Northeast Fisheries Science Center Reference Document 08-15

Assessment of 19 Northeast Groundfish Stocks through 2007

Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008

by Northeast Fisheries Science Center

August 2008

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NOAA's National Marine Fisheries Serv., 166 Water St., Woods Hole MA 02543-1026

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

August 2008

Northeast Fisheries Science Center Reference Documents

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This document's publication history is as follows: manuscript submitted for review August 27, 2008; manuscript accepted through technical review August 29, 2008; manuscript accepted through policy review August 28, 2008; and final copy submitted for publication August 28, 2008. Pursuant to section 515 of Public Law 106-554 (the Information Quality Act), this information product has undergone a pre-dissemination review by the Northeast Fisheries Science Center, completed on August 29, 2008. The signed pre-dissemination review and documentation is on file at the NEFSC Editorial Office. This document may be cited as:

Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

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EXECUTIVE SUMMARY

GARM III Overview

The Groundfish Assessment Review Meeting (GARM) conducted during November 2007 – August 2008 was a regional scientific peer review process to provide benchmark assessments for the 19 groundfish stocks managed under the Northeast Multispecies Fishery Management Plan. The first two GARM reviews took place in October 2002 (GARM I) and August 2005 (GARM II), respectively. The GARM III was the most comprehensive review to date, and provided peer reviewed assessments on the following Northeast Groundfish stocks managed by the New England Fishery Management Council:

A. Georges Bank Cod
B. Georges Bank Haddock
C. Georges Bank Yellowtail Flounder
D. Southern New England/Mid-AtlanticYellowtail Flounder
E. Gulf of Maine/Cape Cod Yellowtail Flounder
F. Gulf of Maine Cod
G. Witch Flounder
H. American Plaice
I. Gulf of Maine Winter Flounder
J. Southern New England/Mid-Atlantic Winter Flounder
K. Georges Bank Winter Flounder
L. White Hake
M. Pollock
N. Acadian Redfish
O. Ocean Pout
P. Gulf of Maine/Georges Bank Windowpane
Q. Southern New England/Mid-Atlantic Windowpane
R. Gulf of Maine Haddock
S. Atlantic Halibut

Whereas GARM II considered updates of the assessments reviewed in GARM I, the GARM III process was much more extensive and involved in-depth reviews of the data, models, biological reference points, and assessments of each of the 19 groundfish stocks. A total of 18 reviewers over four panels were involved in the four GARM III meetings, representing an exceptional level of peer review. Panel Summary Reports from the first three GARM III meetings are available in NEFSC (2008).

The four meetings of GARM III included:

- Data Inputs (29 Oct – 2 Nov 2007)
- Assessment Models (25 – 29 Feb 2008)
- Biological Reference Points (28 April – 2 May 2008)
- Assessments (4 – 8 August 2008)

The ‘Data Inputs’ meeting focused on the data inputs to be used in the assessments. A number of enhancements to the data used in GARM II were developed, including a new multitier trip-based allocation system to match vessel trip and dealer reports. The new system is comprehensive, consistent across species, provides continuity with the previous interview system, is a common data source for all species, and provides a finer scale of spatial resolution than previously possible. While landings allocations among stocks were mostly unchanged from GARM II, the new system provides the opportunity to explore the impact of uncertainty in reported stock area of the landings. The 'Data Inputs' review also considered how best to estimate discards, with a common approach (termed the 'ratio of sums' method) proposed and used in all assessments. The discard estimates in GARM III are similar to those used in GARM II. A number of tagging studies were reviewed that became available since GARM II, and which informed the stock assessments through quantification of migration patterns, spawning areas, age-length keys, and other biological characteristics. Some of these data and results were used in the subsequent GARM III meetings. In addition to reviewing sampling plans and analyses of both NMFS and industry-based resource surveys, the 'Data Inputs' review undertook an extensive stock by stock analysis of temporal trends in a variety of biological and population dynamics parameters including length-at-age, weight-at-age, maturity-at-age, and condition factor. Since GARM II, many stocks have exhibited long term declines in weights-at-age which have significant implications for biological reference points. These analyses informed the subsequent GARM III reviews.

The 'Assessment Models' review considered the most appropriate analytical approaches to be applied to the individual stock datasets vetted and reviewed at the 'Data Inputs' meeting. For each groundfish stock, the appropriate type of assessment model (relative trend survey index model; production model; length-based model; age-based model) was considered given the available data and underlying model assumptions and uncertainties. For 14 of the 19 groundfish stocks, the Virtual Population Analysis (VPA) approach used in GARM II was considered appropriate for the GARM III benchmark assessments. Many of the assessments, however, continued to exhibit a retrospective pattern (systematic over- or under-estimation of stock size, recruitment, or fishing mortality in recent years) which the 'Models' review deemed important be taken into account (a) in determining current stock status and (b) in conducting short-term forecasts and rebuilding plan projections. Two approaches for adjusting for retrospective patterns were developed: splitting survey time series, and adjusting current population numbers based on the observed retrospective pattern in the recent past (used if the first approach did not significantly ameliorate or eliminate the pattern). Adjusting for the retrospective pattern in the current assessments is a marked procedural difference from GARM II, where the extent of the pattern was reported but not formally incorporated into the determination of stock status. The GARM III 'Assessment Models' review resulted in significant improvements to a number of assessments. For example, the assessments of Gulf of Maine haddock, Georges Bank winter flounder, and white hake are now based on age-based formulations, as opposed to the previous relative trends and production model formulations. Atlantic halibut, which had no assessment in GARM II, is now assessed using a production model. Overall, significant advances in assessment methodology are reflected in the GARM III assessments relative to the GARM II assessments.

The GARM 'Biological Reference Points' meeting focused on the fishing mortality and stock biomass biological reference points (BRPs) to be used in the assessments and rebuilding plans for the 19 groundfish stocks. Whereas an array of methods was used to compute BRPs in GARM II, the principal method in GARM III was to (a) estimate F_{MSY} based upon $F_{40\%MSP}$ (50 % for Acadian redfish) from a spawner per recruit analysis, and (b) estimate the associated

B_{MSY} using recruitment values from the population time series. Considerable attention was given in the meeting to the most appropriate historical time period to be used in estimating the BRPs and, by inference, in the stock and rebuilding plan projections. As noted in the GARM III 'Data Inputs' review meeting, the reductions in weights-at-age observed in GARM II has continued for many of the 19 groundfish stocks. As well, age-specific fishery selectivity has shifted in many stocks to older age groups due to a combination of reduced growth, fishery management measures, and changing fishing practices. These trends were incorporated into the updated BRPs for the 19 groundfish stocks, and resultingly many of the newly-estimated biomass reference points are now lower and the fishing mortality reference points higher than those estimated in GARM II. However, a direct one-to-one comparison between the old and new BRPs is inappropriate because of the aforementioned changes in weights and partial recruitment at age. This necessitates a careful and transparent understanding of why the changes in the BRPs have occurred.

In the fourth and last GARM III review (the 'Assessments' meeting), the data and results from the first three GARM III meetings were included and synthesized in the benchmark assessments of the 19 Northeast groundfish stocks. The "Assessments' meeting also identified the appropriate analytical procedures to perform the stock and rebuilding plan projections. The key element in the projections was to use the same assumptions for growth, maturity, natural mortality, and recruitment as used in estimating the BRPs - but with the additional use of historical recruitment values at SSBs below specified 'breakpoints' during the rebuilding period. The meeting also examed the productivity of the Northeast Shelf ecosystem, with particular regard to the joint sustainability of the 19 groundfish stocks and the inclusion of other ecosystem groups (invertebrates, pelagics and elasmobranches). This examination revealed that at the current low biomass of many of the groundfish stocks, the aggregate Maximum Sustainable Yield (MSY) for the multispecies groundfish complex is almost equivalent to the sum of the MSY estimates from each of the stocks. However, as stock biomasses improve, the estimated aggregate MSY could be significantly lower than the sum of the individual stock MSY estimates. The review recognized the ecosystem work as being innovative and early in its development for implementation, and encouraged efforts to more fully explore how broader ecosystem considerations could be used to complement single stock management inthe Northeast Region.

Stock Assessments of 19 Northeast Groundfish Stocks

Of the 19 groundfish stocks, the GARM III benchmark assessments indicated that six stocks were fished below F_{MSY} (or its proxy) in 2007 and 13 above (Tables 1 and 2; Figures 1 and 2). This compares to 10 below and eight above F_{MSY} in 2004 based on the GARM II assessments. Biomass of six of the 19 stocks were at or above ½ B_{MSY}, while the biomasses of 13 stocks were below the threshold, a situation comparable to that in 2004. Eleven of the stocks are now both overfished and experiencing overfishing, compared to seven in 2004. Pollock, witch flounder, Georges Bank (GB) winter flounder, Gulf of Maine (GOM) winter flounder and northern windowpane have deteriorated in status, while GOM cod has improved. This latter stock, while still experiencing overfishing, is no longer overfished. In 2004, five stocks (pollock, redfish, northern windowpane, GOM winter flounder, and witch flounder) were classified as not overfished and not experiencing overfishing. In 2007, four stocks achieved this status – redfish, American plaice, GB haddock, and GOM haddock.

Table 1. Comparison of status of the Northeast groundfish stocks in 2004 (GARM II) and 2007 (GARM III). GARM II used catch data through 2004, and did not assess halibut; GARM III used catch data through 2007.

Stock Status	2004 (GARM II)	2007 (GARM III)
Overfished and Overfishing Biomass < ½ B_{MSY} AND $F > F_{MSY}$	GB Cod GB Yellowtail SNE/MA Yellowtail GOM/CC Yellowtail SNE/MA Winter Flounder White Hake GOM Cod	GB Cod GB Yellowtail SNE/MA Yellowtail GOM/CC Yellowtail SNE/MA Winter Flounder White Hake Pollock Witch GB Winter Flounder GOM Winter Flounder No. Windowpane
Overfished but not Overfishing Biomass < ½ B_{MSY} AND $F \leq F_{MSY}$	GB Haddock GOM Haddock So. Windowpane Plaice Ocean Pout	Ocean Pout Halibut
Not Overfished but Overfishing Biomass ≥ ½ B_{MSY} AND $F > F_{MSY}$	GB Winter Flounder	GOM Cod So. Windowpane
Not Overfished and not Overfishing Biomass ≥ ½ B_{MSY} AND $F \leq F_{MSY}$	Pollock Redfish No. Windowpane GOM Winter Flounder Witch	Redfish Plaice GB Haddock GOM Haddock

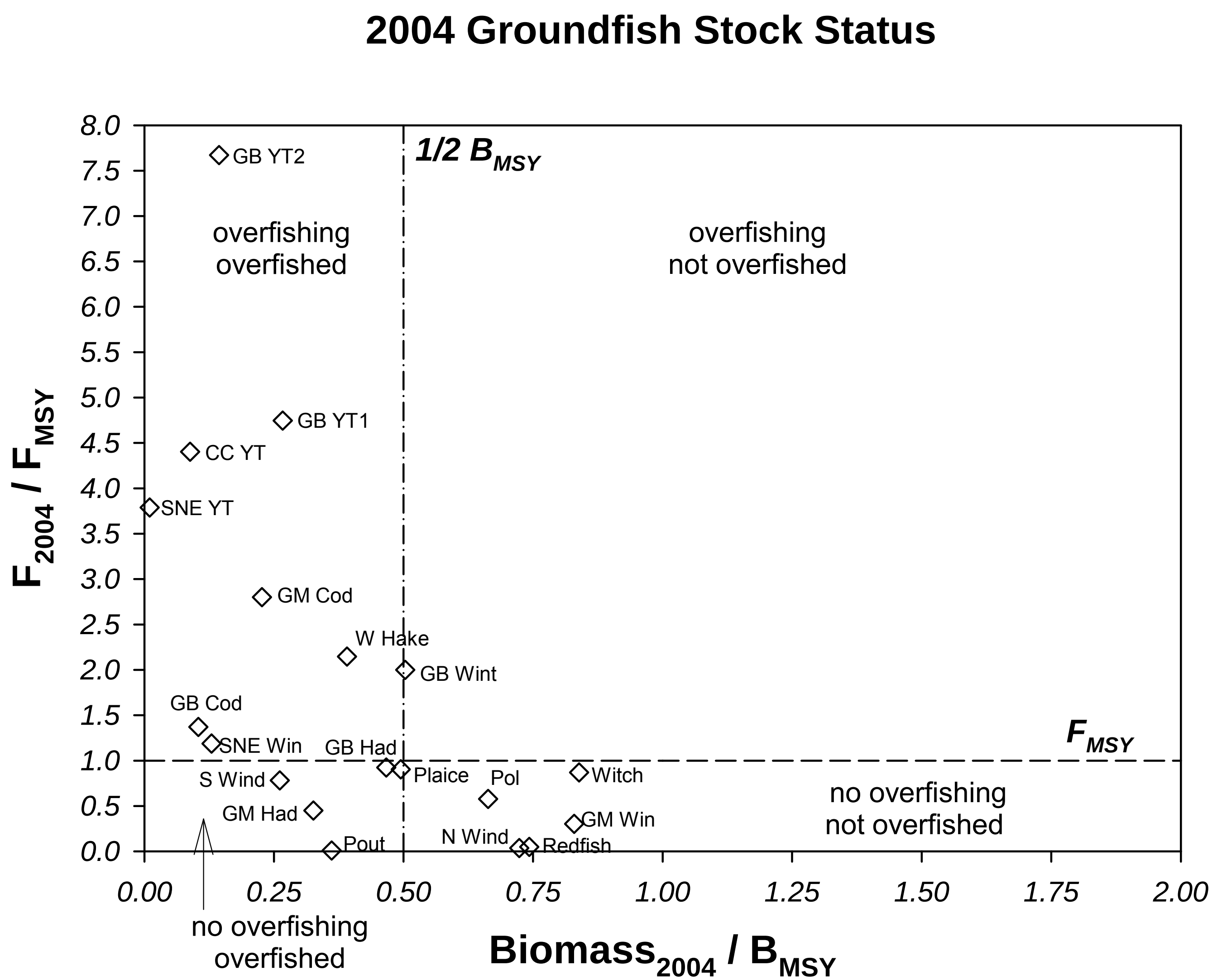

Figure 1. Status of 18 groundfish stocks in 2004 with respect to F_{MSY} and B_{MSY} or their proxies based on the GARM II review.

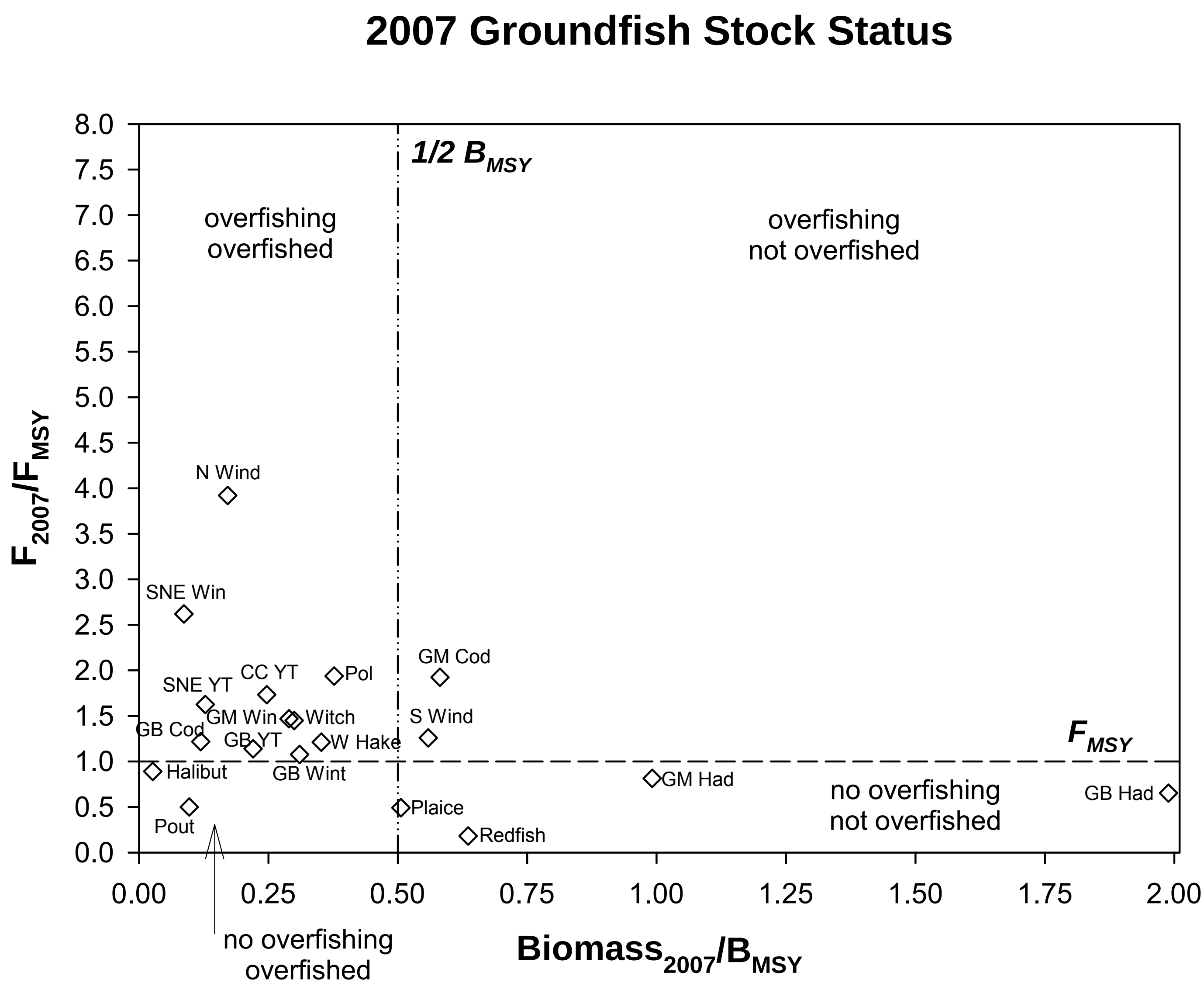

Figure 2. Status of 19 groundfish stocks in 2007 with respect to F_{MSY} and B_{MSY} or their proxies based on the GARM III review

Since 2004, reductions in fishing mortality have occurred for some stocks although exploitation on these stocks remains above F_{MSY}. A comparison of fishing mortality and biomass levels (relative to their BRPs) between GARM II and GARM III (Table 2; Figs. 3 and 4) indicates that moderate to large declines in fishing mortality occurred for the three yellowtail stocks, as well as for GB winter flounder, white hake, and plaice. More modest declines were observed for the GB and GOM cod stocks and for GB haddock. However, moderate to large relative increases in fishing mortality occurred for witch, GOM winter flounder, Southern New England / Mid-Atlantic (SNE/MA) winter flounder, redfish, pollock, northern and southern windowpane, and ocean pout. Fishing mortality of GOM haddock increased slightly.

Large relative increases in biomass occurred in the GB and GOM haddock stocks, and in GOM cod, SNE/MA yellowtail, Cape Cod/Gulf of Maine (CC/SNE) yellowtail, and in southern windowpane. Biomass did not change appreciably change in five stocks (GB cod, GB yellowtail, plaice, redfish and white hake). Moderate relative declines in biomass were observed for witch, the three winter flounder stocks and pollock, while large relative declines in biomass occurred for northern windowpane and for ocean pout.

It is important to note that these trends in fishing mortality and biomass are relative to their biological reference points. In a number of cases, the trends in fishing mortality and biomass without regard to the BRPs are different. For instance, Georges Bank yellowtail biomass is currently increasing due to the strong 2005 year-class. However, relative to B_{MSY}, biomass has slightly declined since GARM II. The value of considering the trends relative to the BRPs is that they provide a clearer indication of progress towards mandated thresholds and targets.

Based on the new B_{MSY} value (Table 2), the GB haddock stock is rebuilt. In 2007, GOM haddock, redfish, plaice, and southern windowpane are between ½ B_{MSY} and B_{MSY}, as is GOM cod. The GOM haddock stock is projected to be rebuilt in 2009 (Section 2.R). For the remaining 13 groundfish stocks, biomass is still well below B_{MSY}.

For most of the groundfish stocks, $F_{REBUILD}$ (the fishing mortality estimated to ensure recovery to B_{MSY} by the end of the rebuilding period) is lower than the 2007 fishing mortality (Table 3). This is particularly so for GB yellowtail, SNE/MA yellowtail, and SNE/MA winter flounder. For some stocks (plaice and redfish), however, $F_{REBUILD}$ is higher than the 2007 fishing mortality. GB haddock is now estimated to be above B_{MSY} (i.e., rebuilt). In the case of SNE/MA winter flounder, $F_{REBUILD}$ is zero implying that the stock cannot be rebuilt to B_{MSY}, even with no catch in 2009. Overall, the trends in projected 2009 catch at $F_{REBUILD}$ are consistent with the general changes in the status of the groundfish stocks between GARM II and GARM III.

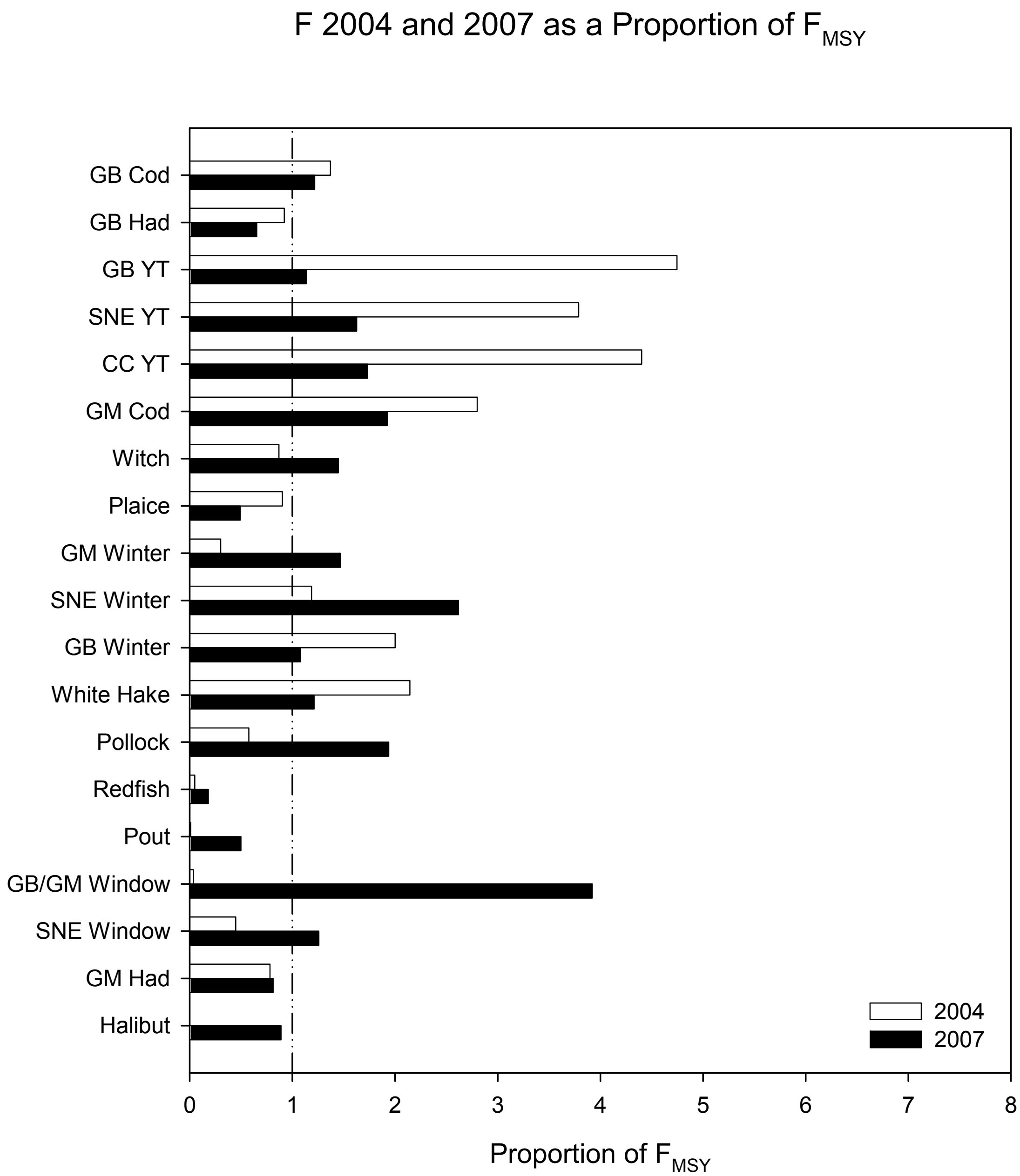

Figure 3. Comparison between 2004 and 2007 fishing mortality with respect to F_{MSY} based on the GARM II and GARM III reviews.

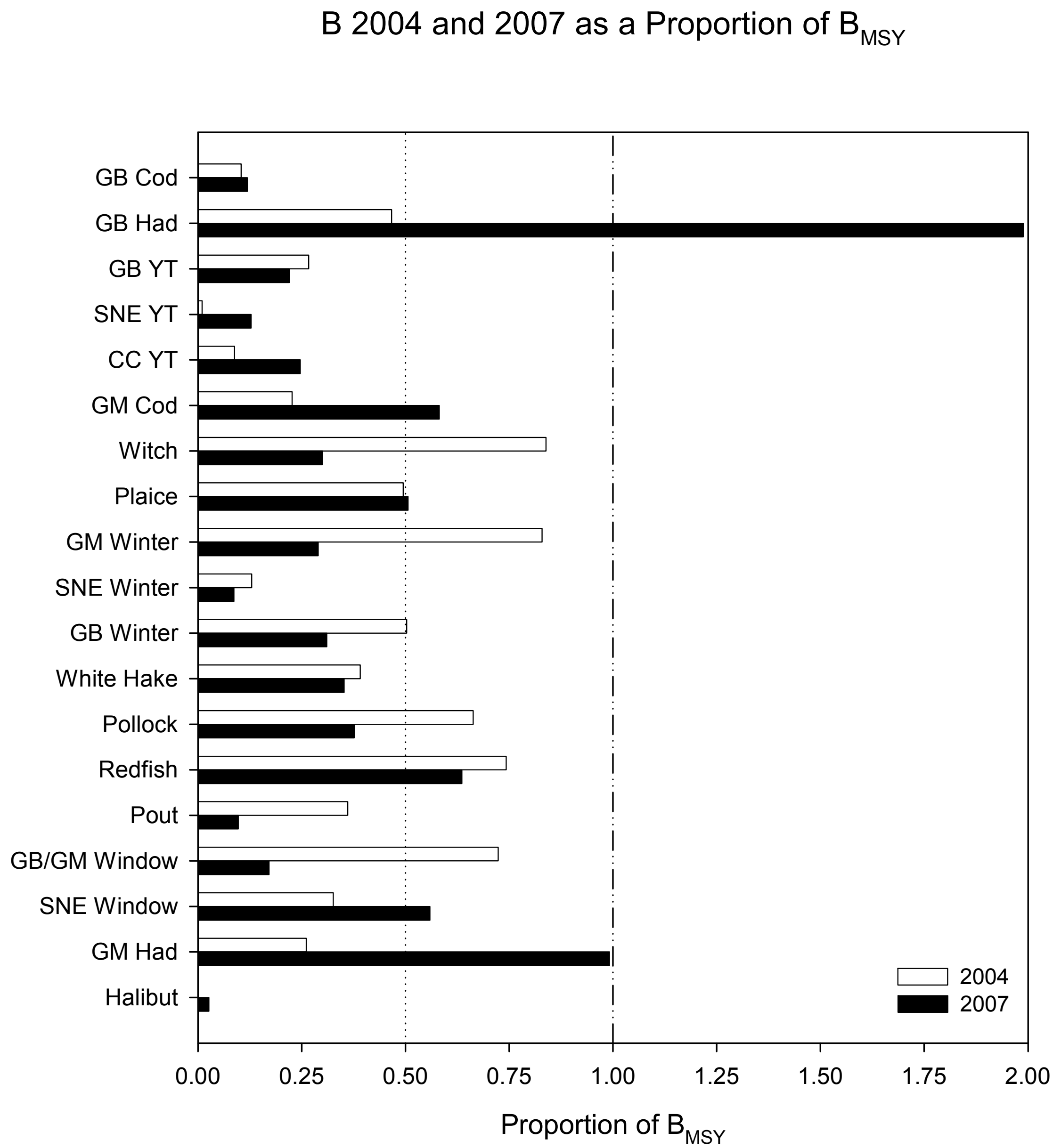

Figure 4. Comparisons between 2004 and 2007 stock biomass with respect to B_{MSY} based on the GARM II and GARM III reviews.

Table 2. 2007 Estimates of fishing mortality (F) and biomass (B), Biological Reference Points, and a comparison of the relative (to Biological Reference Points) change in F and B between GARM II and GARM III; Relative change: small (0-25%), moderate (25-75%) and large (> 75%) increases and decreases are indicated by +, ++, +++ and -, --, --- respectively. "c/i" = catch (mt)/survey index (kg/tow). For survey index stocks, biomass represents total biomass per survey tow; for other stocks, it represents spawning stock biomass (SSB) of the stock.

		2007 Estimates (GARM III)		Biological Refernce Points (GARM III)			Relative Change (2007-2004) / 2004	
Species	Stock	Fishing Mortality	Biomass (mt)	*Fmsy or proxy*	*Bmsy or proxy (mt)*	*MSY (mt)*	Fishing Mortality	Biomass
Cod	GB	0.300	17,672	0.25	148,084	31,159	-	+
Cod	GOM	0.456	33,878	0.24	58,248	10,014	--	+++
Haddock	GB	0.230	315,975	0.35	158,873	32,746	--	+++
Haddock	GOM	0.350	5,850	0.43	5,900	1,360	+	+++
Yellowtail Flounder	GB	0.289	9,527	0.25	43,200	9,400	---	-
Yellowtail Flounder	SNE/MA	0.413	3,508	0.25	27,400	6,100	--	+++
Yellowtail Flounder	CC/GOM	0.414	1,922	0.24	7,790	1,720	--	+++
American Plaice	GB/GOM	0.090	11,106	0.19	21,940	4,011	--	+
Witch Flounder		0.290	3,434	0.20	11,447	2,352	++	--
Winter Flounder	GB	0.280	4,964	0.26	16,000	3,500	--	--
Winter Flounder	GOM	0.417	1,100	0.28	3,792	917	+++	--
Winter Flounder	SNE/MA	0.649	3,368	0.25	38,761	9,742	+++	--
Redfish		0.007	172,342	0.04	271,000	10,139	+++	-
White Hake	GB/GOM	0.150	19,800	0.13	56,254	5,800	--	-
Pollock	GB/GOM	10.975 c/i	0.754 kg/tow	5.66 c/i	2.00 kg/tow	11,320	+++	--
Windowpane Flounder	GOM/GB	1.96 c/i	0.24 kg/tow	0.50 c/i	1.40 kg/tow	700	+++	---
Windowpane Flounder	SNE/MA	1.85 c/i	0.19 kg/tow	1.47 c/i	0.34 kg/tow	500	+++	+++
Ocean Pout		0.38 c/i	0.48 kg/tow	0.76 c/i	4.94 kg/tow	3,754	+++	--
Halibut		0.065	1,300	0.07	49,000	3,500	n/a	n/a

Table 3. Short-term implications of GARM III assessments on fishing mortality ($F_{REBUILD}$) estimated to ensure recovery by end of rebuilding period (see "Footnotes to the TORs") and 2009 Catch assuming $F_{REBUILD}$. "c/i" = catch (mt)/survey index (kg/tow).

						Rebuild Date	
Species	***Stock***	***2007 Fishing Mortality***	***Frebuild***	***2008 Assumed Catch (mt)***	***2009 Catch at Frebuild (mt)***	**Date given in Plan**	**Date Assumed for analysis (no formal plan in place)**
Cod	**GB**	**0.300**	**0.186**	**5,957**	**3,722**	**2026**	
Cod	**GOM**	**0.456**	**0.281**	**5,268**	**12,714**	**2014**	
Haddock	**GB**	**0.230**	**n/a[1]**	**21,929**	**n/a[1]**	**2014**	
Haddock	**GOM**	**0.350**	**n/a[6]**	**1,368**	**n/a[6]**	**2014**	
Yellowtail Flounder	**GB**	**0.289**	**0.107[3]**	**2,500[4]**	**2,114[5]**	**2014**	
Yellowtail Flounder	**SNE/MA**	**0.413**	**0.080**	**396**	**425**	**2014**	
Yellowtail Flounder	**CC/GOM**	**0.414**	**0.238**	**627**	**904**	**2023**	
American Plaice	**GB/GOM**	**0.090**	**0.208**	**1,126**	**3,499**	**2014**	
Witch Flounder		**0.290**	**0.194**	**1,172**	**896**		**2018**
Winter Flounder	**GB**	**0.280**	**0.254**	**980**	**1,907**		**2018**
Winter Flounder	**GOM**	**0.417**	**0.275**	**305**	**376**		**2018**
Winter Flounder	**SNE/MA**	**0.649**	**0.000**	**1,857**	**0**	**2014**	
Redfish		**0.007**	**0.038**	**1,160**	**8,631**	**2051**	
White Hake	**GB/GOM**	**0.150**	**0.078**	**2,200**	**2,200**	**2014**	
Pollock	**GB/GOM**	**10.975 c/i**	**5.31 c/i**	**7,756**	**8,003**		**2018**
Windowpane Flounder	**GOM/GB**	**1.96 c/i**	**n/a[2]**	**n/a[2]**	**n/a[2]**		**n/a[2]**
Windowpane Flounder	**SNE/MA**	**1.85 c/i**	**n/a[2]**	**n/a[2]**	**n/a[2]**	**2014**	
Ocean Pout		**0.38 c/i**	**n/a[2]**	**n/a[2]**	**n/a[2]**	**2014**	
Altantic Halibut		**0.065**	**0.044**	**84**	**68**		**2056**

[1] Stock is rebuilt, not applicable.
[2] Panel did not recommend estimation of $F_{REBUILD}$ as these stocks are primarily discard fisheries.
[3] This Frebuild achieves a 75% probability of rebuilding by 2014.
[4] 2,500 for GByt is based on recommendations called for by the TRAC, August 2008.
[5] 2009 catch is based on $F_{REBUILD}$ necessary to achieve a 75% chance of rebuilding by 2014.
[6] For GOM haddock, SSB in 2007 is close to B_{MSY}, and SSB is projected to be > B_{MSY} in 2009.

Retrospective Patterns and the Determination of Current Status

Of the 14 groundfish stocks assessed in GARM III using an analytical assessment model, seven stocks exhibited retrospective patterns that were considered severe enough that an adjustment to the population numbers and fishing mortality in 2007 was deemed necessary before determining current stock status and subsequently conducting projections. The largest retrospective patterns were observed in GB yellowtail, GOM winter flounder, and SNE/MA winter flounder. Moderate retrospective patterns occurred in GB cod, plaice, witch, and redfish.

Retrospective pattern adjustments were approached in two ways. The first involved an analysis to determine whether a split in the survey time series would either reduce or eliminate the retrospective pattern. This split survey approach had previously been recommended by the GARM III ‘Assessment Models’ review as a way to adjust for the retrospective pattern in the Georges Bank yellowtail flounder assessment, and thus the same approach was attempted on the other stocks. The second approach was an adjustment to the population numbers at age in the terminal year in the VPA based upon a measure of the age-specific retrospective pattern during the past seven years. The split survey approach was used to adjust for retrospective patterns in five of the seven assessments where it was deemed necessary. Only for plaice and redfish was the second approach used, although both approaches produced similar levels of adjustment.

The retrospective pattern adjustments changed the status of four of the seven stocks (Table 4). For both GB cod and GB yellowtail, the adjustment resulted in the stocks being classified as experiencing overfishing (both stocks had already classified as being overfished, which did not change with the adjustments). However, the retrospective patterm adjustments for witch and GOM winter flounder resulted in these stocks being classified as both experiencing overfishing and being overfished. The status of the other three stocks (plaice, SNE/MA winter flounder, and redfish) did not change due to the adjustments.

There are a number of potential causes for retrospective patterns, all related to some unexplained change within the time series of observations. The GARM III ‘Assessment Models’ review identified four potential causes of retrospective patterns: (1) an unrecorded change in catches; (2) a change in natural mortality; (3) a change in the abundance index catchability; and (4) a change in fishery selectivity. It is important to emphasize that retrospective patterns adjustments do not resolve the underlying problem. Rather, further work on the nature and causes of the retrospective pattern is required to facilitate more explicit treatments of these patterns in future assessments.

Table 4. Change in status of GARM III groundfish stocks as a consequence of adjustment for observed retrospective pattern; Base and Final refer to the unadjusted and adjusted assessment model respectively; shaded rows indicate where a change in status occurred (not overfishing or overfished to overfishing or overfished). Adjustments are based on average values of Mohn's rho (see "Issues Relevant to All Assessments") rounded to two or three significant digits.

GARM III

Species	Stock	2007 Fishing Mortality			2007 Biomass		
		Base	Final	Percent Change	Base	Final	Percent Change
Cod	GB	0.141	0.300	112.8	25,377	17,672	-30.4
Yellowtail Flounder	GB	0.118	0.289	145.1	18,248	9,527	-47.8
American Plaice	GB/GOM	0.065	0.090	38.5	15,659	11,106	-29.1
Witch Flounder		0.143	0.290	102.7	7354	3,434	-53.3
Winter Flounder	GOM	0.115	0.417	262.6	2,765	1,100	-60.2
Winter Flounder	SNE/MA	0.438	0.649	48.2	4,565	3,368	-26.2
Redfish		0.005	0.007	36.8	234,609	172,342	-26.5

1.0 INTRODUCTION

The Groundfish Assessment Review Meeting (GARM) is a regional scientific peer review process developed in 2002 to provide assessments for the stocks managed under the Northeast Multispecies Fishery Management Plan. The first two GARM reviews occurred in October 2002 (NEFSC, 2002) and August 2005 (NEFSC, 2005), respectively. The GARM III review is the most extensive to date and took place over four meetings held during October 2007 – August 2008:

- Data Inputs (29 Oct – 2 Nov 2007)
- Assessment Models (25 – 29 Feb 2008)
- Biological Reference Points (28 April – 2 May 2008)
- Assessments (4 – 8 August 2008)

The first three meetings focused on the data inputs (e.g. catch, sampling, surveys, etc), assessment models, and biological reference points (BRPs) to be used in the benchmark assessments and rebuilding projections of the 19 Northeast Groundfish stocks, which were the focus of the fourth meeting. The Panel Summary Reports of these three earlier GARM III meetings are available at NEFSC (2008).

This is the report of the GARM III 'Assessments' meeting which reviewed the status of the 19 Northeast Groundfish stocks through 2007, and evaluated the updated work on Gulf of Maine/Georges Bank ecosystem productivity considered at the GARM III 'Biological Reference Points' review (see Section 1.1 for the meeting Terms of Reference The meeting list of meeting participants and agenda are provided in Sections 1.2 and 1.3, respectively.

The GARM III 'Assessment' review Panel (herein termed the 'Panel') consisted of Matthew Cieri, Robert Mohn, Andrew Rosenberg, Alan Sinclair, and the chair, Robert O'Boyle. All were invited based upon their extensive expertise and experience with the issues to be considered at the meeting. A principal task of the Panel was to ensure that the findings and recommendations of the previous three GARM III reviews had been adequately addressed, and that the resultant benchmark assessments provided a sufficient basis for determination of stock status and rebuilding projections. In this report, each of the stock assessment sections was drafted by the lead assessment scientist for that stock. The ecosystem system was similarly drafted by the lead ecosystem scientist. The Panel's conclusions are provided at the end of each section. The Panel also provided observations on issues relevant to all assessments including retrospective patterns, determination of current status, and recruitment assumptions for projections and rebuilding plans. The Panel also provided comments on the treatment of historical data in the assessments and on alternative assessment methods, and provided its perspective on the ecosystem productivity work.

The first section of this report is an Executive Summary, prepared by the GARM III chair, which highlights the main scientific advances made during GARM III and the status of the 19 groundfish stocks. This is followed by an Introduction which provides information on the GARM III assessment review and a comparison of the GARM II and GARM III scientific basis for the assessments, both drafted by the GARM III chair. The main body of the report consists of the stock assessment sections drafted by the relevant lead scientist. The Panel provided observations on issues relevant to all assessments (retrospective error and the determination of current status, and recruitment assumptions and rebuilding plans) at the beginning of the stock assessment section while its conclusions and research recommendations on each stock are provided at the end of each section. The stock assessment section ends with Panel comments on the treatment of historical data in the assessments and alternative assessment methods. The next section of the report provides a synopsis of the findings on the ecosystem productivity work undertaken during GARM III, drafted by the lead scientist which is followed by the Panel's conclusions. The report ends with concluding remarks by the GARM III chair. An appendix to this report (NEFSC 2008, CRD 08-16) contains the Panel Summary Reports from the first three GARM III meeting as well as detailed information tables for some of the single species assessments.

The discussion at the GARM III 'Assessments' review was recorded by assigned rapporteurs. The rapporteur notes provided valuable reference material to the Panel in drafting its reports. These notes are not included in this report but can be obtained directly from the Northeast Fisheries Science Center (NEFSC).

1.1 Terms of Reference

1. Using models or proxy methods reviewed and recommended* at the previous GARM III meetings* for the stocks** listed below:

a.) Provide updated catch and where applicable, catch-at-age estimates (landings and discards, where appropriate) through 2007
b.) Provide updated research vessel survey indices (through spring 2008) for all appropriate surveys, including NEFSC spring and autumn bottom trawl surveys, Canadian DFO and state surveys
c.) for stocks where sufficient data are available, estimate fishing mortality rates and spawning stock biomass through 2007, and provide associated measures of uncertainty
d.) for the remaining stocks (i.e., those not in 1c.), use proxy methods to estimate the exploitation ratio and biomass index through 2007, and provide measures of uncertainty where possible
e.) Update and provide estimates of the Biological Reference Points (BRPs) based on the most recent data and using methods that were reviewed and recommended at the GARM-III "BRP" meeting*. Provide any new analyses or refinements requested by previous GARM review panels
f.) evaluate stock status by comparing the appropriate estimates of stock size and fishing mortality rate to the updated BRP estimates (from "TOR 1.e")
g.) Identify what data and assumptions will be used for making short-term and long-term stock projections. These data include average weights, maturity at age, partial recruitment at age, and recruitment. For those stocks that are "rebuilding", compute $F_{REBUILD}$ consistent with the agreed NEFMC and NERO schedule***. Provide an estimate of predicted catches in 2009 based on current F (2007), F_{MSY} and where appropriate, $F_{REBUILD}$. In making projections, assume that catches in 2008 are equal to 2007.

2. "Ecosystem approaches to Gulf of Maine/Georges Bank fisheries". Use the most recent data and BRP estimates to update the ecosystem results from the GARM-III "BRP" meeting* with respect to:

a.) production potential of the fishery based on food chain processes and aggregate yield from the ecosystem b.) comment on aggregate single stock yield projections in relation to overall ecosystem production

Footnotes to the TORs:

*: Previous GARM-III Meetings include the "Data Methods" meeting 10/29-11/2/07, "Assessment Methodology" meeting 2/25-2/29/08, and "Biological Reference Points" meeting 4/28-5/2/08. Reports and Working Papers from these meetings are available at **http://www.nefsc.noaa.gov/nefsc/saw/**. In cases where GARM reviewers have not yet recommended a particular assessment model, authors are expected to provide any new analyses or refinements requested by previous GARM review panels.

** :

A. Georges Bank (GB) Cod
B. Georges Bank (GB) Haddock
C. Georges Bank (GB) Yellowtail Flounder
D. Southern New England/Mid-Atlantic (SNE/MA) Yellowtail Flounder
E. Gulf of Maine/Cape Cod (GOM/CC) Yellowtail Flounder
F. Gulf of Maine (GOM) Cod
G. Witch Flounder
H. American Plaice
I. Gulf of Maine (GOM) Winter Flounder
J. Southern New England/Mid-Atlantic (SNE/MA) Winter Flounder
K. Georges Bank (GB) Winter Flounder
L. White Hake
M. Pollock
N. Acadian Redfish
O. Ocean Pout
P. Gulf of Maine/Georges Bank (No.) Windowpane
Q. Southern New England/Mid-Atlantic (So.) Windowpane
R. Gulf of Maine (GOM) Haddock
S. Atlantic Halibut

***: GARM Stocks with Northeast Region FMP Rebuilding Plans (rebuilding dates):

Cod- Gulf of Maine	(4/27/04 to 4/27/2014)
Cod – Georges Bank	(4/27/04 to 4/27/2026)
Haddock – Gulf of Maine	(4/27/04 to 4/27/2014)
Haddock – Georges Bank	(4/27/04 to 4/27/2014)
American Plaice	(4/27/04 to 4/27/2014)
Redfish	(4/27/04 to 4/27/2051)
Yellowtail Flounder – SNE/MA	(4/27/04 to 4/27/2014)
Yellowtail Flounder – CC/GM	(4/27/04 to 4/27/2023)
Yellowtail Flounder –GB	(11/22/06 to 4/27/2014)
Ocean Pout	(4/27/04 to 4/27/2014)
White Hake	(4/27/04 to 4/27/2014)
Windowpane Flounder – SNE/MA	(4/27/04 to 4/27/2014)
Winter Flounder – SNE/MA	(4/27/04 to 4/27/2014)

1.2 List of Meeting Participants

Name	Affiliation	email
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1.3 Meeting Agenda

Date /Day	***Start***	***End***	***Duration (min)***	***Topic***	***Presenter***	***Rapporteur***
4-Aug	9:00	9:10	10	Introduction	Weinberg (SAW Chair)	
1	9:10	9:30	20	Overview of GARM and objectives of this meeting	O'Boyle (GARM Chair)	
				TOR #1 Estimate Stock Status for 19 Groundfish stocks.		
1	9:30	9:45	15	*Working Paper 1.1* Review of previous GARM I and II Results	Rago	Wigley
1	9:45	10:30	45	*Working Paper 1.2* When should time series be split: potential changes in catchability, natural mortality and catches.	Legault	Wigley
1	10:30	10:45	15	Break		
1	10:45	11:15	30	Discussion		
1	11:15	12:00	45	*WP 1.C* Georges Bank Yellowtail Flounder	Legault	Richards
1	12:00	12:30	30	Discussion		
1	12:30	13:30	60	Lunch		
1	13:30	14:15	45	*WP1.D* Southern New England Yellowtail Flounder	Alade	Richards
1	14:15	14:30	15	Discussion		
1	14:30	15:15	45	*WP 1.E* Gulf of Maine-Cape Cod Yellowtail Flounder	Legault	Richards
1	15:15	15:30	15	Discussion		
1	15:30	15:45	15	Break		
1	15:45	16:45	60	*WP 1.B* Georges Bank Haddock	Brooks	Mayo
1	16:45	17:00	15	Discussion		
1	17:00	17:35	35	*WP 1.R* Gulf of Maine Haddock	Palmer	Mayo
1	17:35	17:50	15	Discussion		
1	17:50	18:00	10	Summary/Followup Chair	O'Boyle	

Date /Day	***Start***	***End***	***Duration (min)***	***Topic***	***Presenter***	
5-Aug	***9:00***	9:15	15	Progress review and Order of the Day (Chair)	O'Boyle	
				TOR #1 Estimate Stock Status for 19 Groundfish stocks. (cont.)		
2	9:15	10:15	60	*WP 1.A* Georges Bank Cod	O'Brien	Brooks
2	10:15	10:30	15	Discussion		
2	10:30	10:45	15	Break		
2	10:45	11:35	50	*WP 1.F-a* Gulf of Maine Cod	Mayo	Shepherd
2	11:35	11:50	15	Discussion		
2	11:50	12:40	50	*WP 1.F-b* Gulf of Maine Cod	Butterworth	Shepherd
2	12:40	13:40	60	Lunch		
2	13:40	14:40	60	Discussion of GOM cod (both)		
2	14:40	15:30	50	*WP 1.L-a* White Hake	Sosebee	Palmer
2	15:30	15:40	10	Discussion		
2	15:40	15:55	15	Break		
2	15:55	16:45	50	*WP 1.L-b.* White Hake	Butterworth	Palmer
2	16:45	17:15	30	Discussion of white hake (both 1.La, 1.Lb)		
2	17:15	17:30	15	Summary/Followup	O'Boyle	
Date /Day	***Start***	***End***	***Duration (min)***	***Topic***	***Presenter***	
6-Aug	***9:00***	9:15	15	Progress review and Order of the Day (Chair)	O'Boyle	
3	9:15	10:00	45	*WP 1.G.* Witch Flounder	Wigley	Col
3	10:00	10:15	15	Discussion		
3	10:15	11:00	45	*WP 4.H.* Gulf of Maine/Georges Bank American Plaice	O'Brien	Nitschke
	11:00	11:15	15	Break		
	11:15	11:30	15	Discussion		
3	11:30	12:15	45	*WP 1.J.* Southern New England Winter flounder	Terceiro	Traver
3	12:15	12:30	15	Discussion		
3	12:30	13:30	60	Lunch		
3	13:30	14:15	45	*WP 1.I.* Gulf of Maine Winter Flounder	Nitschke	Blaylock
3	14:15	14:30	15	*Discussion*		

3	14:30	15:15	45	*WP 1.K.* Georges Bank Winter Flounder	Hendrickson	Alade
3	15:15	15:30	15	Discussion		
3	15:30	15:45	15	Break		
3	15:45	16:30	45	*WP 1.N.* Gulf of Maine/ Georges Bank Acadian Redfish	Miller	Sosebee
3	16:30	16:45	15	Discussion		
3	16:45	17:30	45	*WP 1.S.* Atlantic Halibut	Col	Sosebee
3	17:30	17:45	15	Discussion		
3	17:45	18:00	15	Summary/Followup	O'Boyle	
Date /Day	***Start***	***End***	***Duration (min)***	***Topic***	***Presenter***	
7-Aug	***9:00***	9:15	15	Progress review and Order of the Day	O'Boyle	
				TOR #2. Ecosystem approaches to Gulf of Maine/Georges Bank fisheries		
4	9:15	10:15	60	*WP 2.1* US NE Shelf LME Biomass, target biological reference points for fish and worldwide cross-system comparisons: Implications for single species reference points	Overholtz	Chute
4	10:15	10:30	15	Discussion		
4	10:30	10:45	15	Break		
4	10:45	11:15	30	Discussion (cont.)		
4	11:15	11:45	30	*WP 1.O.* Ocean Pout	Wigley	Col
	11:45	12:00	15	Discussion		
4	12:00	13:00	60	Lunch		
				TOR #1 Estimate Stock Status for 19 Groundfish stocks. (cont.)		
4	13:00	13:30	30	*WP 1.M* Pollock	Mayo	Miller
4	13:30	13:45	15	Discussion		
4	13:45	14:15	30	*WP 1.Q.* Southern New England – Mid-Atlantic Windowpane	Hendrickson	Blaylock
4	14:15	14:30	15	Discussion		

4	14:30	15:00	30	*WP 1.P.* Gulf of Maine/Georges Bank Windowpane Flounder	Hendrickson	Blaylock
4	15:00	15:15	15	Break		
4	15:15	15:30	15	Discussion		
4	15:30	17:30	120	Review/Revisits/Revisions		
4	17:30	18:00	30	Summary/Followup (Chair)	Chair	
8-Aug	***9:00***	9:15	15	Progress review and Order of the Day	O'Boyle	
5	9:15	10:15	60	Review of Outstanding Issues as necessary	TBD	
5	10:15	10:30	15	Break		
5	10:30	11:45	75	Report Development [CLOSED]		
5	11:45	12:45	60	Lunch		
5	12:45	16:00	195	Report Development, Summary and Assignments [CLOSED]		
5	16:00	16:00	0	Adjourn		

1.4 List of Working Papers

List of Working Papers for the GARM III Final Meeting
August 4-8, 2008

WP	Description	Author
1.1	Review of Previous GARM I & II Results	Rago
1.2	When should time series be split	Legault
1.A	Georges Bank Cod	O'Brien
App 1.A	Appendix Georges Bank Cod	O'Brien
1.B	Georges Bank Haddock	Brooks
App 1.B	Appendix Georges Bank Haddock	Brooks
1.C	Georges Bank Yellowtail Flounder	Legault
App 1.C	Appendix Georges Bank Yellowtail Flounder	Legault
1.D	Southern New England Yellowtail Flounder	Alade
App 1.D	Appendix Southern New England Yellowtail Flounder	Alade
1.E	Gulf of Maine-Cape Cod Yellowtail Flounder	Legault
App 1.E	Appendix Gulf of Maine CC Yellowtail Flounder	Legault
1.F.a	Gulf of Maine Cod	Mayo
App 1.F.a	Appendix Gulf of Maine Cod	Mayo
1.F.b	Gulf of Maine Cod	Butterworth
1.G	Witch Flounder	Wigley
App 1.G	Appendix Witch Flounder	Wigley
1.H	Gulf of Maine/Georges Bank American Plaice	O'Brien
App 1.H	Appendix Gulf of Maine Georges Bank Plaice	O'Brien
1.I	Gulf of Maine Winter Flounder	Nitschke
App 1.I	Appendix Gulf of Maine Winter Flounder	Nitschke
1.J	Southern New England Winter Flounder	Terceiro
App 1.J	Appendix Southern New England Winter Flounder	Terceiro
1.K	Georges Bank Winter Flounder	Hendrickson
App 1.K	Appendix Georges Bank Winter Flounder	Hendrickson
1.L.a	White Hake	Sosebee
App 1.L.a	Appendix White Hake	Sosebee
1.L.b	White Hake	Butterworth
1.M	Pollock	Mayo
App 1.M	Appendix Pollock	Mayo
1.N	Gulf of Maine/Georges Bank Acadian Redfish	Miller
App 1.N	Appendix Gulf of Maine/Georges Bank Redfish	Miller
1.O	Ocean Pout	Wigley
App 1.O	Appendix Ocean Pout	Wigley
1.P	Gulf of Maine/Georges Bank Windowpane	Hendrickson
1.Q	Southern New England/Mid Atlantic Windowpane	Hendrickson
1.R	Gulf of Maine Haddock	Palmer
App 1.R	Appendix Gulf of Maine Haddock	Palmer
1.S	Atlantic Halibut	Col
App 1.S	Appendix Atlantic Halibut	Col
2.1	US NE Shelf LME Biomass	Fogarty, Overholtz, Link
2.2.a	Statistical Catch at Age Analysis ADAPT vs VPA	Butterworth
2.2.b	Retrospective Analysis for the Gulf of Maine cod	Butterworth

1.5 List of Stock Abbreviations

This report represents the work of over 20 authors and a variety of abbreviations are used throughout the report. These are necessary for both graphical and tabular summaries. For clarity, a list of abbreviation is provided below.

Chapter	Stock	Abbreviation
A.	Georges Bank Cod	GB COD
B.	Georges Bank Haddock	GB Had, GB Haddock
C.	Georges Bank Yellowtail Flounder	GBYT, GBYT1—refers to base model GBYT2—refers to "major change" model
D.	So. New England/Mid-AtlanticYellowtail Flounder	SNE/MA YT
	So. New England Yellowtail Flounder (before 2003)	SNE YT
	Mid-Atlantic Yellowtail Flounder (before 2003)	MA YT
E.	Gulf of Maine/Cape Cod Yellowtail Flounder	CC/GOM YT
	Cape Cod Yellowtail Flounder	CC YT
F.	Gulf of Maine Cod	GOM Cod
G.	Witch Flounder	Witch
H.	American Plaice	Plaice
I.	Gulf of Maine Winter Flounder	GOM Win, GM Wint
J.	So. New England/Mid-Atlantic Winter Flounder	SNE/MA Wint, SNE Wint
K.	Georges Bank Winter Flounder	GB Wint
L.	White Hake	W Hake
M.	Pollock	Pollock
N.	Acadian Redfish	Redfish,
O.	Ocean Pout	Pout
P.	Gulf of Maine/Georges Bank Windowpane	No. Window, N Wind
Q.	So. New England/Mid-Atlantic Windowpane	So. Window, S Wind
R.	Gulf of Maine Haddock	GOM Had
S.	Atlantic Halibut	Halibut

1.6 Comparison of GARM II and GARM III Basis for Assessment

As noted earlier, GARM I occurred in October 2002 (NEFSC, 2002) and was convened to (a) address stock status with respect to newly revised BRPs and (b) consider the effects of asymmetric trawl warps on the stock assessments. GARM II occurred in August 2005 (NEFSC, 2005) and focused on updating stock status using catch data through 2004. Potential revisions to models and BRPs were not part of the GARM II terms of reference. Instead, the updated assessments were used to track the changes in stock status at a waypoint on the rebuilding schedules as required by Amendment 13 to the Northeast Multispecies (Groundfish) Management Plan.

GARM III comprised an in-depth review of the data, models and BRPs for the 19 Northeast groundfish stocks. Rather than just updating the stock assessments, GARM III developed new benchmark assessments for each of the groundfish stocks which will be used until the next benchmark reviews.

Data Inputs

An essential input to each assessment is the landings data. The current Vessel Trip Report (VTR) system was implemented in 1994, before which landings were obtained from the dealer weigh-out system, apportioned to stock area by information from a voluntary interview system of captains and crew members. Until a unique identifier was put in place in 2004, matching of the VTRs (to obtain area of catch) with the Dealer Reports (to obtain amount of catch) was not straightforward. The GARM III assessments benefited from development of a new four level, trip-based hierarchical algorithm, which is comprehensive, consistent across species, provides continuity with the previous interview system, uses a common data source for all species, and provides a finer scale of spatial resolution than was previously available. During the GARM III 'Data Inputs' meeting, attention was focused on changes to the landings dataset that might ensue under the new system. It was noted that 87% of the records in the database had information comprehensive enough to allow VTR – Dealer Report matching, without resorting to the probabilistic matching required when information was incomplete (the remaining 13% of the cases). Overall, there was little impact on the landings allocation amongst stocks, with landings unchanged from GARM II. However, if allocation problems were to occur these likely would occur in small stocks located geographically adjacent to larger ones. A benefit of the new landings allocation system is that it provides the opportunity for future assessments to explore the impact of uncertainty in reported stock area of the landings.

The GARM III 'Data Inputs' review also considered how best to estimate discards. All of the GARM III assessments used a common approach is estimating discards. A number of discard estimators were initially considered, all dependent upon analysis of the extensive Northeast Fisheries Observer Program (NEFOP) dataset. The 'Data Inputs' review indicated that the Ratio of Sums method (sum of discards divided by sum of total landings) was the most appropriate approach for estimating discards. Alternative ways of estimating discards (e.g. mean discard per trip multiplied by the total number of trips) depend upon having accurate estimates of the total number of trips, which is often not the case. Total landings estimates were deemed more reliable than total number of trips. The review also made recommendations on which landings data to use in the discard estimation, suggesting that the observer data base be analyzed to develop a suite of harvested species associated with discards of the species of interest. Discards could then be estimated based on expansion of the observed discards associated with the landings of the particular suite of associated species. Regarding historical (pre-NEFOP) estimates of discards, these have generally been based upon analyses of bottom trawl survey data to infer discard rates with no one common approach employed for all stocks. This issue might be explored in more detail for future reviews. On balance, the discard estimates in GARM III are similar to those in GARM II.

Since GARM II, results from a number of tagging studies have become available to inform the stock assessments through quantification of migration patterns and by providing independent estimates of fishing and natural mortality. However, the migration models that were reviewed were considered too preliminary to accurately provide quantified estimates of migration rates. Tagging data proved most useful in interpreting trends in fishery partial recruitment in several assessments (e.g., GOM cod and white hake) illustrating one aspect of the utility of these data in stock assessments.

The GARM III 'Data Inputs' review also examined a number of issues related to the NMFS/NEFSC bottom trawl surveys, including the interpretation of stratified mean catch per tow values of zero. When such values occur for a species, the implication is that abundance is too low to be detected by the survey - rather than being truly zero. As such, it was recommended that zero values should be interpreted as being missing. Another issue discussed was the use in model tuning of swept area estimates of abundance (rather than numbers per tow) as this allows examination of survey catchability estimates which sometimes unexpectedly may be greater than 1.0. This approach was accepted as it provides a diagnostic in interpreting the assessment results. Overall, the GARM review of the NMFS surveys did not result in any significant changes to the time series of survey data.

The "Data Inputs' review also reviewed the data from various industry-based resource surveys, which were used in some of the groundfish assessments. It was noted that such surveys provide extremely valuable information on fish distributions, spawning areas, age-length keys, maturity and maturation rates, and other biological characteristics on a finer scale (in many cases) than is often available from the NMFS surveys. Further development of these surveys and studies on their applicability was therefore encouraged.

Also reviewed at the 'Data Inputs' meeting was an extensive analysis, by stock, of temporal trends in various biological and population dynamics parameters such as length-at-age, weight-at-age, maturity-at-age, and condition. Many of the groundfish stocks exhibit long term declines in weight-at-age which have significant implications for biological reference points. Unfortunately, without an understanding of the underlying causes for these patterns, it is difficult to determine how best to address these phenomena. Nonetheless, the review recommended specific ways to address these trends in the estimation of BRPs and stock projections. For instance, it was recommended that estimation of maturity-at-age use a multi-year smoothing average, with the size of the smoothing window determined separately for each stock based on influential biological processes. This approach allows for slow change in maturity at age which may be due to some as yet unknown process – but, by using a smoothed average, also recognizes the possibility that the observed patterns may be purely random. In general, to reflect the influence of recent changes in biological and population dynamics parameters, the groundfish assessments used the most recent 5-year average of weights-at-age in both the stock status determination and rebuilding projections.

Assessment Methodology

At the GARM III 'Assessment Models' meeting, the analytical framework proposed to be used to assess each stock was reviewed. A number of different types of assessment models are available including relative trends, production, length-based, and age-based (see NEFSC, 2008 for a glossary of terms). For each stock, attention was focused on data limitations and model assumptions and uncertainties to determine the most appropriate assessment model for that stock. For instance, for data-limited stocks situations such pollock, ocean pout, and the two windowpane stocks, it is only possible to use a relative trends assessment model (e.g. AIM). For more data-rich stocks, one of the principal uncertainties is the error in the catch-at-age information. In cases where this error is substantial, it is necessary to make assumptions on the age- and year-specific pattern of fishery exploitation (termed the 'partial recruitment' pattern). Statistical Catch at Age (SCAA) formulations can be used that predict, in a forward-projecting mode, catch-at-age proportions given estimates of partial recruitment. This class of models allows exploration of a number of processes through software such as ASAP, ASPM and SCALE. When the error in the catch-at-age is considered small, the fishery partial recruitment pattern can be derived from fishing mortality-at-age estimates using backward calculating procedures such as VPA.

For most of the groundfish assessments, the SCAA or VPA results were not substantially different, suggesting that neither error in the catch-at-age nor departures from a stable partial recruitment pattern was critically important. Consequently, most of the assessments used a VPA formulation (Table 5). In two cases, GOM haddock and GB winter flounder, new age-based VPA formulations replaced previous AIM and ASPIC formulations. Both VPA and SCALE were attempted on GOM winter flounder. Given the uncertainty with the catch-at-age of white hake, SCAA was used replacing ASPIC and AIM formulations. The relative trends assessment formulations used for pollock, the two windowpane stocks and for ocean pout remained unchanged from previous assessments due to continuing data limitations. However, a new replacement yield model was developed for Atlantic halibut, a stock which previously lacked an assessment formulation.

Table 5. Comparison of Assessment Models used in GARM II and GARM III

Species	*Stock*	*GARM II*	*GARM III*
Cod	**GB**	**VPA**	**VPA**
Cod	**GOM**	**VPA**	**VPA**
Haddock	**GB**	**VPA**	**VPA**
Haddock	**GOM**	**AIM**	**VPA**
Yellowtail Flounder	**GB**	**VPA**	**VPA**
Yellowtail Flounder	**SNE/MA**	**VPA**	**VPA**
Yellowtail Flounder	**CC/GOM**	**VPA**	**VPA**
American Plaice	**GB/GOM**	**VPA**	**VPA**
Witch Flounder		**VPA**	**VPA**
Winter Flounder	**GB**	**ASPIC**	**VPA**
Winter Flounder	**GOM**	**VPA**	**VPA & SCALE**
Winter Flounder	**SNE/MA**	**VPA**	**VPA**
Redfish		**RED**	**SCAA**
White Hake	**GB/GOM**	**ASPIC & AIM**	**SCAA**
Pollock	**GB/GOM**	**AIM**	**AIM**
Windowpane Flounder	**GOM/GB**	**AIM**	**AIM**
Windowpane Flounder	**SNE/MA**	**AIM**	**AIM**
Ocean Pout		**Index Method**	**Index Method**
Altantic Halibut		**None**	**Replacement Yield**

Retrospective patterns (systematic over or under-estimation of population parameters in recent years) were evident in many of groundfish analytical assessments. One potential cause of a retrospective pattern is mis-specification of the partial recruitment on the oldest age groups in the fishery. The ‘Assessment Models’ review noted that while dome-shaped fishery and survey partial recruitments may resolve retrospective patterns, these may also lead to what was termed ‘cryptic’ biomass – biomass generated by the model that has not been observed in either the fishery or surveys. Throughout the GARM III review, the burden of proof was placed upon analysts to convincingly demonstrate that fish existed in the population when not observed in the fishery and surveys, even if the model fit with dome-shaped partial recruitment appeared superior. In some cases, additional information (data and/or assumptions) external to the model was requested. For example, tagging information was explored to determine whether a domed partial recruitment pattern could be detected, and catch-at-age information was extended out to include as many age groups as reliably possible (from seven to eleven for GOM cod). In just two stocks (GOM cod and white hake) were domed fishery partial recruitment patterns accepted as part of the final assessment formulation.

Several other technical issues related to the stock assessment models (e.g. plus group algorithm, and weighting of model components) were considered at the "Assessment Models' review; these are described in the Panel Summary Report available at NEFSC (2008).

Overall, significant advances were made in the assessment models for the 19 Northeast groundfish stocks through the GARM III process.

Biological Reference Points

The GARM III 'Biological Reference Points' reviewed and evaluated B_{MSY} and F_{MSY} reference points of each of the 19 groundfish stocks. Table 6 (reproduced from the GARM III 'BRP' Panel Summary Report; see NEFSC 2008) provides a comparison of the methodology used to produce these BRPs in GARM II and GARM III.

Table 6. Comparison of Methodology to Estimate Biological Reference Points in GARM II and GARM III

		GARM II		
Species	**Stock**	**S_R Model**	**Bmsy or proxy**	**Fmsy or proxy**
Cod	GB	Parametric	BH SSBmsy	BH Fmsy
Cod	GOM	Parametric	BH SSBmsy	BH Fmsy
Haddock	GB	Non-parametric	SSB/R (F40%MSP) avg R	F 40% MSP
Haddock	GOM	Equilibrium point	Fall RV msy (5100t) Frep (0.23)	Rel F at Rep
Yellowtail Flounder	GB	Non-parametric	SSB/R (F40%MSP) avg R	F 40% MSP
Yellowtail Flounder	SNE/MA	Non-parametric	SSB/R (F40%MSP) avg R	F 40% MSP
Yellowtail Flounder	CC/GOM	Non-parametric	SSB/R (F40%MSP) avg R	F 40% MSP
American Plaice	GB/GOM	Non-parametric	SSB/R (F40%MSP) avg R	F 40% MSP
Witch Flounder		Non-parametric	SSB/R (F40%MSP) avg R	F 40% MSP
Winter Flounder	GB	NA	SP Bmsy	SP Fmsy
Winter Flounder	GOM	Parametric	BH SSBmsy	BH Fmsy
Winter Flounder	SNE/MA	Parametric	BH SSBmsy	BH Fmsy
Redfish		Non-parametric	SSB/R (F50%MSP) avg R	F 50% MSP
White Hake	GB/GOM	Equilibrium point	SP Bmsy	Rel F at Rep
Pollock	GB/GOM	Equilibrium point	Fall RV	Rel F at Rep
Windowpane Flounder	GOM/GB	Equilibrium point	Fall RV	Rel F
Windowpane Flounder	SNE/MA	Equilibrium point	Fall RV	Rel F at Rep
Ocean Pout		Equilibrium point	Spring RV	Rel F at Rep
Altantic Halibut		NA	External: MSY/F0.1	Proxy F 0.1 MSY (300t)
		GARM III		
Species	**Stock**	**S_R Model**	**Bmsy or proxy**	**Fmsy or proxy**
Cod	GB	Non-parametric	SSB/R (40%MSP)	F40%MSP
Cod	GOM	Non-parametric	SSB/R (40%MSP)	F40%MSP
Haddock	GB	Non-parametric	SSB/R (40%MSP)	F40%MSP
Haddock	GOM	Non-parametric	SSB/R (40%MSP	F40%MSP
Yellowtail Flounder	GB	Non-parametric	SSB/R (40%MSP)	F40%MSP
Yellowtail Flounder	SNE/MA	Non-parametric	SSB/R (40%MSP)	F40%MSP
Yellowtail Flounder	CC/GOM	Non-parametric	SSB/R (40%MSP)	F40%MSP
American Plaice	GB/GOM	Non-parametric	SSB/R (40%MSP)	F40%MSP
Witch Flounder		Non-parametric	SSB/R (40%MSP)	F40%MSP
Winter Flounder	GB	Non-parametric	SSB/R(40%MSP)	F40%MSP
Winter Flounder	GOM	Non-parametric	SSB/R (40%MSP)	F40%MSP
Winter Flounder	SNE/MA	Non-parametric	SSB/R (40%MSP)	F40%MSP
Redfish		Non-parametric	SSB/R (50%MSP)	F50%MSP
White Hake	GB/GOM	Non-parametric	SSB/R (40%MSP)	F40%MSP
Pollock	GB/GOM	Visual interpretation	External	Rel F at replacement
Windowpane Flounder	GOM/GB	Visual interpretation	External	Rel F at replacement
Windowpane Flounder	SNE/MA	Visual interpretation	External	Rel F at replacement
Ocean Pout		Visual interpretation	External	Rel F at replacement
Altantic Halibut		Implied	Internal	F0.1

Whereas an array of methods was used to compute BRPs in GARM II, the principal method used in GARM III was to (a) estimate F_{MSY} based upon $F_{40\%MSP}$ (50% for redfish) from a spawning biomass per recruit analysis, and (b) to estimate the associated B_{MSY} using the complete population recruitment time series in a 100 year forward projection. Although a parametric approach was recommended in deriving BRPs when the stock-recruitment relationship derived from an assessment was informative, most of the groundfish assessments did not display compelling support for any particular functional form of stock recruitment (SR) relationship, and the SR parameters were generally poorly determined. Hence, for all 14 groundfish stocks assessed using an analytical framework, $F_{40\%MSP}$ was recommended as a proxy for F_{MSY} and a B_{MSY} proxy computed using a stochastic projection approach (termed the 'non-parametric' approach). The 'non-parametric' approach required inspection of the stock-recruitment relationship from the available historical population time series to select the stream of recruitments for the stochastic stock and rebuilding plan projections. Specifically, it required a decision on whether there was a spawning stock biomass level (termed the 'breakpoint') below which recruitment would be significantly reduced. It also required determination of whether exceptionally large year-classes occurred that were unrelated to the size of the spawning stock biomass, perhaps as a consequence of some environmental process. These breakpoints are a new feature of BRPs estimated for half of the GARM III stocks.

The GARM III recognized that long-term changes in productivity may have had an impact on the BRPs but considered that firm evidence was required to suggest that BRPs have changed due to environmental factors rather than fishery effects. Consequently, when a recruitment time series was selected to use in the estimation of the BRPs, this was related more to data and model estimation issues than to potential long-term changes in ecosystem and stock productivity. For stocks in which there were no long-term trends in the biological parameters (most commonly the maturity at age), the entire recruitment time series was used. This was considered to provide the best estimates of short to medium term stock productivity, and therefore to be most appropriate for calculating BRPs. For stocks exhibiting strong recent trends in biological parameters (e.g. GB haddock weight-at-age), the most recent estimates of these parameters - or the forward projection of these trends – was considered to provide the more accurate estimates of future, short-term conditions.

For some of the groundfish stocks, the BRP values reviewed and evaluated at the 'Biological Reference Points' meeting review were deemed provisional and subject to modification at the final GARM III meeting (the 'Assessments' meeting). The final set of BRPs for all 19 groundfish stocks is provided in Table 7. While some stocks previously (in GARM I and GARM II) had BRPs based upon index approaches (e.g. GOM haddock), many of these stocks now have BRPs based upon age-based models. This was not possible in all cases (e.g. windowpane and ocean pout) due to data and/or modeling constraints. The data sets for some of the stocks were extended considerably back in time (1913 for redfish, and 1893 for Atlantic halibut).

Most of the GARM III biomass reference points are lower and the fishing mortality reference points higher than those determined in GARM II. However, a direct one-to-one comparison between the old and new BRPs is inappropriate due to changes in weights-at-age and partial recruitment at age. For example, if through a combination of lower growth rates and fishery management regulations (e.g., increased mesh sizes), the fishery is now exploiting older individuals, the fishing mortality reference point would be expected to be higher simply based upon yield per recruit considerations alone.

It is therefore important that the nature and reasons for the changes in BRPs be clearly explained and communicated.

Table 7. Biological Reference Points from GARM II and GARM III for 19 Northeast Groundfish Stocks (from GARM III 'BRP' review with updates from the final GARM III 'assessment' review meeting). B_{MSY} or proxies for GARM II were rounded to the nearest 100 mt. F_{MSY} or proxies for GARM II and III were rounded to nearest hundredth. B_{MSY} estimates are in mt unless indicated otherwise. "c/i"= catch (000's mt)/survey index (kg/tow).

		GARM II			
Species	*Stock*	*Model*	*Bmsy or proxy (mt)*	*Fmsy or proxy*	*MSY (mt)*
Cod	**GB**	VPA	216,800	0.18	35,200
Cod	**GOM**	VPA	82,800	0.23	16,600
Haddock	**GB**	VPA	250,300	0.26	52,900
Haddock	**GOM**	Landings & Survey	22.17 kg/tow	0.23c/i	5,100
Yellowtail Flounder	**GB**	VPA	58,800	0.25	12,900
Yellowtail Flounder	**SNE/MA**	VPA	69,500	0.26	14,200
Yellowtail Flounder	**CC/GOM**	VPA	12,600	0.17	2,300
American Plaice	**GB/GOM**	VPA	28,600	0.17	4,900
Witch Flounder		VPA	25,250	0.23	4,375
Winter Flounder	**GB**	ASPIC	9,400	0.32	3,000
Winter Flounder	**GOM**	VPA	4,100	0.43	1,500
Winter Flounder	**SNE/MA**	VPA	30,100	0.32	10,600
Redfish		RED	236,700	0.04	8,200
White Hake	**GB/GOM**	AIM	14,700	0.29	4,200
Pollock	**GB/GOM**	AIM	3.00 kg/tow	5.88 c/i	17,600
Windowpane Flounder	**GOM/GB**	AIM	0.94 kg/tow	1.11 c/i	1,000
Windowpane Flounder	**SNE/MA**	AIM	0.92 kg/tow	0.98 c/i	900
Ocean Pout		Index Method	4.9 kg/tow	0.31 c/i	1,500
Altantic Halibut		None	5,400	0.06	300
		GARM III			
Species	*Stock*	*Model*	*Bmsy or proxy (mt)*	*Fmsy or proxy*	*MSY (mt)*
Cod	**GB**	VPA	148,084	0.25	31,159
Cod	**GOM**	VPA	58,248	0.24	10,014
Haddock	**GB**	VPA	158,873	0.35	32,746
Haddock	**GOM**	VPA	5,900	0.43	1,360
Yellowtail Flounder	**GB**	VPA	43,200	0.25	9,400
Yellowtail Flounder	**SNE/MA**	VPA	27,400	0.25	6,100
Yellowtail Flounder	**CC/GOM**	VPA	7,790	0.24	1,720
American Plaice	**GB/GOM**	VPA	21,940	0.19	4,011
Witch Flounder		VPA	11,447	0.20	2,352
Winter Flounder	**GB**	VPA	16,000	0.26	3,500
Winter Flounder	**GOM**	VPA	3,792	0.28	917
Winter Flounder	**SNE/MA**	VPA	38,761	0.25	9,742
Redfish		ASAP	271,000	0.04	10,139
White Hake	**GB/GOM**	SCAA	56,254	0.13	5,800
Pollock	**GB/GOM**	AIM	2.00 kg/tow	5.66 c/i	11,320
Windowpane Flounder	**GOM/GB**	AIM	1.40 kg/tow	0.50 c/i	700
Windowpane Flounder	**SNE/MA**	AIM	0.34 kg/tow	1.47 c/i	500
Ocean Pout		Index Method	4.94 kg/tow	0.76 c/i	3,754
Altantic Halibut		Replacement Yield	49,000	0.07	3,500

Stock and Rebuilding Plan Projections

The GARM III considered how best to undertake the stock and rebuilding plan projections. A key element was to use the same assumptions for growth, maturity, natural mortality, and recruitment in the projections as used in estimating the BRPs - but with additional consideration of recruitment values in the available population time series when SSBs were below the breakpoint (see section below "Recruitment Assumptions and Rebuilding Plans") during the rebuilding period.

As with the BRPs, a direct comparison of the GARM II and GARM III $F_{REBUILD}$ estimates is inappropriate due to changes in a number of the assumptions on the biological and fishery parameters during the rebuilding period.

Ecosystem Considerations

Unlike the GARM II process, the GARM III process was able review an examination of the productivity of the Northeast Shelf ecosystem with particular regard to the joint sustainability of the 19 Northeast groundfish stocks - and also relative to several other species groups (invertebrates, pelagics and elasmobranchs). The review indicated that at the current low biomass of many of the groundfish stocks, the aggregate MSY is almost equivalent to the sum of the MSY estimates for each stock. However, as the biomasses of the groundfish stocks increase, the estimated aggregate MSY could be significantly less than the sum of the individual stock MSY estimates. The ecosystem work was recognized as being innovative, but too early in its development for implementation. Notwithstanding this, efforts are encouraged that explore how broader ecosystem considerations could be used to complement and enhance single stock management in the Northeast Region.

2.0 STOCK ASSESSMENTS OF 19 NORTHEAST GROUNDFISH STOCKS

Issues Relevant to all Assessments

Retrospective error and the determination of current status and basis of F rebuild

The issue of retrospective patterns (systematic under or over-estimation of spawning stock biomass (SSB) and / or fishing mortality in modeled stock reconstructions) was raised in both the GARM III models and BRP reviews. The former considered potential factors responsible for retrospective patterns while the latter provided guidance on how to address retrospective patterns in relation to the determination of stock status and BRPs. The GARM III 'models' review identified four potential causes of retrospective patterns: an unrecorded change in catches, a change in natural mortality, a change in the abundance index catchability, and a change in fishery selectivity.

Almost all the assessments of the GARM III stocks considered at the current review exhibited a pattern with an over-estimation of SSB and an under-estimation of fishing mortality (F) in the last, current, year of the analysis. It was not possible to determine which single factor or combination of factors was responsible for the observed retrospective patterns. However, it was considered appropriate to adjust for the retrospective when formulating catch advice. To judge whether or not this pattern was severe enough to require adjustment in the 2007 population numbers for the stock and rebuilding plan projections, the Panel compared this pattern to the estimates of uncertainty available for the current year's SSB and F. If the pattern was greater than this uncertainty, then the Panel considered that an adjustment to the 2007 population numbers was required. Of the 14 GARM III stocks that were assessed using an age-based assessment model, seven of these had retrospective patterns severe enough that an adjustment was deemed necessary (table 8).

Table 8. Retrospective Patterns in 14 GARM III Northeast Groundfish Stocks; retrospective patterns were not determined for other stocks which used Relative Trend (Index) models (Pollock, the two Windowpane stocks and Ocean Pout) as well as Halibut.

Species	***Stock***	***Retrospective Pattern***	***Adjustment***
Cod	**GB**	**Moderate**	**Split Survey Time Series**
Cod	**GOM**	**Small**	**Not required**
Haddock	**GB**	**Small**	**Not required**
Haddock	**GOM**	**Small**	**Not required**
Yellowtail Flounder	**GB**	**Large**	**Split Survey Time Series**
Yellowtail Flounder	**SNE/MA**	**Small**	**Not required**
Yellowtail Flounder	**CC/GOM**	**Small**	**Not required**
American Plaice	**GB/GOM**	**Moderate**	**Rho Adjustment**
Witch Flounder		**Moderate**	**Split Survey Time Series**
Winter Flounder	**GB**	**Small**	**Not required**
Winter Flounder	**GOM**	**Large**	**Split Survey Time Series**
Winter Flounder	**SNE/MA**	**Large**	**Split Survey Time Series**
Redfish		**Moderate**	**Rho Adjustment**
White Hake	**GB/GOM**	**Small**	**Not required**

Adjustment for the retrospective pattern was approached in two ways. The first involved an analysis to identify a split in the survey time series which would either reduce or remove the retrospective pattern. This split survey approach (herein termed 'Split') was recommended by GARM III 'models' review as a means to adjust for retrospective patterns in some assessments (e.g. Georges Bank yellowtail) and its broader application was considered at this meeting. The second approach was an adjustment to the numbers at age in the terminal year of the analysis based upon a measure, Rho (Mohn, 1999) of the age-specific retrospective pattern over the previous seven years (herein termed 'Rho Adjusted'). The number of years (seven) to include in the analysis was arbitrary but generally spans the recent time period of the retrospective pattern in most of the assessments.

Regarding the Split approach, an analysis was considered (working paper 1.2) to determine the potential utility of a split in the survey time series for all GARM III assessments. A moving window analysis was employed to detect non-stationarity in the estimates of the survey catchability (q). The analysis provided temporal patterns in q at age, which in turn was used to infer the most appropriate year to split the survey time series. In many cases, splitting the survey time series sometime around 1995 significantly reduced the retrospective pattern. The Split approach was employed in five of the GARM III assessments (table 8).

In a few cases (plaice and redfish), the Split approach did not improve the retrospective pattern and thus the Rho Adjusted approach was used. While the Rho Adjusted approach may be more transparent than the Split approach, it produces a discontinuity in the last year of the analysis, complicating the calculations of the stock projections. Using the Split approach to adjust for the retrospective pattern has the advantage over the Rho Adjusted approach in that it produces a reconstruction of the population dynamics without a discontinuity in the most recent year.

In each of the assessments provided below, where a retrospective pattern adjustment was made, the results of both the Split and Rho Adjusted approach are presented along with the results of the Base, unadjusted, model. A comparison between the two adjustments across all stocks generally shows that either produces the same overall change in current status from the Base model. Also indicated is the Final, adjusted, model that the Panel considered should be the basis for management advice. Preference was given to the Split approach when this reduced the retrospective pattern. Otherwise, the Rho Adjusted approach was employed.

The GARM III 'models' review noted a number of potential causes for the retrospective pattern. These all relate to some unexplained change within the time series of observations. The Panel did not consider the adjustment for the retrospective pattern as a final solution to the problem. Rather, it encouraged further work on the nature and causes of the problem which would result in its more explicit treatment in future assessments.

Recruitment Assumptions and Rebuilding Plans

The GARM III 'BRP' review determined that the recruitment and spawning stock biomass derived from most assessments did not display compelling support for any particular functional form of the stock-recruitment relationship and therefore, a non-parametric approach to stock projections, involving use of $F_{40\%MSP}$ along with a chosen recruitment time series, was generally adopted. The recruitment time series considered typical of productivity conditions at the BRPs was chosen through inspection of the stock – recruitment relationship based on the population reconstructions (VPA in most cases). A determination was made on a spawning stock biomass (termed the 'breakpoint') below which recruitment appeared to be diminished. A determination was also made on whether or not exceptionally large year-classes had occurred which appeared to be unrelated to the size of the spawning stock biomass. In both cases, recruitment estimates below the breakpoint and of the exceptionally large year-classes were excluded from the BRP estimation. While SSB breakpoints could not be identified for many of the GARM III stocks (and the entire recruitment time series was thus used), breakpoints were identified for seven of the stocks (Table 9) for which analytical models were developed.

Table 9. Recruitment Time Series used in Estimation of 14 GARM III Groundfish Stock BRPs. Recruitment estimates are not available for the index based assessments (Pollock, two windowpanes, ocean pout) or halibut

Species	Stock	Model	Recruitment Time Series used for BRP Estimation
Cod	**GB**	VPA	Recruitment from SSB greater than 50,000 t
Cod	**GOM**	VPA	Recruitment from full VPA Time Series
Haddock	**GB**	VPA	Recruitment from SSB greater than 75,000 t (excluding two large year-classes - 1963 and 2003)
Haddock	**GOM**	VPA	Recruitment from SSB greater than 3,000 t (excluding large 1962 year-class and including hindcast estimates back to 1962)
Yellowtail Flounder	**GB**	VPA	Recruitment from SSB greater than 5,000 t (including hindcasts back to 1963)
Yellowtail Flounder	**SNE/MA**	VPA	Recruitment from SSB greater than 5,000 t (excluding hindcast estimates)
Yellowtail Flounder	**CC/GOM**	VPA	Recrutiment from full VPA Time Series (including hindcast estimates back to 1977)
American Plaice	**GB/GOM**	VPA	Recruitment from full VPA Time Series
Witch Flounder		VPA	Recruitment from full VPA Time Series
Winter Flounder	**GB**	VPA	Recruitment from full VPA Time Series
Winter Flounder	**GOM**	VPA	Recruitment from full VPA Time Series
Winter Flounder	**SNE/MA**	VPA	Recruitment from SSB greater than 5,700 t
Redfish		ASAP	Recruitment from 1969-2006
White Hake	**GB/GOM**	SCAA	Recruitment from entire series.

The Panel considered the issue of SSB breakpoints in the estimation of $F_{REBUILD}$ for rebuilding plans. $F_{REBUILD}$ is determined through iteratively calculating the fishing mortality that produces a 50% probability that the stock will recover to B_{MSY} by the end of the rebuilding plan period (see Section 1.1 for the stock-specific rebuilding plan periods). The GARM III 'BRP' review suggested that in developing rebuilding scenarios, careful consideration be given to consistent use of the stream of recruitments used in those scenarios with those used to derive the BRPs.

The Panel considered that for stock projections, either for short – term yield or $F_{REBUILD}$ estimation, the same recruitment assumptions for BRPs should be used. Some of the stocks are currently at an SSB below their breakpoints and recruitment can be expected to be low until SSB grows above the breakpoints. To reflect these short – term stock conditions, the Panel considered that the SSB breakpoints should be used. Thus, for all the $F_{REBUILD}$ estimates reported below, where SSB breakpoints are indicated in Table 9, a two stanza projection was employed with the recruitment estimates stochastically chosen from the recruitment time series either below or above the SSB breakpoint depending upon the level of SSB. Where no breakpoint has been identified, the entire recruitment time series was used to determine $F_{REBUILD}$

On a final note, the Panel considered the assumptions to apply to the 2008 fishery in stock and rebuilding projections. The assumption that was used in all the assessments was that the catch in 2008 would be equal to that in 2007. An alterative assumption that F 2008 equal F 2007 was not considered as robust. The Panel recognized however, that it is optimal to use the observed catch in projections.

Stock Assessments

In evaluating the assessment models, assumptions and results of each stock, the Panel considered the following:

a.) Was the assessment consistent with previously agreed standards and recommendations?
b.) Has the assessment incorporated new information appropriately?
c.) Comment on the sufficiency of stock assessment for management purposes (i.e. stock status)
d.) Provide suggestions for improvement of stock assessments and ecosystem models.
e.) If necessary, the Panel should attempt to reconcile differences between stock assessment formulations, and then recommend what is most appropriate. The rationale for the recommendation and its uncertainty should be described

The Panel's conclusions and research recommendations on each of the stock assessments are provided below. These address items 3 – 5 above which are specific to each stock. Regarding items 1 and 2, the Panel considered that all 19 assessments were consistent with the previously agreed standards and recommendations made at the first three GARM III meetings. Where the previous reviews had recommended explorations of different assessment model assumptions, these were undertaken and provided to the Panel for its consideration. Comment on these is provided, as appropriate, below. The Panel also considered that the 19 assessments had incorporated the most recent information appropriately. Considerable attention was paid at the meeting to the examination of model fit to these data to ensure that the models recommended at the previous GARM III meetings remained valid. Where issues remained, these are commented on below.

All of the assessments except white hake were carried out using the methods implemented and documented in the NOAA Fisheries Toolbox (2008) *[http://nft.nefsc.noaa.gov]*. The assessment model for white hake (Age Structured Production Model--ASPM) was developed by Butterworth and Rademeyer (2008) . More details are provided in Chapter L.

A. Georges Bank cod
by Loretta O'Brien, Kirsten Clark, Nina Shepherd, Michele Traver, Jiashen Tang, and Betty Holmes

Additional information and details concerning Georges Bank cod can be found in the Appendix of the GARM III report (NEFSC 2008).

1.0 Background

This stock was last assessed and peer reviewed in August 2005 (O'Brien *et al*. 2006). The assessment was conducted using VPA with landings only, i.e. discards and recreational landings were not included in the catch at age. For terminal year 2004, total commercial landings were 4,583 mt and fully recruited F (ages 4-8, unweighted average) was estimated to be 0.24, the lowest F in the time series (1978-2004). Spawning stock biomass was 22,564 mt in 2004, 30% higher than the time series low in 1994. Since 1991, recruiting year classes had all been below the long term average (14 million age 1 fish) with the 2000 and 2001 year classes being the lowest in the time series. The 2003 year class, however, was estimated to be above average (21 million age 1 fish). The NEFSC spring and autumn bottom trawl survey indices continued to remain near record low values. The most recent above average autumn recruitment index of age 1 fish had occurred in 1988.

In 2002, biological reference points (BRPs) were developed for Georges Bank cod (NEFSC 2002) based on landings only, using a Beverton-Holt stock-recruit relationship with an assumed prior for the unfished recruitment. The BRPs were:

F_{MSY} = 0.18,
MSY = 35,200 mt and
SSB_{MSY} = 217,000 mt.

This assessment, with terminal year 2007, includes USA and Canadian commercial landings and discards, and USA recreational landings in the catch at age as recommended by the GARM II panel (Mayo and Terceiro 2005).

2.0 Fishery

Georges Bank Atlantic cod is a transboundary stock that is harvested by both USA and Canadian fishing fleets. 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 (Figure A1). The majority of the landings from the eastern part of Georges Bank (SA 561-562) are taken in the first and second calendar quarter (January to June). USA landings are taken primarily by otter trawl gear and gill net gear. Since 1994, the Canadian fishery for Georges Bank 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 of GB cod taken by USA and Canadian fleets, and Distant Water Fleets (DWF) are available from 1893-2007 (Fig. A2a) and total catch is available from 1960-2007 (Table A1, Fig. A2b). USA commercial landings from 1994 to 2007 have been revised using the allocation scheme described at the GARM III data meeting. Total commercial landings of Georges Bank cod were 4,786 mt in 2007, a 26% increase from 2005. The USA accounted for 77% of the total landings and Canada the remaining 23%.

Commercial Discards

Atlantic cod discarded in the USA Georges Bank otter trawl, gillnet, and scallop fisheries were estimated using the NEFSC Observer data from 1989-2007. A ratio of discarded cod to total kept of all species (d:k) was estimated on a trip basis. Total discards (mt) were estimated from the product of d:k and total commercial landings (Table A2). 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 1997-2007.

In 2007, the USA fishery discarded 1,040 mt and the Canadian scallop fleet discarded 124 mt. There were no discards in the Canadian 2007 groundfish fishery due to 100% observer coverage. Discards accounted for 22% of total USA catch and 10% of total Canadian catch in 2007 (Table A1, Fig. A2b).

Recreational Landings

USA recreational landings of Georges Bank cod were re-estimated using revised data provided by NOAA MRFSS from 1981-2007 (Table A3). 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 number of fish landed to obtain the landings at age. Recreational landings represent between 2-15% of the total USA catch of cod during 1981-2007. In 2007, recreational landings represented 0.17% of the total USA cod catch (Table A1,Fig A2b).

Total Catch

Total combined USA and Canadian catch of Georges Bank cod was 5,957 mt in 2007, a 29% increase from 4,411 mt caught in 2006. USA catches accounted for 79% and Canadian catches accounted for 21% of the total catch. Total discards accounted for 20% of the catch (Table A1, Figure 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 A4 and A5. In the USA fishery, sampling intensity has been relatively high since 2003, ranging between one sample per 7 mt to 1 sample per 98 mt (Table A5). In the Canadian fishery, sampling since 2003 has ranged between one sample per 3 mt to one sample per 18 mt. The average number of fish measured per sample was 102 in the USA fishery and 283 in the Canadian fishery during 2007 (Table A5).

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 A6-A10. Total catch at age in numbers (000s), weight (mt), mean weight (kg), and mean length (cm) are presented in Table A11. 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 1978-2007 (App. A. Table A1) and then combined as shown in Table A6.

3.0 Research Bottom Trawl Surveys

Biomass and abundance indices

NEFSC spring and autumn survey biomass and abundance indices 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 A12, Fig. A4-A5). The DFO abundance indices show an overall decline since 1990 (Fig.A5)

Catch at age for NEFSC spring and autumn surveys and DFO spring survey are presented in Table A13-A15 and Fig.A6-A8.

The recruitment indices for age 1 from the NEFSC 2007 autumn bottom trawl survey indicate that the last above average year class occurred in 1988. The 1999, 2001, 2003, and 2005 year classes, although below average, are stronger than the very weak 2000, 2002, and 2004 year classes (Fig. A9). The Canadian 2008 spring survey indices of abundance indicate that the 2003 year class was above average as both one and two year old fish (Fig. A10).

Maturity ogives

Logistic regression analysis was used to estimate female maturity ogives from NEFSC spring research survey data for 1970- 2008. 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, 2007, has only 4 years of data (2005, 2006, 2007 and 2008). 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) (Figure A11).

Mean Length and Weight

Mean length and weight at age were estimated from the NEFSC autumn research bottom trawl surveys, 1970-2007. Mean weights at age were estimated using an historical length-weight equation prior to 1992. Annual length-weight parameters were estimated using data collected on autumn NEFSC surveys from 1992-2007. No trend is apparent in the younger ages, but ages 3-5 show a possible declining trend since the mid-1990s in both length and weight (Fig. A12). Length and weight trend together suggesting there is no change in condition for Georges Bank cod.

4.0 Assessment

In this VPA assessment, fully recruited F shifts from age 4, as seen in previous assessments, to fully recruited F at age 5. This is due, in part, to increases in minimum mesh size requirements to 6.5 inch square or diamond mesh that were invoked in May 2002. Prior to 2002, mesh requirements had been 6.5 inch square or 6.0 inch diamond mesh, since 1999.

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 2007 and beginning year stock sizes in 2008. 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 2008 and corresponding F estimates for ages 1-7 in 2007. 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 (5-year moving window) derived from NEFSC spring research survey data for 1978- 2008 as described above.

The catch at age (Table A11) includes combined USA and Canadian landings and discards, and USA recreational landings from 1978-2007 (Tables A6-A10) for age 1-10+. Swept-area estimates used to calibrate the VPA, estimated from indices of abundance, included the NEFSC 1978-2008 spring survey indices for ages 1-8 (Table A13), the NEFSC 1977-2006 autumn survey indices for ages 0-5 (Table A14) and the Canadian 1986-1992 and 1995-2007 spring survey indices for ages 1-8 (Table A15). The NEFSC spring survey was dis-aggregated into two series based on the use of the Yankee #36 or #41 trawls. 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 1982-2005 for the #36 trawl. The autumn survey indices were shifted forward one age and one year to match cohorts in the spring survey in the subsequent year.
Two formulations of the VPA were conducted and presented below. The Base Model was formulated as described above. The Split Model was also formulated as described above, however, the surveys were split between 1994 and 1995.

VPA Diagnostics – Base Model

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 A16a. Stock size estimates were more precise for ages 2-8, (CVs ranging from 0.27 - 0.31) than for age 1 (CV=0.48). Catchability estimates at age for the NEFSC spring and autumn surveys (Yankee #36 trawl) were similar with relatively low CVs (0.07-0.31), however, the spring survey (Yankee #41 trawl) was not as precise , particularly for ages 1, 7, and 8 (0.37-0.76). The precision of DFO (Division of Fisheries and Oceans, Canada) survey q estimates were similar to NEFSC spring and autumn surveys (Yankee #36 trawl), however, the q's estimates were larger than 1 for ages 6-8. For all surveys, q increases with age and approaches a 'flat-top', with error bars overlapping for the older ages (Fig. A13).

The residuals (observed – predicted), presented in App.A Fig. A1. 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 age 3-7 in the NEFSC spring survey and for ages 4-8 in the DFO survey . The NEFSC autumn residuals show no persistent pattern (App.A Fig. A1).

VPA Diagnostics – Split Model

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 A16b. Stock size estimates were more precise for ages 2-8, (CVs ranging from 0.27 - 0.39) than for age 1 (CV=0.45). Comparison of precision estimates of catchability at age, pre- and post- split, generally show higher CVs for the post-split indices (Table 16b). 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. A13b).

The residuals (observed – predicted) are presented in App.A Fig. A2. The NEFSC spring 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 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 – Base Model

Fully recruited fishing mortality (unweighted, ages 5-8) was estimated at 0.14 in 2007 (Table A17a, Figure A14, App.A Table A2), a 52% decline from 2006, and the lowest F in the time series. Spawning stock biomass in 2007 was estimated at 25,377 mt, a 25% increase from 2006 (Table A17a, Figure A15, App A Table A2). Recruitment (millions of age 1 fish) of the 2003 year class (13.5 million age 1 fish) is estimated to be similar to the 1998 year class (12.4 million age 1 fish) (Table A17, Fig.A15. App.A. Table A2). The 2002 year class (2.0 million age 1 fish) and the 2000 year class (2.8 million age 1 fish) and are the lowest in the time series. The last above average year class (1990) occurred almost 2 decades ago. Stock mean weights at age show no trend for ages 1-3, however, since about 1987 there appears to be an overall general decline in weight, with some fluctuation, for ages 4-8 (App. A. Fig. A3).

VPA Assessment Results – Split Model

Fully recruited fishing mortality (unweighted, ages 5-8) was estimated at 0.30 in 2007 (Table A17b, Figure A14, App.A Table A3), a 42% decline from 2006, and the second lowest F in the time series. Spawning stock biomass in 2007 was estimated at 17,672 mt, a 23% increase from 2006 (Table A17b, Figure A15, App. A Table A3). Recruitment (millions of age 1 fish) of the 2003 year class (10.8 million age 1 fish) is estimated to be similar to the 1998 year class (12.2 million age 1 fish) (Table A17b, Fig.A15. App.A. Table A3). The 2002 year class (2.3 million age 1 fish) and the 2004 year class (2.5 million age 1 fish) and are the lowest in the time series. The last above average year class (1990) occurred almost 2 decades ago.

Precision of F and Stock Biomass Estimates – Base Model

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 2008 and age 1-10+ F estimates in 2007.

Base Model

The bootstrap results (Table A18a) indicate that stock sizes were well estimated for ages 3-8 with CVs varying between 0.26-0.31, however, age 1 (CV=0.73) and age 2 (CV=0.40) were not as well estimated. The fully recruited F for ages 5-8 was well estimated with CVs ranging between 0.17 and 0.29, with the exception of age 7 (CV=0.34). There is an 80% probability that the average F in 2007 is between 0.12 and 0.18 (Figure A16a). There is an 80% probability that SSB in 2008 is between 21,956 mt and 30,777 mt (Figure A16a).

Split Model

The bootstrap results (Table A18b) indicate that stock sizes were well estimated for ages 3-8 with CVs varying between 0.28-0.38, however, age 1 (CV=0.89) ,age 2 (CV=0.43), and age 8(CV=0.42) were not as well estimated. The fully recruited F for ages 5-8 was well estimated with CVs ranging between 0.21 and 0.33, with the exception of age 1 (CV=0.41) and age 7 (CV=0.34). There is an 80% probability that the average F in 2007 is between 0.24 and 0.41 (Figure A16b). There is an 80% probability that SSB in 2008 is between 14,956 mt and 21,655 mt (Figure A16b).

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 2002-2007. 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 for both the Base Model and the Split Model. The shift from fully recruited F on age 4 during 1980-1993 to age 5 during 1994-2001 and 2002-2007 is evident (Figure A17a-A17b).

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, 2007. Mohn's rho, calculated as the average of the 'tips' or terminal year values of each retrospective run, was calculated within each analysis.

Base Model

There is a retrospective pattern of estimating F values lower than the terminal year F (rho = -0.51, Fig. A18a) and a corresponding pattern of estimating higher values of SSB relative to the terminal year SSB (rho=0.36, Fig. A18b). The retrospective analysis in recruits at age 1 indicate that recruits are estimated at higher values relative to the terminal year (rho=0.54). There are three high estimates in 2002, 2003, and 2004 (Fig. A18c). The 2002 and 2004 are the lowest estimated year classes in the time series, and the 2003 year class is the largest estimated since 1991.

Split Model

Although no distinct mechanism (e.g. change in reporting and sampling systems, closed areas, life-history or environmental effect) is apparent as to why the surveys should be split in the mid-1990s, the result is a weaker retrospective pattern, as seen in some of the other GARM stocks (GB yellowtail flounder, witch flounder). The pattern of estimating F values lower than the terminal year F is moderate (rho = -0.14), however, only one year (2002) is estimated as higher than the terminal year (Figure A19a). The corresponding pattern of estimating higher values of SSB relative to the terminal year SSB (rho=0.13) is also moderate with an almost even split of higher and lower values relative to the terminal year (Figure A19b) . The retrospective analysis in recruits at age 1 indicate that recruits are estimated at higher values relative to the terminal year (rho=0.92), almost twice as high as the Base Model. There are three high estimates in 2002, 2003, and 2004 (Fig. A19c).

Sensitivity analysis

Prior to selecting a final model, two sensitivity analyses were conducted. The first analysis was conducted to address the GARM Model Meeting Panel's request to explore the partial recruitment of older ages in recent years. Using the Base Model formulation, the F on the oldest true age (9) was estimated differently in each run by varying the ages used to calculate an average F, which was then set as the F for both ages 9 and 10+. Six runs were made with F on the oldest age estimated as the average of ages 5-6, 5-7, 5-8, 6-7, 6-8, and 7-8.

Estimates of the scaled back-calculated partial recruitment show that for all age group averages, a flat-top PR persists (App.A. Fig. A4a). The F on age 9 for each age group, shows that the average that includes the youngest and oldest ages have the more extreme F values . (App.A. Fig. A4b). Comparing the average F for ages 5-8 from all six runs indicates very little difference between the runs (App.A. Fig. A4c).

The second sensitivity analysis applied the same VPA formulation used by the Transboundary Resources Assessment Committees' (TRAC) Eastern GB cod assessment, which assesses a subset of the stock as a management unit. This VPA formulation used a catch at age from 1 to 9, with no plus group, for the entire GB cod stock. In addition to estimating stock size for ages 1-9 in the terminal year, the oldest age (9) was also estimated for the six years prior to the terminal year, to 2000. This formulation is referred to as 'around-the- corner'. The retrospective pattern of fishing mortality shows lower estimates relative to the terminal year (rho=0.25), however, there are some extreme high values in the mid-1990s (App. A. Fig. A5a). SSB shows a retrospective pattern of both higher and lower values relative to the terminal year (rho= 0.06, App. A. Fig. A5b). The retrospective pattern in recruitment shows higher values relative to the TY in recent years (rho = 0.51), but a mixed pattern prior to 2003 (App. A. Fig. A5c).

A comparison of the sensitivity run and the Base and Split Models is presented in Table A19**.** The Split VPA estimates lower stock size and higher F relative to the Base VPA. The Around the Corner VPA estimates higher stock size, particularly at older ages, and lower F on the older ages. The residual plots for 'around the corner' are presented in App. A. Figs A6.

The August GARM III Review Panel chose the **SPLIT MODEL** as the model to proceed with for determining stock status, primarily based on the lower retrospective pattern in F and SSB compared to the BASE MODEL.

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 (2003-2007). The partial recruitment (PR) was based on a normalized arithmetic mean of 2003-2007 fishing mortality from the VPA and the maturity ogive was estimated as a 5 year moving average as described above for 2004-2008 (Table A20).

Yield per Recruit Analysis- BASE MODEL

The estimated biological reference points of $F_{0.1}$=0.22, F_{max} = 0.50 and $F_{40\%}$ = 0.25 (Fig. A20) are higher than those estimated by the Working Group on Re-Evaluation of Biological Reference Points: $F_{0.1}$=0.17, F_{max} = 0.33, and $F_{40\%}$ = 0.17 (NEFSC 2002)
Non-parametric estimates of MSY and SSB_{MSY} were estimated using the 31-year time series mean recruitment (13.8 million age 1 fish), Y/R (1.3592) and SSB/R (6.5116) as:

BASE MODEL
$F_{40\%}$ = 0.25
MSY = 18,794
SSB_{MSY} = 90,105.

Yield per Recruit Analysis- SPLIT MODEL

Applying the same methods and data input described above, a YPR analysis was conducted based on the Split Model. Non-parametric estimates of MSY and SSB_{MSY} were estimated using the 31-year time series mean recruitment (14.1million age 1 fish), Y/R (1.3437) and SSB/R (6.5257) as:

SPLIT MODEL
$F_{40\%}$ = 0.25
MSY = 19,194
SSB_{MSY} = 91,806.

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 Georges Bank Atlantic cod. Stochastic projections using the same input data as the YPR were run out to 100 years with F_{MSY} = 0.25. Recruitment was estimated from a cumulative distribution function of 14 estimates of age 1 fish associated with SSB > 50,000 mt. The breakpoint of 50,000 mt was based on evidence of reduced recruitment productivity at biomasses below this value. The projection provided the following non-parametric biomass reference points:

BASE MODEL
F40%= 0.25
MSY = 29,445 mt
SSB_{MSY} = 139,458 mt.

SPLIT MODEL
F40%= 0.25
MSY = 31,159 mt
SSB_{MSY} = 148,084 mt.

The August GARM III Review Panel chose the **SPLIT MODEL** as the model to proceed with for determining stock status, primarily based on the lower retrospective pattern in F and SSB compared to the BASE MODEL. The **SPLIT MODEL** stochastic MSY estimates bolded above are the final accepted BRP estimates.

6.0 Projections

Short term, 2-year stochastic projections were performed to estimate landings and SSB during 2008-2009. 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 a cumulative distribution function of 14 estimates of age 1 fish associated with SSB > 50,000 mt from the **SPLIT MODEL**. Catch in 2008 was assumed equal to catch in 2007. The projections were run under three F scenarios: F_{07}, F_{MSY}=$F_{40\%}$, and $F_{REBUILD}$. The rebuilding plan for Georges Bank 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. Under an $F_{REBUILD}$ = 0.186 the stock is projected to rebuild to about SSB_{MSY}= 148,084 mt with a 50% probability by 2026.

The results of the **SPLIT MODEL** short term projections (Table A21) indicate that under all three scenarios catch is projected to decrease and SSB is projected to increase in 2009, relative to 2008.

7.0 Summary

The GARM Review Panel chose the **SPLIT MODEL** as the final model.
The Georges Bank Atlantic cod stock is overfished and overfishing is occurring (Fig. A21). Fishing mortality (unweighted, ages 5-8) in 2007 was estimated to be about 0.30, the second lowest F in the time series. SSB was estimated at 17,672 mt in 2007, about 12% of SSB_{MSY}. The last year class that was above the time series average (14.1 million age 1 fish) occurred almost 2 decades ago in 1990. The 2003 year class (10.8 million age 1 fish) is near average and will be fully recruited to the fishery during 2008.

In this assessment, the VPA formulation was similar to previous assessments, however, fully recruited F shifted from ages 4-8 to ages 5-8, due in part to increases in mesh size since 2002.

Sources of uncertainty

1) the estimation of discards, particularly those hindcasted from 1978-1988,
2) the estimation of recreational landings, with very few length samples available,

8.0 Panel Discussion / Comments

Conclusions

The Panel concluded that the retrospective pattern in this assessment was substantial enough to warrant modifying the VPA by including a split in the survey time series in 1995. This modified assessment was accepted as Final by the Panel and was the best available estimate of stock status, as well as sufficient for management advice.

The Panel also noted that short term projections should utilize recruitment estimates from the VPA bifurcated at 50,000 MT of spawning biomass; to more appropriately reflect recruitment under current stock conditions. This approach was found to be appropriate basis for estimating F rebuild.

It was noted that the US/Canada TRAC assessment used a different formulation from that considered here. These formulations will need to be reconciled for the development of transboundary advice at a later date.

Research Recommendations

The Panel recommended that historical data be used to hindcast recruitment estimates as far back in time as possible for use in the estimation of reference points and projections.

Continued exploration of retrospective pattern and methods to account for it are critical for this stock.

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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), 1960-2007.

	Country												
	USA				Canada							Total	Total
Year	Landings	Discards	Rec.	Total USA	Landings	Discards	Total Canada	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	8783	-	8783	-	-	-	-	35362	35659
1979	32645	537	-	33182	5979	-	5979	-	-	-	-	38624	39161
1980	40053	569	-	40622	8060	-	8060	-	-	-	-	48113	48682
1981	33849	1033	4162	39043	8496	-	8496	-	-	-	-	42345	47539
1982	39333	985	2955	43274	17816	-	17816	-	-	-	-	57149	61090
1983	36756	656	3865	41277	12132	-	12132	-	-	-	-	48888	53409
1984	32915	98	994	34007	5758	-	5758	-	-	-	-	38673	39765
1985	26828	349	4678	31856	10442	-	10442	-	-	-	-	37270	42298
1986	17490	457	425	18372	8503	-	8503	-	-	-	-	25993	26876
1987	19035	266	970	20271	11842	-	11842	-	-	-	-	30877	32113
1988	26310	323	2587	29220	12757	-	12757	-	-	-	-	39067	41977
1989	25056	866	507	26429	7912	-	7912	-	-	-	-	32967	34340
1990	28110	618	1339	30067	14345	-	14345	-	-	-	-	42455	44412
1991	24219	476	657	25352	13457	-	13457	-	-	-	-	37676	38809
1992	16899	766	350	18014	11669	-	11669	-	-	-	-	28569	29684
1993	14590	376	1127	16093	8527	-	8527	-	-	-	-	23117	24620
1994	9737	199	544	10479	5276	-	5276	-	-	-	-	15013	15755
1995	7028	116	826	7970	1099	-	1099	-	-	-	-	8127	9069
1996	7259	139	367	7765	1912	42	1954	-	-	-	-	9171	9719
1997	7545	127	715	8388	2917	479	3396	-	-	-	-	10462	11785
1998	7044	132	434	7609	1908	372	2280	-	-	-	-	8952	9889
1999	8319	132	387	8839	1825	328	2153	-	-	-	-	10144	10992
2000	7612	204	309	8125	1585	62	1647	-	-	-	-	9196	9772
2001	10746	374	205	11325	2144	117	2261	-	-	-	-	12889	13586
2002	9470	311	237	10018	1275	76	1351	-	-	-	-	10745	11369
2003	6856	335	203	7394	1316	191	1507	-	-	-	-	8172	8901
2004	3507	178	345	4029	1111	98	1209	-	-	-	-	4618	5238
2005	2754	541	243	3538	630	233	863	-	-	-	-	3384	4401
2006	2694	387	79	3159	1097	355	1452	-	-	-	-	3790	4611
2007	3678	1040	8	4725	1,108	124	1232	-	-	-	-	4,786	5957

Table A2. Discards of Atlantic cod in Georges Bank large mesh otter trawl and gill net fisheries, 1989-2007. Total includes discards from other gear.

	GB large mesh trawl			GB gillnet trawl			Scallop			Total	
Year	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv
1989	730.0899	0.26	26	0	0	0	0	0	0	865.7	0.22
1990	524.9838	0.33	25	0	0	0	0	0	0	617.9	0.55
1991	425.0898	0.48	28	0	0	0	0	0	0	475.6	0.44
1992	270.63	0.48	29	0	0	0	0	0	0	765.6	0.25
1993	292.9039	0.29	25	0	0	0	0	0	0	375.9	0.23
1994	60.7842	0.41	25	76.1732	0.24	55	0	0	0	198.6	0.27
1995	54.66082	0.47	41	53.73666	0.35	86	0.4	0.68	0	115.7	0.29
1996	17.29	0.55	19	90.91845	0.85	88	27.3	0.50	14	139.0	0.47
1997	21.43163	0.29	27	75.29152	0.47	69	27.4	0.49	13	127.5	0.29
1998	11.00901	0.54	9	62.04998	0.00	194	49.5	0.43	17	131.5	0.40
1999	49.84209	0.48	20	43.28701	0.31	82	32.0	0.44	21	132.5	0.26
2000	110.8575	0.66	20	78.3508	0.33	168	4.2	0.15	26	204.1	0.38
2001	317.7702	0.64	33	39.33952	0.17	115	8.0	0.29	252	374.5	0.55
2002	84.59817	0.27	68	66.86346	0.24	52	5.4	0.42	16	311.4	0.26
2003	249.8549	0.28	147	45.08271	0.21	240	5.8	0.27	22	334.8	0.23
2004	113.6096	0.27	209	32.99943	0.16	451	1.0	0.33	23	178.1	0.19
2005	478.0872	0.12	702	5.66546	0.11	168	2.9	0.32	80	541.4	0.11
2006	334.9372	0.19	363	10.79936	0.13	217	6.4	0.17	80	386.9	0.32
2007	953.2067	0.15	370	16.00482	0.14	423	5.4	0.22	110	1039.6	0.15

Table A3. Estimated numbers (000s) and weight (mt,live) of Atlantic cod caught by marine recreational fishers from the Georges Bank and South stock during 1981-2007. The data has been revised by MRFSS since GARM II and includes new site registers.

	Catch		Landed	
Year	Numbers 000s	Weight* mt	Numbers 000s	Weight* mt
1981	1740.5	3841.4	1684.4	3717.6
1982	1548.2	6820.1	1495.1	6586.1
1983	1839.8	5501.8	1676.1	5012.4
1984	483.0	1293.8	452.7	1212.6
1985	1980.9	8498.9	1890.7	8111.6
1986	357.4	924.1	295.1	763.0
1987	503.2	960.7	461.5	881.1
1988	1362.2	3993.1	1132.0	3318.1
1989	560.1	1865.5	393.0	1309.1
1990	583.7	1438.0	455.2	1121.6
1991	465.9	1838.9	373.1	1472.6
1992	289.8	639.1	204.2	450.4
1993	1176.3	2886.0	761.9	1869.4
1994	603.2	1879.5	288.9	900.2
1995	798.7	2033.4	510.7	1300.3
1996	247.6	802.5	149.7	485.1
1997	543.8	1378.9	328.2	832.0
1998	581.6	1633.1	271.2	761.5
1999	233.4	793.4	126.2	429.2
2000	581.0	1409.3	288.3	699.2
2001	168.6	376.5	99.3	221.7
2002	146.5	442.4	93.1	281.1
2003	162.4	711.6	94.2	412.9
2004	245.2	470.2	130.1	249.5
2005	511.2	1237.5	141.8	343.3
2006	79.4	316.9	39.6	158.2
2007	24.8	83.1	3.9	13.0

* Weight as estimated by MRFSS, re-estimated in assessment

Table A4. USA sampling of commercial Atlantic cod landings, by market category, for the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2007.

	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	93
1998	3	7	23	5	38	10	10	15	3	38	1	2	1	0	3	44	92	573	87
1999	5	3	10	3	21	7	14	10	7	38	2	5	2	0	9	80	118	205	120
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	98
2002	5	7	7	1	20	8	10	11	6	35	14	8	6	3	31	80	153	63	107
2003	4	8	6	10	28	7	16	10	6	39	5	11	10	4	30	21	113	52	69
2004	8	11	4	10	33	14	6	8	13	41	25	13	2	11	51	8	53	20	28
2005	6	13	4	5	28	5	11	12	8	36	7	11	7	7	32	7	51	22	28
2006	11	16	8	14	49	13	15	10	13	51	25	28	7	18	78	6	37	6	15
2007	8	4	5	4	21	10	8	6	4	28	9	10	6	7	32	22	98	14	45

Table A5. USA and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978 - 2007.

	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	29	7684	29	1308
1979	80	6973	79	1647	13	3991	12	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	8	858
1983	146	12544	138	2945	15	3822	14	604
1984	100	8721	100	2431	7	1889	7	385
1985	100	8366	100	2321	29	7644	20	1062
1986	94	7515	94	2222	19	5745	19	888
1987	80	6395	79	1704	33	9477	33	1288
1988	76	6483	76	1576	40	11709	40	1984
1989	66	5547	66	1350	32	8716	32	1561
1990	83	7158	83	1700	40	9901	40	2012
1991	88	7708	88	1865	45	10873	45	1782
1992	77	6549	77	1631	48	10878	48	1906
1993	82	6636	82	1598	51	12158	51	2146
1994	58	4688	54	1064	104	25845	101	1268
1995	40	2879	40	778	36	11598	36	548
1996	55	4600	54	1080	129	26663	129	879
1997	80	6638	80	1581	118	31882	38	1244
1998	80	7076	81	1545	139	26549	139	1720
1999	68	5987	67	1503	84	24954	84	918
2000	154	12421	154	3043	107	20782	107	1436
2001	108	8389	108	2421	108	18190	108	1509
2002	86	6400	86	2179	91	18974	91	1264
2003	92	6116	90	2135	94	20199	94	1070
2004	125	8749	107	2755	127	17859	127	1370
2005	98	4705	86	1681	136	21942	136	1483
2006	178	9431	2798	163	258	43259	258	1455
2007	81	8291	76	2432	494	139816	494	1672

Table A6. Commercial landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	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	142	295	9	32	7785
1980	102	3092	4761	328	2045	858	386	59	125	4	11760
1981	39	2853	3725	2016	171	902	295	90	135	43	10269
1982	428	7565	2817	1750	1228	130	447	95	50	59	14568
1983	88	3461	5638	1374	881	658	85	155	56	82	12477
1984	70	1342	3275	2864	571	422	374	39	145	84	9186
1985	126	4159	1636	1032	1343	314	191	154	16	75	9045
1986	134	1142	3194	467	375	390	56	50	44	24	5877
1987	19	4873	814	1380	204	163	154	34	21	18	7679
1988	0	1679	5492	695	1059	149	88	90	17	24	9293
1989	0	1649	2633	3291	254	352	49	28	23	3	8283
1990	0	4647	3313	1279	1401	126	122	16	9	8	10920
1991	43	1164	2842	1841	830	562	65	42	12	6	7406
1992	1	2307	1333	761	939	256	177	19	15	3	5811
1993	0	769	3118	608	288	283	83	71	16	3	5238
1994	0.0	226	1108	1345	201	59	96	29	14	4	3081
1995	0.0	341	1007	570	310	28	19	19	5	1	2300
1996	0.0	211	753	947	191	137	8	9	10	0	2266
1997	0.0	399	539	674	566	75	60	11	6	3	2331
1998	8.2	693	979	349	259	190	24	8	2	0	2511
1999	0.0	256	1664	607	211	86	113	15	2.0	0.2	2953
2000	9	722	628	866	206	58	30	29	2	0	2550
2001	1	508	2301	616	457	111	34	15	11	1	4054
2002	0	32	1001	1293	310	285	68	13	8	5	3015
2003	0	74	279	650	707	117	95	17	4	2	1946
2004	0	30	272	153	228	158	34	26	6	3	911
2005	0	22	96	358	100	77	55	8	4	2	721
2006	0	12	440	129	185	29	14	13	2	2	825
2007		129	168	771	44	62	5	4	2	1	1186

Table A6 - continued. Commercial landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					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	1,350	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		2533	12755	2313	5556	1021	733	851	201	347	26310
1989		2750	5861	11937	1288	2274	406	262	241	37	25056
1990		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		306	2306	4594	965	427	670	261	140	67	9737
1995		511	2006	2152	1627	231	175	234	66	27	7028
1996	0	320	1820	3021	910	900	79	94	113	2	7259
1997		628	1260	2377	2219	429	447	83	68	34	7545
1998	4.4	1020	2204	1241	1241	1059	192	57	23	2	7044
1999		394	3528	1997	988	504	759	127	22	2	8319
2000	10	1227	1536	3034	978	341	225	242	18	0.2	7612
2001	0	781	5197	1809	1908	599	220	117	101	13	10746
2002		60	2166	3846	1225	1485	439	105	80	63	9470
2003		152	663	1945	2785	570	560	123	37	22	6856
2004		61	744	507	921	791	195	197	56	34	3507
2005		41	246	1226	410	386	313	65	40	29	2754
2006		24	1,110	464	748	138	89	89	14	18	2694
2007		263	423	2,469	175	269	30	27	17	6	3678

Table A6 - continued. Commercial landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2007.

	Age										
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	11.288	2.925
1979	0.868	1.428	2.065	4.402	5.041	7.309	9.702	10.310	9.874	13.568	4.194
1980	0.824	1.491	2.450	3.766	5.703	6.789	8.403	9.517	8.918	12.946	3.406
1981	1.071	1.502	2.388	3.489	4.958	7.247	8.662	9.881	14.572	18.590	3.296
1982	0.661	1.403	2.697	3.738	5.378	6.624	9.625	10.108	13.254	15.415	2.700
1983	1.066	1.479	2.442	3.487	4.895	6.506	8.544	10.774	11.586	16.505	2.945
1984	1.026	1.603	2.468	3.643	5.056	6.689	8.759	10.099	11.168	14.101	3.583
1985	0.935	1.408	2.124	3.926	5.147	6.406	8.190	10.423	12.459	14.012	2.966
1986	0.945	1.434	2.293	3.440	5.434	7.160	9.020	10.099	13.347	14.863	2.976
1987	0.857	1.406	2.474	4.027	5.634	7.910	8.507	9.888	11.670	14.828	2.479
1988	0.000	1.508	2.322	3.329	5.245	6.853	8.350	9.452	11.541	14.755	2.831
1989	0.000	1.668	2.226	3.627	5.066	6.454	8.260	9.348	10.640	10.811	3.025
1990	0.000	1.525	2.305	3.509	4.799	6.200	8.317	11.255	11.547	12.581	2.574
1991	1.174	1.546	2.460	3.594	5.116	6.073	7.667	9.080	11.005	14.979	3.270
1992	1.016	1.484	2.321	3.893	4.477	6.127	7.070	9.323	10.818	17.028	2.908
1993	0.866	1.523	2.177	3.323	5.303	5.741	7.671	8.813	9.617	15.320	2.785
1994	0.000	1.354	2.081	3.415	4.809	7.280	6.983	9.174	9.972	18.039	3.160
1995	0.000	1.499	1.992	3.773	5.253	8.397	9.268	12.303	12.152	19.118	3.056
1996	0.000	1.517	2.418	3.192	4.755	6.555	10.069	10.166	11.114	9.283	3.203
1997	0.000	1.577	2.337	3.529	3.919	5.727	7.473	7.856	11.241	12.006	3.236
1998	0.536	1.473	2.250	3.558	4.799	5.581	7.884	7.587	12.382	10.299	2.804
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	10.789	2.985
2001	0.727	1.539	2.258	2.938	4.174	5.407	6.479	7.785	9.334	10.907	2.650
2002	0.000	1.834	2.165	2.974	3.948	5.221	6.510	8.076	9.425	12.166	3.141
2003	0.000	2.048	2.378	2.992	3.937	4.879	5.927	7.079	8.708	10.994	3.524
2004	0.000	2.020	2.735	3.306	4.037	4.998	5.673	7.655	8.668	11.827	3.847
2005	0.000	1.811	2.569	3.426	4.118	5.033	5.737	8.174	9.189	12.260	3.821
2006	0.000	2.080	2.524	3.594	4.048	4.706	6.129	7.039	8.013	10.197	3.264
2007	0.000	2.080	2.524	3.594	4.048	4.706	6.129	7.039	8.013	8.441	3.387

Table A6 - continued. Commercial landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
	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	100.7	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		53.0	60.6	67.4	78.9	86.5	92.4	96.4	102.8	111.3	63.1
1989		54.7	59.8	69.9	77.9	84.2	91.3	96.6	100.6	101.3	64.8
1990		53.2	60.2	68.9	76.4	83.1	91.8	102.2	103.3	106.4	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	119.1	63.6
1993	45.0	53.0	59.7	68.5	79.9	82.1	91.7	95.7	98.5	112.2	63.2
1994		51.3	58.6	69.0	77.7	89.2	89.0	97.6	100.0	121.4	66.0
1995		52.7	57.9	71.0	80.8	93.3	97.6	106.5	106.8	121.9	64.8
1996		53.1	61.5	67.5	76.9	87.2	96.9	100.9	103.0	99.0	66.5
1997		53.6	60.9	69.6	72.2	83.3	91.2	92.5	104.6	107.2	66.7
1998	38.1	52.4	60.3	70.8	78.5	82.9	93.1	92.0	107.8	102.3	63.5
1999		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		65.2
2001	42.0	53.1	60.3	65.8	74.0	81.2	86.4	91.9	98.4	103.3	62.8
2002		56.4	59.4	66.4	72.8	80.0	86.3	92.6	97.6	107.2	66.6
2003		58.3	61.4	66.5	73.1	78.3	84.0	89.1	94.9	103.2	69.7
2004		58.2	64.0	68.9	73.9	79.5	82.9	92.0	95.5	106.2	71.6
2005		56.1	63.0	69.6	74.7	79.7	83.1	93.9	96.9	106.7	71.6
2006		58.7	62.3	70.6	73.8	77.4	85.0	89.0	90.8	100.4	67.6
2007	0.0	58.7	62.3	70.6	73.8	77.4	85.0	89.0	90.8	92.0	66.9

Table A7. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	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	715	521	89	5	0	0	0	0	0	0	1331
1990	43	444	119	12	4	0	0	0	0	0	623
1991	89	247	52	18	4	3	0	1	0	0	414
1992	91	607	23	8	7	2	2	0	0	0	740
1993	18	273	65	2	2	2	0	1	0	0	363
1994	46.6	135	30	6	1	0	0	0	0	0	219
1995	11.7	70	33	3	1	0	0	0	0	0	119
1996	34.7	29	19	10	2	1	0	0	0	0	96
1997	57.1	54	13	6	4	0	0	0	0	0	134
1998	15.9	25	16	6	3	1	0	0	0	0	69
1999	37.3	45	32	5	0	0	0	0	0.0	0.0	120
2000	13	67	22	17	3	1	0	0	0	0	123
2001	7	179	103	9	7	2	0	0	0	0	307
2002	25	66	116	25	5	0	0	0	0	0	237
2003	10	92	38	36	14	2	1	0	0	0	193
2004	20	30	70	4	4	2	0	0	0	0	129
2005	8	241	61	49	5	3	2	0	0	0	370
2006	19	36	195	10	12	1	0	0	0	0	273
2007	10	364	184	119	5	7	0	0	0	0	689

Table A7 - continued. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	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	292	456	99	15	1	2	0	0	0	0	865
1990	23	412	140	24	17	1	0	0	0	0	618
1991	60	251	69	43	24	18	1	9	0	0	476
1992	62	567	36	26	44	15	13	0	1	0	766
1993	7	251	74	8	12	14	4	5	1	0	376
1994	21	117	40	16	2	1	1	0	0	0	199
1995	5	61	36	12	2	0	0	0	0	0	116
1996	17	25	37	40	13	8	.	0	0	0	139
1997	31	50	23	14	9	0	0	0	0	0	127
1998	9.6	26	42	24	14	7	1	0	8	0	131
1999	19.1	36	58	17	2	0	0	0	0	0	132
2000	7	65	48	62	17	4	1	0	0	0	204
2001	6	152	129	28	43	12	3	2	1	0	374
2002	13	71	175	44	7	1	0	0	0	0	311
2003	6	103	66	87	53	9	7	2	0	0	335
2004	7	34	100	10	13	9	2	1	0	0	178
2005	4	245	106	138	18	16	11	3	1	0	541
2006	8	37	288	23	27	2	1	1	0	1	387
2007	4	453	267	278	14	20	2	1	1	0	1040

Table A7 - continued. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of USA commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Average
	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	0.845
1979	0.658	1.059	1.185	1.209	1.242	0.000	0.000	0.000	0.000	0.000	0.909
1980	0.567	0.910	1.276	1.484	0.000	0.000	0.000	0.000	0.000	0.000	0.832
1981	0.648	1.097	1.257	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.883
1982	0.675	1.119	1.184	1.261	0.000	0.000	0.000	0.000	0.000	0.000	1.030
1983	0.677	1.104	1.148	1.484	0.000	0.000	0.000	0.000	0.000	0.000	1.001
1984	0.474	0.699	0.835	1.484	0.000	0.000	0.000	0.000	0.000	0.000	0.627
1985	0.474	1.119	1.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.108
1986	0.648	0.694	1.049	1.059	0.000	0.000	0.000	0.000	0.000	0.000	0.692
1987	0.610	0.980	1.177	1.028	1.484	0.000	0.000	0.000	0.000	0.000	1.000
1988	0.615	0.900	1.178	1.093	0.000	0.000	0.000	0.000	0.000	0.000	0.898
1989	0.408	0.874	1.114	3.114	5.035	6.119	6.193	6.974	0.000	0.000	0.650
1990	0.524	0.929	1.181	1.964	3.875	4.159	4.536	6.273	0.000	0.000	0.993
1991	0.676	1.015	1.332	2.446	5.868	6.615	5.989	13.874	0.000	0.000	1.149
1992	0.685	0.934	1.579	3.263	5.997	7.374	8.146	8.107	9.389	0.000	1.035
1993	0.387	0.916	1.137	4.400	7.288	7.648	8.614	8.866	9.465	6.735	1.036
1994	0.441	0.867	1.355	2.656	4.480	6.420	6.356	6.974	0.000	0.000	0.909
1995	0.402	0.866	1.089	3.698	4.614	4.639	4.109	0.000	0.000	0.000	0.977
1996	0.499	0.874	1.886	3.856	5.526	6.628	0.000	0.000	5.213	0.000	1.440
1997	0.549	0.927	1.812	2.297	2.193	2.831	3.319	0.000	0.000	0.000	0.951
1998	0.603	1.011	2.590	3.910	4.583	5.176	6.309	7.987	16.634	0.000	1.916
1999	0.512	0.804	1.785	3.200	3.536	3.767	4.124	0.000	0.000	0.000	1.101
2000	0.542	0.964	2.231	3.555	4.882	5.383	6.052	5.608	0.000	0.000	1.654
2001	0.805	0.851	1.256	3.169	5.719	6.456	7.211	6.998	7.323	0.000	1.220
2002	0.522	1.083	1.502	1.735	1.622	4.044	4.215	3.780	5.213	0.000	1.313
2003	0.647	1.117	1.733	2.421	3.861	4.801	6.287	10.006	9.444	11.374	1.732
2004	0.359	1.154	1.439	2.777	3.786	4.865	5.792	8.059	7.990	10.056	1.383
2005	0.431	1.018	1.720	2.799	3.954	4.666	6.119	9.771	10.247	10.770	1.462
2006	0.431	1.010	1.480	2.276	2.199	3.125	5.130	7.728	3.713	16.153	1.418
2007	0.433	1.244	1.452	2.339	2.923	2.757	4.236	7.213	7.656	5.974	1.508

Table A8. Recreational landings at age (thousands of fish; metric tons) and mean weight (kg) at age of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					USA Recreational Landings in Numbers (000's) at Age						
1978											0
1979											0
1980											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	849	388	275	258	44	31	5	3	4	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	9.3	5.0	14.2	2.7	6.0	1.3	1.1	0.3	0.1	0.0	40
2007	0.5	1.1	0.3	1.4	0.2	0.4	0.1	0.0	0.0	0.0	4

Table A8 continued. Recreational landings at age (thousands of fish; metric tons) and mean weight (kg) at age of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2007.

	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	1096	302	206	0	90	4162
1982	73	1335	437	320	311	16	366	63	35	0	2955
1983	189	822	1509	333	340	195	0	24	0	454	3865
1984	52	70	249	346	55	106	34	9	44	29	994
1985	15	1116	834	848	1160	293	273	49	38	52	4678
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	1153	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	715
1998	25.2	164	130	51	41	20	0	3	0	0	434
1999	5.2	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	3.7	3.8	24.7	6.6	18.8	4.5	14.6	1.6	0.3	0.0	79
2007	0.1	0.8	0.4	3.0	0.9	1.9	0.3	0.1	0.0	0.0	8

Table A8 continued. Recreational landings at age (thousands of fish; metric tons) and mean weight (kg) at age of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Average
					USA Recreational Landings Mean Weight (kg) at Age						
1978											
1979											
1980											
1981	0.497	1.497	2.580	4.070	4.608	8.963	8.720	9.583	0.000	12.351	2.471
1982	0.537	1.437	2.163	2.921	4.591	5.839	9.512	9.342	10.619	0.000	1.977
1983	0.557	1.372	2.973	3.671	4.623	5.701	0.000	7.181	0.000	16.211	2.306
1984	0.342	0.756	3.052	3.943	4.600	6.959	8.629	13.780	9.824	13.029	2.194
1985	0.453	1.315	2.152	3.078	4.497	6.675	8.684	10.084	11.956	13.353	2.474
1986	0.527	0.747	2.134	3.343	7.017	7.701	6.959	11.624	16.623	21.883	1.442
1987	0.457	1.558	2.614	4.283	5.587	7.414	7.516	0.000	9.095	26.331	2.100
1988	0.440	0.968	2.420	3.802	5.916	6.059	9.095	13.737	0.000	0.000	2.285
1989	0.543	1.042	2.119	3.093	4.052	5.052	7.178	8.255	11.590	0.000	1.291
1990	0.448	1.267	2.631	4.030	5.515	6.636	7.126	9.990	9.095	17.518	2.943
1991	0.451	1.137	2.818	3.063	3.138	3.021	3.780	0.000	0.000	0.000	1.762
1992	0.513	1.267	2.356	3.738	4.189	5.595	5.568	7.469	0.000	0.000	1.756
1993	0.268	0.794	2.437	3.493	4.289	7.261	9.990	0.000	17.072	9.990	1.492
1994	0.495	0.965	2.434	3.832	4.068	4.086	2.405	14.559	14.559	0.000	1.892
1995	0.393	1.234	1.659	2.715	5.051	3.274	6.051	0.000	0.000	0.000	1.642
1996	0.454	1.399	2.380	3.160	5.936	6.775	2.898	5.415	0.000	0.000	2.455
1997	0.509	1.287	2.693	3.630	4.608	4.952	8.582	4.281	0.000	0.000	2.195
1998	0.642	1.285	2.074	2.907	3.458	3.954	0.000	4.814	0.000	0.000	1.638
1999	0.584	1.203	2.303	4.016	4.568	5.376	4.686	3.780	8.529	0.000	3.121
2000	0.291	0.864	1.861	3.023	4.028	2.818	4.826	0.000	0.000	0.000	1.102
2001	0.255	1.500	2.090	3.265	3.392	4.348	5.621	0.000	0.000	0.000	2.099
2002	0.400	1.189	2.336	3.096	3.942	4.747	5.521	0.000	0.000	0.000	2.562
2003	0.557	1.059	2.173	2.876	3.667	2.766	5.486	5.415	0.000	0.000	2.207
2004	0.316	1.190	1.988	3.267	3.837	4.637	7.081	5.941	7.469	10.301	2.663
2005	0.507	0.918	1.777	2.549	4.452	4.137	4.124	6.735	0.000	0.000	1.714
2006	0.397	0.753	1.733	2.431	3.141	3.447	13.837	5.137	4.281	0.000	1.963
2007	0.289	0.794	1.400	2.132	4.657	5.329	4.652	6.051	0.000	0.000	1.943

Table A9. Landings at age (thousands of fish; metric tons) and mean weight (kg) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Landings in Numbers (000's) at Age						
1978	2	61	1977	654	201	76	56	12	12	7	3058
1979	0	371	328	763	302	55	18	9	4	3	1853
1980	1	776	1122	214	420	125	32	11	14	10	2725
1981	2	146	611	506	135	382	87	51	21	16	1957
1982	6	1287	1362	1108	744	164	222	97	21	26	5037
1983	27	744	2505	1212	201	54	10	17	12	3	4785
1984	0	26	118	376	341	123	72	19	18	39	1132
1985	4	2147	904	383	497	139	45	38	9	11	4177
1986	19	238	1298	369	145	218	29	19	9	3	2347
1987	14	2596	602	741	91	79	117	22	15	6	4283
1988	10	229	2330	320	416	68	60	110	29	29	3601
1989	0	314	281	908	123	177	31	23	37	18	1912
1990	7	340	1776	619	802	95	102	8	14	30	3793
1991	11	493	512	1242	585	516	74	47	15	20	3515
1992	70	1784	899	291	544	186	175	25	21	7	4002
1993	4	252	1069	594	171	244	91	69	17	15	2526
1994	2	140	340	594	213	34	47	22	16	2	1410
1995	0	39	164	64	54	10	2	1	1	0	335
1996	1	25	163	269	52	36	9	2	1	0	558
1997	3	90	129	251	230	60	26	7	4	1	801
1998	0	58	202	97	91	74	13	7	3	2	547
1999	1	30	236	170	48	28	23	7	1	3	547
2000	0	30	59	231	93	25	15	9	2	1	465
2001	0.1	10	197	114	210	61	18	9	3	0	622
2002	0	3	38	150	42	75	14	5	2	1	330
2003	0.2	5	67	80	141	28	38	9	2	1	371
2004	0	3	60	64	54	73	18	19	4	0	295
2005	0	6	12	83	24	18	21	8	4	1	178
2006	0	3	113	44	125	32	14	14	2	1	348
2007	0	17	29	236	19	57	10	6	6	0	380

Table A9 - continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Landings in Weight (Tons) at Age						
1978	1	84	4816	1911	788	470	371	122	113	107	8783
1979		509	525	2842	1398	342	169	105	47	42	5979
1980	1	1042	2722	692	2099	809	228	133	177	157	8060
1981	2	199	1433	1779	704	2638	801	497	220	224	8496
1982	4	1858	3165	4228	3860	1074	2028	914	266	418	17816
1983	24	1084	5519	3854	876	335	80	176	147	37	12132
1984		38	292	1427	1620	743	622	202	195	620	5758
1985	3	3019	1775	1388	2370	895	368	369	94	160	10442
1986	14	374	3734	1458	811	1565	250	180	89	28	8503
1987	9	4185	1556	3302	557	596	1113	243	189	93	11842
1988	8	296	5867	1249	2378	455	555	1177	334	437	12757
1989		411	662	3771	673	1207	231	247	432	276	7912
1990	6	616	5021	2290	4187	632	875	90	183	445	14345
1991	12	866	1425	4281	2593	2885	527	451	127	291	13457
1992	80	2769	2301	1038	2492	1101	1245	241	265	138	11669
1993	3	392	2488	1851	768	1429	638	623	153	183	8527
1994	2	203	817	2270	1023	243	370	196	128	23	5276
1995		57	409	241	286	63	22	10	10	0	1099
1996	1	38	384	898	272	229	62	17	11	0	1912
1997	3	138	292	821	979	351	213	60	47	13	2917
1998		86	480	310	389	431	91	58	33	30	1908
1999	1	47	540	600	200	177	156	56	9	41	1825
2000	0	44	126	710	393	123	93	66	17	13	1585
2001	0	15	445	338	840	312	94	72	28	0	2144
2002		4	86	461	181	379	94	41	18	11	1275
2003	0.1	7	142	213	529	122	216	62	15	9	1316
2004	0	4	122	182	182	333	97	138	37	17	1111
2005		7	21	210	89	89	108	60	34	12	630
2006	0	3	212	108	435	148	87	80	13	11	1097
2007	0	21	52	579	63	239	63	44	42	4	1107

Table A9 - continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
Canadian Commercial Landings Mean Weight (kg) at Age											
1978	0.707	1.376	2.436	2.922	3.918	6.187	6.625	10.148	9.429	15.262	2.872
1979	0.000	1.371	1.601	3.725	4.630	6.222	9.365	11.638	11.699	14.064	3.227
1980	0.567	1.343	2.426	3.235	4.997	6.468	7.119	12.135	12.652	15.721	2.958
1981	0.839	1.362	2.345	3.516	5.216	6.905	9.204	9.747	10.465	13.993	4.341
1982	0.652	1.444	2.324	3.816	5.188	6.550	9.137	9.418	12.667	16.092	3.537
1983	0.904	1.457	2.203	3.180	4.357	6.203	8.042	10.368	12.222	12.270	2.535
1984	0.000	1.477	2.473	3.794	4.751	6.043	8.633	10.622	10.807	15.897	5.087
1985	0.686	1.406	1.964	3.625	4.768	6.440	8.181	9.718	10.499	14.537	2.500
1986	0.723	1.572	2.877	3.952	5.592	7.179	8.612	9.453	9.934	9.437	3.623
1987	0.661	1.612	2.584	4.456	6.125	7.540	9.510	11.031	12.629	15.444	2.765
1988	0.786	1.294	2.518	3.904	5.716	6.694	9.251	10.700	11.531	15.065	3.543
1989	0.000	1.310	2.356	4.153	5.471	6.820	7.459	10.757	11.680	15.356	4.138
1990	0.831	1.812	2.827	3.699	5.221	6.657	8.582	11.227	13.080	14.821	3.782
1991	1.051	1.756	2.783	3.447	4.432	5.591	7.116	9.604	8.457	14.550	3.828
1992	1.148	1.552	2.559	3.568	4.581	5.921	7.112	9.626	12.603	19.714	2.916
1993	0.872	1.557	2.327	3.116	4.489	5.858	7.006	9.035	8.974	12.173	3.376
1994	0.906	1.453	2.404	3.822	4.805	7.141	7.869	8.914	7.970	11.637	3.742
1995	0.906	1.472	2.495	3.759	5.298	6.313	10.903	10.181	10.175		3.279
1996	1.034	1.538	2.358	3.337	5.237	6.358	6.916	8.455	10.594		3.427
1997	0.954	1.536	2.264	3.269	4.257	5.855	8.190	8.546	11.825	12.688	3.641
1998	0.626	1.484	2.375	3.195	4.274	5.828	6.991	8.298	10.984	14.840	3.487
1999	0.799	1.554	2.288	3.527	4.162	6.304	6.768	8.003	9.390	13.572	3.336
2000	0.866	1.458	2.128	3.075	4.230	4.923	6.200	7.344	8.254	12.863	3.408
2001	0.880	1.468	2.261	2.963	4.001	5.119	5.219	7.967	9.218		3.446
2002	0.551	1.421	2.265	3.073	4.301	5.054	6.721	8.277	8.790	10.755	3.863
2003	0.524	1.344	2.119	2.658	3.755	4.363	5.693	6.902	7.610	9.391	3.546
2004	0.704	1.360	2.011	2.827	3.391	4.561	5.517	7.354	9.040	10.328	3.714
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	1.102	1.872	2.430	3.493	4.564	6.340	5.917	7.321	7.646	3.156
2007	0.000	1.234	1.819	2.456	3.260	4.224	6.318	7.008	7.016	10.121	2.916

Table A10. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Discards in Numbers (000's) at Age						
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1984	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1986	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1996	0.07	1.24	3.77	8.41	2.80	2.01	0.77	0.13	0.17	0.05	19
1997	0.32	19.43	27.20	41.70	45.74	8.81	3.26	1.11	0.09	0.06	148
1998	0.02	14.66	50.09	24.84	21.38	14.88	2.81	0.86	0.28	0.71	131
1999	0.44	8.71	55.11	34.36	11.58	6.57	3.56	0.39	0.17	0.16	121
2000	0.06	2.62	4.06	12.93	5.88	2.42	0.90	0.45	0.02	0.04	29
2001	0.26	0.94	11.41	6.43	15.46	5.82	2.26	1.45	0.96	0.24	45
2002	0.04	0.41	2.49	11.28	3.69	6.51	2.37	0.77	0.15	0.26	28
2003	0.22	0.35	4.48	15.11	32.20	7.28	6.36	1.57	0.24	0.00	68
2004	0.35	0.96	4.34	16.48	7.39	5.95	2.54	0.39	0.74	0.12	39
2005	0.75	18.90	16.00	55.80	9.18	4.86	4.78	1.07	0.36	0.06	112
2006	4.70	14.17	81.24	22.18	38.65	7.06	1.85	1.79	0.21	0.18	172
2007	0.14	14.83	14.48	48.80	3.80	3.51	0.20	0.07	0.06	0.00	86

Table A10 - continued. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Discards in Weight (Tons) at Age						
1978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1979	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1980	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1981	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1982	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1983	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1984	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1986	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1989	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1990	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1994	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1995	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1996	0.01	0.70	4.76	15.03	8.13	7.78	3.35	0.63	0.89	0.29	42
1997	0.29	27.18	58.04	128.85	183.58	47.02	24.65	8.94	0.48	0.36	479
1998	0.02	19.24	108.09	67.43	78.89	72.05	14.48	5.66	2.43	4.07	372
1999	0.34	12.40	117.57	102.09	41.01	30.44	18.73	2.94	1.26	1.54	328
2000	0.01	1.47	5.12	23.09	17.05	9.36	3.87	2.22	0.11	0.18	62
2001	0.03	0.53	14.40	11.49	44.86	22.52	9.78	7.13	5.12	1.04	117
2002	0.01	0.23	3.14	20.15	10.69	25.22	10.25	3.79	0.78	1.62	76
2003	0.03	0.20	5.66	26.99	93.42	28.21	27.48	7.76	1.30	0.00	191
2004	0.05	0.54	5.48	29.43	21.43	23.03	10.97	1.92	3.95	0.74	98
2005	0.09	14.06	22.90	119.13	27.88	20.19	20.14	5.42	2.74	0.43	233
2006	0.64	7.64	129.95	46.36	118.36	28.35	10.90	9.99	1.37	1.45	355
2007	0.02	9.91	15.09	79.45	7.90	9.91	0.92	0.44	0.33	0.00	124

Table A10 - continued. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Average
					Canadian Commercial Discards 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	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1982	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1983	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1984	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1986	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1989	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1990	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1994	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1995	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1996	0.128	0.562	1.262	1.786	2.901	3.872	4.322	4.934	5.353	5.912	2.140
1997	0.907	1.399	2.134	3.090	4.014	5.339	7.561	8.049	5.353	5.913	3.245
1998	0.629	1.312	2.158	2.714	3.691	4.843	5.144	6.585	8.728	5.741	2.852
1999	0.773	1.424	2.133	2.971	3.542	4.633	5.257	7.576	7.380	9.472	2.712
2000	0.128	0.562	1.262	1.786	2.901	3.872	4.322	4.934	5.353	5.159	2.128
2001	0.128	0.562	1.262	1.786	2.901	3.872	4.322	4.934	5.353	4.327	2.585
2002	0.128	0.562	1.262	1.786	2.901	3.872	4.322	4.934	5.353	6.232	2.713
2003	0.128	0.562	1.262	1.786	2.901	3.872	4.322	4.934	5.353	0.000	2.817
2004	0.128	0.562	1.262	1.786	2.901	3.872	4.322	4.934	5.353	6.392	2.485
2005	0.120	0.744	1.431	2.135	3.039	4.158	4.211	5.069	7.635	7.608	2.085
2006	0.135	0.539	1.600	2.090	3.063	4.013	5.902	5.586	6.520	8.014	2.064
2007	0.161	0.669	1.042	1.628	2.080	2.821	4.670	6.636	5.277	0.000	1.444

Table A11. Catch at age (thousands of fish; metric tons) and mean weight (kg) at age of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Catch in Numbers (000's) at Age						
1978	152	417	8109	2430	897	178	241	23	42	11	12499
1979	279	2243	954	4585	1207	450	160	304	13	35	10229
1980	340	4239	5955	545	2465	983	418	70	139	14	15168
1981	1219	3911	4738	2685	318	1406	417	163	156	66	15079
1982	775	10457	4434	2988	2040	297	707	199	75	85	22057
1983	626	5182	8753	2680	1155	746	95	175	68	113	19593
1984	281	1548	3486	3328	924	560	450	59	167	125	10928
1985	176	7444	2942	1690	2098	496	267	197	28	90	15428
1986	768	1594	4576	860	525	615	86	70	56	28	9179
1987	104	7956	1515	2170	300	250	277	56	36	26	12691
1988	325	2352	8368	1074	1576	224	150	218	46	53	14386
1989	891	2609	3033	4254	383	534	81	51	60	21	11919
1990	72	5561	5373	1964	2272	231	229	25	23	40	15791
1991	270	1938	3486	3159	1442	1088	141	90	27	26	11667
1992	138	4448	2273	1066	1496	447	355	44	36	10	10313
1993	299	1535	4429	1225	475	536	178	141	43	21	8883
1994	91	605	1541	1987	426	98	146	51	31	6	4981
1995	32	649	1427	670	382	41	21	20	6	1	3251
1996	65	287	987	1270	256	184	18	12	11	0	3089
1997	126	684	749	1021	883	148	94	19	10	4	3738
1998	63	919	1310	494	386	285	40	16	6	3	3522
1999	46	354	2020	852	287	126	144	22	5	3	3859
2000	113	942	741	1156	316	88	46	39	4	1	3446
2001	12	720	2667	752	699	180	55	26	15	1	5126
2002	22	83	1129	1505	363	371	85	19	11	6	3594
2003	17	199	403	800	910	156	142	28	7	3	2665
2004	50	69	434	260	314	253	58	49	12	5	1505
2005	12	355	199	577	144	106	85	18	9	4	1509
2006	31	67	827	207	365	71	31	28	4	3	1635
2007	11	526	395	1176	72	129	16	10	9	1	2345

Table A11 - continued. Catch at age (thousands of fish; metric tons) and mean weight (kg) at age of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Catch in Weight (Tons) at Age						
1978	88	522	19793	8279	3600	1016	1600	197	418	149	35661
1979	194	3060	1804	19625	5951	3227	1542	3147	135	476	39162
1980	219	5990	14476	1933	13759	6634	3473	699	1289	212	48684
1981	716	5636	11284	9478	1607	10268	3661	1597	2180	1,116	47543
1982	499	14564	11262	11116	10775	1954	6694	1935	967	1,321	61088
1983	423	7442	20916	8984	5527	4812	803	1867	792	1,838	53404
1984	152	2320	8631	12207	4562	3672	3934	607	1852	1828	39766
1985	142	10313	6105	6287	10441	3197	2204	2022	326	1260	42298
1986	518	2163	11201	3106	2886	4414	759	700	724	405	26876
1987	60	11683	3753	9052	1728	1944	2470	580	435	406	32112
1988	160	3244	19856	3766	8527	1517	1311	2274	536	784	41976
1989	387	3747	6685	15879	1987	3506	646	511	679	312	34339
1990	38	8282	13235	7018	11285	1477	1928	275	289	586	44413
1991	183	2983	8726	11124	6935	6338	1034	842	264	381	38810
1992	159	6899	5505	4067	6780	2708	2522	418	431	196	29686
1993	85	2005	9781	3953	2369	3117	1313	1258	479	260	24620
1994	45	736	3323	7044	2037	690	1049	466	275	89	15754
1995	13	879	2825	2492	2007	306	200	244	75	27	9068
1996	32	414	2359	4086	1249	1194	145	113	124	2	9718
1997	68	1002	1745	3516	3560	847	730	153	116	47	11784
1998	39.1	1316	2963	1693	1763	1590	298	124	66	36	9888
1999	25.5	510	4321	2861	1302	738	955	187	48	44	10991
2000	44	1442	1768	3917	1437	482	324	311	34	13.0	9771
2001	7	983	5899	2208	2865	950	328	198	134	13	13584
2002	16	149	2490	4483	1443	1915	548	150	98	76	11368
2003	10	293	911	2328	3520	735	824	195	54	31	8901
2004	17	106	1027	801	1218	1221	329	363	101	56	5238
2005	5	377	424	1775	579	522	467	135	79	42	4404
2006	12	75	1,764	647	1,347	321	202	182	28	31	4610
2007	4	747	758	3,408	261	539	96	72	60	10	5956

Table A11 - continued. Catch at age (thousands of fish; metric tons) and mean weight (kg) at age of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2007.

					Age						
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Catch Mean Weight (kg) at Age						
1978	0.579	1.251	2.441	3.407	4.014	5.696	6.645	8.708	9.936	13.887	2.853
1979	0.694	1.364	1.892	4.280	4.931	7.176	9.664	10.350	10.438	13.611	3.829
1980	0.644	1.413	2.431	3.546	5.583	6.748	8.305	9.926	9.295	14.900	3.210
1981	0.587	1.441	2.381	3.529	5.055	7.303	8.780	9.800	14.018	16.799	3.153
1982	0.643	1.393	2.540	3.720	5.282	6.576	9.466	9.745	12.972	15.623	2.770
1983	0.676	1.436	2.389	3.352	4.784	6.447	8.491	10.667	11.699	16.319	2.726
1984	0.540	1.499	2.476	3.668	4.937	6.554	8.738	10.309	11.093	14.643	3.639
1985	0.806	1.385	2.075	3.720	4.977	6.439	8.247	10.279	11.765	14.047	2.742
1986	0.674	1.357	2.448	3.611	5.494	7.173	8.877	9.944	12.947	14.562	2.928
1987	0.582	1.468	2.476	4.171	5.768	7.777	8.908	10.336	12.027	15.642	2.530
1988	0.492	1.379	2.373	3.506	5.412	6.781	8.722	10.433	11.535	14.926	2.918
1989	0.435	1.436	2.204	3.732	5.181	6.563	7.937	9.976	11.287	14.651	2.881
1990	0.531	1.489	2.463	3.573	4.967	6.402	8.404	11.191	12.425	14.512	2.813
1991	0.658	1.520	2.499	3.520	4.809	5.825	7.318	9.388	9.615	14.649	3.315
1992	0.830	1.435	2.408	3.798	4.520	6.043	7.085	9.472	11.841	18.836	2.761
1993	0.284	1.306	2.208	3.227	4.984	5.820	7.378	8.922	11.135	12.228	2.772
1994	0.477	1.198	2.153	3.544	4.787	7.074	7.176	9.116	9.003	15.762	3.153
1995	0.396	1.347	1.977	3.721	5.249	7.430	9.327	12.197	11.841	19.118	2.785
1996	0.487	1.442	2.391	3.218	4.875	6.496	8.101	9.699	10.974	8.621	3.145
1997	0.539	1.463	2.328	3.445	4.033	5.734	7.734	8.090	11.420	12.087	3.151
1998	0.619	1.432	2.261	3.425	4.571	5.576	7.399	7.753	11.825	12.310	2.807
1999	0.534	1.431	2.137	3.355	4.543	5.867	6.641	8.406	9.562	13.201	2.844
2000	0.388	1.529	2.386	3.388	4.550	5.472	6.996	8.013	8.049	12.597	2.834
2001	0.601	1.365	2.212	2.937	4.101	5.265	5.980	7.681	9.043	9.737	2.650
2002	0.490	1.316	2.105	2.957	3.949	5.156	6.475	8.000	9.248	11.708	3.070
2003	0.602	1.458	2.254	2.907	3.866	4.710	5.789	6.918	8.251	10.448	3.334
2004	0.332	1.533	2.364	3.080	3.883	4.824	5.651	7.371	8.552	11.100	3.480
2005	0.431	1.035	2.102	3.068	4.003	4.925	5.467	7.497	8.786	11.370	2.891
2006	0.379	1.079	2.093	3.107	3.679	4.535	6.462	6.394	7.519	9.074	2.781
2007	0.423	1.420	1.917	2.899	3.627	4.173	5.932	6.957	6.922	9.070	2.540

Table A12. 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 - 2008. [1,2,3].

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.79	11.4
1965	-	-	4.25	11.8
1966	-	-	4.90	8.1
1967	-	-	10.33	13.6
1968	4.73	12.7	3.31	8.6
1969	4.63	17.8	2.24	8.0
1970	4.34	15.8	5.12	12.6
1971	3.39	14.3	3.19	9.8
1972	9.16	19.3	13.09	22.9
1973	57.81	94.5	12.28	30.9
1974	14.74	36.4	3.49	8.2
1975	6.89	26.1	6.41	14.1
1976	7.06	18.6	10.43	17.7
1977	6.19	15.3	5.44	12.5
1978	12.31	31.2	8.59	23.3
1979	5.00	16.2	5.95	16.5
1980	7.68	24.1	2.91	6.7
1981	10.44	26.1	9.20	20.3
1982	32.96	101.9	3.34	6.1
1983	7.70	23.5	4.14	6.1
1984	4.08	15.3	4.73	10.0
1985	7.03	21.7	2.31	3.1
1986	5.04	16.7	2.99	3.7
1987	3.24	9.9	2.33	4.4
1988	5.87	13.5	3.07	5.6
1989	4.80	10.9	4.84	4.7
1990	4.79	11.7	4.78	11.5
1991	4.31	8.9	0.96	1.4
1992	2.67	7.4	1.72	3.0
1993	2.40	7.0	2.15	2.2
1994	0.95	1.2	1.82	3.3
1995	3.29	8.4	3.62	5.6
1996	2.70	7.5	1.10	2.7
1997	2.32	5.2	0.87	1.9
1998	4.36	11.7	1.87	2.8
1999	2.15	4.7	1.02	3.0
2000	3.57	8.2	1.31	1.4
2001	1.86	5.5	1.05	2.1
2002	2.08	5.0	4.70	11.3
2003	1.98	4.2	1.25	2.1
2004	5.38	14.3	4.21	5.9
2005	1.96	4.5	1.02	1.6
2006	3.17	6.1	1.44	2.7
2007	3.37	5.1	0.59	1.1
2008	3.57	4.3		
Mean 1963-2008	6.9	17.4	4.0	8.5

[1] During 1963-1984, BMV oval doors used in spring and autumn surveys; since 1985, Portuguese polyvalent doors used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).
[2] Spring surveys during 1980-1982, 1989-1991 and 1994 and autumn surveys during 1977-1981,1989-1991,and1993 were accomplished with the R/V Delaware II; in all other years, the surveys were accomplished using the R/V Albatross IV. Adjustments have been made to the R/V Delaware II catch per tow data to standardize these to R/V Albatross IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991)
[3] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years,spring surveys were accomplished with a 36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

Table A13. 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 - 2008.

	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	0.0614	0.0119	0.4838	0.1378	0.631	0.2744	0.2053	0.1274	0.0298	0			1.9628
2006	0.0127	0.1786	0.231	1.3059	0.3319	0.7234	0.2128	0.1213	0.0539	0	0		3.1715
2007	0.000	0.125	0.639	0.3756	1.7937	0.1809	0.2092	0.0309	0.0181	0	0		3.3724
2008	0.1312	0.6326	0.8316	0.5785	0.3513	0.9606	0.0378	0.045	0	0	0	0	3.5686
average	0.263	0.408	1.123	1.640	1.155	0.711	0.306	0.180	0.094	0.066	0.096		6.877

Table A14. 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 - 2007.

	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	
average	0.340	1.244	1.016	0.695	0.400	0.140	0.120	0.060	0.050	0.028	0.056	4.109

Table A15. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian spring bottom trawl survey, 1986-2008.

	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	1.34	0.47	2.91	1.13	0.51	0.41	0.01	0.05	0.01	6.86
2006	0.00	0.04	1.41	0.66	1.63	0.70	0.20	0.18	0.08	0.05	4.95
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
average	0.27	0.94	1.49	1.51	1.03	0.52	0.27	0.12	0.06	0.05	6.41

** not used in VPA calibration; entire Bank not surveyed*
***R/V Teleost (R/V Needler indices not used since entire GB not surveyed)*

R/V Needler'05	*0.05*	*2.04*	*2.78*	*14.18*	*3.42*	*1.59*	*1.45*	*0.12*	*0.15*	*0.02*	*25.80*

Table A16a. Selected VPA diagnostics, including predicted beginning year stock numbers for ages 1-8 and catchability estimates of each survey index, with standard error and CV for the Georges Bank Atlantic cod stock for the **BASE MODEL**.

```
Levenburg-Marquardt Algorithm Completed     7 Iterations
 Residual Sum of Squares =     383.740

 Number of Residuals     =    595
 Number of Parameters    =      8
 Degrees of Freedom      =    587
 Mean Squared Residual   =     0.653730
 Standard Deviation      =     0.808536

 Number of Years =    30
 Number of Ages  =    10
 First Year      =  1978
 Youngest Age    =     1
 Oldest True Age =     9

 Number of Survey Indices Available        =    30
 Number of Survey Indices Used in Estimate =    30
 VPA Classic Method - Auto Estimated Q's

 Stock Numbers Predicted in Terminal Year Plus One (2008)
 Age    Stock Predicted     Std. Error      CV

   1           5158.350   0.246246E+04   0.477374E+00
   2           5777.533   0.195206E+04   0.337870E+00
   3           4312.780   0.134212E+04   0.311197E+00
   4           1201.636   0.348563E+03   0.290074E+00
   5           4150.462   0.112909E+04   0.272039E+00
   6            348.414   0.977986E+02   0.280697E+00
   7            566.199   0.170298E+03   0.300775E+00
   8            218.540   0.684464E+02   0.313198E+00

 Catchability Values for Each Survey Used in Estimate
 INDEX     Catchability    Std. Error      CV

   1       0.219439E-01   0.434391E-02   0.197955E+00
   2       0.919973E-01   0.727614E-02   0.790908E-01
   3       0.186189E+00   0.193080E-01   0.103701E+00
   4       0.316089E+00   0.450858E-01   0.142637E+00
   5       0.402164E+00   0.624872E-01   0.155377E+00
   6       0.408966E+00   0.614000E-01   0.150135E+00
   7       0.427224E+00   0.771050E-01   0.180479E+00
   8       0.517786E+00   0.835569E-01   0.161374E+00
   9       0.141338E-01   0.106855E-01   0.756029E+00
  10       0.899870E-01   0.208708E-01   0.231931E+00
  11       0.198731E+00   0.467107E-01   0.235044E+00
  12       0.177261E+00   0.223604E-01   0.126144E+00
  13       0.216299E+00   0.540535E-01   0.249901E+00
  14       0.207689E+00   0.355707E-01   0.171269E+00
  15       0.300243E+00   0.112587E+00   0.374986E+00
  16       0.291472E+00   0.165071E+00   0.566335E+00
  17       0.209249E-01   0.562393E-02   0.268767E+00
  18       0.981470E-01   0.209510E-01   0.213466E+00
  19       0.327191E+00   0.335557E-01   0.102557E+00
  20       0.615292E+00   0.779107E-01   0.126624E+00
  21       0.949463E+00   0.112662E+00   0.118658E+00
  22       0.112928E+01   0.189453E+00   0.167763E+00
  23       0.121718E+01   0.235660E+00   0.193612E+00
  24       0.128152E+01   0.264935E+00   0.206735E+00
  25       0.172164E-01   0.366082E-02   0.212636E+00
  26       0.746671E-01   0.874968E-02   0.117182E+00
  27       0.131211E+00   0.152631E-01   0.116325E+00
  28       0.158575E+00   0.229384E-01   0.144654E+00
  29       0.122922E+00   0.223467E-01   0.181795E+00
  30       0.143092E+00   0.233551E-01   0.163218E+00
```

Table A16b. Selected VPA diagnostics, including predicted beginning year stock numbers for ages 1-8 and catchability estimates of each survey index, with standard error and CV for the Georges Bank Atlantic cod stock for the **SPLIT MODEL**.

```
Levenburg-Marquardt Algorithm Completed     9 Iterations
 Residual Sum of Squares =     323.853

 Number of Residuals     =    595
 Number of Parameters    =      8
 Degrees of Freedom      =    587
 Mean Squared Residual   =     0.551709
 Standard Deviation      =     0.742771

 Number of Years =    30
 Number of Ages  =    10
 First Year      =  1978
 Youngest Age    =     1
 Oldest True Age =     9

 Number of Survey Indices Available       =    52
 Number of Survey Indices Used in Estimate =    52

 VPA Classic Method - Auto Estimated Q's

 Stock Numbers Predicted in Terminal Year Plus One (2008)
 Age    Stock Predicted     Std. Error      CV

   1           4874.666   0.218662E+04   0.448568E+00
   2           5751.749   0.182760E+04   0.317747E+00
   3           3851.720   0.113398E+04   0.294410E+00
   4            970.307   0.274066E+03   0.282453E+00
   5           2929.571   0.803594E+03   0.274304E+00
   6            157.359   0.498832E+02   0.317002E+00
   7            237.651   0.866388E+02   0.364564E+00
   8             80.692   0.313443E+02   0.388442E+00

 Catchability Values for Each Survey Used in Estimate
 INDEX     Catchability    Std. Error      CV

   1       0.178394E-01   0.601117E-02   0.336960E+00
   2       0.918544E-01   0.111156E-01   0.121014E+00
   3       0.168705E+00   0.303091E-01   0.179657E+00
   4       0.215614E+00   0.433017E-01   0.200829E+00
   5       0.264241E+00   0.594130E-01   0.224844E+00
   6       0.278657E+00   0.523770E-01   0.187962E+00
   7       0.297561E+00   0.527492E-01   0.177272E+00
   8       0.363074E+00   0.710421E-01   0.195668E+00
   9       0.292985E-01   0.628344E-02   0.214463E+00
  10       0.101150E+00   0.921209E-02   0.910737E-01
  11       0.225276E+00   0.256921E-01   0.114047E+00
  12       0.506259E+00   0.867519E-01   0.171359E+00
  13       0.688799E+00   0.113946E+00   0.165426E+00
  14       0.701770E+00   0.122594E+00   0.174693E+00
  15       0.723118E+00   0.181470E+00   0.250954E+00
  16       0.816798E+00   0.174300E+00   0.213394E+00
  17       0.141338E-01   0.106855E-01   0.756029E+00
  18       0.899870E-01   0.208708E-01   0.231931E+00
  19       0.198731E+00   0.467107E-01   0.235044E+00
  20       0.177261E+00   0.223604E-01   0.126144E+00
  21       0.216299E+00   0.540535E-01   0.249901E+00
  22       0.207689E+00   0.355707E-01   0.171269E+00
  23       0.300243E+00   0.112587E+00   0.374986E+00
  24       0.291472E+00   0.165071E+00   0.566335E+00
  25       0.358799E-01   0.115005E-01   0.320529E+00
  26       0.187587E+00   0.396148E-01   0.211181E+00
  27       0.324684E+00   0.370155E-01   0.114005E+00
  28       0.372132E+00   0.475039E-01   0.127653E+00
  29       0.580779E+00   0.710335E-01   0.122307E+00
  30       0.555873E+00   0.114979E+00   0.206844E+00
```

Table A16b continued. Selected VPA diagnostics, including predicted beginning year stock numbers for ages 1-8 and catchability estimates of each survey index, with standard error and CV for the Georges Bank Atlantic cod stock for the **SPLIT MODEL**.

31	0.730017E+00	0.211842E+00	0.290188E+00
32	0.644843E-03	0.171054E-03	0.265264E+00
33	0.158633E-01	0.567279E-02	0.357605E+00
34	0.779414E-01	0.200113E-01	0.256748E+00
35	0.362628E+00	0.527704E-01	0.145522E+00
36	0.888325E+00	0.130864E+00	0.147315E+00
37	0.140774E+01	0.199374E+00	0.141627E+00
38	0.193422E+01	0.294172E+00	0.152088E+00
39	0.190133E+01	0.391504E+00	0.205911E+00
40	0.127804E-02	0.320091E-03	0.250454E+00
41	0.163752E-01	0.327145E-02	0.199780E+00
42	0.811005E-01	0.114794E-01	0.141545E+00
43	0.119082E+00	0.179800E-01	0.150989E+00
44	0.126944E+00	0.225861E-01	0.177922E+00
45	0.886514E-01	0.215241E-01	0.242795E+00
46	0.104097E+00	0.162056E-01	0.155678E+00
47	0.201548E-01	0.859432E-02	0.426415E+00
48	0.741493E-01	0.152083E-01	0.205104E+00
49	0.162972E+00	0.301554E-01	0.185035E+00
50	0.233271E+00	0.520419E-01	0.223096E+00
51	0.211986E+00	0.510959E-01	0.241035E+00
52	0.253043E+00	0.646169E-01	0.255360E+00

Table A17a . **BASE MODEL** estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and female percent mature (5-year moving window) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2007.

Stock Numbers (Jan 1) in thousands

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	28705	25943	22914	45891	19863	11305	29021	9615	44505	17898	24854	17849	10204	19796	7470
2	4707	23365	20988	18453	36471	15562	8691	23506	7713	35744	14560	20056	13809	8290	15956
3	25333	3478	17107	13370	11591	20473	8096	5723	12569	4881	22111	9803	14070	6330	5023
4	7660	13468	1991	8669	6701	5520	8936	3512	2063	6191	2637	10610	5305	6709	2076
5	2967	4093	6916	1141	4688	2817	2128	4336	1367	920	3124	1198	4880	2584	2671
6	1264	1624	2267	3454	649	2015	1273	916	1678	649	484	1153	637	1967	833
7	1212	874	926	978	1570	266	982	541	308	823	308	197	467	315	642
8	82	776	572	385	428	654	133	402	205	176	425	118	88	178	132
9	174	47	363	405	169	173	378	56	153	105	93	154	51	50	66
10+	44	127	37	173	192	288	283	182	76	75	105	54	88	47	19
Total	72148	73793	74082	92919	82323	59073	59920	48789	70638	67462	68702	61191	49599	46266	34887

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	9873	6318	3928	6690	10672	4976	12399	6159	2858	5338	1983	13523	2945	7178	7068	5158
2	5943	7814	5088	3187	5419	8623	4017	10108	4940	2330	4340	1608	11026	2400	5847	5778
3	8749	3487	5843	3577	2350	3819	6231	2967	7425	3396	1805	3372	1254	8698	1902	4313
4	2070	3214	1476	3500	2043	1252	1952	3289	1764	3690	1721	1115	2369	845	6362	1202
5	745	607	868	610	1728	762	582	836	1656	772	1665	694	679	1420	505	4150
6	853	189	121	369	270	628	280	221	402	731	306	553	288	426	834	348
7	283	223	68	62	138	90	259	117	102	168	268	111	226	141	285	566
8	209	74	53	36	35	30	37	84	54	35	62	92	39	109	87	219
9	68	46	15	26	19	12	10	11	34	22	12	26	32	16	64	62
10+	34	9	3	1	7	6	7	3	3	13	5	11	13	14	9	52
Total	28827	21980	17463	18057	22681	20196	25776	23796	19240	16495	12167	21104	18871	21247	22962	21848

Fishing Mortality

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.01	0.01	0.02	0.03	0.04	0.06	0.01	0.02	0.02	0.01	0.015	0.057	0.008	0.016	0.029
2	0.10	0.11	0.25	0.27	0.38	0.45	0.22	0.43	0.26	0.28	0.196	0.154	0.58	0.301	0.401
3	0.43	0.36	0.48	0.49	0.54	0.63	0.64	0.82	0.51	0.42	0.534	0.414	0.541	0.915	0.686
4	0.43	0.47	0.36	0.41	0.67	0.75	0.52	0.74	0.61	0.48	0.589	0.577	0.519	0.721	0.824
5	0.40	0.39	0.49	0.36	0.64	0.59	0.64	0.75	0.54	0.44	0.797	0.432	0.709	0.932	0.942
6	0.17	0.36	0.64	0.59	0.69	0.52	0.65	0.89	0.51	0.55	0.701	0.704	0.504	0.919	0.88
7	0.25	0.22	0.68	0.63	0.68	0.49	0.69	0.77	0.36	0.46	0.759	0.602	0.766	0.673	0.922
8	0.36	0.56	0.15	0.62	0.71	0.35	0.66	0.76	0.47	0.43	0.818	0.642	0.365	0.798	0.457
9	0.31	0.36	0.54	0.54	0.66	0.56	0.66	0.77	0.51	0.48	0.782	0.559	0.689	0.908	0.926
10+	0.31	0.36	0.54	0.54	0.66	0.56	0.66	0.77	0.51	0.48	0.782	0.559	0.689	0.908	0.926
F 5-8	0.29	0.38	0.49	0.55	0.68	0.49	0.66	0.79	0.47	0.47	0.77	0.59	0.59	0.83	0.80

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.01	0.00
2	0.33	0.09	0.15	0.10	0.15	0.12	0.10	0.11	0.17	0.05	0.05	0.05	0.04	0.03	0.10
3	0.80	0.66	0.31	0.36	0.43	0.47	0.44	0.32	0.50	0.48	0.28	0.15	0.19	0.11	0.26
4	1.03	1.11	0.68	0.51	0.79	0.56	0.65	0.49	0.63	0.60	0.71	0.30	0.31	0.32	0.23
5	1.17	1.41	0.66	0.61	0.81	0.80	0.77	0.53	0.62	0.73	0.90	0.68	0.27	0.33	0.17
6	1.14	0.83	0.47	0.78	0.90	0.68	0.67	0.57	0.67	0.81	0.81	0.69	0.52	0.20	0.19
7	1.14	1.23	0.43	0.38	1.34	0.67	0.92	0.57	0.87	0.80	0.87	0.84	0.53	0.28	0.06
8	1.30	1.38	0.53	0.43	0.89	0.88	1.03	0.70	0.73	0.87	0.69	0.87	0.69	0.34	0.14
9	1.15	1.24	0.62	0.65	0.85	0.74	0.78	0.54	0.64	0.77	0.89	0.70	0.37	0.30	0.14
10+	1.15	1.24	0.62	0.65	0.85	0.74	0.78	0.54	0.64	0.77	0.89	0.70	0.37	0.30	0.14
F 5-8	1.19	1.21	0.52	0.55	0.99	0.76	0.85	0.59	0.72	0.80	0.82	0.77	0.50	0.29	0.14

Table A17a. continued. **BASE MODEL** estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and female percent mature (5-year moving window) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2007.

SSB at start of spawning season

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	836	853	856	1516	656	393	1230	1035	3133	1306	1725	803	371	1107	428
2	1503	6701	7328	6250	10785	5499	3999	10813	4333	19363	7815	9691	4488	3631	6593
3	31517	3803	21975	17270	15480	27649	11557	7748	18717	7186	32866	14041	19881	9025	7376
4	18567	37396	4512	22002	16572	13464	22981	9017	4886	17298	6676	27186	12810	16603	5337
5	7977	15051	29814	4352	17410	10409	7522	15813	5460	3771	12571	4596	18059	8870	8808
6	5197	7938	11369	19342	3223	10432	6181	4308	8903	3748	2606	5910	3262	8779	3750
7	5990	6042	6175	6557	11284	1769	6347	3385	2121	5890	2161	1262	2952	1863	3422
8	594	5667	5289	3026	3402	5999	1076	3240	1659	1514	3457	956	756	1336	982
9	1489	407	3145	4219	1655	1627	3567	525	1570	1023	866	1468	488	432	572
10+	565	1575	489	2566	2600	4135	3591	2170	984	1051	1336	701	1107	577	292
Total	74235	85433	90951	87101	83067	81375	68051	58056	51766	62150	72080	66616	64174	52224	37561

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	52	69	32	91	340	176	265	86	90	103	29	172	47	68	67
2	2434	1779	1923	1099	2459	4018	1833	4424	1689	854	1161	563	2236	551	1509
3	12256	4661	7924	5554	3644	5839	9115	4727	11300	4523	2410	4898	1749	10208	2254
4	4703	7228	3604	7847	4925	3112	4622	7893	4028	8181	3585	2649	5741	1942	14448
5	2579	1823	3246	2267	5257	2560	1955	2892	5387	2253	4683	2013	2205	4365	1592
6	3498	945	646	1830	1188	2568	1255	970	1701	2844	1115	2057	1118	1696	3062
7	1510	1136	495	437	758	505	1307	660	490	831	1224	483	1030	733	1413
8	1294	465	441	309	235	192	241	528	342	203	358	504	221	590	552
9	559	328	138	258	169	97	74	80	253	155	82	170	232	111	400
10+	327	106	55	5	75	63	77	29	25	132	47	104	136	120	79
Total	29212	18540	18503	19697	19050	19130	20744	22290	25305	20078	14694	13613	14714	20385	25377

Percent mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	8	7	9	9	8	8	13	18	16	20	25	20	12	13	9
2	33	34	38	38	36	41	49	59	58	59	64	61	46	53	47
3	75	78	79	79	79	85	87	91	91	89	90	91	85	89	89
4	95	96	96	96	96	98	98	99	99	98	98	98	97	98	99
5	99	99	99	99	99	100	100	100	100	100	100	100	100	100	100
6+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	4	4	4	5	10	9	7	7	8	7	4	7	6	5	4
2	43	41	50	48	57	56	51	51	50	43	33	38	36	35	37
3	93	92	96	95	94	94	93	94	93	88	84	83	83	84	89
4	100	100	100	100	99	100	99	100	99	99	98	98	98	98	99
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table A17b. **SPLIT MODEL** estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and female percent mature (5-year moving window) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2007.

Stock Numbers (Jan 1) in thousands

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	28705	25943	22914	45891	19863	11305	29021	9615	44505	17898	24854	17849	10204	19796	7470
2	4707	23365	20988	18453	36471	15562	8691	23506	7713	35744	14560	20056	13809	8290	15956
3	25333	3478	17107	13370	11591	20473	8096	5723	12569	4881	22111	9803	14070	6330	5023
4	7660	13468	1991	8669	6701	5520	8936	3512	2063	6191	2637	10610	5305	6709	2076
5	2967	4093	6916	1141	4688	2817	2128	4336	1367	920	3124	1198	4880	2584	2671
6	1264	1624	2267	3454	649	2015	1273	916	1678	649	484	1153	637	1967	833
7	1212	874	926	978	1570	266	982	541	308	823	308	197	467	315	642
8	82	776	572	385	428	654	133	402	205	176	425	118	88	178	132
9	174	47	363	405	169	173	378	56	153	105	93	154	51	50	66
10+	44	127	37	173	192	288	283	182	76	75	105	54	88	47	19
Total	72148	73793	74082	92919	82323	59073	59920	48789	70638	67462	68702	61191	49599	46266	34886

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	9871	6316	3925	6675	10621	4944	12234	5977	2295	4239	1461	10802	2523	6490	7037	4875
2	5943	7812	5086	3185	5407	8581	3991	9973	4791	1868	3441	1181	8798	2054	5284	5752
3	8749	3487	5841	3575	2348	3809	6197	2946	7315	3274	1428	2635	904	6874	1619	3852
4	2070	3214	1475	3498	2041	1250	1944	3261	1746	3600	1621	806	1767	559	4869	970
5	745	607	868	610	1727	761	581	830	1634	758	1591	613	427	928	271	2930
6	853	189	121	369	270	627	279	220	397	713	294	493	223	220	432	157
7	283	223	68	62	138	90	258	116	102	164	253	102	179	88	116	238
8	209	74	53	36	35	30	37	84	54	34	59	80	32	70	44	81
9	68	46	15	26	19	12	10	11	34	21	11	23	22	10	32	26
10+	34	9	3	1	7	6	7	3	3	13	5	10	9	9	5	22
Total	28824	21975	17456	18037	22614	20110	25540	23421	18370	14685	10164	16745	14882	17301	19708	18902

Fishing Mortality

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.01	0.01	0.02	0.03	0.04	0.06	0.01	0.02	0.02	0.01	0.015	0.057	0.008	0.016	0.029
2	0.10	0.11	0.25	0.27	0.38	0.45	0.22	0.43	0.26	0.28	0.196	0.154	0.58	0.301	0.401
3	0.43	0.36	0.48	0.49	0.54	0.63	0.64	0.82	0.51	0.42	0.534	0.414	0.541	0.915	0.686
4	0.43	0.47	0.36	0.41	0.67	0.75	0.52	0.74	0.61	0.48	0.589	0.577	0.519	0.721	0.824
5	0.40	0.39	0.49	0.36	0.64	0.59	0.64	0.75	0.54	0.44	0.797	0.432	0.709	0.932	0.942
6	0.17	0.36	0.64	0.59	0.69	0.52	0.65	0.89	0.51	0.55	0.701	0.704	0.504	0.919	0.88
7	0.25	0.22	0.68	0.63	0.68	0.49	0.69	0.77	0.36	0.46	0.759	0.602	0.766	0.673	0.922
8	0.36	0.56	0.15	0.62	0.71	0.35	0.66	0.76	0.47	0.43	0.818	0.642	0.365	0.798	0.457
9	0.31	0.36	0.54	0.54	0.66	0.56	0.66	0.77	0.51	0.48	0.782	0.559	0.689	0.908	0.926
10+	0.31	0.36	0.54	0.54	0.66	0.56	0.66	0.77	0.51	0.48	0.782	0.559	0.689	0.908	0.926
F 5-8	0.29	0.38	0.49	0.55	0.68	0.49	0.66	0.79	0.47	0.47	0.77	0.59	0.59	0.83	0.80

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2	0.33	0.09	0.15	0.10	0.15	0.13	0.10	0.11	0.18	0.07	0.07	0.07	0.05	0.04	0.12
3	0.80	0.66	0.31	0.36	0.43	0.47	0.44	0.32	0.51	0.50	0.37	0.20	0.28	0.14	0.31
4	1.03	1.11	0.68	0.51	0.79	0.57	0.65	0.49	0.63	0.62	0.77	0.44	0.44	0.52	0.31
5	1.17	1.41	0.66	0.61	0.81	0.80	0.77	0.54	0.63	0.75	0.97	0.81	0.46	0.56	0.34
6	1.14	0.83	0.47	0.78	0.90	0.69	0.68	0.57	0.69	0.84	0.86	0.82	0.73	0.44	0.40
7	1.14	1.23	0.43	0.38	1.34	0.67	0.93	0.57	0.88	0.83	0.95	0.97	0.74	0.49	0.17
8	1.30	1.38	0.53	0.43	0.89	0.88	1.03	0.71	0.74	0.90	0.74	1.10	0.95	0.59	0.30
9	1.15	1.24	0.62	0.65	0.85	0.74	0.78	0.55	0.65	0.79	0.95	0.83	0.59	0.54	0.30
10+	1.15	1.24	0.62	0.65	0.85	0.74	0.78	0.55	0.65	0.79	0.95	0.83	0.59	0.54	0.30
F 5-8	1.19	1.21	0.52	0.55	0.99	0.76	0.85	0.60	0.73	0.83	0.88	0.92	0.72	0.52	0.30

Table A17b continued. **SPLIT MODEL** estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and female percent mature (5-year moving window) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2007.

SSB at start of spawning season

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	836	853	856	1516	656	393	1230	1035	3133	1306	1725	803	371	1107	428
2	1503	6701	7328	6250	10785	5499	3999	10813	4333	19363	7815	9691	4488	3631	6593
3	31517	3803	21975	17270	15480	27649	11557	7748	18717	7186	32866	14041	19881	9025	7376
4	18567	37396	4512	22002	16572	13464	22981	9017	4886	17298	6676	27186	12810	16603	5337
5	7977	15051	29814	4352	17410	10409	7522	15813	5460	3771	12571	4596	18059	8870	8808
6	5197	7938	11369	19342	3223	10432	6181	4308	8903	3748	2606	5910	3262	8779	3750
7	5990	6042	6175	6557	11284	1769	6347	3385	2121	5890	2161	1262	2952	1863	3422
8	594	5667	5289	3026	3402	5999	1076	3240	1659	1514	3457	956	756	1336	982
9	1489	407	3145	4219	1655	1627	3567	525	1570	1023	866	1468	488	432	572
10+	565	1575	489	2566	2600	4135	3591	2170	984	1051	1336	701	1107	577	292
Total	74235	85433	90951	87101	83067	81375	68051	58056	51766	62150	72080	66616	64173	52224	37560

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	52	69	32	90	338	175	261	83	72	81	21	137	40	61	66
2	2434	1779	1922	1098	2453	3998	1821	4364	1636	683	918	412	1781	471	1361
3	12256	4661	7922	5551	3641	5823	9061	4691	11114	4344	1878	3798	1243	8025	1902
4	4703	7228	3604	7844	4921	3107	4601	7819	3982	7954	3342	1872	4188	1241	10909
5	2579	1823	3246	2267	5253	2556	1950	2867	5303	2205	4426	1740	1341	2744	831
6	3498	944	645	1829	1187	2564	1251	965	1675	2757	1064	1799	833	842	1532
7	1510	1136	494	437	758	504	1302	656	485	805	1140	434	784	440	568
8	1294	465	441	309	234	192	240	524	338	198	335	422	171	363	270
9	559	328	138	258	169	97	74	79	250	151	77	148	155	67	195
10+	327	106	55	5	75	63	77	29	25	128	44	91	91	72	39
Total	29211	18538	18499	19689	19030	19078	20637	22078	24880	19308	13246	10852	10627	14325	17672

Percent mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	8	7	9	9	8	8	13	18	16	20	25	20	12	13	9
2	33	34	38	38	36	41	49	59	58	59	64	61	46	53	47
3	75	78	79	79	79	85	87	91	91	89	90	91	85	89	89
4	95	96	96	96	96	98	98	99	99	98	98	98	97	98	99
5	99	99	99	99	99	100	100	100	100	100	100	100	100	100	100
6+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	4	4	4	5	10	9	7	7	8	7	4	7	6	5	4
2	43	41	50	48	57	56	51	51	50	43	33	38	36	35	37
3	93	92	96	95	94	94	93	94	93	88	84	83	83	84	89
4	100	100	100	100	99	100	99	100	99	99	98	98	98	98	99
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table A18a. **BASE MODEL** uncertainty measures of predicted stock size in 2008 (A) and fishing mortality in 2007 (B) for ages 1-10 from 1000 bootstrap replications.

A. Stock Size 2008

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 1	5158.	6533.	4768.	0.7298
N 2	5778.	6266.	2534.	0.4044
N 3	4313.	4506.	1340.	0.2974
N 4	1202.	1248.	338.	0.2705
N 5	4150.	4291.	1102.	0.2569
N 6	348.	366.	102.	0.2794
N 7	566.	591.	173.	0.2934
N 8	219.	225.	71.	0.3143

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 1	1375.	157.	26.6579	3783.	1.2603
N 2	489.	82.	8.4565	5289.	0.4792
N 3	194.	43.	4.4871	4119.	0.3254
N 4	47.	11.	3.8994	1155.	0.2925
N 5	141.	35.	3.3966	4009.	0.2749
N 6	17.	3.	4.9691	331.	0.3086
N 7	24.	6.	4.3101	542.	0.3198
N 8	6.	2.	2.8435	212.	0.3327

	LOWER 80. % CI	UPPER 80. % CI
N 1	2262.	12026.
N 2	3513.	9413.
N 3	2952.	6223.
N 4	873.	1747.
N 5	3037.	5708.
N 6	248.	498.
N 7	378.	829.
N 8	139.	320.

Table A18a continued. **BASE MODEL** Uncertainty measures of predicted stock size in 2008 (A) and fishing mortality in 2007 (B) for ages 1-10 from 1000 bootstrap replications.

B. Fishing Mortality (2007)

Bootstrap Output Variable: Fishing Mortality (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0017	0.0018	0.000684	0.3877
AGE 2	0.1044	0.1080	0.030238	0.2801
AGE 3	0.2591	0.2646	0.061457	0.2323
AGE 4	0.2271	0.2321	0.053591	0.2309
AGE 5	0.1705	0.1738	0.044442	0.2557
AGE 6	0.1869	0.1939	0.056194	0.2898
AGE 7	0.0647	0.0694	0.023411	0.3371
AGE 8	0.1407	0.1457	0.025088	0.1721
AGE 9	0.1407	0.1457	0.025088	0.1721
AGE 10	0.1407	0.1457	0.025088	0.1721

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000109	0.000022	6.6054	0.0015	0.4425
AGE 2	0.003606	0.000963	3.4554	0.1008	0.3001
AGE 3	0.005418	0.001951	2.0909	0.2537	0.2422
AGE 4	0.005021	0.001702	2.2111	0.2221	0.2413
AGE 5	0.003348	0.001409	1.9636	0.1671	0.2659
AGE 6	0.007042	0.001791	3.7681	0.1798	0.3125
AGE 7	0.004697	0.000755	7.2536	0.0601	0.3898
AGE 8	0.005029	0.000809	3.5739	0.1357	0.1849
AGE 9	0.005029	0.000809	3.5739	0.1357	0.1849
AGE 10	0.005029	0.000809	3.5739	0.1357	0.1849

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.001016	0.002715
AGE 2	0.073390	0.148701
AGE 3	0.185377	0.341005
AGE 4	0.170090	0.298353
AGE 5	0.121952	0.231915
AGE 6	0.131244	0.266855
AGE 7	0.044370	0.099813
AGE 8	0.116780	0.180193
AGE 9	0.116780	0.180193
AGE 10	0.116780	0.180193

Table A18b. **SPLIT MODEL** Uncertainty measures of predicted stock size in 2008 (A) and fishing mortality in 2007 (B) for ages 1-10 from 1000 bootstrap replications.

A. Stock Size 2008

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 1	4875.	6694.	5979.	0.8932
N 2	5752.	6358.	2707.	0.4257
N 3	3852.	4065.	1293.	0.3181
N 4	970.	1003.	303.	0.3015
N 5	2930.	3019.	841.	0.2787
N 6	157.	165.	50.	0.3014
N 7	238.	251.	96.	0.3835
N 8	81.	85.	36.	0.4197

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 1	1819.	198.	37.3120	3056.	1.9565
N 2	606.	88.	10.5393	5146.	0.5260
N 3	214.	41.	5.5481	3638.	0.3555
N 4	33.	10.	3.4200	937.	0.3228
N 5	89.	27.	3.0394	2841.	0.2961
N 6	7.	2.	4.6315	150.	0.3306
N 7	13.	3.	5.5863	224.	0.4289
N 8	4.	1.	5.4608	76.	0.4682

	LOWER 80. % CI	UPPER 80. % CI
N 1	1954.	13428.
N 2	3484.	9918.
N 3	2596.	5739.
N 4	653.	1395.
N 5	2031.	4074.
N 6	108.	229.
N 7	138.	379.
N 8	44.	130.

Table A18b continued. **SPLIT MODEL** Uncertainty measures of predicted stock size in 2008 (A) and fishing mortality in 2007 (B) for ages 1-10 from 1000 bootstrap replications.

B. Fishing Mortality (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0017	0.0018	0.000727	0.4096
AGE 2	0.1161	0.1200	0.034663	0.2889
AGE 3	0.3119	0.3232	0.081705	0.2528
AGE 4	0.3080	0.3172	0.074404	0.2345
AGE 5	0.3439	0.3520	0.086883	0.2468
AGE 6	0.3973	0.4208	0.140749	0.3345
AGE 7	0.1662	0.1848	0.079164	0.4283
AGE 8	0.3025	0.3192	0.065865	0.2063
AGE 9	0.3025	0.3192	0.065865	0.2063
AGE 10	0.3025	0.3192	0.065865	0.2063

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000111	0.000023	6.6776	0.0016	0.4682
AGE 2	0.003842	0.001103	3.3082	0.1123	0.3087
AGE 3	0.011255	0.002608	3.6084	0.3006	0.2718
AGE 4	0.009239	0.002371	2.9997	0.2988	0.2490
AGE 5	0.008150	0.002760	2.3699	0.3357	0.2588
AGE 6	0.023443	0.004512	5.8998	0.3739	0.3764
AGE 7	0.018574	0.002571	11.1729	0.1477	0.5361
AGE 8	0.016722	0.002149	5.5282	0.2858	0.2305
AGE 9	0.016722	0.002149	5.5282	0.2858	0.2305
AGE 10	0.016722	0.002149	5.5282	0.2858	0.2305

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.000962	0.002744
AGE 2	0.079354	0.167325
AGE 3	0.226352	0.433711
AGE 4	0.230071	0.417925
AGE 5	0.248083	0.468221
AGE 6	0.267313	0.606938
AGE 7	0.105918	0.284319
AGE 8	0.241887	0.406217
AGE 9	0.241887	0.406217
AGE 10	0.241887	0.406217

Table A19. Comparison of Mohn's rho for fishing mortality (F), spawning stock biomass (SSB) and recruitment at age 1, and VPA predicted stock size at age (stk pred) with standard error (std err) and coefficient of variation (cv) and F at age, with average fishing mortality for ages 5-8 (F5-8) for three VPA model formulations. All three VPAs use catch at age with different numbers at age for 2004 compared to final VPA run.

Base

Mohn's rho	
F	-0.49
SSB	0.33
Recruits	0.53

age	stk pred	std err	cv	F
1	5183.3	2468.6	0.48	0
2	5806.7	1957.3	0.34	0.1
3	4336.7	1345.9	0.31	0.26
4	1209.6	349.7	0.29	0.17
5	4179.6	1132.9	0.27	0.19
6	345.1	97.0	0.28	0.07
7	554.4	168.0	0.30	0.14
8	205.4	66.1	0.32	0.14
9	61.0			
10	51.0			
F5-8				0.14

Base Split Surveys

Mohn's rho	
F	0.14
SSB	0.13
Recruits	0.92

age	stk pred	std err	cv	F
1	4956.4	2221.2	0.45	0.00
2	5849.3	1856.8	0.32	0.11
3	3923.7	1152.7	0.29	0.31
4	992.5	279.0	0.28	0.30
5	3005.4	819.1	0.27	0.34
6	160.5	50.7	0.32	0.39
7	239.6	87.2	0.36	0.17
8	77.4	30.6	0.39	0.30
9	27.0			
10	22.0			
F5-8				0.30

Round the Corner

Mohn's rho	
F	0.25
SSB	0.06
Recruits	0.51

age	stk pred	std err	cv	F
1	5440.4	2496.6	0.46	0.00
2	6090.9	1978.8	0.32	0.10
3	4567.7	1362.7	0.30	0.24
4	1296.1	357.8	0.28	0.21
5	4607.1	1185.5	0.26	0.18
6	333.8	94.1	0.28	0.20
7	540.3	168.4	0.31	0.06
8	256.7	76.6	0.30	0.03
9	286.5	90.6	0.32	0.03
F5-8				0.11

Table A20. Input data for yield-per-recruit and projection analysis. Selectivity and mean weight estimated as an average of 2003-2007 data, and proportion mature estimated from a five-year moving average, 2004-2008.

Age	VPA selectivity	Stock weight	Catch weight	Spawning stock weight	Proportion mature
1	0.01	0.255	0.433	0.255	0.05
2	0.11	0.761	1.305	0.761	0.35
3	0.40	1.657	2.146	1.657	0.84
4	0.74	2.564	3.012	2.564	0.98
5	1.00	3.394	3.812	3.394	1.00
6	1.00	4.237	4.633	4.237	1.00
7	1.00	5.317	5.860	5.317	1.00
8	1.00	6.470	7.027	6.470	1.00
9	1.00	7.605	8.006	7.605	1.00
10	1.00	10.213	10.213	10.213	1.00

Table A21. Projection results of catch and spawning stock biomass in 2009 using catch in 2008=2007 for 3 fishing mortality (F) scenarios: $F_{STATUS\ QUO}$, F_{MSY}, and $F_{REBUILD}$.

	Year	Catch mt	SSB mt	F
F status quo				
0.30	2007	5,957	17,672	0.30
	2008	5,957	21,242	0.36
	2009	**5,754**	25,008	0.30
Fmsy	2007	5,957	17,672	0.30
0.25	2008	5,957	21,242	0.36
	2009	**4,885**	25,155	0.25
Frebuild	2007	5,957	17,672	0.30
0.186	2008	5,957	21,242	0.36
	2009	**3,722**	25,360	0.186

Atlantic Cod Assessment Area

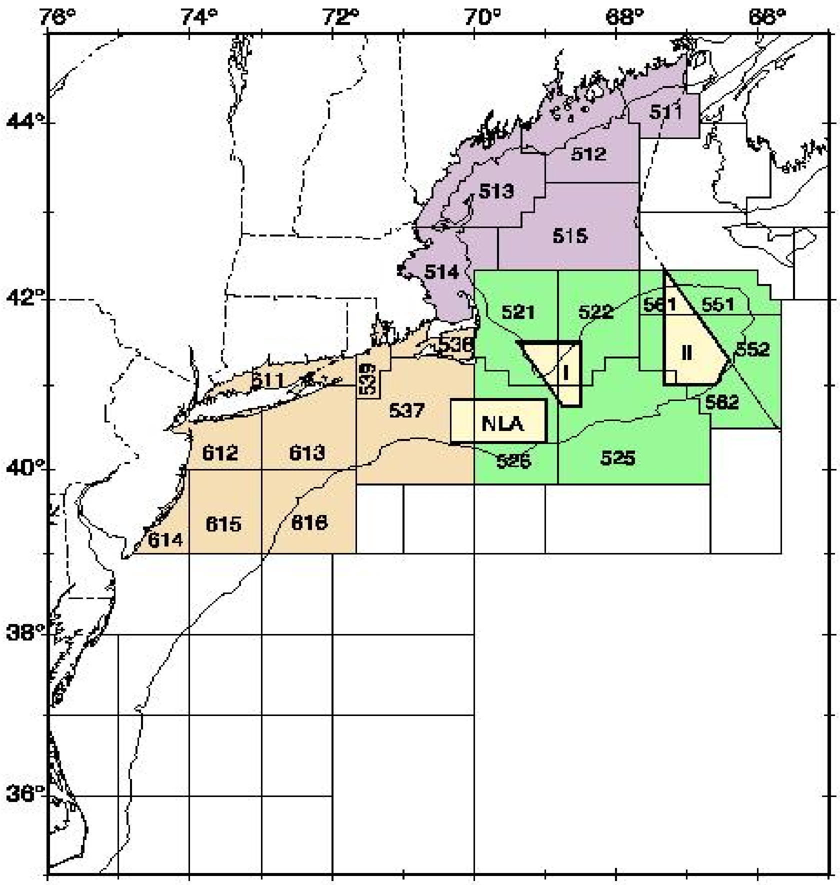


Figure A1. Stock area of Georges Bank cod as defined by Northwest Atlantic Fisheries Organization (NAFO) statistical areas: 521-526, 551-552, 561-562, 537-539, and Subarea 6.

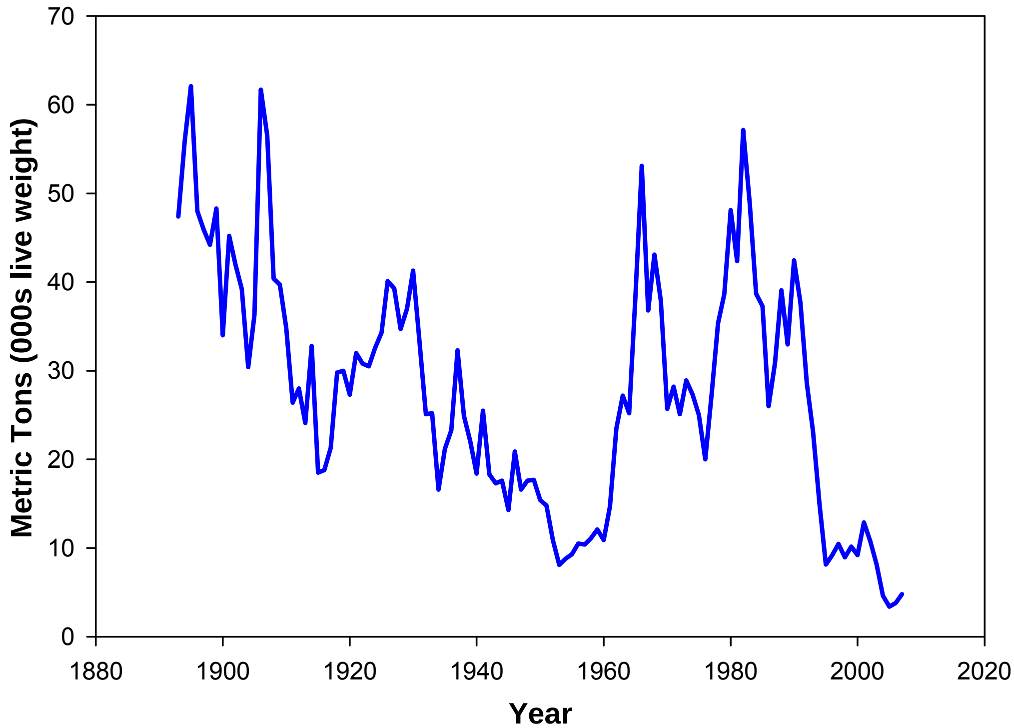


Figure A2a. Total commercial landings of Georges Bank Atlantic cod (NAFO Div. 5Z and SubArea 6, 1893-2007.

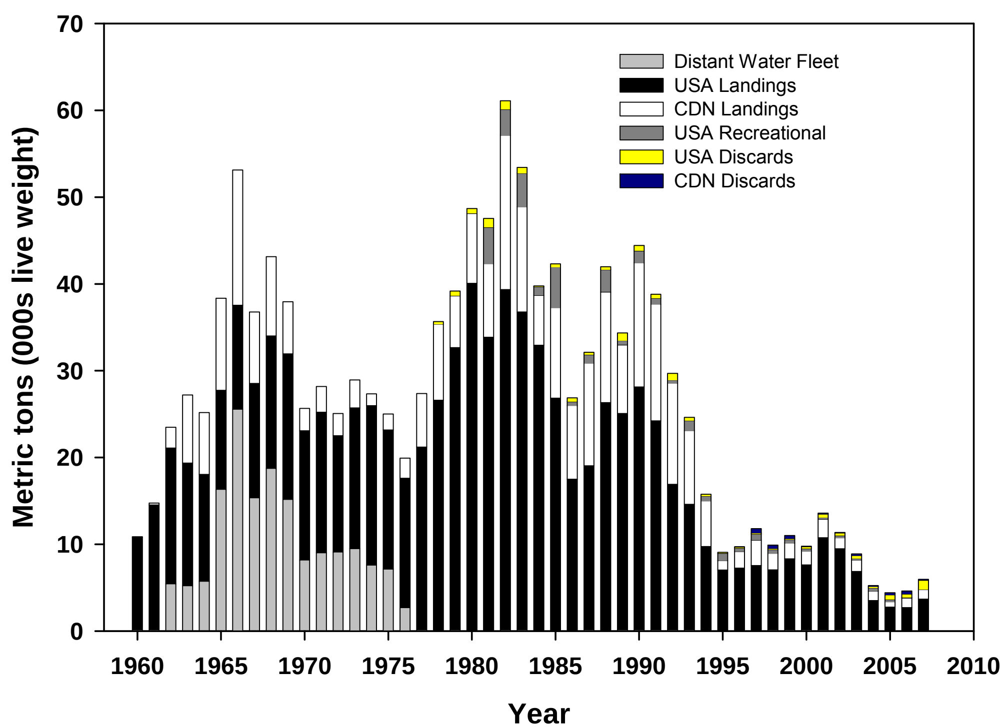


Figure A2b. Total catch of Georges Bank Atlantic cod including USA commercial landings, discards, and recreational landings and Canadian landings and discards, 1960-2007.

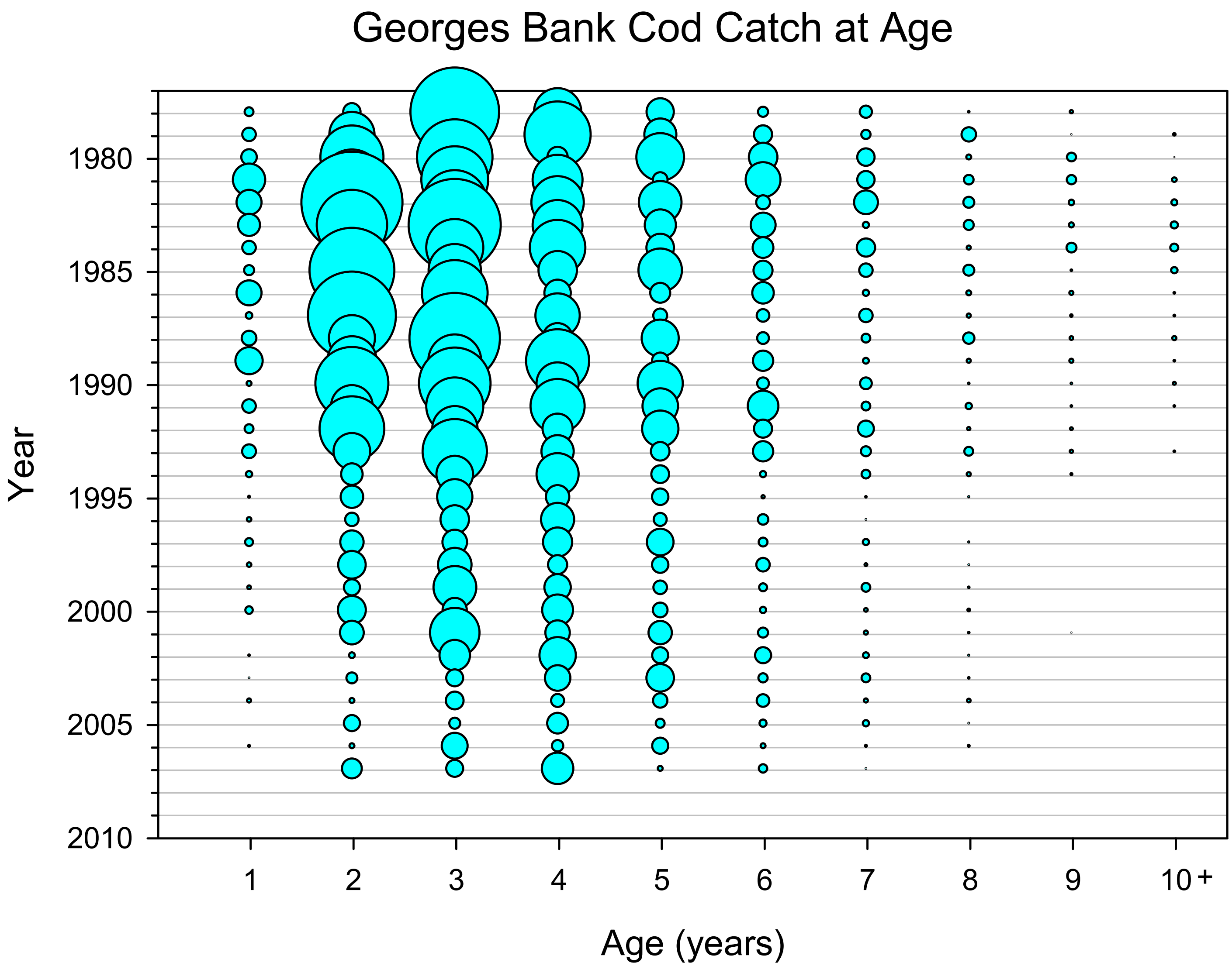


Figure A3. Total catch at age (000s of fish) of combined USA and Canadian commercial landings and discards and USArecreational landings for Georges Bank cod, 1978-2007.

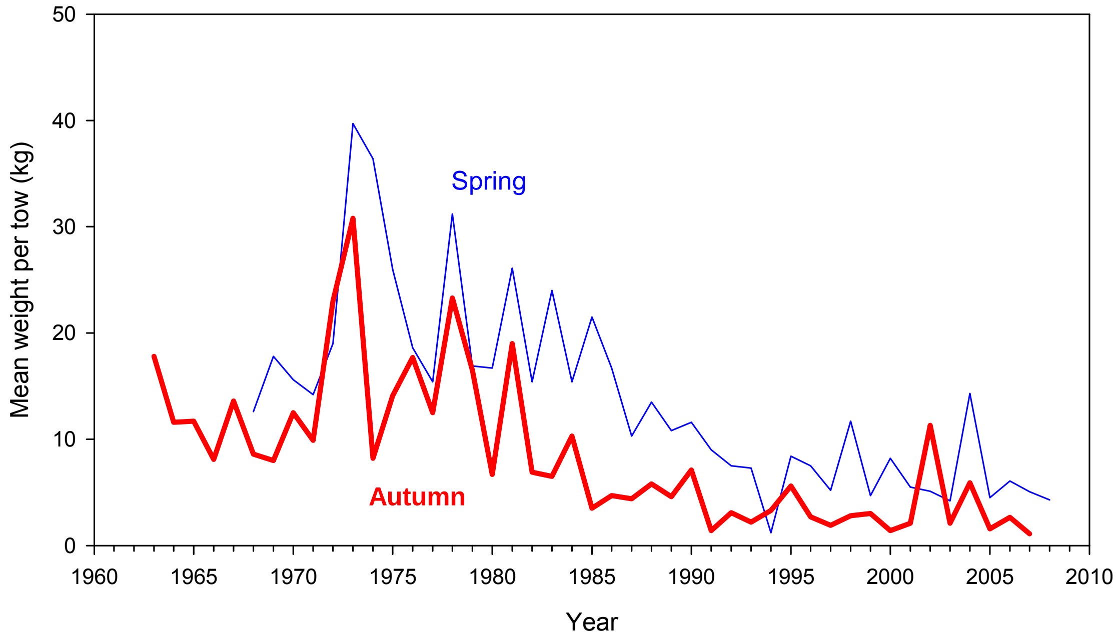


Figure A4. Standardized stratified mean catch per tow (kg) of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963-2008.

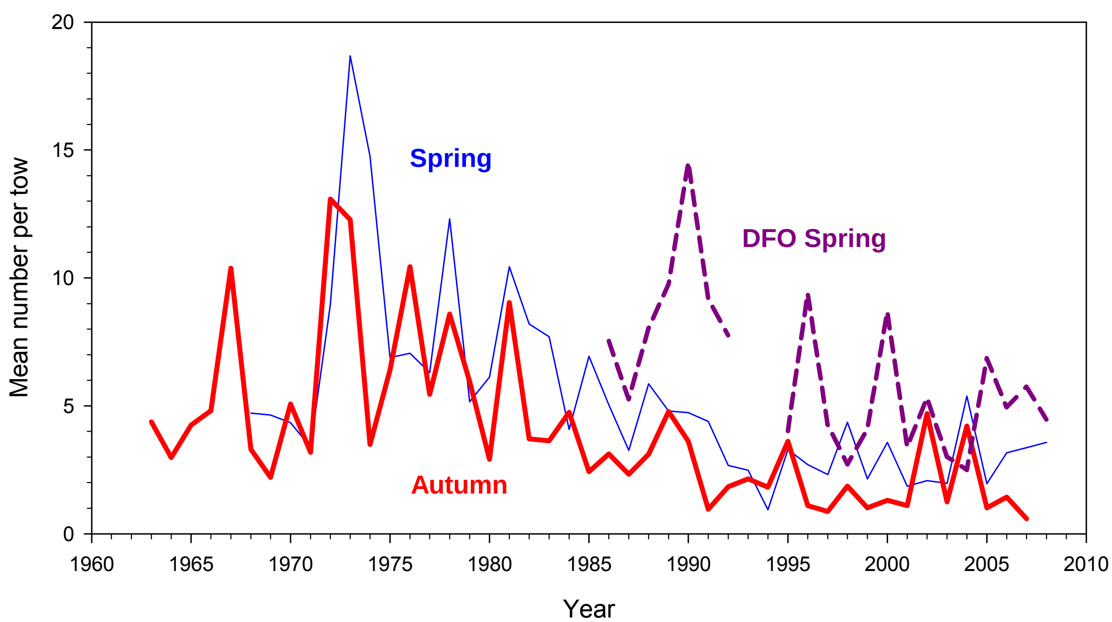


Figure A5. Standardized stratified mean number per tow of Atlantic cod in NEFSC and DFO spring and NEFSC autumn research vessel bottom trawl surveys on Georges Bank, 1963-2008.

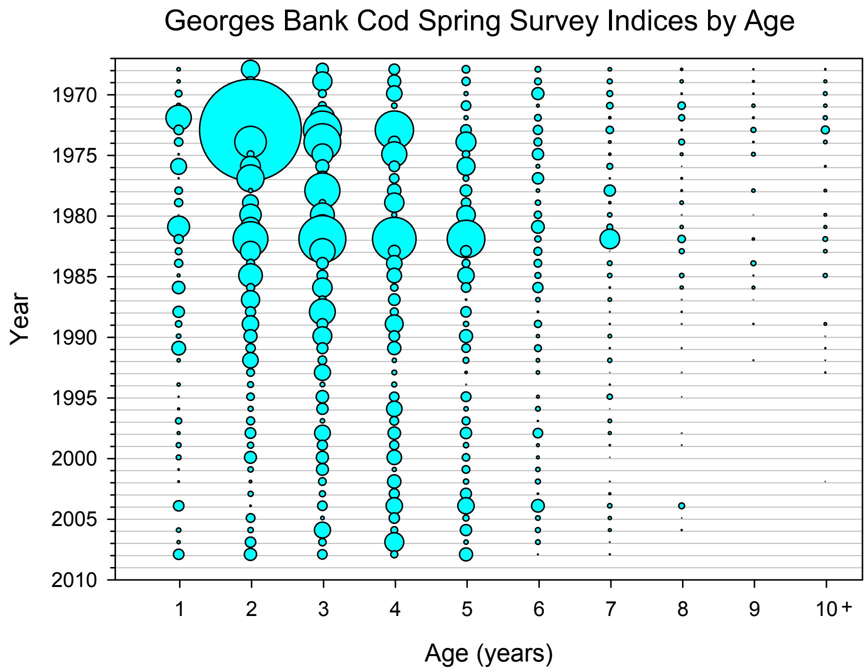


Figure A6. Standardized stratified mean catch per tow at age (numbers) of Georges Bank cod in NEFSC spring bottom trawl surveys, 1968-2008.

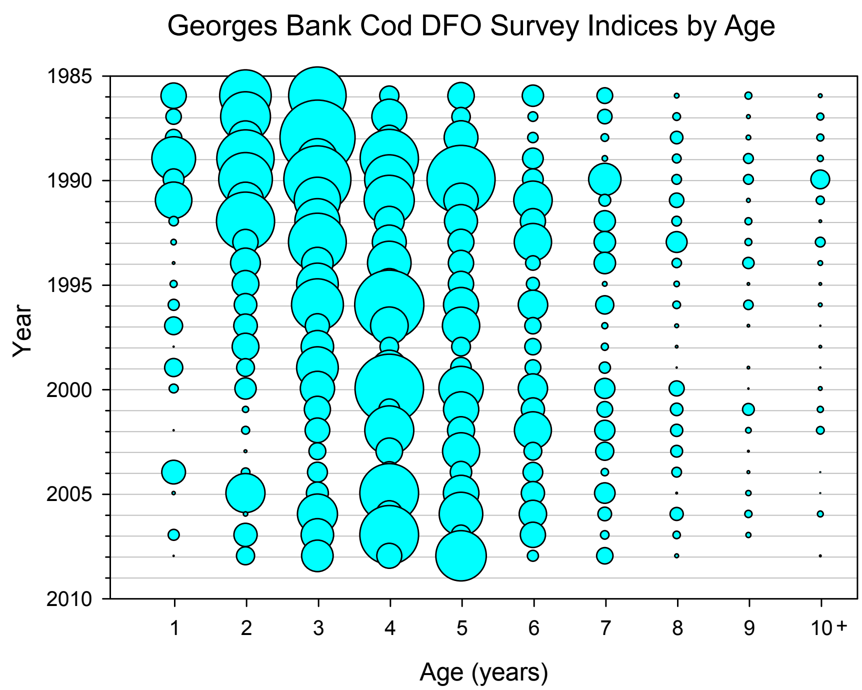


Figure A7. Standardized stratified mean catch per tow at age (numbers) of Georges Bank cod in the DFO spring bottom trawl surveys, 1986-2008.

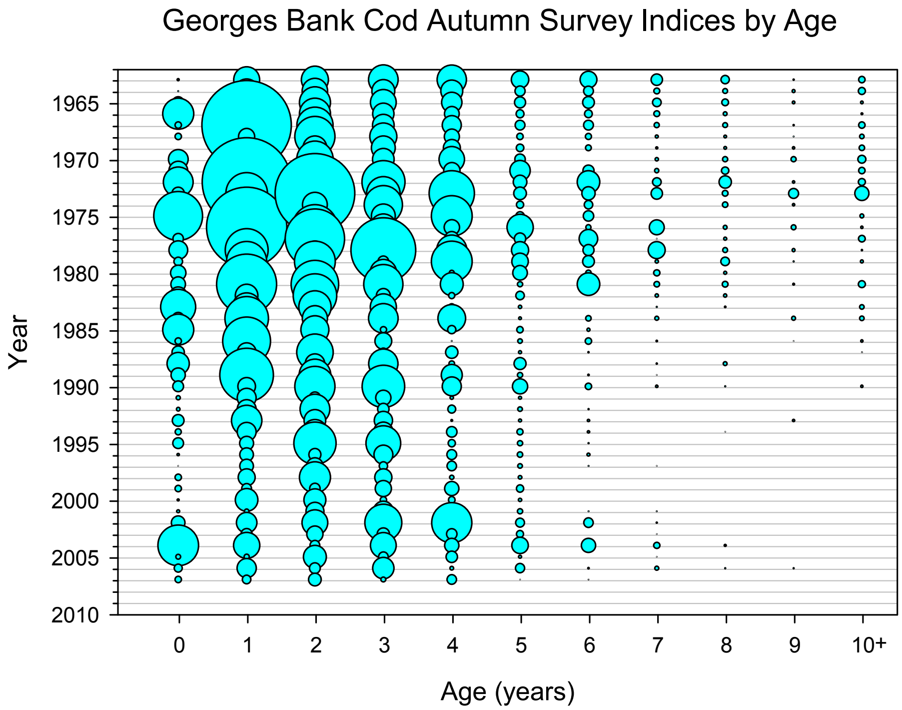


Figure A8. Standardized stratified mean catch per tow at age (numbers) of Georges Bank cod in NEFSC autumn bottom trawl surveys, 1963-2007.

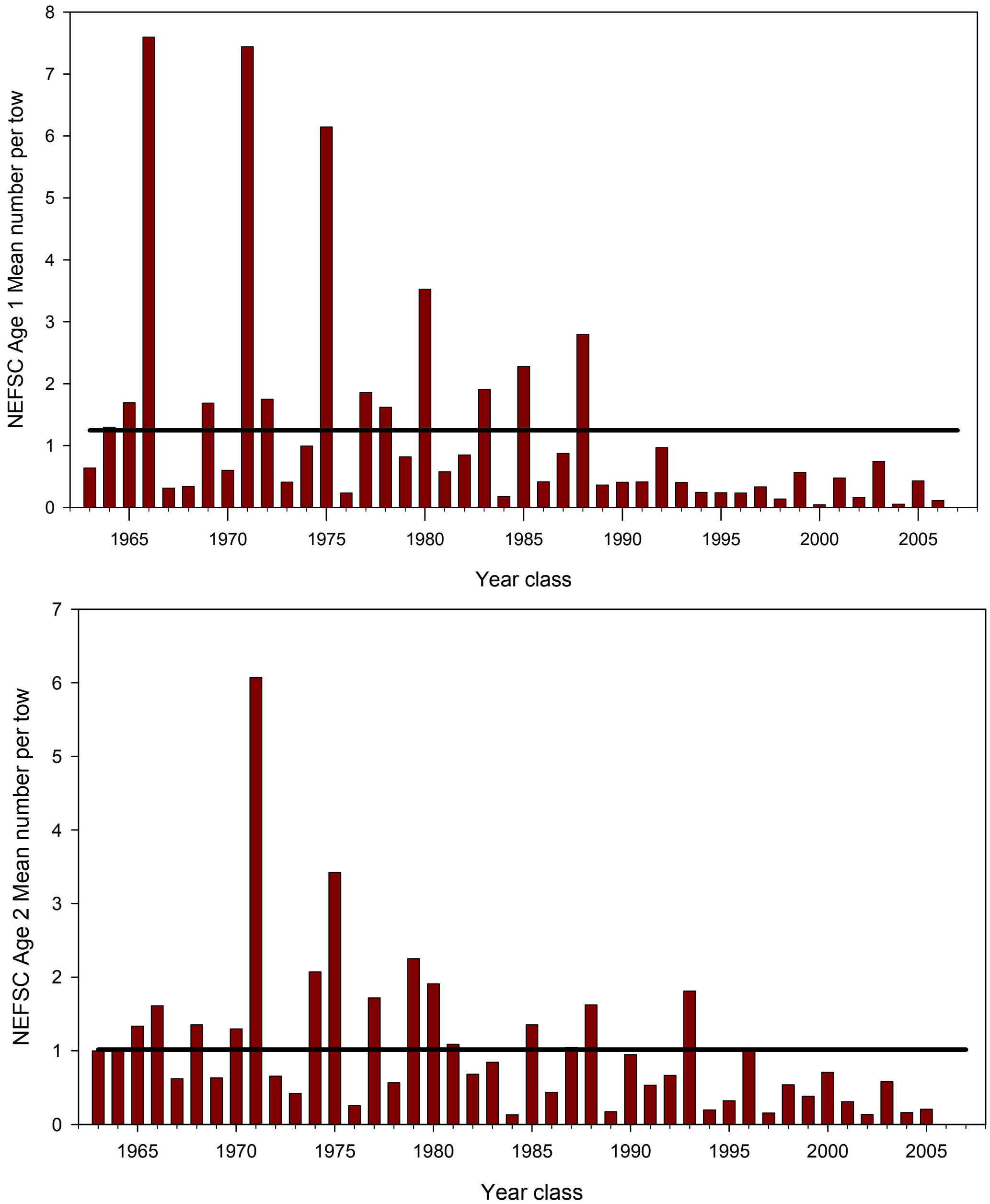


Figure A9. Relative year class strength of age 1 and age 2 Georges Bank cod based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1963-2007. Horizontal line represents the time series average.

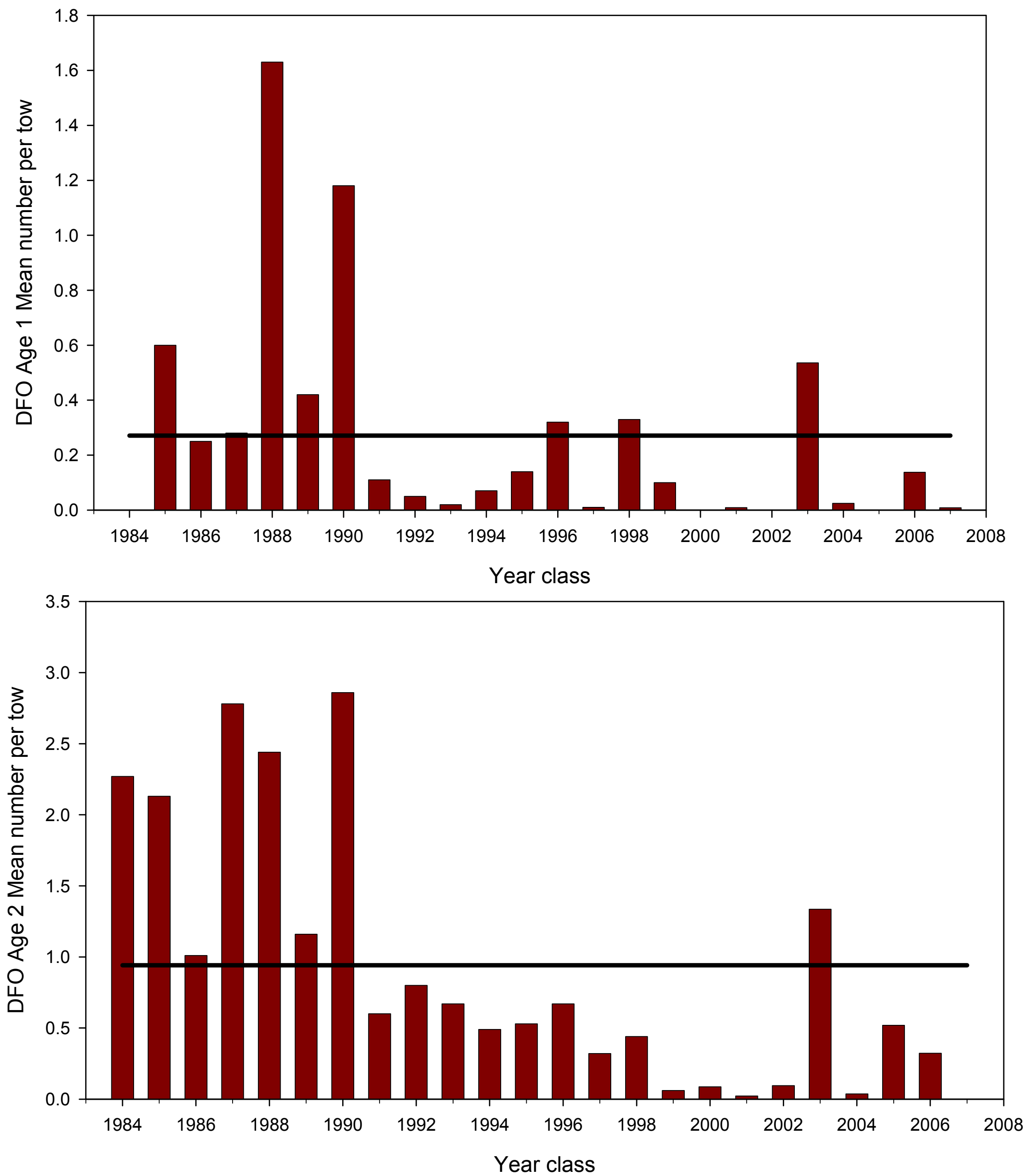


Figure A10. Relative year class strength of age 1 and age 2 Georges Bank cod based on catch (number) per tow indices from DFO spring research vessel bottom trawl surveys, 1986-2007. Horizontal line represents the time series average.

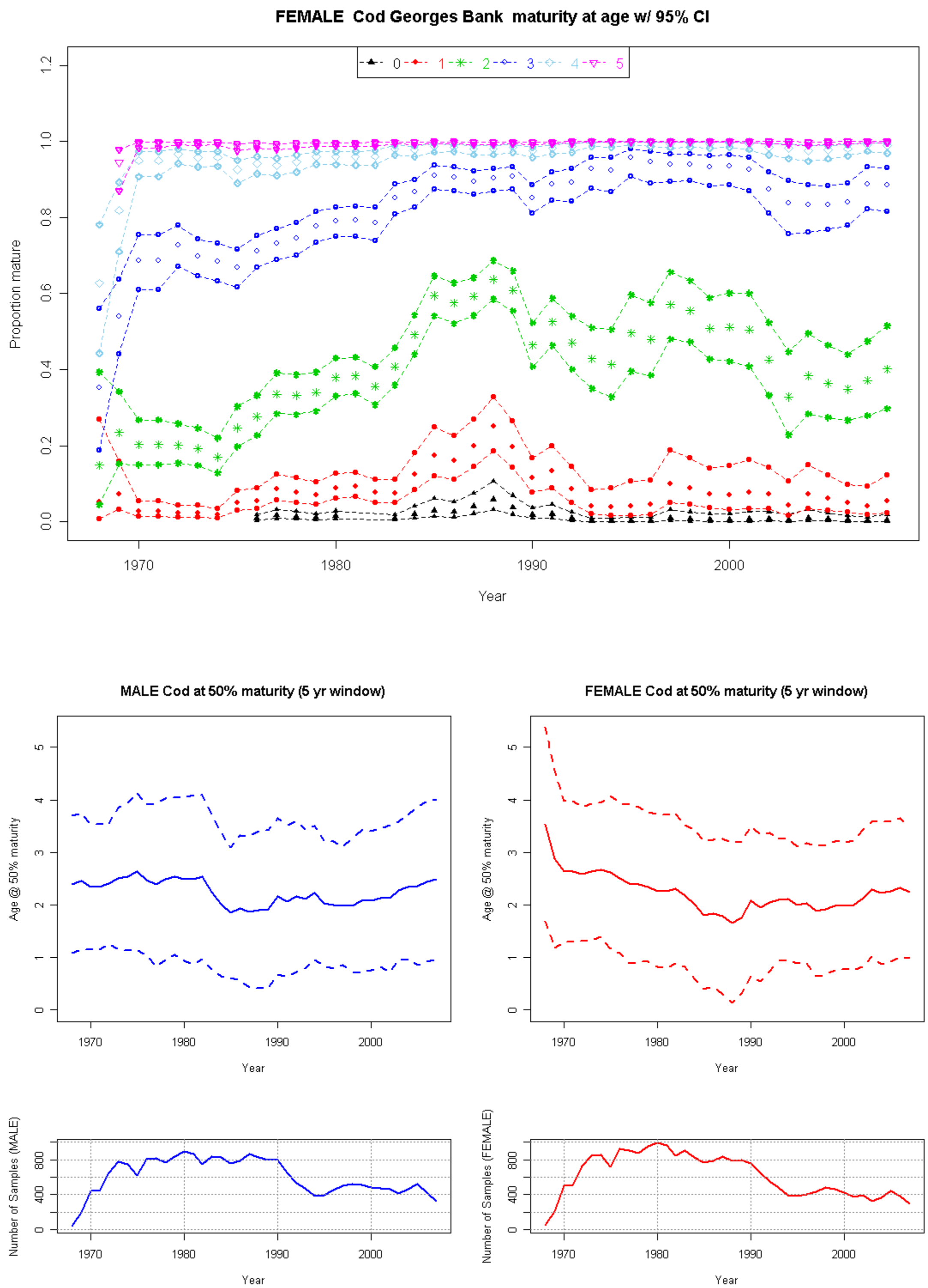


Figure A11. Proportion mature at age with 95% confidence intervals for female Georges Bank cod using a 5-year moving window for ages 1-5 (upper panel), median age at maturity (A50) for males (middle left panel) and females (middle right panel) with 95% confidence intervals, and number of samples in the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

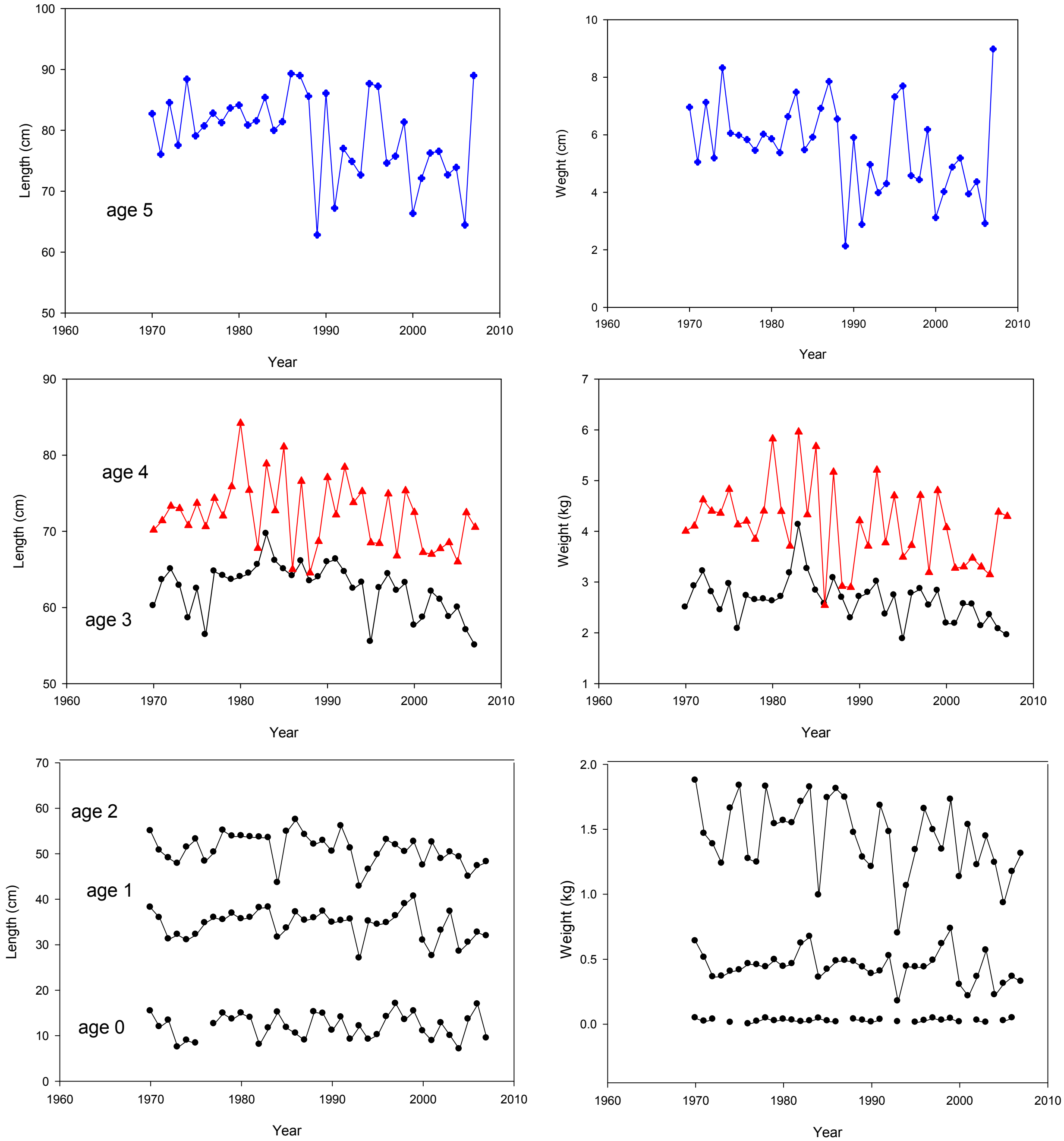


Figure A12. Mean length (left panels) and mean weight (right panels) at ages 0-5 for Georges Bank cod from autumn NEFSC surveys, 1970-2007.

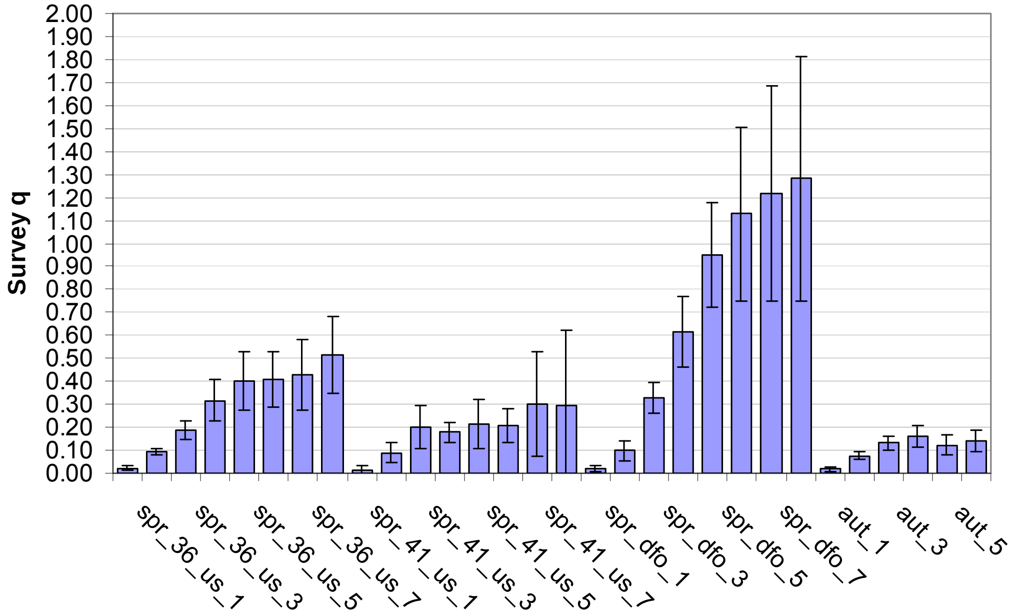


Figure A13a. **BASE MODEL** survey catchability (q) estimates based on swept area estimates of Georges Bank cod in NEFSC and DFO spring and autumn research bottom trawl surveys.

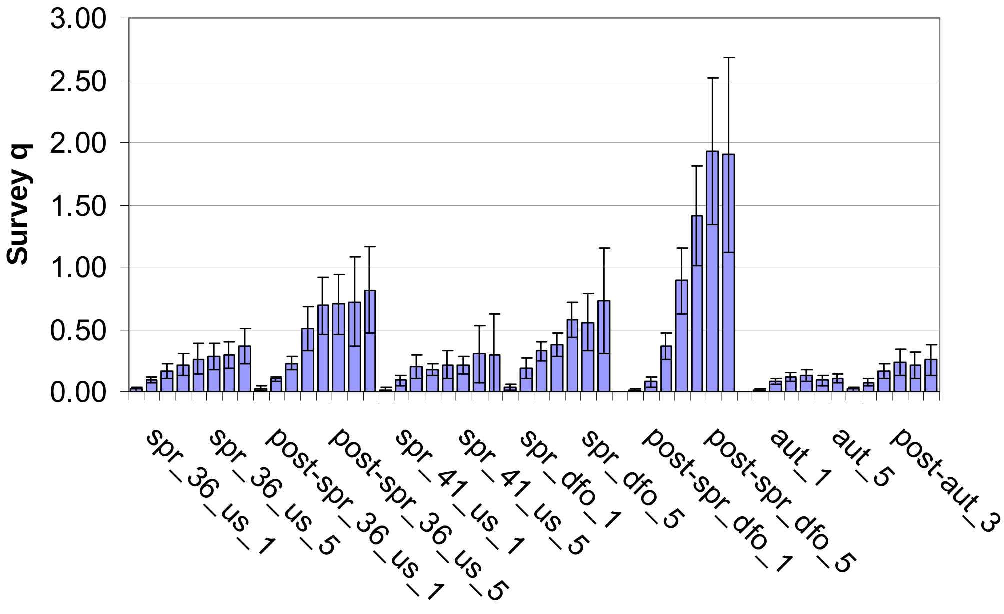


Figure A13b. **SPLIT MODEL** survey catchability (q) estimates based on swept area estimates of Georges Bank cod in NEFSC and DFO spring and autumn research bottom trawl surveys.

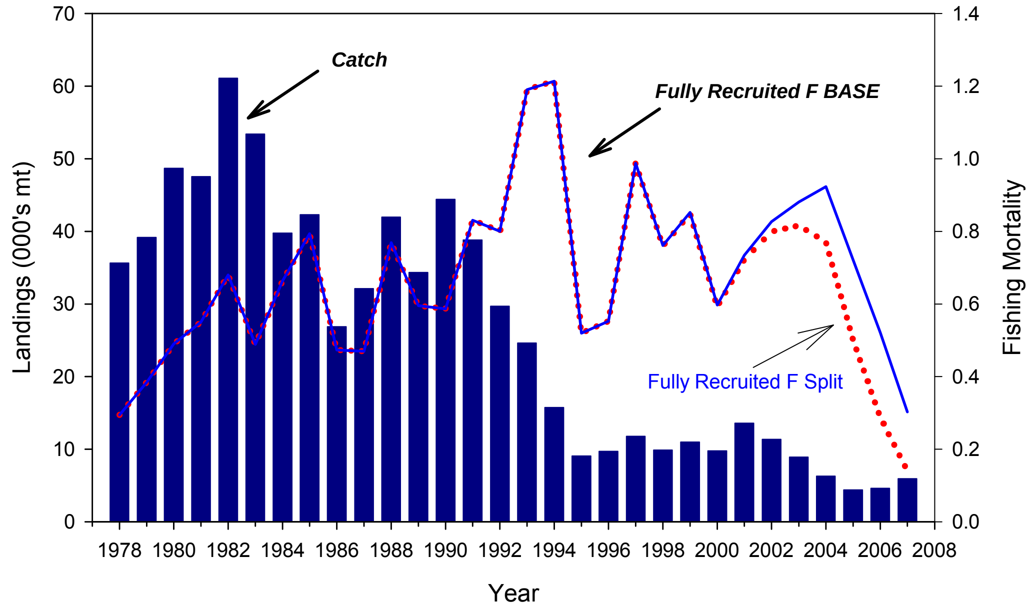


Figure A14. Trends in total catch and fishing mortality (ages 5-8) for Georges Bank cod, 1978-2007.

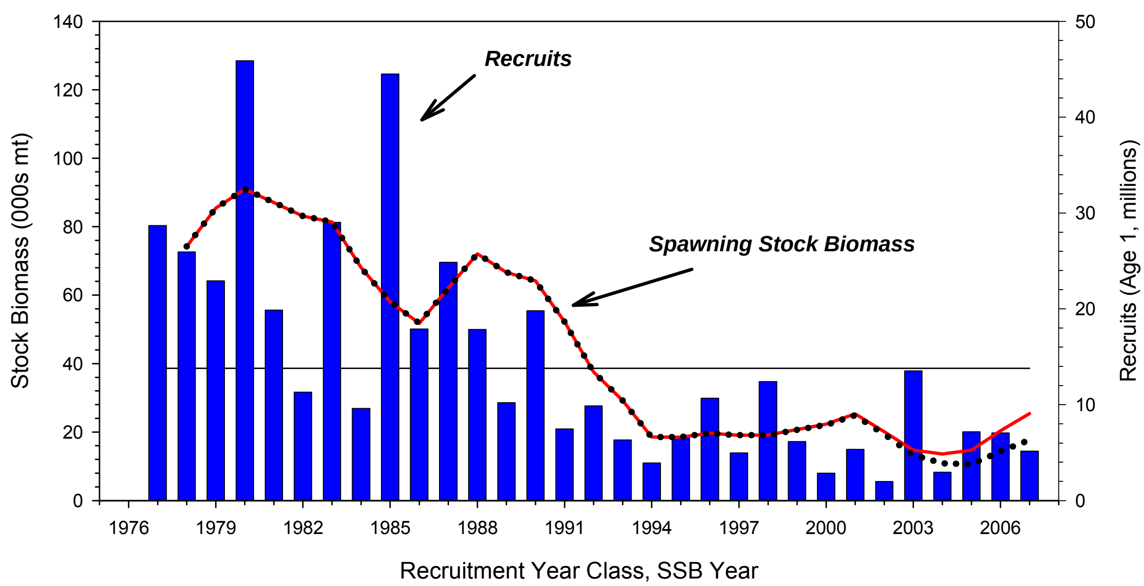
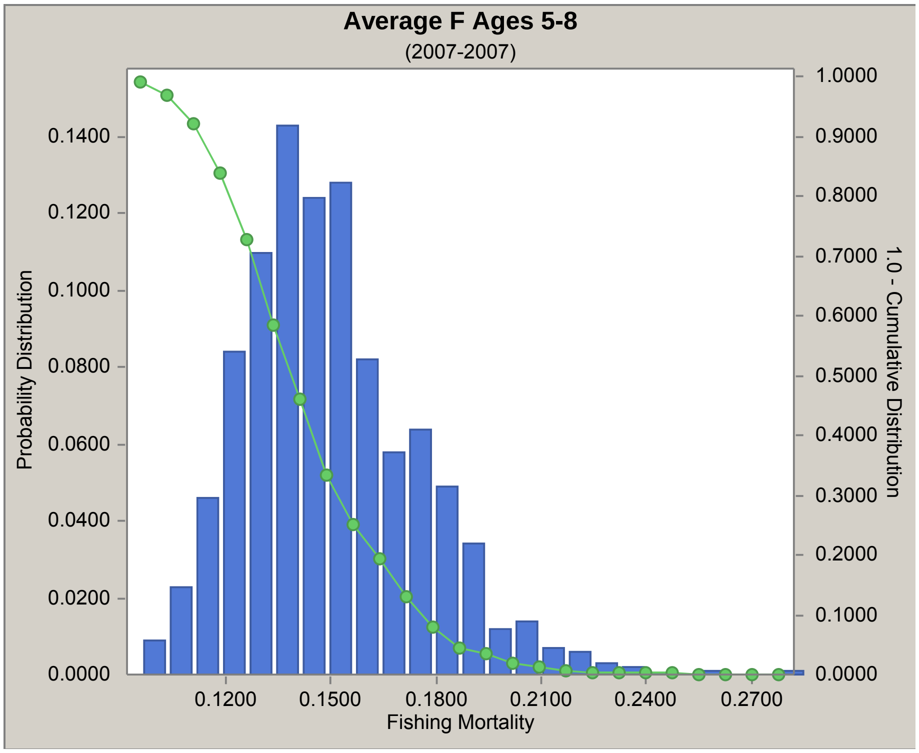


Figure A15. Trends in stock biomass and recruitment for Georges Bank Atlantic cod, 1978-2007. Horizontal line is the average recruitment for the time series. SSB Base =solid line, SSB Split = dotted line.



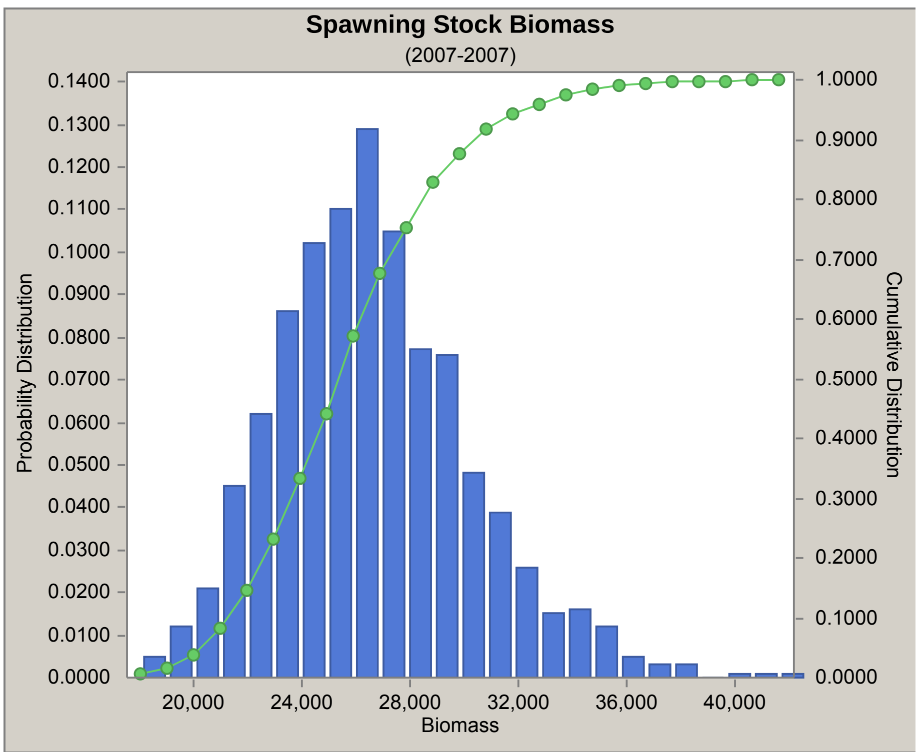
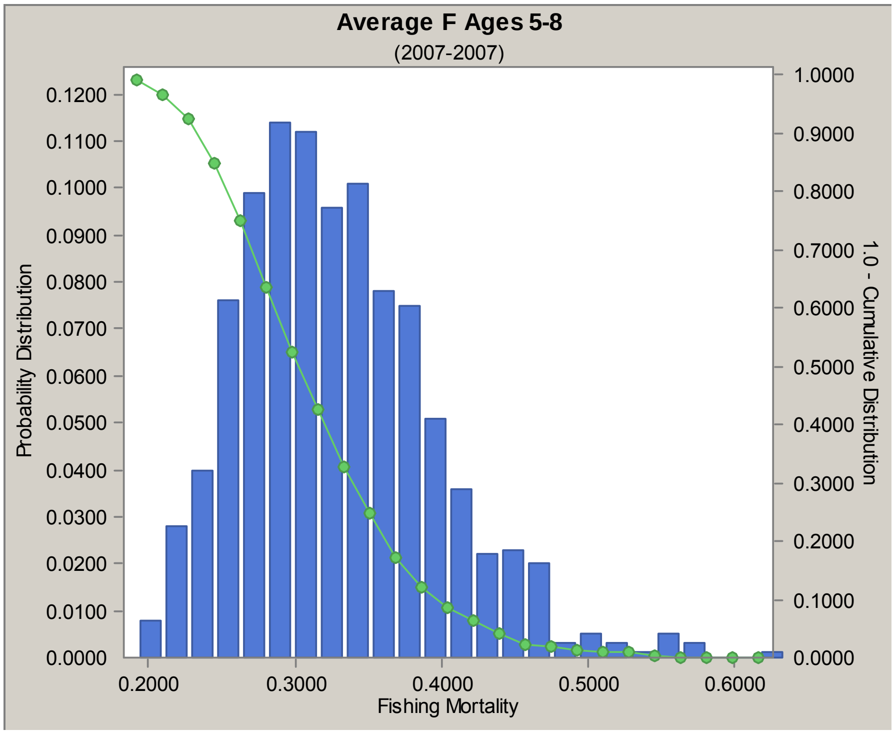


Figure A16a. **BASE MODEL** precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages(5-8) and spawning stock biomass at the beginning of the spawning season for Georges Bank Atlantic cod, 2007. Bar height indicates the frequency of values within that range. The solid line is the cumulative probability that F is greater than, or SSB is less than, any selected value on X- axis.



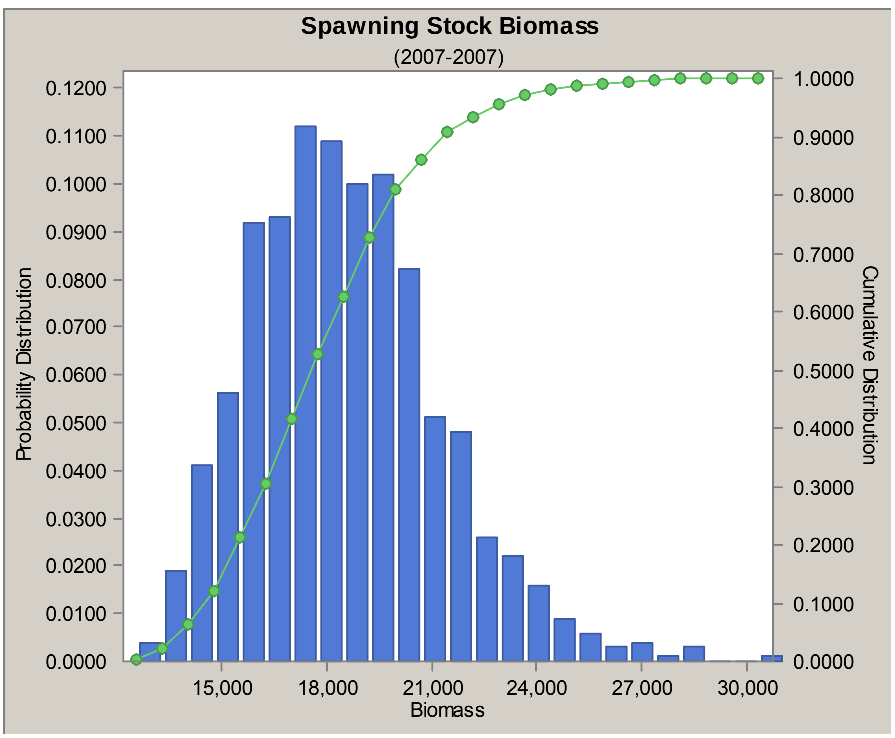


Figure A16b. **SPLIT MODEL** precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages(5-8) and spawning stock biomass at the beginning of the spawning season for Georges Bank Atlantic cod, 2007. Bar height indicates the frequency of values within that range. The solid line is the cumulative probability that F is greater than, or SSB is less than, any selected value on X- axis.

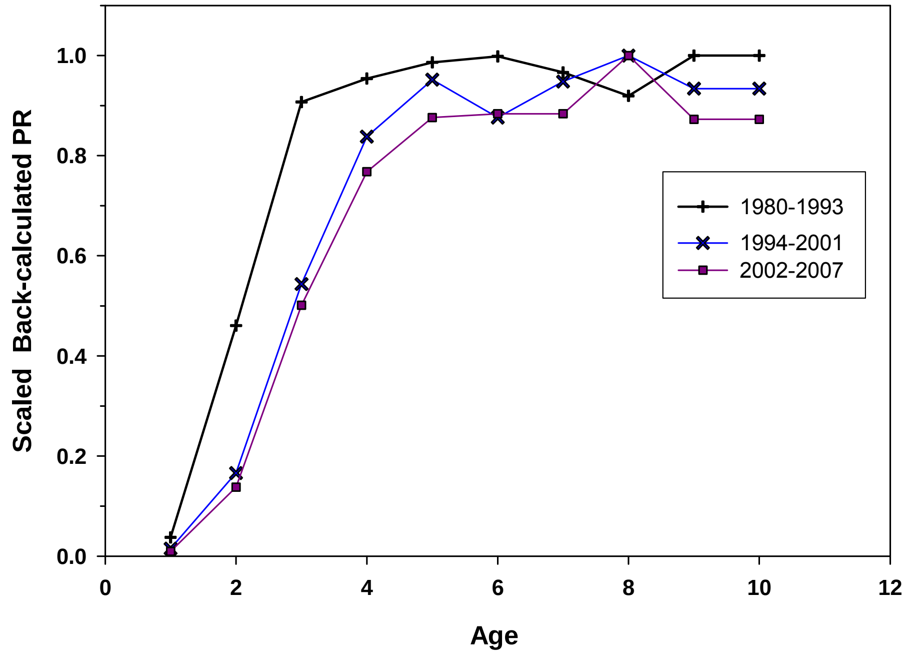


Figure A17a. **BASE MODEL** Scaled back-calculated partial recruitment (PR) from VPA for time periods 1980-1993, 1994-2001, and 2002-2007 for Georges Bank Atlantic cod.

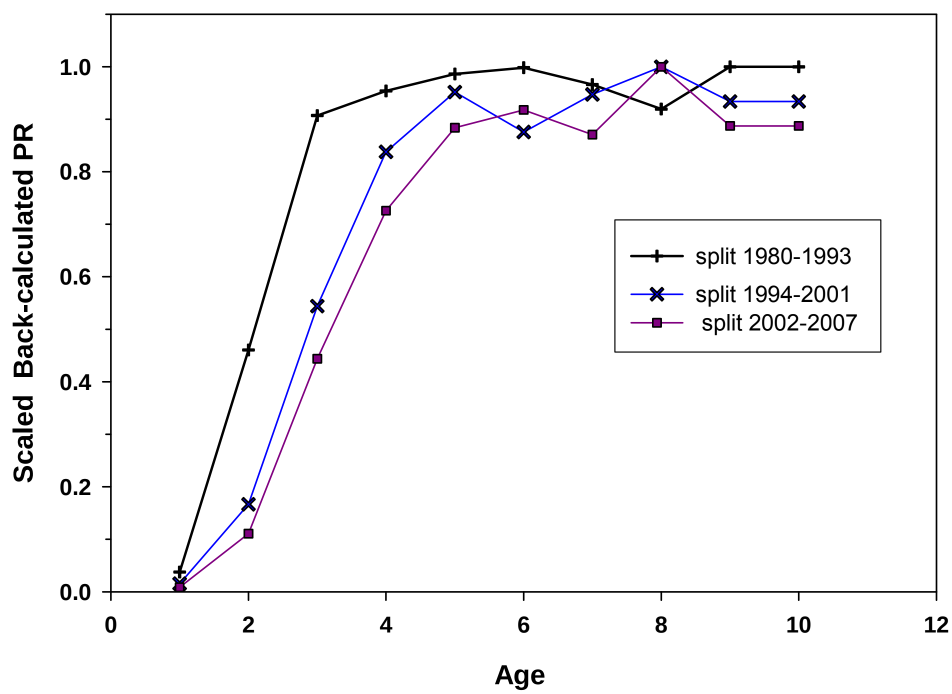


Figure A17b. **SPLIT MODEL** scaled back-calculated partial recruitment (PR) from VPA for time periods 1980-1993, 1994-2001, and 2002-2007 for Georges Bank Atlantic cod.

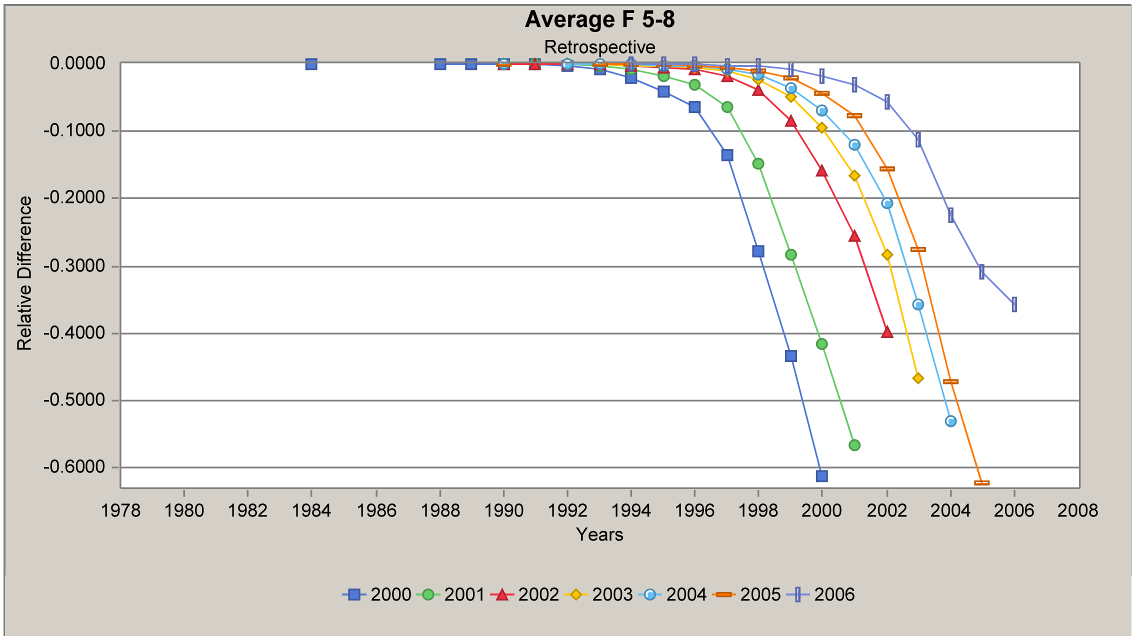


Figure A18a. **BASE MODEL** retrospective analysis of relative difference to terminal year 2007 (rho = -0.50) of Georges Bank Atlantic cod fishing mortality (ages 5-8, unweighted), based on ADAPT VPA, 2000-2007.

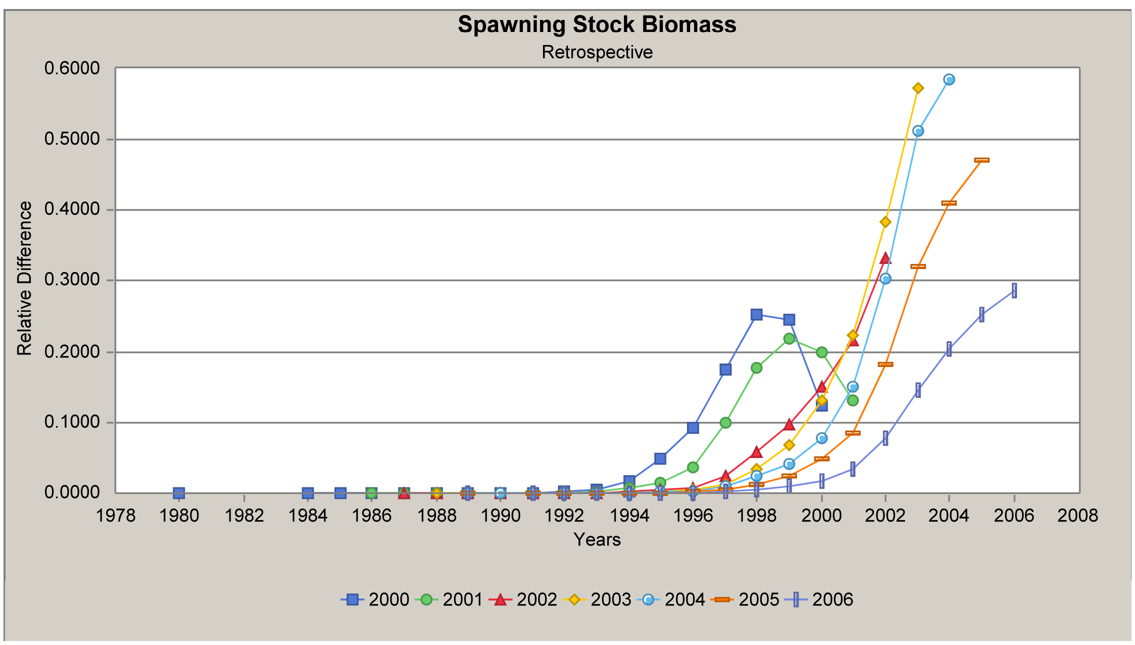


Figure A18b. **BASE MODEL** retrospective analysis of relative difference to terminal year 2007 (rho = 0.36) of Georges Bank Atlantic cod spawning stock biomass based on ADAPT VPA, 2000-2007.

