLIT RUN, 1982-2010. Red vertical line indicates the 1994 and 1995 split.

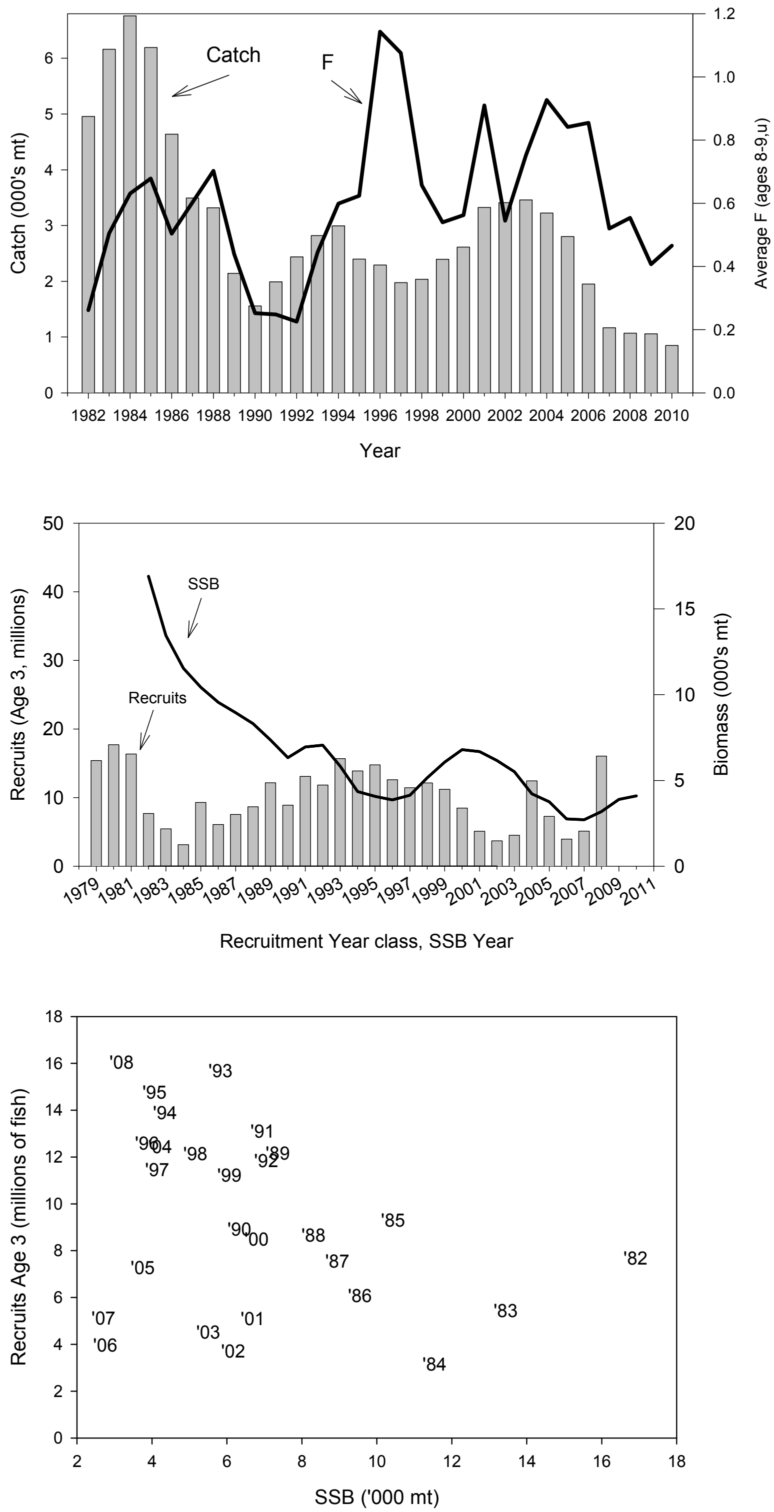
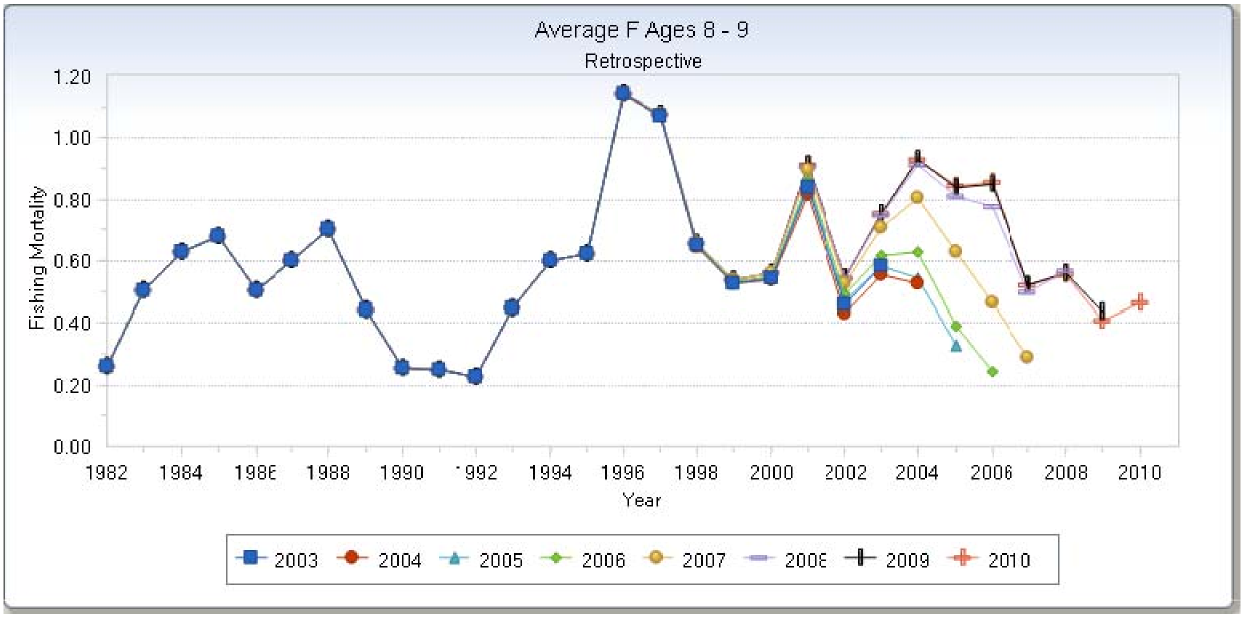


Figure F13. Trends of witch flounder total catch and fishing mortality (top), spawning stock biomass and Age 3 recruitment (middle), and spawning stock biomass (thousands, mt) and recruits (age 3, millions), 1982 – 2008 year classes (bottom) from VPA SPLIT RUN,1982 -2010.



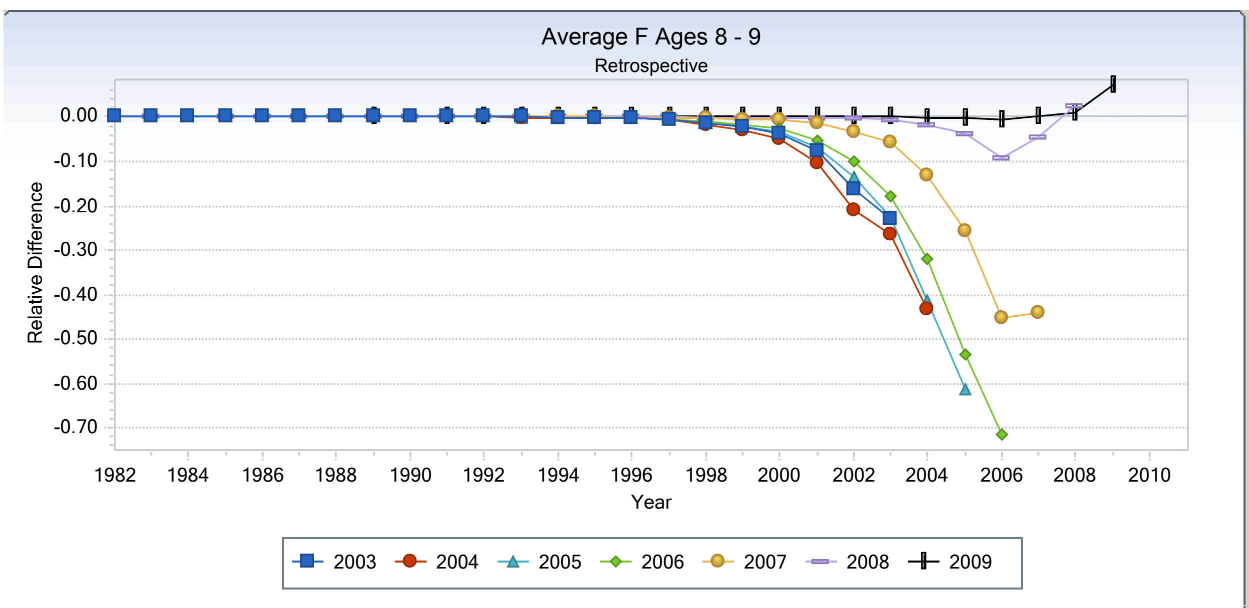
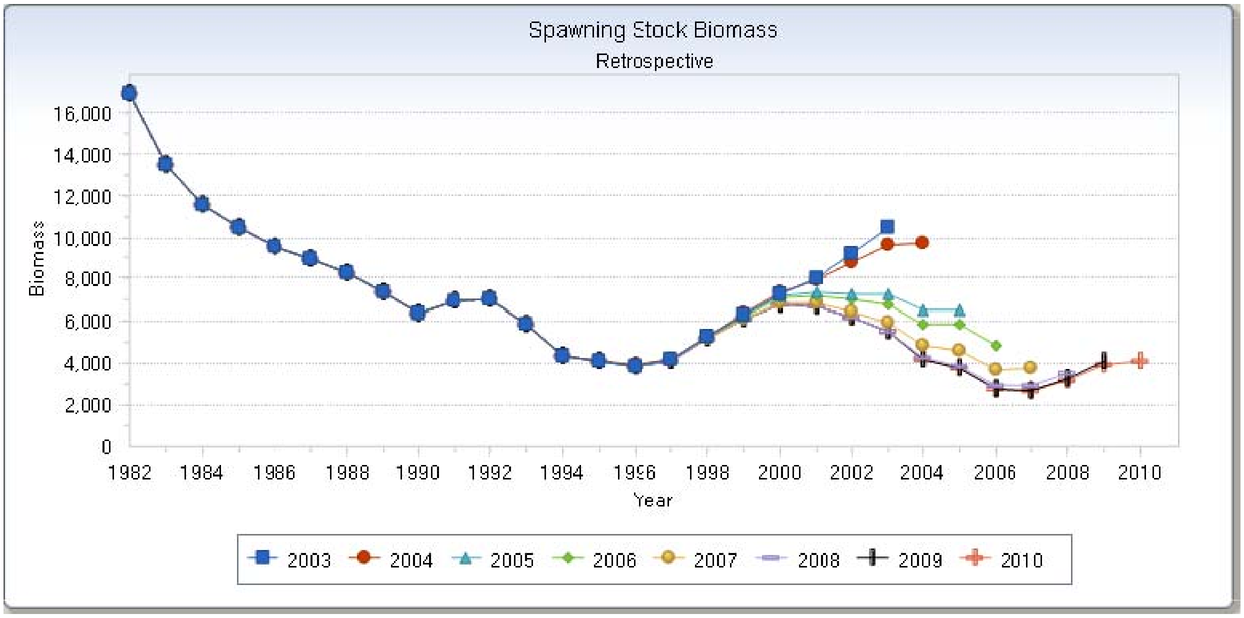


Figure F14. Retrospective analysis results of fishing mortality (top) and relative difference of fishing mortality from the terminal year (bottom) from VPA SPLIT RUN, 1982 – 2010.

SPLIT RUN



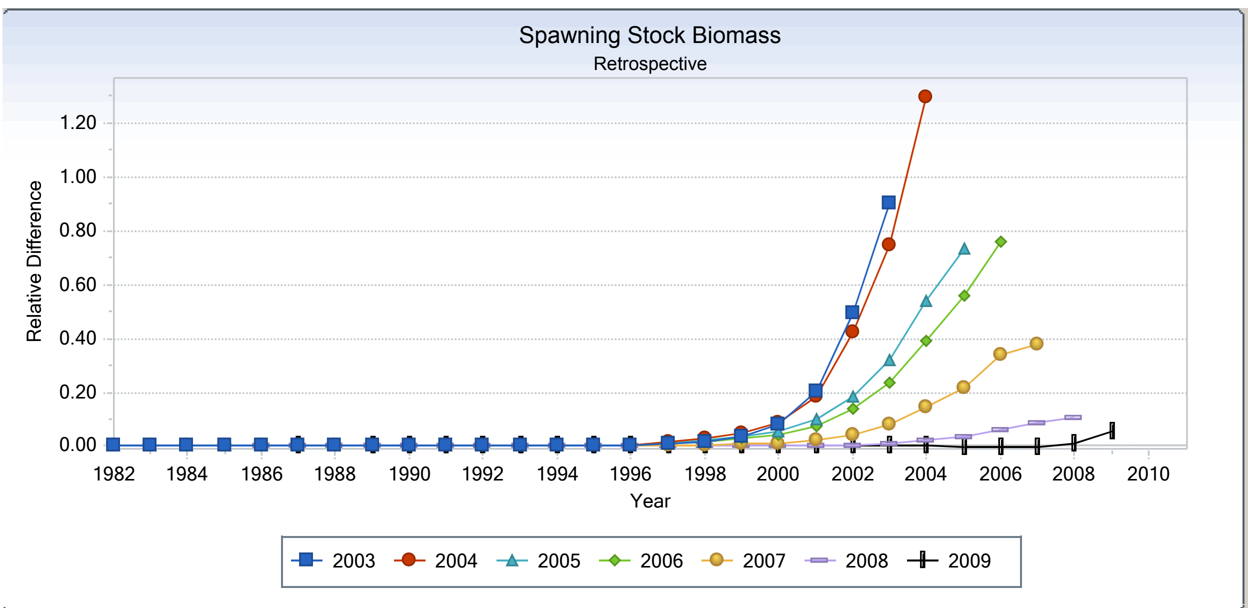
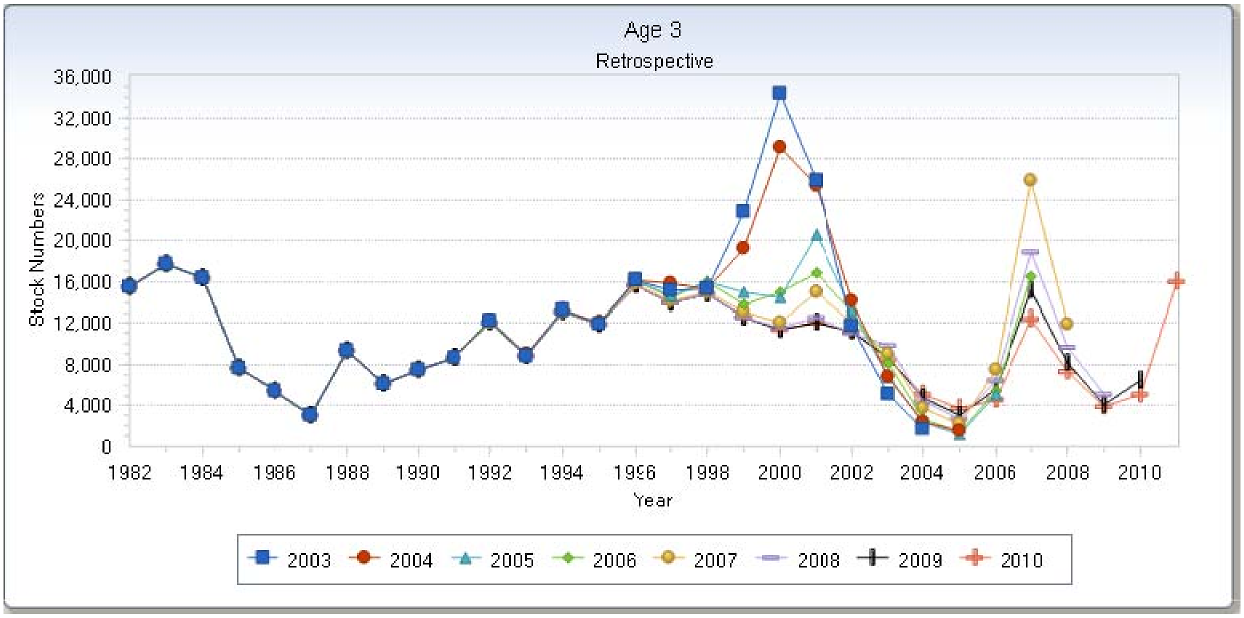


Figure F15. Retrospective analysis results of spawning biomass (top) and relative difference of spawning biomass from the terminal year (bottom) from VPA SPLIT RUN, 1982 – 2010.

SPLIT RUN



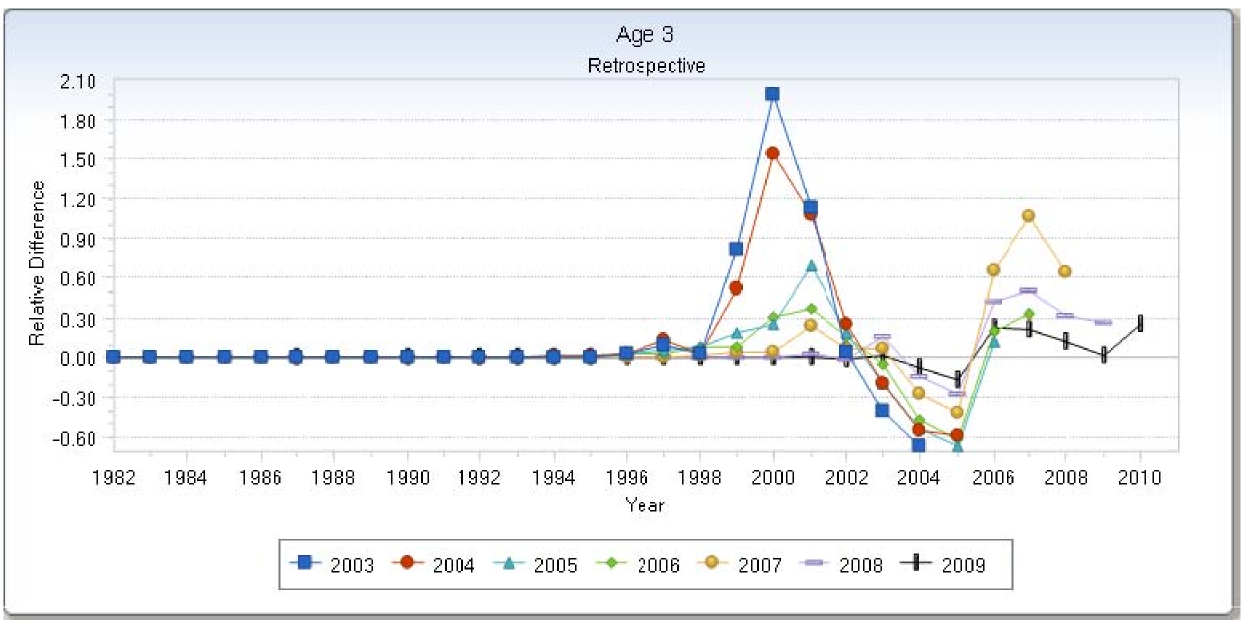
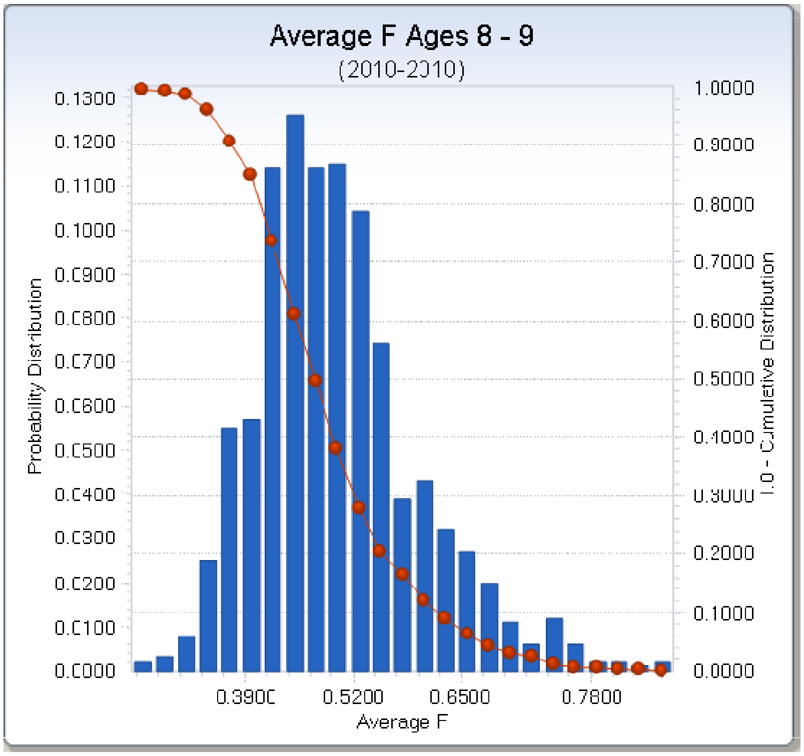


Figure F16. Retrospective analysis results of Age 3 recruitment (top) and relative difference of Age 3 recruitment from the terminal year (bottom) from VPA SPLIT RUN, 1982 – 2010.

SPLIT RUN



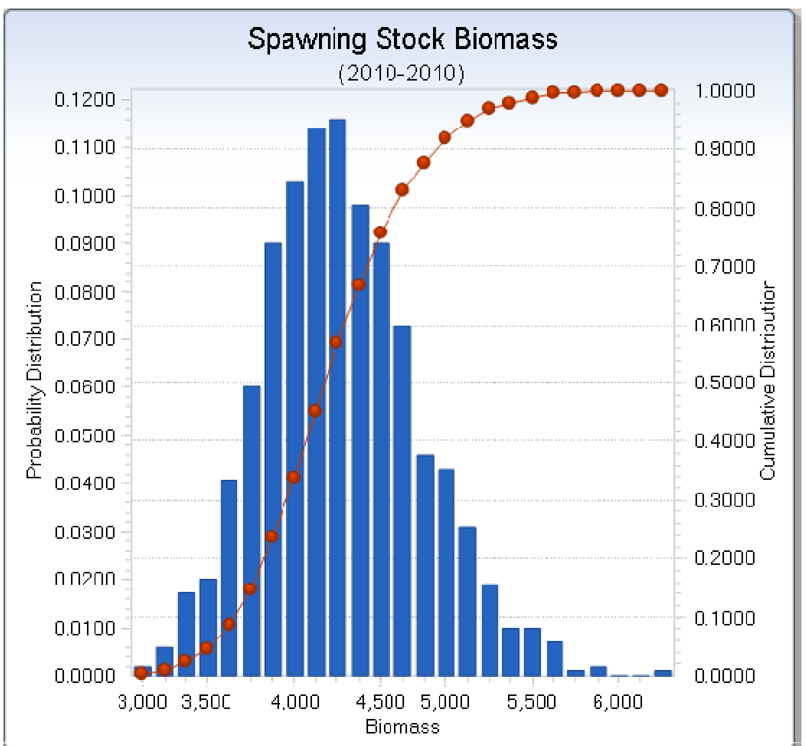


Figure F17. Precision estimates of fishing mortality (top) and spawning stock biomass (mt; bottom) in 2010 from the VPA SPLIT RUN. Vertical bars display both the range of the bootstrap estimates and the probability of the individual values in the range.

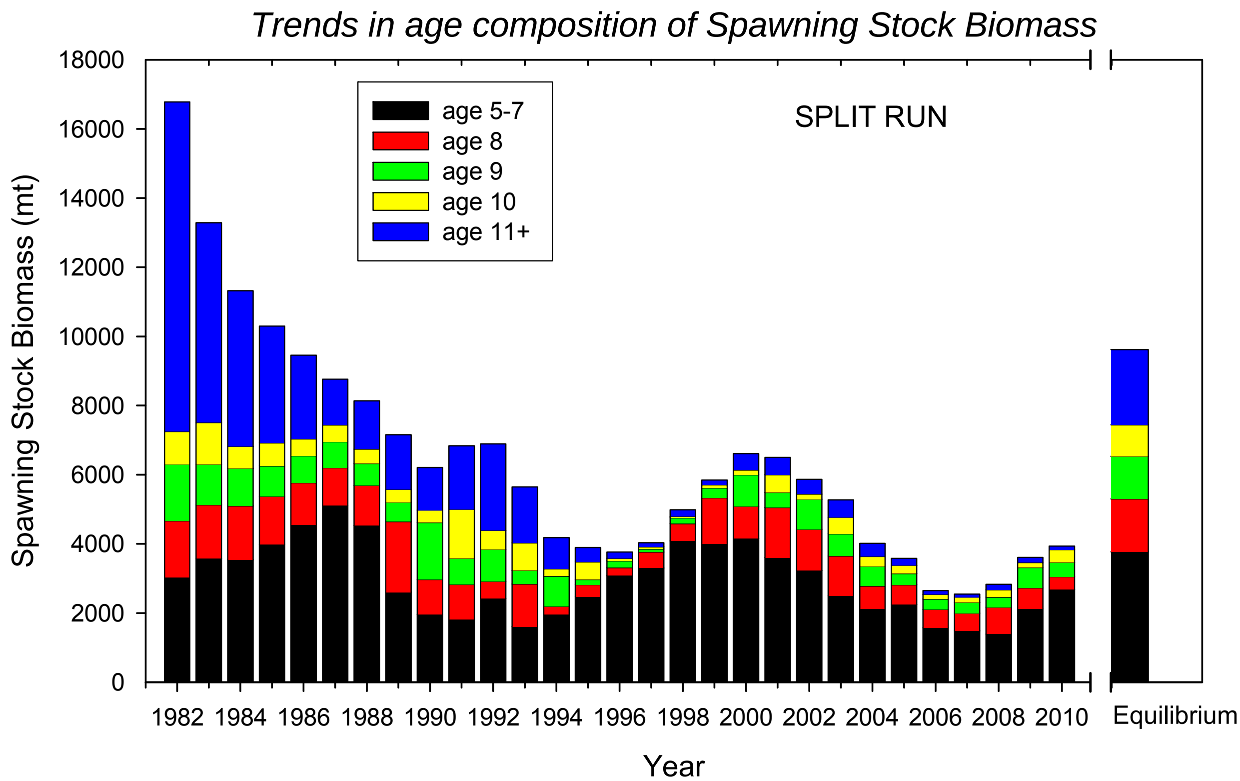


Figure F18. Age distribution of witch flounder spawning stock biomass, 1982-2010, and the expected age distribution at equilibrium, from VPA SPLIT RUN.

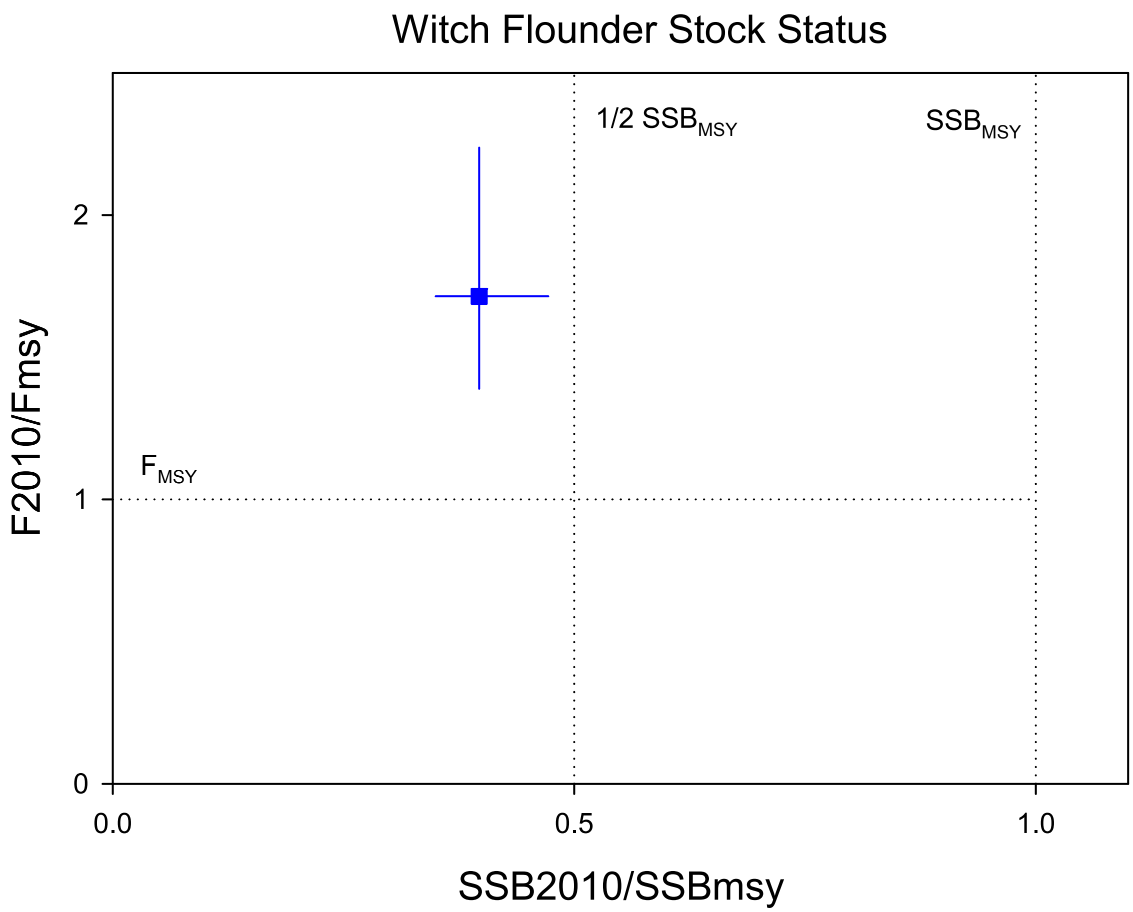


Figure F19. Witch flounder spawning stock biomass and fishing mortality (F8-9, u) with respect to the biological reference points, based on the VPA SPLIT RUN (square) with 80% confidence interval.

Appendix Table F1. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in **Massachusetts Division of Marine Fisheries inshore spring and autumn survey**s in the Cape Cod Bay and Mass. Bay region (Regions 4 and 5), 1978-2011.

	SPRING						AUTUMN					
Year	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow
1978	2.38	27.8	1.67	26.1	44.6	0.699	1.38	21.4	1.26	27.4	46.4	0.908
1979	1.26	30.4	1.32	36.7	48.3	1.046	1.52	60.0	1.08	56.0	42.9	0.708
1980	1.00	42.9	0.93	43.3	44.0	0.932	1.15	40.1	1.12	42.3	46.5	0.966
1981	2.44	44.0	1.83	49.5	40.2	0.747	0.39	91.7	0.23	86.5	41.2	0.589
1982	0.65	43.9	0.47	50.9	44.2	0.728	1.24	63.3	0.64	37.1	37.7	0.511
1983	1.97	40.9	1.02	23.5	36.8	0.519	2.22	35.7	1.46	33.3	44.6	0.658
1984	1.18	32.0	0.76	32.4	40.8	0.645	0.55	42.6	0.37	39.1	43.6	0.674
1985	1.01	25.3	0.73	28.3	43.4	0.720	0.76	51.4	0.50	46.0	43.6	0.655
1986	0.70	23.5	0.65	30.9	47.6	0.934	0.27	39.4	0.24	42.9	46.4	0.893
1987	0.88	48.1	0.73	42.0	45.1	0.821	0.19	39.2	0.13	41.6	44.6	0.713
1988	0.24	25.1	0.20	28.4	45.6	0.844	0.28	82.4	0.16	92.8	39.5	0.579
1989	0.13	46.9	0.05	47.9	34.9	0.369	0.13	56.4	0.06	52.7	38.1	0.491
1990	0.21	75.2	0.17	75.7	44.2	0.809	0.07	71.2	0.03	90.5	36.8	0.436
1991	0.11	58.6	0.04	77.6	34.1	0.393	0.35	39.6	0.21	40.2	41.1	0.602
1992	0.20	63.5	0.12	80.1	40.2	0.583	0.45	50.2	0.25	55.2	40.7	0.557
1993	0.03	100.0	0.01	100.0	33.0	0.200	0.30	47.8	0.15	52.9	40.9	0.5
1994	0.00	0.0	0.00	0.0	-	-	0.38	39.6	0.12	54.0	31.0	0.321
1995	0.10	36.0	0.06	62.6	36.0	0.613	2.41	77.8	0.41	53.0	26.7	0.172
1996	0.02	100.0	0.00	100.0	21.0	0.100	0.04	74.6	0.01	74.6	40.0	0.4
1997	0.05	0.0	0.01	100.0	31.5	0.250	0.51	83.3	0.15	88.9	36.0	0.3
1998	0.00	0.0	0.00	0.0	-	-	0.25	53.1	0.08	49.0	35.2	0.332
1999	0.02	100.0	0.00	0.0	11.0	-	0.67	37.2	0.17	43.6	33.7	0.251
2000	1.15	34.5	0.10	42.3	23.5	0.089	0.92	30.9	0.24	42.5	31.6	0.266
2001	0.07	46.8	0.02	65.2	33.0	0.250	0.43	22.1	0.12	33.2	33.2	0.275
2002	0.11	56.0	0.03	56.0	33.4	0.253	2.21	21.2	0.70	20.2	36.5	0.317
2003	0.19	15.3	0.04	22.0	30.2	0.217	1.19	30.2	0.53	32.1	39.8	0.445
2004	0.00	0.0	0.00	0.0	-	-	0.31	49.9	0.13	54.0	40.5	0.432
2005	0.05	71.0	0.03	75.1	45.5	0.675	0.51	33.1	0.19	31.6	37.8	0.369
2006	0.16	46.1	0.08	50.3	40.9	0.500	0.37	33.0	0.10	24.9	33.0	0.265
2007	0.46	43.6	0.13	49.8	34.6	0.286	0.51	40.9	0.15	33.7	36.8	0.295
2008	0.26	38.6	0.09	52.0	36.6	0.348	1.34	44.7	0.40	37.3	35.2	0.301
2009	0.44	73.1	0.08	65.1	31.1	0.185	1.27	29.6	0.40	44.7	33.4	0.311
2010	0.15	38.6	0.05	46.4	36.9	0.327	1.42	35.7	0.46	34.9	36.1	0.325
2011	0.35	78.9	0.12	76.8	34.9	0.348	3.51	30.9	0.97	30.4	35.1	0.277

Appendix Table F2. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in the **ASMFC summer shrimp surveys** in the Gulf of Maine (strata set 1,3,6,8), 1984 - 2010.

Year	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow
1984	4.68	34.5	1.60	33.0	33.9	0.341
1985	6.19	18.7	2.52	15.4	36.0	0.408
1986	2.05	26.7	0.74	30.7	35.9	0.362
1987	4.87	28.4	1.50	28.5	26.5	0.307
1988	2.53	24.6	0.60	26.5	25.8	0.238
1989	2.92	32.3	0.31	29.4	22.8	0.105
1990	6.66	27.6	1.02	35.2	24.5	0.154
1991	14.94	34.6	1.20	30.0	19.6	0.080
1992	24.28	44.8	1.91	32.0	20.5	0.079
1993	21.42	27.4	0.50	18.2	12.8	0.023
1994	36.36	42.3	2.20	66.5	19.1	0.061
1995	17.95	37.9	1.48	40.9	22.6	0.082
1996	15.45	21.0	1.95	27.0	25.2	0.126
1997	23.19	43.2	1.42	22.1	19.1	0.061
1998	7.35	23.5	0.52	20.4	21.9	0.071
1999	110.07	23.3	5.93	22.6	18.7	0.054
2000	32.43	25.8	3.09	27.8	24.2	0.095
2001	41.52	33.3	5.57	34.2	27.2	0.134
2002	45.25	25.1	7.05	24.8	28.8	0.156
2003	24.06	22.5	4.46	21.3	30.6	0.185
2004	8.75	25.7	1.79	25.3	31.3	0.205
2005	19.77	23.0	2.00	26.4	21.6	0.101
2006	29.98	20.0	2.72	20.0	22.6	0.091
2007	23.10	21.6	2.49	23.5	25.1	0.108
2008	15.19	21.4	2.02	19.6	27.2	0.133
2009	23.21	23.4	3.88	37.3	27.1	0.167
2010	18.13	18.7	1.79	18.7	23.2	0.099

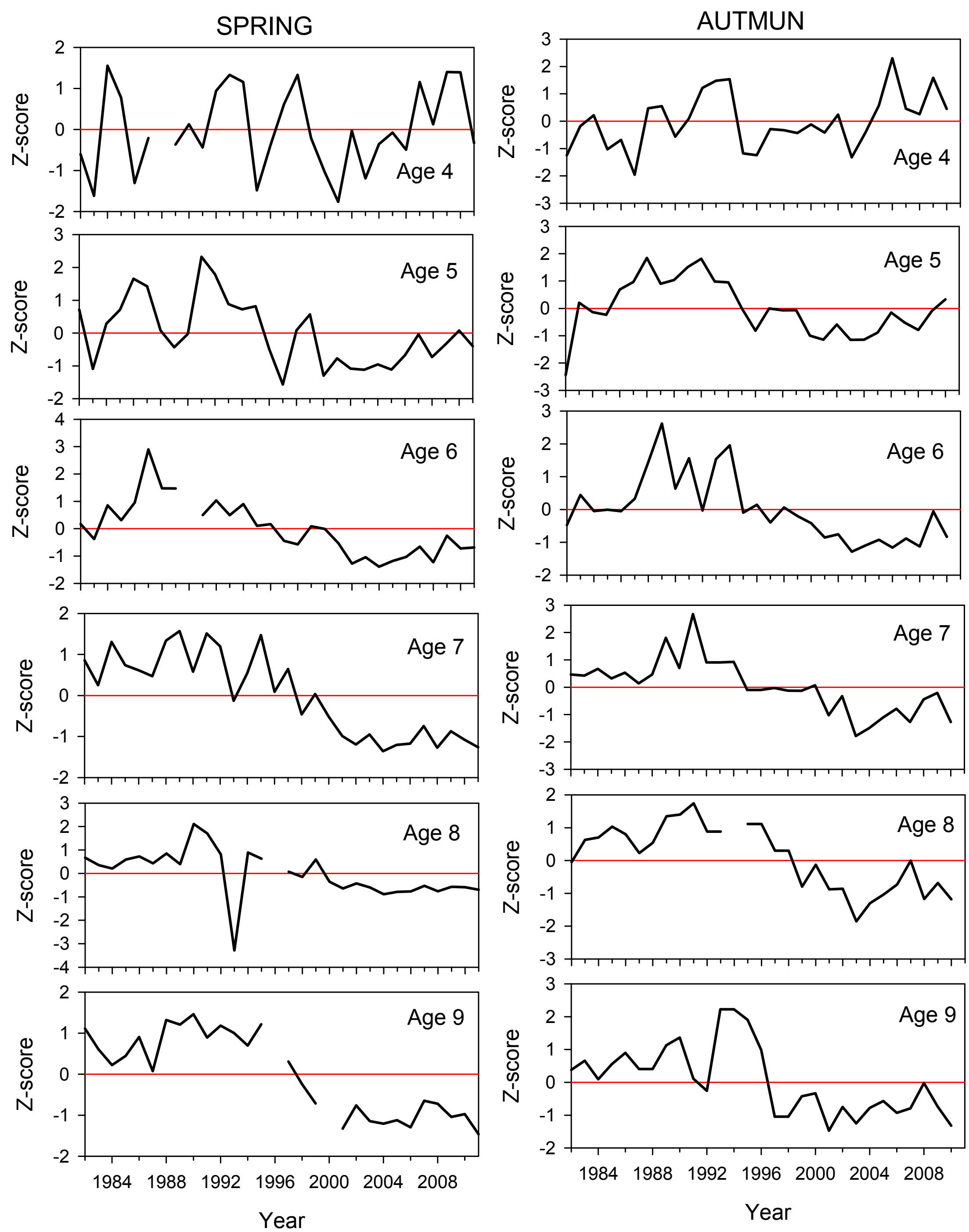
Appendix Table F3. Stratified mean number and weight (kg) per tow and associated standard error of witch flounder in the **ME-NH inshore spring and fall surveys** in the Gulf of Maine (strata set 1-4; regions 1-5), 2001 - 2011. Fixed stations are excluded; re-stratified for 2000, 2001 and 2002. *Indices provided by S. Sherman, ME DMR.*

	SPRING				FALL			
Year	Number per tow	SE	Weight per tow	SE	Number per tow	SE	Weight per tow	SE
2000					3.89	0.56	0.22	0.03
2001	6.96	1.84	0.12	0.03	56.58	4.67	4.18	0.34
2002	4.58	0.86	0.41	0.15	6.29	0.93	0.65	0.13
2003	2.32	0.72	0.24	0.07	7.45	1.16	0.92	0.19
2004	1.42	0.21	0.10	0.02	11.73	1.94	1.41	0.20
2005	8.37	1.33	0.37	0.09	26.20	3.55	0.86	0.10
2006	5.17	1.11	0.24	0.06	12.83	1.37	0.83	0.07
2007	4.37	0.67	0.29	0.04	14.41	2.04	1.47	0.30
2008	4.25	0.60	0.38	0.08	14.78	1.79	1.31	0.23
2009	4.15	0.68	0.23	0.06	10.48	1.08	0.57	0.07
2010	5.17	0.91	0.31	0.06	16.22	1.74	0.81	0.10
2011	5.20	0.63	0.25	0.04				

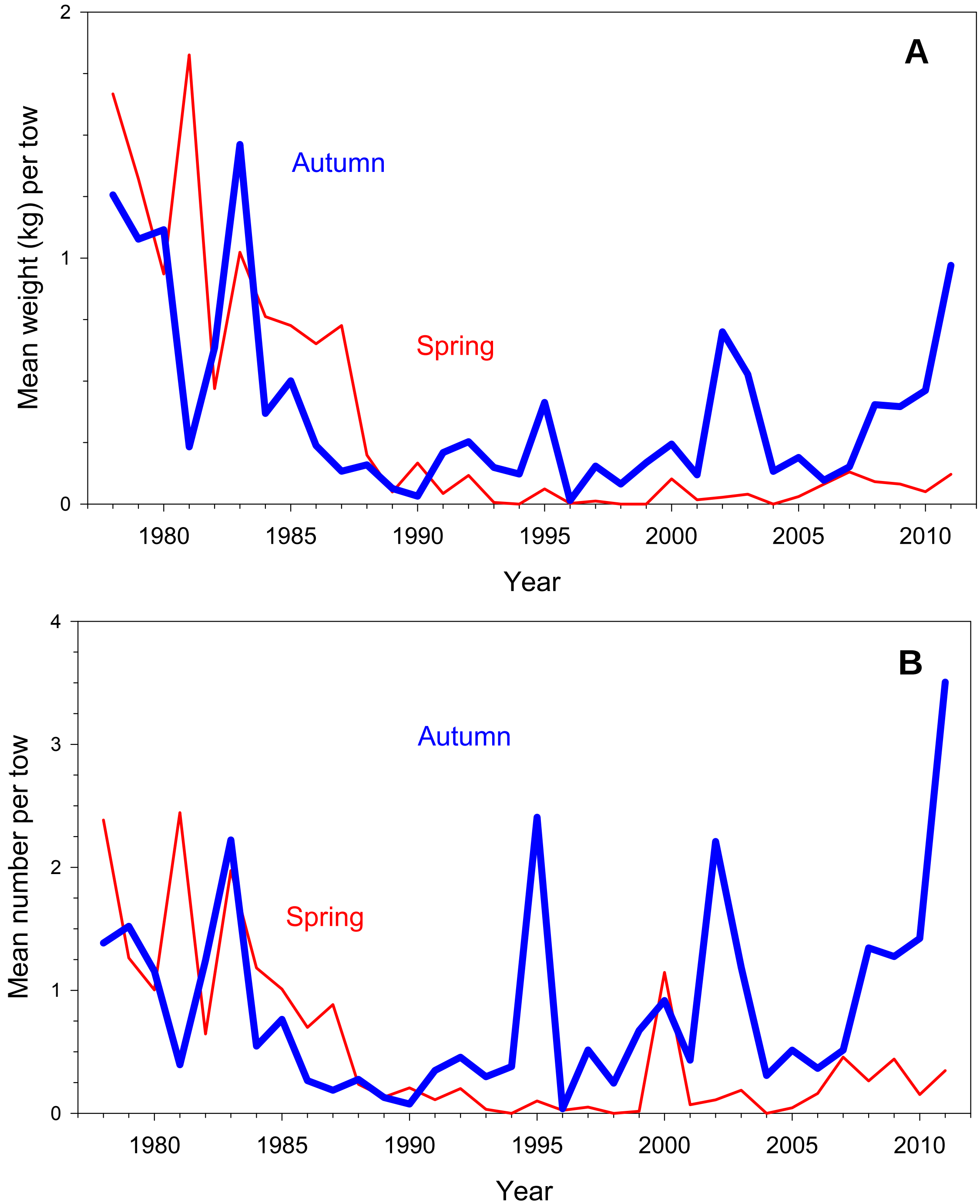
Appendix Table F4. Summary of area (square nautical miles) of NEFSC survey strata (offshore strata 22-30; 36-40) used in the witch flounder stock assessment and the USA statistical areas associated with the witch flounder stock. The statistical areas that comprise approximately 96% of the landings are denoted with an asterisk (*).

Survey Strata	Area
22	454
23	1,016
24	2,569
25	390
26	1,014
27	720
28	2,249
29	3,245
30	619
36	4,069
37	2,108
38	2,560
39	730
40	578
Total	22,321

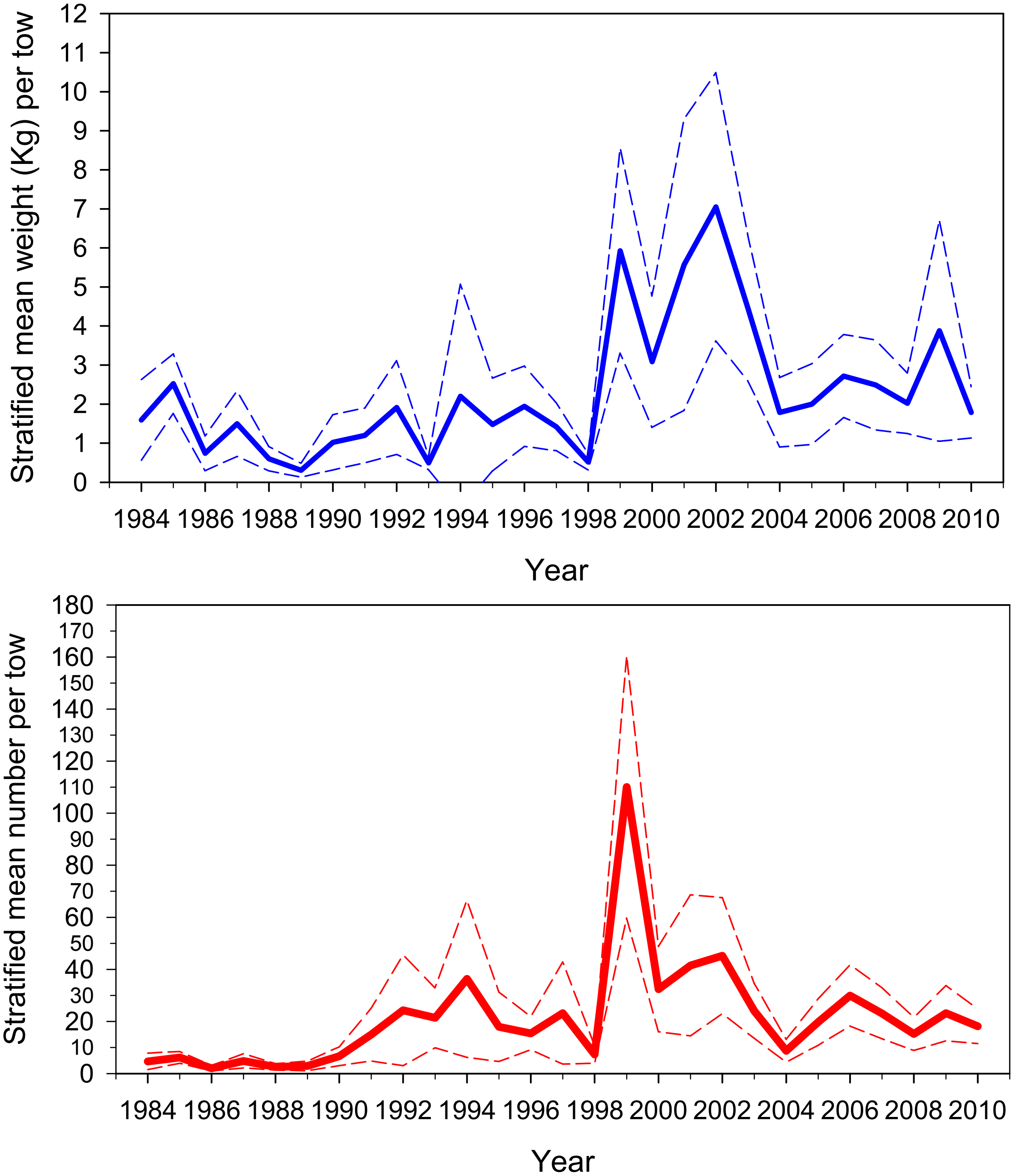
USA Stat Areas	Area
464	208
465	258
467	75
511 *	1,313
512 *	3,652
513 *	3,567
514 *	2,573
515 *	4,603
521 *	3,853
522 *	3,663
525 *	7,461
526 *	4,029
533	1,547
534	2,320
537	6,261
538	800
539	742
541	2,320
542	5,402
543	2,281
561 *	765
562 *	3,562
611	1,421
612	1,893
613	3,258
614	1,131
615	2,781
616	3,707
621	3,702
622	2,820
623	2,820
624	5,638
625	5,104
626	2,858
627	2,858
628	2,858
629	3,375
631	3,115
632	2,895
633	2,895
634	2,895
635	3,485
636	2,931
637	2,931
638	2,931
639	3,508
640	6,906
Unit area	141,966
* Areas	39,581



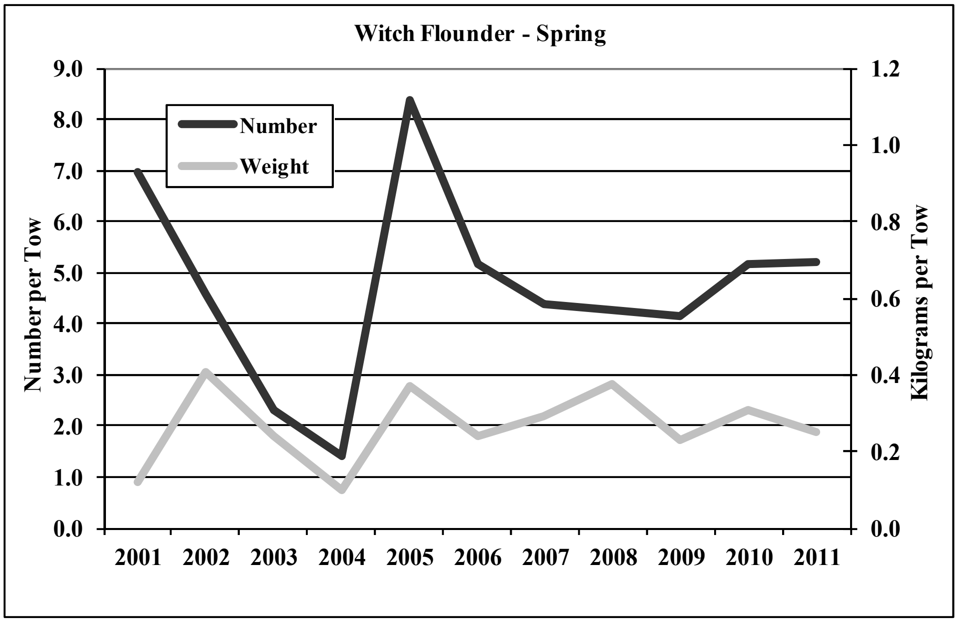
Appendix Figure F1. Z-scores of witch flounder mean weight at age (age groups 4 – 9) in the NEFSC spring survey (left), 1982-2011 and NEFSC autumn survey 1982 -2010 (right).

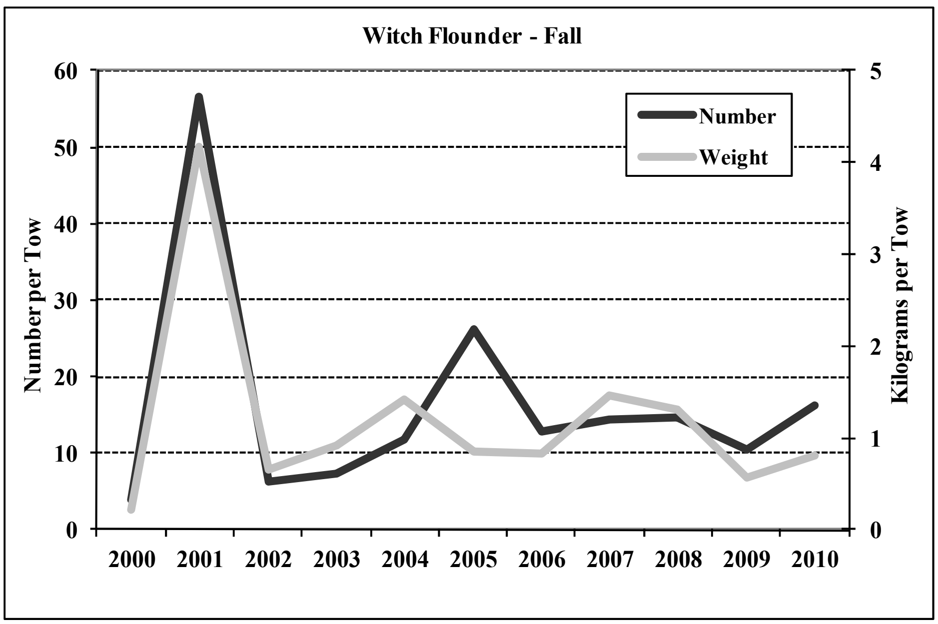


Appendix Figure F2. Stratified mean catch per tow, in weight (A) and number (B), of witch flounder in the Massachusetts Division of Marine Fisheries spring and autumn bottom trawl surveys in Cape Cod Bay – Mass Bay region (Regions 4 and 5), 1978 – 2010.

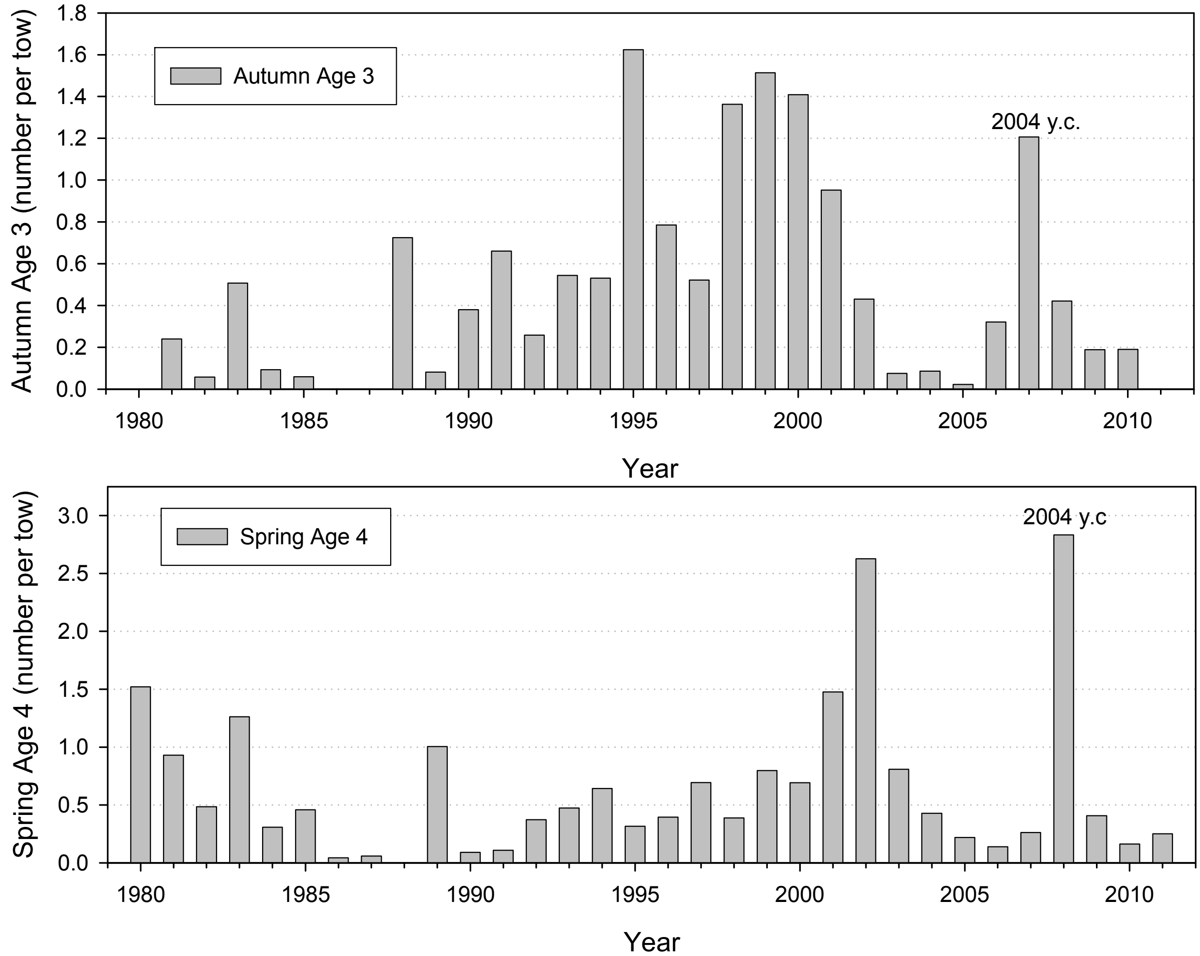


Appendix Figure F3. Stratified mean catch per tow, in weight (kg) and numbers, of witch flounder in the Atlantic States Marine Fisheries Commission summer northern shrimp survey (strata set 1,3,6,8) , 1984-2010. Dash line represents 95% confidence intervals.

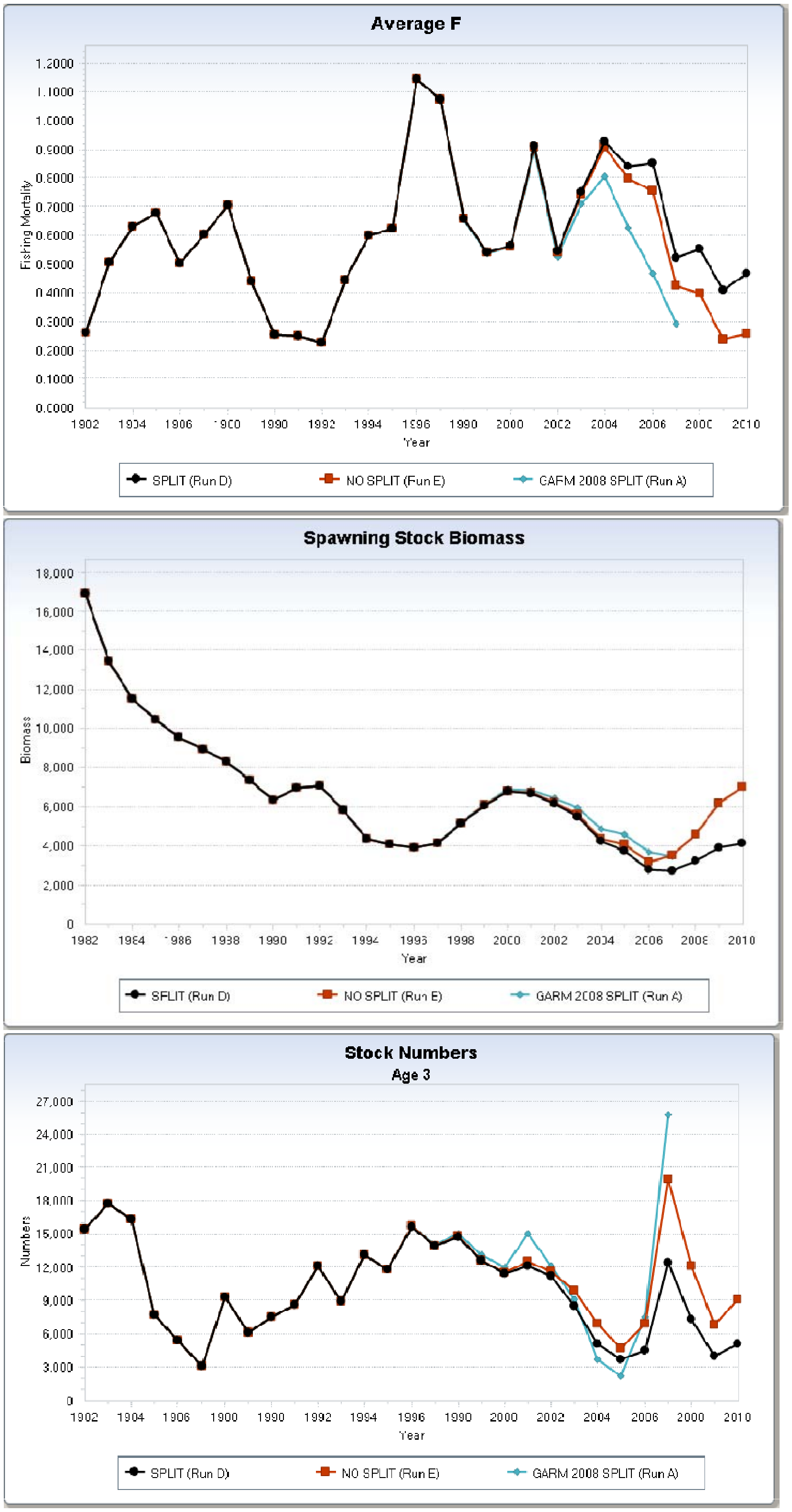




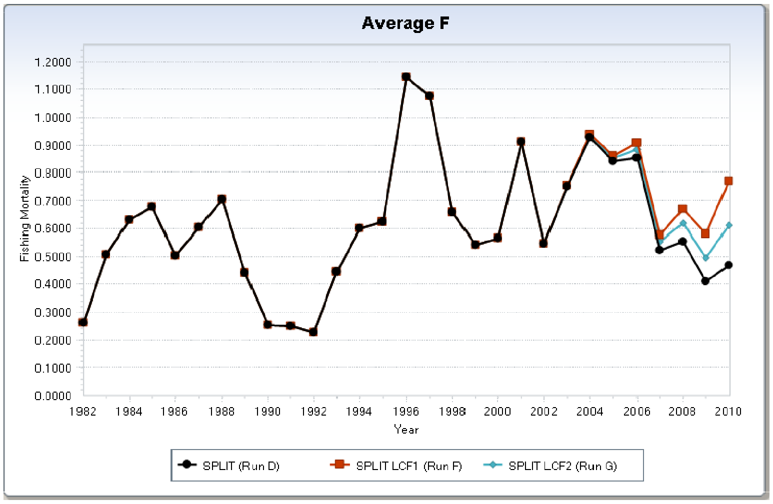
Appendix Figure F4. Stratified mean catch per tow, in weight (kg) and numbers, of witch flounder in the Maine-New Hampshire inshore spring and fall survey (strata 1 through 4; regions 1 to 5), 2000-2011. Fixed stations are excluded; re-stratified for 2000, 2001 and 2002. *Figure provided by S. Sherman, ME DMR.*

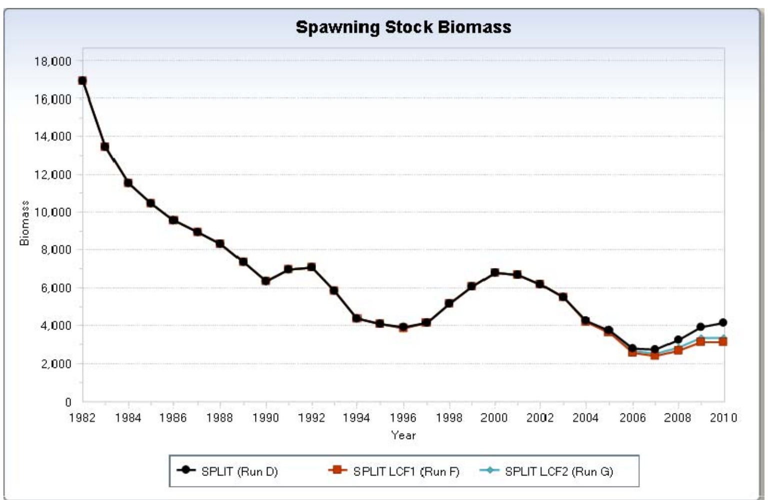


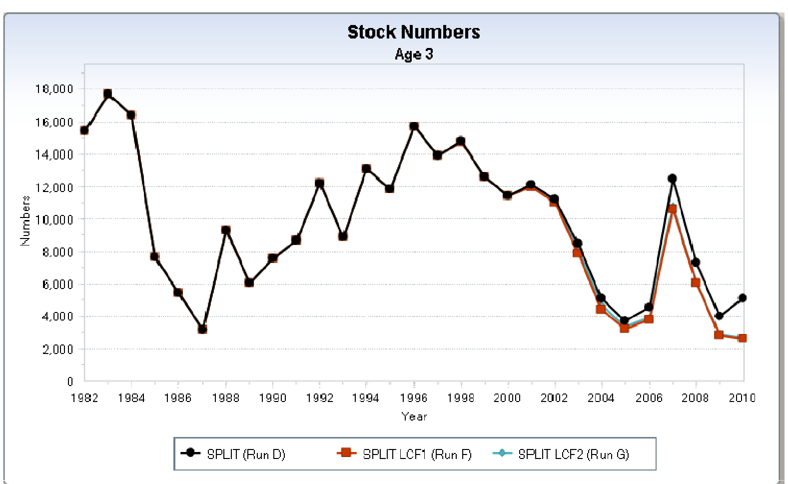
Appendix Figure F4. Stratified mean number per tow of age 3 witch flounder in the NEFSC autumn survey, 1980- 2010 (top), and age 4 witch flounder in the NEFSC spring survey, 1980 - 2011 (bottom). Constant conversion factor of 3.2572 applied to 2009 – 2011 surveys.



Appendix Figure F5. Model comparison of trends in Average F (top), SSB (middle) and Age 3 recruits (bottom) from VPA SPLIT RUN (Runs D; large black circle), NO SPLIT (Run E; red square) and VPA SPLIT RUN from GARM 2008 (Run A; small circle blue).







Appendix Figure F6. Model comparison of trends in Average F (top), SSB (middle) and Age 3 recruits (bottom) from VPA SPLIT RUN (Runs D; large black circle), SPLIT LCF1 (Run F; red square) and SPLIT LCF2 (Run G; small circle blue).

G. Gulf of Maine-Georges Bank Acadian Redfish
Timothy J. Miller

Background

The most recent stock assessment of Gulf of Maine-Georges Bank Acadian redfish was completed and reviewed at the 2008 Groundfish Assessment Review Meeting (GARM III) (NEFSC 2008). The assessment was based on an ASAP (ASAP 2008) model configuration which incorporates information on the age composition of the landings, size and age composition of the population, and trends in relative abundance derived from research vessel survey biomass indices.

Based on the most recent assessment, estimates of redfish population biomass have been increasing in recent years. The increase in biomass estimates is produced by corresponding increases in both the NEFSC spring and autumn survey biomass indices which rose substantially during the mid-1990s and remained relatively high through 2007. The rapid increase in abundance and biomass was attributed to strong recruitment for some cohorts in the early-1990s coupled with extremely low fishing mortality. At GARM III, the stock was found to not be overfished and overfishing was not occurring. Estimated spawning biomass in 2007 after an adjustment for retrospective pattern (172,342 mt) was approximately 64% of the spawning biomass reference point, SSB(50%MSP) =271,000 mt. The estimated fishing mortality in 2007 (0.007) was approximately 18% of overfishing reference point, F(50%MSP) = 0.0377.

Updated data

For this update, we include the catch, discard and survey data from 2008-2010, but no age composition data have been updated. Landings have continued to rise gradually since 2007 and 2010 landings were the largest since 1987 (Table G1, Figure GG1). Between 1964 and the early 1990s nearly all redfish were landed by trawl gear. Since then trawl gear is still by far the primary component, but catches by gillnet gear have also become important (Table G2).

We estimated discards for 2008-2010 using the same methodology as at GARM III (Wigley et al. 2006) and the estimates have stayed relatively constant since 2007 (Table G1, Figure GG2). Similar, to the landings, discards are primarily associated with trawl gear, but some also occur in gillnet gear (Table G3). The precision has improved in recent years primarily due to increased observer effort (Tables G3 and G4).

The NEFSC fall and spring survey indices using the calibration factors (1.456, CV = 0.09 for number/tow and 1.191, CV = 0.11 for kg/tow) in Miller et al. (2010) for years 2009-2010 continue to climb (Tables G5 and G6, Figures G3 and G4).

Assessment model

We use the same parameterization of the final assessment model (ASAP 2008) from GARM III, but upon re-examining the data inputs and model specification, we determined that there was a mismatch between the survey indices and survey age composition. We used biomass indices, but the age composition information was in terms of abundance (numbers). We revise the indices to correct this issue (base model), and there was negligible effect of this change in data on the scale and trend of estimated spawning biomass and fishing mortalities (Figure GG5).

Because of the lack of age composition information since 2007, we considered a parameterization that also included a ramping down of the CV specified on recruitment deviations analogous to the ramp up at the beginning of the availablilty of age composition information (alternate model). The assumed CVs for recruitments in 2008-2010 (0.66, 0.52, and 0.38) mirrored the assumed values in the ramp up prior to the first age composition data in 1969. The results of the alternate model for spawning biomass and fishing mortality were also very similar in scale and trend to the GARM III results and to the base model results (Figure GG5).

Despite the increase in data for the base and alternate models relative to GARM III, the maximized objective function is less for the newer fits (Table G7). This appears to be primarily due to improvements in the fits to age composition data for the fishery and surveys.

There primary difference between the GARM III results and those from the current base and alternate models is the estimated selectivities for the surveys (Figure GG6). The reason for this change is likely due to the change in assumption of the proportions at age from representing biomass to representing numbers. Because the proportion of numbers at age will be greater than proportion of biomass at age for younger fish, estimated selectivity was higher at GARM III under the biomass assumption. Note, that the estimated selectivity for the fishery changed little because there was no mismatch in these data and corresponding model configuration. Both the base and alternate models tend to estimate fishing mortality slightly less and spawning biomass slightly greater than GARM III. The large changes in and poorer precision of some fishing mortality estimates in the 1990s are due to greater uncertainty in total removals for those years which is a result of poor precision of discard estimates (Table G8).

Estimated annual recruitment, numbers at age, and fishing mortality at age are provided for both the base and alternative models (Tables 9-12).

Retrospective results and diagnostics

The retrospective pattern of both the base and alternate model fits as measured by Mohn's Rho were substantially less for spawning biomass and fishing mortality than the corresponding results at GARM III, but the retrospective pattern in recruitment was substantially greater (Figure GG7, Table G13).

There was generally little variation in residuals for the total catch data and the few large residuals were substantially reduced in absolute magnitude for the base and alternative models relative to the GARM III results (Figure GG8). The variability in residuals for the spring and fall indices was also reduced for the current base and alternative models relative to the GARM III results (Figure GG9). There was increased size of the negative residuals for the plus group for the age composition of the catch, but there was a reduction in the absolute magnitude of residuals for many of the younger age classes (Figure GG10). Differences in the age composition residuals for the spring and fall surveys between the GARM III and current results were less apparent (Figures 11 and 12).

Updated Reference Points and Stock Status

We re-estimated the F(50%MSP) reference point using the yield-per-recruit software (YPR 2007) with the updated estimates of fishery selectivity from both the base and alternative model results. All other inputs remained the same as at the last assessment due to unavailable biological information in 2008-2010 (Table G14). The F(50%MSP) reference point was unchanged due to a negligible difference in estimated fishery selectivity between the GARM III and current results (Table G15). We used AgePro (AGEPRO 2005) to re-estimate the SSB(50%MSP) reference point which included the information in the yield-per-recruit analysis along with updated recruitment estimates between 1969 and 2010 (see Table G8) and 10 random draws of numbers-at-age in 2010 from both the base and alternative model results. We projected 300 years with catch in 2011 equal to that in 2010 and fishing mortality in 2012-2309 equal to the reference point (F(50%MSP)). The results are based on 1000 stochastic projections of every numbers-at-age vector. The reported median equilibrium SSB(50%MSP) and Yield(50%MSP) was the average of the median respective values in last 100 years of the projections (Table G15). The SSB(50%MSP) and Yield(50%MSP) from both the base and alternative models alternative models were less than those determined at GARM III.

We also considered whether the current spawning biomass and fishing mortalities should be adjusted for retrospective pattern to determine stock status. For the base model,

$SSB_{adjusted}(2010) = SSB(2010)/(1+0.036) = 302379mt$

and

$F_{adjusted}(2010) = F(2007)/(1-0.035) = 0.0062.$

For the alternate model,

$SSB_{adjusted}(2010) = SSB(2010)/(1+0.047) = 300777mt$

and

$F_{adjusted}(2010) = F(2007)/(1-0.045) = 0.0062.$

The estimated spawning biomass and fishing mortalities for 2010 adjusted for retrospective pattern are within the 80% confidence intervals of the unadjusted values (Figure GG13). Using the rational at GARM III, the retrospective pattern is not severe enough to consider for stock status and projections.

The estimated fishing mortalities for 2010 from the base and alternative models 2010 were 84% less than the new (or GARM III) F(50%MSP) reference point (Table G15). The estimated spawning biomasses in 2010 from the base and alternative models are 24% and 32% greater than the respective new SSB(50%MSP) reference point. In either case, these results would indicate that the stock is not overfished nor is overfishing occurring. These results would also indicate that the Gulf of Maine-Georges Bank Acadian redfish stock is rebuilt. The same conclusions would be drawn from the current spawning biomass and fishing mortality estimates adjusted for retrospective patterns.

Short-term Projections

The same inputs used for the SSB(50%MSP) estimation were used for the short-term projection scenarios. These results are based on 100 random numbers-at-age vectors in 2010 and we performed 1000 stochastic projections per numbers-at-age vector through 2015. In 3 different scenarios, fishing mortality in 2012-2015 was assumed equal to status quo, the reference point (F(50%MSP)), or 75% of the reference point (for acceptable biological catch).

The differences between the base and alternative models in median catch or spawning biomass in years 2012-2015 under a given fishing mortality rate scenario are small (Tables 16-19). If fishing at status quo median catch increases to approximately 2700 mt in 2015. At 0.75F(50%MSP) median catch increases to approximately 12000 mt and at F(50%MSP) to approximately 15000 mt. Median SSB at status quo, 0.75F(50%MSP) and F(50%MSP) is approximately, 440,000-450,000 mt, 410,000-420,000 mt, and 400,000-410,000 mt, respectively.

Summary

There is little difference in the diagnostics, results, or stock status for the base and alternative models. Because the alternative model treats variance of recruitment in recent years without age information consistent to the years preceding age composition information, it may be preferable.

Conclusions

<u>Status of Stock</u>

SSB in 2010 is estimated to be 314,780 mt.
F in 2010 is estimated to be 0.006.
<u>Revised</u> estimates of the biological reference points are:

SSBmsy proxy= 238,000 mt,
Fmsy proxy = 0.04, and
MSY proxy= 8891.

Based on these results, the stock of Gulf of Maine-Georges Bank Acadian redfish is not overfished and overfishing is not occurring. The stock is above the biomass target.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15), but includes a decrease in assumed variability in recruitment from the stock-recruitment relationship in years 2008-2010. A strong retrospective pattern was present in the GARM III assessment, but not in this assessment. Thus, no retrospective adjustment was applied.

The updated biological reference points are based on the following updates: estimates of fishery selectivity and annual recruitment from updated and revised model results. All other inputs remained the same as at the last assessment due to unavailable biological information in 2008-2010.

Acadian Redfish. Summary of Assessment Information

Acadian Redfish	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Landings (mt)	360	368	361	398	564	499	787	1193	1461	1646	10456	7	55892	1913-2010
Discards (mt)	368	126	203	125	101	149	373	180	206	206	241	30	1514	1989-2010
Catch(mt)	728	494	564	523	665	648	1160	1373	1667	1852	10510	7	55892	1913-2010
Recruits (000's)	48904	98871	32443	74048	84812	67654	223820	81644	66353	55434	43724	824.61	223820	1913-2010
F	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.08	0.00	0.36	1913-2010
SSB (mt)	114580	133270	152880	173530	195270	217900	241090	264670	289090	314780	289873	14202	670180	1913-2010

Reviewer Comments

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

The assessment was revised in two ways. An inconsistency in the currency of aggregate survey indices and survey age compositions was corrected so that they are now both expressed in terms of abundance rather than biomass. Age data were not available for years since the 2008 GARM, so variation in recruitment was decreased for years 2008-2010, similar to variation in recruitment assumed for the historic periods when age composition data were unavailable.

The revised assessment was considered to be an improvement by the Review Panel. Estimates of survey selectivity were much more realistic, presumably from the corrected currency of age distributions. Anomalous spikes in annual estimates of fishing mortality from the 2008 GARM assessment were reduced (1991) or removed (1996), and the model estimated total catch much better in those years.

The previous assessment had a considerable retrospective pattern, so retrospective adjustments were used for status determination and catch projections by the 2008 GARM. However, the retrospective pattern in the updated assessment was substantially reduced (e.g., now only 4% inconsistency in fishing mortality and spawning biomass). A retrospective adjustment is no longer needed according to the criteria developed by the 2008 GARM.

Some uncertainties remain in the assessment. The seasonal difference in survey selectivities is not well understood. Given the interest in developing a targeted fishery for redfish with smaller mesh, there is a need to collect age samples from the commercial fishery to inform possible changes in selectivity.

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YPR. 2007. Yield per recruit, version 2.7. NOAA Fisheries Toolbox. NEFSC, Woods Hole, MA. Available at http://nft.nefsc.noaa.gov.

Table G1. Nominal redfish catches (metric tons) and estimated discards for the Gulf of Maine-Georges Bank Acadian redfish fishery.

	Nominal Catch (Metric tons)			Estimated		Total	
Year	USA	Others	Total	Discards (mt)	CV	Removals (mt)	CV
1913	7		7			7	
1914	30		30			30	
1915	40		40			40	
1916	53		53			53	
1917	82		82			82	
1918	73		73			73	
1919	25		25			25	
1920	31		31			31	
1921	13		13			13	
1922	9		9			9	
1923	7		7			7	
1924	40		40			40	
1925	25		25			25	
1926	30		30			30	
1927	30		30			30	
1928	57		57			57	
1929	34		34			34	
1930	54		54			54	
1931	108		108			108	
1932	60		60			60	
1933	120		120			120	
1934	519		519			519	
1935	7549		7549			7549	
1936	23162		23162			23162	
1937	14823		14823			14823	
1938	20640		20640			20640	
1939	25406		25406			25406	
1940	26762		26762			26762	
1941	50796		50796			50796	
1942	55892		55892			55892	
1943	48348		48348			48348	
1944	50439		50439			50439	
1945	37912		37912			37912	
1946	42423		42423			42423	
1947	40160		40160			40160	
1948	43631		43631			43631	
1949	30743		30743			30743	
1950	34307		34307			34307	
1951	30077		30077			30077	
1952	21377		21377			21377	
1953	16791		16791			16791	
1954	12988		12988			12988	
1955	13914		13914			13914	
1956	14388		14388			14388	
1957	18490		18490			18490	
1958	16043	4	16047			16047	
1959	15521		15521			15521	
1960	11373	2	11375			11375	
1961	14040	61	14101			14101	
1962	12541	1593	14134			14134	

1963	8871	1175	10046			10046	
1964	7812	501	8313			8313	
1965	6986	1071	8057			8057	
1966	7204	1365	8569			8569	
1967	10442	422	10864			10864	
1968	6578	199	6777			6777	
1969	12041	414	12455			12455	
1970	15534	1207	16741			16741	
1971	16267	3767	20034			20034	
1972	13157	5938	19095			19095	
1973	11954	5406	17360			17360	
1974	8677	1794	10471			10471	
1975	9075	1497	10572			10572	
1976	10131	565	10696			10696	
1977	13012	211	13223			13223	
1978	13991	92	14083			14083	
1979	14722	33	14755			14755	
1980	10085	98	10183			10183	
1981	7896	19	7915			7915	
1982	6735	168	6903			6903	
1983	5215	113	5328			5328	
1984	4722	71	4793			4793	
1985	4164	118	4282			4282	
1986	2790	139	2929			2929	
1987	1859	35	1894			1894	
1988	1076	101	1177			1177	
1989	628	9	637	32	0.62	669	0.03
1990	588	13	601	38	0.49	639	0.03
1991	525		525	1514	0.74	2039	0.55
1992	849		849	129	0.30	978	0.04
1993	800		800	246	0.53	1046	0.13
1994	440		440	106	2.60	546	0.51
1995	440		440	191	0.47	631	0.14
1996	322		322	367	0.37	689	0.20
1997	251		251	181	0.44	432	0.18
1998	320		320	266	0.97	586	0.44
1999	353		353	30	0.51	383	0.04
2000	319		319	169	0.48	488	0.17
2001	360		360	368	0.33	728	0.17
2002	368		368	126	0.37	494	0.10
2003	361		361	203	0.19	564	0.07
2004	398		398	125	0.18	523	0.04
2005	564		564	101	0.15	665	0.02
2006	499		499	149	0.24	648	0.06
2007	787		787	373	0.34	1160	0.11
2008	1193		1193	180	0.17	1373	0.02
2009	1461		1461	206	0.25	1667	0.03
2010	1646		1646	206	0.16	1852	0.02

Table G2. Proportion of redfish landed by two main gear categories in 1964-2010.

Year	Otter trawl	Gillnet
1964	1	0
1965	1	0
1966	1	0
1967	1	0
1968	1	0
1969	1	0
1970	1	0
1971	1	0
1972	1	0
1973	1	0
1974	1	0
1975	1	0
1976	1	0
1977	1	0
1978	1	0
1979	1	0
1980	0.99	0
1981	1	0
1982	0.99	0
1983	0.99	0.01
1984	0.99	0.01
1985	0.99	0.01
1986	0.99	0.01
1987	0.98	0.02
1988	0.96	0.04
1989	0.93	0.06
1990	0.94	0.06
1991	0.9	0.1
1992	0.94	0.06
1993	0.95	0.05
1994	0.92	0.07
1995	0.92	0.07
1996	0.91	0.08
1997	0.9	0.09
1998	0.87	0.09
1999	0.83	0.16
2000	0.8	0.2
2001	0.83	0.17
2002	0.89	0.11
2003	0.86	0.13
2004	0.82	0.14
2005	0.81	0.1
2006	0.88	0.1
2007	0.89	0.11
2008	0.89	0.11
2009	0.92	0.06
2010	0.95	0.04

Table G3. Estimated redfish discards (mt) by two main gear categories in 2008-2010 with associated CVs.

Year	Otter Trawl	CV	Gillnet	CV
1989	33.9	0.59	0	0
1990	38.38	0.48	0	0
1991	1543.2	0.75	0	0
1992	129.91	0.3	0	0
1993	253.6	0.52	0	0
1994	125.68	2.1	3.36	0.84
1995	196.06	0.47	4.26	0.4
1996	426.13	0.38	6.71	0.45
1997	175.7	0.45	3.52	0.58

1998	248.04	1.05	11.82	0.65
1999	29.6	0.52	6.41	0.55
2000	164.95	0.49	3.81	0.44
2001	360.42	0.34	3.2	0.67
2002	128.85	0.36	0.12	0.71
2003	203.8	0.19	5.83	0.53
2004	115.86	0.2	6.46	0.27
2005	93.95	0.16	4.48	0.25
2006	147.99	0.23	10.19	0.31
2007	335.92	0.37	40.53	0.58
2008	156.42	0.19	23.82	0.32
2009	198.28	0.26	7.83	0.39
2010	200.84	0.16	5.41	0.34

Table G4. Number of observed trips on vessels in two main gear categories in 2008-2010.

Year	Otter Trawl	Gillnet
1989	232	213
1990	140	156
1991	299	957
1992	226	1187
1993	139	770
1994	203	862
1995	291	697
1996	229	575
1997	188	702
1998	162	707
1999	188	280
2000	269	317
2001	378	229
2002	588	217
2003	649	620
2004	1197	1504
2005	2013	1242
2006	976	360
2007	1153	453
2008	1161	387
2009	1616	536
2010	2044	2366

Table G5. Estimated numbers and biomass per tow of Gulf of Main-Georges Bank Acadian redfish for offshore strata 24, 26-30, 36-40 in the spring NEFSC bottom trawl survey.

Year	Numbers/tow	CV	Biomass (kg)/tow	CV
1968	45.18	0.45	17.09	0.34
1969	46.43	0.26	19.69	0.29
1970	54.72	0.67	18.93	0.53
1971	157.23	0.28	71.56	0.30
1972	101.22	0.51	44.36	0.50
1973	44.35	0.31	25.30	0.32
1974	34.31	0.59	18.84	0.66
1975	38.93	0.32	17.61	0.35
1976	62.22	0.49	26.19	0.54
1977	25.06	0.26	11.59	0.26
1978	23.98	0.20	12.17	0.20
1979	61.41	0.32	32.21	0.33
1980	29.81	0.34	20.34	0.34
1981	33.04	0.69	18.31	0.69
1982	16.96	0.39	9.41	0.37

1983	9.85	0.36	6.07	0.41
1984	4.96	0.32	2.68	0.33
1985	11.72	0.39	6.61	0.40
1986	5.27	0.27	3.22	0.32
1987	24.50	0.80	12.93	0.84
1988	8.09	0.49	3.27	0.47
1989	7.81	0.28	2.98	0.36
1990	12.34	0.36	6.81	0.43
1991	9.47	0.32	4.26	0.38
1992	37.86	0.41	10.67	0.41
1993	35.50	0.45	17.50	0.50
1994	16.14	0.58	3.92	0.63
1995	7.23	0.32	1.92	0.40
1996	28.74	0.46	11.89	0.64
1997	212.02	0.77	34.04	0.71
1998	34.67	0.33	7.84	0.33
1999	76.05	0.33	19.02	0.29
2000	180.09	0.55	56.01	0.58
2001	101.61	0.46	37.97	0.54
2002	225.18	0.68	61.21	0.63
2003	109.15	0.41	33.34	0.43
2004	152.30	0.38	55.67	0.43
2005	145.34	0.53	46.26	0.53
2006	34.70	0.35	10.33	0.34
2007	122.25	0.33	35.10	0.35
2008	125.16	0.45	46.01	0.42
2009	171.54	0.58	59.92	0.72
2010	116.53	0.25	29.41	0.32

Table G6. Estimated numbers and biomass per tow of Gulf of Main-Georges Bank Acadian redfish for offshore strata 24, 26-30, 36-40 in the autumn NEFSC bottom trawl survey.

Year	Numbers/tow	CV	Biomass (kg)/tow	CV
1963	87.34	NA	24.11	NA
1964	116.26	0.68	53.64	0.75
1965	57.00	0.23	13.20	0.37
1966	93.84	0.34	29.27	0.45
1967	100.59	0.34	24.37	0.37
1968	143.45	0.41	40.43	0.43
1969	71.23	0.24	23.76	0.26
1970	93.98	0.23	32.96	0.19
1971	48.00	0.19	23.42	0.22
1972	55.57	0.17	24.63	0.19
1973	39.16	0.16	17.03	0.18
1974	48.30	0.22	24.16	0.30
1975	74.84	0.22	39.95	0.29
1976	28.85	0.31	15.29	0.39
1977	40.39	0.19	17.25	0.15
1978	45.21	0.17	20.74	0.16
1979	28.89	0.21	15.98	0.21
1980	20.58	0.28	12.63	0.31
1981	20.36	0.32	12.24	0.32
1982	9.18	0.46	3.48	0.27
1983	10.04	0.21	4.12	0.23
1984	7.77	0.42	3.93	0.38
1985	13.01	0.32	5.69	0.31
1986	26.05	0.39	8.01	0.34
1987	13.72	0.41	5.46	0.32
1988	12.43	0.41	6.33	0.57
1989	20.25	0.29	6.81	0.30
1990	35.53	0.34	12.16	0.33
1991	19.06	0.34	8.36	0.45
1992	22.37	0.26	8.09	0.29
1993	35.62	0.31	11.20	0.33
1994	20.86	0.32	5.94	0.43
1995	33.22	0.25	4.65	0.24
1996	169.64	0.35	30.63	0.33
1997	65.02	0.30	18.94	0.39
1998	116.95	0.42	31.72	0.45
1999	82.48	0.23	22.86	0.24
2000	104.43	0.27	26.16	0.29
2001	89.62	0.23	28.17	0.25
2002	185.19	0.31	41.88	0.33
2003	250.94	0.47	65.49	0.49
2004	127.29	NA	36.63	NA
2005	166.07	0.21	46.95	0.23
2006	183.43	0.31	50.22	0.30
2007	170.03	0.23	50.39	0.25
2008	219.43	0.25	62.28	0.24
2009	221.24	0.26	41.31	0.23
2010	283.61	0.24	81.48	0.28

Table G7. Objective function components for the GARM III and current base and alternative models.

	GARM III	Base	Alternative
Objective Function Components			
Catch (landings + discards)	433.8	429.5	429.5
Autumn survey index	513.5	564.1	564
Spring survey index	471.3	533.8	533.8
Landings age composition	893.2	859.3	860.9
Survey age composition	2034.9	1934.6	1934.5
Catch selectivity penalties	110.2	32.9	32.9
Survey selectivity penalties	6.2	15.1	15.2
Initial numbers-at-age penalty	265.0	265.8	265.9
Recruitment deviations	1104.2	1140.4	1138.9
Other	15.2	14.9	13.8
Total	5847.5	5790.2	5789.4

Table G8. Annual estimates of spawning biomass (mt), recruitment (1000s), and fully selected fishing mortality from base and alternative models.

Year	Base Model Spawning Biomass at Year + 0.4	CV	Recruitment on January 1	CV	Full Fishing Mortality	CV	Alternate Model Spawning Biomass at Year + 0.4		Recruitment on January 1	CV	Full Fishing Mortality	CV
1913	662580	0.02	52882	0.02	1.10E-05	0.02	663930	0.02	52992	0.02	1.10E-05	0.02
1914	662570	0.02	54103	0.1	4.52E-05	0.02	663920	0.02	54248	0.1	4.51E-05	0.02
1915	662550	0.02	54115	0.1	6.10E-05	0.02	663900	0.02	54259	0.1	6.09E-05	0.02
1916	662540	0.02	54128	0.1	8.06E-05	0.02	663890	0.02	54271	0.1	8.05E-05	0.02
1917	662520	0.02	54141	0.1	0.000125	0.02	663880	0.02	54282	0.1	0.000125	0.02
1918	662540	0.02	54154	0.1	0.000111	0.02	663900	0.02	54293	0.1	0.00011	0.02
1919	662640	0.02	54167	0.1	3.76E-05	0.02	664000	0.02	54305	0.1	3.75E-05	0.02
1920	662820	0.02	54182	0.1	4.65E-05	0.02	664190	0.02	54319	0.1	4.64E-05	0.02
1921	663070	0.02	54198	0.1	1.90E-05	0.02	664450	0.02	54334	0.1	1.90E-05	0.02
1922	663400	0.01	54215	0.1	1.30E-05	0.02	664780	0.01	54350	0.1	1.30E-05	0.02
1923	663780	0.01	54233	0.1	1.05E-05	0.02	665170	0.01	54366	0.1	1.05E-05	0.02
1924	664190	0.01	54251	0.1	6.01E-05	0.02	665600	0.01	54384	0.1	6.00E-05	0.02
1925	664630	0.01	54269	0.1	3.74E-05	0.02	666040	0.01	54401	0.1	3.74E-05	0.02
1926	665090	0.01	54286	0.1	4.49E-05	0.02	666520	0.01	54418	0.1	4.49E-05	0.02
1927	665580	0.01	54302	0.1	4.54E-05	0.02	667010	0.01	54435	0.1	4.53E-05	0.02
1928	666060	0.01	54318	0.1	8.61E-05	0.02	667510	0.01	54450	0.1	8.59E-05	0.02
1929	666550	0.01	54332	0.1	5.10E-05	0.02	668010	0.01	54465	0.1	5.09E-05	0.02
1930	667040	0.01	54344	0.1	8.10E-05	0.02	668520	0.01	54477	0.1	8.08E-05	0.02
1931	667510	0.01	54355	0.1	0.000162	0.02	668990	0.01	54489	0.1	0.000162	0.02
1932	667960	0.01	54366	0.1	9.01E-05	0.02	669450	0.01	54501	0.1	8.99E-05	0.02
1933	668410	0.01	54375	0.1	0.00018	0.02	669910	0.01	54511	0.1	0.00018	0.02
1934	668670	0.01	54383	0.1	0.00078	0.02	670180	0.01	54521	0.1	0.000778	0.02
1935	665910	0.01	54387	0.1	0.011399	0.02	667430	0.01	54525	0.1	0.011374	0.02
1936	652860	0.01	54341	0.1	0.035758	0.02	654390	0.01	54479	0.1	0.035676	0.02
1937	634290	0.01	54128	0.1	0.023533	0.02	635830	0.01	54259	0.1	0.023477	0.02
1938	618520	0.01	53812	0.1	0.03364	0.02	620060	0.01	53932	0.1	0.033558	0.02
1939	597800	0.01	53522	0.1	0.042889	0.02	599350	0.01	53632	0.1	0.042779	0.02
1940	574220	0.01	53115	0.1	0.047062	0.02	575780	0.01	53211	0.1	0.046936	0.02
1941	540550	0.01	52610	0.1	0.095322	0.02	542100	0.01	52690	0.1	0.095051	0.02
1942	491740	0.01	51831	0.1	0.11557	0.02	493300	0.01	51885	0.1	0.1152	0.02
1943	444130	0.02	50573	0.1	0.11072	0.02	445700	0.02	50588	0.1	0.11033	0.02
1944	400820	0.02	49120	0.1	0.12827	0.02	402390	0.02	49092	0.1	0.12777	0.02
1945	362530	0.02	47518	0.1	0.10648	0.02	364090	0.02	47450	0.1	0.10603	0.02
1946	330250	0.02	45405	0.1	0.13114	0.02	331810	0.02	45302	0.1	0.13052	0.02
1947	297200	0.02	44942	0.1	0.13811	0.02	298740	0.02	44804	0.1	0.13738	0.02
1948	264610	0.02	44397	0.09	0.16904	0.02	266140	0.02	44223	0.09	0.16806	0.02
1949	236100	0.02	41308	0.09	0.1332	0.03	237600	0.02	41112	0.09	0.13234	0.03
1950	213670	0.02	39554	0.09	0.16475	0.03	215140	0.02	39337	0.09	0.16359	0.03
1951	191390	0.03	38280	0.09	0.16134	0.03	192820	0.03	38057	0.09	0.16011	0.03
1952	175290	0.03	35300	0.09	0.12487	0.03	176680	0.03	35087	0.09	0.12387	0.03
1953	166080	0.03	41473	0.08	0.10329	0.03	167410	0.03	41221	0.08	0.10245	0.03
1954	161150	0.03	37968	0.08	0.082158	0.03	162420	0.03	37742	0.08	0.081499	0.03
1955	158170	0.03	41594	0.07	0.089652	0.03	159370	0.02	41362	0.07	0.08896	0.03
1956	154590	0.02	35533	0.07	0.094868	0.03	155710	0.02	35341	0.07	0.094169	0.03
1957	149130	0.02	37441	0.07	0.12686	0.03	150160	0.02	37251	0.07	0.12596	0.03
1958	142320	0.02	39770	0.06	0.1153	0.03	143270	0.02	39586	0.06	0.11452	0.03
1959	137060	0.02	33227	0.06	0.11594	0.03	137920	0.02	33072	0.06	0.1152	0.03
1960	133780	0.02	41050	0.06	0.086917	0.02	134550	0.02	40885	0.06	0.086409	0.02
1961	131800	0.02	30906	0.06	0.10954	0.02	132490	0.02	30771	0.06	0.10897	0.02
1962	128310	0.02	45377	0.05	0.1128	0.02	128920	0.02	45224	0.05	0.11227	0.02
1963	126410	0.02	28534	0.06	0.081051	0.02	126940	0.02	28413	0.06	0.080716	0.02
1964	127550	0.02	51839	0.04	0.06647	0.02	128000	0.02	51696	0.04	0.066237	0.02
1965	129940	0.02	33475	0.06	0.063159	0.02	130320	0.02	33451	0.06	0.062979	0.02
1966	132460	0.01	18424	0.07	0.065888	0.02	132760	0.01	18422	0.07	0.065739	0.02

1967	133890	0.01	4641.3	0.14	0.082745	0.02	134120	0.01	4648.1	0.14	0.082605	0.02
1968	135490	0.01	3368.5	0.16	0.050766	0.02	135660	0.01	3377.1	0.16	0.050706	0.02
1969	136810	0.01	1583.8	0.21	0.092069	0.02	136930	0.01	1592.5	0.21	0.092003	0.02
1970	132270	0.01	1861.9	0.19	0.12728	0.01	132340	0.01	1870.3	0.19	0.12723	0.01
1971	122400	0.01	1928.2	0.18	0.16495	0.01	122430	0.01	1936.2	0.18	0.16493	0.01
1972	109220	0.01	116820	0.03	0.17486	0.01	109220	0.01	116870	0.03	0.17488	0.01
1973	95710	0.01	4428.8	0.11	0.18171	0.01	95692	0.01	4436.8	0.11	0.18175	0.01
1974	85247	0.01	2103.8	0.16	0.12432	0.02	85218	0.01	2110	0.16	0.12437	0.02
1975	78615	0.01	1315.1	0.18	0.14077	0.02	78580	0.01	1320.2	0.18	0.14084	0.02
1976	72581	0.01	1285.5	0.18	0.15605	0.02	72544	0.01	1290.3	0.18	0.15614	0.02
1977	66264	0.01	820.39	0.22	0.20456	0.02	66227	0.01	824.61	0.22	0.20471	0.02
1978	58267	0.02	1039.5	0.19	0.25333	0.03	58233	0.02	1044	0.19	0.25352	0.03
1979	48732	0.02	25785	0.06	0.31999	0.03	48702	0.02	25813	0.06	0.32024	0.03
1980	39745	0.02	1013.2	0.2	0.24985	0.02	39718	0.02	1018	0.2	0.25001	0.02
1981	33123	0.03	1911	0.17	0.23808	0.03	33099	0.03	1917.8	0.17	0.23825	0.03
1982	27550	0.03	9500.5	0.11	0.25759	0.04	27529	0.03	9523.2	0.11	0.25781	0.04
1983	23027	0.04	12340	0.11	0.24158	0.04	23009	0.04	12372	0.11	0.2418	0.04
1984	19645	0.05	3439.5	0.16	0.25162	0.05	19629	0.05	3452.5	0.16	0.25186	0.05
1985	16818	0.07	5378.7	0.15	0.27208	0.07	16807	0.07	5398.2	0.15	0.27233	0.07
1986	14884	0.08	16672	0.12	0.21406	0.08	14876	0.08	16724	0.12	0.21424	0.08
1987	14205	0.09	16242	0.12	0.13654	0.09	14202	0.09	16281	0.12	0.1366	0.09
1988	14540	0.1	11361	0.13	0.083929	0.1	14543	0.1	11381	0.13	0.083938	0.1
1989	15718	0.1	13623	0.13	0.045612	0.11	15727	0.1	13647	0.13	0.045601	0.11
1990	17546	0.1	14397	0.14	0.038828	0.11	17562	0.1	14427	0.14	0.038802	0.11
1991	17752	0.08	19098	0.14	0.34947	0.41	17739	0.08	19141	0.14	0.35538	0.41
1992	17364	0.1	78928	0.09	0.060243	0.11	17311	0.1	79058	0.09	0.060463	0.11
1993	20017	0.1	108000	0.09	0.058798	0.16	19967	0.1	108210	0.09	0.058992	0.16
1994	23870	0.09	50890	0.12	0.032967	0.56	23825	0.09	51030	0.12	0.033111	0.56
1995	29730	0.09	52050	0.12	0.02495	0.17	29694	0.09	52223	0.12	0.025	0.17
1996	38046	0.08	38094	0.15	0.021724	0.22	38026	0.08	38258	0.15	0.021754	0.22
1997	49208	0.08	33675	0.16	0.009919	0.2	49211	0.08	33852	0.16	0.009925	0.2
1998	63100	0.08	42288	0.16	0.010353	0.44	63134	0.08	42535	0.16	0.010357	0.44
1999	79031	0.08	53667	0.16	0.005201	0.09	79104	0.08	54015	0.16	0.005198	0.09
2000	96381	0.08	125390	0.13	0.005205	0.18	96502	0.08	126160	0.13	0.005201	0.18
2001	114410	0.08	48483	0.19	0.006332	0.19	114580	0.08	48904	0.19	0.006324	0.19
2002	133020	0.08	98070	0.17	0.003722	0.12	133270	0.08	98871	0.17	0.003716	0.12
2003	152550	0.08	31953	0.31	0.003746	0.1	152880	0.08	32443	0.31	0.003739	0.1
2004	173090	0.08	73038	0.29	0.003074	0.09	173530	0.08	74048	0.29	0.003067	0.09
2005	194690	0.08	83018	0.4	0.003466	0.08	195270	0.08	84812	0.4	0.003457	0.08
2006	217160	0.08	65041	0.56	0.003044	0.09	217900	0.08	67654	0.55	0.003034	0.09
2007	240150	0.08	215320	0.53	0.004907	0.13	241090	0.08	223820	0.53	0.00489	0.13
2008	263470	0.08	100110	0.68	0.005247	0.08	264670	0.08	81644	0.59	0.005226	0.08
2009	287600	0.08	104380	0.69	0.005878	0.08	289090	0.08	66353	0.49	0.00585	0.08
2010	313140	0.08	107940	0.69	0.006007	0.08	314780	0.08	55434	0.37	0.005974	0.08

Table G9. Estimated numbers at age (1000s) on January 1 from base model.

year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	Age 21	Age 22	Age 23	Age 24	Age 25	Age 26
1913	52882.1	50293.4	47840.4	45507.1	43287.5	41176.1	39167.5	37256.9	35439.5	33710.6	32066.1	30501.8	29013.8	27598.5	26252.2	24971.5	23753.4	22594.6	21492.5	20444	19446.7	18498.1	17595.7	16737.4	15920.9	310439
1914	54102.7	50303	47840.6	45507.2	43287.7	41176.2	39167.7	37257	35439.6	33710.7	32066.1	30501.9	29013.9	27598.5	26252.2	24971.6	23753.4	22594.7	21492.5	20444	19446.7	18498.1	17595.7	16737.4	15920.9	310439
1915	54115.1	51464	47849.7	45507.3	43287.7	41176	39167	37256.3	35438.8	33709.6	32065.1	30500.9	29013	27597.6	26251.3	24970.7	23752.6	22593.9	21491.7	20443.3	19446.1	18497.5	17595.1	16736.8	15920.4	310430
1916	54127.7	51475.9	48954	45515.9	43287.7	41175.8	39166.4	37255.3	35437.7	33708.4	32063.6	30499.4	29011.6	27596.3	26250.1	24969.5	23751.4	22592.8	21490.7	20442.3	19445.1	18496.6	17594.3	16736	15919.6	310415
1917	54140.6	51487.8	48965.3	46566.4	43295.9	41175.6	39165.8	37254.3	35436.2	33706.7	32061.8	30497.4	29009.6	27594.4	26248.3	24967.8	23749.8	22591.2	21489.2	20440.9	19443.8	18495.3	17593.1	16734.8	15918.5	310394
1918	54153.6	51500	48976.6	46577	44295	41182.9	39164.6	37252.6	35434.1	33703.8	32058.8	30494.3	29006.4	27591.4	26245.4	24965	23747.2	22588.7	21486.8	20438.6	19441.6	18493.2	17591.1	16732.9	15916.7	310359
1919	54167.1	51512.4	48988.2	46587.8	44305.2	42133.4	39171.8	37251.8	35432.9	33702.2	32056.5	30491.9	29003.9	27588.7	26242.8	24962.6	23744.8	22586.5	21484.7	20436.6	19439.6	18491.3	17589.3	16731.3	15915.1	310329
1920	54181.9	51525.3	49000.1	46598.9	44315.6	42143.9	40077.6	37260.5	35434	33703.5	32057.3	30491.9	29003.7	27588.3	26242.2	24962	23744.3	22585.9	21484.1	20436.1	19439.2	18490.9	17588.9	16730.8	15914.7	310321
1921	54198.1	51539.4	49012.4	46610.2	44326.2	42153.8	40087.4	38121.9	35442	33704.3	32058.3	30492.4	29003.5	27587.9	26241.6	24961.2	23743.5	22585.2	21483.4	20435.4	19438.5	18490.2	17588.2	16730.3	15914.1	310311
1922	54215.1	51554.8	49025.7	46622	44337	42164.1	40097.5	38131.9	36262.1	33712.9	32059.9	30494.2	29004.8	27588.4	26241.9	24961.3	23743.4	22585.1	21483.3	20435.3	19438.4	18490.1	17588.1	16730.1	15914	310309
1923	54232.8	51571	49040.4	46634.7	44348.1	42174.5	40107.4	38141.6	36271.8	34493.2	32068.3	30495.9	29006.6	27589.8	26242.6	24961.7	23743.6	22585.1	21483.3	20435.3	19438.4	18490.1	17588.1	16730.1	15914	310309
1924	54250.8	51587.8	49055.8	46648.7	44360.3	42185.1	40117.4	38151.1	36281.1	34502.5	32810.6	30503.9	29008.3	27591.7	26244	24962.5	23744.1	22585.4	21483.4	20435.3	19438.4	18490.2	17588.1	16730.2	15914	310309
1925	54268.6	51604.9	49071.8	46663.3	44373.4	42196.1	40126.3	38159.3	36288.9	34509.6	32817.8	31208.5	29014.5	27591.9	26244.4	24962.5	23743.6	22584.7	21482.6	20434.4	19437.5	18489.3	17587.3	16729.4	15913.3	310294
1926	54285.7	51621.8	49088.1	46678.5	44387.4	42208.9	40137.3	38168.4	36297.3	34517.7	32825.3	31216.1	29685.3	27598.4	26245.3	24963.5	23744.2	22584.8	21482.5	20434.1	19437.1	18488.9	17586.9	16729	15912.9	310287
1927	54302.3	51638.1	49104.2	46693.9	44401.8	42222	40149.2	38178.6	36305.7	34525.5	32832.8	31223	29692.3	28236.3	26251.2	24964.1	23745	22585.2	21482.3	20433.8	19436.7	18488.3	17586.4	16728.4	15912.4	310277
1928	54317.5	51653.9	49119.6	46709.3	44416.5	42235.8	40161.8	38190	36315.4	34533.5	32840.1	31230.1	29698.9	28242.9	26858	24969.8	23745.6	22585.9	21482.7	20433.7	19436.4	18487.9	17585.8	16727.9	15911.8	310267
1929	54332	51668.3	49134.6	46723.9	44431	42249.3	40173.9	38200.9	36325.2	34541.3	32846.4	31235.8	29704.5	28248	26863.2	25545.9	23750	22585.5	21482.5	20433.2	19435.5	18486.9	17584.7	16726.7	15910.7	310244
1930	54343.8	51682.1	49148.4	46738.2	44445	42263.5	40187.6	38213.3	36336.5	34551.8	32855.1	31242.9	29710.9	28254.3	26869	25551.7	24298.8	22590.5	21482.9	20433.8	19435.7	18486.6	17584.3	16726.2	15910.1	310232
1931	54354.9	51693.4	49161.5	46751.3	44458.6	42276.5	40200.3	38225.6	36347.4	34561.5	32864	31250.2	29716.8	28259.6	26874.2	25556.5	24303.6	23111.8	21487	20433.5	19435.6	18486.3	17583.6	16725.4	15909.2	310211
1932	54366.1	51703.9	49172.1	46763.6	44470.8	42288.4	40210.8	38235.7	36356.9	34569.1	32870.6	31256.2	29721.3	28262.9	26877	25559.3	24306.1	23114.6	21981.1	20435.8	19433.8	18484.7	17581.9	16723.3	15907.1	310165
1933	54375.1	51714.6	49182.1	46773.8	44482.7	42300.9	40223.8	38247.4	36368.5	34580.7	32880.2	31264.7	29729.1	28269.2	26882.1	25563.9	24310.6	23118.6	21985.3	20907.2	19437.4	18484.4	17581.6	16722.9	15906.3	310141
1934	54383.2	51723	49192.2	46783.2	44492.1	42311.1	40233.5	38257.6	36377.2	34588.5	32888.2	31271	29734.5	28274.1	26885.6	25566.4	24312.8	23120.8	21987.2	20909.3	19883.9	18486.1	17579.7	16721.2	15904.4	310090
1935	54387.1	51730.2	49199.6	46792	44499.6	42313.2	40228.9	38251.9	36370.7	34576.1	32876	31259.9	29722.7	28262.3	26874.2	25554.5	24300.6	23109	21976	20898.5	19874	18899.5	17570.8	16709.3	15893.3	309854
1936	54341.3	51723.9	49194.4	46783.4	44481.1	42197	39976.6	37983.7	36080.4	34204.8	32517	30918.2	29398.3	27952.7	26579.2	25273.8	24032.7	22853.4	21732.8	20667.3	19654	18690.5	17773.9	16524.4	15714.2	306348
1937	54128	51657.5	49160.8	46742.7	44411.4	41898.1	39291.4	37151	35187	33115.2	31393.7	29844.6	28377.2	26982.2	25655.4	24394.8	23196.7	22057.6	20975.2	19946.7	18968.8	18038.7	17154.4	16313.2	15166.4	295594
1938	53812	51466.2	49111.5	46728.7	44403.7	41973.3	39298.9	36806.4	34728.6	32692.4	30767.5	29168.1	27728.8	26365.4	25069.3	23836.6	22665.4	21552.2	20493.8	19488.2	18532.6	17624	16759.9	15938.3	15156.7	288729
1939	53521.7	51156.4	48918.2	46667.1	44364.9	41849.6	39132.6	36571.6	34149.9	31942.1	30069.2	28298.8	26827.7	25503.9	24249.9	23057.8	21924	20846.7	19822.9	18849.4	17924.5	17045.6	16209.9	15415.1	14659.4	279503
1940	53114.9	50871.8	48613.3	46469.9	44283.2	41706.9	38802.5	36198	33700.5	31120.6	29108.7	27401.9	25788.5	24447.9	23241.6	22098.8	21012.5	19979.2	18997.5	18064.5	17177.4	16334.5	15533.5	14772	14047.7	268068
1941	52610.2	50481.3	48338.3	46174.3	44085.6	41582.4	38574	35795.2	33253.3	30583.2	28242	26416.1	24867.3	23403.1	22186.5	21091.7	20054.7	19068.8	18131.1	17240.3	16393.5	15588.5	14823.6	14096.7	13405.6	256020
1942	51830.9	49957.9	47913.9	45843.7	43685.3	40851.7	37366.8	34482.7	31728.8	28755.6	26446.6	24422	22843.2	21503.8	20237.7	19185.6	18238.9	17342.1	16489.6	15678.8	14908.4	14176.2	13480	12818.6	12190	232984
1943	50572.9	49199.8	47395	45412.4	43322.7	40256.3	36269.4	32965.8	30110.7	26887.5	24367.9	22411.3	20695.6	19357.6	18222.6	17149.7	16258.2	15455.9	14696	13973.5	13286.4	12633.6	12013.1	11423.2	10862.6	207764
1944	49119.9	48009.9	46681	44927.4	42926.9	39975.4	35844.3	32098.9	28889.6	25640.2	22895.5	20750	19083.9	17622.9	16483.6	15517.1	14603.5	13844.3	13161.2	12514.1	11898.9	11313.8	10757.9	10229.5	9727.18	186168
1945	47517.7	46615.7	45533.6	44226.3	42426.2	39419.6	35223.1	31361.8	27766.5	24172.3	21453.5	19157	17361.8	15967.7	14745.3	13792.1	12983.4	12218.9	11583.7	11012.2	10470.7	9955.97	9466.4	9001.27	8559.18	163908
1946	45404.7	45113	44233.5	43168.6	41815.7	39193.7	35188.1	31259	27570.2	23744.4	20670.8	18345.8	16382	14846.9	13654.7	12609.4	11794.2	11102.7	10449	9905.77	9416.99	8953.96	8513.79	8095.14	7697.39	147484
1947	44942.4	43087.7	42783.2	41903.7	40758.7	38369	34475.4	30730.3	26982.8	23002.4	19810.4	17246.1	15306.3	13667.8	12387.1	11392.4	10520.3	9840.16	9263.2	8717.79	8264.6	7856.8	7470.48	7103.24	6753.95	129471
1948	44397	42643.6	40856	40521	39548.7	37327.6	33609.9	29971.4	26389.8	22355.9	19058.1	16413.5	14288.9	12681.7	11324.2	10263	9438.93	8716.35	8152.84	7674.82	7222.93	6847.44	6509.57	6189.49	5885.23	112866
1949	41308.1	42102.4	40406	38658.2	38176.6	35913	32099.4	28635.8	25155.1	21198.6	17958.2	15309.1	13184.7	11478	10187	9096.55	8244.13	7582.16	7001.72	6549.06	6165.07	5802.08	5500.45	5229.04	4971.93	95391.4
1950	39554.4	39198.6	39926.2	38275.4	36495.7	35010	31550.9	27995.3	24680.8	20944.3	17650	14952.1	12746.4	10977.7	9556.68	8481.77	7573.84	6864.11	6312.95	5829.67	5452.78	5133.07	4830.84	4579.71	4353.73	83563.1
1951	38279.6	37513	37145.5	37783.5	36069.7	33179.8	30183.8	26956.9	23571.5	19911.1	16896.7	14239.1	12062.6	10283.1	8856.19	7709.81	6842.63	6110.16	5537.59	5092.95	4703.06	4399.01	4141.09	3897.26	3694.66	70926.5
1952	35299.6	36306.3	35551	35155.8	35613	32823.1	28664	25846.1	22754.4	19081	16118	13677.8	11526.5	9764.58	8324.16	7169.05	6241.06	5539.08	4946.15	4482.66	4122.72	3807.11	3560.98	3352.19	3154.82	60405.5
1953	41472.7	33502	34436.3	33685.1	33204.9	32733.9	28979.9	25135.1	22414.1	19103.8	16019.7	13532	11483.4	9677.22	8197.99	6988.66	6018.87	5239.76	4650.41	4152.61	3763.47	3461.28	3196.31	2989.67	2814.38	53363
1954	37968.2	39376.2	31792.3	32651	31854.9	30701.9	29275.8	25772	22148.6	19228.5	16388.7	13743	11608.9	9851.38	8301.88	7032.88	5995.43	5163.46	4495.08	3989.49	3562.43	3228.6	2969.36	2742.05	2564.77	48193.3
1955	41593.9	36062.7	37384.9	30164	30914.1	29625.2	27807	26396.2	23068	19406.7	16848.1	14359.8	12041.6	10171.7	8631.8	7274.13	6162.23	5253.21	4524.24	3938.6	3495.6	3121.41	2828.91	2601.76	2402.59	44474.4
1956	35532.9	39501	34233	35461.9	28547.2	28691	26712.1	24949.8	23496	20061.4	16877.2	14652.1	12488.2	10472.1	8845.94	7506.74	6326.03	5359.05	4568.51	3934.55	3425.25	3039.99	2714.57	2460.19	2262.65	40767.1
1957	37440.6	33741.9	37492.4	32466.8	33551.2	26456.5	25789.4	23886	22122.9	20327.2	17355.8	14601.1	12676.1	10804	9059.83	7652.94	6494.36	5472.88	4636.31	3952.38	3403.92	2963.31	2630	2348.47	2128.4	37226.6
1958	39769.8	35532.7	32002.5	35522.5	30661.8	30821.9	23331.1	22585.2	20683.8	18536.8	17032.2	14542.5	12234.3	10621.3	9052.67	7591.23	6412.4	5441.62	4585.73	3884.77	3311.7	2852.15	2482.96	2203.68	1967.79	32975.6
1959	33227.1	37751.1	33710	30332	33569.5	28257.1	27368.9	20586.7	19725.4	17532.3	15712.4	14437.1	12326.7	10370.2	9003.01	7673.37	6434.61	5435.39	4612.52	3887.03	3292.87	2807.12	2417.59	2104.64	1867.92	29619.3
1960	41050.1	31540.2	35814.1	31949.7	28663.4	30931.4	25081.9	24139.6	17971.6	16709.4	14851.7	13310	12229.7	10442	8784.61	7626.46	6500.12	5450.76	4604.32	3907.27	3292.71	2789.39	2377.92	2047.94	1782.85	26672.8
1961	30906.1	38986.5	29941.9	33974.8	30241.9	26622.2	27935.4	22544.8	21530.9	15672	14571.3	12951.3	11606.9	10664.8	9105.84	7660.55	6650.59	5668.38	4753.29	4015.16	3407.3	2871.38	2432.47	2073.64	1785.89	24814.5
1962	45376.7	29340.4	36991.5	28384.1	32117.4	27914.3	23721.1	24742.2	19774.4	18355.8	13360.9	12422.5	11041.4	9895.28	9092.11	7763.04	6530.88	5669.86	4832.49	4052.34	3423.06	2904.84	2447.95	2073.76	1767.85	22677.8
1963	28533.5	43075.4	27837	35063.3	26827.4	29618.9	24824	20964.9	21649.3	16803.4	15598	11353.5	10556.2	9382.52	8408.59	7726.09	6596.7	5549.67	4818.01	4106.44	3443.51	2908.78	2468.41	2080.16	1762.2	20772.9
1964	51838.6	27102.1	40898.1	26412.2	33200.1	24957.1	26843.9	22398.4	18780.7	18990.2	14739.5	13682.2	9959.01	9259.57	8230.09	7375.79	6777.12	5786.45	4868.02	4226.22	3602.06	3020.56	2551.5	2165.22	1824.66	19767.1
1965	33474.6	49251	25740.8	38822.6	25029.4	31009.6	22816.6	24452.2	20282.7	16715.9	16902.4	13119	12177.9	8864.09	8241.55	7325.25	6564.87	6032.02	5150.27	4332.81	3761.58	3206.04	2688.47	2270.98	1927.17	19217.9
1966	18423.8	31805.6	46780.8	24437	36797	23399.2	28406	20828.6	22196.8	18112.6	14927.5	15094	11715.4	10875	7915.71	7359.77	6541.52	5862.49	5386.65	4599.24	3869.24	3359.12	2863.02	2400.82	2028	18882.8
1967	4641.25	17504.3	30208.5	44407.5	23158.4	34374.6	21399.7	25884.9	18869.3	19768	16130.7	13294	13442.3	10433.4	9684.99	7049.54	6554.43	5825.71	5220.99	4797.22	4095.97	3445.85	2991.55	2549.74	2138.12	18622.6
1968	3368.53	4408.28	16618.9	28660.8	42043.8	21533.9	31122.5	19287.5	23159.1	16523.6	17310.6	14125.4	11641.4	11771.3	9136.43	8481.03	6173.19	5739.64	5101.51	4571.96	4200.86	3586.79	3017.49	2619.67	2232.77	18179.9
1969	1583.84	3201.29	4188.38	15783.2	27184.5	39439.4	19872.3	28641.2	17669.9	20939.1	14939.7	15651.2	12771.4	10525.5	10642.9	8260.65	7668.07	5581.46	5189.46	4612.5	4133.71	3798.19	3242.98	2728.25	2368.56	18456
1970	1861.9	1504.08	3038.7	3972.63	14935.2	25212.9	35510	17802.3	25448.8	15329.7	18166	12961.1	13578.4	11080	9131.54	9233.39	7166.62	6652.52	4842.26	4502.17	4001.62	3586.25	3295.16	2813.48	2366.92	18066.6
1971	1928.17	1767.01	1426.54	2879	3751.67	13718.7	22228.9	31089.5	15410.9	21314.5	12839.3	15214.9	10855.6	11372.6	9280.01	7648.09	7733.4	6002.38	5571.8	4055.62	3770.78	3351.55	3003.65	2759.85	2356.42	17114
1972	116818	1828.65	1674.45	1349.97	2713.06	3410.61	11826.1	18989.7	26172.8	12430.2	17191.9	10356	12272	8755.89	9172.9	7485.09	6168.81	6237.62	4841.41	4494.11	3271.19	3041.44	2703.3	2422.69	2226.05	15704.5
1973	4428.82	110768	1732.47	1584.09	1271.44	2459.72	2922.76	10037.8	15869.7	20902.4	9927.1	13730	8270.59	9800.8	6992.71	7325.75	5977.82	4926.6	4981.55	3866.49	3589.13	2612.47	2428.99	2158.93	1934.83	14319.9
1974	2103.78	4198.96	104926	1638.62	1491.37	1150.55	2099.28	2469.74	8346.13	12587.5	16579.3	7873.96	10890.3	6560.05	7773.79	5546.47	5810.63	4741.48	3907.67	3951.26	3066.82	2846.82	2072.15	1926.62	1712.42	12892.9
1975	1315.13	1996.67	3982.74	99420.5	1547.74	1371.01	1016.17	1841.5	2142.67	7011	10573.9	13927.1	6614.37	9148.2	5510.65	6530.22	4659.21	4881.1	3982.98	3282.56	3319.18	2576.22	2391.42	1740.67	1618.42	12268.9
1976	1285.51	1247.8	1893.14	3771.83	93818.8	1416.42	1199.04	881.883	1578.28	1770.54	5793.34	8737.42	11508.3	5465.6	7559.36	4553.57	5396.06	3850	4033.36	3291.23	2712.45	2742.71	2128.79	1976.08	1438.35	11475.4
1977	820.389	1219.36	1182.68	1792.03	3556.23	85498.7	1227.52	1030.28	747.327	1284.4	1440.85	4714.6	7110.47	9365.38	4447.88	6151.77	3705.67	4391.29	3133.11	3282.33	2678.38	2207.38	2232	1732.4	1608.12	10509.1
1978	1039.53	777.487	1154.43	1117.81	1684.95	3197.95	71981.6	1021.92	842.276	579.373	995.741	1117.04	3655.04	5512.46	7260.61	3448.26	4769.22	2872.86	3404.39	2428.98	2544.66	2076.44	1711.29	1730.38	1343.06	9394.04
1979	25785	984.294	735.261	1089.45	1048.11	1495.03	2615.11	58050.8	805.805	621.897	427.781	735.208	824.766	2698.71	4070.14	5360.89	2546.03	3521.37	2121.18	2513.64	1793.44	1878.86	1533.15	1263.54	1277.63	7927.76
1980	1013.2	24385.4	929.407	692.427	1017.66	913.104	1174.87	2019.35	43569.5	556.604	429.57	295.487	507.839	569.701	1864.11	2811.42	3702.99	1758.65	2432.36	1465.19	1736.28	1238.81	1297.81	1059.01	872.78	6358.56
1981	1911	959.429	23062.9	877.187	649.379	903.817	748.242	949.649	1596.41	32281.9	412.404	318.281	218.935	376.273	422.108	1381.17	2083.06	2743.66	1303.04	1802.21	1085.6	1286.46	917.868	961.582	784.652	5357.91
1982	9500.51	1809.97	907.641	21775.1	823.203	578.605	745.855	609.462	757.323	1196.83	24201.9	309.181	238.617	164.136	282.094	316.456	1035.47	1561.68	2056.93	976.893	1351.12	813.881	964.465	688.13	720.903	4605.11
1983	12339.7	8995.03	1711.5	856.436	20412.4	729.562	471.951	599.84	479.058	556.795	879.93	17793.6	227.314	175.435	120.675	207.399	232.663	761.295	1148.17	1512.29	718.226	993.364	598.377	709.088	505.923	3915.76
1984	3439.48	11686.6	8508.81	1615.76	803.569	18170.2	600.798	383.54	477.12	357.897	415.973	657.383	13293.3	169.823	131.065	90.1548	154.945	173.819	568.752	857.782	1129.81	536.576	742.128	447.039	529.75	3303.37
1985	5378.67	3256.84	11052.3	8030.29	1515.15	713.33	14873.8	485.064	302.811	352.886	264.706	307.66	486.211	9831.95	125.604	96.9375	66.6799	114.6	128.56	420.658	634.429	835.623	396.86	548.889	330.637	2835.04
1986	16672	5091.15	3078.62	10424.1	7521.55	1337.47	576.834	11849.6	377.208	219.429	255.715	191.817	222.943	352.328	7124.64	91.0178	70.2448	48.319	83.0437	93.1595	304.826	459.733	605.526	287.581	397.748	2293.98
1987	16242.5	15797.4	4819.01	2908.91	9795.88	6746.14	1119.65	477.256	9619.31	289.668	168.505	196.37	147.301	171.204	270.562	5471.19	69.8948	53.9428	37.1054	63.7713	71.5395	234.083	353.04	464.999	220.841	2067.04
1988	11360.7	15412.1	14979.7	4564.42	2745.67	8975.11	5914.9	974.366	410.32	7982.31	240.373	139.829	162.952	122.234	142.069	224.518	4540.11	58.0002	44.7629	30.7908	52.9188	59.365	194.247	292.961	385.866	1898.54
1989	13623.2	10790.2	14632.1	14211.7	4321.17	2552.24	8120.26	5326.95	870.994	358.888	6981.75	210.242	122.302	142.527	106.912	124.261	196.375	3971.02	50.73	39.1519	26.9313	46.2855	51.9238	169.899	256.239	1998.06
1990	14397.2	12948.1	10253.1	13898.6	13483.6	4059.25	2362.56	7498.01	4898.86	791.574	326.163	6345.13	191.072	111.15	129.531	97.1633	112.93	178.469	3608.93	46.1043	35.5819	24.4756	42.0651	47.1892	154.407	2048.74
1991	19097.8	13685.4	12305.6	9741.23	13191.6	12690	3772.82	2191.19	6930.17	4482.47	724.292	298.44	5805.81	174.831	101.703	118.521	88.9047	103.331	163.3	3302.18	42.1856	32.5576	22.3952	38.4897	43.1782	2015.89
1992	78928.4	18051.6	12913.5	11578	9084.08	11399.7	9798.51	2857.88	1609.06	4647.9	3006.29	485.766	200.157	3893.82	117.255	68.2096	79.4891	59.6263	69.3019	109.521	2214.69	28.2929	21.8356	15.02	25.8141	1380.97
1993	108004	74997	17147.4	12260.5	10975.7	8499.23	10460.8	8961.8	2599.89	1441.1	4162.74	2692.48	435.06	179.264	3487.37	105.016	61.0896	71.1918	53.4023	62.068	98.089	1983.52	25.3396	19.5563	13.4521	1259.94
1994	50889.6	102627	71242.7	16281.1	11623.7	10273.1	7805.92	9576.52	8161.51	2331.87	1292.54	3733.61	2414.92	390.21	160.784	3127.86	94.1898	54.792	63.8527	47.8971	55.6694	87.9771	1779.04	22.7273	17.5403	1142.12
1995	52050	48378.7	97547.6	67698.2	15458.1	10957.1	9581.71	7267.39	8889.77	7511.7	2146.21	1189.63	3436.34	2222.64	359.142	147.982	2878.82	86.6905	50.4295	58.7688	44.0836	51.2371	80.9725	1637.39	20.9178	1067.33
1996	38094.4	49489.1	45992.8	92717.7	64305.4	14603.7	10268.7	8967.41	6786.41	8247.84	6969.28	1991.23	1103.73	3188.2	2062.15	333.208	137.296	2670.94	80.4306	46.788	54.5251	40.9003	47.5373	75.1254	1519.16	1009.66