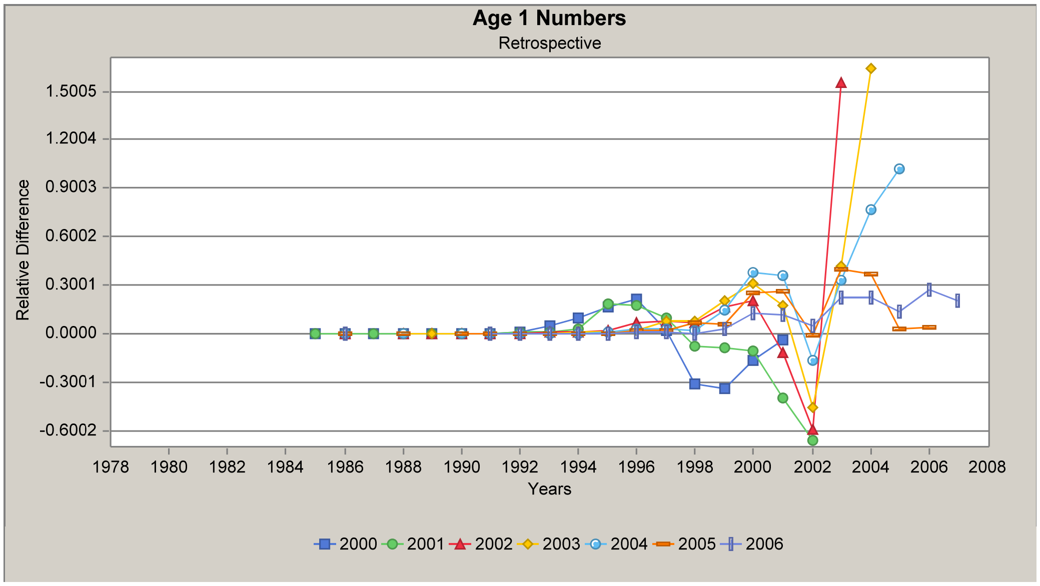


Figure A18c. **BASE MODEL** retrospective analysis of relative difference to terminal year 2007 (rho = 0.54) of Georges Bank Atlantic cod age 1 recruitment based on ADAPT VPA , 2000-2007.

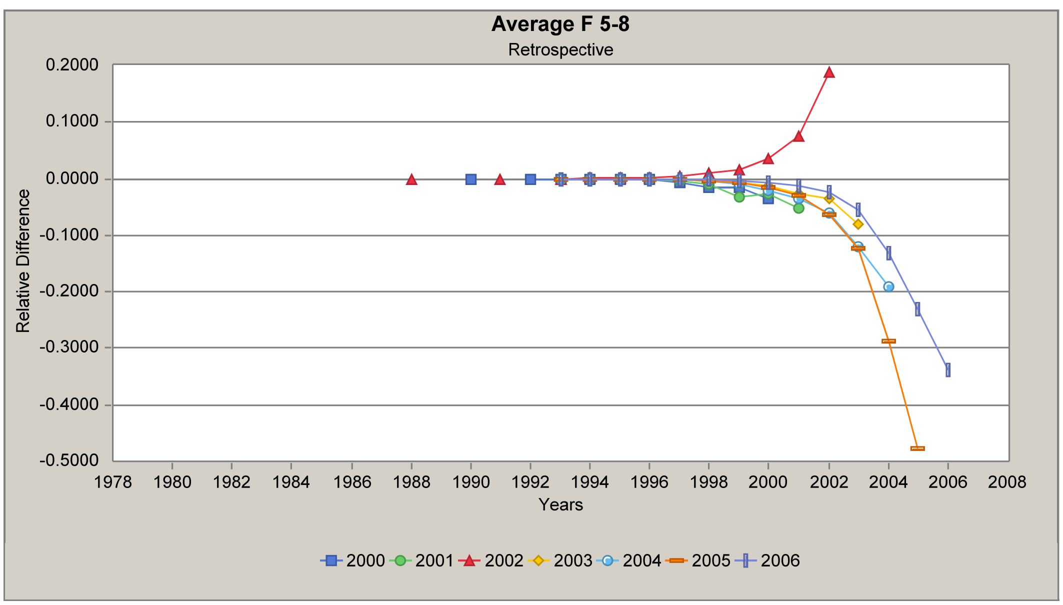


Figure A19a. **SPLIT MODEL** retrospective analysis of relative difference to terminal year 2007 (rho = -0.14) of Georges Bank Atlantic cod fishing mortality (ages 5-8, unweighted), based on ADAPT VPA, 2000-2007.

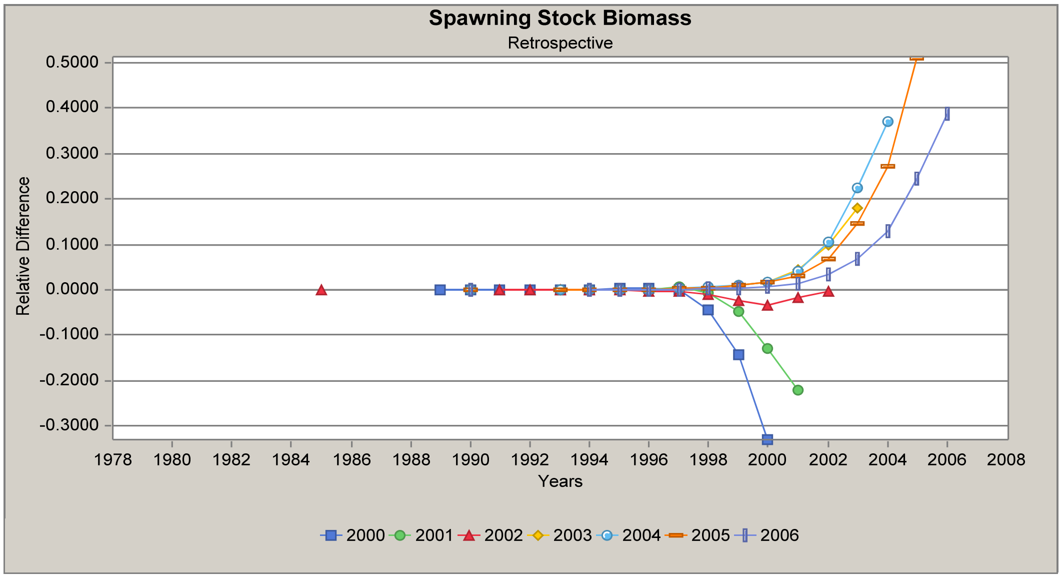


Figure A19b. **SPLIT MODEL** retrospective analysis of relative difference to terminal year 2007 (rho = 0.13) of Georges Bank Atlantic cod spawning stock biomass based on ADAPT VPA, 2000-2007

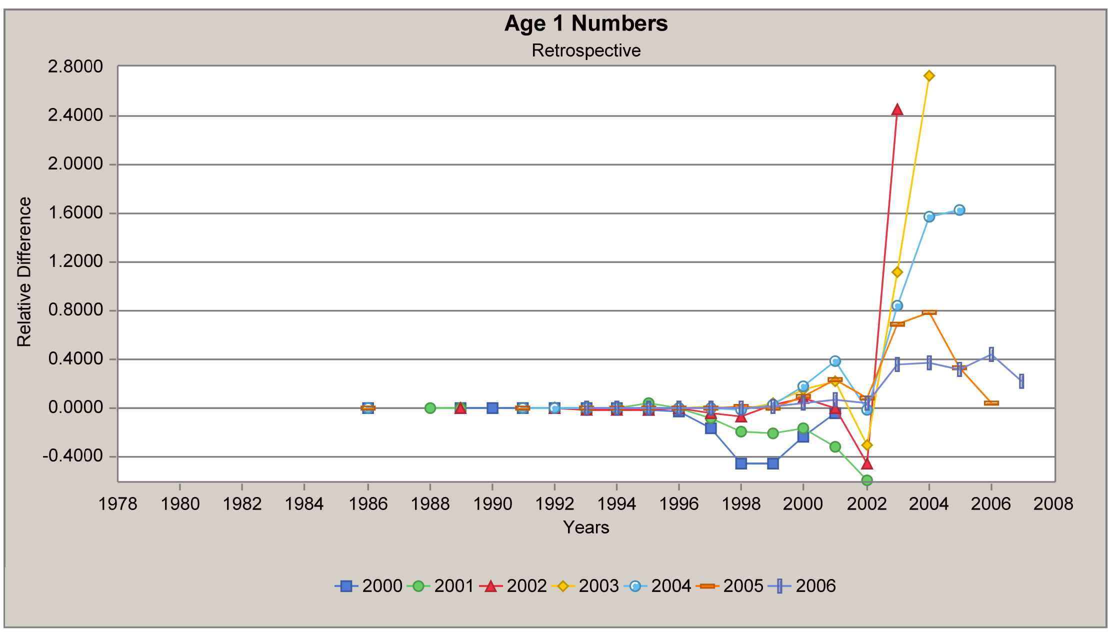


Figure A19c.**SPLIT MODEL** retrospective analysis of relative difference to terminal year 2007 (rho = 0.93) of Georges Bank Atlantic cod age 1 recruitment based on ADAPT VPA , 2000-2007.

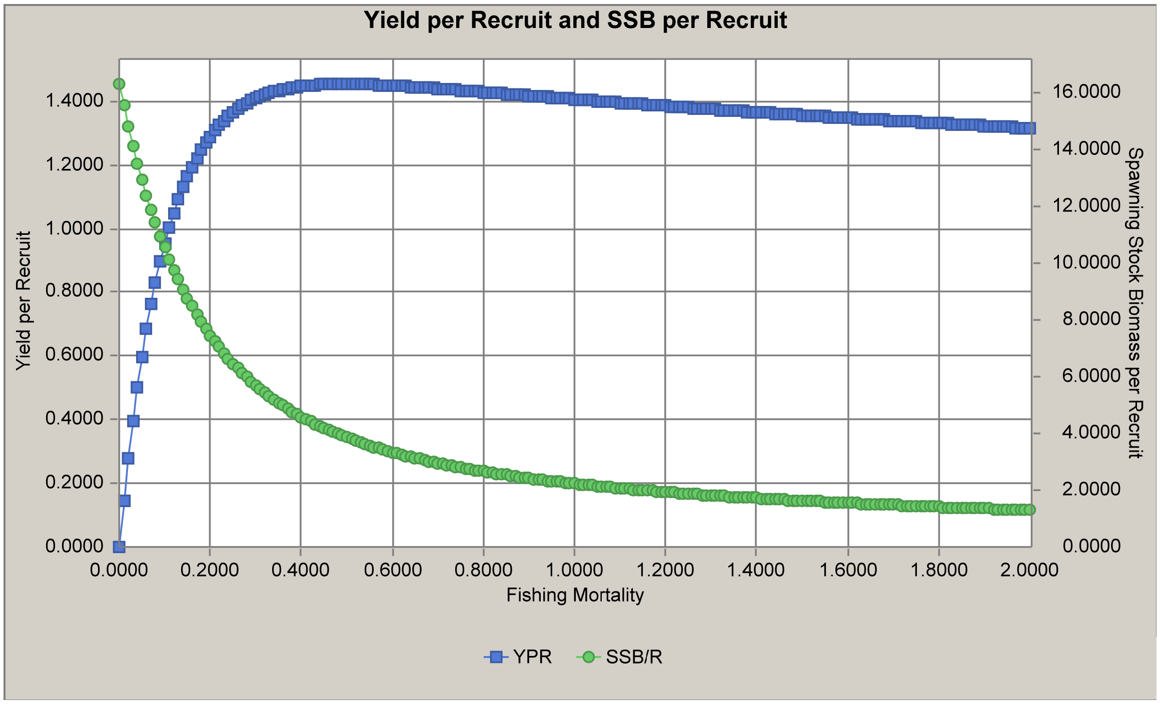


Figure A20. BASE MODEL Yield- and Spawning Stock Biomass per-recruit analysis for Georges Bank Atlantic cod . $F_{0.1}$ =0.22 , F_{max} = 0.50 and $F_{40\%}$= 0.25.

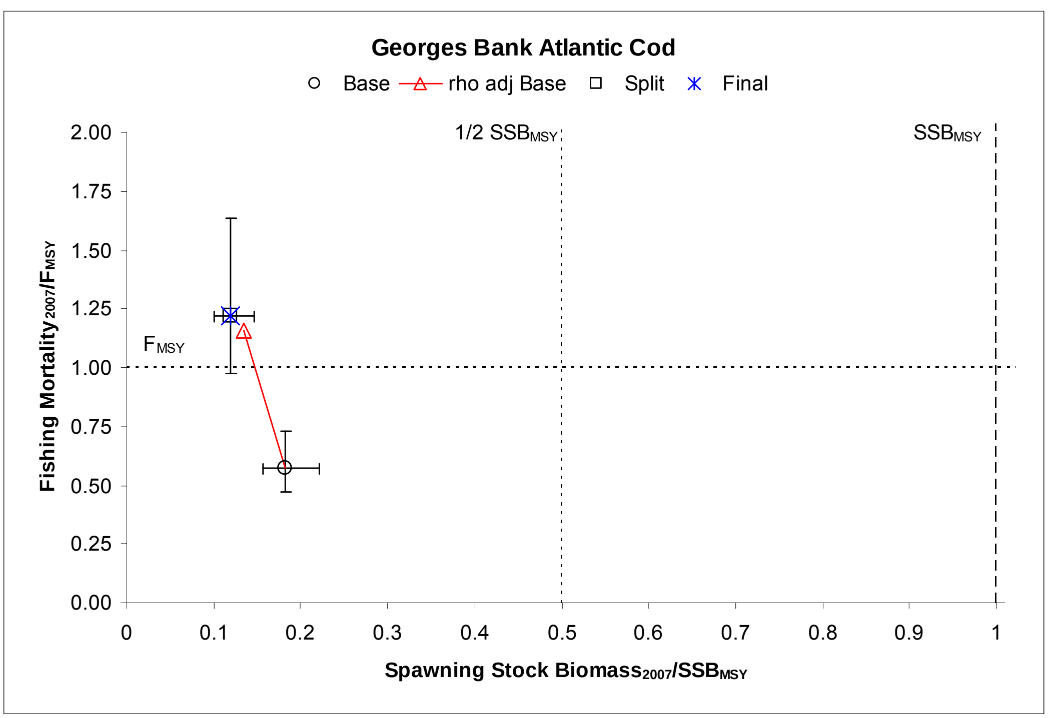


Figure A21. Status of 2007 fishing mortality (F) and spawning stock biomass (SSB) of Georges Bank Atlantic cod to F_{MSY} and SSB_{MSY}.

B. Georges Bank haddock
by Elizabeth N. Brooks, Michele L. Traver, Sandy Sutherland, L. Van Eeckhaute and Laurel Col

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

1.0 Background

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

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

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

2.0 Fishery

Landings

Total catches of Georges Bank haddock increased from a low of 2,442 mt in 1995 to the recent high of 21,814 mt in 2005 (Table B1, Fig. B2). Historically, the largest catches were taken in the 1960s, peaking at nearly 182,000 mt in 1965. For the years of re-estimated US Georges Bank haddock catches (1989-2007), there was a maximum of 8415 mt in 2004 and a minimum of 309 mt in 1995. US catch increased steadily from the low in 1995 to 2002, and has fluctuated since then. The average US catch for years 2001-2007 is 6032 mt (Table B1). US landings show the same trend as US catches, with a steady increase since 1995 and fluctuations since 2002. US landings in 2006 and 2007 were 2643 mt and 2930 mt, respectively, which is less than half of the 2001-2005 average landings of 6218 mt (Table B2). Most of the US landings come from trawl gear, with a small amount of landings from hook and line and gillnet. Canadian landings totaled 11,985 mt in 2006 and 11,889 mt in 2007, over four times the US landings in the same years. Estimated landings for the recreational sector were 0 for 2007, and in previous years they were either estimated to be 0 or assumed to be negligible.

Discards

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

Biological sampling

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

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

3.0 Research surveys

Indices

Mean number and mean weight per tow in the spring and fall NEFSC groundfish surveys are down from the peak observed in 2004, which corresponded to the availability of the extraordinary 2003 year class to the survey. Prior to 2004, the indices showed a slow but stable increase in numbers since the early 1990s; the rate of increase in weight was about half the rate of the increase in numbers (Table B13, Fig. B3). Total swept area estimates of abundance at age were calculated for the spring and fall NEFSC groundfish surveys (Table B14). The indices were generated with the calibration coefficients given in Table B15. Canadian swept area estimates of abundance at age in the spring survey are available for the years 1986-2008 (Table B16).

Length and weight

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

4.0 Assessment

Model

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

Maturity

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

Natural Mortality

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

Indices

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

Model selection process

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

VPA Results

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

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

VPA Diagnostics

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

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

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

5.0 Biological reference points (BRPs)

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

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

6.0 Projection

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

7.0 Summary

Stock Status

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

Sources of Uncertainty

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

8.0 GARM Panel Discussion/Comments

Conclusions

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

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

Research Recommendations

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

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

9.0 References

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

Year	USA	Canada	USSR	Spain	Other	Total
1960	40800	77	0	0	0	40877
1961	46384	266	0	0	0	46650
1962	49409	3461	1134	0	0	54004
1963	44150	8379	2317	0	0	54846
1964	46512	11625	5483	2	464	64086
1965	52823	14889	81882	10	758	150362
1966	52918	18292	48409	1111	544	121274
1967	34728	13040	2316	1355	30	51469
1968	25469	9323	1397	3014	1720	40923
1969	16456	3990	65	1201	540	22252
1970	8415	1978	103	782	22	11300
1971	7306	1630	374	1310	242	10862
1972	3869	742	137	1098	20	5866
1973	2777	1661	602	386	3	5429
1974	2396	622	109	764	559	4450
1975	3989	1544	8	61	4	5606
1976	2904	1521	4	46	9	4484
1977	7934	3060	0	0	0	10994
1978	12160	10356	0	0	0	22516
1979	14279	5368	0	0	0	19647
1980	17470	10168	0	0	0	27638
1981	19176	5835	0	0	0	25011
1982	12625	5002	0	0	0	17627
1983	8682	3327	0	0	0	12009
1984	8807	1587	0	0	0	10394
1985	4273	3670	0	0	0	7943
1986	3339	3507	0	0	0	6846
1987	2156	4841	0	0	0	6997
1988	2492	4197	0	0	0	6689
1989	1718	3197	0	0	0	4915
1990	2106	3468	0	0	0	5574
1991	1434	5563	0	0	0	6997
1992	2053	4191	0	0	0	6244
1993	827	3841	0	0	0	4668
1994	2302	2525	0	0	0	4827
1995	309	2133	0	0	0	2442
1996	436	3695	0	0	0	4131
1997	1151	2682	0	0	0	3833
1998	2192	3473	0	0	0	5665
1999	2628	3729	0	0	0	6357
2000	3280	5431	0	0	0	8711
2001	5037	6751	0	0	0	11788
2002	6741	6517	0	0	0	13258
2003	5954	6873	0	0	0	12827

Table B1 (cont.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table B8 (cont.)

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

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

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

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

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

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

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

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

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

Table B12 (cont.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

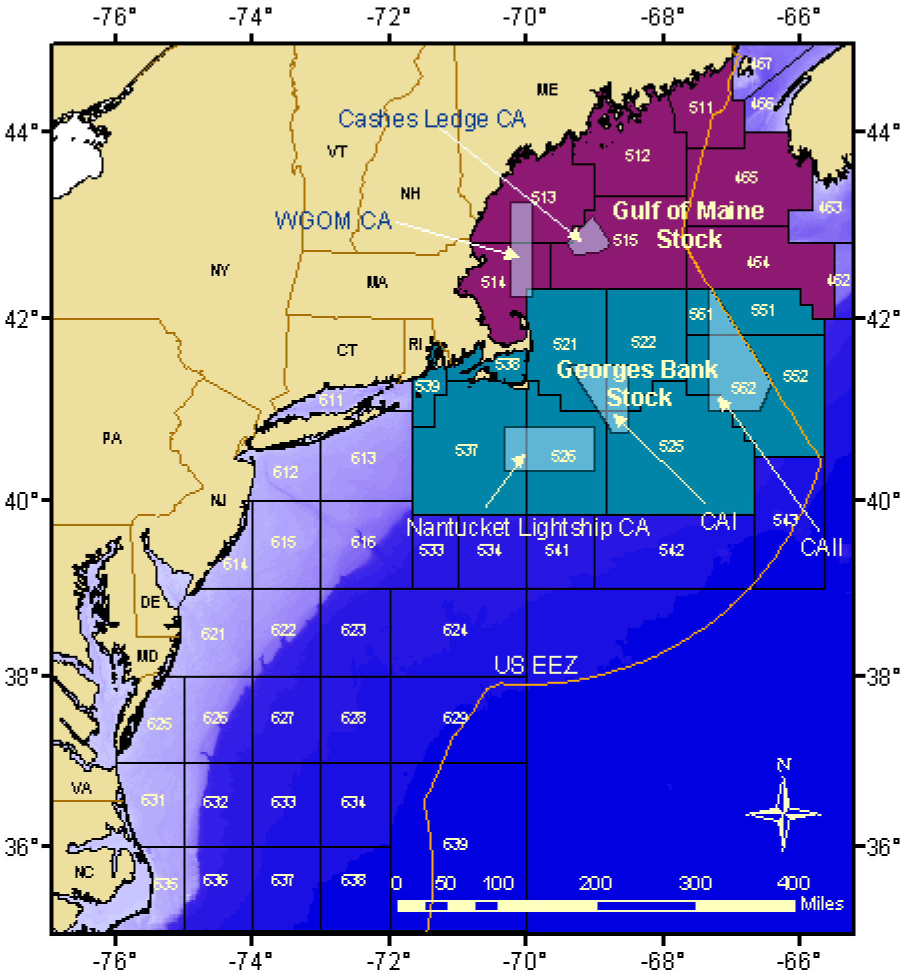


Figure B1. Statistical areas used to define the Gulf of Maine and Georges Bank haddock stocks.

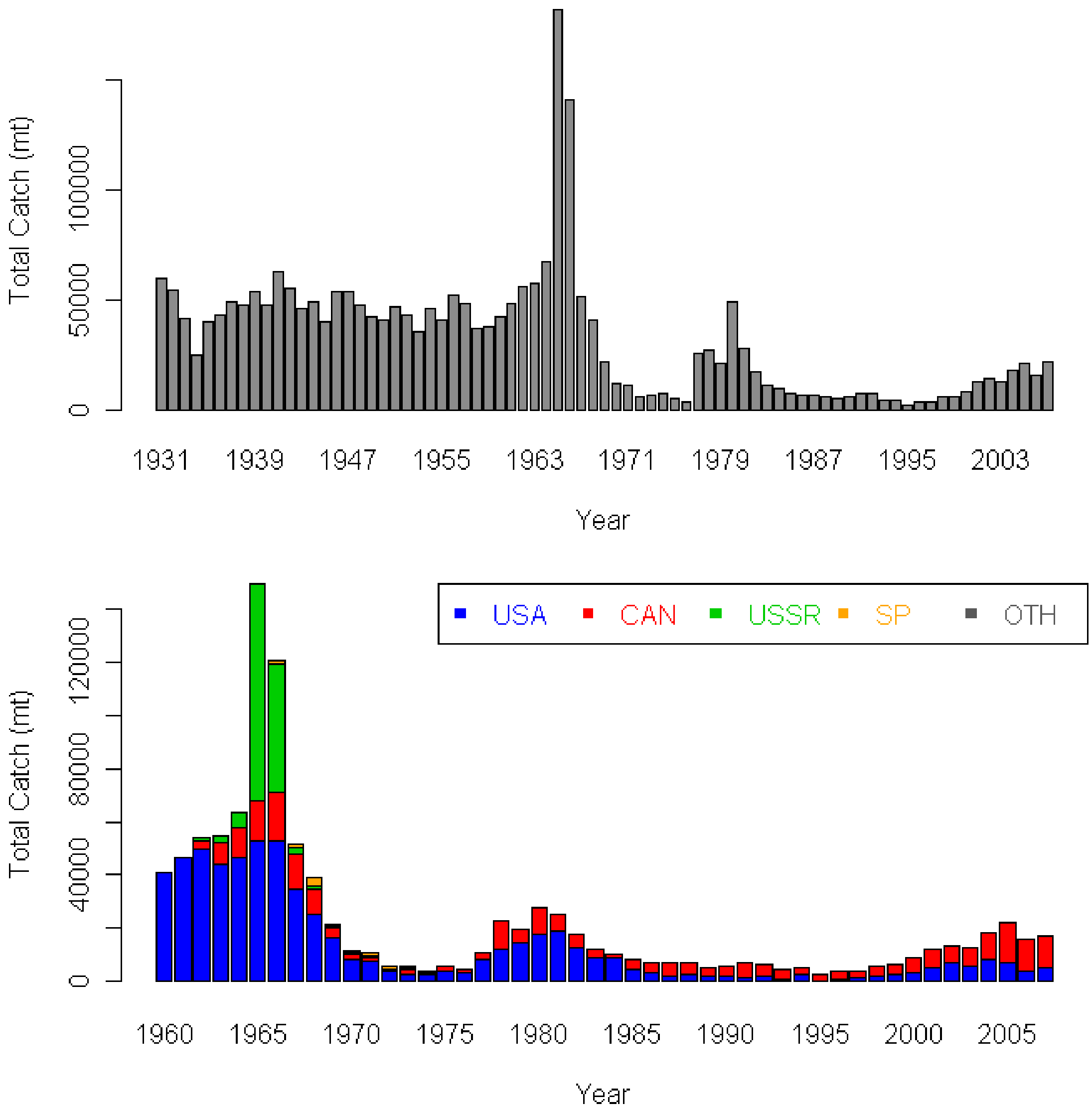
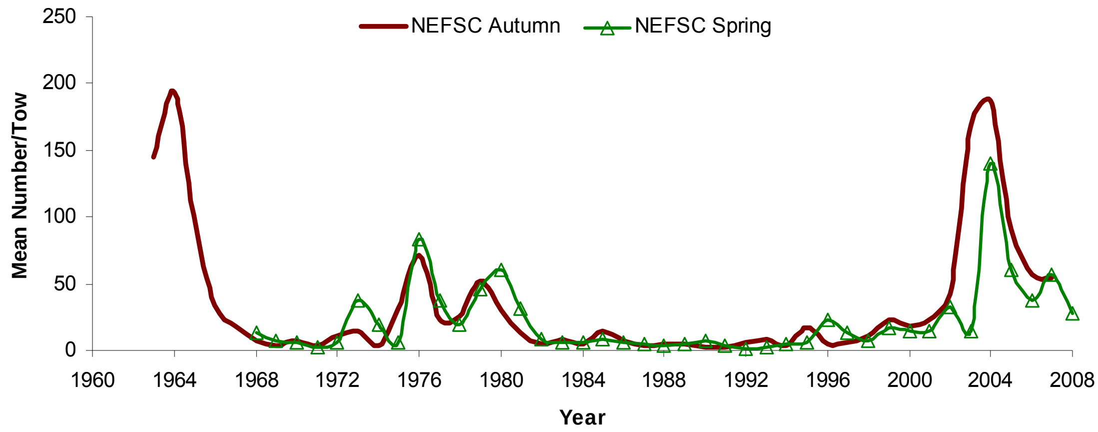


Figure B2. Historical total catch (1931-2007) and total catch by country (1960-2007) for Georges Bank haddock.



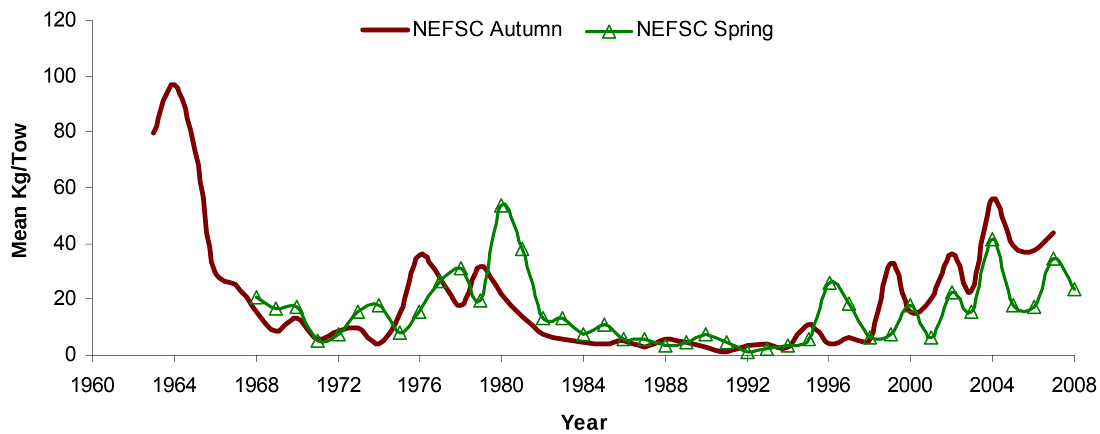
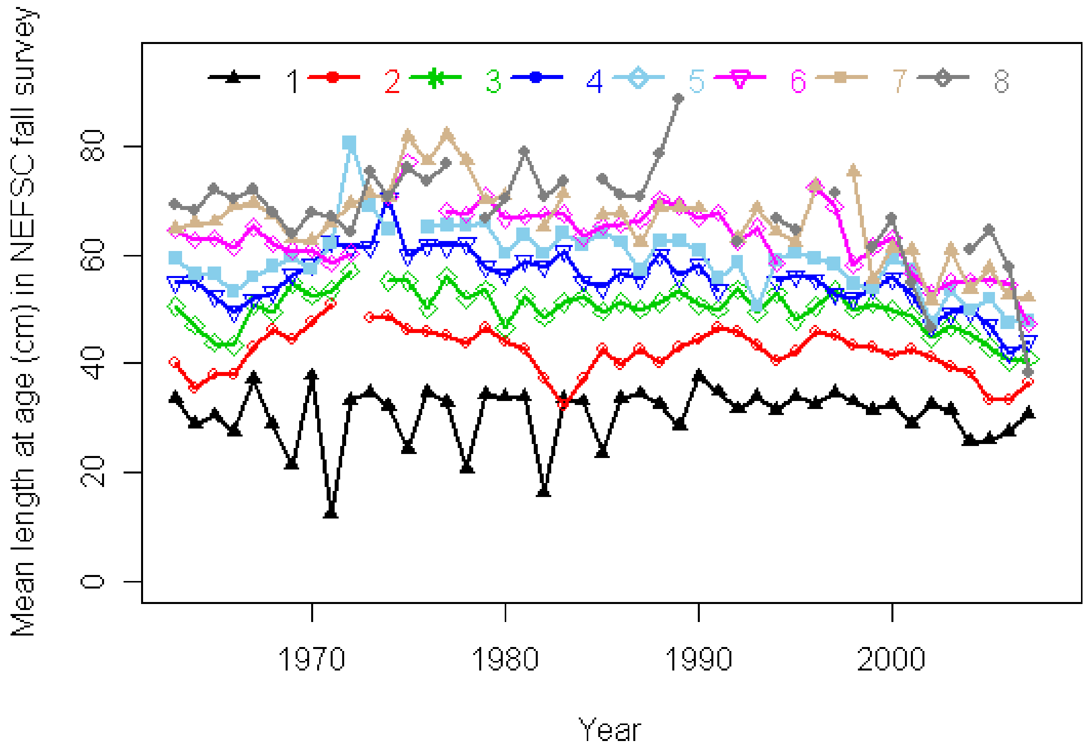


Figure B3. NEFSC spring and autumn bottom-trawl surveys in mean number per tow (top) and mean kg per tow (bottom) of Georges Bank haddock.



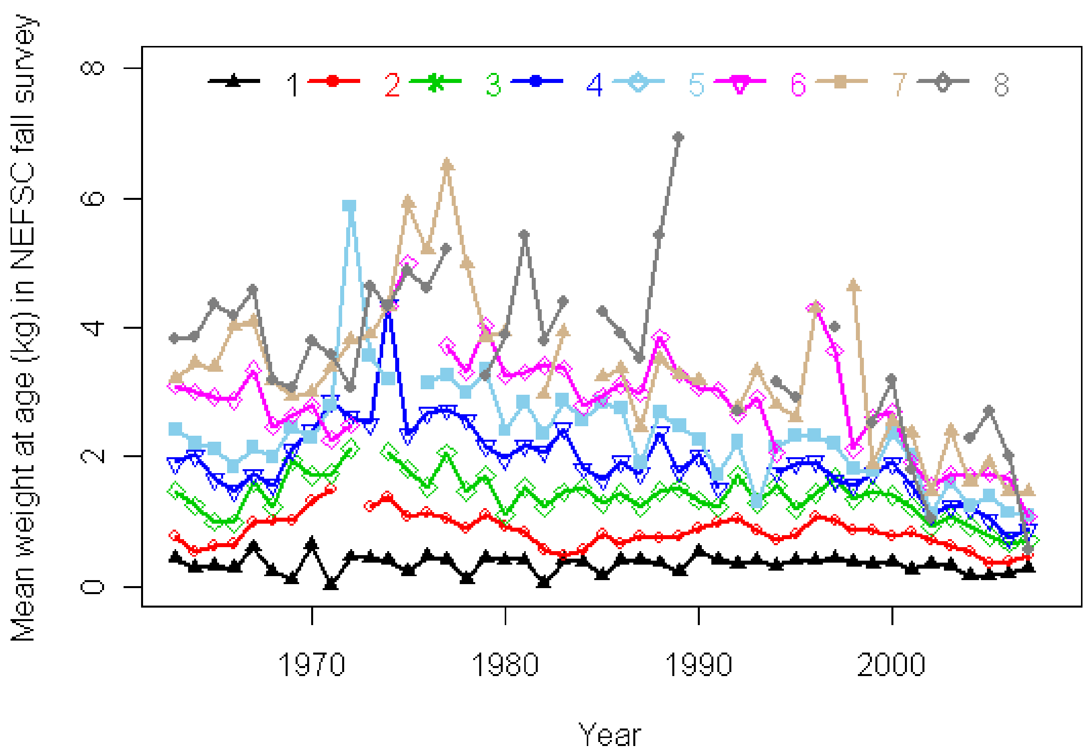


Figure B4a. Mean length and mean weight at age of Georges Bank haddock in the fall NEFSC bottom-trawl survey (1963-2007).

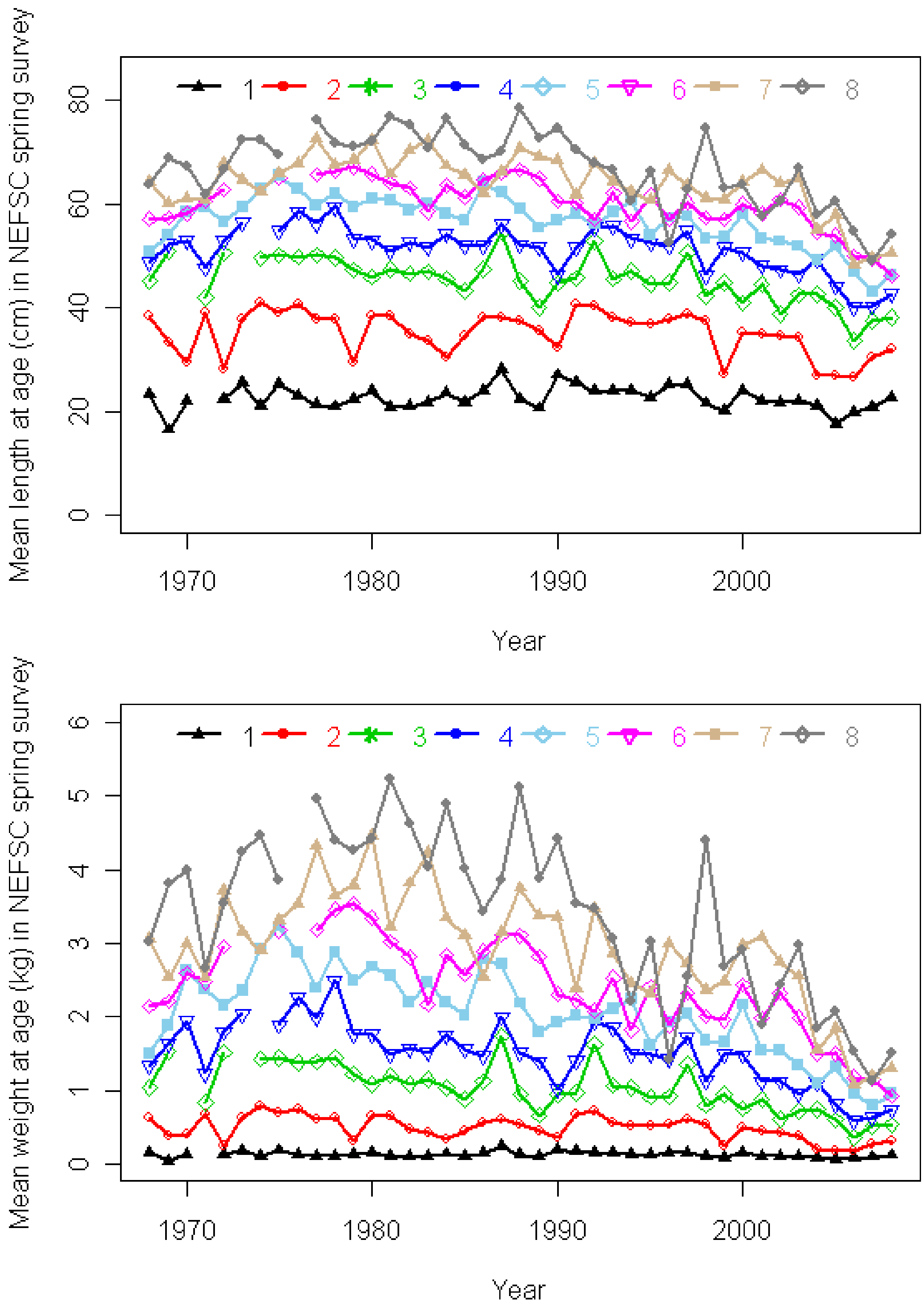
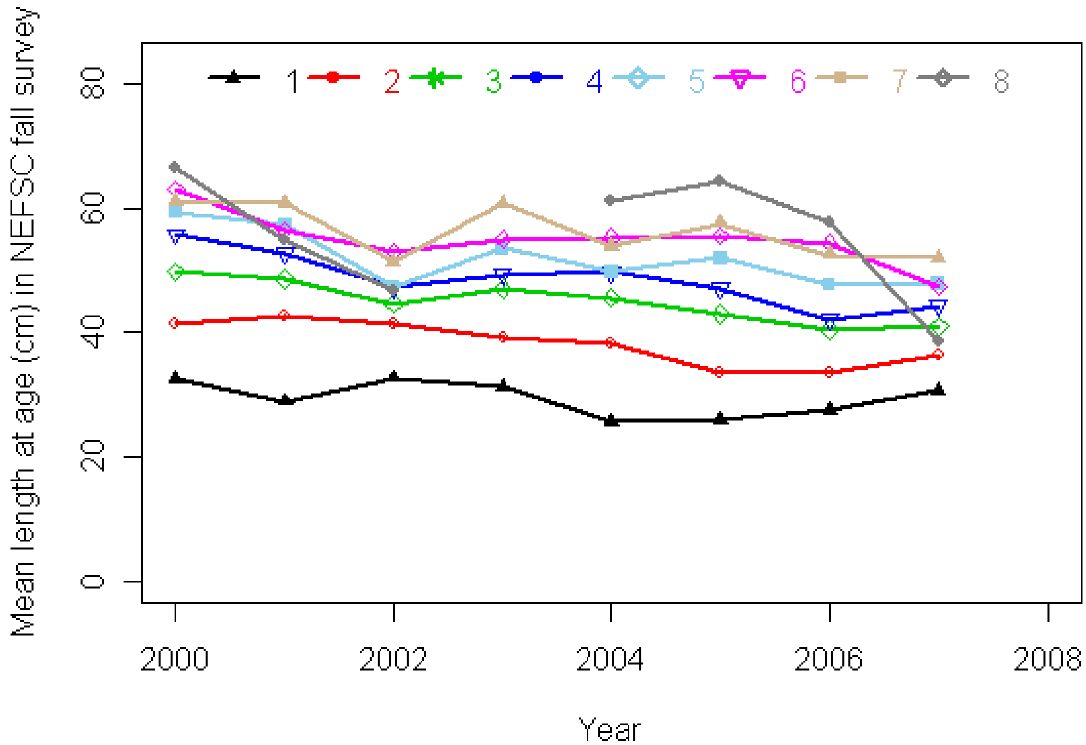


Figure B4b. Mean length (cm) and mean weight (kg) at age of Georges Bank haddock in the spring NEFSC bottom-trawl survey (1968-2007).



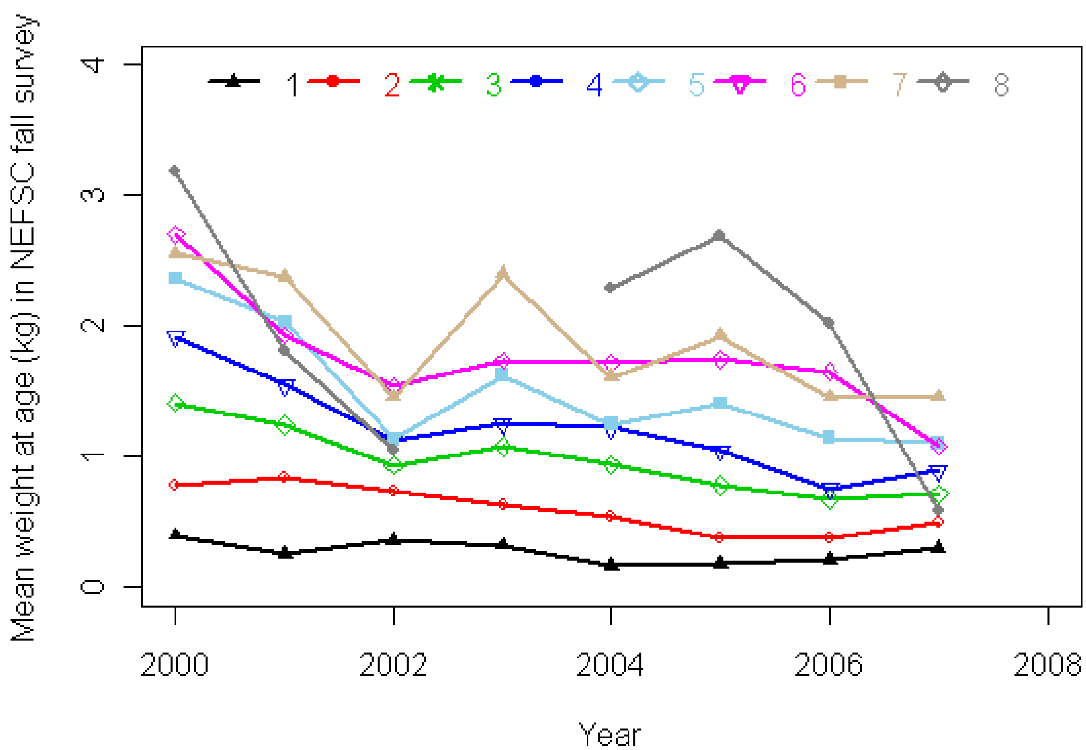
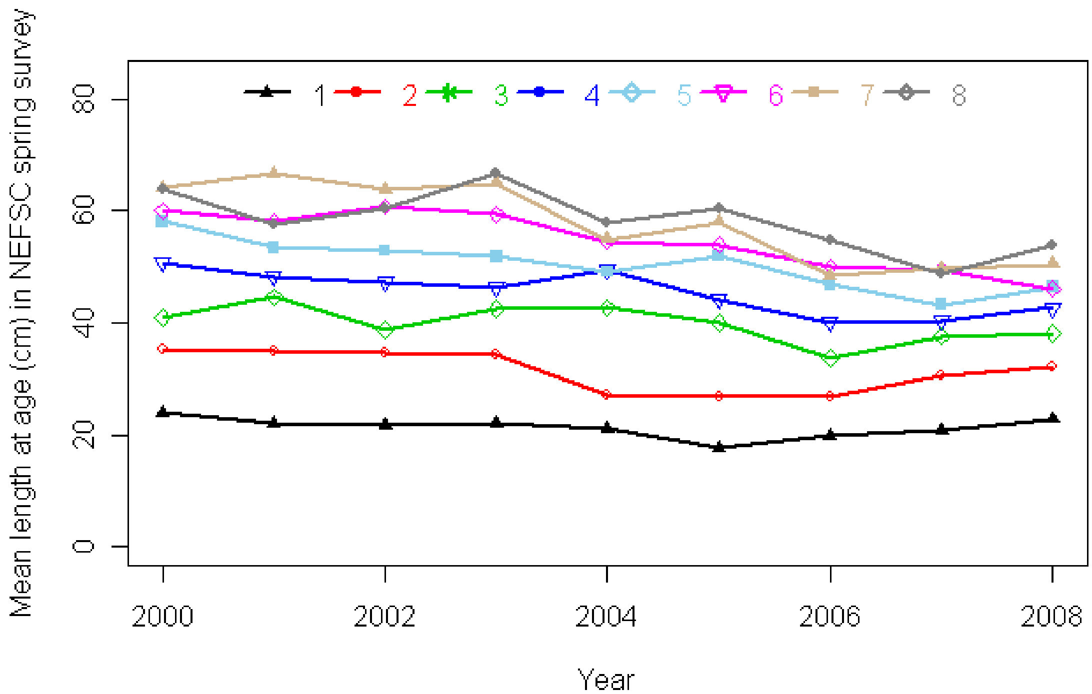


Figure B5a. Mean length and mean weight at age of Georges Bank haddock in the fall NEFSC bottom-trawl survey (2000-2007).



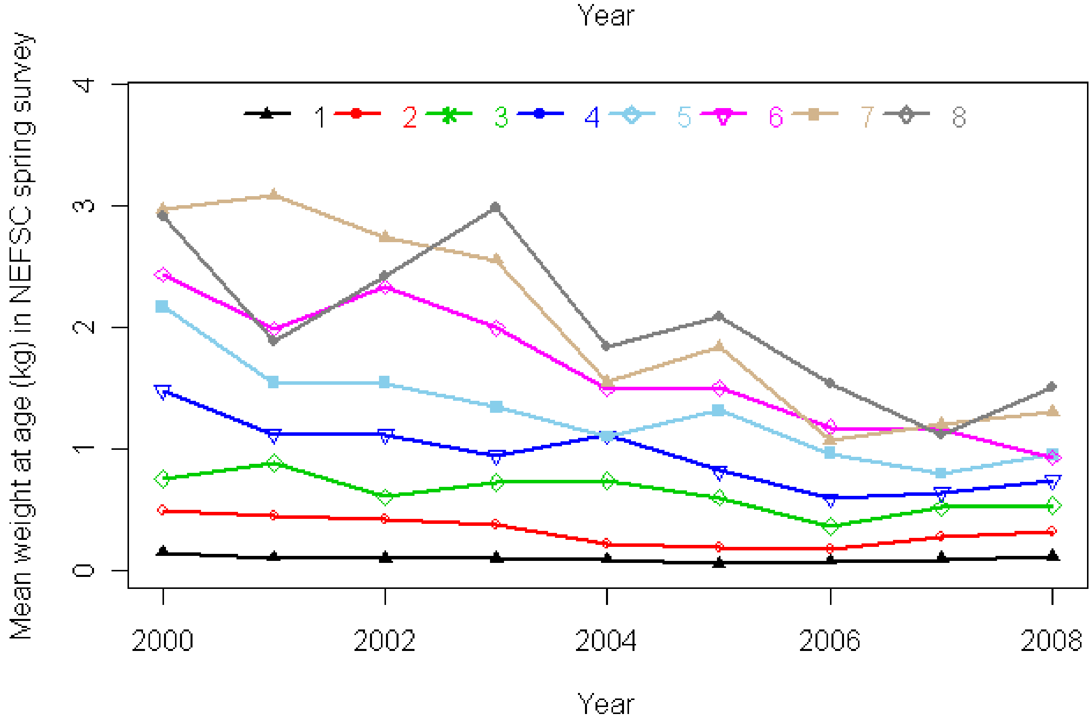
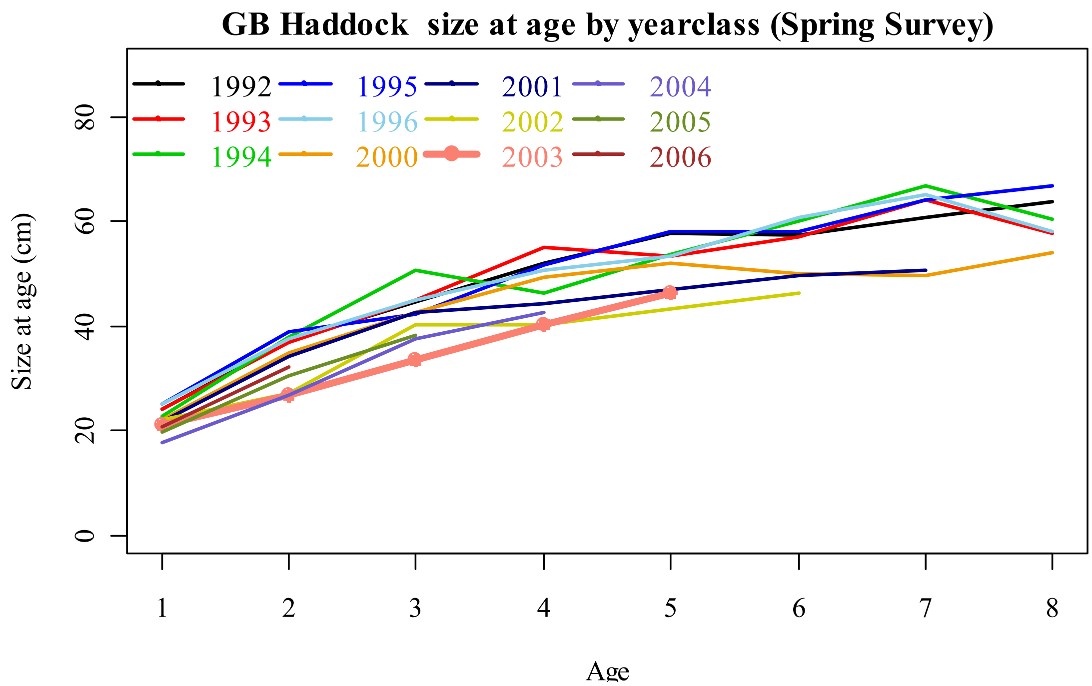


Figure B5b. Mean length and mean weight at age of Georges Bank haddock in the fall NEFSC bottom-trawl survey (2000-2007).



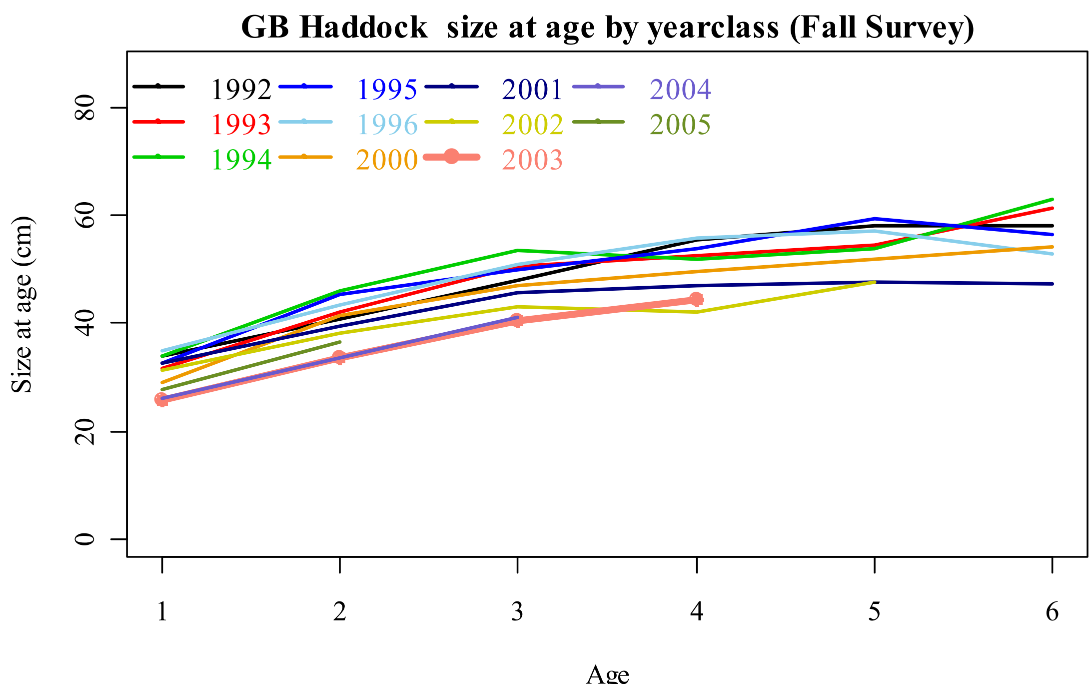


Figure B6. Mean size at age (cm) by year class of Georges Bank haddock in the spring and fall NEFSC surveys. The strong 2003 year class is indicated by a bold line with filled circles.

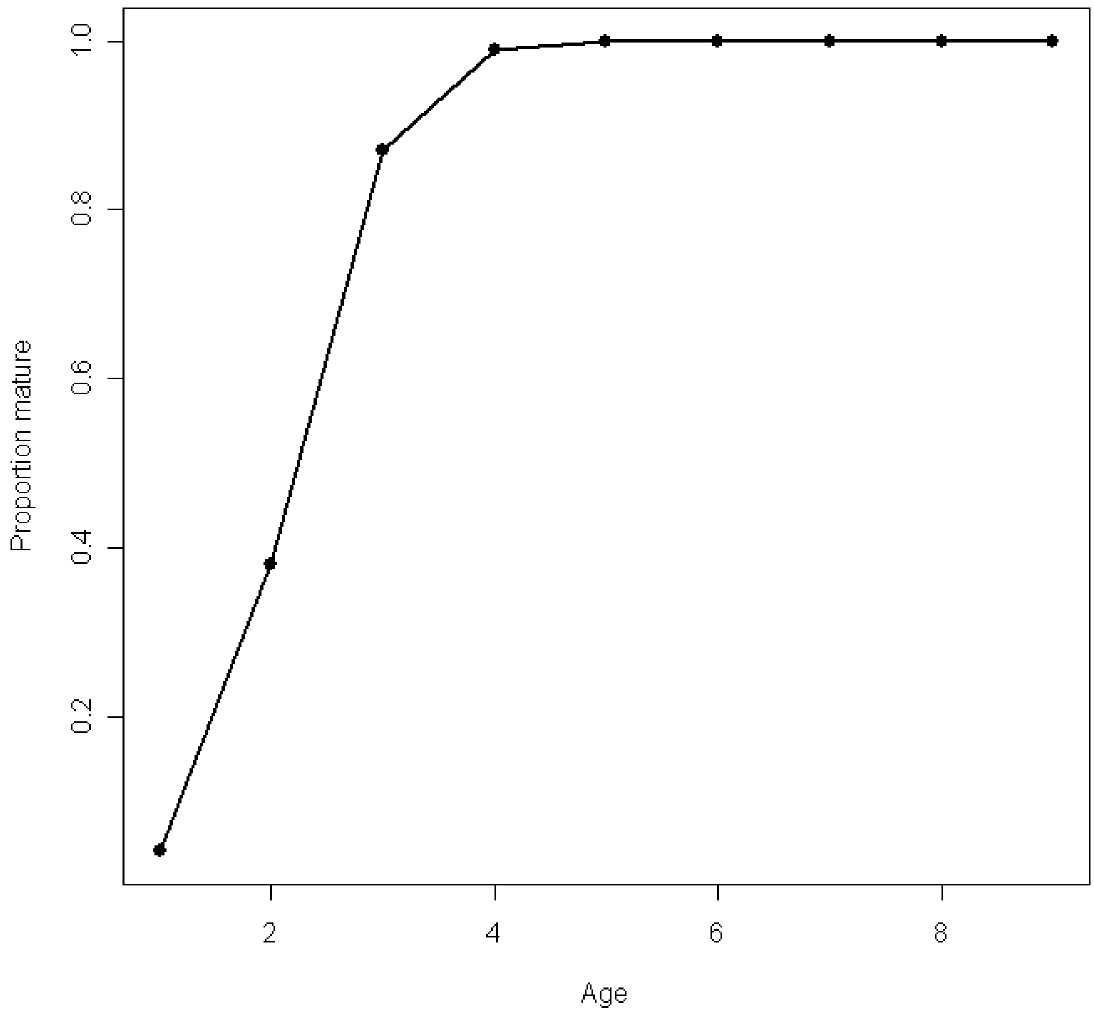


Figure B7. Proportion mature at age for Georges Bank haddock.

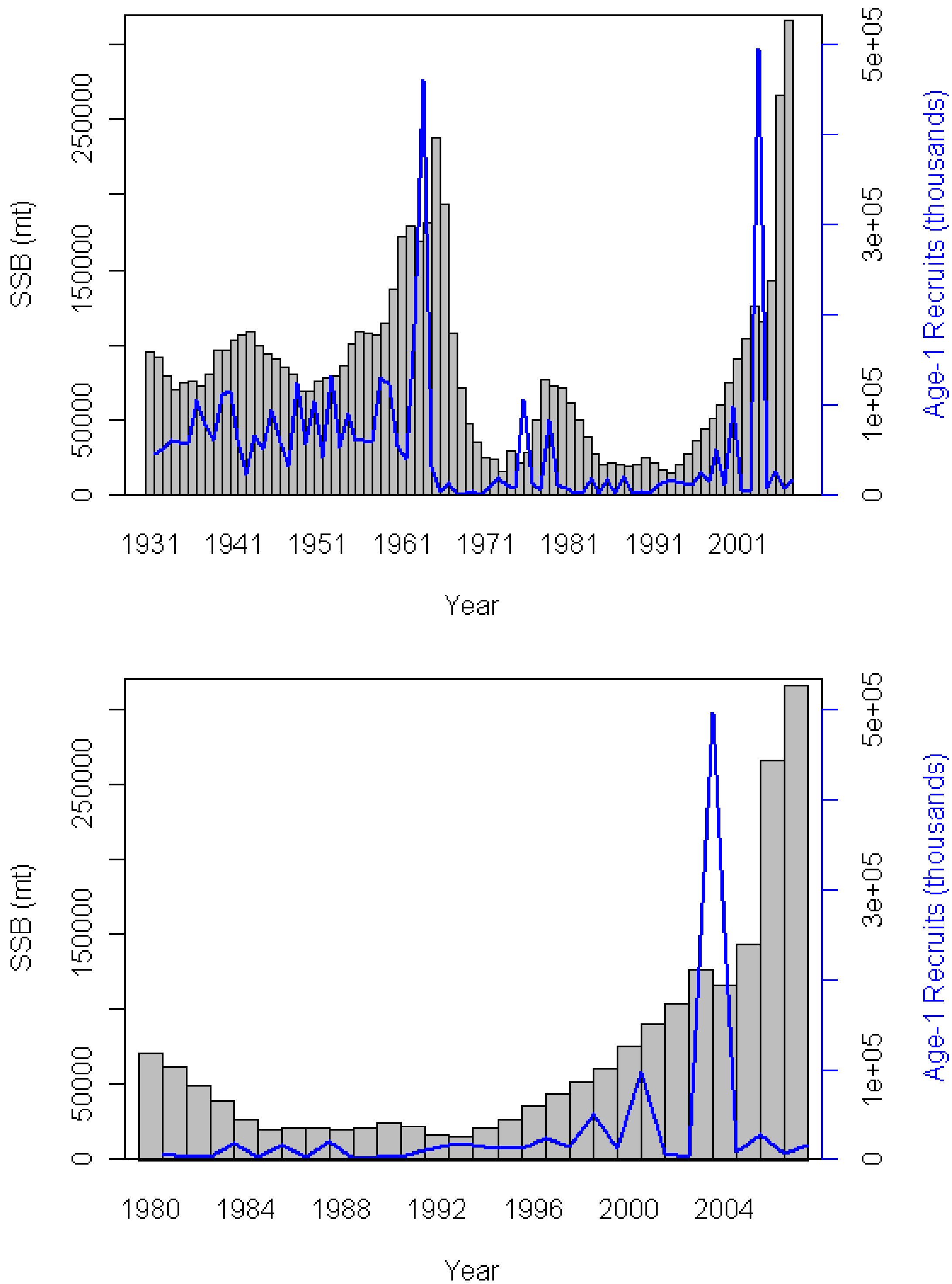


Figure B8. VPA estimates of spawning stock biomass (SSB, mt) and age-1 recruits (thousands) for Georges Bank haddock.

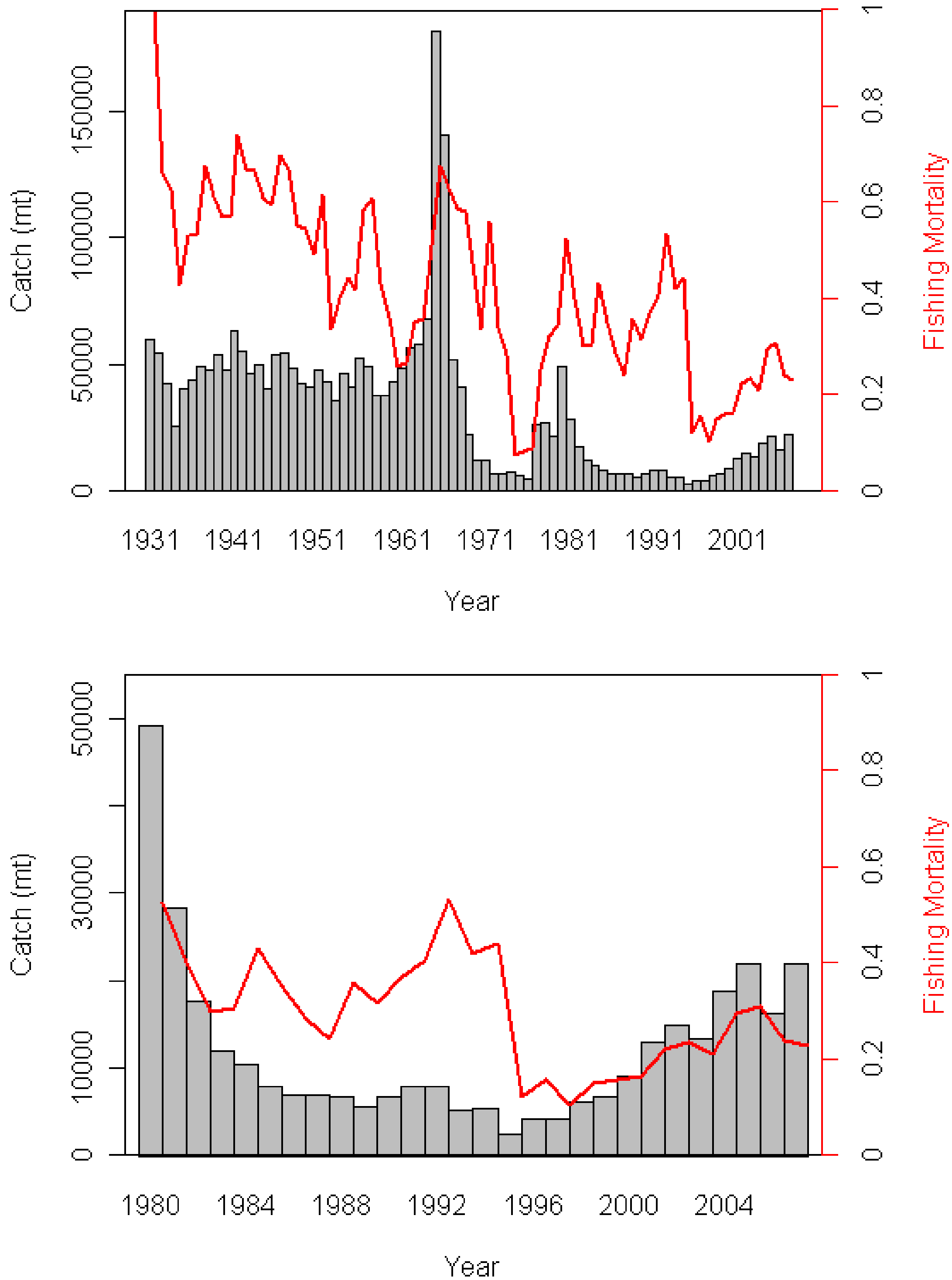


Figure B9. Total catch (mt) and VPA estimates of average fishing mortality on ages 5-7 for Georges Bank haddock.

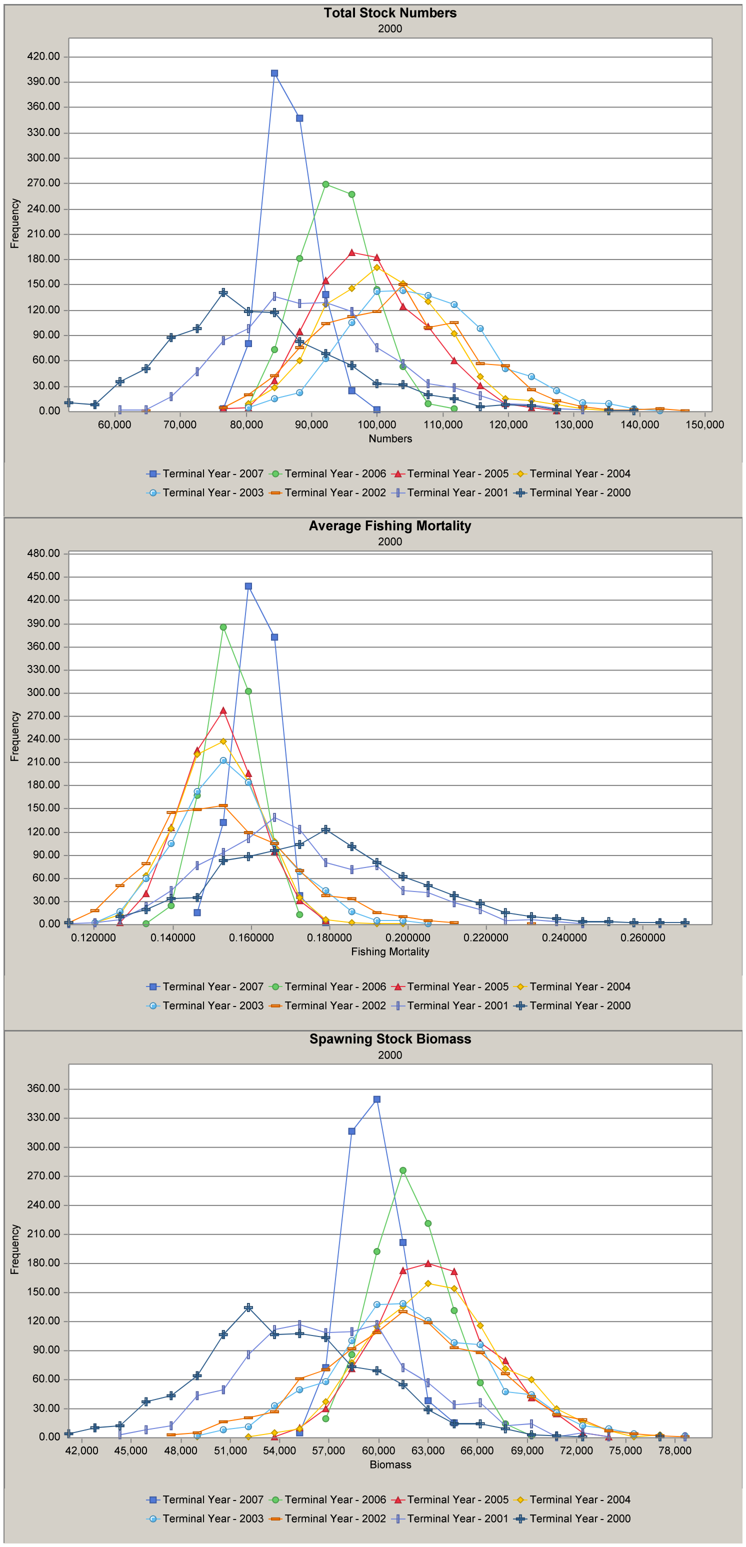


Figure B10. Bootstrapped retrospective distributions of total numbers (top), fishing mortality (middle) and spawning stock biomass (bottom) in year 2000 for Georges Bank haddock.

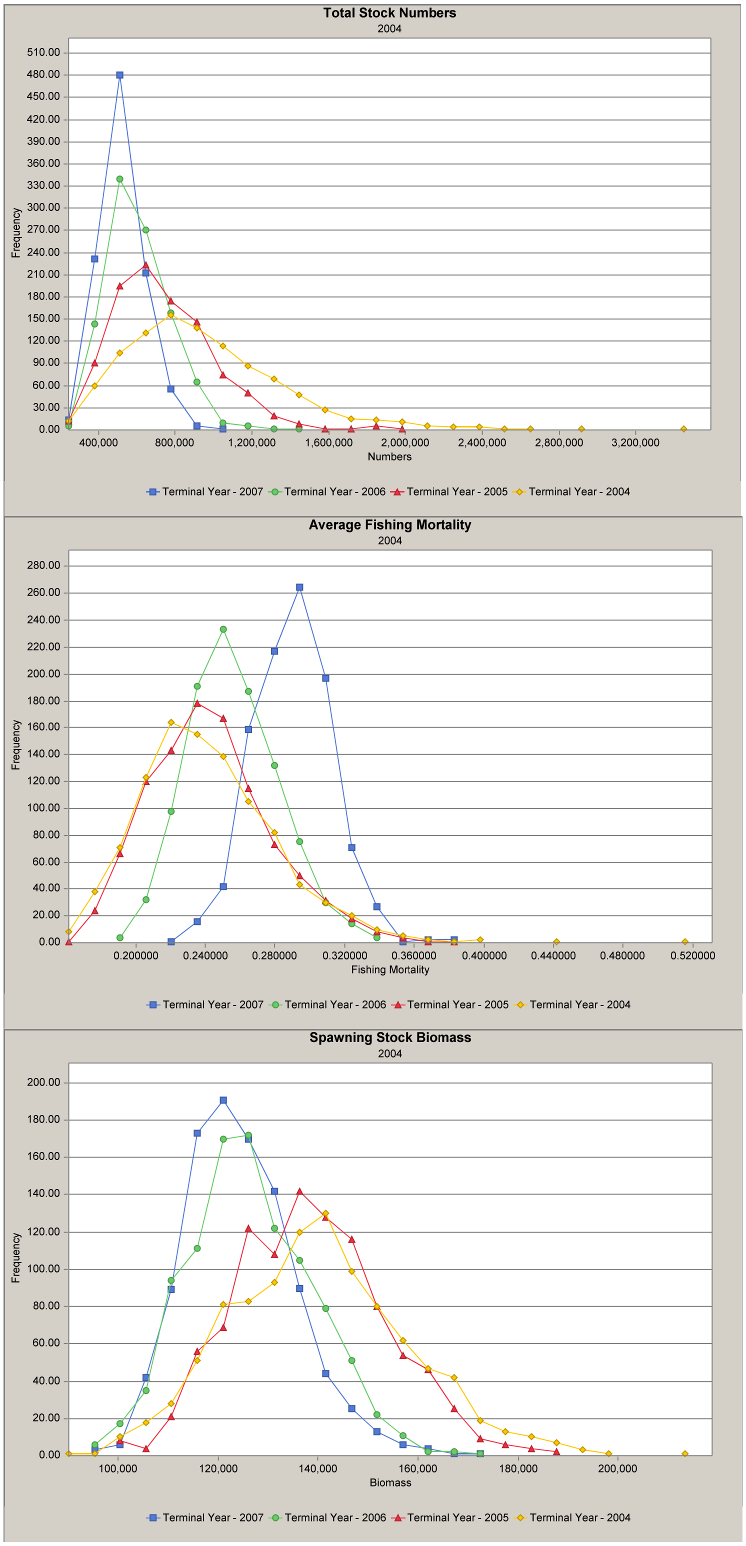


Figure B11. Bootstrapped retrospective distributions of total numbers (top), fishing mortality (middle) and spawning stock biomass (bottom) in year 2004 for Georges Bank haddock.

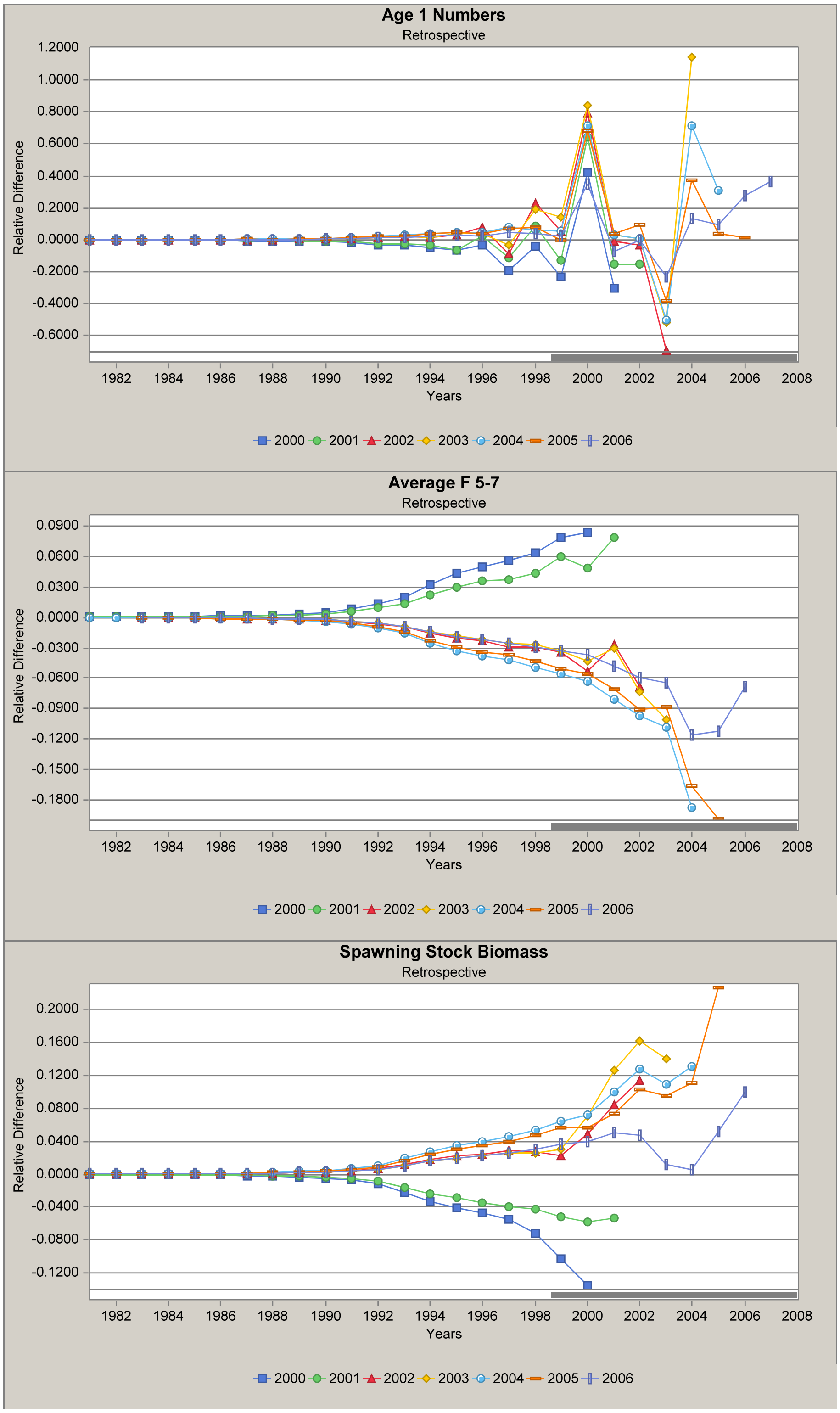


Figure B12. Retrospective analysis of relative differences from terminal year estimates of age-1 recruits (top), fishing mortality (middle) and spawning stock biomass (bottom) for Georges Bank haddock.

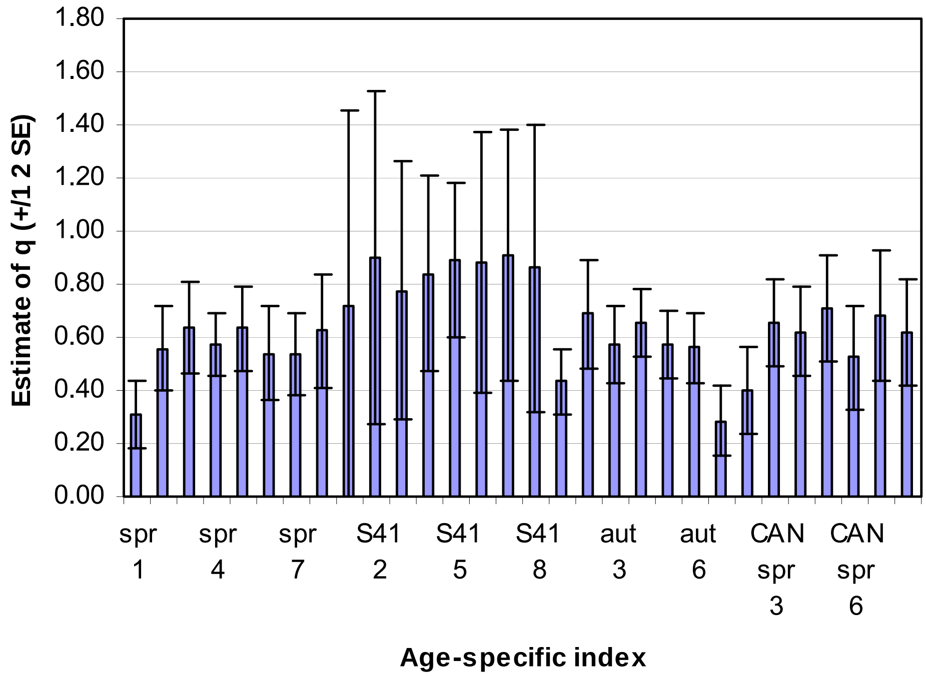


Figure B13. VPA estimates of catchability (q), +/- 2 standard errors, for swept area age-specific abundance indices of Georges Bank haddock.

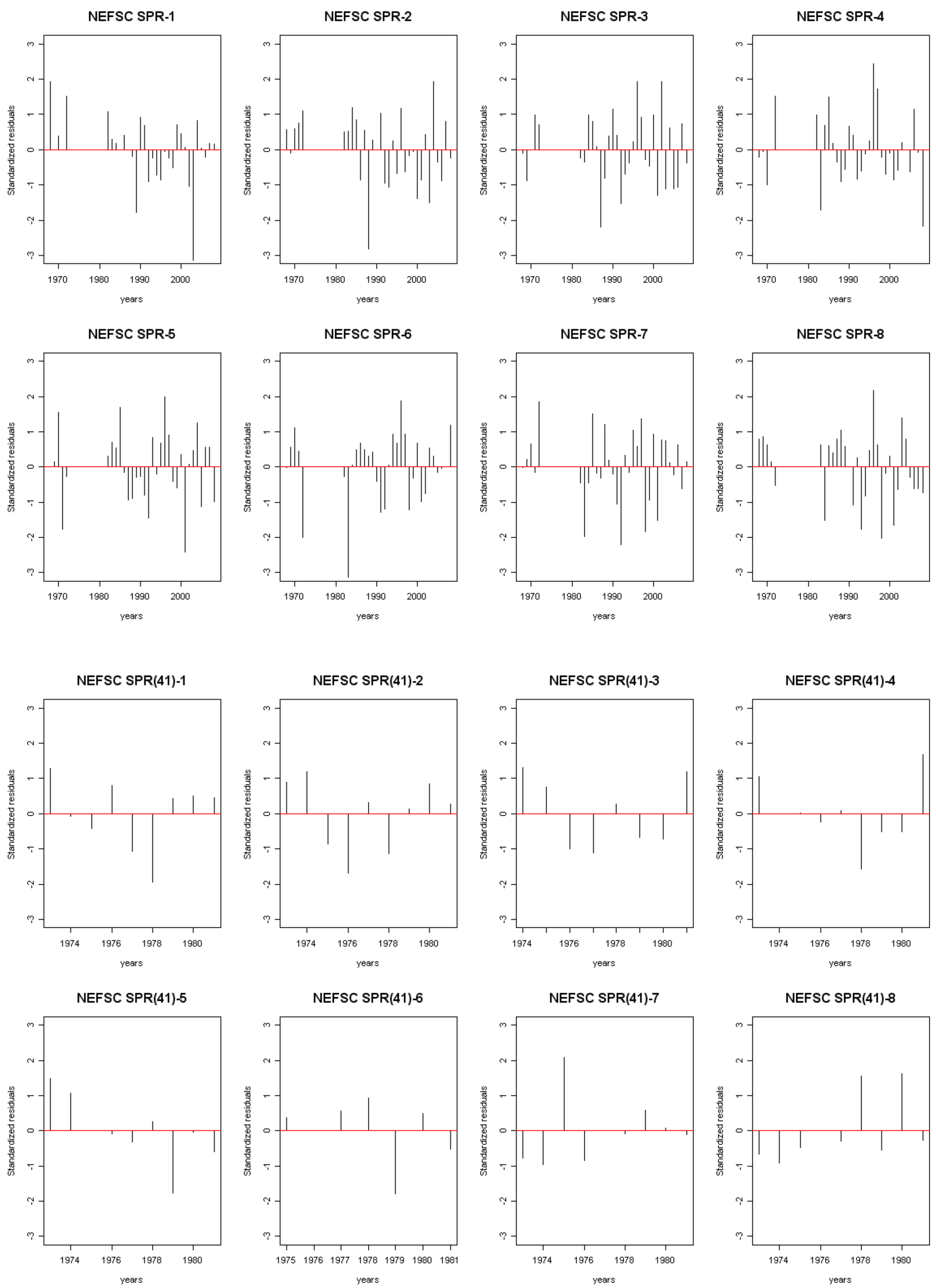


Figure B14a. Residuals from fitting to NEFSC spring swept area indices of abundance at age for Georges Bank haddock.

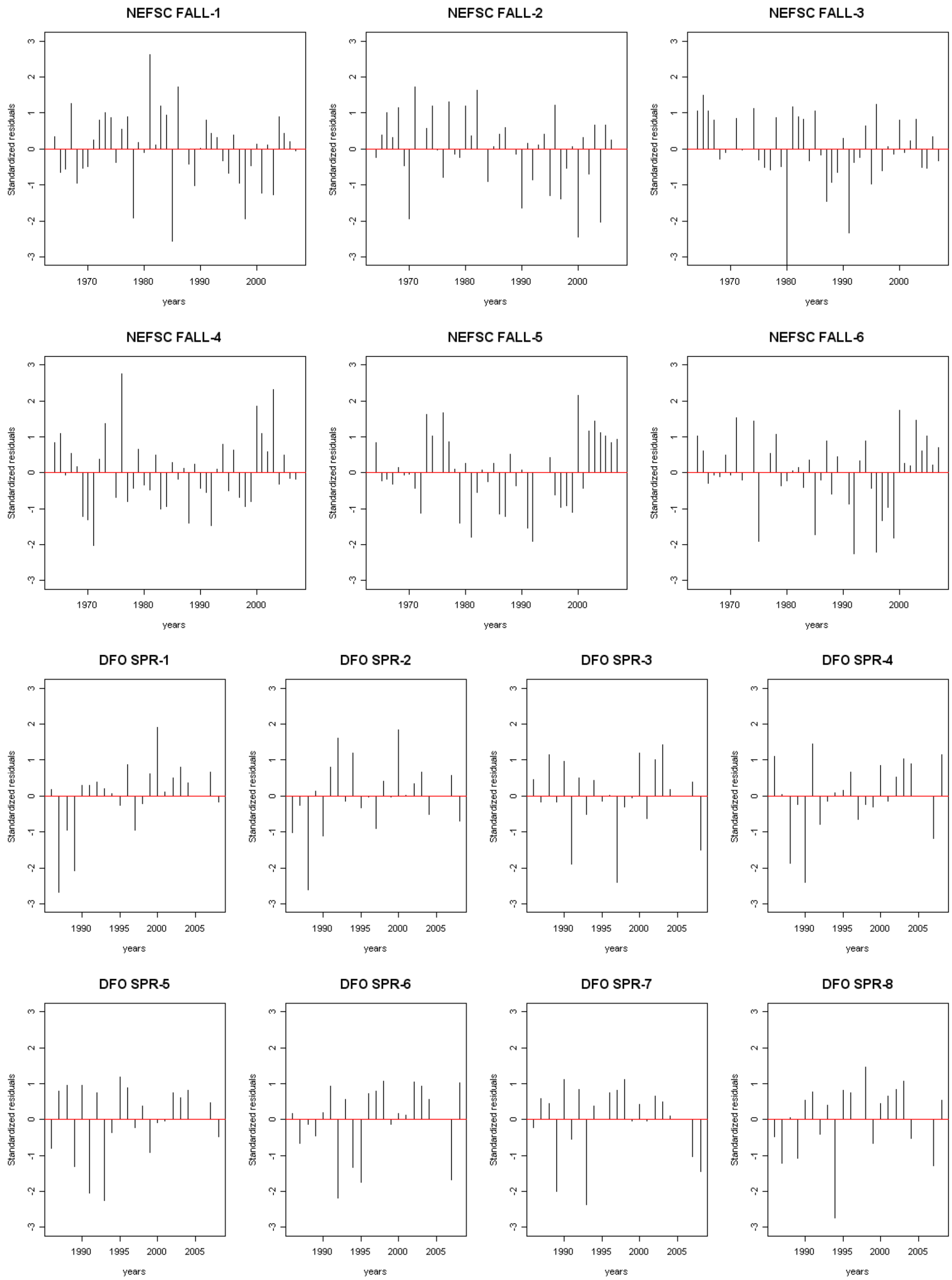
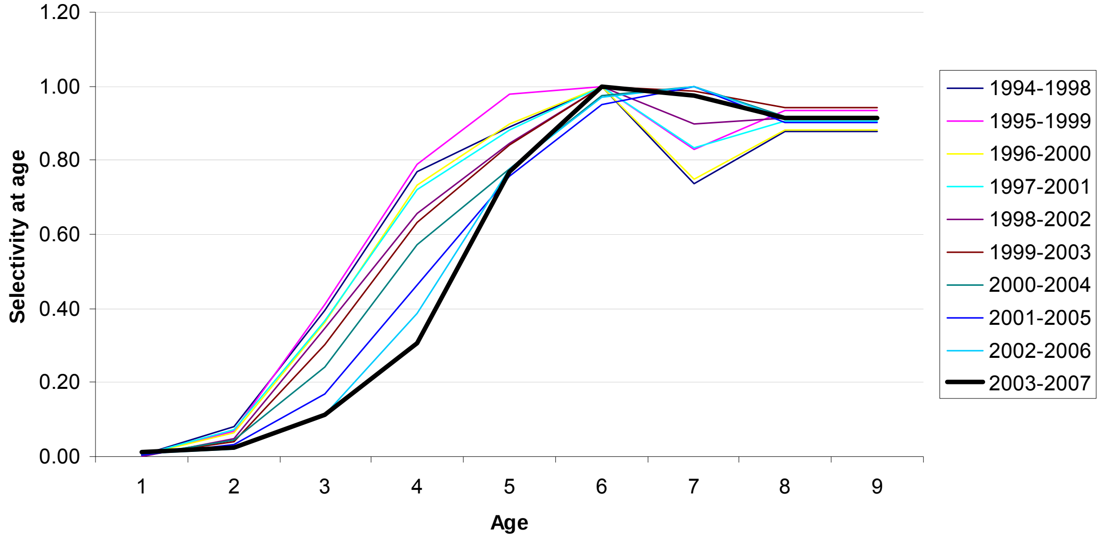


Figure B14b. Residuals from fitting to NEFSC fall and Canadian DFO spring swept area indices of abundance at age for Georges Bank haddock.



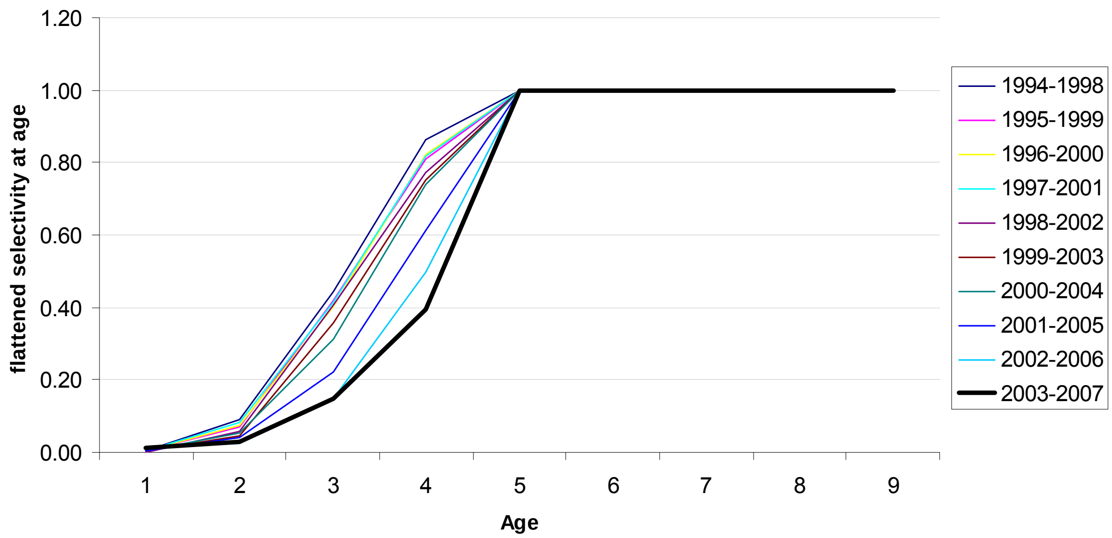
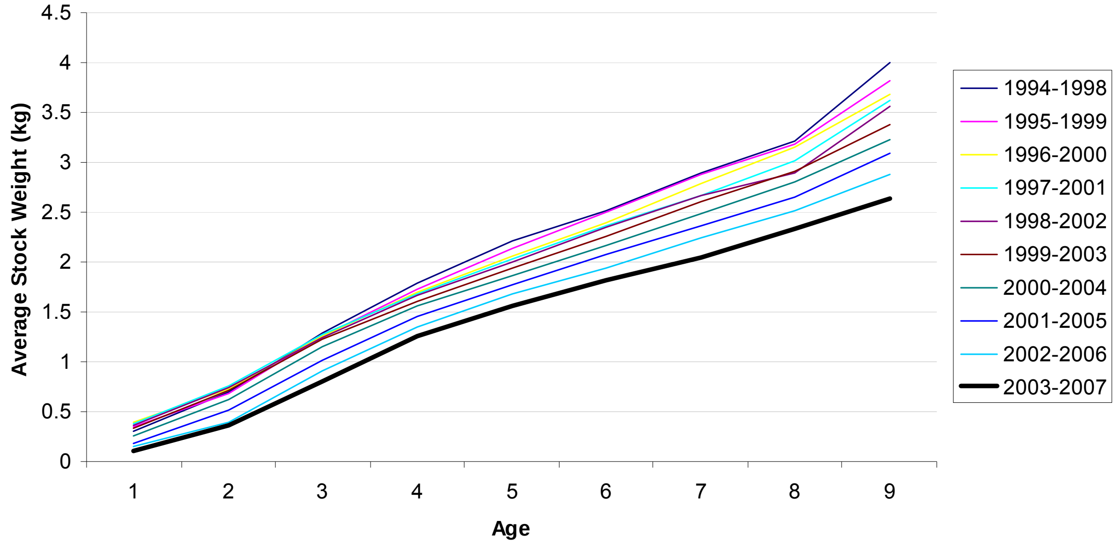


Figure B15. Five-year average selectivity at age for Georges Bank haddock as estimated in the VPA (top), and rescaled to asymptote at age 5 (bottom).



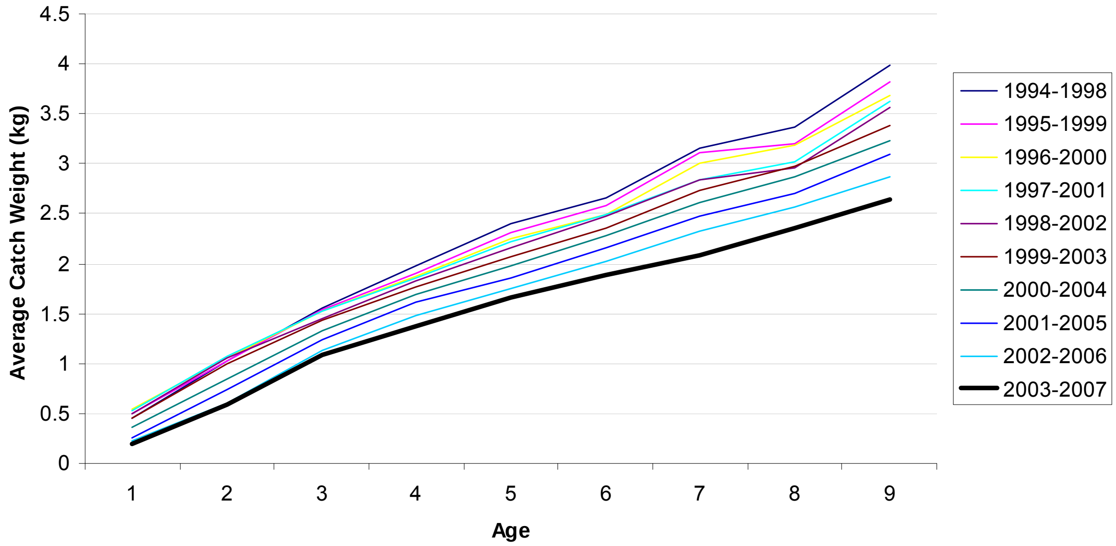


Figure B16. Five-year average weights at age for Georges Bank haddock.

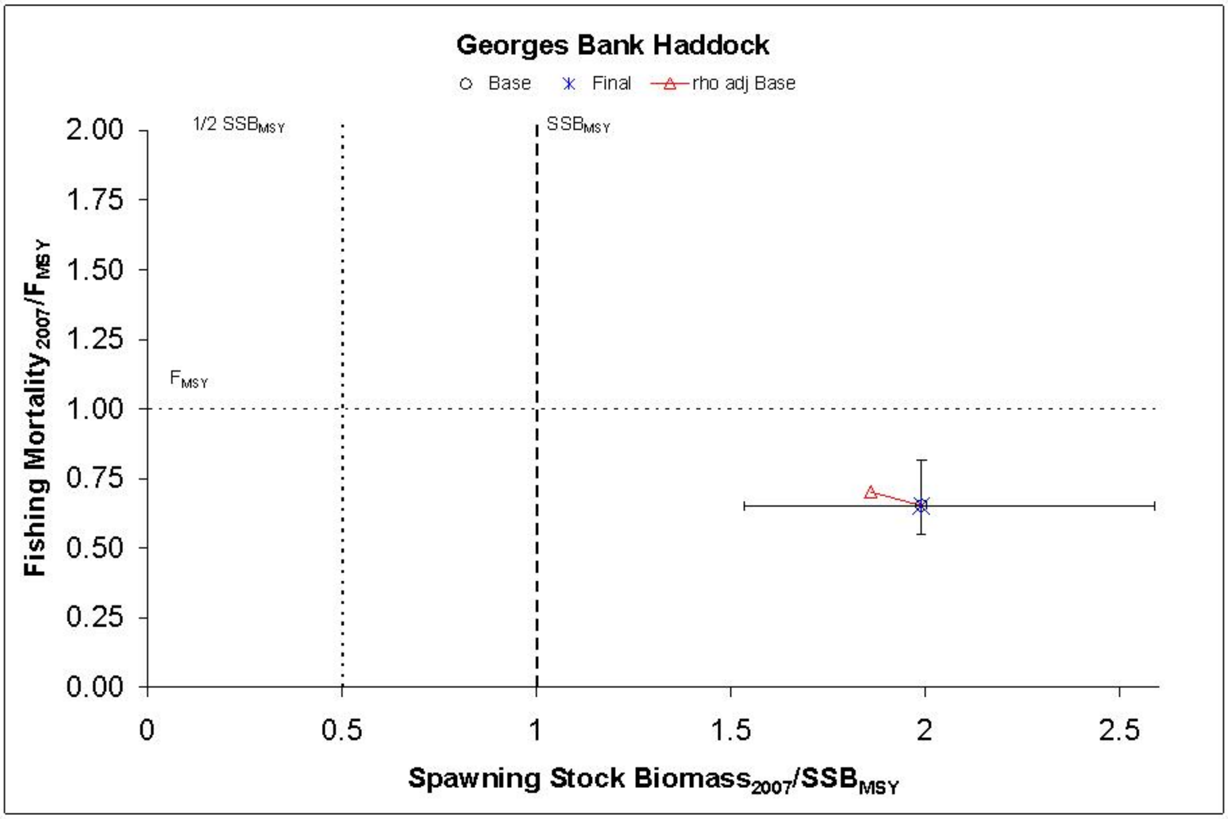


Figure B17. Estimated stock status of Georges Bank haddock, with 10^th and 90^th percentiles for 2007. Stock status after applying a correction for Mohn's rho ('rho adj Base') is shown for comparison, although management advice is based on the Base (Final) unadjusted stock status.

C. Georges Bank yellowtail flounder

by Chris Legault, Larry Alade, Heath Stone, Stratis Gavaris, and Christa Waters

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

1.0 Background

The Georges Bank yellowtail flounder stock is jointly managed by the US and Canada through the Transboundary Management Guidance Committee (TMGC). Stock assessments are conducted annually by the Transboundary Resources Assessment Committee (TRAC). A benchmark assessment completed in 2005 (TRAC 2005) focused on the issue of the strong retrospective pattern. Based on this benchmark assessment and subsequent assessments (Legault et al. 2006, Legault et al. 2007), the so-called "Major Change" model has been utilized to provide stock management advice. This model splits the survey time series between 1994 and 1995 to reduce the retrospective pattern. This split is most appropriately thought of as "aliasing of an unknown mechanism that produces a better fitting model" (Legault et al. 2007). Although the TMGC does not have explicit biomass reference points, these were calculated previously and have been used in US management decisions (NEFSC 2002a). Based on the current biological reference points, the stock is currently overfished and overfishing is occurring. This report revises and updates the 1994-2007 US catch to reflect the Groundfish Assessment Review Meeting (GARM) III Data meeting recommendations (GARM 2007) and updates the research survey abundance indices and analytical models though 2007/2008 as recommended in the TRAC benchmark assessment and at the GARM III Methods meeting (GARM 2008a) and the GARM III Biological Reference Points meeting (GARM 2008b). Finally, biological reference points for this stock were calculated using the VPA results and a two-stanza recruitment approach (i.e. recruitment associated with SSB either greater than or less than 5000 mt) as recommended in the GARM III Biological Reference Points meeting (GARM2008b) to determine the current status of the stock.

2.0 Fishery

US Landings

U.S. landings of yellowtail flounder from Georges Bank (Figure C1) during 1994-2007 were derived from the new trip-based allocation described in the GARM III Data meeting (GARM 2007, Palmer 2008, Wigley et al. 2007a, Table C1, Figure C2). Changes to previous estimates were minimal and uncertainty in the landings due to the random component of the allocation was insignificant (Legault et al. 2008). US landings have been limited by quotas in recent years. Landings at age and mean weight at age are determined by port sampling of small, medium, large, and unclassified market categories and pooled age-length keys by half year. Sampling intensity has increased in recent years (Table C2) resulting in lower variability in landings at age estimates (Table C3).

US Discards

US discarded catch for years 1994-2007 was estimated using the Standardized Bycatch Reporting Methodology recommended in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b). Observed ratios of discards of yellowtail flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, and scallop dredge were applied to the total landings by these gears by half-year. Uncertainty in the discard estimates was estimated based on the SBRM approach detailed in the GARM III Data meeting (GARM 2007, Wigely at al. 2007b, Table C4). US discards were approximately 13% of the US catch in years 1994-2007 (Table C1; Figure C2). Discards at age and associated mean weights at age were estimated from sea sampled lengths and pooled observer and survey age-length keys.

Canadian Landings

Canadian landings since 2004 have been well below previous levels and the allowed quota for that fishery (Table C1; Figure C2). Since 2003, scale samples from Canadian landings were aged by the US readers and these age-length keys used directly for these landings. Previously, US age-length keys had been applied to Canadian length frequency distributions. In 2008, Canadian landings were so low (17 mt) that no port samples were collected. These landings were assumed to follow the same age distribution as the US landings in 2008.

Canadian Discards

During the 2005 benchmark assessment, yellowtail flounder discards from the Canadian scallop fleet were estimated for the entire time series and used in the stock assessment for the first time (Stone and Legault 2005). Inclusion of this catch did not cause a large change in the assessment results because the magnitude is relatively constant throughout the time series used in the assessment, 1973 onward (Table C1; Figure C2). Discards at length were estimated from ogives of relative selectivity compared to research survey catches at length and converted to ages using age-length keys from US and Canada commercial landings and observers by quarter.

Total Catch at Age

Total catch at age was formed by adding the US landings, US discards, Canadian landings, and Canadian discards (Table C5a-c). Average catch weight at age was computed as the catch numbers weighted average of the weights at age from these four sources (Table C6a). Beginning of year weights at age were calculated using the Rivard weights approach (Table C6b). Spawning stock biomass weights at age were set equal to the catch weights at age.

3.0 Research Surveys

Survey abundance and biomass indices are reported in Table C7a-d. Estimates from research vessel surveys are from valid tows on Georges Bank (NEFSC offshore strata 13-21; Canadian strata 5Z1-5Z4; NEFSC scallop strata 54, 55, 58-72, 74) standardized according to net, vessel, and door changes. The three bottom trawl surveys are presented as minimum swept area estimates to allow direct interpretation of the catchability estimates associated with each survey and age combination. The three surveys of biomass show a similar pattern of rapid increase from lows in the early to mid 1990s to highs in the early 2000s followed by a decline in the most recent years (Figure C3).

The 2008 DFO survey had one tow with over 7.5 mt of yellowtail. This catch is well above any previous single catch in the survey time series (<1 mt) and the total catch summed from the remaining 56 stations in the 2008 survey (~0.5 mt). The estimated population abundance at ages 2-4 and the total biomass from the survey varied by an order of magnitude depending on whether this one tow was included or not (Table C.7c). During the TRAC meeting of June 2008, it was agreed that the 2008 DFO survey would not be included as an index of abundance, although the rest of the time series would be used in assessment, for the reference case. Two sensitivity runs of the VPA were conducted which included the 2008 DFO survey: one with the large tow and one which dropped the large tow.

4.0 Assessment

Input Data and Model Formulation

The 2005 benchmark assessment could not select a single formulation for Georges Bank yellowtail flounder VPA stock assessment. Instead, the previously used "Base Case VPA" (same formulation as GARM I, NEFSC 2002b and GARM II, Mayo and Terceiro 2005) was used along with a "Major Change VPA" which extended the ages from 6+ to 12, split the survey time series in 1995, and allowed for power functions relating survey abundance at age to model estimates. Assessments since the benchmark have modified the Major Change model to only differ from the Base Case by splitting the survey series between 1994 and 1995.

Model Selection Process

Since the Base Case and Major Change formulations were both recommended at the last benchmark assessment, and even though only the Major Change model has been used for management advice in recent years, both were updated with 2007 catch and 2008 NEFSC Spring survey values. Results were not noticeably different from the 2007 TRAC or GARM III Biological Reference Point meeting assessments with the Base Case VPA exhibiting a strong retrospective pattern while the Major Change VPA does not (Table C8; Figures C4a-c). Thus, the Base Case formulation was dropped from further consideration and only the Major Change formulation considered.

Assessment Results

The VPA estimates when the 2008 DFO survey were not included, the reference case, were estimated relatively precisely, CVs 25-46% for N and 9-66% for q (Table C9). Population abundance is increased in 2007 due to the strong 2005 year class (Table C10) as well as reduced fishing mortality on all ages. The fishing mortality rate on ages 4-5 has been trending down for the past 4 years and is now approaching the TRAC reference level of 0.25 (Table C11; Figure C5). Spawning stock biomass more than doubled from 2006 to 2007 and Jan-1 biomass more than tripled from 2007 to 2008 due mainly to the strength of the 2005 year class (Tables C12a-b; Figure C6). The 2007 estimates of F, SSB, and Jan-1 biomass were well estimated as seen in the relatively tight 80% confidence intervals derived from bootstrapping (Table C13).

Diagnostics

Residuals for indices of abundance do not show strong patterns, although occasional year effects are apparent in some surveys (Figure C7). The estimated catchability coefficients increase between the early and recent period for all indices, but show reasonable patterns at age and magnitudes with only the recent DFO values above one (Figure C8). These q values above one could be due to herding of yellowtail by the doors combined with the high selectivity of the DFO net for yellowtail. Back-calculated partial recruitment patterns from the fishery are flat-topped due to the formulation of the VPA, but also show a decrease in selectivity of age 2 yellowtail in recent years most likely due to increased mesh size regulations (Figure C9).

Sensitivity Analyses

The two sensitivity analyses, including the 2008 DFO survey with and without the big tow, had similar precision in the estimates but quite different estimates 2007 F and SSB (Table C8). Both sensitivity runs resulted in higher estimates of 2007 F. While this was expected for the run without the big tow, the increase in F when the big tow was included is due to the lack of age 6+ fish in the big tow requiring a high F. The SSB increased when the big tow was included and decreased when in was not, due mainly to the change in strength of the 2005 year class, as seen in the estimates of age 1 recruitment in 2006. Both sensitivity runs had relatively large residuals for the 2008 DFO survey and so were not pursued further.

5.0 Biological Reference Points

Method and Special Considerations

As in previous assessments, the estimated stock and recruitment values did not follow a parametric relationship (Figure C10) and so the non-parametric approach was undertaken. Hindcast recruitment estimates were derived by regressing the estimated numbers of recruits from the stock assessments on the NEFSC Fall survey index at age 1 (Figure C11). Following the recommendation of the GARM III Biological Reference Points review (GARM 2008b), recruitment values were split into two groups based on the associated spawning stock biomass levels being above or below 5000 mt and used to estimate the SSB_{MSY} and MSY proxies.

Use of historical hindcast recruitment implies that the productivity conditions have not changed over the long term. The GARM III Biological Reference Points Panel recommended that the hindcast recruitment values be checked for consistency with the catch which occurred during those years. This check was done by averaging the recruitment and catch values for years 1963-1972, averaging the first five years of partial recruitment and weight at age in the VPA, and solving for the resulting full F. The full F estimated was 0.78, quite similar to the level in the earliest years of the VPA, thus confirming that the hindcast estimates of recruitment are reasonable.

Recent five year averages of partial recruitment, maturity, and weight at age were used in yield per recruit analysis to estimate $F_{40\%MSP}$ as a proxy for F_{MSY} (Table C14). Applying F_{MSY} for 100 years in stochastic projections, while sampling recruitment from the empirical distribution described above, allowed estimation of SSB_{MSY} and MSY as the median values at the end of the 100 year projections (see Legault 2008).

Final Values: F_{MSY}, SB_{MSY}, and MSY

The estimated values of F_{MSY} (0.254), SSB_{MSY} (43200 mt), and MSY (9400 mt) are quite similar those from the GARM III Biological Reference Points meeting and slightly different from the GARM II meeting (Table C15). The change in SSB_{MSY} and MSY from GARM II to GARM III is due to the change from the Base Case formulation to the Major Change formulation resulting in lower recruitments in recent years. Dividing the 2007 values of F and SSB by F_{MSY} and SSB_{MSY}, respectively, results in a current status of overfishing ($F2007/F_{MSY} > 1.0$) and overfished ($SSB2007/SSB_{MSY} < 0.5$) (Figure C12).

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 C14). The population abundance at age at the start of 2008 was derived from the bootstrap results, with the recruitment estimate generated as the geometric mean of the estimated recruitments during 1973-2007 from each bootstrap solution. Catch in 2008 was assumed equal to the catch in 2007 (1686 mt).

$F_{REBUILD}$

Georges Bank yellowtail flounder is currently in a rebuilding plan with end date of 2014. The $F_{REBUILD}$ was found by iteratively solving for the F which applied in years 2009-2014 resulted in median 2014 SSB equal to SSB_{MSY}.

Projected Catch in 2009 for GARM III

Median catch in 2009 was estimated under three scenarios for F in 2009: 1) $F_{STATUS\ QUO}$, meaning the F2009 is set equal to F2007, 2) F_{MSY}, and 3) $F_{REBUILD}$ (Table C16). All three scenarios estimated catch much higher than the 2007 catch while still allowing SSB to more than double relative to the 2007 value due to the progression of the 2005 year class through the fishery. Note that neither the $F_{STATUS\ QUO}$ nor the F_{MSY} projections would result in rebuilding to SSB_{MSY} with at least 50% probability by 2014.

TRAC and NEFMC Projections

The Transboundary Resource Assessment Committee (TRAC) met via conference call the week after the GARM III Stock Assessment meeting to review the Georges Bank yellowtail flounder assessment. At this meeting, some variations on the projections were requested to conform to standard procedures in the TRAC and the 75% probability level or rebuilding agreed to by the New England Fishery Management Council. Specifically, the 2008 recruitment values in the bootstrapped VPA were filled by the geometric mean for years 1998-2007 instead of the GARM III approach of using the geometric mean of the entire time series. This resulted in only a minor change to the point estimate (19.002 million using 1998-2007, 19.120 million using 1973-2007) but the 80% confidence interval was much wider using the shorter time series (17.630-20.632 million using 1998-2007, 18.715-19.575 using 1973-2007) due to the convergence properties of VPA. Additionally, the 2008 catch was set equal to the quota for that year (2,500 mt) instead of set equal to the 2007 catch as in the GARM III projections.

Two projections were conducted: 1) F_{ref} where F in years 2009-2014 is set equal to the TRAC F_{ref} of 0.25 and 2) F_{reb75} where a constant F in years 2009-2014 is calculated to achieve SSB_{MSY} in 2014 with 75% probability (the probability level agreed to by the New England Fishery Management Council) (Table C17). The median catch in 2009 is quite different in these two projections, 4648 mt using Fref and 2114 mt using Freb75. The median SSB in 2014 also differs in these two projections, 39,000 mt using Fref and 53,200 mt using F_{reb75}. Catches lower than those associated with fishing at Fref are required to meet the USA rebuilding plan.

Additionally, a risk plot was created for the TRAC projections by setting catch in 2009 to different levels and determining the probability of F in 2009 exceeding Fref = 0.25 (Table C18; Figure C13). In these same projections, the percent change in median adult biomass (age 3+) from 2009 to 2010 was calculated as a proxy for the risk of a biomass change under different catch levels (Table C18). These results confirm that a catch of about 4600 mt in 2009 is risk neutral and is expected to be associated with an increase in adult biomass from 2009 to 2010 of about 9%.

Finally, due to the changes observed in age 3 partial recruitment in the fishery in recent years and the important of the 2005 year class at age 3 in 2008, a sensitivity analysis was conducted that examined the impact of different age 3 PR in the projections. The age 3 PR was 64.9% based on the average of the last five years. Projections were conducted which set the age 3 PR to 40% and 90% (Table C19). The changes in 2009 catch, 2008 F and 2009 SSB were not great and changed in the direction expected. Lower age 3 PR meant that the 2005 year class was less heavily fished in 2008 forcing a higher fishing mortality rate on ages 4+ (but still below Fref). This higher fishing mortality rate reduced the adult population and the lower PR at age 3 caused 2009 catches to be lower. However, the slight protection of the 2005 year class in 2008, due to the lower PR at age 3, caused the 2009 SSB to be larger.

7.0 Summary

Georges Bank yellowtail flounder continues to be overfished ($SSB2007/SSB_{MSY}$ = 0.22) and overfishing is continuing ($F2007/ F_{MSY}$ = 1.14). However, the trend in F is down and SSB is should continue to increase as the strong 2005 year class progresses through the fishery. The Major Change formulation continues to be recommended as the basis for management because of the strong retrospective pattern in the Base Case formulation. The 2008 DFO survey was not included in the reference case due to a single large tow of yellowtail which resulted in substantial increase of abundance for all ages from 2 to 5, inconsistent with stock dynamics and indicative that the tow results were outliers. The major source of uncertainty in this assessment continues to be the inability of the Base Case formulation to produce consistent results as exhibited by the retrospective pattern. Although the Major Change formulation reduces the retrospective pattern, the three bottom trawl surveys have not changed operating procedures and are not expected to have a change in catchability. Thus, the change in q is aliasing some other mechanism, such as changes in catch estimation or natural mortality rate.

8.0 Panel Discussion/Comments

Conclusions

The Panel accepted the split survey VPA formulation ,after exclusion of the 2008 Canadian survey, as Final and the best available estimate of stock status and a sufficient basis for management advice. It noted, however, that while this split reduced the retrospective pattern, it did not address the underlying cause. The exclusion of the 2008 Canadian survey estimate from the assessment was due to the presence of one tow over 7.5 mt. This exclusion was consistent with the recent TRAC advice.

Hindcast recruitment estimates were accepted for 1963 – 72 when the US fall survey index was available but VPA estimates were not. An analysis, as recommended by the GARM III ‘models’ review, confirmed that the estimated year-classes could support the observed catch during this period at a moderate F of 0.78.

The Panel recommended that the $F_{REBUILD}$ forecast use the same recruitment assumptions as for the BRP estimation but also sample from recruitment estimates below the SSB breakpoint of 5,000t. It was noted that the reduction of B_{MSY} and MSY estimates between GARM II and GARM III was due to reduced recruitment estimates in the current assessment, this due to splitting the survey time series.

It was also noted that using the split formulation still resulted in a small retrospective pattern in the estimates of recent SSB; suggesting that SSB may still be overestimated.

Research Recommendations

The Panel had no specific research recommendations for this stock.

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Table C1. Landings, discards, total catch (metric tons), and proportion of total catch which is discards for Georges Bank yellowtail flounder.

Year	US Landings	US Discards	Canada Landings	Canada Discards	Other Landings	Total Catch	% discards
1935	300	100	0	0	0	400	25%
1936	300	100	0	0	0	400	25%
1937	300	100	0	0	0	400	25%
1938	300	100	0	0	0	400	25%
1939	375	125	0	0	0	500	25%
1940	600	200	0	0	0	800	25%
1941	900	300	0	0	0	1200	25%
1942	1575	525	0	0	0	2100	25%
1943	1275	425	0	0	0	1700	25%
1944	1725	575	0	0	0	2300	25%
1945	1425	475	0	0	0	1900	25%
1946	900	300	0	0	0	1200	25%
1947	2325	775	0	0	0	3100	25%
1948	5775	1925	0	0	0	7700	25%
1949	7350	2450	0	0	0	9800	25%
1950	3975	1325	0	0	0	5300	25%
1951	4350	1450	0	0	0	5800	25%
1952	3750	1250	0	0	0	5000	25%
1953	2925	975	0	0	0	3900	25%
1954	2925	975	0	0	0	3900	25%
1955	2925	975	0	0	0	3900	25%
1956	1650	550	0	0	0	2200	25%
1957	2325	775	0	0	0	3100	25%
1958	4575	1525	0	0	0	6100	25%
1959	4125	1375	0	0	0	5500	25%
1960	4425	1475	0	0	0	5900	25%
1961	4275	1425	0	0	0	5700	25%
1962	5775	1925	0	0	0	7700	25%
1963	10990	5600	0	0	100	16690	34%
1964	14914	4900	0	0	0	19814	25%
1965	14248	4400	0	0	800	19448	23%
1966	11341	2100	0	0	300	13741	15%
1967	8407	5500	0	0	1400	15307	36%
1968	12799	3600	122	0	1800	18321	20%
1969	15944	2600	327	0	2400	21271	12%
1970	15506	5533	71	0	300	21410	26%
1971	11878	3127	105	0	500	15610	20%
1972	14157	1159	8	515	2200	18039	9%
1973	15899	364	12	378	300	16953	4%
1974	14607	980	5	619	1000	17211	9%
1975	13205	2715	8	722	100	16750	21%
1976	11336	3021	12	619	0	14988	24%
1977	9444	567	44	584	0	10639	11%
1978	4519	1669	69	687	0	6944	34%
1979	5475	720	19	722	0	6935	21%
1980	6481	382	92	584	0	7539	13%
1981	6182	95	15	687	0	6979	11%
1982	10621	1376	22	502	0	12520	15%
1983	11350	72	106	460	0	11989	4%
1984	5763	28	8	481	0	6280	8%
1985	2477	43	25	722	0	3267	23%
1986	3041	19	57	357	0	3474	11%
1987	2742	233	69	536	0	3580	21%
1988	1866	252	56	584	0	2759	30%
1989	1134	73	40	536	0	1783	34%
1990	2751	818	25	495	0	4089	32%
1991	1784	246	81	454	0	2564	27%
1992	2859	1873	65	502	0	5299	45%
1993	2089	1089	682	440	0	4300	36%
1994	1431	158	2139	440	0	4167	14%
1995	360	38	464	268	0	1130	27%
1996	743	71	472	388	0	1675	27%
1997	888	58	810	438	0	2194	23%
1998	1619	116	1175	708	0	3619	23%
1999	1818	484	1971	597	0	4870	22%
2000	3373	408	2859	415	0	7055	12%
2001	3613	337	2913	815	0	7677	15%
2002	2476	248	2642	493	0	5859	13%
2003	3236	373	2107	809	0	6525	18%
2004	5837	549	96	422	0	6905	14%
2005	3161	476	30	255	0	3922	19%
2006	1196	377	25	565	0	2162	44%
2007	1061	503	17	105	0	1686	36%

Table C2. Georges Bank US landings (metric tons) and number of lengths available from port samples by half year and market category along with number of ages available for age-length key and number of lengths sampled per 100 metric tons.

		Landings (metric tons)					Number of Lengths					Number	Lengths /
Year	half	unclass	large	small	medium	Total	unclass	large	small	medium	Total	of Ages	100 mt
1994	1	5	109	58		172							
	2	1	664	593		1258		517	724		1241		
	Total	7	773	650		1431		517	724		1241	302	87
1995	1	1	114	76		191		411	475		886		
	2	2	80	87		169		92	131		223		
	Total	3	195	162		360		503	606		1109	284	308
1996	1	1	382	161		544		254	250		504		
	2	2	102	95	0	199		192	268		460		
	Total	3	485	256	0	743		446	518		964	260	130
1997	1	10	428	169	0	607		628	1072		1700		
	2	3	179	99		281		91	121		212		
	Total	14	607	268	0	888		719	1193		1912	508	215
1998	1	43	383	141		567		555	490		1045		
	2	26	448	577		1052		199	85		284		
	Total	69	832	718		1619		754	575		1329	293	82
1999	1	39	679	296		1014		435	451		886		
	2	25	536	243	0	804		137	125		262		
	Total	63	1215	539	0	1818		572	576		1148	213	63
2000	1	55	1454	520	0	2029	114	526	260		900		
	2	38	885	420		1344	300	543	595		1438		
	Total	94	2339	941	0	3373	414	1069	855		2338	529	69
2001	1	98	1887	585		2570		1015	592		1607		
	2	31	777	235		1043		459	958		1417		
	Total	128	2664	820		3613		1474	1550		3024	702	84
2002	1	45	1679	356	0	2080		780	357		1137		
	2	10	271	115	0	396		680	327		1007		
	Total	55	1950	471	0	2476		1460	684		2144	543	87
2003	1	31	1586	457		2074		1276	994		2270		
	2	7	897	258		1162		1244	1028		2272		
	Total	37	2483	715		3236		2520	2022		4542	1144	140
2004	1	52	2477	439	4	2972		3249	2314		5563		
	2	29	2132	684	20	2865		1565	1362		2927		
	Total	81	4609	1123	24	5837		4814	3676		8490	1699	145
2005	1	17	851	497	9	1374		2351	1282		3633		
	2	21	1114	639	12	1787	93	2636	1686		4415		
	Total	38	1965	1136	22	3161	93	4987	2968		8048	1798	255
2006	1	24	580	170	7	781	128	3183	2447		5758		
	2	6	248	155	7	415		2147	1600		3747		
	Total	29	827	325	14	1196	128	5330	4047		9505	2248	795
2007	1	25	470	240	14	749		2844	2025		4869		
	2	5	159	144	5	312		1221	732		1953		
	Total	30	628	384	19	1061		4065	2757		6822	1457	643
Grand Total		652	21573	8509	79	30812	635	29230	22751		52616	11980	171

Table C3. Georges Bank yellowtail flounder coefficient of variation for US landings at age by year.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1994		57%	6%	14%	27%	41%
1995		27%	11%	13%	22%	40%
1996		23%	7%	15%	26%	60%
1997		17%	11%	8%	30%	35%
1998		64%	31%	16%	36%	30%
1999	97%	21%	9%	25%	33%	34%
2000		11%	9%	11%	20%	32%
2001		17%	11%	10%	22%	48%
2002	76%	15%	11%	11%	15%	22%
2003		16%	8%	9%	11%	16%
2004		53%	8%	6%	9%	11%
2005		11%	4%	6%	12%	16%
2006		10%	5%	6%	6%	13%
2007		12%	5%	6%	14%	18%

Table C4. Georges Bank yellowtail flounder US discards (metric tons) and coefficient of variation by gear and year.

	Otter Trawl Large Mesh		Otter Trawl Small Mesh		Scallop Dredge	
Year	D (mt)	CV	D (mt)	CV	D (mt)	CV
1994	138	150%	0	0%	10	6%
1995	36	70%	0	0%	7	20%
1996	51	30%	0	0%	45	0%
1997	211	22%	0	0%	117	74%
1998	185	66%	0	0%	297	46%
1999	11	67%	0	0%	566	13%
2000	25	71%	0	90%	669	12%
2001	50	51%	0	105%	28	7%
2002	24	42%	0	79%	29	27%
2003	115	39%	1	95%	293	0%
2004	324	20%	55	62%	81	21%
2005	177	12%	52	28%	186	20%
2006	107	14%	26	95%	251	19%
2007	270	12%	111	107%	121	25%

Table C5a. Georges Bank yellowtail flounder landings at age (thousands of fish).

Year	age1	age2	age3	age4	age5	age6+
1973	0	3840	13086	9281	3746	1618
1974	180	6299	7821	7400	3545	1478
1975	427	16861	6947	3393	2085	1150
1976	43	19341	5091	1348	533	869
1977	31	6647	9851	1729	396	477
1978	0	2172	4030	1685	466	176
1979	17	6827	3408	1246	552	273
1980	0	2405	8819	1439	326	100
1981	6	480	5279	4566	798	126
1982	217	13159	7075	3252	1033	84
1983	241	7739	16166	2338	631	128
1984	244	1916	4272	4741	1594	321
1985	375	3369	824	659	414	66
1986	92	5841	996	354	164	77
1987	15	1865	2798	780	135	114
1988	0	1700	1217	643	170	39
1989	0	1385	688	271	70	20
1990	0	742	4624	745	106	20
1991	0	28	906	2358	302	63
1992	0	3256	1934	1203	513	28
1993	5	655	2398	1889	342	79
1994	44	936	5971	1715	435	136
1995	6	183	1020	646	119	26
1996	2	368	1513	604	133	19
1997	35	399	1188	1456	268	70
1998	23	784	2402	1452	938	67
1999	17	1562	3347	1282	644	230
2000	63	3213	4952	2703	697	387
2001	111	2434	6093	2587	894	458
2002	169	3845	3041	1728	604	430
2003	85	2897	3638	1950	660	607
2004	0	380	2474	3454	1842	1355
2005	0	932	3319	1501	336	158
2006	0	336	796	628	277	169
2007	3	332	1143	565	121	49

Table C5b. Georges Bank yellowtail flounder discards at age (thousands of fish).

Year	age1	age2	age3	age4	age5	age6+
1973	359	1335	479	192	69	31
1974	2187	3201	473	258	97	42
1975	4209	9533	428	147	90	58
1976	592	12597	411	77	42	49
1977	347	2447	716	117	23	18
1978	9962	1370	549	229	74	34
1979	304	3689	382	186	71	52
1980	318	1590	866	99	26	12
1981	101	617	684	354	57	19
1982	1946	4933	405	149	62	12
1983	462	259	495	138	49	26
1984	270	102	263	302	202	58
1985	596	1004	233	160	102	15
1986	87	562	131	35	40	36
1987	141	1420	338	203	57	23
1988	499	1303	327	203	57	14
1989	190	791	433	157	40	11
1990	231	1373	2372	234	34	6
1991	663	119	585	653	81	8
1992	2414	5912	1037	270	90	14
1993	5229	731	928	436	69	11
1994	27	401	331	104	41	7
1995	41	130	416	232	51	11
1996	99	313	551	281	68	9
1997	47	733	645	400	111	20
1998	146	1207	986	433	183	79
1999	43	1191	848	266	149	72
2000	68	650	762	470	130	141
2001	65	449	863	306	109	67
2002	42	324	406	188	79	55
2003	75	1022	1072	370	123	86
2004	64	821	697	349	128	95
2005	60	597	767	211	76	20
2006	154	965	902	375	96	45
2007	50	1131	622	135	22	8

Table C5c. Georges Bank yellowtail flounder catch at age (thousands of fish).

Year	age1	age2	age3	age4	age5	age6+
1973	359	5175	13565	9473	3815	1650
1974	2368	9500	8294	7658	3643	1520
1975	4636	26394	7375	3540	2175	1207
1976	635	31938	5502	1426	574	918
1977	378	9094	10567	1846	419	495
1978	9962	3542	4580	1914	540	211
1979	321	10517	3789	1432	623	325
1980	318	3994	9685	1538	352	113
1981	107	1097	5963	4920	854	145
1982	2164	18091	7480	3401	1095	96
1983	703	7998	16661	2476	680	155
1984	514	2018	4535	5043	1796	379
1985	970	4374	1058	818	517	81
1986	179	6402	1127	389	204	113
1987	156	3284	3137	983	192	137
1988	499	3003	1544	846	227	53
1989	190	2175	1121	428	110	30
1990	231	2114	6996	978	140	26
1991	663	147	1491	3011	383	71
1992	2414	9167	2971	1473	603	42
1993	5233	1386	3327	2326	411	91
1994	71	1336	6302	1819	477	144
1995	47	313	1435	879	170	37
1996	101	681	2064	885	201	28
1997	82	1132	1832	1857	378	90
1998	169	1991	3388	1885	1121	146
1999	60	2753	4195	1548	794	301
2000	132	3864	5714	3173	826	528
2001	176	2884	6956	2893	1004	525
2002	212	4169	3446	1916	683	485
2003	160	3919	4710	2320	782	693
2004	64	1201	3171	3804	1970	1451
2005	60	1529	4086	1712	411	178
2006	154	1300	1698	1003	373	214
2007	53	1464	1765	700	142	58

Table C6a. Georges Bank yellowtail flounder catch weight at age (kg).

Year	age1	age2	age3	age4	age5	age6+
1973	0.101	0.348	0.462	0.527	0.603	0.778
1974	0.115	0.344	0.496	0.607	0.678	0.832
1975	0.113	0.316	0.489	0.554	0.619	0.695
1976	0.108	0.312	0.544	0.635	0.744	0.861
1977	0.116	0.342	0.524	0.633	0.780	0.931
1978	0.102	0.314	0.510	0.690	0.803	0.970
1979	0.114	0.329	0.462	0.656	0.736	0.950
1980	0.101	0.322	0.493	0.656	0.816	1.072
1981	0.122	0.335	0.489	0.604	0.707	0.840
1982	0.115	0.301	0.485	0.650	0.754	1.082
1983	0.140	0.296	0.441	0.607	0.740	1.010
1984	0.162	0.239	0.379	0.500	0.647	0.797
1985	0.181	0.361	0.505	0.642	0.729	0.800
1986	0.181	0.341	0.540	0.674	0.854	1.015
1987	0.121	0.324	0.524	0.680	0.784	0.875
1988	0.103	0.328	0.557	0.696	0.844	0.975
1989	0.100	0.327	0.520	0.720	0.866	1.053
1990	0.105	0.290	0.395	0.585	0.693	0.845
1991	0.121	0.237	0.369	0.486	0.723	0.877
1992	0.101	0.293	0.365	0.526	0.651	1.110
1993	0.100	0.285	0.379	0.501	0.564	0.863
1994	0.193	0.260	0.353	0.472	0.621	0.775
1995	0.174	0.275	0.347	0.465	0.607	0.768
1996	0.119	0.276	0.407	0.552	0.707	1.012
1997	0.214	0.302	0.408	0.538	0.718	0.947
1998	0.178	0.305	0.428	0.546	0.649	0.966
1999	0.202	0.368	0.495	0.640	0.755	0.901
2000	0.229	0.383	0.480	0.615	0.766	0.954
2001	0.251	0.362	0.460	0.612	0.812	1.027
2002	0.282	0.381	0.480	0.665	0.833	1.068
2003	0.228	0.359	0.474	0.653	0.824	1.048
2004	0.211	0.296	0.440	0.586	0.728	0.956
2005	0.119	0.341	0.445	0.594	0.767	0.997
2006	0.100	0.309	0.411	0.555	0.760	0.998
2007	0.148	0.288	0.406	0.536	0.764	1.002

Table C6b. Georges Bank yellowtail flounder beginning of year weight at age (kg).

Year	age1	age2	age3	age4	age5	age6+
1973	0.055	0.292	0.403	0.465	0.564	0.778
1974	0.069	0.186	0.416	0.530	0.598	0.832
1975	0.068	0.191	0.410	0.524	0.613	0.695
1976	0.061	0.188	0.415	0.557	0.642	0.861
1977	0.071	0.192	0.404	0.587	0.704	0.931
1978	0.057	0.191	0.418	0.601	0.713	0.970
1979	0.068	0.183	0.381	0.578	0.713	0.950
1980	0.056	0.192	0.403	0.551	0.732	1.072
1981	0.078	0.184	0.397	0.546	0.681	0.840
1982	0.072	0.192	0.403	0.564	0.675	1.082
1983	0.107	0.185	0.364	0.543	0.694	1.010
1984	0.109	0.183	0.335	0.470	0.627	0.797
1985	0.132	0.242	0.347	0.493	0.604	0.800
1986	0.135	0.248	0.442	0.583	0.741	1.015
1987	0.074	0.242	0.423	0.606	0.727	0.875
1988	0.058	0.199	0.425	0.604	0.758	0.975
1989	0.059	0.184	0.413	0.633	0.776	1.053
1990	0.070	0.170	0.359	0.552	0.706	0.845
1991	0.078	0.158	0.327	0.438	0.650	0.877
1992	0.060	0.188	0.294	0.441	0.563	1.110
1993	0.062	0.170	0.333	0.428	0.545	0.863
1994	0.162	0.161	0.317	0.423	0.558	0.775
1995	0.138	0.230	0.300	0.405	0.535	0.768
1996	0.075	0.219	0.335	0.438	0.573	1.012
1997	0.179	0.190	0.336	0.468	0.630	0.947
1998	0.124	0.256	0.360	0.472	0.591	0.966
1999	0.147	0.256	0.389	0.523	0.642	0.901
2000	0.182	0.278	0.420	0.552	0.700	0.954
2001	0.204	0.288	0.420	0.542	0.707	1.027
2002	0.250	0.309	0.417	0.553	0.714	1.068
2003	0.200	0.318	0.425	0.560	0.740	1.048
2004	0.166	0.260	0.397	0.527	0.690	0.956
2005	0.074	0.268	0.363	0.511	0.670	0.997
2006	0.059	0.192	0.374	0.497	0.672	0.998
2007	0.129	0.170	0.354	0.469	0.651	1.002
2008	0.087	0.210	0.364	0.493	0.665	0.999

Table C7a. NEFSC Spring survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in 000s of fish and metric tons.

Year	age1	age2	age3	age4	age5	age6+	B (mt)
1973	1882.9	3184.3	2309.4	1036.7	399.4	210.2	2852.2
1974	308.2	2168.5	1795.5	1225.0	336.9	273.8	2639.6
1975	409.2	2918.0	809.1	262.6	201.5	86.3	1626.4
1976	1008.4	4259.0	1216.0	302.4	191.2	108.4	2205.8
1977	0.0	654.0	1097.7	363.7	81.9	12.8	969.8
1978	912.2	778.4	494.4	213.9	25.7	7.7	719.8
1979	394.0	1956.8	395.2	328.3	58.7	88.7	1233.8
1980	55.3	4528.6	5617.2	460.6	55.0	35.3	4325.1
1981	11.4	995.9	1724.2	698.9	206.9	56.9	1902.8
1982	44.1	3656.5	1096.5	992.5	444.5	88.3	2426.3
1983	0.0	1810.0	2647.8	514.4	119.6	237.3	2564.2
1984	0.0	90.3	806.0	837.9	810.4	236.5	1597.6
1985	106.4	2134.2	254.4	273.4	143.4	0.0	959.0
1986	26.6	1753.0	282.6	54.6	132.9	53.2	822.5
1987	26.6	73.3	133.0	129.3	51.0	53.2	319.2
1988	75.5	266.9	355.2	234.7	193.2	26.6	549.1
1989	45.2	391.3	737.7	281.0	59.3	43.5	707.7
1990	0.0	63.7	1074.7	358.4	112.2	100.8	678.3
1991	422.5	0.0	246.9	665.1	255.5	20.0	612.5
1992	0.0	1987.7	1840.7	621.8	160.0	16.7	1520.1
1993	44.7	281.1	485.8	307.9	26.0	0.0	467.9
1994	0.0	602.3	614.7	343.6	140.4	38.7	641.1
1995	39.0	1144.6	4670.4	1441.7	621.5	9.5	2503.6
1996	24.4	958.1	2548.6	2621.8	591.6	56.2	2769.3
1997	18.2	1134.5	3623.1	3960.7	682.3	129.7	4230.6
1998	0.0	2020.1	1022.2	1123.4	737.1	339.6	2255.8
1999	48.7	4606.3	10501.7	2640.5	1575.2	756.3	9033.4
2000	177.3	4677.6	7440.5	2828.5	789.2	508.4	6498.9
2001	0.0	2246.7	6370.5	2340.0	469.2	439.7	4858.8
2002	182.4	2341.5	11971.1	3958.4	1690.3	845.4	9281.7
2003	196.1	4241.4	6564.9	2791.9	428.6	836.9	6524.2
2004	47.1	957.3	2114.4	659.9	247.7	263.8	1835.3
2005	0.0	1953.5	4931.0	2332.7	261.8	111.4	3307.2
2006	493.5	907.8	3419.2	2112.7	307.7	79.8	2349.3
2007	87.1	4899.7	6079.1	2762.3	540.0	125.2	4563.3
2008	0.0	2206.7	4921.5	1681.1	300.3	26.6	3151.6

Table C7b. NEFSC Fall survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in 000s of fish and metric tons.

Year	age1	age2	age3	age4	age5	age6+	B (mt)
1973.5	2420.4	5336.0	4954.5	2857.4	1181.2	599.9	6299.2
1974.5	4486.7	2779.5	1471.6	1029.1	444.3	368.1	3560.7
1975.5	4548.6	2437.3	851.7	555.2	324.4	61.1	2257.4
1976.5	333.5	1863.9	460.3	113.6	118.5	97.3	1463.3
1977.5	906.7	2147.1	1572.8	615.4	102.3	105.7	2699.0
1978.5	4620.6	1243.3	757.2	399.2	131.6	34.9	2274.3
1979.5	1282.0	2008.5	253.7	116.7	134.3	108.6	1450.4
1980.5	743.6	4970.0	5912.0	662.0	212.3	250.9	6412.4
1981.5	1548.2	2279.4	1592.8	570.5	76.4	52.8	2500.1
1982.5	2353.3	2120.3	1543.4	410.4	86.6	0.0	2203.3
1983.5	105.7	2216.4	1858.5	495.7	29.9	47.7	2068.5
1984.5	641.6	388.1	296.7	236.0	72.7	60.7	575.8
1985.5	1310.2	527.5	165.9	49.1	78.3	0.0	688.4
1986.5	273.4	1075.1	338.7	71.9	0.0	0.0	795.5
1987.5	98.7	388.8	384.6	51.4	77.1	0.0	493.9
1988.5	18.2	206.7	104.0	26.6	0.0	0.0	165.5
1989.5	241.0	1934.1	750.4	76.6	54.0	0.0	948.1
1990.5	0.0	359.2	1429.9	285.8	0.0	0.0	703.2
1991.5	2038.8	267.0	426.2	347.2	0.0	0.0	708.4
1992.5	146.8	383.9	691.0	157.1	139.4	26.6	559.2
1993.5	814.6	135.2	568.8	520.4	0.0	21.4	529.5
1994.5	1159.8	214.6	954.1	692.2	254.9	54.8	870.7
1995.5	267.7	115.4	335.2	267.2	44.6	12.1	343.7
1996.5	144.3	341.3	1813.8	433.5	72.7	0.0	1264.6
1997.5	1351.8	517.7	3341.0	2028.5	1039.8	79.8	3669.7
1998.5	1844.4	4675.3	4078.9	1154.6	289.5	71.7	4219.7
1999.5	2998.7	8175.9	5558.9	1390.3	1394.2	252.8	7738.3
2000.5	610.8	1647.5	4672.5	2350.3	919.7	802.6	5666.1
2001.5	3414.2	6083.6	7853.7	2524.8	1667.8	1988.2	11213.4
2002.5	2031.4	5581.8	2064.5	576.1	295.6	26.6	3643.9
2003.5	1045.3	4882.8	2725.9	548.0	97.0	185.7	3919.2
2004.5	850.3	5346.1	4862.4	2044.4	897.1	170.7	4966.4
2005.5	304.0	2033.6	3652.1	595.9	179.3	0.0	2390.6
2006.5	6012.1	6067.2	3556.7	1132.9	247.7	44.4	4388.4
2007.5	1026.5	11110.9	7634.7	1939.6	371.3	90.9	7911.6

Table C7c. DFO Spring survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in 000s of fish and metric tons. Note that two vectors are presented for 2008: 2008a includes the large tow while 2008b does not.

Year	age1	age2	age3	age4	age5	age6+	B (mt)
1987	75.2	751.1	1238.5	309.7	54.9	30.9	785.9
1988	0.0	1116.5	801.9	383.6	174.9	14.8	776.7
1989	71.8	645.8	383.2	185.2	41.8	14.1	295.9
1990	0.0	1500.9	2281.1	575.0	131.3	8.6	951.2
1991	15.4	539.6	745.8	2364.1	330.3	9.1	1105.6
1992	34.8	6942.1	2312.0	622.4	219.8	18.8	1556.7
1993	49.4	1528.8	2568.8	2562.9	557.5	81.8	1661.3
1994	0.0	3808.4	2178.6	1890.1	491.4	130.0	1731.4
1995	132.0	786.5	2737.4	1600.8	406.6	63.6	1274.6
1996	280.5	4491.0	5769.2	3399.8	726.5	77.2	3334.9
1997	13.6	7849.2	8742.1	10293.6	2543.2	421.5	8359.0
1998	561.7	2094.3	3085.9	2725.6	1250.4	351.2	2699.4
1999	99.8	13118.5	13101.2	4822.9	3364.5	1383.5	11109.4
2000	6.8	8655.8	17256.5	12100.9	3187.6	2319.8	12544.7
2001	183.3	12511.6	26489.4	8368.0	2881.0	1507.2	13933.8
2002	55.5	7522.3	19503.3	7693.6	3491.7	1781.4	13016.4
2003	56.3	7476.4	15480.7	6971.1	2151.0	1249.9	10217.8
2004	20.6	2263.5	10225.3	5788.7	1429.2	890.5	5693.4
2005	377.3	1007.5	17581.9	12931.4	3581.9	983.8	8399.2
2006	391.5	3076.8	11696.4	4132.7	515.4	149.4	4137.0
2007	108.9	7646.4	17423.7	8048.5	1439.1	156.2	8391.2
2008a	0.0	30382.5	107131.7	35919.3	5067.8	34.5	42333.4
2008b	0.0	2907.3	6882.8	1964.6	367.1	35.9	4104.4

Table C7d. NEFSC Scallop survey index of abundance (stratified mean catch/tow) for Georges Bank yellowtail flounder.

Year	age 1	Year	age 1
1982.5	0.313	1995.5	0.609
1983.5	0.140	1996.5	0.508
1984.5	0.233	1997.5	1.062
1985.5	0.549	1998.5	1.872
1986.5	0.103	1999.5	1.038
1987.5	0.047	2000.5	0.912
1988.5	0.116	2001.5	0.789
1989.5	0.195	2002.5	1.005
1990.5	0.100	2003.5	0.880
1991.5	2.117	2004.5	0.330
1992.5	0.167	2005.5	0.573
1993.5	1.129	2006.5	2.422
1994.5	1.503		

Table C8. Mohn's rho retrospective statistic for F, SSB, and R.

	Major Change			**Base Case**		
Peel	**F**	**SSB**	**R**	**F**	**SSB**	**R**
2000	-37%	89%	90%	-80%	312%	146%
2001	-57%	115%	68%	-88%	416%	162%
2002	13%	23%	143%	-80%	266%	253%
2003	136%	-25%	35%	-45%	110%	90%
2004	4%	57%	-4%	-41%	168%	-16%
2005	5%	36%	-40%	-52%	101%	-45%
2006	-5%	13%	22%	-32%	21%	9%
Average	**8%**	**44%**	**45%**	**-60%**	**199%**	**86%**

Table C9. Diagnostics for VPA estimates.

Stock Numbers Predicted in Terminal Year Plus One (2008)

	No 2008 DFO			With Big Tow			Without Big Tow		
Age	N	Std. Error	CV	N	Std. Error	CV	N	Std. Error	CV
2	14994	6927	0.46	24272	9838	0.41	12568	5109	0.41
3	31704	9893	0.31	36110	10611	0.29	23866	7114	0.30
4	5339	1845	0.35	6462	2014	0.31	3969	1350	0.34
5	1875	476	0.25	1496	374	0.25	1097	293	0.27

Catchabiility Values for Each Survey Used in Estimate

	No 2008 DFO			With Big Tow			Without Big Tow		
Index	Catchability	Std. Error	CV	Catchability	Std. Error	CV	Catchability	Std. Error	CV
USsearly 1	0.007	0.005	0.66	0.007	0.005	0.66	0.007	0.005	0.66
USsearly 2	0.076	0.014	0.19	0.076	0.014	0.19	0.076	0.014	0.19
USsearly 3	0.096	0.017	0.18	0.096	0.017	0.18	0.096	0.017	0.18
USsearly 4	0.093	0.012	0.12	0.093	0.012	0.12	0.093	0.012	0.12
USsearly 5	0.076	0.015	0.20	0.076	0.015	0.20	0.076	0.015	0.20
USsearly 6	0.072	0.023	0.31	0.072	0.023	0.31	0.072	0.023	0.31
USspr 1	0.004	0.001	0.25	0.004	0.001	0.25	0.004	0.001	0.25
USspr 2	0.046	0.014	0.32	0.046	0.014	0.32	0.046	0.014	0.32
USspr 3	0.095	0.015	0.16	0.095	0.015	0.16	0.095	0.015	0.16
USspr 4	0.152	0.020	0.13	0.152	0.020	0.13	0.152	0.020	0.13
USspr 5	0.229	0.046	0.20	0.229	0.046	0.20	0.229	0.046	0.20
USspr 6	0.423	0.093	0.22	0.423	0.093	0.22	0.423	0.093	0.22
USspr95 1	0.005	0.001	0.30	0.004	0.001	0.30	0.005	0.002	0.31
USspr95 2	0.144	0.017	0.11	0.137	0.017	0.13	0.153	0.017	0.11
USspr95 3	0.500	0.088	0.18	0.495	0.090	0.18	0.529	0.092	0.17
USspr95 4	0.593	0.099	0.17	0.596	0.104	0.18	0.631	0.109	0.17
USspr95 5	0.481	0.109	0.23	0.498	0.111	0.22	0.520	0.115	0.22
USspr95 6	0.391	0.092	0.24	0.405	0.091	0.23	0.423	0.090	0.21
USfall 1	0.040	0.010	0.25	0.040	0.010	0.25	0.040	0.010	0.25
USfall 2	0.088	0.014	0.16	0.088	0.014	0.16	0.088	0.014	0.16
USfall 3	0.150	0.016	0.11	0.150	0.016	0.11	0.150	0.016	0.11
USfall 4	0.156	0.022	0.14	0.156	0.022	0.14	0.156	0.022	0.14
USfall 5	0.205	0.041	0.20	0.205	0.041	0.20	0.205	0.041	0.20
USfall 6	0.306	0.065	0.21	0.306	0.065	0.21	0.306	0.065	0.21
USfall95 1	0.065	0.015	0.23	0.062	0.015	0.24	0.070	0.016	0.23
USfall95 2	0.212	0.074	0.35	0.210	0.072	0.35	0.225	0.080	0.36
USfall95 3	0.556	0.108	0.19	0.557	0.108	0.19	0.586	0.122	0.21
USfall95 4	0.471	0.083	0.18	0.484	0.088	0.18	0.501	0.097	0.19
USfall95 5	0.490	0.128	0.26	0.504	0.133	0.26	0.521	0.140	0.27
USfall95 6	0.362	0.131	0.36	0.372	0.135	0.36	0.386	0.140	0.36
Canada 2	0.145	0.046	0.32	0.145	0.046	0.32	0.145	0.046	0.32
Canada 3	0.232	0.034	0.14	0.232	0.034	0.14	0.232	0.034	0.14
Canada 4	0.389	0.072	0.19	0.389	0.072	0.19	0.389	0.072	0.19
Canada 5	0.436	0.097	0.22	0.436	0.097	0.22	0.436	0.097	0.22
Canada 6	0.253	0.064	0.25	0.253	0.064	0.25	0.253	0.064	0.25
Can95 2	0.312	0.067	0.21	0.341	0.076	0.22	0.321	0.062	0.19
Can95 3	1.297	0.200	0.15	1.375	0.213	0.15	1.210	0.229	0.19
Can95 4	1.660	0.227	0.14	1.843	0.289	0.16	1.586	0.263	0.17
Can95 5	1.512	0.277	0.18	1.632	0.294	0.18	1.414	0.293	0.21
Can95 6	1.170	0.213	0.18	0.984	0.249	0.25	1.032	0.240	0.23
Scall 1	2.33E-05	6.87E-06	0.29	2.33E-05	6.87E-06	0.29	2.33E-05	6.87E-06	0.29
Scall95 1	5.39E-05	4.69E-06	0.09	5.33E-05	4.73E-06	0.09	5.72E-05	4.74E-06	0.08
F2007	0.2892			0.3505			0.4523		
SSB2007	9527			10351			7053		
R2006	49437			56011			37743		
MSR	0.582			0.600			0.603		

Table C10. Estimated population abundance at age (000s).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1973	29384	24172	29516	17300	6966	3013	110351
1974	52184	23733	15136	12051	5732	2391	111229
1975	70632	40588	10930	5010	3079	1709	131948
1976	24731	53646	9852	2425	977	1562	93193
1977	17283	19674	15554	3171	719	850	57252
1978	54437	13809	7987	3390	956	373	80953
1979	25508	35604	8124	2468	1073	559	73336
1980	24034	20595	19711	3268	747	239	68594
1981	62997	19390	13268	7499	1302	221	104677
1982	22846	51480	14885	5535	1783	156	96685
1983	6581	16754	25937	5517	1514	345	56648
1984	10843	4755	6579	6472	2305	487	31441
1985	16749	8414	2089	1379	870	136	29636
1986	8473	12837	2991	767	402	224	25695
1987	9193	6776	4801	1440	282	201	22692
1988	22841	7386	2617	1153	309	73	34379
1989	9661	18250	3361	771	198	55	32296
1990	11217	7738	12981	1747	250	47	33980
1991	22557	8975	4437	4399	560	104	41032
1992	17518	17869	7215	2296	940	65	45904
1993	13938	12168	6459	3250	574	126	36516
1994	13180	6725	8713	2323	609	184	31734
1995	11672	10726	4304	1576	305	66	28650
1996	13470	9514	8500	2237	509	70	34299
1997	19801	10938	7175	5104	1040	246	44303
1998	22402	16138	7934	4228	2515	328	53545
1999	24564	18189	11418	3467	1778	675	60091
2000	19880	20057	12412	5591	1456	931	60327
2001	22331	16157	12945	5060	1756	918	59167
2002	15547	18124	10633	4404	1570	1116	51394
2003	11770	12537	11091	5615	1894	1678	44585
2004	10472	9492	6749	4870	2522	1857	35962
2005	14435	8516	6689	2695	647	280	33263
2006	49437	11764	5596	1850	688	395	69731
2007	18373	40337	8460	3058	622	252	71101
2008	19120	14994	31704	5339	1875	536	73568

Table C11. Estimated fishing mortality rate at age.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1973	0.01	0.27	0.70	0.90	0.90	0.90
1974	0.05	0.58	0.91	1.16	1.16	1.16
1975	0.08	1.22	1.31	1.43	1.43	1.43
1976	0.03	1.04	0.93	1.02	1.02	1.02
1977	0.02	0.70	1.32	1.00	1.00	1.00
1978	0.22	0.33	0.97	0.95	0.95	0.95
1979	0.01	0.39	0.71	0.99	0.99	0.99
1980	0.01	0.24	0.77	0.72	0.72	0.72
1981	0.00	0.06	0.67	1.24	1.24	1.24
1982	0.11	0.49	0.79	1.10	1.10	1.10
1983	0.13	0.73	1.19	0.67	0.67	0.67
1984	0.05	0.62	1.36	1.81	1.81	1.81
1985	0.07	0.83	0.80	1.03	1.03	1.03
1986	0.02	0.78	0.53	0.80	0.80	0.80
1987	0.02	0.75	1.23	1.34	1.34	1.34
1988	0.02	0.59	1.02	1.56	1.56	1.56
1989	0.02	0.14	0.45	0.93	0.93	0.93
1990	0.02	0.36	0.88	0.94	0.94	0.94
1991	0.03	0.02	0.46	1.34	1.34	1.34
1992	0.16	0.82	0.60	1.19	1.19	1.19
1993	0.53	0.13	0.82	1.47	1.47	1.47
1994	0.01	0.25	1.51	1.83	1.83	1.83
1995	0.00	0.03	0.45	0.93	0.93	0.93
1996	0.01	0.08	0.31	0.57	0.57	0.57
1997	0.00	0.12	0.33	0.51	0.51	0.51
1998	0.01	0.15	0.63	0.67	0.67	0.67
1999	0.00	0.18	0.51	0.67	0.67	0.67
2000	0.01	0.24	0.70	0.96	0.96	0.96
2001	0.01	0.22	0.88	0.97	0.97	0.97
2002	0.02	0.29	0.44	0.64	0.64	0.64
2003	0.02	0.42	0.62	0.60	0.60	0.60
2004	0.01	0.15	0.72	1.82	1.82	1.82
2005	0.00	0.22	1.09	1.16	1.16	1.16
2006	0.00	0.13	0.40	0.89	0.89	0.89
2007	0.00	0.04	0.26	0.29	0.29	0.29

Table C12a. Estimated spawning stock biomass (mt).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1973	0	3198	9079	5754	2651	1479	22161
1974	0	2730	4580	4142	2201	1127	14780
1975	0	3285	2760	1404	964	601	9014
1976	0	4616	3232	928	438	810	10024
1977	0	2135	4177	1218	340	480	8351
1978	0	1606	2415	1449	475	224	6169
1979	0	4230	2483	984	480	323	8501
1980	0	2551	6282	1461	416	175	10884
1981	0	2688	4358	2489	506	102	10144
1982	0	5380	4616	2096	783	98	12975
1983	0	1552	6202	2328	779	242	11103
1984	0	373	1257	1402	646	168	3847
1985	0	912	672	529	380	65	2558
1986	0	1342	1152	341	226	150	3210
1987	0	682	1342	516	116	93	2750
1988	0	806	847	385	125	34	2198
1989	0	2392	1287	347	107	36	4170
1990	0	822	3159	636	108	25	4750
1991	0	897	1203	1124	213	48	3485
1992	0	1583	1827	678	344	41	4472
1993	0	1394	1546	810	161	54	3966
1994	0	671	1459	471	162	61	2823
1995	0	1237	1100	457	116	32	2941
1996	0	1079	2705	897	261	51	4993
1997	0	1335	2271	2045	556	174	6380
1998	0	1969	2326	1609	1138	221	7262
1999	0	2637	4059	1546	935	424	9600
2000	0	2957	3964	2122	688	548	10280
2001	0	2270	3674	1902	875	579	9300
2002	0	2600	3782	2060	920	838	10201
2003	0	1606	3608	2627	1118	1260	10219
2004	0	1122	1959	1231	792	766	5869
2005	0	1126	1685	906	281	158	4157
2006	0	1464	1729	652	332	250	4427
2007	0	4855	2742	1337	387	206	9526

Table C12b. Estimated Jan-1 biomass (mt).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum 1+	sum 3+
1973	1607	7046	11898	8038	3927	2344	34860	26207
1974	3622	4424	6289	6382	3427	1990	26134	18088
1975	4803	7736	4483	2626	1887	1187	22722	10183
1976	1501	10075	4085	1351	627	1345	18984	7408
1977	1218	3781	6289	1861	506	792	14447	9448
1978	3092	2636	3335	2039	681	362	12145	6417
1979	1729	6523	3094	1427	765	531	14069	5817
1980	1334	3946	7938	1799	547	256	15820	10540
1981	4895	3566	5265	4092	887	186	18891	10430
1982	1638	9864	6000	3121	1203	169	21995	10493
1983	705	3091	9449	2994	1050	348	17637	13841
1984	1177	870	2203	3039	1445	388	9122	7075
1985	2209	2034	726	680	525	109	6283	2040
1986	1146	3189	1321	448	298	227	6629	2294
1987	676	1641	2029	872	205	176	5599	3282
1988	1320	1471	1112	696	234	71	4904	2113
1989	567	3349	1388	488	154	58	6004	2088
1990	784	1318	4665	963	177	39	7946	5844
1991	1755	1415	1451	1927	364	91	7003	3833
1992	1053	3365	2122	1012	529	73	8154	3736
1993	864	2065	2152	1390	313	109	6893	3964
1994	2131	1084	2764	983	340	142	7444	4229
1995	1613	2471	1293	638	163	51	6229	2145
1996	1006	2085	2844	979	292	71	7277	4186
1997	3550	2074	2408	2388	655	233	11308	5684
1998	2773	4123	2852	1996	1486	317	13547	6651
1999	3604	4655	4437	1815	1141	608	16260	8001
2000	3620	5578	5217	3085	1019	888	19407	10209
2001	4549	4652	5433	2742	1241	943	19560	10359
2002	3885	5604	4432	2436	1121	1192	18670	9181
2003	2355	3989	4714	3144	1402	1759	17363	11019
2004	1738	2466	2682	2566	1739	1775	12966	8762
2005	1065	2284	2428	1378	434	279	7868	4519
2006	2912	2256	2095	919	463	394	9039	3871
2007	2372	6845	2997	1436	405	252	14307	5090
2008	1669	3147	11534	2629	1246	535	20760	15944

Table C13. Bootstrap estimates of uncertainty in 2007 fishing mortality rates at age, 2007 spawning stock biomass (mt), and 2008 January 1 biomass (mt).

	Point	10th%ile	90th%ile
F 2007			
age 1	0.0032	0.0019	0.0056
age 2	0.0408	0.0270	0.0610
age 3	0.2603	0.1826	0.3809
age 4	0.2892	0.2170	0.3820
age 5	0.2892	0.2170	0.3820
age 6+	0.2892	0.2170	0.3820
SSB 2007	9526	7653	12328
Jan-1 B 2008	15944	11980	22121

Table C14. Values for partial recruitment, maturity, and weight at age (kg) used in yield per recruit calculations and age based projections.

Age	PR	Maturity	WAA
1	0.0069	0.000	0.161
2	0.2015	0.462	0.319
3	0.6490	0.967	0.435
4	1.0000	1.000	0.585
5	1.0000	1.000	0.769
6+	1.0000	1.000	1.000

Table C15. Biological reference points for Georges Bank yellowtail flounder from GARM II, GARM III Reference Points meeting, and this assessment.

	GARM II	GARM III BRP	GARM III Final
Fmsy	0.25	0.254	0.254
SSBmsy (mt)	58800	46000	43200
MSY (mt)	12900	10000	9400

Table C16. Three projections for 2009 catch all of which assume catch in 2008 equal to catch in 2007: F status quo applied F2007 in 2009; F_{MSY} applies F_{MSY} in 2009; and $F_{REBUILD}$ is solved iteratively to produce 50% probability of SSB>SSB_{MSY} in 2014 when the F is applied every year from 2009 to 2014.

	2007	2008	2009		
			F st quo	Fmsy	$F_{REBUILD}$
C (mt)	1686	1686	5503	4908	3989
F (4-5)	0.289	0.126	0.289	0.254	0.202
SSB (mt)	9527	18760	22196	22468	22895

Table C17. Two additional projections requested by the TRAC assuming catch in 2008 equal to the quota of 2,500 mt: Fref where F in years 2009-2014 is set equal to Fref of 0.25 and Freb75 where a constant F in years 2009-2014 is calculated to achieve SSB_{MSY} in 2014 with 75% probability.

	2007	2008	2009		2010	
			Fref	Freb75	Fref	Freb75
C (mt)	1686	2500	4648	2114		
F (4-5)	0.289	0.191	0.25	0.107		
SSB (mt)	9527	18421	21719	22844		
3+ B (mt)	5090	15944	20520	20520	22347	24913

Table C18. Risk, defined as the probability that F in 2009 will exceed Fref = 0.25, and relative change in age 3+ Jan-1 biomass from 2009 to 2010 under different scenarios of catch in 2009.

Catch (mt)	Risk	Relative Change in Median Age 3+ B
1000	0	27%
2000	0	22%
3000	0.032	17%
4000	0.271	12%
4500	0.455	9%
5000	0.619	7%
6000	0.843	2%
7000	0.961	-3%
8000	0.992	-8%
9000	0.999	-13%

Table C19. Results of sensitivity analysis for change in age 3 partial recruitment used in projections.

	Age 3 PR		
	0.649	0.40	0.90
2008 C (mt)	2500	2500	2500
2009 C (mt)	4648	4370	4901
2008 F (4-5)	0.191	0.248	0.156
2009 F (4-5)	0.25	0.25	0.25
2008 SSB (mt)	18421	18429	18413
2009 SSB (mt)	21719	21842	21593

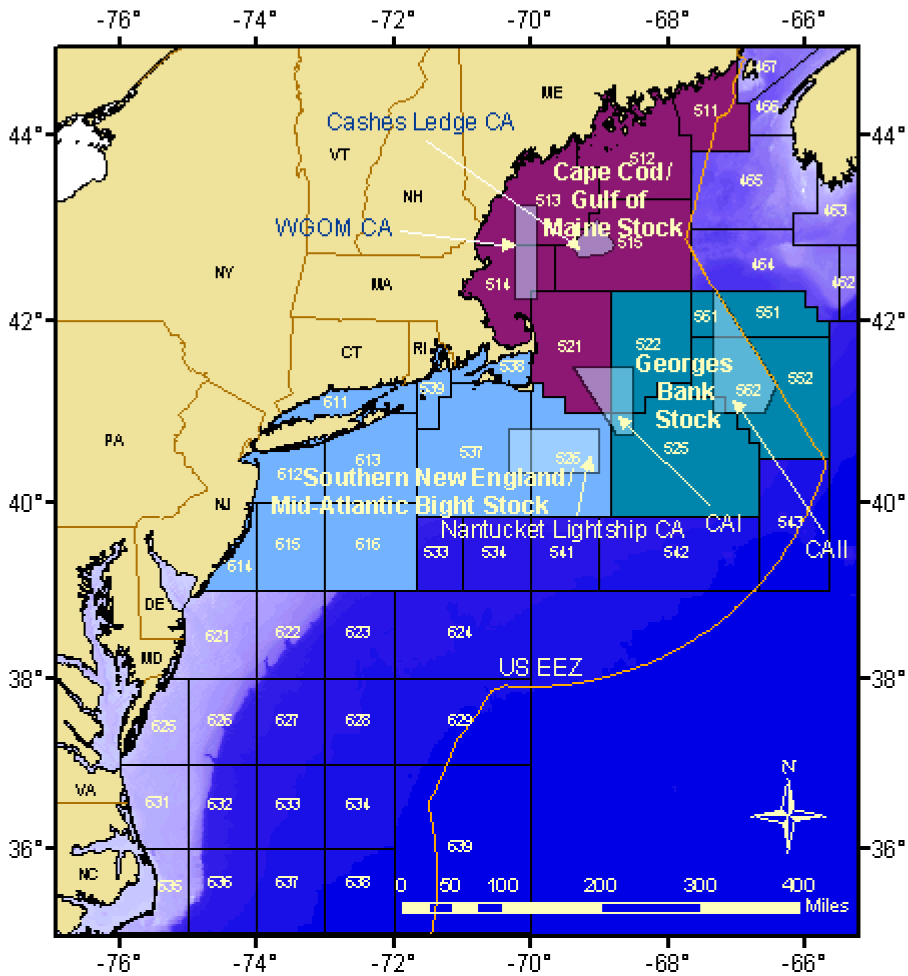


Figure C1. Stock area map for yellowtail flounder from Status of Stocks website (http://www.nefsc.noaa.gov/sos/).

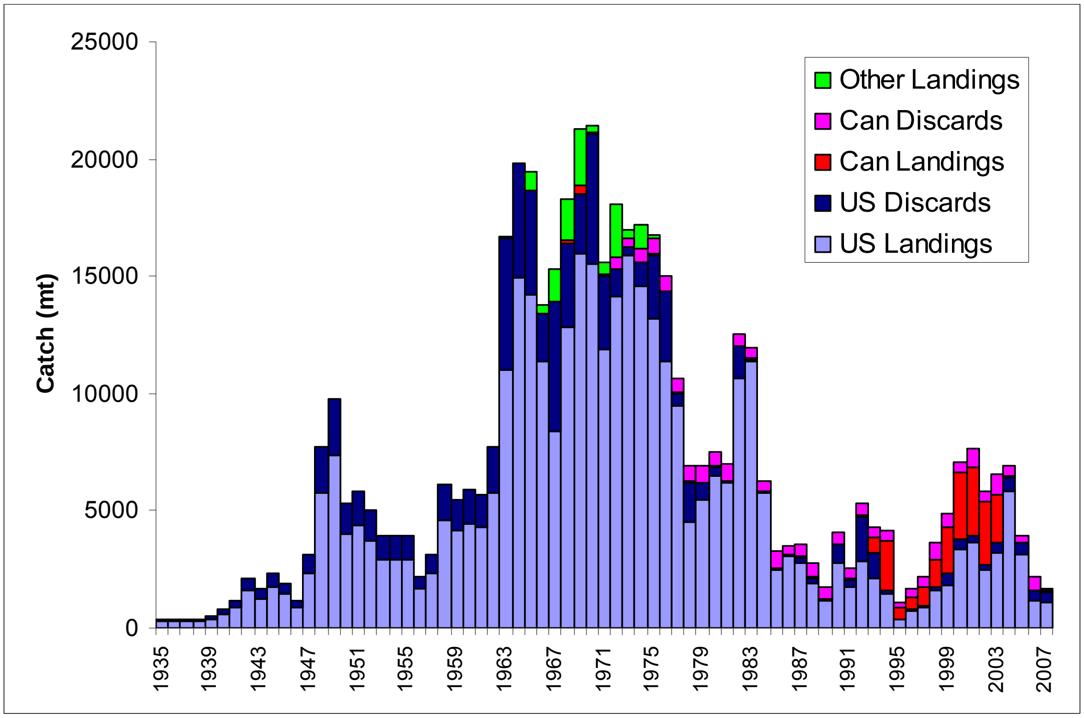


Figure C2. Total catch of Georges Bank yellowtail flounder.

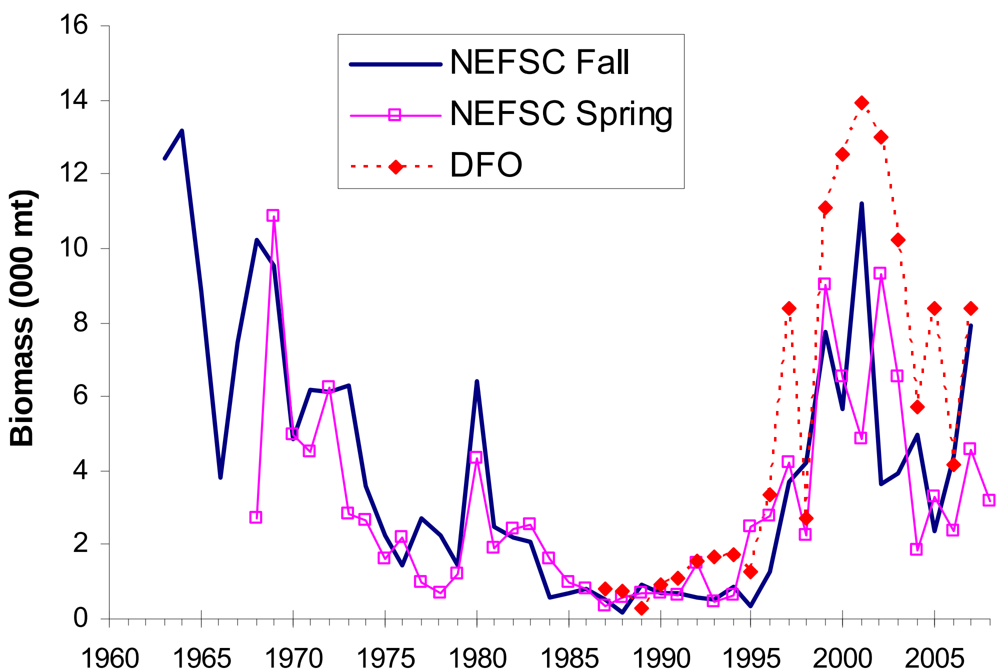


Figure C3. Trends in survey biomass for Georges Bank yellowtail flounder expressed as minimum swept area estimates. The 2008 value for the DFO survey is not shown.

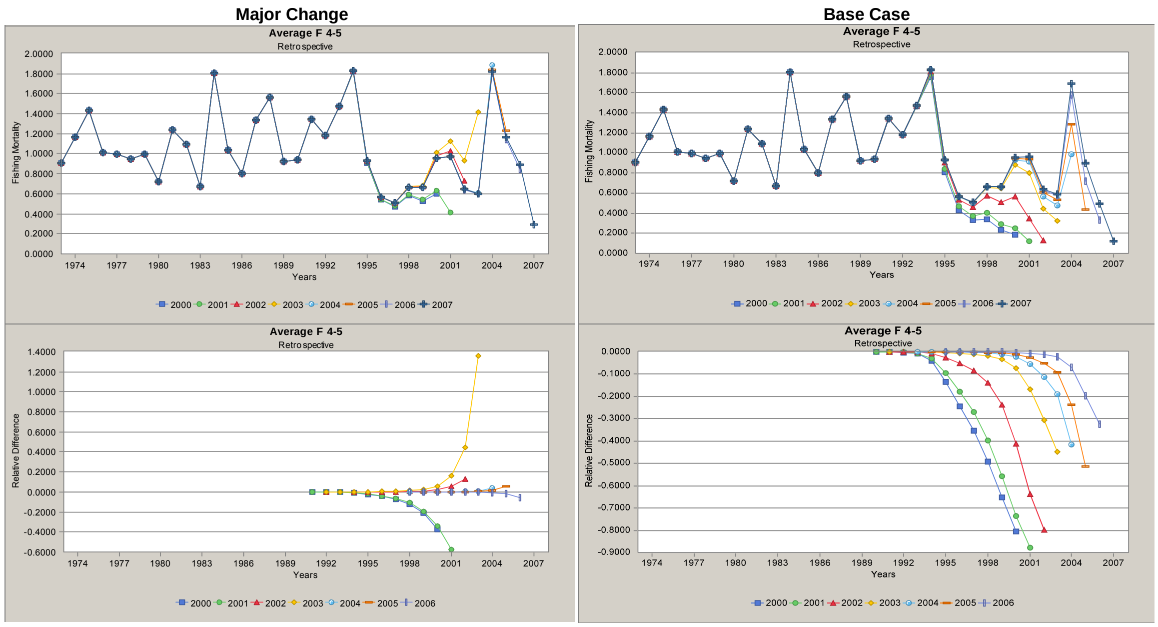


Figure C4a. Retrospective plots of fully recruited fishing mortality rate (ages 4-5).

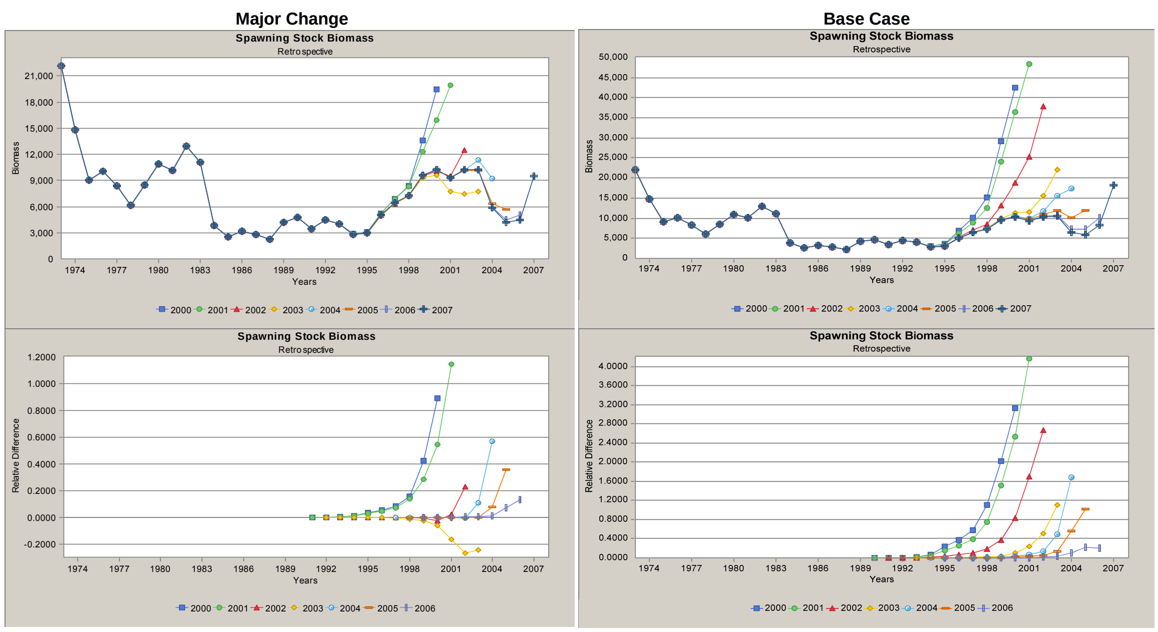


Figure C4b. Retrospective plots of spawning stock biomass.

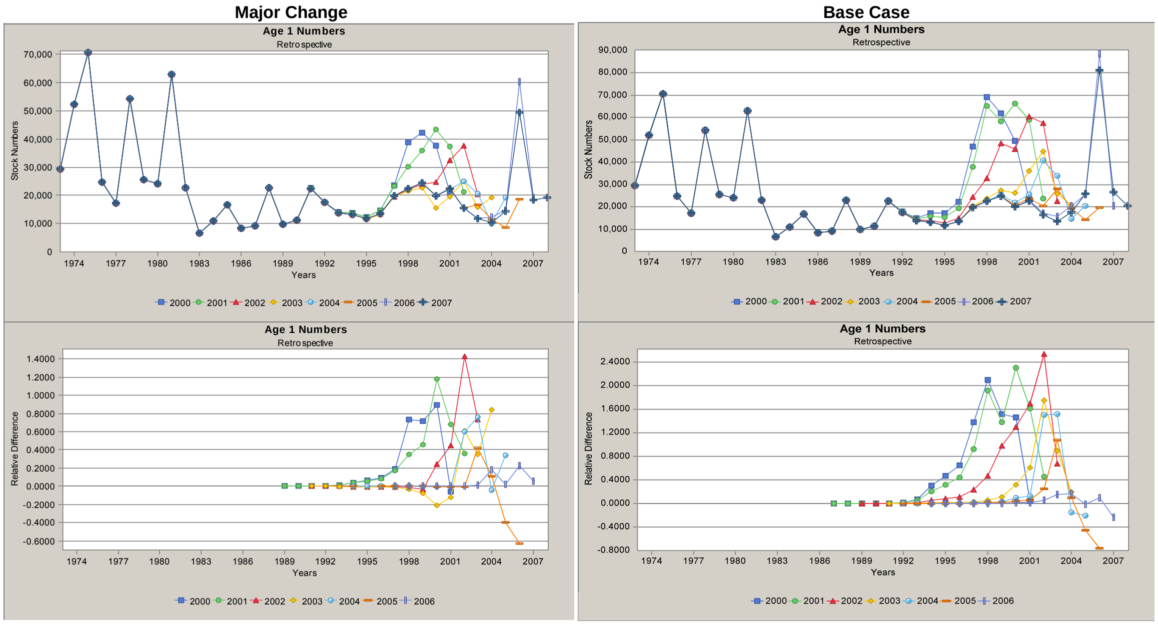


Figure C4c. Retrospective plots of recruitment. Note the final estimate in each series is the geometric mean of the previous values.

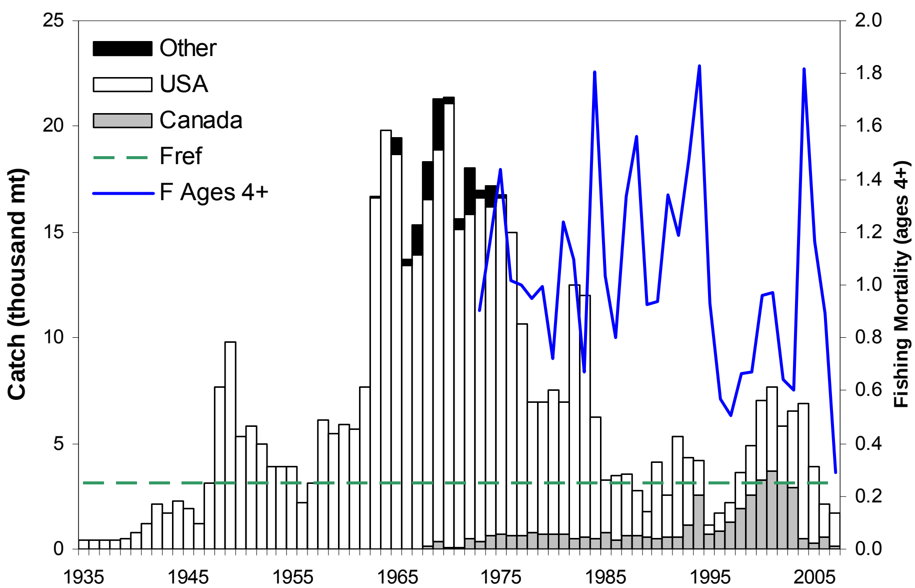


Figure C5. Catch and estimated fishing mortality rate (ages 4-5 unweighted) from the Major Change model.

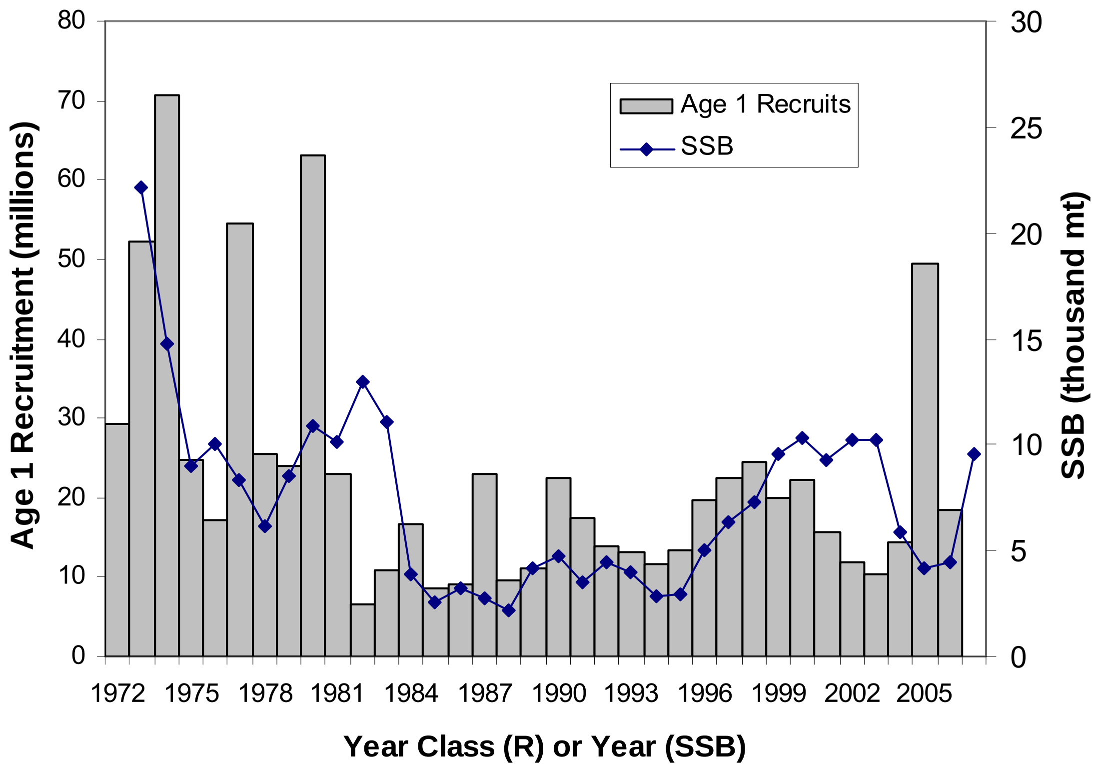


Figure C6. Recruitment (millions of fish) and spawning stock biomass (thousand mt) estimated from the Major Change model.

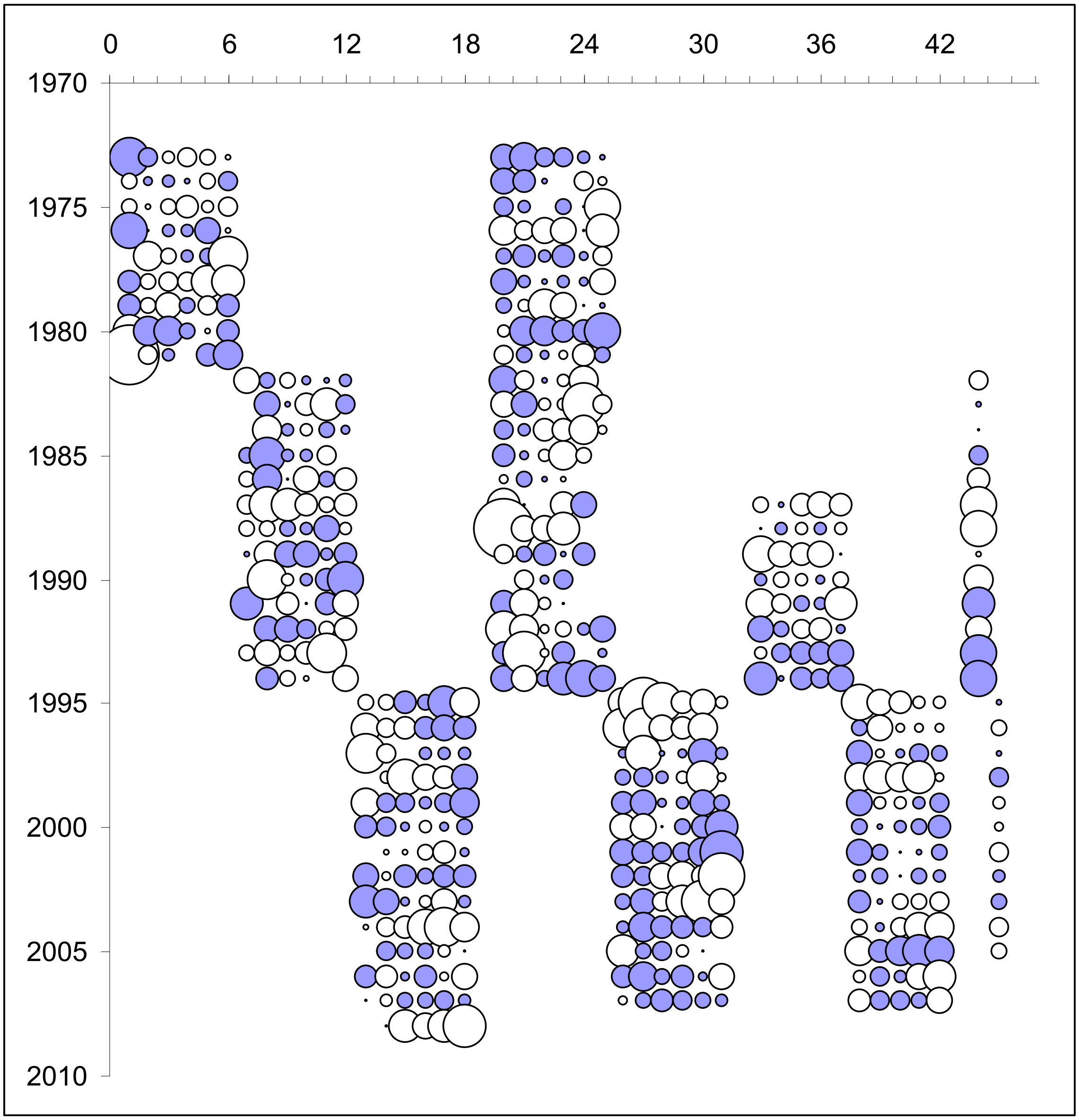


Figure C7. Residuals for indices of abundance in VPA grouped by survey: columns 1-18 are NEFSC Spring ages 1-6 separated into Yankee 41, Yankee 36 early, Yankee 36 recent, columns 20-31 are NEFSC Fall ages 1-6 separated into early and recent, columns 33-42 are DFO separated into early and recent, and columns 44-45 and NEFSC scallop separated into early and recent.

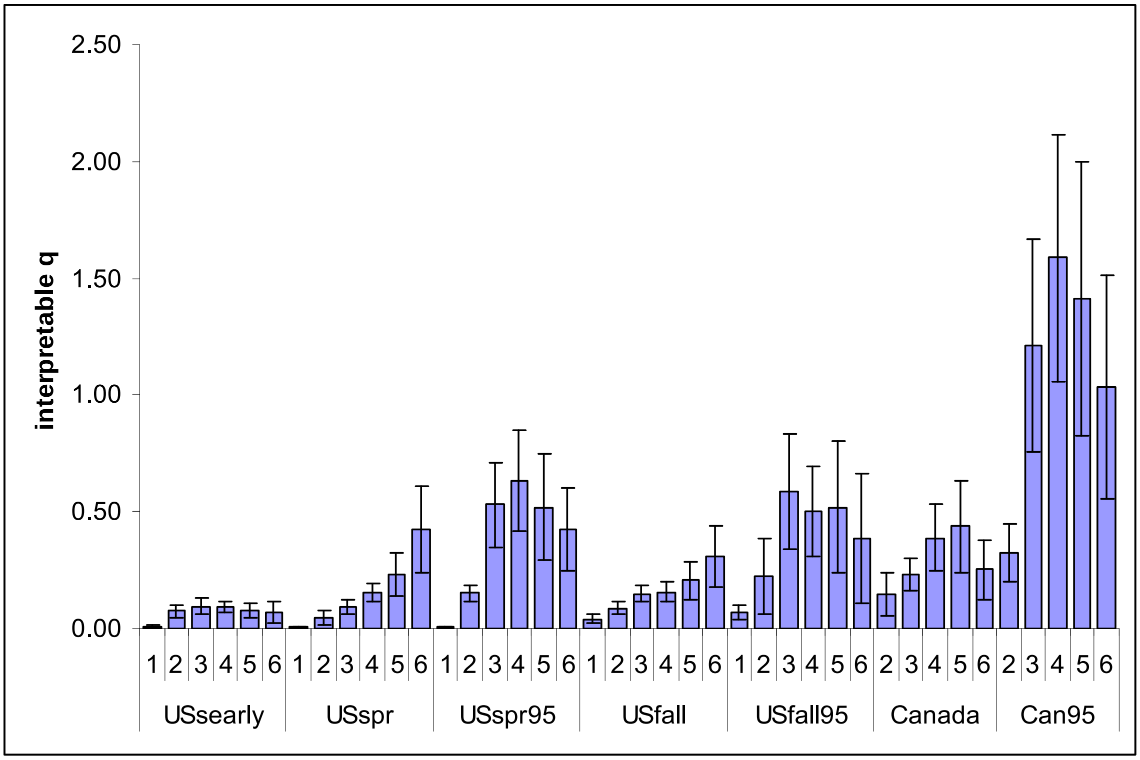


Figure C8. Catchability estimates with plus and minus two standard deviations for swept area indices for those surveys which have interpretable q values.

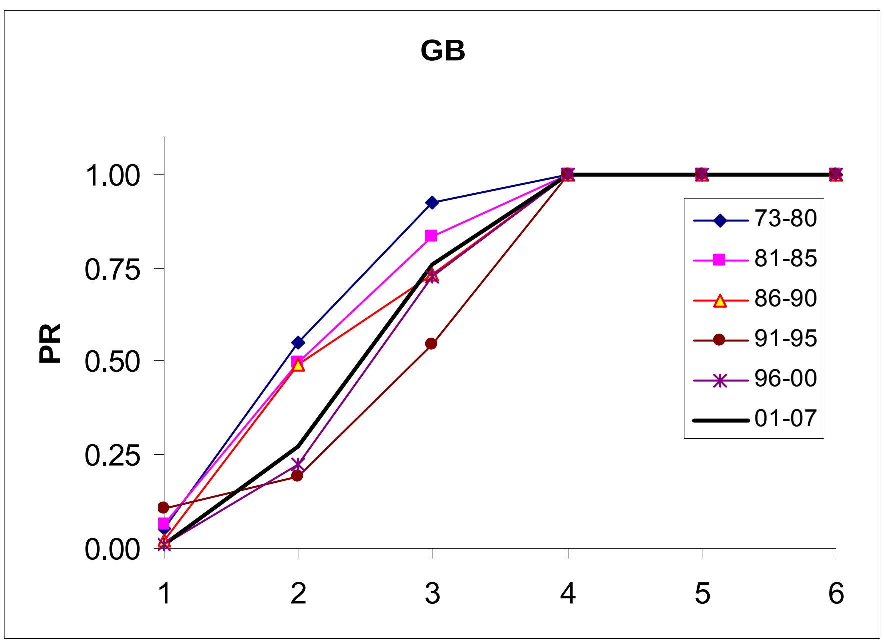


Figure C9. Average back-calculated partial recruitment from VPA.

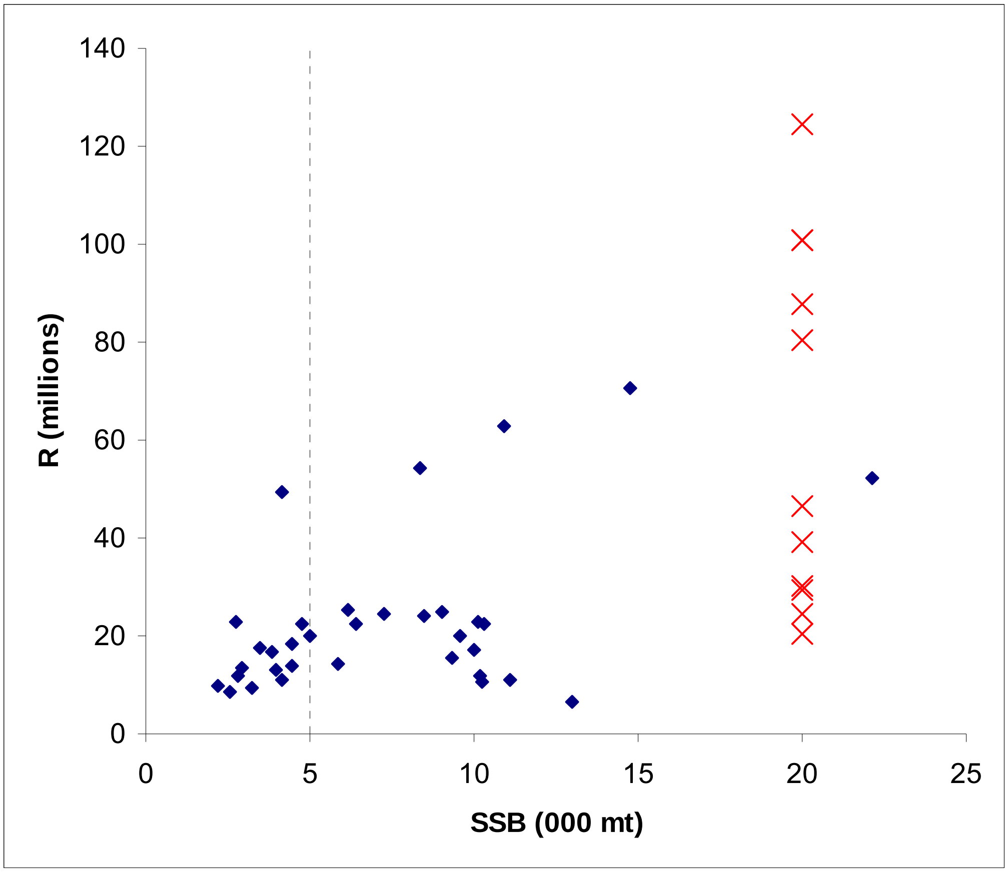
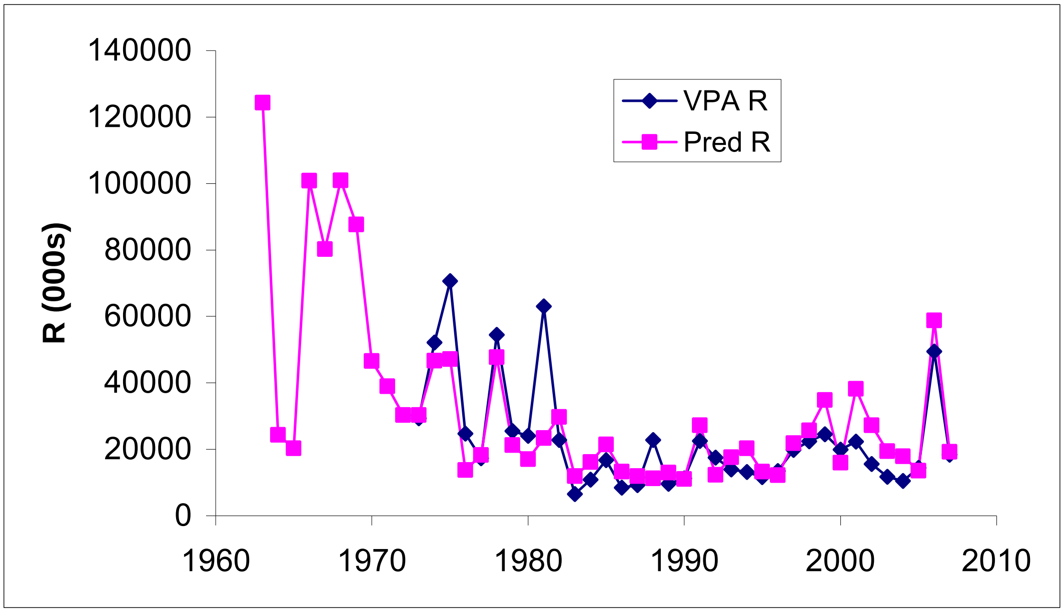


Figure C10. Stock recruitment relationship. Filled diamonds denote SSB and R pairs from VPA, crosses denote hindcast R estimates (SSB set to 20 kt for presentation purposes only), and dashed line denotes breakpoint at SSB of 5 kt for use in determining R values in projections.



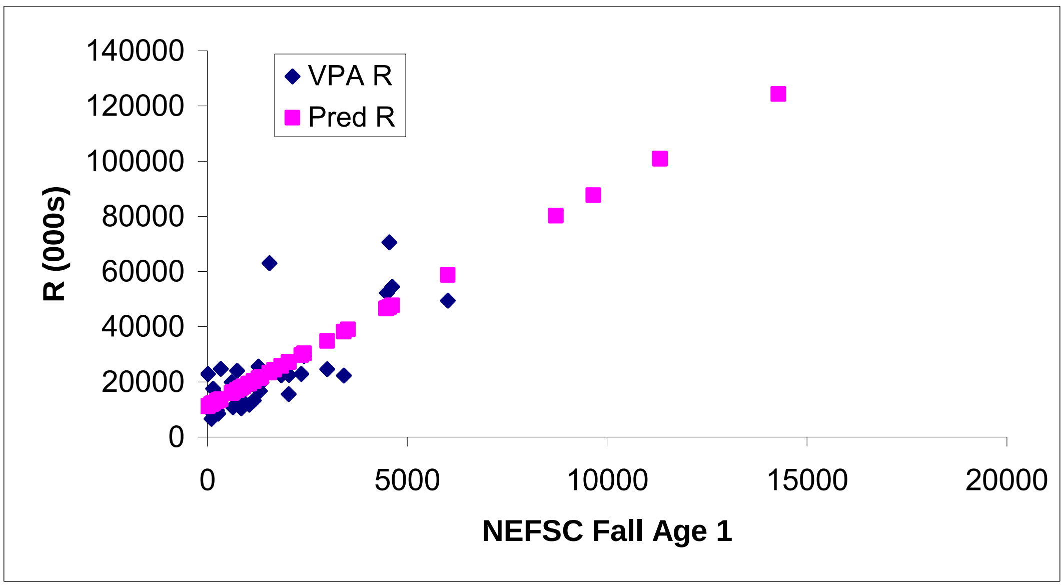


Figure C11. Hindcast estimates of recruitment using the NEFSC Fall survey at age 1.

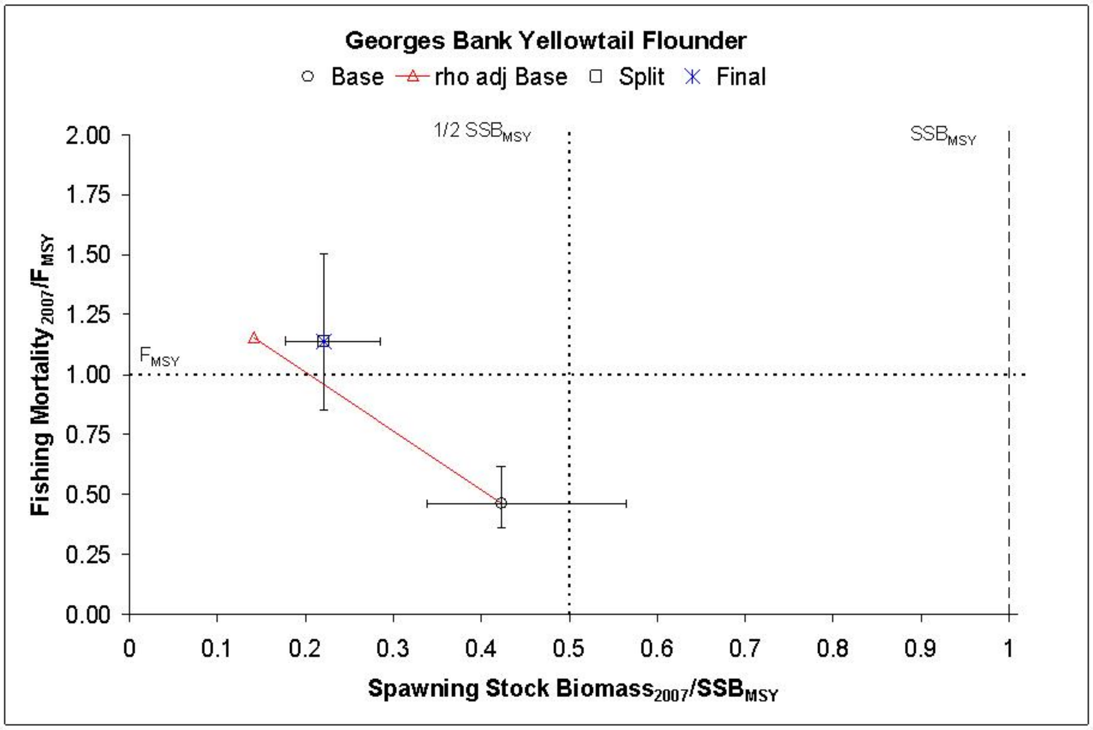


Figure C12. Current status of Georges Bank yellowtail flounder. The point labeled Split corresponds to the Major Change model, the model used for final status determination and projections. The Base and rho adj Base results are presented for comparison purposes only and were not used for status determination nor projections.

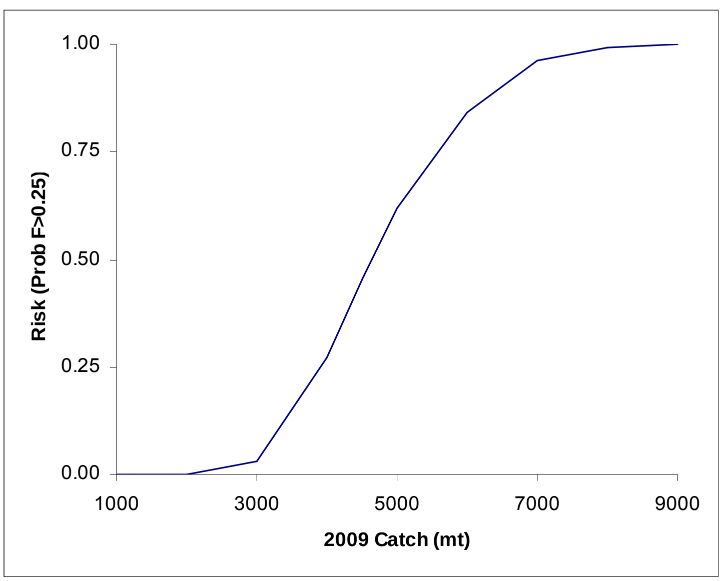


Figure C13. Risk of F_{2009} exceeding F_{ref}=0.25 for a range of 2009 catch (mt).

D. Southern New England/Mid Atlantic yellowtail flounder
by Larry Alade, Chris Legault and Steven Cadrin

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

1.0 Background

The Southern New England-Mid Atlantic yellowtail flounder stock was last assessed at the Groundfish Assessment Meeting (GARM) in 2005 (Cadrin and Legault 2005). That assessment was based on a virtual population analyses (VPA) with a 7+ age group formulation. The stock exhibited poor recruitment and high fishing mortality rates, leading to very low abundance. Reference point estimation was derived from spawning stock biomass per recruit (SSB/R) and yield per recruit (YPR) analyses, with the assumption of constant recruitment (Cadrin 2003). The value for $F_{40\%}$ (i.e. proxy for F_{MSY}) was 0.26 and the corresponding SSB_{MSY} and MSY was 69,500mt and 14,200mt respectively. VPA estimate of SSB (694mt) was 1% of SSB_{MSY} and the estimate of F_{2004} (0.99) was four times F_{MSY}, indicating that the stock was severely overfished and overfishing was occurring. The current benchmark assessment revises and updates the 1994-2007 fishery catch estimates to reflect recommendations at the GARM III data meeting (GARM 2007), and updates research survey abundance indices and analytical models (VPA) through 2007/2008 as recommended at both the GARM III Methods and Biological Reference Points meetings (GARM 2008a, GARM 2008b). The VPA analysis uses an age-6+ formulation by incorporating the entire time series of catch data and tunes to winter, spring and fall survey swept area biomass indices. Finally, reference points were re-evaluated using the revised VPA formulation, and a two-stanza recruitment approach (i.e. recruitment associated with SSB either greater than or less than 5000t) to determine the current status of the stock.

2.0 Fishery

Landings

Landings of yellowtail flounder from the Southern New England-Mid Atlantic stock (Figure D1) during 1994-2007 were derived from the new trip-based allocation described in the GARM data meeting (GARM 2007, Table D1, Figure D2). Changes to previous estimates were minimal and uncertainty in the landings due to the random component of the allocation was insignificant (Legault et al. 2008). Landings at age and mean weight at age were determined by port sampling of small, medium, large, and unclassified market categories and pooled age-length keys by half year to achieve the full length frequency distributions. Sampling intensity has increased in recent years (Table D2) resulting in lower variability in landings at age estimates (Table D3). Of special note for this stock, port sampling in years 2003-2005 was supplemented heavily by an industry-based survey (IBS) which provided length distributions for the unclassified market category as well as the majority of the age samples for these years.

Discards

Discarded catch for years 1994-2007 was estimated using the Standardized Bycatch Reporting Methodolgy (SBRM) recommended in the GARM III data meeting (GARM 2007).

Three commercial fleets (large mesh otter trawl, ≥ 5.5"; small mesh otter trawl, < 5.5"; and scallop dredge) were considered to estimate discards as these fleets constituted the majority of the total discards of yellowtail flounder in the Southern New England-Mid Atlantic stock area. Observed ratios of discards of yellowtail flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, and scallop dredge were applied to the total landings by half-year. Uncertainty in discards was estimated based on the SBRM approach detailed in the GARM III data meeting (GARM 2007, Table D4). Discards were approximately 28% of the catch in years 1994-2007 and contributed to almost 50% of the catch in 2007 (Table D1; Figure D2). Discards at age and associated mean weights at age were estimated from sea sampled lengths and pooled observer and survey age-length keys. The age-length key was supplemented significantly by the industry-based survey (IBS) in years 2003-2005. However, precision of discards at age could not be assessed using the conventional method due to the combined sources of information used (i.e. survey and commercial discards).

Total Catch at Age

Total catch at age was generated by adding the landings and discards (Table D5a-c). Average weight at age was computed as the catch numbers weighted average of the weights at age from these two sources (Table D6).

3.0 Research Surveys

Survey abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices are reported in Table D7a-c. Estimates are from valid NEFSC winter, spring, and fall bottom trawl surveys (BTS) from 1973-2008 (note: autumn surveys commenced in 1992). The indices were derived from station-catches defined within the NEFSC survey strata for the Southern New England-Mid Atlantic area [offshore strata 1, 2, 5, 6, 9, 10, 69, 73, 74 (strata 69, 73, 74 excluded from the fall series)], and standardized according to net, vessel, and door changes. These indices are presented as minimum swept area estimates to allow direct interpretation of the catchability estimates associated with each catch at age from the surveys. Survey trends generally indicate stock biomass has remained low since the early 1990s with an indication of a stronger 2005 year-class relative to the previous decade (Figure D3).

4.0 Assessment Results

Input Data and Model Formulation

The previous VPA formulation for the Southern New England-Mid Atlantic yellowtail flounder stock was based on a plus group definition set at age-7 (Cadrin and Legault 2005). However, an age-6+ VPA formulation was also considered for comparative analyses due to continued age truncation (i.e. predominance of zeros at older age classes) observed in the survey series. The winter, spring and fall NEFSC survey minimum swept area estimates were used as age-specific tuning indices in both VPA formulations (i.e. age-6+ and age-7+). Mohn's rho retrospective statistics (Mohn 1999), calculated based on a seven year series of retrospective estimates was used to quantify the relative bias in terminal year estimates of fishing mortality (F), spawning stock biomass (SSB) and recruitment (R) for both model formulations. It was further recommended by the panel reviewers at the benchmark GARM III meeting to adjust terminal year point estimates for F and SSB based on Mohn's rho estimates to characterize the degree of bias in the final status determination. Finally, 1000 bootstrap realizations were conducted to evaluate the precision of the 2008 (terminal year + 1) stock size at age, F at age in 2007, and SSB in 2007.

Model Selection Process

A comparison between both the plus group formulations (age-6+ and age-7+) with the addition of new catch data indicated that the results from the age-7+ definition exhibited a much higher mean square residual than the 6+ results (Table D8a-b). The VPA for the age-6+ formulation was also estimated with better precision for stock size, *N* (CV =31-51%), and catchability estimates, *q* (CV = 10-35%). Relatively, the age-6+ formulation did not exhibit strong retrospective patterns compared to the age-7+ formulation (Figures D4a-b, D5a-b, D6a-b). Additionally, Mohn's rho values for F, SSB and R showed less retrospective pattern in the age-6+ formulation (Tables D9a-b). Given the improvement of the age-6+ VPA model formulation over the age-7+ definition the review panel at the GARM III benchmark assessment meeting agreed with the recommendations made at the Biological Reference Points meeting and accepted the age 6+ formulation as the final model for basis for this assessment to provide scientific advice.

Assessment Results

VPA assessment results show that stock numbers has continued to show an increasing trend since 2004, driven potentially by two moderately strong recruitment levels in 2004 and 2005 (Table D10; Figure D6a). Fishing mortality continues to decline with F_{2007} on fully recruited fish (F_{2007} = 0.41) and significantly lower than the levels estimated in recent years (Table D11). Spawning stock biomass slightly increased in the 1990's and remained fairly stable between 1999 and 2003. In 2004 and 2005, SSB declined by more than 50%. Moderate recruitment of the 2004 and 2005 year classes led to the recent increases in SSB for 2006 and 2007. The 2007 SSB is estimated at approximately 3508mt, which is more than twice the average estimated SSB over the last ten years. However, SSB is still relatively low compared to levels observed in the past decades (Table D12). The 2007 estimates of F and SSB were well estimated as seen in the relatively precise 80% confidence intervals derived from bootstrapping (Table D13a). The Mohn's Rho adjusted estimates for SSB were well within the confidence bounds of the bootstrap estimates but barely overlaps with the F bootstrap confidence limits (Table D13b). Adopting the panel recommendations at the final benchmark assessment meeting, the point estimates were used for final status determination.

Diagnostics

Survey residuals do not have strong patterns, but there are some occasional year effects in some surveys (Figure D7). With the exception of the winter survey, catchability coefficients have reasonable magnitudes ($q < 1.00$) with the NEFSC survey exhibiting a flat-top pattern (Figure D8). Estimates of winter survey catchability suggest that either swept area calculations or VPA abundances are underestimated, but catchability estimates may not be reliable because of the narrow range of abundance during the winter survey series. Alternatively, it is worth noting that the autumn surveys are conducted with a net design specifically to catch flounder and may have significant herding effect between the doors, which could explain the q values above 1.00. Back calculated partial recruitment pattern from the fishery are flat-topped due to the formulation of the VPA, but also show a decrease in selectivity of age-2 and 3 yellowtail flounder in recent years, potentially due to the mesh size regulations (Figure D9).

5.0 Biological Reference Points

Method and Special Consideration

For the 2008 GARM Biological Reference Point meeting, the stock-recruitment estimates from the VPA did not conform to a parametric relationship (Figure D10) and therefore a non-parametric approach was adopted. Following the panel recommendations from the final benchmark assessment meeting, recruitment values associated with spawning stock biomass below and above 5000t were used to estimate SSB_{MSY} and MSY proxies. The 5000t threshold was derived based on the minimum residual variance analysis from the stock-recruitment relationship. The Panel also agreed with previous recommendations (GARM 2008b) that the hindcast estimates should not be included in the recruitment sample for projection as these values tends to extend beyond the range of 'observed' recruitment, and may not be representative of current stock productivity.

Recent five year averages of partial recruitment, maturity, and weight at age were used in yield per recruit analysis to estimate F40%MSP as a proxy for F_{MSY} (Table D14). Applying F_{MSY} for 100 years in stochastic projections, while sampling of recruitments from the empirical distribution generated equilibrium SSB_{MSY} and MSY as median values at the end of the projections (Legault 2008).

Final Values: F_{MSY}, SSB_{MSY}, MSY

The estimated values of F_{MSY} (0.254), SSB_{MSY} (27,400 mt) and MSY (6100 mt) are similar to those from the GARM III Biological Reference Points meeting and significantly different from the GARM II meeting with the exception of F_{MSY} (Table D15). The relatively large changes observed in SSB_{MSY} and MSY from GARM II to GARM III reflect mainly changes in recruitment used in the calculations. In the previous assessment, hindcast recruitments were used while current assessments uses only updated VPA estimated recruitment. The panel at the final benchmark assessment meeting supported the no-hindcast approach due to the continued low recruitment in the recent decade which could potentially indicate a change in stock productivity. Based on VPA 2007 estimates of F and SSB (F_{2007} = 0.413; SSB_{2007} = 3508 mt) relative to F_{MSY} and SSB_{MSY}, Southern New England-Mid Atlantic yellowtail is overfished (SSB_{2007} = 13%SSB_{MSY}) and overfishing is occurring (F_{2007} = 1.6F_{MSY}; Figure D11)

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 the projections (Table D14). The population abundance at age at the start of 2008 was derived from the bootstrap results, with recruitment generated as geometric mean of the estimated recruitments during 1973-2007 from each bootstrap solution. Catch in 2008 was assumed equal to the catch in 2007 (396 mt).

$F_{REBUILD}$

The Southern New England-Mid Atlantic yellowtail flounder stock is currently in a rebuilding plan with end date of 2014. The $F_{REBUILD}$ (0.08) was estimated by iteratively solving for the F which applied in years 2009-2014 and resulted in median 2014 SSB equal to SSB_{MSY}.

Projected Catch in 2009

Median catch in 2009 was estimated under four conditions for F in 2009: 1) $F_{STATUS\ QUO}$, meaning the F_{2009} is equal to F_{2007}, 2) F_{2008} which sets F_{2009} equal to the estimated F_{2008} from the 100yr projection, 3) $F_{MSY,}$ and 4) $F_{REBUILD}$ (Table D16). All four scenarios estimate catch higher than the levels in 2007 while allowing SSB to increase. This is probably due to the 2005 strong year class progressing through the fishery. However, it should be noted that neither $F_{status\text{-}quo}$ nor F_{MSY} will reach rebuilding target of SSB_{MSY} by 2014.

7.0 Summary

Based on this assessment, the Southern New England-Mid Atlantic yellowtail flounder continues to be overfished (SSB2007/SSB_{MSY} = 13%) and overfishing is still occurring (F2007/ F_{MSY} = 160%). However, fishing mortality has been declining since 2005 and it is at lowest levels observed in the time series. SSB has shown slight increases over the past couple of years and could potentially continue to grow with the support of the incoming 2005 strong year class. The age-6+ VPA formulation is recommended as the basis of management because it does not exhibit strong retrospective patterns and overall, demonstrates reasonable diagnostics. Given the strength of the 2005 year class in other adjacent stock areas (i.e. Georges Bank and Cape Cod-Gulf of Maine) and the current knowledge of yellowtail flounder movement among stock areas (GARM 2007), a source of uncertainty for this assessment is determining which causing factor(s) (i.e. favorable environmental conditions or migration) may have contributed to the coincidental strong year class. Another area of uncertainty is the lack of age-length data available for discard estimation.

8.0 Panel Discussion/Comments

Conclusions

Two VPA assessment formulations were presented which used different age ranges in the plus group - 6+ and 7+. As the best available estimate of stock status and a sufficient basis for management advice, the Panel accepted as Final the formulation that used the 6+ age group. This model had a considerably lower mean square residual and lower coefficients of variation (CVs) on the survey catchability estimates. As well, the 7+ formulation estimated catchability for the NMFS winter survey greater than 1.0, which was considered unreasonable.

There was a small retrospective pattern for which the Panel considered not sufficient to warrant an adjustment.

The Panel recommended that one year forward projections use a 2008 recruitment estimate equal to the geometric mean of recruitment estimates since 1990, and not include recruitment estimates from the early part of the assessment time series as these were much larger than any observed since 1990.

The Panel recommended that the $F_{REBUILD}$ forecast use the same recruitment assumptions as for the BRP estimation but also sample from recruitment estimates below the SSB breakpoint of 5,000t.

Research Recommendations

The use of 'windows' of biomass rather than the breakpoint should be explored to create the stanzas in the stock – recruitment relationship. This may better address inconsistencies in rebuilding plans that might arise as the biomass grows from the lower to the higher stanza.

9.0 References

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Table D1. Landings, discards, total catch (metric tons), and proportion of total catch which is discards for Southern New England-Mid Atlantic yellowtail flounder.

Year	U.S. landings	U.S. discards	foreign catch	total catch	percent discards
1935	6000	2400	0	8400	29%
1936	6800	2700	0	9500	28%
1937	7600	3000	0	10600	28%
1938	7700	3100	0	10800	29%
1939	9500	3800	0	13300	29%
1940	14200	5700	0	19900	29%
1941	19300	7700	0	27000	29%
1942	28400	9900	0	38300	26%
1943	18000	7300	0	25300	29%
1944	10600	4800	0	15400	31%
1945	10400	4200	0	14600	29%
1946	10800	4400	0	15200	29%
1947	12100	4900	0	17000	29%
1948	9900	4000	0	13900	29%
1949	4900	1900	0	6800	28%
1950	4900	1900	0	6800	28%
1951	2900	1100	0	4000	28%
1952	3200	1200	0	4400	27%
1953	2300	800	0	3100	26%
1954	1700	600	0	2300	26%
1955	2500	900	0	3400	26%
1956	4100	1400	0	5500	25%
1957	6200	2200	0	8400	26%
1958	9500	3600	0	13100	27%
1959	8200	3100	0	11300	27%
1960	8800	3200	0	12000	27%
1961	13000	4700	0	17700	27%
1962	13500	5300	0	18800	28%
1963	22600	5400	200	28200	19%
1964	21809	9500	0	31309	30%
1965	22517	7000	1400	30917	23%
1966	22540	5300	700	28540	19%
1967	25140	7700	2800	35640	22%
1968	25372	6300	3500	35172	18%
1969	23686	2400	18283	44369	5%
1970	21350	4500	2618	28468	16%
1971	15867	2200	1261	19328	11%
1972	17574	1800	3117	22491	8%
1973	12441	1711	397	14549	12%
1974	8284	8688	116	17088	51%
1975	3833	1896	3	5732	33%
1976	1853	1583	0	3436	46%
1977	3335	1888	0	5223	36%
1978	3059	5026	0	8085	62%
1979	5452	4431	0	9883	45%
1980	6300	1721	0	8021	21%
1981	5400	1207	0	6607	18%
1982	10726	5038	0	15764	32%
1983	18500	3711	0	22211	17%
1984	10100	1125	0	11225	10%
1985	3600	1217	0	4817	25%
1986	3548	1072	0	4620	23%
1987	1771	881	0	2652	33%
1988	994	1788	0	2782	64%
1989	2897	5452	0	8349	65%
1990	8236	9680	0	17916	54%
1991	4113	2317	0	6430	36%
1992	1640	1055	0	2695	39%
1993	674	97	0	771	13%
1994	367	362	0	729	50%
1995	200	144	0	345	42%
1996	477	277	0	754	37%
1997	849	398	0	1247	32%
1998	690	416	0	1106	38%
1999	1307	172	0	1479	12%
2000	1122	138	0	1261	11%
2001	1295	31	0	1326	2%
2002	792	24	0	816	3%
2003	496	106	0	603	18%
2004	489	125	0	614	20%
2005	242	125	0	367	34%
2006	209	160	0	369	43%
2007	209	187	0	396	47%

Table D2. Southern New England-Mid Atlantic landings (metric tons) and number of lengths available from port samples by half year and market category along with number of ages available for age-length key and number of lengths sampled per 100 metric tons.

		Landings (metric tons)					Number of Lengths					Number	Lengths /
Year	half	unclass	large	small	medium	Total	unclass	large	small	medium	Total	of Ages	100 mt
1994	1	17	58	59		134		102	228		330		
	2	4	126	103	0	233		170	254		424		
	Total	22	184	162	0	367		272	482		754	204	205
1995	1	19	37	48	0	104	78				78		
	2	24	28	45	0	97							
	Total	43	65	92	0	200	78				78	36	39
1996	1	102	32	87	0	222							
	2	75	66	114	0	256	129	752	939		1820		
	Total	178	98	201	0	477	129	752	939		1820	456	381
1997	1	456	95	110	0	660	277	736	915		1928		
	2	76	40	73		189	319	328	548		1195		
	Total	532	134	182	0	849	596	1064	1463		3123	729	368
1998	1	129	59	52	0	240	92	283	596		971		
	2	105	109	236	0	450	230		127		357		
	Total	235	168	287	0	690	322	283	723		1328	337	192
1999	1	314	303	427	0	1044	535	1016	560		2111		
	2	82	83	98	0	263		84	239		323		
	Total	396	386	525	0	1307	535	1100	799		2434	337	186
2000	1	136	282	193	0	612	85	251	555		891		
	2	128	154	228	0	510	51	186	411		648		
	Total	264	436	421	1	1122	136	437	966		1539	348	137
2001	1	198	468	357	0	1023		336	1227		1563		
	2	56	95	121	0	272	212	413	514		1139		
	Total	254	563	478	0	1295	212	749	1741		2702	736	209
2002	1	86	355	170	1	612	373	643	533		1549		
	2	38	69	73	1	180	214	347	329		890		
	Total	124	423	242	2	792	587	990	862		2439	553	308
2003	1	51	156	103		310	9990	341	515		10846		
	2	34	102	50	0	186	2140	209	84		2433		
	Total	85	258	153	0	496	12130	550	599		13279	485	2676
2004	1	21	177	44	2	243	4692	277			4969		
	2	16	172	51	8	246	3207	99			3306		
	Total	37	349	94	10	489	7899	376			8275	943	1692
2005	1	13	46	34	7	100	5140	205	61		5406		
	2	9	72	52	9	142	4212	191	192		4595		
	Total	23	118	86	16	242	9352	396	253		10001	1921	4130
2006	1	8	56	31	11	105	73	536	726		1335		
	2	6	38	41	18	104	83	452	629		1164		
	Total	14	94	72	29	209	156	988	1355		2499	851	1195
2007	1	17	31	37	14	100	379	563	1077		2019		
	2	10	28	51	20	109	720	1191	1697		3608		
	Total	27	59	88	35	209	1099	1754	2774		5627	1497	2692
Grand Total		2233	3337	3083	93	8746	33231	9711	12956		55898	9433	639

Table D3. Southern New England-Mid Atlantic yellowtail flounder coefficient of variation for landings at age by year.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1994		71%	13%	15%	18%	28%
1995			39%	17%	52%	41%
1996		27%	10%	27%	29%	31%
1997		31%	10%	13%	32%	40%
1998		12%	11%	15%	44%	78%
1999		36%	8%	23%	34%	59%
2000	137%	13%	10%	13%	44%	96%
2001		19%	6%	10%	24%	36%
2002		17%	8%	16%	42%	
2003		2%	1%	1%	2%	5%
2004		3%	2%	12%	4%	8%
2005		2%	7%	10%	5%	18%
2006		12%	8%	9%	14%	13%
2007		12%	3%	7%	14%	15%

Table D4. Southern New England-Mid Atlantic yellowtail flounder discards (metric tons) and coefficient of variation by gear and year.

	Otter Trawl Large Mesh		Otter Trawl Small Mesh		Scallop Dredge	
Year	D (mt)	CV	D (mt)	CV	D (mt)	CV
1994	4	107%	299	30%	58	90%
1995	5	87%	2	39%	137	76%
1996	15	109%	12	56%	251	30%
1997	172	24%	13	80%	212	46%
1998	271	137%	16	50%	130	44%
1999	6	47%	19	0%	147	50%
2000	4	0%	17	416%	118	57%
2001	2	99%	10	66%	20	116%
2002	0	123%	5	227%	19	57%
2003	24	66%	17	317%	64	78%
2004	104	49%	2	52%	19	26%
2005	48	47%	8	39%	68	23%
2006	79	27%	10	158%	71	29%
2007	81	29%	5	60%	91	28%

Table D5a. Southern New England-Mid Atlantic yellowtail flounder landings at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1973	28	2650	10595	7927	5226	6286
1974	130	1853	4760	7325	3687	3347
1975	176	2692	1883	1120	1597	1452
1976	0	1474	1167	327	449	896
1977	68	2260	4848	507	278	649
1978	21	4089	2157	1470	247	179
1979	19	5114	8548	1062	438	131
1980	137	4774	6577	3829	512	167
1981	0	3016	7259	2926	1111	183
1982	56	17980	13453	1855	415	86
1983	57	14416	37156	3584	385	192
1984	47	3058	19038	8054	878	276
1985	166	5030	2155	1968	1109	246
1986	40	6215	3287	635	356	149
1987	76	1403	2349	926	167	65
1988	0	1213	532	506	134	32
1989	0	5918	1513	331	42	3
1990	0	423	18922	1536	79	5
1991	0	253	2343	6814	156	51
1992	0	301	1011	2080	264	18
1993	0	245	432	702	145	4
1994	0	14	273	221	212	78
1995	0	0	84	252	46	29
1996	0	292	621	174	21	23
1997	0	39	947	646	85	40
1998	0	495	772	337	48	5
1999	0	261	2053	383	110	7
2000	2	688	1089	465	53	7
2001	0	392	1626	468	125	39
2002	0	225	945	377	23	0
2003	0	95	462	304	79	18
2004	0	199	187	251	262	99
2005	0	82	149	110	87	38
2006	0	88	154	97	39	45
2007	0	38	303	87	22	15

Table D5b. Southern New England-Mid Atlantic yellowtail flounder discards at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1973	192	2982	1355	52	0	0
1974	731	26666	796	45	0	0
1975	8734	1438	1	10	0	0
1976	214	5203	14	0	0	0
1977	5445	2767	43	0	0	0
1978	8677	10102	7	0	0	0
1979	186	14305	119	0	0	0
1980	869	5441	18	0	0	0
1981	38	4013	319	0	0	0
1982	113	17716	905	3	0	0
1983	2611	4872	5682	18	0	0
1984	470	3141	951	75	0	0
1985	2073	3044	20	0	0	0
1986	423	3755	39	0	0	0
1987	1518	2034	19	0	0	0
1988	5899	896	4	0	0	0
1989	24	14002	1834	131	6	0
1990	192	1634	23721	673	11	0
1991	446	1357	2826	2889	12	0
1992	477	1152	1086	659	33	0
1993	13	212	15	9	0	0
1994	362	836	126	183	85	8
1995	1	373	114	37	4	7
1996	3	227	497	58	11	7
1997	22	446	565	142	25	2
1998	19	968	364	60	3	25
1999	10	214	164	24	15	1
2000	2	217	101	49	2	6
2001	0	13	57	9	1	0
2002	1	26	20	11	2	1
2003	2	60	131	41	10	5
2004	4	80	56	60	51	25
2005	66	144	68	40	31	15
2006	19	224	190	42	6	12
2007	6	206	261	47	22	0

Table D5c. Southern New England-Mid Atlantic yellowtail flounder catch at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1973	220	5632	11951	7978	5226	6286
1974	861	28519	5556	7370	3687	3347
1975	8910	4129	1884	1130	1597	1452
1976	214	6677	1181	327	449	896
1977	5513	5027	4891	507	278	649
1978	8698	14191	2164	1470	247	179
1979	205	19419	8667	1062	438	131
1980	1006	10215	6595	3829	512	167
1981	38	7029	7578	2926	1111	183
1982	169	35696	14358	1858	415	86
1983	2668	19288	42837	3601	385	192
1984	517	6200	19990	8129	878	276
1985	2239	8074	2175	1968	1109	246
1986	463	9970	3326	635	356	149
1987	1594	3437	2368	926	167	65
1988	5899	2109	536	506	134	32
1989	24	19920	3347	462	48	3
1990	192	2056	42644	2209	90	5
1991	446	1610	5169	9703	168	51
1992	477	1453	2097	2739	297	18
1993	13	457	447	711	145	4
1994	362	851	399	404	297	86
1995	1	373	198	288	51	36
1996	3	519	1117	232	32	30
1997	22	485	1512	789	110	42
1998	19	1463	1136	396	52	31
1999	10	475	2217	407	125	8
2000	4	905	1190	514	55	13
2001	0	405	1683	477	126	39
2002	1	250	966	388	25	1
2003	2	155	594	344	89	23
2004	4	280	243	311	313	124
2005	66	226	217	150	118	52
2006	19	312	344	139	44	57
2007	6	245	564	135	44	15

Table D6. Southern New England-Mid Atlantic yellowtail flounder catch weight at age (kg).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1973	0.210	0.296	0.348	0.375	0.382	0.428
1974	0.203	0.308	0.352	0.396	0.439	0.457
1975	0.218	0.289	0.376	0.432	0.435	0.481
1976	0.228	0.303	0.408	0.498	0.499	0.557
1977	0.215	0.283	0.381	0.504	0.513	0.542
1978	0.234	0.293	0.383	0.536	0.662	0.656
1979	0.189	0.301	0.364	0.475	0.590	0.662
1980	0.206	0.281	0.384	0.500	0.682	0.925
1981	0.140	0.262	0.342	0.474	0.596	0.650
1982	0.226	0.263	0.353	0.499	0.660	0.833
1983	0.175	0.261	0.339	0.496	0.668	0.819
1984	0.182	0.237	0.295	0.388	0.487	0.656
1985	0.183	0.260	0.365	0.408	0.504	0.608
1986	0.186	0.284	0.331	0.463	0.587	0.642
1987	0.247	0.268	0.353	0.404	0.520	0.631
1988	0.270	0.293	0.396	0.493	0.611	0.821
1989	0.311	0.338	0.394	0.553	0.735	0.957
1990	0.301	0.327	0.378	0.455	0.763	0.884
1991	0.206	0.262	0.337	0.414	0.678	0.800
1992	0.167	0.316	0.368	0.434	0.599	0.918
1993	0.122	0.354	0.430	0.451	0.641	1.040
1994	0.123	0.198	0.353	0.416	0.504	0.672
1995	0.072	0.227	0.356	0.446	0.597	0.849
1996	0.105	0.344	0.381	0.469	0.613	0.734
1997	0.192	0.254	0.402	0.512	0.665	0.841
1998	0.168	0.280	0.384	0.519	0.587	0.693
1999	0.200	0.361	0.430	0.609	0.769	1.114
2000	0.144	0.348	0.479	0.625	0.748	0.888
2001	0.153	0.378	0.444	0.614	0.753	0.917
2002	0.165	0.374	0.473	0.628	0.838	0.797
2003	0.100	0.347	0.436	0.620	0.639	0.846
2004	0.158	0.320	0.403	0.493	0.576	0.744
2005	0.096	0.298	0.422	0.528	0.669	0.841
2006	0.118	0.255	0.391	0.534	0.675	0.852
2007	0.124	0.273	0.382	0.501	0.737	0.869

Table D7a. NEFSC Spring survey indices of minimum swept area abundance for Southern New England-Mid Atlantic yellowtail flounder in 000's and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1973	912.670	5523.648	15096.903	8491.120	6586.563	9407.466	13266.215
1974	592.291	2507.711	2956.943	5712.165	3454.975	3114.542	6081.679
1975	414.470	1512.983	454.914	588.280	866.042	1020.298	1616.433
1976	49.803	4269.710	580.091	278.430	264.559	499.871	1879.989
1977	1572.981	1642.170	2881.736	263.222	164.785	457.923	2226.606
1978	3105.517	11899.133	2109.786	900.971	292.636	483.158	4344.414
1979	986.706	2921.846	1548.413	278.263	121.166	61.001	1384.965
1980	708.610	6520.048	4418.451	2786.141	274.419	109.300	5314.074
1981	849.162	18261.415	4743.509	2497.516	554.354	94.760	7284.143
1982	340.099	29950.638	9722.831	2437.852	799.025	273.584	10663.745
1983	66.349	10831.873	17948.557	1220.180	389.234	0.000	8764.871
1984	78.382	924.034	1838.208	4301.296	800.027	456.084	2786.308
1985	446.057	2695.893	677.859	802.869	1192.938	258.542	1584.178
1986	27.241	4834.425	1530.029	395.251	207.402	26.406	1758.656
1987	0.000	144.396	1170.711	278.430	0.000	0.000	532.962
1988	476.473	595.801	208.071	290.129	491.348	48.132	631.733
1989	229.797	15925.508	761.923	160.607	0.000	0.000	2968.641
1990	127.015	689.558	21804.632	3115.711	112.475	0.000	7193.394
1991	346.450	844.483	3564.609	5903.691	765.433	85.234	3563.105
1992	60.165	84.732	954.618	2669.488	0.000	0.000	1326.973
1993	27.241	423.328	187.180	827.102	28.578	0.000	569.896
1994	22.395	382.048	23.230	0.000	97.267	27.241	193.364
1995	26.406	1952.856	114.146	154.089	31.252	115.316	550.176
1996	0.000	664.322	2178.140	946.596	119.829	0.000	1247.922
1997	87.908	1479.223	1911.576	546.165	112.141	0.000	1318.115
1998	113.478	5040.490	644.601	269.238	60.666	34.261	1417.220
1999	59.329	1087.148	3225.513	583.266	124.341	38.272	1902.384
2000	32.088	1935.809	2478.297	355.141	0.000	0.000	1654.370
2001	0.000	115.651	1934.639	400.599	137.377	38.272	1090.491
2002	81.557	1990.292	393.078	333.916	111.807	0.000	851.669
2003	51.642	125.678	339.431	179.492	54.149	0.000	279.266
2004	27.241	227.123	488.172	169.465	58.494	32.088	383.051
2005	245.507	343.275	161.443	112.475	254.531	26.406	370.182
2006	83.897	2646.926	374.360	176.818	0.000	52.812	651.286
2007	0.000	962.974	1320.622	145.900	0.000	0.000	613.850
2008	0.000	83.061	1144.806	802.367	82.393	0.000	741.199

Table D7b. NEFSC Fall survey indices of minimum swept area abundance for Southern New England-Mid Atlantic yellowtail flounder in 000's and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1973	2006.103	2935.399	5725.930	3248.458	2191.641	1302.439	4595.242
1974	949.631	1735.092	582.002	2273.783	962.842	698.954	2271.715
1975	1994.155	553.281	180.023	290.312	289.852	146.477	837.848
1976	2752.274	5892.512	490.439	64.795	102.247	714.348	2873.017
1977	2726.540	1714.068	618.076	93.745	33.431	92.826	1406.064
1978	2477.587	5684.227	352.579	280.776	28.606	88.690	2504.814
1979	1778.288	3910.879	1880.535	286.521	31.248	30.329	2272.404
1980	1373.667	3464.095	901.609	372.454	0.000	0.000	1692.585
1981	11330.772	11315.263	1490.734	235.397	108.336	57.787	5057.076
1982	2858.542	24940.267	6155.251	749.618	301.800	0.000	8390.548
1983	2691.156	15806.650	7839.909	642.316	53.651	37.108	6603.069
1984	2023.795	1786.560	2142.930	468.152	0.000	0.000	1519.570
1985	848.762	365.790	106.038	103.166	0.000	0.000	291.001
1986	604.519	1832.284	511.119	114.769	39.750	0.000	754.213
1987	1226.386	518.816	411.974	34.580	27.457	27.457	461.029
1988	5019.853	373.947	153.255	161.757	15.165	56.753	586.482
1989	134.989	10303.710	1337.364	70.769	0.000	0.000	2303.882
1990	240.797	2089.279	3043.275	189.214	0.000	0.000	1274.063
1991	574.075	237.235	1480.279	358.093	0.000	0.000	737.440
1992	192.431	27.457	82.257	326.845	0.000	0.000	168.879
1993	324.432	27.227	126.947	101.213	0.000	0.000	112.931
1994	841.065	514.450	122.811	163.710	60.659	28.606	353.728
1995	159.689	741.001	295.481	132.576	0.000	60.544	349.247
1996	514.910	184.733	367.054	0.000	0.000	0.000	238.499
1997	944.691	596.248	1676.501	311.450	27.227	0.000	978.122
1998	1022.467	1861.464	141.882	55.834	0.000	26.308	752.375
1999	1422.148	450.000	320.526	32.053	32.053	0.000	537.082
2000	56.753	1917.413	348.098	196.566	0.000	26.308	824.867
2001	448.507	701.711	181.976	81.568	0.000	0.000	481.938
2002	291.231	1977.957	982.372	191.741	0.000	0.000	1257.519
2003	1344.142	28.491	289.508	263.199	0.000	56.982	498.826
2004	80.649	112.471	0.000	26.423	55.029	28.491	118.216
2005	2031.148	532.832	212.880	84.325	164.744	0.000	569.250
2006	1369.991	2472.072	196.222	22.058	0.000	0.000	804.992
2007	257.455	1286.355	409.331	0.000	30.329	0.000	518.356

Table D7c. NEFSC Winter survey indices of minimum swept area abundance for Southern New England-Mid Atlantic yellowtail flounder in 000's and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1992	13.717	2098.702	4591.911	10616.249	1235.388	0.000	6910.085
1993	852.026	2749.117	1510.728	3553.277	417.369	0.000	3026.172
1994	444.803	10510.800	901.322	2009.113	1173.519	571.971	4765.231
1995	128.311	15261.314	3854.908	853.169	361.357	286.771	4948.839
1996	58.154	1835.793	11767.192	1216.527	200.468	136.741	4780.949
1997	222.758	3400.961	13981.632	4226.839	755.436	53.582	8172.765
1998	168.891	11203.223	2280.310	1654.614	160.460	26.005	3972.931
1999	347.069	4155.968	14540.028	1109.935	444.517	112.880	7467.910
2000	155.174	7025.394	4294.709	1658.043	103.878	142.457	4322.000
2001	40.151	1278.682	12204.850	2307.458	362.215	202.469	6838.643
2002	17.289	3907.775	3683.588	2924.866	143.028	28.006	3698.734
2003	473.808	996.483	3710.451	756.150	60.869	37.007	2204.152
2004	72.157	1373.844	455.948	841.596	204.612	62.155	1184.092
2005	559.397	1112.792	880.318	741.861	837.881	148.029	1350.982
2006	993.912	26771.027	6512.578	493.669	127.311	205.041	5494.090
2007	46.152	9756.650	10771.280	1909.379	135.170	0.000	5582.822

Table D8a. Diagnostics for VPA estimates (Age 6+ formulation).

Model MSR 0.746

Stock Numbers Predicted in Terminal Year Plus One (2008)

Age	N	Std. Error	CV
2	953	487	0.51
3	6071	2083	0.34
4	5190	1602	0.31
5	237	90	0.38

Catchability Values for Each Survey Used in Estimate

Index	Catchability	Std. Error	CV
NEFSC_S_1	0.014	0.002	0.168
NEFSC_S_2	0.183	0.027	0.150
NEFSC_S_3	0.283	0.037	0.131
NEFSC_S_4	0.419	0.044	0.104
NEFSC_S_5	0.550	0.095	0.173
NEFSC_S_6	0.568	0.114	0.200
NEFSC_F_1	0.101	0.016	0.158
NEFSC_F_2	0.176	0.029	0.163
NEFSC_F_3	0.200	0.025	0.124
NEFSC_F_4	0.217	0.028	0.130
NEFSC_F_5	0.222	0.042	0.190
NEFSC_F_6	0.450	0.133	0.295
NEFSC_W_1	0.045	0.013	0.276
NEFSC_W_2	1.426	0.259	0.182
NEFSC_W_3	2.292	0.418	0.183
NEFSC_W_4	2.548	0.320	0.126
NEFSC_W_5	1.895	0.439	0.232
NEFSC_W_6	2.341	0.827	0.353

Table D8b. Diagnostics for VPA estimates (Age 7+ formulation).

Model MSR 1.528

Stock Numbers Predicted in Terminal Year Plus One (2008)

Age	N	Std. Error	CV
2	986	720	0.73
3	6321	3100	0.49
4	5534	2431	0.44
5	322	208	0.65
6	55	48	0.88

Catchability Values for Each Survey Used in Estimate

Index	Catchability	Std. Error	CV
NEFSC_S_1	0.014	0.002	0.165
NEFSC_S_2	0.177	0.026	0.148
NEFSC_S_3	0.267	0.035	0.131
NEFSC_S_4	0.367	0.041	0.111
NEFSC_S_5	0.367	0.068	0.186
NEFSC_S_6	0.250	0.068	0.271
NEFSC_S_7	0.753	0.588	0.782
NEFSC_F_1	0.098	0.015	0.157
NEFSC_F_2	0.168	0.027	0.163
NEFSC_F_3	0.183	0.023	0.128
NEFSC_F_4	0.176	0.023	0.130
NEFSC_F_5	0.138	0.030	0.220
NEFSC_F_6	0.092	0.048	0.521
NEFSC_F_7	0.555	0.702	1.265
NEFSC_W_1	0.044	0.012	0.280
NEFSC_W_2	1.365	0.246	0.180
NEFSC_W_3	2.163	0.392	0.181
NEFSC_W_4	2.284	0.260	0.114
NEFSC_W_5	1.372	0.315	0.229
NEFSC_W_6	1.521	0.593	0.390
NEFSC_W_7	4.992	4.987	0.999

Table D9a. Mohn's Rho retrospective statistics for F, SSB, and R (Age 6+ Formulation).

	Mohn's rho		
Peel	**F**	**SSB**	**Rec**
2000	-49%	95%	-65%
2001	-24%	8%	66%
2002	51%	-21%	35%
2003	204%	-31%	221%
2004	89%	-20%	-11%
2005	24%	20%	76%
2006	28%	25%	9%
Average	**46%**	**11%**	**47%**

Table D9b. Mohn's Rho retrospective statistics for F, SSB, and R (Age 7+ Formulation).

	Mohn's rho		
Peel	**F**	**SSB**	**Rec**
2000	302%	302%	-59%
2001	149%	149%	67%
2002	-14%	-14%	31%
2003	-30%	-30%	248%
2004	-17%	-17%	-18%
2005	8%	8%	71%
2006	18%	18%	8%
Average	**59%**	**59%**	**50%**

Table D10. Estimated population abundance at age (000's).

	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1973	42491	18128	29322	16834	11027	13264	131066
1974	10362	34590	9789	13316	6662	6047	80766
1975	31479	7707	3386	3074	4344	3950	53940
1976	14339	17773	2633	1096	1504	3002	40347
1977	49917	11547	8572	1101	604	1409	73150
1978	53116	35899	4961	2670	449	325	97420
1979	30998	35657	16692	2127	877	262	86613
1980	43355	25194	11907	5943	795	259	87453
1981	136011	34588	11488	3880	1473	243	187683
1982	62906	111322	21995	2697	602	125	199647
1983	16407	51350	59128	5292	566	282	133025
1984	18836	11031	24770	10637	1149	361	66784
1985	20560	14955	3516	2772	1562	346	43711
1986	7067	14815	5055	949	532	223	28641
1987	14717	5369	3309	1194	215	84	24888
1988	121166	10612	1349	620	164	39	133950
1989	17049	93879	6791	625	65	4	118413
1990	8019	13937	58946	2575	105	6	83588
1991	4092	6392	9559	10656	184	56	30939
1992	2476	2948	3787	3224	350	21	12806
1993	2223	1598	1118	1234	252	7	6432
1994	4434	1809	898	515	379	110	8145
1995	4288	3304	721	379	67	47	8806
1996	3465	3510	2369	413	57	53	9867
1997	6904	2834	2406	942	131	50	13267
1998	3624	5633	1884	629	83	49	11902
1999	5372	2950	3298	534	164	10	12328
2000	4192	4389	1987	739	79	19	11405
2001	2428	3429	2779	570	151	47	9404
2002	1133	1987	2442	781	50	2	6395
2003	1326	926	1402	1135	294	76	5159
2004	1666	1084	619	617	621	246	4853
2005	10877	1360	636	289	228	100	13490
2006	9408	8846	910	326	103	134	19727
2007	1170	7686	6961	437	143	49	16446
2008	9744	953	6071	5190	237	104	22299

Table D11. Estimated fishing mortality rate at age

	age 1	age 2	age 3	age 4	age 5	age 6+
1973	0.01	0.42	0.59	0.73	0.73	0.73
1974	0.10	2.12	0.96	0.92	0.92	0.92
1975	0.37	0.87	0.93	0.51	0.51	0.51
1976	0.02	0.53	0.67	0.40	0.40	0.40
1977	0.13	0.64	0.97	0.70	0.70	0.70
1978	0.20	0.57	0.65	0.91	0.91	0.91
1979	0.01	0.90	0.83	0.78	0.78	0.78
1980	0.03	0.59	0.92	1.19	1.19	1.19
1981	0.00	0.25	1.25	1.66	1.66	1.66
1982	0.00	0.43	1.22	1.36	1.36	1.36
1983	0.20	0.53	1.52	1.33	1.33	1.33
1984	0.03	0.94	1.99	1.72	1.72	1.72
1985	0.13	0.88	1.11	1.45	1.45	1.45
1986	0.07	1.30	1.24	1.28	1.28	1.28
1987	0.13	1.18	1.47	1.78	1.78	1.78
1988	0.06	0.25	0.57	2.06	2.06	2.06
1989	0.00	0.27	0.77	1.59	1.59	1.59
1990	0.03	0.18	1.51	2.44	2.44	2.44
1991	0.13	0.32	0.89	3.22	3.22	3.22
1992	0.24	0.77	0.92	2.35	2.35	2.35
1993	0.01	0.38	0.57	0.98	0.98	0.98
1994	0.09	0.72	0.66	1.84	1.84	1.84
1995	0.00	0.13	0.36	1.70	1.70	1.70
1996	0.00	0.18	0.72	0.94	0.94	0.94
1997	0.00	0.21	1.14	2.23	2.23	2.23
1998	0.01	0.34	1.06	1.15	1.15	1.15
1999	0.00	0.19	1.30	1.71	1.71	1.71
2000	0.00	0.26	1.05	1.39	1.39	1.39
2001	0.00	0.14	1.07	2.23	2.23	2.23
2002	0.00	0.15	0.57	0.78	0.78	0.78
2003	0.00	0.20	0.62	0.40	0.40	0.40
2004	0.00	0.33	0.56	0.80	0.80	0.80
2005	0.01	0.20	0.47	0.83	0.83	0.83
2006	0.00	0.04	0.53	0.63	0.63	0.63
2007	0.01	0.04	0.09	0.41	0.41	0.41

Table D12. Estimated spawning stock biomass (mt).

	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1973	0	1876	7852	5731	5523	7833	28815
1974	0	1982	2071	3306	1834	1733	10926
1975	0	698	775	986	1403	1411	5273
1976	0	1947	728	426	586	1304	4991
1977	0	1126	1956	382	213	525	4202
1978	0	3746	1300	900	187	134	6267
1979	0	3330	3848	670	343	115	8306
1980	0	2501	2791	1662	303	134	7391
1981	0	3677	2092	846	404	73	7092
1982	0	11021	4177	702	207	54	16161
1983	0	4847	9553	1389	200	122	16111
1984	0	796	2857	1856	252	107	5868
1985	0	1212	724	569	396	106	3007
1986	0	1104	893	237	168	77	2479
1987	0	397	566	211	49	23	1246
1988	0	1265	378	119	39	13	1814
1989	0	12807	1740	164	23	2	14736
1990	0	1908	10640	391	27	2	12968
1991	0	660	1995	1062	30	11	3758
1992	0	305	851	484	72	7	1719
1993	0	218	339	340	99	4	1000
1994	0	120	216	92	82	32	542
1995	0	320	198	77	18	18	631
1996	0	505	599	120	22	24	1270
1997	0	298	539	175	32	15	1059
1998	0	618	417	186	28	19	1268
1999	0	443	740	147	57	5	1392
2000	0	619	551	238	30	9	1447
2001	0	551	708	127	41	16	1443
2002	0	315	818	326	28	1	1488
2003	0	133	423	547	146	50	1299
2004	0	136	177	201	236	121	871
2005	0	168	198	99	99	55	619
2006	0	1000	255	123	49	81	1508
2007	0	932	2292	170	81	33	3508

Table D13a. Bootstrap estimates of uncertainty in 2007 Fishing Mortality (F) and Spawning Stock Biomass (SSB)

	Point	10th%ile	90th%ile	CV's
F 2007				
age 1	0.006	0.003	0.012	0.619
age 2	0.036	0.022	0.056	0.361
age 3	0.094	0.066	0.133	0.286
age 4	0.413	0.290	0.626	0.334
age 5	0.413	0.290	0.626	0.334
age 6+	0.413	0.290	0.626	0.334
Avg F 4-5	0.413	0.290	0.626	0.334
SSB	3508	2679	4609	0.207

Table D13b. Mohn's rho adjusted estimate in 2007 Fishing Mortality and Spawning Stock Biomass

SSB adj	3160
F adj.	0.282

Table D14. Values of Partial Recruitment, maturity, and weight at age (kg) used in yield per recruit calculations and age based projections

Age	PR	Maturity	WAA
1	0.006	0.000	0.119
2	0.265	0.490	0.298
3	0.741	0.974	0.407
4	1.000	1.000	0.535
5	1.000	1.000	0.659
6+	1.000	1.000	0.830

Table D15. Biological Reference Points for Southern New England-Mid Atlantic yellowtail flounder from GARM-II, GARM-III Reference points meeting, and this assessment.

	GARM-II	GARM-III BRP	GARM-III Final
Fmsy	0.26	0.264	0.254
SSBmsy (mt)	69500	27600	27400
MSY (mt)	14200	6300	6100

Table D16. Four projection scenarios for 2009 catch, based on the assumption that catch in 2007 equal to catch in 2008: F status quo applied F2007 in 2009; F2008 uses F2008 from the 100year projections in 2009; F_{MSY} is assumed in 2009; and $F_{REBUILD}$ is solved iteratively to generate a 50% probability of SSB>SSB_{MSY} in 2014, assuming that F is applied every year from 2009 to 2014.

	2007	2008	2009			
			$F_{STATUS\ QUO}$	F2008	Fmsy	$F_{REBUILD}$
C(mt)	396	396	1893	525	1247	425
F(4-5)	0.413	0.089	0.413	0.089	0.254	0.080
SSB(mt)	3508	5143	4957	6604	5272	5638

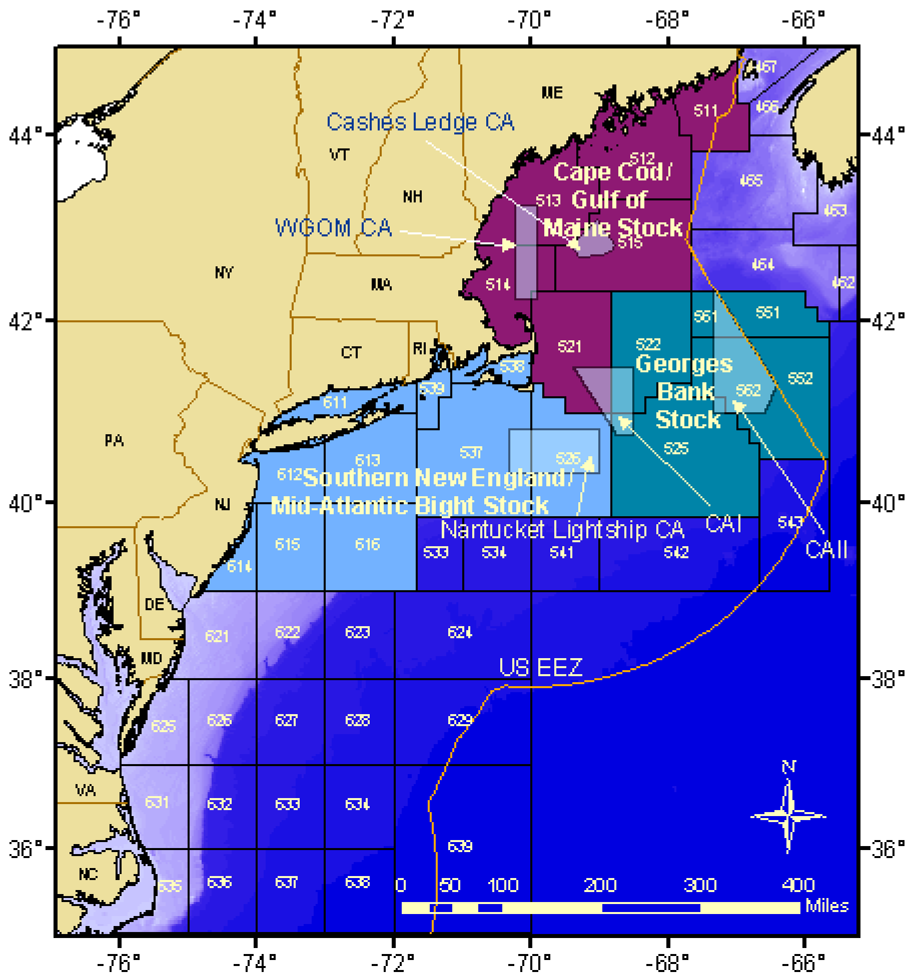


Figure D1. Statistical areas used to define the Southern New England-Mid Atlantic yellowtail flounder stock (http://www.nefsc.noaa.gov/sos)

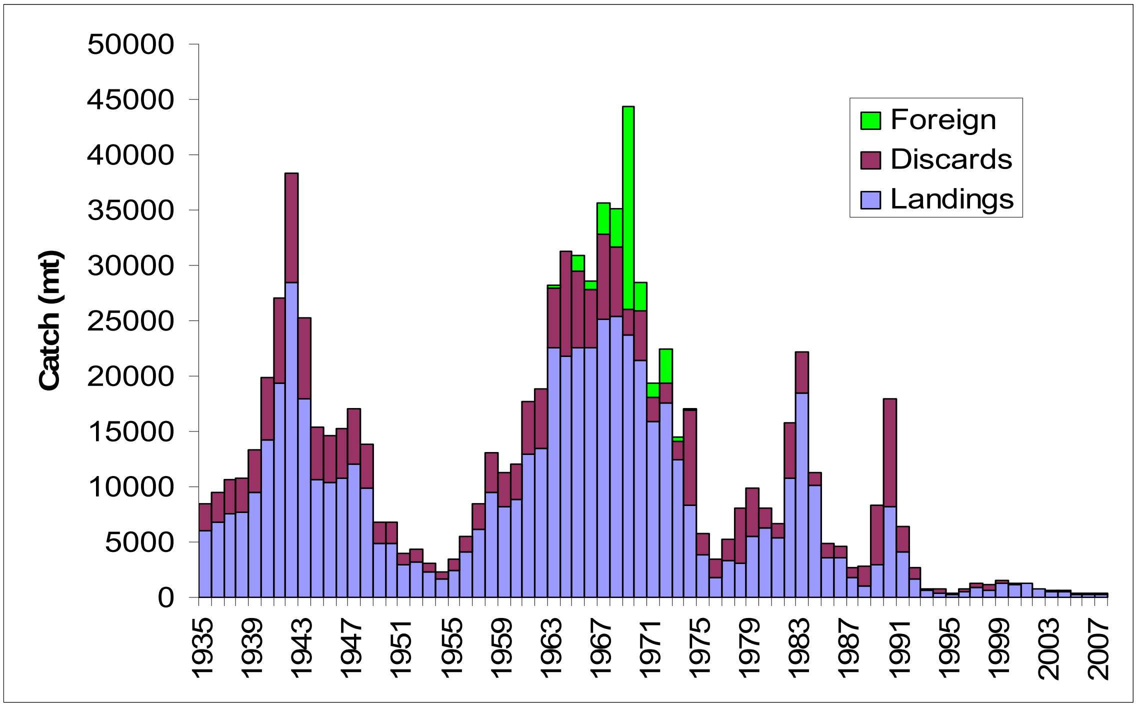


Figure D2. Total catch (mt) of Southern New England-Mid Atlantic yellowtail flounder.

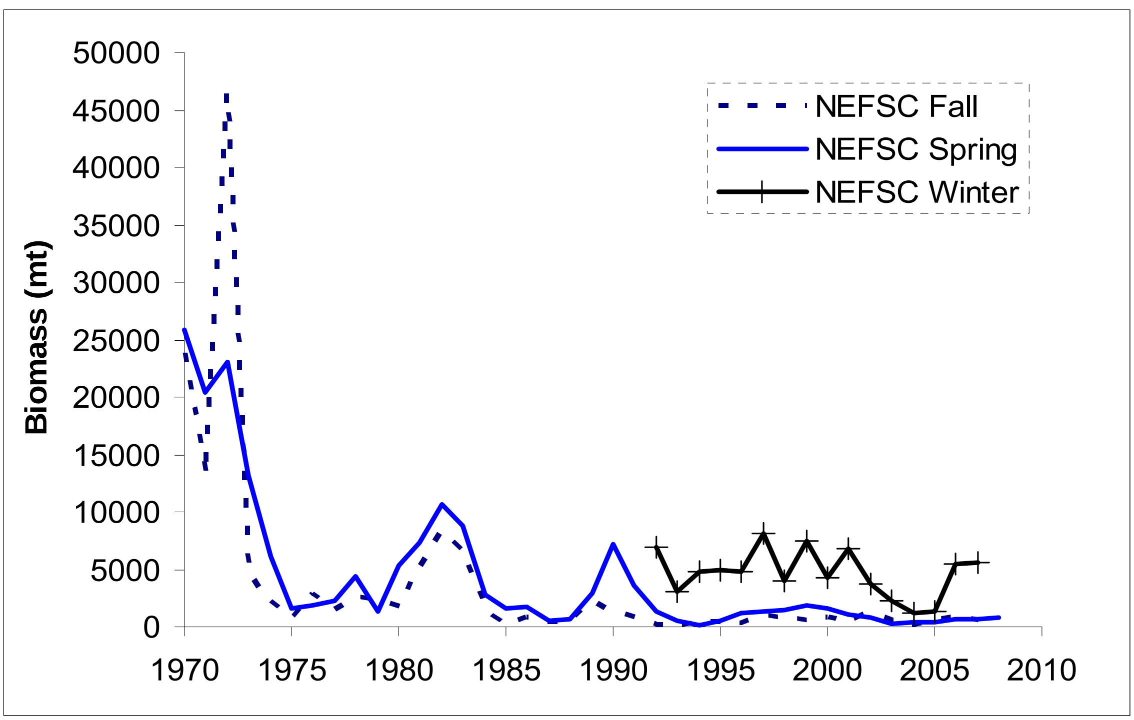
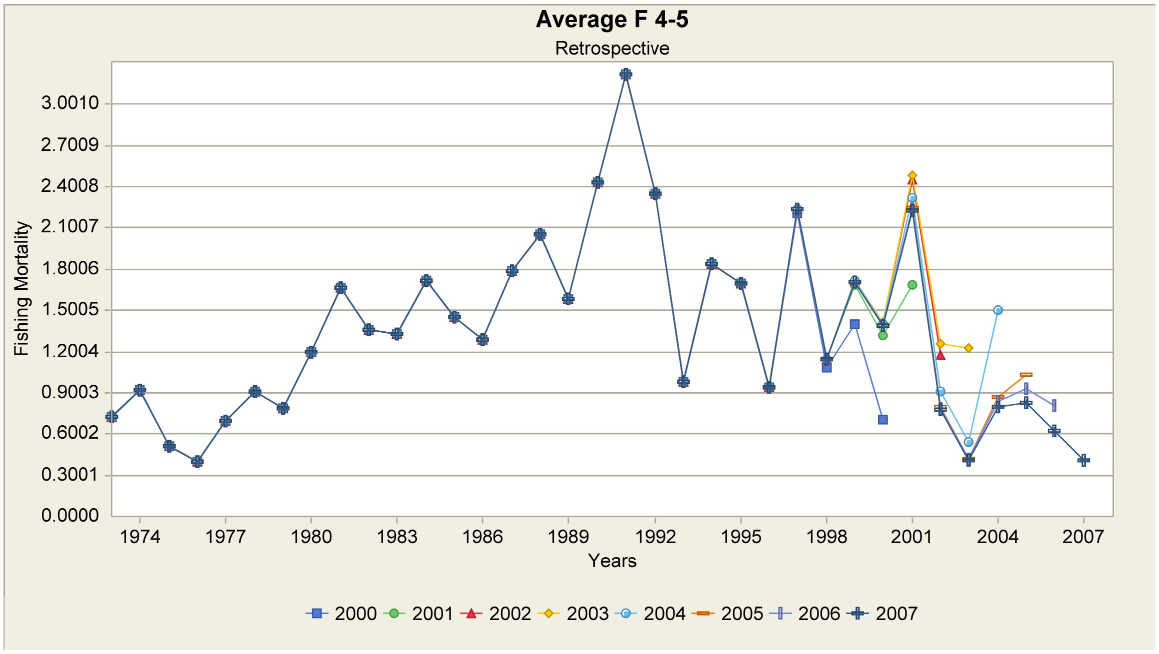


Figure D3. Trends in survey biomass for Southern New England-Mid Atlantic yellowtail flounder.