1997	33674.9	36222.3	47051.9	43719.9	88087.1	60805.2	13712.6	9630.55	8393.94	6316.71	7676.99	6486.92	1853.41	1027.34	2967.54	1919.42	310.146	127.794	2486.08	74.8638	43.5497	50.7513	38.0695	44.2471	69.9259	2353.79
1998	42287.7	32026.8	34447.8	44743.2	41564.3	83563	57498.3	12959.7	9093.82	7905.75	5949.33	7230.5	6109.65	1745.62	967.587	2794.95	1807.79	292.108	120.361	2341.49	70.5098	41.0169	47.7997	35.8554	41.6737	2282.76
1999	53667.4	40217.7	30457.5	32757.1	42536.1	39424.9	78998	54326.3	12233.5	8561.22	7442.73	5600.89	6807.03	5751.82	1643.38	910.917	2631.26	1701.91	275	113.312	2204.36	66.3802	38.6146	45.0001	33.7555	2188.29
2000	125388	51045.2	38251.7	28967.4	31150.4	40403.8	37385.9	74890.9	51478.2	11576.5	8101.44	7043.02	5300.1	6441.46	5442.92	1555.13	861.997	2489.95	1610.51	260.231	107.227	2085.97	62.8152	36.5408	42.5834	2102.71
2001	48483.4	119262	48549.9	36380.2	27546.5	29588.8	38314.1	35442.1	70964.4	48713.3	10954.8	7666.32	6664.75	5015.43	6095.49	5150.59	1471.6	815.7	2356.21	1524.01	246.255	101.468	1973.94	59.4415	34.5782	2030.08
2002	98069.6	46113.5	113429	46172.9	34593.5	26157.5	28039.6	36295.4	33555.9	67077.4	46045.1	10354.7	7246.4	6299.69	4740.72	5761.62	4868.47	1391	771.02	2227.15	1440.53	232.766	95.9098	1865.82	56.1856	1951.56
2003	31952.8	93280.4	43860.7	107884	43911.7	32872.7	24826.6	26607.5	34430.2	31800.8	63568.9	43636.7	9813.14	6867.38	5970.19	4492.76	5460.26	4613.83	1318.24	730.693	2110.66	1365.19	220.592	90.8933	1768.23	1902.74
2004	73038.2	30392.4	88723.4	41716.7	102601	41727.2	31199.7	23558.2	25239.7	32628.6	30136.7	60242.6	41353.3	9299.65	6508.03	5657.79	4257.66	5174.54	4372.4	1249.26	692.458	2000.22	1293.75	209.049	86.1372	3478.87
2005	83018	69472.2	28908.1	84388.2	39675.3	97514.4	39619.4	29618.7	22358.3	23935	30942	28579	57128.6	39215.8	8818.95	6171.63	5365.34	4037.59	4907.07	4146.39	1184.69	656.665	1896.83	1226.88	198.243	3380.73
2006	65041.4	78964.2	66078.7	27495.2	80256.7	37704.4	92566.9	37602.1	28101.9	21194.3	22688.9	29331.1	27091.1	54154.4	37174.1	8359.82	5850.33	5086.01	3827.38	4651.6	3930.52	1123.01	622.477	1798.07	1163	3392.65
2007	215319	61865.8	75107.8	62850	26149.8	76278.7	35800.4	87877.9	35687.7	26650.1	20099.3	21516.8	27815.8	25691.5	51356.7	35253.7	7927.94	5548.09	4823.26	3629.65	4411.29	3727.46	1064.99	590.319	1705.18	4320.3
2008	100115	204800	58842	71433.8	59768.2	24840.9	72346.4	33945.7	83288.8	33781	25226.3	19025.5	20367.2	26329.7	24318.9	48612.9	33370.2	7504.37	5251.67	4565.57	3435.73	4175.61	3528.32	1008.09	558.781	5703.56
2009	104385	95223.1	194788	55963	67929.7	56771.3	23555.5	68583.1	32164.9	78812.1	31965.3	23870.4	18002.9	19272.5	24914.5	23011.8	46000	31576.6	7101.02	4969.4	4320.17	3251.07	3951.17	3338.67	953.91	5925.75
2010	107942	99283.4	90566.7	185254	53215.9	64512.5	53813.5	22321	64954.9	30416.9	74529.1	30228.1	22573.2	17024.5	18225.1	23560.5	21761.2	43500.1	29860.5	6715.11	4699.34	4085.39	3074.39	3736.45	3157.23	6505.78

Table G10. Estimated numbers at age (1000s) on January 1 from alternate model.

year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	Age 21	Age 22	Age 23	Age 24	Age 25	Age 26
1913	52992.3	50397.4	47939.4	45601.2	43377.1	41261.3	39248.6	37334	35512.8	33780.3	32132.4	30564.9	29073.9	27655.6	26306.5	25023.2	23802.6	22641.4	21537	20486.4	19487	18536.4	17632.2	16772.1	15953.9	311056
1914	54248.5	50407.8	47939.5	45601.4	43377.2	41261.4	39248.7	37334.1	35512.9	33780.4	32132.5	30565	29073.9	27655.6	26306.5	25023.2	23802.6	22641.4	21537	20486.4	19487	18536.4	17632.2	16772.1	15953.9	311058
1915	54259.5	51602.7	47949.3	45601.4	43377.3	41261.2	39248	37333.4	35512.1	33779.4	32131.5	30564	29073	27654.7	26305.7	25022.4	23801.8	22640.7	21536.2	20485.7	19486.4	18535.8	17631.6	16771.5	15953.4	311049
1916	54270.6	51613.2	49086	45610.7	43377.3	41261	39247.4	37332.4	35511.1	33778.1	32130	30562.6	29071.6	27653.4	26304.4	25021.2	23800.6	22639.6	21535.2	20484.7	19485.4	18534.9	17630.7	16770.7	15952.6	311036
1917	54281.9	51623.7	49095.9	46691.9	43386.1	41260.8	39246.8	37331.3	35509.6	33776.4	32128.2	30560.5	29069.7	27651.5	26302.6	25019.5	23799	22638	21533.7	20483.2	19484	18533.6	17629.5	16769.5	15951.5	311016
1918	54293.4	51634.4	49105.8	46701.3	44414.4	41268.7	39245.6	37329.7	35507.4	33773.5	32125.1	30557.4	29066.5	27648.5	26299.7	25016.7	23796.3	22635.5	21531.3	20480.9	19481.8	18531.5	17627.5	16767.6	15949.7	310982
1919	54305.4	51645.3	49116	46710.7	44423.3	42247	39253.4	37328.9	35506.2	33771.9	32122.8	30555	29063.9	27645.8	26297.1	25014.3	23794	22633.2	21529.1	20478.9	19479.9	18529.6	17625.7	16765.9	15948.1	310953
1920	54318.9	51656.9	49126.5	46720.5	44432.5	42256.3	40185.7	37338.1	35507.3	33773.3	32123.7	30555	29063.7	27645.4	26296.5	25013.7	23793.4	22632.7	21528.6	20478.4	19479.4	18529.2	17625.3	16765.5	15947.6	310946
1921	54333.8	51669.6	49137.5	46730.5	44441.8	42265	40194.4	38224.6	35515.9	33774.1	32124.6	30555.6	29063.5	27645	26295.9	25012.9	23792.6	22631.9	21527.9	20477.7	19478.7	18528.5	17624.7	16764.9	15947.1	310937
1922	54349.7	51683.9	49149.7	46741	44451.4	42274.2	40203.3	38233.6	36359.9	33783.1	32126.3	30557.3	29064.8	27645.5	26296.2	25013	23792.5	22631.8	21527.8	20477.6	19478.6	18528.4	17624.5	16764.8	15947	310935
1923	54366.5	51699	49163.2	46752.6	44461.4	42283.3	40212.1	38242.2	36368.6	34586.1	32135.1	30559.1	29066.7	27646.9	26296.9	25013.4	23792.8	22631.9	21527.8	20477.6	19478.6	18528.4	17624.5	16764.8	15946.9	310936
1924	54383.8	51715	49177.6	46765.5	44472.4	42292.9	40220.9	38250.7	36376.8	34594.5	32899	30567.5	29068.4	27648.8	26298.3	25014.1	23793.2	22632.1	21527.9	20477.6	19478.7	18528.4	17624.6	16764.8	15947	310938
1925	54401	51731.4	49192.8	46779.1	44484.6	42302.8	40228.8	38257.8	36383.6	34600.6	32905.3	31292.6	29075	27649	26298.7	25014.2	23792.7	22631.5	21527.1	20476.7	19477.8	18527.6	17623.7	16764	15946.2	310923
1926	54417.9	51747.8	49208.4	46793.5	44497.6	42314.6	40238.7	38265.9	36391	34607.8	32911.9	31299.3	29765.4	27655.9	26299.6	25015.2	23793.4	22631.5	21526.9	20476.4	19477.3	18527.1	17623.3	16763.6	15945.8	310916
1927	54434.5	51763.9	49224	46808.4	44511.3	42326.9	40249.8	38275.2	36398.4	34614.6	32918.5	31305.4	29771.5	28312.4	26305.9	25015.8	23794.1	22631.9	21526.8	20476.1	19476.9	18526.6	17622.8	16763.1	15945.3	310907
1928	54450	51779.7	49239.3	46823.3	44525.4	42339.9	40261.5	38285.7	36407.2	34621.7	32924.9	31311.6	29777.2	28318.3	26930.4	25021.9	23794.7	22632.7	21527.2	20476	19476.6	18526.2	17622.2	16762.5	15944.8	310898
1929	54464.8	51794.3	49254.2	46837.7	44539.4	42352.9	40272.9	38295.8	36416.1	34628.7	32930.3	31316.5	29782	28322.6	26934.8	25614.8	23799.5	22632.3	21527	20475.5	19475.7	18525.1	17621.1	16761.3	15943.6	310875
1930	54477.4	51808.5	49268.2	46852	44553.3	42366.6	40286.1	38307.5	36426.7	34638.3	32938.1	31322.7	29787.6	28328.1	26939.9	25619.9	24364.3	22637.6	21527.4	20476.1	19475.9	18524.9	17620.8	16760.9	15943.1	310864
1931	54489.4	51820.4	49281.6	46865.3	44566.8	42379.4	40298.5	38319.3	36437.1	34647.4	32946.3	31329.2	29792.7	28332.6	26944.3	25623.9	24368.4	23174.2	21531.8	20475.8	19475.9	18524.6	17620	16760	15942.1	310843
1932	54501.3	51831.7	49292.9	46877.9	44579.2	42391.4	40308.7	38329	36446.1	34654.4	32952.3	31334.5	29796.4	28335.1	26946.4	25626.1	24370.3	23176.2	22040.4	20478.4	19474.1	18523	17618.3	16758	15940.1	310798
1933	54511.3	51843.2	49303.8	46888.7	44591.4	42404	40321.8	38340.6	36457.3	34665.5	32961.3	31342.3	29803.6	28340.7	26950.7	25629.9	24374.1	23179.7	22043.9	20963.6	19477.9	18522.6	17618.1	16757.5	15939.2	310775
1934	54520.6	51852.6	49314.6	46898.9	44601.5	42414.6	40331.6	38350.8	36465.8	34673	32968.9	31348.1	29808.4	28344.9	26953.6	25631.7	24375.6	23181.2	22045.2	20965.1	19937.6	18524.6	17616.1	16755.8	15937.4	310724
1935	54525.4	51860.8	49322.8	46908.3	44609.7	42417.2	40327.3	38345.2	36459.4	34660.4	32956.3	31336.6	29796.1	28332.6	26941.6	25619.2	24362.7	23168.7	22033.5	20953.7	19927.1	18950.5	17607.5	16743.9	15926.2	310488
1936	54479	51855.5	49318.6	46900.6	44591.8	42301.8	40075.7	38077.4	36169.3	34289	32597.1	30994.5	29471.2	28022.4	26646	25337.8	24094.1	22912.4	21789.5	20721.9	19706.4	18740.9	17822.4	16559.3	15747.2	306984
1937	54258.7	51788.6	49286	46861	44523	42003.7	39391.7	37245.6	35276.3	33199.5	31473.6	29920.6	28449.6	27051.3	25721.5	24458.1	23257.4	22115.8	21031.1	20000.4	19020.4	18088.3	17202.1	16359	15199.7	296232
1938	53931.9	51590.6	49236.2	46847.8	44516.2	42079.6	39399.7	36901.9	34818.8	32777.3	30847.6	29243.9	27801	26434.2	25135	23899.3	22725.5	21609.7	20549	19541.2	18583.5	17673	16806.9	15983.4	15200.1	289369
1939	53631.6	51270.4	49036.5	46785.8	44478.3	41956.9	39234.3	36667.9	34241	32027.6	30149.8	28374.8	26899.7	25572.4	24315.1	23120.1	21983.5	20903.7	19877.5	18901.8	17974.8	17093.9	16256.3	15459.6	14702.2	280154
1940	53211	50976.4	48721.9	46582.6	44396.1	41815.2	38905.4	36295.3	33792.4	31207.1	29189.8	27478.4	25860.6	24516.2	23306.5	22160.7	21071.5	20035.7	19051.5	18116.2	17227	16382.1	15579.2	14815.9	14089.8	268731
1941	52689.5	50572.8	48437.9	46277.7	44193	41690.3	38678	35893.7	33346.3	30670.4	28324	26493.1	24939.7	23471.4	22251.3	21153.3	20113.4	19124.8	18184.6	17291.5	16442.5	15635.5	14868.6	14139.9	13447.1	256692
1942	51885	50033.6	48001.2	45938.7	43784	40955.1	37471.9	34582.9	31823.5	28843.8	26529.3	24499.6	22915.9	21572.3	20302.3	19246.9	18297.2	17397.6	16542.6	15729.3	14956.7	14222.4	13524.3	12861	12230.7	233664
1943	50588	49251.6	47467.3	45495.8	43413.7	40352.3	36371.3	33067.6	30207.4	26977.5	24451.6	22489.5	20768.9	19426.4	18287.4	17210.7	16316	15510.9	14748.4	14023.5	13334.1	12679.2	12056.7	11464.9	10902.6	208451
1944	49092.4	48024.7	46730.7	44996.7	43007	40064.5	35940.2	32198.4	28988.1	25732.5	22981.1	20829.3	19157.9	17692.2	16548.6	15578.3	14661.2	13899	13213.2	12563.6	11946.1	11358.8	10800.9	10270.6	9766.5	186859
1945	47449.7	46590.1	45548.2	44274.3	42493.1	39499.6	35314.6	31457.3	27864	24266.9	21541.5	19238.2	17436.9	16037.7	14810.7	13853.3	13041.1	12273.3	11635.3	11061.2	10517.3	10000.4	9508.82	9041.77	8597.86	164601
1946	45301.6	45049	44209.8	43183.3	41862.5	39261.3	35271.2	31350.7	27664.5	23838.7	20761.2	18429.6	16459	14917.9	13720.8	12671.1	11852	11157.1	10500.3	9954.41	9463.23	8997.98	8555.74	8135.15	7735.57	148178
1947	44803.9	42990.4	42723.3	41882.3	40774.3	38419.5	34550.1	30816.7	27075.5	23095.4	19901.5	17332.3	15385.7	13740.6	12454.1	11454.7	10578.3	9894.54	9314.41	8766.03	8310.33	7900.28	7511.87	7142.67	6791.54	130163
1948	44222.8	42512.8	40764.6	40465.3	39530.5	37350.4	33671.2	30052	26479.3	22449	19149	16500.9	14370.6	12756.7	11392.7	10326	9497.38	8770.78	8203.83	7722.82	7268.15	6890.31	6550.33	6228.29	5922.18	113553
1949	41111.9	41938.2	40283.2	38573.1	38126.6	35907.4	32140.9	28708.1	25242.6	21291.5	18050.8	15397.3	13268	11555.1	10257.4	9160.64	8302.92	7636.66	7052.41	6596.53	6209.77	5844.17	5540.36	5266.99	5008.04	96067.2
1950	39337.4	39013.2	39771.4	38160.3	36417.5	34973.5	31564.4	28048.4	24759.9	21035.2	17742.7	15042.1	12830.9	11056.5	9629.14	8547.71	7633.76	6918.99	6363.79	5876.92	5497.03	5174.73	4870.07	4616.9	4389.09	84228.1
1951	38056.7	37308.1	36970.9	37638.6	35963.9	33120.3	30175.8	26990.3	23637.7	19998	16989.7	14330.4	12149.2	10363.3	8930.11	7777.26	6903.81	6165.62	5588.33	5139.9	4746.66	4439.83	4179.52	3933.46	3728.97	71574.3
1952	35087.5	36095.8	35357.9	34992.1	35479.3	32739	28636.2	25861.4	22804.6	19158.2	16208.3	13770	11614.7	9846.85	8399.37	7237.8	6303.42	5595.5	4997.2	4529.3	4165.85	3847.14	3598.46	3387.48	3188.04	61032.8
1953	41221.3	33301.4	34237.6	33503.4	33052.5	32620.8	28925	25128.2	22444.9	19165.2	16100.7	13621.6	11572.4	9761.08	8275.38	7058.9	6082.71	5297.45	4702.5	4199.69	3806.47	3501.02	3233.17	3024.18	2846.87	53971.8
1954	37742.3	39138.2	31602.6	32463.6	31684.8	30568.7	29190.9	25738.2	22157.1	19271.3	16455.3	13824.1	11695.5	9936.14	8380.89	7105.27	6060.8	5222.63	4548.41	4037.58	3605.87	3268.24	3005.99	2776.01	2596.57	48784.7
1955	41361.9	35848.6	37159.6	29984.8	30737.9	29472.8	27698.5	26331.7	23049.6	19426.9	16896.7	14427.6	12120.7	10254.4	8711.81	7348.2	6229.76	5313.99	4579.1	3987.95	3540.07	3161.55	2865.53	2635.59	2433.95	45050.1
1956	35340.7	39281.3	34030.5	35249	28378.9	28533.5	26586.9	24864.3	23451.3	20059.2	16906.5	14704.6	12555.8	10548.2	8924.03	7581.56	6394.87	5421.53	4624.56	3985.02	3470.57	3080.79	2751.38	2493.77	2293.66	41323.6
1957	37251	33559.8	37284.6	32275.5	33351.3	26306	25659.8	23785.7	22059.2	20302.8	17366.1	14636.7	12730.3	10870.1	9132.03	7725.91	6563.68	5536.3	4693.64	4003.68	3450	3004.61	2667.17	2381.99	2158.96	37761.3
1958	39585.5	35353.4	31830.6	35326.7	30482.9	30646.6	23212.4	22485.8	20611.5	18500	17027	14564.2	12275.1	10676.3	9116.26	7658.6	6479.36	5504.65	4643.04	3936.34	3357.7	2893.35	2519.83	2236.83	1997.66	33479.2
1959	33071.7	37576.9	33540.7	30169.9	33386.2	28098.9	27227.6	20493.2	19650.7	17484.7	15693.5	14444	12354.7	10412.9	9056.72	7733.31	6496.78	5496.43	4669.58	3938.68	3339.19	2848.33	2454.43	2137.57	1897.5	30095
1960	40884.7	31393.2	35649.5	31790.1	28511.6	30769.5	24954.1	24027.5	17900.4	16658.4	14822.2	13303.8	12244.5	10473.4	8827.32	7677.62	6555.73	5507.49	4659.47	3958.53	3338.92	2830.72	2414.6	2080.68	1812.07	27120.9
1961	30771.1	38829.9	29802.7	33819.3	30091.8	26485.4	27798.9	22438	21439.6	15617.9	14534.2	12932.2	11607.4	10683.2	9137.93	7701.71	6698.62	5719.78	4805.21	4065.32	3453.76	2913.16	2469.76	2106.71	1815.37	25243.6
1962	45223.5	29212.6	36843.6	28252.8	31971.7	27780.8	23608.7	24631.4	19689.8	18288.5	13322.4	12398.1	11031.5	9901.41	9113.02	7794.89	6569.76	5714.09	4879.12	4098.96	3467.82	2946.14	2485	2106.77	1797.07	23082
1963	28413.2	42930.5	27716.1	34923.8	26704.3	29489.5	24714.7	20873.7	21561.7	16740.5	15549.1	11326.9	10541	9379.09	8418.29	7747.99	6627.3	5585.68	4858.19	4148.28	3484.99	2948.38	2504.85	2112.78	1791.2	21152.4
1964	51695.8	26988	40760.9	26297.9	33068.8	24845.3	26733.1	22305.3	18704.1	18919.7	14689.2	13643.8	9938.96	9249.35	8229.84	7386.77	6798.61	5815.24	4901.25	4262.9	3639.98	3057.96	2587.11	2197.92	1853.89	20132.3
1965	33451.3	49115.6	25632.7	38692.7	24921.5	30889.3	22718.3	24355.6	20202.2	16651.6	16843.5	13077.3	12146.6	8848.3	8234.36	7326.73	6576.18	6052.56	5177.1	4363.41	3795.11	3240.54	2722.39	2303.21	1956.73	19573.5
1966	18421.7	31783.6	46652.5	24334.5	36674.4	23299.8	28299.8	20741.8	22112.5	18044	14872.7	15044.1	11680.2	10849	7903.03	7354.68	6544.01	5873.65	5405.96	4624.03	3897.27	3389.67	2894.36	2431.56	2057.16	19230.2
1967	4648.15	17502.4	30187.7	44286	23061.6	34262	21311.4	25791.3	18793.1	19695.8	16071.9	13247.2	13399.9	10403.7	9663.27	7039.29	6550.87	5828.8	5231.7	4815.13	4118.65	3471.32	3019.21	2578.02	2165.81	18960.8
1968	3377.11	4414.84	16617.1	28641.3	41929.3	21445.1	31024.5	19210.2	23078.3	16459.2	17249.8	14076	11602.1	11735.8	9111.63	8463.19	6165.08	5737.32	5104.93	4581.98	4217.14	3607.16	3040.22	2644.25	2257.86	18502.9
1969	1592.49	3209.45	4194.63	15781.7	27166.2	39333.1	19791.6	28552.7	17600.1	20867.3	14882.4	15597.2	12727.5	10490.6	10611.5	8238.72	7652.4	5574.46	5187.68	4615.87	4143.02	3813.13	3261.59	2748.96	2390.93	18771.8
1970	1870.27	1512.3	3046.46	3978.58	14933.8	25196.9	35417.4	17731.3	25372.1	15270.2	18104.9	12912.2	13532.4	11042.6	9101.8	9206.72	7148.07	6639.37	4836.5	4500.92	4004.81	3594.56	3308.34	2829.82	2385.05	18361.2
1971	1936.19	1774.96	1434.33	2886.37	3757.33	13718	22216.9	31010.7	15350.6	21251.3	12790.1	15164.4	10815.1	11334.6	9249.14	7623.55	7711.43	5987.13	5561.05	4050.99	3769.92	3354.38	3010.76	2771.03	2370.22	17376.8
1972	116868	1836.26	1681.99	1357.36	2720.04	3415.89	11826.7	18980.8	26108.2	12381.8	17141.2	10316.5	12231.6	8723.43	9142.44	7460.32	6149.13	6220.02	4829.2	4485.52	3267.52	3040.8	2705.63	2428.47	2235.1	15927.9
1973	4436.78	110817	1739.68	1591.23	1278.42	2466.12	2927.53	10038.8	15862.9	20850.4	9888.26	13689.3	8238.9	9768.32	6966.67	7301.3	5957.93	4910.79	4967.4	3856.67	3582.21	2609.49	2428.43	2160.76	1939.41	14505.2
1974	2109.95	4206.52	104972	1645.46	1498.1	1156.89	2104.89	2473.85	8347.13	12581.5	16537.3	7842.79	10857.5	6534.61	7747.66	5525.55	5790.96	4725.48	3894.95	3939.85	3058.89	2841.2	2069.7	1926.09	1713.79	13042.9
1975	1320.21	2002.53	3989.92	99464.7	1554.2	1377.21	1021.81	1846.44	2146.24	7011.5	10568.3	13891.2	6587.86	9120.2	5489	6507.95	4641.4	4864.34	3969.35	3271.72	3309.43	2569.43	2386.58	1738.52	1617.89	12395.5
1976	1290.27	1252.62	1898.7	3778.64	93860.9	1422.34	1204.51	886.774	1582.5	1773.36	5793.33	8732.21	11477.7	5443.29	7535.67	4535.35	5377.27	3835.01	4019.22	3279.72	2703.29	2734.46	2123.02	1971.93	1436.47	11578.7
1977	824.61	1223.87	1187.25	1797.3	3562.66	85537.6	1232.68	1034.97	751.455	1287.71	1443.01	4714.13	7105.54	9339.63	4429.3	6131.9	3690.49	4375.57	3120.61	3270.5	2668.76	2199.71	2225.07	1727.54	1604.6	10590.7
1978	1043.98	781.489	1158.71	1122.14	1689.91	3203.74	72016	1026.2	846.072	582.487	998.159	1118.54	3654.13	5507.83	7239.57	3433.35	4753.11	2860.66	3391.7	2418.93	2535.12	2068.68	1705.1	1724.75	1339.09	9453.09
1979	25812.5	988.514	739.047	1093.49	1052.17	1499.43	2619.92	58076.4	809.129	624.583	430	736.855	825.723	2697.53	4065.95	5344.35	2534.55	3508.81	2111.78	2503.8	1785.69	1871.46	1527.13	1258.73	1273.24	7966.94
1980	1017.98	24411.6	933.393	695.995	1021.44	916.636	1178.36	2022.95	43585	558.757	431.315	296.943	508.847	570.216	1862.82	2807.81	3690.63	1750.27	2423.07	1458.32	1729.04	1233.13	1292.36	1054.58	869.234	6380.95

1981	1917.81	963.955	23087.7	880.953	652.729	907.18	751.165	952.444	1599.18	32288.1	413.931	319.522	219.978	376.958	422.42	1379.99	2080.05	2734.04	1296.61	1795.03	1080.34	1280.89	913.515	957.394	781.243	5370.99
1982	9523.19	1816.42	911.925	21798.6	826.741	581.59	748.65	611.823	759.513	1198.71	24202.3	310.272	239.505	164.89	282.558	316.635	1034.41	1559.15	2049.37	971.908	1345.5	809.793	960.118	684.747	717.637	4611.56
1983	12372.4	9016.52	1717.6	860.481	20434.4	732.693	474.392	602.055	480.877	558.285	881.116	17790.1	228.068	176.05	121.203	207.696	232.745	760.348	1146.06	1506.4	714.407	989.021	595.244	705.741	503.328	3917.26
1984	3452.54	11717.6	8529.14	1621.52	807.366	18189.6	603.377	385.5	478.841	359.176	416.994	658.123	13287.7	170.348	131.495	90.5291	155.132	173.842	567.919	856.016	1125.16	533.605	738.72	444.599	527.132	3301.82
1985	5398.2	3269.2	11081.6	8049.49	1520.56	716.691	14889.6	487.11	304.329	354.073	265.589	308.341	486.641	9825.46	125.962	97.2325	66.9406	114.711	128.545	419.941	632.971	831.986	394.567	546.237	328.753	2831.27
1986	16723.9	5109.65	3090.31	10451.7	7539.55	1342.22	579.549	11861.3	378.762	220.473	256.511	192.407	223.38	352.55	7118.12	91.2538	70.4406	48.4955	83.1028	93.1252	304.229	458.56	602.738	285.847	395.725	2289.3
1987	16281.2	15846.6	4836.53	2919.96	9821.91	6762.25	1123.64	479.481	9628.2	290.808	169.276	196.946	147.728	171.508	270.684	5465.2	70.0635	54.0834	37.2343	63.8052	71.5004	233.583	352.076	462.774	219.47	2061.53
1988	11381	15448.8	15026.4	4581.03	2756.11	8999.06	5929.26	977.848	412.234	7989.23	241.305	140.461	163.42	122.581	142.313	224.606	4534.88	58.1369	44.877	30.896	52.9439	59.3292	193.821	292.144	383.998	1892.71
1989	13646.9	10809.5	14667	14256.1	4336.91	2561.99	8142.26	5340.01	874.124	360.558	6987.74	211.056	122.853	142.935	107.215	124.473	196.451	3966.41	50.8491	39.2514	27.023	46.3071	51.8919	169.524	255.522	1991.31
1990	14426.8	12970.6	10271.5	13931.8	13525.8	4074.08	2371.66	7518.5	4910.98	794.427	327.685	6350.64	191.814	111.652	129.903	97.4395	113.125	178.539	3604.78	46.213	35.6727	24.5592	42.0851	47.1607	154.068	2041.98
1991	19140.6	13713.6	12327	9758.73	13223.2	12729.8	3786.75	2199.69	6949.33	4493.68	726.922	299.84	5811.01	175.515	102.165	118.865	89.1597	103.512	163.368	3298.47	42.2862	32.6415	22.4724	38.509	43.1534	2009.45
1992	79058.4	18090.2	12938.4	11596.1	9097.55	11409.3	9796.55	2857.75	1608.44	4633.28	2996.04	484.657	199.911	3874.34	117.02	68.1159	79.2499	59.4449	69.0139	108.922	2199.17	28.1932	21.7629	14.9829	25.6749	1368.52
1993	108214	75120.3	17184	12284.2	10992.8	8511.42	10468.5	8958.91	2599.39	1440.23	4148.73	2682.71	433.971	179.004	3469.16	104.782	60.9923	70.9619	53.2282	61.7964	97.5306	1969.18	25.2447	19.4869	13.416	1248.39
1994	51029.9	102826	71359.7	16315.8	11646	10288.8	7816.46	9582.61	8157.86	2330.98	1291.51	3720.33	2405.69	389.158	160.52	3110.93	93.9618	54.6941	63.6342	47.7317	55.4152	87.4594	1765.84	22.6379	17.4747	1131.51
1995	52222.8	48512	97736.6	67809.1	15491	10977.8	9595.62	7276.61	8894.57	7507.26	2145.08	1188.51	3423.63	2213.84	358.122	147.718	2862.83	86.4683	50.3322	58.5593	43.9251	50.9958	80.4844	1625.01	20.8325	1057.35
1996	38257.9	49653.4	46119.5	92897.3	64410.6	14634.7	10287.9	8980.21	6794.82	8251.88	6964.82	1990.08	1102.63	3176.25	2053.87	332.246	137.044	2655.97	80.2204	46.6953	54.328	40.7512	47.311	74.6688	1507.59	1000.28
1997	33852.1	36377.7	47208.1	43840.4	88257.6	60904.5	13741.5	9648.46	8405.79	6324.34	7680.52	6482.57	1852.29	1026.28	2956.32	1911.66	309.241	127.555	2472.07	74.6659	43.4622	50.5663	37.9296	44.0352	69.4988	2334.22
1998	42534.6	32195.3	34595.6	44891.8	41678.8	83724.9	57592.3	12987.1	9110.72	7916.87	5956.49	7233.78	6105.51	1744.55	966.589	2784.37	1800.47	291.254	120.136	2328.28	70.323	40.9342	47.6252	35.7234	41.4739	2263.91
1999	54015.3	40452.6	30617.8	32897.7	42677.3	39533.6	79151.2	54415.2	12259.4	8577.09	7453.16	5607.61	6810.09	5747.9	1642.37	909.975	2621.28	1695.01	274.195	113.1	2191.91	66.204	38.5366	44.8357	33.631	2170.35
2000	126162	51376.1	38475.1	29119.9	31284.1	40538	37489.1	75036.5	51562.5	11601	8116.48	7052.91	5306.47	6444.37	5439.23	1554.17	861.107	2480.52	1603.99	259.47	107.026	2074.2	62.6487	36.4671	42.4279	2085.62
2001	48904	119998	48864.6	36592.7	27691.5	29715.9	38441.6	35540.1	71102.7	48793.4	10978	7680.59	6674.14	5021.48	6098.27	5147.11	1470.7	814.861	2347.3	1517.85	245.535	101.278	1962.8	59.2842	34.5086	2013.77
2002	98870.9	46513.6	114129	46472.3	34795.6	26295.3	28160.2	36416.4	33649	67208.6	46121.1	10376.8	7259.95	6308.61	4746.47	5764.29	4865.22	1390.16	770.234	2218.75	1434.72	232.088	95.7314	1855.31	56.0374	1936.1
2003	32443.3	94042.6	44241.3	108550	44196.5	33064.8	24957.5	26722.1	34545.2	31889.2	63693.7	43709.1	9834.08	6880.26	5978.68	4498.24	5462.83	4610.78	1317.45	729.952	2102.71	1359.68	219.95	90.7248	1758.28	1887.95
2004	74047.7	30859	89448.4	42078.7	103234	41997.9	31382.2	23682.6	25348.6	32737.8	30220.7	60361.2	41422.2	9319.55	6520.29	5665.88	4262.89	5177.01	4369.54	1248.52	691.761	1992.69	1288.55	208.442	85.9781	3455.46
2005	84811.7	70432.4	29351.9	85077.8	40019.5	98116.5	39876.6	29792.1	22476.5	24038.5	31045.8	28658.8	57241.5	39281.4	8837.89	6183.3	5373.05	4042.57	4909.45	4143.71	1184	656.008	1889.71	1221.95	197.669	3358.4
2006	67653.5	80670.3	66992.1	27917.4	80912.6	38031.7	93139.1	37846.5	28266.7	21306.5	22787.2	29429.8	27167	54261.9	37236.6	8377.85	5861.44	5093.36	3832.14	4653.89	3928.02	1122.37	621.861	1791.34	1158.34	3370.96
2007	223821	64350.5	76730.6	63718.8	26551.2	76902.4	36111.4	88421.7	35919.9	26806.6	20206	21610.2	27909.7	25763.8	51459.2	35313.3	7945.11	5558.68	4830.28	3634.2	4413.51	3725.12	1064.39	589.74	1698.81	4295.36
2008	81644.3	212886	61205.2	72977.2	60594.4	25222.4	72938.8	34241	83805.5	34001.4	25374.9	19126.7	20456	26419	24387.7	48710.7	33427.2	7520.76	5261.79	4572.29	3440.1	4177.78	3526.16	1007.54	558.242	5674.02
2009	66353.5	77655.1	202479	58210.7	69397.5	57556.5	23917.7	69145.8	32445.3	79302.7	32174.6	24011.5	18099.1	19356.9	24999.5	23077.4	46093.5	31631.2	7116.68	4979.08	4326.63	3255.26	3953.31	3336.71	953.409	5897.41
2010	55433.5	63110.7	73857.8	192569	55353.3	65907	54558.8	22664.7	65489.3	30682.9	74995	30426.9	22707.2	17116	18305.5	23641.6	21823.9	43589.8	29913	6730.1	4708.62	4091.61	3078.44	3738.57	3155.46	6478.69

Table G11. Estimated fishing mortality at age for ages 1-10 from base model. Fishing mortalities for ages greater than 10 are equal to the last column.

year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1913	1.99E-07	2.53E-07	3.44E-07	6.23E-07	3.01E-06	6.55E-06	7.15E-06	8.13E-06	1.10E-05	1.10E-05
1914	8.20E-07	1.04E-06	1.42E-06	2.57E-06	1.24E-05	2.70E-05	2.94E-05	3.35E-05	4.52E-05	4.52E-05
1915	1.11E-06	1.41E-06	1.91E-06	3.46E-06	1.68E-05	3.64E-05	3.97E-05	4.52E-05	6.10E-05	6.10E-05
1916	1.46E-06	1.86E-06	2.53E-06	4.58E-06	2.21E-05	4.81E-05	5.25E-05	5.97E-05	8.06E-05	8.06E-05
1917	2.27E-06	2.88E-06	3.92E-06	7.10E-06	3.44E-05	7.46E-05	8.15E-05	9.26E-05	0.000125	0.000125
1918	2.01E-06	2.55E-06	3.47E-06	6.28E-06	3.04E-05	6.60E-05	7.21E-05	8.19E-05	0.000111	0.000111
1919	6.82E-07	8.67E-07	1.18E-06	2.13E-06	1.03E-05	2.24E-05	2.45E-05	2.78E-05	3.76E-05	3.76E-05
1920	8.43E-07	1.07E-06	1.46E-06	2.64E-06	1.28E-05	2.77E-05	3.03E-05	3.44E-05	4.65E-05	4.65E-05
1921	3.45E-07	4.38E-07	5.95E-07	1.08E-06	5.22E-06	1.13E-05	1.24E-05	1.41E-05	1.90E-05	1.90E-05
1922	2.36E-07	3.00E-07	4.08E-07	7.39E-07	3.58E-06	7.77E-06	8.49E-06	9.64E-06	1.30E-05	1.30E-05
1923	1.90E-07	2.41E-07	3.28E-07	5.95E-07	2.88E-06	6.25E-06	6.82E-06	7.76E-06	1.05E-05	1.05E-05
1924	1.09E-06	1.39E-06	1.88E-06	3.41E-06	1.65E-05	3.59E-05	3.92E-05	4.45E-05	6.01E-05	6.01E-05
1925	6.79E-07	8.63E-07	1.17E-06	2.13E-06	1.03E-05	2.23E-05	2.44E-05	2.77E-05	3.74E-05	3.74E-05
1926	8.15E-07	1.04E-06	1.41E-06	2.55E-06	1.23E-05	2.68E-05	2.93E-05	3.33E-05	4.49E-05	4.49E-05
1927	8.23E-07	1.05E-06	1.42E-06	2.58E-06	1.25E-05	2.71E-05	2.96E-05	3.36E-05	4.54E-05	4.54E-05
1928	1.56E-06	1.98E-06	2.70E-06	4.89E-06	2.36E-05	5.14E-05	5.61E-05	6.37E-05	8.61E-05	8.61E-05
1929	9.26E-07	1.18E-06	1.60E-06	2.90E-06	1.40E-05	3.04E-05	3.32E-05	3.78E-05	5.10E-05	5.10E-05
1930	1.47E-06	1.87E-06	2.54E-06	4.60E-06	2.23E-05	4.84E-05	5.28E-05	6.00E-05	8.10E-05	8.10E-05
1931	2.94E-06	3.73E-06	5.07E-06	9.20E-06	4.45E-05	9.67E-05	0.000106	0.00012	0.000162	0.000162
1932	1.64E-06	2.08E-06	2.82E-06	5.12E-06	2.48E-05	5.38E-05	5.87E-05	6.67E-05	9.01E-05	9.01E-05
1933	3.27E-06	4.15E-06	5.64E-06	1.02E-05	4.95E-05	0.000108	0.000117	0.000133	0.00018	0.00018
1934	1.41E-05	1.80E-05	2.44E-05	4.43E-05	0.000214	0.000465	0.000508	0.000577	0.00078	0.00078
1935	0.000207	0.000263	0.000357	0.000647	0.003131	0.006804	0.007429	0.008441	0.011399	0.011399
1936	0.000649	0.000825	0.00112	0.00203	0.009822	0.021342	0.023303	0.02648	0.035758	0.035758
1937	0.000427	0.000543	0.000737	0.001336	0.006464	0.014046	0.015336	0.017427	0.023533	0.023533
1938	0.00061	0.000776	0.001054	0.00191	0.009241	0.020078	0.021923	0.024912	0.03364	0.03364

1939	0.000778	0.000989	0.001343	0.002435	0.011781	0.025598	0.02795	0.031761	0.042889	0.042889
1940	0.000854	0.001085	0.001474	0.002672	0.012927	0.028089	0.030669	0.03485	0.047061	0.047062
1941	0.001729	0.002198	0.002986	0.005412	0.026184	0.056893	0.06212	0.070589	0.095322	0.095322
1942	0.002097	0.002665	0.00362	0.006562	0.031745	0.068975	0.075312	0.08558	0.115565	0.115565
1943	0.002009	0.002553	0.003468	0.006287	0.030413	0.066083	0.072154	0.081991	0.110719	0.110719
1944	0.002327	0.002958	0.004018	0.007283	0.035236	0.076561	0.083594	0.094991	0.128274	0.128274
1945	0.001932	0.002455	0.003335	0.006046	0.02925	0.063556	0.069394	0.078855	0.106485	0.106485
1946	0.002379	0.003024	0.004108	0.007446	0.036022	0.078269	0.085459	0.09711	0.131136	0.131136
1947	0.002506	0.003184	0.004326	0.007842	0.037936	0.082429	0.090001	0.102271	0.138106	0.138106
1948	0.003067	0.003898	0.005295	0.009598	0.046435	0.100894	0.110163	0.125183	0.169044	0.169045
1949	0.002417	0.003071	0.004172	0.007563	0.036587	0.079498	0.086801	0.098635	0.133195	0.133196
1950	0.002989	0.003799	0.00516	0.009354	0.045254	0.098329	0.107362	0.121999	0.164746	0.164746
1951	0.002927	0.00372	0.005054	0.009161	0.044319	0.096298	0.105145	0.11948	0.161344	0.161344
1952	0.002266	0.002879	0.003911	0.00709	0.034301	0.074531	0.081378	0.092472	0.124873	0.124873
1953	0.001874	0.002382	0.003235	0.005865	0.028373	0.06165	0.067314	0.076491	0.103292	0.103293
1954	0.001491	0.001894	0.002573	0.004665	0.022568	0.049036	0.053541	0.06084	0.082158	0.082158
1955	0.001627	0.002067	0.002808	0.00509	0.024626	0.053509	0.058424	0.06639	0.089652	0.089652
1956	0.001721	0.002187	0.002972	0.005387	0.026059	0.056622	0.061824	0.070253	0.094868	0.094868
1957	0.002302	0.002925	0.003973	0.007203	0.034846	0.075714	0.08267	0.093941	0.126856	0.126856
1958	0.002092	0.002659	0.003612	0.006547	0.031673	0.068819	0.075141	0.085386	0.115303	0.115304
1959	0.002103	0.002673	0.003631	0.006583	0.031846	0.069196	0.075553	0.085854	0.115935	0.115935
1960	0.001577	0.002004	0.002722	0.004935	0.023875	0.051877	0.056642	0.064365	0.086917	0.086917
1961	0.001987	0.002526	0.003431	0.00622	0.03009	0.065381	0.071387	0.081119	0.109542	0.109542
1962	0.002047	0.002601	0.003533	0.006405	0.030986	0.067327	0.073512	0.083534	0.112804	0.112804
1963	0.001471	0.001869	0.002539	0.004602	0.022264	0.048376	0.05282	0.060021	0.081051	0.081051
1964	0.001206	0.001533	0.002082	0.003774	0.018259	0.039672	0.043317	0.049223	0.066469	0.06647
1965	0.001146	0.001456	0.001978	0.003586	0.017349	0.037696	0.041159	0.046771	0.063159	0.063159
1966	0.001195	0.001519	0.002064	0.003741	0.018099	0.039325	0.042938	0.048792	0.065887	0.065888
1967	0.001501	0.001908	0.002592	0.004698	0.022729	0.049387	0.053924	0.061275	0.082745	0.082745
1968	0.000921	0.001171	0.00159	0.002883	0.013945	0.0303	0.033084	0.037594	0.050766	0.050767
1969	0.00167	0.002123	0.002884	0.005228	0.02529	0.054952	0.06	0.06818	0.092069	0.092069
1970	0.002309	0.002935	0.003987	0.007227	0.034962	0.075966	0.082945	0.094253	0.127278	0.127278
1971	0.002993	0.003803	0.005167	0.009366	0.04531	0.098451	0.107495	0.12215	0.16495	0.16495
1972	0.003172	0.004032	0.005477	0.009928	0.048032	0.104364	0.113952	0.129487	0.174858	0.174858
1973	0.003297	0.00419	0.005692	0.010317	0.049913	0.108452	0.118415	0.134559	0.181707	0.181707
1974	0.002256	0.002866	0.003894	0.007059	0.034149	0.074199	0.081015	0.09206	0.124317	0.124317
1975	0.002554	0.003246	0.004409	0.007993	0.038668	0.084019	0.091738	0.104245	0.140771	0.140771
1976	0.002831	0.003598	0.004888	0.00886	0.042864	0.093137	0.101693	0.115557	0.156046	0.156046
1977	0.003711	0.004717	0.006407	0.011615	0.05619	0.12209	0.133306	0.15148	0.204556	0.204557
1978	0.004596	0.005841	0.007935	0.014384	0.069588	0.151203	0.165093	0.187601	0.253334	0.253334
1979	0.005806	0.007378	0.010023	0.018169	0.087897	0.190985	0.20853	0.236961	0.319988	0.319988
1980	0.004533	0.005761	0.007826	0.014187	0.068631	0.149123	0.162823	0.185021	0.24985	0.24985
1981	0.004319	0.00549	0.007457	0.013518	0.065397	0.142096	0.15515	0.176302	0.238076	0.238076
1982	0.004674	0.00594	0.008069	0.014626	0.070758	0.153745	0.167869	0.190755	0.257593	0.257593
1983	0.004383	0.00557	0.007567	0.013717	0.066358	0.144185	0.157431	0.178894	0.241576	0.241576
1984	0.004565	0.005802	0.007882	0.014287	0.069119	0.150182	0.163979	0.186335	0.251624	0.251625
1985	0.004936	0.006274	0.008522	0.015449	0.074737	0.162391	0.177309	0.201483	0.272079	0.272079

1986	0.003884	0.004936	0.006705	0.012155	0.058801	0.127764	0.139501	0.15852	0.214063	0.214063
1987	0.002477	0.003148	0.004277	0.007753	0.037507	0.081497	0.088984	0.101115	0.136544	0.136544
1988	0.001523	0.001935	0.002629	0.004766	0.023054	0.050093	0.054695	0.062152	0.083929	0.083929
1989	0.000828	0.001052	0.001429	0.00259	0.012529	0.027224	0.029724	0.033777	0.045612	0.045612
1990	0.000704	0.000895	0.001216	0.002205	0.010666	0.023174	0.025303	0.028753	0.038828	0.038828
1991	0.00634	0.008058	0.010946	0.019843	0.095995	0.208581	0.227742	0.258792	0.349469	0.349469
1992	0.001093	0.001389	0.001887	0.003421	0.016548	0.035956	0.039259	0.044612	0.060243	0.060243
1993	0.001067	0.001356	0.001842	0.003339	0.016151	0.035094	0.038318	0.043542	0.058798	0.058799
1994	0.000598	0.00076	0.001033	0.001872	0.009056	0.019677	0.021484	0.024413	0.032967	0.032967
1995	0.000453	0.000575	0.000781	0.001417	0.006853	0.014891	0.016259	0.018476	0.02495	0.02495
1996	0.000394	0.000501	0.00068	0.001233	0.005967	0.012966	0.014157	0.016087	0.021724	0.021724
1997	0.00018	0.000229	0.000311	0.000563	0.002725	0.00592	0.006464	0.007345	0.009919	0.009919
1998	0.000188	0.000239	0.000324	0.000588	0.002844	0.006179	0.006747	0.007667	0.010353	0.010353
1999	9.44E-05	0.00012	0.000163	0.000295	0.001429	0.003104	0.003389	0.003851	0.005201	0.005201
2000	9.44E-05	0.00012	0.000163	0.000296	0.00143	0.003107	0.003392	0.003855	0.005205	0.005205
2001	0.000115	0.000146	0.000198	0.00036	0.001739	0.003779	0.004126	0.004689	0.006332	0.006332
2002	6.75E-05	8.58E-05	0.000117	0.000211	0.001022	0.002221	0.002425	0.002756	0.003722	0.003722
2003	6.80E-05	8.64E-05	0.000117	0.000213	0.001029	0.002236	0.002441	0.002774	0.003746	0.003746
2004	5.58E-05	7.09E-05	9.63E-05	0.000175	0.000844	0.001835	0.002003	0.002276	0.003074	0.003074
2005	6.29E-05	7.99E-05	0.000109	0.000197	0.000952	0.002069	0.002259	0.002567	0.003466	0.003466
2006	5.52E-05	7.02E-05	9.53E-05	0.000173	0.000836	0.001817	0.001984	0.002254	0.003044	0.003044
2007	8.90E-05	0.000113	0.000154	0.000279	0.001348	0.002929	0.003198	0.003634	0.004907	0.004907
2008	9.52E-05	0.000121	0.000164	0.000298	0.001441	0.003132	0.00342	0.003886	0.005247	0.005247
2009	0.000107	0.000136	0.000184	0.000334	0.001615	0.003508	0.00383	0.004353	0.005878	0.005878
2010	0.000109	0.000139	0.000188	0.000341	0.00165	0.003585	0.003915	0.004448	0.006007	0.006007

Table G12. Estimated fishing mortality at age for ages 1-10 from alternate model. Fishing mortalities for ages greater than 10 are equal to the last column.

year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1913	1.98E-07	2.52E-07	3.43E-07	6.21E-07	3.01E-06	6.53E-06	7.13E-06	8.11E-06	1.10E-05	1.10E-05
1914	8.17E-07	1.04E-06	1.41E-06	2.56E-06	1.24E-05	2.69E-05	2.94E-05	3.34E-05	4.51E-05	4.51E-05
1915	1.10E-06	1.40E-06	1.90E-06	3.45E-06	1.67E-05	3.63E-05	3.96E-05	4.51E-05	6.09E-05	6.09E-05
1916	1.46E-06	1.85E-06	2.52E-06	4.56E-06	2.21E-05	4.80E-05	5.24E-05	5.96E-05	8.05E-05	8.05E-05
1917	2.26E-06	2.87E-06	3.90E-06	7.08E-06	3.43E-05	7.44E-05	8.13E-05	9.24E-05	0.000125	0.000125
1918	2.00E-06	2.54E-06	3.46E-06	6.26E-06	3.03E-05	6.59E-05	7.19E-05	8.17E-05	0.00011	0.00011
1919	6.80E-07	8.64E-07	1.17E-06	2.13E-06	1.03E-05	2.24E-05	2.44E-05	2.78E-05	3.75E-05	3.75E-05
1920	8.41E-07	1.07E-06	1.45E-06	2.63E-06	1.27E-05	2.77E-05	3.02E-05	3.43E-05	4.64E-05	4.64E-05
1921	3.44E-07	4.37E-07	5.93E-07	1.08E-06	5.20E-06	1.13E-05	1.24E-05	1.40E-05	1.90E-05	1.90E-05
1922	2.36E-07	2.99E-07	4.07E-07	7.37E-07	3.57E-06	7.75E-06	8.47E-06	9.62E-06	1.30E-05	1.30E-05
1923	1.89E-07	2.41E-07	3.27E-07	5.93E-07	2.87E-06	6.23E-06	6.81E-06	7.74E-06	1.05E-05	1.05E-05
1924	1.09E-06	1.38E-06	1.88E-06	3.40E-06	1.65E-05	3.58E-05	3.91E-05	4.44E-05	6.00E-05	6.00E-05
1925	6.77E-07	8.60E-07	1.17E-06	2.12E-06	1.03E-05	2.23E-05	2.43E-05	2.77E-05	3.74E-05	3.74E-05
1926	8.13E-07	1.03E-06	1.40E-06	2.54E-06	1.23E-05	2.67E-05	2.92E-05	3.32E-05	4.49E-05	4.49E-05
1927	8.20E-07	1.04E-06	1.42E-06	2.57E-06	1.24E-05	2.70E-05	2.95E-05	3.35E-05	4.53E-05	4.53E-05
1928	1.56E-06	1.98E-06	2.69E-06	4.87E-06	2.36E-05	5.12E-05	5.59E-05	6.36E-05	8.59E-05	8.59E-05
1929	9.22E-07	1.17E-06	1.59E-06	2.89E-06	1.40E-05	3.04E-05	3.32E-05	3.77E-05	5.09E-05	5.09E-05

1930	1.46E-06	1.86E-06	2.53E-06	4.59E-06	2.22E-05	4.82E-05	5.27E-05	5.98E-05	8.08E-05	8.08E-05
1931	2.93E-06	3.72E-06	5.06E-06	9.17E-06	4.44E-05	9.64E-05	0.000105	0.00012	0.000162	0.000162
1932	1.63E-06	2.07E-06	2.81E-06	5.10E-06	2.47E-05	5.36E-05	5.86E-05	6.66E-05	8.99E-05	8.99E-05
1933	3.26E-06	4.14E-06	5.62E-06	1.02E-05	4.93E-05	0.000107	0.000117	0.000133	0.00018	0.00018
1934	1.41E-05	1.79E-05	2.43E-05	4.41E-05	0.000214	0.000464	0.000507	0.000576	0.000778	0.000778
1935	0.000206	0.000262	0.000356	0.000645	0.003122	0.006782	0.007408	0.008419	0.011374	0.011374
1936	0.000647	0.000822	0.001116	0.002024	0.009792	0.021274	0.023237	0.026408	0.035676	0.035676
1937	0.000425	0.000541	0.000734	0.001332	0.006444	0.013999	0.015292	0.017378	0.023477	0.023477
1938	0.000608	0.000773	0.00105	0.001903	0.009211	0.020011	0.021858	0.02484	0.033558	0.033558
1939	0.000775	0.000985	0.001338	0.002426	0.011742	0.02551	0.027864	0.031666	0.042779	0.04278
1940	0.000851	0.001081	0.001468	0.002662	0.012883	0.027988	0.030571	0.034742	0.046936	0.046936
1941	0.001722	0.002189	0.002974	0.005391	0.02609	0.056679	0.061911	0.070357	0.095051	0.095051
1942	0.002088	0.002653	0.003604	0.006534	0.031621	0.068695	0.075036	0.085273	0.115201	0.115201
1943	0.001999	0.002541	0.003452	0.006258	0.030284	0.065791	0.071864	0.081668	0.110331	0.110331
1944	0.002315	0.002943	0.003997	0.007247	0.035072	0.076193	0.083225	0.09458	0.127774	0.127775
1945	0.001921	0.002442	0.003317	0.006014	0.029102	0.063224	0.069059	0.078481	0.106026	0.106026
1946	0.002365	0.003006	0.004083	0.007403	0.035825	0.077828	0.085011	0.096609	0.130516	0.130516
1947	0.00249	0.003164	0.004298	0.007792	0.037709	0.081922	0.089484	0.101692	0.137382	0.137383
1948	0.003045	0.003871	0.005258	0.009532	0.046129	0.100213	0.109463	0.124397	0.168056	0.168057
1949	0.002398	0.003048	0.00414	0.007506	0.036324	0.078913	0.086197	0.097956	0.132336	0.132336
1950	0.002965	0.003768	0.005118	0.009279	0.044903	0.09755	0.106554	0.121091	0.16359	0.163591
1951	0.002901	0.003688	0.005009	0.009082	0.043948	0.095475	0.104288	0.118516	0.160111	0.160111
1952	0.002245	0.002853	0.003875	0.007026	0.033999	0.073862	0.08068	0.091687	0.123866	0.123867
1953	0.001857	0.00236	0.003205	0.005811	0.028121	0.061091	0.06673	0.075833	0.102449	0.102449
1954	0.001477	0.001877	0.00255	0.004623	0.02237	0.048598	0.053084	0.060326	0.081499	0.081499
1955	0.001612	0.002049	0.002783	0.005046	0.024418	0.053047	0.057944	0.065849	0.08896	0.08896
1956	0.001706	0.002169	0.002946	0.005341	0.025848	0.056153	0.061336	0.069704	0.094168	0.094169
1957	0.002283	0.002901	0.003941	0.007144	0.034573	0.07511	0.082042	0.093235	0.125958	0.125958
1958	0.002075	0.002638	0.003583	0.006496	0.031435	0.068291	0.074594	0.084771	0.114523	0.114523
1959	0.002088	0.002653	0.003604	0.006534	0.03162	0.068693	0.075033	0.08527	0.115197	0.115197
1960	0.001566	0.00199	0.002703	0.004901	0.023718	0.051526	0.056282	0.063961	0.086409	0.086409
1961	0.001975	0.00251	0.003409	0.006181	0.029909	0.064977	0.070974	0.080657	0.108966	0.108966
1962	0.002035	0.002586	0.003512	0.006368	0.030816	0.066948	0.073127	0.083103	0.11227	0.11227
1963	0.001463	0.001859	0.002525	0.004578	0.022155	0.048131	0.052574	0.059747	0.080716	0.080716
1964	0.0012	0.001526	0.002072	0.003757	0.018181	0.039497	0.043143	0.049029	0.066237	0.066237
1965	0.001141	0.001451	0.00197	0.003572	0.017287	0.037555	0.041021	0.046617	0.062979	0.062979
1966	0.001191	0.001514	0.002057	0.003729	0.018044	0.039201	0.042819	0.048661	0.065739	0.06574
1967	0.001497	0.001903	0.002584	0.004685	0.022674	0.049258	0.053805	0.061145	0.082605	0.082605
1968	0.000919	0.001168	0.001586	0.002876	0.013918	0.030237	0.033027	0.037533	0.050706	0.050707
1969	0.001667	0.002119	0.002878	0.005218	0.025253	0.054862	0.059926	0.068102	0.092003	0.092003
1970	0.002306	0.00293	0.00398	0.007217	0.034922	0.075868	0.08287	0.094176	0.127229	0.12723
1971	0.002989	0.003799	0.00516	0.009355	0.045271	0.09835	0.107427	0.122083	0.164931	0.164931
1972	0.003169	0.004028	0.005471	0.009919	0.048001	0.104279	0.113904	0.129444	0.174876	0.174876
1973	0.003294	0.004186	0.005686	0.010309	0.049888	0.108381	0.118384	0.134535	0.181753	0.181754
1974	0.002254	0.002864	0.003891	0.007054	0.034137	0.07416	0.081005	0.092057	0.124366	0.124366
1975	0.002552	0.003244	0.004406	0.007989	0.038659	0.083986	0.091738	0.104254	0.140844	0.140844
1976	0.00283	0.003596	0.004885	0.008857	0.042859	0.093109	0.101703	0.115578	0.156143	0.156143

1977	0.00371	0.004715	0.006404	0.011611	0.056188	0.122067	0.133334	0.151524	0.204705	0.204705
1978	0.004594	0.005839	0.007932	0.01438	0.069587	0.151176	0.16513	0.187658	0.253521	0.253521
1979	0.005803	0.007376	0.010019	0.018165	0.087902	0.190963	0.208589	0.237047	0.320244	0.320244
1980	0.004531	0.005758	0.007822	0.014181	0.068625	0.149085	0.162845	0.185062	0.250014	0.250014
1981	0.004317	0.005487	0.007454	0.013514	0.065396	0.14207	0.155183	0.176355	0.23825	0.238251
1982	0.004672	0.005938	0.008066	0.014623	0.070764	0.153732	0.167922	0.190831	0.257808	0.257808
1983	0.004382	0.005569	0.007565	0.013715	0.066369	0.144185	0.157494	0.17898	0.241797	0.241798
1984	0.004564	0.005801	0.00788	0.014286	0.069133	0.150189	0.164051	0.186432	0.251865	0.251865
1985	0.004935	0.006272	0.00852	0.015447	0.074751	0.162394	0.177383	0.201584	0.272334	0.272334
1986	0.003882	0.004934	0.006703	0.012152	0.058806	0.127754	0.139546	0.158584	0.214242	0.214243
1987	0.002475	0.003146	0.004274	0.007748	0.037495	0.081457	0.088975	0.101114	0.136602	0.136602
1988	0.001521	0.001933	0.002626	0.004761	0.02304	0.050053	0.054673	0.062131	0.083938	0.083938
1989	0.000826	0.00105	0.001427	0.002587	0.012517	0.027192	0.029702	0.033754	0.045601	0.045601
1990	0.000703	0.000894	0.001214	0.002201	0.010651	0.023138	0.025273	0.028721	0.038802	0.038802
1991	0.00644	0.008185	0.011118	0.020157	0.097546	0.211915	0.231474	0.263054	0.355379	0.355379
1992	0.001096	0.001393	0.001892	0.003429	0.016596	0.036054	0.039382	0.044755	0.060463	0.060463
1993	0.001069	0.001359	0.001846	0.003346	0.016192	0.035177	0.038424	0.043666	0.058991	0.058992
1994	0.0006	0.000763	0.001036	0.001878	0.009088	0.019744	0.021567	0.024509	0.033111	0.033111
1995	0.000453	0.000576	0.000782	0.001418	0.006862	0.014908	0.016284	0.018505	0.025	0.025
1996	0.000394	0.000501	0.000681	0.001234	0.005971	0.012972	0.014169	0.016103	0.021754	0.021754
1997	0.00018	0.000229	0.000311	0.000563	0.002724	0.005918	0.006465	0.007347	0.009925	0.009925
1998	0.000188	0.000239	0.000324	0.000587	0.002843	0.006176	0.006746	0.007666	0.010357	0.010357
1999	9.42E-05	0.00012	0.000163	0.000295	0.001427	0.0031	0.003386	0.003848	0.005198	0.005198
2000	9.42E-05	0.00012	0.000163	0.000295	0.001427	0.003101	0.003387	0.00385	0.005201	0.005201
2001	0.000115	0.000146	0.000198	0.000359	0.001736	0.003771	0.004119	0.004681	0.006324	0.006324
2002	6.73E-05	8.56E-05	0.000116	0.000211	0.00102	0.002216	0.00242	0.00275	0.003716	0.003716
2003	6.78E-05	8.61E-05	0.000117	0.000212	0.001026	0.002229	0.002435	0.002767	0.003739	0.003739
2004	5.56E-05	7.06E-05	9.59E-05	0.000174	0.000842	0.001829	0.001998	0.00227	0.003067	0.003067
2005	6.26E-05	7.96E-05	0.000108	0.000196	0.000949	0.002061	0.002252	0.002559	0.003457	0.003457
2006	5.50E-05	6.99E-05	9.49E-05	0.000172	0.000833	0.001809	0.001976	0.002246	0.003034	0.003034
2007	8.86E-05	0.000113	0.000153	0.000277	0.001342	0.002916	0.003185	0.003619	0.00489	0.00489
2008	9.47E-05	0.00012	0.000163	0.000296	0.001434	0.003116	0.003404	0.003868	0.005226	0.005226
2009	0.000106	0.000135	0.000183	0.000332	0.001606	0.003489	0.003811	0.00433	0.00585	0.00585
2010	0.000108	0.000138	0.000187	0.000339	0.00164	0.003562	0.003891	0.004422	0.005974	0.005974

Table G13. Mohn's Rho as a measure of retrospective pattern for SSB, recruitment and fishing mortality.

	SSB	Rec	F
Base	0.036	0.753	-0.035
Alternate	0.047	0.742	-0.045

Table G14. Inputs for yield-per-recruit analysis.

	Age	Age	Age	v	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
M	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Weight	0	0.02	0.05	0.1	0.16	0.23	0.3	0.37	0.45	0.51	0.58	0.64	0.7	0.75	0.79	0.83	0.87	0.9	0.93	0.96	0.98	1	1.01	1.03	1.04	1.05
Maturity	0.14	0.2	0.29	0.39	0.51	0.62	0.73	0.81	0.87	0.91	0.94	0.96	0.98	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1
GARM III selectivity	0.03	0.03	0.03	0.05	0.23	0.53	0.63	0.84	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Base selectivity	0.02	0.02	0.03	0.06	0.27	0.6	0.65	0.74	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Alternative selectivity	0.02	0.02	0.03	0.06	0.27	0.6	0.65	0.74	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table G15. Spawning biomass and fishing mortality estimates (and standard errors in parentheses) for 2010. Spawning biomass-per-recruit and fishing mortality at 50% maximum spawning potential (MSP) as estimated using a spawning biomass- and yield-per-recruit analysis (fishery selectivity inputs are estimates from the ASAP model fits). AGEPRO estimates of median spawning biomass and yield at F(50%MSP) with 80% intervals in parentheses. Spawning biomass and fishing mortality for 2007 for the base (final) model adjusted for retrospective pattern are also given.

	2008 Assessment	2011 Base Model	2011 Alternate Model
SSB(2007)	234609mt	240151mt	241090mt
$SSB_{adjusted}$(2007)	172342mt		
F(2007)	0.0051	0.0049	0.0049
$F_{adjusted}$(2007)	0.0068		
SSB(2010)		313140mt	314780mt
$SSB_{adjusted}$(2010)		302379mt	300777mt
F(2010)		0.0060	0.0060
$F_{adjusted}$(2010)		0.0062	0.0062
SSB-per-recruit(50%MSP)	6.2021kg	6.1987kg	6.1991kg
F(50%MSP)	0.0377	0.0377	0.0377
SSB(50%MSP)	271,000mt	253,000mt (196,000-316,000mt)	238,000mt (185,000-298,000mt)
Yield(50%MSP)	10,139mt	9,437mt (7284-11826mt)	8,891mt (6880-11167mt)

Table G16. Projected SSB (mt) through 2015 based on base model.

Fishing Scenario	Percentile	2012	2013	2014	2015
Status Quo	90%	421961.6	454235.3	490963.5	527603.9
	50%	364550.3	392072.2	422523.3	448485.4
	10%	333722.5	359021.8	381348.9	402613.8
0.75 F(50%MSP)	90%	418478.5	441539.3	467922.4	495106.6
	50%	361503.2	381076.8	402824.3	419563.8
	10%	330995.2	348947.2	363409	376156
F(50%MSP)	90%	417013.3	436279	458570.8	482017.2
	50%	360217.8	376555.9	394792.5	407962.6
	10%	329848	344771.5	356083.9	365502.5

Table G17. Projected total catch (mt) through 2015 based on base model.

Fishing Scenario	Percentile	2012	2013	2014	2015
Status Quo	90%	2504.393	2709.891	2912.762	3194.582
	50%	2171.006	2331.604	2515.164	2728.476
	10%	1956.692	2146.429	2276.942	2432.405
0.75 F(50%MSP)	90%	11665.41	12367.95	13033.35	14071.51
	50%	10111.41	10638.67	11270.08	11968.51
	10%	9114.659	9793.779	10188.1	10671.25
F(50%MSP)	90%	15485.27	16277	17009.88	18243.58
	50%	13421.81	13999.6	14717.92	15495.61
	10%	12099.52	12887.79	13296.49	13811.71

Table G18. Projected SSB (mt) through 2015 based on alternate model.

Fishing Scenario	Percentile	2012	2013	2014	2015
Status Quo	90%	411274.2	446586.1	479963.9	517586.2
	50%	371234.8	396693.3	420077.3	442748.1
	10%	342124.5	368012	389880.6	406753.1
0.75 F(50%MSP)	90%	407996.8	433780.6	458553.9	484512.9
	50%	368118.5	385319	400139.5	413680.4
	10%	339254.1	357485.9	371141.6	379421.5
F(50%MSP)	90%	406620.1	428485.9	449816.4	470930.5
	50%	366809.7	380614.9	392014.8	402006
	10%	338047.6	353130.3	363507	368443.7

Table G19. Projected total catch (mt) through 2015 based on alternate model.

Fishing Scenario	Percentile	2012	2013	2014	2015
Status Quo	90%	2426.664	2651.579	2822.826	3137.663
	50%	2196.601	2355.483	2507.482	2672.113
	10%	2019.35	2183.433	2326.522	2438.151
0.75 F(50%MSP)	90%	11364.28	12164.43	12686.85	13885.06
	50%	10286.84	10804.5	11279.54	11786.27
	10%	9456.702	10020.32	10464.03	10735.77
F(50%MSP)	90%	15084.7	16006.99	16550.44	17972.43
	50%	13654.5	14217.01	14720.14	15254.17
	10%	12552.57	13187.58	13656.1	13885.2

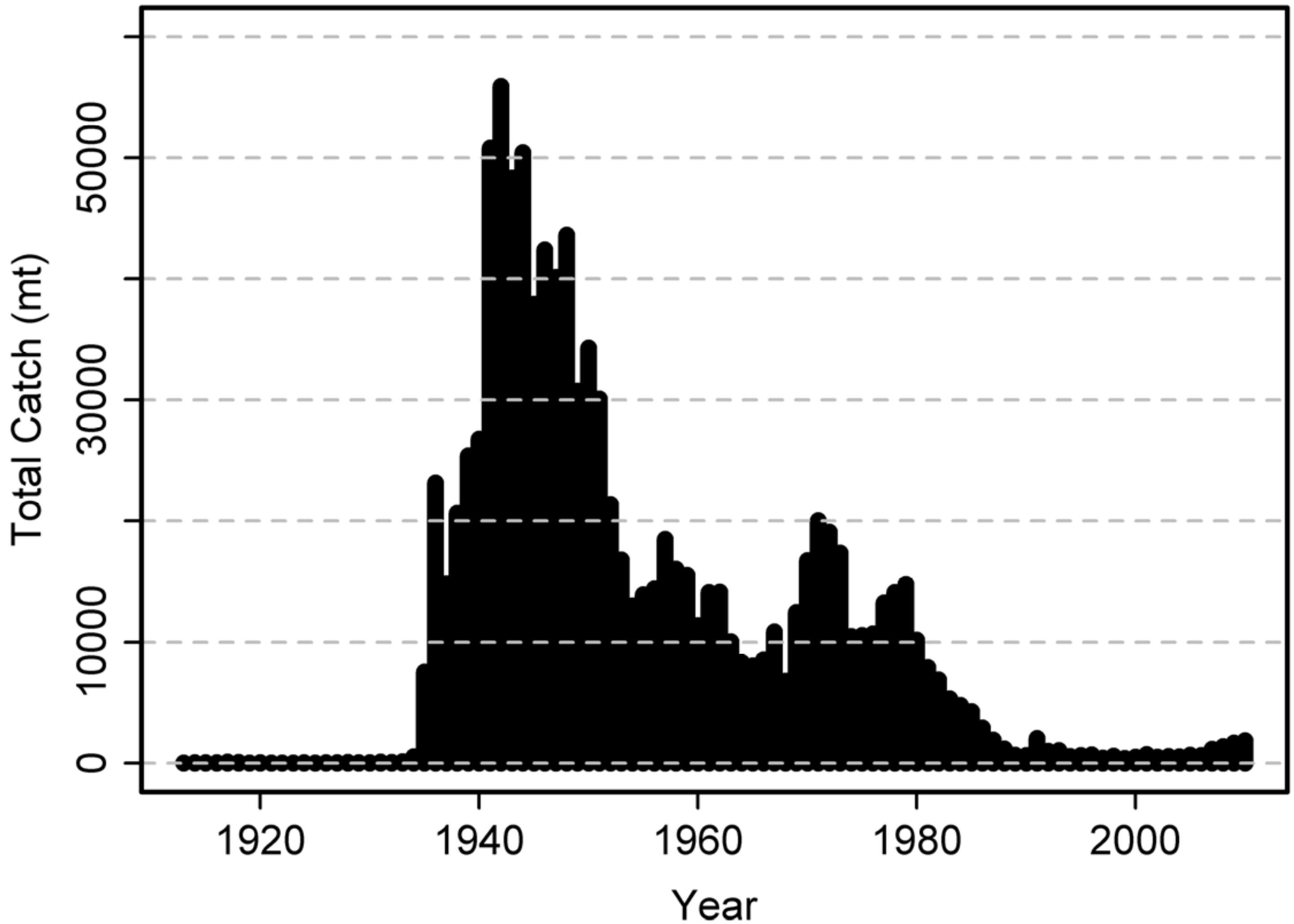

Figure GG1. Annual total catch (mt) of Gulf of Maine-Georges Bank Acadian redfish between 1913-2010.

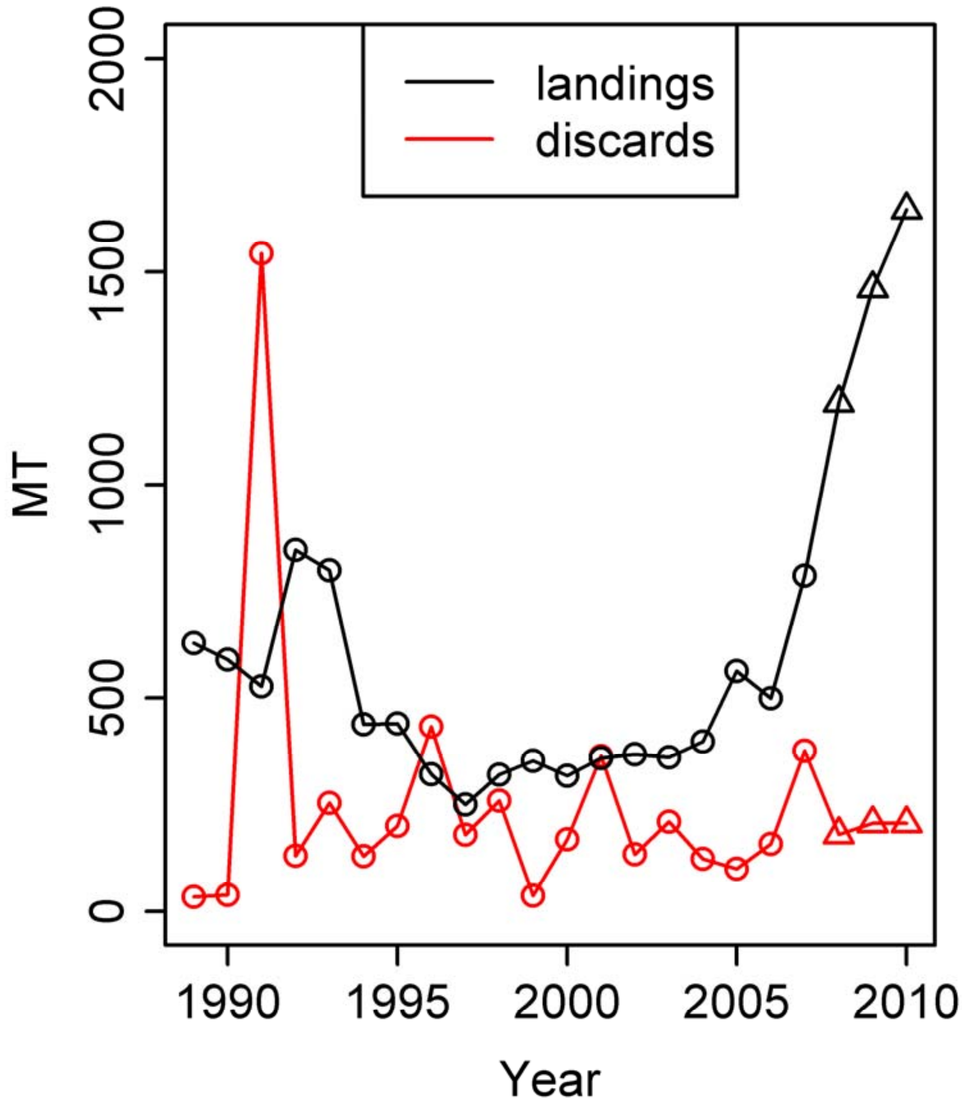

Figure GG2. Annual landings (mt) and estimated discards of Gulf of Maine-Georges Bank Acadian redfish between 1989-2010. Updated data since previous assessment are triangles.

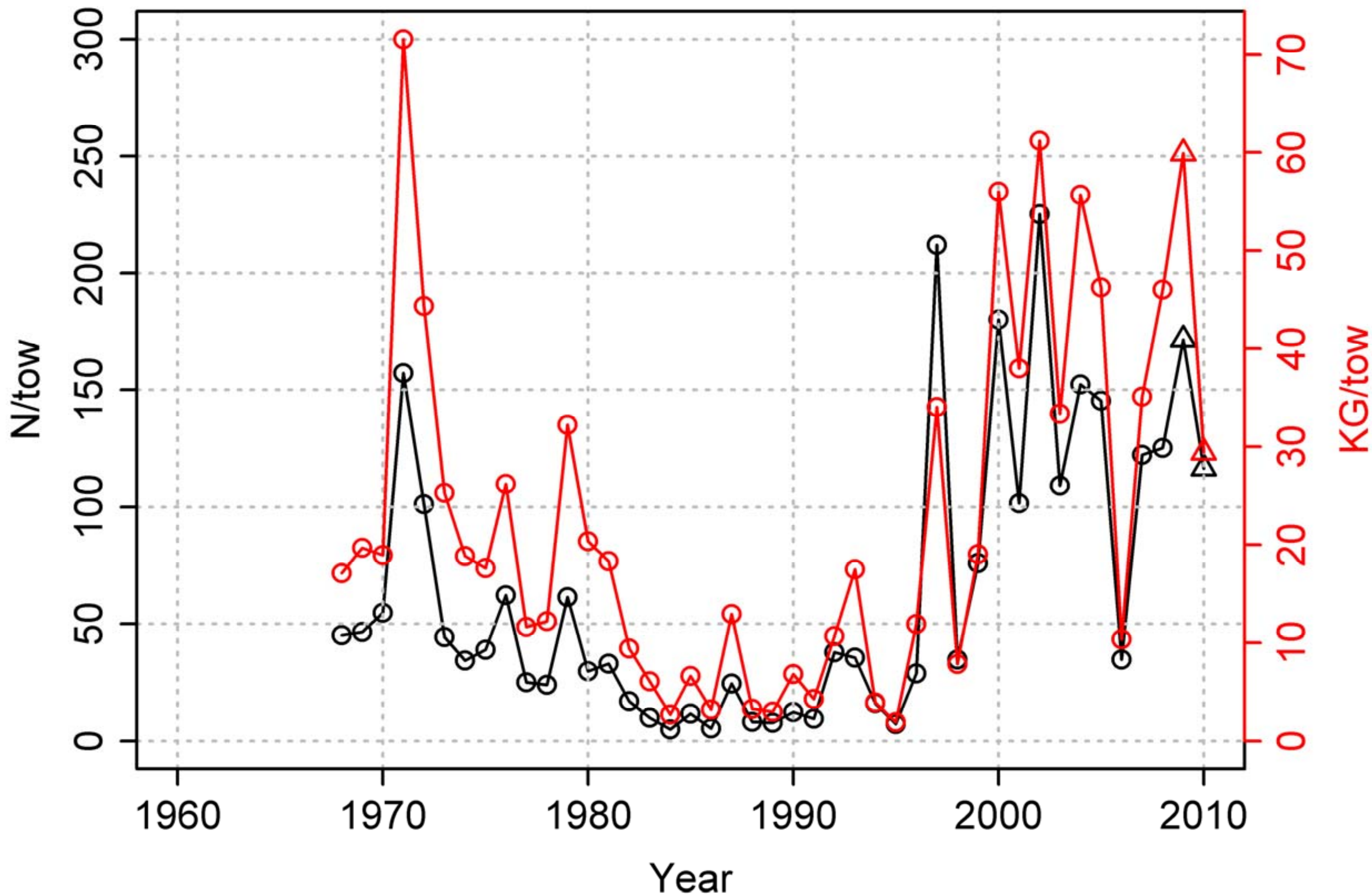

Figure G3. Estimated numbers- (black) and kg-per-tow (red) for Gulf of Maine-Georges Bank Acadian redfish in the NEFSC spring survey covering offshore strata 24, 26-30, 36-40. Triangles represent values calibrated to Albatross IV units.

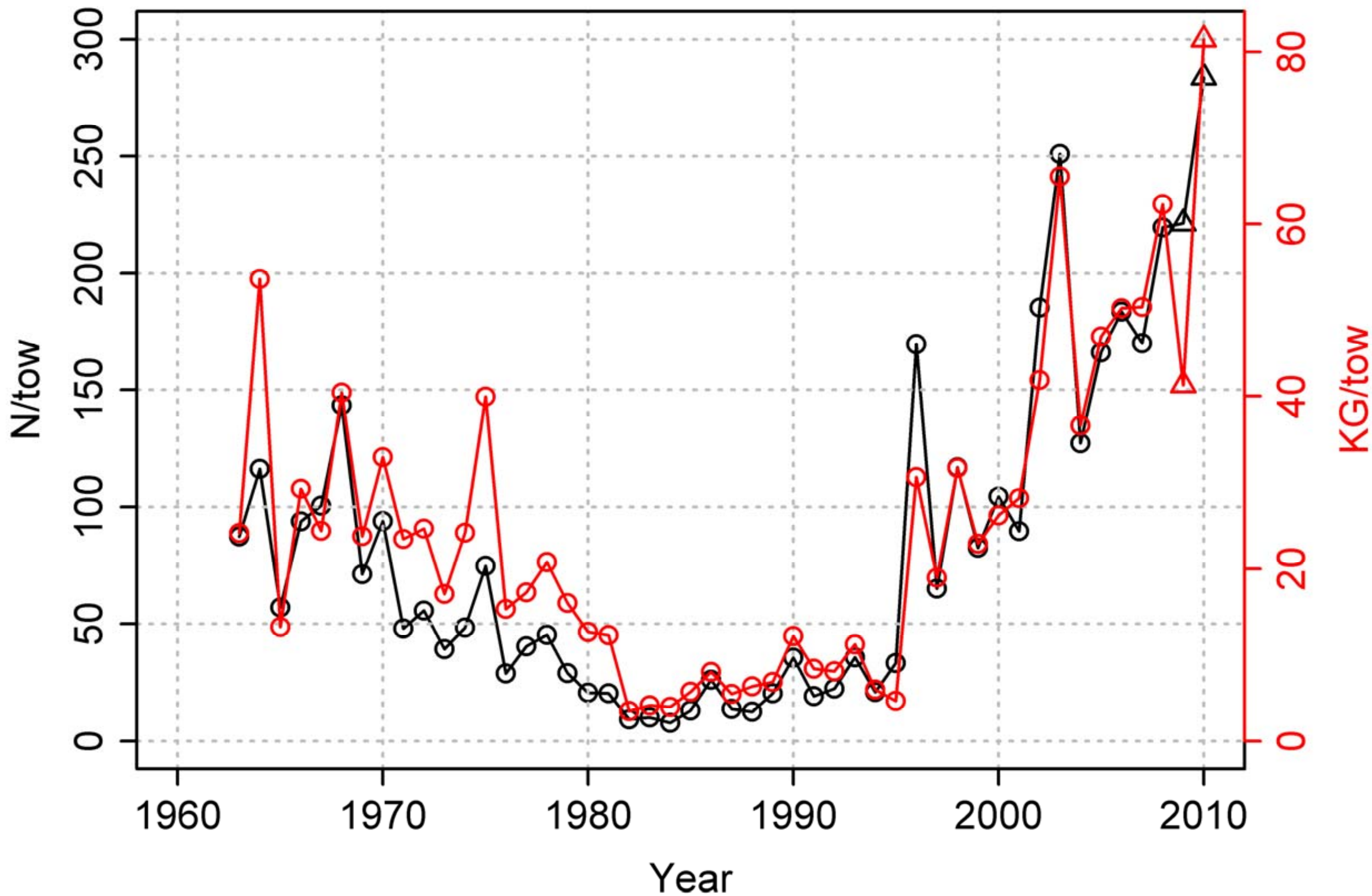

Figure G4. Estimated numbers- (black) and kg-per-tow (red) for Gulf of Maine-Georges Bank Acadian redfish in the NEFSC fall survey covering offshore strata 24, 26-30, 36-40. Triangles represent values calibrated to Albatross IV units.

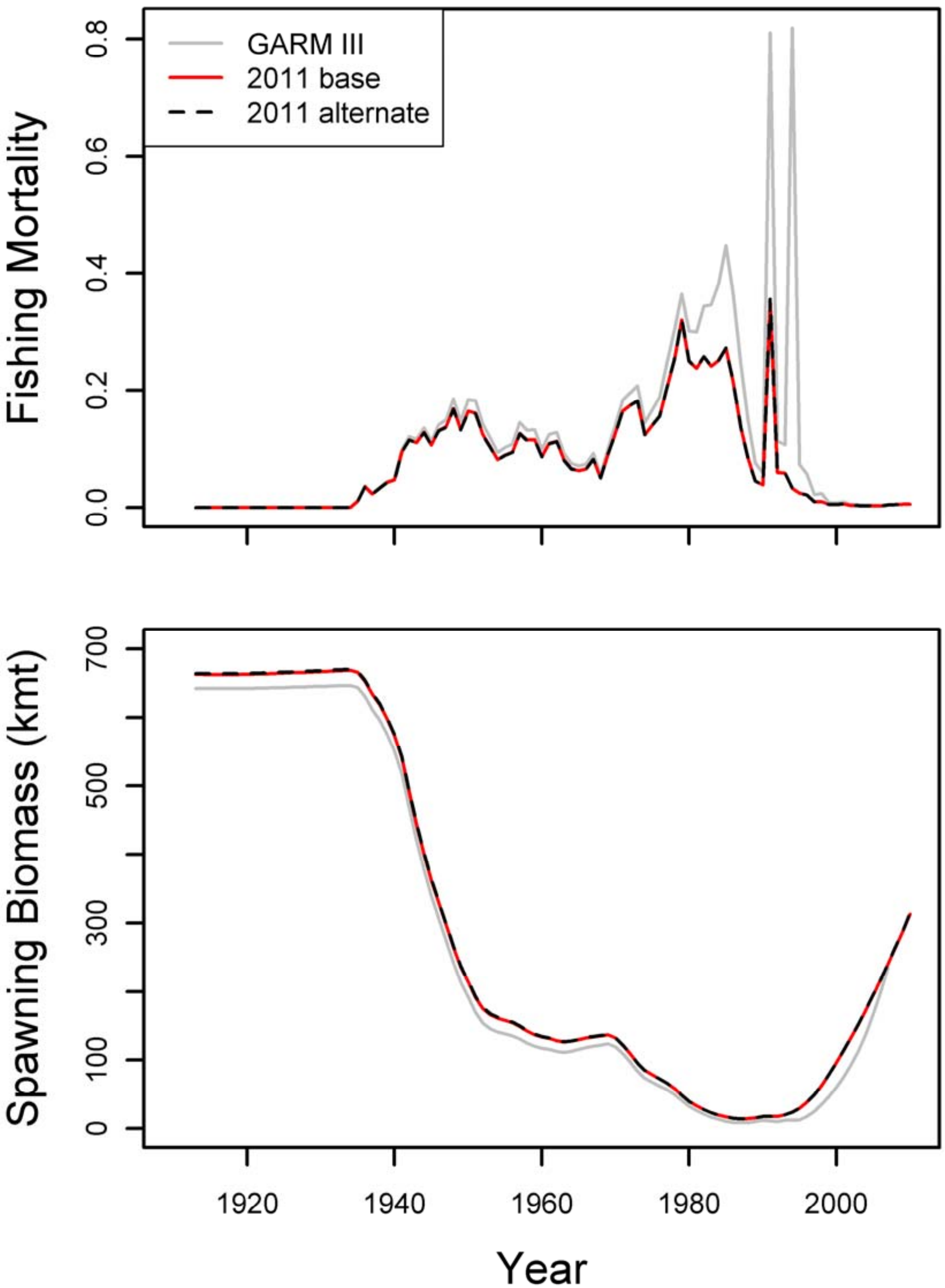

Figure G5. Estimated annual fishing mortality (top) and spawning biomass from the last assessment (gray), 2011 base model (red), , and also the 2011 alternate model (black dashed).

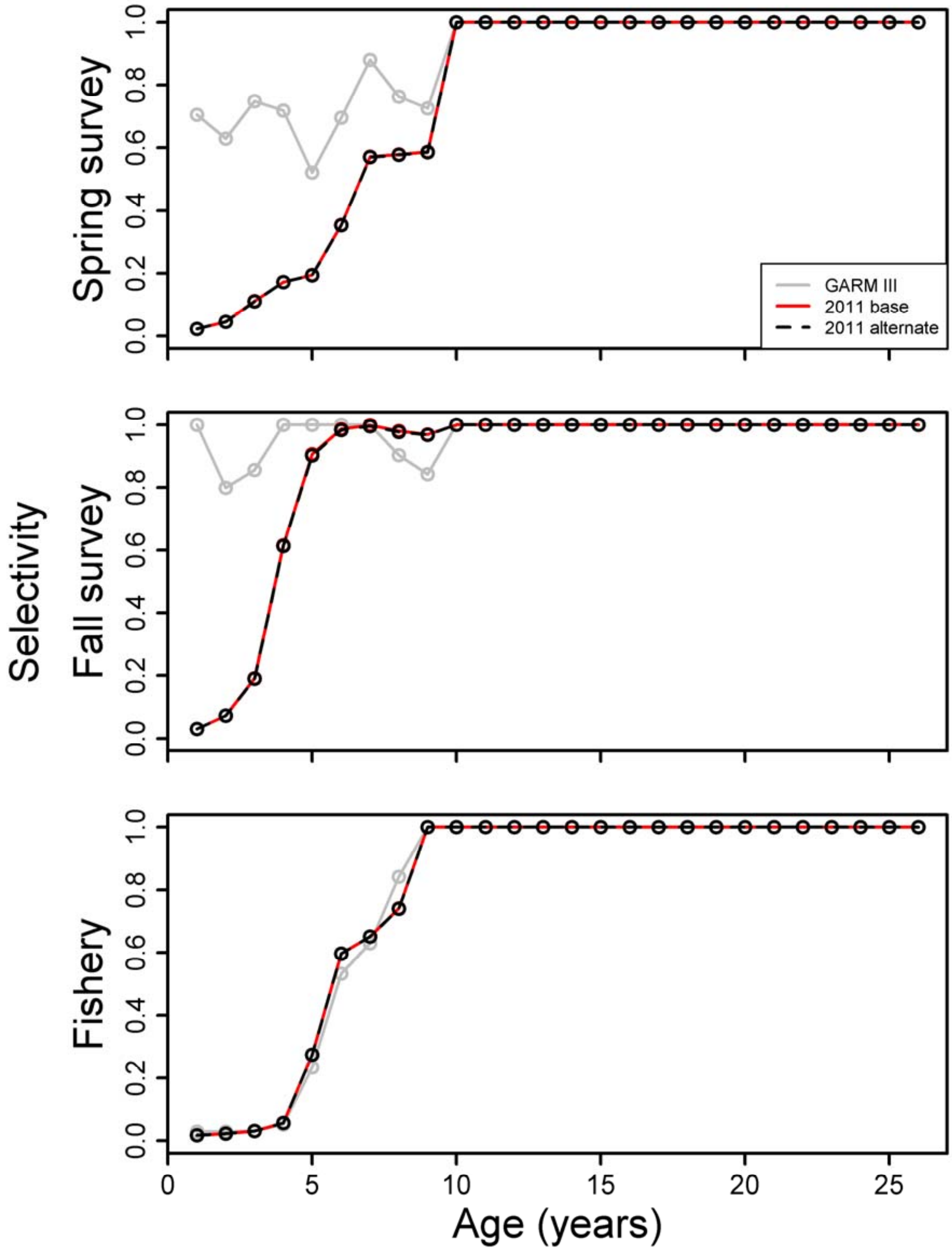

Figure G6. Estimated selectivity from the last assessment (gray), base model (red), and alternate model (black dashed).

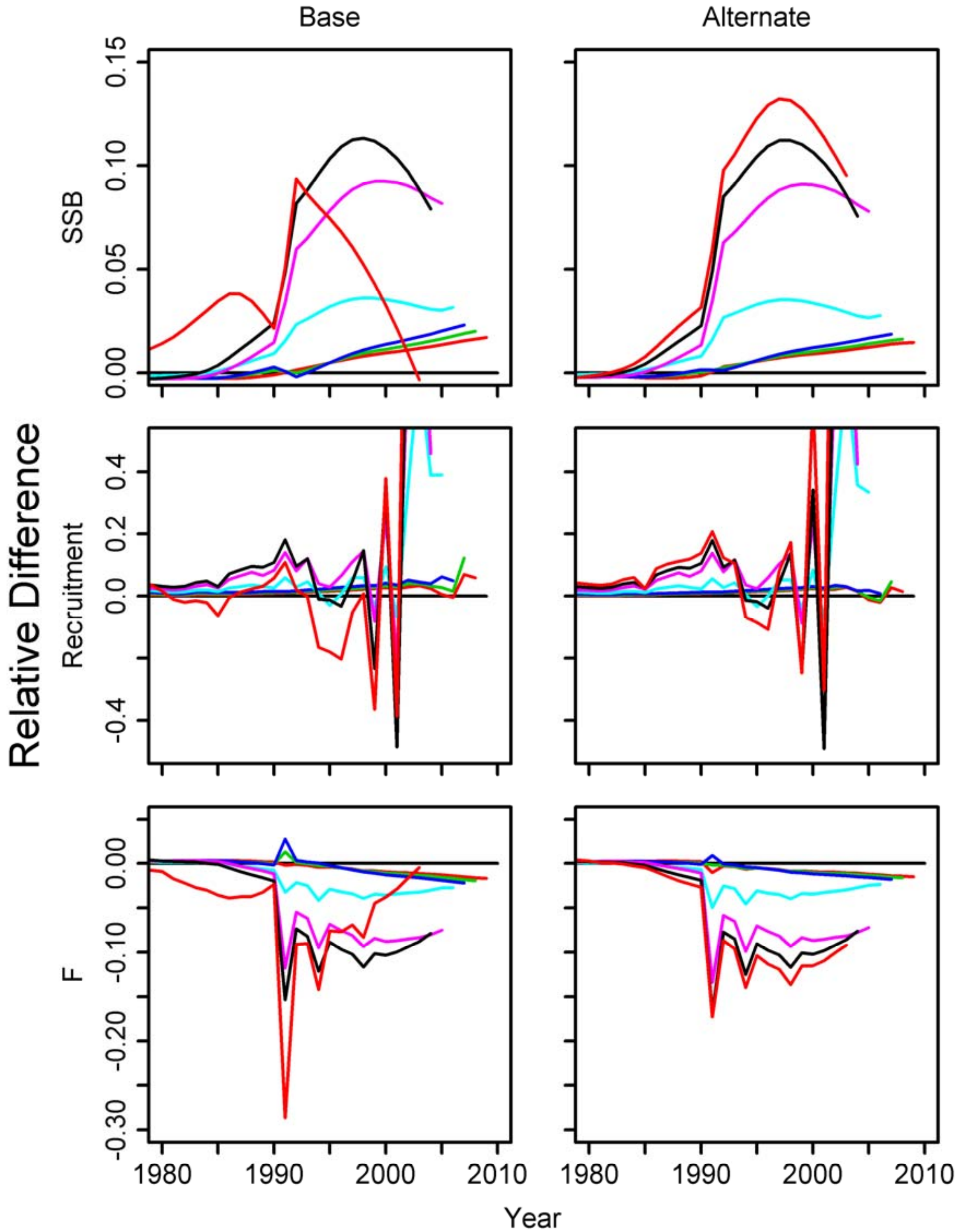

Figure G7. Retrospective patterns of relative differences in spawning biomass (top), recruitment (middle) and fishing mortality (bottom) from the base model (left) and alternate model (right).

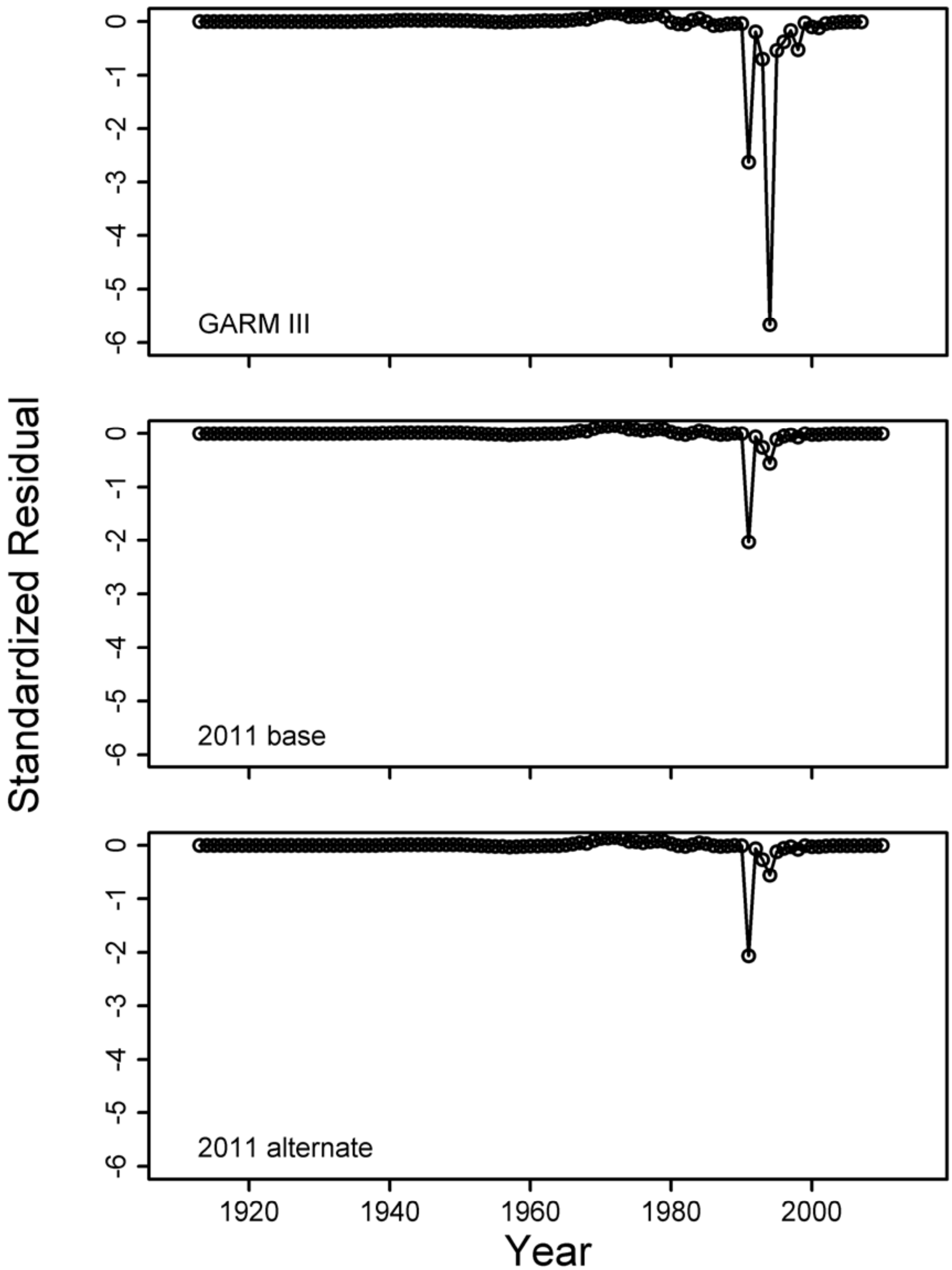

Figure G8. Standardized residuals for total catch from GARM III, base and alternative models.

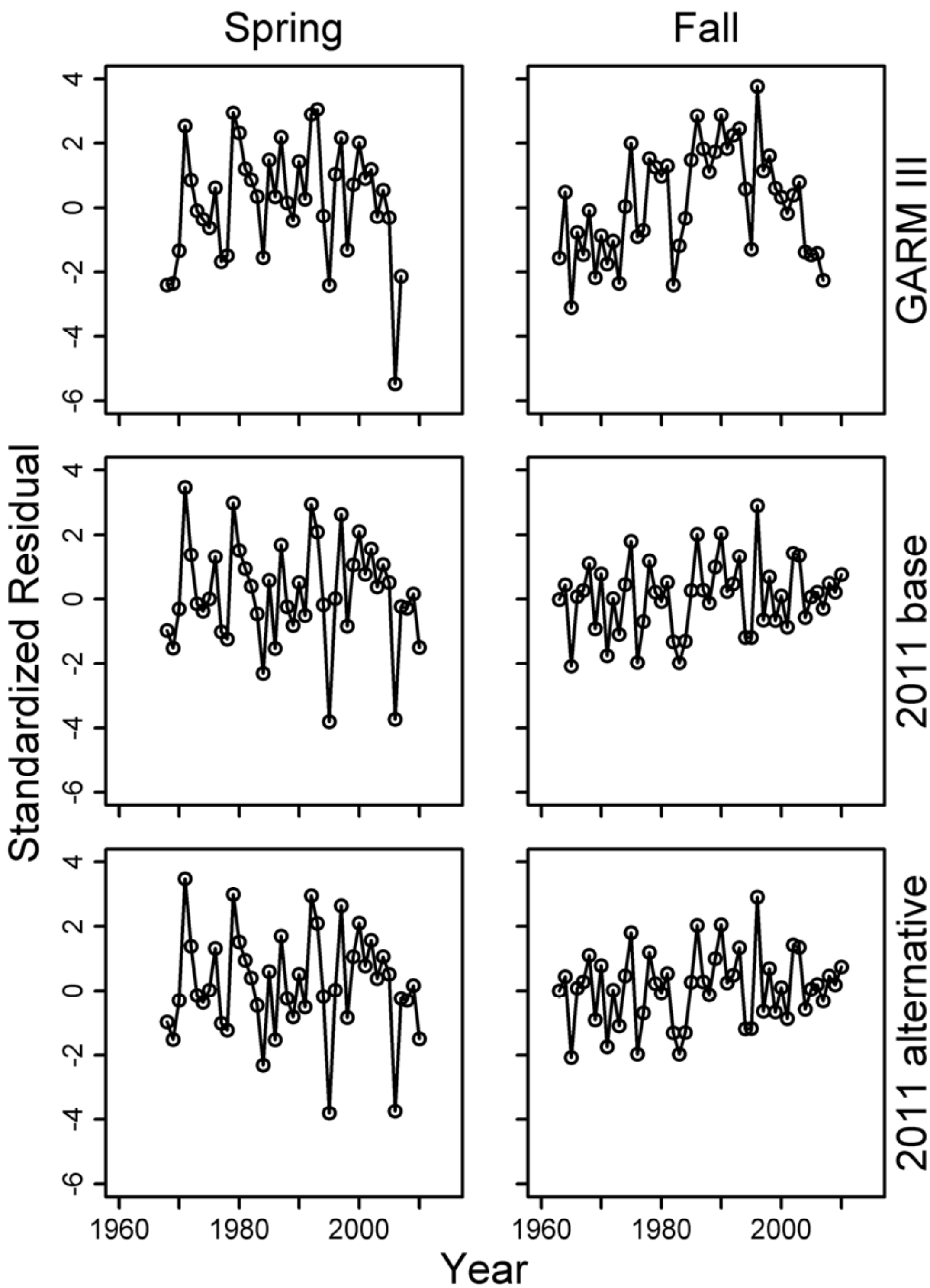

Figure G9. Standardized residuals for NEFSC spring and fall abundance indices from GARM III, base and alternative models.

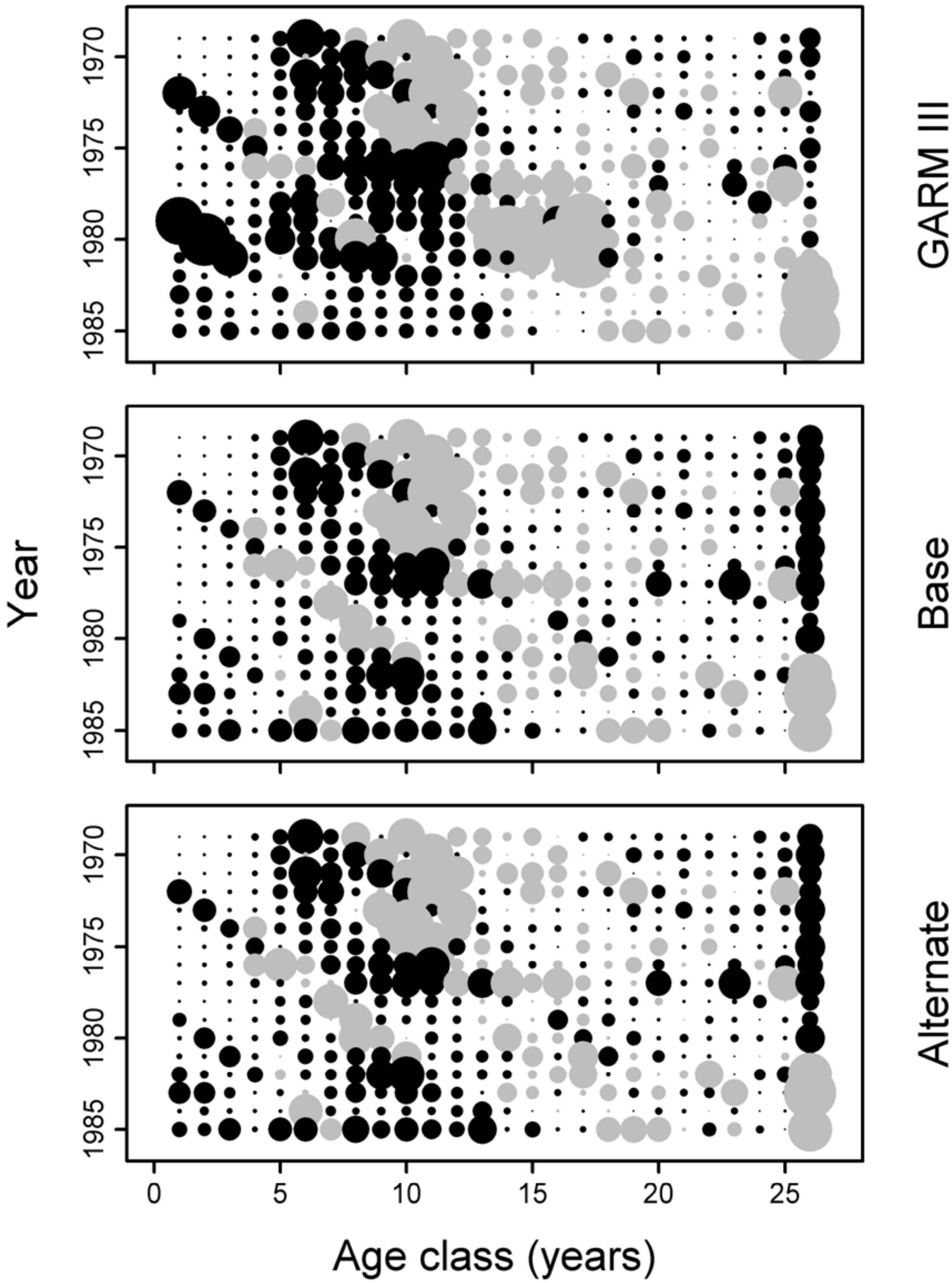

Figure G10. Pearson residuals for age composition of catch from GARM III, base and alternative models. Grey represents positive residuals and black represent negative residuals.

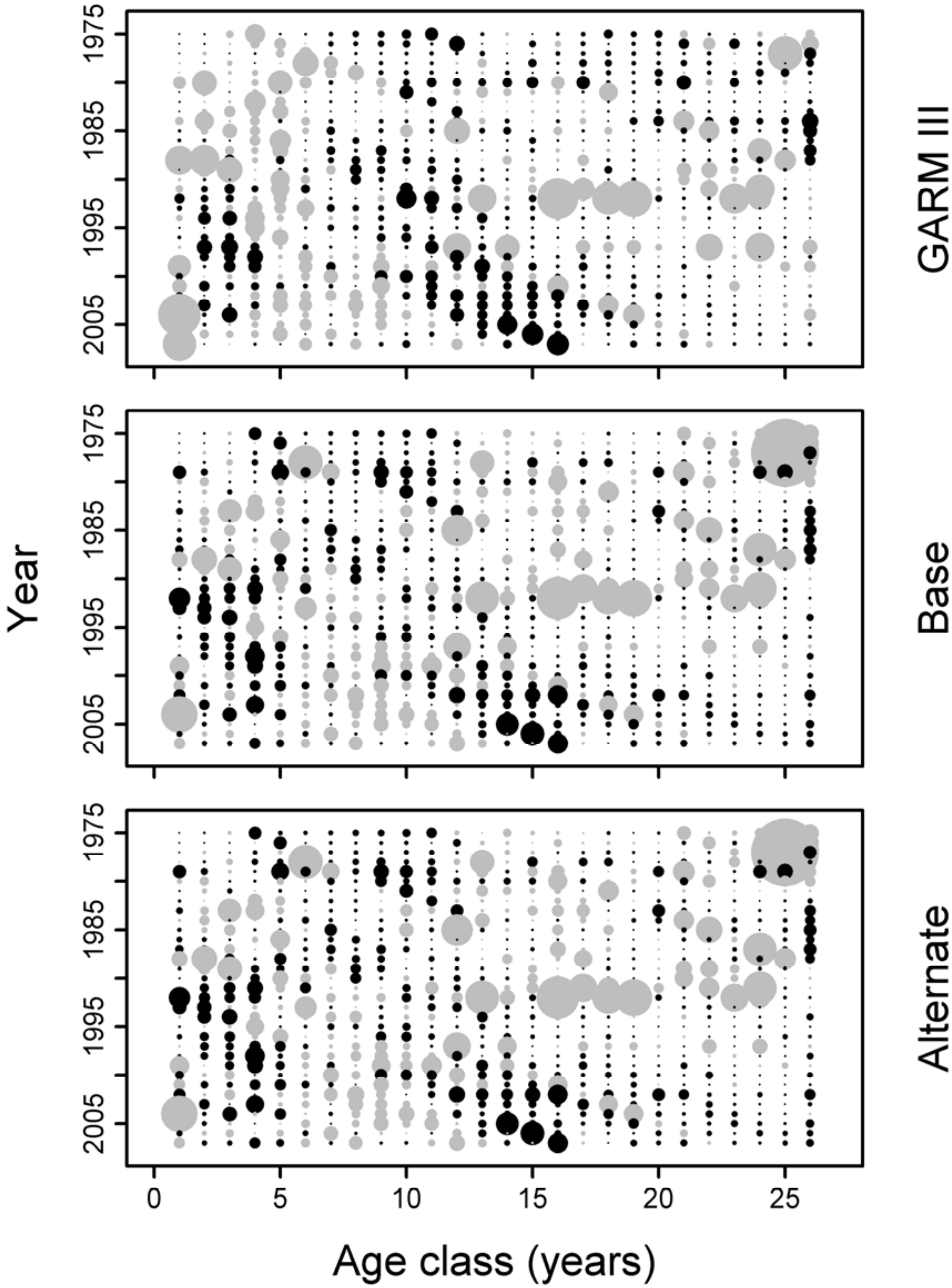

Figure G11. Pearson residuals for age composition of NEFSC fall survey from GARM III, base and alternative models. Grey represents positive residuals and black represent negative residuals.

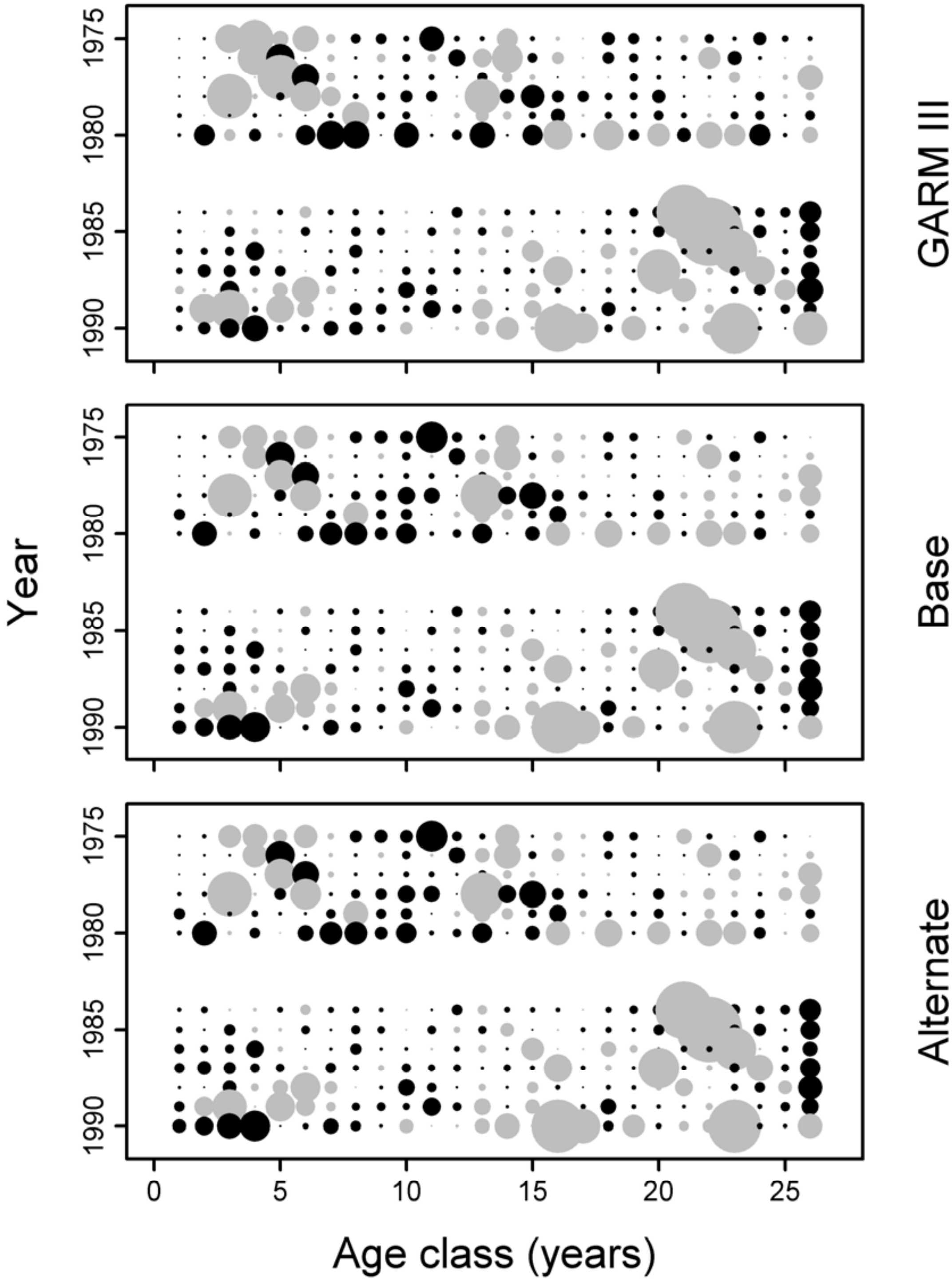

Figure G12. Pearson residuals for age composition of NEFSC spring survey from GARM III, base and alternative models. Grey represents positive residuals and black represent negative residuals.

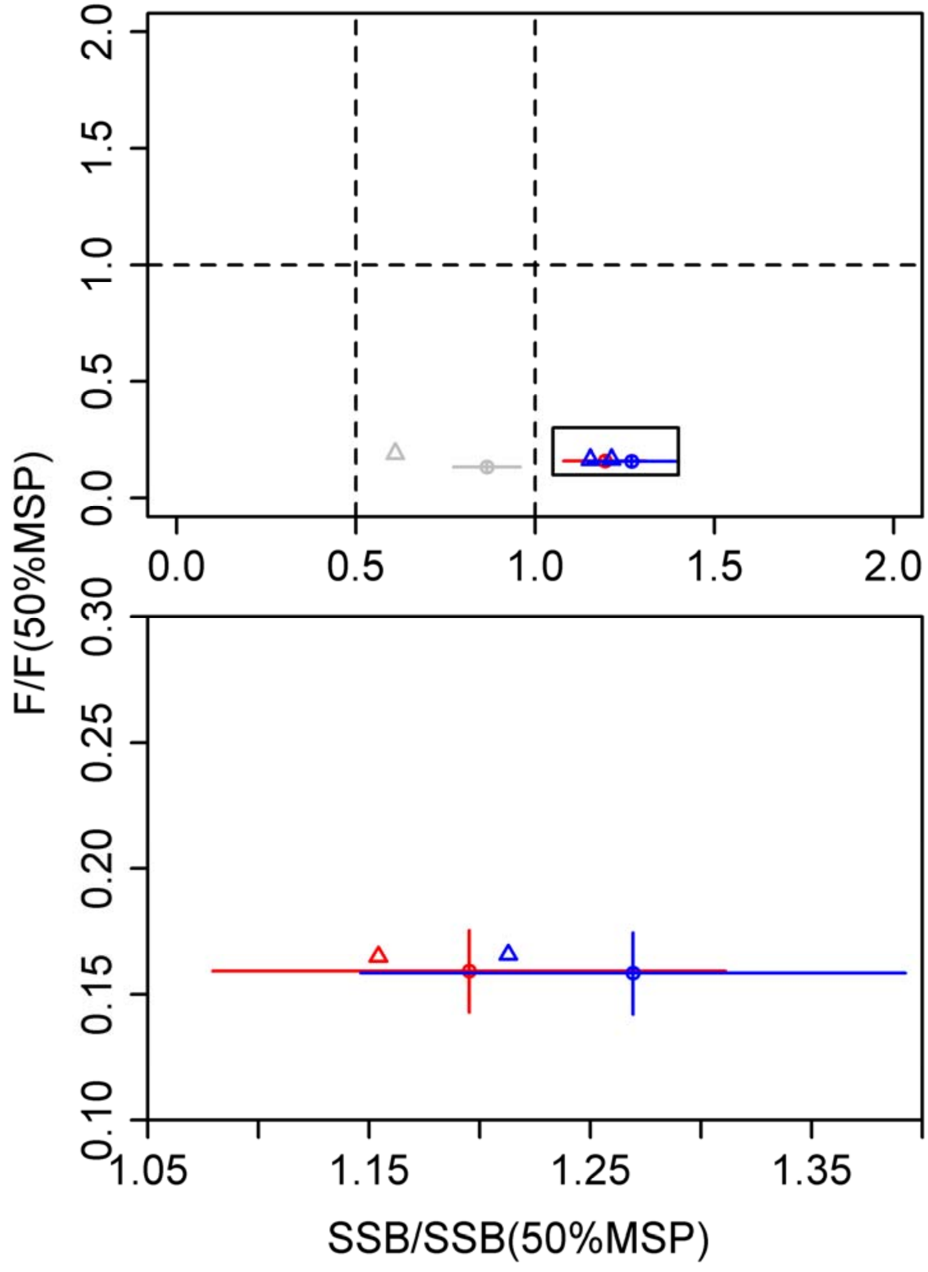

Figure G13. Stock status in 2010 based on unadjusted (circle) or retrospective-adjusted (triangle) base model (red) or alternate model (blue). Vertical and horizontal bars around status points are 80% confidence intervals based on ASAP provided standard errors. Vertical and horizontal dashed lines represent thresholds for rebuilding, overfished, and overfishing definitions.

H. Georges Bank/Gulf of Maine White Hake

by K.A. Sosebee

1.0 Background

This stock was last assessed and reviewed at the Groundfish Assessment Review Committee meeting in 2008 (NEFSC 2008). A statistical catch-at-age model (Age-Structured Production Model (ASPM)) was used to assess the status of the stock relative to reference points developed at the same meeting. Landings and discards of fish at age were used in the model as well as spring and autumn survey indices of biomass and age composition. Fishing mortality in 2007 was estimated to be above F_{msy} and biomass estimates were less than 1/2 B_{msy}.

The assessment for this stock has evolved over time from index-based in the early 1990s, to Collie-Sissenwine in 1994, finally to VPA in 1998. However, the addition of years to the VPA model created a significant retrospective pattern in the assessment in 2001. The assessment then became a surplus production model which was itself unstable and rejected in 2002. An Index Method (AIM) was used in 2002 and 2005 using only fish > 60 cm in the model to eliminate any contamination from the congener red hake. The ASPM method accepted by GARM III cannot be updated at this time so this document is a summary of the catch and survey data through 2010.

2.0 The Fishery

Commercial Landings: United States commercial landings of white hake increased from a low of 2,225 mt in 1997 to 4,435 mt in 2003 (Table H1; Figure H1). Landings subsequently declined to 1,335 mt in 2008. Landings increased through 2010 to 1807 mt. Canadian landings declined to a time-series low of 39 mt in 2008 but have since increased to 204 mt in 2010. Historical landings of white hake from the United States ranged from almost 22,000 mt in 1898 to 5,500 mt in 1950 with many years more than double the largest landings seen since 1964 (Table H2).

The primary gear type used to catch white hake is the otter trawl (Table H3). Historically, line trawls were also important, but from 1980 to 1991, this gear accounted for less than 5% of the total. Line trawls again increased in importance and, in 1997, represented 18% of the total landings. However, in recent years they averaged less than one percent. Sink gill nets historically (1960s) accounted for less than 10% of total landings but the share enlarged in the 1970s to between 20 and 40% of the total and currently account for about 25% of the total landings.

Discards: Commercial discards were estimated for white hake for 2007-2010 using the SBRM (Wigley et al. 2006) method of white hake discard/all kept (Table H3). In recent years, discards in the otter trawl fishery have been less than 150 mt and the sink gill net discards have been less than 30 mt.

Commercial Catch: The GARM III Models Meeting recommended using the ratio of white hake to red hake in the survey to split out white hake catch. This involved estimating red and white hake landings-at-length as well as red and white hake discards-at-length. At SARC 51, it was recommended to use nominal catch for red hake so future white hake assessments should use nominal catch as well. For this document, both are presented (NEFSC 2011).

Sampling intensity for white hake landings was good and the coverage adequate, except for unclassified (Table H5). These were prorated at the end for 1998-2010. Sampling for red hake was sufficient for most years but was the intensity was low for some years (Table H6).

Commercial discards were updated for red hake for 2007-2010 using the SBRM method of red hake discard/all kept (Table H7). There were sufficient length samples for both white and red hake to estimate otter trawl discards-at-length (Tables H8-H9).

The four components were added together by half year and then the ratio of white hake to red hake numbers at length from the appropriate survey was used to split out white hake (Table H10; Figure H3). Then the length-weight equation was used to convert the numbers to weight. The ratio between the old data and the new data was used to estimate landings back to 1964. Landings between 1951 and 1963 were imputed to ramp down the landings to the 1964 level (Table H10). The catch estimated from using the red/white hake split is generally higher than the nominal catch.

Commercial Catch-at-length

The mean and median lengths of the commercial catch have generally increased over time from around 50 cm in 1989 to 63 cm in the last three years as mesh sizes have changed and discards have declined (Table H11, Figure H4). The 95 percentile of length has also increased from about 70 cm to 90 cm over the same time period. The maximum size was around 130 cm for the first few years, declined to around 110 cm in the late 1990s and has since increased to 135 cm over the last 6 years.

3.0 Research Vessel Surveys

NEFSC has conducted research vessel bottom trawl surveys off the northeast coast of the United States since 1963 (autumn) and 1968 (spring). The NOAA research vessels Albatross IV and Delaware II were used exclusively from 1963-2008 during these surveys. Gear and door changes have occurred during the survey period. Calibration coefficients for these changes were not significant for white hake. In 2009, the Albatross IV was replaced by the FSV Henry B. Bigelow. An extensive calibration exercise was conducted. The constant calibration factors for white hake were estimated (Miller et al. 2010). At SARC51, length-based calibration factors were investigated for white hake but the constant were found to fit the data (Table H12, Figure H5).

The NEFSC spring survey biomass indices are more variable than the autumn, but declined during the 1990s, increased in the early 2000s, declined through 2006 and have since increased to around the same level as the early 2000s (Figure H7, Table H13). The NEFSC autumn bottom trawl survey biomass index fluctuated about a relatively high level during the 1970s and 1980s but declined during the 1990s, falling to near record low in 1999 (Figure H7; Table H14). The biomass index increased between 2000 and 2002 because of the recruitment of a good 1998 year class (NEFSC 2001), but has since declined to a very low level. The 2007 index is higher and seems to indicate another year class.

The mean, median and 95th percentile of length compositions from the spring survey have largely declined over the survey (Figure H8, Table H13). The maximum length has also followed this pattern. There was a period of increase in the 95th percentile and maximum during the late 1990s into the early 2000s, followed by a decline. Over the last three years, both have increased, but not to the same value as in the 1970s.

The mean of the length composition of the autumn survey has declined slightly from about 50 cm in the 1970s to just above 40 cm in the last decade (Figure H9, Table H14). The 95th percentile decreased from about 80 cm in the 1970s to 70 cm. The maximum length was stable at around 120 cm from the 1960s to the 1980s. In the 1990s and 2000s, the maximum has been around 105 cm.

GB-GOM-White Hake. Summary of Assessment Information

GB-GOM-White Hake	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Landings (mt)	3685	3424	4563	3595	2755	1789	1578	1374	1832	2011	4201	1142	9582	1964-2010
Discards (mt)	344.1	115	265	103.8	84.7	59.3	29.4	163.2	62.3	73.7	310	29.4	1384	1989-2010
Catch (mt)	3981	3530	4814	3687	2821	1833	1599	1523	1886	2057	4243	1523	10098	1989-2010

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Table H1. Total nominal landings (mt, live) of white hake by country from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1964-2010.

	Canada	USA	Other	Grand Total
1964	29	3016	0	3045
1965	0	2617	0	2617
1966	0	1563	0	1563
1967	16	1126	0	1142
1968	85	1210	0	1295
1969	34	1343	6	1383
1970	46	1807	280	2133
1971	100	2583	214	2897
1972	40	2946	159	3145
1973	117	3279	5	3401
1974	232	3773	0	4005
1975	146	3672	0	3818
1976	195	4104	0	4299
1977	170	4976	338	5484
1978	155	4869	29	5053
1979	251	4044	4	4299
1980	305	4746	2	5053
1981	454	5969	0	6423
1982	764	6179	2	6945
1983	810	6408	0	7218
1984	1013	6757	0	7770
1985	953	7353	0	8306
1986	956	6109	0	7065
1987	555	5818	0	6373
1988	534	4783	0	5317
1989	583	4548	0	5131
1990	547	4927	0	5474
1991	552	5607	0	6159
1992	1138	8444	0	9582
1993	1681	7466	0	9147
1994	955	4737	0	5692
1995	481	4333	0	4814
1996	372	3287	0	3659
1997	290	2225	0	2515
1998	228	2367	0	2595
1999	174	2621	0	2795
2000	224	2984	0	3208
2001	203	3482	0	3685
2002	158	3266	0	3424
2003	128	4435	0	4563
2004	85	3510	0	3595
2005	85	2670	0	2755
2006	89	1700	0	1789
2007	46	1532	0	1578
2008	39	1335	0	1374
2009	135	1697	0	1832
2010	204	1807	0	2011

Table H2. Total United States nominal landings (mt, live) of white hake from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1893-1950.

Year	Landings	Year	Landings
1893	17424	1922	10894
1894	17121	1923	11222
1895	16227	1924	11214
1896	14332	1925	10462
1897	14239	1926	11177
1898	21669	1927	10392
1899	15275	1928	7798
1900	11977	1929	10840
1901	14090	1930	13976
1902	19198	1931	6678
1903	14927	1932	6991
1904	17525	1933	6021
1905	19039	1934	6214
1906	14910	1935	10225
1907	17134	1936	8947
1908	19170	1937	9399
1909	16177	1938	9384
1910	17603	1939	8222
1911	15548	1940	5982
1912	14745	1941	5001
1913	15788	1942	4985
1914	13068	1943	7426
1915	14623	1944	6155
1916	14469	1945	5876
1917	11003	1946	7398
1918	10048	1947	6159
1919	11862	1948	6660
1920	9615	1949	6123
1921	9787	1950	5492

Table H3. US nominal commercial landings (mt, live) and the annual percentage of total landings of white hake by gear type, 1964-2010.

	Landings (mt,live)					Percentage of Annual Landings				
		Bottom	Sink				Bottom	Sink		
	Line	Otter	Gill	Other		Line	Otter	Gill	Other	
Year	Trawl	Trawl	Net	Gear	Total	Trawl	Trawl	Net	Gear	Total
1964	1228	1681	99	8	3016	40.7	55.7	3.3	0.3	100
1965	1513	1034	64	4	2617	57.8	39.5	2.5	0.2	100
1966	704	755	99	5	1563	45.0	48.3	6.3	0.3	100
1967	326	730	67	4	1126	28.9	64.8	5.9	0.4	100
1968	265	825	116	3	1210	21.9	68.2	9.6	0.2	100
1969	228	1005	108	2	1343	17.0	74.8	8.0	0.1	100
1970	201	1474	129	4	1807	11.1	81.5	7.1	0.2	100
1971	532	1925	118	9	2583	20.6	74.5	4.6	0.3	100
1972	834	1717	384	11	2946	28.3	58.3	13.0	0.4	100
1973	840	1941	491	6	3279	25.6	59.2	15.0	0.2	100
1974	638	1852	1274	9	3773	16.9	49.1	33.8	0.2	100
1975	993	1356	1320	4	3672	27.0	36.9	35.9	0.1	100
1976	546	1606	1943	9	4104	13.3	39.1	47.3	0.2	100
1977	391	2316	2257	12	4976	7.9	46.5	45.4	0.2	100
1978	321	2183	2341	23	4869	6.6	44.8	48.1	0.5	100
1979	206	2058	1752	28	4044	5.1	50.9	43.3	0.7	100
1980	90	2656	1967	33	4746	1.9	56.0	41.4	0.7	100
1981	108	3473	2376	13	5970	1.8	58.2	39.8	0.2	100
1982	97	3860	2202	20	6179	1.6	62.5	35.6	0.3	100
1983	79	4868	1395	66	6408	1.2	76.0	21.8	1.0	100
1984	22	5158	1486	90	6757	0.3	76.3	22.0	1.3	100
1985	315	5508	1418	112	7353	4.3	74.9	19.3	1.5	100
1986	231	4671	1163	44	6109	3.8	76.5	19.0	0.7	100
1987	86	4798	911	24	5819	1.5	82.5	15.7	0.4	100
1988	85	3655	1008	35	4783	1.8	76.4	21.1	0.7	100
1989	15	2552	1892	88	4548	0.3	56.1	41.6	1.9	100
1990	78	3286	1508	54	4927	1.6	66.7	30.6	1.1	100
1991	249	3553	1616	189	5607	4.4	63.4	28.8	3.4	100
1992	948	5195	2262	40	8444	11.2	61.5	26.8	0.5	100
1993	1203	4656	1590	16	7466	16.1	62.4	21.3	0.2	100
1994	1186	2479	1065	7	4737	25.0	52.3	22.5	0.1	100
1995	764	2407	1123	39	4333	17.6	55.6	25.9	0.9	100
1996	307	2036	926	19	3287	9.3	61.9	28.2	0.6	100
1997	394	1284	543	5	2225	17.7	57.7	24.4	0.2	100
1998	326	1370	662	9	2367	13.8	57.9	28.0	0.4	100
1999	140	1535	922	23	2621	5.4	58.6	35.2	0.9	100
2000	95	1832	1042	15	2984	3.2	61.4	34.9	0.5	100
2001	48	2484	931	18	3482	1.4	71.3	26.8	0.5	100
2002	19	2445	776	25	3266	0.6	74.9	23.8	0.8	100
2003	93	2993	1341	7	4435	2.1	67.5	30.2	0.2	100
2004	49	2514	850	98	3510	1.4	71.6	24.2	2.8	100
2005	89	1730	660	191	2670	3.3	64.8	24.7	7.1	100
2006	7	1290	318	85	1700	0.4	75.9	18.7	5.0	100
2007	12	1019	384	117	1532	0.8	66.5	25.0	7.7	100

Table H3 cont. US nominal commercial landings (mt, live) and the annual percentage of total landings of white hake by gear type, 1964-2010.

	Landings (mt,live)					Percentage of Annual Landings				
Year	Line Trawl	Bottom Otter Trawl	Sink Gill Net	Other Gear	Total	Line Trawl	Bottom Otter Trawl	Sink Gill Net	Other Gear	Total
2008	11	912	343	69	1335	0.9	68.3	25.7	5.1	100.0
2009	9	1170	414	104	1697	0.5	69.0	24.4	6.2	100.0
2010	7	1110	375	315	1807	0.4	61.4	20.8	17.4	100.0

Table H4. Number of trips sampled and the resulting discards of white hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2010.

	SGN						OT						
	Half 1		Half 2		Total		Half 1		Half 2		Total		Total
YEAR	trips	discards	trips	discards	trips	discards	trips	discards	trips	discards	trips	discards	discards
1989	1	2.3	106	21.8	107	24.1	72	171.6	104	509.7	176	681.3	705.4
1990	75	10.2	78	78.4	153	88.6	67	661.0	71	634.3	138	1295.3	1383.9
1991	194	25.5	763	54.7	957	80.2	92	12.3	164	231.4	256	243.7	323.9
1992	497	37.3	690	84.0	1187	121.3	116	242.5	70	273.4	186	515.9	637.2
1993	348	56.4	422	153.7	770	210.0	37	70.1	29	564.8	66	634.9	844.9
1994	188	0.5	216	11.5	404	12.0	28	155.0	35	64.3	63	219.3	231.3
1995	298	1.2	239	27.2	537	28.4	81	50.1	144	116.0	225	166.1	194.5
1996	254	2.8	168	48.1	422	50.9	69	102.6	125	12.1	194	114.7	165.6
1997	257	4.8	132	27.3	389	32.1	72	76.9	40	91.1	112	168.0	200.1
1998	267	2.2	136	2.0	403	4.1	42	27.5	28	30.6	70	58.0	62.1
1999	88	12.7	101	5.4	189	18.2	42	3.4	66	556.5	108	559.9	578.1
2000	118	6.2	108	11.1	226	17.3	108	90.9	79	86.6	187	177.5	194.8
2001	98	1.4	69	47.2	167	48.6	110	131.1	172	164.4	282	295.5	344.1
2002	67	6.6	106	2.6	173	9.2	76	45.6	290	60.2	366	105.8	115
2003	162	6.4	330	7.7	492	14.2	267	34.5	290	216.3	557	250.8	265
2004	289	1.0	800	10.6	1089	11.5	371	26.9	688	65.4	1059	92.3	103.8
2005	260	3.9	744	14.2	1004	18.0	855	15.8	1013	50.9	1868	66.7	84.7
2006	136	2.0	115	13.0	251	14.9	542	19.9	382	24.4	924	44.4	59.3
2007	100	2.3	234	2.2	334	4.6	453	14.1	616	10.7	1069	24.8	29.4
2008	115	4.1	194	9.9	309	14.0	513	100.5	573	48.6	1086	149.2	163.2
2009	190	3.2	226	5.0	416	8.2	671	24.1	856	30.0	1527	54.1	62.3
2010	419	16.5	1460	10.8	1879	27.3	824	28.8	1096	17.6	1920	46.4	73.7

Table H5. Summary of US Commercial white hake landings (mt), number of length samples (n), and number of fish measured (len) by market category and quarter from the Gulf of Maine to the Mid-Atlantic for all gear types, 1985-2010.

		small					medium					large					unclassified					All	Sampling
		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	Intensity
1985	mt	129	162	235	167	694	63	78	181	124	446	237	433	1135	623	2428	367	737	1690	988	3782	7349	272
	N		2	4	3	9					0		5	5	3	13		1	3	1	5	27	
	# fish		233	323	317	873					0		632	519	271	1422		101	293	104	498	2793	
1986	mt	59	134	105	100	398	86	89	55	54	284	274	422	835	417	1948	455	752	1578	694	3478	6107	235
	N	1	3	2	1	7	1	1		2	4	1	3	2	1	7	2	2	3	1	8	26	
	# fish	102	263	215	101	681	94	122		229	445	122	315	248	96	781	215	206	292	106	819	2726	
1987	mt	98	300	641	576	1616	13	49	122	123	306	171	326	943	372	1813	262	482	1035	301	2080	5814	194
	N		2	4	5	11		2	1	1	4		1	6	3	10	2	1	1	1	5	30	
	# fish		240	291	507	1038		203	91	109	403		111	518	236	865	218	140	112	125	595	2901	
1988	mt	181	549	893	397	2020	26	82	262	120	489	136	330	695	325	1486	73	137	437	134	782	4776	165
	N	5	6	3	5	19	1	1	1		3	1	1	2	1	5		1		1	2	29	
	# fish	558	764	240	478	2040	100	92	105		297	112	121	214	85	532		100		41	141	3010	
1989	mt	149	221	404	358	1132	41	54	124	68	287	188	473	904	470	2035	33	190	774	96	1092	4547	350
	N	1	1	2	2	6			1		1			2	2	4	1		1		2	13	
	# fish	91	94	213	195	593			103		103			206	204	410	100		106		206	1312	
1990	mt	207	411	885	450	1953	43	108	303	171	625	167	300	596	320	1382	24	182	580	176	962	4922	234
	N	3	4	4	2	13			2	1	3	2		1	1	4				1	1	21	
	# fish	309	408	399	151	1267			202	99	301	214		101	103	418				101	101	2087	
1991	mt	150	366	1215	612	2342	88	160	381	129	758	126	241	533	338	1238	52	358	714	138	1262	5601	156
	N	2	5	6	4	17	1	1	3	1	6	4	1	1	4	10		2	1		3	36	
	# fish	151	471	485	244	1351	103	100	382	100	685	375	99	96	539	1109		207	94		301	3446	
1992	mt	424	626	1735	848	3633	102	202	766	358	1428	231	351	699	371	1651	60	280	1246	141	1727	8439	211
	N	4	4	8	3	19	1	4	3	3	11		2	3	2	7	1		2		3	40	
	# fish	329	432	655	240	1656	80	388	266	317	1051		194	325	297	816	97		237		334	3857	
1993	mt	331	502	453	214	1500	161	397	1117	461	2136	173	476	795	416	1860	94	463	975	433	1965	7462	191
	N	2	5	4	1	12	2	3	2	1	8	2	3	7	2	14		2	2	1	5	39	
	# fish	150	504	275	50	979	184	309	196	95	784	199	262	676	175	1312		214	196	97	507	3582	
1994	mt	63	82	116	56	317	154	374	593	265	1386	206	481	687	407	1782	193	352	457	251	1252	4737	144
	N		2	4	1	7		2	3	3	8		3	4	2	9		2	4	3	9	33	
	# fish		167	386	100	653		230	305	272	807		303	363	304	970		236	431	372	1039	3469	
1995	mt	39	43	98	66	245	140	238	616	399	1393	197	398	595	374	1564	134	225	504	268	1130	4333	361
	N		1	1	1	3		2	2	1	5		2		1	3		1			1	12	
	# fish		107	97	105	309		191	222	111	524		221		103	324		100			100	1257	

Table H5 cont. Summary of US Commercial white hake landings (mt), number of length samples (n), and number of fish measured (len) by market category and quarter from the Gulf of Maine to the Mid-Atlantic for all gear types, 1985-2010.

		small					medium					large					unclassified					All	Sampling
		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	Intensity
1996	mt	23	34	80	43	181	96	207	531	269	1103	208	331	416	280	1234	110	152	339	169	769	3287	122
	N					0	1		4	4	9		2	4	5	11	1	1	3	2	7	27	
	# fish					0	101		435	541	1077		202	451	759	1412	127	72	326	220	745	3234	
1997	mt	31	58	124	83	295	76	113	370	193	752	146	146	438	335	1066	34	28	26	26	113	2225	32
	N	4	2	4	2	12	3	7	6	13	29	5	7	7	9	28				1	1	70	
	# fish	458	206	430	261	1355	276	694	564	1200	2734	541	720	678	896	2835				58	58	6982	
1998	mt	31	54	128	105	318	55	77	218	152	502	159	311	571	407	1449	28	23	34	14	100	2370	74
	N	1	2	1	1	5	3		3	2	8	7	2	8	1	18			1		1	32	
	# fish	53	220	120	59	452	327		402	305	1034	684	213	1311	110	2318			118		118	3922	
1999	mt	50	76	103	87	317	85	110	236	149	580	303	468	633	257	1661	11	14	25	16	66	2624	119
	N			1		1	1	1	3	4	9	1	6	2	3	12					0	22	
	# fish			119		119	111	102	315	313	841	166	665	202	327	1360					0	2320	
2000	mt	55	70	81	81	286	118	202	289	201	811	293	497	596	446	1833	14	15	20	12	60	2990	120
	N	4			1	5	5	1	5	4	15	1	1		3	5					0	25	
	# fish	428			123	551	527	106	573	450	1656	103	126		336	565					0	2772	
2001	mt	59	122	167	177	525	131	155	219	310	815	413	497	697	434	2041	10	22	57	12	101	3482	97
	N	2	3	2	2	9	2	1	2	2	7	3	4	7	6	20					0	36	
	# fish	231	329	213	224	997	221	100	235	215	771	328	456	797	660	2241					0	4009	
2002	mt	124.5	58	51	31	264	330	186	234	163	912	454	378	640	576	2047	7	14	15	6	43	3266	58
	N		2	1	11	14	6	4	4	7	21	7	4	7	3	21					0	56	
	# fish		154	103	968	1225	626	391	417	629	2063	768	372	665	335	2140					0	5428	
2003	mt	35	20	42	32	129	153	92	158	134	537	918	997	1066	742.9	3724	6	5	26	9	46	4435	46
	N	3	6	6	4	19	4	8	4	8	24	6	14	17	17	54					0	97	
	# fish	249	424	306	208	1187	355	768	387	796	2306	576	1369	1620	1665	5230					0	8723	
2004	mt	17	17	44	38	116	113	87	180	122	503	869	632	721	420	2642	5	53	98	88	245	3505	42
	N	2	3		7	12	5	5	2	6	18	20	14	5	15	54					0	84	
	# fish	83	162		445	690	383	456	211	579	1629	2062	1474	524	1213	5273					0	7592	
2005	mt	22	24	33	24	102	79	84	167	120	450	446	352	418	246	1463	270	148	137	104	659	2673	30
	N	7	7	8	6	28	3	5	6	5	19	9	10	8	11	38	1	1	1		3	88	
	# fish	349	360	400	313	1422	161	494	554	493	1702	825	924	738	973	3460	28	111	61		200	6784	
2006	mt	27	10	14	17	67	69	48	78	76	271	336	163	299	226	1025	193	47	49	66	355	1718	18
	N	6	9	5	9	29	5	3	6	6	20	12	13	9	10	44					0	93	
	# fish	372	398	254	547	1571	434	263	534	601	1832	958	1013	776	972	3719					0	7122	

Table H5 cont. Summary of US Commercial white hake landings (mt), number of length samples (n), and number of fish measured (len) by market category and quarter from the Gulf of Maine to the Mid-Atlantic for all gear types, 1985-2010.

		small					medium					large					unclassified					All	Sampling
		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	Intensity
2007	mt	11	16	31	41	99	39	53	75	76	244	207	220	338	198	963	75	59	59	28	222	1528	15
	N	12	6	7	10	35	5	5	7	7	24	9	8	10	11	38	1	1			2	99	
	# fish	478	264	325	388	1455	396	386	428	618	1828	753	716	667	922	3058	100	101			201	6542	
2008	mt	22	20	50	40	132	48	44	110	114	316	176	125	308	203	813	28	18	18	9	73	1335	14
	N	5	5	6	7	23	7	5	6	6	24	11	17	8	10	46					0	93	
	# fish	283	255	328	385	1251	474	356	528	616	1974	597	1106	790	677	3170					0	6395	
2009	mt	36	32	42	74	184	75	76	120	144	415	270	203	334	220	1028	29	15	11	15	70	1697	20
	N	5	5	8	6	24	5	4	7	5	21	10	8	10	13	41					0	86	
	# fish	282	279	599	519	1679	385	209	285	506	1385	773	558	1113	1104	3548					0	6612	
2010	mt	59	28	30	31	147	131	83	109	124	447	360	270	267	242	1139	38	9	13	15	75	1807	15
	N	11	6	8	9	34	7	8	11	10	36	10	12	17	11	50					0	120	
	# fish	500	483	580	428	1991	645	704	866	681	2896	953	1071	1203	898	4125					0	9012	

Table H6. Summary of US Commercial red hake landings (mt), number of length samples (n), and number of fish measured (len) by quarter from the Gulf of Maine to the Mid-Atlantic for all gear types, 1985-2010.

		unclassified					Sampling
		Q1	Q2	Q3	Q4	sum	Intensity
1985	mt	175	494	637	398	1705	61
	N	6	6	8	8	28	
	# fish	669	513	711	802	2695	
1986	mt	303	585	543	671	2102	68
	N	5	11	8	7	31	
	# fish	339	944	770	777	2830	
1987	mt	328	632	559	438	1956	89
	N	5	3	10	4	22	
	# fish	486	300	920	260	1966	
1988	mt	286	498	467	482	1733	62
	N	5	9	6	8	28	
	# fish	516	762	633	639	2550	
1989	mt	153	539	467	392	1550	155
	N	1	2	2	5	10	
	# fish	111	201	200	519	1031	
1990	mt	140	543	581	332	1595	100
	N	5	2	3	6	16	
	# fish	502	258	309	573	1642	
1991	mt	197	439	493	481	1611	81
	N	8	7	1	4	20	
	# fish	860	667	100	413	2040	
1992	mt	395	586	575	471	2027	225
	N	1	3	1	4	9	
	# fish	101	299	101	414	915	
1993	mt	242	382	511	407	1541	308
	N	1	2	2		5	
	# fish	103	200	195		498	
1994	mt	253	427	541	387	1608	201
	N	3	1	1	3	8	
	# fish	299	120	67	289	775	
1995	mt	300	369	500	430	1599	145
	N	6	4	1		11	
	# fish	701	366	62		1129	
1996	mt	173	322	326	274	1094	547
	N			1	1	2	
	# fish			72	121	193	
1997	mt	339	357	310	314	1319	55
	N	14	7	1	2	24	
	# fish	1162	679	99	147	2087	

Table H6. Cont.

		unclassified					Sampling

		Q1	Q2	Q3	Q4	sum	Intensity
1998	mt	295	326	402	304	1327	74
	N	5	6	3	4	18	
	# fish	392	512	227	220	1351	
1999	mt	397	423	388	349	1557	87
	N	3	6	4	5	18	
	# fish	234	514	364	478	1590	
2000	mt	374	466	442	307	1589	227
	N	3			4	7	
	# fish	250			388	638	
2001	mt	493	583	360	236	1672	80
	N	5	6	7	3	21	
	# fish	440	570	660	255	1925	
2002	mt	188	215	308	197	908	91
	N	5	1	2	2	10	
	# fish	448	70	213	193	924	
2003	mt	169	168	243	228	808	37
	N	5	7	7	3	22	
	# fish	389	679	746	257	2071	
2004	mt	145	175	236	118	674	28
	N	4	3	12	5	24	
	# fish	370	385	1134	431	2320	
2005	mt	102	116	157	54	430	19
	N	8	3	5	7	23	
	# fish	696	334	491	717	2238	
2006	mt	80	117	186	69	453	16
	N	8	6	5	10	29	
	# fish	688	567	496	743	2494	
2007	mt	83	109	169	88	449	8
	N	11	19	9	15	54	
	# fish	982	1837	843	1200	4862	
2008	mt	110	156	171	150	587	12
	N	14	13	9	14	50	
	# fish	1332	1228	803	1380	4743	
2009	mt	144	200	166	104	613	23
	N	8	6	6	7	27	
	# fish	781	605	557	590	2533	
2010	mt	120	225	167	90	603	20
	N	7	10	7	6	30	
	# fish	690	957	714	604	2965	

Table H7. Number of trips sampled and the resulting discards of red hake from otter trawl trips by the Domestic Observer Program, 1989-2010.

	OT					
	Half 1		Half 2		Total	
	trips	discards	trips	discards	trips	discards
1989	72	1867.7	104	2143.9	176	4011.6
1990	67	3996.3	71	1122.1	138	5118.4
1991	92	1676.6	164	1283.8	256	2960.4
1992	116	4118.5	70	1485.3	186	5603.9
1993	37	1461.7	29	1075.8	66	2537.5
1994	28	186.8	35	544.2	63	730.9
1995	81	519.1	144	529.3	225	1048.4
1996	69	997.9	125	1110.9	194	2108.8
1997	72	3116.0	40	987.4	112	4103.3
1998	42	1574.1	28	6678.7	70	8252.9
1999	42	3060.5	66	950.1	108	4010.7
2000	108	2167.1	79	133.0	187	2300.1
2001	110	2051.7	172	73.9	282	2125.6
2002	76	28.7	290	330.6	366	359.3
2003	267	80.2	290	141.5	557	221.7
2004	371	249.0	688	400.5	1059	649.5
2005	855	267.5	1013	555.1	1868	822.6
2006	542	598.9	382	760.9	924	1359.8
2007	453	1456.0	616	1004.4	1069	2460.4
2008	513	515.6	573	417.2	1086	932.8
2009	671	214.3	856	612.1	1527	826.4
2010	824	750.0	1096	485.4	1920	1235.3

Table H8. Number of length samples taken for white hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2010.

		SGN						OT					
		Half 1		Half 2		Total		Half 1		Half 2		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips			14	1	14	1	4	10	3	19	7	29
	len			512	2	512	2	123	916	154	1734	277	2650
1990	trips	6		8	1	14	1	3	4	1	5	4	9
	len	206		1197	32	1403	32	68	53	138	312	206	365
1991	trips	20	1	89	7	109	8	2	1	3	2	5	3
	len	2526	134	9973	30	12499	164	53	180	413	45	466	225
1992	trips	34	1	182	4	216	5	7	6	2	4	9	10
	len	1620	1	8473	4	10093	5	265	17	59	144	324	161
1993	trips	26	1	129	10	155	11	8	20	5	2	13	22
	len	1276	1	4001	13	5277	14	681	333	658	44	1339	377
1994	trips	10		81	3	91	3	12	37	8	7	20	44
	len	44		1835	12	1879	12	247	570	489	294	736	864
1995	trips	9	1	117	7	126	8	12	49	9	10	21	59
	len	167	1	2638	30	2805	31	1111	1375	697	372	1808	1747
1996	trips	11	2	78	2	89	4	8	16	6	13	14	29
	len	70	13	826	3	896	16	284	526	331	381	615	907
1997	trips	8		24	2	32	2	5	9	6	6	11	15
	len	85		427	4	512	4	117	93	110	64	227	157
1998	trips	8		31	1	39	1	3	2	1	1	4	3
	len	36		411	1	447	1	39	17	12	2	51	19
1999	trips	6		17	3	23	3	1		7	17	8	17
	len	79		218	20	297	20	23		113	287	136	287
2000	trips	7	2	5		12	2	7	5	15	10	22	15
	len	47	9	143		190	9	421	119	475	76	896	195
2001	trips	1	1	6	1	7	2	1	1	4		5	1
	len	15	3	4501	2	4516	5	46	43	2217		2263	43
2002	trips	1		10	1	11	1	4		35	15	39	15
	len	1		49	2	50	2	125		1050	189	1175	189
2003	trips	8	2	38	6	46	8	55	14	57	16	112	30
	len	16	5	362	24	378	29	2353	83	2477	246	4830	329
2004	trips	5	4	125	17	130	21	50	26	80	49	130	75
	len	28	6	1826	67	1854	73	1733	336	2147	733	3880	1069
2005	trips	6		155	10	161	10	158	61	131	72	289	133
	len	16		2225	21	2241	21	3442	597	3988	1075	7430	1672
2006	trips	10	2	24	1	34	3	81	35	54	25	135	60
	len	63	2	159	2	222	4	2231	535	1591	419	3822	954
2007	trips	3	1	25	1	28	2	54	29	64	40	118	69
	len	40	6	177	5	217	11	740	292	1427	252	2167	544

Table H8 cont. Number of length samples taken for white hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2010.

		SGN						OT					
		Half 1		Half 2		Total		Half 1		Half 2		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
2008	trips	7		37	3	44	3	59	23	80	58	139	81
	len	131		265	5	396	5	900	148	1779	741	2679	889
2009	trips	8	1	42	1	50	2	61	25	57	25	118	50
	len	147	1	514	1	661	2	1582	109	1413	176	2995	285
2010	trips	12	1	36	1	48	2	60	15	24	13	84	28
	len	820	3	571	1	1391	4	2111	96	1335	80	3446	176

Table H9. Number of length samples taken for red hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2010.

		SGN						OT					
		Half 1		Half 2		Total		Half 1		Half 2		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips				1		1		14	3	11	3	25
	len				1		1		1352	297	859	297	2211
1990	trips								4	2	5	2	9
	len								383	157	755	157	1138
1991	trips	2	1	1	6	3	7		1	2	10	2	11
	len	2	2	21	7	23	9		45	151	643	151	688
1992	trips	9	2	8	1	17	3	7	13	9	5	16	18
	len	12	4	16	1	28	5	633	2190	624	536	1257	2726
1993	trips	2		2	1	4	1	3	4	2	6	5	10
	len	2		6	1	8	1	228	741	250	680	478	1421
1994	trips	2	1	5	1	7	2	1	4	1	3	2	7
	len	2	1	13	2	15	3	42	136	3	27	45	163
1995	trips			6		6		2	4	12	4	14	8
	len			8		8		80	102	972	42	1052	144
1996	trips	1	2	3	2	4	4			1	15	1	15
	len	1	2	30	4	31	6			17	1187	17	1187
1997	trips							1	4	1	7	2	11
	len							122	203	2	874	124	1077
1998	trips	2				2			4		2		6
	len	2				2			442		251		693
1999	trips	1	1	2	3	3	4		2	1	7	1	9
	len	1	2	20	5	21	7		210	13	302	13	512
2000	trips		3		1		4		5		6		11
	len		22		1		23		540		158		698
2001	trips	1	1	2	1	3	2		3		1		4
	len	18	3	16	3	34	6		21		99		120
2002	trips		1	3	2	3	3		1	19	25	19	26
	len		1	12	6	12	7		26	870	544	870	570
2003	trips	3	9		2	3	11	2	17	4	15	6	32
	len	5	12		5	5	17	114	232	57	442	171	674
2004	trips		9	4	16	4	25	4	14	9	58	13	72
	len		12	27	29	27	41	96	460	366	2380	462	2840
2005	trips		1	2	6	2	7	6	51	13	60	19	111
	len		1	3	10	3	11	42	1021	655	2175	697	3196
2006	trips				2		2	3	30	6	24	9	54
	len				2		2	5	530	614	1322	619	1852
2007	trips							13	26	8	23	21	49
	len							641	1248	592	1366	1233	2614

Table H9 cont. Number of length samples taken for red hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2010.

		SGN						OT					
		Half 1		Half 2		Total		Half 1		Half 2		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
2008	trips	1	1		1	1	2	2	17	3	35	5	52
	len	1	1		2	1	3	10	347	21	311	31	658
2009	trips	1		1	1	2	1	7	13	8	33	15	46
	len	1		1	2	2	2	268	100	118	1244	386	1344
2010	trips	1	1	1	1	2	2	1	10	2	15	3	25
	len	1	2	1	2	2	4	111	606	83	546	194	1152

Table H10. Catch (split landings and otter trawl discards) used in GARM III assessment from 1963-2007 and updated through 2010. The value for 1963 was estimated using a linear ramp down from 1950-1964. Nominal catch (raw landings and otter trawl discards) from 1989-2010.

GARM III Catch				Nominal Catch	
Year	Catch	Year	Catch	Year	Catch
1963	4100	1988	6976		
1964	3995	1989	7955	1989	5812
1965	3434	1990	8154	1990	6769
1966	2051	1991	8215	1991	6403
1967	1498	1992	12602	1992	10098
1968	1699	1993	10342	1993	9782
1969	1815	1994	7108	1994	5911
1970	2799	1995	5791	1995	4980
1971	3801	1996	4108	1996	3774
1972	4127	1997	3391	1997	2683
1973	4462	1998	3724	1998	2653
1974	5255	1999	4462	1999	3355
1975	5010	2000	4375	2000	3385
1976	5641	2001	5998	2001	3981
1977	7196	2002	3763	2002	3530
1978	6630	2003	5081	2003	4814
1979	5641	2004	4229	2004	3687
1980	6630	2005	3136	2005	2821
1981	8428	2006	2256	2006	1833
1982	9112	2007	2163	2007	1599
1983	9471	2008	1911	2008	1523
1984	10195	2009	2375	2009	1886
1985	10898	2010	2219	2010	2057
1986	9270				
1987	8362				

Table H11. Minimum, mean, and maximum length of white hake from the commercial fishery nominal catch. The 5th, 50th and 95th percentiles of length composition are also provided.

	Min Length	5% Length	Mean Length	50% Length	95% Length	Max Length
1989	19	27	51.4	49	76	123
1990	20	26	43.2	37	68	135
1991	17	19	44.8	49	71	132
1992	17	19	43.5	45	75	126
1993	9	24	50.1	51	72	130
1994	8	15	44.5	48	76	121
1995	6	18	49.7	51	70	127
1996	9	17	52.6	56	76	120
1997	18	26	56.8	60	82	111
1998	18	31	66.6	69	88	106
1999	18	26	49.5	41	85	109
2000	23	24	54.7	58	91	106
2001	23	27	56.6	57	88	114
2002	21	45	66.1	66	85	103
2003	20	33	67.8	71	91	112
2004	13	27	69.8	74	96	111
2005	12	23	65.5	68	98	136
2006	11	25	61.7	65	98	133
2007	16	33	69.7	71	95	139
2008	19	27	56.1	54	85	136
2009	21	35	65.1	64	88	129
2010	25	40	70.1	70	93	140

Table H12. AIC values for models fit to **white hake** length data.

Model	Model	-LL	# parameters	AIC_c	$\Delta(AIC_c)$	AIC_c Weights
1	All stations, constant (no length effect)	1586.674	2	3177.354	12.415	0.0017
2	Survey, S-S, constant	1584.259	4	3176.541	11.6022	0.0026
3	S,F,S-S, constant model	1576.446	6	3164.939	0	0.856
4	All stations, logistic model (free slope)	1579.413	5	3168.859	3.9203	0.1206
5	All stations, logistic model (declining slope)	1581.257	5	3172.547	7.6079	0.0191

Table H13. Stratified mean catch per tow in numbers and weight (kg) for white hake and associated CVs from NEFSC offshore spring research vessel bottom trawl surveys (strata 21-30,34-40), 1968-2011. The minimum, mean, and maximum lengths are shown in cm as well as the 5th, 50th, and 95th percentiles of the length composition. These have been revised since GARM III. The values for spring 2009-2011 have been adjusted using constant calibration factors of 2.235435 for numbers and 2.088108 for weight (Miller et al 2010). No other adjustments for vessel, gear or doors were significant. In 1975 strata 35 and 39 were not covered and in 1992 and 1999 stratum 35 was not occupied.

Year	No/Tow	CV No	Wt/Tow	CV Wt	Min Length	5% Length	Mean Length	50% Length	95% Length	Max Length	Non-zero tows	Total tows
1968	1.601	19.5	1.795	26.0	10	24	44.1	41	87	118	32	82
1969	3.772	22.1	5.320	19.3	17	27	46.5	49	78	127	41	81
1970	5.836	20.7	12.304	39.7	21	27	52.9	49	80	114	47	85
1971	3.343	17.6	5.354	20.7	17	28	51.3	39	78	121	45	90
1972	10.198	17.4	13.108	26.7	18	28	47.3	46	77	112	59	90
1973	9.240	23.7	12.636	20.6	18	30	49.9	57	79	120	55	81
1974	8.079	15.6	14.466	18.0	13	14	55.8	42	76	126	53	77
1975	9.315	18.5	11.229	16.5	9	27	44.8	48	82	115	48	81
1976	9.979	15.8	17.572	23.2	10	29	52.8	52	84	122	69	93
1977	6.125	19.2	11.391	19.6	22	26	55.6	46	82	127	56	101
1978	3.218	17.7	6.342	19.8	20	24	51.7	39	74	131	49	107
1979	5.256	18.0	5.135	24.8	16	28	43.0	45	79	113	66	127
1980	10.375	15.3	13.488	17.1	10	26	49.7	39	78	123	53	79
1981	16.907	14.1	20.364	28.5	11	29	46.2	46	77	131	64	81
1982	6.056	23.0	9.189	23.2	16	24	50.9	41	72	122	51	86
1983	3.225	15.3	3.226	16.2	15	29	43.7	49	75	102	54	84
1984	2.753	16.7	4.310	25.4	15	28	51.5	46	73	118	38	80
1985	4.328	16.0	5.565	21.4	20	25	48.5	35	68	117	39	75
1986	8.243	11.5	5.795	14.9	11	27	40.0	42	67	96	60	84
1987	7.145	13.3	6.656	14.9	12	23	45.2	37	69	128	49	77
1988	4.518	10.6	3.820	12.1	13	25	41.8	39	72	95	50	84
1989	3.650	22.3	3.220	31.7	16	26	43.0	54	76	92	42	79
1990	11.110	47.2	18.996	74.1	22	24	53.3	39	67	119	50	83
1991	8.424	12.9	6.351	17.4	9	28	41.8	43	66	131	54	80
1992	7.593	17.8	7.114	25.7	22	25	45.1	43	67	105	48	80
1993	7.926	15.6	7.073	17.6	17	25	45.1	36	64	85	48	81

Table H13 cont. Stratified mean catch per tow in numbers and weight (kg) for white hake and associated CVs from NEFSC offshore spring research vessel bottom trawl surveys (strata 21-30,34-40), 1968-2011. The minimum, mean, and maximum lengths are shown in cm as well as the 5th, 50th, and 95th percentiles of the length composition. These have been revised since GARM III. The values for spring 2009-2011 have been adjusted using constant calibration factors of 2.235435 for numbers and 2.088108 for weight (Miller et al 2010). No other adjustments for vessel, gear or doors were significant. In 1975 strata 35 and 39 were not covered and in 1992 and 1999 stratum 35 was not occupied.

Year	No/Tow	CV No	Wt/Tow	CV Wt	Min Length	5% Length	Mean Length	50% Length	95% Length	Max Length	Non-zero tows	Total tows
1994	4.586	14.5	3.284	24.0	18	28	40.1	41	71	96	55	82
1995	4.377	13.7	4.155	18.3	14	19	44.1	45	69	100	47	82
1996	2.872	12.5	3.174	14.1	12	24	46.3	38	55	104	46	76
1997	1.875	16.5	0.917	17.8	18	25	38.6	33	59	67	36	83
1998	2.247	15.3	1.129	18.1	18	26	37.7	41	69	74	53	109
1999	3.307	23.9	2.967	35.8	10	25	44.7	36	65	89	44	81
2000	5.186	13.2	3.444	15.5	14	27	40.5	46	69	75	53	83
2001	4.861	13.2	5.369	17.0	12	25	48.3	50	70	108	45	83
2002	5.143	19.6	6.543	24.2	17	27	49.0	38	75	124	47	85
2003	5.160	13.8	5.925	15.1	16	24	46.5	42	74	110	40	82
2004	4.911	21.6	5.365	36.9	19	22	46.0	43	92	99	41	82
2005	3.779	14.4	5.705	24.3	15	21	48.8	31	69	106	41	81
2006	2.559	13.4	1.510	19.7	17	27	37.0	43	76	97	53	89
2007	2.506	16.0	2.855	29.1	19	21	47.0	38	61	110	39	80
2008	6.337	22.6	3.899	31.9	10	19	39.3	37	62	84	52	80
2009	7.009	17.2	4.608	24.1	13	24	39.6	39	68	89	80	106
2010	6.126	14.8	5.481	19.0	12	27	43.3	44	72	91	81	98
2011	4.949	12.9	5.126	15.8	8	29	46.6	45	72	93	69	86

Table H14. Stratified mean catch per tow in numbers and weight (kg) for white hake and associated CVs from NEFSC offshore autumn research vessel bottom trawl surveys (strata 21-30,34-40), 1963-2010. The minimum, mean, and maximum lengths are shown in cm as well as the 5th, 50th, and 95th percentiles of the length composition. These have been revised since GARM III. The values for 2009-2010 have been adjusted using constant calibration factors of 2.235435 for numbers and 2.088108 for weight (Miller et al 2010). No other adjustments for vessel, gear or doors were significant. In 1979 and 1983 stratum 35 was not occupied.

Year	No/Tow	CV No	Wt/Tow	CV Wt	Min Length	5% Length	Mean Length	50% Length	95% Length	Max Length	Non-zero tows	Total tows
1963	5.391	12.2	7.170	18.5	13	23	47.5	44	74	121	53	86
1964	1.765	17.1	4.174	20.8	24	31	56.6	51	101	123	36	82
1965	4.501	19.2	6.915	17.1	15	27	50.1	45	79	125	57	83
1966	7.052	13.2	7.800	13.1	18	26	45.0	40	72	121	60	77
1967	3.862	15.1	3.805	18.2	20	22	43.3	40	70	117	52	81
1968	4.368	20.2	4.678	23.5	11	23	45.0	42	71	120	53	80
1969	9.499	12.0	12.293	14.8	14	23	46.8	42	74	112	60	82
1970	8.182	12.1	13.132	15.6	21	26	51.5	50	77	119	65	85
1971	10.282	21.0	12.473	11.2	12	25	44.6	40	74	130	72	88
1972	12.789	27.7	13.481	17.8	9	24	45.4	42	72	122	71	88
1973	9.234	15.2	13.762	16.5	8	26	51.8	49	80	119	69	86
1974	5.389	12.1	11.330	14.2	19	26	55.2	53	83	130	69	91
1975	5.325	12.3	7.340	12.9	15	25	48.5	43	81	116	71	100
1976	6.235	16.5	10.903	15.3	8	33	54.7	51	81	134	67	82
1977	10.048	10.6	14.158	12.0	10	22	47.9	44	81	123	93	119
1978	7.988	10.7	12.576	11.8	12	26	50.0	44	82	131	142	187
1979	5.700	11.4	10.550	15.2	22	33	53.2	47	83	127	153	199
1980	11.031	16.6	17.100	24.3	4	8	49.1	49	78	118	74	91
1981	8.479	11.1	12.269	10.6	22	31	50.7	45	79	132	61	84
1982	1.904	16.3	2.022	19.8	12	25	46.4	44	75	93	46	89
1983	8.487	13.1	11.132	12.5	22	29	48.8	43	73	117	57	76
1984	5.345	9.2	8.396	10.2	22	27	52.3	49	77	123	65	82
1985	9.596	14.2	10.038	17.1	9	22	43.1	40	74	128	66	83
1986	14.830	11.0	11.871	9.0	10	17	41.9	40	68	108	76	85
1987	7.800	9.7	9.908	15.1	17	26	49.2	46	76	113	59	81
1988	8.385	11.1	10.187	15.6	19	27	46.1	41	69	136	68	83
1989	12.160	16.6	9.551	10.2	9	19	40.5	39	71	91	68	81
1990	13.372	13.1	10.831	18.1	5	12	41.6	39	64	83	69	83

Table H14 cont. Stratified mean catch per tow in numbers and weight (kg) for white hake and associated CVs from NEFSC offshore autumn research vessel bottom trawl surveys (strata 21-30,34-40), 1963-2010. The minimum, mean, and maximum lengths are shown in cm as well as the 5th, 50th, and 95th percentiles of the length composition. These have been revised since GARM III. The values for 2009-2010 have been adjusted using constant calibration factors of 2.235435 for numbers and 2.088108 for weight (Miller et al 2010). No other adjustments for vessel, gear or doors were significant. In 1979 and 1983 stratum 35 was not occupied.

Year	No/Tow	CV No	Wt/Tow	CV Wt	Min Length	5% Length	Mean Length	50% Length	95% Length	Max Length	Non-zero tows	Total tows
1991	13.602	13.4	12.602	17.4	16	24	44.6	41	69	94	74	83
1992	10.363	8.1	11.559	9.8	16	30	47.9	46	67	115	66	81
1993	10.439	11.0	11.858	12.3	14	24	47.7	47	68	86	71	80
1994	8.553	10.9	7.218	14.6	3	21	42.5	41	66	88	70	81
1995	9.812	9.3	8.449	11.0	3	4	40.8	41	66	126	70	87
1996	4.672	9.7	6.565	12.9	10	25	51.2	51	70	97	56	82
1997	4.834	12.1	4.689	14.1	18	21	41.5	37	70	118	63	84
1998	4.549	9.5	4.417	11.6	12	25	44.5	41	67	97	71	98
1999	5.811	19.3	3.537	14.2	11	17	36.3	30	62	92	70	100
2000	7.741	11.0	6.912	11.2	5	25	43.9	41	66	110	60	81
2001	5.928	10.8	8.242	9.8	19	35	52.7	51	69	99	57	84
2002	7.027	22.6	6.951	14.8	17	21	42.3	38	71	110	56	80
2003	4.708	15.7	5.068	17.3	12	22	44.7	41	75	87	50	82
2004	3.646	12.1	3.849	14.2	17	23	44.9	40	72	116	59	79
2005	3.417	12.8	3.711	15.1	18	22	45.5	42	73	114	48	81
2006	4.842	10.0	4.297	10.8	9	25	43.1	38	70	111	64	88
2007	6.655	12.2	7.046	14.3	10	25	47.3	46	64	118	64	84
2008	7.657	12.2	7.175	15.2	4	12	43.2	42	69	92	64	84
2009	5.767	11.7	4.841	14.4	12	23	42.4	40	64	98	71	79
2010	7.941	13.4	7.569	16.7	12	24	44.4	42	66	96	70	77

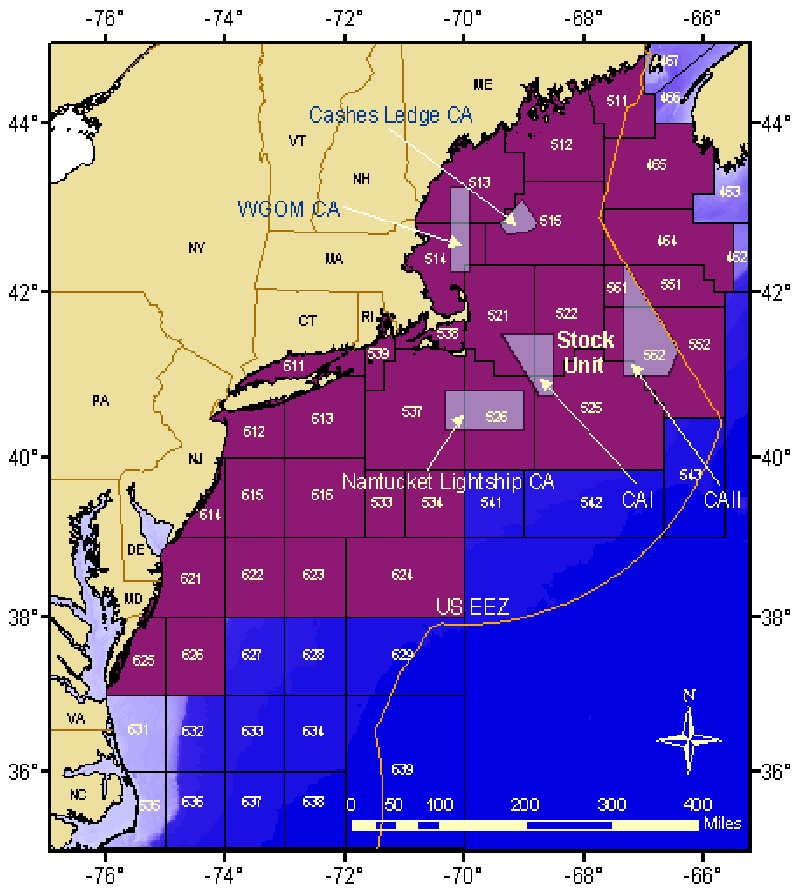

Figure H1. Map showing statistical areas used in the white hake stock unit.

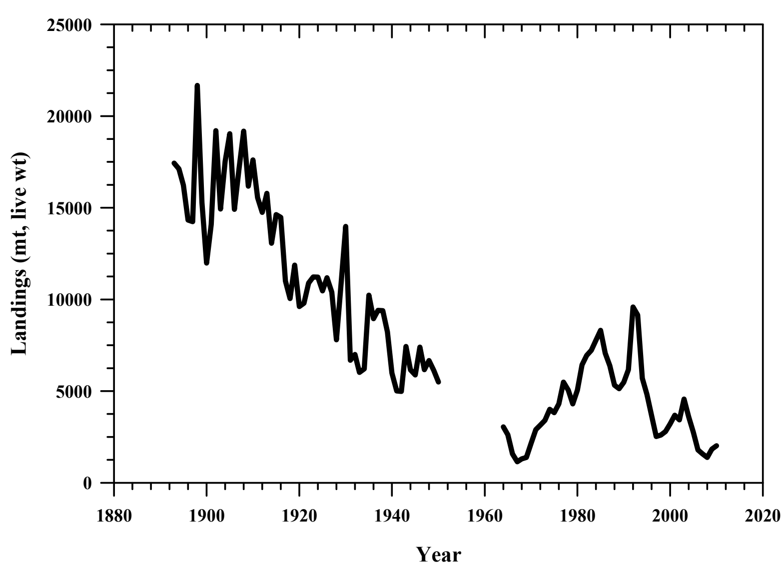

Figure H2. Reported total nominal landings of white hake (mt, live weight) from the Gulf of Maine to Mid-Atlantic region, 1893-2010.

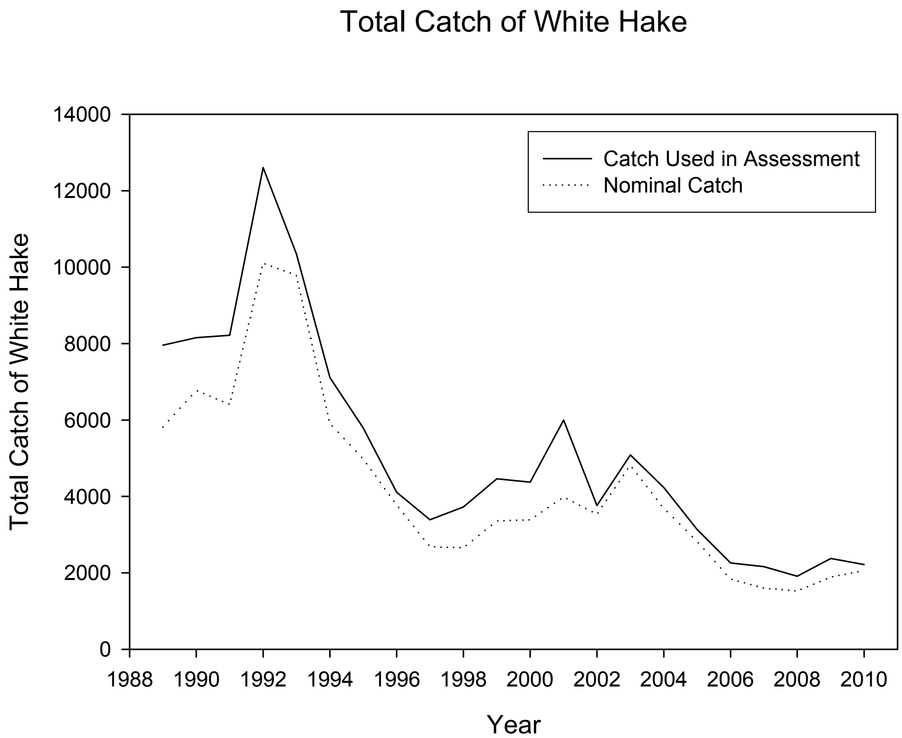

Figure H3. Total catch of white hake from 1989-2010 using just white hake data (Nominal Catch) and using survey data to split out combined red and white hake catches (Catch Used in Assessment).

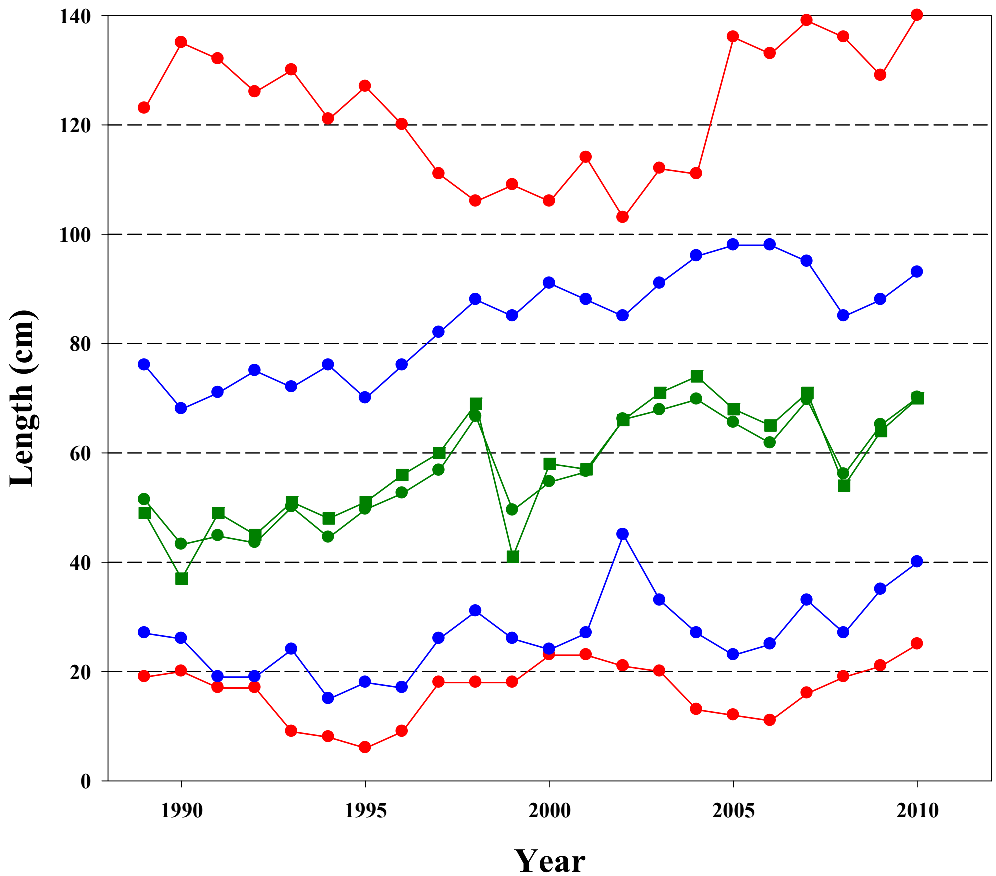

Figure H4. Minimum, mean, and maximum lengths (cm) of white hake from the commercial catch from 1989-2010. The 5th, 50th (squares), and 95th percentiles of length composition are also shown.

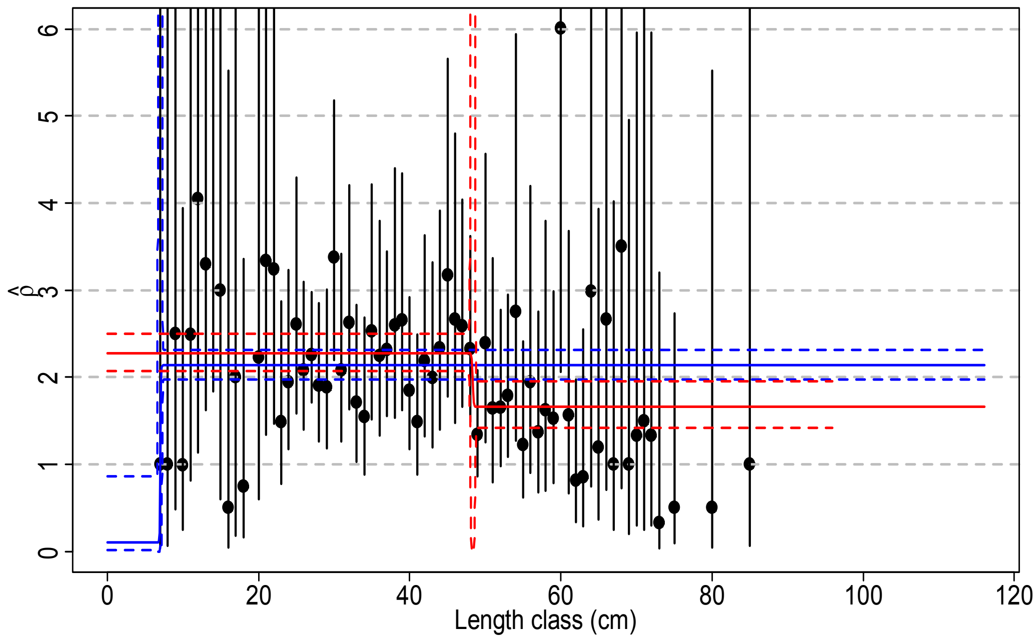

Figure H5. Beta-binomial based estimates of calibration factors and corresponding 95% confidence intervals by length class (1 cm bins) for **white hake**. The black points and vertical bars represent results where different calibration factors are estimated for each length class. The blue lines represent results from logistic model where the slope is estimated to be positive whereas the red lines represent results from a logistic model where the slope is forced to be negative.

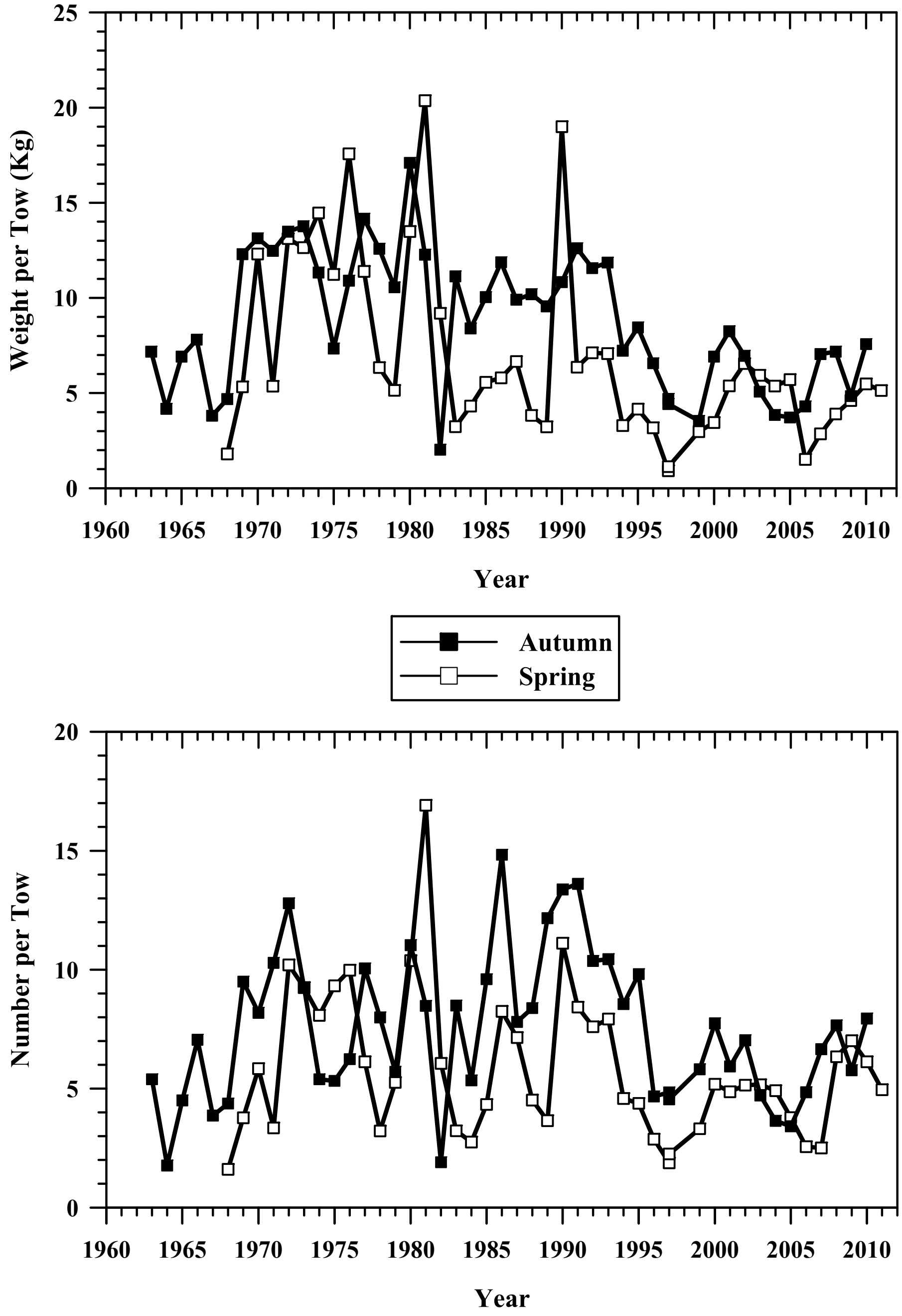

Figure H6. White hake indices of biomass (top panel) and abundance (bottom panel) from the NEFSC bottom trawl spring (open squares) and autumn (solid squares) surveys in the Gulf of Maine to Northern Georges Bank region (offshore strata 21-30, 34-40), 1963-2011.

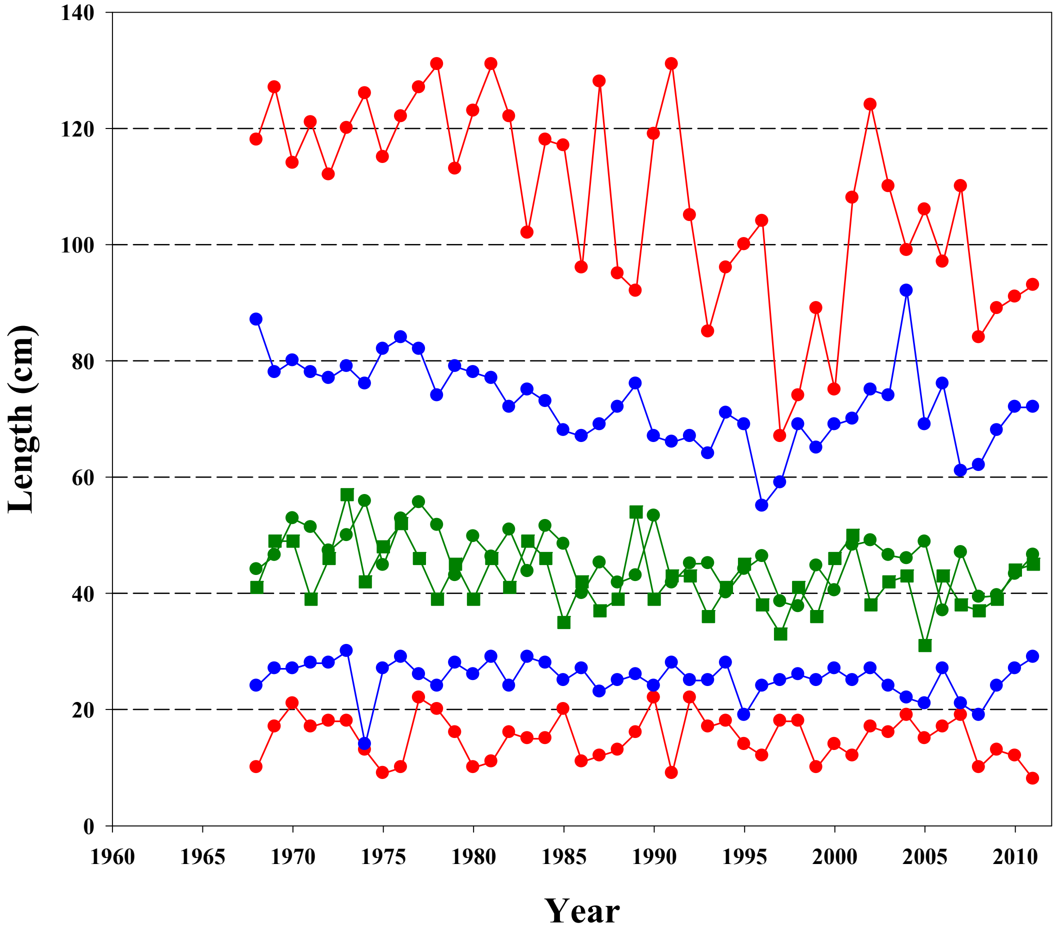

Figure H7. Minimum, mean, and maximum length (cm) of white hake from the NESFC spring surveys from 1968-2011. The 5th, 50th (squares), and 95th percentiles of length composition are also shown.

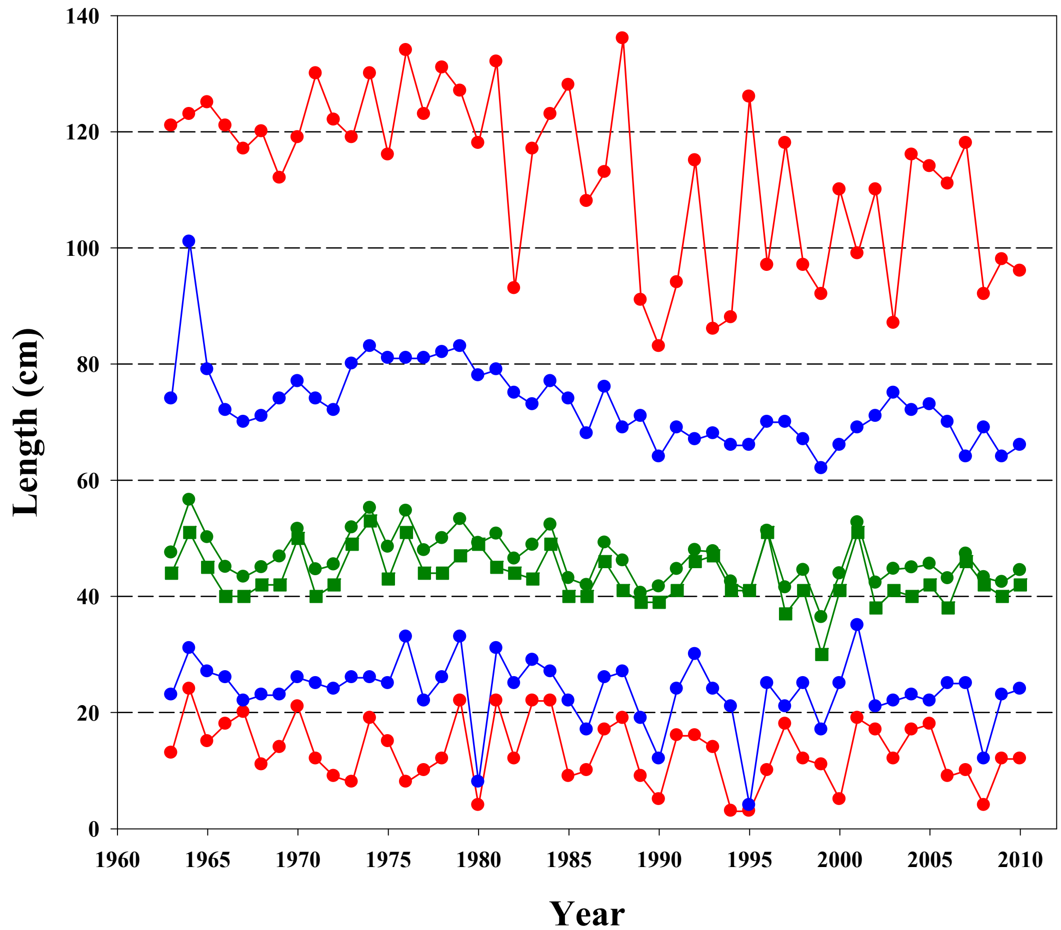

Figure H8. Minimum, mean, and maximum length (cm) of white hake from the NESFC autumn surveys from 1963-2010. The 5th, 50th (squares), and 95th percentiles of length composition are also shown.

I. Gulf of Maine-Georges Bank windowpane flounder
by Lisa Hendrickson

1.0 Background

Windowpane flounder (*Scophthalmus aquosus*) is a left-eyed, flatfish species which is primarily found between the high water mark and 50 m, but also inhabits depths of up to 200 m in the Gulf of Maine (Klein-MacPhee 2002). The Gulf of Maine-Georges Bank (GOM-GB) windowpane flounder stock was most recently assessed in 2008 at a Groundfish Assessment Review Meeting (GARM III) using "An Index-based Model" (AIM) for the period 1975-2007 (NEFSC 2008). Input data to AIM consisted of U.S. discards, U.S. landings, and relative biomass indices derived from the fall surveys conducted by the Northeast Fisheries Science Center (NEFSC).

The current biological reference points (BRPs) were adopted at the 2008 GARM (NEFSC 2008) and promulgated via Amendment 16 to the Northeast Multispecies Fishery Management Plan (NEFMC 2009). The current BRPs are: F_{MSY} proxy = 0.50 kt/kg per tow and B_{MSY} proxy = 1.40 kg per tow. The F_{MSY} proxy was estimated from the AIM model and the MSY proxy was assumed as the median catch during 1995-2001, a period when the stock appeared to be able to replace itself based on the AIM replacement ratios. The MSY proxy was divided by the F_{MSY} proxy to compute the B_{MSY} proxy. Based on the results from the 2008 GARM, the stock was overfished and overfishing was occurring in 2007 (NEFSC 2008). Rebuilding is required by 2017 (NEFMC 2003).

The stock assessment provided herein does not represent a simple update of the 2008 assessment because the entire catch and survey biomass time series were revised. It was necessary to re-compute the relative biomass time series using catches from a different survey strata set which excludes depths that cannot be sampled by the FSV *H. B. Bigelow* (i.e., depths ≤ 18 m), which replaced the RV*Albatross IV* in 2009. In addition, it was necessary to revise the entire discard time series to account for recent corrections made to the Northeast Fisheries Observer Program (NEFOP) Database regarding some windowpane flounder hail weights. The 2007 landings data were also updated. The same AIM model configuration from the 2008 assessment was utilized and the catch and relative biomass indices for 2008-2010 were added to the revised time series. It was also necessary to re-estimate the BRPs, in order to be consistent with the revised data series used in AIM.

2.0 The Fishery

Landings

Statistical Areas used for reporting fishery data for the GOM-GB windowpane flounder stock include: 511-525, 542-543, 551-552, and 561-562 (Figure I1). U.S. commercial landings and fishery-related data for windowpane flounder are available beginning in 1975. Several different methods have been used to collect the landings, fishing area and effort data. During 1963 through April of 1994, such data were collected and entered into Northeast Region Commercial Fisheries Database (CFDBS) by NMFS port agents, who entered landings data from all dealer purchase receipts and interviewed a subset of captains to obtain information about fishing location and effort (Burns *et al*. 1983). During May of 1994-2003, reporting of landings by vessel and trip was mandatory for dealers issued federal permits to purchase groundfish. The data were collected and entered into the CFDBS by NMFS port agents. Since 2004, such data have been self-reported, electronically, by federally permitted dealers. Beginning in May of 1994, mandatory reporting of fishing location and effort data, gear type, estimated kept and discarded catch, and other trip-based fishing data were self-reported by fishermen on logbooks (i.e., Vessel Trip Reports or VTRs) and the data were entered into the Vessel Trip Report Database. In order to integrate data from the VTR Database with data from the CFDBS, an "allocation" database was created using a trip-based allocation scheme (Wigley et al. 2008a). Data retrieved from the allocation database were used to assign landings, by Statistical Area, to each of the two windowpane flounder stocks.

Landings of GOM-GB windowpane flounder were updated for 2007 and extended through 2010. During most years, at least 98% of the landings were taken with bottom trawls, but during 1987-1994, 2.8-6.0% of the landings were taken with scallop dredges (Table I1). Landings were highest (1,079 - 2,862 mt) during 1985-1993 when a directed fishery existed (Figure I2, I2). Since 1994, landings have occurred as a result of bycatch, primarily in the groundfish bottom trawl fleet. During 1994-2000, landings averaged 399 mt, but then declined further and averaged only 33 mt during 2001-2006. Landings increased to 117 mt in 2007, but then declined again and reached the lowest level on record in 2010 (0.4 mt) as a result of a prohibition on possession. Possession of GOM-GB windowpane flounder was initially prohibited by a NMFS interim action on May 1, 2009 and was extended through the 2010 fishing year via Amendment 16 (NEFMC 2010) and will remain in effect for fishing year 2012 (T. Nies pers. comm.).

<u>Discards</u>

Discards (mt) of GOM-GB windowpane flounder and estimates of their precision were initially provided for 1975-2007 at the 2008 GARM (NEFSC 2008). The combined ratio method of Wigley *et al.* (2008b), which is based on a ratio estimate pooled across all strata and trips within each fleet, was used to estimate discards for 1989-2010. For each trip, a combined discard to kept (d/k) ratio was computed using NEFOP data, where d = discard weight of GOM-GB windowpane flounder and k = kept weight of all species. The discard ratios were then expanded by the total weight of all species landed during a trip (using landings from the CFDBS) to estimate total discard weight.

Discards were estimated for the large mesh bottom trawl fleet (codend mesh size ≥ 5.5 inches), small mesh bottom trawl fleet (codend mesh size < 5.5 inches), and the sea scallop dredge fleet ("limited permits" only). Due to low numbers of trips sampled by quarter, the small mesh bottom trawl and scallop dredge fleets were binned by half year to derive discard estimates. For both fleets, imputations were necessary during years where fewer than two trips were available. There were no observed trips for the scallop fleet during 1989 and 1990 and only one trip in 1991. As a result, scallop fleet discards for 1989-1991 were estimated using the hindcast method described below. Discards from the large mesh bottom trawl fleet were estimated by quarter and cells with fewer than two trips were imputed using annual values. Discards were hindcast for the large mesh bottom trawl fleet (1982-1988), small mesh bottom trawl fleet (1975-1988), and the scallop dredge fleet (1975-1991) based on the following equation:

(1) $$\hat{D}_{t,h} = \bar{r}_{c,1989-1991,h} * K_{t,h}$$

where:

$\hat{D}_{t,h}$ is the annual discarded pounds of windowpane flounder for fleet *h* in year *t*

$\bar{r}_{c,1989-1991,h}$ is an average combined D/K ratio (discarded pounds of windowpane flounder / total pounds of all species kept) for the fleet *h* during either 1989-1991 (for the trawl fleets) or 1992-1998 (for the scallop fleet)

$K_{t,h}$ is the total pounds of all species kept (landed) for fleet *h* in year *t*

For the subject stock assessment, the 1975-2007 discard time series was revised using the same methods that were used for the 2008 assessment (NEFSC 2008), in order to account for recent corrections made to the NEFOP Database. Discards were estimated anew for 2008-2010. The NEFOP database errors were discovered when NEFOP staffs were asked by New England Fishery Management Council staff to examine several scallop dredge hauls, conducted in the southern windowpane flounder stock area, with unusually large quantities of windowpane flounder discards during 2010. Following an audit of windowpane catches for these hauls, it was determined that the database errors were primarily related to incorrect assignments, by editors, of the windowpane species code. Some catches recorded by observers as "sand dollar" were incorrectly assigned the "sand dab" or windowpane flounder species code. Therefore, the NEFOP Database hail weights (discard plus kept weight) of both stocks of windowpane flounder, for all scallop dredge and scallop trawl hauls reviewed by the subject editors, were checked against the original haul logs to identify and correct windowpane species coding errors as well as any other errors associated with windowpane flounder hail weights. In addition, all database haul records with scallop dredge and scallop trawl hail weights of ≥ 50 lbs of windowpane flounder were compared with the original haul logs to identify and correct any hail weight errors pertaining to windowpane flounder.

NEFOP Database errors involving hail weights of GOM-GB windowpane flounder occurred during a subset of years beginning in 1995. For the SNE-MAB stock, most (68%) of the total incorrect hail weight of windowpane flounder involved scallop dredge hauls for which sand dollars were miscoded as windowpane flounder. However, most (67%) of the total incorrect hail weight of GOM-GB windowpane flounder was attributable to hail weight keypunch errors for bottom trawl hauls. Some hail weight errors were also attributable to observer miscalculations and species miscoding by editors.

Most of the NEFOP database errors involved discards, but two records (in 2000 and 2005) totaling 8,153 pounds (3.7 mt) were also erroneously entered as kept weights of GOM-GB windowpane flounder. The net effect of the corrections was a reduction in the database discard weights of GOM-GB windowpane flounder. During most years, the discard reductions represented small percentages of the total database discards of GOM-GB windowpane flounder for both gear groups. Reductions in the database discards of windowpane flounder for scallop dredges were minor, totaling 272 lbs. (0.123 mt) during all four years combined, and ranged from 0.5% of the scallop dredge discard total in 2007 to 22.1% in 1995 (Tables I3 and I4). Database reductions in windowpane flounder discards for bottom trawls were also minor, totaling 9,259 lbs (4.2 mt) during all years combined, and ranged from 0.3% of the bottom trawl discard total in 2010 to 20.9% in 2000.

During most years, discards were primarily (> 70%) from the large mesh bottom trawl fleet (considered as the small mesh bottom trawl fleet prior to 1982 when the minimum codend mesh size was less than 5.5 inches). However, the scallop dredge fleet also contributed a substantial percentage (32%-57%) of the total discards during two time periods, 1977-1981 and 1987-1993 (Table I5). The small mesh bottom trawl fleet comprised a small percentage of the total discards, generally ≤ 7%, during most years. The CVs of the annual discard estimates for the small mesh fleet were the highest of all three fleets, and averaged 0.69 (Table I5). CVs for the scallop dredge and large mesh bottom trawl fleets averaged 0.42 and 0.38, respectively. Discard estimates for the large mesh bottom trawl fleet during 2002-2010 were more precisely estimated (CV range of 0.09-0.28) than during 1989-2001 (CV range of 0.32-0.92).

During the directed fishery period (1985-1993), windowpane flounder catches filled the market void left by depleted yellowtail flounder stocks, and landings exceeded discards (Figure I2). NEFOP data indicated that prior to the 2009 moratorium on possession; the primary reason for discarding was the lack of a market for this thin-bodied flatfish. There is no minimum size limit for landed fish, but the landings length composition data indicated that only the largest fish were retained (fish ≥ 29 cm) during 1994-2008. During the 1985-1993, discards averaged 27%, of the catch, but have since comprised a majority and averaged 92% during 2001-2010 (Figure I2, Table I2). In recent years, total discards (mostly from large mesh bottom trawls) increased from a record low of 58 mt in 1999 to 301 mt in 2004, and then increased further to 917 mt in 2007 (Table I2). During 2008-2010, discards were lower and ranged between 412 mt in 2009 and 235 mt in 2010. CVs of the total discard estimates averaged 0.30 and ranged between 0.09 and 0.69 during 1992-2010 (Table I5).

<u>Catch</u>

Differences between the revised catch time series and that from the 2008 assessment, for 1975-2007, reflect not only the NEFOP database edits described above, but also reflect any other updates or changes which may have occurred to all three of the databases (i.e., NEFOP, VTR and CFDBS Databases) which were used to estimate discards. The revised catch time series for 1975-2007 ranged from a reduction of 3.4% to an increase of 5.2%, with an average reduction of 2.0%, when compared with the 2008 GARM catch series (Table I2).

During 1975-2010, catches were highest during 1985-1991 and ranged between 2,000 mt and 3,657 mt (Table I2, Figure I2). Thereafter, catches declined to a time series low of 106 mt in 1999. During 2002-2007, catches generally increased due to increased discarding, primarily in the large mesh bottom trawl fleet (82-96% of the total discards). In 2007, catches reached the highest level (1,091 mt) since 1997. During 2008-2010, catches were lower and ranged between 440 mt in 2009 and 236 mt in 2010.

3.0 Research Survey Data

The Northeast Fisheries Science Center (NEFSC) conducts annual research bottom trawl surveys, between the Gulf of Maine and Cape Hatteras, North Carolina, during the spring and fall (Azarovitz 1981). Beginning in 2009, the FSV *Henry B. Bigelow* replaced the RV *Albatross IV* as the research vessel used to conduct the NEFSC surveys. The draft of the *Bigelow* is deeper than that of the RV *Albatross*, and as a result, inshore strata with depths ≤ 18 m can no longer be sampled. With respect to the GOM-GB windowpane flounder stock, the vessel change resulted in the exclusion of sampling in stratum 58 located in Cape Cod Bay. Windowpane flounder catches during NEFSC fall bottom trawl surveys conducted from 1975 onward were used to derive the relative biomass indices used in the stock assessment model. Therefore, the fall survey indices were recomputed for 1975-2010 without the inclusion of catches from inshore stratum 58. The revised strata set included offshore strata 13-30 and 37-40 along with inshore strata 59-61 and 65-66. Survey indices were standardized for changes in trawl doors (numbers = 1.54, weight = 1.67), gear (numbers = 1.67, weight = 1.37), and vessels (numbers = 0.82, weight = 0.80). Door conversion coefficients (Byrne and Forrester 1991a) were applied to the 1975-1984 catches and vessel conversion coefficients (Byrne and Forrester 1991b) were applied when the RV *Delaware II* was utilized instead of the RV *Albatross IV*.

A comparison of the differences between the 1979-2007 relative biomass indices from the 2008 assessment with biomass indices derived using the revised survey strata set suggest that the omission of windowpane flounder catches from inshore stratum 58 had little effect on the annual biomass indices (Figure I3). Inshore stratum 58 was sampled beginning in 1979 and although windowpane flounder catches occurred in the stratum during most (69%) years, such catches were low (average = 19 fish per tow). Biomass indices derived using the revised strata set were generally lower than the indices from the 2008 GARM, but the amounts were small; < 0.01 kg per tow during most years (Figure I3). The precision of the biomass estimates was slightly lower for the revised biomass time series, but increases in the CVs were < 1% during most years. The greatest reduction in biomass indices (0.057 kg per tow) and their precision (CV increase of 3.7%) occurred in 1992 (Figure I3).

In order to extend the NEFSC fall survey indices beyond 2008, catches of windowpane flounder by the SRV *H. B. Bigelow* were converted to RV *Albatross IV* equivalents to account for catchability differences between the vessels due to vessel, gear, and towing protocol differences. Calibration coefficients were computed from paired-tow studies conducted during the spring and fall of 2008 (Miller *et al*. 2010). Since AIM relies on biomass indices for all sizes combined, the influence of length-specific calibration effects are relatively unimportant in the model. Therefore, *Bigelow* catches of windowpane flounder were divided by constant calibration coefficients for catch numbers (2.044, SE = 0.2004) and weight in kg (1.901, SE = 0.2091) using a ratio estimator based on data from the fall calibration study (Miller et al. 2010).

Although annual relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices were highly variable, some general trends were evident. Indices were consistently above the 1975-2009 median (= 0.732 kg per tow) during 1976-1986, but then declined to levels that were generally below the median during 1987-1997 (Figure I4 and Table I6). During 1998-2003, biomass indices increased to levels at or slightly above the median during most years, but then fell below the median during 2004-2010 and ranged between 0.671 kg per tow in 2004 to 0.295 kg per tow in 2010.. CVs of the survey biomass indices from 2009 onward account for the variance associated with the *Bigelow* calibration factors. CVs (%) of the revised biomass time series averaged 29.7 and ranged between 16.6 and 55.9 (Table I6).

Relative abundance and biomass indices (stratified mean number and kg per tow, respectively) of windowpane flounder caught during Canadian (CA) spring (February) bottom trawl surveys (Georges Bank strata 5Z1-5Z4), during 1996-2011, were presented to the 2012 GARM Review Panel. Similar to the AIM run from the 2008 GARM, the CA spring survey indices were not included in the AIM run for the subject assessment. Relative biomass indices for the CA spring surveys were at their lowest levels during 2003-2011 (Figure A.I1), similar to the trend in biomass indices for the NEFSC fall surveys.

4.0 Assessment

AIM (version 2.2.0) software provided in version 3.1 of the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/) was used to assess the stock. AIM was run using the model formulation from the 2008 assessment, but with the revised catch and biomass indices for 1975-2010 (Table I7). As was done for the 2008 GARM, stock replacement ratios were computed as the NEFSC fall survey biomass index in year *t* / average biomass index for the previous five years. Relative fishing mortality rates were computed as the catch in year *t* / average fall survey biomass index during years *t* through *t*-2.

As a means of evaluating the applicability of the index method calculation to the data, a randomization test was performed based on 2,000 realizations (trim factor = 200). The randomization test evaluated the correlation between the **ln(replacement ratio)** and **ln(relative F) time series.** The critical value for the randomization test is the estimated correlation coefficient for the original catch and biomass index data. The significance level is the cumulative distribution probability evaluated at the critical value.

The AIM input data and model results for 1975-2010 are shown in Figure I5. A randomization test indicated that the correlation between the **ln(replacement ratio)** and **ln(relative F) was marginally significant (*p* = 0.090), similar to** the results from the 2008 AIM run (*p* = 0.087). Probability and cumulative distributions from the randomization test are shown in Figure I6. There was no trend in the standardized residuals from the model, but several values were greater than 2.0 (Figure I7).

5.0 Biological Reference Points

The current BRPs were adopted at the 2008 GARM (NEFSC 2008) and are: F_{MSY} proxy = 0.50 kt/kg per tow and B_{MSY} proxy = 1.40 kg per tow. The F_{MSY} proxy was estimated from the AIM model and represents the relative fishing mortality rate (catch in year *t* / average of the NEFSC fall survey biomass index during years *t* through *t*-2, in kt/kg per tow) at which the stock can replace itself. Stock replacement ratios were computed as NEFSC fall survey biomass index in year *t* / average biomass index for the previous five years. Based on trends in stock replacement ratios, during a period when catches were most precisely estimated (1989-2007), the stock appeared to be able to sustain itself at the catch levels which occurred during 1995-2001 (i.e., replacement ratios were near or above 1.0 during this period). Therefore, the median catch during 1995-2001 (= 700 mt) was considered as an MSY proxy. The MSY proxy was divided by the F_{MSY} proxy to compute the B_{MSY} proxy.

The current BRPs cannot be used to determine the 2010 stock status because the current BRPs were computed using biomass indices for a different survey strata set and a different catch series. Therefore, the 2010 stock status was determined based on re-estimated BRPs and the 1975-2010 revised input data. The re-estimated F_{MSY} proxy is 0.44 kt/kg per tow (90% CI = 0.24, 0.79, Figure I8), and based on the MSY proxy of 700 mt, resulted in a new B_{MSY} proxy of 1.60 kg per tow and a $B_{threshold}$ proxy of 0.80 kg per tow.

6.0 Projections

Stochastic projections of catches during 2008 and 2009 were run for the 2008 GARM using AIM (NEFSC 2008). However, the results were not used by the Science and Statistical Committee (SSC) to set the 2009 Acceptable Biological Catches (ABCs) for either of the windowpane flounder stocks. Instead, the SSC used the target fishing mortality rate, 75% of the F_{MSY} proxy, applied to the most recent three-year average of the relative biomass index from the NEFSC fall surveys to calculate the ABC.

Projected catches and relative biomass indices for 2011-2014 were estimated for the subject assessment, using AIM, in order to be consistent with the assessment methods from the 2008 GARM. Projections were run assuming fishing at the re-estimated F_{MSY} proxy (= 0.44 kt/kg per tow) and 75%F_{MSY} proxy (= 0.33 kt/kg per tow). Catch was 236 mt in 2010. Under the 75%F_{MSY} proxy scenario, which is used to provide catch advice, catches would increase by a small amount between 2013 and 2014, from 180 mt to 190 mt, respectively (Table I8, Figure I9).

7.0 Summary

Although the results are not presented herein, an AIM sensitivity run based on the revised biomass and catch series for 1975-2007 did not change the 2007 stock status determination (NEFSC 2008). The new 2007 relative F value of 2.08 kt/kg per tow was greater than the new F_{MSY} proxy of 0.51 kt/kg per tow and the new 2007 biomass index of 0.24 kg per tow was below the new $B_{Threshold}$ proxy (= 0.68 kg per tow). Therefore, the stock was overfished and overfishing was occurring in 2007.

Relative F in 2010 (= 0.51 kt/kg per tow), for the AIM run that incorporated the revised input data for 1975-2010, was above the re-estimated F_{MSY} proxy (= 0.44 kt/kg per tow), indicating that overfishing was occurring in 2010 (Table I9). The 2010 biomass index (= 0.46 kg per tow, the average from 2008-2010) was below the re-estimated $B_{threshold}$ (50% of B_{MSY} = 0.80 kg per tow), indicating that the stock was also overfished in 2010.

Sources of uncertainty

Catches were underestimated because discards from the Canadian scallop dredge and groundfish bottom trawl fleets were not available for inclusion in the assessment. However, quarterly maps of VMS fishing location data for observer trips for the Canadian scallop fleet (Van Eeckhaute et al. 2010), when compared to distribution maps of windowpane flounder catches during NEFSC spring and fall bottom trawl surveys, suggested spatial overlap. In addition, effort by the Canadian scallop dredge fleet has increased since 2004 due to an increase in the number of freezer trawlers, which have larger dredges (Van Eeckhaute 2010). Landings of groundfish bycatch have been prohibited in the Canadian scallop fishery since 1996, so presumably there are no windowpane flounder landings included in the Canadian landings of "unspecified flounder".

8.0 Panel Discussions/Conclusions

Status of Stock

The biomass index in 2010 (i.e., 2008-2010 average of the NEFSC fall survey) is estimated to be 0.46 kg per tow. Relative F in 2010 (i.e., catch in 2010/average biomass index during 2008-2010) is estimated to be 0.51 kt/kg per tow.

The Fmsy proxy was re-estimated in an AIM analysis that incorporated revised catch and relative biomass time series. The Bmsy proxy was also re-estimated based on the MSY value from the 2008 GARM. Revised estimates of the biological reference points are:

Bmsy proxy= 1.60 kg per tow,
Fmsy proxy = 0.44 kt/kg per tow, and
MSY proxy= 700 mt.

Based on these results, the stock of GOM-GB windowpane flounder is overfished and overfishing is occurring. The 2008 GARM determined that the stock was overfished and overfishing was occurring in 2007.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15), which includes the use of catch and NEFSC fall survey biomass indices, during 1975-2010, in AIM. However, the assessment is more than a simple update because the entire catch and biomass time series were re-estimated because of some NEFOP database corrections and the use of a different survey strata set to derive the biomass indices (i.e., the FSV *H. B. Bigelow* cannot sample strata ≤ 18 m deep), respectively.

The biological reference points are based on the following revisions: re-estimation of the F_{MSY} proxy using AIM and the MSY value from the 2008 GARM.

GOM-GB Windowpane Flounder. Summary of Assessment Information

GOM-GB Windowpane Flounder	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Landings (mt)	42	14	16	27	51	46	117	46	28	0.4	730	0.4	2862	1975-2010
Discards (mt)	186	162	361	301	917	637	974	329	412	235	522	58	1115	1975-2010
Catch (mt)	229	176	377	328	968	683	1091	376	440	236	1252	106	3657	1975-2010
SSB Proxy (kg/tow)	0.894	0.858	0.742	0.671	0.677	0.653	0.242	0.447	0.633	0.295	0.851	0.183	3.313	1975-2010
F relative	0.294	0.214	0.453	0.433	1.389	1.024	2.082	0.841	0.998	0.515	1.719	0.116	7.667	1977-2010

Reviewer Comments

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

Changes in discard estimates were relatively minor for the northern windowpane stock, but were considered to be an improvement, because they corrected data entry errors regarding windowpane hail weights, which occurred primarily in bottom trawls.

There was some ambiguity between the 2008 GARM and Amendment 16 to the Multispecies Fishery Management Plan regarding whether to use the terminal year biomass index (i.e., that used for stock status determination at the 2008 GARM) or a 3-year lagged biomass index for stock status determination. The Review Panel agreed to use the method in Amendment 16 (i.e., relative biomass index during 2008-2010).

Biomass indices from the NEFSC fall surveys were below the 1975-2009 median during 2004-2010. Biomass indices from a survey not used in the assessment, the February Canadian bottom trawl surveys on Georges Bank (i.e., 5Z1-5Z4), were also at their lowest levels during 2003-2011.

The 2008 GARM developed catch projections using AIM. Even though the SSC did not use AIM projections in 2009, these projections were conducted for this assessment to be consistent with the 2008 GARM methods.

Catches are under-estimated because discards of windowpane in the Canadian trawl and scallop dredge fisheries are not included in the assessment, but should be included in future assessments.

Validation of age determination and processing of archived age samples from NEFSC fall surveys would help to inform a more analytical assessment.

9.0 Acknowledgements

This assessment could not have been conducted without: data preparation and technical assistance provided by Susan Wigley; survey data collected and audited by ESB staffs; fishery data collected by NMFS port agents and REMSA staffs; observer data collected and audited by NEFOP and AIS staffs; and the database maintenance provided by DMS staffs.

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Table I1. Landings (mt) of GOM-GB windowpane flounder, by gear category, during 1975-2010.

	Landings (mt)					
Year	Bottom trawls	Scallop dredges	Gillnets	Other[1]	Total	Percent landed by bottom trawls
1975	1298.910	0.000	0.000	0.850	1,300	99.9
1976	1513.695	0.000	0.141	2.257	1,516	99.8
1977	1096.110	0.000	0.560	1.874	1,099	99.8
1978	879.896	0.939	0.113	17.455	898	97.9
1979	848.462	2.869	0.041	3.588	855	99.2
1980	383.089	2.815	0.018	2.469	388	98.6
1981	410.149	1.143	0.068	1.173	413	99.4
1982	406.948	1.767	0.067	3.513	412	98.7
1983	456.079	0.647	0.000	2.454	459	99.3
1984	737.549	1.329	0.797	2.494	742	99.4
1985	2137.158	1.447	0.094	2.745	2,141	99.8
1986	1810.333	23.925	4.365	2.815	1,841	98.3
1987	1354.375	38.751	0.242	2.461	1,396	97.0
1988	1315.494	59.954	1.200	0.849	1,377	95.5
1989	1508.006	57.302	10.563	1.580	1,577	95.6
1990	1002.372	64.796	9.840	2.081	1,079	92.9
1991	2735.956	124.213	0.791	1.382	2,862	95.6
1992	1433.726	79.144	1.782	4.596	1,519	94.4
1993	1151.025	47.972	0.666	14.718	1,214	94.8
1994	321.646	12.840	3.637	0.865	339	94.9
1995	662.976	0.872	2.389	1.597	668	99.3
1996	771.241	0.390	0.800	0.719	773	99.8
1997	413.116	0.479	0.587	2.031	416	99.3
1998	395.215	0.440	1.004	1.287	398	99.3
1999	48.174	0.212	0.056	0.045	48	99.4
2000	146.855	0.238	0.234	0.057	147	99.6
2001	42.386	0.069	0.018	0.011	42	99.8
2002	13.637	0.002	0.075	0.062	14	99.0
2003	16.293	0.000	0.098	0.057	16	99.1
2004	26.270	0.000	0.511	0.035	27	98.0
2005	49.732	0.000	0.079	0.915	51	98.0
2006	43.652	0.696	0.156	1.462	46	95.0
2007	116.649	0.401	0.015	0.000	117	99.6
2008	46.156	0.032	0.040	0.005	46	99.8
2009	27.799	0.047	0.101	0.001	28	99.5
2010	0.427	0.000	0.010	0.000	0.4	97.7

[1] Includes other gear types and unknown gear types.

Table I2. Landings, discards, and catches (mt) of GOM-GB windowpane flounder during 1975-2010 and differences (%) between these catches and those used in the 2008 AIM run for 1975-2007.

Year	Landings	Discards	Catch (mt)	Catch difference (%)
1975	1,300	251	1,551	-0.1
1976	1,516	275	1,791	-0.5
1977	1,099	404	1,502	-2.4
1978	898	454	1,352	-0.8
1979	855	516	1,370	-0.8
1980	388	570	958	-2.1
1981	413	626	1,039	-1.9
1982	412	802	1,214	-1.2
1983	459	881	1,340	-1.3
1984	742	801	1,544	-0.9
1985	2,141	680	2,821	-0.4
1986	1,841	614	2,456	-0.4
1987	1,396	605	2,000	-0.6
1988	1,377	677	2,055	-1.3
1989	1,577	457	2,034	-1.2
1990	1,079	1,031	2,110	-0.5
1991	2,862	794	3,657	0.3
1992	1,519	327	1,847	0.0
1993	1,214	383	1,597	1.1
1994	339	335	674	-1.1
1995	668	750	1,418	-3.4
1996	773	415	1,188	0.5
1997	416	1,115	1,531	-1.0
1998	398	271	669	-0.2
1999	48	58	106	1.7
2000	147	199	346	-1.0
2001	42	186	229	-1.8
2002	14	162	176	5.2
2003	16	361	377	1.8
2004	27	301	328	4.0
2005	51	917	968	1.2
2006	46	637	683	-0.5
2007	117	974	1,091	-0.7
2008	46	329	376	
2009	28	412	440	
2010	0.4	235	236	

Table I3. Discards (pounds) of GOM-GB windowpane flounder, by year and gear type, which were incorrect in the NEFOP Database. All values were subtracted from the original discard amounts of GOM-GB windowpane flounder recorded in the database. Most errors involved data keypunch errors.

Year	Windowpane database discards, lbs, by gear type (negear code)		
	Scallop dredge (132)	Bottom trawl (050)	Total
1995	81		81
2000		700	700
2004		210	210
2005	45	3,030	3,075
2006		2,130	2,130
2007	50	1,918	1,968
2008		1,051	1,051
2009	96		96
2010		220	220
Total	272	9,259	9,531

Table I4. Discards (%, in pounds) of GOM-GB windowpane flounder, by year and gear type, which were incorrect in the NEFOP Database. Values are expressed as percentages of the total database discards of GOM-GB windowpane flounder within each category. All values were subtracted from the original discard amounts of windowpane flounder recorded in the database. Most errors involved data keypunch errors.

Year	Windowpane database discards, % of total, by gear type (negear code)		
	Scallop dredge (132)	Bottom trawl (050)	Total
1995	22.1%		1.3%
2000		20.9%	7.8%
2004		0.7%	0.7%
2005	2.2%	0.9%	0.9%
2006		1.2%	1.2%
2007	0.5%	0.9%	0.9%
2008		1.2%	1.1%
2009	12.2%		0.1%
2010		0.3%	0.3%
Total	0.9%	0.9%	0.9%

Table I5. GOM-GB windowpane flounder discard estimates (mt) and CVs for large mesh bottom trawls (codend mesh size ≥ 5.5 in.), small mesh bottom trawls (codend mesh size < 5.5 in.), and scallop dredges (limited permits) during 1975-2010. Discards were hindcast for large mesh trawls (1982-1988), small mesh trawls (1975-1988), and scallop dredges (1975-1991) due to no sampling.

	Large Mesh Bottom Trawls			**Small Mesh Bottom Trawls**			**Scallop Dredges**			**Total**	
Year	**N Observer trips**	**Discards (mt)**	**CV**	**N Observer trips**	**Discards (mt)**	**CV**	**N Observer trips**	**Discards (mt)**	**CV**	**Discards (mt)**	**CV**
1975					200.9			50		251	
1976					213.2			62		275	
1977					267.6			136		404	
1978					291.9			162		454	
1979					305.2			210		516	
1980					344.6			225		570	
1981					329.0			297		626	
1982		360			206.7			235		802	
1983		616			89.0			176		881	
1984		631			48.7			121		801	
1984		536			40.2			104		680	
1986		441			35.3			138		614	
1987		420			19.7			165		605	
1988		406			23.0			248		677	
1989	52	193	0.48	41	1.8	0.74	0	262		457	
1990	38	598	0.36	19	59.9	0.60	0	373		1,031	
1991	70	482	0.47	38	1.4	0.74	1	311		794	
1992	60	145	0.48	25	0.0		9	182	0.74	327	0.46
1993	29	254	0.96	9	5.6	0.82	11	123	0.82	383	0.69
1994	24	113	0.42	2	158.3	0.00	7	63	0.48	335	0.17
1995	48	713	0.59	31	8.4	0.39	6	28	0.28	750	0.56
1996	23	355	0.43	41	0.6	0.75	14	59	0.17	415	0.37
1997	17	818	0.92	4	27.1	1.39	11	270	0.42	1,115	0.68
1998	9	193	0.42	1	0.0		10	78	0.71	271	0.36
1999	31	35	0.58	12	1.1	0.32	60	22	0.23	58	0.36
2000	93	124	0.32	6	55.5	0.70	183	19	0.12	199	0.28
2001	138	164	0.38	12	0.2	1.07	17	22	0.23	186	0.34
2002	205	134	0.21	49	7.0	0.66	10	21	0.45	162	0.18

2003	372	347	0.28	39	1.4	0.47	10	13	0.44	361	0.27
2004	423	279	0.26	92	15.2	0.41	30	7	0.42	301	0.24
2005	1,080	629	0.10	145	271.6	0.25	71	17	0.31	917	0.10
2006	516	522	0.14	42	42.4	0.45	84	73	0.40	637	0.13
2007	523	873	0.15	31	3.5	0.84	80	98	0.45	974	0.14
2008	665	286	0.10	19	0.4	2.19	57	43	0.35	329	0.10
2009	740	395	0.09	46	0.7	0.47	67	15	0.45	412	0.09
2010	917	223	0.14	65	3.8	0.47	26	9	0.60	235	0.13

Table I6. Stratified mean number and weight tow indices for GOM-GB windowpane flounder caught during NEFSC fall bottom trawl surveys, 1975-2010. Indices include catches from offshore strata 13-30 and 37-40 and inshore strata 59-61 and 65-66. Standardization coefficients were applied for trawl door changes which occurred in 1985 (numbers = 1.54, weight = 1.67) and for vessel changes which occurred during various years (numbers = 0.82, weight = 0.80). From 2009 onward, fall calibration factors were used to convert FSV *H. B. Bigelow* catches to RV *Albatross IV* catches (numbers = 2.04, weight = 1.90) and the associated CVs (%) were adjusted to account for the variances of the calibration factor estimates.

Year	Mean number per tow	CV (%)	Mean kg per tow	CV (%)
1975	9.1	61.8	0.629	47.5
1976	8.7	30.3	1.910	23.6
1977	9.0	24.5	2.033	22.4
1978	10.2	38.3	1.505	18.9
1979	4.1	17.1	0.945	16.6
1980	2.7	28.2	0.867	29.3
1981	3.9	29.0	1.022	29.8
1982	3.4	30.5	0.808	33.6
1983	3.3	26.9	0.940	26.4
1984	18.5	25.2	3.313	26.4
1985	10.9	28.8	0.823	23.0
1986	5.2	20.7	1.143	24.4
1987	3.4	52.9	0.626	47.6
1988	4.5	28.0	0.677	27.9
1989	1.4	36.1	0.323	35.0
1990	5.2	47.0	0.925	45.2
1991	1.1	21.6	0.183	22.2
1992	1.8	22.8	0.372	27.6
1993	4.2	41.5	0.465	28.2
1994	1.4	34.6	0.262	40.9
1995	7.4	28.1	0.790	27.9
1996	3.1	25.5	0.510	25.6
1997	4.9	46.0	0.425	29.2
1998	12.5	16.1	1.590	22.2
1999	4.2	24.3	0.732	23.8
2000	3.8	60.6	0.710	55.9
2001	9.9	34.1	0.894	21.7
2002	5.5	28.1	0.858	27.7
2003	4.6	29.7	0.742	31.9
2004	7.4	33.3	0.671	36.3
2005	9.0	39.3	0.677	26.4
2006	5.9	48.5	0.653	33.6
2007	15.6	38.7	0.242	29.1
2008	2.6	35.0	0.447	35.9
2009	4.8	23.5	0.633	20.1
2010	6.3	32.4	0.295	23.7

Table I7. AIM input data for the assessment of the GOM-GB windowpane flounder stock including: catch (000's mt); NEFSC fall survey relative biomass indices (stratified mean kg per tow); relative fishing mortality rates (catch in year *t* / average of the NEFSC fall survey biomass indices in year *t* through *t*-2, in kt/kg per tow); and stock replacement ratios (NEFSC fall survey biomass index in year *t* / average biomass index for the previous five years) during 1975-2010. Survey indices were derived using catches from offshore strata 13-30 and 37-40 plus inshore strata 59-61 and 65-66.

Year	Catch (000's mt)	Relative biomass index (kg per tow)	Relative F	Replacement ratio
1975	1.551	0.629		
1976	1.791	1.910		
1977	1.502	2.033	0.986	
1978	1.352	1.505	0.744	
1979	1.370	0.945	0.917	
1980	0.958	0.867	0.866	0.617
1981	1.039	1.022	1.100	0.704
1982	1.214	0.808	1.350	0.634
1983	1.340	0.940	1.451	0.913
1984	1.544	3.313	0.915	3.615
1985	2.821	0.823	1.667	0.592
1986	2.456	1.143	1.396	0.828
1987	2.000	0.626	2.315	0.445
1988	2.055	0.677	2.520	0.495
1989	2.034	0.323	3.753	0.245
1990	2.110	0.925	3.288	1.288
1991	3.657	0.183	7.667	0.248
1992	1.847	0.372	3.744	0.680
1993	1.597	0.465	4.697	0.938
1994	0.674	0.262	1.840	0.578
1995	1.418	0.790	2.804	1.790
1996	1.188	0.510	2.282	1.231
1997	1.531	0.425	2.663	0.886
1998	0.669	1.590	0.795	3.242
1999	0.106	0.732	0.116	1.023
2000	0.346	0.710	0.342	0.877
2001	0.229	0.894	0.294	1.127
2002	0.176	0.858	0.214	0.986
2003	0.377	0.742	0.453	0.776
2004	0.328	0.671	0.433	0.852
2005	0.968	0.677	1.389	0.874
2006	0.683	0.653	1.024	0.850
2007	1.091	0.242	2.082	0.336
2008	0.376	0.447	0.841	0.749
2009	0.440	0.633	0.998	1.177
2010	0.236	0.295	0.515	0.556

[1]Indices for 2009 onward were adjusted from FSV *Henry B. Bigelow* units to RV *Albatross IV* equivalents and account for the variance associated with the *Bigelow* calibration factor.

Table I8. Stochastic projections of GOM-GB windowpane flounder catches (kt) and NEFSC fall survey relative biomass indices (kg per tow), for 2011-2014, assuming fishing at the F_{MSY} proxy (= 0.44 kt/kg per tow) and 75%F_{MSY} proxy (= 0.33 kt/kg per tow).

	2011		2012		2013		2014	
	Catch (mt)	Relative Biomass Index (kg per tow)	Catch (mt)	Relative Biomass Index (kg per tow)	Catch (mt)	Relative Biomass Index (kg per tow)	Catch (mt)	Relative Biomass Index (kg per tow)
F_{MSY} proxy (= 0.44)	201	0.458	201	0.457	201	0.457	201	0.456
75%F_{MSY} proxy (= 0.33)	160	0.485	170	0.514	180	0.545	190	0.577

Table I9. Current (1975-2007) and re-estimated (1975-2010) biological reference points (BRPs) for GOM-GB windowpane flounder and stock status during 2010. The 2010 B index is the average biomass index for 2008-2010 for NEFSC fall bottom trawl surveys and the 2010 relative F is the catch in 2010 / average biomass index for 2008-2010 for NEFSC fall bottom trawl surveys. Biomass indices from 2009 onward were converted from FSV *Henry B. Bigelow* units to RV *Albatross IV* equivalents.

	Current[1]	Re-estimated	Stock status in 2010
F_{MSY} proxy (kt/kg per tow)	0.50	0.44	
F_{Target} (= 75%F_{MSY} proxy, kt/kg per tow)	0.38	0.33	
B_{MSY} proxy (kg per tow)	1.40	1.60	
$B_{threshold}$ (50% of B_{MSY})	0.70	0.80	
2010 relative F (kt/kg per tow)		0.51	overfishing was occurring
2010 B index (kg per tow)		0.46	overfished

[1] The current BRPs should not be compared with either the proposed BRPs or the 2010 biomass index and relative F value because the current BRPs were computed using biomass indices based on a different survey strata set and a different catch time series.