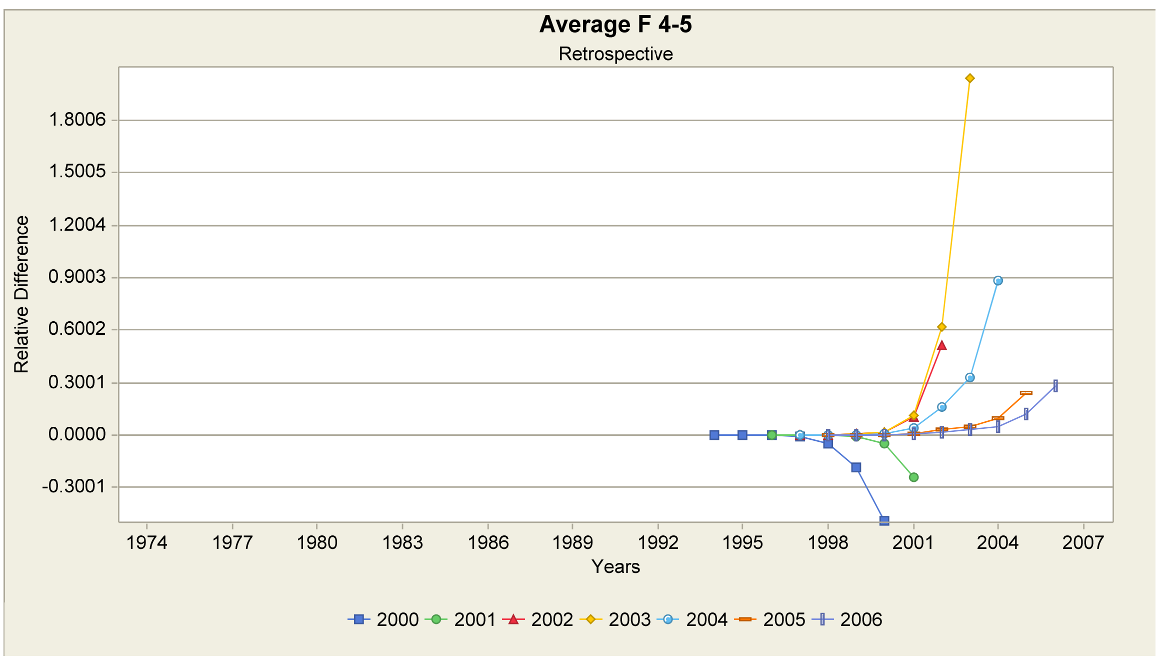
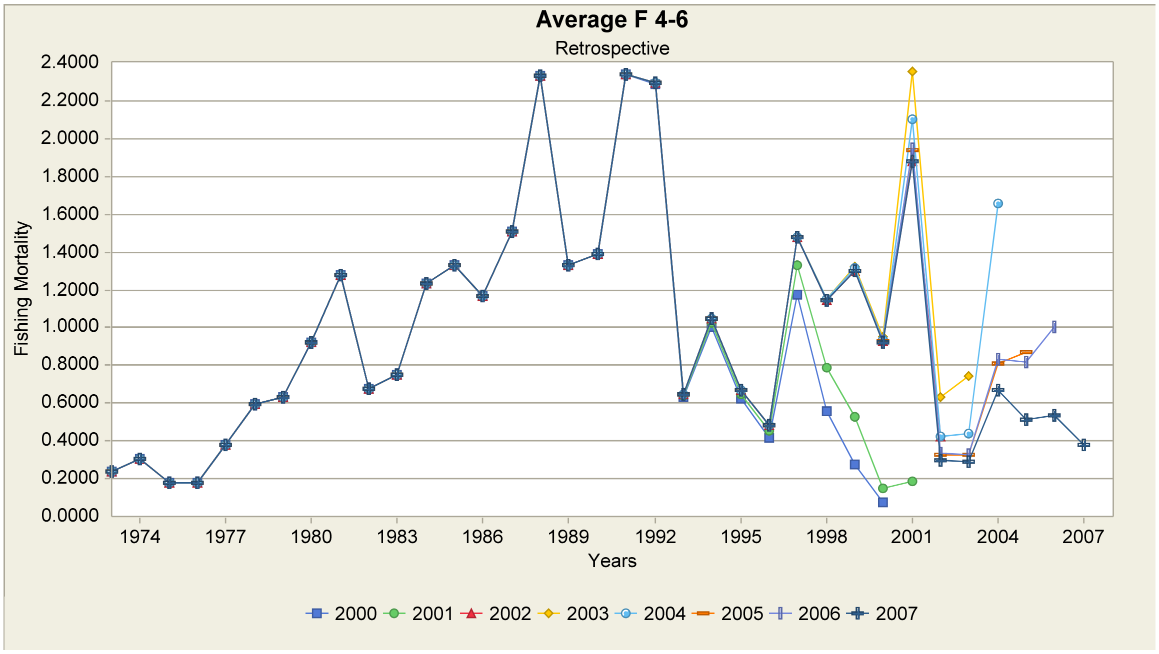


Figure D4a. Age 6+ VPA formulation - Retrospective plots of fully recruited fishing mortality rate (ages 4-5)



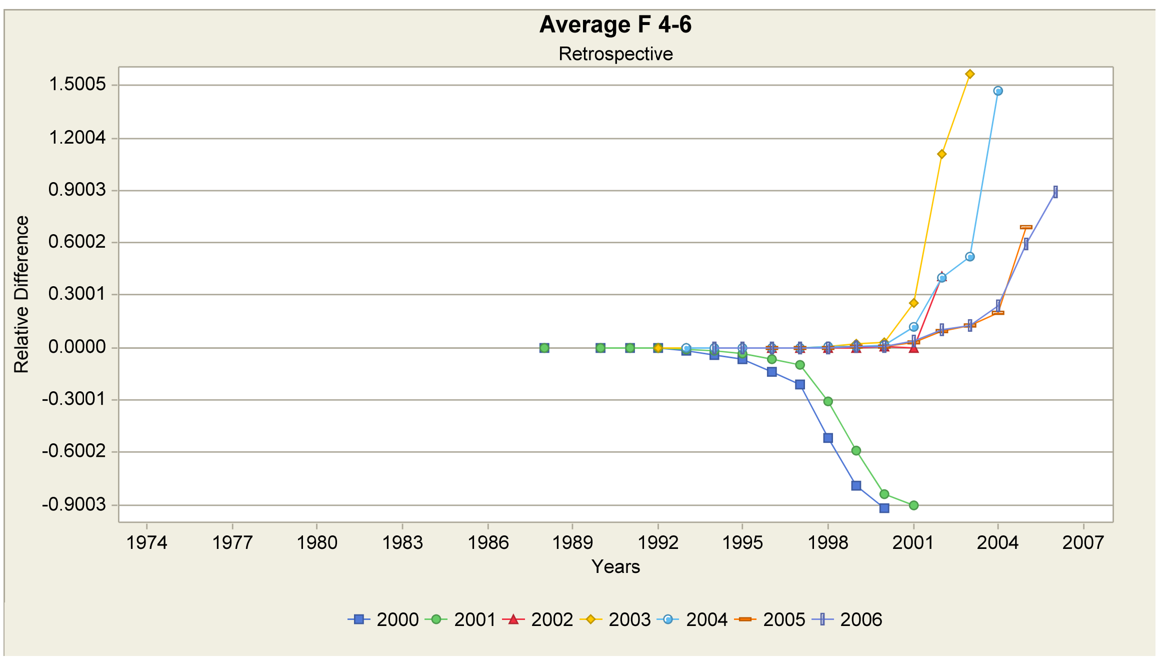
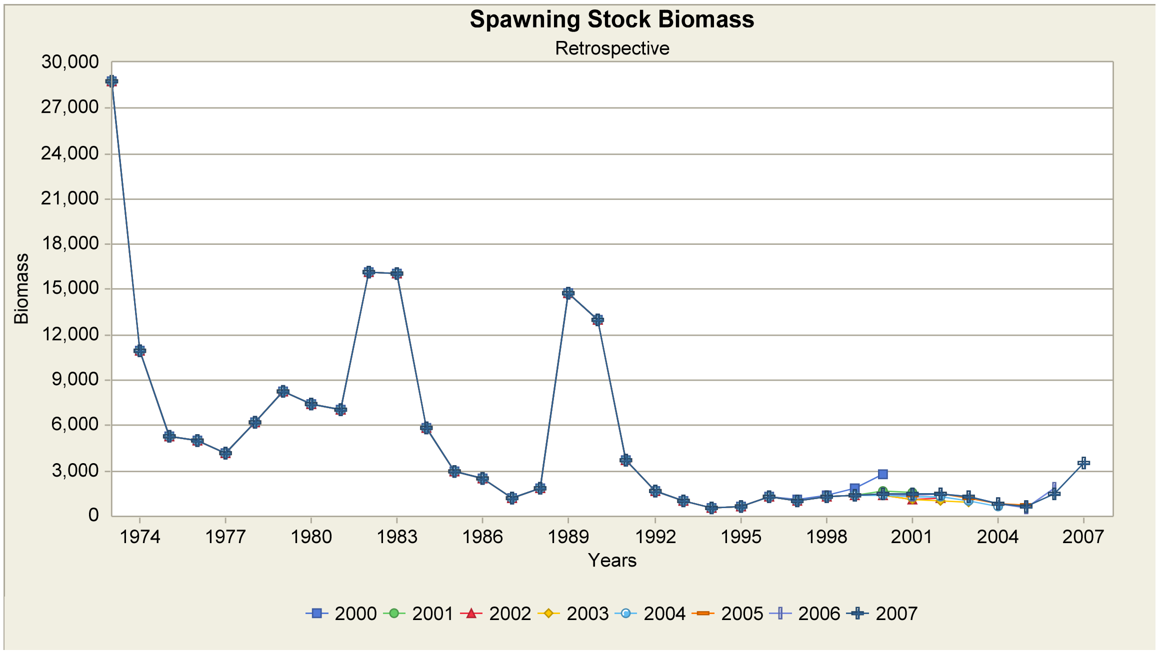


Figure D4b. Age 7+ VPA formulation - Retrospective plots of fully recruited fishing mortality rate (ages 4-5)



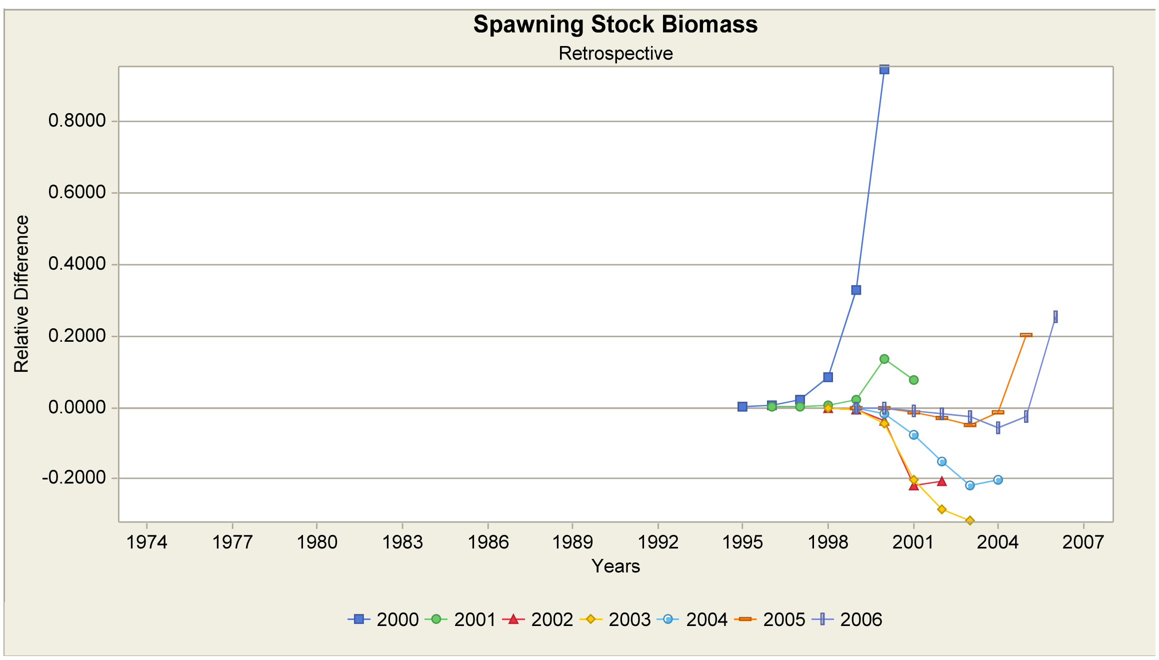
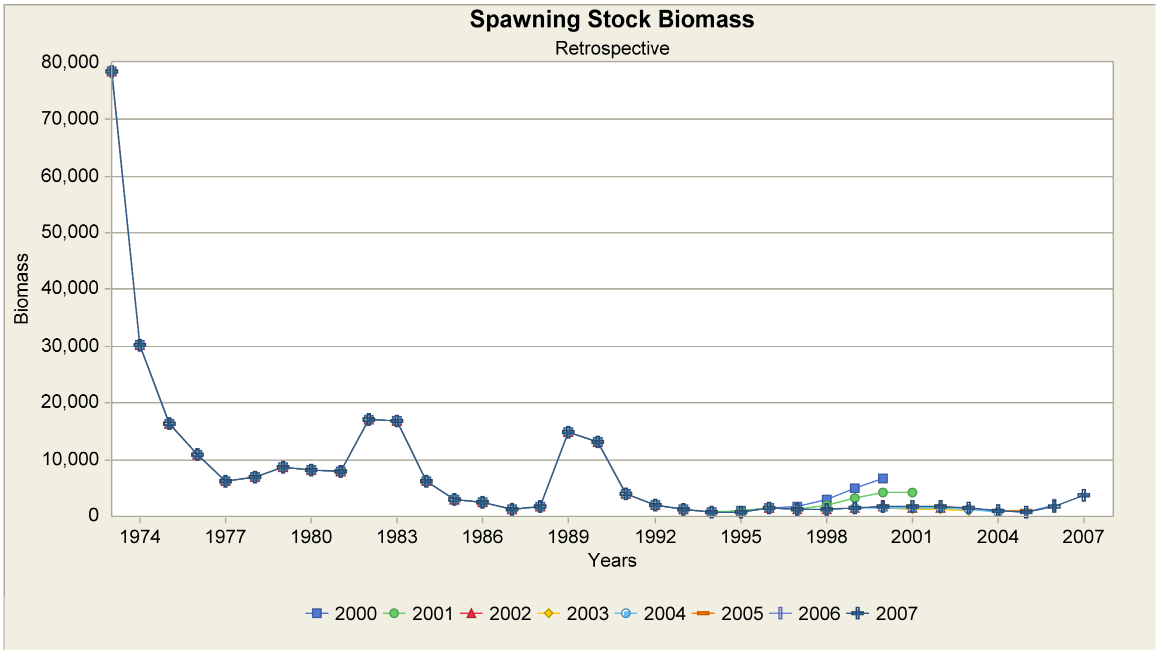


Figure D5a. Age 6+ VPA formulation - Retrospective plots of spawning stock biomass



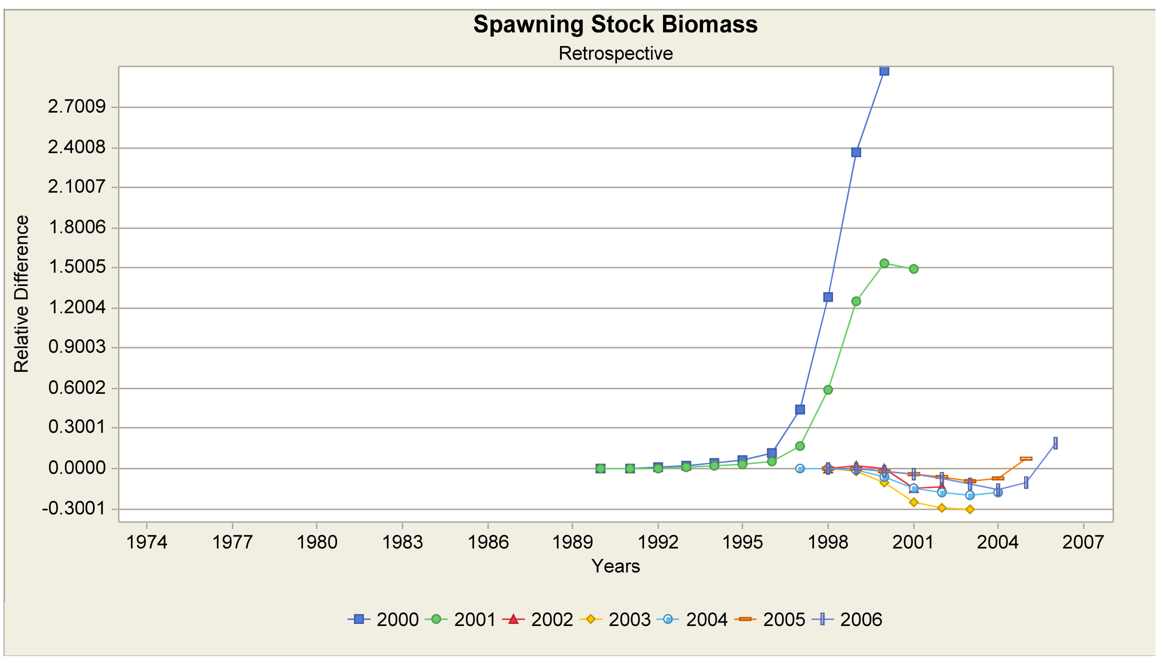
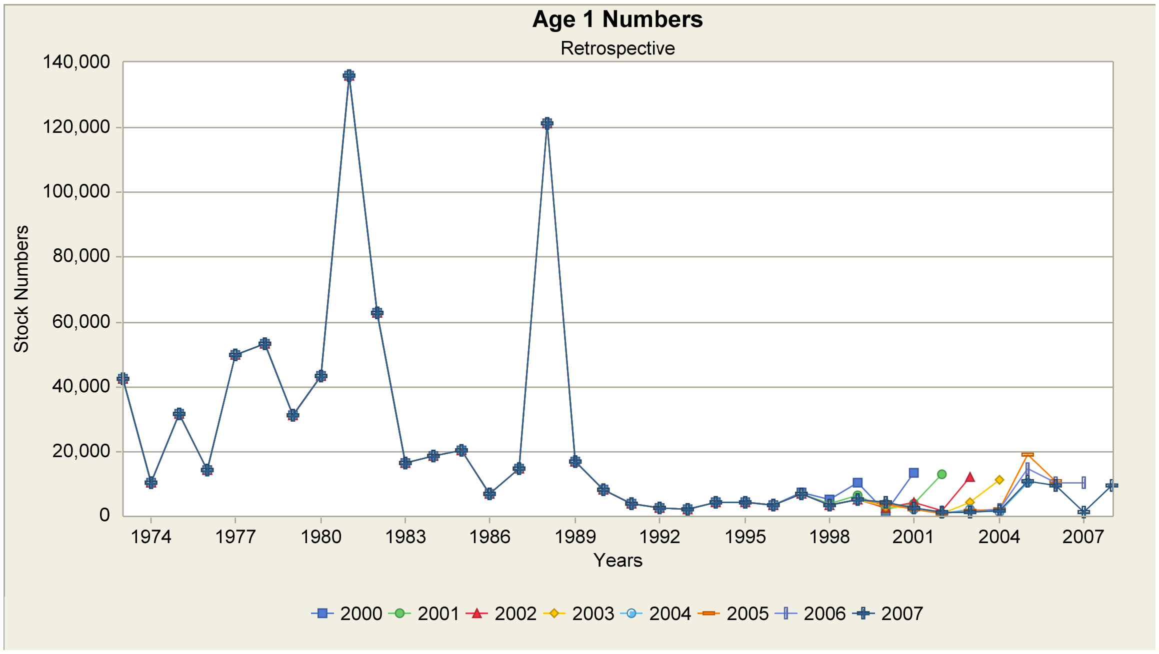


Figure D5b. Age 7+ VPA formulation - Retrospective plots of spawning stock biomass



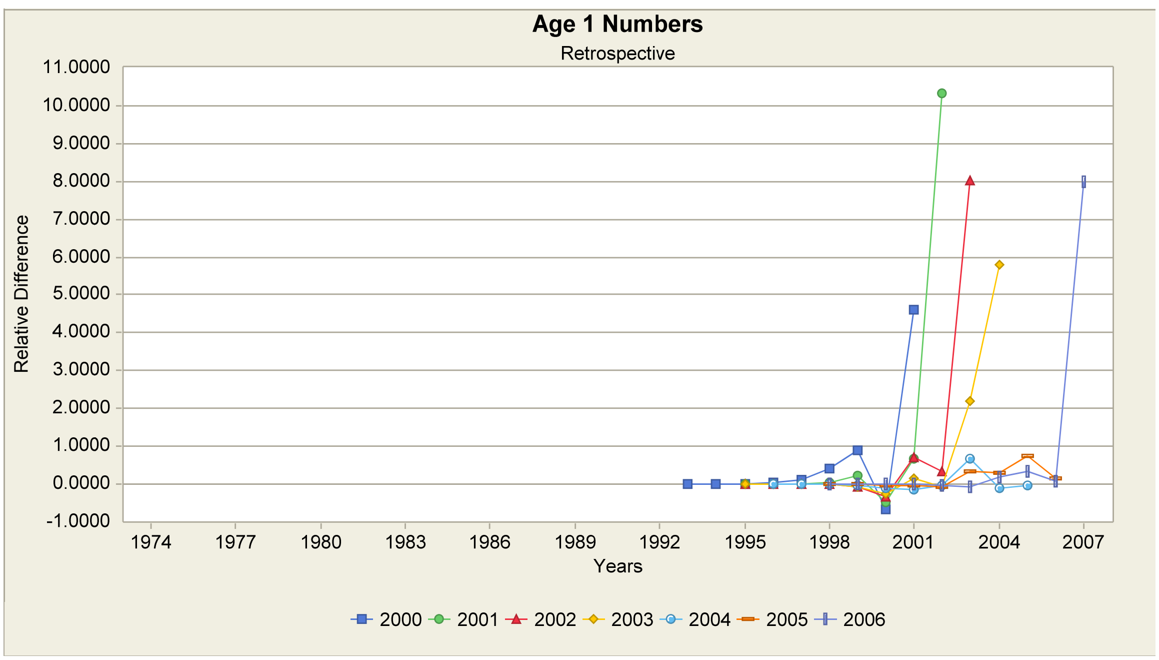
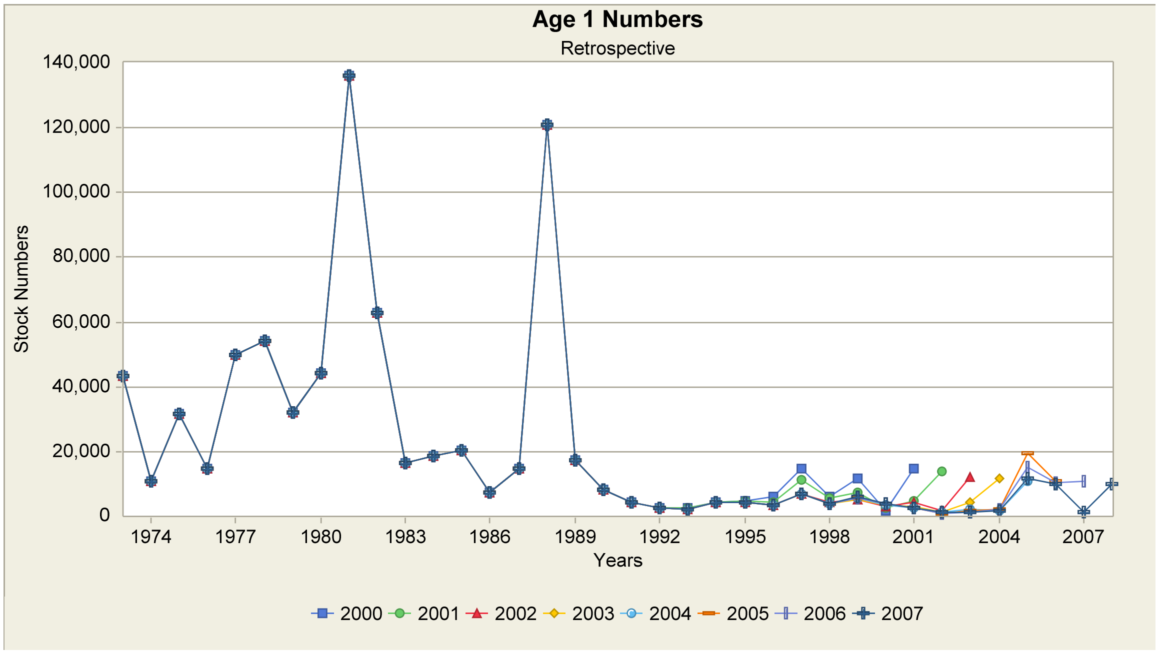


Figure D6a. Age 6+ VPA formulation - Retrospective plots of Age-1 recruitment.



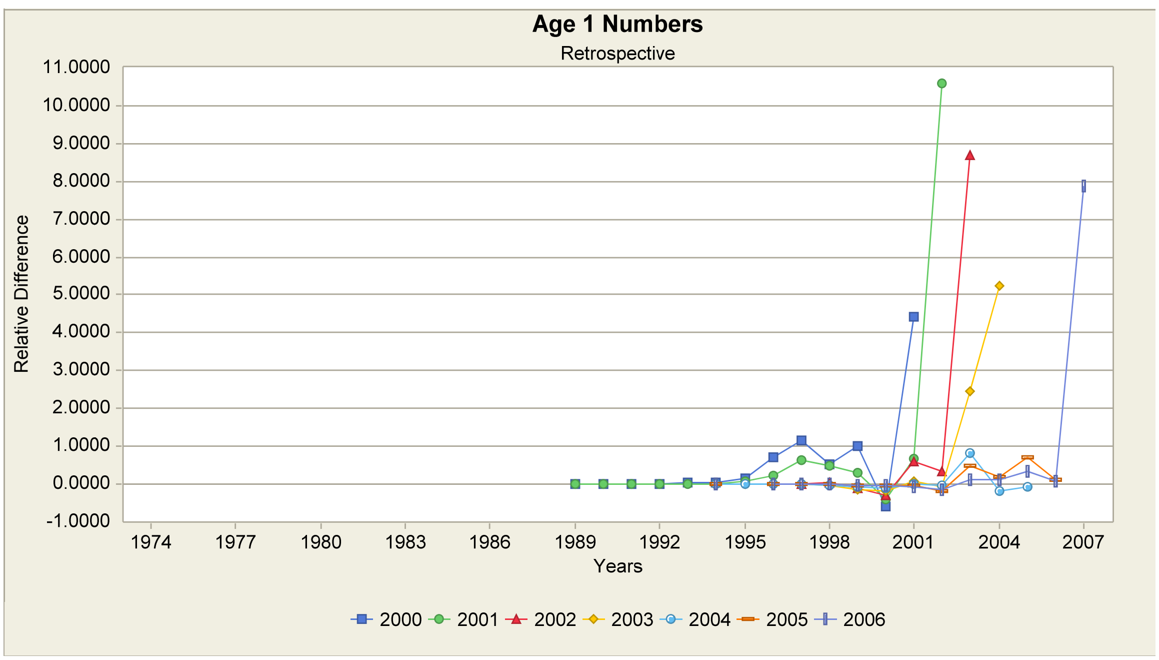


Figure D6b. Age 7+ VPA formulation - Retrospective plots of Age-1 recruitment.

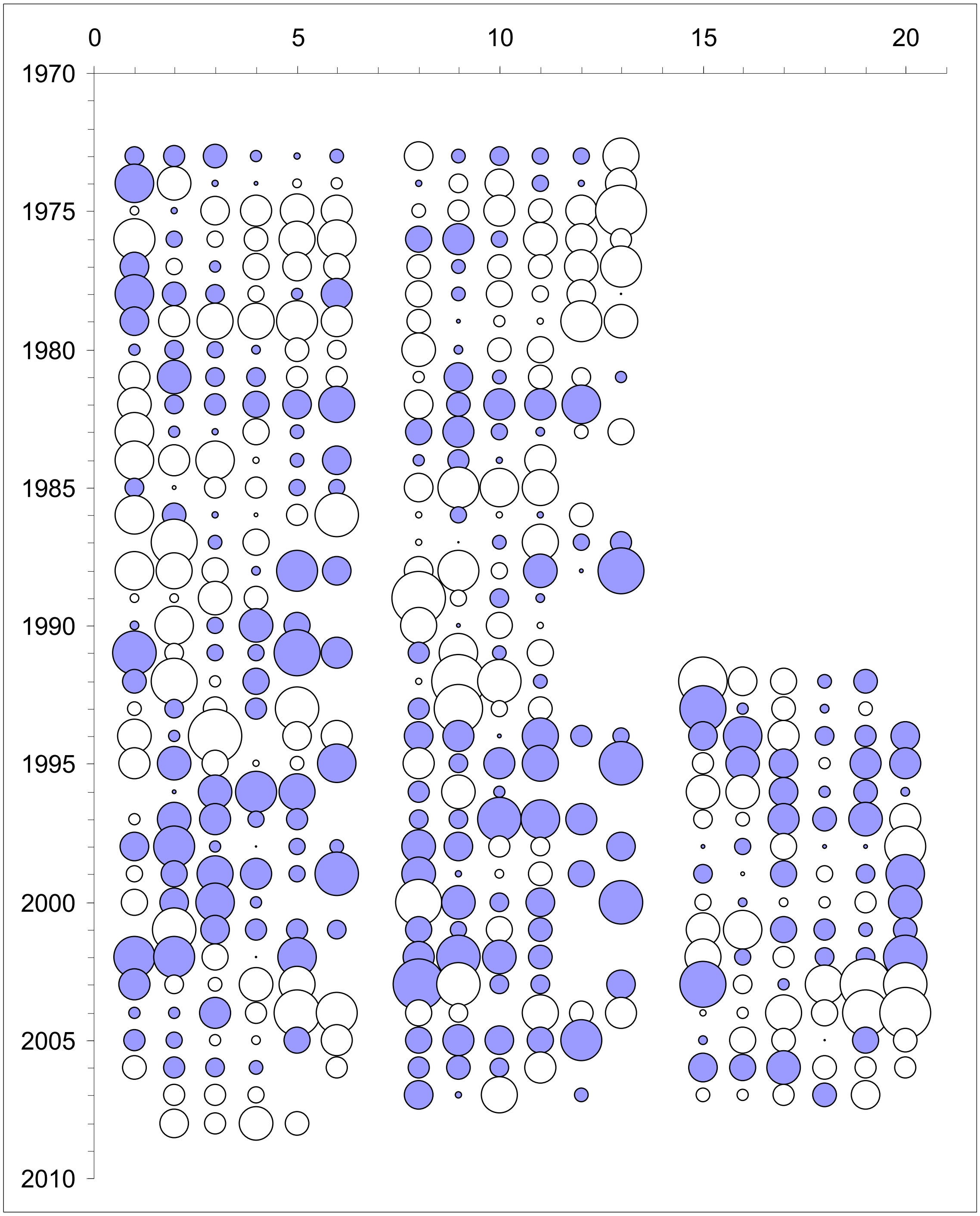
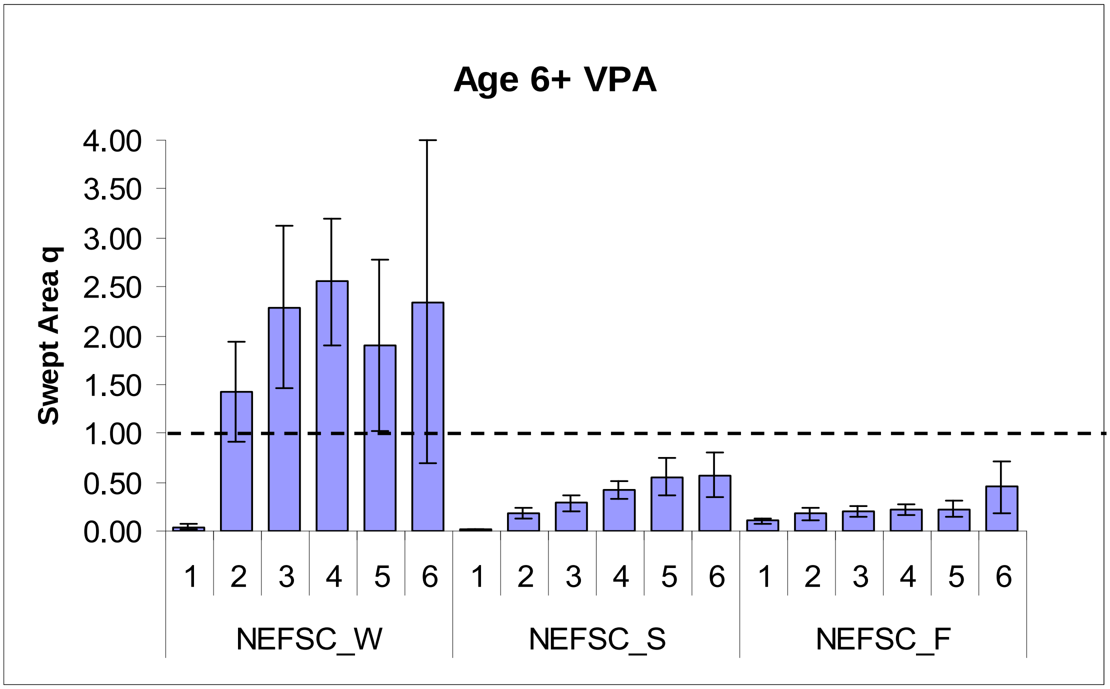


Figure D7. Residuals for indices of abundance in VPA grouped by survey: columns 1-6 are the NEFSC Spring ages 1-6, columns 8-13 are the NEFSC Fall ages 1-6 and columns 15-20 are the NEFSC autumn ages 1-6.



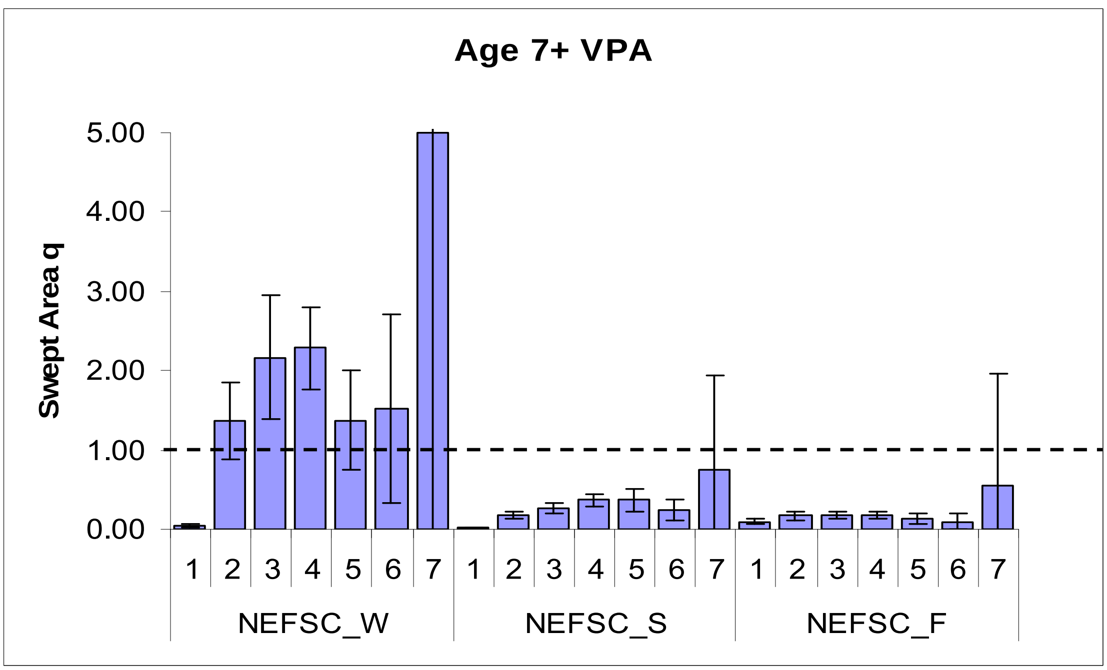


Figure D8. Catchability estimates with two standard deviations for swept area indices for both ages 6+ and 7+ formulation.

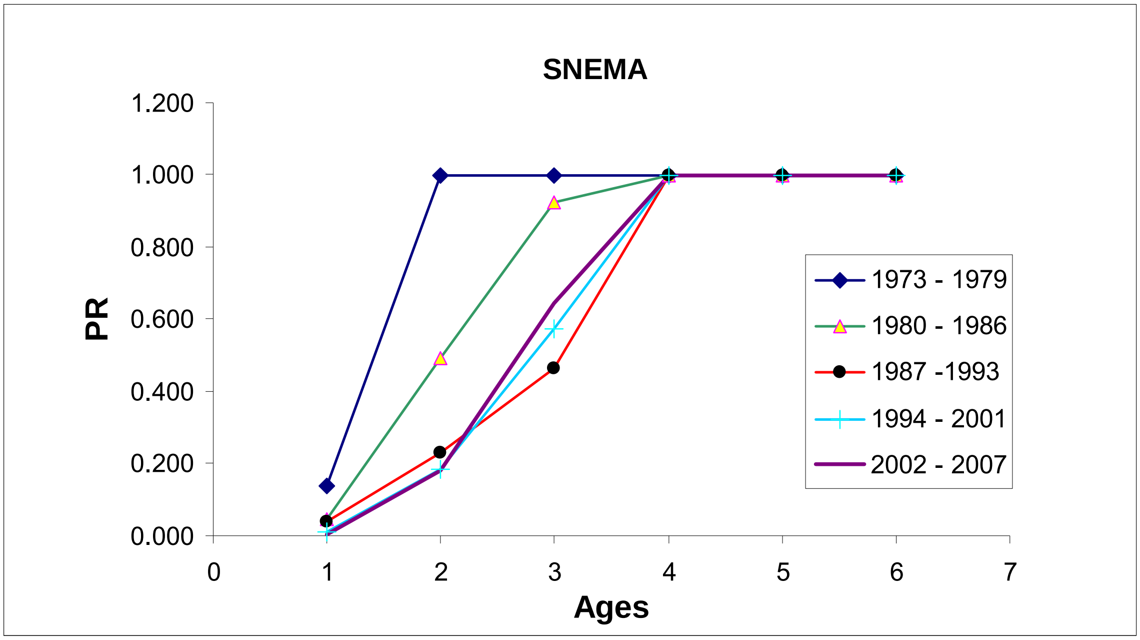


Figure D9. Average back-calculated partial recruitment from VPA showing age 2 PR is well below 1.0 in recent years

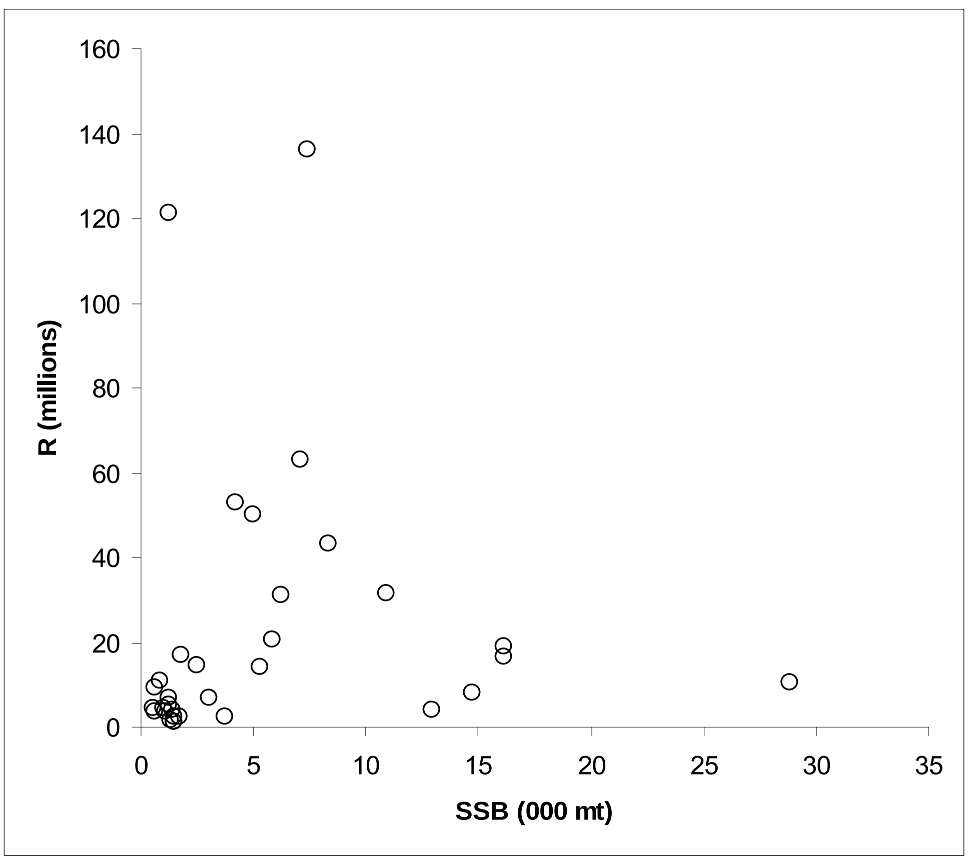


Figure D10. Stock recruitment relationship for Southern New England-Mid Atlantic yellowtail flounder

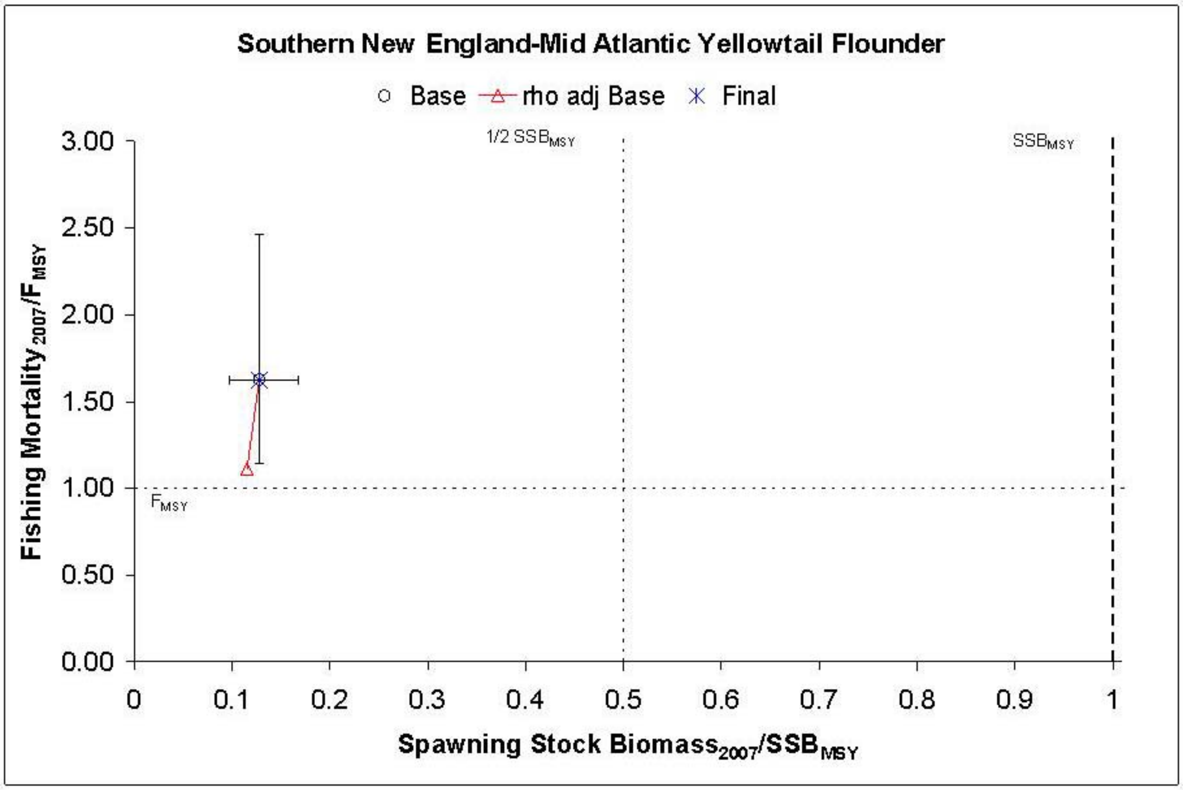


Figure D11. Current Status of Southern New England-Mid Atlantic yellowtail flounder with rho-adjusted base-run (triangle) and the associated point estimate base-run (circle) with 80% confidence intervals. The final accepted VPA run (asterisk) is the point estimate base-run for the 2007 status determination.

E. Cape Cod/Gulf of Maine yellowtail flounder
by Chris Legault, Larry Alade, Steve Cadrin, Jeremy King, and Sally Sherman

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

1.0 Background

The Cape Cod-Gulf of Maine yellowtail flounder stock was most recently assessed at the Groundfish Assessment Review Meeting (GARM) in 2005 (Cadrin et al. 2005). That assessment was based on a virtual population analysis (VPA) with a 5+ age group formulation. At the time it was recognized that this formulation was sub-optimal because the age 3 partial recruitment had to be 1.0 even though this age was thought to be less than fully selected. The stock exhibited high fishing mortality rates and low abundance. Reference point estimation was derived from spawning stock biomass per recruit and yield per recruit analyses, with the assumption of constant recruitment. The value for F40% (i.e. the proxy for F_{MSY}) was 0.17 and the corresponding SSB_{MSY} and MSY were 12,600 mt and 2,300 mt, respectively. The estimate of SSB_{2004} (1,111 mt) was 9% of SSB_{MSY} and the estimate of F_{2004} (0.75) was four times F_{MSY}, indicating that the stock was severely overfished and overfishing was occurring. The current benchmark assessment revises and updates the 1994-2007 fishery catch estimates to reflect recommendations at the GARM III Data meeting (GARM 2007), and updates research survey abundance indices and analytical models (VPA) though 2007/2008 as recommended at both the GARM III Methods meeting (GARM 2008a) and the GARM III Biological Reference Points meeting (GARM 2008b). The VPA analysis now uses a 6+ formulation which allows appropriate estimation of age 3 partial recruitment. Biological reference points for this stock were re-evaluated based on recommendations at the GARM III Biological Reference Points meeting (GARM 2008b) to determine the status of the stock.

2.0 Fishery

Landings

Landings of yellowtail flounder from the Cape Cod-Gulf of Maine stock (Figure E1) during 1994-2007 were derived from the new trip-based allocation described in the GARM III Data meeting (GARM 2007, Palmer 2008, Wigley et al. 2007a, Table E1, Figure E2). Changes to previous estimates were minimal and uncertainty in the landings due to the random component of the allocation was insignificant (Legault et al. 2008). Landings at age and mean weight at age were determined by port sampling of small, medium, large, and unclassified market categories and pooled age-length keys by half year. Sampling intensity has increased in recent years (Table E2) resulting in lower variability in landings at age estimates (Table E3).

Discards

Discarded catch for years 1994-2007 was estimated using the Standardized Bycatch Reporting Methodology recommended in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b). Observed ratios of discards of yellowtail flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, scallop dredge, and gillnet were applied to the total landings by these gears by half-year. Uncertainty in the discard estimates was estimated based on the

SBRM approach detailed in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b, Table E4). Discards were approximately 15% of the catch in years 1994-2006 (Table E1; Figure E1). Discards at age and associated mean weights at age were estimated from sea sampled lengths and pooled observer and survey age-length keys

Total Catch at Age

Total catch at age was formed by adding the landings and discards (Table E5a-c). Average weight at age was computed as the catch weighted average of the weights at age from these two sources (Table E6).

3.0 Research Surveys

Survey abundance and biomass indices are reported in Table E7a-f. Estimates are from valid tows in the Cape Cod-Gulf of Maine area [offshore strata 25-27, 39, 40 (stratum 27 excluded from the fall series); inshore strata 56-66; Massachusetts strata 17-36] standardized according to net, vessel, and door changes. Massachusetts survey indices were slightly revised to account for more accurate delineation of survey strata. These four bottom trawl surveys are presented as minimum swept area estimates to allow direct interpretation of the catchability estimates associated with each survey and age combination. Two new series were included in this assessment from the Maine-New Hampshire inshore survey, but were available only as stratified mean catch/tow. Survey data do not show any strong trends overall (Figure E3).

4.0 Assessment

Input Data and Model Formulation

The previous VPA formulation for the Cape Cod-Gulf of Maine yellowtail flounder stock had the plus group set at age 5 (Cadrin and King 2003, Cadrin et al. 2005). This formulation estimated the F on the oldest true age (4) from the F on age 3. However, it was recognized that this was not appropriate because the age 3 yellowtail are not fully selected, while ages 4 and older are. At the time, the age 6+ formulation exhibited a strong retrospective pattern and so the age 5+ formulation was adopted for management purposes. Mohn's rho retrospective statistics (Mohn 1999), calculated based on a seven year series of retrospective estimates were used to quantify the relative bias in terminal year estimates of fishing mortality (F), spawning stock biomass (SSB) and recruitment (R). The degree of retrospective pattern in the final status was compared to the estimates of precision to determine whether or not an adjustment was required. Based on this comparison, no adjustment for retrospective pattern was undertaken.

Model Selection Process

Due to the change in estimated landings and discards, the age 6+ formulation was examined first. This VPA was estimated with relatively good precision, CVs for N 30-42% and q 13-75% (Table E8). Significantly, this formulation did not exhibit a strong retrospective pattern (Table E9; Figures E4-E6). Given the estimated partial recruitment on age 3 in recent years was well below one (Figure E9), the age 5+ formulation was not considered, and the GARM III benchmark assessment panel recommended use of the age 6+ formulation to provide scientific advice.

Assessment Results

VPA assessment results show that population abundance has an increasing trend since 2004 and indicates a moderately strong 2005 year class entering the fishery (Table E10). The fishing mortality rates have been high during the entire assessment period, but decreased in 2007 (Table E11). Spawning stock biomass has varied without much trend during the assessment period (Table E12). The 2007 estimates of F and SSB were well estimated as seen in the relatively tight 80% confidence intervals derived from bootstrapping (Table E13a). The Mohn's Rho adjusted estimates for SSB were well within the confidence bounds of the bootstrap estimates (Table E13b). Adopting the panel recommendations at the GARM III final benchmark assessment meeting, the point estimates were used for final status determination.

Diagnostics

Residuals for indices of abundance do not show strong patterns, although occasional year effects are apparent in some surveys (Figure E7). The estimated catchability coefficients have reasonable magnitudes (<1.0) with the NEFSC surveys exhibiting flat-topped patterns while the two state surveys (MADMF and MENH) showing dome patterns (Figure E8). Back-calculated partial recruitment patterns from the fishery are flat-topped due to the formulation of the VPA, but also show a decrease in selectivity of age 2 and 3 yellowtail in recent years potentially due to mesh size regulations (Figure E9).

5.0 Biological Reference Points

Method and Special Considerations

As in the GARM III Biological Reference Points assessment, the estimated stock and recruitment values did not follow a parametric relationship (Figure E10) and so the non-parametric approach was undertaken. Hindcast recruitment estimates were derived by regressing the estimated numbers of recruits from the stock assessments on the NEFSC Fall survey index at age 1 (Figure E11). Following the recommendation of the GARM III Biological Reference Points review (GARM 2008b), all recruitment values (both estimated in the VPA and hindcast) were used to estimate the SSB_{MSY} and MSY proxies.

The GARM III Biological Reference Points Panel recommended that the hindcast recruitment values be checked for consistency with the catch which occurred during those years. This check was first attempted by averaging the recruitment and catch values for years 1977-1984, averaging the first five years of partial recruitment and weight at age in the VPA, and solving for the resulting full F. It was found that no F could produce the average catch given the average R. However, examination of the patterns of R and C during the hindcast period indicated that a pulse of recruitment had translated into a pulse of catch during this short time period. So a non-equilibrium approach was applied which assumed equilibrium population age structure in 1977 and the estimated hindcast recruitment values in years 1977-1984, and solved for the annual F in these years to match the observed catch. This approach was successful (Figure E12) but required high F, similar to the F at the start of the VPA. This analysis confirmed the hindcast estimates of recruitment are reasonable and can be used in setting the biological reference points.

Recent five year averages of partial recruitment, maturity, and weight at age were used in yield per recruit analysis to estimate $F_{40\%}$ as a proxy for F_{MSY} (Table E14). Applying F_{MSY} for 100 years in stochastic projections, while sampling recruitment from the empirical distribution described above, allowed estimation of SSB_{MSY} and MSY as the median values at the end of the 100 year projections (see Legault 2008).

Final Values: F_{MSY}, SSB_{MSY}, MSY

The estimated values of F_{MSY} (0.239), SSB_{MSY} (7790 mt), and MSY (1720 mt) are quite similar those from the GARM III Biological Reference Points meeting and slightly different from the GARM II meeting (Table E15). The change in F_{MSY} from GARM II to GARM III is due to changes in partial recruitment and weight at age. Specifically, the GARM II estimates used weight at age that would be expected under a rebuild stock, while the current estimates use the recent five year average for weight at age, meaning much lower weight at age in the plus group because the stock has been overfished for many years. The Cape Cod-Gulf of Maine yellowtail F_{MSY} is now quite similar to the other two yellowtail stocks, while previously it had been much lower due to the slower growth exhibited in this stock. Dividing the 2007 values of F (0.36) and SSB (1,922 mt) by F_{MSY} and SSB_{MSY}, respectively, results in a current status of overfishing (F_{2007}=1.7 F_{MSY}) and overfished (SSB_{2007}=25% SSB_{MSY}) (Figure E13).

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 E14). The population abundance at age at the start of 2008 was derived from the bootstrap results, with the recruitment estimate generated as the geometric mean of the estimated recruitments during 1985-2007 from each bootstrap solution. Catch in 2008 was assumed equal to the catch in 2007 (627 mt).

$F_{REBUILD}$

The Cape Cod-Gulf of Maine yellowtail flounder stock is currently in a rebuilding plan with end date of 2023. The $F_{REBUILD}$ (0.238) was found by iteratively solving for the F which applied in years 2009-2023 resulted in median 2023 SSB equal to SSB_{MSY}.

Projected Catch in 2009

Median catch in 2009 was estimated under three scenarios for F in 2009: 1) $F_{STATUS\ QUO}$, meaning the F_{2009} is set equal to F_{2007}, 2) F_{MSY}, and 3) $F_{REBUILD}$ (Table E16). All three scenarios estimated catch higher than the 2007 catch while still allowing SSB to increase. Note that neither the $F_{STATUS\ QUO}$ nor the F_{MSY} projections would result in rebuilding to SSB_{MSY} with at least 50% probability by 2023.

7.0 Summary

Based on this assessment, the Cape Cod-Gulf of Maine yellowtail flounder stock continues to be overfished (SSB_{2007}/ SSB_{MSY} = 0.25) and overfishing is continuing (F_{2007}/ F_{MSY} = 1.73). However, fishing mortality has been declining since 2004 and is currently at the lowest level observed in the time series. Spawning stock biomass has increased the past two years and could continue to increase with the support of the moderately strong 2005 year class. The age 6+ VPA formulation is recommended as the basis for management because it does not exhibit a retrospective pattern, has good diagnostics, and the age 5+ formulation makes the untenable assumption that age 3 partial recruitment is full. Given that the 2005 year class is strong in the Georges Bank and Southern New England-Mid Atlantic yellowtail stocks as well, a source of uncertainty for this assessment is whether the coinciding strong year class is due to favorable environmental conditions or due to migration among the stocks.

8.0 Panel Discussion/Comments

Conclusions

The Panel accepted the VPA formulation as Final, as best available estimate of stock status, and as a sufficient basis for management advice. The assessment displayed a small retrospective pattern which did not require adjustment. The Panel noted that the model fit here appeared to be the best of the three yellowtail stocks.

As recommended by the GARM III 'BRP' review, the hindcast recruitment estimates for 1977 – 84 were checked for consistency with the catch that occurred during those years. The analysis confirmed that these catches were consistent with the hindcast recruitment estimates assuming a high fishing mortality similar to what was observed in the early years. Thus, these hindcast recruitment estimates were accepted by the Panel.

Movement amongst the three yellowtail stocks and growth differences amongst these stocks complicates their assessment

Research Recommendations

The Panel had no specific research recommendations for this stock.

9.0 References

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Table E1. Landings, discards, catch (metric tons), and proportion of total catch which is discards 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%
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%
2003	1834	136	1970	7%
2004	913	273	1186	23%
2005	715	282	997	28%
2006	534	85	620	14%
2007	483	144	627	23%

Table E2. Cape Cod-Gulf of Maine landings (metric tons) and number of lengths available from port samples by half year and market category along with number of ages available for age-length key and number of lengths sampled per 100 metric tons.

		Landings (metric tons)					Number of Lengths					Number	Lengths /
Year	half	unclass	large	small	medium	Total	unclass	large	small	medium	Total	of Ages	100 mt
1994	1	77	191	201	8	476		170	261		431		
	2	24	351	285	6	667		144	106		250		
	Total	101	543	486	14	1143		314	367		681	175	60
1995	1	88	325	346	6	765		491	276		767		
	2	18	321	254	9	603		264	407		671		
	Total	106	646	600	15	1368		755	683		1438	327	105
1996	1	55	270	373	17	714		87			87		
	2	18	233	205	5	462	118	640	495		1253		
	Total	73	503	578	22	1176	118	727	495		1340	367	114
1997	1	46	221	312	11	590		633	388		1021		
	2	20	338	177	10	544		869	996		1865		
	Total	66	558	489	21	1134		1502	1384		2886	703	254
1998	1	194	246	333	22	795		67	281		348		
	2	50	230	232	3	515			619		619		
	Total	244	476	566	25	1310		67	900		967	259	74
1999	1	176	160	222	24	582		150			150		
	2	90	340	284	7	720		268	116		384		
	Total	267	499	506	31	1303		418	116		534	78	41
2000	1	343	442	522	50	1357	464	642	2831	231	4168		
	2	109	471	485	17	1082	102	916	1155		2173		
	Total	452	913	1007	66	2439	566	1558	3986	231	6341	1423	260
2001	1	315	380	382	27	1104	105	218	344		667		
	2	159	611	491	18	1278	534	727	774		2035		
	Total	474	990	873	44	2381	639	945	1118		2702	630	113
2002	1	181	322	187	21	711	304	496	764		1564		
	2	173	596	542	35	1346	225	1098	1646	101	3070		
	Total	354	918	729	56	2057	529	1594	2410	101	4634	1131	225
2003	1	349	264	283	15	910	565	416	1188	133	2302		
	2	234	390	280	19	923	421	1572	1424	574	3991		
	Total	583	654	562	35	1834	986	1988	2612	707	6293	1479	343
2004	1	168	160	143	30	501	263	574	778	679	2294		
	2	73	151	176	12	412	162	267	349	120	898		
	Total	241	311	320	42	913	425	841	1127	799	3192	794	350
2005	1	102	169	116	0	388	2007	186	540		2733		
	2	88	146	92	2	327	667	409	618		1694		
	Total	190	314	208	2	715	2674	595	1158		4427	858	619
2006	1	63	150	96	1	310	214	187	581		982		
	2	57	105	62	0	225	93	1257	1883		3233		
	Total	119	255	158	1	534	307	1444	2464		4215	1029	789
2007	1	59	128	53	1	241	564	295	732		1591		
	2	45	118	79	0	242	350	2631	2282		5263		
	Total	104	245	133	2	483	914	2926	3014		6854	1484	1419
Grand Total		3374	7827	7214	375	18791	7158	15674	21834	1838	46504	10737	247

Table E3. Cape Cod-Gulf of Maine yellowtail flounder coefficient of variation for landings at age by year.

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%

Table E4. Cape Cod-Gulf of Maine yellowtail flounder discards (metric tons) and coefficient of variation by gear and year.

	Otter Trawl Large Mesh		Otter Trawl Small Mesh		Scallop Dredge		Gillnet	
Year	D (mt)	CV	D (mt)	CV	D (mt)	CV	D (mt)	CV
1994	3	58%	13	0%	163	15%	30	141%
1995	32	91%	7	47%	32	11%	76	56%
1996	121	98%	2	51%	148	40%	64	70%
1997	27	35%	9	3%	354	29%	162	47%
1998	33	67%	3	0%	228	9%	48	51%
1999	91	36%	0	27%	27	19%	31	43%
2000	53	48%	2	44%	27	12%	67	58%
2001	127	30%	1	43%	98	7%	13	41%
2002	70	20%	6	53%	13	10%	11	40%
2003	88	28%	1	95%	24	7%	22	58%
2004	220	28%	5	47%	17	3%	32	17%
2005	225	24%	1	36%	4	43%	51	56%
2006	68	29%	3	21%	4	18%	9	89%
2007	81	19%	10	21%	34	59%	19	50%

Table E5a. Cape Cod-Gulf of Maine yellowtail flounder landings at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	6	876	839	635	329	121
1986	0	2232	695	273	40	8
1987	0	684	2101	309	116	53
1988	1	918	1281	744	199	41
1989	0	838	1284	287	38	9
1990	0	717	6663	472	35	28
1991	0	361	1065	1718	291	74
1992	0	410	1030	644	188	14
1993	0	34	868	723	110	54
1994	0	107	1365	668	198	108
1995	0	379	1442	1136	176	170
1996	0	448	1911	426	49	8
1997	0	630	1175	632	119	13
1998	0	51	1896	575	134	0
1999	0	511	2028	379	26	7
2000	0	925	2773	1355	127	30
2001	0	942	3317	822	144	24
2002	20	997	2338	885	107	34
2003	0	614	1930	1151	148	70
2004	0	86	1182	453	227	66
2005	0	100	759	523	80	45
2006	0	106	506	351	76	53
2007	0	115	512	341	54	14

Table E5b. Cape Cod-Gulf of Maine yellowtail flounder discards at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	681	369	68	0	0	0
1986	95	1993	90	32	0	0
1987	19	1201	230	0	0	0
1988	451	1664	221	0	0	0
1989	118	1459	528	11	0	0
1990	84	2180	2738	21	0	0
1991	465	1011	700	234	7	0
1992	1709	3569	930	87	3	0
1993	159	391	206	72	0	0
1994	19	710	332	47	11	1
1995	37	147	335	52	3	0
1996	26	339	516	219	55	0
1997	8	850	831	215	61	7
1998	38	443	616	75	18	3
1999	9	231	265	18	6	0
2000	2	189	209	52	6	5
2001	20	400	404	27	0	0
2002	37	207	111	21	1	0
2003	10	245	193	49	4	0
2004	13	389	412	118	15	9
2005	15	394	502	63	2	3
2006	7	84	156	39	7	0
2007	14	158	221	69	18	0

Table E5c. Cape Cod-Gulf of Maine yellowtail flounder catch at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	686	1245	907	635	329	121
1986	95	4225	785	304	40	8
1987	19	1885	2331	309	116	53
1988	452	2582	1503	744	199	41
1989	118	2297	1812	298	38	9
1990	84	2897	9400	493	35	28
1991	465	1372	1765	1953	298	74
1992	1709	3979	1961	731	191	14
1993	159	425	1074	795	111	54
1994	19	817	1697	716	210	109
1995	37	526	1777	1188	178	170
1996	26	787	2428	645	104	9
1997	8	1480	2007	847	180	20
1998	38	495	2512	650	152	3
1999	9	743	2292	397	32	7
2000	2	1114	2981	1408	133	35
2001	20	1342	3721	849	145	24
2002	58	1204	2449	905	109	34
2003	10	859	2122	1200	152	70
2004	13	475	1594	571	243	75
2005	15	494	1262	585	82	48
2006	7	189	662	390	84	54
2007	14	274	732	410	71	14

Table E6. Cape Cod-Gulf of Maine yellowtail flounder catch weight at age (kg).

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	0.855

Table E7a. NEFSC Spring survey indices of minimum swept area abundance for Cape Cod-Gulf of Maine yellowtail flounder in 000s of fish and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1985	18.1	310.9	334.0	80.7	49.9	12.7	237.3
1986	6.3	692.5	76.5	52.8	38.4	0.0	181.6
1987	20.5	524.5	773.5	208.9	177.0	487.2	975.5
1988	345.6	1459.2	355.9	197.8	103.6	59.4	415.7
1989	58.2	714.8	473.2	122.1	127.3	0.0	283.0
1990	0.0	727.5	2025.3	81.7	0.0	32.6	639.2
1991	136.7	1167.4	945.7	327.1	74.1	15.4	585.0
1992	59.7	353.0	708.2	192.4	7.0	0.0	295.1
1993	24.5	253.0	403.4	217.3	0.0	0.0	193.3
1994	113.8	863.0	517.7	310.4	197.9	66.6	393.9
1995	70.4	401.2	1535.5	1163.6	157.3	18.4	785.9
1996	5.7	211.1	552.1	775.3	129.3	0.0	427.7
1997	8.1	360.4	781.4	596.5	111.2	0.0	506.1
1998	0.0	279.7	1135.6	347.9	55.4	0.0	445.7
1999	6.8	327.2	1402.4	715.3	128.2	56.7	763.1
2000	26.9	3717.7	6558.6	911.5	64.3	32.2	3669.2
2001	0.0	463.4	1882.8	397.4	83.3	0.0	882.5
2002	5.8	603.3	2729.3	1259.0	82.3	20.0	1425.2
2003	36.1	333.3	928.4	678.6	303.9	9.8	737.6
2004	141.7	230.4	1010.1	138.4	54.2	0.0	415.0
2005	34.3	224.7	1474.6	495.6	0.0	0.0	546.1
2006	52.0	429.4	1319.7	466.0	36.6	12.9	489.8
2007	19.5	836.8	2410.2	1648.8	82.5	0.0	1334.3
2008	90.0	670.7	3017.5	656.2	56.9	17.8	1141.6

Table E7b. NEFSC Fall survey indices of minimum swept area abundance for Cape Cod-Gulf of Maine yellowtail flounder in 000s of fish and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1985	1482.0	568.3	483.1	0.0	0.0	0.0	502.0
1986	398.5	1108.1	97.5	0.0	0.0	0.0	291.8
1987	181.6	436.4	160.8	14.6	11.9	0.0	178.9
1988	1006.1	1475.7	142.5	43.2	0.0	0.0	362.2
1989	474.0	1408.6	609.3	83.8	57.9	0.0	602.0
1990	957.0	1695.7	785.8	12.4	2.7	0.0	641.1
1991	503.0	449.2	448.3	90.8	0.0	0.0	328.8
1992	810.3	887.2	604.1	305.0	58.9	45.8	621.5
1993	1215.6	1232.5	164.2	27.1	0.0	0.0	302.4
1994	795.3	2370.2	835.3	265.1	114.0	0.0	868.8
1995	179.3	218.2	345.7	91.1	55.1	0.0	251.8
1996	340.5	935.1	1585.2	379.3	42.9	0.0	841.0
1997	337.5	799.8	950.5	403.1	187.7	37.0	732.6
1998	328.6	959.8	385.0	317.1	75.2	0.0	526.6
1999	1324.0	2602.6	1777.8	544.0	228.1	8.7	1924.7
2000	287.9	2183.9	1443.4	73.6	0.0	0.0	1116.9
2001	43.3	1227.9	730.1	30.4	0.0	0.0	608.3
2002	128.5	458.0	180.3	48.9	6.2	0.0	227.6
2003	192.0	2822.8	593.9	139.6	81.2	0.0	1107.9
2004	76.2	371.3	202.1	7.8	0.0	0.0	157.9
2005	533.7	425.2	174.6	21.2	0.0	0.0	200.2
2006	780.3	487.2	273.8	22.0	0.0	0.0	259.4
2007	119.9	2095.7	1539.5	490.7	40.1	0.0	1110.1

Table E7c. MADMF Spring survey indices of minimum swept area abundance for Cape Cod-Gulf of Maine yellowtail flounder in 000s of fish and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1985	497.0	2105.0	1908.9	411.9	120.2	92.2	1330.9
1986	501.9	4329.5	464.1	68.5	19.2	15.3	1208.0
1987	681.0	1275.2	1346.4	267.2	69.3	40.7	937.2
1988	813.9	3487.9	665.1	183.8	0.0	11.2	960.3
1989	203.4	4953.0	910.6	252.1	12.0	0.0	1128.0
1990	260.0	2752.2	4106.5	176.7	38.0	9.0	1734.3
1991	15.7	1211.3	822.4	509.7	111.9	36.9	781.6
1992	323.2	2204.8	2112.5	559.5	359.6	20.7	1467.0
1993	188.2	1625.2	1489.1	495.5	62.2	79.9	1088.6
1994	607.6	5237.6	1739.9	357.4	82.0	26.5	1416.7
1995	1659.1	2801.8	5042.4	635.8	253.9	5.7	2123.2
1996	290.1	3230.8	2758.7	1419.0	393.6	14.6	1805.8
1997	133.1	2988.6	2082.4	724.2	87.2	0.0	1298.3
1998	157.7	841.1	2369.4	228.6	38.7	4.4	916.7
1999	65.1	1290.6	2134.2	239.8	17.8	0.0	309.3
2000	158.5	3766.2	5789.5	1941.2	238.9	82.7	2073.2
2001	32.2	1681.2	6305.2	1739.3	280.3	0.0	1075.0
2002	115.8	296.3	3236.1	1244.8	58.5	40.7	586.2
2003	12.7	1873.4	1796.1	1977.9	301.7	11.9	748.0
2004	42.4	608.2	1987.9	978.5	124.1	5.1	1093.3
2005	92.1	1537.7	3878.1	1018.3	19.0	6.4	1745.8
2006	167.3	1648.9	5100.0	1370.4	60.5	25.2	2249.5
2007	127.1	3237.2	4743.2	1731.2	182.7	0.0	2527.2

Table E7d. MADMF Fall survey indices of minimum swept area abundance for Cape Cod-Gulf of Maine yellowtail flounder in 000s of fish and metric tons.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	B (mt)
1985	1564.3	447.5	282.7	0.0	0.0	4.9	358.8
1986	712.5	1357.1	55.5	9.1	2.0	0.0	375.5
1987	1605.9	629.6	135.1	19.4	5.5	0.0	289.3
1988	2457.5	3083.3	622.7	41.3	0.0	0.0	1074.2
1989	723.4	1431.2	263.4	28.3	0.0	0.0	400.9
1990	1425.3	3273.6	1327.8	1.6	0.0	0.0	942.1
1991	1031.0	1409.6	1379.1	235.1	0.0	0.0	629.9
1992	1968.6	993.5	569.5	129.3	55.6	0.0	524.7
1993	2301.8	1998.7	1591.4	393.0	0.0	0.0	831.3
1994	562.2	2375.3	349.2	36.1	0.0	0.0	650.1
1995	2356.2	3484.5	1235.5	0.0	0.0	0.0	1278.4
1996	468.3	815.5	463.4	32.8	0.0	0.0	325.1
1997	274.7	1410.3	171.3	21.7	12.6	0.0	378.5
1998	1617.8	1438.8	464.0	0.0	0.0	0.0	570.5
1999	1296.7	2669.9	846.5	134.8	16.5	0.0	557.4
2000	317.1	1825.2	808.5	56.1	23.9	8.6	366.0
2001	188.4	1638.3	868.6	29.7	0.0	0.0	338.9
2002	427.3	178.9	626.4	250.7	9.9	0.0	140.3
2003	151.1	1612.4	856.7	655.8	16.0	0.0	533.2
2004	638.2	2381.7	1743.6	522.6	2.5	0.0	1198.3
2005	242.1	1165.0	1047.0	56.2	0.0	0.0	545.0
2006	343.3	1370.4	1044.4	112.0	0.0	0.0	691.5
2007	105.1	1206.5	931.8	155.7	0.0	0.0	611.0

Table E7e. MENH Spring survey indices of abundance (stratified mean catch/tow) for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
2001	0.000	0.599	2.087	0.535	0.132	0.000
2002	0.000	0.226	1.981	0.845	0.048	0.041
2003	0.000	0.473	0.805	0.850	0.114	0.000
2004	0.000	0.151	1.241	0.492	0.039	0.000
2005	0.021	0.287	1.107	0.280	0.003	0.000
2006	0.000	0.148	0.560	0.152	0.014	0.003
2007	0.000	0.859	2.661	1.071	0.129	0.000

Table E7f. MENH Fall survey indices of abundance (stratified mean catch/tow) for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
2000	0.053	1.799	0.640	0.030	0.010	0.000
2001	0.062	0.907	0.419	0.011	0.000	0.000
2002	0.000	0.202	0.560	0.177	0.005	0.000
2003	0.000	0.950	0.334	0.258	0.000	0.000
2004	0.032	1.374	0.780	0.184	0.000	0.000
2005	0.000	0.252	0.212	0.000	0.000	0.000
2006	0.000	0.121	0.120	0.002	0.000	0.000

Table E8. Diagnostics for VPA estimates.

Stock Numbers Predicted in Terminal Year Plus One (2008)

Age	N	Std. Error	CV
2	2886	1221	0.42
3	6575	2032	0.31
4	2295	692	0.30
5	615	189	0.31

Catchability Values for Each Survey Used in Estimate

INDEX	Catchability	Std. Error	CV
NEFSC_S 1	0.004	0.001	0.257
NEFSC_S 2	0.090	0.011	0.126
NEFSC_S 3	0.283	0.041	0.146
NEFSC_S 4	0.348	0.057	0.164
NEFSC_S 5	0.413	0.095	0.230
NEFSC_S 6	0.393	0.154	0.393
NEFSC_F 1	0.059	0.010	0.164
NEFSC_F 2	0.206	0.028	0.136
NEFSC_F 3	0.231	0.034	0.149
NEFSC_F 4	0.166	0.049	0.292
NEFSC_F 5	0.549	0.216	0.393
MADMF_S 1	0.023	0.006	0.239
MADMF_S 2	0.341	0.044	0.129
MADMF_S 3	0.663	0.087	0.132
MADMF_S 4	0.587	0.098	0.167
MADMF_S 5	0.503	0.084	0.166
MADMF_S 6	0.350	0.099	0.284
MADMF_F 1	0.106	0.018	0.172
MADMF_F 2	0.306	0.045	0.146
MADMF_F 3	0.302	0.051	0.170
MADMF_F 4	0.134	0.043	0.318
MADMF_F 5	0.123	0.050	0.408
MENH_S 2	6.61E-05	1.22E-05	0.184
MENH_S 3	4.03E-04	5.82E-05	0.144
MENH_S 4	5.01E-04	8.64E-05	0.173
MENH_S 5	2.20E-04	1.02E-04	0.462
MENH_F 2	1.35E-04	5.22E-05	0.387
MENH_F 3	1.89E-04	4.17E-05	0.220
MENH_F 4	8.05E-05	6.01E-05	0.747

Table E9. Mohn's rho retrospective statistic for F, SSB, and R.

Peel	F	SSB	R
2000	-56%	67%	-45%
2001	-18%	19%	-75%
2002	-22%	-11%	-31%
2003	14%	-15%	-40%
2004	56%	4%	21%
2005	12%	12%	-10%
2006	-8%	18%	-2%
Average	**-3%**	**13%**	**-26%**

Table E10. 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	7842	6181	3475	753	176	3	18430
1999	9755	6386	4614	630	51	11	21446
2000	8849	7978	4559	1733	164	43	23325
2001	6428	7243	5528	1092	187	31	20509
2002	5264	5245	4722	1235	149	46	16661
2003	3905	4257	3212	1684	213	98	13370
2004	3947	3188	2713	751	320	99	11018
2005	5653	3220	2182	805	113	66	12040
2006	10185	4615	2191	665	143	92	17892
2007	3540	8332	3608	1200	198	51	16929
2008	7211	2886	6575	2295	615	142	19724

Table E11. Estimated fishing mortality rate at age.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	0.07	0.53	0.84	2.07	2.07	2.07
1986	0.02	0.72	0.76	0.78	0.78	0.78
1987	0.00	0.59	1.23	0.79	0.79	0.79
1988	0.02	0.55	1.45	2.60	2.60	2.60
1989	0.02	0.15	0.97	1.56	1.56	1.56
1990	0.01	0.60	1.49	0.79	0.79	0.79
1991	0.06	0.29	0.95	2.02	2.02	2.02
1992	0.27	0.90	0.88	1.56	1.56	1.56
1993	0.03	0.10	0.65	1.20	1.20	1.20
1994	0.00	0.21	0.71	1.36	1.36	1.36
1995	0.01	0.11	0.95	2.02	2.02	2.02
1996	0.00	0.21	1.07	1.22	1.22	1.22
1997	0.00	0.32	1.21	1.66	1.66	1.66
1998	0.01	0.09	1.51	2.50	2.50	2.50
1999	0.00	0.14	0.78	1.15	1.15	1.15
2000	0.00	0.17	1.23	2.03	2.03	2.03
2001	0.00	0.23	1.30	1.79	1.79	1.79
2002	0.01	0.29	0.83	1.56	1.56	1.56
2003	0.00	0.25	1.25	1.46	1.46	1.46
2004	0.00	0.18	1.02	1.70	1.70	1.70
2005	0.00	0.18	0.99	1.53	1.53	1.53
2006	0.00	0.05	0.40	1.01	1.01	1.01
2007	0.00	0.04	0.25	0.47	0.36	0.36

Table E12. Estimated spawning stock biomass (mt).

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	1713
2002	0	265	1126	328	55	23	1797
2003	0	194	606	440	72	46	1359
2004	0	117	507	153	88	37	902
2005	0	122	409	197	38	30	796
2006	0	217	557	187	68	51	1080
2007	0	364	988	437	99	34	1922

Table E13a. Bootstrap estimates of uncertainty in 2007 F at age and spawning stock biomass.

	Point	10th%ile	90th%ile
F 2007			
age 1	0.004	0.003	0.007
age 2	0.037	0.027	0.051
age 3	0.252	0.193	0.338
age 4	0.468	0.330	0.682
age 5	0.360	0.285	0.482
age 6+	0.360	0.285	0.482
Avg F 4-5	0.414	0.312	0.578
SSB	1922	1592	2354

Table E13b. Mohn's rho adjusted estimates of F and spawning stock biomass in 2007.

F adj	0.427
SSB adj.	1701

Table E14. Values for partial recruitment, maturity, and weight at age (kg) used in yield per recruit calculations and age based projections.

Age	PR	Maturity	WAA
1	0.0024	0.000	0.074
2	0.1145	0.171	0.284
3	0.6420	0.833	0.389
4	1.0000	0.977	0.496
5	1.0000	1.000	0.677
6+	1.0000	1.000	0.896

Table E15. Biological reference points for Cape Cod-Gulf of Maine yellowtail flounder from GARM II, GARM III Reference Points meeting, and this assessment.

	GARM II	GARM III BRP	GARM III Final
Fmsy	0.17	0.238	0.239
SSBmsy (mt)	12600	8310	7790
MSY (mt)	2300	1820	1720

Table E16. Three projections for 2009 catch all of which assume catch in 2008 equal to catch in 2007: $F_{STATUS\ QUO}$ applied F2007 in 2009; F_{MSY} applies F_{MSY} in 2009; and $F_{REBUILD}$ is solved iteratively to produce 50% probability of SSB> SSB_{MSY} in 2023 when the F is applied every year from 2009 to 2023.

	2007	2008	2009		
			F st quo	Fmsy	$F_{REBUILD}$
C (mt)	627	627	1457	904	900
F (4-5)	0.4144	0.218	0.4144	0.239	0.238
SSB (mt)	1922	3407	3825	4076	4078

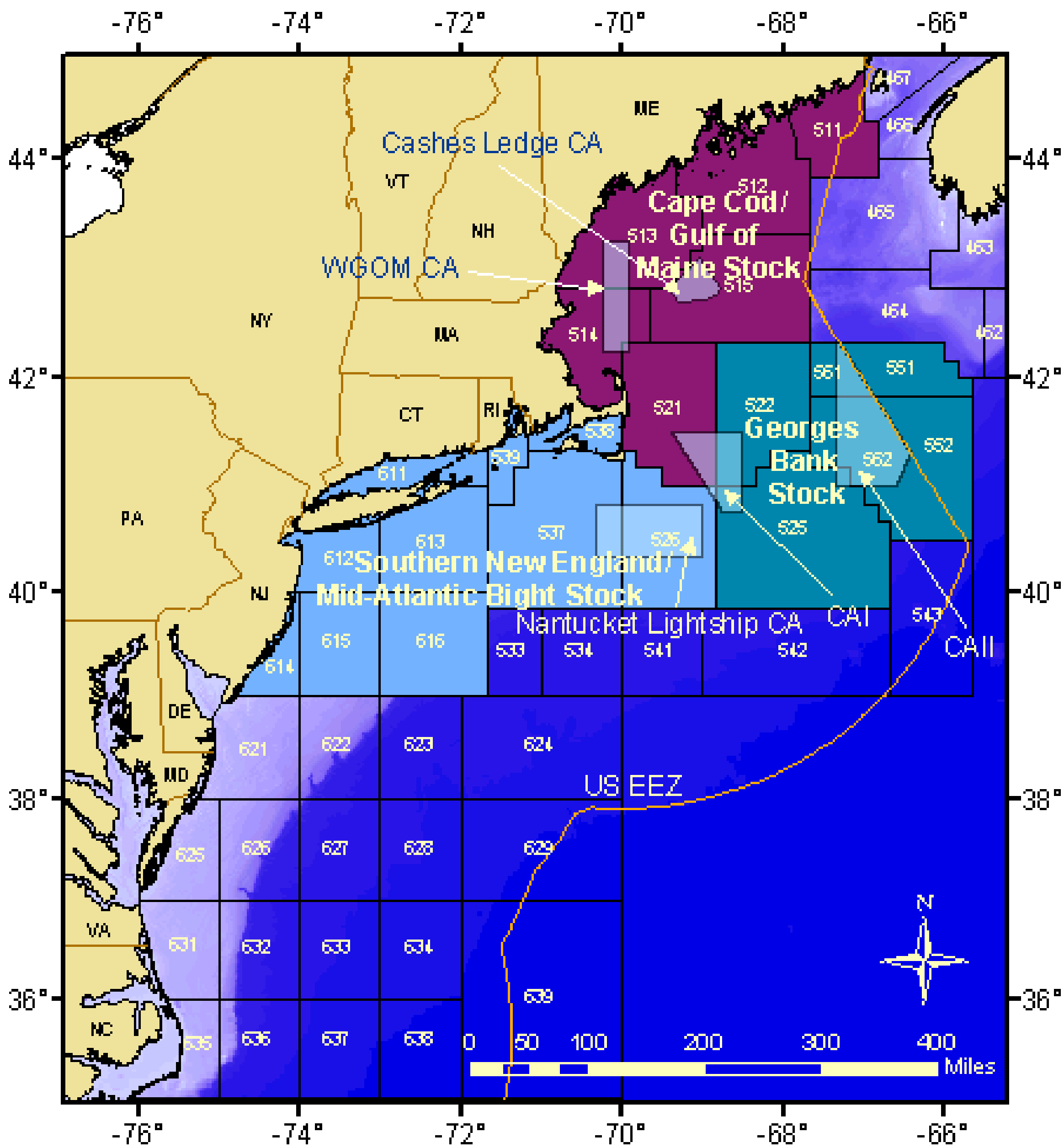


Figure E1. Stock area map for yellowtail flounder from Status of Stocks website (http://www.nefsc.noaa.gov/sos/).

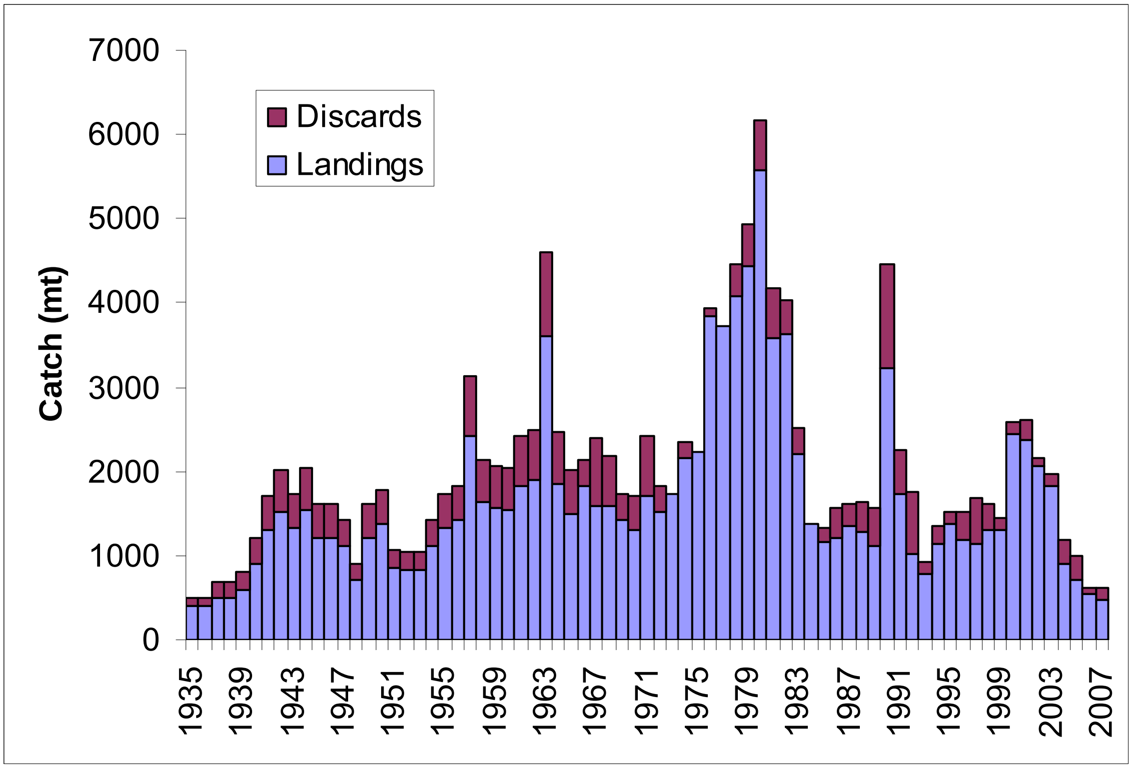


Figure E2. Catch (mt) of Cape Cod-Gulf of Maine yellowtail flounder.

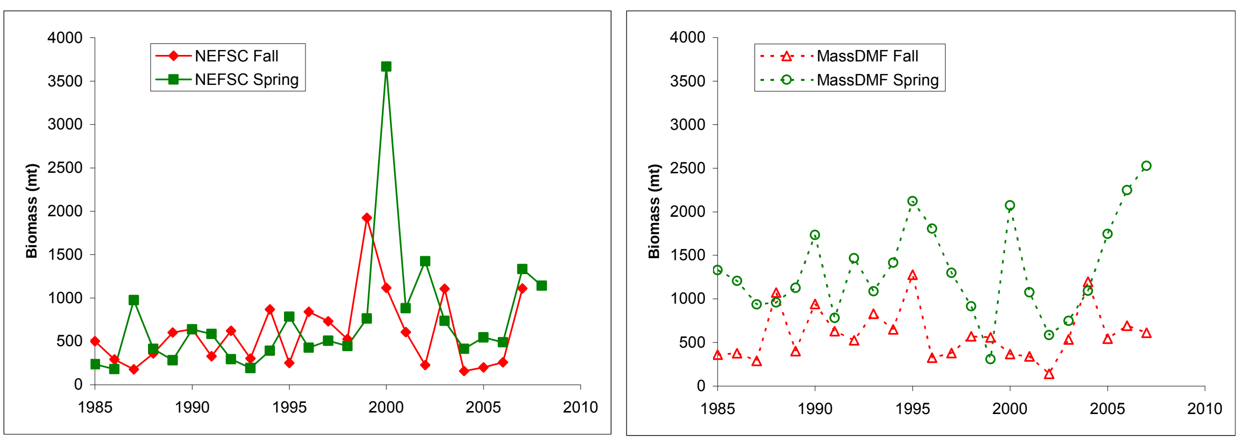
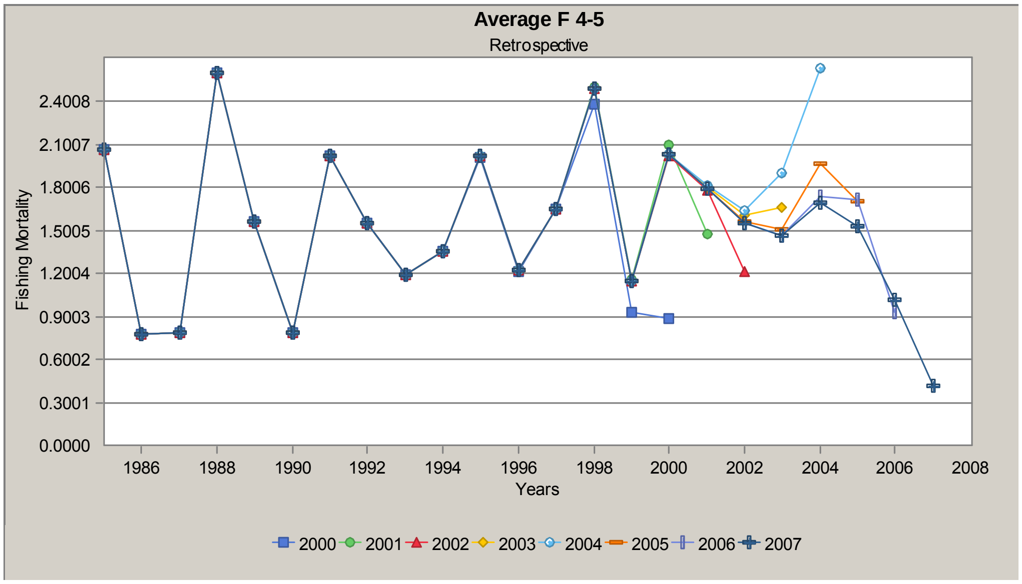


Figure E3. Trends in survey biomass for Cape Cod-Gulf of Maine yellowtail flounder.



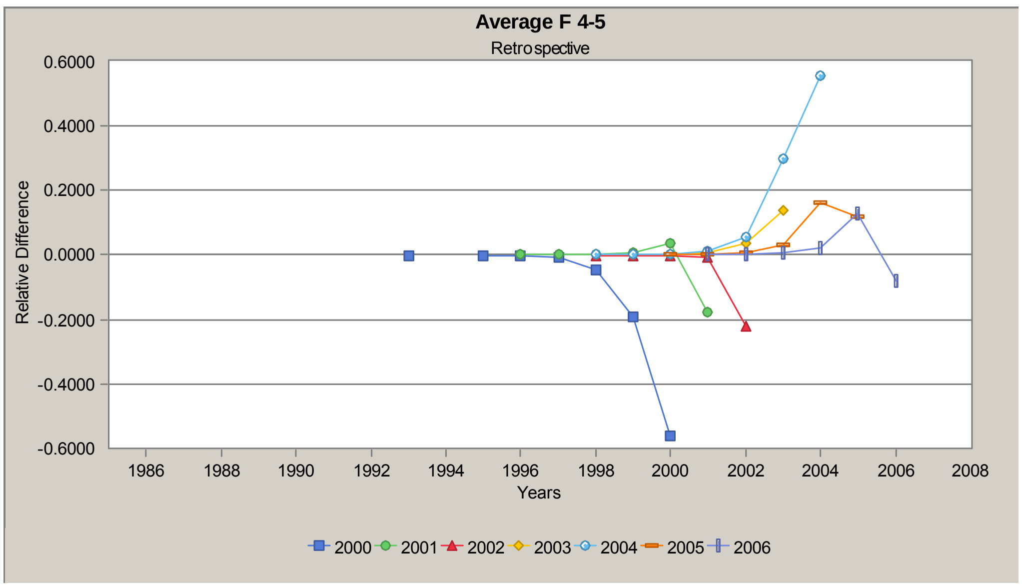
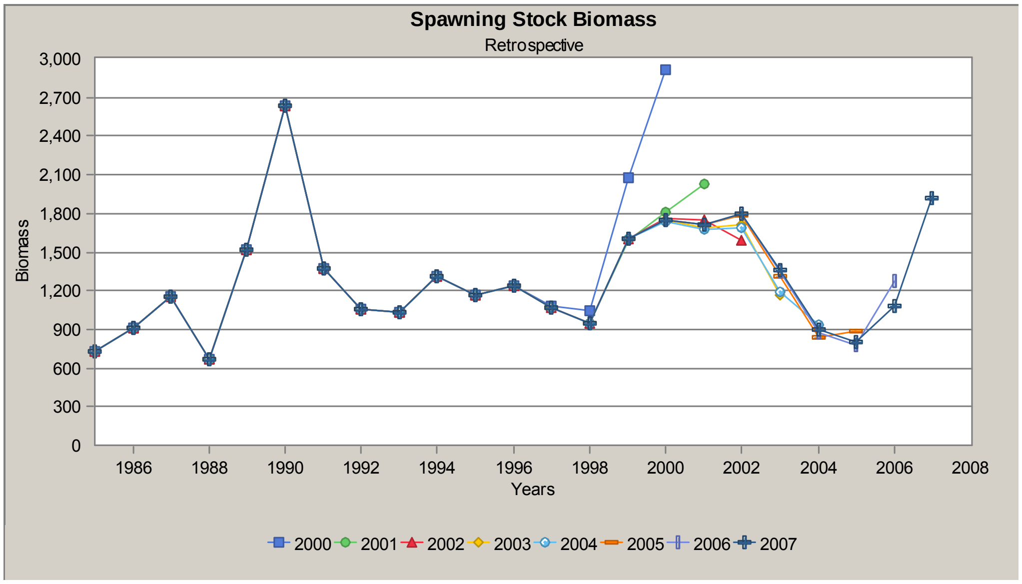


Figure E4. Retrospective plots of fully recruited fishing mortality rate (ages 4-5).



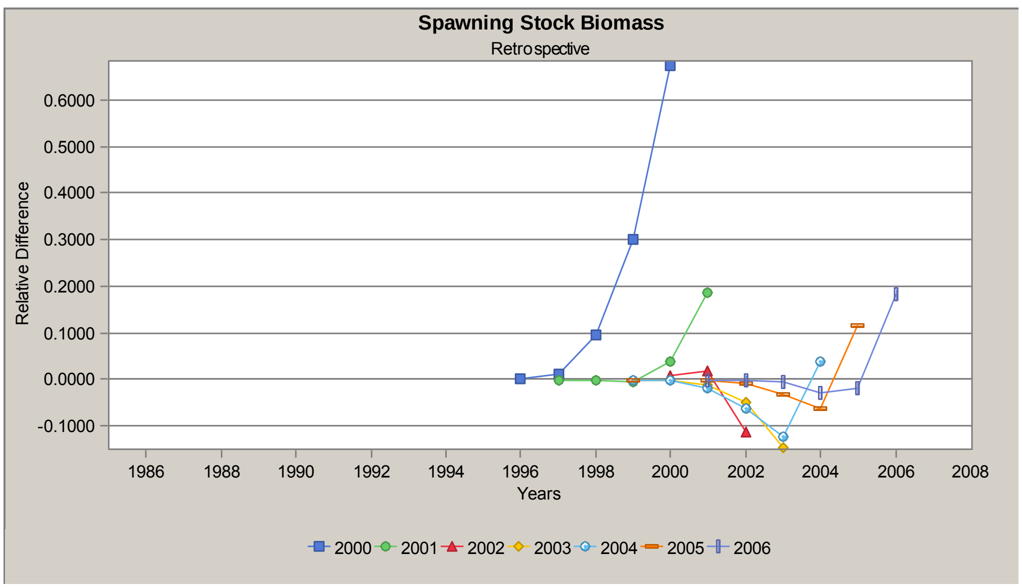
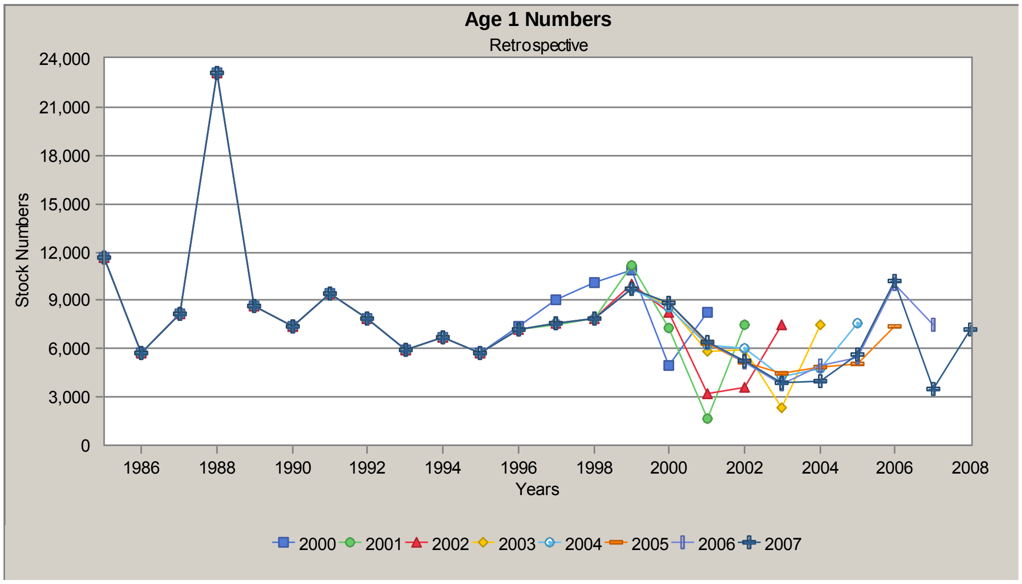


Figure E5. Retrospective plots of spawning stock biomass.



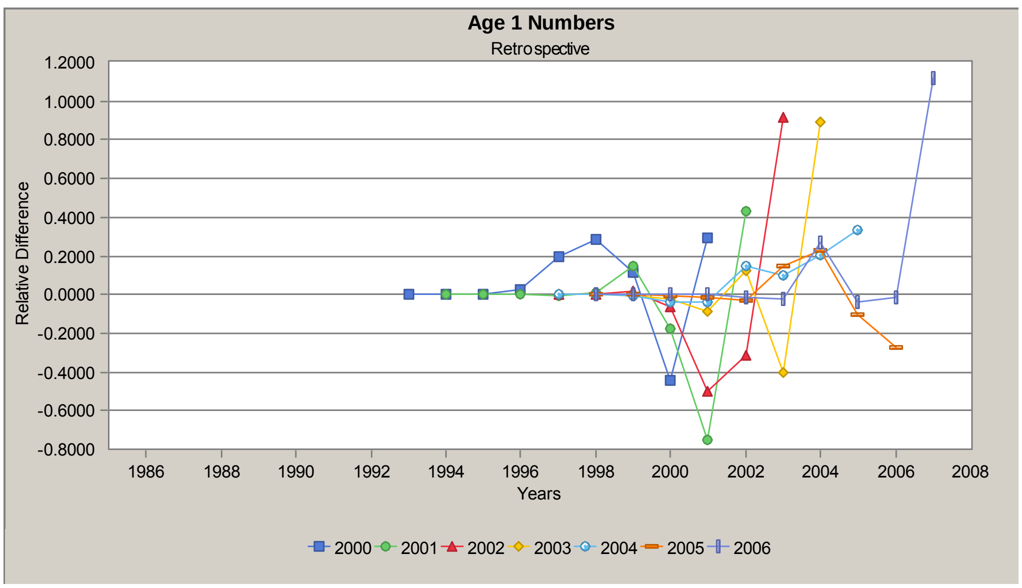


Figure E6. Retrospective plots of recruitment.

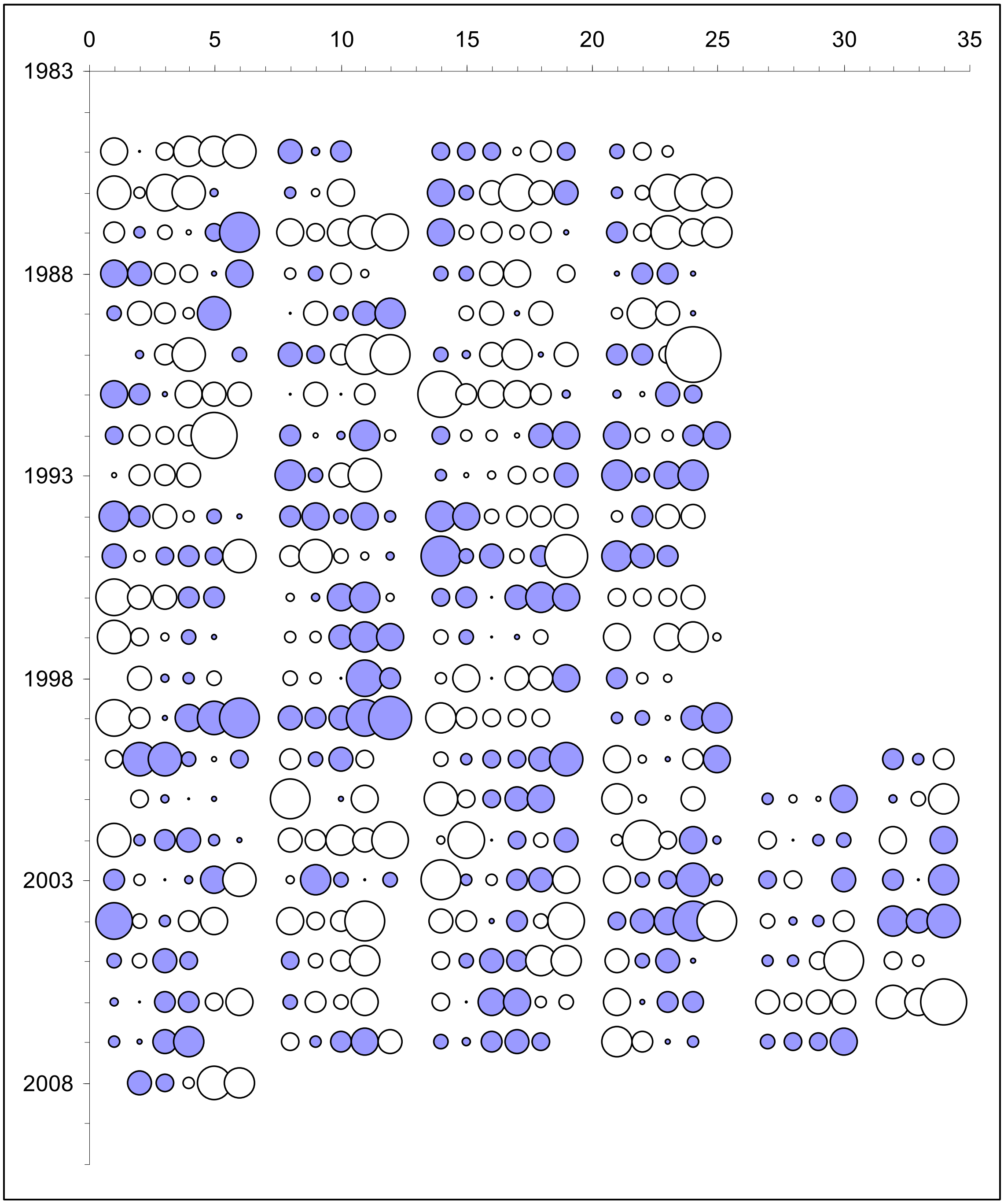


Figure E7. Residuals for indices of abundance in VPA grouped by survey: columns 1-6 are NEFSC Spring ages 1-6, columns 8-12 are NEFSC Fall ages 1-5, columns 14-19 are MADMF Spring ages 1-6, columns 21-25 are MADMF Fall ages 1-5, columns 27-30 are MENH Spring ages 2-5, and columns 32-34 are MENH Fall ages 2-4.

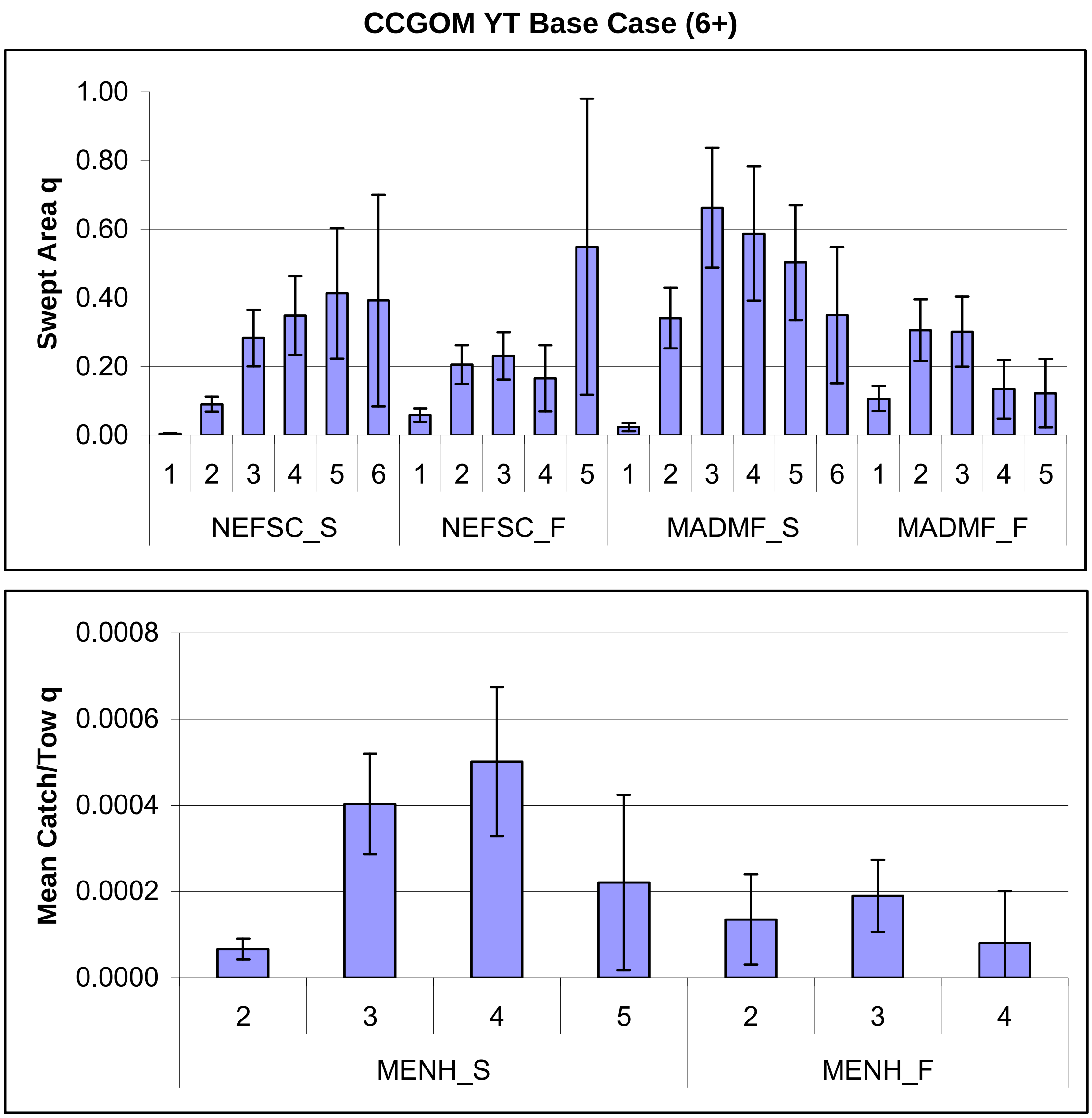


Figure E8. Catchability estimates with plus and minus two standard deviations for swept area indices (top panel, q is interpretable) and mean catch per tow (bottom panel, q is not directly interpretable).

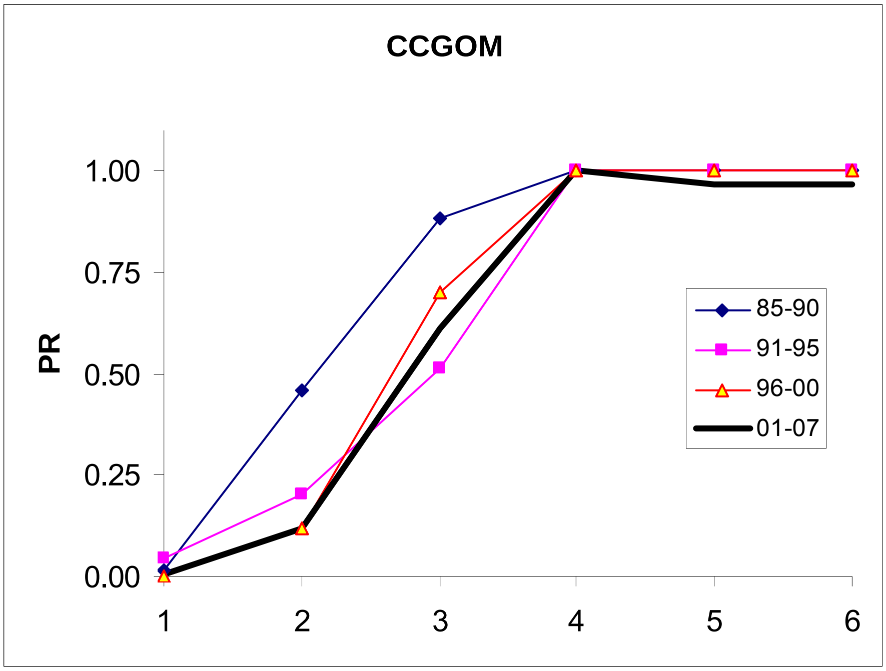


Figure E9. Average back-calculated partial recruitment from VPA showing age 3 PR is well below 1.0 in recent years.

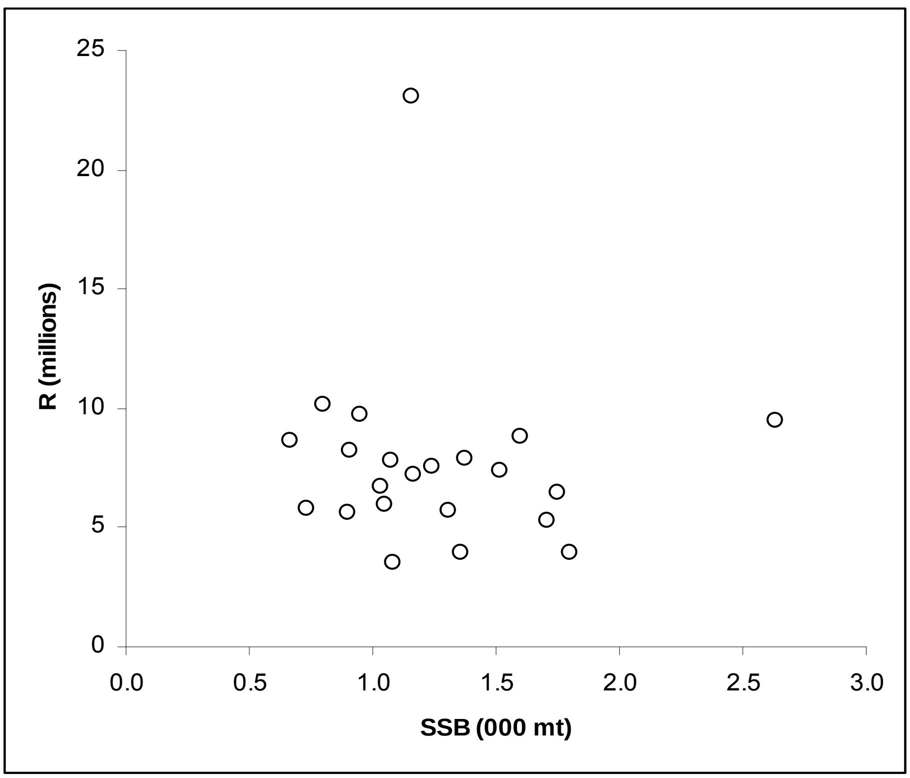
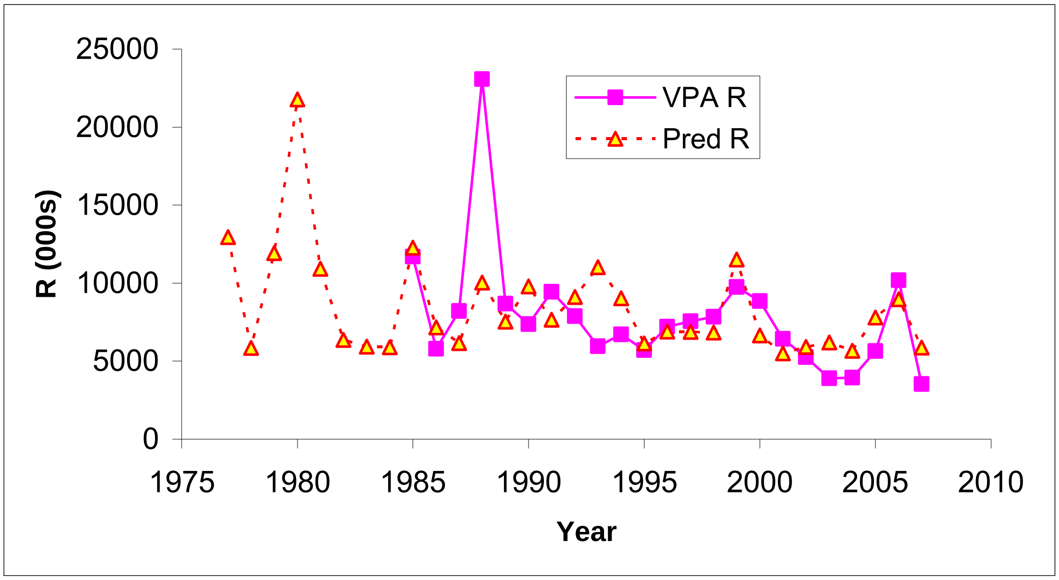


Figure E10. Stock recruitment relationship.



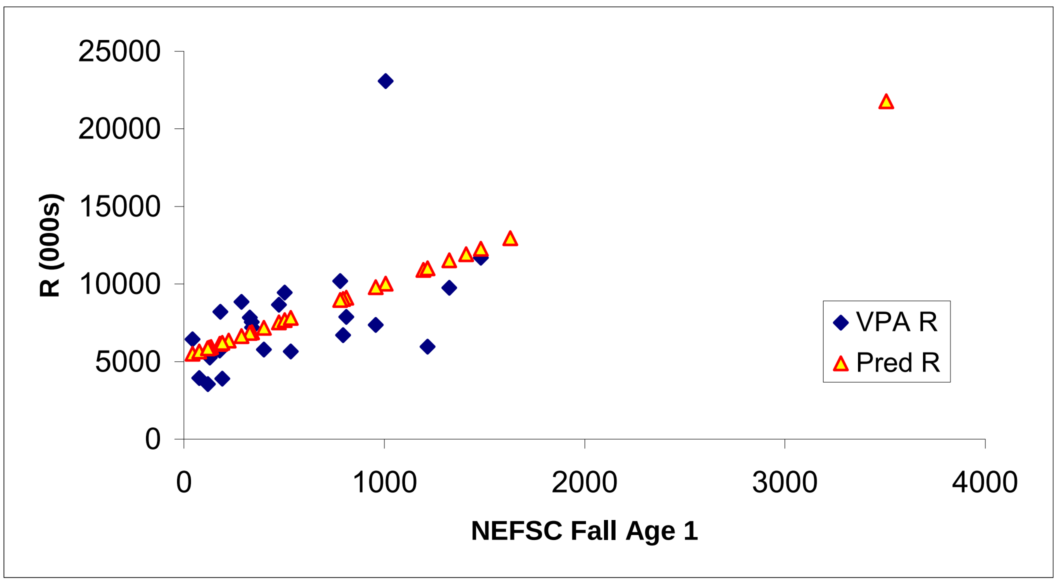


Figure E11. Hindcast estimates of recruitment using the NEFSC Fall survey at age 1.

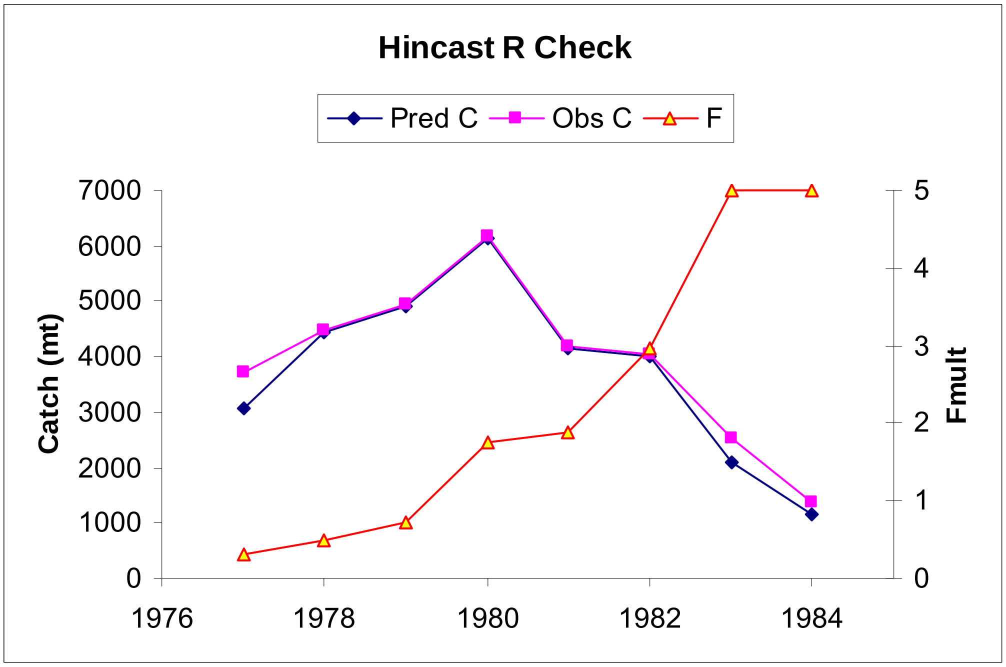


Figure E12. Comparison of observed and predicted catch using hindcast recruitment along with fishing mortality rate in each hindcast year

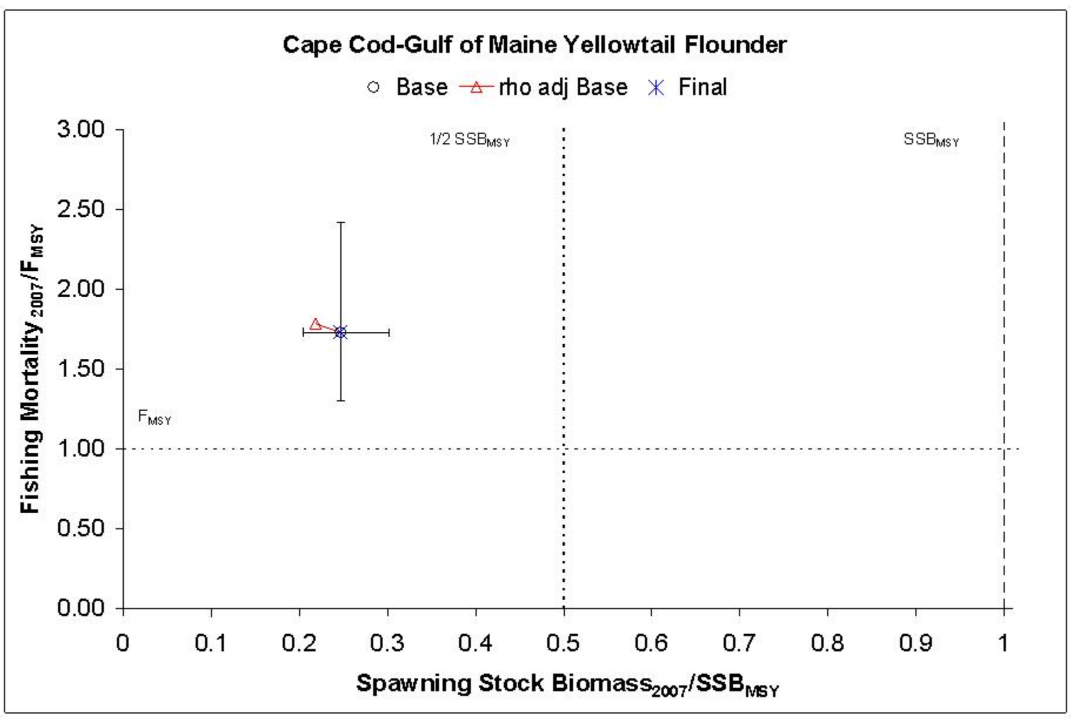


Figure E13. Current status of Cape Cod-Gulf of Maine yellowtail flounder.

F. Gulf of Maine cod
by R. Mayo, G. Shepherd, L. O'Brien, L. Col and M. Traver

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

1.0 Background

The area occupied by the Gulf of Maine Atlantic cod stock is shown in Figure F1. This stock was last assessed in 2005 at the August 2005 Groundfish Assessment Review Meeting (GARM II) (NEFSC 2005; Mayo and Col 2006). The methodology applied in the present default assessment is the same as in the 2005 and 2002 GARM assessments and the 2001 assessment as described in Mayo *et al.* (2002).

In the 2005 assessment, fully recruited fishing mortality (ages 4+) in 2004 was estimated to be 0.58. This was a result of a very high estimate of F on age 4. Spawning stock biomass was estimated to have increased from a low point of about 11,000 metric tons (mt) in 1997 and 1998 to about 25,000 mt in 2002 followed by a slight decline to 20,500 mt in 2004. The strength of several recent recruiting year classes (1999, 2000 and 2002) was estimated to be below average. The 2001 year class was estimated to be slightly above average and the 2003 year class appeared to be equivalent to the 1987 year class, the largest in the assessment series dating back to 1982. NEFSC spring and autumn research vessel bottom trawl survey indices for Gulf of Maine cod had declined to record low levels in the mid-1990s; indices from both surveys fluctuated at relatively low levels but had begun to increase in 2001 and 2002, continuing through 2004.

2.0 The Fishery

This section provides updated information on Gulf of Maine cod commercial landings, commercial discards, and recreational landings through 2007, and NEFSC and MADMF survey results through spring 2008.

Revised landings by stock were derived for the 1994-2007 period using the preferred allocation scheme reviewed at the GARMIII Data Meeting, October, 2007. Length and age samples associated with each allocated trip were also assigned to the corresponding stock. Both approaches required that landings at age be re-estimated from 1994 onward.

Commercial landings of Gulf of Maine cod declined to 1,380 mt in 1999, a 66 % decline from 1998 (Tables F1 and F2; Figure F2). Commercial landings have since increased to 4,280 mt in 2001, fluctuated between 3,500 and 3,800 mt between 2000 and 2005, declined to 3,028 mt in 2006 and increased to 3,989 mt in 2007. Gulf of Maine cod are caught by 2 primary gears: otter trawls and gillnets (Table F2). These two gear types account for over 90% of the catch with minor amounts coming from line trawls and handlines (hook gear). Otter trawls have generally taken over 50-70% of the catch and gillnets have taken about 30-40%. In recent years, the percentages have been about equal.

The number of commercial port samples for this stock declined from 89 in 1997 to 50 in 1998 to 10 in 1999 (Table F3). Port sampling has since improved, increasing to 74 samples in 2000 and over 300 samples per year since 2005; however a large part of this increase is due to acquisition of more 'Large' market category samples, many consisting of as few as 4-5 fish. Nevertheless, the number of fish sampled increased from a low of 733 in 1999 to over 10,000 per year since 2003. Sampling was not well distributed among quarters and market categories in

1999 and 2000, as only 1 biological sample was taken in the 3rd and 4th quarter of 1999, requiring substantial pooling over quarters. In 1999 and 2000 samples from each market category were pooled on an annual basis, but improved sampling beginning in 2001 allowed a return to the traditional quarterly or semi-annual pooling of samples within each market category. Landings from this fishery had been dominated by age 3 and 4 fish during the 1980s. Since then, however, the fishery has been dominated by age 4-6 fish, and the age structure of the landings appears to have expanded compared to the late 1990s (Table F4, Figure F4). Mean weights (kg) at age of the landed cod (Table F5) have remained relatively constant over time for ages up to age 5, but appear to have declined at ages 6 and older.

Commercial discards (Table F6, Figure F3) were re-estimated for the 1989-2007 period on a gear-quarter basis from NEFSC Observer Program data using SBRM methods incorporating cod discard/cod kept ratios. The revised estimates compare favorably with those presented at GARMII and indicate a substantial increase in the overall discard/kept ratio in 1999 compared to previous years (Table F6). Ratios calculated for years after 1999 were lower, but still remain substantially greater than the 1991-1998 ratios. Discards estimated from the Observer Program data have ranged from 97 mt in 1998 to 3,092 in 1990. These discard estimates were then used to generate the discards at age from 1999 to present (Table F7).

Recreational catches (Table F8) were re-estimated and partitioned by Gulf of Maine and Georges Bank stocks for the 1981-2007 period using revised MRFSS data and a revised site list (Steinbak and Thunberg, pers. comm.). The estimated recreational catch of Gulf of Maine cod (retained component only) has varied considerably over the past decade ranging from 337 mt in 1997 to 4,218 mt in 1981 (Table F8). The age composition and mean weights (kg) at age of the numbers of kept (A+B1) cod (Tables F9 and F10) were derived using available length measurements from the MRFSS database assigned to the Gulf of Maine area and a combination of age/length keys derived from commercial, survey (NEFSC and MADMF) and the cod industry-based survey (2004 and 2005 only). Recreational landings at age (Table F9) exhibit the same age structure as the commercial landings, with ages 4 and 5 always dominant and age 6 often replacing age 3 as the next most prevalent age.

Estimated numbers caught at age (including commercial and recreational landings and commercial discards (Table F11), estimated weight caught at age (Table F12), and weighted estimates of mean weights (kg) at age (Table F13) were derived from the various components. Most of the revisions occurred since 1994, but some differences are noted back to 1982 because of the changes in the estimates of recreational landings at age. The total catch at age in numbers was dominated by age 3 and 4 fish through 2001, with ages 4-6 predominating during the past 6 years. In terms of total weight at age, the fishery was dominated by age 3-5 fish through 2001, shifting thereafter to ages 4-6. The total catch at age reveals an increase in mean weights at age for ages 2, 3 and 4, no apparent trend for ages 4 and 5, and a decline for ages 6 and older (Table F13). The increase in mean weights at the younger ages reflects the trends in the recreational landings**.** See Appendix for a complete set of age composition tables (NEFSC 2008).

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* have been used exclusively during these surveys. Gear and door changes have occurred during the survey period. Vessel and door calibration coefficients have been applied to the data as described below Table F14. The Commonwealth of Massachusetts has also conducted research vessel bottom trawl surveys during spring and autumn primarily in state waters in the southwest portion of the Gulf of Maine since 1978. These surveys are conducted in relatively shallow water and, as such do not provide an abundance index of the stock as a whole. However they do provide an abundance index of recruiting year classes.

Results (stratified mean number and weight [kg] per tow) from bottom trawl surveys conducted by NEFSC were updated through spring 2008 (Tables F14-16, Figures F5-F7) and MADMF survey indices were recalculated over the entire time period beginning in 1978 (Tables F17 - F18).

NEFSC research vessel bottom trawl survey abundance and biomass indices for Gulf of Maine cod remained relatively low through autumn 1999 and spring 2000 (Table F14; Figure F5). The autumn 1999 indices increased slightly from 1998, while the spring 2000 indices decreased slightly from 1999. However, biomass indices began to increase substantially in 2001 and spring 2002, but the large apparent increase evident in autumn 2002 resulted from a single large haul unduly influencing the stratified mean. Spring indices in 2003, 2004 and 2005 suggest a substantial decline in biomass since 2002 to levels evident during the mid-1990s. Autumn indices through 2004 suggest that biomass remains above the mid-1990s lows. Spring indices have increased since 2005, but the autumn indices have remained relatively low through 2007.

Recruitment indices for the 1994-1997 year classes derived from the NEFSC and Mass. DMF bottom trawl surveys are among the lowest in the respective series, although indices for the 1998 and 1999 year classes appear to be above the recent average. The 2000 year class appears to be extremely weak in all surveys. More recently, there are indications in both NEFSC and Mass. DMF surveys that the 2003 year class may be relatively strong compared those produced over the past decade. The 2005 year class also appears to be strong especially at ages 2 and 3 in the spring 2007 and 2008 NEFSC surveys, respectively (Figure F6). High indices at ages 0 and 1 in the Mass. DMF surveys also suggest improved recruitment (2003, 2005 and possibly 2006 year classes) (Table F18).

Maturity data collected on NEFSC spring surveys were also analyzed in order to construct a series of maturity at age moving windows over the assessment time period. This was accomplished to provide a smoother transition in the maturity schedule used to determine spawning stock biomass. A series of annual 3-year moving windows was employed in order to achieve a smooth transition across years.

4.0 Assessment

Input Data and Model Formulation

The present assessment represents more than a three-year update to the previous assessment (Mayo and Col 2006). As noted above, each component of the total catch at age has changed since the 2005 GARMII assessment. This required re-estimation of the landings at age from 1994 to present, the recreational catch at age from 1981 to present and the observer based discards since 1989.

The VPA formulation used in the previous assessment was evaluated and, based on a shift in the age of full recruitment from age 4 to age 5, the age 7 plus group formulation was discontinued in favor of an extended age range out to age 11 plus. Catch at age data were revised over the 1982 to present assessment time period to account for the data changes described above. NEFSC survey abundance indices (stratified mean number per tow at age) were updated through spring 2008. Massachusetts DMF spring and autumn survey indices were recalculated over the entire period since 1978 due to slight changes in the strata boundaries that affected the stratified mean calculations. Differences were minor in most cases. The formulation in the present assessment is: catch at age from 1982-2007 out to age 11+, estimation of age 2-10 stock sizes in terminal year+1. Calibration included NEFSC spring and autumn age 2-8 indices, Massachusetts DMF spring ages 2-4 and autumn age 2 indices. As in recent VPAs, commercial CPUE indices were included only through 1993. This formulation of the present assessment addresses the recommendations of the GARMIII Model Selection Panel and the GARMIII Biological Reference Point Panel, and this base formulation was accepted by the GARMIII Assessment Review Panel as the final assessment.

Precision of the 2007 spawning stock biomass and fully recruited fishing mortality was estimated from 1,000 bootstrap replicates of the VPA. Retrospective analyses of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB were also carried out.

Assessment Results

Fully recruited fishing mortality (ages 5-7) in 2007 is estimated at 0.46 (Table F20b; Figure F8), a substantial decrease since 2004 and 2005. Annual estimates of fully recruited fishing mortality are also given in Table F21. The 2004 year class is estimated to be equivalent to the 1998 year class (approximately 7-8 million fish), the 2003 year class (11 million fish) is about twice the long term average and the 2005 year class (24 million fish) is equivalent to the strong 1987 year class (Table F20a). The 2000 year class (1.2 million fish) is by far the lowest in the entire VPA series and the 2002 year class (1.7 million fish) is the second lowest.

Spawning stock biomass increased to 18,000 mt in 2001, but declined to 11,000 mt in 2005 as a result of the above average 1998 year class being removed from the population followed by subsequent poor recruiting year classes of 2000 and 2002 (Table F20c; Figure F9). Spawning stock biomass increased substantially to 19,000 mt in 2006 on the strength of the 2003 year class becoming partially mature, and further to 34,000 mt in 2007 on the combined strength of the 2003 year class (95% mature) and the partially mature 2005 year class (34% mature). The complete VPA output can be found in Appendix (NEFSC 2008).

VPA Diagnostics and Uncertainty

Extension of the age range out to 11+ resulted in a partial recruitment pattern that peaked at ages 5-7, followed by a reduction at ages 8 and 9 to about 70-80 percent of the maximum. Estimates of F at ages 8 and 9 were highly variable, however, especially during the 1990s. The calculation of F on the oldest true age (age 10) was evaluated for a series of ages ranging from ages 5-6 to ages 5-9. There were no discernable differences in the age 5-7 average F estimates, only minor differences in the estimates of F on age 10, and no appreciable differences in the estimates of SSB over time. An additional trial using ages 8 and 9 to estimate F on age 10 produced similar trends in SSB but highly variable estimates of F on age 10. Taking account of these results we elected to include as many ages as possible (ages 5-9) to calculate F on age 10. Further details and graphics of this analysis can be found in Appendix (NEFSC 2008).

The 2008 NLLS stock size estimates were relatively precise for ages less than 8, with CVs for these ages ranging from 26% (ages 4 and 5) to 44% (ages 2 and 7) (Table F22). However the CVs on ages 8-10 were considerably higher, ranging from 55% (age8) to 72% (age 10). The bootstrapped estimates of bias were relatively low for intermediate ages ranging from

3% (ages 4 and 5) to 6-7% (ages 3, 6 and 7). Bias was higher, ranging from 13% on age 8 and about 21% on ages 2, 9 and 10 (Table F23). Coefficients of Variation on the NEFSC survey Qs varied between 10 and 17% for ages 2-6, increasing to between 20 and 28% on ages 7 and 8. The CVs on the Mass. DMF spring survey Qs ranged from 9-15% while the Q on the Mass. DMF autumn survey was estimated to be about 30%.

An analysis was also carried out to determine the magnitude and trends in survey Qs by raising the Qs estimated by the VPA using survey swept area calculations. For Gulf of Maine cod, these raised values of Q ranged from about 10% at age 2 to about 50-60% at age 5 and leveling off at about 70-90% at ages 7-8. Further details and graphics of this analysis can be found in Appendix (NEFSC 2008). Residual patterns from the NEFSC and Mass. DMF survey data used to calibrate the VPA appear for the most part random, although there are some instances of 3-4 year blocks of positive and negative residuals (Figure F10).

A weak retrospective pattern is evident in the estimates of terminal F whereby fully recruited F alternates between over- and under-estimation in the terminal year (Figure F11). The same pattern is evident for SSB (Figure F12). A retrospective pattern is also evident for age 1 recruitment estimates whereby recruitment was well overestimated for the 2001 and 2003 year classes (Figure F13). The estimate of the size of the 2005 year class appears to not suffer the same fate, as it is supported by an additional year of data in the present assessment (Figure F13). The degree of retrospective change in the estimates of average F (ages 5-7), SSB and age 1 recruitment was computed by calculating a Mohn's average Rho based on the relative difference between terminal year estimates over the last 7 years of the assessment (2000 – 2006). The relative differences are as follows:

	Mohn's Average Rho		
Year	Avg F (Ages 5-7)	SSB	Recruits (Age 1)
2000	0.8828	-0.0170	0.9246
2001	0.2544	0.2032	-0.6116
2002	-0.2325	0.5366	1.8357
2003	-0.0181	0.1856	1.8471
2004	0.0925	0.1677	1.0833
2005	0.2243	0.0653	-0.2613
2006	-0.1045	0.2228	0.1340
Avg	0.1570	0.1949	0.7074

The relative differences are mostly positive during these years, although some negative values appear in the F and recruitment retrospective analyses. These results suggest about a 15-20% positive relative difference for average F and about a 70% positive relative difference for age 1 recruitment. The latter value is driven by 3 very high values in 2002, 2003 and 2004. Owing to relatively small magnitude of the retrospective pattern, no adjustment was made in the final assessment formulation.

The bootstrap analysis (Table F23) provides an 80% CI about the 2007 fully recruited F estimate (0.46) of 0.36 – 0.67 (Figure F 14) and an 80% CI about the 2007 SSB estimate (33,877 mt) of 29,133 mt – 41,747 mt (Figure F15).

5.0 Biological Reference Points

The existing biological reference points first developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) are:

B_{MSY}	82,830 mt
F_{MSY}	0.225
MSY	16,600 mt

Two approaches for estimating biological reference points have been evaluated for this stock. The existing reference points are based on a parametric approach whereby spawning biomass and age 1 recruitment results obtained from the VPA were included in a model (SRFIT) that also included life history and fishery parameters using the Sissenwine-Shepherd approach (See Brodziak and Legault 2005). This approach was employed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002). Because the updated relationship between stock and recruitment was weak, the GARMIII Biological Reference point Panel recommended against a parametric model in favor of a non-parametric approach . This helps ensure consistency between reference point estimation and projection methodology.

Non-Parametric Approach

In the non-parametric empirical approach, a yield and SSB per recruit analysis was conducted using catch and stock mean weights at age and maturity at age averaged over the 2003-2007 time period. Partial recruitment at age was derived from the average of the 2003-2007 time period Fs from the VPA results as:

Age 1: 0.0000, Age 2: 0.0021, Age 3: 0.1618, Age 4: 0.6821, Age 5: 0.9004 Age 6: 1.0000, Age 7: 0.8260, Age 8: 0.7326, Age 9: 0.7705, Ages 10 and 11: 0.7530.

Yield and SSB per recruit input and results are given in Table F24 and Figure F16. A proxy for F_{MSY} taken from this analysis is F40% MSP = 0.237. A stochastic projection program (AGEPRO) was used to project 100 year scenarios to obtain equilibrium SSB_{MSY} and MSY estimates based on the cumulative distribution function of age 1 recruits from the 1981-2005 year classes obtained from the current VPA. The initial conditions of 2008 stock size were based on the 1,000 bootstrap iterations performed by the VPA. Catch and stock mean weights at age, maturity at age and partial recruitment averaged over the 2003-2007 time period were the same as used in the yield and SSB per recruit analyses above. A constant F strategy was employed setting F at an F_{MSY} proxy F40% MSP (0.237) obtained from the SSB per recruit analysis. Results from this approach provide the following estimates:

SSB_{MSY}	58,248 mt
MSY	10,014 mt

6.0 Projections

The stochastic AGEPRO projection software was also used to conduct short-term projections of 2009 catches under 3 scenarios of F in 2009 ($F_{STATUS\ QUO}$, F_{MSY} and $F_{REBUILD}$).

The same initial conditions of stock size, mean weights, maturity and partial recruitment were used as in the long-term 100 year simulation used to derive SSB_{MSY} and MSY above. In each case F in 2008 was derived by assuming the 2008 catch will equal that of 2007.

$F_{REBUILD}$

$F_{REBUILD}$ was first estimated based on the current rebuilding plan for Gulf of Maine cod which required that the SSB be rebuilt to SSB_{MSY} by 2014, which is a 6-year time horizon beginning in 2009. Results from this projection suggest that the stock can almost reach the SSB_{MSY} target in 2009-2010 and then level off, remaining near the target through 2014, at $F_{REBUILD}$ (0.281) [slightly greater than the F40% proxy F_{MSY} (0.237)]. However, if F remains at 0.35 or greater, not only will SSB fail to rebuild by 2014, it will begin to decline after 2009. It should be recognized that these projections depend in large part on the estimated strength of the 2005 year class.

2009 Catch Estimates

Annual Catch estimates were determined for 2009 under the 3 scenarios of 2009 F as described above. Results are as follows: $F_{STATUS\ QUO}$: 19,191 mt, $F_{REBUILD}$: 12,591 mt, F_{MSY}: 10,798 mt. Further details are given in Table F25.

7.0 Summary

Stock Status

Fishing mortality in 2007 is estimated to be 0.46 (80% CI: 0.36 – 0.67) and current spawning stock biomass in 2007 is estimated to be 33,877 mt (80% CI: 29,133 mt – 41,747 mt). The set of biological reference points, based on the non-parametric SSB/R and AGEPRO projection approach, are as follows: F40% proxy F_{MSY} = 0.237, SSB_{MSY} = 58,248 mt and MSY = 10,014 mt.

Spawning stock biomass in 2007 is above ½ SSB_{MSY}, but F in 2007 is about twice the F_{MSY} level. Thus the stock is not overfished, but overfishing is occurring (Figure F17).

Sources of Uncertainty

High CVs (> 50%) on 2008 stock size estimates for ages > 7.
Bias on age 8-10 stock size estimates in 2008 ranges from 13% to 21%.
Bias on age 7-9 F estimates in 2007 ranges from 26% to 144%.
Estimates of F on ages >7 are highly variable during the 1990s.

Differences from Previous Assessment

Commercial and recreational landings at age revised from 1994 and 1982 to 2004, respectively.
Catch at age range extended from ages 7+ to ages 11+.
Includes ages 7-8 from NEFSC spring and autumn surveys in calibration.
Now estimating stock sizes on ages 2-10 vs. ages 2-6 in previous assessments.
Moderate dome in partial recruitment at ages 8 to 10.
Average F represented by ages 5-7 vs. ages 4-5.

8.0 Panel Discussion/Comments

Conclusions

The VPA assessment, with the modifications recommended by previous panels, was accepted by the Panel as Final, as the best available estimate of stock status, and as a sufficient basis for management advice

. The Panel particularly noted the extension of the catch at age to 11+ as recommended by both the GARM III 'models' and 'BRP' reviews to explore the possibility of the presence of a dome-shaped fishery partial recruitment. The previous panels had recommended that a flat-top PR be assumed unless there was compelling evidence otherwise. The current assessment provides evidence for a domed PR which peaks at ages 5 – 7 followed by a reduction at ages 8 and 9 to about 70 – 80% of the maximum. This pattern is not as steep as determined by the alternative ASPM assessment.

The Panel concluded that the retrospective pattern in this assessment was small and did not require an adjustment.

An alternative ASPM assessment resulted in higher estimated spawning biomass and lower fishing mortality rates although the overall temporal trend in these parameters was similar to that in the VPA. Improved statistical model fits resulted from steeply dome-shaped PR (compared to the VPA), domed survey catchability and increasing natural mortality (M) after age four. The Panel was concerned that increasing M after age four and the domed survey catchability did not have a clear biological basis. Consequently, the Panel could not accept this formulation as the basis for management advice. The examination of both models (VPA and ASPM) during the GARM III dramatically improved final assessment formulation. Comparing the two formulations, the Panel noted that the VPA may be underestimating current stock status.

The Panel noted that the BRPs were estimated as per the GARM III 'BRP' review and the projections are appropriate for estimating $F_{REBUILD}$.

Regarding uncertainties, it was noted that survival of released recreational cod is assumed to be 100%. This needs confirmation in future assessments.

Research Recommendations

As with Georges Bank cod, the Panel recommended that historical data be used to hindcast recruitments as far back in time as possible for use in the estimation of reference points and projections.

9.0 References

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10. Tables and Figures

Table F1. Commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (NAFO Division 5Y), 1960 - 2007.[1]

	Gulf of Maine				
Year	USA	Canada	USSR	Other	Total
1960	3448	129	-	-	3577
1961	3216	18	-	-	3234
1962	2989	83	-	-	3072
1963	2595	3	133	-	2731
1964	3226	25	-	-	3251
1965	3780	148	-	-	3928
1966	4008	384	-	-	4392
1967	5676	297	-	-	5973
1968	6360	61	-	-	6421
1969	8157	59	-	268	8484
1970	7812	26	-	423	8261
1971	7380	119	-	163	7662
1972	6776	53	11	77	6917
1973	6069	68	-	9	6146
1974	7639	120	-	5	7764
1975	8903	86	-	26	9015
1976	10172	16	-	-	10188
1977	12426	-	-	-	12426
1978	12426	-	-	-	12426
1979	11680	-	-	-	11680
1980	13528	-	-	-	13528
1981	12534	-	-	-	12534
1982	13582	-	-	-	13582
1983	13981	-	-	-	13981
1984	10806	-	-	-	10806
1985	10693	-	-	-	10693
1986	9664	-	-	-	9664
1987	7527	-	-	-	7527
1988	7958	-	-	-	7958
1989	10397	-	-	-	10397
1990	15154	-	-	-	15154
1991	17781	-	-	-	17781
1992	10891	-	-	-	10891
1993	8287	-	-	-	8287
1994	7994	-	-	-	7994
1995	6536	-	-	-	6536
1996	6976	-	-	-	6976
1997	5420	-	-	-	5420
1998	4045	-	-	-	4045
1999	1380	-	-	-	1380
2000	3721	-	-	-	3721
2001	4280	-	-	-	4280
2002	3604	-	-	-	3604
2003	3851	-	-	-	3851
2004	3776	-	-	-	3776
2005	3525	-	-	-	3525
2006	3028	-	-	-	3028
2007	3989	-	-	-	3989

[1] USA 1960-1993 landings from NMFS, NEFSC Detailed Weighout Files and Canvass data.

[2] USA 1994-2007 landings from NMFS, NEFSC Detailed Weighout Files estimated by allocating landings on a trip basis from Vessel Trip Reports.

Table F2. USA commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965 - 2007.

Year	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	2480	501	462	168	1	3612	68.7	13.9	12.8	4.6	-	100.0
1966	2549	830	308	150	4	3841	66.4	21.6	8.0	3.9	0.1	100.0
1967	4312	734	206	274	<1	5526	78.0	13.3	3.7	5.0	-	100.0
1968	4143	1377	213	339	4	6076	68.2	22.7	3.5	5.6	-	100.0
1969	6553	851	258	162	4	7828	83.7	10.9	3.3	2.1	-	100.0
1970	5967	951	407	178	9	7512	79.4	12.7	5.4	2.4	0.1	100.0
1971	5117	1043	927	98	8	7193	71.1	14.5	12.9	1.4	0.1	100.0
1972	4004	1492	1234	54	2	6786	59.0	22.0	18.2	0.8	-	100.0
1973	3542	1182	1305	23	9	6061	58.4	19.5	21.5	0.4	0.2	100.0
1974	5056	1412	904	36	17	7425	68.1	19.0	12.2	0.5	0.2	100.0
1975	6255	1480	920	12	8	8675	72.1	17.1	10.6	0.1	0.1	100.0
1976	6701	2511	621	4	41	9878	67.8	25.4	6.3	0.1	0.4	100.0
1977	8415	2872	534	6	166	11993	70.2	23.9	4.5	-	1.4	100.0
1978	7958	3438	393	10	91	11890	66.9	28.9	3.3	0.1	0.8	100.0
1979	7567	2900	334	19	167	10987	68.9	26.4	3.0	0.2	1.5	100.0
1980	8420	3733	251	48	61	12513	67.3	29.8	2.0	0.4	0.5	100.0
1981	7937	4102	276	23	45	12383	64.1	33.1	2.2	0.2	0.4	100.0
1982	9758	3453	188	46	34	13479	72.4	25.6	1.4	0.3	0.3	100.0
1983	9975	3744	77	4	67	13867	71.9	27.0	0.6	-	0.5	100.0
1984	6646	3985	22	3	69	10725	62.0	37.2	0.2	-	0.6	100.0
1985	7119	3090	55	6	326	10596	67.2	29.1	0.5	0.1	3.1	100.0
1986	6664	2692	56	12	180	9604	69.4	28.0	0.6	0.1	1.9	100.0
1987	4356	2994	70	13	68	7501	58.1	39.9	0.9	0.2	0.9	100.0
1988	4513	3308	68	27	22	7938	56.9	41.7	0.8	0.3	0.3	100.0
1989	6152	4000	72	36	119	10379	59.3	38.5	0.7	0.4	1.1	100.0
1990	10420	4343	126	20	186	15095	69.0	28.8	0.8	0.1	1.2	100.0
1991	13049	4158	212	59	266	17744	73.5	23.4	1.2	0.3	1.5	100.0
1992	7344	3081	359	94	14	10891	67.4	28.3	3.3	0.9	0.1	100.0
1993	4876	3130	236	16	29	8287	58.8	37.8	2.8	0.2	0.3	100.0
1994[1]	4368	3287	302	19	18	7994	54.6	41.1	3.8	0.2	0.2	100.0
1995	3309	2876	255	57	39	6536	50.6	44.0	3.9	0.9	0.6	100.0
1996	3901	2642	308	83	42	6976	55.9	37.9	4.4	1.2	0.6	100.0
1997	2891	2109	326	68	26	5420	53.3	38.9	6.0	1.3	0.5	100.0
1998	2277	1400	228	115	25	4045	56.3	34.6	5.6	2.8	0.6	100.0
1999	762	442	69	101	6	1380	55.2	32.0	5.0	7.3	0.4	100.0
2000	2025	1387	74	214	21	3721	54.4	37.3	2.0	5.8	0.6	100.0
2001	2375	1546	89	260	10	4280	55.5	36.1	2.1	6.1	0.2	100.0
2002	1903	1402	119	174	6	3604	52.8	38.9	3.3	4.8	0.2	100.0
2003	1912	1631	139	148	21	3851	49.6	42.4	3.6	3.8	0.5	100.0
2004	1612	1878	114	75	97	3776	42.7	49.7	3.0	2.0	2.6	100.0
2005	1448	1658	119	79	221	3525	41.1	47.0	3.4	2.2	6.3	100.0
2006	1329	1437	139	36	87	3028	43.9	47.5	4.6	1.2	2.9	100.0
2007	1495	2123	155	70	146	3989	37.5	53.2	3.9	1.8	3.7	100.0

1 Landings estimates revised since 1994

Table F3. USA sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 2007.

Year	Number of Samples				Number of Samples, by Market Category & Quarter															No. Tons
	Length Samples		Age Samples		Scrod					Market					Large					No. Tons
	No.	No. Fish Measured	No.	No. Fish Aged	Q1	Q2	Q3	Q4	3	Q1	Q2	Q3	Q4	3	Q1	Q2	Q3	Q4	3	per Sample
1982	48	3848	48	866	6	7	6	6	25	4	3	7	4	18	0	2	1	2	5	266
1983	71	5241	67	1348	14	10	10	4	38	4	10	6	2	22	1	3	5	2	11	197
1984	55	3925	55	1224	7	5	6	7	25	4	3	5	6	18	1	6	3	2	12	193
1985	69	5426	66	1546	5	6	7	5	23	8	6	7	4	25	7	5	3	6	21	155
1986	53	3970	51	1160	5	5	6	3	19	5	6	8	2	21	1	5	4	3	13	182
1987	43	3184	42	939	4	4	3	4	15	5	5	3	5	18	4	2	3	1	10	175
1988	34	2669	33	741	4	3	4	4	15	1	5	3	5	14	1	2	2	0	5	234
1989	32	2668	32	714	3	3	3	3	12	4	1	5	4	14	2	2	1	1	6	325
1990	39	2982	38	789	3	7	3	5	18	4	7	4	3	18	0	2	1	0	3	387
1991	56	4519	56	1152	2	10	4	3	19	5	11	11	3	30	0	3	3	1	7	318
1992	51	4086	51	1002	2	8	6	3	19	6	7	7	3	23	3	1	1	4	9	214
1993	23	1753	23	447	3	3	3	1	10	1	2	4	1	8	1	1	2	1	5	360
1994	29	2575	33	649	0	2	2	3	7	1	5	3	6	15	0	2	3	2	7	275
1995	31	2557	32	682	4	3	2	4	13	2	8	2	2	14	0	3	0	1	4	208
1996	71	6486	66	1380	5	4	7	9	25	6	9	11	11	37	1	2	3	3	9	97
1997	89	7559	80	1643	7	13	3	10	33	12	11	10	9	42	2	8	2	2	14	61
1998	50	4536	46	992	4	7	0	3	14	9	9	9	5	32	1	0	2	1	4	80
1999	10	733	10	195	5	0	0	0	5	2	1	1	0	4	1	0	0	0	1	137
2000	74	5737	74	1680	15	6	4	7	32	13	14	5	9	41	0	0	0	1	1	49
2001	109	6895	107	2436	4	4	4	7	19	4	9	8	15	36	2	15	18	19	54	38
2002	129	5263	124	2405	4	2	0	1	7	15	3	6	5	29	50	8	16	19	93	29
2003	248	11479	231	5630	5	1	17	8	31	14	8	25	19	66	50	34	34	33	151	15
2004	221	11031	162	3467	17	11	6	22	56	18	21	15	15	69	37	20	11	25	95	15
2005	364	10073	256	3486	23	29	33	16	101	13	15	20	19	67	20	41	68	63	192	9
2006	322	10735	255	4309	15	8	8	3	34	17	20	18	12	67	48	48	62	60	218	9
2007	376	10702	285	3907	10	6	11	8	35	7	14	18	17	56	43	73	104	60	280	11

Table F4. Total commercial landings in numbers (000s) at age for Gulf of Maine cod.

Year	Total Commercial Landings in Numbers (000's) at Age								Revised LAA 1994+		Jul-08	
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1982	30	1380	1633	1143	633	69	91	61	41	4	33	5118
1983	0	866	2357	1058	638	422	47	61	23	9	15	5496
1984	4	446	1240	1500	437	194	74	19	15	11	17	3957
1985	0	407	1445	991	630	128	78	32	4	11	11	3737
1986	0	84	2164	813	250	177	39	24	20	4	8	3583
1987	2	216	595	1109	277	66	51	9	8	8	3	2344
1988	0	160	1443	953	406	43	9	17	1	2	1	3035
1989	0	337	1583	1454	449	81	35	6	3	5	7	3960
1990	0	205	3425	2064	430	157	27	30	10	15	17	6380
1991	0	344	934	4161	851	143	41	30	6	1	1	6512
1992	0	313	530	484	2018	202	62	7	12	3	0	3631
1993	0	76	1487	641	129	457	28	6	2	0	0	2825
1994	0	37	1094	1114	305	69	84	29	7	1	1	2742
1995	18	221	885	1035	222	27	14	18	1	2	0	2443
1996	0	69	513	1744	365	37	4	0	1	0	0	2734
1997	0	79	445	427	801	68	5	3	0	1	0	1829
1998	0	94	396	530	146	176	25	4	0	1	0	1373
1999	0	3	184	176	81	16	22	2	0	2	0	487
2000	0	102	256	501	122	69	11	5	0	0	0	1067
2001	0	46	484	323	212	68	39	6	9	1	0	1187
2002	0	2	115	439	172	106	43	12	4	4	0	898
2003	0	7	48	205	393	124	54	21	9	5	3	870
2004	0	1	156	133	226	178	54	28	15	8	2	799
2005	0	1	40	437	65	181	85	22	13	6	5	856
2006	0	1	120	192	307	22	66	31	11	6	5	761
2007	0	5	101	643	101	187	6	17	8	4	5	1077

Table F5. Total commercial landings mean weights (kg) at age for Gulf of Maine cod.

Total Commercial Landings Mean Weight (kg) at Age

Year	1	2	3	4	5	6	7	8	9	10	11+	Average
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	9.931	12.922	10.618	18.456	2.654
1983	0.000	1.164	1.660	2.475	3.778	5.962	5.808	10.522	10.089	10.898	17.813	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	9.595	12.889	13.951	15.028	2.731
1985	0.000	1.260	1.746	2.840	4.466	5.525	7.901	11.218	11.420	13.386	14.523	2.861
1986	0.000	1.304	1.837	2.923	4.619	6.067	7.669	10.030	12.463	12.907	16.554	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	10.023	13.752	14.738	14.596	3.212
1988	0.000	1.268	1.881	2.426	5.166	6.767	9.932	11.126	14.960	15.763	20.356	2.622
1989	0.000	1.247	1.776	2.993	3.864	4.872	9.267	11.938	14.806	18.196	21.521	2.626
1990	0.000	1.071	1.692	2.271	4.265	7.645	10.734	11.758	15.015	14.784	20.295	2.366
1991	0.000	1.130	1.568	2.512	4.136	7.309	9.642	12.322	15.547	24.328	21.885	2.731
1992	0.000	1.533	1.922	2.714	3.061	5.000	9.566	12.462	13.449	16.631		2.999
1993	0.000	1.293	1.889	2.513	4.356	6.174	9.999	13.869	17.544			2.933
1994	0.000	1.401	1.882	3.034	3.452	6.324	7.159	10.464	10.362	18.542	20.637	2.915
1995	0.274	1.388	1.854	2.774	5.138	5.837	10.760	11.510	18.893	20.064	20.347	2.675
1996	0.000	1.543	2.220	2.350	3.543	7.347	10.406	14.126	14.929	0.000	0.000	2.551
1997	0.000	1.777	2.242	3.090	3.171	4.880	8.409	11.560	14.726	15.814	21.874	2.964
1998	0.000	1.323	2.055	2.879	4.204	4.321	5.254	11.391	18.893	14.953	20.347	2.947
1999	0.000	1.483	1.809	2.511	3.691	5.712	7.311	10.081	0.000	13.402	0.000	2.837
2000	0.000	1.673	2.513	3.646	4.637	5.813	6.394	8.580	0.000	0.000	0.000	3.488
2001	0.000	1.843	2.491	3.365	4.880	6.359	7.451	8.733	8.789	12.414	24.418	3.605
2002	0.000	1.348	2.569	3.320	4.152	6.066	6.792	8.618	9.589	10.482	14.333	4.013
2003	0.000	1.810	2.415	3.179	4.183	5.343	7.247	8.480	10.295	11.771	12.638	4.426
2004	0.000	1.483	2.550	3.588	4.138	5.742	7.167	9.329	11.688	12.822	12.914	4.723
2005	0.000	1.876	2.185	3.018	4.467	4.622	6.226	7.736	10.355	13.331	14.098	4.120
2006	0.000	2.394	2.430	3.271	3.790	4.789	5.453	7.284	9.245	11.974	15.718	3.980
2007	0.000	1.945	2.493	3.241	3.961	4.827	6.243	6.839	9.625	11.369	14.255	3.703

Table F6. Discard estimates (weight, mt) and measures of precision (coefficient of variation) with a comparison of estimates derived for GARMII in 2005.

	Number of Trips	Otter Trawl	Shrimp Trawl	Gillnet	Total	d/k ratio	CV	2005 est.
1989	190	746.6	242.1	169.0	1157.8	0.111	32.3%	1545.0
1990	185	2505.6	349.0	238.0	3092.5	0.204	37.0%	3598.0
1991	935	774.6	94.9	143.4	1012.9	0.057	28.1%	1049.0
1992	1038	546.9	15.0	98.7	660.7	0.061	17.9%	603.0
1993	664	335.0	0.0	86.0	421.0	0.051	26.2%	329.0
1994	171	74.1	63.4	80.4	217.8	0.027	18.8%	239.0
1995	202	121.0	0.0	186.5	307.4	0.047	22.5%	426.0
1996	140	58.9	0.0	123.7	182.6	0.026	20.7%	199.0
1997	59	12.6	0.0	91.0	103.7	0.019	56.5%	179.0
1998	85	16.6		80.3	96.9	0.024	37.8%	154.0
1999	108	1170.3		1453.8	2624.2	1.902	25.1%	2630.0
2000	202	718.1		280.3	998.5	0.268	17.7%	1170.0
2001	192	667.6	0.0	708.6	1376.2	0.322	18.8%	1621.0
2002	311	943.1		594.9	1538.0	0.427	16.2%	1950.0
2003	608	930.3	0.0	293.8	1224.1	0.318	19.4%	1486.0
2004	1175	301.5	0.0	168.0	469.5	0.124	21.1%	575.0
2005	1262	157.0	0.0	112.1	269.0	0.076	9.5%	
2006	384	324.9	0.0	129.2	454.1	0.150	34.9%	
2007	381	327.3	0.0	188.4	515.7	0.129	12.8%	

Table F7. Total commercial discards in numbers (000s) at age for Gulf of Maine cod.

		Total Commercial Discards in Numbers (000's) at Age							Revised Discards 1999+			
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1999	0	6	350	335	155	31	43	4	0	3	0	925
2000	0	27	69	134	33	19	3	1	0	0	0	286
2001	0	15	155	104	68	22	12	2	3	0	0	382
2002	0	1	49	187	74	45	18	5	2	2	0	383
2003	0	2	15	65	125	39	17	7	3	2	1	277
2004	0	0	19	17	28	22	7	3	2	1	0	99
2005	0	0	3	33	5	14	6	2	1	0	0	65
2006	0	0	18	29	46	3	10	5	2	1	1	114
2007	0	1	13	83	13	24	1	2	1	1	1	139

		Total Commercial Discards in Weight (Tons) at Age										
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1999	0	8.229152	632.3211	840.8807	570.5593	175.6108	310.7809	44.92337	0	38.4042	0	2626.099
2000	0	45.69613	172.5082	490.2897	151.7367	107.5641	18.96529	12.59727	0	0	0	992.4665
2001	0	27.26515	387.2823	349.5529	332.4472	138.964	92.24515	16.02044	26.24963	3.653747	2.836484	1375.022
2002	0	0.894573	126.3784	621.6192	305.4864	275.5153	124.4507	44.46742	16.24992	18.99534	2.67322	1541.092
2003	0	4.041596	36.94529	207.3986	522.9986	210.9961	123.682	55.84634	30.87597	17.99572	13.4672	1223.025
2004	0	0.094445	49.38522	59.43709	116.1658	127.4585	48.25518	32.15067	21.24175	12.4877	3.384399	468.9256
2005	0	0.171457	6.598477	100.6273	22.12268	63.95506	40.40933	13.25934	10.42035	5.597503	5.891383	268.328
2006	0	0.362839	43.68574	94.059	174.4595	15.98146	53.74157	33.53138	15.2962	11.3954	11.77911	451.9766
2007	0	1.345042	32.46468	268.9374	51.85083	116.4489	5.086826	14.94985	10.0594	6.010341	8.426732	510.4338

Table F8. Recreational catch estimates for Gulf of Maine cod using revised site lists for partitioning total cod estimates into Gulf of Maine and GeorgesBank stocks.

	Gulf of Maine (me,ma,nh)			
	tot n	tot wt mt	n retain	wt retain mt
	a,b1,b2	ab1b2	a,b1	a,b1
	gm_totn lnd	tot wt mt	gm_lnded	ab1 mt
1981	2841.9	4523.3	2650.0	4218.0
1982	1943.9	3412.6	1849.2	3246.4
1983	1488.2	2110.3	1257.8	1783.7
1984	1107.5	1728.3	910.8	1421.3
1985	1833.5	2348.9	1633.9	2093.2
1986	1111.6	2059.8	990.1	1834.6
1987	2597.8	4308.1	2031.1	3368.3
1988	1448.7	2626.7	1272.3	2306.9
1989	1775.1	3763.5	1203.0	2550.5
1990	1727.1	3659.6	1254.5	2658.1
1991	1788.2	3711.7	1377.8	2859.9
1992	560.7	1097.4	321.6	629.5
1993	1517.8	2762.8	766.6	1395.3
1994	1272.2	2333.4	542.6	995.2
1995	1192.3	2116.8	509.6	904.8
1996	801.4	1816.3	350.6	794.6
1997	440.0	1060.0	139.8	336.7
1998	577.3	1585.3	194.3	533.5
1999	724.7	2338.6	248.9	803.2
2000	1443.8	4306.8	522.8	1559.5
2001	2330.3	6079.1	1018.3	2656.5
2002	1640.6	5050.7	551.4	1697.6
2003	1721.0	7095.2	613.0	2527.1
2004	1427.6	4897.2	531.9	1824.5
2005	1859.0	6237.5	584.2	1960.3
2006	932.4	3561.1	249.7	953.6
2007	1337.1	4470.4	307.0	1026.5

Table F9. Total recreational landings in numbers (000s) at age for Gulf of Maine cod.

Total Recreational Landings in Numbers (000's) at Age							Revised Recr Catch 1982+					
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1982	41	601	787	279	114	8	7	5	0	0	0	1842
1983	11	458	561	131	49	31	3	4	2	3	4	1258
1984	21	356	342	137	33	14	4	0	0	1	1	908
1985	44	658	743	146	37	5	0	0	0	0	0	1634
1986	13	102	593	117	27	23	7	6	16	4	51	958
1987	94	674	726	397	69	25	33	5	6	2	0	2031
1988	2	389	685	164	23	6	2	1	0	0	0	1273
1989	4	183	698	262	39	12	6	0	0	0	0	1203
1990	0	49	701	392	93	20	0	0	0	0	0	1254
1991	0	94	407	750	80	16	6	0	2	0	0	1355
1992	0	25	57	48	170	17	3	0	0	0	0	322
1993	0	52	545	142	10	17	1	0	0	0	0	767
1994	1	17	394	103	26	2	1	0	0	0	0	543
1995	0	56	285	157	10	2	0	0	0	0	0	510
1996	0	21	117	193	19	0	0	0	0	0	0	351
1997	0	6	51	28	52	3	0	0	0	0	0	140
1998	0	14	87	64	13	16	1	0	0	0	0	194
1999	1	14	114	57	37	11	14	1	0	0	0	249
2000	0	72	209	192	36	11	2	0	0	0	0	523
2001	0	86	544	259	98	19	9	1	1	0	0	1018
2002	0	1	95	258	100	52	20	18	4	3	0	551
2003	0	7	55	172	248	68	33	13	9	4	3	611
2004	0	0	183	100	156	65	14	6	3	3	1	531
2005	0	6	92	344	25	70	29	8	5	2	2	584
2006	0	0	39	61	96	7	22	13	5	3	3	250
2007	0	2	41	182	26	43	1	4	3	2	2	307

Table F10. Total recreational landings mean weights (kg) at age for Gulf of Maine cod.

	Total Recreational Landings Mean Weight (kg) at Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Average
1982	0.531	1.009	1.526	2.423	4.431	5.686	6.100	7.050	10.522	12.655	16.456	1.700
1983	0.446	0.867	1.399	2.156	3.412	6.831	5.913	8.331	10.808	17.726	18.784	1.635
1984	0.459	0.849	1.408	2.460	3.428	4.476	6.755	6.618	5.621	16.868	17.991	1.510
1985	0.466	0.830	1.320	2.326	3.021	3.370	3.798	4.458	10.522	12.655	16.456	1.236
1986	0.399	0.968	1.646	2.641	4.014	5.740	11.181	13.651	14.756	13.780	20.055	3.240
1987	0.189	0.837	1.435	2.705	4.704	8.009	10.456	10.559	11.344	10.943	16.456	1.826
1988	0.318	0.838	1.434	2.104	3.881	3.669	6.773	7.109	10.522	12.655	16.456	1.405
1989	0.680	1.111	1.601	2.610	3.555	6.351	7.837	9.095	10.522	12.655	16.456	1.888
1990	0.421	1.141	1.656	2.453	3.830	5.508	7.176	8.160	10.522	12.655	16.456	2.107
1991	0.421	1.378	1.485	1.990	2.609	8.450	9.387	8.160	9.387	3.468	16.456	1.950
1992	0.421	1.810	2.205	3.030	3.323	4.827	7.781	2.515	10.522	12.655	16.456	3.087
1993	0.421	1.023	1.636	1.877	2.681	4.207	9.685	8.160	10.522	12.655	16.456	1.722
1994	0.131	1.342	1.601	2.182	2.086	4.300	8.623	8.476	9.095	12.655	16.456	1.755
1995	0.482	1.523	1.620	1.924	3.120	1.798	7.176	5.833	10.522	12.655	16.456	1.734
1996	0.582	1.542	1.808	1.952	2.387	8.127	12.664	12.664	12.664	12.655	16.456	1.915
1997	0.421	1.733	1.992	2.381	2.388	2.806	6.275	6.501	10.522	12.655	16.456	2.224
1998	0.456	1.718	2.151	2.570	3.332	3.140	3.288	6.735	10.522	12.655	16.456	2.423
1999	0.334	1.253	1.958	3.048	4.820	6.032	6.706	8.851	10.522	12.655	16.456	3.070
2000	0.421	1.521	1.929	2.688	3.543	4.898	3.419	4.826	10.522	12.655	16.456	2.334
2001	0.421	1.716	2.266	2.912	4.308	6.000	6.211	6.261	6.966	12.655	16.456	2.695
2002	0.421	1.381	2.265	3.147	3.716	5.357	6.422	14.256	11.036	10.987	16.456	3.890
2003	0.421	2.083	2.402	2.869	3.611	5.159	8.120	9.367	11.555	13.161	13.712	4.031
2004	0.421	1.459	2.140	2.681	2.849	3.780	5.664	9.757	12.265	13.369	14.001	2.960
2005	0.421	1.523	1.990	2.574	3.857	4.187	6.270	8.120	10.685	13.692	15.088	3.154
2006	0.421	2.053	2.409	3.222	3.610	5.054	5.727	8.514	10.601	12.556	15.562	4.217
2007	0.421	2.292	2.617	3.146	3.776	4.634	6.958	8.142	11.376	12.503	14.439	3.661

Table F11. Total catch in numbers (000s) at age for Gulf of Maine cod.

	Total Catch in Numbers (000's) at Age								Revised LAA 1994+			
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1982	71.4	1980.9	2420.3	1422.1	747.1	77.1	97.7	65.6	41.0	4.0	33.0	6960.1
1983	11.3	1324.4	2917.6	1189.0	687.2	452.6	50.0	65.4	25.2	11.8	19.4	6754.0
1984	24.7	801.5	1581.5	1636.5	470.1	207.6	78.4	19.3	15.0	11.6	18.4	4864.9
1985	44.3	1064.5	2187.8	1137.1	667.5	133.2	78.5	32.1	4.0	11.0	11.0	5371.0
1986	12.8	186.0	2756.8	929.6	277.0	199.9	45.7	30.2	35.6	8.0	59.5	4541.1
1987	96.3	889.6	1321.0	1505.8	346.4	91.5	83.7	13.9	13.6	10.3	3.0	4375.0
1988	2.4	549.1	2128.0	1117.1	428.8	49.3	11.2	17.9	1.0	2.0	1.0	4308.0
1989	3.8	519.5	2280.6	1715.7	488.0	92.8	41.2	6.4	3.0	5.0	7.0	5163.0
1990	0.0	253.6	4125.6	2455.9	523.3	176.6	27.0	30.0	10.0	15.0	17.0	7634.0
1991	0.0	438.5	1341.1	4910.7	930.6	158.8	46.8	30.0	7.9	1.3	1.0	7866.6
1992	0.0	338.3	587.1	531.9	2188.4	219.1	65.3	7.4	12.0	3.0	0.0	3952.5
1993	0.0	127.8	2031.8	783.0	139.4	473.8	29.2	6.0	2.0	0.0	0.0	3592.0
1994	0.9	54.0	1488.2	1216.6	330.9	71.0	85.7	29.5	6.7	0.6	1.2	3285.3
1995	18.1	277.0	1169.9	1192.0	232.5	28.6	13.9	18.4	0.8	1.6	0.2	2953.2
1996	0.0	90.0	630.7	1936.7	384.3	36.9	4.5	0.5	1.3	0.0	0.0	3085.0
1997	0.0	85.4	495.2	455.5	852.4	71.4	5.0	2.6	0.3	0.7	0.1	1968.6
1998	0.0	107.5	482.4	594.8	158.7	191.4	26.2	3.9	0.4	1.1	0.4	1566.7
1999	1.2	22.1	647.2	568.0	272.6	58.0	79.2	7.9	0.0	4.4	0.0	1660.7
2000	0.0	201.1	534.0	828.3	190.3	98.9	16.1	7.1	0.0	0.0	0.0	1875.8
2001	0.0	147.2	1183.5	685.5	378.0	109.1	59.8	8.9	13.3	1.2	0.5	2587.1
2002	0.0	3.0	259.5	884.3	346.0	203.5	81.0	35.5	9.5	9.4	0.6	1832.4
2003	0.0	16.4	118.6	442.9	766.1	231.4	103.3	39.9	21.7	9.9	7.4	1757.5
2004	0.0	0.9	357.8	249.9	409.6	266.0	74.6	36.9	19.3	11.3	3.5	1429.8
2005	0.0	7.5	134.1	813.8	95.2	265.3	120.9	32.5	19.2	8.1	8.3	1504.9
2006	0.0	1.6	177.4	281.3	449.3	32.5	97.2	48.0	18.2	10.8	8.8	1124.9
2007	0.0	7.9	154.8	907.5	140.4	253.8	8.5	23.3	12.6	6.7	7.5	1523.3

Table F12. Total catch in weight (mt) at age for Gulf of Maine cod.

Total Catch in Weight (Tons) at Age

Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1982	46.0	2201.2	3918.4	3836.2	3524.6	507.1	853.8	640.4	531.0	41.0	613.0	16712.7
1983	5.1	1406.6	4697.6	2901.4	2578.0	2726.9	288.7	679.9	250.6	151.8	350.8	16037.4
1984	12.5	817.8	2551.7	4415.8	1720.6	1206.0	633.0	188.0	193.3	162.9	275.9	12187.3
1985	20.6	1058.9	3503.3	3155.7	2927.2	722.6	616.9	363.7	51.0	141.0	152.0	12712.9
1986	5.1	208.7	4952.0	2682.8	1261.2	1203.5	371.5	327.1	482.7	109.0	1164.8	12768.4
1987	19.8	846.6	2042.5	4714.2	1666.2	654.9	796.9	139.7	180.0	134.7	40.0	11235.5
1988	0.8	529.1	3697.5	2656.3	2185.6	318.3	99.9	197.6	11.0	36.0	14.0	9746.0
1989	2.6	622.7	3928.2	5034.1	1875.8	399.7	371.9	70.7	43.0	87.0	163.0	12668.7
1990	0.0	274.4	6954.4	5648.2	2191.4	1307.9	290.0	354.0	153.0	214.0	350.0	17737.3
1991	0.0	518.2	2067.6	11946.7	3727.6	1178.3	453.8	369.0	111.3	33.0	17.0	20422.5
1992	0.0	525.8	1144.9	1458.3	6741.3	1093.5	619.8	89.0	161.0	49.0	0.0	11883.6
1993	0.0	152.0	3700.4	1877.6	588.9	2889.5	292.3	79.0	27.0	0.0	0.0	9606.6
1994	0.1	74.7	2690.0	3603.4	1107.2	446.1	615.4	307.9	69.6	10.7	25.8	8950.9
1995	5.0	392.0	2102.4	3172.9	1174.5	159.5	150.0	211.5	15.5	31.2	5.0	7419.3
1996	0.0	138.9	1351.8	4474.6	1339.8	271.3	46.4	7.4	19.8	0.0	0.0	7650.1
1997	0.0	151.5	1097.5	1387.3	2662.5	342.1	42.4	29.7	4.3	11.7	2.1	5731.3
1998	0.0	147.6	999.7	1692.7	656.2	808.3	135.8	43.7	6.9	16.4	7.4	4514.7
1999	0.4	29.6	1187.7	1457.0	1047.8	335.1	570.6	78.0	0.0	58.6	0.0	4769.2
2000	0.0	325.4	1219.7	2835.7	843.7	564.7	96.7	60.1	0.0	0.0	0.0	5939.0
2001	0.0	260.3	2825.3	2189.5	1788.6	687.0	434.5	74.5	115.3	15.0	11.7	8400.2
2002	0.0	4.1	637.8	2891.3	1392.9	1198.0	542.8	408.5	96.7	100.3	8.9	7285.6
2003	0.0	31.7	285.7	1354.5	3062.8	1223.8	776.7	349.1	235.5	121.3	97.4	7537.3
2004	0.0	1.3	837.4	805.6	1493.6	1398.9	514.1	347.1	227.5	146.6	46.0	5817.0
2005	0.0	11.8	276.1	2305.7	410.0	1196.1	754.4	255.0	199.9	108.7	118.9	5635.9
2006	0.0	3.6	430.1	917.2	1685.5	157.2	535.7	365.6	175.4	131.0	137.1	4536.1
2007	0.0	16.1	391.1	2924.0	551.3	1217.0	54.4	165.1	127.4	78.5	108.1	5627.8

Table F13. Total catch mean weights (kg) at age for Gulf of Maine cod.

	Total Catch Mean Weight (kg) at Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Average
1982	0.644	1.111	1.619	2.698	4.718	6.577	8.740	9.763	12.951	10.250	18.576	2.401
1983	0.446	1.062	1.610	2.440	3.751	6.025	5.775	10.391	9.951	12.855	18.125	2.375
1984	0.506	1.020	1.613	2.698	3.660	5.808	8.070	9.741	12.845	13.987	14.962	2.505
1985	0.466	0.995	1.601	2.775	4.385	5.424	7.859	11.312	12.750	12.818	13.818	2.367
1986	0.399	1.122	1.796	2.886	4.554	6.020	8.120	10.845	13.572	13.640	19.578	2.812
1987	0.206	0.952	1.546	3.131	4.811	7.161	9.521	10.053	13.195	13.132	13.333	2.568
1988	0.318	0.964	1.738	2.378	5.097	6.450	8.919	11.022	11.000	18.000	14.000	2.262
1989	0.680	1.199	1.722	2.934	3.844	4.309	9.018	11.034	14.333	17.400	23.286	2.454
1990	0.416	1.082	1.686	2.300	4.187	7.407	10.741	11.800	15.300	14.267	20.588	2.323
1991	0.416	1.182	1.542	2.433	4.006	7.421	9.689	12.300	14.003	25.672	17.000	2.596
1992	0.416	1.554	1.950	2.741	3.080	4.991	9.489	12.027	13.417	16.333	17.576	3.007
1993	0.416	1.189	1.821	2.398	4.225	6.099	10.022	13.167	13.500	14.785	17.576	2.674
1994	0.132	1.383	1.808	2.962	3.347	6.280	7.185	10.448	10.331	18.542	20.637	2.725
1995	0.274	1.415	1.797	2.662	5.051	5.578	10.760	11.492	18.893	20.064	20.347	2.512
1996	0.588	1.543	2.143	2.310	3.486	7.353	10.426	13.912	14.724	14.785	17.576	2.480
1997	0.416	1.774	2.216	3.046	3.124	4.791	8.405	11.547	14.726	15.814	21.874	2.911
1998	0.417	1.373	2.072	2.846	4.135	4.224	5.177	11.313	18.893	14.953	20.347	2.882
1999	0.334	1.341	1.835	2.565	3.843	5.773	7.201	9.915	12.870	13.402	17.576	2.872
2000	0.416	1.619	2.284	3.423	4.432	5.707	6.013	8.521	12.870	14.785	17.576	3.166
2001	0.416	1.768	2.387	3.194	4.732	6.296	7.266	8.351	8.643	12.414	24.418	3.247
2002	0.416	1.357	2.458	3.269	4.026	5.886	6.702	11.514	10.174	10.662	14.333	3.976
2003	0.416	1.929	2.409	3.058	3.998	5.289	7.522	8.760	10.834	12.269	13.074	4.289
2004	0.416	1.474	2.340	3.224	3.647	5.259	6.889	9.396	11.775	12.944	13.260	4.068
2005	0.416	1.574	2.058	2.833	4.307	4.509	6.239	7.835	10.440	13.428	14.382	3.745
2006	0.416	2.303	2.425	3.261	3.751	4.845	5.514	7.610	9.654	12.162	15.664	4.033
2007	0.416	2.027	2.526	3.222	3.927	4.794	6.362	7.075	10.106	11.721	14.314	3.695

Table F14. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (NEFSC strata 01260-01300 and 01360-01400), 1963 - 2008 [a,b,c].

	Spring		Autumn	
Year	no/tow (kg)	wt/tow (kg)	no/tow	wt/tow
1963	No Survey Conducted		5.914	17.95
1964	No Survey Conducted		4.015	22.799
1965	No Survey Conducted		4.5	12.005
1966	No Survey Conducted		3.784	12.916
1967	No Survey Conducted		2.56	9.225
1968	5.583	18.195	4.374	19.437
1969	3.247	13.194	2.758	15.368
1970	2.191	11.077	4.905	16.442
1971	1.429	6.996	4.361	16.527
1972	2.057	8.029	9.301	12.988
1973	7.525	18.807	4.452	8.758
1974	2.902	7.418	4.328	8.959
1975	2.512	6.039	6.143	8.619
1976	2.782	7.556	2.148	6.74
1977	3.872	8.541	3.073	10.199
1978	2.05	7.697	5.773	12.899
1979	3.993	8.363	3.142	13.927
1980	2.154	6.232	7.034	14.202
1981	4.831	10.65	2.349	7.533
1982	3.763	8.616	7.768	15.919
1983	3.912	10.962	2.786	8.416
1984	3.667	6.143	2.449	8.735
1985	2.517	7.645	2.821	8.264
1986	1.957	3.476	1.95	4.715
1987	1.083	1.976	2.996	3.394
1988	3.127	3.603	5.903	6.616
1989	2.112	2.424	4.553	4.535
1990	2.362	3.076	2.986	4.912
1991	2.393	2.891	1.252	2.781
1992	2.435	8.626	1.433	2.448
1993	2.507	5.875	1.232	1.002
1994	1.271	2.427	2.13	2.737
1995	1.93	2.431	2.008	3.665
1996	2.465	5.427	1.327	2.351
1997	2.192	5.615	0.872	1.872
1998	1.71	4.18	0.843	1.5
1999	2.301	5.089	1.807	3.505
2000	3.083	3.211	2.604	4.652
2001	2.147	6.216	1.98	7.325
2002	3.724	10.933	5.328	24.659
2003	3.677	9.495	2.529	5.993
2004	0.981	2.414	3.53	4.90
2005	1.765	2.703	1.338	2.87
2006	1.363	2.70	3.594	4.23
2007	12.393	15.81	1.992	2.71
2008	6.811	9.39		

[a] **Indices in all years have been recalculated and may differ slightly from those reported previously (e.g., Mayo *et al.* 2002) due to a better accounting of vessel effects in years when Albatross IV and Delaware II were used to conduct a portion of the same survey (e.g. 1979 and 1987).**

[b] **Spring surveys during 1973-1981 were conducted with a '41 Yankee' trawl; in all other years, spring surveys were conducted with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these differences.**

[c] **During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in the standardization (NEFSC 1991).**

[d] **In the Gulf of Maine, spring and autumn surveys were conducted primarily by R/V ALBATROSS IV. During several periods since 1979, however, surveys were conducted either entirely or in part by R/V DELAWARE II. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBATROSS IV equivalents. Conversion coefficients of 0.79 (number) and 0.67 (weight) were used in the standardization (NEFSC 1991).**

Table F15. Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore spring research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1968-2008. [a,b]

Year [c,d,e]	Age Group															Totals				Standardized Mean Wt/tow (Kg)
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	0+	4+	5+	6+	
1968	0.128	0.613	1.234	1.407	0.846	0.538	0.207	0.129	0.111	0.059	0.165	-	-	-	-	5.438	2.056	1.211	0.673	18.20
1969	0.000	0.000	0.036	0.307	0.880	0.807	0.633	0.256	0.144	0.089	0.101	-	-	-	-	3.253	2.909	2.030	1.223	13.19
1970	0.000	0.159	0.124	0.053	0.091	0.271	0.465	0.611	0.094	0.059	0.098	0.100	0.042	0.012	0.012	2.191	1.855	1.764	1.494	11.08
1971	0.000	0.026	0.151	0.105	0.286	0.048	0.084	0.300	0.206	0.154	0.058	0.013	0.000	0.000	0.000	1.429	1.148	0.862	0.814	7.00
1972	0.000	0.371	0.135	0.521	0.195	0.181	0.044	0.124	0.093	0.229	0.056	0.056	0.034	0.000	0.017	2.057	1.030	0.835	0.653	8.03
1973	0.000	0.035	4.250	0.890	0.632	0.348	0.194	0.096	0.221	0.261	0.198	0.075	0.106	0.132	0.088	7.525	2.350	1.718	1.370	18.81
1974	0.000	0.475	0.103	1.503	0.172	0.235	0.075	0.028	0.057	0.033	0.045	0.043	0.081	0.000	0.051	2.902	0.820	0.648	0.413	7.42
1975	0.006	0.096	0.686	0.131	1.105	0.269	0.079	0.000	0.006	0.018	0.028	0.026	0.062	0.000	0.000	2.512	1.593	0.488	0.219	6.04
1976	0.000	0.051	0.265	1.104	0.137	0.902	0.090	0.095	0.027	0.000	0.011	0.000	0.074	0.027	0.000	2.782	1.362	1.225	0.323	7.56
1977	0.000	0.025	0.297	0.553	1.925	0.111	0.831	0.011	0.083	0.000	0.000	0.000	0.000	0.000	0.038	3.872	2.998	1.073	0.962	8.54
1978	0.000	0.048	0.110	0.308	0.351	0.744	0.095	0.252	0.013	0.107	0.000	0.022	0.000	0.000	0.000	2.050	1.584	1.233	0.488	7.70
1979	0.044	0.484	1.630	0.219	0.449	0.299	0.587	0.102	0.112	0.013	0.031	0.000	0.000	0.000	0.025	3.993	1.617	1.168	0.869	8.36
1980	0.070	0.037	0.423	0.492	0.138	0.238	0.304	0.317	0.000	0.122	0.014	0.000	0.000	0.000	0.000	2.155	1.133	0.994	0.756	6.23
1981	0.000	1.075	0.644	0.841	1.342	0.331	0.264	0.116	0.121	0.100	0.000	0.000	0.000	0.000	0.000	4.832	2.272	0.930	0.600	10.65
1982	0.014	0.359	1.007	0.476	0.655	0.988	0.087	0.112	0.000	0.026	0.039	0.000	0.000	0.000	0.000	3.763	1.907	1.251	0.264	8.62
1983	0.013	0.632	0.949	0.997	0.465	0.404	0.212	0.068	0.016	0.071	0.018	0.008	0.030	0.000	0.030	3.912	1.322	0.857	0.453	10.96
1984	0.000	0.151	1.312	1.023	0.823	0.212	0.047	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.667	1.182	0.359	0.147	6.14
1985	0.000	0.029	0.231	0.662	0.663	0.662	0.103	0.091	0.052	0.000	0.026	0.000	0.000	0.000	0.000	2.517	1.596	0.933	0.272	7.65
1986	0.000	0.537	0.248	0.754	0.237	0.091	0.035	0.038	0.000	0.000	0.000	0.000	0.018	0.000	0.000	1.957	0.419	0.182	0.090	3.48
1987	0.000	0.030	0.460	0.199	0.231	0.074	0.000	0.066	0.008	0.000	0.000	0.000	0.000	0.000	0.015	1.083	0.394	0.163	0.088	1.98
1988	0.029	0.717	0.923	0.823	0.218	0.254	0.092	0.065	0.000	0.007	0.000	0.000	0.000	0.000	0.000	3.127	0.635	0.417	0.163	3.60
1989	0.000	0.017	0.605	0.723	0.600	0.091	0.063	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.112	0.768	0.168	0.077	2.42
1990	0.000	0.000	0.208	1.365	0.637	0.102	0.032	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.362	0.789	0.152	0.050	3.08
1991	0.000	0.038	0.068	0.234	1.717	0.299	0.020	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.393	2.054	0.337	0.038	2.89
1992	0.000	0.050	0.226	0.242	0.282	1.328	0.226	0.069	0.000	0.012	0.000	0.000	0.000	0.000	0.000	2.435	1.917	1.635	0.307	8.63
1993	0.000	0.201	0.497	0.799	0.334	0.091	0.484	0.055	0.023	0.000	0.000	0.023	0.000	0.000	0.000	2.507	1.010	0.676	0.585	5.88
1994	0.000	0.015	0.316	0.388	0.215	0.094	0.049	0.127	0.027	0.022	0.018	0.000	0.000	0.000	0.000	1.271	0.553	0.338	0.244	2.43
1995	0.000	0.050	0.179	1.116	0.372	0.145	0.028	0.000	0.011	0.000	0.000	0.000	0.000	0.028	0.000	1.930	0.585	0.213	0.068	2.43
1996	0.000	0.057	0.022	0.593	1.331	0.403	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.465	1.793	0.463	0.059	5.43
1997	0.000	0.159	0.132	0.399	0.264	0.876	0.242	0.120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.192	1.502	1.238	0.362	5.62
1998	0.000	0.018	0.224	0.330	0.517	0.142	0.421	0.023	0.037	0.000	0.000	0.000	0.000	0.000	0.000	1.710	1.139	0.622	0.481	4.18
1999	0.000	0.166	0.344	0.713	0.345	0.315	0.134	0.273	0.000	0.000	0.000	0.000	0.000	0.011	0.000	2.301	1.078	0.733	0.418	5.09
2000	0.026	1.184	0.725	0.439	0.457	0.107	0.101	0.024	0.022	0.000	0.000	0.000	0.000	0.000	0.000	3.083	0.710	0.253	0.146	3.21
2001	0.000	0.029	0.323	0.716	0.497	0.354	0.064	0.098	0.055	0.000	0.011	0.000	0.000	0.000	0.000	2.146	1.078	0.581	0.227	6.22
2002	0.000	0.340	0.045	0.524	1.601	0.614	0.362	0.164	0.057	0.016	0.000	0.000	0.000	0.000	0.000	3.724	2.814	1.213	0.598	10.93
2003	0.000	0.069	0.831	0.063	0.708	1.089	0.395	0.321	0.103	0.073	0.027	0.000	0.000	0.000	0.000	3.677	2.715	2.007	0.918	9.50
2004	0.000	0.136	0.045	0.221	0.118	0.191	0.232	0.014	0.014	0.010	0.000	0.000	0.000	0.000	0.000	0.981	0.579	0.461	0.270	2.41
2005	0.000	0.020	0.726	0.101	0.608	0.015	0.145	0.130	0.014	0.000	0.000	0.000	0.000	0.000	0.000	1.765	0.917	0.309	0.294	2.70
2006	0.028	0.186	0.227	0.434	0.060	0.189	0.021	0.131	0.073	0.000	0.013	0.000	0.000	0.000	0.000	1.363	0.487	0.428	0.238	2.70
2007	0.000	0.092	3.480	2.890	4.346	0.538	0.944	0.065	0.038	0.000	0.000	0.000	0.000	0.000	0.000	12.393	5.931	1.585	1.047	15.81
2007	0.000	0.066	1.099	3.211	1.357	0.939	0.058	0.081	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.811	2.435	1.078	0.139	9.39

[a] Indices from 1970-2001 have been recalculated and may differ slightly from those reported previously (Mayo *et al.* 2002) due to slight modifications to the age-length keys and a better accounting of vessel effects in 1979 and 1987.
[b] Spring catch per tow at age indices for 1968-1969 were obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey. Calculations were carried out only to age 10+.
[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these differences.
[d] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NESFC 1991).
[e] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991, 1994 and 2003, were conducted aboard R/V DELAWARE II; in all other years, the surveys were conducted aboard R/V ALBATROSS IV except in 1979 and 1987 when both vessels were deployed on portions of the survey. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBATROSS IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Table F16. Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1963-2007. [a,b]

Year	Age Group															Totals				Standardized Mean Wt/tow
[c,d]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	0+	3+	4+	5+	(Kg)
1963	0.050	0.649	1.349	1.253	0.849	0.579	0.537	0.300	0.183	0.095	0.075	B	-	-	-	5.917	3.869	2.616	1.767	17.95
1964	0.000	0.092	0.122	0.417	0.856	0.853	0.783	0.373	0.237	0.114	0.101	-	-	-	-	4.003	3.789	3.318	2.462	22.80
1965	0.002	0.850	0.880	0.824	0.750	0.496	0.374	0.170	0.080	0.044	0.025	-	-	-	-	4.494	2.763	1.939	1.189	12.01
1966	0.170	0.204	0.640	0.697	0.718	0.558	0.441	0.192	0.078	0.048	0.036	-	-	-	-	3.783	2.769	2.072	1.354	12.92
1967	0.012	0.129	0.215	0.574	0.671	0.384	0.268	0.162	0.070	0.041	0.034	-	-	-	-	2.562	2.204	1.630	0.959	9.23
1968	0.012	0.036	0.179	0.719	1.256	0.973	0.627	0.261	0.156	0.072	0.095	-	-	-	-	4.387	4.159	3.440	2.184	19.44
1969	0.016	0.059	0.123	0.354	0.630	0.552	0.466	0.220	0.145	0.129	0.062	-	-	-	-	2.758	2.560	2.206	1.576	15.37
1970	0.802	0.883	0.260	0.538	0.329	0.486	0.425	0.811	0.132	0.094	0.036	0.037	0.073	0.000	0.000	4.905	2.960	2.422	2.093	16.44
1971	1.319	0.179	0.276	0.219	0.578	0.478	0.455	0.236	0.298	0.163	0.066	0.034	0.061	0.000	0.000	4.361	2.588	2.368	1.790	16.53
1972	0.031	5.578	1.215	1.528	0.233	0.090	0.140	0.070	0.138	0.262	0.000	0.000	0.000	0.000	0.016	9.301	2.477	0.949	0.716	12.99
1973	0.638	0.329	2.170	0.139	0.507	0.213	0.077	0.027	0.051	0.183	0.102	0.000	0.000	0.016	0.000	4.452	1.315	1.176	0.669	8.76
1974	0.283	1.134	0.266	1.876	0.167	0.274	0.051	0.046	0.036	0.033	0.033	0.098	0.000	0.000	0.033	4.328	2.646	0.770	0.603	8.96
1975	0.047	0.177	3.045	0.138	2.333	0.259	0.109	0.017	0.006	0.000	0.000	0.006	0.006	0.000	0.000	6.143	2.874	2.736	0.403	8.62
1976	0.000	0.230	0.221	0.633	0.077	0.773	0.052	0.132	0.000	0.000	0.031	0.000	0.000	0.000	0.000	2.148	1.697	1.064	0.988	6.74
1977	0.000	0.042	0.416	0.465	1.157	0.114	0.629	0.044	0.090	0.022	0.032	0.000	0.044	0.019	0.000	3.073	2.615	2.150	0.994	10.20
1978	0.248	1.373	0.378	1.135	0.658	1.426	0.109	0.310	0.005	0.083	0.007	0.013	0.000	0.028	0.000	5.773	3.773	2.638	1.980	12.90
1979	0.002	0.381	0.588	0.145	0.708	0.337	0.688	0.044	0.181	0.000	0.053	0.000	0.000	0.000	0.018	3.142	2.172	2.027	1.319	13.93
1980	0.027	1.321	2.520	1.780	0.492	0.194	0.360	0.207	0.036	0.025	0.000	0.036	0.000	0.014	0.022	7.034	3.165	1.385	0.894	14.20
1981	0.010	0.618	0.419	0.539	0.405	0.121	0.076	0.029	0.090	0.000	0.043	0.000	0.000	0.000	0.000	2.349	1.302	0.763	0.358	7.53
1982	0.000	0.843	3.353	2.275	1.089	0.209	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.769	3.573	1.298	0.209	15.92
1983	0.000	0.317	0.916	0.828	0.197	0.227	0.210	0.000	0.000	0.000	0.027	0.028	0.037	0.000	0.000	2.786	1.553	0.726	0.529	8.42
1984	0.022	0.432	0.426	0.631	0.387	0.214	0.163	0.079	0.000	0.030	0.000	0.000	0.030	0.035	0.000	2.449	1.569	0.938	0.551	8.74
1985	0.121	0.526	0.957	0.609	0.248	0.182	0.075	0.000	0.034	0.021	0.010	0.000	0.010	0.000	0.029	2.821	1.218	0.609	0.361	8.26
1986	0.000	0.392	0.401	0.657	0.342	0.073	0.041	0.000	0.011	0.034	0.000	0.000	0.000	0.000	0.000	1.950	1.157	0.501	0.159	4.72
1987	0.128	0.578	1.380	0.592	0.243	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.996	0.910	0.318	0.075	3.39
1988	0.000	1.938	2.313	0.990	0.443	0.099	0.065	0.033	0.011	0.011	0.000	0.000	0.000	0.000	0.000	5.903	1.652	0.662	0.219	6.62
1989	0.000	0.150	2.407	1.502	0.293	0.161	0.033	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	4.553	1.997	0.495	0.202	4.54
1990	0.006	0.045	0.187	1.829	0.598	0.259	0.052	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.986	2.748	0.919	0.321	4.91
1991	0.009	0.144	0.139	0.223	0.633	0.081	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.252	0.960	0.737	0.104	2.78
1992	0.059	0.291	0.446	0.140	0.036	0.350	0.104	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.433	0.638	0.498	0.462	2.45
1993	0.043	0.198	0.568	0.360	0.034	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.232	0.424	0.064	0.030	1.00
1994	0.032	0.207	0.883	0.826	0.085	0.051	0.000	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.130	1.008	0.182	0.096	2.74
1995	0.008	0.068	0.285	1.228	0.325	0.082	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.008	1.647	0.419	0.093	3.67
1996	0.029	0.124	0.383	0.188	0.542	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.327	0.792	0.604	0.062	2.35
1997	0.000	0.297	0.086	0.177	0.173	0.140	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.872	0.490	0.313	0.140	1.87
1998	0.050	0.097	0.320	0.115	0.192	0.039	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.843	0.376	0.262	0.069	1.50
1999	0.025	0.431	0.367	0.586	0.243	0.132	0.016	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.807	0.984	0.398	0.155	3.51
2000	0.008	0.533	0.984	0.394	0.507	0.134	0.010	0.000	0.011	0.023	0.000	0.000	0.000	0.000	0.000	2.604	1.079	0.686	0.178	4.65
2001	0.018	0.034	0.141	0.752	0.469	0.337	0.122	0.084	0.000	0.023	0.000	0.000	0.000	0.000	0.000	1.980	1.788	1.035	0.566	7.33
2002	0.000	0.269	0.081	0.364	2.797	1.096	0.627	0.051	0.043	0.000	0.000	0.000	0.000	0.000	0.000	5.328	4.979	4.615	1.818	24.66
2003	0.542	0.455	0.198	0.185	0.529	0.450	0.073	0.077	0.000	0.011	0.000	0.011	0.000	0.000	0.000	2.529	1.335	1.150	0.622	5.99
2004	1.380	0.651	0.168	0.581	0.231	0.253	0.168	0.068	0.011	0.010	0.011	0.000	0.000	0.000	0.000	3.533	1.334	0.753	0.522	4.90
2005	0.034	0.153	0.381	0.080	0.450	0.022	0.092	0.082	0.023	0.021	0.000	0.000	0.000	0.000	0.000	1.338	0.690	0.241	0.219	2.87
2006	0.064	1.251	0.580	1.033	0.248	0.286	0.034	0.050	0.030	0.006	0.014	0.000	0.000	0.000	0.000	3.594	0.666	0.418	0.133	4.23
2007	0.011	0.146	0.831	0.384	0.528	0.023	0.069	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.992	0.620	0.092	0.069	2.71

[a] Indices from 1970-2001 have been recalculated and may differ slightly from those reported previously (Mayo *et al.* 2002) due to slight modifications to the age-length keys and a better accounting of vessel effects in 1979.

[b] Autumn catch per tow at age indices for 1963-1969 were obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey. Calculations were carried out only to age 10+.

[c] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFSC 1991).

[d] In the Gulf of Maine, autumn surveys during 1977-1978, 1980, 1989-1991 and 1993 were conducted aboard R/V DELAWARE II; in all other years, the surveys were conducted aboard R/V ALBATROSS IV except in 1979 when both vessels were deployed on portions of the survey. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBATROSS IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Table F17. Stratified mean number per tow and weight per tow (kg) of Atlantic cod in MADMF inshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Mass regions 4 and 5), 1978-2007

	Spring		Autumn	
Year	Mean No per Tow	Mean Wt per Tow	Mean No per Tow	Mean Wt per Tow
1978	47.89	11.05	156.06	1.51
1979	96.56	14.28	8.92	1.05
1980	65.98	14.51	12.53	1.28
1981	69.41	18.69	9.29	3.64
1982	25.84	12.16	6.12	0.66
1983	54.85	18.75	1.68	0.09
1984	10.33	7.24	10.55	0.13
1985	8.46	4.77	2.87	0.07
1986	24.09	7.84	2.75	0.25
1987	17.21	7.87	313.15	0.35
1988	22.24	7.70	8.87	0.37
1989	52.24	16.82	4.15	0.22
1990	32.41	15.88	12.71	0.76
1991	13.70	8.73	7.48	0.48
1992	16.92	8.77	27.50	0.27
1993	92.66	5.86	51.50	1.35
1994	15.96	3.89	49.00	2.00
1995	23.36	3.99	4.66	0.81
1996	12.96	3.15	7.01	0.08
1997	17.89	2.50	1.46	0.01
1998	27.57	3.25	4.33	0.36
1999	161.06	9.00	8.01	0.31
2000	50.77	20.60	0.68	0.27
2001	41.84	26.45	49.55	0.76
2002	24.34	11.16	3.30	3.99
2003	1120.37	10.98	122.28	1.85
2004	131.59	8.15	57.62	5.58
2005	193.26	10.40	40.35	0.21
2006	1077.03	9.18	7.50	1.94
2007	61.58	8.43	7.92	2.94

Table F18. Stratified mean number per tow at age of Atlantic cod in MADMF inshore spring research vessel bottom trawl surveys in the Gulf of Maine (Mass regions 4 and 5), 1978-2007

	Age Group																Totals			
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	0+	1+	2+	3+
1978	31.43	6.33	2.59	3.61	2.00	1.76	0.07	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.89	47.87	16.44	10.11	7.52
1979	69.49	19.62	2.07	0.56	2.41	1.02	1.27	0.02	0.11	0.00	0.00	0.00	0.00	0.00	0.00	96.56	96.57	27.08	7.46	5.39
1980	9.03	42.81	10.45	1.80	0.22	0.89	0.40	0.35	0.00	0.04	0.00	0.00	0.00	0.00	0.00	65.98	65.99	56.96	14.15	3.70
1981	26.48	23.01	12.52	6.15	0.96	0.15	0.02	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	69.41	69.41	42.93	19.92	7.40
1982	1.71	13.29	7.17	2.41	0.87	0.22	0.08	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	25.84	25.84	24.13	10.84	3.67
1983	0.77	34.75	14.61	2.86	1.50	0.25	0.03	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	54.85	54.84	54.07	19.32	4.71
1984	0.26	1.96	5.15	2.07	0.70	0.05	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.33	10.32	10.06	8.10	2.95
1985	1.09	1.79	2.77	2.27	0.45	0.05	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.46	8.45	7.36	5.57	2.80
1986	1.14	9.26	11.68	1.23	0.68	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.09	24.09	22.95	13.69	2.01
1987	0.78	8.29	4.71	2.96	0.22	0.09	0.06	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	17.21	17.21	16.43	8.14	3.43
1988	1.88	10.05	6.35	2.45	1.45	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.24	22.25	20.37	10.32	3.97
1989	0.18	21.59	20.51	8.76	1.06	0.10	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.24	52.24	52.06	30.47	9.96
1990	4.92	4.63	5.45	14.75	2.31	0.31	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.41	32.41	27.49	22.86	17.41
1991	0.35	5.01	2.69	1.57	3.66	0.40	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.70	13.69	13.34	8.33	5.64
1992	1.51	4.50	5.13	3.67	0.75	1.26	0.09	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.92	16.93	15.42	10.92	5.79
1993	79.84	2.99	6.11	2.55	0.90	0.09	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	92.66	92.65	12.81	9.82	3.71
1994	4.63	4.79	4.07	1.75	0.49	0.16	0.01	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	15.96	15.94	11.31	6.52	2.45
1995	12.03	5.83	1.92	2.76	0.78	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.36	23.37	11.34	5.51	3.59
1996	8.94	0.64	0.52	1.08	1.49	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.96	12.97	4.03	3.39	2.87
1997	12.47	2.88	0.98	0.93	0.17	0.42	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.89	17.90	5.43	2.55	1.57
1998	23.48	1.49	0.83	0.70	0.75	0.06	0.24	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.57	27.56	4.08	2.59	1.76
1999	143.00	11.68	2.39	2.31	0.78	0.64	0.07	0.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	161.06	161.06	18.06	6.38	3.99
2000	2.15	35.14	7.02	2.89	2.20	0.71	0.49	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	50.77	50.77	48.62	13.48	6.46
2001	25.99	0.08	4.50	4.97	3.52	2.07	0.42	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	41.84	41.84	15.85	15.77	11.27
2002	0.92	19.29	0.26	1.23	1.41	0.56	0.30	0.16	0.13	0.03	0.03	0.00	0.01	0.00	0.00	24.34	24.33	23.41	4.12	3.86
2003	1097.97	6.20	12.70	0.28	1.43	1.33	0.29	0.13	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1120.37	1120.37	22.40	16.20	3.50
2004	116.15	9.21	1.56	2.58	0.46	0.90	0.64	0.04	0.04	0.01	0.00	0.00	0.00	0.00	0.00	131.59	131.59	15.44	6.23	4.67
2005	180.85	1.06	7.15	0.57	2.07	0.18	0.95	0.35	0.08	0.00	0.00	0.00	0.00	0.00	0.00	193.26	193.26	12.41	11.35	4.20
2006	1053.70	14.89	3.67	3.38	0.54	0.69	0.01	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.00	1077.03	1077.01	23.31	8.42	4.75
2007	49.35	4.37	3.36	1.84	1.75	0.32	0.54	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	61.58	61.58	12.23	7.86	4.50

Table F19. Stratified mean number per tow at age of Atlantic cod in MADMF inshore autumn research vessel bottom trawl surveys in the Gulf of Maine (Mass regions 4 and 5), 1978-2007

	Age Group																Totals			
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total	0+	1+	2+	3+
1978	151.81	3.95	0.02	0.07	0.01	0.09	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	156.06	156.06	4.25	0.30	0.28
1979	5.72	2.93	0.20	0.00	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.92	8.92	3.20	0.27	0.07
1980	6.00	5.46	1.06	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.53	12.54	6.54	1.08	0.02
1981	1.45	6.20	1.25	0.36	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.29	9.28	7.83	1.63	0.38
1982	4.59	1.14	0.31	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.12	6.12	1.53	0.39	0.08
1983	1.27	0.28	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68	1.68	0.41	0.13	0.03
1984	10.30	0.16	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.55	10.54	0.24	0.08	0.01
1985	2.65	0.19	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.87	2.87	0.22	0.03	0.01
1986	1.80	0.55	0.37	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.75	2.75	0.95	0.40	0.03
1987	311.72	1.40	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.15	313.14	1.42	0.02	0.00
1988	5.53	3.10	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.87	8.87	3.34	0.24	0.00
1989	3.94	0.02	0.10	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.15	4.15	0.21	0.19	0.09
1990	7.81	4.22	0.31	0.32	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.71	12.71	4.90	0.68	0.37
1991	5.04	2.00	0.36	0.02	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.48	7.49	2.45	0.45	0.09
1992	26.42	0.99	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.50	27.49	1.07	0.08	0.04
1993	49.43	1.53	0.36	0.17	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51.50	51.51	2.08	0.55	0.19
1994	40.01	5.36	3.45	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	49.00	49.01	9.00	3.64	0.19
1995	2.93	0.80	0.41	0.49	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.66	4.65	1.72	0.92	0.51
1996	6.90	0.08	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.01	7.01	0.11	0.03	0.02
1997	1.43	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.46	1.46	0.03	0.00	0.00
1998	3.27	0.64	0.32	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.33	4.32	1.05	0.41	0.09
1999	7.33	0.59	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.01	8.00	0.67	0.08	0.01
2000	0.05	0.40	0.17	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.68	0.63	0.23	0.06
2001	49.19	0.01	0.13	0.13	0.04	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	49.55	49.56	0.37	0.36	0.23
2002	0.96	1.09	0.13	0.25	0.36	0.44	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.30	3.29	2.33	1.24	1.11
2003	120.17	1.60	0.14	0.05	0.20	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	122.28	122.28	2.11	0.51	0.37
2004	44.67	9.94	0.92	1.19	0.19	0.45	0.25	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.62	57.62	12.95	3.01	2.09
2005	39.47	0.61	0.24	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.35	40.35	0.88	0.27	0.03
2006	2.08	4.35	0.42	0.48	0.06	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	7.50	5.42	1.07	0.65
2007	7.61	0.16	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.92	7.91	0.30	0.14	0.01

Table F20a. VPA estimates of population size for Gulf of Maine cod.

JAN-1 Population Numbers

AGE	1982	1983	1984	1985	1986
1	7857.	7929.	10674.	6679.	10260.
2	11123.	6368.	6481.	8717.	5428.
3	5520.	7314.	4015.	4581.	6174.
4	3128.	2329.	3348.	1856.	1771.
5	1767.	1274.	831.	1261.	491.
6	226.	771.	421.	255.	428.
7	260.	116.	222.	157.	88.
8	140.	124.	49.	111.	58.
9	71.	55.	42.	23.	62.
10	10.	21.	22.	21.	15.
11	79.	35.	36.	21.	113.
Total	30180.	26336.	26143.	23683.	24888.

AGE	1987	1988	1989	1990	1991
1	12744.	24612.	4254.	4135.	6975.
2	8388.	10347.	20148.	3480.	3386.
3	4276.	6063.	7974.	16026.	2620.
4	2560.	2306.	3038.	4465.	9388.
5	609.	734.	877.	935.	1434.
6	151.	185.	213.	276.	292.
7	170.	41.	107.	90.	66.
8	31.	63.	24.	50.	49.
9	20.	13.	35.	14.	14.
10	18.	4.	10.	26.	2.
11	5.	2.	13.	30.	2.
Total	28973.	44369.	36694.	29528.	24228.

AGE	1992	1993	1994	1995	1996
1	6340.	9123.	3180.	3805.	3545.
2	5711.	5191.	7469.	2603.	3099.
3	2375.	4369.	4134.	6066.	1880.
4	931.	1414.	1739.	2038.	3908.
5	3243.	281.	449.	323.	590.
6	332.	675.	104.	68.	54.
7	96.	73.	124.	21.	30.
8	12.	19.	34.	24.	5.
9	13.	3.	10.	1.	3.
10	4.	0.	1.	2.	0.
11	0.	0.	2.	0.	0
Total	19057.	21148.	17245.	14951.	13113.

Table F20a (continued).

JAN-1 Population Numbers

AGE	1997	1998	1999	2000	2001
1	5245.	4458.	7847.	4016.	1187.
2	2902.	4294.	3650.	6424.	3288.
3	2455.	2299.	3419.	2969.	5077.
4	969.	1562.	1446.	2213.	1947.
5	1447.	381.	741.	670.	1063.
6	135.	414.	168.	360.	376.
7	11.	46.	166.	85.	205.
8	20.	4.	14.	64.	55.
9	3.	14.	0.	4.	46.
10	1.	2.	11.	0.	4.
11	0.	1.	0.	0.	2.
Total	13190.	13477.	17462.	16805.	13250.

AGE	2002	2003	2004	2005	2006
1	4953.	1681.	10966.	6713.	23910.
2	972.	4055.	1377.	8979.	5496.
3	2559.	793.	3305.	1126.	7344.
4	3086.	1860.	542.	2382.	801.
5	974.	1726.	1122.	218.	1214.
6	528.	484.	720.	548.	92.
7	209.	248.	187.	349.	209.
8	114.	98.	110.	86.	176.
9	37.	61.	44.	56.	41.
10	25.	22.	30.	19.	29.
11	2.	16.	9.	19.	23.
Total	13459.	11046.	18414.	20495.	39336.

AGE	2007	2008
1	4808.	6105.
2	19576.	3937.
3	4498.	16020.
4	5852.	3543.
5	401.	3970.
6	587.	201.
7	46.	251.
8	83.	30.
9	101.	47.
10	17.	71.
11	21.	19.
Total	35992.	34196.

Table F20b. VPA estimates of instantaneous fishing mortality for Gulf of Maine cod.

Fishing Mortality Calculated

AGE	1982	1983	1984	1985	1986
1	0.0101	0.0016	0.0026	0.0074	0.0014
2	0.2192	0.2612	0.1470	0.1450	0.0386
3	0.6628	0.5814	0.5714	0.7503	0.6802
4	0.6981	0.8305	0.7769	1.1299	0.8676
5	0.6295	0.9064	0.9811	0.8800	0.9766
6	0.4723	1.0461	0.7862	0.8605	0.7259
7	0.5377	0.6505	0.4954	0.8028	0.8481
8	0.7294	0.8727	0.5657	0.3866	0.8646
9	1.0140	0.7010	0.4948	0.2139	1.0200
10	0.6088	0.9342	0.8265	0.8317	0.8523
11	0.6088	0.9342	0.8265	0.8317	0.8523

AGE	1987	1988	1989	1990	1991
1	0.0084	0.0001	0.0010	0.0000	0.0000
2	0.1247	0.0604	0.0289	0.0840	0.1545
3	0.4177	0.4909	0.3799	0.3348	0.8343
4	1.0499	0.7667	0.9783	0.9361	0.8630
5	0.9906	1.0384	0.9547	0.9634	1.2635
6	1.1023	0.3485	0.6584	1.2250	0.9179
7	0.7884	0.3576	0.5545	0.4021	1.5057
8	0.6852	0.3761	0.3568	1.0760	1.1140
9	1.4099	0.0904	0.0981	1.7050	0.9720
10	0.9568	0.7939	0.8422	0.9642	1.2033
11	0.9568	0.7939	0.8422	0.9642	1.2033

AGE	1992	1993	1994	1995	1996
1	0.0000	0.0000	0.0003	0.0053	0.0000
2	0.0677	0.0276	0.0080	0.1251	0.0326
3	0.3191	0.7214	0.5072	0.2397	0.4631
4	0.9977	0.9473	1.4838	1.0395	0.7934
5	1.3696	0.7941	1.6866	1.5888	1.2721
6	1.3085	1.4954	1.4035	0.6248	1.4090
7	1.4079	0.5791	1.4467	1.3241	0.1825
8	1.1311	0.4254	3.4380	1.9107	0.1292
9	8.8324	1.1807	1.2844	6.1427	0.6870
10	1.3641	1.1501	1.6321	1.3635	1.1851
11	1.3641	1.1501	1.6321	1.3635	1.1851

Table F20b (continued).

Fishing Mortality Calculated

AGE	1997	1998	1999	2000	2001
1	0.0000	0.0000	0.0002	0.0000	0.0000
2	0.0331	0.0281	0.0067	0.0352	0.0507
3	0.2522	0.2638	0.2347	0.2216	0.2979
4	0.7331	0.5461	0.5695	0.5337	0.4927
5	1.0524	0.6167	0.5220	0.3769	0.4994
6	0.8742	0.7161	0.4791	0.3620	0.3864
7	0.7168	0.9838	0.7526	0.2337	0.3888
8	0.1523	6.4333	0.9591	0.1311	0.1957
9	0.1066	0.0314	0.2164	0.0002	0.3866
10	1.0156	0.6873	0.5515	0.3465	0.4486
11	1.0156	0.6873	0.5515	0.3465	0.4486

AGE	2002	2003	2004	2005	2006
1	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0034	0.0045	0.0007	0.0009	0.0003
3	0.1189	0.1807	0.1274	0.1411	0.0271
4	0.3808	0.3053	0.7125	0.4741	0.4914
5	0.4985	0.6741	0.5164	0.6606	0.5260
6	0.5550	0.7507	0.5245	0.7653	0.4948
7	0.5582	0.6163	0.5806	0.4825	0.7225
8	0.4224	0.5975	0.4648	0.5426	0.3577
9	0.3310	0.4983	0.6597	0.4716	0.6789
10	0.5163	0.6793	0.5218	0.6406	0.5272
11	0.5163	0.6793	0.5218	0.6406	0.5272

AGE	2007
1	0.0000
2	0.0004
3	0.0388
4	0.1880
5	0.4892
6	0.6492
7	0.2288
8	0.3714
9	0.1484
10	0.4888
11	0.4888

Table F20c. VPA estimates of spawning stock biomass for Gulf of Maine cod.

Spawning Stock Biomass

AGE	1982	1983	1984	1985	1986
1	419.	158.	37.	19.	179.
2	3063.	1268.	866.	2102.	2226.
3	4035.	5238.	3928.	4797.	6913.
4	5361.	3431.	5870.	3147.	3186.
5	6169.	3270.	2040.	3621.	1435.
6	1406.	3307.	1669.	952.	1885.
7	1840.	618.	1377.	898.	492.
8	1160.	989.	326.	959.	446.
9	755.	469.	437.	239.	622.
10	96.	226.	223.	229.	168.
11	1283.	521.	449.	247.	1854.
Total	25587.	19494.	17223.	17211.	19406.

AGE	1987	1988	1989	1990	1991
1	35.	156.	155.	296.	145.
2	1910.	1854.	4192.	1452.	582.
3	4725.	6394.	7555.	15007.	1509.
4	4929.	3725.	5469.	6324.	12582.
5	1861.	2384.	2187.	2538.	3137.
6	696.	941.	864.	1128.	1311.
7	1089.	300.	719.	549.	420.
8	241.	587.	213.	420.	456.
9	182.	128.	424.	128.	148.
10	200.	52.	111.	310.	32.
11	58.	24.	262.	506.	21.
Total	15926.	16546.	22151.	28657.	20342.

AGE	1992	1993	1994	1995	1996
1	91.	121.	1.	0.	35.
2	834.	773.	1040.	160.	640.
3	1554.	3593.	4418.	8266.	2639.
4	1223.	2196.	3020.	3637.	6680.
5	6355.	786.	928.	927.	1406.
6	1131.	2183.	410.	256.	252.
7	607.	456.	623.	133.	213.
8	104.	193.	188.	153.	53.
9	38.	32.	93.	4.	32.
10	51.	0.	9.	26.	0.
11	0.	0.	24.	5.	0.
Total	11988.	10334.	10755.	13566.	11949.

Table F20c (continued).

Spawning Stock Biomass

AGE	1997	1998	1999	2000	2001
1	12.	60.	104.	110.	24.
2	456.	1125.	897.	1771.	757.
3	3326.	3345.	3634.	3438.	5603.
4	2098.	3361.	2727.	4467.	4030.
5	3155.	1180.	2129.	1990.	3654.
6	463.	1290.	735.	1519.	1784.
7	73.	189.	779.	468.	1198.
8	210.	14.	84.	473.	367.
9	45.	203.	0.	49.	357.
10	15.	31.	159.	0.	41.
11	3.	15.	0.	0.	33.
Total	9856.	10814.	11246.	14285.	17848.

AGE	2002	2003	2004	2005	2006
1	176.	54.	295.	34.	523.
2	289.	1334.	313.	773.	1665.
3	3440.	902.	3657.	630.	8704.
4	6729.	4079.	999.	3782.	1590.
5	2953.	5179.	2993.	632.	3366.
6	2408.	1889.	2810.	1855.	371.
7	1186.	1441.	982.	1767.	893.
8	939.	658.	826.	557.	1108.
9	314.	608.	389.	500.	307.
10	217.	211.	319.	204.	288.
11	21.	185.	111.	239.	326.
Total	18673.	16539.	13693.	10974.	19139.

AGE	2007
1	70.
2	5911.
3	7924.
4	14568.
5	1267.
6	2162.
7	237.
8	471.
9	836.
10	161.
11	271.
Total	33877.

Table F21. Average Fully recruited fishing mortality (F) for Gulf of Maine cod. The unweighted values in column 1 are used to indicate annual fishing mortality on this stock.

Average Fishing Mortality For Ages 5-7

Year	Average F	N Weighted	Biomass Wtd	Catch Wtd
1982	0.5465	0.6031	0.5896	0.6066
1983	0.8677	0.9426	0.9506	0.9488
1984	0.7543	0.8523	0.7919	0.8772
1985	0.8478	0.8698	0.8641	0.8702
1986	0.8502	0.8588	0.8383	0.8695
1987	0.9605	0.9719	0.9537	0.9778
1988	0.5815	0.8761	0.8204	0.9533
1989	0.7225	0.8662	0.8154	0.8839
1990	0.8635	0.9800	0.9711	1.0061
1991	1.2290	1.2161	1.1983	1.2252
1992	1.3620	1.3651	1.3643	1.3652
1993	0.9562	1.2385	1.2349	1.3016
1994	1.5123	1.5992	1.5540	1.6032
1995	1.1792	1.4161	1.3970	1.4752
1996	0.9545	1.2348	1.1860	1.2724
1997	0.8811	1.0350	1.0243	1.0369
1998	0.7722	0.6858	0.6925	0.6928
1999	0.5846	0.5508	0.5638	0.5605
2000	0.3242	0.3611	0.3550	0.3645
2001	0.4249	0.4598	0.4506	0.4648
2002	0.5373	0.5233	0.5298	0.5244
2003	0.6804	0.6834	0.6816	0.6848
2004	0.5405	0.5252	0.5285	0.5256
2005	0.6362	0.6564	0.6361	0.6736
2006	0.5811	0.5512	0.5613	0.5572
2007	0.4557	0.5685	0.5686	0.5845

Table F22. VPA model Diagnostics and Stock size estimates from the NLLS Solution for Gulf of Maine cod.

```
Levenburg-Marquardt Algorithm Completed    21 Iterations
 Residual Sum of Squares =    279.707
 Number of Residuals     =    508
 Number of Parameters    =      9
 Degrees of Freedom      =    499
 Mean Squared Residual   =     0.560535
 Standard Deviation      =     0.748689
 Number of Years =    26
 Number of Ages  =    11
 First Year      =  1982
 Youngest Age    =     1
 Oldest True Age =    10
 Number of Survey Indices Available        =    25
 Number of Survey Indices Used in Estimate =    23
 VPA Classic Method - Auto Estimated Q's

 Stock Numbers Predicted in Terminal Year Plus One (2008)
 Age    Stock Predicted     Std. Error      CV

   2          3936.752   0.173583E+04   0.440929E+00
   3         16020.398   0.499998E+04   0.312101E+00
   4          3542.738   0.930299E+03   0.262593E+00
   5          3970.448   0.103469E+04   0.260597E+00
   6           201.340   0.776978E+02   0.385903E+00
   7           251.280   0.110401E+03   0.439357E+00
   8            29.920   0.163265E+02   0.545679E+00
   9            46.873   0.324104E+02   0.691456E+00
  10            71.277   0.516470E+02   0.724592E+00

 Catchability Values for Each Survey Used in Estimate
 INDEX     Catchability    Std. Error      CV

   1       0.639060E-04   0.988283E-05   0.154646E+00
   2       0.131940E-03   0.141520E-04   0.107261E+00
   3       0.225008E-03   0.228294E-04   0.101460E+00
   4       0.293998E-03   0.386906E-04   0.131602E+00
   5       0.382779E-03   0.641901E-04   0.167695E+00
   6       0.566609E-03   0.109588E-03   0.193411E+00
   7       0.511812E-03   0.139644E-03   0.272843E+00
   8       0.533836E-04   0.687041E-05   0.128699E+00
   9       0.113582E-03   0.128656E-04   0.113272E+00
  10       0.223833E-03   0.225992E-04   0.100965E+00
  11       0.370258E-03   0.463840E-04   0.125275E+00
  12       0.478237E-03   0.565335E-04   0.118212E+00
  13       0.451154E-03   0.836411E-04   0.185394E+00
  14       0.566767E-03   0.129170E-03   0.227906E+00
  15       0.710558E-03   0.107424E-03   0.151183E+00
  16       0.544643E-03   0.474923E-04   0.871988E-01
  17       0.453706E-03   0.562280E-04   0.123930E+00
  19       0.122958E-03   0.367937E-04   0.299238E+00
  21       0.245830E-05   0.690050E-06   0.280702E+00
  22       0.140563E-04   0.164576E-05   0.117084E+00
  23       0.231650E-04   0.128111E-05   0.553035E-01
  24       0.229116E-04   0.123947E-05   0.540979E-01
  25       0.218712E-04   0.246650E-05   0.112774E+00
```

Table F23. Bootstrap estimates of precision and bias on 2008 N and 2007 F estimates at age from the Gulf of Maine cod VPA.

Bootstrap Summary Report
Number of Bootstrap Repetitions Requested = 1000
Number of Bootstrap Repetitions Completed = 1000

Bootstrap Output Variable: Stock Estimates (2008)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 2	3937.	4778.	3549.	0.7428
N 3	16020.	17071.	6345.	0.3717
N 4	3543.	3648.	986.	0.2703
N 5	3970.	4078.	1050.	0.2575
N 6	201.	214.	80.	0.3741
N 7	251.	270.	126.	0.4652
N 8	30.	34.	19.	0.5717
N 9	47.	56.	45.	0.7909
N 10	71.	86.	70.	0.8079

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 2	841.	115.	21.3697	3095.	1.1466
N 3	1050.	203.	6.5570	14970.	0.4239
N 4	105.	31.	2.9687	3438.	0.2868
N 5	107.	33.	2.6968	3863.	0.2718
N 6	13.	3.	6.5231	188.	0.4263
N 7	19.	4.	7.4963	232.	0.5406
N 8	4.	1.	13.6268	26.	0.7521
N 9	9.	1.	20.1704	37.	1.1906
N 10	15.	2.	21.1718	56.	1.2418

Bootstrap Output Variable: Fishing Mortality (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0000	0.0000	0.000000	0.7193
AGE 2	0.0004	0.0005	0.000180	0.3776
AGE 3	0.0388	0.0403	0.010717	0.2657
AGE 4	0.1880	0.1940	0.047462	0.2446
AGE 5	0.4892	0.5077	0.151260	0.2979
AGE 6	0.6492	0.7011	0.268324	0.3827
AGE 7	0.2288	0.2890	0.246963	0.8546
AGE 8	0.3714	0.5913	0.645212	1.0911
AGE 9	0.1484	0.3630	0.603834	1.6637
AGE 10	0.4888	0.5279	0.202048	0.3827
AGE 11	0.4888	0.5279	0.202048	0.3827

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000000	0.000000	25.9547	0.0000	1.2235
AGE 2	0.000031	0.000006	6.9738	0.0004	0.4343
AGE 3	0.001556	0.000342	4.0140	0.0372	0.2880
AGE 4	0.006058	0.001513	3.2227	0.1819	0.2609
AGE 5	0.018527	0.004819	3.7875	0.4706	0.3214
AGE 6	0.051977	0.008643	8.0070	0.5972	0.4493
AGE 7	0.060197	0.008039	26.3126	0.1686	1.4650
AGE 8	0.219925	0.021557	59.2126	0.1515	4.2591
AGE 9	0.214574	0.020266	144.6129	-0.0662	-9.1219
AGE 10	0.039139	0.006508	8.0070	0.4497	0.4493
AGE 11	0.039139	0.006508	8.0070	0.4497	0.4493

Table F24. Input data and F reference point estimates from yield and SSB per recruit analyses for Gulf of Maine cod.

Yield and SSB per Recruit Input Data

Age	Partial Recruitment	Sel on M	Mean Wts Stock	Mean Wts Catch	Mean Wts Sp Stock	Maturity
1	0	1	0.198	0.416	0.198	0.077
2	0.0021	1	0.877	1.862	0.877	0.272
3	0.1618	1	2.008	2.352	2.008	0.627
4	0.6821	1	2.698	3.12	2.698	0.883
5	0.9004	1	3.504	3.926	3.504	0.971
6	1	1	4.413	4.939	4.413	0.993
7	0.8264	1	5.791	6.505	5.791	0.999
8	0.7333	1	7.31	8.135	7.31	1
9	0.772	1	9.739	10.562	9.739	1
10	0.753	1	11.499	12.505	11.499	1
11+	0.753	1	14.139	14.139	14.139	1

Yield and SSB per Recruit Results

F	F	YpR	SSBpR	TBpR	Mean Age	Mean Gen	Exp Spws
Zero	0	0	21.31971	23.48204	5.14351	9.80601	2.50221
F0.1	0.2328	1.47453	8.63823	10.60663	3.54135	7.14426	1.58877
Fmax	0.5351	1.61796	4.58581	6.43139	2.85064	5.28891	1.09851
F40%	0.2372	1.48155	8.52856	10.49424	3.52445	7.10535	1.57786

Table F25. Projected catch and SSB in 2009 under 3 F scenarios in 2009 (Fsq, F_{MSY} and $F_{REBUILD}$), assuming catch in 2008 equals catch in 2007, for Gulf of Maine cod.

F2009 = Fstatus quo = F2007 = 0.456

	2007	2008	2009
F	0.456	0.203	0.456
SSB (mt)	33,877	46,433	56,619
Catch (mt)	5,628	5,628	19,191

F2009 = Frebuild = 0.281

	2007	2008	2009
F	0.456	0.203	0.281
SSB (mt)	33,877	46,433	57,797
Catch (mt)	5,628	5,628	12,591

F2009 = Fmsy = 0.237

	2007	2008	2009
F	0.456	0.203	0.237
SSB (mt)	33,877	46,433	58,091
Catch (mt)	5,628	5,628	10,798

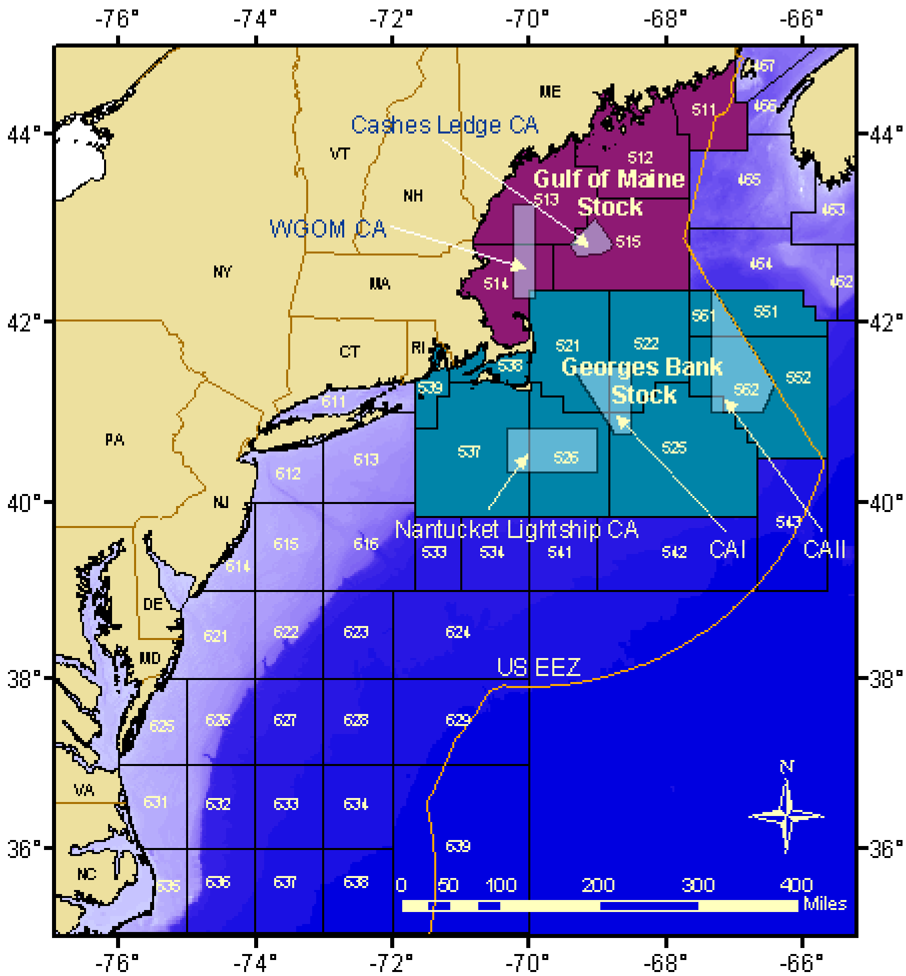


Figure 1.1. Statistical areas used to define the Gulf of Maine and Georges Bank cod stocks.

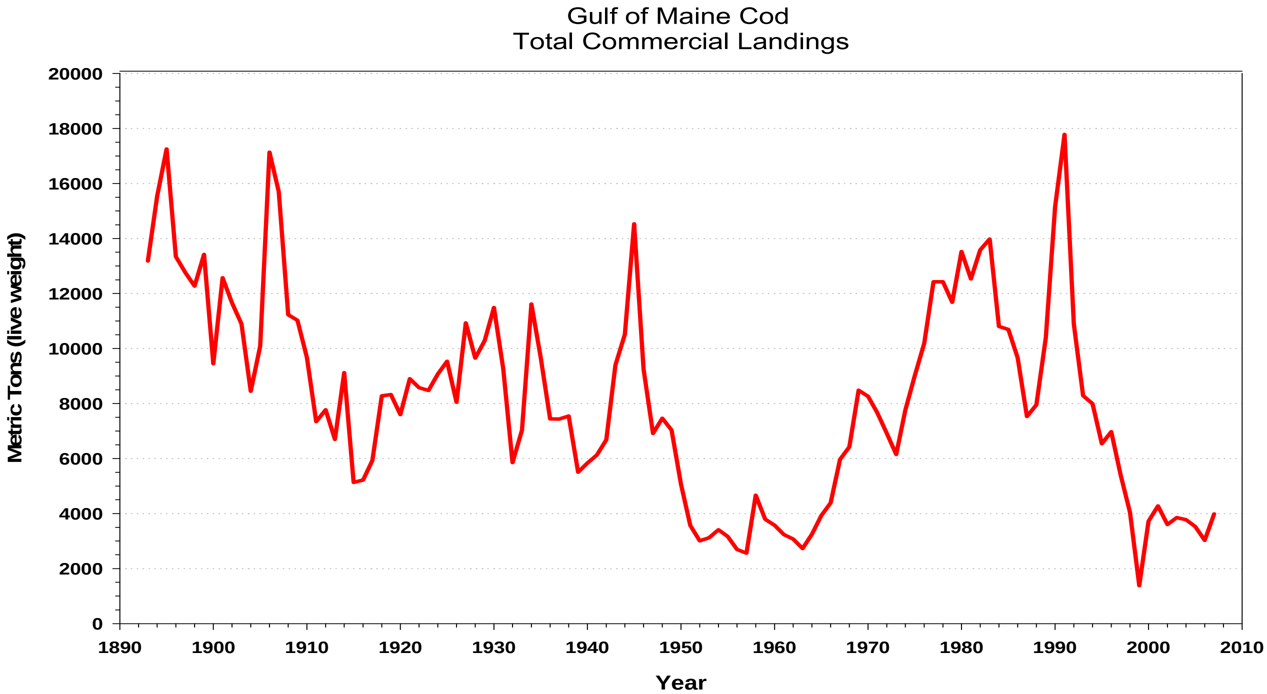


Figure F2. Total landings (mt) of Atlantic cod from the Gulf of Maine stock, 1893-2007.

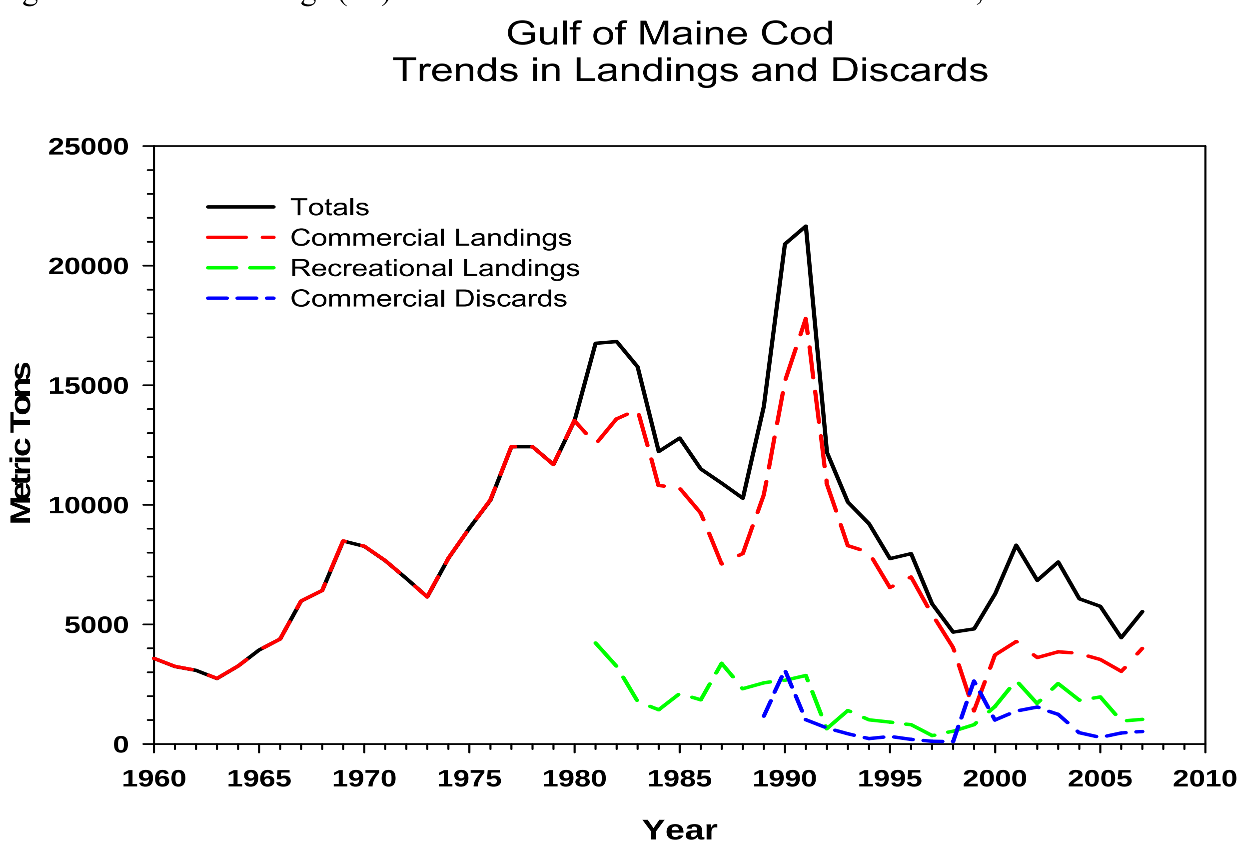


Figure F3. Commercial and recreational landings and commercial discards of Atlantic cod from the Gulf of Maine stock from 1960 to present.

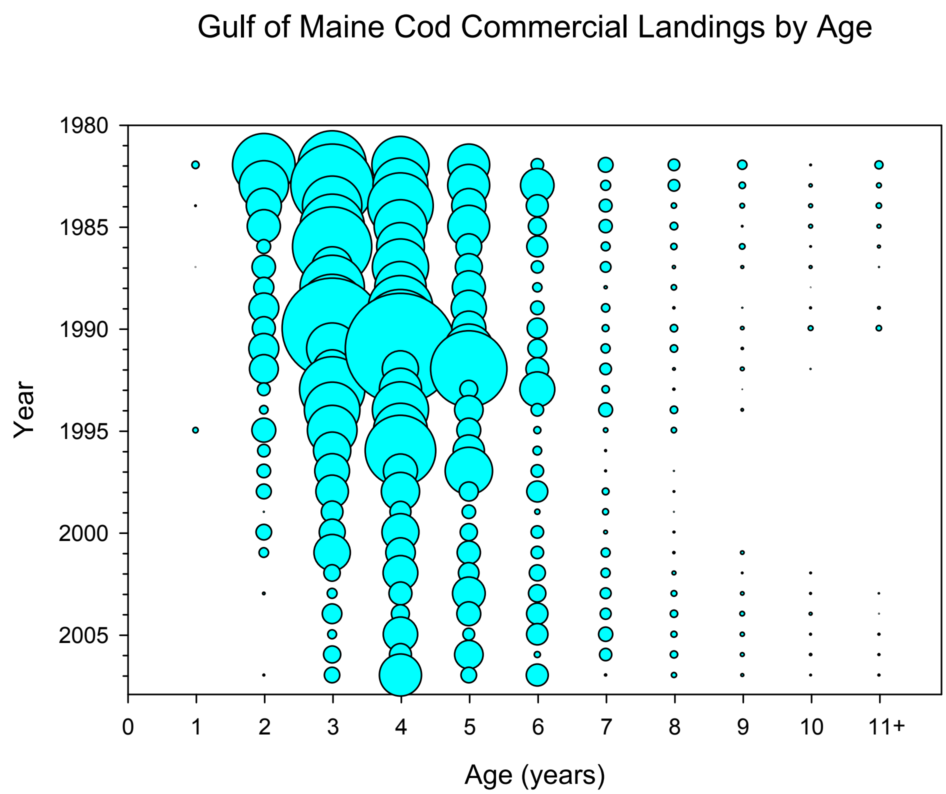


Figure F4. Age composition of total catch (commercial landings and discard and recreational landings) for Gulf of Maine cod.

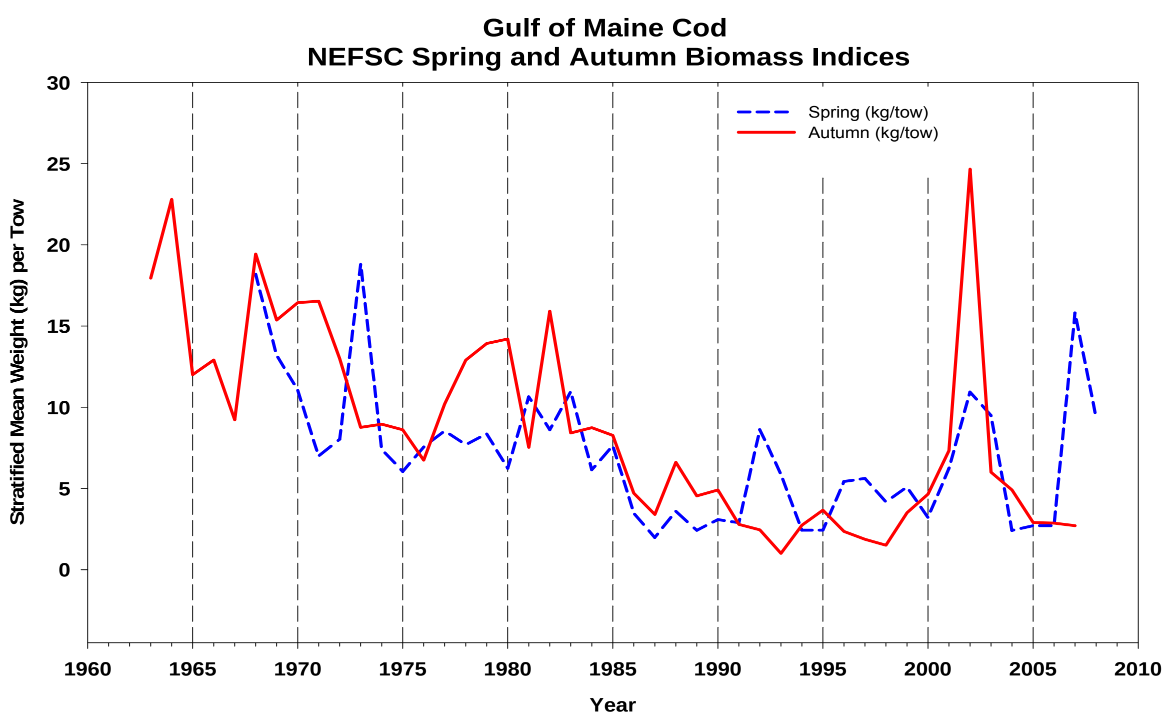


Figure F5. Trends in biomass (stratified mean weight, kg, per tow) of Atlantic cod in the Gulf of Maine based on NEFSC spring and autumn surveys, 1963-2008.

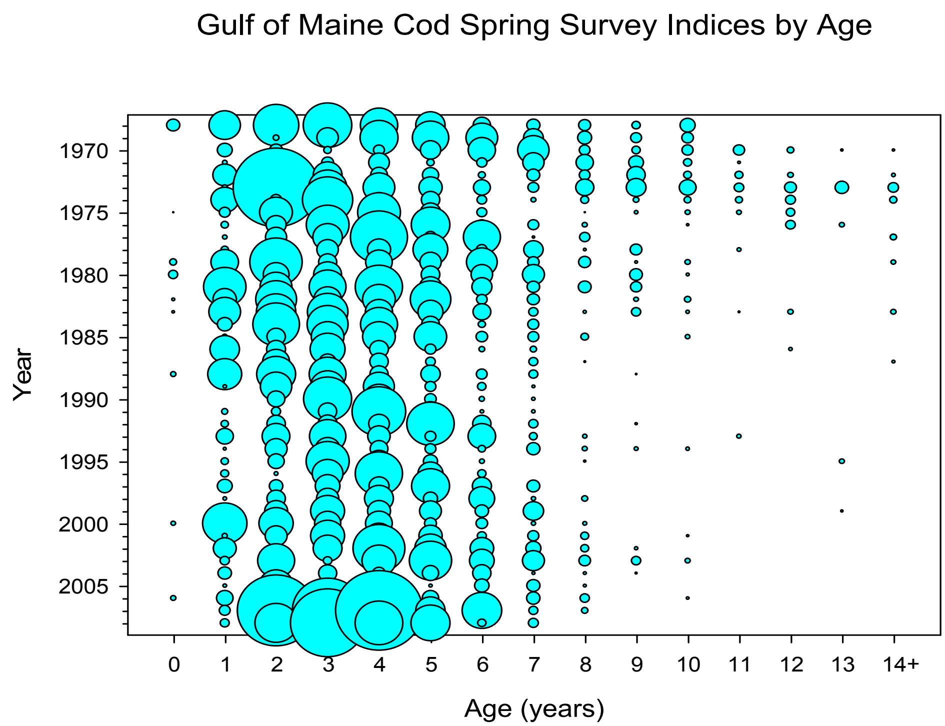


Figure F6. Relative abundance of Atlantic cod by age in the Gulf of Maine based on NEFSC spring bottom trawl surveys, 1970-2008.

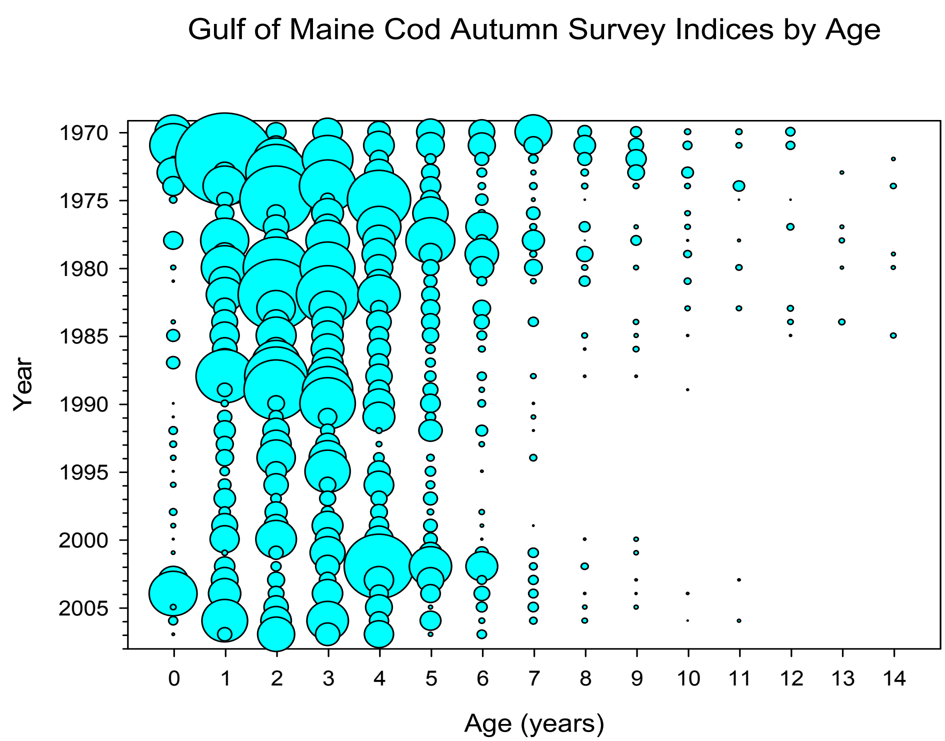


Figure F7. Relative abundance of Atlantic cod by age n the Gulf of Maine based on NEFSC autumn bottom trawl surveys, 1970-2007.

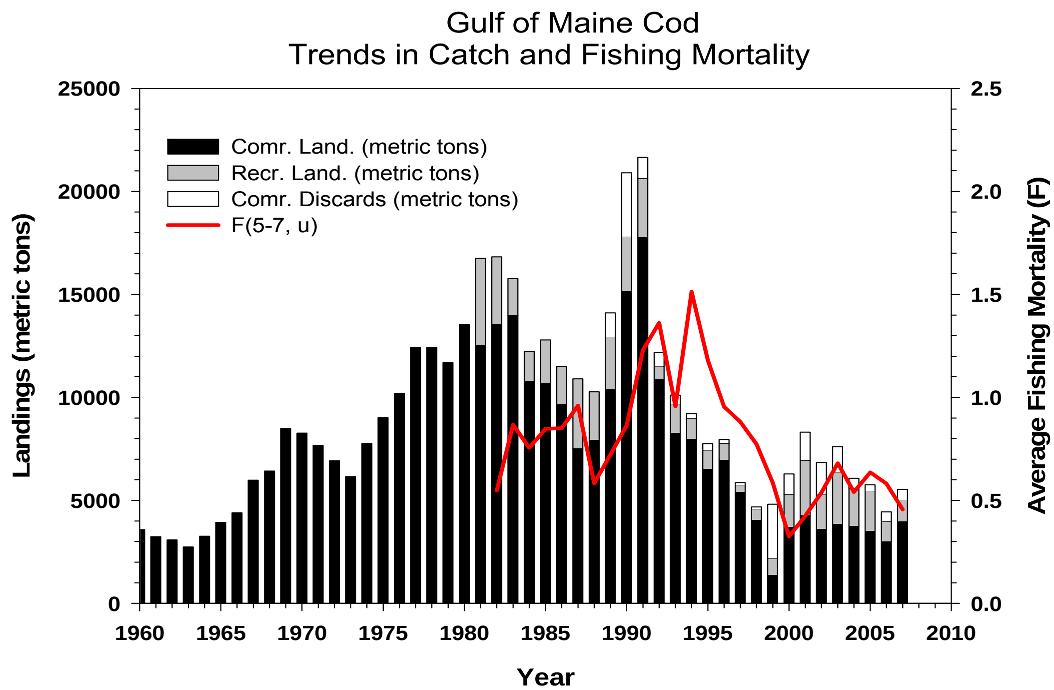


Figure F8. Trends in commercial and recreational landings and commercial discards compared to estimates of instantaneous fishing mortality (avg of ages 5-7) for Gulf of Maine cod.

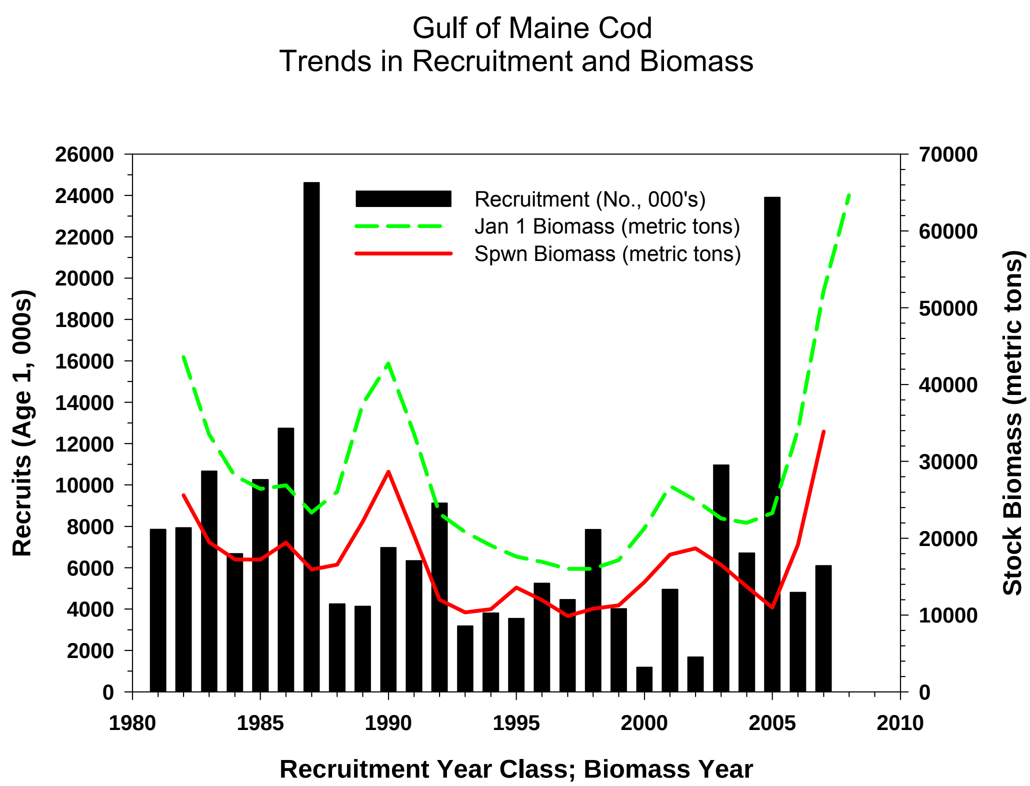
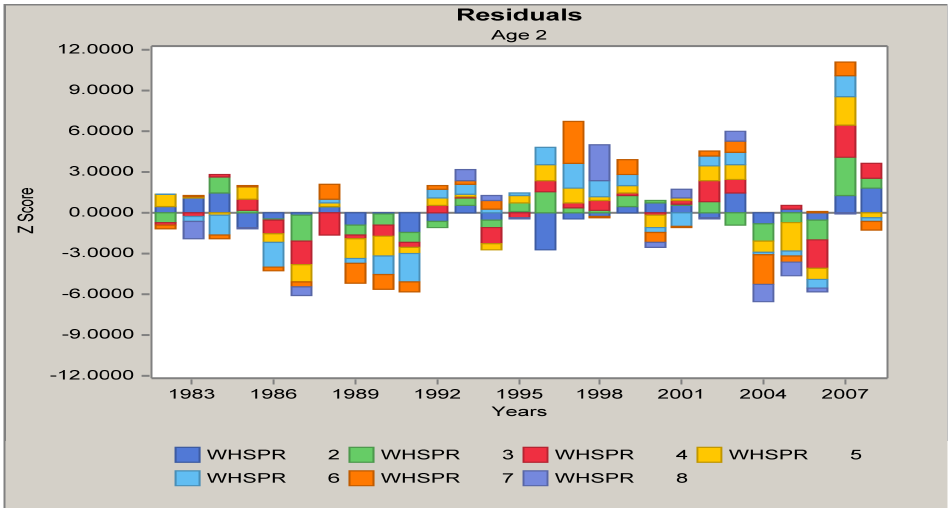
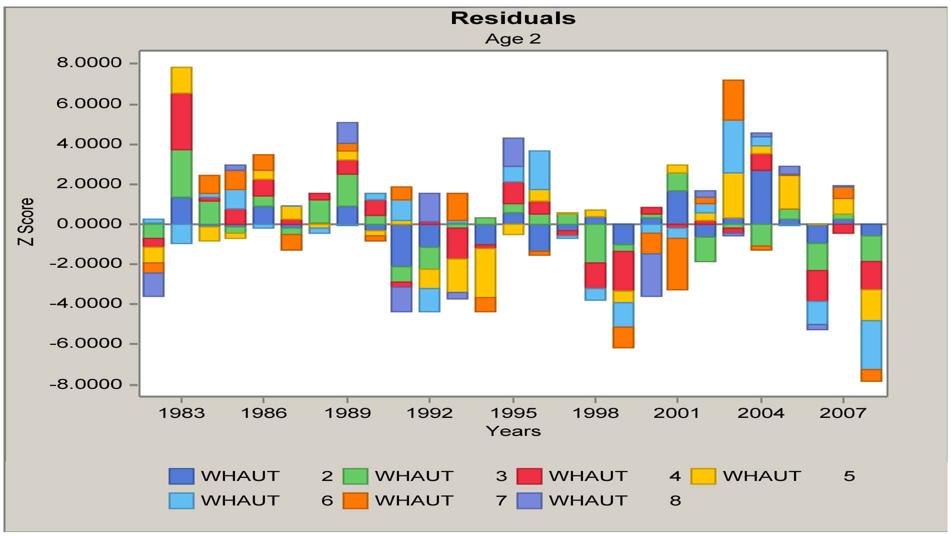


Figure F9. Trends in spawning stock biomass (SSB) and age 1 recruitment) for Gulf of Maine cod.





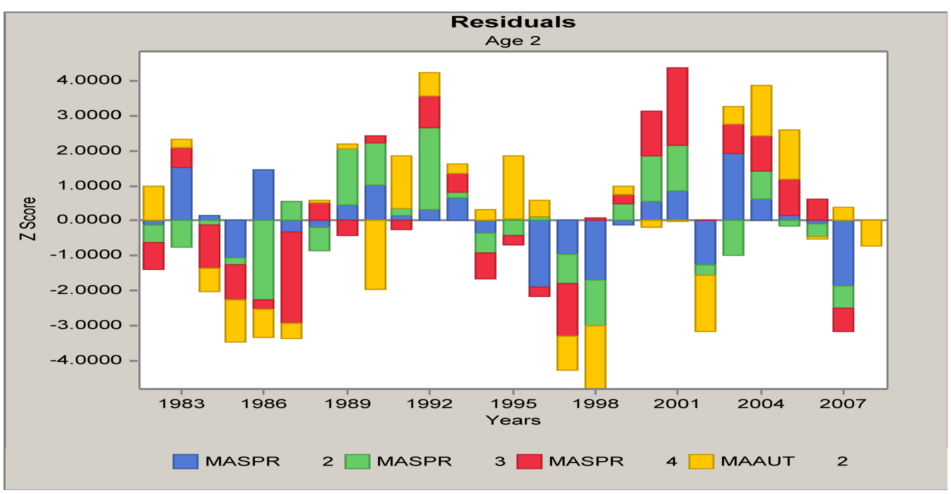


Figure F10. Residual patters for NEFSC spring (top), autumn (middle) and Massachusetts DMF (bottom) bottom trawl surveys for ages used to calibrate the Gulf of Maine cod VPA.

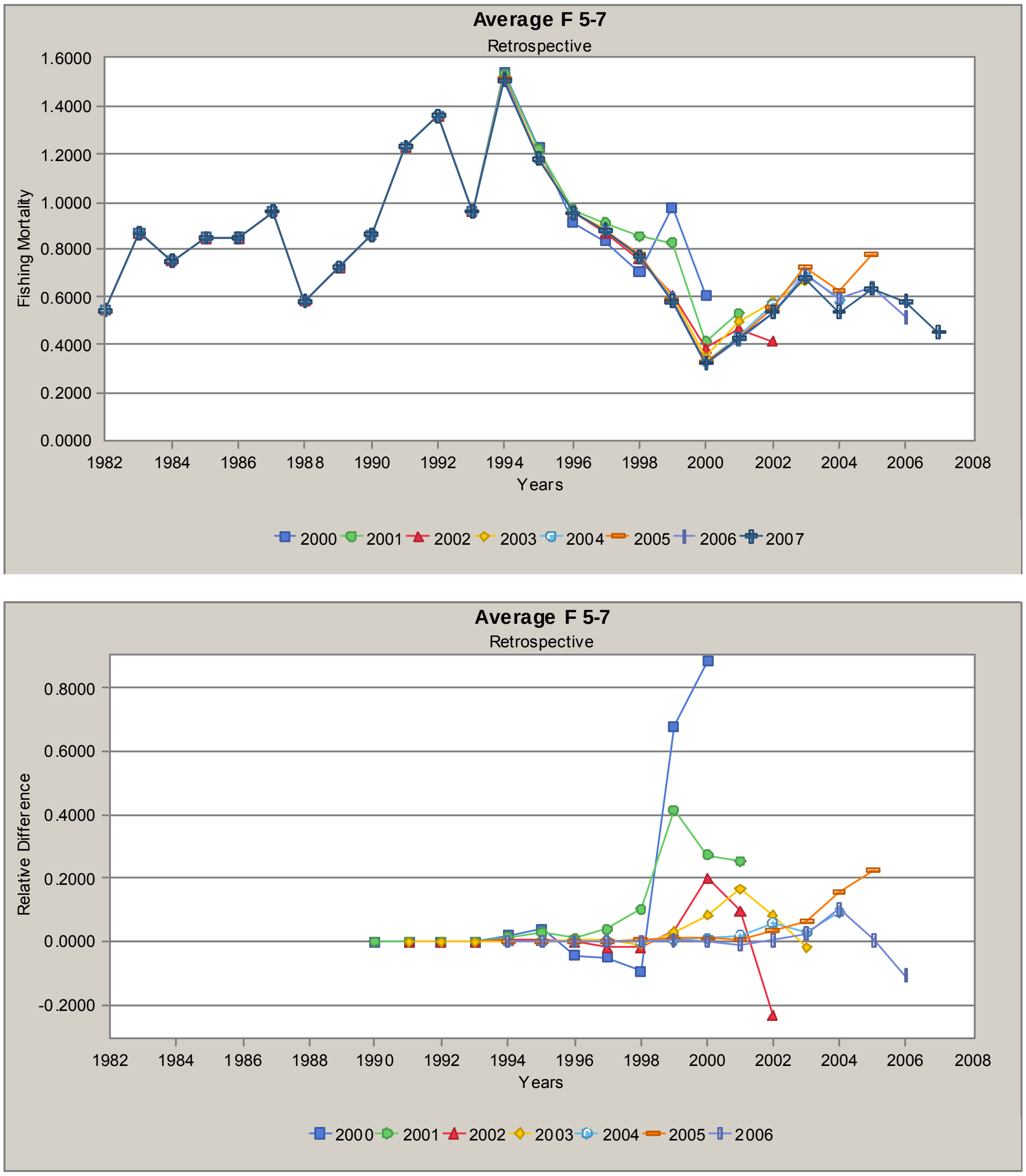
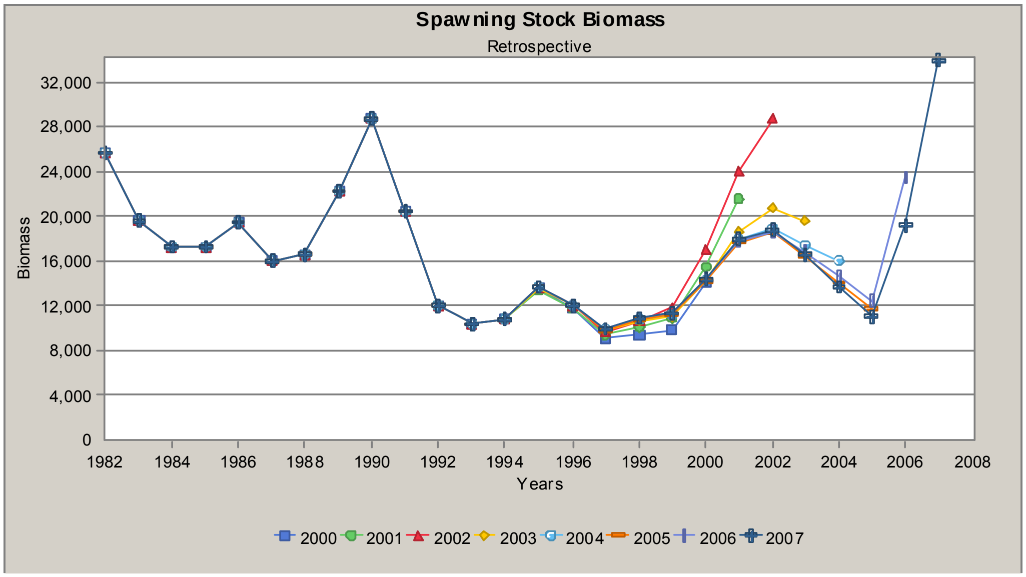


Figure F11. Retrospective plots (standard top, relative difference bottom) of average F (ages 5-7) for Gulf of Maine cod. Mohn's average Rho based on relative difference = 0.157.



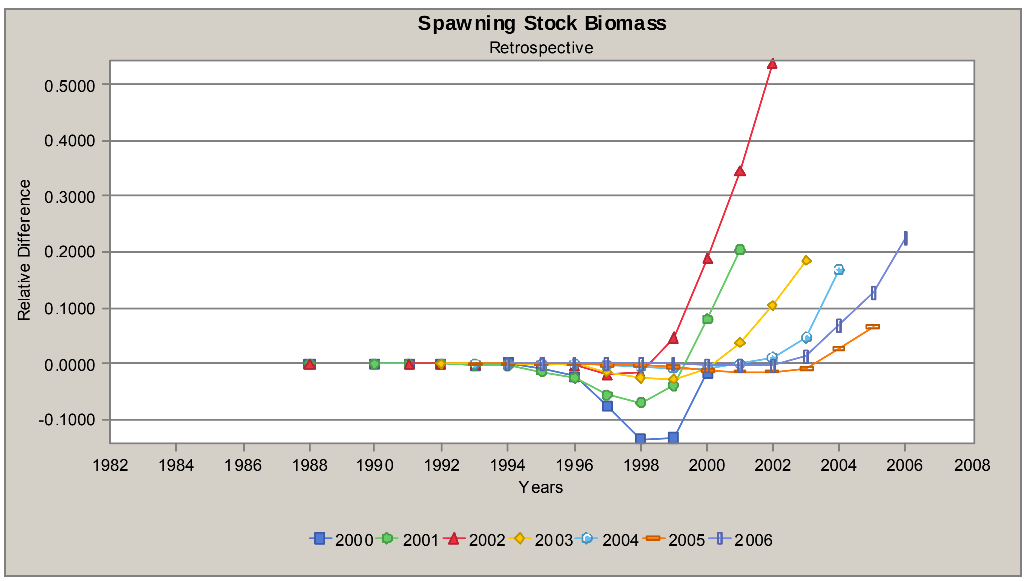
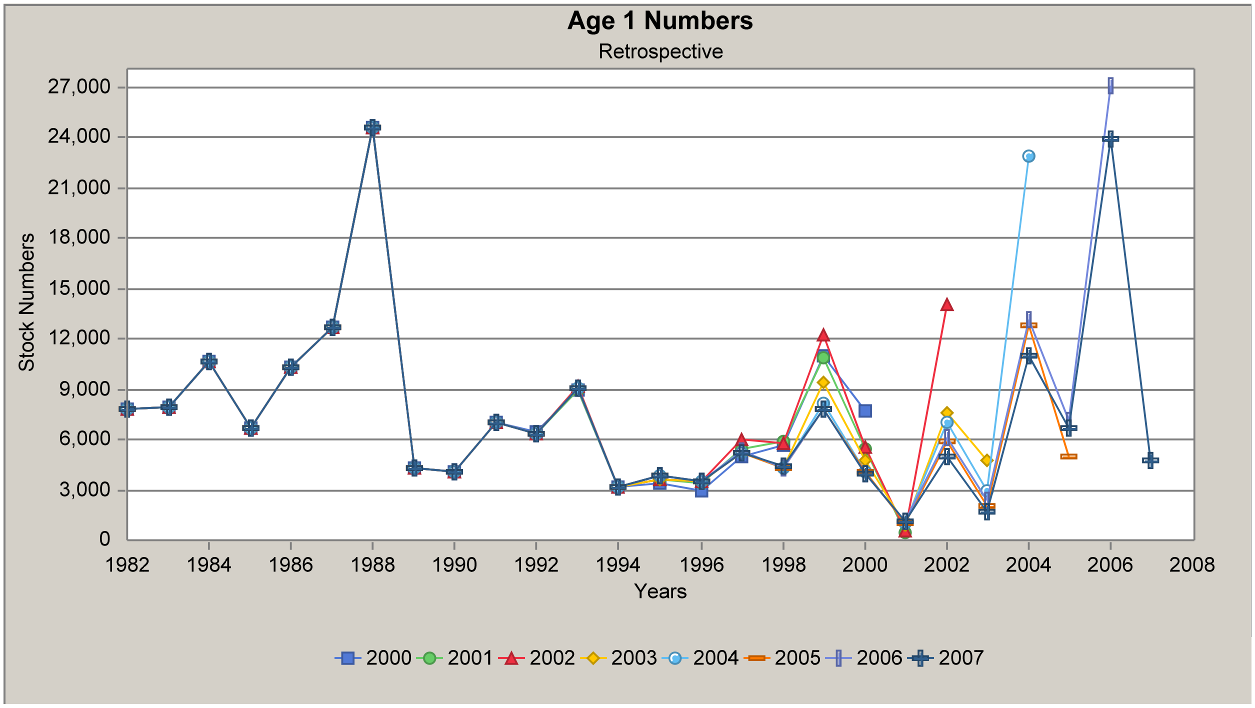


Figure F12. Retrospective plots (standard top, relative difference bottom) of spawning stock biomass for Gulf of Maine cod. Mohn's average Rho based on relative difference = 0.195.



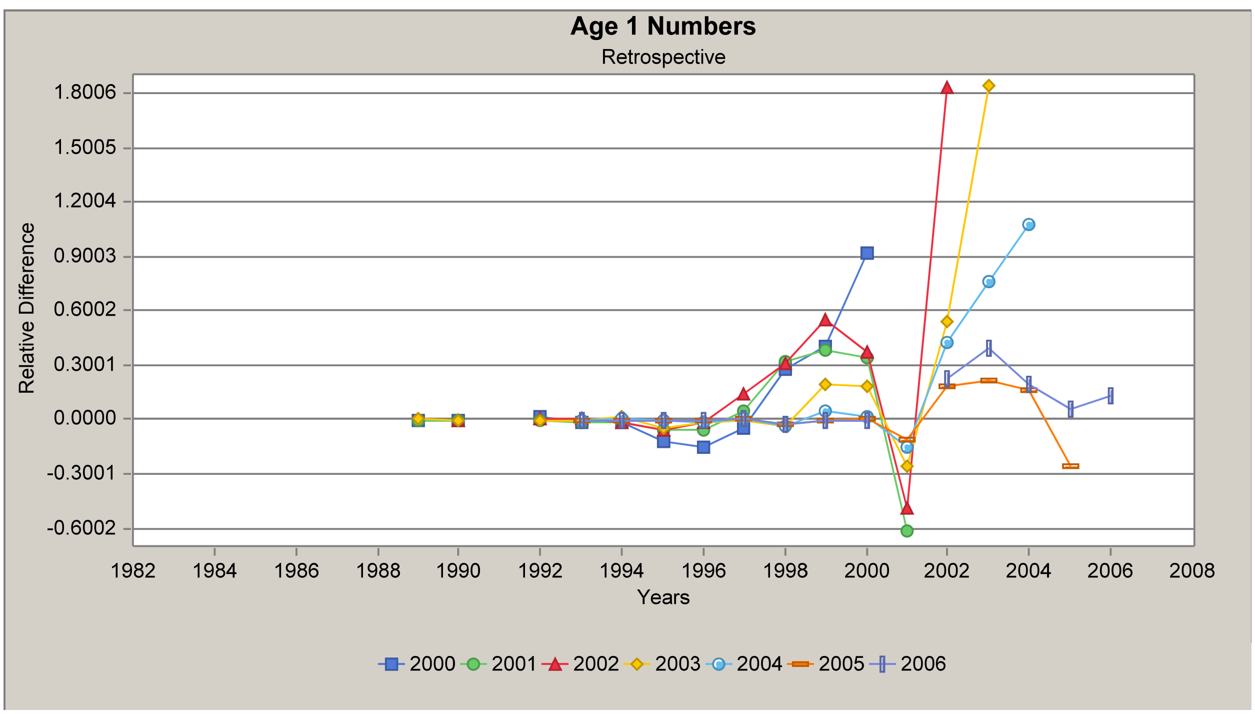


Figure F13. Retrospective plots (standard top, relative difference bottom) of age 1 recruitment for Gulf of Maine cod. Mohn's average Rho based on relative difference = 0.707.

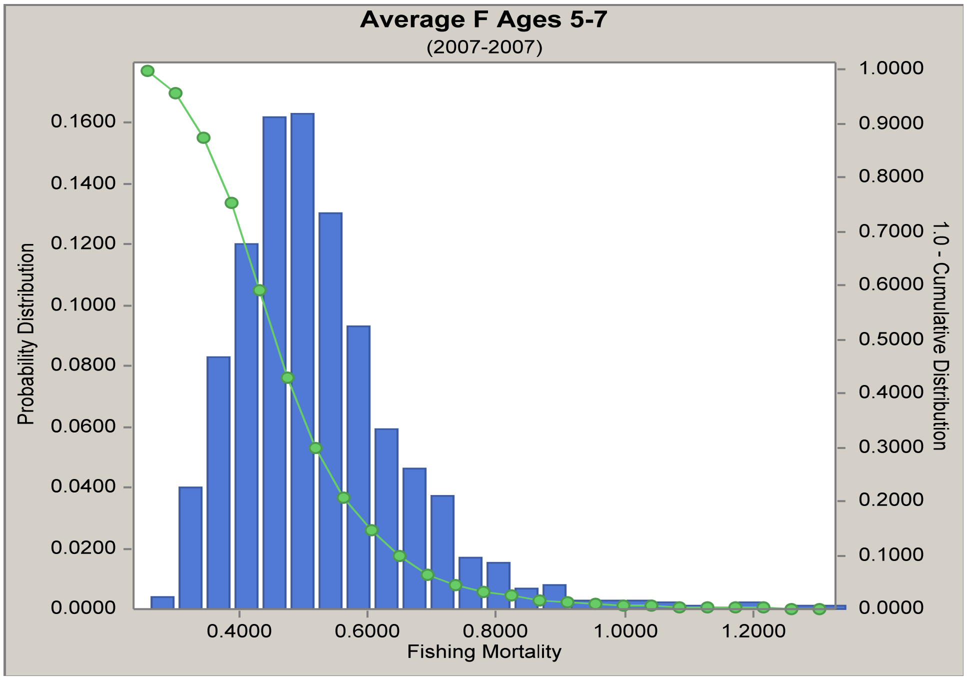


Figure F14. Distribution of estimates of 2007 average F (ages 5-7) based on 1000 bootstrap iterations for Gulf of Maine cod. The 10-90 percentile range is 0.36 – 0.67.

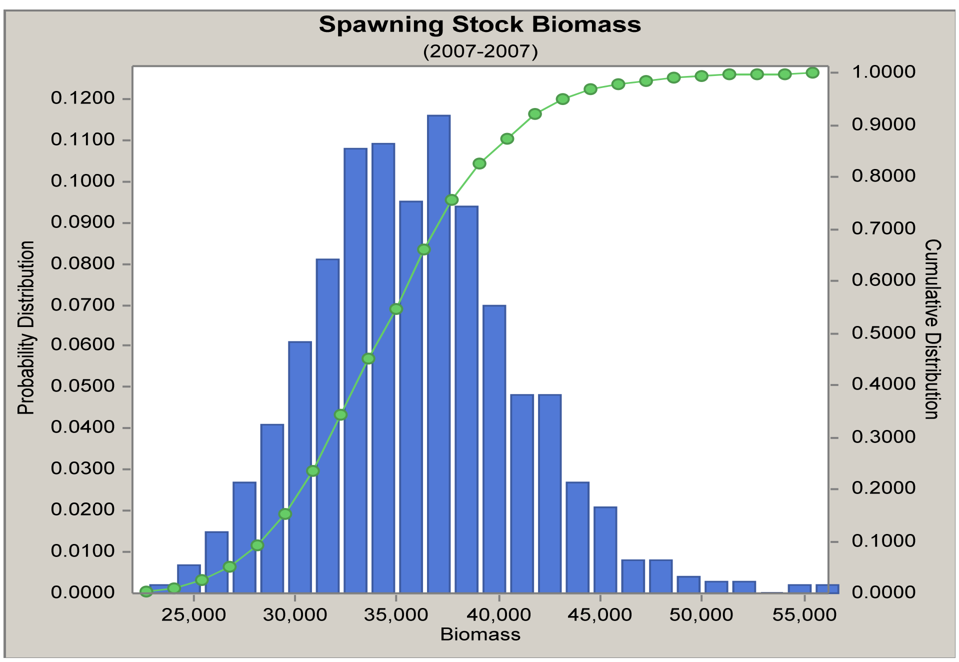


Figure F15. Distribution of estimates of 2007 spawning stock biomass based on 1000 bootstrap iterations for Gulf of Maine cod. The 10-90 percentile range is 29,133 mt – 41, 747 mt.

Figure F16. Yield and SSB per Recruit results for Gulf of Maine cod. Input data and output values are given in Table F23.

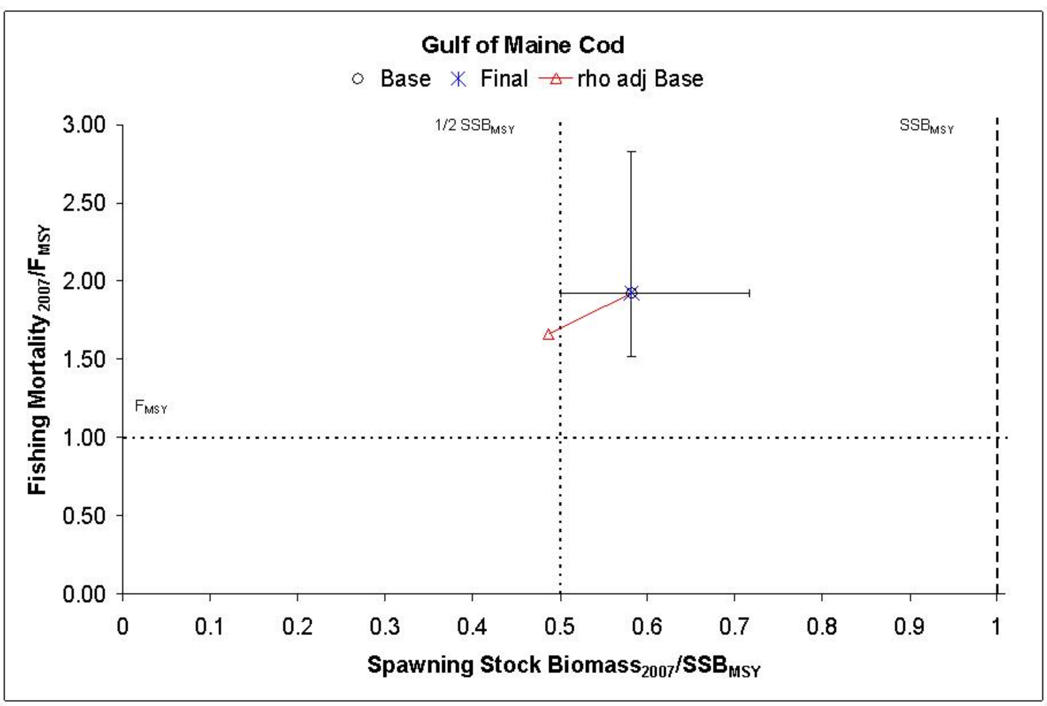


Figure F17. Status determination of Gulf of Maine cod in 2007.

G. Witch flounder

by S.E. Wigley and L. Col

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

1.0 Background

Witch flounder, *Glyptocephalus cynoglossus*, is assessed as a unit stock from the Gulf of Maine southward (Figure G1). An analytical assessment was last conducted for this species in 2005 at the Groundfish Assessment Review Meeting (GARM 2005; NEFSC 2005). Witch flounder was not overfished and overfishing was not occurring in 2004. The 2005 assessment indicated average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.68 in 1985, declined to 0.22 in 1992, increased to 1.12 in 1996, then declined to 0.20 in 2004. Spawning stock biomass declined steadily from 16,897 mt in 1982 to 3,901 mt in 1996 and then increased to 21,175 mt in 2004. Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 45 million fish (1997 year class) with a mean (1979 – 2002 year classes) of 15.5 million fish. The retrospective analysis indicates that average F was underestimated in the late 1990s and early 2000s, spawning stock biomass was consistently overestimated and recruitment was relatively consistently estimated, with notable exceptions of the 1995, 1996 and 1997 year classes which were considerably overestimated. 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 2000. Biological reference points were updated at the SARC 37 benchmark assessment in 2003 (NEFSC 2003, Wigley et al. 2003).

This report updates catch through 2007, survey indices through spring 2008, and estimates 2007 fishing mortality and spawning stock biomass. Biological reference points are estimated. Commercial witch flounder landings were updated for the 1994 to 2007 period, with negligible changes occurring for this unit stock species. The NEFSC and Massachusetts inshore survey indices have been revised using re-audited (NEFSC) and re-stratified (MA inshore) survey data.

Discards from the large-mesh otter trawl fishery have been re-estimated using a discard to kept ratio for 1989 to 2007 and discards from the small-mesh otter fishery have been estimated for 1989 to 2007.

2.0 Fishery

Commercial landings

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 G2). Canadian landings from both areas have been minor (not more than 68 mt annually). USA landings generally increased from the early 1960s, peaking in 1984 at 6,660 mt. Subsequently, landings declined and have fluctuated about 2,300 mt. In 2007, landings were 1,075 mt (Table G1 and Figure G2).

Sampling of landings has increased in recent years (Table G3). 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 G4 and G5, respectively.

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 G6 and Figure G3). The majority of discards occur between ages 1 to 6, and the discards are a small component of total catch (Figure G2). 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 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, 2003-2007), 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 and 2007, 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 G6).

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 2007, 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 G6). 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 G7 and G8 and Figure G3.

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 G6). The small-mesh otter trawl discard length frequencies for 1989 to 2007 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 G9 and G10, and Figure G4. The age composition data reveal strong 1979-1981 year classes; the 1989 and 1993 year classes also appear strong. The poor 1984 year class is also evident as well as a truncated age-structure in the late-1990's and again in the mid-2000s. For fish age 6 and older, mean weights at age declined between 1992 and 2003 and have steadily increased since, however the current mean weights at age remain below the time series average (Figure G5)

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. Since then survey indices increased but have exhibited a declining trend since 2000 (Table G11, Figures G6a-b). Survey age compositions (mean number per tow at age) are presented in Table G12, Figure G7. The survey mean weights at age show a similar pattern of decline and then increase as reported for the commercial landings (Appendix Figure G1; NEFSC 2008). 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 stable in recent years, with median A50 at approximately age 6 (Figure G8) for females.

Both the Massachusetts inshore survey (Appendix Table G1 and Appendix Figure G2; NEFSC 2008) and the Atlantic States Marine Fisheries Commission summer shrimp survey (Appendix Table G2. and Appendix Figure G3; NEFSC 2008) show similar trends in abundance and biomass to the NEFSC surveys.

4.0 Assessment

Input Data and analysis

The Virtual Population Analysis (VPA) is calibrated using the NOAA Fisheries Toolbox (NFT) ADAPT VPA version 2.7.7. Since the last assessment, only minor changes in software and data have occurred. The VPA formulation is the same as the previous assessment and uses catch (landings and discards for ages 3 to 11+) through 2007 and NEFSC spring and autumn survey abundance indices (ages 3 to 11+) through 2008 and 2007, 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 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 2008, 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. VPA analyses were performed for a BASE case and 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 two runs, as well as from the previous assessment, are given in Table G13.

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) between the BASE RUN and the SPLIT RUN. Survey catchabilities from the BASE and SPLIT runs are given in Figure G9. In the BASE RUN, the swept area survey qs range between 0.02 and 0.21. In the SPLIT RUN, the 1982-1994 series qs ranged between 0.01 and 0.24 and the 1995-2007 qs ranged between 0.05 and 0.30. The magnitude and pattern of increasing survey catchabilities at age for younger fish and a general level pattern at older ages in the BASE and SPLIT runs appear reasonable. The causes of the increased qs between the 1982-1994 and 1995-2007 series in the SPLIT RUN remain unknown.

Selection of a final VPA run

As will be discussed below, the precision of the stock size estimates are similar between the two formulations. Both VPA formulations have retrospective patterns: the BASE RUN has a consistent pattern while the SPLIT RUN exhibits a 'flip' (change in direction) pattern. 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 G4; NEFSC 2008), indicates 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. Additionally, the Mohn rho statistics of the VPA SPLIT run indicate that the respective pattern is less severe then the VPA BASE RUN. The VPA SPLIT RUN is selected as the final run to use for biological reference point calculations and for stock status determination. For transparency, subsequent analyses based on both VPA formulations have been brought forward.

VPA BASE RUN results

The VPA BASE run had a mean square residual of 0.85, the coefficients of variation (CVs) for estimated stock size at age ranged between 26% and 67% (Table G13), and the CVs for survey catchability coefficients (q) were consistent, ranging from 13% to 26%. Residual patterns from the NEFSC survey tuning indices are given in Figure G10. The patterns appear random for most ages; however, for ages 7 and 10 there appear to be blocks of positive and negative residuals.

VPA 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 0.14 in 2007 (Table G14 and Figure G11). Spawning stock biomass declined steadily from 16,903 mt in 1982 to 3,888 mt in 1996, and has increased to 7,354 mt in 2007 (Tables G14 and Figure G11). Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 48 million fish (2004 year class) with a mean of 13.6 million fish (Table G14 and Figure G11). The addition of the 2003 to 2005 year classes to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment (Figure G11).

The retrospective analysis indicates that average F was underestimated (Figure G12) and spawning stock biomass was consistently overestimated (Figure G13). The retrospective analysis indicated a pattern of relatively consistent estimates of the number of age 3 recruits, with the notable exception of the 1998 to 2002 year classes, which were considerably overestimated (Figure G14).

Mohn rho statistic (Mohn 1999; GARM 2008) was derived by taking the average of seven (2000 – 2007) 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 BASE RUN Mohn rho statistics for F, SSB and Age 3 was -0.31, 0.91 and 0.56, respectively (Table G15).

The precision of the 2008 stock size at age, F at age in 2007, and SSB in 2007 from the VPA BASE RUN was evaluated using bootstrap techniques (Efron 1982). Bootstrap results suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 27% and 14%, respectively. The 80% confidence interval for F_{2007}= 0.14 was 0.10 and 0.20, and for SSB_{2007} = 7,354 mt the 80% confidence interval was 6,337 mt and 9,045 mt. The range of the bootstrap estimates and the probability of the individual values are presented in Figure G15.

VPA SPLIT RUN results

The VPA SPLIT RUN had a mean square residual of 0.730, the coefficients of variation (CVs) for estimated stock size at age ranged between 34% and 63% (Table G16), and the CVs for survey catchability coefficients (q) were consistent, ranging from 15% to 43%. Similar to the BASE RUN, residual patterns from the NEFSC survey tuning indices from the SPLIT RUN are given in Figure G16. The patterns appear random for most ages; however, for ages 7 and 10 there appear to be blocks of positive and negative residuals.

VPA 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 0.29 in 2007 (Tables G16 and G17; Figure G17). Spawning stock biomass declined steadily from 16,903 mt in 1982 to 3,877 mt in 1996, and has increased to 6,874 mt in 2000 and then declined to 3,434 mt in 2007 (Tables G16 and G17; Figure G17). 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 of 11.1 million fish (Tables G16 and G17; Figure G17). The addition of the 2003 to 2005 year classes to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment (Figure G17).

The retrospective analysis of the VPA SPLIT RUN indicates a pattern of overestimation of average F prior to 2003 and then underestimation for average F from 2003 onward (Figure G18). A similar 'flip' pattern is also evident for spawning stock biomass. Spawning stock biomass was underestimated prior to 2001 and then overestimated from 2001 onward (Figure G19). The retrospective analysis for Age 3 recruits indicates an overestimation prior to 2001 and then an underestimation from 2002 onward (Figure G20). The SPLIT RUN Mohn rho statistics for F, SSB and Age 3 was -0.02, 0.43 and -0.13, respectively (Table G15). The magnitude of the average relative difference for F, SSB and Age3 are all lower in the SPLIT RUN than the VPA BASE RUN (Table G15).

Bootstrap results of the VPA SPLIT RUN suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 27% and 15%, respectively. The 80% confidence interval for F_{2007}=0.29 was 0.21 and 0.42, and for SSB_{2007} = 3,434 mt the 80% confidence interval was 2,930 mt and 4,262 mt. The range of the bootstrap estimates and the probability of the individual values are presented in Figure G21.

5.0 Biological Reference Points

During the SAW/SARC 37 (NEFSC 2003), biological reference points were updated for witch flounder using yield and spawning stock biomass per recruit analyses (Thompson and Bell 1934) and the arithmetic mean of the VPA Age 3 recruitment (NEFSC 2003). The biological reference points from that analysis are:

SSB_{MSY} = 25,248 mt;
F_{MSY} = F40% = 0.23; and
MSY = 4,375 mt.

For this assessment, yield and spawning stock per recruit analysis were performed using 5-year (2003-2007) averages for partial recruitment, stock weights, catch weights and maturity (2004-2008; Table G18). Based on yield and SSB per recruit analyses, a proxy of F_{MSY} is F40%MSP = 0.20 for both the BASE and SPLIT runs (Table G19).

Two long-term (100 year) stochastic projections (AGEPRO v3.1.3) were performed to estimate spawning stock biomass and MSY under equilibrium conditions. The same partial recruitment vectors, 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 = F_{MSY} = 0.20). 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 2008 (1979 to 2005 year classes) from the BASE RUN and the SPLIT RUN (Table G18). The proportions of F and M which occurs before spawning equals 0.1667 (March 1); M equals 0.15. Comparisons of current (SARC 37) and updated (GARM2008) biological references points are given in Table G19.

BASE RUN
SSB_{MSY} = 12,180 mt
MSY = 2,528 mt

SPLIT RUN
SSB_{MSY} = 11,447 mt
MSY = 2,352mt

Trends of the age structure of the spawning stock biomass and the age structure under MSY conditions are given in Figure G22. As reported above, SSB in 2007 is well below SSB_{MSY}, and the distribution of spawning biomass at age is concentrated at younger ages in 2007, indicating a truncated age structure.

6.0 Projections

Short term projections of catch and spawning stock biomass in 2009 were conducted under two F scenarios using bootstrapped VPA SPLIT RUN calibrated stock sizes in 2008. The partial recruitment, maturity ogive, and mean weights at age (Table G20) are the same as described for biological reference points (using 5 year average mean weight and the full entire series of Age 3 recruitment) and an assumed natural mortality of 0.15.

Short-term median estimates of catch and spawning stock biomass in 2009 are given in Table G20. When 2008 catch is assumed equal to 2007 catch, the projection forecasts F in 2008 = 0.31 and spawning biomass to be 3,876 mt. If 2009 fishing mortality is held at F status quo (F=0.29), then 2009 spawning stock biomass is forecast to be 4,792 mt. If 2009 fishing mortality is held at F_{MSY} (F=0.20), then 2009 spawning stock biomass is forecast to be 4,838 mt.

Projections to estimate $F_{REBUILD}$ in 2009- 2018 that will rebuild the spawning biomass to SSB_{MSY} = 11,447 mt by 2018 with a 50% probability indicate that $F_{REBUILD}$ = 0.194. Catches in 2009 are estimated to be 896 mt (Table G20).

7.0 Summary

Witch flounder fishing mortality and spawning stock biomass in 2007 are summarized, relative to the biological reference points, for the SPLIT RUN, the BASE RUN, and the rho-adjusted BASE RUN (where F and SSB are adjusted by the Mohn's rho for F and SSB, -0.31 and 0.91 respectively; Figure G23). The final accepted VPA run is the SPLIT RUN. Based on the VPA SPLIT run, the 2007 spawning stock biomass was 3,434 mt, 30% below SSB_{MSY} (11,447 mt) and 2007 fishing mortality was 0.29, 45% above F_{MSY} (F=0.20); therefore, witch flounder was overfished and overfishing occurred in 2007 (Figure G23).

The 2007 witch flounder assessment reveals that discards continue to be a minor component of the total catch. Total catch has declined slightly in recent years and is below the time series average. Fishing mortality has declined substantially since 1996 and is currently near the low levels estimated in the early 1990s. Spawning stock biomass has shown a declining trend between 1982 and 1996 and a slight increasing trend until 2000, following by a declining trend through 2007; spawning stock biomass remains below the time series average. Age 3 recruits has averaged 11.1 million fish over the time series. The three most recent year classes (2003 – 2005 year classes) are at or above the average, and the 2004 year class appears to be very strong.

Based on yield per recruit analyses, F_{MSY} = F40%MSP = 0.20. SSB_{MSY} and MSY were estimated using a long-term stochastic projection. SSB_{MSY} = 11,447 mt and MSY = 2,352 mt. The 2007 spawning stock biomass age structure remains truncated compared to the conditions under MSY (Figure G22).

Changes from last assessment

Changes from the last assessment were minor and include: minor revisions to landings, use of re-audited historical NEFSC survey, re-estimation of large-mesh otter trawl discards from 1989-onward and the estimation of small-mesh otter trawl discards.

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.
- 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 Panel Discussion/Comments

Conclusions

The BASE VPA model put forth by the NEFSC exhibited a moderate retrospective pattern and lack of model fit, as determined by the residuals, on the youngest age classes. The VPA using the split survey time series reduced the retrospective pattern and reduced the residuals on the younger ages but not for older ages. Therefore, the Panel accepted the VPA with the survey time series split as Final and the best available estimate of stock status and a sufficient basis for management advice.

As noted elsewhere in this report, the Panel was concerned that the split in the survey time series reduces the retrospective pattern, yet the underlying mechanism for its cause remains unknown. It should also be noted that even with the split in the survey time series, the retrospective pattern "flips" back and forth from over-estimating SSB and underestimating F to the reverse. This highlights the uncertainties in the determination of the stock status and projections of this resource.

Concerns were raised that the negative stock – recruitment relationship observed in the VPA time series implies that higher SSB would lead to lower recruitment, an issue that would need to be addressed in the stock and rebuilding plan projections. An analysis of the stock – recruitment relationship based upon the survey data alone (not shown in this report) did not support this negative relationship. Consequently, the Panel agreed to the BRP and projections which were consistent with the GARM III 'BRP' review.

Research Recommendations

The Panel had no specific research recommendations for this stock.

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 J. Burnett for providing the age determinations used in the assessment. We thank all the members of the Groundfish Assessment Review Meetings for their review and helpful comments.

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Table G1. Witch flounder landings, discards and catch (metric tons, live) by country, 1937-2007 [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 G1 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	34		3222	225	3413
2003	3124		3124	30		3154	334	3458
2004	2917		2917	33		2950	309	3226
2005	2652		2652	18		2670	150	2802
2006	1863		1863	15		1878	87	1950
2007	1075		1075	17		1091	97	1172

Table G2. Witch flounder landings (metric tons, live) by gear type, 1964-2007.

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	95.7	0.3	3.4	0.2	0.5	100.0

Dealer Electronic Reporting (DER) was implemented in 2004.

Table G3. 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 - 2007. The sampling ratio represents the amount of landings per length sample.

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
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 G3 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 G3 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
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	26	5	267	37	7	226	40	8	173	19	3	1075	
	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 G4. USA commercial landings at age (thousands of fish), of witch flounder, 1982 – 2007.

USA Commercial Landings in Numbers (1000's) at Age

	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	15.045	48.587	219.968	851.389	594.379	167.352	96.877	42.672

Table G5. USA commercial landings mean weight (kg) at age of witch flounder, 1982 – 2007.

USA Commercial Landings Mean Weight (kg) at Age

						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	-	-	-	0.000	0.253	0.311	0.429	0.565	0.691	0.842	0.964	1.326
1986	-	-	-	0.084	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
Mean												
2003-2007	-	-	-	-	0.287	0.322	0.372	0.456	0.545	0.630	0.701	0.886
1982-2007	-	-	-	-	0.287	0.340	0.412	0.520	0.633	0.773	0.890	1.170

Table G6. 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 – 2007.

	Large-mesh Otter Trawl			Small-mesh Otter Trawl			Shrimp Trawl		Total (used in VPA)	
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	526	48	0.15	32	49	0.28	14	2	97	0.16

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 G7. Witch flounder discards at age (thousands of fish) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2007.

Discards in Numbers (1000's) at Age

					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	2.598	20.379	47.230	36.226	61.067	136.839	36.599	9.802	3.726	2.121	1.770
2007	0.000	2.072	19.077	69.653	69.752	52.922	37.439	18.101	1.989	1.884	0.000	0.539

Table G8. Witch flounder discard mean weight (kg) at age in the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2007.

Discards Mean Weight (kg) at Age												
						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	0.050	0.097	0.163	0.203	0.232	0.271	0.343	0.351	0.523	0.694
2007		0.015	0.038	0.109	0.177	0.220	0.245	0.304	0.449	0.607		0.816
mean												
2003-2007		0.013	0.049	0.097	0.161	0.207	0.241	0.285	0.381	0.477	0.490	0.744
1982-2007	0.004	0.011	0.032	0.076	0.153	0.202	0.251	0.316	0.395	0.502	0.505	0.687

Table G9. 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 - 2007.

	USA Commercial Catch in Numbers (1000's) at Age											
	Age											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1982	0.03	0.06	1.72	190.49	1064.47	1207.67	1475.40	665.20	656.00	399.50	239.40	1578.40
1983	0.00	0.02	4.28	337.11	1346.17	1520.76	1575.12	1590.20	977.80	737.70	510.40	1675.50
1984	0.00	0.33	0.88	146.61	1466.31	2002.70	1739.59	1486.50	1497.50	696.70	375.10	1718.80
1985	0.00	0.34	3.47	123.58	1176.12	2118.21	1936.24	1524.90	1247.90	606.00	400.40	1359.20
1986	0.00	0.53	3.86	22.95	377.07	1516.79	2775.35	1566.90	834.90	412.70	222.80	758.20
1987	2.08	18.92	79.93	22.25	181.26	467.06	1280.06	1574.70	870.90	480.60	252.40	489.40
1988	0.42	14.66	130.29	600.27	139.91	264.30	658.27	1382.70	1154.10	401.50	266.70	597.50
1989	0.74	11.12	52.66	89.74	311.05	153.94	314.62	760.05	883.33	349.97	123.50	348.32
1990	1.20	5.22	117.92	305.65	385.30	781.09	257.65	276.04	474.83	336.59	82.00	178.91
1991	2.96	17.82	79.08	497.05	631.52	1083.53	650.24	236.14	244.94	292.57	314.06	258.18
1992	2.71	43.43	137.00	161.96	970.00	1114.06	1066.18	729.44	201.76	177.99	120.11	377.24
1993	112.07	78.85	108.19	86.48	1006.47	1418.48	923.63	599.46	585.62	218.79	278.56	390.52
1994	8.07	1370.81	499.31	67.34	641.95	2065.25	1350.16	949.10	199.65	543.77	113.87	333.27
1995	2.69	50.16	661.31	643.52	379.64	1045.61	1712.55	854.64	269.56	97.91	270.61	157.49
1996	5.32	33.40	52.61	144.96	381.21	905.28	1354.51	1462.04	269.04	220.23	58.31	116.13
1997	8.70	75.09	107.06	124.59	699.82	897.06	1208.59	1022.33	594.36	84.16	49.93	70.53
1998	51.34	404.65	287.25	227.94	311.02	751.85	1324.83	1643.24	382.48	146.04	16.03	72.51
1999	33.80	266.33	198.81	154.22	485.29	975.04	1519.49	1256.56	805.31	265.33	33.23	57.22
2000	21.98	172.82	123.24	124.23	372.75	568.90	1167.10	1717.48	1023.95	567.53	94.70	238.57
2001	12.57	98.84	67.57	66.33	335.65	1045.64	1129.50	1760.21	1483.88	644.90	435.77	315.59
2002	2.33	19.19	15.82	32.66	578.26	1124.13	1363.56	2150.52	1280.80	645.27	95.59	202.99
2003	0.00	1.45	6.79	32.49	287.43	1120.69	1627.05	1910.69	1583.63	759.14	441.73	353.87
2004	0.00	0.00	9.68	33.16	359.88	1180.74	1615.10	1530.13	1161.57	805.24	328.99	294.89
2005	0.00	5.97	14.73	15.45	185.87	841.30	1877.55	1815.86	835.41	416.97	238.02	134.36
2006	0.00	2.62	20.54	47.60	72.99	240.31	713.96	1567.83	886.04	362.44	135.77	75.38
2007	0.00	2.16	19.92	72.72	88.52	105.97	268.72	907.71	622.58	176.68	101.14	45.11

Table G10. USA commercial catch mean weight (kg) at age of witch flounder, 1982 - 2007.

	USA Commerical Catch Mean Weight (kg) at Age											
	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	0.050	0.097	0.227	0.295	0.345	0.460	0.549	0.652	0.716	0.927
2007		0.015	0.038	0.109	0.198	0.269	0.372	0.476	0.564	0.678	0.742	0.905
mean												
2003-2007		0.014	0.049	0.097	0.207	0.277	0.349	0.448	0.542	0.628	0.698	0.884
1982-2007	0.004	0.011	0.032	0.087	0.204	0.296	0.400	0.518	0.632	0.772	0.890	1.170

Table G11. 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), 1963-2007, spring 2008 provisional.

	SPRING				AUTUMN			
Year	Number per tow	Weight per tow	Length per tow	Ave. wt. per tow	Number per tow	Weight per tow	Length per tow	Ave. wt. per tow
1963	-	-	-	-	5.52	3.46	39.7	0.627
1964	-	-	-	-	2.89	2.09	44.2	0.724
1965	-	-	-	-	3.94	2.29	40.6	0.580
1966	-	-	-	-	7.89	4.61	41.2	0.585
1967	-	-	-	-	3.00	1.99	43.7	0.666
1968	4.71	3.27	42.3	0.693	4.82	3.52	44.8	0.731
1969	3.73	2.59	45.3	0.695	5.81	4.21	43.5	0.725
1970	6.39	4.50	44.7	0.705	4.89	3.68	45.0	0.753
1971	2.74	2.04	46.5	0.747	4.32	2.96	42.1	0.686
1972	5.35	4.01	45.8	0.749	3.24	2.42	43.9	0.747
1973	8.20	6.21	44.8	0.758	3.18	2.05	43.6	0.646
1974	6.23	3.62	39.3	0.581	2.38	1.58	41.0	0.666
1975	3.72	2.75	43.9	0.739	1.66	1.03	39.8	0.621
1976	5.50	3.70	42.3	0.673	1.34	0.94	41.9	0.699
1977	4.20	1.96	37.2	0.467	5.05	3.38	42.0	0.669
1978	3.87	2.56	41.7	0.662	4.04	2.94	42.8	0.727
1979	2.91	1.71	38.2	0.587	1.94	1.62	45.2	0.838
1980	8.46	3.89	36.0	0.460	2.62	2.04	43.7	0.777
1981	8.14	4.05	38.0	0.497	3.66	2.19	40.4	0.600
1982	3.64	1.87	37.2	0.513	0.99	0.83	44.7	0.842
1983	6.41	2.74	36.3	0.427	4.72	2.12	36.7	0.448
1984	3.00	1.66	39.9	0.554	4.37	2.33	39.7	0.534
1985	5.18	2.75	40.3	0.531	2.76	1.59	41.9	0.577
1986	2.07	1.35	44.1	0.650	1.59	1.09	43.3	0.683
1987	1.01	0.65	43.4	0.646	0.48	0.37	43.9	0.774
1988	1.43	0.85	42.3	0.590	1.38	0.57	35.2	0.414
1989	1.95	0.74	35.8	0.382	0.89	0.38	31.4	0.423
1990	0.63	0.24	35.2	0.378	2.00	0.40	24.7	0.200
1991	1.68	0.57	31.5	0.341	2.08	0.54	29.2	0.258
1992	1.26	0.48	34.8	0.383	0.94	0.24	29.5	0.254
1993	1.47	0.36	30.3	0.245	5.15	0.54	17.0	0.105
1994	3.13	0.53	27.4	0.170	2.21	0.42	24.9	0.191
1995	1.88	0.47	30.6	0.248	4.74	0.62	25.7	0.132
1996	1.36	0.28	30.5	0.204	5.38	1.02	29.7	0.189
1997	2.22	0.43	31.0	0.195	5.10	0.77	24.9	0.150
1998	4.27	0.77	29.0	0.179	3.70	0.47	24.2	0.127
1999	3.15	0.48	28.1	0.153	5.91	0.88	26.3	0.148
2000	3.45	0.52	27.3	0.151	6.63	1.11	27.1	0.167
2001	4.41	0.75	29.5	0.170	7.94	1.71	32.3	0.216
2002	8.10	1.61	31.4	0.199	4.31	1.06	33.2	0.246
2003	5.20	1.30	34.2	0.250	2.66	0.79	35.4	0.298
2004	3.80	1.08	35.5	0.283	3.82	1.03	33.3	0.271
2005	3.36	0.89	34.6	0.265	1.93	0.38	27.8	0.197
2006	3.09	0.72	32.2	0.235	2.03	0.46	30.5	0.226
2007	2.37	0.58	32.9	0.245	2.74	0.57	31.6	0.208
2008	7.45	1.40	31.3	0.188				

No significant survey conversion factors for witch flounder.

Table G12. Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys (Strata 22-30, 36-40), 1980 – 2007, 2008 provisional.

	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

Table G12 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

Table G13. Parameter estimates (with coefficient of variation) and estimates of terminal F from ADAPT VPA formulations for witch flounder, stock size (N) in '000 of fish.

	GARM 2005 BASE RUN	GARM 2008 BASE RUN	GARM 2008 SPLIT RUN
Software	NFT 231	NFT VPA 2.7.7	NFT VPA 2.7.7
Catch-At-Age	1982-2004 3-11+	1982-2007 3-11+	1982-2007 3-11+
Est.Ages	3-10	3-10	3-10
NMFS-s	3-11+	3-11+	3-11+
NMFS-a	3-11+	3-11+	3-11+
Residual Sum Sq.	322.2	378.1	324.1
Mean Sq.Residual	0.811	0.851	0.730
N3 (cv)	3,902 (.65)	26,824 (.67)	11,992 (.63)
N4 (cv)	4,053 (.46)	41,562 (.47)	22,123 (.45)
N5 (cv)	9,206 (.39)	9,973 (.39)	5,433 (.37)
N6 (cv)	14,614 (.35)	2,239 (.35)	1,220 (.34)
N7 (cv)	19,943 (.32)	2,630 (.34)	1,442 (.35)
N8 (cv)	17,315 (.30)	3,903 (.36)	2,074 (.39)
N9 (cv)	8,815 (.27)	2,031 (.38)	957 (.44)
N10 (cv)	2,245 (.37)	4,367 (.26)	1,354 (.36)
F 3	0.006	0.002	0.003
F 4	0.032	0.008	0.015
F 5	0.066	0.043	0.077
F 6	0.069	0.090	0.159
F 7	0.077	0.195	0.339
F 8	0.114	0.249	0.470
F 9	0.284	0.037	0.114
F10	0.199	0.143	0.292
F11+	0.199	0.143	0.292
Avg F 8-9	0.199	0.143 (.27)	0.292 (.27)
SSB (mt)	21,175	7,354 (.14)	3,434 (.15)
Age 3 in terminal yr	4,737	48,367	25,781

SPLIT survey indices are: 1982-1994 and 1995 - onward.

Table G14. Summary of witch flounder spawning stock biomass (mt), fully recruited fishing mortality (F8-9), and recruitment (age 3, millions fish) and year class from VPA **BASE RUN**, 1982 to 2007.

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	11,543	0.63	16.371	1981
1985	10,433	0.68	7.670	1982
1986	9,550	0.50	5.438	1983
1987	8,951	0.60	3.137	1984
1988	8,313	0.70	9.302	1985
1989	7,361	0.44	6.070	1986
1990	6,334	0.25	7.542	1987
1991	6,952	0.25	8.660	1988
1992	7,054	0.23	12.162	1989
1993	5,833	0.45	8.920	1990
1994	4,352	0.60	13.237	1991
1995	4,073	0.62	11.907	1992
1996	3,888	1.14	16.094	1993
1997	4,179	1.07	14.561	1994
1998	5,242	0.65	15.835	1995
1999	6,242	0.53	14.609	1996
2000	7,109	0.55	13.814	1997
2001	7,256	0.86	23.664	1998
2002	7,213	0.48	14.740	1999
2003	7,249	0.60	12.951	2000
2004	6,733	0.58	5.864	2001
2005	7,351	0.36	3.774	2002
2006	7,100	0.21	13.624	2003
2007	7,354	0.14	48.367	2004
			26.825	2005
min	3,888	0.14	3.137	
max	16,903	1.14	48.367	
mean	7,616	0.53	13.639	
geomean			11.548	
median			13.237	

Table G15. Mohn rho statistic (average of relative differences) for fishing mortality (F 8-9), spawning stock biomass (SSB) and Age 3 recruits (Age 3) for the VPA BASE RUN and VPA SPLIT RUN.

		2000	2001	2002	2003	2004	2005	2006	Mean
BASE	F 8-9	0.13	-0.36	-0.13	-0.42	-0.45	-0.57	-0.42	**-0.31**
	SSB	0.50	0.85	1.34	1.38	1.36	0.65	0.31	**0.91**
	Age 3	2.05	1.92	0.45	-0.24	0.00	-0.05	-0.17	**0.56**
SPLIT	F 8-9	0.96	0.03	0.34	-0.18	-0.35	-0.48	-0.48	**-0.02**
	SSB	-0.24	0.19	0.57	0.76	1.01	0.43	0.31	**0.43**
	Age 3	0.44	0.35	-0.18	-0.54	-0.29	-0.32	-0.36	**-0.13**

Table G16. Summary of witch flounder spawning stock biomass (mt), fully recruited fishing mortality (F8-9), and recruitment (age 3, millions fish) and year class from VPA **SPLIT RUN**, 1982 to 2007.

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	11,543	0.63	16.371	1981
1985	10,433	0.68	7.670	1982
1986	9,550	0.50	5.437	1983
1987	8,951	0.60	3.137	1984
1988	8,312	0.70	9.301	1985
1989	7,360	0.44	6.070	1986
1990	6,333	0.25	7.541	1987
1991	6,952	0.25	8.659	1988
1992	7,054	0.23	12.158	1989
1993	5,833	0.45	8.909	1990
1994	4,351	0.60	13.138	1991
1995	4,070	0.62	11.855	1992
1996	3,877	1.14	15.781	1993
1997	4,150	1.07	14.063	1994
1998	5,181	0.66	15.040	1995
1999	6,114	0.54	13.104	1996
2000	6,874	0.56	12.039	1997
2001	6,831	0.90	15.032	1998
2002	6,429	0.53	12.083	1999
2003	5,941	0.71	9.073	2000
2004	4,835	0.81	3.697	2001
2005	4,575	0.63	2.175	2002
2006	3,696	0.47	7.495	2003
2007	3,434	0.29	25.781	2004
			11.992	2005
min	3,434	0.23	2.175	
max	16,903	1.14	25.781	
mean	7,039	0.58	11.138	
geomean			9.805	
median			11.992	

Table G17. 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, 1982-2007 VPA **SPLIT RUN**.

JAN-1 Population Numbers

AGE	1982	1983	1984	1985	1986
3	15409.	17706.	16371.	7670.	5437.
4	12176.	13086.	14927.	13955.	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.	62340.	51884.	40818.

AGE	1987	1988	1989	1990	1991
3	3137.	9301.	6070.	7541.	8659.
4	4659.	2680.	7449.	5142.	6208.
5	5234.	3842.	2177.	6124.	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	30227.	30535.	27856.	28300.	30654.

AGE	1992	1993	1994	1995	1996
3	12158.	8909.	13138.	11855.	15781.
4	6993.	10314.	7588.	11245.	9607.
5	4759.	5121.	7946.	5936.	9327.
6	2502.	3067.	3099.	4933.	4143.
7	3313.	1173.	1788.	1426.	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	34689.	33586.	36429.	37299.	42572.

AGE	1997	1998	1999	2000	2001
3	14063.	15040.	13104.	12039.	15032.
4	13448.	11989.	12734.	11136.	10247.
5	7916.	10927.	10031.	10511.	9239.
6	7190.	5983.	8709.	7731.	8520.
7	2317.	5071.	3926.	6091.	5575.
8	955.	1054.	2850.	2221.	3658.
9	136.	279.	555.	1710.	970.
10	80.	40.	106.	234.	948.
11	113.	183.	182.	589.	687.
Total	46220.	50567.	52196.	52261.	54875.

JAN-1 Population Numbers

AGE	2002	2003	2004	2005	2006
3	12083.	9073.	3697.	2175.	7495.
4	12876.	10370.	7779.	3152.	1858.
5	8508.	10547.	8659.	6362.	2541.
6	6985.	6283.	8041.	6361.	4697.
7	6288.	4752.	3906.	5428.	3743.
8	3175.	3430.	2331.	1953.	2998.
9	1783.	1554.	1497.	940.	913.
10	246.	940.	640.	550.	425.
11	523.	753.	574.	310.	236.
Total	52467.	47701.	37124.	27231.	24906.

AGE	2007	2008
3	25781.	11992.
4	6407.	22123.
5	1531.	5433.
6	1964.	1220.
7	3383.	1442.
8	1779.	2074.
9	1763.	957.
10	452.	1354.
11	191.	414.
Total	43252.	47009.

Fishing Mortality Calculated

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	0.0840	0.1158
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	0.1704	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	0.0602	0.0099
4	0.1614	0.1109	0.0954	0.0370	0.0436
5	0.2893	0.3523	0.3268	0.2097	0.1102
6	0.6079	0.3897	0.6265	0.4648	0.4311
7	0.2696	0.7880	0.8343	1.0151	0.8769
8	0.2904	0.3402	0.6252	0.5647	1.0313
9	0.1605	0.5501	0.5725	0.6824	1.2535
10	0.2104	0.3793	0.5857	0.5917	1.1195
11	0.2104	0.3793	0.5857	0.5917	1.1195

AGE	1997	1998	1999	2000	2001
3	0.0096	0.0165	0.0128	0.0112	0.0048
4	0.0576	0.0283	0.0419	0.0367	0.0359
5	0.1299	0.0769	0.1104	0.0600	0.1297
6	0.1991	0.2713	0.2075	0.1770	0.1537
7	0.6375	0.4263	0.4199	0.3600	0.4129
8	1.0825	0.4916	0.3609	0.6781	0.5688
9	1.0661	0.8187	0.7139	0.4393	1.2219
10	1.0804	0.5516	0.4106	0.5672	0.6747
11	1.0804	0.5516	0.4106	0.5672	0.6747

Fishing Mortality Calculated

AGE	2002	2003	2004	2005	2006
3	0.0029	0.0039	0.0097	0.0077	0.0069
4	0.0495	0.0303	0.0511	0.0656	0.0432
5	0.1532	0.1213	0.1585	0.1533	0.1073
6	0.2352	0.3253	0.2429	0.3804	0.1783
7	0.4560	0.5622	0.5430	0.4435	0.5939
8	0.5645	0.6792	0.7585	0.6108	0.3808
9	0.4901	0.7366	0.8515	0.6425	0.5528
10	0.5371	0.6968	0.7938	0.6210	0.4184
11	0.5371	0.6968	0.7938	0.6210	0.4184

AGE	2007
3	0.0030
4	0.0150
5	0.0774
6	0.1590
7	0.3393
8	0.4696
9	0.1140
10	0.2918
11	0.2918

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	0.5070
1987	0.6027	0.6050	0.6042	0.6051
1988	0.7027	0.7439	0.7349	0.7524
1989	0.4388	0.3546	0.3635	0.3799
1990	0.2524	0.2421	0.2345	0.2664
1991	0.2481	0.2283	0.2352	0.2558
1992	0.2254	0.2124	0.2078	0.2295
1993	0.4451	0.3827	0.3913	0.3973
1994	0.5988	0.5860	0.5840	0.5866
1995	0.6235	0.5930	0.5993	0.5961
1996	1.1424	1.1255	1.1364	1.1313
1997	1.0743	1.0804	1.0799	1.0805
1998	0.6551	0.5599	0.5787	0.5819
1999	0.5374	0.4185	0.4247	0.4484
2000	0.5587	0.5742	0.5659	0.5929
2001	0.8953	0.7057	0.7241	0.7666
2002	0.5273	0.5378	0.5348	0.5396
2003	0.7079	0.6971	0.6988	0.6978
2004	0.8050	0.7949	0.7983	0.7966
2005	0.6267	0.6211	0.6223	0.6214
2006	0.4668	0.4210	0.4274	0.4308
2007	0.2918	0.2926	0.2766	0.3910

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.	8313.	7360.	6334.	6951.

AGE	1992	1993	1994	1995	1996
3	25.	22.	31.	11.	11.
4	137.	162.	137.	163.	98.
5	473.	479.	685.	629.	860.
6	585.	712.	652.	1291.	1167.
7	1362.	422.	622.	546.	1061.
8	501.	1228.	235.	354.	228.
9	921.	393.	872.	146.	199.
10	550.	794.	218.	516.	70.
11	2500.	1621.	899.	414.	183.
Total	7053.	5833.	4350.	4069.	3875.

AGE	1997	1998	1999	2000	2001
3	6.	18.	21.	26.	45.
4	104.	157.	204.	167.	164.
5	582.	976.	776.	801.	621.
6	1826.	1305.	1873.	1447.	1410.
7	905.	1823.	1377.	1958.	1655.
8	459.	500.	1344.	943.	1474.
9	87.	173.	288.	917.	439.
10	62.	33.	86.	137.	520.
11	119.	196.	145.	478.	503.
Total	4150.	5181.	6113.	6874.	6831.

Spawning Stock Biomass

AGE	2002	2003	2004	2005	2006
3	72.	30.	26.	21.	45.
4	292.	218.	179.	99.	46.
5	574.	744.	556.	551.	180.
6	1096.	867.	1075.	949.	644.
7	1686.	1177.	870.	1297.	849.
8	1225.	1196.	755.	680.	1058.
9	892.	682.	626.	428.	430.
10	155.	498.	321.	302.	245.
11	437.	529.	427.	248.	199.
Total	6431.	5942.	4834.	4574.	3695.

AGE	2007
3	172.
4	130.
5	98.
6	272.
7	783.
8	637.
9	906.
10	275.
11	161.
Total	3434.

Table G18. Witch flounder input vectors for biological reference points (yield and spawning biomass per recruit analyses and long-term stochastic projections).

BASE RUN

Age	Partial recruit-ment	Sel. on M	Mean Stock wts	Mean Catch wts	Mean SpStock wts	Maturity
3	0.009	1	0.068	0.097	0.068	0.09
4	0.075	1	0.140	0.207	0.140	0.16
5	0.236	1	0.242	0.277	0.242	0.29
6	0.427	1	0.312	0.349	0.312	0.45
7	0.891	1	0.398	0.448	0.398	0.63
8	1.000	1	0.493	0.542	0.493	0.78
9	1.000	1	0.582	0.628	0.582	0.88
10	1.000	1	0.659	0.698	0.659	0.94
11+	1.000	1	0.884	0.884	0.884	1.00

SPLIT RUN

Age	Partial recruit-ment	Sel. on M	Mean Stock wts	Mean Catch wts	Mean SpStock wts	Maturity
3	0.009	1	0.068	0.097	0.068	0.09
4	0.076	1	0.140	0.207	0.140	0.16
5	0.225	1	0.242	0.277	0.242	0.29
6	0.427	1	0.312	0.349	0.312	0.45
7	0.849	1	0.398	0.448	0.398	0.63
8	1.000	1	0.493	0.542	0.493	0.78
9	1.000	1	0.582	0.628	0.582	0.88
10	1.000	1	0.659	0.698	0.659	0.94
11+	1.000	1	0.884	0.884	0.884	1.00

BASE RUN

year	Age - 3 ('000 fish)
1982	15,409
1983	17,706
1984	16,371
1985	7,670
1986	5,438
1987	3,137
1988	9,302
1989	6,070
1990	7,542
1991	8,660
1992	12,162
1993	8,920
1994	13,237
1995	11,907
1996	16,094
1997	14,561
1998	15,835
1999	14,609
2000	13,814
2001	23,664
2002	14,740
2003	12,951
2004	5,864
2005	3,774
2006	13,624
2007	48,367
2008	26,825
mean	13,639

SPLIT RUN

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	12,158
1993	8,909
1994	13,138
1995	11,855
1996	15,781
1997	14,063
1998	15,040
1999	13,104
2000	12,039
2001	15,032
2002	12,083
2003	9,073
2004	3,697
2005	2,175
2006	7,495
2007	25,781
2008	11,992
mean	11,138

Table G19. Witch flounder yield and spawning stock biomass per recruit results and corresponding biological reference points. For SARC37, the F_{MSY}, SSB_{MSY} and MSY were based on yield and spawning stock biomass per recruit and mean 3 age recruitment.

For GARM 2008, the F_{MSY} = F40%MSP is based on yield per recruit analyses, while the SSB_{MSY} and MSY estimates are based on long-term stochastic projections using the VPA BASE RUN and the VPA SPLIT RUN. (*Note: mean age 3 recruitment values are not used in the calculations of GARM2008* SSB_{MSY} *and MSY estimates*).

					Y/R and SSB/R		Agepro Projections	
	Fmsy F40%	Y/R (kg)	SSB/R (kg)	Mean Age 3 Recruitment (fish,millions)	SSBmsy (mt)	MSY (mt)	SSBmsy (mt)	MSY (mt)
SARC 37	0.23	0.2232	1.2882	19.6	25,248	4,375		
GARM 2008 (using data through 2006)								
BASE RUN	0.22	0.1982	0.9890	13.2			12,687	2,578
SPLIT RUN	0.22	0.1987	0.9889	10.9			10,863	2,195
GARM 2008								
BASE RUN	0.20	0.1939	0.9347	13.6			12,180	2,528
SPLIT RUN	0.20	0.1943	0.9346	11.1			11,447	2,352

Table G20. Short-term projected median estimates of catch (mt) and spawning stock biomass (mt) of witch flounder in 2009 under three fishing mortality scenarios: F status quo, F_{MSY} and F-rebuild based on the VPA **SPLIT RUN**. Projections assumed 2008 catches = 2007 catches; initial 2008 stock sizes for ages 3 to 11+ are from the calibrated VPA, average 2003-2007 partial recruitment, average 2003-2007 mean weights and maturation ogive representing 2004-2008 maturities are given below.

Projection input vectors:

age	VPA SPLIT RUN partial recruitment	Selectivity On M	Stock wts	Catch wts	Spawning wts	2006 Maturity
3	0.009	1	0.0678	0.0975	0.0678	0.09
4	0.076	1	0.1399	0.2067	0.1399	0.16
5	0.225	1	0.2423	0.2773	0.2423	0.29
6	0.427	1	0.3125	0.3487	0.3125	0.45
7	0.849	1	0.3979	0.4484	0.3979	0.63
8	1.000	1	0.4926	0.5424	0.4926	0.78
9	1.000	1	0.5820	0.6279	0.5820	0.88
10	1.000	1	0.6588	0.6985	0.6588	0.94
11+	1.000	1	0.8838	0.8838	0.8838	1.00

Projection results based on SPLIT RUN:

2007			2008		2009	
Catch	SSB	F	Catch	SSB	Catch	SSB
1,172	3,434	Fsq= 0.29	*1,172*	3,876	1,297	4,792
		Fmsy= 0.20			921	4,838
		Frebuild = 0.194			896	4,853

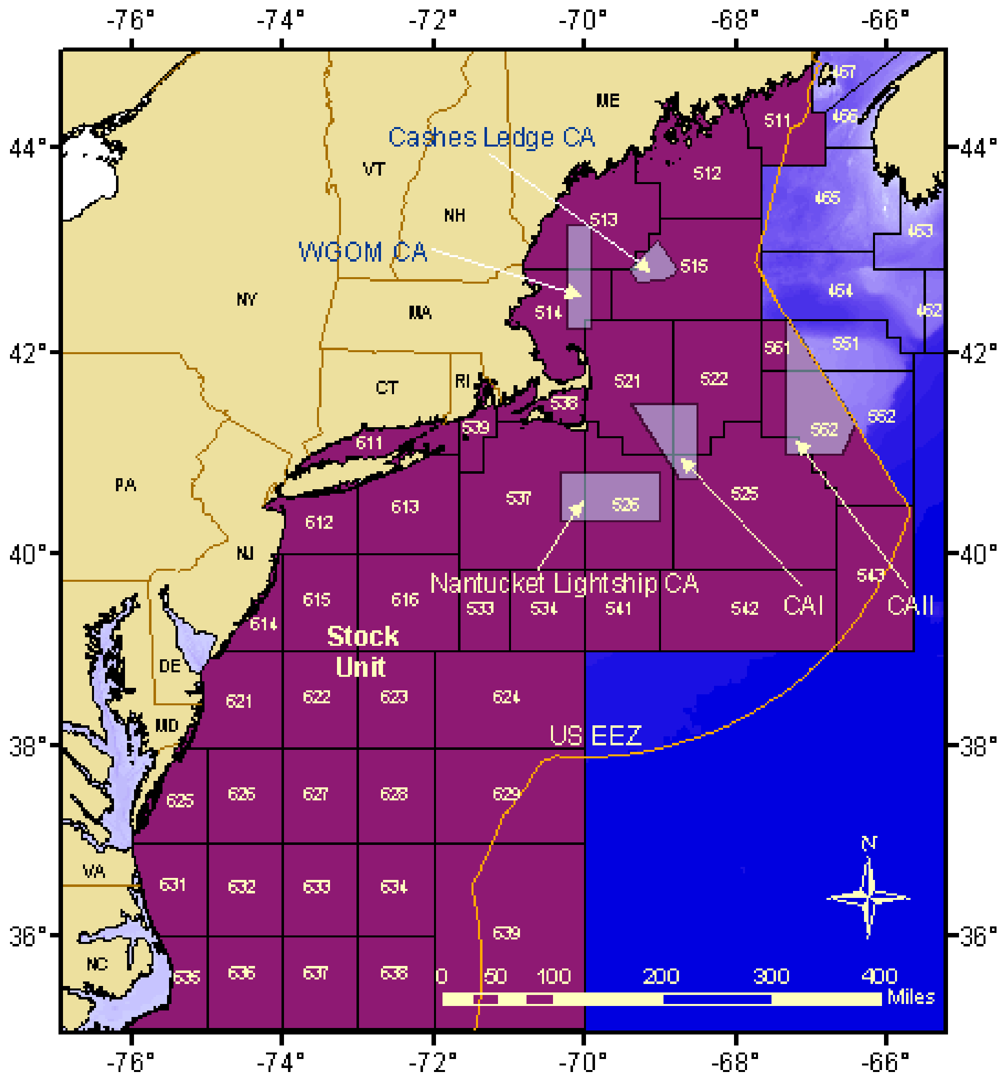


Figure G1. Statistical areas used to define the witch flounder stock.

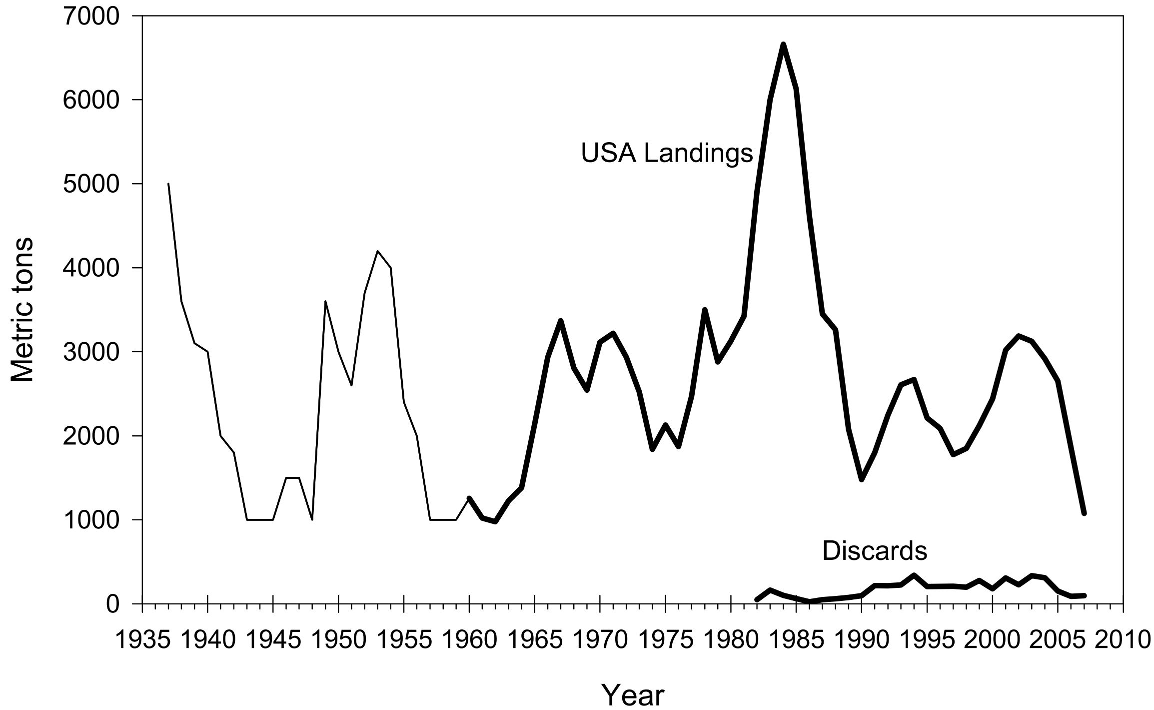


Figure G2. Historical USA witch flounder landings (mt), excluding USA landings from the Grand Banks in the mid-1980's. The thin line represents provisional landings data taken from Lange and Lux (1978). Discards are from the northern shrimp, small-mesh (<5.5 inch) otter trawl and large-mesh (>5.5 inch) otter trawl fisheries.

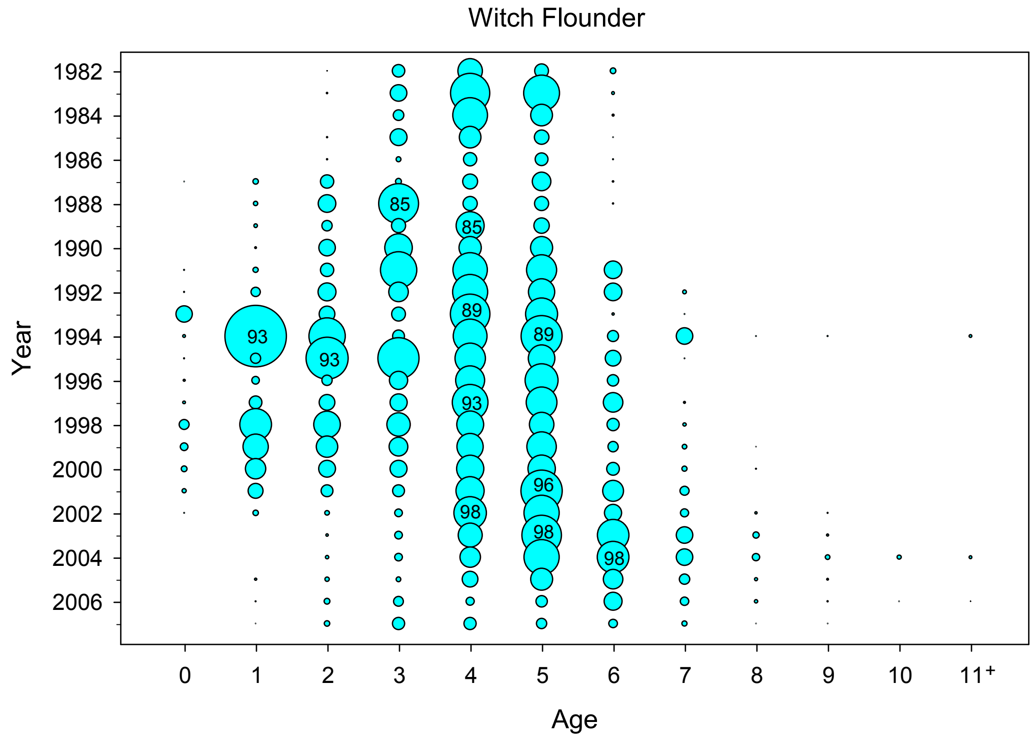


Figure G3. Witch flounder discards at age (in numbers) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 to 2007; selected cohorts are labeled.

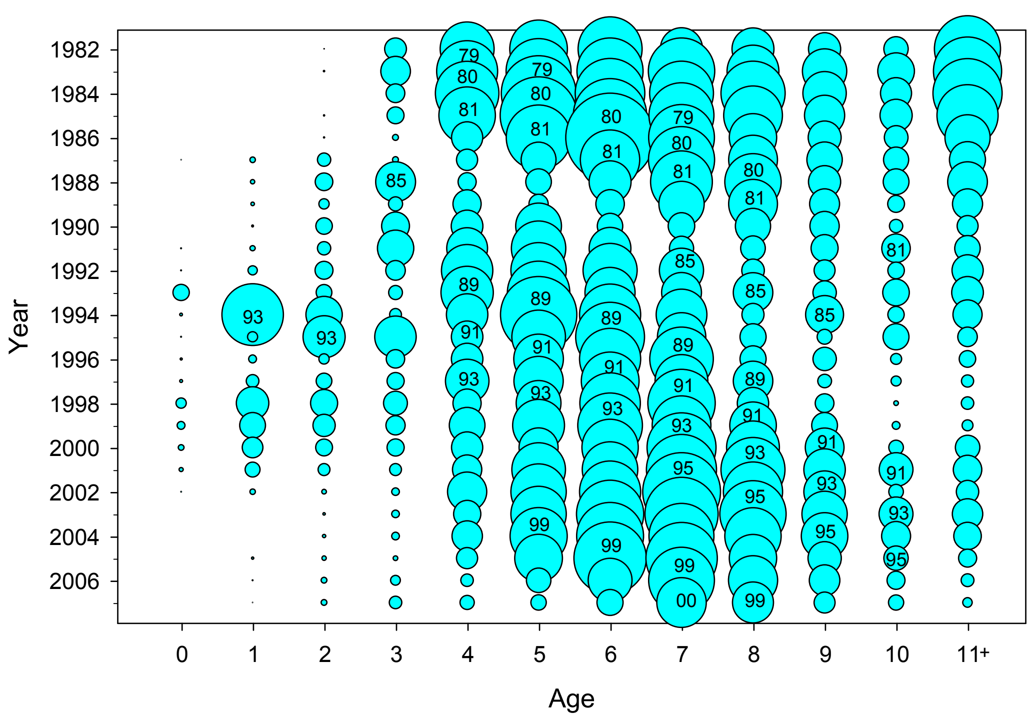


Figure G4. Witch flounder catch at age (in numbers), 1982-2007; selected cohorts are labeled.

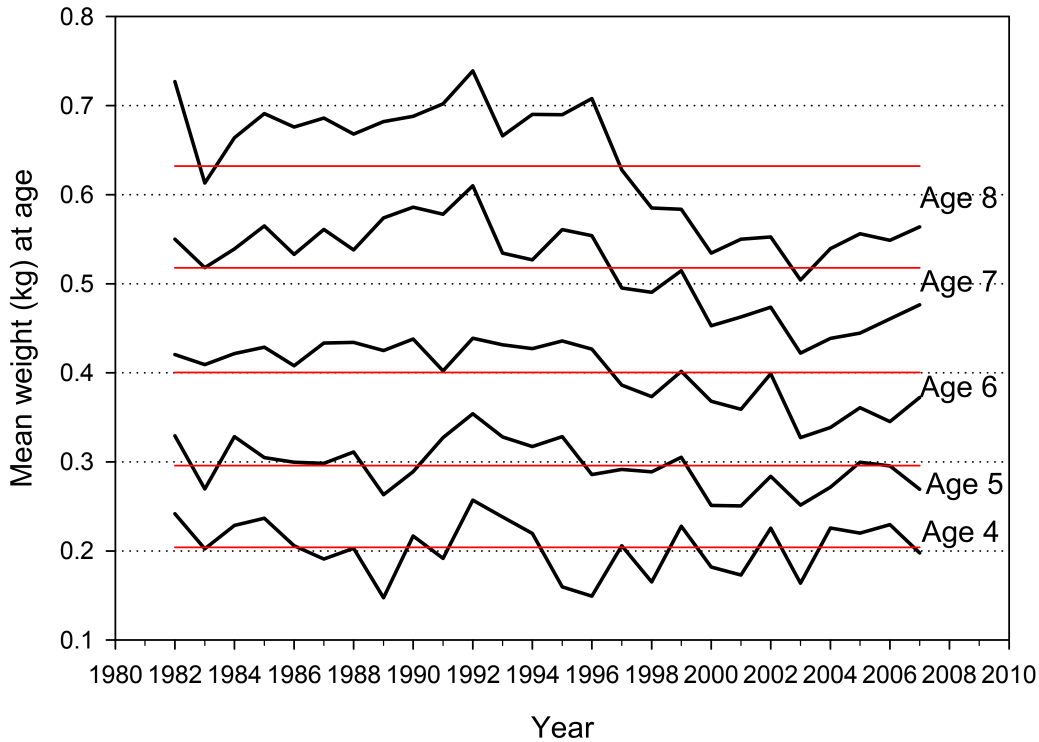


Figure G5. Witch flounder mean weight at age in the catch, 1982 -2007. Horizontal red line represents the 1982-2007 average for each age.

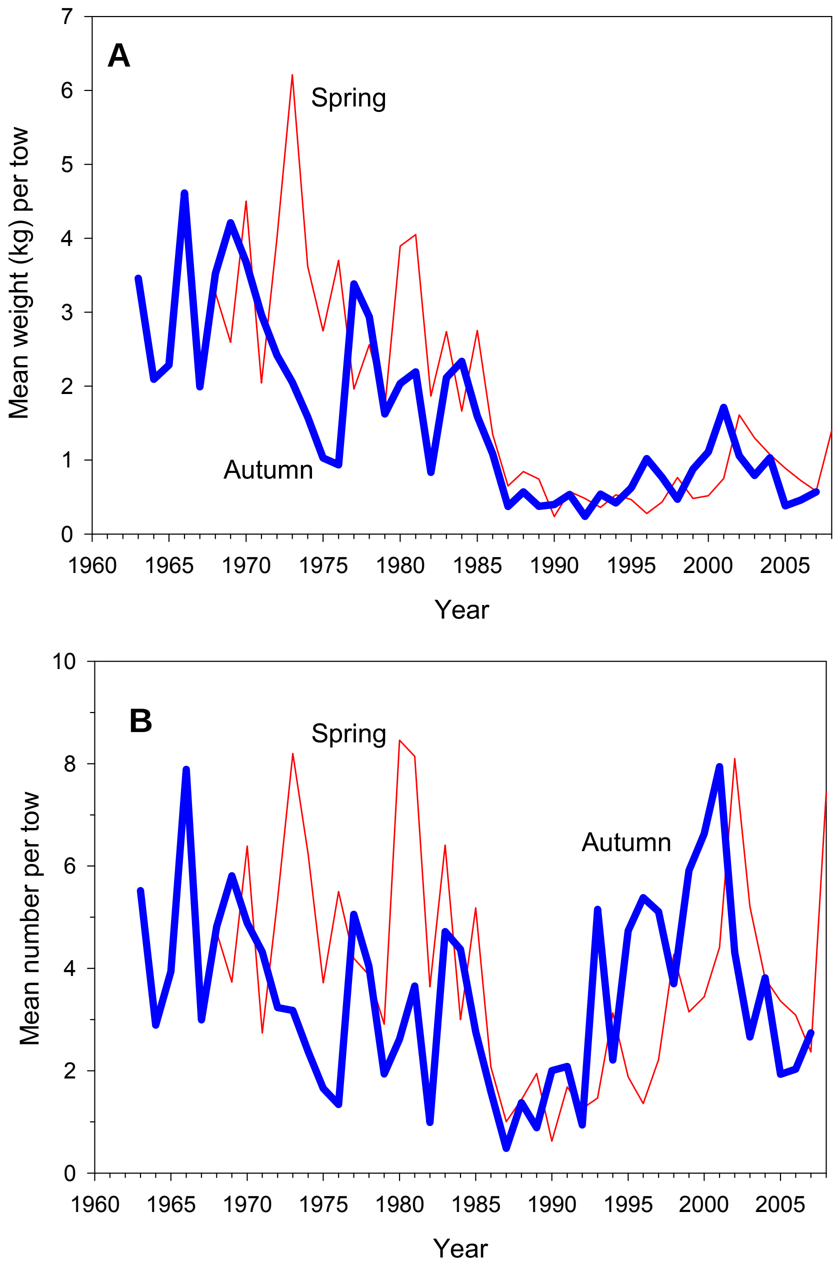
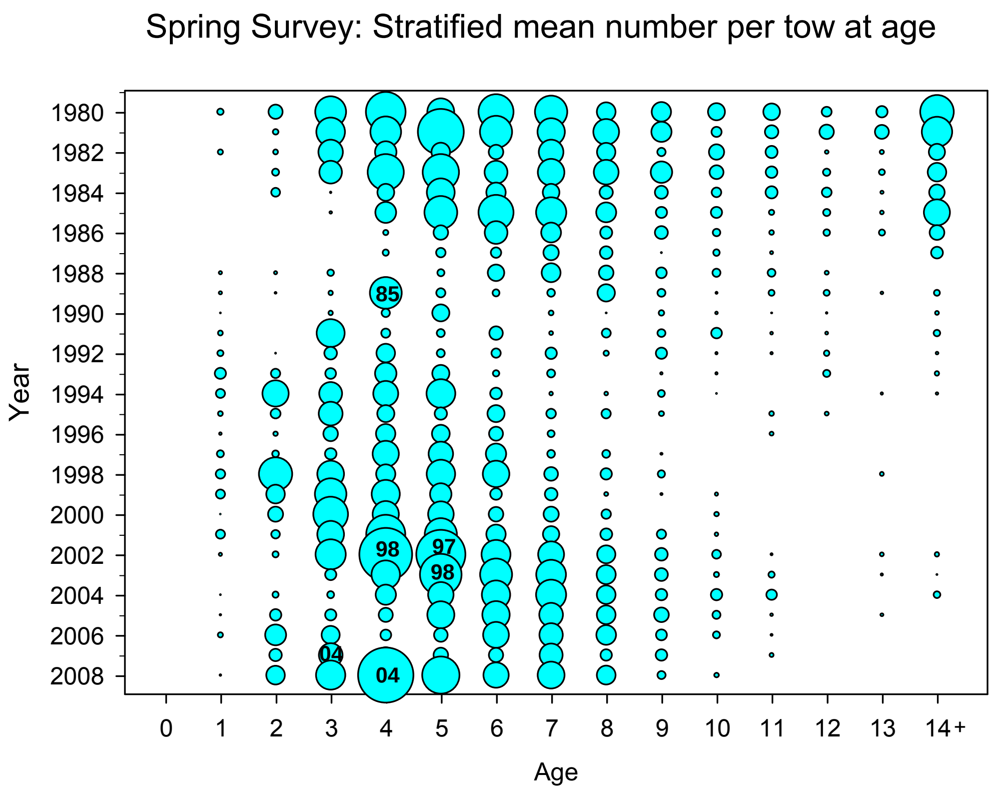


Figure G6. Stratified mean weight (kg) per tow (A) and mean number per tow (B) of witch flounder in the NEFSC spring and autumn bottom trawl surveys, 1963-2007, provisional spring 2008.



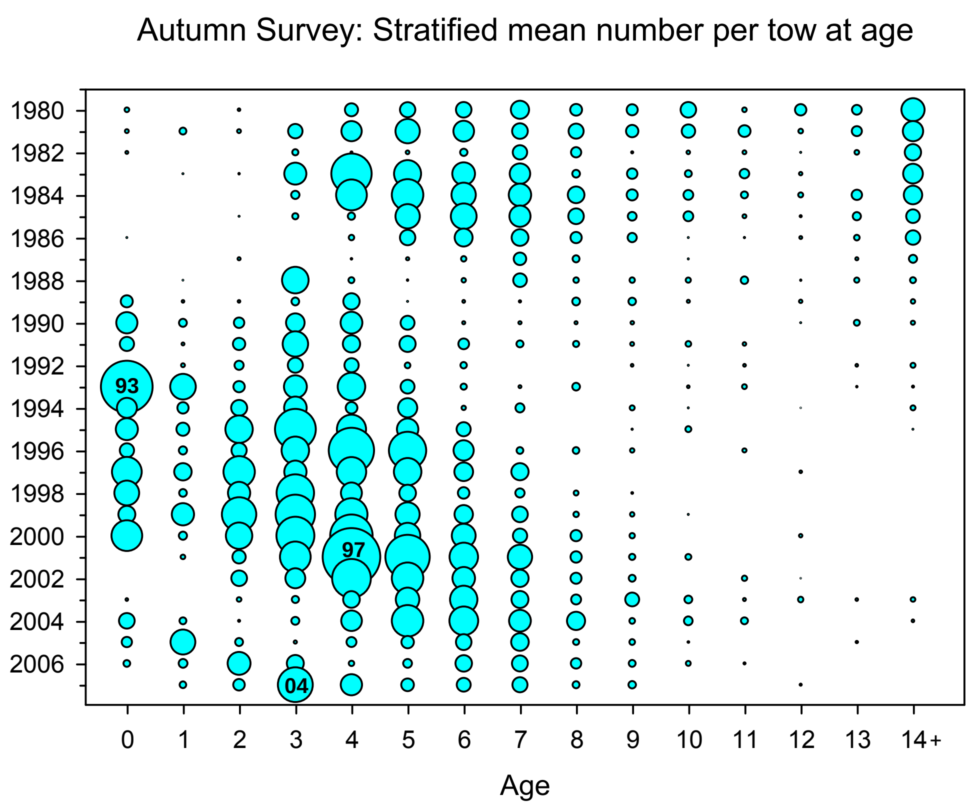


Figure G7. Stratified mean number of witch flounder per tow at age from NEFSC spring (top) and autumn (bottom) surveys, 1982- 2007, provisional spring 2008.

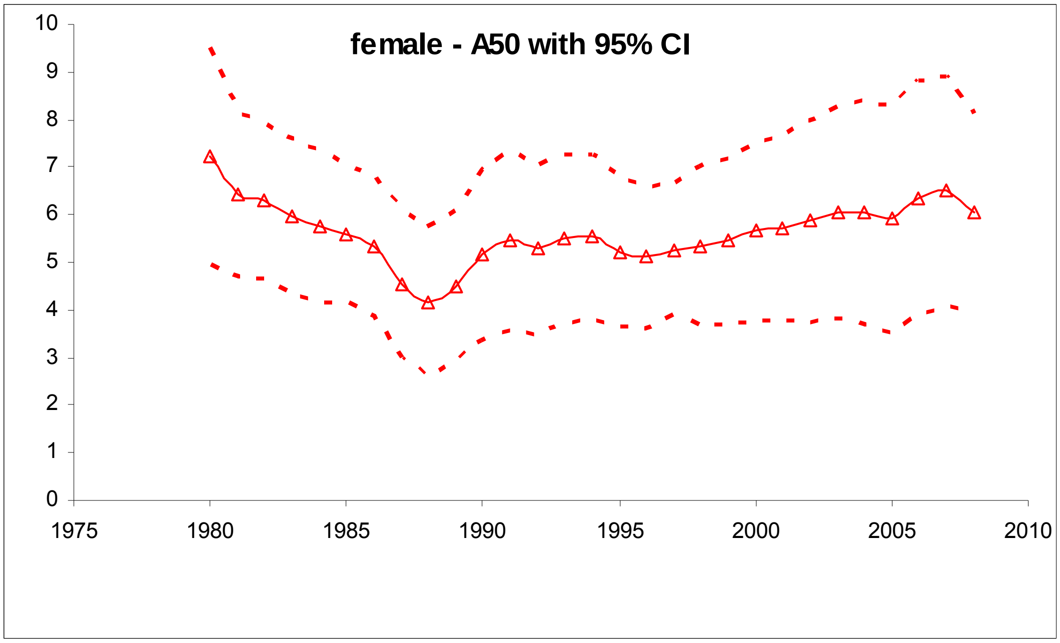
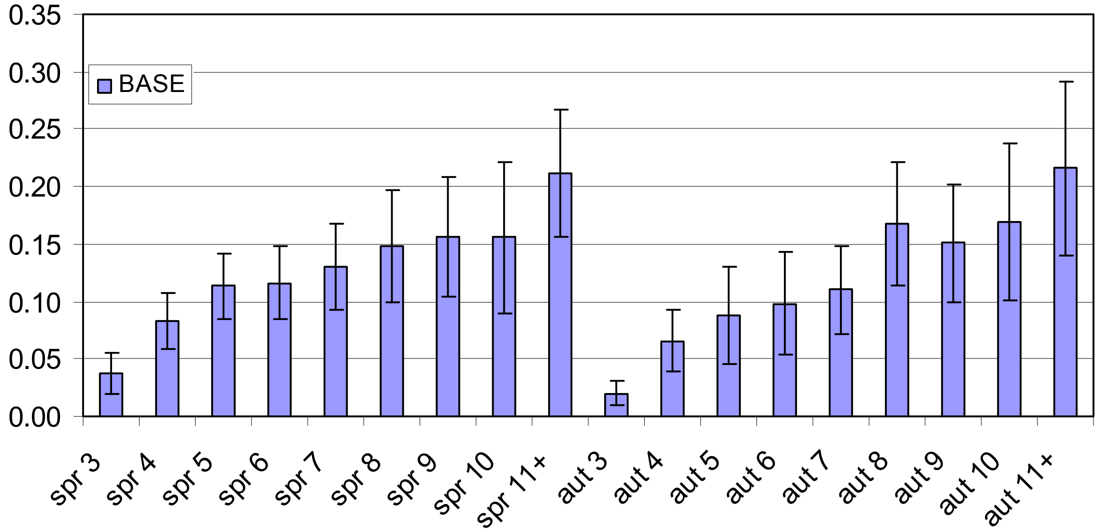


Figure G8. Annual estimates of median age (A50) of female witch flounder maturity derived from a five-year moving time block of maturity observations collected during the NEFSC spring survey, 1980 – 2008.



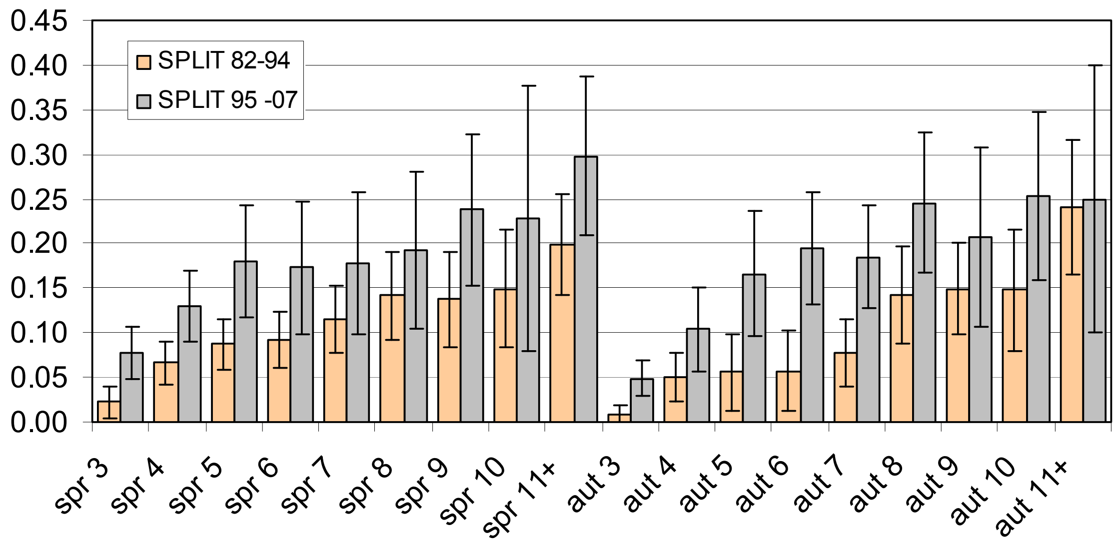


Figure G9. NEFSC swept-area survey catchabilities (q) by age (3 to 11+) and season (spring and autumn) from the VPA BASE RUN (top) and the VPA SPLIT RUN (bottom; survey tuning indices split between 1994 and 1995).

BASE RUN

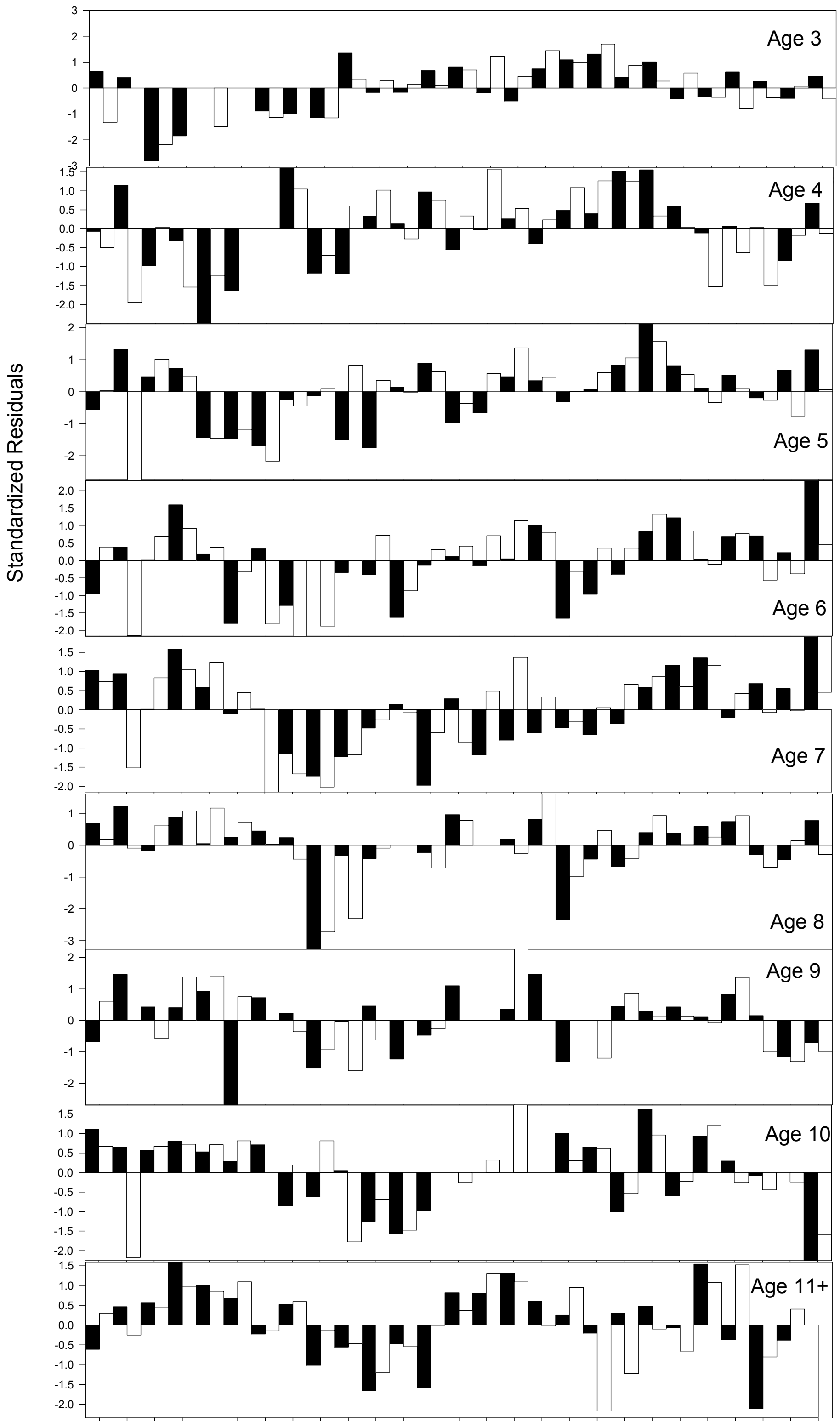


Figure G10. Witch flounder standardized residuals for NEFSC survey indices (spring solid bar and autumn open bar) at age from the VPA **BASE RUN**; 1982-2007.

BASE RUN

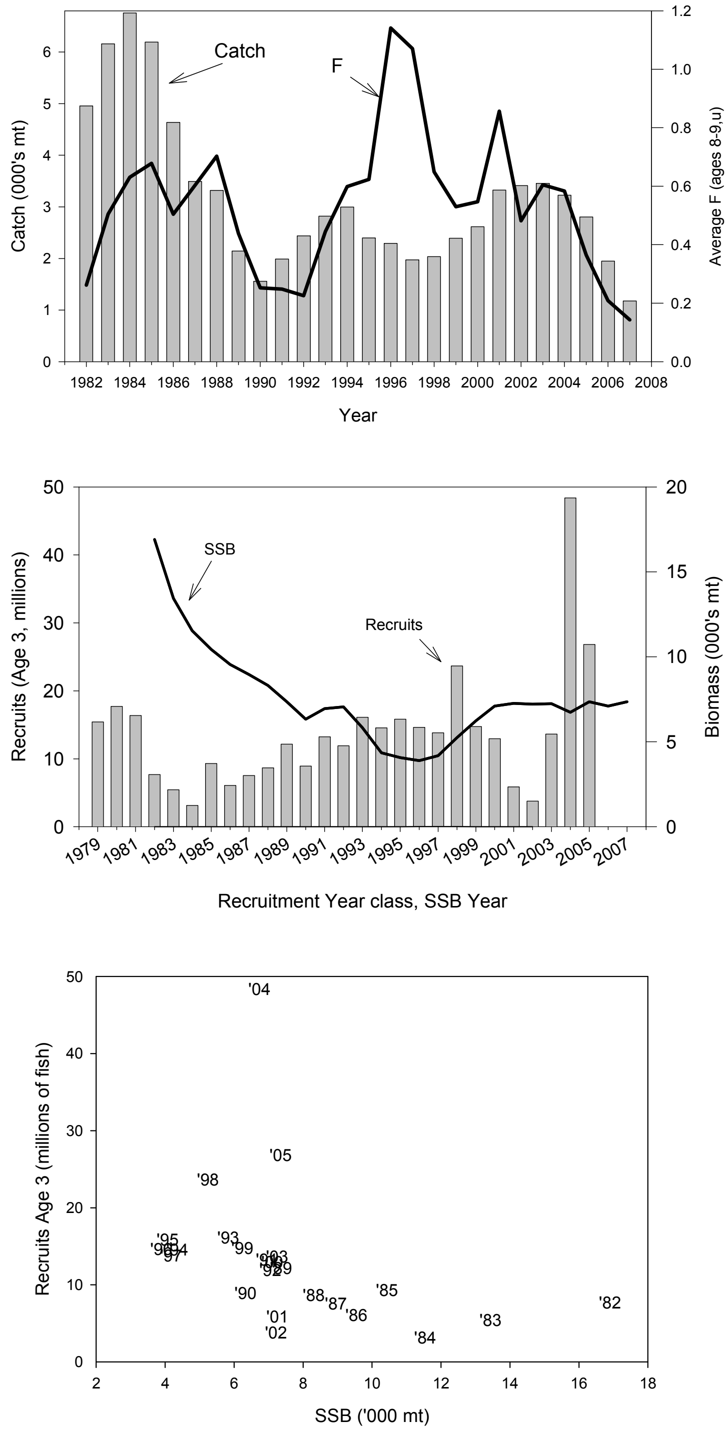


Figure G11. Trends of witch flounder total catch and fishing mortality (top), spawning stock biomass and Age 3 recruitment (middle), and spawning stock biomass (thousands, mt) and recruits (age 3, millions), 1982 – 2005 year classes (bottom) from VPA **BASE RUN,** 1982 – 2007.

VPA BASE RUN

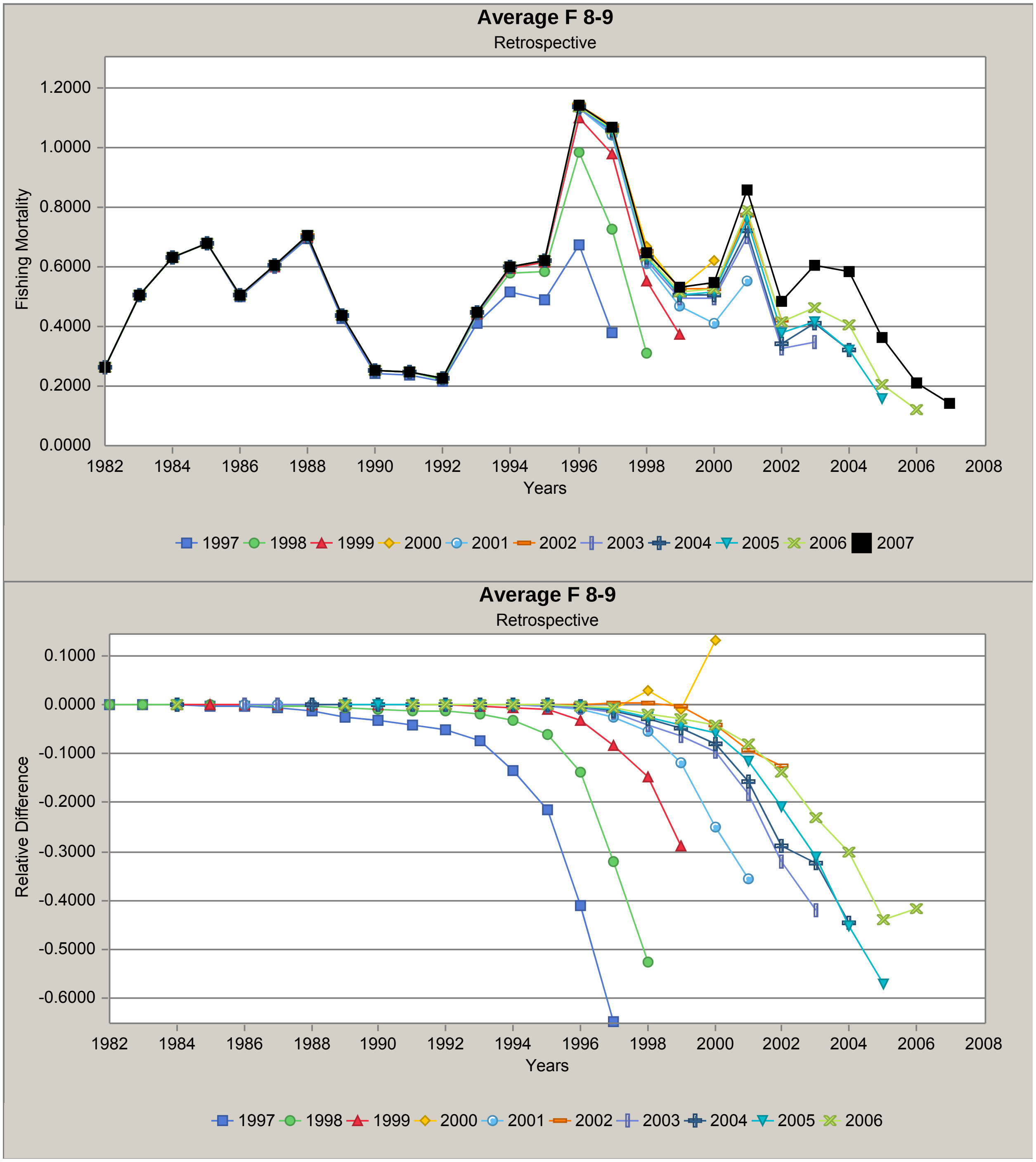


Figure G12. Retrospective analysis results of fishing mortality (top) and relative difference of fishing mortality from the terminal year (bottom) from VPA **BASE RUN**.

VPA BASE RUN

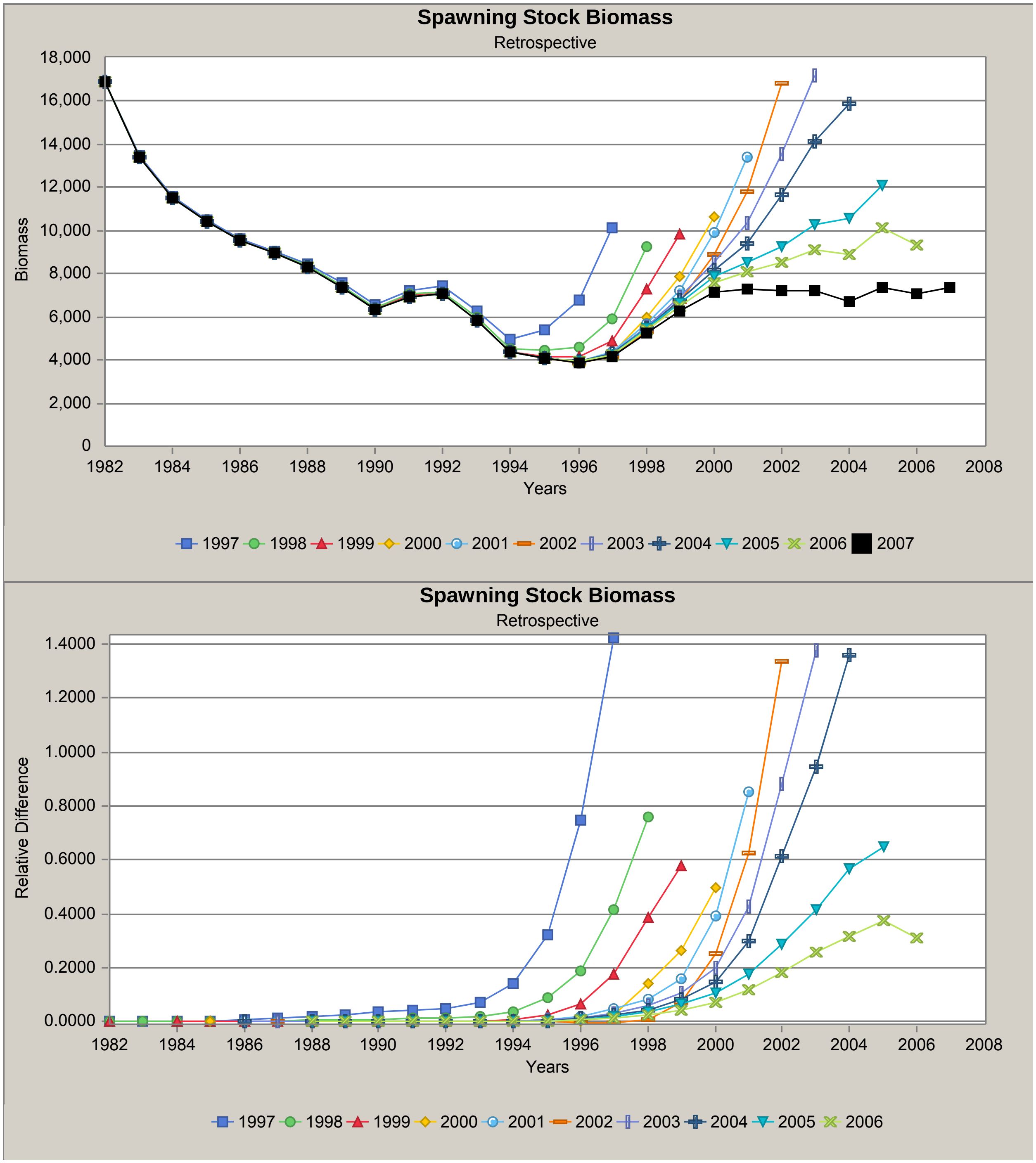
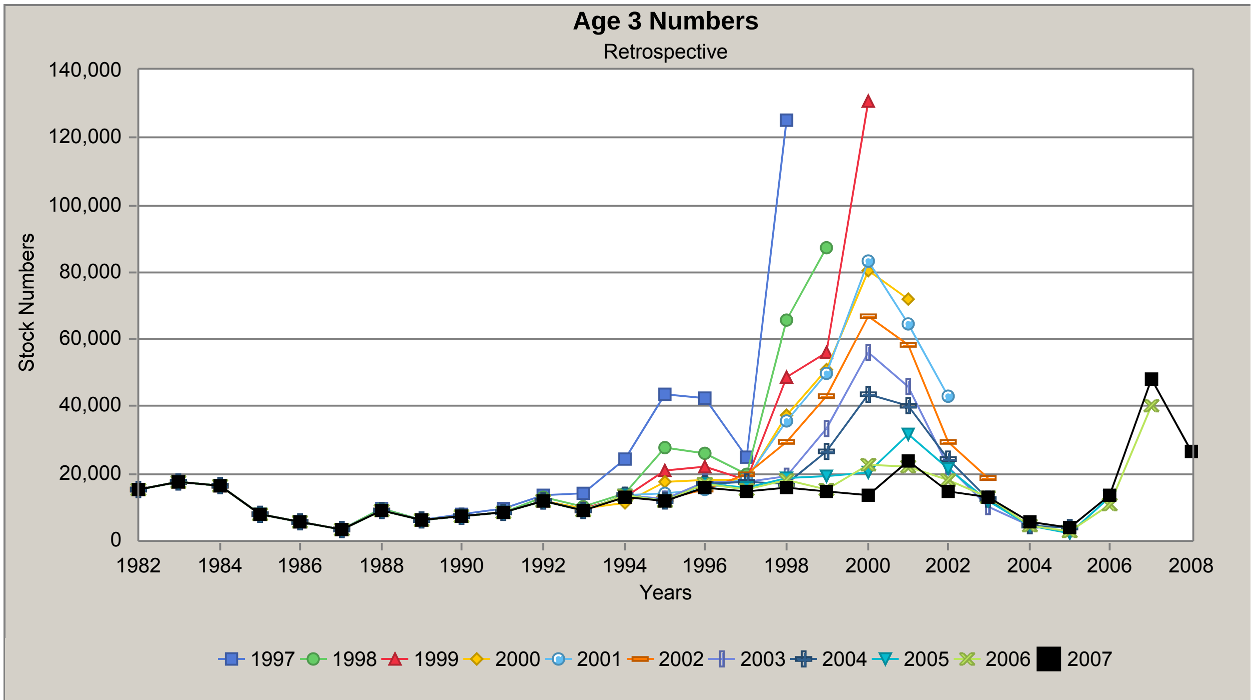


Figure G13. Retrospective analysis results of spawning biomass (top) and relative difference of spawning biomass from the terminal year (bottom) from VPA **BASE RUN**.



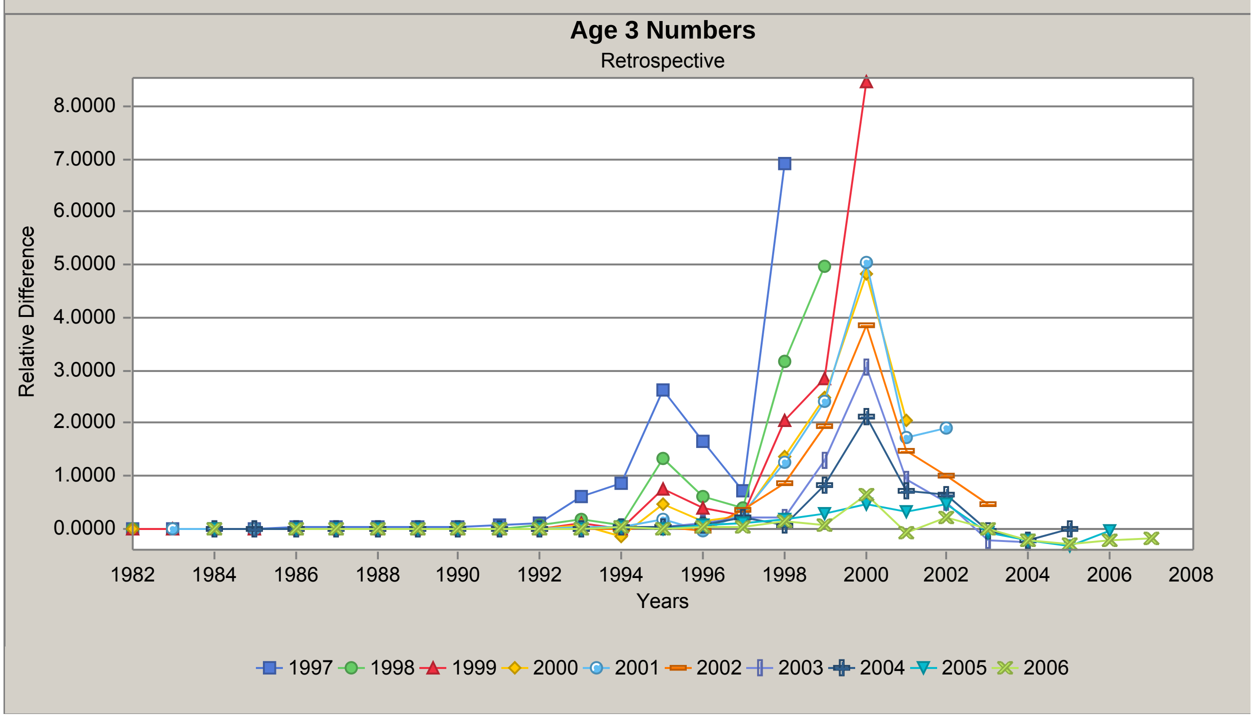


Figure G14. Retrospective analysis results of Age 3 recruitment (top) and relative difference of Age 3 recruitment from the terminal year (bottom) from VPA **BASE RUN**.

BASE RUN

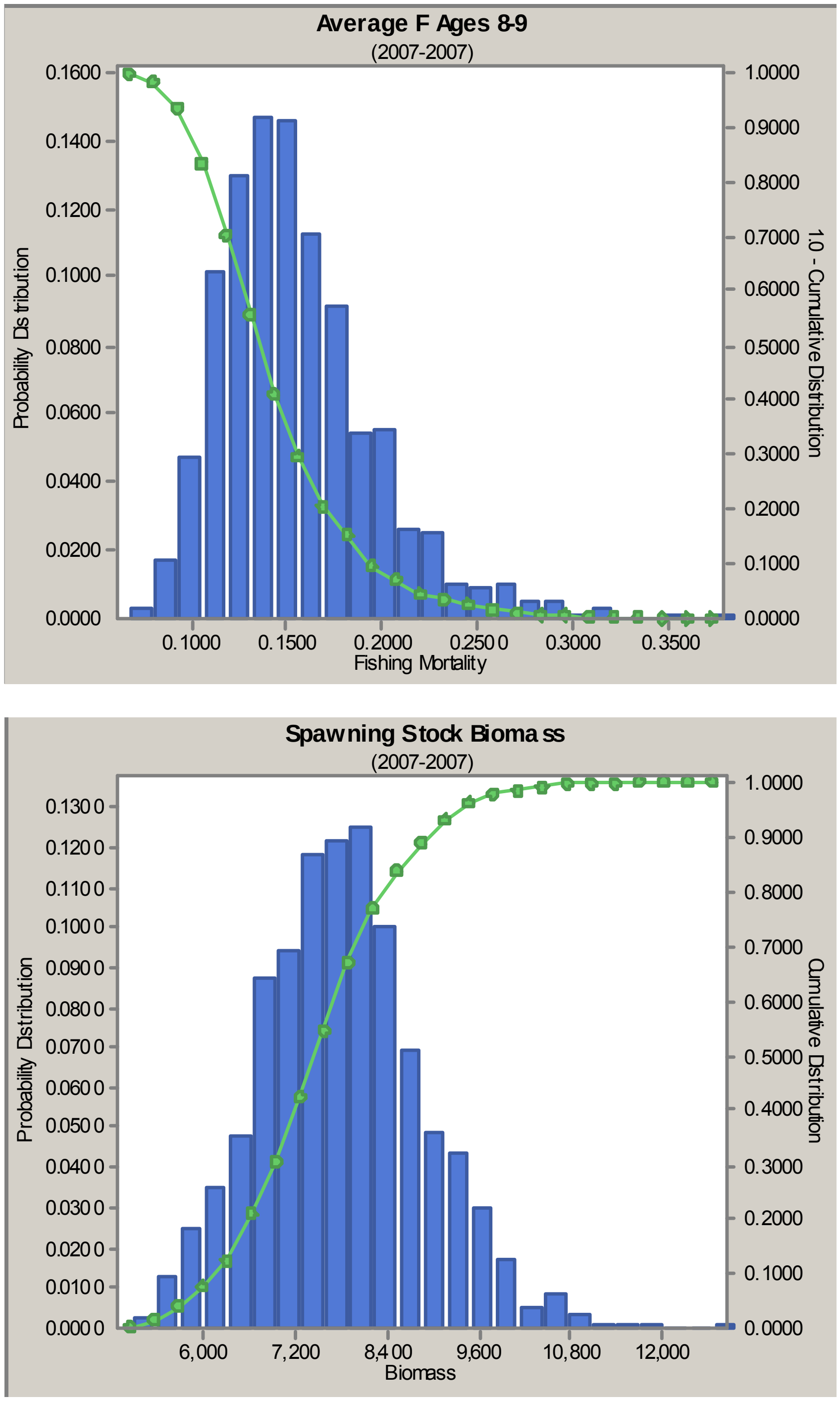


Figure G15 Precision estimates of fishing mortality (top) and spawning stock biomass (mt; bottom) in 2007 from the VPA **BASE RUN**. Vertical bars display both the range of the bootstrap estimates and the probability of the individual values in the range.

SPLIT RUN

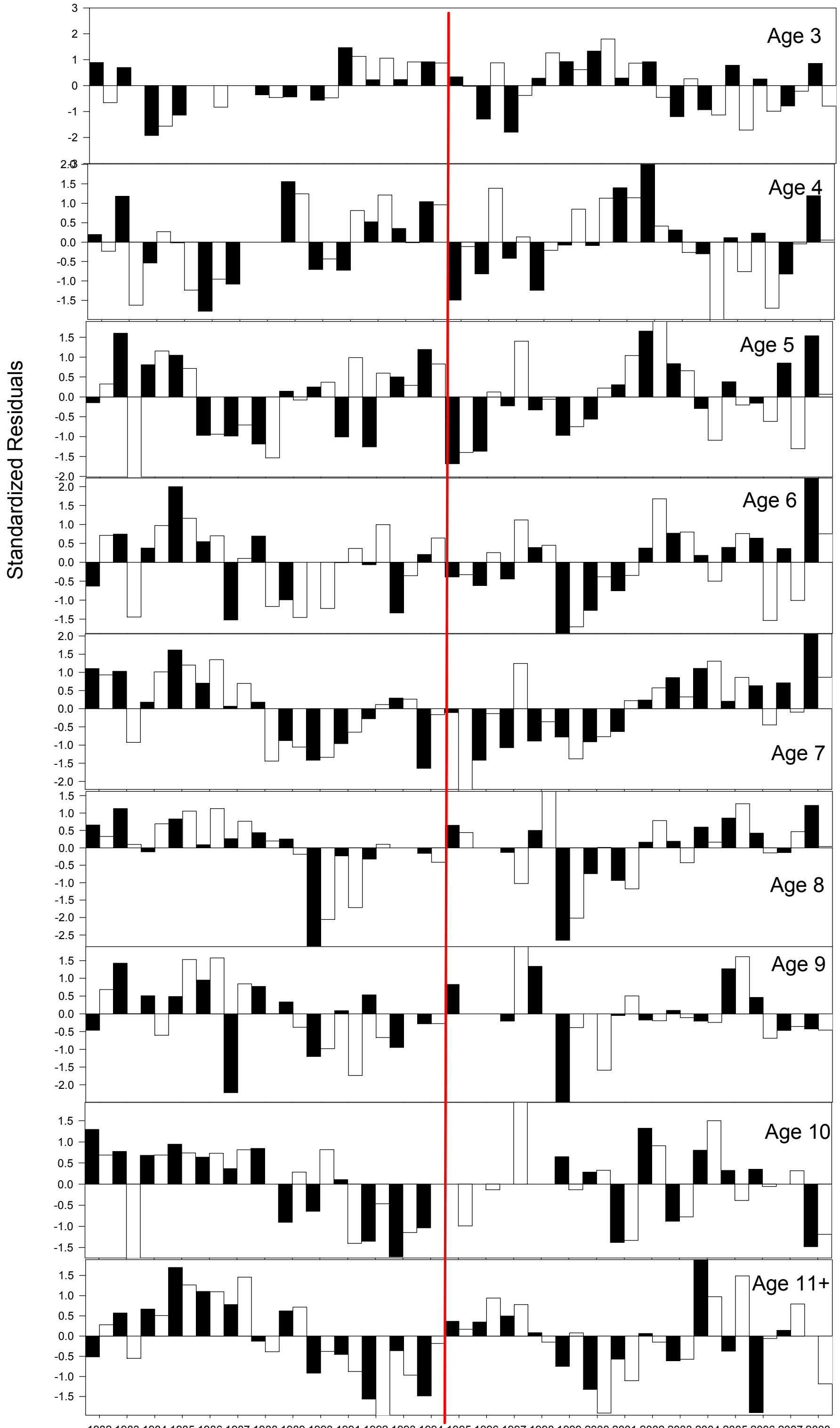


Figure G16. Witch flounder standardized residuals for NEFSC survey indices (spring solid bar and autumn open bar) at age from the VPA **SPLIT RUN**; 1982-2007. Red line indicates the 1994 and 1995 split.

SPLIT RUN

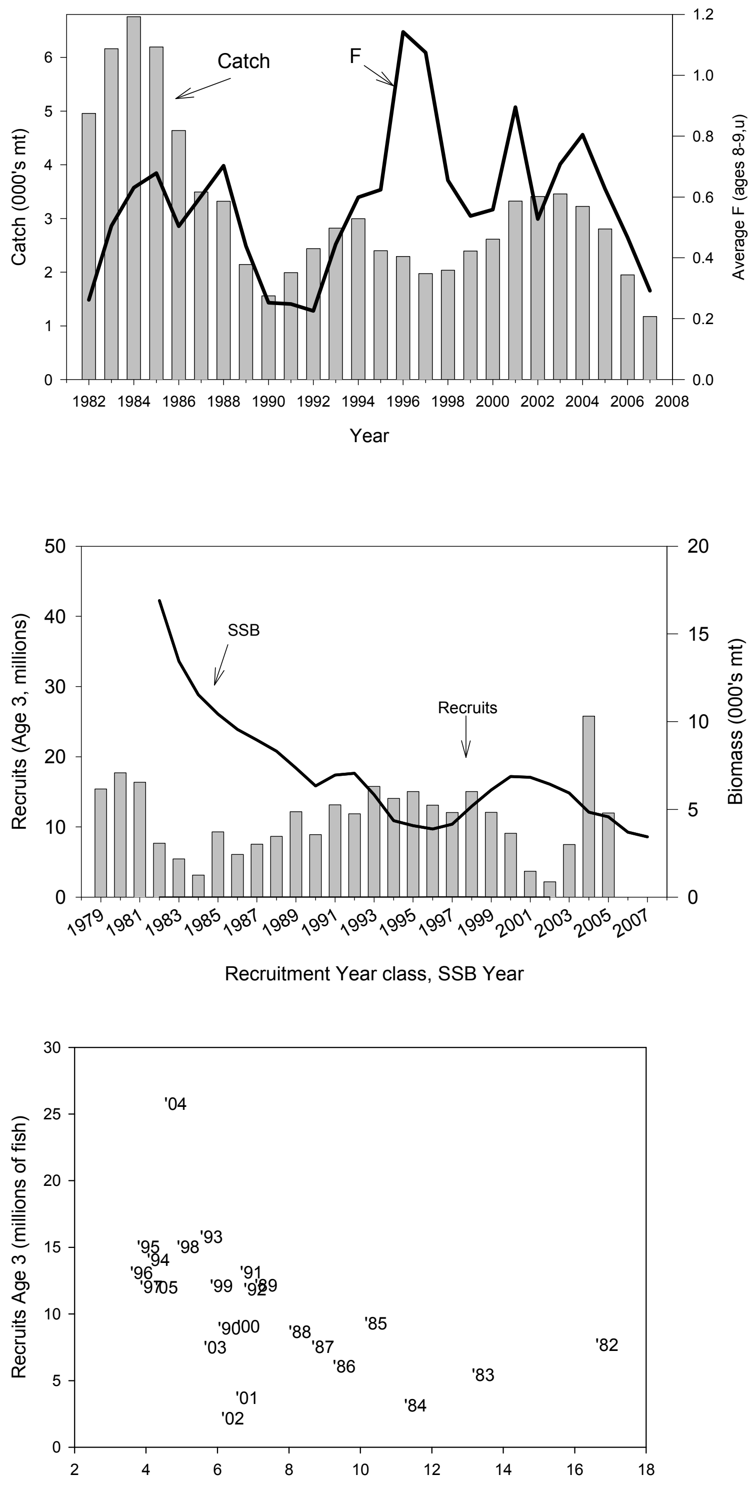
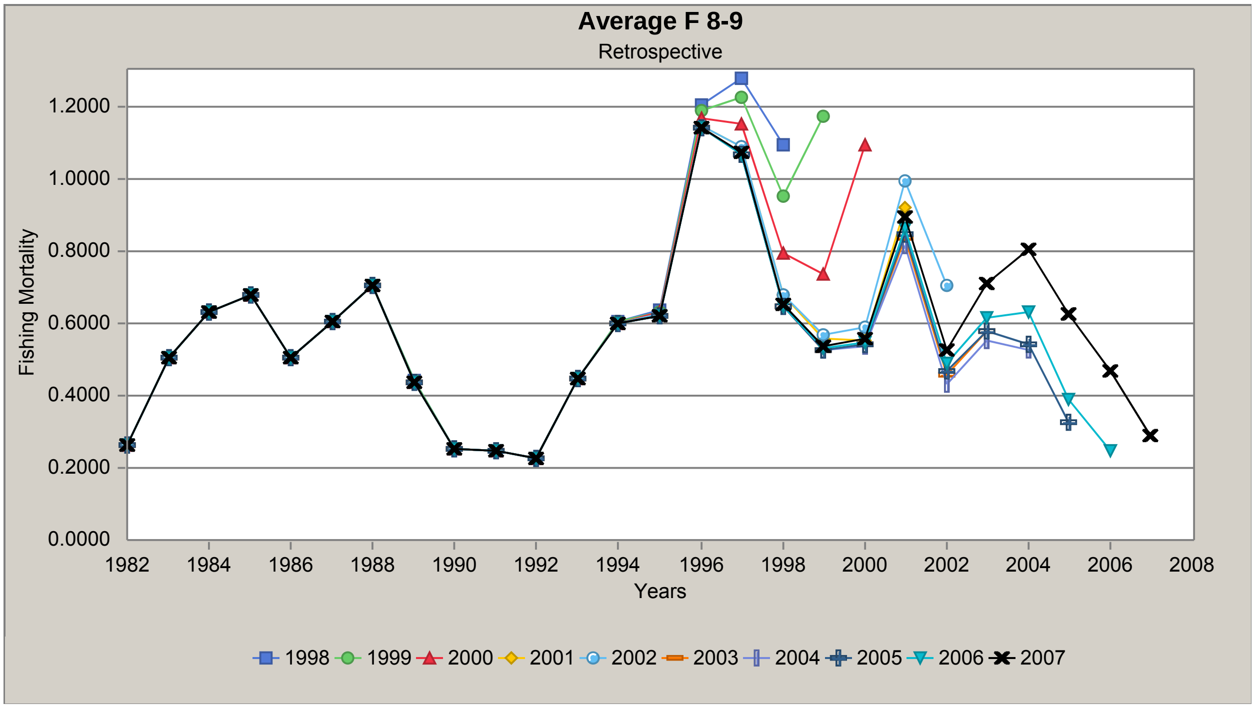


Figure G17. Trends of witch flounder total catch and fishing mortality (top), spawning stock biomass and Age 3 recruitment (middle), and spawning stock biomass (thousands, mt) and recruits (age 3, millions), 1982 – 2005 year classes (bottom) from VPA **SPLIT RUN**.

SPLIT RUN



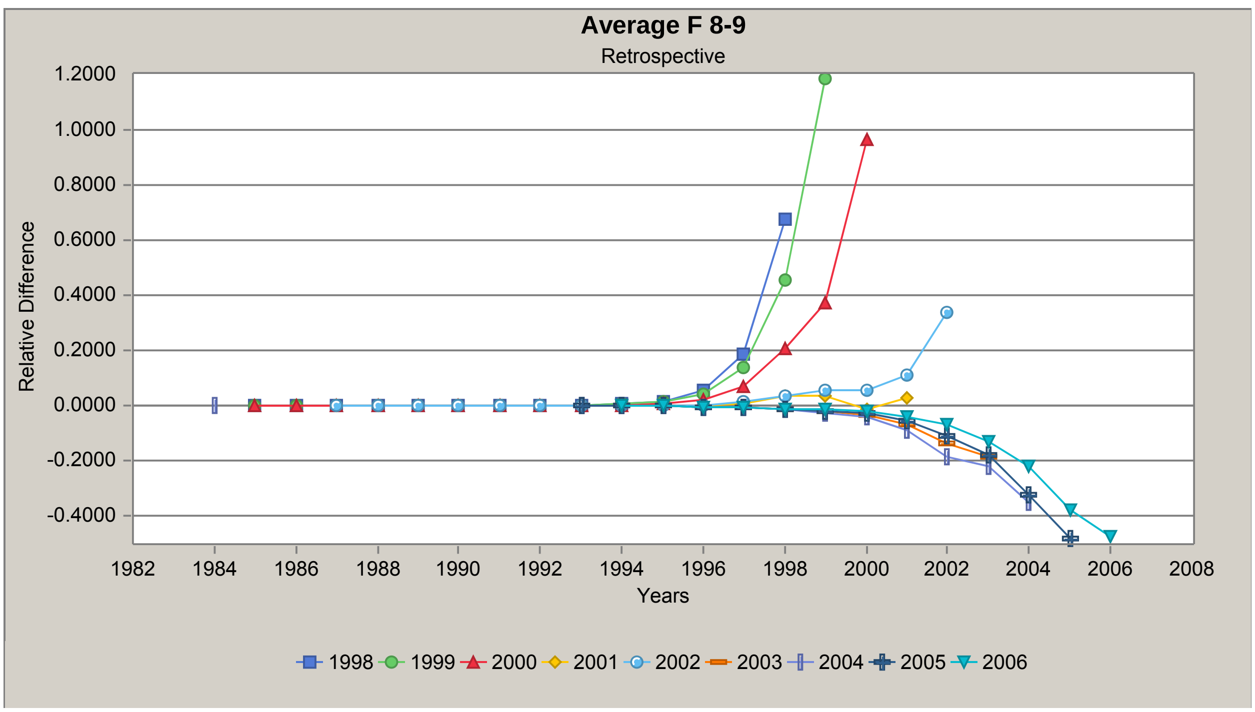
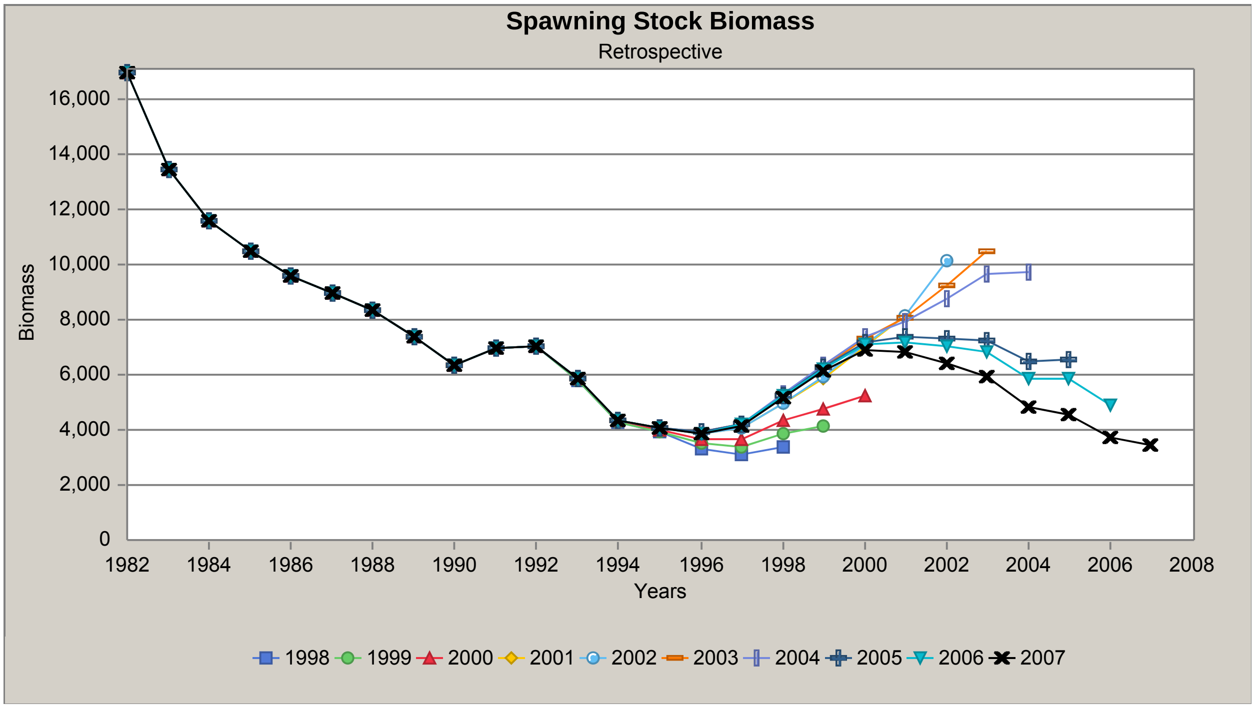


Figure G18. Retrospective analysis results of fishing mortality (top) and relative difference of fishing mortality from the terminal year (bottom) from VPA **SPLIT RUN**, 1982 – 2007.

SPLIT RUN



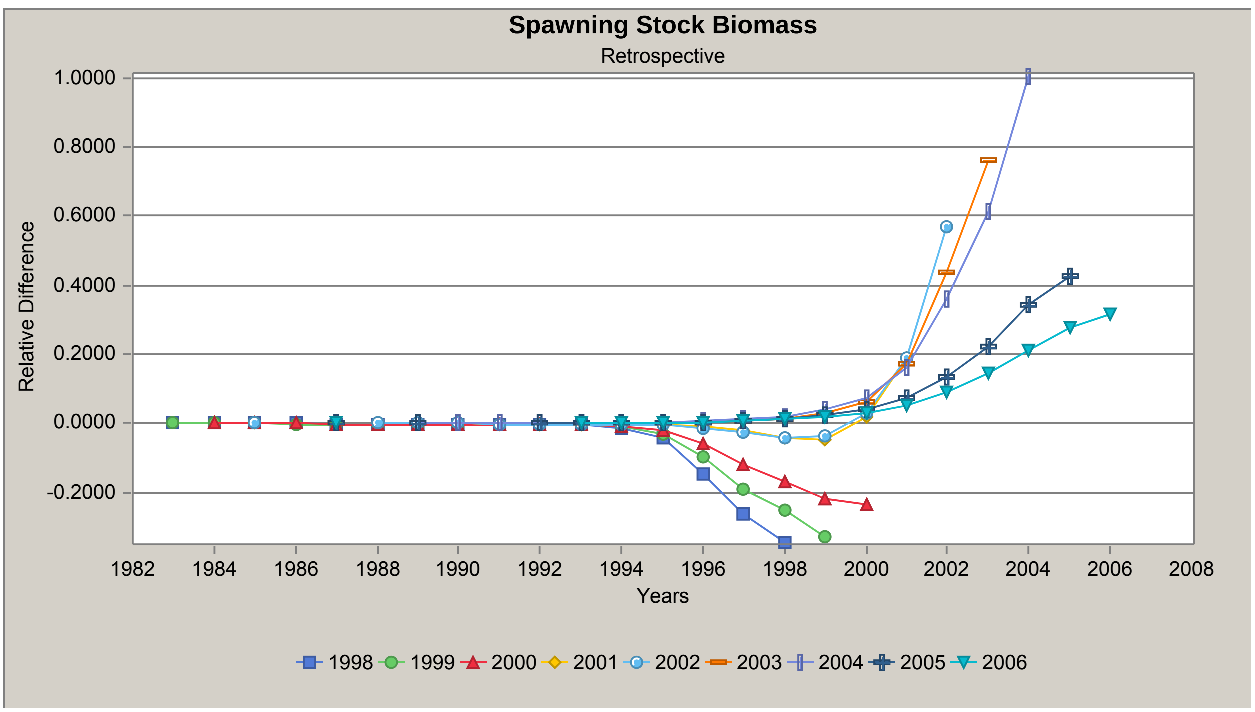
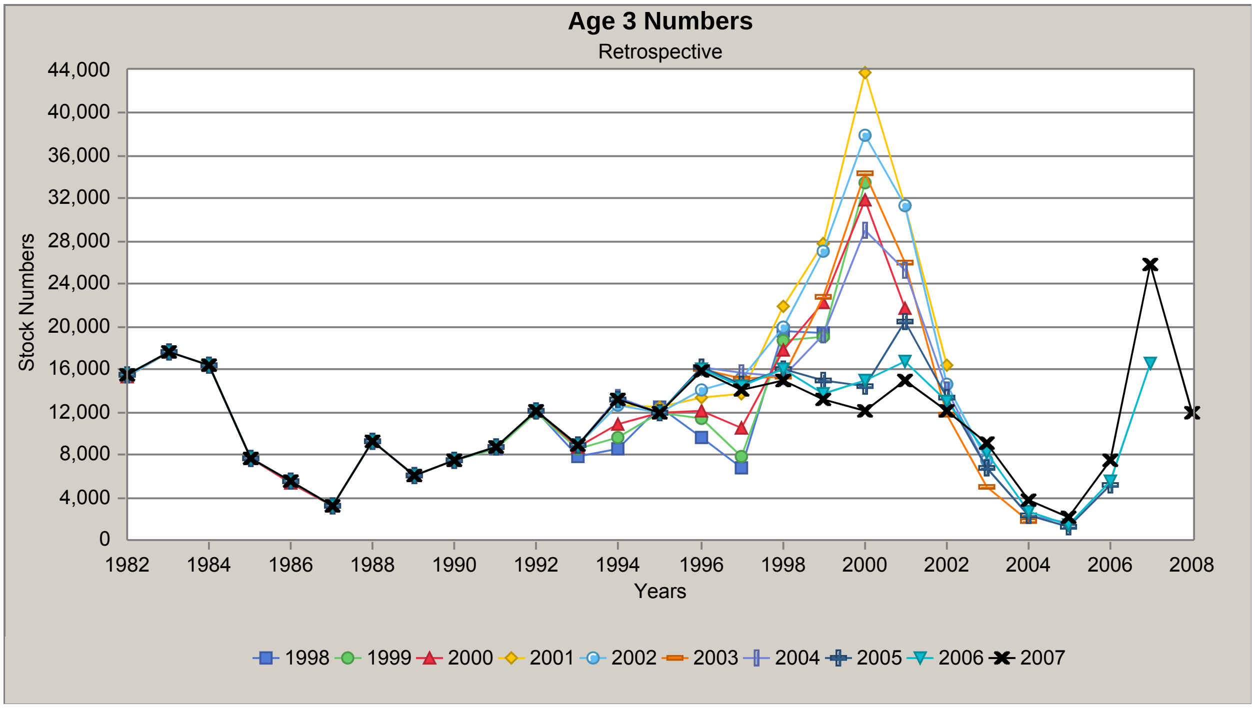


Figure G19. Retrospective analysis results of spawning biomass (top) and relative difference of spawning biomass from the terminal year (bottom) from VPA **SPLIT RUN**, 1982 – 2007.

SPLIT RUN



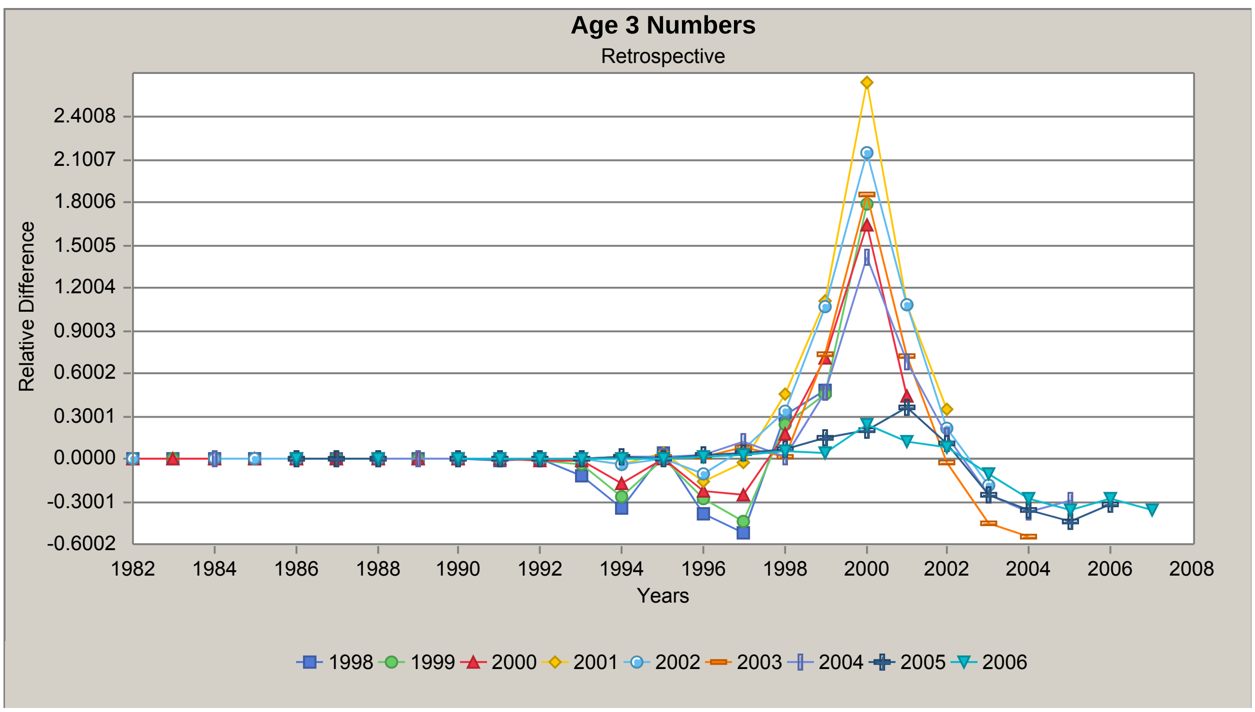
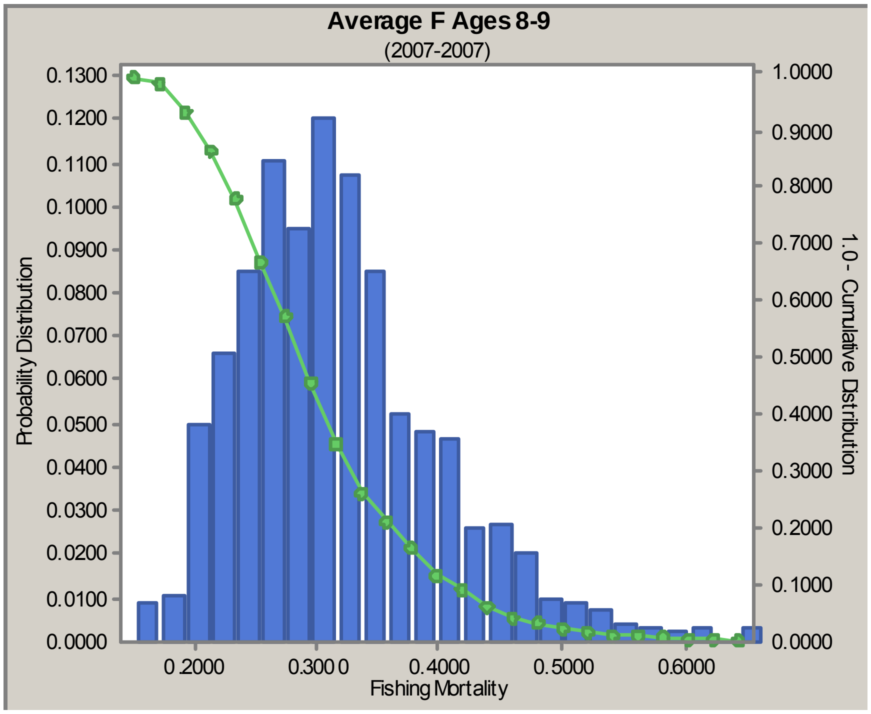


Figure G20. Retrospective analysis results of Age 3 recruitment (top) and relative difference of Age 3 recruitment from the terminal year (bottom) from VPA **SPLIT RUN**, 1982 – 2007.

SPLIT RUN



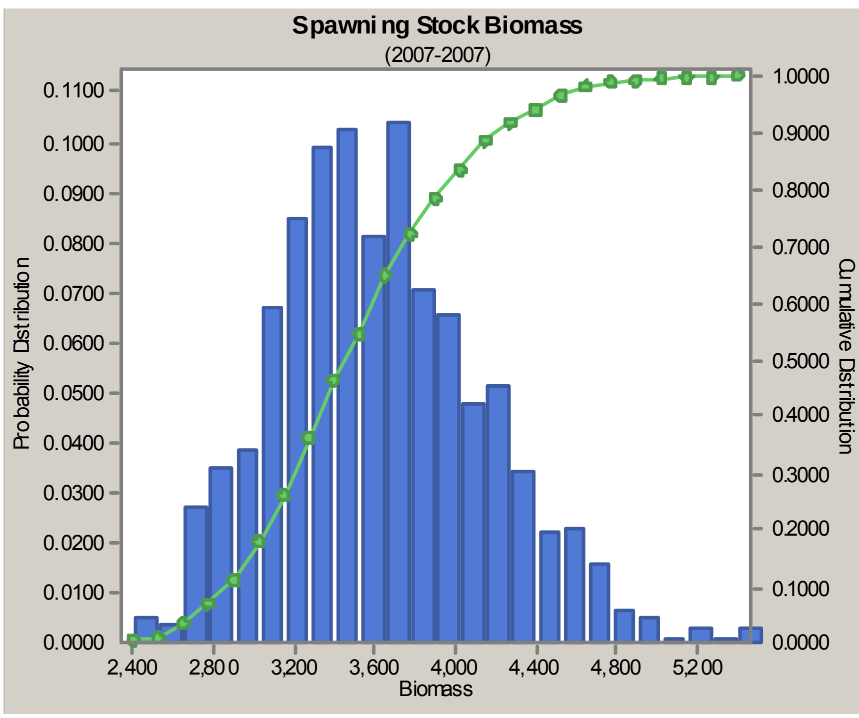


Figure G21. Precision estimates of fishing mortality (top) and spawning stock biomass (mt; bottom) in 2007 from the **SPLIT RUN**. Vertical bars display both the range of the bootstrap estimates and the probability of the individual values in the range.

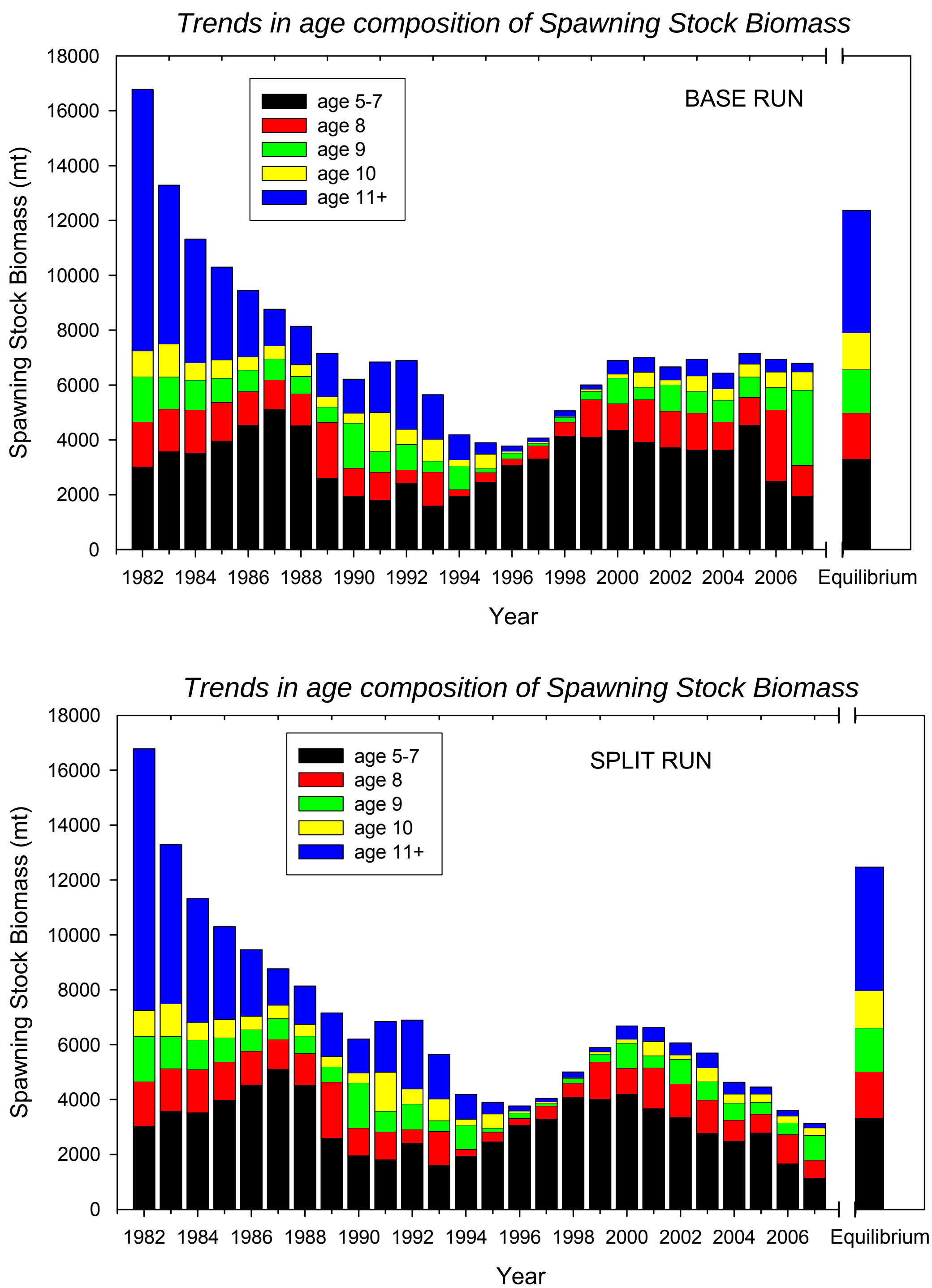


Figure G22. Age distribution of witch flounder spawning stock biomass, 1982-2007, and the expected age distribution at equilibrium, from the BASE RUN (top) and SPLIT RUN (bottom).

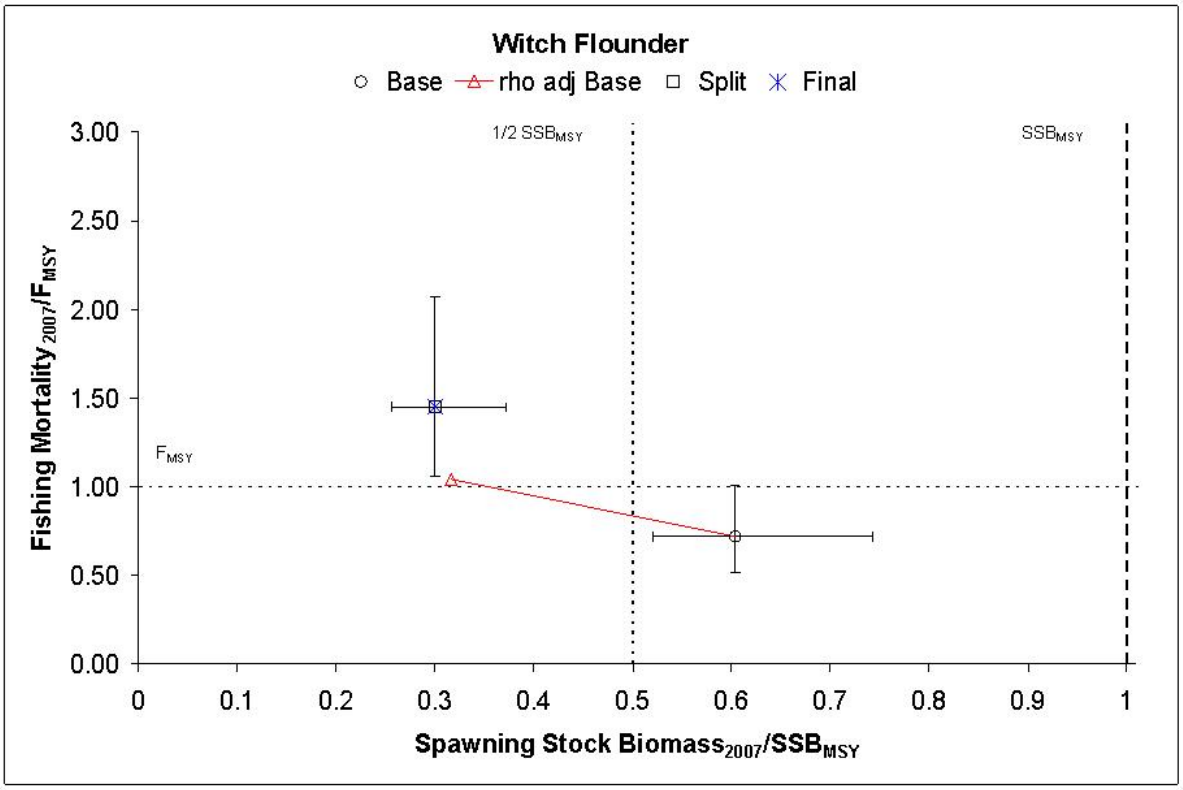


Figure G23. Witch flounder spawning stock biomass and fishing mortality (F8-9) in 2007, with respect to the biological reference points, for the rho-adjusted BASE RUN (triangle) and for the BASE RUN (circle) and SPLIT RUN (square) with 80% confidence interval. The final accepted VPA run (asterisk) is the SPLIT RUN and is used to determine witch flounder stock status in 2007.

H. Gulf of Maine/Georges Bank American plaice
by Loretta O'Brien, Jay Burnett , and Michele Traver

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

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 H1) 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 2005 at the GARM-II meeting (O'Brien *et al.* 2005). The assessment was conducted using VPA with total catch including commercial landings, large mesh discards, and shrimp trawl discards for ages 1-9+. For terminal year 2004, total commercial landings were 1,711 mt and fully recruited F (ages 5-8, unweighted average) was estimated to be 0.15, the lowest F in the time series (1980-2004). Spawning stock biomass was 14,149 mt in 2004, a 10% decrease from 2003. The 2003 (54.8 million age 1 fish) and 2004 (66.7 million age 1 fish) year classes were well above the long term average (33.1 million age 1 fish). The spring and autumn research survey indices of abundance indicated a decreasing trend during 2000-2005. Recruitment indices of age 1 fish from NEFSC autumn surveys indicated that both the 1997 and 1998 year classes were above average and the 2001 year class was just about average. The 1997 and 1998 year classes were just below average in the autumn Massachusetts state survey, however the 2003 was above average.

In 2002, biological reference points (BRPs) were developed for Gulf of Maine - Georges Bank American plaice (NEFSC 2002) in a Yield-pre-recruit (YPR) analysis based on landings and discards using VPA estimated mean recruitment at age 1 during 1980-2004. The BRPs were estimated as:

F_{MSY} = 0.17,
MSY = 4,900 mt and
SSB_{MSY} = 28,600 mt.

2.0 Fishery

Total commercial landings of Gulf of Maine-Georges Bank (GM-GB) American plaice were 988 mt in 2007, a 10% decrease from 2006 (Table H1, Figure H2). 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 (Table H2) and the fishery is prosecuted primarily during the 2^{nd} and 3^{rd} calendar quarter of the year. Since the mid-1990s the largest proportion of the landings are in the small market category (Table H3).
Sampling intensity (metric tons landed per sample) has increased since the mid-1990s (Table H4). During 2000-2007, sampling intensity ranged between 8 mt -92 mt per sample for the three market categories : small, medium and large.

Landings at age were estimated separately for the Gulf of Maine and Georges Bank and then combined for the years 1985-1993 and 2003-2007, 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 H4).

Discards of American plaice were estimated for both the large mesh fisheries in the GM and GB and for the northern shrimp fishery in the GM. Discards were estimated from 1980-1988 for both 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. For 1989-2007, 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 mt of American plaice discards were then estimated by applying the d:k to commercial landings. Observer length frequencies, and both research survey and commercial age-length keys were applied to estimate discards at age.

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 (Table H5). Total discards accounted for about 18% of the total catch during 2005-2007.

Commercial landings, shrimp and large mesh fishery discards, and total catch at age, in numbers and weight, and mean weight and mean length at age are presented in Tables H6-H9. Total catch at age is dominated by ages 4-7 (Figure H3).

3.0 Research Bottom Trawl Surveys

Biomass and abundance indices

The NEFSC survey indices of abundance and biomass peaked around 1980, declined until the late 1980s, and have since fluctuated with no strong trend (Table H10, Figure H4-H5). The Canadian Department of Fisheries and Oceans (DFO) spring survey shows no strong trends during 1987-2008 (Table H10, Figure H4-H5). The Massachusetts Division of Marine Fisheries (MADMF) spring and autumn surveys indicate a peak in abundance in the late 1980s, with a generally declining trend until about 2000, then generally increasing, however the 2006-2007 autumn indices show a decline (Figure H6).

Catch at age for NEFSC and MADMF spring and autumn surveys is presented in Tables H11-H13 and Figures H7-10. NEFSC autumn age 1 recruitment indices indicate that the 1997, 1998, 2005, and 2006 year classes are the most recent above average year classes (Table H12,Fig. H11a). The autumn MADMF age 1 recruitment indices indicate the most recent above average year classes are the 1997, 2001, 2003, and 2004 (Table H13, Fig. H11b).

Maturity ogives

Logistic regression analysis was used to estimate female maturity ogives from NEFSC spring research survey data for 1980 - 2008. 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, 2007, has only 4 years of data (2005, 2006, 2007, and 2008). 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) (App.H. Fig. H1).

4.0 Assessment

The Panel Summary for the GARM Model meeting indicated that GM-GB American plaice might better be assessed by applying a statistical catch at age model (SCAA) given that discards account for 10%-100% of the fish younger than age 4 in the catch at age. The estimate of total discards (mt) have CVs that range between 0.10 – 0.80, with an average of 0.30 during 1989-2007 (Table H5). CVs for discards at age are not available. The landings at age have CVs ranging between 0.06- 0.48 for ages 5-9 for the years 2003-2007 (App.H.Table H1). Given that these measures of uncertainty are relatively low on average and similar to other stocks that incorporate discards, e.g. witch flounder, a SCAA model was not explored at this time. In addition, at the GARM BRP meeting preliminary reference points for American plaice were estimated based on recruitment from the 2005 VPA model formulation (O'Brien et al. 2005).

The Panel Summary for the GARM Model meeting also stated the following:
"There is a potential problem of conducting an assessment on the combined Georges Bank and Gulf of Maine stock subcomponents if the relative proportion of abundance of these stocks is not stable over time. The survey trends in the two areas should be examined; if they are similar, then a combined assessment of the two components should not be problematic. However, if the trends are different, there may be a need to partition the catch-at-age between the two stocks and conduct separate assessments on each assuming that there is negligible migration between the two populations."
This issue was addressed by examining the relationship between American plaice caught on Georges Bank and those caught in the Gulf of Maine using regression analysis. The ln(number per tow) and ln(weight per tow) of fish from NEFSC spring and autumn research bottom trawl surveys from Georges Bank were regressed against corresponding indices of fish from the Gulf of Maine. A positive slope is shown for both numbers and weight, with a higher R2 for ln(weight per tow), indicating that production is similar between the two areas (App. H. Fig. H2). Given these results, a combined assessment of fish from the two areas does not appear to be problematic.

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 2007 and beginning year stock sizes in 2008. The catch at age used in the VPA includes commercial landings and discards from the Northern shrimp and large mesh fisheries from 1980-2007 for ages 1 to 11+. Research survey indices used for calibration include spring NEFSC abundance indices for ages 1-8, 9-11+, spring MADMF abundance indices for ages 1-5, autumn NEFSC abundance indices for ages 0-7, 8-10+, 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.

In this formulation the average F is based on ages 6-9 which is a shift from the previous assessment that used F averaged on ages 5-8 (O'Brien et al. 2005). The catch at age is now 1-11+, whereas, in the previous assessment the catch at age was 1-9+.

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 H14. Stock size estimates are more precise for ages 3-10, (CVs ranging from 0.15 -.22) than for ages 1 and 2 (CVs between 0.29-0.65). Catchability estimates at age for the NEFSC surveys were more precise for ages 3-7 (0.07-0.09), than for ages 1-2 (0.12-0.19). The MADMF autumn survey q estimates at age were less precise for ages 2-5 (0.11-0.19) then the spring survey estimates for ages 3-5 (0.08-0.09)
(Table H14, Figure H12). There appears to be a dome in the survey q's where the youngest and oldest fish have relatively low catchability.

The residuals (observed – predicted), presented in App.H. Fig. H3, 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 all ages 4 and older in all four surveys. Average fully recruited F (ages 6-9) in 2007 was estimated as 0.06, the lowest in the time series (Table H15, Figure H12, App.H.Table H2). The 2007 estimate of SSB was 15,569 mt, a 33% increase from 2006, and the highest SSB since 1984 (Table H15, Figure H13, App.H. Table H2). Since 1980, recruitment has ranged from 12 million to 53 million age 1 fish with a time series average of 28.8 million age 1 fish. The 2003 (36.8 million fish), 2004 (42.7 million), 2005 (51.4 million) and 2007 (42.1 million) are all above average year classes, and are the first to appear since the 1993 (38.8 million fish) above average year class (Table H15, Figure H13, App.H. Table H2).

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 2008 and age 1-11+ F estimates in 2007 (App. H. Table H3). The bootstrap results indicate that stock sizes were well estimated for ages 3-10 with CVs varying between 0.14-0.26., however, age 1(CV=1.09) and age 2 (CV=0.41) were not as well estimated. The fully recruited F for ages 6-9 was well estimated with CVs ranging between 0.14 and 0.19, with the exception of age 7 (CV=1.29). There is an 80% probability that the average F in 2007 is between 0.0573 and 0.0746 (Figure H15, App. H Table H3). 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 2008 is between 14,382 mt and 17,229 mt (Figure H15, App.H.Table H3).

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 2002-2007. 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 2002-2007 is apparent (Figure H16).

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, 2007. 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 pattern of estimating F values lower than the terminal year F (rho = -0.31) (Figure H17a) and a corresponding pattern of estimating higher values of SSB relative to the terminal year SSB (rho=0.41). The retrospective analysis in recruits at age 1 indicate that recruits are estimated at higher values relative to the terminal year (rho=0.60). There is one extremely high value in 2003 (Fig. H17c). The estimation of age 1 recruits is likely influenced by the absence of the MADMF spring survey data for terminal year + 1 (2008), which is typically available. The relative difference plot (Fig. H17c) in the current assessment is estimated by differencing the final run (without the spring survey) with retrospective runs that do have the terminal year + 1 spring survey available for estimation.

Sensitivity runs

Prior to selecting a final model, several sensitivity runs were conducted. The final model chosen was based primarily on comparisons of retrospective patterns and Mohn's rho statistic between model formulations. The VPAs included a 9+ and an 11+ catch at age, with the survey indices either split or not split between 1993 and 1994, and different average ages for estimation of F on the oldest age. Mohn's rho statistic for F, SSB, and age 1 recruitment are presented below for selected model formulations.

Initially, several runs were conducted using the 2005 assessment formulation (O'Brien et al. 2005) with a catch at age of 9+ and F on the oldest age averaged on ages 5-8. This base run was compared with a VPA that split the survey time series between 1993 and 1994, and another VPA that dropped several MADMF indices. Comparison of the rho statistic for recruitment at age 1 showed an increase from 0.52 (base) to 2.42 (split) and 1.96 (Ma. indices dropped).

Several more runs were conducted comparing a 9+ and 11+ catch at age with fully recruited F beginning at age 6. The 11+ catch at age was chosen over the 9+, primarily because the catch is well represented out to age 11 and in addition Mohn's rho statistics for F, SSB, and recruitment were similar between base VPAs (see table below). The final model selected included an aggregate survey tuning index of ages 9-11+ that provided more information on the older age classes. Mohn's rho statistic is slightly higher for SSB and recruitment compared to a model with no aggregate index, however, the rho for F is equivalent. The terminal year SSB is actually lower in the aggregate formulation compared to the model without the aggregate index.

CAA	9+	9+	11+	11+	11+
F average	6-7	6-7	6-9	6-9	6-9
survey split	no	yes	no	no	yes
SV + group	no	no	no	9-11+	9-11+
Mohn's rho statistic					
F	-0.30	-0.34	-0.31	-0.31	-0.31
SSB	0.36	0.70	0.36	0.43	0.52
age 1	0.56	2.47	0.57	0.60	2.44

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 H16) for catch weights and stock weights (ages 1-11+) were estimated as an average of the most recent 5 years (2003-2007). The PR was based on a normalized geometric mean of the 2003-2007 Fs from the VPA and the maturity ogive was estimated annually as a 5 year moving average as described above. The YPR and spawning stock biomass/recruit (SSB/R) plot is presented in Fig. H18.

The estimated biological reference points of $F_{0.1}$= 0.21 , F_{max} = 0.48 and $F_{40\%}$ = 0.19 are higher than those estimated by the Working Group on Re-Evaluation of Biological Reference Points: $F_{0.1}$=0.17 , F_{max} = 0.31 and $F_{40\%}$ = 0.17 (NEFSC 2002). Non-parametric estimates of MSY and SSB_{MSY} were derived from mean recruitment (28.8 million age 1 fish), Y/R (0.141) and SSB/R (0.772) as:

F_{MSY} = 0.19
MSY = 4,059 mt
SSB_{MSY} = 22,243 mt.

The GARM III BRP Panel selected the non-parametric YPR analysis as the basis for the estimation of BRPs for American plaice. Stochastic projections out to 100 years with F_{MSY} = 0.19 and recruitment estimated from a cumulative distribution function of 29 recruitments from the 2008 VPA provided the following parametric biomass reference points:

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

6.0. Projections

Short term, 2-year stochastic projections were performed to estimate landings and SSB during 2008-2009. The input values for mean catch and stock weights, PR, and maturity are the same as described above for the YPR analysis. Catch in 2008 was assumed equal to catch in 2007. The projections were run under three F scenarios : F_{07}, F_{MSY}=$F_{40\%,}$ and $F_{REBUILD}$. Recruitment was projected from a cumulative distribution function of 29 recruitments from the 2008 VPA. The rebuilding plan for American plaice requires that the stock reach SSB_{MSY} by 2014. The $F_{REBUILD}$ was estimated in a separate medium term projection out to 2014 using the same input data as above.

Short term projections were run for the Base Model unadjusted for retrospective pattern and Base Model adjusted for retrospective pattern. The results for both models (Table H17) indicate that under all three F scenarios both landings and SSB are projected to increase in 2009.

7.0 Summary

The GARM review panel accepted the final model as the Base Model adjusted for retrospective pattern using the 7-year Mohn's rho estimate.

The Gulf of Maine –Georges Bank American plaice stock is not overfished and overfishing is not occurring (Fig. H19), as determined by the **rho-adjusted Base Model.** Commercial landings have been declining since 2001. Fishing mortality in 2007 was 0.09 the lowest in the time series. Biomass has been increasing since 2002 and at 11,106 mt is 50% 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 near or above average.

Sources of uncertainty
1) Small mesh fishery discards not included in catch at age
2) Georges Bank landings are not as well sampled as Gulf of Maine landings

8.0 Panel Discussion / Comments

Conclusions

The Base VPA exhibited a moderate retrospective pattern which the Panel considered needed to be addressed. In contrast to many other GARM III stocks, a VPA using a split survey time series did not reduce the retrospective pattern and appeared to make it worse.

Given that the retrospective pattern could not be adjusted by a split in the survey time series, the Panel agreed with the GARM III 'BRP' review that an adjustment to the terminal year's population numbers was required. Panel accepted the VPA with the Rho Adjustment to the 2007 population numbers as Final and the best available estimate of stock status and a sufficient basis for management advice. It agreed with the GARM III 'BRP' review which concluded that short term stock projections should be based on the adjusted terminal estimates from the Final run. It should be noted that while the adjustment reduced the retrospective pattern, it did not eliminate it, nor does the adjustment account for other sources of uncertainty in the terminal estimates of F and SSB.

A number of technical issues were encountered as to the appropriate method in which to undertake stock and rebuilding projections when there is a Rho Adjustment to the terminal year estimates of F and SSB. The approach used here was considered a pragmatic solution to the complicated issue of an accounting for retrospective pattern. This issue required further examination.

In particular, the use of age-specific Rho adjustments for stock numbers at start of 2007 gives an SSB estimate in 2007 of 10,873 mt. This is slightly different (~2%) than the SSB estimate obtained by applying the scalar adjustment for SSB based on a the average Rho (11,106 mt). These differences are considered minor but result in two different estimates of SSB in 2007. Average Rho adjusted SSB and F were used to derive stock status in 2007. Projections for 2008 and 2009 however, are based on the age-specific Rho-adjusted population estimates at the start of 2008.

The Panel noted that the BRPs and stock projections were consistent with the GARM III 'BRP' review.

Research Recommendations

Further analytical work is required to better characterize the uncertainties in stock size, projections, and rebuilding plans when using the Rho Adjustment to address retrospective pattern.

9.0 References

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Table H1. Commerical landings (metric tons, live weight) of American plaice from the Gulf of Maine, Georges Bank, Southern New England and the Mid-Atlantic, 1960-2007 (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	0	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	957	2388	242	279	1	2910	-	-	-	0	-	-	0	3343	524	3867
1967	1066	6	1072	2166	203	1018	10	3397	-	-	-	0	4	-	4	3236	1237	4473
1968	904	5	909	1695	173	193	5	2066	637	145	-	782	18	2	20	3254	523	3777
1969	1059	7	1066	1738	71	63	17	1889	505	349	-	854	130	-	130	3432	507	3939
1970	895	-	895	1603	92	927	658	3280	88	18	40	146	8	-	8	2594	1735	4329
1971	648	5	653	1511	38	228	296	2071	11	112	206	329	6	2	8	2176	887	3063
1972	569	-	569	1222	22	358	-	1602	3	71	-	74	-	-	0	1794	451	2245
1973	687	-	687	910	38	289	-	1237	5	158	-	163	-	-	0	1602	485	2087
1974	945	2	947	1039	27	16	2	1084	92	4	-	96	-	-	0	2076	51	2127
1975	1507	-	1507	913	25	148	-	1086	3	-	-	3	-	-	0	2423	173	2596
1976	2550	-	2550	948	24	3	-	975	10	-	-	10	1	-	1	3509	27	3536
1977	5647	-	5647	1408	35	50	-	1493	6	78	-	84	7	-	7	7068	163	7231
1978	7287	30	7317	2193	77	-	-	2270	15	-	-	15	8	-	8	9503	107	9610
1979	8835	-	8835	2478	23	-	-	2501	13	-	7	20	4	-	4	11330	30	11360
1980	11139	-	11139	2399	43	-	5	2447	10	-	-	10	1	-	1	13549	48	13597
1981	10327	1	10328	2482	15	-	2	2499	26	-	2	28	46	-	46	12881	20	12901
1982	11147	-	11147	3935	27	-	1	3963	35	-	2	37	9	-	9	15126	30	15156
1983	9142	7	9149	3955	30	-	-	3985	40	-	-	40	4	-	4	13141	37	13178
1984	6833	2	6835	3277	6	-	-	3283	17	-	-	17	7	-	7	10134	8	10142
1985	4766	1	4767	2249	40	-	-	2289	12	-	-	12	2	-	2	7029	41	7070
1986	3319	-	3319	1146	34	-	-	1180	4	-	-	4	3	-	3	4472	34	4506
1987	2766	-	2766	1032	48	-	-	1080	2	-	-	2	1	-	1	3801	48	3849
1988	2271	-	2271	1097	108	-	-	1205	13	-	-	13	1	-	1	3382	108	3490
1989	1646	-	1646	703	68	-	-	771	1	-	-	1	3	-	3	2353	68	2421
1990	1802	-	1802	639	52	-	-	690	2	-	-	2	2	-	2	2445	52	2497
1991	2936	-	2936	1310	26	-	-	1310	15	-	-	15	0	-	0	4261	26	4287
1992	4564	-	4566	1838	3	-	-	1838	10	-	-	10	4	-	4	6416	3	6419
1993	3866	-	3866	1839	-	-	-	1839	11	-	-	11	4	-	4	5720	-	5720
1994	3545	-	3545	1387	30	-	-	1417	29	-	-	29	8	-	8	4969	30	4999
1995	3125	-	3125	1437	2	-	-	1439	34	-	-	34	8	-	8	4604	2	4606
1996	3014	-	3014	1309	2	-	-	1311	31	-	-	31	4	-	4	4358	2	4360
1997	2305	-	2305	1544	65	-	-	1609	37	-	-	37	1	-	1	3887	65	3952
1998	2287	-	2287	1312	20	-	-	1332	20	-	-	20	4	-	4	3623	20	3643
1999	1629	-	1629	1444	123	-	-	1567	23	-	-	23	4	-	4	3100	123	3223
2000	2590	-	2590	1571	143	-	-	1714	22	-	-	22	9	-	9	4192	143	4335
2001	2718	-	2718	1610	50	-	-	1660	44	-	-	44	2	-	2	4374	50	4424
2002	2003	-	2003	1355	98	-	-	1453	15	-	-	15	5	-	5	3378	98	3476
2003	1517	0.23	1517	873	114	-	-	987	29	-	-	29	3	-	3	2422	115	2537
2004	1014	0.17	1014	622	6	-	-	628	28	-	-	28	4	-	4	1668	6	1674
2005	733	0.56	734	537	9	-	-	546	13	-	-	13	2	-	2	1285	9	1294
2006	577	0.04	577	481	20	-	-	501	17	-	-	17	1	-	1	1076	20	1096
2007	607	0.1	607	366	3	-	-	369	6	-	-	6	6	-	6	985	3	988

Table H2. Percentage of landings of American plaice by gear type, 1980-2007.

	GEAR TYPE					
Year	Otter Trawl	Shrimp Trawl	Sink Gill Net	Scottish Seine	Danish Seine	Other
1980	96.8	0.7	0.8	0.0	1.5	0.3
1981	96.5	2.2	0.7	0.0	0.5	0.1
1982	96.3	2.0	0.8	0.5	0.3	0.1
1983	96.3	1.7	0.3	1.1	0.3	0.3
1984	97.2	1.0	0.2	0.6	0.6	0.4
1985	96.9	1.6	0.1	0.5	0.8	0.1
1986	96.1	2.5	0.3	0.3	0.7	0.1
1987	95.5	2.6	0.6	0.4	0.9	0.2
1988	96.2	1.7	0.6	0.4	1.0	0.2
1989	95.5	1.4	1.2	0.9	1.0	0.1
1990	93.4	2.2	2.0	0.9	1.2	0.4
1991	94.8	0.9	0.9	1.2	0.9	1.2
1992	96.1	1.3	0.1	0.9	0.2	1.4
1993	95.9	1.2	0.1	0.0	0.3	2.5
1994	97.2	0.1	1.1	0.2	0.0	1.4
1995	93.0	0.7	4.0	0.7	0.0	1.6
1996	94.6	0.1	3.2	0.7	0.0	1.4
1997	93.8	0.2	2.9	0.7	0.0	2.4
1998	91.4	2.0	3.5	0.9	0.0	2.2
1999	93.7	1.8	2.0	0.4	0.0	2.1
2000	96.7	1.4	1.0	0.3	0.0	0.6
2001	98.2	0.5	1.0	0.1	0.0	0.2
2002	98.3	0.0	0.6	0.1	0.0	0.9
2003	96.7	0.2	0.9	0.1	0.0	2.1
2004	95.4	0.0	1.0	0.1	0.0	3.5
2005	91.8	0.0	2.2	0.0	0.0	6.0
2006	94.8	0.0	1.4	0.0	0.0	3.8
2007	97.5	0.5	1.4	0.0	0.0	0.6

Table H3. 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, 1980-2007.

	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	54	2	114	58	43	9	205	64	43	3	137	56	55	2	555	219	195	16

Table H4. Sampling of commercial American plaice landings, by market category, for the Gulf of Maine and Georges Bank areas (NAFO Division 5Y and 5Z), 1985-2007. Outline indicates samples pooled to estimate landings at age.

		Small				**Medium**				**Large**				Number of tons landed / sample		
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	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 H4 continued . Sampling of commercial American plaice landings, by market category, for the Gulf of Maine and Georges Bank areas (NAFO Division 5Y and 5Z), 1985-2007. Outline indicates samples pooled to estimate landings at age.

		Small				Medium				Large				Number of tons landed / sample		
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	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
	GB	14	11	3	1	1	2	---	1	2	2	2	2			
2000	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
	GB	4	2	1	2	---	2	2	4	---	3	2	1			
2001	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
	GB	1	2	2	1	2	1	2	---	4	3	2	---			
2002	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
	GB	1	3	---	---	2	---	---	---	---	3	2	---			
2003	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
	GB	1	1	1	4	3	---	2	4	1	---	3	1			
2004	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
	GB	3	2	2	3	1	3	---	2	7	2	2	4			
2005	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
	GB	2	2	---	2	3	2	1	1	4	5	2	2			
2006	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
	GB	3	3	2	2	2	1	3	---	3	3	1	1			
2007	GM	4	4	6	1	3	2	3	2	5	1	6	4			
	total	7	7	8	3	5	3	6	2	8	4	7	5	22	14	8

Table H5. Discards of American plaice in Gulf of Maine and Georges Bank large mesh otter trawl and Gulf of Maine shrimp trawl fisheries, coefficient of variance (cv) of mean, and number of trips. Estimated with the SBRM method, 1989-2007.

	GM large mesh trawl			GB large mesh trawl			Shrimp			Total		
Year	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips
1989	617.0	0.31	52	111.7	0.60	36	387.0	0.22	40	1115.7	0.20	128
1990	796.9	0.65	35	68.8	0.69	25	570.0	0.18	31	1435.6	0.37	91
1991	1367.5	0.37	48	199.8	0.63	28	232.5	0.13	52	1799.9	0.29	128
1992	438.0	0.26	52	57.6	0.52	29	124.4	0.19	82	620.0	0.19	163
1993	264.4	0.52	22	102.0	0.61	25	31.3	0.19	82	397.7	0.38	129
1994	546.9	0.91	10	44.6	0.24	31	33.8	0.22	87	625.3	0.80	128
1995	381.3	0.44	30	355.3	0.35	41	110.6	0.18	82	847.2	0.25	153
1996	208.2	0.35	14	120.1	0.85	19	142.2	0.28	35	470.5	0.28	68
1997	407.1	0.57	7	230.1	0.47	27	44.8	0.21	16	681.9	0.37	50
1998	634.6	0.77	10	77.0	0.00	9	*28.7* *			711.7	0.69	19
1999	584.5	0.38	41	97.2	0.31	26	*26.0* *			681.7	0.33	67
2000	58.5	0.37	79	159.6	0.33	20	*32.9* *			218.1	0.26	99
2001	198.0	0.39	113	148.4	0.17	33	*29.5* *			353.7	0.23	152
2002	182.1	0.48	149	103.3	0.24	68	*3.0* *			285.4	0.32	217
2003	193.4	0.14	253	50.0	0.21	147	22.0	0.27	30	265.4	0.11	430
2004	269.8	0.30	258	73.8	0.16	209	6.1	0.32	12	349.7	0.23	479
2005	208.3	0.15	498	55.2	0.11	702	8.0	0.19	17	271.6	0.12	1217
2006	114.1	0.43	206	122.1	0.13	363	6.6	0.23	26	242.8	0.21	595
2007	70.3	0.14	224	154.6	0.14	370	12.9	0.29	14	237.9	0.10	608

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

Table H6. Landings at age (thousands of fish; metric tons), mean weight (kg), and mean length (cm) at age of American plaice commercial landings from Gulf of Maine - Georges Bank,1980-2007.

Year	1	2	3	4	5	6	7	8	9	10	11+	Total
						Landings in Numbers (000's) at Age						
1980	0	0	22	770	3129	3903	3629	1185	1139	850	1380	16007
1981	0	587	1332	4331	5100	3618	2381	1573	645	440	621	20628
1982	0	113	2134	3495	4295	3481	3293	2038	1256	737	717	21558
1983	0	1	438	3735	4270	3809	2252	1271	697	450	911	17834
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	3686
1991	0	0	23	1850	2818	1105	319	164	201	97	104	6682
1992	0	0	46	739	4871	2563	812	191	131	118	93	9564
1993	0	0	123	1029	2037	2452	1382	265	287	151	125	7851
1994	0	23	196	896	1866	1262	1155	597	234	150	290	6670
1995	0	0	140	711	2854	1729	641	577	210	53	50	6964
1996	0	100	173	2493	2375	1400	529	239	124	35	63	7532
1997	0	0	2	1259	2582	1539	612	182	85	66	116	6443
1998	0	0	6	174	1493	1889	997	317	59	57	154	5147
1999	0	0	2	224	986	1663	1157	442	147	42	79	4741
2000	0	0	113	417	1430	2118	1713	566	138	70	20	6584
2001	0	0	0	391	1901	1991	1514	894	287	56	46	7080
2002	0	0	3	328	1072	1664	1155	500	273	157	176	5328
2003	0	0	0	129	782	1098	714	523	267	153	109	3775
2004	0	0	7	123	457	837	437	350	190	76	73	2550
2005	0	0	3	188	582	574	385	167	96	42	48	2085
2006	0	0	2	168	492	402	294	177	97	55	43	1729
2007	0	0	20	255	586	421	202	109	68	31	31	1722
						Landings at Age (mt)						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	12898
1982	0	23	620	1166	1845	2007	3164	2320	1502	1144	1364	15153
1983	0	0	149	1720	2484	2596	1864	1326	867	650	1531	13187
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	547	330	240	338	210	125	273	2496
1991	0	0	8	839	1532	790	307	191	256	150	189	4261
1992	0	0	22	314	2623	1895	774	237	173	193	188	6418
1993	0	0	51	463	1055	1591	1306	327	400	238	289	5720
1994	0	3	47	383	989	792	920	646	302	213	704	4999
1995	0	0	50	298	1468	1131	526	647	280	111	95	4606
1996	0	17	59	1008	1225	910	486	288	171	55	142	4360
1997	0	0	0	535	1229	979	504	205	114	104	282	3952
1998	0	0	2	69	653	1097	823	328	80	83	509	3643
1999	0	0	0	98	483	987	871	409	164	61	151	3223
2000	0	0	46	173	702	1234	1322	570	151	99	37	4335
2001	0	0	0	173	872	1082	1078	755	304	82	77	4424
2002	0	0	1	133	495	870	785	451	292	196	254	3476
2003	0	0	0	52	348	618	498	447	261	169	144	2537
2004	0	0	2	55	217	468	303	277	187	77	88	1674
2005	0	0	1	78	281	325	265	146	91	45	61	1294
2006	0	0	1	72	237	235	199	150	90	57	55	1096
2007	0	0	8	103	276	233	133	91	67	33	46	988

Table H6 continued. Landings at age (thousands of fish; metric tons), mean weight (kg), and mean length (cm) at age of commercial landings of American plaice from Gulf of Maine - Georges Bank, 1980-2007.

Year	1	2	3	4	5	6	7	8	9	10	11+	
							Mean Weight at age (kg)					Average
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	0.383	0.403	0.471	0.552	0.658	0.836	0.985	1.085	1.512	0.574
							Mean Length at age (cm)					Average
1980	0	0.0	32.6	34.7	37.1	41.7	44.8	47.9	49.9	52.2	30.2	41.8
1981	0	25.8	28.8	34.0	36.9	43.3	45.2	46.7	48.8	50.3	34.7	38.9
1982	0	29.0	32.4	33.7	36.4	39.5	46.3	48.8	49.9	53.9	30.1	39.9
1983	0	28.7	34.2	37.2	39.8	41.9	44.2	47.5	50.2	52.9	32.7	41.0
1984	0	28.5	33.9	36.3	40.3	41.8	45.3	49.9	49.3	52.2	30.1	41.1
1985	0	0.0	30.0	31.9	34.6	39.1	45.0	49.6	52.0	55.2	27.9	40.8
1986	0	29.0	31.9	33.6	36.0	40.1	44.6	49.5	53.3	56.0	27.3	40.2
1987	0	29.4	32.5	35.5	37.8	41.0	45.6	49.5	53.3	55.8	26.5	41.0
1988	0	27.0	32.4	34.8	37.6	41.4	45.6	50.4	52.3	55.7	26.9	39.6
1989	0	0.0	34.3	35.8	38.2	40.2	43.0	44.6	51.5	52.9	29.7	41.0
1990	0	0.0	35.6	36.5	38.9	41.6	44.5	46.7	48.3	51.1	32.6	40.3
1991	0	0.0	34.2	37.4	39.4	42.6	46.6	49.3	50.6	53.9	31.1	40.4
1992	0	0.0	38.0	36.7	39.2	43.1	46.4	50.5	51.4	54.9	29.0	41.2
1993	0	0.0	36.5	37.3	38.8	41.4	46.6	50.5	52.4	54.4	26.1	41.7
1994	0	26.2	30.4	36.7	39.2	41.2	44.2	48.6	51.2	52.6	25.3	40.8
1995	0	0.0	35.0	36.6	38.8	41.6	44.6	49.0	51.7	59.4	30.0	41.1
1996	0	27.7	34.1	36.2	38.8	41.4	46.1	50.0	52.1	54.3	26.9	39.2
1997	0	0.0	30.0	36.7	37.9	41.3	44.5	49.0	51.7	54.2	25.2	39.5
1998	0	0.0	34.5	35.9	37.0	40.1	44.7	47.8	51.8	53.0	20.4	40.1
1999	0	0.0	31.6	36.9	38.2	40.4	43.4	46.2	48.9	52.9	30.0	41.2
2000	0	0.0	36.4	36.4	38.2	40.1	43.5	47.2	48.6	52.5	30.6	41.2
2001	0	0.0	0.0	37.1	37.5	39.3	42.6	44.7	47.8	53.1	32.8	40.5
2002	0	0.0	33.0	36.3	37.6	39.0	42.1	45.9	48.3	50.6	36.6	40.6
2003	0	0.0		36.1	37.2	39.8	42.4	45.1	46.7	48.4	38.6	41.2
2004	0	0.0	34.4	37.3	37.9	39.7	42.2	43.8	46.7	47.3	40.9	41.0
2005	0	0.0	37.0	36.4	38.1	39.8	42.1	45.4	46.3	48.0	39.8	40.4
2006	0	0.0	34.0	36.9	38.1	40.2	42.0	44.9	45.9	47.5	39.3	40.6
2007	0	0.0	35.7	36.1	37.8	39.5	41.6	44.6	46.6	48.3	35.5	39.3

Table H7. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of American plaice discarded in the **northern shrimp fishery** in the Gulf of Maine region , 1980-2007.

Year	0	1	2	3	4	5	6	7	8	9	10	11+	
						Discards in Numbers (000's) at Age							Total
1980	0.0	0.0	0.0	114.0	115.1	28.7	0.0	0.0	0.0	0.0	0.0	0.0	257.8
1981	0.0	0.9	147.8	364.4	287.2	79.6	0.4	0.0	2.9	0.0	0.0	0.0	883.2
1982	0.0	6.9	154.7	545.6	632.7	105.9	95.7	4.2	0.0	0.0	0.0	0.0	1545.7
1983	0.2	14.0	614.3	641.0	760.7	319.9	51.0	5.9	0.0	0.7	0.0	0.0	2407.8
1984	0.0	2.5	302.0	488.3	575.1	494.6	98.1	5.9	2.8	0.0	0.0	0.0	1969.3
1985	0.0	53.9	103.2	930.9	464.9	307.8	79.0	14.8	0.0	0.0	0.0	0.0	1954.6
1986	0.2	53.7	552.0	399.9	933.5	131.9	9.9	0.0	0.1	0.0	0.0	0.0	2081.2
1987	0.0	31.4	439.1	1107.6	609.5	338.4	12.8	0.7	0.0	0.0	0.0	0.0	2539.6
1988	0.0	283.1	587.4	786.4	408.4	90.8	11.8	10.1	0.0	0.0	0.0	0.0	2178.0
1989	0.0	14.8	1597.5	1396.5	736.7	227.6	100.6	22.6	6.6	0.1	0.0	0.0	4103.0
1990	0.0	0.0	957.5	3138.2	1053.8	221.7	35.2	14.3	11.4	0.1	0.0	0.0	5432.1
1991	0.0	0.4	225.3	609.6	670.8	143.9	6.8	0.1	0.0	0.0	0.0	0.0	1657.0
1992	0.0	9.6	242.1	649.4	213.5	88.0	2.9	3.9	0.0	0.0	0.0	0.0	1209.3
1993	0.0	21.8	278.7	125.2	36.1	8.7	2.5	0.1	0.0	0.0	0.0	0.0	473.0
1994	0.7	58.2	860.2	99.1	22.6	6.5	2.1	1.7	0.2	0.2	0.0	0.0	1051.4
1995	1.1	42.7	2101.7	576.8	49.8	13.6	3.3	0.3	0.2	0.0	0.0	0.0	2789.6
1996	0.0	12.5	788.3	545.8	511.3	85.6	23.7	8.4	0.0	0.0	0.0	0.0	1975.6
1997	0.0	14.7	627.0	128.0	120.5	55.3	8.5	0.3	0.0	0.0	0.0	0.0	954.3
1998	0.0	37.2	61.3	127.0	78.3	48.7	7.3	1.3	0.0	0.0	0.0	0.0	361.3
1999	0.0	4.2	200.0	73.6	79.0	41.5	26.0	6.8	0.6	0.0	0.0	0.0	431.6
2000	0.0	2.7	292.0	191.9	57.6	36.6	11.3	6.4	0.2	0.0	0.0	0.0	598.8
2001	0.0	0.0	84.7	274.1	82.9	39.2	11.8	5.0	0.5	0.1	0.0	0.0	498.2
2002	0.0	0.7	3.2	16.0	16.1	3.6	0.9	0.2	0.1	0.0	0.0	0.0	40.9
2003	0.0	10.2	666.6	11.7	11.5	5.4	1.1	0.0	0.6	0.0	0.4	1.0	708.8
2004	0.0	4.6	111.8	37.0	6.7	1.7	1.5	0.5	0.2	0.2	0.1	0.1	164.3
2005	0.0	33.8	269.6	33.9	3.6	0.9	0.1	0.3	0.0	0.0	0.0	0.5	342.7
2006	0.0	24.9	55.4	18.2	6.1	2.7	1.3	0.5	0.4	0.5	0.2	0.3	110.6
2007	0.0	159.1	210.2	35.0	9.0	3.8	0.8	0.3	0.1	0.0	0.0	0.0	418.3
						Discards at age (mt)							Total
1980	0.0	0.0	0.0	11.9	19.6	6.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5
1981	0.0	0.0	5.9	31.9	43.4	15.2	0.1	0.0	0.7	0.0	0.0	0.0	97.3
1982	0.0	0.1	4.6	49.4	87.9	20.9	17.2	1.0	0.0	0.0	0.0	0.0	181.1
1983	0.0	0.2	18.0	58.3	103.4	53.4	9.8	1.1	0.0	0.2	0.0	0.0	244.3
1984	0.0	0.0	9.5	35.4	73.2	73.2	17.5	1.2	0.7	0.0	0.0	0.0	210.6
1985	0.0	0.8	4.4	63.2	56.2	44.4	16.7	2.9	0.0	0.0	0.0	0.0	188.6
1986	0.0	0.7	20.5	31.2	129.5	24.1	2.0	0.0	0.0	0.0	0.0	0.0	208.1
1987	0.0	0.3	12.7	83.0	80.3	66.1	3.2	0.2	0.0	0.0	0.0	0.0	245.8
1988	0.0	4.4	22.4	66.6	54.6	15.9	3.0	2.1	0.0	0.0	0.0	0.0	168.9
1989	0.0	0.1	51.4	123.8	132.2	51.5	20.4	5.2	2.3	0.0	0.0	0.0	386.8
1990	0.0	0.0	38.3	290.2	171.2	53.6	9.6	3.9	3.0	0.0	0.0	0.0	569.8
1991	0.0	0.0	5.9	54.7	128.4	40.7	2.7	0.1	0.0	0.0	0.0	0.0	232.5
1992	0.0	0.1	7.9	52.1	38.6	23.1	1.3	1.3	0.0	0.0	0.0	0.0	124.4
1993	0.0	0.1	8.6	12.6	6.8	2.2	1.0	0.0	0.0	0.0	0.0	0.0	31.3
1994	0.0	0.3	19.4	8.2	3.4	1.3	0.3	0.2	0.2	0.3	0.0	0.0	33.7
1995	0.0	0.3	53.2	42.5	9.4	3.8	1.2	0.1	0.1	0.0	0.0	0.0	110.5
1996	0.0	0.0	18.1	30.4	62.4	21.1	7.2	2.1	0.0	0.0	0.0	0.0	141.4
1997	0.0	0.1	12.3	8.4	12.9	9.3	1.6	0.1	0.0	0.0	0.0	0.0	44.8
1998	0.0	0.5	1.7	7.8	8.3	8.2	1.8	0.3	0.0	0.0	0.0	0.0	28.7
1999	0.0	0.0	3.4	3.2	7.9	5.1	4.4	1.8	0.2	0.0	0.0	0.0	26.0
2000	0.0	0.0	5.2	11.4	6.5	5.6	2.5	1.5	0.1	0.0	0.0	0.0	32.9
2001	0.0	0.0	1.5	10.9	8.6	5.1	2.0	1.2	0.2	0.0	0.0	0.0	29.5
2002	0.0	0.0	0.1	0.7	1.4	0.6	0.2	0.0	0.0	0.0	0.0	0.0	3.0
2003	0.0	0.3	15.8	0.9	1.2	0.8	0.2	0.0	0.1	0.0	0.8	1.8	21.8
2004	0.0	0.0	2.0	1.9	0.8	0.4	0.5	0.2	0.1	0.2	0.1	0.1	6.2
2005	0.0	0.3	4.6	1.7	0.4	0.1	0.0	0.1	0.0	0.0	0.0	0.8	8.0
2006	0.0	0.3	1.6	1.2	0.8	0.6	0.4	0.1	0.4	0.5	0.3	0.4	6.6
2007	0.0	1.2	6.0	2.8	1.5	0.9	0.3	0.1	0.0	0.0	0.0	0.0	12.8

Table H7 continued. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of American plaice discarded in the northern shrimp fishery in the Gulf of Maine region , 1980-2007.

Year	0	1	2	3	4	5	6	7	8	9	10	11+	
						Mean weight at age (kg)							Average
1980	0.000	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	0.000	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	0.000	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	0.002	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	0.000	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	0.000	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	0.001	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	0.000	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	0.000	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	0.000	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	0.000	0.040	0.092	0.162	0.242	0.272	0.275	0.261	0.472	0.000	0.000	0.105
1991	0.000	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	0.000	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	0.000	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	0.001	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	0.001	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	0.000	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	0.000	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	0.001	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	0.000	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	0.000	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	0.000	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	0.000	0.022	0.046	0.085	0.163	0.223	0.222	0.318	0.432	0.000	0.000	0.074
2003	0.000	0.030	0.024	0.078	0.102	0.141	0.161	0.283	0.137	0.326	1.776	1.725	0.031
2004	0.000	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	0.000	0.009	0.017	0.049	0.118	0.151	0.191	0.191	0.000	0.000	0.000	1.628	0.023
2006	0.000	0.010	0.029	0.066	0.134	0.229	0.265	0.253	1.001	1.183	1.110	1.183	0.060
2007	0.000	0.008	0.029	0.081	0.162	0.243	0.299	0.319	0.266	0.000	0.000	0.000	0.031
						Mean Length at age (cm)							Average
1980	----	----	----	23.8	27.7	29.6	35.0	----	----	----	----	----	26.2
1981	----	11.0	17.9	22.5	26.6	28.8	33.8	----	31.0	----	----	----	23.7
1982	----	13.2	16.2	22.6	26.0	28.9	28.3	31.0	----	----	----	----	24.1
1983	6.8	12.6	16.3	22.9	25.8	27.5	28.9	28.1	35.0	33.0	----	----	22.8
1984	----	8.5	16.1	21.1	25.1	26.3	28.2	29.3	31.0	----	----	----	23.2
1985	----	13.3	18.0	20.6	24.9	26.3	29.7	29.0	----	----	----	----	22.6
1986	5.0	13.2	16.8	21.6	25.9	28.3	29.5	----	35.0	----	----	----	22.5
1987	----	11.9	15.9	21.6	25.6	29.0	31.2	33.4	----	----	----	----	22.5
1988	----	13.6	17.2	22.0	25.7	28.0	31.5	29.7	----	----	----	----	20.6
1989	----	11.5	16.5	22.7	28.2	30.4	29.2	30.2	34.6	37.0	----	----	21.9
1990	----	----	17.9	22.9	27.1	30.9	32.1	32.2	31.7	38.0	----	----	23.3
1991	----	9.0	15.7	22.9	28.7	32.4	35.8	42.8	0.0	38.9	----	----	25.1
1992	3.0	10.0	16.8	21.9	28.1	31.7	36.7	33.5	0.0	47.0	----	----	22.7
1993	3.0	8.3	16.3	23.7	28.6	31.0	35.7	42.1	0.0	0.0	----	----	19.2
1994	5.0	9.1	15.0	22.1	26.8	29.3	26.7	26.0	52.0	52.0	----	----	15.7
1995	5.0	10.1	15.4	21.5	28.5	32.0	34.7	35.9	33.9	0.0	----	----	16.9
1996	5.0	8.6	15.1	19.7	24.8	30.7	33.1	31.1	----	41.0	----	----	19.8
1997	----	10.3	14.5	20.6	24.0	27.5	28.6	37.0	----	0.0	----	----	17.3
1998	5.0	12.8	15.9	20.3	23.8	27.5	30.8	31.4	40.8	43.0	----	----	20.8
1999	----	10.0	13.6	18.4	23.4	24.8	27.6	31.5	32.9	39.4	----	----	18.4
2000	---	13.0	13.9	20.2	24.4	26.5	29.5	30.6	37.3	----	----	----	18.2
2001	---	----	13.8	17.8	23.8	25.3	27.4	30.9	36.2	36.8	----	----	19.1
2002	--	9.5	15.1	18.6	22.3	27.3	30.0	29.6	33.6	36.5	----	----	20.7
2003	---	16.3	15.4	22.0	23.8	26.2	27.0	32.5	26.2	34.0	56.4	55.8	15.8
2004	---	8.8	14.1	19.2	24.9	31.0	33.2	34.9	41.8	48.0	49.4	49.5	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	----	----	----	15.0

Table H8. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of American plaice discarded in the **large mesh fishery** in the Gulf of Maine-Georges Bank region , 1980-2007.

Discards in Numbers (000's) at Age

Year	0	1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0.0	5.2	98.9	935.7	1786.7	781.2	30.2	2.9	0.0	0.0	0.0	0.0	3641
1981	0.0	4.2	246.7	495.9	436.9	157.6	29.8	19.9	5.4	0.0	0.0	0.0	1396
1982	0.0	2.7	335.4	668.9	446.8	101.8	21.7	0.0	0.0	0.0	0.0	0.0	1577
1983	0.0	0.6	47.8	399.5	681.4	327.8	52.6	12.2	1.4	3.4	0.0	0.0	1527
1984	0.0	0.0	65.0	249.1	549.4	718.1	281.5	16.3	0.3	0.0	0.0	0.0	1880
1985	0.0	10.9	54.6	227.0	85.8	30.8	5.6	0.0	0.0	0.0	0.0	0.0	415
1986	0.0	5.6	85.9	139.6	268.3	65.7	4.4	0.1	0.0	0.0	0.0	0.0	570
1987	0.0	7.1	135.9	390.4	343.7	241.1	53.2	3.8	1.9	0.0	0.0	0.0	1177
1988	0.0	30.4	197.1	606.9	276.6	50.3	5.7	0.2	0.0	0.0	0.0	0.0	1167
1989	0.0	0.7	677.5	1133.6	1329.3	608.6	223.1	64.3	58.4	2.7	0.7	2.3	4101
1990	0.0	0.0	136.9	1385.4	1707.2	701.4	160.6	62.6	43.6	0.1	0.0	0.0	4198
1991	0.0	0.0	29.9	398.3	3476.4	1903.7	148.8	7.1	1.4	0.7	0.0	0.0	5966
1992	0.0	0.0	2.4	166.3	652.0	851.3	83.6	32.4	0.0	0.0	0.0	0.0	1788
1993	0.0	0.0	1.9	173.8	709.7	336.4	123.8	1.9	0.0	0.0	0.0	0.0	1348
1994	0.0	0.0	2.4	112.0	791.8	968.2	77.5	1.6	0.0	0.0	0.0	0.0	1953
1995	0.0	2.6	332.0	855.9	1598.7	426.9	121.7	13.7	11.2	0.5	0.0	0.0	3363
1996	0.0	0.0	261.2	538.1	727.4	251.8	82.7	29.0	3.3	2.7	2.0	4.8	1903
1997	0.0	0.0	9.1	207.0	937.6	977.8	169.4	21.2	0.3	0.0	0.0	0.0	2322
1998	0.0	0.0	24.1	216.0	613.8	1317.3	707.3	73.5	0.4	0.0	0.0	0.0	2952
1999	0.0	0.0	16.3	93.8	833.4	647.7	662.9	224.9	46.1	2.4	0.4	0.0	2528
2000	0.0	0.0	11.0	137.3	323.0	183.6	94.9	35.5	1.4	0.0	0.0	0.0	787
2001	0.0	0.0	7.0	139.7	484.8	356.8	195.1	60.2	17.5	5.9	0.1	5.9	1273
2002	0.0	0.4	9.6	90.1	428.0	374.2	146.2	36.1	15.6	9.8	4.2	1.3	1115
2003	0.0	1.7	22.5	33.8	156.2	450.7	175.9	30.0	33.6	11.5	0.2	9.3	925
2004	0.0	1.6	28.2	182.6	310.5	464.8	357.0	70.1	14.5	4.6	1.5	1.1	1437
2005	0.0	0.5	13.9	69.9	242.9	406.8	192.6	56.7	10.6	0.7	0.4	0.3	995
2006	0.0	3.5	27.9	94.0	303.5	273.4	132.7	59.5	13.9	2.0	4.4	0.5	915
2007	0.0	0.9	27.5	168.4	332.4	216.6	88.7	14.4	3.6	0.8	2.8	0.0	856

Discards at age (mt)

Year	0	1	2	3	4	5	6	7	8	9	10	11+	Total
1980	0.0	0.2	7.5	147.2	423.8	218.3	9.4	1.1	0.0	0.0	0.0	0.0	808
1981	0.0	0.2	21.9	61.7	70.0	26.7	5.6	3.4	1.1	0.0	0.0	0.0	191
1982	0.0	0.1	42.1	98.8	69.3	18.6	3.8	0.0	0.0	0.0	0.0	0.0	233
1983	0.0	0.0	4.0	65.8	134.5	69.7	12.0	2.8	0.4	0.8	0.0	0.0	290
1984	0.0	0.0	6.7	40.2	112.4	172.8	71.3	5.2	0.1	0.0	0.0	0.0	409
1985	0.0	0.3	4.8	25.4	11.3	4.8	0.9	0.0	0.0	0.0	0.0	0.0	48
1986	0.0	0.2	6.2	17.9	44.7	12.4	0.7	0.0	0.0	0.0	0.0	0.0	82
1987	0.0	0.1	11.4	60.2	69.5	59.2	15.2	1.1	0.2	0.0	0.0	0.0	217
1988	0.0	0.6	13.5	100.1	53.5	11.3	1.5	0.1	0.0	0.0	0.0	0.0	181
1989	0.0	29.3	123.3	298.5	164.4	59.9	24.2	23.0	2.2	1.0	1.0	1.9	729
1990	0.0	3.8	200.6	392.2	190.4	45.9	19.6	13.1	0.0	0.0	0.0	0.0	866
1991	0.0	1.1	50.5	851.3	595.2	62.2	5.2	0.9	0.5	0.0	0.0	0.0	1567
1992	0.0	0.1	24.3	160.5	266.7	30.3	9.5	0.0	0.0	0.0	0.0	0.0	491
1993	0.0	0.2	32.4	183.3	107.4	42.4	0.8	0.0	0.0	0.0	0.0	0.0	366
1994	0.0	0.1	21.7	230.4	315.3	23.8	0.2	0.0	0.0	0.0	0.0	0.0	592
1995	0.0	13.3	108.7	412.0	133.2	47.3	6.8	5.3	0.5	0.1	0.0	0.1	727
1996	0.0	8.0	35.0	113.0	97.2	39.3	12.8	4.3	4.6	3.7	9.9	0.0	328
1997	0.0	0.5	40.4	257.6	278.7	52.0	7.9	0.1	0.0	0.0	0.0	0.0	637
1998	0.0	0.9	25.4	135.1	333.5	197.3	19.0	0.3	0.0	0.0	0.0	0.0	712
1999	0.0	0.7	10.4	179.3	177.3	214.7	78.2	17.0	2.0	0.4	0.0	0.0	680
2000	0.0	0.6	24.5	79.0	58.4	36.1	15.3	1.1	0.0	0.0	0.0	0.0	215
2001	0.0	0.3	20.0	122.2	110.1	63.5	20.5	5.7	2.2	0.0	1.9	0.0	346
2002	0.0	0.4	13.3	93.7	107.0	46.1	11.9	5.3	3.6	1.7	0.7	1.7	285
2003	0.0	0.8	3.4	30.7	124.9	56.7	10.2	9.7	4.1	0.2	2.6	0.0	243
2004	0.0	0.7	12.8	50.7	128.1	112.2	25.8	7.3	3.1	1.0	0.8	0.2	343
2005	0.0	0.4	4.7	48.1	113.0	63.2	18.5	4.2	0.6	0.4	0.2	0.1	253
2006	0.0	1.1	10.8	66.8	82.2	44.0	20.7	6.6	1.6	1.9	0.4	0.1	236
2007	0.0	1.8	27.8	84.5	70.4	30.4	6.6	1.8	0.6	1.0	0.0	0.0	225

Table H8 continued. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of American plaice discarded in the **large mesh fishery** in the Gulf of Maine-Georges Bank region , 1980-2007.

Year	0	1	2	3	4	5	6	7	8	9	10	11+	Total
						Mean weight at age (kg)							
1980	0.000	0.030	0.076	0.157	0.237	0.279	0.311	0.392	0.000	0.000	0.000	0.000	0.2
1981	0.000	0.037	0.089	0.124	0.160	0.169	0.189	0.171	0.209	0.000	0.000	0.000	0.1
1982	0.000	0.029	0.126	0.148	0.155	0.182	0.173	0.000	0.000	0.000	0.000	0.000	0.1
1983	0.007	0.024	0.083	0.165	0.197	0.213	0.228	0.234	0.308	0.229	0.000	0.000	0.2
1984	0.000	0.000	0.103	0.162	0.205	0.241	0.253	0.317	0.432	0.000	0.000	0.000	0.2
1985	0.000	0.030	0.088	0.112	0.132	0.155	0.168	0.000	0.000	0.000	0.000	0.000	0.1
1986	0.000	0.035	0.072	0.128	0.167	0.189	0.171	0.295	0.000	0.000	0.000	0.000	0.1
1987	0.000	0.020	0.084	0.154	0.202	0.246	0.286	0.295	0.116	0.000	0.000	0.000	0.2
1988	0.000	0.019	0.068	0.165	0.193	0.226	0.262	0.359	0.000	0.000	0.000	0.000	0.2
1989	0.000	0.010	0.043	0.108	0.224	0.271	0.268	0.376	0.394	0.828	1.350	1.242	0.2
1990	0.000	0.000	0.028	0.145	0.229	0.271	0.286	0.313	0.300	0.472	0.000	0.000	0.2
1991	0.000	0.000	0.037	0.127	0.245	0.313	0.418	0.732	0.660	0.675	0.000	0.000	0.3
1992	0.000	0.000	0.042	0.146	0.246	0.313	0.363	0.292	0.000	0.000	0.000	0.000	0.3
1993	0.000	0.000	0.083	0.186	0.258	0.319	0.342	0.418	0.000	0.000	0.000	0.000	0.3
1994	0.000	0.000	0.056	0.194	0.291	0.325	0.308	0.133	0.000	0.000	0.000	0.000	0.3
1995	0.000	0.007	0.040	0.127	0.258	0.312	0.389	0.498	0.478	1.089	1.183	1.183	0.2
1996	0.000	0.000	0.031	0.065	0.155	0.386	0.474	0.440	1.312	1.715	1.867	2.036	0.2
1997	0.000	0.000	0.060	0.195	0.275	0.285	0.307	0.373	0.561	0.000	0.000	0.000	0.3
1998	0.000	0.000	0.037	0.118	0.220	0.253	0.279	0.259	0.772	0.000	0.000	0.000	0.2
1999	0.000	0.000	0.041	0.110	0.215	0.274	0.324	0.348	0.369	0.855	1.106	0.000	0.3
2000	0.000	0.000	0.051	0.178	0.244	0.318	0.380	0.430	0.801	0.714	0.000	0.000	0.3
2001	0.000	0.000	0.036	0.143	0.252	0.309	0.326	0.341	0.328	0.370	0.432	0.326	0.3
2002	0.000	0.007	0.039	0.148	0.219	0.286	0.315	0.329	0.341	0.370	0.402	1.815	0.3
2003	0.000	0.011	0.035	0.100	0.197	0.277	0.322	0.340	0.288	0.360	0.787	0.278	0.3
2004	0.000	0.006	0.025	0.070	0.163	0.276	0.315	0.368	0.504	0.675	0.661	0.906	0.2
2005	0.000	0.009	0.025	0.066	0.198	0.278	0.328	0.327	0.396	0.814	0.992	1.155	0.3
2006	0.000	0.010	0.041	0.115	0.220	0.301	0.332	0.348	0.478	0.797	0.429	0.975	0.3
2007	0.000	0.010	0.065	0.165	0.254	0.325	0.343	0.458	0.500	0.702	0.343	0.945	0.3
					Mean Length at age (cm)								
1980													
1981													
1982													
1983													
1984													
1985													
1986													
1987													
1988													
1989		12.0	18.3	24.0	30.1	32.0	31.7	34.7	35.6	44.0	51.8	50.1	27.0
1990		0.0	16.0	26.2	30.3	32.0	32.6	33.5	33.0	38.0	0.0	0.0	28.9
1991		0.0	17.7	25.1	31.0	33.5	36.3	43.3	42.0	42.1	0.0	0.0	31.5
1992		0.0	17.9	26.4	31.1	33.5	35.1	32.9	0.0	0.0	0.0	0.0	32.0
1993		0.0	22.5	28.5	31.6	33.7	34.4	36.5	0.0	0.0	0.0	0.0	32.0
1994		0.0	20.0	28.9	32.7	33.9	33.3	26.0	0.0	0.0	0.0	0.0	33.1
1995		11.0	17.8	25.2	31.5	33.3	35.5	38.1	37.2	48.6	50.0	50.0	28.9
1996		0.0	16.5	20.5	26.4	34.6	37.1	35.6	51.3	55.5	57.3	58.8	25.2
1997		0.0	20.2	28.9	32.1	32.5	33.2	35.4	40.0	0.0	0.0	0.0	32.0
1998		0.0	17.6	24.5	29.9	31.3	32.3	31.3	44.0	0.0	0.0	0.0	30.6
1999		0.0	18.2	23.9	29.7	31.9	33.5	34.2	34.5	45.0	49.0	0.0	31.5
2000		0.0	19.4	28.1	31.0	33.3	35.1	35.9	44.2	43.0	0.0	0.0	31.6
2001		0.0	17.3	25.9	31.2	33.3	33.9	34.4	34.0	35.3	37.0	34.0	31.8
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		10.9	17.2	23.7	28.8	32.1	33.7	34.0	32.4	34.8	44.0	32.2	31.3
2004		10.1	15.3	21.1	27.4	32.1	33.4	34.8	38.0	42.0	41.5	45.5	29.9
2005		11.6	15.7	21.0	28.9	32.2	33.9	33.5	35.6	44.4	46.6	48.5	30.8
2006		12.0	17.9	24.5	29.9	33.0	34.0	34.3	37.3	44.2	36.2	46.8	30.9
2007		11.8	20.5	27.4	31.3	33.8	34.3	37.2	37.6	42.6	34.2	46.8	31.3

Table H9. Catch at age (thousands of fish; metric tons) and mean weight (kg), of commercial landings, and large mesh and northern shrimp fisherydiscards of American plaice, ages 1-11+, from Gulf of Maine - Georges Bank, 1980-2007.

Year	1	2	3	4	5	6	7	8	9	10	11+	Total
					Catch in Numbers (000's) at Age							
1980	5	99	1072	2672	3939	3933	3632	1185	1139	850	1380	19906
1981	5	982	2192	5055	5337	3648	2401	1582	645	440	621	22907
1982	10	603	3348	4574	4503	3599	3297	2038	1256	737	717	24681
1983	15	663	1478	5177	4918	3913	2270	1272	701	450	911	21768
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	15	2275	2606	2517	1522	827	835	534	196	104	118	11550
1990	0	1094	4726	3607	1972	696	367	404	193	96	161	13316
1991	0	255	1031	5998	4866	1261	326	166	202	97	104	14306
1992	10	244	862	1605	5811	2649	849	191	131	118	93	12562
1993	22	281	422	1775	2382	2579	1384	265	287	151	125	9671
1994	58	886	407	1711	2841	1342	1158	597	235	150	290	9674
1995	45	2434	1573	2360	3294	1854	655	589	210	53	50	13116
1996	12	1150	1257	3732	2713	1506	566	243	126	37	68	11411
1997	15	636	337	2317	3615	1717	634	182	85	66	116	9720
1998	37	85	349	866	2859	2604	1071	318	59	57	154	8461
1999	4	216	169	1136	1675	2352	1389	488	150	42	79	7700
2000	3	303	442	797	1650	2224	1755	567	138	70	20	7970
2001	0	92	414	959	2297	2198	1579	912	293	56	52	8852
2002	1	13	109	772	1449	1811	1191	516	283	161	177	6484
2003	12	689	45	297	1238	1275	744	557	279	154	119	5409
2004	6	140	226	440	924	1195	508	364	195	77	74	4151
2005	34	283	106	434	990	767	442	177	97	42	49	3423
2006	28	83	114	478	768	536	354	191	99	60	43	2755
2007	160	238	224	596	806	511	216	113	68	33	31	2996
					Catch at Age (mt)							
1980	0	8	165	715	1611	2571	3009	1232	1347	1168	2616	14442
1981	0	106	370	1598	2360	2837	2125	1547	729	552	963	13186
1982	0	69	768	1323	1884	2028	3165	2320	1502	1144	1364	15567
1983	0	22	273	1957	2607	2618	1868	1326	868	650	1531	13721
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	29	175	448	474	446	340	581	407	258	151	226	3536
1990	4	239	760	717	647	360	257	341	210	125	273	3932
1991	1	56	914	1562	1634	798	308	191	256	150	189	6060
1992	0	32	234	619	2677	1906	775	237	173	193	188	7034
1993	0	41	247	578	1099	1593	1306	327	400	238	289	6118
1994	0	44	285	702	1014	792	920	646	303	213	704	5624
1995	14	162	505	441	1520	1139	531	647	280	111	95	5444
1996	8	70	202	1168	1285	930	493	292	175	64	142	4829
1997	1	53	266	826	1291	989	504	205	114	104	282	4634
1998	1	27	145	410	858	1118	824	328	80	83	509	4383
1999	1	14	183	283	702	1069	889	411	164	61	151	3929
2000	1	30	137	238	744	1252	1325	570	151	99	37	4583
2001	0	21	133	292	941	1104	1085	758	304	84	77	4800
2002	0	13	95	242	542	882	790	454	293	197	256	3764
2003	1	19	32	178	405	629	507	452	261	173	145	2802
2004	1	15	55	184	330	494	310	281	188	78	88	2023
2005	1	9	51	191	345	344	269	147	92	45	62	1556
2006	1	12	69	155	282	256	205	152	92	57	56	1338
2007	3	34	95	174	307	240	135	92	67	33	46	1226

Table H9 continued. Catch at age (thousands of fish; metric tons) and mean weight (kg), of commercial landings, and large mesh and northern shrimp fishery discards of American plaice, ages 1-11+, from Gulf of Maine - Georges Bank, 1980-2007.

Year		1	2	3	4	5	6	7	8	9+	10	11+	Average
							Mean Weight at age (kg)						
1980		0.030	0.076	0.154	0.267	0.409	0.653	0.829	1.039	1.183	1.374	1.895	0.725
1981		0.032	0.108	0.168	0.316	0.442	0.778	0.885	0.978	1.130	1.254	1.551	0.576
1982		0.018	0.115	0.230	0.290	0.418	0.564	0.960	1.138	1.196	1.552	1.901	0.631
1983		0.013	0.033	0.185	0.378	0.530	0.670	0.823	1.042	1.238	1.446	1.680	0.630
1984		0.004	0.045	0.161	0.303	0.524	0.630	0.888	1.187	1.133	1.369	1.958	0.636
1985		0.018	0.058	0.084	0.209	0.331	0.534	0.847	1.167	1.377	1.665	2.128	0.596
1986		0.016	0.042	0.138	0.229	0.384	0.587	0.842	1.174	1.491	1.747	2.194	0.516
1987		0.013	0.046	0.131	0.234	0.409	0.609	0.892	1.173	1.483	1.732	2.284	0.465
1988		0.016	0.046	0.159	0.284	0.449	0.641	0.880	1.231	1.396	1.717	2.238	0.429
1989		0.009	0.035	0.105	0.241	0.362	0.454	0.697	0.801	1.327	1.462	1.926	0.306
1990	*	0.011	0.038	0.120	0.254	0.401	0.554	0.717	0.876	1.088	1.305	1.696	0.295
1991		0.004	0.027	0.110	0.303	0.445	0.678	0.958	1.157	1.274	1.541	1.813	0.424
1992		0.006	0.032	0.114	0.320	0.501	0.727	0.925	1.240	1.319	1.640	2.007	0.560
1993		0.003	0.031	0.228	0.368	0.489	0.634	0.944	1.234	1.394	1.577	2.313	0.633
1994		0.004	0.026	0.189	0.360	0.460	0.608	0.794	1.083	1.289	1.424	2.424	0.581
1995		0.006	0.027	0.128	0.305	0.489	0.665	0.905	1.155	1.099	2.104	1.920	0.423
1996		0.003	0.037	0.099	0.317	0.495	0.635	0.884	1.203	1.390	1.581	2.227	0.423
1997		0.006	0.021	0.146	0.347	0.420	0.601	0.807	1.127	1.336	1.570	2.425	0.477
1998		0.013	0.030	0.101	0.245	0.348	0.498	0.786	1.031	1.350	1.463	3.293	0.518
1999		0.008	0.019	0.083	0.251	0.397	0.513	0.685	0.872	1.109	1.458	1.908	0.510
2000		0.013	0.019	0.185	0.324	0.464	0.572	0.763	1.007	1.094	1.411	1.864	0.575
2001	*	0.011	0.019	0.075	0.317	0.430	0.522	0.696	0.835	1.045	1.454	1.529	0.542
2002		0.002	0.035	0.136	0.296	0.415	0.506	0.669	0.884	1.043	1.224	1.446	0.580
2003		0.027	0.024	0.095	0.282	0.383	0.530	0.683	0.820	0.950	1.106	1.243	0.518
2004		0.005	0.019	0.075	0.242	0.374	0.486	0.647	0.782	0.972	1.009	1.207	0.487
2005		0.009	0.017	0.070	0.291	0.399	0.507	0.641	0.848	0.946	1.073	1.280	0.454
2006		0.010	0.033	0.110	0.293	0.416	0.522	0.621	0.823	0.922	0.983	1.296	0.486
2007		0.008	0.033	0.172	0.316	0.430	0.515	0.644	0.825	0.981	1.023	1.511	0.409

*average of age 1 time series

Table H10. Standardized stratified mean catch per tow in numbers and weight (kg) for American plaice in N offshore spring and autumn and DFO spring research vessel bottom trawl surveys surveys, 1963 - 2008.

	NEFSC Spring		NEFSC Autumn		DFO Spring	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	14.2	5.9		
1964	-	-	8.2	2.8		
1965	-	-	12.0	3.8		
1966	-	-	17.8	4.9		
1967	-	-	11.1	2.7		
1968	11.4	3.4	8.6	2.9		
1969	8.6	2.7	7.5	2.4		
1970	5.4	1.8	6.5	2.0		
1971	3.8	1.3	7.5	2.0		
1972	4.3	1.3	7.4	1.6		
1973	7.2	1.9	6.2	1.9		
1974	8.3	1.9	6.9	1.4		
1975	5.8	1.7	8.1	2.4		
1976	11.9	3.4	10.0	3.0		
1977	14.6	5.1	11.8	3.5		
1978	10.6	3.8	15.1	4.7		
1979	9.2	3.6	10.0	4.0		
1980	18.3	4.8	14.2	5.1		
1981	18.8	5.9	13.0	5.6		
1982	11.6	3.8	5.9	2.5		
1983	16.9	4.6	9.3	3.5		
1984	4.1	1.4	7.1	2.0		
1985	4.9	1.9	7.0	2.0		
1986	3.1	0.9	5.6	1.6		
1987	3.5	0.8	4.4	1.1	1.81	0.75
1988	3.6	0.8	9.7	1.5	1.72	0.56
1989	4.8	0.8	9.2	1.2	2.75	0.52
1990	5.1	0.8	15.5	2.9	5.06	1.13
1991	5.9	1.1	7.7	1.6	4.05	1.05
1992	4.1	1.4	6.3	1.8	7.07	1.33
1993	5.3	1.4	11.9	2.4	2.72	1.47
1994	4.9	0.9	18.1	2.7	1.07	0.49
1995	9.4	1.9	11.8	2.6	3.87	0.77
1996	7.8	1.7	7.6	2.2	3.86	1.01
1997	7.6	1.6	6.3	1.9	6.79	1.62
1998	4.5	1.1	9.3	2.2	2.28	0.85
1999	4.2	1.2	11.0	2.6	3.22	1.06
2000	10.0	2.3	12.2	2.8	5.07	1.44
2001	10.6	2.2	10.4	2.6	2.13	0.67
2002	6.7	1.8	9.7	2.2	3.88	1.2
2003	4.2	0.9	9.3	2.3	1.02	0.4
2004	8.2	1.4	5.4	1.0	1.17	0.44
2005	5.0	0.8	5.8	1.0	1.91	0.37
2006	7.4	1.0	12.5	1.7	3.94	0.56
2007	10.0	1.3	11.0	1.4	6.53	0.86
2008	8.0	1.5			2.8	0.54
1963-2008	7.8	2.0	9.7	2.6	3.4	0.9

* 2006 DFO, no tows in 5Z5,5Z7, 5Z8
* 2007 DFO, no tows in 5Z8

Table H11.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) , 1980-2008.

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	no/tow	wt/tow
Spring																	
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	4.78
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	5.88
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	3.80
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	4.60
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	1.42
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	1.88
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	0.92
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	0.81
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	0.84
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	0.75
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	0.75
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	1.05
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	1.36
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	1.39
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	0.85
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	1.94
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	1.69
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	1.62
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	1.11
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	1.20
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	2.30
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	2.19
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	1.76
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	0.87
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	1.35
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	0.83
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	0.99
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	1.29
2008	0.00	0.11	0.58	2.05	2.84	1.40	0.64	0.22	0.09	0.06	0.04	0	0	0	0.005	8.04	1.47
Average 1980-2008	0.00	0.14	1.22	1.79	1.87	1.24	0.62	0.34	0.15	0.09	0.06	0.03	0.02	0.02	0.02	7.54	1.78

Table H12. Standardized stratified mean number per tow by age and mean weight per tow (kg) of American plaice in the NEFSC autumn research bottom trawl surveys in the Gulf of Maine and Georges Bank area (offshore strata 13-30,36-40) , 1980-2007.

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	no/tow	wt/tow
Autumn																	
1980	0	1.58	2.23	2.72	2.84	1.53	1.02	0.93	0.57	0.3	0.19	0.11	0.04	0.09	0.09	14.24	5.12
1981	0.003	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	5.62
1982	0	0.2	0.91	1.65	1.27	0.57	0.48	0.3	0.17	0.19	0.08	0.03	0	0	0.02	5.87	2.49
1983	0.06	0.5	1.01	2.02	2.92	1.36	0.68	0.34	0.17	0.1	0.03	0.05	0.06	0.01	0.03	9.34	3.45
1984	0.02	0.22	2.24	1.56	1.21	1.07	0.51	0.12	0.1	0	0.03	0.01	0.02	0	0.01	7.12	2.02
1985	0.02	0.91	0.83	2.64	1.05	0.79	0.41	0.19	0.05	0.03	0.02	0	0	0.01	0	6.95	2
1986	0.1	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	0	5.61	1.56
1987	0.01	0.53	1.27	0.99	0.43	0.69	0.25	0.1	0.04	0.04	0.01	0.02	0	0	0	4.38	1.09
1988	0	2.84	2.97	2.39	0.78	0.47	0.1	0.07	0	0.03	0	0.02	0	0	0	9.67	1.46
1989	0.05	0.48	4.45	2.86	0.98	0.19	0.1	0.02	0.02	0.02	0.02	0	0.01	0.02	0	9.22	1.17
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	15.46	2.9
1991	0.01	0.47	2.47	2.02	1.59	0.73	0.29	0.04	0.06	0	0.01	0	0	0	0.01	7.70	1.56
1992	0.02	0.65	1.23	1.85	1.28	0.78	0.3	0.07	0.05	0.03	0.02	0	0.02	0	0	6.30	1.78
1993	0.01	1.7	2.34	3.47	2.28	1.05	0.8	0.11	0.04	0.04	0.04	0	0	0	0	11.88	2.39
1994	0.04	3.83	7.53	2.81	1.71	1.3	0.4	0.25	0.13	0.01	0.03	0.02	0	0	0	18.06	2.67
1995	0.01	0.5	3.8	3.82	2.5	0.9	0.22	0.04	0.03	0	0	0	0.02	0	0	11.84	2.58
1996	0.01	0.54	0.81	2	2.74	0.93	0.39	0.07	0.04	0.03	0	0	0.02	0	0.02	7.60	2.23
1997	0.01	0.36	1.06	1.55	1.86	1.04	0.32	0.04	0.01	0.01	0	0	0	0	0.02	6.28	1.94
1998	0.01	1.73	0.6	1.88	2.01	1.78	1.08	0.12	0.05	0.01	0.01	0	0.01	0	0	9.29	2.22
1999	0.02	2	2.2	2.05	2.13	1.6	0.81	0.2	0.03	0	0	0	0	0	0	11.04	2.57
2000	0.03	0.47	2.9	3.91	2.28	1.35	0.75	0.33	0.14	0.03	0.03	0	0	0	0	12.22	2.79
2001	0.02	0.4	1.22	3.31	2.64	1.46	0.53	0.41	0.2	0.17	0.02	0	0.01	0	0	10.39	2.63
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	2.241
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	2.27
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	0.96
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	0.99
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	1.71
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	1.44
Average																	
1980-2(	0.02	1.03	2.14	2.35	1.90	1.07	0.53	0.22	0.13	0.06	0.05	0.04	0.02	0.02	0.05	9.54	2.28

Table H13. Stratified mean number per tow by age of American plaice in Massachusetts State spring and autumn bottom trawl surveys in Massachusetts Bay and Cape Cod Bay (Regions 4+5), 1982-2007.

	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	not available												
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	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	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	1.2	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	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	60.02	19.1	9.96	6.31	2.74	1.03	0.18	0.08	0	0	0.08	99.5
2005	0	41.42	54.52	14.74	11.65	4.22	1.43	0.2	0.18	0.06	0	0.03	128.44
2006	0	14.51	45.14	20.8	10.88	4.13	1.38	1.03	0.14	0.04	0.08	0	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	67.6

Table H14. Selected VPA diagnostics, including predicted beginning year stock numbers for ages 1-10 and catchability estimates of each survey index, with standard error and CV for Gulf of Maine – Georges Bank American plaice.

```
Levenburg-Marquardt Algorithm Completed     9 Iterations
 Residual Sum of Squares =     300.043

 Number of Residuals     =    743
 Number of Parameters    =     10
 Degrees of Freedom      =    733
 Mean Squared Residual   =     0.409336
 Standard Deviation      =     0.639793


 Number of Years =    28
 Number of Ages  =    11
 First Year      =  1980
 Youngest Age    =     1
 Oldest True Age =    10

 Number of Survey Indices Available       =    30
 Number of Survey Indices Used in Estimate =    27
```

Age	Stock Predicted	Std. Error	CV
1	42084.333	0.274534E+05	0.652342E+00
2	19084.898	0.559295E+04	0.293056E+00
3	34216.404	0.749229E+04	0.218968E+00
4	23147.560	0.423645E+04	0.183019E+00
5	15758.500	0.259021E+04	0.164369E+00
6	7052.158	0.113337E+04	0.160712E+00
7	6866.112	0.105831E+04	0.154136E+00
8	1632.210	0.330953E+03	0.202763E+00
9	1801.068	0.358493E+03	0.199044E+00
10	2375.051	0.443839E+03	0.186875E+00

Catchability Values for Each Survey Used in Estimate

INDEX	Catchability	Std. Error	CV
1	0.756315E-02	0.142550E-02	0.188479E+00
2	0.117776E+00	0.131015E-01	0.111241E+00
3	0.237083E+00	0.226727E-01	0.956320E-01
4	0.345291E+00	0.278629E-01	0.806939E-01
5	0.332013E+00	0.234096E-01	0.705080E-01
6	0.270544E+00	0.198359E-01	0.733185E-01
7	0.239287E+00	0.222962E-01	0.931778E-01
8	0.178071E+00	0.243164E-01	0.136554E+00
9	0.183208E+00	0.279889E-01	0.152771E+00
11	0.106649E+00	0.124861E-01	0.117077E+00
12	0.299685E+00	0.259527E-01	0.865999E-01
13	0.454693E+00	0.396251E-01	0.871469E-01
14	0.545345E+00	0.407639E-01	0.747489E-01
15	0.521424E+00	0.446796E-01	0.856877E-01
16	0.460618E+00	0.447785E-01	0.972141E-01
17	0.328359E+00	0.416616E-01	0.126878E+00
18	0.310350E+00	0.441360E-01	0.142214E+00
20	0.421847E-01	0.102605E-01	0.243227E+00
21	0.234209E+00	0.370230E-01	0.158077E+00
22	0.318789E+00	0.249546E-01	0.782794E-01
23	0.228953E+00	0.182832E-01	0.798555E-01
24	0.128202E+00	0.126938E-01	0.990135E-01
26	0.265599E+00	0.400073E-01	0.150631E+00
27	0.341196E+00	0.393301E-01	0.115271E+00
28	0.271214E+00	0.304525E-01	0.112282E+00
29	0.140295E+00	0.194801E-01	0.138851E+00
30	0.542392E-01	0.102775E-01	0.189484E+00

Table H15. 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, 1980-2007.

Stock Numbers (Jan 1) in thousands

Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	50300	26027	20849	24666	15520	19012	23602	41613	53494	20981	21648	22668	25137	39653
2	39477	41178	21304	17061	20182	12704	15507	19270	34035	43514	17164	17722	18557	20571
3	32635	32231	32827	16898	13370	16189	10259	12120	15245	27156	33573	13065	14279	14973
4	24065	25752	24412	23858	12502	10053	12156	7733	8265	10824	19884	23231	9767	10913
5	19254	17295	16536	15870	14878	8056	7027	7897	5037	5118	6599	13034	13632	6552
6	13955	12221	9371	9494	8582	6785	4438	4225	4417	2691	2825	3633	6314	5966
7	9947	7894	6732	4451	4273	4121	2987	2310	2260	2321	1461	1687	1844	2800
8	4678	4891	4309	2570	1621	1770	1390	1278	1090	1354	1152	866	1088	752
9	3006	2765	2586	1709	970	807	489	574	561	649	630	581	560	719
10	2776	1441	1684	996	772	548	271	173	302	300	356	342	295	340
11+	4509	2035	1640	2019	1932	373	258	169	189	342	597	368	235	281
Total	204602	173729	142248	119593	94601	80418	78384	97362	124895	115250	105888	97197	91707	103521

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	38756	26619	24201	21348	16743	26464	16173	12409	28387	22483	36846	42696	51397	23487	42084
2	32445	31678	21753	19803	17465	13674	21663	13239	10159	23239	18396	30161	34926	42054	19085
3	16589	25764	23741	16772	15639	14222	11000	17462	10756	8306	18404	14935	24438	28519	34216
4	11878	13215	19675	18303	13428	12489	11491	8607	13923	8708	6759	14864	12132	19905	23148
5	7337	8184	8695	12750	12897	10212	9201	8689	6182	10703	6862	5137	11777	9502	15759
6	3230	3464	3753	4686	7193	7988	6853	6047	5051	3759	7647	4785	3315	8949	7052
7	2580	1445	1185	1725	2299	3557	4429	3617	2982	2513	1934	5185	3228	2232	6866
8	1058	1077	598	465	844	926	1669	2056	1550	1376	1390	1128	3846	2324	1632
9	379	335	358	273	218	407	323	858	868	806	628	811	763	2976	1801
10	332	102	88	180	147	125	199	141	440	457	410	339	576	536	2375
11+	644	96	163	315	400	233	56	129	483	353	392	391	418	543	828
Total	115228	111979	104210	96620	87273	90296	83058	73255	80782	82703	99669	120431	146816	141027	154846

Fishing Mortality

Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
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
2	0.00	0.03	0.03	0.04	0.02	0.01	0.05	0.03	0.03	0.06	0.07	0.02	0.01	0.02
3	0.04	0.08	0.12	0.10	0.09	0.09	0.08	0.18	0.14	0.11	0.17	0.09	0.07	0.03
4	0.13	0.24	0.23	0.27	0.24	0.16	0.23	0.23	0.28	0.29	0.22	0.33	0.20	0.20
5	0.25	0.41	0.35	0.41	0.59	0.40	0.31	0.38	0.43	0.39	0.40	0.52	0.63	0.51
6	0.37	0.40	0.54	0.60	0.53	0.62	0.45	0.43	0.44	0.41	0.32	0.48	0.61	0.64
7	0.51	0.41	0.76	0.81	0.68	0.89	0.65	0.55	0.31	0.50	0.32	0.24	0.70	0.77
8	0.33	0.44	0.72	0.77	0.50	1.09	0.68	0.62	0.32	0.57	0.48	0.24	0.21	0.49
9	0.53	0.30	0.75	0.59	0.37	0.89	0.84	0.44	0.42	0.40	0.41	0.48	0.30	0.57
10	0.41	0.41	0.65	0.68	0.57	0.76	0.55	0.49	0.39	0.47	0.35	0.37	0.57	0.66
11+	0.41	0.41	0.65	0.68	0.57	0.76	0.55	0.49	0.39	0.47	0.35	0.37	0.57	0.66
Total	0.44	0.38	0.70	0.69	0.52	0.87	0.66	0.51	0.37	0.47	0.38	0.36	0.46	0.62

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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	0.00	0.01
2	0.03	0.09	0.06	0.04	0.01	0.02	0.02	0.01	0.00	0.03	0.01	0.01	0.00	0.01
3	0.03	0.07	0.06	0.02	0.02	0.01	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.01
4	0.17	0.22	0.23	0.15	0.07	0.11	0.08	0.13	0.06	0.04	0.07	0.03	0.04	0.03
5	0.55	0.58	0.42	0.37	0.28	0.20	0.22	0.34	0.30	0.14	0.16	0.24	0.07	0.10
6	0.60	0.87	0.58	0.51	0.50	0.39	0.44	0.51	0.50	0.46	0.19	0.19	0.20	0.06
7	0.67	0.68	0.74	0.51	0.71	0.56	0.57	0.65	0.57	0.39	0.34	0.10	0.13	0.11
8	0.95	0.90	0.59	0.56	0.53	0.85	0.47	0.66	0.45	0.58	0.34	0.19	0.06	0.05
9	1.11	1.14	0.49	0.42	0.36	0.52	0.63	0.47	0.44	0.48	0.42	0.14	0.15	0.03
10	0.68	0.83	0.61	0.52	0.55	0.46	0.48	0.57	0.51	0.46	0.23	0.15	0.12	0.06
11+	0.68	0.83	0.61	0.52	0.55	0.46	0.48	0.57	0.51	0.46	0.23	0.15	0.12	0.06
Total	0.84	0.90	0.60	0.50	0.53	0.58	0.53	0.57	0.49	0.48	0.32	0.16	0.13	0.06

Table H15 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, 1980-2007.

SSB at start of spawning season

Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	8	4	3	2	0	6	4	3	5	1	0	0	0	0
2	77	111	61	20	32	18	28	25	39	39	6	6	4	5
3	496	612	812	389	191	241	205	196	299	384	298	118	111	157
4	2069	2339	2080	2751	1326	927	848	811	976	1236	1811	2326	995	1154
5	4076	3925	3871	4054	4299	1758	1472	1923	1312	1315	1661	3400	3974	1998
6	6449	5523	3535	3827	3839	2719	1595	1730	1906	1032	1101	1583	2901	2699
7	6293	5055	4436	2308	2591	2248	1604	1385	1456	1302	731	1101	1167	1819
8	4086	3755	3398	2015	1332	1293	1111	1033	1003	939	759	707	1069	677
9	2874	2646	2203	1663	913	785	498	645	614	714	505	518	611	779
10	3040	1508	1803	1052	829	593	348	234	416	362	408	384	352	396
11+	7339	2711	2521	2724	3121	625	469	324	366	556	882	578	388	524
Total	36807	28190	24722	20805	18474	11215	8183	8310	8393	7881	8162	10722	11572	10208

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0	0	0	0	0	0	0	0	0	0	0	2	3	1
2	5	6	6	3	4	4	5	4	4	5	8	8	17	29
3	156	181	161	140	95	101	98	100	78	68	96	93	181	408
4	1767	1600	1991	1740	1375	1013	1037	1190	1146	867	517	1181	932	2065
5	2302	2600	2635	3710	3658	2595	2601	2662	1822	2916	1833	1273	3405	2818
6	1426	1451	1705	2118	2731	2854	2756	2469	1959	1463	2964	1851	1343	3800
7	1471	860	719	1033	1259	1720	2287	1846	1452	1274	990	2685	1668	1197
8	803	783	513	384	642	589	1174	1323	1032	837	888	758	2620	1561
9	344	262	382	296	234	364	256	745	690	624	480	640	618	2527
10	376	129	95	222	171	148	210	146	416	416	361	317	513	487
11+	1255	142	297	640	1092	377	89	163	584	372	424	458	500	768
Total	9905	8014	8503	10285	11261	9764	10512	10648	9183	8843	8560	9266	11799	15659

Percent mature (females)

Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
2	0.04	0.05	0.05	0.05	0.07	0.10	0.07	0.05	0.05	0.04	0.02	0.02	0.02	0.02
3	0.15	0.18	0.17	0.17	0.21	0.26	0.24	0.24	0.25	0.22	0.15	0.15	0.15	0.13
4	0.45	0.46	0.43	0.44	0.50	0.55	0.56	0.65	0.69	0.66	0.62	0.60	0.60	0.57
5	0.80	0.77	0.74	0.76	0.79	0.80	0.84	0.92	0.94	0.93	0.94	0.93	0.92	0.92
6	0.95	0.93	0.91	0.93	0.93	0.93	0.96	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	0.99	0.98	0.97	0.98	0.98	0.98	0.99	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
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
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

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.04
3	0.13	0.13	0.14	0.12	0.14	0.15	0.16	0.16	0.15	0.15	0.13	0.18	0.18	0.20
4	0.57	0.56	0.56	0.56	0.58	0.55	0.59	0.62	0.59	0.54	0.54	0.57	0.57	0.59
5	0.92	0.92	0.91	0.92	0.92	0.90	0.92	0.94	0.92	0.88	0.90	0.89	0.89	0.90
6	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.99	0.98	0.99	0.98	0.98	0.98
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	1.00	1.00
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
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
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

Table H16. Input data for yield-per-recruit and projection analysis. Selectivity and mean weight estimated as an average of 2003-2007 data, and proportion mature estimated as five-year moving average, 2004-2008.

Age	VPA selectivity	Stock weight	Catch weight	Spawning stock weight	Proportion mature
1	0.00	0.0097	0.0118	0.0097	0.01
2	0.05	0.0148	0.0254	0.0148	0.03
3	0.05	0.0510	0.1041	0.0510	0.18
4	0.25	0.1649	0.2849	0.1649	0.57
5	0.76	0.3350	0.4004	0.3350	0.89
6	1.00	0.4510	0.5118	0.4510	0.98
7	1.00	0.5745	0.6472	0.5745	1.00
8	1.00	0.7309	0.8194	0.7309	1.00
9	1.00	0.8904	0.9544	0.8904	1.00
10	1.00	1.0020	1.0388	1.0020	1.00
11+	1.00	1.3074	1.3075	1.3074	1.00

Table H17. Projection results of catch and biomass in 2009 where 2008 catch = 2007 for 3 fishing mortality scenarios: $F_{STATUS\ QUO}$, F_{MSY}, and $F_{REBUILD}$ for the BASE Model , unadjusted for retrospective pattern and the BASE Model Adjusted for retropsective pattern using 7-year average rho.

BASE Model – unadjusted for retrospective

BASE	Year	Catch	SSB	F
F status quo	2008	1126	19,497	0.07
0.06	2009	**1495**	25,258	0.06
Fmsy	2008	1126	19,497	0.07
0.19	2009	**4,481**	24,558	0.19
Frebuild	2008	1126	19,497	0.07
0.257	2009	**5,896**	24,205	0.257

BASE Model with retrospective adjustment

BASE Adj.	Year	Catch	SSB	F
F status quo	2008	1,126	13,226	0.01
0.09	2009	**1,588**	18,143	0.09
Fmsy	2008	1,126	13,226	0.01
0.19	2009	**3,219**	17,768	0.19
Frebuild	2008	1,126	13,226	0.01
0.208	2009	**3,499**	17,703	0.208

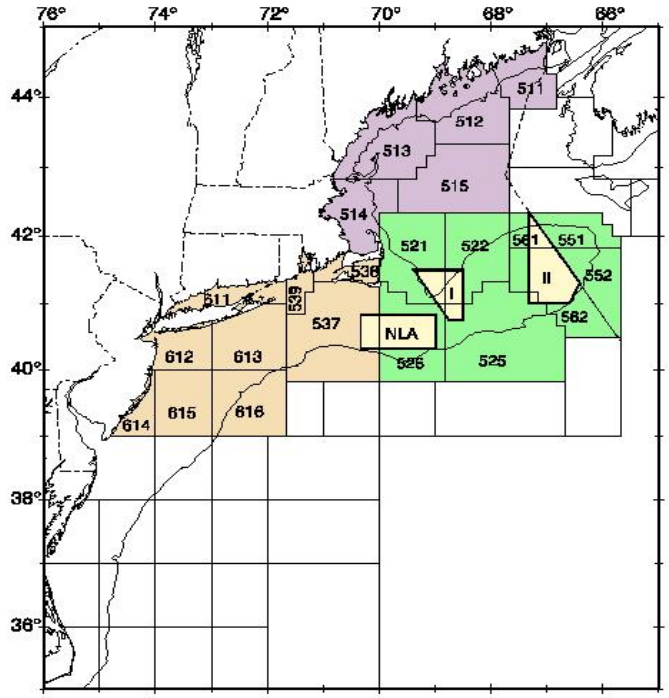


Figure H1. Stock area of American plaice as defined by Northwest Atlantic Fisheries Organization (NAFO) statistical areas : 511-515, 521-526, 551-552, and 561-562.

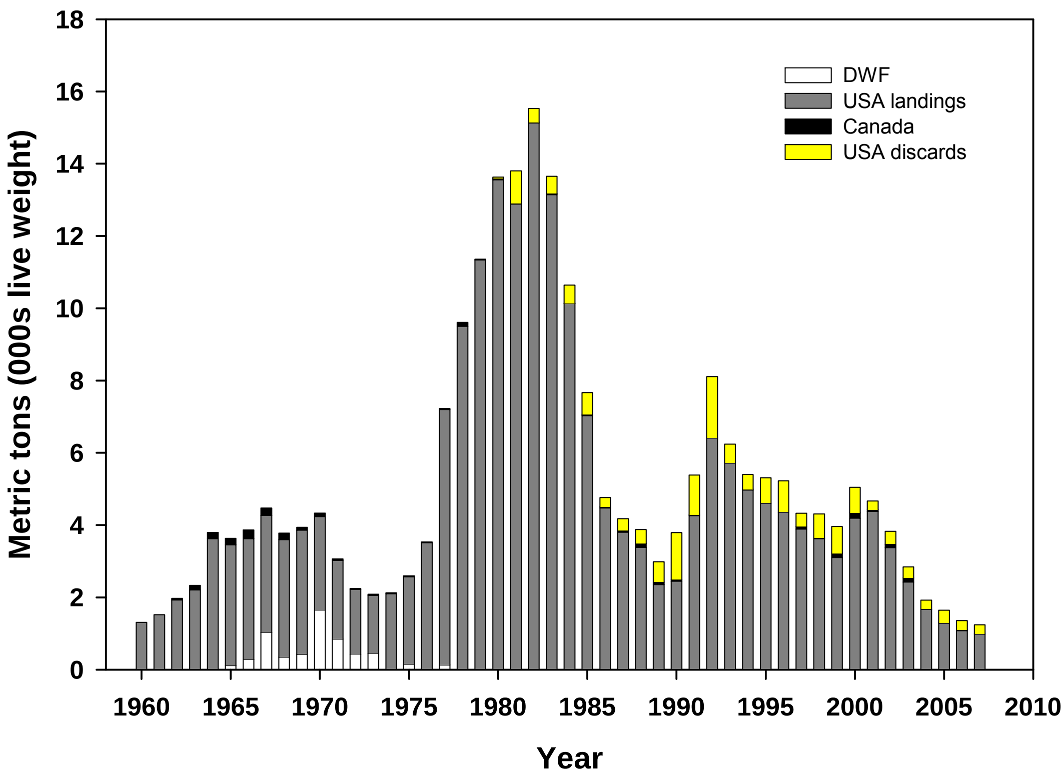


Figure H2. Total catch of Gulf of Maine-Georges Bank American plaice including USA commercial landings and discards, and Canadian landings, 1960-2007.

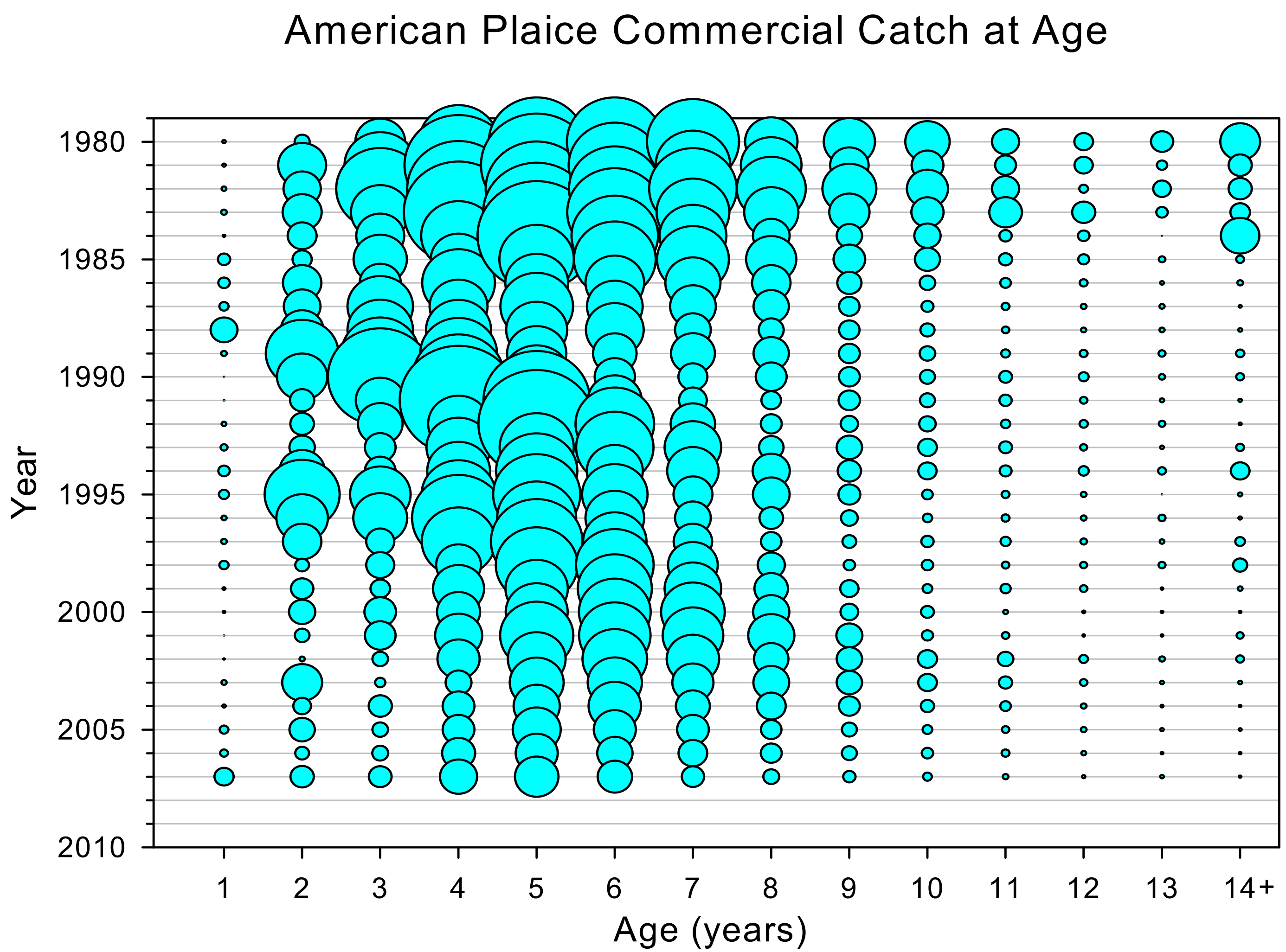


Figure H3. Catch at age (thousands of fish) of commercial landings, and large mesh and northern shrimp fishery discards for American plaice in the Gulf of Maine-Georges Bank region, 1980-2007.

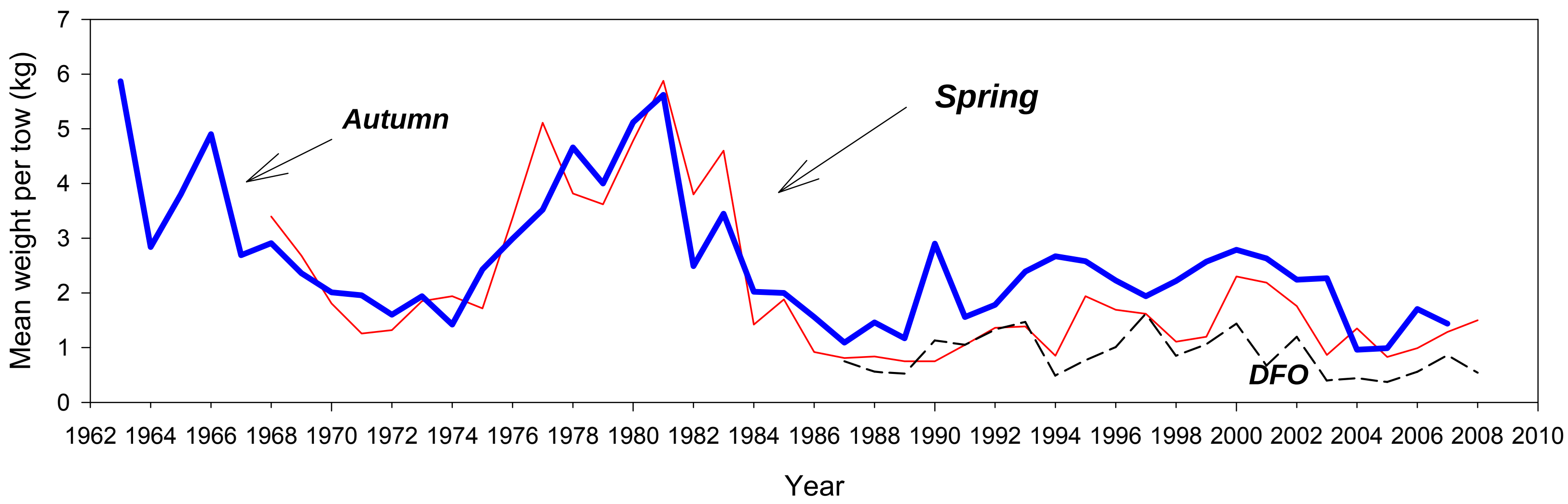


Figure H4. Standardized stratified mean weight per tow (kg) of American plaice in NEFSC and spring and autumn and spring DFO research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963-2008.

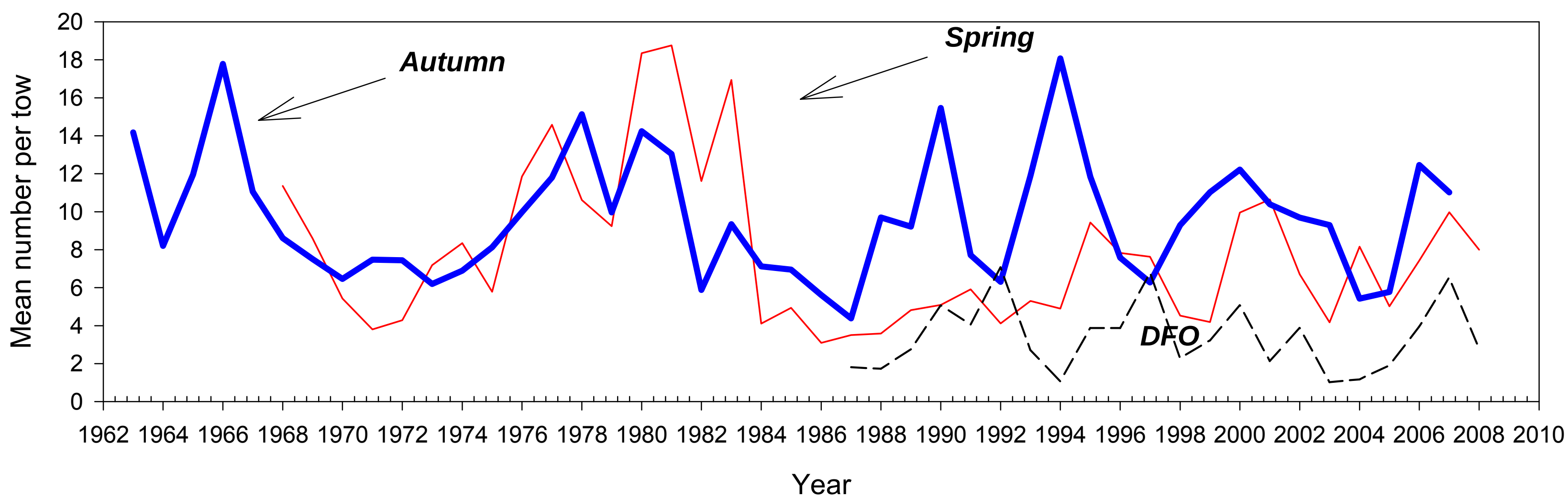


Figure H5. Standardized stratified mean number per tow (kg) of American plaice in NEFSC spring and autumn research and spring DFO research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963-2008.

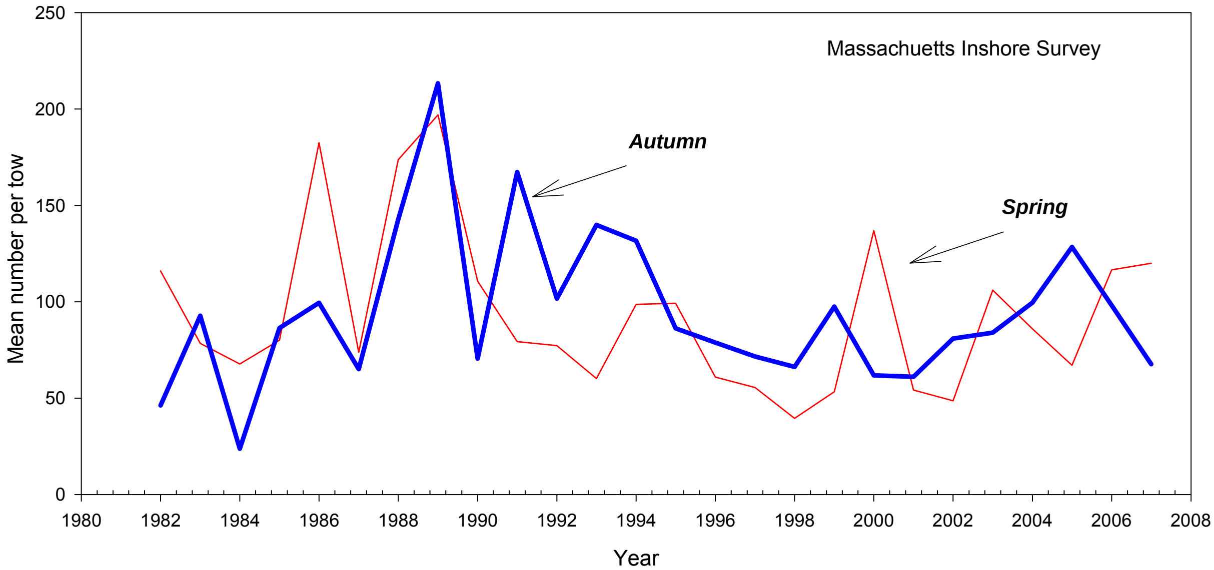


Figure H6. Standardized stratified mean number per tow (kg) of American plaice in MADMF spring and autumn research research vessel bottom trawl surveys region, 1982-2007.

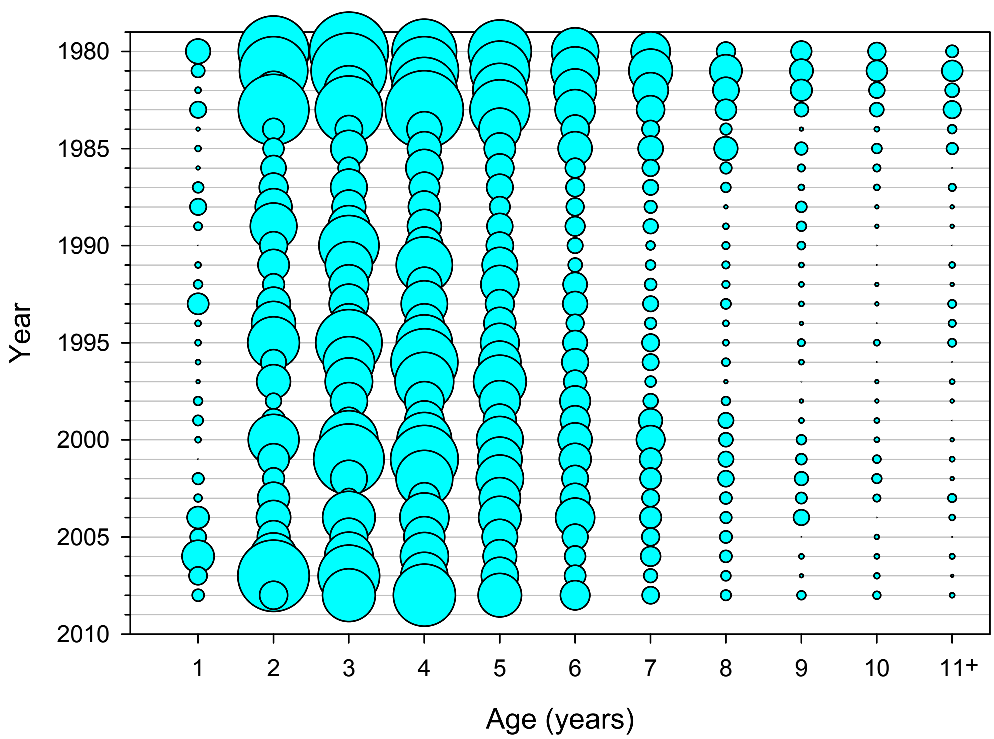


Figure H7. Standardized stratified mean catch per tow at age (numbers) of American plaice in NEFSC spring bottom trawl surveys, 1980-2008.

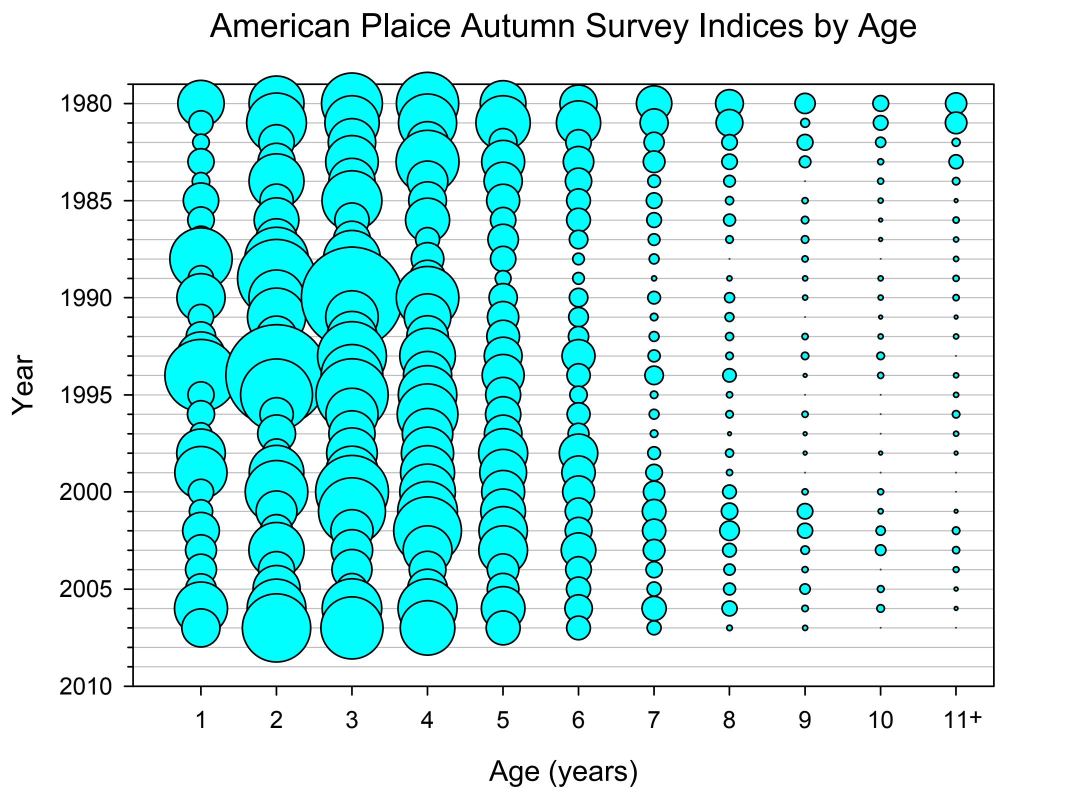


Figure H8. Standardized stratified mean catch per tow at age (numbers) of American plaice in NEFSC autumn bottom trawl surveys, 1980-2007.

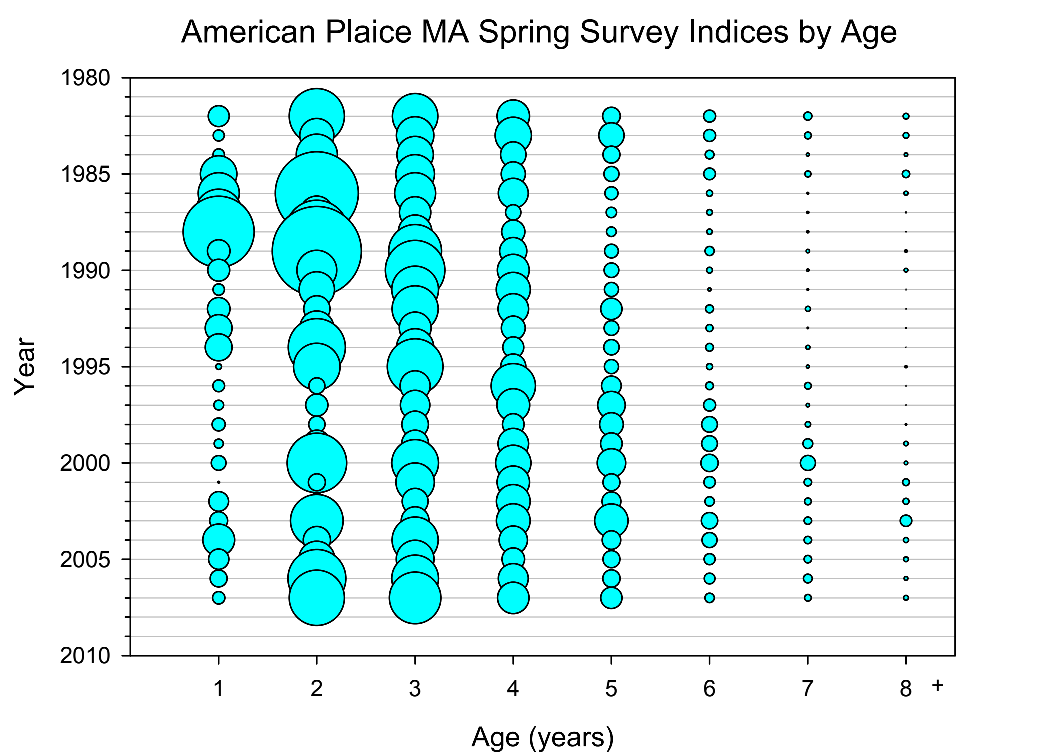


Figure H9. Standardized stratified mean catch per tow at age (numbers) of American plaice in Massachusetts State spring bottom trawl surveys, 1982-2007.

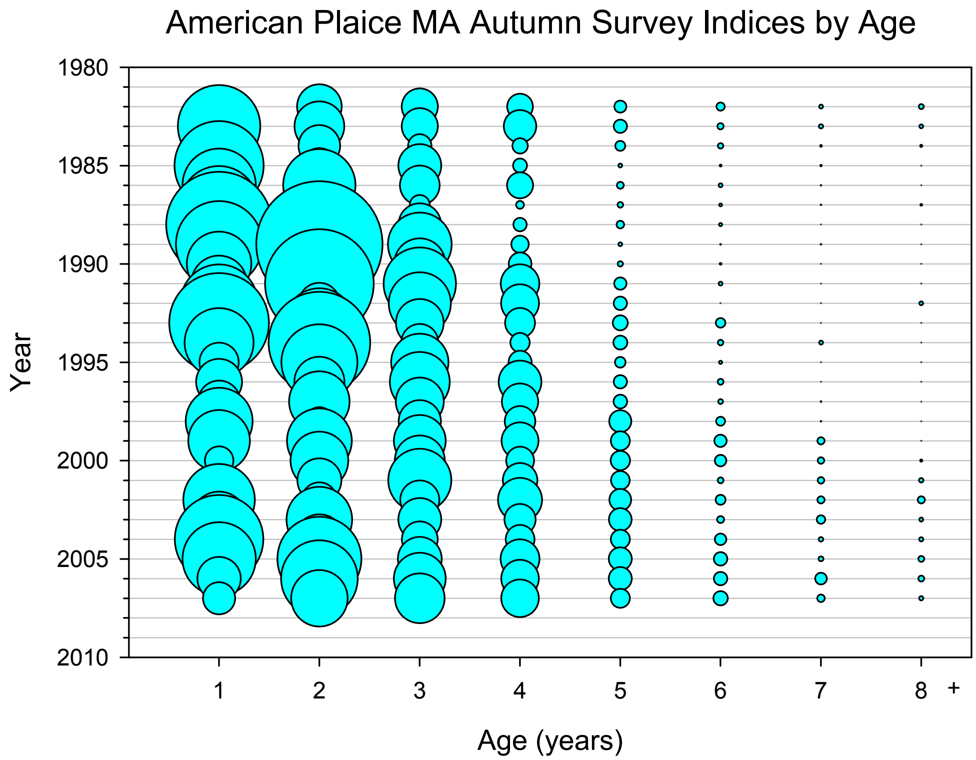


Figure H10. Standardized stratified mean catch per tow at age (numbers) of American plaice in Massachusetts State autumn bottom trawl surveys, 1982-2007.