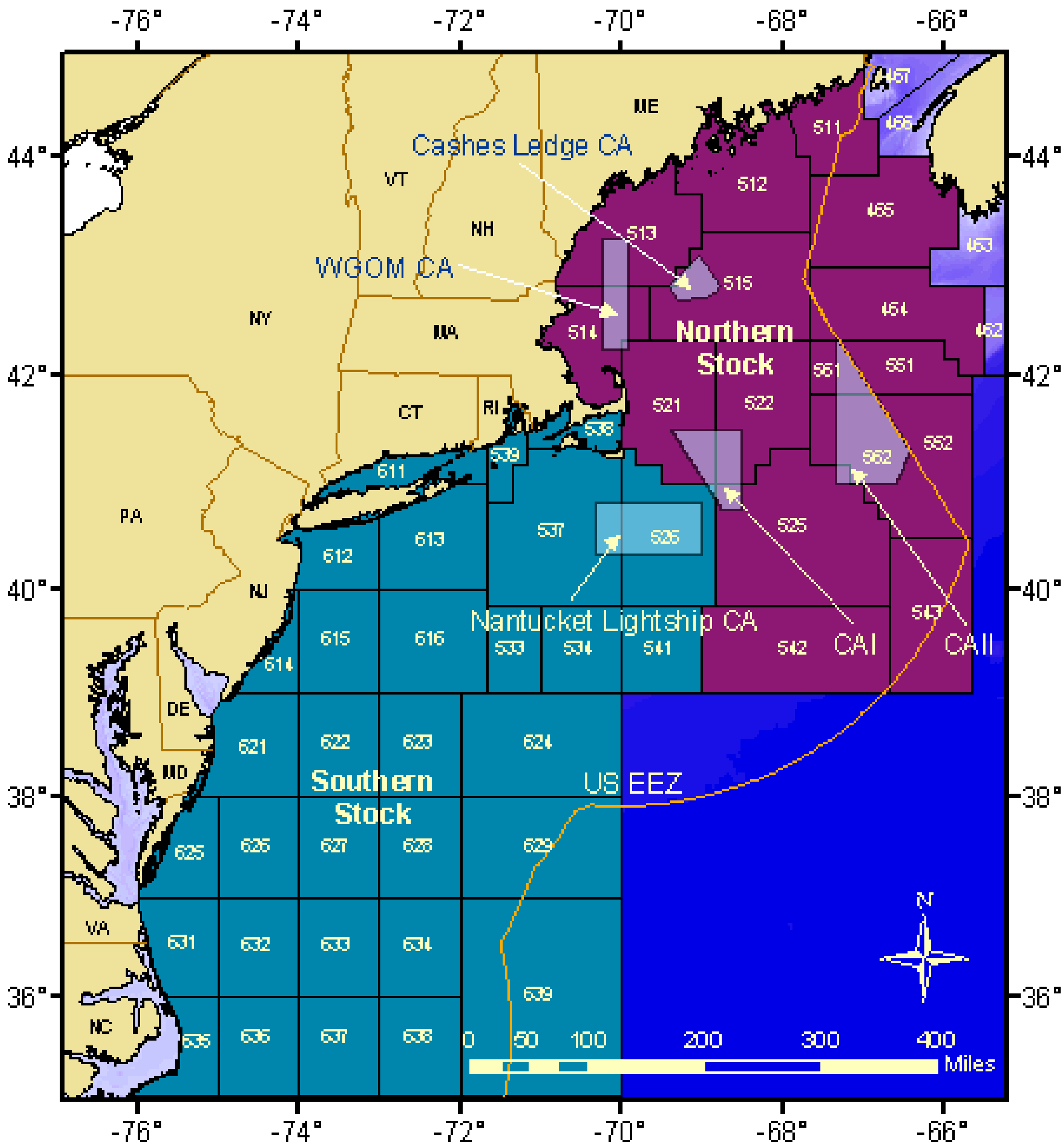

Figure I1. Statistical Areas used for reporting fishery data for the northern (Gulf of Maine-Georges Bank) and southern (Southern New England-Mid-Atlantic Bight) windowpane flounder stocks.

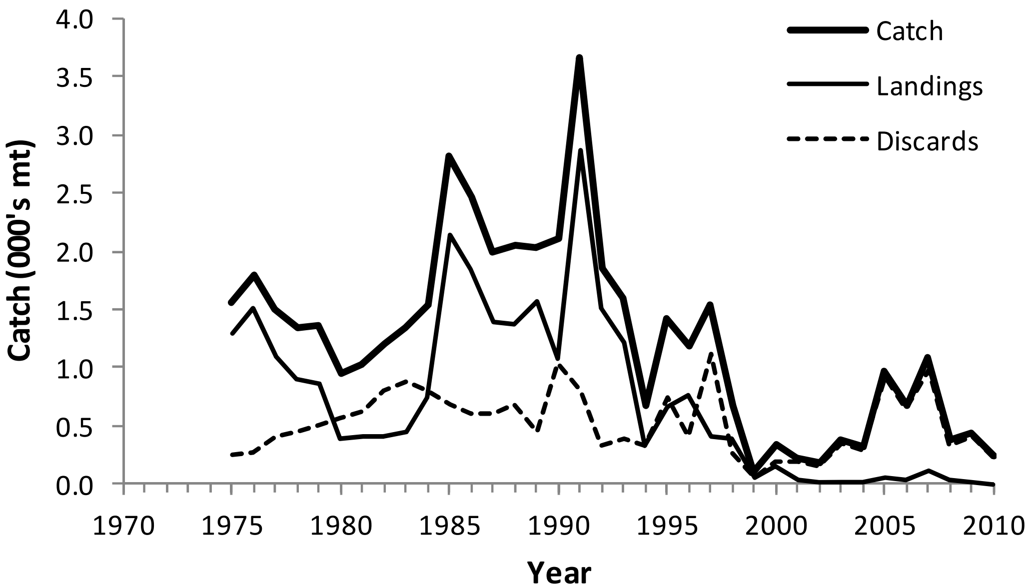

Figure I2. U.S. landings, discards and catches (000's mt) of GOM-GB windowpane flounder during 1975-2010.

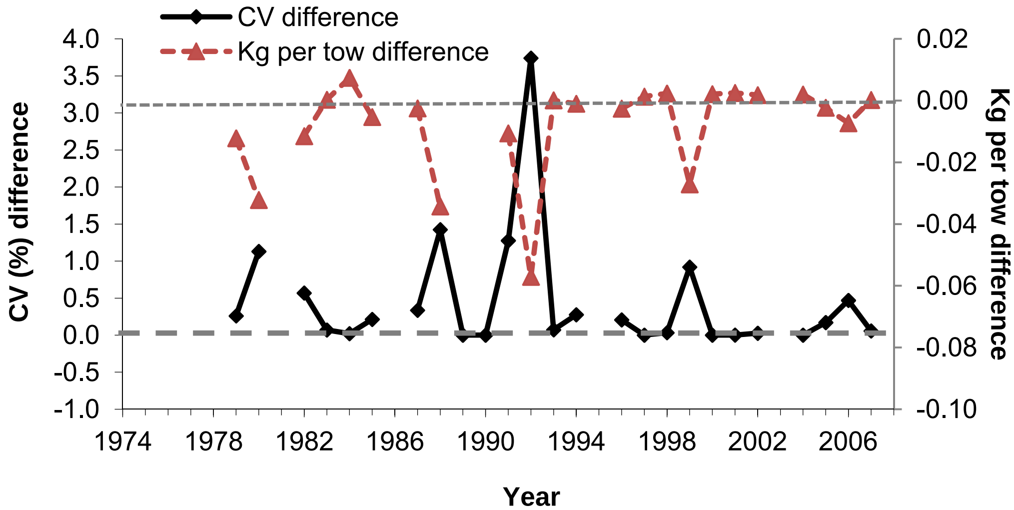

Figure I3. Effects of omitting windowpane flounder catches from inshore stratum 58 on the GOM-GB relative biomass indices (differences in stratified mean kg per tow) and their precision estimates (differences in CVs, %) for NEFSC fall research bottom trawl surveys, 1979-2007.

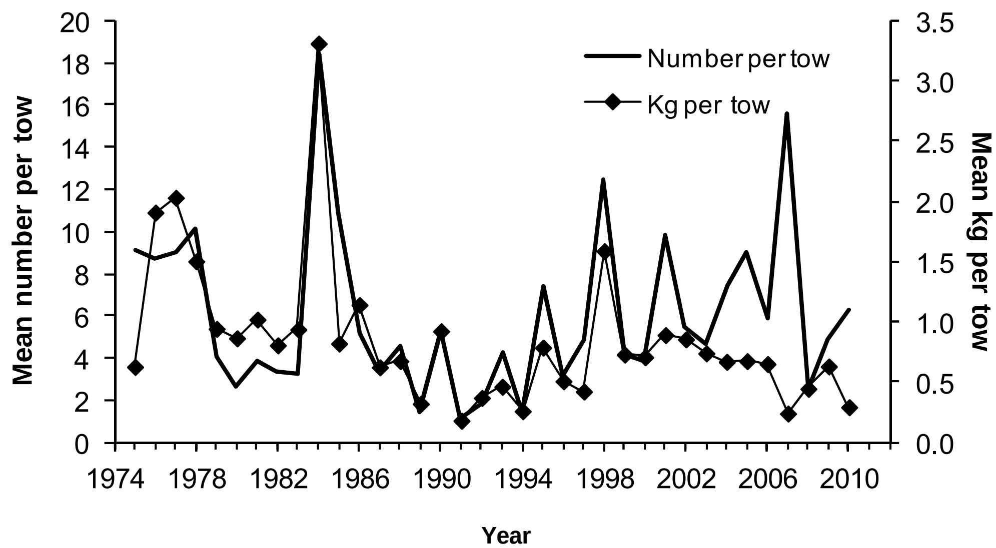

Figure I4. NEFSC fall survey relative abundance and biomass indices, during 1975-2010, for GOM-GB windowpane flounder. Survey indices were derived using catches from offshore strata 13-30 and 37-40 plus inshore strata 59-61 and 65-66. Indices from 2009 onward represent SRV *H. B. Bigelow* catches adjusted to RV *Albatross IV* equivalents.

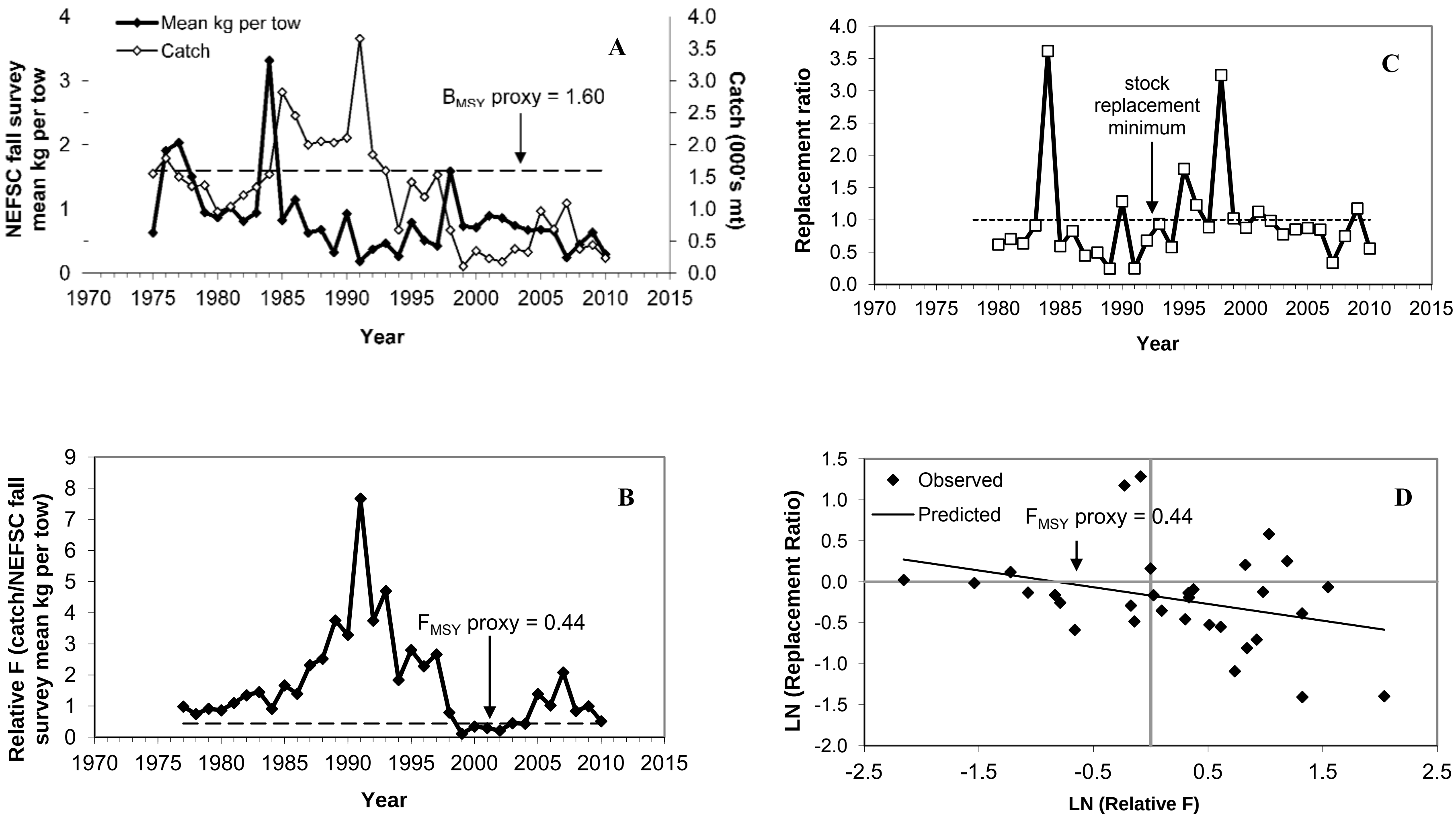

Figure I5. Trends in (A) GOM-GB windowpane flounder catches (000's mt) and NEFSC fall survey relative biomass indices (stratified mean kg per tow), (B) relative fishing mortality rates (catch in 2008 / 2008-2010 average of the NEFSC fall survey biomass indices), (C) stock replacement ratios, and (D) the regression of ln(relative F) against ln(replacement ratio) to calculate the relative F value where ln(replacement ratio) is equal to 0 (= F_{MSY} proxy of 0.44) during 1975-2010.

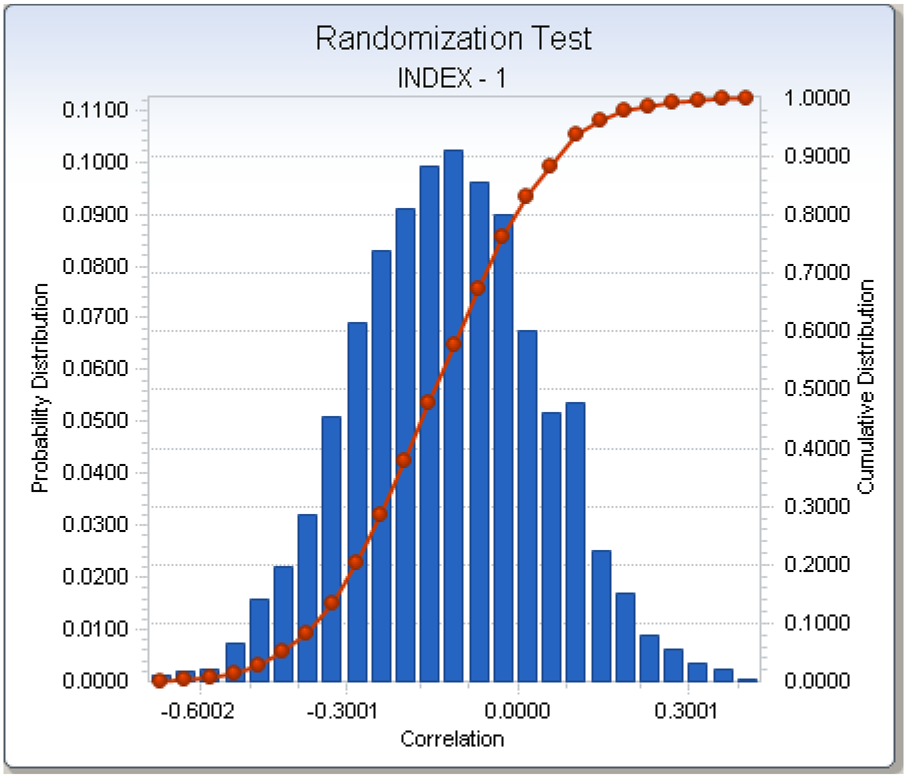

Figure I6. Probability and cumulative distributions from a randomization test, with 2,000 realizations, used to evaluate the correlation between the revised **ln(replacement ratio)** and **ln(relative F) time series (1975-2010)** for GOM-GB windowpane flounder**.** The critical value is -0.333 (p = 0.090).

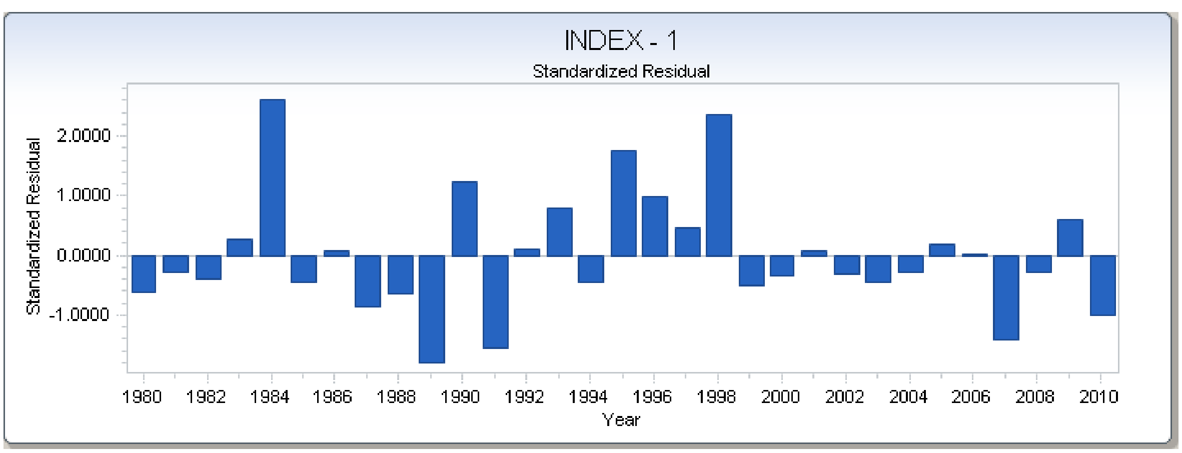

Figure I7. Standardized residuals from the AIM model run, 1975-2010, for GOM-GB windowpane flounder.

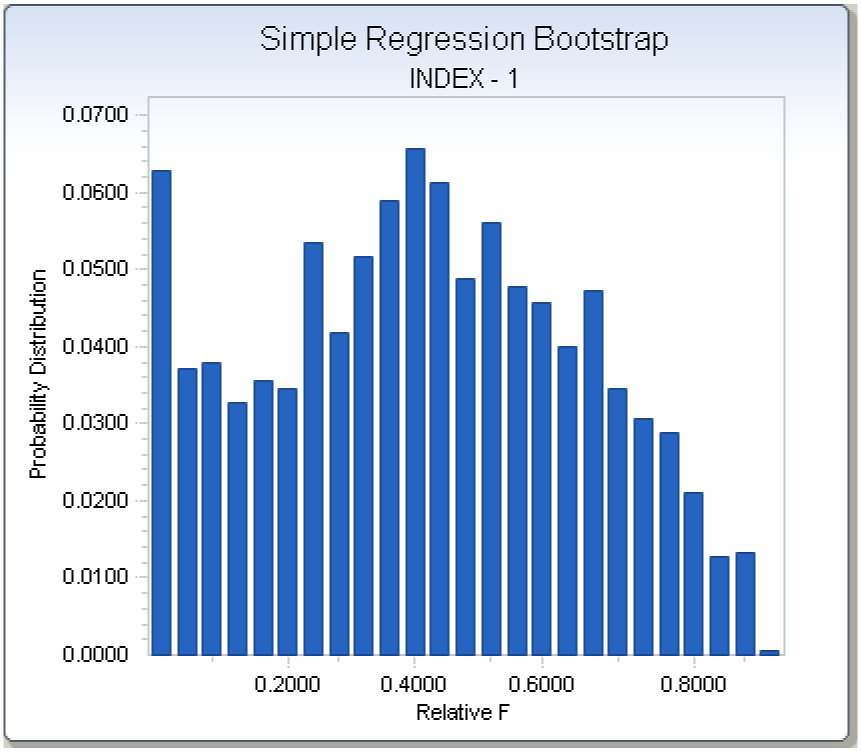

Figure I8. Probability distribution, based on 2,000 bootstrap realizations (trim factor = 200), of the estimate of relative F when the stock replacement ratio equals 1.0, which represents the F_{MSY} proxy estimate of 0.44 (90% CI = 0.24, 0.79) from the AIM run (1975-2010).

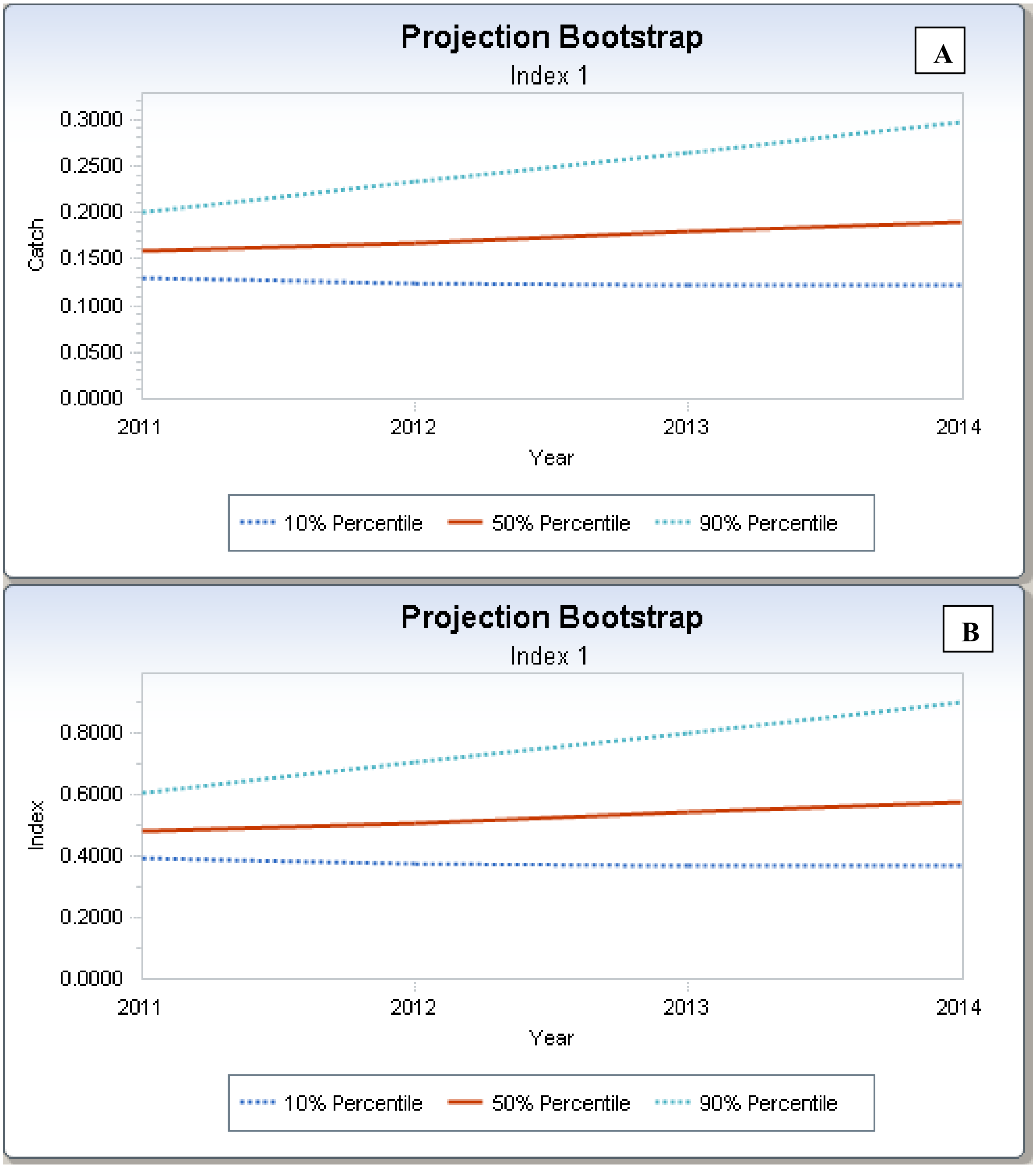

Figure I9. Stochastic projections of GOM-GB windowpane flounder (A) catches (kt) and (B) NEFSC fall survey relative biomass indices (kg per tow), for 2011-2014, assuming fishing at 75%F_{MSY} proxy (= 0.33 kt/kg per tow).

11.0 Appendices

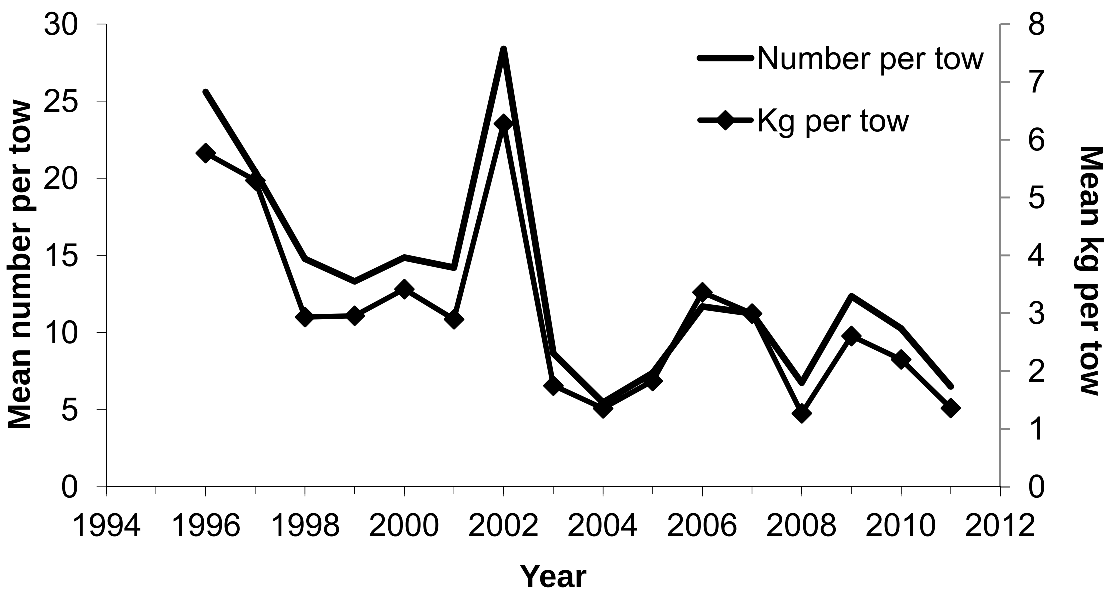

Figure A.I1. Relative abundance and biomass indices for GOM-GB windowpane flounder caught during Canadian spring (February) bottom trawl surveys conducted on Georges Bank (strata 5Z1-5Z4) during 1996-2011.

J. Southern New England-Mid-Atlantic Bight windowpane flounder
by Lisa Hendrickson

8.0 Background

Windowpane flounder (*Scophthalmus aquosus*) is a left-eyed, flatfish species which is primarily found between the high water mark and 50 m, but also inhabits depths of up to 200 m (Klein-MacPhee 2002). The Southern New England-Mid-Atlantic Bight (SNE-MAB) windowpane flounder stock was most recently assessed in 2008 at a Groundfish Assessment Review Meeting (GARM III) using An Index-based Model (AIM) for the period 1975-2007 (NEFSC 2008). Input data to the AIM model consisted of: discards, landings, and the NEFSC fall survey biomass indices.

The current biological reference points, adopted at the 2008 GARM and in Amendment 16 to the Northeast Multispecies Fishery Management Plan (NEFMC 2009), are: F_{MSY} proxy = 1.47 kt/kg per tow and B_{MSY} proxy = 0.34 kg per tow. The F_{MSY} proxy was estimated from the AIM model and represents the relative fishing mortality rate (catch in year *t* / average fall survey biomass index during years *t* through *t*-2) at which the stock can replace itself. The MSY proxy (= 500 mt) is the median catch during a period of time when the stock was assumed to have been replacing itself (1995-2001), and was divided by the F_{MSY} proxy to compute the B_{MSY} proxy. At the 2008 GARM, the stock was not deemed overfished but overfishing was occurring (NEFSC 2008). Rebuilding is required by 2014 (NEFMC 2003).The stock was not rebuilt in 2007.

The stock assessment provided herein does not represent a simple update of the 2008 assessment because the entire catch and survey biomass time series were revised. It was necessary to re-compute the relative biomass time series using catches from a different survey strata set which excludes depths that cannot be sampled by the FSV *H. B. Bigelow,* which replaced the RV*Albatross IV* in 2009. The depths which cannot be sampled by the Bigelow consist of the two shallowest series of inshore strata and the waters within these strata constitute important windowpane flounder habitat during the fall surveys (Figure J1). In addition, it was necessary to revise the entire discard time series to account for recent corrections made to the Northeast Fisheries Observer Program (NEFOP) Database regarding some windowpane flounder hail weights. The 2007 landings data were also updated. The same AIM model configuration from the 2008 assessment was utilized and the catch and relative biomass indices for 2008-2010 were added to the revised time series. It was necessary to re-estimate the BRPs, in order to be consistent with the revised data series used in AIM.

9.0 The Fishery

<u>Landings</u>

Statistical Areas used for reporting fishery data for the SNE-MAB windowpane flounder stock include: 526, 533-539, 541, and 611-639 (Figure J2). Commercial landings and fishery-related data for windowpane flounder are available beginning in 1975. Several different methods have been used to collect the landings, fishing area and effort data. During 1963 through April of 1994, such data were collected and entered into Northeast Region Commercial Fisheries

Database (CFDBS) by NMFS port agents, who entered landings data from all dealer purchase receipts and interviewed a subset of captains to obtain information about fishing location and effort (Burns *et al*. 1983). During May of 1994-2003, reporting of landings by vessel and trip was mandatory for dealers issued federal permits to purchase groundfish. The data were collected and entered into the CFDBS by NMFS port agents. Since 2004, such data have been self-reported, electronically, by federally permitted dealers. Beginning in May of 1994, mandatory reporting of fishing location and effort data, gear type, estimated kept and discarded catch, and other trip-based fishing data were self-reported by fishermen on logbooks (i.e., Vessel Trip Reports or VTRs) and the data were entered into the Vessel Trip Report Database. In order to integrate data from the VTR Database with data from the CFDBS, an "allocation" database was created using a trip-based allocation scheme (Wigley *et al*. 2008a). Data retrieved from the allocation database were used to assign landings, by Statistical Area, to each of the two windowpane flounder stocks.

Landings of SNE-MAB windowpane flounder were updated for 2007 and extended through 2010. During most years, at least 97% of the landings were taken with bottom trawls, but 3.0-12.5% of the landings were taken with scallop dredges during 1987-1994 (Table J1). Landings were highest during the directed fishery period (1984-1990) and averaged 1,204 mt with a peak of 1,967 mt in 1985 (Figure J1, Table J2). Thereafter, landings gradually declined to 120 mt in 1995 and remained at this low level until 2001. During 2002-2010, landings were at the lowest levels on record and ranged between 38 mt and 84 mt. Landings in 2010 totaled 53 mt. A moratorium on the possession of SNE-MAB windowpane flounder was implemented in May of 2010 (NEFSMC 2010) and will remain in effect through the 2012 fishing year (T. Nies pers. comm.).

<u>Discards</u>

Discards (mt) of SNE-MAB windowpane flounder and estimates of their precision were initially provided for 1975-2007 at the 2008 GARM (NEFSC 2008). The combined ratio method of Wigley *et al.* (2008b), which is based on a ratio estimate pooled across all strata and trips within each fleet, was used to estimate discards for 1989-2010. For each trip, a combined discard to kept (d/k) ratio was computed using NEFOP data, where d = discard weight of SNE-MAB windowpane flounder and k = kept weight of all species. The discard ratios were then expanded by the total weight of all species landed during a trip (using landings from the CFDBS) to estimate total discard weight.

Discards were estimated for the large mesh bottom trawl fleet (codend mesh size ≥ 5.5 inches), small mesh bottom trawl fleet (codend mesh size < 5.5 inches), and the sea scallop dredge fleet ("limited permits" only). Due to low numbers of trips sampled by quarter, the small mesh bottom trawl and scallop dredge fleets were binned by half year to derive discard estimates. For both fleets, imputations were necessary during years where fewer than two trips were available. There were no observed trips for the scallop fleet during 1989 and 1990 and only two trips in 1991. As a result, scallop fleet discards for 1989-1991 were estimated using the hindcast method described below. Discards from the large mesh bottom trawl fleet were estimated by quarter and cells with fewer than two trips were imputed using annual values. Discards were hindcast for the large mesh bottom trawl fleet (1982-1988), small mesh bottom trawl fleet (1975-1988), and the scallop dredge fleet (1975-1991) based on the following equation:

(1) $$\hat{D}_{t,h} = \bar{r}_{c,1989-1991,h} * K_{t,h}$$

where:

$\hat{D}_{t,h}$ is the annual discarded pounds of windowpane flounder for fleet *h* in year *t*

$\bar{r}_{c,1989-1991,h}$ is an average combined D/K ratio (discarded pounds of windowpane flounder / total pounds of all species kept) for the fleet *h* during either 1989-1991 (for the trawl fleets) or 1992-1998 (for the scallop fleet)

$K_{t,h}$ is the total pounds of all species kept (landed) for fleet *h* in year *t*

For the subject stock assessment, the 1975-2007 discard time series was revised using the same methods that were used for the 2008 assessment (NEFSC 2008), in order to account for recent corrections made to the NEFOP Database. Discards were estimated anew for 2008-2010. The NEFOP database errors were discovered when NEFOP staffs were asked by New England Fishery Management Council staff to examine several scallop dredge hauls, conducted in the southern windowpane flounder stock area, with unusually large quantities of windowpane flounder discards during 2010. Following an audit of windowpane catches for these hauls, it was determined that the database errors were primarily related to incorrect assignments, by editors, of the windowpane species code. Some catches recorded by observers as "sand dollar" were incorrectly assigned the "sand dab" or windowpane flounder species code. Therefore, the NEFOP Database hail weights (discard plus kept weight) of both stocks of windowpane flounder, for all scallop dredge and scallop trawl hauls reviewed by the subject editors, were checked against the original haul logs to identify and correct windowpane species coding errors as well as any other errors associated with windowpane flounder hail weights. In addition, all database haul records with scallop dredge and scallop trawl hail weights of $\geq$ 50 lbs of windowpane flounder were compared with the original haul logs to identify and correct any hail weight errors pertaining to windowpane flounder.

NEFOP Database errors involving hail weights of SNE-MAB windowpane flounder occurred during a subset of years beginning in 1997. Sand dollar catches were first recorded in the database in 1994, for scallop dredges and finfish bottom trawls, and in 2004 for scallop trawls. Most (68%) of the total incorrect hail weight of SNE-MAB windowpane flounder was associated with scallop dredge hauls for which sand dollars were miscoded as windowpane flounder. When all gear types included in the NEFOP database were considered, scallop dredges accounted for most (99.8%) of all sand dollar catches that occurred in the SNE-MAB windowpane flounder stock area. The highest incidence of sand dollar catches also occurred in scallop dredges (30.5% of all hauls during 1994-2010) followed by scallop trawls (5.9% of all hauls during 2004-2010). The incidence of sand dollar catches in finfish bottom trawls was very low (0.4% of all hauls during 1994-2010) and the gear type accounted for only 0.03% of all sand dollar catches in the SNE-MAB stock area. Consequently, the aforementioned systematic species coding error for windowpane flounder was not expected for finfish bottom trawls. In addition to species miscoding errors by some editors, some hail weight errors were also attributable to hail weight keypunch errors and observer miscalculations.

The audit results suggested that a hail weight cutoff of 50 lbs per haul of windowpane flounder was an appropriate auditing limit because the 2010 error incidence rate (the year with the highest error incidence rate for scallop dredges and trawls) decreased with windowpane hail weight, from 67% for hauls with greater than 100 lbs of catch to 13% for hauls with 50-100 lbs of catch. Following correction of the database errors, an examination of the distribution of hauls with windowpane flounder catches indicated that most of the hail weights for scallop dredges (1991-2010) and scallop trawls (2004-2010) were well under 50 lbs. Hauls with windowpane flounder hail weights of ≤ 20 lbs comprised 98% of all hauls with positive catches and 90% of the total hail weight of windowpane flounder in scallop dredges and comprised 92% of all hauls with positive catches and 53% of the total hail weight of windowpane flounder in scallop trawls.

Trends were different for hail weights of SNE-MAB windowpane flounder in finfish bottom trawls. Hauls with windowpane flounder hail weights of ≤ 20 lbs comprised most (68%) of all hauls with positive catches, but only 13% of the total hail weight of windowpane flounder from this gear type. Hauls with hail weights of 91-2,550 lbs of windowpane flounder also comprised a small percentage (7%) of all positive hauls, but a much larger percentage (57%) of the total windowpane flounder hail weight.

All of the database errors involved discards and the net effect of the corrections was a reduction in the database discard weights of SNE-MAB windowpane flounder. During most years, the discard reductions represented small percentages of the total database discards of windowpane flounder for each of the three gear types. Reductions in the database discards of SNE-MAB windowpane flounder were highest for scallop dredges, totaling 8,529 lbs (3.9 mt), and ranged from 0.7% of the scallop dredge discard total in 2005 to 37.9% in 2010 (Tables J3 and J4). Database reductions in windowpane flounder discards for scallop trawls totaled 2,681 lbs (1.2 mt) and ranged from 17% of the scallop trawl total in 2005 to 38.4% in 2010. Reductions in the database discards for finfish bottom trawls totaled 435 lbs (0.2 mt) and ranged from 1.1% of the finfish bottom trawl total in 2008 to 2.3% in 2007.

During most years since 1975, windowpane discards were primarily from the large mesh bottom trawl fleet (considered as the small mesh fleet prior to 1982 when the minimum codend mesh size was less than 5.5 inches, Table J5). However, a majority of the total discards occurred in the scallop dredge/trawl fleet during 1993 and 1996-1999, ranging between 43% and 66%, and in the small mesh groundfish trawl fleet during 1989, 1992, 1994 and 2001-2002 and ranged between 53% and 69%.

Even during the directed fishery period, landings were dwarfed by the high level of discards that occurred; generally 2-5 times the landings (Table J2, Figure J1). During 1982-1991, total discards ranged between 2,779 mt and 4,429 mt. Since 1992, total discards have been much lower and averaged 378 mt. Total discards increased from 246 mt in 2008 to 436 mt in 2010. CVs during 1992-2010 averaged 0.37 and ranged from 0.11-0.19 during 2004-2010 (Table J5).

Catch

Differences between the revised catch time series and that from the 2008 assessment, for 1975-2007, reflect not only the NEFOP database edits described above, but also reflect any other updates or changes which may have occurred to all three of the databases (i.e., NEFOP, VTR and CFDBS Databases) which were used to estimate discards. The revised catch time series ranged from a reduction of 16.6% to an increase of 38.0% (Table J2).
Catches increased gradually from 1,145 mt in 1975 to 1,748 in 1981, then doubled in 1982 and remained at the highest levels during 1982-1991, ranging between 3,524 mt and 5, 318 mt (Table J2, Figure J3). After 1991, catches declined rapidly to a time series low of 184 mt in 2001 then ranged between 321 mt and 522 mt during 2002-2009 and totaled 490 mt in 2010. Since 1994, most of the catch has been comprised of discards.

10.0 Research Survey Data

The Northeast Fisheries Science Center (NEFSC) conducts annual research bottom trawl surveys, between the Gulf of Maine and Cape Hatteras, North Carolina, during the spring and fall (Azarovitz 1981). Beginning in 2009, the FSV *Henry B. Bigelow* replaced the RV *Albatross IV* as the research vessel used to conduct the NEFSC surveys. The draft of the *Bigelow* is deeper than that of the RV *Albatross*, and as a result, inshore strata with depths ≤ 18 m can no longer be sampled. Windowpane flounder catches during NEFSC fall bottom trawl surveys conducted from 1975 onward were used to derive the relative biomass indices used in the stock assessment model. Therefore, the fall survey indices were recomputed for 1975-2010 without the inclusion of catches from inshore strata that cannot be sampled by the FSV *Bigelow*. Biomass indices from the 2008 assessment were derived using catches from offshore strata 1-12 and 61-76 and inshore strata 2-46 and 55. The revised indices were based on catches from offshore strata 1-12 and 61-76, and inshore strata 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41 and 44-46. Survey indices were standardized for changes in trawl doors (numbers = 1.54, weight = 1.67), gear (numbers = 1.67, weight = 1.37), and vessels (numbers = 0.82, weight = 0.80). Door conversion coefficients (Byrne and Forrester 1991a) were applied to the 1975-1984 catches and vessel conversion coefficients (Byrne and Forrester 1991b) were applied when the RV *Delaware II* was utilized instead of the RV *Albatross IV*.

A comparison of trends in the NEFSC fall relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices from the 2008 assessment with indices derived using the revised survey strata set suggest that windowpane flounder catches in strata ≤ 18 m contributed small amounts, during most years, to the annual indices. The contribution was generally greater when stock sizes were highest, during 1979-1985 (Figure J4). The 1975-2008 biomass indices for the revised strata set were generally lower, but the 95% confidence intervals consistently overlapped (Figure J5). However, the exclusion of catches in strata ≤ 18 m reduced the precision of the biomass indices; CVs (%) increased by 4.3 on average, with a maximum increase of 10.4 (Figure J6).

In order to extend the NEFSC fall survey indices beyond 2008, catches of windowpane flounder by the SRV *H. B. Bigelow* were converted to RV *Albatross IV* equivalents to account for catchability differences between the vessels due to vessel, gear, and towing protocol differences.

Calibration coefficients were computed from paired-tow studies conducted during the spring and fall of 2008 (Miller *et al*. 2010). Since AIM relies on biomass indices for all sizes combined, the influence of length-specific calibration effects are relatively unimportant in the model. Therefore, *Bigelow* catches of windowpane flounder were divided by constant calibration coefficients for catch numbers (2.044, SE = 0.2004) and weight in kg (1.901, SE = 0.2091) using a ratio estimator based on data from the fall calibration study (Miller et al. 2010).

Biomass levels for the NEFSC fall bottom trawl surveys were much higher during 1976-1988 than during 1989-2008 (Figure J7, Table J6). Biomass indices then increased and were above the 1975-2009 median (0.32 kg per tow) during 2009 (0.36 kg per tow) and 2010 (0.49 kg per tow). CVs of the biomass indices from 2009 onward account for the variance associated with the *Bigelow* calibration factors. CVs (%) of the revised biomass time series averaged 30.0 and ranged between 16.4 and 80.3 (Table J6).

The Review Panel requested a review of several additional series of biomass indices which were not included in AIM, to determine whether such indices corroborate the high biomass indices observed for the NEFSC fall surveys during 2009-2010, because the 2009-2010 indices were dependent on the *Bigelow* calibration factor. The results indicated that the 2009-2011 biomass indices for the NEFSC spring surveys and the inshore fall surveys conducted by the MA Division of Marine Fisheries (MA DMF) showed an increase similar to the biomass indices for the NEFSC fall surveys (Figure A.J1).

11.0 Assessment

AIM (version 2.2.0) software provided in version 3.1 of the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/) was used to assess the stock. AIM was run using the model formulation from the 2008 assessment, but with the revised catch and biomass indices for 1975-2010 (Table J7). As was done for the 2008 GARM, stock replacement ratios were computed as the NEFSC fall survey biomass index in year *t* / average biomass index for the previous five years. Relative fishing mortality rates were computed as the catch in year *t* / average fall survey biomass index during years *t* through *t*-2.

As a means of evaluating the applicability of the index method calculation to the data, a randomization test was performed based on 2,000 realizations. The randomization test evaluated the correlation between the **ln(replacement ratio)** and **ln(relative F) time series.** The critical value for the randomization test is the estimated correlation coefficient for the original catch and biomass index data. The significance level is the cumulative distribution probability evaluated at the critical value.

The AIM input data and model results for 1975-2010 are shown in Figure J8. A randomization test indicated that the correlation between the **ln(replacement ratio)** and **ln(relative F) was highly significant (*p* = 0.006)**. Probability and cumulative distributions from the randomization test are shown in Figure J9. There was no trend in the standardized residuals from the model, but the 1983 value was -3.0 (Figure J10).

12.0 Biological Reference Points

The current BRPs were adopted at the 2008 GARM (NEFSC 2008) and are: F_{MSY} proxy = 1.47 kt/kg per tow and B_{MSY} proxy = 0.34 kg per tow. The F_{MSY} proxy was estimated from the AIM model and represents the relative fishing mortality rate (catch in year *t* / average of the NEFSC fall survey biomass index during years *t* through *t*-2, in kt/kg per tow) at which the stock can replace itself. Stock replacement ratios were computed as NEFSC fall survey biomass index in year *t* / average biomass index for the previous five years. Based on trends in stock replacement ratios, during a period when catches were most precisely estimated (1989-2007), the stock appeared to be able to sustain itself at the catch levels which occurred during 1995-2001 (i.e., replacement ratios were near or above 1.0 during this period). Therefore, the median catch during 1995-2001 (= 500 mt) was considered as an MSY proxy. The MSY proxy was divided by the F_{MSY} proxy to compute the B_{MSY} proxy.

The current BRPs cannot be used to determine the 2010 stock status because the current BRPs were computed using biomass indices for a different survey strata set and a different catch series. Therefore, the 2010 stock status was determined based on re-estimated BRPs and the 1975-2010 revised input data. The re-estimated F_{MSY} proxy is 2.09 kt/kg per tow (90% CI = 1.00, 3.03, Figure J11), and based on the MSY proxy of 500 mt, resulted in a new B_{MSY} proxy of 0.24 kg per tow and a $B_{threshold}$ proxy of 0.12 kg per tow.

13.0 Projections

Stochastic projections of catches during 2008 and 2009 were run for the 2008 GARM using AIM (NEFSC 2008). However, the results were not used by the Science and Statistical Committee (SSC) to set the 2009 Acceptable Biological Catches (ABCs) for either of the windowpane flounder stocks. Instead, the SSC used the target fishing mortality rate, 75% of the F_{MSY} proxy, applied to the most recent three-year average of the relative biomass index from the NEFSC fall surveys to calculate the ABC.

Projected catches and relative biomass indices for 2011-2014 were estimated for the subject assessment, using AIM, in order to be consistent with the assessment methods from the 2008 GARM. Projections were run assuming fishing at the re-estimated F_{MSY} proxy (= 2.09 kt/kg per tow) and 75%F_{MSY} proxy (= 1.57 kt/kg per tow). Catch was 490 mt in 2010. Under the 75%F_{MSY} proxy scenario, which is used to provide catch advice, catches would increase from 752 mt in 2013 to 835 mt in 2014 (Table J8, Figure J12).

14.0 Summary

Although the results are not presented herein, an AIM sensitivity run based on the revised biomass and catch series for 1975-2007 did not change the 2007 stock status determination (NEFSC 2008). The new 2007 relative F value of 1.82 kt/kg per tow was greater than the new F_{MSY} proxy of 1.69 kt/kg per tow and the new 2007 biomass index of 0.19 kg per tow was above the new $B_{Threshold}$ proxy (= 0.15 kg per tow). Therefore, overfishing was occurring but the stock was not overfished in 2007. The stock was also not rebuilt in 2007.

Relative F in 2010 (= 1.40 kt/kg per tow), for the AIM run that incorporated the revised input data for 1975-2010, was below the re-estimated F_{MSY} proxy (= 2.09 kt/kg per tow), indicating that overfishing was not occurring in 2010 (Table J9). The 2010 biomass index (= 0.35 kg per tow) was above the re-estimated $B_{threshold}$ (50% of B_{MSY} = 0.12 kg per tow) as well as the re-estimated B_{MSY} proxy (= 0.24 kg per tow), indicating that the stock was not overfished in 2010 and was rebuilt.

8.0 Panel Discussions/Conclusions

Status of Stock

The biomass in 2010 (i.e., 2008-2010 average index of the NEFSC fall survey) is estimated to be 0.35 kg per tow. Relative F in 2010 (i.e., catch in 2010/average biomass index during 2008-2010) is estimated to be 1.40 kt/kg per tow.

The Fmsy proxy was re-estimated in an AIM analysis that incorporated revised catch and relative biomass time series. The Bmsy proxy was also re-estimated based on the MSY value from GARM-III. Revised estimates of the biological reference points are:

Bmsy proxy= 0.24 kg per tow,
Fmsy proxy = 2.09 kt/kg per tow, and
MSY proxy= 500 mt.

Based on these results, the stock of SNE-MAB windowpane flounder is not overfished and overfishing is not occurring. The stock is above the biomass target and is therefore rebuilt. At GARM-III, the stock was not overfished, but overfishing was occurring in 2007.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15), which includes the use of catch and NEFSC fall survey biomass indices, during 1975-2010, in AIM. However, the assessment is more than a simple update because the entire catch and biomass time series were re-estimated because of some NEFOP database corrections and the use of a different survey strata set to derive the biomass indices (i.e., the FSV *H. B. Bigelow* cannot sample strata ≤ 18 m deep), respectively.

The biological reference points are based on the following revisions: re-estimation of the F_{MSY} proxy using AIM and the MSY value from the 2008 GARM.

SNE-MAB Windowpane Flounder. Summary of Assessment Information

SNE-MAB Windowpane Flounder	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Landings (mt)	135	84	47	60	38	57	83	74	53	53	505	38	1967	1975-2010
Discards (mt)	49	256	474	340	293	374	266	246	410	436	1255	49	4429	1975-2010
Catch (mt)	184	339	522	400	330	431	349	321	463	490	1760	184	5318	1975-2010
SSB Proxy (kg/tow)	0.347	0.176	0.336	0.129	0.154	0.228	0.192	0.191	0.3631	0.4941	0.415	0.039	1.733	1975-2010
F relative	0.86	1.47	1.82	1.87	1.6	2.53	1.82	1.58	1.86	1.4	4.728	0.86	22.89	1977-2010

Reviewer Comments

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

The revised discard estimates were considered to be an improvement, because they corrected the previous problem of miscoding of "sand dollars" as "sand dabs" for some NEFOP database discard records. Revisions to the NEFOP database discards were more substantial for the southern stock of windowpane flounder than for the northern stock and were associated primarily with scallop dredges. Catches were mostly discards. Annual CVs of discard estimates for recent years were low and ranged from 0.19 in 2004 to 0.11 in 2010. As a research recommendation, the Review Panel suggested that alternative stratification schemes (e.g., geographic regions and gear types within fisheries) be investigated to further improve the precision of discard estimates.

There was some ambiguity between the 2008 GARM and Amendment 16 (NEFMC 2009) in the Multispecies Fishery Management Plan regarding whether to use the terminal year biomass index (i.e., that used for stock status determination at the 2008 GARM) or a 3-year lagged biomass index for stock status determination. The Review Panel agreed to use the method in the Fishery Management Plan (i.e., relative biomass index during 2008-2010).

The status of the stock is based on an analysis that incorporates the NEFSC fall survey indices. The 2009 and 2010 survey values are driving the perception of recovery for this stock, which depends on the calibration of the SRV *Bigelow*. However, the fall survey biomass calibration coefficient was relatively well-estimated (10% CV) and the coefficient estimate was similar to other flatfishes. The recent increase in the NEFSC fall survey biomass indices was supported by the recent trend in the NEFSC spring surveys, as well as in the inshore fall surveys conducted by the Massachusetts Division of Marine Fisheries (MA DMF).

The 2008 GARM developed catch projections based on AIM. Even though the SSC did not use AIM projections in 2009, these projections were conducted for this assessment to be consistent with the 2008 GARM methods.

Validation of age determination and processing of archived age samples from NEFSC fall surveys would help to inform a more analytical assessment.

9.0 References

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Table J1. Landings (mt) of SNE-MAB windowpane flounder, by gear category, during 1975-2010.

	Landings (mt)					
	Bottom trawls	Sea scallop dredges/trawls	Gillnets	Other[1]	Total	Percent landed by bottom trawls
1975	678.068	0.000	0.000	0.090	678	100.0
1976	563.308	0.079	0.000	0.014	563	100.0
1977	646.205	0.395	0.000	0.169	647	99.9
1978	889.539	2.656	0.000	0.665	893	99.6
1979	630.296	1.209	0.000	1.628	633	99.6
1980	523.582	0.873	0.000	0.257	525	99.8
1981	862.567	0.494	0.000	2.906	866	99.6
1982	627.620	1.664	0.000	2.099	631	99.4
1983	768.423	3.556	0.000	2.711	775	99.2
1984	1,042.413	1.722	0.000	1.139	1,045	99.7
1985	1,964.659	0.695	0.034	1.481	1,967	99.9
1986	1,356.512	20.660	0.050	0.911	1,378	98.4
1987	853.239	26.552	0.370	1.284	881	96.8
1988	1,097.798	39.338	0.037	9.816	1,147	95.7
1989	1,077.836	40.874	0.000	2.659	1,121	96.1
1990	832.860	55.235	0.060	1.669	890	93.6
1991	712.090	101.696	0.074	2.733	817	87.2
1992	512.853	68.117	0.053	2.545	584	87.9
1993	444.910	23.028	0.210	1.163	469	94.8
1994	176.885	7.639	1.330	0.068	186	95.1
1995	111.969	0.970	0.818	5.795	120	93.7
1996	189.516	0.179	0.123	1.077	191	99.3
1997	114.631	0.347	0.250	0.797	116	98.8
1998	119.680	0.154	0.524	1.427	122	98.3
1999	115.848	0.128	0.123	1.588	118	98.4
2000	121.332	0.014	0.157	3.311	125	97.2
2001	132.908	0.118	0.381	1.294	135	98.7
2002	81.542	0.000	0.250	1.974	84	97.3
2003	45.928	0.018	0.139	1.235	47	97.1
2004	57.883	0.000	0.186	2.214	60	96.0
2005	36.673	0.000	0.116	1.016	38	97.0
2006	55.066	0.052	0.453	1.331	57	96.8
2007	81.573	0.000	0.932	0.495	83	98.3
2008	72.852	0.001	0.990	0.652	74	97.8
2009	49.397	0.000	0.595	2.978	53	93.3
2010	50.599	0.000	0.696	2.128	53	94.7

[1] Includes other gear types and unknown gear types.

Table J2. Landings, discards, and catches (mt) of SNE-MAB windowpane flounder during 1975-2010 and differences (%) between these catches and those used in the 2008 AIM run for 1975-2007.

	Landings (mt)	Discards (mt)	Catch (mt)	Catch difference (%)
1975	678	467	1,145	-1.8
1976	563	595	1,159	-2.4
1977	647	557	1,204	-2.2
1978	893	949	1,842	-2.5
1979	633	1,022	1,655	-2.8
1980	525	957	1,482	-2.3
1981	866	882	1,748	-2.2
1982	631	2,893	3,524	-2.0
1983	775	3,612	4,387	-1.5
1984	1,045	3,417	4,463	-1.5
1985	1,967	2,779	4,746	-1.2
1986	1,378	3,021	4,399	-3.0
1987	881	2,984	3,865	-3.1
1988	1,147	3,015	4,162	-3.2
1989	1,121	3,442	4,564	-1.3
1990	890	4,429	5,318	-1.5
1991	817	2,983	3,799	-3.8
1992	584	517	1,101	-2.9
1993	469	397	866	-0.7
1994	186	1,032	1,218	3.7
1995	120	375	494	1.6
1996	191	548	739	22.1
1997	116	213	329	-3.3
1998	122	363	485	-7.5
1999	118	470	588	11.7
2000	125	130	255	-3.0
2001	135	49	184	1.4
2002	84	256	339	38.0
2003	47	474	522	16.2
2004	60	340	400	5.2
2005	38	293	330	5.5
2006	57	374	431	-6.7
2007	83	266	349	-16.6
2008	74	246	321	
2009	53	410	463	

2010	53	436	490

Table J3. Discards (pounds) of SNE-MAB windowpane flounder, by year and gear type, which were incorrect in the NEFOP Database. All values were subtracted from the original discard amounts of SNE-MAB windowpane flounder recorded in the database. Most errors involved species miscoding, by editors, and data keypunch errors.

	Windowpane database discards, lbs, by gear type (negear code)			
Year	Scallop dredge (132)	Bottom trawl (050)	Scallop trawl (052)	Total
1997	150			150
1998	495			495
2002	100			100
2005	67		90	157
2006	75			75
2007		1,294		1,294
2008	131	490		621
2009	500			500
2010	7,011	897	345	8,253
Total	8,529	2,681	435	11,645

Table J4. Discards (%, in pounds) of SNE-MAB windowpane flounder, by year and gear type, which were incorrect in the NEFOP Database. Values are expressed as percentages of the total database discards of SNE-MAB windowpane flounder within each category. All values were subtracted from the original discard amounts of windowpane flounder recorded in the database. Most errors (in terms of discard weight) involved species miscoding, by editors, and data keypunch errors.

	Windowpane database discards, % of total, by gear type (negear code)			
Year	Scallop dredge (132)	Bottom trawl (050)	Scallop trawl (052)	Total
1997	4.9%			3.3%
1998	19.3%			13.6%
2002	3.5%			1.0%
2005	0.7%		17.0%	0.3%
2006				0.1%
2007		2.3%		2.1%
2008		1.1%		1.1%
2009	5.8%			0.9%
2010	37.9%	1.9%	38.4%	12.7%
Total	12.8%	0.9%	17.9%	3.1%

Table J5. SNE-MAB windowpane flounder discard estimates (mt) and CVs for large mesh bottom trawls (codend mesh size ≥ 5.5 in.), small mesh bottom trawls (codend mesh size < 5.5 in.), and scallop dredges (limited permits) during 1975-2010. Discards were hindcast for large mesh trawls (1982-1988), small mesh trawls (1975-1988), and scallop dredges (1975-1991) due to no sampling.

	Large Mesh Bottom Trawls			**Small Mesh Bottom Trawls**			**Scallop Dredges/Trawls, Limited Permits**			**Total**	
Year	**N Observer trips**	**Discards (mt)**	**CV**	**N Observer trips**	**Discards (mt)**	**CV**	**N Observer trips**	**Discards (mt)**	**CV**	**Discards (mt)**	**CV**
1989	10	1,342	0.54	75	1,814	0.54	0				
1990	22	3,827	0.27	63	346	0.39	0				
1991	21	1,871	1.04	118	817	0.63	2				
1992	25	80	0.44	67	299	0.41	12	139	0.52	517	0.28
1993	13	150	0.43	18	74	4.59	14	173	0.54	397	0.90
1994	17	196	0.54	17	698	0.56	20	138	0.79	1032	0.41
1995	71	211	0.31	70	108	0.55	22	56	0.51	375	0.25
1996	32	215	0.42	84	90	0.39	32	243	0.33	548	0.23
1997	11	44	1.29	61	27	0.81	19	142	0.56	213	0.47
1998	14	232	0.46	30	21	1.02	13	109	0.52	363	0.34
1999	8	244	0.55	40	71	0.62	8	155	1.08	470	0.47
2000	34	87	0.60	43	16	4.76	69	27	0.85	130	0.73
2001	55	17	0.21	61	26	0.95	93	7	0.71	49	0.51
2002	49	30	0.26	51	175	1.71	91	50	0.22	256	1.17
2003	50	299	0.38	93	102	0.43	103	73	0.27	474	0.26
2004	197	205	0.27	301	91	0.37	218	44	0.22	340	0.19
2005	364	126	0.20	257	63	0.28	120	103	0.34	293	0.16
2006	171	273	0.17	174	38	0.50	90	63	0.39	374	0.15
2007	263	162	0.17	252	62	0.31	185	41	0.25	266	0.13
2008	253	134	0.17	174	58	0.40	339	53	0.16	246	0.14
2009	293	295	0.15	403	61	0.23	250	55	0.14	410	0.11
2010	381	202	0.12	480	48	0.29	223	187	0.21	436	0.11

Table J6. Stratified mean number and weight tow indices for SNE-MAB windowpane flounder caught during NEFSC fall bottom trawl surveys, 1975-2010. Indices include catches from offshore strata 1-12 and 61-76 plus inshore strata 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41 and 44-46. Standardization coefficients were applied for trawl door changes which occurred in 1985 (numbers = 1.54, weight = 1.67) and for vessel changes which occurred during various years (numbers = 0.82, weight = 0.80). From 2009 onward, fall calibration factors were used to convert FSV *H. B. Bigelow* catches to RV *Albatross IV* catches (numbers = 2.04, weight = 1.90) and the associated CVs (%) account for the variances of the calibration factor estimates.

Year	Mean number per tow	CV (%)	Mean kg per tow	CV (%)
1975	2.00	27.1	0.33	27.9
1976	3.14	25.6	0.63	23.4
1977	3.93	26.7	0.87	33.4
1978	3.64	23.0	0.73	23.1
1979	5.88	16.8	1.18	16.4
1980	2.66	18.6	0.58	17.9
1981	3.77	23.6	0.86	21.0
1982	8.95	22.8	1.73	22.4
1983	3.05	21.0	0.70	18.8
1984	2.75	24.9	0.58	25.3
1985	3.34	17.8	0.54	20.0
1986	3.45	75.8	0.64	80.3
1987	2.61	35.6	0.41	32.9
1988	2.25	42.7	0.41	41.3
1989	0.98	31.3	0.14	31.5
1990	0.91	28.0	0.15	27.4
1991	1.63	39.2	0.30	42.3
1992	1.07	18.6	0.19	21.1
1993	0.24	29.1	0.04	35.1
1994	0.92	41.8	0.19	43.8
1995	1.51	26.3	0.25	23.4
1996	1.71	23.2	0.26	21.2
1997	0.62	23.3	0.13	24.2
1998	1.17	28.7	0.20	23.5
1999	0.82	26.4	0.13	22.4
2000	1.00	65.5	0.17	54.8
2001	1.52	49.8	0.35	47.9
2002	0.80	26.6	0.18	28.3
2003	1.82	30.0	0.34	21.5
2004	0.70	24.3	0.13	22.1
2005	0.72	33.2	0.15	34.4
2006	1.08	29.6	0.23	34.3
2007	1.20	27.7	0.19	30.7
2008	1.11	44.9	0.19	45.8
2009	2.89	24.5	0.36	22.1
2010	3.01	18.2	0.49	17.0

Table J7. Revised AIM model input data for the assessment of SNE-MAB windowpane flounder including: catch (000's mt); NEFSC fall survey relative biomass indices (stratified mean kg per tow); relative fishing mortality rates (catch in year *t* / average of the NEFSC fall survey biomass indices in year *t* through *t*-2); and stock replacement ratios (NEFSC fall survey biomass index in year *t* / average biomass index for the previous five years) during 1975-2010. Survey indices are based on offshore strata 1-12 and 61-76, and inshore strata 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41 and 44-46.

	Catch	NEFSC fall survey stratified mean			
Year	(000's mt)	Kg per tow	CV (%)	Relative F	Replacement Ratio
1975	1.145	0.328	27.9		
1976	1.159	0.630	23.4		
1977	1.204	0.870	33.4	1.98	
1978	1.842	0.731	23.1	2.48	
1979	1.655	1.177	16.4	1.79	
1980	1.482	0.581	17.9	1.79	0.778
1981	1.748	0.858	21.0	2.00	1.075
1982	3.524	1.733	22.4	3.33	2.055
1983	4.387	0.699	18.8	4.00	0.688
1984	4.463	0.580	25.3	4.45	0.574
1985	4.746	0.544	20.0	7.81	0.611
1986	4.399	0.636	80.3	7.50	0.720
1987	3.865	0.413	32.9	7.28	0.493
1988	4.162	0.406	41.3	8.58	0.707
1989	4.564	0.137	31.5	14.32	0.266
1990	5.318	0.154	27.4	22.89	0.360
1991	3.799	0.303	42.3	19.19	0.868
1992	1.101	0.186	21.1	5.14	0.658
1993	0.866	0.039	35.1	4.92	0.164
1994	1.218	0.192	43.8	8.76	1.172
1995	0.494	0.249	23.4	3.09	1.424
1996	0.739	0.264	21.2	3.14	1.362
1997	0.329	0.129	24.2	1.54	0.694
1998	0.485	0.195	23.5	2.47	1.117
1999	0.588	0.125	22.4	3.93	0.607
2000	0.255	0.169	54.8	1.56	0.878
2001	0.184	0.347	47.9	0.86	1.967
2002	0.339	0.176	28.3	1.47	0.912
2003	0.522	0.336	21.5	1.82	1.660
2004	0.400	0.129	22.1	1.87	0.559
2005	0.330	0.154	34.4	1.60	0.666
2006	0.431	0.228	34.3	2.53	0.998
2007	0.349	0.192	30.7	1.82	0.938
2008	0.321	0.191	45.8	1.58	0.919
2009	0.463	0.363[1]	32.3	1.86	2.030

2010	0.490	0.494[1]	29.2	1.40	2.190

[1] Indices for 2009 onward were adjusted from FSV *Henry B. Bigelow* units to RV *Albatross IV* equivalents and the associated CVs account for the variance associated with the *Bigelow* calibration factor.

Table J8. Stochastic projections of SNE-MAB windowpane flounder catches (kt) and NEFSC fall survey relative biomass indices (kg per tow), for 2011-2014, assuming fishing at the F_{MSY} proxy (= 2.09 kt/kg per tow) and 75%F_{MSY} proxy (= 1.57 kt/kg per tow).

	2011		2012		2013		2014	
	Catch (mt)	Relative Biomass Index (kg per tow)	Catch (mt)	Relative Biomass Index (kg per tow)	Catch (mt)	Relative Biomass Index (kg per tow)	Catch (mt)	Relative Biomass Index (kg per tow)
F_{MSY} proxy (= 2.09)	730	0.349	730	0.349	729	0.349	729	0.349
75%F_{MSY} proxy (= 1.57)	609	0.388	677	0.431	752	0.479	835	0.532

Table J9. Current (1975-2007) and re-estimated (1975-2010) biological reference points (BRPs) for SNE-MAB windowpane flounder and stock status during 2010. The 2010 B index is the average biomass index for 2008-2010 for NEFSC fall bottom trawl surveys and the 2010 relative F is the catch in 2010 / average biomass index for 2008-2010 for NEFSC fall bottom trawl surveys. Biomass indices from 2009 onward were converted from FSV *Henry B. Bigelow* units to RV *Albatross IV* equivalents.

	Current[1]	Re-estimated	Stock status in 2010
F_{MSY} proxy (kt/kg per tow)	1.47	2.09	
F_{Target} (= 75%F_{MSY} proxy, kt/kg per tow)	1.10	1.57	
B_{MSY} proxy (kg per tow)	0.34	0.24	
$B_{threshold}$ (50% of B_{MSY})	0.17	0.12	
2010 relative F (kt/kg per tow)		1.40	overfishing is not occurring
2010 B index (kg per tow)[1]		0.35	not overfished and is rebuilt

1 The current BRPs should not be compared with either the proposed BRPs or the 2010 biomass index and relative F value because the current BRPs were computed using biomass indices based on a different survey strata set and a different catch time series.

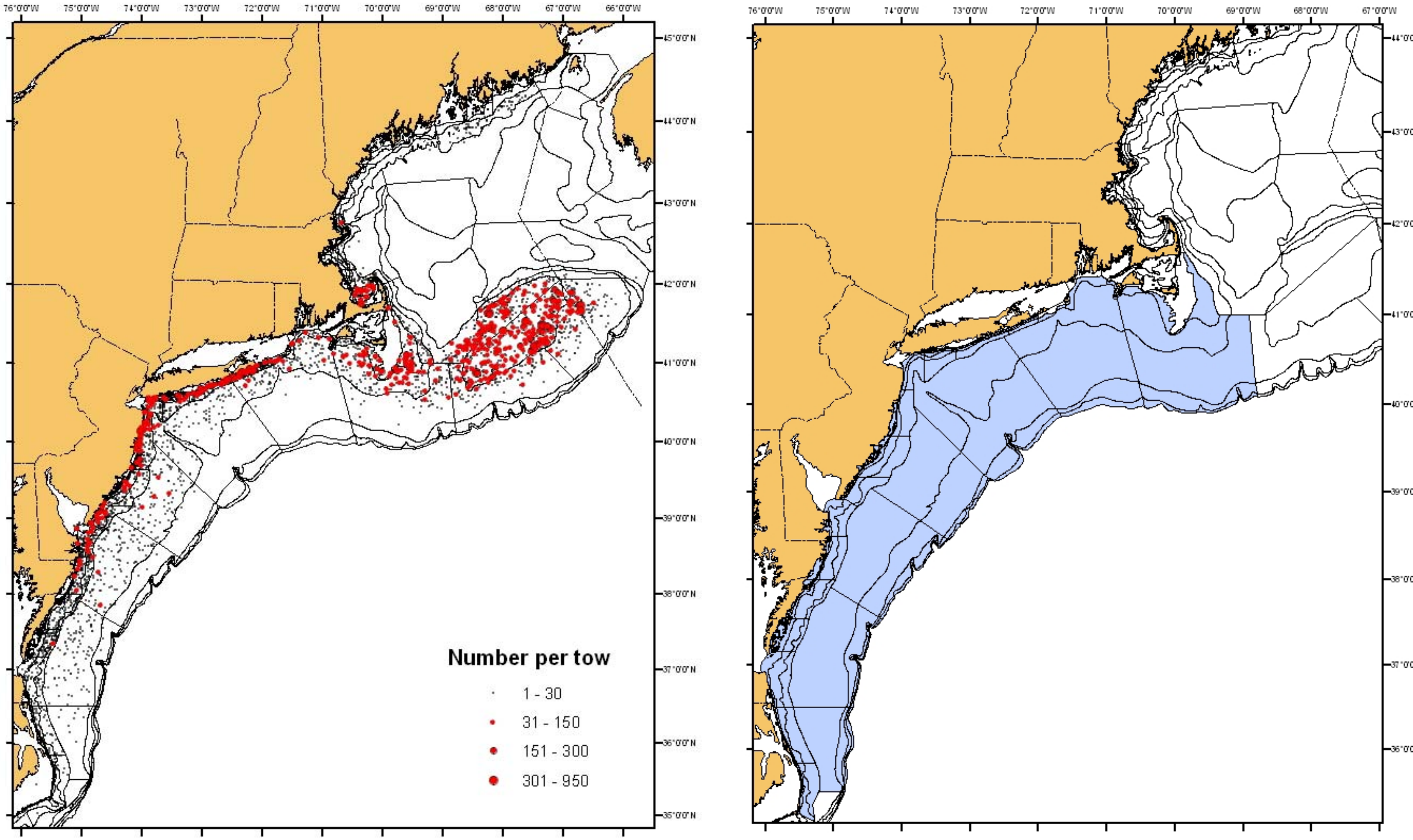


Figure J1. Distribution of windowpane flounder (number per tow) during NEFSC fall research bottom trawl surveys, 1968-2007 (left panel), and NEFSC survey depth strata, shaded blue (right panel), used to derive relative abundance and biomass indices for the SNE-MAB stock. As of 2009, abundance and biomass indices do not include catches from the two shallowest depth strata series (depths ≤ 18 m) because the strata cannot be sampled by the FSV *Henry B. Bigelow.*

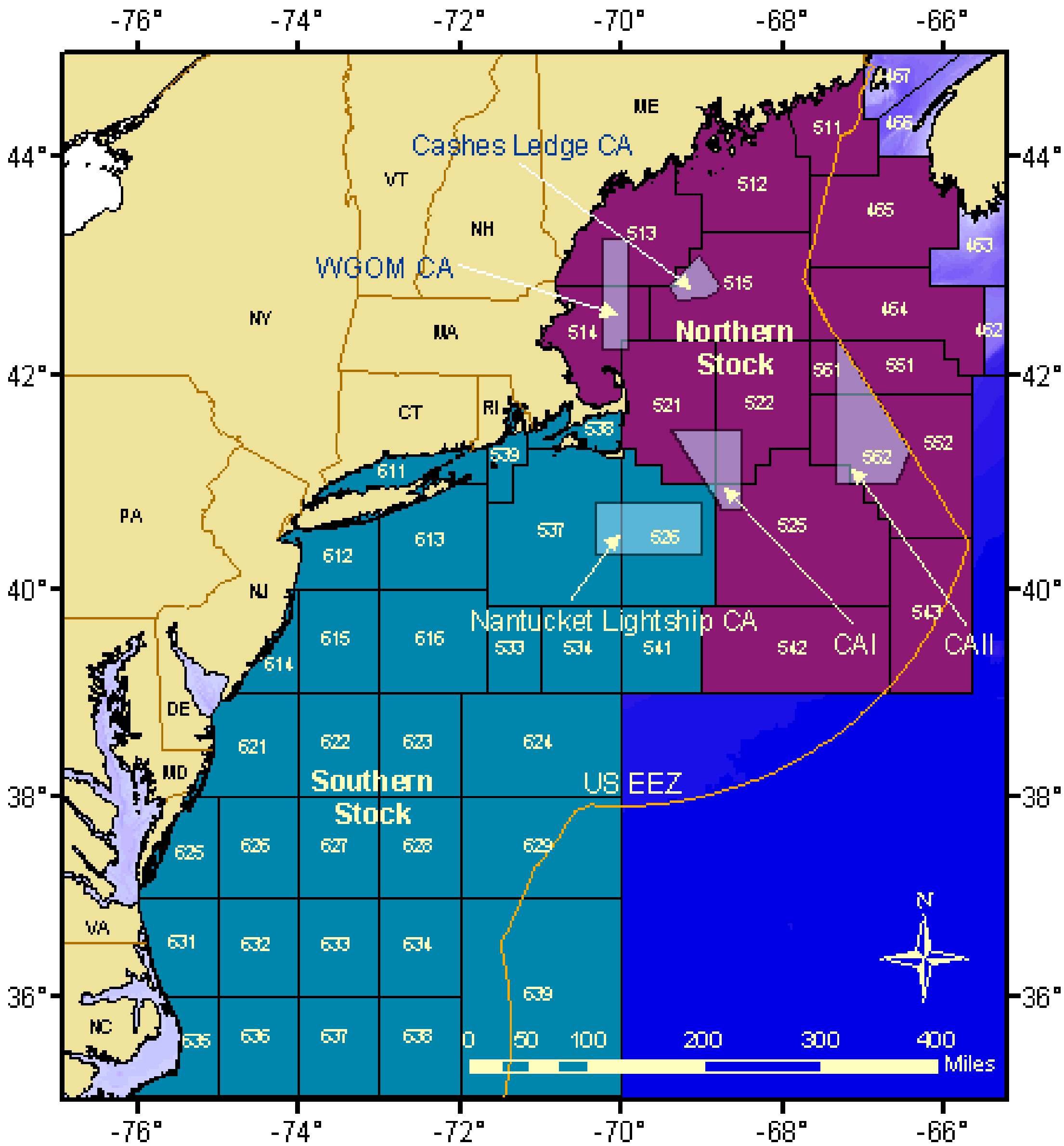


Figure J2. Statistical Areas used for reporting fishery data for the northern (Gulf of Maine-Georges Bank) and southern (Southern New England-Mid-Atlantic Bight) windowpane flounder stocks.

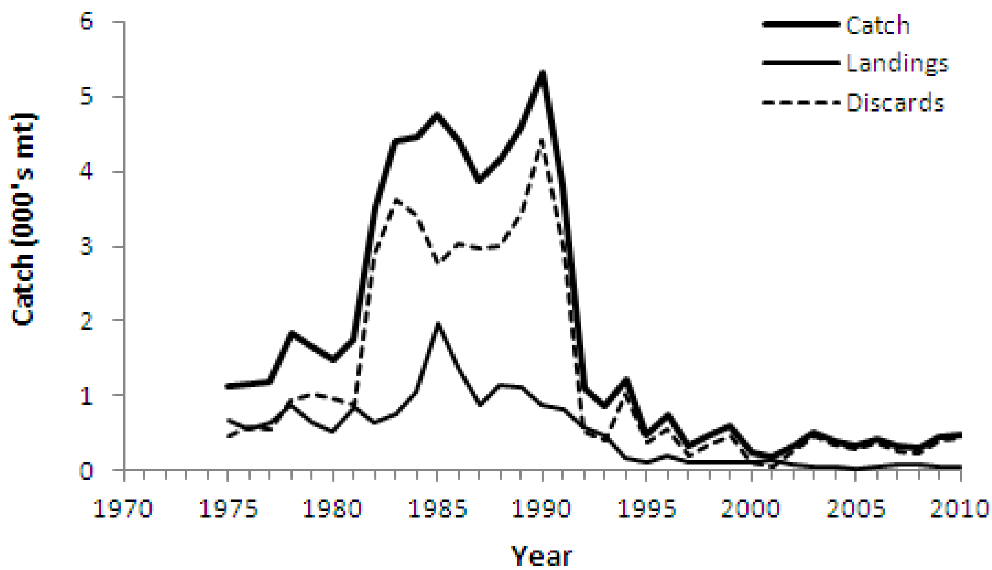
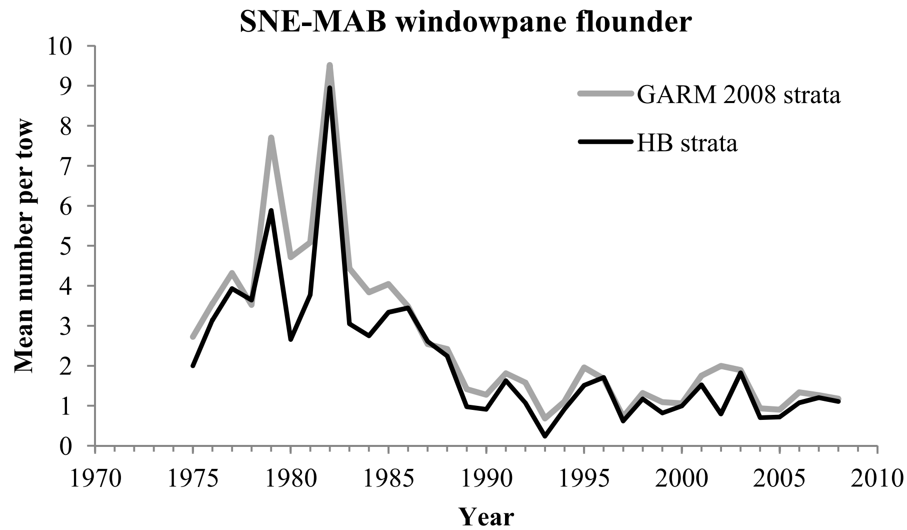


Figure J3. Landings, discards and catches (000's mt) of SNE-MAB windowpane flounder during 1975-2010.



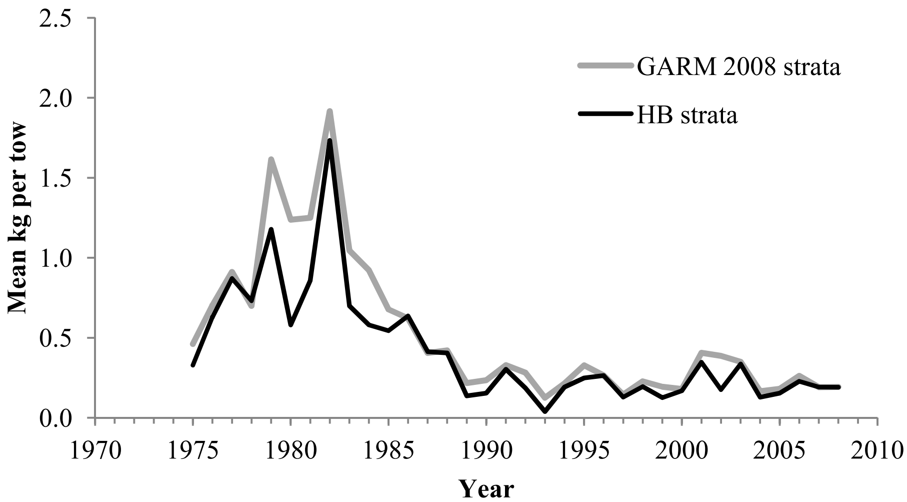


Figure J4. NEFSC fall survey relative abundance (top) and biomass (bottom) indices, during 1975-2008, for SNE-MAB windowpane flounder derived using catch data from two different strata sets. The grey line represents indices used in the 2008 stock assessment (NEFSC 2008) which included catches from strata ≤ 18 m (offshore strata 1-12 and 61-76 plus inshore strata 2-46 and 55). The black line represents the revised indices computed without including catches from strata ≤ 18 m (offshore strata 1-12 and 61-76 plus inshore strata 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41 and 44-46) which cannot be sampled by the FSV *Henry B. Bigelow* as of 2009.

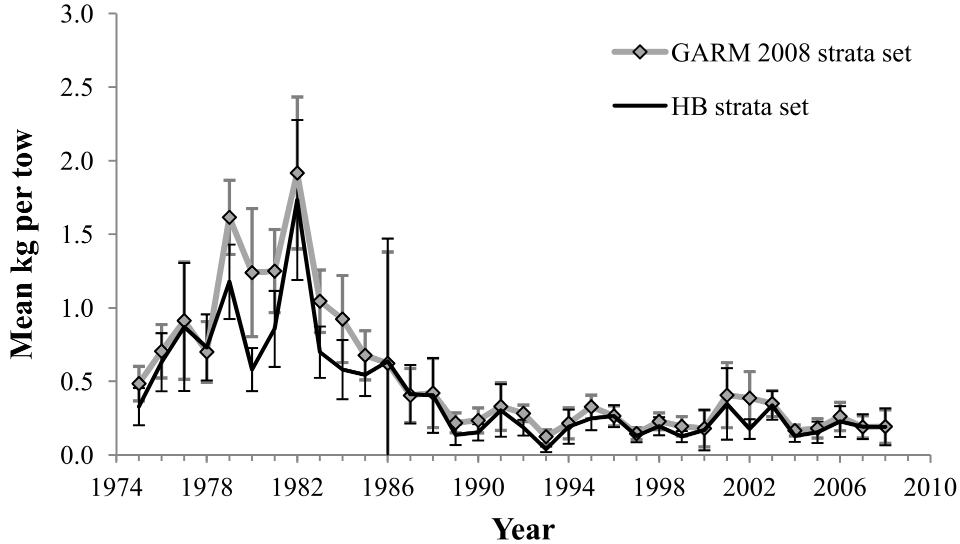


Figure J5. Comparison of NEFSC fall survey relative biomass indices (stratified mean kg per tow, +/- 2 SE), for SNE-MAB windowpane flounder, computed with (GARM 2008 strata set) and without catches from strata ≤ 18 m deep (HB strata set), 1975-2008. Strata ≤ 18 m deep cannot be sampled by the FSV *Henry B. Bigelow* as of 2009.

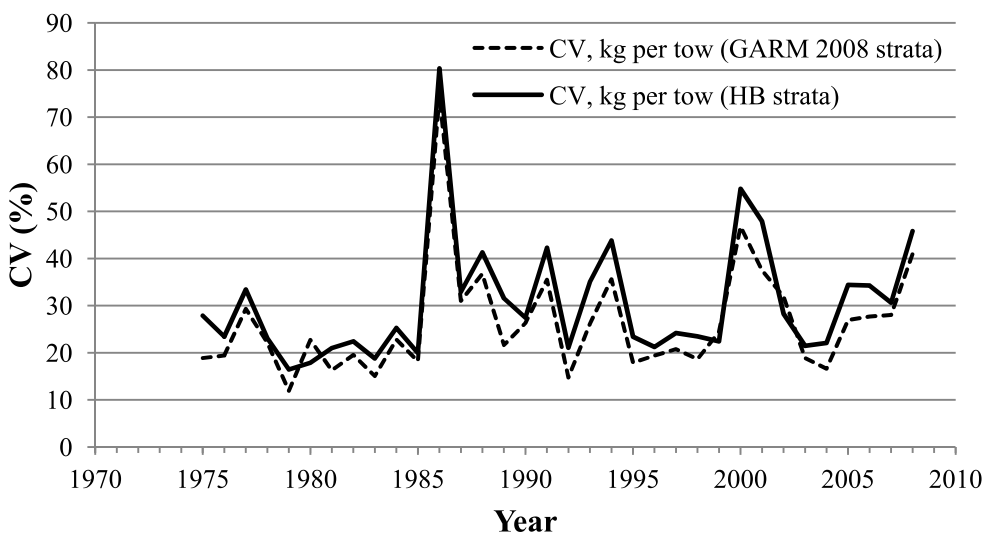


Figure J6. Comparison of CVs for NEFSC fall survey relative biomass indices (stratified mean kg per tow), for SNE-MAB windowpane flounder, computed with (GARM 2008 strata set) and without catches from strata ≤ 18 m deep (HB strata set) during 1975-2008. Strata ≤ 18 m deep cannot be sampled by the FSV *Henry B. Bigelow* as of 2009.

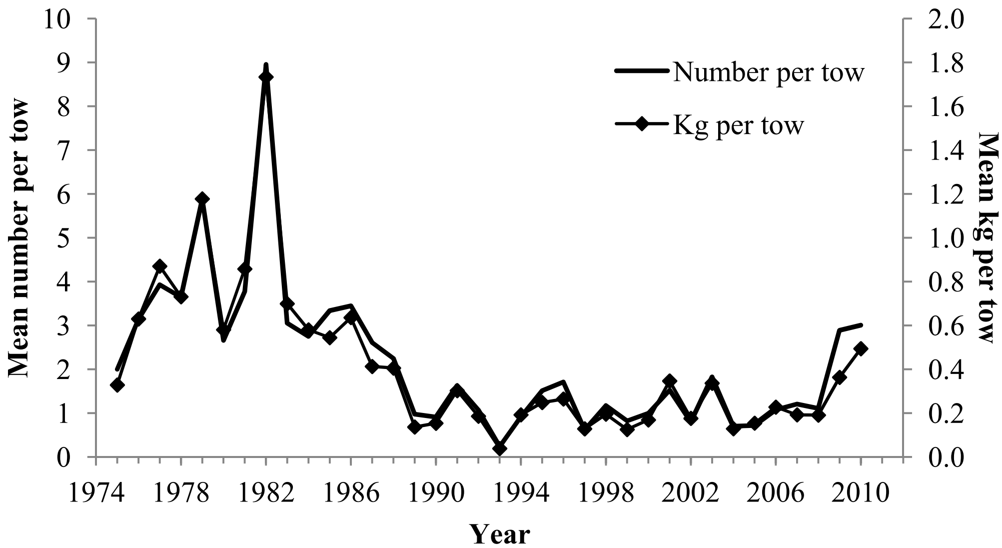


Figure J7. Revised NEFSC fall survey relative abundance and biomass indices, during 1975-2010, for SNE-MAB windowpane flounder. Survey indices were derived using catches from offshore strata 1-12 and 61-76 plus inshore strata 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41 and 44-46. Indices from 2009 onward represent SRV *H. B. Bigelow* catches adjusted to RV *Albatross IV* equivalents.

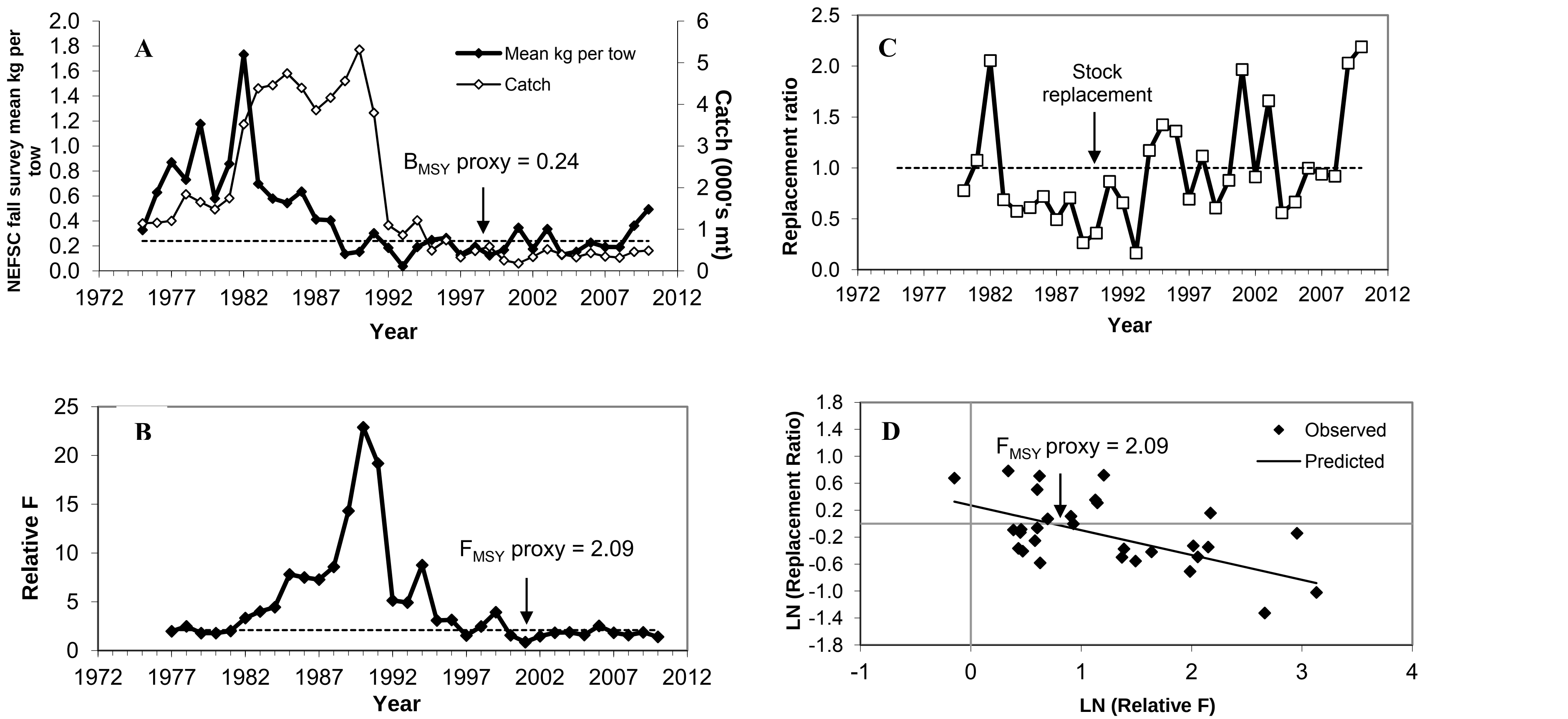


Figure J8. Trends in (A) the revised SNE-MAB windowpane flounder catches (000's mt) and revised NEFSC fall survey relative biomass indices (stratified mean kg per tow), (B) fishing mortality rates (catch in 2010 / 2008-2010 average of the NEFSC fall survey biomass indices), (C) stock replacement ratios, and (D) the regression of ln(relative F) against ln(replacement ratio) to calculate the relative F value where ln(replacement ratio) is equal to 0 (= F_{MSY} proxy of 2.09). Biomass indices were computed without the catches from NEFSC survey strata ≤ 18 m.

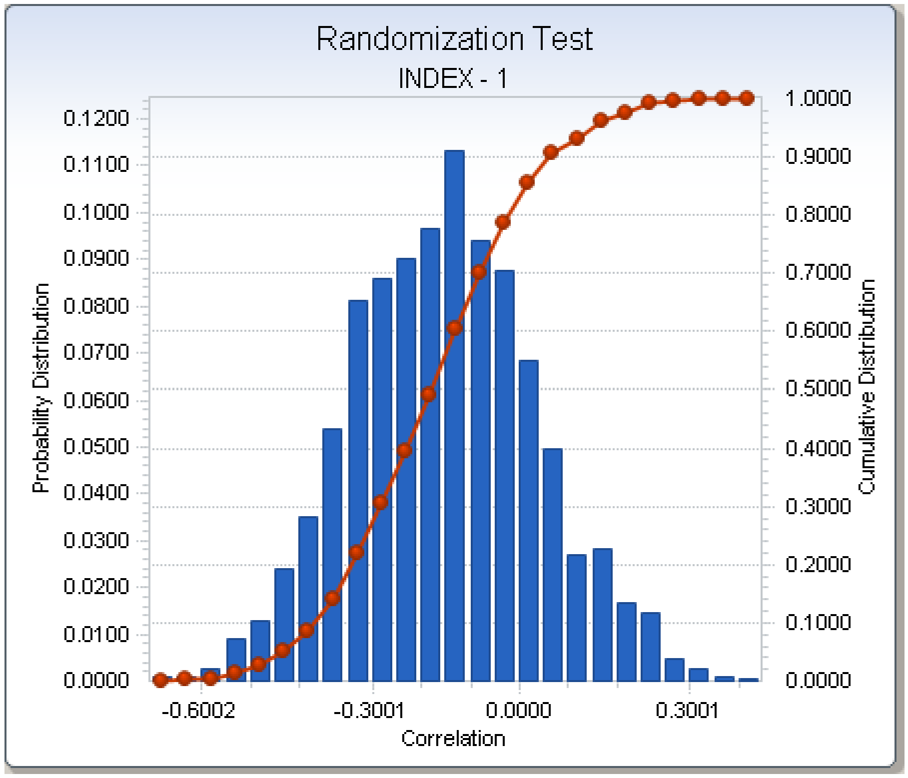


Figure J9. Probability and cumulative distributions from a randomization test, with 2,000 realizations, used to evaluate the correlation between the revised **ln(replacement ratio)** and **ln(relative F) time series (1975-2010)** for SNE-MAB windowpane flounder**.**

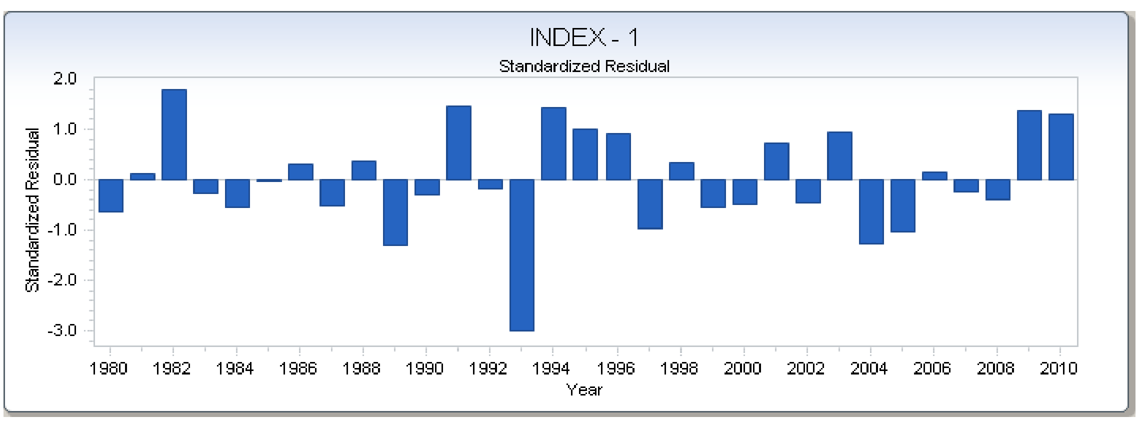


Figure J10. Standardized residuals from the AIM model run using the revised catches and biomass indices (1975-2010) for SNE-MAB windowpane flounder.

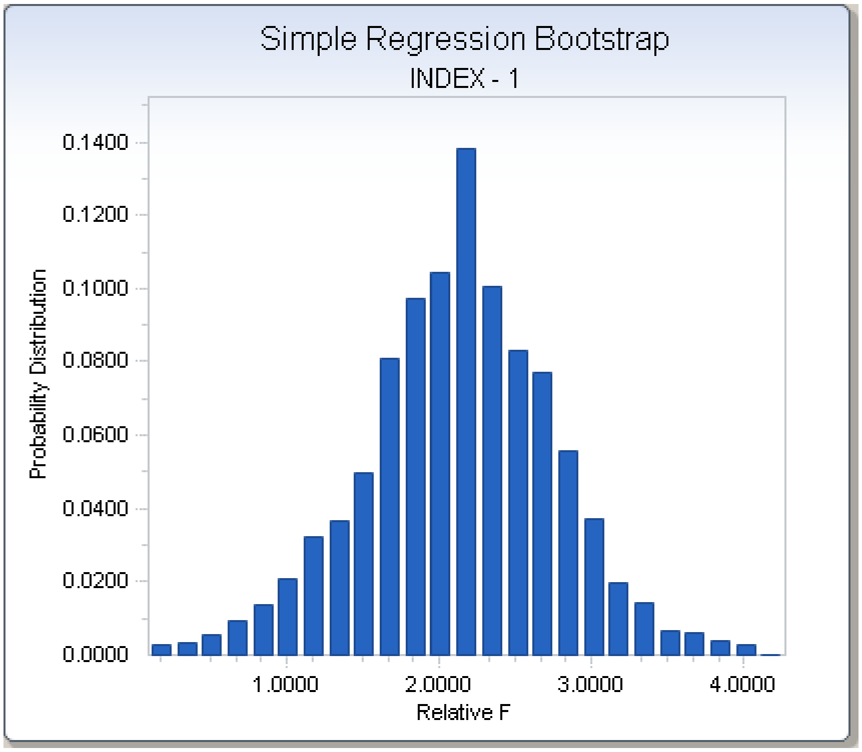


Figure J11. Probability distribution, based on 2,000 bootstrap realizations, of the estimate of relative F when the stock replacement ratio equals 1.0, which represents the re-estimated F_{MSY} proxy of 2.09 (90% CI = 1.00, 3.03), for the AIM run using the revised series of catches and biomass indices (i.e., where catches in strata ≤ 18 m were excluded) for 1975-2010.

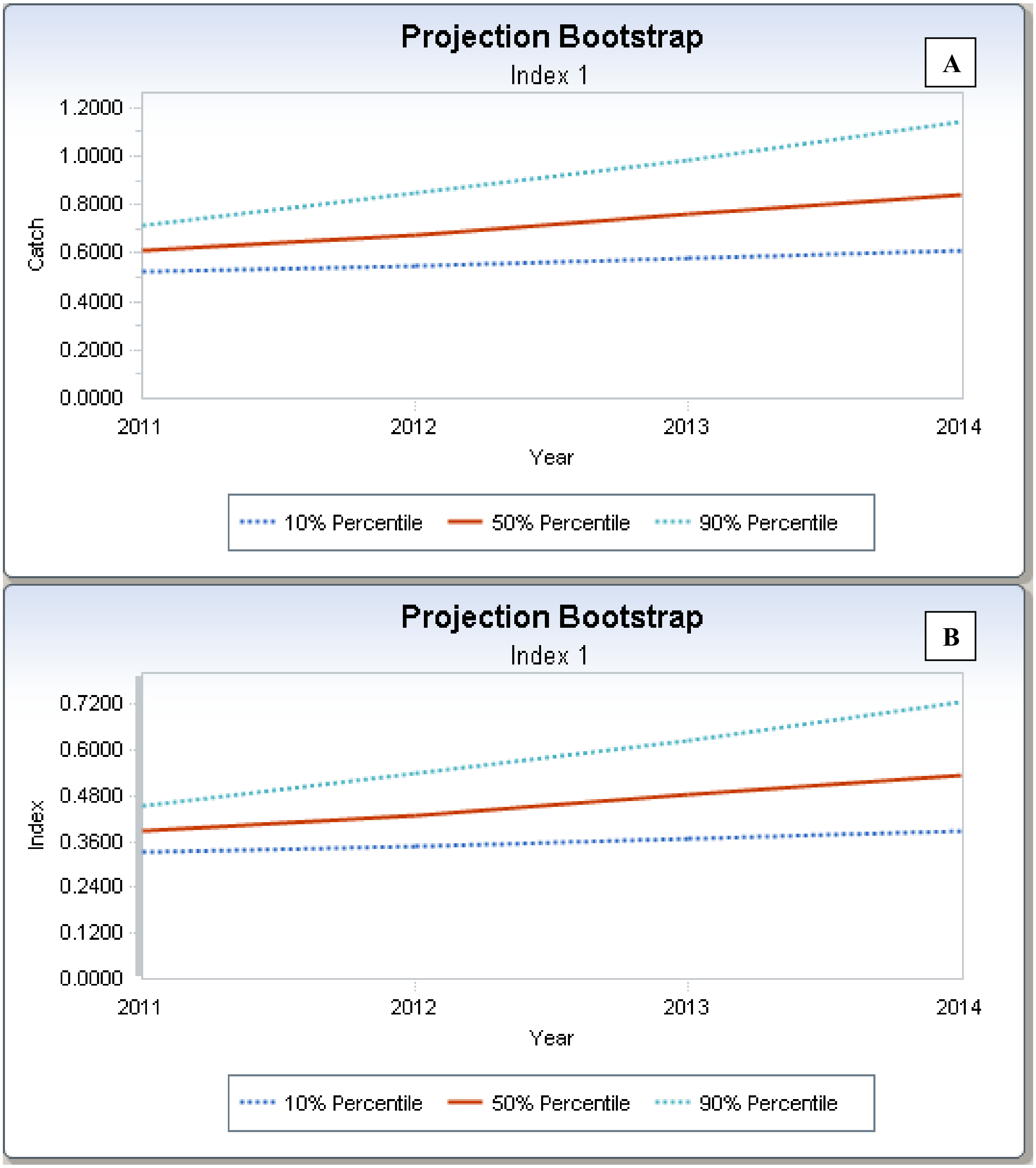


Figure J12. Stochastic projections of SNE-MAB windowpane flounder (A) catches (kt) and (B) NEFSC fall survey relative biomass indices (kg per tow), for 2011-2014, assuming fishing at 75% F_{MSY} proxy (= 1.57 kt/kg per tow).

10.0 Appendices

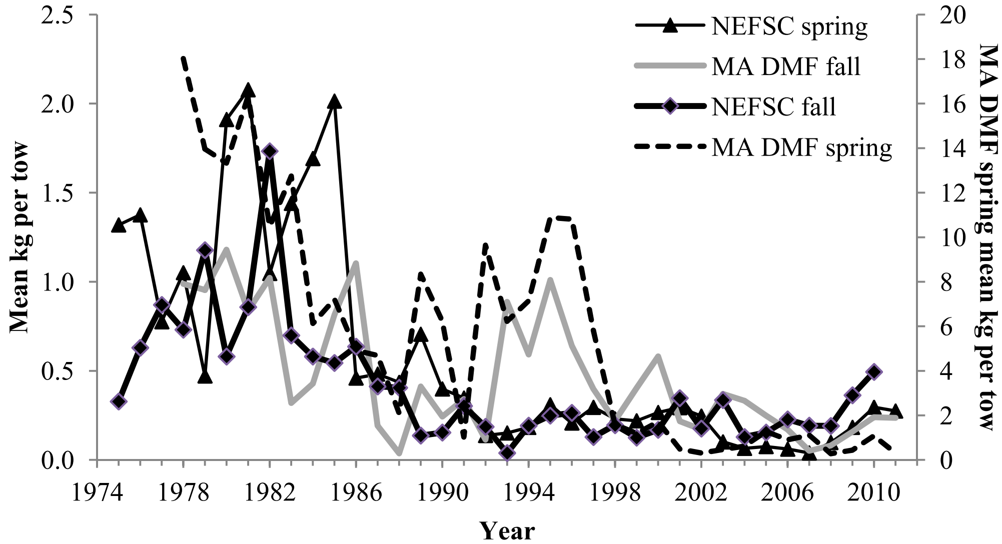


Figure A. J1. Relative biomass indices for the MA spring and fall bottom trawl surveys (1978-2011) and the NEFSC spring (1975-2011) and fall (1975-2010) bottom trawl surveys.

NEFSC indices from 2009 onward represent SRV *H. B. Bigelow* catches adjusted to RV *Albatross IV* equivalents.

K. Ocean Pout by S.E. Wigley

1.0. Background

Ocean pout, *Zoarces americanus*, are assessed as a unit stock from Cape Cod Bay south to Delaware (Figure K1). An index assessment for this species was last reviewed at the 2008 Groundfish Assessment Review Meeting (Wigley et al. 2008). At that time, the three year average spring biomass index (2006-2008 average = 0.48 kg/tow) was below the biomass threshold (½ Bmsy = 2.4 kg/tow) of the Bmsy proxy (1977-1985 median = 4.9 kg/tow). The relative exploitation ratio (0.38) indicated that fishing mortality was well below the F threshold (Fmsy proxy = 0.76). Ocean pout are included in the New England Fishery Management Council's Multispecies Fishery Management Plan and is one of twelve species listed in the "Large Mesh/Groundfish" group based on fish size and type of gear used to harvest the fish.

2.0. Fishery

From 1964 to 1974, an industrial fishery developed for ocean pout, and nominal catches by the U.S. fleet averaged 4,700 mt (Table K1, Figure K2). Distant-water fleets began harvesting ocean pout in large quantities in 1966, and total nominal catches peaked at 27,000 mt in 1969. Foreign catches declined substantially afterward, and none have been reported since 1974. United States landings declined to an average of 600 mt annually during 1975 to 1983. Catches increased in 1984 and 1985 to 1,300 mt and 1,500 mt respectively, due to the development of a small directed fishery in Cape Cod Bay supplying the fresh fillet market. Landings have declined more or less continually since 1987. In recent years, landings from the southern New England/Mid-Atlantic area have continued to dominate the catch, reversing landing patterns observed in 1986-1987, when the Cape Cod Bay fishery was dominant. The shift in landings is attributed to the changes in management (gear/mesh) regulations. The majority of landings are taken using otter trawl gear, except in 2010 (Table K2). On May 1, 2010, the Multispecies FMP prohibited ocean pout landings. Total landings in 2010 were less than 1 mt, a record low in the time series (Table K1, Figure K2).

Dock-side sampling of commercial ocean pout landings began in 1984 (Appendix Table K1); landed ocean pout range between 40 and 90 cm, with most fish between 50 and 60 cm. In recent years, dock-side sampling has been sporadic or non-existent.

Discard Estimation

The primary reason reported in the Northeast Fisheries Observer Program[3] (NEFOP) for ocean pout discards is "no market". For the 1989 to 2010 time period, limited NEFOP data are available for gear types other than otter trawl, gillnet and scallop dredge gear. A combined ratio estimator, discard weight of ocean pout to kept weight of all species, was used to estimate ocean pout discards in the otter trawl fishery by large (>=5.5 inch) and small (<5.5 inch) mesh groups, gillnet, and scallop dredge using the NEFOP data from the

[3] Northeast Fisheries Observer Program was implemented in 1989.

Cape Cod Bay, Georges Bank, Southern New England and Mid-Atlantic regions[4] for 1989 to 2010[5] Total discards were derived by expanding the discard ratios by the kept weight of all species, by gear type and mesh group, using the Dealer weighout data for 1989 – 2010 (Appendix Tables K2 and K3).

Prior to 1989, ocean pout discards were estimated using the survey-scale method (as described in Palmer et al. 2008) utilizing an average combined ratio based on 2004 to 2006 NEFOP data, the NEFSC spring survey weight per tow indices, and the kept weight of all species. Ocean pout discards (mt) were derived for four fleets (large-mesh otter trawl, small-mesh otter trawl, gillnet and scallop dredge) from 1968 – 1988 (Appendix Table K4). Total discards range between 120 mt in 2008 to 9,434 mt in 1990; discards in 2010 was the second lowest in the time series (Table K3 and Figure K2). The majority of ocean pout discards occur in the large-mesh and small-mesh otter trawl fisheries. Discards from the otter trawl fleets exceed landings in most years (Table K1).

3.0 Research Surveys

Commercial landings and the NEFSC spring research vessel survey biomass index followed similar trends during 1968 to 1975 (encompassing peak levels of foreign fishing and the domestic industrial fishery); both declined from very high values in 1968-1969 to lows of 300 mt and 1.3 kg per tow, respectively, in 1975 (Table K4 and Figure K2). Between 1975 and 1985, survey indices increased to record high levels, peaking in 1981 and 1985. Since 1985, survey catch per tow indices have generally declined, and the 2010 index (0.299 kg/tow) is the lowest value in the time series (Figure K3). The NEFSC survey strata areas are given in Appendix Table K5. Both NEFSC winter survey and the Massachusetts Division of Marine Fisheries inshore research vessel surveys confirm the declining trend observed in the NEFSC spring survey (Appendix Tables K6 and K7, Appendix Figures K1 and K2). Decreases in maximum size can be observed in the NEFSC spring survey length frequencies over time (Appendix Figure K3).

Survey conversion factors: 1968 – 2008

There are no significant net or door conversion factors for ocean pout, however, there are significant vessel conversion factors between *R/V Albatross IV and R/V Delaware II* for ocean pout (Byrne and Forrester 1991). Vessel conversion factors for numbers and weight are 0.70 and 0.69 (p-value 0.004), respectively. The vessel conversion factors were based upon 510 paired tows from five experiments conducted in the Mid-Atlantic, Southern New England, Georges Bank, and Gulf of Maine regions during the autumn, with the exception of 40 paired tows that were conducted during February. These experiments are spatially appropriate for this species; however, the temporal aspect is problematic. The availability of ocean pout to the otter trawl gear is very different between spring and autumn due to the life history behavior of ocean pout to nest-guard their egg masses in rocky areas during the autumn. In the autumn, ocean pout are not as available to the otter trawl gear as in the

[4] Statistical areas (514, 521,522,561,562,525,562,537-539,611-616).

[5] In 2010, NEFOP At-Sea Monitoring (ASM) data were pooled with NEFOP observer (OB) data for the large-mesh otter trawl discard estimation. A comparison of the discard rates using ASM and OB indicated no statistical differences for ocean pout in otter trawl gear by quarter (Wigley et al. 2011).

spring. Given this, the NESFC spring survey is used to monitor trends for this species. Since the majority of paired tows during these experiments took place in the autumn when breeding behavior is occurring and relatively low numbers of ocean pout are caught, it is questionable whether it is appropriate to apply the vessel conversion factors to the NEFSC spring survey. As in past assessments, the vessel conversion factors have not been applied to the 1968 - 2008 survey indices (see Wigley et al. 2008 for sensitivity analyses with and without vessel conversion factors).

Survey conversion factors: 2009 – 2011

There are significant vessel conversion factors between the *FS/V Bigelow* and the *R/V Albatross IV* for ocean pout (Miller et al. 2010). Vessel conversion factors for numbers and weight are 3.9115 and 4.5752, respectively. These vessel conversion factors have been applied to the 2009 - 2011 NEFSC spring bottom trawl surveys. Length-based conversion factors have not been established for ocean pout.

4.0 Assessment

In previous assessments, the data for ocean pout had insufficient dynamic range over the time series to provide estimates for biological reference points; the AIM and LOSS (an age structured biomass dynamic model; Palmer and Legault 2008) analyses were non-informative (NEFSC 2002; Wigley and Col 2005, Wigley et al. 2008). These analyses were not updated.

Relative Exploitation Rate

Computing survey biomass indices of exploitable biomass for use in calculating exploitation ratio were updated. Given no minimum fish size, no market demand, no mesh selection parameters, and limited commercial length frequency data, there was insufficient information to apply a selection ogive to the ocean pout survey length frequency data. In this assessment update, revised 2007 catch was used and 2008 - 2010 catch were added. Revised 2008 survey data were used and 2009 - 2011 survey data were added.

Exploitation ratios were derived using catch (landings and discards) divided by the three year average of NEFSC spring survey biomass indices (without vessel conversion factors applied during the 1968 to 2008 period and with vessel conversion factors applied during the 2009 through 2011 period). Exploitation ratios have declined sharply from a peak in 1973 to low levels in the early 1980s then increased slightly in the late-1980s, after which they declined to record low levels (Table K5, Figure K4). The 2010 exploitation index is 0.31.

Sensitivity Analyses

Since GARM 2008, the 2007 catch and the 2008 survey biomass index have been revised (Tables K1, K4 and Appendix Table K8). There was no change in 2007 landings, however there was a 10 mt decrease in discards that resulted in a -5.6% change in total catch in 2007. The change in 2007 discards was a result of changes in NEFOP data as well as changes to commercial landings of all kept species. The NEFSC spring 2008 index changed slightly (-0.002 kg/tow) from the preliminary value of 0.424 kg/tow used in GARM 2008. These changes had a negligible effect on the 2007 exploitation ratio in (0.375 in GARM 2008 and 0.355, Appendix Table K7) and would not have resulted in a change in stock status for ocean pout in 2007.

5.0 Biological Reference Points

Biological reference point proxies were first established for ocean pout by the Overfishing Definition Panel (Applegate et al. 1998). The Overfishing Definition Panel visually inspected the landings and survey trends and chose values for MSY and Bmsy that appeared to be sustainable. The Bmsy proxy (4.9 kg/tow) was based on the 1980-1991 median NEFSC spring survey biomass index. The MSY=1,500 mt was chosen because stock biomass appears to decline when landings exceeded this level (Applegate et al. 1998). MSY was based on landings, not catch. Fmsy proxy (0.31) was derived from MSY and Bmsy proxy.

Discards were estimated in the GARM 2008 assessment, thus biological reference point proxies were updated using catch. The median NEFSC 3yr average spring biomass index (4.94 kg/tow) and the median exploitation ratio (0.76) during 1977-1985 are used as Bmsy and Fmsy proxies, respectively. The 1977-1985 time period corresponds to the time when the replacement ratio was above 1 and biomass increased (Appendix Figure K4). Based on these proxies, MSY is estimated to be 3,754 mt (4.94 * 0.76 * 1000). Given below are biological reference point proxies used in GARM 2005 and the re-estimated proxies for GARM 2008 that were accepted by the GARM 2008 Biological Reference Point Meeting Panel. For the 2012 Update, the biological reference points do not change.

GARM 2005 using landings	GARM 2008 using catch	Update 2012
Bmsy = 4.9 kg/tow Fmsy = 0.31 MSY = 1,500 mt	Bmsy = 4.94 kg/tow Fmsy = 0.76 MSY = 3,754 mt	Same as GARM 2008

Trends in average survey biomass indices and relative exploitation rates are given in Figure K5. Since the mid-1990s, the 3yr average survey biomass index has been at or below the ½ Bmsy proxy and the relative exploitation rate has been below the Fmsy proxy (Table K5 and Figure K5).

The NEFSC spring survey biomass indices have been expanded to total population biomass using the survey strata area and the swept-area of the survey net. In recent years, estimates of total population biomass are below the estimate of MSY (Figure K6).

6.0 Projections

No projections have been conducted for ocean pout.

7.0 Summary

The updated analysis presented above was used to determine stock status in 2010. The three year average of NEFSC spring survey indices and the exploitation ratio (2010 catch / average of 2009, 2010, 2011 spring survey biomass indices) are used as proxies for biomass and fishing mortality, respectively. In 2010, the three year average survey index (0.41 kg/tow) was 8% of the Bmsy proxy (1977-1985 median = 4.94 kg/tow; Figure K7). The relative exploitation ratio (0.31) indicates that fishing mortality was 41% of the F threshold (Fmsy proxy = 0.76; Figure K7). In 2010, ocean pout was overfished, but overfishing was not occurring.

This index assessment reveals that catch, survey indices and exploitation ratios remain at, or near, record low levels and the annual estimates of discards exceed the landings. Although exploitation has been low, stock size has not increased suggesting that this stock may be in a depensatory state. Discards are estimated to be an important component of catch and may be sufficiently high to hinder recovery of the stock.

For ocean pout, the replacement ratio and relative F analyses, as well as age-structured biomass dynamics model analyses, were not informative upon which to base Bmsy, Fmsy, and MSY. Thus, biological reference points for ocean pout remain based upon research vessel survey biomass trends and the exploitation history based on total catch.

Changes from Last Assessment

Catch (landings and discards) have been updated from 2007 onward. Survey indices have been updated for 2008 onward.

Sources of Uncertainty

- Due to the lack of commercial length samples (13 samples since 1997), the size composition of the commercial landings could not be characterized.

- Biological reference points are based on catch; the estimated discards used in catch are based on a mix of direct and indirect methods. The catch used to determine MSY is based on indirect methods.

8.0 Conclusions

Status of Stock for Ocean Pout

SSB in 2010 is estimated to be 0.41 kg/tow.
Relative F in 2010 is estimated to be 0.31 kt/kg/tow.
No change in biological reference points.
The estimates of the biological reference points are:

SSBmsy proxy= 4.94 kg/tow,
Fmsy proxy = 0.76 kt/kg/tow, and
MSY proxy= 3,754 mt.

Based on these results, ocean pout is overfished and overfishing is not occurring. The stock is below the biomass target, the same stock status as GARM-III.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15), which includes catch (landings and discards), survey indices and relative exploitation ratios.

The BRPs remain the same as GARM-III.

Ocean Pout. Summary of Assessment Information

Ocean Pout	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average	Min	Max	Year Range
Landings (mt)	18	12	26	5	4	5	4	7	3	<1	2282	3	26972	1963-2010
Discards (mt)	532	576	427	291	201	183	165	120	164	127	1891	120	9434	1968-2010
Catch (mt)	549	588	452	296	205	188	169	127	168	127	3928	20	30101	1963-2010
Centered 3 yr ave SSB (kg/tow)	2.280	2.527	1.776	1.277	0.533	0.510	0.475	0.485	0.450	0.409	2.918	0.409	6.126	1969-2010
F catch/3 year avg index	0.241	0.233	0.255	0.232	0.384	0.368	0.355	0.261	0.373*	0.311*	1.061	0.149	5.394	1968-2010

*Vessel conversion factors have been applied.

Panel Comments

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

The Review Panel recognized that an AIM analysis was attempted at previous assessments, including the 2008 GARM, but there was not a significant relationship between the exploitation rate and stock productivity. The same lack of relationship continues during the updated fishery catch and survey observations, which both remained extremely low. The lack of correspondence between exploitation history and productivity would present a problem for any conventional stock assessment modeling approach. Therefore, the Review Panel concluded that status determination and catch advice should continue to be based on relative exploitation ratios with no change in the biological reference points.

The index-based assessment approach does not support catch projections, so catch advice should continue to be based on the target exploitation rate and the most recent, centered 3-year average biomass index from the NEFSC spring survey.

There was extensive discussion on the continued low productivity, despite low fishery catch, and the slow population growth rate. Previous productivity may have been supported by a few large year classes (e.g., in the late 1970s), but there has been weak recruitment in the last decade. The cause of the abrupt decrease in survey biomass and abundance at all sizes in 2004 remains unknown. The decrease in biomass in the last decade is supported by other surveys (e.g., the NEFSC winter survey and the Mass DMF surveys). Declines in ocean pout on the Scotian Shelf (not included in this stock assessment) are similar to those in U.S. waters, but the abrupt decrease occurred earlier (Clark et al. 2010). Other factors, such as environmental change, loss of habitat or increased natural mortality may be negatively influencing production. The life history and recent low productivity of ocean pout are relevant for catch advice. Prospects for rebuilding in the near term are poor.