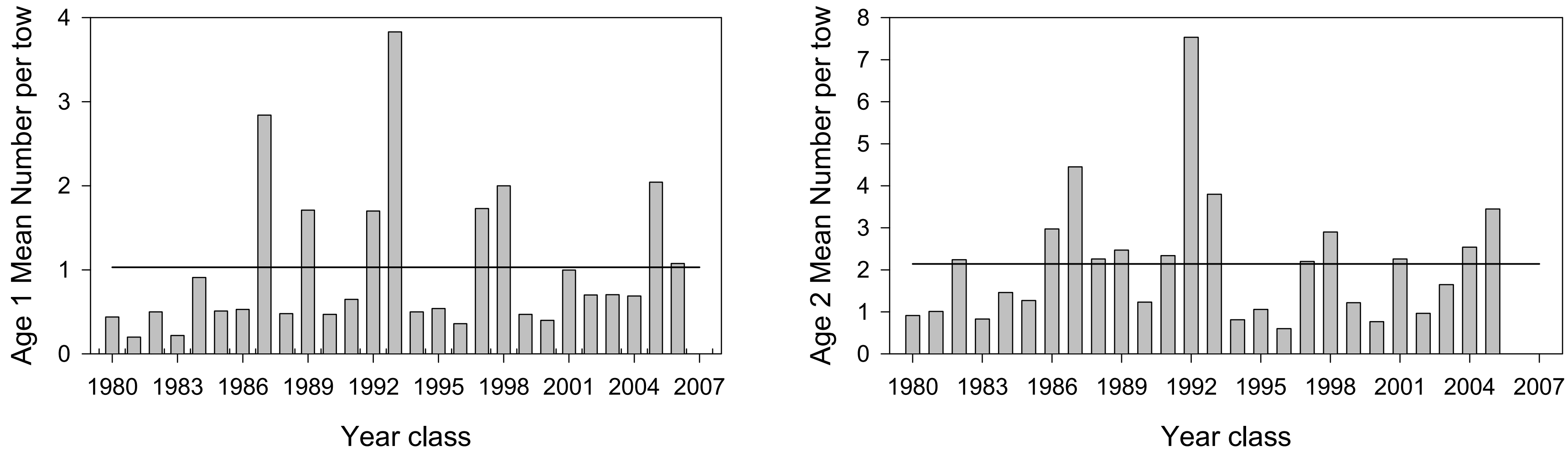


Figure H11a. Relative year class strength of age 1 and age 2 Gulf of Maine-George Bank American plaice from standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1980-2007.

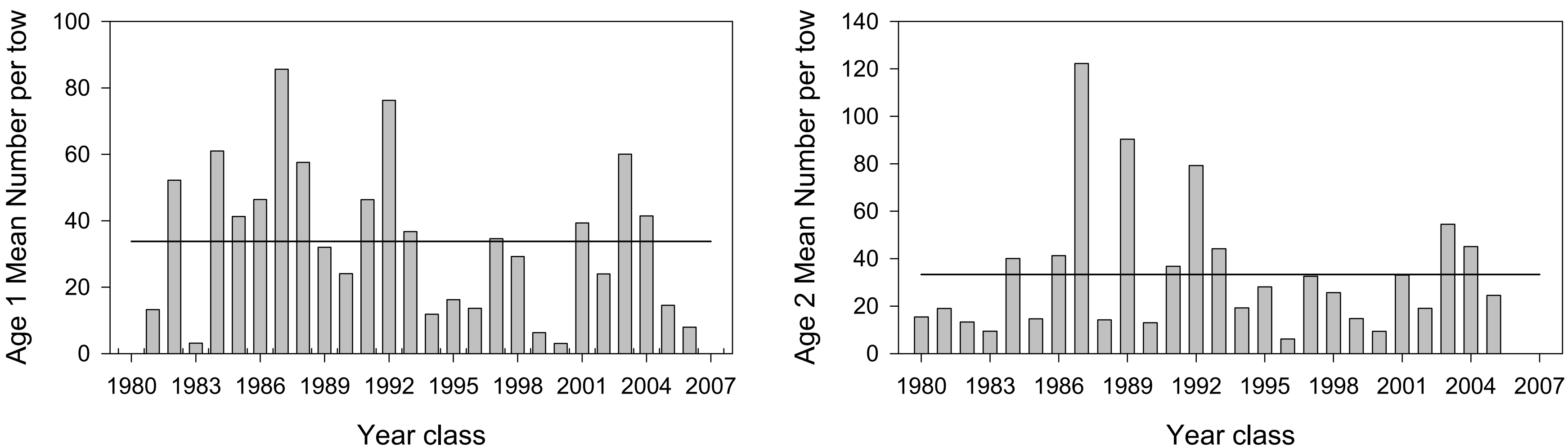


Figure H11b. Relative year class strength of age 1 and age 2 Gulf of Maine-George Bank American plaice from standardized catch (number) per tow indices from MADMF autumn research vessel bottom trawl surveys, 1982-2007.

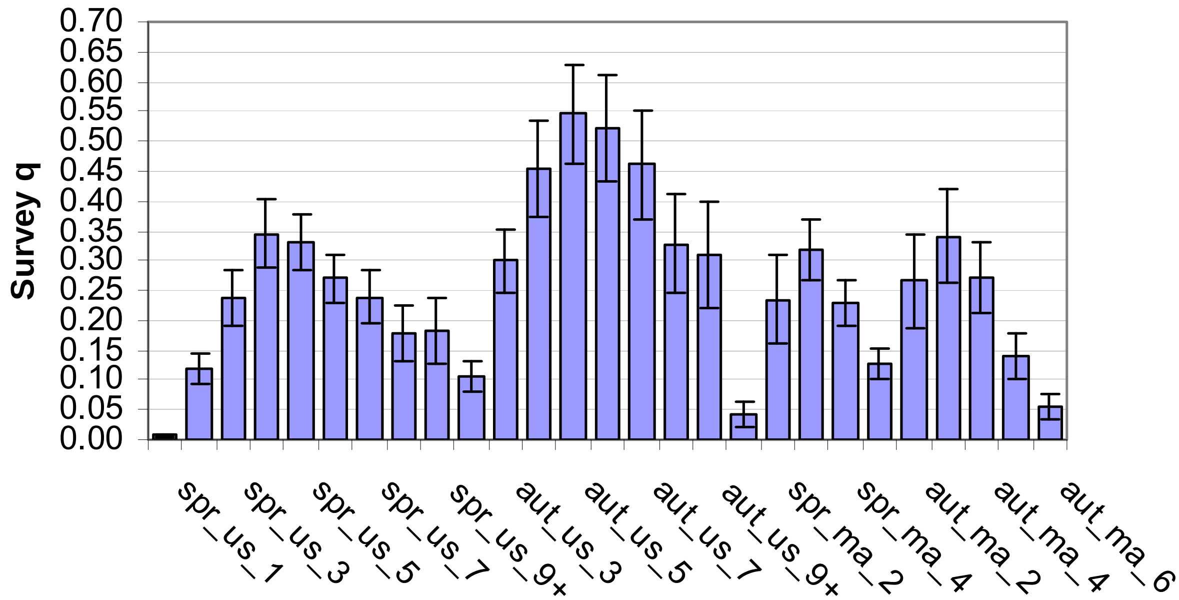


Figure H12. Survey catchability (q) estimates based on swept area estimates of American plaice in NMFS and MADMF spring and autumn research bottom trawl surveys.

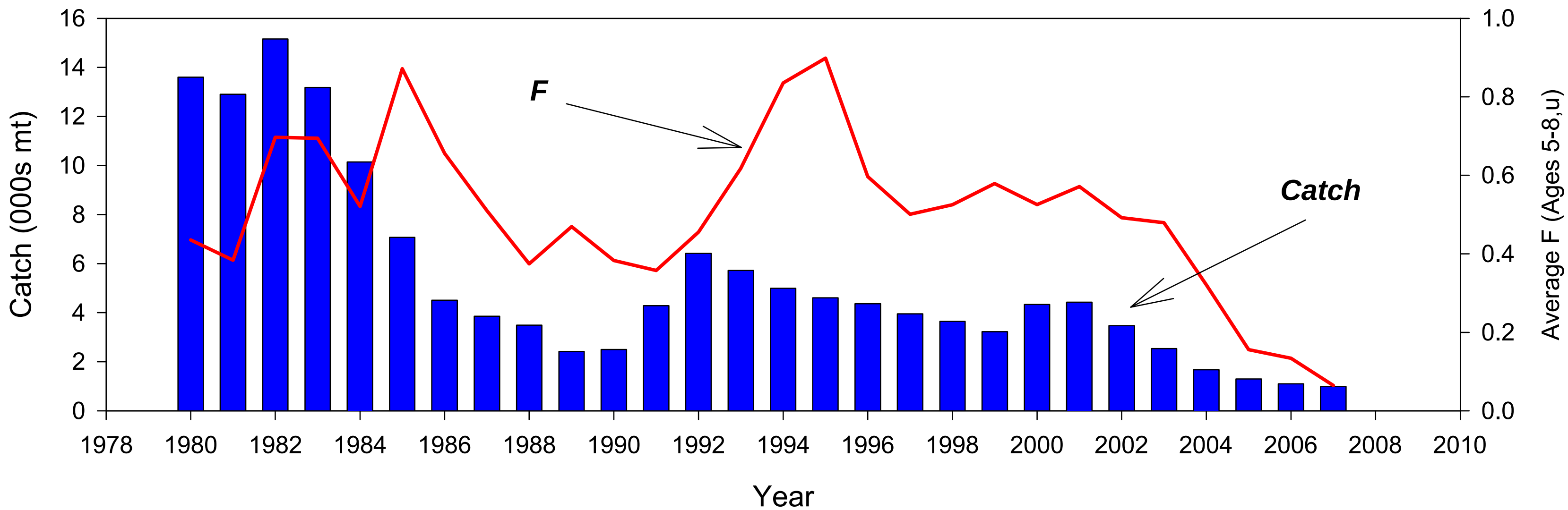


Figure H13. Trends in total commercial catch and fishing mortality for Gulf of Maine-Georges Bank American plaice, 1980-2007.

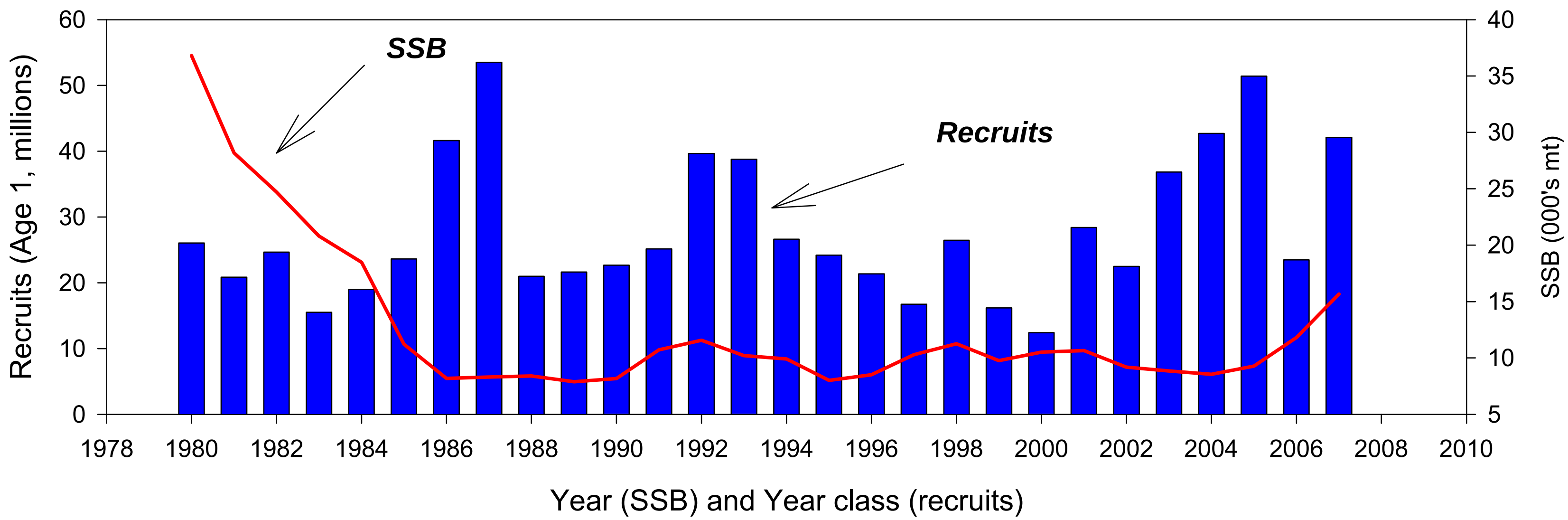
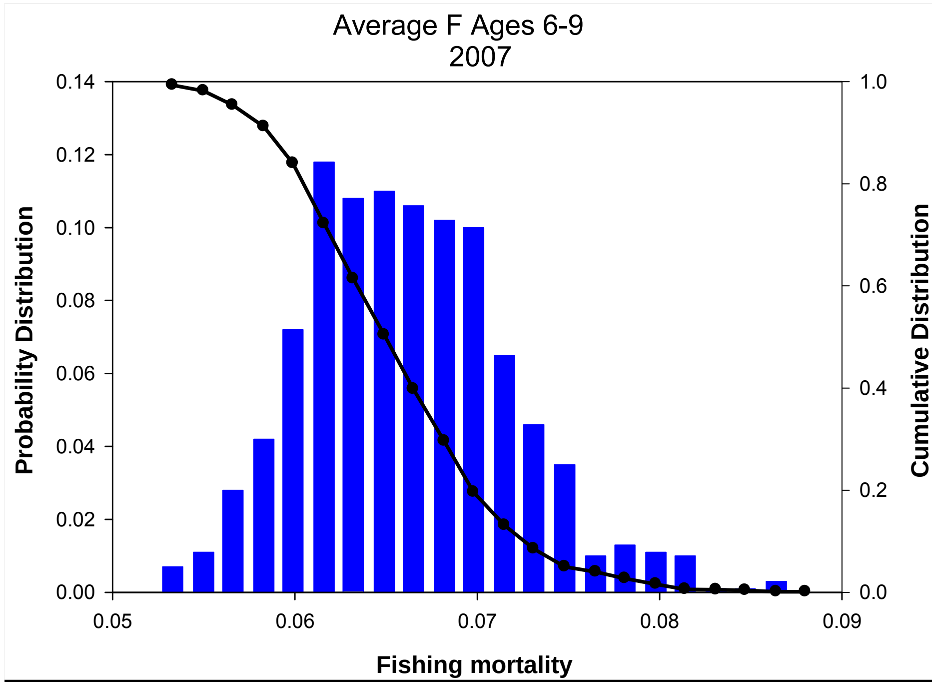


Figure H14. Trends in recruitment and spawning stock biomass for Gulf of Maine-Georges Bank American plaice, 1980 - 2007.



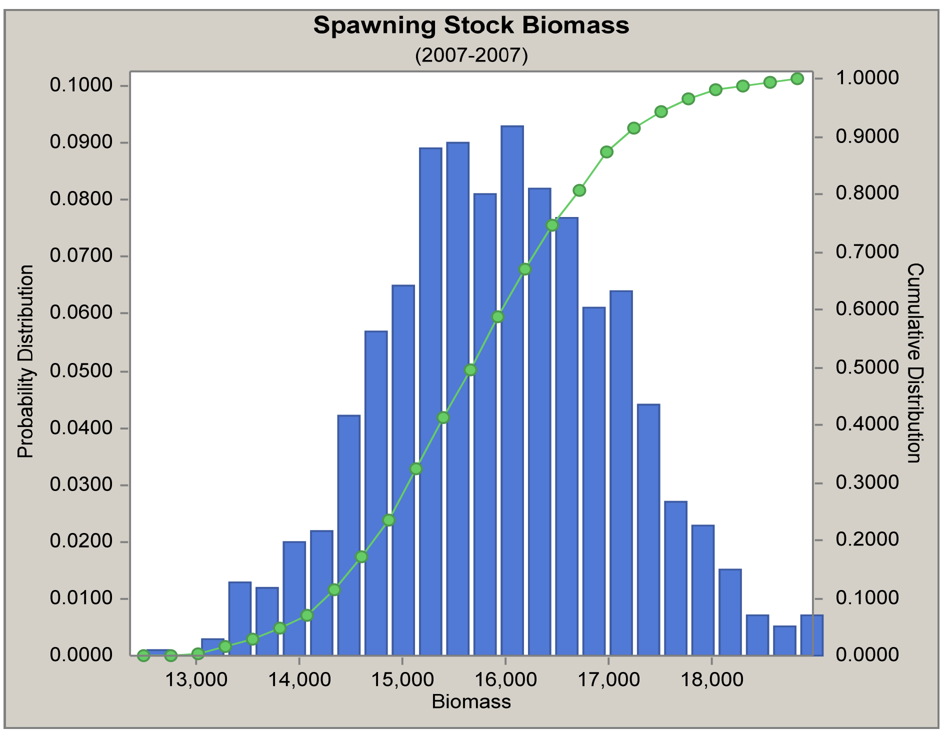


Figure H15. Precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages(6-9) and spawning stock biomass at the beginning of the spawning season for Gulf of Maine – Georges Bank American plaice, 2007. Bar height indicates the frequency of values within that range. The solid line is the cumulative probability that F is greater than or SSB is less than any selected value on X- axis.

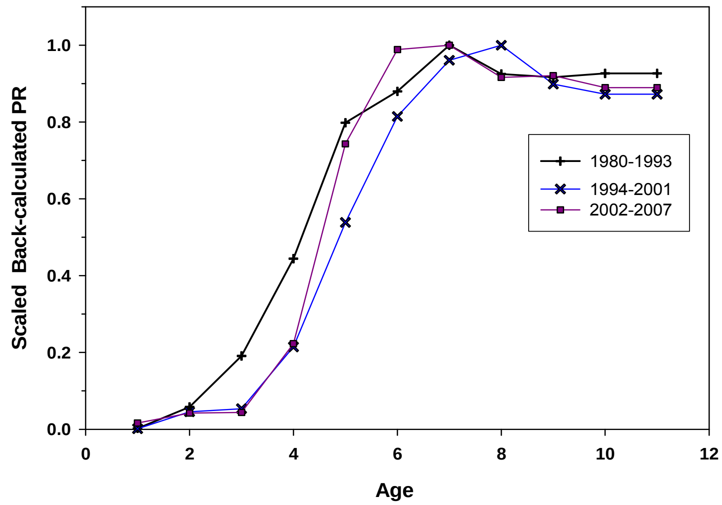


Figure H16. Scaled back-calculated partial recruitment (PR) from VPA for time periods 1980-1993, 1994-2001, and 2002-2007 for Gulf of Maine-Georges Bank American plaice.

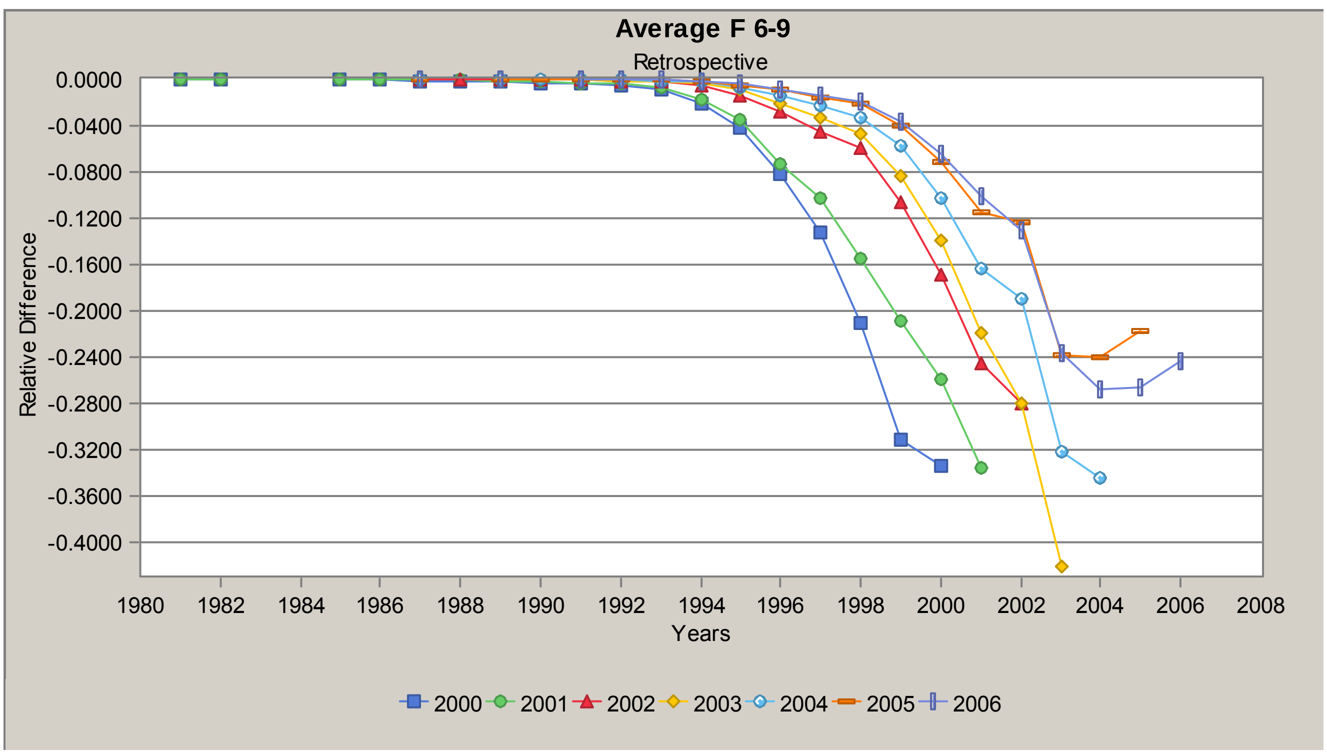


Figure H17a. Retrospective analysis of relative difference to terminal year 2007 of Gulf of Maine-Georges Bank American plaice fishing mortality (ages 6-9, unweighted), based on ADAPT VPA , 2000-2007.

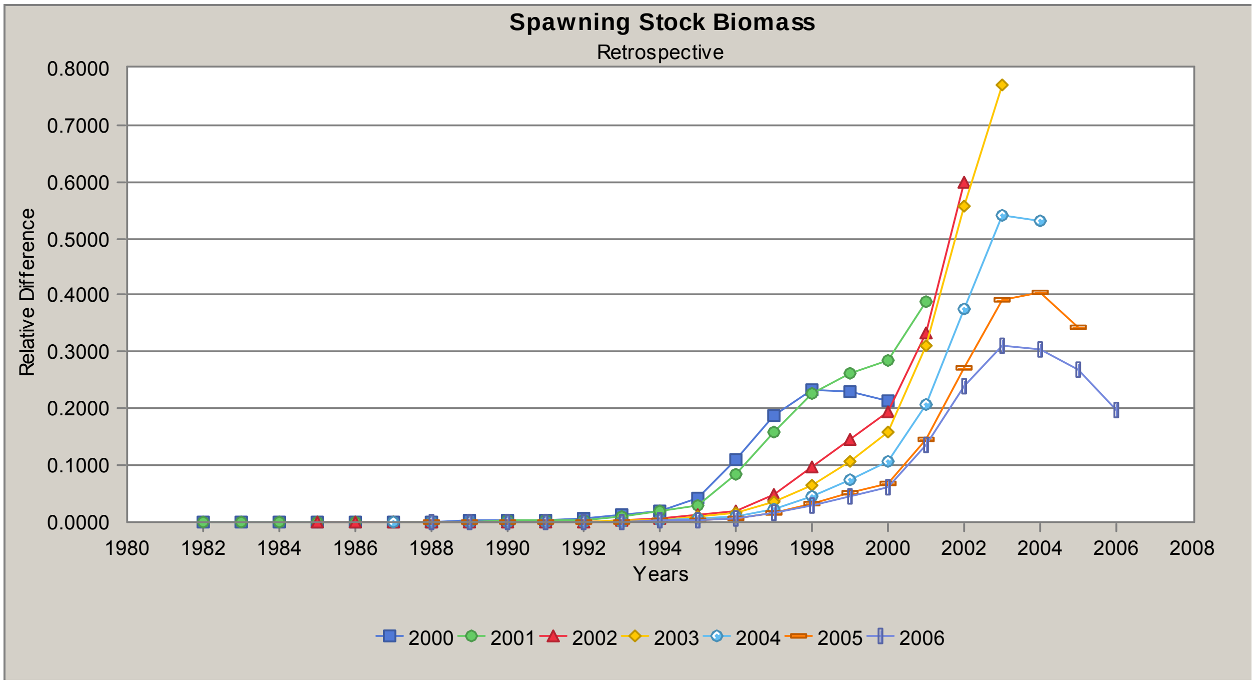


Figure H17b. Retrospective analysis of relative difference to terminal year 2007 of Gulf of Maine-Georges Bank American plaice spawning stock biomass based on ADAPT VPA , 2000-2007.

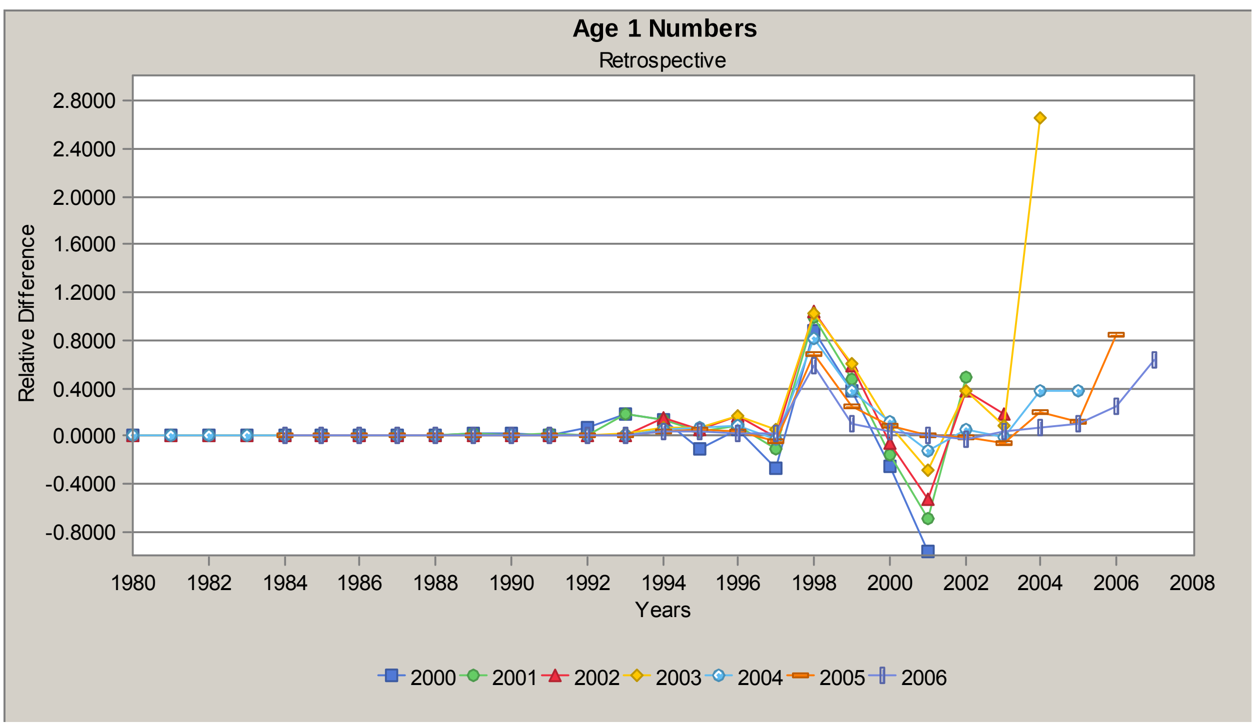


Figure H17c. Retrospective analysis of relative difference to terminal year 2007 of Gulf of Maine-Georges Bank American plaice age 1 recruits based on ADAPT VPA , 2000-2007.

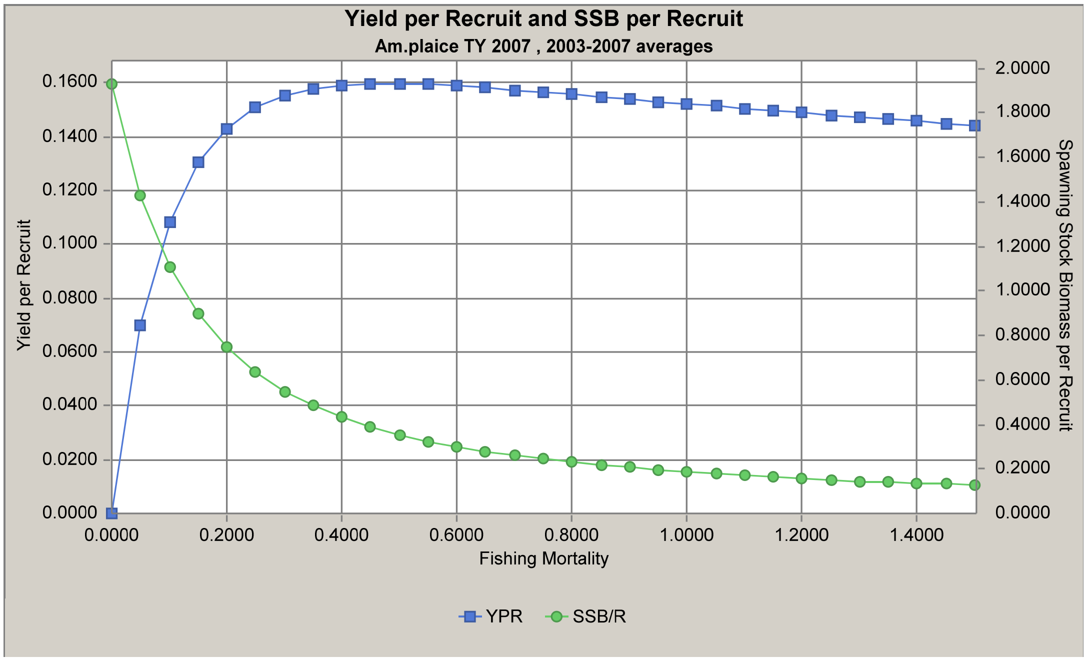


Figure H18. Yield- and Spawning Stock Biomass per-recruit analysis for Gulf of Maine – Georges Bank American plaice. $F_{0.1}$ =0.2 , F_{max} = 0.48 and $F_{40\%}$= 0.19.

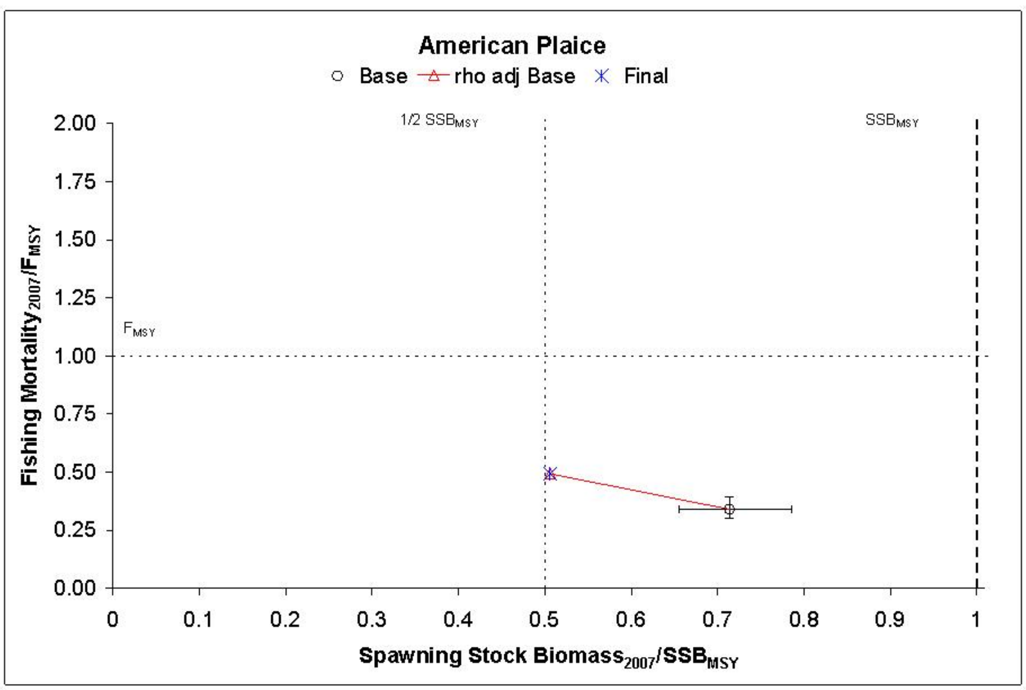


Figure H19. Status of 2007 fishing mortality (F) and spawning stock biomass (SSB) of Gulf of Maine-Georges Bank American plaice relative to F_{MSY} and SSB_{MSY} .

I. Gulf of Maine winter flounder
by Paul Nitschke

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

1.0 Background

Gulf of Maine winter flounder is the smallest of three winter flounder stocks (Figure I1). Gulf of Maine winter flounder was assessed in GARM II with ADAPT VPA model with catch through 2004 (NEFSC 2005). The GARM II assessment concluded that the stock is not overfished and overfishing is not occurring. Spawning stock biomass was estimated to be at 3,400 mt and fully recruited F = 0.13 in 2004. SSB at B_{MSY} was estimated to be at 4,100 mt and F_{MSY} = 0.43. The GARM II VPA possessed a severe retrospective pattern in F and a large overestimation of SSB. GARM II concluded that VPA results are too uncertain as a basis for performing projections.

Commercial and recreational landings were re-estimated from 1990 to 2007. Discards were re-estimated for the large mesh trawl and gillnet fisheries using discarded winter flounder to sum kept all species ratios from 1989-2007. The catch at age and catch at length was re-estimated through 2007. The lack of a relationship between catch and the indices did not produce reliable results from the AIM model (GARM III model meeting). Examination of an alternative forward projecting model (SCALE) that tunes to length data produced similar results and had similar diagnostic issues as the VPA. The lack of fit to the survey indices in the VPA results in high uncertainty in the status determination.

2.0 Fishery

Commercial landings were near 1,000 mt from 1964 to the mid 1970s. Thereafter commercial landings increased to a peaked of 2,793 mt in 1982, and then steadily declined to 350 mt in 1999. Landings have been near 500 mt from 2000 to 2004. Landings have declined to a record low of 200 mt in 2006 (Table I1, Figure I2). Landings remained low in 2007 at 260 mt. The primary gear used was the otter trawl from 1964-1985 that accounted for an average of 95% of the landings. Otter trawl accounted for an average of 75% of the landings from 1986- 2007 with an increase in the proportion of the landings coming from gillnets (25% from 1986-2007) (Table I2). In 2002 gillnet landings also shifted from occurring mostly in the first half of the year to a greater proportion coming from the second half. Since 1999 around 95% percent of the landings are taken in Massachusetts from statistical area 514 (Appendix I Figures I3 and I4, NEFSC 2008).

Recreational landings reached a peak in 1981 with 2,554 mt but declined substantially thereafter (Table I3, Figure I3). Landings have been less than 100 mt since 1995, with the lowest estimated landings in 2004 of 19 mt. Recreational landing weight was re-estimated using the expanded numbers at length and the length weight relationship by half year for input to the Scale and Aim models.

In the commercial fishery, annual sampling intensity varied from 6 to 310 mt landed per sample during 1982-2007. Overall sampling intensity was adequate, however temporal and market category coverage in some year was poor (Table I4). Samples were pooled by half year when possible. In 1982 mediums were pooled with unclassified by half year, in 1985, 1995, 2005, 2006, and 2007, smalls were pooled with mediums, and the large samples from adjacent years were used for the lack of samples in 1996, 1999, and 2001. Sampling coverage may have been poor but length frequency samples appeared relatively constant over time and there was a substantial amount of overlap between market categories which help justify the pooling used in the assessment. Lengths of kept fish from observer data were used to supplement length data of unclassified fish. Kept fish lengths taken from gillnet trips in the observer data were used to characterize the gillnet proportion of the landings (Table I5). The decline in landings has made it difficult to get samples from the medium and large market categories in recent years. Catch at age and catch at length was also estimated using only observe kept length measurements by gear type from 1999 to 2007. Characterization of the landings using the observer data produced expanded catch at length distributions similar to the length expansions using the port samples by market category for years which had relatively good port sampling (Figures I4 and I5). Observer length samples were used in the VPA and SCALE model to characterize the size distribution of the landings from 1999 to 2007.

Discards were estimated for the large mesh trawl (1982-2007), gillnet (1986-2007), and northern shrimp fishery (1982-2007) (Table I6 through I8). The survey method was used in estimating both the discard and proportion discards at length for the large mesh trawl fishery from 1982-1988 (Mayo et al. 1992). Observer discard to landings of all species ratios were applied to corresponding commercial fishery landings to estimate discards in weight from 1989 to 2007 for the large mesh trawl fishery. In GARM II the VTR large mesh otter trawl discards to landings of winter flounder ratios were used to estimate the discards. The Fishery Observer length frequency samples were judged inadequate to characterize the proportion discarded at length from 1989 to 1998 for the large mesh trawl fishery and the length proportion from the survey method was used to characterize the size distribution of discarded fish. Observer kept length sampling increased in 1999 and were used to characterize the large mesh trawl discards from 1999 to 2007. The observer sum discarded to landing of all species ratios were used for estimating gillnet discard rates. Observer sum discarded to days fished ratios were used for the northern shrimp fishery since landing of winter flounder in the shrimp fishery is prohibited. The observer length frequency data for gillnet and the northern shrimp fishery were used to characterize the proportion discarded at length. The sample proportion at length, converted to weight, was used to convert the discard estimate in weight to numbers at length. As in the southern New England stock (NEFSC 1999), a 50% mortality rate was applied to all commercial discard data (Howell et al., 1992). Numbers at ages were determined using NEFSC/MDMF spring and NEFSC fall survey age-length keys.

A discard mortality of 15% was assumed for recreational discards (B2 category from MRFSS data), as assumed in Howell et al. (1992). Discard losses peaked in 1982 at 140,000 fish. Discards have since declined to 4,000 fish in 2007 (Table I3, Figure I3). Since 1997, irregular sampling of the recreational fisheries by state fisheries agencies has indicated that the discard is usually of fish below the minimum landing size of 12 inches (30 cm). For 1982-2007, the recreational discard has been assumed to have the same length frequency as the catch in the MDMF survey below the legal size and above an assumed hookable fish size (13 cm). The recreational discard for 1982-2007 is aged using NEFSC/MDMF spring and NEFSC fall survey age-length keys.

A summary of how the catch at age was constructed can be seen in Table I9. The re-estimated discards for the large mesh trawl and gillnet fisheries are on the same order of magnitude with the previous GARM II estimates (Appendix I Figure I5). However, discard estimates from 1989 to 1992 using the survey filter method were higher than estimates from the new discard to kept all observer ratios. The predicted landings using the kept to landing of all species ratio are also on the same order of magnitude with the dealer landings (Appendix I Table I1 and Figure I6). Decreases in the catch at age components are shown in Table I10 through I13 and Figure I6. Mean weights at age and the total catch at age are given in Table I14 and I15 and Figures I7 and I8.

3.0 Research Surveys

Mean number per tow indices for the NEFSC and the Massachusetts Division of Marine Fisheries (MDMF) spring and fall time series are presented in Table I16 and Figures I9 through I12. All of the indices generally show a slight decrease in the population in the late 1980s from a high in the early 1980s with low abundance remaining through the early 1990s. All of the indices show signs of increase abundance starting in 1998 and 1999. Since 2001 all indices indicate a decrease in abundance. The MDMF survey catchability is on the order of 60 to 100 fish per tow while NEFSC survey catchability is on the order of 4 to 14 fish per tow. Age data for the MDMF fall survey are not available. The NEFSC fall ages where used to age the MDMF fall index.

Maine and New Hampshire have been conducting an inshore bottom trawl survey in the Spring since 2001 and in the Fall since 2000 (Appendix I Figures I10 through I12; NEFSC 2008)). These survey indices are relatively flat over the time series with slightly higher abundance in 2004 (Figure I13). Comparison of the Spring and Fall surveys show similar trends. Age information for this index is not available for the GARM III assessment.

The Seabrook Nuclear Power Plant in New Hampshire has conducted a monthly bottom trawl survey at 3 fixed sites since 1985. The monthly survey was broken down to a spring and fall survey. No survey was conducted in 1993. This survey also shows an increase in the number of fish in the late 1990s (Figure I14). However this survey does not show as much of a recent decline in the stock as the NEFSC and MDMF surveys. The Seabrook fall index is not used for tuning due to a lack of sampling in more recent years at one of the three stations because of the presence of lobster gear. Only age 1 and age 2 indices estimated by length slicing was used in the VPA and Scale model from this survey. Very few fish over 30 cm are caught in this survey. Some correspondence between the estimated age 1 and 2 indices can be seen in the indices (weak 1999 and strong 2003 yearclass) (Appendix I Figure I13; NEFSC 2008)).

Normandeau Associates, Inc. (2000-2006) and the Massachusetts Division of Marine Fisheries (1995-1999) conducted an area swept estimate of winter flounder in the Western Cape Cod Bay to assess impacts of the Pilgrim Nuclear power plant. Thousands of fish were measured in each year from 1995 to 2007 from a spatially limited area. A difference in the size distributions by sex is evident in the data (Appendix I Figure I14; NEFSC 2008)). The length frequency distributions where used for tuning in the SCALE model. There is little change in the distribution of 30+ cm fish over the 1995 to 2007 time series.

An examination of the survey catch per tow at length was conducted to determine the ability of the survey in tracking cohorts. Survey catch per tow at length were plotted with alternating spring and fall surveys over time (Figures I15 and I16, Appendix I Figures I16 and I17). Yearclasses were estimated using growth information. The growth and tracking of cohorts in the younger ages can be seen in the MDMF spring and fall surveys. The younger length modes are more difficult to observe in the NEFSC survey which has a lower catchability. However the MDMF survey appears to have lower catchability at larger sizes (30+cm) which is reflected in the VPA Q estimates for the older fish. The NH/ME survey catches very few fish over 30 cm (Appendix I Figure I18). Length modes also did not appear to match the MDMF survey for young fish. Aging of the NH/ME samples will be needed to determine if slower growth exists in inshore waters north of Massachusetts. Uncertainty in the age structure makeup of this survey precludes its use in the assessment models at this time. There was relatively good correspondence between the estimated age index by slicing the survey length frequencies and the actual index at age for both the NEFSC and MDMF surveys (Appendix I Figures I19 through I22; NEFSC 2008). The raw length frequency data suggests the occurrence of a strong 1998 yearclass evident in both the MDMF and NEFSC surveys. However the detection of this yearclass as it growths above legal size is more difficult to discern (Figure I15 and I16). The strong 1998 yearclass is not estimated in the VPA model. A relatively weak 1999 and stronger 2003 yearclasses can also be observed in the indices at length. However the tracking of yearclassess is more difficult to observe in the indices at age (Figures I17 through I19).

Some evidence for a change in the spatial distribution can be seen in the MDMF and NEFSC surveys. There appears to be a shift in abundance for all sizes from shallow water in early 1980s to deeper strata at the end of the time series (Figure I20). Offshore stratum 26 which contains Stellwagon bank also shows increase abundance starting in 1999 while the northern offshore strata off the coast of Maine show no signs of rebuilding (Appendix I Figures I23 and I24; NEFSC 2008).

4.0 Assessment

Abundance indices at age were available from several research surveys: NEFSC spring bottom trawl ages 1-8+, NEFSC fall ages 1-8+ (advanced to tune January 1 abundance of ages 2-8+), Massachusetts spring ages 1-8+, and Massachusetts fall ages 0-8+ (advanced to tune January 1 abundance of ages 1-8+) (Figures I21). There was little change in the female 3 year moving average maturity using MDMF spring survey (Appendix I Figure I28; NEFSC 2008). A logistic maturity estimate using all years combined (1982-2007) from the spring MDMF survey was used for the maturity schedule (Figure I22).

Both the VPA and an alternative SCALE model suffer from unstable estimates of fishing mortality and population abundance. There are conflicting trends between an overall increasing trend in the age 1 and age 2 recruitment indices and a large decline in the catch over the time series. A decline in the 4+ age indices at the end of the time series also contributes to the estimation difficulties.

Results of the alternative SCALE model are shown in Appendix I (NEFSC 2008). The SCALE model is a simple forward projecting model that tunes to age data for the younger recruitment ages (age 1, 2, and 3) and length data for the larger adult fish (30+ cm). The SCALE model assumes an overall time invariant growth curve with assumed input variation around the mean lengths at age. The population can be modeled with sex specific growth and natural mortality or with the sexes combined. The SCALE model suffered from similar diagnostic issues as seen in the VPA. The Base SCALE model run possessed a similar retrospective pattern as the VPA. Winter flounder exhibit sexual dimorphic growth. Abundance in the surveys by age and sex also suggests there is a difference in natural mortality between the sexes (Appendix I Figures I25 through I27). However modeling the population by sex did not produce a change the overall results nor did it improve model diagnostics. The split SCALE model results were sensitive to the weighting on the recruitment indices (Appendix I Figure I29). The SCALE model run with a low weight on fitting the recruitment ages indices produced similar results to the split VPA model (Appendix I Figure I32) and the SCALE model run which increased the weight on the recruitment indices produced a status determination similar to the base case VPA (Appendix I Table I4). The VPA model was considered for stock status determination since an a priori rationale for a higher weight on the surveys did not exist. In fact there was some evidence of a change in the surveys through a population distributional shift over time (Figure I20).

Sensitivity of the VPA model results to the inclusion of the poorest fitting indices and to indices which displaced the worst residual patterns can be seen in Table I17. The split VPA run (run 2b) which included all of the indices was used for the status determination. The geometric mean recruitment from 1982 to 2007 was used to estimate recruitment in t+1 due to the limited amount of survey indices available to estimate recruitment in t+1 (the preliminary NEFSC spring 2008 index). The high estimate of recruitment in t+1 in run 2A was thought to be unreliable since there appears to be a year effect in the NEFSC Spring 2008 index.

The base VPA run showed a severe pattern in the residuals (Figure I23). The base VPA run also exhibits a severe retrospective pattern in F, recruitment, and a large overestimation of SSB (Figures I24 and I25). Splitting all of the surveys between 1993 and 1994 did improve the retrospective pattern (Figures I26 and I27). The improvement in Mohn's rho from a seven year peel in the split VPA run can be seen in Table I18. A residual pattern still exists within each survey block (1982-1993 & 1994-2006) for the younger ages 1 to 3 (Figure I23). However the residual pattern did improve for the older ages (4+). Splitting the surveys allows the model to estimate further declines in abundance with higher Fs at the end of the time series (Figures I28 and I29). The split survey model is less constrained by the conflicts between the large decline in the catch and the survey abundance of the older fish (4+) at the end of the time series.

Area swept Q estimates suggest some efficiencies greater than one in both the base and split model runs (Figure I30). However the area coverage for an average MDMF survey tow is based on a limited number of mensuration tows. A doming of the survey Q for older ages can be seen in the MDMF survey. Many of the survey Qs more than tripled in the split VPA run. Only the base run limited to just the NEFSC surveys estimated all of the Qs under 1 (Appendix I Figure I34).

Split VPA Run 2b is summarized in Table I19. Fishing mortality ages 5-6 was 0.42 in 2007 from the split VPA (run 2b). There is a 80% chance that the 2007 F was between 0.34 and 0.53 Spawning stock biomass was estimated to be 1,100 mt in 2007 (Figure I31). There is an 80% chance that the spawning stock biomass was between 970 mt and 1,277 mt in 2007.

5.0 Biological reference points (BRPs)

Stock recruit relationships from the split VPA model are shown in Figure I32. The GARM III biological reference point review panel recommended not using stock recruit reference points due to uncertainty with the estimated recruitment. The VPA appears to produce a linear relationship between stock and recruitment. Empirical biological reference points were developed using the entire time series of recruitment and F40% as a proxy for F_{MSY} (Table I20). An age based yield per recruit model from the split VPA estimated F40% at 0.28 (Figure I33). The average of 2003 to 2007 partial recruitment, and mean weights at age from the VPA were used as inputs to the age based yield per recruit and the AGEPRO biological reference point calculations (Table I21).

SSB_{MSY} and MSY were estimated using long term AGEPRO projection using the models CDF of age-1 recruitment and the estimated F40% for the F_{MSY} proxy. Estimated reference points and status determination is summarized in Table I20 and Figure I34. Differences in estimated age-1 recruitment and a small difference in the partial recruitment pattern between the base and split VPA did produce some differences in the estimated reference points between the runs (Table I20). The change in status determination from the GARM I and GARM II and base GARM III VPA assessment runs are due to the large retrospective pattern.

6.0 Projections

The Gulf of Maine winter flounder assessment is too uncertain as a basis for performing projections.

7.0 Summary

The split VPA model estimated spawning stock biomass in 2007 at 1,100 mt or about 29% of SSB_{MSY} = 3,792 mt and fishing mortality in 2007 was 0.42 or about 147% of F_{MSY} = 0.28. Thus, the stock is likely in an overfished condition and overfishing is probably occurring. There is high uncertainty on the status determination in this assessment. The base case VPA and a split forward projection model (SCALE) which puts higher weight on the recruitment indices suggests the stock was not overfished and overfishing was not occurring. However the base case VPA had a severe strong retrospective pattern (Mohn's Rho on SSB was 212% and -70% on F). The VPA shows greater reductions in biomass than observed in the survey biomass trends. All models have difficulty fitting the relatively flat age 1 and age 2 recruitment indices and the decrease in adult indices with the large decline in the catch at the end of the time series. Questions remain with the high area swept Qs estimates along with the large magnitude of the change in Q from the split. The conflicting trends between the catch and the indices in the assessment results in high uncertainty in the status determination. However all models (VPA and SCALE) suggest spawning stock biomass is well below SSB_{MSY} and is likely below ½ SSB_{MSY}. This is consistent with biomass trends in the other flatfish stocks (southern New England winter flounder, American plaice, and Cape Cod – Gulf of Maine yellowtail). Projections were not conducted due to the high uncertainty in the assessment.

8.0 Panel discussion / comments

Conclusions

The proposed VPA exhibited a large retrospective pattern that could not be adjusted for by splitting the survey time series. A SCALE model which had been suggested (GARM III 'models' review) as an exploratory tool also did not fit the data. The Panel noted many of the difficulties in the assessment including a lack of tracking of year - classes in the surveys and catch, conflicting abundance trends between survey and catch, estimated survey efficiencies greater than one, and so on. For instance, whereas catch declined during the early part of the time series, survey abundance has relatively stable. Further, there was an apparent increase in survey abundance in the early 2000s that was inconsistent with trends in the catch and recruitment. These issues highlighted the problems with using an age-based class of model on this resource, a point raised earlier in the GARM III 'models' review. The Panel also had concerns about the unit stock, not only for this stock, but for all of the Winter Flounder stocks assessed. It recommended an analysis of Winter Flounder as a stock complex, rather than as individual stocks, be undertaken.

Given the problems encountered, the Panel agreed that none of the models put forth gave a clear picture of the status of the resource. Further, the Panel noted that until these issues were resolved, the proposed analysis could not be used to provide management advice nor stock projections.

While the Panel was unable to determine the stock's status relative to the BRPs, it agreed that the current trend in the population was very troubling. The Panel generally agreed that it is highly likely that biomass is below B_{MSY}, and that there is a substantial probability that it is below ½ B_{MSY}. The Panel noted that other stocks in the area of this mixed fishery were also at low levels.

Research Recommendations

Assessment approaches needs to be explored that consider all three Winter Flounder stocks as a stock complex within which there is significant interaction amongst the individual stock components.

9.0 References

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Mayo RK, O'Brien L, Buxton N. 1992. Discard estimates of American plaice, *Hippoglossoides platessoides*, in the Gulf of Maine northern shrimp fishery and the Gulf of Maine-Georges Bank large-mesh otter trawl fishery. SAW 14 Res Doc. 14/3; 40 p.

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NEFSC. 2005. Assessment of 19 Northeast groundfish stocks through 2004. 2005 Groundfish Assessment Review Meeting (GARM) 2005. August 15-19. NEFSC Ref Doc. 05-13.; 508 p. Woods Hole, MA.

Witherell B, Burnett J. 1993. Growth and maturation of winter flounder, *Pleuronectes americanus*, in Massachusetts. Fish Bull. 91; p 816-820.

Table I1. Winter flounder commercial landings (metric tons) for Gulf of the Maine stock (U.S. statistical reporting areas 511 to 515). Landings from 1964-1977 is taken from SARC 21, 1982-1993 is re-estimated from the WODETS data, 1994-2007 is estimated using the trip based allocated AA tables.

Year	metric tons	Year	Metric tons
1964	1,081	1990	1,116
1965	665	1991	1,008
1966	785	1992	825
1967	803	1993	611
1968	864	1994	543
1969	975	1995	707
1970	1,092	1996	606
1971	1,113	1997	569
1972	1,085	1998	643
1973	1,080	1999	350
1974	885	2000	535
1975	1,181	2001	698
1976	1,465	2002	683
1977	2,161	2003	754
1978	2,194	2004	623
1979	2,021	2005	335
1980	2,437	2006	199
1981	2,407	2007	260
1982	2,793		
1983	2,096		
1984	1,699		
1985	1,582		
1986	1,188		
1987	1,140		
1988	1,250		
1989	1,253		

Table I2. Gulf of Maine winter flounder commercial landings (metric tons) by gear.

Year	Trawl	Shrimp	Gillnet	Other	Total
1982	2,485	151	59	99	2,793
1983	1,819	142	54	80	2,096
1984	1,438	139	26	96	1,699
1985	1,446	62	16	59	1,582
1986	912	69	164	42	1,188
1987	848	97	135	60	1,140
1988	1,016	61	161	12	1,250
1989	1,008	58	138	48	1,253
1990	857	25	214	21	1,116
1991	868	22	94	25	1,008
1992	632	17	160	16	825
1993	460	1	138	13	611
1994	438	0	100	5	543
1995	511	1	184	10	706
1996	464	0	135	6	606
1997	426	0	134	9	569
1998	461	0	176	6	643
1999	248	0	101	1	350
2000	412	0	122	1	535
2001	529	0	160	9	698
2002	585	0	82	15	682
2003	564	0	185	5	754
2004	427	0	137	59	623
2005	230	0	67	38	335
2006	133	0	47	19	198
2007	169	0	70	20	260

Table I3. Estimated number (000's) and MRFSS estimated weight and predicted weight(mt) from length frequencies for Gulf of Maine winter flounder caught, landed, and discarded in the recreational fishery.

	Number (000's)				Metric tons	
	Catch A+B1+B2	Landed A+B1	Released B2	15% Release Mortality	MRFSS Landed A+B1	Predicted Landed
1981	6,200	5,433	767	115	2,554	2,270
1982	8,207	7,274	933	140	1,876	3,024
1983	2,169	1,988	181	27	868	817
1984	2,477	2,285	191	29	1,300	1,103
1985	3,694	3,220	474	71	1,896	1,629
1986	946	691	255	38	523	411
1987	3,070	2,391	679	102	1,809	1,443
1988	953	841	111	17	345	537
1989	1,971	1,678	294	44	620	1,035
1990	786	652	134	20	370	344
1991	213	154	59	9	91	86
1992	186	137	48	7	90	77
1993	398	249	150	22	140	134
1994	232	145	88	13	83	77
1995	150	83	67	10	40	40
1996	183	98	86	13	56	52
1997	192	64	129	19	43	32
1998	109	65	44	7	30	27
1999	109	65	44	7	33	34
2000	146	59	87	13	32	31
2001	173	72	102	15	45	37
2002	101	61	40	6	42	35
2003	86	52	34	5	32	29
2004	61	41	20	3	19	29
2005	79	40	39	6	25	24
2006	94	53	41	6	34	35
2007	74	48	26	4	28	26

Table I4. Number of lengths, samples, and metric tons per sample for Gulf of Maine winter flounder. Number of samples and calculations of metric tons per sample does not include observer data or gillnet landings from 1990-2007. * = redistributed according to market category and half year proportions. Bold numbers have additional lengths from observer trawl data but are not included in the number of samples.

	Number of lengths.						Number of samples						mt/samples					
year	half	lg	sm	med	un	total	half	lg	sm	med	un	total	half	lg	sm	med	un	total
1982	1	102	101		455		1	1	1		4		1	838	453		46	
	2	84	81		106	929	2	1	1		1	9	2	396	691		231	310
1983	1	380	100	99	407		1	4	1	1	4		1	120	510		53	
	2	115	1344		106	2551	2	2	11		1	24	2	125	44	64	95	87
1984	1	438	503		221		1	5	4		2		1	74	95			
	2	126	813	100		2201	2	1	6	1		19	2	189	67	114	124	89
1985	1	665	735				1	6	5				1	54				
	2	121			80	1601	2	2			1	14	2	87		182	176	113
1986	1	237	109	109	266		1	3	1	1	3		1		242	126	48	
	2		500	193	89	1503	2		6	2	1	17	2	113	37	31	56	70
1987	1				113		1				1		1					
	2	47	251	272		683	2	1	3	3		8	2	257	137	75	249	143
1988	1	102	258	706	*		1	1	3	7	*		1		108	23		
	2		169	107	*	1342	2		2	1	*	14	2	340	164	96		89
1989	1	113		91	**234**		1	1		1	**1**		1			168		
	2		95	220	**32**	785	2		1	2		6	2	313	435	42	**254**	209
1990	1	328	301		102		1	3	4		1		1	64	48			
	2	117	197	97		1142	2	1	2	1		12	2	83	90	144	111	75
1991	1	188	254	205	**143**		1	2	2	2	**2**		1	91	72			
	2	236	349			1375	2	3	3			14	2	32	62	95	57	65
1992	1	246	100	93	**107**		1	3	1	1			1					
	2	57	74	253		930	2	1	1	3		10	2	54	126	35		66
1993	1	100		288	**91**		1	1		3			1	84		17		
	2	80	55	157	**51**	822	2	1	1	2		8	2	47	178	30		59

Table I4. Continued.

	Number of lengths.						Number of samples						mt/samples					
year	half	lg	sm	med	un	total	half	lg	sm	med	un	total	half	lg	sm	med	un	total
1994	1		71	92			1		1	1			1			57		
	2	94		235	*	492	2	1		3		6	2	118	157	18		64
1995	1	101		474	**33**	474	1	1		5			1			29		
	2			414	**609**	1631	2			4		10	2	94		59		52
		↑																
1996	1		378				1		4				1		29			
	2		795	338	**112**	1623	2		7	4		15	2		23	16		31
		↓																
1997	1		127	75	*		1		2	1	*		1		34	33		
	2	407	1014	218	*	1841	2	5	11	3	*	22	2	20	11	19		18
1998	1		299	280	*		1		5	3	*		1		16	16		
	2	69	746	110	*	1504	2	1	9	1	*	19	2	51	12	32		17
		↑						↑										
1999	1			275	**122**		1			3			1					
	2		80		**430**	907	2		2			5	2		42	15		50
		↓				552												
2000	1	104	4331	250	**1046**		1	1	59	4			1	19	1			
	2	244	344		**130**	6449	2	4	6		**1**	75	2	7	20	24		6
		↑																
2001	1		89	474	**795**		1		1	6			1		66	10		
	2		254	250	**1756**	3618	2		3	3		13	2		35	47		41
		↓																
2002	1	28	507	173	**573**		1	1	7	2	**1**		1		7	34	**59**	
	2		982	133	**2734**	5130	2		14	2	**2**	29	2	57	14	48	**35**	21
2003	1		744		**2410**		1	1	10	1	**2**		1		11		**48**	
	2	384	818	110	**914**	5380	2	12	19	1	**6**	52	2	3	9	28	**18**	11
2004	1	223	692	86	**1915**		1	7	14	1	**6**		1		6		**12**	
	2	7	706		**2955**	6584	2	1	12		**4**	45	2	18	9	48	**6**	11
2005	1		269		**3202**		1		4		**11**		1		16.8		**3**	
	2	600	807		**5696**	10574	2	10	7		**11**	43	2	11	10		**2**	9
2006	1		732		**2330**		1		3		**11**		1		7		**1**	
	2	341	281		**823**	4507	2	4	3		**9**	30	2	14	14		**13**	9
2007	1		296		**1316**		1		3		**3**		1		11.3		**6**	
	2	15	272		**831**	2730	2	1	3		**3**	13	2	54	24.7		**4**	15

Table I5. Number of kept observer lengths, trips, and gillnet metric tons landed per 100 lengths sampled for Gulf of Maine winter flounder by half year.

Year	half	lengths	trips	gillnet landings	Mt/100 lengths
1990	1	500	90	185	
	2	78	1	29	
		578	91	215	37
1991	1	167	6	85	
	2	30	8	12	
		197	14	97	49
1992	1	1925	39	135	
	2	172	25	25	
		2097	64	160	8
1993	1	1990	63	97	
	2	375	20	42	
		2365	83	139	6
1994	1	330	22	75	
	2	207	10	25	
		537	32	100	19
1995	1	1132	20	156	
	2	275	23	28	
		1407	43	184	13
1996	1	930	26	114	
	2	118	17	22	
		1048	43	136	13
1997	1	656	18	105	
	2	42	4	29	
		698	22	134	19
1998	1	1163	19	145	
	2	431	8	31	
		1594	27	176	11
1999	1	747	5	84	
	2	538	12	17	
		1285	17	101	8
2000	1	911	8	104	
	2	259	4	18	
		1170	12	122	10

year	half	lengths	trips	gillnet landings	Mt/100 lengths
2001	1	862		124	
	2	42		36	
		904		160	18
2002	1	237		37	16
	2	691		45	7
		928		82	9
2003	1	1702		89	5
	2	3041		96	3
		4743		185	4
2004	1	2255		62	3
	2	4605		75	2
		6860		137	2
2005	1	635		26	4
	2	3982		41	1
		4617		67	1
2006	1	385		25	7
	2	174		21	12
		559		47	8
2007	1	651		30	5
	2	662		40	6
		1313		70	5

Table I6. Gulf of Maine winter flounder estimated discard ratios in the shrimp fishery (total discard kg / total days fished) estimated from NEFSC and MA Observer data by shrimp season. Ratio for 1982-1988 is the average ratio from 1989-1992. Total shrimp fishery days fished and estimated discards are also shown. A 50% mortality is used for estimating dead discards. Dotted line indicates the introduction of the Nordmore grate.

Year	trips	tows	ratio	Shrimp df	discard wt (kg)	dead discards (kg)
1982			*13.5*	970	13,120	6,560
1983			*13.5*	1157	15,646	7,823
1984			*13.5*	1754	23,721	11,860
1985			*13.5*	2081	28,149	14,074
1986			*13.5*	2395	32,391	16,196
1987			*13.5*	3708	50,149	25,075
1988			*13.5*	2815	38,072	19,036
1989	12	24	3.5	2840	10,023	5,011
1990	25	53	13.1	3205	41,853	20,927
1991	38	94	16.3	2588	42,265	21,132
1992	72	225	21.2	2313	48,978	24,489
1993	63	178	7.0	1902	13,401	6,700
1994	63	183	5.8	1982	11,586	5,793
1995	58	136	4.8	3376	16,186	8,093
1996	40	92	4.0	3243	13,126	6,563
1997	21	55	7.5	3661	27,391	13,695
1998	3	6	3.9	2204	8,526	4,263
1999	4	5	1.4	1217	1,696	848
2000	4	10	7.7	793	6,091	3,046
2001	4	6	6.1	673	4,095	2,048
2002	1	2	2.4	246	581	291
2003	18	36	8.7	532	4,628	2,314
2004	11	47	8.5	304	2,588	1,294
2005	17	47	15.9	313	4,973	2,486
2006	17	55	12.7	170	2,162	1,081
2007	17	58	4.1	451	1,851	926

Table 17. Gulf of Maine winter flounder re-estimated large and small mesh trawl and gillnet discard ratios (discard/sum all species kept), estimated discard CVs, and estimated discards in metric tons.

	Discard Ratio			CV			Metric Tons		
	trawl			trawl			trawl		
year	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet
1989	0.0011	0.0032	0.0006	0.51	0.54	0.34	23	6	9
1990	0.0004	0.0001	0.0027	0.55	1.00	0.44	11	0	44
1991	0.0011	0.0010	0.0005	0.45	0.61	0.23	34	2	7
1992	0.0005	0.0002	0.0020	0.37	0.86	0.15	14	0	25
1993	0.0003	0.0042	0.0023	0.79	0.92	0.17	8	10	38
1994	0.0000	0.0000	0.0009			1.42	0		13
1995	0.0009	0.0091	0.0015	0.53	0.43	0.46	16	21	23
1996	0.0003	0.0008	0.0008	1.69	0.29	0.56	4	2	12
1997	0.0001	0.0098	0.0061	0.61	0.02	0.58	2	19	75
1998	0.0011	0.0000	0.0011	0.45		0.43	15		14
1999	0.0016	0.0081	0.0010	0.38	0.30	0.50	18	14	8
2000	0.0004	0.0000	0.0030	0.84		0.39	6		24
2001	0.0016	0.0017	0.0008	0.38	1.91	0.64	27	2	6
2002	0.0021	0.0077	0.0014	0.37	0.43	0.43	33	10	9
2003	0.0014	0.0016	0.0008	0.33	0.50	0.32	25	1	5
2004	0.0023	0.0064	0.0010	0.29	0.40	0.30	62	2	7
2005	0.0025	0.0072	0.0003	0.28	1.10	0.23	47	2	2
2006	0.0018	0.0038	0.0001	0.33	0.44	0.42	20	2	1
2007	0.0031	0.0054	0.0002	0.35	0.42	0.39	31	4	1

Table I8. Gulf of Maine winter flounder updated number of trips in the large and small mesh trawl and gillnet fishery in the dealer and observer data.

	Large Mesh Trawl						Small Mesh Trawl						Gillnet					
	Dealer trips		Ob trips		Dealer	Ob	Dealer trips		Ob trips		Dealer	Ob	Dealer trips		Ob trips		Dealer	Ob
YEAR	half 1	half 2	half 1	half 2	sum	sum	half 1	half 2	half 1	half 2	sum	sum	half 1	half 2	half 1	half 2	sum	sum
1989	105,164	85,152	16	21	190,316	37	1,061	10,321	7	16	11,382	23	62,067	87,886		84	149,952	84
1990	100,659	91,373	10	16	192,032	26	321	12,384		8	12,705	8	60,170	102,906	64	56	163,076	120
1991	119,499	106,244	12	36	225,743	48	396	13,905		29	14,301	29	55,164	78,681	153	648	133,845	801
1992	131,273	104,500	33	11	235,773	44	291	19,427	3	12	19,718	15	49,030	78,145	357	539	127,175	896
1993	108,243	101,322	9	8	209,565	17	314	17,162	2	4	17,476	6	55,144	93,844	251	309	148,988	560
1994	88,950	61,405	4	2	150,356	6	745	9,029			9,774		42,555	63,675	55	30	106,230	85
1995	64,850	53,353	18	7	118,203	25	994	2,802		30	3,796	30	40,987	56,676	23	46	97,663	69
1996	59,537	51,512	8	3	111,049	11	268	3,789	2	38	4,057	40	32,990	45,074	21	25	78,064	46
1997	53,697	42,004	4	1	95,701	5	542	3,735	3		4,276	3	28,906	36,957	13	20	65,863	33
1998	59,039	45,854	6		104,893	6	236	2,689			2,925		30,234	34,076	29	49	64,309	78
1999	41,248	46,507	1	20	87,755	21	186	3,220		11	3,406	11	20,067	24,447	18	55	44,514	73
2000	48,204	50,184	48	31	98,387	79	349	2,176			2,524		21,613	30,685	41	40	52,298	81
2001	50,659	51,722	37	76	102,381	113	498	2,497	1	3	2,996	4	24,426	32,695	25	22	57,121	47
2002	44,086	56,806	28	121	100,892	149	213	2,374	1	34	2,587	35	16,513	32,746	23	57	49,259	80
2003	37,226	60,664	117	136	97,890	253	169	941	7	12	1,110	19	18,954	34,893	93	202	53,846	295
2004	31,568	51,904	70	188	83,471	258	146	945	12	55	1,091	67	16,860	33,270	156	619	50,130	775
2005	29,099	44,132	171	327	73,231	498	347	681	20	49	1,027	69	14,209	38,823	138	513	53,031	651
2006	24,765	34,470	143	63	59,235	206	223	1,034	14	10	1,257	24	15,359	35,986	74	54	51,344	128
2007	25,388	32,216	98	126	57,603	224	275	1,099	1	15	1,374	16	17,800	45,116	32	86	62,916	118

Table I9. GARM III Gulf of Maine winter flounder catch at age component summary.

Catch at age component	years	Half yr	length data	age data
trawl and other commercial landings	82-98	mix	commercial and observer (unclassified)	commercial
trawl and other commercial landings	99-07	whole & half yr	Observer (Trawl kept)	commercial
gillnet commercial Landings	90-07	whole & half yr	observer (gillnet kept)	commercial
recreational Landings	82-07	Half yr	MRFSS	combine NEFSC and MA DMF ages by half yr
recreational Discards	82-07	Half yr	spr & fall MA DMF	combine NEFSC and MA DMF ages by half yr
large mesh trawl discards (survey filter)	82-88	whole yr	survey method (spr & fall MA DMF)	combine NEFSC spr & fall survey
large mesh trawl disc (obs disc/keptall)	89-07	whole yr	survey method (89-00) observer disc (01-06)	combine NEFSC spr & fall survey
gillnet discards (obs disc/keptall)	86-07	Whole	observer discards	combine spr NEFSC and MA DMF ages
shrimp discards (obs disc/days fished)	82-04	shrimp season	observer (discards)	combine spr NEFSC and MA DMF ages

Table I10. Gulf of Maine winter flounder composition of the catch by number (000's).

	Landings		Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1982	7,274	5,282	140		1,397	56	14,149
1983	1,988	3,842	27		428	67	6,353
1984	2,285	3,992	29		249	102	6,657
1985	3,220	2,965	71		340	121	6,717
1986	691	2,055	38	45	253	139	3,221
1987	2,391	2,086	102	45	308	216	5,146
1988	841	2,210	17	45	406	164	3,682
1989	1,678	2,329	44	16	42	61	4,171
1990	652	1,981	20	84	20	113	2,870
1991	154	1,844	9	12	64	165	2,247
1992	137	1,620	7	44	27	241	2,078
1993	249	1,440	22	70	16	83	1,880
1994	145	1,153	13	24	23	86	1,443
1995	83	1,501	10	31	29	94	1,748
1996	98	1,228	13	21	8	59	1,427
1997	64	1,101	19	128	18	175	1,504
1998	65	1,147	7	24	28	53	1,323
1999	65	605	7	7	31	11	725
2000	59	940	13	39	11	38	1,100
2001	72	1,160	15	9	52	25	1,333
2002	61	1,126	6	11	72	3	1,279
2003	51	1,269	5	8	52	25	1,410
2004	41	993	3	12	137	15	1,200
2005	40	549	6	4	94	26	718
2006	53	317	6	1	40	10	427
2007	48	407	4	2	59	8	528

Table I11. Gulf of Maine winter flounder composition of the catch by weight (mt).

	Landings		Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1981	2,270						
1982	3,024	2,793	11		343	7	6,178
1983	817	2,096	2		112	8	3,035
1984	1,103	1,699	3		67	12	2,883
1985	1,629	1,582	8		93	14	3,327
1986	411	1,185	5	12	63	16	1,692
1987	1,443	1,140	12	12	81	25	2,713
1988	537	1,250	2	12	106	19	1,927
1989	1,035	1,253	6	4	11	5	2,315
1990	344	1,116	3	22	5	21	1,511
1991	86	1,008	1	3	17	21	1,136
1992	77	825	1	12	7	24	947
1993	134	611	3	19	4	7	778
1994	77	543	2	6	6	6	640
1995	40	707	1	12	8	8	776
1996	52	606	2	6	2	7	674
1997	32	569	3	38	5	14	660
1998	27	643	1	7	7	4	689
1999	34	350	1	4	9	1	399
2000	31	535	2	12	3	3	587
2001	37	698	3	3	14	2	756
2002	35	682	1	5	17	0	740
2003	29	754	1	3	13	2	801
2004	29	623	0	4	31	1	687
2005	24	335	1	1	23	2	387
2006	35	199	1	0	10	1	247
2007	26	260	0	1	15	1	303

Table I12. Gulf of Maine winter flounder landing at age (000's).

year	1	2	3	4	5	6	7	8+
1982	40	2,097	4,551	3,468	1,401	617	276	104
1983	93	748	1,680	1,799	856	362	158	133
1984	12	765	1,935	1,829	852	348	312	225
1985	0	137	1,335	2,039	1,922	398	218	136
1986	0	327	731	812	359	353	102	62
1987	0	312	1,626	1,161	792	311	138	136
1988	2	337	848	1,046	359	248	123	89
1989	0	162	1,309	1,462	774	212	51	38
1990	0	216	721	950	496	172	49	29
1991	0	186	782	580	232	119	57	41
1992	0	207	657	569	205	72	28	18
1993	0	132	688	644	145	68	9	3
1994	0	8	466	608	149	44	16	7
1995	0	8	291	744	387	120	16	18
1996	0	176	706	336	76	13	7	11
1997	0	150	499	382	92	22	8	12
1998	0	26	232	458	328	115	40	12
1999	0	0	61	229	224	101	29	27
2000	0	5	59	375	371	140	34	15
2001	0	0	52	358	425	239	101	56
2002	0	3	135	364	401	185	65	34
2003	0	6	156	382	412	242	77	46
2004	0	32	127	327	245	191	64	49
2005	0	12	119	235	136	54	17	16
2006	0	2	79	150	87	28	13	11
2007	0	6	69	157	133	61	18	11

Table I13. Gulf of Maine winter flounder discards at age (000's).

year	1	2	3	4	5	6	7	8+
1982	72	786	716	19	0	0	0	0
1983	42	167	275	38	0	0	0	0
1984	11	151	142	72	4	0	0	0
1985	31	151	263	83	3	0	0	0
1986	49	178	196	39	14	0	0	0
1987	53	174	378	63	2	0	0	0
1988	22	134	340	131	3	1	0	0
1989	24	77	43	16	3	1	0	0
1990	9	47	114	58	8	0	0	0
1991	18	117	82	30	2	0	0	0
1992	44	182	77	15	1	0	0	0
1993	28	64	70	25	4	0	0	0
1994	18	73	37	15	3	0	0	0
1995	27	62	44	22	5	2	1	0
1996	16	41	27	14	2	0	0	0
1997	19	136	93	66	26	0	0	0
1998	20	38	32	16	4	0	1	0
1999	7	13	18	11	3	2	1	1
2000	17	24	30	19	9	2	0	0
2001	13	21	32	26	7	3	0	0
2002	4	28	32	20	6	2	0	0
2003	9	36	28	11	4	1	0	1
2004	10	57	77	17	2	2	1	0
2005	15	42	46	20	4	2	0	0
2006	7	12	25	11	2	0	0	0
2007	7	11	34	16	4	0	0	0

Table I14. Gulf of Maine winter flounder total catch at age (000's).

year	1	2	3	4	5	6	7	8+
1982	112	2,883	5,267	3,487	1,402	617	276	104
1983	135	915	1,955	1,838	857	362	158	133
1984	23	916	2,077	1,901	856	348	312	225
1985	31	288	1,598	2,122	1,925	398	218	136
1986	49	505	928	851	373	353	102	62
1987	53	486	2,004	1,224	794	311	138	136
1988	23	471	1,188	1,177	361	248	123	89
1989	24	238	1,353	1,478	777	213	51	38
1990	9	263	836	1,008	504	172	49	29
1991	18	304	864	610	234	119	57	41
1992	44	390	734	585	207	72	28	18
1993	28	197	758	669	149	69	9	3
1994	18	81	503	623	152	44	16	7
1995	27	70	335	765	392	122	18	18
1996	16	217	733	350	79	13	7	11
1997	19	286	592	449	117	22	8	12
1998	20	64	264	474	333	115	41	12
1999	7	13	79	240	227	103	29	28
2000	17	29	89	394	380	142	34	15
2001	13	21	84	384	432	242	101	56
2002	4	31	167	383	408	187	65	34
2003	9	42	184	393	416	243	77	46
2004	10	89	205	344	247	193	65	49
2005	15	54	165	255	140	57	18	16
2006	7	14	104	160	89	28	13	11
2007	7	17	103	173	138	62	18	11

Table I15. Gulf of Maine winter flounder mean weights at age.

year	1	2	3	4	5	6	7	8+
1982	0.084	0.224	0.375	0.487	0.595	0.802	0.943	2.037
1983	0.123	0.257	0.358	0.502	0.644	0.795	0.946	1.164
1984	0.082	0.264	0.306	0.401	0.543	0.708	0.855	1.115
1985	0.043	0.174	0.312	0.447	0.584	0.809	0.927	1.122
1986	0.050	0.309	0.410	0.510	0.664	0.813	1.005	1.221
1987	0.035	0.259	0.392	0.527	0.690	0.858	1.070	1.284
1988	0.038	0.396	0.426	0.487	0.648	0.754	1.022	1.204
1989	0.040	0.229	0.427	0.582	0.629	1.004	1.175	1.397
1990	0.034	0.301	0.421	0.538	0.625	0.763	0.979	1.226
1991	0.038	0.277	0.451	0.583	0.599	0.695	0.744	0.929
1992	0.027	0.227	0.406	0.533	0.638	0.788	1.051	1.465
1993	0.028	0.238	0.367	0.439	0.645	0.667	1.115	1.453
1994	0.028	0.090	0.369	0.470	0.610	0.747	1.068	1.229
1995	0.038	0.105	0.341	0.421	0.535	0.635	0.833	1.563
1996	0.028	0.321	0.454	0.541	0.643	0.722	0.767	1.321
1997	0.038	0.240	0.421	0.512	0.628	0.889	0.784	0.921
1998	0.029	0.202	0.392	0.472	0.615	0.755	0.910	1.557
1999	0.039	0.114	0.377	0.487	0.542	0.665	0.838	1.219
2000	0.041	0.146	0.353	0.473	0.581	0.698	0.817	1.030
2001	0.034	0.115	0.319	0.448	0.538	0.693	0.852	1.194
2002	0.050	0.182	0.415	0.496	0.593	0.705	0.882	1.284
2003	0.035	0.158	0.360	0.480	0.559	0.703	0.887	1.449
2004	0.035	0.209	0.350	0.494	0.627	0.767	0.929	1.281
2005	0.042	0.172	0.380	0.505	0.670	0.896	1.038	1.335
2006	0.048	0.138	0.404	0.535	0.715	0.817	1.024	1.367
2007	0.050	0.195	0.372	0.491	0.649	0.845	0.956	1.502

Table I16. NEFSC and MDMF survey indices of abundance for Gulf of Maine winter flounder. Indices are stratified mean number and mean weight (kg) per tow. NEFSC indices are for inshore strata (58,59,60,61,65,66) and offshore strata (26,27,38,39,40). NEFSC indices are calculated with trawl door conversion factors where appropriate. MA DMF uses strata 25-36.

	NEFSC spring		NEFSC fall		MA spring		MA fall	
year	number	weight	number	weight	number	weight	number	weight
1978					98.556	20.772	59.152	12.741
1979	4.487	1.730	6.003	2.602	71.834	15.787	134.251	32.837
1980	5.586	2.391	13.141	6.553	72.142	19.108	83.805	17.868
1981	6.461	2.122	4.179	3.029	106.341	30.383	50.847	13.595
1982	7.670	3.022	4.201	1.924	61.612	14.713	108.203	24.418
1983	12.367	5.653	10.304	3.519	112.487	28.984	76.658	15.143
1984	5.155	1.979	7.732	3.106	68.949	16.716	39.541	12.212
1985	3.469	1.418	7.638	2.324	54.210	15.302	48.677	8.288
1986	2.342	0.998	2.502	0.938	68.984	16.352	44.646	6.920
1987	5.609	1.503	1.605	0.488	85.180	18.640	54.434	8.018
1988	6.897	1.649	3.000	1.030	54.039	11.266	38.419	8.237
1989	3.717	1.316	6.402	2.013	64.696	13.940	39.249	8.602
1990	5.415	2.252	3.527	1.177	82.125	14.375	67.661	13.218
1991	4.517	1.436	7.035	1.467	46.630	11.513	101.716	17.580
1992	3.932	1.160	10.447	3.096	79.000	15.356	87.581	15.089
1993	1.556	0.353	7.559	1.859	78.018	12.051	93.527	15.109
1994	3.481	0.891	4.870	1.319	72.578	9.779	67.789	13.246
1995	12.185	3.149	4.765	1.446	89.361	14.960	76.736	15.092
1996	2.736	0.732	10.099	3.116	70.494	12.082	77.006	13.144
1997	2.806	0.664	10.008	2.950	85.396	12.959	78.402	14.438
1998	2.001	0.527	3.218	0.987	77.771	13.473	98.450	15.454
1999	6.510	1.982	10.921	3.269	80.776	14.957	125.742	23.204
2000	10.383	2.885	12.705	5.065	162.190	34.160	99.953	25.100
2001	5.242	1.663	8.786	3.133	89.743	24.510	81.072	17.743
2002	12.066	3.692	10.691	4.003	91.083	22.391	65.812	16.264
2003	7.839	2.544	10.182	4.315	83.693	17.323	90.477	15.801
2004	3.879	1.103	2.763	0.867	79.115	11.201	107.591	14.091
2005	6.920	2.056	8.807	2.314	94.044	11.980	78.591	11.812
2006	4.173	1.211	7.117	2.346	85.548	14.434	86.985	15.463
2007	2.500	0.717	6.378	1.820	53.583	10.060	76.669	11.599
2008	11.543	2.177			NA	NA		

Table I17. Comparative Results from ADAPT/VPA runs. Run 2b is the preferred run for status determination. Run 4 also excludes surveys listed under run 3. Runs 6 through 9 use either the NEFSC or MDMF Spring and Fall surveys exclusively.

VPA RUNS	BASE	SPLIT	SPLIT	SPLIT	SPLIT	BASE	SPLIT	BASE	SPLIT
run	1	2A	2B	3	4	5	6	7	8
Indices Excluded	none	none	none	N_S1, N_F2, M_F6, M_F7 M_F8	N_S2_8, M_S1, M_S2 M_S3, M_F3, M_F5, M_S2_7, M_S2_8	NEFSC Seabrook	NEFSC Seabrook	MDMF Seabrook	MDMF Seabrook
Number	34	64	64	59	51	16	32	15	30
RSS	878	624	617	470	415	462	316	392	291
N t+1 age 1 (cv)	not est	9.5 (0.65)	not est	9.5 (0.58)	9.6 (0.58)	not est	not est	not est	not est
N t+1 age 2 (cv)	5.2 (0.43)	2.7 (0.38)	2.7 (0.37)	2.7 (0.34)	2.7 (0.34)	3.6 (0.63)	1.7 (0.53)	7.4 (0.00)	1.7 (0.00)
N t+1 age 3 (cv)	2.6 (0.32	1.4 (0.28)	1.4 (0.28)	1.4 (0.25)	1.4 (0.25)	2.5 (0.49)	1.2 (0.42)	2.8 (0.00)	1.2 (0.00)
N t+1 age 4 (cv)	2.0 (0.27)	1.0 (0.25)	1.0 (0.25)	1.0 (0.22)	1.0 (0.23)	2.9 (0.43)	1.4 (0.37)	1.5 (0.00)	1.4 (0.00)
N t+1 age 5 (cv)	2.2 (0.26)	1.1 (0.24)	1.1 (0.24)	1.1 (0.22)	1.1 (0.22)	2.4 (0.39)	1.1 (0.36)	1.8 (0.00)	1.1 (0.00)
N t+1 age 6 (cv)	1.0 (0.24)	0.2 (0.30)	0.2 (0.29)	0.2 (0.27)	0.3 (0.26)	0.8 (0.37)	0.2 (0.49)	0.9 (0.00)	0.2 (0.01)
N t+1 age 7 (cv)	0.5 (0.24)	0.1 (0.32)	0.1 (0.32)	0.1 (0.29)	0.1 (0.28)	0.4 (0.39)	< 0.1 (0.52)	0.6 (0.00)	< 0.1 (0.01)
N t+1 age 8 (cv)	0.1 (1.06)	< 0.1 (0.92)	< 0.1 (0.91)	< 0.1 (0.82)	< 0.1 (0.83)	< 0.1 (1.09)	< 0.1 (0.92)	0.2 (0.00)	< 0.1 (0.00)
F age 1	0.001	0.002	0.002	0.002	0.002	0.002	0.004	0.001	0.002
F age 2	0.006	0.011	0.011	0.011	0.011	0.006	0.013	0.006	0.010
F age 3	0.046	0.087	0.087	0.087	0.086	0.032	0.064	0.059	0.113
F age 4	0.068	0.134	0.134	0.134	0.131	0.063	0.131	0.081	0.162
F age 5	0.119	0.406	0.406	0.406	0.341	0.141	0.522	0.130	0.383
F age 6	0.111	0.428	0.428	0.428	0.353	0.136	0.536	0.090	0.324
F age 7	0.115	0.428	0.428	0.428	0.353	0.139	0.536	0.110	0.324
F (ages 5-6)	0.1149	0.4169	0.4169	0.4169	0.3468	0.1385	0.5291	0.11	0.3532
SSB (mt)	2,765	1,099	1,099	1,099	1,195	2,686	1,062	2,607	1,055

Table I18. Estimated Mohn's rho from the Base (run 1) and Split VPA run (2b).

	Mohn's rho		
Model	F (5-6)	SSB	age 1 recruitment
2000	-0.81	2.86	1.90
2001	-0.84	3.27	3.18
2002	-0.84	3.43	1.36
2003	-0.83	2.98	1.43
2004	-0.78	1.82	1.07
2005	-0.59	0.75	0.51
2006	-0.22	0.19	-0.06
Base VPA average	**-0.70**	**2.12**	**1.30**
2000	-0.26	0.31	0.76
2001	-0.32	0.43	1.50
2002	-0.14	0.40	0.93
2003	-0.12	0.29	1.39
2004	-0.07	0.16	0.96
2005	-0.15	0.31	0.52
2006	0.19	0.14	-0.07
Split VPA average	**-0.13**	**0.29**	**0.86**

Table I19. Split VPA run 2b results using 1000 bootstrap iterations.

JAN-1 Population Numbers

AGE	1982	1983	1984	1985	1986
1	11556.	8594.	6119.	9004.	7294.
2	14198.	9360.	6914.	4989.	7344.
3	10952.	9031.	6838.	4836.	3825.
4	6122.	4267.	5636.	3735.	2526.
5	3038.	1912.	1850.	2910.	1171.
6	1170.	1236.	800.	751.	679.
7	575.	408.	687.	344.	260.
8	217.	344.	495.	214.	158.
Total	47829.	35151.	29339.	26782.	23257.

AGE	1987	1988	1989	1990	1991
1	5710.	3740.	3507.	3739.	4092.
2	5928.	4627.	3041.	2850.	3053.
3	5557.	4415.	3364.	2275.	2096.
4	2297.	2755.	2548.	1543.	1114.
5	1305.	791.	1203.	772.	371.
6	624.	364.	325.	297.	186.
7	241.	234.	79.	77.	90.
8	238.	169.	59.	46.	65.
Total	21900.	17094.	14125.	11599.	11067.

AGE	1992	1993	1994	1995	1996
1	3161.	2292.	3611.	3886.	3420.
2	3334.	2548.	1851.	2940.	3157.
3	2225.	2378.	1909.	1443.	2344.
4	943.	1164.	1267.	1111.	880.
5	369.	253.	358.	482.	233.
6	96.	118.	75.	157.	51.
7	47.	15.	35.	22.	22.
8	30.	5.	15.	22.	34.
Total	10206.	8774.	9122.	10064.	10142.

Table I19. Cont.

JAN-1 Population Numbers

AGE	1997	1998	1999	2000	2001
1	3070.	2988.	2641.	2031.	1659.
2	2786.	2497.	2429.	2156.	1647.
3	2389.	2023.	1986.	1977.	1739.
4	1261.	1424.	1418.	1555.	1538.
5	407.	631.	741.	945.	919.
6	120.	228.	220.	403.	434.
7	30.	79.	84.	88.	203.
8	46.	23.	82.	39.	112.
Total	10110.	9893.	9601.	9193.	8251.

AGE	2002	2003	2004	2005	2006
1	1653.	1729.	3026.	2060.	2047.
2	1346.	1350.	1408.	2468.	1673.
3	1330.	1074.	1067.	1072.	1972.
4	1348.	938.	714.	689.	729.
5	914.	760.	417.	278.	336.
6	367.	384.	252.	122.	102.
7	140.	134.	99.	36.	49.
8	73.	80.	75.	32.	41.
Total	7171.	6449.	7057.	6758.	6950.

AGE	2007	2008
1	3248.	3513.
2	1670.	2653.
3	1357.	1352.
4	1521.	1018.
5	453.	1089.
6	195.	247.
7	59.	104.
8	35.	28.
Total	8538.	10005.

Table I19. Cont.

Fishing Mortality Calculated

AGE	1982	1983	1984	1985	1986
1	0.0107	0.0175	0.0042	0.0038	0.0074
2	0.2524	0.1139	0.1576	0.0657	0.0788
3	0.7427	0.2715	0.4048	0.4493	0.3097
4	0.9639	0.6355	0.4610	0.9600	0.4602
5	0.6997	0.6716	0.7022	1.2559	0.4293
6	0.8529	0.3874	0.6445	0.8599	0.8350
7	0.7400	0.5502	0.6844	1.1609	0.5598
8	0.7400	0.5502	0.6844	1.1609	0.5598

AGE	1987	1988	1989	1990	1991
1	0.0103	0.0068	0.0076	0.0027	0.0049
2	0.0947	0.1189	0.0902	0.1072	0.1161
3	0.5018	0.3498	0.5791	0.5141	0.5984
4	0.8665	0.6285	0.9937	1.2259	0.9045
5	1.0772	0.6892	1.2004	1.2241	1.1499
6	0.7827	1.3312	1.2338	0.9934	1.1805
7	0.9722	0.8509	1.2074	1.1546	1.1600
8	0.9722	0.8509	1.2074	1.1546	1.1600

AGE	1992	1993	1994	1995	1996
1	0.0155	0.0136	0.0055	0.0077	0.0052
2	0.1378	0.0890	0.0494	0.0266	0.0787
3	0.4482	0.4295	0.3413	0.2943	0.4195
4	1.1145	0.9785	0.7671	1.3605	0.5704
5	0.9396	1.0163	0.6226	2.0388	0.4632
6	1.6355	1.0053	1.0104	1.7829	0.3255
7	1.0490	1.0128	0.6799	1.9695	0.4369
8	1.0490	1.0128	0.6799	1.9695	0.4369

AGE	1997	1998	1999	2000	2001
1	0.0069	0.0074	0.0029	0.0093	0.0087
2	0.1200	0.0287	0.0059	0.0149	0.0142
3	0.3174	0.1550	0.0448	0.0509	0.0547
4	0.4935	0.4533	0.2059	0.3258	0.3202
5	0.3783	0.8548	0.4090	0.5786	0.7185
6	0.2246	0.7947	0.7164	0.4870	0.9315
7	0.3412	0.8385	0.4714	0.5503	0.7820
8	0.3412	0.8385	0.4714	0.5503	0.7820

Table I19. Cont.

Fishing Mortality Calculated

AGE	2002	2003	2004	2005	2006
1	0.0027	0.0058	0.0037	0.0081	0.0038
2	0.0257	0.0349	0.0722	0.0244	0.0093
3	0.1488	0.2086	0.2371	0.1854	0.0599
4	0.3733	0.6117	0.7446	0.5186	0.2757
5	0.6676	0.9045	1.0308	0.7966	0.3433
6	0.8097	1.1566	1.7316	0.7151	0.3562
7	0.7063	0.9822	1.2413	0.7711	0.3463
8	0.7063	0.9822	1.2413	0.7711	0.3463

AGE	2007
1	0.0024
2	0.0113
3	0.0873
4	0.1338
5	0.4060
6	0.4278
7	0.4278
8	0.4278

Average Fishing Mortality For Ages 5-6

Year	Average F
1982	0.7763
1983	0.5295
1984	0.6734
1985	1.0579
1986	0.6322
1987	0.9300
1988	1.0102
1989	1.2171
1990	1.1088
1991	1.1652
1992	1.2876
1993	1.0108
1994	0.8165
1995	1.9109
1996	0.3943
1997	0.3015
1998	0.8248
1999	0.5627
2000	0.5328
2001	0.8250
2002	0.7386
2003	1.0305
2004	1.3812
2005	0.7559
2006	0.3498
2007	0.4169

Spawning Stock Biomass

AGE	1982	1983	1984	1985	1986
1	0.	0.	0.	0.	0.
2	90.	51.	46.	22.	32.
3	982.	796.	577.	413.	315.
4	1706.	1322.	1593.	909.	752.
5	1236.	852.	763.	969.	540.
6	664.	734.	437.	382.	361.
7	396.	295.	454.	198.	194.
8	349.	332.	443.	171.	160.
Total	5422.	4381.	4313.	3065.	2352.

AGE	1987	1988	1989	1990	1991
1	0.	0.	0.	0.	0.
2	25.	20.	11.	12.	11.
3	568.	447.	398.	207.	221.
4	720.	861.	828.	456.	368.
5	557.	366.	464.	323.	149.
6	368.	179.	183.	152.	87.
7	168.	168.	52.	55.	48.
8	228.	156.	58.	40.	43.
Total	2633.	2198.	1995.	1244.	927.

AGE	1992	1993	1994	1995	1996
1	0.	0.	0.	0.	0.
2	11.	8.	3.	6.	13.
3	222.	205.	173.	78.	153.
4	293.	322.	364.	261.	274.
5	168.	109.	149.	137.	102.
6	42.	57.	39.	60.	28.
7	29.	11.	24.	10.	13.
8	32.	5.	15.	20.	38.
Total	797.	717.	767.	572.	622.

Table I19. Cont.

Spawning Stock Biomass

AGE	1997	1998	1999	2000	2001
1	0.	0.	0.	0.	0.
2	8.	8.	5.	6.	4.
3	270.	199.	180.	130.	123.
4	450.	475.	493.	507.	473.
5	203.	269.	319.	410.	365.
6	82.	123.	112.	209.	207.
7	20.	55.	57.	54.	122.
8	37.	28.	84.	33.	105.
Total	1070.	1155.	1250.	1348.	1400.

AGE	2002	2003	2004	2005	2006
1	0.	0.	0.	0.	0.
2	4.	5.	4.	7.	5.
3	93.	87.	79.	96.	170.
4	409.	301.	209.	213.	257.
5	375.	301.	166.	123.	174.
6	176.	177.	102.	73.	66.
7	87.	79.	56.	26.	41.
8	75.	86.	67.	34.	49.
Total	1219.	1034.	683.	572.	763.

AGE	2007
1	0.
2	6.
3	100.
4	548.
5	227.
6	130.
7	44.
8	44.
Total	1100

Table I19. Cont.

Bootstrap Summary Report

Number of Bootstrap Repetitions Requested = 1000
Number of Bootstrap Repetitions Completed = 1000
Bootstrap Output Variable: Stock Estimates (2008)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 2	2653.	2797.	854.	0.3053
N 3	1352.	1366.	281.	0.2059
N 4	1018.	1035.	179.	0.1730
N 5	1089.	1102.	175.	0.1586
N 6	247.	253.	63.	0.2495
N 7	104.	107.	34.	0.3138
N 8	28.	44.	42.	0.9683

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 2	144.	27.	5.4283	2509.	0.3403
N 3	14.	9.	1.0447	1338.	0.2103
N 4	17.	6.	1.6609	1001.	0.1788
N 5	13.	6.	1.1717	1076.	0.1623
N 6	6.	2.	2.3103	242.	0.2613
N 7	3.	1.	2.6007	101.	0.3305
N 8	15.	1.	54.1696	13.	3.2573

	LOWER 80. % CI	UPPER 80. % CI
N 2	1812.	3918.
N 3	1029.	1734.
N 4	817.	1277.
N 5	886.	1330.
N 6	177.	341.
N 7	66.	150.
N 8	8.	99.

Bootstrap Output Variable: Fishing Mortality (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0024	0.0025	0.000744	0.3015
AGE 2	0.0113	0.0117	0.002459	0.2109
AGE 3	0.0873	0.0883	0.014738	0.1668
AGE 4	0.1338	0.1353	0.020095	0.1485
AGE 5	0.4060	0.4161	0.088605	0.2129
AGE 6	0.4278	0.4481	0.119997	0.2678
AGE 7	0.4278	0.4481	0.119997	0.2678
AGE 8	0.4278	0.4481	0.119997	0.2678

Table I19. Cont.

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000086	0.000024	3.6123	0.0023	0.3240
AGE 2	0.000365	0.000079	3.2281	0.0109	0.2250
AGE 3	0.001007	0.000467	1.1531	0.0863	0.1707
AGE 4	0.001473	0.000637	1.1007	0.1323	0.1519
AGE 5	0.010154	0.002820	2.5012	0.3958	0.2239
AGE 6	0.020311	0.003849	4.7479	0.4075	0.2945
AGE 7	0.020311	0.003849	4.7479	0.4075	0.2945
AGE 8	0.020311	0.003849	4.7479	0.4075	0.2945

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.001604	0.003479
AGE 2	0.008765	0.014744
AGE 3	0.070206	0.107528
AGE 4	0.110876	0.162019
AGE 5	0.310293	0.528673
AGE 6	0.314910	0.607000
AGE 7	0.314910	0.607000
AGE 8	0.314910	0.607000

Bootstrap Output Variable: Average F (2007) AGES 5 - 6

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AVG F	0.4169	0.4321	0.077296	0.1789
N WTD	0.4125	0.4184	0.072220	0.1726
B WTD	0.4139	0.4197	0.071644	0.1707
C WTD	0.4127	0.4260	0.073988	0.1737

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AVG F	0.015233	0.002491	3.6540	0.4016	0.1925
N WTD	0.005918	0.002291	1.4347	0.4066	0.1776
B WTD	0.005807	0.002273	1.4031	0.4081	0.1756
C WTD	0.013303	0.002377	3.2231	0.3994	0.1852

	LOWER 80. % CI	UPPER 80. % CI
AVG F	0.340225	0.529325
N WTD	0.334120	0.513389
B WTD	0.336272	0.512869
C WTD	0.340363	0.519663

Table I19. Cont.

JAN-1 Biomass (2008) Mean Biomass & SSB (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
JAN-1	2064.	2123.	200.	0.0940
MEAN	1938.	1970.	177.	0.0898
SSB	1100.	1116.	113.	0.1015

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
JAN-1	59.	7.	2.8549	2005.	0.0996
MEAN	33.	6.	1.7002	1905.	0.0929
SSB	15.	4.	1.3865	1085.	0.1043

	LOWER 80. % CI	UPPER 80. % CI
JAN-1	1875.	2379.
MEAN	1755.	2208.
SSB	970.	1277.

Table I20. Biological reference points and stock status for Gulf of Maine winter flounder from GARM I, GARM II, GARM III BRP meeting and the final GARM III review. F_{MSY} was estimated from a stock recruit relationship in GARM I and F40% in GARM III. T-yr is for terminal year.

	GARM I	GARM II	GARM III BRP Meeting	GARM III Final Meeting	GARM III Final Meeting
Model	VPA Base	VPA Base	VPA Split	VPA Base	VPA Split
Terminal year	2001	2004	2006	2007	2007
F_{msy}	0.43	0.43			
F40%	0.26	0.26	0.267	0.295	0.283
YPR	0.220	0.220	0.217	0.237	0.235
SSBR	0.833	0.833	0.872	0.972	0.972
Mean Recruit million	6.726	5.638	4.046	4.585	4.072
MSY (mt)	1,500	1,500	854	1,052	917
SSB_{MSY} (mt)	4,100	4,100	3,557	4,312	3,792
SSB terminal year	5,866	3,436	806	2,765	1,100
F terminal year	0.14	0.13	0.49	0.11	0.42
$SSB_{t\text{-}yr}/SSB_{MSY}$	143%	84%	23%	64%	29%
$F_{t\text{-}yr}/F_{MSY}$	33%	30%	185%	39%	147%

Table I21. Partial recruitment pattern, maturity schedule, and mean weights at age inputs to the yield per recruit and the biological reference point AGEPRO calculations for the split VPA run.

age	Stock Size on 1 Jan 2008	Fishing Mortality Pattern	proportion mature	Mean Weights Spawning Stock	Mean Weights Catch
1	3,513	0.005	0.000	0.021	0.042
2	2,653	0.035	0.040	0.085	0.174
3	1,352	0.177	0.350	0.253	0.373
4	1,018	0.521	0.880	0.437	0.501
5	1,089	0.793	0.990	0.568	0.644
6	247	1.000	1.000	0.713	0.806
7	104	1.000	1.000	0.867	0.967
8+	28	1.000	1.000	1.387	1.387

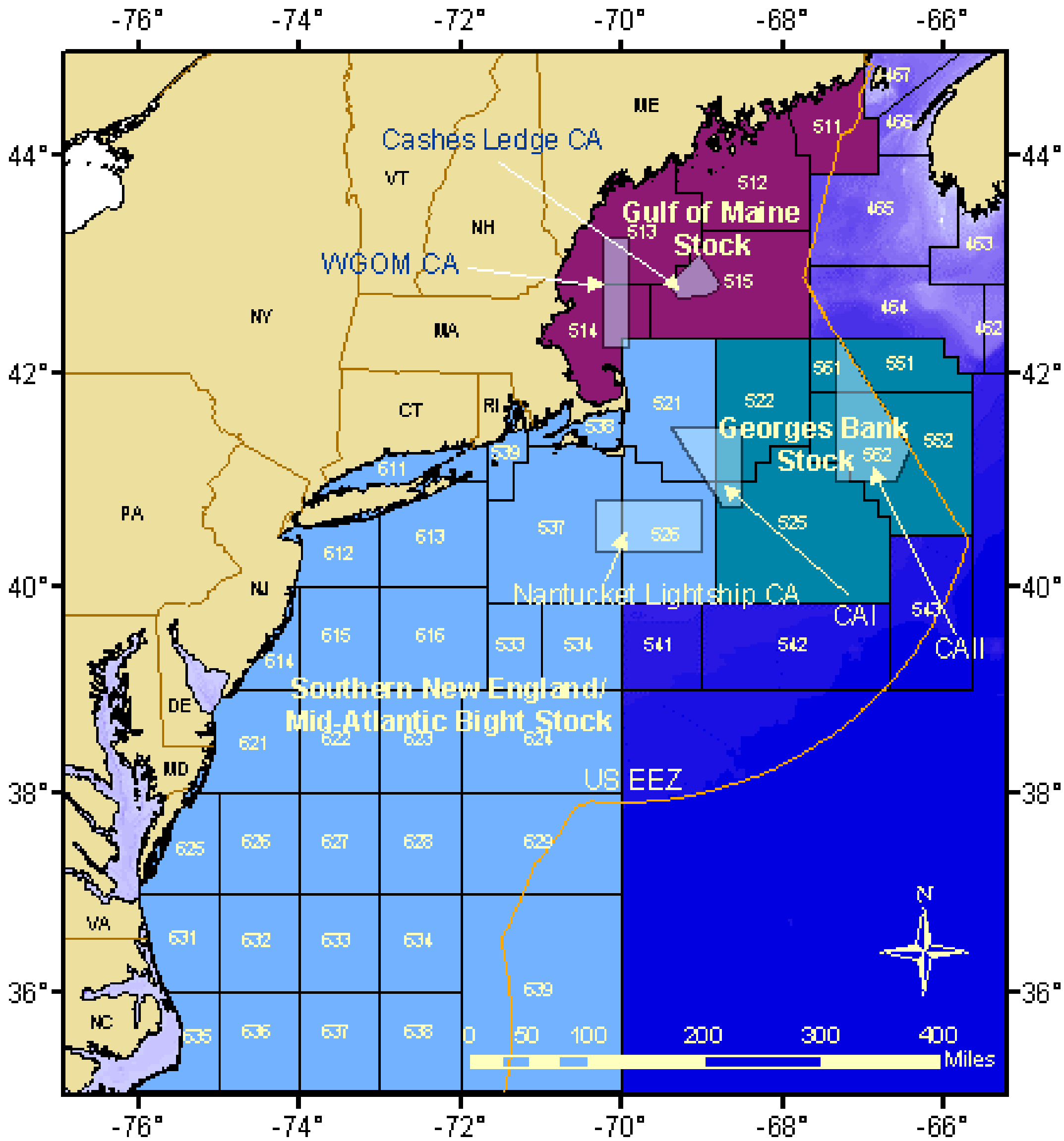


Figure I1. Statistical areas used to define winter flounder stocks. The Gulf of Maine stock includes area 511-515.

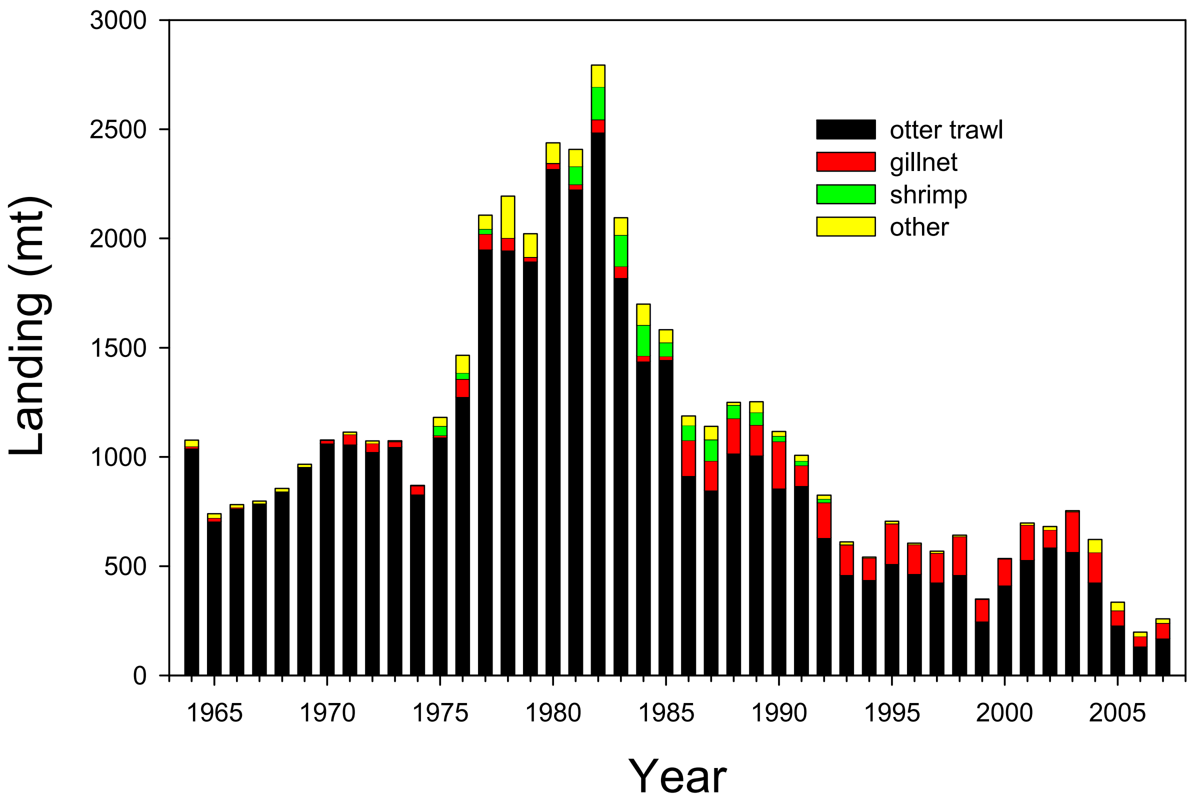


Figure I2. Commercial landings by gear 1964-2007.

Gulf of Maine Winter Flounder Recreational landings and b2 Catch

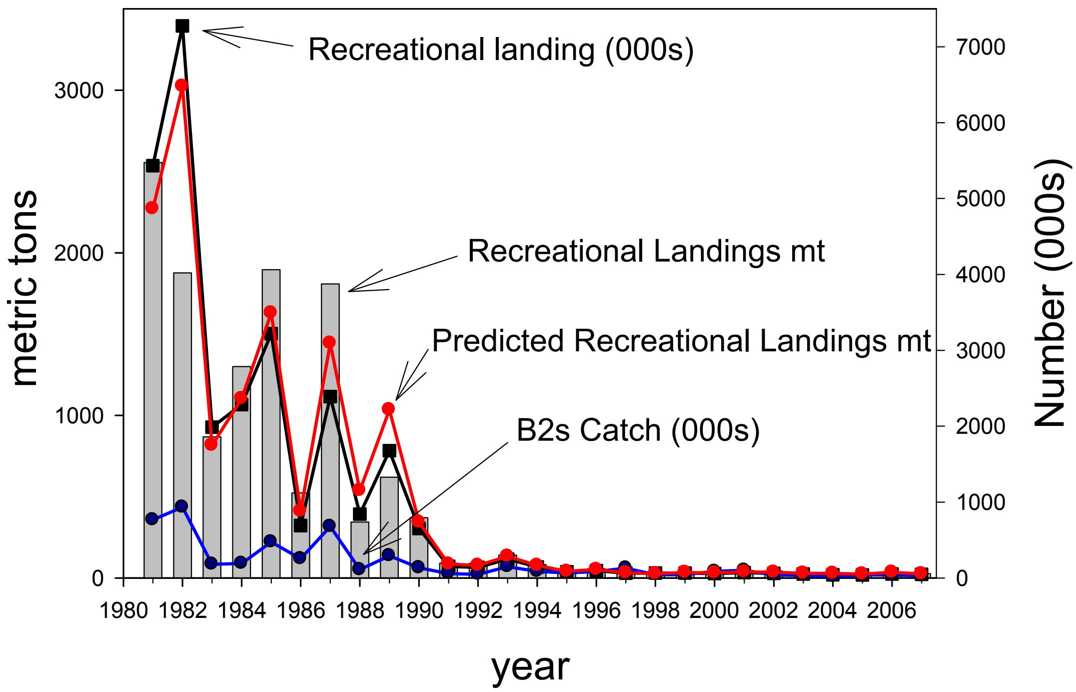


Figure I3 . Recreational landings in numbers and metric tons for Gulf of Maine winter flounder. B2 catch in numbers is also shown.

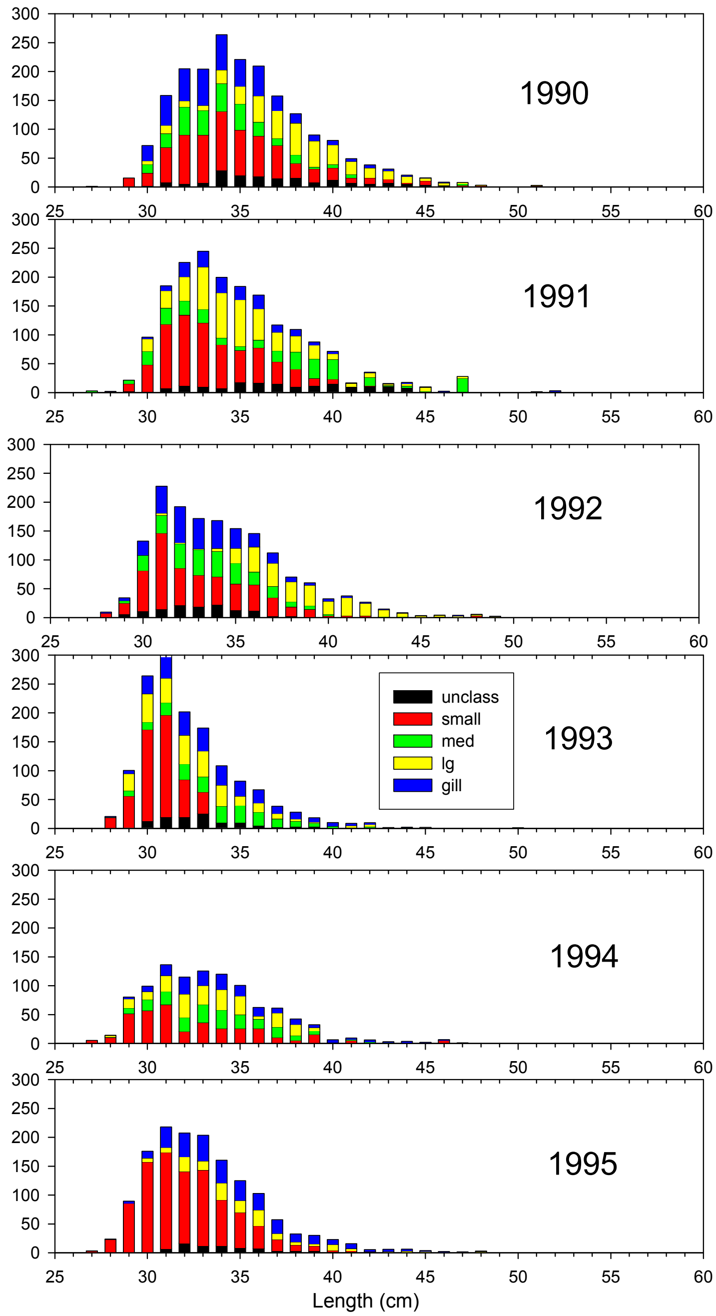


Figure I4. Expanded landing length distribution using port sampling data.

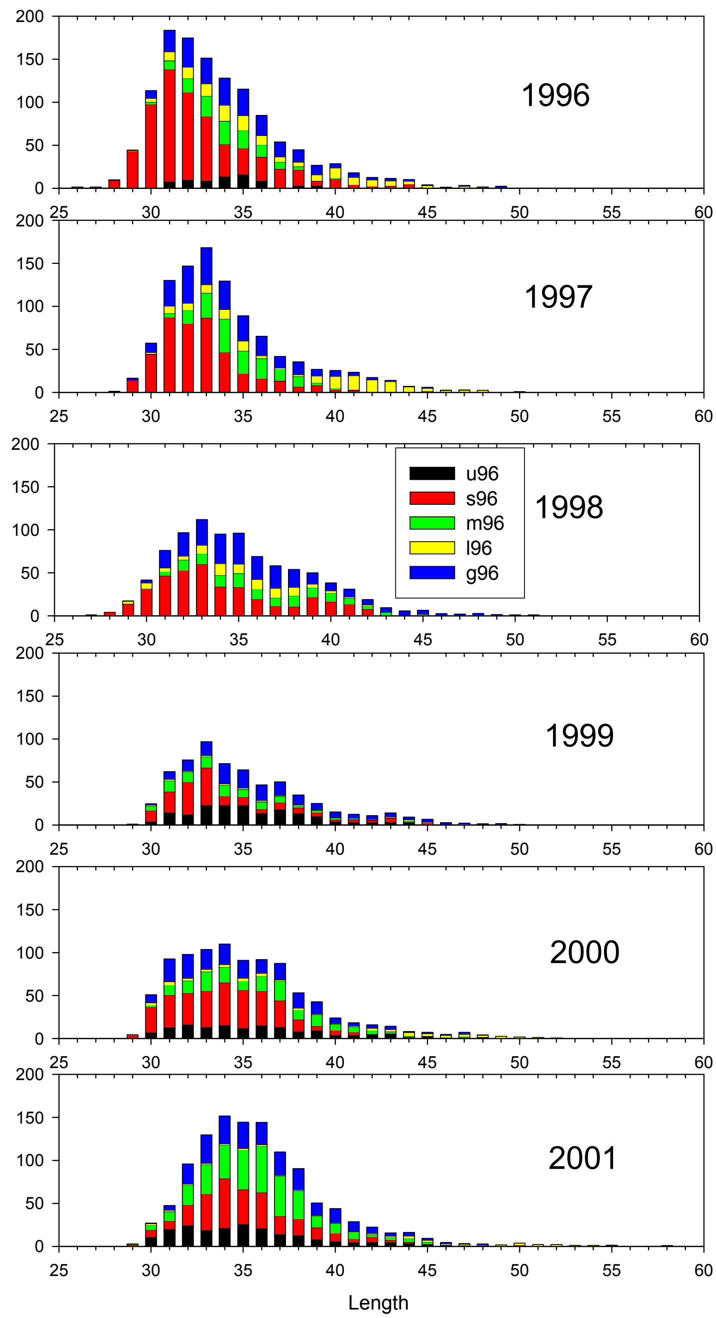


Figure I4. Cont.

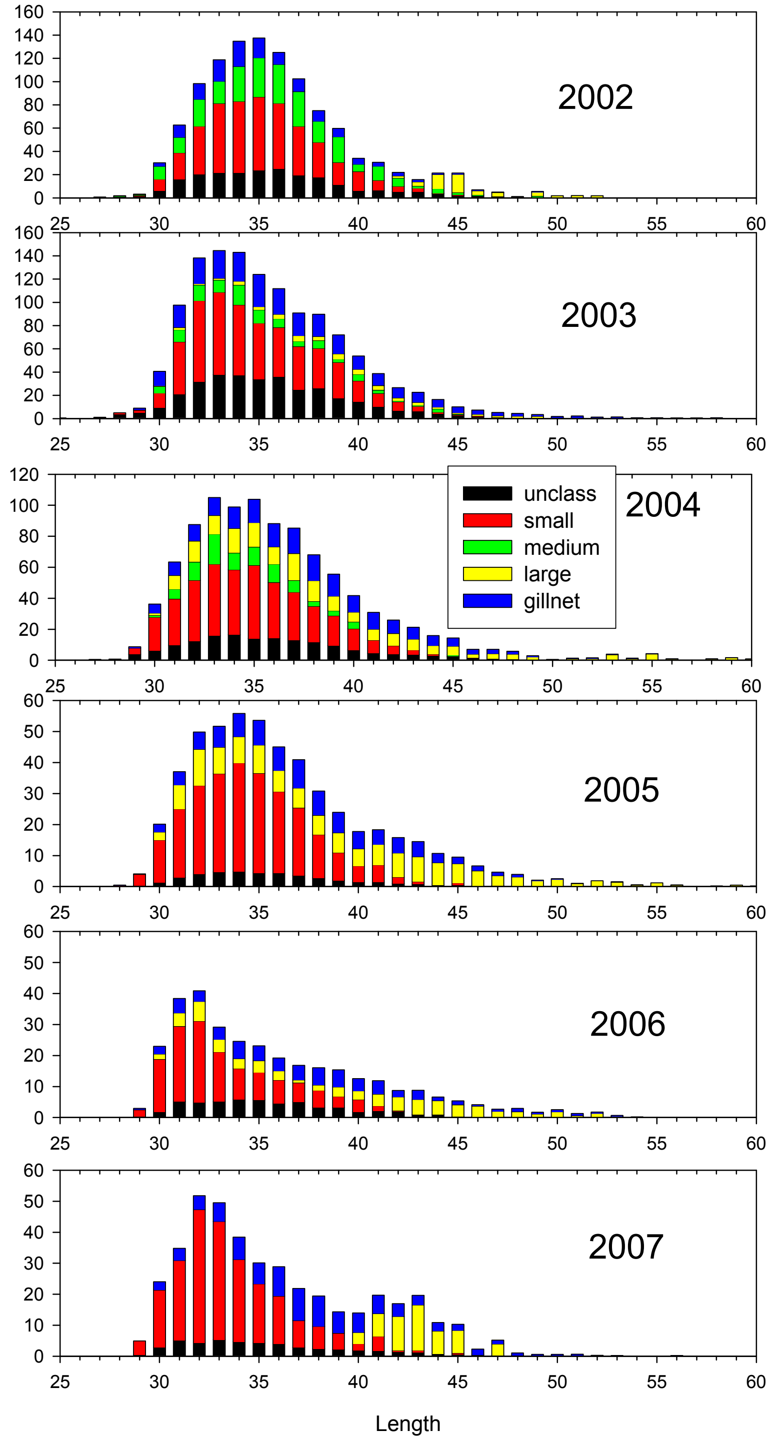


Figure I4. Cont.

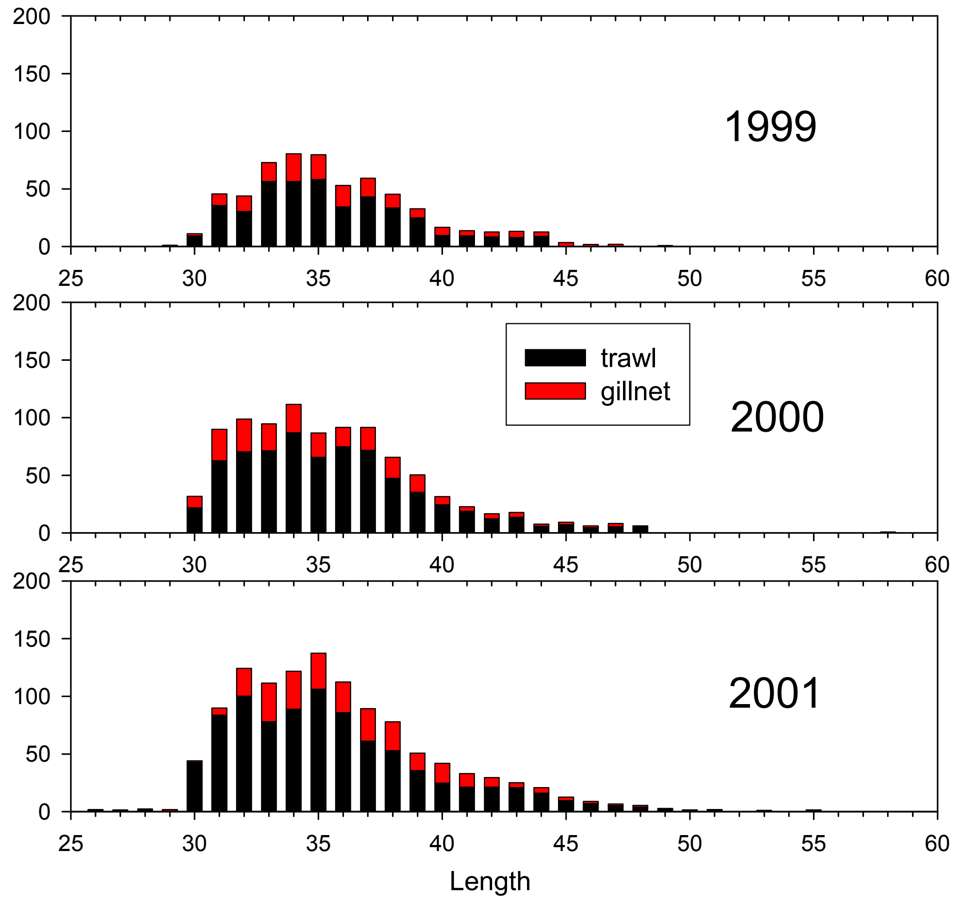


Figure I5. Expanded landing length distribution using observer data.

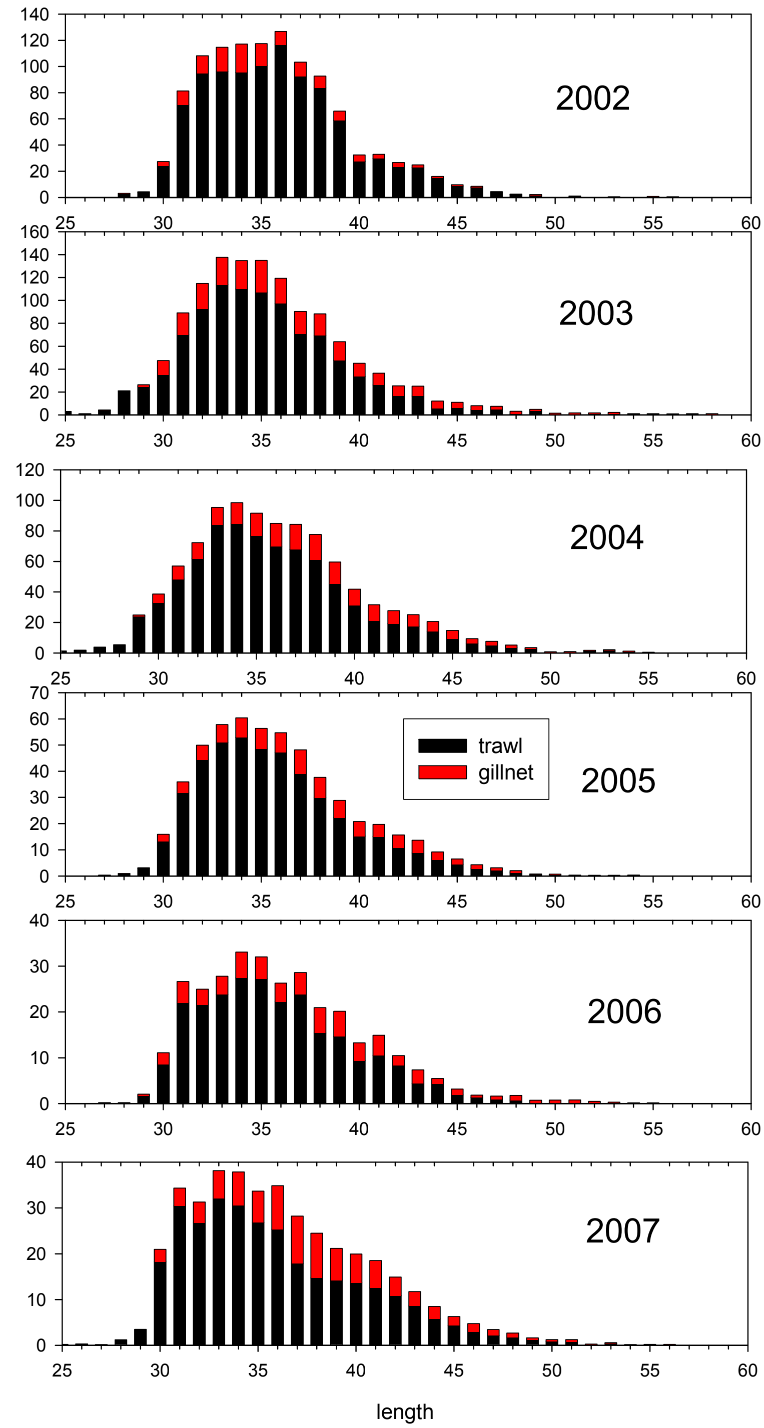


Figure I5 continued.

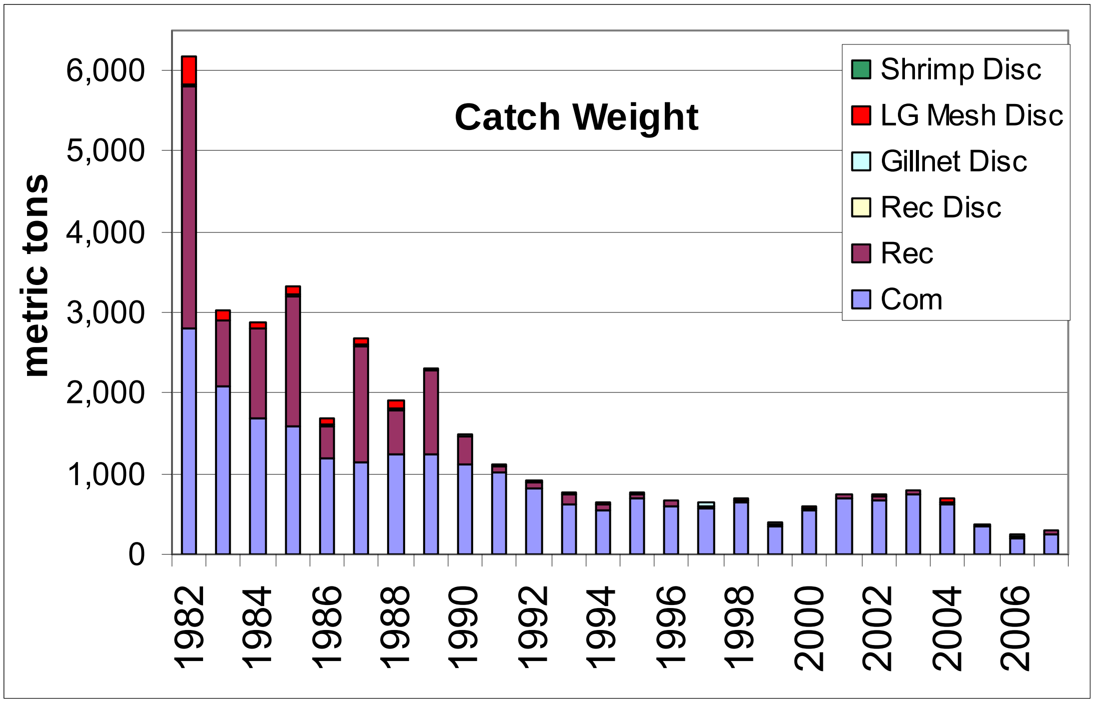


Figure I6. Gulf of Maine winter flounder composition of the catch by weight.

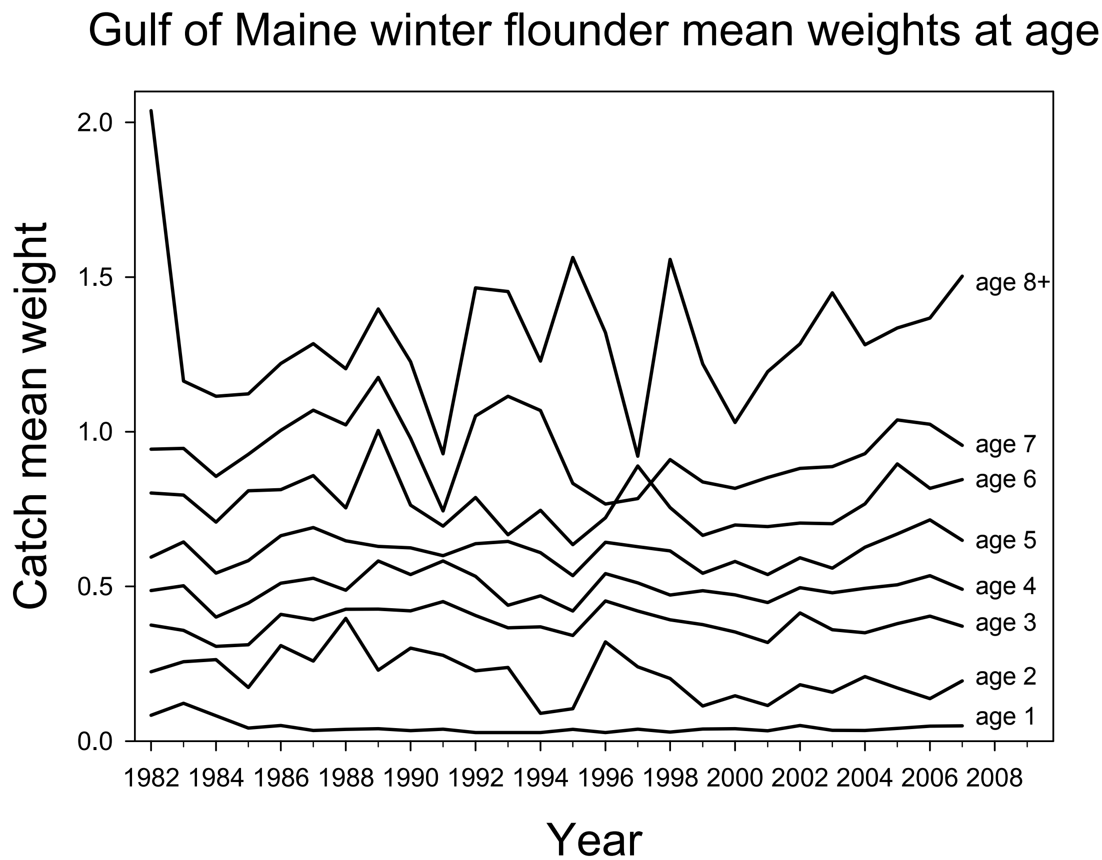


Figure I7. Gulf of Maine winter flounder mean catch weights at age (kg).

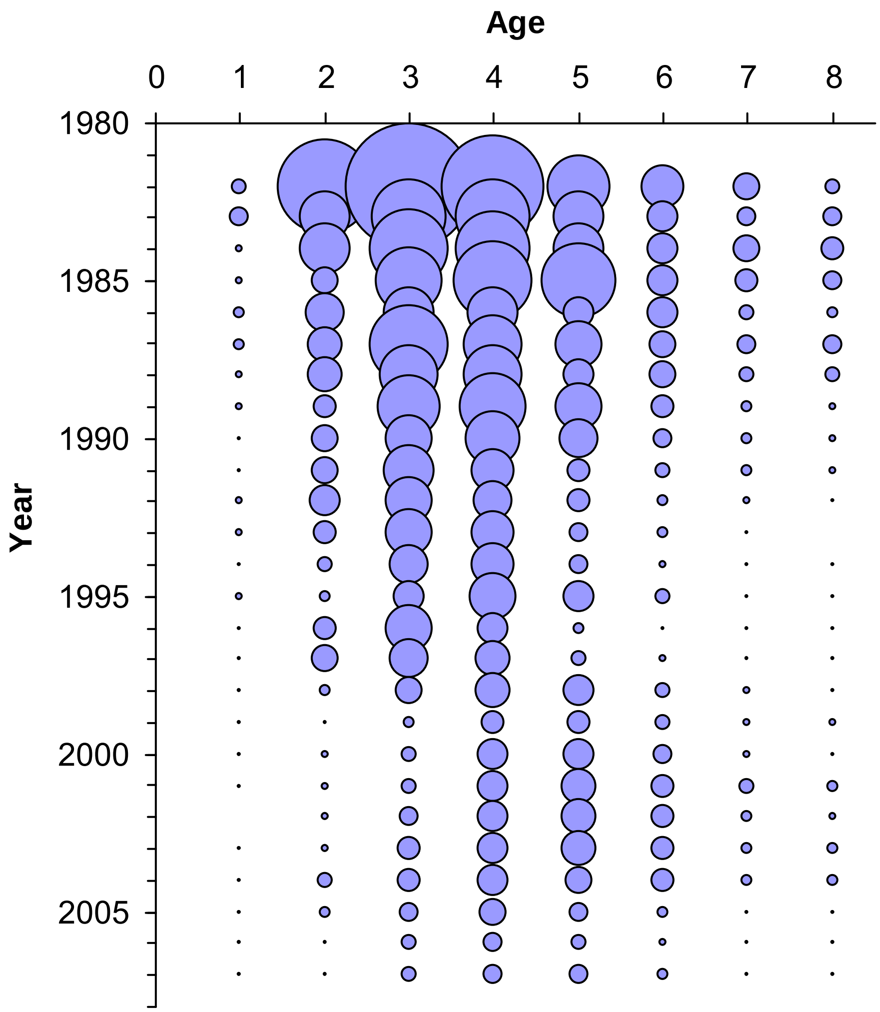


Figure I8. Gulf of Maine winter flounder bubble plot of the catch at age.

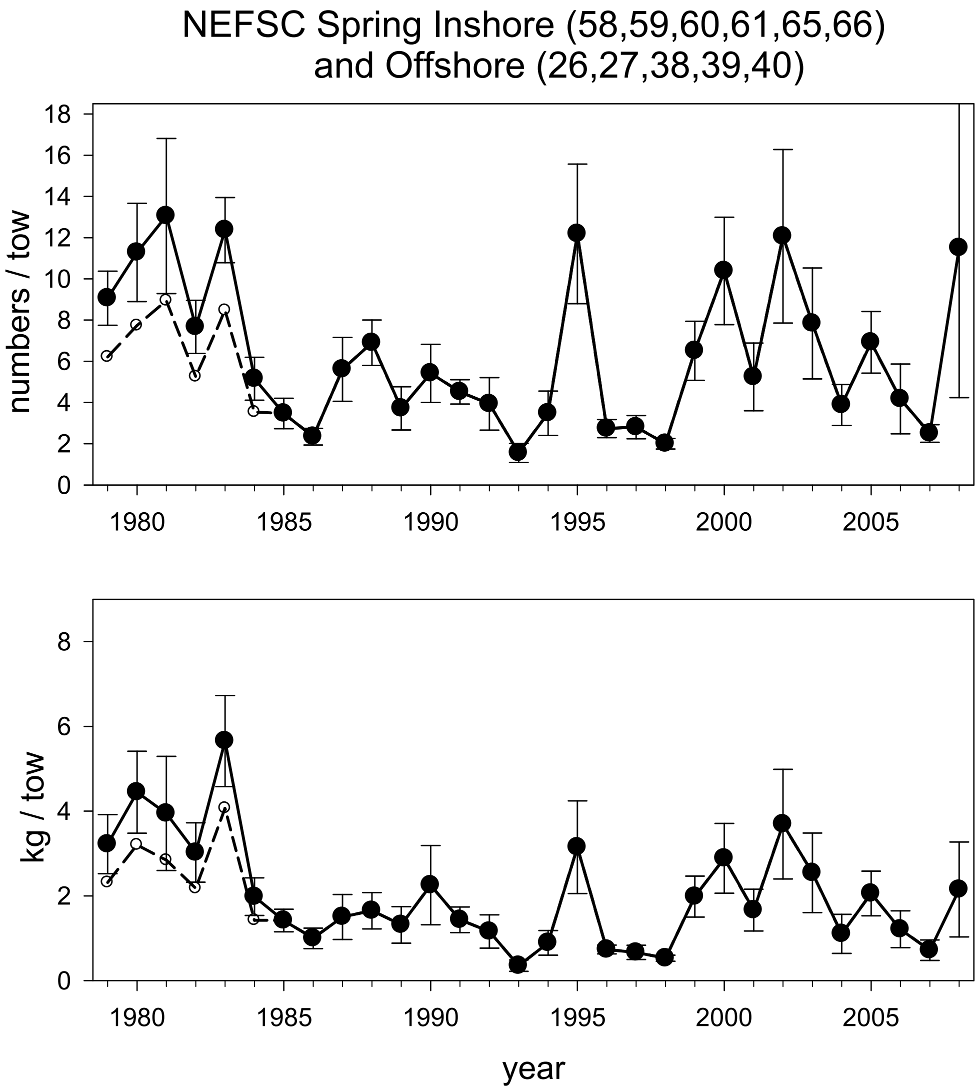


Figure I9. NEFSC Spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are use where appropriate. Dotted lines are the unconverted indices. Data for 2008 is preliminary.

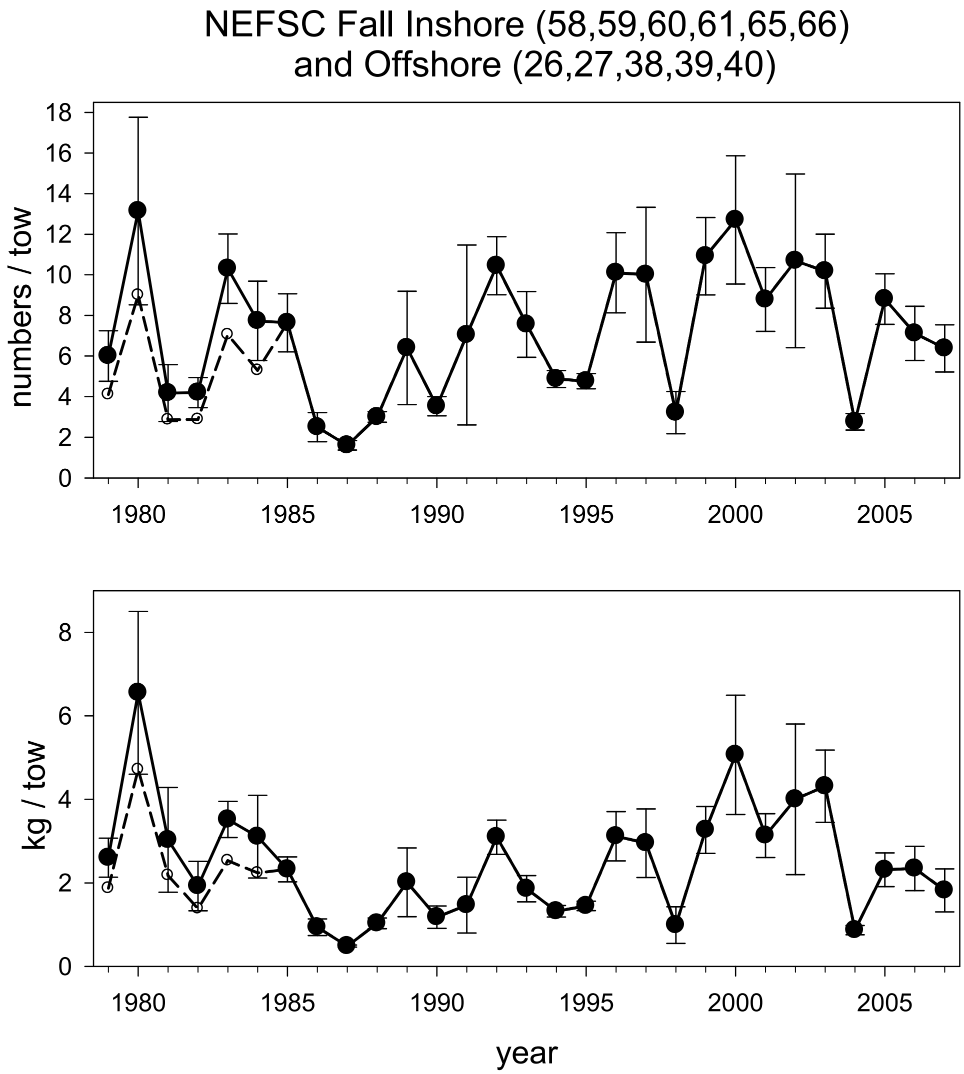


Figure I10. NEFSC Fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are use where appropriate. Dotted lines are the unconverted indices.

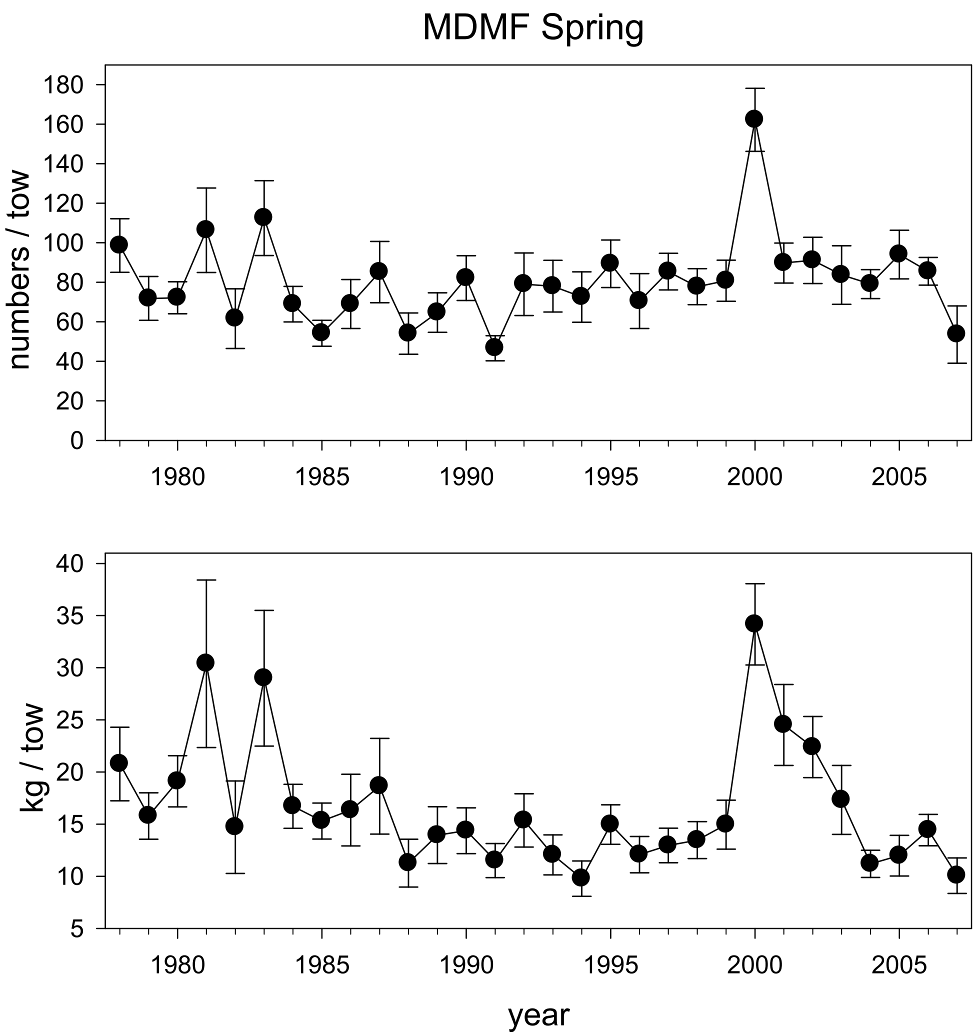


Figure I11. Massachusetts Division of Marine Fisheries (MDMF) Spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

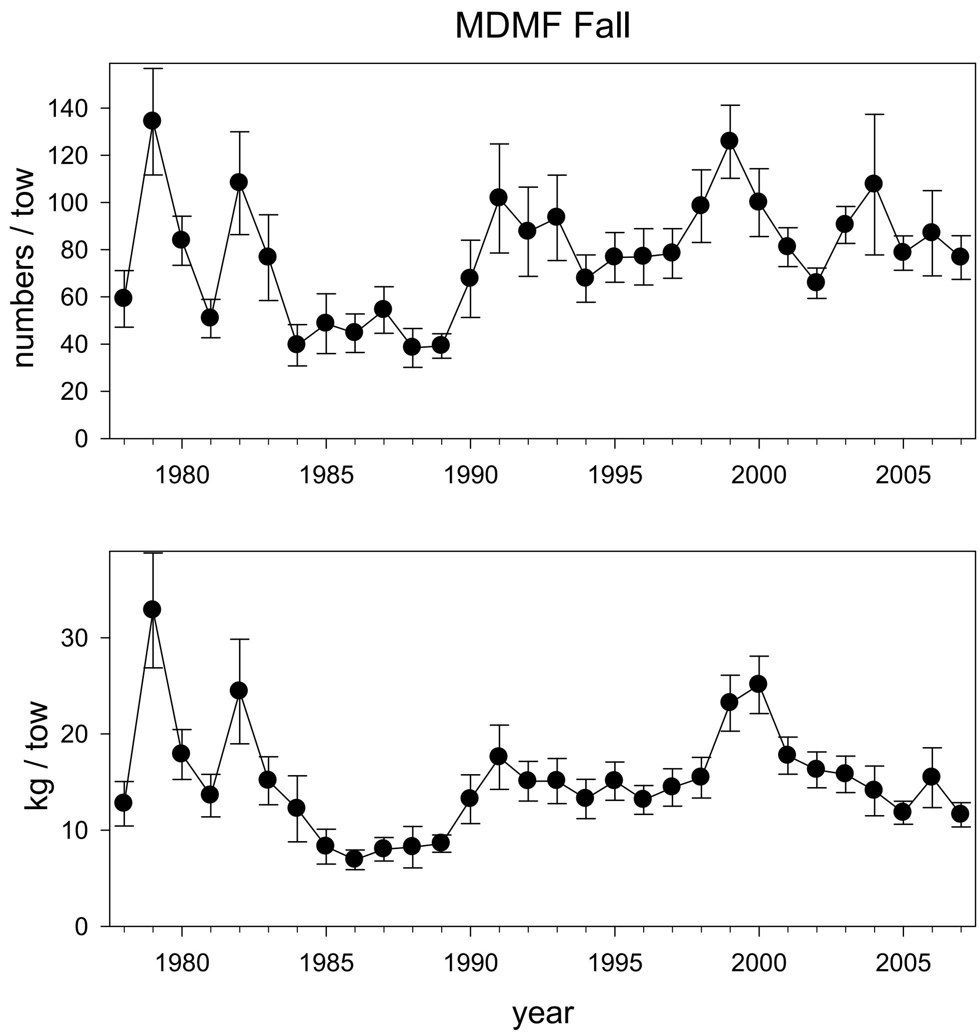
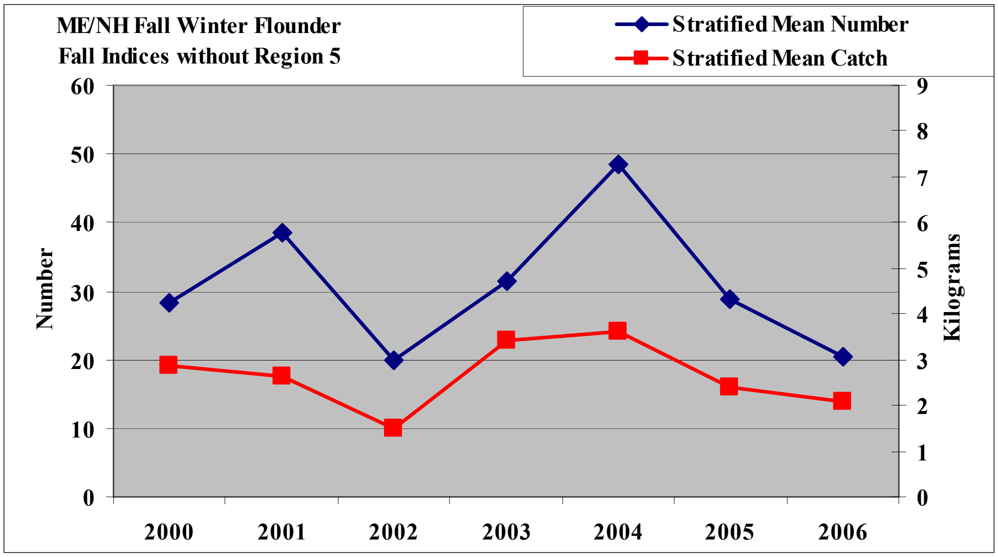


Figure I12. Massachusetts Division of Marine Fisheries (MDMF) Fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.



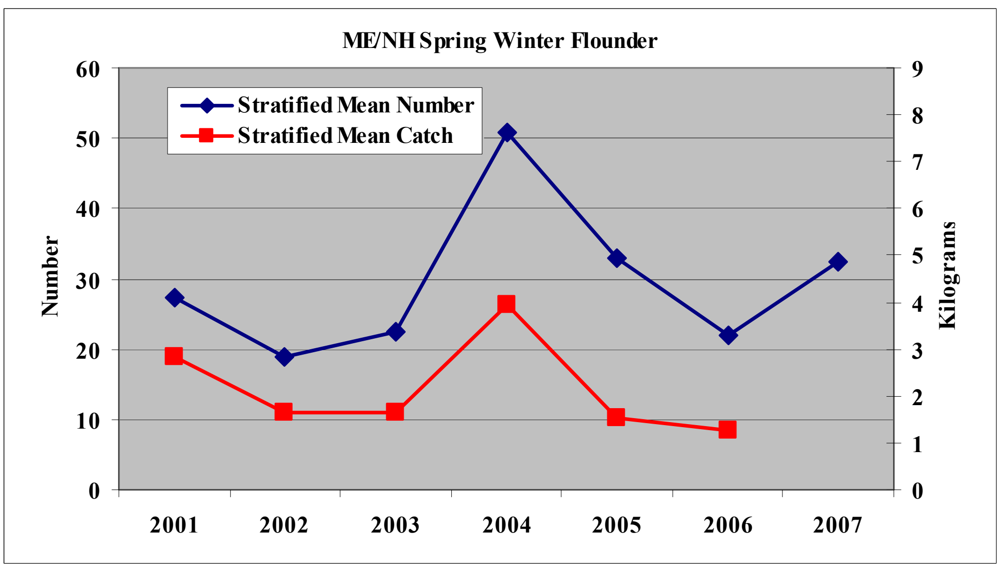


Figure I13. Spring and Fall ME/NH bottom trawl survey winter flounder abundance indices.

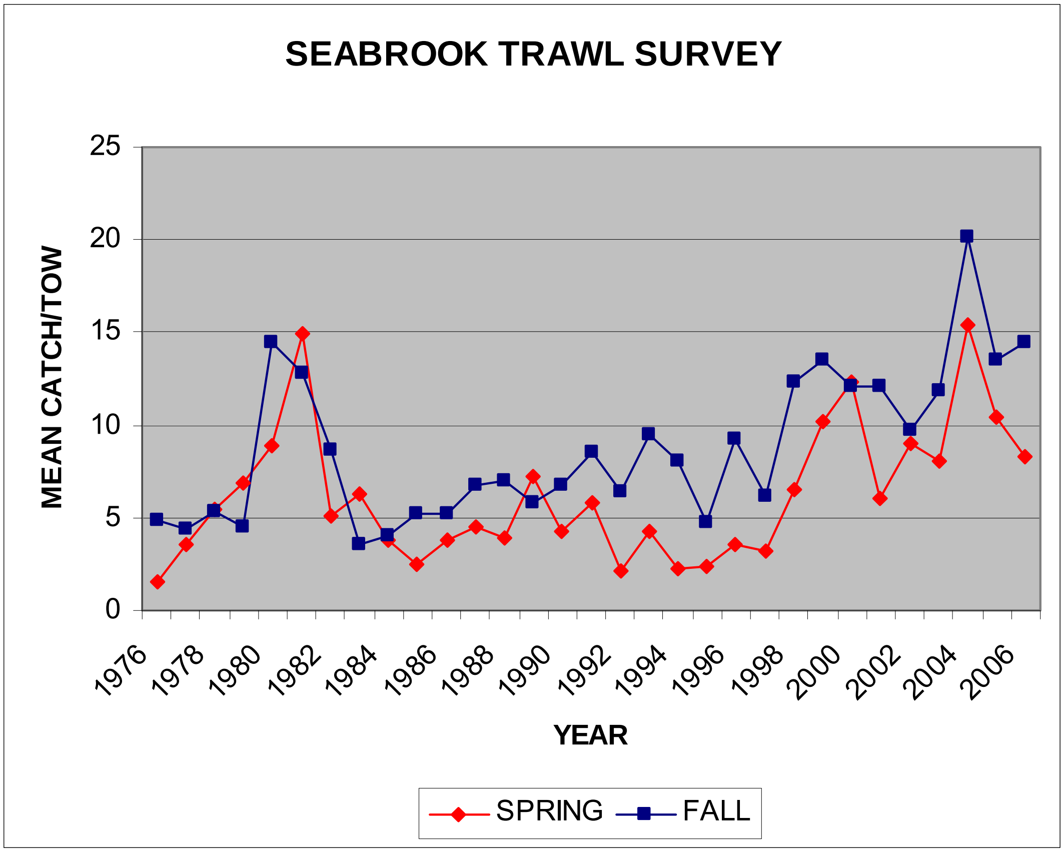


Figure I14. Seabrook Nuclear power plant in New Hampshire Spring and Fall survey mean number per tow for Gulf of Maine winter flounder.

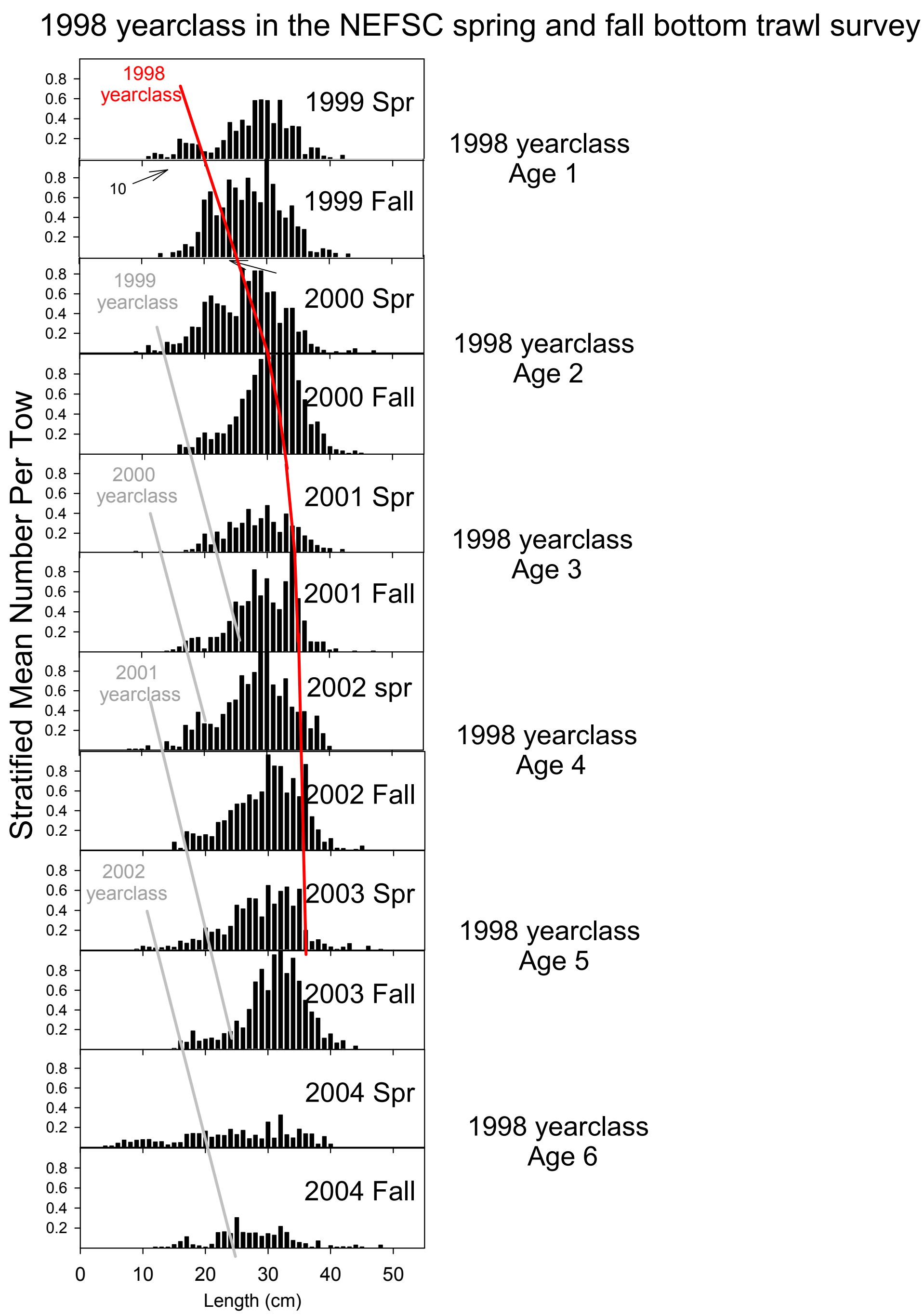


Figure I15. MDMF bottom trawl survey tracking of the 1998 yearclass in the Gulf of Maine winter flounder catch per tow at length (cm) distributions.

1998 yearclass in the NEFSC spring and fall bottom trawl survey

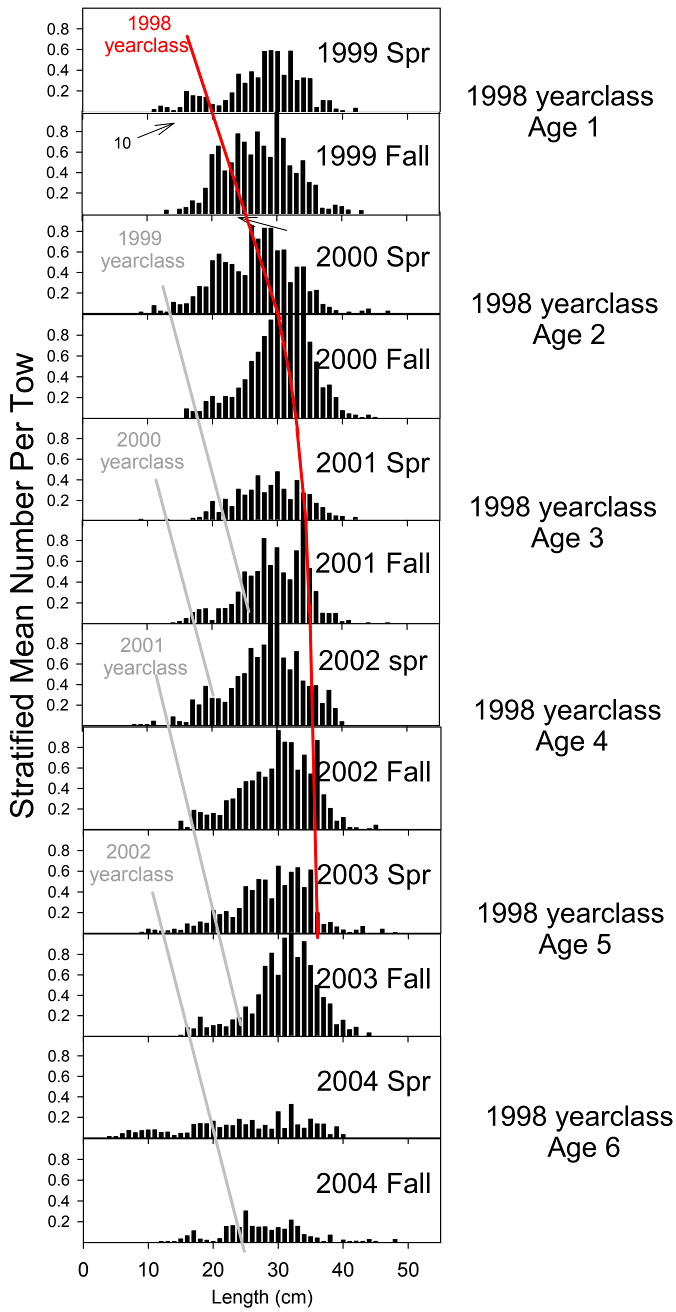


Figure I16. NEFSC bottom trawl survey tracking of the 1998 yearclass in the Gulf of Maine winter flounder catch per tow at length (cm) distributions.

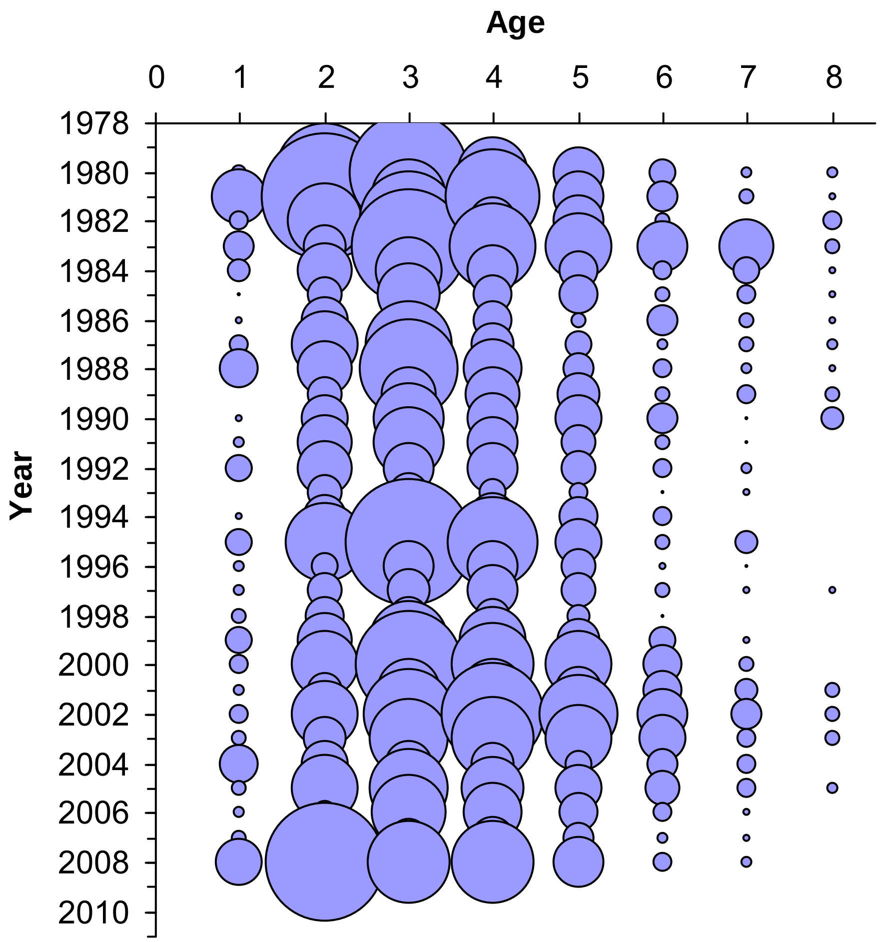


Figure I17. NEFSC Spring indices of abundance by age.

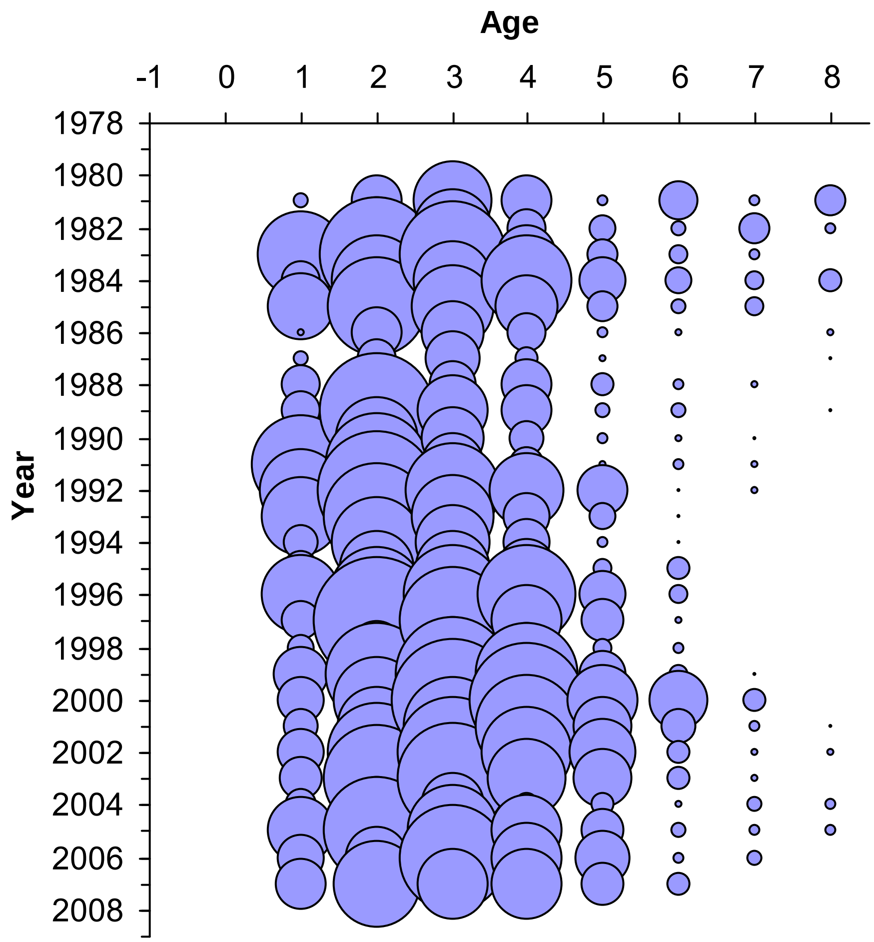


Figure I18. NEFSC Fall indices of abundance by age.

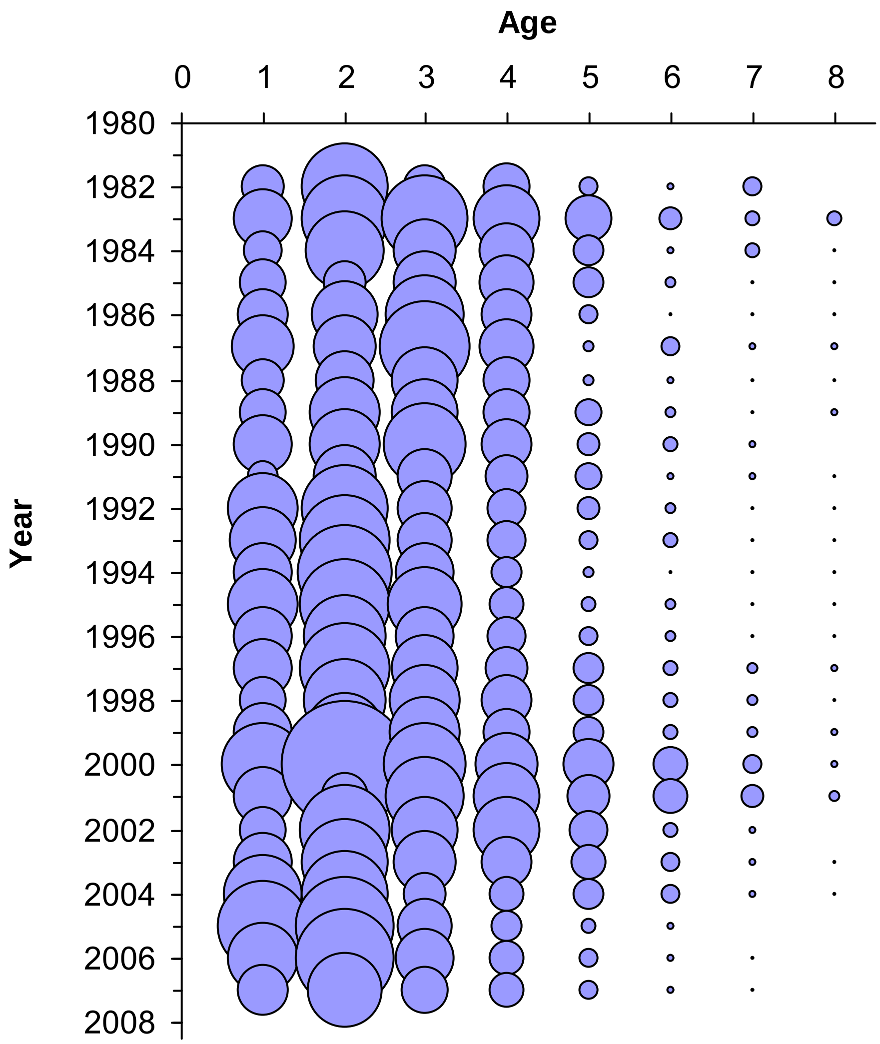


Figure I19. MDMF spring indices of abundance by age.

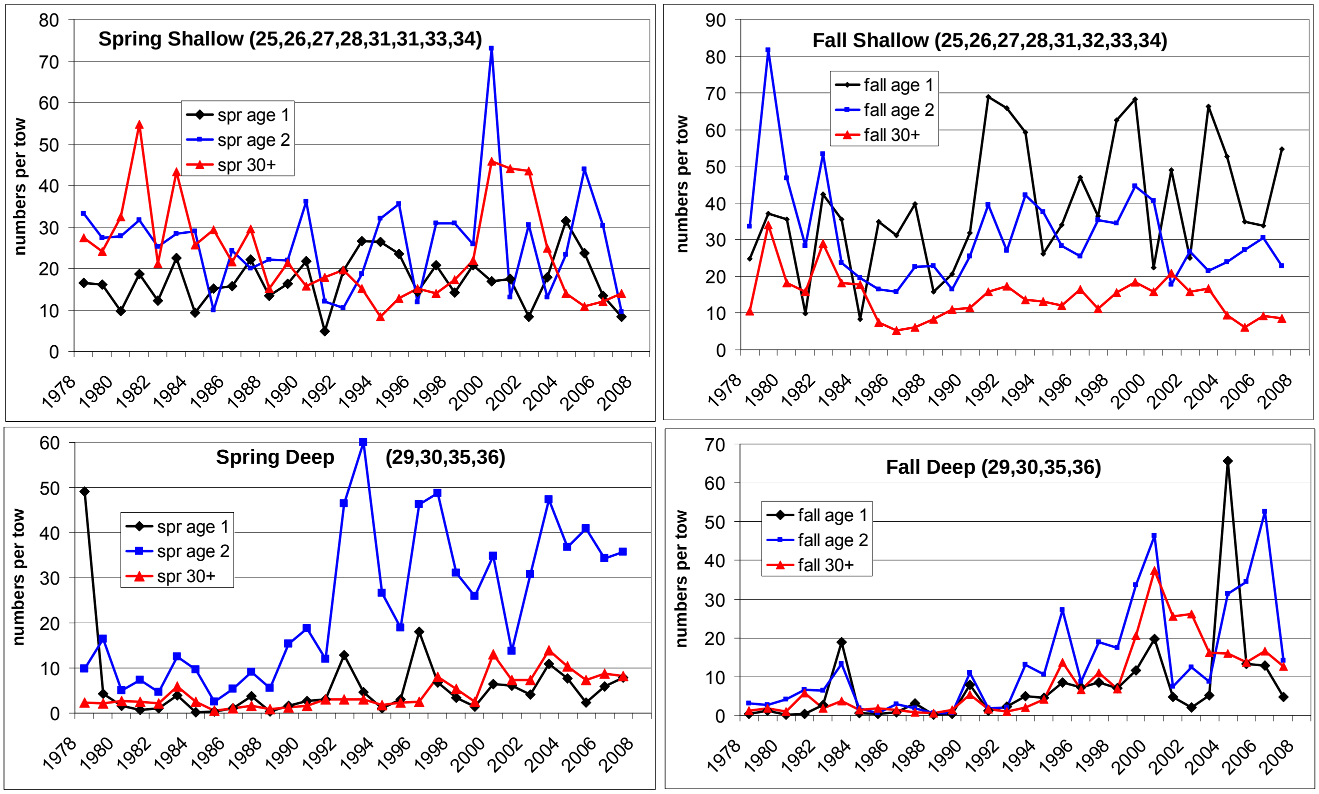


Figure I20. Number per tow indices from the Spring and Fall MDMF surveys by depth category (shallow and deep).

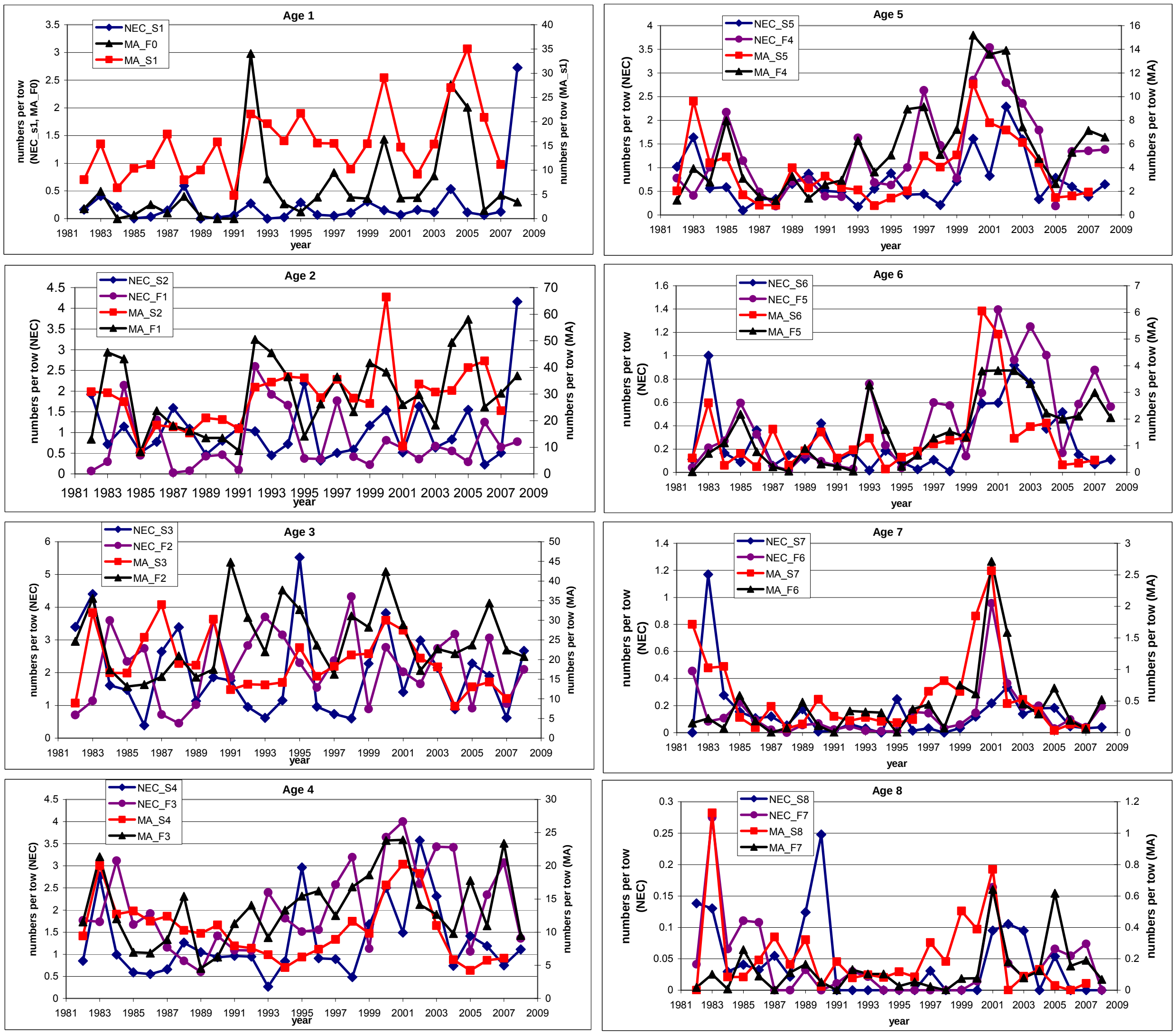
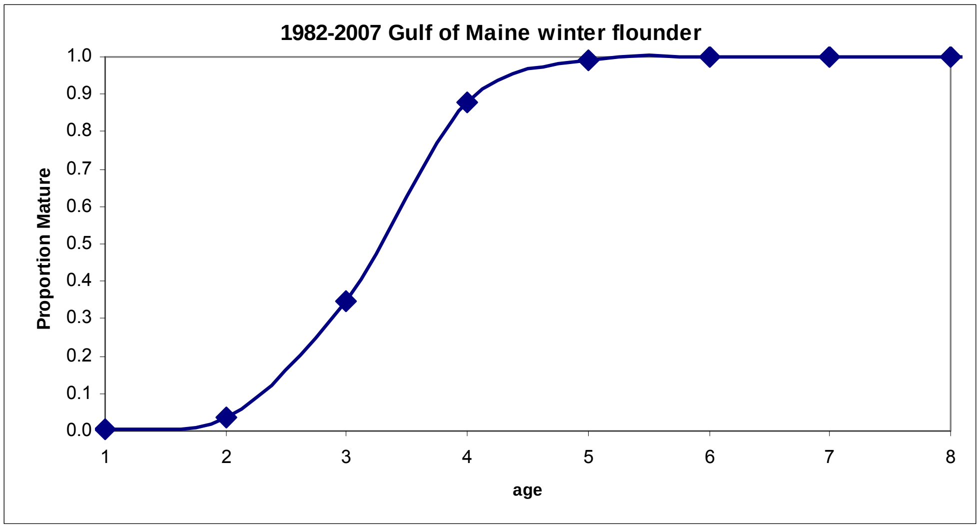


Figure I21. Indices at age from the Spring and Fall NEFSC and MDMF surveys.



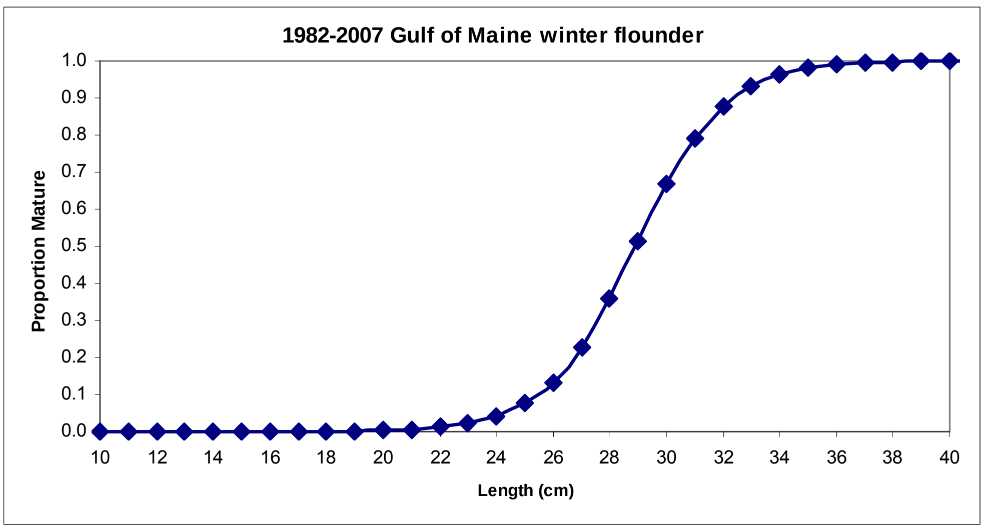


Figure I22. Female Gulf of Maine winter flounder logistic length and age maturity curves estimated with all years combine (1982-2007, n = 12,108) from the MDMF spring survey.

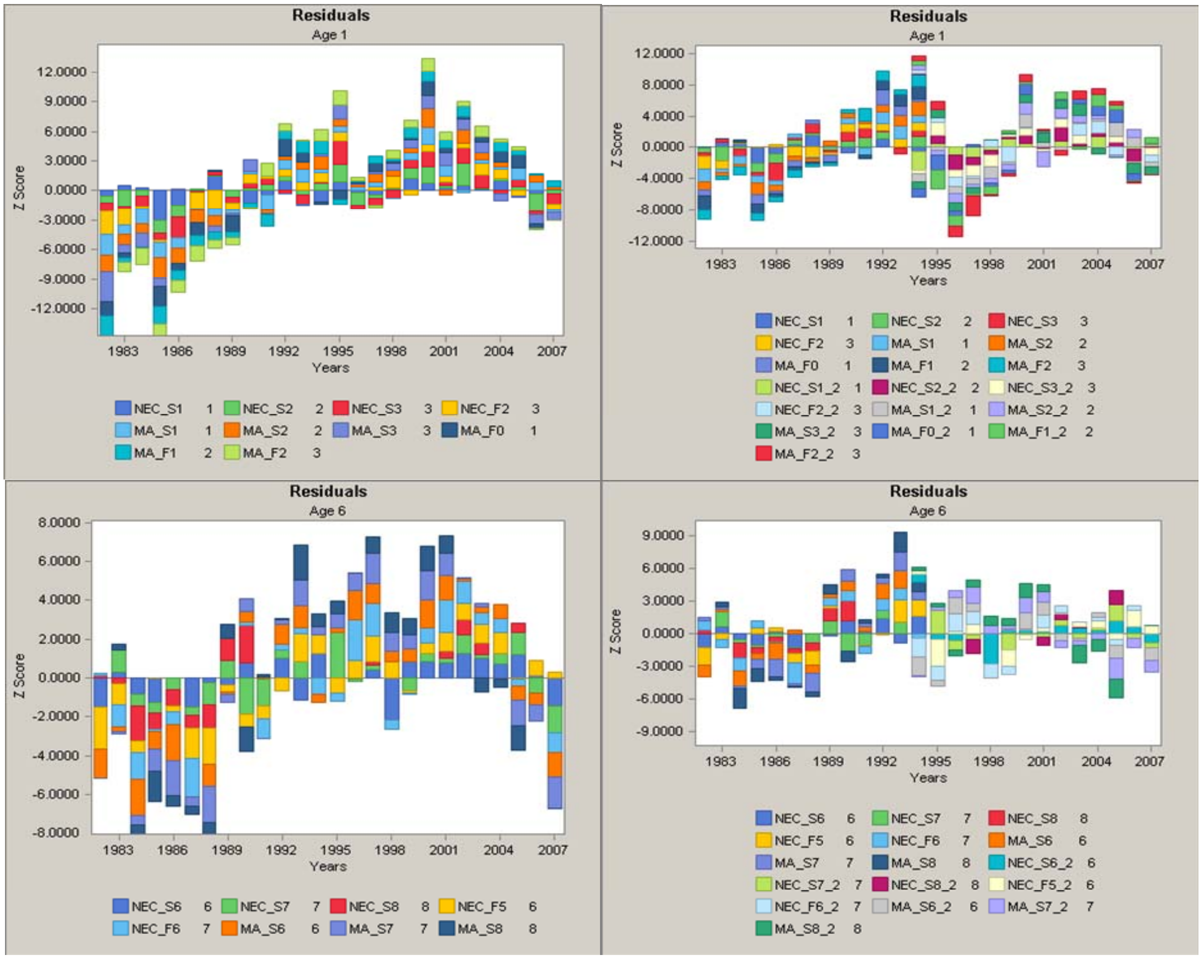


Figure I23. Base and split VPA residual pattern. Top plots are residuals for ages 1 through 3 for the base (left) and split VPA (right). Bottom plots are residuals patterns for ages 6 through 8 for the base (left) and split VPA (right).

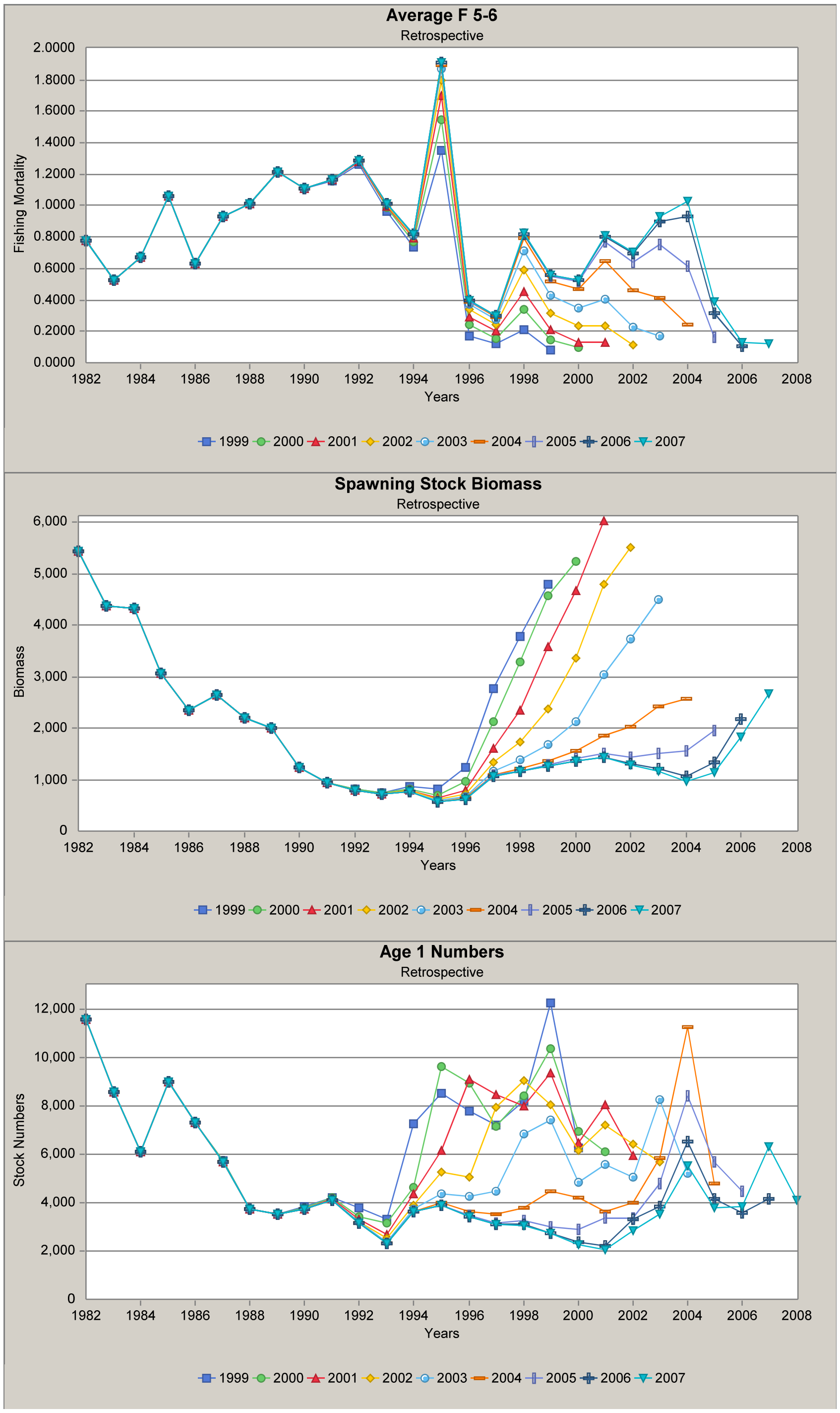


Figure I24. Gulf of Maine winter flounder Base VPA retrospective.

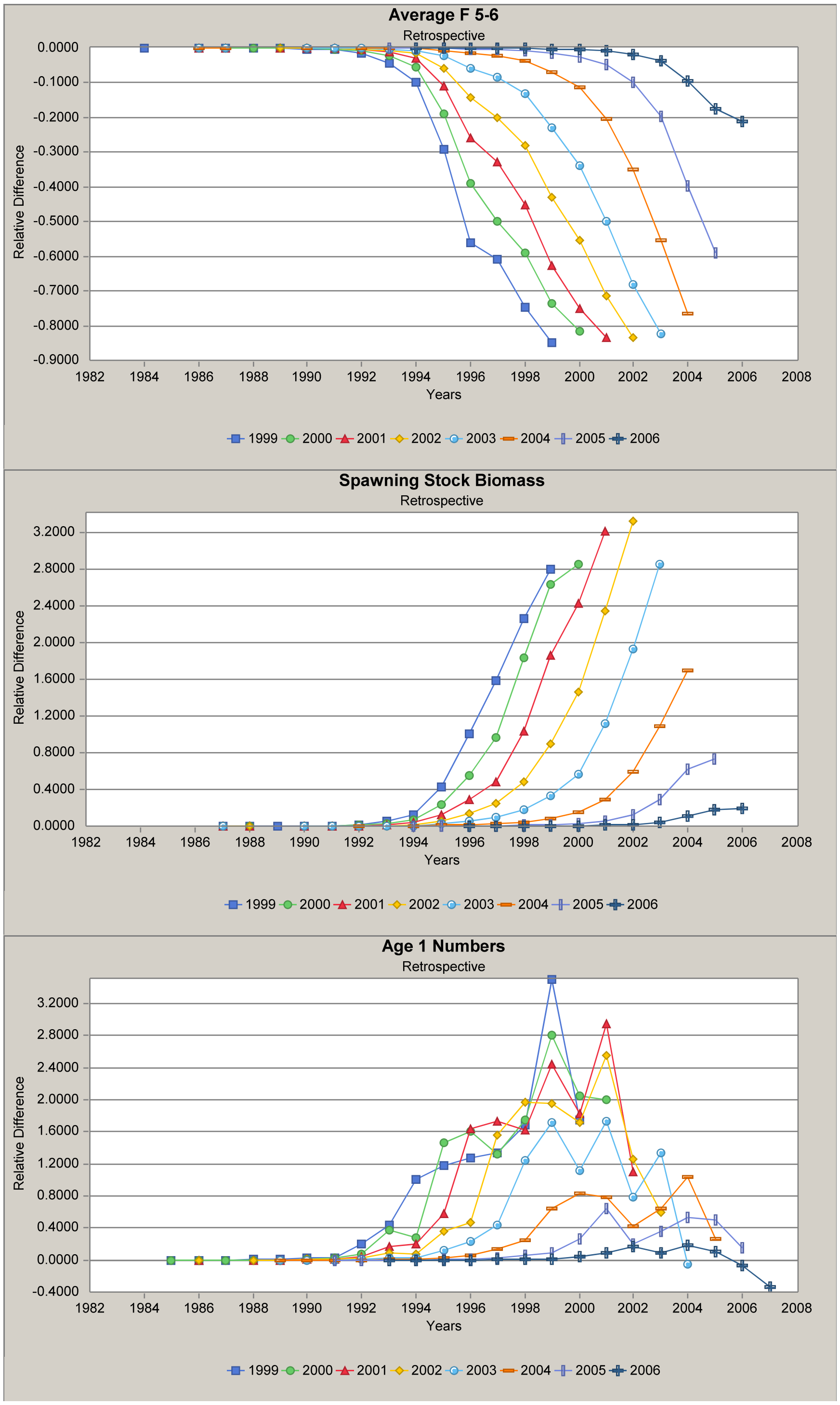


Figure I25. Gulf of Maine winter flounder Base VPA relative difference retrospective.

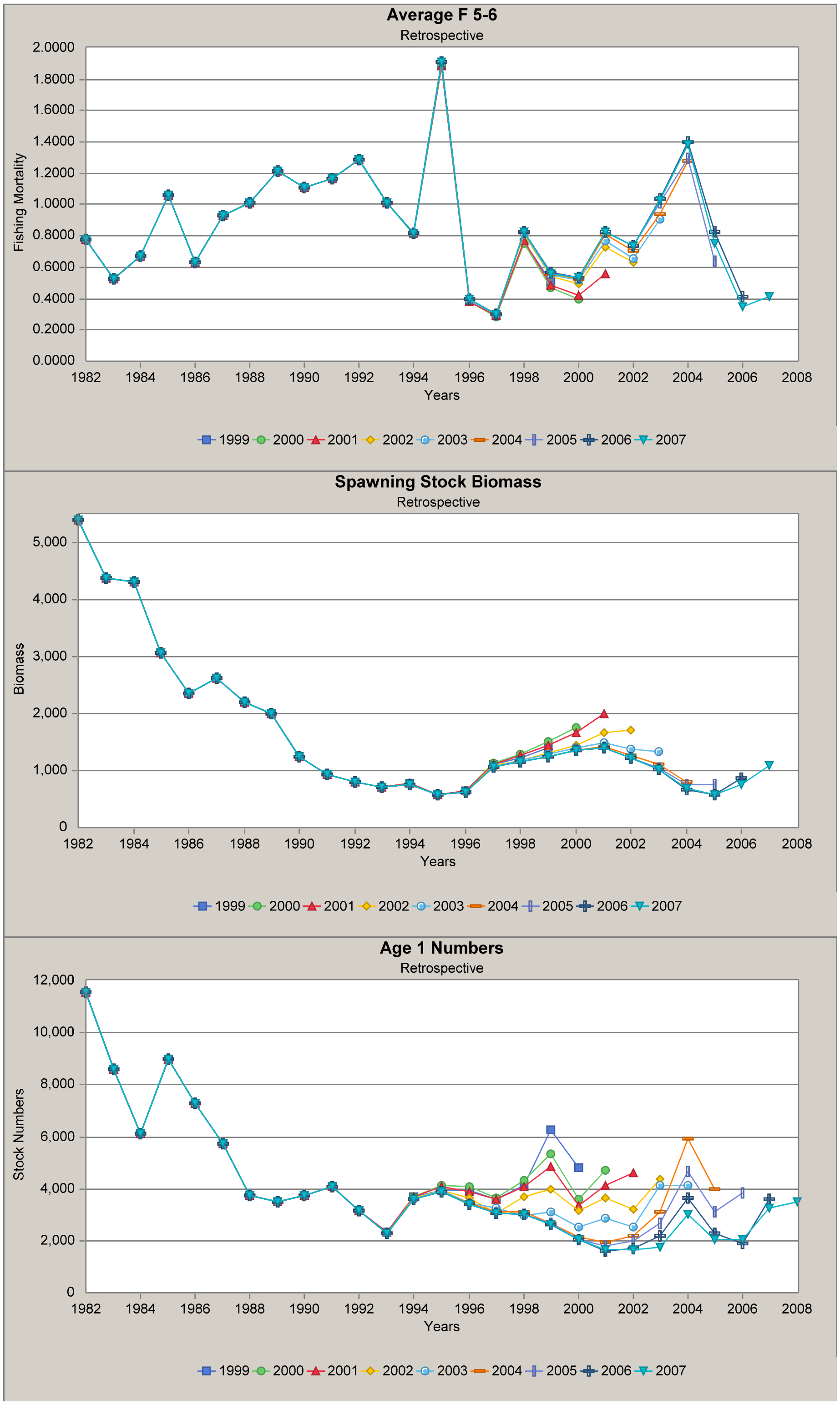


Figure I26. Gulf of Maine winter flounder split VPA retrospective.

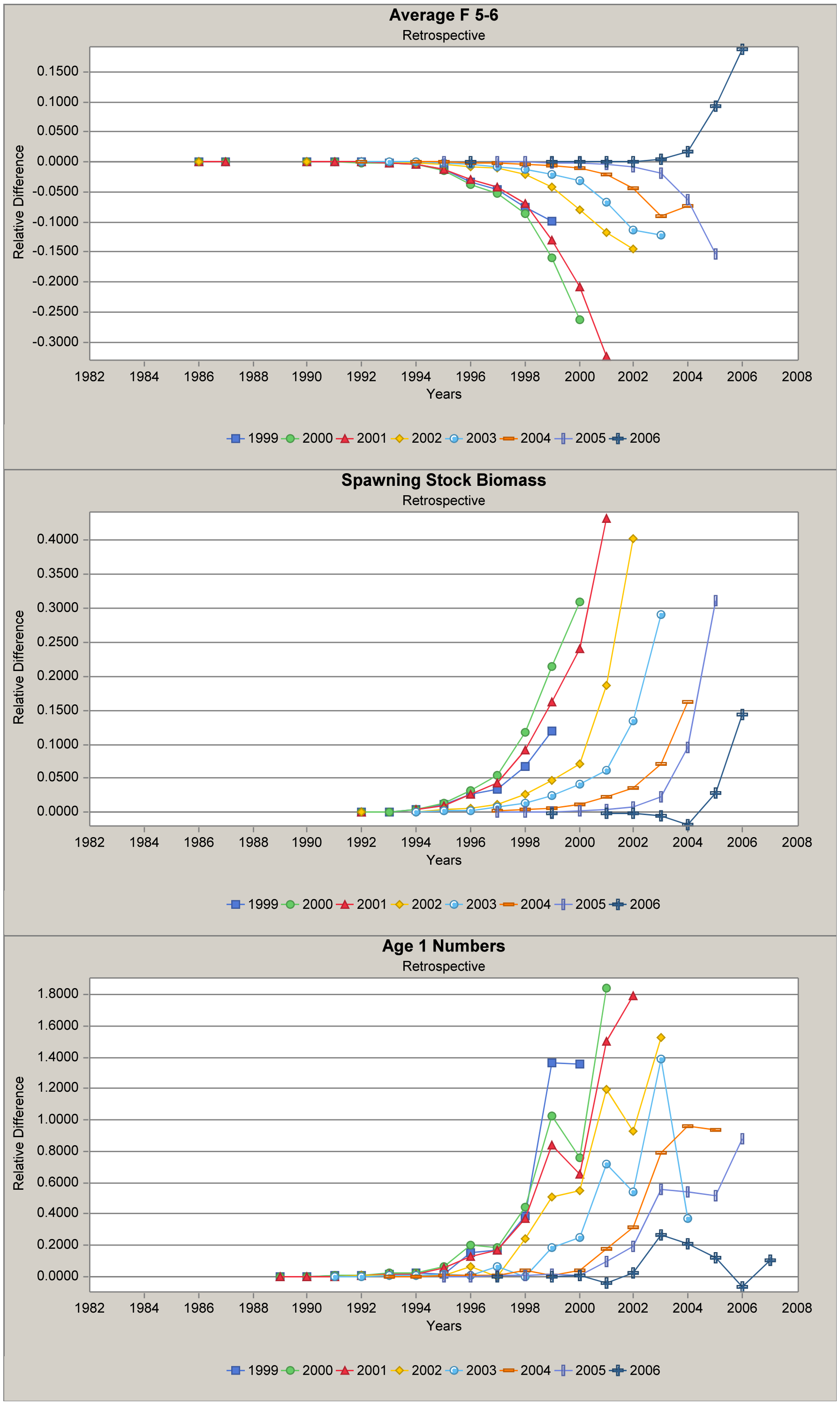


Figure I27. Gulf of Maine winter flounder split VPA relative difference retrospective.

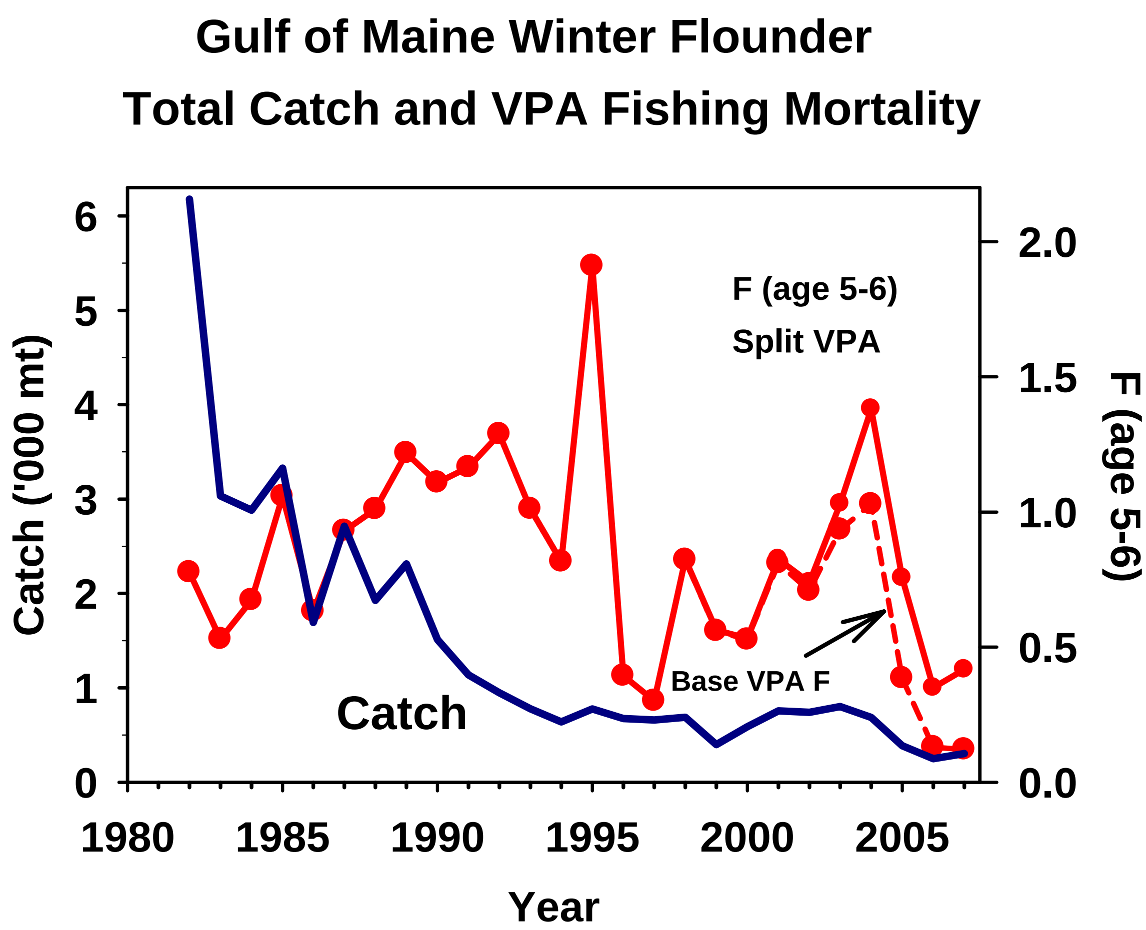


Figure I28. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (F, ages 5-6) from the split and base VPA for Gulf of Maine winter flounder.

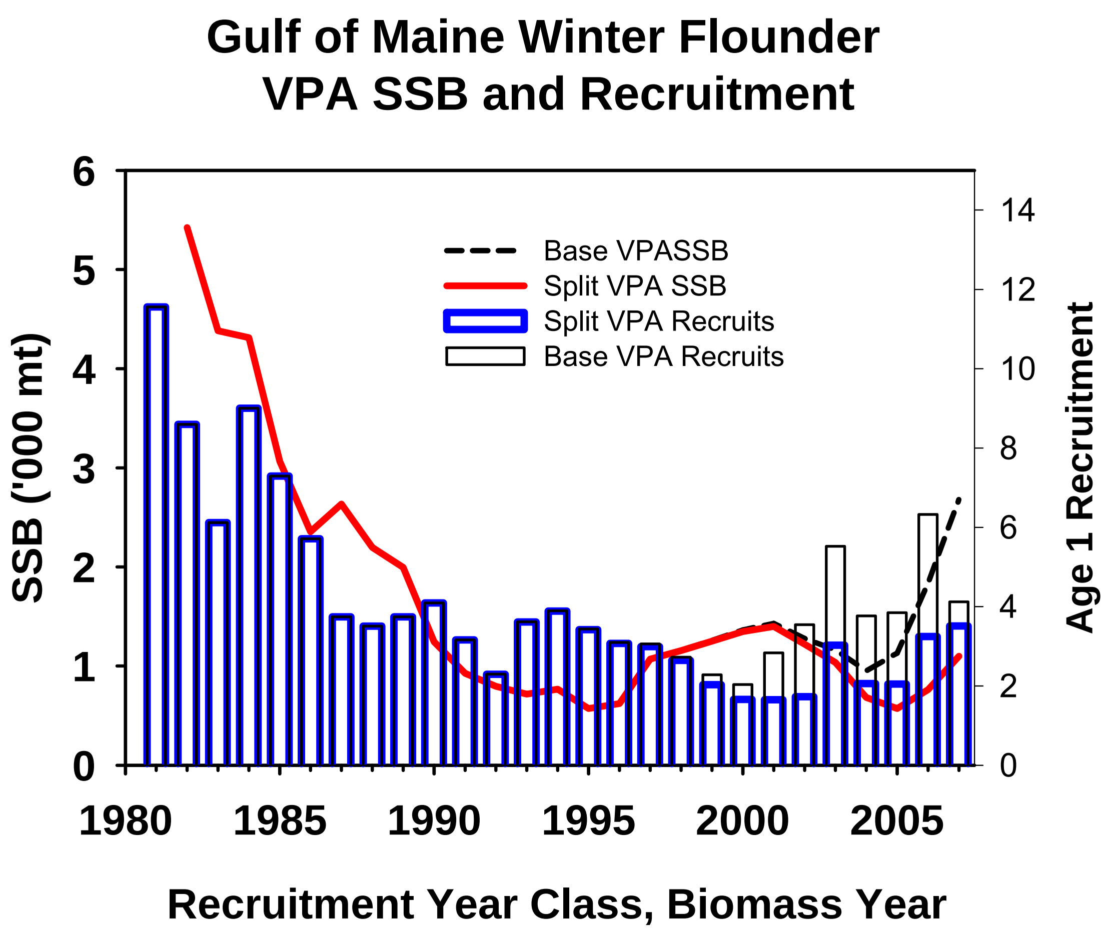
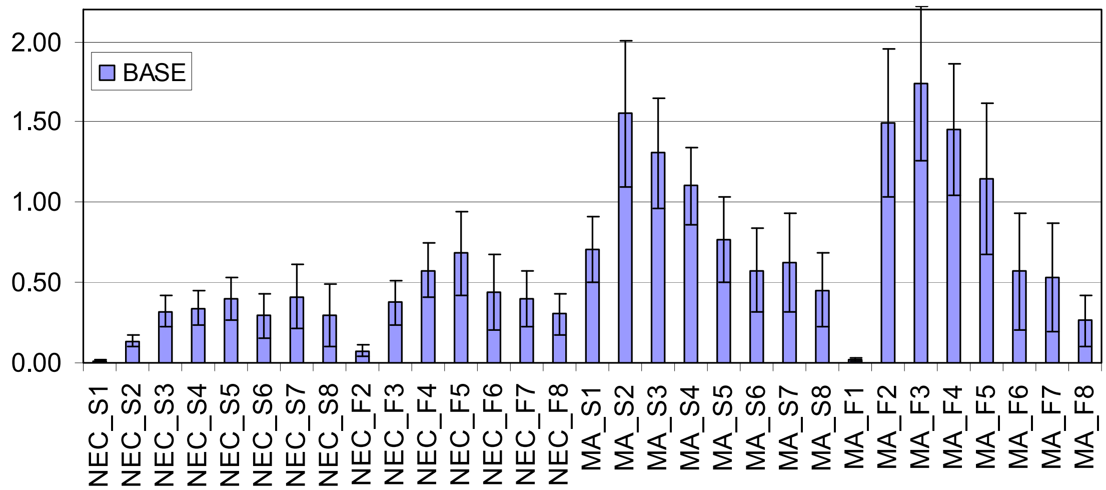


Figure I29. Estimated age 1 recruitment and spawning stock biomass from the split and base VPA runs for Gulf of Maine winter flounder.



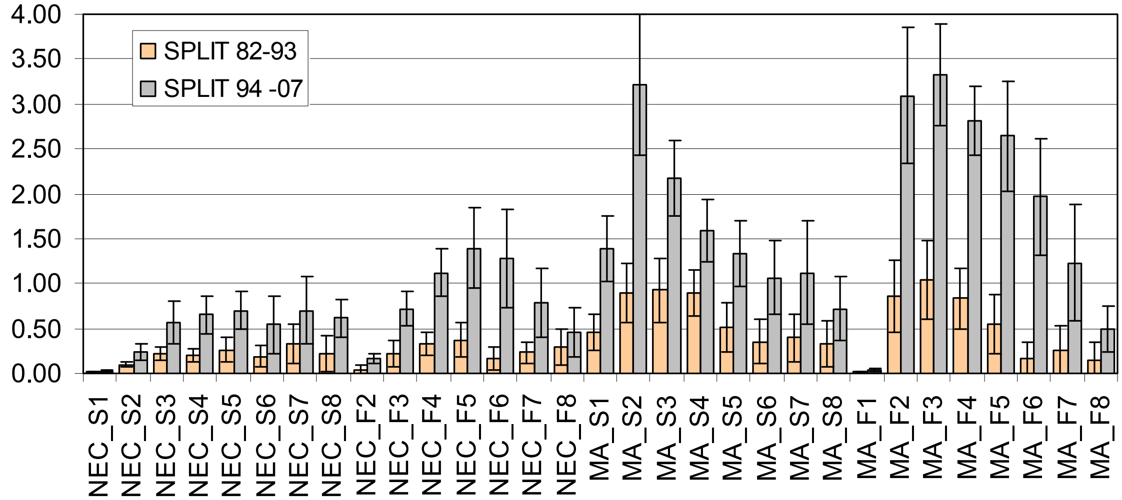


Figure I30. Gulf of Maine winter flounder Base and split VPA area swept Q estimates with standard deviations.

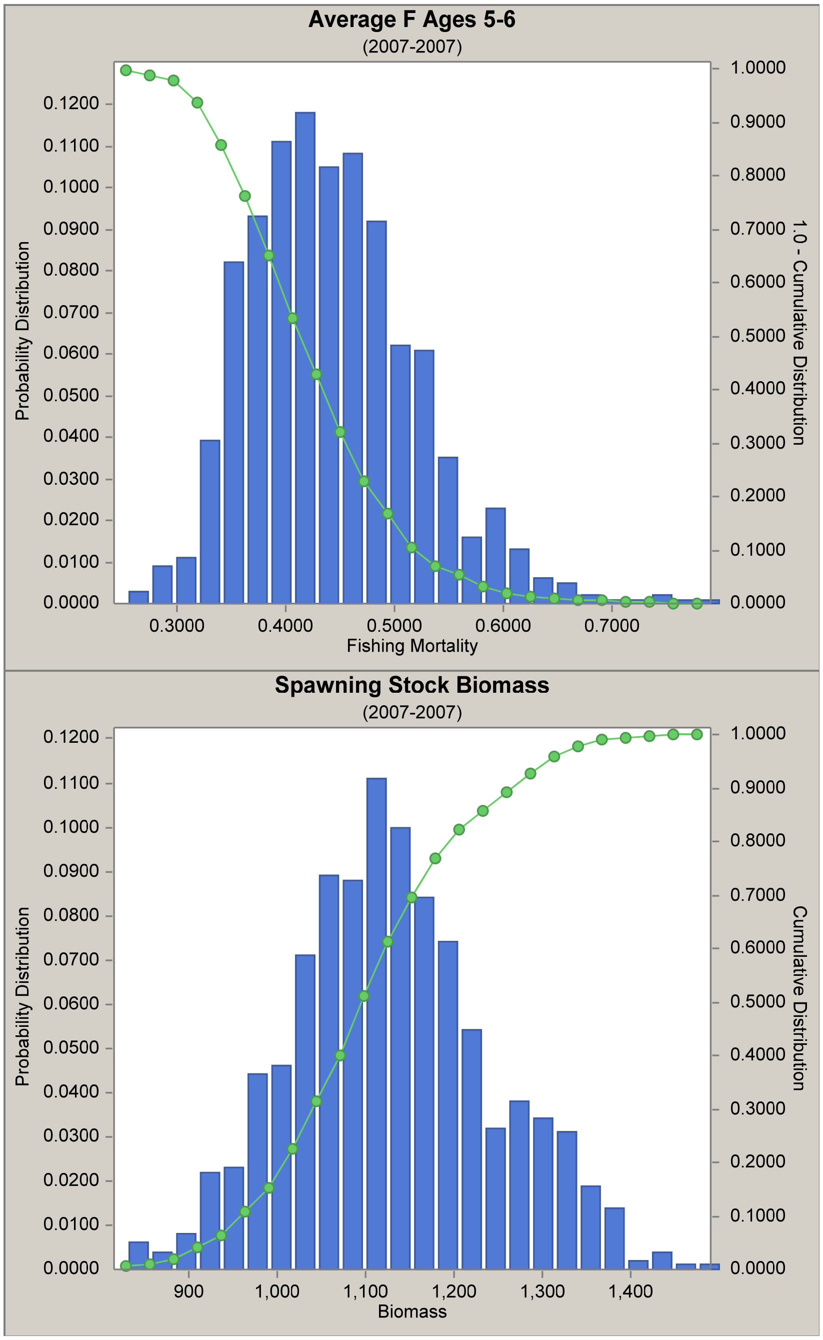


Figure I31. Precision estimates of spawning stock biomass and fishing mortality rate in 2007 for Gulf of Maine winter flounder from the split VPA (run 2b).

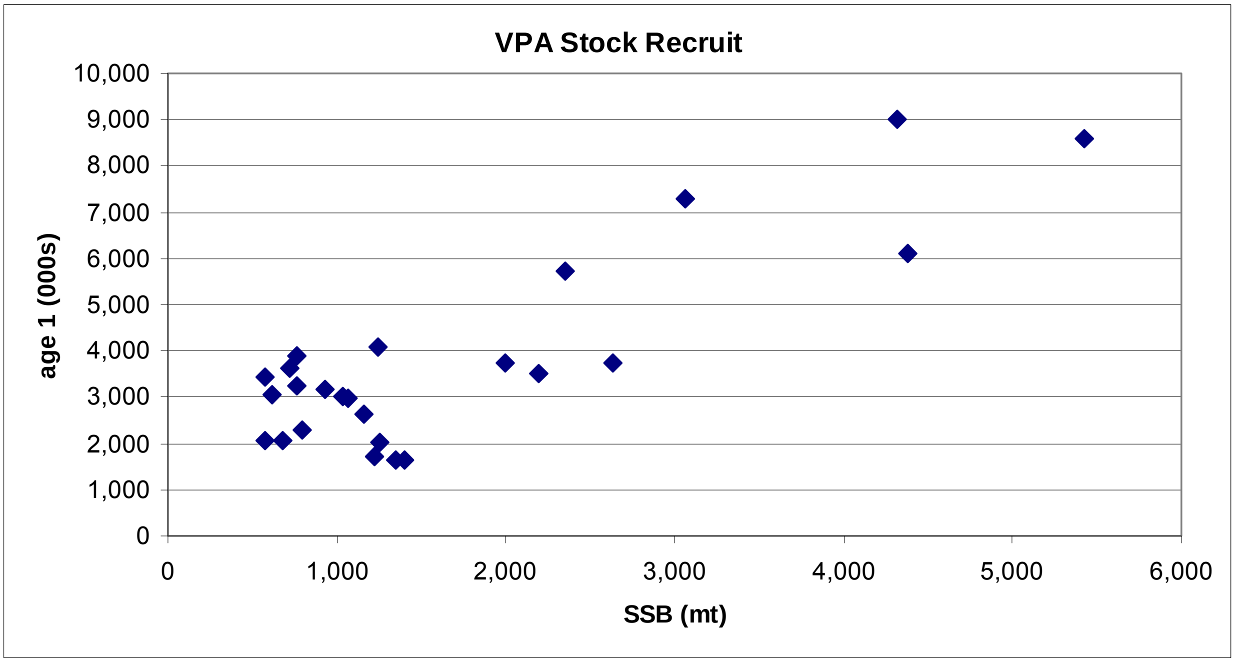


Figure I32. Stock recruit relationship for Gulf of Maine winter flounder from the split VPA (run 2b).

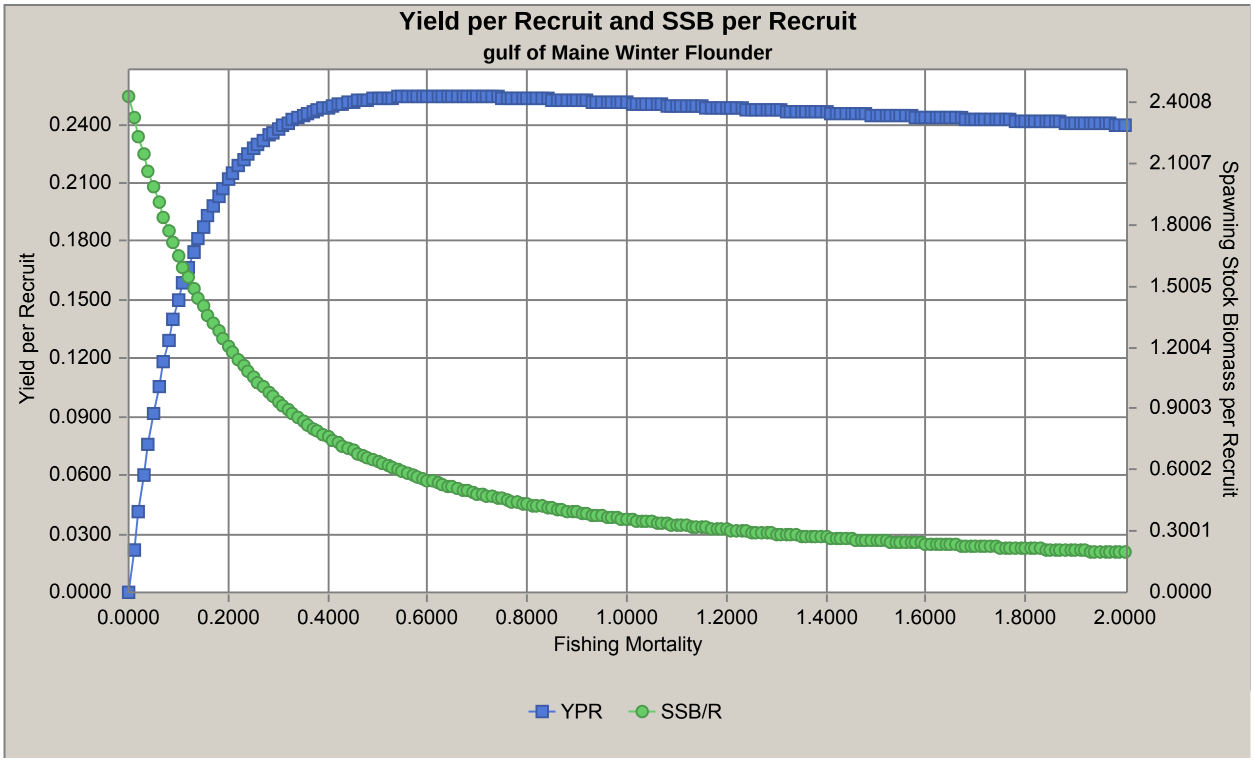


Figure I33. Age based yield per recruit and spawning stock biomass per recruit curves for Gulf of Maine winter flounder.

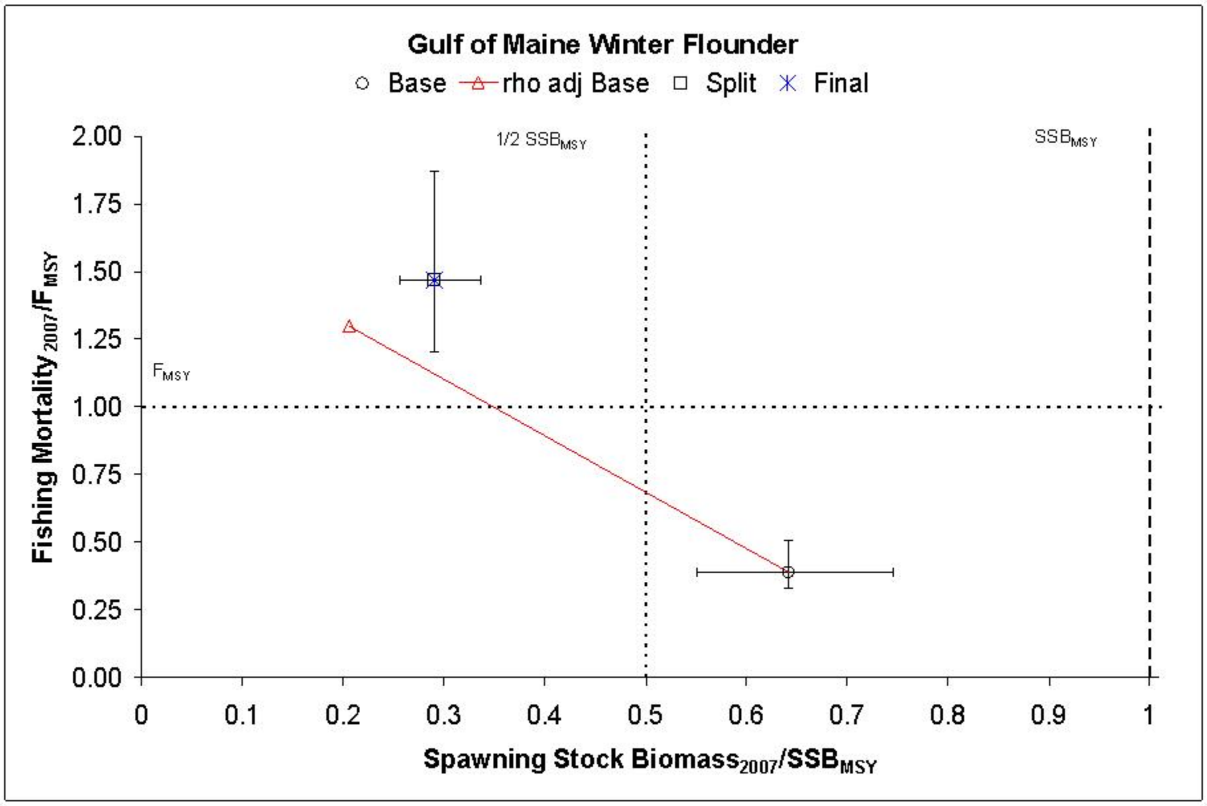


Figure I34. Gulf of Maine winter flounder 2007 status determination with 80% confidence intervals for the base VPA (circle), split VPA (rectangle), and Mohn's rho adjustment to the base VPA (triangle).

J. Southern New England/Mid-Atlantic winter flounder
by Mark Terceiro

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

1.0 Background

The current assessment of the Southern New England/Mid-Atlantic (SNE/MA) stock complex of winter flounder (Figure J1) is an update of the previous assessment completed in 2005 at GARM2 (NEFSC 2005). The GARM2 assessment included catch through 2004, research survey abundance indices through 2005, and catch at age analyzed by Virtual Population Analysis (VPA) for 1981-2004. Current biological reference points are based on stock-recruitment modeling conducted by the 2002 Working Group on Re-estimation of Biological Reference points for New England Groundfish (NEFSC 2002), which indicated that F_{MSY} = 0.32, SSB_{MSY} = 30,100 mt, and MSY = 10,600 mt. The GARM2 assessment concluded that the stock complex was overfished and that overfishing was occurring. Spawning stock biomass (SSB) in 2004 was estimated to be 3,938 mt, about 13% of SSB_{MSY} = 30,100 mt. The fully recruited fishing mortality rate in 2004 was estimated to be F = 0.38, about 19% above F_{MSY} = 0.32. The current assessment updates fishery catch estimates, research survey abundance indices, and analytical models through 2007/08.

2.0 Fishery

After reaching an historical peak of 11,977 metric tons (mt) in 1966, then declining through the 1970s, total U.S. commercial landings again peaked at 11,176 mt in 1981, and then steadily declined to 2,128 mt in 1994. Commercial landings then increased to 4,556 mt in 2001 before falling to a record low of 1,320 mt in 2005; commercial landings were 1,622 mt in 2007 (Table J1, Figure J2). The primary gear in the fishery is the otter trawl which accounts for an average of 98% of landings since 1989. Scallop dredges, handlines, pound nets, fyke nets, and gill nets account for the remaining 2% of total landings. Recreational landings reached a peak in 1984 of 5,510 mt but declined substantially thereafter (Table J2, Figure J2). Landings have been less than 1,000 mt since 1991, with record low estimated landings in 2007 of 116 mt. The principal mode of fishing is private/rental boats, with most recreational landings occurring during January to June.

Length samples of winter flounder are available from both the commercial and recreational landings. In the commercial fishery, annual sampling intensity varied from 15 to 251 mt landed per 100 lengths measured during 1981-2007 (Table J3). Port sampling has generally been adequate to develop the commercial fishery landings at age on a half-year, market category basis. In the recreational fishery, annual sampling intensity varied from 28 to 270 mt landed per 100 lengths measured during 1981-2007 (Table J4). Ages were determined using NEFSC survey spring and fall age-length keys.

Prior to 1994, NEFSC trawl survey length frequencies and commercial trawl fishery mesh selection data were used to estimate the magnitude and characterize the length frequency of the commercial fishery discard. For 1994-2007, NEFSC Fishery Observer trawl and scallop fishery discards to landings ratio estimates were applied to corresponding commercial fishery landings to estimate discards in weight (Table J5, Figure J2). The NEFSC Fishery Observer length frequency samples (Table J6) were used to characterize the proportion discarded at length for 1994-2007. Commercial fishery discard length samples were applied on a semi- annual basis and ages were determined using NEFSC survey spring and fall age-length keys. A discard mortality rate of 50% (Howell et al., 1992) was applied to commercial fishery live discards.

Recreational fishery discard losses peaked in 1984-1985 at 0.7 million fish. Discards have since declined and reached a low in 2007 of 11,000 fish (Table J7). Since 1997, irregular sampling of the recreational fisheries by state fisheries agencies has indicated that the discard is usually of fish below the minimum landing size of 12 inches (30 cm). For 2002-2007, discard length samples from the NYDEC sampling of the recreational party-boat fishery and from the CTDEP Volunteer Angling Survey (VAS) have been used to better characterize the recreational fishery discard. Ages were determined using NEFSC survey spring and fall age-length keys. A discard mortality rate of 15% was applied to recreational live discard estimates (B2 category from MRFSS data), as assumed in Howell et al. (1992).

Total fishery catches are summarized in Table J7.

3.0 Research vessel surveys

Mean weight per tow and number per tow indices for the NEFSC spring, fall, and winter time series are presented in Table J8. Indices declined from the beginning of the time series in the 1960s to a low point in the early to mid-1970s, then increased to a peak by the early 1980s. Following several years of high indices, abundance once again declined to below the low levels of the 1970s. NEFSC survey indices reached near- or record low levels for the time series in the late 1980s-1990s. Indices from the three survey series generally increased during 1993-1998/1999, but have since declined again (Figure J3).

Several state survey indices were available to characterize the abundance of SNE/MA winter flounder. The Massachusetts Division of Marine Fisheries (MADMF) spring and fall survey, Rhode Island Division of Fish and Wildlife (RIDFW) spring and fall survey, Connecticut Department of Environmental Protection (CTDEP) Long Island Sound Trawl Survey, and the New Jersey Division of Fish, Game and Wildlife (NJDFW) ocean survey trends are summarized in Tables J9-J10 and Figure J3. The numerous state recruitment surveys (MADMF, RIDFW, CTDEP, New York Department of Environmental Conservation (NYDEC), NJDFW, Delaware Division of Fish and Wildlife (DEDFW)) are summarized in Table J11 and Figure J3.

4.0 Assessment

Input data and model formulation

The 2008 GARM3 VPA was calibrated using the NOAA Fisheries Toolbox (NFT) ADAPT VPA version 2.8.0. Commercial and recreational fishery landings and discards estimates at age, the total fishery catch at age, and the total fishery mean weights at age used as input to the VPA are presented in Tables J12-J17. The following NEFSC and state agency trawl survey abundance indices at age were used in the ADAPT VPA calibration: NEFSC spring trawl ages 1-7+ (Figure J5), NEFSC fall trawl ages 1-5 (advanced to calibrate January 1 abundance of ages 2-6), NEFSC winter trawl ages 1-5, Massachusetts spring trawl ages 1-7+, Rhode Island fall seine age 0 (advanced to age-1), Rhode Island spring trawl ages 1-7+, Connecticut spring trawl ages 1-7+, New York trawl age 0 (advanced to age-1) and age-1, Massachusetts summer seine index of age-0 (advanced to age-1), Delaware juvenile trawl age-0 (advanced to age-1), New Jersey Ocean trawl ages 1-7+, and New Jersey River trawl ages 1-7+ (Tables J18-J26). Survey indices were selected for inclusion in VPA calibration based on consideration of the partial variance in an initial VPA trial run including all indices, the precision of the survey series, residual error patterns from the various trail runs, and on the significance of the correlation among indices and with VPA abundance estimates from the initial trial run including all potential calibration indices. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality and SSB. A retrospective analysis was performed for terminal year fishing mortality (F), SSB and age-1 recruitment.

Model selection process

The GARM3 Assessment Methodology Review Panel (March 2008) reviewed the 2005 GARM2 VPA with catch through 2004 and a version of the assessment implemented in ASAP v2.0.9. The two models provided similar results, and both exhibited a strong retrospective pattern through the late 1990s and into 2001. The Panel concluded that the data appeared sufficient for an age-structured model and that negligible error in the catch-at-age could be assumed. The Panel noted that the strong retrospective pattern appeared to be transitory as it was not as evident in terminal years 2002 and 2003. The Panel advised that model results should be checked for the retrospective pattern when the 2005-2006 catch data were added and that if pattern reappeared, then "consideration should be given to splitting the survey time series pre and post 1994." Splitting the survey series used in calibration acts as a proxy for fishery and biological factors that could have changed in the mid-1990s, resulting in the observed retrospective pattern.

The same set of survey calibration indices as used in the SAW 36 assessment (NEFSC 2003) and the 2005 GARM2 assessment (NEFSC 2005) was retained in the 2008 GARM3 VPA BASE case. The BASE case continued to exhibit a strong retrospective pattern, although it was less severe in recent years than in the 2005 GARM2 assessment. Given the persistence of the retrospective pattern in the BASE configuration, all survey series were split "pre and post 1994" (i.e., split between 1993 and 1994, given the change in commercial discard estimation and commercial landings reporting methods between these years) as per the GARM3 Modeling Panel recommendation, except for the NEFSC Winter, NJDFW Ocean, and NJDFW River survey series, which began in 1992, 1993, and 1995, respectively. Under this SPLIT run configuration, the retrospective pattern was somewhat reduced. No significant problems in residual patterns developed as a result of splitting the survey series, and the pattern for the NEFSC Fall survey appeared to be somewhat improved (less of a trend/blocking from negative residuals in the 1980s to positive residuals in the 1990s-2000s, likely corresponding to the change in retrospective patterns; compare Appendix Figures 2 and 11; NEFSC 2008). There was not much change in the pattern of the CTDEP Spring residuals, which continue to show a trend/ blocking in both the BASE and SPLIT run configurations (compare Appendix Figures 6 and 15; NEFSC 2008). The precision of the SPLIT run terminal year estimates was comparable to the BASE run estimates.

The BASE and SPLIT runs were again considered by the GARM3 Biological Reference Point Review Panel (June 2008) and the GARM3 Final Review Panel (August 2008), and those reviews recommended the SPLIT configuration as the preferred run configuration. Subsequent to the GARM3 Biological Reference Point Meeting, the assessment was updated with 2007 fishery catch data and NEFSC 2008 spring survey indices. The BASE run retrospective analyses continue to show a substantial pattern in both F and SSB during 1996-2001 terminal years, with a reduced pattern thereafter (Figures J6-J7). Under the SPLIT run configuration, the retrospective patterns are reduced, with a shift from underestimation of F during 1996-199 terminal years, and lack of a long-term pattern thereafter (Figures J8-J10). The Mohn's rho statistic calculated for the BASE and SPLIT runs ([retrospective year – terminal year]/terminal year), either summed or averaged over the last seven retrospective years (peels), is comparable in absolute magnitude but opposite in sign for F. The absolute value of the Mohn's rho for SSB is about 85% smaller for the SPLIT run; the value for recruitment at age 1 is about 30% smaller (Table J27).

Catchability coefficients (qs) from the BASE and SPLIT runs are compared in Table J28. As noted above, times series were sufficiently long to be split at 1993/1994 for the NEFSC Spring, NEFSC Fall, MADMF Spring, RIDFW Spring, and CTDEP Spring full age-matrix series. The NEFSC Winter and NJDFW Ocean and River survey series were not split. The qs for the split series generally decreased before 1994, with average decreases (when compared to the BASE run qs) ranging from about 50% for the NEFSC Fall survey to 5% for the CTDEP Spring survey. The qs for the split series generally increased after 1993, with average increases ranging from about 213% for the NEFSC Fall survey to 17% for the CTDEP Spring survey. For the unsplit series in the SPLIT run, qs generally increased by 1% to 7% compared to the BASE values.

For the NEFSC Spring, NEFSC Fall, NEFSC Winter and MADMF Spring survey series, estimates of survey trawl effective swept area were available to allow calculation of swept area absolute abundance indices (assuming 100% trawl efficiency). These swept area indices were then used as calibration indices in the BASE and SPLIT run configurations to investigate the implication of the changes in survey catchability (q) of these four survey series in the SPLIT runs (i.e., are the resulting swept area qs feasible given the biological and behavioral characteristics of the stock). In the BASE case (1981-2007), the swept area qs are always 0.60 or less; in the SPLIT case (1981-1993, 1994-2007), the magnitude and pattern of increases is as indicated in Table J28, and the largest q is for the NEFSC Fall age 4 index, at about 0.9 (Figure J11). These results indicate that the SPLIT run configuration provides a realistic model of the population dynamics of SNE/MA winter flounder. However, the causes for the increases in qs in the SPLIT configuration are unclear, and may alias multiple changes in the relationship between the research survey catch data, fishery catch data, and biological characteristics (e.g., M or growth) of the stock.

Based on the GARM3 Panel recommendations and subsequent work, the ADAPT VPA SPLIT run was carried forward as the basis for final estimates, biological reference point calculations, and status determination. Detailed results discussed below refer to the SPLIT run.

Assessment Results

The 2008 GARM3 SPLIT run adopted as the FINAL model indicated that during 1981-1993, fishing mortality (fully recruited F, ages 4-5) varied between 0.4 (1982) and 1.4 (1988) and then declined to 0.7 by 1999. Fishing mortality has been in the range of 0.6-0.7 during 2004-2007 (Figure J12). SSB declined from 14,714 mt in 1983 to a record low of 2,098 mt in 2005, before increasing to 3,368 mt in 2007 (Table J29, Figure J12). Recruitment at age 1 declined nearly continuously from 62.5 million age-1 fish in 1981 to 4.4 million in 2003. The 2006 year class of 3.6 million (age 1 in 2007) is estimated to be the smallest on record; the 2007 year class (age 1 in 2008) is estimated to be 8.8 million fish (Table J29, Figure J13).

The precision of the 2008 stock size at age, F at age in 2007, and SSB in 2007 from the GARM3 SPLIT run was evaluated using bootstrap techniques (Efron 1982). One thousand bootstrap iterations were realized in which errors (differences between predicted and observed survey values) were resampled. Bootstrap estimates of stock size at age indicate low bias (<10%) for ages 2-6; bias was estimated to be greater than 15% for ages 1 and 7+. Bootstrap standard errors provide stock size CVs ranging from 17% at age 3 to 121% at age 7+. Bootstrapped estimates of SSB indicate a CV of 11%, with relatively low bias (bootstrap mean estimate of SSB of 3,390 mt compared with NLLS estimate of 3,368 mt). There is an 80% probability that SSB in 2007 was between 2,936 mt and 3,825 mt (Table J29, Figure J14). The bootstrap estimates of standard error associated with fishing mortality rates at age indicate moderate precision. Coefficients of variation for F estimates ranged from 17% at age 3 to 30% at age 1. There is an 80% probability that fully recruited F for ages 4-5 in 2007 was between 0.522 and 0.861 (Table J29, Figure J15).

5.0 Biological reference points

The Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) estimated the biological reference points for SNE/MA winter flounder using yield and SSB per recruit analyses (Thompson and Bell 1934) and Beverton-Holt stock-recruitment models (Beverton and Holt 1957, Brodziak et al. 2001, Mace and Doonan 1988) based on the SARC 28 assessment (NEFSC 1999). A Beverton-Holt function fit with a prior on unfished recruitment (R_0) equal to the average of the five largest year classes (1981-1985) in the VPA time series was selected as the best stock-recruitment model. The yield per recruit (YPR) and SSB per recruit (SSBR) analyses indicated that $F_{40\%}$ = 0.21 and $F_{0.1}$ = 0.25. The stock-recruitment model indicated that MSY = 10,600 mt, F_{MSY} = 0.32, and B_{MSY} = 30,100 mt.

Both the parametric Beverton-Holt stock-recruitment model and the non-parametric empirical approach (YPR and SSBR model combined with VPA recruitment estimates and long-term projections) were considered in the current assessment to estimate biological reference points for SNE/MA winter flounder, based on the GARM3 BASE and SPLIT VPA results. Stock-recruitment data were modeled for the 1981-2007 year classes (1981-2007 SSB; 1982-2008 recruitment at age 1). In the non-parametric empirical approach, a long-term (100 year) stochastic projection using the cumulative distribution function of the year classes produced when SSB exceeded 5,700 mt was used to estimate MSY and SSB_{MSY}.

Fishery catch and NEFSC Spring survey mean weights at age do not exhibit any significant long-term trends (Figures J16-J17). The time series pattern in female maturity at age is stable (Figure J18). Table J30 presents the input values for the YPR, SSBR, and stock-recruitment analyses using average values for 2003-2007 from the GARM3 SPLIT run. As in the NEFSC (2002) analyses, maturity at age 2 was rounded to 0.00 due to the low and likely imprecise estimate of the maturity of those fish.

The GARM3 Biological Reference Point Review Panel concluded that the prior on unfished recruitment used to fit the parametric Beverton-Holt stock-recruitment model was inappropriate. The Beverton-Holt stock-recruitment model fit without the prior did not provide feasible results. The Panel recommended the non-parametric empirical approach (YPR and SSBR model combined with VPA recruitment estimates and long-term projections) be used to estimate biological reference points for SNE/MA winter flounder based on a) the GARM3

SPLIT VPA results, b) the estimate of F40% as a proxy for F_{MSY}, and c) a long-term (100 year) stochastic projection using the cumulative distribution function of the year classes produced when SSB exceeded 5,700 mt (1981-1988 year classes; mean R = 35.239 million fish at age 1; Figure J19) of the SPLIT VPA series to estimate MSY and SSB_{MSY}. Table J31 summarizes the BRPs for SNE/MA winter flounder.

6.0 Projections

Projections of future stock status to the rebuilding deadline of 2014 were conducted with a stochastic model for recruitment based on the GARM3 SPLIT VPA results and corresponding non-parametric BRPs (Tables J29 & J31). Mean weights and partial recruitment patterns estimated for the most recent 5 years in the assessment (2003-2007) were used in projections to reflect current conditions in the stock and fishery (Table J30). Female maturity at age was based on the MADMF Spring survey 1982-2007 time series (Table J30). Projections assumed total catch in 2008 = total catch in 2007 = 1,857 mt, resulting in a forecast F in 2008 = 0.481. For projections to the rebuilding deadline of 2014, the GARM Final Review Panel (August 2008) recommended a two-stanza recruitment model (Model 15 in the AGEPRO projection software) for SSB levels above and below 5,700 mt of SSB. Recruitment below 5,700 mt averages 11 million age-1 fish; recruitment above 5,700 mt averages 35 million age-1 fish.

Projections at F in 2009-2014 = F40% = 0.248 indicate a <1% chance that the stock will rebuild to SSB_{MSY} = 38,761 mt by 2014 (Table J32; Figure J20). Projections further indicate that fishing at F = 0.000 during 2009-2014 will provide only a 1% chance to rebuild the stock to SSB_{MSY} = 38,761 by 2014 (Table J32; Figure J20).

7.0 Summary

The Southern New England/Mid-Atlantic (SNE/MA) winter flounder stock complex is overfished and overfishing is occurring (Figure J21; SPLIT run used as FINAL model). Fishing mortality (F) in 2007 was estimated to be 0.649, over twice the F_{MSY} proxy = F40% = 0.248 (Table J32). There is an 80% chance that the F in 2007 was between 0.522 and 0.861. SSB in 2007 was estimated to be 3,368 mt, about 9% of SSB_{MSY} = 38,761 mt (Table J32). There is an 80% probability that SSB in 2007 was between 2,936 mt and 3,825 mt. The 2006 year class of 3.6 million (age 1 in 2007) is estimated to be the smallest on record; the 2007 year class (age 1 in 2008) is estimated to be 8.8 million fish.

The 2008 GARM3 BASE run estimates of 2007 F = 0.438 and 2007 SSB = 4,565 mt (and associated 80% confidence intervals) are provided in Figure J21 to illustrate the change in these quantities due to the adjustment provided by the SPLIT run configuration that was adopted as the FINAL model for status determination. The BASE run results also indicate that the SNE/MA winter flounder stock complex is overfished and overfishing is occurring. An adjustment to the BASE model results using the average Mohn's rho retrospective change in F and SSB shifts the BASE results toward the FINAL model results.

8.0 Panel Discussion/Comments

Conclusions

The Base VPA for this stock exhibited such a large retrospective pattern that the Panel concluded it required an adjustment. The VPA with the survey time series split in 1993/1994 appeared to reduce the retrospective pattern and was consistent with the GARM III 'models' review. This adjustment was undertaken consistent with the GARM III 'models' review. Though the underlying causes for the retrospective pattern remain unknown, the Panel accepted the VPA with the survey time series split as Final and the best available estimate of stock status and a sufficient basis for management advice.

The Panel expressed concern about the uncertainties with the Final run. In particular, the declining rate of sampling of the recreational fishery and the persistent retrospective pattern that was not completely resolved by using the split in the survey time series.

The Panel noted that current biomass is extremely low and could remain so until recruitment improves. For this reason, it recommended that the stock and rebuilding plan projections be undertaken consistent with the GARM III 'BRP' review but including sampling from the VPA time series of recruitment guided by the 5,700 mt SSB breakpoint used in BRP determination.

Research Recommendations

The Panel had no specific research recommendations for this stock.

9.0 References

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10.0 Tables and Figures

Table J1. Winter flounder commercial landings (metric tons) for Southern New England/Mid-Atlantic stock complex area (U.S. statistical reporting areas 521, 526, divisions 53, 61-63) as reported by NEFSC weighout, dealer, state bulletin and general canvas data.

Year	Metric tons
1964	7,474
1965	8,678
1966	11,977
1967	9,478
1968	7,070
1969	8,107
1970	8,603
1971	7,367
1972	5,190
1973	5,573
1974	4,259
1975	3,982
1976	3,265
1977	4,413
1978	6,327
1979	6,543
1980	10,627
1981	11,176
1982	9,438
1983	8,659
1984	8,882
1985	7,052
1986	4,929
1987	5,172
1988	4,312
1989	3,670
1990	4,232
1991	4,823
1992	3,816
1993	3,010
1994	2,128
1995	2,593
1996	2,783
1997	3,548
1998	3,137
1999	3,349

Table J1 continued.

Year	Metric tons
2000	3,704
2001	4,556
2002	3,084
2003	2,308
2004	1,636
2005	1,320
2006	1,720
2007	1,622

Table J2. Estimated number (000's) and weight (mt) of winter flounder caught, landed, and discarded in the recreational fishery, Southern New England/Mid-Atlantic stock complex.

Year	Catch A+B1+B2 (N; >000)	Landed A+B1 (N; >000)	Landed A+B1 (mt)	Released B2 (N; >000)	15% Release Mortality (N; >000)	15% Release Mortality (mt)
1981	11259	8253	3154	3007	451	91
1982	10379	8216	3493	2163	324	63
1983	10994	8295	3485	2699	405	127
1984	17410	12441	5510	4968	745	148
1985	17871	13086	5075	4785	718	230
1986	9338	7001	2949	2337	351	66
1987	9200	6857	3169	2342	351	61
1988	10166	7354	3510	2811	422	69
1989	6097	3799	1792	2297	345	49
1990	3845	2487	1063	1359	204	31
1991	4347	2808	1184	1539	231	51
1992	1358	809	387	550	83	15
1993	3184	1879	813	1305	155	31
1994	2067	1203	594	864	80	29
1995	2140	1348	650	792	119	32
1996	2655	1607	714	1049	157	30
1997	1921	1220	627	701	105	31
1998	1008	584	290	425	64	13
1999	1071	658	320	412	62	14
2000	2128	1401	870	727	109	32
2001	1421	892	549	528	79	14
2002	707	408	223	299	45	12
2003	761	572	323	189	28	11
2004	442	344	214	98	15	8
2005	484	215	124	269	40	14
2006	591	273	136	318	48	16
2007	289	215	116	74	11	5

Table J3. The total number of commercial lengths sampled by market category for Southern New England/Mid-Atlantic winter flounder. The landings (metric tons) and metric tons per 100 lengths are also shown.

			Market Category				
Year	Unclass	Large	Medium	Small	Total	Landings (mt)	Metric tons per 100 lengths
1981	1,904	918	0	1,638	4,460	11,176	251
1982	784	2,932	978	3,348	8,042	9,438	117
1983	927	2,044	1,044	1,921	5,936	8,659	146
1984	551	1,338	637	1,439	3,965	8,882	224
1985	716	1,396	1,663	2,632	6,407	7,052	110
1986	799	1,091	1,024	2,206	5,120	4,929	96
1987	99	1,978	670	2,524	5,271	5,172	98
1988	269	1,250	958	1,731	4,208	4,312	102
1989	106	975	1,220	1,224	3,525	3,670	104
1990	102	1,333	1,180	1,473	4,088	4,232	104
1991	0	917	921	1,220	3,058	4,823	158
1992	402	1,159	1,259	1,343	4,163	3,816	92
1993	62	642	401	1,249	2,354	3,010	128
1994	327	600	644	912	2,483	2,128	86
1995	589	758	225	1,295	2,867	2,593	90
1996	580	764	324	1,027	2,695	2,783	103
1997	201	1,140	1,097	1,614	4,052	3,548	88
1998	942	415	1,325	734	3,416	3,138	92
1999	2,381	700	607	682	4,370	3,349	77
2000	1,553	1,075	942	2,580	6,150	3,704	60
2001	658	2,384	2,222	1,129	6,393	4,556	71
2002	716	1,608	1,099	1,983	5,406	3,084	57
2003	1,037	1,626	692	1,115	4,470	2,308	52
2004	373	1,974	652	1,822	4,821	1,636	34
2005	239	2,283	721	627	4,294	1,320	31
2006	1,614	2,661	1,805	1,408	7,488	1,720	23
2007	3,061	4,319	1,661	1,463	10,504	1,622	15

Table J4. The total number of lengths sampled from the recreational fishery for Southern New England/Mid-Atlantic winter flounder. The landings (metric tons) and metric tons per 100 lengths are also shown.

Year	Landings	Lengths	Metric tons per 100 lengths
1981	3,154	1,725	183
1982	3,493	1,971	177
1983	3,485	2,587	135
1984	5,510	3,123	176
1985	5,075	2,357	215
1986	2,949	2,237	132
1987	3,169	1,360	233
1988	3,510	1,944	181
1989	1,792	2,810	64
1990	1,063	2,548	42
1991	1,184	1,755	67
1992	387	1,083	36
1993	813	1,288	63
1994	594	948	63
1995	650	767	85
1996	714	936	76
1997	627	752	83
1998	290	1030	28
1999	320	643	50
2000	870	360	242
2001	549	922	60
2002	223	657	34
2003	323	355	91
2004	214	449	48
2005	124	134	93
2006	136	101	135
2007	116	43	270

Table J5. NEFSC Fishery Observer Program observed trips in the trawl and scallop dredge fisheries (in SNE/MA winter flounder stock areas) and precision (%) of live discard estimates (metric tons) .

Year	Fishery	N Trips	Discards (Live mt)	CV (%)
1994	Trawl	111	650	35
	Scallop	56	31	31
1995	Trawl	248	261	33
	Scallop	65	57	16
1996	Trawl	216	138	50
	Scallop	86	211	15
1997	Trawl	159	105	32
	Scallop	63	449	16
1998	Trawl	98	230	41
	Scallop	45	115	15
1999	Trawl	123	38	43
	Scallop	26	86	20
2000	Trawl	186	137	31
	Scallop	140	159	27
2001	Trawl	244	39	35
	Scallop	161	17	16
2002	Trawl	248	108	23
	Scallop	187	78	51
2003	Trawl	383	69	27
	Scallop	138	201	31
2004	Trawl	854	137	20
	Scallop	458	31	36
2005	Trawl	1220	126	27
	Scallop	406	83	27
2006	Trawl	612	198	21
	Scallop	257	103	17
2007	Trawl	902	151	18
	Scallop	457	77	16

Table J6. The total number of lengths sampled from the commercial fishery discards for Southern New England/Mid-Atlantic winter flounder. The discards before the 50% mortality rate is applied (metric tons) and metric tons per 100 lengths are also shown.

Year	Discards (before mortality)	Lengths	Metric tons per 100 lengths
1994	682	307	222
1995	318	719	44
1996	350	603	58
1997	554	968	57
1998	346	774	45
1999	124	367	34
2000	296	481	62
2001	56	307	18
2002	186	942	20
2003	370	1,185	31
2004	168	2,889	6
2005	210	3,318	6
2006	302	3,942	8
2007	228	4,093	6

Table J7. Total winter flounder recreational and commercial catch for the Southern New England/Mid-Atlantic stock complex in weight (metric tons; mt) and in numbers (000s).

Year	Commercial Landings		Commercial Discards		Recreational Landings		Recreational Discards		Total Catch	
	mt	000s	Mt	000s	Mt	000s	mt	000s	mt	000s
1981	11,176	20,705	1,343	5,123	3,154	8,253	91	451	15,764	34,532
1982	9,438	19,026	1,149	4,271	3,493	8,216	63	324	14,143	31,837
1983	8,659	16,312	1,311	5,251	3,485	8,295	127	405	13,582	30,263
1984	8,882	17,116	986	3,936	5,510	12,441	148	745	15,526	34,238
1985	7,052	14,210	1,534	4,531	5,075	13,086	230	718	13,891	32,545
1986	4,929	9,460	1,273	4,902	2,949	7,001	66	351	9,217	21,714
1987	5,172	10,523	950	3,545	3,169	6,857	61	351	9,352	21,276
1988	4,312	8,378	904	3,729	3,510	7,354	69	422	8,795	19,882
1989	3,670	7,888	1,404	5,761	1,792	3,799	49	345	6,915	17,793
1990	4,232	7,203	673	2,567	1,063	2,487	31	204	5,999	12,461
1991	4,823	9,062	784	2,700	1,184	2,808	51	231	6,842	14,801
1992	3,816	6,758	511	1,812	387	809	15	83	4,729	9,462
1993	3,010	5,335	457	1,580	813	1,879	31	155	4,311	8,949
1994	2,128	4,305	341	1,362	594	1,203	29	80	3,092	6,956
1995	2,593	4,639	159	561	650	1,348	32	119	3,434	6,667
1996	2,783	5,235	175	418	714	1,607	30	157	3,702	7,417
1997	3,548	6,411	277	651	627	1,220	31	105	4,483	8,388
1998	3,138	5,924	173	462	290	584	13	64	3,614	7,033
1999	3,349	7,386	62	158	320	658	14	62	3,745	8,265
2000	3,704	6,465	148	354	870	1,401	32	109	4,754	8,328
2001	4,556	7,667	28	102	549	892	14	79	5,147	8,740
2002	3,084	4,908	93	221	223	408	12	45	3,412	5,583
2003	2,308	3,554	185	219	323	572	11	28	2,827	4,374
2004	1,636	2,420	84	214	214	344	8	15	1,942	2,992
2005	1,320	2,014	105	243	124	215	14	40	1,563	2,512
2006	1,720	2,936	151	342	136	273	16	48	2,023	3,601
2007	1,622	2,794	114	254	116	215	5	11	1,857	3,274

Table J8. Winter flounder NEFSC survey index stratified mean number and mean weight (kg) per tow for the Southern New England- Mid-Atlantic stock complex. Spring and fall strata set (offshore 1-12, 25, 69-76; inshore 1-29, 45-56); winter strata set (offshore 1-2, 5-6, 9-10, 69, 73). Indices include door and gear conversion factors.

	Spring					Fall			
Year	Number	N(CV)	Weight	W(CV)		Number	N(CV)	Weight	W(CV)
1963						9.175	33.2	3.874	41.4
1964						13.673	22.1	4.897	19.4
1965						15.537	32.5	4.463	28.7
1966						9.852	31.5	3.310	27.3
1967						9.109	20.6	2.811	18.7
1968	2.444	26.7	0.748	37.2		8.099	21.0	2.218	18.7
1969	5.640	34.3	3.414	53.7		7.065	34.9	2.009	29.7
1970	2.729	30.9	1.326	35.6		5.159	36.1	2.467	47.8
1971	2.035	32.9	0.756	36.2		3.861	17.5	1.231	19.1
1972	1.865	28.1	0.656	32.1		7.687	39.4	3.053	44.6
1973	6.233	19.9	1.688	20.6		2.691	26.9	0.775	25.8
1974	2.439	21.9	0.822	19.3		2.032	31.1	0.822	29.4
1975	0.683	22.6	0.218	20.8		2.196	20.3	0.688	22.1
1976	1.527	16.3	0.432	17.2		2.376	32.2	1.251	42.9
1977	2.084	17.2	0.639	18.6		4.722	22.5	1.735	25.2
1978	3.315	11.1	0.945	13.3		3.743	17.6	1.430	22.6
1979	1.468	16.8	0.575	25.0		10.059	18.4	2.606	15.4
1980	7.550	17.5	1.900	13.6		9.964	31.0	3.216	29.5
1981	9.027	20.9	2.560	16.9		10.206	20.3	3.110	19.9
1982	6.986	20.1	1.918	15.8		4.927	22.8	1.683	25.9
1983	6.262	18.4	2.469	28.0		8.757	37.6	2.690	31.7
1984	5.524	19.0	2.072	28.4		2.681	21.1	0.887	21.0
1985	5.360	17.4	1.983	16.5		2.727	21.5	0.991	21.5
1986	2.266	23.9	0.766	23.4		1.538	21.9	0.487	19.1
1987	1.763	21.3	0.568	17.9		1.167	28.9	0.419	37.8
1988	2.126	19.6	0.730	19.3		1.246	22.4	0.530	27.5
1989	2.485	33.5	0.582	29.6		1.435	40.7	0.341	30.4
1990	1.992	36.8	0.472	33.1		1.979	29.6	0.546	25.8
1991	2.473	15.6	0.692	14.7		1.950	23.6	0.708	25.6

Table J8 continued.

	Spring				Fall				Winter			
Year	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)
1992	1.579	23.4	0.435	22.1	2.963	32.4	0.829	31.8	3.680	27.3	0.928	26.0
1993	0.961	19.1	0.219	14.8	1.328	25.0	0.382	25.9	2.590	29.4	0.456	21.5
1994	1.510	26.4	0.329	21.9	4.134	24.8	1.482	27.3	3.797	30.8	1.183	35.5
1995	2.097	23.4	0.592	19.1	2.253	20.7	0.626	17.3	2.221	26.1	0.697	29.1
1996	1.517	14.3	0.428	15.2	3.186	39.8	1.063	45.3	3.778	28.4	0.734	25.2
1997	1.436	22.1	0.399	20.0	7.893	32.6	2.583	26.7	3.906	19.7	1.043	21.6
1998	2.774	20.6	0.845	22.1	6.597	13.6	2.232	9.9	7.169	21.6	1.830	24.1
1999	4.171	16.2	1.245	16.4	3.596	17.0	1.549	16.5	10.328	31.8	3.100	32.3
2000	3.172	26.6	1.123	31.9	6.168	25.5	2.143	26.2	5.571	32.9	1.525	29.5
2001	1.568	14.3	0.581	13.3	4.877	28.1	2.029	28.5	3.096	31.6	0.873	29.0
2002	2.043	15.7	0.782	16.3	8.858	18.9	3.634	19.8	2.901	27.7	1.188	38.3
2003	0.767	11.8	0.267	11.1	3.209	24.2	1.568	27.5	2.199	42.1	0.782	42.0
2004	1.243	27.1	0.442	30.6	3.357	27.6	0.879	27.0	4.336	35.2	0.881	44.4
2005	0.928	28.8	0.306	30.0	3.707	29.4	1.326	32.3	4.045	30.4	1.143	26.0
2006	1.810	20.4	0.465	17.5	2.952	28.7	1.043	29.0	5.082	48.4	1.497	36.2
2007	0.934	18.3	0.350	20.2	3.483	31.9	1.153	30.7	2.794	40.1	1.075	39.7
2008	1.808	18.9	0.642	19.0								

NOTE: 1968-1972 spring index does not include inshore strata; 1963-1971 fall index does not include inshore strata. All indices calculated with trawl door and trawl gear conversion factors where appropriate. Winter trawl survey began in 1992 and ended in 2007.

Table J9. SNE/MAB winter flounder mean weight per tow for annual state surveys.

Year	MADM	RIDFW	RIDFW	CTDEP
1978	18.24			
1979	18.42	7.72	7.24	
1980	15.13	13.57	4.88	
1981	16.20	12.13	2.12	
1982	15.18	5.23	1.30	
1983	20.01	9.52	2.28	
1984	14.80	8.43	3.38	15.68
1985	11.79	5.93	3.01	13.91
1986	10.50	6.47	3.12	10.33
1987	9.85	8.14	2.25	11.76
1988	6.73	6.02	1.45	18.28
1989	8.92	3.09	0.79	22.62
1990	5.68	3.07	0.71	29.01
1991	3.01	7.38	0.18	24.59
1992	8.05	0.95	0.42	12.29
1993	8.42	0.22	0.50	10.26
1994	12.93	1.67	0.33	12.20
1995	7.85	6.04	0.89	7.72
1996	9.92	4.45	0.91	20.41
1997	9.89	4.57	0.64	15.53
1998	8.15	5.00	0.32	14.66
1999	4.61	3.66	0.57	10.29
2000	6.26	4.52	0.56	12.63
2001	3.69	3.56	0.28	14.02
2002	1.91	3.29	0.28	10.83
2003	5.00	1.56	0.68	8.87
2004	2.97	1.85	0.53	6.11
2005	4.14	2.05	1.08	3.37
2006	3.80	3.45	0.44	1.82
2007	3.82			7.02

Table J10. Winter flounder mean number per tow for annual state surveys.

Year	MADMF	RIDFW Spring	RIDFW Fall	CTDEP	NYDEC	NJDFW Ocean	NJDFW Rivers
1978	52.00						
1979	54.87	83.76					
1980	39.35	63.10					
1981	47.80	87.97	25.21				
1982	41.46	31.39	18.55				
1983	58.14	58.97	17.29				
1984	38.02	41.64	19.02	111.96			
1985	39.49	34.97	21.44	83.58	4.87		
1986	36.78	41.02	31.28	63.65			
1987	39.16	56.21	20.90	79.92	6.07		
1988	28.36	34.44	10.64	137.59	4.31		
1989	27.38	20.88	7.17	148.19	17.02		
1990	27.72	20.33	8.83	223.09	12.22		
1991	11.02	41.95	1.77	150.20	21.50		
1992	28.96	4.40	10.60	61.39	79.11		
1993	50.40	2.92	6.65	63.60	31.20	19.17	
1994	50.84	10.25	2.21	84.44	22.09	14.06	
1995	37.37	32.19	7.00	50.12	8.15	30.41	2.82
1996	30.92	20.67	7.79	110.62	19.24	9.40	3.05
1997	38.51	22.28	5.48	71.31	10.99	36.02	3.35
1998	35.88	19.22	2.02	72.91	7.20	18.20	4.25
1999	25.98	13.45	2.80	41.35	10.96	17.79	3.23
2000	24.64	16.32	2.58	45.41	2.61	10.12	2.11
2001	15.79	12.49	2.10	54.50	7.99	13.83	2.84
2002	6.70	11.56	1.45	43.71	0.43	22.58	2.80
2003	17.73	5.56	5.21	27.84	1.40	12.52	1.57
2004	11.14	11.16	4.40	20.46	5.99	14.21	1.27
2005	27.02	15.74	10.38	16.10		25.67	0.99
2006	17.63	15.36	2.33	5.59		18.13	
2007	16.68			28.68		18.57	

Table J11. State survey indices (stratified mean number per tow or haul) for young-of-year winter flounder in Southern New England/Mid-Atlantic stock complex.

Year	CTDEP	RIDFW	DEDFW	MADMF	NYDEC
1976				0.344	
1977				0.641	
1978				0.366	
1979				0.507	
1980				0.432	
1981				0.340	
1982				0.370	
1983				0.231	
1984				0.323	
1985				0.335	1.52
1986		29.00	0.17	0.325	
1987		11.60	0.09	0.274	2.65
1988	15.50	8.90	0.02	0.184	1.45
1989	1.90	18.90	0.29	0.421	11.15
1990	3.10	21.50	0.63	0.325	8.53
1991	5.80	12.30	0.03	0.267	14.60
1992	13.70	33.30	0.27	0.294	76.87
1993	6.00	5.30	0.04	0.067	16.99
1994	16.60	2.50	0.31	0.148	14.84
1995	12.50	5.60	0.10	0.154	4.04
1996	19.20	6.20	0.04	0.221	16.25
1997	7.47	4.70	0.10	0.392	4.42
1998	9.38	2.60	0.13	0.165	3.11
1999	8.70	15.00	0.07	0.201	7.49
2000	4.30	53.00	0.08	0.347	0.90
2001	1.30	13.70	0.06	0.214	2.31
2002	3.06	18.10	0.01	0.100	0.07
2003	8.10	31.20	0.28	0.197	0.86
2004	10.96	18.70	0.20	0.095	0.50
2005	5.63	5.30	0.02	0.075	
2006	0.93	12.80	0.15	0.168	
2007	4.73	17.04		0.168	

Table J12. Commercial fishery landings at age for the Southern New England/Mid-Atlantic winter flounder stock complex.

Commercial Landings at Age

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	7+
1981	194	7,154	9,740	2,750	606	178	42	32	0	0	9	0	0	20,705	83
1982	54	6,897	8,496	2,715	488	187	78	59	21	17	7	7	0	19,026	189
1983	6	2,795	7,114	3,957	1,322	584	269	91	34	70	6	29	35	16,312	534
1984	0	4,518	6,367	3,197	1,503	768	355	158	67	86	27	33	37	17,116	763
1985	27	3,936	5,688	3,052	1,014	326	104	32	17	7	5	2	0	14,210	167
1986	0	2,122	4,187	2,206	551	271	84	27	6	3	1	2	0	9,460	123
1987	0	2,488	5,465	1,895	465	122	40	20	14	12	2	0	0	10,523	88
1988	0	2,241	3,929	1,607	412	122	37	24	3	2	1	0	0	8,378	67
1989	0	1,542	4,057	1,747	431	58	34	13	5	1	0	0	0	7,888	53
1990	0	1,003	3,977	1,757	315	95	37	16	0	3	0	0	0	7,203	56
1991	0	1,406	4,756	2,239	447	143	48	16	5	1	1	0	0	9,062	71
1992	0	484	3,416	2,127	574	111	32	11	3	0	0	0	0	6,758	46
1993	13	885	2,516	1,377	361	102	71	7	0	0	2	0	1	5,335	81
1994	2	1,281	1,681	995	261	59	21	3	1	1	0	0	0	4,305	26
1995	0	116	2,067	1,935	424	77	13	6	1	0	0	0	0	4,639	20
1996	108	564	2,283	1,676	445	119	22	18	0	0	0	0	0	5,235	40
1997	1	1,485	2,705	1,734	387	60	23	12	3	1	0	0	0	6,411	39
1998	0	975	2,691	1,515	492	178	63	3	7	0	0	0	0	5,924	73
1999	0	1,962	3,658	1,380	311	59	12	4	0	0	0	0	0	7,386	16
2000	0	1,066	2,804	1,934	518	91	42	10	0	0	0	0	0	6,465	52
2001	0	1,524	3,186	1,963	717	169	65	30	10	2	1	0	0	7,667	108
2002	0	292	1,693	1,688	839	293	75	23	4	1	0	0	0	4,908	103
2003	0	342	1,469	1,068	432	152	56	31	4	0	0	0	0	3,554	91
2004	0	240	861	699	280	194	94	32	17	3	0	0	0	2,420	146
2005	0	239	648	667	286	108	35	22	6	3	0	0	0	2,014	66
2006	1	555	1,339	590	232	119	66	26	7	1	0	0	0	2,936	100
2007	0	267	1,311	871	261	64	15	3	1	1	0	0	0	2,794	20

Table J13. Recreational fishery landings at age for the Southern New England/Mid-Atlantic winter flounder stock complex.

Recreational Landings at Age

	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	7+
1981	792	4,136	2,475	757	60	4	28	0	0	0	0	0	0	8,253	28
1982	447	4,146	2,659	806	120	25	13	0	0	0	0	0	0	8,216	13
1983	287	1,616	4,159	1,687	424	111	10	0	0	0	0	0	0	8,295	10
1984	286	4,153	6,071	1,527	261	104	40	0	0	0	0	0	0	12,441	40
1985	216	1,560	4,202	2,517	1,865	1,489	864	0	330	43	0	0	0	13,086	1,237
1986	106	1,766	2,434	1,798	492	171	81	77	51	8	17	0	0	7,001	234
1987	16	920	1,725	1,016	2,215	629	81	114	64	77	0	0	0	6,857	336
1988	21	534	2,856	2,077	774	856	128	51	37	20	0	0	0	7,354	236
1989	102	762	974	1,238	397	166	94	37	17	8	3	1	0	3,799	160
1990	7	189	814	852	439	101	52	20	3	3	0	2	5	2,487	85
1991	13	233	1,128	883	401	108	38	0	1	0	3	0	0	2,808	42
1992	3	124	236	304	85	50	7	0	0	0	0	0	0	809	7
1993	49	370	511	459	347	86	32	16	6	3	0	0	0	1,879	57
1994	10	411	424	233	73	38	13	0	0	0	0	0	0	1,203	13
1995	2	243	779	238	80	6	0	0	0	0	0	0	0	1,348	0
1996	6	306	771	423	90	9	0	0	0	0	0	0	0	1,607	0
1997	1	83	504	416	181	36	0	0	0	0	0	0	0	1,220	0
1998	2	89	191	235	58	7	1	0	0	0	0	0	0	584	1
1999	1	101	340	151	49	16	0	0	0	0	0	0	0	658	0
2000	0	117	458	491	272	46	15	0	0	0	0	0	0	1,401	15
2001	1	83	265	299	165	62	16	0	0	0	0	0	0	892	16
2002	1	85	136	103	59	19	5	0	0	0	0	0	0	408	5
2003	1	100	257	103	51	36	25	0	0	0	0	0	0	572	25
2004	2	57	92	120	37	21	14	0	0	0	0	0	0	344	14
2005	0	54	67	55	22	11	6	0	0	0	0	0	0	215	6
2006	0	51	138	57	23	3	1	0	0	0	0	0	0	273	1
2007	0	1	82	100	16	10	8	0	0	0	0	0	0	215	8

Table J14. Commercial fishery discards at age for the Southern New England/Mid-Atlantic winter flounder stock complex.

Commercial Discards at Age

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	7+
1981	322	2,514	2,186	101	0	0	0	0	0	0	0	0	0	5,123	0
1982	43	2,817	1,219	192	0	0	0	0	0	0	0	0	0	4,271	0
1983	260	2,479	2,000	467	45	0	0	0	0	0	0	0	0	5,251	0
1984	159	2,102	1,502	166	6	1	0	0	0	0	0	0	0	3,936	0
1985	22	1,504	2,516	442	43	4	0	0	0	0	0	0	0	4,531	0
1986	78	2,220	2,389	205	10	0	0	0	0	0	0	0	0	4,902	0
1987	11	1,600	1,755	170	9	0	0	0	0	0	0	0	0	3,545	0
1988	6	887	2,540	276	20	0	0	0	0	0	0	0	0	3,729	0
1989	315	2,724	2,131	555	33	2	1	0	0	0	0	0	0	5,761	1
1990	16	781	1,433	322	14	0	1	0	0	0	0	0	0	2,567	1
1991	17	1,238	1,205	227	12	1	0	0	0	0	0	0	0	2,700	0
1992	15	845	787	150	14	1	0	0	0	0	0	0	0	1,812	0
1993	201	849	467	57	6	0	0	0	0	0	0	0	0	1,580	0
1994	233	914	186	28	1	0	0	0	0	0	0	0	0	1,362	0
1995	86	254	193	25	3	0	0	0	0	0	0	0	0	561	0
1996	16	117	181	82	21	1	0	0	0	0	0	0	0	418	0
1997	73	205	256	102	16	0	0	0	0	0	0	0	0	651	0
1998	10	257	153	37	5	0	0	0	0	0	0	0	0	462	0
1999	2	30	57	45	16	7	2	0	0	0	0	0	0	158	2
2000	42	113	111	41	32	9	5	0	0	0	0	0	0	354	5
2001	12	44	35	11	1	0	0	0	0	0	0	0	0	102	0
2002	10	74	58	36	25	11	6	0	0	0	0	0	0	221	6
2003	8	47	68	26	16	35	19	0	0	0	0	0	0	219	19
2004	31	76	45	37	12	7	5	0	0	0	0	0	0	214	5
2005	22	107	47	30	17	12	8	0	0	0	0	0	0	243	8
2006	36	131	102	37	21	9	6	0	0	0	0	0	0	342	6
2007	9	60	100	57	15	8	4	0	0	0	0	0	0	254	4

Table J15. Recreational fishery discards at age for the Southern New England/Mid-Atlantic winter flounder stock complex.

Recreational Discards at Age

	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	7+
1981	72	379	0	0	0	0	0	0	0	0	0	0	0	451	0
1982	31	293	0	0	0	0	0	0	0	0	0	0	0	324	0
1983	63	342	0	0	0	0	0	0	0	0	0	0	0	405	0
1984	48	697	0	0	0	0	0	0	0	0	0	0	0	745	0
1985	9	342	365	2	0	0	0	0	0	0	0	0	0	718	0
1986	32	219	91	9	0	0	0	0	0	0	0	0	0	351	0
1987	47	257	43	3	1	0	0	0	0	0	0	0	0	351	0
1988	58	284	76	3	0	0	0	0	0	0	0	0	0	421	0
1989	51	247	46	1	0	0	0	0	0	0	0	0	0	345	0
1990	13	137	52	2	0	0	0	0	0	0	0	0	0	204	0
1991	22	152	57	0	0	0	0	0	0	0	0	0	0	231	0
1992	7	54	21	1	0	0	0	0	0	0	0	0	0	83	0
1993	29	96	26	4	0	0	0	0	0	0	0	0	0	155	0
1994	6	48	24	2	0	0	0	0	0	0	0	0	0	80	0
1995	1	41	73	4	0	0	0	0	0	0	0	0	0	119	0
1996	41	62	54	0	0	0	0	0	0	0	0	0	0	157	0
1997	14	68	23	0	0	0	0	0	0	0	0	0	0	105	0
1998	5	49	8	1	0	0	0	0	0	0	0	0	0	64	0
1999	2	53	6	1	0	0	0	0	0	0	0	0	0	62	0
2000	0	40	62	7	0	0	0	0	0	0	0	0	0	109	0
2001	22	39	17	1	0	0	0	0	0	0	0	0	0	79	0
2002	3	28	9	3	2	0	1	0	0	0	0	0	0	45	1
2003	6	9	7	2	2	0	1	0	0	0	0	0	0	28	1
2004	2	5	1	2	1	2	1	0	0	0	0	0	0	15	1
2005	10	17	3	4	3	3	0	0	0	0	0	0	0	40	0
2006	2	21	19	2	1	1	1	0	0	0	0	0	0	48	1
2007	0	1	5	5	1	0	0	0	0	0	0	0	0	11	0

Table J16. Total fishery catch at age for the Southern New England/Mid-Atlantic winter flounder stock complex.

Total Catch at Age

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	7+
1981	1380	14183	14401	3608	666	182	70	32	0	0	9	0	0	34532	111
1982	575	14153	12374	3713	608	212	91	59	21	17	7	7	0	31837	202
1983	616	7232	13273	6111	1791	695	279	91	34	70	6	29	35	30263	544
1984	493	11470	13940	4890	1770	873	395	158	67	86	27	33	37	34238	803
1985	274	7342	12771	6013	2922	1819	968	32	347	50	5	2	0	32545	1404
1986	216	6327	9101	4218	1053	442	165	104	57	11	18	2	0	21714	357
1987	74	5265	8988	3084	2690	751	121	134	78	89	2	0	0	21276	424
1988	85	3946	9401	3963	1206	978	165	75	40	22	1	0	0	19882	303
1989	468	5275	7208	3541	861	226	129	50	22	9	3	1	0	17793	214
1990	36	2110	6276	2933	768	196	90	36	3	6	0	2	5	12461	142
1991	52	3029	7146	3349	860	252	86	16	6	1	4	0	0	14801	113
1992	25	1507	4460	2582	673	162	39	11	3	0	0	0	0	9462	53
1993	292	2200	3520	1897	714	188	103	23	6	3	2	0	1	8949	138
1994	251	2612	2339	1280	337	97	34	3	1	1	0	0	0	6956	39
1995	88	654	3112	2202	506	83	13	6	1	0	0	0	0	6667	20
1996	171	1050	3289	2181	556	129	22	18	0	0	0	0	0	7417	40
1997	88	1841	3488	2252	584	96	23	12	3	1	0	0	0	8388	39
1998	16	1371	3043	1788	555	185	64	3	7	0	0	0	0	7033	74
1999	5	2146	4062	1577	375	82	14	4	0	0	0	0	0	8265	18
2000	43	1336	3436	2473	822	146	62	10	0	0	0	0	0	8328	72
2001	35	1689	3503	2274	883	231	81	30	10	2	1	0	0	8740	124
2002	14	478	1897	1830	925	324	87	23	4	1	0	0	0	5583	115
2003	15	498	1802	1199	501	223	101	31	4	0	0	0	0	4374	136
2004	36	378	999	858	331	223	115	32	17	3	0	0	0	2992	167
2005	32	417	765	755	328	134	50	22	6	3	0	0	0	2512	81
2006	39	758	1598	686	277	133	74	26	7	1	0	0	0	3598	108
2007	9	328	1498	1033	293	82	27	3	1	1	0	0	0	3275	32

Table J17. Total fishery mean weight at age for the Southern New England/Mid-Atlantic winter flounder stock complex.

Total Catch Mean Weights at Age

	Age						
Year	1	2	3	4	5	6	7+
1981	0.130	0.276	0.478	0.802	1.065	1.243	1.202
1982	0.090	0.261	0.438	0.694	1.048	1.253	1.837
1983	0.195	0.237	0.353	0.516	0.774	1.046	1.552
1984	0.146	0.258	0.366	0.542	0.693	0.913	1.282
1985	0.111	0.282	0.364	0.482	0.522	0.467	0.613
1986	0.129	0.292	0.398	0.480	0.685	0.879	0.961
1987	0.046	0.287	0.384	0.551	0.475	0.564	0.853
1988	0.039	0.279	0.351	0.508	0.634	0.517	0.827
1989	0.118	0.258	0.378	0.508	0.660	0.716	1.073
1990	0.082	0.295	0.394	0.525	0.672	0.808	0.990
1991	0.093	0.317	0.420	0.534	0.603	0.823	1.168
1992	0.079	0.287	0.427	0.599	0.802	0.945	1.395
1993	0.169	0.334	0.460	0.592	0.689	0.878	1.167
1994	0.311	0.430	0.473	0.564	0.750	0.985	1.281
1995	0.267	0.420	0.470	0.559	0.789	1.089	1.741
1996	0.136	0.380	0.464	0.607	0.824	0.851	1.085
1997	0.245	0.443	0.515	0.644	0.771	0.957	1.477
1998	0.196	0.362	0.465	0.568	0.665	1.090	1.116
1999	0.136	0.359	0.439	0.524	0.684	0.903	1.147
2000	0.106	0.407	0.492	0.622	0.729	0.975	1.079
2001	0.089	0.436	0.519	0.640	0.783	1.051	1.234
2002	0.135	0.372	0.499	0.617	0.747	0.927	1.143
2003	0.167	0.426	0.517	0.672	0.854	1.000	1.135
2004	0.094	0.384	0.549	0.619	0.786	0.945	1.251
2005	0.129	0.342	0.488	0.675	0.834	1.013	1.259
2006	0.118	0.379	0.468	0.652	0.872	1.065	1.229
2007	0.069	0.379	0.468	0.624	0.849	1.116	1.363

Table J18. NEFSC Spring survey: stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set: offshore 1-12, 25, 69-76; inshore 1-29, 45-56).

Year	1	2	3	4	5	6	7	8	9+	Total
1980	1.09	4.06	2.05	0.25	0.06	0.03	0.01			7.55
1981	0.99	4.00	3.41	0.47	0.13	0.01	0.01			9.02
1982	1.16	3.20	1.56	0.74	0.21	0.09	0.02	0.01		6.99
1983	0.58	0.97	2.14	1.23	0.81	0.37	0.08	0.08		6.26
1984	0.22	1.36	2.18	0.85	0.46	0.29	0.07	0.06	0.03	5.52
1985	0.41	1.21	2.16	0.72	0.51	0.20	0.14	0.01		5.36
1986	0.10	0.49	1.16	0.31	0.15	0.05	0.01			2.27
1987	0.14	0.54	0.70	0.28	0.06	0.02		0.01	0.01	1.76
1988	0.09	0.48	0.99	0.37	0.16	0.02	0.02			2.13
1989	0.14	0.95	0.90	0.34	0.11	0.02	0.02	0.01		2.49
1990	0.23	0.49	0.89	0.28	0.05	0.04	0.01			1.99
1991	0.14	0.60	1.22	0.41	0.05	0.02	0.02	0.01		2.47
1992	0.14	0.39	0.62	0.36	0.05	0.02				1.58
1993	0.14	0.35	0.26	0.12	0.07	0.01	0.01			0.96
1994	0.16	0.74	0.43	0.11	0.04	0.02	0.01			1.51
1995	0.22	0.75	0.87	0.22	0.03		0.01			2.10
1996	0.07	0.54	0.66	0.17	0.06	0.01	0.01			1.52
1997	0.13	0.50	0.56	0.18	0.06	0.01				1.44
1998	0.33	1.21	0.72	0.37	0.13	0.01				2.77
1999	0.41	1.89	1.35	0.36	0.11	0.04	0.01			4.17
2000	0.28	0.70	1.19	0.65	0.27	0.07	0.01			3.17
2001	0.17	0.26	0.47	0.44	0.20	0.02	0.01			1.57
2002	0.11	0.60	0.56	0.38	0.23	0.11	0.04		0.01	2.04
2003	0.12	0.11	0.33	0.10	0.05	0.04	0.02			0.77
2004	0.30	0.19	0.29	0.26	0.11	0.05	0.03	0.01		1.24
2005	0.10	0.45	0.11	0.16	0.07	0.03	0.01			0.93
2006	0.30	0.62	0.62	0.16	0.08	0.02	0.01			1.81
2007	0.11	0.14	0.36	0.26	0.04	0.01	0.01	0.01		0.94
2008	0.17	0.61	0.48	0.41	0.12	0.01	0.01			1.81

Table J19. NEFSC Fall survey: stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set: offshore 1-12, 25, 69-76; inshore 1-29, 45-56).

Year	0	1	2	3	4	5	6	7	8+	Total
1980	0.40	1.76	4.62	2.74	0.43	0.01				9.96
1981	0.04	2.13	5.03	2.49	0.30	0.10	0.09	0.02	0.01	10.21
1982	0.01	0.76	2.21	1.34	0.47	0.12	0.02			4.93
1983		1.63	3.82	2.06	0.62	0.35	0.11	0.07	0.10	8.76
1984		0.17	1.04	1.17	0.26	0.03	0.01			2.68
1985		0.16	1.18	0.99	0.30	0.09	0.01			2.73
1986		0.23	0.90	0.36	0.03	0.01		0.01		1.54
1987		0.03	0.64	0.36	0.12	0.02				1.17
1988		0.03	0.30	0.64	0.22	0.04	0.01	0.01		1.25
1989		0.28	0.83	0.26	0.05	0.01	0.01			1.44
1990		0.08	0.89	0.85	0.15	0.01				1.98
1991		0.07	1.02	0.73	0.12	0.01				1.95
1992		0.13	1.74	0.79	0.26	0.03	0.01			2.96
1993		0.43	0.52	0.35	0.08					1.38
1994		0.45	2.23	1.08	0.30	0.04	0.03			4.13
1995		0.58	0.93	0.63	0.09	0.01	0.01			2.25
1996		0.61	1.40	0.80	0.31	0.06	0.01			3.19
1997		1.48	3.58	2.20	0.55	0.08				7.89
1998		1.39	2.83	1.91	0.41	0.05	0.01			6.60
1999		0.43	0.95	1.46	0.54	0.18	0.04			3.60
2000		0.90	2.30	2.02	0.71	0.22	0.01	0.01		6.17
2001		0.49	1.79	1.61	0.63	0.30	0.02	0.04		4.88
2002	0.05	0.52	4.01	2.35	1.14	0.59	0.18	0.01	0.01	8.86
2003		0.40	1.06	1.15	0.46	0.10	0.03	0.01		3.21
2004		1.89	0.79	0.28	0.28	0.06	0.04	0.02		3.36
2005		0.72	1.83	0.73	0.21	0.13	0.08	0.01		3.71
2006		0.47	1.39	0.79	0.22	0.06	0.02			2.95
2007	0.01	0.60	1.64	1.03	0.16	0.02	0.03			3.48

Table J20. NEFSC Winter survey: stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set: offshore 1-2, 5-6, 9-10, 69, 73). The Winter survey ended in 2007. Lengths converted to age using NEFSC spring survey ALKs.

Year	0	1	2	3	4	5	6	7	8+	Total
1992		0.73	0.86	1.09	0.73	0.24	0.02	0.02		3.68
1993		0.56	1.16	0.54	0.18	0.12	0.02	0.01		2.59
1994		0.36	1.16	1.76	0.25	0.28				3.80
1995		0.04	0.75	1.26	0.17					2.22
1996		1.01	0.87	1.55	0.32	0.02				3.78
1997		0.43	1.49	1.32	0.54	0.13				3.91
1998		0.42	3.52	1.95	0.96	0.32				7.17
1999		0.84	5.94	2.23	0.96	0.20	0.16			10.33
2000		0.23	2.82	2.12	0.24	0.16				5.57
2001		1.04	0.55	0.70	0.54	0.22	0.05			3.10
2002		0.08	1.34	0.74	0.15	0.21	0.06	0.21	0.11	2.90
2003		0.09	0.57	1.04	0.25	0.22			0.03	2.20
2004		2.17	1.02	0.43	0.36	0.22	0.09	0.03	0.02	4.34
2005		0.39	2.56	0.36	0.43	0.27	0.04			4.05
2006		0	2.40	1.73	0.51	0.27	0.08	0.07	0.02	5.08
2007		0.02	0.56	1.03	1.03	0.13	0.02			2.79

Table J21. MADMF spring trawl survey mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex.

Year	1	2	3	4	5	6	7	8	9+	Total
1978	10.00	9.80	15.86	9.40	3.17	1.10	1.34	0.51	0.82	52.00
1979	4.72	13.18	21.58	9.08	2.99	1.02	0.97	0.47	0.86	54.87
1980	1.65	8.30	14.66	9.23	3.04	0.97	0.80	0.28	0.43	39.36
1981	8.65	9.07	13.66	9.72	3.81	1.20	0.78	0.33	0.58	47.80
1982	3.06	11.88	12.72	8.80	2.66	1.07	0.69	0.18	0.40	41.46
1983	1.71	15.32	17.85	14.11	4.14	2.34	1.12	0.64	0.90	58.14
1984	1.28	9.59	11.82	10.18	3.35	1.22	0.46	0.01	0.12	38.02
1985	3.13	9.98	16.48	6.35	2.48	0.75	0.15	0.07	0.11	39.49
1986	3.27	7.07	19.36	5.69	0.83	0.13	0.19	0.16	0.08	36.78
1987	9.44	7.74	12.35	6.59	2.21	0.22	0.38	0.12	0.11	39.16
1988	3.61	7.02	14.66	2.45	0.35	0.07	0.18	0.00	0.02	28.36
1989	2.26	6.08	12.30	4.68	1.01	0.29	0.28	0.09	0.41	27.38
1990	4.43	11.73	8.03	2.99	0.40	0.02	0.10	0.00	0.02	27.72
1991	1.65	2.88	4.90	1.18	0.24	0.13	0.02	0.00	0.02	11.02
1992	8.06	7.40	6.73	4.21	1.67	0.60	0.07	0.08	0.14	28.96
1993	16.03	18.75	12.02	2.76	0.65	0.14	0.02	0.04	0.00	50.40
1994	12.15	17.35	14.96	4.72	0.62	0.59	0.37	0.05	0.02	50.84
1995	14.31	11.14	8.10	1.93	0.61	0.80	0.28	0.14	0.06	37.37
1996	4.98	10.12	7.72	2.86	2.00	1.46	0.85	0.29	0.64	30.92
1997	10.43	9.30	10.27	4.26	1.32	1.00	0.49	0.75	0.69	38.51
1998	8.62	13.09	7.21	3.51	1.47	1.22	0.41	0.31	0.03	35.88
1999	9.66	8.00	5.81	1.89	0.21	0.25	0.13	0.04	0.00	25.98
2000	6.41	7.78	6.68	1.74	1.09	0.46	0.15	0.23	0.10	24.64
2001	5.47	4.73	2.39	2.02	0.66	0.20	0.13	0.16	0.04	15.79
2002	0.94	3.00	1.55	0.82	0.29	0.08	0.01	0.00	0.00	6.70
2003	4.12	3.78	6.15	2.25	1.14	0.24	0.03	0.01	0.00	17.73
2004	3.46	3.15	1.97	1.67	0.56	0.21	0.09	0.03	0.00	11.14
2005	14.05	8.42	2.68	1.07	0.59	0.11	0.02	0.06	0.00	27.02
2006	3.19	9.61	2.98	1.12	0.32	0.20	0.12	0.06	0.02	17.63
2007	3.69	5.59	5.32	1.63	0.35	0.09	0.02	0.00	0.00	16.68

Table J22. CTDEP spring survey for winter flounder in the Southern New England-Mid Atlantic stock complex.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+	Total
1984	0.00	8.21	44.01	31.83	20.96	4.23	1.23	0.67	0.74	0.04	0.01	0.03	0.00	111.96
1985	0.00	4.11	28.46	32.88	14.17	2.33	0.82	0.45	0.19	0.11	0.04	0.02	0.00	83.58
1986	0.00	6.69	26.00	15.53	12.26	2.05	0.50	0.24	0.24	0.10	0.01	0.03	0.00	63.65
1987	0.00	7.32	44.69	14.56	5.05	6.55	1.28	0.11	0.24	0.13	0.00	0.00	0.00	79.93
1988	15.50	14.49	71.87	39.10	8.59	1.83	1.46	0.16	0.04	0.02	0.02	0.00	0.00	153.08
1989	1.90	13.56	78.43	41.23	10.85	2.84	0.98	0.14	0.09	0.06	0.01	0.00	0.00	150.09
1990	3.10	11.31	131.52	64.97	8.97	4.09	1.96	0.19	0.05	0.00	0.02	0.00	0.00	226.18
1991	5.80	8.52	66.99	60.39	9.31	4.05	0.80	0.14	0.00	0.00	0.00	0.01	0.00	156.01
1992	13.70	6.80	31.32	12.78	8.97	1.10	0.36	0.05	0.00	0.00	0.00	0.00	0.00	75.08
1993	6.00	19.11	19.87	15.46	4.81	3.24	0.80	0.15	0.11	0.04	0.01	0.00	0.00	69.60
1994	16.60	9.57	64.14	5.86	3.01	1.14	0.49	0.17	0.05	0.01	0.01	0.00	0.00	101.05
1995	12.50	14.35	23.69	9.77	1.36	0.63	0.20	0.08	0.02	0.02	0.00	0.00	0.00	62.62
1996	19.20	11.46	59.07	24.17	14.41	0.97	0.28	0.14	0.06	0.04	0.01	0.00	0.00	129.81
1997	7.47	12.53	25.53	19.41	9.45	3.76	0.51	0.07	0.03	0.01	0.01	0.01	0.00	78.79
1998	9.28	11.22	32.40	12.23	12.67	3.15	0.99	0.14	0.02	0.07	0.00	0.00	0.00	82.17
1999	8.70	6.56	12.42	11.27	6.09	3.20	1.14	0.61	0.04	0.01	0.02	0.00	0.00	50.06
2000	4.30	7.11	16.66	8.40	7.70	3.42	1.53	0.31	0.26	0.01	0.01	0.00	0.01	49.72
2001	1.30	8.45	19.60	10.85	8.06	5.46	1.28	0.68	0.05	0.08	0.00	0.00	0.00	55.81
2002	3.06	6.27	19.90	9.56	4.43	1.95	1.02	0.35	0.11	0.03	0.10	0.00	0.00	46.78
2003	8.10	2.47	7.83	8.71	4.79	1.95	0.77	0.82	0.29	0.07	0.14	0.00	0.00	35.94
2004	10.96	6.34	3.84	3.49	3.88	1.91	0.64	0.21	0.11	0.03	0.01	0.00	0.01	31.43
2005	5.63	7.06	6.18	0.84	0.81	0.67	0.21	0.16	0.10	0.05	0.01	0.01	0	16.10
2006	0.93	1.14	2.60	1.10	0.19	0.14	0.17	0.09	0.01	0.09	0.03	0.02	0	5.59
2007	4.73	2.98	10.83	10.70	3.10	0.61	0.15	0.11	0.12	0.04	0.01	0.01	0	28.68

Table J23. RIDFW spring survey for winter flounder in the Southern New England-Mid Atlantic stock complex.

	Age						
Year	1	2	3	4	5	6	7+
1981	45.67	27.88	12.86	1.27	0.23	0.05	0.02
1982	13.42	9.74	5.02	2.31	0.33	0.11	0.02
1983	29.49	9.79	10.98	6.00	2.13	0.56	0.00
1984	6.67	16.79	13.94	2.96	0.83	0.35	0.10
1985	6.01	15.69	10.35	2.24	0.60	0.08	0.01
1986	11.94	15.63	9.59	2.63	1.14	0.09	0.00
1987	15.30	24.59	13.14	2.66	0.41	0.08	0.04
1988	8.93	12.37	9.53	2.92	0.68	0.01	0.00
1989	4.79	8.20	4.95	2.33	0.51	0.07	0.03
1990	6.46	6.36	4.88	2.16	0.48	0.04	0.06
1991	11.21	14.36	12.00	2.78	0.41	0.10	0.11
1992	1.30	0.95	1.17	0.75	0.20	0.04	0.00
1993	2.32	0.35	0.17	0.06	0.02	0.00	0.00
1994	2.84	4.56	1.97	0.63	0.19	0.04	0.03
1995	9.36	11.36	9.87	1.47	0.13	0.00	0.00
1996	3.11	8.36	7.47	1.56	0.15	0.03	0.00
1997	4.90	8.77	6.86	1.48	0.26	0.00	0.00
1998	2.11	9.47	5.90	1.60	0.13	0.01	0.00
1999	1.71	6.52	4.26	0.82	0.09	0.06	0.00
2000	2.88	4.98	5.51	2.19	0.66	0.10	0.00
2001	2.46	3.47	3.67	2.23	0.63	0.02	0.01
2002	1.60	4.76	3.21	1.24	0.54	0.15	0.06
2003	1.72	0.86	1.76	0.50	0.30	0.28	0.14
2004	5.47	3.97	1.03	0.44	0.12	0.09	0.04
2005	8.86	2.41	1.73	1.38	0.79	0.43	0.14
2006	2.07	4.72	5.24	2.24	0.74	0.30	0.05

Table J24. NYDEC Peconic Bay Small Mesh Trawl Survey for winter flounder in the Southern New England-Mid Atlantic stock complex. No sampling in 1986; the survey ended in 2004.

	AGE			
Year	0	1	2+	Total
1985	1.52	3.05	0.30	4.87
1987	2.65	3.30	0.12	6.07
1988	1.45	2.55	0.31	4.31
1989	11.15	5.52	0.35	17.02
1990	8.53	3.43	0.26	12.22
1991	14.60	6.32	0.58	21.50
1992	76.87	2.04	0.20	79.11
1993	16.99	14.09	0.12	31.20
1994	14.84	6.93	0.32	22.09
1995	4.04	3.84	0.27	8.15
1996	16.25	2.84	0.15	19.24
1997	4.42	6.46	0.11	10.99
1998	3.11	3.80	0.29	7.20
1999	7.49	3.25	0.22	10.96
2000	0.90	1.56	0.15	2.61
2001	2.31	5.52	0.16	7.99
2002	0.07	0.17	0.19	0.43
2003	0.86	0.45	0.09	1.40
2004	0.50	5.38	0.11	5.99

Table J25. NJDFW Ocean survey (April) for winter flounder in the Southern New England-Mid Atlantic stock complex.

	AGE							
Year	1	2	3	4	5	6	7+	Total
1993	5.10	6.50	2.50	2.40	1.70	0.40	0.57	19.17
1994	3.70	4.20	3.90	1.40	0.40	0.30	0.16	14.06
1995	8.00	10.10	8.60	2.40	0.90	0.30	0.11	30.41
1996	0.60	2.90	2.60	1.90	0.90	0.30	0.20	9.40
1997	16.60	5.40	6.10	6.00	1.50	0.30	0.12	36.02
1998	4.50	3.90	4.80	3.30	1.20	0.40	0.10	18.20
1999	2.40	2.20	5.90	3.10	2.90	0.70	0.59	17.79
2000	0.70	0.30	2.10	3.30	2.00	0.90	0.82	10.12
2001	3.90	0.60	1.30	2.70	3.80	0.70	0.83	13.83
2002	5.81	3.21	4.55	2.22	2.80	2.16	1.83	22.58
2003	2.08	1.10	4.79	1.24	1.09	0.87	1.35	12.52
2004	6.48	0.72	1.42	2.08	0.56	1.38	1.57	14.21
2005	4.97	10.04	2.55	2.76	2.61	1.32	1.42	25.67
2006	0.64	2.49	9.43	3.23	0.62	0.75	0.97	18.13
2007	3.80	0.67	4.33	6.09	1.51	0.62	1.56	18.58

Table J26. NJDFW Rivers survey (March-May) for winter flounder in the Southern New England-Mid Atlantic stock complex. The Rivers Survey ended in 2005.

	AGE							
Year	1	2	3	4	5	6	7+	Total
1995	0.60	0.30	1.40	0.40	0.10	0.01	0.01	2.82
1996	0.30	0.90	0.70	0.70	0.20	0.10	0.15	3.05
1997	1.10	0.40	0.90	0.40	0.40	0.10	0.05	3.35
1998	1.90	0.90	0.40	0.70	0.20	0.10	0.05	4.25
1999	0.20	0.50	1.40	0.50	0.40	0.10	0.13	3.23
2000	0.40	0.20	0.40	0.80	0.20	0.10	0.01	2.11
2001	1.40	0.30	0.20	0.40	0.40	0.10	0.04	2.84
2002	1.21	0.48	0.49	0.18	0.27	0.13	0.04	2.80
2003	0.05	0.22	0.90	0.18	0.03	0.10	0.09	1.57
2004	0.67	0.02	0.10	0.29	0.05	0.00	0.14	1.27
2005	0.42	0.24	0.17	0.02	0.09	0.02	0.03	0.99

Table J27. Mohn's rho statistic for the BASE and SPLIT ADAPT VPA configurations for F (ages 4-5, unweighted), SSB, and recruitment (R) at age 1.

F

Year	BASE	Split
2000	-0.4477	-0.0495
2001	-0.3403	0.0324
2002	-0.0616	0.3145
2003	-0.1108	0.1954
2004	-0.2883	-0.0461
2005	-0.1145	0.1513
2006	0.3166	0.4141
Total	-1.0466	1.0121
Average	-0.1495	0.1446

SSB

Year	BASE	Split
2000	0.5172	0.0288
2001	0.2369	-0.1198
2002	0.0674	-0.1518
2003	0.3294	0.0724
2004	0.3444	0.0727
2005	0.079	-0.1058
2006	-0.0195	-0.0231
Total	1.5548	-0.2266
Average	0.2221	-0.0324

R age 1

Year	BASE	Split
2000	0.4547	0.1691
2001	1.7625	1.2171
2002	-0.1101	-0.0546
2003	-0.1106	-0.1983
2004	0.8004	0.8576
2005	0.0303	0.0468
2006	-0.1203	-0.0580
2007	-0.5070	-0.4286
Total	2.1999	1.5511
Average	0.2750	0.1939

Table J28. Catchability coefficients (q) estimated in the BASE and SPLIT run configurations.

Catchability Coefficients: BASE vs SPLIT

Survey	BASE	SPLIT-1	SPLIT-1/BASE	SPLIT-2	SPLIT-2/BASE
NEFSC	(split)				
Spring 1	1.25E-05	8.66E-06	0.69	1.92E-05	1.54
Spring 2	4.50E-05	3.39E-05	0.75	6.29E-05	1.40
Spring 3	7.46E-05	6.73E-05	0.90	8.70E-05	1.17
Spring 4	7.20E-05	6.34E-05	0.88	8.54E-05	1.19
Spring 5	7.61E-05	6.41E-05	0.84	9.43E-05	1.24
Spring 6	7.04E-05	5.92E-05	0.84	8.96E-05	1.27
Spring 7	8.00E-05	5.57E-05	0.70	1.21E-04	1.51
NEFSC	(split)				
Fall 2	2.93E-05	9.35E-06	0.32	8.61E-05	2.94
Fall 3	1.46E-04	7.92E-05	0.54	2.65E-04	1.81
Fall 4	2.20E-04	1.34E-04	0.61	3.59E-04	1.63
MADMF	(split)				
Spring 2	5.49E-04	3.54E-04	0.64	8.80E-04	1.60
Spring 3	7.29E-04	6.85E-04	0.94	8.08E-04	1.11
Spring 4	7.11E-04	7.56E-04	1.06	7.00E-04	0.99
Spring 5	6.54E-04	5.88E-04	0.90	7.51E-04	1.15
RIDFW	(split)				
Spring 1	3.05E-04	3.12E-04	1.02	3.19E-04	1.05
Spring 2	4.24E-04	3.34E-04	0.79	5.62E-04	1.33
Spring 3	4.44E-04	3.33E-04	0.75	6.09E-04	1.37
Spring 4	3.32E-04	2.63E-04	0.79	4.30E-04	1.29
CTDEP	(split)				
Spring 1	5.35E-04	4.16E-04	0.78	7.03E-04	1.31
Spring 2	1.93E-03	2.28E-03	1.18	1.83E-03	0.95
Spring 3	1.40E-03	1.90E-03	1.36	1.18E-03	0.84
Spring 4	1.39E-03	1.60E-03	1.15	1.31E-03	0.94
Spring 5	1.52E-03	1.41E-03	0.93	1.67E-03	1.10
Spring 6	1.59E-03	1.29E-03	0.81	1.92E-03	1.21
Spring 7	1.68E-03	7.61E-04	0.45	3.09E-03	1.84

Table J28 continued.

Catchability Coefficients: BASE vs SPLIT

Survey	BASE	SPLIT-1	SPLIT-1/BASE	SPLIT-2	SPLIT-2/BASE
NEFSC	(not split)				
Winter 1	2.94E-05	3.14E-05	1.07	3.14E-05	1.07
Winter 2	1.48E-04	1.57E-04	1.06	1.57E-04	1.06
Winter 3	1.66E-04	1.73E-04	1.04	1.73E-04	1.04
Winter 4	1.31E-04	1.36E-04	1.04	1.36E-04	1.04
Winter 5	1.88E-04	1.95E-04	1.04	1.95E-04	1.04
NJ-Ocean	(not split)				
Spring 3	5.76E-04	6.01E-04	1.04	6.01E-04	1.04
Spring 4	9.07E-04	9.43E-04	1.04	9.43E-04	1.04
Spring 5	1.48E-03	1.53E-03	1.04	1.53E-03	1.04
Spring 6	2.27E-03	2.35E-03	1.04	2.35E-03	1.04
Spring 7	4.35E-03	4.53E-03	1.04	4.53E-03	1.04
NJ-River	(not split)				
Spring 1	4.91E-05	5.18E-05	1.05	5.18E-05	1.05
Spring 2	3.43E-05	3.55E-05	1.03	3.55E-05	1.03
Spring 3	7.73E-05	7.85E-05	1.02	7.85E-05	1.02
Spring 4	1.24E-04	1.25E-04	1.01	1.25E-04	1.01
Spring 5	1.62E-04	1.64E-04	1.01	1.64E-04	1.01

Table J29. SNE/MA winter flounder GARM3 SPLIT VPA results.

JAN-1 Population Numbers

AGE	1981	1982	1983	1984	1985
1	62523.	51649.	56232.	35570.	34617.
2	52498.	49941.	41766.	45482.	28676.
3	27775.	30148.	28082.	27652.	26859.
4	7151.	9710.	13487.	10982.	10026.
5	1466.	2590.	4590.	5513.	4566.
6	362.	598.	1570.	2138.	2912.
7	221.	569.	1229.	1966.	2248.
Total	151995.	145205.	146957.	129301.	109904.

AGE	1986	1987	1988	1989	1990
1	32860.	25995.	26675.	22572.	16474.
2	28094.	26708.	21216.	21763.	18057.
3	16835.	17277.	17103.	13799.	13045.
4	10434.	5548.	6012.	5496.	4776.
5	2768.	4726.	1752.	1337.	1296.
6	1095.	1313.	1436.	343.	315.
7	884.	741.	445.	325.	228.
Total	92970.	82308.	74638.	65635.	54192.

AGE	1991	1992	1993	1994	1995
1	12273.	13061.	15589.	12962.	12525.
2	13456.	10001.	10671.	12499.	10385.
3	12875.	8276.	6825.	6746.	7870.
4	5001.	4075.	2740.	2402.	3406.
5	1256.	1065.	1000.	527.	809.
6	366.	250.	263.	173.	126.
7	164.	82.	193.	69.	30.
Total	45391.	36809.	37279.	35378.	35152.

AGE	1996	1997	1998	1999	2000
1	14078.	17348.	16597.	13768.	9446.
2	10175.	11371.	14124.	13574.	11267.
3	7911.	7381.	7644.	10323.	9172.
4	3627.	3501.	2887.	3505.	4777.
5	797.	996.	829.	746.	1443.
6	204.	149.	287.	176.	271.
7	63.	61.	115.	39.	134.
Total	36855.	40807.	42483.	42131.	36510.

Table 29 continued.

AGE	2001	2002	2003	2004	2005
1	6950.	5241.	4398.	9355.	10057.
2	7695.	5659.	4278.	3587.	7627.
3	8016.	4772.	4201.	3052.	2595.
4	4400.	3393.	2191.	1809.	1595.
5	1673.	1545.	1122.	709.	704.
6	437.	571.	428.	466.	281.
7	235.	203.	261.	349.	170.
Total	29407.	21383.	16879.	19326.	23027.

AGE	2006	2007	2008
1	6159.	3600.	8837.
2	8205.	5008.	2939.
3	5867.	6032.	3803.
4	1432.	3357.	3583.
5	623.	552.	1814.
6	280.	259.	187.
7	227.	73.	83.
Total	22793.	18881.	21246.

Table 29 Continued.

Fishing Mortality Calculated

AGE	1981	1982	1983	1984	1985
1	0.0247	0.0124	0.0122	0.0154	0.0088
2	0.3546	0.3757	0.2124	0.3267	0.3326
3	0.8510	0.6044	0.7389	0.8145	0.7455
4	0.8156	0.5492	0.6947	0.6775	1.0872
5	0.6974	0.3004	0.5643	0.4383	1.2283
6	0.7945	0.4914	0.6599	0.5910	1.1292
7	0.7945	0.4914	0.6599	0.5910	1.1292

AGE	1986	1987	1988	1989	1990
1	0.0073	0.0032	0.0035	0.0232	0.0024
2	0.2862	0.2457	0.2301	0.3118	0.1383
3	0.9100	0.8556	0.9352	0.8610	0.7587
4	0.5920	0.9527	1.3037	1.2449	1.1354
5	0.5456	0.9916	1.4301	1.2446	1.0643
6	0.5820	0.9704	1.3309	1.2449	1.1198
7	0.5820	0.9704	1.3309	1.2449	1.1198

AGE	1991	1992	1993	1994	1995
1	0.0047	0.0021	0.0209	0.0216	0.0078
2	0.2861	0.1822	0.2586	0.2626	0.0721
3	0.9504	0.9054	0.8440	0.4832	0.5745
4	1.3472	1.2048	1.4488	0.8887	1.2531
5	1.4127	1.1997	1.5560	1.2273	1.1759
6	1.3600	1.2037	1.4763	0.9418	1.2379
7	1.3600	1.2037	1.4763	0.9418	1.2379

AGE	1996	1997	1998	1999	2000
1	0.0135	0.0056	0.0011	0.0004	0.0050
2	0.1211	0.1971	0.1135	0.1920	0.1405
3	0.6152	0.7387	0.5797	0.5707	0.5345
4	1.0922	1.2411	1.1536	0.6876	0.8491
5	1.4759	1.0436	1.3481	0.8115	0.9933
6	1.1513	1.1938	1.1938	0.7083	0.8807
7	1.1513	1.1938	1.1938	0.7083	0.8807

AGE	2001	2002	2003	2004	2005
1	0.0056	0.0030	0.0038	0.0043	0.0035
2	0.2778	0.0980	0.1377	0.1238	0.0623
3	0.6596	0.5786	0.6427	0.4490	0.3942
4	0.8466	0.9063	0.9287	0.7429	0.7407
5	0.8754	1.0838	0.6798	0.7263	0.7228
6	0.8545	0.9586	0.8373	0.7382	0.7352
7	0.8545	0.9586	0.8373	0.7382	0.7352

Table 29 Continued.

AGE	2006	2007
1	0.0070	0.0028
2	0.1077	0.0751
3	0.3581	0.3209
4	0.7535	0.4156
5	0.6768	0.8833
6	0.7296	0.6495
7	0.7296	0.6495

Average Fishing Mortality For Ages 4- 5

Year	Average F	N Weighted	Biomass Wtd	Catch Wtd
1981	0.7565	0.7955	0.7893	0.7972
1982	0.4248	0.4968	0.4751	0.5142
1983	0.6295	0.6615	0.6498	0.6651
1984	0.5579	0.5976	0.5801	0.6139
1985	1.1577	1.1313	1.1388	1.1333
1986	0.5688	0.5822	0.5796	0.5827
1987	0.9721	0.9706	0.9708	0.9708
1988	1.3669	1.3322	1.3392	1.3332
1989	1.2447	1.2449	1.2448	1.2449
1990	1.0999	1.1202	1.1167	1.1206
1991	1.3800	1.3604	1.3626	1.3606
1992	1.2022	1.2037	1.2035	1.2037
1993	1.5024	1.4774	1.4829	1.4781
1994	1.0580	0.9496	0.9642	0.9593
1995	1.2145	1.2383	1.2350	1.2387
1996	1.2840	1.1613	1.1759	1.1701
1997	1.1423	1.1973	1.1892	1.2004
1998	1.2509	1.1970	1.2038	1.1997
1999	0.7496	0.7094	0.7139	0.7114
2000	0.9212	0.8825	0.8870	0.8851
2001	0.8610	0.8546	0.8559	0.8547
2002	0.9951	0.9619	0.9698	0.9659
2003	0.8043	0.8444	0.8314	0.8554
2004	0.7346	0.7382	0.7374	0.7383
2005	0.7317	0.7352	0.7345	0.7352
2006	0.7151	0.7303	0.7250	0.7314
2007	0.6495	0.4816	0.5019	0.5189

Table 29 Continued.

Back Calculated Partial Recruitment

AGE	1981	1982	1983	1984	1985
1	0.0290	0.0205	0.0165	0.0190	0.0072
2	0.4167	0.6216	0.2875	0.4011	0.2708
3	1.0000	1.0000	1.0000	1.0000	0.6069
4	0.9585	0.9087	0.9401	0.8318	0.8851
5	0.8195	0.4970	0.7636	0.5381	1.0000
6	0.9336	0.8131	0.8931	0.7256	0.9193
7	0.9336	0.8131	0.8931	0.7256	0.9193

AGE	1986	1987	1988	1989	1990
1	0.0080	0.0032	0.0025	0.0186	0.0021
2	0.3145	0.2478	0.1609	0.2505	0.1218
3	1.0000	0.8628	0.6539	0.6916	0.6682
4	0.6505	0.9608	0.9116	1.0000	1.0000
5	0.5995	1.0000	1.0000	0.9997	0.9374
6	0.6396	0.9786	0.9306	0.9999	0.9863
7	0.6396	0.9786	0.9306	0.9999	0.9863

AGE	1991	1992	1993	1994	1995
1	0.0033	0.0018	0.0134	0.0176	0.0062
2	0.2025	0.1512	0.1662	0.2140	0.0576
3	0.6727	0.7515	0.5424	0.3937	0.4585
4	0.9536	1.0000	0.9311	0.7242	1.0000
5	1.0000	0.9958	1.0000	1.0000	0.9383
6	0.9627	0.9991	0.9488	0.7674	0.9878
7	0.9627	0.9991	0.9488	0.7674	0.9878

AGE	1996	1997	1998	1999	2000
1	0.0092	0.0045	0.0008	0.0005	0.0051
2	0.0820	0.1589	0.0842	0.2366	0.1414
3	0.4169	0.5952	0.4300	0.7033	0.5381
4	0.7400	1.0000	0.8558	0.8474	0.8548
5	1.0000	0.8409	1.0000	1.0000	1.0000
6	0.7801	0.9619	0.8856	0.8728	0.8867
7	0.7801	0.9619	0.8856	0.8728	0.8867

Table 29 Continued.

AGE	2001	2002	2003	2004	2005
1	0.0064	0.0027	0.0041	0.0057	0.0048
2	0.3174	0.0904	0.1483	0.1667	0.0842
3	0.7535	0.5339	0.6920	0.6044	0.5323
4	0.9672	0.8363	1.0000	1.0000	1.0000
5	1.0000	1.0000	0.7320	0.9776	0.9758
6	0.9761	0.8845	0.9016	0.9937	0.9925
7	0.9761	0.8845	0.9016	0.9937	0.9925

AGE	2006	2007
1	0.0093	0.0031
2	0.1429	0.0851
3	0.4753	0.3632
4	1.0000	0.4705
5	0.8981	1.0000
6	0.9683	0.7352
7	0.9683	0.7352

Spawning Stock Biomass

AGE	1981	1982	1983	1984	1985
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	4733.	4730.	3744.	3523.	3611.
4	3890.	4574.	5093.	3829.	3092.
5	1203.	2148.	2887.	2902.	1825.
6	341.	601.	1384.	1534.	1270.
7	217.	911.	1606.	2152.	1056.
Total	10384.	12964.	14714.	13939.	10855.

AGE	1986	1987	1988	1989	1990
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	2394.	2483.	2293.	1921.	1820.
4	3537.	1960.	1868.	1652.	1548.
5	1370.	1778.	747.	580.	588.
6	634.	646.	524.	173.	177.
7	727.	500.	271.	261.	174.
Total	8661.	7368.	5702.	4586.	4305.

Table 29 Continued.

AGE	1991	1992	1993	1994	1995
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	1908.	1294.	1066.	1240.	1606.
4	1599.	1466.	941.	935.	1244.
5	512.	527.	452.	264.	410.
6	199.	143.	158.	113.	86.
7	140.	86.	161.	71.	40.
Total	4359.	3515.	2778.	2623.	3386.

AGE	1996	1997	1998	1999	2000
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	1573.	1434.	1573.	1869.	1764.
4	1421.	1363.	1132.	1376.	1922.
5	387.	531.	398.	380.	702.
6	128.	100.	199.	114.	178.
7	52.	68.	97.	37.	116.
Total	3561.	3496.	3399.	3776.	4683.

AGE	2001	2002	2003	2004	2005
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	1644.	1009.	825.	687.	529.
4	1902.	1462.	962.	805.	764.
5	942.	826.	683.	428.	421.
6	310.	386.	301.	347.	208.
7	235.	184.	241.	362.	177.
Total	5033.	3867.	3011.	2628.	2098.

Table 29 Continued.

AGE	2006	2007
1	0.	0.
2	0.	0.
3	1113.	1213.
4	634.	1524.
5	401.	331.
6	219.	216.
7	232.	84.
Total	2599.	3368.

Bootstrap Summary Report

Number of Bootstrap Repetitions Requested = 1000
Number of Bootstrap Repetitions Completed = 1000
Bootstrap Output Variable: Stock Estimates (2008)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 1	8837.	10251.	6192.	0.6040
N 2	2939.	3015.	806.	0.2674
N 3	3803.	3835.	658.	0.1715
N 4	3583.	3631.	670.	0.1845
N 5	1814.	1816.	381.	0.2099
N 6	187.	197.	75.	0.3803
N 7	83.	106.	72.	0.6807

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 1	1414.	201.	16.0029	7423.	0.8341
N 2	76.	26.	2.5759	2864.	0.2815
N 3	32.	21.	0.8503	3771.	0.1744
N 4	49.	21.	1.3575	3534.	0.1896
N 5	2.	12.	0.1291	1812.	0.2105
N 6	10.	2.	5.2210	177.	0.4222
N 7	23.	2.	27.9950	60.	1.2100

	LOWER 80. % CI	UPPER 80. % CI
N 1	3926.	19130.
N 2	2082.	4103.
N 3	3001.	4690.
N 4	2815.	4478.
N 5	1348.	2317.
N 6	107.	295.
N 7	32.	203.

Table 29 Continued.

Bootstrap Output Variable: Fishing Mortality (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0028	0.0029	0.000784	0.2710
AGE 2	0.0751	0.0766	0.012928	0.1687
AGE 3	0.3209	0.3255	0.053652	0.1648
AGE 4	0.4156	0.4277	0.074216	0.1735
AGE 5	0.8833	0.9178	0.250750	0.2732
AGE 6	0.6495	0.6727	0.136016	0.2022
AGE 7	0.6495	0.6727	0.136016	0.2022

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000127	0.000025	4.5736	0.0026	0.2969
AGE 2	0.001469	0.000411	1.9554	0.0737	0.1755
AGE 3	0.004627	0.001703	1.4422	0.3162	0.1697
AGE 4	0.012098	0.002378	2.9110	0.4035	0.1839
AGE 5	0.034455	0.008004	3.9006	0.8489	0.2954
AGE 6	0.023277	0.004364	3.5840	0.6262	0.2172
AGE 7	0.023277	0.004364	3.5840	0.6262	0.2172

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.001982	0.003899
AGE 2	0.061349	0.094284
AGE 3	0.264199	0.391995
AGE 4	0.338684	0.526526
AGE 5	0.639456	1.244800
AGE 6	0.522168	0.860745
AGE 7	0.522168	0.860745

Table 29 Continued.

Bootstrap Output Variable: Average F (2007) AGES 4 - 5

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AVG F	0.6495	0.6727	0.136016	0.2022
N WTD	0.4816	0.4937	0.078975	0.1600
B WTD	0.5019	0.5140	0.081910	0.1593
C WTD	0.5189	0.5360	0.085905	0.1603

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AVG F	0.023277	0.004364	3.5840	0.6262	0.2172
N WTD	0.012027	0.002526	2.4971	0.4696	0.1682
B WTD	0.012116	0.002618	2.4140	0.4898	0.1672
C WTD	0.017038	0.002770	3.2832	0.5019	0.1712

	LOWER 80. % CI	UPPER 80. % CI
AVG F	0.522168	0.860745
N WTD	0.397060	0.596489
B WTD	0.414336	0.620860
C WTD	0.437215	0.650059

Table 29 Continued.

Bootstrap Output Variable: Biomass

JAN-1 Biomass (2008) Mean Biomass & SSB (2007)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
JAN-1	6347.	6522.	737.	0.1129
MEAN	6197.	6252.	606.	0.0969
SSB	3368.	3390.	357.	0.1053

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
JAN-1	175.	24.	2.7496	6173.	0.1193
MEAN	55.	19.	0.8845	6142.	0.0986
SSB	23.	11.	0.6757	3345.	0.1067

	LOWER 80. % CI	UPPER 80. % CI
JAN-1	5600.	7474.
MEAN	5482.	7043.
SSB	2936.	3825.

Table J30. Input values for SNE/MA winter flounder BRP calculations based on 2003-2007 average values from the GARM3 SPLIT VPA run; mean weights in kilograms.

M = 0.2

Age	PR	Maturity	Mid-Year Catch XW	SSB XW	Jan 1 XW
1	0.01	0.00	0.115	0.065	0.065
2	0.14	0.00	0.382	0.221	0.221
3	0.59	0.55	0.498	0.435	0.435
4	0.97	0.95	0.648	0.572	0.572
5	1.00	1.00	0.839	0.736	0.736
6	1.00	1.00	1.028	0.917	0.917
7+	1.00	1.00	1.247	1.247	1.247

Table J31. Biological reference points for SNE/MA Winter flounder from the non-parametric empirical approach; MSY and SSB_{MSY} in metric tons, R in thousands of age 1 fish.

Parametric BRPs

	BRP2002; GARM 2 SRFIT	GARM3 BASE AGEPRO T2006	GARM3 SPLIT AGEPRO T2006	GARM3 BASE AGEPRO T2007	GARM3 SPLIT AGEPRO T2007
MSY	10606	n/a	n/a	n/a	n/a
FMSY	0.320	n/a	n/a	n/a	n/a
SSB_{MSY}	30144	n/a	n/a	n/a	n/a

Non-Parametric BRPs

	BRP2002; GARM 2	GARM3 BASE AGEPRO T2006	GARM3 SPLIT AGEPRO T2006	GARM3 BASE AGEPRO T2007	GARM3 SPLIT AGEPRO T2007
F40%	0.210	0.260	0.260	0.248	0.248
YPR	0.246	0.274	0.274	0.276	0.276
SSBR	1.106	1.070	1.070	1.098	1.098
Mean R	35920	35239	35239	35239	35239
MSY	10420	9658	9658	9742	9742
SSB_{MSY}	46810	37608	37608	38761	38761

Table J32. Stock status in 2007 and 2009-2014 projection results for SNE/MA winter flounder. Catch and SSB in metric tons.

Status and Projections

	GARM3 SPLIT AGEPRO T2007
FMSY = F40%	0.248
F2007	0.649
F2007/FMSY	2.62
SSB_{MSY}	38761
SSB2007	3368
$SSB2007/SSB_{MSY}$	0.09
F2009-2014	0.248
Total Catch 2009	1116
SSB2014	14202
SSB_{MSY}	38761
Prob => SSB_{MSY}	<1%
F2009-2014	0.000
Total Catch 2009	0
SSB2014	28663
SSB_{MSY}	38761
Prob => SSB_{MSY}	1%

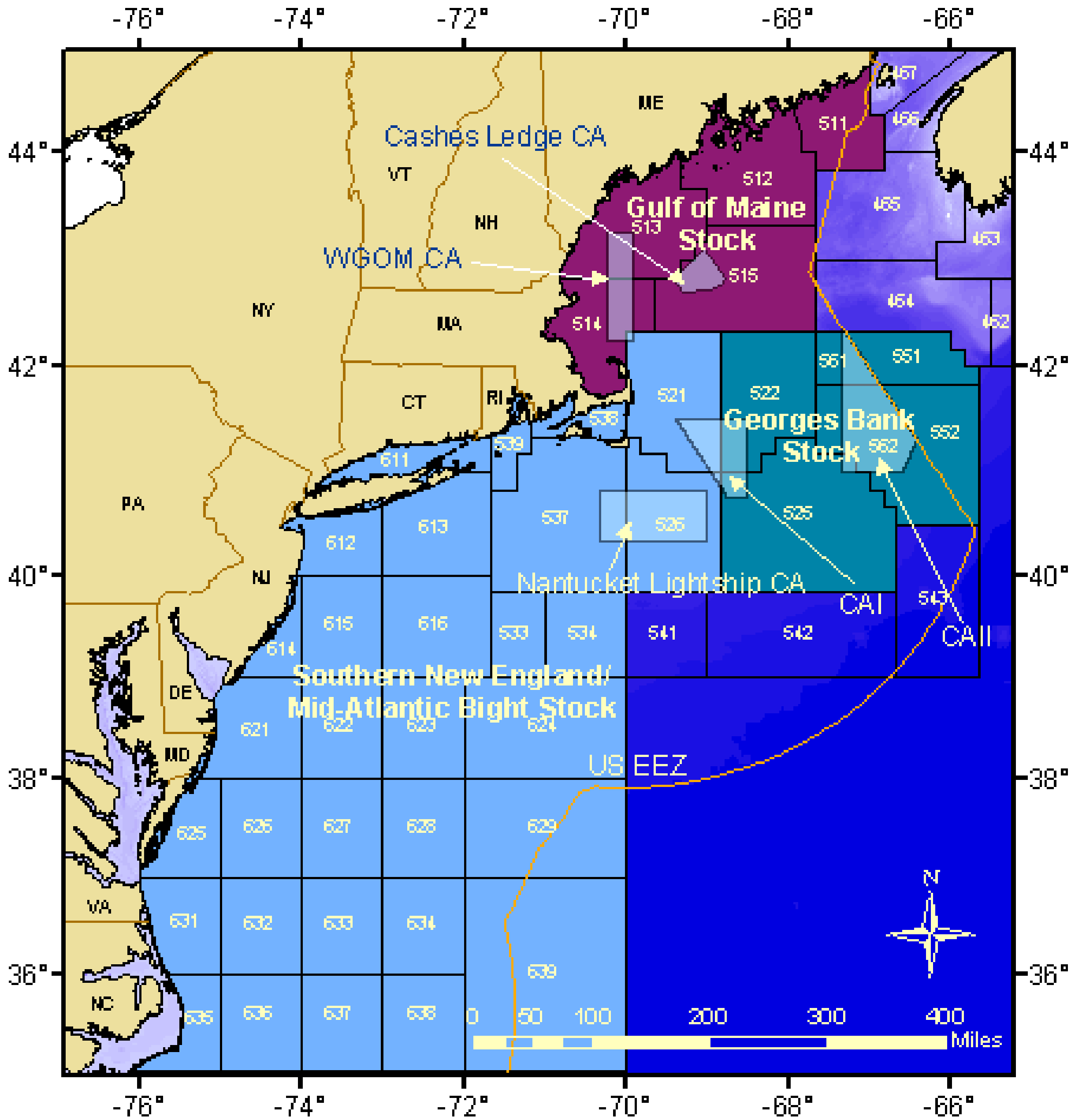


Figure J1. Statistical areas used to define winter flounder stocks. The Southern New England/Mid-Atlantic Bight complex includes areas 521, 526, and 533-639.

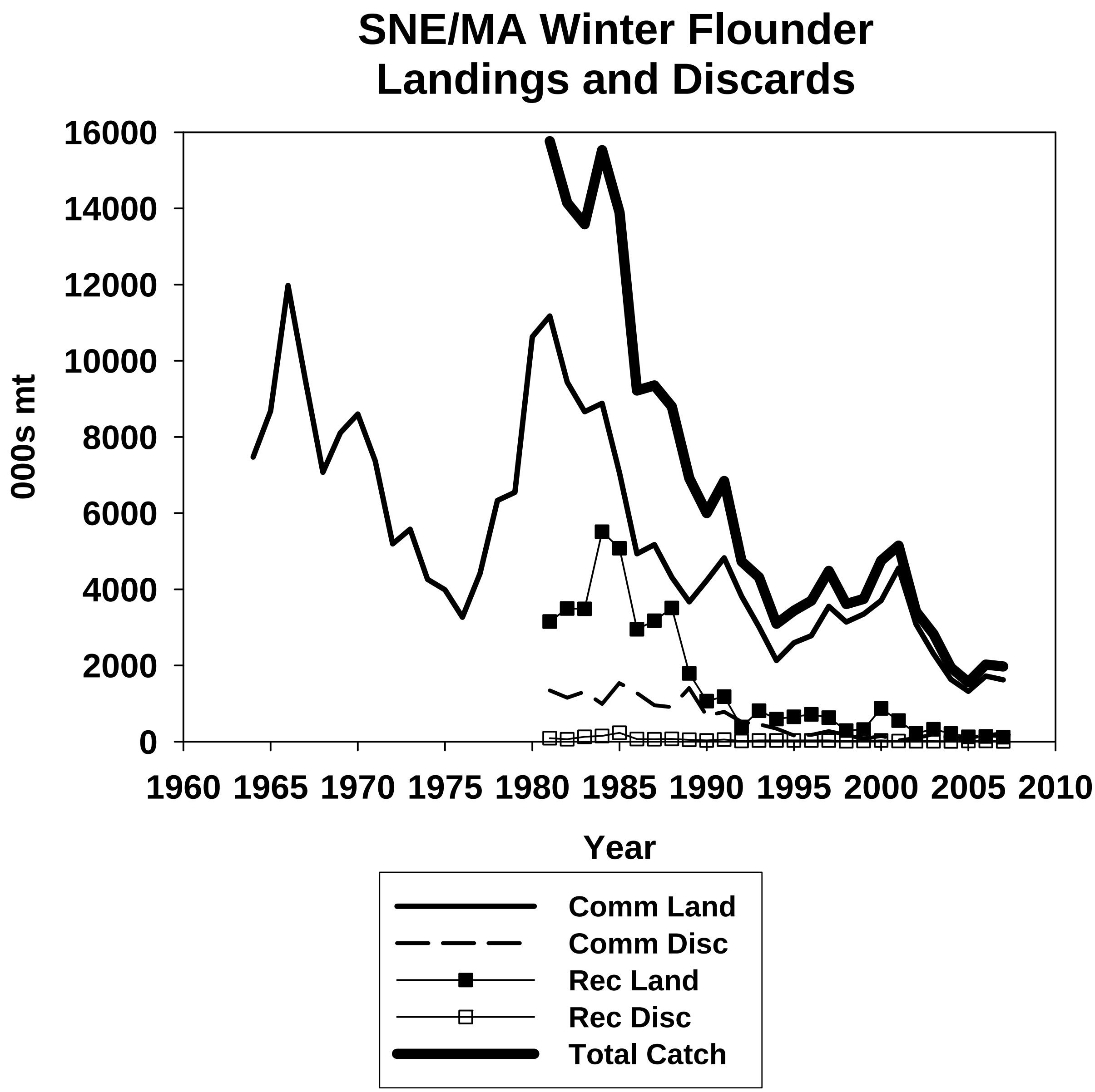


Figure J2. Commercial landings (1964-2007), commercial discards (1981-2007) recreational landings (1981-2007), recreational discards (1981-2007) and total fishery catch (1981-2007) for the SNE/MA winter flounder stock complex.

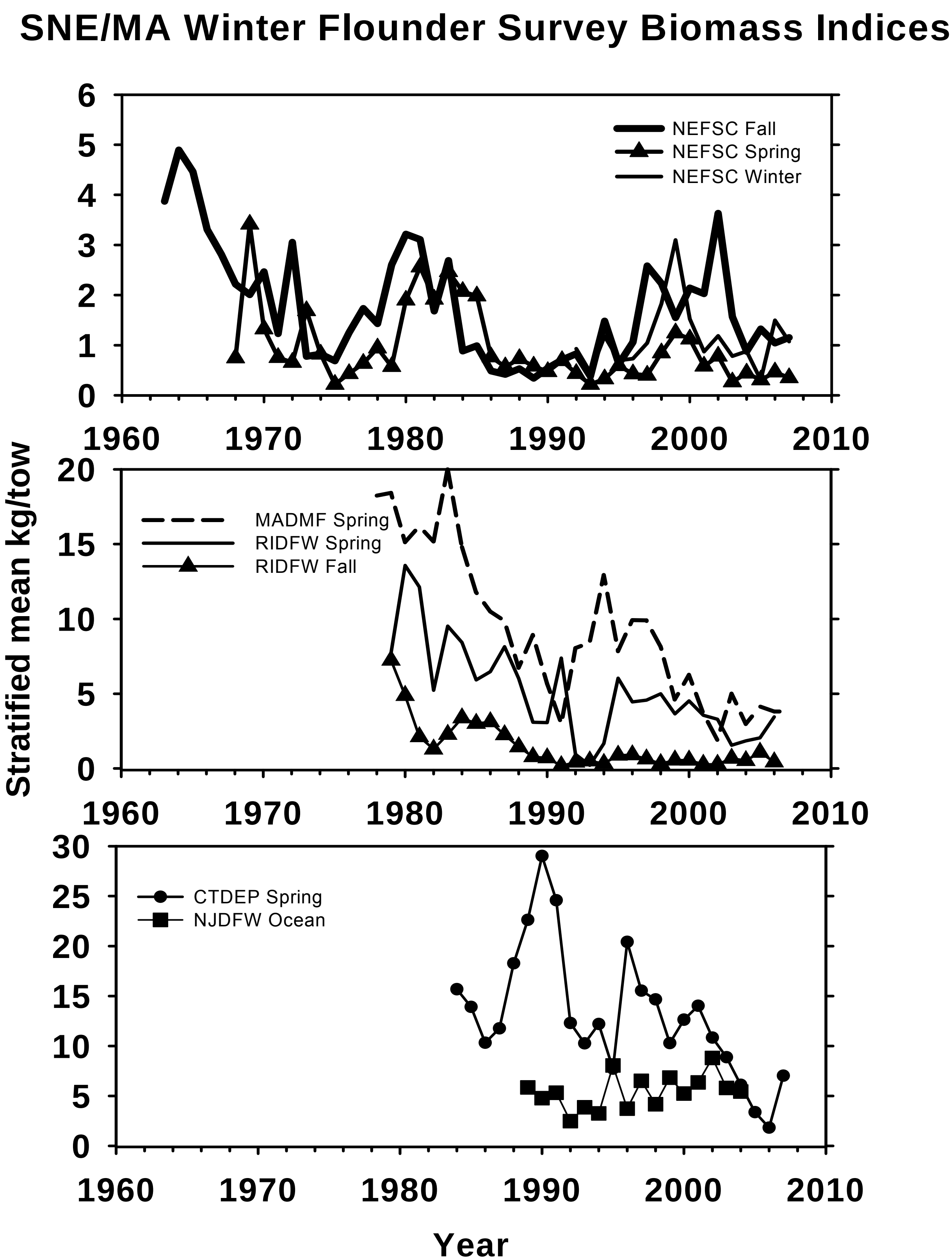


Figure J3. Trends in research survey biomass indices for SNE/MA winter flounder.

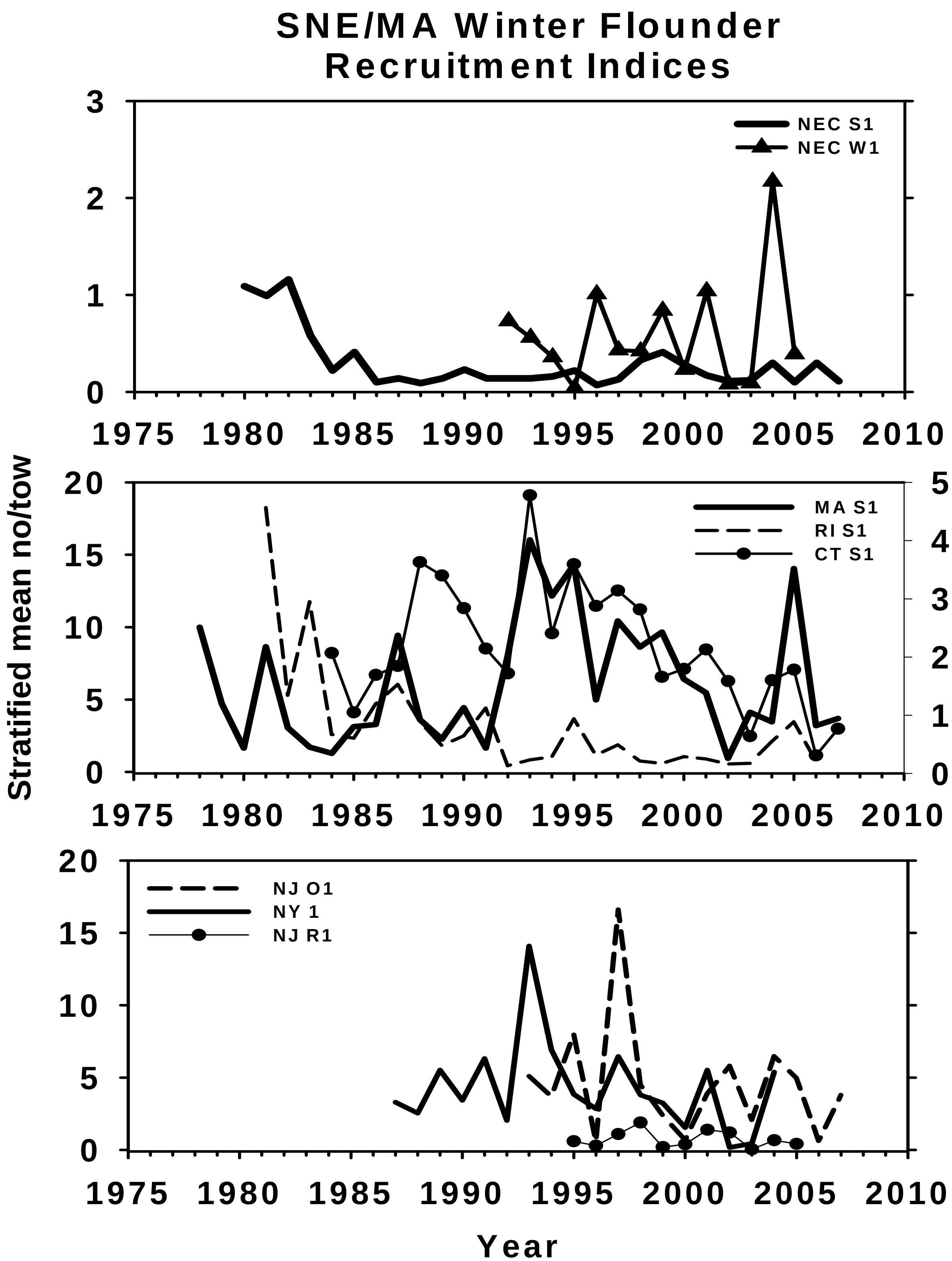


Figure J4. Trends in research survey recruitment indices for SNE/MA winter flounder.

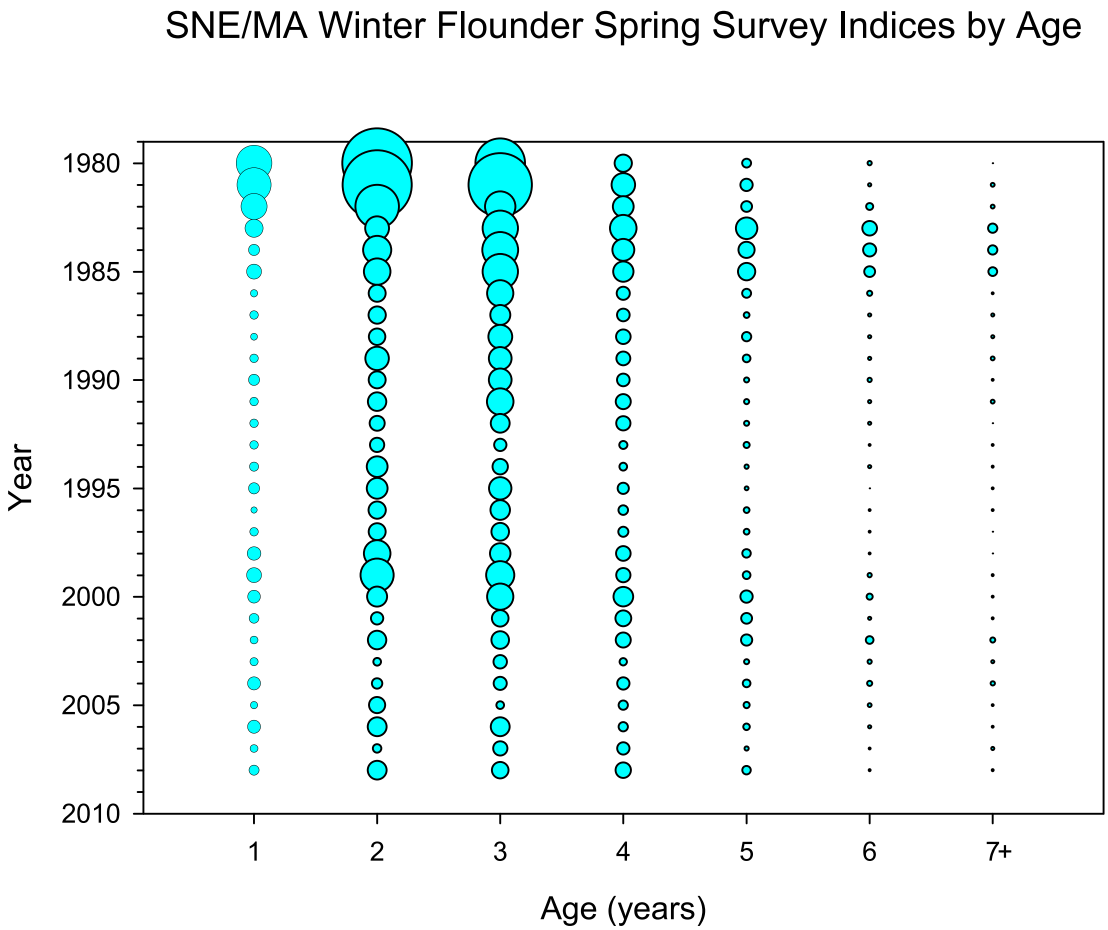


Figure J5. Age 1+ structure of the SNE/MA winter flounder population, 1980-2008.

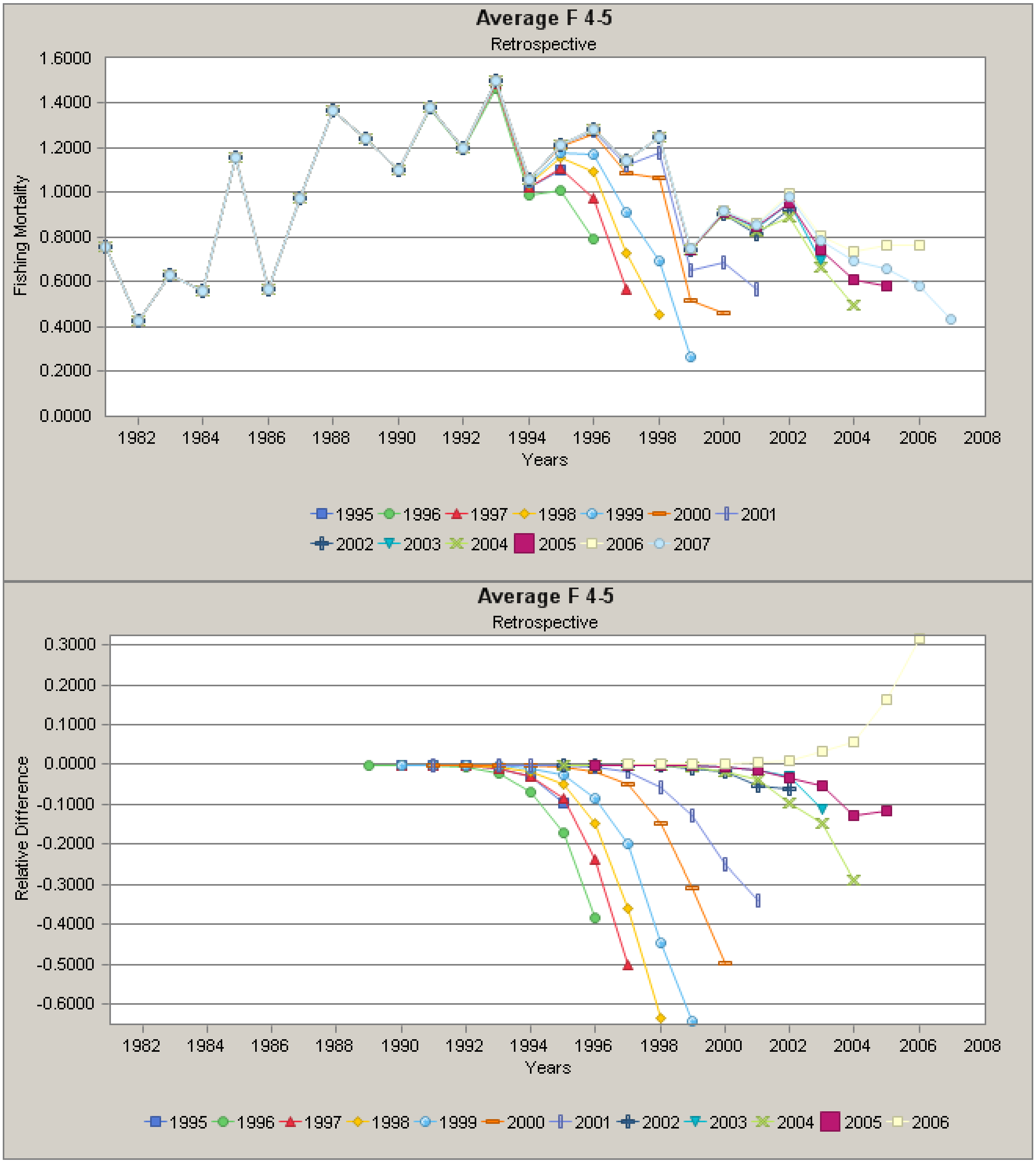


Figure J6. Retrospective analysis of F for the GARM3 BASE run.

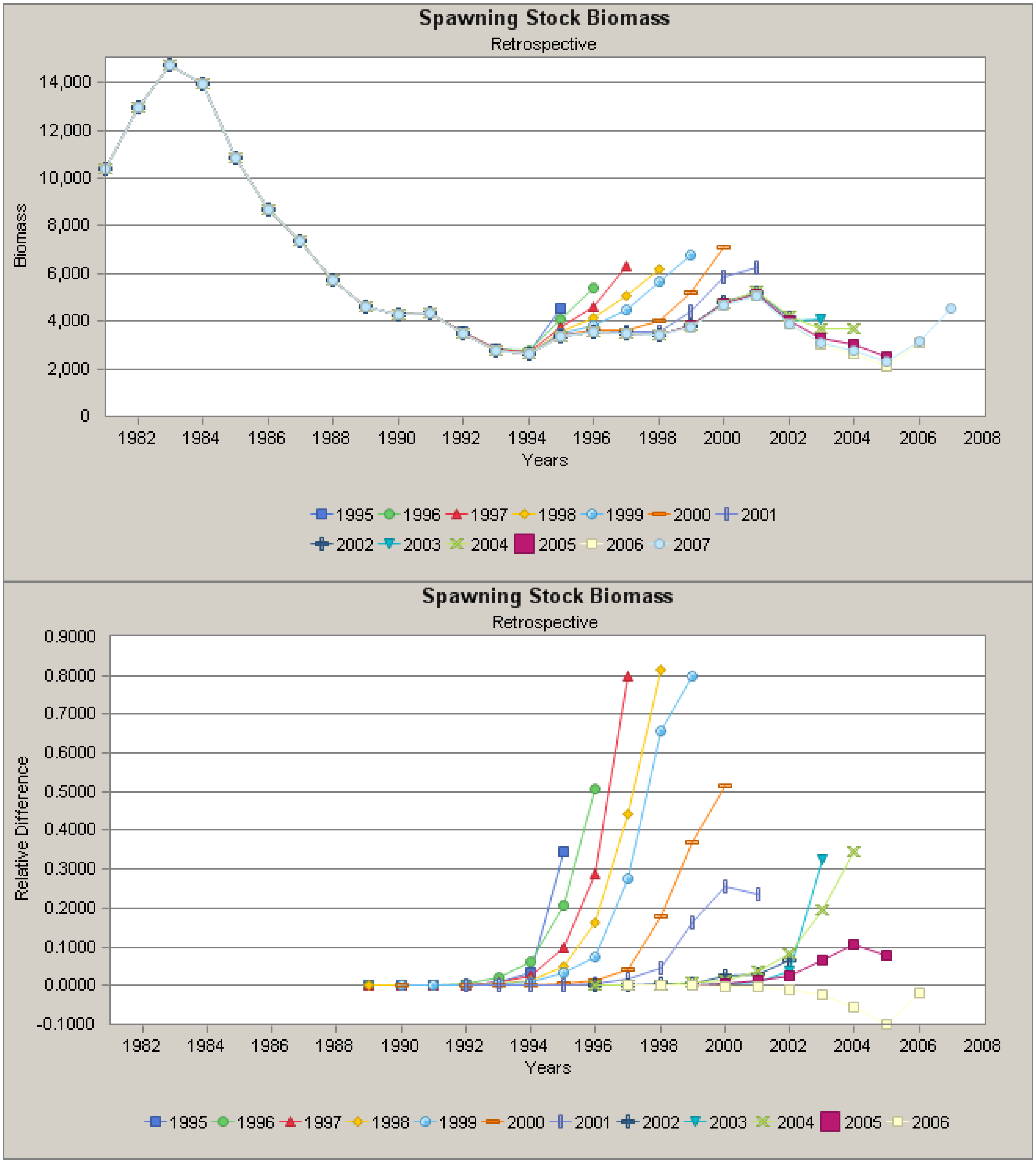


Figure J7. Retrospective analysis of SSB for the GARM3 BASE run.

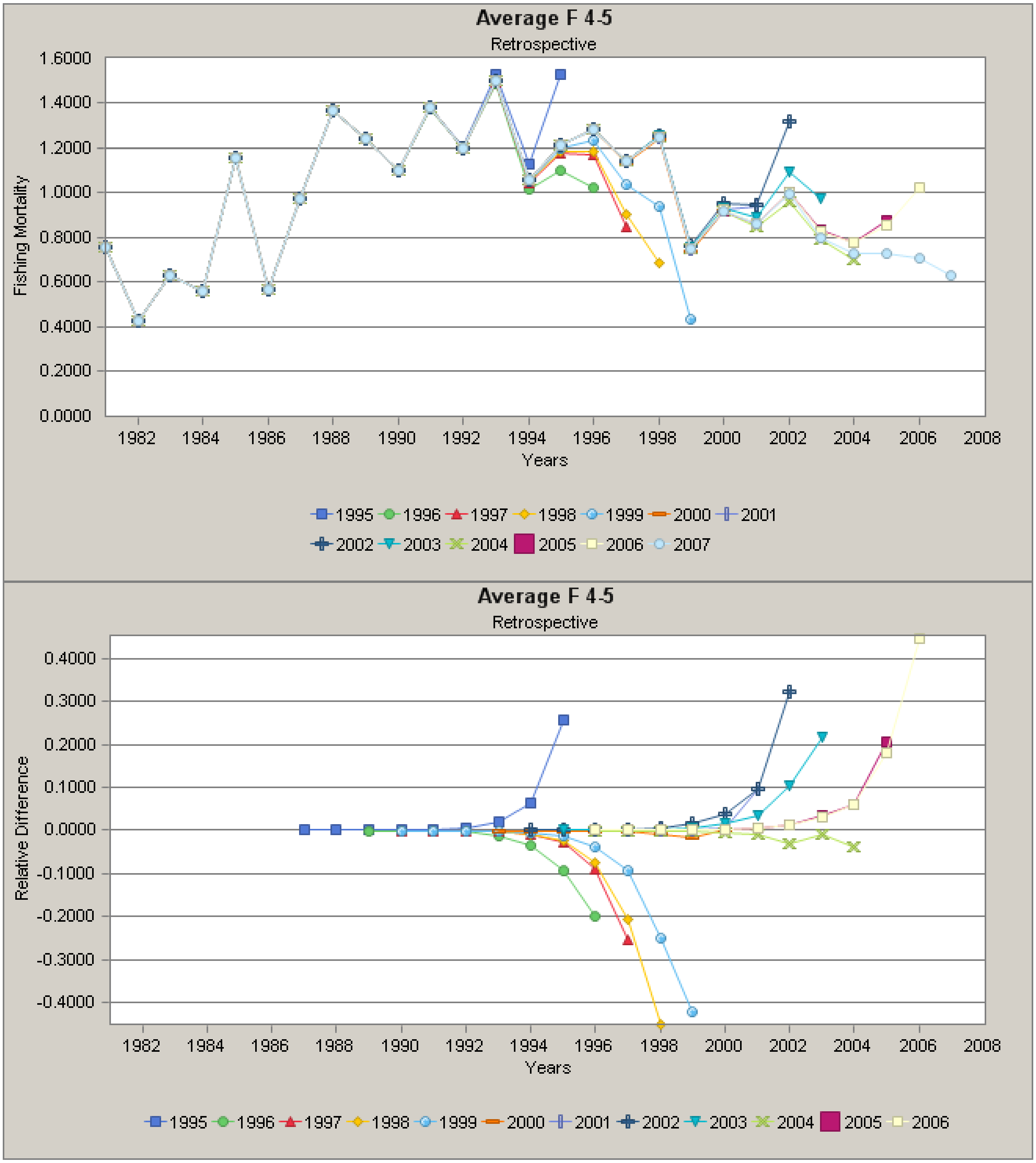


Figure J8. Retrospective analysis of F for the GARM3 SPLIT run.

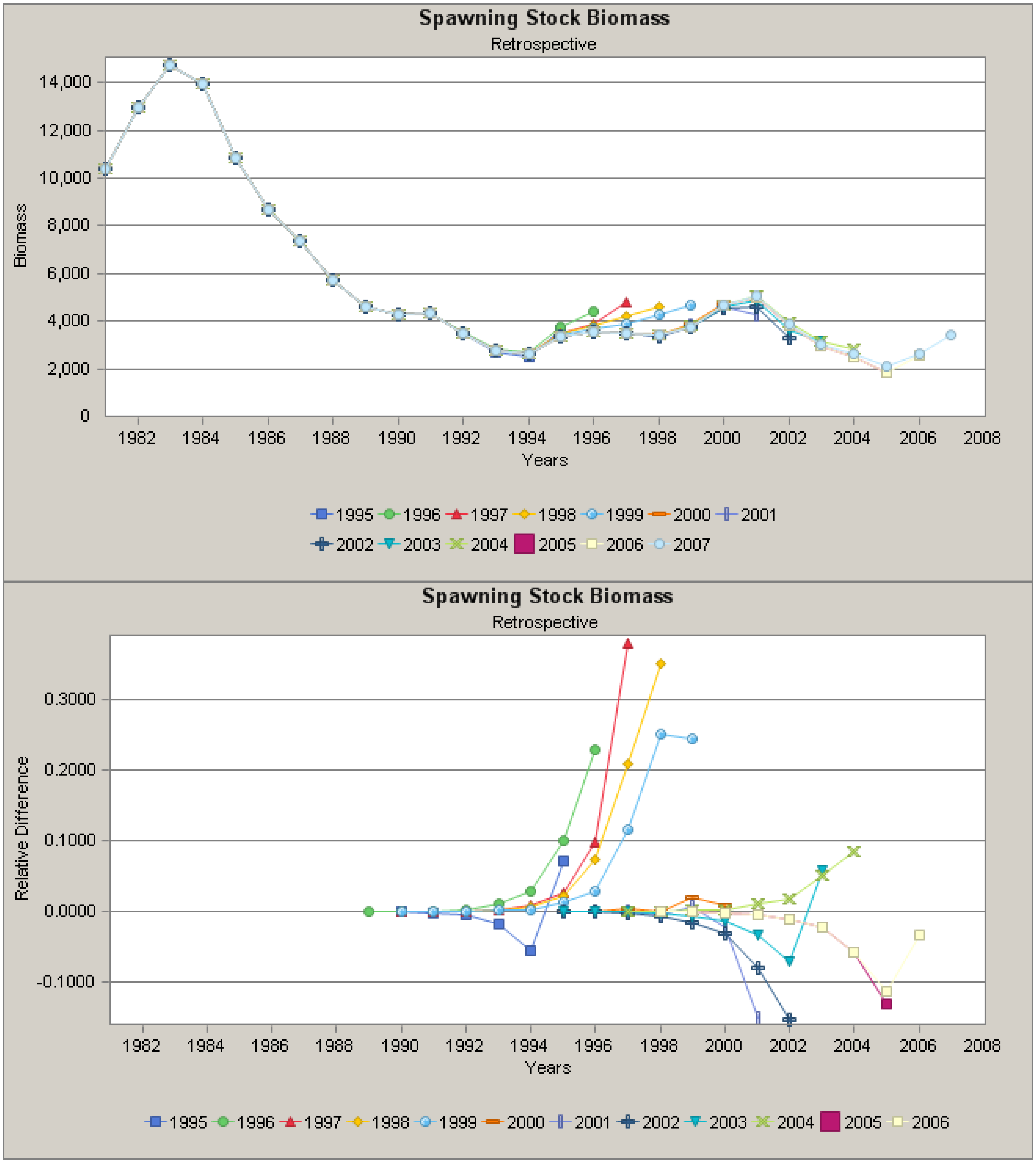


Figure J9. Retrospective analysis of SSB for the GARM3 SPLIT run.

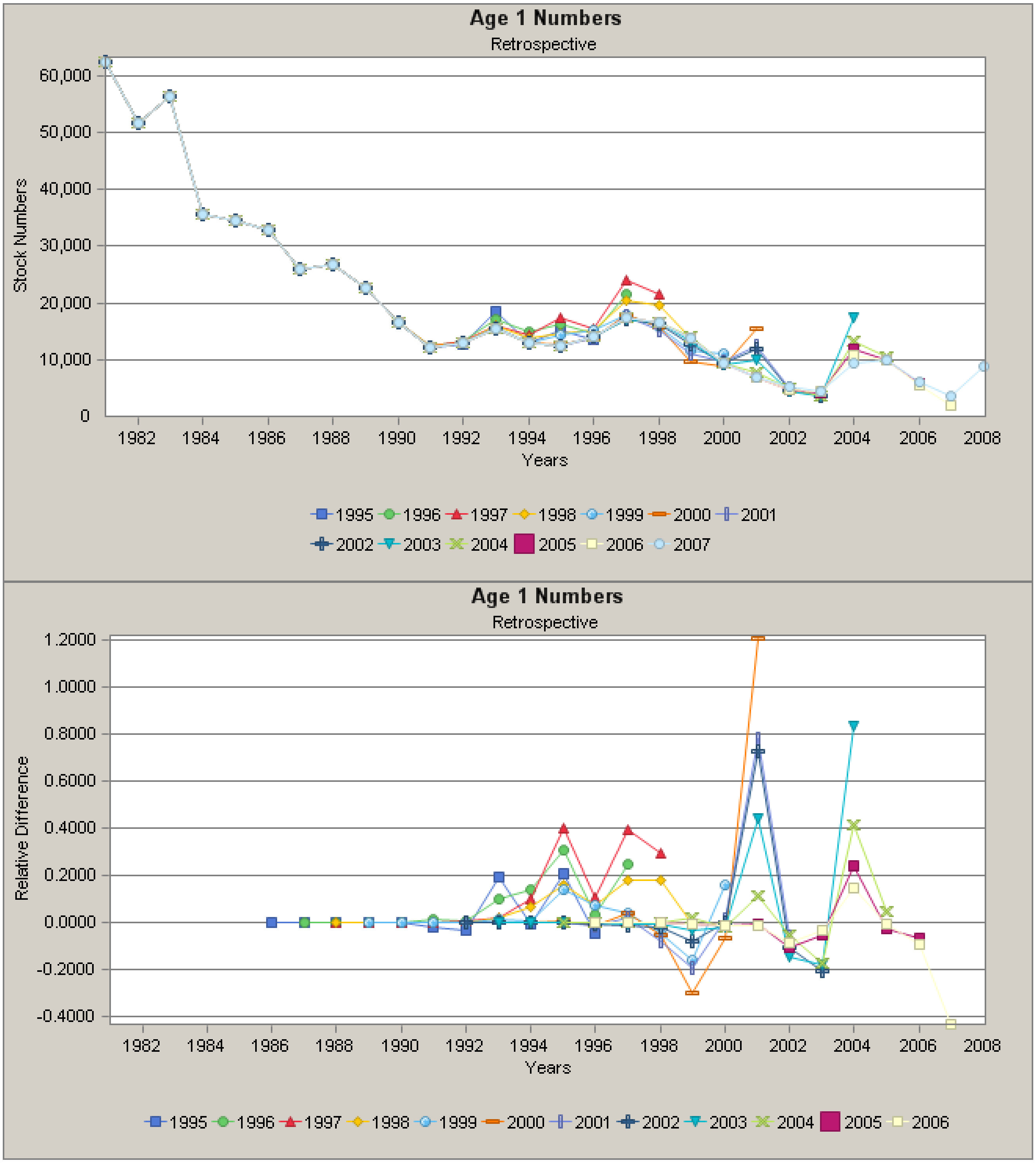
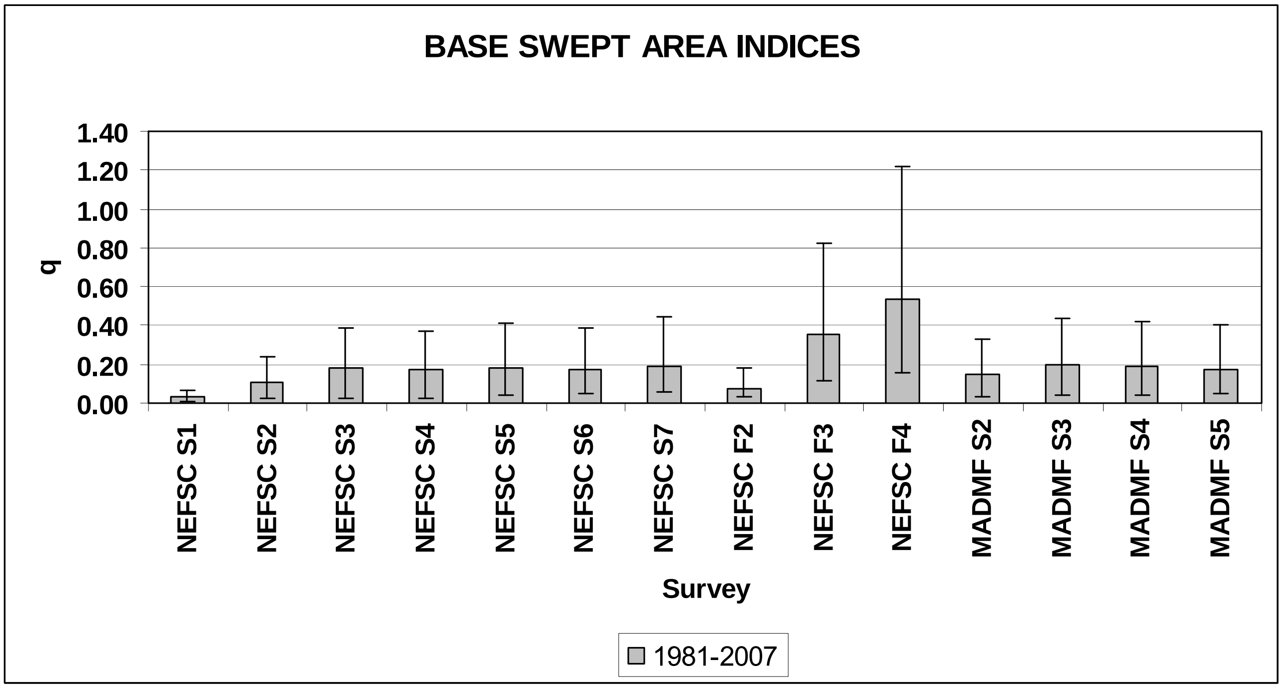


Figure J10. Retrospective analysis of recruitment at age 1 for the GARM3 SPLIT run.



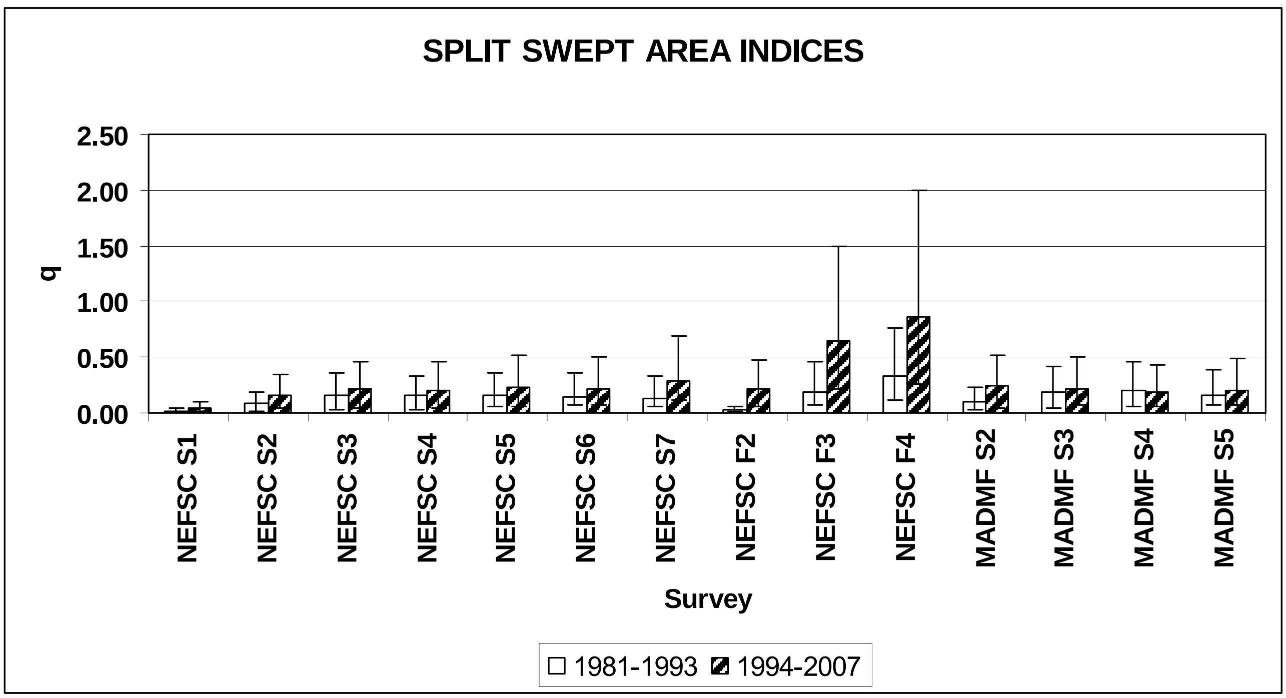


Figure J11. Comparison of swept area (absolute N) survey index catchability coefficents (q) for the BASE and SPLIT VPA run configurations; error bars are +/- 2 standard errors.

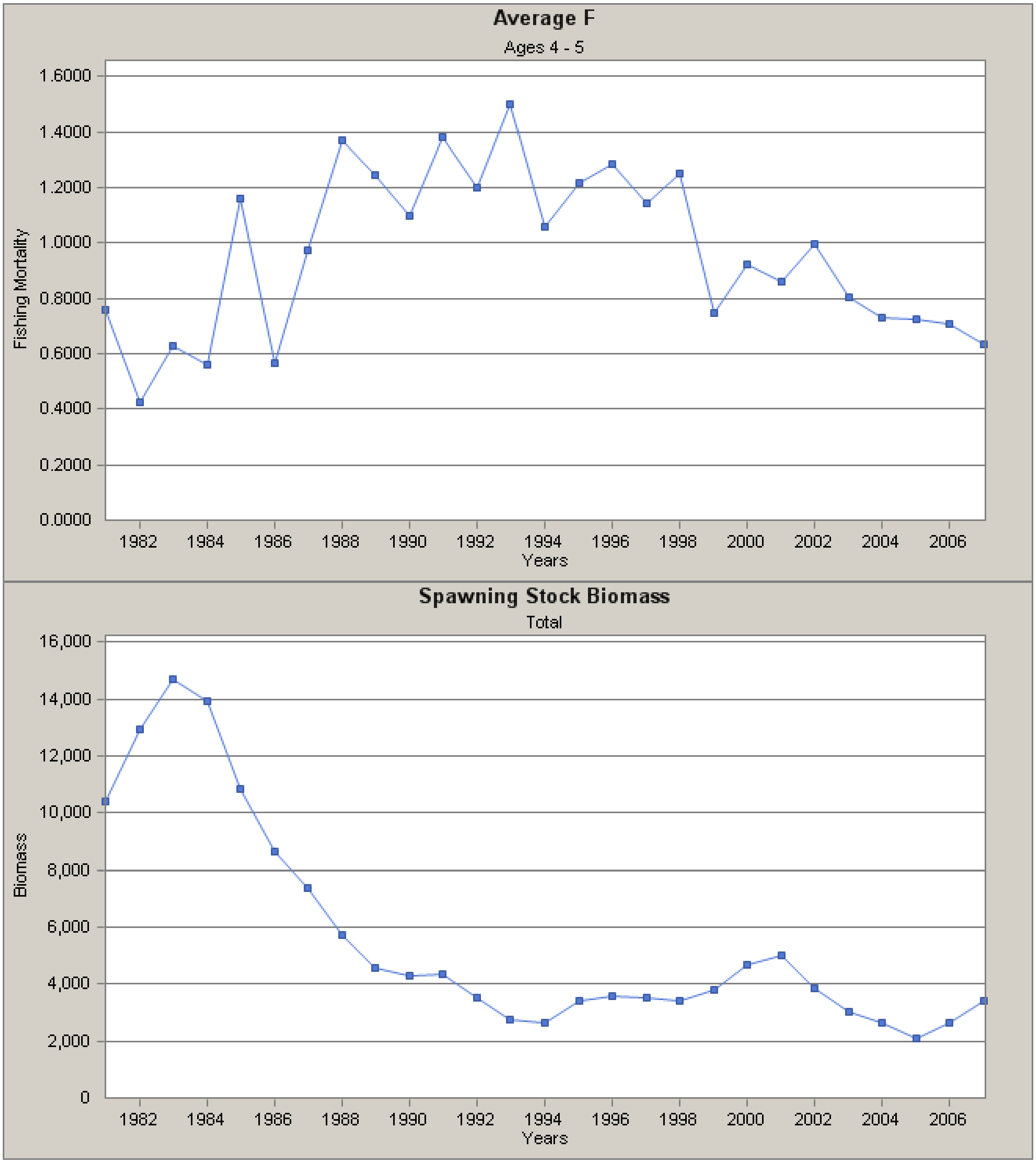


Figure J12. Fishing mortality (F ages 4-5, unweighted) and SSB for the GARM3 SPLIT run.

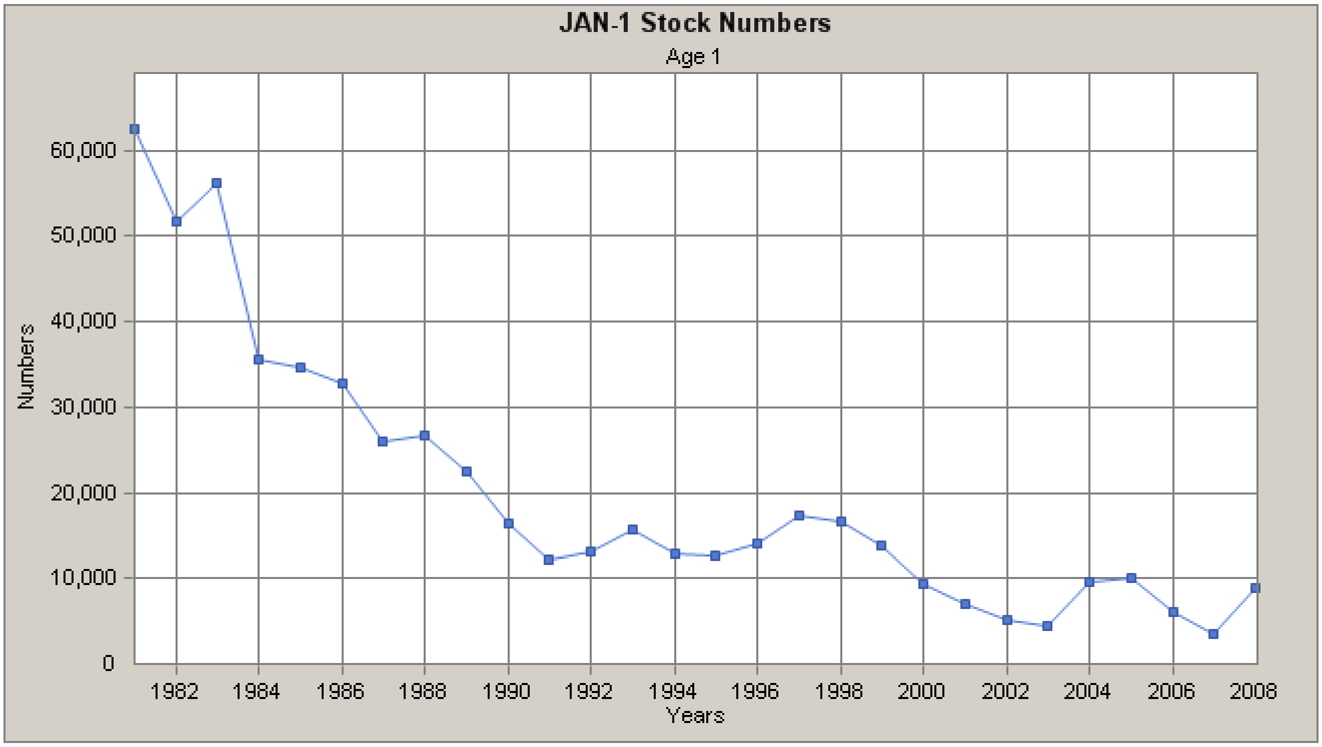


Figure J13. Recruitment at age 1 (000s) for the GARM3 SPLIT run.

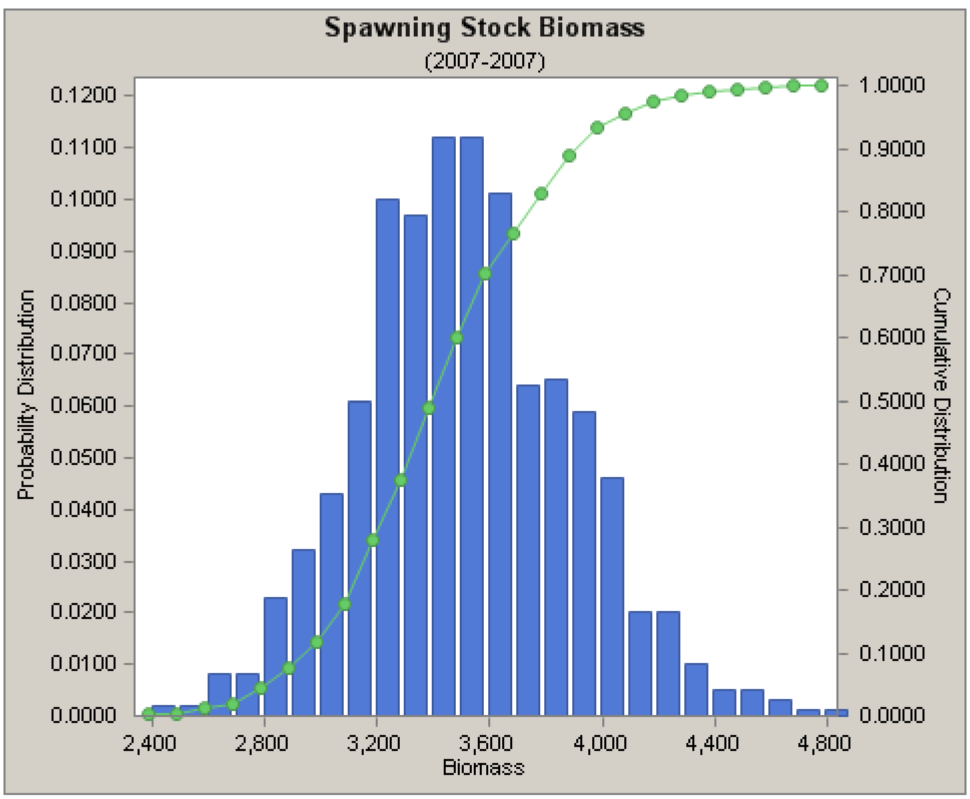


Figure J14. Bootstrap distribution of 2007 Spawning Stock Biomass (SSB, metric tons).

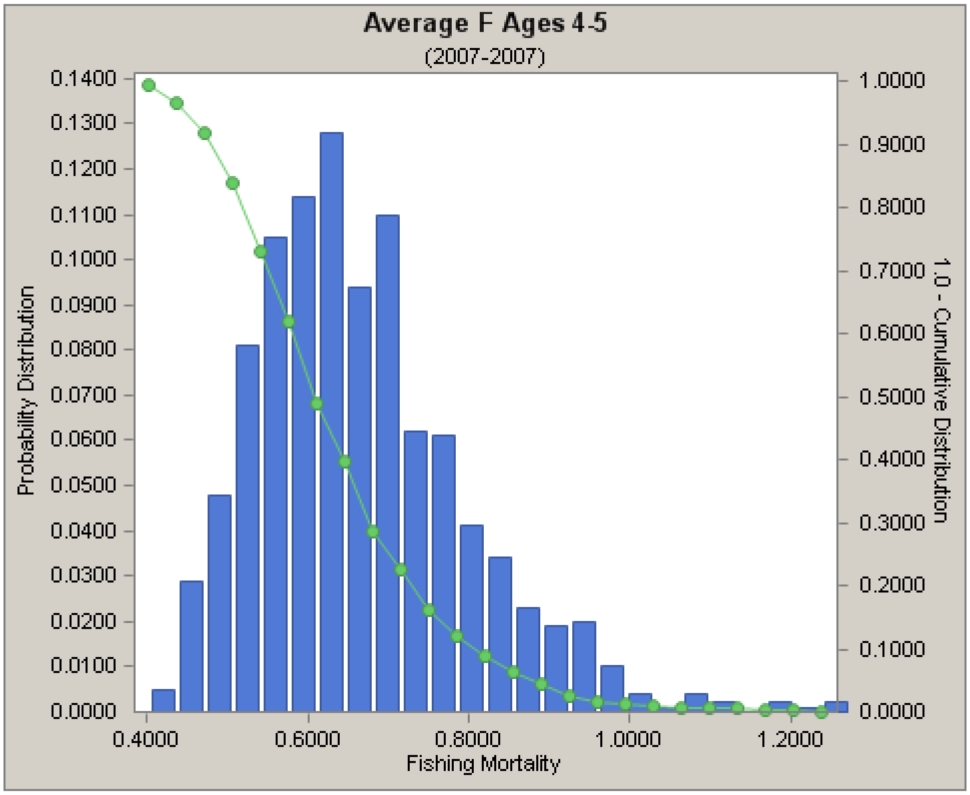


Figure J15. Bootstrap distribution of 2007 Fishing Mortality (F ages 4-5, unweighted).

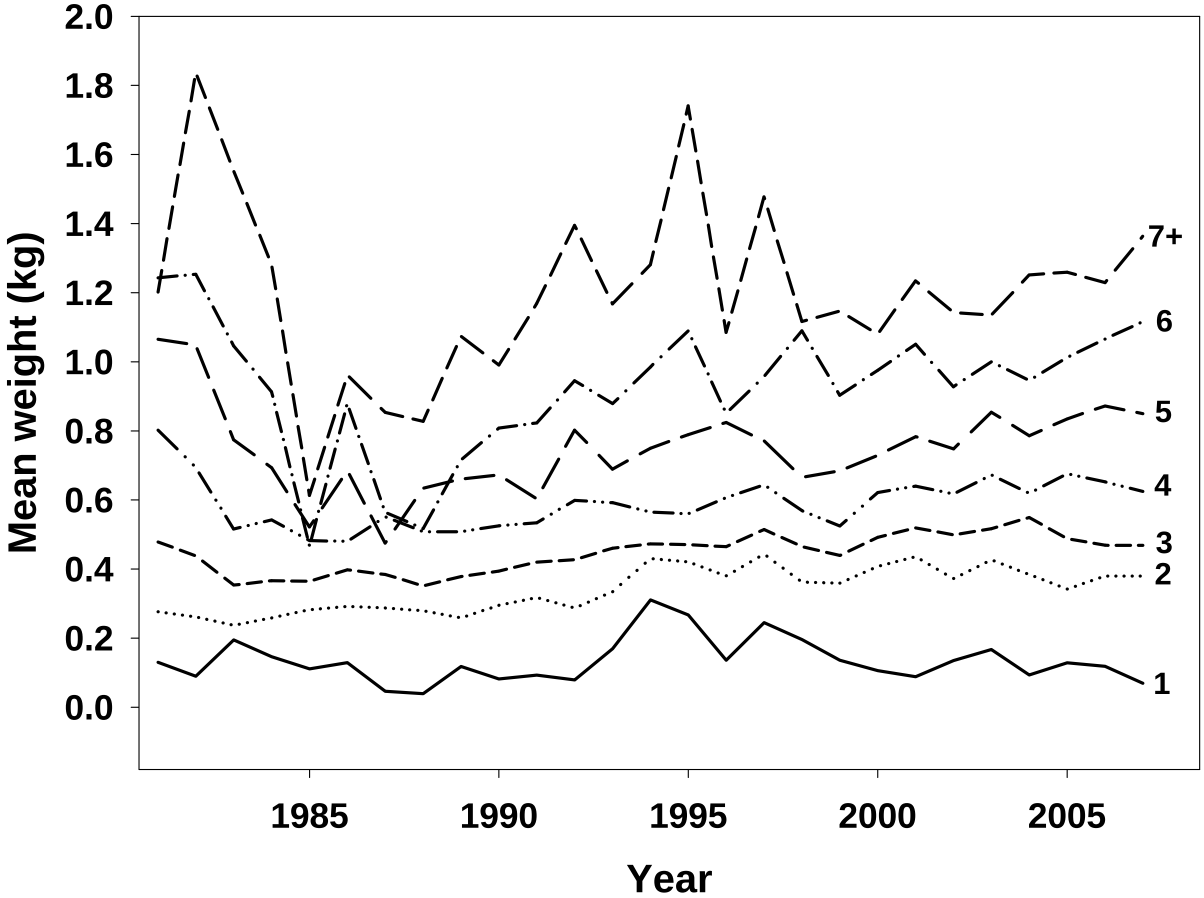


Figure J16. Trends in mean weight at age in the total catch of SNE/MA winter flounder.

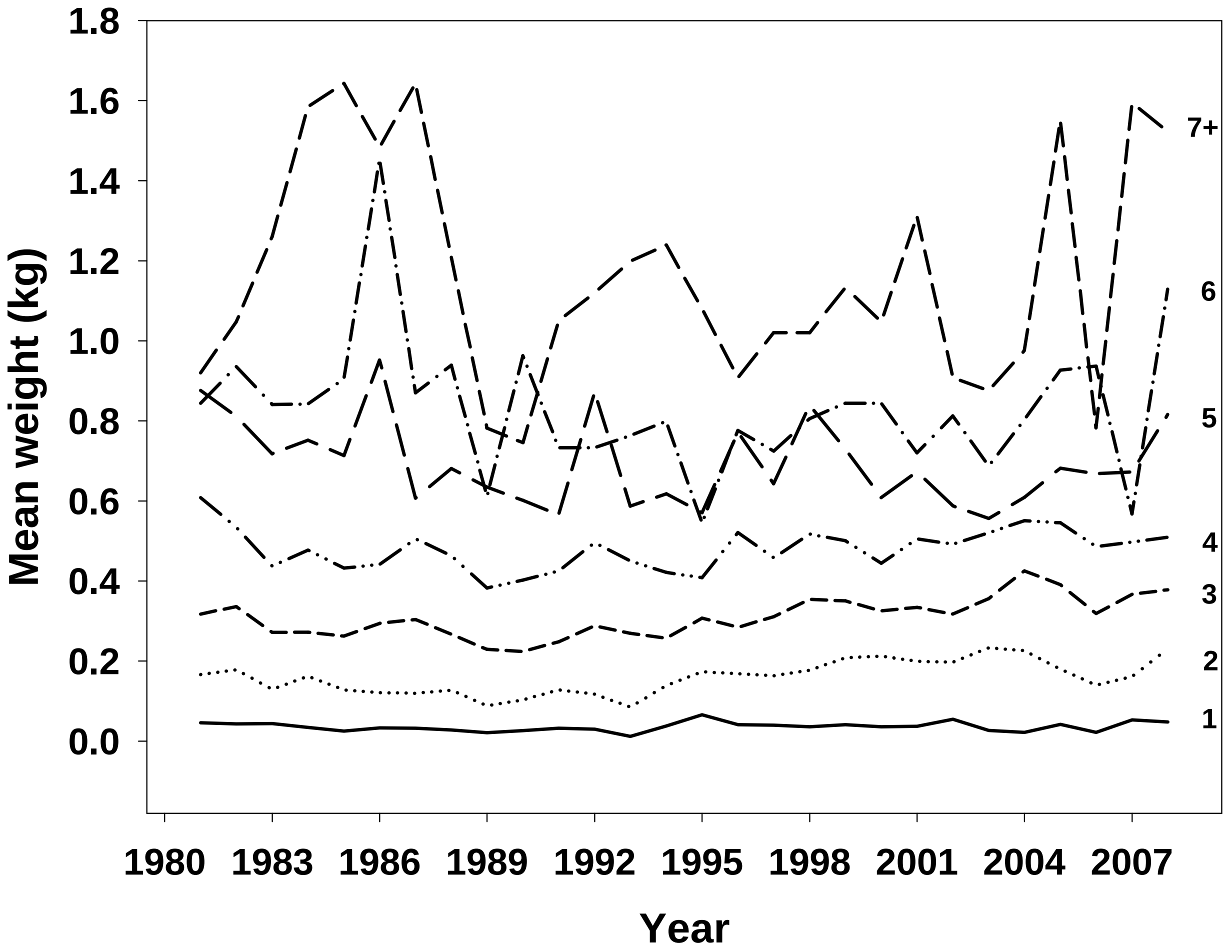
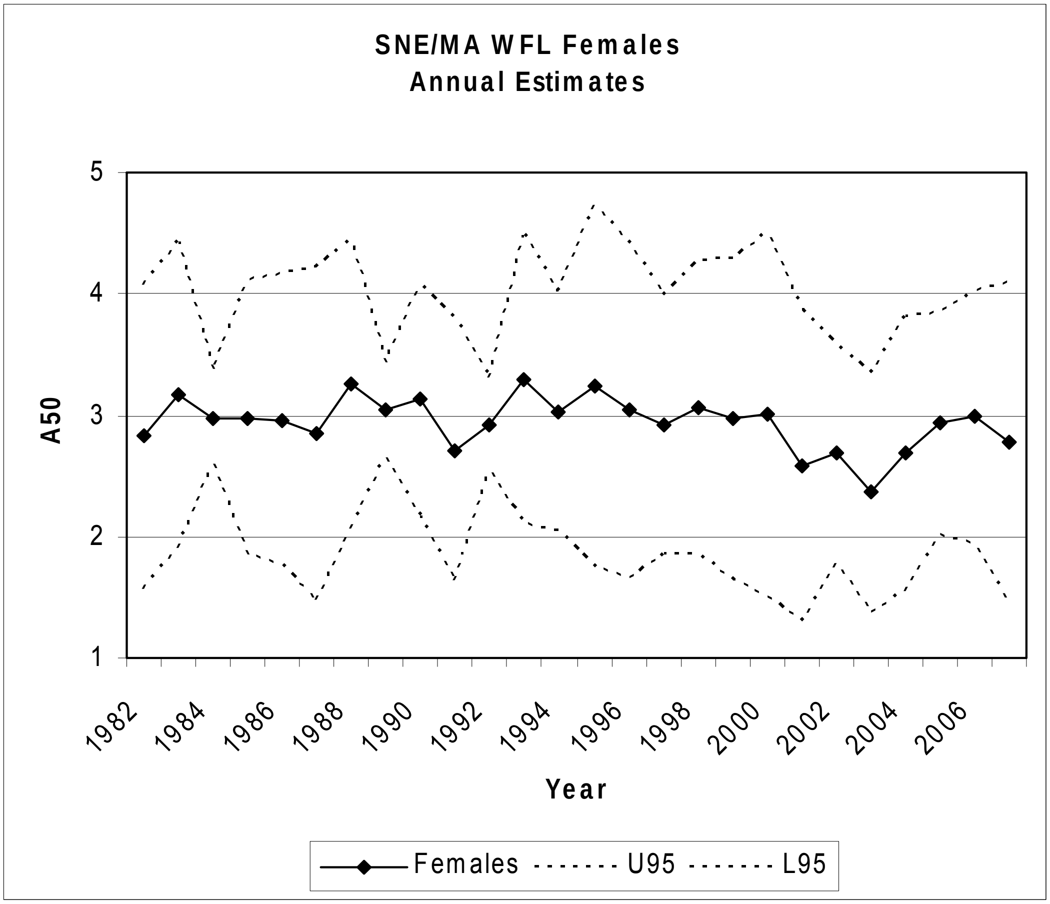


Figure J17. Trends in mean weight at age in the NEFSC Spring survey catch of SNE/MA winter flounder.



	1999 SAW28 BRP2002		2008 GARM 3	
L50	29.00		29.20	
A50	3.00		2.90	
Age				
1	0.00		0.00	
2	0.06	*0.00*	0.07	*0.00*
3	0.53		0.55	
4	0.95		0.95	
5	1.00		1.00	
6	1.00		1.00	
7+	1.00		1.00	

Figure J18. Time series pattern in female age of 50% maturity (A50) and time series estimates of female maturity at age for SNE/MA winter flounder.

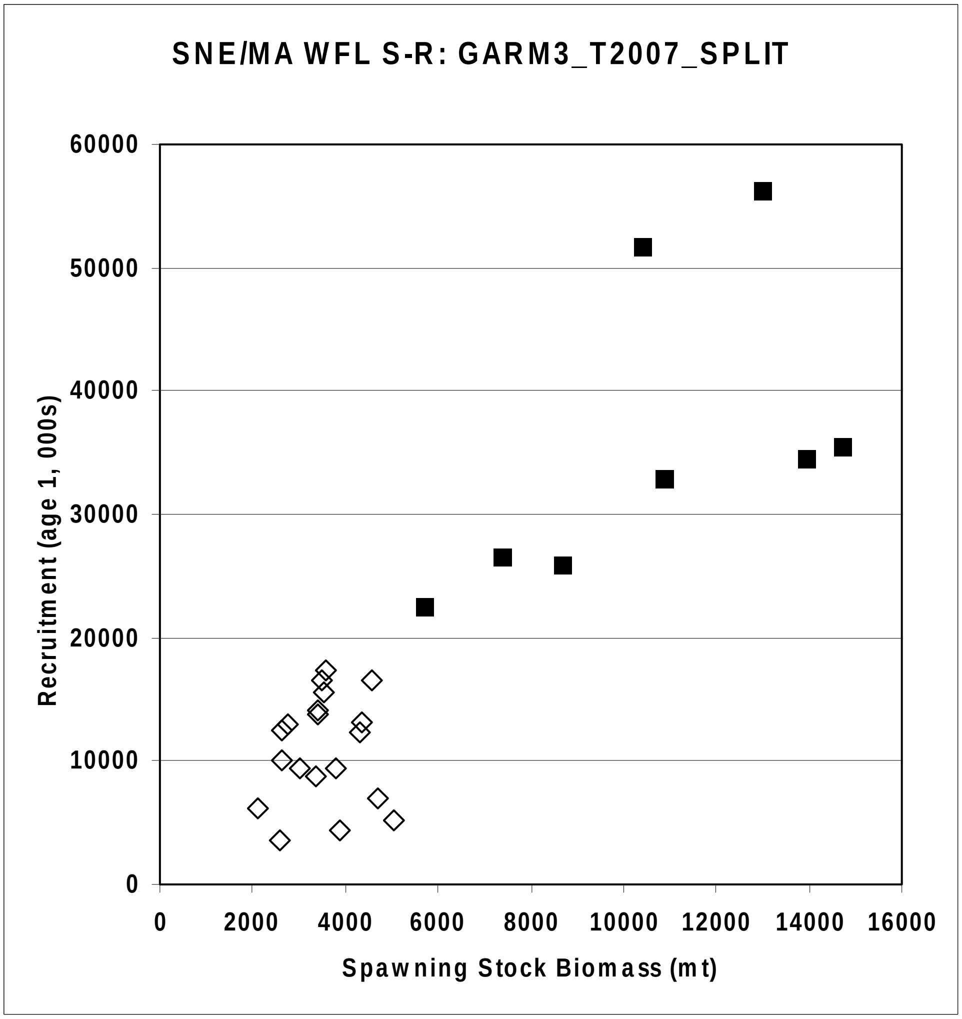


Figure J19. Spawning stock biomass (SSB; mt) and recruitment (age 1, 000s) estimates for SNE/MA winter flounder: GARM3 ADAPT VPA SPLIT run configuration; top 8 year classes used in reference point calculations (SSB > 5,700 mt) in solid square symbols, others in open diamonds.

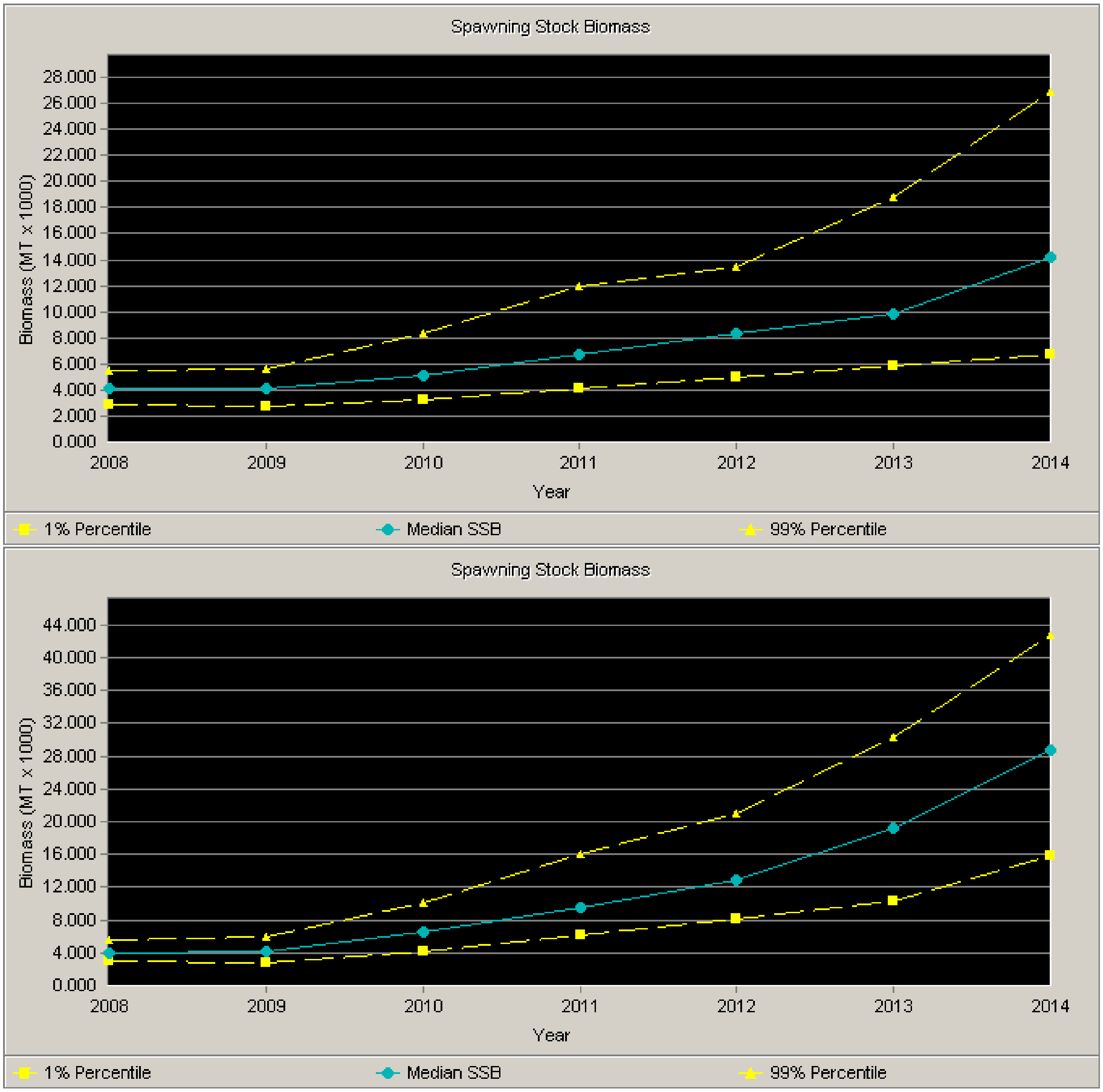


Figure J20. Top panel: projection of SNE/MA winter flounder SSB to 2014 under F_{MSY} = F40% = 0.248 during 2009-2014; median SSB in 2014 = 14,202 mt. Bottom panel: projection of SNE/MA winter flounder SSB to 2014 under F = 0.000 during 2009-2014; median SSB in 2014 = 28,663 mt.

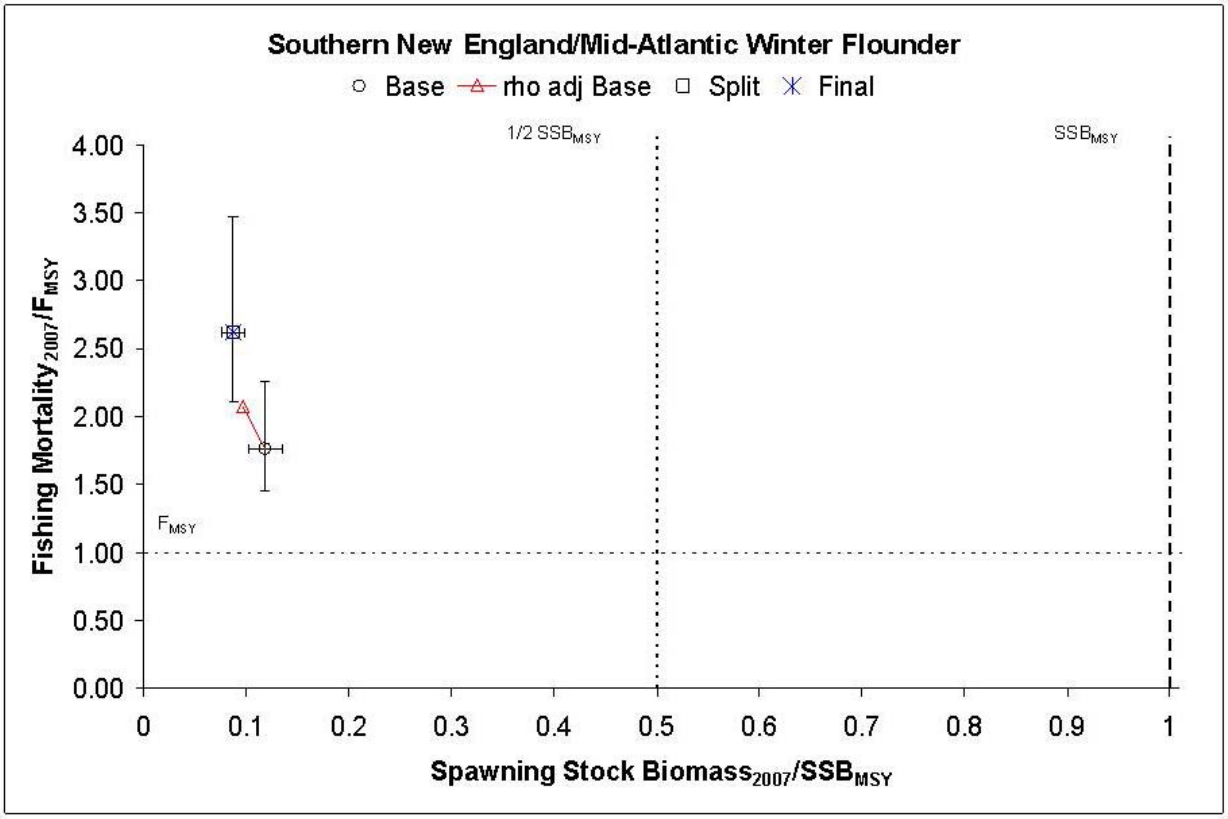


Figure J21. Southern New England/Mid-Atlantic winter flounder stock status in 2007.

K. Georges Bank winter flounder
by Lisa Hendrickson

1.0 Background

The Georges Bank (GB) winter flounder stock was last assessed in September 2005 during a Groundfish Assessment Review Meeting (GARM) meeting (NEFSC 2005). The assessment consisted of an updated run of the SARC 34 ASPIC production model (Prager 2004), because the results of the VPA model runs were considered unreliable at SARC 34, primarily due to poorly sampled fishery length and age compositions during the terminal years of the assessment period (NEFSC 2002a). Input data to the 2005 GARM model included landings (1964-2004) and NEFSC fall (1964-2004) and spring (1968-2005, lagged back one year) survey relative biomass indices.

The biological reference point estimates from the SARC 34 ASPIC model were also recommended for implementation by the 2002 Working Group on Re-estimation of Biological Reference Points for New England Groundfish (NEFSC 2002b). The current reference points are: F_{MSY} = 0.32, B_{MSY} = 9,400 mt, and MSY = 3,000 mt. The 2002 Working Group concluded that the use of absolute reference point values from the ASPIC model (based on total biomass rather than exploitable biomass) are appropriate because the NEFSC surveys appear to measure the biomass of the exploitable portion of the stock. However, ASPIC-based biological reference points are re-estimated each time the model is run and model estimates of relative total biomass (B_t/B_{MSY}) and fishing mortality rates (F_t/F_{MSY}) are more precisely estimated than the absolute values (Prager 1995). As a result, the 2005 GARM review panel concluded that bias-corrected relative estimates of annual total biomass and fishing mortality rates from the updated ASPIC model run should be compared to relative biological reference points (biomass threshold = 0.5, fishing mortality rate threshold = 1.0) to determine stock status. In 2005, it was determined that the stock was not overfished, but overfishing was occurring.

For the current GARM, the use of a Virtual Population Assessment model (VPA) was selected because of improved biological sampling of the fishery since the SARC34 VPA, the need to assess changes in the population's truncated age structure, and to avoid the pitfalls associated with the biomass-based ASPIC model. Initial estimates of discards-at-age, for the bottom trawl and scallop dredge fleets, are also included in the updated version of the model. Additional assessment details and supporting information can be found in the Appendix of the GARM-III Report (NEFSC 2008).

2.0 The Fishery

Landings

The stock boundary includes statistical areas 522-525, 542, 551-552 and 561-562 (Figure K1). Commercial landings data are available for 1964-2007. During 1964 through May of 1994, U.S. commercial landings and fishery-related data were collected and entered into a Federal database by NMFS port agents. Since then, such data have been electronically reported by fish dealers. However, fishing location (statistical area) and fishing effort data related to the landings are only available in the Vessel Trip Report database, which contains logbook data which are self-reported by fishermen. Consequently, the landings data and biological sampling data were allocated to stock areas (Statistical Areas) based on Vessel Trip Report data using the method described in Wigley et al. (2007a).

There are no significant recreational landings of winter flounder from Georges Bank. Total commercial landings are predominately from the U.S. bottom trawl fleet, but landings from Georges Bank have also been reported in the Canadian groundfish trawl fisheries, since 1964, as bycatch in the haddock and cod fisheries (Heath Stone pers. comm.). During 1964-1977, landings were also reported by the former USSR (Table K1, Figure K2). Canadian landings generally comprised a low percentage (1-2 %) of the total landings until 1994, at which time Canadian landings increased from 6 % of the total to a peak of 24 % in 2001 (529 mt). The increasing trend in Canadian landings occurred primarily during the second half of the year because since 1994 there has been a Canadian prohibition on trawling for groundfish on Georges Bank during January-May (Eeckhaute and Brodziak 2005). After 2001, Canadian landings declined from 10% of the total landings in 2002 to 1.5% in 2007 (12 mt).

Total landings increased during 1964-1972, reaching a peak of 4,509 mt in 1972, then declined to1,892 mt in 1976 (Figure K2, Table K1). A sustained period of high landings occurred during 1977-1984, ranging from 3,061-4,009 mt. After 1984, landings gradually declined to 783 mt in 1995 then increased again to 3,139 mt in 2003. Thereafter, landings declined rapidly and reached the lowest level on record in 2007 (787 mt).

A majority of the annual U.S. landings (92-100 %) are taken with bottom trawls (Table K2). Most of the remainder of the total landings is taken by the scallop dredge fleet. During most years since 1982, landings taken by the scallop dredge fleet have been less than 1%. However, a high period of landings by the scallop dredge fleet (4-8% of the total landings) occurred during 1988-1993 and in 2005 (6% of the total landings).

Discards

Initial estimates of GB winter flounder discards, during 1964-2006, are provided for the large mesh bottom trawl fleet (codend mesh size ≥ 5.5 inches), small mesh groundfish fleet (codend mesh size < 5.5 inches), and the sea scallop dredge fleet ("limited permits" only) in Tables K3 and K4. Discards (mt) for 1989-2006 were estimated based on fisheries observer data and the landings data using the combined ratio method described in Wigley et al. (2007b). The discard ratio estimator consisted of discards of GB winter flounder divided by the sum of all species kept by a particular fleet. Discards were estimated by quarter and cells with fewer than two trips were imputed using annual

Values (Appendix Table K1; NEFSC 2008). Due to a lack of fisheries observer data, prior to 1989 for the trawl fleets and prior to 1992 for the scallop fleet, discard estimates were hindcast back to 1964 based on the following equation:

(1) $$\hat{D}_{t,h} = \bar{r}_{c,2003-2004,h} * K_{t,h}$$

where:

$\hat{D}_{t,h}$ is the annual discarded pounds of GB winter flounder for fleet *h* in year *t*

$\bar{r}_{c,2003-2004,h}$ is an average combined D/K ratio (discarded pounds of GB winter flounder / total pounds of all species kept) for the fleet *h* during either 2003-2004 (for the trawl fleets) or 1992-1998 (for the scallop dredge fleet)

$K_{t,h}$ is the total pounds of all species kept (landed) for fleet *h* in year *t*

During 1964-1975, discards were predominately (49-87%) attributable to the large mesh groundfish trawl fleet (listed in Table K3 as the small mesh fleet because the minimum codend mesh size prior to 1982 was less than 5.5 in.) (Table K3). During 1976-2007, discards were primarily attributable to the scallop dredge fleet during most years, ranging between 66% and 100%. Discards ranged from 1-25 % of the total landings during 1964-2007 and were higher during 1964-1991 than during 1992-2007 (Table K1). Discards reached a peak of 314 mt in 1991 then declined sharply to their lowest level (1 mt) in 1995. During 1999-2003, discards declined from 85 mt in 1999 to 9 mt in 2003, but have increased since then. Discards nearly doubled between between 2006 (110 mt) and 2007 (193) mt and predominately from the scallop dredge fleet. The precision of the annual discard estimates varies by fleet (Table K4) and the precision of the annual estimates of total discards, during most years since 2000, is fairly high (Table K3).

Catches

Catches increased during 1964-1972, reaching a peak of 4,600 mt in 1972, then declined to 2,000 mt in 1976 (Figure K3, Table K1). Catches subsequently increased to 4,300 mt in 1981 then gradually declined to a time series low of 800 mt in 1995. Catches increased to 3,100 mt in 2003 then declined to 980 mt in 2007.

Historical catches are likely to have been higher than those observed since 1964 because the U.S. landings alone reached a peak of 4,089 mt in 1945, close to the magnitude of the 1964-2007 peak in catch (4,608 mt), and without the addition of discards, at a time when codend mesh sizes were smaller, and landings from international fleets (Figure K4).

Landings-at-age

There is no sampling program for length and age composition data from the Canadian landings of Georges Bank winter flounder, but length and age samples from the U.S. landings were collected by market category and quarter during 1982-2007. Samples are collected for eight market categories (Lemon Sole = 1201, Extra Large = 1204, Large = 1202, Large /Mixed = 1205, Medium = 1206, Small = 1203, Peewee = 1207, and Unclassified = 1200). However, the data were binned as Lemon Sole (1201 and 1204), Large (1202 and 1205) and Small (1203, 1206 and 1207) because these three market categories comprise a majority of the landings during 1982-2007. The annual sampling intensity of lengths ranged between 14 mt and 269 mt landed per 100 lengths measured during 1982-2007 (Table K5). Sampling intensity was lowest during 1996-2000. During 1998 and 1999 there were no lemon sole samples (the largest market category size) and only one large sample collected each of these two years (Table K6) although this market category represented 42% and 45% of the total landings, respectively, during this period (Table K7). After 2000, sampling intensity improved substantially and was highest in recent years (2004-2007). During 1982-2002, most of the landings consisted of Large and Small fish, but since 2003, the landings have been dominated by larger fish (Lemon Sole and Large, Table K7) and sampling intensity of these larger fish has increased as well.

During most years, biological sampling of the landings was adequate to construct the landings-at-age (LAA) matrix by applying commercial age-length keys to commercial numbers at length on either a quarterly or half-year basis by market category group (Table K8). The LAA matrix for 1982-1993 was based on that provided in Brown et al. (2000) and was updated for 1994-2007 using the allocation scheme noted above for landings and age and length samples. The LAA matrix includes U.S. and Canadian landings during 1982-2007 (Table K9). The U.S. unclassified market category samples and the Canadian landings were assumed to have the same age compositions as the sampled U.S. landings and the U.S. LAA was adjusted by a raising factor to incorporate the Canadian landings. Large year classes are trackable in the landings-at-age matrix. For example, large numbers of fish from the 1994 cohort were landed as age 1 fish in 1995, as age 2 in 1996 and as age 3 fish in 1997. Landings of age 1 fish are insignificant during most years (Table K9). During 1982-1984, the landings were dominated by age 3-5 fish and were dominated by age 2-4 fish during 1985-2000. During 2001-2007, the landings were dominated by age 3-5 fish.

Discards-at-age

The annual number of lengths sampled from winter flounder discards in the bottom trawl and scallop dredge fisheries were inadequate to characterize discard length compositions during most years (Table K10). As a result, discards at age were characterized based on the assumption that fish smaller than the minimum regulatory size limits were discarded. The minimum size limit for winter flounder in the bottom trawl fishery was 28 cm during 1986-April, 1994 and has been 30 cm since then. Examination of length-at-age data indicates that fish of this size are one year old in the NEFSC fall surveys and two years old in the spring surveys. Therefore, discards at age for the bottom trawl fleet, during 1982-2001, were estimated by dividing the estimated weight of discarded winter flounder from the bottom trawl fleet, during January-June, by the annual mean weights of age 2 fish from the NEFSC spring surveys. Likewise, winter flounder discard weights for July-December were divided by the annual mean weights of age 1 fish from the NEFSC fall surveys. Discards at age for the bottom trawl fleet, during 2002-2007, were estimated by using the discard numbers at length, binned as January-June and July-December, to characterize the proportion discarded at length and ages were determined by applying the NEFSC spring and fall survey age-length keys and length-weight relationships, respectively. Length compositions of discarded fish in the bottom trawl fishery indicate that for most years during 2002-2007, discarding of all sizes of winter flounder occurred (Figure K5), particularly since the establishment of Georges Bank winter flounder trip limits in May of 2006. Length samples of winter flounder discarded in the scallop dredge fishery are also limited (Table K10). The limited discard length composition data suggested that, in general, all sizes of winter flounder are discarded (Figure K6). Therefore, discards at age for the scallop dredge fishery were estimated by scaling up the LAA by the ratio of scallop dredge discards to total landings. During years when sufficient numbers of length samples of winter flounder discards were available, 1997 and 2004-2007, these annual length frequency distributions were used to characterize the proportion of discards at length for the scallop dredge fleet and ages were determined using the fall survey age-length keys and length-weight relationships because most discards occurred during the second half of the year. There were no data available to estimate Canadian discards of GB winter flounder in either the groundfish trawl fleet or the scallop dredge fleet. Since 1994, the Canadian groundfish fishery on Georges Bank has been closed during January-May and Canadian regulations do not permit discarding of groundfish species and the scallop fishery is not permitted to land groundfish (Van Eeckhaute and Brodziak 2005). Consequently, any discarding is expected during May-December in the groundfish trawl fishery and throughout the year in the scallop dredge fishery that operate on the Canadian side of Georges Bank. Discards occur across all age categories, but primarily ages 2-4 during 1982-1997 and ages 3-5 during 1998-2003 (Table K11). Total discards were lower after 2004 than before and discards of age 1 fish were much higher prior to the 1994 when the minimum codend mesh size (5.5 in) and minimum fish retention size (28 cm) was smaller.

Catch-at-age

The catch-at-age (CAA) consists of the combined U.S. and Canadian landings-at-age and discards-at-age for the U.S. large and small groundfish bottom trawl fleets and the scallop dredge fleet, during 1982-2007, for ages 1-6 with a 7+ age group. Trends in mean weights at age in the catch remained relatively stable between 1982 and 1996 then declined through 1998 for ages 3-5 and became more variable for older age groups, likely due to poor sampling (Figure K7, Table K12). However, during 2000 and 2001-2006, mean weights in the catch have been increasing for all age groups except age one, but particularly for ages 4 and older. Mean weights for ages 3-7+ declined slightly between 2006 and 2007. The catch-at-age is presented in Table K13.

2.0 Research Survey Data

Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices were derived from the NEFSC spring (April, 1968-2008) and autumn (October, 1963-2007) bottom trawl surveys, for offshore strata 13-23 (Figure K8), as well the Canadian spring bottom trawl surveys (February, 1987-2008) for strata 5Z1-Z4 (Figure K9). NEFSC survey indices prior to 1985 were standardized for gear changes (weight = 1.86 and numbers = 2.02, Sissenwine and Bowman 1978) and trawl door changes (weight = 1.39 and numbers = 1.4, Byrne and Forrester 1991). In addition, the NEFSC survey indices were revised to include offshore strata 13-23 rather than the strata set from previous assessments (strata 13-22) because a majority of fish caught in stratum 23 exhibit a Georges Bank-type growth pattern which is much more rapid than the growth patterns of the other two winter flounder stocks and which is readily apparent to the ageing analyst as a much greater distance between the first and second annuli (Jay Burnett pers. comm.). In addition, the relative abundance of winter flounder caught in stratum 23 is similar to the relative abundance of winter flounder caught in the Georges Bank strata (13-22, Appendix Figure K1). The addition of fish from stratum 23 mainly affects the fall survey indices because winter flounder densities in stratum 23 are low during spring (Appendix Figure K2).

Despite considerable inter-annual variability, the NEFSC fall survey relative abundance indices show an increasing trend during the 1970's, followed by a declining trend during the 1980s to a time series low in 1991 (Figure K10, Table K14). Thereafter, relative abundance increased through 2001 then declined and was below the 1963-2006 median during 2005-2007. Trends in the NEFSC spring survey relative abundance indices exhibited more inter-annual variability, but trends were similar to the fall survey time series after 1982. NEFSC spring survey abundance indices were at the lowest levels on record during 2006 and 2007. The second highest abundance index of the time series occurred in 2008. However, most of the fish were caught at two consecutively sampled stations and consisted of a broad range of sizes. Relative abundance trends in the Canadian survey were similar to those in the NEFSC spring survey during most years but were of greater magnitude during blocks of years (1988-1990 and 1993-1997). Similar to the NEFSC spring survey, relative abundance indices from the Canadian surveys were at the lowest levels observed during 2006-2008.

In order to estimate catchability coefficients for each survey (q) in the VPA, annual relative abundance indices were converted to annual minimum population sizes. Minimum population sizes at age (000's) are presented for the U.S. fall (1981-2007, ages 0-6 lagged forward one year and age) and spring bottom trawl surveys (1982-2008) and the Canadian spring bottom trawl surveys (1987-2008) in Tables K15, K16, and K17, respectively. Age samples are not collected during Canadian bottom trawl surveys so the NEFSC spring survey age-length keys, augmented during some years with commercial age-length keys from the first quarter of the corresponding year (when larger fisher were caught), were used to partition stratified mean numbers at length from the Canadian surveys into numbers at age. Although the indices are highly variable, large cohorts appear to track through the numbers-at-age matrices for the 1980, 1987, 1994, and 1998-2001 cohorts (Figure K11). Age truncation occurred between 1983 and 1997 during which time the population was dominated by four age groups rather than seven or more. During 1997-2004, the age structure improved but has since become truncated again. Both the U.S. and Canadian spring surveys show reduced numbers of age 1-3 fish (and age 4 fish in the CA surveys) after 2000. The U.S. spring survey numbers at age during 2008 were some of the highest on record for a broad number of ages (ages 1-5, Figure K11B). This characteristic, combined with the fact that these indices do not track back to large year classes suggests that the indices are likely just an effect of high catches from two consecutively sampled stations.

Maturity and age data for females from the NEFSC spring surveys were used to derive the proportion mature-at-age for input to the VPA and to compute age at 50% maturity during 1982-2008. The female A_{50} is approximately 2 years (Appendix Figure K3) and all fish are mature by age 4, and in recent years, by age 3 (Appendix Figure K4). There has been an increase in the female A_{50} since 2005 that is more pronounced in females than males (Appendix Figure K3) and which is reflected in a reduction in the proportion of mature age 2 females during this time period (Appendix Figure K4). These maturity-at-age trends are also concurrent with a declining trend, after 2003, in the mean weight and length of females caught in the fall surveys (Appendix Figure K5). However, a time series average of the proportion mature-at-age rather than a moving window was used in the VPA because the sample size on which the recent declining trend in the female proportion mature-at-age is based has also been declining (Appendix Figure K3). Since 2001, all winter flounder caught in strata 13-23 during NEFSC spring and fall surveys are sampled for age and maturity, and as relative abundance has declined, so has the number of maturity and age samples.

4.0 Assessment

Input Data and Analyses

The catch at age input to the VPA consisted of combined U.S. and Canadian landings during 1982-2007 for ages 1-6 with a 7+ age group. The VPA was calibrated using minimum population abundance at age indices from the U.S. spring (1982-2008, ages 1-7) and fall bottom trawl surveys (1981-2007, ages 0-6 lagged forward one year and age) and the Canadian spring bottom trawl surveys (1987-2008, ages 1-7) in order to estimate catchability coefficients (q) for each survey. Stock size was estimated for ages 2-6 in the terminal year+1. The natural mortality rate was assumed as 0.2 per year. Maturity data from the 1982-2008 NEFSC spring surveys were used to estimate the average proportion mature at age for 1982-2008. The time series average maturity vector for ages 1-7+ (0.08, 0.54, 0.94, 1.00, 1.00, 1.00, 1.00, respectively) was used in the VPA analysis.

Precision of the 2007 spawning stock biomass and fully recruited fishing mortality were derived from 1,000 bootstrap replicates of the VPA. A retrospective analysis of terminal year estimates of age 1 recruitment, fully recruited fishing mortality on ages 4-6, and SSB were also carried out back to 1993.

VPA Diagnostics

Residuals patterns were evident for a number of ages included in each of the three VPA calibration indices. For example, residuals patterns were negative for abundance indices of age 2 and 3 fish from the NEFSC spring surveys, during 2001-2007, and for age 6 fish during 1993-1997 (Figure K12). Residuals for the NEFSC spring surveys were positive for age 1 fish during 1990-1995 and age 2 fish during 1990-1996, as well as for age 6 fish during 1999-2003 and for age 7 fish during 1998-2002. The Canadian spring survey indices for ages 2-4 showed major residuals trends (Figure K13), both positive and negative, but the patterns differed from those evident in the NEFSC spring surveys. Residuals patterns for the NEFSC fall survey abundance indices were evident during some years for ages 4-7 (actually ages 3-6 lagged forward one year and age) and were generally positive (Figure K14). In order to determine whether omitting certain tuning indices would remove the observed residuals patterns and improve the retrospective pattern, the following additional VPA formulations were run: all indices except the CA series; all indices except ages 1-3 in the CA series; NEFSC spring surveys ages 4-7 plus fall surveys ages 1-7; and all indices except the CA series and ages 1-3 from the fall surveys. However, all of these runs resulted in worse retrospective patterns and shifted the residuals patterns to other ages and years. A VPA run involving a pre- and post-1994 split for all of the survey time series has removed retrospective patterns for GB yellowtail flounder. However, such a run resulted in very strong retrospective patterns in F and SSB, probably because 1994 was generally not a problematic year for the GB winter flounder stock with respect to residuals patterns.

VPA estimates of survey catchability coefficients (q), by age, indicate that catchabilities for all three surveys increased with age for ages 1-6 then decreased for age 7 but the decrease was not significant (Figure K15). Catchabilities were higher for the NEFSC fall surveys than the NEFSC spring surveys (e.g., q = 0.33 and 0.25 for age 6, respectively). Catchabilities for the Canadian spring surveys can be compared across ages but not between surveys because the ships and gear were different.

A plot of the VPA average of back-calculated partial recruitment across ages, and scaled by the highest value, was prepared for each of three time periods (1983-1993, 1994-2001, and 2002-2007) within which occurred major changes in the minimum codend mesh size for bottom trawls. A flat-topped logistic curve was present in all three cases (Figure K16).

Very mild retrospective patterns were present for terminal year estimates of fishing mortality rates (underestimation of F) and spawning stock biomass (overestimation of SSB, Figure K17A and B). There was no retrospective pattern for terminal year age 1 recruitment, but the estimates were highly variable (Figure K17C). In order to quantitatively evaluate the severity of the retrospective pattern, the rho statistic of Mohn (1999) was computed for each year during 2000-2006. The Mohn statistic is a relative measure defined as the sum of relative difference between an estimated quantity from an assessment with a reduced time series and the same quantity estimated from the full time series:

$$\rho = \sum_{y=1}^{npeels} \frac{X_{Y-y,tip} - X_{Y-y,ref}}{X_{Y-y,ref}} \qquad (1)$$

where X denotes the average F for ages 4-6 and SSB from the stock assessment, y denotes year (i.e., 2000-2006), n peels denotes the number of years that are dropped in successive fashion from the assessment rerun, Y is the last year in the full time series (i.e., 2007), tip denotes the terminal estimate from an assessment with a reduced time series, and ref denotes the assessment using the full time series. The rho value is zero when the peeled assessments match exactly with the full time series assessment, or when the differences between the peeled assessments and full time series assessment are balanced both positive and negative. The former case has no change from year to year, while the latter case would be characterized as exhibiting noise but not a retrospective pattern. Rho becomes large, either positive or negative, when there is a consistent retrospective pattern (change in the peeled assessments relative to the full time series assessment). For GB winter flounder, relative differences in estimates of average F, SSB and age 1 recruitment, during year t (for 2000-2006) versus 2007, are presented in Figure K18. The average Mohn rho values estimated for 2000-2006 were quite low for F and SSB (Table K18). The average rho value for age 1 recruitment was slightly higher, as expected, due to the high variability in the annual estimates of this variable during 2000-2006.

VPA Results

VPA estimates of Jan. 1 population size (numbers, 000's), fishing mortality rates, and spawning stock biomass (mt) are presented in Tables K19-21, respectively. Fishing mortality (average F for fully recruited fish, ages 4-6) was highest during 1984-1993, ranging between 0.65 and 1.32, then declined to levels ranging between 0.38 and 0.64 during 1994-1998 (Figure K19A, Table K20). Fishing mortality was low (0.32) during 1999 and 2000 then increased rapidly to 0.97 in 2003 and was followed by a rapid decline to a record low of 0.25 in 2006. The fishing mortality rate in 2007 was 0.28. SSB declined rapidly from a time series peak of 16,300 mt in 1982 to 5,573 mt in 1985, and then increased slightly through 1987 to 7,519 mt (Figure K19B, Table K21). After 1987, SSB declined again to a time series low of 3,226 mt in 1994. SSB subsequently increased to 10,924 mt in 2000, but then declined to 4,478 mt in 2005. SSB increased slightly thereafter to 4,964 mt in 2007. Trends in age 1 recruitment (numbers) indicate two periods of rise-and-fall. Recruitment increased from 5.9 million fish in 1983 to a time series peak of 18.6 million fish in 1988, and then declined to 3.4 million fish in 1993 (Figure K19C, Table K19). Recruitment increased again to fairly high levels during 1995-1999 (9.9-14.6 million fish) then declined to the lowest level on record (2.6 million fish) in 2005. Recruitment of age 1 fish increase to 12.1 million fish in 2007, but in 2008 is estimated to be much lower (5.1 million fish). However, the 2008 estimate is uncertain because it is based solely on survey indices. Stock size declined between 2000 and 2005, from 36.2 to 12.3 million fish then increased to 22.5 million fish in 2008 (Table K19).

Bootstrap results suggest that the 2007 estimates of fully recruited average F on ages 4-6 and spawning stock biomass are fairly precise with CVs of 20% and 24%, respectively. There is an 80% probability that the 2007 average F for ages 4-6 is between 0.22 and 0.37 (Figure K20). There is an 80% probability that the 2007 SSB estimate is between 4,204 mt and 6,249 mt (Figure K20). Bootstrapped estimates of the 2008 stock sizes and 2007 fishing mortality rates at age are presented in Table K22 and Table K23, respectively.

5.0 Biological Reference Points

A YPR and SSB/R model (Thompson and Bell 1934) were used to estimate an F_{MSY} proxy of $F_{40\%\ MSP}$. Input data for the YPR and SSB/R model included: the fishery selectivity vector, proportion mature at age, and the 2003-2007 mean catch weights, mean stock weights, and spawning stock weights from the VPA (Table K24). The yield-per-recruit and SSB-per-recruit analysis resulted in an F_{MSY} proxy estimate for $F_{40\%}$ of 0.26.

At the GARM III BRP meeting, the review panel determined the stock-recruitment relationship predicted from a Beverton-Holt model was not well defined by any particular model (e.g., Beverton-Holt). As a result, BRPs were derived based on the empirical cumulative distribution function of age 1 recruitment from the VPA and assumed that recruitment is independent of stock size. A long-term (100-year) stochastic projection was run using an age-structured projection model, AGEPRO software (v. 3.13) from the NOAA Fisheries Toolbox, assuming a constant harvest scenario of $F_{40\%}$ = 0.26 (from the YPR model) to predict the median MSY and SSB_{MSY} under equilibrium conditions. The projection included the data presented in Table K24. The entire recruitment time series was included in the analysis with the exception of the 2008 data point due to the uncertainty of this value which is based solely on survey data. Median SSB_{MSY} and MSY estimates from the projection were 16,000 mt and 3,500 mt, respectively. The current and re-estimated BRPs are presented in Table K25. Several factors suggest that the estimated SSB_{MSY} value for this stock is reasonable. Firstly, SSB_{MSY} was derived based on the average selectivity during 2003-2007, a period of time when full selectivity shifted from age 4 to age 5 (Figure K16). Secondly, the SSB estimate from the first year of the VPA, in 1982, is the same as the SSB_{MSY} value (16,000 mt) and ASPIC model results from the 2005 GARM confirm that total biomass during 1964-2004 was highest prior to 1982, the intial year of the VPA (NEFSC 2005).

6.0 Projections

Stochastic projections were run using AGEPRO software to predict catch and biomass levels during 2009-2018 under the following three scenarios: F status quo (F_{sq} = 0.28), F_{MSY} proxy ($F_{40\%}$ = 0.26), and F rebuild (to SSB_{MSY} of 16,000 mt). The catch in 2008 was assumed to be the same as the 2007 catch (980 mt). Under all three scenarios, the projected catch for 2009 is more than double the 2007 catch of 980 mt for F_{sq} and nearly double for F_{MSY} and $F_{REBUILD}$ (Table K26). Likewise, the projected SSB in 2009 is nearly double for F_{sq} and F_{MSY}. Higher catches are predicted in 2009 because the 2006 year class, the largest since 1998 and of similar size (Figure K21), will be supporting the fishery in 2009. However, it should be noted that discards of winter flounder from Georges Bank nearly doubled between 2006 and 2007, due to increased discarding by the scallop dredge fleet and secondarily by the large mesh bottom trawl fleet. In 2007, discards represented 20% of the catch.

7.0 Summary

The fishing mortality rate in 2007 (0.28) was higher than the value of the F_{MSY} proxy (0.26), indicating that overfishing was occurring in 2007 (Table K25). The spawning stock biomass in 2007 (4,964 mt) was well below the SSB_{MSY} target (8,000 mt), indicating that the stock was also overfished in 2007 (Table K25, Figure K22). The 2007 estimates of average F and SSB do not require adjustments for the VPA retrospective pattern because the 2000-2006 average rho values for average F and SSB fell within the 80% confidence limits of the average F and SSB estimates.

Landings have been decreasing since 2003 and were at the second lowest level on record in 2007 (787 mt). However, regulatory discards increased during 2005-2007, primarily in the scallop fishery, but also the large mesh trawl fishery. Overall, catches declined during 2003-2007, but relative abundance and biomass indices from NEFSC and Canadian surveys have also declined to below median levels. During 1997-2004, the age structure improved but has since become truncated again. Both the U.S. and Canadian spring surveys show reduced numbers of age 1-3 fish (and age 4 fish in the CA surveys) after 2000.

Average fishing mortality rates (average F) on age 4-6 fish declined from 0.97 in 2003 to 0.25 in 2006. However, average F increased slightly in 2007 (0.28) to a level slightly above the F_{MSY} proxy. Therefore, overfishing was occurring in 2007. The age range comprising a majority of the spawning stock biomass has become reduced from a broad range of ages to fewer, younger ages. Spawning stock biomass declined by nearly half between 2000 (10,924 mt) and 2005 (4,478 mt), then increased gradually to 4,964 in 2007 but remained well below the SS_{BMSY} value of 16,000 mt. Therefore, the stock was overfished in 2007. The 2009 catch projections are much higher than the actual 2007 catch because the 2006 year class, the largest since 1998 and of similar size, is assumed to support the fishery in 2009. However, the projections assume 2007 catch levels in 2008 and discards have been increasing in recent years and represented 20% of the catch in 2007.

Sources of uncertainty include the underestimation of total discards because discards in the Canadian groundfish trawl fleet and sea scallop fleet are not available. In addition, the lack of adequate discard size composition data for the U.S. large mesh bottom trawl fleet and sea scallop fleet results in imprecise estimates of discards by age. The lack of age-length keys for the Canadian spring surveys requires the use of U.S. commercial age-length keys (for fish greater than 60 cm) in combination with the NEFSC spring survey age-length keys to assign ages to the broader size range of fish caught in the Canadian spring surveys than in either of the NEFSC spring or fall surveys. The cause of the recent decline in the female age at 50% maturity, since 2005, cannot be attributed to the decline in the NEFSC fall survey mean weight- and length-at-age which has occurred since 2003, because a concurrent decline in female age and maturity samples has also occurred.

8.0 Panel Discussion/Comments

Conclusions

The age-based VPA considered in GARM III is a significant improvement over the Surplus Production Model used in GARM II. There was such a small retrospective pattern in the VPA Base run that it did not require an adjustment. The Panel accepted the VPA Base run as Final and the best available to provide management advice on stock status and from which to base stock and rebuilding plan projections.

The Panel had a number of concerns with the Base VPA run. Year – classes were not being tracked well in the model, similar to the situation in the other winter flounder stocks although the problem here is not as severe. Another concern is the apparent lack of correlation between catch and surveys in the recent time period. The Panel reiterated its earlier comment that the Winter Flounder stocks be considered as a stock complex for assessment purposes (See Panel Conclusions on Gulf of Maine Winter Flounder).

The Panel queried why the resource was declining when harvest has not exceeded MSY levels since 1984. This issue requires further exploration.

Research Recommendations

Assessment approaches needs to be explored that consider all three Winter Flounder stocks as a stock complex within which there is significant interaction amongst the individual stock components.

Further examination of the reasons for why the resource has declined when harvest has not exceeded MSY since 1984 needs to be undertaken.

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10.0 Acknowledgements

This assessment could not have been conducted without the data preparation and technical help provided by Susan Wigley, the age data provided by Jay Burnett, and data collected and entered by the NMFS port agents, NEFSC staffs from DMS, NEFOP and ESB. Many thanks to Christa Waters, Lou Van Eeckhaute, and Heath Stone (CA Department of Fisheries and Oceans) for providing Canadian survey and landings data.

Table K1. Landings, discards, and catches (mt) of Georges Bank winter flounder during 1964-2007.

YEAR	522-525 561-562 USA[1]	5Ze[2] (521-526 and 541-562) CA		5Z (521-562) CA		TOTAL LANDINGS	DISCARDS	CATCH
		CA	USSR	CA	USSR			
1964	1,370			146		1,516	231	1,747
1965	1,175			199	312	1,686	165	1,851
1966	1,876			164	156	2,196	137	2,333
1967	1,916			83	349	2,348	106	2,454
1968	1,569	57	372			1,998	140	2,138
1969	2,165	116	235			2,516	117	2,633
1970	2,613	61	40			2,714	109	2,824
1971	3,089	62	1,029			4,180	105	4,286
1972	2,802	8	1,699			4,509	98	4,608
1973	2,267	14	693			2,974	94	3,068
1974	2,123	12	82			2,217	98	2,315
1975	2,407	13	515			2,935	118	3,053
1976	1,876	15	1			1,892	142	2,034
1977	3,569	15	7			3,591	207	3,798
1978	3,183	65				3,248	262	3,510
1979	3,042	19				3,061	257	3,319
1980	3,928	44				3,972	255	4,227
1981	3,990	19				4,009	281	4,290
1982	2,959	19				2,978	246	3,224
1983	3,894	14				3,908	225	4,133
1984	3,927	4				3,931	195	4,126
1985	2,151	12				2,163	158	2,321
1986	1,761	25				1,786	182	1,968
1987	2,637	32				2,669	272	2,941
1988	2,804	55				2,859	293	3,152
1989	1,880	11				1,891	316	2,207
1990	1,898	55				1,953	338	2,291
1991	1,814	14				1,828	314	2,142
1992	1,822	27				1,849	29	1,877
1993	1,662	21				1,683	11	1,693
1994	931	65				996	10	1,005
1995	729	54				783	1	784
1996	1,370	71				1,441	26	1,467

Table K1 – continued.

YEAR	522-525 561-562 USA[1]	5Ze[2] (521-526 and 541-562) CA	USSR	5Z (521-562) CA	USSR	TOTAL LANDINGS	DISCARDS	CATCH
1997	1,226	143				1,369	69	1,438
1998	1,308	93				1,401	52	1,453
1999	939	104				1,043	85	1,128
2000	1,603	161				1,764	65	1,829
2001	1,674	529				2,203	11	2,214
2002	2,100	244				2,344	20	2,364
2003	2,829	310				3,139	9	3,149
2004	2,660	191				2,851	69	2,921
2005	2,012	73				2,085	118	2,202
2006	825	55				880	110	990
2007	775	12				787	193	980

[1] USA landings prior to 1985 include those from Statistical Areas 551 and 552, and since May of 1994, landings have been self-reported by dealers and were allocated to statistical areas based on Vessel Trip Report data.
[2] Includes landings from statistical areas 521, 526, and 541 which are outside of the Georges Bank winter flounder stock area.

Table K2. Landings (mt) of Georges Bank winter flounder, by major gear type, during 1964-2007.

	Landings (mt)			
Year	Bottom Trawl	Scallop Dredge	Other	Total
1964	1,359	11.2	0.0	1,370
1965	1,174	0.9	0.0	1,175
1966	1,850	4.2	21.6	1,876
1967	1,914	1.8	0.0	1,916
1968	1,564	4.6	0.0	1,569
1969	2,163	1.8	0.0	2,165
1970	2,609	4.4	0.0	2,613
1971	3,085	4.8	0.0	3,089
1972	2,795	7.9	0.0	2,802
1973	2,264	3.4	0.1	2,267
1974	2,115	7.7	0.0	2,123
1975	2,385	0.0	22.6	2,407
1976	1,873	1.0	1.6	1,876
1977	3,568	1.1	0.5	3,569
1978	3,164	17.9	1.1	3,183
1979	3,018	24.9	0.0	3,042
1980	3,885	42.5	0.3	3,928
1981	3,932	53.5	3.7	3,990
1982	2,917	41.2	0.1	2,959
1983	3,861	25.4	7.2	3,894
1984	3,897	18.4	11.1	3,927
1985	2,145	3.1	3.1	2,151
1986	1,723	36.0	2.3	1,761
1987	2,559	77.9	0.0	2,637
1988	2,697	106.4	0.0	2,804
1989	1,760	119.7	0.0	1,880
1990	1,778	118.1	1.6	1,898
1991	1,672	141.1	0.7	1,814
1992	1,677	136.3	8.6	1,822
1993	1,534	115.4	12.4	1,662
1994	894	21.6	15.3	931
1995	716	8.5	4.9	729
1996	1,365	4.6	0.7	1,370
1997	1,211	12.0	3.2	1,226
1998	1,274	13.3	20.5	1,308
1999	925	11.2	2.5	939
2000	1,545	23.1	35.2	1,603
2001	1,667	6.3	0.3	1,674
2002	2,092	1.0	7.1	2,100
2003	2,826	0.4	3.2	2,829
2004	2,627	4.5	28.7	2,660
2005	1,892	111.8	7.8	2,012
2006	778	21.9	25.8	825
2007	754	11.1	9.8	775

Table K3. Georges Bank winter flounder discards (mt) for large mesh (codend mesh ≥ 5.5 in.) and small mesh (codend mesh < 5.5 in.) groundfish bottom trawl fisheries and the scallop dredge/trawl fisheries.

	Discards (mt)				
Year	Large mesh	Small mesh	Scallop dredge	Total	CV
1964		112.1	118.4	230.6	
1965		135.4	29.7	165.1	
1966		118.9	18.2	137.1	
1967		82.0	24.0	106.0	
1968		74.1	65.9	140.0	
1969		74.8	42.2	117.0	
1970		72.6	36.8	109.4	
1971		69.5	35.9	105.4	
1972		61.4	36.7	98.1	
1973		61.1	32.8	94.0	
1974		59.7	38.3	97.9	
1975		60.4	57.6	118.0	
1976		48.8	93.0	141.9	
1977		68.3	138.8	207.0	
1978		77.0	184.9	261.9	
1979		75.8	181.7	257.4	
1980		83.1	171.6	254.7	
1981		97.3	184.0	281.3	
1982	11.4	72.3	162.6	246.3	
1983	39.8	21.8	163.6	225.3	
1984	47.3	3.3	144.5	195.1	
1985	28.9	1.6	127.7	158.2	
1986	23.3	1.6	156.6	181.5	
1987	24.8	1.9	245.5	272.1	
1988	28.3	6.4	258.3	293.0	
1989	13.8	0.1	302.4	316.2	
1990	15.7	0.0	322.3	338.0	
1991	1.9	0.0	311.9	313.8	
1992	8.5	0.0	20.3	28.8	0.22
1993	2.5	0.0	8.1	10.6	0.49
1994	2.3	0.9	6.4	9.5	0.16
1995	1.1	0.0	0.0	1.1	0.56
1996	8.3	0.0	17.4	25.7	0.31
1997	0.0	0.0	69.2	69.2	
1998	0.1	0.0	51.5	51.7	0.01
1999	44.0	0.0	41.2	85.2	0.46
2000	16.7	0.1	48.2	64.9	0.31
2001	2.4	0.0	8.3	10.7	0.15
2002	3.1	0.0	16.5	19.7	0.13
2003	6.5	0.9	2.1	9.5	0.34
2004	46.6	15.4	7.3	69.3	0.48
2005	15.0	15.3	87.5	117.9	0.09
2006	26.3	14.9	68.8	110.0	0.12
2007	51.1	12.6	129.5	193.0	0.18

Table K4. Summary of Georges Bank winter flounder discards (mt) estimated for large (codenc mesh size ≥ 5.5 in.) and small mesh (codend mesh size < 5.5 in.) groundfish bottom trawl fishe and the scallop dredge/trawl fisheries (limited permit category), 1964-2007. D/K represents discards of GB winter flounder/weight of all species kept. Discards were hindcast for: large me bottom trawls (1982-1988); small mesh groundfish bottom trawls (1964-1988); and scallop dredges (1964-1991).

	Large Mesh Bottom Trawl			
YEAR	**N observed trips**	**D/K**	**Discards (mt)**	**CV**
1982			11.4	
1983			39.8	
1984			47.3	
1985			28.9	
1986			23.3	
1987			24.8	
1988			28.3	
1989	17	0.00069	13.8	0.59
1990	13	0.00070	15.7	0.80
1991	13	0.00017	1.9	0.37
1992	16	0.00045	8.5	0.60
1993	17	0.00014	2.5	1.69
1994	22	0.00019	2.3	0.65
1995	37	0.00011	1.1	0.52
1996	13	0.00076	8.3	0.81
1997	6	0.00000	0.0	
1998	5	0.00003	0.1	0.47
1999	7	0.00373	44.0	0.70
2000	17	0.00088	16.7	1.24
2001	26	0.00012	2.4	0.70
2002	48	0.00016	3.1	0.86
2003	107	0.00028	6.5	0.46
2004	154	0.00188	46.6	0.59
2005	569	0.00081	15.0	0.25
2006	303	0.00221	26.3	0.31
2007	302	0.00388	51.1	0.26

Table K4 (cont.)

YEAR	Small Mesh Groundfish Bottom Trawl			
	N observed trips	D/K	Discards (mt)	CV
1964			112.1	
1965			135.4	
1966			118.9	
1967			82.0	
1968			74.1	
1969			74.8	
1970			72.6	
1971			69.5	
1972			61.4	
1973			61.1	
1974			59.7	
1975			60.4	
1976			48.8	
1977			68.3	
1978			77.0	
1979			75.8	
1980			83.1	
1981			97.3	
1982			72.3	
1983			21.8	
1984			3.3	
1985			1.6	
1986			1.6	
1987			1.9	
1988			6.4	
1989	15	0.00001	0.1	0.87
1990	8	0.00000	0.0	
1991	8	0.00000	0.0	
1992	6	0.00000	0.0	
1993	1	0.00000	0.0	
1994	2	0.01141	0.9	0.00
1995	3	0.00000	0.0	
1996	2	0.00000	0.0	
1997	1	0.00000	0.0	
1998	1	0.00000	0.0	
1999	1	0.00000	0.0	
2000	5	0.00003	0.1	0.97
2001	7	0.00000	0.0	
2002	7	0.00002	0.0	0.82
2003	15	0.00010	0.9	0.85
2004	17	0.00363	15.4	0.89
2005	79	0.00279	15.3	0.64
2006	18	0.00461	14.9	0.77
2007	12	0.00207	12.6	2.48

Table.K4 (cont.)

YEAR	Scallop dredge/trawl, Limited category permits			
	N observed trips	D/K	Discards (mt)	CV
1964			118.4	
1965			29.7	
1966			18.2	
1967			24.0	
1968			65.9	
1969			42.2	
1970			36.8	
1971			35.9	
1972			36.7	
1973			32.8	
1974			38.3	
1975			57.6	
1976			93.0	
1977			138.8	
1978			184.9	
1979			181.7	
1980			171.6	
1981			184.0	
1982			162.6	
1983			163.6	
1984			144.5	
1985			127.7	
1986			156.6	
1987			245.5	
1988			258.3	
1989			302.4	
1990			322.3	
1991			311.9	
1992	6	0.00101	20.3	0.98
1993	8	0.00030	8.1	3.06
1994	5	0.00156	6.4	0.91
1995	3	0.00004	0.0	0.00
1996	54	0.00331	17.4	0.00
1997	6	0.00951	69.2	0.78
1998	4	0.00677	51.5	1.51
1999	19	0.00124	41.2	0.59
2000	179	0.00209	48.2	0.14
2001	16	0.00203	8.3	0.21
2002	4	0.00305	16.5	0.56
2003	2	0.00024	2.1	0.00
2004	30	0.00045	7.3	0.28
2005	62	0.00186	87.5	0.28
2006	68	0.00119	68.8	0.37
2007	59	0.00359	129.5	0.30

Table K5. Numbers of Georges Bank winter flounder sampled for length, by year and market category, and sampling intensity (mt landed per 100 lengths) during 1982-2007.

Year	N lengths by market category					Sampling intensity (mt landed per 100 lengths)
	Unclassified (1200)	Lemon/XL (1201, 1204)	Large/Lg mix (1202, 1205)	Med/small (1203, 1206, 1207)	Total	
1982	350	724	1,019	807	2,900	101
1983		625	1,768	2,100	4,493	86
1984		518	1,435	902	2,855	137
1985	68	728	1,675	1,456	3,927	55
1986	124	389	1,125	1,184	2,822	61
1987		603	1,068	1,437	3,108	82
1988		478	1,034	1,447	2,959	91
1989		167	566	737	1,470	120
1990	399	27	1,285	1,758	3,469	51
1991	103	136	1,603	1,295	3,137	53
1992		131	1,420	1,483	3,034	56
1993		336	509	590	1,435	108
1994		183	632	556	1,371	66
1995		103	279	469	851	85
1996		370	484	138	992	138
1997		43	518	443	1,004	121
1998			79	403	482	269
1999	94		121	274	489	190
2000		486	160	697	1,343	118
2001	102	670	990	804	2,566	65
2002	274	699	1,458	424	2,855	74
2003	268	1,589	2,863	625	5,345	53
2004		1,579	4,643	188	6,410	41
2005	161	1,987	3,790	576	6,514	29
2006	100	1,978	3,196	293	5,567	14
2007		1,164	1,256	61	2,481	31

Table K6. Port sampling of U.S. winter flounder landings from Georges Bank (Statistical Areas 522-525, 551-562), for length and age compositions, during 1982-2007. Total number of samples does not include unclassified market category samples collected in: 1980 (1), 1981 (2), 1982 (4), 1985 (1), 1986 (1), 1990 (4), 1991 (1), 1999 (1), 2001 (1), 2002 (3), 2003 (4), 2005 (3), and 2006 (1).

				Number of Samples by Market Category and Quarter															Annual Sampling Intensity (mt landed/sample)		
				Lemon Sole: Lemon Sole (1201), Extra-Large (1204)					Large: Large (1202), Large/Mixed (1205)					Small: Small (1203), Medium (1206), Pee-Wee (1207)					1201 1204	1202 1205	1203 1206 1207
Year	N Samples	N Lengths	N Ages	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Lemon	Large	Small
1982	26	2,900	739	0	1	6	2	**9**	0	1	6	3	**10**	0	1	5	1	**7**	26	71	190
1983	36	4,493	874	0	3	2	1	**6**	2	5	6	2	**15**	2	3	9	1	**15**	37	42	84
1984	24	2,855	593	0	1	3	1	**5**	3	3	4	3	**13**	1	2	0	3	**6**	135	111	48
1985	38	3,927	827	1	2	5	1	**9**	2	4	9	1	**16**	2	3	7	1	**13**	50	28	75
1986	29	2,822	563	1	1	0	3	**5**	2	3	3	2	**10**	1	6	3	4	**14**	178	67	144
1987	33	3,108	618	2	1	1	2	**6**	4	3	3	1	**11**	5	3	4	4	**16**	87	51	131
1988	34	2,959	693	2	2	1	2	**7**	4	3	3	1	**11**	4	4	4	4	**16**	86	61	111
1989	16	1.470	280	1	1	0	0	**2**	3	2	0	1	**6**	1	3	3	1	**8**	412	124	282
1990	34	3,469	737	0	0	0	1	**1**	3	3	4	3	**13**	6	7	3	4	**20**	902	58	116
1991	35	3,137	698	1	1	1	1	**4**	6	6	2	2	**16**	6	3	3	3	**15**	129	37	114
1992	35	3,034	688	1	2	1	1	**5**	5	4	3	3	**15**	6	5	3	1	**15**	301	36	118
1993	16	1,435	338	1	2	0	1	**4**	3	2	0	0	**5**	1	5	0	1	**7**	93	408	195
1994	14	1,371	276	0	2	1	0	**4**	1	2	2	1	**6**	1	2	1	1	**5**	15	62	92
1995	9	851	215	1	0	0	1	**2**	1	0	0	2	**3**	2	1	0	1	**4**	22	86	91
1996	10	992	218	0	2	1	1	**4**	0	2	1	1	**4**	0	0	1	1	**2**	16	111	315
1997	13	1,004	232	0	0	0	1	**1**	1	2	1	1	**5**	2	2	0	3	**7**	44	87	51

Table K6 (cont.).

				Number of Samples by Market Category and Quarter															Annual Sampling Intensity (mt landed/sample)		
				Lemon Sole Lemon Sole (1201) Extra-Large (1204)					Large Large (1202) Large/Mixed (1205)					Small Small (1203) Medium (1206) Pee-Wee (1207)					1201 1204	1202 1205	1203 1206 1207
Year	N Samples	N Lengths	N Ages	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Lemon	Large	Small
1998	6	482	70	0	0	0	0	**0**	0	1	0	0	**1**	0	1	1	3	**5**	-----	493	148
1999	6	395	78	0	0	0	0	**0**	0	0	0	1	**1**	2	0	0	3	**5**	-----	379	97
2000	17	1,343	283	0	0	1	4	**5**	0	0	0	2	**2**	2	4	1	3	**10**	23	329	77
2001	27	2.464	606	2	2	1	3	**8**	1	5	3	1	**10**	1	0	2	6	**9**	24	82	65
2002	33	2,485	753	2	4	3	2	**11**	0	9	5	3	**17**	1	1	0	3	**5**	34	70	83
2003	60	4,864	1,396	2	7	4	5	**18**	5	17	8	5	**35**	1	1	0	5	**7**	56	40	47
2004	78	6,343	1,862	1	5	6	5	**17**	6	15	22	13	**56**	1	2	1	1	**5**	35	32	46
2005	75	6,353	1,561	3	9	8	4	**24**	4	17	13	6	**40**	1	4	4	2	**11**	17	33	24
2006	68	5,467	1,458	5	13	4	6	**28**	4	17	9	5	**35**	0	3	1	1	**5**	1	14	20
2007	35	2,481	736	4	6	2	4	**16**	7	6	3	0	**16**	3	0	0	0	**3**	8	30	44

Table K7. Percentage of U.S. landings, during 1982-2007, by market category group.

	% of U.S. Landings by Market Category Group			
	Lemon	Large	Small	Unclassified
Year	1201	1202	1203	1200
1982	18.6	57.9	18.9	4.7
1983	9.3	45.5	43.4	1.8
1984	9.6	51.7	34.8	3.9
1985	12.4	50.1	33.9	3.5
1986	10.1	42.0	37.5	10.4
1987	9.2	38.9	47.4	4.5
1988	5.9	35.5	53.3	5.3
1989	5.9	38.1	49.2	6.7
1990	3.8	33.1	57.3	5.9
1991	3.0	37.5	51.2	8.3
1992	3.6	36.9	51.2	8.3
1993	5.3	38.2	49.3	7.1
1994	6.5	40.3	49.4	3.8
1995	6.1	35.4	50.3	8.2
1996	4.8	32.6	46.1	16.6
1997	3.6	35.5	29.2	31.7
1998	4.0	37.7	56.4	1.9
1999	4.8	40.4	51.8	2.9
2000	7.3	41.1	48.4	3.3
2001	11.4	48.7	34.9	4.9
2002	17.6	56.5	19.8	6.0
2003	35.9	49.3	11.6	3.2
2004	22.3	67.9	8.7	1.2
2005	20.0	65.6	13.4	1.0
2006	25.3	59.4	12.3	3.0
2007	17.1	61.2	17.1	4.7

Table K8. Data pooling procedures used to apply length frequency samples to landings by market category to estimate catch (numbers) at age of Georges Bank winter flounder, 1982-2007. An “X” indicates that the time bin applies to all market categories unless otherwise noted.

<table>
<tr><th>Year</th><th>Quarter 1</th><th>Quarter 2</th><th>Quarter 3</th><th>Quarter 4</th><th>Market Category Comments</th></tr>
<tr><td>1982</td><td colspan="2">Pooled each mkt cat</td><td>X</td><td>X</td><td rowspan="12">1204 (Extra Large) pooled with 1201 Lemon Sole

1205 (Large/Mixed) pooled with 1202 (Large)

1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)</td></tr>
<tr><td>1983</td><td colspan="2">Pooled each mkt cat</td><td>X</td><td>X</td></tr>
<tr><td>1984</td><td colspan="2">Pooled each mkt cat</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1985</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1986</td><td>X</td><td>X</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1987</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1988</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1989</td><td>X</td><td>X</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1990</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1991</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1992</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1993</td><td>X</td><td colspan="3">Pooled each mkt category</td></tr>
<tr><td rowspan="2">1994</td><td colspan="2">Pooled Lemon/Lg</td><td colspan="2">Pooled Lemon/Lg</td><td rowspan="7">1201 (Lemon Sole) and 1204 (Extra Large) pooled with 1202 (Large) and 1205 (Large/Mixed)

1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td rowspan="2">1995</td><td colspan="2">Pooled Lemon/Lg</td><td colspan="2">Pooled Lemon/Lg</td></tr>
<tr><td>X</td><td>X</td><td colspan="2">Pooled Med/Sm</td></tr>
<tr><td rowspan="2">1996</td><td colspan="2">Pooled Lemon/Lg</td><td>X</td><td>X</td></tr>
<tr><td colspan="4">Pooled Med/Sm</td></tr>
<tr><td>1997</td><td>X</td><td>X</td><td colspan="2">Pooled Lemon/Lg
Pooled Med/Sm</td></tr>
<tr><td>1998</td><td colspan="4">Pooled all mkt categories</td><td rowspan="2">Pooled all market categories and included all kept lengths from otter trawl observer trips</td></tr>
<tr><td>1999</td><td colspan="4">Pooled all mkt categories</td></tr>
<tr><td>2000</td><td colspan="2">Pooled all mkt categories</td><td colspan="2">Pooled Lemon/Lg
Pooled Med/Sm</td><td>Pooled market categories as in 1994-1997 and included kept lengths from otter trawl observer trips (months 1-6)</td></tr>
</table>

Table K8 (cont.).

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Market Category Comments
2001	Pooled Med/Sm		X	X	1204 (Extra Large) pooled with 1201 Lemon Sole 1205 (Large/Mixed) pooled with 1202 (Large) 1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)
2002	X	X	Pooled Med/Sm		
2003	X	X	Pooled Med/Sm		
2004	X	X	X	X	
2005	X	X	X	X	
2006	Pooled Med/Sm		X	X	
2007	Pooled Med/Sm				
	X	X	Pooled Lg		
	X	X	X	X	

Table K9. Landings (numbers, in thousands) at age for Georges Bank winter flounder during 1982-2007.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	0	353	1,707	1,048	511	258	281	4,157
1983	10	787	2,902	1,454	551	206	528	6,438
1984	0	282	570	1,371	1,408	635	920	5,186
1985	20	805	693	812	491	112	100	3,031
1986	0	665	1,328	235	229	131	88	2,675
1987	0	1,294	1,681	899	133	89	121	4,217
1988	0	835	2,774	843	197	90	93	4,832
1989	0	1,381	1,222	509	147	107	61	3,427
1990	0	295	2,032	668	185	46	17	3,241
1991	0	593	1,270	951	136	38	60	3,047
1992	0	796	756	727	468	92	61	2,902
1993	37	301	1,143	451	320	163	47	2,461
1994	0	367	635	360	97	50	45	1,554
1995	371	701	172	142	105	32	41	1,563
1996	0	1,319	423	185	95	98	88	2,208
1997	0	355	993	444	176	79	87	2,135
1998	0	10	1,426	826	131	43	12	2,447
1999	0	296	786	521	147	20	20	1,790
2000	0	646	1,108	369	254	186	160	2,723
2001	11	372	1,280	801	586	158	99	3,307
2002	0	121	927	757	445	236	189	2,675
2003	0	259	694	925	455	252	400	2,987
2004	0	62	579	844	520	234	367	2,606
2005	0	224	529	752	362	142	217	2,227
2006	0	25	283	278	122	55	113	876
2007	0	0	143	125	223	77	96	864

Table K10. Number of Georges Bank winter flounder lengths sampled from the discards of the bottom trawl and scallop dredge fisheries by fisheries observers during 1989-2007.

	N lengths sampled from discards	
Year	Bottom trawl	Scallop dredge
1989	70	0
1990	22	0
1991	5	0
1992	15	1
1993	5	3
1994	6	35
1995	11	0
1996	39	2
1997	1	417
1998	1	84
1999	2	17
2000	4	15
2001	1	0
2002	95	1
2003	92	1
2004	299	125
2005	420	807
2006	438	421
2007	730	887

Table K11. Discards (numbers, in thousands) at age for Georges Bank winter flounder during 1982-2007.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	116	692	1,776	1,090	531	268	292	4,776
1983	137	1,037	3,000	1,503	570	213	546	7,007
1984	138	427	587	1,412	1,450	654	947	5,616
1985	66	946	733	858	519	118	106	3,346
1986	38	763	1,416	251	244	139	94	2,945
1987	99	1,461	1,789	956	142	94	129	4,670
1988	72	1,013	2,925	889	208	95	98	5,300
1989	34	1,556	1,340	559	161	117	66	3,833
1990	36	370	2,248	739	204	50	18	3,667
1991	2	656	1,389	1,040	149	41	66	3,343
1992	23	764	704	678	436	86	57	2,748
1993	39	285	1,062	419	297	152	44	2,296
1994	8	353	598	339	92	47	43	1,478
1995	365	688	168	138	103	31	40	1,534
1996	35	1,336	424	185	95	98	88	2,261
1997	2	52	27	12	2	1	1	96
1998	0	10	1,445	837	132	44	12	2,480
1999	70	395	808	536	151	20	21	2,001
2000	52	676	1,100	366	253	185	159	2,791
2001	15	376	1,276	799	584	157	99	3,306
2002	0	117	890	728	427	227	182	2,571
2003	0	257	689	918	452	251	398	2,968
2004	3	25	15	17	5	4	8	76
2005	4	41	18	19	11	18	12	123
2006	4	12	23	24	24	6	9	102
2007	11	34	32	35	47	13	14	186

Table K12. Mean weights at age (kg) in the catches of Georges Bank winter flounder during 1982-2007.

				Age				All
Year	1	2	3	4	5	6	7+	Ages
1982	0.216	0.234	0.444	0.779	1.041	1.228	1.615	0.647
1983	0.149	0.260	0.451	0.668	0.899	0.991	1.340	0.576
1984	0.110	0.281	0.467	0.585	0.744	0.891	1.266	0.719
1985	0.191	0.386	0.522	0.782	1.050	1.366	1.720	0.683
1986	0.197	0.392	0.617	0.778	1.029	1.194	1.589	0.650
1987	0.081	0.375	0.549	0.868	1.107	1.217	1.724	0.606
1988	0.145	0.327	0.510	0.760	1.149	1.323	1.761	0.567
1989	0.123	0.355	0.459	0.826	1.076	1.332	1.742	0.538
1990	0.110	0.432	0.510	0.757	0.992	1.339	2.021	0.588
1991	0.190	0.415	0.479	0.702	0.985	1.438	1.751	0.594
1992	0.137	0.386	0.494	0.744	0.906	1.185	1.465	0.627
1993	0.246	0.382	0.537	0.758	0.941	1.294	1.900	0.680
1994	0.200	0.413	0.543	0.803	0.954	1.380	1.618	0.651
1995	0.285	0.387	0.590	0.666	0.999	1.267	1.652	0.501
1996	0.120	0.444	0.649	0.892	1.223	1.467	1.763	0.639
1997	0.140	0.429	0.540	0.696	0.981	1.233	1.439	0.648
1998	0.178	0.244	0.486	0.631	0.809	1.322	1.829	0.572
1999	0.215	0.337	0.452	0.703	1.040	1.569	1.778	0.534
2000	0.119	0.416	0.478	0.568	1.003	1.277	1.627	0.628
2001	0.238	0.306	0.488	0.750	0.827	1.241	1.821	0.664
2002	0.137	0.481	0.554	0.845	1.071	1.340	1.812	0.878
2003	0.124	0.404	0.608	0.968	1.254	1.540	1.893	1.052
2004	0.095	0.471	0.703	0.962	1.216	1.435	1.753	1.090
2005	0.157	0.378	0.592	0.929	1.157	1.435	1.740	0.936
2006	0.131	0.428	0.639	0.919	1.232	1.528	1.874	1.013
2007	0.153	0.465	0.579	0.755	1.036	1.348	1.722	0.935

Table K13. Catch (numbers, in thousands) at age for Georges Bank winter flounder during 1982-2007.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	116	1,045	3,483	2,138	1,042	526	573	8,924
1983	147	1,824	5,902	2,957	1,121	419	1,075	13,445
1984	138	709	1,157	2,783	2,859	1,289	1,867	10,802
1985	86	1,751	1,426	1,670	1,010	229	206	6,378
1986	38	1,428	2,744	486	472	270	182	5,621
1987	99	2,755	3,470	1,855	275	183	250	8,887
1988	72	1,848	5,699	1,731	405	184	192	10,131
1989	34	2,936	2,562	1,068	309	224	127	7,260
1990	36	665	4,280	1,408	389	96	35	6,908
1991	2	1,248	2,659	1,990	284	79	126	6,390
1992	23	1,560	1,460	1,405	904	178	118	5,649
1993	76	585	2,205	870	617	315	90	4,757
1994	8	720	1,232	699	189	96	88	3,032
1995	736	1,388	340	280	209	63	80	3,097
1996	35	2,655	846	370	190	196	176	4,469
1997	2	407	1,020	456	179	80	87	2,231
1998	0	20	2,870	1,662	263	87	25	4,927
1999	70	691	1,595	1,057	298	40	41	3,790
2000	52	1,322	2,208	735	507	371	319	5,514
2001	26	748	2,556	1,600	1,170	315	198	6,613
2002	0	238	1,816	1,485	872	463	371	5,245
2003	0	517	1,383	1,843	908	504	797	5,954
2004	1	69	584	861	525	237	374	2,682
2005	2	260	545	771	373	160	229	2,350
2006	0	32	301	300	146	61	120	978
2007	11	34	174	360	271	90	110	1,050

Table K14. Relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices for Georges Bank winter flounder caught in the U.S. spring and autumn (strata 13-23) and Canada spring (strata 5Z1-5Z4) research vessel bottom trawl surveys. Standardization coefficients for trawl door changes (numbers = 1.46 and weight = 1.39) and gear changes (numbers = 2.02 and weight = 1.86) were applied to NEFSC survey indices.

Year	U.S. Spring Survey		U.S. Autumn Survey		Canada Spring Survey	
	Number/tow	Kg/tow	Number/tow	Kg/tow	Number/tow	Kg/tow
1963			1.94	3.02		
1964			1.75	2.77		
1965			2.70	3.03		
1966			4.79	5.26		
1967			1.78	2.11		
1968	2.66	2.99	1.92	1.83		
1969	2.95	4.02	2.59	2.53		
1970	1.81	2.20	7.02	7.73		
1971	1.71	2.04	1.53	1.32		
1972	4.71	4.90	1.64	1.56		
1973	1.34	1.73	2.56	2.30		
1974	3.19	3.16	1.36	1.55		
1975	0.92	0.72	3.74	2.09		
1976	2.23	1.57	5.52	3.63		
1977	1.95	0.90	4.81	3.97		
1978	3.25	2.52	4.22	3.47		
1979	0.79	1.09	5.06	4.08		
1980	1.63	1.45	2.03	2.32		
1981	1.92	2.00	5.50	4.41		
1982	2.42	1.57	5.61	3.32		
1983	8.29	6.93	3.03	2.89		
1984	5.12	5.22	4.90	3.28		
1985	3.54	2.44	1.98	1.18		
1986	2.10	1.26	3.31	2.00		
1987	2.61	1.16	0.96	1.03	1.24	1.74
1988	2.68	1.51	3.90	1.29	4.31	2.75
1989	1.25	0.73	1.43	0.96	4.05	1.95
1990	2.65	1.48	0.51	0.34	4.93	2.64
1991	2.21	1.21	0.31	0.24	1.98	1.38
1992	1.34	0.83	0.69	0.38	0.51	0.59
1993	1.00	0.58	1.22	0.78	3.53	1.76
1994	1.25	0.56	0.85	0.56	5.10	2.01
1995	2.42	1.38	2.74	1.62	5.63	1.96
1996	2.12	1.38	1.48	1.68	4.12	2.30

Table K14 (cont.)

Year	U.S. Spring Survey		U.S. Autumn Survey		Canada Spring Survey	
	Number/tow	Kg/tow	Number/tow	Kg/tow	Number/tow	Kg/tow
1997	1.48	1.09	1.78	1.55	4.58	3.09
1998	0.78	0.71	3.50	3.40	1.14	1.21
1999	3.56	3.21	2.45	2.47	1.25	1.89
2000	4.25	3.55	4.60	4.82	1.48	2.22
2001	1.25	1.16	6.08	4.85	2.28	2.54
2002	4.73	4.82	4.67	5.60	3.17	3.85
2003	1.22	1.30	2.36	2.96	1.09	1.31
2004	0.42	0.51	5.01	4.06	2.10	1.79
2005	1.00	0.80	1.94	2.11	1.19	1.23
2006	0.58	0.49	1.36	1.42	0.09	0.17
2007	0.75	0.68	2.13	2.00	[1]0.18	0.27
2008	7.35	5.42			1.07	0.65
Grand Mean	2.42	2.03	2.92	2.57	2.50	1.79

[1] No tows conducted in the northwest portion of stratum 5Z3 due to adverse weather conditions.

Table K15. NEFSC fall survey minimum population sizes at age (000's) for Georges Bank winter flounder (offshore strata 13-23). Numbers at age include data for 1981-2007 lagged forward one year and age.

Year	1	2	3	4	5	6	7	8	9	10+	Total
1982	0	2,396	674	814	1,082	504	135	244	147	63	6,059
1983	284	2,094	2,178	583	542	283	184	0	33	0	6,181
1984	27	70	568	1,347	619	236	264	95	57	57	3,339
1985	239	654	1,189	1,391	1,408	368	113	26	12	0	5,401
1986	110	341	885	550	80	190	27	0	0	0	2,182
1987	145	1,160	1,627	370	205	48	24	23	0	48	3,652
1988	36	53	239	256	208	99	80	62	27	0	1,061
1989	49	2,958	620	468	139	9	25	25	0	0	4,293
1990	24	97	1,072	73	143	74	58	9	27	0	1,577
1991	24	61	44	376	0	52	0	0	0	0	557
1992	109	46	0	81	53	18	36	0	0	0	344
1993	0	53	509	158	9	27	0	0	0	0	757
1994	0	592	192	283	213	27	0	18	0	18	1,343
1995	0	167	424	224	86	33	0	0	0	0	934
1996	18	937	1,115	685	187	57	0	0	18	0	3,018
1997	0	124	344	614	259	131	94	63	0	0	1,628
1998	18	79	648	758	344	79	30	3	0	0	1,960
1999	91	273	386	1,713	1,109	190	66	27	0	0	3,854
2000	18	388	796	381	367	608	88	27	24	0	2,697
2001	18	53	1,286	1,666	753	902	270	56	69	0	5,073
2002	18	599	1,536	2,442	1,276	322	332	100	53	25	6,703
2003	0	206	496	1,053	1,309	1,148	410	477	23	23	5,146
2004	309	176	27	352	770	652	209	80	21	0	2,597
2005	231	326	1,353	1,377	1,328	282	349	230	44	0	5,520
2006	97	55	167	493	464	297	358	132	18	58	2,139
2007	0	101	179	307	380	422	72	42	0	0	1,502
2008	231	313	317	307	428	613	91	34	18	0	2,351

Table K16. NEFSC spring survey minimum population sizes at age for Georges Bank winter flounder (offshore strata 13-23) during 1982-2008.

Year	1	2	3	4	5	6	7	8	9	10+	Total
1980	92	444	506	268	292	97	7	73	18	0	1,796
1981	53	128	829	579	133	119	247	13	12	0	2,113
1982	74	903	555	660	191	151	41	18	36	36	2,665
1983	27	1,037	3,704	1,555	692	796	608	424	125	169	9,135
1984	36	168	2,107	1,635	390	379	477	280	27	146	5,644
1985	0	1,701	821	636	402	223	47	24	49	0	3,902
1986	255	752	857	192	170	85	0	0	0	0	2,310
1987	163	1,647	670	275	91	0	24	0	0	0	2,871
1988	73	556	1,433	692	117	42	18	0	27	0	2,958
1989	49	560	293	251	157	18	0	53	0	0	1,381
1990	129	653	1,611	357	99	74	0	0	0	0	2,923
1991	273	349	834	587	278	36	24	0	49	0	2,430
1992	73	652	302	141	148	111	0	24	27	0	1,477
1993	172	291	362	175	0	47	33	24	0	0	1,105
1994	127	604	436	96	66	45	0	0	0	0	1,374
1995	150	790	1,295	297	103	30	0	0	0	0	2,664
1996	38	1,233	436	494	70	27	43	0	0	0	2,339
1997	24	194	542	677	115	24	27	0	24	0	1,627
1998	0	24	218	468	125	0	27	0	0	0	861
1999	225	548	675	1,313	896	200	53	18	0	0	3,927
2000	18	620	1,069	697	1,155	734	200	120	71	0	4,685
2001	0	73	335	314	197	193	268	0	0	0	1,380
2002	113	167	245	1,935	772	784	701	312	159	26	5,215
2003	52	27	163	231	367	320	154	27	0	0	1,341
2004	0	36	27	63	215	73	24	28	0	0	465
2005	98	188	130	315	212	132	0	27	0	0	1,101
2006	43	0	188	210	88	81	0	24	0	0	634
2007	91	128	67	159	180	100	56	23	19	0	822
2008	945	1,280	1,513	1,945	1,427	386	94	504	0	0	8,094

Table K17. Canada spring (February) survey minimum population sizes at age for Georges Bank winter flounder (strata 5Z1-5Z4) during 1987-2008.

Year	1	2	3	4	5	6	7	8	9	10+	Total
1987	0	68	153	202	255	102	0	0	0	0	780
1988	102	386	1,396	653	101	46	0	23	0	0	2,708
1989	54	1,244	623	448	141	27	7	6	0	0	2,550
1990	0	88	683	1,991	262	42	25	3	0	0	3,094
1991	44	57	412	577	129	29	0	0	0	0	1,247
1992	0	17	38	131	48	86	0	3	0	0	323
1993	746	419	595	282	85	48	41	3	0	0	2,219
1994	10	2,083	705	155	234	1	11	10	0	0	3,207
1995	992	1,544	799	134	57	8	2	0	0	0	3,534
1996	562	792	589	408	136	50	48	2	3	4	2,594
1997	11	609	990	1,102	120	23	9	17	0	0	2,880
1998	11	19	100	382	180	21	0	0	0	0	714
1999	32	154	146	252	145	36	12	4	4	0	784
2000	6	0	7	87	82	227	227	120	121	54	932
2001	150	49	121	147	276	92	232	348	10	11	1,437
2002	0	58	136	51	729	256	270	284	126	83	1,993
2003	29	135	37	53	80	131	86	126	7	2	686
2004	331	113	59	138	136	327	101	96	17	0	1,319
2005	55	100	55	104	107	107	102	63	37	17	748
2006	0	3	3	36	36	33	68	2	3	1	186
2007	0	0	3	0	8	39	24	21	8	9	112
2008	260	123	48	54	75	26	32	54	0	0	671

Table K18. Annual and average values of Mohn's rho statistic for average F (ages 4-6), spawning stock biomass, and age 1 recruits for Georges Bank winter flounder.

	Relative difference (Year *t*-2007)		
	Avg Fages 4-6	SSB	Age 1 Recruits
2000	-0.01	-0.03	-0.83
2001	-0.27	0.13	0.12
2002	-0.30	0.10	-0.16
2003	-0.11	0.04	-0.07
2004	-0.28	0.16	2.06
2005	-0.20	0.13	0.47
2006	0.09	-0.10	-0.11
Total	-1.08	0.43	1.48
Average	-0.15	0.06	0.21

Table K19. VPA estimates of Jan. 1 population size (numbers, 000's) for Georges Bank winter flounder, 1982-2008.

AGE	1982	1983	1984	1985	1986
1	9809.	5883.	12716.	12242.	16440.
2	16950.	7926.	4684.	10287.	9945.
3	13084.	12935.	4850.	3196.	6846.
4	6882.	7584.	5319.	2930.	1343.
5	2556.	3716.	3562.	1875.	914.
6	1563.	1161.	2036.	411.	637.
7	1702.	2978.	2950.	370.	430.
Total	52546.	42183.	36117.	31312.	36555.

AGE	1987	1988	1989	1990	1991
1	11146.	18565.	10206.	6873.	8955.
2	13426.	9036.	15135.	8325.	5595.
3	6856.	8514.	5735.	9749.	6216.
4	3150.	2520.	1928.	2407.	4157.
5	664.	931.	533.	628.	720.
6	328.	298.	400.	162.	170.
7	447.	310.	227.	59.	271.
Total	36017.	40174.	34164.	28204.	26083.

AGE	1992	1993	1994	1995	1996
1	4365.	3412.	5220.	14569.	10724.
2	7329.	3553.	2725.	4267.	11264.
3	3458.	4598.	2382.	1585.	2248.
4	2712.	1526.	1796.	852.	991.
5	1628.	968.	476.	845.	447.
6	335.	528.	246.	220.	505.
7	223.	152.	226.	279.	452.
Total	20050.	14737.	13072.	22617.	26631.

AGE	1997	1998	1999	2000	2001
1	9940.	12243.	12524.	9900.	6060.
2	8748.	8136.	10022.	10191.	8058.
3	6835.	6795.	6643.	7582.	7152.
4	1083.	4678.	2997.	4006.	4226.
5	480.	479.	2340.	1506.	2618.
6	196.	233.	158.	1648.	779.
7	215.	66.	161.	1417.	489.
Total	27497.	32629.	34846.	36250.	29382.

AGE	2002	2003	2004	2005	2006
1	4807.	3788.	4829.	2584.	5580.
2	4937.	3935.	3101.	3951.	2112.
3	5923.	3827.	2755.	2460.	2995.
4	3566.	3220.	1894.	1721.	1522.
5	2027.	1591.	997.	782.	721.
6	1098.	881.	496.	349.	307.
7	880.	1396.	781.	500.	609.
Total	23239.	18638.	14854.	12348.	13845.

AGE	2007	2008
1	12033.	5122.
2	4565.	9842.
3	1696.	3706.
4	2176.	1231.
5	975.	1457.
6	458.	555.
7	491.	586.
Total	22393.	22500.

Table K20. VPA estimates of fishing mortality rates, by year and age, for Georges Bank winter flounder, 1982-2007.

AGE	1982	1983	1984	1985	1986
1	0.0131	0.0279	0.0120	0.0078	0.0026
2	0.0703	0.2913	0.1821	0.2072	0.1719
3	0.3454	0.6886	0.3037	0.6671	0.5763
4	0.4162	0.5556	0.8424	0.9647	0.5042
5	0.5892	0.4015	1.9583	0.8806	0.8265
6	0.4602	0.5023	1.1567	0.9310	0.6225
7	0.4602	0.5023	1.1567	0.9310	0.6225
Average Ages 4-6	0.4885	0.4865	1.3192	0.9254	0.6511

AGE	1987	1988	1989	1990	1991
1	0.0099	0.0043	0.0037	0.0058	0.0003
2	0.2555	0.2546	0.2398	0.0922	0.2811
3	0.8009	1.2851	0.6684	0.6523	0.6294
4	1.0192	1.3537	0.9210	1.0073	0.7378
5	0.6018	0.6444	0.9909	1.1093	0.5655
6	0.9329	1.1080	0.9357	1.0276	0.7104
7	0.9329	1.1080	0.9357	1.0276	0.7104
Average	0.8513	1.0354	0.9492	1.0480	0.6712

AGE	1992	1993	1994	1995	1996
1	0.0058	0.0248	0.0016	0.0573	0.0036
2	0.2664	0.1998	0.3423	0.4407	0.2995
3	0.6184	0.7399	0.8279	0.2690	0.5305
4	0.8299	0.9652	0.5538	0.4458	0.5246
5	0.9257	1.1690	0.5698	0.3158	0.6245
6	0.8648	1.0395	0.5571	0.3790	0.5546
7	0.8648	1.0395	0.5571	0.3790	0.5546
Average	0.8734	1.0579	0.5602	0.3802	0.5679

AGE	1997	1998	1999	2000	2001
1	0.0002	0.0001	0.0062	0.0059	0.0048
2	0.0527	0.0027	0.0790	0.1541	0.1078
3	0.1793	0.6187	0.3058	0.3845	0.4960
4	0.6156	0.4926	0.4878	0.2252	0.5346
5	0.5228	0.9079	0.1507	0.4596	0.6687
6	0.5862	0.5247	0.3259	0.2840	0.5838
7	0.5862	0.5247	0.3259	0.2840	0.5838
Average	0.5749	0.6417	0.3215	0.3229	0.5957

AGE	2002	2003	2004	2005	2006
1	0.0001	0.0001	0.0006	0.0019	0.0008
2	0.0547	0.1564	0.0315	0.0769	0.0196
3	0.4095	0.5032	0.2703	0.2804	0.1195
4	0.6069	0.9721	0.6850	0.6709	0.2455
5	0.6339	0.9663	0.8499	0.7350	0.2524
6	0.6166	0.9702	0.7389	0.6905	0.2477
7	0.6166	0.9702	0.7389	0.6905	0.2477
Average	0.6191	0.9695	0.7579	0.6988	0.2485

AGE	2007
1	0.0010
2	0.0084
3	0.1199
4	0.2009
5	0.3634
6	0.2821
7	0.2821
Average	0.2821

Table K21. VPA estimates of spawning stock biomass (mt) for Georges Bank winter flounder, 1982-2007.

AGE	1982	1983	1984	1985	1986
1	148.	49.	57.	125.	180.
2	1462.	919.	479.	1055.	1364.
3	3992.	3307.	1436.	968.	2689.
4	4411.	3551.	2218.	1403.	743.
5	2329.	2757.	1631.	1184.	668.
6	1548.	1025.	1389.	331.	605.
7	2409.	3468.	2847.	507.	579.
Total	16300.	15077.	10058.	5573.	6828.

AGE	1987	1988	1989	1990	1991
1	34.	132.	51.	30.	92.
2	1799.	725.	1698.	977.	586.
3	2447.	2600.	1756.	3288.	2252.
4	1806.	1193.	1000.	1114.	2062.
5	525.	785.	380.	438.	533.
6	292.	277.	394.	152.	169.
7	615.	420.	315.	94.	396.
Total	7519.	6133.	5594.	6094.	6090.

AGE	1992	1993	1994	1995	1996
1	27.	50.	58.	253.	52.
2	976.	405.	421.	564.	1958.
3	1250.	1630.	830.	669.	915.
4	1318.	739.	1014.	450.	622.
5	1036.	616.	347.	683.	342.
6	292.	446.	241.	216.	525.
7	263.	225.	314.	410.	686.
Total	5163.	4112.	3226.	3245.	5101.

AGE	1997	1998	1999	2000	2001
1	81.	122.	149.	56.	78.
2	1019.	780.	1253.	1533.	781.
3	2917.	2476.	1874.	2545.	2636.
4	618.	2377.	1526.	1864.	2185.
5	389.	288.	1767.	1109.	1508.
6	206.	230.	160.	1724.	743.
7	265.	104.	258.	2093.	761.
Total	5494.	6376.	6988.	10924.	8691.

AGE	2002	2003	2004	2005	2006
1	29.	19.	18.	19.	30.
2	857.	466.	386.	383.	283.
3	2029.	1690.	1256.	1109.	1298.
4	1949.	1865.	1214.	1169.	1027.
5	1538.	1297.	877.	684.	704.
6	982.	895.	551.	386.	373.
7	1354.	2091.	1135.	729.	1044.
Total	8739.	8323.	5437.	4478.	4759.

AGE	2007
1	88.
2	584.
3	744.
4	1395.
5	850.
6	536.
7	767.
Total	4964.

Table K22. Bootstrapped estimates of the 2008 stock sizes-at-age (numbers, 000's) and 80% confidence intervals for Georges Bank winter flounder.

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 2	9842.	11820.	7544.	0.6383
N 3	3706.	4048.	1839.	0.4542
N 4	1231.	1336.	572.	0.4281
N 5	1457.	1507.	496.	0.3290
N 6	555.	590.	205.	0.3481

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 2	1978.	247.	20.0933	7865.	0.9593
N 3	342.	59.	9.2163	3365.	0.5464
N 4	105.	18.	8.5084	1127.	0.5077
N 5	49.	16.	3.3877	1408.	0.3520
N 6	35.	7.	6.2893	520.	0.3949

	LOWER 80. % CI	UPPER 80. % CI
N 2	4493.	21106.
N 3	2126.	6413.
N 4	727.	2094.
N 5	930.	2164.
N 6	352.	849.

Table K23. Bootstrapped estimates of the 2007 fishing mortality rates-at-age and 80% confidence intervals for Georges Bank winter flounder.

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0010	0.0012	0.000850	0.7071
AGE 2	0.0084	0.0092	0.004312	0.4663
AGE 3	0.1199	0.1291	0.050977	0.3948
AGE 4	0.2009	0.2129	0.065914	0.3096
AGE 5	0.3634	0.3756	0.111159	0.2959
AGE 6	0.2821	0.2943	0.059064	0.2007
AGE 7	0.2821	0.2943	0.059064	0.2007

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000199	0.000028	19.8822	0.0008	1.0580
AGE 2	0.000877	0.000139	10.4812	0.0075	0.5755
AGE 3	0.009190	0.001638	7.6622	0.1108	0.4603
AGE 4	0.012055	0.002119	6.0015	0.1888	0.3491
AGE 5	0.012208	0.003536	3.3592	0.3512	0.3165
AGE 6	0.012131	0.001907	4.2998	0.2700	0.2187
AGE 7	0.012131	0.001907	4.2998	0.2700	0.2187

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.000468	0.002192
AGE 2	0.004822	0.014537
AGE 3	0.072221	0.194724
AGE 4	0.139716	0.298322
AGE 5	0.252005	0.524366
AGE 6	0.225821	0.371011
AGE 7	0.225821	0.371011

Table K24. Input data, based on 2003-2007 average values from the VPA, for the Georges Bank winter flounder SSB- and yield-per-recruit model (M = 0.2) and stochastic projections.

Age	Selectivity on F	Selectivity on M	Mean stock weights	Mean catch weights	Spawning stock weights	Proportion mature
1	0.001	1	0.074	0.132	0.074	0.08
2	0.10	1	0.235	0.429	0.235	0.54
3	0.43	1	0.518	0.624	0.518	0.94
4	1.00	1	0.747	0.907	0.747	1.00
5	1.00	1	1.043	1.179	1.043	1.00
6	1.00	1	1.313	1.457	1.313	1.00
7+	1.00	1	1.796	1.796	1.796	1.00

Table K25. Current and re-estimated biological reference points for Georges Bank winter flounder and 2007 VPA estimates of fishing mortality rate and spawning stock biomass (mt).

Input data	$\mathbf{F_{40\%MSP}}$	**F 2007** (80% CI)	$\mathbf{SSB_{MSY}}$	**SSB 2007** (80% CI)	**MSY**
1982-2007	0.26	0.28	16,000	4,964	3,500
		(0.22,0.37)		(4,204, 6,249)	
	$\mathbf{F_{MSY}}$		$\mathbf{B_{MSY}}$		**MSY**
Current[1]	0.32		9,400		3,000

[1] Derived from an ASPIC model that included landings data for 1964-2000 and NEFSC spring and fall survey indices for strata 13-22.

Table K26. Stochastic projections of catch (mt) and spawning stock biomass (mt) in 2009 for Georges Bank winter flounder, assuming that the 2008 catch is the same as in 2007, for F_{sq} (status quo), F_{MSY} proxy (= $F_{40\%MSP}$), and F rebuild by 2018.

2008			2009	
Catch (mt)	**SSB (mt)**	**F 2009**	**Catch (mt)**	**SSB (mt)**
980	4,964	F_{sq} (= 0.28)	2,084	9,792
		F_{MSY} ($F_{40\%MSP}$ = 0.26)	1,948	9,822
		$F_{REBUILD}$ (= 0.254)	1,907	9,831

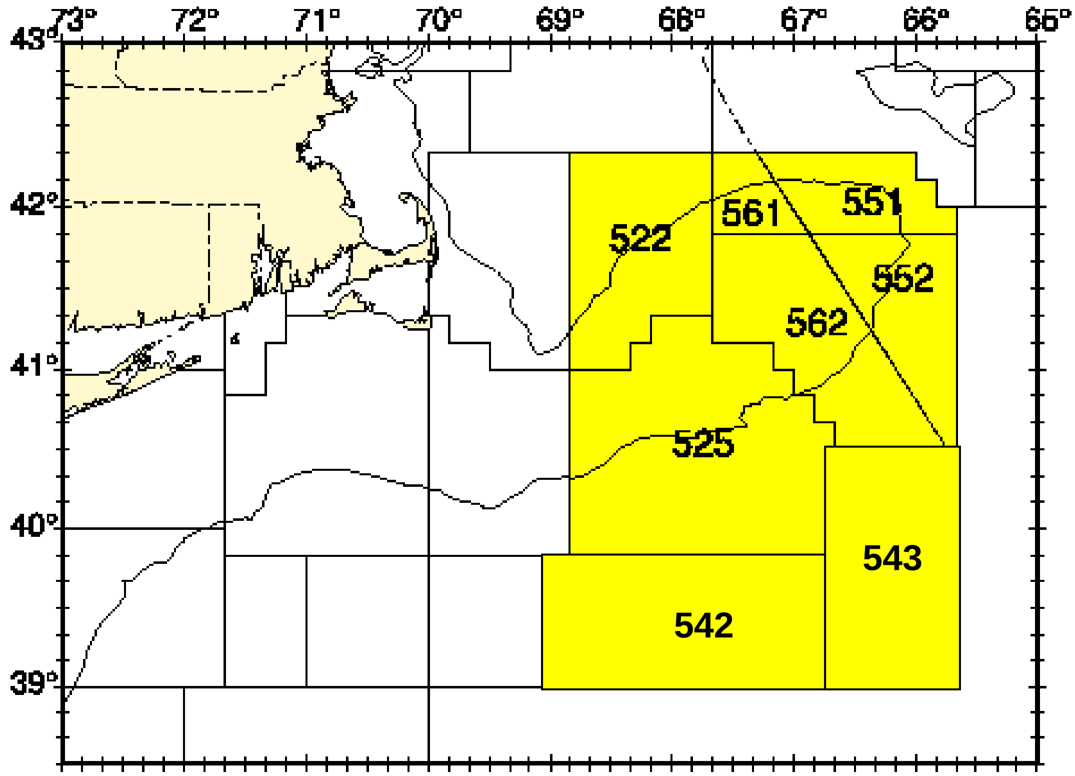

Figure K1. Statistical Areas included in the assessment of the Georges Bank winter flounder stock.

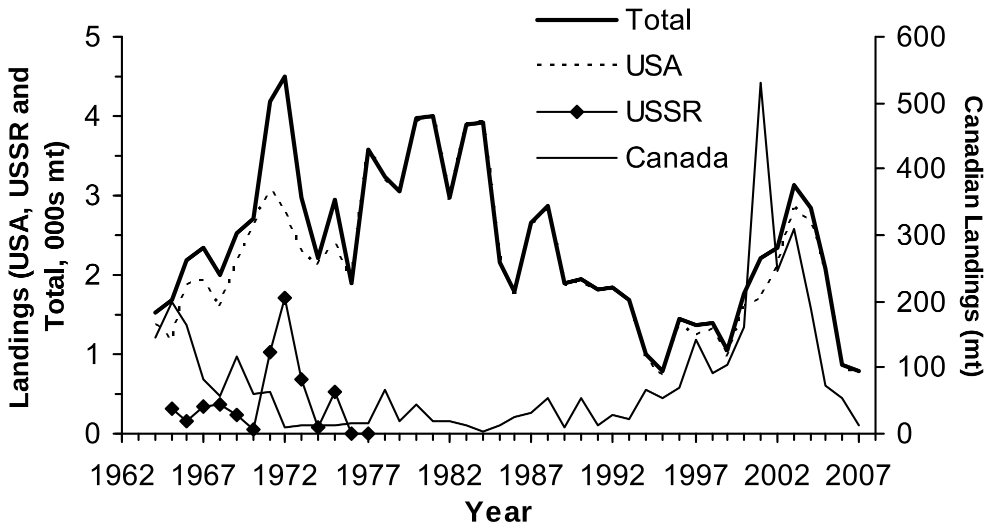

Figure K2. Landings of Georges Bank winter flounder during 1964-2007.

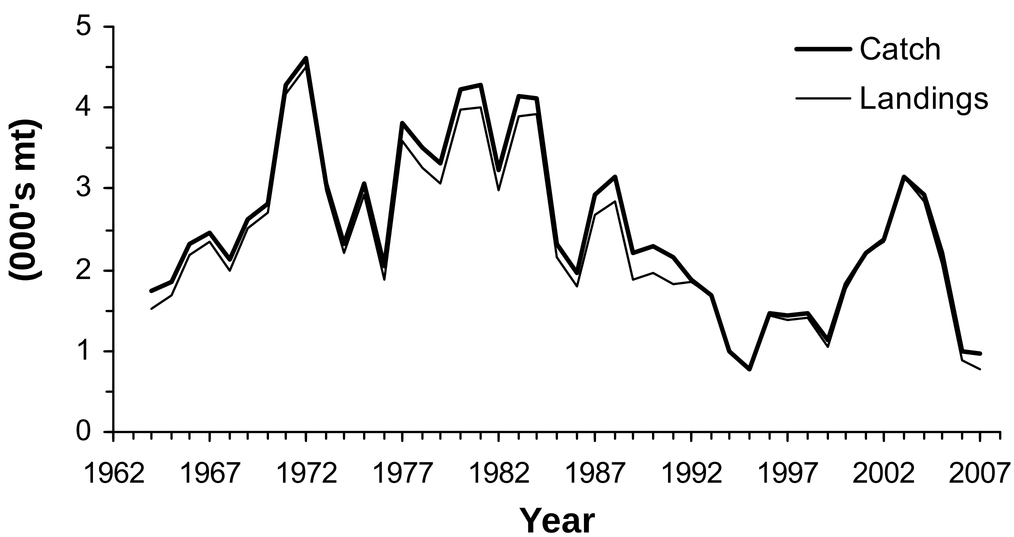

Figure K3. Landings and catches of Georges Bank winter flounder during 1964-2007.

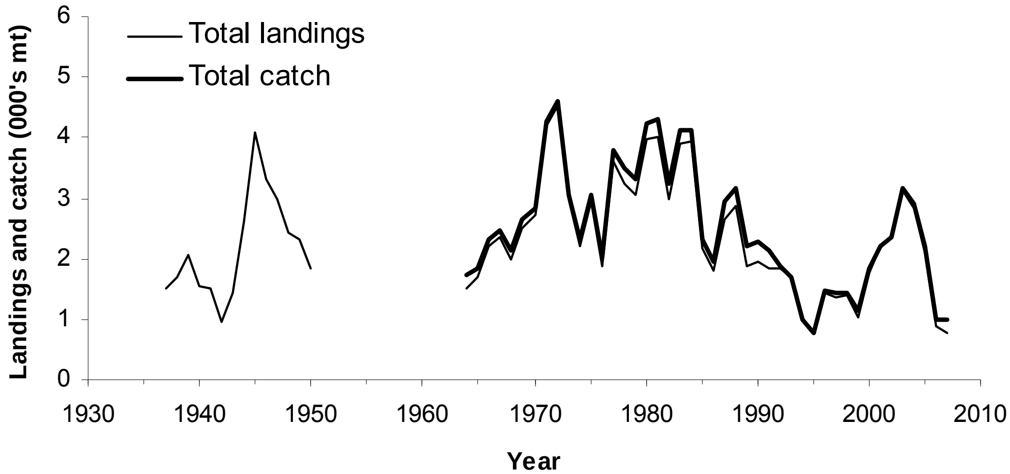

Figure K4. Historical total landings of winter flounder from Georges Bank, during 1937-1950, in relation to total landings and catches during 1964-2007.

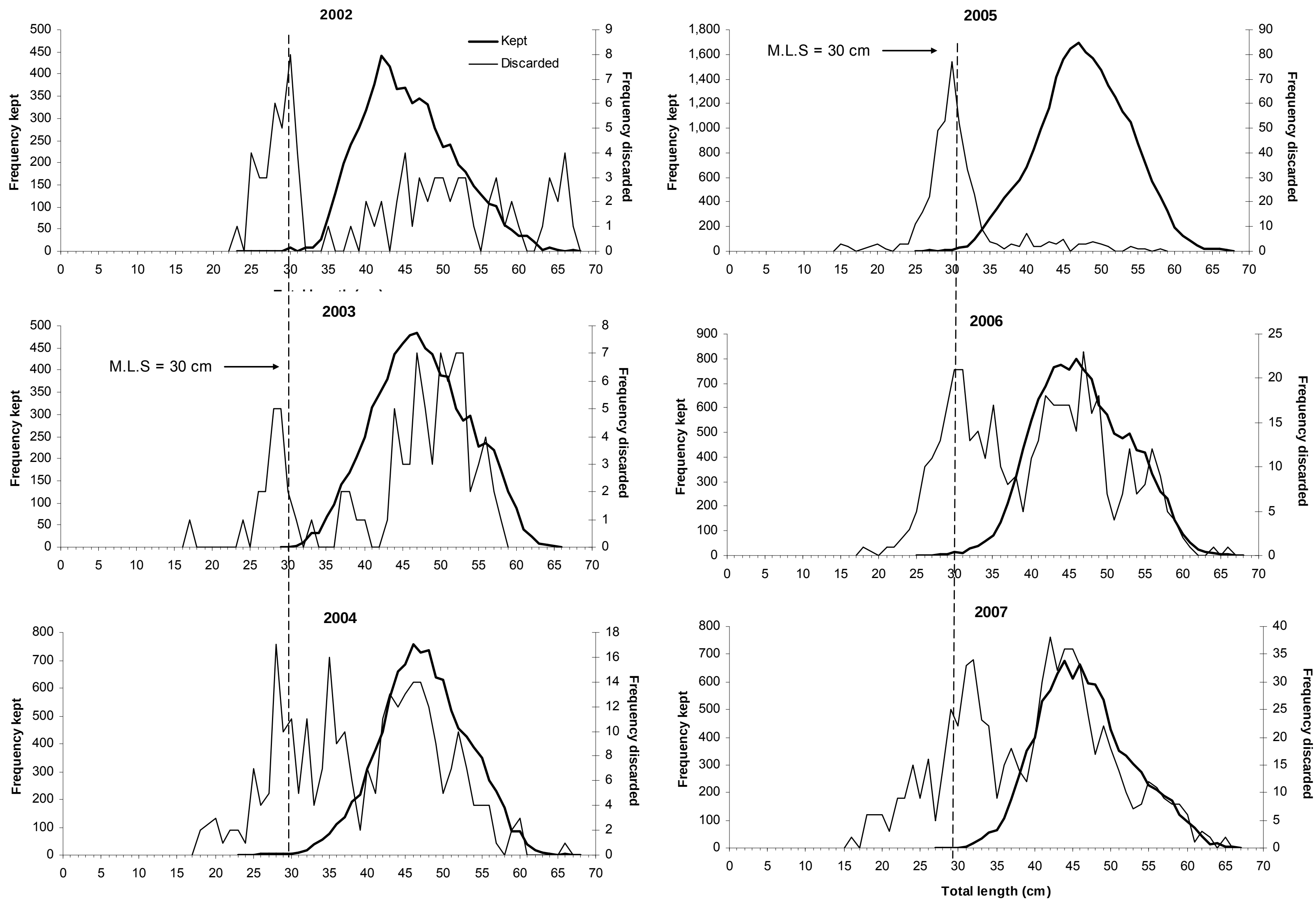

Figure K5. Length frequency distributions of Georges Bank winter flounder kept and discarded portions of bottom trawl catches during 2002-2007.

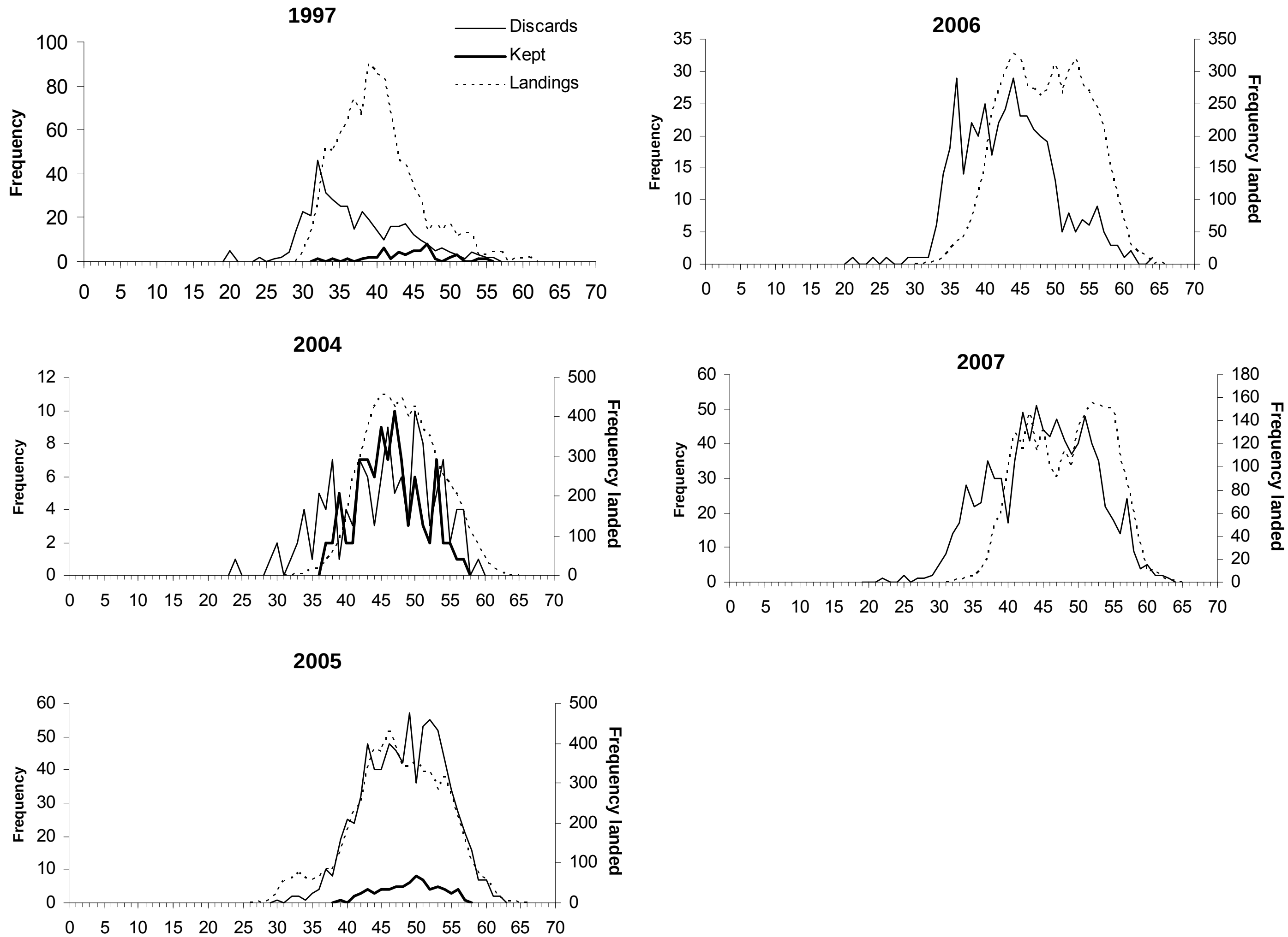

Figure K6. Length frequency distributions of Georges Bank winter flounder kept and discarded portions of scallop dredge catches and landings during 1997 and 2004-2007.

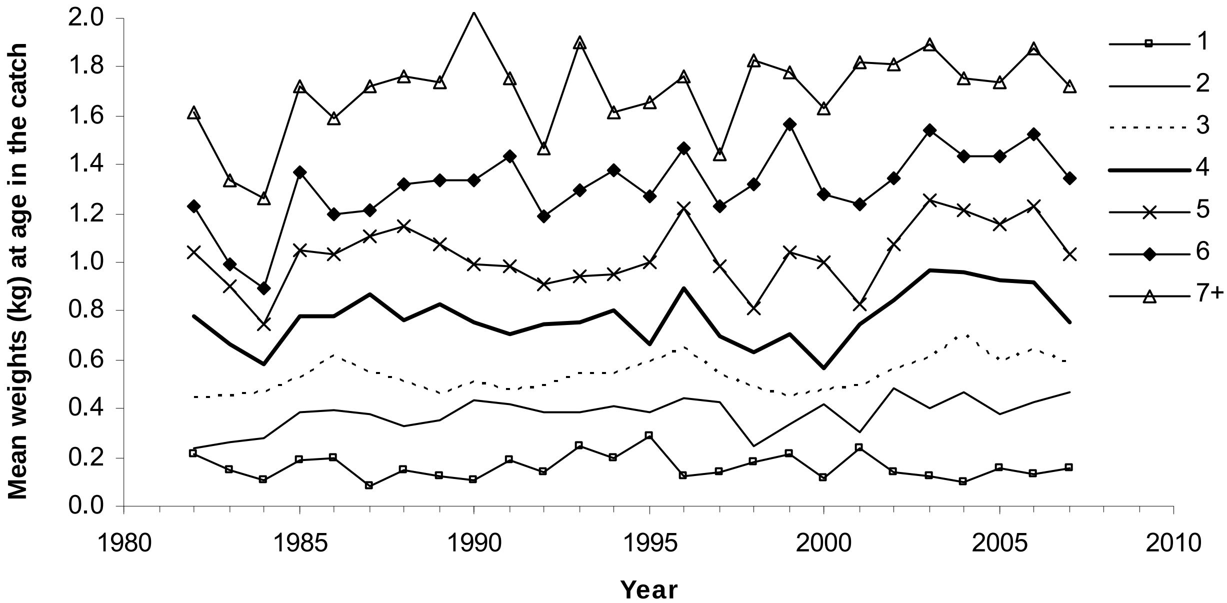

Figure K7. Trends in mean weights (kg) at age for the total catch of GB winter flounder, 1982-2007.

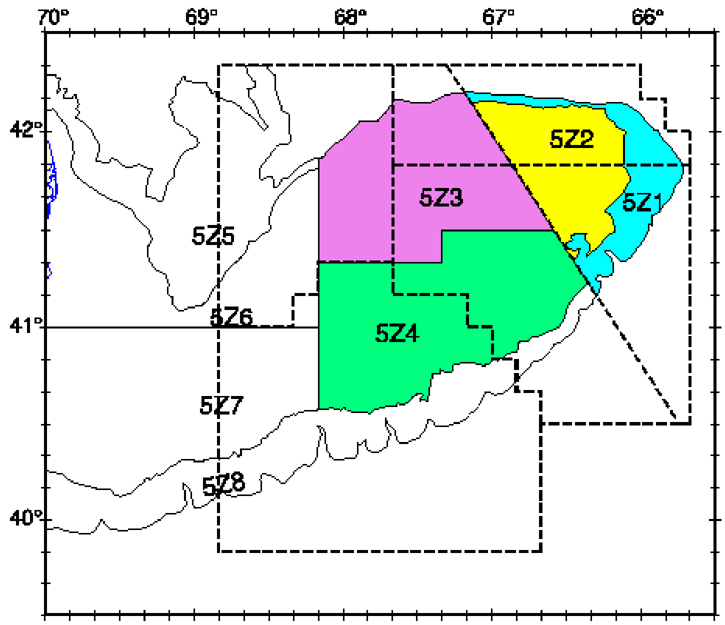

Figure K8 NEFSC survey strata (13-23) included in the assessment of Georges Bank winter flounder in relation to fishery Statistical Areas for the stock.

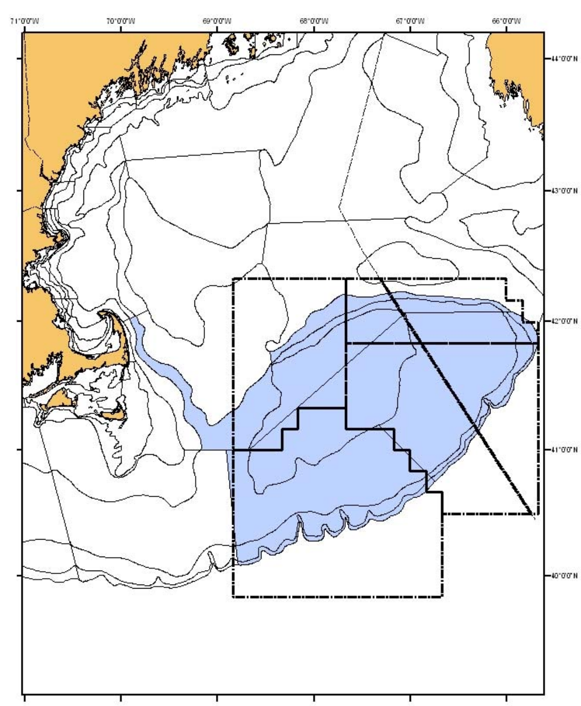

Figure K9. Canadian spring survey strata (5Z1-5Z4) included in the assessment of Georges Bank winter flounder in relation to fishery Statistical Areas for the stock.

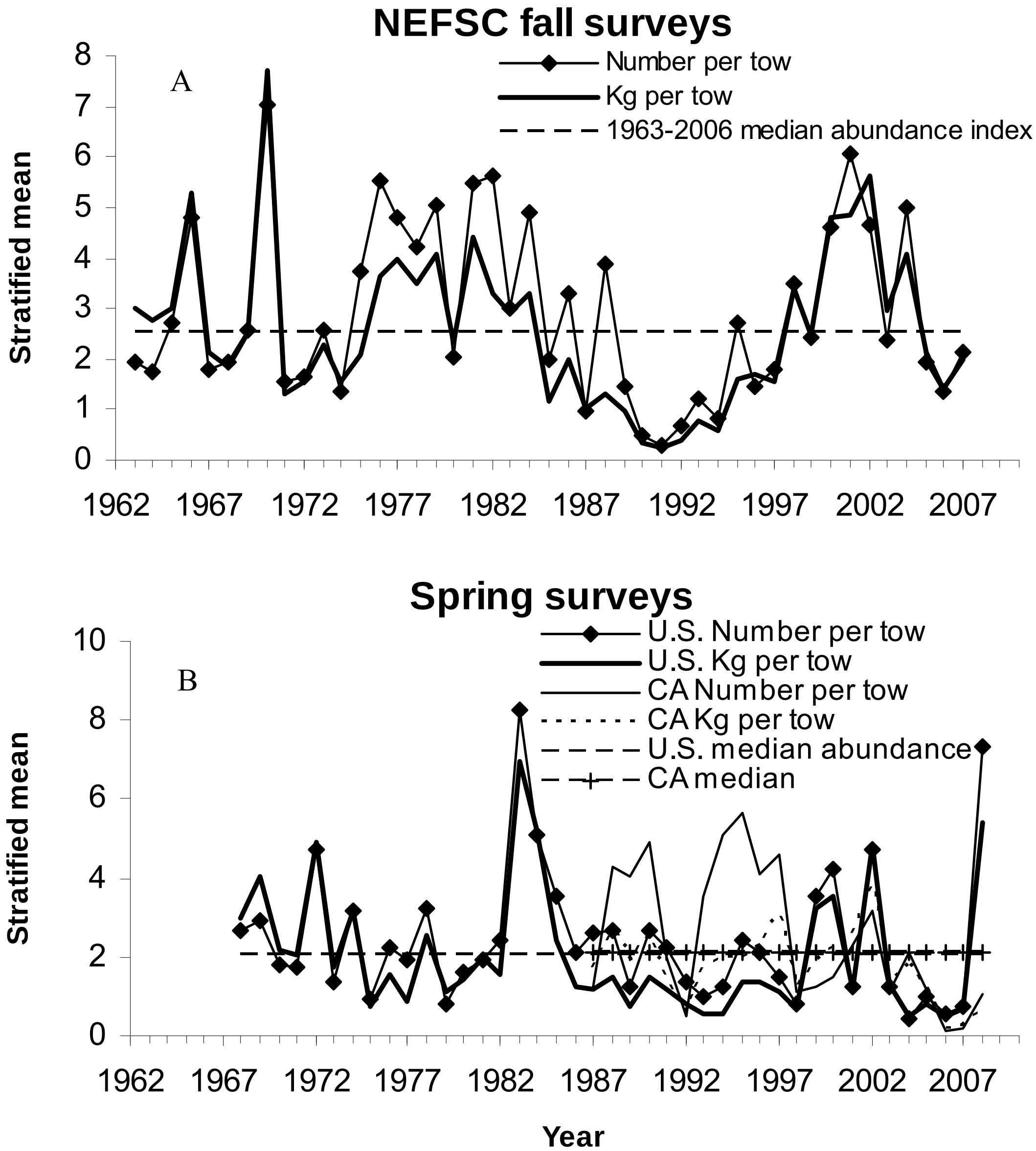

Figure K10. Relative biomass (stratified mean kg per tow) and abundance (stratified mean numbers per tow) indices for Georges Bank winter flounder caught during (A) NEFSC fall (1963-2007) bottom trawl surveys and (B) NEFSC spring (1968-2008) and Canadian spring (1987-2008 strata 5Z1-5Z4) bottom trawl surveys. NEFSC survey indices include strata 13-23 and were standardized for gear changes (weight = 1.86 and numbers = 2.02) and trawl door changes (weight = 1.39 and numbers = 1.46) prior to 1985.

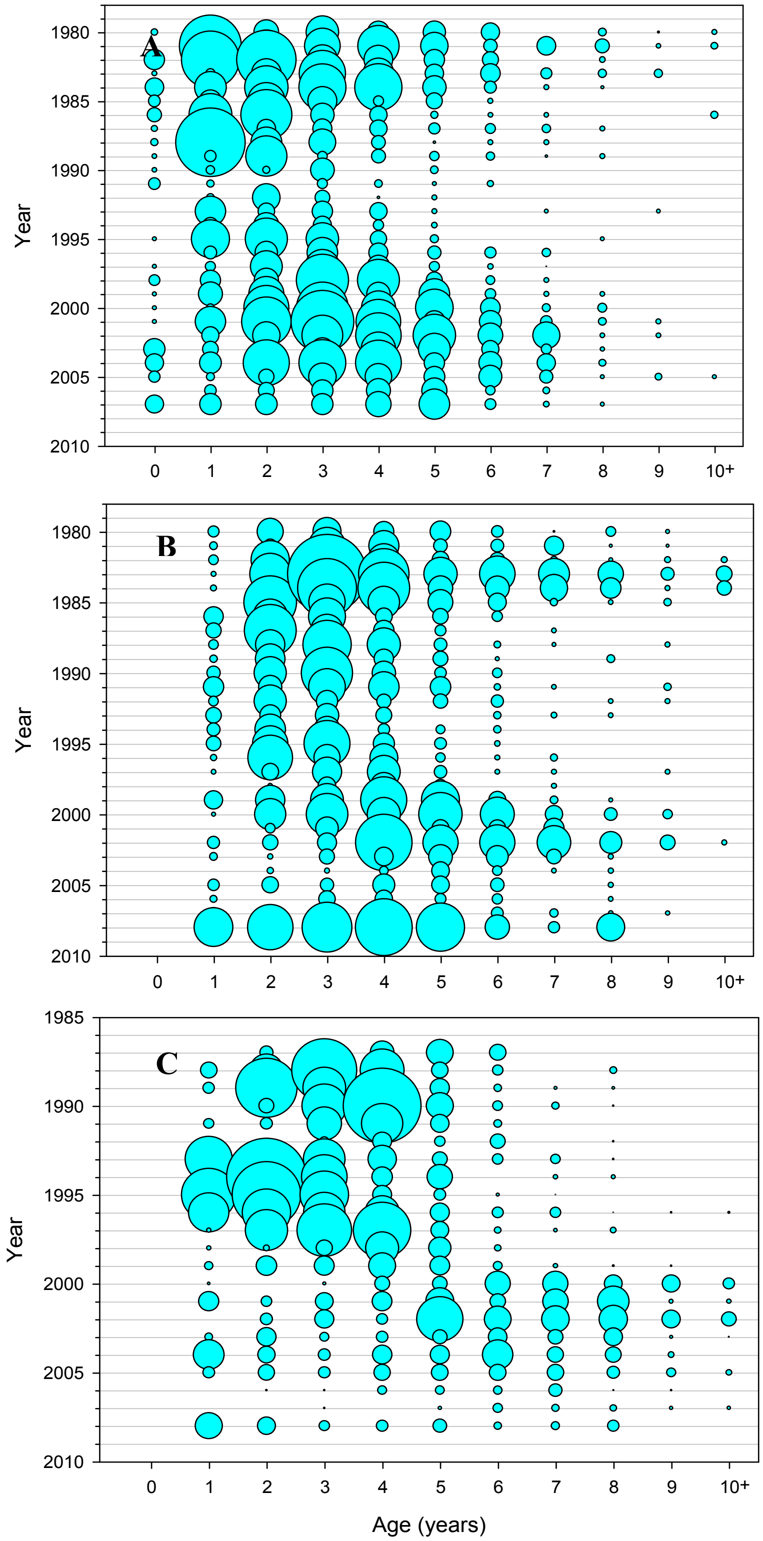

Figure K11. Stratified mean number per tow at age indices for (A) NEFSC fall bottom trawl surveys (1963-2007), (B) NEFSC spring surveys (1968-2008) and (C) CA spring surveys (1987-2008). NEFSC survey indices include offshore strata 13-23 and CA spring surveys include strata 5Z1-5Z4.

Figure K12. Residual patterns NEFSC spring bottom trawl survey indices (ages 1-7, 1982-2008) used to calibrate the VPA for Georges Bank winter flounder.

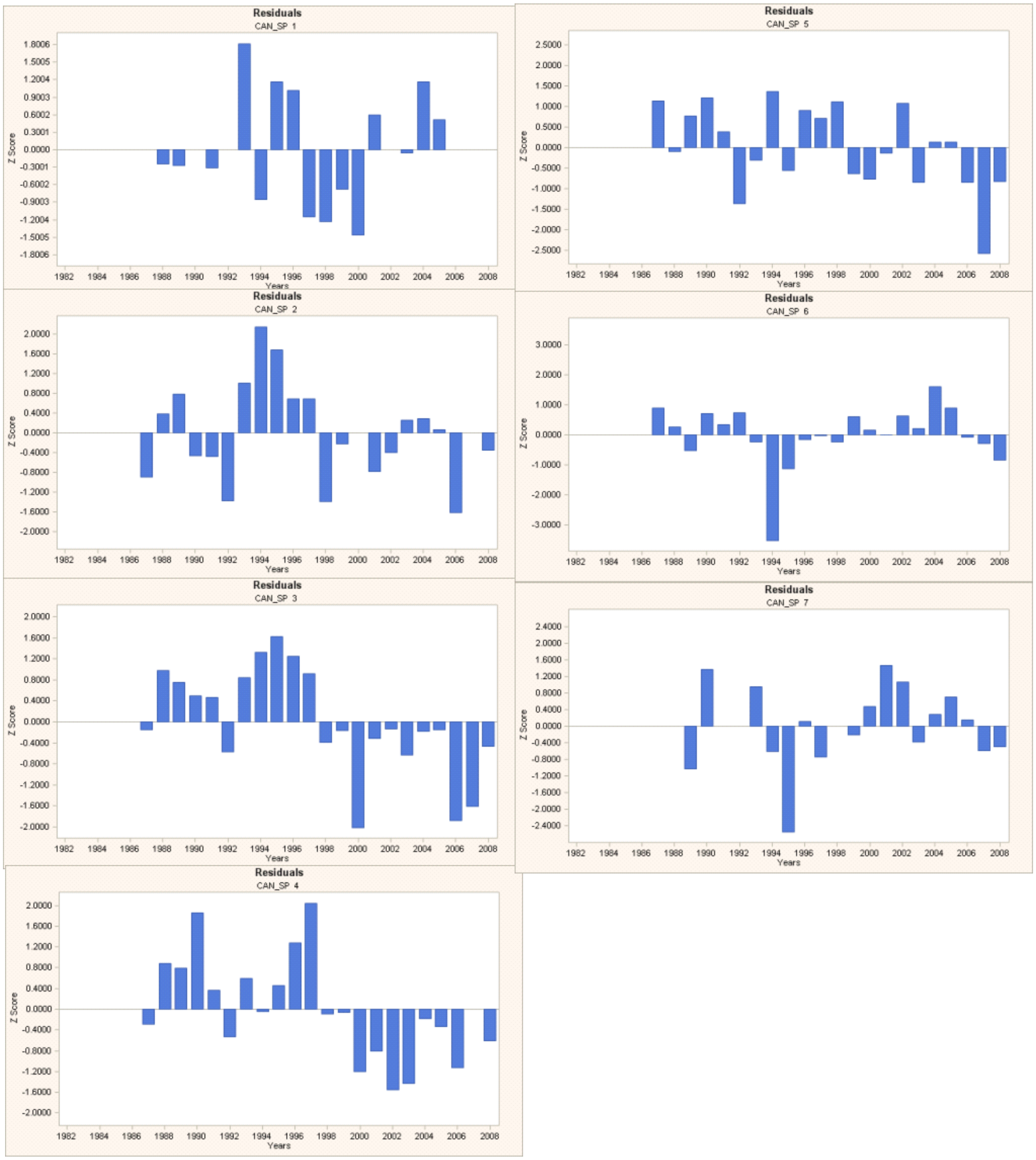

Figure K13. Residual patterns Canadian spring bottom trawl survey indices (ages 1-7, 1982-2008) used to calibrate the VPA for Georges Bank winter flounder.

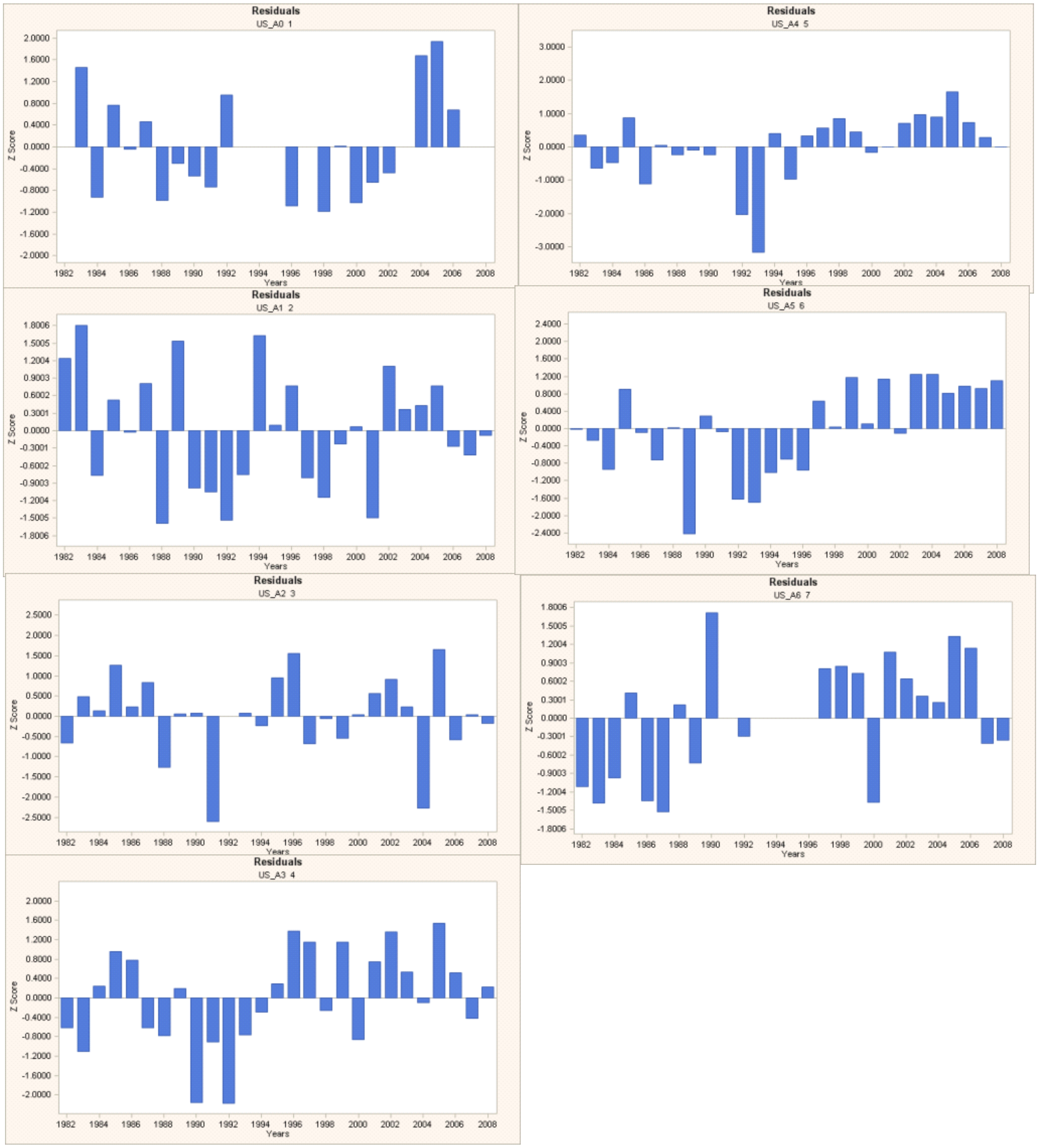

Figure K14. Residual patterns NEFSC autumn bottom trawl survey indices (ages 1-7, 1982-2006 lagged forward one year and age) used to calibrate the VPA for Georges Bank winter flounder.

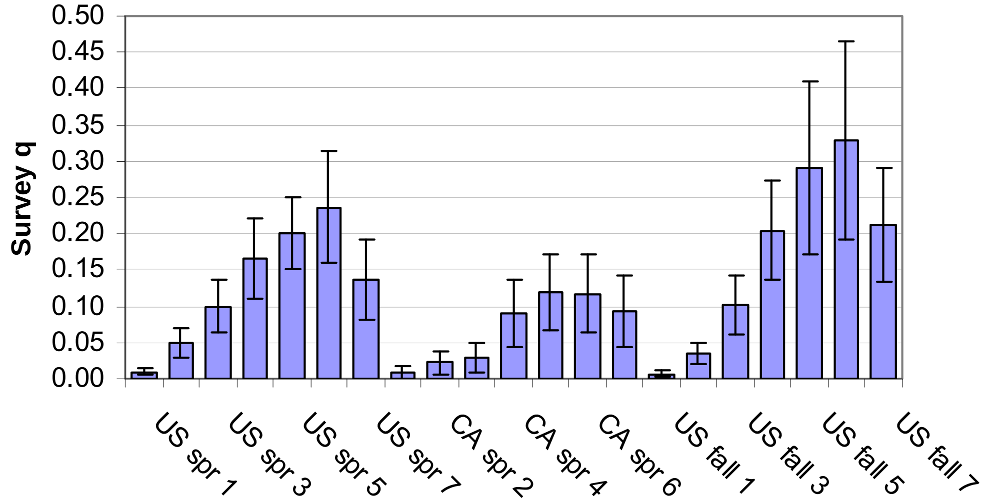

Figure K15. VPA estimates of catchability coefficients, by age, for Georges Bank winter flounder caught during the US spring (1982-2008), Canadian spring (1987-2008), and US fall bottom trawl surveys (1982-2007, lagged forward one year and age). Error bars represent 2 SE.

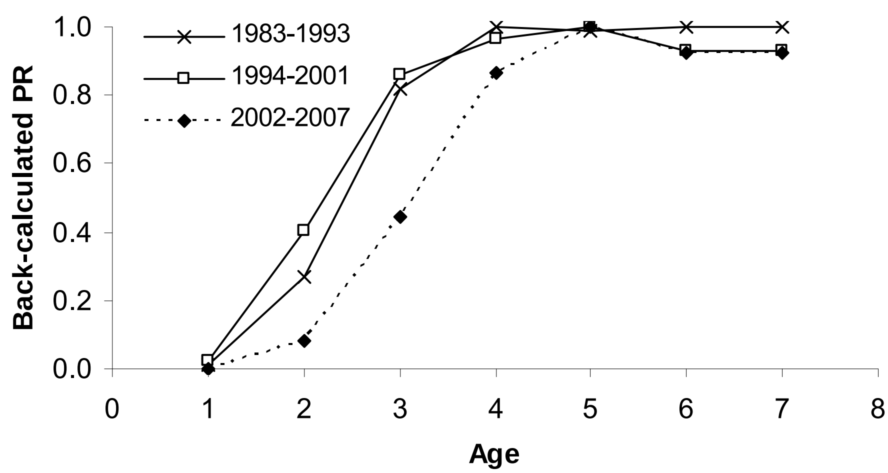

Figure K16. Back-calculated partial recruitment of Georges Bank winter flounder during management periods with major changes in codend minimum mesh sizes.