9.0 Acknowledgements

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Table K1. Commercial landings and discards (mt, live) of ocean pout from the Gulf of Maine to the Mid-Atlantic region (NAFO Subareas 5 and 6), 1962-2010.

	USA Landings			Other	Total		Total
Year	5	6	Total	Landings	Landings	Discards	Catch
1962	0	0	0	0	0		0
1963	20	0	20	0	20		20
1964	2123	0	2123	0	2123		2123
1965	877	0	877	0	877		877
1966	7149	0	7149	6231	13380		13380
1967	7090	0	7090	271	7361		7361
1968	8373	364	8737	4324	13061	3476.9	16538
1969	5571	966	6537	20435	26972	3129.5	30101
1970	5851	426	6277	895	7172	2765.8	9938
1971	2678	1448	4126	1784	5910	2021.5	7932
1972	1927	358	2285	1066	3351	1498.2	4849
1973	2810	285	3095	2275	5370	1294.2	6664
1974	2790	459	3249	483	3732	1133.9	4866
1975	209	65	274	3	277	716.6	994
1976	341	337	678	0	678	522.2	1200
1977	809	250	1059	0	1059	928.1	1987
1978	715	320	1035	0	1035	1377.6	2413
1979	658	14	672	0	672	1509.3	2181
1980	339	11	350	0	350	2015.9	2366
1981	234	17	251	0	251	2743.2	2994
1982	317	4	321	0	321	4439.5	4761
1983	408	0	408	0	408	4488.7	4897
1984	1324	0	1324	0	1324	3692.2	5016
1985	1450	54	1504	0	1504	3161.0	4665
1986	801	1	802	0	802	3296.4	4098
1987	2111	74	2185	0	2185	2623.6	4809
1988	1765	46	1811	0	1811	2243.6	4055
1989	1308	6	1314	0	1314	7414.9	8729
1990	1299	13	1312	0	1312	9434.0	10746
1991	1361	63	1424	0	1424	4925.6	6350
1992	406	68	474	0	474	1520.0	1994
1993	217	15	232	0	232	1345.9	1578
1994	137	59	196	0	196	1280.9	1477
1995	51	14	65	0	65	573.5	639
1996	34.7	16.3	51.0	0	51	628.6	680
1997	7.6	25.4	33.0	0	33	521.5	555
1998	8.6	8.4	17.0	0	17	672.9	690
1999	8.9	9.1	18.0	0	18	786.1	804
2000	8.4	10.6	19.0	0	19	347.8	367
2001	8.4	9.2	17.6	0	18	531.6	549
2002	3.5	8.6	12.1	0	12	575.7	588
2003	18.1	7.4	25.6	0	26	426.8	452
2004	3.0	2.4	5.4	0	5	290.7	296
2005	0.6	3.0	3.6	0	4	200.8	205
2006	0.2	4.9	5.1	0	5	182.5	188
2007	1.4	2.1	3.5	0	4	165.3	169
2008	1.7	5.6	7.2	0	7	119.5	127
2009	0.5	2.7	3.2	0	3	164.4	168
2010	0.0	0.3	0.3	0	<1	126.8	127

Table K2. Percentage of annual commercial landings of ocean pout by gear type, 1964 -2010.

YEAR	Longline & Handline	Otter Trawl	Fish Pot	Lobster Pot	Unknown	Other	Total
1964		100					100.0
1965		100					100.0
1966		100					100.0
1967		100					100.0
1968		100					100.0
1969		100					100.0
1970		100					100.0
1972		100					100.0
1973		100					100.0
1975	4.0	96.0					100.0
1976	0.1	99.9					100.0
1977	0.0	100.0					100.0
1978		100.0				0.0	100.0
1979		99.9				0.1	100.0
1980		100.0					100.0
1981		100.0					100.0
1982		100.0				0.0	100.0
1983		100.0					100.0
1984		100.0					100.0
1985		100.0					100.0
1986		100.0					100.0
1987	0.6	99.2				0.2	100.0
1988	0.2	99.6	0.0			0.2	100.0
1989	0.2	99.5	0.0	0.1		0.2	100.0
1990	0.3	99.5	0.0	0.0		0.2	100.0
1991	1.2	97.5	1.2	0.0		0.1	100.0
1992	6.6	90.1	2.5	0.0		0.8	100.0
1993	5.3	91.3	2.2	0.3		0.9	100.0
1994	4.7	91.2	3.2	0.2	0.0	0.7	100.0
1995	9.7	77.9	3.5	1.0	6.5	1.4	100.0
1996	5.4	89.3	2.4	1.6	0.0	1.3	100.0
1997	3.8	85.7	1.6	6.1	0.0	2.8	100.0
1998	9.0	77.9	4.9	3.9	0.3	4.0	100.0
1999	12.7	74.4	7.3	2.7		2.9	100.0
2000	11.7	65.2	4.7	9.1		9.3	100.0
2001	15.5	71.5	5.9	5.0	2.0	0.1	100.0
2002	1.1	73.8	12.6	5.7	6.3	0.5	100.0
2003	4.9	80.3	6.9	0.9	0.2	6.8	100.0
2004	18.2	62.4	5.0	10.8	3.0	0.6	100.0
2005	31.8	32.8	9.2	25.8	0.4		100.0
2006	25.6	35.5	21.4	4.9	11.3	1.3	100.0
2007	12.9	47.4	14.9	16.9	2.0	5.9	100.0
2008	14.0	37.6	34.5	10.8	3.1		100.0
2009	10.2	47.1	11.5	14.7	16.3	0.2	100.0
2010	11.4	0.6	48.4	38.6	0.3	0.7	100.0

Table K3. Ocean pout discards (mt) and coefficient of variation from the large-mesh (>= 5.5 inches) otter trawl, small-mesh (<5.5 inches) otter trawl, gillnet, and scallop dredge fleets, 1968 – 2010. A combined ratio estimator of ocean pout discard to kept of all species based on NEFOP data is used to estimate discards from 1989 to 2010. The survey scale method is used to estimate discards prior to 1989.

	Large-mesh Otter Trawl		Small-mesh Otter Trawl		Gillnet		Scallop Dredge		Total	
YEAR	mt	CV	mt	CV	mt	CV	mt	CV	mt	CV
1968			3470.4		1.0		5.5		3476.9	
1969			3125.1		0.9		3.5		3129.5	
1970			2761.6		0.9		3.2		2765.8	
1971			2018.4		0.6		2.5		2021.5	
1972			1495.9		0.8		1.4		1498.2	
1973			1292.2		0.6		1.4		1294.2	
1974			1131.6		0.7		1.6		1133.9	
1975			714.8		0.3		1.5		716.6	
1976			520.0		0.2		2.0		522.2	
1977			922.9		0.4		4.7		928.1	
1978			1369.5		1.3		6.9		1377.6	
1979			1499.2		1.9		8.1		1509.3	
1980			2002.6		5.1		8.3		2015.9	
1981			2724.3		5.5		13.5		2743.2	
1982	2110.5		2308.1		6.3		14.6		4439.5	
1983	3308.0		1161.2		6.0		13.4		4488.7	
1984	2988.9		687.0		7.0		9.3		3692.2	
1985	2506.7		636.8		7.4		10.1		3161.0	
1986	2420.9		851.0		10.4		14.1		3296.4	
1987	2002.6		597.1		7.5		16.5		2623.6	
1988	1681.5		541.4		6.7		14.0		2243.6	
1989	4912.2	0.33	2488.3	0.50	0.1	1.50	14.3		7414.9	0.28
1990	8887.3	0.30	525.4	0.42	1.8	1.26	19.5		9434.0	0.29
1991	3189.1	0.41	1713.2	0.37	3.5	0.58	19.7		4925.6	0.30
1992	1147.6	0.36	192.3	0.42	3.1	0.27	177.1	0.57	1520.0	0.29
1993	941.5	0.28	146.6	0.62	3.9	0.39	254.0	0.34	1345.9	0.21
1994	445.0	0.40	784.8	4.51	4.9	0.85	46.1	0.52	1280.9	2.77
1995	417.9	0.34	146.2	0.48	0.8	0.65	8.6	0.45	573.5	0.28
1996	448.7	0.39	137.6	1.21	1.1	0.84	41.2	0.72	628.6	0.39
1997	456.3	0.53	29.3	0.49	3.2	0.59	32.6	0.29	521.5	0.46
1998	595.7	0.63	30.2	0.57	0.3	0.80	46.7	0.75	672.9	0.56
1999	701.5	0.30	45.6	0.69	4.4	0.57	34.6	0.68	786.1	0.27
2000	310.3	0.64	19.5	0.51	8.4	0.75	9.6	0.27	347.8	0.57
2001	490.0	0.36	30.4	0.43	1.3	0.56	9.8	0.41	531.6	0.34
2002	539.4	0.33	28.0	0.34	3.4	0.54	5.0	0.56	575.7	0.31
2003	379.7	0.17	34.6	0.40	3.1	0.34	9.3	0.28	426.8	0.15
2004	248.1	0.12	38.8	0.29	2.7	0.34	1.2	0.54	290.7	0.11
2005	140.5	0.09	56.2	0.21	1.0	0.62	3.1	0.20	200.8	0.09
2006	113.3	0.12	65.0	0.54	0.5	0.77	3.8	0.21	182.5	0.21
2007	133.0	0.11	27.1	0.44	0.9	0.72	4.3	0.28	165.3	0.11
2008	101.6	0.13	12.2	0.38	3.1	0.50	2.6	0.15	119.5	0.12
2009	153.7	0.12	7.7	0.31	0.3	0.58	2.7	0.27	164.4	0.11
2010	88.3	0.12	34.2	0.28	0.5	0.28	3.9	0.27	126.8	0.11

Table K4. Stratified mean catch per tow in weight and numbers, individual average fish weight, mean length and swept-area population biomass of ocean pout in **NEFSC spring surveys**, in the Gulf of Maine-Mid-Atlantic region (strata 1-26, 73-76), 1968-2011.

Year	Mean weight per tow (kg)	CV	Mean number per tow	CV	Individual average weight (kg)	Mean length (cm)	Swept-area population biomass (mt)
1968	5.446	28.3	6.768	25.1	0.805	51.1	17,065
1969	6.154	15.6	8.629	15.2	0.713	49.3	19,282
1970	5.143	24.5	6.133	25.2	0.839	51.9	16,115
1971	2.195	22.9	3.135	28.8	0.700	50.2	6,879
1972	4.463	28.3	5.104	27.8	0.874	51.6	13,986
1973	3.373	17.4	4.591	15.6	0.735	48.8	10,569
1974	1.479	20.6	2.310	14.8	0.640	47.0	4,636
1975	1.293	25.3	1.358	23.8	0.952	53.4	4,052
1976	1.400	22.8	2.440	36.1	0.574	46.5	4,387
1977	3.605	55.3	6.366	56.9	0.566	44.8	11,274
1978	3.371	15.0	11.831	17.6	0.285	31.6	10,562
1979	1.493	25.0	5.197	54.6	0.287	34.7	4,678
1980	5.729	23.2	11.837	23.2	0.484	42.6	17,952
1981	7.605	22.4	14.131	26.0	0.538	42.7	23,829
1982	4.743	24.6	8.690	43.2	0.546	44.0	14,863
1983	4.236	15.9	5.076	13.7	0.835	50.5	13,274
1984	5.540	21.8	7.275	26.5	0.762	50.0	17,359
1985	6.494	18.1	9.011	19.6	0.721	48.7	20,348
1986	6.345	25.1	6.995	22.8	0.907	53.0	19,880
1987	2.705	33.7	3.076	31.3	0.879	51.7	8,475
1988	3.244	18.1	5.405	27.6	0.600	45.0	10,165
1989	2.792	15.5	5.323	20.6	0.525	44.0	8,748
1990	5.074	21.1	6.369	21.1	0.797	50.3	15,898
1991	3.783	16.2	5.596	15.3	0.676	49.7	11,853
1992	2.257	16.0	2.639	13.6	0.855	52.9	7,071
1993	3.084	21.5	3.546	18.9	0.870	53.4	9,663
1994	2.309	18.4	2.640	16.1	0.875	54.3	7,234
1995	1.916	18.2	2.525	15.5	0.759	50.5	6,004
1996	2.058	29.6	3.127	22.6	0.658	47.6	6,450
1997	1.632	22.0	2.069	20.0	0.789	52.4	5,113
1998	1.733	31.1	2.957	27.9	0.586	46.1	5,430
1999	2.561	21.2	3.340	19.9	0.767	50.2	8,025
2000	2.016	22.8	3.113	21.5	0.648	48.2	6,317
2001	2.798	28.4	3.748	26.3	0.746	51.6	8,767
2002	2.025	24.3	2.809	23.0	0.721	51.3	6,345
2003	2.758	56.8	2.919	41.6	0.945	55.4	8,643
2004	0.546	21.3	0.673	19.3	0.812	50.8	1,712
2005	0.526	28.0	0.854	23.8	0.616	45.9	1,648
2006	0.526	34.5	0.789	24.4	0.667	47.4	1,649
2007	0.477	28.0	1.076	20.2	0.443	42.9	1,493
2008	0.422	17.1	0.835	17.1	0.506	43.8	1,327
*2009	0.556	30.3	1.621	22.5	0.304	37.5	1,807
*2010	0.371	25.4	1.097	20.6	0.289	35.5	1,164
*2011	0.299	31.9	0.909	19.7	0.281	34.5	936
mean 1968-2011	2.922						9,157
median 1968-2011	2.633						8,250

** F/V Bigelow to R/V Albatross conversion factors have been applied (3.9115 and 4.5752 for weight and numbers, respectively). The uncertainty associated with the conversion factor is included in the CV.*

Table K5. NEFSC spring survey index (kg/tow), total catch ('000 mt), 3 year moving average of spring survey biomass index, relative exploitation rate (catch/ 3 yr average of spring survey biomass index) for ocean pout, 1968 – 2010.

Year	NEFSC Spring Index kg/tow	Total Catch ('000, mt)	Annual relative expliotation rate (catch/spr index)	3 year moving average (kg/tow)	Exploitation ratio (catch/ 3yr avg index)
1968	5.446	16.5379	3.037	5.800	2.851
1969	6.154	30.1015	4.892	5.581	5.394
1970	5.143	9.9378	1.932	4.497	2.210
1971	2.195	7.9315	3.613	3.934	2.016
1972	4.463	4.8492	1.086	3.344	1.450
1973	3.373	6.6642	1.976	3.105	2.146
1974	1.479	4.8659	3.289	2.048	2.375
1975	1.293	0.9936	0.768	1.391	0.714
1976	1.400	1.2002	0.857	2.099	0.572
1977	3.605	1.9871	0.551	2.792	0.712
1978	3.371	2.4126	0.716	2.823	0.855
1979	1.493	2.1813	1.461	3.531	0.618
1980	5.729	2.3659	0.413	4.942	0.479
1981	7.605	2.9942	0.394	6.026	0.497
1982	4.743	4.7605	1.004	5.528	0.861
1983	4.236	4.8967	1.156	4.840	1.012
1984	5.540	5.0162	0.905	5.423	0.925
1985	6.494	4.6650	0.718	6.126	0.761
1986	6.345	4.0984	0.646	5.181	0.791
1987	2.705	4.8086	1.778	4.098	1.173
1988	3.244	4.0546	1.250	2.914	1.392
1989	2.792	8.7289	3.126	3.703	2.357
1990	5.074	10.7460	2.118	3.883	2.768
1991	3.783	6.3496	1.679	3.704	1.714
1992	2.257	1.9940	0.884	3.041	0.656
1993	3.084	1.5779	0.512	2.550	0.619
1994	2.309	1.4769	0.640	2.436	0.606
1995	1.916	0.6385	0.333	2.094	0.305
1996	2.058	0.6796	0.330	1.869	0.364
1997	1.632	0.5545	0.340	1.808	0.307
1998	1.733	0.6899	0.398	1.975	0.349
1999	2.561	0.8041	0.314	2.103	0.382
2000	2.016	0.3668	0.182	2.458	0.149
2001	2.798	0.5492	0.196	2.280	0.241
2002	2.025	0.5879	0.290	2.527	0.233
2003	2.758	0.4524	0.164	1.777	0.255
2004	0.546	0.2960	0.542	1.277	0.232
2005	0.526	0.2048	0.389	0.533	0.384
2006	0.526	0.1875	0.356	0.510	0.368
2007	0.477	0.1688	0.354	0.475	0.355
2008	0.422	0.1267	0.300	0.485	0.261
*2009	0.556	0.1676	0.302	0.450	0.373
*2010	0.371	0.1271	0.342	0.409	0.311
*2011	0.299				
mean 1968-2010	2.92			2.99	1.01
median 1968-2010	2.63			2.79	0.62
median 1977-1985				4.94	0.76

** F/V Bigelow to R/V Albatross conversion factors have been applied (3.9115 and 4.5752 for weight and numbers, respectively).*

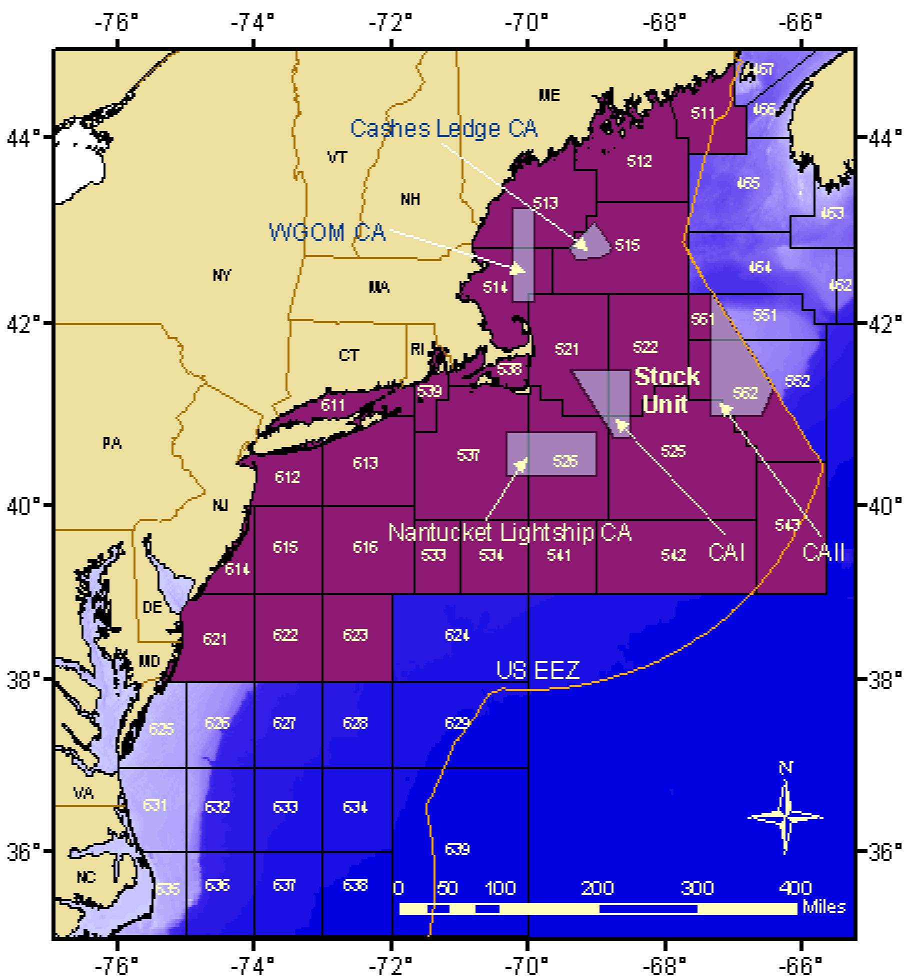


Figure 17.1. Statistical areas used to define the ocean pout stock.

Figure K1. Statistical areas used to define the ocean pout stock.

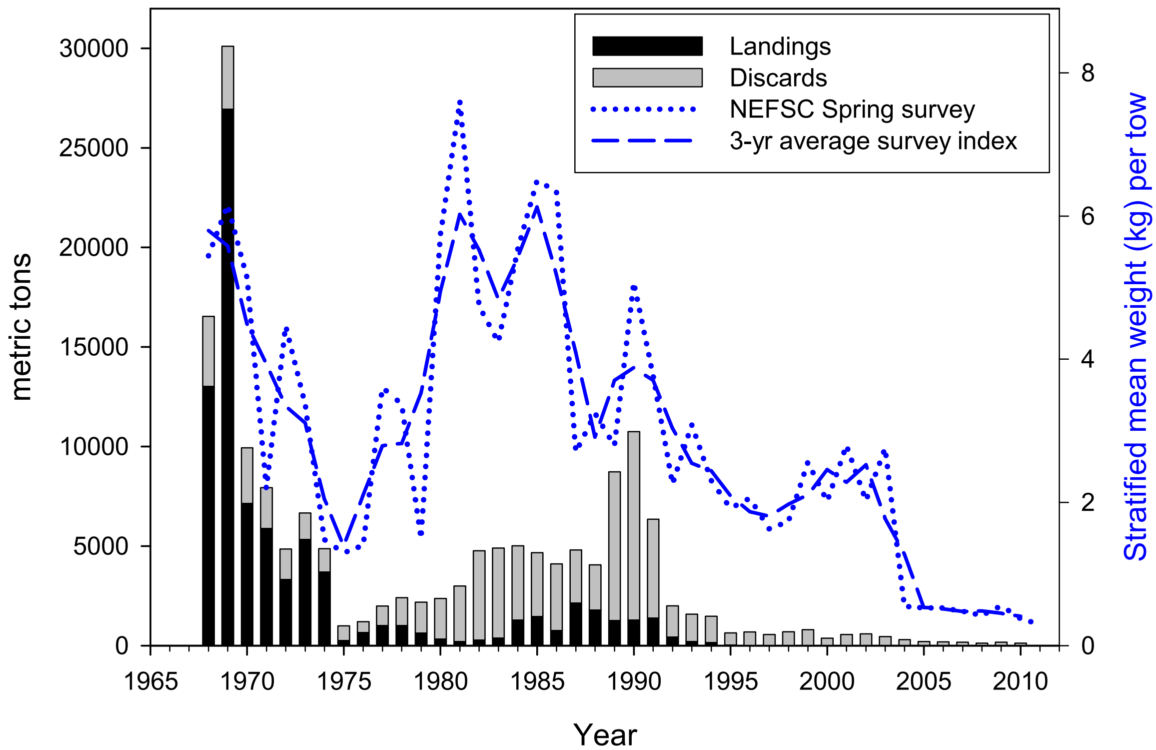


Figure K2. Trends in landings (mt), discards (mt) and NEFSC spring survey biomass (kg/tow) for ocean pout, 1968 – 2010.

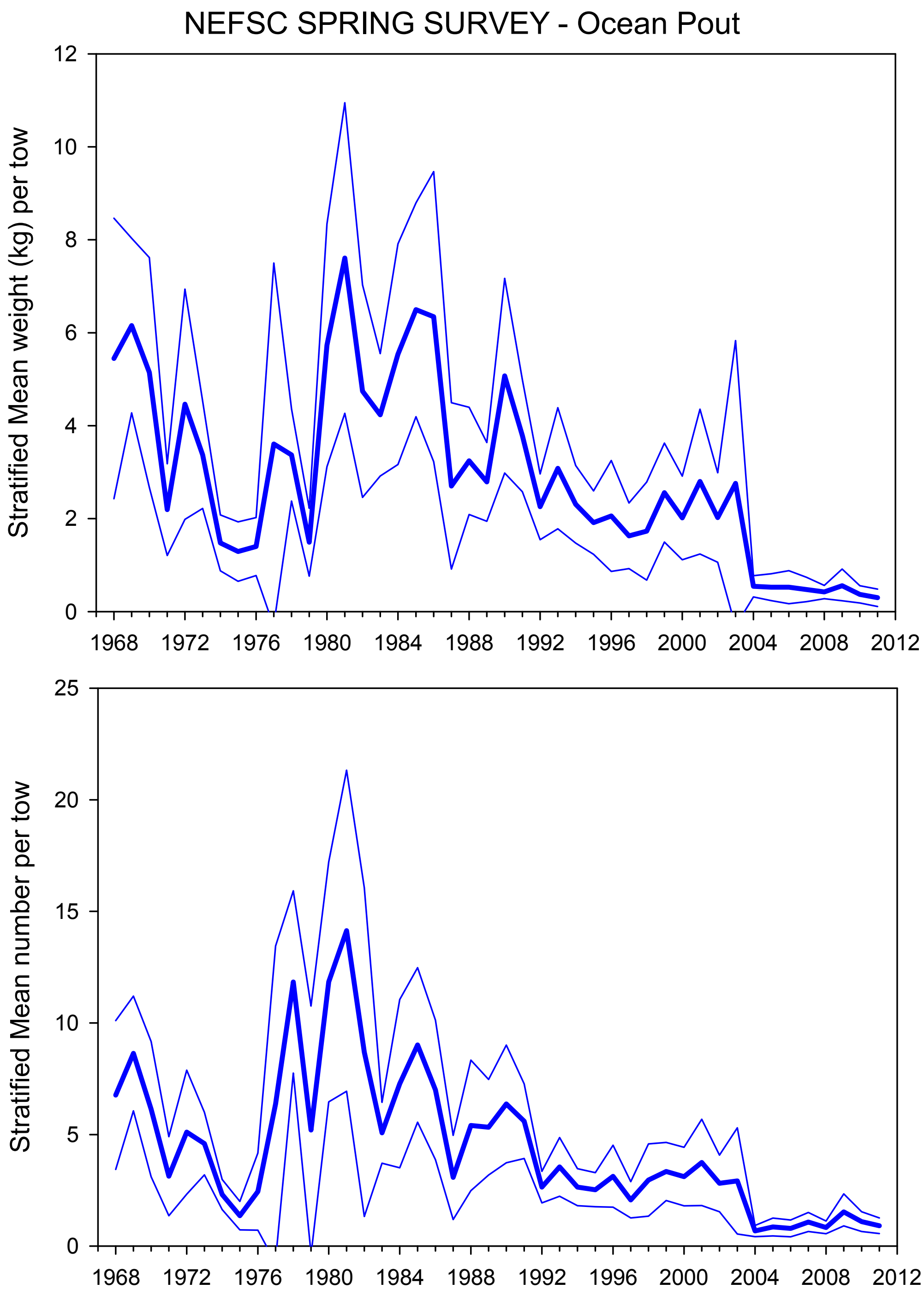


Figure K3. Stratified mean weight (kg) per tow (top) and mean number per tow (bottom) of ocean pout in the NEFSC spring survey, 1968 – 2011. Thin lines represent 95% confidence intervals.

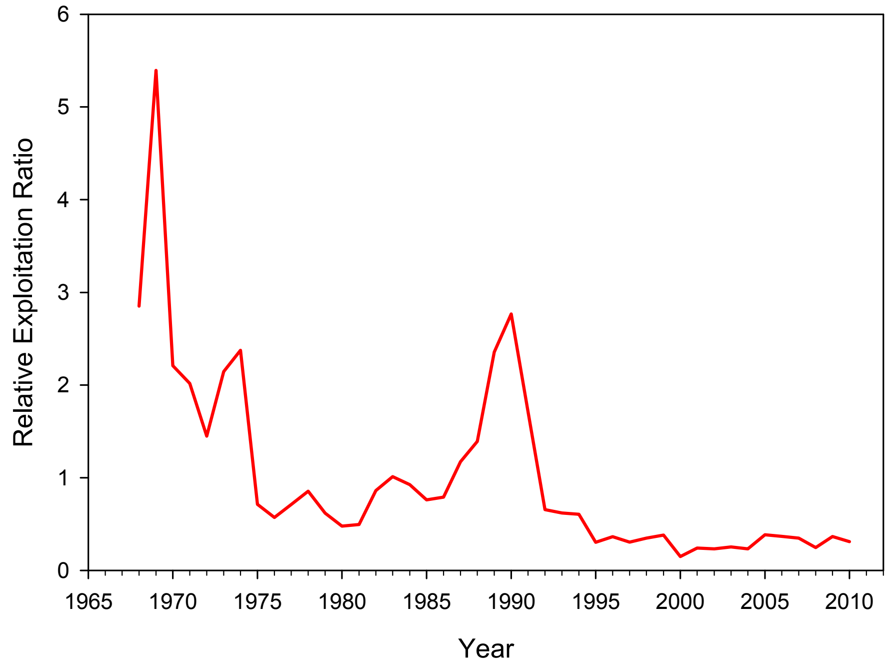


Figure K4. Trends in relative exploitation ratio (catch / 3-yr average of spring biomass index) for ocean pout, 1968 – 2010.

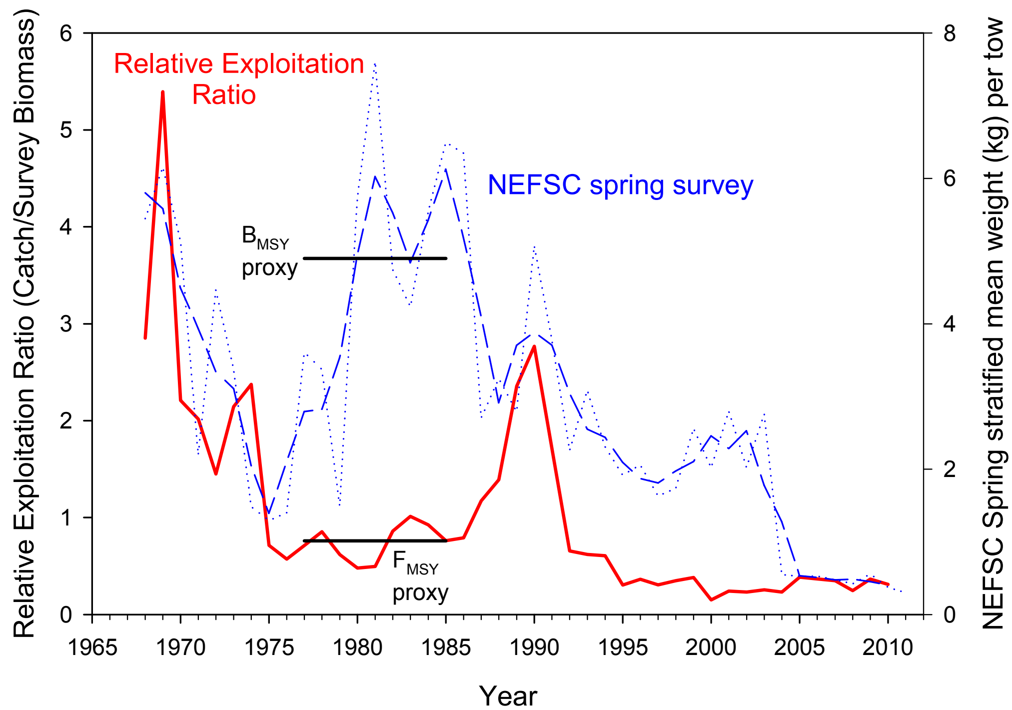


Figure K5. Trends in relative exploitation rate (catch / 3-yr average of spring biomass index) and NEFSC spring survey weight (kg) per tow for ocean pout, 1968 – 2010, with biological references point proxies based on total catch.

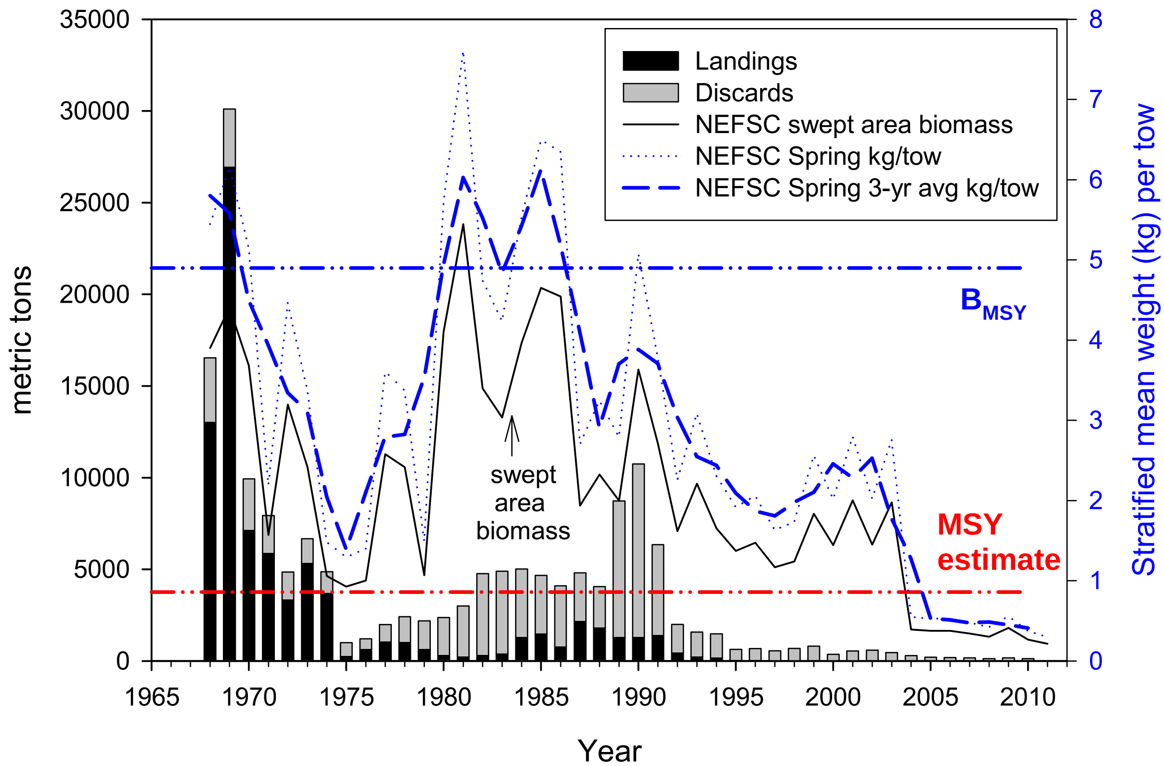


Figure K6. Trends in landings (mt), discards (mt), NEFSC spring survey biomass (kg/tow) and total population biomass (mt) for ocean pout, 1968 – 2010, with biological reference points based on total catch.

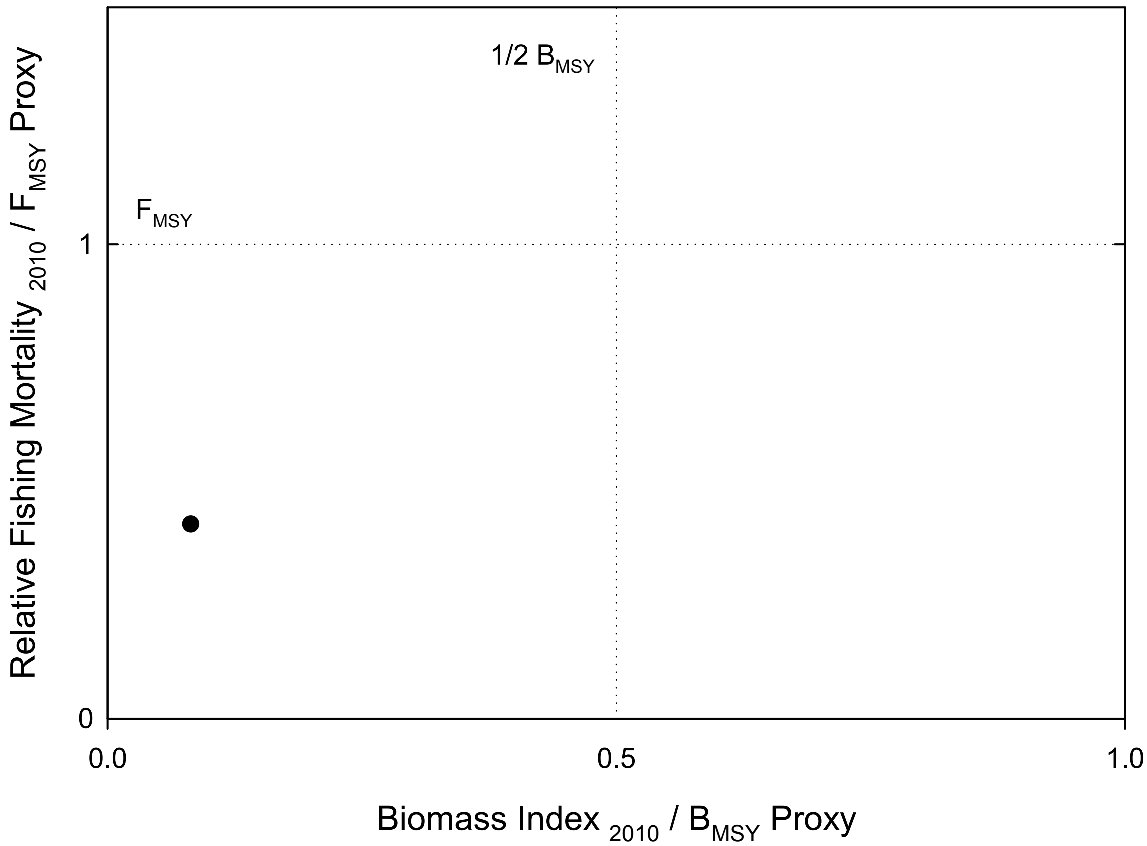


Figure K7. Ocean pout survey biomass index and relative fishing mortality in 2010, with respect to biological reference point proxies. The updated analysis was used to determine ocean pout stock status in 2010.

Appendix Table K1. Number of commercial lengths (individual fish measured) and number of samples for ocean pout collected during 1969 to 2010, by calendar quarter.

Year	Q1	Q2	Q3	Q4	Total	# of Samples
1969					0	
1970					0	
1971					0	
1972					0	
1973					0	
1974					0	
1975					0	
1976					0	
1977					0	
1978					0	
1979					0	
1980					0	
1981					0	
1982					0	
1983					0	
1984		592			592	5
1985	670	335			1005	9
1986	780	458			1238	11
1987	1477	717			2194	19
1988	1093	805		106	2004	17
1989	1283	864			2147	17
1990	1006	112			1118	12
1991	1044	259		93	1396	14
1992	402	181			583	6
1993	93				93	1
1994					0	1
1995		76			76	1
1996				17	17	1
1997					0	0
1998					0	0
1999					0	0
2000					0	0
2001					0	0
2002	109				109	1
2003	136	76			212	4
2004	37				37	1
2005					0	0
2006	133	54			187	4
2007	167	11			178	3
2008	112	16			128	5
2009	31	42			73	3
2010					0	

Five commercial age samples have been obtained: 28 fish in 1985; 29 fish in 1989; 53 fish in 1991(from 2 samples); and 21 fish in 1992.

Appendix Table K2. Number of observed trips and combined discard ratio of ocean pout discards to kept of all species for selected fleets, 1989 – 2010 using NEFOP data.

	Large-mesh Otter Trawl		Small-mesh Otter Trawl		Gillnet		Scallop Dredge	
YEAR	OB trips	d/k ratio	OB trips	d/k ratio	OB trips	d/k ratio	OB trips	d/k ratio
1989	34	0.07836	91	0.06529	67	0.00001		
1990	43	0.11079	55	0.01436	84	0.00014		
1991	56	0.04205	127	0.04462	448	0.00028		
1992	58	0.01583	74	0.00543	599	0.00023	13	0.00177
1993	27	0.01606	23	0.00374	420	0.00024	20	0.00457
1994	28	0.00792	17	0.01852	195	0.00030	18	0.00200
1995	74	0.00890	77	0.00456	182	0.00004	22	0.00026
1996	44	0.00840	59	0.00356	136	0.00005	35	0.00087
1997	26	0.00922	60	0.00074	152	0.00016	26	0.00075
1998	17	0.01144	34	0.00075	209	0.00001	23	0.00138
1999	33	0.01458	53	0.00123	122	0.00023	28	0.00056
2000	93	0.00572	43	0.00058	137	0.00059	250	0.00012
2001	150	0.00827	59	0.00101	92	0.00009	64	0.00009
2002	197	0.00945	101	0.00111	125	0.00020	84	0.00004
2003	352	0.00656	106	0.00150	418	0.00017	91	0.00008
2004	563	0.00375	312	0.00163	971	0.00014	213	0.00001
2005	1363	0.00299	358	0.00293	787	0.00008	268	0.00002
2006	639	0.00269	185	0.00175	221	0.00003	199	0.00002
2007	725	0.00344	220	0.00127	259	0.00005	288	0.00127
2008	817	0.00244	144	0.00064	225	0.00019	303	0.00064
2009	937	0.00385	353	0.00032	338	0.00002	192	0.00032
2010	1046	0.00238	443	0.00180	1392	0.00003	222	0.00180

Appendix Table K3. Ocean pout discards (mt) and coefficient of variation from the large-mesh otter trawl, small-mesh otter trawl, gillnet, and scallop dredge fleets, 1989 – 2010. Discards were derived using a combined ratio estimator of ocean pout discarded weight to kept weight of all species.

	Large-mesh Otter Trawl		Small-mesh Otter Trawl		Gillnet		Scallop Dredge		Total	
YEAR	mt	CV	mt	CV	mt	CV	mt	CV	mt	CV
1989	4912.2	0.33	2488.3	0.50	0.1	1.50			*7400.6*	0.28
1990	8887.3	0.30	525.4	0.42	1.8	1.26			*9414.5*	0.29
1991	3189.1	0.41	1713.2	0.37	3.5	0.58			*4905.9*	0.30
1992	1147.6	0.36	192.3	0.42	3.1	0.27	177.1	0.570	1520.0	0.29
1993	941.5	0.28	146.6	0.62	3.9	0.39	254.0	0.340	1345.9	0.21
1994	445.0	0.40	784.8	4.51	4.9	0.85	46.1	0.525	1280.9	2.77
1995	417.9	0.34	146.2	0.48	0.8	0.65	8.6	0.451	573.5	0.28
1996	448.7	0.39	137.6	1.21	1.1	0.84	41.2	0.722	628.6	0.39
1997	456.3	0.53	29.3	0.49	3.2	0.59	32.6	0.290	521.5	0.46
1998	595.7	0.63	30.2	0.57	0.3	0.80	46.7	0.748	672.9	0.56
1999	701.5	0.30	45.6	0.69	4.4	0.57	34.6	0.679	786.1	0.27
2000	310.3	0.64	19.5	0.51	8.4	0.75	9.6	0.265	347.8	0.57
2001	490.0	0.36	30.4	0.43	1.3	0.56	9.8	0.413	531.6	0.34
2002	539.4	0.33	28.0	0.34	3.4	0.54	5.0	0.561	575.7	0.31
2003	379.7	0.17	34.6	0.40	3.1	0.34	9.3	0.276	426.8	0.15
2004	248.1	0.12	38.8	0.29	2.7	0.34	1.2	0.544	290.7	0.11
2005	140.5	0.09	56.2	0.21	1.0	0.62	3.1	0.196	200.8	0.09
2006	113.3	0.12	65.0	0.54	0.5	0.77	3.8	0.210	182.5	0.21
2007	133.0	0.11	27.1	0.44	0.9	0.72	4.3	0.28	165.3	0.12
2008	101.6	0.13	12.2	0.38	3.1	0.50	2.6	0.15	119.5	0.12
2009	153.7	0.12	7.7	0.31	0.3	0.58	2.7	0.27	164.4	0.11
2010	88.3	0.12	34.2	0.28	0.5	0.28	3.9	0.27	126.8	0.11

Note: 1989 – 1991 total discards do not include scallop discards.

Appendix Table K4. Ocean pout discards (mt) from the large-mesh otter trawl, small-mesh otter trawl, gillnet from 1968 - 1988 and scallop dredge fleets from 1968 – 1991 based on the survey scale method.

YEAR	Large-mesh Otter Trawl	Small-mesh Otter Trawl	Gillnet	Scallop Dredge	Total
1968		3470.4	1.0	5.5	3476.9
1969		3125.1	0.9	3.5	3129.5
1970		2761.6	0.9	3.2	2765.8
1971		2018.4	0.6	2.5	2021.5
1972		1495.9	0.8	1.4	1498.2
1973		1292.2	0.6	1.4	1294.2
1974		1131.6	0.7	1.6	1133.9
1975		714.8	0.3	1.5	716.6
1976		520.0	0.2	2.0	522.2
1977		922.9	0.4	4.7	928.1
1978		1369.5	1.3	6.9	1377.6
1979		1499.2	1.9	8.1	1509.3
1980		2002.6	5.1	8.3	2015.9
1981		2724.3	5.5	13.5	2743.2
1982	2110.5	2308.1	6.3	14.6	4439.5
1983	3308.0	1161.2	6.0	13.4	4488.7
1984	2988.9	687.0	7.0	9.3	3692.2
1985	2506.7	636.8	7.4	10.1	3161.0
1986	2420.9	851.0	10.4	14.1	3296.4
1987	2002.6	597.1	7.5	16.5	2623.6
1988	1681.5	541.4	6.7	14.0	2243.6
1989				14.3	
1990				19.5	
1991				19.7	

Note: Regulatory otter trawl mesh size prior to 1982 was less than 5.5 inches; 1989 – 1991 scallop dredge discards were estimated using this method due to no observer coverage of this fleet.

Appendix Table K5. Summary of NEFSC survey area (square nautical miles; offshore strata 1-26; 73-76) used in the ocean pout stock assessment and the USA statistical areas associated with ocean pout stock (Figure K1).

NEFSC Survey Strata	Area
1	2,516
2	2,078
3	566
4	188
5	1,475
6	2,554
7	514
8	230
9	1,522
10	2,722
11	622
12	176
13	2,374
14	656
15	230
16	2,980
17	360
18	172
19	2,454
20	1,221
21	424
22	454
23	1,016
24	2,569
25	390
26	1,014
73	2,145
74	1,273
75	139
76	60
Total	35,094

USA Statistical Areas	Area
464	208
465	258
467	75
511	1,313
512	3,652
513	3,567
514	2,573
515	4,603
521	3,853
522	3,663
525	7,461
526	4,029
533	1,547
534	2,320
537	6,261
538	800
539	742
541	2,320
542	5,402
543	2,281
561	765
562	3,562
611	1,421
612	1,893
613	3,258
614	1,131
615	2,781
616	3,707
621	3,702
622	2,820
623	2,820
Total	84,786

Appendix Table K6. Stratified mean catch per tow in weight and numbers, mean length and individual average fish weight of ocean pout in **NEFSC winter surveys** (strata 1-3, 5-7, 9-11, 13-14, 73-75), 1992-2007. The NEFSC winter survey time series ended in 2007.
No vessel conversion factors applied.

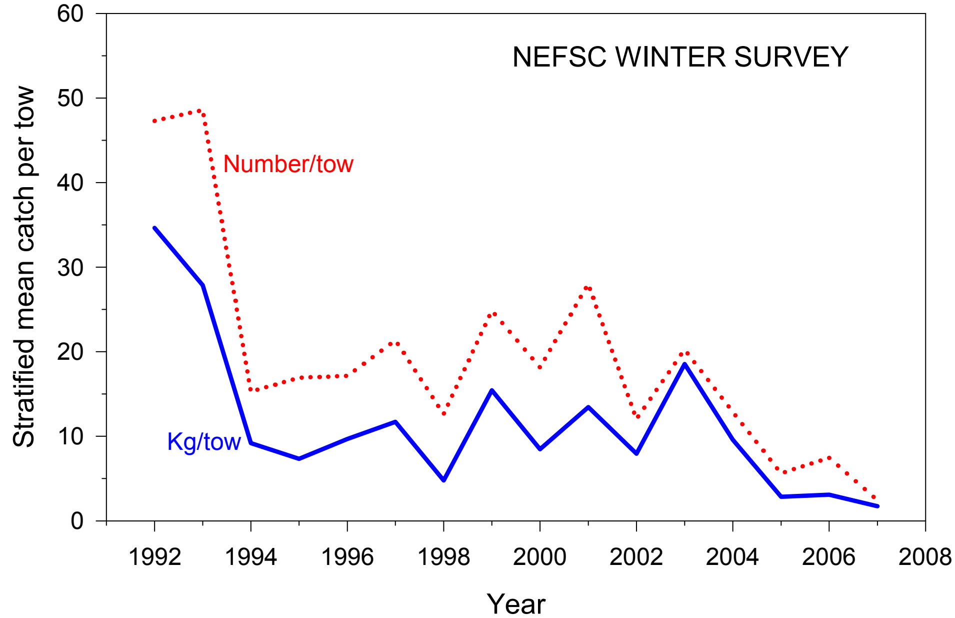
Year	Mean weight per tow (kg)	Mean number per tow	Individual average weight (kg)	Mean length (cm)
1992	34.64	47.29	0.733	51.9
1993	27.86	48.57	0.574	47.1
1994	9.18	15.28	0.601	47.1
1995	7.32	16.92	0.433	43.3
1996	9.68	17.13	0.565	47.2
1997	11.70	21.36	0.548	47.5
1998	4.77	12.63	0.378	40.4
1999	15.44	24.85	0.621	48.3
2000	8.46	18.14	0.466	44.6
2001	13.45	28.01	0.480	46.1
2002	7.94	12.05	0.659	51.1
2003	18.54	20.25	0.916	56.0
2004	9.58	12.89	0.744	49.6
2005	2.84	5.61	0.506	41.3
2006	3.09	7.44	0.415	40.3
2007	1.72	2.43	0.709	48.9

Appendix Table K7. Stratified mean catch per tow in weight and numbers, individual average fish weight and mean length of ocean pout in **Mass. inshore spring surveys** (strata 25-36), 1978-2011.

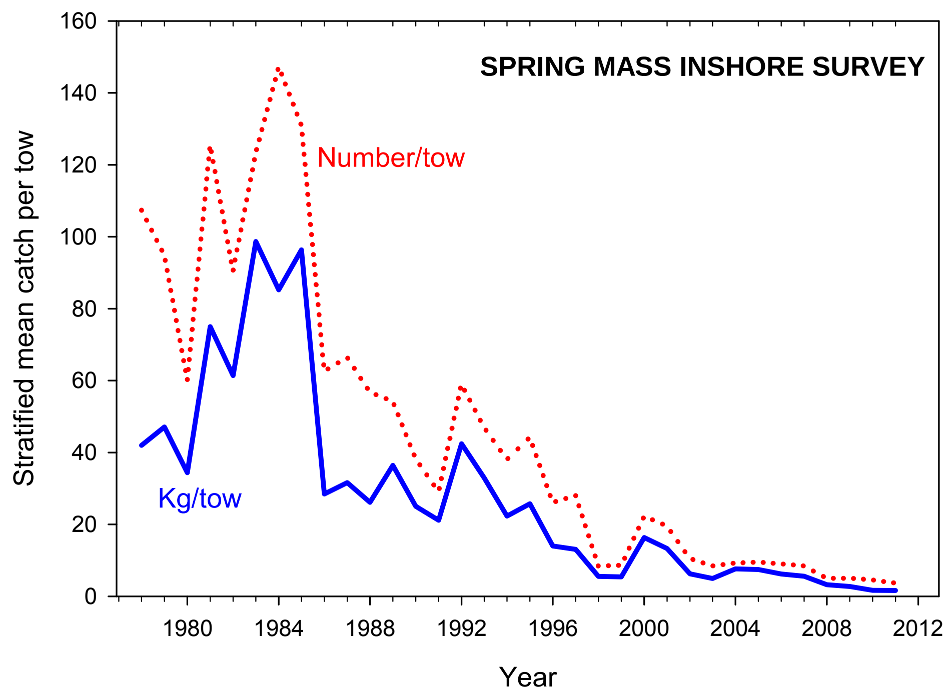
Year	Mean weight per tow (kg)	CV	Mean number per tow	CV	Individual average weight (kg)	Mean length (cm)
1978	42.00	30.9	107.39	20.9	0.391	38.8
1979	47.11	16.5	94.79	18.2	0.497	39.6
1980	34.42	17.7	60.13	20.3	0.572	42.9
1981	74.98	16.6	125.46	19.6	0.598	43.5
1982	61.39	24.3	90.50	21.0	0.678	47.2
1983	98.69	17.2	123.35	15.7	0.800	50.2
1984	85.25	27.5	147.25	29.6	0.579	45.0
1985	96.36	32.4	130.93	19.4	0.736	47.2
1986	28.46	17.0	62.62	22.9	0.454	39.4
1987	31.61	27.2	66.44	19.9	0.476	41.3
1988	26.18	17.7	56.71	28.5	0.462	39.7
1989	36.40	20.4	54.19	15.8	0.672	46.8
1990	25.04	23.3	38.19	20.8	0.656	47.0
1991	21.20	21.6	29.08	23.0	0.729	49.6
1992	42.43	23.6	59.02	21.6	0.719	48.5
1993	32.87	19.6	46.82	16.7	0.702	51.0
1994	22.92	20.5	38.05	21.9	0.602	46.9
1995	25.75	16.4	44.22	14.4	0.582	46.5
1996	14.03	20.5	26.06	16.6	0.538	45.6
1997	13.05	17.0	28.04	16.1	0.465	41.9
1998	5.56	25.8	8.45	28.9	0.658	49.7
1999	5.42	19.8	8.61	15.5	0.630	46.5
2000	16.35	38.8	22.22	31.8	0.736	49.8
2001	13.27	26.9	19.55	23.0	0.679	49.9
2002	6.27	31.9	10.47	26.0	0.599	48.1
2003	4.96	16.3	8.42	14.9	0.589	47.8
2004	7.66	39.8	9.27	32.4	0.827	53.0
2005	7.48	40.4	9.51	40.3	0.787	53.4
2006	6.22	22.9	9.03	17.8	0.689	49.6
2007	5.58	29.1	8.44	26.2	0.661	48.6
2008	3.22	28.3	4.94	26.4	0.651	47.7
2009	2.76	23.9	5.01	17.8	0.550	43.4
2010	1.66	31.5	4.53	24.4	0.365	37.6
2011	1.61	23.9	3.69	18.1	0.436	38.5

Appendix Table K8. Sensitivity run of GARM 2007 using updated values for 2007 catch and 2008 survey index. Bold values represent revised values used.

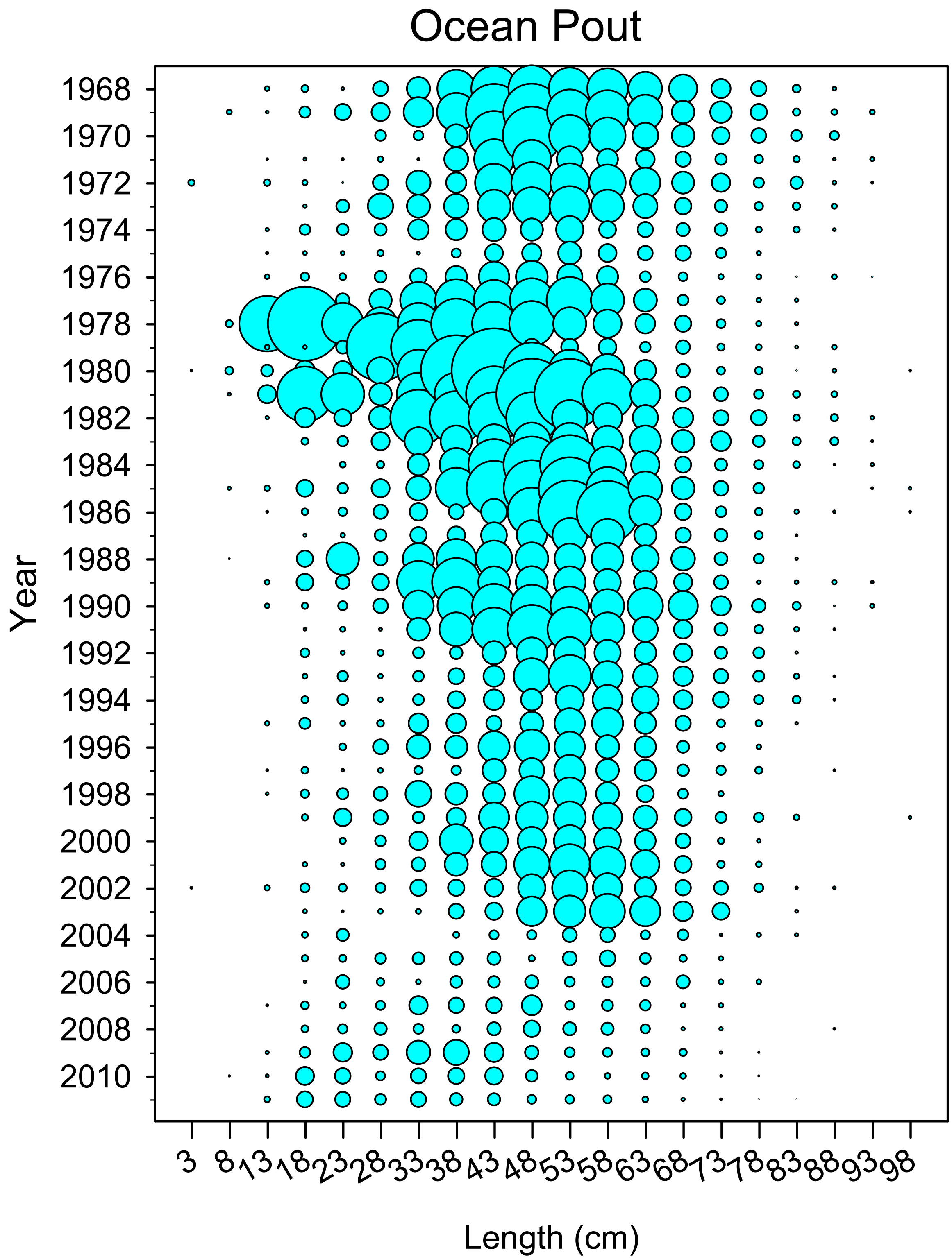
Year	NEFSC Spring Index kg/tow	Total Catch ('000, mt)	Annual relative expliotation rate (catch/spr index)	3 year moving average (kg/tow)	Exploitation ratio (catch/ 3yr avg index)
1968	5.446	16.5379	3.037	5.800	2.851
1969	6.154	30.1015	4.892	5.581	5.394
1970	5.143	9.9378	1.932	4.497	2.210
1971	2.195	7.9315	3.613	3.934	2.016
1972	4.463	4.8492	1.086	3.344	1.450
1973	3.373	6.6642	1.976	3.105	2.146
1974	1.479	4.8659	3.289	2.048	2.375
1975	1.293	0.9936	0.768	1.391	0.714
1976	1.400	1.2002	0.857	2.099	0.572
1977	3.605	1.9871	0.551	2.792	0.712
1978	3.371	2.4126	0.716	2.823	0.855
1979	1.493	2.1813	1.461	3.531	0.618
1980	5.729	2.3659	0.413	4.942	0.479
1981	7.605	2.9942	0.394	6.026	0.497
1982	4.743	4.7605	1.004	5.528	0.861
1983	4.236	4.8967	1.156	4.840	1.012
1984	5.540	5.0162	0.905	5.423	0.925
1985	6.494	4.6650	0.718	6.126	0.761
1986	6.345	4.0984	0.646	5.181	0.791
1987	2.705	4.8086	1.778	4.098	1.173
1988	3.244	4.0546	1.250	2.914	1.392
1989	2.792	8.7289	3.126	3.703	2.357
1990	5.074	10.7460	2.118	3.883	2.768
1991	3.783	6.3496	1.679	3.704	1.714
1992	2.257	1.9940	0.884	3.041	0.656
1993	3.084	1.5779	0.512	2.550	0.619
1994	2.309	1.4769	0.640	2.436	0.606
1995	1.916	0.6385	0.333	2.094	0.305
1996	2.058	0.6796	0.330	1.869	0.364
1997	1.632	0.5545	0.340	1.808	0.307
1998	1.733	0.6899	0.398	1.975	0.349
1999	2.561	0.8041	0.314	2.103	0.382
2000	2.016	0.3668	0.182	2.458	0.149
2001	2.798	0.5492	0.196	2.280	0.241
2002	2.025	0.5879	0.290	2.527	0.233
2003	2.758	0.4524	0.164	1.777	0.255
2004	0.546	0.2960	0.542	1.277	0.232
2005	0.526	0.2048	0.389	0.533	0.384
2006	0.526	0.1875	0.356	0.510	0.368
2007	0.477	**0.1688**	0.354	0.475	0.355
2008	**0.422**				
mean 1968-2007	3.17			3.18	1.06
median 1968-2007	2.78			2.87	0.68
median 1977-1985				4.94	0.76



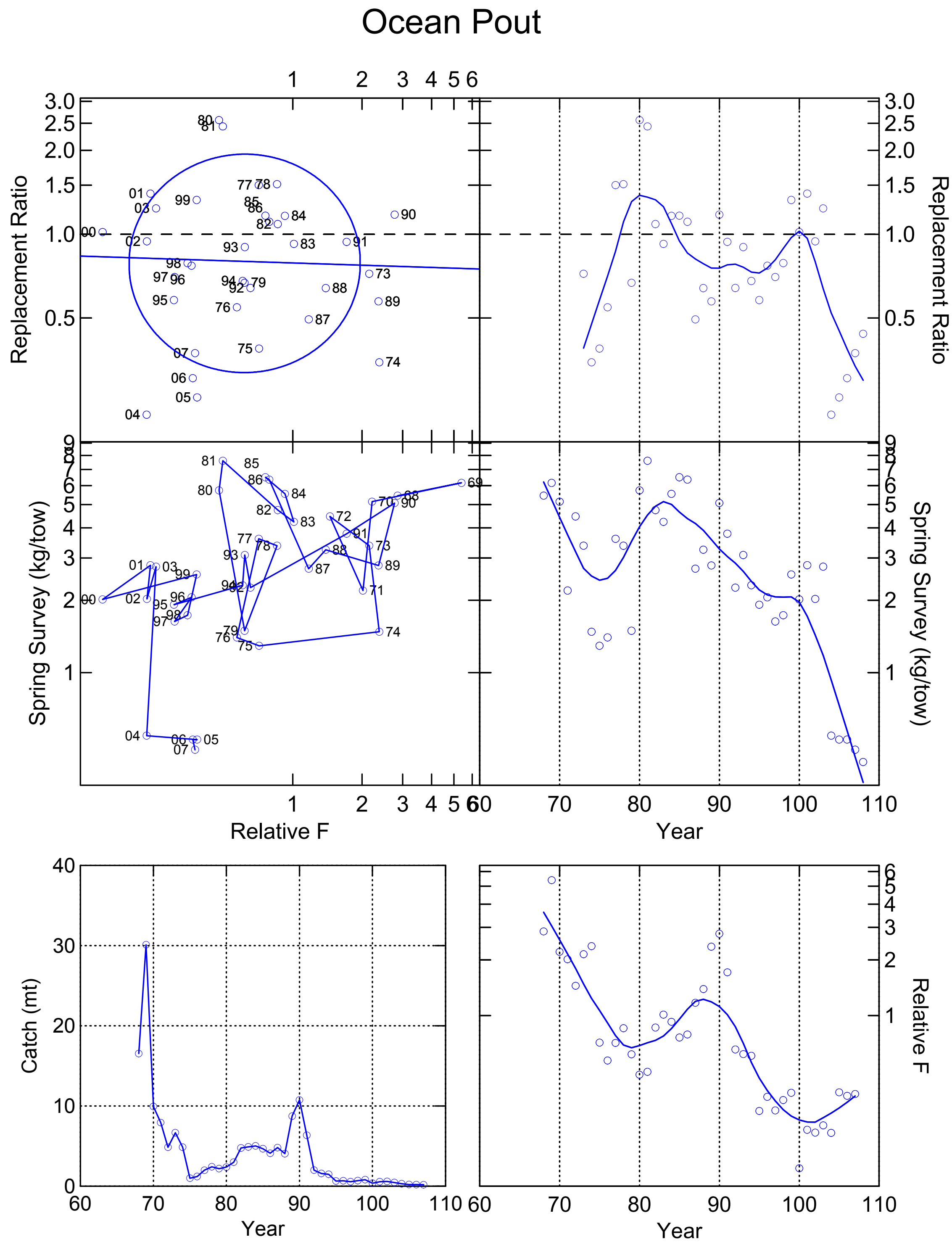
Appendix Figure K1. Trends in mean catch per tow, in numbers and weight (kg) for ocean pout in the NEFSC winter survey, 1992 – 2007. The NEFSC winter survey time series ended in 2007.



Appendix Figure K2. Trends in mean catch per tow, in numbers and weight (kg) for ocean pout in the Massachusetts inshore survey, 1978 – 2011.



Appendix Figure K3. Stratified mean number per tow at length for ocean pout from the NEFSC research vessel spring survey, 1968 to 2011, binned into 5 cm intervals.



Appendix Figure K4. Trends in relative biomass, total catch, fishing mortality rate indices (catch / survey index) and replacement ratios for ocean pout. Relative F is computed as catch in year t divided by a 3 yr average of indices in year t-1, t, and t+1. ***Taken from GARM 2008, see Wigley et al. 2008.***

L. Atlantic Wolffish -2010 Groundfish Update
Charles Keith and Paul Nitschke

1. Background

Atlantic wolffish was most recently assessed in 2008 as part of the Northeast Data Poor Stocks Working Group (NDPSWG 2009). The NDPSWG Peer Review Report indicated that there are three main issues which combine to make wolffish a "data poor" species, including concerns over which geographical regions to include in developing and assessing population status relative to BRPs, over the reliability of survey data as indices of population abundance and over life history parameters for the species within the northwestern Atlantic Ocean (NDPSWG 2009). Atlantic wolffish continue to be a data poor species.

Atlantic wolffish in the Gulf of Maine and Georges Bank regions inhabit the southern edge of the species distribution. Analyses for this update were limited to the stock component completely within US waters. Catchability is believed to be low in Northeast Fisheries Science Center (NEFSC) trawl surveys due to the habitat preference of wolffish for rough topography. Atlantic wolffish are long-lived (22+ years), late maturing, and of low fecundity. Males guard the eggs in nests in the fall. Larger wolffish have typically been caught in the spring survey compared to the fall, perhaps due to mating and nest guarding behavior making them less available to survey gear. All fishery independent survey indices show a declining trend in abundance over the time series with slight improvement in recent years. Confounding the recent trends in all wolffish indices is the lack of any reliable calibration coefficients for changes in research survey vessels and survey gear. The commercial catch has also declined steadily since 1983 and possession of Atlantic wolffish is currently prohibited. Atlantic wolffish were added to Northeast Multispecies Fishery Management Plan, Amendment 16, by the New England Fishery Management Council (Federal Register 2010).

A forward projection model, Statistical Catch At Length (SCALE), which tunes to the size and age data from trawl survey recruitment and adult indices, total catch, and catch size distributions along with overall growth information was accepted by the Peer Review Panel as a basis for determining the biological reference points (BRPs) for Atlantic wolffish (Miller et al 2009). In 2008 overfishing status was uncertain and the stock was considered overfished (Table L1).

Commercial and recreational fisheries data and fishery independent data has been updated for use in the model. BRPs have also been updated using the guidance from the Peer Review Panel Report. Biological reference points for the F 50% proxy were not updated. BRPs were estimated for two commercial selectivity regimes and for three knife edge maturity cutoffs. There is preliminary biological evidence to support the 40 cm knife edge L50 maturity cutoff (Atlantic Wolffish Appendix 1, Personal Communication McBride 2012). Sensitivity analyses are presented to evaluate the effects on SCALE model results through changes in swept area biomass due to vessel/gear changes, adding length frequency data for discarded fish in 2010, and comparing commercial discard mortality rates at 100% and 10%.

1. Fishery

Commercial Landings

Landings and Total Catch

NMFS Commercial Fishery Databases contain historical and current catch and effort information of Atlantic wolffish, 1963 - 2010. Data presented here are only from fishery statistical reporting areas that are completely or almost entirely within US territorial waters throughout the time series (Figure L1). US landings increased until it peaking in 1983 at 1,100 metric tons (mt) and then decline steadily until 2009 (last full fishing year), where landings were 33.41 mt (Figure L2 and Table L2). In the US, Atlantic wolffish were harvested primarily as bycatch in the otter trawl fishery. As of May 2010 commercial and recreational harvest for Atlantic wolffish has been closed in an effort to improve stock biomass. Landings in 2010 were at a time series low of 2.69 mt. Over all years and areas, percent commercial landings of wolffish were dominated by otter trawl gear (90.98%), followed by fixed gillnets (4.29%) and bottom tending longlines (3.2%) (Figure L3). Comparing landings in the Gulf of Maine and Georges Bank regions shows relatively no change in otter trawl landings but some shifting of fixed gill net and bottom tending longlines to scallop dredge and pelagic longline gears (Table L3, Figure L3).

Reported US commercial wolffish landings come primarily from fishery statistical areas 513, 514, 515, 521 and 522 (Figure L4, Table L4). Landings have fluctuated between statistical areas over time and spatial differences may be difficult to interpret due to management actions, such as permanent closures and rolling time closures, in the Gulf of Maine. Commercial landings in the US GBK/GOM region appear to be contracting into a single statistical reporting area, 514 (Table L4, Figure L4).

Commercial Discards

Commercial fishery discards from the Northeast Fisheries Observer Program database were updated for the period 1989-2010 from US only statistical areas based on the Standardized Bycatch Reporting Methodology combined ratio estimation (Wigley et al 2007). Discards have been a small component of the overall catch of Atlantic wolffish for the majority of the time series (Figure L2, Table L2). The maximum estimated discards in any one year was 26.98 mt in 1989, which is the first year of discard estimates (Table L2). Otter trawls account for 93.6% of the total discarded wolffish from all years. Discards appear to be increasing in the gillnet sector, which reported approximately 18.9% of the total wolffish discarded for 2009, the last full year of commercial fishing (Table L5). Discards estimates in 2010 are relatively high as a result of management action.

Recreational Landings

Recreational landings data were updated from the MRFSS database (Figure L5, Table L6). Landings are reported in total number of fish and total weight per year. Landings include both A and B1 fish, these are fish permanently removed from the population. B2 fish are discarded live and are assumed to have survived. Adjusted landings were developed because average weight of an individual wolffish was highly variable. Average weight (kg) was calculated based on the reported numbers of landed fish (A + B1) divided by the reported landed weight (kg). A grand mean was updated from average weights and used in the new adjusted landings values. Adjusted landing are less variable than the original MRFSS reported values and are likely to describe the recreational portion of total catch. Recreational landings have become more significant in recent years as commercial landings have steadily declined (Figure L2, Table L2). The recreational component of total catch makes up approximately 22% of the total catch and is nearly 1/4 as large as the commercial landings for 2009 (Table L2). Recreational landings are extremely low in 2010 as possession of Atlantic wolffish was also prohibited in the recreational sector as of May 2010.

Total Catch

Total Catch is comprised of reported landings, estimates of commercial discards from the primary fishery sectors and recreational catch from US waters as previously described (Figure L2, Table L2). Recreational catches begin in 1981 and discard estimates begin in 1989. Discard mortality has been assumed to be 100% in the commercial sector. Total US catch peaked in 1983 with 1,112 mt and has decreased steadily reaching a low of 17.47 mt in 2010. The 2010 total catch is dominated by the commercial discard component, 14.3 mt, followed by 2.7 mt of landings, and 0.5 mt of recreational landings.

Commercial Landings – Length Frequencies

Fishery observers collect length samples at sea opportunistically providing information on the size structure of the population for Atlantic wolffish. Observer lengths have been collected since 1989. Starting in May, 2010 At-Sea Monitors (ASM) began to collect fishery dependent information aboard commercial fishing vessels including length data for Atlantic wolffish. Sample sizes from early in the time series are low but have exceeded 100 lengths per year during 2003-2007 and in 2010 (Table L7). Commercial lengths presented are from kept fish only for all years except 2010 when kept and discards were combined. Kept and discards for 2010 were combined because all Atlantic wolffish after May, 2010 were required to be discarded. Of the 268 fish sampled in 2010 only 7 were kept and 261 discarded. Discarded observer length data are sparse from 1989-2009, maximum of 18 wolffish in a year, and therefore not reported. Median length has been variable over time but increased slightly during the 2003-2007 period indicating that larger fish were being harvested (Figure L6). Since 2008 median length has trended down. Commercial lengths from port samples have been taken irregularly during the span of the commercial fishery. A significant amount of samples were collected during 1982 – 1985 and have also been taken consistently during 2001-2009. Few port samples were obtained in 2010 as landing this species was not allowed after May 1st. Commercial port sample length distributions were plotted by year (Figure L7). An increase in median length was seen during the 2001 – 2007 time period but has since been on a downward trend. The median increased from 75 cm in 2001 to 84 cm in 2007 and has declined back to 80 cm in 2010 (Table L8). A pooled length dataset was created for port sample and observer and At-Sea monitor data. The pooled data also showed a declining trend on the median length of Atlantic wolffish after 2007 (Figure8, Table L9). In 2009 the NDPSWG reported that there was little evidence of any truncation of length frequency over time. This still appears true as the range of commercial lengths is the same although median length for observer-ASM and port samples has decreased recently. A subset of the pooled data is used as input into the observed catch length frequency distribution of the SCALE model. Some years were omitted from the model due to low sample sizes or skewed length distributions.

2. Research Bottom Trawl Surveys

Biomass and abundance indices

Atlantic wolffish are encountered infrequently on NEFSC bottom trawl surveys. The NDPSWG Report indicated that there is uncertainty over the degree to which the NEFSC surveys provide a reliable index of the population (NDPSWG, 2009). Strata used in wolffish analyses were limited to offshore areas completely or almost completely within US waters (Figure L9). In 2009 the RSV Bigelow replaced the RV Albatross IV for conducting resources surveys. Calibration coefficients for Atlantic wolffish indices are not available as the species was only encountered in 3 pairs of tows between the Bigelow and Albatross (Miller et al, 2010).

In general the NEFSC spring and fall bottom trawl survey indices show abundance and biomass of Atlantic wolffish has declined over the last two to three decades (Figure L10). The spring survey typically encountered higher abundance and biomass than the fall survey and was considered the preferred index by the Data Poor Working Group in 2008 for assessing resource trends. Survey differences may be attributed to wolffish being less available to the sampling gear while nest guarding in the fall (Rountree, R.A. 2002). Inter-annual variability among both surveys has been high. Zero catches have been observed in the spring (2005, 2006, 2008) and fall surveys (2007). Spring and fall indices of abundance and biomass show increasing trends since 2008 but these are difficult to interpret without vessel calibration coefficients.

The current spring biomass is at low levels in relation to the time series (Table L10, Figure L10). The spring biomass index from 1968 to 1988 averaged 0.786 kg/tow and varied between 0.38 and 1.44 kg/tow. Since the mid to late 1980's the resource has steadily declined. The average spring biomass index for 1989-2010 was 0.15 kg/tow and ranged from 0 to 0.42 kg/tow. CV's for the spring biomass are high, averaging 50% over the full time series. The fall biomass index shows little trend over time and is relatively low over most of the time series, which may be prescribed to availability issues during mating (Figure L11) (NDPSWG, 2009). A large peak of biomass appears in 1981 but is not seen again in subsequent years. Since the mid 1990's wolffish biomass has fluctuated with a declining trend. Current stratified mean biomass for the fall index is low but has increased slight since the last assessment in 2007 (Table L11, Figure L11). The MADMF spring has also declined over time and suffers from frequent zero catches in last decade (Table L12, Figure L12)

Abundance indices in spring and fall surveys show a declining trend in stratified mean number per tow since the mid 1990's to 2008. Recent estimates of abundance appear to be increasing slightly but care should be used when interpreting these non-calibrated survey results. 3-year centered moving average plots of abundance and biomass helps reduce the inter-annual variability within the indices and depicts an overall declining trend in the resource until 2009, when a slight positive response is detected (Figures L10 & L11).

Spring and fall percent positive Atlantic wolffish catch were plotted by year (Figures 10 & 11). This type of index for species rarely captured can be a good indicator of how frequently rare events occur over time. These indices indicate that the number of survey tows catching at least one wolffish has decreased with time in both the spring and fall until recent. The spring percent positive tows index shows an almost continuous declining trend since the late 1970's/early 1980's, averaging around 12% and dropping to approximately 2% in 2007 with a slight improvement in 2010 (Table L10). The fall index appears relatively stable from the mid 1970's through the early 1990's, fluctuating around 6 %. It then declines quickly from 1994 to 1996 and becomes relatively stable again at low levels near 2 % until 2007 where it reaches zero. Since 2007 fall percent positive has also increased slightly (Table L11).

Spring and fall indices and population estimates are also calculated for the adult component (40+ cm) of the resource (Table L13, Figure L13). Because calibration coefficients are not available the annual swept area estimates are calculated using the tow footprint of the corresponding vessel and gear configuration times the total survey area coverage. The Albatross tow footprint is estimated at 0.012 square nautical miles the Bigelow tow footprint is estimated at 0.007 nmi^2. The area coverage of survey strata used to assess Atlantic wolffish is 25,911 nmi^2. Bigelow swept area estimates are calculated for the 2009 and 2010 data points; all other years are Albatross swept area units. Swept area abundance estimates are used as input into the SCALE model.

Maturity

Atlantic wolffish maturity schedules for the Gulf of Maine are not well understood at present. A logistic maturity ogive was developed for female Atlantic wolffish based on spring and fall survey vessel data in 2008 (Figure L14) (NDPSWG, 2009). L_{50} was estimated at approximately 35 cm from these data. This L_{50} for female wolffish is lower than estimates reported in Newfoundland (65cm) and Iceland (75cm) where females containing second generation eggs were considered immature (Templeman 1986; Gunnarsson et al. 2006). These L50 estimates from these different regions provided the range of knife edge maturity cutoffs for determining biological reference points.

Gonad histology samples have been collected since 2009, including 33 female wolffish. Preliminary analysis by the NEFSC Population Biology Branch indicate that size at maturity in Gulf of Maine Atlantic wolffish is lower than in studies from Newfoundland-Labrador and Iceland, approximately 40 cm (Atlantic Wolffish Appendix 1, Personal Communication R. McBride, 2012). While sample size is small and these analyses are preliminary they may help narrow the range of biological reference points needed to determine the status of Atlantic wolffish.

4. Assessment

SCALE Model
Background

Incomplete or lack of age-specific catch and survey indices often limits the application of a full age-structured assessment (e.g. Virtual Population Analysis and many forward projecting age-structured models). Stock assessments will often rely on the simpler size/age aggregated models (e.g. surplus production models) when age-specific information is lacking. However the simpler size/age aggregated models may not utilize all of the available information for a stock assessment. Knowledge of a species growth and lifespan, along with total catch data, size composition of the removals, recruitment indices and indices on numbers and size composition of the large fish in a survey can provide insights on population status using a simple model framework.

The Statistical Catch At Length (SCALE) model, is a forward projecting age-structured model tuned with total catch (mt), catch at length or proportional catch at length, recruitment at a specified age (usually estimated from first length mode in the survey), survey indices of abundance of the larger/older fish (usually adult fish) and the survey length frequency distributions (NOAA Fisheries Toolbox 2008a). The model parameter estimates are fishing mortality and recruitment in each year, fishing mortality to produce the initial population (Fstart), logistic selectivity parameters for each year or blocks of years and Qs for each survey index.

The SCALE model was developed as an age-structured model that does NOT rely on age-specific information on a yearly basis. The model is designed to fit length information, abundance indices, and recruitment at age which can be estimated by using survey length slicing. However the model does require an accurate representation of the average overall growth of the population which is input to the model as mean lengths at age. Growth can be modeled as sex-specific growth and natural mortality or growth and natural mortality can be model with the sexes combined. The SCALE model will allow for missing data.

Model Input and Base Model Results

A base SCALE model run was developed by balancing the need to keep inputs as similar to the previously accepted model as possible and from guidance derived from the NDPSWG Peer Review Panel Report (NDPSWGR, 2009, Miller et al, 2009). The SCALE model has been updated for this assessment using 1968-2010 data from NEFSC spring and fall trawl surveys, Massachusetts Division of Marine Fisheries (MADMF) spring trawl survey, and an age 1 (1-7cm) recruitment index from the NEFSC spring survey (Table L14). Only one recruitment index exists in the SCALE model (Figure L15). The recruitment index suffers from zero catches in many years and at times in blocks of several years. A 40+ cm index was developed from the NEFSC spring, NEFSC fall and the MADMF spring survey (Table L13, Figure L13). All three surveys show an overall declining trend in abundance with the indices also suffering from zero catches at the end of the time series. Zero catches were a major concern of the NDPSWG Peer Review Panel (Miller et al 2009). The survey length frequency distributions are limited due to the low numbers of wolffish caught in the surveys. The adult abundance indices are scaled to swept area units, the approximate area of survey coverage divided by the average coverage of a survey tow, in the SCALE model and include non-calibrated estimates (2009-2010) when vessel and gear changes occurred in 2009 (Table L15). The area swept estimates can provide some insight from estimated survey efficiencies using the estimated Qs in the SCALE model (Table L15). The recruitment index (1-7cm) was not affected by swept area adjustments as no age 1 wolffish were captured in the spring. Total catch is reported as commercial landings, estimated commercial discards, and estimated recreational harvest from 1968 – 2010. Commercial discard mortality is assumed at 100%.

Age information did not change during this update. Mean lengths at age and variation in mean length at age were based on fish collected during the 1980s from Nelson and Ross (1992). A Gompertz relationship had the best fit using all ages. We have re-estimated a von Bertalanffy relationship using data limited to fish older than 4 with L-infinity fixed at 110 cm (Figure L16). The mean lengths from Nelson and Ross's Gompertz relationship for fish younger than age 5 were also used in the SCALE model. The mean lengths from the younger fish do not have a large effect on the SCALE model results. In the final growth model we fixed L-infinity (110) at a slightly higher value than what was estimated by the Gompertz (98.9) model because few larger and older fish exist in Nelson and Ross's study and the SCALE model had difficultly predicting larger fish that are in seen in the catch length frequency distributions. The assumed variation around the mean lengths at age can be seen in Figure L17. Nelson and Ross's oldest fish was 22 years. The age matrix was dimensioned from ages 1 to 30 with an assumed natural mortality of 0.15.

Zero catches were set to missing in the SCALE model. Setting zeros to the smallest value in the time series appears to have a large unsubstantiated influence on the model results. The age-1 recruitment series was given a relatively low weight (Table L16). Setting the weight to high on the recruitment index will force SCALE to fit the recruitment index very closely but the model is less constrained in estimating recruitment for years where recruitment information is missing which can produce unrealistic results. The age-1 index was used more as a guide with setting the penalty on recruitment variation. The penalty on recruitment variation was set high enough to produce recruitment variation within the bounds of what was observed in the recruitment index. The model has to estimate a declining trend in recruitment to fit the decline in the 40+ cm indices and the declining trend in the catch since 1983. The recruitment index was used as guidance on whether recruitment failure has occurred for the wolffish stock.

The catch length frequency distributions are an important component of the SCALE model and were updated for this assessment. Observer trawl kept length sampling and port samples where combined to characterize the catch size distributions. Catch length frequency information exists from 1982 to 1985 and from 2001 to 2010. 2010 catch length distributions include lengths of discarded wolffish from the ASM databasee. A single selectivity block was used due to insufficient commercial length samples over the time series. Commercial length distributions have declined slightly over the last few years.

The lack of data prevents the SCALE model from estimating a reliable logistic selectivity curve. The SCALE model estimates a very flat selectivity curve that produces a L-50 at very large sizes. There is a tradeoff in the SCALE model between the estimated selectivity and fishing mortality rates. Two different selectivity regimes were chosen to determine its influence of stock status determination as was previously conducted in the 2008 assessment (Figure L18) (NDPSWGR, 2009). Run one had a relativity flat selectivity curve which was allowed to hit the L-50 bound of 90 cm. Run two was setup to hit the slope parameter bound of 0.15 which produces a steeper selectivity function with a lower L-50 estimate. Results of the two selectivity runs are summarized in Figures 19-22 and Table L16.

The SCALE model time series starts in 1968 with the beginning of the NEFSC spring index. The SCALE model estimates virgin conditions at the beginning of the time series with a low Fstart estimate (0.001) in 1968 when the catch was low. Strong retrospective patterns were not apparent in the 2008 or in the current assessment for the SCALE model run2 (Slope = 0.15) (Figure L23.) (NDPSWG, 2009).

SCALE model results are optimistic in the current assessment. Total biomass and exploitable biomass show an increasing trend while catch and estimates of fishing mortality are at series lows (Figure L24). Caution should be used when interpreting trends in estimated biomass as the increase may be the result of the combination of extremely low catch and slight increase in non-calibrated survey abundance.

5. Biological Reference Points

Non-parametric biological reference points (BRP) were re-estimated for both the selectivity L-50 = 90 run (Run 1) and the slope = 0.15 run (Run 2) within the SCALE model using $F_{40\%}$ as a Proxy for F_{MSY} (Table L17). Reference points were not re-estimated for the $F_{50\%}$ proxy as the 2009 NDPSWG Peer Review Panel indicated that $F_{40\%}$ was reasonable and justifiable. A range of knife edge maturities values were used in estimating the BRPs. Maturity as 40+ cm fish was used to correspond to NEFSC survey maturity results and the 65+ cm and 75+ cm cutoffs correspond to studies in Labrador and Iceland (NDPSWG, 2009). Based on reference points from both SCALE model runs, the wolfish stock in 2010 is at a low biomass (48% to 72% of B_{MSY}) but has improved since 2008 (Table L17). The overfished status is dependent upon SCALE model selectivity and size at 50% maturity. Under both selectivity regimes a small (40+ cm) L50 maturity cutoff indicates the resource is not overfished. For both selectivity regimes and the large L50 maturity cutoff (75 cm) the resource is overfished. Status is split at the 65 cm maturity cutoff; for run 1 (L50 = 90cm) status is overfished and for run 2 (Slope = 0.15) the resource is not overfished. Overfishing is not occurring in all model runs as the F_{2010} to F_{MSY} ratios range from 7% to 14% (Table L17, Figure L25). MSY ranges from 272-301 mt and SSB_{MSY} are likely between 1,590-2,032 mt.

Sensitivity Analysis

Sensitivity of Swept Area Estimates in SCALE model

Sensitivity analyses are presented to evaluate the effects on SCALE model results through changes in the swept area abundance estimates due to vessel/gear changes, adding length frequency data for discarded wolffish in 2010, and comparing commercial discard mortality rates at 100% and 10%. A fourth sensitivity was added during the course of the Groundfish Update meeting to examine the use of a proxy Bigelow to Albatross calibration coefficient for Atlantic wolffish.

Swept Area Abundance

Fishery independent survey indices (numbers per tow) are converted into swept area estimates for use in the SCALE model. Estimates come from NEFSC spring and fall time series beginning in 1968 and through 2010. A vessel change occurred in 2009, where the RSV Bigelow replaced the R/V Albatross IV. Conversion factors are not available for Atlantic wolffish as too few fish were encountered during the Albatross/Bigelow calibration exercises (Miller et al. 2010). The spring Massachusetts DMF index is also used in the SCALE model but is not affected by the Albatross/Bigelow calibration. Swept area calculations for the survey time series were done according to the appropriate fishing gear configurations for each research vessel. The Albatross IV survey gear has a swept area scalar equal to 0.0112 and the FRV H. B. Bigelow is equal 0.007 (Table L15). The swept area footprint of the Bigelow is approximately 40% smaller than the Albatross therefore more Bigelow tows may be conducted per same unit area. This scaling factor results in higher swept area indices for the Bigelow when compared to the Albatross (Table L18).

Results of this sensitivity analysis indicate that swept area scaling differences have only a minimal effect on SCALE model output. The base model for all the sensitivity analyses was the steep sloped selectivity curve (slope =0.15 – run 2), commercial catch length frequencies including discarded wolffish from 2010, commercial discard mortality assumed at 100% and swept area survey indices scaled to the appropriate vessel, 1968-2008 Albatross and 2009-2010 Bigelow (HB runs). The base model was compared to a nearly identical model run, which differed only in that the spring and fall survey indices were scaled to the Albatross IV survey gear footprint for all years, 1968-2010 (A4 runs) (Table L13). SCALE model outputs analyzed were total biomass, exploitable biomass, and fishing mortality. Total biomass appears to be most sensitive among the SCALE outputs examined. The largest differences in total biomass occur in the early part of the time series, 1968-1975, and the conclusion of the time series, 2001-2010 (Table L18, Figure L26). Differences in total biomass between Bigelow swept area and Albatross swept area model runs for 2001-2010 are on the order of 15 to 254 metric tons per year or 2 to 16%. Differences in exploitable biomass appear less sensitive to changes in swept area calculations than total biomass and also peak at the end of the time series in 2010 with 10.5% difference (Table L18). Estimates of fishing mortality do not appear to be sensitive to changes in the calculations of swept area indices. Percent differences in F estimates were largest at -12.5% in 2010 when F was extremely low, estimated Bigelow = 0.024 vs ALIV = 0.027 (Table L19, Figure L27). Fishing mortality values are higher for the base run during the years of peak commercial catches through 2000.

Total biomass estimates differ very slightly between the base model run and the final 2009 NDPSWG model run. Input differences to the models include using kept and discarded commercial length frequency data for 2010 and using the Bigelow swept area estimates for 2009 and 2010 spring and fall survey indices in the base model run. The total biomass estimates from the NDPSWG assessment model are nearly identical to the base model run and no significant differences are detectable (Figure L28). Estimates of fishing mortality are also nearly identical (Figure L28).

Combining Commercial Length Frequency 2010 Kept and Discards.

In May of 2010 commercial landings of Atlantic wolffish was no longer permitted due to management action to help rebuild this stock. Commercial length frequency information is critical for the SCALE model to project the population dynamics for this species. Although it was not the practice in the 2008 Atlantic wolffish assessment, length data were combined between discarded and kept catch dispositions for the 2010 commercial catch length data. During the 2001-2010 time frame port samplers, commercial fishery observers and At Sea Monitors have taken length data to describe the distribution of the commercial landings (Figure L29). Up until 2010, hundreds of length samples were available in the “kept” catch disposition to be input into the SCALE model.

In 2010 only 55 lengths are classified as “kept”. When kept and discarded wolffish are combined 316 lengths are available to describe the catch data in 2010.

A sensitivity analysis was conducted to determine the extent of any differences in the SCALE model output estimates by the addition of discarded length frequency data in 2010 year only. The base model SCALE run 2 (slope = 0.15) with Bigelow swept area, with kept and discarded wolffish in 2010 and commercial discards assumed at a 100% mortality rate. The sensitivity runs differed by not having the discarded fish included in 2010. A total of 261 discarded fish from the Observer and At Sea Monitoring database were added to the 55 kept wolffish. Discarded and kept commercial length frequencies are similar when plotted but sample size is very low in the 2010 kept category (Figure L30) Also compared in the figure is the 2009 kept wolffish distribution from port samples and observers. These distributions have a similar modes and ranges and were considered a good fit for a data poor species.

No difference in model output was detected due the addition of discarded length frequency data. Results of the sensitivity show both total and exploitable biomass increased very slightly in the base model run as a result of adding a more complete 2010 length frequency distribution to the SCALE model (Figure L31). The average percent change between kept/discarded and kept only for total biomass was +0.76% and the maximum percent change was +1.2%. Percent change of exploitable biomass was more variable. The maximum percent increase was 5.7% and the exploitable biomass increased on average 3.5% (Table L20). The effect of additional discard length frequency information was also minimal on fishing mortality estimates from SCALE model runs.

Commercial Discard Mortality

A sensitivity analysis was conducted on the effects of choosing a low discard mortality rate for Atlantic wolffish. The base run and previous assessments assumed 100% discard mortality. A 10% mortality rate was chosen to compare results from the SCALE model based on an otter trawl study in Canada (Grant et al, 2005).

No difference in model output was detected due changing the commercial discard mortality rate to 10%. Results of the sensitivity show both total and exploitable biomass increased by as much as 71 and 56 metric tons resulting in a 2.5 and 4.2% increase in total and exploitable biomass for 1989 respectively (Table L20, Figure L32). The effect was minimal due to the low amount of estimated commercial discards in the fishery compared to the commercial landings. The greatest change was seen in 1989, the first year of commercial discard estimates.

Proxy Bigelow to Albatross Calibration Coefficient

A Bigelow to Albatross calibration coefficient is not available for Atlantic wolffish. Using non-calibrated survey indices was believed to be inappropriate by the Groundfish Update Review Panel 2012. It was suggested that a proxy species, Ocean pout *Zoarces americanus*, be used to calibrate the NEFSC spring and fall survey indices. Other species lacking Bigelow to Albatross calibration have adopted similar methodology using proxy species. Atlantic wolffish and ocean pout are related and from the same suborder, Zoarcoidei. They share similar body type, long and eel-like, and have similar reproductive strategies, including low fecundity, multi-generation oocytes and nest guarding. They inhabit similar environs, preferring rocky habitat in the Gulf of Maine region. Ocean pout are found further south than Atlantic wolffish, their range extending into the Mid-Atlantic Bight region of the Northeast continental shelf.

Ocean pout were captured in a total of 100 calibration tows aboard both the FRV Bigelow and RV Albatross IV. Of those 100 tows they were encountered 32 times on both the Bigelow and Albratross in the spring. A beta-binomial calibration coefficient was estimated at 4.575 with a standard error of 0.45 (Miller et al. 2010). This value was used as a proxy calibration coefficient to estimate the number of Bigelow fish in Albatross units.

Comparisons were made between the base run (slope 0.15) and ocean pout proxy run, all other SCALE model inputs were kept the same. Both the spring and fall swept area indices were reduced by incorporating the ocean pout calibration coefficient (Figures 33-34). The age-1 recruitment index for the ocean pout proxy run shows a lower recruitment than the base model run at the end of the time series (Figure L35). The total biomass projected by the ocean pout proxy SCALE model were significantly less than the base model run (Figure L36).

Biological reference points for the 40 cm and 65 cm knife edge maturity cutoffs were developed using the ocean pout proxy run for Atlantic wolffish. The Review Panel was presented with preliminary maturity findings that indicated the size at maturity in the Gulf of Maine is lower than in Canadian or Icelandic waters (Atlantic Wolffish Appendix 1, McBride Personal Communication 2012). The sensitivity run indicates that the wolffish stock is currently overfished but overfishing is not occurring for both of the knife edge maturity cutoffs examined (Table L22, Figure L37). SSB_{2010} is between 371 and 505 mt and F_{2010} is at 0.069. For status determination, the Peer Review Panel recommended adopting the SCALE model run that used, as a proxy, the ocean pout survey calibration coefficient (Table L23).

Projections

Projections were not conducted for Atlantic wolffish due to the data poor condition of the resource. The NDPSWG Peer Review Panel believed that projections would be unreliable due to the occurrence of zero catches in the survey indices and should not be undertaken (Miller et al, 2009).

Stock: Atlantic wolffish *Anarhichas lupus*

Conclusions:

SSB in 2010 is estimated to be 505 mt
F in 2010 is estimated to be 0.07
Revised estimates of the biological reference points based on a $F_{40\%}$ proxy are:
SSB_{msy} proxy= 1756 mt,
F_{msy} proxy = 0.33, and
MSY proxy= 261 mt.

Based on the preferred run the Atlantic wolffish stock is presently overfished with current SSB being at 29% of SSB_{MSY} and overfishing is not occurring (F_{2010} is only 21% of F_{MSY}).

Atlantic wolffish continues to be considered a data poor species and was previously assessed and reviewed at the DPSWG in 2008.

The "overfished" status remains unchanged since the 2008 assessment. The overfishing status has changed from "unknown" to "overfishing not occurring".

The results are based on a forward projection model, Statistical Catch At Length (SCALE), which was used in the 2008 assessment and approved by the DPSWG.

The assessment update included the selection of a single cutoff size of maturation (40 cm) and the application of the ocean pout Bigelow to Albatross IV conversion factor to the wolfish survey indices. The non-parametric biological reference points (BRP) were re-estimated for both the selectivity L-50= 90 and the slope = 0.15 run (Run 2) within the SCALE model using F40% as a Proxy for FMSY.

Atlantic Wolffish. Summary of Assessment Information

Atlantic Wolffish	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Comm Landings (mt)	236	146	123	117	114	80	63	49	33	3	361	3	1100	1964-2010
Comm discards (mt)	6.5	13.1	3.8	1.6	1.3	1.5	0.8	1.8	1.5	14.3	6.0	0.1	27.0	1989-2010
Rec Landings (mt)	17.0	10.0	24.7	12.7	10.9	18.2	13.1	11.8	10.1	0.5	15.3	0.5	38.4	1981-2010
Catch (mt)	259	169	152	131	126	100	77	63	45	17	374	17	1112	1964-2010
SSB (mt)	808	729	704	655	594	521	490	492	482	505	2443	482	4577	1968-2010
Recruitment (000's)	79.20	86.01	95.59	76.86	60.71	110.02	300.07	301.87	301.85	301.85	360.79	60.71	1596.74	1968-2010
F full	0.970	0.665	0.635	0.600	0.633	0.475	0.330	0.363	0.220	0.069	0.471	0.035	1.209	1968-2010

Panel Comments
The work that is presented is accepted by the Review Panel for determining stock status and providing catch advice.
The Panel reviewed the DPSWG report and concluded that the WG recommended using the model run with the slope =0.15 (Run 2 in 2008 report). The panel agreed and proceeded with this recommendation.

The Panel reviewed three options of the cut off length of maturity (40 cm, 65 cm and 75 cm) which were from the DPSWG (2009) and concluded that based on visual observations of gonads and limited histological evidence, currently the 40 cm knife edge maturity is a more appropriate description of wolfish maturity in US waters. Although concerns were expressed about the low sample size of histological data, the analysis repeated with the 65 cm maturity cutoff resulted in the same conclusions regarding the status of the stock. A preliminary run of a logistic curve through the available maturity data indicated that the two smallest sizes at maturity (40 and 65cm) are more likely than the 75 cm size at maturity.

The panel noted that the direct use of uncalibrated survey indices derived from Bigelow in 2009-2010 was inappropriate. Due to the lack of Bigelow to Albatross calibration estimate for wolffish, the panel agreed to use an ocean pout conversion factor (4.58) as a proxy for Atlantic wolffish. When the Bigelow series can be treated as its own tuning series, the conversion factor will become unnecessary.
The Panel expressed concerns that the surveys have reached the limit of wolffish detectability due to the significant decline in abundance which is expressed in increased occurrence of zero values in observations. The treatment of zeroes in the survey data as missing data may introduce a non-negligible bias in population estimates.

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Tables

Table L1. 2008 Biological reference points from the Data Poor Stocks Working Group Report.

SCALE run		1			2	
Selectivity		L50 = 90			slope = 0.15	
Length of maturity	40cm	65cm	75cm	40cm	65cm	75cm
F_{MSY} proxy	F40%	F40%	F40%	F40%	F40%	F40%
F_{MSY}	0.686	0.486	0.374	0.319	0.233	0.185
YPR	0.872	0.839	0.799	0.861	0.817	0.771
SSB per Recruit	6.098	5.432	4.846	6.098	5.430	4.838
Initial Recruits (000s)	355	355	355	361	361	361
MSY (mt)	310	298	284	311	295	278
SSB_{MSY} (mt)	2,167	1,931	1,722	2,202	1,961	1,747
SSB_{07} (mt)	890	656	475	998	753	562
F_{07}	0.413	0.413	0.413	0.158	0.158	0.158
SSB_{07}/SSB_{MSY}	41%	34%	28%	45%	38%	32%
F_{07}/F_{MSY}	60%	85%	111%	50%	68%	86%

Table L2. Updated commercial landings, recreational landings, commercial discards and total catch.

Year	Commercial Landings	Commercial Discards	MRFSS Landings	Total Catch
1964	114.325			114.325
1965	166.511			166.511
1966	174.424			174.424
1967	149.584			149.584
1968	116.224			116.224
1969	163.283			163.283
1970	154.828			154.828
1971	172.795			172.795
1972	243.940			243.940
1973	242.634			242.634
1974	352.789			352.789
1975	313.118			313.118
1976	401.932			401.932
1977	393.763			393.763
1978	605.240			605.240
1979	656.494			656.494
1980	826.463			826.463
1981	671.613		0.82	672.433
1982	760.400		23.53	783.932
1983	1099.924		12.12	1112.039
1984	935.314		13.42	948.735
1985	879.963		16.24	896.199
1986	789.792		7.37	797.164
1987	665.128		38.38	703.509
1988	505.586		9.19	514.777
1989	466.840	26.983	20.85	514.677
1990	378.156	2.629	29.69	410.474
1991	446.563	1.948	17.16	465.674
1992	430.919	19.177	10.93	461.022
1993	467.222	13.378	20.47	501.068
1994	455.389	0.107	18.88	474.371
1995	449.805	5.769	20.81	476.389
1996	347.980	4.534	12.55	365.060
1997	301.767	7.821	20.57	330.155
1998	286.841	2.247	17.14	306.225
1999	242.748	0.351	8.69	251.793
2000	191.341	0.545	12.63	204.512
2001	235.998	6.470	16.97	259.437
2002	145.577	13.104	10.00	168.680
2003	123.053	3.825	24.66	151.539
2004	116.953	1.577	12.68	131.206
2005	114.040	1.306	10.92	126.269
2006	80.051	1.451	18.18	99.679
2007	63.323	0.838	13.10	77.257
2008	49.443	1.756	11.79	62.985
2009	33.409	1.451	10.09	44.953
2010	2.685	14.263	0.53	17.474

Table L3. Percent Landings by Major Gear Groups in the Georges Bank, Gulf of Maine and Combined regions - 1968-2010

Gear Groups	GBK	GOM	Grand Total
DANISH SEINE	0.07	0.29	0.29
DREDGE, SCALLOP,SEA	3.52	0.31	0.39
GILL NET, FIXED OR ANCHORED	1.27	4.37	4.30
HANDLINE	0.15	0.24	0.24
LONGLINE, BOTTOM	1.29	3.23	3.18
LONGLINE, PELAGIC	2.12	0.03	0.08
POT/TRAP, LOBSTER INSH NK	0.02	0.03	0.03
POT/TRAP, LOBSTER OFFSH NK	0.04	0.03	0.03
TRAWL,OTTER,BOTTOM,FISH	91.52	90.97	90.98
TRAWL,OTTER,BOTTOM,SHRIMP	<0.01	0.50	0.49
Grand Total	100	100	100

Table L4. Updated percent of US Commercial Landings of Atlantic Wolffish by Statistical Area and Year.

Year	512	513	514	515	521	522	525	526	537	Grand Total
1964	3.12%	4.04%	37.04%	3.23%	27.92%	19.68%	4.20%	0.76%	0.00%	100%
1965	8.06%	3.35%	29.81%	0.92%	29.43%	25.04%	0.72%	2.64%	0.04%	100%
1966	1.04%	5.00%	40.12%	0.98%	30.95%	16.79%	1.47%	3.60%	0.05%	100%
1967	1.45%	17.26%	35.79%	1.27%	29.84%	13.21%	0.49%	0.70%	0.00%	100%
1968	1.72%	10.96%	32.65%	0.55%	37.79%	12.71%	2.55%	0.97%	0.10%	100%
1969	0.86%	12.90%	43.91%	1.74%	24.19%	14.83%	1.31%	0.26%	0.01%	100%
1970	1.12%	11.05%	41.51%	1.25%	31.19%	13.03%	0.19%	0.63%	0.03%	100%
1971	1.85%	8.25%	42.71%	1.63%	26.40%	16.68%	0.85%	1.08%	0.54%	100%
1972	1.07%	8.43%	33.76%	0.31%	32.09%	17.60%	2.50%	3.95%	0.28%	100%
1973	0.74%	10.16%	42.75%	0.80%	33.97%	8.85%	1.32%	1.41%	0.00%	100%
1974	0.74%	8.16%	37.03%	0.21%	37.61%	12.80%	1.21%	2.21%	0.02%	100%
1975	1.36%	10.36%	41.55%	2.50%	33.34%	9.56%	0.60%	0.50%	0.23%	100%
1976	1.70%	12.99%	34.29%	1.53%	32.27%	13.75%	1.06%	2.40%	0.00%	100%
1977	1.34%	10.35%	37.32%	2.02%	41.23%	6.41%	0.58%	0.69%	0.06%	100%
1978	3.72%	14.36%	35.43%	2.38%	34.24%	8.90%	0.32%	0.52%	0.13%	100%
1979	3.10%	17.31%	28.33%	3.09%	36.69%	10.71%	0.16%	0.62%	0.00%	100%
1980	2.94%	21.78%	21.63%	7.24%	33.58%	11.75%	0.49%	0.57%	0.00%	100%
1981	3.99%	22.81%	24.84%	6.61%	28.62%	11.73%	0.39%	0.80%	0.21%	100%
1982	7.88%	22.65%	23.83%	10.27%	26.92%	7.67%	0.35%	0.19%	0.24%	100%
1983	4.65%	25.89%	28.50%	13.92%	19.84%	6.35%	0.22%	0.57%	0.06%	100%
1984	4.46%	28.29%	16.08%	16.53%	23.95%	9.41%	0.70%	0.49%	0.09%	100%
1985	6.17%	25.18%	14.83%	19.47%	26.63%	7.09%	0.21%	0.35%	0.05%	100%
1986	8.92%	25.29%	14.59%	18.43%	24.31%	7.10%	0.78%	0.52%	0.06%	100%
1987	5.90%	25.24%	17.55%	18.22%	25.56%	6.91%	0.18%	0.42%	0.01%	100%
1988	5.82%	26.09%	15.76%	9.69%	32.96%	8.31%	0.26%	1.10%	0.00%	100%
1989	6.39%	22.29%	11.77%	8.76%	41.19%	8.01%	0.10%	1.37%	0.13%	100%
1990	7.90%	29.96%	15.65%	8.59%	29.71%	5.04%	0.83%	2.01%	0.30%	100%
1991	6.10	24.38	16.46	16.73	25.43	9.08%	0.33	1.19	0.29	100%

	%	%	%	%	%		%	%	%	
1992	5.76%	24.47%	15.62%	18.07%	23.35%	10.60%	0.49%	1.24%	0.40%	100%
1993	3.73%	20.37%	15.57%	20.63%	19.52%	17.47%	0.82%	1.47%	0.42%	100%
1994	4.33%	18.88%	15.46%	15.30%	28.57%	15.70%	0.39%	1.19%	0.19%	100%
1995	2.26%	14.93%	20.68%	17.80%	28.22%	14.38%	0.30%	1.04%	0.39%	100%
1996	2.16%	15.08%	25.99%	13.79%	28.99%	12.18%	0.63%	0.97%	0.21%	100%
1997	1.82%	13.56%	24.11%	11.09%	33.51%	13.71%	0.54%	0.43%	1.22%	100%
1998	1.87%	9.26%	35.38%	10.09%	29.87%	11.24%	0.43%	1.58%	0.28%	100%
1999	1.18%	9.36%	18.41%	7.92%	41.21%	17.37%	0.83%	2.65%	1.07%	100%
2000	1.53%	13.69%	29.24%	8.74%	29.32%	14.39%	0.91%	0.59%	1.61%	100%
2001	0.96%	9.95%	19.13%	5.80%	34.24%	26.32%	0.83%	0.59%	2.19%	100%
2002	1.36%	11.85%	28.66%	6.18%	35.34%	14.20%	1.02%	0.27%	1.13%	100%
2003	1.91%	14.17%	36.01%	5.83%	29.50%	7.83%	1.17%	0.25%	3.32%	100%
2004	3.89%	17.18%	40.12%	7.06%	24.36%	4.65%	0.18%	0.06%	2.50%	100%
2005	2.56%	20.20%	40.86%	12.90%	15.75%	6.39%	0.65%	0.66%	0.03%	100%
2006	2.56%	17.07%	42.67%	8.32%	19.93%	8.64%	0.29%	0.10%	0.41%	100%
2007	3.61%	15.44%	39.34%	9.69%	23.03%	7.82%	0.73%	0.33%	0.01%	100%
2008	2.38%	13.95%	52.38%	4.18%	21.61%	4.99%	0.17%	0.06%	0.29%	100%
2009	2.27%	9.39%	63.52%	5.23%	13.13%	5.29%	0.64%	0.34%	0.20%	100%
2010	0.00%	9.00%	62.96%	6.33%	6.43%	13.84%	1.44%	0.00%	0.00%	100%
Grand Total	4.10%	19.25%	24.82%	10.26%	29.12%	10.67%	0.59%	0.93%	0.26%	100%

Table L5. Commercial discard estimates from major gear components in US waters only, 1989-2010.

	Metric Tons				**Percent Discards**			
YEAR	LL	OT	GN	Grand Total	LL	OT	GN	Grand Total
1989	0.00	26.98	0.00	26.98	0.00	100.00	0.00	100.00
1990	0.00	2.63	0.00	2.63	0.00	100.00	0.00	100.00
1991	0.00	1.95	0.00	1.95	0.00	100.00	0.00	100.00
1992	0.51	18.67	0.00	19.18	2.66	97.34	0.00	100.00
1993	0.00	13.38	0.00	13.38	0.00	100.00	0.00	100.00
1994	0.00	0.11	0.00	0.11	0.00	100.00	0.00	100.00
1995	0.00	5.77	0.00	5.77	0.00	100.00	0.00	100.00
1996	0.00	4.53	0.00	4.53	0.00	100.00	0.00	100.00
1997	0.00	7.11	0.71	7.82	0.00	90.91	9.09	100.00
1998	0.00	2.25	0.00	2.25	0.00	100.00	0.00	100.00
1999	0.00	0.35	0.00	0.35	0.00	100.00	0.00	100.00
2000	0.00	0.49	0.06	0.54	0.00	89.28	10.72	100.00
2001	0.00	6.47	0.00	6.47	0.00	100.00	0.00	100.00
2002	0.00	13.10	0.00	13.10	0.00	100.00	0.00	100.00
2003	0.00	3.67	0.15	3.82	0.00	96.01	3.99	100.00
2004	0.00	1.34	0.23	1.58	0.00	85.28	14.72	100.00
2005	0.00	1.22	0.09	1.31	0.00	93.37	6.63	100.00
2006	0.03	1.42	0.00	1.45	1.90	98.10	0.00	100.00
2007	0.01	0.69	0.14	0.84	0.65	82.16	17.19	100.00
2008	0.000	1.102	0.654	1.76	0.00	62.74	37.26	100.00
2009	0.055	1.122	0.274	1.45	3.79	77.32	18.89	100.00
2010	2.173	8.697	3.393	14.26	15.24	60.98	23.79	100.00
Grand Total	2.77	123.05	5.71	131.53	2.11	93.55	4.34	100.00

Table L6. Recreational landings estimates from MRFSS data updated through 2010

Year	HARVEST (TYPE A + B1)	Num PSE	Weight (TYPE A + B1) (kg)	Wkl PSE	Weight (TYPE A + B1) (mt)	Mean Weight (TYPE A + B1) (kg)	Ave Wt per fish (wt / #'s)	Weight Adjusted (kg)	Weight Adjusted (mt)
1981	334	99.9						820.80	0.82
1982	9576	58.6	4952	0	4.952	2.1	0.52	23532.77	23.53
1983	4930	38.7	16776	39.3	16.776	3.4	3.40	12115.35	12.12
1984	5461	30.9	12740	47.3	12.74	2.4	2.33	13420.27	13.42
1985	6607	33	14428	33.5	14.428	2.2	2.18	16236.53	16.24
1986	3000	44.4						7372.42	7.37
1987	15618	28.5	31733	32.4	31.733	2.9	2.03	38380.83	38.38
1988	3740	32.8	3748	3.3	3.748	2.8	1.00	9190.95	9.19
1989	8486	28.1	21415	34.1	21.415	2.9	2.52	20854.13	20.85
1990	12081	33.2	9628	21.1	9.628	2.6	0.80	29688.75	29.69
1991	6984	31.8	14250	41.8	14.25	3.5	2.04	17163.00	17.16
1992	4446	52.6	4985	71.3	4.985	3.7	1.12	10925.93	10.93
1993	8329	28.4	11969	66.6	11.969	1.8	1.44	20468.30	20.47
1994	7681	27.7	10526	32.1	10.526	1.7	1.37	18875.86	18.88
1995	8470	26.1	32287	27	32.287	3.8	3.81	20814.81	20.81
1996	5105	27.5	10391	34	10.391	2.6	2.04	12545.41	12.55
1997	8369	28	37474	40.1	37.474	4.5	4.48	20566.60	20.57
1998	6974	32.2	19760	37.9	19.76	3	2.83	17138.43	17.14
1999	3538	31.1	4741	45.6	4.741	1.8	1.34	8694.54	8.69
2000	5138	27.1	11592	29.9	11.592	3	2.26	12626.50	12.63
2001	6905	21.4	15628	30.4	15.628	3.2	2.26	16968.86	16.97
2002	4069	34.2	17996	35.6	17.996	4.5	4.42	9999.46	10.00
2003	10035	22.3	42207	5.4	42.207	4.4	4.21	24660.76	24.66
2004	5158	31.4	9573	11.6	9.573	2.5	1.86	12675.65	12.68
2005	4445	23.7	14955	20.3	14.955	3.4	3.36	10923.47	10.92
2006	7397	31.8	28614	12.5	28.614	3.9	3.87	18177.94	18.18
2007	5329	31.7	15253	36.5	15.253	2.9	2.86	13095.88	13.10
2008	4796	42.1	12506	40.9	12.506	2.6	2.61	11786.05	11.79
2009	4107	41.8	11565	54	11.565	2.8	2.82	10092.85	10.09
2010	214	61.2	648	69.6	0.648	3.5	3.03	525.90	0.53
					grand mean =	**3.01**	**2.46**		

Table L7. Observer and At-Sea monitor Length Summary Statistics by Year, 1989 and 1991-2010.

year	n	mean	sd	median	min	max	range	skew	kurtosis	se
1989	4	74.25	5.91	72	70	83	13	0.69	3.56	2.95
1991	9	81.89	13.25	77	70	114	44	1.48	4.93	4.42
1992	70	49.14	10.93	45.5	39	80	41	1.3	0.62	1.31
1993	20	63.8	11.9	60	49	86	37	0.63	-0.81	2.66
1994	23	74	8.97	73	58	95	37	0.13	-0.15	1.87
1995	12	71.67	13.91	68.5	54	102	48	0.78	0.81	4.02
1996	23	73.57	11.02	75	42	94	52	-0.75	2.11	2.3
1997	12	81	8.6	83.5	70	92	22	-0.15	-1.95	2.48
1998	19	85.58	9.89	89	67	99	32	-0.54	-0.64	2.27
1999	5	80.2	12.24	83	65	92	27	-0.18	-2.58	5.47
2000	50	77.3	7.19	77	60	89	29	-0.72	0.51	1.02
2001	73	75.88	10.81	76	52	96	44	-0.54	-0.06	1.27
2002	35	83.11	10.07	83	68	105	37	0.44	-0.28	1.7
2003	175	74.42	13.19	77	31	113	82	-0.58	1.14	1
2004	245	74.23	12.43	75	41	115	74	-0.01	0.08	0.79
2005	260	80.4	11.35	81	29	107	78	-0.82	1.99	0.7
2006	151	83.07	11.81	83	58	111	53	0	-0.57	0.96
2007	124	82.49	11.18	83	52	105	53	-0.52	0.17	1
2008	45	81.33	12.44	80	60	112	52	0.39	-0.24	1.85
2009	24	74.33	13.31	78.5	53	99	46	-0.17	-1.21	2.72
2010	268	75.73	13.51	76	37	115	78	-0.15	0.15	0.83

Table L8. Commercial Port Sample Summary Statistics by Year, 1981-1986, 1994, 2001-2010

year	var	n	mean	sd	median	min	max	range	skew	kurtosis	se
1981	2	13	86.77	12.32	85	63	110	47	0.17	0.53	3.42
1982	2	354	71.71	15.35	69	45	114	69	0.56	-0.4	0.82
1983	2	1349	78.25	14.46	78	42	128	86	0.53	0.57	0.39
1984	2	445	76.1	12.76	76	51	130	79	0.57	0.56	0.6
1985	2	729	76.98	11.86	77	47	119	72	0.26	0.3	0.44
1986	2	106	85.03	10.92	86.5	57	100	43	-0.79	0.1	1.06
1994	2	18	80.22	15.27	78.5	59	106	47	0.16	-1.16	3.6
2001	2	176	76.59	10.12	75	59	110	51	0.8	0.82	0.76
2002	2	297	76.34	10.3	76	38	104	66	-0.06	0.46	0.6
2003	2	473	76.88	11.07	76	52	109	57	0.24	-0.62	0.51
2004	2	1142	80.9	10.64	81.5	50	115	65	-0.11	-0.25	0.31
2005	2	453	81.27	10.01	82	54	110	56	-0.1	-0.54	0.47
2006	2	896	83.03	10.36	83	37	111	74	-0.3	0.55	0.35
2007	2	816	83.56	10	84	51	108	57	-0.25	-0.25	0.35
2008	2	410	81.92	11.66	83	52	114	62	-0.31	-0.39	0.58
2009	2	210	80.63	11.19	81	40	112	72	-0.18	0.54	0.77
2010	2	47	77.77	11.07	80	48	100	52	-0.55	0.38	1.61

Table L9. Commercial Port Samples, Observer and At-Sea monitor Length Summary Statistics by Year, 1981-1986, 1989, 1991-2010.

year	n	mean	sd	median	min	max	range	skew	kurtosis	se
1981	13	86.77	12.32	85	63	110	47	0.17	0.53	3.42
1982	354	71.71	15.35	69	45	114	69	0.56	-0.4	0.82
1983	1349	78.25	14.46	78	42	128	86	0.53	0.57	0.39
1984	445	76.1	12.76	76	51	130	79	0.57	0.56	0.6
1985	729	76.98	11.86	77	47	119	72	0.26	0.3	0.44
1986	106	85.03	10.92	86.5	57	100	43	-0.79	0.1	1.06
1989	4	74.25	5.91	72	70	83	13	0.69	3.56	2.95
1991	9	81.89	13.25	77	70	114	44	1.48	4.93	4.42
1992	70	49.14	10.93	45.5	39	80	41	1.3	0.62	1.31
1993	20	63.8	11.9	60	49	86	37	0.63	-0.81	2.66
1994	41	76.73	12.38	77	58	106	48	0.51	-0.22	1.93
1995	12	71.67	13.91	68.5	54	102	48	0.78	0.81	4.02
1996	23	73.57	11.02	75	42	94	52	-0.75	2.11	2.3
1997	12	81	8.6	83.5	70	92	22	-0.15	-1.95	2.48
1998	19	85.58	9.89	89	67	99	32	-0.54	-0.64	2.27
1999	5	80.2	12.24	83	65	92	27	-0.18	-2.58	5.47
2000	50	77.3	7.19	77	60	89	29	-0.72	0.51	1.02
2001	249	76.38	10.31	75	52	110	58	0.35	0.58	0.65
2002	332	77.05	10.47	77	38	105	67	0	0.46	0.57
2003	648	76.22	11.72	76	31	113	82	-0.13	0.38	0.46
2004	1387	79.72	11.26	80	41	115	74	-0.18	-0.07	0.3
2005	713	80.95	10.52	82	29	110	81	-0.44	0.8	0.39
2006	1047	83.04	10.57	83	37	111	74	-0.24	0.33	0.33
2007	940	83.42	10.16	84	51	108	57	-0.31	-0.14	0.33
2008	455	81.87	11.72	83	52	114	62	-0.23	-0.39	0.55
2009	234	79.98	11.56	81	40	112	72	-0.24	0.32	0.76
2010	315	76.03	13.18	77	37	115	78	-0.21	0.19	0.74

Table L10. NEFSC Spring survey abundance, biomass and proportion positive tows of Atlantic wolffish. 2009 and 2010 data were collected aboard the RSV Bigelow.