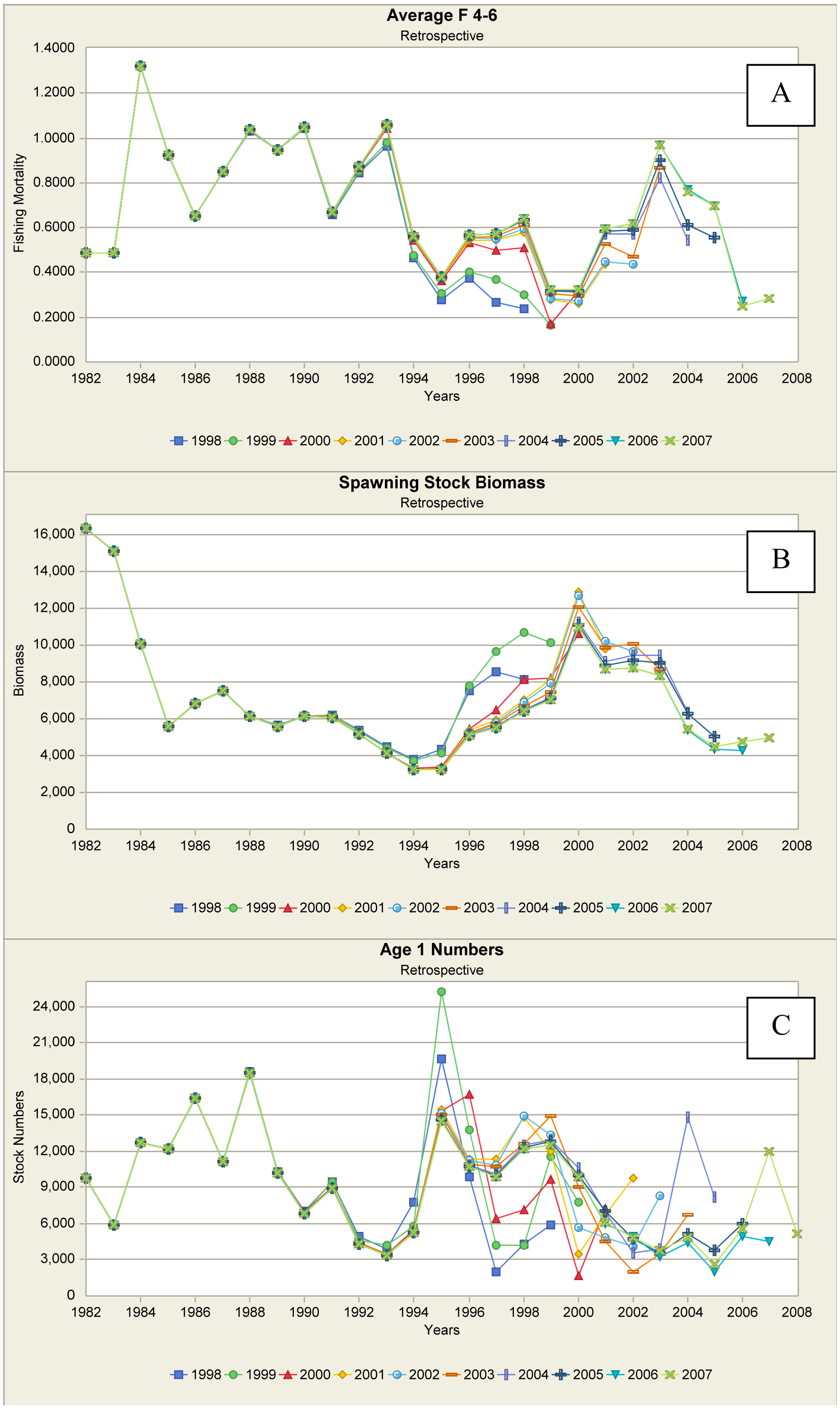

Figure K17. Retrospective analysis of (A) average F (ages 4-6), (B) spawning stock biomass (mt), and (C) Age 1 recruitment (numbers, 000's) during 1993-2007 for the Georges Bank winter flounder VPA (1982-2007).

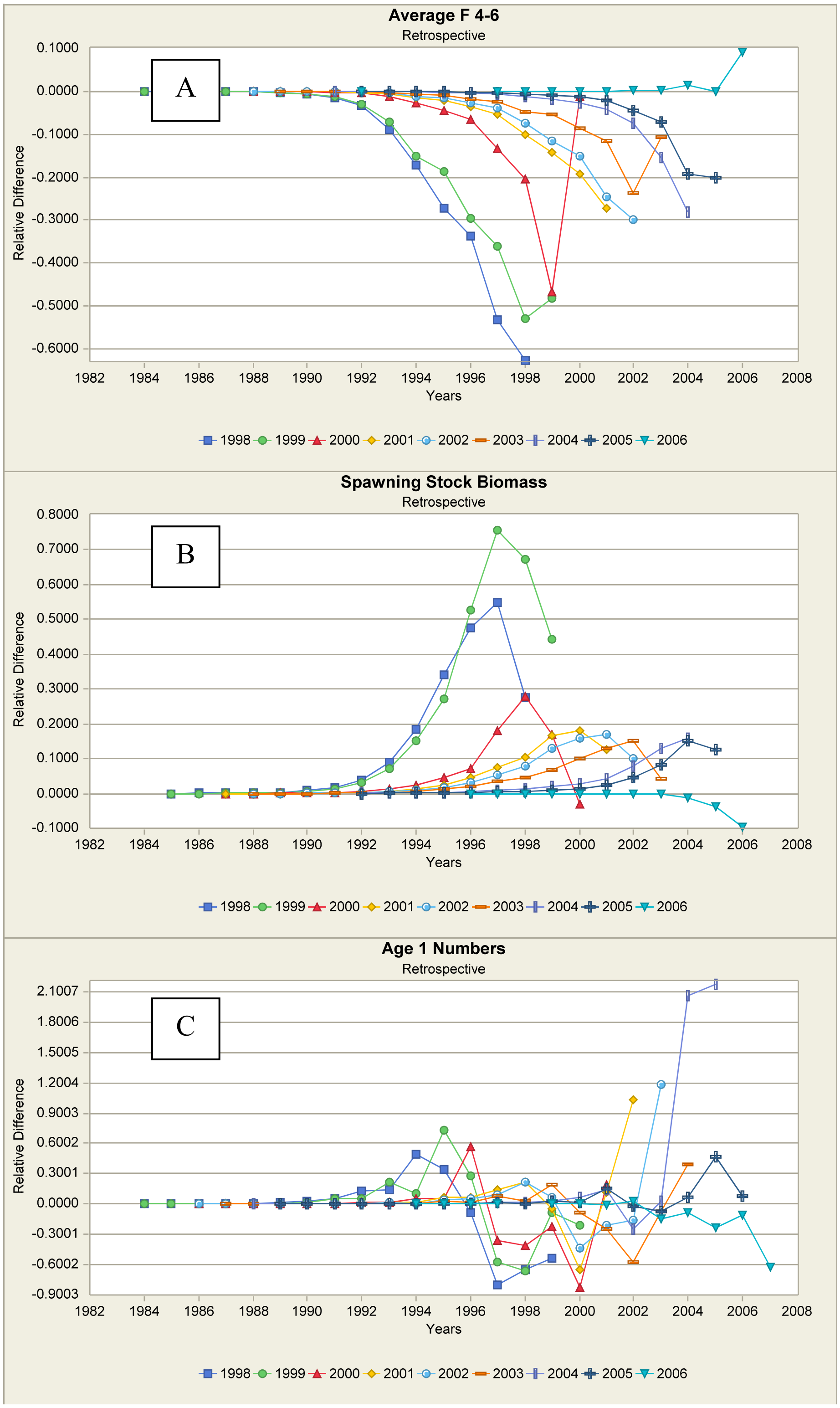

Figure K18. Relative differences between (A) average F (ages 4-6), (B) spawning stock biomass (mt), and (C) Age 1 recruitment estimates (numbers, 000's) in year t and 2007 (1993-2006) from the Georges bank winter flounder VPA (1982-2007).

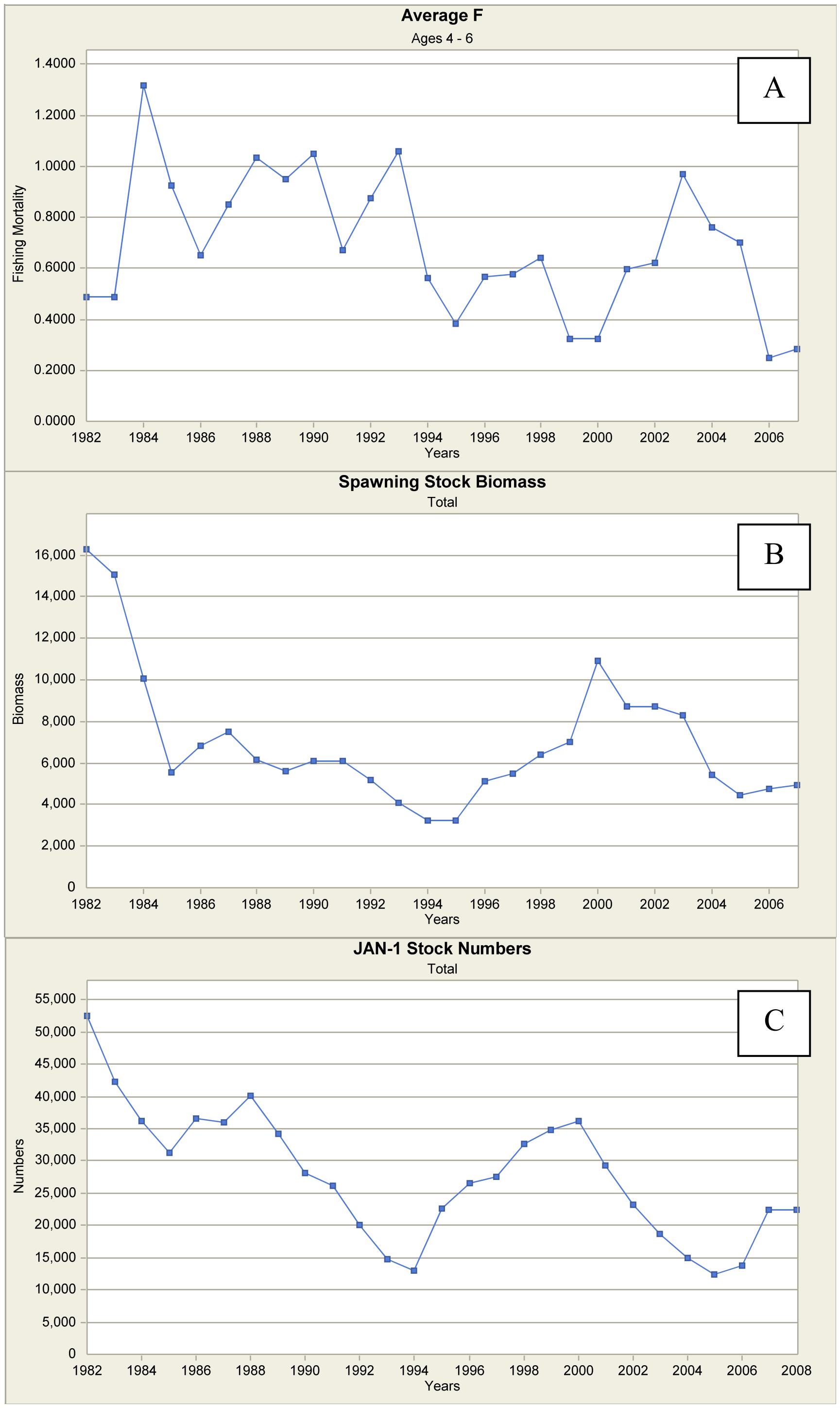

Figure K19. Annual trends in VPA estimates of Georges Bank winter flounder (A) average fishing mortality rates on fully-recruited ages 4-6, (B) spawning stock biomass (mt) and (C) age 1 recruitment (numbers, 000's) during 1982-2007.

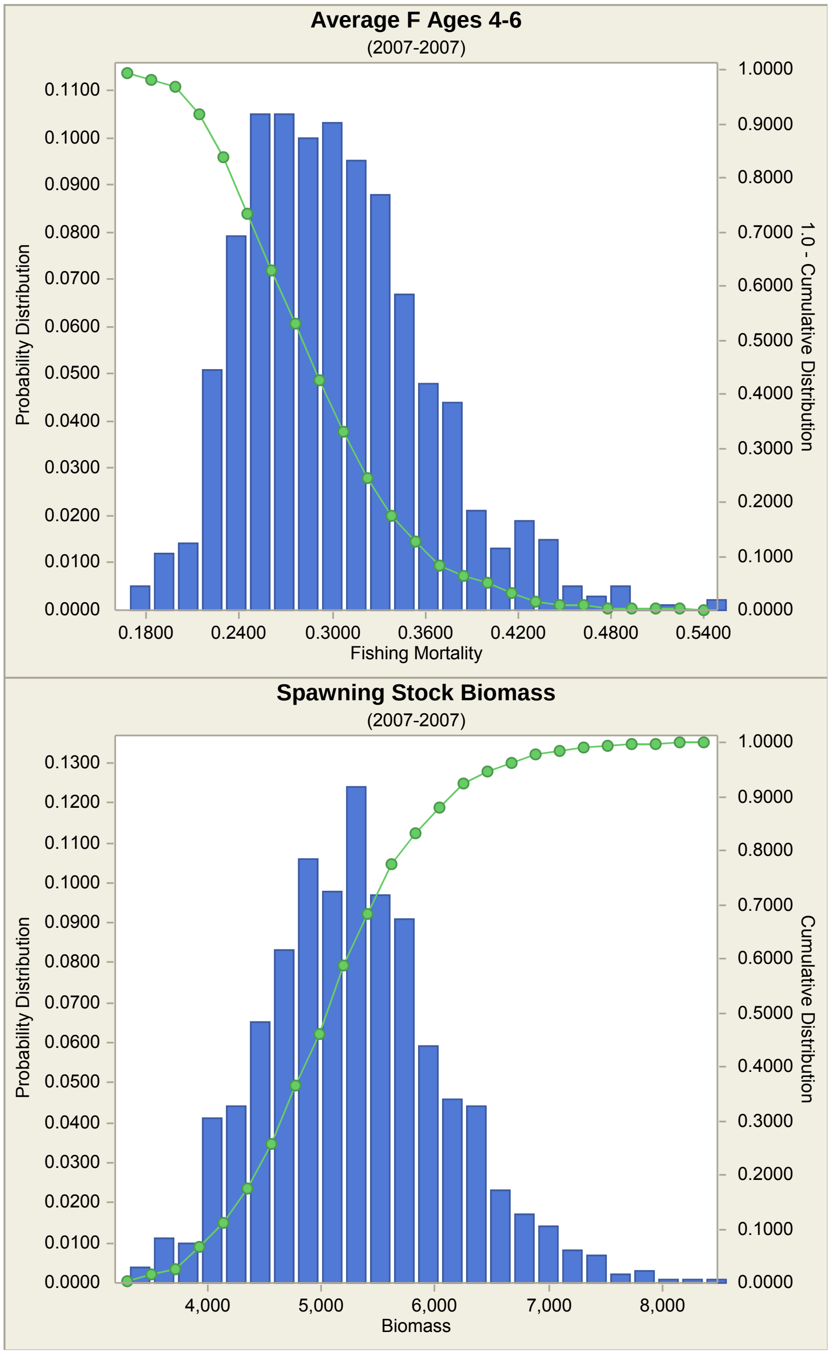

Figure K20. Precision (80% CI) of the terminal year estimates (2007) of average fishing mortality rate on ages 4-6 and spawning stock biomass from the Georges Bank winter flounder VPA.

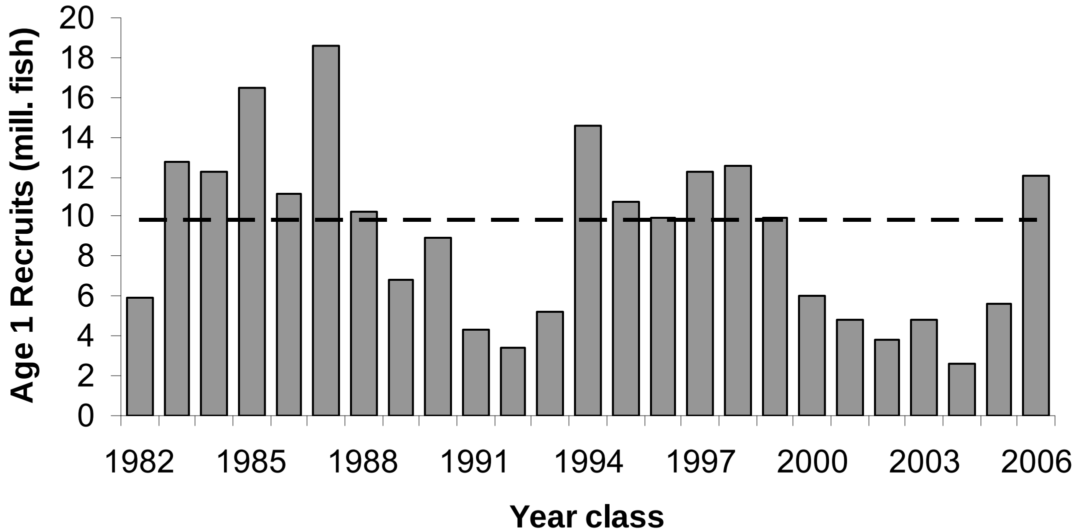

Figure K21. Year class strengths of age 1 recruitment of Georges Bank winter flounder during 1982-2006.

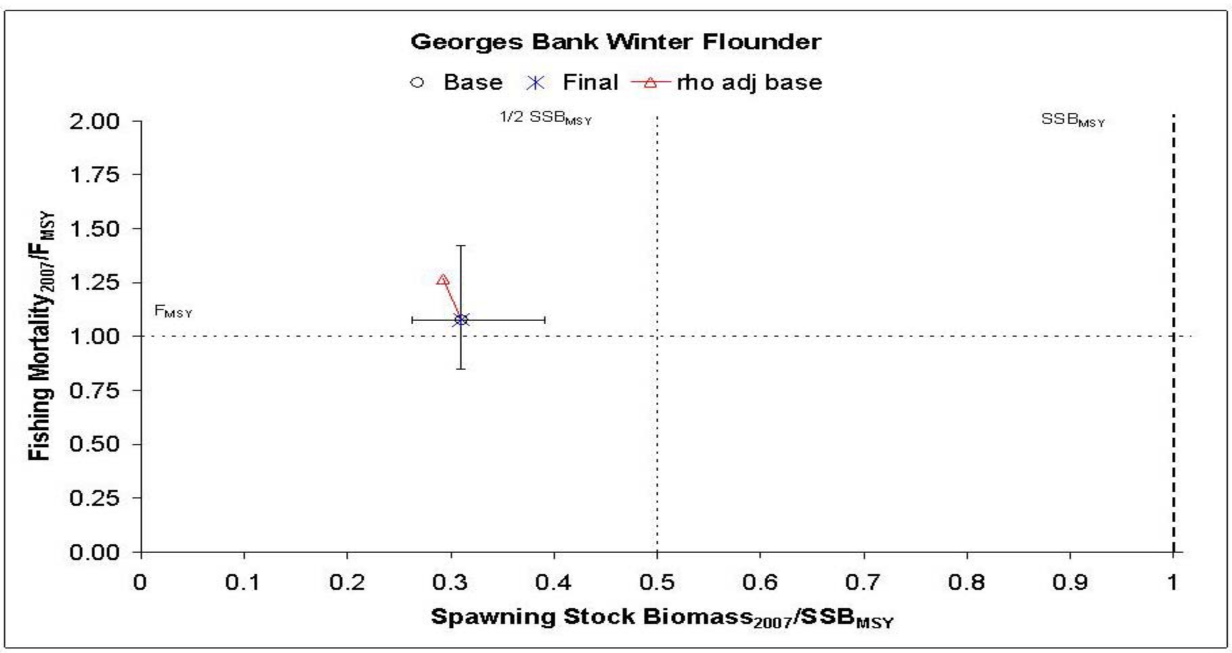

Figure K22. Stock status during 2007 for Georges Bank winter flounder

L. Georges Bank/Gulf of Maine white hake
by D.S. Butterworth and R.A. Rademeyer
University of Cape Town, and K.A. Sosebee, NEFSC

1.0 Background

The white hake, *Urophycis tenuis*, occurs from Newfoundland to Southern New England and is common on muddy bottom throughout the Gulf of Maine (Bigelow and Schroeder 1953; Klein-MacPhee 2002). Depth distribution of white hake varies by age and season; juveniles typically occupy shallower areas than adults, but individuals of all ages tend to move inshore or shoalward in summer, dispersing to deeper areas in winter (Musick 1974; Markel et al. 1982). Small white hake are difficult to distinguish from red hake, *Urophycis chuss*, resulting in a small degree of bias in reported nominal catches (NEFSC 2005).

Larval distributions indicate the presence of two spawning groups in the Gulf of Maine, Georges Bank and Scotian Shelf region, one which spawns in deep water on the continental slope in late winter and early spring, and a second which spawns on the Scotian Shelf in the summer (Fahay and Able 1989; Lang et al. 1994). The population found in U.S. waters appears to be supported by both spawning events, but individuals are not distinguishable in commercial landings. The stock is currently assessed as a single unit in United States waters, although Canadian catch from Georges Bank is included (Figure L1).

This stock was last assessed and reviewed at the Groundfish Assessment Review Committee meeting in 2005 (NEFSC 2005). The AIM method was used to assess the status of the stock relative to reference points developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002). Landings and discards of fish greater than 60 cm were used in the model as well as autumn survey indices of biomass. Fishing mortality in 2004 was estimated to be more than twice the value for F_{rel}. 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 marked retrospective pattern in the assessment in 2001. The assessment then became based upon a surplus production model which was itself unstable and rejected in 2002. The AIM method is currently used to assess the status of the stock relative to biological reference points. The GARM III Models Panel (O'Boyle et al. 2008a) recommended examining forward projecting length or age-based models to include all portions of the stock. The GARM III Biological Reference Points Panel (O'Boyle et al. 2008b) accepted a forward projecting age-based model, but suggested some more exploration of the model formulation to mitigate some of the problems encountered in the model.

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 L1; Figure L2). Landings subsequently declined to 1,532 mt. Canadian landings declined to 46 mt. Historical landings of white hake from the United States were discovered in ICNAF (1952) (Table L2). These landings 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.

The primary gear type used to catch white hake is the otter trawl (Table L3). 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, accounted for 18% of the total landings. However, in recent years they have 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 re-estimated for white hake for 1989-2007 using the SBRM (Wigley et al. 2006) method of white hake discard/all kept (Table L4). In recent years, discards in both the otter trawl and the sink gill net fisheries have been very low.

Commercial Catch

The GARM III Models Meeting (O'Boyle et al. 2008a) recommended using the ratio of white hake to red hake in the survey to split out white hake discards. This involved estimating red and white hake landings-at-length as well as red and white hake discards-at-length.

Sampling intensity for white hake landings was good and the coverage adequate, except for unclassified (Table L5). These were prorated at the end for 1998-2007. Sampling for red hake was sufficient for most years but was the intensity was low for some years (Table L6). For example, the same length samples were used for both halves of the year in 1996.

Red hake discards were estimated in the same fashion as white hake discards (Table L7). There were sufficient length samples for both species to estimate only otter trawl discards-at-length (Tables L8-L11).

The four components were added together by half year and then the ratio of white hake to red hake at length from the appropriate survey was used to split out white hake (Table L12; Figure L3). The ratio between the old data and the new data was used to estimate landings back to 1964. Age-length keys combining survey and observer age data by half year were used to derive the catch-at-age from 1989-2000 (Table L13, Figure L4). A pooled age-length key by half year was used to derive the catch-at-age from 2001-2007. Mean weights-at-age at the start of the year as well as spawning stock biomass weights-at-age were derived using the Rivard equation (Table L14).

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 have been used exclusively during these surveys. Gear and door changes have occurred during the survey period. Calibration coefficients for all changes were not significant for white hake.

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 a near record low in 1999 (Figure L5; Table L15). 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 may indicate another year class, although it also may be a year effect. The NEFSC spring survey biomass indices are more variable than the autumn, but declined during the 1990s, increased in the early 2000s, but have since declined.

Maturity information was not updated. The single maturity ogive used in the last VPA assessment was carried forward for this assessment (NEFSC 1999). Natural mortality was assumed to be 0.2 as in the last several assessments.

4.0 Assessment

Input data and Model Formulation

The catch data used for the assessments considered cover the period 1963-2007 (Table L12). Catch-at-age information is provided for the commercial catches during the 1989 to 2007 period (Table L13). Table L14 lists weight-at-age data input, and Table L15 provides annual mean catch per tow information for the NEFSC surveys. Catch-at-age information for these surveys is available for the years 1982 to 2003/2002 (for the spring and autumn surveys respectively) (Tables L16 and L17; see also Figure L6), with survey catch-at-length data being available for the remaining years. The plus-group for the age data fitted by the assessment model is 7+, though within the model itself, the age structure is taken to age 9+.

An SCAA/ASPM assessment method was applied. Table L18 provides a list of symbols used for this assessment approach and the results evaluated there from. Further details of the method are specified in Appendix 2 of Butterworth and Rademeyer (2008a), augmented by the procedure to incorporate catch-at-length data in the likelihood that is detailed in Butterworth and Rademeyer (2008b). This last procedure requires a value for the parameter β which relates to the width of the distribution of length at age about its expected value (see equation 3 of Butterworth and Rademeyer, 2008b). Since there appeared to be insufficient information in the data to be able to satisfactorily treat this as an estimable parameter when fitting the assessment model, β was fixed to 0.15 for all computations. For years for which catch-at-age data are included in the likelihood, the corresponding catch-at-length data were omitted.

Because the assessments commence in 1963, either specification on input or estimation is required of the parameters that determine the starting numbers-at-age, namely θ which is the ratio of the starting spawning biomass B^{sp} to that for the pristine resource K^{sp}, and ϕ which effectively specifies the extent to which the mean Z reflected by the starting age-structure of the population exceeds M (for full details, see Butterworth and Rademeyer (2008a), equations A.2.13 and 14). Table L19 shows results for assessment "A1" (which assumes a Ricker stock-recruitment function and fits to both catch-at-age and catch-at-length data) for three fixed values of each of θ and ϕ, as well at the best estimate of θ for each of these ϕ values. From these results it was judged that it is reasonable to estimate θ, but that ϕ is somewhat less well determined, though the highest value of 0.4 considered does show some deterioration in fits to the data. The decision was made to fix $\phi = 0.2$, noting that any bias introduced by this choice would tend to err on the conservative side in terms of the current status of the resource relative to its spawning biomass at MSY.

Model Selection Process and Sensitivity Runs

The assessments considered focused on two factors found to be particularly influential in relation to key results:

a) the shape of the stock-recruitment relationship (specifically here Ricker *vs* Beverton-Holt: "A" vs "B");

b) whether the survey catch-at-length data for years for which survey catch-at-age data are not available are included in the likelihood or not("1" vs "2").

The selection basis (for assessments based upon the same data) was AIC. This indicated a slight preference for "A" assessments. Sensitivity to forcing the q parameter (see Table L18) for the autumn survey not to exceed 1 (corresponding to no herding of fish by the survey fishing gear) was investigated but rejected because of markedly inferior AIC values. Estimation of the ϕ parameter was justified in AIC terms and indicated slightly better resource status, but this was not pursued to avoid a possible undue dependence of results on some minor feature of the initial years' data from the survey series. AIC values indicated a clear preference for domed rather than flat survey selectivity, but none for increasing M above 0.2 at larger ages.

Assessment results and Diagnostics

Results for four assessments A1, A2, B1 and B2, corresponding to the four possible combinations of the two factors in a) and b) above, are presented in Table L20. These results include Bayesian posterior medians and CVs which are based on wide uniform priors for all estimable parameters except recruitment residuals which are taken to be lognormally distributed with a standard deviation of the associated normal distribution of 0.5.

Figure L7 compares spawning biomass trends over time across the different assessments, while Figures L8 and L9 show diagnostics for the A1 and A2 assessments respectively. Although better precision is evident for the "1" assessments which incorporate catch-at-length data, the serious lack of fit for the residuals for fit to the autumn survey catch-at-length data (see Figure L8) led to the "2" assessments (which do not fit to these data) being preferred.

Further diagnostics for the consequently preferred A2 assessment's fit to the data are shown in Figures L10 and L11. Overall the model provides reasonable fits to the various sets of input data. There is a mild retrospective pattern as illustrated in Figures L12 to L14, and summarized in Table L21. Tables L22 and L23 provide the fishing mortality and numbers-at-age matrices estimated for this A2 assessment.

The results for the final choice of the A2 assessment are summarized in Figure L15 in terms of estimated spawning biomass, fishing mortality and recruitment trends. These reflect a resource whose size grew from the early 1960s to peak in the late 1970s, and then decline sharply under increased catches until the turn of the century, following which a slow recovery trend is indicated, together with improved recruitment for the last three years. Figure 16 provides posterior distribution plots for the 2007 fishing mortality and spawning biomass; point estimates for these two quantities are 0.15 and 19,800 mt respectively.

5.0 Biological Reference Points

Figure L17 shows the Ricker curve estimated for the chosen A2 assessment and the associated estimated stock-recruitment data points. Although the Ricker relationship is marginally preferred over the Beverton-Holt, estimates of biological reference points related to fishing mortality and spawning biomass differ markedly between the two (see Table L20). However estimates of mean recruitment are very similar across the four assessments, so that for a robust basis for BRP estimation, the approach finally chosen is to use the F40% proxy basis, coupled to the average recruitment for assessment A2, for computation.
The resultant estimates for biological reference points are:

F_{msy} = 0.125 (on age 6)
SSB_{MSY} = 56,300 mt
MSY = 5,800 mt

The resultant status for the resource is that it is overfished and that overfishing took place in 2007 (see Figure L18 which compares these results to those which would follow from the Ricker stock-recruitment curve estimated in assessment A2 for which the estimated F_{msy} is somewhat higher).

6.0 Projections

Projections were conducted with a stochastic model for recruitment using a five-year average for mean catch and stock weights and the life history and selectivity parameters from the A2 assessment (Table L24). Starting population vectors were provided by the joint Bayesian posterior distribution computed using MCMC, and future recruitment was generated from a lognormal distribution with parameters estimated from the set of recruitments estimated in the A2 assessment. Catch in 2008 was assumed to be the same as catch in 2007 (2163 mt). Three scenarios for 2009 were evaluated: 1) F_{MSY}; 2) $F_{STATUS\ QUO}$; and 3) the F required to rebuild the stock by 2014 (see Table L18). The results are reported in Table L20. The F associated with the rebuilding in 3) was estimated to be 0.078, with an associated 2009 projected catch of 2,200 mt.

7.0 Summary

Fishing mortality in 2007 is estimated to be 0.150 and current spawning stock biomass in 2007 is estimated to be 19,800 mt. The stock is overfished and overfishing is occurring (Figure L19). The assessment has changed since GARM II and the reference points and biomass estimates are not comparable. Two sources of uncertainty in the assessment are the use of survey ages to age the commercial fishery, and the unavailability of age information for the earlier years of the surveys. The latter is of consequence because estimates of the current status of the resource are closely linked to its status in the early 1960s, which is in turn difficult to estimate given the limited information for that period.

8.0 Panel Discussion /Comments:

Conclusions

Following from the recommendations of earlier GARM III reviews, the Panel considered two SCAA formulations, one by Sosebee (working paper 1.L.a), and the other by Butterworth and Rademeyer (working paper 1.L.b). Both models used age composition data for the 1989-2000 commercial fishery and for 1982 - 2003/2002 for the spring and autumn surveys respectively. A pooled age-length key was created from these observations and was used, in concert with year-specific length frequency samples, to derive age compositions for commercial catches for 2001-2007. The Sosebee model used this combined age-length key to estimate survey age compositions for 1963-1988. The Butterworth and Rademeyer model used survey catch at length data for 1963-1981 and 2004/3 – 2007 in some model formulations, but these were considered inferior to the Final model.

The two models produced similar trends in stock size but differed in scale with the Sosebee model generally producing lower estimates than the Butterworth and Rademeyer model. Both models produced a dome shaped selectivity in the fishery and the survey. Both models indicated that younger and older fish had higher selectivity in the fishery than in the survey.

The Panel had reservations about the use of a common age-length key in this assessment as this would not follow recruitment variability very well. However, it was recognized that it was important to have age composition estimates for the most recent years, since these would be used in catch projections. The Panel accepted the Butterworth and Rademeyer model as Final and the best available to provide management advice on stock status and from which to base stock and rebuilding plan projections. This model made less use of the common age-length key and had a more realistic method of deriving the population age composition in the initial year of the analysis (1963). It also made more use of the historical data.

A number of formulations of the Butterworth and Rademeyer model were also considered. One used length composition data for years that did not have age compositions. However, this formulation had poor model fit for younger ages, and thus these data were not incorporated in the Final model. Two Stock - Recruitment relationships were examined (Ricker and Beverton / Holt). There was little difference in estimates between the two, and the Panel selected the model with the Ricker relationship. Residual plots and retrospective diagnostics indicated a small retrospective pattern and no adjustment was required.

The Panel recommended that the catch forecasts include $F_{40\%MSP}$ instead of the estimated F_{MSY}. The Panel accepted that the catch forecasts use recruitment modeled as lognormal variation about the average historical recruitment with a standard deviation equal to the historical pattern.

Research Recommendations

The Panel had no specific research recommendations for this stock.

9.0 References

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Table L1. Total nominal landings (mt, live) of white hake by country from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1964-2007.

	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

Table L2. 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 L3. US nominal commercial landings (mt,live) and the annual percentage of total landings of white hake by gear type, 1964-2007.

	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
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 L4. Number of trips sampled and the resulting discards of white hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2007.

	SGN						OT					
	Half 1		Half 2		Total		Half 1		Half 2		Total	
YEAR	trips	discards	trips	discards	trips	discards	trips	discards	trips	discards	trips	discards
1989	1	2.3	106	21.8	107	24.1	72	171.6	104	509.7	176	681.3
1990	75	10.2	78	78.4	153	88.6	67	661.0	71	634.3	138	1295.3
1991	194	25.5	763	54.7	957	80.2	92	12.3	164	231.4	256	243.7
1992	497	37.3	690	84.0	1187	121.3	116	242.5	70	273.4	186	515.9
1993	348	56.4	422	153.7	770	210.0	37	70.1	29	564.8	66	634.9
1994	188	0.5	216	11.5	404	12.0	28	155.0	35	64.3	63	219.3
1995	298	1.2	239	27.2	537	28.4	81	50.1	144	116.0	225	166.1
1996	254	2.8	168	48.1	422	50.9	69	102.6	125	12.1	194	114.7
1997	257	4.8	132	27.3	389	32.1	72	76.9	40	91.1	112	168.0
1998	267	2.2	136	2.0	403	4.1	42	27.5	28	30.6	70	58.0
1999	88	12.7	101	5.4	189	18.2	42	3.4	66	556.5	108	559.9
2000	118	6.2	108	11.1	226	17.3	108	90.9	79	86.6	187	177.5
2001	98	1.4	69	47.2	167	48.6	110	131.1	172	164.4	282	295.5
2002	67	6.6	106	2.6	173	9.2	76	45.6	290	60.2	366	105.8
2003	162	6.4	330	7.7	492	14.2	267	34.5	290	216.3	557	250.8
2004	289	1.0	800	10.6	1089	11.5	371	26.9	688	65.4	1059	92.3
2005	260	3.9	744	14.2	1004	18.0	855	15.8	1013	50.9	1868	66.7
2006	136	2.0	115	13.0	251	14.9	542	19.9	382	24.4	924	44.4
2007	100	2.3	234	2.2	334	4.6	453	14.1	616	10.7	1069	24.8

Table L5. 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, 1985-2006.

		small					medium					large					unclassified					All	Samplin
		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	tensity
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 L5 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, 1985-2007.

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	
	# fis	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	
	# fis	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	
	# fis	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	
	# fis	231	329	213	224	997	221	100	235	215	771	328	456	797	660	2241					0	4009	
2002	mt	125	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	743	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	
	# fis	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	
	# fis	83	162		445	690	383	456	211	579	1629	2062	1474	524	1213	5273					0	7592	
2005	mt	23	24	32	24	103	78	83	167	120	449	445	352	414	250	1461	269	148	136	105	658	2671	30
	N	7	7	8	6	28	3	5	6	5	19	9	10	8	11	38	1	1	1		3	88	
	# fis	349	360	400	313	1422	161	494	554	493	1702	825	924	738	973	3460	28	111	61		200	6784	
2006	mt	26	10	14	17	67	66	48	78	76	268	327	161	299	225	1012	192	47	48	66	354	1700	18
	N	6	9	5	9	29	5	3	6	6	20	12	13	9	10	44					0	93	
	# fis	372	398	254	547	1571	434	263	534	601	1832	958	1013	776	972	3719					0	7122	
						67																	
2007	mt	12	16	31	42	102	39	53	75	76	244	207	221	338	198	964	75	58	59	31	223	1532	15
	N	12	6	7	10	35	5	5	7	7	24	9	8	10	11	38	1	1			2	99	
	# fis	478	264	325	388	1455	396	386	428	618	1828	753	716	667	922	3058	100	101			201	6542	

Table L6. 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, 1985-2007.

		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 L6. 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	

Table L7. Number of trips sampled and the resulting discards of red hake from otter trawl trips by the Domestic Observer Program, 1989-2007.

	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

Table L8. Number of length samples taken for white hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2007.

		SGN						OT						Grand	
		Half 1		Half 2		Total		Half 1		Half 2		Total		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips			14	1	14	1	4	10	3	19	7	29	21	30
	len			512	2	512	2	123	916	154	1734	277	2650	789	2652
1990	trips	6		8	1	14	1	3	4	1	5	4	9	18	10
	len	206		1197	32	1403	32	68	53	138	312	206	365	1609	397
1991	trips	20	1	89	7	109	8	2	1	3	2	5	3	114	11
	len	2526	134	9973	30	12499	164	53	180	413	45	466	225	12965	389
1992	trips	34	1	182	4	216	5	7	6	2	4	9	10	225	15
	len	1620	1	8473	4	10093	5	265	17	59	144	324	161	10417	166
1993	trips	26	1	129	10	155	11	8	20	5	2	13	22	168	33
	len	1276	1	4001	13	5277	14	681	333	658	44	1339	377	6616	391
1994	trips	10		81	3	91	3	12	37	8	7	20	44	111	47
	len	44		1835	12	1879	12	247	570	489	294	736	864	2615	876
1995	trips	9	1	117	7	126	8	12	49	9	10	21	59	147	67
	len	167	1	2638	30	2805	31	1111	1375	697	372	1808	1747	4613	1778
1996	trips	11	2	78	2	89	4	8	16	6	13	14	29	103	33
	len	70	13	826	3	896	16	284	526	331	381	615	907	1511	923
1997	trips	8		24	2	32	2	5	9	6	6	11	15	43	17
	len	85		427	4	512	4	117	93	110	64	227	157	739	161
1998	trips	8		31	1	39	1	3	2	1	1	4	3	43	4
	len	36		411	1	447	1	39	17	12	2	51	19	498	20
1999	trips	6		17	3	23	3	1		7	17	8	17	31	20
	len	79		218	20	297	20	23		113	287	136	287	433	307
2000	trips	7	2	5		12	2	7	5	15	10	22	15	34	17
	len	47	9	143		190	9	421	119	475	76	896	195	1086	204
2001	trips	1	1	6	1	7	2	1	1	4		5	1	12	3
	len	15	3	4501	2	4516	5	46	43	2217		2263	43	6779	48
2002	trips	1		10	1	11	1	4		35	15	39	15	50	16
	len	1		49	2	50	2	125		1050	189	1175	189	1225	191
2003	trips	8	2	38	6	46	8	55	14	57	16	112	30	158	38
	len	16	5	362	24	378	29	2353	83	2477	246	4830	329	5208	358
2004	trips	5	4	125	17	130	21	50	26	80	49	130	75	260	96
	len	28	6	1826	67	1854	73	1733	336	2147	733	3880	1069	5734	1142
2005	trips	6		155	10	161	10	158	61	131	72	289	133	450	143
	len	16		2225	21	2241	21	3442	597	3988	1075	7430	1672	9671	1693
2006	trips	10	2	24	1	34	3	81	35	54	25	135	60	169	63
	len	63	2	159	2	222	4	2231	535	1591	419	3822	954	4044	958
2007	trips	3	1	25	1	28	2	54	29	64	40	118	69	146	71
	len	40	6	177	5	217	11	740	292	1427	252	2167	544	2384	555

Table L9. Number of length samples taken for white hake from shrimp trawl and scallop dredge trips by the Domestic Observer Program, 1989-2007.

		ST						SD						Grand	
		Half 1		Half 2		Total		Half 1		Half 2		Total		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips		2				2								
	len		200				200								
1990	trips		1				1								
	len		37				37								
1991	trips	1				1									
	len	52				52									
1992	trips	1	6		3	1	9								
	len	37	17		58	37	75								
1993	trips		17				17		1	1		1	1	1	18
	len		282				282		1	1		1	1	1	283
1994	trips		30		4		34		1		3		4		38
	len		517		256		773		1		3		4		777
1995	trips		37				37		2	1	1	1	3	1	40
	len		958				958		51	1	73	1	124	1	1082
1996	trips		9		2		11				1		1		12
	len		325		15		340				1		1		341
1997	trips										1		1		1
	len										1		1		1
1998	trips							1	1		5	1	6	1	6
	len							1	5		63	1	68	1	68
1999	trips										3		3		3
	len										35		35		35
2000	trips								1				1		1
	len								2				2		2
2001	trips														
	len														
2002	trips														
	len														
2003	trips		1				1		1				1		2
	len		1				1		2				2		3
2004	trips			1		1			1		6		7		8
	len			111		111			6		212		218		329
2005	trips	2	5			2	5			1	5	1	5	3	10
	len	157	28			157	28			1	64	1	64	158	92
2006	trips		4				4			1	2	1	2	1	6
	len		131				131			1	5	1	5	1	136
2007	trips		3				3		1		1		2		5
	len		43				43		1		15		16		59

Table L10. Number of length samples taken for red hake from sink gill net and otter trawl trips by the Domestic Observer Program, 1989-2007.

		SGN						OT						Grand	
		Half 1		Half 2		Total		Half 1		Half 2		Total		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips				1		1		14	3	11	3	25	3	26
	len				1	512	1		1352	297	859	297	2211	297	2212
1990	trips					14	0		4	2	5	2	9	2	9
	len					1403	0		383	157	755	157	1138	157	1138
1991	trips	2	1	1	6	109	7		1	2	10	2	11	5	18
	len	2	2	21	7	12499	9		45	151	643	151	688	174	697
1992	trips	9	2	8	1	216	3	7	13	9	5	16	18	33	21
	len	12	4	16	1	10093	5	633	2190	624	536	1257	2726	1285	2731
1993	trips	2		2	1	155	1	3	4	2	6	5	10	9	11
	len	2		6	1	5277	1	228	741	250	680	478	1421	486	1422
1994	trips	2	1	5	1	91	2	1	4	1	3	2	7	9	9
	len	2	1	13	2	1879	3	42	136	3	27	45	163	60	166
1995	trips			6		126	0	2	4	12	4	14	8	20	8
	len			8		2805	0	80	102	972	42	1052	144	1060	144
1996	trips	1	2	3	2	89	4			1	15	1	15	5	19
	len	1	2	30	4	896	6			17	1187	17	1187	48	1193
1997	trips					32	0	1	4	1	7	2	11	2	11
	len					512	0	122	203	2	874	124	1077	124	1077
1998	trips	2				39	0		4		2	0	6	2	6
	len	2				447	0		442		251	0	693	2	693
1999	trips	1	1	2	3	23	4		2	1	7	1	9	4	13
	len	1	2	20	5	297	7		210	13	302	13	512	34	519
2000	trips		3		1	12	4		5		6	0	11	0	15
	len		22		1	190	23		540		158	0	698	0	721
2001	trips	1	1	2	1	7	2		3		1	0	4	3	6
	len	18	3	16	3	4516	6		21		99	0	120	34	126
2002	trips		1	3	2	11	3		1	19	25	19	26	22	29
	len		1	12	6	50	7		26	870	544	870	570	882	577
2003	trips	3	9		2	46	11	2	17	4	15	6	32	9	43
	len	5	12		5	378	17	114	232	57	442	171	674	176	691
2004	trips		9	4	16	130	25	4	14	9	58	13	72	17	97
	len		12	27	29	1854	41	96	460	366	2380	462	2840	489	2881
2005	trips		1	2	6	161	7	6	51	13	60	19	111	21	118
	len		1	3	10	2241	11	42	1021	655	2175	697	3196	700	3207
2006	trips				2	34	2	3	30	6	24	9	54	9	56
	len				2	222	2	5	530	614	1322	619	1852	619	1854
2007	trips					0	0	13	26	8	23	21	49	21	49
	len					0	0	641	1248	592	1366	1233	2614	1233	2614

Table L11. Number of length samples taken for red hake from shrimp trawl and scallop dredge trips by the Domestic Observer Program, 1989-2007.

		ST						SD						Grand	
		Half 1		Half 2		Total		Half 1		Half 2		Total		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	trips	1	11	1		2	11							2	11
	len	40	1815	135		175	1815							175	1815
1990	trips	1	2			1	2							1	2
	len	48	160			48	160							48	160
1991	trips	2				2								2	0
	len	98				98								98	0
1992	trips		7		2		9								9
	len		39		152		191								191
1993	trips		1				1		1				1		2
	len		2				2		4				4		6
1994	trips		1		3		4				3		3		7
	len		1		116		117				51		51		168
1995	trips		12		1		13		1				1		14
	len		136		3		139		2				2		141
1996	trips		7		1		8				2		2		10
	len		151		32		183				7		7		190
1997	trips		6				6		1		1		2		8
	len		104				104		184		7		191		295
1998	trips														0
	len														0
1999	trips								1		2		3		3
	len								1		36		37		37
2000	trips								4		2		6		6
	len								202		3		205		205
2001	trips														0
	len														0
2002	trips										3		3		3
	len										115		115		115
2003	trips		2				2		2		3		5		7
	len		7				7		3		207		210		217
2004	trips		3				3		2		10		12		15
	len		48				48		28		186		214		262
2005	trips		2				2				8		8		10
	len		82				82				219		219		301
2006	trips		1		1		2				7		7		9
	len		1		34		35				21		21		56
2007	trips		2				2								2
	len		30				30								30

Table L12. Catch (landings and discards) used in assessment from 1963-2007. The value for 1963 was estimated using a linear ramp down from 1950-1964.

Year	Landings	Year	Landings
1963	4100	1986	9270
1964	3995	1987	8362
1965	3434	1988	6976
1966	2051	1989	7955
1967	1498	1990	8154
1968	1699	1991	8215
1969	1815	1992	12602
1970	2799	1993	10342
1971	3801	1994	7108
1972	4127	1995	5791
1973	4462	1996	4108
1974	5255	1997	3391
1975	5010	1998	3724
1976	5641	1999	4462
1977	7196	2000	4375
1978	6630	2001	5998
1979	5641	2002	3763
1980	6630	2003	5081
1981	8428	2004	4229
1982	9112	2005	3136
1983	9471	2006	2256
1984	10195	2007	2163
1985	10898		

Table L13. Catch-at-age and mean weight-at-age for white hake from 1989-2007. Catches-at-age from 2001 are based on a pooled age-length key.

Year	1	2	3	4	5	6	7	8	9+
1989	493	2178	3150	932	542	243	30	32	12
1990	345	4840	3528	1289	316	97	43	12	19
1991	481	3540	2596	1322	358	116	37	11	18
1992	227	3651	4817	3067	423	204	127	26	12
1993	1322	2452	2326	2483	622	181	18	6	12
1994	116	915	1846	1270	500	231	42	24	8
1995	74	1928	2030	806	309	147	41	19	22
1996	388	635	724	510	389	237	68	22	8
1997	1326	946	881	260	294	162	93	33	11
1998	3349	1705	554	189	155	176	168	36	1
1999	376	1196	2112	281	236	151	97	75	45
2000	18	1800	1407	244	224	136	98	104	83
2001	3	155	1801	1257	274	178	90	47	25
2002	234	178	302	421	377	197	56	21	7
2003	44	372	481	224	241	298	183	78	34
2004	82	655	483	176	163	163	134	95	47
2005	255	408	276	183	166	133	63	54	45
2006	186	888	333	114	105	96	38	25	31
2007	109	717	425	175	108	86	35	16	21

Year	1	2	3	4	5	6	7	8	9+
1989	0.101	0.370	0.738	1.770	2.944	4.052	6.099	6.684	11.580
1990	0.142	0.287	0.713	1.731	3.072	4.203	5.536	7.977	13.671
1991	0.174	0.302	0.865	1.606	2.667	3.582	6.136	8.170	13.213
1992	0.192	0.271	0.696	1.547	3.318	5.017	5.426	7.571	14.041
1993	0.094	0.227	0.892	1.811	3.131	4.439	6.530	8.447	14.288
1994	0.103	0.400	0.759	1.804	2.912	4.340	6.347	8.385	12.904
1995	0.124	0.445	0.927	1.665	2.464	3.176	4.491	6.519	**11.676**
1996	0.083	0.304	0.781	1.746	2.696	3.585	4.330	7.126	10.448
1997	0.107	0.249	0.552	1.739	2.637	3.519	4.616	6.273	8.726
1998	0.105	0.216	0.708	1.752	2.806	3.912	5.138	7.765	10.132
1999	0.155	0.286	0.513	1.724	2.534	3.670	5.043	6.406	8.234
2000	0.175	0.287	0.449	1.710	2.594	3.321	4.602	6.606	7.716
2001	0.207	0.431	0.768	1.397	3.075	4.706	6.199	7.093	8.754
2002	0.127	0.398	0.958	1.970	3.137	4.292	5.689	6.559	7.683
2003	0.150	0.351	0.656	1.960	3.387	4.873	6.098	6.857	8.040
2004	0.156	0.329	0.670	1.936	3.436	4.843	6.491	7.541	8.613
2005	0.120	0.297	0.680	2.035	3.319	4.562	6.146	7.822	10.048
2006	0.149	0.255	0.590	1.842	3.548	4.672	5.959	7.556	11.737
2007	0.147	0.312	0.630	1.657	3.457	4.661	5.976	7.046	12.920

Table L14. Rivard Jan-1 weights-at-age for white hake from 1989-2007.

Year	1	2	3	4	5	6	7	8	9+
1989	0.060	0.267	0.482	1.344	2.464	3.467	5.333	6.385	11.580
1990	0.097	0.170	0.514	1.130	2.332	3.518	4.736	6.975	13.671
1991	0.139	0.207	0.498	1.070	2.149	3.317	5.078	6.725	13.213
1992	0.177	0.217	0.459	1.157	2.308	3.658	4.409	6.816	14.041
1993	0.046	0.209	0.492	1.123	2.201	3.838	5.724	6.770	14.288
1994	0.050	0.194	0.415	1.269	2.296	3.686	5.308	7.400	12.904
1995	0.079	0.214	0.609	1.124	2.108	3.041	4.415	6.432	11.676
1996	0.048	0.194	0.590	1.272	2.119	2.972	3.708	5.657	10.448
1997	0.075	0.144	0.410	1.165	2.146	3.080	4.068	5.212	8.726
1998	0.064	0.152	0.420	0.983	2.209	3.212	4.252	5.987	10.132
1999	0.114	0.173	0.333	1.105	2.107	3.209	4.442	5.737	8.234
2000	0.112	0.211	0.358	0.937	2.115	2.901	4.110	5.772	7.716
2001	0.149	0.275	0.470	0.792	2.293	3.494	4.537	5.713	8.754
2002	0.076	0.287	0.643	1.230	2.093	3.633	5.174	6.377	7.683
2003	0.101	0.211	0.511	1.370	2.583	3.910	5.116	6.246	8.040
2004	0.113	0.222	0.485	1.127	2.595	4.050	5.624	6.781	8.613
2005	0.082	0.215	0.473	1.168	2.535	3.959	5.456	7.126	10.048
2006	0.103	0.175	0.419	1.119	2.687	3.938	5.214	6.815	11.737
2007	0.100	0.216	0.401	0.991	2.524	4.067	5.284	6.480	12.921

Table L15. Stratified mean catch per tow in numbers and weight (kg) for white hake from NEFSC offshore spring and autumn research vessel bottom trawl surveys (strata 21-30,33-40), 1963-2008. The mean length shown is in cm.

	Spring			Autumn		
Year	No/Tow	Wt/Tow	Length	No/Tow	Wt/Tow	Length
1963				5.00	6.31	46.2
1964				1.77	4.14	56.3
1965				4.39	6.86	50.4
1966				6.79	7.67	45.1
1967				3.92	3.64	42.6
1968	1.60	1.74	44.1	4.24	4.54	44.9
1969	3.76	5.09	46.3	9.24	13.09	46.8
1970	5.84	11.86	52.9	8.05	12.82	51.3
1971	3.31	5.14	51.3	10.38	12.10	43.6
1972	10.18	12.66	47.3	12.52	13.10	45.2
1973	9.24	12.22	49.9	9.05	13.46	51.7
1974	8.08	13.99	55.0	5.35	11.00	54.5
1975	9.32	11.22	44.7	5.28	7.23	48.5
1976	9.98	17.01	52.7	6.04	10.56	54.7
1977	6.13	11.01	55.5	9.78	13.74	47.8
1978	3.22	6.14	51.8	7.87	12.54	50.2
1979	5.26	4.97	43.0	5.62	10.31	53.1
1980	10.38	13.96	49.7	10.86	16.66	48.8
1981	17.09	19.92	45.9	8.70	12.16	49.9
1982	6.06	8.91	51.0	1.96	2.11	46.7
1983	3.23	3.12	43.7	8.22	10.79	48.8
1984	2.75	4.17	51.4	5.32	8.23	51.9
1985	4.33	5.38	48.5	9.37	9.74	42.9
1986	8.24	5.61	40.0	14.42	11.56	41.9
1987	7.15	6.44	45.3	7.59	9.62	49.2
1988	4.52	3.69	41.9	8.12	9.88	46.1
1989	3.65	3.22	43.0	11.76	9.23	40.5
1990	11.11	18.37	53.3	13.09	10.58	41.5
1991	8.42	6.14	41.6	13.22	12.20	44.6
1992	7.59	7.11	45.1	10.16	11.24	47.7
1993	7.93	6.84	45.1	11.35	11.66	45.2
1994	4.59	3.17	40.1	8.44	7.02	42.3
1995	4.38	4.02	44.1	9.54	8.20	40.8
1996	2.87	3.07	45.9	4.52	6.35	51.2
1997	1.88	0.89	38.4	4.69	4.55	41.5
1998	2.25	1.09	37.7	4.41	4.27	44.5
1999	3.32	2.97	44.6	5.68	3.44	36.3
2000	5.19	3.33	40.4	7.57	6.72	43.8
2001	4.81	5.18	48.4	5.74	7.97	52.7
2002	5.13	6.32	49.0	6.91	6.73	42.0
2003	5.16	5.73	46.5	4.58	4.91	44.6
2004	4.91	5.19	46.0	3.55	3.72	44.8
2005	3.78	5.52	48.8	3.32	3.59	45.5
2006	2.56	1.46	36.8	4.69	4.18	43.1
2007	2.30	2.64	47.3	6.36	6.56	46.6
2008	6.33	3.77	39.3			

Table L16. Stratified mean number per tow at age of white hake in the NEFSC bottom trawl spring survey (Strata 21-30,33-40), 1982-2008. The years for which a pooled age-length key has been applied are indicated in bold.

						Age									
Year	0	1	2	3	4	5	6	7	8	9	10+	Total	9+	1+	1+ Abundance
1982	0.0000	0.0559	0.8951	2.7397	0.8080	1.1785	0.2447	0.0205	0.0341	0.0177	0.0618	6.0560	0.0795	6.0560	14007.204
1983	0.0000	0.0658	1.0135	1.2366	0.5966	0.1495	0.0854	0.0435	0.0339	0.0000	0.0000	3.2248	0.0000	3.2248	7458.790
1984	0.0000	0.0193	0.4363	1.0334	0.5940	0.4108	0.1602	0.0479	0.0352	0.0000	0.0156	2.7527	0.0156	2.7527	6366.848
1985	0.0000	0.0605	0.8190	1.7399	1.1089	0.4023	0.1100	0.0298	0.0189	0.0000	0.0388	4.3281	0.0388	4.3281	10010.663
1986	0.0000	0.1429	3.2192	3.1799	1.0404	0.4654	0.1794	0.0000	0.0153	0.0000	0.0000	8.2425	0.0000	8.2425	19064.461
1987	0.0000	0.0196	1.3290	4.1538	1.1008	0.3596	0.1181	0.0000	0.0313	0.0000	0.0326	7.1448	0.0326	7.1448	16525.540
1988	0.0000	0.1813	1.6423	1.2877	0.8169	0.3738	0.1099	0.0221	0.0697	0.0000	0.0139	4.5176	0.0139	4.5176	10448.967
1989	0.0000	0.0663	1.2371	1.5201	0.2697	0.3827	0.1540	0.0203	0.0000	0.0000	0.0000	3.6502	0.0000	3.6502	8442.717
1990	0.0000	0.0706	1.7355	2.3733	4.3770	1.8403	0.2864	0.1086	0.1417	0.0589	0.1178	11.1101	0.1767	11.1101	25697.066
1991	0.0000	0.2341	2.7823	2.4390	1.7550	0.8637	0.2549	0.0439	0.0153	0.0000	0.0276	8.4158	0.0276	8.4158	19465.295
1992	0.0000	0.0000	0.8169	2.5201	3.8107	0.3157	0.0879	0.0337	0.0084	0.0000	0.0000	7.5934	0.0000	7.5934	17563.127
1993	0.0000	0.0362	2.0586	3.1199	2.2549	0.4293	0.0276	0.0000	0.0000	0.0000	0.0000	7.9265	0.0000	7.9265	18333.570
1994	0.0000	0.0335	1.6935	1.8829	0.6658	0.1965	0.0831	0.0080	0.0224	0.0000	0.0000	4.5857	0.0000	4.5857	10606.478
1995	0.0000	0.1134	0.8956	2.1134	0.7609	0.2467	0.1499	0.0331	0.0638	0.0000	0.0000	4.3768	0.0000	4.3768	10123.304
1996	0.0000	0.2441	0.4780	1.0302	0.5293	0.4181	0.0978	0.0188	0.0298	0.0261	0.0000	2.8722	0.0261	2.8722	6643.245
1997	0.0000	0.0360	0.6734	0.8669	0.2508	0.0479	0.0000	0.0000	0.0000	0.0000	0.0000	1.8750	0.0000	1.8750	4336.775
1998	0.0000	0.0127	1.1398	0.8587	0.1591	0.0641	0.0126	0.0000	0.0000	0.0000	0.0000	2.2470	0.0000	2.2470	5197.191
1999	0.0000	0.0417	0.5923	1.5783	0.6007	0.3522	0.0832	0.0499	0.0084	0.0000	0.0000	3.3067	0.0000	3.3067	7648.210
2000	0.0000	0.1057	1.5878	2.4689	0.6951	0.2369	0.0790	0.0124	0.0000	0.0000	0.0000	5.1858	0.0000	5.1858	11994.478
2001	0.0000	0.0426	0.5178	2.0788	1.4451	0.4426	0.1839	0.0160	0.0317	0.0196	0.0310	4.8091	0.0506	4.8091	11123.191
2002	0.0000	0.0380	1.4163	0.9713	1.4177	1.0753	0.1328	0.0077	0.0347	0.0238	0.0114	5.1291	0.0352	5.1291	11863.255
2003	0.0000	0.0226	1.3396	1.6120	0.7166	0.7947	0.4727	0.0776	0.0196	0.0000	0.0103	5.0657	0.0103	5.0657	11716.693
2004	0.0000	0.0472	1.1934	1.9781	0.8486	0.5110	0.1617	0.0722	0.0853	0.0128	0.0010	4.9113	0.0138	4.9113	11359.605
2005	0.0000	0.1077	0.9615	1.0570	0.8013	0.4092	0.1250	0.0945	0.1582	0.0497	0.0150	3.7792	0.0647	3.7792	8741.013
2006	0.0000	0.1642	1.3036	0.6817	0.2006	0.1273	0.0471	0.0060	0.0249	0.0038	0.0000	2.5592	0.0038	2.5592	5919.239
2007	0.0000	0.0341	0.4589	0.9053	0.5339	0.1993	0.0937	0.0359	0.0152	0.0067	0.0135	2.2966	0.0203	2.2966	5311.811
2008	0.0000	0.3307	2.3368	2.1491	1.1832	0.2408	0.0722	0.0121	0.0050	0.0020	0.0015	6.3333	0.0035	6.3333	14648.653

Table L17. Stratified mean number per tow at age of white hake in the NEFSC bottom trawl autumn surveys (Strata 21-30,33-40), 1982-2007. The years for which a pooled age-length key has been applied are indicated in bold.

Year	0	1	2	3	4	5	6	7	8	9	10+	Total	9+	1+	1+ Abundance
1982	0.0043	0.3170	0.5152	0.7349	0.2107	0.1048	0.0577	0.0171	0.0000	0.0000	0.0000	1.9617	0.0000	1.9574	4527.361
1983	0.0000	0.5652	2.8285	2.6364	1.6096	0.2440	0.2413	0.0076	0.0000	0.0139	0.0696	8.2161	0.0835	8.2161	19003.399
1984	0.0000	0.3774	1.0913	2.1531	1.1271	0.3589	0.1357	0.0292	0.0107	0.0000	0.0346	5.3180	0.0346	5.3180	12300.249
1985	0.3101	2.9641	1.8769	2.0345	1.4613	0.4341	0.1397	0.0685	0.0245	0.0000	0.0517	9.3654	0.0517	9.0553	20944.424
1986	0.8543	1.1644	6.6635	4.0970	0.8765	0.4968	0.1413	0.0831	0.0000	0.0281	0.0153	14.4203	0.0434	13.5660	31377.431
1987	0.0633	0.5314	1.6312	3.7002	1.0633	0.2483	0.1572	0.0804	0.0452	0.0390	0.0314	7.5909	0.0704	7.5276	17410.936
1988	0.0000	0.5094	3.7547	2.0666	1.2842	0.3477	0.1104	0.0000	0.0000	0.0000	0.0448	8.1178	0.0448	8.1178	18776.037
1989	0.2911	3.0347	3.2924	3.4743	0.8438	0.4093	0.3410	0.0441	0.0196	0.0000	0.0057	11.7560	0.0057	11.4649	26517.700
1990	0.9693	1.8051	4.8687	3.6504	1.4762	0.2934	0.0222	0.0000	0.0000	0.0000	0.0000	13.0853	0.0000	12.1160	28023.659
1991	0.1897	1.1341	5.8094	4.3180	1.3777	0.3326	0.0431	0.0000	0.0196	0.0000	0.0000	13.2242	0.0000	13.0345	30148.100
1992	0.1454	0.4136	2.3525	5.5875	1.2894	0.1618	0.1287	0.0346	0.0299	0.0000	0.0196	10.1630	0.0196	10.0176	23170.172
1993	0.1559	1.4687	2.6703	4.1235	2.3872	0.4213	0.1202	0.0000	0.0000	0.0000	0.0000	11.3471	0.0000	11.1912	25884.646
1994	0.3556	0.9621	2.8374	2.9629	0.9868	0.2072	0.1024	0.0204	0.0000	0.0000	0.0000	8.4348	0.0000	8.0792	18686.757
1995	1.1788	0.5332	3.9421	2.8394	0.7083	0.1930	0.0124	0.1070	0.0000	0.0000	0.0302	9.5444	0.0302	8.3656	19349.185
1996	0.0239	0.2953	1.0225	1.5424	1.2022	0.3342	0.0276	0.0274	0.0248	0.0000	0.0160	4.5163	0.0160	4.4924	10390.681
1997	0.0000	1.6117	1.2346	0.9233	0.5920	0.1766	0.0640	0.0124	0.0196	0.0000	0.0558	4.6900	0.0558	4.6900	10847.719
1998	0.0356	0.3728	1.7562	1.4964	0.4728	0.1455	0.0797	0.0336	0.0159	0.0000	0.0000	4.4084	0.0000	4.3728	10114.052
1999	0.3428	2.2359	1.2231	1.1093	0.5024	0.1951	0.0643	0.0035	0.0000	0.0000	0.0000	5.6764	0.0000	5.3336	12336.331
2000	0.1158	0.5175	3.4850	2.2224	0.6976	0.3171	0.0874	0.0410	0.0430	0.0174	0.0224	7.5666	0.0398	7.4508	17233.301
2001	0.0080	0.1420	0.5833	3.1547	1.5129	0.2216	0.0698	0.0178	0.0112	0.0107	0.0068	5.7386	0.0175	5.7307	13254.724
2002	0.034	2.7951	1.1104	0.8529	1.315	0.3727	0.0718	0.0124	0.0000	0.0124	0.0000	6.5767	0.0124	6.5427	15132.915
2003	0.0283	1.1844	1.0789	1.1644	0.7103	0.2110	0.1448	0.0485	0.0054	0.0000	0.0000	4.5761	0.0000	4.5478	10518.743
2004	0.0248	0.3739	1.5348	0.9560	0.3892	0.1409	0.0606	0.0255	0.0132	0.0078	0.0208	3.5474	0.0286	3.5225	8147.446
2005	0.0316	0.6346	0.9799	0.8289	0.5011	0.2409	0.0573	0.0164	0.0123	0.0039	0.0078	3.3147	0.0117	3.2831	7593.536
2006	0.0107	0.5591	2.3562	1.0113	0.4753	0.1867	0.0583	0.0177	0.0000	0.0000	0.0164	4.6918	0.0164	4.6810	10826.970
2007	0.0684	0.5021	1.8013	2.8207	0.9616	0.1343	0.0339	0.0014	0.0010	0.0004	0.0359	6.3611	0.0363	6.2926	14554.474

Table L18. Definitions of symbols used in presenting results. Unless otherwise indicated biomasses are "deterministic", i.e. as estimated in the model fit, prior to any bias adjustment for recruitment variability.

'-lnL:overall	Total negative log-likelihood
-lnL:Survey/CAAcom/CAAsurv /CALsurv/RecRes	Contributed to -lnL from survey indices/survey catch-at-age proportions/survey catch-at-length proportions/commercial catch-at-age proportions/ recruitment residuals
h	Stock recruitment curve steepness
γ	Parameter of generalised Ricker S/R function (γ=1 for Ricker)
θ	B^{sp}/K^{sp} for starting year
ϕ	$Z_a \approx M_a + \phi$ for starting year
K^{sp}	Pristine spawning biomass
B^{sp}_{2007}	Spawning biomass in 2007
$MSYL^{sp}$	B^{sp}_{MSY}/K^{sp}
B^{sp}_{MSY}	Spawning biomass at MSY
B^{*sp}_{MSY}	Spawning biomass at MSY adjusted for recruitment variability by multiplying by $\exp(\sigma_R out^2/2)$
MSY	Maximum sustainable yield
MSY^*	MSY adjusted for recruitment variability as above
F_{MSY}	Fishing mortality rate (F) at MSY (corresponds to F at the age at which commercial selectivity = 1, which here is age 6)
$F_{rebuild}$	F to achieve 50% probability that B^{sp} recovers to B^{*sp}_{MSY} by 2014
F_{2007}	F for year 2007
$F_{40\%}$	F at which B^{sp}/R (R = recruitment) equals 40% of its value when F=0
B^{*sp}_{MSY}_40%	Spawning biomass corresponding to $F_{40\%}$; evaluated as $(B^{sp}/R$ for $F_{40\%})\bar{R}$ where $\bar{R}$ is average of recruitment estimates
MSY^*_40%	MSY corresponding to $F_{40\%}$; evaluated as (Y/R for $F_{40\%})\bar{R}$; shown with * as based on average over fluctuations
K^{sp} (av. rec.)	Pristine biomass corresponding to recruitment constant at $\bar{R}$
$MSYL^{sp}$ (av. rec.)	B^{sp}_{MSY}/K^{sp} (av. rec.)
$F_{rebuild}$ (av. rec.)	F to achieve 50% probability that B^{sp} recovers to B^{*sp}_{MSY}_40% by 2014
C_{2008}	Catch in 2008, assumed equal to 2007 catch
C_{2009} (F_{MSY})	Projected 2009 catch under F_{MSY}
C_{2009} ($F_{status\ quo}$)	Projected 2009 catch under $F_{2009}=F_{2008}$
C_{2009} ($F_{rebuild}$)	Projected 2009 catch under $F_{rebuild}$
C_{2009} ($F_{rebuild}$ (av. rec.))	Projected 2009 catch under $F_{rebuild}$ - av. rec.
q spring/autumn	Multiplicative bias for spring/autumn NEFSC survey swept-area-based biomass estimate relative to actual survey selectivity-at-age weighted biomass
Slope_com/surv 6/7	Selectivity slope given by $S_7 = e^{-Slope} S_6$
$\sigma_R$out	Standard deviation of distribution of logs of multiplicative recruitment residuals about estimated S/R relationship
$M1/M9+$	Natural mortality rate for age 1/9+

Table L19. Overall negative log-likelihood and current spawning biomass relative to B^{*sp}_{MSY} for a series of θ and ϕ values for assessment A1. For the final column, θ is estimated rather than fixed.

ϕ = 0.1	θ	0.15	0.25	0.35	0.40
	'-lnL:overall	15.5	10.0	6.8	6.5
	$B^{sp}_{2007}/B^{sp}_{MSY}$	0.18	0.34	0.48	0.53
ϕ = 0.2	θ	0.15	0.25	0.35	0.26
	'-lnL:overall	12.9	8.3	9.9	8.3
	$B^{sp}_{2007}/B^{sp}_{MSY}$	0.27	0.48	0.60	0.50
ϕ = 0.4	θ	0.15	0.25	0.35	0.16
	'-lnL:overall	14.4	19.4	28.8	14.3
	$B^{sp}_{2007}/B^{sp}_{MSY}$	0.46	0.67	0.82	0.49

Table L20. Estimates of management quantities for white hake. Values in bold are inputs. Values in parenthesis are CVs: Hessian-based for MLE's and for Bayes posteriors for the Bayesian MCMC computations. Mass units are '000 tons. Note that the MLE's are Bayesian posterior modes for the estimable parameters of the model.

	Run A1: Reference Case 1 Domed survey sel, with survey CAL				Run A2: Reference Case 2 Domed survey sel, without survey CAL			
	MLE and Hessian-based CVs		Posterior medians and CVs		MLE and Hessian-based CVs		Posterior medians and CVs	
'-lnL:overall	8.3				-100.8			
'-lnL:Survey	-30.0				-32.2			
'-lnL:CAAcom	-13.4				-10.8			
'-lnL:CAAsurv	-52.0				-66.2			
'-lnL:CALsurv	89.5				-			
'-lnL:RecRes	14.2				8.4			
h	2.28	(0.17)	2.00	(0.10)	1.24	(0.27)	1.23	(0.09)
γ	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-
θ	0.26	(0.16)	0.27	(0.10)	0.19	(0.23)	0.20	(0.11)
ϕ	**0.20**	-	**0.20**	-	**0.20**	-	**0.20**	-
K^{sp}	62.0	(0.16)	69.1	(0.08)	116.5	(0.32)	113.3	(0.11)
B^{sp}_{2007}	13.8	(0.26)	15.8	(0.22)	19.8	(0.31)	20.8	(0.22)
B^{sp}_{2007}/K^{sp}	0.22	(0.25)	0.23	(0.21)	0.17	(0.28)	0.18	(0.20)
$MSYL^{sp}$	0.41	(0.13)	0.41	(0.01)	0.42	(0.15)	0.42	(0.01)
B^{sp}_{MSY}	25.6	(0.18)	28.5	(0.08)	49.1	(0.23)	47.8	(0.11)
B^{*sp}_{MSY}	27.7	(0.18)	30.7	(0.08)	51.5	(0.23)	51.3	(0.11)
$B^{sp}_{2007}/B^{*sp}_{MSY}$	0.50	(0.25)	0.51	(0.22)	0.38	(0.24)	0.40	(0.20)
MSY	8.1	(0.07)	7.9	(0.06)	8.1	(0.12)	7.8	(0.08)
MSY^*	8.8	(0.07)	8.6	(0.06)	8.5	(0.12)	8.4	(0.08)
F_{MSY}	0.24	(0.00)	0.24	(0.10)	0.19	(0.00)	0.19	(0.08)
$F_{rebuild}$	0.261	-	0.261	-	0.130	-	0.134	-
F_{2007}	0.15	(0.26)	0.14	(0.23)	0.15	(0.21)	0.15	(0.21)
F_{2007}/F_{MSY}	0.61	(0.26)	0.61	(0.25)	0.82	(0.21)	0.79	(0.23)
$F_{40\%}$	0.10	(0.00)	0.11	(0.07)	0.13	(0.00)	0.13	(0.06)
B^{*sp}_{MSY}_40%	52.0	(0.13)	52.0	(0.04)	56.3	(0.15)	56.3	(0.06)
MSY^*_40%	6.9	(0.08)	6.5	(0.03)	5.8	(0.04)	5.8	(0.03)
$B^{sp}_{2007}/B^{*sp}_{MSY}$_40%	0.27	(0.23)	0.30	(0.21)	0.35	(0.21)	0.37	(0.19)
$F_{2007}/F_{40\%}$	1.40	(0.25)	1.27	(0.22)	1.21	(0.21)	1.17	(0.21)
K^{sp} (av. rec.)	130.1	(0.05)	130.2	(0.04)	140.8	(0.08)	141.0	(0.06)
$MSYL^{sp}$ (av. rec.)	0.40	(0.10)	0.40	(0.00)	0.40	(0.07)	0.40	(0.00)
$F_{rebuild}$ (av. rec.)	0.080	-	0.080	-	0.078	-	0.078	-
C_{2008}	**2.2**	-	**2.2**	-	**2.2**	-	**2.2**	-
C_{2009} (F_{MSY})	6.7	(0.25)	6.1	(0.23)	4.9	(0.22)	4.8	(0.24)
C_{2009} ($F_{status\ quo}$)	2.8	(0.03)	2.7	(0.04)	2.7	(0.04)	2.7	(0.05)
C_{2009} ($F_{rebuild}$)	7.3	(0.25)	6.7	(0.23)	3.6	(0.22)	3.5	(0.23)
C_{2009} ($F_{rebuild}$ (av. rec.))	2.3	(0.23)	2.3	(0.23)	2.2	(0.23)	2.2	(0.23)
q spring	1.04	(0.09)	1.00	(0.06)	1.09	(0.10)	1.07	(0.08)
q autumn	1.73	(0.08)	1.63	(0.07)	1.98	(0.10)	1.91	(0.09)
Slope_com 6/7	0.01	(0.15^{+})	0.09	(0.64)	0.35	(0.50)	0.36	(0.28)
Slope_surv 6/7	0.42	(0.38)	0.43	(0.29)	0.69	(0.25)	0.71	(0.23)
σ_R out	0.40	(0.09)	0.39	(0.06)	0.31	(0.10)	0.38	(0.08)

Selectivity	WHSpr	WHAut	Comm	WHSpr	WHAut	Comm	WHSpr	WHAut	Comm	WHSpr	WHAut	Comm
1	0.03	0.22	0.19	0.03	0.22	0.20	0.03	0.26	0.23	0.03	0.27	0.23
2	0.41	0.51	0.57	0.42	0.52	0.57	0.43	0.58	0.66	0.44	0.60	0.65
3	0.96	1.00	0.88	0.94	1.00	0.89	1.00	1.00	1.00	0.99	1.00	0.99
4	1.00	0.89	0.90	1.00	0.89	0.87	1.00	0.75	0.96	1.00	0.75	0.92
5	0.92	0.58	0.84	0.89	0.58	0.79	0.74	0.36	0.84	0.73	0.36	0.82
6	0.68	0.58	1.00	0.64	0.59	1.00	0.44	0.25	1.00	0.45	0.27	1.00
7	0.45	0.35	0.99	0.41	0.32	0.91	0.22	0.13	0.71	0.22	0.14	0.70
8	0.29	0.21	0.98	0.27	0.17	0.83	0.11	0.07	0.50	0.11	0.07	0.49
9+	0.19	0.12	0.97	0.17	0.10	0.76	0.06	0.04	0.35	0.05	0.04	0.34

Table L20 continued

	Run B1: Beverton-Holt Domed survey sel, with survey CAL				Run B2: Beverton-Holt Domed survey sel, without survey CAL			
	MLE and Hessian-based CVs		Posterior medians and CVs		MLE and Hessian-based CVs		Posterior medians and CVs	
'-lnL:overall	9.0				-100.6			
'-lnL:Survey	-29.4				-32.1			
'-lnL:CAAcom	-13.4				-10.7			
'-lnL:CAAsurv	-51.9				-66.4			
'-lnL:CALsurv	88.9				-			
'-lnL:RecRes	14.8				8.5			
h	0.98*	-	0.98	(0.00)	0.76	(0.14)	0.76	(0.09)
γ	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-
θ	0.12	(0.20)	0.16	(0.15)	0.10	(0.33)	0.10	(0.15)
ϕ	**0.20**	-	**0.20**	-	**0.20**	-	**0.20**	-
K^{sp}	140.6	(0.09)	140.2	(0.08)	243.0	(0.35)	229.9	(0.17)
B^{sp}_{2007}	15.4	(0.24)	18.2	(0.22)	20.4	(0.30)	22.7	(0.28)
B^{sp}_{2007}/K^{sp}	0.11	(0.23)	0.13	(0.22)	0.08	(0.38)	0.10	(0.24)
MSYL^{sp}	0.27	(0.11)	0.26	(0.03)	0.31	(0.10)	0.31	(0.05)
B^{sp}_{MSY}	38.6	(0.17)	37.2	(0.08)	76.5	(0.30)	71.8	(0.21)
B^{*sp}_{MSY}	42.0	(0.17)	40.1	(0.08)	80.3	(0.30)	76.7	(0.21)
$B^{sp}_{2007}/B^{*sp}_{\text{MSY}}$	0.37	(0.23)	0.45	(0.22)	0.25	(0.32)	0.29	(0.25)
MSY	7.5	(0.09)	6.9	(0.07)	8.6	(0.22)	8.1	(0.09)
MSY^*	8.2	(0.09)	7.5	(0.07)	9.0	(0.22)	8.6	(0.09)
F_{MSY}	0.16	(0.00)	0.18	(0.10)	0.14	(0.00)	0.14	(0.10)
$F_{rebuild}$	0.183	-	0.183	-	0.034	-	0.034	-
F_{2007}	0.14	(0.22)	0.14	(0.23)	0.15	(0.21)	0.14	(0.22)
F_{2007}/F_{MSY}	0.86	(0.22)	0.77	(0.25)	1.09	(0.21)	1.02	(0.24)
$F_{40\%}$	0.11	(0.00)	0.12	(0.08)	0.13	(0.00)	0.13	(0.07)
B^{*sp}_{MSY}_40%	52.6	(0.12)	53.7	(0.04)	56.7	(0.14)	57.6	(0.07)
MSY^*_40%	6.8	(0.06)	6.3	(0.04)	5.8	(0.03)	5.8	(0.03)
$B^{sp}_{2007}/B^{*sp}_{\text{MSY}}$_40%	0.29	(0.21)	0.34	(0.21)	0.36	(0.21)	0.39	(0.22)
$F_{2007}/F_{40\%}$	1.31	(0.23)	1.15	(0.23)	1.21	(0.21)	1.12	(0.23)
K^{sp} (av. rec.)	131.7	(0.04)	134.5	(0.04)	141.9	(0.08)	144.1	(0.07)
MSYL^{sp} (av. rec.)	0.40	(0.09)	0.40	(0.00)	0.40	(0.07)	0.40	(0.00)
$F_{rebuild}$ (av. rec.)	0.082	-	0.082	-	0.082	-	0.082	-
C_{2008}	**2.2**	-	**2.2**	-	**2.2**	-	**2.2**	-
C_{2009} (F_{MSY})	4.9	(0.20)	5.0	(0.23)	3.7	(0.22)	3.8	(0.26)
C_{2009} ($F_{\text{status quo}}$)	2.8	(0.03)	2.7	(0.04)	2.7	(0.04)	2.7	(0.05)
C_{2009} (F_{rebuild})	5.4	(0.20)	5.0	(0.22)	0.9	(0.22)	1.0	(0.23)
C_{2009} (F_{rebuild} (av. rec.))	2.5	(0.22)	2.5	(0.22)	2.4	(0.23)	2.4	(0.23)
q spring	1.02	(0.08)	0.99	(0.07)	1.08	(0.10)	1.04	(0.09)
q autumn	1.70	(0.08)	1.58	(0.08)	1.97	(0.10)	1.87	(0.10)
Slope_com 6/7	0.07	(0.13^{+})	0.21	(0.42)	0.37	(0.45)	0.40	(0.34)
Slope_surv 6/7	0.43	(0.36)	0.52	(0.30)	0.69	(0.25)	0.73	(0.23)
$\sigma_R$out	0.41	(0.08)	0.39	(0.08)	0.31	(0.10)	0.37	(0.08)

Selectivity	WHSpr	WHAut	Comm	WHSpr	WHAut	Comm	WHSpr	WHAut	Comm	WHSpr	WHAut	Comm
1	0.03	0.22	0.19	0.03	0.22	0.20	0.03	0.26	0.23	0.03	0.27	0.23
2	0.41	0.50	0.56	0.41	0.51	0.57	0.43	0.59	0.66	0.44	0.60	0.66
3	0.96	1.00	0.88	0.95	1.00	0.88	1.00	1.00	1.00	0.99	1.00	0.99
4	1.00	0.89	0.89	1.00	0.88	0.88	1.00	0.74	0.96	1.00	0.74	0.92
5	0.93	0.59	0.83	0.88	0.58	0.82	0.73	0.35	0.84	0.73	0.36	0.82
6	0.68	0.58	1.00	0.67	0.60	1.00	0.43	0.25	1.00	0.44	0.26	1.00
7	0.44	0.35	0.93	0.40	0.32	0.81	0.22	0.13	0.69	0.21	0.13	0.67
8	0.29	0.21	0.87	0.23	0.17	0.66	0.11	0.07	0.48	0.10	0.07	0.45
9+	0.19	0.12	0.82	0.14	0.09	0.54	0.05	0.04	0.33	0.05	0.03	0.30

Table L21. Retrospective statistics (Mohn's Rho) for the ASPM run A2.

	RunA2		
	SSB	F	N1
2000	0.015	0.146	0.638
2001	0.209	-0.143	0.554
2002	0.264	-0.209	1.718
2003	0.237	-0.225	0.160
2004	0.096	-0.212	0.230
2005	0.153	-0.209	-0.121
2006	0.022	-0.005	-0.391
Average	0.142	-0.123	0.319

Table L22. Fishing mortality estimates from the ASPM run A2.

	1	2	3	4	5	6	7	8	9+
1963	0.066	0.189	0.287	0.275	0.242	0.287	0.203	0.143	0.101
1964	0.067	0.193	0.293	0.281	0.247	0.293	0.207	0.146	0.103
1965	0.059	0.170	0.258	0.248	0.218	0.258	0.182	0.129	0.091
1966	0.034	0.097	0.147	0.141	0.124	0.147	0.103	0.073	0.052
1967	0.022	0.063	0.095	0.091	0.080	0.095	0.067	0.047	0.033
1968	0.021	0.061	0.092	0.088	0.078	0.092	0.065	0.046	0.032
1969	0.019	0.053	0.081	0.078	0.068	0.081	0.057	0.040	0.029
1970	0.024	0.069	0.105	0.101	0.089	0.105	0.074	0.052	0.037
1971	0.028	0.082	0.124	0.119	0.105	0.124	0.088	0.062	0.044
1972	0.028	0.080	0.121	0.116	0.102	0.121	0.085	0.060	0.042
1973	0.028	0.080	0.122	0.117	0.103	0.122	0.086	0.061	0.043
1974	0.032	0.092	0.140	0.134	0.118	0.140	0.099	0.070	0.049
1975	0.030	0.087	0.132	0.126	0.111	0.132	0.093	0.066	0.046
1976	0.034	0.098	0.148	0.142	0.125	0.148	0.104	0.074	0.052
1977	0.044	0.128	0.193	0.186	0.163	0.193	0.137	0.096	0.068
1978	0.042	0.120	0.183	0.175	0.154	0.183	0.129	0.091	0.064
1979	0.036	0.102	0.155	0.149	0.131	0.155	0.110	0.077	0.055
1980	0.042	0.120	0.183	0.175	0.154	0.183	0.129	0.091	0.064
1981	0.055	0.159	0.241	0.231	0.203	0.241	0.170	0.120	0.085
1982	0.063	0.182	0.276	0.265	0.233	0.276	0.195	0.138	0.097
1983	0.070	0.200	0.303	0.291	0.256	0.303	0.214	0.151	0.107
1984	0.084	0.243	0.368	0.353	0.311	0.368	0.260	0.184	0.130
1985	0.103	0.295	0.448	0.430	0.378	0.448	0.316	0.223	0.158
1986	0.099	0.284	0.431	0.413	0.363	0.431	0.304	0.215	0.152
1987	0.095	0.272	0.413	0.396	0.348	0.413	0.291	0.206	0.145
1988	0.080	0.231	0.350	0.336	0.296	0.350	0.247	0.175	0.123
1989	0.090	0.259	0.393	0.377	0.332	0.393	0.278	0.196	0.138
1990	0.087	0.251	0.381	0.365	0.321	0.381	0.269	0.190	0.134
1991	0.088	0.254	0.384	0.369	0.324	0.384	0.271	0.192	0.135
1992	0.143	0.411	0.624	0.599	0.526	0.624	0.440	0.311	0.220
1993	0.135	0.388	0.588	0.564	0.496	0.588	0.415	0.293	0.207
1994	0.108	0.311	0.472	0.453	0.398	0.472	0.333	0.235	0.166
1995	0.108	0.312	0.472	0.453	0.398	0.472	0.333	0.235	0.166
1996	0.087	0.251	0.381	0.365	0.321	0.381	0.269	0.190	0.134
1997	0.082	0.235	0.356	0.341	0.300	0.356	0.251	0.177	0.125
1998	0.080	0.230	0.348	0.334	0.294	0.348	0.246	0.174	0.123
1999	0.099	0.284	0.431	0.414	0.364	0.431	0.304	0.215	0.152
2000	0.094	0.270	0.409	0.392	0.345	0.409	0.288	0.204	0.144
2001	0.107	0.307	0.465	0.447	0.393	0.465	0.329	0.232	0.164
2002	0.063	0.181	0.274	0.263	0.231	0.274	0.194	0.137	0.097
2003	0.089	0.255	0.387	0.371	0.326	0.387	0.273	0.193	0.136
2004	0.079	0.228	0.346	0.332	0.292	0.346	0.244	0.172	0.122
2005	0.064	0.183	0.277	0.266	0.234	0.277	0.196	0.138	0.097
2006	0.043	0.125	0.189	0.181	0.159	0.189	0.133	0.094	0.066
2007	0.035	0.100	0.152	0.146	0.128	0.152	0.107	0.076	0.053

Table L23. Abundance estimates from the ASPM run A2 (units are in 000's).

	1	2	3	4	5	6	7	8	9+	Total
1963	4359.1	3403.1	2418.3	1583.9	1047.6	713.0	467.0	328.5	1016.5	15336.9
1964	5753.6	3357.1	2316.3	1474.2	978.6	672.8	434.6	313.6	993.0	16293.7
1965	5255.2	4424.7	2274.4	1401.0	904.0	624.6	407.0	290.4	962.5	16543.7
1966	6148.1	4069.2	3064.3	1427.5	889.8	594.4	392.0	278.4	934.1	17797.8
1967	7430.2	4872.5	3028.5	2163.1	1014.0	643.8	419.6	289.8	940.4	20801.9
1968	8005.7	5957.3	3754.4	2258.4	1619.3	767.7	480.1	321.9	972.8	24137.6
1969	8304.9	6424.7	4602.9	2811.7	1697.6	1230.4	575.0	369.5	1025.2	27041.7
1970	8589.1	6680.1	4997.7	3483.8	2135.0	1301.3	931.2	445.7	1108.5	29672.4
1971	8508.1	6871.4	5113.8	3689.1	2582.7	1602.8	960.5	709.6	1223.5	31261.7
1972	8153.1	6775.9	5189.9	3695.5	2679.9	1905.1	1158.3	721.5	1507.9	31787.0
1973	8232.5	6494.9	5121.9	3755.2	2687.7	1978.9	1378.5	870.7	1741.2	32261.4
1974	8625.0	6555.6	4903.7	3699.2	2726.4	1981.7	1429.2	1035.0	2038.2	32993.9
1975	8662.7	6843.2	4895.6	3480.5	2641.4	1981.5	1406.5	1060.5	2382.8	33354.6
1976	8284.4	6886.9	5141.4	3508.4	2508.2	1935.0	1420.0	1050.5	2680.7	33415.5
1977	8618.6	6565.4	5125.3	3629.2	2492.0	1814.7	1365.9	1049.8	2890.5	33551.4
1978	10590.5	6769.0	4753.4	3461.0	2471.2	1738.6	1225.4	980.4	3006.8	34996.3
1979	6422.2	8336.8	4935.4	3246.6	2382.4	1740.2	1187.5	886.2	3056.2	32193.4
1980	10588.4	5083.5	6181.8	3463.5	2293.3	1715.4	1221.2	874.5	3051.7	34473.3
1981	9466.2	8334.3	3705.3	4220.1	2383.0	1614.3	1171.0	882.9	3010.8	34787.9
1982	10720.3	7366.7	5864.0	2387.6	2748.2	1600.4	1040.2	815.0	2928.5	35470.8
1983	7105.8	8285.8	5072.1	3644.6	1502.4	1792.7	994.7	707.2	2783.9	31889.1
1984	8883.8	5463.8	5611.0	3065.4	2233.4	958.3	1083.4	664.3	2575.0	30538.5
1985	14607.4	6753.6	3564.8	3180.8	1768.1	1353.9	543.2	695.0	2343.1	34809.7
1986	7836.7	10957.2	4212.4	1865.8	1701.8	1006.9	708.6	331.8	2144.3	30765.6
1987	12305.2	5894.4	6898.0	2241.9	1014.0	981.8	535.9	437.3	1765.9	32074.4
1988	9608.9	9283.2	3748.6	3738.2	1239.3	593.3	532.1	334.3	1573.4	30651.4
1989	13543.9	7326.6	6116.7	2161.7	2191.3	761.5	342.2	345.0	1389.0	34177.9
1990	14713.1	10251.4	4711.3	3380.4	1217.3	1302.0	420.9	216.1	1245.3	37457.7
1991	8940.0	11160.0	6638.7	2636.2	1925.9	730.4	728.5	267.8	1056.1	34083.6
1992	8071.9	6776.7	7211.6	3700.6	1496.6	1152.1	407.1	462.5	953.0	30232.0
1993	7616.4	5896.3	3848.5	3164.9	1679.3	745.5	505.6	224.5	945.6	24626.7
1994	5620.1	5591.8	3410.6	1750.3	1484.7	859.2	339.1	284.4	797.5	20137.6
1995	4543.7	4199.5	3441.9	1742.8	915.6	830.0	439.0	204.2	756.8	17073.5
1996	5674.8	3394.9	2584.1	1757.8	911.1	511.6	423.9	264.3	674.3	16196.8
1997	8998.6	4304.5	2198.7	1446.2	1001.7	546.8	286.3	269.7	673.6	19726.2
1998	10162.3	6855.5	2828.3	1261.8	843.8	613.1	313.8	185.1	682.1	23745.6
1999	11197.5	7752.2	4524.0	1635.3	741.5	519.6	354.5	203.8	630.7	27559.0
2000	3183.1	8423.1	4881.9	2409.0	889.2	428.0	276.7	218.8	591.3	21301.1
2001	3445.0	2403.5	5372.4	2659.4	1338.3	522.4	233.1	173.2	577.1	16724.4
2002	5896.6	2577.3	1485.6	2766.1	1401.0	752.5	269.0	141.0	527.0	15816.1
2003	3726.8	4559.6	1777.1	925.5	1744.6	915.7	468.8	183.2	497.3	14798.6
2004	3737.6	2824.7	2945.5	990.1	525.2	1043.2	510.1	297.5	488.0	13361.9
2005	7157.6	2853.0	1867.9	1709.1	583.8	324.3	605.3	332.0	567.4	16000.4
2006	7871.0	5531.9	1964.1	1160.7	1075.3	380.7	201.5	411.5	664.9	19261.6
2007	4865.5	6187.1	4015.7	1332.0	793.5	752.8	258.2	145.0	820.0	19169.8

Table L24. Input values for white hake BRP calculations and projections based on 2003-2007 average values from the ASPM run A2.

Age	S[PR]	Maturity	Mid-year catch weights	SSB weights	Jan1 Weights
1	0.232	0.058	0.144	0.100	0.100
2	0.660	0.268	0.309	0.208	0.208
3	1.000	0.683	0.645	0.458	0.458
4	0.961	0.927	1.887	1.155	1.155
5	0.844	0.987	3.430	2.585	2.585
6	1.000	0.998	4.722	3.985	3.985
7	0.704	1.000	6.134	5.339	5.339
8	0.495	1.000	7.364	6.689	6.689
9+	0.349	1.000	10.271	10.272	10.272

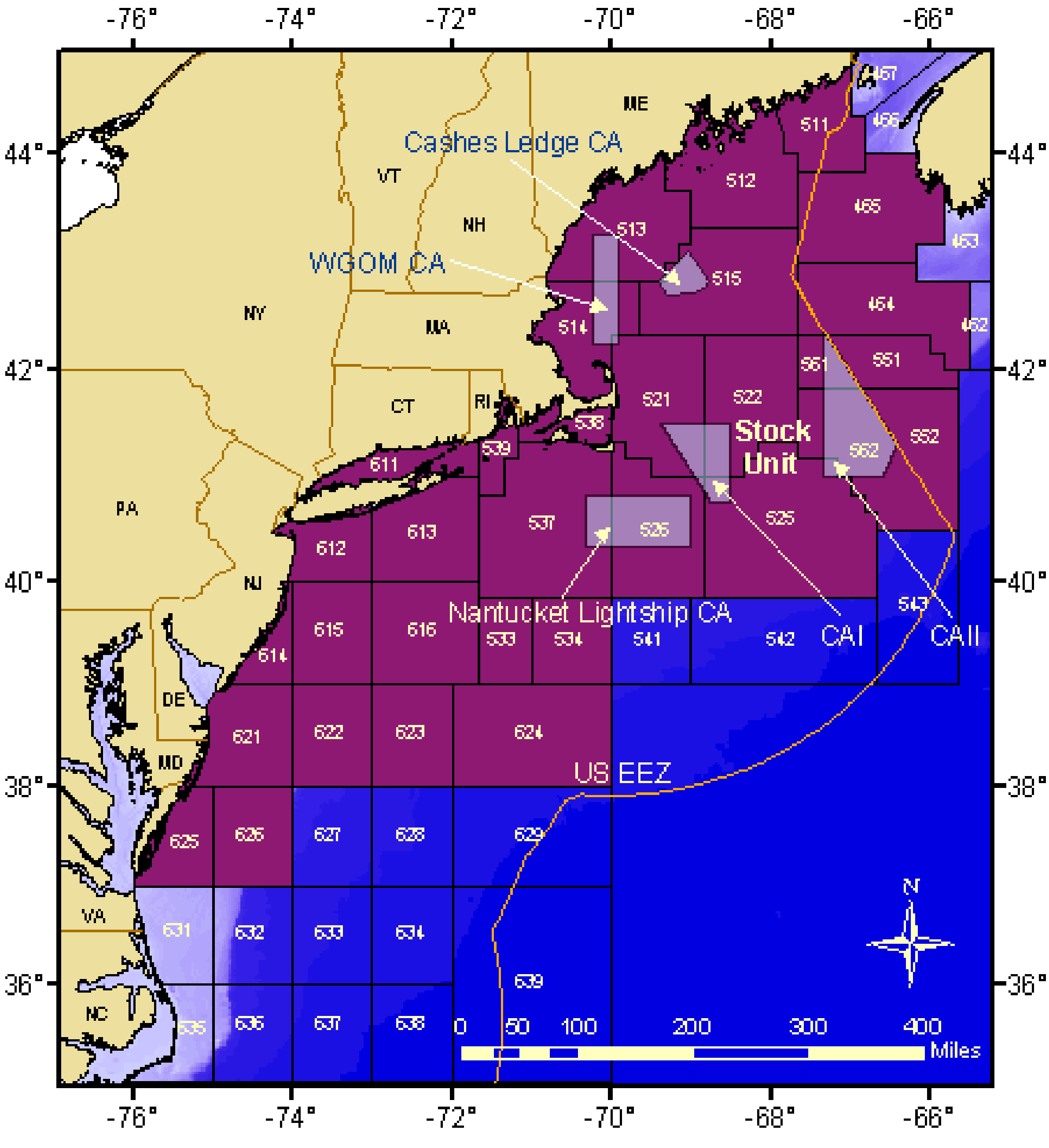


Figure L1. Map showing statistical areas used in the white hake stock unit.

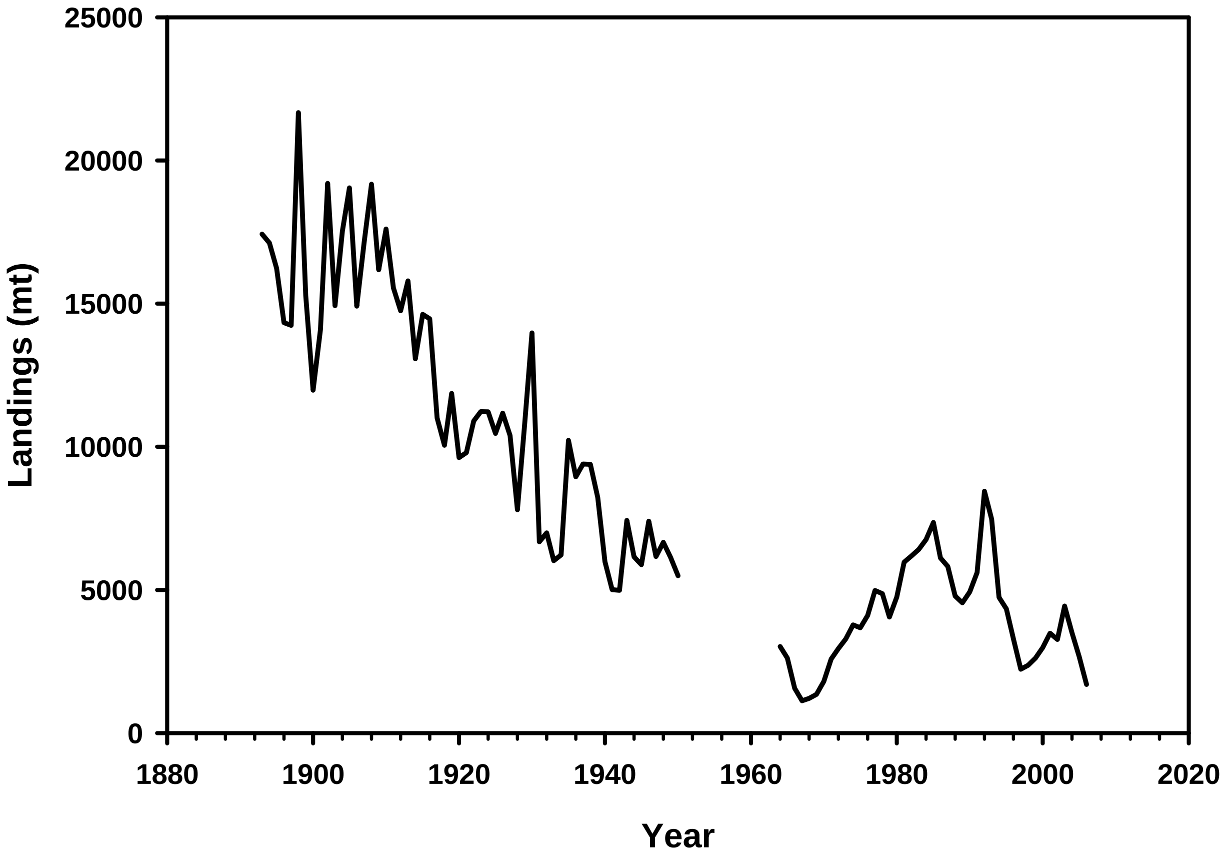


Figure L2. Reported total nominal landings of white hake (mt, live weight) from the Gulf of Maine to Mid-Atlantic region, 1893-2007.

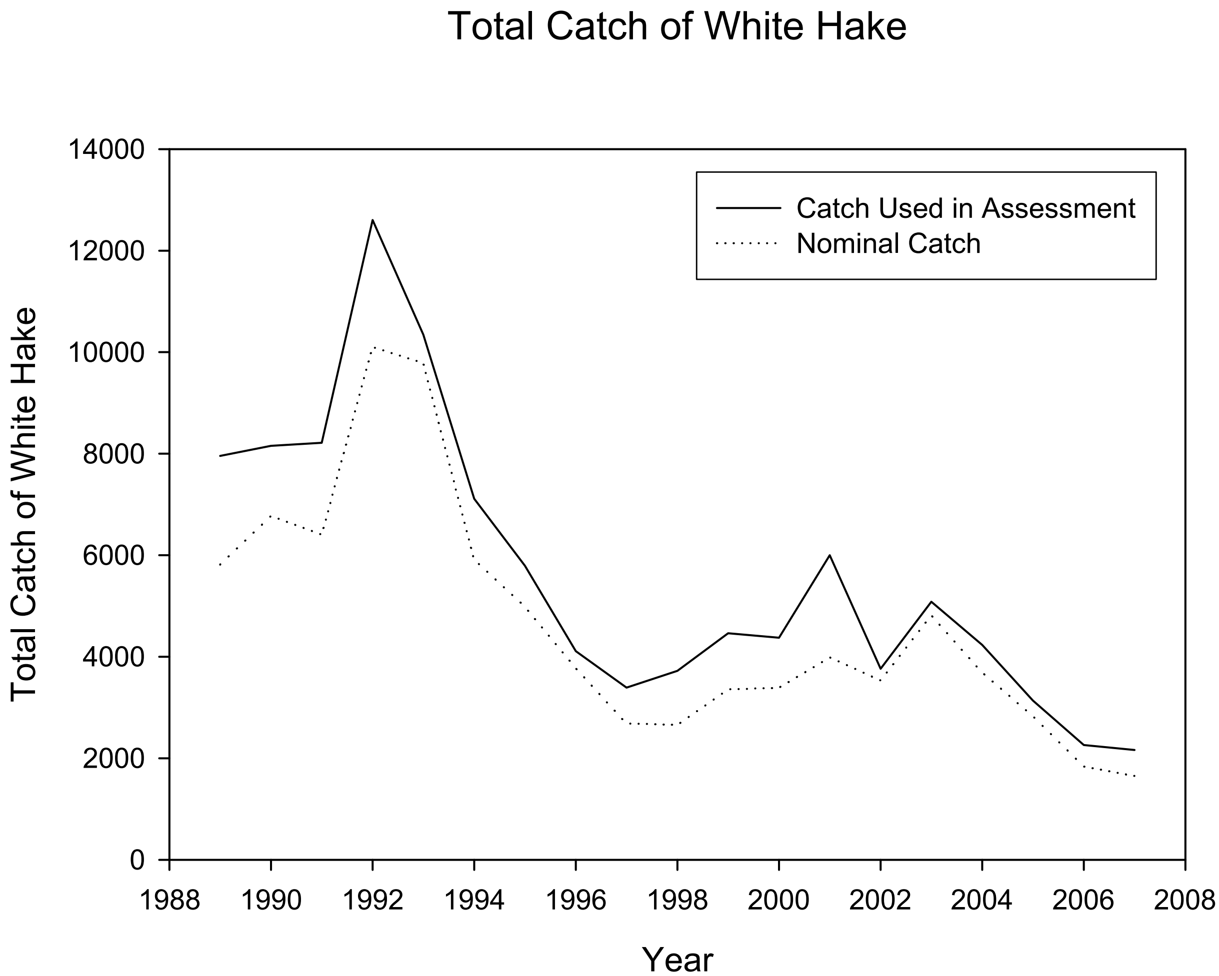


Figure L3. Total catch of white hake from 1989-2007 using just white hake data (Nominal Catch) and using survey data to split out combined red and white hake catches (Catch Used in Assessment).

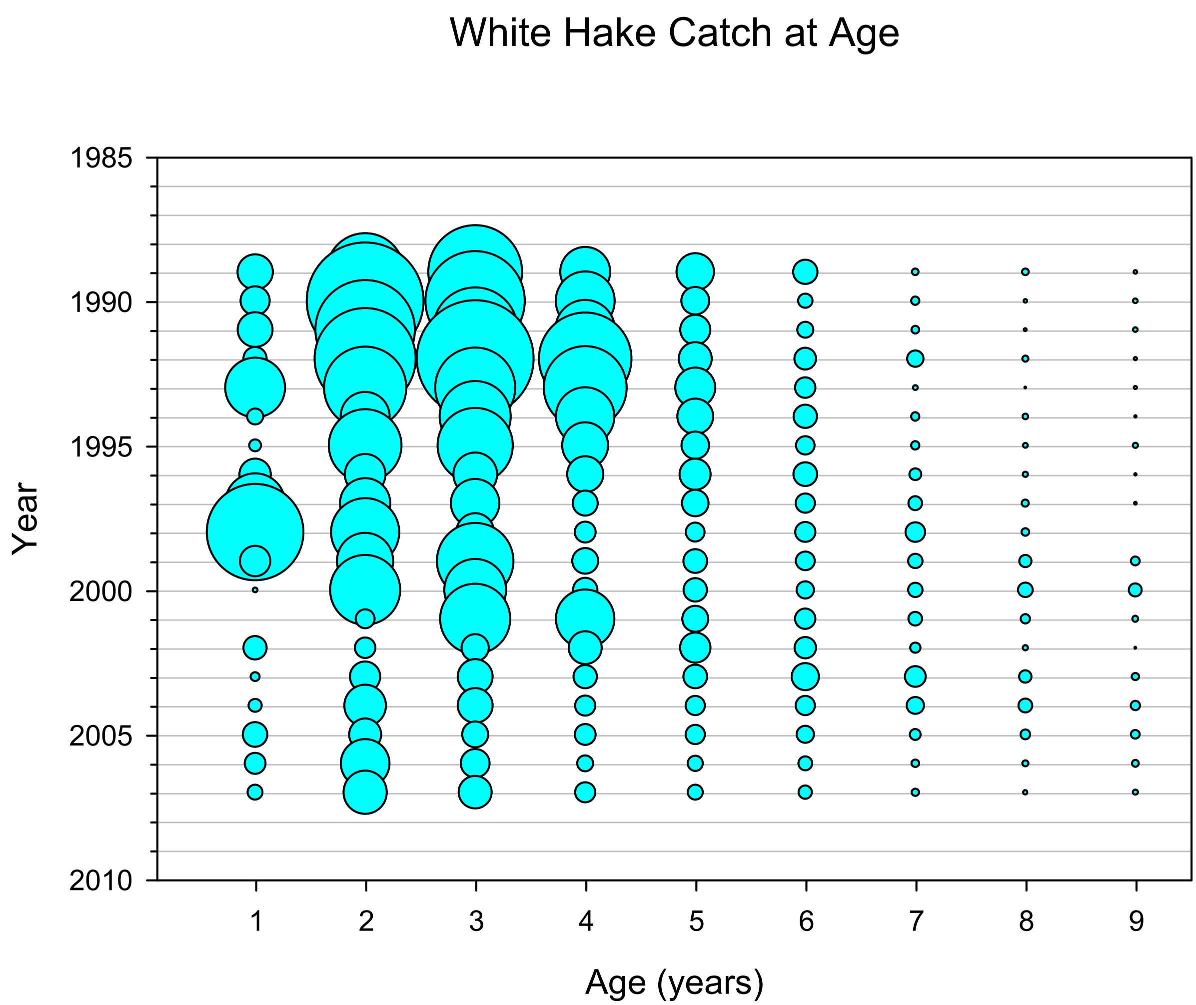


Figure L4. Catch at age (thousands of fish) of commercial landings for white hake, 1989-2007. Values from 2001 are based on a pooled age-length key.

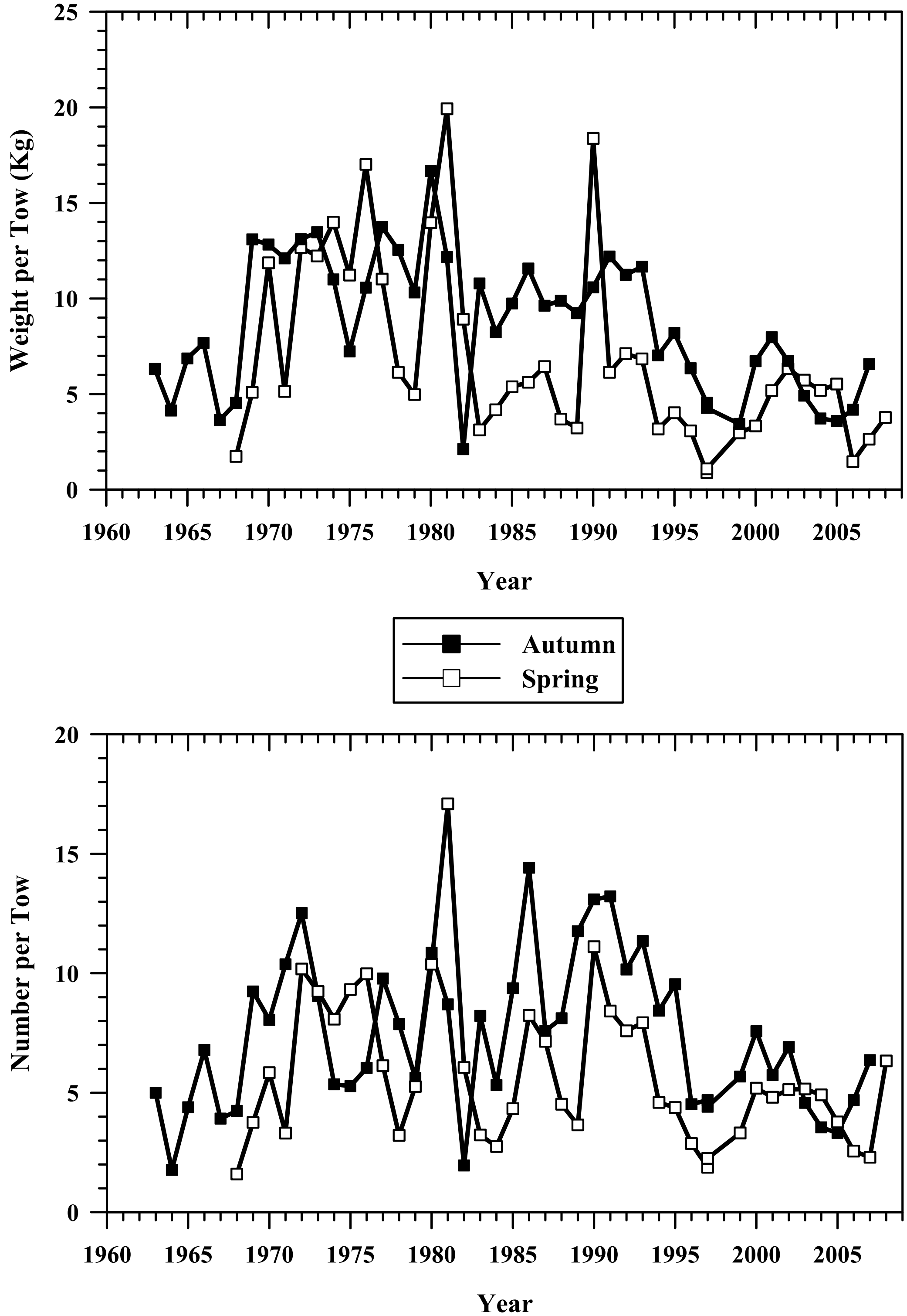
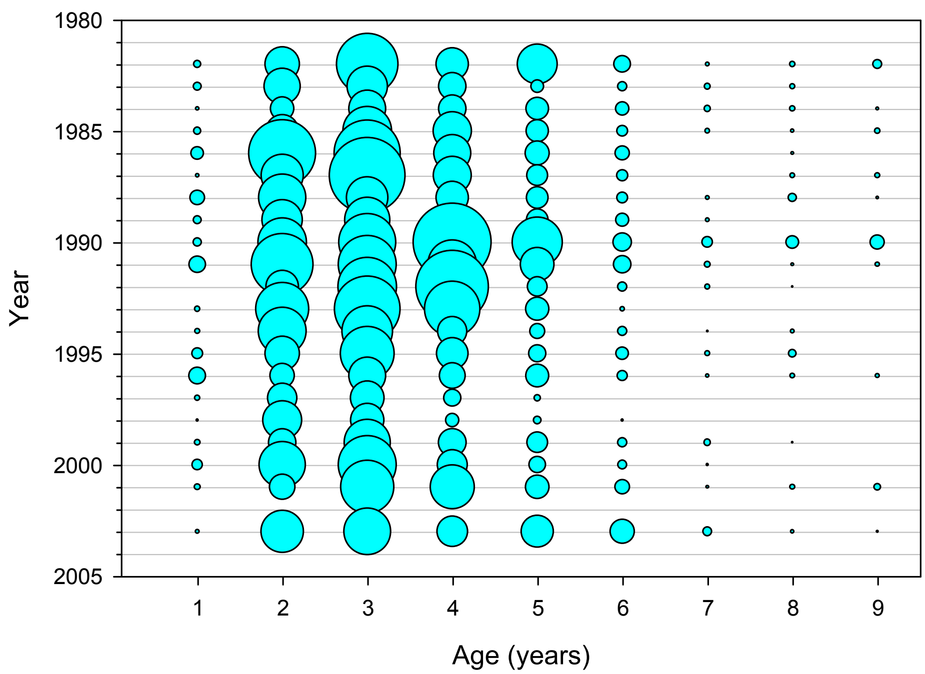


Figure L5. White hake indices of biomass (top panel) and abundance (bottom panel) from the NEFSC bottom trawl spring (open squares) and autumn (solid squares) surveys in the Gulf of Maine to Northern Georges Bank region (offshore strata 21-30, 33-40), 1963-2008.

White Hake Spring Survey Indices by Age



White Hake Autumn Survey Indices by Age

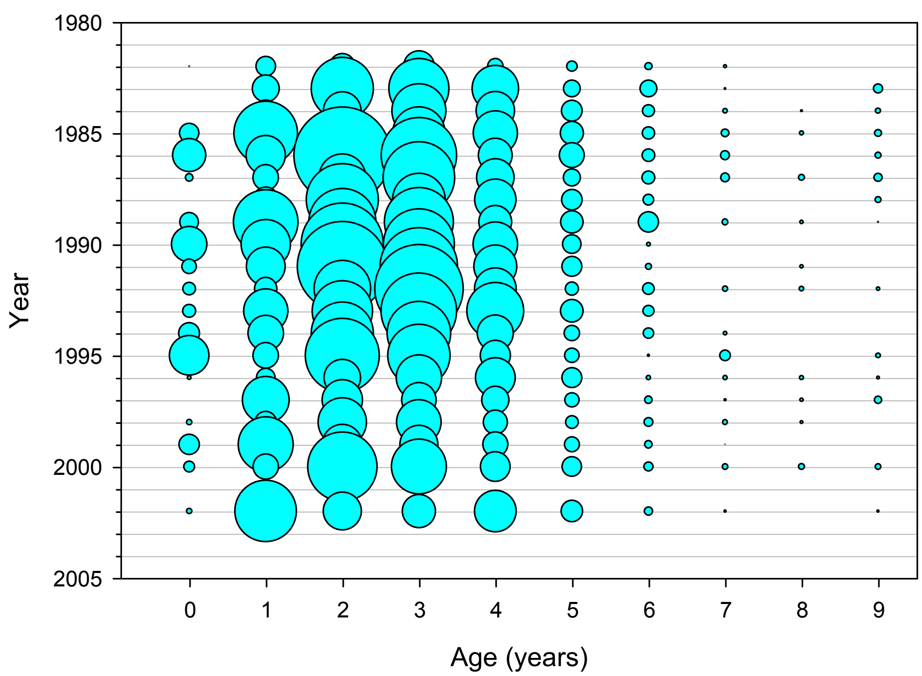


Figure L6. Age composition of white hake from the spring and autumn surveys from 1982-2003.

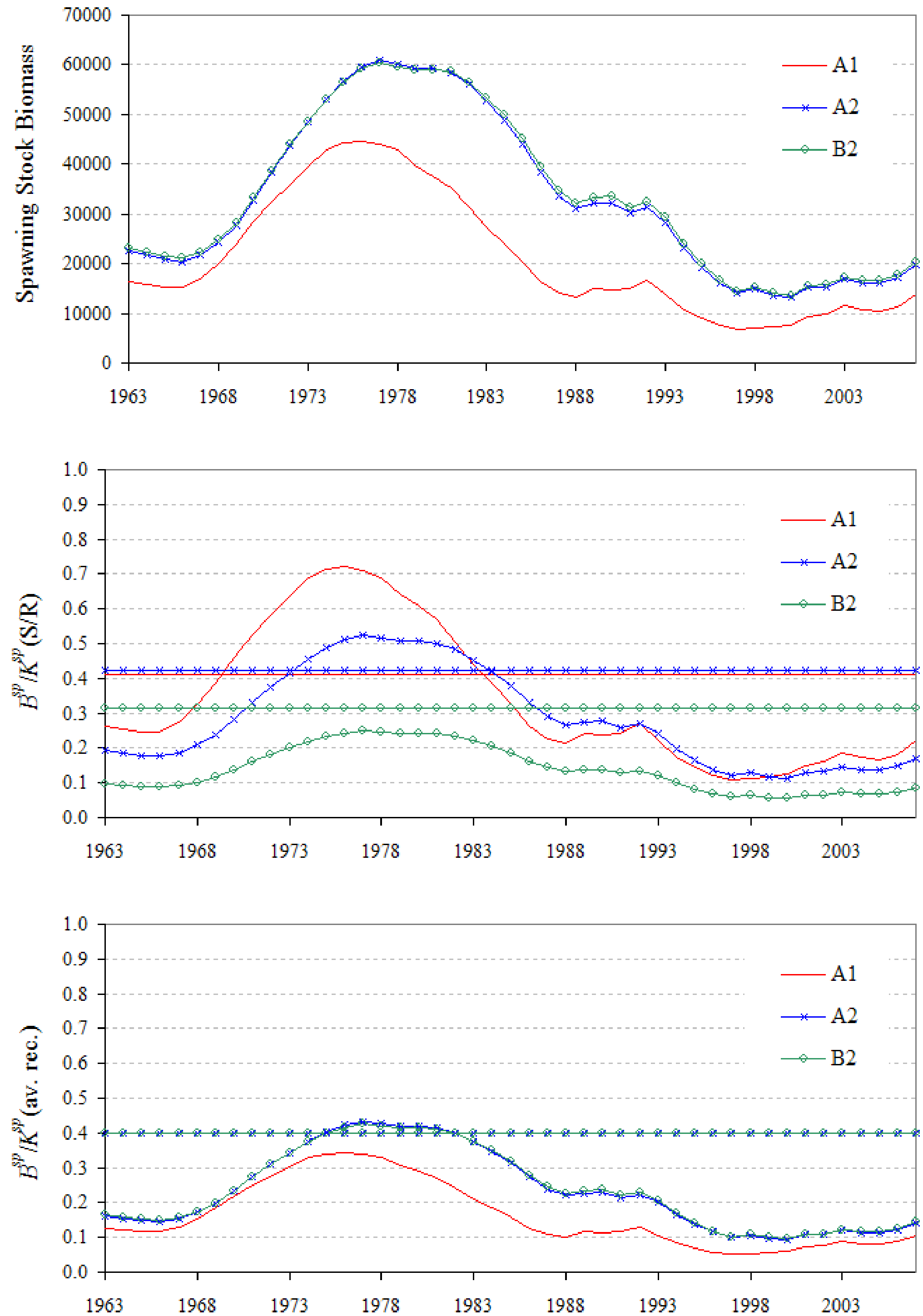


Figure L7. Spawning stock biomass trajectories for ASPM runs A1, A2 and B2. The flat horizontal lines shown are the corresponding MSYL target levels.

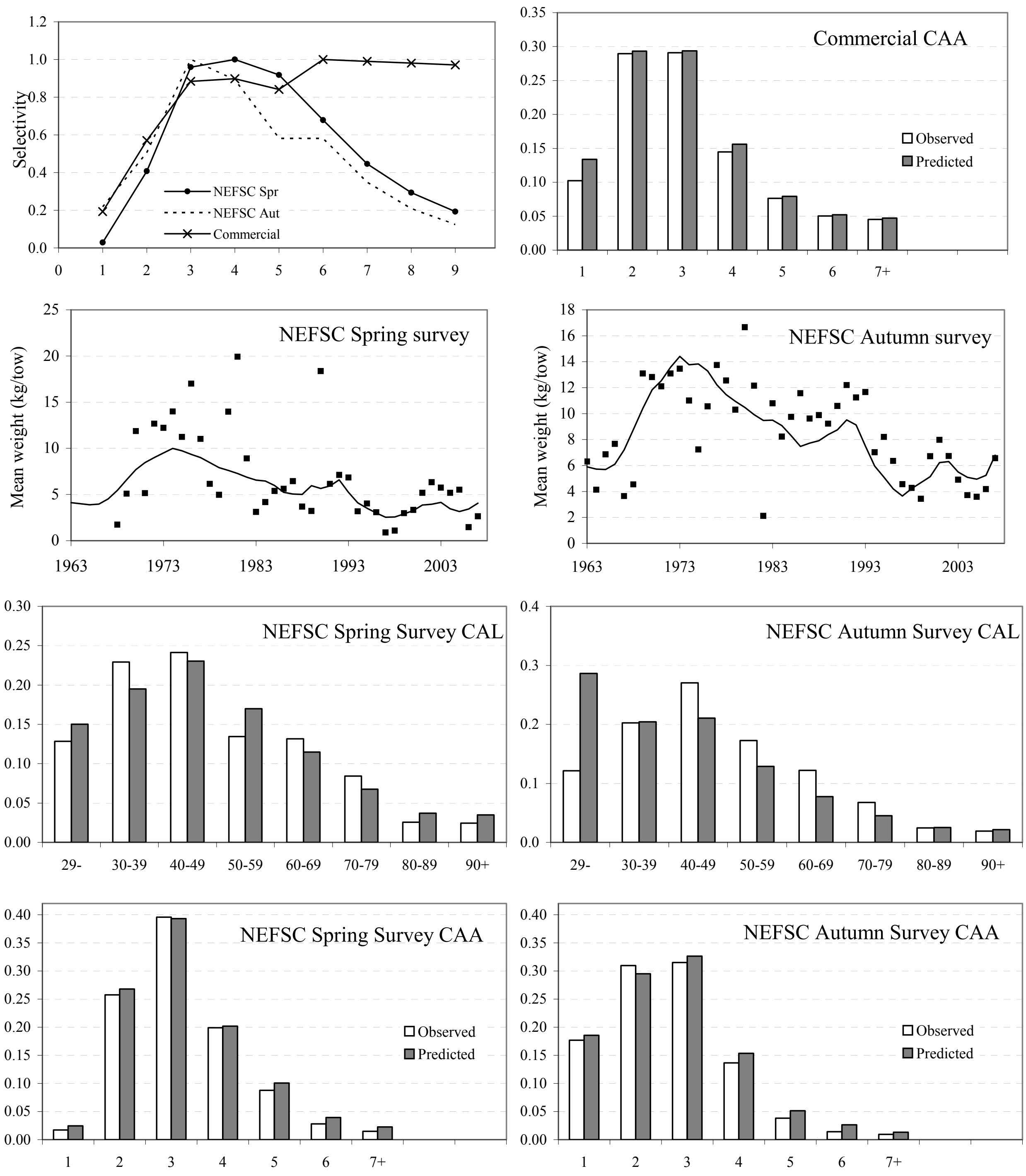


Figure L8. Estimates of selectivity-at-age and fits to the data input for ASPM run A1.

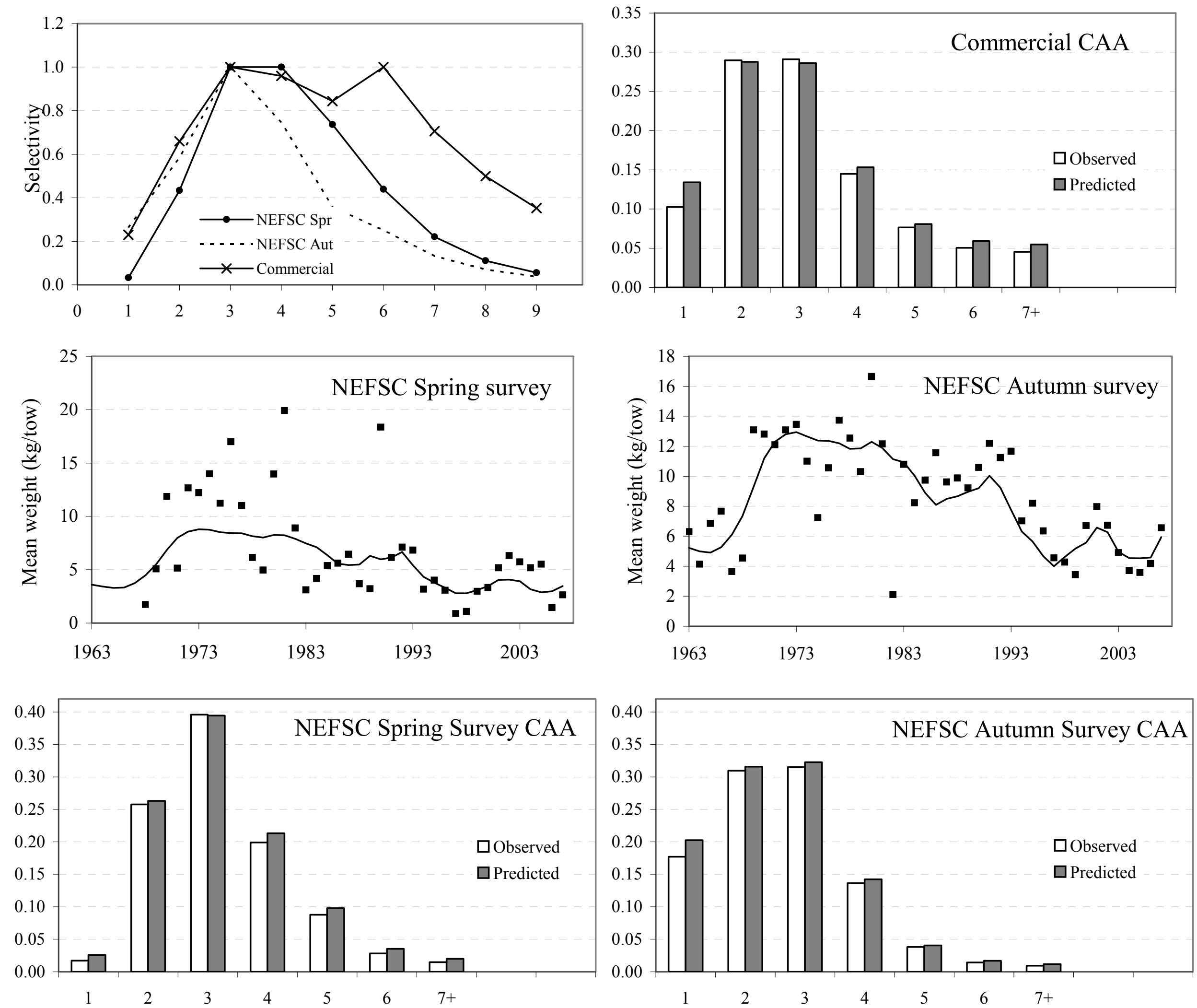


Figure L9. Estimates of selectivity-at-age and fits to the data input for ASPM run A2.

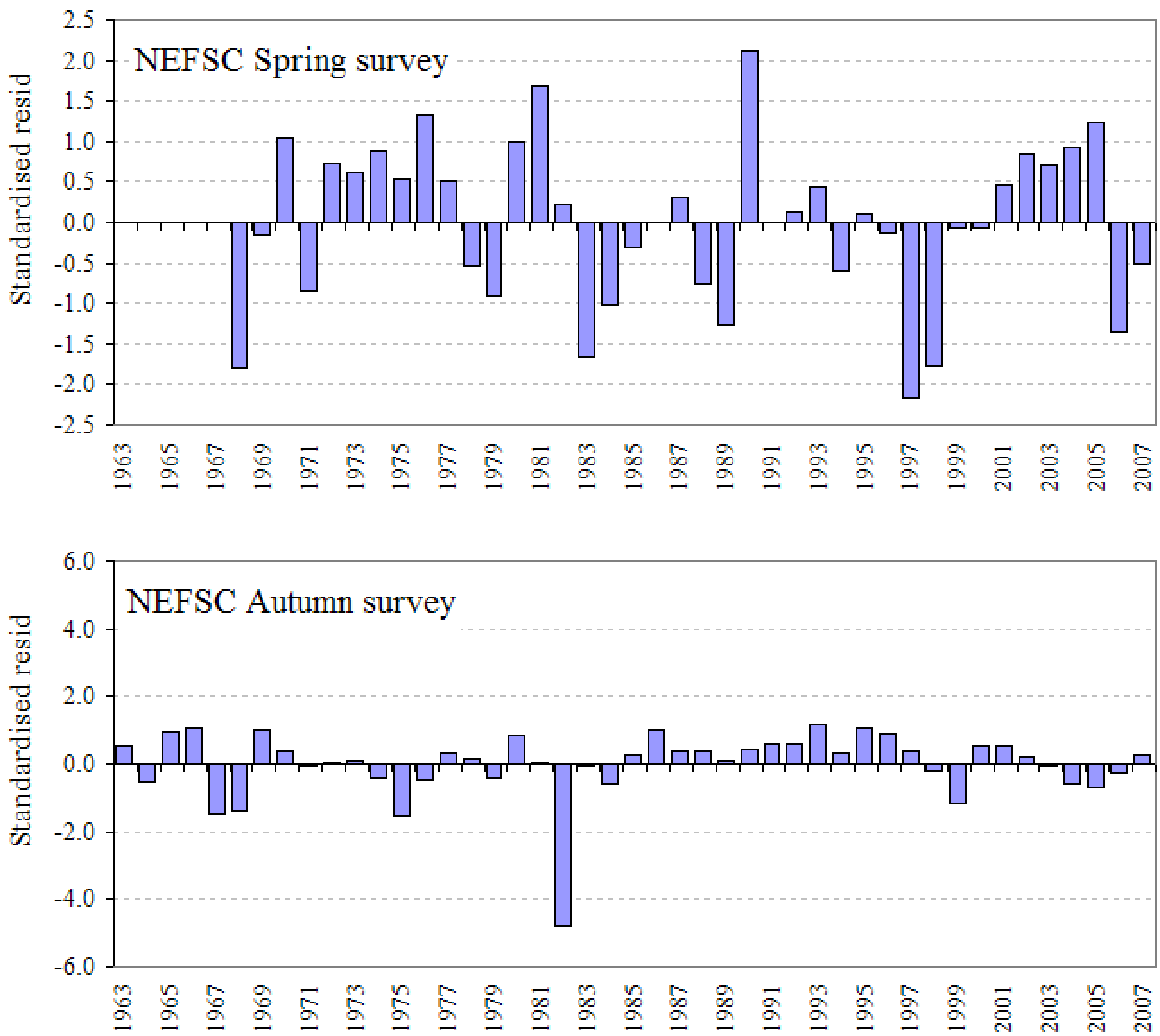


Figure L10. Standardised residuals for the fits to surveys for the ASPM run A2.

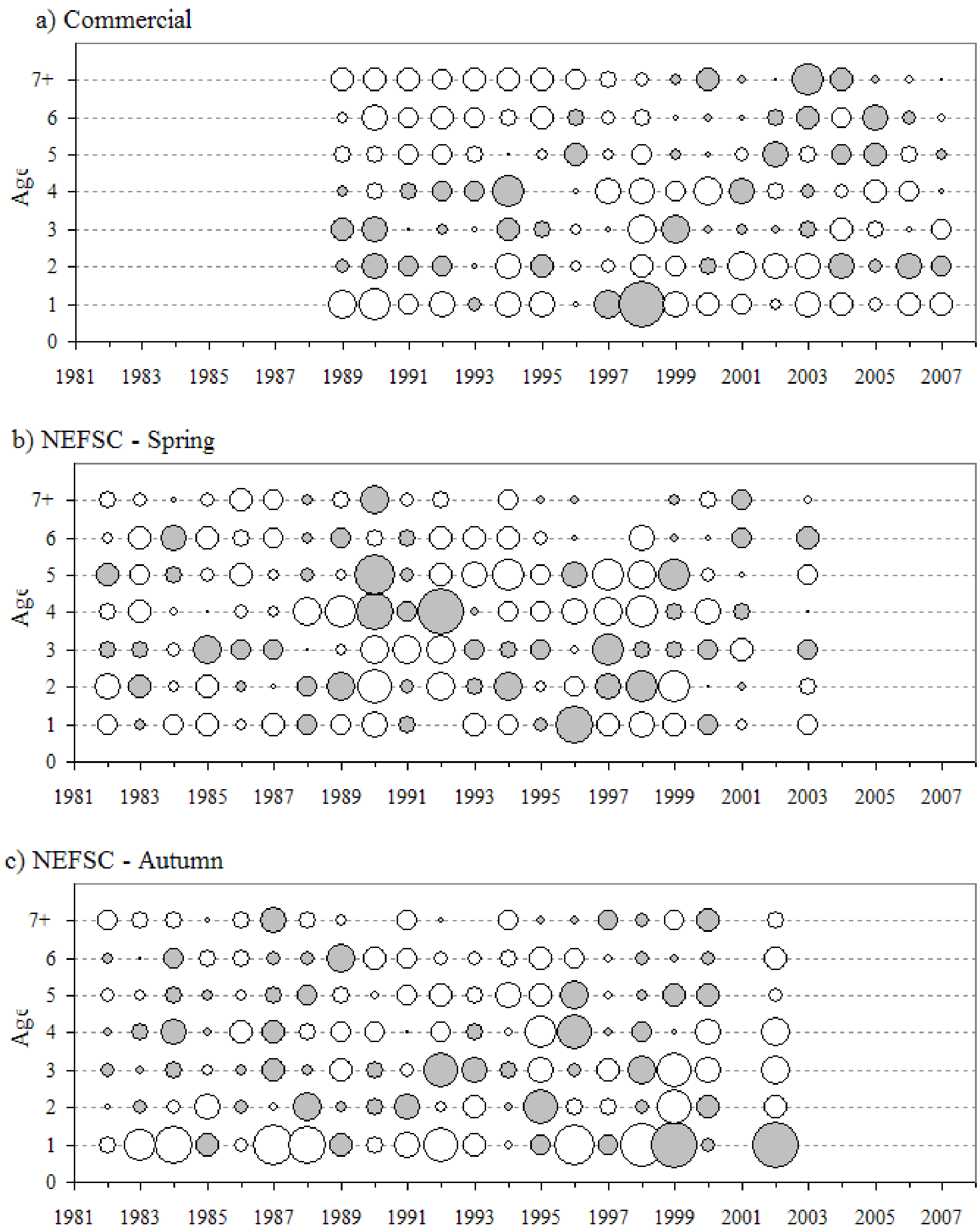


Figure L11. Bubble plots of the standardised residuals for the catch-at-age data for ASPM run A2. The size (area) of the bubbles represents the size of the residuals. Grey bubbles represent positive residuals and white bubbles represent negative residuals. Commercial catches-at-age post 2000 are based on a pooled age-length key.

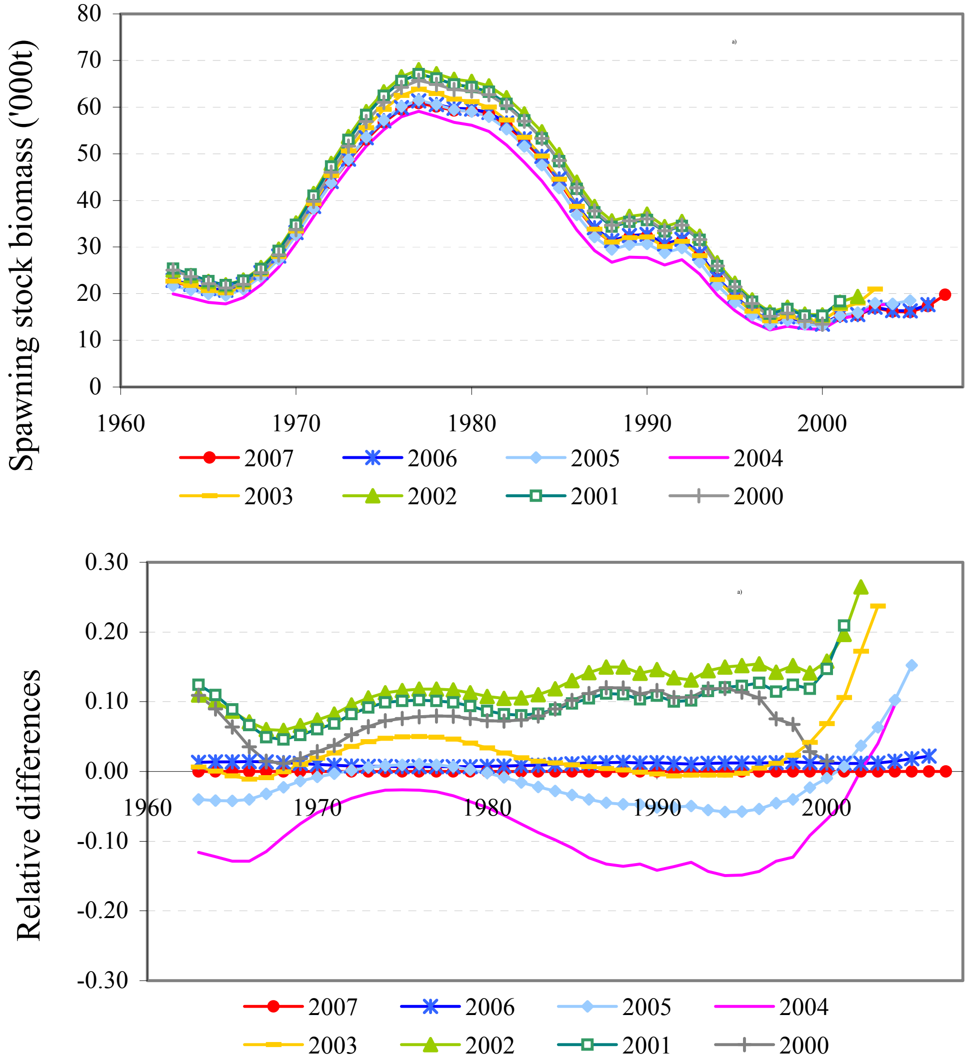


Figure L12. Retrospective plots for spawning biomass (SSB) from the ASPM run A2.

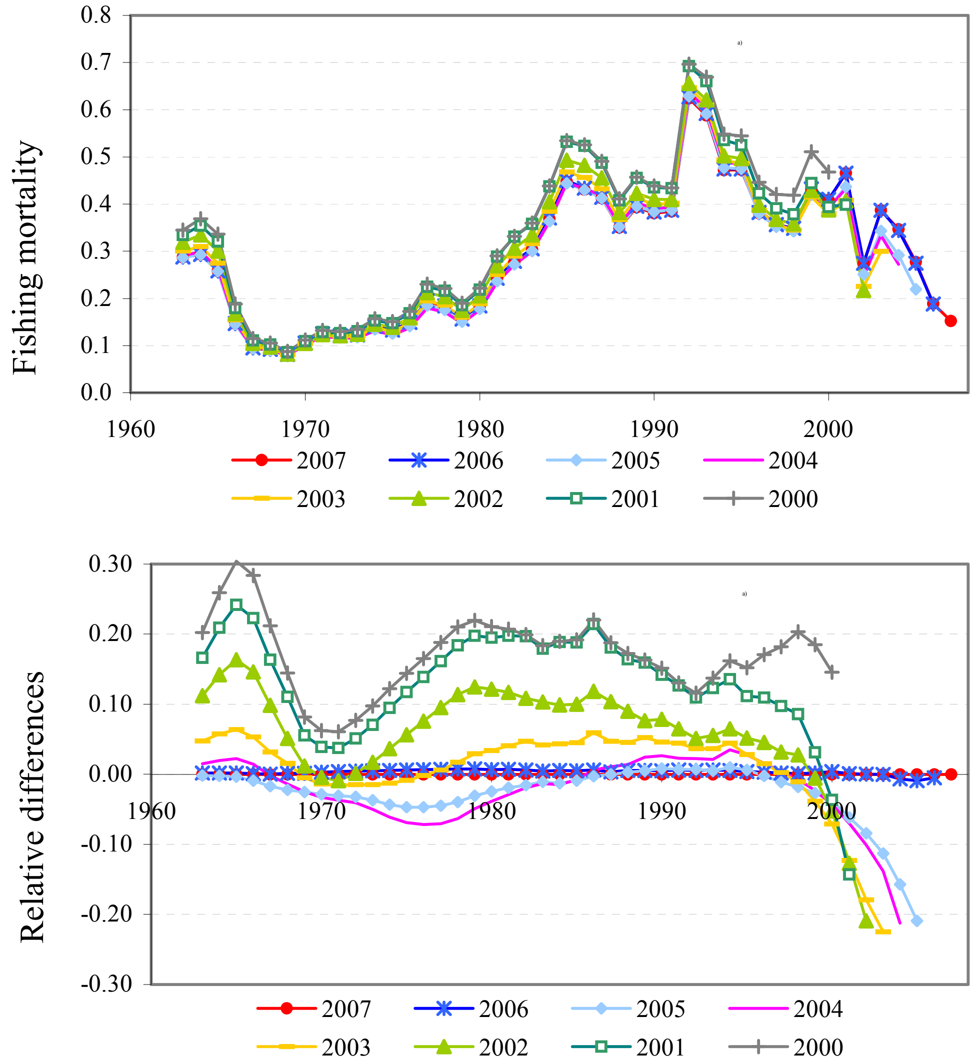


Figure L13. Retrospective plots for fully selected (age 6) fishing mortality from the ASPM run A2.

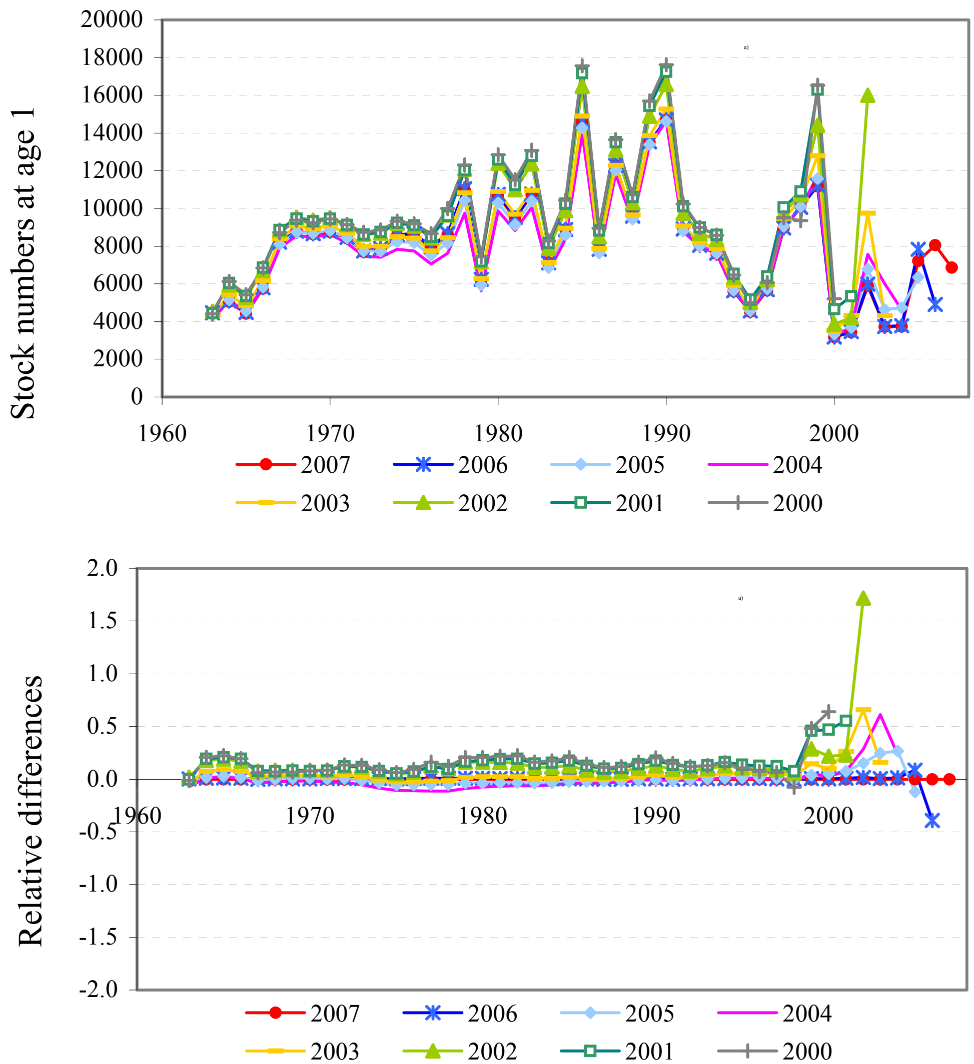


Figure L14. Retrospective plots for recruitment (numbers at age 1) from the ASPM run A2.

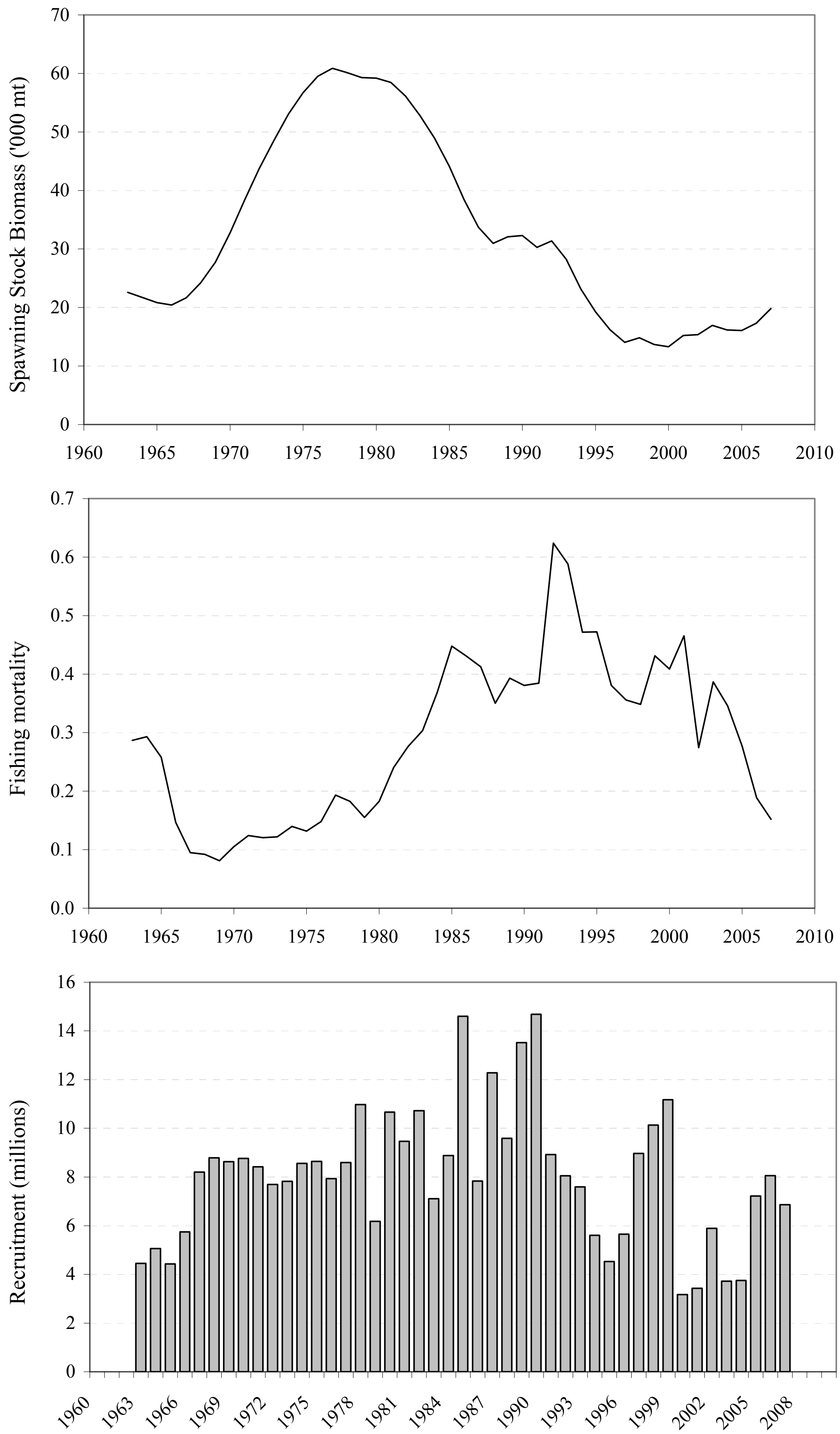


Figure L15. Results of the ASPM run A2. Top panel is spawning stock biomass, middle panel is fishing mortality (on age 6) and lower panel is recruitment.

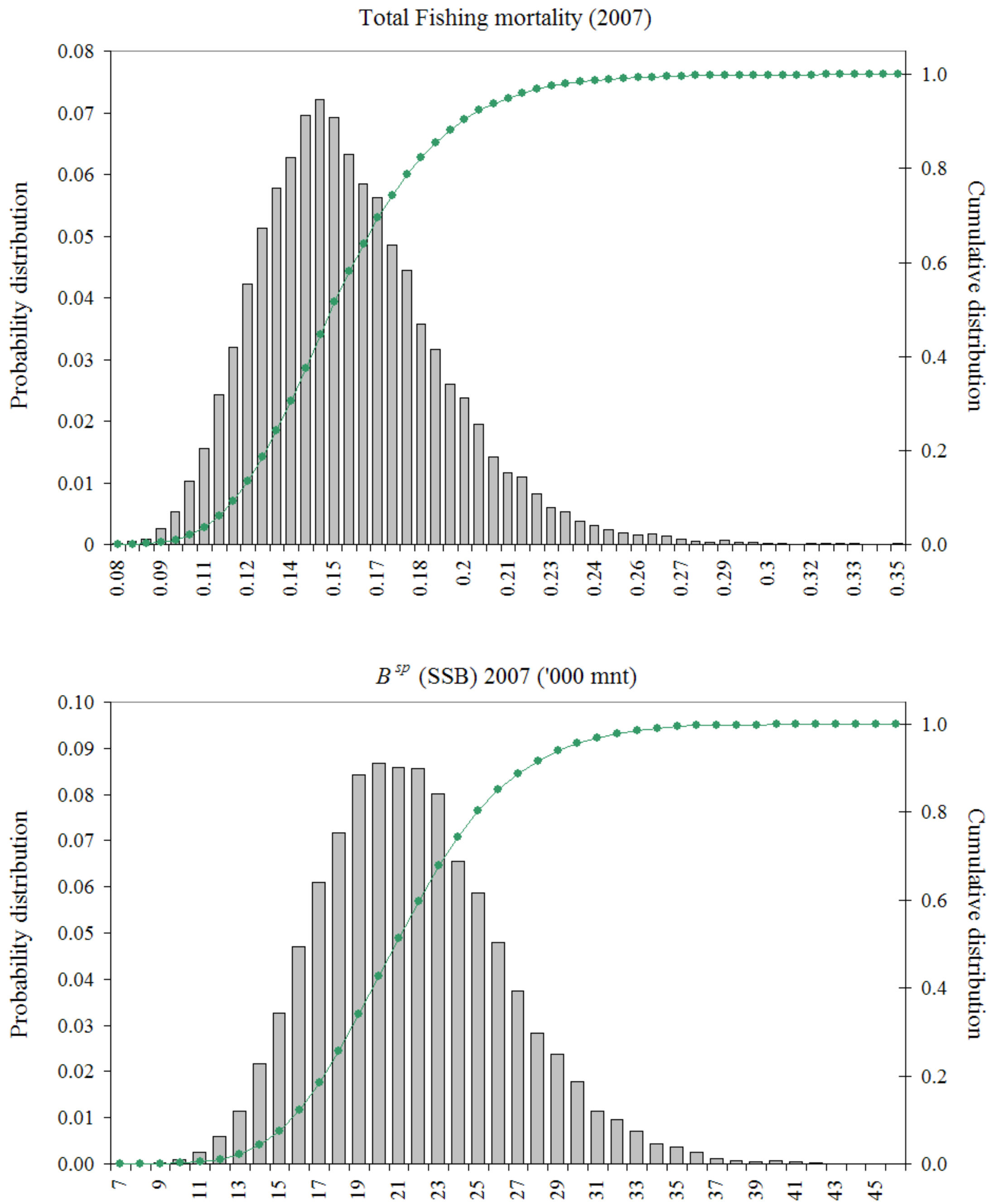


Figure L16. Uncertainty plots for fully selected fishing mortality and spawning stock biomass from the ASPM run A2 as indicated by the Bayesian posterior MCMC computations.

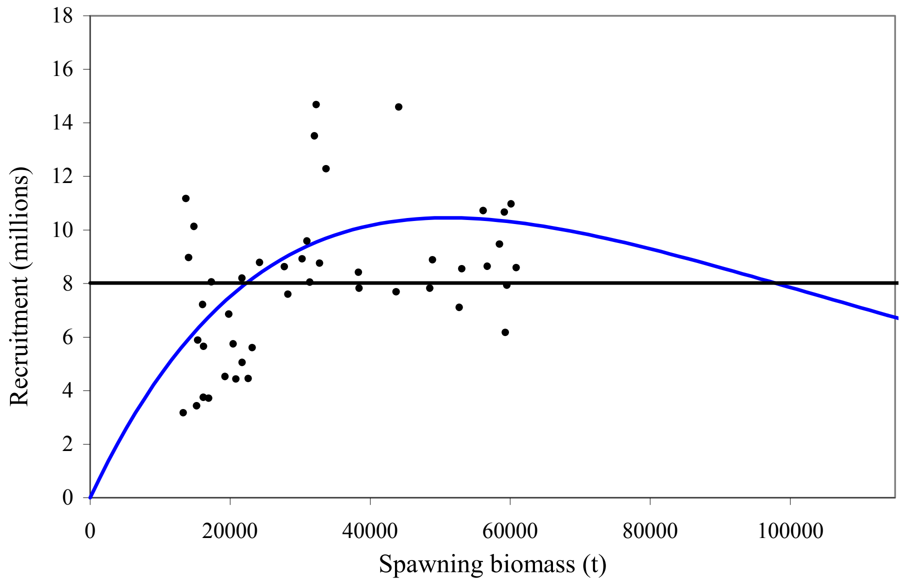


Figure L17. The estimated Ricker stock-recruitment curve and estimated recruitment and spawning biomass each year for ASPM run A2. The horizontal line represents the average recruitment over the whole period as used for the MSY proxy calculations.

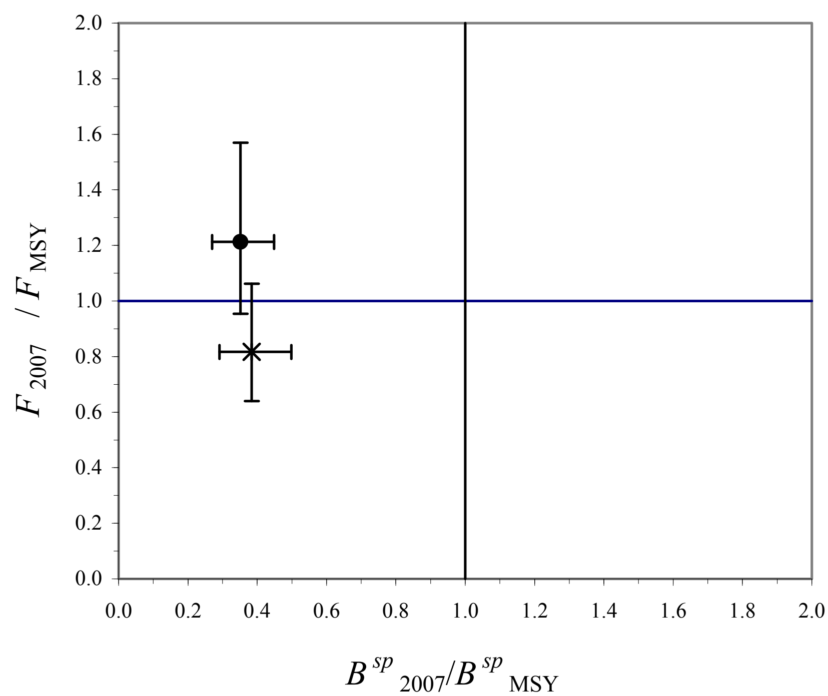


Figure L18. The current status of white hake with regard to the new biological reference points. The cross is for ASPM run A2 in terms of the estimated Ricker stock-recruitment function, while the full dot corresponds to BRPs computed for the F40% proxy and average recruitment. The point estimates are MLEs (corresponding to calculations from Bayesian posterior modes for the estimable parameters of the model) and the errors bars are 80% Bayesian posterior probability intervals.

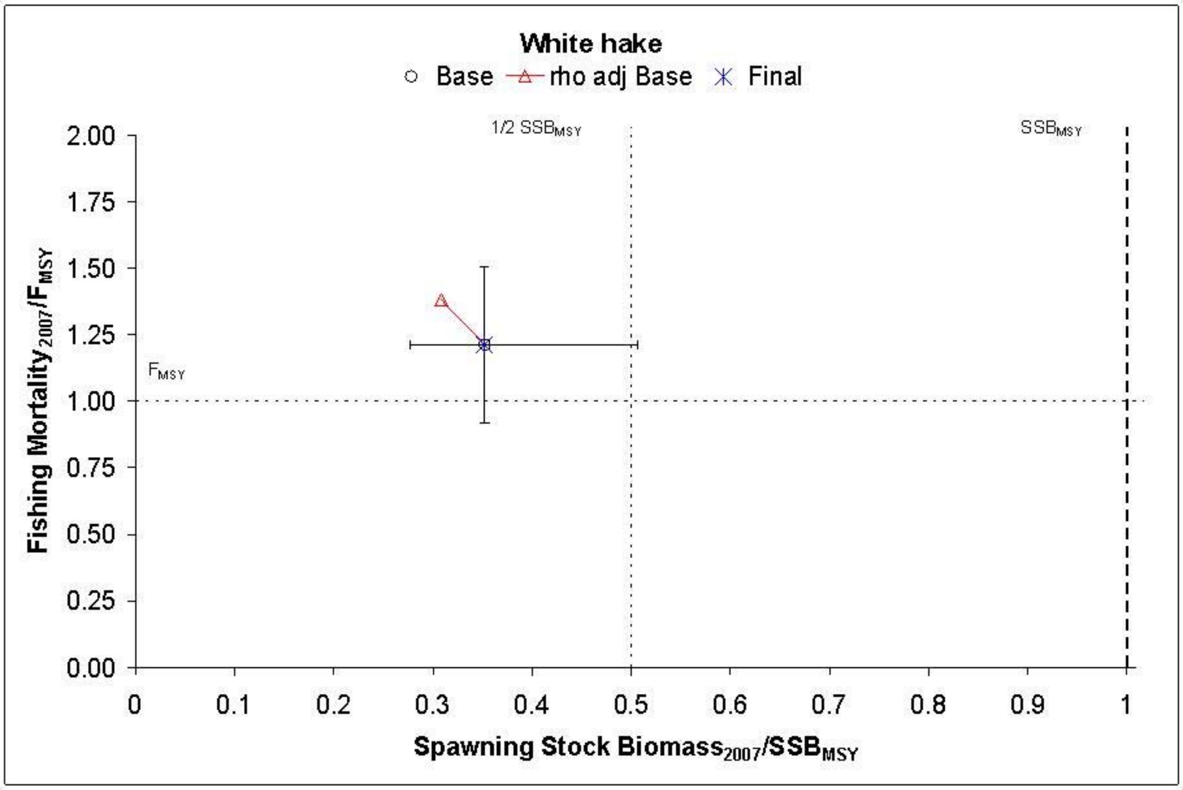


Figure L19. The current status of white hake with regard to the biological reference points as given by MLE's corresponding to F40% proxies for MSY and associated parameters.

M. Pollock in Subareas 5 and 6
by R.K. Mayo, L.Col and M. Traver

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

1.0 Background

Pollock, *Pollachius virens* (L.) have traditionally been assessed as a unit stock from the Scotian Shelf (NAFO Divisions 4VWX) to Georges Bank, the Gulf of Maine and portions of the Mid-Atlantic region (Subareas 5 and 6). This stock was last assessed over its range *via* VPA at SAW 16 in 1993 (Mayo and Figuerido 1993, NEFSC 1993a, 1993b). At that time, spawning stock biomass had been declining since the mid-1980s, and was expected to reach its long-term average (144,000 mt). Fishing mortality was estimated to be 0.72 in 1992, above F20% (0.65) and well above Fmed (0.47). The stock was then considered to be fully exploited and at a medium biomass level.

The state of this stock was first evaluated *via* index assessment in 2000 (Mayo 2001). At that time, it was noted that biomass indices for the Gulf of Maine-Georges Bank portion of the stock, derived from NEFSC autumn bottom trawl surveys, had increased during the mid-1970s, declined sharply during the 1980s, but have been generally increasing since the mid-1990s. Indices derived from Canadian bottom trawl surveys, conducted on the Scotian Shelf, increased during the 1980s, but declined sharply during the early 1990s. The index assessment provided no basis with which to evaluate the state of the stock relative to the control rule as determined by the Overfishing Definition Review Panel (Applegate et al. 1998).

In 2002, index-based biological reference points were developed for a portion of the pollock stock primarily under US management jurisdiction (Subareas 5 and 6), including a portion of eastern Georges Bank (Subdivision 5Zc) that is under Canadian management jurisdiction (NEFSC 2002). The most recent assessment of the resource inhabiting the area comprising this management unit was conducted in August, 2005 at the Second Groundfish Assessment Review Meeting (GARM II) (NEFSC 2005). At that time it was determined that the index of current biomass was greater than ½ of the B_{MSY} proxy reference point and that the index of current F was below the F_{MSY} proxy reference point (Mayo et al. 2005).

2.0 The Fishery

Since 1984, the USA fishery has been restricted to areas of the Gulf of Maine and Georges Bank west of the line delimiting the USA and Canadian fishery zones. The Canadian fishery occurs primarily on the Scotian Shelf and additional landings are obtained from Georges Bank east of the line delimiting the USA and Canadian fishery zones. This fishery on the Scotian Shelf has shifted westward over time and the contribution to the total catch from larger, mobile gear vessels has steadily diminished since 1981.

Commercial landings from the USA portion of the fishery in SA 5&6 were updated through 2007 (Table M1). Revised Canadian landings from Divs. 5Y and 5Z were also included through 2007. There was no need to apply the preferred allocation scheme reviewed at the GARMIII Data Meeting, October, 2007 as pollock are assessed as a unit stock.

The commercial fishery in Subareas 5&6 is dominated by United States vessels; additional catches are taken by Canada and, for a period primarily during the 1970s, by some distant water fleets. The total landings increased steadily from less than 10,000 mt during the 1960s to a maximum of over 26,000 mt in 1986 (Table M1). Landings declined sharply during the late 1980s and have remained below 10,000 mt throughout most of the 1990s. Landings since 1994 have fluctuated between 4,420 and 9,017 mt.

Length and age samples continue to be collected from the USA and Canadian fisheries. For this assessment of the SA5&6 portion of the stock, length and age data have not been utilized since the 1992 assessment of the entire Divs 4VWX and SA 5&6 stock (Mayo and Figuerido 1993, NEFSC 1993a, 1993b). The extent of discarding in the commercial fishery has not been investigated to date.

USA Recreational landings are available in the MRFSS database (Table M2), and have been included in one formulation of this assessment. Annual catches of pollock from the recreational fishery in Subareas 5&6, excluding those caught and released alive, have fluctuated between 52 and 819 mt. In most years the total catch remained below 400 mt.

3.0 Research Survey Indices

Indices of relative biomass (ln re-transformed), derived from NEFSC autumn research vessel bottom trawl surveys covering Georges Bank and the Gulf of Maine have varied considerably since 1963 (Table M3, Figure M2). Indices generally fluctuated between 2 and 5 kg per tow throughout most of the 1960s and 1970s, peaking at over 8 kg per tow during the mid-to-late 1970s, reflecting recruitment of several moderate-to strong year classes from the early 1970s.

Biomass indices declined rapidly during the early 1980s, and continued to decline steadily through the early 1990s, remaining below 1 kg per tow and reaching a minimum during the mid-1990s. Since then, biomass indices from the Gulf of Maine-Georges Bank region have generally increased, and have recently been fluctuating between 2.0 and 2.5 kg/tow (Table M4, Figure M2). The most recent biomass indices once again declined below 1.0 in 2006 and 2007.

4.0 Assessment

Input Data and Model Formulation

An index of relative exploitation (catch/survey biomass index) corresponding to a replacement ratio of 1.0 was developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) for the portion of the unit stock of pollock in NAFO Subareas 5&6 based on the AIM (An Index Method) model. This model was employed again for the present assessment. Autumn NEFSC survey biomass indices (stratified mean catch (kg) per tow) from the Gulf of Maine and Georges Bank region from 1963 through 2007 were used to calculate the replacement ratios, defined as the biomass index in the current year divided by the average biomass indices from the previous 5 years.

Autumn survey biomass indices and total landings were used to compute the relative exploitation rates, defined as the catch in the current year divided by the 3 year average survey biomass index for the current year and the previous and following years. These relative exploitation rates (or relative F) may be considered a proxy for F on that portion of the pollock stock considered in this analysis. The relationship between replacement ratios and relative F was evaluated by a linear regression of the Log_e replacement ratio on Log_e relative F and the results were used to derive an estimate of relative F corresponding to a replacement ratio of 1.0. This base formulation of the AIM model was accepted by the review panel as the final assessment. A complete description of the AIM model can be found in NEFSC (2002).

Assessment Results

As evident from recent trends in total landings from Subareas 5 and 6 and NEFSC autumn biomass indices calculated for the Gulf of Maine-Georges Bank region, relative Fs (landings/NEFSC autumn biomass index) peaked in the mid-1980s to mid-1990s, after which they began to steadily decline. However, relative Fs have been steadily increasing since 2002 and rose sharply in 2007 (Table M4 Figure M3). Biomass indices from the Gulf of Maine-Georges Bank region had been increasing since the late 1990s, but declined substantially in 2006 and 2007 (Figure M2).

Trends in average replacement ratios are given in Figure M4. Prior to the 1980s, a high proportion of the replacement ratios equaled or exceeded 1.0. During the 1980s and early 1990s, however, most of the replacement ratios were less than 1.0, with ratios greater than 1.0 appearing again by the late 1990s as the biomass indices began to gradually increase from the very low levels of the mid-1990s. However, in 2006 and 2007, the replacement ratios were once again substantially below 1.0.

The information displayed in Table M4 also provides a means to derive a biomass index which relates to the replacement ratios. In this case, it is evident that most of the replacement ratios below 1.0 occurred during the 1980s and early 1990s when all of the biomass indices were below 2.0 kg/tow (Table M4). During this period the relative Fs were also well above the relative replacement F (Figure M3). This biomass index may be considered as the biomass proxy for B_{MSY} that corresponds to the relative F proxy for F_{MSY}. This represents a change in the present assessment compared to the value (3.0 kg/tow) derived in 2002 (NEFSC 2002) and was accepted by the Biological Reference Point Review Panel. This base model formulation was accepted by the GARM III Panel as the final formulation (see Figure M8).

5.0 Biological Reference Points

A regression of Log_e replacement ratios on Log_e relative F was significant (p=0.03, Table M5). The replacement relative F based on this regression equals 5.66 (Table M5, Figure M5). This can be taken as a proxy for F_{MSY}.

The biological reference points first developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) are:

B_{MSY} 3.00 kg/tow
F_{MSY} 5.88 (Relative F)
MSY 17,640 mt

Since the relative F relates the catch directly to survey biomass, the catch corresponding to the B_{MSY} proxy can be estimated by multiplying the relative F and the biomass index of B_{MSY}. The following biological reference point proxies were obtained from the index-based AIM model that included commercial and recreational landings.

B_{MSY} 2.0 kg/tow
F_{MSY} 5.66 (Relative F)
MSY 11,320 mt

The proxy B_{MSY} and F_{MSY} reference points are given in Table M6 along with corresponding estimates of current (2007) biomass and F proxies.

Diagnostics and Uncertainty

Precision of the estimate of replacement Relative F was derived from the distribution of 1000 bootstrap iterations of the regression of replacement ratio on relative F (Figure M6). The bootstrap analysis provides a 90% CI about the replacement relative F estimate (5.66) of 3.87 – 7.44. The bootstrap mean (5.66) matched the point estimate (Table M5) indicating negligible bias. The range of the 95% confidence limits about the 2007 autumn survey biomass index (0.754 kg/tow) are: 0.552 – 0.982.

Residual patterns from the regression of replacement ratio on relative F appear for the most part random, although there are some instances of 3-4 year blocks of positive and negative residuals (Figure M7). A randomization test indicates that the regression was significant ($p = 0.03$) (Table M5).

6.0 Projections

The AIM software was also used to conduct short-term projections of 2009 catches under 3 scenarios of relative F in 2009 ($F_{STATUS\ QUO}$, F_{MSY} and $F_{REBUILD}$).

$F_{REBUILD}$

Although pollock are not in a rebuilding plan based on the results of the GARMII assessment, the 2007 status shows that biomass is currently below ½ B_{MSY}. A 10 year projection was run to obtain an estimate of the relative F required to rebuild biomass to B_{MSY} by 2018. The relative $F_{REBUILD}$ determined from this projection is 5.31, slightly below the estimate of the F_{MSY} proxy relative F (5.66). These projections should be considered as an example for illustration purposes.

2009 Catch Estimates

Annual catches were estimated for 2009 under the 3 scenarios of 2009 relative F as described above. Results are as follows: $F_{STATUS\ QUO}$: 8,133 mt, F_{MSY}: 8,015 mt, $F_{REBUILD}$: 8,003 mt. If relative F is not reduced in 2009, the population biomass index will remain below ½ B_{MSY} in 2009 and will likely decline further in subsequent years. Further details are given in Table M7.

7.0 Summary

Stock Status

The NEFSC autumn survey biomass had been increasing towards the current 2.0 kg/tow B_{MSY} proxy since the mid-1990s. However, the biomass index declined substantially in 2006 and 2007 to 0.959 and 0.754 kg/tow, respectively and is presently below ½ B_{MSY}. Between 1999 and 2006, the relative F remained below the relative F_{MSY} proxy, but the 2007 average value (10.975) increased to more than twice the relative F_{MSY} proxy. Replacement ratios remained close to or above 1.0 between 1996 and 2005, but then declined to less than 0.5 in 2006 and 2007. The biological reference points, based on the AIM model approach, including commercial and recreational landings, are: F_{MSY} proxy (relative F) = 5.66, B_{MSY} proxy = 2.0 kg/tow and MSY = 11,320 mt.

Based on these results, the stock is overfished and overfishing is occurring.

Sources of Uncertainty

The AIM model provides an objective means of estimating an F_{MSY} proxy value. Assessment of current stock status is essentially deterministic and relies on a subjective determination of either B_{MSY} or MSY external to the AIM model. This approach does not afford a means of quantifying uncertainty in the estimates of current biomass or exploitation rate within the model framework. Therefore, the status determination plot (Figure M8) is presented without error bars. The Assessment Review Panel recommended that this be explored in the future.

Differences From Previous Assessment

The present assessment includes recreational landings beginning in 1981 in addition to commercial landings. The current basis for the B_{MSY} proxy is the period during the 1980s and 1990s when the biomass indices were below 2.0 kg/tow instead of 3.0 kg/tow in the previous assessment.

8.0 Panel Discussion/Comments

Conclusions

The Panel considered the AIM – based assessment sufficient as a basis for management advice. The relationship between Replacement Ratio and Relative Fishing Mortality is likely informative. Some improvements were suggested including use of a linear rather than a logarithmic relationship in the AIM analysis.

The Panel noted the high uncertainty of the determination of stock status, implying that the estimate of F rebuild is also uncertain. It noted that the transboundary nature of the resource likely confounds interpretation of the survey and catch trends.

As with the other stocks for which stock status is based upon the examination of relative trends in abundance, the Panel recommended that the BRPs and associated indicators of stock status be expressed in their original units (survey kg/tow) as opposed to being converted to swept area biomass. This helps avoid confusion with BRPs and indicators which are expressed in terms of biomass and not proxies.

Research Recommendations

The Panel encouraged the NEFSC to consider the use of state space and other like modeling approaches in this and other relative index based assessed stocks. These models allow comprehensive incorporation of estimates of process and observation uncertainty into the assessment formulations which is lacking from the current approach. This is similar to a recommendation made during the GARM III 'models' review. It suggested that the Replacement Ratio – Relative Fishing Mortality relationship be used to provide estimates of uncertainty in stock status.

9.0 References

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NEFSC 1993b. Report of the 16th Northeast Regional Stock Assessment Workshop (16th SAW). The Plenary. NEFSC Ref Doc. 93-19; 57p.

NEFSC 2002. Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NEFSC Ref Doc. 02-04; 254 p.

NEFSC 2005. Assessment of 19 Northeast Groundfish Stocks Through 2004. 2005 Groundfish Assessment Review Meeting (2005 GARM), NEFSC. Woods Hole, Massachusetts. 2005 August 15-19. Mayo RK, Terceiro M. eds. NEFSC Ref Doc 05-13; 499 p

Table M1. Commercial landings (mt) of pollock from SA5&6 by USA, Canadian and DWF fleets and NEFSC autumn bottom trawl survey biomass indices (kg/tow).

Year	Autumn Biom Index	Total 5&6 Landings(mt)	000s mt	USA 5&6 Landings	Other 5&6 Landings	USA 5&6 Percent
1960		10397	10.397	8186	2211	78.7
1961		8219	8.219	7861	358	95.6
1962		6151	6.151	5550	601	90.2
1963	4.939	6241	6.241	4673	1568	74.9
1964	2.716	9008	9.008	4768	4240	52.9
1965	2.362	9000	9.000	4916	4084	54.6
1966	1.795	9847	9.847	3171	6676	32.2
1967	1.310	8534	8.534	2784	5750	32.6
1968	2.654	5222	5.222	2981	2241	57.1
1969	3.424	9822	9.822	3507	6315	35.7
1970	1.699	11976	11.976	3592	8384	30.0
1971	2.189	15203	15.203	4732	10471	31.1
1972	3.279	13013	13.013	5243	7770	40.3
1973	4.037	13076	13.076	5731	7345	43.8
1974	1.542	12393	12.393	8050	4343	65.0
1975	1.494	13871	13.871	8577	5294	61.8
1976	8.567	13382	13.382	10244	3138	76.6
1977	5.628	16273	16.273	12729	3544	78.2
1978	3.862	22305	22.305	17545	4760	78.7
1979	4.074	18452	18.452	15420	3032	83.6
1980	2.647	23539	23.539	17905	5634	76.1
1981	1.083	22068	22.068	18018	4050	81.6
1982	1.364	19466	19.466	14092	5374	72.4
1983	1.274	17816	17.816	13433	4383	75.4
1984	0.564	20633	20.633	17343	3290	84.1
1985	1.742	21069	21.069	19305	1764	91.6
1986	1.089	26507	26.507	24316	2191	91.7
1987	1.223	23467	23.467	20251	3216	86.3
1988	1.787	17648	17.648	14900	2748	84.4
1989	0.619	12434	12.434	10518	1916	84.6
1990	0.994	11518	11.518	9432	2086	81.9
1991	0.649	10053	10.053	7882	2171	78.4
1992	0.910	10671	10.671	7192	3479	67.4
1993	0.505	10238	10.238	5676	4562	55.4
1994	0.328	7332	7.332	3769	3563	51.4
1995	0.504	4611	4.611	3358	1253	72.8
1996	0.654	4420	4.420	2963	1457	67.0
1997	1.003	5794	5.794	4252	1542	73.4
1998	0.772	7865	7.865	5583	2282	71.0
1999	1.532	5726	5.726	4595	1131	80.2
2000	0.844	5376	5.376	4043	1333	75.2
2001	2.448	5784	5.784	4111	1673	71.1
2002	1.855	5354	5.354	3580	1774	66.9
2003	2.197	6735	6.735	4794	1941	71.2
2004	1.925	7254	7.254	5070	2184	69.9
2005	2.533	8358	8.358	6510	1848	77.9
2006	0.959	7043	7.043	6067	976	86.1
2007	0.754	9017	9.017	8370	647	92.8

Table M2. Recreational catch of pollock from SA5&6.

	Total Catch of Pollock (Including Released Alive)			Retained Catch of Pollock (Excluding Released Alive)				
Year	Numbers (000s)	SE	Weight (mt)	Numbers (000s)	SE	Weight (mt)	SE	AB1 Avg Wgt (kg)
1981	2226.624	12.2	1158.963	1444.987	13.3	752.119	13.5	0.520502
1982	1539.039	16.9	1573.219	800.907	15	818.694	15.5	1.022209
1983	971.096	18.4	1313.407	429.476	20	580.866	20	1.352499
1984	508.016	22.2	179.5818	324.49	32.1	114.706	32.1	0.353496
1985	1491.151	35.2	317.1506	1217.767	42.5	259.005	42.8	0.212688
1986	522.937	20.2	177.1421	421.769	24	142.872	24.6	0.338745
1987	670.942	22.5	302.8073	255.847	19.8	115.468	20.3	0.451317
1988	1266.767	47.5	572.7964	369.793	19.2	167.21	19.9	0.452172
1989	602.586	18.1	495.5234	315.064	17.1	259.086	16.1	0.822328
1990	352.358	19	270.9374	201.94	30.9	155.277	31.6	0.768926
1991	440.764	35.9	389.2567	113.179	17.6	99.953	18.8	0.883141
1992	167.569	15.3	96.78733	85.738	21.2	49.522	22.7	0.577597
1993	396.704	15.3	109.7715	187.381	19.1	51.85	20.2	0.276709
1994	861.982	20.2	455.0012	479.202	29.2	252.949	29.5	0.527855
1995	806.888	28.4	760.9678	261.394	31.8	246.518	32	0.94309
1996	464.625	18.2	562.4352	280.171	25.3	339.151	25.6	1.210514
1997	284.892	17	368.364	151.825	28.9	196.309	29	1.292995
1998	452.361	10.3	314.1495	184.906	17.7	128.411	17.8	0.694466
1999	562.123	13.5	230.3734	217.516	26.4	89.144	26.4	0.409827
2000	1075.624	9.7	976.4788	436.617	15.9	396.372	15.9	0.907825
2001	1058.024	7.6	1920.753	355.713	11.6	645.767	11.6	1.815416
2002	496.294	14.4	791.9331	239.175	15.8	381.65	15.8	1.595694
2003	356.07	15.2	210.058	158.465	17.2	93.484	17.2	0.589935
2004	307.629	13.7	354.2347	223.697	16.8	257.587	16.8	1.1515
2005	254.132	12.5	533.5437	156.804	13.8	329.206	13.8	2.099475
2006	278.236	15	551.5738	175.068	20.8	347.054	20.9	1.982395
2007	239.035	15.3	568.3184	161.172	20.8	383.195	18	2.377553

Table M3. Stratified mean catch per tow in weight (kg) and numbers for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in NEFSC offshore spring and autumn bottom trawl surveys[1], 1963-2007[3]. Indices for the total stock and the mature component are listed.

	NEFSC Spring Survey[2]								NEFSC Autumn Survey							
	Total Biomass		Mature Biomass		Total Numbers		Mature Numbers		Total Biomass		Mature Biomass		Total Numbers		Mature Numbers	
	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans
1963	-	-	-	-	-	-	-	-	5.502	4.939	5.164	4.636	1.401	1.289	1.113	1.024
1964	-	-	-	-	-	-	-	-	4.755	2.716	4.092	2.337	1.770	1.136	0.975	0.626
1965	-	-	-	-	-	-	-	-	2.977	2.362	2.657	2.108	0.903	0.847	0.555	0.521
1966	-	-	-	-	-	-	-	-	2.567	1.795	2.003	1.401	1.060	0.637	0.488	0.293
1967	-	-	-	-	-	-	-	-	1.973	1.310	1.809	1.201	0.560	0.478	0.391	0.334
1968	4.537	2.876	4.292	2.721	1.121	0.932	0.677	0.563	3.494	2.654	3.343	2.539	0.758	0.696	0.569	0.522
1969	2.723	2.584	2.404	2.281	1.157	1.014	0.519	0.455	7.208	3.424	6.994	3.322	1.395	0.884	1.248	0.791
1970	5.295	3.920	4.928	3.648	1.659	1.449	0.994	0.868	2.251	1.699	2.082	1.571	0.609	0.588	0.377	0.364
1971	3.474	2.831	3.266	2.661	0.973	0.897	0.593	0.547	4.365	2.189	3.833	1.922	1.201	0.778	0.612	0.396
1972	5.003	3.618	4.051	2.930	3.871	2.140	0.867	0.479	4.589	3.279	4.079	2.915	1.448	1.174	0.733	0.594
1973	4.927	3.835	3.508	2.731	4.329	1.710	1.018	0.402	4.683	4.037	4.382	3.778	1.267	1.106	0.865	0.755
1974	3.951	4.157	3.553	3.738	1.344	1.176	0.755	0.661	3.332	1.542	2.912	1.348	0.953	0.576	0.654	0.395
1975	5.919	5.580	5.409	5.099	1.621	1.298	1.014	0.812	2.087	1.494	1.905	1.364	0.718	0.493	0.381	0.262
1976	7.204	7.490	6.798	7.068	1.612	1.483	1.227	1.129	18.261	8.567	17.406	8.166	4.038	1.895	3.674	1.724
1977	3.591	3.295	3.205	2.941	1.717	1.318	0.882	0.677	9.376	5.628	8.789	5.276	2.272	1.303	1.739	0.997
1978	5.130	3.107	4.272	2.587	1.898	0.835	1.091	0.480	6.275	3.862	6.033	3.713	1.064	0.723	0.790	0.537
1979	4.585	3.750	4.348	3.556	1.036	0.939	0.785	0.712	4.770	4.074	4.504	3.847	0.865	0.719	0.718	0.597
1980	4.191	3.531	3.711	3.127	1.451	1.069	0.987	0.727	3.298	2.647	3.202	2.570	0.580	0.544	0.470	0.441
1981	5.749	5.391	5.415	5.078	1.395	1.221	0.989	0.866	2.683	1.083	2.178	0.879	1.033	0.341	0.672	0.222
1982	6.372	3.349	5.839	3.069	3.755	1.767	2.076	0.977	2.118	1.364	1.966	1.266	0.759	0.574	0.493	0.373
1983	1.592	1.018	1.533	0.980	0.897	0.662	0.251	0.185	2.989	1.274	2.834	1.208	0.976	0.579	0.479	0.284
1984	3.119	2.298	3.002	2.212	1.084	0.914	0.688	0.580	0.909	0.564	0.778	0.483	0.421	0.367	0.188	0.164
1985	29.132	8.446	26.404	7.655	14.587	2.725	12.014	2.244	2.114	1.742	1.875	1.545	1.080	0.708	0.454	0.298
1986	8.256	4.283	8.123	4.214	1.973	1.333	1.686	1.139	1.707	1.089	1.466	0.935	0.898	0.571	0.528	0.336
1987	2.778	1.870	2.510	1.690	1.616	0.738	0.599	0.274	2.035	1.223	1.924	1.156	0.597	0.506	0.383	0.325
1988	2.015	1.384	1.950	1.339	0.907	0.758	0.339	0.283	13.021	1.787	12.088	1.659	3.754	0.869	3.131	0.725
1989	5.216	2.156	5.041	2.084	1.998	1.024	1.577	0.808	1.223	0.619	0.723	0.366	1.883	0.771	0.461	0.189
1990	1.821	1.165	1.675	1.072	0.760	0.560	0.442	0.326	2.079	0.994	1.888	0.903	0.823	0.586	0.502	0.357
1991	5.051	2.797	4.738	2.624	2.303	1.399	1.762	1.070	1.055	0.649	0.851	0.524	0.728	0.535	0.409	0.301
1992	3.349	2.166	3.139	2.030	1.787	1.242	0.755	0.525	1.697	0.910	1.507	0.808	1.051	0.643	0.520	0.318
1993	1.602	1.248	1.358	1.058	1.648	1.163	0.534	0.377	0.769	0.505	0.570	0.374	1.043	0.567	0.195	0.106
1994	1.065	0.840	0.972	0.767	0.562	0.504	0.380	0.341	0.603	0.328	0.500	0.272	0.422	0.311	0.270	0.199
1995	3.716	1.307	2.659	0.935	3.432	0.820	1.984	0.474	1.017	0.504	0.787	0.390	0.840	0.465	0.516	0.286
1996	1.080	0.758	1.023	0.718	0.650	0.510	0.342	0.268	1.060	0.654	0.862	0.532	1.009	0.666	0.435	0.287
1997	4.573	2.060	3.866	1.742	3.369	1.802	1.693	0.906	1.512	1.003	1.095	0.726	1.766	0.921	0.611	0.319
1998	2.643	1.564	2.139	1.266	2.609	1.506	0.900	0.520	1.308	0.772	0.860	0.508	2.104	0.748	0.539	0.192
1999	1.069	0.862	0.745	0.601	2.165	1.022	0.419	0.198	3.099	1.532	2.595	1.283	2.414	1.394	1.161	0.670
2000	1.369	0.997	1.222	0.890	1.502	0.973	0.434	0.281	1.441	0.844	0.522	0.306	2.770	1.333	0.583	0.278
2001	2.029	1.275	1.854	1.165	1.693	1.272	0.728	0.547	3.567	2.448	3.067	2.105	2.385	1.811	1.361	1.033
2002	1.578	1.247	1.475	1.166	0.760	0.630	0.482	0.400	5.920	1.855	5.420	1.698	3.135	1.460	2.305	1.073
2003	0.890	0.667	0.731	0.548	1.439	0.734	0.242	0.123	7.951	2.197	6.348	1.754	7.363	2.043	4.790	1.329
2004	0.744	0.585	0.703	0.553	0.487	0.380	0.180	0.140	4.206	1.925	3.440	1.574	3.221	1.395	2.122	0.919
2005	5.620	2.377	5.459	2.305	2.016	1.235	1.588	0.973	7.415	2.533	6.507	2.223	4.769	1.636	2.700	0.926
2006	2.589	1.493	2.534	1.467	0.972	0.758	0.766	0.597	1.856	0.959	1.578	0.815	1.591	0.568	0.574	0.205
2007	4.671	2.655	4.466	2.538	1.988	1.423	1.425	0.805	1.394	0.754	1.314	0.711	0.607	0.438	0.404	0.292

[1] NEFSC Strata 01130-01300, 01330-01340, 01360-01400.

[2] The "36 Yankee" trawl was used from 1970-1972, and 1982-2002; the "41 Yankee" trawl was used from 1973-1981.
No gear conversion factors are available to adjust for differences in fishing power.

[3] BMV oval doors were used from 1970-1984; since 1985 Portuguese polyvalent doors have been used. No door conversion factors were applied. Surveys performed using *R/V Albatross IV* and *R/V Delaware II*; No vessel conversion factors were applied.

Table M4. Assessment measures used to evaluate the SA 5&6 component of the pollock stock Landings include recreational harvest.

Year Factor	Autumn Kg/tow	Landings (mt)	Relative F	Replacement Ratio
1963	4.939	6241	1.631	
1964	2.716	9008	2.698	
1965	2.362	9000	3.928	
1966	1.795	9847	5.404	
1967	1.31	8534	4.446	
1968	2.654	5222	2.120	1.011
1969	3.424	9822	3.789	1.580
1970	1.699	11976	4.914	0.736
1971	2.189	15203	6.364	1.006
1972	3.279	13013	4.107	1.454
1973	4.037	13076	4.429	1.524
1974	1.542	12393	5.256	0.527
1975	1.494	13871	3.586	0.586
1976	8.567	13382	2.559	3.416
1977	5.628	16273	2.704	1.487
1978	3.862	22305	4.933	0.908
1979	4.074	18452	5.231	0.966
1980	2.647	23539	9.049	0.560
1981	1.083	22820	13.439	0.219
1982	1.364	20285	16.354	0.394
1983	1.274	18397	17.236	0.489
1984	0.564	20748	17.387	0.270
1985	1.742	21328	18.847	1.256
1986	1.089	26650	19.721	0.903
1987	1.223	23583	17.260	1.014
1988	1.787	17815	14.727	1.516
1989	0.619	12693	11.200	0.483
1990	0.994	11674	15.483	0.769
1991	0.649	10153	11.931	0.568
1992	0.91	10721	15.583	0.863
1993	0.505	10290	17.711	0.509
1994	0.328	7585	17.019	0.446
1995	0.504	4858	9.808	0.744
1996	0.654	4759	6.607	1.129
1997	1.003	5991	7.399	1.729
1998	0.772	7994	7.252	1.289
1999	1.532	5815	5.542	2.349
2000	0.844	5772	3.590	0.945
2001	2.448	6430	3.748	2.547
2002	1.855	5735	2.647	1.406
2003	2.197	6829	3.427	1.474
2004	1.925	7512	3.386	1.084
2005	2.533	8687	4.811	1.366
2006	0.959	7390	5.221	0.438
2007	0.754	9400	10.975	0.398

Table M5. AIM model estimates of the F_{MSY} proxy and the probability value for the randomization test for Pollock in Subareas 5 and 6.

	Point Estimate (90 % CI)	Bootstrap Mean
F_{MSY} proxy	5.66 (3.87 – 7.44)	5.66
Randomization test p value	0.03	

Table M6. Biological reference point estimates and 2007 stock status for Pollock in Subareas 5 and 6.

2007 Relative F	F_{MSY} proxy
10.97	5.66
2007 Biomass Index	B_{MSY} Proxy
0.754 kg/tow	2.0 kg/tow

Table M7. Projections of catch and minimum population biomass in 2009 under 3 relative F scenarios in 2009.

2008			2009	
Catch (mt)	Population Biomass Index (kg/tow)	Relative F (2009)	Catch (mt)	Population Biomass Index (kg/tow)
11,240	1.02	Fsq (10.975)	8,133	0.74
8,013	1.42	F_{MSY} (5.66)	8,015	1.42
7,756	1.46	$F_{REBUILD}$ (5.31)	8,003	1.51

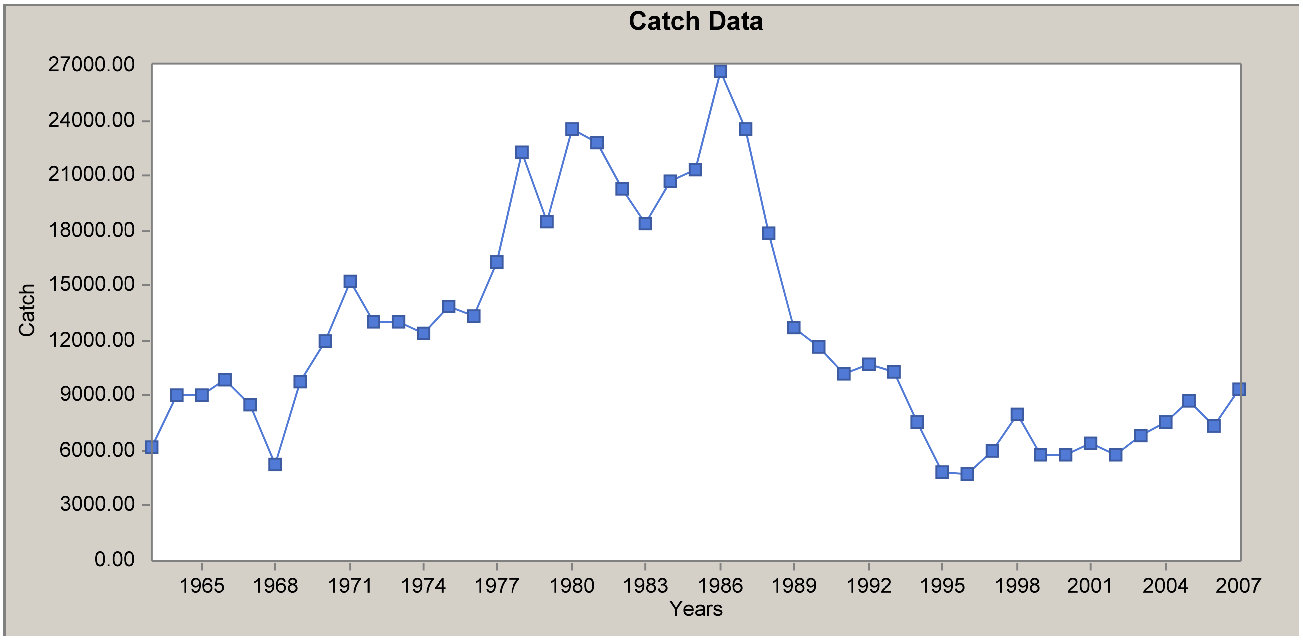

Figure M1. Total commercial and recreational landings (mt) of pollock from SA 5&6.

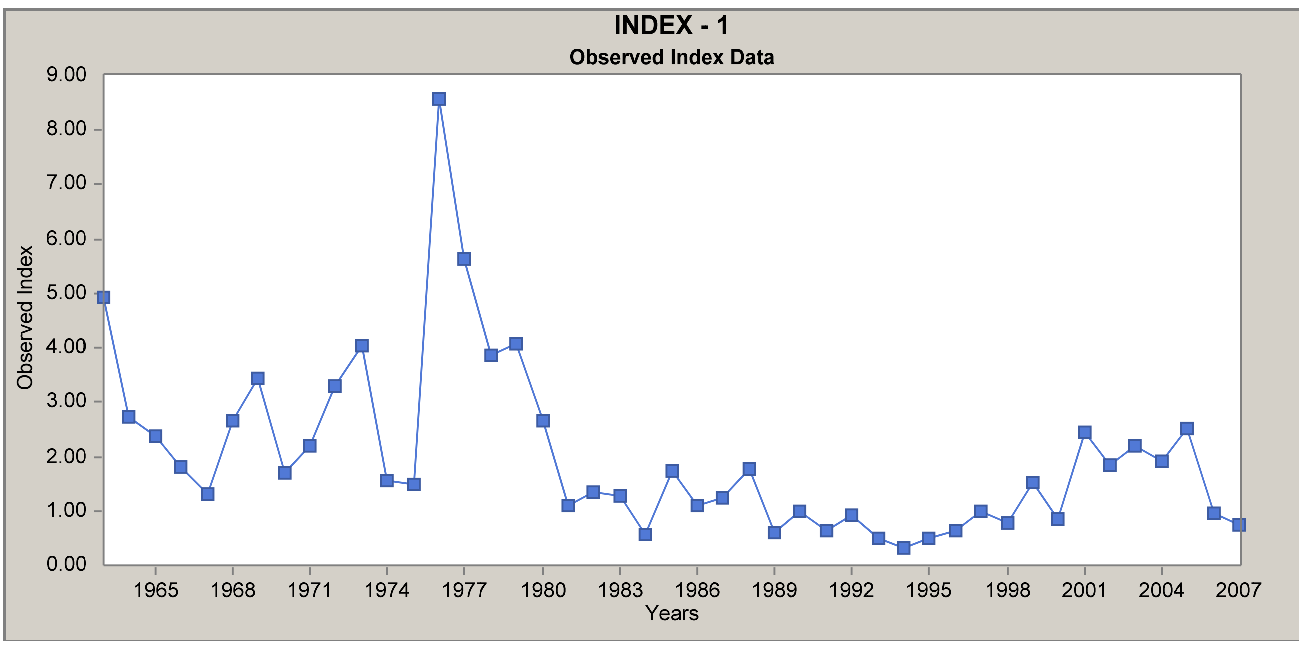

Figure M2. Population biomass index (kg/tow) for pollock in SA 5&6 from the NEFSC autumn bottom trawl surveys.

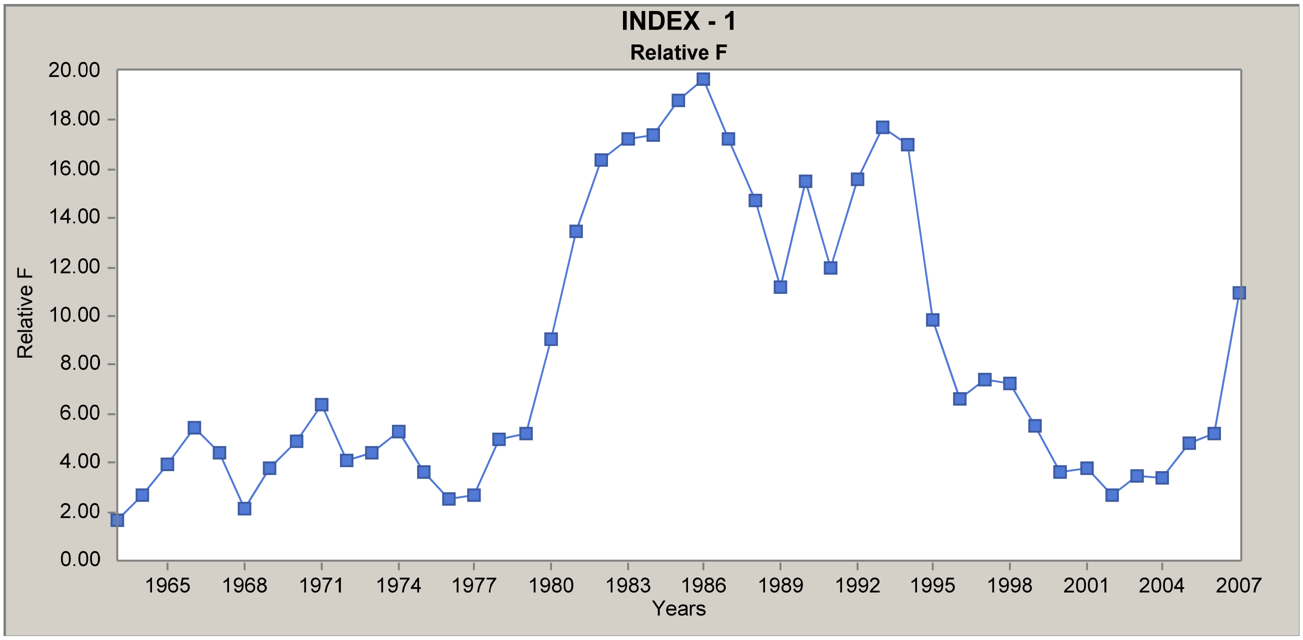

Figure M3. Average relative F (commercial and recreational landings/biomass index) for pollock in SA 5&6.

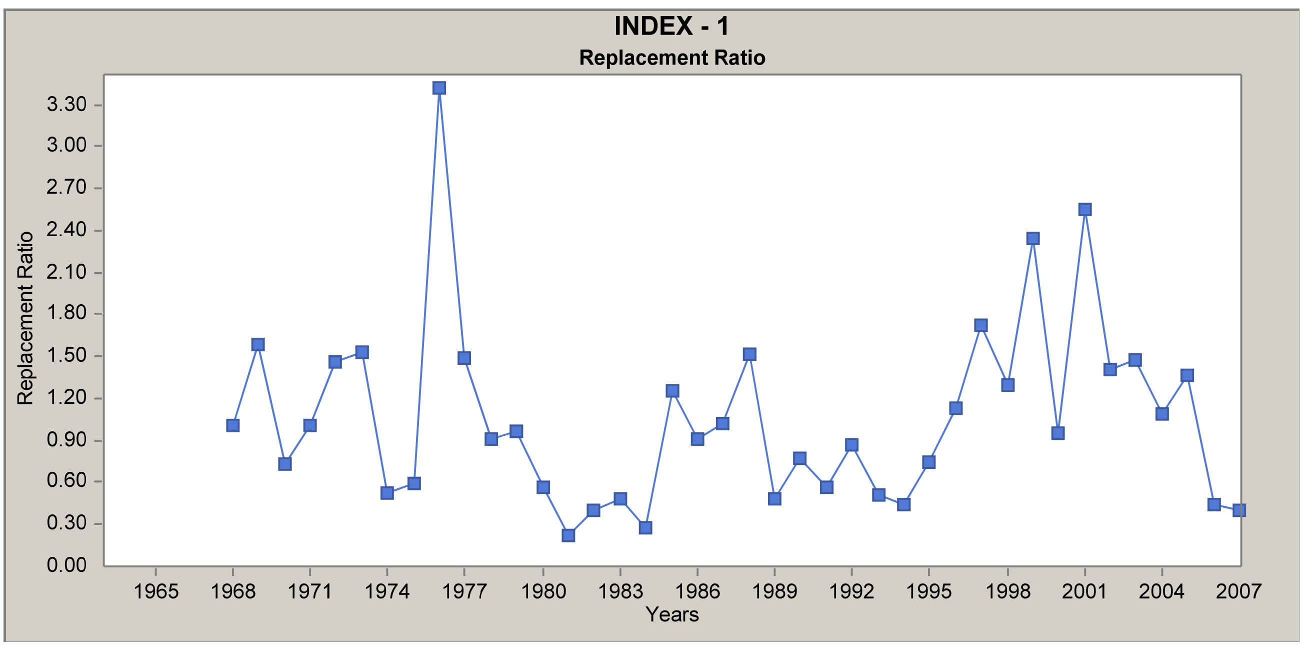

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Figure M4. Replacement Ratios for pollock in SA 5&6.

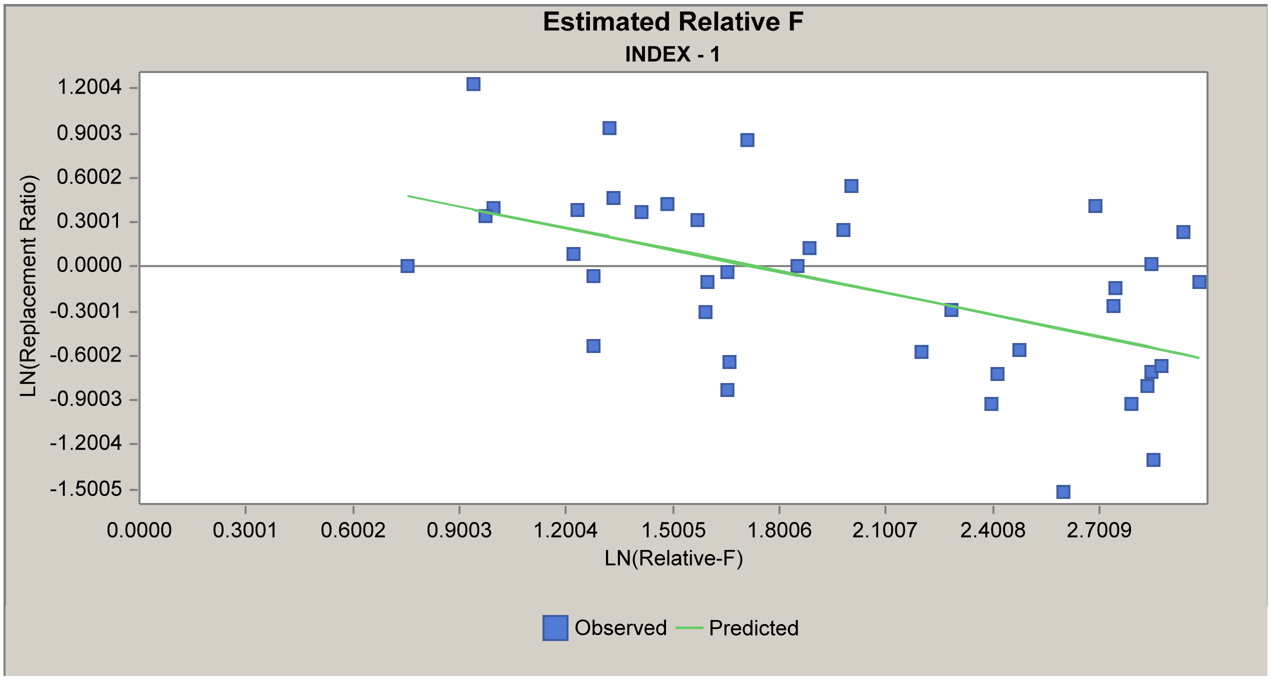

Figure M5. Regression of replacement ratio on relative F used to estimate F_{MSY} proxy (5.66 = exp 1.733) derived from the AIM model for pollock in SA 5&6.

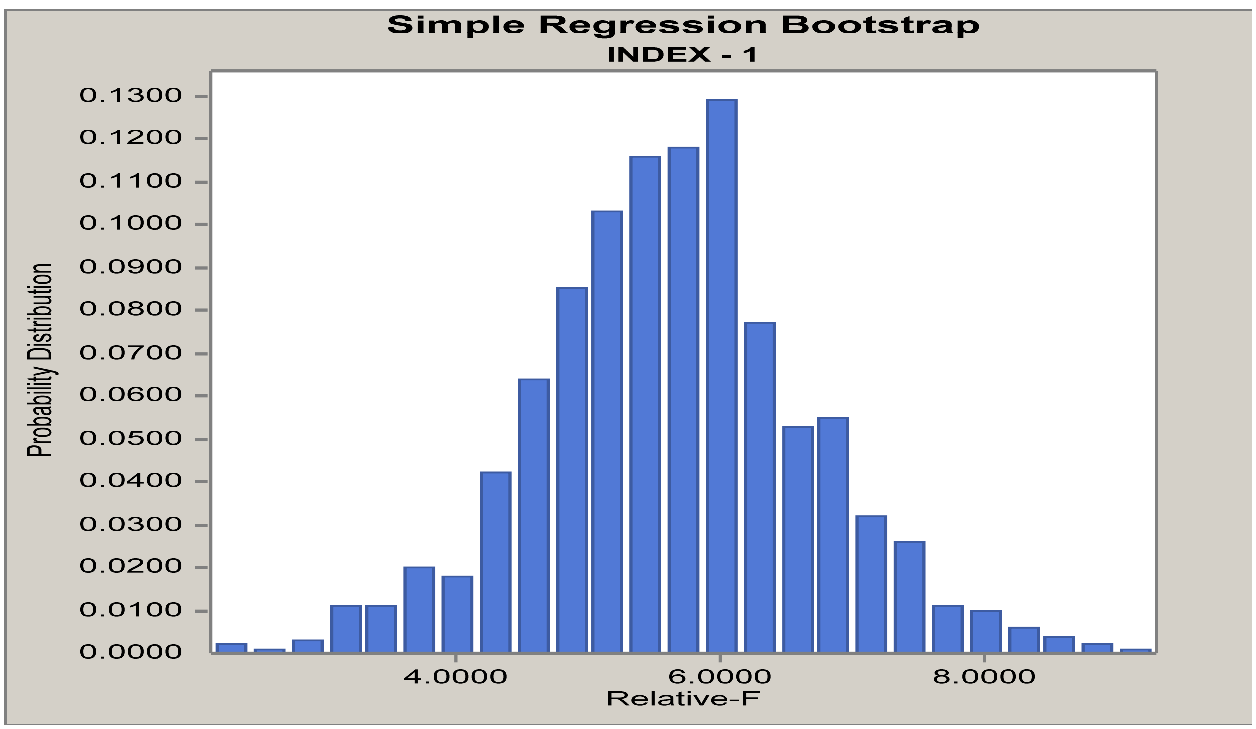

Figure M6. Distribution of 1000 bootstrap iterations of the regression of replacement ratio on relative F for pollock in SA 5&6. The 90% confidence interval about the replacement relative F estimate (5.66) ranges from 3.87 to 7.44.

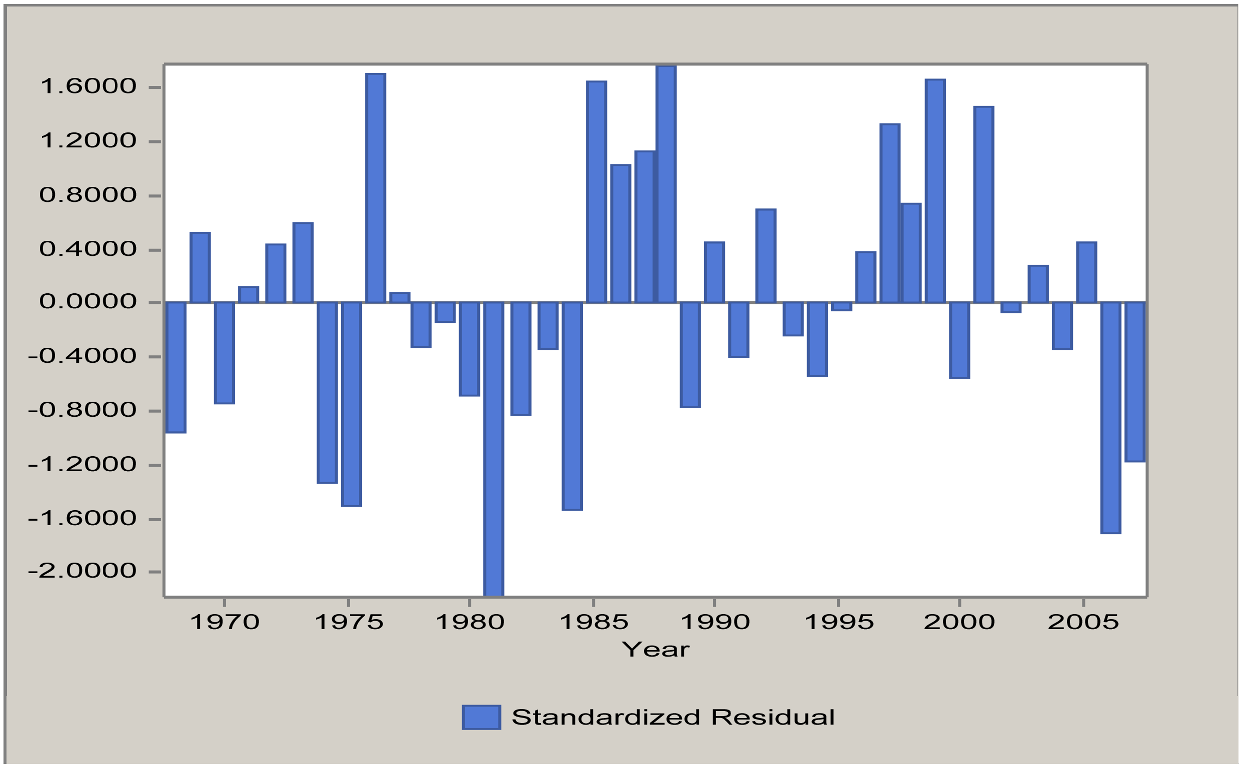

Figure M7. Residual patterns from the regression of replacement ratio on relative F for pollock in SA 5&6.

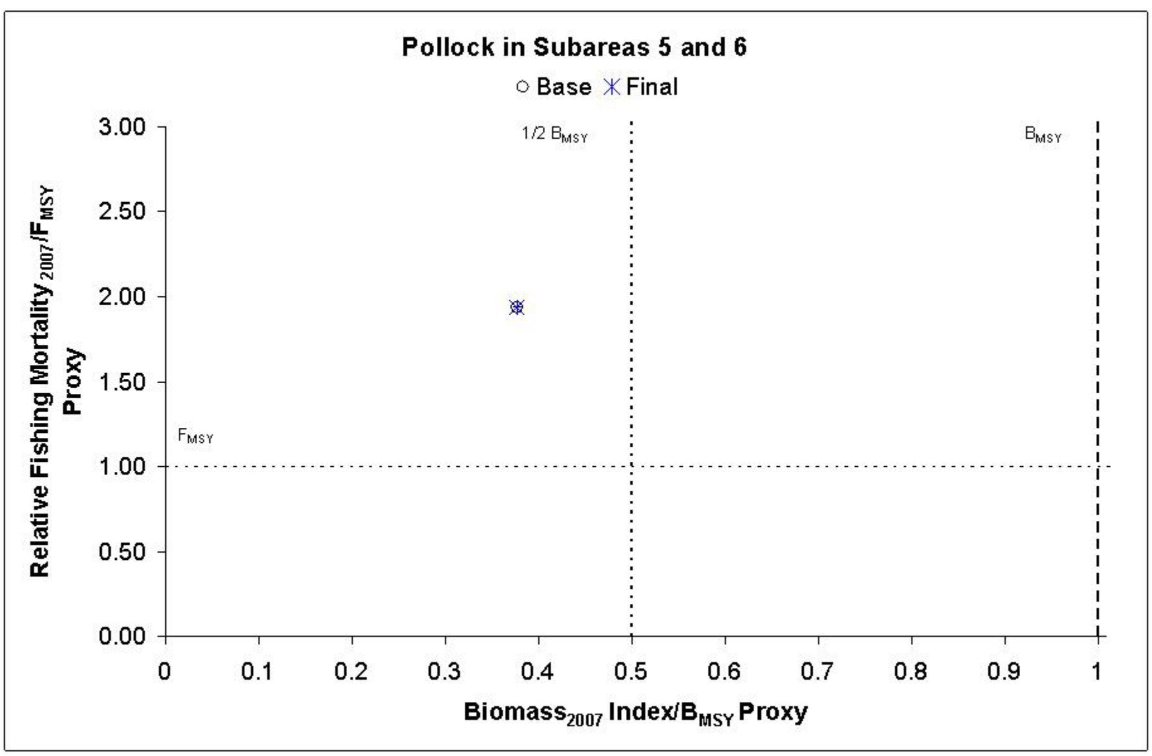

Figure M8. Status determination of pollock in Subareas 5 and 6 in 2007.

N. Gulf of Maine/Georges Bank Acadian redfish
by Timothy J. Miller, Ralph K. Mayo, Michelle L. Traver and Laurel A. Col

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

1.0 Background

The most recent stock assessment of Gulf of Maine-Georges Bank Acadian redfish was completed and reviewed at the 2005 Groundfish Assessment Review Meeting (GARM) (Mayo et al. 2005, Mayo et al. 2007). The assessment was based on several analyses including trends in catch/survey biomass exploitation ratios; a yield- and biomass-per-recruit analysis; an age-structured dynamics model which incorporates information on the age composition of the landings, size and age composition of the population, and trends in relative abundance derived from commercial CPUE and research vessel survey biomass indices (NEFSC 2001a, 2001b).

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 2005. The rapid increase in abundance and biomass was attributed to strong recruitment for some cohorts in the early-1990s. The state of this stock was reviewed at the 2005 GARM by comparing the estimated 2005 spawning biomass with spawning biomass at 50% maximum spawning potential (SB(50%MSP), estimated previously; NEFSC 2002). Estimates of fishing mortality derived from the age-structured dynamics model in the last assessment were less than 10% of F(50%MSP) between 2000 and 2004 (<0.004). The 2004 spawning biomass was estimated to be about 175,790mt (74% of SB(50%MSP)) and the 2004 fishing mortality rate estimate was 0.0024 (F(50%MSP) = 0.04). Thus, it was concluded that the stock was not overfished and overfishing was not occurring.

For the 2008 GARM on assessment models, we updated the catch and survey data to 2006 and provide estimates of discards between 1989 and 2006. Two versions of a statistical catch at age model (RED and STATCAM) were explored for the 2005 GARM, but the definitive results were ultimately based on the RED model. As such, for initial meetings of the 2008 GARM we had also used both RED and STATCAM to estimate assessment parameters and we also made estimates using landings data from 1913-1933 that we found primarily in annual reports of the U.S. Bureau of Fisheries (e.g., Fielder 1928). We also note that, for consistency, we used the same version of STATCAM as that used in the 2005 assessment. We had also explored an alternative finite-state continuous-time population dynamics model (FSCTPD) on a limited set of age measurements from surveys and landings between 1969 and 1985 to estimate recruitment, selectivity, survey catchability and annual fishing mortality (see Miller 2008). The statistical framework is the same as that described by Miller and Andersen (2008) for various types of tagging experiments. We compared the results from FSCTPD with corresponding results from the RED and STATCAM models for corroborative purposes.

There was concern raised at the 2008 GARM on assessment models about the problematic estimation of biomass levels prior to the substantial landings starting 1936 using RED and STATCAM. The review panel suggested implementing a Beverton-Holt stock-recruitment relationship. As ASAP (ASAP 2008) is also a statistical catch-at-age model with the stock-recruitment implementation readily available, we moved to this as the assessment model. We presented ASAP alternative models at the 2008 GARM on biological reference points and, ultimately, the panel recommended a model alternative where we assumed a 5 year linear ramp from 0.1 in 1964 to 0.8 in 1969 for the CVs of recruitment residuals. We also used revised estimates of maturity- and weight-at-age and CVs for survey biomass indices and we included discards with landings for total catch estimates between 1989 and 2006 with corresponding CVs.

2.0 The Fishery

Substantial exploitation of Gulf of Maine-Georges Bank Acadian redfish began in the late 1930s and was highest in the 1940s (Table N1, Figure N1). Landings declined drastically in the early 1950s, but continued to range from about 8,000 – 20,000mt annually until the early 1980s. Landings of redfish declined steeply throughout the1960s, but stabilized somewhat in the 1970s'. Finally landings dropped steeply again in the 1980s and remained below 1,000mt per year since1989, and at less than 600 mt per year until 2007 where landed biomass was 787mt.

As a consequence of the relatively low landings of redfish after the mid 1980s, age measurements from landings halted after 1985 (Tables N2). Authors of previous assessments derived estimates of catch at age between 1969 and 1985 (Figure N2).

Discards

We estimated discards between 1989 and 2007 using the d/k ratio (ratio of sums) method described in Wigley et al. (2006). The discard estimates are generally low (< 400mt), but are sometimes a substantial proportion of total removals during this period (discards and landings) (Table N1). One particularly high estimate in 1991 is roughly 3 times the corresponding landed biomass but the precision is estimated quite low (CV =0.74).

3.0 Research Survey Estimates

We estimated annual numbers and biomass per tow and mean fish weight and length for the NEFSC spring and autumn research vessel bottom trawl surveys (Tables N3 and N4, Figures N3-N4). For both surveys, the estimates of annual numbers and biomass per tow are generally low and have generally higher precision between the late 1970s and middle 1990s than annual estimates from years outside this range. This period roughly corresponds to the last decline in landings. The increase in annual estimates of numbers and biomass per tow since the middle 1990s is accompanied by increased estimates of uncertainty. Note that although there is increased uncertainty in higher estimates of numbers and biomass per tow, the relative uncertainty (CV) is fairly consistent across all years.

In a few of the yearly surveys, there were sampling deficiencies in some strata. For the spring survey in 1975 no trawls were made in stratum 1390 and this stratum is not included in estimation for that year. For the autumn survey, only one trawl was made in stratum 1300 in 1963 and in stratum 1400 in 2004 so that stratified sampling variance estimates over sets of strata where these are included is not possible.

Survey Age Composition

Age observations are available from 1975 through 2007 for the NEFSC autumn bottom trawl survey and from 1975-1980 and 1984-1990 for the NEFSC spring bottom trawl survey

(Figures N5 and N6). Estimates of proportions at age appear to show infrequent large recruitment pulses followed by periods of small recruitment between 1975 and the early 1990s. Several strong cohorts began to appear in the early 1990s and the biomass in the middle age classes appears to be building at present.

4.0 Assessment

Input data and Model Formulation

The reviewers at the 2008 GARM on assessment models, were concerned with the problematic estimation of biomass levels prior to the substantial landings starting 1936 using RED and STATCAM (O'Boyle et al. 2008a). The reviewers suggested implementing a Beverton-Holt stock-recruitment relationship with a steepness as estimated for Pacific Ocean Perch and assume low coefficient of variation (CV, ≤0.2) of recruitment residuals in years where age observations are not available and high CV (≥ 0.4) of recruitment residuals where age observations are available. The reviewers were also interested in relaxing the constant selectivity assumption (i.e., the separability assumption).

In the revised assessment, we have used ASAP (ASAP 2008) as the assessment model because it is also a statistical catch-at-age model and it has options for assuming a Beverton-Holt stock-recruitment relationship. Prior to the 2008 GARM on biological reference points, we fit three ASAP models assuming the suggested CVs for recruitment residuals (0.2 and 0.4, alternative 1) assuming more drastic differences in the CVs for periods with and without age sampling (0.1 without age observations and 0.8 with age observations, alternative 2) and assuming the same CVs as alternative 2 except with a 5 year linear ramp from 0.1 in 1964 to 0.8 in 1969 (alternative 3) (Miller et al. 2008). However, we estimated both the steepness and unexploited spawning biomass for the stock-recruitment function. In addition, we revised the maturity-at-age (Figure N7) and weight-at-age (Figure N8) estimates and assumed CVs for survey biomass indices. The CVs for the biomass indices were estimates provided by the sampling design used in the autumn and spring bottom trawl surveys when available. In years where design-based CV estimates were not possible, we assumed CV = 0.3. Finally, we also included discards with landings for total catch estimates between 1989 and 2007 with corresponding CVs provided by variance estimates for the annual discards. Further assumptions in the ASAP models were intended to mimic those used previously in STATCAM and RED models where possible (Table N5). However, we did not attempt to relax the constant selectivity assumption because the time span over which age composition data are available from landings (1969-1985) is short relative to the entire time span of landings (1913-2007) and, as such, there is no ability to estimate different selectivity patterns in the periods prior to and after age observations from landings.

Model Selection Process

Overall, the diagnostics of the three ASAP alternatives presented at the 2008 GARM on biological reference points were similar and estimation of initial annual spawning biomass estimates were better behaved than those from any of the STATCAM alternatives. ASAP alternative 3 was deemed the best of the alternative assessment models to use for this assessment and determination of stock status (O'Boyle et al. 2008b).

Since the 2008 Groundfish Assessment meeting on Biological Reference Points, we updated the landings and discard estimates (Table N1), NEFSC survey indices and age composition for the NEFSC autumn survey for 2007 and investigated retrospective patterns in the model. We quantified retrospective pattern of a given parameter (spawning biomass, recruitment or fishing mortality in the terminal year) using the average relative differences of estimates from 7 fits of the ASAP model to data where terminal years were removed. Specifically, we fit models to data up to 2000, 2001, …, 2007 and we averaged the relative differences between estimates from the models using data up to 2000, …, 2006 and the model using all data (up to 2007).

We found retrospective pattern in spawning biomass and fishing mortality in the terminal year using the model chosen at the 2008 GARM meeting on biological reference points. Because the reviewers were interested in exploration of the sensitivity of the results to alternative values of natural mortality, we calculated the retrospective statistics described above for a suite of models assuming different natural mortality rates as well as an alternative model where catchability and selectivities were allowed to be different for both autumn and spring surveys up to 1994 and afterward. We also report the total and component values of the optimized objective function for the models fit to all data (Table N6). The alternative model where M=0.1 provided the least retrospective pattern for spawning biomass and fishing mortality as measured by the average relative differences whereas the alternatives with M = 0.05 and 0.075 provided least retrospective pattern for recruitment. The total objective function is best for the model where M=0.04, but the measures of retrospective pattern for this model were worse than the base model (M = 0.05). The model with survey catchability and selectivities different in the two time periods provided very strong retrospective patterns in spawning biomass and fishing mortality.

We chose to provide assessment results for two models: the Base model (M = 0.05) and the alternative where M = 0.1 because the total objective function value for the base model (M = 0.05) is nearly as good as that of the alternative where M = 0.04 and the retrospective patterns were lessened when M = 0.1. However the fit for the alternative model as measured by the objective function value is so much worse than the Base model and the retrospective pattern was not entirely eradicated (Figure N9). In addition, M=0.05 has been used in assessment of Icelandic redfish (*Sebastes marinus*; Stefánsson and Sigurðsson 1997) and the age composition of the spawning biomass as estimated from the 2007 fall survey and corresponding selectivity-, weight- and maturity-at-age is different than that predicted at equilibrium using a spawning biomass-per-recruit analysis when spawning biomass is nearly twice its reference point as the alternative model estimates (Figure N10; see Section 4.3 below). Given these results, we recommend the Base model (including 2007 data) for determining stock status and catch and biomass projections.

The review panel at this final 2008 GARM accepted the base model as the Final model for determining stock status. However, the panel also recommended that stock status be determined by adjusting the 2007 spawning biomass and fishing mortality rate for the corresponding retrospective patterns exhibited by this model (see Section 8.0 below for panel recommendations). The adjustments we made to determining stock status are described in Section 5.0. The panel also recommended current numbers-at-age estimates be adjusted for catch and rebuilding projections and those adjustments are described in Section 6.0.

Assessment Results

The annual recruitments and spawning biomass estimates are similar for the base models excluding and including the 2007 data (Figure N11). The recruitments are substantially higher on average for the alternative where M = 0.1, but spawning biomass estimates in recent and initial years are similar to the base models. Similarly, the annual fishing mortality rate, survey catchabilties and fishery and survey selectivity estimates are similar for the base models, but often somewhat lower when M=0.1 is assumed (Table N7; Figures N12 and N13). The similar spawning biomass estimates of the base and alternative model reflect that the lower survey catchability and selectivity parameters in the alternative model are being balanced by the higher natural mortality rate. In addition, a much lower steepness for the stock-recruitment function was estimated by the alternative model than the base model, but the unexploited biomass estimates were similar. The worse fit of the lower steepness estimate in combination with higher recruitment estimates at lower spawning stock sizes is reflected in the higher objective function value for the component corresponding to recruitment deviations (Table N8; Figure N14).

Diagnostics

Residual patterns for catch and autumn and spring surveys are not noticeably different among the base and alternative models (Figure N15) which is also reflected in the similar values for the corresponding objective function components. Likewise, the recruitment residuals largest in magnitude are often slightly larger for the alternative model which results in a somewhat larger corresponding objective function component for that model.

Differences between predicted and observed landings and survey age composition are similar between the base and alternative models (Figure N16). In view of the objective function component for the survey age composition the alternative model fits these observations somewhat better (Table N8).

5.0 Biological Reference Points

For the 2008 GARM on biological reference points, we re-evaluated the reference points, the methods for calculating the reference points and the current status of the population relative to those reference points. We used AGEPRO (AGEPRO 2005) to determine median SB(50%MSP) under a few alternative scenarios. Ultimately, the review panel recommended using a projection approach that assumed future recruitment was drawn from the distribution of recruitments between 1969 and present as estimated using the base ASAP model where age composition data are available and the CV for recruitment residuals is assumed 0.8 (O'Boyle et al. 2008b). The same class of reference points, F(50%MSP) and SB(50%MSP), as the 2005 GARM were also recommended. We calculated the F(50%MSP) using a yield-per-recruit analysis (YPR 2007) with the same weight- and maturity-at-age estimates and natural mortality assumption used in the ASAP fits and the estimated fishery selectivity resulting from those fits (i.e., base and alternative models).

For AGEPRO projection scenarios, we used 10 draws of numbers-at-age vectors in 2007 from the posterior distribution provided by the ASAP fits and we projected 300 years forward with 100 simulations per numbers-at-age vector. In this approach, the annual spawning biomass and fishing mortality still vary to some degree after convergence, so we use the average of the yearly median values after convergence (over 200 yearly values) as the reference point estimates.

The fishing mortality rate and spawning biomass-per-recruit at 50%MSP are similar whether 2007 data are included or not and the fishing mortality rate is also similar to that provided at the 2005 GARM, but spawning biomass-per-recruit estimates were different from that in the previous assessment due primarily to the revised weight- and maturity-at-age estimates we have used (Table N8). For the alternate model when M=0.1, the fishing mortality reference point is greater and the spawning biomass-per-recruit is lower as would be expected. The spawning biomass reference point and corresponding yield are somewhat greater for the base model when the 2007 data are used which is primarily due to the increased average annual recruitment estimates used in the projection (Figure N17). The spawning biomass reference point using the alternate model (M=0.1) is less than half that of the base model.

The review panel at this final 2008 GARM recommended that the base model be used as the final assessment model for Gulf of Maine-Georges Bank Acadian redfish (see Section 8.0). The panel also recommended that the status of the stock be determined by adjusting the 2007 spawning biomass and fishing mortality rate estimates using the base model for the observed retrospective pattern. Specifically, the spawning biomass and fishing mortality estimates are adjusted for the average relative bias (see also Table N8) so that

$SB_{adjusted}(2007) = SB(2007)/(1+0.361) = 172{,}342$mt

and

$F_{adjusted}(2007) = F(2007)/(1-0.269) = 0.0068$.

When comparing the 2007 spawning biomass and fishing mortality rate estimates to the corresponding reference point estimates (Table N8; Figure N18),

SB(50%MSP) = 271,000mt

and

F(50%MSP) = 0.0377,

The stock is not overfished and overfishing is not occurring.

6.0 Catch and Rebuilding Projections

The same general approach as that for defining the spawning biomass reference point is used here. The exception is that we use 100 draws of numbers-at-age vectors in 2007 from the posterior distribution provided by the ASAP fits and we projected 44 years forward with 1000 simulations per numbers-at-age vector to ensure that estimates in the near term are precise. We also assume catch in 2008 equal to that in 2007. The review panel at this final 2008 GARM recommended that the 2007 numbers-at-age (and ultimately 2007 spawning biomass) be adjusted for the observed retrospective pattern in corresponding estimates in the same manner as the current spawning biomass and fishing mortality are adjusted for stock status (see Section 5.0).

Projected median 2009 catch biomass under the base (and final) ASAP model with status quo fishing mortality (F = 0.007) is 1,277mt and the spawning biomass will be rebuilt to 271,000mt with nearly 50% probability by 2010, greater than 90% probability by 2011 and greater than 99% probability in 2012. At $F(_{50\%MSP}=F_{REBUILD}) = 0.0377$, the median 2009 catch biomass is 8,631mt and the spawning biomass will be rebuilt with greater than 50% probability by 2011, greater than 95% probability by 2013 and greater than 99% probability by 2014.

7.0 Summary

We applied a completely revised forward-projecting statistical catch-at-age assessment model (ASAP) to data and inputs for Gulf of Maine-Georges Bank Acadian redfish stock. We extended the time series of total catch back to 1913 and included discards from 1989 to 2007. We weighted the influence of these data on the total objective function by yearly variance estimates associated with discards for years where these estimates are available. We also weighted yearly spring (1968-2007) and autumn (1963-2007) NEFSC survey indices by sampling design-based variance estimates. Finally, we also revised maturity-at-age and weight-at-age estimates used as inputs in the assessment model.

Due to moderate retrospective patterns exhibited by fits of the base ASAP model, we explored a suite of models where we assumed a range of alternative natural mortality rates and a change in survey catchability and selectivity after 1994. Based on those results, we went forward with estimation of reference points and stock status for the base ASAP model (M = 0.05) and an alternative where the natural mortality rate was assumed to be 0.1. At the final 2008 Groundfish Assessment Review Meeting the review panel recommended using the base model as the final model and adjusting current spawning biomass, fishing mortality and numbers-at-age estimates for the observed retrospective pattern when determining stock status and making catch and rebuilding projections.

The spawning biomass reference point (spawning biomass at 50% maximum spawning potential) estimate under the base model (271,000mt) is slightly greater than that used in the previous assessment (236,700mt). The fishing mortality rate reference point estimate under the base model (0.0377) is similar to that used in the previous assessment (0.04). The adjusted current (2007) spawning biomass estimate is 172,342mt and the adjusted current fishing mortality rate is 0.007. The Acadian redfish stock is not overfished and overfishing is not occurring (Figure N18).

8.0 Panel Discussion

Conclusions

This stock was assessed using a Statistical Catch at Age formulation consistent with the GARM 'models' review which the Panel found to be sufficient for management purposes. It displayed a moderate retrospective pattern which the Panel felt should be adjusted in the stock and rebuilding projections. Consequently, the Rho Adjustment was applied to the 2007 population numbers. This represents the Final formulation as accepted by the Panel, and it lowered the estimate of the 2007 SSB considerably although not enough to change the status from not-over fished.

Two large spikes in fishing mortality were estimated by the model around 1990. It was noted that these were likely due to discard estimates for which there are relatively large coefficients of variation (CV). The Panel considered that the impact of these estimates should be investigated and perhaps more restrictive CVs considered in future analyses.

As requested by the GARM III 'BRP' review, an exploration of the appropriate estimate of natural mortality (M) to use in the model was undertaken by observing how the model fit changes over a range of Ms. Based on goodness-of-fit criteria, M = 0.05 was chosen. It was noted that this is similar to the M used for Icelandic redfish while estimates of M for Pacific

Ocean Perch are slightly higher (0.5 – 1.0). While the Panel was concerned about the choice of a low estimate of M and encouraged further research on its estimation, it noted that the estimate of MSY was fairly robust to the assumption of M.

Research Recommendations

Dimorphic growth in this stock is fairly substantial with females growing faster than males. The use of female weights at age in the stock and rebuilding projections may result in overly optimistic rates of recovery although the implications for the BRPs would also have to be considered. The Panel recommends that the sensitivity of BRPs and stock projections to the weights at age should be investigated.

The Panel had difficulty interpreting the model residual plots and recommended alternative graphical approaches.

The Panel was concerned about this choice of a relatively low value for natural mortality and was suggested that consideration be given to M estimates from other redfish stocks as well as further exploration of existing data on this stock. Specifically, it noted that the data provide a unique opportunity to examine year – class specific M as recent catches have been very low.

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Table N1. Nominal redfish catches (metric tons), actual and standardized catch per unit effort, calculated standardized USA and total effort and estimated discards for the Gulf of Maine-Georges Bank Acadian redfish fishery.

	Nominal Catch (Metric tons)			USA Catch per Unit Effort (tons/day)		Calculated Standard Effort (days fished)		Estimated		Total
Year	USA	Others	Total	Actual	Standard	USA	Total	Discards (mt)	CV	Removals (mt)
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	6.9	6.9	8100	8100			55892
1943	48348		48348	6.7	6.7	7216	7216			48348
1944	50439		50439	5.4	5.4	9341	9341			50439
1945	37912		37912	4.5	4.5	8425	8425			37912
1946	42423		42423	4.7	4.7	9026	9026			42423
1947	40160		40160	4.9	4.9	8196	8196			40160
1948	43631		43631	5.4	5.4	8080	8080			43631
1949	30743		30743	3.3	3.3	9316	9316			30743
1950	34307		34307	4.1	4.1	8368	8368			34307
1951	30077		30077	4.1	4.1	7336	7336			30077
1952	21377		21377	3.5	3.4	6287	6287			21377
1953	16791		16791	3.8	3.6	4664	4664			16791
1954	12988		12988	3.4	3.1	4190	4190			12988
1955	13914		13914	4.5	4.0	3479	3479			13914
1956	14388		14388	4.4	3.8	3786	3786			14388
1957	18490		18490	4.3	3.6	5136	5136			18490
1958	16043	4	16047	4.4	3.6	4456	4458			16047
1959	15521		15521	4.3	3.5	4435	4435			15521
1960	11373	2	11375	3.8	3.0	3791	3792			11375
1961	14040	61	14101	4.6	3.5	4011	4029			14101
1962	12541	1593	14134	5.4	4.0	3135	3534			14134

1963	8871	1175	10046	4.1	3.0	2957	3349			10046
1964	7812	501	8313	4.3	2.9	2694	2867			8313
1965	6986	1071	8057	7.0	4.4	1588	1831			8057
1966	7204	1365	8569	11.7	6.4	1126	1339			8569
1967	10442	422	10864	12.4	5.6	1865	1940			10864
1968	6578	199	6777	14.7	6.1	1078	1111			6777
1969	12041	414	12455	11.4	4.9	2457	2542			12455
1970	15534	1207	16741	9.0	4.0	3884	4185			16741
1971	16267	3767	20034	7.0	3.2	5083	6261			20034
1972	13157	5938	19095	5.7	2.9	4537	6584			19095
1973	11954	5406	17360	5.3	2.9	4122	5986			17360
1974	8677	1794	10471	5.0	2.6	3337	4027			10471
1975	9075	1497	10572	4.0	2.2	4125	4805			10572
1976	10131	565	10696	4.6	2.3	4405	4650			10696
1977	13012	211	13223	4.9	2.5	5205	5289			13223
1978	13991	92	14083	4.8	2.4	5830	5868			14083
1979	14722	33	14755	3.6	1.9	7748	7766			14755
1980	10085	98	10183	3.2	1.6	6303	6364			10183
1981	7896	19	7915	2.7	1.4	5640	5654			7915
1982	6735	168	6903	2.7	1.5	4490	4602			6903
1983	5215	113	5328	2.1	1.2	4346	4440			5328
1984	4722	71	4793	1.9	1.1	4293	4357			4793
1985	4164	118	4282	1.4	0.9	4627	4758			4282
1986	2790	139	2929	1.0	0.6	4650	4882			2929
1987	1859	35	1894	1.1	0.7	2656	2706			1894
1988	1076	101	1177	0.9	0.5	2152	2354			1177
1989	628	9	637	1.1	0.6	1047	1062	32	0.62	669
1990	588	13	601	**	**			38	0.49	639
1991	525		525	**	**			1514	0.74	2039
1992	849		849	**	**			129	0.30	978
1993	800		800	**	**			246	0.53	1046
1994	440		440	**	**			106	2.60	546
1995	440		440	**	**			191	0.47	631
1996	322		322	**	**			367	0.37	689
1997	251		251	**	**			181	0.44	432
1998	320		320	**	**			266	0.97	586
1999	353		353	**	**			30	0.51	383
2000	319		319	**	**			169	0.48	488
2001	360		360	**	**			368	0.33	728
2002	368		368	**	**			126	0.37	494
2003	361		361	**	**			203	0.19	564
2004	398		398	**	**			125	0.18	523
2005	564		564	**	**			101	0.15	665
2006	499		499	**	**			149	0.24	648
2007	787		787	**	**			373	0.34	1160

** CPUE and effort not calculated due to sharp reduction in directed redfish trips

Table N2. Number of length and age measurements by year and quarter and annual landings and number of samples for Gulf of Maine-Georges Bank Acadian redfish between 1969-1985.

	Number of length measurements				Number of age measurements						
Year	1	2	3	4	1	2	3	4	Annual Landings (mt)	Number of samples	Landings per sample
1969	200	1000	2000	0	40	178	398	0	12455	14	890
1970	200	900	1100	100	40	180	241	0	16741	18	930
1971	1196	2399	3201	1000	160	359	279	181	20034	34	589
1972	100	3026	1659	300	20	631	350	65	19095	16	1193
1973	1401	3141	1405	299	264	467	204	67	17360	23	755
1974	2407	2518	2217	803	263	335	251	162	10471	34	308
1975	2558	3097	916	300	411	494	198	46	10572	27	392
1976	1200	2747	2523	1624	234	278	252	261	10696	24	446
1977	3398	2148	2322	627	227	239	273	125	13223	31	427
1978	2470	1423	869	731	434	214	201	162	14083	30	469
1979	1132	1693	3569	2581	213	225	310	377	14755	35	422
1980	1308	1964	1385	201	292	418	354	45	10183	21	485
1981	800	1704	703	511	198	375	175	103	7915	21	377
1982	1262	1020	1321	613	246	186	284	131	6903	27	256
1983	1351	1020	1717	1012	295	195	284	220	5328	31	172
1984	1552	1959	624	609	353	448	84	133	4793	26	184
1985	931	1345	1808	1691	223	330	468	443	4282	37	116

Table N3. Estimated catch-per-tow, average weight and average length of Gulf of Main-Georges Bank Acadian redfish for all inshore and offshore strata (24, 26-30, 36-40) in the spring NEFSC bottom trawl survey.

Year	Numbers/tow	CV	Biomass (kg)/tow	CV	Mean weight (kg)	CV	Mean length (cm)	CV
1968	45.18	0.45	17.09	0.34	0.38	0.29	26.22	0.09
1969	46.43	0.26	19.69	0.29	0.42	0.10	28.64	0.04
1970	54.72	0.67	18.93	0.53	0.35	0.15	26.24	0.04
1971	157.23	0.28	71.56	0.30	0.46	0.07	29.54	0.02
1972	101.22	0.51	44.36	0.50	0.44	0.03	28.56	0.01
1973	44.35	0.31	25.30	0.32	0.57	0.07	30.90	0.02
1974	34.31	0.59	18.84	0.66	0.55	0.09	30.21	0.05
1975	38.93	0.32	17.61	0.35	0.45	0.05	28.06	0.02
1976	62.22	0.49	26.19	0.54	0.42	0.11	28.16	0.06
1977	25.06	0.26	11.59	0.26	0.46	0.17	28.90	0.05
1978	23.98	0.20	12.17	0.20	0.51	0.08	29.12	0.03
1979	61.41	0.32	32.21	0.33	0.52	0.07	29.69	0.02
1980	29.81	0.34	20.34	0.34	0.68	0.06	32.11	0.02
1981	33.04	0.69	18.31	0.69	0.55	0.01	30.45	0.01
1982	16.96	0.39	9.41	0.37	0.55	0.15	29.84	0.06
1983	9.85	0.36	6.07	0.41	0.62	0.11	30.37	0.04
1984	4.96	0.32	2.68	0.33	0.54	0.12	29.41	0.04
1985	11.72	0.39	6.61	0.40	0.56	0.08	29.99	0.03
1986	5.27	0.27	3.22	0.32	0.61	0.09	31.00	0.04
1987	24.50	0.80	12.93	0.84	0.53	0.05	30.25	0.02
1988	8.09	0.49	3.27	0.47	0.40	0.10	27.23	0.04
1989	7.81	0.28	2.98	0.36	0.38	0.14	25.85	0.06
1990	12.34	0.36	6.81	0.43	0.55	0.08	30.18	0.03
1991	9.47	0.32	4.26	0.38	0.45	0.14	27.23	0.07
1992	37.86	0.41	10.67	0.41	0.28	0.11	25.30	0.03
1993	35.50	0.45	17.50	0.50	0.49	0.07	29.33	0.02
1994	16.14	0.58	3.92	0.63	0.24	0.10	23.50	0.05
1995	7.23	0.32	1.92	0.40	0.27	0.27	22.86	0.09
1996	28.74	0.46	11.89	0.64	0.41	0.21	27.19	0.08
1997	212.02	0.77	34.04	0.71	0.16	0.11	21.20	0.02
1998	34.67	0.33	7.84	0.33	0.23	0.04	23.40	0.01
1999	76.05	0.33	19.02	0.29	0.25	0.14	23.92	0.04
2000	180.09	0.55	56.01	0.58	0.31	0.07	25.88	0.02
2001	101.61	0.46	37.97	0.54	0.37	0.12	27.61	0.04
2002	225.18	0.68	61.21	0.63	0.27	0.10	25.32	0.03
2003	109.15	0.41	33.34	0.43	0.31	0.04	26.03	0.02
2004	152.30	0.38	55.67	0.43	0.37	0.07	27.14	0.02
2005	145.34	0.53	46.26	0.53	0.32	0.06	26.24	0.02
2006	34.70	0.35	10.33	0.34	0.30	0.13	25.58	0.04
2007	122.25	0.33	35.10	0.35	0.29	0.11	25.32	0.03

Table N4. Estimated catch-per-tow, average weight and average length of Gulf of Main-Georges Bank Acadian redfish for all inshore and offshore strata (24, 26-30, 36-40) in the autumn NEFSC bottom trawl survey.

Year	Numbers/tow	CV	Biomass (kg)/tow	CV	Mean weight (kg)	CV	Mean length (cm)	CV
1963	87.34	NA	24.11	NA	0.28	NA	25.04	NA
1964	116.26	0.68	53.64	0.75	0.46	0.09	29.66	0.06
1965	57.00	0.23	13.20	0.37	0.23	0.22	21.53	0.08
1966	93.84	0.34	29.27	0.45	0.31	0.16	24.27	0.07
1967	100.59	0.34	24.37	0.37	0.24	0.17	23.04	0.06
1968	143.45	0.41	40.43	0.43	0.28	0.07	24.76	0.03
1969	71.23	0.24	23.76	0.26	0.33	0.10	25.88	0.04
1970	93.98	0.23	32.96	0.19	0.35	0.12	26.12	0.04
1971	48.00	0.19	23.42	0.22	0.49	0.07	29.21	0.02
1972	55.57	0.17	24.63	0.19	0.44	0.05	28.40	0.02
1973	39.16	0.16	17.03	0.18	0.43	0.05	28.32	0.02
1974	48.30	0.22	24.16	0.30	0.50	0.13	28.47	0.05
1975	74.84	0.22	39.95	0.29	0.53	0.11	29.57	0.04
1976	28.85	0.31	15.29	0.39	0.53	0.12	29.71	0.05
1977	40.39	0.19	17.25	0.15	0.43	0.12	27.49	0.04
1978	45.21	0.17	20.74	0.16	0.46	0.05	28.67	0.02
1979	28.89	0.21	15.98	0.21	0.55	0.06	30.35	0.02
1980	20.58	0.28	12.63	0.31	0.61	0.10	30.68	0.03
1981	20.36	0.32	12.24	0.32	0.60	0.09	31.44	0.03
1982	9.18	0.46	3.48	0.27	0.38	0.27	26.31	0.09
1983	10.04	0.21	4.12	0.23	0.41	0.09	27.17	0.03
1984	7.77	0.42	3.93	0.38	0.51	0.08	28.86	0.02
1985	13.01	0.32	5.69	0.31	0.44	0.10	27.77	0.04
1986	26.05	0.39	8.01	0.34	0.31	0.13	25.04	0.04
1987	13.72	0.41	5.46	0.32	0.40	0.20	27.14	0.07
1988	12.43	0.41	6.33	0.57	0.51	0.19	27.50	0.06
1989	20.25	0.29	6.81	0.30	0.34	0.15	25.58	0.05
1990	35.53	0.34	12.16	0.33	0.34	0.11	26.01	0.03
1991	19.06	0.34	8.36	0.45	0.44	0.17	28.01	0.05
1992	22.37	0.26	8.09	0.29	0.36	0.09	26.90	0.03
1993	35.62	0.31	11.20	0.33	0.31	0.09	24.90	0.03
1994	20.86	0.32	5.94	0.43	0.28	0.16	24.24	0.05
1995	33.22	0.25	4.65	0.24	0.14	0.11	19.92	0.02
1996	169.64	0.35	30.63	0.33	0.18	0.11	21.83	0.03
1997	65.02	0.30	18.94	0.39	0.29	0.15	24.63	0.05
1998	116.95	0.42	31.72	0.45	0.27	0.08	24.47	0.03
1999	82.48	0.23	22.86	0.24	0.28	0.05	24.87	0.02
2000	104.43	0.27	26.16	0.29	0.25	0.07	24.22	0.03
2001	89.62	0.23	28.17	0.25	0.31	0.05	26.23	0.02
2002	185.19	0.31	41.88	0.33	0.23	0.09	23.77	0.04
2003	250.94	0.47	65.49	0.49	0.26	0.08	25.36	0.02
2004	127.29	NA	36.63	NA	0.29	NA	24.89	NA
2005	166.07	0.21	46.95	0.23	0.28	0.04	25.54	0.02
2006	183.43	0.31	50.22	0.30	0.27	0.05	24.96	0.02
2007	170.03	0.23	50.39	0.25	0.30	0.08	25.59	0.03

Table N5. Further assumptions made for ASAP model implementation for Gulf of Maine-Georges Bank Acadian Redfish.

Unestimated Parameter	Assumed Value
CV NAA in 1913	0.01
CV Catch	0.01 or estimate provided by variance estimation for discards where available
CV Survey Indices	Design-based estimates where available, 0.3 otherwise
CV of Survey/Fishery Selectivity Parameters	0.5
Fishery effective sample size (input)	200
Survey effective sample size (input)	100
Fraction of year at spawning	0.4
Fraction of year at spring survey	0.375
Fraction of year at autumn survey	0.875

Table N6. Objective function components and retrospective statistics for spawning biomass, recruitment, and fully selected fishing mortality for the suite of fitted ASAP models.

	M = 0.025	M = 0.03	M = 0.04	M = 0.05 FINAL MODEL	M = 0.075	M = 0.1	M = 0.15	Split Survey (1995)
Objective Function Components								
Catch (landings + discards)	432.0	432.2	432.9	433.8	436.6	440.0	421.6	437.2
Autumn survey index	523.0	520.6	516.7	513.5	506.7	502.7	506.3	506.2
Spring survey index	476.5	475.3	473.1	471.3	467.5	465.0	467.0	464.8
Landings age composition	916.8	907.6	898.0	893.2	887.9	884.8	883.1	888.8
Survey age composition	2048.5	2046.4	2041.1	2034.9	2022.9	2010.16	2005.0	2017.1
Catch selectivity penalties	106.4	106.8	108.3	110.2	115.8	121.9	132.0	112.5
Survey selectivity penalties	5.8	5.8	6.0	6.2	6.6	7.3	8.4	11.0
Initial numbers-at-age penalty	252.0	255.5	260.9	265.0	272.2	277.2	285.2	264.9
Recruitment deviations	1078.4	1078.8	1089.7	1104.2	1141.4	1177.1	1256.2	1116.0
Other	15.9	15.7	15.4	15.2	14.8	14.7	12.5	14.9
Total	5855.3	5844.9	5842.3	5847.5	5872.4	5900.8	5977.3	5833.3
Retrospective parameter								
Spawning biomass	0.837	0.487	0.419	0.361	0.244	0.147	0.172	0.933
Recruitment	0.288	0.086	0.086	0.053	-0.051	-0.163	0.539	-0.091
Fishing mortality	-0.453	-0.324	-0.295	-0.269	-0.208	-0.148	-0.157	-0.395

Table N7. Parameter estimates from the ASAP base (final) models using data prior to 2007 (left) and including 2007 data (middle) and the ASAP alternate (M = 0.1) model using data from all years (right).

Parameter	Without 2007 Data M = 0.05	With 2007 Data M = 0.05	M = 0.1
Steepness	0.64003	0.65873	0.34356
Unexploited spawning biomass (mt)	643,793	642,383	621,522
Autumn q	0.582012	0.594601	0.457688
Spring q	0.532395	0.542274	0.414501
MSY	10,237	10,491	8,042
SB_{MSY} (mt)	207,580	203,582	265,192
F_{MSY}	0.039110	0.040895	0.024285

Table N8. Recent spawning biomass and fishing mortality estimates (and standard errors in parentheses) from ASAP models. 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 ASAP models). AGEPRO estimates of median spawning biomass (and 95% prediction interval) and yield at F(50%MSP). Spawning biomass and fishing mortality for 2007 for the base (final) model adjusted for retrospective pattern are also given.

	2005 Assessment	Without 2007 Data M = 0.05	With 2007 Data M = 0.05 (Final Model)	M = 0.1
SB(2006)	NA	215,722mt	199,012mt	197,242mt
SB(2007)	NA	NA	234,609mt (19,754mt)	222,619mt (19,177mt)
$SB_{adjusted}$(2007)	NA	NA	172,342mt	NA
F(2006)		0.003	0.0034 (0.0003)	0.0036 (0.0004)
F(2007)	NA	NA	0.0051 (0.0007)	0.0055 (0.0008)
$F_{adjusted}$(2007)	NA	NA	0.0068	NA
SB-per-recruit(50%MSP)	4.1073kg	6.1970kg	6.2021kg	1.9825kg
F(50%MSP)	0.04	0.0387	0.0377	0.0691
SB(50%MSP)	236,700mt	239,309mt	271,000mt	126,000mt
SB 95% prediction interval	NA	169,250-319,700mt	183,600-377,000mt	80,000-182,800mt
Yield(50%MSP)	8,235mt	8,951mt	10,139mt	8,329mt

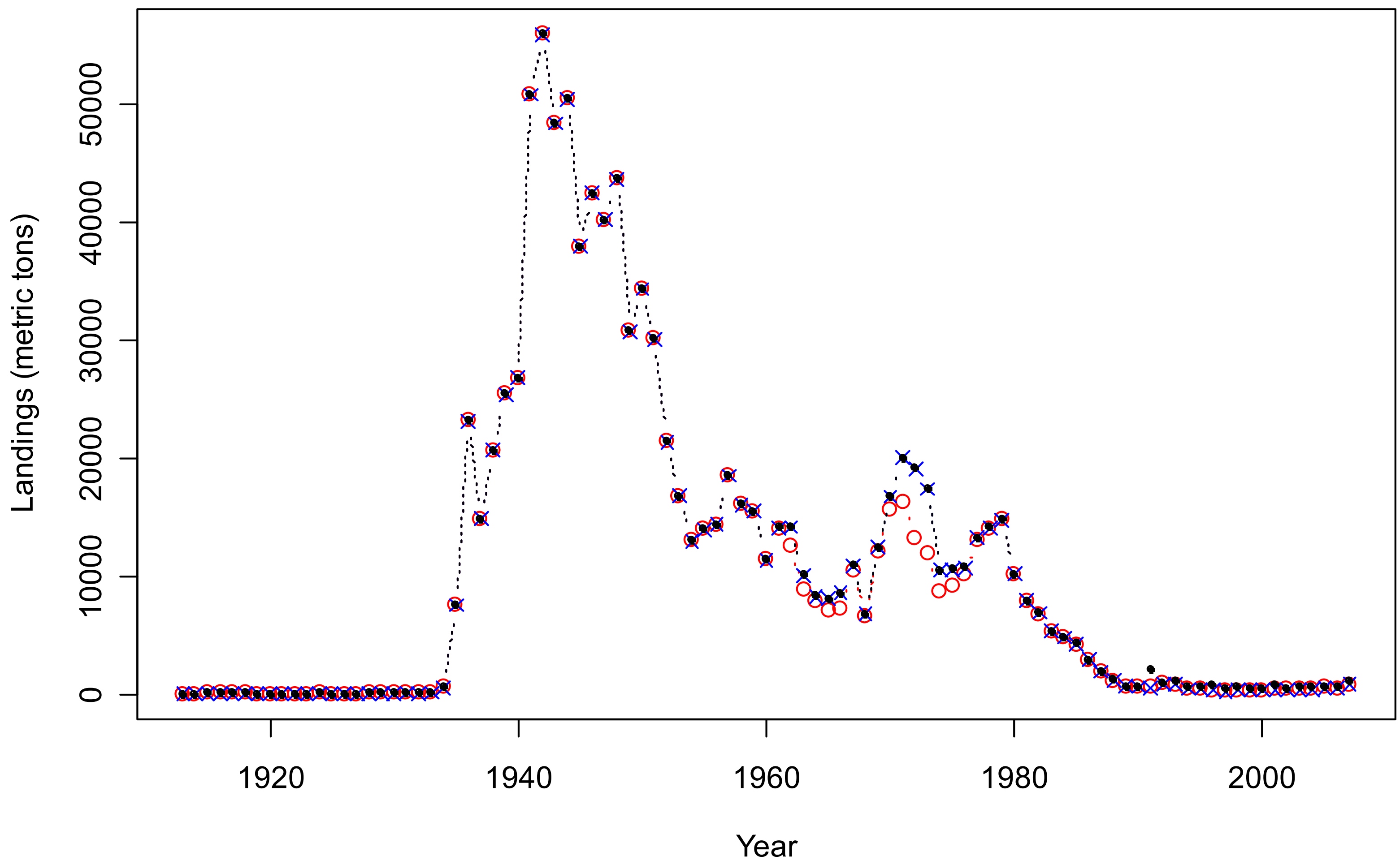

Figure N1. Annual landings (mt) of Gulf of Maine-Georges Bank Acadian redfish between 1913-2007 for US fleet only (red), US and foreign fleets combined (blue) and total landings combined with annual discard estimates between 1989-2007 (black).

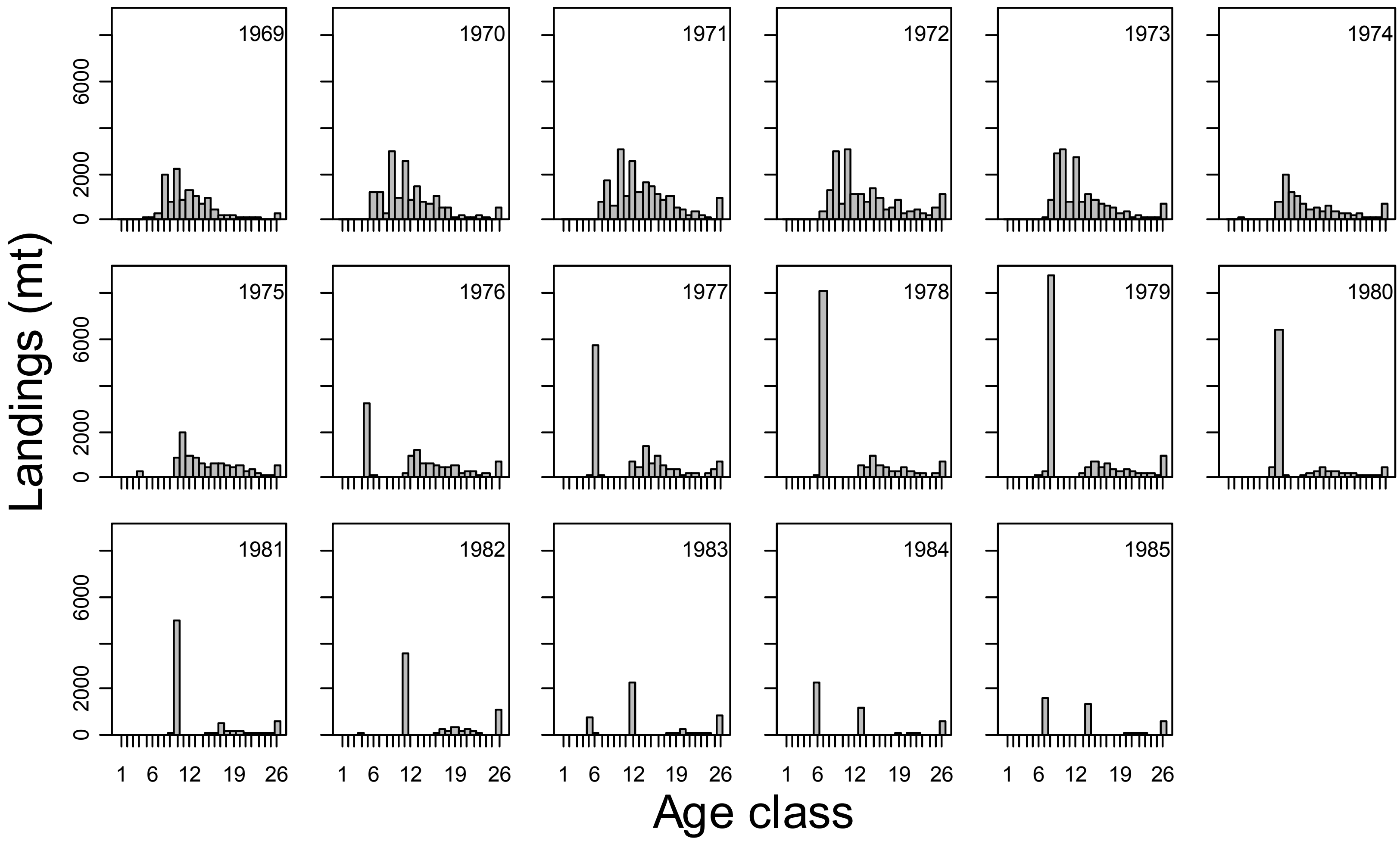

Figure N2. Estimated annual landings (mt) at age for Gulf of Maine-Georges Bank Acadian redfish between 1969-1985.

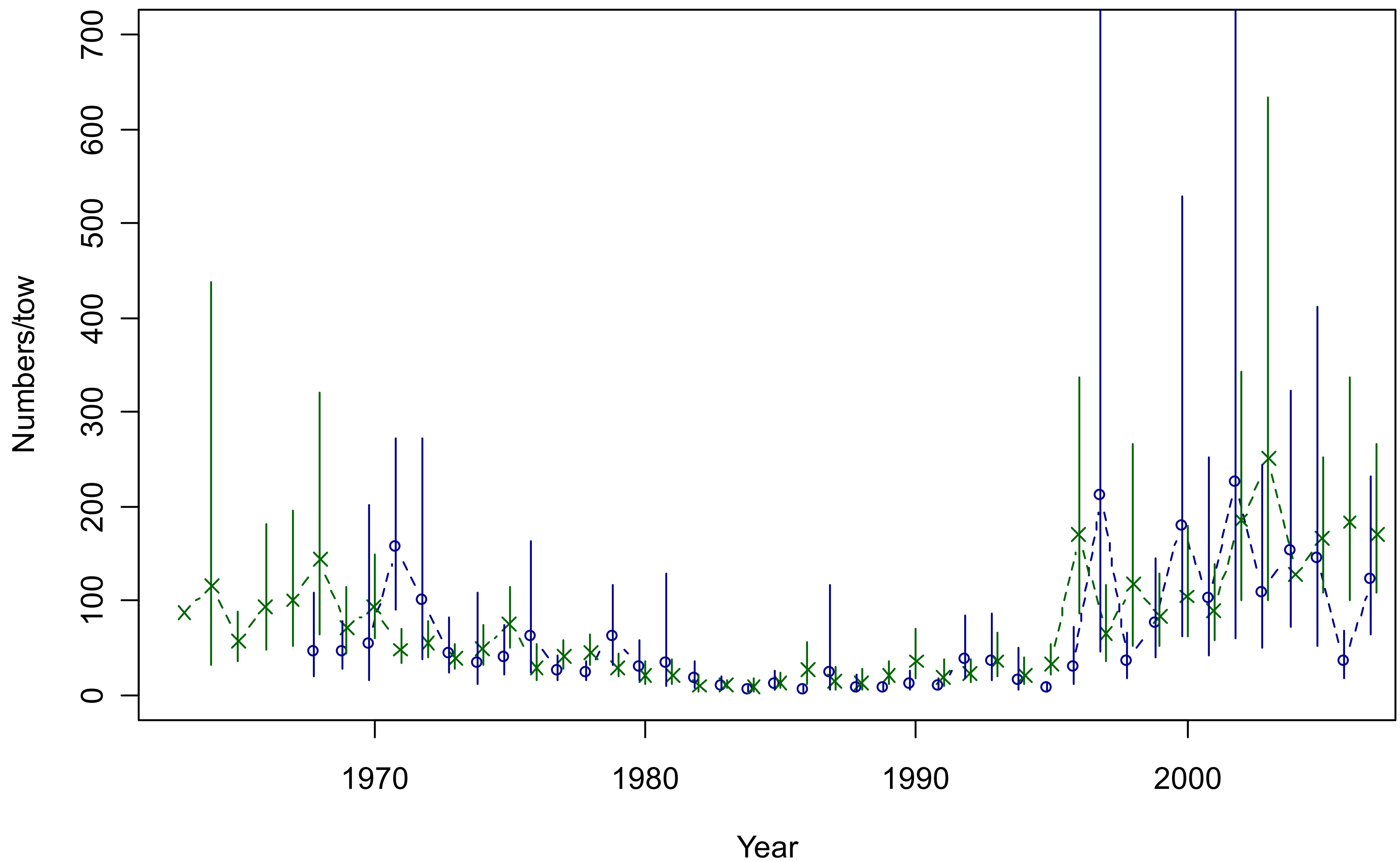

Figure N3. Estimated numbers-per-tow for Gulf of Maine-Georges Bank Acadian redfish in the NEFSC spring (blue, circle) and autumn (green, x) survey over all inshore and offshore strata. Vertical bars represent approximate 95% confidence intervals.