YEAR	stratified mean number	CV mean num	80% Lower CI (boot)	80% Upper CI (boot)	stratified mean weight	CV mean wt	80% Lower CI (boot)	80% Upper CI (boot)	Total Number Tows	Number Positive Tows	Prop Positive
1968	0.074832	45.48	0.036	0.121	0.379935	55.73	0.1351	0.6373	93	6	0.065
1969	0.146360	28.17	0.097	0.194	1.110400	49.88	0.5031	1.7424	96	11	0.115
1970	0.184209	31.46	0.118	0.253	1.123650	41.92	0.609	1.6872	98	9	0.092
1971	0.139439	29.97	0.093	0.189	0.601683	35.00	0.3554	0.8468	105	11	0.105
1972	0.337351	46.62	0.178	0.5	0.509674	51.96	0.2093	0.8063	101	7	0.069
1973	0.139069	47.41	0.064	0.221	0.866688	53.63	0.3491	1.4008	94	7	0.074
1974	0.528880	36.50	0.309	0.76	1.109440	33.52	0.6819	1.5368	93	14	0.151
1975	0.140400	44.37	0.071	0.206	0.924290	64.32	0.2774	1.6191	100	11	0.110
1976	0.102373	30.76	0.067	0.141	0.530604	35.88	0.3131	0.743	111	12	0.108
1977	0.223311	32.02	0.144	0.309	0.619603	33.08	0.3644	0.8656	116	17	0.147
1978	0.304785	30.19	0.198	0.416	1.169070	43.18	0.591	1.8358	111	18	0.162
1979	0.211721	35.75	0.126	0.307	0.712763	26.92	0.486	0.9534	166	19	0.114
1980	0.297972	38.32	0.167	0.429	0.696510	38.02	0.3884	0.9988	117	13	0.111
1981	0.305932	46.66	0.147	0.465	0.627849	33.29	0.4031	0.897	98	10	0.102
1982	0.186281	23.14	0.138	0.236	0.680649	32.86	0.4366	0.9567	100	18	0.180
1983	0.127162	42.00	0.071	0.198	0.737782	55.36	0.2809	1.2037	98	8	0.082
1984	0.122841	30.12	0.082	0.168	0.474255	38.21	0.2758	0.6884	95	10	0.105
1985	0.284045	32.31	0.183	0.39	0.741842	37.75	0.46	1.0459	92	11	0.120
1986	0.237597	26.27	0.165	0.31	1.438940	33.92	0.8924	1.9864	97	12	0.124
1987	0.247225	31.44	0.158	0.328	0.913709	31.67	0.6102	1.2462	93	11	0.118
1988	0.198091	35.76	0.119	0.282	0.541849	48.12	0.2585	0.8353	92	10	0.109
1989	0.274190	36.84	0.165	0.394	0.403499	41.00	0.2224	0.5986	89	9	0.101
1990	0.059452	46.92	0.031	0.092	0.166516	53.53	0.0729	0.2727	92	5	0.054
1991	0.052251	46.54	0.025	0.081	0.360148	48.66	0.1783	0.5756	89	5	0.056
1992	0.139869	47.46	0.067	0.221	0.114772	54.99	0.0464	0.1957	90	5	0.056
1993	0.127671	36.81	0.076	0.177	0.420072	50.72	0.173	0.6702	90	8	0.089
1994	0.206584	36.59	0.118	0.299	0.138898	44.91	0.0708	0.2104	91	9	0.099
1995	0.123460	41.29	0.065	0.182	0.196500	50.15	0.0928	0.3283	91	5	0.055
1996	0.106639	39.70	0.059	0.157	0.167041	62.52	0.0408	0.2933	87	7	0.080
1997	0.045510	59.10	0.016	0.079	0.041146	61.60	0.011	0.0713	91	3	0.033
1998	0.037444	55.52	0.014	0.061	0.104679	65.70	0.0234	0.1893	114	4	0.035
1999	0.039134	44.72	0.016	0.055	0.059484	49.34	0.0282	0.0939	92	3	0.033
2000	0.030916	79.67	0	0.062	0.208352	74.13	0.0714	0.4109	93	2	0.022
2001	0.034004	55.47	0.016	0.058	0.063016	64.57	0.0233	0.1097	93	3	0.032
2002	0.059240	39.79	0.032	0.088	0.084007	60.52	0.0277	0.1573	95	6	0.063
2003	0.092651	49.40	0.039	0.147	0.181660	44.35	0.0817	0.2628	89	5	0.056
2004	0.015708	63.25	0.008	0.024	0.000031	74.16	0	0.0001	90	2	0.022
2005	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-
2007	0.024351	75.09	0.008	0.049	0.009262	94.80	0	0.0185	90	2	0.022
2008	-	-	-	-	-	-	-	-	-	-	-
2009	0.149162	45.34	0.066	0.227	0.062343	52.69	0.026	0.1071	123	6	0.049
2010	0.083825	38.69	0.046	0.123	0.108849	56.95	0.0403	0.178	110	5	0.045

Table L11. NEFSC Fall survey abundance, biomass and proportion positive tows of Atlantic wolffish. 2009 and 2010 data were collected aboard the RSV Bigelow.

YEAR	stratified mean number	CV mean num	80% Lower CI (boot)	80% Upper CI (boot)	stratified mean weight	CV mean wt	80% Lower CI (boot)	80% Upper CI (boot)	Total Number Tows	Number Positive Tows	Prop Positive
1963	0.031086	62.91	0.0091	0.0548	0.004032	75.44	0.0001	0.0079	79	3	0.038
1964	0.087940	48.56	0.0376	0.1382	0.185740	92.49	0.0014	0.37	86	5	0.058
1965	0.305541	50.91	0.1496	0.5042	0.296804	39.57	0.1682	0.4424	91	8	0.088
1966	0.333844	51.00	0.148	0.5197	0.169165	43.50	0.0889	0.2494	88	6	0.068
1967	0.088979	64.41	0.0277	0.1558	0.232514	81.78	0.0332	0.4428	97	4	0.041
1968	0.146726	38.24	0.0896	0.2096	0.407058	36.47	0.2463	0.5859	97	8	0.082
1969	0.009391	100.00	0	0.0188	0.033808	100.00	0	0.0676	97	1	0.010
1970	0.076562	55.34	0.0307	0.1287	0.357788	56.11	0.132	0.5836	100	4	0.040
1971	0.121017	45.52	0.06	0.1856	0.161766	59.00	0.0544	0.2842	106	6	0.057
1972	0.129339	46.45	0.0627	0.2038	0.161805	68.88	0.0334	0.2931	100	6	0.060
1973	0.341706	35.12	0.2087	0.4861	0.133042	44.25	0.0712	0.2053	99	8	0.081
1974	0.229524	78.51	0.0356	0.4295	0.096172	87.88	0.0074	0.1854	102	4	0.039
1975	0.038254	33.87	0.0235	0.0539	0.032399	37.84	0.018	0.0491	112	8	0.071
1976	0.069622	66.81	0.0236	0.125	0.046311	50.97	0.0206	0.073	99	4	0.040
1977	0.042050	37.78	0.0216	0.062	0.084916	45.43	0.0427	0.1328	135	7	0.052
1978	0.472066	26.94	0.3203	0.6332	0.536890	23.46	0.386	0.6951	218	26	0.119
1979	0.054341	29.26	0.0343	0.0759	0.102655	42.93	0.0509	0.1658	234	13	0.056
1980	0.139714	35.14	0.0843	0.1953	0.180163	42.34	0.0968	0.2711	98	7	0.071
1981	0.260816	47.79	0.1147	0.4069	1.137620	76.64	0.2151	2.1505	97	6	0.062
1982	0.048125	44.86	0.0226	0.0729	0.191943	83.03	0.0235	0.376	99	5	0.051
1983	0.247228	35.61	0.1432	0.343	0.334220	37.16	0.1954	0.4889	97	10	0.103
1984	0.039978	53.20	0.0163	0.0637	0.071304	69.63	0.0033	0.1309	95	3	0.032
1985	0.188415	45.86	0.0952	0.2822	0.319381	51.58	0.1343	0.5011	95	8	0.084
1986	0.096276	38.06	0.0528	0.1368	0.368753	42.40	0.1935	0.5423	94	6	0.064
1987	0.035614	38.70	0.0208	0.0504	0.063314	36.06	0.0363	0.089	91	4	0.044
1988	0.114253	35.12	0.0639	0.1649	0.102314	43.31	0.0538	0.1524	93	8	0.086
1989	0.135309	48.01	0.065	0.2057	0.106517	52.35	0.0433	0.1768	90	6	0.067
1990	0.105232	57.78	0.0383	0.1732	0.214463	67.51	0.0541	0.3981	92	5	0.054
1991	0.133637	43.30	0.0675	0.2067	0.295392	44.90	0.145	0.4696	91	7	0.077
1992	0.131571	36.59	0.0762	0.1866	0.183606	47.47	0.0869	0.2886	89	8	0.090
1993	0.194925	55.98	0.0739	0.3193	0.411690	68.61	0.098	0.7345	89	6	0.067
1994	0.112726	48.72	0.0495	0.1762	0.279722	55.88	0.1192	0.4698	91	6	0.066
1995	0.148715	80.03	0.0217	0.2826	0.266597	66.64	0.0876	0.4863	95	4	0.042
1996	0.007827	100.00	0	0.0157	0.014088	100.00	0	0.0282	92	1	0.011
1997	0.073725	56.51	0.0283	0.1202	0.208050	57.88	0.0702	0.3346	93	4	0.043
1998	0.013045	100.00	0	0.0261	0.007175	100.00	0	0.0143	104	1	0.010
1999	0.052009	44.09	0.027	0.0804	0.185929	44.72	0.0882	0.2829	110	6	0.055
2000	0.006947	100.00	0	0.0139	0.025009	100.00	0	0.05	92	1	0.011
2001	0.044447	51.89	0.0172	0.0717	0.122631	52.62	0.0492	0.1961	94	4	0.043
2002	0.028729	71.01	0.013	0.0575	0.071735	74.40	0.0241	0.1428	89	2	0.022
2003	0.079503	71.86	0	0.1446	0.084381	73.54	0	0.1627	91	2	0.022
2004	0.014774	70.84	0.0069	0.0287	0.020610	99.77	0	0.0412	88	2	0.023
2005	0.046081	67.49	0.0078	0.0835	0.019457	95.09	0.0001	0.0389	90	3	0.033
2006	0.042326	52.45	0.0163	0.0684	0.001579	65.90	0.0004	0.0029	102	3	0.029
2007	-	-	-	-	-	-	-	-	-	-	-
2008	0.105453	75.17	0.0163	0.1953	0.147088	64.57	0.04	0.2675	93	3	0.032
2009	0.169910	57.54	0.0614	0.2874	0.034842	53.41	0.014	0.0576	99	7	0.071
2010	0.119737	56.64	0.0425	0.1983	0.126993	84.06	0.0021	0.2519	97	3	0.031

Table L12. Stratified mean and proportion positive indices of Atlantic wolffish for the spring MA DMF resource survey.

YEAR	stratified mean number	CV mean num	80% Lower CI (boot)	80% Upper CI (boot)	stratified mean weight	CV mean wt	80% Lower CI (boot)	80% Upper CI (boot)	Total Number Tows	Number Positive Tows	Prop Positive
1978	0.09035	38.79	0.051600	0.129900	0.32664	43.88	0.17890	0.48700	95	6	0.06
1979	0.07601	42.10	0.044200	0.106600	0.29359	53.15	0.14470	0.45440	100	6	0.06
1980	0.10386	29.25	0.071900	0.138000	0.43393	26.85	0.30470	0.55890	98	10	0.10
1981	0.01518	71.92	0.000000	0.030400	0.03514	72.58	0.00000	0.06490	97	2	0.02
1982	0.05409	37.68	0.029700	0.075600	0.24120	44.30	0.12460	0.35400	95	6	0.06
1983	0.12744	58.94	0.049100	0.208600	0.29530	59.70	0.10570	0.49600	94	5	0.05
1984	0.06037	34.86	0.038700	0.083700	0.30701	40.90	0.16970	0.44890	99	6	0.06
1985	0.04965	78.88	0.012500	0.099300	0.27943	71.08	0.00000	0.53040	93	2	0.02
1986	0.02637	45.38	0.014200	0.036000	0.08916	68.30	0.03950	0.14170	94	3	0.03
1987	0.02810	59.06	0.012000	0.044200	0.18470	71.29	0.08040	0.28900	97	3	0.03
1988	0.02182	58.71	0.009000	0.034600	0.18189	59.11	0.07560	0.28820	91	3	0.03
1989	0.05696	49.38	0.030000	0.084700	0.47100	54.10	0.22150	0.71630	94	5	0.05
1990	0.00927	100.00	0.000000	0.018500	0.02597	100.00	0.00000	0.05190	95	1	0.01
1991	0.00900	100.00	0.000000	0.018000	0.07021	100.00	0.00000	0.14040	98	1	0.01
1992											
1993	0.00964	100.00	0.000000	0.019300	0.12048	100.00	0.00000	0.24100	88	1	0.01
1994											
1995	0.00742	100.00	0.000000	0.014800	0.00445	100.00	0.00000	0.00890	97	1	0.01
1996	0.01237	100.00	0.000000	0.024700	0.16076	100.00	0.00000	0.32150	101	1	0.01
1997	0.01637	71.34	0.007100	0.027800	0.01473	71.34	0.00640	0.02310	98	2	0.02
1998											
1999											
2000	0.00618	100.00	0.000000	0.012400	0.01669	100.00	0.00000	0.03340	97	1	0.01
2001											
2002											
2003	0.00618	100.00	0.000000	0.012400	0.03895	100.00	0.00000	0.07790	96	1	0.01
2004											
2005											
2006	0.01806	71.83	0.007400	0.028700	0.11315	73.41	0.04080	0.19480	100	2	0.02
2007											
2008	0.01855	57.74	0.009300	0.027800	0.11964	66.77	0.03520	0.20400	103	2	0.02
2009											
2010											

Table L13. The adult (40+ cm) index of abundance and population abundance estimates using swept area adjustments for the Albatross, Bigelow and MADMF surveys. Population estimates for the Albatross, 2009-2010 in (), are adjusted Bigelow mean number per tow values.

	Spring	ALIV	HB	Fall	ALIV	HB	Spr	MADMF
Year	40+ str mean num / tow	40+ str mean N population estimate	40+ str mean N population estimate	40+ str mean num / tow	40+ str mean N population estimate	40+ str mean N population estimate	40+ str mean num / tow	40+ str mean N population estimate
1963	-	-	-	0	0	-		
1964	-	-	-	0.020230	46802	-		
1965	-	-	-	0.081600	188780	-		
1966	-	-	-	0.072020	166617	-		
1967	-	-	-	0.034200	79121	-		
1968	0.074860	173187	-	0.099350	229844	-		
1969	0.120430	278613	-	0.009390	21724	-		
1970	0.137260	317549	-	0.069620	161065	-		
1971	0.096310	222811	-	0.036770	85067	-		
1972	0.075740	175223	-	0.050440	116692	-		
1973	0.122560	283540	-	0.053310	123332	-		
1974	0.165360	382557	-	0.023490	54344	-		
1975	0.096410	223043	-	0.013050	30191	-		
1976	0.096850	224061	-	0.027940	64639	-		
1977	0.078220	180961	-	0.035550	82244	-		
1978	0.273040	631673	-	0.175390	405762	-	0.09035	43061
1979	0.140130	324188	-	0.030890	71463	-	0.07601	36226
1980	0.203730	471326	-	0.083670	193569	-	0.09765	46540
1981	0.188510	436115	-	0.226900	524929	-	0.01518	7235
1982	0.102280	236623	-	0.027910	64569	-	0.05409	25779
1983	0.119340	276091	-	0.117440	271695	-	0.11324	53970
1984	0.113030	261493	-	0.023710	54853	-	0.05073	24178
1985	0.177350	410296	-	0.067980	157271	-	0.04963	23654
1986	0.206280	477225	-	0.096270	222719	-	0.01673	7974
1987	0.160860	372147	-	0.035630	82429	-	0.01909	9098
1988	0.094410	218416	-	0.031330	72481	-	0.02182	10399
1989	0.142120	328792	-	0.058030	134251	-	0.05696	27147
1990	0.043790	101307	-	0.038860	89902	-	0.00927	4418
1991	0.044810	103667	-	0.076250	176403	-	0.009	4289
1992	0.078390	181354	-	0.093200	215617	-	0	0
1993	0.096710	223737	-	0.180110	416681	-	0.00964	4594
1994	0.089420	206872	-	0.097080	224593	-	0	0
1995	0.056640	131036	-	0.126120	291776	-	0.00742	3536
1996	0.056110	129809	-	0.007830	18115	-	0.01236	5891
1997	0.030630	70862	-	0.066780	154494	-	0.01636	7797
1998	0.037430	86594	-	0.006520	15084	-	0	0
1999	0.039150	90573	-	0.047680	110307	-	0	0
2000	0.030930	71556	-	0.006950	16079	-	0.00618	2945
2001	0.023490	54344	-	0.044460	102857	-	0	0
2002	0.031320	72458	-	0.028720	66443	-	0	0
2003	0.054810	126802	-	0.024100	55755	-	0.00618	2945
2004	0	0	-	0.006950	16079	-	0	0
2005	0	0	-	0.006950	16079	-	0	0
2006	0	0	-	0.000000	0	-	0.01806	8607
2007	0.007830	18115	-	0.000000	0	-	0	0
2008	0	0	-	0.024100	55755	-	0.01854	8836
2009	0.029340	(67878)	108604	0.032310	(74749)	119598	0	0
2010	0.019560	(45252)	72403	0.033720	(78011)	124817	0	0

Table L14. SCALE model input data updates and general model configuration.

Main Parameter Configuration of the SCALE Model Base Run

Input data	**Parameters**	**Update Status**
General Parameters	Years - 1968-2010, 30 Ages, 1 Selectivity Block, 1 Recruitment Index, 3 Adult Indices, 1 Survey with LF, 145 Length bins	Addition of 2008-2010 – all else same as 2008 assessment
Biological Data	Mean Lengths at Age	Same as 2008 assessment - modified growth from Nelson & Ross Study
Catch Length Frequency	Observed Catch LF Distributions	Updated - same 1968-2007 - new data for 2008-2010 - 2010 includes kept and discard LFs
Fishery Data	Total Catch in Weight (mt)	Updated – small changes 1968-2007 via recalculation of recreational landings- new values for 2008-2010 - same 100% discard mortality all years
Recruitment Indices	NEFSC spring age 1	Updated - same 1968-2007 - no new data for 1-7 cm 2008-2010
Swept area survey indices	NEFSC spring 40+	Updated - same 1968-2007 - new values for 2008-2010, 2009-2010 swept area scaled to Bigelow
	NEFSC fall 40+	Updated - same 1968-2007 - new values for 2008-2010, 2009-2010 swept area scaled to Bigelow
	MADMF spring 40+	Updated - same 1978-2007 - no new catch for 2008-2010
Survey Length Frequencies	Observed LF Distribution	Updated - same 1968-2007 - new data for 2009-2010 - 2008 no catch
Selectivity	Selectivity Bounds	Same as 2009 assessment Slope = 0.15 preferred by NDPSWG Peer Review Panel

Table L15. Updated SCALE model survey area coverage, estimated average survey tow coverage, total area divided by the survey footprint and the survey efficiency Q estimates for run 1 and 2. *MADMF survey was not affected by vessel change from Albatross to Bigelow.

Atlantic Wolffish	Vessel	NEFSC Spr Age 1	NEFSC Spr 40+	NEFSC Fall 40+	MADMF* 40+
survey area (nm^2)		25,911	25,911	25,911	1,833
Avg tow area swept	ALIV	0.0112	0.0112	0.0112	0.003846
	HB	0.007	0.007	0.007	
Tow duration	ALIV	30 min	30 min	30 min	20 min
	HB	20 min	20 min	20 min	
total area / tow area swept	ALIV	2,313,482	2,313,482	2,313,482	476,573
	HB	3,701,571	3,701,571	3,701,571	
Q L50 = 90 (run 1)		0.142	0.194	0.104	0.012
Q Slope = 0.15 (run2)		0.144	0.186	0.099	0.011

Table L16. Diagnostics from the Atlantic wolffish SCALE model runs. Run 1 was allowed to hit the L50 bound on the selectivity and run 2 hit the selectivity slope bound of 0.15.

SCALE Model Run	1			2		
	L_{50} = 90			slope = 0.15		
	Weight	Qs	Residuals or Parameters	Weight	Qs	Residuals or Parameters
total objective function			262.99			265.39
total catch	10		0.21	10		0.21
catch len freq 1+	500		14.21	500		12.77
Variation in recruit penalty	2		13.56	2		14.46
NEFSC Spr 1 Age-1 1968-2007	2	0.142	8.80	2	0.144	8.94
NEFSC Spr 40+ 1968-2007	12	0.194	6.21	12	0.186	6.34
MDMF Spr 40+ 1978-2007	3	0.012	9.87	3	0.011	9.79
NEFSC Fall 40+ 1968-2007	3	0.104	27.96	3	0.099	28.09
NEFSC Spr 40+ len freq	5		13.94	5		13.91
Fstart			0.021			0.001
recruitment year 1 (1968, 000s)			356			362
Selectivity Alpha (L50) 1982-1984			90			72.86
Selectivity Beta (slope) 1982-1984			0.095			0.15

Table L17. Updated biological reference points for Atlantic wolffish for 2 selectivity regimes and 3 knife edge maturity cutoffs. Run 2 was considered the preferred model.

SCALE run	1			2		
Selectivity	L_{50} = 90			slope = 0.15		
Length of maturity	40cm (L_{50} = 90)	65cm (L_{50} = 90)	75cm (L_{50} = 90)	40cm (slope = 0.15)	65cm (slope = 0.15)	75cm (slope = 0.15)
F_{MSY} proxy	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$
F_{MSY}	0.740	0.520	0.398	0.341	0.248	0.196
YPR	0.878	0.848	0.810	0.867	0.827	0.784
SSB per Recruit	5.934	5.268	4.686	5.828	5.156	4.582
Initial Recruits (000s)	342	342	342	347	347	347
MSY (mt)	301	290	277	301	287	272
SSB_{MSY} (mt)	2,032	1,804	1,605	2,022	1,789	1,590
SSB10 (mt)	1,335	892	652	1,463	1,006	759
F_{10}	0.057	0.057	0.057	0.024	0.024	0.024
SSB_{10}/SSB_{MSY}	66%	49%	41%	72%	56%	48%
F_{10}/F_{MSY}	8%	11%	14%	7%	10%	12%

Table L18. Sensitivity of SCALE Model output, Total and Exploitable Biomass (mt), due to swept area indices adjustments. The base run was HB and the sensitivity run was A4.

Year	**HB** Total Biomass	**A4** Total Biomass	**HB** Exploitable Biomass	**A4** Exploitable Biomass	**HB – A4** Differ Tot Bio	**HB – A4** Differ Exp Bio	**HB v A4** % Change Tot Bio	**HB v A4** % Change Exp Bio
1968	5,647	5,533	4,284	4,219	114	65	2.02	1.53
1969	5,539	5,425	4,183	4,117	114	66	2.06	1.57
1970	5,397	5,284	4,047	3,982	113	66	2.09	1.62
1971	5,280	5,169	3,929	3,863	111	66	2.11	1.67
1972	5,173	5,066	3,805	3,739	107	66	2.07	1.73
1973	5,029	4,929	3,633	3,567	101	66	2.01	1.82
1974	4,929	4,836	3,477	3,411	93	66	1.89	1.90
1975	4,797	4,718	3,243	3,178	79	65	1.65	2.00
1976	4,802	4,738	3,086	3,026	63	60	1.32	1.95
1977	4,772	4,722	2,898	2,847	51	51	1.06	1.76
1978	4,926	4,896	2,776	2,739	30	37	0.61	1.35
1979	4,927	4,915	2,550	2,533	12	17	0.24	0.65
1980	4,978	4,976	2,413	2,421	2	-8	0.04	-0.34
1981	4,880	4,888	2,262	2,292	-8	-30	-0.16	-1.31
1982	4,913	4,929	2,308	2,350	-16	-41	-0.33	-1.79
1983	4,843	4,865	2,363	2,415	-22	-52	-0.46	-2.18
1984	4,429	4,460	2,207	2,273	-32	-66	-0.72	-3.01
1985	4,113	4,146	2,133	2,207	-34	-75	-0.82	-3.51
1986	3,738	3,771	1,967	2,043	-33	-76	-0.89	-3.87
1987	3,298	3,331	1,715	1,786	-32	-71	-0.98	-4.14
1988	2,936	2,967	1,452	1,515	-30	-63	-1.03	-4.34
1989	2,785	2,811	1,352	1,407	-26	-55	-0.94	-4.05
1990	2,523	2,549	1,188	1,237	-26	-49	-1.04	-4.15
1991	2,452	2,475	1,168	1,212	-23	-44	-0.93	-3.80
1992	2,325	2,345	1,084	1,124	-20	-40	-0.86	-3.70
1993	2,228	2,245	957	994	-17	-37	-0.76	-3.90
1994	2,044	2,057	792	827	-13	-35	-0.64	-4.48
1995	1,827	1,838	685	717	-10	-32	-0.57	-4.63
1996	1,543	1,551	602	627	-8	-25	-0.51	-4.11
1997	1,384	1,388	583	603	-4	-20	-0.31	-3.42
1998	1,244	1,244	531	546	-1	-15	-0.06	-2.92
1999	1,141	1,138	465	477	3	-11	0.31	-2.44
2000	1,084	1,075	415	423	9	-8	0.80	-1.93
2001	1,083	1,069	419	425	15	-6	1.34	-1.36
2002	1,026	1,003	400	402	23	-2	2.22	-0.45
2003	1,033	1,000	436	433	32	3	3.14	0.60
2004	1,033	986	467	458	47	10	4.55	2.11
2005	1,052	987	504	486	65	18	6.19	3.58
2006	1,080	990	530	502	89	28	8.28	5.28
2007	1,147	1,026	563	524	121	39	10.56	6.89
2008	1,264	1,105	615	565	159	50	12.58	8.08
2009	1,422	1,218	681	618	204	63	14.31	9.25
2010	1,628	1,374	777	696	254	81	15.59	10.48

Table L19. Sensitivity of fishing mortality estimates due to swept area indices adjustments.

Year	HB K + D Fmult	A4 K + D Fmult	HB v A4 diff in F	HBv A4 % change
1968	0.029	0.030	-0.001	-3.45
1969	0.042	0.043	-0.001	-2.38
1970	0.042	0.042	0.000	0.00
1971	0.048	0.049	-0.001	-2.08
1972	0.070	0.071	-0.001	-1.43
1973	0.073	0.074	-0.001	-1.37
1974	0.113	0.116	-0.003	-2.65
1975	0.106	0.108	-0.002	-1.89
1976	0.141	0.144	-0.003	-2.13
1977	0.142	0.145	-0.003	-2.11
1978	0.242	0.245	-0.003	-1.24
1979	0.285	0.285	0.000	0.00
1980	0.400	0.394	0.006	1.50
1981	0.349	0.341	0.008	2.29
1982	0.375	0.364	0.011	2.93
1983	0.535	0.512	0.023	4.30
1984	0.463	0.442	0.021	4.54
1985	0.495	0.470	0.025	5.05
1986	0.543	0.514	0.029	5.34
1987	0.580	0.547	0.033	5.69
1988	0.467	0.442	0.025	5.35
1989	0.616	0.582	0.034	5.52
1990	0.460	0.438	0.022	4.78
1991	0.505	0.481	0.024	4.75
1992	0.561	0.535	0.026	4.63
1993	0.773	0.734	0.039	5.05
1994	0.990	0.934	0.056	5.66
1995	1.194	1.130	0.064	5.36
1996	0.884	0.846	0.038	4.30
1997	0.817	0.788	0.029	3.55
1998	0.773	0.750	0.023	2.98
1999	0.751	0.734	0.017	2.26
2000	0.607	0.597	0.010	1.65
2001	0.775	0.770	0.005	0.65
2002	0.519	0.523	-0.004	-0.77
2003	0.462	0.478	-0.016	-3.46
2004	0.361	0.379	-0.018	-4.99
2005	0.320	0.342	-0.022	-6.88
2006	0.239	0.261	-0.022	-9.21
2007	0.156	0.171	-0.015	-9.62
2008	0.115	0.129	-0.014	-12.17
2009	0.074	0.082	-0.008	-10.81
2010	0.024	0.027	-0.003	-12.50

Table L20. Sensitivity of SCALE Model output, Total and Exploitable Biomass (mt), due to changes in commercial length frequency between model runs. The base run included kept and discarded length data for the 2010 year only and the sensitivity run had only kept length data for all years.

Year	**Base K+D** Total Biomass	**K only** Total Biomass	**Base K+D** Exploitable Biomass	**K only** Exploitable Biomass	**K+D – K** Differ Tot Bio	**K+D – K** Differ Exp Bio	**K+D v K** % Change Tot Bio	**K+D v K** % Change Exp Bio
1968	5,647	5,622	4,284	5,622	25	60	0.44	1.40
1969	5,539	5,514	4,183	5,514	25	59	0.44	1.42
1970	5,397	5,373	4,047	5,373	24	59	0.45	1.45
1971	5,280	5,257	3,929	5,257	24	58	0.45	1.48
1972	5,173	5,150	3,805	5,150	24	57	0.46	1.51
1973	5,029	5,006	3,633	5,006	23	56	0.47	1.55
1974	4,929	4,905	3,477	4,905	24	55	0.48	1.59
1975	4,797	4,773	3,243	4,773	24	54	0.50	1.67
1976	4,802	4,776	3,086	4,776	26	54	0.53	1.76
1977	4,772	4,745	2,898	4,745	27	54	0.57	1.88
1978	4,926	4,896	2,776	4,896	30	56	0.62	2.01
1979	4,927	4,894	2,550	4,894	33	60	0.68	2.37
1980	4,978	4,942	2,413	4,942	35	70	0.71	2.91
1981	4,880	4,843	2,262	4,843	36	80	0.75	3.52
1982	4,913	4,877	2,308	4,877	36	88	0.73	3.79
1983	4,843	4,808	2,363	4,808	35	92	0.72	3.89
1984	4,429	4,395	2,207	4,395	33	89	0.75	4.02
1985	4,113	4,081	2,133	4,081	31	83	0.76	3.87
1986	3,738	3,709	1,967	3,709	30	73	0.79	3.72
1987	3,298	3,271	1,715	3,271	27	63	0.83	3.68
1988	2,936	2,911	1,452	2,911	26	56	0.88	3.85
1989	2,785	2,761	1,352	2,761	25	54	0.89	4.00
1990	2,523	2,500	1,188	2,500	23	52	0.92	4.36
1991	2,452	2,430	1,168	2,430	22	49	0.89	4.23
1992	2,325	2,304	1,084	2,304	20	44	0.87	4.06
1993	2,228	2,209	957	2,209	19	40	0.85	4.15
1994	2,044	2,026	792	2,026	18	39	0.86	4.88
1995	1,827	1,811	685	1,811	16	38	0.86	5.62
1996	1,543	1,529	602	1,529	13	33	0.87	5.53
1997	1,384	1,372	583	1,372	12	29	0.89	4.96
1998	1,244	1,232	531	1,232	12	24	0.96	4.60
1999	1,141	1,129	465	1,129	12	21	1.05	4.61
2000	1,084	1,072	415	1,072	12	21	1.13	5.03
2001	1,083	1,071	419	1,071	12	22	1.14	5.29
2002	1,026	1,014	400	1,014	12	23	1.18	5.67
2003	1,033	1,021	436	1,021	12	24	1.13	5.50
2004	1,033	1,022	467	1,022	11	25	1.07	5.31
2005	1,052	1,042	504	1,042	10	25	0.95	4.99
2006	1,080	1,071	530	1,071	9	24	0.80	4.61
2007	1,147	1,139	563	1,139	8	23	0.68	4.01
2008	1,264	1,257	615	1,257	7	20	0.59	3.30
2009	1,422	1,414	681	1,414	8	19	0.57	2.77
2010	1,628	1,619	777	1,619	9	20	0.57	2.55

Table L21. Sensitivity of SCALE Model output, Total and Exploitable Biomass (mt), due to assumed discard mortality rates. The base run was 100% discard mortality and the sensitivity run was 10% discard mortality.

Year	**Base 100** Total Biomass	**10%** Total Biomass	**Base 100** Exploitable Biomass	**10%** Exploitable Biomass	**100 – 10** Differ Tot Bio	**100 – 10** Differ Exp Bio	**100 v 10** % Change Tot Bio	**100 v 10** % Change Exp Bio
1968	5,647	5,594	4,284	4,244	53	40	0.95	0.93
1969	5,539	5,485	4,183	4,143	53	40	0.96	0.96
1970	5,397	5,344	4,047	4,008	53	40	0.99	0.99
1971	5,280	5,227	3,929	3,889	54	40	1.01	1.02
1972	5,173	5,120	3,805	3,765	54	40	1.04	1.05
1973	5,029	4,976	3,633	3,593	54	40	1.07	1.10
1974	4,929	4,875	3,477	3,437	54	40	1.09	1.15
1975	4,797	4,743	3,243	3,203	54	40	1.13	1.23
1976	4,802	4,747	3,086	3,046	55	40	1.14	1.30
1977	4,772	4,717	2,898	2,858	56	40	1.17	1.38
1978	4,926	4,870	2,776	2,736	57	40	1.15	1.44
1979	4,927	4,869	2,550	2,511	58	39	1.18	1.54
1980	4,978	4,918	2,413	2,375	60	38	1.20	1.58
1981	4,880	4,818	2,262	2,225	62	37	1.26	1.63
1982	4,913	4,848	2,308	2,270	65	38	1.32	1.66
1983	4,843	4,776	2,363	2,323	67	41	1.38	1.73
1984	4,429	4,362	2,207	2,164	67	43	1.51	1.95
1985	4,113	4,045	2,133	2,086	67	47	1.64	2.18
1986	3,738	3,671	1,967	1,917	67	50	1.80	2.54
1987	3,298	3,230	1,715	1,662	69	53	2.08	3.11
1988	2,936	2,866	1,452	1,397	70	55	2.39	3.81
1989	2,785	2,714	1,352	1,296	71	56	2.56	4.16
1990	2,523	2,485	1,188	1,159	38	29	1.51	2.43
1991	2,452	2,414	1,168	1,141	38	26	1.55	2.24
1992	2,325	2,285	1,084	1,059	39	25	1.69	2.30
1993	2,228	2,203	957	945	25	12	1.12	1.25
1994	2,044	2,028	792	788	16	3	0.76	0.44
1995	1,827	1,806	685	678	21	7	1.15	1.06
1996	1,543	1,524	602	595	19	7	1.24	1.22
1997	1,384	1,366	583	575	18	8	1.30	1.34
1998	1,244	1,230	531	526	13	5	1.06	0.96
1999	1,141	1,127	465	460	14	6	1.22	1.20
2000	1,084	1,067	415	408	17	7	1.54	1.78
2001	1,083	1,064	419	410	19	9	1.76	2.20
2002	1,026	1,009	400	392	17	8	1.64	2.02
2003	1,033	1,025	436	434	7	2	0.70	0.46
2004	1,033	1,028	467	467	5	1	0.51	0.13
2005	1,052	1,046	504	503	6	1	0.53	0.16
2006	1,080	1,073	530	528	6	1	0.58	0.22
2007	1,147	1,140	563	562	7	1	0.60	0.23
2008	1,264	1,256	615	613	8	2	0.66	0.31
2009	1,422	1,413	681	679	9	2	0.66	0.27
2010	1,628	1,617	777	775	11	2	0.67	0.29

Table L22. A comparison of biological reference points estimated using the base run (slope 0.15) and the ocean pout ("op") sensitivity run SCALE model output.

SCALE run		**Base Run**		**Sensitivity Run**		
Selectivity		slope = 0.15		slope = 0.15 op conversion 4.58		
Length of maturity	40cm	65cm	75cm	40cm	65cm	
F_{MSY} proxy	F40%	F40%	F40%	F40%	F40%	
F_{MSY}	0.341	0.248	0.196	0.334	0.243	
YPR	0.867	0.827	0.784	0.864	0.824	
SSB per Recruit	5.828	5.156	4.582	5.818	5.155	
Initial Recruits (000s)	347	347	347	302	302	
MSY (mt)	301	287	272	261	249	
SSB_{MSY} (mt)	2,022	1,789	1,590	1,756	1,556	
SSB_{2010} (mt)	1,463	1,006	759	505	371	
F_{2010}	0.024	0.024	0.024	0.069	0.069	
SSB_{2010}/SSB_{MSY}	72%	56%	48%	29%	24%	
F_{2010}/F_{MSY}	7%	10%	12%	21%	28%	-

Table L23. Accepted SCALE model run for wolffish, which assumed the same survey vessel conversion coefficient as for ocean pout.

Year	Recruitment (mt)	SSB (mt)	Total Biomass (mt)	Fmult
1968	302	4,577	4,702	0.035
1969	657	4,467	4,596	0.050
1970	340	4,323	4,458	0.050
1971	170	4,198	4,349	0.058
1972	1,597	4,069	4,258	0.084
1973	350	3,932	4,140	0.089
1974	805	3,855	4,070	0.141
1975	997	3,666	3,993	0.133
1976	977	3,678	4,054	0.177
1977	666	3,771	4,068	0.177
1978	571	3,924	4,288	0.295
1979	331	3,983	4,349	0.336
1980	497	4,112	4,419	0.446
1981	204	4,113	4,346	0.378
1982	830	4,201	4,389	0.383
1983	346	4,175	4,345	0.529
1984	310	3,807	3,984	0.455
1985	223	3,493	3,689	0.485
1986	230	3,130	3,333	0.548
1987	806	2,766	2,902	0.574
1988	322	2,456	2,580	0.501
1989	505	2,283	2,425	0.612
1990	162	2,026	2,222	0.467
1991	148	1,963	2,171	0.526
1992	225	1,902	2,053	0.571
1993	204	1,854	1,973	0.776
1994	252	1,736	1,812	1.020
1995	181	1,530	1,611	1.209
1996	197	1,266	1,356	0.928
1997	129	1,110	1,199	0.833
1998	112	986	1,071	0.824
1999	84	891	963	0.879
2000	72	820	881	0.725
2001	79	808	854	0.970
2002	86	729	767	0.665
2003	96	704	737	0.635
2004	77	655	688	0.600
2005	61	594	629	0.633
2006	110	521	557	0.475
2007	300	490	527	0.330
2008	302	492	532	0.363
2009	302	482	541	0.220
2010	302	505	599	0.069

Figures

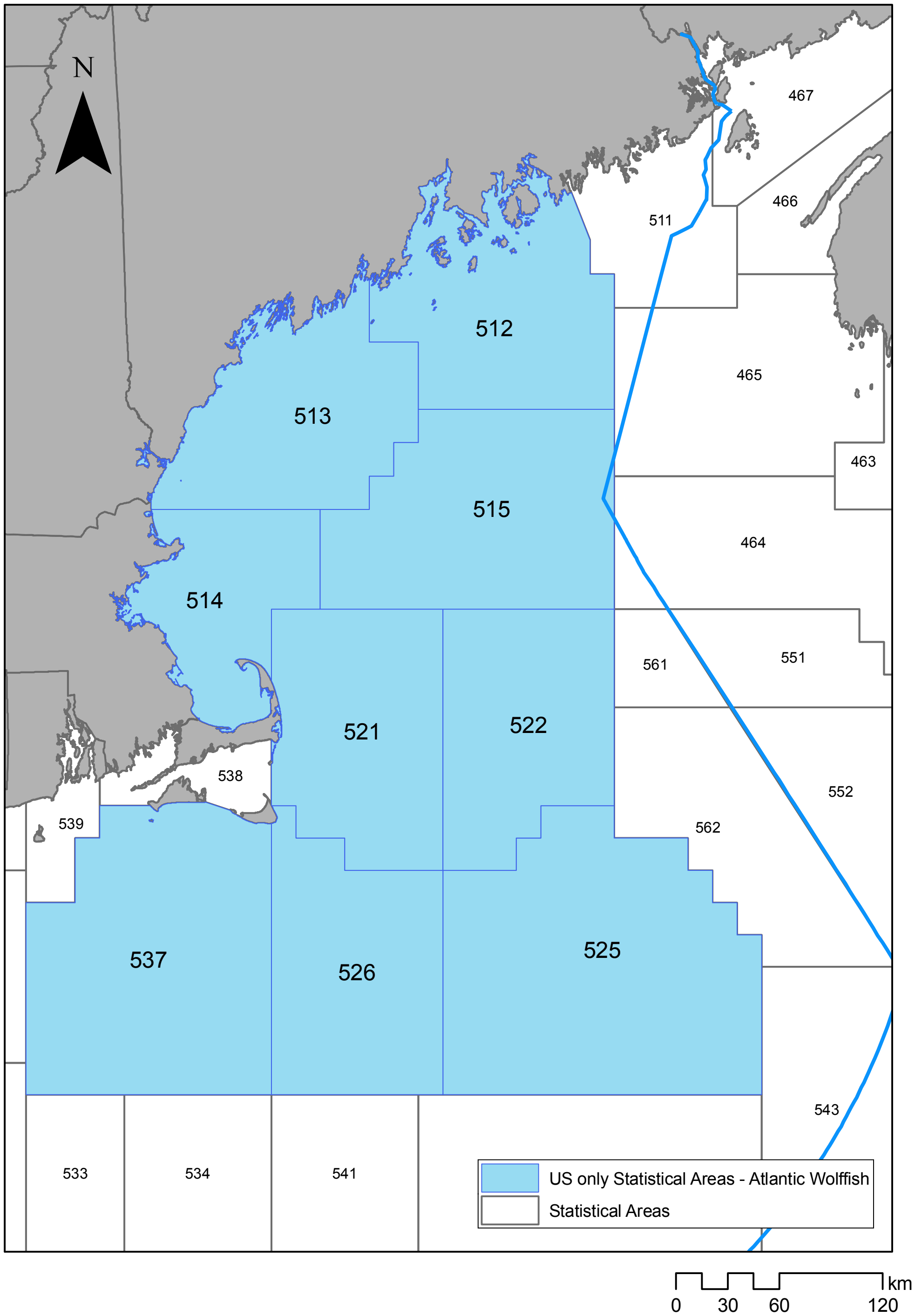


Figure L1. Fishery statistical areas used for Atlantic wolffish landings and discard estimates.

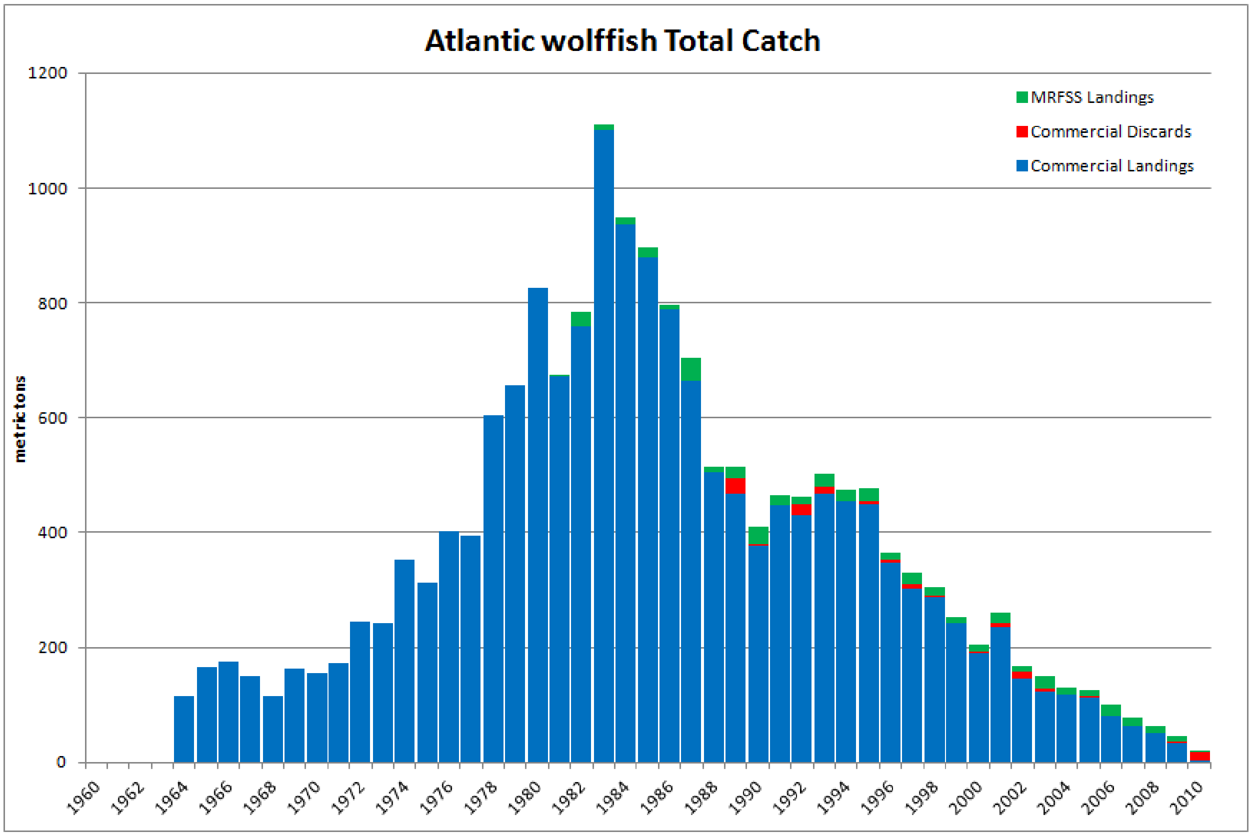


Figure L2. Updated commercial landings, recreational landings, commercial discards and total catch.

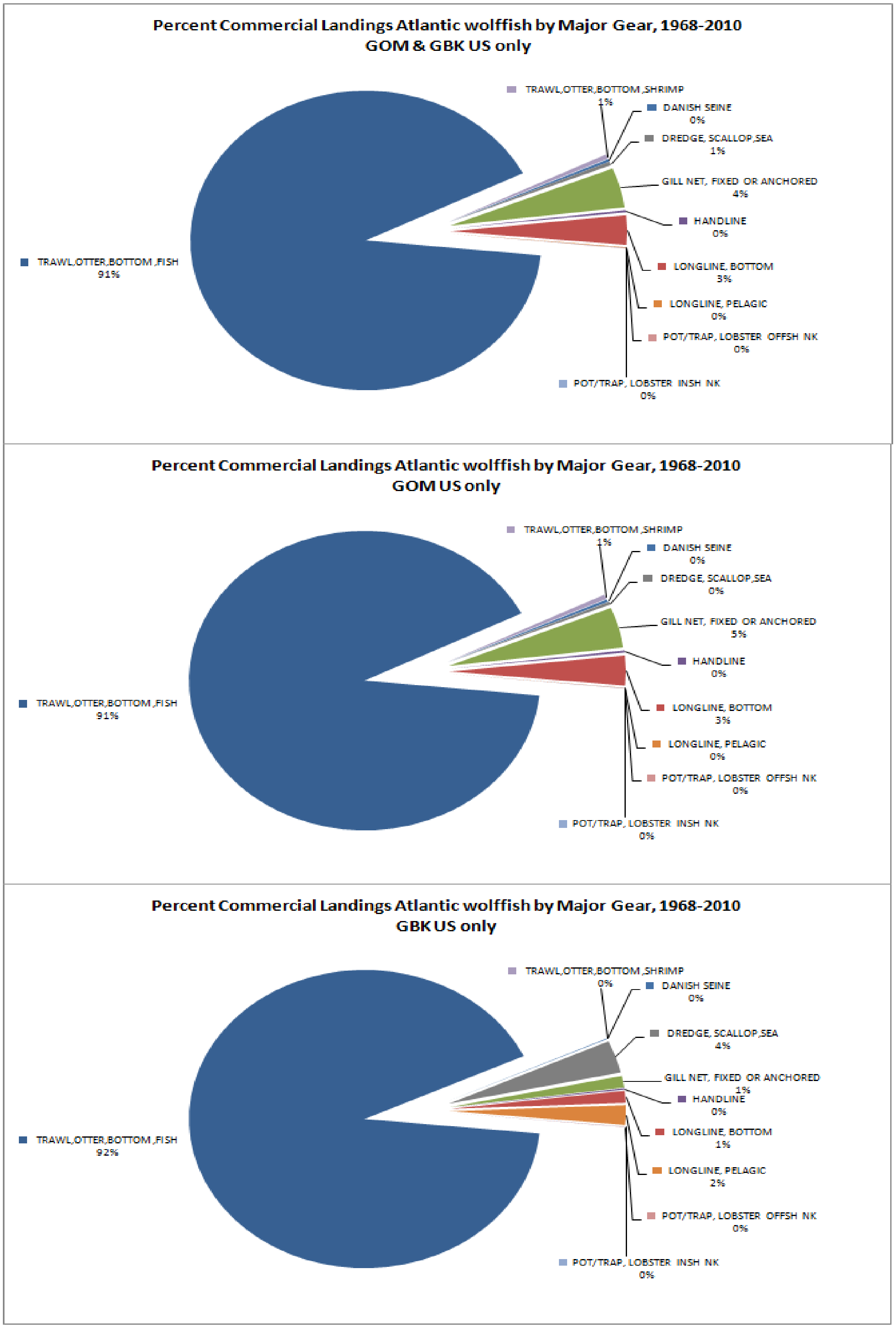


Figure L3. Updated commercial landings of Atlantic wolffish by major gear types and region, 1968-2010.

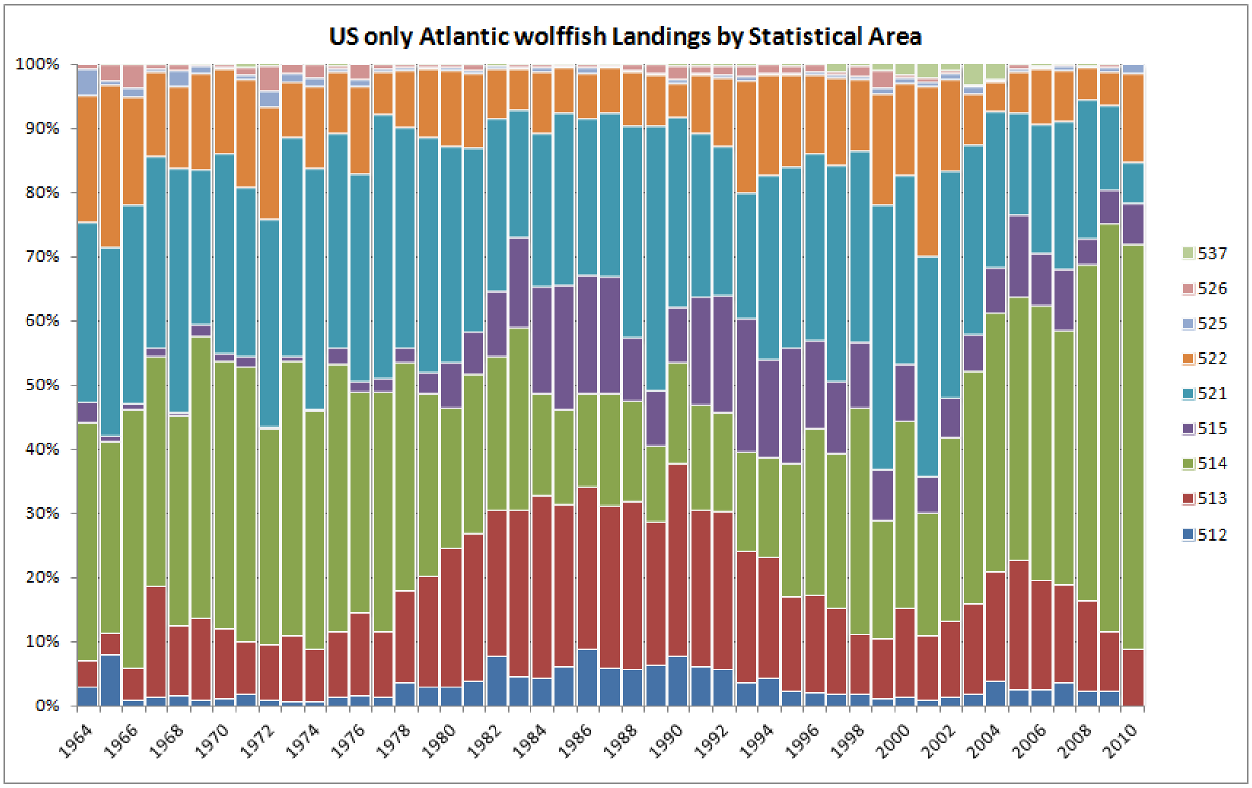


Figure L4. Updated commercial landings by statistical area.

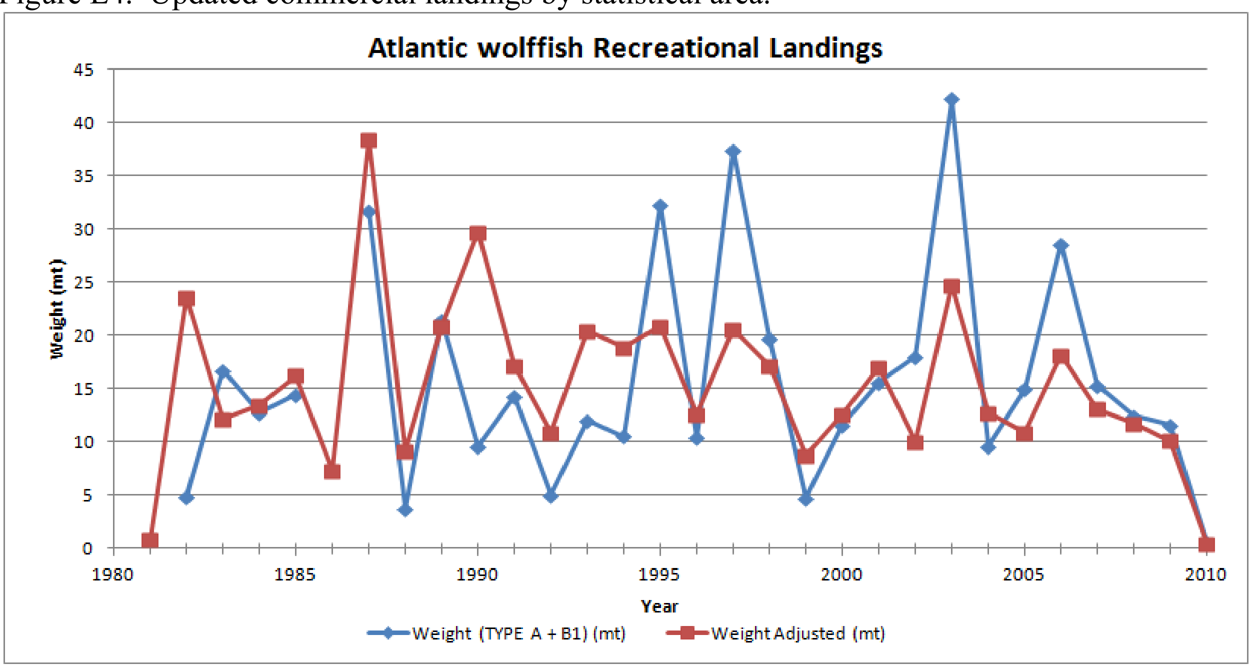


Figure L5. Updated recreational landings from MRFSS data.

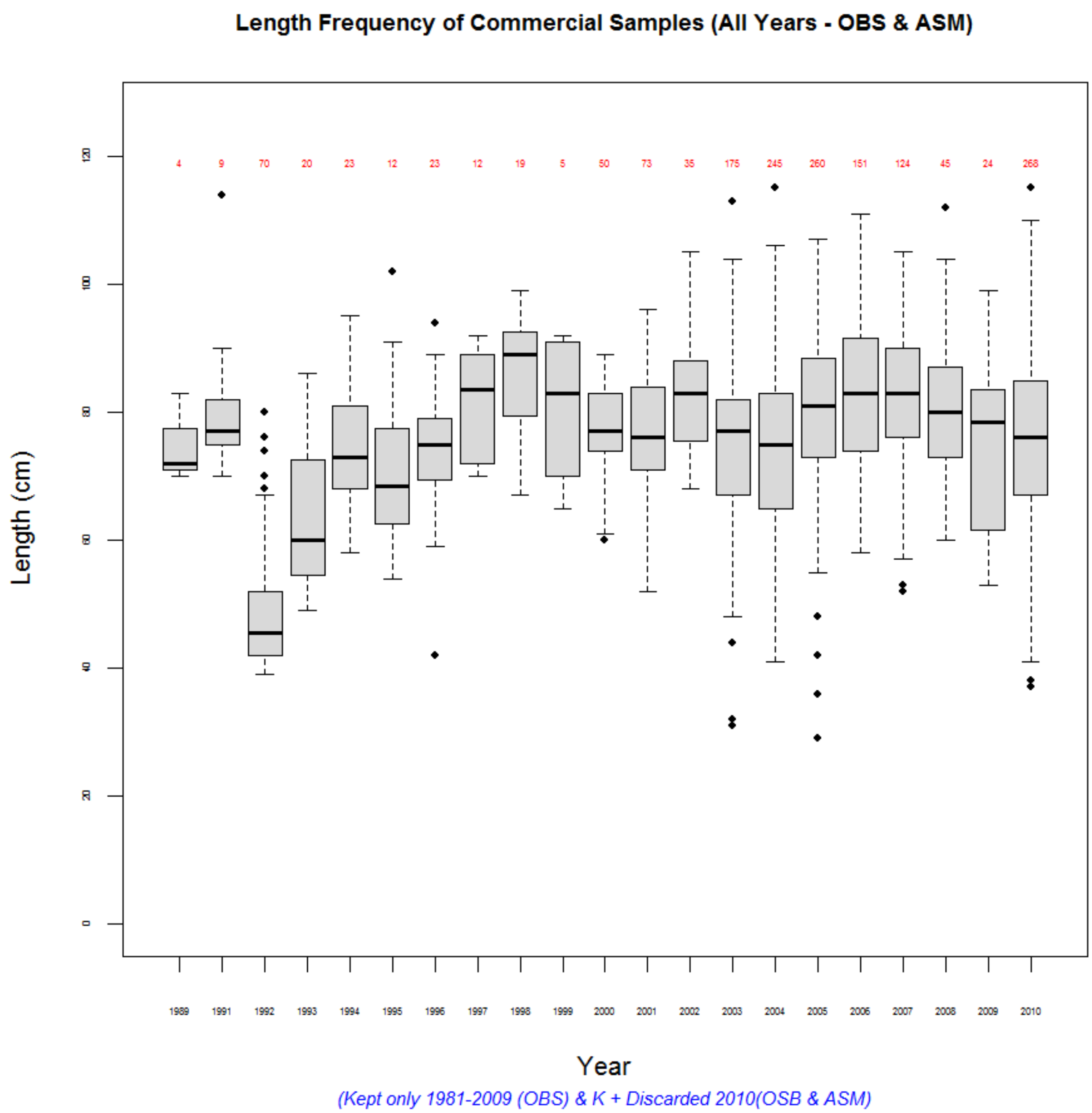


Figure L6. Boxplots of observer length frequency data by year. Mean number at length is shown by the solid black line in the boxplot. Sample size is shown in red at the top of the graph. Observer data is from kept fish only until 2010 when kept and discarded fish are combined.

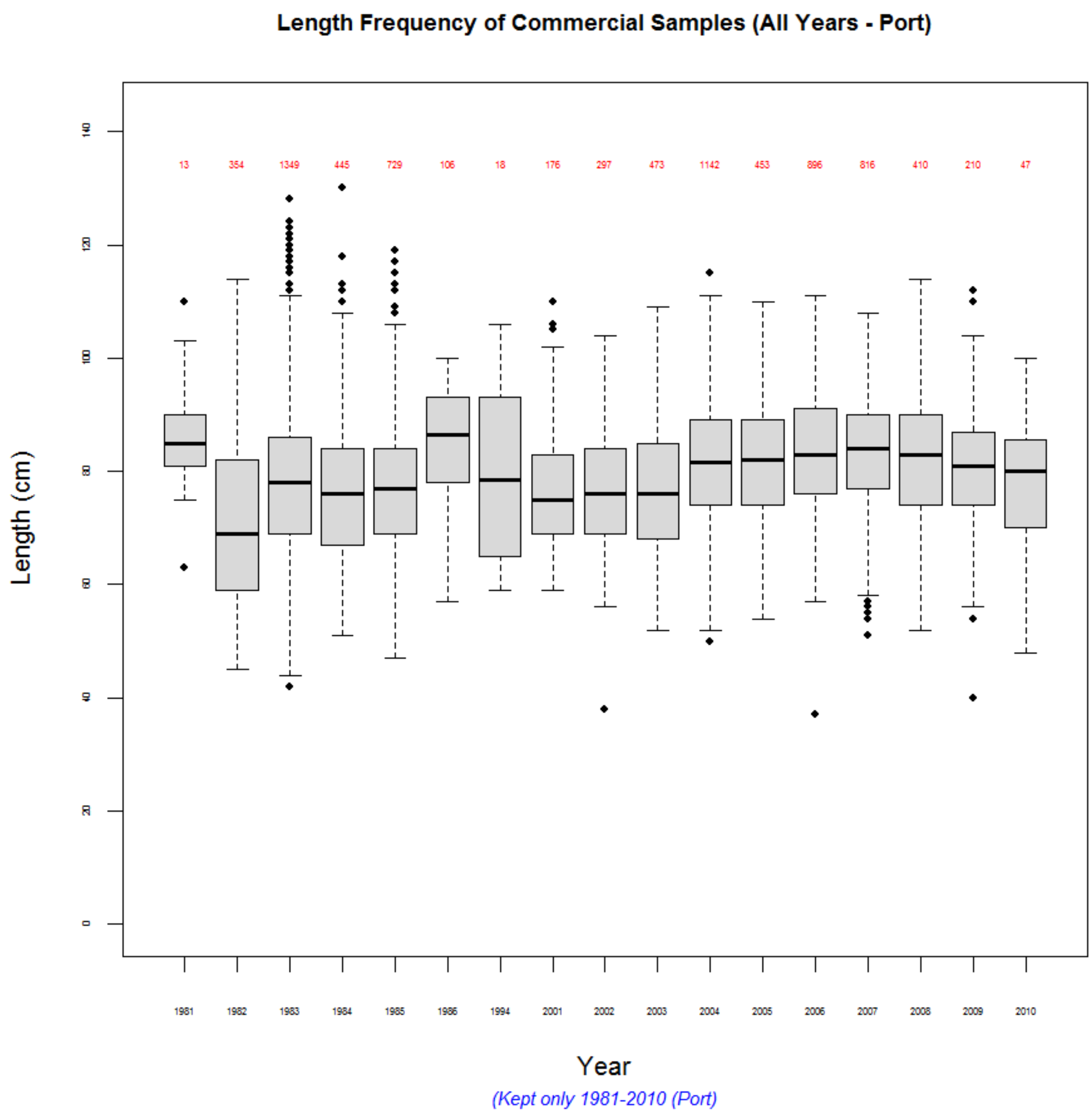


Figure L7. Boxplots of commercial port length frequency data by year. Mean number at length is shown by the solid black line in the boxplot. Sample size is shown in red at the top of the graph.

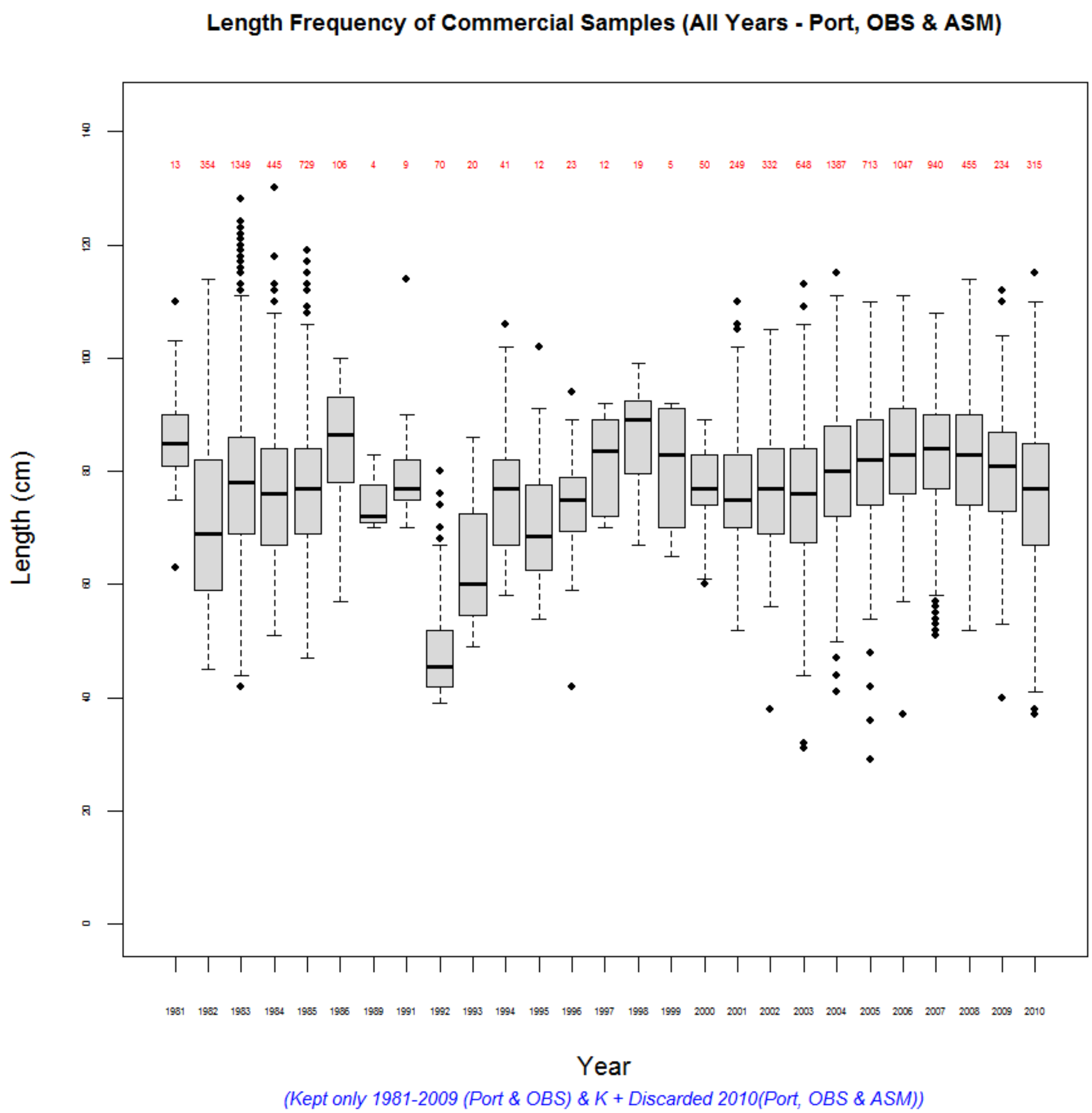


Figure L8. Combination boxplots of observer and port sample length frequency data by year. Mean number at length is shown by the solid black line in the boxplot. Sample size is shown in red at the top of the graph. Observer data is from kept fish only until 2010 when kept and discarded fish are combined.

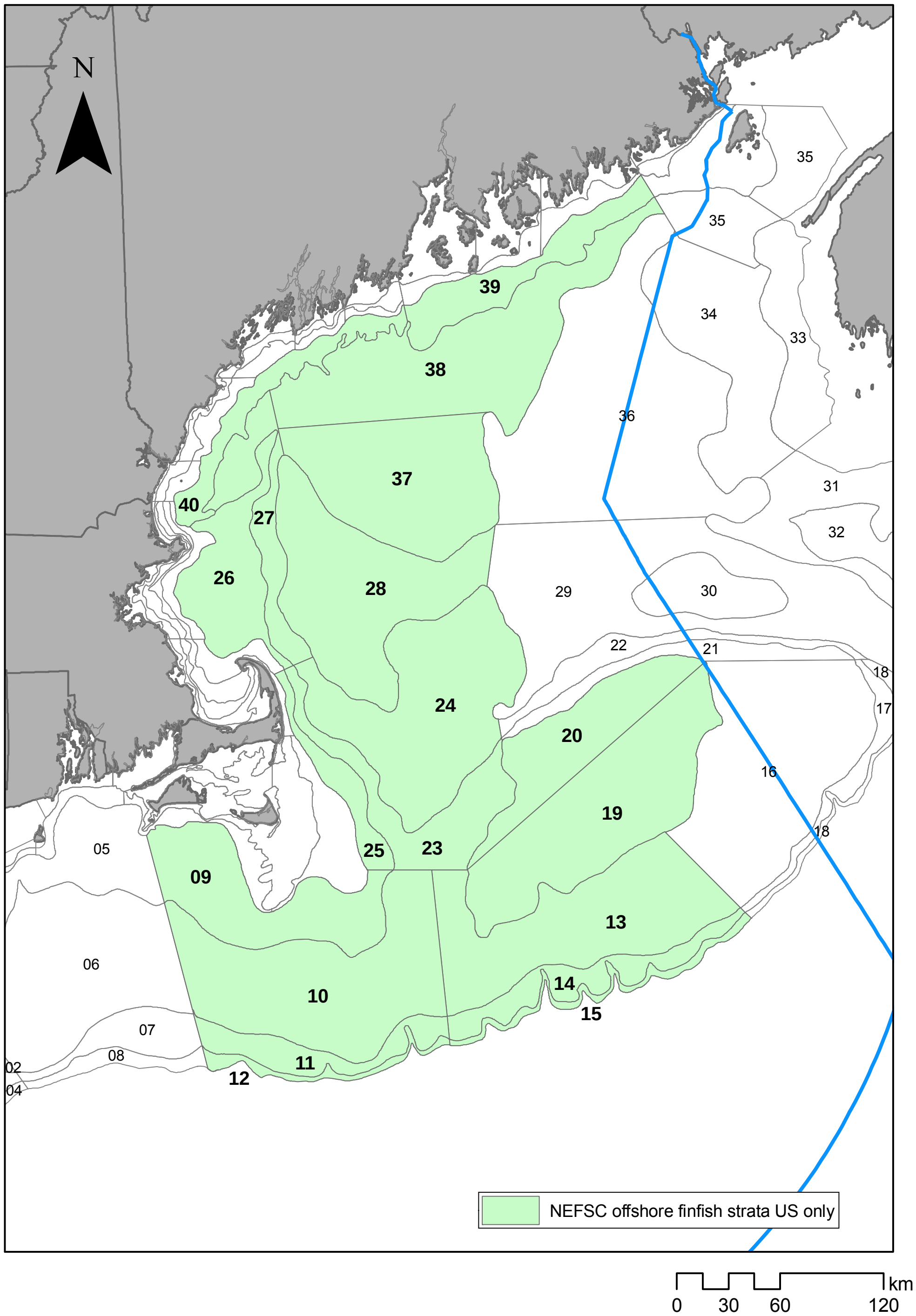


Figure L9. NEFSC survey strata used to assess Atlantic wolffish in the 2008 and 2010 assessments.

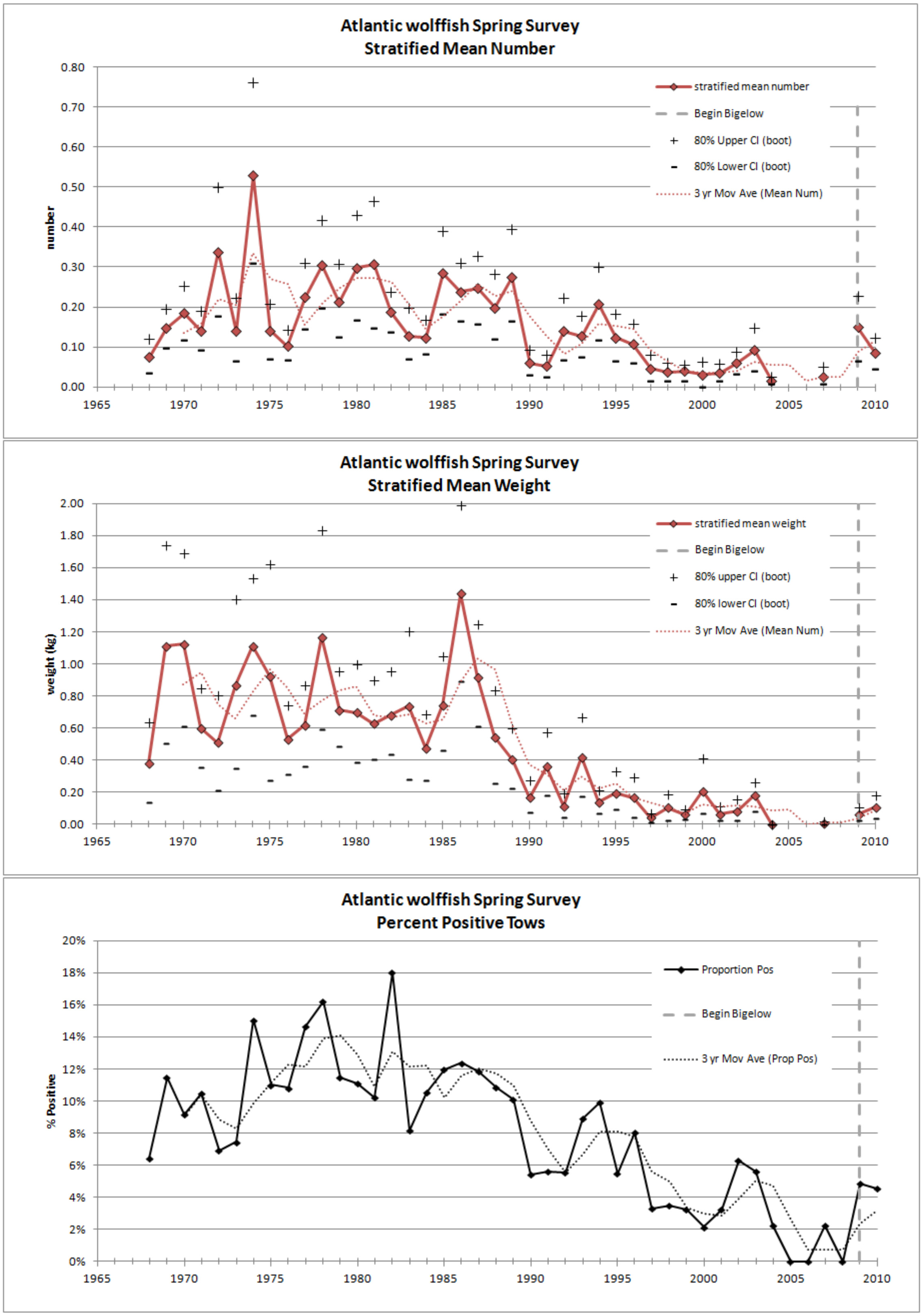


Figure L10. Updated NEFSC spring abundance, biomass and percent positive indices for Atlantic wolffish.

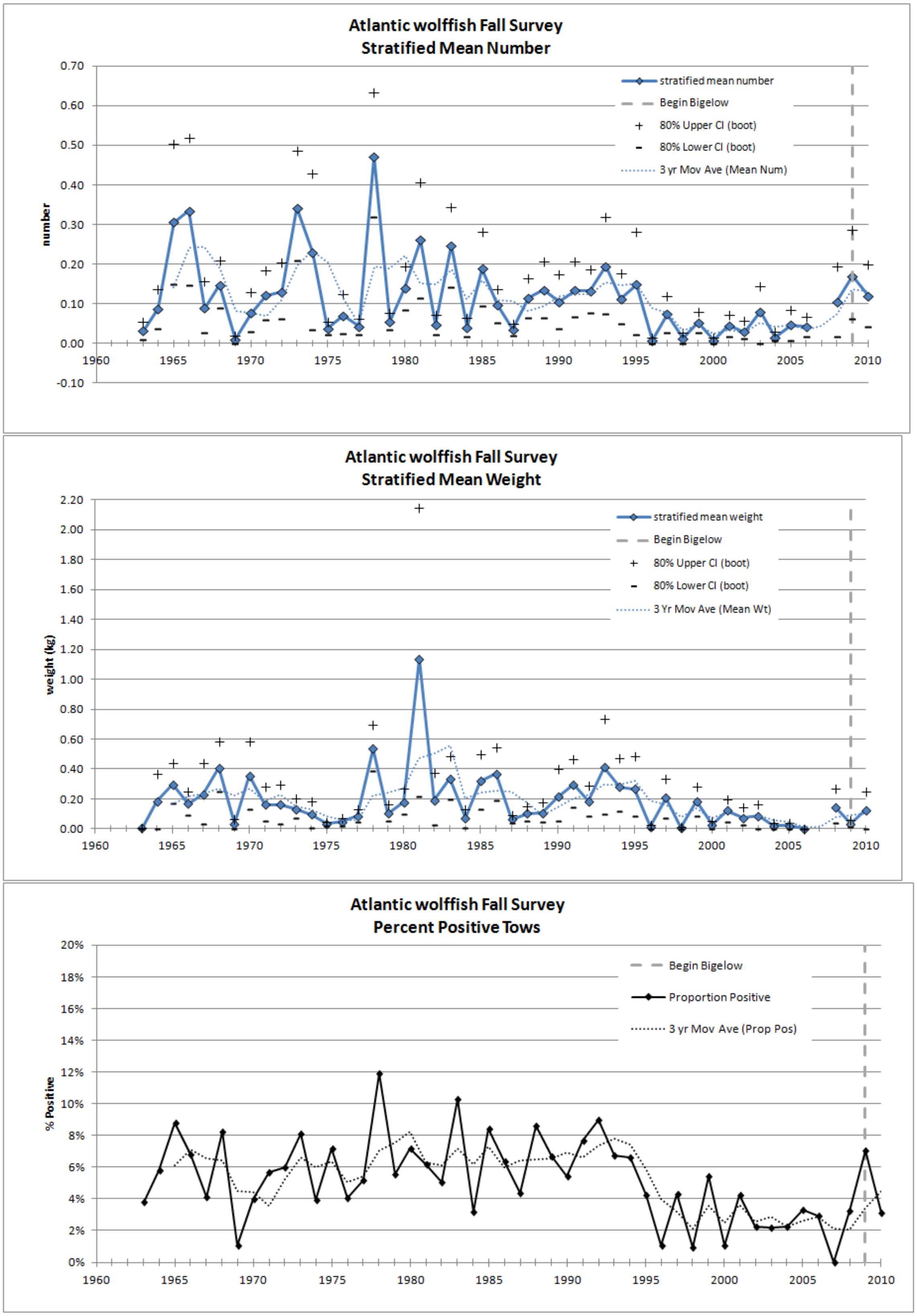


Figure L11. Updated NEFSC fall abundance, biomass and percent positive indices for Atlantic wolffish.

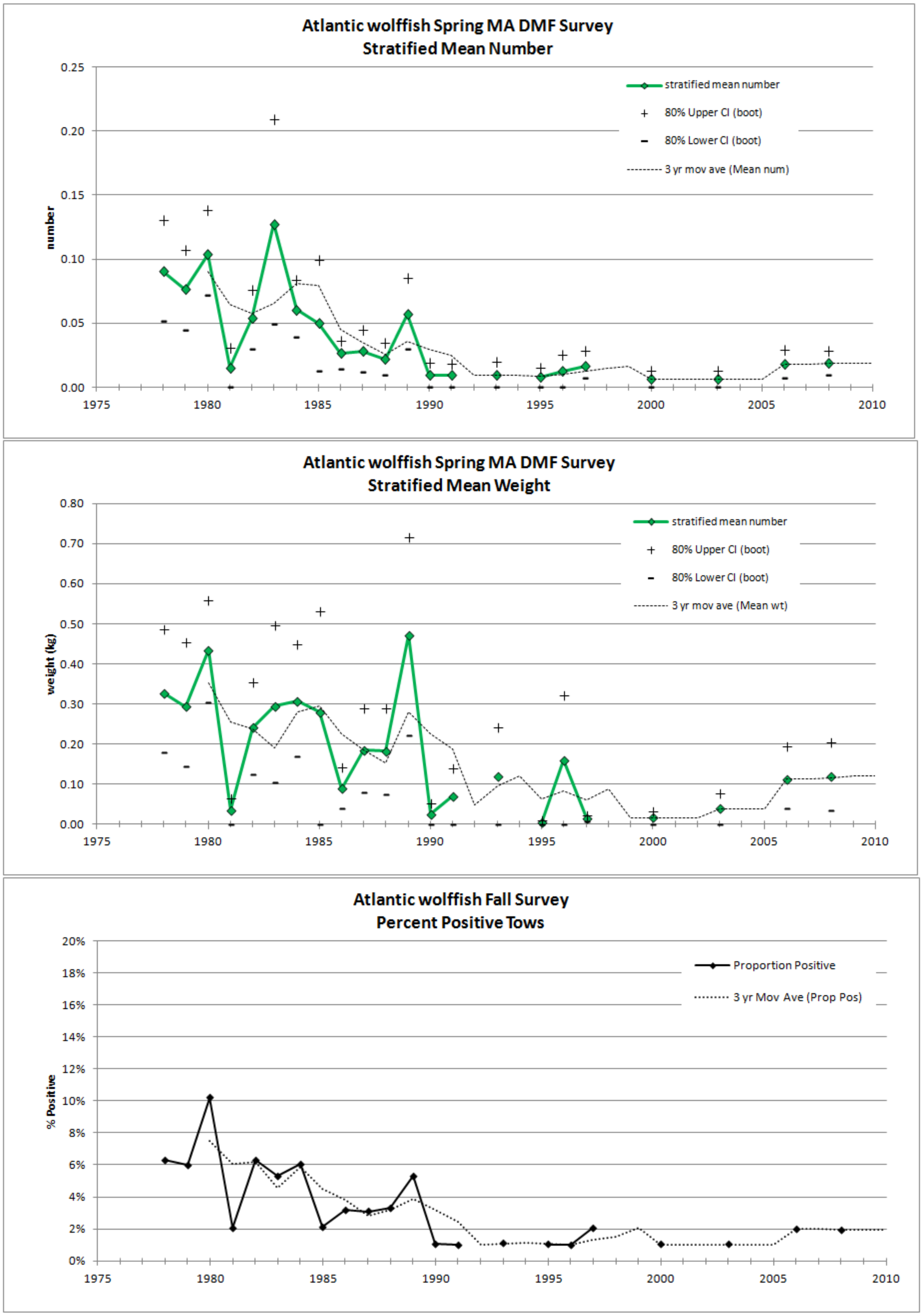
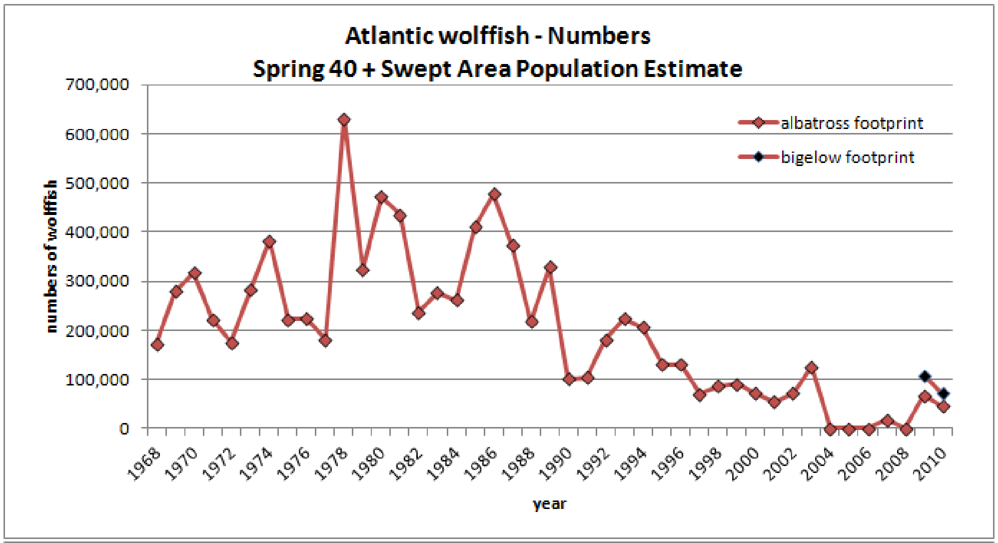
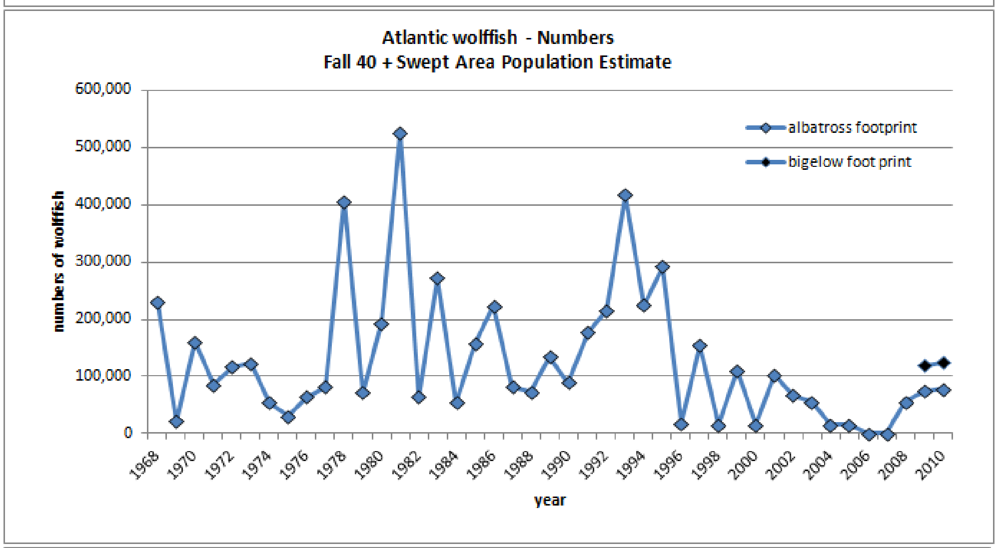


Figure L12. Updated NEFSC fall abundance, biomass and percent positive indices for Atlantic wolffish.





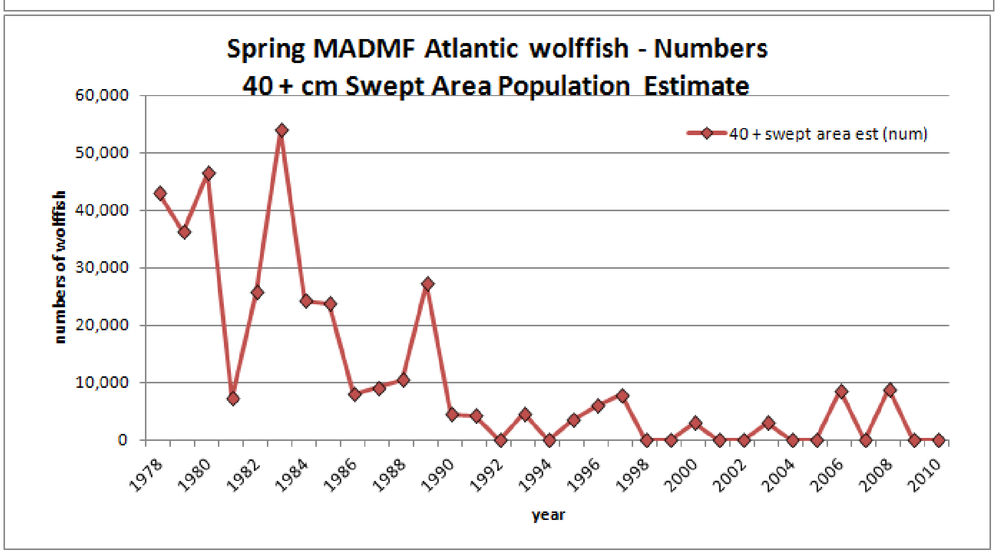


Figure L13. Updated NEFSC spring/fall and MADMF adult (40+ cm) abundance indices for Atlantic wolffish.

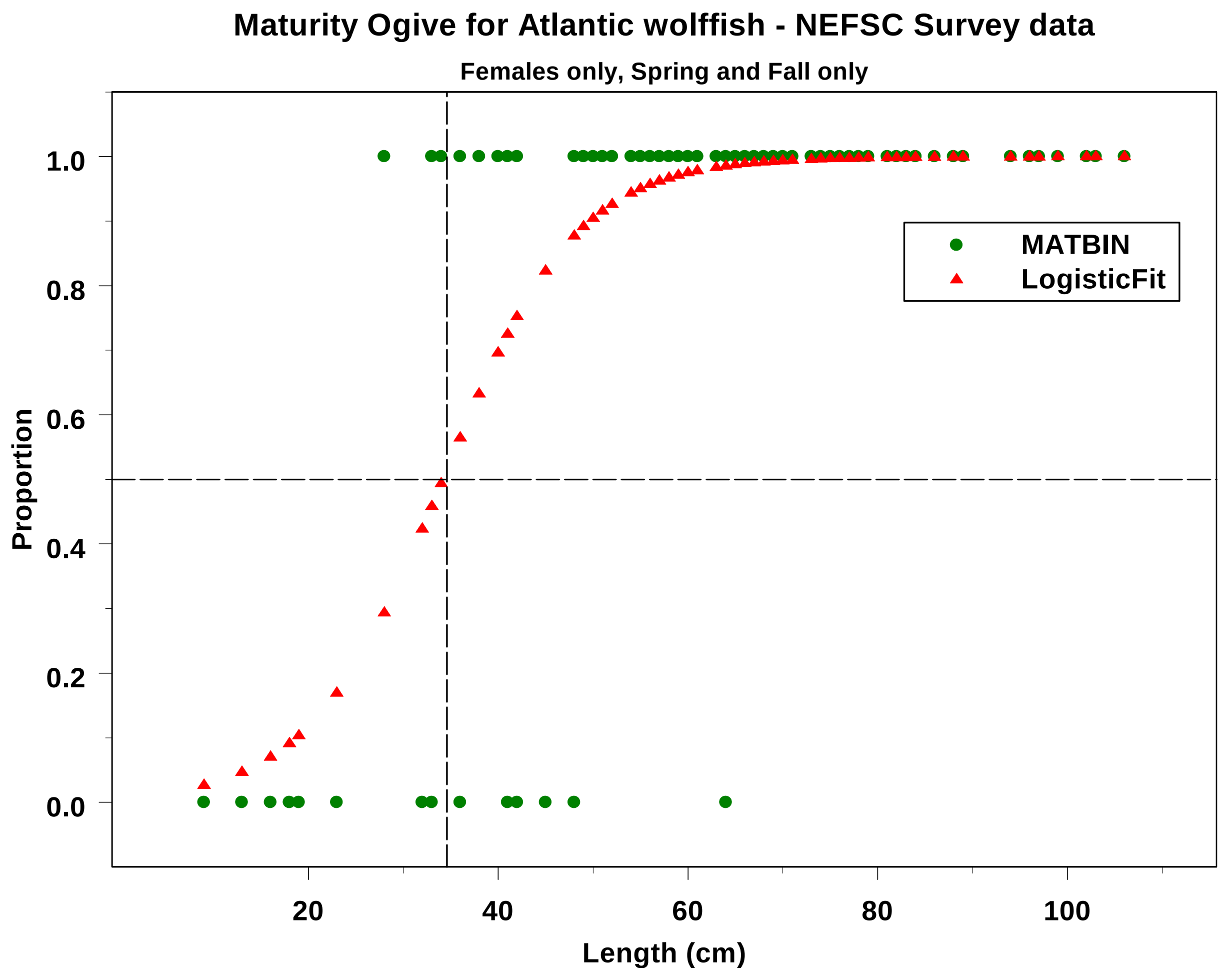


Figure L14. Maturity ogive for female Atlantic wolffish from NEFSC spring and fall data, all years.

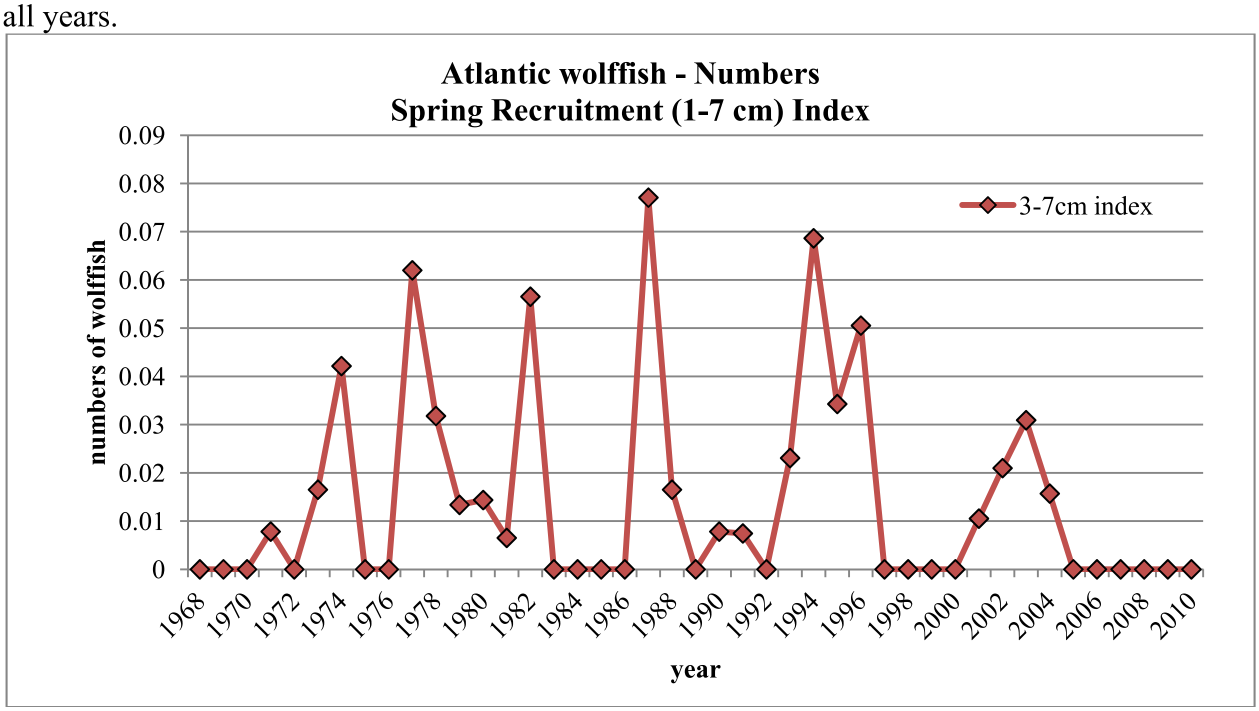


Figure L15. NEFSC spring survey recruitment index for Atlantic wolffish, 1-7 cm = Age 1.

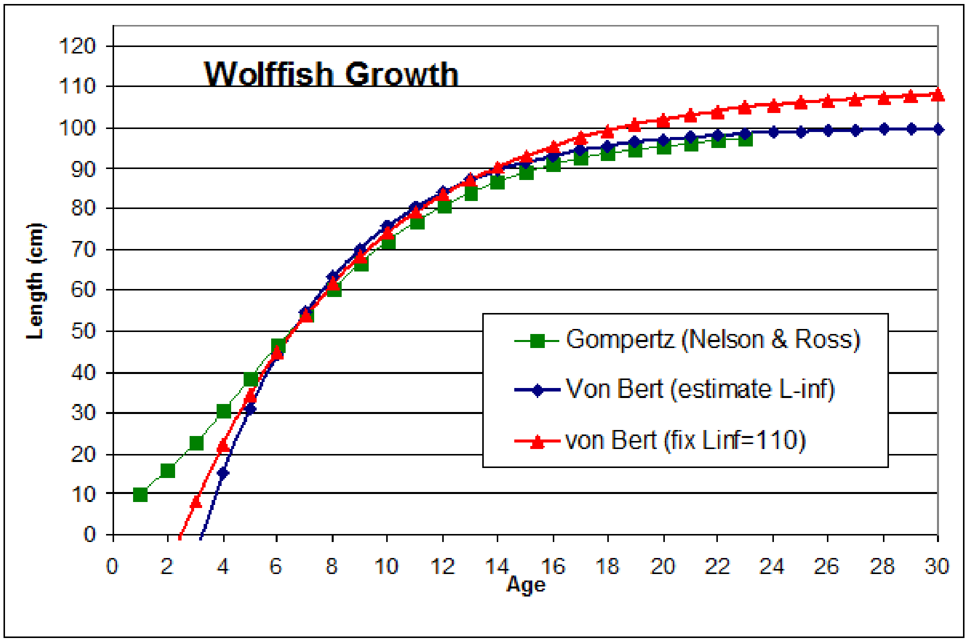


Figure L16. Wolffish estimated growth from Nelson and Ross (1992), von Bertalanffy model limited to 5+ fish, and von Bertalanffy model limited to 5+ fish with fixed L-infinity at 110 cm.

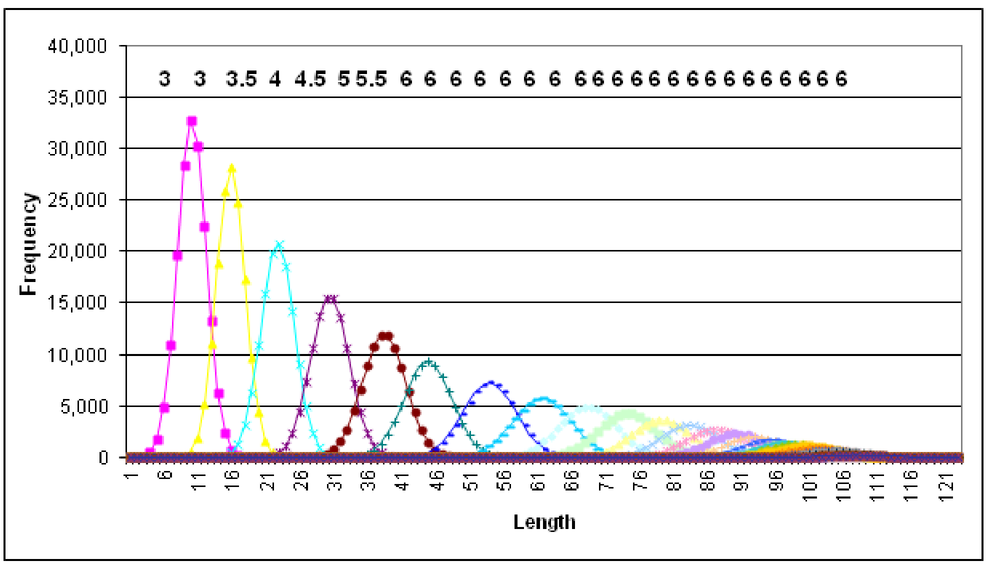


Figure L17. Mean lengths at age distributions assumed for wolffish growth. The input standard deviation is given in the top row of numbers. Ages greater than 7 had a standard deviation of 6.

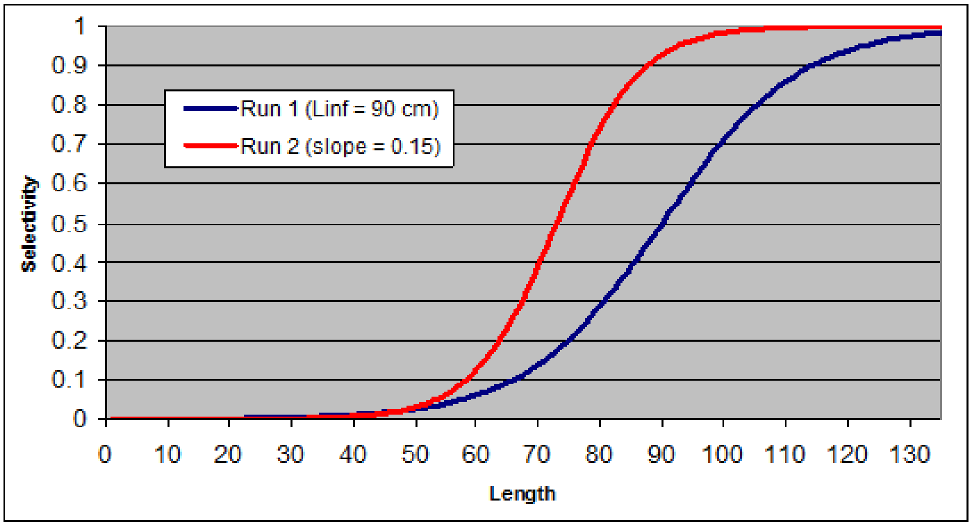


Figure L18. SCALE run 1 selectivity was allowed to hit the L-infinity bound of 90 cm which estimates a relatively flat selectivity curve. SCALE run 2 hits the slope bound of 0.15 which estimated a lower L-infinity.

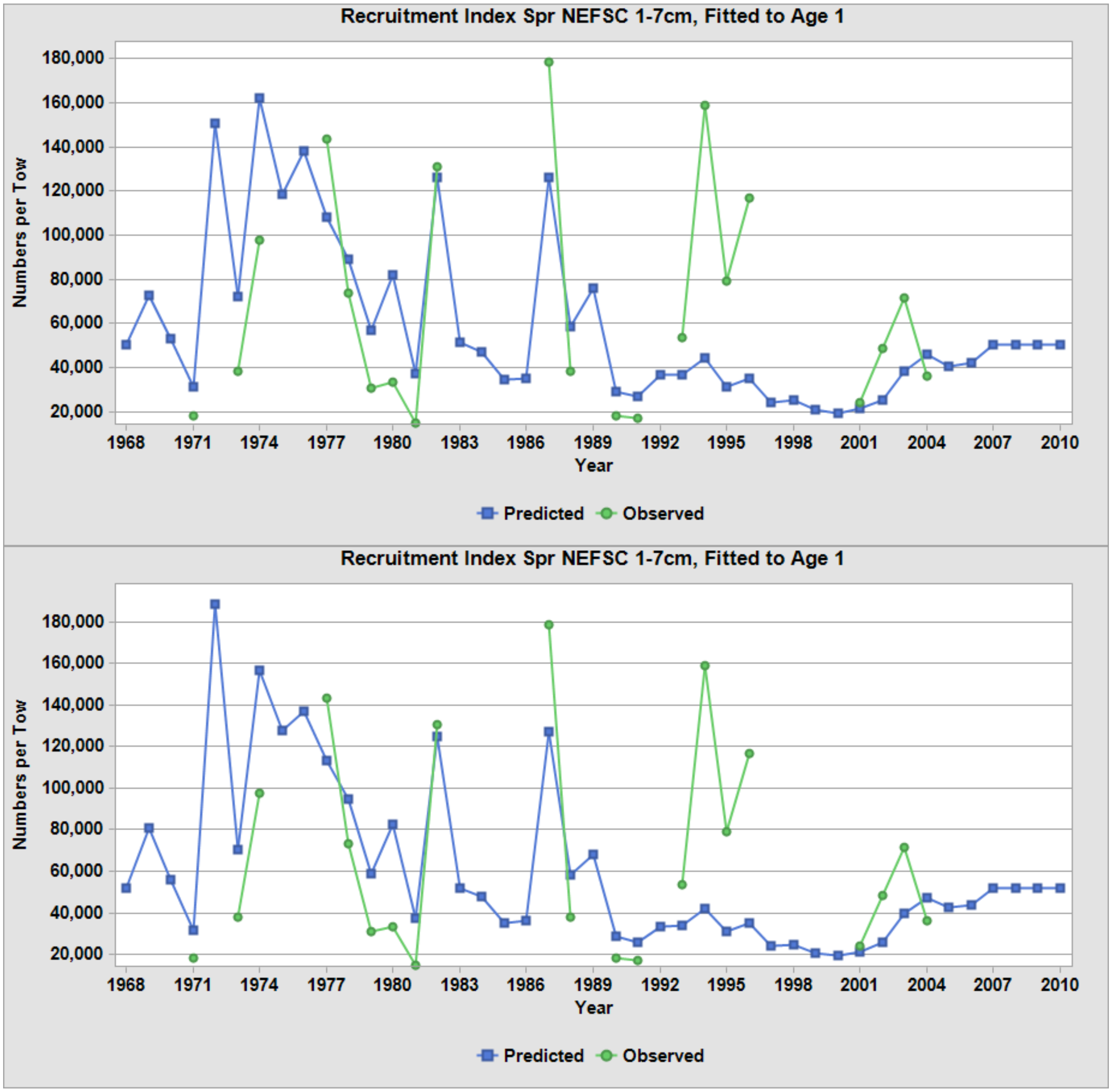


Figure L19. SCALE run 1 (L-infinity = 90 cm) top and SCALE run 2 (Slope = 0.15) fit to the NEFSC spring age-1 recruitment index.

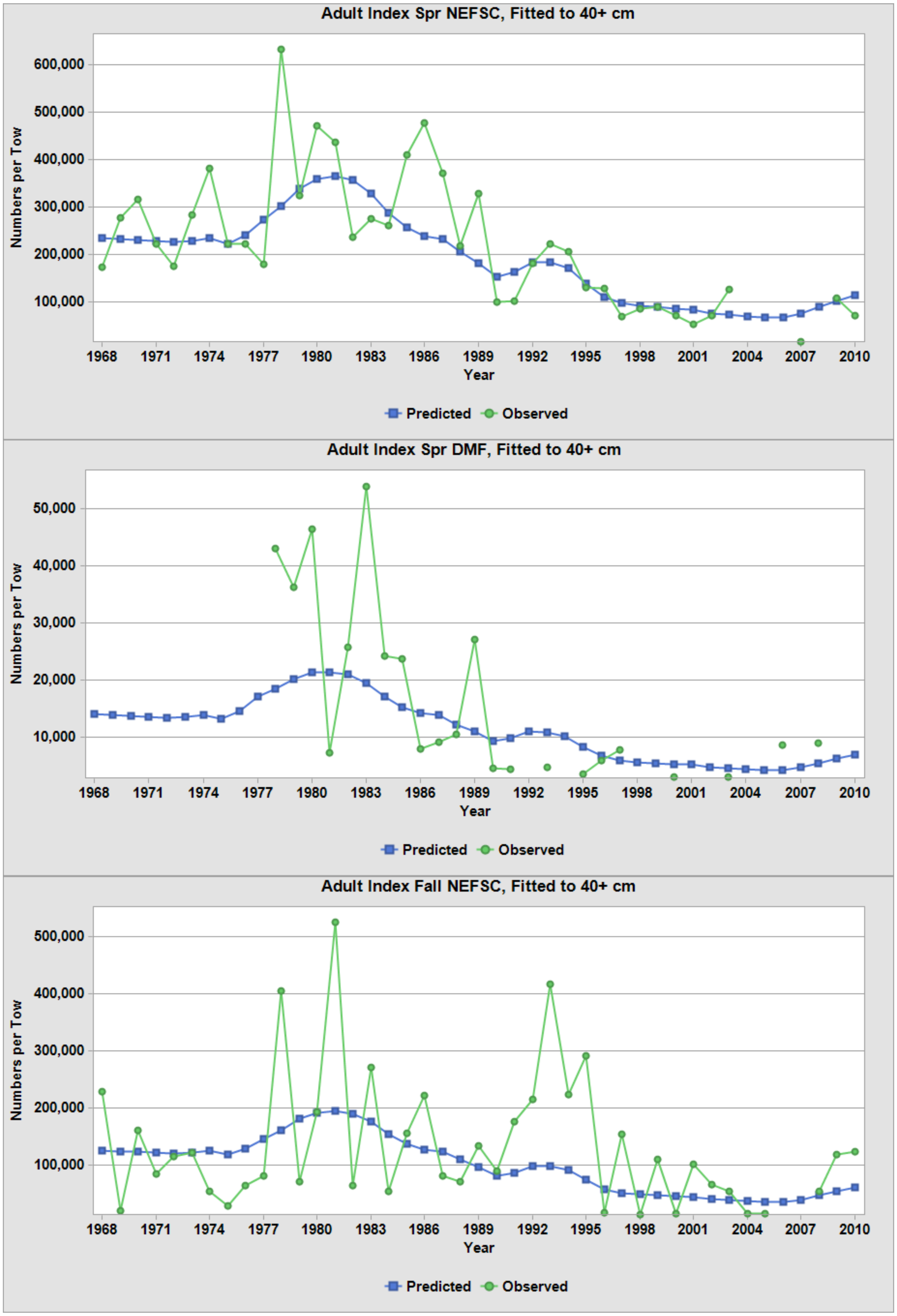


Figure L20. SCALE model fit to the NEFSC spring 40+ cm, MDMF 40+ cm, and NEFSC fall 40+ cm indices.

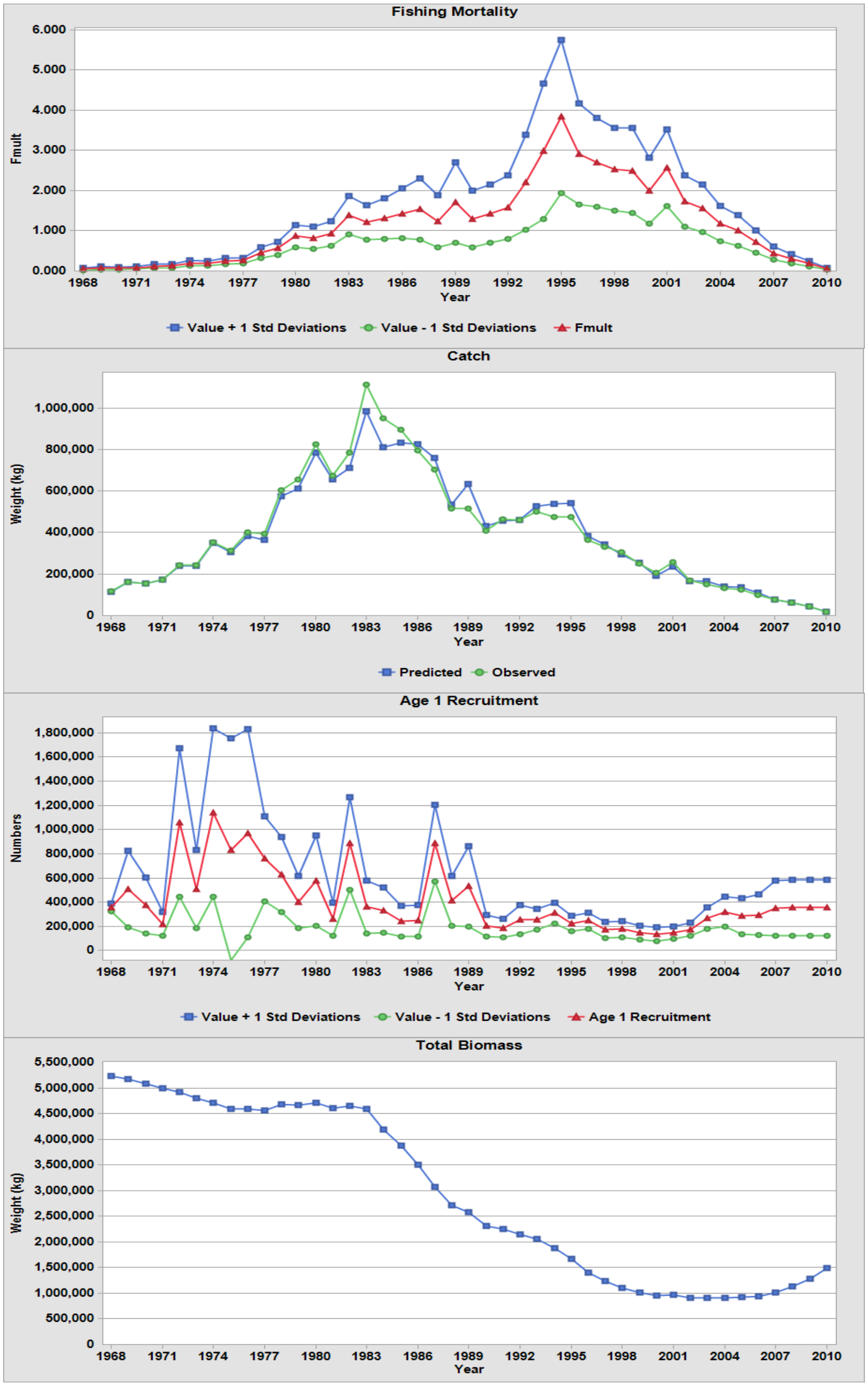


Figure L21. Run 1 (L-infinity = 90 cm) F, fit to the catch, recruitment and total biomass. Plus 1 and minus 1 standard deviations are shown on F and recruitment.

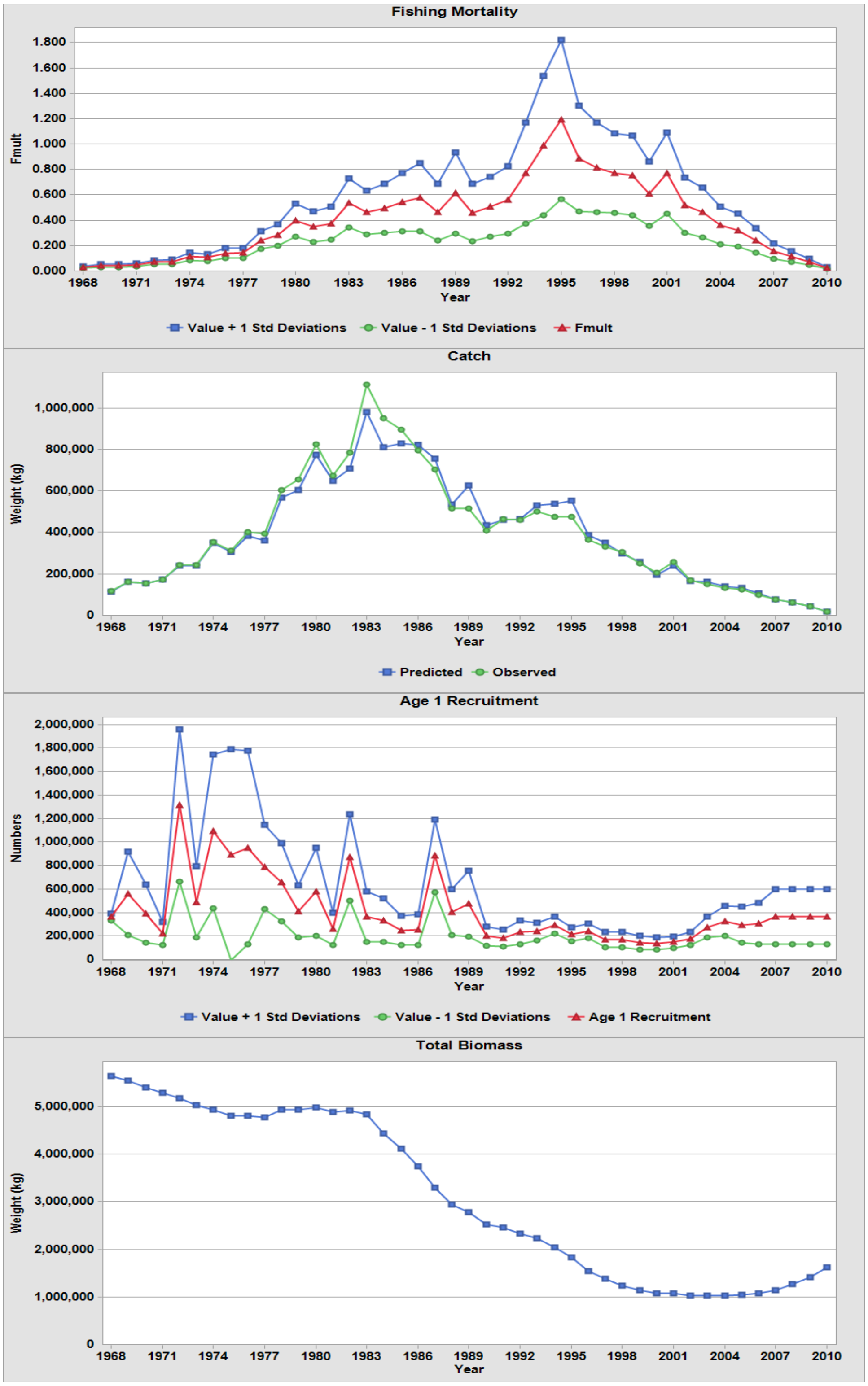


Figure L22. Run 2 (Slope = 0.15) F, fit to the catch, recruitment and total biomass. Plus 1 and minus 1 standard deviations are shown on F and recruitment.

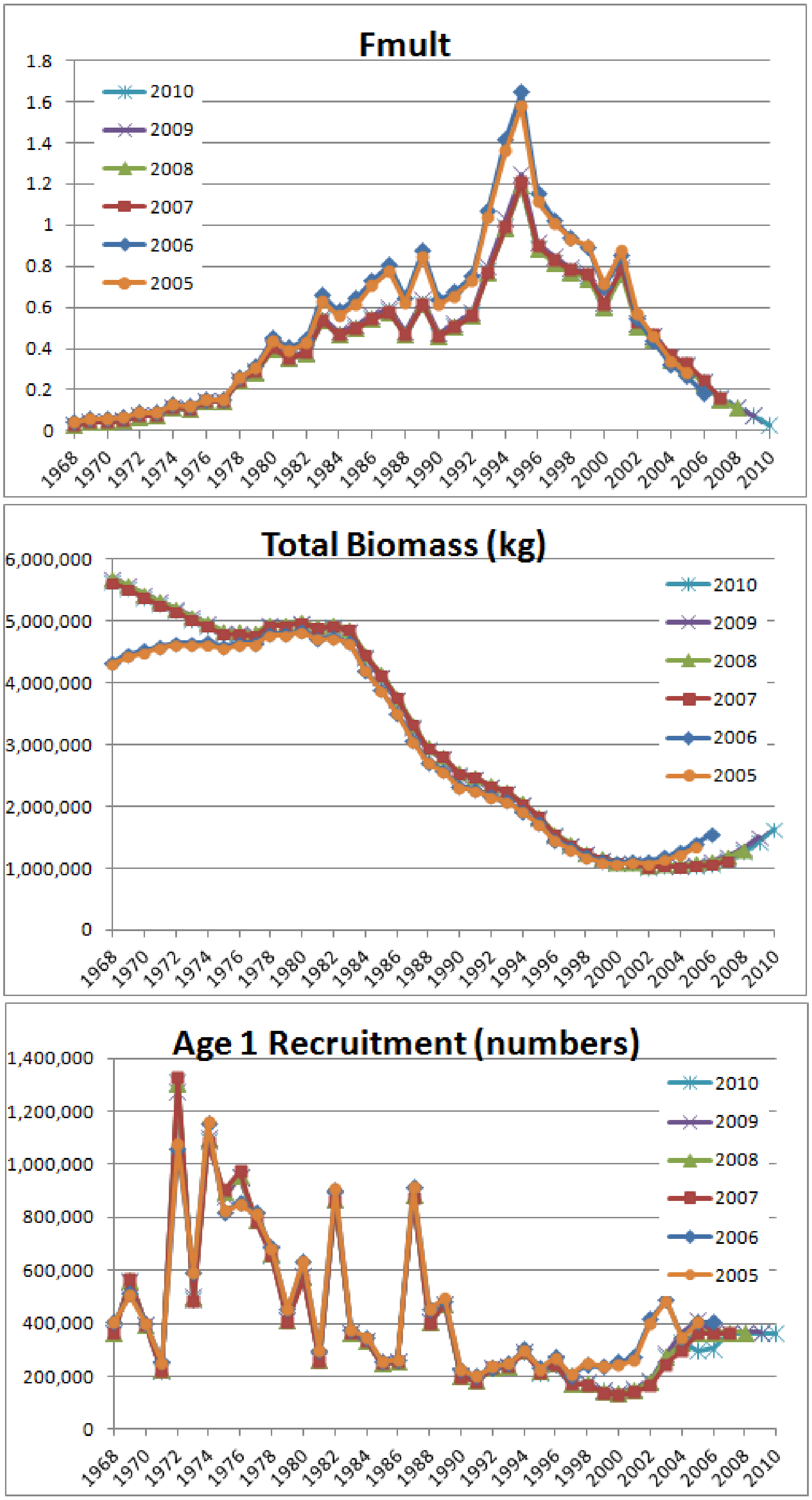


Figure L23. Run 2 (slope = 0.15) retrospective on F, total biomass and age-1 recruitment.

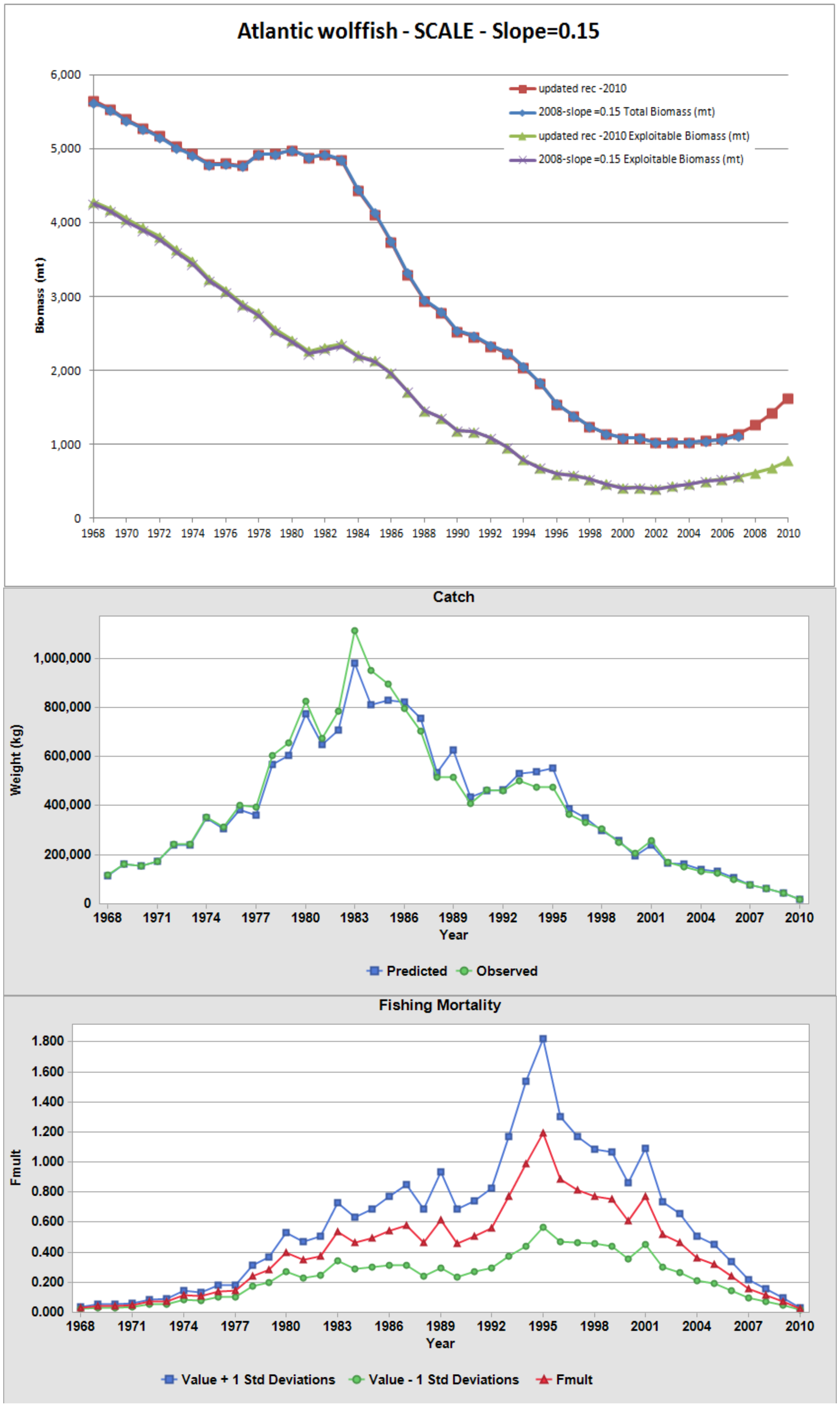


Figure L24. SCALE model run 2 (Slope = 0.15) results for total and exploitable biomass, catch, and fishing mortality.

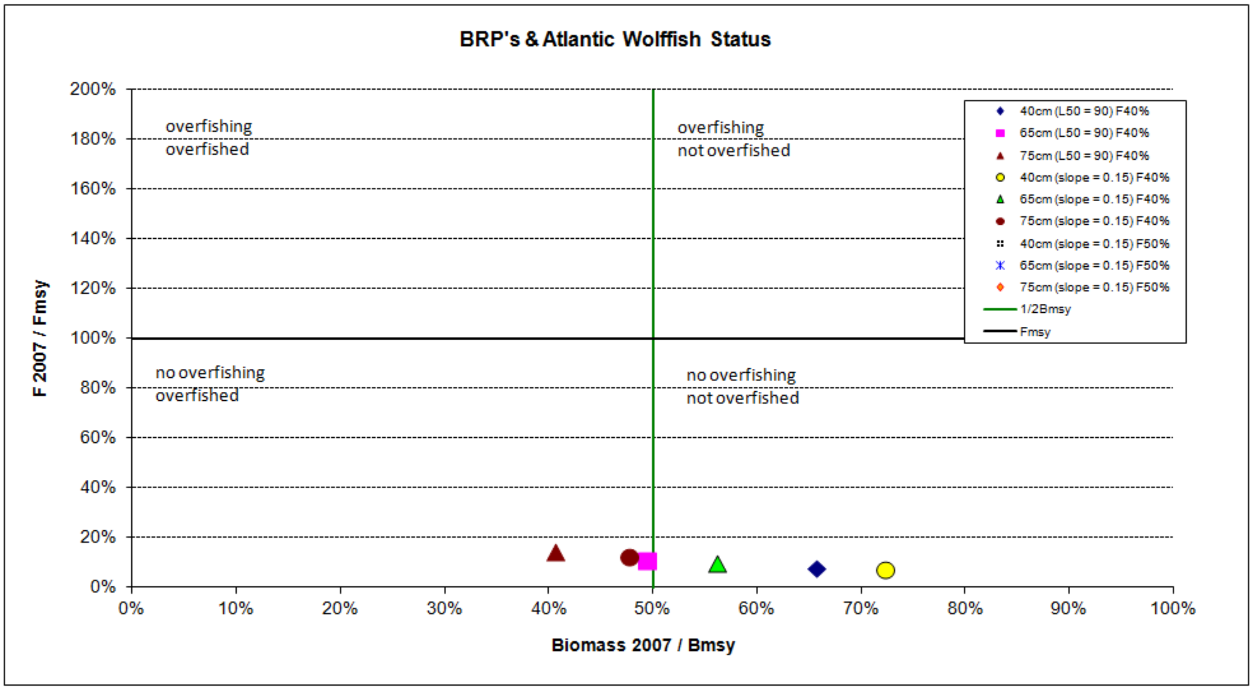


Figure L25. Atlantic wolffish biological reference points and status in 2010.

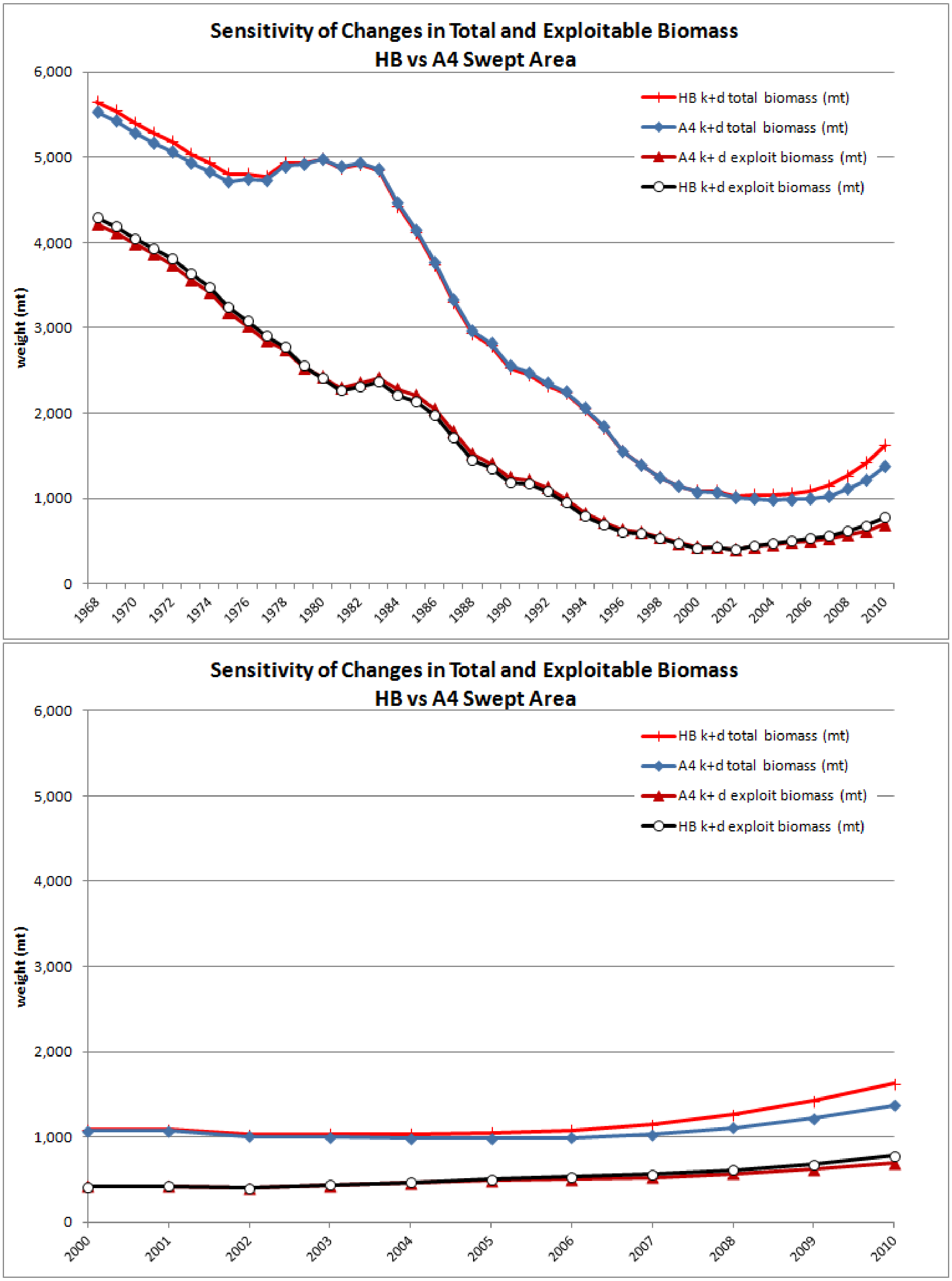


Figure L26. A comparison of changes in total biomass estimated by the SCALE model due to changes in the swept area abundance input for the Bigelow and the Albatross IV.

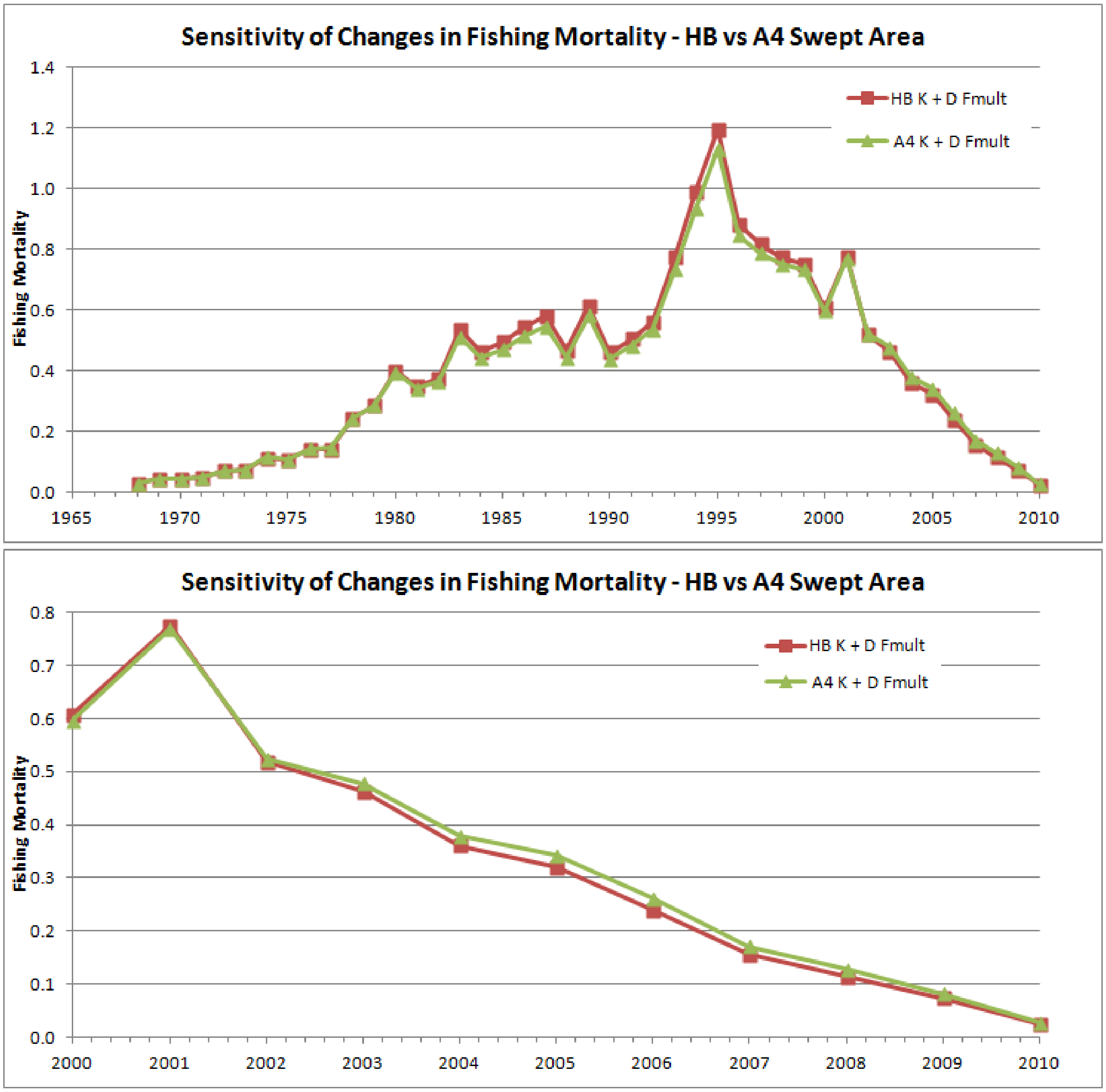


Figure L27. A comparison of changes in fishing mortality estimated by the SCALE model due to changes in the swept area abundance input for the Bigelow and the Albatross IV.

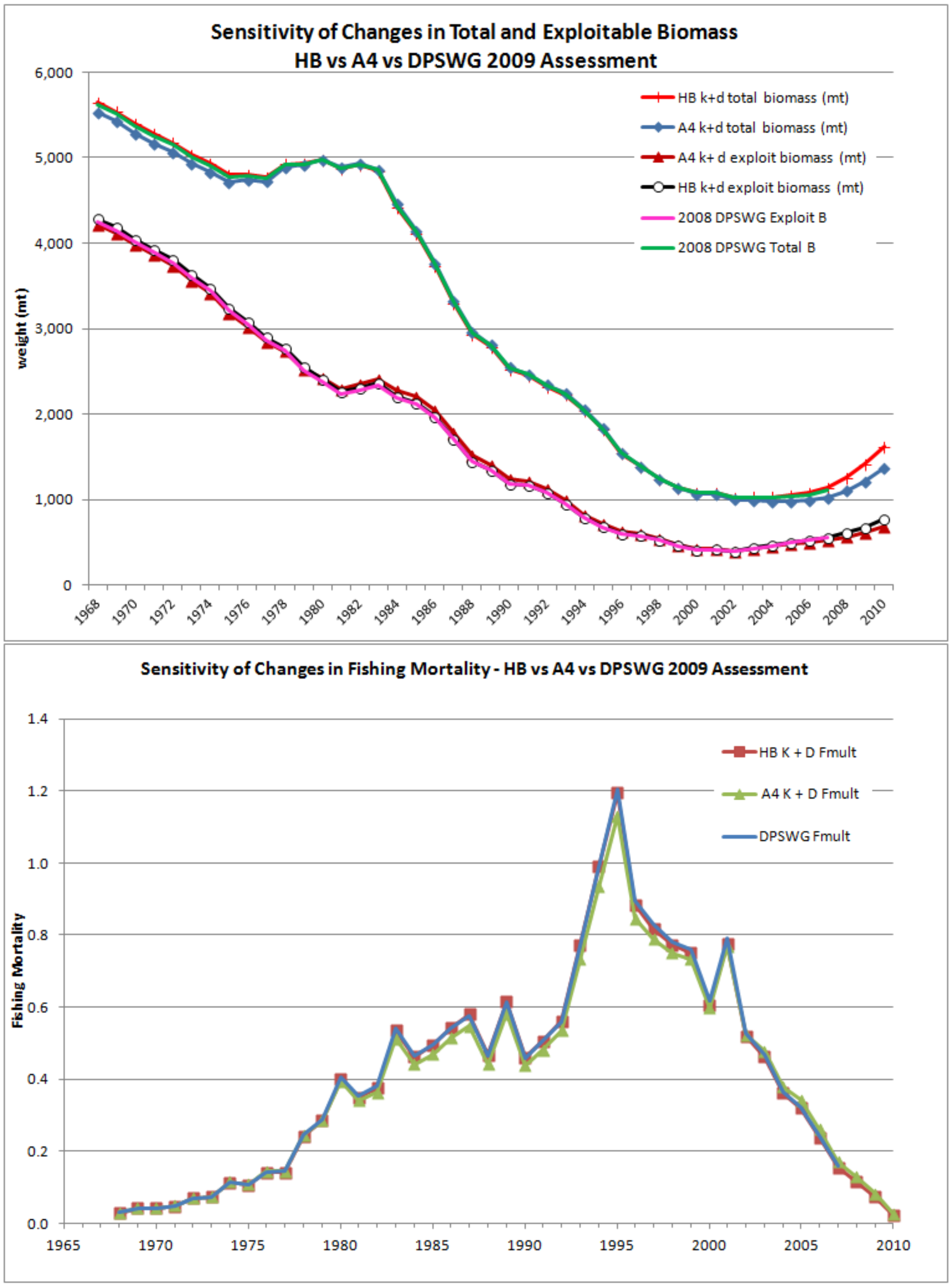


Figure L28. A comparison between the 2009 NDPSWG model results and the of changes in total and exploitable biomass and fishing mortality estimated by the SCALE model due to changes in the swept area abundance input for the Bigelow and the Albatross IV.

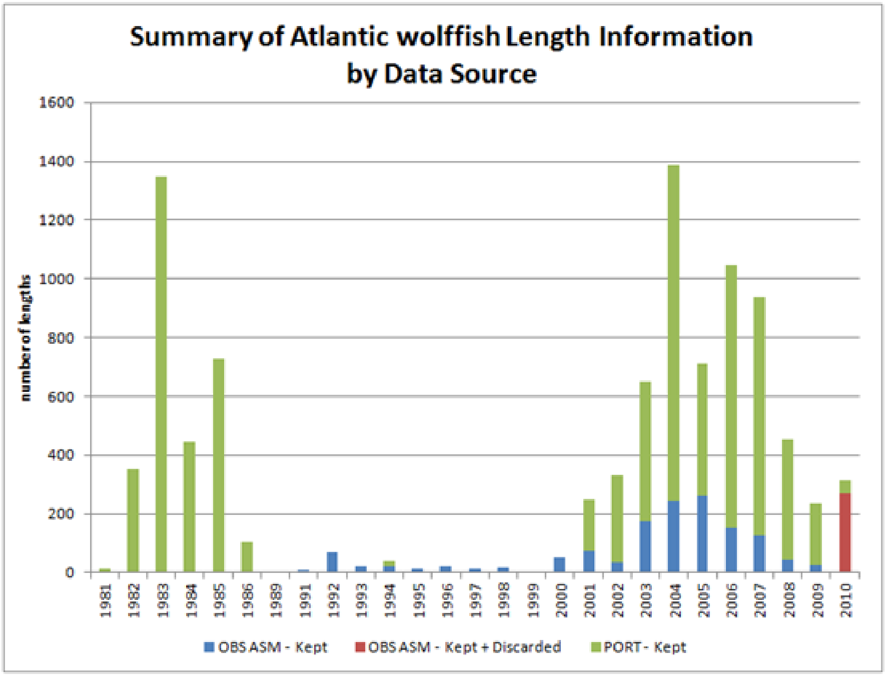


Figure L29. Commercial length frequency data used in the SCALE model by data source. Only the 2010 year includes length information from discarded wolffish.

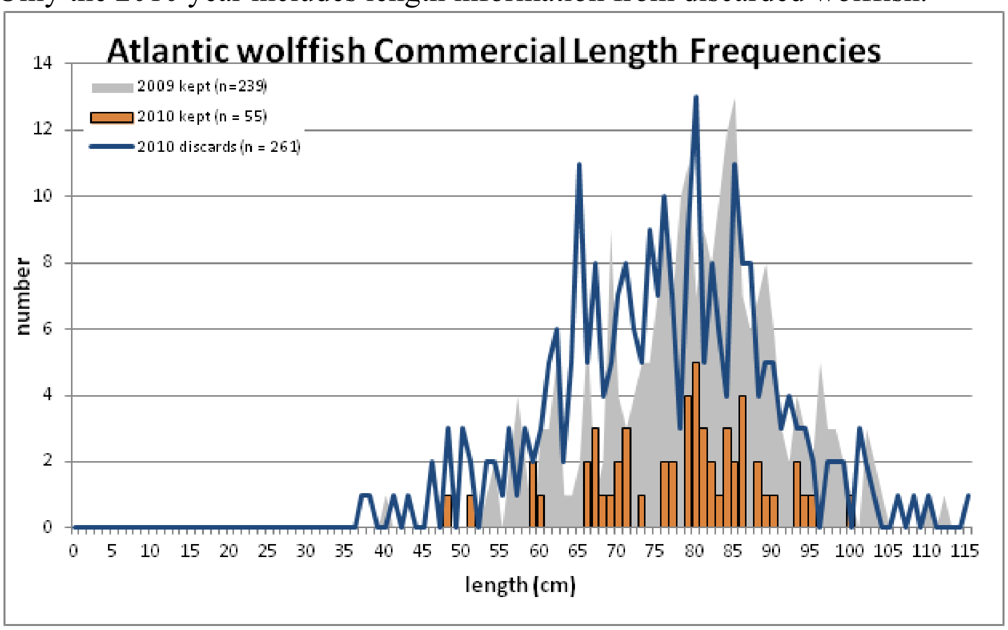
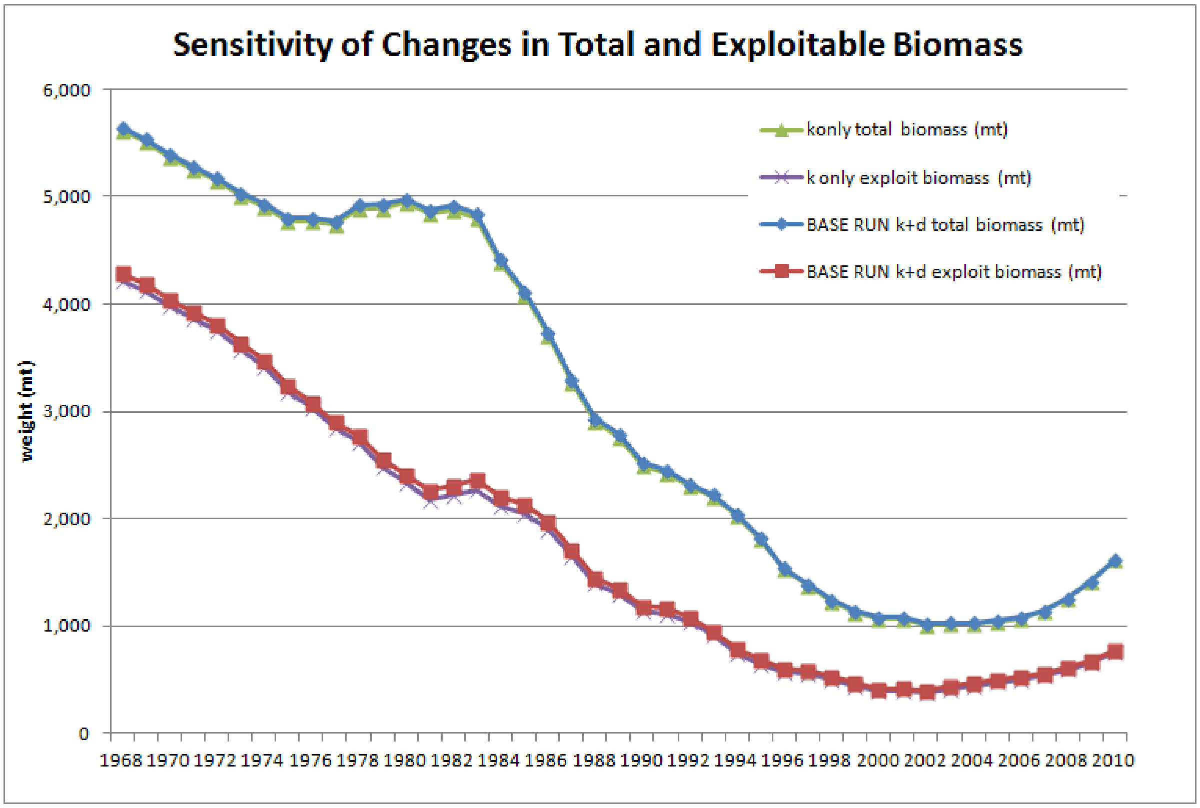


Figure L30. Length frequency comparisons of 2009 kept, 2010 kept and 2010 discarded commercial Atlantic wolffish.



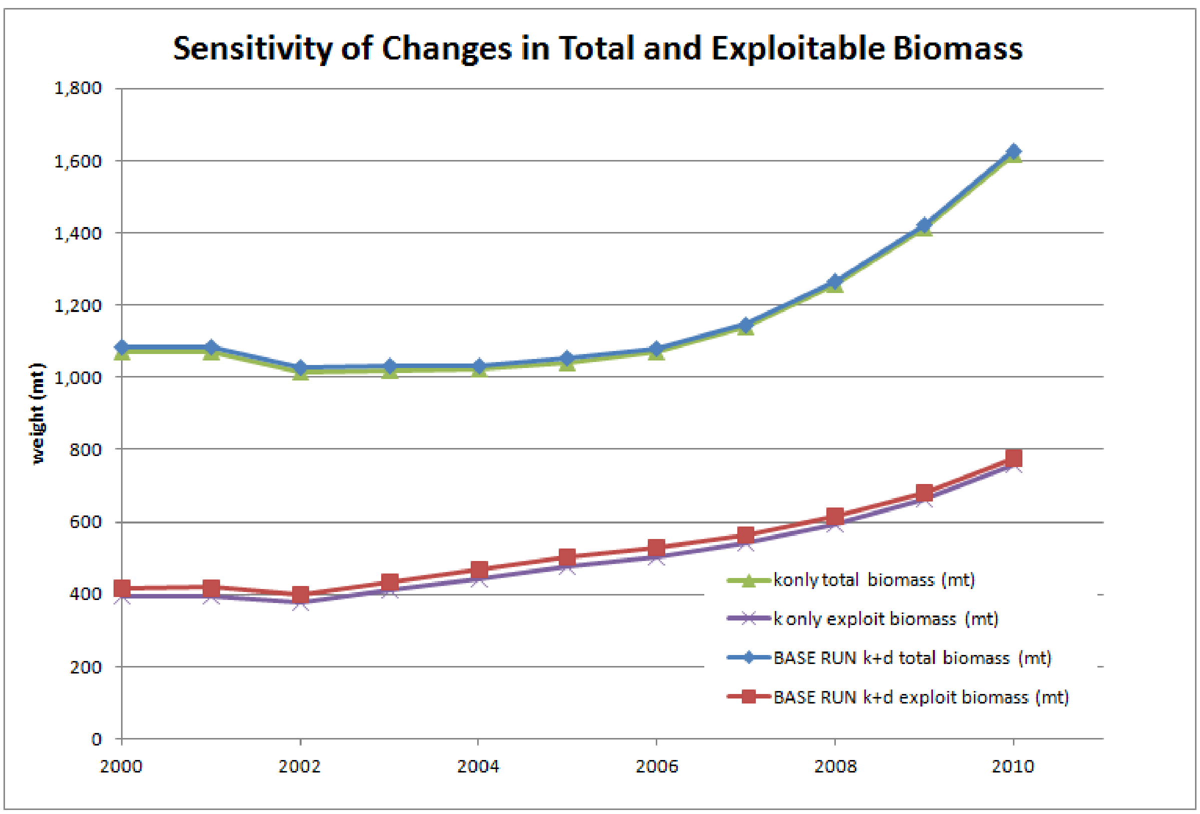
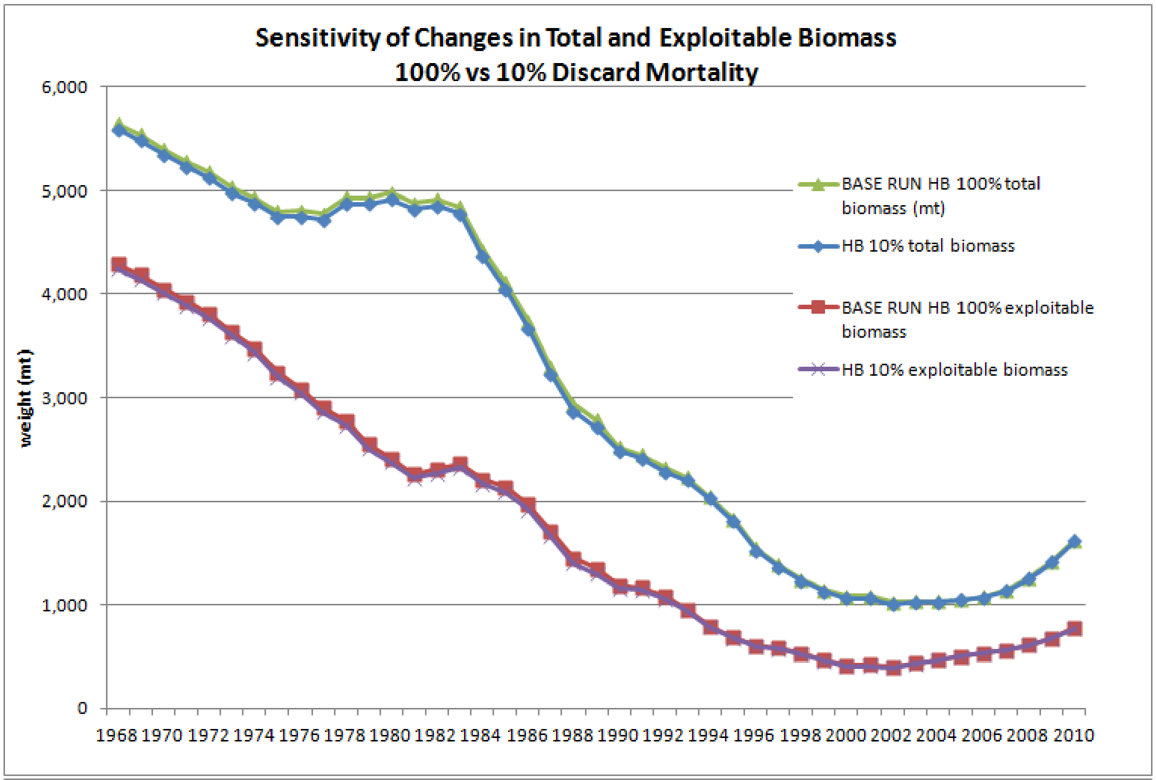


Figure L31. A comparison of changes in the total and exploitable biomass estimated by the SCALE model due to changes in the 2010 length frequency distribution.



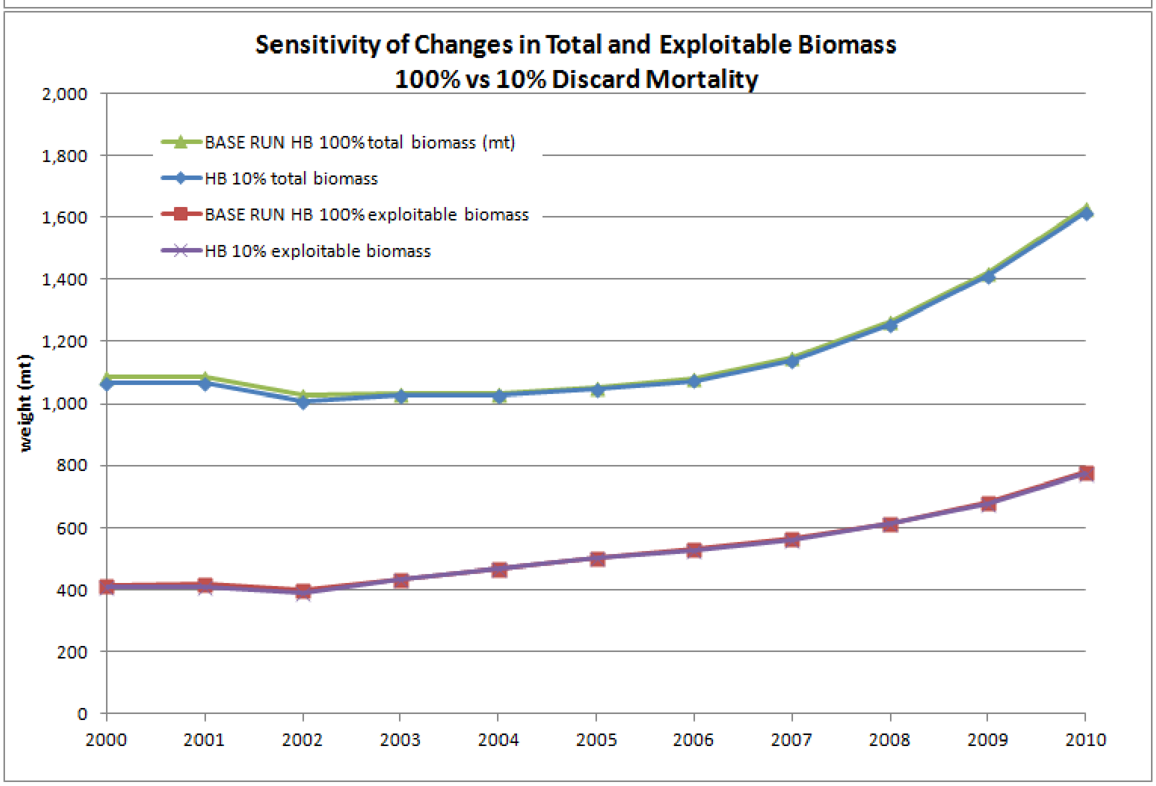


Figure L32. A comparison of changes in the total and exploitable biomass estimated by the SCALE model due to changes to assumed discard mortality rates (BASE run 100% vs discard mortality 10%). Bottom graph scaled to the end of the time series.

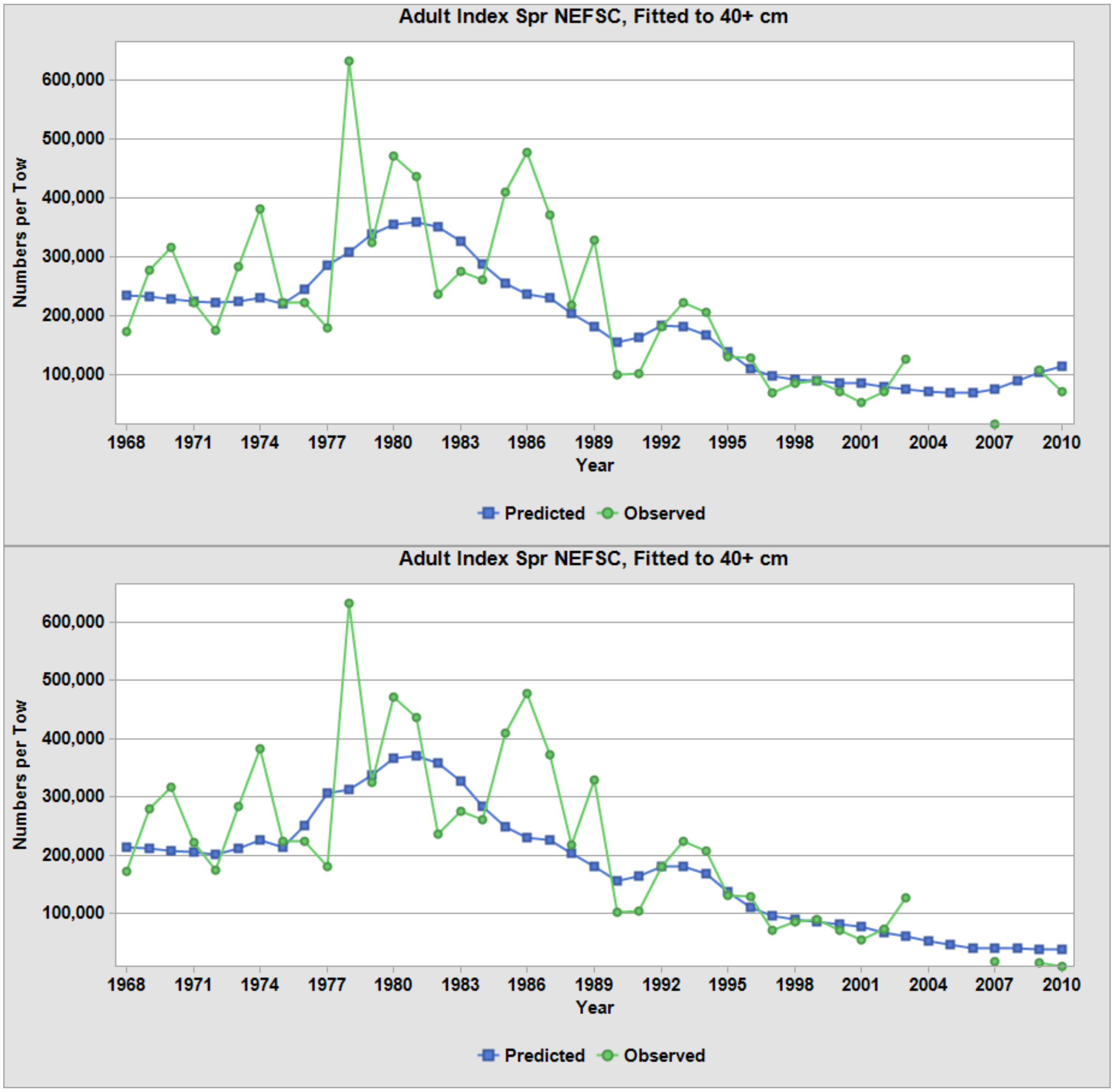


Figure L33. A comparison of spring survey indices (swept area units) from the NEFSC. The top panel is the Atlantic wolffish base run and the bottom is the ocean pout proxy run using the 4.575 Bigelow to Albatross calibration coefficient.

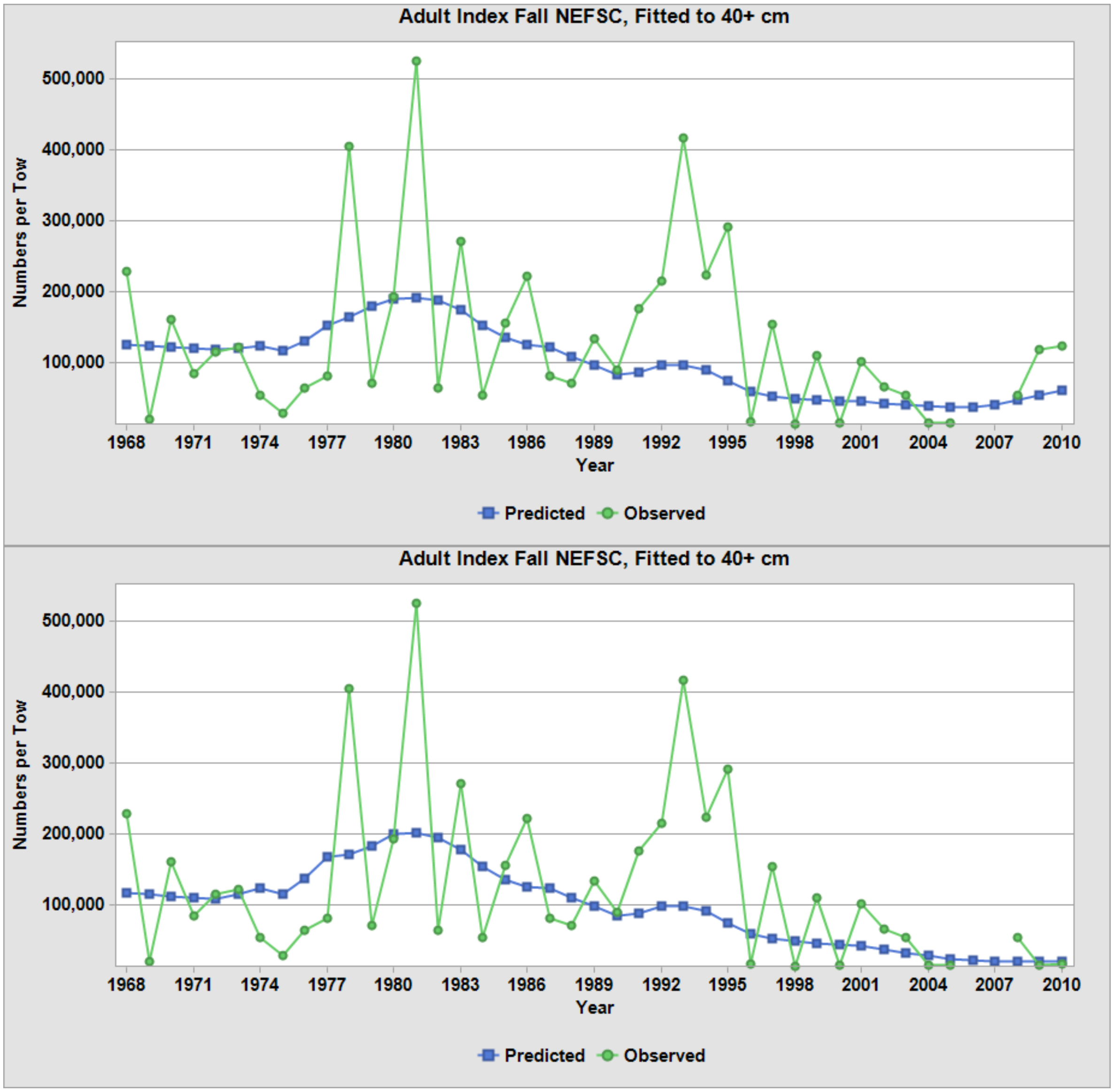


Figure L34. A comparison of fall survey indices (swept area units) from the NEFSC. The top panel is the Atlantic wolffish base run and the bottom is the ocean pout proxy run using the 4.575 Bigelow to Albatross calibration coefficient.

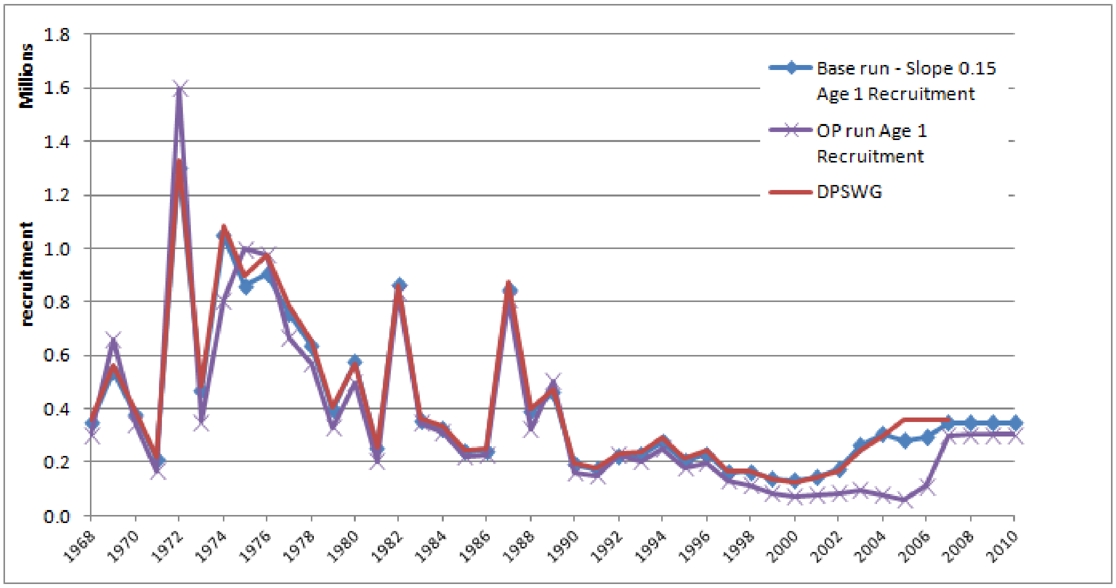


Figure L35. Estimated age 1 recruitment of Atlantic wolffish from the SCALE model showing the base run, 2008 DPSWG preferred run and the ocean pout proxy run.

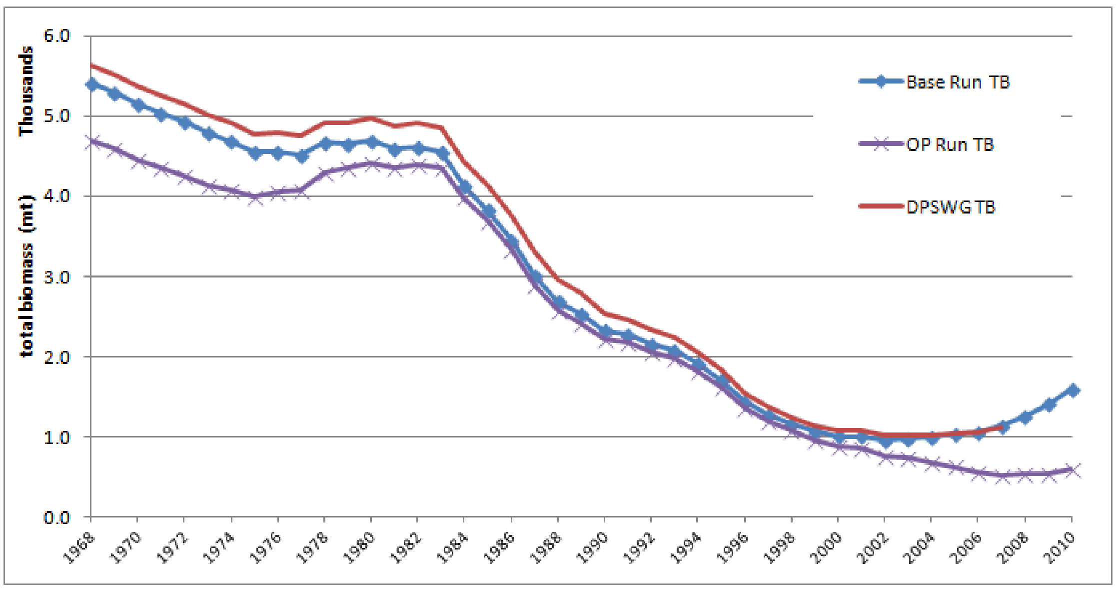


Figure L36. Estimated total biomass of Atlantic wolffish from the SCALE model showing the base run, 2008 DPSWG preferred run and the ocean pout proxy run.

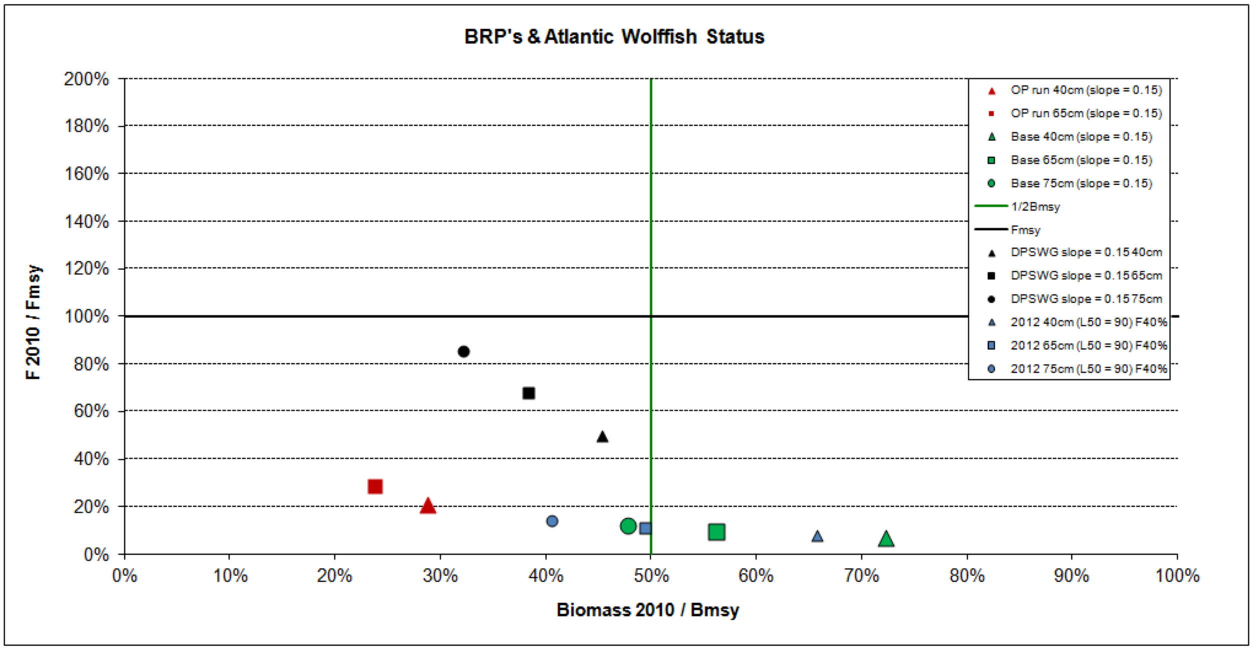


Figure L37. A comparison of biological reference points developed for the ocean pout proxy run, base runs and 2008 DPSWG preferred run (slope 0.15).

Atlantic Wolffish Appendix 1

Appendix Table L1. Number of wolffish collected by year (2009, 2010), season (spring, autumn), and sex (female, male, or unknown) from NEFSC groundfish surveys (FSV Bigelow). Sex was determined from gonad histology. A section of gonad tissue was excised from the middle of one lobe of the gonad, fixed in 10% buffered formalin, preserved and dehydrated later in an increasing series of ethyl alcohol, embedded in paraffin, sectioned to 5 microns, and stained with Schiff's Mallory Trichrome. Three fish were not identified by sex because the tissue sampled was not from the gonad.

Appendix Figure L1. Size frequency of wolffish with respect to maturity, based on the examination of gonad histology from 33 females. Histology slides were examined by one reader (R. McBride, NEFSC) three times at 40-100 x. Fish were scored mature if the tissue contained vitellogenic oocytes or there was evidence of previous spawning. Fish size is total length (TL) in centimeters.

Atlantic Wolffish Appendix 1.

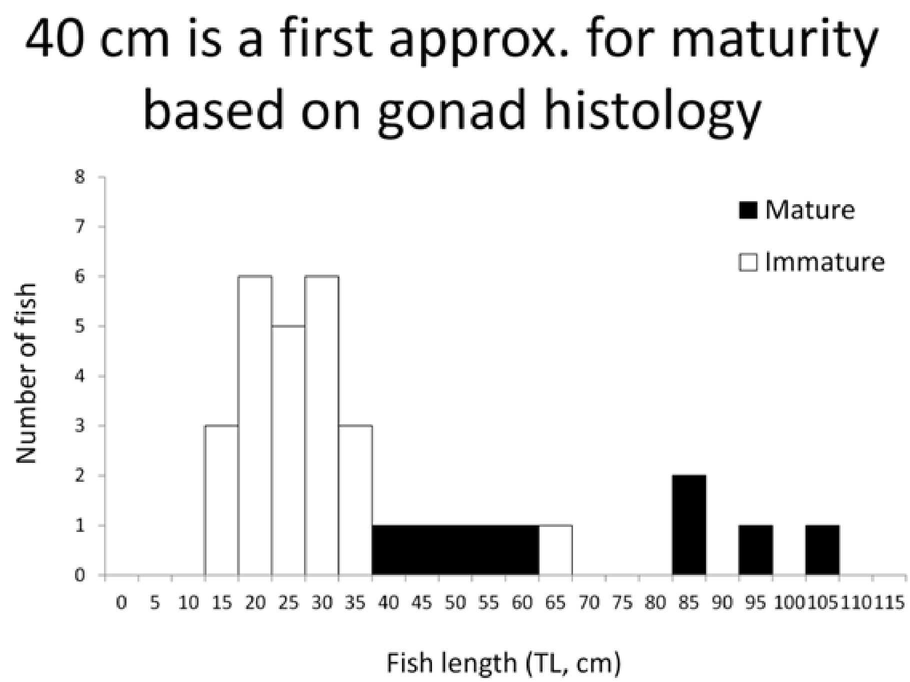
Sample size (NEFSC groundfish survey)

Year	Season	Females	Males	Unknown
2009	Spring	12	8	
2009	Autumn	5	3	
2010	Spring	12	9	3
2010	Autumn	4	4	
	Total	**33**	**24**	**3**

Small sample size (33 females)

but very detailed (gonad histology)

Appendix Table L1. Number of wolffish collected by year (2009, 2010), season (spring, autumn), and sex (female, male, or unknown) from NEFSC groundfish surveys (FSV Bigelow). Sex was determined from gonad histology. A section of gonad tissue was excised from the middle of one lobe of the gonad, fixed in 10% buffered formalin, preserved and dehydrated later in an increasing series of ethyl alcohol, embedded in paraffin, sectioned to 5 microns, and stained with Schiff's Mallory Trichrome. Three fish were not identified by sex because the tissue sampled was not from the gonad.



Appendix Figure L1. Size frequency of wolffish with respect to maturity, based on the examination of gonad histology from 33 females. Histology slides were examined by one reader (R. McBride, NEFSC) three times at 40-100 x. Fish were scored mature if the tissue contained vitellogenic oocytes or there was evidence of previous spawning. Fish size is total length (TL) in centimeters.

M. Atlantic halibut by Jessica Blaylock and Christopher M. Legault

1.0 Background

Atlantic halibut (*Hippoglossus hippoglossus*) is the largest species of flatfish in the northwest Atlantic Ocean. It is a long-lived, late-maturing species distributed from Labrador to southern New England (Bigelow and Schroeder 1953). Within the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z, Figure M1) halibut have been exploited since the early 1800s, with major abundance declines noted as early as the 1870s (Goode 1884, Grasso 2008).

Atlantic halibut was assessed in 2002 and 2005 using index-based methods (Brodziak 2002, Brodziak and Col 2005). Northeast Fisheries Science Center (NEFSC) autumn weight per tow survey indices were expanded to swept-area biomass estimates (assuming a catchability coefficient of one), and the 5-year average biomass index was compared to B_{MSY} proxy reference points for status determination (Col and Legault 2009). Based on the 2005 Groundfish Assessment Review Meeting (GARM) assessment of Gulf of Maine-Georges Bank Atlantic halibut, the stock was overfished (B_{2004} was 5% of B_{MSY} proxy) and it was unknown whether overfishing was occurring (Brodziak and Col 2005). During the 2008 GARM, halibut was assessed using a simple production model called Replacement Yield Model (Col and Legault 2009) enabling overfishing status to be determined for the first time. The fishing mortality reference point proxy (F_{MSY} proxy = 0.073) from the re-estimated yield per recruit analysis was used to inform the intrinsic rate of growth for the Replacement Yield Model, and the model was tuned to the NEFSC autumn survey swept-area biomass index. The resulting fishing mortality (0.065) was slightly below the F_{MSY} proxy, indicating that overfishing was not occurring for Atlantic halibut. On the other hand, the resulting biomass (B_{2007} = 1,300 mt) from the Replacement Yield Model was well below both the B_{MSY} proxy (49,000 mt) and ½ B_{MSY} proxy (24,000 mt), indicating that Atlantic halibut continued to be in an overfished condition (Col and Legault 2009).

The present assessment is an update of the 2008 GARM assessment with updated 2007 catch and survey data and new data for 2008-2010. The 2008 GARM yield per recruit analysis was not re-evaluated and therefore the fishing mortality reference point proxy has not changed (F_{MSY} proxy = 0.073). Results from the Replacement Yield Model indicate that the 2010 fishing mortality (0.032) was below the F_{MSY} proxy, therefore overfishing was not occurring for Atlantic halibut. However, the 2010 biomass (B_{2010} = 1,700 mt) was still well below the B_{MSY} proxy (49,000 mt) and ½ B_{MSY} proxy (24,000 mt), indicating that this stock remains in an overfished condition.

2.0 Fishery

Commercial landings

Consistent records of Atlantic halibut landings from the Gulf of Maine-Georges Bank region (Statistical Areas 511-515, 521-522, 525-526, 561-562) began in 1893 (ICNAF 1952, Table M1, Figure M2). Current US landings were extracted from the NEFSC commercial fisheries database (CFDBS) AA tables, and current Canadian landings (Division 5Zc) were extracted from the

NAFO 21A database[6]. Historical distant water fleet landings are also included from 1962-1974 (Table M1, Figure M3). Landings have continued to decrease since the 1890s as components of the resource have been sequentially depleted. Annual landings averaged 663 mt between 1893 and 1940, declined to an average of 144 mt during 1941-1976, and declined further to an average of 75 mt during 1977-2010 (Table M1, Figure M2). Total reported commercial landings of halibut increased somewhat from record lows of 17-20 mt during 1998-2000 to 60 mt in 2009. Of the 2009 landings, 45 mt (75%) were landed by US fishermen and 15 mt (25%) were landed by Canadian fishermen (Table M1, Figure M 3). Most recent US landings of Atlantic halibut come from the trawl gear fisheries followed by the hook and line fisheries although it should be noted that primary gear types for halibut landings have changed over time (Table M2, Figure M4).

Commercial discards

Discards from the Northeast Fisheries Observer Program database were estimated for the period 1989 to 2010 based on the Standardized Bycatch Reporting Methodology combined ratio estimation (Wigley et al. 2007). Because discard estimates by gear have high variability, these were combined to obtain an estimate of total discards (Table M3). The 1999 implementation of a one halibut per trip limit as well as minimum retention sizes of 91 cm in 1999 and 104 cm in 2009 increased the discard-to-kept ratio from 17% during 1989-1998 to 105% during 1999-2010 (Table M3(b), Figure M5). Due to the low occurrence of Atlantic halibut in the observer database, the 1989-1998 average discard ratio was applied to the landings from 1893 to 1998 and the 1999-2010 average discard ratio was applied to landings in those years to obtain the average discard estimates used in this assessment update (Table M4, Figures M5 and M6). Including US discards, total catch increased from 18 mt in 1998 to 107 mt in 2009 (Table M4, Figure M6). Canadian discard estimates were not available.

3.0 Research Surveys

The NEFSC spring and autumn bottom trawl surveys provide measures of relative abundance of Atlantic halibut within the Gulf of Maine-Georges Bank region (offshore survey strata 13-30 and 36-40, Tables 5 and 6, Figure M7). In 2009 the NEFSC survey changed research vessels from the R/V *Albatross IV* to the R/V *Henry B. Bigelow*. Due to the low sample size for halibut in the calibration experiments between both vessels where very few fish were caught by the *Albatross IV* (Miller et al. 2010), it was not possible to derive species-specific conversion coefficients for Atlantic halibut. Instead, the coefficients for mean numbers and weight at age for other flounders (Miller et al. 2010) were averaged to obtain coefficients for the NEFSC spring and autumn survey for halibut (Table M7).

Both indices have high interannual variability since the surveys capture low numbers of halibut, and in some years there have been no halibut caught (Figure M8) indicating that halibut abundance is close to being below the detectability levels of the surveys, although this might improve with the use of the *Henry B. Bigelow*. The autumn survey biomass and abundance indices show little contrast or trend over the time series (Figure M9), whereas the spring survey biomass and abundance indices (Figure M9) suggest a relative increase during the late 1970s to

[6] http://www.nafo.int/science/frames/research.html

early 1980s, a decline during the 1990s, and an increase since the late 1990s. The differences in trends between the two surveys likely reflects the high variability due to low encounter rates of halibut in the NEFSC surveys, although it is possible that environmental forcing in the spring survey is occurring (Col and Legault 2009).

4.0 Assessment

Input data and model formulation

Yield per Recruit (YPR)

The current assessment update did not re-evaluate the Yield per Recruit (YPR) analysis conducted during the GARM 2008 assessment (Col and Legault 2009). This YPR was conducted for ages 0 to 40 with a plus group for ages 41-50. The models and assumptions underlying the YPR input data for that analysis (Table M8) are briefly reviewed below.

The von Bertalanffy growth equation used to calculate mean weight at age was derived by Sigourney (2002, Figure M10):

$$L_t = L_\infty\left[1 - e^{(-K(t-t_0))}\right]$$, with $L_\infty = 263.2$, $K = 0.07$, and $t_0 = 0.27$,

and the length-weight equation was based on combined years (1992-2007) of NEFSC spring and autumn length and weight data over all strata (Col and Legault 2009, Figure M11):

$$W = \alpha L^{\beta}$$, with $\alpha = 0.00415$ (using cm and grams) and $\beta = 3.23040$

The following maturity ogive was used for females (Sigourney et al. 2006, Figure M12):

$$S(a) = (1+e^{(-\alpha - \beta a)})^{-1}$$

where a is age, β is a parameter assumed to be equal to $(2\ln 3)/(L_{75}-L_{25})$, estimated to be 0.518, and α is a parameter assumed to be equal to $-\beta L_{50,}$ estimated to be -3.778 (Col and Legault 2009). Natural mortality, M, was assumed to be 0.15 based on Clark and Hare's (2006) estimate for Pacific halibut (Col and Legault 2009). Finally, knife-edge selectivity was set at age 4 (Table M8), although disparity in gear selectivity was recognized and further research in this area is recommended (Col and Legault 2009).

Replacement Yield Model

The present assessment update used the same model as the 2008 GARM assessment for Gulf of Maine-Georges Bank Atlantic halibut (Col and Legault 2009). The F_{MSY} proxy ($F_{0.1}$) from the YPR analysis was used to inform the intrinsic growth rate (defined as $2{*}F_{0.1}$) in a Replacement Yield Model (RYM), and the model was tuned to the NEFSC autumn survey swept-area biomass index (Table M6). Since Atlantic halibut catch predates reliable landings statistics beginning in

1893 (ICNAF 1953, Grasso 2008), a linear increase in catch was assumed from 1800-1892 (Col and Legault 2009, Table M9).

The RYM is similar to that described in Brandao and Butterworth (2008) and was used to provide annual estimates of biomass, replacement yield and fishing mortality (Col and Legault 2009). In this model, estimated biomass is defined as:

$$B_y = B_{y-1} + R_{y-1} - C_{y-1}$$

where B_y is the biomass at the start of year y, B_{y-1} is the biomass at the start of the previous year, R_{y-1} is the replacement yield in the previous year, and C_{y-1} is the total catch in the previous year. Replacement yield is defined as:

$$R_y = rB_y (1- B_y /K)$$

where r is the intrinsic rate of growth, and K is the carrying capacity (assumed to be equal to the model estimated biomass in 1800).

As in the 2008 GARM assessment, the model was fitted to the NEFSC autumn survey swept-area biomass index, and the following negative log-likelihood (-ln*L*) was used to determine the model with the best estimates of carrying capacity and predicted survey catchability coefficient parameters:

$$-\ln L = \log(\delta) + 0.5\sum(\ln(I_y)-\ln(B_y q))^2/\delta^2 + p_1 + p_2$$

where δ is a constant, I_y is the swept-area biomass index in year y, q is the catchability of the NEFSC fall survey defined as the exponent of the average of $\ln(I_y)-\ln(B_y)$, p_1 is the sum of the penalties for biomass going to the defined minimum boundary in a given year, and p_2 is a penalty for the difference between the model-estimated q and the assumption that the NEFSC autumn survey q is 0.5 (Col and Legault 2009).

Assessment results

The 2008 GARM YPR analysis was run using NFT YPR Version 2.7.2[7] and resulted in an $F_{0.1}$ of 0.073 (Col and Legault 2009, Figure M13). The intrinsic growth rate for the Replacement Yield Model was assumed to be $2*F_{0.1}$ (0.146), and the model was tuned to the NEFSC autumn survey swept-area biomass. The model results for this assessment update are almost identical to those of the 2008 GARM assessment. The model-estimated biomass indicated a sharp decline from around 4,000-5,000 mt during the early 1900s to around 1,000 mt during the mid-1900s. Atlantic halibut hit a record low biomass level of around 400 mt in the mid-1990s and has since increased to close to 1,700 mt in 2010 (Table M9, Figure M14). Relative F (catch/biomass) has been highly variable with spikes of fishing mortality close to 0.7 in the late 1800s, and around 0.4 in 1940 and 1967. However fishing mortality has been relatively low since the mid-1990s, with a slight increase to 0.069 in 2009 (Table M9, Figure M15). Replacement yield decreased

[7] http://nft.nefsc.noaa.gov/YPR.html NOAA Fisheries Toolbox Version 3.0, 2008. Age Based Yield per Recruit Version 2.7.2

sharply in the 1870s to a low of 500 mt in 1900, increased slightly to 700 mt around 1920, gradually decreased to about 60 mt in the early 1990s, and is currently close to 200 mt (Table M9, Figure M16).

Diagnostics

Only the most recent 48 years where survey swept-area biomass estimates are available can be included for residual pattern analyses. The predicted survey index from the Replacement Yield Model is fairly flat compared to the noisy observed NEFSC survey index (Figure M17a). There was minor patterning in the residuals (Table M10, Figure M17b), with the Replacement Yield Model slightly overestimating biomass during the mid-1960s and underestimating biomass in several other years due to the high variability in the autumn survey index. However there are no periods of consistently strong residual patterns.

Sensitivity analyses

Three sensitivity analyses were run for the Replacement Yield Model. The first was to evaluate the impact of updated 2007 catch and survey data on the 2008 GARM assessment result, which indicated no differences at all except for a very slight change in relative F for 2007 (Table M11). The second and third runs tested the sensitivity of the Replacement Yield Model to the value of the conversion factor, rho, used to calibrate the NEFSC autumn survey weight index from *Henry B. Bigelow* units to *Albatross IV* units (Tables 6 and 7). While the base run for this assessment update uses the average of coefficients for other flounders (rho_{mean} = 2.057), sensitivity runs were performed using the minimum (rho_{min} = 1.692, American Plaice) and the maximum (rho_{max} = 2.402, Yellowtail Flounder) from the group of 5 flounders. In both cases, the resulting biomass estimates for 2010 varied slightly from the base run, but there was no change on the Replacement Yield Reference Points (Table M11). Overall, differences observed in the sensitivity runs were minor (Table M11).

5.0 Biological Reference Points

From the 2008 GARM assessment (Col and Legault 2009), the fishing mortality reference point was estimated to be F_{MSY} proxy ($F_{0.1}$) = 0.073 from the YPR analyses described above, using M = 0.15 based on Pacific halibut estimates (Clark and Hare 2006). Biomass reference points were based on the Replacement Yield Model estimated carrying capacity (97,000 mt), which was informed by the F_{MSY} proxy ($F_{0.1}$) from the YPR analysis. Target biomass (B_{MSY} proxy) was defined as half of K (49,000 mt) and threshold biomass (½ B_{MSY} proxy) was equal to 24,000 mt (note that only two significant digits were included to reflect input data). A maximum sustainable yield of 3,500 mt was calculated as the F_{MSY} proxy multiplied by the B_{MSY} proxy from the Replacement Yield Model. Therefore, the Atlantic halibut reference points based on the base run with the average conversion coefficient for the NEFSC autumn survey biomass index (rho_{mean}) are as follows:

	Threshold	Target	Current Estimate	% Threshold	MSY
Fishing mortality	0.073		0.032	43%	3,500 mt
Stock Biomass	24,000 mt	49,000 mt	1,700 mt	7 %	

These reference points (threshold, target, and MSY) are identical to the results from the 2008 GARM assessment (Col and Legault 2009).

6.0 Projection

$F_{rebuild}$

As was done for the 2008 GARM III assessment (Col and Legault 2009), projections were run for Atlantic halibut using the Replacement Yield Model, assuming M = 0.15 and a linear increase in catch from 1800-1893. In 2004 Amendment 13 was adopted, and although a trajectory for halibut could not be calculated at that time, a rebuilding program was initiated in that year. Therefore, the rebuilding time period for Atlantic halibut was determined to be from 2004 to the estimated year in which halibut would rebuild to B_{MSY} at F = 0, plus one mean generation time from the updated YPR analyses. The resulting rebuilding time frame for Atlantic halibut was 2056, and $F_{rebuild}$ = 0.044 (Col and Legault 2009). Updated projections were run assuming that catch for 2011 would be equal to catch in 2010 (Table M12, Figure M18).

7.0 Atlantic halibut conclusion

Status of Stock

Biomass in 2010 is estimated to be 1,700 mt.
Relative F in 2010 is estimated to be 0.032.
Revised estimates of the biological reference points are:
Bmsy proxy= 49,000 mt,
Fmsy proxy = 0.0731, and
MSY proxy= 3,500 mt.

Based on these results, the stock of Atlantic halibut is overfished and overfishing is not occurring (Figure M19). The stock is below the biomass target.

The results are based on the same model used in GARM-III (NEFSC 2008, CRD#08-15, and Col and Legault 2009, CRD 09-08), which is a Replacement Yield Model using the fishing mortality reference point proxy from a yield-per-recruit analysis to inform the intrinsic rate of growth, and tuning to the NEFSC autumn survey swept-area biomass index.

The BRPs are based on the following revisions: Biomass reference point was updated through the re-run of the Replacement Yield Model using updated catch and survey data including 2007-2010. No revisions were made for the fishing mortality reference point.

8.0 Sources of uncertainty

Uncertainty linked to the YPR analysis include uncertainty in growth and maturity at age estimates, although these were updated during the 2008 GARM based on recent relevant data at the time (Col and Legault 2009). The use of Pacific halibut estimates for natural mortality also contributes to uncertainty in MSY and biomass reference point estimation in the Replacement Yield Model. However, the resulting status of Atlantic halibut remained the same regardless of M during the 2008 GARM (Col and Legault 2009). A lack of reported landings prior to 1893 lead to rough estimates of catch during 1800-1892; however Col and Legault (2009) determined that the Replacement Yield Model did not appear to be highly sensitive to these estimates.

The most problematic aspect of the Replacement Yield Model is providing informative tuning indices (Col and Legault 2009). Although the NEFSC autumn survey swept-area biomass index was considered to be the best available estimate of commercially independent biomass in previous assessments, there is a great deal of uncertainty as to whether this index is reliable for detecting population biomass trends due to the low encounter rates of Atlantic halibut (Col and Legault 2009).

Another source of uncertainty is the stock boundary determination of Atlantic halibut. Although not discussed specifically here, the 2008 GARM assessment (Col and Legault 2009) determined that future assessments should consider combining the Gulf of Maine-Georges Bank region with Canadian stocks, based on recent tagging information (Kanwit 2007).

Atlantic Halibut. Summary of Assessment Information

Atlantic Halibut	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Catch (mt)	38	35	56	39	51	45	82	88	107	52	120	18	531	1959-2010
Biomass (mt)	752	823	908	983	1086	1193	1320	1429	1547	1662	919	424	1662	1959-2010
Rel F	0.051	0.042	0.062	0.04	0.047	0.037	0.062	0.062	0.069	0.032	0.133	0.032	0.386	1959-2010

9.0 Panel Discussion/Comments

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

Based on decisions made during the 2008 GARM, estimated US discards for 1893 to 1998 were calculated by multiplying the recorded US landings by the 1989-1998 average discard-to-kept discard ratio. Reasons for early discarding of halibut included the inability to keep the fish onboard (before refrigeration) and the belief that halibut were affecting the numbers of cod through predation (leading to halibut being purposefully killed before discarding). Thus while there is evidence that discarding did occur throughout the 1893 to 1998 period, there is some concern that historical discarding behavior was different than in recent years. Therefore, it should be noted that actual historical discards are hard to estimate and are a source of uncertainty in this assessment.

In the future, one should consider adding discards from the longline fishery to the aggregate estimate (currently only based on discards from otter trawl and gillnet gears) since the landings from this gear type have been increasing over recent years, especially in the Maine state fishery where the 'one halibut per trip' rule does not apply.

In early assessments M was assumed to be 0.1 but it was redefined as 0.15 during the 2008 GARM based on an estimated value for Pacific halibut. Another way to derive an estimate of M would be to use an allometric equation, which would give an estimate closer to 0.08 for a species with a 50 year lifespan such as halibut. However it was recognized that this type of derivation is very sensitive to sample size and often has wide confidence intervals. In conclusion, the estimate of M should be added to the list of uncertainties in this assessment. In the future, alternative estimates for Atlantic halibut natural mortality (e.g. from European side of the Atlantic) should also be considered.

The proxy for intrinsic growth rate, $r = 2^* F_{0.1}$ is a source of uncertainty in the model.

Despite the sources of uncertainty identified in this assessment update, none of these (except possibly the stock structure) are expected to impact the conclusions regarding the assessment result or stock status.

The terminology for the model used for the assessment should be refined to indicate that a Replacement Yield Model is equivalent to a Biomass Dynamics Model. However, the name will not be changed here as it might seem like the model had changed since the 2008 GARM assessment when it has not.

As time allows, future research on this stock should include additional analysis to better understand what the historical biomass should have been to support the catch that is recorded in the early 1800's. Here K was driven by $r = 2^*F_{0.1}$, but one could do an Age-structured Production Model for example.

10.0 Acknowledgements

We wish to thank Laurel Col for her previous work on Atlantic halibut and her availability to provide helpful comments and support during the completion of this update.

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Table M1. Reported US and foreign commercial landings (mt) of Atlantic halibut from the Gulf of Maine and Georges Bank (NAFO Division 5Y and 5Z), 1893-2010.

Year	USA	Canada	Other	Total	Year	USA	Canada	Other	Total
1893	684	0	0	684	1952	123	0	0	123
1894	843	0	0	843	1953	104	0	0	104
1895	4200	0	0	4200	1954	125	0	0	125
1896	4908	0	0	4908	1955	74	0	0	74
1897	733	0	0	733	1956	62	0	0	62
1898	564	0	0	564	1957	80	0	0	80
1899	407	0	0	407	1958	73	0	0	73
1900	331	0	0	331	1959	59	0	0	59
1901	287	0	0	287	1960	63	0	0	63
1902	367	0	0	367	1961	79	5	0	84
1903	502	0	0	502	1962	86	35	25	146
1904	332	0	0	332	1963	94	88	1	183
1905	580	0	0	580	1964	115	120	1	236
1906	542	0	0	542	1965	128	153	18	299
1907	447	0	0	447	1966	110	110	62	282
1908	891	0	0	891	1967	102	386	26	514
1909	193	0	0	193	1968	74	193	3	270
1910	329	0	0	329	1969	63	96	9	168
1911	389	0	0	389	1970	52	67	19	138
1912	460	0	0	460	1971	81	38	0	119
1913	402	0	0	402	1972	63	37	8	108
1914	329	0	0	329	1973	51	38	0	89
1915	336	0	0	336	1974	46	29	1	76
1916	478	0	0	478	1975	70	36	0	106
1917	293	0	0	293	1976	58	33	0	91
1918	375	0	0	375	1977	50	31	0	81
1919	498	0	0	498	1978	84	50	0	134
1920	896	0	0	896	1979	125	29	0	154
1921	689	0	0	689	1980	80	88	0	168
1922	694	0	0	694	1981	80	118	0	198
1923	508	0	0	508	1982	85	116	0	201
1924	616	0	0	616	1983	72	131	0	203
1925	843	0	0	843	1984	75	62	0	137
1926	944	0	0	944	1985	61	57	0	118
1927	831	0	0	831	1986	44	32	0	76
1928	781	0	0	781	1987	27	23	0	50
1929	570	0	0	570	1988	47	81	0	128
1930	716	0	0	716	1989	13	65	0	78
1931	511	0	0	511	1990	16	58	0	74
1932	443	0	0	443	1991	30	58	0	88
1933	279	0	0	279	1992	22	47	0	69
1934	192	0	0	192	1993	15	50	0	65
1935	292	0	0	292	1994	22	24	0	46
1936	374	0	0	374	1995	11	8	0	19
1937	187	0	0	187	1996	13	12	0	25
1938	146	0	0	146	1997	14	14	0	28
1939	124	0	0	124	1998	8	9	0	17
1940	499	0	0	499	1999	12	8	0	20
1941	145	0	0	145	2000	11	6	0	17
1942	250	0	0	250	2001	11	11	0	22
1943	76	0	0	76	2002	10	10	0	20
1944	77	0	0	77	2003	17	14	0	31
1945	55	0	0	55	2004	11	12	0	23
1946	124	0	0	124	2005	17	9	0	26
1947	198	0	0	198	2006	14	10	0	24
1948	156	0	0	156	2007	25	32	0	57
1949	157	0	0	157	2008	29	29	0	58
1950	116	0	0	116	2009	45	15	0	60
1951	154	0	0	154	2010	20	11	0	31

Table M2. Reported US commercial landings (mt) of Atlantic halibut from the Gulf of Maine and Georges Bank (NAFO Division 5Y and 5Z) by gear, 1994-2010.

Year	Trawl	Hook/Line	Gillnet	Other	Total
1994	18	3	1	0	22
1995	7	2	2	0	11
1996	10	0	1	1	13
1997	6	2	1	5	14
1998	7	1	1	0	8
1999	10	0	1	0	12
2000	5	0	5	0	11
2001	7	1	3	0	11
2002	5	2	2	0	10
2003	12	2	2	0	17
2004	9	0	2	0	11
2005	6	2	7	3	17
2006	7	5	1	1	14
2007	16	3	2	4	25
2008	19	4	2	4	29
2009	25	17	2	2	45
2010	9	9	1	1	20

Table M3. Atlantic halibut estimates of US discards (mt) based on the Standardized Bycatch Reporting Methodology combined ratio estimation, with associated coefficient of variation (CV) and number of observed trips for 1989-2010, by gear (a), and total (b). Note that average discards are used to calculate catch since several years of low observer coverage led to very low sample sizes of observed Atlantic halibut. Average discards are derived by multiplying the average discard ratios for 1989-1998 and 1999-2010 time periods by the annual US landings.

(a)

Otter trawl				Gillnet			
YEAR	Discard	CV	Trips	YEAR	Discard	CV	Trips
1989	1.7	0.639	185	1989	1.6	0.847	107
1990	8.7	0.644	133	1990	1.5	1.226	153
1991	4.1	0.428	268	1991	1.1	0.358	957
1992	1.1	0.542	187	1992	0.5	0.379	1,187
1993	0.3	1.110	107	1993	1.0	0.474	770
1994	1.1	0.585	96	1994	0.3	0.618	404
1995	2.8	1.341	240	1995	0.0	1.037	537
1996	0.5	0.535	214	1996	0.1	1.224	422
1997	0.6	0.788	119	1997	0.0	.	389
1998	0.0	.	74	1998	0.2	1.014	403
1999	75.8	0.705	124	1999	0.3	1.144	189
2000	8.6	0.372	249	2000	0.7	1.036	226
2001	8.8	0.281	336	2001	0.6	1.045	167
2002	16.8	0.410	441	2002	0.0	.	173
2003	9.5	0.168	601	2003	6.2	0.472	492
2004	16.4	0.228	1,154	2004	1.8	0.240	1,089
2005	12.0	0.107	1,911	2005	1.9	0.491	1,004
2006	11.3	0.167	953	2006	3.0	0.520	251
2007	7.6	0.130	1,119	2007	1.7	0.321	334
2008	9.1	0.114	1,119	2008	2.1	0.322	309
2009	12.1	0.122	1,572	2009	1.0	0.378	416
2010	21.3	0.103	1,967	2010	4.6	0.151	1,879

(b)

Total				Hauls encountering Atl. Halibut	US Landings (mt)		Average discards (mt)
YEAR	Discard	CV	Trips				
1989	3.4	0.525	292	41	13		2
1990	10.2	0.578	286	64	16		3
1991	5.2	0.348	1,225	172	30		5
1992	1.6	0.394	1,374	127	22		4
1993	1.3	0.444	877	69	15	1989-1998 Average	2
1994	1.4	0.474	500	75	22	Discards/Landings:	4
1995	2.8	1.319	777	60	11	0.166	2
1996	0.6	0.491	636	28	13		2
1997	0.6	0.788	508	55	14		2
1998	0.2	1.014	477	4	8		1
1999	76.1	0.702	313	11	12		13
2000	9.3	0.352	475	40	11		12
2001	9.4	0.271	503	28	11		12
2002	16.8	0.410	614	61	10	1999-2010 Average	11
2003	15.7	0.212	1,093	186	17	Discards/Landings:	18
2004	18.2	0.207	2,243	263	11	1.052	12
2005	14.0	0.114	2,915	770	17		18
2006	14.3	0.171	1,204	346	14		15
2007	9.2	0.121	1,453	309	25		26
2008	11.2	0.111	1,428	446	29		30
2009	13.1	0.117	1,988	457	45		47
2010	25.9	0.089	3,846	529	20		21

Table M4. Total catch (mt) of Atlantic halibut from the Gulf of Maine and Georges Bank (NAFO Division 5Y and 5Z), 1893-2010. US discards for 1893-1998 were obtained by applying the 1989-1998 average discard/landing ratio (0.166) to the US landings.

Year	US Landings	US Discards	Canadian Landings	Other Landings	Total Landings	Total Catch	Year	US Landings	US Discards	Canadian Landings	Other Landings	Total Landings	Total Catch
1893	684	114	0	0	684	798	1952	123	20	0	0	123	143
1894	843	140	0	0	843	983	1953	104	17	0	0	104	121
1895	4200	699	0	0	4200	4899	1954	125	21	0	0	125	146
1896	4908	817	0	0	4908	5725	1955	74	12	0	0	74	86
1897	733	122	0	0	733	855	1956	62	10	0	0	62	72
1898	564	94	0	0	564	658	1957	80	13	0	0	80	93
1899	407	68	0	0	407	475	1958	73	12	0	0	73	85
1900	331	55	0	0	331	386	1959	59	10	0	0	59	69
1901	287	48	0	0	287	335	1960	63	10	0	0	63	73
1902	367	61	0	0	367	428	1961	79	13	5	0	84	97
1903	502	84	0	0	502	586	1962	86	14	35	25	146	160
1904	332	55	0	0	332	387	1963	94	16	88	1	183	199
1905	580	97	0	0	580	677	1964	115	19	120	1	236	255
1906	542	90	0	0	542	632	1965	128	21	153	18	299	320
1907	447	74	0	0	447	521	1966	110	18	110	62	282	300
1908	891	148	0	0	891	1039	1967	102	17	386	26	514	531
1909	193	32	0	0	193	225	1968	74	12	193	3	270	282
1910	329	55	0	0	329	384	1969	63	10	96	9	168	178
1911	389	65	0	0	389	454	1970	52	9	67	19	138	147
1912	460	77	0	0	460	537	1971	81	13	38	0	119	132
1913	402	67	0	0	402	469	1972	63	10	37	8	108	118
1914	329	55	0	0	329	384	1973	51	8	38	0	89	97
1915	336	56	0	0	336	392	1974	46	8	29	1	76	84
1916	478	80	0	0	478	558	1975	70	12	36	0	106	118
1917	293	49	0	0	293	342	1976	58	10	33	0	91	101
1918	375	62	0	0	375	437	1977	50	8	31	0	81	89
1919	498	83	0	0	498	581	1978	84	14	50	0	134	148
1920	896	149	0	0	896	1045	1979	125	21	29	0	154	175
1921	689	115	0	0	689	804	1980	80	13	88	0	168	181
1922	694	115	0	0	694	809	1981	80	13	118	0	198	211
1923	508	85	0	0	508	593	1982	85	14	116	0	201	215
1924	616	103	0	0	616	719	1983	72	12	131	0	203	215
1925	843	140	0	0	843	983	1984	75	12	62	0	137	149
1926	944	157	0	0	944	1101	1985	61	10	57	0	118	128
1927	831	138	0	0	831	969	1986	44	7	32	0	76	83
1928	781	130	0	0	781	911	1987	27	4	23	0	50	54
1929	570	95	0	0	570	665	1988	47	8	81	0	128	136
1930	716	119	0	0	716	835	1989	13	2	65	0	78	80
1931	511	85	0	0	511	596	1990	16	3	58	0	74	77
1932	443	74	0	0	443	517	1991	30	5	58	0	88	93
1933	279	46	0	0	279	325	1992	22	4	47	0	69	73
1934	192	32	0	0	192	224	1993	15	2	50	0	65	67
1935	292	49	0	0	292	341	1994	22	4	24	0	46	50
1936	374	62	0	0	374	436	1995	11	2	8	0	19	21
1937	187	31	0	0	187	218	1996	13	2	12	0	25	27
1938	146	24	0	0	146	170	1997	14	2	14	0	28	30
1939	124	21	0	0	124	145	1998	8	1	9	0	17	18
1940	499	83	0	0	499	582	1999	12	13	8	0	20	33
1941	145	24	0	0	145	169	2000	11	12	6	0	17	29
1942	250	42	0	0	250	292	2001	11	12	11	0	22	34
1943	76	13	0	0	76	89	2002	10	11	10	0	20	31
1944	77	13	0	0	77	90	2003	17	18	14	0	31	49
1945	55	9	0	0	55	64	2004	11	12	12	0	23	35
1946	124	21	0	0	124	145	2005	17	18	9	0	26	44
1947	198	33	0	0	198	231	2006	14	15	10	0	24	39
1948	156	26	0	0	156	182	2007	25	26	32	0	57	82
1949	157	26	0	0	157	183	2008	29	30	29	0	58	88
1950	116	19	0	0	116	135	2009	45	47	15	0	60	107
1951	154	26	0	0	154	180	2010	20	21	11	0	31	52

Table M5. Atlantic halibut stratified mean numbers and weight (kg) per tow with associated coefficients of variation (CVs) from the Northeast Fisheries Science Center **spring** bottom trawl survey (offshore strata 13-30, 36-40), and swept –area biomass estimates for 1968-2011. * indicates that indices for 2010 and 2011 (in bold) were converted from *H.B. Bigelow* units (HBB_i) to *Albatross IV* units ($A\ IV_i$) using the mean calibration coefficient, rho_i, for Atlantic halibut (see Table M7).

Year	Stratified Mean Number per Tow	Coefficient of Variation (CV)	Stratified Mean Weight (kg) per Tow	Coefficient of Variation (CV)	Swept-Area Biomass (mt)
1968	0.046	0.454	0.129	0.585	428
1969	0.028	0.448	0.236	0.575	783
1970	0.015	0.607	0.105	0.744	349
1971	0.013	0.601	0.033	0.714	110
1972	0.006	1.000	0.005	1.000	17
1973	0.015	0.720	0.113	0.845	375
1974	0.052	0.390	0.112	0.555	372
1975	0.000	0.000	0.000	0.000	0
1976	0.031	0.495	0.644	0.910	2,138
1977	0.052	0.473	0.142	0.481	471
1978	0.025	0.592	0.163	0.743	541
1979	0.048	0.269	0.357	0.412	1,185
1980	0.056	0.457	0.563	0.676	1,869
1981	0.027	0.637	0.066	0.724	219
1982	0.011	0.724	0.082	0.768	272
1983	0.035	0.555	0.611	0.574	2,028
1984	0.009	0.732	0.022	0.846	73
1985	0.024	0.731	0.063	0.869	209
1986	0.000	0.000	0.000	0.000	0
1987	0.009	1.000	0.287	1.000	953
1988	0.039	0.826	0.023	1.000	76
1989	0.000	0.000	0.000	0.000	0
1990	0.026	1.000	0.064	1.000	212
1991	0.034	0.911	0.062	0.950	206
1992	0.031	0.655	0.037	0.681	123
1993	0.003	1.000	0.006	1.000	20
1994	0.008	1.000	0.017	1.000	56
1995	0.008	0.716	0.005	0.713	17
1996	0.009	0.722	0.013	0.708	43
1997	0.025	0.671	0.063	0.659	209
1998	0.016	0.523	0.017	0.656	56
1999	0.012	0.790	0.239	0.969	793
2000	0.000	0.000	0.000	0.000	0
2001	0.046	0.667	0.163	0.880	541
2002	0.013	0.408	0.128	0.639	425
2003	0.037	0.718	0.052	0.949	173
2004	0.025	0.811	0.168	0.983	558
2005	0.034	0.582	0.025	0.670	83
2006	0.113	0.308	0.383	0.460	1,271
2007	0.109	0.441	0.195	0.603	647
2008	0.062	0.407	0.100	0.572	332
2009	0.063	0.528	0.037	0.411	123
* 2010	**0.037**	0.294	**0.060**	0.341	200
* 2011	**0.018**	0.527	**0.029**	0.673	97

* Conversion of indices: $AIV_i = \dfrac{HBB_i}{rho_i}$

rho(numbers) = 2.811		rho(weight) = 2.704	
$HBB_{(numbers)}$	$A\ IV_{(numbers)}$	$HBB_{(weight)}$	$A\ IV_{(weight)}$
0.103	**0.037**	0.163	**0.060**
0.050	**0.018**	0.079	**0.029**

Table M6. Atlantic halibut stratified mean numbers and weight (kg) per tow with associated coefficients of variation (CVs) from the Northeast Fisheries Science Center **autumn** bottom trawl survey (offshore strata 13-30, 36-40), and swept –area biomass estimates for 1963-2010. * indicates that indices for 2009 and 2010 (in bold) were converted from *H.B. Bigelow* units (HBB_i) to *Albatross IV* units ($A\ IV_i$) using the mean calibration coefficient, rho_i, for Atlantic halibut (see Table M7).

Year	Stratified Mean Number per Tow	Coefficient of Variation (CV)	Stratified Mean Weight (kg) per Tow	Coefficient of Variation (CV)	Swept-Area Biomass (mt)
1963	0.039	0.527	0.085	0.602	282
1964	0.022	0.472	0.067	0.521	222
1965	0.015	0.574	0.032	0.538	106
1966	0.003	1.000	0.004	1.000	13
1967	0.003	1.000	0.009	1.000	30
1968	0.013	1.000	0.233	1.000	773
1969	0.025	0.682	0.494	0.943	1,640
1970	0.000	1.000	0.000	0.000	0
1971	0.011	1.000	0.091	1.000	302
1972	0.013	0.739	0.018	0.806	60
1973	0.015	0.829	0.131	0.913	435
1974	0.004	1.000	0.014	1.000	46
1975	0.017	0.732	0.095	0.954	315
1976	0.038	0.513	0.378	0.690	1,255
1977	0.012	0.603	0.059	0.699	196
1978	0.028	0.532	0.294	0.797	976
1979	0.015	0.416	0.040	0.510	133
1980	0.007	0.791	0.010	0.733	33
1981	0.024	0.518	0.321	0.674	1,065
1982	0.015	0.735	0.115	0.862	382
1983	0.000	0.000	0.000	0.000	0
1984	0.005	1.000	0.124	1.000	412
1985	0.015	1.000	0.106	1.000	352
1986	0.029	0.620	0.313	0.739	1,039
1987	0.029	0.635	0.033	0.682	110
1988	0.006	1.000	0.004	1.000	13
1989	0.046	0.353	0.066	0.677	219
1990	0.045	0.375	0.060	0.417	199
1991	0.034	0.547	0.243	0.829	807
1992	0.018	0.762	0.201	0.738	667
1993	0.013	0.408	0.046	0.461	153
1994	0.000	0.000	0.000	0.000	0
1995	0.011	1.000	0.066	1.000	219
1996	0.004	1.000	0.053	1.000	176
1997	0.046	0.556	0.174	0.700	578
1998	0.060	0.546	0.103	0.589	342
1999	0.006	0.577	0.015	0.615	50
2000	0.006	1.000	0.021	1.000	70
2001	0.030	0.551	0.247	0.807	820
2002	0.003	1.000	0.004	1.000	13
2003	0.040	0.518	0.049	0.569	163
2004	0.047	0.471	0.112	0.290	372
2005	0.030	0.589	0.111	0.620	368
2006	0.021	0.545	0.031	0.610	103
2007	0.033	0.629	0.077	0.613	256
2008	0.044	0.316	0.070	0.497	232
* 2009	**0.057**	0.401	**0.062**	0.411	207
* 2010	**0.062**	0.308	**0.139**	0.410	461

* Conversion of indices: $$AIV_i = \frac{HBB_i}{rho_i}$$

$rho_{(numbers)} = 2.266$		$rho_{(weight)} = 2.057$	
$HBB_{(numbers)}$	$A\ IV_{(numbers)}$	$HBB_{(weight)}$	$A\ IV_{(weight)}$
0.129	**0.057**	0.128	**0.062**
0.140	**0.062**	0.286	**0.139**

Table M7. Calibration coefficients (rho) from *H.B. Bigelow* units to *Albatross IV* units and coefficients of variation (CV) used for mean numbers and weight at age for Atlantic halibut for the Northeast Fisheries Science Center spring (a) and autumn (b) bottom trawl surveys. Because the low sample size for halibut in the calibration experiments precludes calculating species-specific coefficients, the average (in bold) of coefficients for other flounders (Miller et al 2010) is used.

(a) Spring

	Numbers at age		Weight at age	
Species	rho	CV	rho	CV
American Plaice	2.074	0.091	2.092	0.112
Summer Flounder	3.226	0.099	3.066	0.117
Fourspot Flounder	3.099	0.147	3.05	0.151
Yellowtail Flounder	2.347	0.152	2.244	0.156
Windowpane	3.311	0.117	3.069	0.144
Average	**2.811**	0.126	**2.704**	0.140

(b) Autumn

	Numbers at age		Weight at age	
Species	rho	CV	rho	CV
American Plaice	2.160	0.076	1.692	0.111
Summer Flounder	2.405	0.109	2.141	0.135
Fourspot Flounder	2.356	0.094	2.151	0.106
Yellowtail Flounder	2.366	0.087	2.402	0.092
Windowpane	2.044	0.098	1.901	0.110
Average	**2.266**	0.094	**2.057**	0.111

Table M8. Input data used for the Atlantic halibut yield per recruit (YPR) analysis in the 2008 GARM assessment (Col and Legault 2009).

Age	Selectivity on Fishing Mortality	Natural Mortality Rate	Fraction Mature	Mean Weight (kg)
0	0	0.15	0.02	0.00
1	0	0.15	0.04	0.02
2	0	0.15	0.06	0.25
3	0	0.15	0.10	0.96
4	1	0.15	0.15	2.36
5	1	0.15	0.23	4.57
6	1	0.15	0.34	7.64
7	1	0.15	0.46	11.57
8	1	0.15	0.59	16.32
9	1	0.15	0.71	21.83
10	1	0.15	0.80	28.01
11	1	0.15	0.87	34.78
12	1	0.15	0.92	42.03
13	1	0.15	0.95	49.68
14	1	0.15	0.97	57.63
15	1	0.15	0.98	65.79
16	1	0.15	0.99	74.09
17	1	0.15	0.99	82.46
18	1	0.15	1.00	90.83
19	1	0.15	1.00	99.15
20	1	0.15	1.00	107.36
21	1	0.15	1.00	115.43
22	1	0.15	1.00	123.33
23	1	0.15	1.00	131.02
24	1	0.15	1.00	138.48
25	1	0.15	1.00	145.70
26	1	0.15	1.00	152.65
27	1	0.15	1.00	159.35
28	1	0.15	1.00	165.77
29	1	0.15	1.00	171.91
30	1	0.15	1.00	177.78
31	1	0.15	1.00	183.38
32	1	0.15	1.00	188.70
33	1	0.15	1.00	193.76
34	1	0.15	1.00	198.57
35	1	0.15	1.00	203.12
36	1	0.15	1.00	207.43
37	1	0.15	1.00	211.50
38	1	0.15	1.00	215.35
39	1	0.15	1.00	218.98
40	1	0.15	1.00	222.40
41-50	1	0.15	1.00	222.40

Table M9. Atlantic halibut catch, swept-area biomass (as of 1963), and resulting biomass, replacement yield, and relative F from the Replacement Yield Model (M=0.15). Note that reported landings began in 1893, and 1800-1892 catch is assumed to be a linear increase from 1800 to 1892.

Year	Total Catch (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F	Year	Total Catch (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F
1800	10	97,018	0	0.000	1853	3,387	72,858	2,653	0.046
1801	20	97,008	1	0.000	1854	3,454	72,123	2,706	0.048
1802	30	96,990	4	0.000	1855	3,521	71,375	2,758	0.049
1803	37	96,964	8	0.000	1856	3,588	70,612	2,810	0.051
1804	104	96,935	12	0.001	1857	3,655	69,834	2,861	0.052
1805	171	96,843	26	0.002	1858	3,722	69,040	2,911	0.054
1806	238	96,698	47	0.002	1859	3,789	68,229	2,960	0.056
1807	305	96,507	74	0.003	1860	3,856	67,400	3,008	0.057
1808	372	96,276	108	0.004	1861	3,923	66,552	3,055	0.059
1809	439	96,012	146	0.005	1862	3,990	65,684	3,101	0.061
1810	506	95,718	188	0.005	1863	4,057	64,796	3,146	0.063
1811	573	95,400	233	0.006	1864	4,124	63,885	3,190	0.065
1812	640	95,060	281	0.007	1865	4,191	62,951	3,232	0.067
1813	707	94,700	331	0.007	1866	4,258	61,992	3,272	0.069
1814	774	94,324	383	0.008	1867	4,325	61,006	3,311	0.071
1815	841	93,933	437	0.009	1868	4,392	59,992	3,347	0.073
1816	908	93,529	492	0.010	1869	4,459	58,947	3,382	0.076
1817	975	93,113	548	0.010	1870	4,526	57,870	3,414	0.078
1818	1,042	92,686	605	0.011	1871	4,593	56,758	3,443	0.081
1819	1,109	92,249	663	0.012	1872	4,660	55,608	3,470	0.084
1820	1,176	91,803	722	0.013	1873	4,727	54,418	3,493	0.087
1821	1,243	91,348	781	0.014	1874	4,794	53,185	3,513	0.090
1822	1,310	90,886	840	0.014	1875	4,861	51,904	3,529	0.094
1823	1,377	90,416	900	0.015	1876	4,928	50,571	3,540	0.097
1824	1,444	89,938	960	0.016	1877	4,995	49,183	3,545	0.102
1825	1,511	89,454	1,020	0.017	1878	5,062	47,733	3,545	0.106
1826	1,578	88,963	1,080	0.018	1879	5,129	46,217	3,538	0.111
1827	1,645	88,465	1,140	0.019	1880	5,196	44,626	3,523	0.116
1828	1,712	87,960	1,201	0.019	1881	5,263	42,953	3,500	0.123
1829	1,779	87,449	1,261	0.020	1882	5,330	41,189	3,465	0.129
1830	1,846	86,931	1,321	0.021	1883	5,397	39,325	3,419	0.137
1831	1,913	86,406	1,382	0.022	1884	5,464	37,347	3,358	0.146
1832	1,980	85,875	1,442	0.023	1885	5,531	35,241	3,281	0.157
1833	2,047	85,337	1,502	0.024	1886	5,598	32,991	3,183	0.170
1834	2,114	84,792	1,562	0.025	1887	5,665	30,576	3,061	0.185
1835	2,181	84,240	1,622	0.026	1888	5,732	27,972	2,910	0.205
1836	2,248	83,682	1,682	0.027	1889	5,799	25,151	2,724	0.231
1837	2,315	83,115	1,741	0.028	1890	5,866	22,075	2,493	0.266
1838	2,382	82,542	1,801	0.029	1891	5,933	18,702	2,207	0.317
1839	2,449	81,960	1,860	0.030	1892	6,000	14,977	1,852	0.401
1840	2,516	81,371	1,919	0.031	1893	798	10,828	1,406	0.074
1841	2,583	80,774	1,977	0.032	1894	983	11,437	1,475	0.086
1842	2,650	80,168	2,036	0.033	1895	4,899	11,929	1,530	0.411
1843	2,717	79,554	2,094	0.034	1896	5,725	8,559	1,141	0.669
1844	2,784	78,931	2,151	0.035	1897	855	3,975	557	0.215
1845	2,851	78,298	2,209	0.036	1898	658	3,678	517	0.179
1846	2,918	77,656	2,266	0.038	1899	475	3,537	498	0.134
1847	2,985	77,004	2,323	0.039	1900	386	3,561	502	0.108
1848	3,052	76,341	2,379	0.040	1901	335	3,677	517	0.091
1849	3,119	75,668	2,435	0.041	1902	428	3,859	542	0.111
1850	3,186	74,983	2,490	0.042	1903	586	3,973	557	0.147
1851	3,253	74,287	2,545	0.044	1904	387	3,944	553	0.098
1852	3,320	73,579	2,599	0.045	1905	677	4,110	575	0.165

Table M9, continued. Atlantic halibut catch, swept-area biomass (as of 1963), and resulting biomass, replacement yield, and relative F from the Replacement Yield Model (M=0.15). Note that reported landings began in 1893, and 1800-1892 catch is assumed to be a linear increase from 1800 to 1892.

Year	Total Catch (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F	Year	Total Catch (mt)	Swept-Area Biomass (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F
1906	632	4,009	562	0.158	1959	69		1,186	171	0.058
1907	521	3,939	553	0.132	1960	73		1,288	186	0.057
1908	1,039	3,970	557	0.262	1961	97		1,400	202	0.069
1909	225	3,488	492	0.065	1962	160		1,505	217	0.107
1910	384	3,754	528	0.102	1963	199	282	1,561	225	0.127
1911	454	3,898	547	0.116	1964	255	222	1,587	228	0.161
1912	537	3,991	559	0.134	1965	320	106	1,561	224	0.205
1913	469	4,014	563	0.117	1966	300	13	1,465	211	0.205
1914	384	4,108	575	0.093	1967	531	30	1,375	198	0.386
1915	392	4,299	601	0.091	1968	282	773	1,043	151	0.271
1916	558	4,508	628	0.124	1969	178	1,640	911	132	0.196
1917	342	4,579	638	0.075	1970	147	0	865	125	0.170
1918	437	4,875	677	0.090	1971	132	302	843	122	0.157
1919	581	5,114	708	0.114	1972	118	60	833	121	0.142
1920	1,045	5,242	725	0.199	1973	97	435	835	121	0.117
1921	804	4,922	683	0.163	1974	84	46	859	124	0.097
1922	809	4,801	667	0.169	1975	118	315	899	130	0.131
1923	593	4,659	648	0.127	1976	101	1,255	912	132	0.110
1924	719	4,714	656	0.152	1977	89	196	943	137	0.095
1925	983	4,652	647	0.211	1978	148	976	991	143	0.149
1926	1,101	4,316	603	0.255	1979	175	133	986	143	0.177
1927	969	3,818	536	0.254	1980	181	33	954	138	0.190
1928	911	3,385	478	0.269	1981	211	1,065	911	132	0.232
1929	665	2,951	418	0.225	1982	215	382	831	121	0.259
1930	835	2,705	384	0.309	1983	215	0	737	107	0.292
1931	596	2,254	322	0.264	1984	149	412	629	91	0.238
1932	517	1,980	284	0.261	1985	128	352	571	83	0.225
1933	325	1,747	251	0.186	1986	83	1,039	525	76	0.159
1934	224	1,672	240	0.134	1987	54	110	518	75	0.105
1935	341	1,688	243	0.202	1988	136	13	539	78	0.252
1936	436	1,590	229	0.274	1989	80	219	482	70	0.166
1937	218	1,383	199	0.158	1990	77	199	472	69	0.162
1938	170	1,364	197	0.125	1991	93	807	464	67	0.200
1939	145	1,390	200	0.104	1992	73	667	438	64	0.166
1940	582	1,446	208	0.403	1993	67	153	429	63	0.157
1941	169	1,072	155	0.158	1994	50	0	424	62	0.117
1942	292	1,058	153	0.276	1995	21	219	437	64	0.048
1943	89	919	133	0.096	1996	27	176	479	70	0.057
1944	90	964	140	0.093	1997	30	578	522	76	0.058
1945	64	1,014	147	0.063	1998	18	342	567	82	0.032
1946	145	1,096	158	0.132	1999	38	50	631	92	0.060
1947	231	1,110	160	0.208	2000	33	70	686	100	0.048
1948	182	1,039	150	0.175	2001	38	820	752	109	0.051
1949	183	1,008	146	0.182	2002	35	13	823	119	0.042
1950	135	970	140	0.139	2003	56	163	908	131	0.062
1951	180	975	141	0.184	2004	39	372	983	142	0.040
1952	143	937	136	0.153	2005	51	368	1,086	157	0.047
1953	121	929	135	0.131	2006	45	103	1,193	172	0.037
1954	146	942	136	0.155	2007	82	256	1,320	190	0.062
1955	86	933	135	0.093	2008	88	232	1,429	206	0.062
1956	72	982	142	0.074	2009	107	207	1,547	222	0.069
1957	93	1,052	152	0.089	2010	52	461	1,662	239	0.032
1958	85	1,110	160	0.077						

Table M10. Residuals of Northeast Fisheries Science Center autumn survey swept-area biomass indices to predicted swept-area biomass indices from the Replacement Yield Model.

Year	Log Z-score Residuals
1963	-0.263
1964	-0.455
1965	-0.999
1966	-2.518
1967	-1.860
1968	0.801
1969	1.469
1970	
1971	0.253
1972	-0.959
1973	0.534
1974	-1.172
1975	0.236
1976	1.266
1977	-0.159
1978	1.015
1979	-0.485
1980	-1.505
1981	1.144
1982	0.439
1983	
1984	0.707
1985	0.662
1986	1.540
1987	-0.145
1988	-1.765
1989	0.432
1990	0.376
1991	1.443
1992	1.343
1993	0.247
1994	
1995	0.506
1996	0.271
1997	1.103
1998	0.644
1999	-0.888
2000	-0.697
2001	1.091
2002	-2.084
2003	-0.270
2004	0.293
2005	0.211
2006	-0.820
2007	-0.211
2008	-0.343
2009	-0.491
2010	0.061

Table M11. Results of sensitivity runs for the Replacement Yield Model for Atlantic halibut. Note: An extensive amount of decimals is presented to indicate the scale at which differences between the models had any effect.

Sensitivity Run	Description	B_{MSY} (Target)	1/2 B_{MSY} (Threshold)	B in terminal year	F_{MSY} proxy	Relative F in terminal year
	2008 GARM	**48,509.22756**	**24,254.613781**	**1,320.22**	**0.0731**	**0.0638**
1	2008 GARM sensitivity with updated 2007 data	48,509.22756	24,254.613781	1,319.33	0.0731	0.0622
	Base model using rho_{mean} (2.057)	**48,509.22756**	**24,254.613781**	**1,661.60**	**0.0731**	**0.0316**
2	Sensitivity using rho_{min} (1.692)	48,509.22756	24,254.613778	1,492.42	0.0731	0.0351
3	Sensitivity using rho_{max} (2.402)	48,509.22755	24,254.613774	1,310.66	0.0731	0.0400

Table M12. Short-term projection results (2011-2014) under a constant $F_{rebuild}$ = 0.044 after 2011 and assuming catch in 2011 equals catch in 2010.

Year	Catch (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F
2011	52	1,848	265	0.028
2012	91	2,060	295	0.044
2013	100	2,264	323	0.044
2014	110	2,488	354	0.044

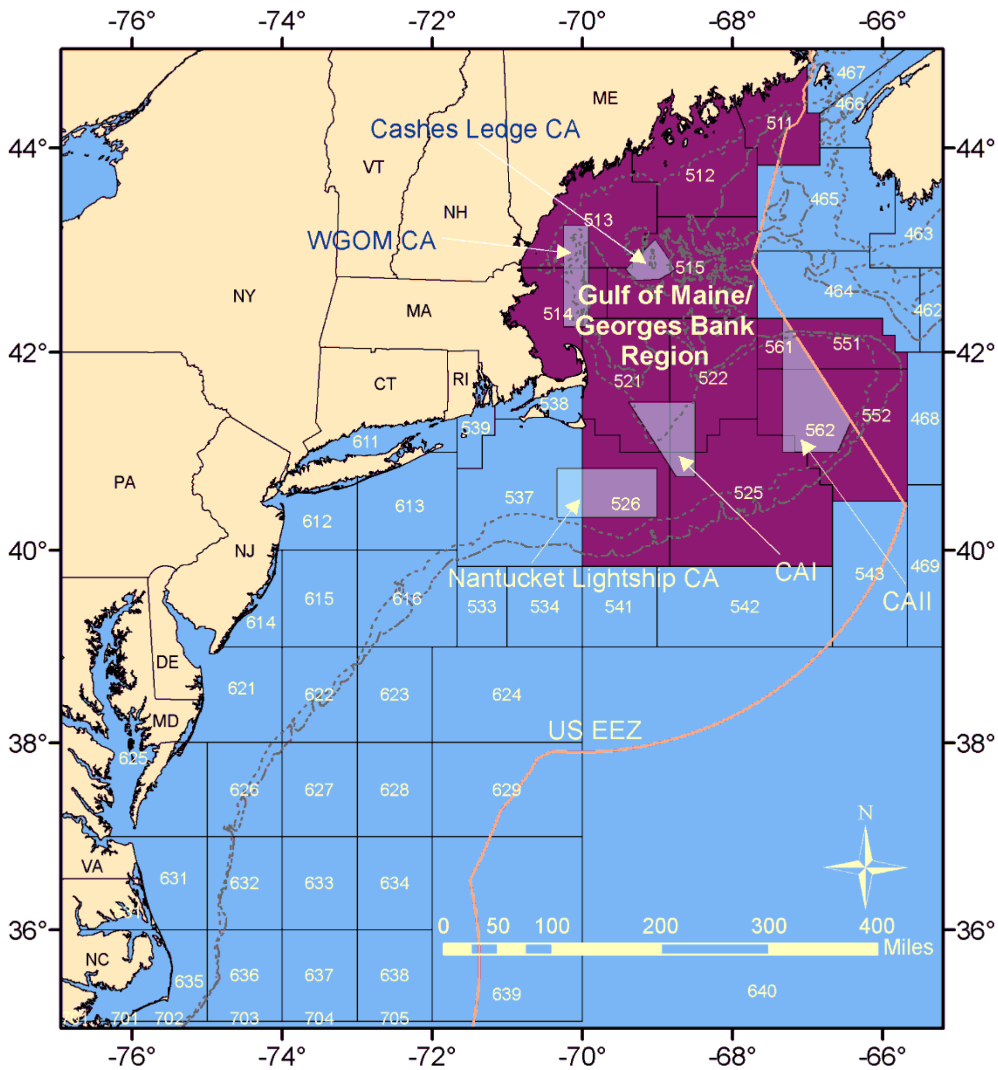


Figure M1. Statistical areas used to define United States commercial fishing catch for the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z) of the Atlantic halibut stock.

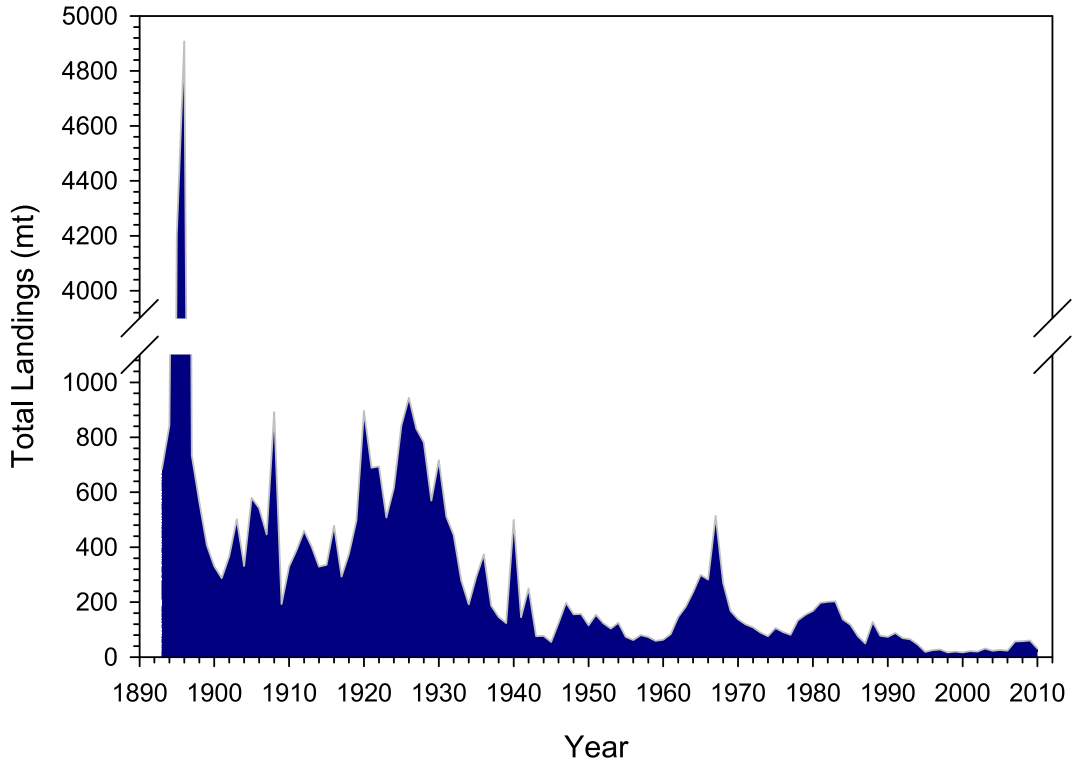


Figure M2. Atlantic halibut total landings (mt) from the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z), 1893-2010.

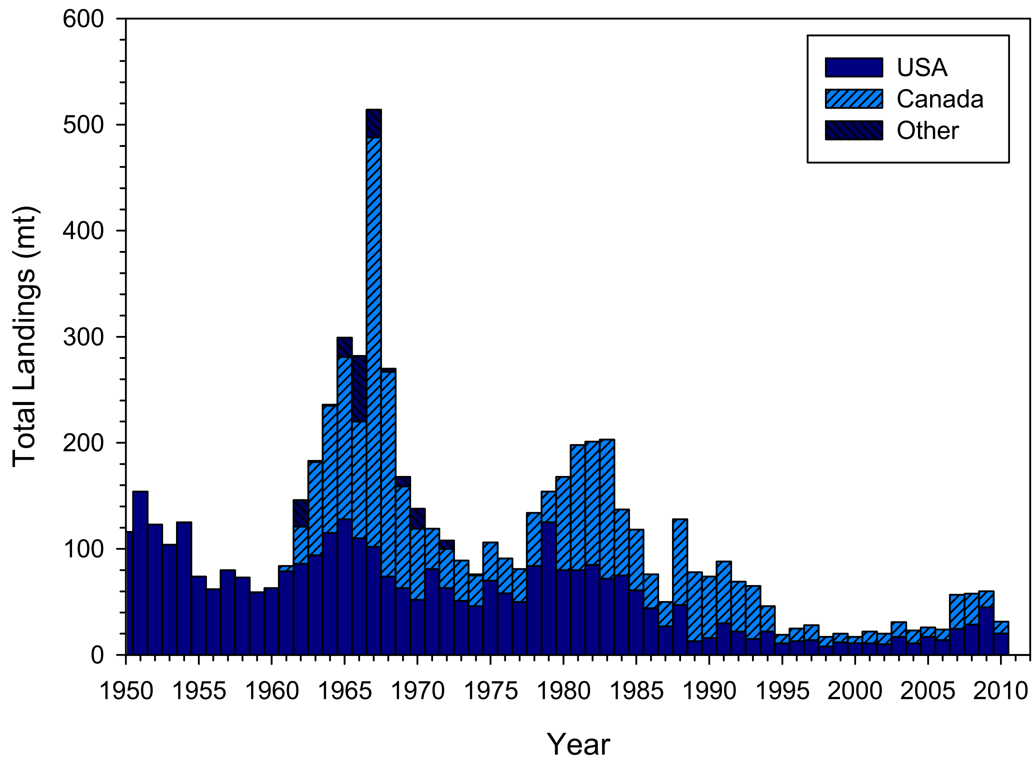


Figure M3. Atlantic halibut total landings (mt) from the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z) by country, 1950-2010.

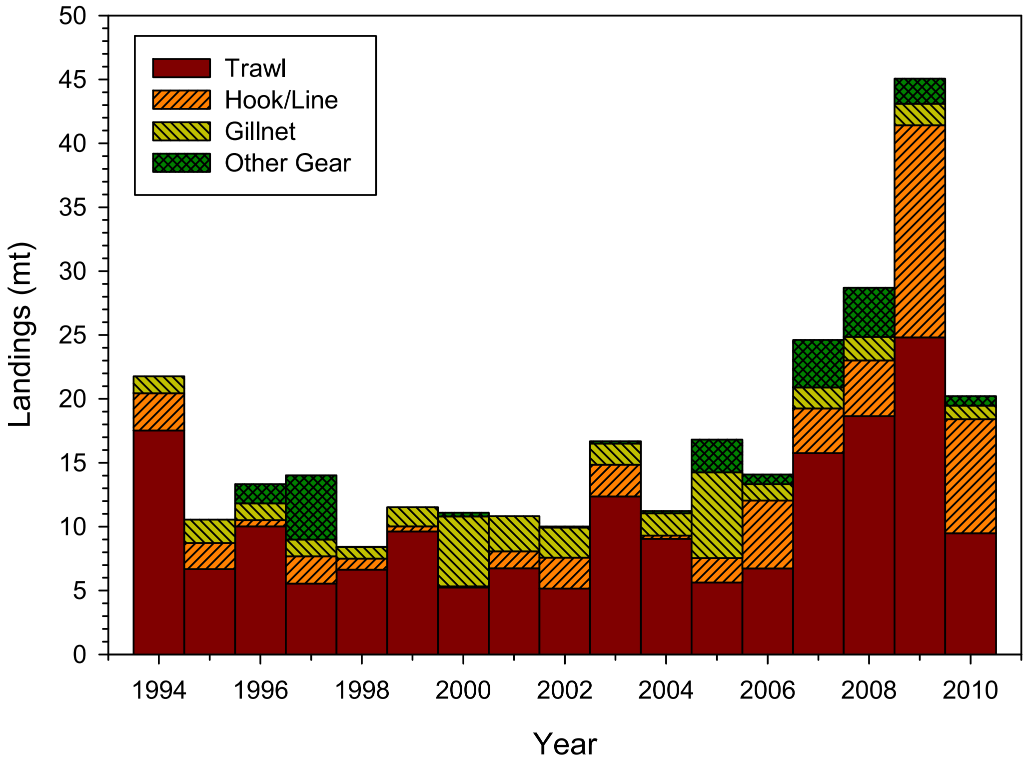


Figure M4. Atlantic halibut US landings (mt) from the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z) by gear, 1994-2010.

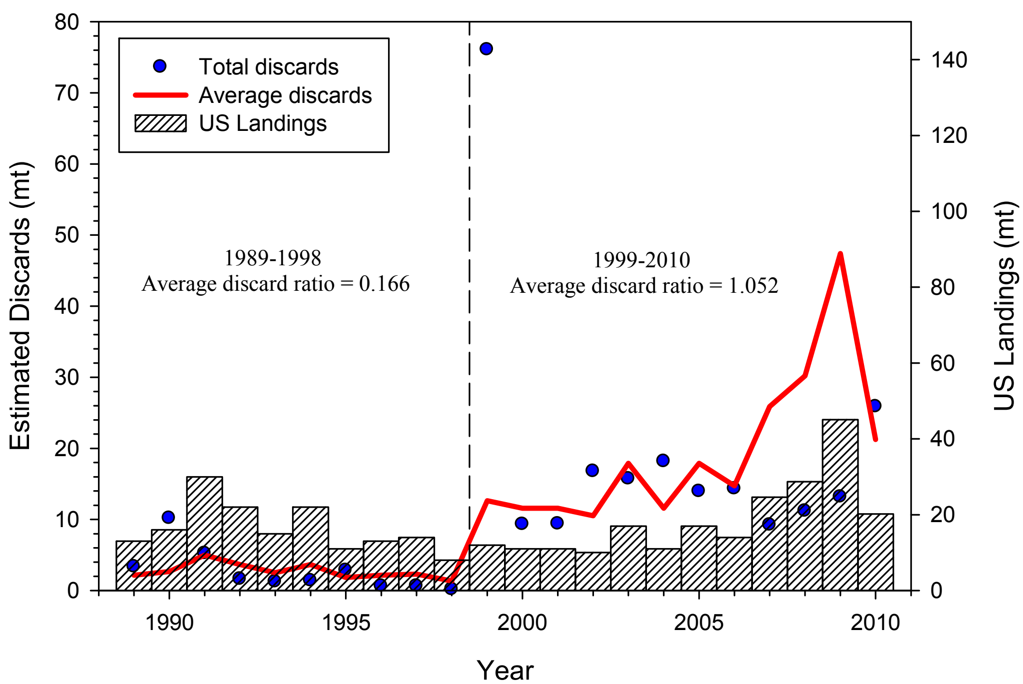


Figure M5. Atlantic halibut total US discard estimates (mt) based on the Standardized Bycatch reporting Methodology, average discard estimates (mt) using average discard ratios for 1989-1998 and 1999-2010 time periods, and US landings (mt) from the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z), 1989-2010.

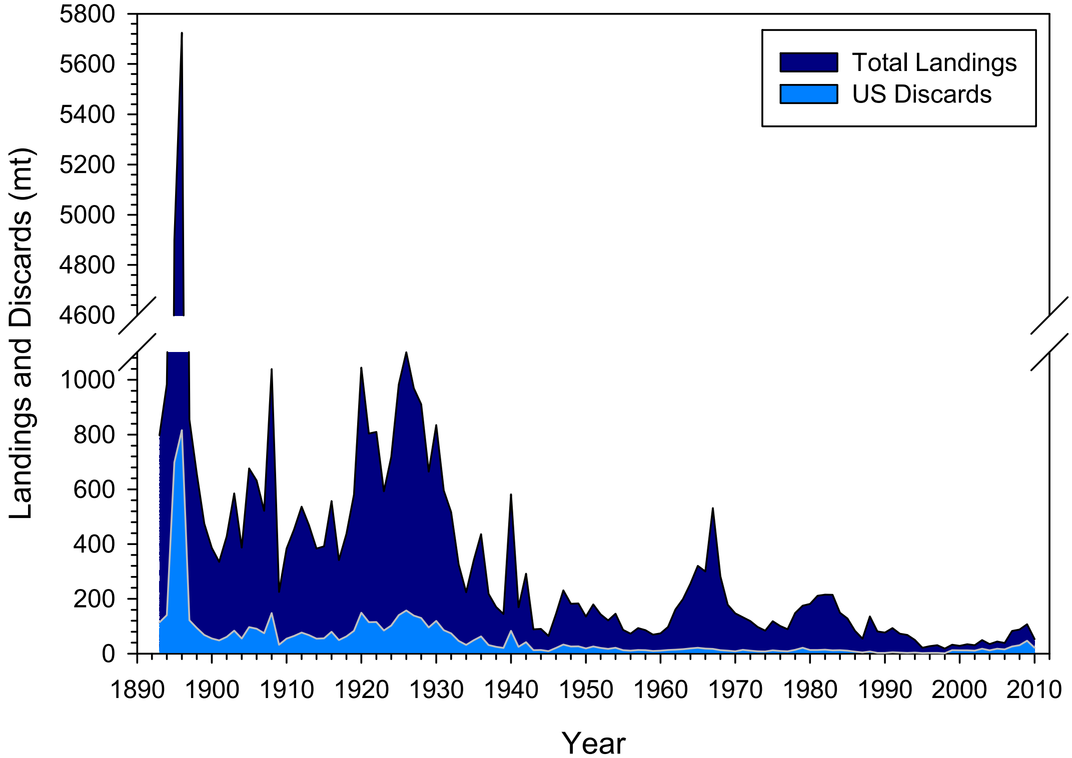


Figure M6. Atlantic halibut total catch (mt) from the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z), 1893-2010.

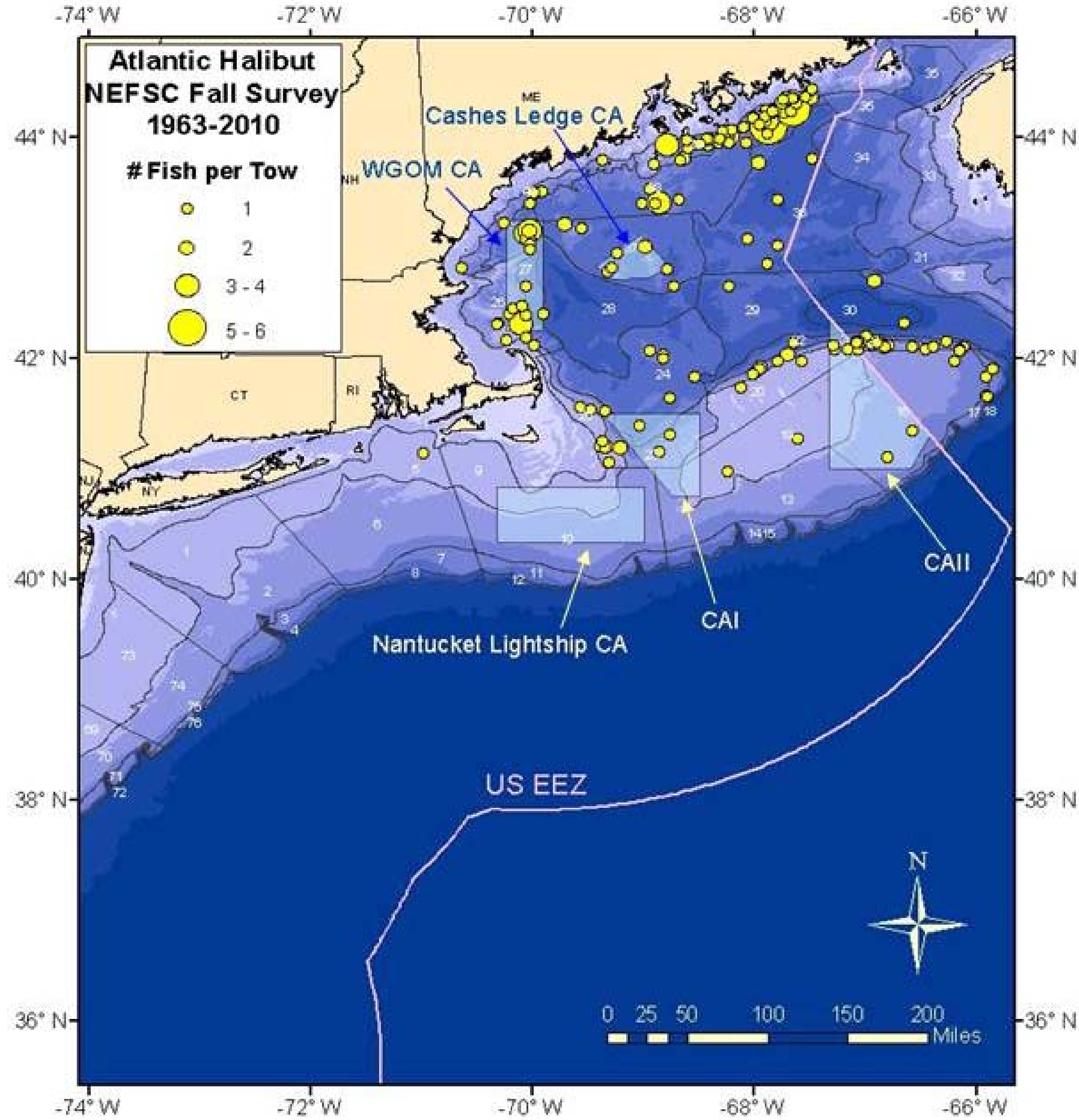


Figure M7. Distribution of Atlantic halibut from Northeast Fisheries Science Center autumn surveys (1963-2010) used to calculate the survey biomass time series. Halibut caught outside of NEFSC survey strata 13-30 or 36-40 were excluded due to inconsistent sampling throughout the survey time series.

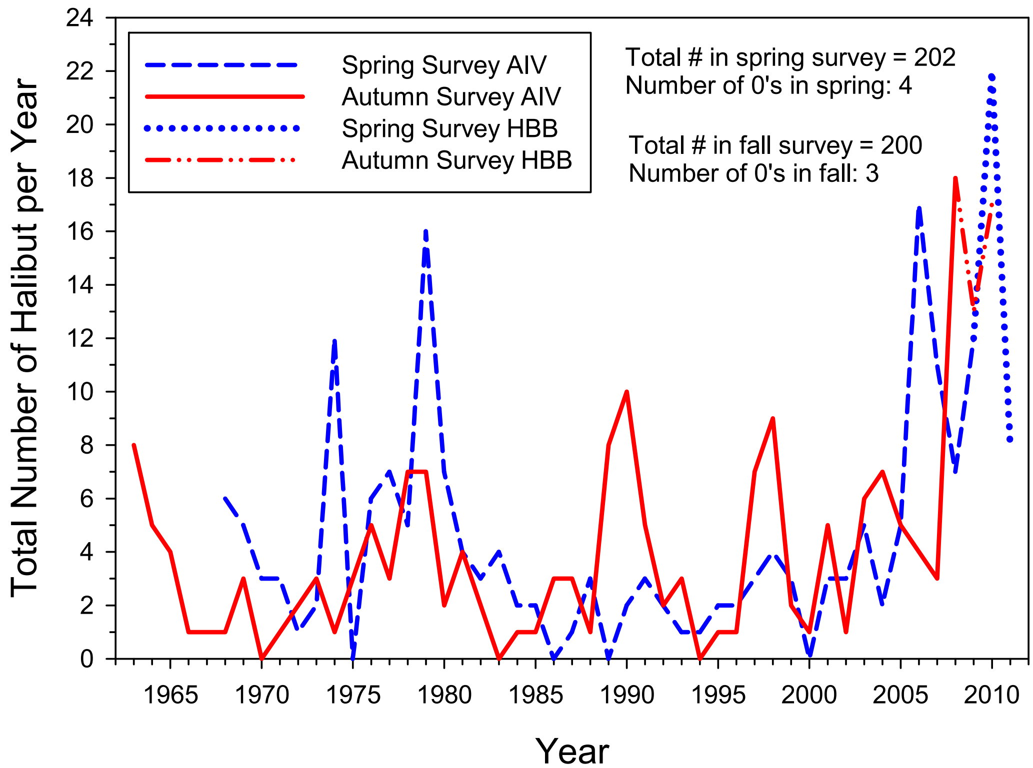
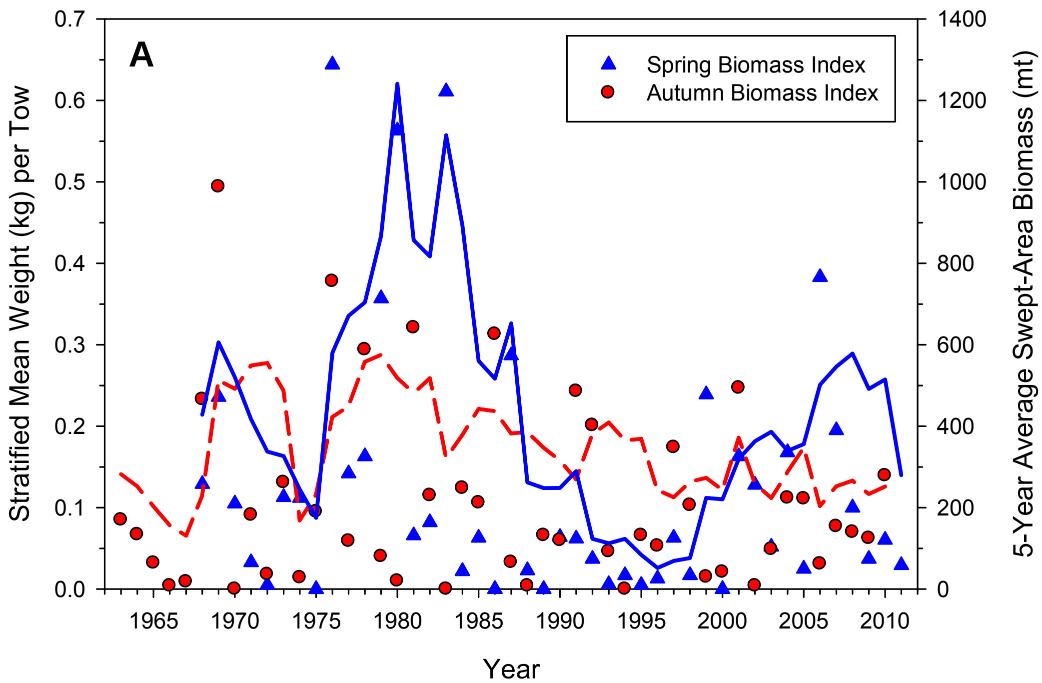


Figure M8. Total numbers of Atlantic halibut caught annually in the Northeast Fisheries Science Center spring and autumn bottom trawl surveys, using the R/V *Albatross IV* (AIV) until spring 2009, and the R/V *Henry B. Bigelow* (HBB) starting in autumn 2009.



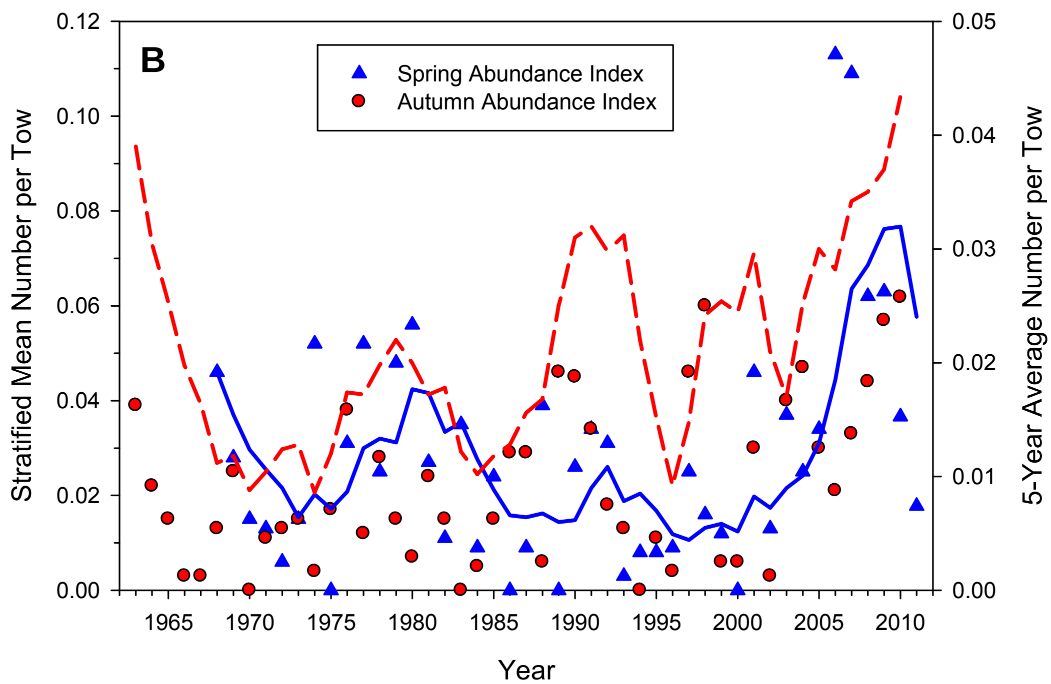


Figure M9. Northeast Fisheries Science Center survey trends for Atlantic halibut from the Gulf of Maine-Georges Bank region (offshore strata 13-30, 36-40), 1963-2011: A) weight per tow indices and 5-year average swept-area biomass for spring (solid line) and autumn (dashed line), and B) number per tow indices and 5-year average number per tow for spring (solid line) and autumn (dashed line). Note: these indices include the conversion from *Henry B. Bigelow* to *Albatross IV* units as of autumn 2009 (see Tables 5 and 6).

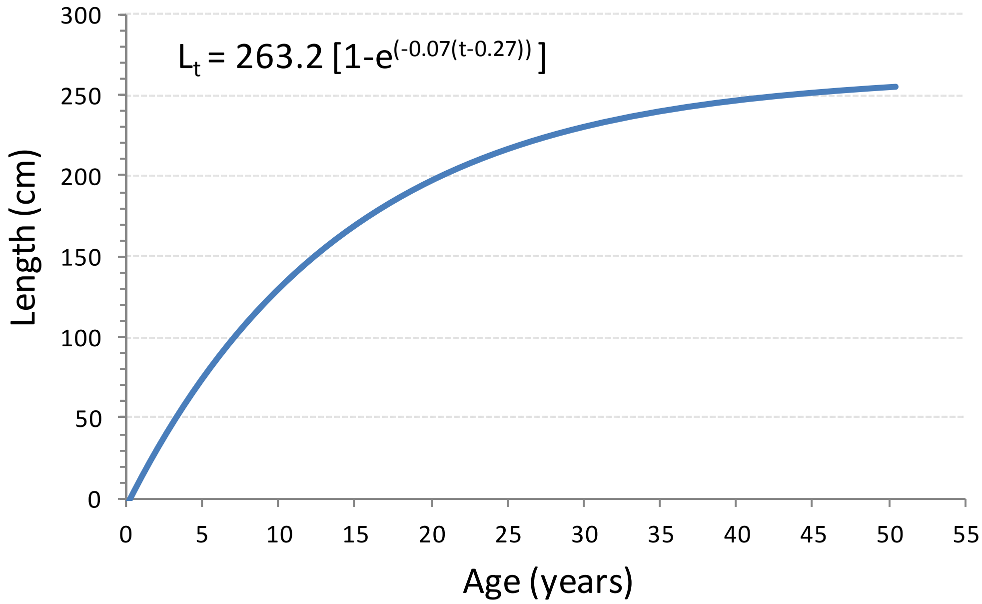


Figure M10. Von Bertalanffy growth for female Atlantic halibut from Sigourney 2002 (Col and Legault 2009).

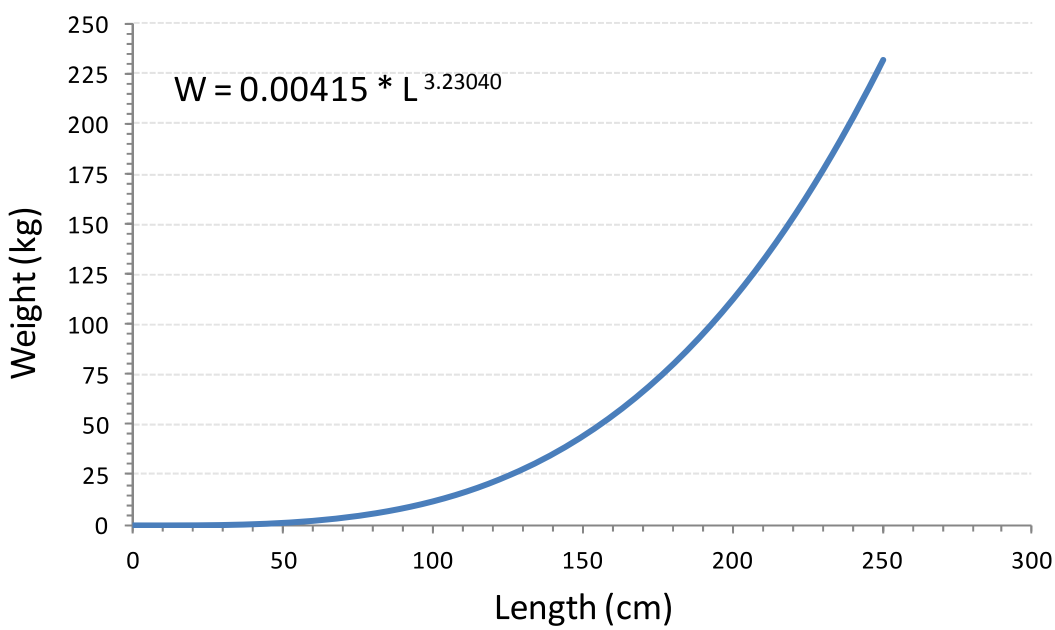


Figure M11. Female Atlantic halibut length-weight relationship (Col and Legault 2009).

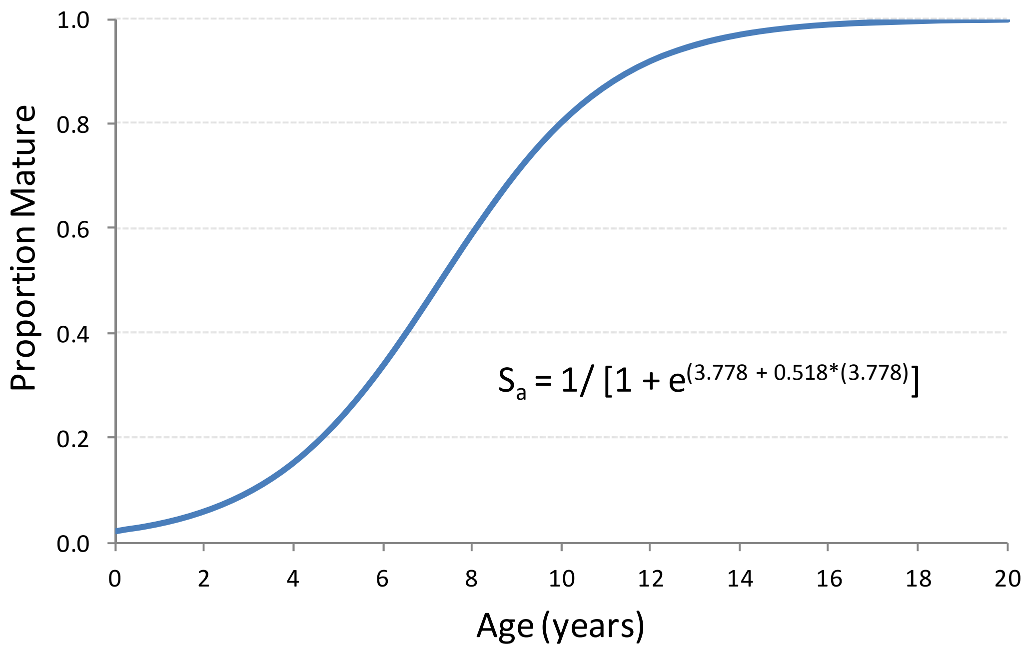


Figure M12. Maturity ogive for female Atlantic halibut based on Sigourney et al. 2006 (Col and Legault 2009).

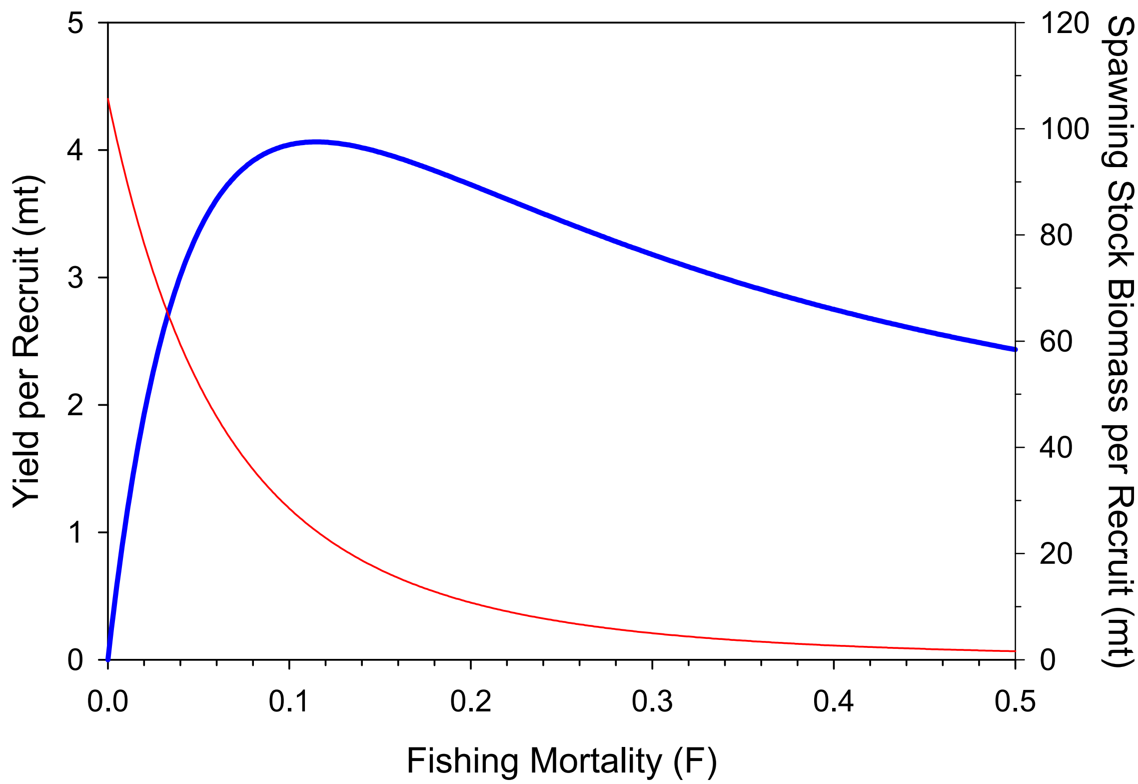


Figure M13. Yield per recruit and spawning stock biomass per recruit for Atlantic halibut (Col and Legault 2009).

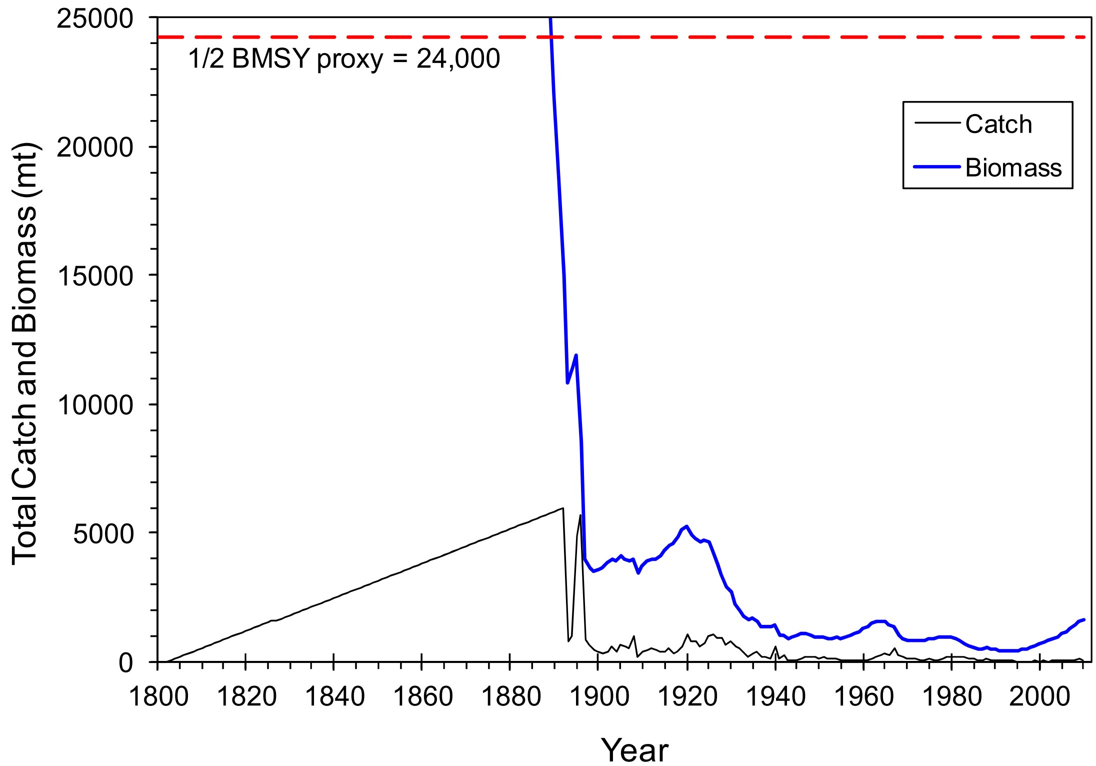


Figure M14. Atlantic halibut catch, and biomass and ½ BMSY proxy estimated from the Replacement Yield Model (M = 0.15).

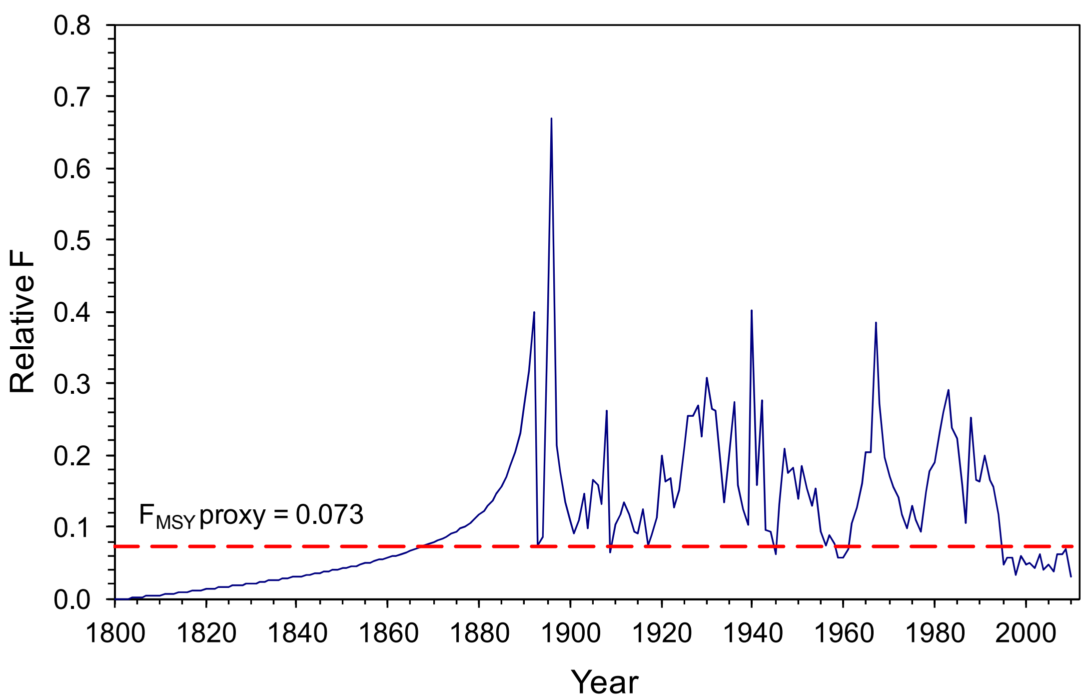


Figure M15. Atlantic halibut relative fishing mortality from the Replacement Yield Model (M = 0.15).

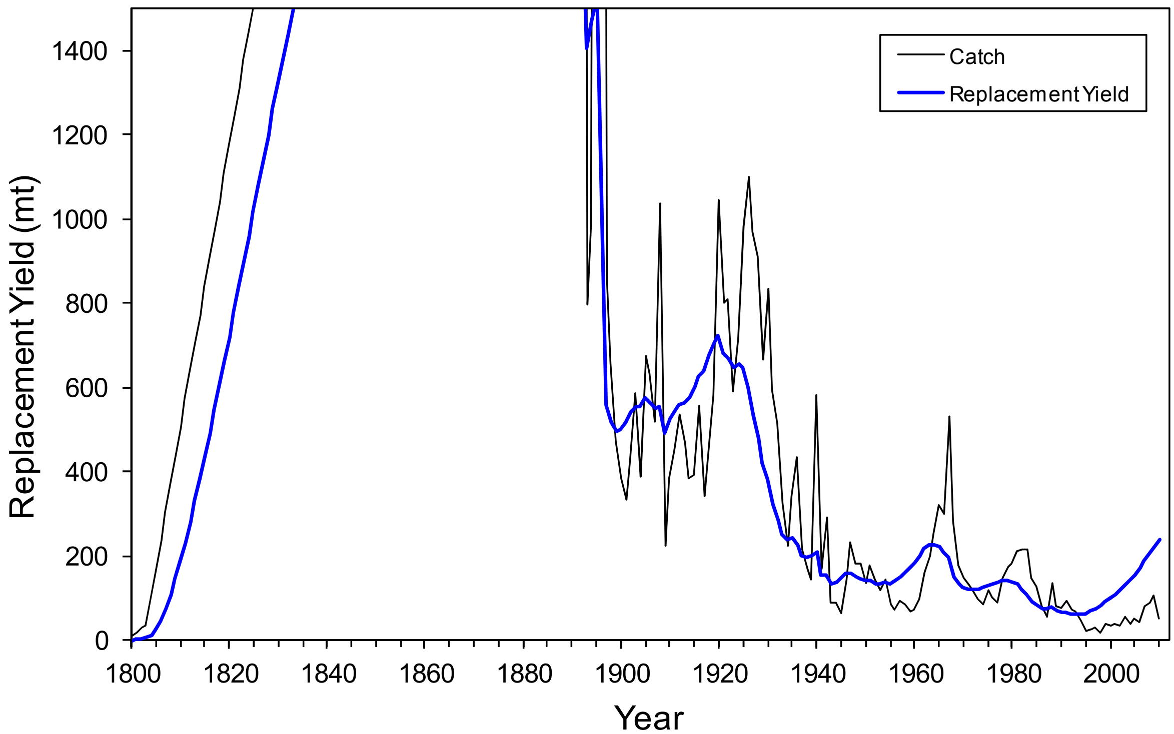
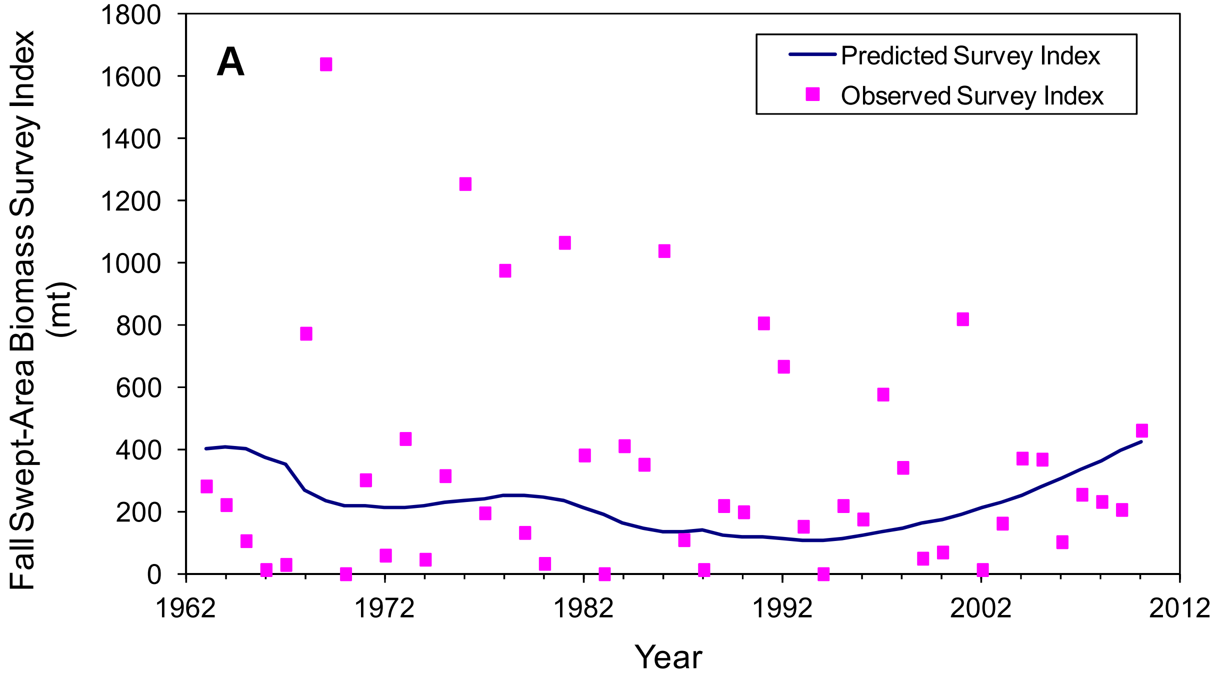


Figure M16. Atlantic halibut replacement yield from the Replacement Yield Model (M = 0.15).



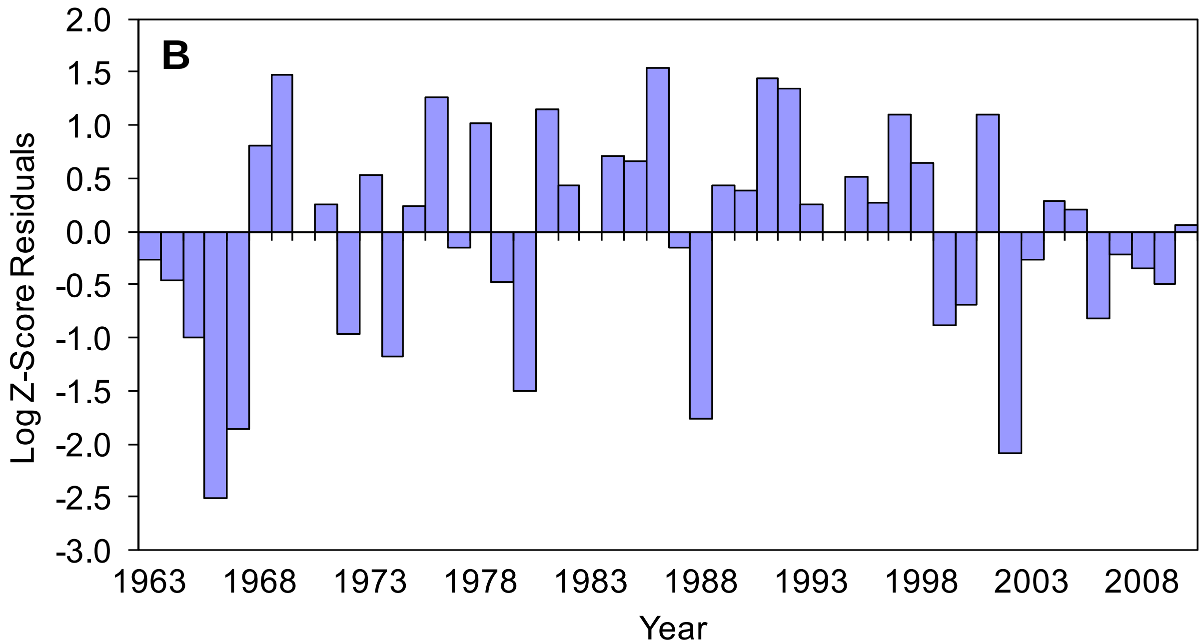


Figure M17. Atlantic halibut swept-area biomass estimates: A) observed indices based on the Northeast Fisheries Science Center autumn survey and predicted indices from the Replacement Yield Model, and B) log Z-score residuals.

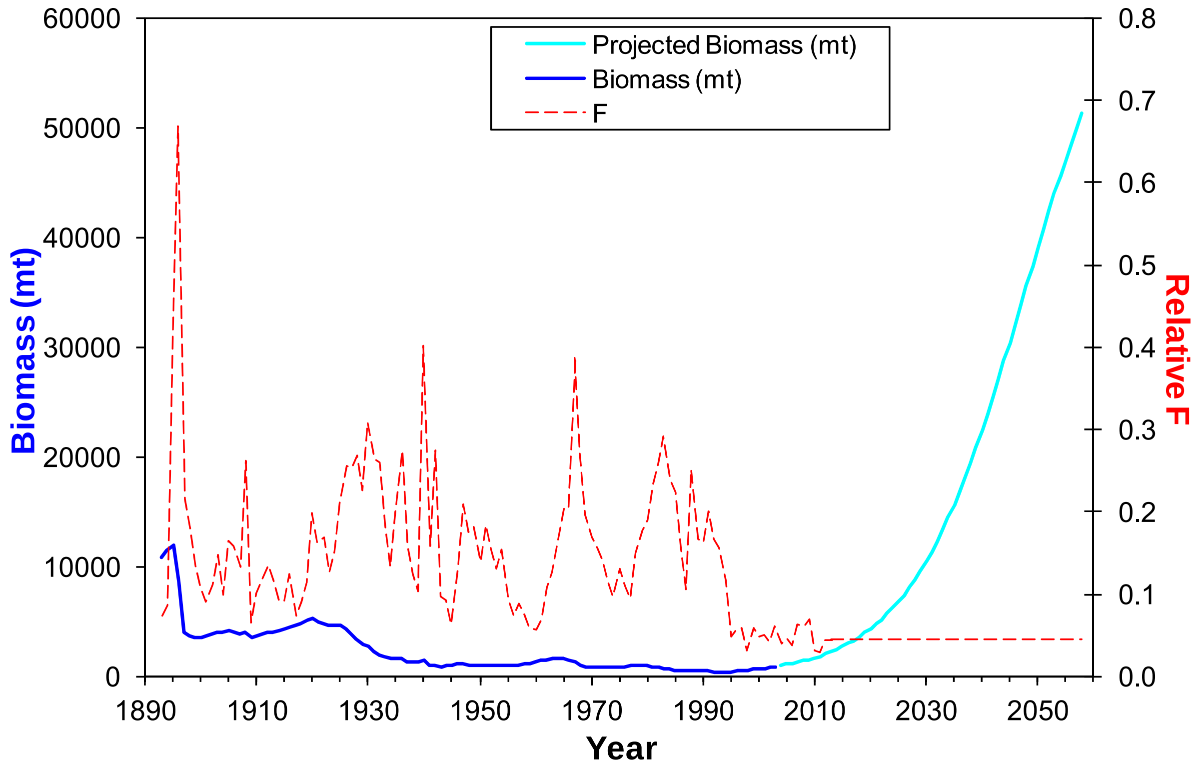


Figure M18. Projected biomass and fishing mortality under a rebuilding scenario with a constant $F_{rebuild}$ = 0.044 after 2011.

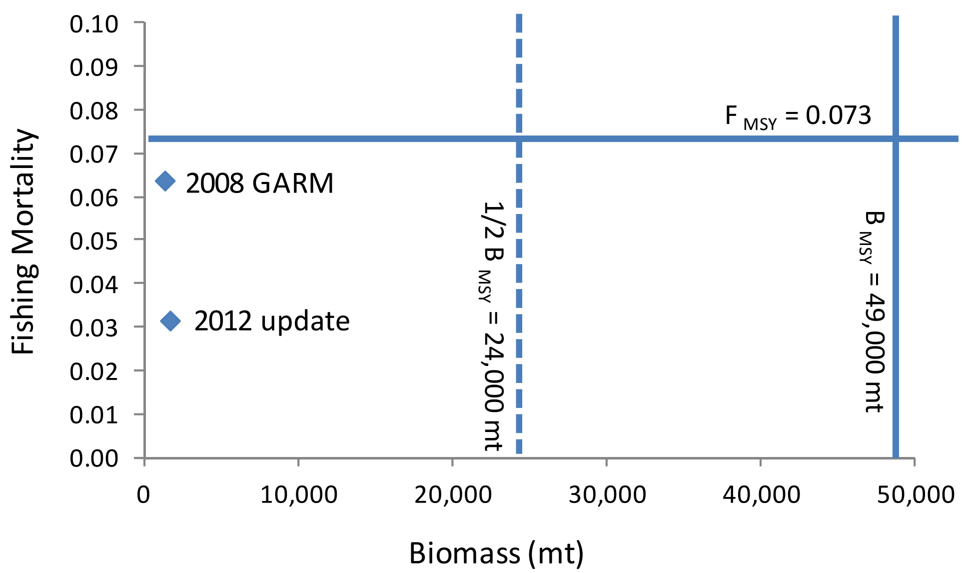


Figure M19. Status plot for Gulf of Maine-Georges Bank Atlantic halibut.

IV. Appendices

Appendix 1. Description of New Assessment Process

[NOTE TO READERS: This following text is an excerpt from of a white paper delivered to the Northeast Regional Coordinating Committee on April 6, 2011. The paper was written by a subcommittee of the NRCC known as the ACL Working Group. At the time the paper was delivered, the ACL WG was chaired by Dr. Richard Merrick, NEFSC. Among other things, the NRCC asked the ACL WG to "Define a system for delivering operational assessments (Task 3)", "Define a system for a Research Track (Task 4)" and "Develop a transition plan (Task 5)". Those three sections of the report are included here. The report represents a plan and vision for the future. At the time the report was written, the process had not been tested or put into practice.]

NOAA Fisheries Response to NRCC Tasking to Develop a New Process for Assessment of Managed Fishery Resources off the Northeastern United States

Task 3: Define system for delivering operational assessments - Establish general framework for how system will function, outlining:

a. Roles and responsibilities of participant groups: NEFSC; Council and Commission PDTs, working groups, and technical committees; SSCs ; external scientific expertise; public participation - The NRCC will remain responsible for final scheduling of assessments, and for oversight on the general a Terms of Reference for assessments. Operational assessments themselves will be prepared by NEFSC or Council/Commission staff. A senior NEFSC assessment scientist and the chairs of the Mid-Atlantic and New England SSCs will constitute the Assessment Oversight Panel and will be advised by staff of the NERO, NEFMC, MAFMC, and ASMFC. The public may participate in the deliberations of the AOP. Finally, peer review of operational assessments will be conducted by an Integrated Peer Review team including at least the lead assessor(s), the SSC member responsible for the stock, and an assessment scientist either from outside of NMFS or if from within NMFS, from outside of the lead assessor's working group. Results from the peer review will then be forwarded to the PDT/TC/SSC for the Councils' use in the ABC setting process.

b. Terms of reference - The baseline model, developed as part of a previous benchmark assessment or through the research track, will be used to produce operational assessments. Typically, this will be the model used at the last operational assessment and the process for application of the model will follow Figure 1:

i. Step 1 - In the year prior to an operational assessment year, the NRCC will meet to determine the final operational assessment schedule for the next year. This schedule will build off of the 2-5 year assessment intervals for stocks that reflect the NEFMC /MAFMC/ASMFC specification setting cycles and stock biology.

ii. Step 2 - After the NRCC has set the schedule but prior to initiating the operational assessments, each lead assessor will determine how the baseline model will be applied in his/her upcoming operational assessment. Little, if any, change is expected or encouraged in the application of the baseline model in the operational assessments. However, it is incumbent upon the lead assessor to consider all relevant results from the research track, and to explore applying them in the operational track. Each assessment will be guided by the following generic Terms of Reference prepared to guide all operational assessments, with some tailoring to meet the characteristics of individual stocks:

1. Update all fishery-dependent data (landings, discards, catch-at-age, etc.) and all fishery-independent data (research survey information) used as inputs in the baseline model or in the last operational assessment.
2. Estimate fishing mortality and stock size for the current year, and update estimates of these parameters in previous years, if these have been revised.
3. Identify and quantify data and model uncertainty that can be considered for setting Acceptable Biological Catch limits.
4. If appropriate, update the values of biological reference points (BRPs).
5. Evaluate stock status with respect to updated status determination criteria.
6. Perform short-term projections; compare results to rebuilding schedules.
7. Comment on whether assessment diagnostics—or the availability of new types of assessment input data—indicate that a new assessment approach is warranted (i.e., referral to the research track).
8. Should the baseline model fail when applied in the operational assessment, provide guidance on how stock status might be evaluated. Should an alternative assessment approach not be readily available, provide guidance on the type of scientific and management advice that can be.

iii. Step 3 - The Assessment Oversight Panel (AOP) will meet with all of the lead stock assessors to review each stock's proposed operational assessment. All stocks proposed for the assessment year will be reviewed by the Assessment Oversight Panel at this meeting(s).

1. The Assessment Oversight Panel will be composed, at a minimum, of a senior NEFSC assessment scientist, and the chairs of the Mid-Atlantic and New England SSCs, and will be advised by staff of the NERO, NEFMC, MAFMC, and ASMFC. Should an SSC Chair be a NEFSC scientist or not have the appropriate skills to technically review assessments, the SSC will appoint an alternative member scientist to the Assessment Oversight Panel.
2. The Assessment Oversight Panel meeting will be open to the public.
3. The purpose of the AOC's review is to finalize the Terms of Reference for each assessment and review the assessor's proposed approach for every assessment.
4. Each assessor is also expected to provide an alternative approach to the assessment should the baseline model fail.
5. The Assessment Oversight Panel review will focus on any proposed changes in the baseline model proposed by the lead assessor, recognizing that the

proposed modeling approach should follow the baseline model as closely as possible (Terms of Reference need development for this review). Other possible approaches to the assessment can be discussed, and proposals from other potential assessors can also be tabled. However, any approaches significantly different from the baseline model will be referred to be research track for study, development, and peer review.

6. The Assessment Oversight Panel may determine that, based on advice from the lead assessor, that the baseline model will not work; if so, the alternative approach will be implemented in the operational assessment, and the stock will be referred to the research track.

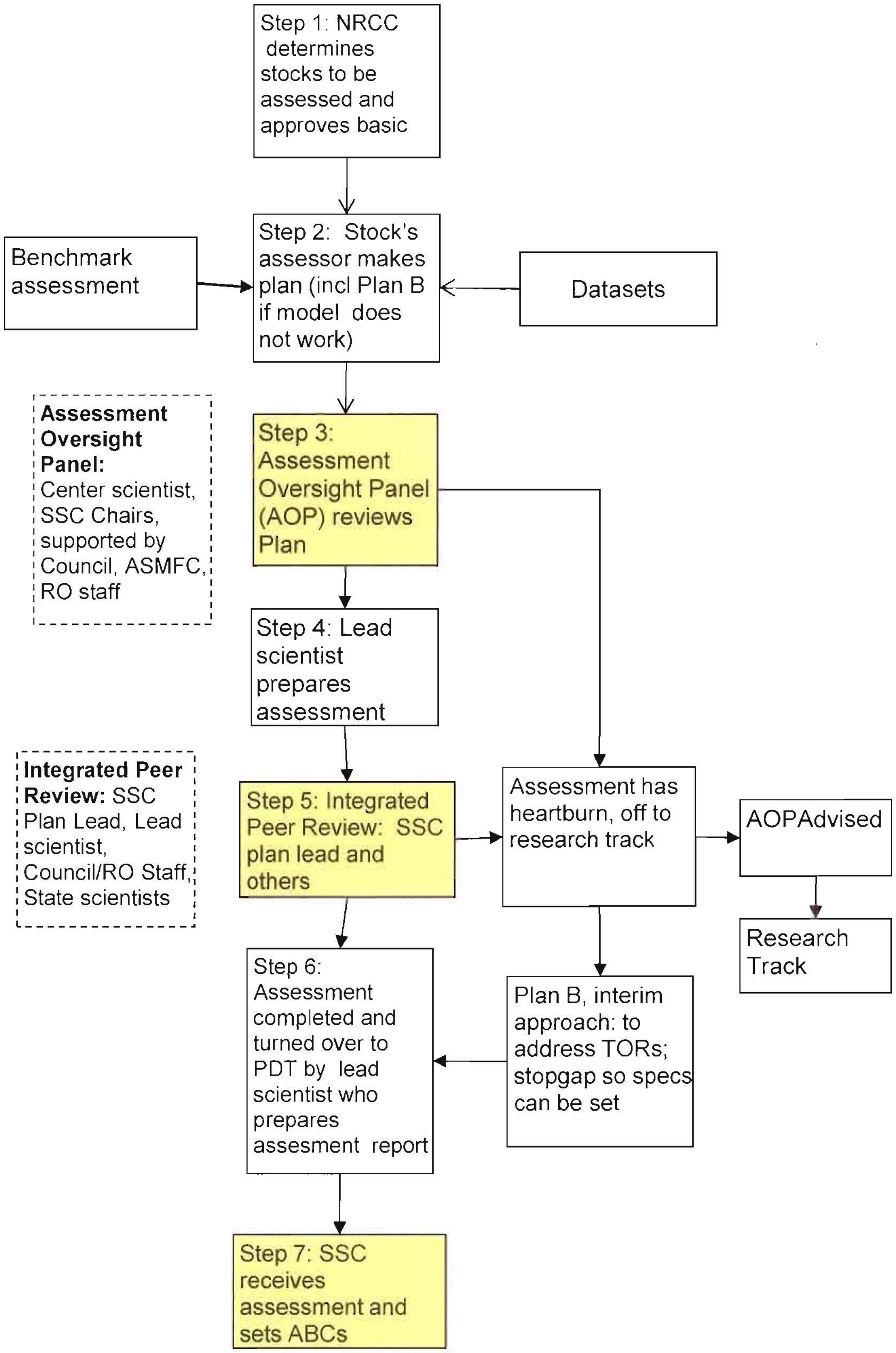


Figure 1. New Stock Assessment Framework

iv. Step 4 - The operational assessment will then be developed by the lead assessment scientist.
v. Step 5 – The operational assessment will be subjected to an Integrated Peer.
vi. Step 6 – PDT/TC review of assessment with conclusions forwarded to SSC.
vii. Step 7 – SSC review of assessment with ABC recommendations forwarded to Council.

c. Operational assessment development completion process and finalization - Following the Integrated Peer Review of an operational assessment, two reports will be provided to the appropriate PDT/TC. One report will summarize the results of the Integrated Peer Review (and authored by the Chair of the Integrated Peer Review). The second report will be the assessment document, which will be an NEFSC Reference Document, and will serve as the basis for the stock status determination (and will be authored by the stock's assessment scientist). A standardized template will be used in preparing this report (see attached Appendix Figure 1). The SSC will then review the two reports, and the PDT/TC recommendations. The SSC will also review situations where the Integrated Peer Review determined the baseline model was inappropriate and where the Integrated Peer Review subsequently provided scientific and management guidance based on an alternative approach.

d. Process for identifying interim year stock evaluation metrics through operational assessment - In years between operational assessments, the PDT/TC will provide assessment data and information to the SSC. Such information could include: a) Recent survey indices, and recent landings and discard estimates, b) projections based on the last operational assessment, and c) resource status and/or fishery performance metrics. The PDT/TC (as supported by the NEFSC) will be responsible for obtaining the above data, updating projections, and providing the relevant information to the SSC.

e. Peer review of operational assessment outputs (uncertainties, interim year stock evaluation metrics, etc.), Process to be applied (integrated/internal, handoff/external) - The operational assessment will be subjected to an Integrated Peer Review by a team including at least the lead assessor(s), the SSC member responsible for the stock, and an assessment scientist either from outside of NMFS or if from within NMFS, from outside of the lead assessor's working group. Terms of Reference remain to be developed for the Integrated Peer Review. The Integrated Peer Review will make the determination whether the completed operational assessment is technically sufficient to (a) evaluate stock status and (b) provide scientific advice; (c) successfully address the Terms of Reference. The Integrated Peer Review may determine that application of the baseline model in the operational assessment has not worked; if so, the alternative approach to the assessment will be implemented, and the stock will be referred to the research track.

f. Define amount of latitude/modification of methods is permissible from established assessment baseline - A stock assessment will be a candidate for development of a new (or substantially revised) assessment approach via the research track if one or more of the following criteria apply, as determined during the peer review of the operational assessment:

i. A change in stock definition is contemplated.

ii. Diagnostics from the operational assessment indicate the assessment model is inadequate to continue to serve as a scientific basis for management.

iii. New types of input data are available which, if incorporated into the assessment, might significantly change the assessment results. A significant change is one in which the estimates of stock size and OFL might differ by a stock specific amount (e.g., 20-30% for groundfish) from the assessment estimates without incorporating such new types of data.

iv. A significant retrospective pattern has become evident in the assessment estimates of stock size, fishing mortality, or recruitment.

v. A significantly different value of natural mortality (e.g., derived from analysis of trophic interactions) is considered appropriate in characterizing non-fishing stock dynamics.

vi. Significant changes in management practices have occurred that have markedly reduced the accuracy and utility of the existing assessment data inputs, or significantly diminished the reliability or validity of the assessment model itself.

vii. If any of the above criteria are met, the issue will be referred (through the Center Director/appropriate SSC Chair) to the research track for development of a new baseline model. However, until the issue is resolved for use in an operational assessment, either the existing baseline model or the alternative assessment approach will be followed. Note that not all topics referred to the research track will indicate that the baseline model is an inappropriate analytic tool.

viii. If the assessment is considered acceptable by the Integrated Peer Review but involves significant deviations from the approach outlined from in the Assessment Oversight Panel review, then the assessment <u>may</u> be referred back to the Assessment Oversight Panel with a brief description of changes that were made from what was agreed to during the Assessment Oversight Panel review. The Assessment Oversight Panel can then review as necessary (and likely by correspondence) the assessment, and determine the course of action for the assessment.

a. <u>Protocols for incorporation of results into fishery management plans (as needed, i.e., regulatory changes or specifications process)</u> – See Task 5, but an example of how the process would work (compared to the prior years) is shown in the Figure 2.

Task 4: Define system for research track - Establish general framework for how system will function, outlining:

a. Roles and responsibilities of participant groups: NEFSC; Council and Commission PDTs, working groups, and technical committees; SSCs; external scientific expertise, and public participation - SSC Chairs, and the NEFSC Science and Research Director will refer stocks to the NEFSC for development of new approaches to the assessment through the research track. The NRCC will be responsible, as appropriate, with prioritizing the research projects. External experts will participate in the development and peer review of the research, and the public will be invited to sit in on the peer review.

b. Protocols for remand, re-examination, addressing errors or new information (as needed) - The research track will be used to develop improved stock assessment models and approaches, and will not provide stock status determinations. Three general types of research projects will be referred to the research track: (1) stocks where the analytic method works but some biological issue requires investigation (e.g., stock structure), (2) stocks where application of the baseline model has not worked, or where a competing model has been suggested as a better analytic approach, and (3) stocks where an acceptable assessment has not yet been developed. The research track is not, however, meant as the repository for a host of research items. A stock assessment will be a candidate for development of a new (or substantially revised) assessment approach via the research track if one or more of the following criteria apply, as determined during the peer review of the operational assessment:

   i. A change in stock definition is contemplated.
   ii. Diagnostics from the operational assessment indicate the assessment model is inadequate to continue to serve as a scientific basis for management.
   iii. New types of input data are available which, if incorporated into the assessment, might significantly change the assessment results. A significant change is one in which the estimates of stock size and OFL might differ by a stock specific amount (e.g., 20-30% for groundfish) from the assessment estimates without incorporating such new types of data.
   iv. A significant retrospective pattern has become evident in the assessment estimates of stock size, fishing mortality, or recruitment.
   v. A significantly different value of natural mortality (e.g., derived from analysis of trophic interactions) is considered appropriate in characterizing non-fishing stock dynamics.
   vi. Significant changes in management practices have occurred that have markedly reduced the accuracy and utility of the existing assessment data

inputs, or significantly diminished the reliability or validity of the assessment model itself.

c. Terms of Reference – TORs for research track activities will vary depending on the reason for forwarding a project to the research track. Research track TORs for new baseline assessment models would include:
    i. Develop scientifically valid methodologies and models to serve as the baseline model in future operational assessments. All new assessment models/approaches will be tested on datasets from the last operational assessment.
    ii. Identify a framework /protocol for using available data to monitor the fishery and stock, and for setting specifications during the interval between operational assessments.
    iii. Identify the metrics most useful to monitor in evaluating whether a management change may be needed
    iv. Develop BRPs that are consistent with any newly-developed assessment model or methodologies
    v. Suggest alternative approaches to assessing the stock should the baseline model fail when applied in a future operational assessment

d. Peer review of transitional assessment results - Work products developed in the research track will undergo an independent peer review process, which may be similar to that used in the Stock Assessment Review Committee/SARC (e.g., a sequential peer review involving the Center for Independent Experts and chaired by an SSC member).

e. Process for transitioning a research assessment to an operational assessment baseline - The timing of research within the research track should be such that all work is completed and peer reviewed before the next scheduled operational assessment. At end of research track:
    i. A decision will be made by the peer reviewers as to whether (a) the work products are adequate to replace the existing baseline model; (b) the new model or methods can be run either from the assessment model toolbox or through other available software; and (c) the revised/new BRPs are technically appropriate.
    ii. Once accepted by the peer review panel, the new assessment model/approach will become the new baseline model.
    iii. To facilitate timely incorporation of new, peer-reviewed baseline research into the operational track, the NRCC will review the operational assessment schedule in response to research track output and may amend the operational assessment schedule, subject to the availability of resources.

Task 5: Develop transition plan - Establish general framework for how system will function, outlining:

a. Identify FMPs that would require regulatory changes to be more responsive to scientific advice. To better match available resources to management needs, because the current assessment process cannot meet the increased management needs of an annual catch limit (ACL)-based management program for every fishery. If the current practices are significantly changed, FMPs and implementing regulations will need to be amended accordingly.

   There are currently 50 managed stocks in the Northeast Region, in 13 Fishery Management Plans (FMPs), managed under Magnuson-Stevens Act (MSA) authority. Each FMP and its implementing regulations describe a process for setting specifications or making framework adjustments to the fishery on a periodic basis.

   Although the MSA requires ACLs to be set for each stock in a fishery, ACLs can be set for more than 1 year at a time (e.g., a 3-year specification action could set ACLs for each of the 3 years; the ACLs could be the same for each year in the cycle, or different). With the exception of Atlantic salmon, for which there is no fishery, the authority currently exists, or will likely soon exist through the MAFMC's Omnibus ACL/AM Amendment, in every FMP, for setting multi-year specifications (see Table 5). The currently authorized specification periods are from 2 to 5 years, but generally are 2 or 3 years. In the Mid-Atlantic, the ACLs and related specifications are established through specification actions, which are implemented through proposed and final rulemaking. In New England, fishery specifications are established through Framework Adjustments, which are also implemented through proposed and final rulemaking.

   While the authority for multi-year specification setting has existed in most fisheries for several years, it has been used only to a limited extent. In the Mid-Atlantic, only the surfclam and ocean quahog fisheries have routinely been managed through multi-year specifications, though tilefish has been operating under a constant-catch scenario, pending the next stock assessment. Two-year specifications were set for the summer flounder fishery once, but the specifications were subsequently changed in the second year in response to new information; multi-year specifications in this fishery have not been used again. In New England, the scallop, groundfish, skate, and monkfish fisheries are managed through biennial Framework Adjustments; the herring fishery is currently under a 3-year specification cycle, and it is anticipated that the small-mesh groundfish species will be managed through 3-year specifications, beginning in FY 2012. In some cases (e.g., groundfish and scallops), "biennial" adjustments in New England have established specifications for 3 years, as a default in case the next biennial adjustment specifications are delayed.

If use of multi-year specifications is to be expanded, the ACL Working Group has recommended that there be objective criteria identified that would be used to determine a rational schedule for operational assessments; biologically-based criteria are being developed by the Task 2 Working Group ("Develop prioritization and scheduling system for operational assessments"). These criteria are based on the properties of each stock, including such factors as life history, stock condition, recruitment patterns, stock resilience, etc. It is envisioned that these criteria would be used, at least in part, to determine the optimal frequency of operational assessments for each stock or group of stocks, and that the operational assessments would be coupled with specification/adjustment processes to convert the results of the assessments into management action. In addition to the biological criteria, there are other aspects of management that should be considered by the NRCC in determining the frequency of assessments and specification setting; these other factors are discussed under item 5.b. below.

If, based on the criteria developed by the Task 2 Working Group and consideration of the information described under item b. below, the NRCC concludes that the optimal frequency of assessment and specification setting for a stock is not consistent with the authority in the FMP (e.g., if the NRCC determines that assessments and specifications for surfclams be done every 7 years, but the Surfclam Ocean Quahog FMP only allows specifications to be set for up to 3 years), then that FMP will need to be amended to provide that authority. This could be done through either an FMP amendment or framework action, as appropriate, either as part of another action (i.e., combined with changes to other management measures in the FMP), or as a stand-alone action. Such a change should be relatively straightforward, from a technical standpoint. If the optimal frequency of assessment and specification setting is within the existing authority in an FMP, no change to the FMP or implementing regulations would be required.

Each FMP and its implementing regulations define the fishing year for each stock or groups of stocks (see Table 6). Fishing years can be changed, if doing so would spread workloads or make it easier to use the most recent scientific and/or fishery information for the operational assessment and associated specification setting. The issues associated with changing fishing years are discussed in item c. below. If the NRCC determines that the timing of assessments and/or the resultant specifications is such that it is desirable and/or necessary to change the starting date of any fishing year, this could be accomplished through either an FMP amendment or framework action, as appropriate to the FMP, with an associated proposed and final rule to change the implementing regulations. This would require analysis of the environmental, economic, and social impacts of such a change.

Each FMP and its implementing regulations also describe a process for specification setting or framework adjustments, including the parties involved (e.g., Plan

Development Teams (PDTs), Fishery Management Action Teams (FMATs), Technical Committees, Monitoring Committees, Councils, Scientific and Statistical Committees (SSCs), etc.) and their respective roles; the timing of the process; and the range of specifications and/or adjustments that can be made through that process. If the new assessment/specification process approved by the NRCC requires changes to the existing process in a given FMP, there would need to be a change to that FMP and to its implementing regulations to define the new process for setting specifications and/or adjustments.

If multi-year specifications are used more extensively, which is recommended by the ACL Working Group, it is likely that the Councils will want some way to ensure that the specifications for out-years (e.g., years 2 and 3 in a 3-year specification cycle) are still appropriate. The approaches to doing this are discussed in item d. below. If the Councils choose to provide for out-year adjustments or responses to new information, establishing the process and criteria to be used to do that may require changes to the FMP and its implementing regulations. This could be done through an FMP amendment or framework, as appropriate to the FMP, and implemented through proposed and final rulemaking, which would likely be relatively straightforward. If the existing process in an FMP is sufficient to accommodate the adjustment approach (e.g., if the Council chooses to use the current specification process to make the out-year adjustment), no changes to the FMP or regulations would be necessary.

Summary/Recommendations: Changes in multi-year authorities, fishing years, specification processes, and/or out-year adjustment procedures that result from the NRCC's decisions on the new assessment process will need to be made through FMP amendments or frameworks, as appropriate to the FMP, with accompanying changes to the implementing regulations, and the expected impacts of those changes will need to be analyzed as part of that process. If multiple FMPs need to be amended, an omnibus amendment could be an efficient way to accomplish this. The regulatory sections of 50 CFR that would potentially need to be amended are listed in Tables 6 and 7 (these could be different if/when the MAFMC's Omnibus ACL/AM amendment is implemented). The administrative/regulatory changes would take several months for the Councils to develop, and 5 -7 months for NMFS to review, approve, and implement.

b. Define optimal duration of specifications by stock (connected to Task 2) - To match assessment advice to the management cycle, provide greater stability and predictability to the process and for the industry, and streamline the process to better balance workloads of Council and NMFS staff. Staggering the assessment and specification processes for different fisheries and/or stocks would spread out the assessment and specification setting workloads.

As discussed above under item 5.a., authority already exists to use multi-year specifications, and any additional authorities could be obtained through FMP amendments and/or frameworks, if necessary. To rationalize the frequency of operational assessments and the setting of multi-year specifications, the ACL Working Group has recommended that criteria should be established to determine the most appropriate duration of specifications for each stock and/or fishery. The Task 2 Working Group is developing biologically-based criteria for this purpose, to consider such things as life histories, generation times, stock status, stock resiliency, etc. However, there are other issues that are also relevant to these decisions, such as the importance of the fishery (value, number of participants, etc.), the stability of the fishery and the resources, whether the stock is overfished or experiencing overfishing, where the stock is relative to the end of a rebuilding plan, past performance of the management program, etc. Table 8 summarizes information for each managed stock that could be relevant for determining optimal assessment and specification cycles, but does not include the results of the Task 2 workgroup, which are not yet available. A first cut at estimating what appropriate assessment and specification frequencies might look like is also provided, as a straw man for further discussion. The frequencies vary from 3 to 7 years. The largest challenge will be the 20 multispecies stocks; it would be very difficult to assess all 20 stocks in the same year. It is possible, however, that the multispecies stocks could be grouped in such a way that the most important stocks (e.g., cod, haddock, yellowtail flounder, etc.) are assessed more often than the minor stocks (e.g., ocean pout, wolffish, cusk, halibut, etc.), and/or that groups of stocks could be assessed at staggered times (e.g., the roundfish in the same year, and the flatfish in a different year.

<u>Summary/Recommendations:</u> For the proposed process of operational assessments to make meaningful and necessary changes to better match assessment resources to management needs, the use of multi-year specifications will need to be expanded. To rationalize the decision process, it is recommended that there be science-based criteria developed (by Task 2 Working Group), and that other factors such as those in Table 8 also be considered by the NRCC, such that the assessment/specification process can be optimized consistent with available assessment resources. The implications of doing this are explored further under item c. below. One hurdle to be overcome is the timing of the start-up of a new process, because the benefits of a staggered assessment/specification process will not be realized immediately.

c. <u>Examine modifications to fishing years, specifications cycles to optimize available resources (i.e., offset FMPs by years, change seasons to better synchronize with survey data and analytical availability)</u> - Establish a schedule that ensures that operational assessment results are available at the right times to feed into the Councils' specification/adjustment processes; stagger the process such that the assessment workloads are manageable with existing resources.; and make best use of scientific and fishery-dependent data in the operational assessment and specification setting process.

Table 6 shows the current fishing years for Northeast MSA-managed stocks. Most fishing years are based on calendar years, and begin on January 1. Four fishing years (groundfish, spiny dogfish, skates, and monkfish) start May 1. Two fishing years (scallops and red crab) begin on March 1. Only one fishing year (tilefish) begins November 1. The current staggered fishing years provide some administrative benefits, in that they spread out the specification processes such that not all specifications are being developed, submitted, reviewed, published, and implemented at the same time. On the other hand, having different fishing years for different fisheries could be more confusing to the public and the industry than a standard fishing year across all fisheries. Also, having fishing years not aligned with calendar years causes some complications in data reporting and use in assessments (assessments are generally based on calendar year data and specifications for some fisheries are not). A downside of having all fishing years begin January 1 is that the specification packages and implementing rules must be processed late in the year, when holidays and weather can cause delays, and when many Federal agencies, including other regions of NMFS, are trying to get year-end actions in place and published in the Federal Register.

Making changes to fishing years to facilitate availability of assessment and/or data (surveys, landings data, recreational data, etc.) is administratively straightforward, but may be complicated by resistance from the fishing industry, since there are practical aspects of the timing of the fishing year such as fish availability (inshore/offshore, north/south, among different states or regions, etc.), fish prices, fish quality, weather, etc. For example, recent attempts to change the Atlantic sea scallop fishing year were vigorously opposed by industry. Nevertheless, this remains an available mechanism to better align scientific advice and the management process, as well as to stagger assessments and specification setting within the same year.

The ability to change fishing years is not explicitly frameworked in any FMP, though the frameworkable measure descriptions for many fisheries are broad (see Table 7). FMP amendments would likely be needed to change the fishing years in most, if not all, FMPs, given recent litigation that found that frameworking options may be narrower than previously assumed. The impacts of any changes to a fishing year would need to be analyzed along with the amendment.

Changes to the specification/adjustment processes are listed as frameworkable measures in several FMPs (Atlantic Mackerel, Squid, Butterfish; NE Multispecies; Summer Flounder, Scup, and Black Seabass; Tilefish), and may be possible under the broad interpretation of frameworkable measures in others (Table 7). Depending on the FMP and the magnitude and impacts of such changes, they could be accomplished through FMP amendments or frameworks.

The staggering of specification/adjustment cycles will be necessary to accomplish meaningful resource-smoothing, i.e., to ensure that assessment resources are deployed to provide the necessary scientific advice on a schedule that is appropriate to each fishery. The frequency of assessments and specifications will depend on the results of the Working Group for Task 2 regarding biological criteria for assessment frequency, and on the other factors discussed above in item b., and in Table 8. Regardless of the final decisions on assessment/specification frequency made by the NRCC, it will be necessary to schedule assessments such that they meet the timelines of the Council and ASMFC processes (i.e., that the final operational assessment results feed into the management process in a way to allow them to be used quickly), and that they are sufficiently spaced to allow the assessment process to be completed with existing resources. In addition, to allow flexibility in making out-year changes to multi-year specifications, changes to the analyses accompanying the specification/adjustment actions will be necessary (see item 5.e. below).

The current status of specification and adjustment schedules is shown in Table 9, and the frequency and timing of specifications and adjustments based on the straw man assumptions in Table 8 are shown in Table 10. There would be a significant start-up workload, because the new process would necessitate a large number of specifications/adjustments to be performed in the first year as the new processes and schedules are phased in. The information in Table 10 is for illustrative purposes, and is subject to change based on decisions by the NRCC. Table 11 illustrates an example comparing the status quo process with the proposed operational/research track process.

Summary/Recommendations: Changing fishing years is possible, but may be opposed by the industry, if there are significant practical implications of the changes. Nevertheless, it is a tool available to stagger the starts of fishing years and/or to align assessments and specification setting with the availability of input data. It will be necessary to stagger the operational assessments and specification setting for different fisheries, consistent with biological and management factors discussed under item b. above. The start-up of the new process will require a large investment of resources to transition to the new process, since most fisheries will need initial specifications set in the first year or two, before the staggered schedules are effective at spreading out the assessments and specification setting.

d. Discuss issues/policy for interim year modifications to established multiple year specifications. - If multi-year specifications are used more extensively, and there are limited resources available to provide assessment advice to the Councils and/or ASMFC outside of the operational assessment process, there needs to be a way to ensure that the specifications remain appropriate throughout the specification cycle, through an out-year examination process, with at least some ability to make changes, if deemed necessary (not through MSA emergency or interim rules.

Under multi-year specifications, there needs to be some assurance that the original specifications remain adequate to protect the stocks from overfishing, to rebuild overfished stocks in the specified time frame, and to prevent ACLs from being exceeded. There also will be industry/public interest in determining whether the stock status has improved more than anticipated, such that the catch levels could be increased in the out-years. However, there will be no operational assessment possible while the multi-year specifications are in place. This will require a disciplined approach to avoid reacting to "noise" in the information; without this, the process will revert to the existing process whereby specifications are set or adjusted every year or two. It also would undermine the objective of a more stable and predictable assessment and management program.

At a minimum, there needs to be an annual examination of the performance of the fishery relative to the ACL(s), including the discard mortality associated with each stock. If an ACL is exceeded, associated accountability measures will be triggered, as specified in each FMP. Regardless of the number of years that specifications are set for, ACLs need to be established for each year in the time series (through the initial specification setting), and the performance of the fishery will need to be examined every year, relative to the ACL. This process is to ensure that ACLs are not exceeded, and to take appropriate measures to correct the overages and to prevent them from occurring again, but it does not examine whether the ACLs are still appropriate for the out years. This is a requirement of the MSA, and is not reflective of the new proposed process.

To address the issue of whether the ACLs as set for the out-years are still appropriate, the Councils have at least two alternatives. One approach is to set the multi-year specifications and to agree to leave them in place, without change, unless something unexpected and significant were to occur, and to not undertake any formal examination in the out-years. A second approach is, in years between operational assessments and the associated specification/adjustment process, to have the Council's PDT and/or Technical Committee (TC) provide assessment data and information to the Council's SSC (but note there would be no new assessment). Such information could include: Recent survey indices and recent landings and discard estimates; projections based on the last operational assessment; and resource status and/or fishery performance metrics. The PDT/TC (as supported by the NEFSC) would be responsible for obtaining these data, updating projections, and providing the relevant information to the Council's SSC. This could include a staff recommendation from the Council, or not. Based on the SSC's review of the out-year information, the SSC would recommend to the Council whether there should be a change to the out-year specifications, and what that change should be. If the SSC recommends, and the Council agrees, that a change should be made, a regulatory response would be required.

The regulatory response to the SSC's recommendation and Council's determination to make an out-year change could take at least two forms. In the first, the Council could recommend a new set of specifications that would be sent to NMFS for consideration, and proposed and final rules would be used to implement the changes, much the way the existing processes work. This would take 5-7 months to implement any change. Alternatively, it may be possible/advantageous to identify very specific criteria that the SSC and the Council would use to determine whether any adjustments are necessary, and to specify what the regulatory response to a triggering of the criteria would be. For example, the Council could pre-determine that, if Criterion X is exceeded by Amount Y, the ACL for the stock would be increased/decreased by Amount Z. The better defined the linkages (i.e., the less discretionary the decision), the faster the response could likely be. It is possible that, if the response is sufficiently non-discretionary, and the impacts of the change have been anticipated and analyzed in advance (see also the discussion under item e. below), the change could be made directly through a final rule.

Whichever out-year process is chosen (and a Council could choose to apply one process to some FMPs, and the other to other FMPs), to achieve stability in the fishery and the management process, it is recommended that any out-year changes should be made only in response to significant deviations from the established specifications; it would not be productive to require changes to the specifications in out-years if only small deviations have occurred. Further, any such changes should be triggered whether the stock condition is improving or worsening (i.e., whether the news is good or bad).

Another consideration of out-year adjustments is timing of the availability of the information needed, when the decision can be made as to whether a criterion is triggered, and whether an adjustment can be made part way through the fishing year. Because data on the performance of a fishery is typically not available until a few months after the fishing year ends, determinations on ACLs typically cannot be made until the next fishing year has begun. The same would be true for adjustment criteria that are based on fishery-dependent information. It would likely be necessary to wait to make any adjustment until the beginning of the following fishing year (e.g., if information from fishing year 2012, examined in fishing year 2013, indicated an adjustment to the specifications would be necessary, that adjustment would be made in fishing year 2014. Fishery-independent data, such as survey results, could potentially be obtained and examined prior to the start of, or very early in a fishing year. In this case, it is possible that an out-year adjustment could be made in that same fishing year.

<u>Summary/Recommendations:</u> To be effective and consistent with the overall goals of the ACL Working Group recommendations, the out-year examination process needs to be simple, structured, have well-defined criteria, and strive for stability. Non-discretionary adjustments could likely be accomplished most quickly. Adjustments

should be responsive to either improving or declining stock conditions. MSA emergency rules and interim rules should be avoided.

e. Discuss ways to streamline and improve required analyses (e.g., NEPA, RIR) in multiple year specification packages; provide recommendations for NERO and Council consideration. - To facilitate the use of multi-year specifications, including out-year adjustments, by anticipating and satisfying analytical requirements at the beginning of the process.

It appears that it would be relatively easy to address analytical issues associated with multi-year specifications, including any necessary out-year adjustments. The key to making this work is to appropriately determine the range of possible outcomes that could reasonably be expected, including the out-year adjustments. For example, assume the preferred alternative for the ACLs for the fishery over a 3-year specification cycle is 10,000 mt in year 1; 12,000 mt in year 2; and 14,000 mt in year 3, and that there is an adjustment criterion that could change the ACLs by up to 2,000 mt, up or down. The analyses of the initial specification package would then include, at a minimum, the no action alternative, the preferred alternative, and alternatives that would include a year-2 ACL of between 10,000 and 14,000 mt (if an adjustment can be made in year 2), and a year-3 ACL of between 12,000 and 16,000 mt. So long as any adjustments stay within the range of those alternatives, the analyses under the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA section 7), the Regulatory Flexibility Act (RFA), E.O. 12866, and essential fish habitat (EFH) should be adequate to cover any out-year adjustment(s). This would make adjustments easier and faster.

Summary/Recommendations: In most circumstances, analytical requirements should not be an impediment to using multi-year specifications, or to making out-year adjustments. Planning for a reasonable range of anticipated outcomes will be necessary, but should make any out-year adjustments easier and quicker to do.

f. Recommend consolidation of species/stocks into FMPs; discuss logical species/stocks groupings. - To determine whether combining stocks into fewer FMPs would make the assessment/specification process more efficient.

It is possible that some efficiencies in assessments and specification setting could be obtained from changing the way species are grouped into FMPs. Any such changes in stocks in the fisheries would need to be done through FMP amendments. However, it is not clear that any such changes would necessarily result in changes to how often the stocks would be assessed.

Several of the fisheries appear unique enough that they would likely not be easily combined with others. These are:

- Atlantic Salmon (no fishery),
- Tilefish,
- Surfclams/Ocean Quahogs,
- Sea Scallops,
- Deep-sea Red Crab, and
- Spiny Dogfish.

Other fisheries have at least some characteristics sufficiently in common that it might be possible to combine them into a single FMP. These are:

- Northeast Multispecies; Monkfish; Skates
- Atlantic Herring; Atlantic Mackerel, Squid, and Butterfish
- Summer Flounder, Scup, Black Sea Bass; Atlantic Bluefish

The first group of species (multispecies, monkfish, skates) are caught by many of the same fishermen, using similar gear (bottom trawls, gillnets, hook gear). The fisheries for multispecies and monkfish are already somewhat linked though days-at-sea provisions in both FMPs. One potential complication of this grouping is that the Monkfish FMP is a joint FMP, with the NEFMC the lead; the other FMPs are solely the responsibility of the NEFMC. Another consideration is the Limited Access Privilege (LAPP) referendum requirements for NEFMC-managed fisheries. If these FMPs were combined into one, it is unclear how the referendum requirements would apply. For example, to approve a monkfish IFQ program, would it require a referendum approval by everyone with a multispecies, skates, and/or monkfish permit? Or only those with monkfish permits?

The second potential grouping (Atlantic herring; Atlantic mackerel, squid, and butterfish) consists of species caught with much the same gear (trawls and/or purse seines), in large volumes (with the exception of butterfish in recent years), with relatively short life spans, and with similar roles in the ecosystem (e.g., as important prey species for other fish, marine mammals, and seabirds, as well as being predators themselves). Many of the industry participants in these fisheries are the same. A complication in this grouping, however, is that herring are currently managed by the NEFMC and the ASMFC; whereas mackerel, squid, and butterfish are managed by the MAFMC.

The third grouping (summer flounder, scup, black sea bass; Atlantic bluefish) contains fisheries with significant recreational components, as well as commercial components. The management processes for these two FMPs are already similar, and all of these species are managed by the MAFMC and the ASMFC.

<u>Summary/Recommendations</u>: Combining species/stocks into fewer FMPs is possible, and would be done through FMP amendments. However, there are potentially significant jurisdictional and statutory (i.e., LAPP referendum) issues that would need to be addressed. This is likely not something that could be accomplished quickly or

easily, and it is not clear that making such changes would result in meaningful improvements to stock assessment or management workloads or efficiencies.

Appendix 2. List of reviewers at the integrated peer review of assessments:

Steven Cadrin	UMass Dartmouth, SMAST
Alexei Sharov	Maryland Dept. Natural Resources
Steven Correia	Massachusetts Div. Marine Fisheries
Sandra Lowe	NMFS Alaska Fisheries Sci. Center
Paul Rago (co-chair)	NMFS Northeast Fisheries Sci. Center
James Weinberg (co-chair)	NMFS Northeast Fisheries Sci. Center

Appendix 3. List of meeting attendees at the integrated peer review of assessments, Feb. 2012:

Name	Affiliation	Email
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Appendix 4. Meeting agenda for the Integrated Peer Review of assessments.

Groundfish Updates Integrated Peer Review Meeting, February 13 – 17, 2012
Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts
DRAFT AGENDA* (version: 02-10-2012)

TIME	TOPIC/ PRESENTER		LEAD PANEL REVIEWER
Monday, 13 Feb			
9:00 AM – 10:00 AM			
Opening	B. Karp		
Welcome	P. Rago		
Introduction			
Agenda			
Conduct of Meeting	J. Weinberg		
10:00 AM – 12:00 PM	GB cod,	L. O'Brien	S. Correia
12:00 PM – 1:00 PM	Lunch		
1:00 PM – 3:00 PM	GB haddock,	L. Brooks	S. Correia
3:00 PM – 5:00 PM	GOM haddock,	M. Palmer	S. Correia
Tuesday, 14 Feb			
9:00 AM – 10:30 AM	American plaice,	L. O'Brien	A. Sharov
10:30 AM – 10:45 AM	Break		
10:45 AM – 12:15 PM	Witch flounder,	S. Wigley	A. Sharov
12:15 PM – 1:15 PM	Lunch		
1:15 PM – 2:30 PM	Atlantic wolffish,	C. Keith	A. Sharov
2:30 PM – 2:45 PM	Break		
2:45 PM – 3:45 PM	Atlantic halibut,	J. Blaylock	A. Sharov
Wednesday, 15 Feb			
9:00 AM – 10:30 AM	GOM/Cape Cod yellowtail flounder	C. Legault	S.Cadrin
10:30 AM – 10:45 AM	Break		
10:45 AM – 12:15 PM	Acadian redfish,	T. Miller	S.Cadrin
12:15 PM – 1:15 PM	Lunch		
1:15 PM – 2:00 PM	GOM-GB windowpane flounder,	L. Hendrickson	S.Cadrin
2:00 PM – 2:45 PM	SNE-MA windowpane flounder,	L. Hendrickson	S.Cadrin
2:45 PM – 3:00 PM	Break		
3:00 PM – 3:45 PM	Ocean pout,	S. Wigley	S. Cadrin
3:45 PM – 4:30 PM	White hake,	K. Sosebee	S. Correia
Thursday, 16 Feb			
9:00 – 5:00 PM	TBD - Time allocated to revisit topics as needed		
Friday, 17 Feb			
9:00 – 5:00 PM	Final Report writing Conclusions		

*Times are approximate, and may be changed at the discretion of the meeting chair. The meeting is open to the public.

Appendix 5.

Performance of GARM III Projections
By Tom Nies
February 22, 2012

The 2012 assessment updates provide an opportunity to evaluate the performance of projections based on the GARM III assessments for seven analytic assessments. There are relatively minor differences between the model formulations used at GARM III and those used in the assessment updates. This minimizes the complications caused by changes in the assessment model. In addition, in most cases the actual catches are close to the assumed or projected catches; this makes it easier to evaluate the projections as opposed to the failure of the management system to limit catches. Evaluating projection performance may provide insights for setting future catch levels.

Catch advice for the 2010 -2012 period was based on projections that were performed in 2009 based on the GARM III assessments that had a terminal year of 2007. All recruitment, weights-at-age, selectivity, etc. assumptions were those approved at GARM III. By the time the projections were performed, the 2008 catch was estimated by NEFSC lead assessment scientists and provided to the PDT. This catch was input into the projection as a harvest quota. For 2009, an estimated fishing mortality was calculated based on the expected impacts of measures adopted by an interim rule. The 2010 catch advice was calculated based on the desired fishing mortality: usually either 75 percent of FMSY or and $F_{rebuild}$, whichever was lower. For these analyses the projections were then re-run with this catch as an input in order to get a distribution of fishing mortality. The median catch was used as the ABC for 2010 (and 2011-2012, but these years are not examined in these analyses).

GARM III attempted to address assessment retrospective patterns in one of two ways: either by splitting the survey time series or by making an adjustment in the numbers at age based on the retrospective pattern.

The projections are evaluated based on (a) did stock size change as projected, and (b) was the realized fishing mortality consistent with the mortality expected from the actual catches. The primary way the information is presented here is through a series of charts that compare the 90 percent confidence interval of the projected SSB to assessment update point estimates of the SSB, and GARM III and the 90 percent confidence interval of the projected fishing mortality to the assessment update point estimate of fishing mortality. For stocks that used a retrospective adjustment in the terminal year of either GARM III or the assessment update, both unadjusted and adjusted values are plotted but the written comparison is based on the adjusted value.

Generally, actual catches for 2008 and 2009 were similar to the projection inputs. In 2010, catches were substantially lower than projected for GB haddock, CC/GOM yellowtail flounder, plaice, and redfish.

The results of these comparisons can be summarized as follows:

- Projections over-estimated 2010 stock size for six of seven stocks:
    - GB cod
    - GB haddock
    - CC/GOM yellowtail flounder
    - Plaice
    - Witch Flounder
    - GOM haddock

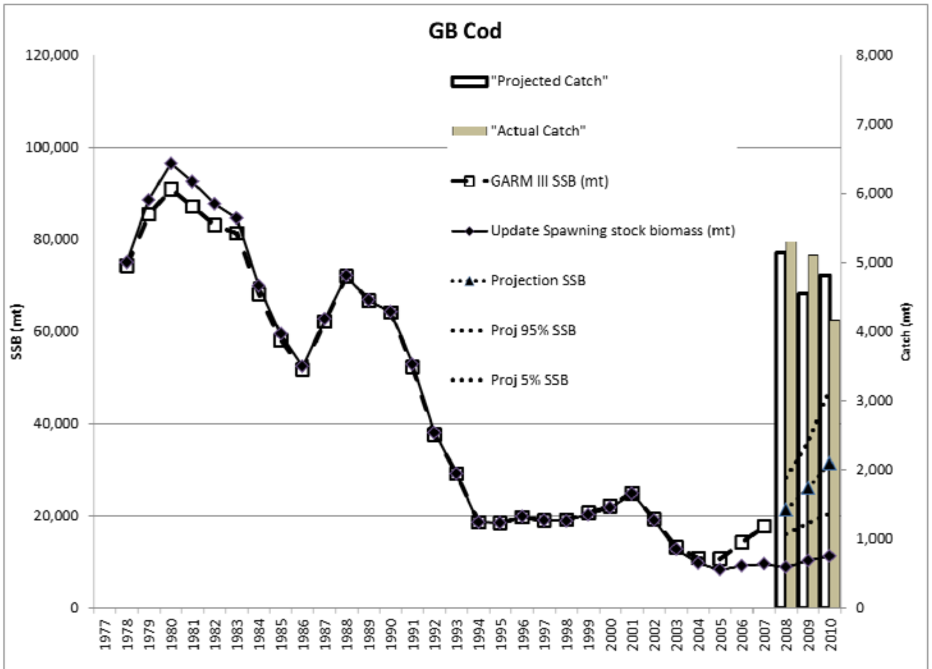
- Projections under-estimated 2010 stock size for one of seven stocks:
    - Redfish

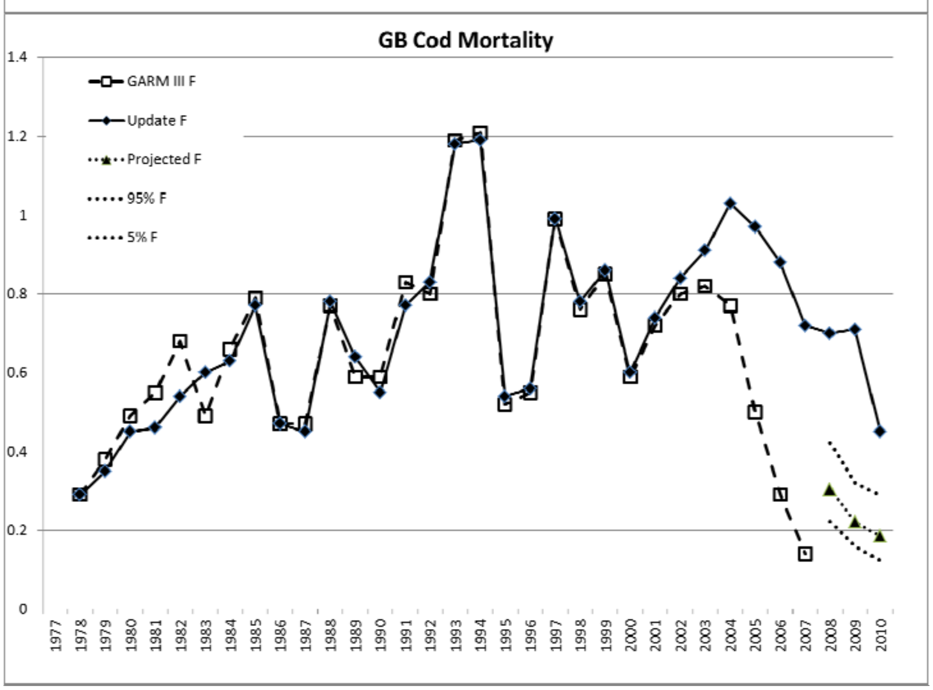
- Projections under-estimated 2010 fishing mortality for four of seven stocks:
    - GB cod
    - CC/GOM yellowtail flounder
    - Witch flounder
    - GOM haddock

- Projections accurately estimated 2010 fishing mortality (note that for these three stocks, 2010 catches were substantially lower than projected catches):
    - GB haddock
    - Plaice
    - Redfish

GB Cod

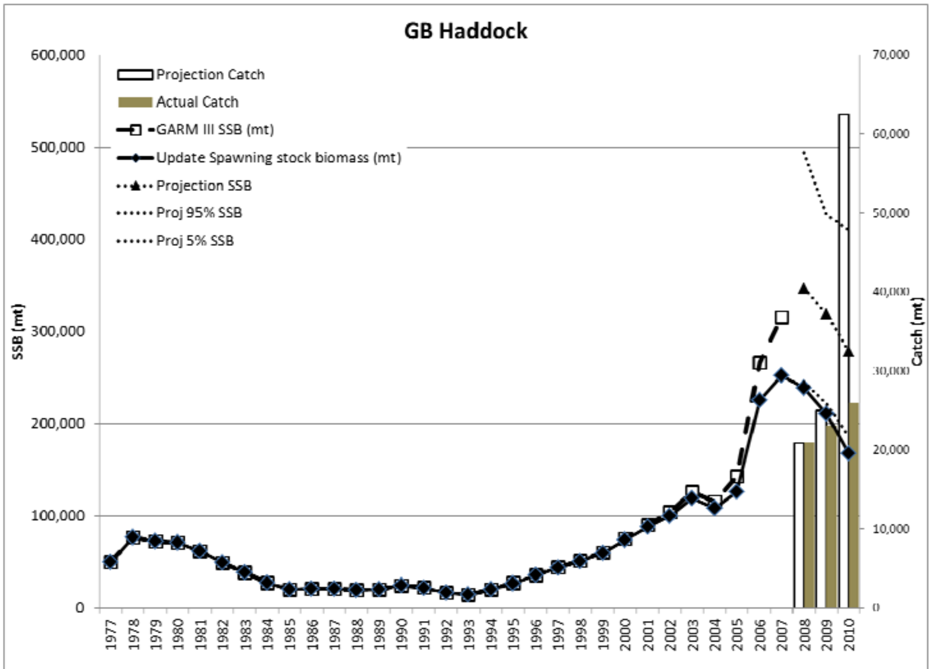
GARM III used a split-survey time series to correct for a retrospective pattern. Catches in 2008 and 2009 exceeded the projection values, but 2010 catch was less. Current stock size is less than the 98 pct CI of the projection, and mortality is roughly twice the projection input and is outside the 98 pct CI

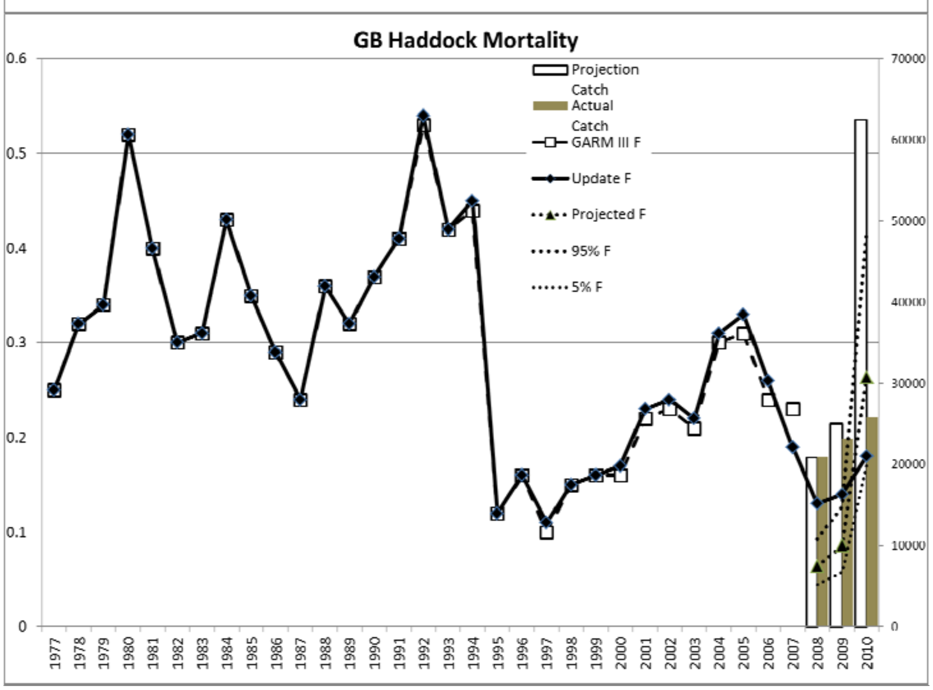




GB Haddock

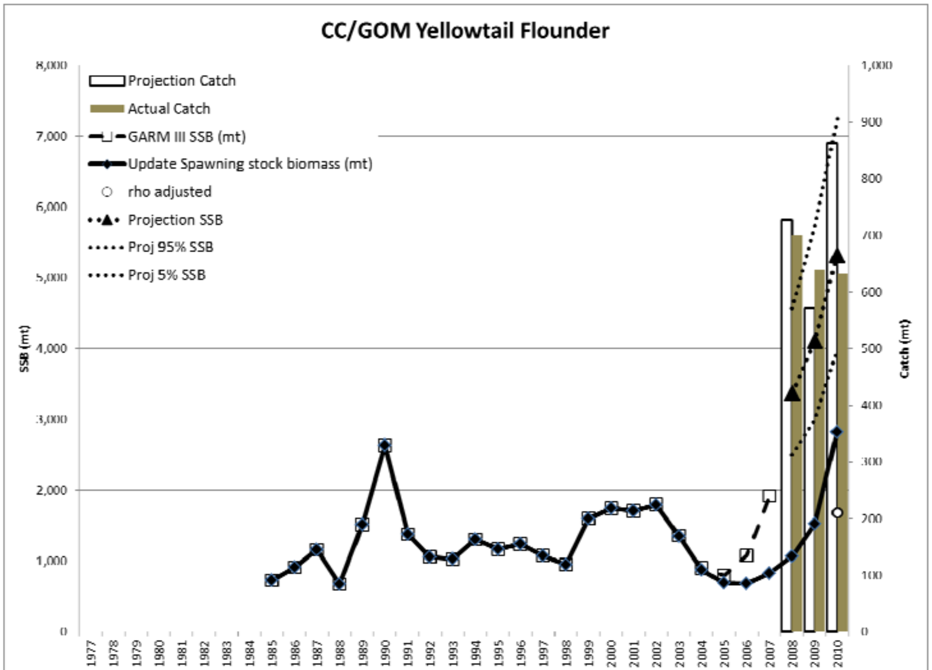
This assessment did not have a retrospective pattern at GARM III or in the assessment update. Catches in 2008 and 2009 were similar to the projection values, but in 2010 were lower. SSB was outside the 90 pct CI of the projection in all three years. Fishing mortality in 2008 and 2009 was outside the 90 pct CI, but was within the interval in 2010.

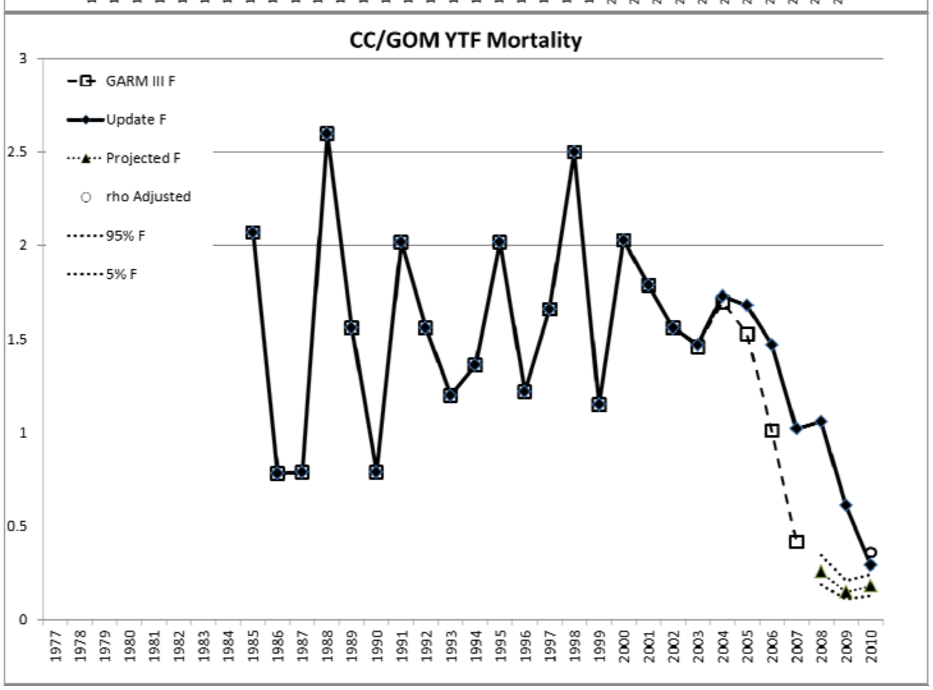




CC/GOM Yellowtail Flounder

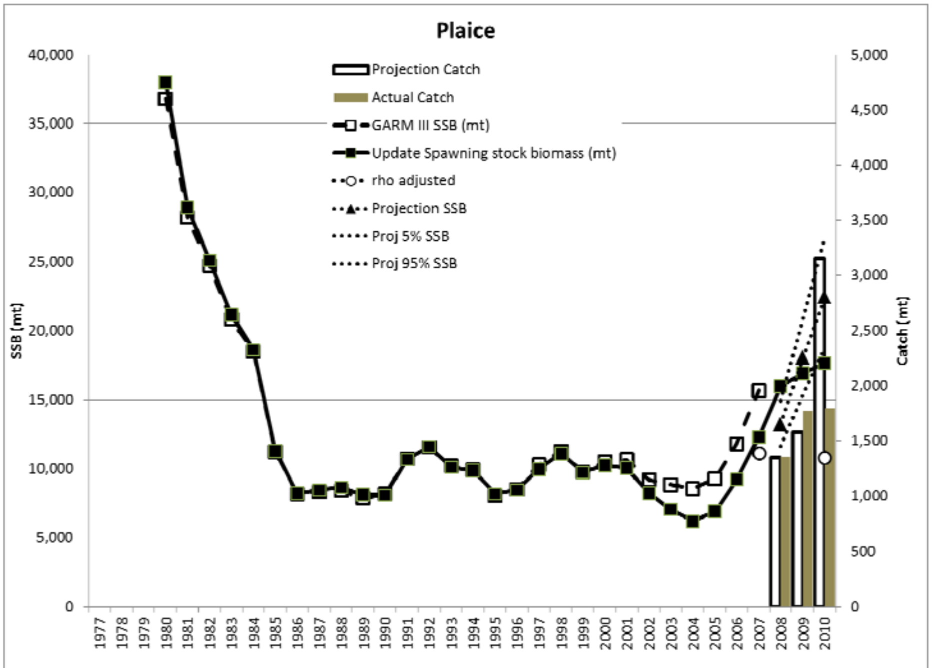
This assessment did not have a retrospective pattern at GARM III but a pattern exists in the update and 2010 estimates of SSB and mortality are rho-adjusted. Catches in 2008 and 2009 were similar to the projection, and in 2010 were lower. Current stock size is less than the 98 pct CI of the projection. Fishing mortality in 2008 was four times the projected value and in 2010 is outside the 90 pct CI.

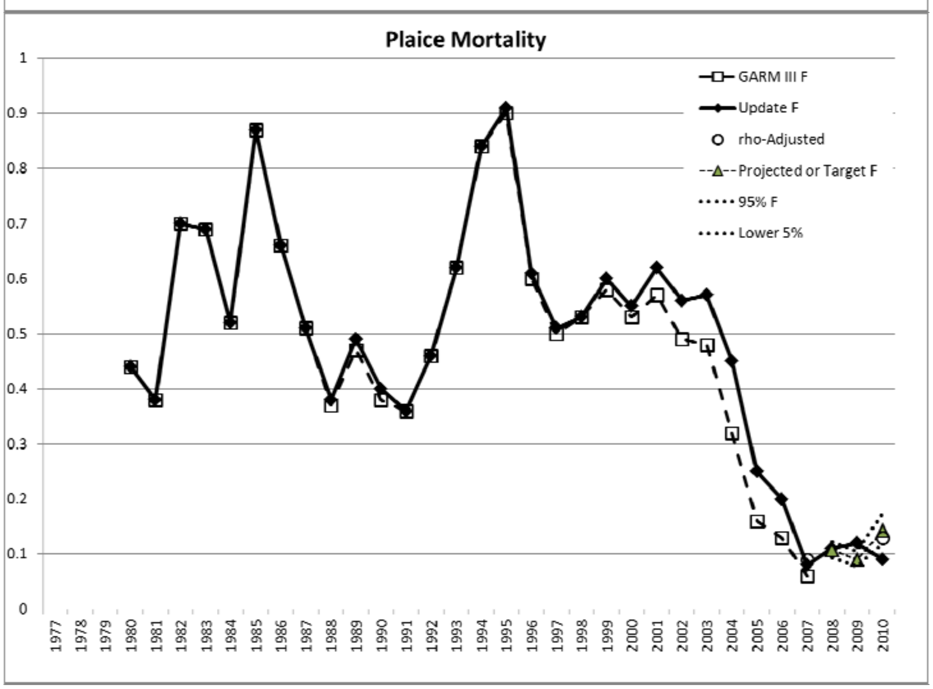




American Plaice

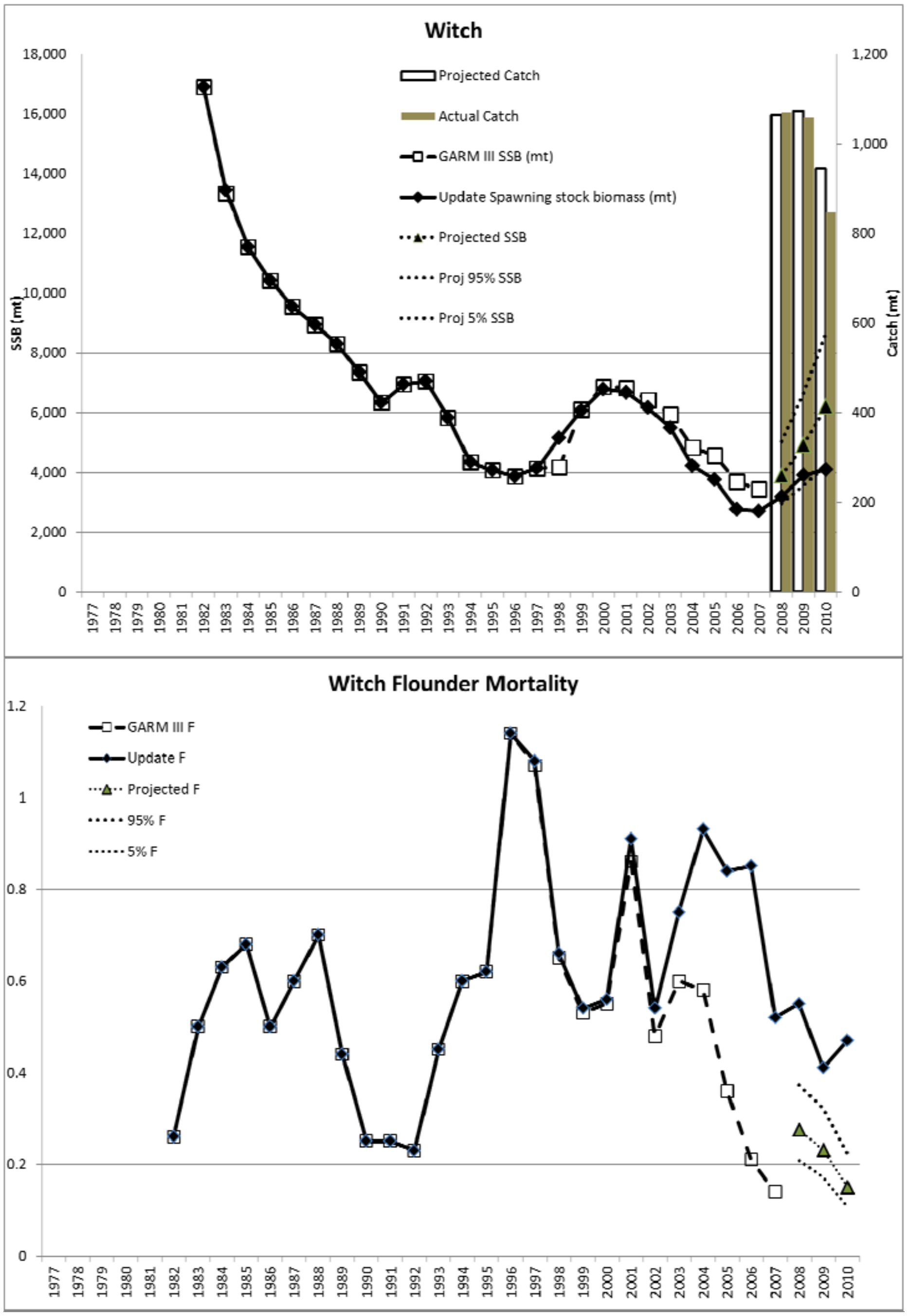
GARM III used a rho-adjustment to numbers at age to correct for a retrospective pattern in 2008, and the assessment update does so for 2010 . Catches were below projected catches in 2009 and 2010. 2010 SSB is less than the 90 pct CI of the projected stock size. Fishing mortality in 2010 is similar to the projection input, but note that 2010 catches were about 55 percent of the projected catch.





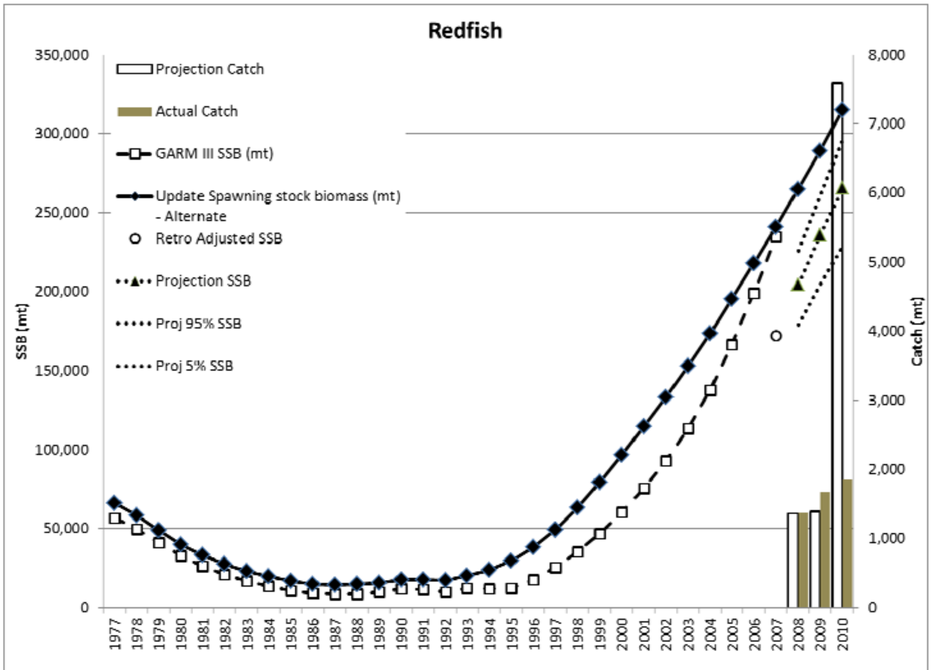
Witch Flounder

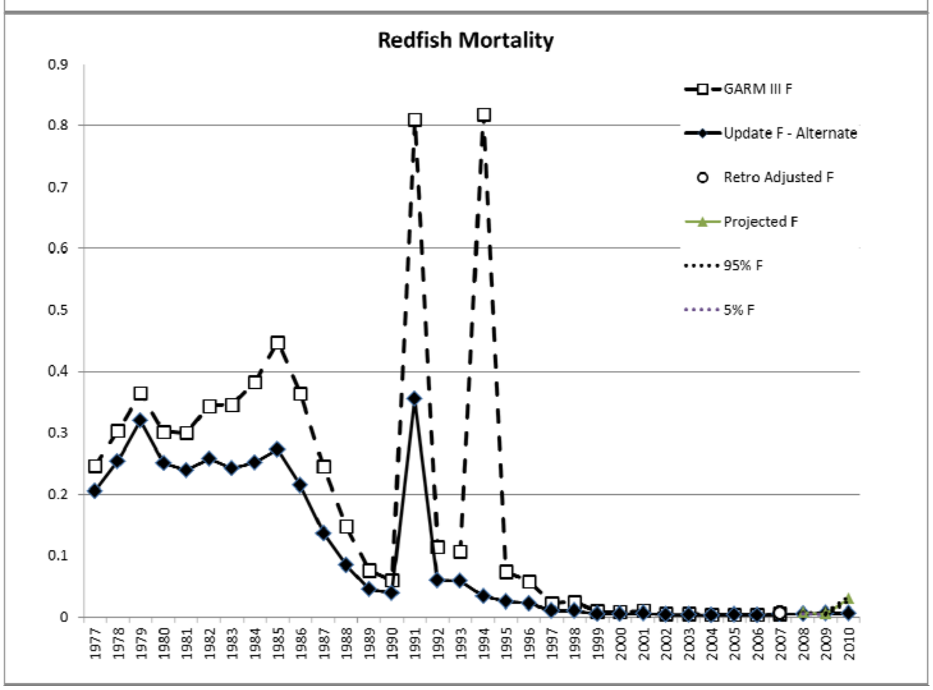
GARM III used a split-survey time series to correct for a retrospective pattern. Catches from 2008 to 2010 were similar to projected catches. 2010 stock size is outside the 90 pct CI of the projection. Fishing mortality is about twice as high projected and is outside the 90 pct CI.



Redfish

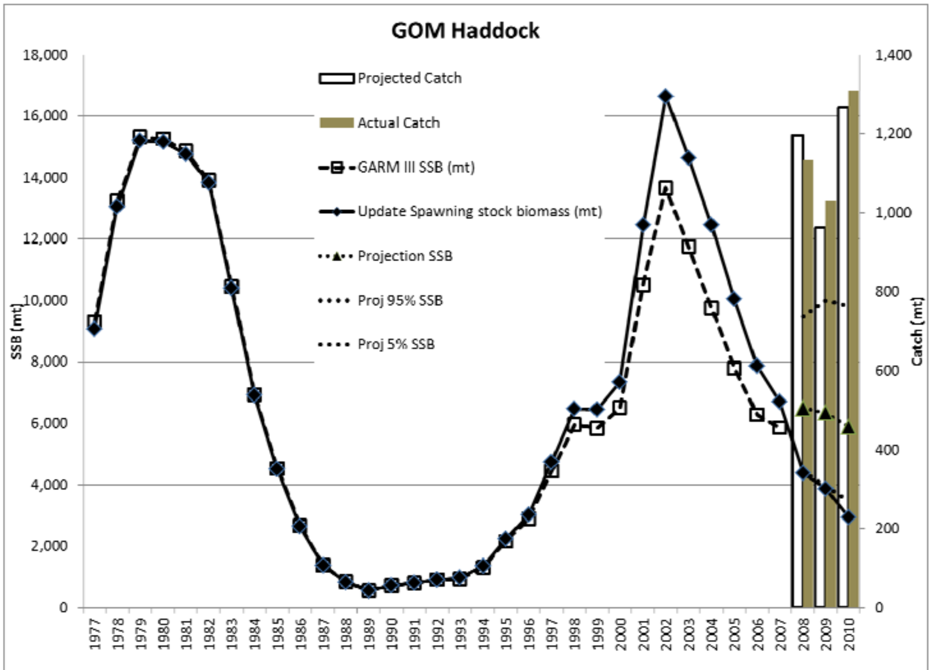
GARM III adjusted 2007 estimates of SSB and mortality for a retrospective pattern but the updated assessment did not. Catches in 2008 and 2009 were similar to projection values but in 2010 were far lower. Stock size is higher than forecast and is outside the 90 pct CI; fishing mortality is very low. In 2009 mortality was within the 90 pct CI of the projected value and in 2010 was well below the 90 pct CI.

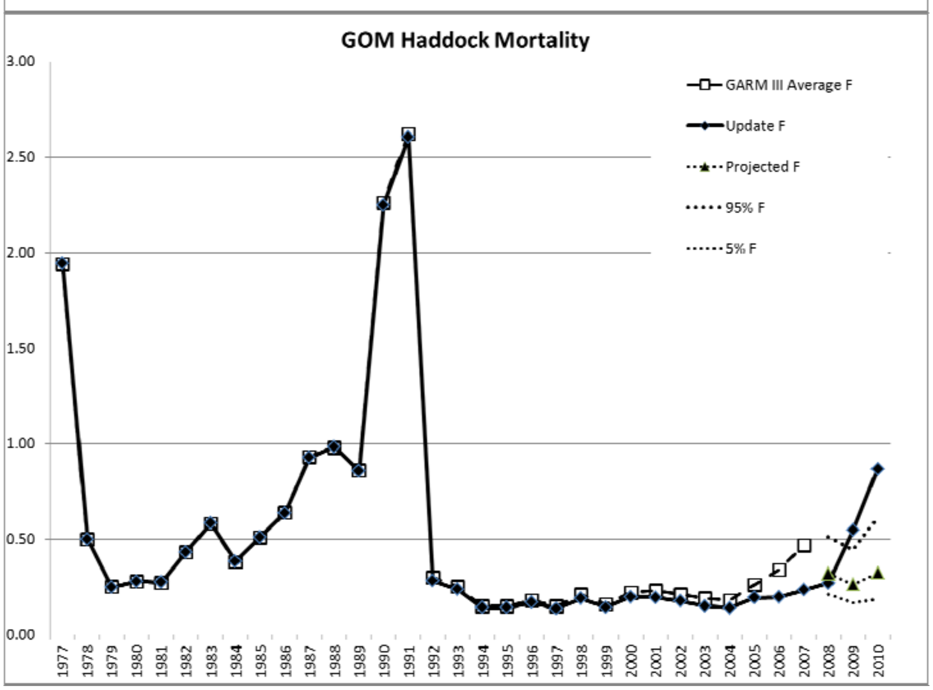




GOM Haddock

This assessment did not have a retrospective pattern at GARM III. Catches were similar to projected catches from 2008 - 2010. Stock size in 2010 is less than the 98 pct CI from the projection. Fishing mortality is more than twice the projection input and is outside the 98 pct CI.





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