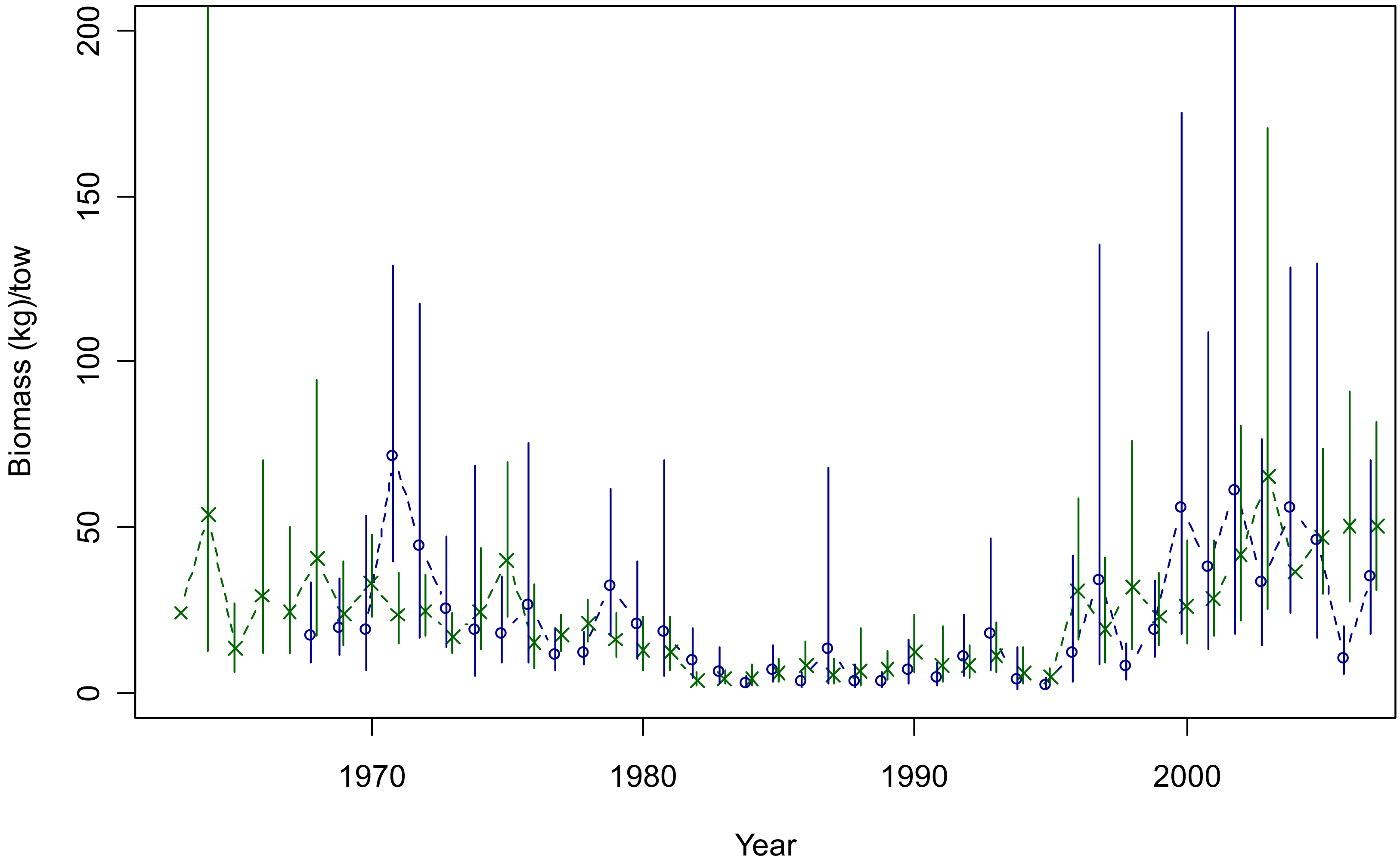

Figure N4. Estimated biomass-per-tow for Gulf of Maine-Georges Bank Acadian redfish in the NEFSC spring (blue, circle) and autumn (green, x) survey over all inshore and offshore strata. Vertical bars represent approximate 95% confidence intervals.

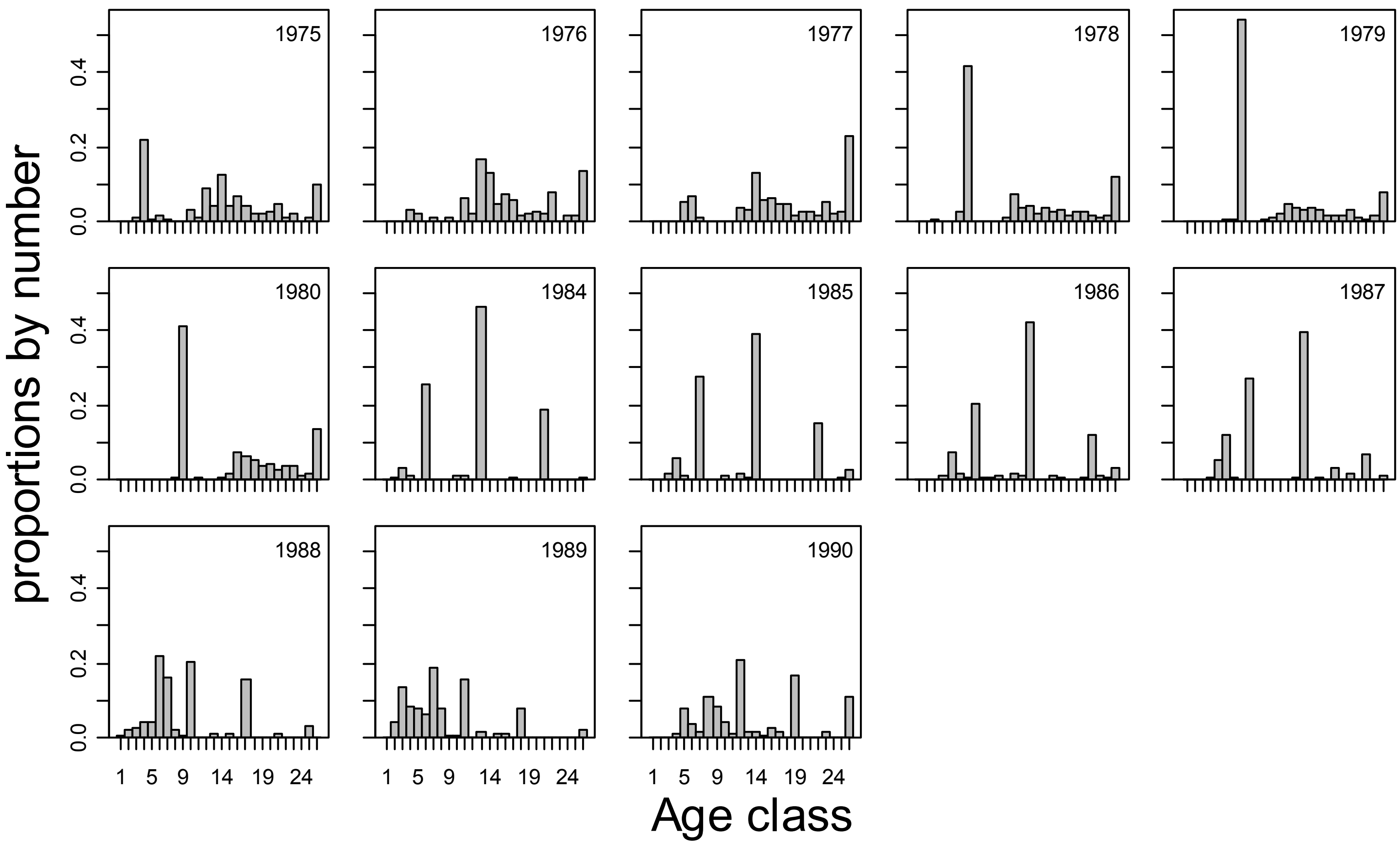

Figure N5. Estimated proportions at age for Gulf of Maine-Georges Bank Acadian redfish in the NEFSC spring survey.

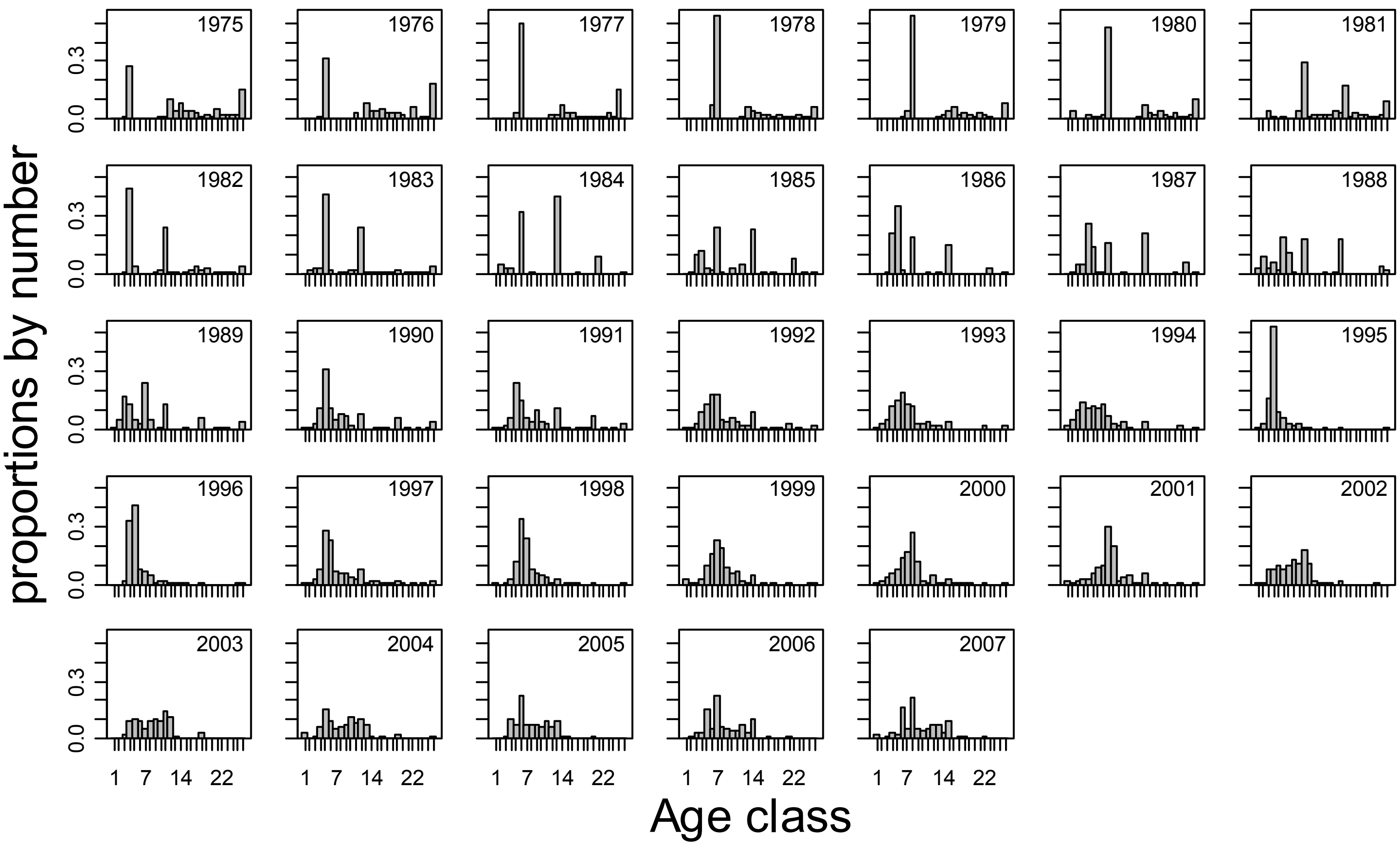

Figure N6. Estimated proportions-at-age for Gulf of Maine-Georges Bank Acadian redfish in the NEFSC autumn survey.

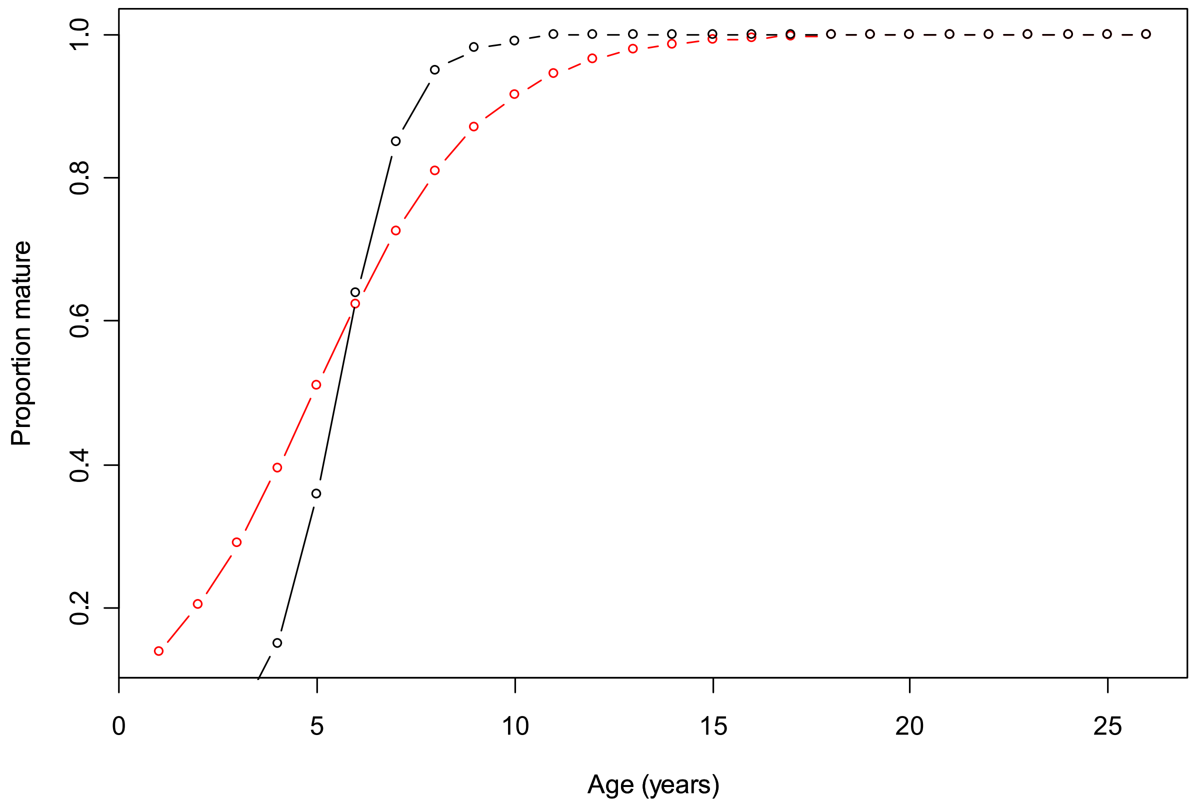

Figure N7. Proportion mature-at-age assumed in previous assessments (black) and estimated for females (red line) maturity and age data from Gulf of Maine-Georges Bank Acadian redfish caught in spring bottom trawl surveys.

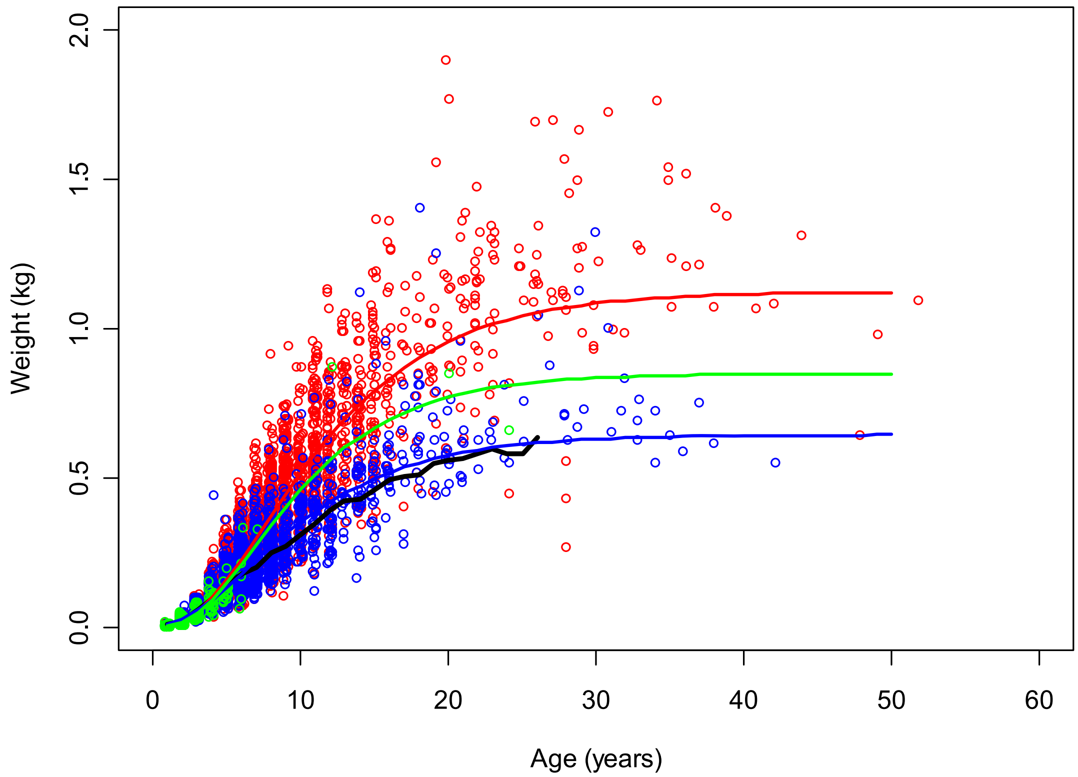

Figure N8. Weight-at-age assumed in previous assessments (black line) and estimated for females (red line), males (blue line) and combined (green line) from length, weight and age data from Gulf of Maine-Georges Bank Acadian redfish caught in bottom trawl surveys. Red, blue and green points represent female, male and unknown sex individuals.

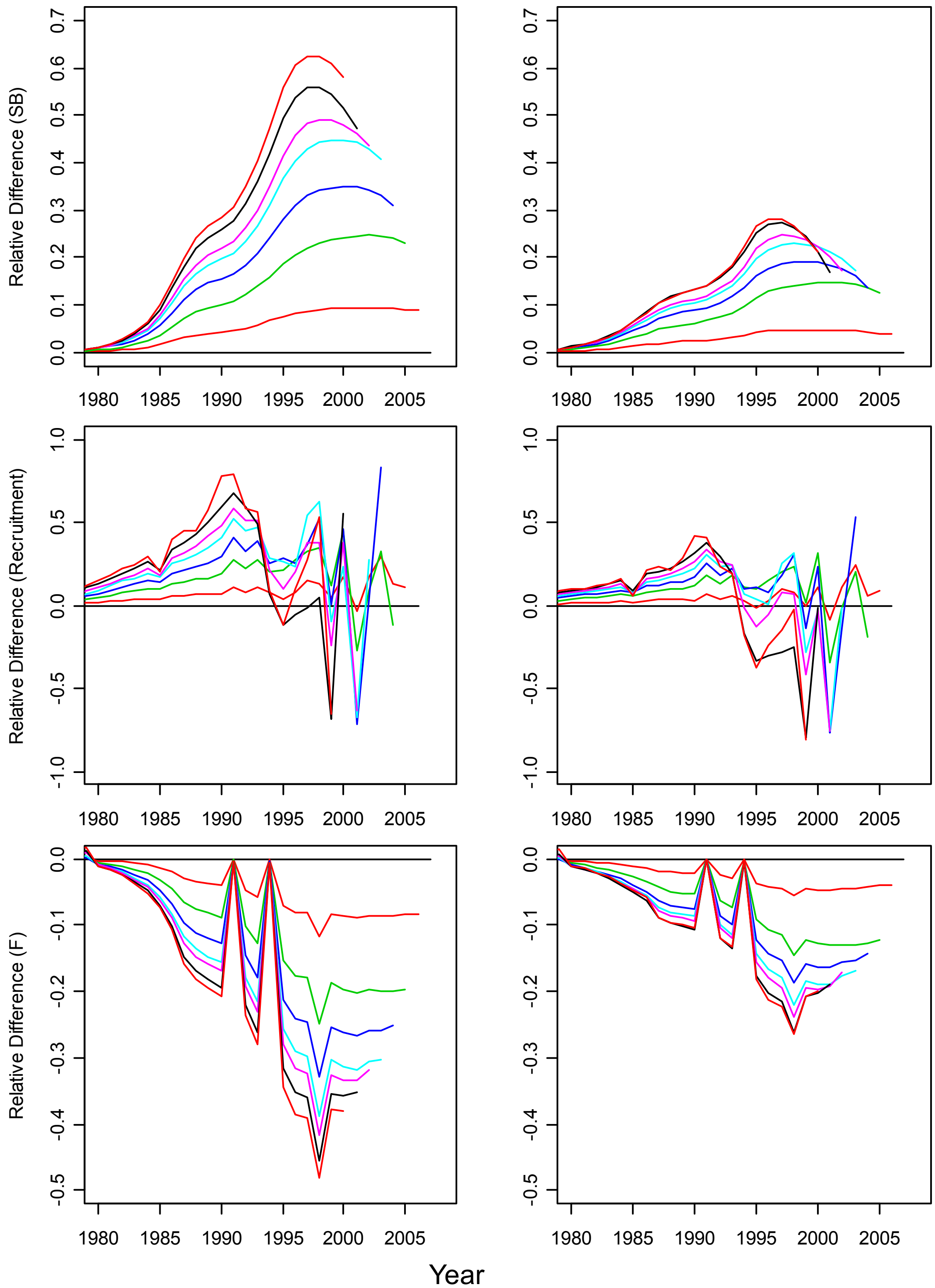

Figure N9. Retrospective patterns for relative differences in spawning biomass (top), recruitment (middle) and fishing mortality (bottom) from the ASAP base (final) model including 2007 data (left) and the ASAP alternate (M = 0.1) model (right).

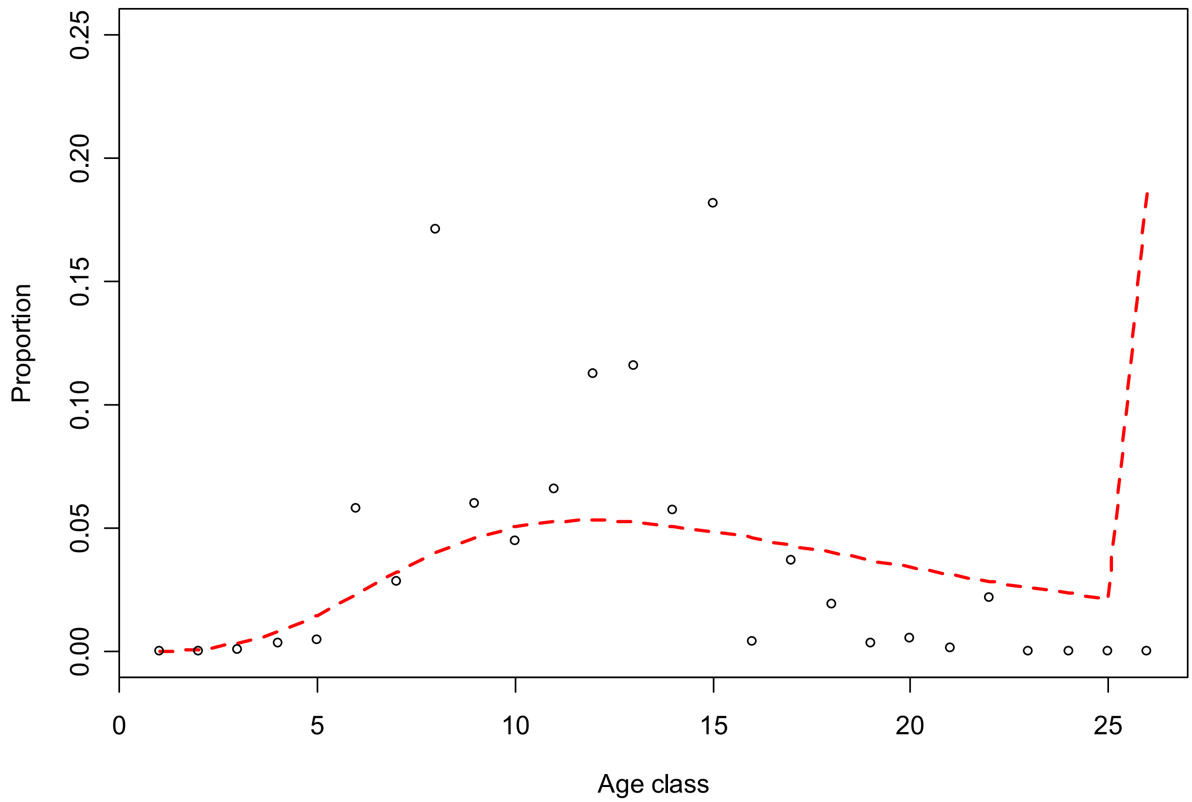

Figure N10. Estimated proportion of biomass-at-age for autumn survey in 2007 (circles) and at equilibrium with M = 0.1, F = 0.01 and selectivity-at-age as estimated under the ASAP model with M = 0.1 (red dashed line).

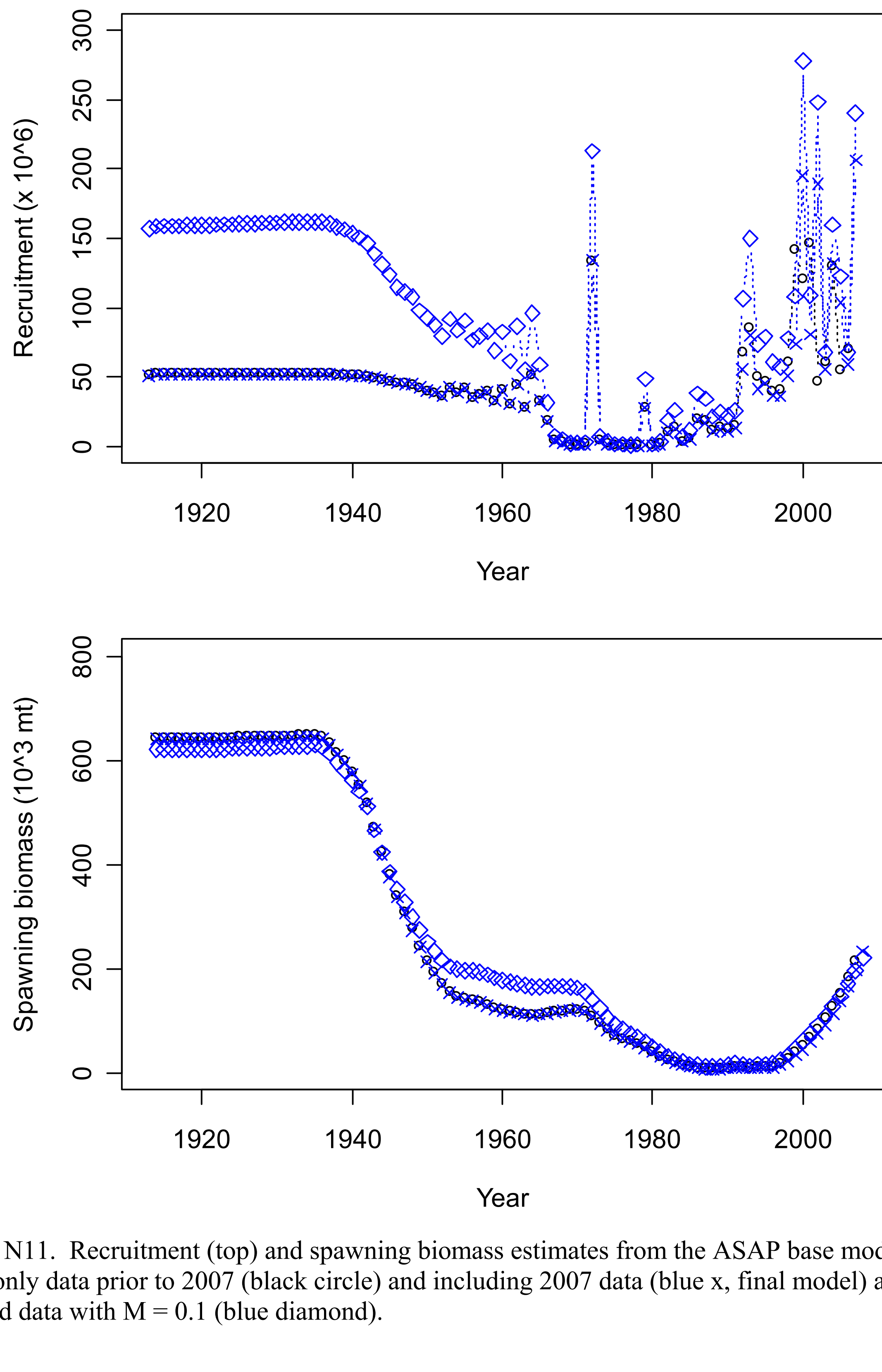

Figure N11. Recruitment (top) and spawning biomass estimates from the ASAP base models using only data prior to 2007 (black circle) and including 2007 data (blue x, final model) and updated data with M = 0.1 (blue diamond).

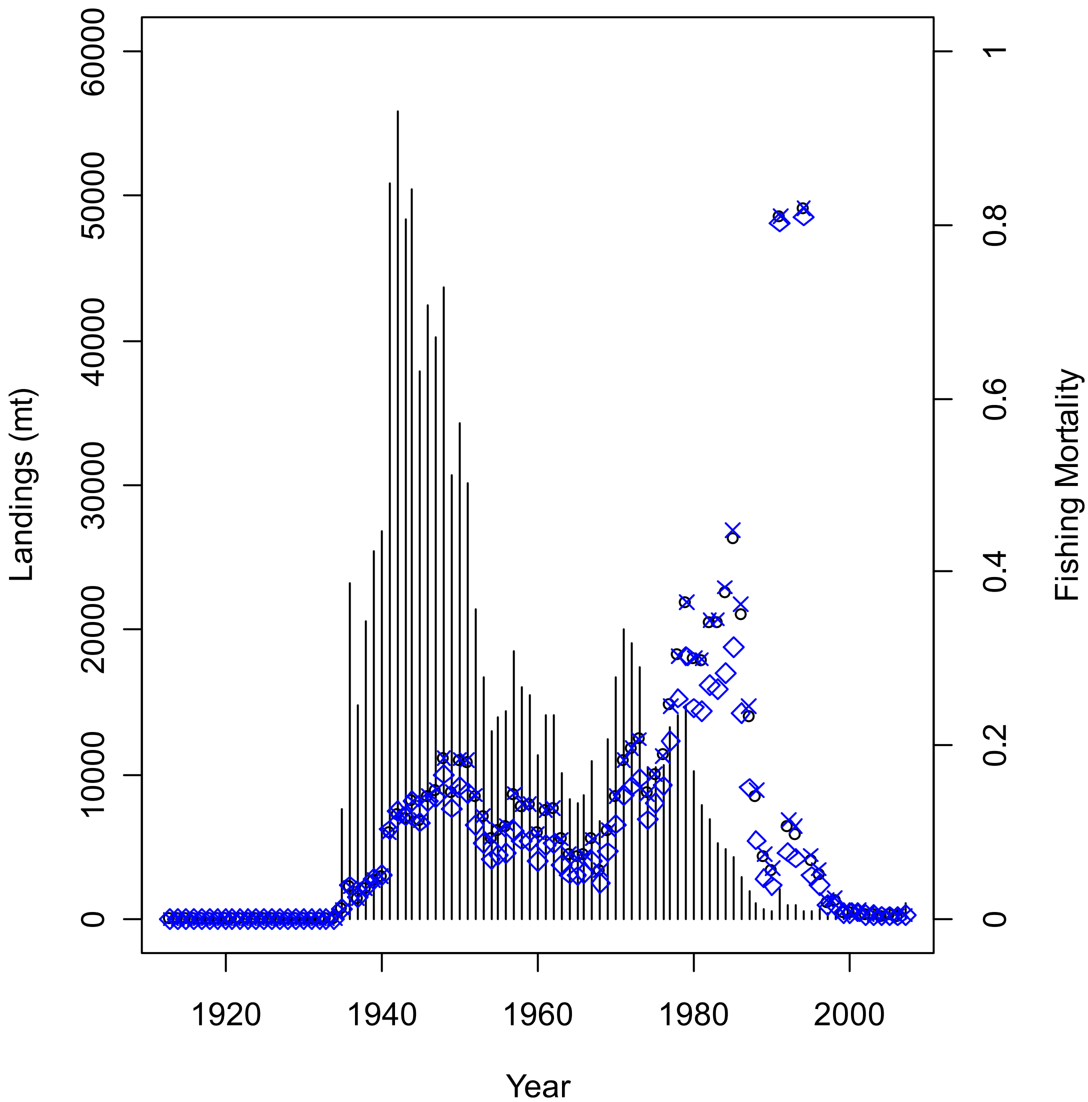

Figure N12. Landings and fully selected fishing mortality estimates from the ASAP base models using only data prior to 2007 (black circle) and including 2007 data (blue x, final model) and updated data with M = 0.1 (blue diamond).

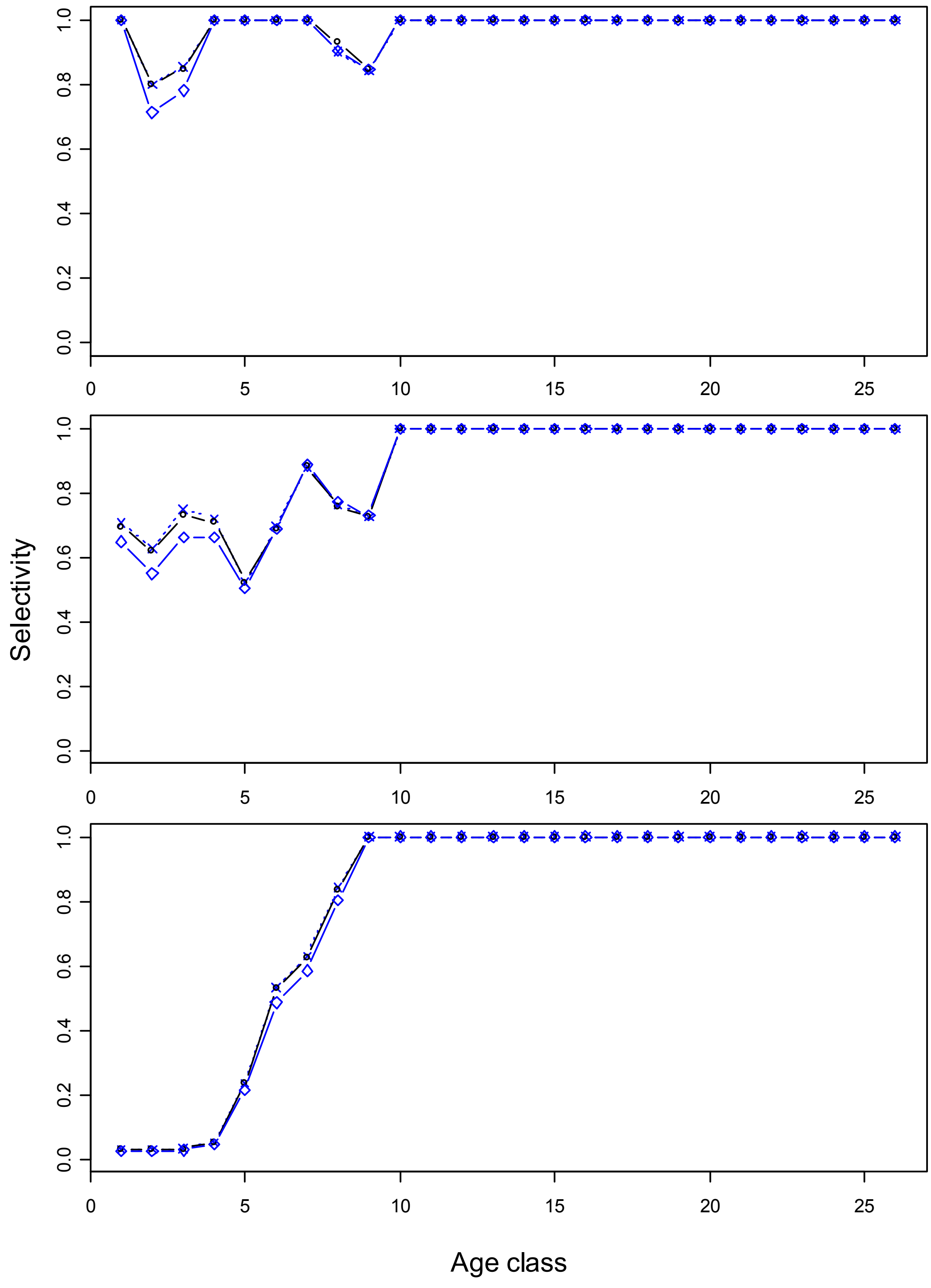

Figure N13. Selectivity-at-age for the NEFSC autumn (top) and spring (middle) surveys and the fishery (bottom) as estimated from the ASAP base models using only data prior to 2007 (black circle) and including 2007 data (blue x, final model) and updated data with M = 0.1 (blue diamond).

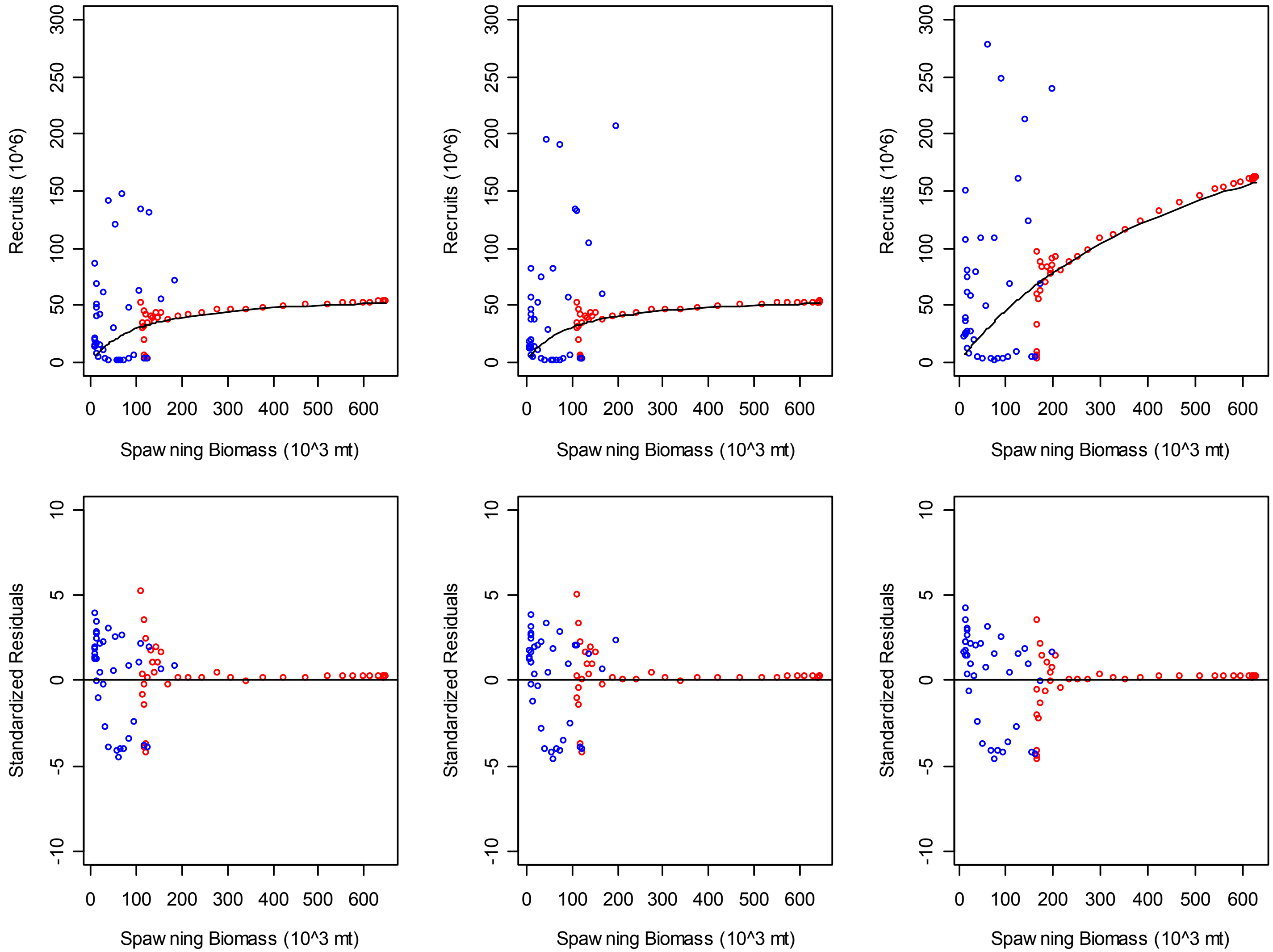

Figure N14. Spawning biomass and recruitment (top) and spawning biomass and standardized recruitment residuals (bottom) from the ASAP base models using data prior to 2007 (left) and including 2007 data (middle, final model) and the ASAP alternate (M = 0.1) model using data from all years (right). The blue and red points are for years where survey age observations are or are not available, respectively.

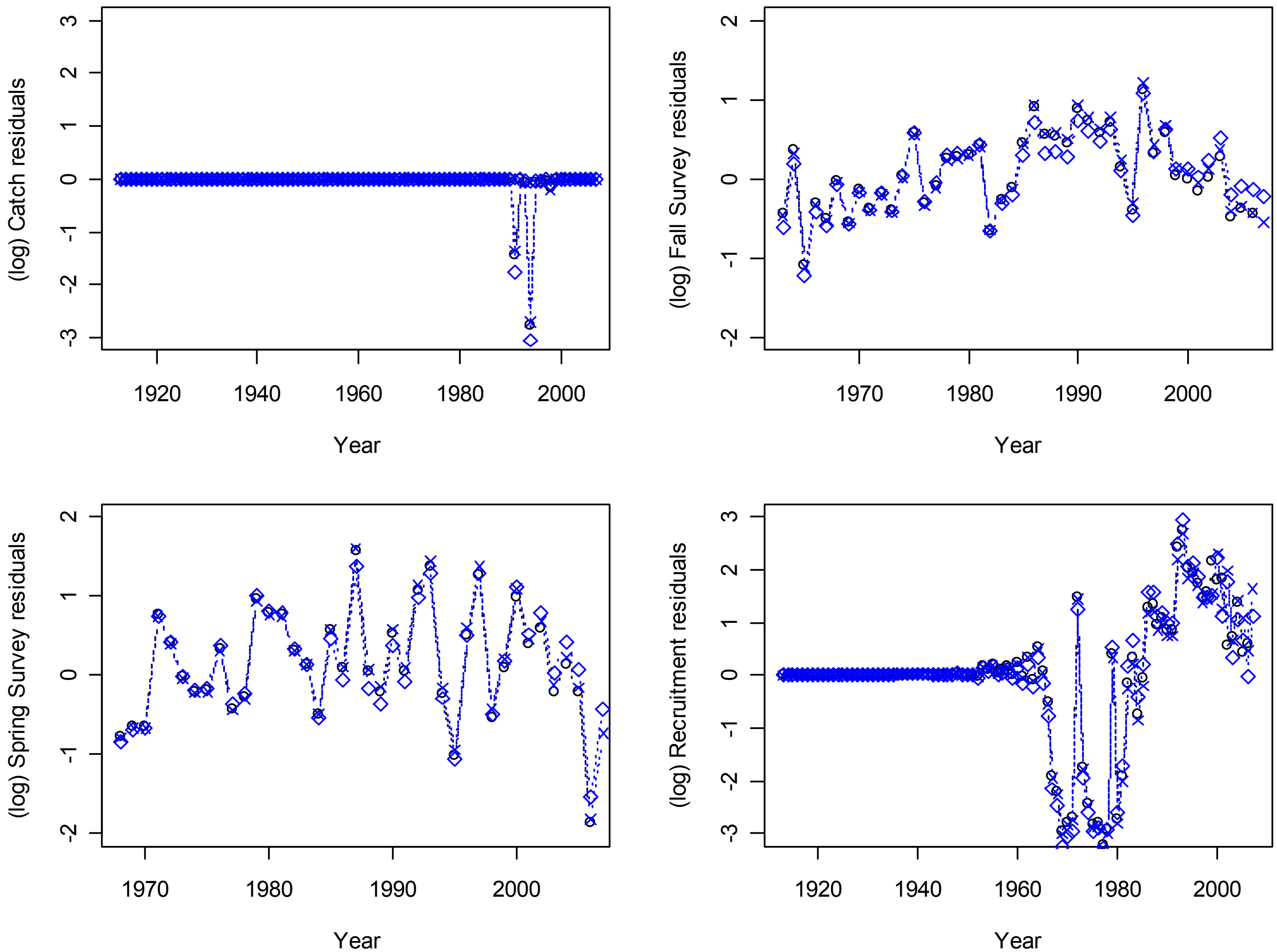

Figure N15. Model residuals for log catch, autumn and spring survey biomass-per-tow and recruitment produced by ASAP base models using only data prior to 2007 (black circle) and including 2007 data (blue x, final model) and updated data with M = 0.1 (blue diamond).

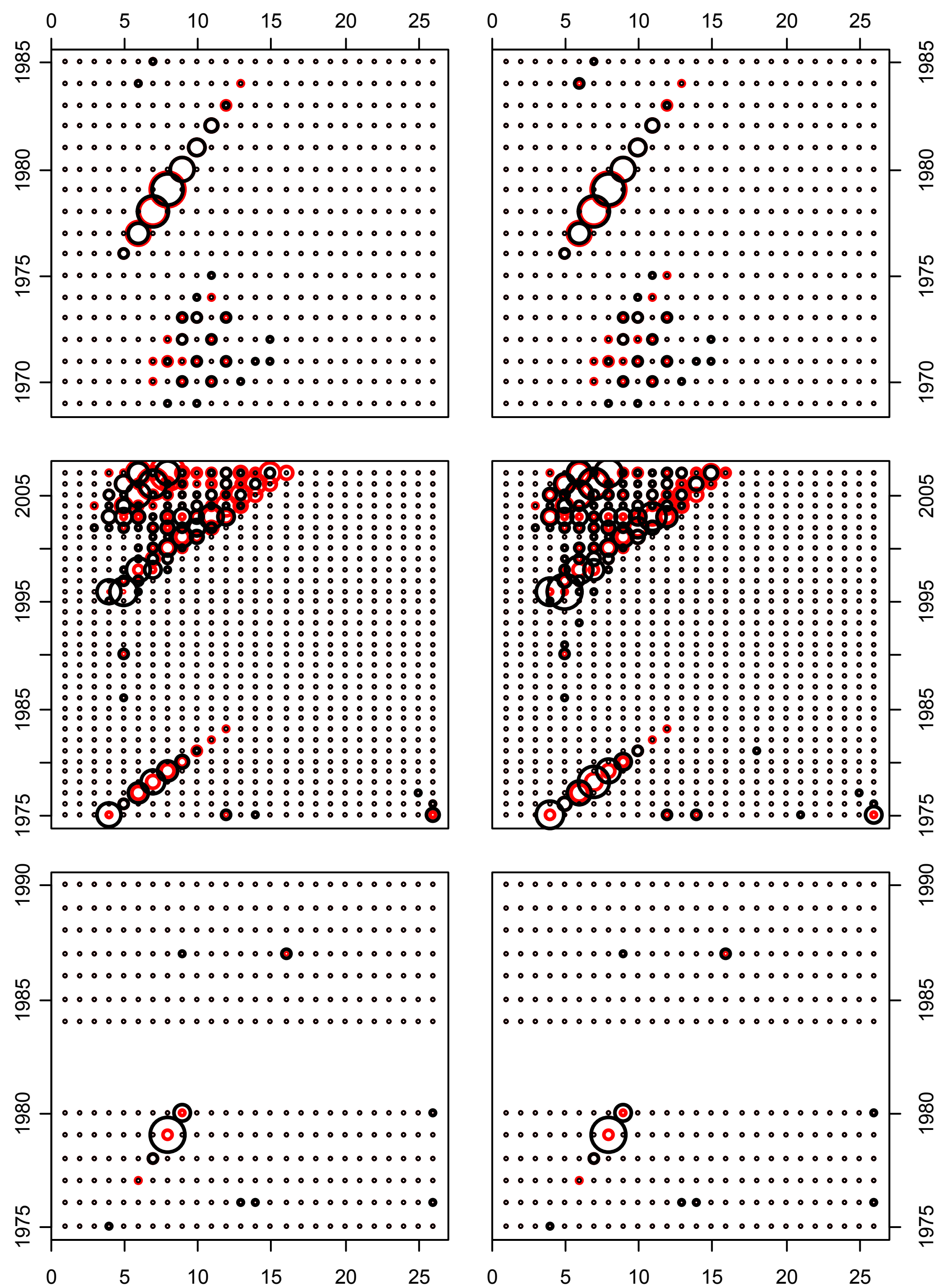

Figure N16. Observed (black) and predicted (red) numbers-at-age for ASAP base (left, final model) and alternate (M = 0.1) (right) models in landings (top), autumn survey (middle) and spring survey (bottom).

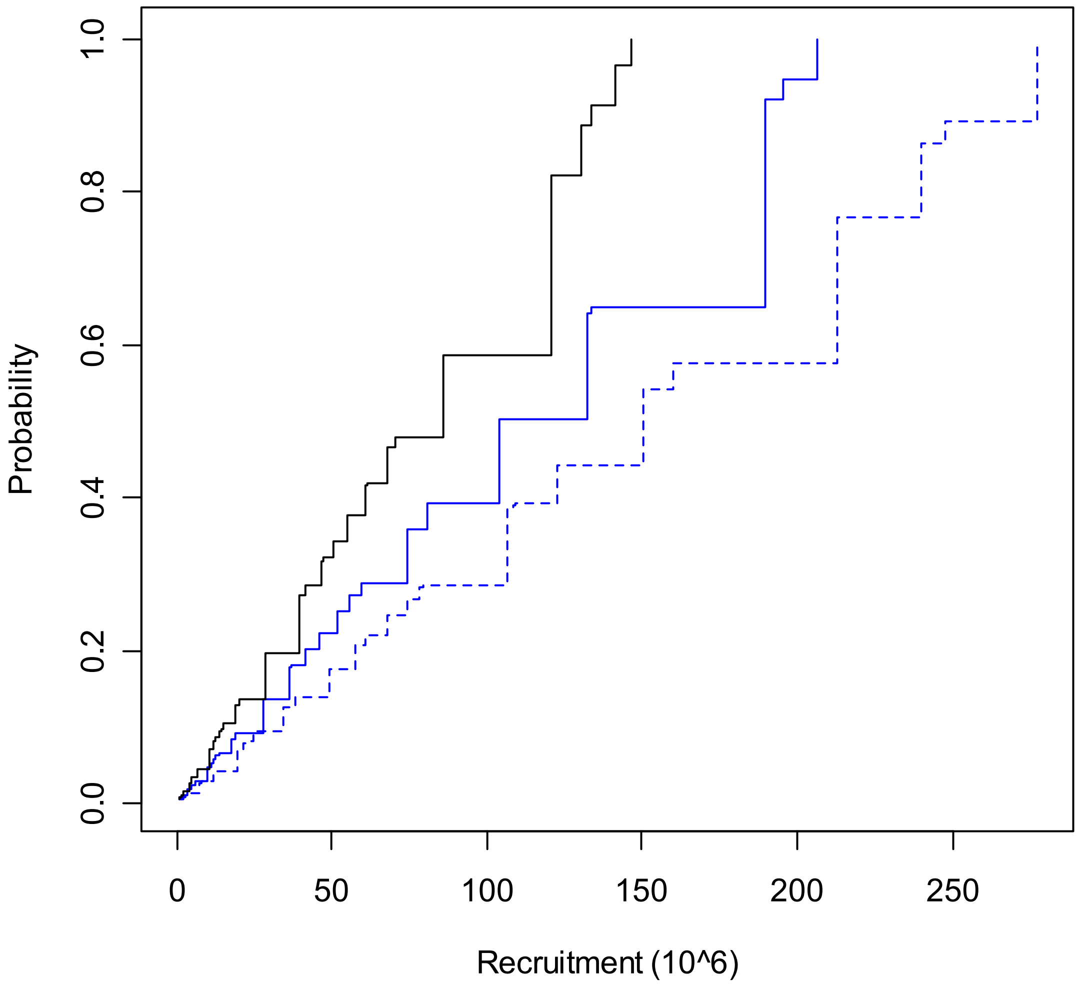

Figure N17. Cumulative distributions of the recruitment estimates from 1969 to present provided by the ASAP base models using data prior to 2007 (black) and including 2007 data (solid blue, final model) and the ASAP alternate (M = 0.1) model using data from all years (dashed blue).

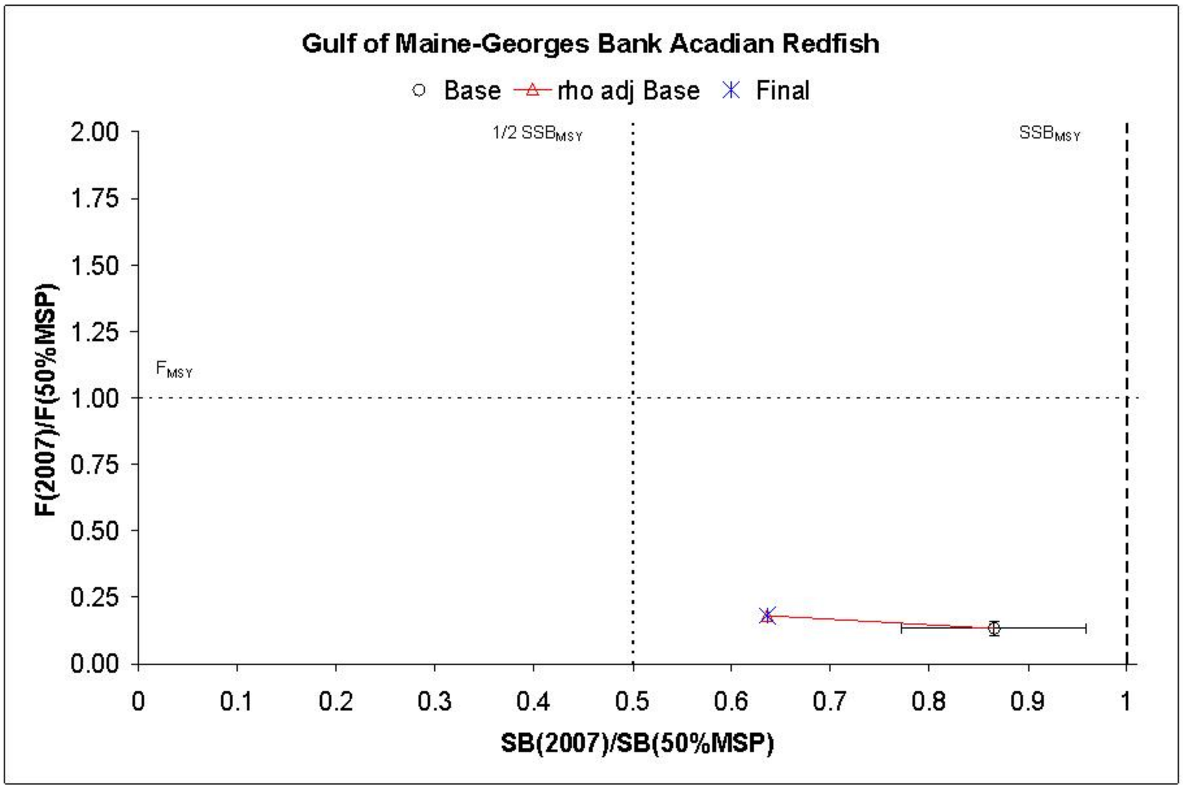

Figure N18. Stock status in 2007 using the base ASAP model and recruits in 1969-2006 (black open circle) and final status (black x and red triangle) given by adjusting status from base (final) model by the retrospective statistic. Vertical and horizontal bars around status points are 80% confidence intervals based on ASAP provided standard errors. Vertical and horizontal dotted lines represent MSY-proxy thresholds for defining whether the stock is overfished or overfishing is occurring, respectively.

O. Ocean pout
by S.E. Wigley, L. Col, and C.M. Legault

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

1.0. Background

Ocean pout, *Zoarces americanus*, are assessed as a unit stock from Cape Cod Bay south to Delaware. An index assessment for this species was last reviewed at the 2005 Groundfish Assessment Review Meeting (Wigley and Col 2005). At that time, the three year average spring biomass index (2002-2004 average = 1.78 kg/tow) was below the biomass threshold (½ B_{MSY} = 2.4 kg/tow) of the B_{MSY} proxy (1980-1991 median = 4.9 kg/tow). The relative exploitation ratio (0.003) indicated that fishing mortality was well below the F threshold (F_{MSY} proxy = 0.31). 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 O1, Figures O1 and O2). 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 (Table O2). Total landings in 2007 were 4 mt, a record low in the time series (Table O1, Figure O2).

Dock-side sampling of commercial ocean pout landings began in 1984 (Appendix Table O1; NEFSC 2008); 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.

Discard Estimation

The primary reason reported in the Northeast Fisheries Observer Program[1] (NEFOP) for ocean pout discards is "no market". 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 Cape Cod Bay, Georges Bank and Southern New England and

[1] Northeast Fisheries Observer Program was implemented in 1989.

Mid-Atlantic regions[2]. 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 – 2007 (Appendix Tables O2 and O3).

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 O4). Total discards range between 175 mt in 2007 to 9,434 mt in 1990 (Table O3 and Figure O2). 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 (Tables O1 and O3).

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 O4 and Figure O2). 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 2007 index (0.48 kg/tow) is the lowest value in the time series. 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 O5 and O6, Appendix Figures O1 and O2). Decreases in maximum size can be observed in the NEFSC spring survey length frequencies over time (Appendix Figure O3).

Survey conversion factors

There are no significant net or door conversion factors for ocean pout, however, there are significant vessel conversion factors 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 spring (Appendix Figure O4). 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. In this assessment, the vessel conversion factors have been applied as an 'alternative' series for comparison purposes only. Trends in survey catch with vessel conversion factors are given in Appendix Table O7 and Appendix Figure O5.

[2] statistical areas (514, 521,522,561,562,525,562,537-539,611-616).

4.0 Assessment

In the previous assessment, the data for ocean pout had insufficient dynamic range over the time series to provide estimates for biological reference points; however, for this assessment, the AIM model was explored using catch through 2006 and a three-year centered average of the NEFSC spring biomass (kg/tow) index through 2007. Exploratory analyses were conducted to evaluate the effect of using survey vessel conversion factors and the sensitivity of the discard estimates. Two series of analyses were conducted, with and without vessel conversion factors. Each series used a range of catch values: landings only, catch (landings and discards), catch derived using half of the discard estimate, and catch derived using twice the discards. Similar to the previous AIM analyses (NEFSC 2002), all AIM runs were non-informative to base recommendation for B_{MSY}, F_{MSY} and MSY (Appendix Table O8). The AIM analysis was updated to include catch through 2007 and the 2008 NEFSC spring biomass index; the lack of a significant relationship between relative F and replacement ratio persisted (Appendix Figure O6).

Exploratory analyses were also conducted using an age-structured biomass dynamic model (LOSS; Palmer and Legault 2008). Analyses were conducted using a range of values for stock-recruit steepness, stock depletion (S1/S0) and initial stock size while holding other input parameters constant. Natural mortality was assumed constant (0.2); mean weights-at-age, maturity-at-age, fishing selectivity and index selectivity were estimated for ocean pout based on information provided within FISHBASE[3]. These results were also non-informative, with little change occurring in the objective function with large changes in reference points and stock status (Appendix Tables O9a and O9b).

Relative Exploitation Rate

Computing survey biomass indices of exploitable biomass for use in calculating exploitation ratio was explored. However, 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.

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). 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 O5, Figure O3). The 2007 exploitation index is 0.38. Exploitation ratios derived using the survey biomass indices adjusted by the vessel conversion factor are presented in Appendix Table O10.

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 B_{MSY} that appeared to be sustainable. The B_{MSY} 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. F_{MSY} proxy (0.31) was derived from MSY and B_{MSY} proxy.

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[3] http://www.fishbase.org/search.php

With discards estimated in this assessment, 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 B_{MSY} and F_{MSY} proxies, respectively. The 1977-1985 time period corresponds to the time when the replacement ratio was above 1 and biomass increased (Appendix Figure O6). 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 re-estimated proxies for GARM 2008 that were accepted by the GARM Biological Reference Point Meeting Panel.

GARM 2005 using landings	GARM 2008 using catch
B_{MSY} = 4.9 kg/tow F_{MSY} = 0.31 MSY = 1,500 mt	B_{MSY} = 4.94 kg/tow F_{MSY} = 0.76 MSY = 3,754 mt

Trends in average survey biomass indices and relative exploitation rates are given in Figure O4. Since the mid-1990s, the 3yr average survey biomass index has been at or below the ½ B_{MSY} proxy and the relative exploitation rate has been below the F_{MSY} proxy (Table O5 and Figure O4).

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 O5)

6.0 Projections

No projections have been conducted for ocean pout.

7.0 Stock Status Summary

The base analysis presented above was accepted as the final analysis. The three year average of NEFSC spring survey indices and the exploitation ratio (2007 catch / average of 2006, 2007, 2008 spring survey biomass indices) are used as proxies for biomass and fishing mortality, respectively. In 2007, the three year average survey index (0.48 kg/tow) was 10% of the B_{MSY} proxy (1977-1985 median = 4.94 kg/tow; Figure O6). The relative exploitation ratio (0.38) indicates that fishing mortality was 50% of the F threshold (F_{MSY} proxy = 0.76; Figure O6). In 2007, 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 exceeds 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 B_{MSY}, F_{MSY}, 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

Discards have been estimated for 1968 onward for four fleets (large-mesh otter trawl, small-mesh otter trawl, gillnet and scallop dredge). Biological references points have been updated using total catch.

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 Panel Discussion/Comment

Conclusions

The Panel noted the unsuccessful application of the Relative Trends Model (AIM) to this stock. The Panel accepted the analysis notwithstanding the following concerns. The relationship between the Replacement Ratio and the Relative Exploitation Rate, that was significant at the time of GARM II is now weak. This is largely attributed to the four most recent, and low, Relative Exploitation Ratio estimates, which are among the lowest in the time series. However, the trend in the survey abundance index (used for the Replacement Ratio) continues downward. Thus, the GARM II AIM analysis was not updated and status is based upon interpretation of trends in the NMFS spring survey time series in relation to fishery catches. In relation to the latter, it is important to note that the BRPs have been adjusted to include discards and not just landings.

As was noted at the GARM III 'models' review; it is possible that the stock's dynamics have been so severely impacted by historical overfishing, that it may not be possible to determine the link between exploitation rate and productivity. The lack of response of the resource to a reduction in exploitation suggests that ocean pout may be in a depensatory state where the stock unlikely to rebuild to BRPs even in the absence of removals. Limiting catch may not result in a positive stock response.

Research Recommendations

The Panel noted that the spatial contraction of the stock may be leading to local depletion. It encouraged the examination of the stock's distribution in association with changes in abundance to provide more insight on the resource's status and dynamics at low population sizes.

9.0 Acknowledgements

We would like to recognize and thank all those who diligently collected data from the commercial fisheries (port and at-sea) and the research vessel surveys. We thank Jessica Blaylock for her assistance. We thank all the members of the Groundfish Assessment Review Meeting for their review and helpful comments.

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Table O1. Commercial landings and discards (mt, live) of ocean pout from the Gulf of Maine to the Mid-Atlantic region (NAFO Subareas 5 and 6), 1962-2007.

	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	175.0	178

Table O2. Percentage of annual commercial landings of ocean pout by gear type, 1964 -2007.

YEAR	Longline & Handline	Otter Trawl	Fish Pot	Lobster Pot	Unknown	Other	Total
1964		100.0					100.0
1965		100.0					100.0
1966		100.0					100.0
1967		100.0					100.0
1968		100.0					100.0
1969		100.0					100.0
1970		100.0					100.0
1972		100.0					100.0
1973		100.0					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		0.1	100.0
1991	1.2	97.5	1.2	0.0		0.1	100.0
1992	6.6	90.1	2.5	0.0		0.7	100.0
1993	5.3	91.3	2.2	0.3		1.0	100.0
1994	4.7	91.2	3.2	0.2	0.0	0.6	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	2.7	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	2.1	0.1	100.0
2002	1.1	73.8	12.6	5.7	6.4	0.5	100.0
2003	4.9	80.3	6.9	0.9	0.1	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	11.2	1.3	100.0
2007	12.9	44.4	15.2	16.3	5.0	6.2	100.0

Table O3. 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 – 2007. 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 2007. 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	143.4	0.11	26.3	0.44	0.8	0.78	4.3	0.28	175.0	0.11

Table O4. 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 without conversion factors applied**, in the Gulf of Maine-Mid-Atlantic region (strata 1-26, 73-76), 1968-2007; 2008 preliminary

	without vessel conversion factors				
Year	Mean weight per tow (kg)	Mean number per tow	Individual average weight (kg)	Mean length (cm)	Swept-area population biomass (mt)
1968	5.446	6.768	0.805	51.1	17,065
1969	6.154	8.629	0.713	49.3	19,282
1970	5.143	6.133	0.839	51.9	16,115
1971	2.195	3.135	0.700	50.2	6,879
1972	4.463	5.104	0.874	51.6	13,986
1973	3.373	4.591	0.735	48.8	10,569
1974	1.479	2.310	0.640	47.0	4,636
1975	1.293	1.358	0.952	53.4	4,052
1976	1.400	2.440	0.574	46.5	4,387
1977	3.605	6.366	0.566	44.8	11,274
1978	3.371	11.831	0.285	31.6	10,562
1979	1.493	5.197	0.287	34.7	4,678
1980	5.729	11.837	0.484	42.6	17,952
1981	7.605	14.131	0.538	42.7	23,829
1982	4.743	8.690	0.546	44.0	14,863
1983	4.236	5.076	0.835	50.5	13,274
1984	5.540	7.275	0.762	50.0	17,359
1985	6.494	9.011	0.721	48.7	20,348
1986	6.345	6.995	0.907	53.0	19,880
1987	2.705	3.076	0.879	51.7	8,475
1988	3.244	5.405	0.600	45.0	10,165
1989	2.792	5.323	0.525	44.0	8,748
1990	5.074	6.369	0.797	50.3	15,898
1991	3.783	5.596	0.676	49.7	11,853
1992	2.257	2.639	0.855	52.9	7,071
1993	3.084	3.546	0.870	53.4	9,663
1994	2.309	2.640	0.875	54.3	7,234
1995	1.916	2.525	0.759	50.5	6,004
1996	2.058	3.127	0.658	47.6	6,450
1997	1.632	2.069	0.789	52.4	5,113
1998	1.733	2.957	0.586	46.1	5,430
1999	2.561	3.340	0.767	50.2	8,025
2000	2.016	3.113	0.648	48.2	6,317
2001	2.798	3.748	0.746	51.6	8,767
2002	2.025	2.809	0.721	51.3	6,345
2003	2.758	2.919	0.945	55.4	8,643
2004	0.546	0.673	0.812	50.8	1,712
2005	0.526	0.854	0.616	45.9	1,648
2006	0.526	0.789	0.667	47.4	1,649
2007	0.477	1.076	0.443	42.9	1,493
2008	*0.424*	*0.839*	*0.505*	*43.9*	1,327
mean 1968-2007	3.173				9,942
median 1968-2007	2.775				8,696

Table O5. 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 – 2007. Without vessel conversion factors applied.

	Year	NEFSC Spring Index kg/tow	Total Catch ('000, mt)	3 year moving average (kg/tow)	Exploitation ratio (catch/ 3yr avg index)
	1968	5.446	16.5379	5.800	2.851
	1969	6.154	30.1015	5.581	5.394
	1970	5.143	9.9378	4.497	2.210
	1971	2.195	7.9315	3.934	2.016
	1972	4.463	4.8492	3.344	1.450
	1973	3.373	6.6642	3.105	2.146
	1974	1.479	4.8659	2.048	2.375
	1975	1.293	0.9936	1.391	0.714
	1976	1.400	1.2002	2.099	0.572
	1977	3.605	1.9871	2.792	0.712
	1978	3.371	2.4126	2.823	0.855
	1979	1.493	2.1813	3.531	0.618
	1980	5.729	2.3659	4.942	0.479
	1981	7.605	2.9942	6.026	0.497
	1982	4.743	4.7605	5.528	0.861
	1983	4.236	4.8967	4.840	1.012
	1984	5.540	5.0162	5.423	0.925
	1985	6.494	4.6650	6.126	0.761
	1986	6.345	4.0984	5.181	0.791
	1987	2.705	4.8086	4.098	1.173
	1988	3.244	4.0546	2.914	1.392
	1989	2.792	8.7289	3.703	2.357
	1990	5.074	10.7460	3.883	2.768
	1991	3.783	6.3496	3.704	1.714
	1992	2.257	1.9940	3.041	0.656
	1993	3.084	1.5779	2.550	0.619
	1994	2.309	1.4769	2.436	0.606
	1995	1.916	0.6385	2.094	0.305
	1996	2.058	0.6796	1.869	0.364
	1997	1.632	0.5545	1.808	0.307
	1998	1.733	0.6899	1.975	0.349
	1999	2.561	0.8041	2.103	0.382
	2000	2.016	0.3668	2.458	0.149
	2001	2.798	0.5492	2.280	0.241
	2002	2.025	0.5879	2.527	0.233
	2003	2.758	0.4524	1.777	0.255
	2004	0.546	0.2960	1.277	0.232
	2005	0.526	0.2048	0.533	0.384
	2006	0.526	0.1875	0.510	0.368
	2007	0.477	0.1785	0.475	0.375
	2008	0.424			
mean	1968-2007	3.17		3.18	1.06
median 1968-2007		2.78		2.87	0.68
1980-91 median				4.89	0.97
1977-85 median				4.94	0.76

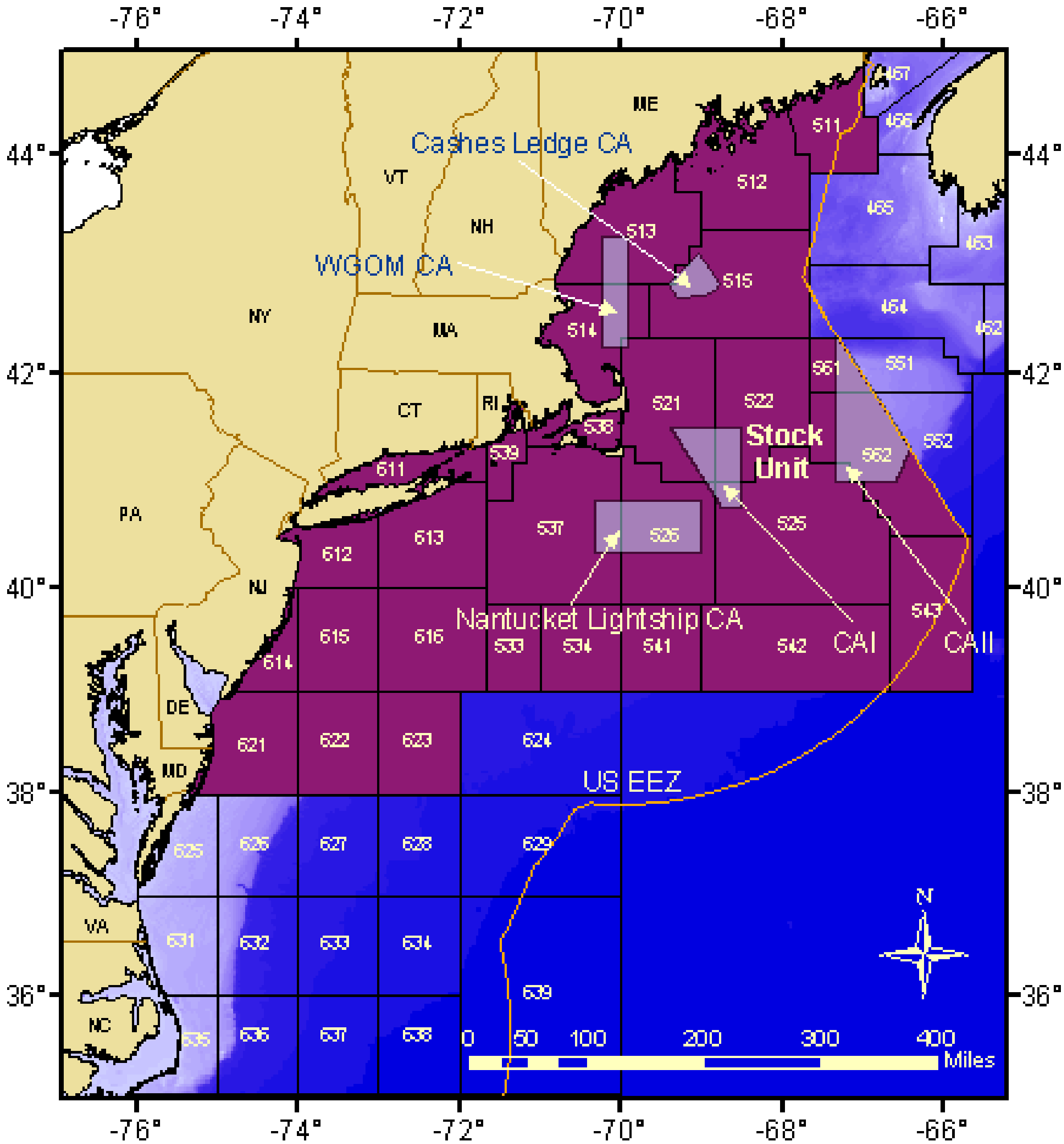

Figure O1. Statistical areas used to define the ocean pout stock.

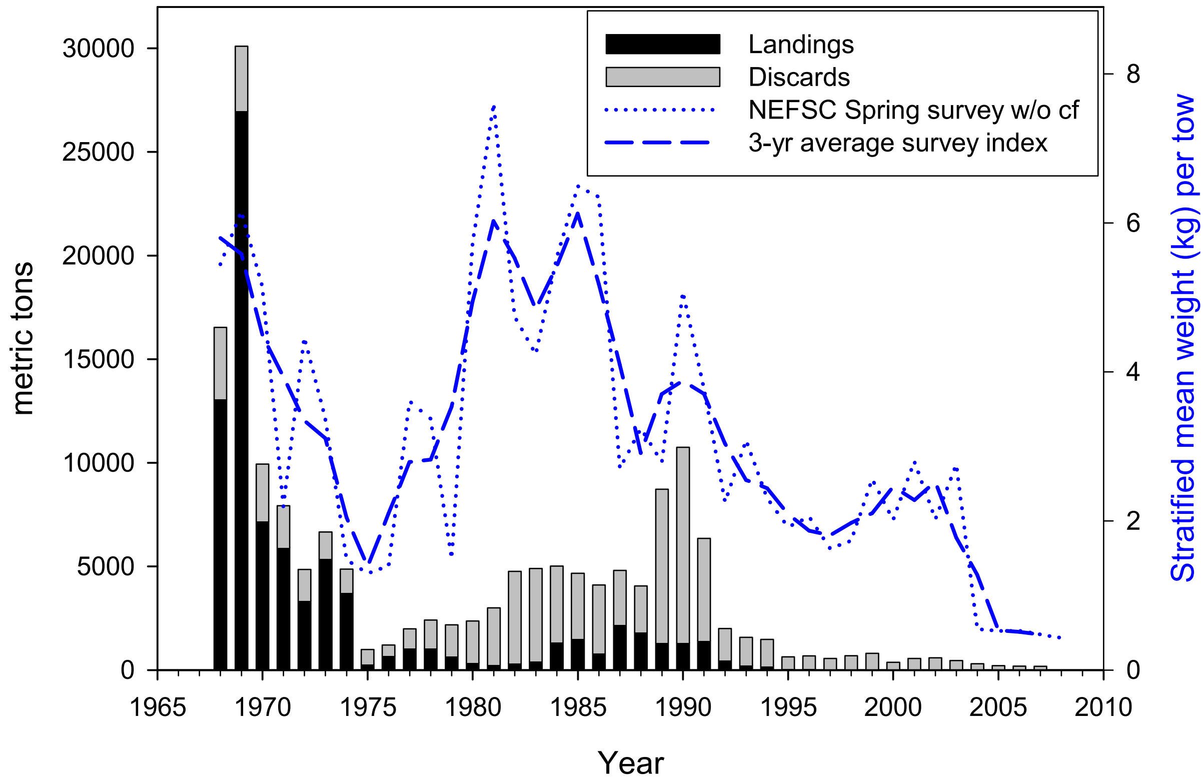

Figure O2. Trends in landings (mt), discards (mt) and NEFSC spring survey biomass (kg/tow) for ocean pout, 1968 – 2007.

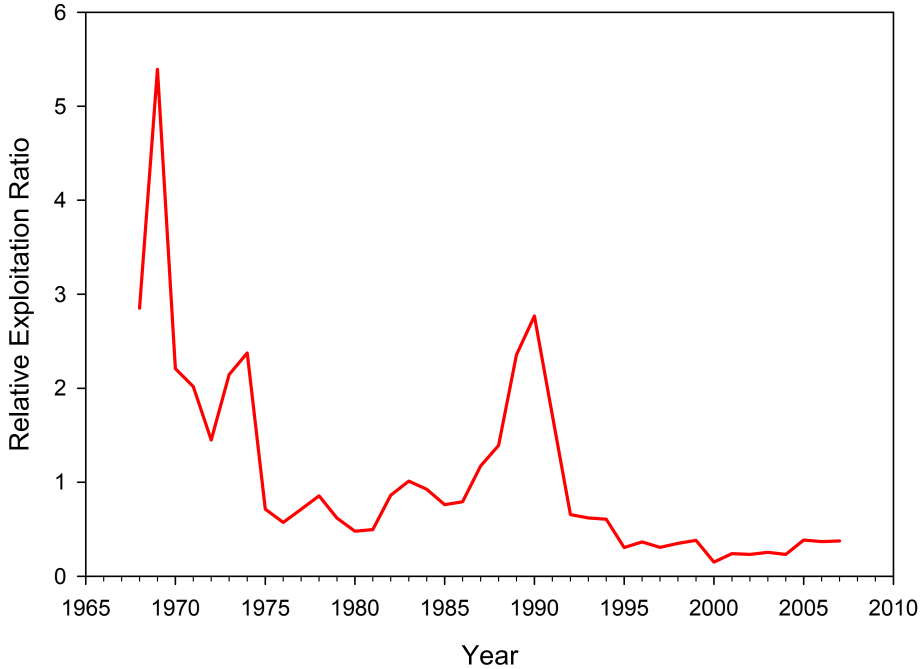

Figure O3. Trends in relative exploitation ratio (catch / 3-yr average of spring biomass index) for ocean pout, 1968 – 2007.

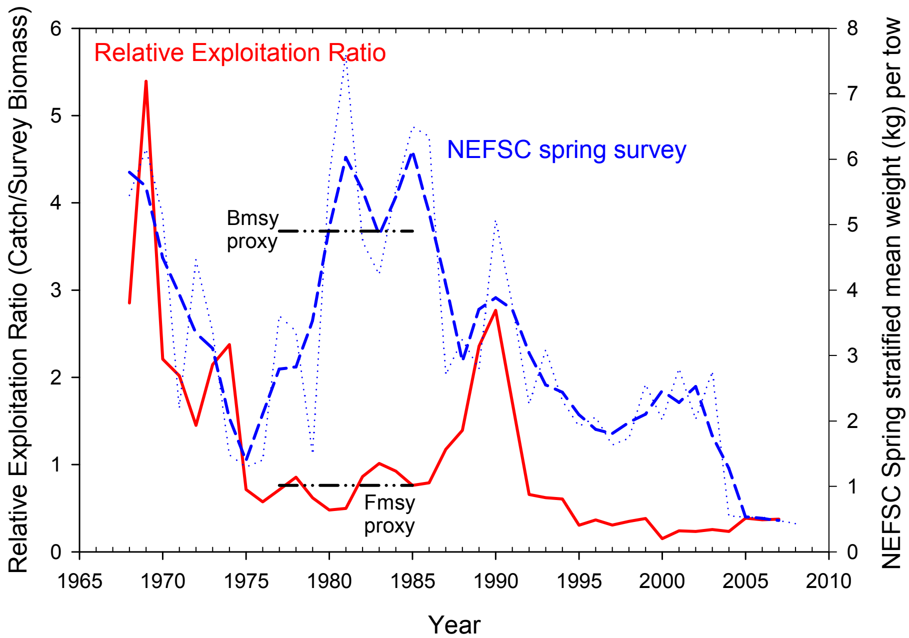

Figure O4. Trends in relative exploitation rate (catch / 3-yr average of spring biomass index) and NEFSC spring survey weight (kg) per tow for ocean pout, 1968 – 2007, with updated biological references point proxies based on total catch.

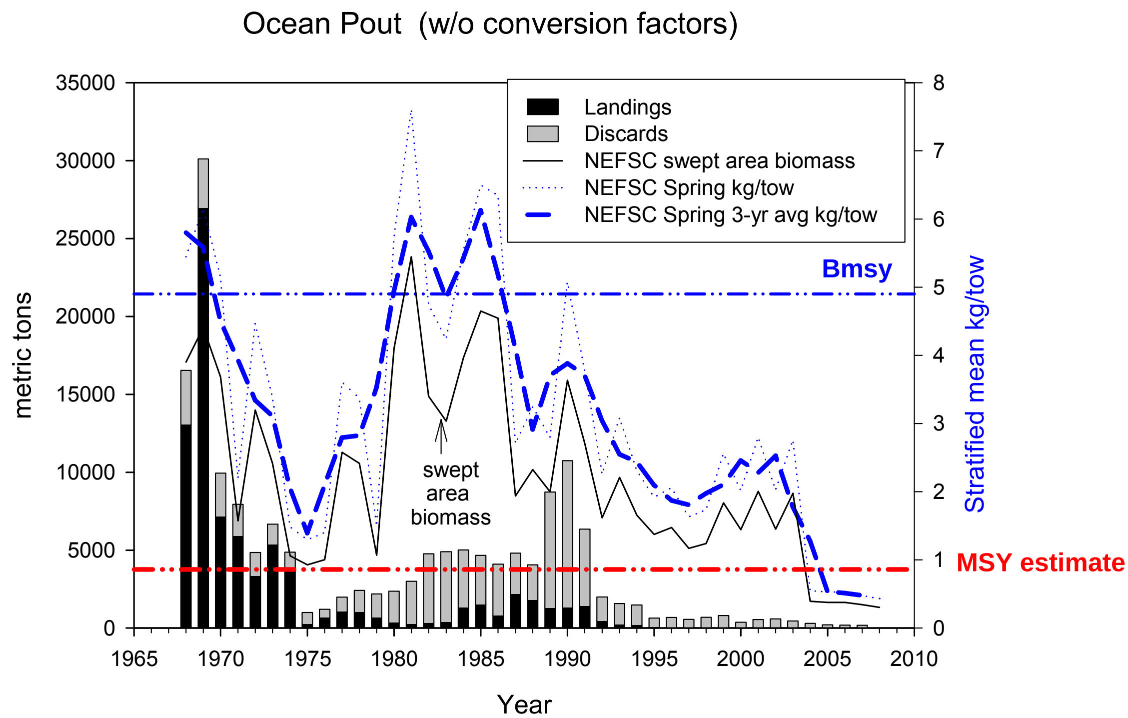

Figure O5. Trends in landings (mt), discards (mt), NEFSC spring survey biomass (kg/tow) and total population biomass (mt) for ocean pout, 1968 – 2007, with updated biological reference points based on total catch.

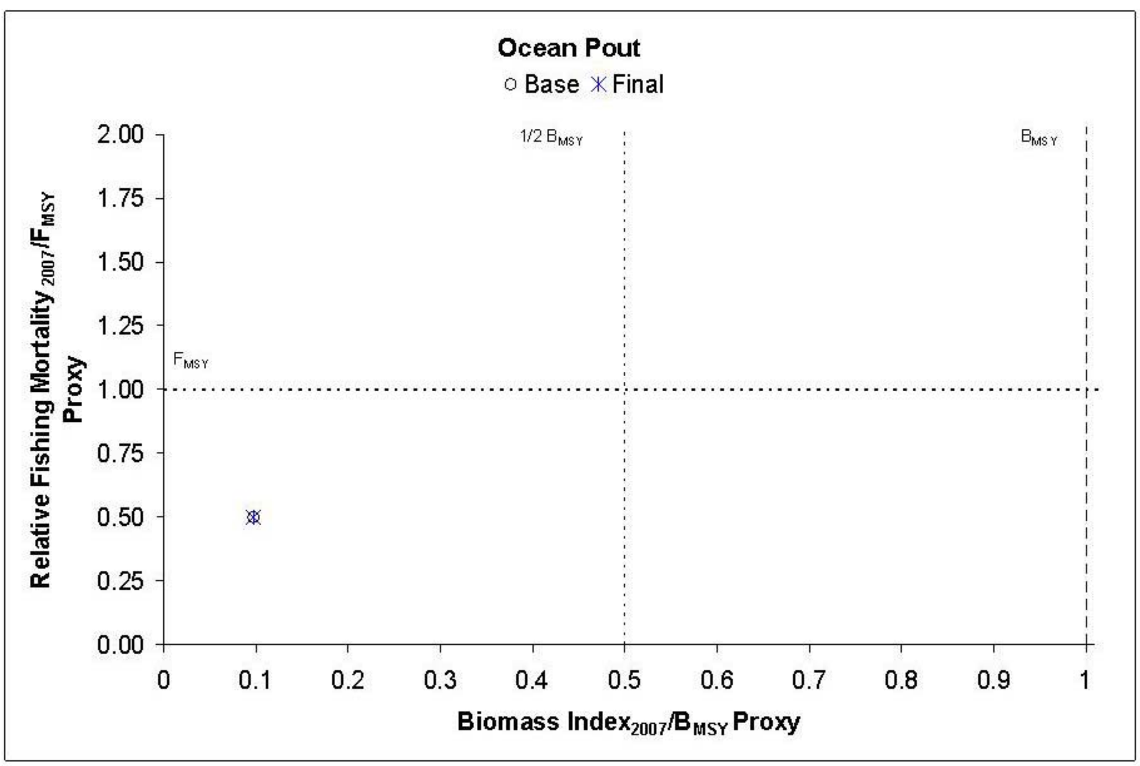

Figure O6. Ocean pout survey biomass index and relative fishing mortality in 2007, with respect to biological reference point proxies. The base analysis was accepted as the final analysis to determine ocean pout stock status in 2007.

P. Gulf of Maine/Georges Bank windowpane flounder
by Lisa Hendrickson

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

1.0 Background

No stock structure information is available. Therefore, a provisional arrangement has been adopted that recognizes two stock areas based on apparent differences in growth, sexual maturity, and abundance trends between windowpane flounder from Georges Bank and Southern New England. The proportion of total landings contributed by the Gulf of Maine is low, so these windowpane flounder landings are combined with those from Georges Bank and the two regions are assessed as the Gulf of Maine-Georges Bank (GOM-GB) stock.

An age-based assessment for this stock is not possible because there is no age composition data available from either the research surveys or fishery samples. The stock has never been formally assessed as part of the SAW/SARC process. However, index-based assessments have been conducted at previous Groundfish Assessment Review Meetings (GARM). At the most recent GARM, in September 2005, the stock was assessed based on trends in relative biomass indices (stratified mean kg per tow) from the NEFSC fall surveys and relative fishing mortality rates (landings / NEFSC fall survey biomass index) during 1963-2004. Stock status was determined from the 2002-2004 averages of the NEFSC fall survey biomass indices and relative fishing mortality rates. In 2004, the stock was not overfished and overfishing was not occurring (NEFSC 2005).

Several major changes have been made to the current assessment, including model type and input data. Two of the research recommendations from the 2005 GARM, discard estimation and the inclusion of inshore survey strata in the calculation of survey indices are addressed herein. An index-based model (AIM) is used to estimate an F_{MSY} proxy, defined as the relative fishing mortality rate (catch in year t / average NEFSC fall survey relative biomass index during year t, t-1, and t-2) at which the stock can replace itself.

2.0 The Fishery

Landings

The GOM-GB stock boundary includes statistical areas 511-525, 542-543, 551-552, and 561-562 (Figure P1). Commercial landings data are available for 1975-2007. During 1964 through May of 1994, commercial landings and additional fishery-related data were collected and entered into a Federal database by NMFS port agents. Since then, such data have been electronically reported by fish dealers and fishing location (statistical area) and fishing effort data related to landings are only available in the Vessel Trip Report database. As a result, the landings data and biological sampling data were allocated to Statistical Areas (SA) based on Vessel Trip Report data using the method described in Wigley et al. (2007a).

Landings of GOM-GB windowpane flounder were highest (1,212 - 2,862 mt) when a directed fishery existed during 1985-1993 (Figure P2, Table P1). Since 1994, landings have occurred as a result of bycatch and during 1994-2000, ranged between 339 and 147 mt. During

2001-2006, landings declined to their lowest levels, totaling less than 50 mt. Landings in 2007 totaled 119 mt.

During most years, at least 97% of the annual landings were taken with bottom trawls. During 1988-1994 and in 2006, a higher percentage of the annual landings (4.4-7.1%) were taken with scallop dredges (Table P2). A majority of the landings occurred during the first half of the year and the percentage during this time period increased after 1994 and ranged between 61% and 97% (Figure P3). During the period of the directed fishery, landings occurred over a broader area. However, since 1994, landings from Georges Bank (mainly SA 561, denoted as 524 in Figure P4) have been reduced from some SAs due to regulatory measures. During 1994-1999, most of the landings occurred in SAs 521 and 525, and since 2000, in SA 525 (32-74%, Figure P4).

Discards

Initial estimates of windowpane flounder discards, during 1975-2007, are provided for the large mesh bottom trawl fleet (codend mesh size ≥ 5.5 inches), small mesh groundfish fleet (codend mesh size < 5.5 inches), and the sea scallop fleets (dredge and bottom trawl combined, "limited permits" only) in Table P1. Discards (mt) for 1989-2007 were estimated using Northeast Fisheries Observer Program (NEFOP) data and the combined ratio method described in Wigley et al. (2007b). Due to the low numbers of trips sampled by quarter, the small mesh bottom trawl and scallop dredge/trawl fleets were binned by half year to derive discard estimates (Table P3). For both fleets, imputations were necessary during years where fewer than two trips were available. There were no observed trips for the scallop fleets during 1989 and 1990 and only one trip in 1991. As a result, scallop dredge 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. Due to a lack of fisheries observer data prior to 1989 for the trawl fleets and prior to 1992 for the scallop fleet, discard estimates were hindcast back to 1975 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*

During most years, discards are primarily (70%-80%) 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). However, the scallop dredge fleet also contributed a substantial percentage (30%-60%) of the total discards during two time periods, 1977-1981 and 1987-1993 (Table P1). The small mesh bottom trawl fleet comprised a low percentage of the total discards, generally ≤ 5%, during most years. However, the CVs of the annual discard estimates for the small mesh fleet were high, greater than 40% during most years, due to the low numbers of trips sampled (Table P4). Although scallop dredge trips were sampled in much lower numbers than the large mesh fleet, CV's of the discard estimates were not as high as for the small mesh fleet and ranged between 12% and 48% during most years. Discard estimates for the large mesh fleet during

2000-2007 were more precisely estimated (CV range of 16%-38%) than during 1989-1999 (CV range of 36%-98%).

During the directed fishery period, windowpane flounder catches filled the market void left by depleted yellowtail flounder stocks. NEFOP data indicate the primary reason for discarding since 1994 is 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 indicate that only the largest fish are retained (fish ≥ 29 cm since 1994). During the directed fishery period, 1985-1993, discards represented a smaller percentage of the total catch, averaging 27%, but have since comprised a majority of the catch and ranged between 82% and 96% during 2001-2007 (Figure P2, Table P1). The amount of discards declined during 1997-2002, but has been increasing since then and reached the third highest level on record in 2007 (913 mt). Discards more than tripled between 2004 (288 mt) and 2005 (806 mt). The precision of the total discard estimates was moderate to high during most years (Table P1).

The bycatch of GOM-GB windowpane flounder is likely higher during winter and spring when the species is distributed across a broader area on Georges Bank (Figure P5). The discard analyses confirm that during most years since 1989, discards by the large mesh bottom trawl fleet have been highest during the first half of the year.

Catches

During 1975-2007, catches of windowpane flounder were highest during 1985-1991 and ranged between 2,013 mt and 3,645 mt (Table P1, Figure P2). Thereafter, catches declined to a time series low of 105 mt in 1999. Since 2002, catches have been increasing due to increased discarding, primarily in the large mesh bottom trawl fleet (69-96% of the total discards). In 2007, catches reached the highest level (1,032 mt) since 1997.

3.0 Research Survey Data

Previous assessments incorporated NEFSC fall survey relative abundance and biomass indices (stratified mean number and kg per tow) that were derived using data from an offshore strata set (13-30 and 37-40) and that were not standardized for changes in trawl doors, vessels, and gear. However, the inshore strata comprise a substantial portion of the total windowpane flounder habitat. Therefore, NEFSC fall survey indices were revised to include catches from inshore strata 58-61 and 65-66, along with offshore strata 13-30 and 37-40 (Figure P6). The revised survey indices were also standardized for changes in trawl doors (numbers = 1.54 and weight = 1.67), gear (numbers = 1.67 and weight = 1.37), and vessels (numbers = 0.82 and weight = 0.80). For the fall survey biomass indices used in the assessment, 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 R/V *Delaware II* was utilized instead of the R/V *Albatross IV*. The latter occurred both within and between surveys on an irregular basis.

Annual relative biomass indices were above the median during 1976-1986 (Figure P7, Table P5). During 1984-1991, biomass indices declined to a level below the median but increased thereafter and were above the median in 1998. However, biomass indices declined in 1999 and remained stable near the median through 2002. During 2002-2006 biomass indices declined gradually but declined further in 2007 to the second lowest level on record. The spike in abundance during 2007, the second highest in the time series, was attributable to very large catches of juveniles at three stations located on Georges Bank, one of which was located within Closed Area II near its western edge.

Trends in relative biomass indices are also presented for: NEFSC spring (March) surveys (1975-2008, inshore strata 58-61 and 65-66 and offshore strata 13-30 and 37-40); Canadian spring (February) surveys (1996-2008, Georges Bank strata 5Z1-5Z4); Massachusetts spring (May) and fall (September) surveys (1978-2007, strata 25-36) and Maine/ New Hampshire (2000-2006, spring and fall, strata 1-3 in regions 1-5) bottom trawl surveys are also presented (Figure P8). The Canadian, MA, and NH/ME surveys do not encompass the entire stock area and consist of shorter time series than the two NEFSC survey series. Therefore, the NEFSC fall survey time series is considered the best indicator of stock abundance and biomass. However, these other surveys can be used to confirm trends in the NEFSC fall survey indices. Similar to NEFSC fall survey indices, recent trends in the MA fall and spring biomass indices indicate a general decline during 2000-2004 to some of the lowest levels observed, followed by a gradual increase through 2006, then a decrease during 2007 (Figure P8). The Canadian spring survey biomass indices show a general declining trend after1996 to the lowest levels observed in 2008.

4.0 Assessment

Annual catches and NEFSC fall survey relative biomass indices were used as input data to the AIM (version 2.0) software provided in version 3.0 of the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/). Computations conducted within the AIM software package and an explanation of the model parameters are provided in the Final Report of the Working Group on Re-evaluation of Biological Reference Points for New England Groundfish (Anon 2002). The NEFSC fall survey indices were utilized in the final model run because an initial run that included relative biomass indices from all of the available surveys indicated that the model regression was only significant for the NEFSC fall survey time series. Lagged smoothers of three years and five years were applied to the relative F values and survey biomass indices, respectively. The 90% CI for the AIM model estimate of F_{MSY} were determined from 1,800 bootstrap iterations.

Input data to the AIM model include annual catches and NEFSC fall survey biomass indices for 1975-2007 which were used to compute annual relative fishing mortality rates (relative F) and stock replacement ratios (Table P6). Trends in catches, survey biomass indices, relative F values, and stock replacement ratios, along with the relationship between ln(relative F) and ln(replacement ratio) are also presented in Figure P9. Annual relative fishing mortality rates increased during 1977-1991 then decreased through 2002 (Figure P9B). Thereafter, relative fishing mortality rates increased through 2007. Stock replacement ratios increased between 1991 and 1998 and were above or near 1.0 during 1995-2001. However, concurrent with the 2002-2007 increase in relative fishing mortality rates, stock replacement ratios declined and the stock was unable to replace itself during 2002-2007 (Figure P9C). The decline in replacement ratio was particularly severe between 2006 and 2007. The correlation between relative fishing mortality rates and stock replacement ratios was marginally significant ($p = 0.087$) and the model results suggest that the stock can replace itself at a relative F value of 0.50 (the relative F value where the log of the replacement ratio is equal to 0, Figure P9D). Positive trends in the standardized residuals were evident during 1995-1998 and negative trends existed for 1999-2004 (Figure P10).

5.0 Biological Reference Points

The current biological reference points are: F_{MSY} proxy = 1.11 and B_{MSY} proxy = 0.94 kg per tow and were derived by an Overfishing Definition Review Panel (Applegate et al. 1998) based on trends in the landings and NEFSC fall survey biomass indices for 1975-1996. MSY was assumed to be 1,000 mt because landings greater than this amount appeared to cause declines in the biomass indices. The 1975-1987 median of the NEFSC fall survey biomass indices was chosen as a B_{MSY} proxy based on trends in relative fishing mortality rates (landings / NEFSC fall survey biomass indices) and NEFSC fall survey biomass indices. The F_{MSY} proxy was computed from the assumed MSY and B_{MSY} values.

The BRPs were re-estimated using data for 1975-2007 and represent survey-based proxies of relative biomass and relative fishing mortality rates (catch / NEFSC fall survey relative biomass index). The re-estimated BRPs are shown in Table P8 in relation to the 2007 biomass index and relative F value which were used to determine stock status. The F_{MSY} proxy (relative F) was estimated using the AIM model and the results indicate that the stock can replace itself at a relative F value of 0.50. Thus, this value can serve as an F_{MSY} proxy for the stock. The 90% CI for the F_{MSY} point estimate indicate that the estimate is very imprecise (Table P7). Based on an examination of the trends in replacement ratios during a period when catches were most precisely estimated (1989-2007), the stock appeared to be able to sustain the levels of catch that occurred during 1995-2001 because replacement ratios were near or above 1.0 during this period (Figure P9C). During 1995-2001, the median catch was approximately 700 mt and this value was considered as an MSY proxy. Division of the MSY proxy (700 mt) by the estimated F_{MSY} proxy from the AIM model (0.50) results in a B_{MSY} proxy of 1.40 kg per tow. It is important to note that the re-estimated BRPs cannot be compared to the current BRPs because different survey strata sets and time series were used in their derivations and the revised estimates include discards. Furthermore, different estimation methods were utilized.

5.0 Projections

Stochastic projections were run for 2008 and 2009 using the AIM model for two scenarios: F status quo (F_{sq}) and F_{MSY}. Estimated catches and NEFSC fall survey relative biomass indices for 2008 and 2009 catches are presented in Table P9 for both projection scenarios. Although the stock is overfished, the August GARM Review Panel recommended against projections based on a $F_{REBUILD}$ scenario because there is no directed fishery.

7.0 Summary

The relative F value for 2007 was computed as the catch in 2007 divided by the average of the NEFSC fall survey relative biomass indices during 2005-2007 (Table P8). The 2007 relative F value of 1.96 was much higher than the F_{MSY} proxy value of 0.50, indicating that overfishing was occurring in 2007. The 2007 relative biomass index of 0.24 kg per tow was well below 1/2 B_{MSY} (= 0.70 kg per tow), indicating that the stock was also overfished in 2007 (Figure P11).

Although there continues to be no directed fishery, increased discarding resulted in an increase in catches during 2004-2007. Relative biomass indices declined gradually between 2002 and 2004 to a level slightly below the median and remained at this level through 2006, but then dropped sharply in 2007 to the second lowest level on record. Concurrent with an increase in relative fishing mortality rates during 2002-2007 and below-median biomass indices, stock replacement ratios have declined and the stock has not been able to replace itself since 2002.

Sources of uncertainty

The underestimation of total discards, because discards from the Canadian scallop dredge and bottom trawl fleets were not available and the species is distributed on the Canadian side of Georges Bank; the imprecision of the F_{MSY} estimate from the AIM model; and the fact that either MSY or B_{MSY} must be subjectively determined external to the AIM model and this approach does not afford a means of quantifying uncertainty in the estimates of current biomass and relative F. The August 2008 GARM Review Panel recommended that quantification of such uncertainty be investigated in the future.

8.0 Panel Discussion/Comments

Conclusions

The Panel concluded that that index based assessment was appropriate for this stock and provides the best available information for management. The Panel recommended that the estimates of relative biomass and fishing mortality should not be converted to absolute units. Given that current catch is mostly incidental and also given the high uncertainty of index based assessments, it was concluded that it was not appropriate to calculate F rebuild for this stock.

Research Recommendations

The Panel had no specific research recommendations for this stock.

9.0 References

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10.0 Acknowledgements

This assessment could not have been conducted without the data preparation and technical help provided by Susan Wigley, the age data provided by Jay Burnett, and data collected and entered by the NMFS port agents, NEFSC staffs from DMS, NEFOP and ESB. I am also grateful to the state fisheries scientists who provided me with windowpane flounder relative biomass and abundance indices from their bottom trawl surveys.

Table P1. Landings, discards, and catches (mt) of GOM-GB windowpane flounder during 1975-2007. Landings and discards include data from statistical areas 511-525, 542-543, 551-552, and 561-562. Discards estimates include the large mesh (codend mesh size ≥ 5.5 inches) bottom trawl fleet, small mesh groundfish fleet (codend mesh size < 5.5 inches) and the sea scallop dredge fleet.

Year	Landings[1] (mt)	Discards (mt)					Catch (mt)
		Large mesh	Small mesh	Scallop dredge	Total	CV	
1975	1,300		201	52	253		1,553
1976	1,516		213	70	283		1,799
1977	1,099		267	173	441		1,539
1978	923		292	173	465		1,388
1979	856		305	222	527		1,383
1980	408		344	246	591		999
1981	413		329	317	646		1,059
1982	411	368	206	243	816		1,227
1983	460	628	88	182	898		1,358
1984	743	642	49	124	815		1,558
1985	2,141	545	40	106	691		2,833
1986	1,842	447	35	141	623		2,465
1987	1,396	427	20	170	617		2,013
1988	1,377	413	23	269	705		2,082
1989	1,577	188	2	293	483		2,060
1990	1,079	600	60	382	1,042		2,121
1991	2,862	463	1	319	783		3,645
1992	1,519	137	0	190	454	0.46	1,974
1993	1,212	249	6	110	497	0.72	1,709
1994	339	118	158	66	458	0.17	796
1995	668	740	24	35	889	0.53	1,557
1996	773	346	0.4	63	452	0.35	1,226
1997	416	828	27	276	996	0.67	1,412
1998	398	192	0	80	363	0.36	761
1999	49	34	1	20	305	0.40	354
2000	147	124	57	21	202	0.26	349
2001	43	167	0.3	23	190	0.33	233
2002	13	126	6	21	153	0.19	166
2003	16	342	2	11	354	0.27	371
2004	26	268	13	7	288	0.25	315
2005	50	627	262	17	906	0.11	955
2006	46	530	34	76	641	0.13	687
2007	119	811	4.5	97	913	0.15	1,032

[1] Since May of 2004, landings have been self-reported by dealers and were allocated to statistical area based on Vessel Trip Report data.

Table P2. Landings (mt) of Gulf of Maine-Georges Bank windowpane flounder, by gear type, during 1975-2007.

Year	Bottom trawls	Sea scallop dredges	Gillnets	Other	Total	Percent landed by bottom trawls
1975	1,299	0.3	0.0	0.5	1,300	99.9
1976	1,514	1.4	0.1	0.9	1,516	99.8
1977	1,096	1.3	0.6	0.5	1,099	99.8
1978	905	0.9	0.1	42.5	923	98.0
1979	849	2.9	0.0	5.6	856	99.2
1980	383	2.8	0.0	22.5	408	98.7
1981	410	1.1	0.1	1.2	413	99.4
1982	405	1.8	0.1	3.5	412	98.7
1983	456	0.6	0.0	2.5	459	99.3
1984	739	1.3	0.8	2.5	742	99.4
1985	2,137	1.4	0.1	2.8	2,141	99.8
1986	1,810	23.9	4.3	2.8	1,841	98.3
1987	1,354	38.7	0.2	2.5	1,396	97.0
1988	1,315	59.9	1.2	0.9	1,377	95.5
1989	1,508	57.3	10.6	1.6	1,577	95.6
1990	1,001	64.8	9.8	2.1	1,079	92.9
1991	2,736	124.2	0.8	1.4	2,862	95.6
1992	1,434	79.1	1.8	4.6	1,519	94.4
1993	1,149	48.0	0.7	14.7	1,212	94.9
1994	322	12.8	3.6	0.9	339	94.9
1995	663	0.9	2.4	1.6	668	99.3
1996	771	0.4	0.8	0.7	773	99.8
1997	413	0.5	0.6	2.0	416	99.3
1998	395	0.4	1.0	1.3	398	99.3
1999	48	0.2	0.1	0.0	48	99.4
2000	147	0.2	0.2	0.1	147	99.6
2001	42	0.1	0.0	0.0	42	99.8
2002	14	0.0	0.1	0.1	14	99.0
2003	16	0.0	0.1	0.1	16	99.1
2004	26	0.0	0.5	0.0	27	98.0
2005	50	0.0	0.1	0.9	51	98.0
2006	44	0.7	0.2	1.5	46	95.0
2007	117	0.4	0.2	1.9	119	97.9

Table P3. Number of observed trips, by fleet and quarter, included in the discards of GOM-GB windowpane flounder estimated using data from the Northeast Fisheries Observer Program, 1989-2007.

	Large mesh otter trawl					Small mesh groundfish otter trawl			Scallop dredge/otter trawl		
Year	Q1	Q2	Q3	Q4	Total	Q1and Q2	Q3 and Q4	Total	Q1and Q2	Q3 and Q4	Total
1989	3	22	20	7	52	11	30	41			0
1990	4	13	10	11	38	2	17	19			0
1991	14	12	18	26	70	1	37	38		1	1
1992	31	15	5	9	60	4	21	25	3	6	9
1993	8	10	4	7	29	2	7	9	7	4	11
1994	12	6	3	3	24	1	1	2	2	5	7
1995	22	12	6	8	48	2	30	32	1	5	6
1996	7	12		4	23	3	38	41	8	6	14
1997	10		5	2	17	4		4	6	5	11
1998	3	4	2		9	1		1	2	8	10
1999		3	14	14	31	1	11	12	4	17	21
2000	25	29	20	19	93	4	3	7	25	159	184
2001	18	30	39	52	139	6	6	12	17		17
2002	24	14	78	89	205	3	48	51		10	10
2003	105	77	102	88	372	15	25	40	3	7	10
2004	71	72	118	164	425	19	74	93	2	28	30
2005	278	259	241	302	1,080	61	87	148	10	61	71
2006	219	107	132	58	516	24	20	44	16	68	84
2007	106	140	118	158	522	10	22	32	25	55	80

Table P4. Summary of GOM-GB windowpane flounder discard estimates (mt) for the large mesh (codend mesh size ≥ 5.5 in.) and small mesh (codend mesh size < 5.5 in.) groundfish bottom trawl fisheries and the scallop dredge/trawl fisheries (limited permit category), 1975-2007. Discards were hindcast for: large mesh bottom trawls (1982-1988); small mesh bottom trawls (1975-1988); and scallop dredges (1975-1991).

Large Mesh Bottom Trawl				
YEAR	**N Observed trips**	**D/K**	**Discards (mt)**	**CV**
1975			-	
1976			-	
1977			-	
1978			-	
1979			-	
1980			-	
1981			-	
1982			368	
1983			628	
1984			642	
1985			545	
1986			447	
1987			427	
1988			413	
1989	52	0.004	188	0.50
1990	38	0.009	600	0.36
1991	70	0.007	463	0.48
1992	60	0.002	137	0.50
1993	29	0.005	249	0.98
1994	24	0.003	118	0.41
1995	48	0.021	740	0.57
1996	23	0.008	346	0.42
1997	17	0.023	828	0.91
1998	9	0.005	192	0.42
1999	31	0.001	34	0.61
2000	93	0.003	124	0.32
2001	139	0.003	167	0.38
2002	205	0.003	126	0.22
2003	372	0.007	342	0.28
2004	425	0.006	268	0.27
2005	1,080	0.017	627	0.11
2006	516	0.019	530	0.15
2007	522	0.026	811	0.16

Table P4. (cont.)

Small Mesh Groundfish Bottom Trawl				
YEAR	**N Observed trips**	**D/K**	**Discards (mt)**	**CV**
1975			201	
1976			213	
1977			267	
1978			292	
1979			305	
1980			344	
1981			329	
1982			206	
1983			88	
1984			49	
1985			40	
1986			35	
1987			20	
1988			23	
1989	41	0.00027	1.9	0.72
1990	19	0.00708	59.6	0.60
1991	38	0.00016	1.4	0.75
1992	25	0.00000	0.0	
1993	9	0.00073	5.7	0.81
1994	2	0.02282	158.0	0.00
1995	32	0.00393	24.0	1.02
1996	41	0.00005	0.4	0.99
1997	4	0.00453	26.8	1.39
1998	1	0.00000	0.0	
1999	12	0.00011	1.0	0.34
2000	7	0.00797	56.8	0.61
2001	12	0.00004	0.3	0.82
2002	51	0.00091	5.6	0.73
2003	40	0.00019	1.5	0.43
2004	93	0.00065	13.4	0.46
2005	148	0.02097	261.7	0.26
2006	44	0.00623	34.0	0.52
2007	32	0.00065	4.5	0.70

Table P4. (cont.)

Scallop dredge/trawl, Limited category permits				
YEAR	**N Observed trips**	**D/K**	**Discards (mt)**	**CV**
1975			52	
1976			70	
1977			173	
1978			173	
1979			222	
1980			246	
1981			317	
1982			243	
1983			182	
1984			124	
1985			106	
1986			141	
1987			170	
1988			269	
1989			293	
1990			382	
1991			319	
1992	9	0.0034	190	0.71
1993	11	0.0030	110	0.91
1994	7	0.0051	66	0.45
1995	6	0.0035	35	0.41
1996	14	0.0032	63	0.16
1997	11	0.0120	276	0.42
1998	10	0.0044	80	0.71
1999	21	0.0005	20	0.37
2000	184	0.0007	21	0.12
2001	17	0.0008	23	0.24
2002	10	0.0009	21	0.46
2003	10	0.0004	11	0.47
2004	30	0.0004	7	0.44
2005	71	0.0004	17	0.32
2006	84	0.0010	76	0.40
2007	80	0.0021	97	0.48

Table P5. Stratified mean catch per tow indices (in kg and numbers) for GOM-GB windowpane flounder caught during NEFSC fall research bottom trawl surveys, 1975-2007. Indices include catches from offshore strata 13-30, 37-40 and inshore strata 58-61, 65-66 and standardization coefficients were applied for trawl door changes (numbers = 1.54 and weight = 1.67), gear changes (numbers = 1.67 and weight = 1.37), and vessels (numbers = 0.82 and weight = 0.80).

Year	Mean kg per tow	Mean number per tow
1975	0.629	9.10
1976	1.910	8.73
1977	2.033	8.99
1978	1.505	10.16
1979	0.958	4.12
1980	0.899	2.80
1981	1.022	3.86
1982	0.820	3.43
1983	0.940	3.27
1984	3.305	18.41
1985	0.828	10.86
1986	1.143	5.15
1987	0.629	3.39
1988	0.712	4.73
1989	0.323	1.41
1990	0.925	5.23
1991	0.193	1.18
1992	0.429	2.12
1993	0.464	4.24
1994	0.263	1.43
1995	0.790	7.40
1996	0.513	3.14
1997	0.423	4.87
1998	1.588	12.46
1999	0.759	4.29
2000	0.708	3.83
2001	0.891	9.82
2002	0.856	5.45
2003	0.742	4.62
2004	0.669	7.35
2005	0.680	9.07
2006	0.660	5.94
2007	0.242	15.59

Table P6. AIM model input data for 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* / mean NEFSC fall survey biomass index for years *t*, *t*-1, and *t*-2), and stock replacement ratios (NEFSC fall survey biomass index in year *t* / mean biomass index for previous five years).

Year	Catch (000's mt)	Relative biomass index (kg per tow)	Relative F	Replacement Ratio
1975	1.553	0.629		
1976	1.799	1.910		
1977	1.539	2.033	1.010	
1978	1.388	1.505	0.764	
1979	1.383	0.958	0.923	
1980	0.999	0.899	0.891	0.639
1981	1.059	1.022	1.104	0.700
1982	1.227	0.820	1.343	0.639
1983	1.358	0.940	1.464	0.903
1984	1.558	3.305	0.923	3.562
1985	2.833	0.828	1.675	0.593
1986	2.465	1.143	1.402	0.826
1987	2.013	0.629	2.323	0.447
1988	2.082	0.712	2.514	0.520
1989	2.060	0.323	3.714	0.244
1990	2.120	0.925	3.245	1.272
1991	3.645	0.193	7.588	0.259
1992	1.847	0.429	3.582	0.771
1993	1.577	0.464	4.356	0.899
1994	0.681	0.263	1.767	0.563
1995	1.467	0.790	2.901	1.737
1996	1.183	0.513	2.266	1.199
1997	1.547	0.423	2.689	0.860
1998	0.670	1.588	0.796	3.237
1999	0.105	0.759	0.114	1.061
2000	0.349	0.708	0.343	0.869
2001	0.233	0.891	0.296	1.116
2002	0.166	0.856	0.203	0.980
2003	0.371	0.742	0.447	0.773
2004	0.315	0.669	0.417	0.846
2005	0.955	0.680	1.370	0.879
2006	0.687	0.660	1.026	0.860
2007	1.032	0.242	1.957	0.335

Table P7. AIM model estimate of the F_{MSY} proxy and the probability value for the randomization test for GOM-GB windowpane flounder.

	Point estimate (90% CI)	Bootstrap mean
F_{MSY} proxy	0.50 (0.26, 0.88)	0.45
Randomization test *p* value	0.087	

Table P8. Biological reference point estimates for GOM-GB windowpane flounder and stock status for 2007. Relative F for 2007 is the catch in 2007 divided by the average relative biomass index for the NEFSC fall surveys during 2005-2007.

2007 Relative F	F_{MSY} proxy
1.96	0.50
2007 Relative biomass index (kg per tow)	**B_{MSY} proxy (kg per tow)**
0.24	1.40

Table P9. Stochastic projections of catch (mt) and NEFSC fall survey relative biomass indices (kg per tow) in 2008 and 2009, assuming F status quo (F_{sq}) and F_{MSY}, for GOM-GB windowpane flounder.

2008			2009	
Catch (mt)	Relative Biomass Index (kg per tow)	F 2009	Catch (mt)	Relative Biomass Index (kg per tow)
871	0.44	F_{sq} (= 1.96)	647	0.33
299	0.60	F_{MSY} (= 0.50)	299	0.60

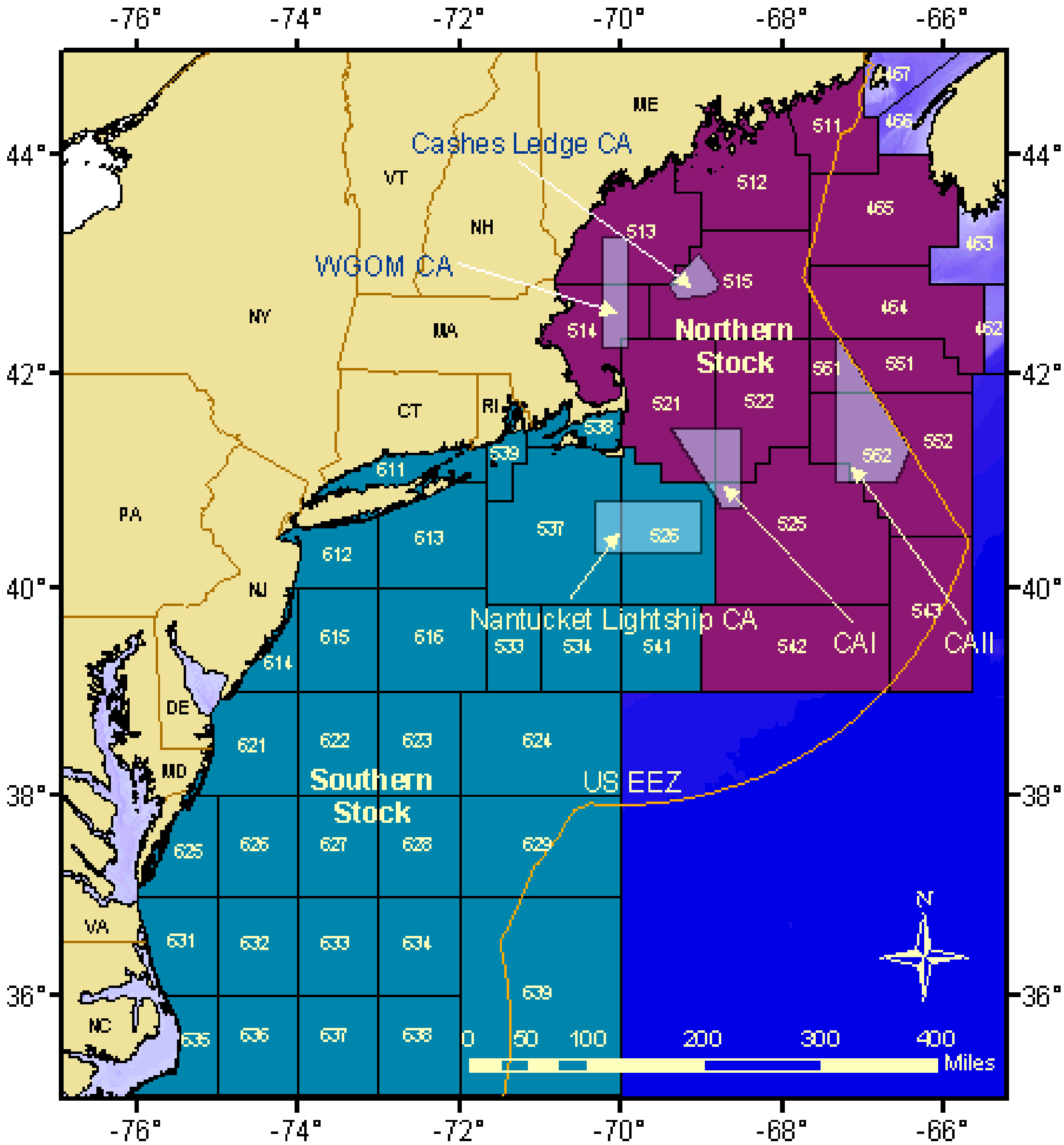

Figure P1. Statistical Areas comprising the northern (Gulf of Maine-Georges Bank) and southern (Southern New England-Mid-Atlantic Bight) windowpane flounder stocks.

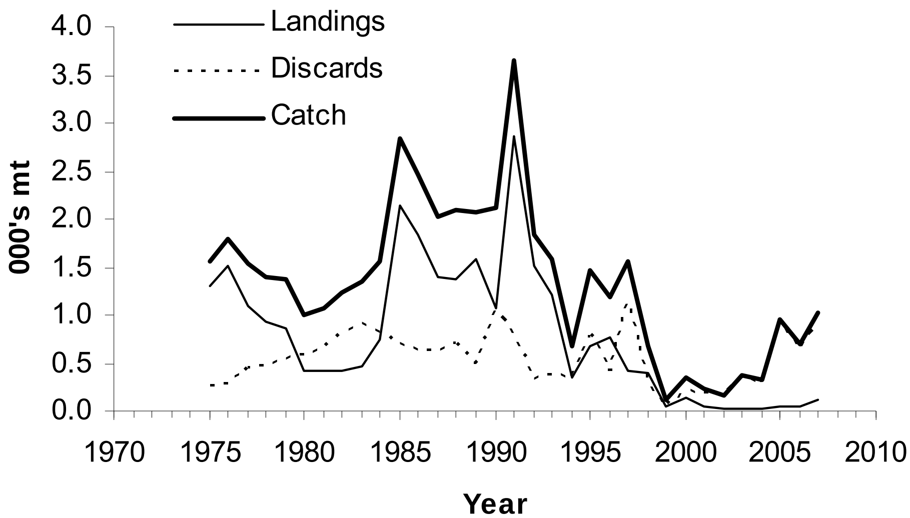

Figure P2. Commercial landings, discards, and catches (000's mt) of Gulf of Maine-Georges Bank windowpane flounder during 1975-2007.

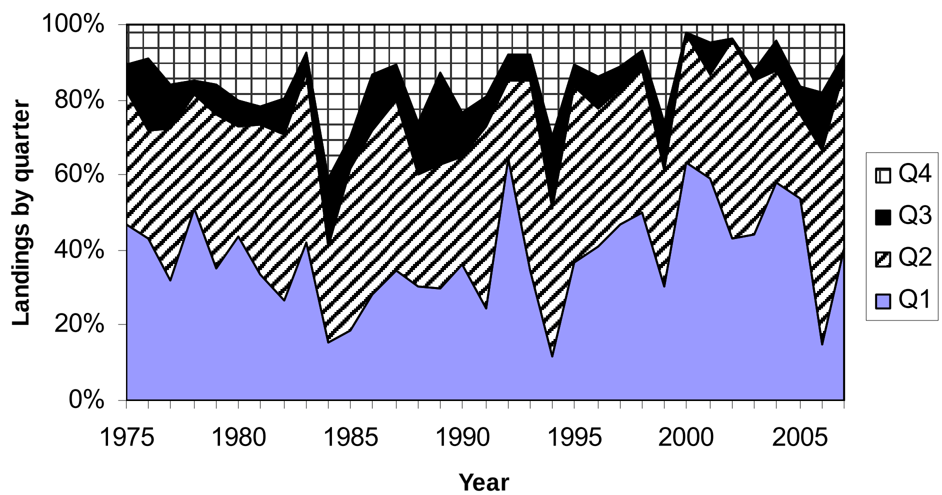

Figure P3. Percentage of landings of GOM-GB windowpane flounder. by quarter, during 1975-2007.

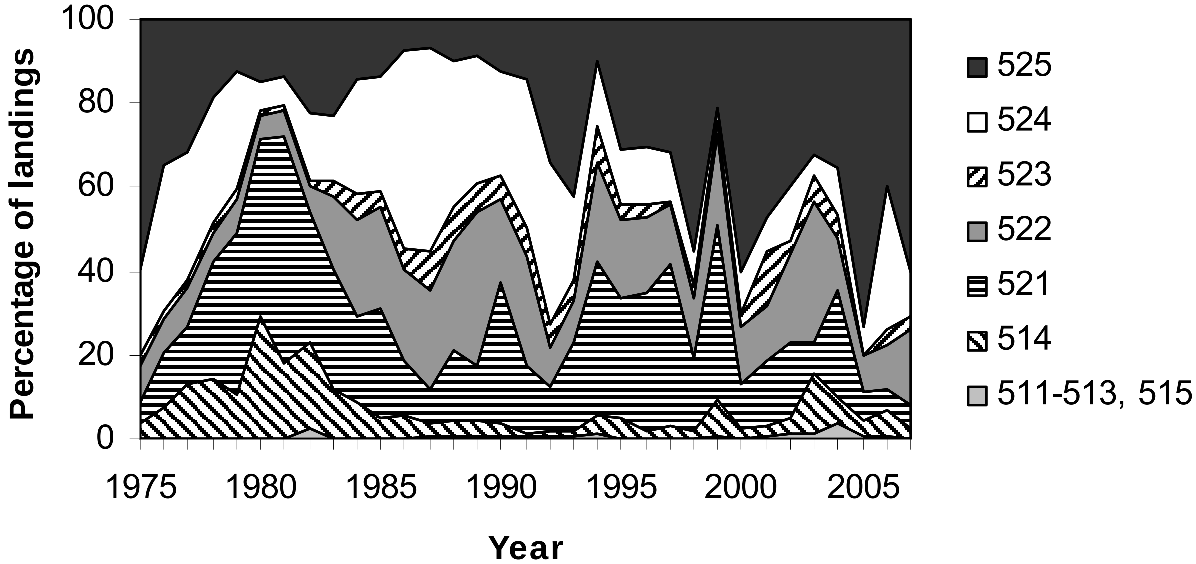

Figure P4. Percentage of landings of GOM-GB windowpane flounder, by Statistical Area, during 1975-2007.

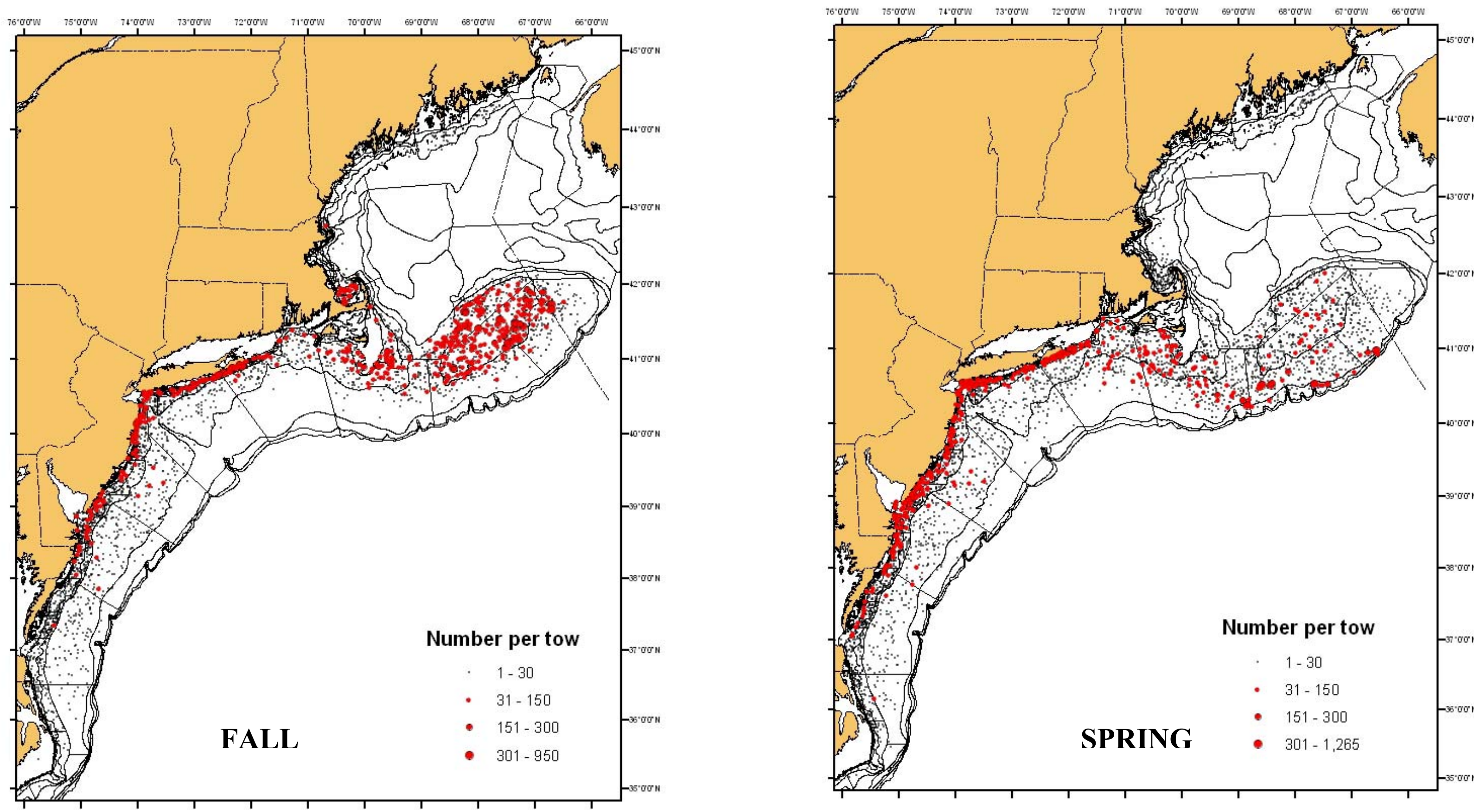

Figure P5. Spatial distribution of windowpane flounder during NEFSC fall and spring bottom trawl surveys, 1968-2007.

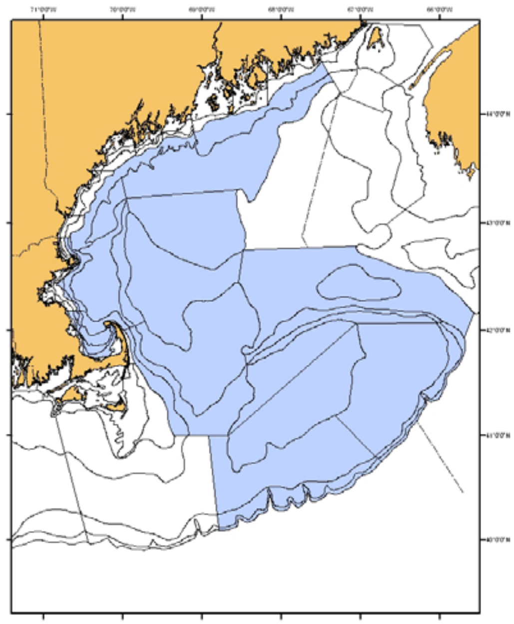

Figure P6. Strata set used to derive abundance and biomass indices, from NEFSC fall and spring bottom trawl surveys, for the Gulf of Maine-Georges Bank windowpane flounder stock.

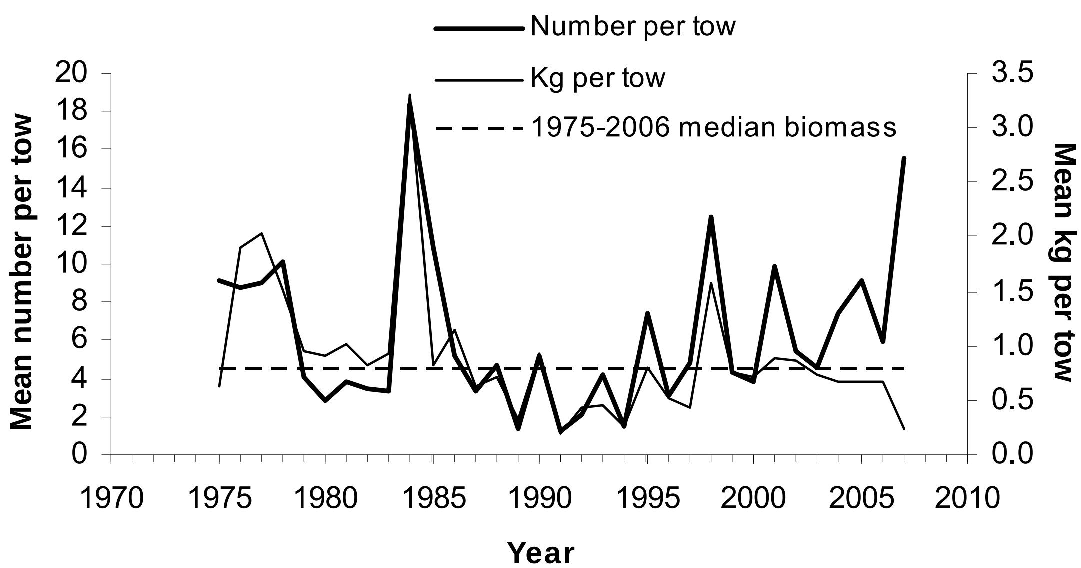

Figure P7. Relative abundance (stratified mean number per tow) and biomass indices (stratified mean kg per tow) for GOM-GB windowpane flounder caught during NEFSC autumn bottom trawl surveys, 1975-2007.

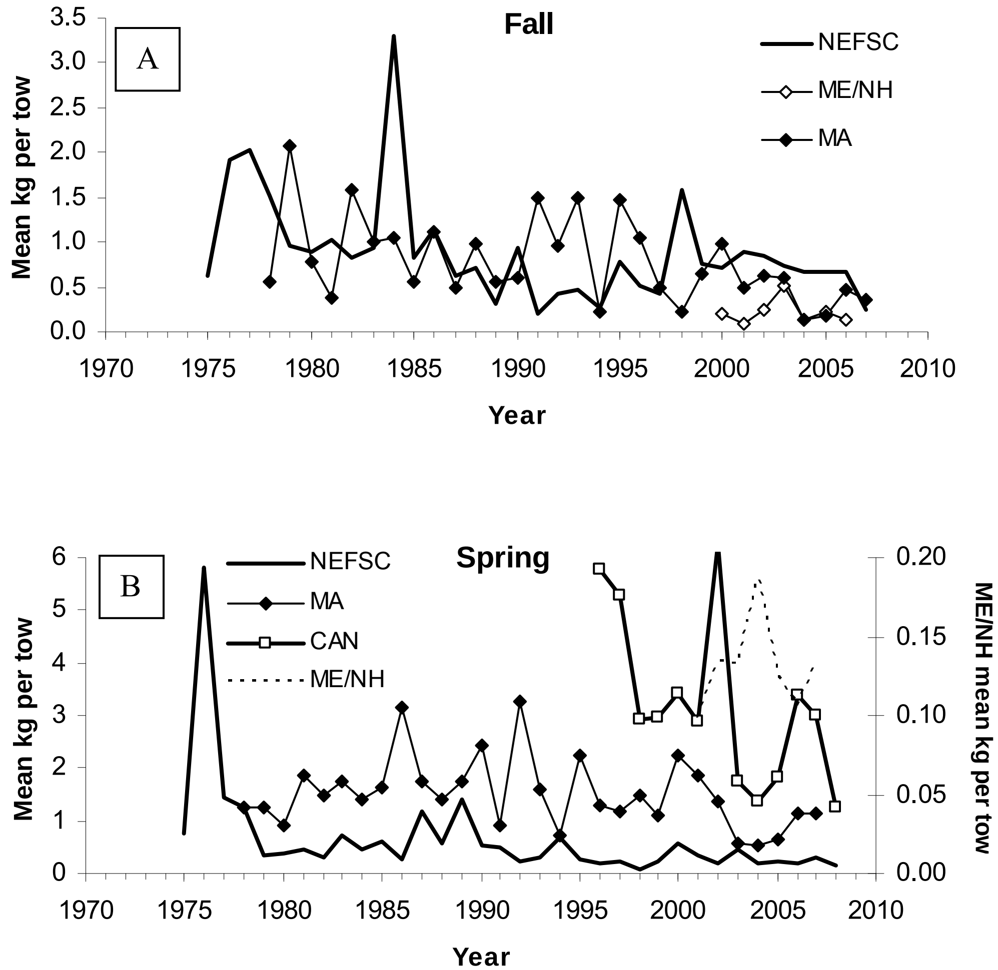

Figure P8. Relative biomass indices (stratified mean kg per tow) for GOM-GB windowpane flounder caught during (A) NEFSC, MA, and ME/NH fall surveys and (B) during NEFSC, MA, ME/NH and Canada spring surveys.

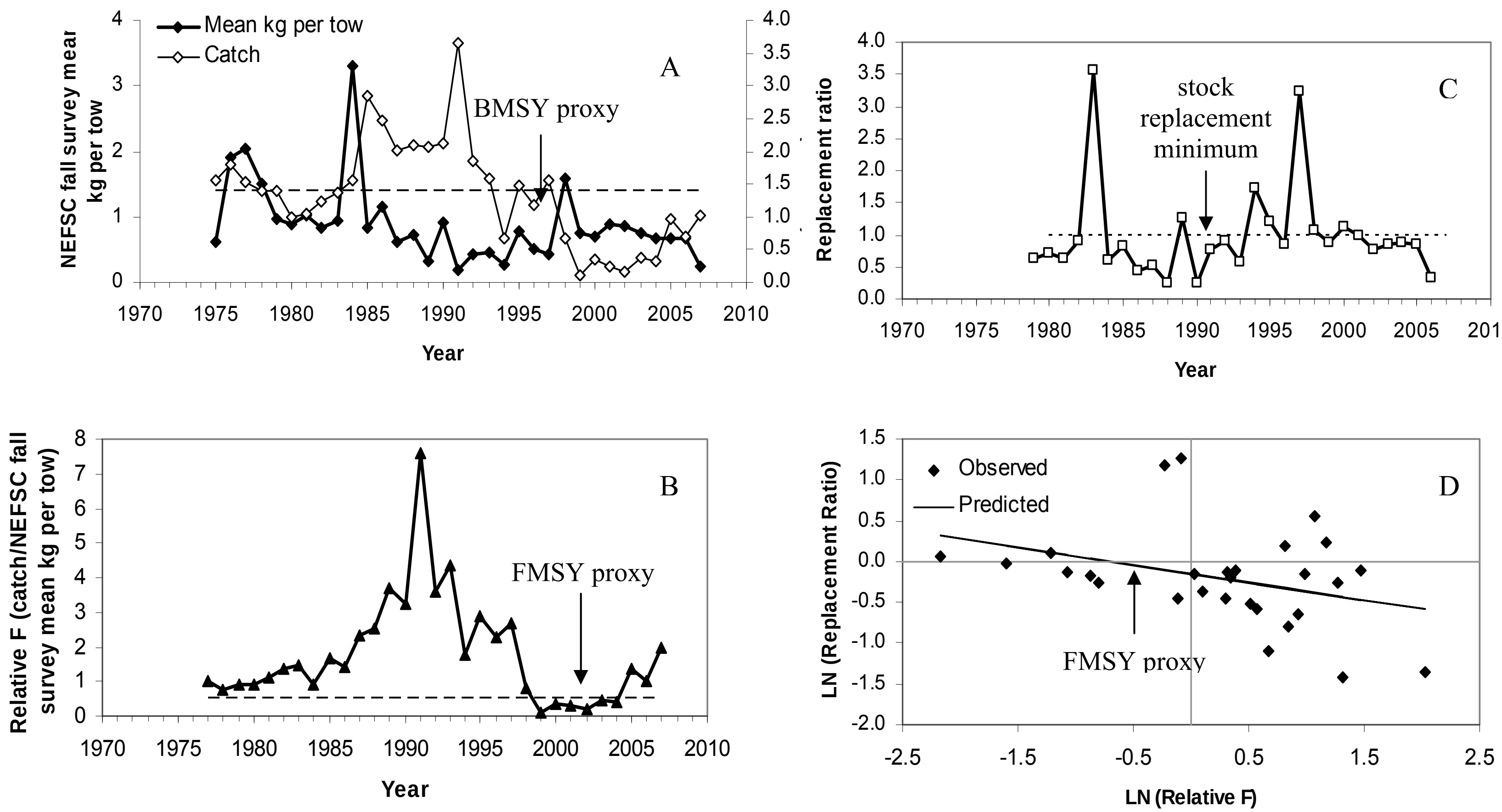

Figure P9. Trends in (A) GOM-GB windowpane flounder catches (000's mt) and NEFSC fall survey relative biomass indices (stratified mean kg per tow), (B) relative fishing mortality rates (catch/NEFSC fall survey biomass index), (C) stock replacement ratios, and (D) the regression of ln(relative F) against ln(replacement ratio) used to calculate an F_{MSY} proxy (= 0.50), 1975-2007.

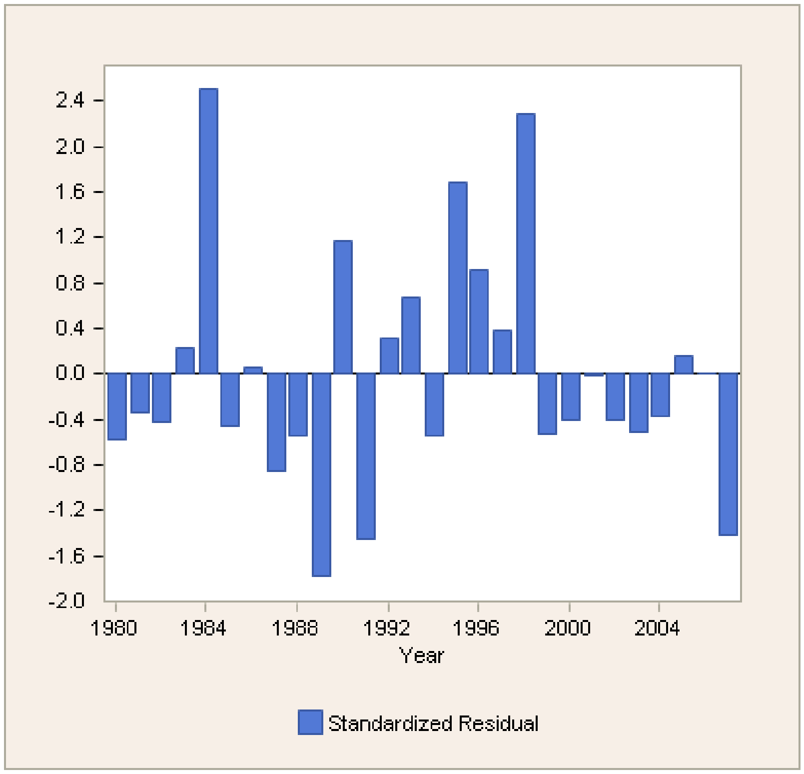

Figure P10. Standardized residuals from the final AIM model run for GOM-GB windowpane flounder.

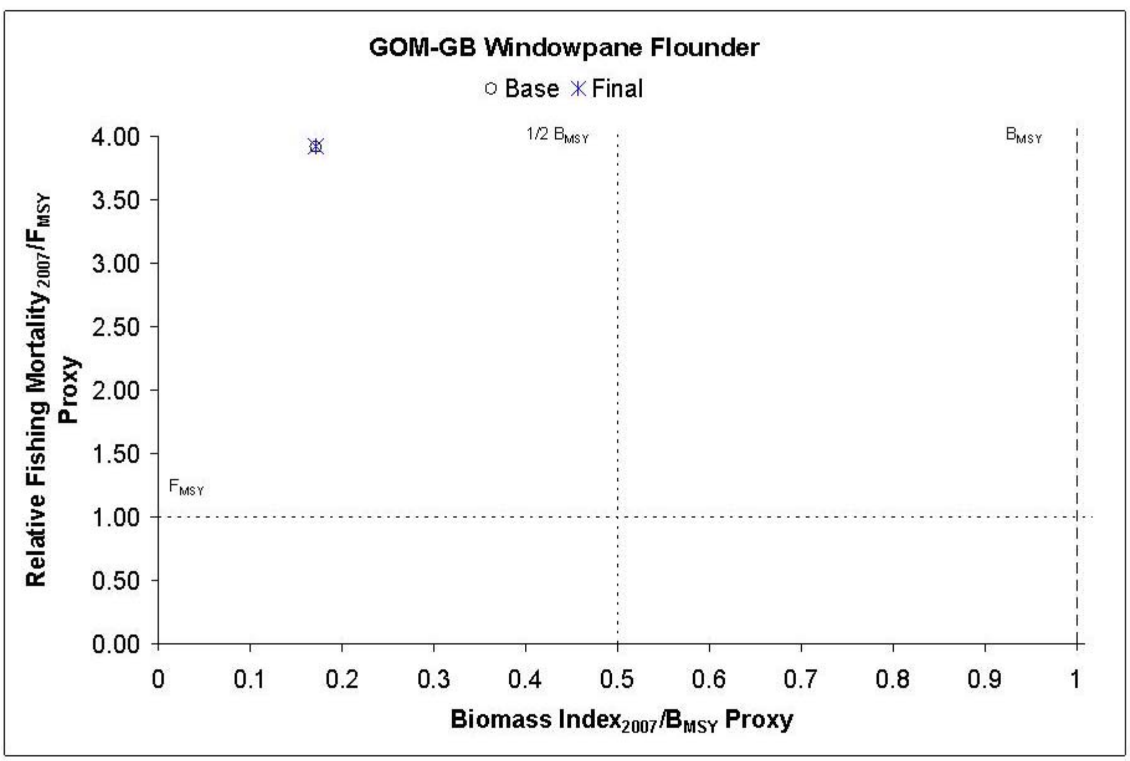

Figure P11. Stock status for GOM-GB windowpane flounder during 2007.

Q. Southern New England/Mid-Atlantic Bight windowpane flounder
by Lisa Hendrickson

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

1.0 Background

No stock structure information is available. Therefore, a provisional arrangement has been adopted that recognizes two stock areas based on apparent differences in growth, sexual maturity, and abundance trends between windowpane flounder from Georges Bank and Southern New England. The proportion of total landings contributed by the Mid-Atlantic area is low, so these windowpane flounder landings are combined with those from Southern New England and the two regions are assessed as the southern New England and Mid-Atlantic Bight (SNE-MAB) stock.

An age-based assessment for this stock is not possible because there is no age composition data available from either the research surveys or fishery samples. The stock has never been formally assessed as part of the SAW/SARC process. However, index-based assessments have been conducted at previous Groundfish Assessment Review Meetings (GARM). At the most recent GARM, in September 2005, the stock was assessed based on trends in relative biomass indices (stratified mean kg per tow) from the NEFSC fall surveys and relative exploitation rates (landings / NEFSC fall survey biomass index) during 1963-2004. Stock status was determined from the 2002-2004 averages of the NEFSC fall survey relative biomass indices and relative exploitation rates. In 2004, the stock was overfished but overfishing was not occurring (NEFSC 2005). The rebuilding plan established by the New England fishery Management Council (NEFMC) requires that the stock be rebuilt by May of 2014.

Several major changes have been made to the current assessment, including model type and input data. Two of the research recommendations from the 2005 GARM, discard estimation and the inclusion of inshore survey strata in the calculation of survey indices are addressed herein. An index-based model (AIM) is used to estimate an F_{MSY} proxy, defined as the relative fishing mortality rate (catch in year *t* / average NEFSC fall survey relative biomass index during year *t*, *t*-1, and *t*-2) at which the stock can replace itself.

2.0 The Fishery

Landings

The SNE-MAB stock boundary includes Statistical Areas 526, 533-539, 541, and 611-639. Commercial landings data are available for 1975-2007 (Table Q1, Figure Q1). During 1964 through May of 1994, commercial landings and additional fishery-related data were collected and entered into a Federal database by NMFS port agents. Since then, such data have been electronically reported by fish dealers and fishing location (statistical area) and fishing effort data related to landings are only available in the Vessel Trip Report database. As a result, the landings data and biological sampling data were allocated to Statistical Areas (SA) based on Vessel Trip Report data using the method described in Wigley et al. (2007a).

Landings of SNE-MAB windowpane flounder fluctuated between 532 mt in 1975 and 898 mt in 1982 then increased sharply to a peak of 2,065 mt in 1985 (Figure Q2, Table Q1). A directed fishery occurred for a short while, during 1984-1990, and landings ranged between 890 mt and 2,065 mt. Thereafter, landings gradually declined to 120 mt in 1995 and remained stable at this low level until 2001. During 2002-2007, landings were at the lowest levels on record and ranged between 39 mt and 85 mt. Landings in 2007 totaled 81 mt.

During most years, at least 97% of the annual landings were taken with bottom trawls. During 1988-1995, a higher percentage of the annual landings (3.9-12.8%) were taken with scallop dredges (Table Q2). With the exception of 1993-1998, a majority of the landings occurred in the first half of the year during 1975-2007 (Figure Q3). During 1993-1998, most of the landings occurred during the second half of the year. The spatial distribution of the landings varies pre- and post-1995. During 1975-1994, landings were predominately taken in in Southern New England, south of Cape Cod (SAs 526 and 537, with lesser amounts taken in 538 and 539, Figure Q4). After 1995, landings occurred primarily in the waters surrounding Long Island (SAs 611-613).

Discards

Initial estimates of windowpane flounder discards, during 1975-2007, are provided for the large mesh bottom trawl fleet (codend mesh size ≥ 5.5 inches), small mesh groundfish fleet (codend mesh size < 5.5 inches), and the sea scallop fleets (dredge and bottom trawl combined, "limited permits" only) in Table Q1. Discards (mt) for 1989-2007 were estimated using Northeast Fisheries Observer Program (NEFOP) data and the combined ratio method described in Wigley et al. (2007b). Due to the low numbers of trips sampled by quarter, the large mesh bottom trawl and scallop dredge/trawl fleets were binned by half year to estimate discards (Table Q3). As a result, no imputations were necessary. There were no observed trips for the scallop fleets during 1989 and 1990 and only two trips in 1991. As a result, scallop dredge discards for 1989-1991 were estimated using the hindcast method described below. Discards for the small mesh groundfish bottom trawl fleet were estimated by quarter with the exception of 1993 and 1994 which were binned by half year. The discard estimate for the first half of 1994 was imputed. Due to a lack of fisheries observer data, prior to 1989 for the trawl fleets and prior to 1992 for the scallop fleet, discard estimates were hindcast back to 1975 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*

The NEFOP database indicates that since 1994, the primary reason for discarding windowpane flounder is the lack of a market for this thin-bodied flatfish. However, trip limits were implemented beginning in November of 2004. There is no minimum size limit on landed fish but the length data indicate that only the largest fish are landed (fish ≥ 26 cm since 1994). 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) and ranged between 44% and 92% during years when the predominate discard source (Table Q1). However, a majority of the total discards occurred in the scallop dredge/trawl fleet during 1993 and 1996-1999, ranging between 30% and 67%, and in the small mesh groundfish trawl fleet during 1989, 1992, 1994 and 2001-2002 and ranged between 46% and 69%. Recent discard estimates for 2001-2007 for the large mesh fleet, 2002-2007 for the scallop fleet, and 2004-2007 of the small mesh fleet, were more precisely estimated (CVs generally less than 38%) than the estimates prior to these time periods due to the increased number of trips sampled (Table Q4). In general, discard estimates for the large mesh fleet were the most precisely estimated and those for the small mesh groundfish fleet were the least precise.

Even during the period of the directed fishery, the landings were dwarfed by the high level of discards that occurred; generally 2-5 times the landings (Table Q1, Figure Q2). During 1982-1991, total discards ranged between 2,838 mt and 4,510 mt. Since 1992, total discards have been much lower. However, during 2003-2007, discards from the large mesh trawl fleet have increased to 200-300 mt per year, in part, a result of the November 2004 implementation of a windowpane flounder trip limit of 1,000 lbs (100 lbs per day) when conducting a “B day” fishing trip. Discards totaled 309 mt in 2007. Precision of the total discard estimates was much higher during 2003-2007 (CVs of 14%-31%) then during 1992-2002, when CVs during most years ranged between 40% and 89% because the number of sampled trips was higher (Table Q1).

Catches

Catches of windowpane flounder increased gradually from 1,169 mt in 1975 to 1,805 in 1981 then doubled in 1982 and remained at the highest levels during 1982-1991, ranging between 3,614 mt and 5,400 mt (Table Q1, Figure Q2). After 1991, catches declined rapidly to a time series low of 181 mt in 2001, but then increased to 449 mt in 2003. During 2004-2007, catches remained fairly stable at some of the lowest levels observed, between 314 and 449 mt. Since 1994, most of the catch has been comprised of discards. In recent years (2003-2007), total discards represented 80%-89% of the catch and were primarily from the large mesh bottom trawl fleet (44-77% of the total).

3.0 Research Survey Data

Previous assessments incorporated NEFSC fall survey relative abundance and biomass indices (stratified mean number and kg per tow) that were derived using data from an offshore strata set (1-12 and 61-76) and that were not standardized for changes in trawl doors, vessels, and gear. However, the inshore strata comprise a substantial portion of the total windowpane flounder habitat (Figure Q5). Therefore, NEFSC fall survey indices were revised to include catches from inshore strata 2-46 and 55 and offshore strata 1-12 and 61-76 (Figure Q6). The revised survey indices were also standardized for changes in trawl doors (numbers = 1.54 and weight = 1.67), gear (numbers = 1.67 and weight = 1.37), and vessels (numbers = 0.82 and weight = 0.80). For the fall survey indices used in the assessment, 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 R/V *Delaware II* was utilized instead of the R/V *Albatross IV*. The latter occurred both within and between surveys on an irregular basis.

There are two distinct stanzas exhibited by the stock with respect to relative biomass indices: high levels during 1979-1983 followed by a rapid decline to very low levels since 1989 (Figure Q7, Table Q5). Trends in relative biomass indices are also presented for: the NEFSC spring (March) bottom trawl surveys (same strata as fall surveys); Massachusetts spring

(May) and fall (September) surveys (strata 11-21); Connecticut (spring and fall, all strata in Long Island Sound); and the New Jersey (spring and fall, all strata) in Figure Q8. The state surveys do not encompass the entire stock area and consist of shorter time series than the two NEFSC survey series. Therefore, the NEFSC fall survey time series is considered the best indicator of stock relative abundance and biomass. However, these other surveys can be used to confirm NEFSC fall survey trends. For example, both the Long Island Sound (LIS) and MA fall survey biomass indices have been near record low levels since 1999 and 2002, respectively. The MA fall survey biomass indices declined sharply after 2004 and reached the lowest level on record in 2007. In addition, the overall declining trend in the NEFSC fall survey relative biomass indices, after 1982, is mirrored by the NEFSC spring surveys. Both the MA and LIS spring survey indices have been at the lowest observed levels since 2002.

4.0 Assessment Results

Annual catches and NEFSC fall survey relative biomass indices were used as input data to the AIM (An Index-based Model, version 2.0) software provided in version 3.0 of the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/). Computations conducted within the AIM software package and an explanation of the model parameters are provided in the Final Report of the Working Group on Re-evaluation of Biological Reference Points for New England groundfish (Anon 2002). The NEFSC fall survey indices were utilized in the final model run because an initial run that included relative biomass indices from all of the available surveys indicated that the model regression was only significant for the NEFSC fall survey time series. Lagged smoothers of three years and five years were applied to the relative F values and survey biomass indices, respectively. The 90% CI for the AIM model estimate of F_{MSY} were determined from 2,000 bootstrap iterations.

Input data to the AIM model include annual catches and NEFSC fall survey biomass indices for 1975-2007 which were used to compute annual relative fishing mortality rates (relative F) and stock replacement ratios (Table Q6). Trends in catches, survey biomass indices, relative F values, and stock replacement ratios, along with the relationship between (relative F) and ln(replacement ratio) are also presented in Figure Q9. Catches were highest during 1983-1991, a period when biomass indices were declining and reached very low levels (Figure Q9A). Annual relative fishing mortality rates increased rapidly between 1981 and 1990, at which time they reached a time series peak, then declined sharply between 1990 and 1992 (Figure Q9B). Relative fishing mortality rates declined further thereafter, reaching a time series low in 2001, but then increased gradually during 2001-2006 and were above the F_{MSY} proxy in 2006 and 2007. Stock replacement ratios were above 1.0 during 1980-1982 then declined sharply to a time series low in 1989 (Figure Q9C). Since then, the stock has only been able to replace itself for short periods of time (1995-1996, 1998, 2001-2003). After 2001, replacement ratios declined sharply and remained been below 1.0 during 2004-2006 but have shown an increasing trend until declining slightly in 2007. The correlation between relative exploitation rates and stock replacement ratios was highly significant ($p = 0.001$) and the model results suggest that the stock can replace itself at a relative F value of 1.47 (the relative F value where the log of the replacement ratio is equal to 0, Figure Q9D). A negative trend in the standardized residuals was evident during 1983-1987, a period of increasing relative F and decreasing replacement ratios (Figure Q10).

5.0 Biological Reference Points

The current biological reference points are: F_{MSY} proxy = 0.98 and B_{MSY} = 0.92 kg per tow. The F_{MSY} proxy is a relative fishing mortality rate computed as landings divided by the NEFSC fall survey relative biomass index (mean kg per tow) for 1975-2000. The F_{MSY} proxy was derived using an index-based model (AIM) and computed as the relative fishing mortality rate at which the stock can replace itself. The B_{MSY} proxy was computed from the AIM F_{MSY} proxy estimate and an MSY estimate of 900 mt derived from an ASPIC surplus production model for the period 1963-1996.

The BRPs were re-estimated using data for 1975-2007 and represent survey-based proxies of relative biomass and relative fishing mortality rates (catch / NEFSC fall survey relative biomass index). The re-estimated BRPs are shown in Table Q8 in relation to the 2007 biomass index and relative F value which were used to determine stock status. The F_{MSY} proxy (relative F) was estimated using the AIM model and the results indicate that the stock can replace itself at a relative F value of 1.47. Thus, this value can serve as an F_{MSY} proxy for the stock. The 90% CI for the F_{MSY} point estimate indicate that the estimate is fairly imprecise (Table Q7). Based on an examination of trends in the replacement ratios, during a period when catches were most precisely estimated (1989-2007), the stock appeared to be able to sustain the levels of catch that occurred during 1995-2001, because replacement ratios were near or above 1.0 during this period (Figure Q9C). During 1995-2001, the median catch was approximately 500 mt and this value was considered as an MSY proxy. Division of the MSY proxy (500 mt) by the estimated F_{MSY} proxy from the AIM model (= 1.47) results in a B_{MSY} proxy of 0.34 kg per tow. It is important to note that the re-estimated BRPs cannot be compared to the current BRPs because different survey strata sets and time series were used in their derivations and the revised estimates include discards. Furthermore, different estimation methods were utilized.

6.0 Projections

Stochastic projections were run for 2008 and 2009 using the AIM model for two scenarios: F status quo (F_{sq}) and F_{MSY}. Estimated catches and NEFSC fall survey relative biomass indices for 2008 and 2009 are presented in Table Q9 for both projection scenarios. Although the stock is no longer overfished, the stock is not rebuilt and has a rebuilding deadline of 2014. However, the August GARM Review Panel recommended against projections based on a $F_{REBUILD}$ scenario because there is no directed fishery.

7.0 Summary

The relative F value for 2007 was computed as the catch in 2007 divided by the average of the NEFSC fall survey relative biomass indices during 2005-2007 (Table Q8). The 2007 relative F value of 1.85 was higher than the F_{MSY} proxy value of 1.47, indicating that overfishing was occurring in 2007. The 2007 relative biomass index of 0.19 kg per tow was above 1/2 B_{MSY} (= 0.17 kg per tow), indicating that the stock was not overfished in 2007 (Figure Q11).

The catches are comprised predominately of discards because a directed fishery has not existed since 1990. During 2001-2003, catches increased, but then remained at some of the lowest levels recorded during 2004-2007. Despite the low current catch levels, relative fishing mortality rates gradually increased during 2002-2006 and recently were above the F_{MSY} proxy in

2006 and 2007. The stock has not been able to replace itself since 2003 because relative biomass indices have been at very low levels for a prolonged period of time, since 1989.

Sources of uncertainty include: the underestimation of total discards, because discards from vessels fishing in state waters without a Federal fishing permit are unavailable; the imprecision of the F_{MSY} estimate from the AIM model; and the fact that either MSY or B_{MSY} must be subjectively determined external to the AIM model and this approach does not afford a means of quantifying uncertainty in the estimates of current biomass and relative F. The August 2008 GARM Review Panel recommended that quantification of such uncertainty be investigated in the future.

8.0 Panel Discussion/Comments

Conclusions

The Panel concluded that that index based assessment was appropriate for this stock and provides the best available information for management. The Panel recommended that the estimates of relative biomass and fishing mortality should not be converted to absolute units. Given that current catch is mostly incidental and also given the high uncertainty of index based assessments, it was concluded that it was not appropriate to calculate F rebuild for this stock.

Research Recommendations

The Panel had no specific research recommendations for this stock.

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10.0 Acknowledgements

This assessment could not have been conducted without the data preparation and technical help provided by Susan Wigley, the age data provided by Jay Burnett, and data collected and entered by the NMFS port agents, NEFSC staffs from DMS, NEFOP and ESB. I am also grateful to the state fisheries scientists who provided me with windowpane flounder relative biomass and abundance indices from their bottom trawl surveys.

Table Q1. Landings, discards, and catches (mt) of SNE-MAB windowpane flounder during 1975-2007. Landings and discards include data from statistical areas 526, 533-539, 541, and 611-639. Discards estimates include the large mesh (codend mesh size ≥ 5.5 inches) bottom trawl fleet, small mesh groundfish fleet (codend mesh size < 5.5 inches) and the sea scallop dredge fleet.

Year	Landings[1] (mt)	Discards (mt)					Catch (mt)
		Large mesh	Small mesh	Scallop dredge	Total	CV	
1975	681		429	59	488		1,169
1976	568		517	107	624		1,192
1977	647		478	105	583		1,230
1978	898		811	185	996		1,894
1979	633		929	142	1,070		1,704
1980	532		887	106	992		1,524
1981	883		850	72	922		1,805
1982	651	2,087	784	93	2,964		3,614
1983	798	2,830	709	141	3,681		4,478
1984	1,088	2,523	809	153	3,485		4,572
1985	2,065	2,098	602	138	2,838		4,903
1986	1,381	2,257	740	161	3,158		4,539
1987	887	2,054	760	292	3,106		3,993
1988	1,172	2,159	756	237	3,152		4,324
1989	1,121	1,347	1,861	295	3,503		4,624
1990	890	3,904	346	261	4,510		5,400
1991	817	1,940	902	292	3,133		3,950
1992	584	78	342	130	550	0.28	1,134
1993	469	152	71	180	403	0.89	872
1994	186	207	679	104	989	0.40	1,175
1995	120	210	105	52	367	0.25	486
1996	191	138	60	216	414	0.24	605
1997	116	51	23	151	224	0.44	340
1998	122	237	16	149	402	0.29	524
1999	117	258	27	124	408	0.46	526
2000	125	91	21	26	138	0.61	263
2001	135	18	21	7	47	0.53	181
2002	85	31	86	45	162	0.81	247
2003	47	310	20	71	402	0.31	449
2004	61	205	76	40	320	0.19	381
2005	39	123	50	103	275	0.17	314
2006	56	300	33	72	405	0.15	461
2007	81	178	61	70	309	0.14	390

[1] Since May of 2004, landings have been self-reported by dealers and were allocated to statistical area based on Vessel Trip Report data.

Table Q2. Landings (mt) of SNE-MAB windowpane flounder, by gear type, during 1975-2007.

	Landings					
Year	Bottom trawls	Sea scallop dredges/trawls	Gillnets	Other	Total	% landed by bottom trawls
1975	678.1	0.0	0.0	0.1	678	100.0
1976	563.3	0.1	0.0	0.0	563	100.0
1977	646.2	0.4	0.0	0.2	647	99.9
1978	889.5	1.2	0.0	2.1	893	99.6
1979	630.3	1.2	0.0	1.6	633	99.6
1980	523.6	0.9	0.0	0.3	525	99.8
1981	862.6	0.5	0.0	2.9	866	99.6
1982	627.6	1.1	0.0	2.6	631	99.4
1983	768.4	3.6	0.0	2.7	775	99.2
1984	1,042.4	1.7	0.0	1.1	1,045	99.7
1985	1,964.7	0.7	0.0	1.5	1,967	99.9
1986	1,356.5	20.7	0.1	0.9	1,378	98.4
1987	853.2	26.6	0.4	1.3	881	96.8
1988	1,097.8	39.3	0.0	9.8	1,147	95.7
1989	1,077.8	40.9	0.0	2.7	1,121	96.1
1990	832.9	55.2	0.1	1.7	890	93.6
1991	712.1	101.7	0.1	2.7	817	87.2
1992	512.9	68.1	0.1	2.5	584	87.9
1993	444.9	23.0	0.2	1.2	469	94.8
1994	176.9	7.6	1.3	0.1	186	95.1
1995	112.0	1.0	0.8	5.8	120	93.7
1996	189.5	0.2	0.1	1.1	191	99.3
1997	114.6	0.3	0.3	0.9	116	98.8
1998	119.7	0.0	0.5	1.6	122	98.3
1999	115.8	0.1	0.1	1.6	118	98.4
2000	121.3	0.0	0.2	3.3	125	97.2
2001	132.9	0.0	0.4	1.4	135	98.7
2002	81.5	0.0	0.2	2.0	84	97.3
2003	45.9	0.0	0.1	1.3	47	97.1
2004	57.9	0.0	0.2	2.2	60	96.0
2005	36.7	0.0	0.1	1.0	38	97.0
2006	55.1	0.1	0.5	1.3	57	96.8
2007	80.0	0.1	0.4	0.5	81	98.8

Table Q3. Number of observed trips, by fleet and quarter, included in the discard estimates of SNE-MAB windowpane flounder, 1989-2007.

	Large mesh otter trawl			Small mesh groundfish otter trawl [1]					Scallop dredge/otter trawl		
Year	Q1and Q2	Q3 and Q4	Total	Q1	Q2	Q3	Q4	Total	Q1and Q2	Q3 and Q4	Total
1989	6	4	10	13	18	21	23	75			0
1990	13	9	22	16	21	11	15	63			0
1991	10	11	21	31	21	20	46	118		2	2
1992	19	6	25	28	9	13	17	67	7	5	12
1993	4	9	13	14		4		18	11	3	14
1994	9	8	17	1		18		19	9	9	18
1995	23	49	72	13	12	30	17	72	14	8	22
1996	11	21	32	9	25	30	27	91	16	15	31
1997	9	2	11	32	13	23	3	71	13	6	19
1998	10	4	14	15	4	7	15	41	6	7	13
1999	3	5	8	11	19	12	12	54	2	6	8
2000	19	14	33	17	12	16	8	53	9	68	77
2001	10	45	55	19	17	18	13	67	43	48	91
2002	10	38	48	10	18	24	13	65	34	57	91
2003	29	19	48	16	36	23	33	108	42	61	103
2004	73	125	198	55	63	89	112	319	76	137	213
2005	141	221	362	66	50	80	77	273	71	49	120
2006	93	79	172	64	34	56	36	190	20	68	88
2007	92	172	264	41	68	95	46	250	74	108	182

[1] Trips were combined by half year during 1993 and 1994.

Table Q4. Summary of SNE-MAB windowpane flounder discard estimates (mt) for the large mesh (codend mesh size ≥ 5.5 in.) and small mesh (codend mesh size < 5.5 in.) groundfish bottom trawl fisheries and the scallop dredge/trawl fisheries (limited permit category), 1975-2007. Discards were hindcast for: large mesh bottom trawl (1982-1988); small mesh bottom trawl (1975-1988); and scallop dredges (1975-1991).

Large Mesh Bottom Trawl				
YEAR	**N Observed trips**	**D/K**	**Discards (mt)**	**CV**
1975			-	
1976			-	
1977			-	
1978			-	
1979			-	
1980			-	
1981			-	
1982			2,087	
1983			2,830	
1984			2,523	
1985			2,098	
1986			2,257	
1987			2,054	
1988			2,159	
1989	10	0.057	1,347	0.54
1990	22	0.135	3,904	0.27
1991	21	0.064	1,940	0.99
1992	25	0.002	78	0.44
1993	13	0.006	152	0.45
1994	17	0.008	207	0.51
1995	72	0.009	210	0.32
1996	32	0.006	138	0.42
1997	11	0.002	51	1.14
1998	14	0.010	237	0.46
1999	8	0.011	258	0.52
2000	33	0.005	91	0.58
2001	55	0.001	18	0.20
2002	48	0.002	31	0.25
2003	48	0.018	310	0.39
2004	198	0.010	205	0.28
2005	362	0.006	123	0.20
2006	172	0.015	300	0.19
2007	264	0.012	178	0.20

Table Q4. (cont.)

Small Mesh Groundfish Bottom Trawl				
YEAR	N Observed trips	D/K	Discards (mt)	CV
1975			429	
1976			517	
1977			478	
1978			811	
1979			929	
1980			887	
1981			850	
1982			784	
1983			709	
1984			809	
1985			602	
1986			740	
1987			760	
1988			756	
1989	75	0.0361	1,861	0.53
1990	63	0.0067	346	0.39
1991	118	0.0149	902	0.59
1992	67	0.0057	342	0.39
1993	18	0.0012	71	4.78
1994	37	0.0111	679	0.55
1995	72	0.0022	105	0.56
1996	91	0.0011	60	0.39
1997	71	0.0004	23	0.61
1998	41	0.0002	16	0.89
1999	54	0.0006	27	0.77
2000	53	0.0005	21	3.30
2001	67	0.0006	21	1.11
2002	65	0.0031	86	1.77
2003	108	0.0007	20	1.84
2004	319	0.0014	76	0.38
2005	273	0.0015	50	0.36
2006	190	0.0006	33	0.53
2007	250	0.0021	61	0.32

Table Q4. (cont.)

Scallop dredge/trawl, Limited category permits				
YEAR	N Observed trips	D/K	Discards (mt)	CV
1975			59	
1976			107	
1977			105	
1978			185	
1979			142	
1980			106	
1981			72	
1982			93	
1983			141	
1984			153	
1985			138	
1986			161	
1987			292	
1988			237	
1989			295	
1990			261	
1991			292	
1992	12	0.0020	130	0.52
1993	14	0.0057	180	0.50
1994	18	0.0022	104	0.92
1995	22	0.0010	52	0.52
1996	31	0.0051	216	0.35
1997	19	0.0052	151	0.53
1998	13	0.0056	149	0.50
1999	8	0.0034	124	1.16
2000	77	0.0003	26	0.84
2001	91	0.0001	7	0.71
2002	91	0.0003	45	0.24
2003	103	0.0004	71	0.28
2004	213	0.0003	40	0.21
2005	120	0.0010	103	0.36
2006	88	0.0009	72	0.38
2007	182	0.0005	70	0.31

Table Q5. Stratified mean catch per tow indices (in kg and numbers) for SNE-MAB windowpane flounder caught during NEFSC fall research bottom trawl surveys, 1975-2007. Indices include offshore strata 1-12 and 61-76 and inshore strata 2-46 and 55. Standardization coefficients were applied for trawl door changes (numbers = 1.54 and weight = 1.67), gear changes (numbers = 1.67 and weight = 1.37), and vessels (numbers = 0.82 and weight = 0.80).

Year	Mean kg per tow	Mean number per tow
1975	0.460	2.72
1976	0.702	3.56
1977	0.912	4.32
1978	0.700	3.52
1979	1.615	7.71
1980	1.238	4.71
1981	1.250	5.08
1982	1.917	9.52
1983	1.045	4.44
1984	0.921	3.84
1985	0.677	4.04
1986	0.622	3.48
1987	0.405	2.54
1988	0.421	2.42
1989	0.217	1.42
1990	0.235	1.27
1991	0.329	1.81
1992	0.282	1.58
1993	0.124	0.68
1994	0.215	1.11
1995	0.328	1.96
1996	0.265	1.68
1997	0.145	0.72
1998	0.228	1.32
1999	0.194	1.09
2000	0.180	1.06
2001	0.406	1.75
2002	0.387	2.00
2003	0.350	1.89
2004	0.166	0.93
2005	0.181	0.91
2006	0.262	1.33
2007	0.191	1.26

Table Q6. AIM model input data for the SNE-MAB 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*/ mean NEFSC fall survey biomass index for years *t*, *t*-1, and *t*-2), and stock replacement ratios (NEFSC fall survey biomass index in year *t* / mean biomass index for previous five years) during 1975-2007.

Year	Catch (000's mt)	Relative biomass index (kg per tow)	Relative F	Replacement Ratio
1975	1.169	0.460		
1976	1.192	0.702		
1977	1.230	0.912	1.78	
1978	1.894	0.700	2.46	
1979	1.704	1.615	1.58	
1980	1.524	1.238	1.29	1.410
1981	1.805	1.250	1.32	1.210
1982	3.614	1.917	2.46	1.677
1983	4.478	1.045	3.19	0.778
1984	4.572	0.921	3.53	0.652
1985	4.903	0.677	5.57	0.531
1986	4.539	0.622	6.13	0.535
1987	3.993	0.405	7.03	0.391
1988	4.324	0.421	8.96	0.574
1989	4.624	0.217	13.30	0.356
1990	5.400	0.235	18.56	0.502
1991	3.950	0.329	15.17	0.866
1992	1.134	0.282	4.02	0.877
1993	0.872	0.124	3.56	0.418
1994	1.175	0.215	5.68	0.906
1995	0.486	0.328	2.19	1.384
1996	0.605	0.265	2.25	1.037
1997	0.340	0.145	1.38	0.597
1998	0.524	0.228	2.46	1.058
1999	0.526	0.194	2.78	0.821
2000	0.263	0.180	1.31	0.776
2001	0.181	0.406	0.70	2.006
2002	0.247	0.387	0.76	1.678
2003	0.449	0.350	1.18	1.254
2004	0.381	0.166	1.27	0.547
2005	0.314	0.181	1.35	0.608
2006	0.461	0.262	2.27	0.879
2007	0.390	0.191	1.85	0.710

Table Q7. AIM model estimate of the F_{MSY} proxy and the probability value for the randomization test for SNE-MAB windowpane flounder.

	Point estimate (90% CI)	Bootstrap mean
F_{MSY} proxy	1.47 (0.77, 2.11)	1.46
Randomization test *p* value	0.001	

Table Q8. Biological reference point estimates for SNE-MAB windowpane flounder and stock status for 2007. Relative F for 2007 is the catch in 2007 divided by the average relative biomass index from the NEFSC fall surveys during 2005-2007.

2007 Relative F	F_{MSY} proxy
1.85	1.47
2007 Relative biomass index (kg per tow)	**B_{MSY} proxy (kg per tow)**
0.19	0.34

Table Q9. Stochastic projections of catch (mt) and NEFSC fall survey relative biomass indices (kg per tow) in 2008 and 2009, F status quo (F_{sq}) and F_{MSY}, for SNE-MAB windowpane flounder.

2008			2009	
Catch (mt)	Relative Biomass Index (kg per tow)	F 2009	Catch (mt)	Relative Biomass Index (kg per tow)
396	0.21	F_{sq} (= 1.85)	368	0.20
338	0.23	F_{MSY} (= 1.47)	338	0.23

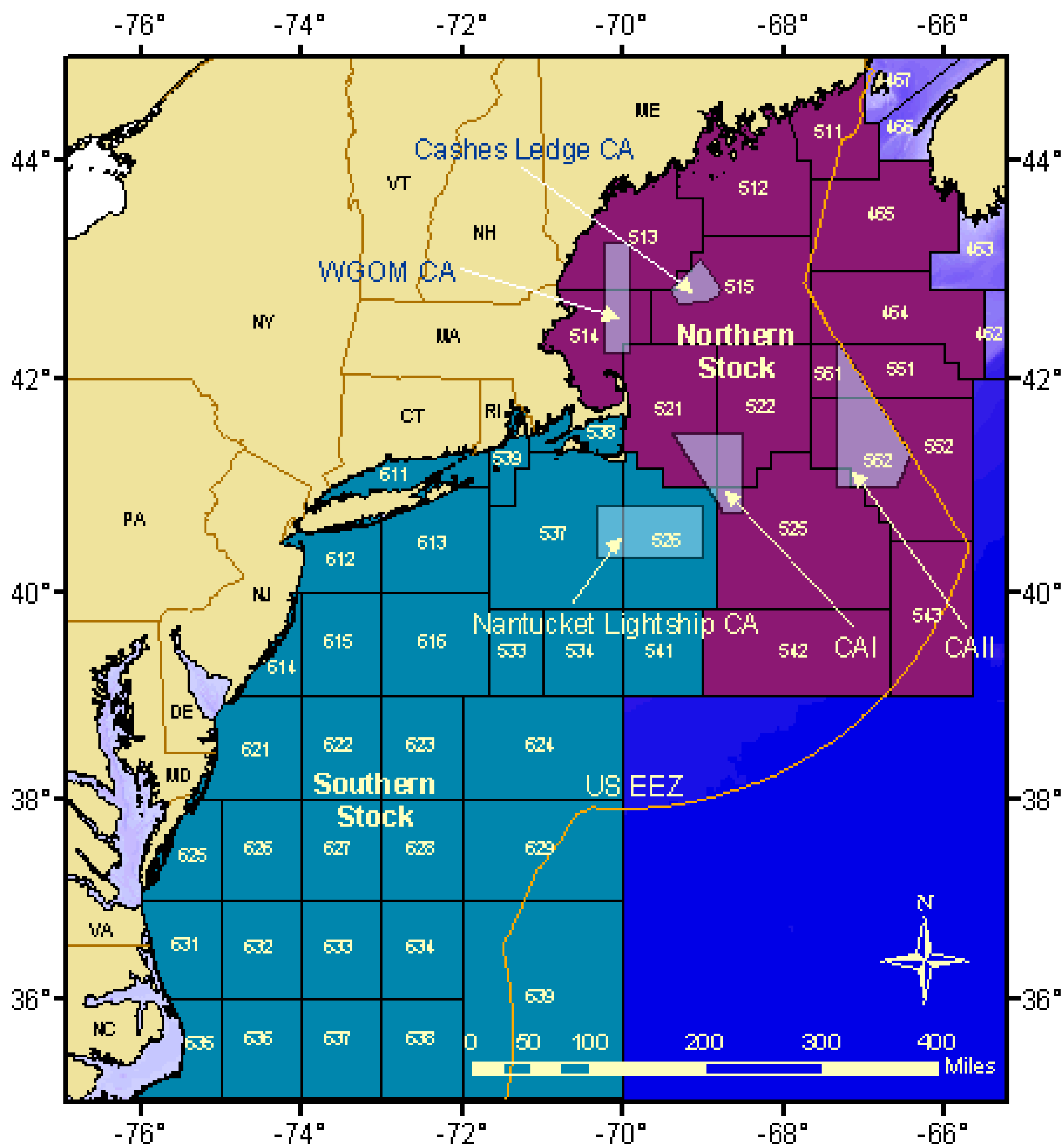


Figure Q1. Statistical Areas comprising the northern (Gulf of Maine-Georges Bank) and southern (Southern New England-Mid-Atlantic Bight) windowpane flounder stocks.

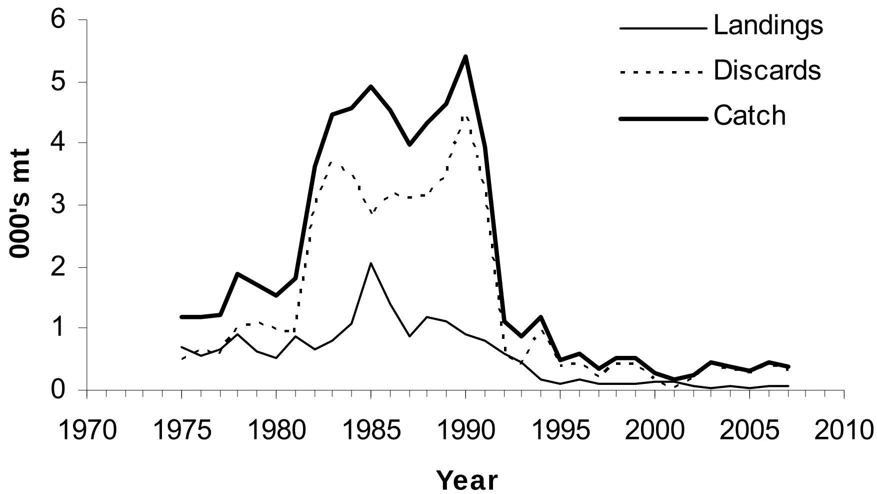


Figure Q2. Commercial landings, discards and catches of Southern New England-Mid-Atlantic Bight windowpane flounder during 1975-2007.

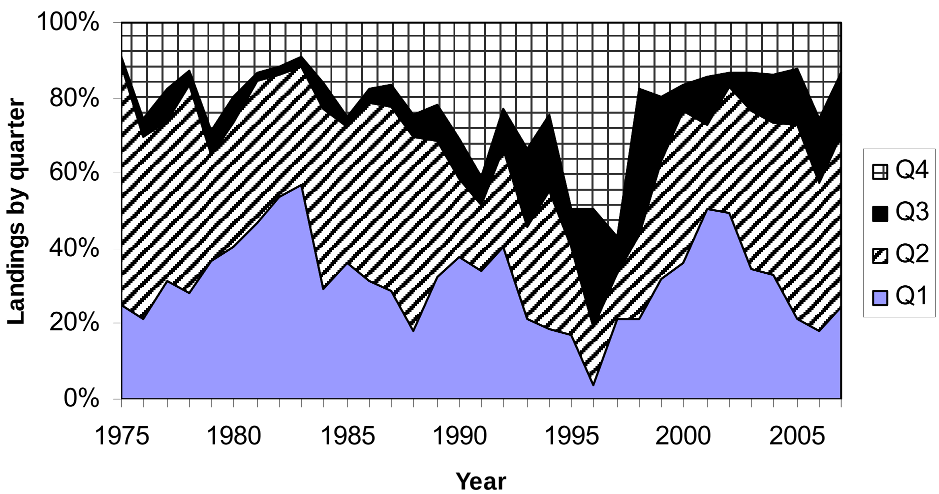


Figure Q3. Percentage of landings of SNE-MAB windowpane flounder, by quarter, during 1975-2007.

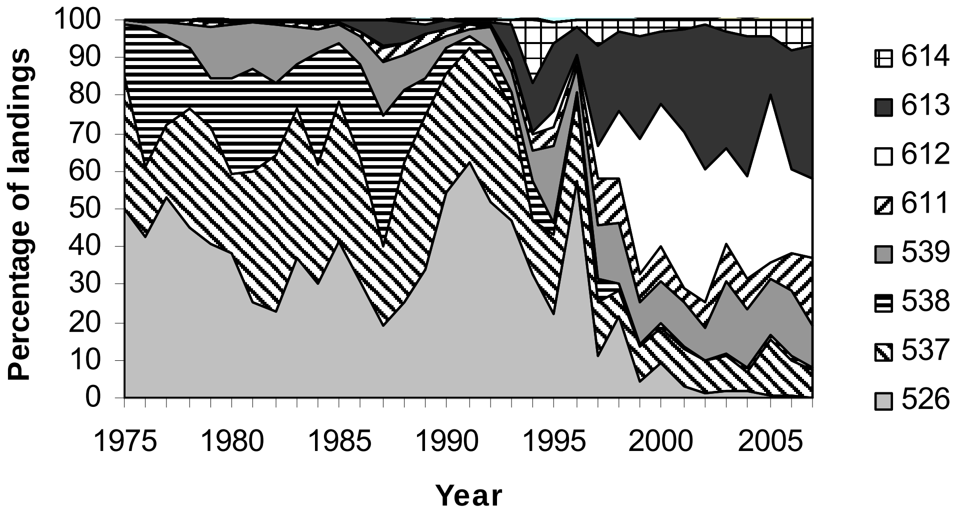


Figure Q4. Percentage of landings of SNE-MAB windowpane flounder, by Statistical Area, during 1975-2007.

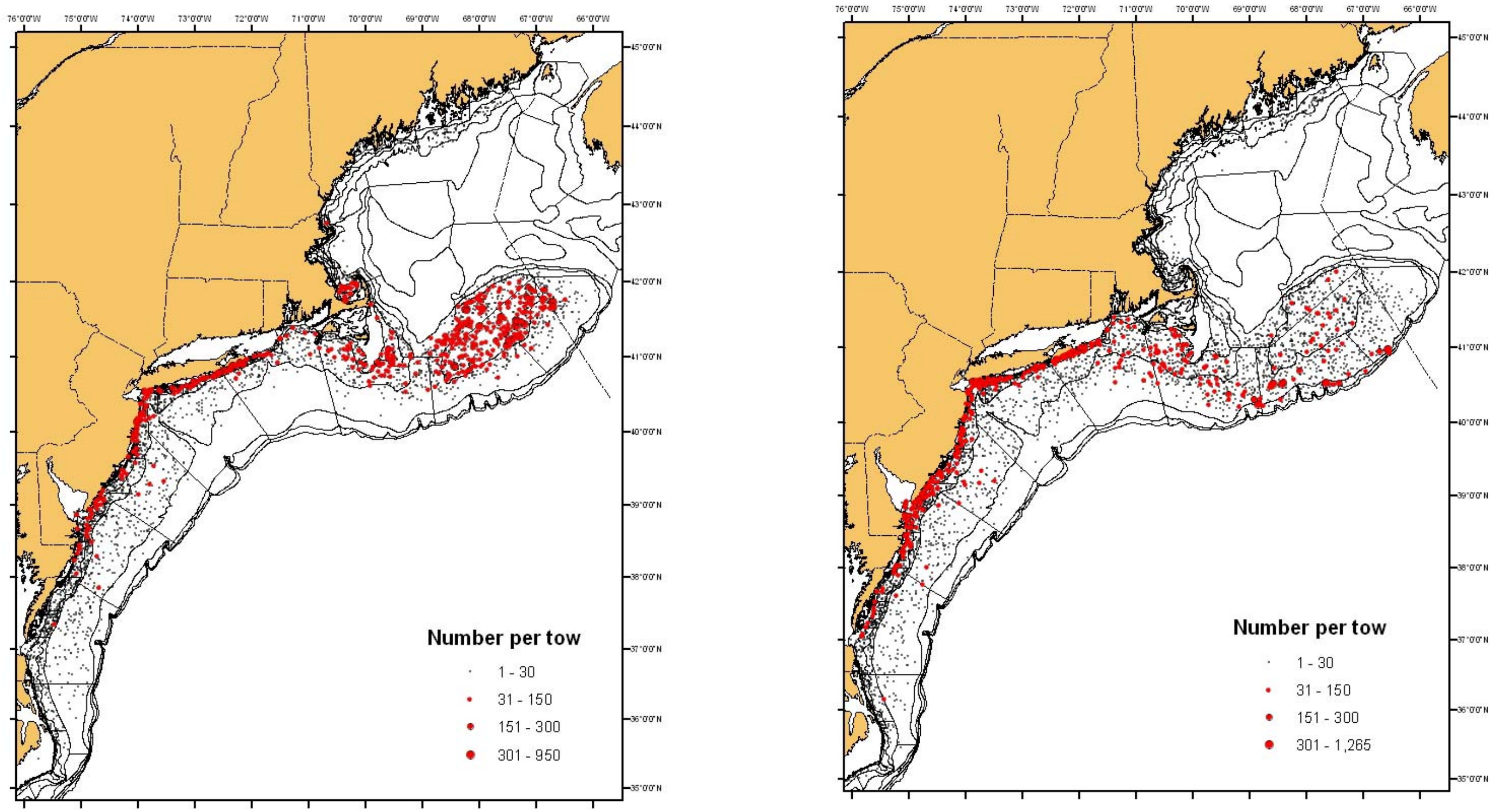


Figure Q5. Spatial distribution of windowpane flounder during NEFSC fall and spring bottom trawl surveys, 1968-2007.

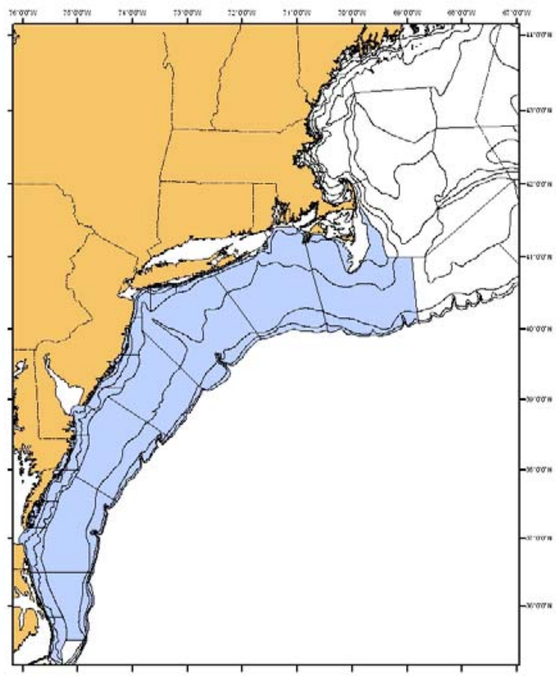


Figure Q6. Strata set used to derive abundance and biomass indices, from NEFSC fall and spring bottom trawl surveys, for the SNE-MAB windowpane flounder stock.

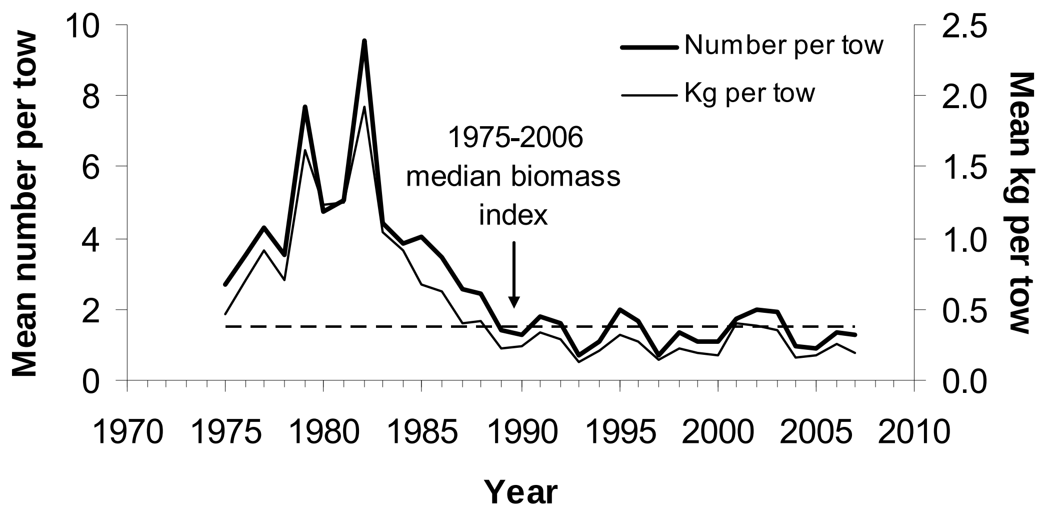
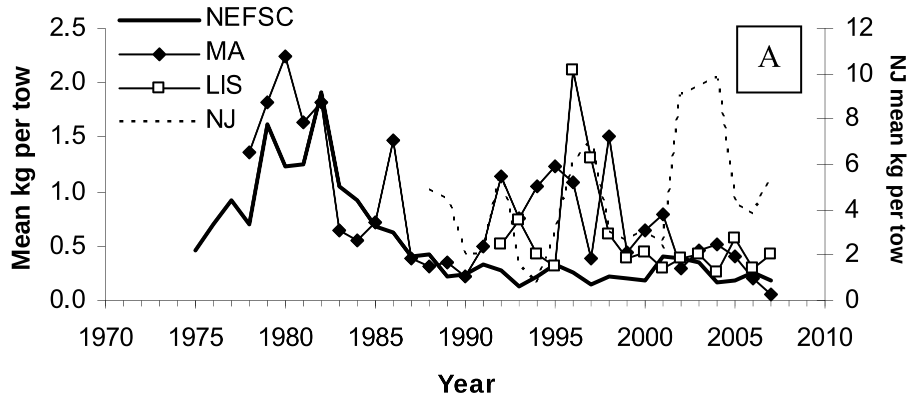


Figure Q7. Relative abundance (stratified mean number per tow) and biomass indices (stratified mean kg per tow) for SNE-MAB windowpane flounder caught during NEFSC autumn bottom trawl surveys, 1975-2007.



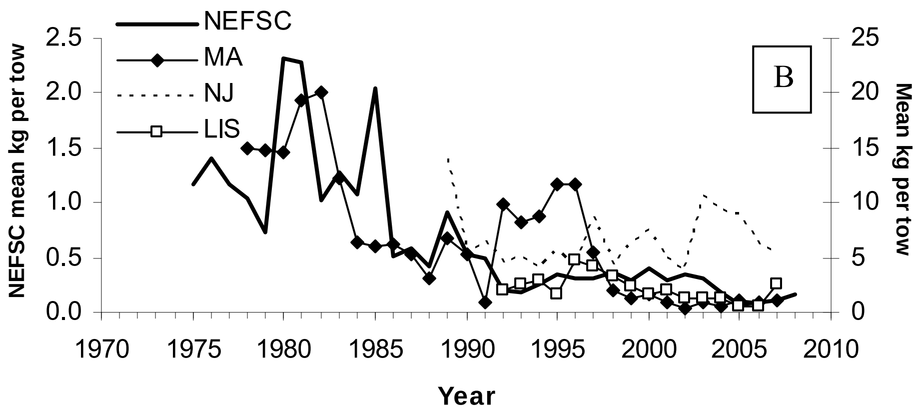


Figure Q8. Relative biomass indices for SNE-MAB windowpane flounder caught during (A) fall surveys conducted by the NEFSC, MA, NJ, and CT (= LIS) and (B) spring surveys conducted by the NEFSC, MA, NJ, and CT.

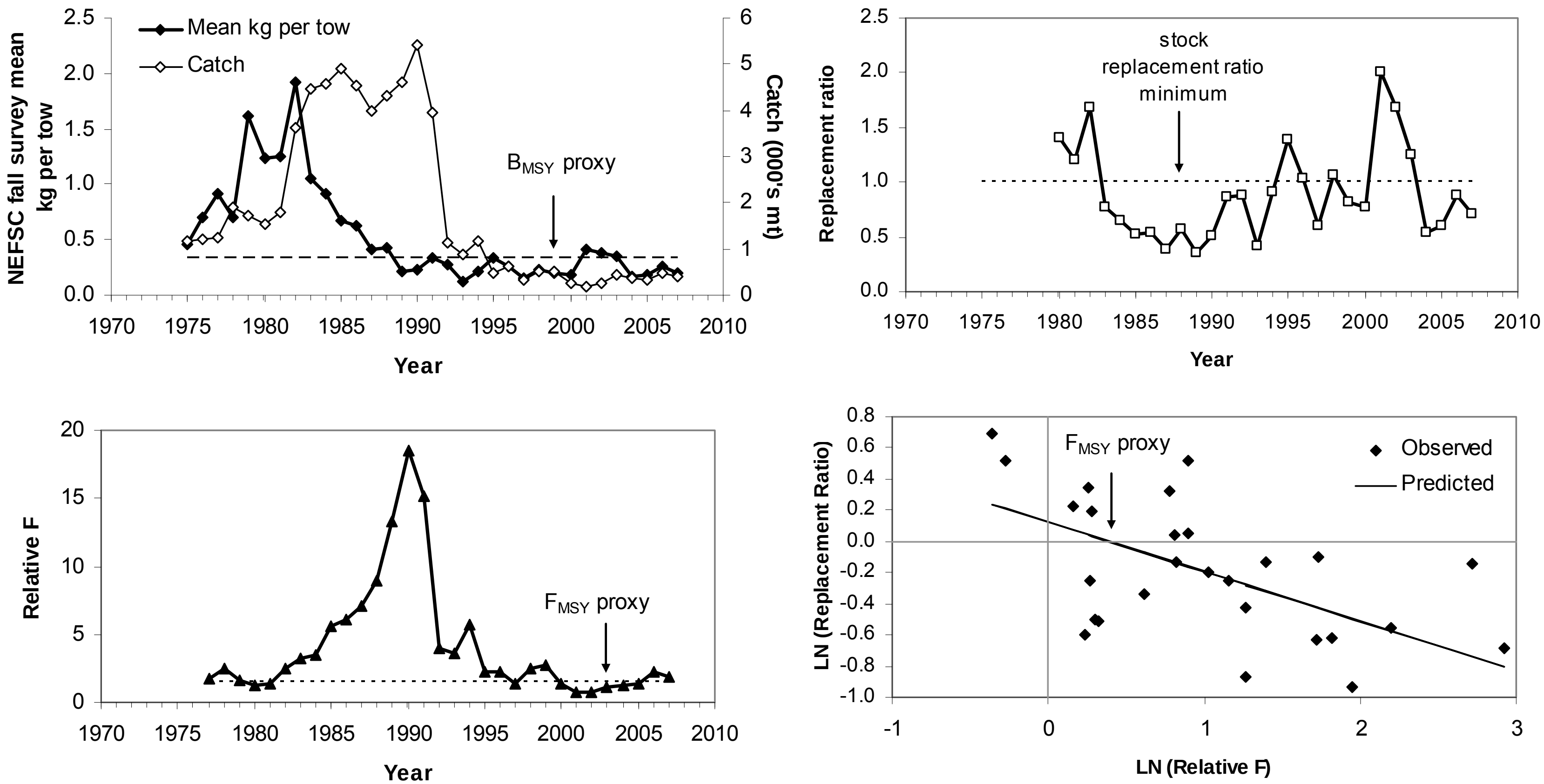


Figure Q9. Trends in (A) SNE-MAB windowpane flounder catches (000's mt) and NEFSC fall survey relative biomass indices (stratified mean kg per tow), (B) relative fishing mortality rates (catch/NEFSC fall survey biomass index), (C) stock replacement ratios, and (D) the regression of ln(relative F) against ln(replacement ratio) used to calculate an F_{MSY} proxy (1.47), 1975-2007.

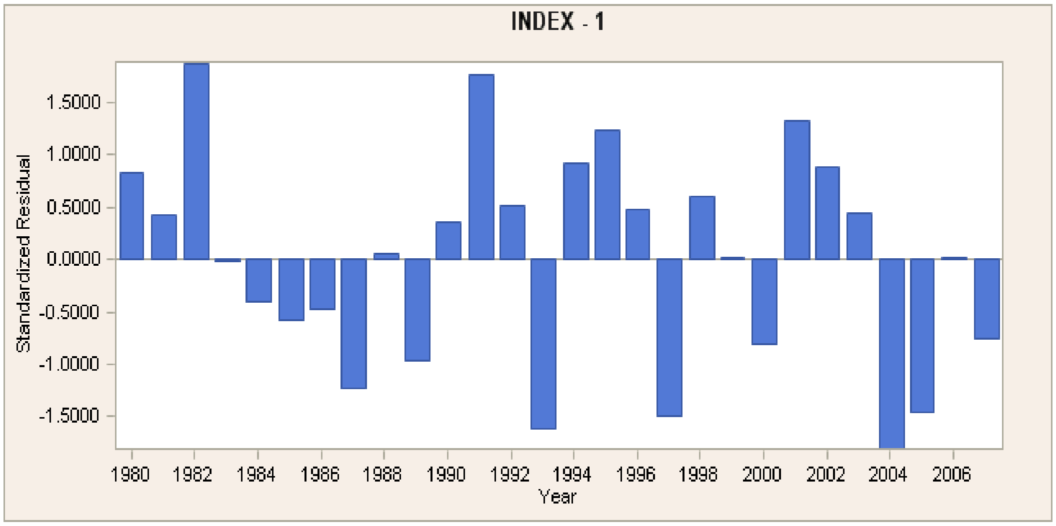


Figure Q10. Standardized residuals from the final AIM model run for SNE-MAB windowpane flounder.

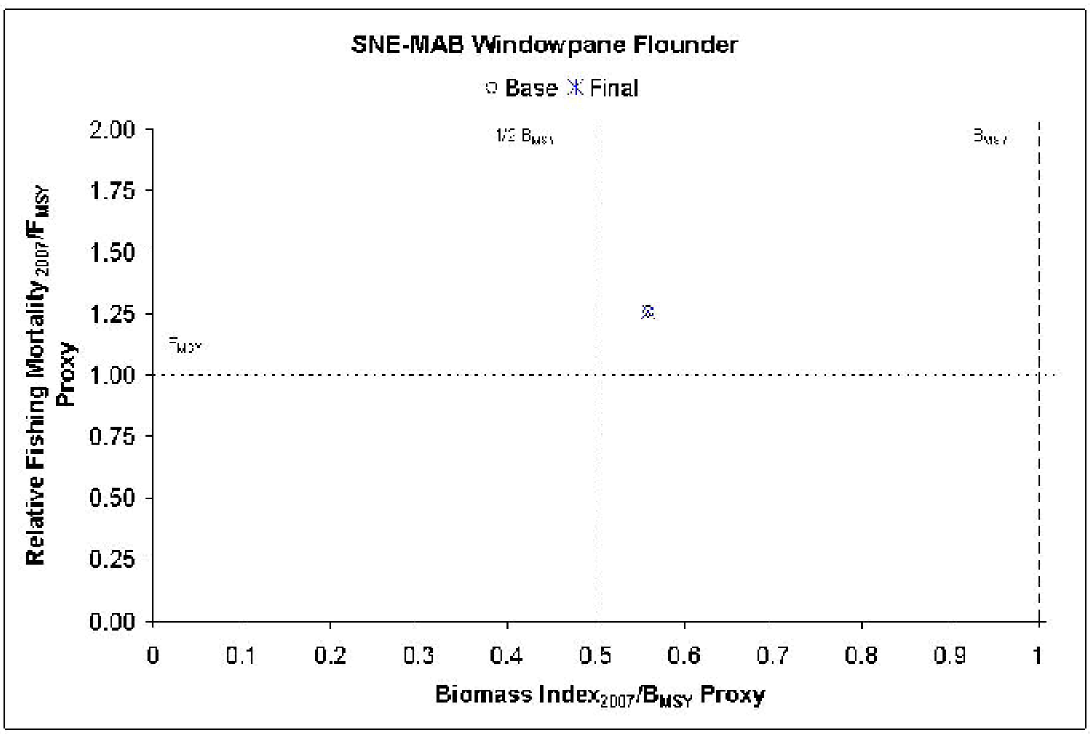


Figure Q11. Stock status for SNE-MAB windowpane flounder during 2007.

R. Gulf of Maine haddock
by Michael Palmer

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

1.0 Background

The Gulf of Maine haddock stock was last assessed at the Groundfish Assessment Review Meeting (GARM) in 2005 (NEFSC 2005). That assessment compared survey biomass and exploitation rate indices to biological reference points (BRPs) generated in 2002 using the index-based model, An Index Method (AIM[4], NEFSC 2002). The proxy F_{MSY} (exploitation rate index) and $B_{Threshold}$ (1/2 B_{MSY}) were estimated at 0.23 and 11.09 kg/tow, respectively (NEFSC 2002). Based on the 2005 assessment, the terminal year (2004) exploitation rate index was 0.18 and the 3-year survey biomass index was 5.79 kg/tow. Stock status was overfished but overfishing was not occurring. The 2005 assessment did not include estimates of recreational catch or commercial discards in the exploitation rate.

The 2005 GARM Review Panel recommended that future assessments include recreational catches in estimates of fishery removals and that an age-structured assessment be attempted. Past assessments have not utilized age-structured models because biological data (length frequencies, age and maturity sampling) were sparse during the late 80s and early- to mid-90s (NEFSC 2001). The 2008 GARM Models Meeting Review Panel (O'Boyle 2008a) also encouraged the exploration of age-structured models but supported the AIM model as a fall-back method for the determination of BRPs.

For the 2008 GARM BRP Meeting a virtual population analysis (VPA) assessment was performed and the model was accepted by the Panel as a basis for BRP determination (O'Boyle 2008b). The current assessment updates fishery catch estimates (including recreational landings and commercial discards), research survey abundance indices and analytical models (i.e., VPA) through 2007/08 analyzed by VPA. Additionally, BRPs are recalculated using the updated VPA results.

2.0 Fishery

Commercial landings

For the purposes of describing fishery removals, the Gulf of Maine region is defined as statistical areas 510 – 515 (NAFO area 5Y; Fig. R.1). The commercial fishery has been largely dominated by the United States (US) domestic fleet (Table R.1; Fig.R.2). There were two periods of significant Canadian landings, the first from 1965 to 1968 and the second from 1978 to 1986. Domestic landings remained above 4,500 mt until 1967, subsequently dropping below 600 mt in 1973 before rising back above 6000 mt by 1980. Subsequent to 1980 landings began to decrease, reaching a historic low of 120 mt in 1994. Landings gradually increased after 1994 and remained relatively constant at approximately 1000 mt from 2003 to 2005. Landings have dropped off in the most recent two years and remain below 700 mt. The US commercial fishery is primarily composed of otter trawl, sink gillnet and benthic longline vessels which account for on average,

[4] *NOAA Fisheries http://nft.nefsc.noaa.gov/Toolbox Version 3.0, 2008. An Index Method (AIM) Version 2.0. [Internet address: http://nft.nefsc.noaa.gov].*

99% of total landings (Table R.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 some 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 (Table R.3). From 1977 on, sampling remained relatively high until the late-1980s when landings began to decline. Sampling remained low until 1997 when haddock trip limit restrictions were relaxed and landings increased. Age-length keys were supplemented with survey age data to the extent possible when the number of ages per year was less than 100. Commercial landings at age were estimated from 1977 to the present using the Commercial Data Biostatistical Analysis Program (BioStat v 5.10[5]) software (Table R.4). Length-weight relationships were calculated using the Northeast Fisheries Science Center (NEFSC) bottom trawl survey data from 1992 to 2007 [autumn] / 2008 [spring]. Before 1992, individual weights were not recorded in the bottom trawl survey. Spring survey data were used to represent the relationship during the first two quarters of the calendar year, and the autumn survey for quarters three and four. Regression equations were calculated using non-linear least squares regression. The representative equations for each half year block are:

$$\text{Spring: } W_{\text{live (kg)}} = 0.00000769 \cdot L_{\text{(fork cm)}}^{3.0622} \ (p < 0.0001,\ n=2502)$$

$$\text{Autumn: } W_{\text{live (kg)}} = 0.00000987 \cdot L_{\text{(fork cm)}}^{3.0987} \ (p < 0.0001,\ n=4890)$$

Uncertainty in the catch at age was determined using the BioStat bootstrap option (1000 realizations; Legault et al. 2007). The catch at age coefficient of variation (CV) were generally less than 30% (Table R.5). CVs are large for the youngest and oldest age classes. Catch at age uncertainty could only be determined back to 1984; prior to 1984 individual sampling events can not be identified in the data.

Commercial discards

Commercial discards were estimated for five commercial fleets: the large mesh bottom otter trawl (≥ 5.5"), small mesh bottom otter trawl (< 5.5"), benthic longline, sink gillnet, midwater-paired otter trawl, and midwater otter trawl fleets. These five fleets constitute the majority of total Gulf of Maine haddock discards (Table R.6). 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). Discards prior to 1989 were estimated using the survey-scaling method (Palmer et al. 2008). Prior to 1982, the large mesh otter trawl fishery did not exist.

With the exception of the period from 1994 to 1997 when possession limits ranged from 500 to 1,000 lb/day, Gulf of Maine haddock are primarily discarded because of minimum size limits (Table R.7). Federal size limits were first imposed in 1977 and have ranged from 16" to 19" for the commercial fishery (Table R.8). 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

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[5] *NOAA Fisheries Toolbox Version 3.0 2008. Commercial Data Biostatistical Analysis Program 5.10. [Internet address: http://nft.nefsc.noaa.gov].*

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 R.9). There are two predominant peaks in discards, the first between 1964 to 1966 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. R.2).

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 R.10). 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. 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 (or 5^{th} percentile observed in commercial landings for those years where no minimum size restrictions existed). 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 R.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.

Recreational landings

Gulf of Maine haddock recreational landings (types A and B1 catch) were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS). There was assumed 100% survival of recreational live releases (type B2 catch). Landings were partitioned among stock complexes using a standard algorithm (S. Steinback pers. comm.). MRFSS data are available from 1981 onward. Historically, recreational landings have been a minor component of overall fishery removals, though over the past five years recreational landings have averaged less than 500 mt (Table R.12; Fig. R.2).

Recreational length samples were extremely limited prior to 2002 (Table R.13). 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 (Table R.8; Fig. R.3). 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 R.14). 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.

Total fishery catch at age are presented in Table R.15. The mean catch weight at age has exhibited declines in the last ten years, particularly among the older age classes (Table R.16).

3.0 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 from 1963 to 2007 (spring survey commenced in 1968). The indices include catch data from stations within the NEFSC offshore survey strata 01260 – 01280 and 01360 – 01400 (Fig. R.4). The survey indices were adjusted for differences between the fishing power of the Albatross IV and Delaware II and for differences in the catchability of the BMV trawl doors used prior to 1985 (Forrester et al. 1997; Table R.17). Spring and autumn survey indices exhibit similar trends over the time series (Table R.18; Fig. R.5).

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 since 1997 with current indices equal to those observed during the late 1970's and early 1980's. The increases in both abundance and biomass observed throughout the time series have been largely driven by moderate to strong year classes observed in 1963, 1975, 1998, and 2003 (Fig. R.6 and R.7) that track strongly through the survey abundance at age matrices (Tables R.19 and R.20). Survey biological sampling (lengths, ages) was sparse during the late 1980s and early to mid-1990s during the periods of low stock abundance (Table R.21).

4.0 Assessment

Model Selection

A VPA assessment was accepted by the GARM 2008 BRP Panel for the purpose of calculating BRPs. The accepted VPA configuration included catch, survey and biological data for years 1977 through 2006 with a maximum age of 9^+ calibrated using the ADAPT VPA version 2.8.0[6]. 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. For the BRP meeting, several calibration runs were undertaken to assess the sensitivity of the VPA results to inclusion/exclusion of the survey indices at age. The BRP-selected model configuration, BRP1 (Table R.22), 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 R.19 and R.20). The ALT1 model examined survey index ages from 1 to 9+ for both the spring and autumn surveys.

For the NEFSC spring and autumn survey series trawl effective area swept estimates were available to calculate swept area abundance indices. These calculations assume 100% trawl efficiency. Swept area abundance indices were used as calibration indices in both the BASE and ALT1 runs. BASE run survey catchability coefficients (*q*'s) were < 1.0 for all but the autumn 7 and 8:9^+ indices (Fig. R.8a). ALT1 survey *q*'s were comparable for the spring indices (< 0.4), however they were considerably higher for the older autumn age classes (Fig. R.8b). Mohn's rho (Mohn 1999) statistic was used to quantify the relative retrospective pattern in terminal year estimates of fishing mortality (F), spawning stock biomass (SSB) and recruitment (R) for both the BASE and ALT1 configurations:

$$\rho = \frac{\left(\sum_{y}^{n} \frac{x_{y,tip} - x_{y,ref}}{x_{y,ref}} \right)}{n} \qquad (1)$$

[6] *NOAA Fisheries Toolbox Version 3.0 2008. Virtual Population Analysis Model VPA/ADAPT version 2.8.0. [Internet address: http://nft.nefsc.noaa.gov].*

Mohn's rho values were calculated using a seven year peel (n=7); rho values for both the BASE and ALT1 configurations are presented in Table R.22. With the exception of the Mohn's rho value for SSB, the BASE run exhibited lower retrospective pattern. However, the recent relative differences in the terminal year SSB estimates were lower in the BASE run compared to ALT1. Based on the GARM 2008 BRP Panel acceptance of the BRP1 configuration (which is identical to the BASE configuration), survey *q* patterns and retrospective pattern statistics, the GARM 2008 Panel selected the BASE run as the final model configuration with which to use for calculation of BRPs, and stock status determination.

Diagnostics

Age-specific survey residual plots for the BASE run do not exhibit any evidence of systematic patterning (Fig. R.9 and R.10).

There is a moderate retrospective pattern observable in the terminal year F estimates of the BASE model configuration (Fig. R.11 and R.12), however there is no separation of the bootstrap distributions (1000 iterations; Fig. R.13) suggesting absence of a strong retrospective pattern (Legault 2008). There is no retrospective pattern evident in the terminal year estimates of recruitment (Fig. R.14); however, there are large relative differences (Fig. R.15), though no patterning is observed.

There are minor retrospective patterns in the SSB terminal year estimates (Fig. R.16), though these difference are < 10% in the most recent year "peels" (Table R.22; Fig. R.17). There is no separation of the bootstrapped distributions in the recent year peels, suggesting this is not a strong retrospective pattern (Fig. R.18).

The precision of the 2008 (terminal year + 1) stock size at age, SSB in 2007, and F at age in 2007 was evaluated by resampling errors from 1000 bootstrap realizations. Bootstrapped estimates of stock size at age indicate low bias (< 15%) in ages 2 – 7 (Table R.23). Bootstrapped CVs range from 0.33 at age 7 to 201% at age 1. The SSB CV = 19% with an 80% probability of the SSB being between 4,690 mt and 7,520 mt (Table R.24; Fig. R.18). Bootstrapped CVs of F at age ranged from 0.26 at age 0 to 500% at age 7 (2000 year class; Table R.25). The 2000 year class is a weak year class that has experienced high fishing mortality. Excluding age 7 F CVs, the highest CV is 71% at age 1. There is an 80% probability that fully recruited unweighted average F for ages 6-8 in 2007 was between 0.31 and 1.40. The 80% confidence intervals for the N-weighted average $F_{6\text{-}8}$ range from 0.26 to 0.55 (Fig. R.20). Because of the presence of a weak year class with a high degree of uncertainty in the estimated unweighted average F, it is more appropriate to use an N-weighted average F as the basis for stock status determination. The N-weighted F has tracked very closely with the unweighted average F over time with the exception of periods where the unweighted average F was influenced by high mortality on weak year classes (Fig. R.21; Table R.26).

Results

The BASE VPA assessment results indicate the stock numbers were around 29 million fish during the late 1970s and declined to 1.8 million fish by 1990 (Table R.27). The high abundances in the late 1970s were driven by the strong year class of 1975 and moderate year classes of 1978 and 1979 (Fig. R.22). Two back-to-back moderate strength year classes in 1993 and 1994 contributed to an increase in population numbers following the low of 1990. A very strong year class developed in 1998. The 1998 year class increased stock numbers above 20 million for the first time since 1980. Several moderate year classes have been observed since

1998, sustaining a current population size of approximately 10 million fish. There is some evidence of a moderately strong year class in 2003, but not of the relative magnitude as observed on Georges Bank (NEFSC 2005). Median and mean age 1 recruitment from 1977 to 2006 is estimated at 1.4 and 2.3 million fish respectively (Fig, R.22).

SSB was estimated at approximately 15,000 mt during the early 1980s, declining to a low of 550 mt by 1989 (Table R.28). 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 13,700 mt (Fig. R.22). SSB has since declined as the 1998 year class is removed from the population. The 2003 year class should have reached near 100% maturity in 2007. Low recruitment and high F ($F_{6\text{-}8} > 0.5$) during the period from 1983 to 1991 reduced the biomass of the older age classes. With low F in the recent period combined with strong to moderate recruitment, the current population age structure has expanded to levels similar to those observed in the early 1980's. F among the younger age classes (< age 4) has declined in the last ten years in response to decreases in the fishery selectivity brought about by increases in mesh size (Fig. R.23) and the greater contribution of the recreational fishery to total catch (Fig. R.2). The 2007 SSB is estimated at 5,850 mt and the N-weighted fully-recruited F, $F_{6\text{-}8}$, is estimated at 0.35.

5.0 Biological Reference Points

The 2008 GARM BRP Review Panel supported the use of BRPs calculated from yield per recruit (YPR) and SSB per recruit (SSBPR) analyses based on mean weight and partial recruitment patterns calculated from an unweighted average of the most recent five years in the assessment (2003 – 2007; O'Boyle 2008b). Given the observed declined in haddock size at age, applying averages of the recent values 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. Input vectors are presented in Table R.29.

In general, mean weights of the commercial catch have declined in recent years (Table R.16). A similar trend has been observed in survey weights at age and lengths at age over time (Fig. R.24; O'Brien et al. 2008). It is notable that the recent observed weights at age are similar to those observed in the 1960s when the stock was abundant. The fishery and stock weights at age were less than those estimated for Georges Bank haddock (Brooks et al. 2008). It is not clear why stock weights at age differ; spring survey weights at age between the two stocks are similar in recent years (O'Brien et al. 2008). Differences in fishery weights-at-age may be partly explained because the Gulf of Maine fishery tends to occur earlier in the year relative to the Georges Bank fishery.

There is some evidence of declining maturity at age in recent years (Fig. R.25), however this trend is not apparent in the age at 50% maturity (Fig. R.26). The VPA assessment used a time series averaged maturity at age. This is held consistent for BRP calculations.

There are appreciable differences in the partial recruitment vectors between Gulf of Maine and Georges Bank haddock stocks. This may be explained in part because of the large fraction of the Gulf of Maine landings contributed by the recreational fishery; it's expected that the selectivity of the hook and line recreational fishery is low for smaller/younger fish. Additionally, anecdotal evidence suggests that Gulf of Maine trawlers use a 6.5" square body mesh size to target flatfish in the Gulf of Maine, with haddock constituting non-targeted catch.

The larger mesh size (compared to 6.0" inch diamond body mesh) could allow for greater escapement of the smaller/younger haddock. Currently the codend mesh size must be 6.5" for both diamond and square hung nets in both the Gulf of Maine and on Georges Bank.

Natural mortality estimates have not been considered in previous assessments of Gulf of Maine haddock. The longevity of Gulf of Maine haddock is similar to that of Georges Bank haddock (e.g., 15 years), thus an assumption of 0.2 was used consistent with previous Georges Bank assessments and those of other groundfish (NEFSC 2005).

F estimates from the yield per recruit analysis were $F_{0.1}$ = 0.32, $F_{40\%}$ = 0.43 and F_{max} = 1.66 (all fully recruited Fs; Table R.30). The 2008 GARM BRP Panel recommend $F_{40\%}$ as the appropriate proxy for F_{MSY}. The SSBPR and YPR at $F_{40\%}$ were estimated at 2.15 and 0.50 kg/recruit respectively.

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[7]) model run at a constant harvest of $F_{40\%}$ = 0.43 (Brodziak and Rago 1994; Brodziak et al. 1998). Input vectors for the AGEPRO runs are the same as those used for the YPR/SSBR analyses (Table R.29). 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. 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. R.27a). Using the regression relationship, recruitment was estimated back to the 1962 year class (Fig. R.27b). 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). As the current SSB is above 3,000 mt, it was not necessary to include recruitment estimates below 3,000 mt in the projection. The resulting BRP estimates were: SSB_{MSY} = 5,900 mt (80% confidence interval of 3,200 – 10,300 mt), and MSY = 1,360 mt (80% confidence interval of 730 – 2,450 mt).

6.0 Projections

Projections of SSB and MSY in 2009 were conducted using the same recruitment series and input vectors used in BRP determinations. Catch in 2008 was assumed equivalent to 2007 (1,368 mt). Two projections were conducted assuming different levels of F_{6-8} in 2009: $F_{40\%}$, and N-weighted average $F_{6-8,2007}$. Under both assumptions of F, 2009 SSB will exceed SSB_{MSY} and catch will remain ± 17% of MSY (Table R.31).

7.0 Summary

Stock Status

Based on the current assessment, Gulf of Maine haddock is not overfished and overfishing is not occurring (Fig. R.28). This stock status determination is based on the use of the N-weighted average of F_{6-8} in this unique situation. The high mortality on a weak year class results in large

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[7] *NOAA Fisheries http://nft.nefsc.noaa.gov/Toolbox Version 3.0, 2008. Age Structured Model Projections (AGEPRO). Version3.1.3. [Internet address: http://nft.nefsc.noaa.gov].*

uncertainty of the unweighted average $F_{6\text{-}8}$. Using the N-weighted average $F_{6\text{-}8}$ reduces the uncertainty, but it is a departure from other current age-based groundfish assessments.

The previous assessment of this stock in 2005 compared survey biomass and exploitation rate indices to BRPs generated in 2002 using the index-based model, AIM. Based on the 2005 assessment, the stock status was overfished but overfishing was not occurring. That assessment did not include estimates of recreational catch or commercial discards in the exploitation rate. The results of this current assessment are not comparable to the previous assessment due to the major shift in assessment methods (i.e., index-based to age-based assessment).

Sources of Uncertainty

Sources of uncertainty in the current assessment include: 1) assumption of 100% survival in the recreational released live catch (type B2); and, 2) use of the size at age from the recent five years for long term projections. The exclusion of recreational fishery discards of live releases (type B2 catch) assumes 100% survival of this component of the recreational catch. Over the last ten years, the average number of recreational releases is approximately equal to the number of fish landed. Other GARM assessments have applied mortality rates to the live releases (e.g., southern New England/mid-Atlantic winter flounder); however there is little information on the survival rates of haddock caught in hook and line fisheries. The use of the recent size at age for long term projections introduces additional uncertainty. However, without better understanding the underlying cause(s) of the observed declines in size at age, the current conditions are the best indicator of future conditions.

8.0 Panel discussion/comments

Conclusions

This stock was assessed using a VPA model which is an improvement over the GARM II Relative Index. The Panel accepted as Final and sufficient for management purposes this VPA and also concluded that an adjustment for the small retrospective pattern was unnecessary.

The large difference between Gulf of Maine and Georges Bank haddock BRPs was questioned. The Gulf of Maine fishery does not target haddock and is directed mostly at flatfish for which the fleet uses large square (6.5 in) mesh gear, which leads to reduced selectivity on haddock. It was noted that the current analysis indicates that Gulf of Maine haddock have lower weights at age than the Georges Bank stock. As well, the age at 50% maturity was also lower for Gulf of Maine as compared to Georges Bank haddock.

Uncertainty of the estimated fishing mortality on the weak 2000 year – class in 2007 raised the issue on how best to compute the current year's age 6 – 8 fishing mortality. Variability in the year-class specific Fs of small year-classes is to be expected. Reflecting the 2007 fishing mortality as the weighted (by population numbers) average of ages 6 to 8 was considered a more robust approach than using the unweighted average. It was noted that the use of the unweighted versus weighted average needs to be considered on a case by case basis.

Regarding uncertainties, the recreational fishery commenced in the late 1990s and in recent years represents about 50% of the annual catch, with about 20 – 60 of this being live releases. The assumption has been made that 100% of these releases survive. There is very little information of the survival of haddock after their release.

Research Recommendations

Inverse variance weighting should be investigated as a means to compute the current year's fishing mortality as it has superior statistical characteristics than either the unweighted or weighted (by population) numbers.

Research should be undertaken on the estimation of the survivorship of haddock released in the recreational fishery.

9.0 References

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10.0 Tables

Table R1. Gulf of Maine haddock commercial landings by country, 1956 to 2007. The Gulf of Maine stock comprises Northwest Atlantic Fisheries Organization division 5Y and United States statistical areas 511 – 515.

Year	United States landings (mt)	Canada landings (mt)	USSR landings (mt)	Other landings (mt)	Total (mt)
1956	7,278	29	0	0	7,307
1957	6,141	25	0	0	6,166
1958	7,082	285	0	0	7,367
1959	4,497	163	0	0	4,660
1960	4,541	383	0	0	4,924
1961	5,297	56	0	0	5,353
1962	5,003	107	0	0	5,110
1963	4,742	3	44	0	4,789
1964	5,379	70	0	0	5,449
1965	4,155	159	0	0	4,314
1966	4,524	1,125	0	0	5,649
1967	4,852	589	0	0	5,441
1968	3,417	120	0	0	3,537
1969	2,405	59	0	231	2,695
1970	1,436	38	0	67	1,541
1971	1,190	85	0	27	1,302
1972	912	23	4	0	939
1973	526	49	0	0	575
1974	629	198	0	9	836
1975	1,180	79	0	4	1,263
1976	1,835	91	0	0	1,926
1977	3,230	26	0	0	3,256
1978	4,382	641	0	0	5,023
1979	4,131	257	0	0	4,388
1980	6,318	203	0	0	6,521
1981	5,720	513	0	0	6,233
1982	5,637	1,278	0	0	6,915
1983	5,593	2,003	0	0	7,596
1984	2,793	1,245	0	0	4,038
1985	2,234	791	0	0	3,025
1986	1,590	225	0	0	1,815
1987	829	0	0	0	829
1988	416	0	0	0	416
1989	264	0	0	0	264
1990	433	0	0	0	433
1991	431	0	0	0	431
1992	312	0	0	0	312
1993	193	0	0	0	193
1994	120	0	0	0	120
1995	173	0	0	0	173
1996	247	0	0	0	247
1997	589	0	0	0	589
1998	885	0	0	0	885
1999	543	0	0	0	543
2000	738	0	0	0	738
2001	929	0	0	0	929
2002	977	0	0	0	977
2003	1,023	0	0	0	1,023
2004	946	0	0	0	946
2005	962	0	0	0	962
2006	618	0	0	0	618
2007	694	0	0	0	694

Table R2. Gulf of Maine haddock landings by gear type from the United States commercial fishery, 1964 to 2007.

Year	Longline, benthic (mt)	Otter trawl, bottom (mt)	Gillnet, sink (mt)	Otter trawl, paired midwater (mt)	Otter trawl, midwater (mt)	Other (mt)	Total (mt)
1964	527.6	4689.5	155.5	0.0	0.0	6.0	5378.8
1965	686.8	3308.5	147.2	0.0	0.0	12.1	4154.7
1966	335.3	4107.2	78.7	0.0	0.0	2.9	4524.0
1967	160.6	4621.5	64.4	0.0	0.0	5.6	4852.2
1968	93.9	3285.5	32.7	0.0	0.0	5.2	3417.3
1969	103.8	2226.7	73.6	0.0	0.0	0.6	2404.6
1970	210.8	1155.4	68.0	0.0	0.0	1.7	1435.8
1971	260.0	850.1	76.6	0.0	0.0	3.5	1190.2
1972	374.9	440.0	95.4	0.0	0.0	2.1	912.3
1973	205.0	235.1	84.7	0.0	0.0	1.1	526.0
1974	126.9	456.1	45.1	0.0	0.0	0.7	628.8
1975	89.7	1016.3	73.8	0.0	0.0	0.4	1180.2
1976	37.9	1551.8	244.0	0.8	0.0	0.1	1834.5
1977	101.8	2576.1	551.7	0.1	0.0	0.5	3230.1
1978	84.1	3563.8	733.9	0.0	0.0	0.7	4382.5
1979	51.7	3362.5	715.0	0.0	0.0	1.4	4130.6
1980	72.0	4835.5	1387.5	0.6	0.0	22.1	6317.6
1981	74.5	4560.3	1085.2	0.0	0.0	0.4	5720.4
1982	6.7	5293.2	332.1	0.0	0.0	5.0	5637.0
1983	15.9	4905.7	654.3	0.0	0.0	17.4	5593.4
1984	11.9	2359.6	410.3	0.0	0.0	11.1	2792.8
1985	8.6	1885.2	247.4	0.0	0.0	93.1	2234.3
1986	8.7	1361.0	183.6	0.0	0.0	37.1	1590.4
1987	11.2	653.1	159.0	0.0	0.0	5.9	829.2
1988	14.0	252.2	145.4	0.0	0.0	4.6	416.2
1989	2.5	150.2	101.0	0.0	0.0	10.2	263.8
1990	10.4	332.5	84.9	0.0	0.0	5.5	433.3
1991	7.4	356.9	62.3	0.0	0.0	4.3	430.9
1992	13.5	256.7	40.1	0.0	0.0	1.5	311.8
1993	6.3	160.1	26.4	0.0	0.0	0.1	193.0
1994	9.4	83.7	26.9	0.0	0.0	0.1	120.1
1995	37.1	92.6	38.1	0.0	0.0	5.3	173.0
1996	42.7	162.3	38.7	0.0	0.0	2.9	246.6
1997	68.9	463.6	54.7	0.0	0.6	0.8	588.6
1998	81.3	705.3	67.8	0.0	25.7	5.0	885.2
1999	21.8	437.5	78.7	0.0	1.2	3.3	542.5
2000	20.9	587.7	122.8	0.0	0.0	6.5	737.9
2001	8.4	813.4	104.4	0.0	0.0	2.9	929.2
2002	29.9	689.6	242.2	0.0	0.0	15.2	976.9
2003	86.8	809.6	82.2	0.0	0.0	44.5	1023.0
2004	81.5	707.3	127.9	0.0	0.0	29.8	946.5
2005	143.9	592.3	93.4	0.0	14.9	117.0	961.5
2006	137.5	384.5	78.6	0.0	0.0	17.7	618.2
2007	153.0	432.7	82.9	0.0	0.0	27.7	696.4
Average	105.4	1631.2	213.6	0.0	1.0	12.3	1963.5

Table R3. Summary of United States (US) Gulf of Maine haddock number of fish lengths measured from the commercial fishery by market category and quarter, 1965 – 2007.

Year	Large				Scrod				Unclassified				Total lengths (numbers)	US commercial landings (mt)	Metric tons per 100 lengths
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4			
1969		93	59				282	92					526	2,405	457
1970													0	1,436	
1971	86			101				82					269	1,190	442
1972			74	115									189	912	483
1973	99		627					205					931	526	56
1974					207	47							254	629	248
1975					64	100							164	1,180	720
1976	30						74	108					212	1,835	865
1977		197	358		382	511	481	569					2,498	3,230	129
1978	149	35	200		223	322	179	203					1,311	4,382	334
1979	195		124	100	114			66					599	4,131	690
1980		319	102		51	175	257	201					1,105	6,318	572
1981		52	257	638	53	358	514	381					2,253	5,720	254
1982	103		1,361	104	473	53	273	154				87	2,608	5,637	216
1983	249	868	1,317	496	312	308	340	203			102		4,195	5,593	133
1984		79	828	391	187	94	139	113					1,831	2,793	153
1985	347	597	573	536	353	202	298	84					2,990	2,234	75
1986	283	234	789	271	181	242	207	204					2,411	1,590	66
1987	214	102	515	405	162	79	75	136					1,688	829	49
1988	91		100	202	261	50	42						746	416	56
1989			65	118	99			129					411	264	64
1990	34			100	41	50		50					275	433	158
1991		146	216	213	57		179	212					1,023	431	42
1992	121			19	107		53	111					411	312	76
1993					103	56	125			54			338	193	57
1994		100	52	297				219					668	120	18
1995	62				194								256	173	68
1996	77			427		92		100					696	247	35
1997	120	255	497	355		124	358	147					1,856	589	32
1998	309	111	78	313	689	49	156	35					1,740	885	51

Table R3 continued. Summary of United States (US) Gulf of Maine haddock number of fish lengths measured from the commercial fishery by market category and quarter, 1965 – 2007.

Year	Large				Scrod				Unclassified				Total lengths (numbers)	US commercial landings (mt)	Metric tons per 100 lengths
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4			
1999	117		300	211			214	102					944	543	57
2000	488	313	339	107	414	259	105	287					2,312	738	32
2001	528	93	207	579	353	108	66	847					2,781	929	33
2002	729	210		262	348	143	247	161					2,100	977	47
2003	792	348	1,282	1,043	485	216	716	513					5,395	1,023	19
2004	1,898	942	101	601	1,021	1,085	262	451					6,361	946	15
2005	1,313	325	573	752	661	449	733	769					5,575	962	17
2006	1,193	687	453	617	928	535	569	514					5,496	618	11
2007	385	266	539	480	324	357	415	426					3,192	694	22

Table R4. Commercial landings (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	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	0.2	1.7	102.8	5.5	27.4	22.6	49.3	222.0	431.5

Table R5. Coefficients of variation (CV) at age for Gulf of Maine haddock commercial landings, 1984 to 2007. **Note: CVs can not be determined for landings before 1984 because individual biological samples can not be identified in the database.*

Year	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	1.39	0.59	0.08	0.37	0.14	0.15	0.10	0.05	0.19	0.26	0.52	0.57	0.61	1.36

Table R6. Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program (NEFOP), 1989 to 2007.

Year	Otter trawl, bottom, large mesh (≥ 5.5") (kg)	Otter trawl, bottom, small mesh (< 5.5") (kg)	Otter trawl, paired-midwater (kg)	Otter trawl, midwater (kg)	Longline, benthic (kg)	Gillnet, sink (kg)	Other (kg)	Percent of total discards by other fleets (%) (kg)
1989	12.7	0.5	0.0	0.0	0.0	16.8	0.9	2.9
1990	0.9	0.0	0.0	0.0	0.0	12.7	4.1	23.2
1991	11.8	0.0	0.0	0.0	2.7	87.5	1.8	1.7
1992	66.2	0.0	0.0	0.0	0.0	54.9	10.0	7.6
1993	70.3	0.0	0.0	0.0	0.0	73.0	21.3	12.9
1994	67.6	0.0	0.0	0.0	0.0	30.4	21.3	17.9
1995	773.2	13.2	0.0	0.0	0.0	27.2	16.8	2.0
1996	319.3	44.0	0.0	0.0	0.0	92.5	6.8	1.5
1997	1214.9	0.0	0.0	0.0	0.0	0.9	1.8	0.1
1998	12.7	0.0	0.0	0.0	0.0	25.4	0.0	0.0
1999	1.4	3.6	0.0	0.0	0.0	31.7	0.0	0.0
2000	161.0	0.0	0.0	0.0	0.0	63.5	0.0	0.0
2001	110.7	112.9	0.0	0.0	0.0	25.4	0.0	0.0
2002	118.4	41.7	0.0	0.0	0.0	83.9	0.0	0.0
2003	441.7	15.0	0.0	0.0	68.9	157.8	0.0	0.0
2004	343.8	166.4	154.2	119.3	5.4	268.0	0.9	0.1
2005	799.1	57.6	497.9	110.2	542.4	375.5	0.5	0.0
2006	868.9	24.0	0.0	2.7	345.1	70.7	9.5	0.7
2007	375.0	25.4	127.4	0.0	318.8	528.8	4.1	0.3
Annual average	303.7	26.5	41.0	12.2	67.5	106.7	5.3	0.9

Table R7. Discard reasons by year described as a percent occurrence from Northeast Fisheries Observer Program (NEFOP), 1989 to 2007.

Year	Discard reason by percent of total weight					Total weight of discards with discard reason available (lb)	Count of observed hauls with discard reasons available
	Other / unknown	Quota filled / retention prohibited	Upgraded	Poor quality	Below minimum size		
1989	49.3	0.0	0.0	50.7	0.0	69	6
1990	66.7	0.0	0.0	33.3	0.0	30	2
1991	71.1	0.0	0.0	28.9	0.0	225	7
1992	79.8	0.0	0.0	20.2	0.0	297	8
1993	72.2	13.6	0.0	14.2	0.0	316	8
1994	47.8	42.7	0.0	0.0	9.5	216	23
1995	22.5	46.9	0.0	0.5	30.1	1,794	127
1996	1.0	29.6	13.1	5.6	50.7	1,095	120
1997	4.8	34.5	0.0	50.5	10.2	4,173	56
1998	44.2	0.0	0.0	4.4	51.4	91	15
1999	9.9	0.0	0.0	76.5	13.6	81	17
2000	0.2	0.0	0.0	22.6	77.3	532	42
2001	2.6	0.0	0.0	3.9	93.5	696	72
2002	4.9	0.0	0.0	16.0	79.1	614	85
2003	1.9	0.0	0.0	7.7	90.3	1,544	250
2004	48.6	0.0	0.0	9.0	42.5	2,876	296
2005	24.8	0.6	0.0	13.3	61.3	5,178	558
2006	0.9	0.0	0.0	2.7	96.4	2,854	183
2007	12.2	0.0	0.0	34.5	53.2	3,006	160

Table R8. Gulf of Maine haddock minimum size limits for commercial and recreational landings, 1977 to 2008. Prior to 1977 there were no federal minimum size limits for either fishery. Values in italics are assumed pending clarification of regulations.

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	Large-mesh multispecies 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	

Table R9. Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Large mesh otter trawl (≥ 5.5" mesh)			Small mesh otter trawl (< 5.5" mesh)			Sink gillnet			Benthic longline		
	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
1964				232.5			8.3			163.7		
1965				126.1			5.8			208.3		
1966				101.3			7.4			112.2		
1967				36.3			2.6			21.8		
1968				13.5			1.1			5.5		
1969				2.1			0.1			0.7		
1970				1.6			0.1			0.6		
1971				9.4			0.4			4.3		
1972				8.6						7.1		
1973				15.7			1.8			16.8		
1974				16.6			3.6			22.3		
1975				24.5			6.7			48.0		
1976				38.3			12.9			36.2		
1977				39.0			14.3			25.3		
1978				25.8			11.8			9.9		
1979				11.2			3.3			3.4		
1980				14.5			4.4			2.8		
1981				11.9			4.7			2.9		
1982	8.5			3.1			2.7			1.0		
1983	10.4			3.5			3.1			0.9		
1984	12.4			3.7			4.7			0.6		
1985	10.9			2.5			3.3			0.7		
1986	4.7			1.0			1.8			0.5		
1987	0.7			0.1			0.3			0.1		
1988	0.8			0.1			0.5			0.1		

Table R9 (cont.). Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Paired-midwater trawl			Midwater trawl			Total	
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	CV
1964	0.0			0.0			404.5	
1965	0.0			0.0			340.3	
1966	0.0			0.0			220.9	
1967	0.0			0.0			60.8	
1968	0.0			0.0			20.1	
1969	0.0			0.0			2.8	
1970	0.0			0.0			2.3	
1971	0.0			0.0			14.1	
1972	0.0			0.0			15.7	
1973	0.0			0.0			34.3	
1974	0.0			0.0			42.5	
1975	0.1			0.0			79.3	
1976	0.1			0.0			87.4	
1977	0.1			0.0			78.7	
1978	0.0			0.0			47.6	
1979	0.0			0.0			18.0	
1980	0.0			0.0			21.7	
1981	0.0			0.0			19.4	
1982	0.0			0.0			15.3	
1983	0.0			0.0			17.9	
1984	0.0			0.0			21.4	
1985	0.0			0.0			17.3	
1986	0.0			0.0			8.0	
1987	0.0			0.0			1.2	
1988	0.0			0.0			1.5	

Table R9 (cont.). Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Large mesh otter trawl (≥ 5.5" mesh)			Small mesh otter trawl (< 5.5" mesh)			Sink gillnet			Benthic longline		
	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
1989	5.8	37	0.91	0.0	23	0.97	2.9	84	0.50			
1990	0.5	26	1.10	0.0	8		1.9	120	0.43			
1991	2.3	48	0.62	0.0	29		1.4	801	0.31	0.4	2	1.20
1992	18.0	44	0.66	0.0	15		1.0	896	0.25	0.0	9	
1993	26.3	17	0.53	0.0	6		3.4	560	0.34	0.0	2	
1994	85.8	6	0.56				7.6	85	0.44			
1995	121.4	25	0.37	0.5	30	0.34	5.7	69	0.39			
1996	85.9	11	0.69	2.4	40	0.19	18.3	46	0.50			
1997	368.0	5	1.65	0.0	3		0.3	33	1.08			
1998	20.9	6	0.42				3.2	78	0.64			
1999	1.3	21	1.47	0.2	11	0.47	1.3	73	0.53			
2000	30.0	79	0.59				7.9	81	0.44			
2001	13.1	113	0.51	8.3	4	0.71	5.7	47	0.31			
2002	11.1	149	0.32	0.8	35	0.53	11.8	80	0.36	0.0	1	
2003	11.2	253	0.20	0.3	19	0.56	5.8	295	0.19	5.3	14	0.46
2004	20.1	258	0.30	0.7	67	0.89	3.9	775	0.20	0.5	8	0.37
2005	14.5	498	0.21	0.1	69	0.54	4.5	651	0.14	17.0	58	0.26
2006	38.8	206	0.50	0.2	24	0.43	3.2	128	0.23	7.1	36	0.35
2007	4.9	224	0.34	0.5	16	0.40	25.2	118	0.87	15.1	36	0.40

Table R9 (cont.). Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Paired-midwater trawl			Midwater trawl			Total	
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	CV
1989							8.7	0.62
1990							2.4	0.41
1991							4.1	0.38
1992							19.1	0.62
1993							29.7	0.47
1994							93.5	0.52
1995				0.0	4		127.6	0.36
1996							106.5	0.57
1997							368.2	1.65
1998							24.1	0.37
1999	0.0	2					2.9	0.70
2000				0.0	3		37.9	0.47
2001							27.1	0.34
2002				0.0	1		23.6	0.24
2003	0.0	8		0.0	20		22.6	0.16
2004	0.0	41	0.09	1.5	27	0.95	26.6	0.23
2005	0.6	63	0.14	0.6	7	1.16	37.4	0.15
2006	0.0	7		0.0	3	1.51	49.4	0.40
2007	0.0	4	4.41	0.0	4		45.7	0.50

Table R10. Summary of Gulf of Maine haddock length and age measurements taken of United States commercial discards by quarter, 1989 – 2007.

Year	Commercial discards (mt)	Total lengths (numbers)	Metric tons per 100 lengths
1989	8.7	10	87
1990	2.4	0	
1991	4.1	1	410
1992	19.1	41	47
1993	29.7	104	29
1994	93.5	163	57
1995	127.6	550	23
1996	106.5	190	56
1997	368.2	808	46
1998	24.1	14	172
1999	2.9	29	10
2000	37.9	17	223
2001	27.1	48	56
2002	23.6	129	18
2003	22.6	426	5
2004	26.6	569	5
2005	37.4	950	4
2006	49.4	600	8
2007	45.7	558	8

Table R11. Commercial discards (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	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	1.7	12.7	4.1	27.8	0.3	1.8	0.5	1.4	4.8	55.1

Table R12. Recreational landings and releases of Gulf of Maine haddock, 1981 – 2007. The weight of recreational landings from 1981 to 2001 were estimated from the total numbers multiplied by the average weight of individually sampled fish from 1981 to 2001.

Year	Estimated recreational landings, A + B1 (numbers)	Estimated recreational live releases, B2 (numbers)	Estimated recreational landings (mt)
1981	22,990	0	36.3
1982	19,531	122	30.9
1983	36,455	0	57.6
1984	31,277	1,687	49.4
1985	19,417	92	30.7
1986	34,777	432	55.0
1987	18,765	0	29.7
1988	7,630	2,970	12.1
1989	5,995	5,134	9.5
1990	1,836	278	2.9
1991	242	0	0.4
1992	0	0	0.0
1993	336	0	0.5
1994	2,385	1,720	3.8
1995	110,818	43,469	175.1
1996	4,190	8,597	6.6
1997	20,022	15,733	31.6
1998	28,161	9,550	44.5
1999	12,128	16,673	19.2
2000	80,735	101,016	127.6
2001	120,422	112,326	190.3
2002	83,283	171,955	165.9
2003	119,788	260,881	191.8
2004	278,497	142,426	429.6
2005	444,739	116,168	717.1
2006	277,858	164,196	503.9
2007	398,229	105,432	627.9

Table R13. Summary of Gulf of Maine haddock length and age measurements taken of United States recreational fishery by quarter, 1981 – 2007.

Year	Recreational landings (mt)	Total lengths (numbers)	Metric tons per 100 lengths
1981	36.3	13	279
1982	30.9	2	1545
1983	57.6	10	576
1984	49.4	16	309
1985	30.7	7	439
1986	55.0	0	
1987	29.7	6	495
1988	12.1	2	605
1989	9.5	3	317
1990	2.9	0	
1991	0.4	0	
1992	0.0	0	
1993	0.5	0	
1994	3.8	4	95
1995	175.1	153	114
1996	6.6	25	26
1997	31.6	21	150
1998	44.5	62	72
1999	19.2	32	60
2000	127.6	34	375
2001	190.3	25	761
2002	165.9	119	139
2003	191.8	210	91
2004	429.6	928	46
2005	717.1	1,711	42
2006	503.9	1,171	43
2007	627.9	1,068	59

Table R14. Recreational landings (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	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

Table R15. Total catch (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1977	8.2	548.4	1791.5	51.1	365.0	215.0	143.6	4.8	1.6	6.3	3135.4
1978	9.9	3.1	433.5	1959.5	181.2	320.3	154.6	32.0	0.0	5.6	3099.8
1979	46.5	69.5	87.4	614.6	1348.8	200.5	105.5	32.4	23.8	0.0	2529.0
1980	76.6	121.9	865.2	110.0	754.9	1235.8	165.4	134.1	11.5	25.3	3500.8
1981	3.8	164.0	1466.5	645.6	268.9	360.0	503.2	70.1	98.3	12.7	3593.0
1982	178.9	77.9	458.6	1256.6	513.9	81.2	225.7	401.3	89.8	59.8	3343.6
1983	2.5	76.1	17.0	612.5	724.2	596.3	110.3	185.7	254.1	88.0	2666.8
1984	0.0	11.4	96.4	34.1	420.0	176.2	253.7	44.0	49.8	102.1	1187.5
1985	0.2	3.1	25.5	266.2	63.3	270.5	109.3	176.0	35.3	38.3	987.7
1986	10.0	21.1	0.0	159.6	304.0	66.2	101.7	75.8	90.0	11.8	840.1
1987	14.6	8.1	3.6	18.1	96.7	51.5	35.0	54.2	38.7	18.4	339.0
1988	0.0	18.5	0.0	13.0	10.1	55.0	40.1	9.4	22.7	4.8	173.6
1989	0.0	3.4	23.9	4.4	51.2	17.7	22.4	17.2	1.8	0.9	142.9
1990	4.5	4.5	1.9	136.0	1.8	24.2	17.8	28.6	3.7	0.0	223.0
1991	9.2	7.9	28.9	48.3	61.7	17.7	19.2	13.0	2.7	2.2	210.7
1992	4.8	20.4	18.3	93.7	36.4	23.3	2.4	2.3	0.0	1.1	202.8
1993	15.7	12.4	29.6	28.7	31.7	17.8	6.5	6.4	0.4	0.6	149.8
1994	60.4	89.9	23.4	52.2	13.5	3.4	10.3	6.7	1.3	1.0	262.1
1995	0.9	50.1	78.5	99.4	83.2	12.1	6.5	6.1	3.4	3.1	343.4
1996	47.7	9.9	35.0	141.0	64.8	16.1	4.8	6.6	5.6	0.8	332.3
1997	0.2	2.9	8.3	177.0	235.9	80.1	18.1	6.1	1.8	1.8	532.1
1998	107.6	13.3	26.6	23.7	126.1	188.0	52.4	16.9	7.6	7.6	569.8
1999	1.1	8.4	0.9	43.4	62.4	93.5	63.6	32.1	7.1	6.2	318.7
2000	1.1	5.4	51.2	47.8	106.6	66.3	138.6	61.2	31.0	15.3	524.6
2001	1.2	1.6	23.4	213.5	130.0	88.5	79.0	74.7	37.3	23.7	672.9
2002	0.0	2.1	1.3	18.0	217.4	108.0	107.5	33.1	63.5	68.6	619.6
2003	0.0	0.1	3.9	3.6	38.6	430.8	87.9	62.1	22.2	72.7	721.9
2004	0.3	8.1	0.5	8.4	34.9	79.3	546.0	69.1	36.4	54.5	837.5
2005	0.0	0.6	16.7	4.1	49.0	87.0	147.4	569.0	60.1	83.1	1016.9
2006	5.2	9.4	1.6	69.9	4.9	45.2	70.5	77.3	351.5	61.5	697.0
2007	0.0	1.7	13.2	8.5	290.0	10.6	54.3	44.1	88.0	374.4	884.8

Table R16. Mean catch weight at age (kg) of Gulf of Maine haddock, 1977 to 2007. Catch weights at age do not include biological samples from the recreational landings due to low sampling of this fishery prior to 2002.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age9+
1977	0.02	0.14	0.74	1.14	2.01	2.62	3.30	4.66	5.98	5.70
1978	0.02	0.12	0.72	1.22	1.78	2.42	2.95	4.14	4.64	5.00
1979	0.02	0.25	0.79	1.22	1.80	2.25	2.54	2.83	3.29	4.48
1980	0.02	0.15	0.76	1.25	1.87	2.39	3.29	3.38	3.99	4.36
1981	0.03	0.11	0.68	1.49	1.97	2.52	3.28	3.84	4.19	3.79
1982	0.04	0.33	0.64	1.00	2.14	2.56	3.10	3.65	4.26	4.09
1983	0.03	0.12	0.57	1.19	1.73	2.38	2.96	3.38	3.72	4.23
1984	0.04	0.24	0.68	1.22	1.80	2.30	3.16	3.95	4.41	4.09
1985	0.05	0.33	0.91	1.06	1.91	2.36	2.66	3.57	4.12	4.21
1986	0.07	0.37	0.98	1.22	1.46	2.28	2.50	3.05	3.63	4.51
1987	0.03	0.10	1.06	1.30	2.00	2.43	2.62	3.36	4.19	5.18
1988	0.03	0.08	1.15	1.23	1.49	2.65	2.34	3.65	4.89	5.35
1989	0.03	0.25	1.12	1.67	1.64	2.51	2.30	3.38	4.47	4.33
1990	0.03	0.23	0.80	1.51	3.36	2.36	2.96	3.63	3.51	3.85
1991	0.01	0.24	1.30	1.48	2.49	2.96	2.96	3.31	4.25	3.37
1992	0.04	0.21	1.09	1.68	1.91	2.68	2.94	2.92	4.21	2.80
1993	0.03	0.19	0.86	1.36	1.92	2.52	3.29	3.89	4.17	4.60
1994	0.03	0.07	0.85	1.65	2.23	2.93	2.98	3.80	3.53	3.99
1995	0.02	0.07	0.78	1.19	1.93	2.64	3.63	4.45	5.15	5.56
1996	0.07	0.24	0.56	1.00	1.75	2.21	3.07	2.37	2.12	3.19
1997	0.07	0.15	0.93	1.80	1.68	2.33	2.98	3.21	3.82	3.74
1998	0.02	0.22	0.95	1.48	1.85	2.21	2.86	3.38	3.12	3.00
1999	0.05	0.17	0.62	1.32	1.70	1.72	1.94	2.35	3.11	3.34
2000	0.04	0.19	0.59	1.02	1.53	1.84	2.07	2.38	2.61	3.39
2001	0.02	0.20	0.84	1.31	1.50	1.81	2.24	2.27	2.46	2.58
2002	0.07	0.18	0.37	1.04	1.37	1.67	2.20	2.67	2.46	2.75
2003	0.05	0.13	0.52	0.95	1.30	1.53	1.85	2.19	2.52	2.57
2004	0.02	0.16	0.58	0.83	1.38	1.42	1.72	2.10	2.16	2.24
2005	0.10	0.15	0.50	0.92	1.16	1.53	1.53	1.80	2.02	2.38
2006	0.04	0.09	0.45	0.81	0.69	1.41	1.75	1.60	1.78	2.12
2007	0.04	0.22	0.60	0.81	1.05	1.23	1.59	1.63	1.71	1.83

Table R17. Vessel and door types used in the Northeast Fisheries Science Center's spring and autumn bottom trawl surveys where Gulf of Maine haddock were caught and the types of conversion factors applied to the annual indices, 1963 – 2008. Coefficients of 0.82 (Delaware II) and 1.49 (BMV trawl door) were applied to abundance indices and 0.79 (Delaware II) and 1.51 (BMV trawl door) wee applied to biomass indices.

Year	Door	Spring survey vessel	Spring conversion factor	Autumn survey vessel	Autumn conversion factor
1963	BMV			Albatross IV	door
1964	BMV			Albatross IV	door
1965	BMV			Albatross IV	door
1966	BMV			Albatross IV	door
1967	BMV			Albatross IV	door
1968	BMV	Albatross IV	door	Albatross IV	door
1969	BMV	Albatross IV	door	Albatross IV	door
1970	BMV	Albatross IV	door	Albatross IV	door
1971	BMV	Albatross IV	door	Albatross IV	door
1972	BMV	Albatross IV	door	Albatross IV	door
1973	BMV	Albatross IV	door	Albatross IV	door
1974	BMV	Albatross IV	door	Albatross IV	door
1975	BMV	Albatross IV	door	Albatross IV	door
1976	BMV	Albatross IV	door	Albatross IV	door
1977	BMV	Albatross IV	door	Delaware II	door
1978	BMV	Albatross IV	door	Delaware II	door
1979	BMV	Albatross IV/Delaware II	door, vessel	Albatross IV/Delaware II	door, vessel
1980	BMV	Delaware II	door, vessel	Delaware II	door
1981	BMV	Delaware II	door, vessel	Albatross IV/Delaware II	door, vessel
1981	BMV	Delaware II	door, vessel	Delaware II	door
1982	BMV	Albatross IV	door	Albatross IV	door
1983	BMV	Albatross IV	door	Albatross IV	door
1984	BMV	Albatross IV	door	Albatross IV	door
1985	Polyvalent	Albatross IV		Albatross IV	
1986	Polyvalent	Delaware II	vessel	Albatross IV	
1987	Polyvalent	Albatross IV		Albatross IV	
1988	Polyvalent	Delaware II	vessel	Albatross IV	
1989	Polyvalent	Delaware II	vessel	Delaware II	vessel
1990	Polyvalent	Delaware II	vessel	Delaware II	vessel
1991	Polyvalent	Albatross IV		Delaware II	vessel
1992	Polyvalent	Albatross IV		Albatross IV	
1993	Polyvalent	Delaware II	vessel	Delaware II	vessel
1994	Polyvalent	Albatross IV		Albatross IV	
1995	Polyvalent	Albatross IV		Albatross IV	
1996	Polyvalent	Albatross IV		Albatross IV	
1997	Polyvalent	Albatross IV		Albatross IV	
1998	Polyvalent	Albatross IV		Albatross IV	
1999	Polyvalent	Albatross IV		Albatross IV	
2000	Polyvalent	Albatross IV		Albatross IV	
2001	Polyvalent	Albatross IV		Albatross IV	
2002	Polyvalent	Delaware II	vessel	Albatross IV	
2003	Polyvalent	Albatross IV		Albatross IV	
2004	Polyvalent	Albatross IV		Albatross IV	
2005	Polyvalent	Albatross IV		Albatross IV	
2006	Polyvalent	Albatross IV		Albatross IV	
2007	Polyvalent	Albatross IV		Albatross IV	
2008	Polyvalent	Albatross IV		N/A	

Table R18. Northeast Fisheries Science Center (NEFSC) spring and autumn survey indices of abundance (stratified mean numbers/tow) and biomass (stratified mean kg/tow) for Gulf of Maine haddock with, 1968 – 2008. *Note Spring 2008 data are preliminary.

Year	NEFSC spring numbers per tow	NEFSC spring numbers per tow standard error	NEFSC spring weight (kg) per tow	NEFSC spring weight (kg) per tow standard error	NEFSC autumn numbers per tow	NEFSC autumn numbers per tow standard error	NEFSC autumn weight (kg) per tow	NEFSC autumn weight (kg) per tow standard error
1963					69.549	20.456	50.697	8.362
1964					14.176	5.432	18.386	3.533
1965					17.434	6.342	17.731	3.991
1966					10.742	3.786	13.103	3.962
1967					12.186	3.092	16.871	4.444
1968	6.066	1.907	8.107	2.194	8.564	1.430	17.307	2.900
1969	3.719	0.802	6.607	1.523	5.451	1.373	12.721	3.055
1970	0.906	0.232	1.784	0.482	2.918	0.672	7.354	1.663
1971	0.878	0.436	2.523	1.203	2.880	1.010	8.159	2.863
1972	0.862	0.329	0.867	0.555	1.984	0.504	3.036	1.101
1973	1.312	0.347	1.598	0.651	4.165	0.905	8.583	2.905
1974	1.437	0.611	1.059	0.472	2.687	1.642	3.347	1.131
1975	2.770	0.815	3.482	1.650	5.533	1.517	8.616	2.856
1976	8.326	3.015	6.350	2.487	6.035	1.496	8.040	2.365
1977	6.799	2.299	6.725	2.797	8.296	2.878	8.752	2.624
1978	1.356	0.621	1.434	0.454	9.775	1.773	21.658	4.299
1979	2.890	0.691	3.948	0.926	6.174	1.300	15.567	3.523
1980	2.212	0.975	2.673	1.351	7.152	2.666	9.835	2.543
1981	3.613	0.958	3.545	0.846	4.456	0.878	10.874	2.645
1982	2.047	0.732	2.555	0.967	2.627	1.000	4.164	1.301
1983	3.678	1.684	3.567	1.721	2.598	0.820	5.219	1.613
1984	1.095	0.502	1.144	0.532	1.697	0.513	3.893	1.164
1985	1.773	0.739	1.882	0.618	4.079	1.780	6.149	1.994
1986	0.707	0.362	1.284	0.696	0.623	0.285	1.392	0.585
1987	0.092	0.038	0.063	0.036	1.035	0.354	2.645	0.755
1988	0.187	0.108	0.301	0.199	0.335	0.233	1.476	1.126
1989	0.083	0.069	0.125	0.115	0.283	0.119	0.631	0.335
1990	0.024	0.015	0.000	0.000	0.145	0.059	0.432	0.168
1991	0.074	0.044	0.066	0.046	0.142	0.092	0.120	0.091
1992	0.193	0.125	0.271	0.268	0.211	0.128	0.091	0.062
1993	0.450	0.229	0.200	0.158	0.866	0.709	0.472	0.453
1994	0.402	0.151	0.253	0.105	0.325	0.150	0.217	0.207
1995	0.806	0.414	0.350	0.172	0.977	0.598	1.099	0.501
1996	0.305	0.105	0.338	0.129	2.407	0.970	3.543	1.632
1997	1.935	0.848	1.222	0.691	2.688	1.071	2.424	0.752
1998	0.197	0.085	0.112	0.054	3.130	1.735	2.917	1.321
1999	4.267	1.873	1.108	0.438	6.730	2.116	4.910	1.254
2000	3.610	1.620	1.815	0.833	16.589	8.290	14.032	6.095
2001	2.364	1.547	3.205	2.306	9.960	2.918	11.981	3.326
2002	5.704	3.222	2.793	0.991	3.920	1.491	4.835	1.746
2003	3.191	0.871	3.908	1.196	4.733	1.147	5.359	1.367
2004	1.061	0.404	1.199	0.530	5.704	1.636	7.171	2.278
2005	0.862	0.383	0.971	0.508	4.132	0.886	3.932	0.692
2006	3.151	1.536	2.661	1.188	3.910	1.073	3.945	0.881
2007	0.771	0.315	0.675	0.262	5.153	1.669	4.393	1.175
2008	1.848	0.773	1.510	0.437				
Average	2.049	0.801	2.056	0.800	6.337	2.022	7.957	2.081

Table R19. Stratified mean numbers-at-age per tow of Gulf of Maine haddock from the Northeast Fisheries Science Center (NEFSC) spring survey, 1968 – 2008. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors. *Note 2008 data are preliminary.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+
1968	0.000	0.000	0.000	0.051	0.301	4.433	0.893	0.134	0.112	0.142
1969	0.000	0.000	0.000	0.054	0.019	0.263	2.526	0.785	0.029	0.043
1970	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.612	0.092	0.059
1971	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.026	0.637	0.189
1972	0.000	0.584	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.278
1973	0.000	0.129	0.784	0.000	0.054	0.000	0.000	0.000	0.000	0.345
1974	0.000	0.900	0.088	0.333	0.000	0.000	0.000	0.000	0.016	0.101
1975	0.000	0.030	1.958	0.152	0.380	0.000	0.203	0.000	0.000	0.048
1976	0.000	5.114	0.124	1.734	0.176	0.942	0.067	0.033	0.000	0.136
1977	0.000	1.158	3.268	0.049	1.339	0.407	0.578	0.000	0.000	0.000
1978	0.000	0.085	0.716	0.333	0.030	0.192	0.000	0.000	0.000	0.000
1979	0.000	0.371	0.314	0.400	1.379	0.233	0.194	0.000	0.000	0.000
1980	0.000	1.053	0.152	0.171	0.455	0.318	0.025	0.000	0.000	0.037
1981	0.000	1.181	0.993	0.607	0.213	0.356	0.160	0.025	0.038	0.038
1982	0.000	0.045	0.433	0.892	0.465	0.147	0.066	0.000	0.000	0.000
1983	0.143	1.352	0.137	1.236	0.319	0.306	0.000	0.163	0.000	0.022
1984	0.000	0.019	0.570	0.054	0.299	0.108	0.000	0.000	0.045	0.000
1985	0.000	0.042	0.280	1.095	0.058	0.170	0.059	0.050	0.020	0.000
1986	0.000	0.051	0.000	0.121	0.403	0.000	0.036	0.073	0.023	0.000
1987	0.000	0.036	0.025	0.031	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.043	0.000	0.000	0.015	0.119	0.010	0.000	0.000	0.000
1989	0.000	0.000	0.036	0.012	0.000	0.012	0.012	0.012	0.000	0.000
1990	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.014	0.007	0.052	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.085	0.000	0.000	0.109	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.261	0.146	0.000	0.000	0.029	0.015	0.000	0.000	0.000
1994	0.000	0.074	0.182	0.122	0.024	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.441	0.240	0.073	0.030	0.000	0.000	0.000	0.023	0.000
1996	0.000	0.000	0.037	0.146	0.123	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.775	0.231	0.239	0.592	0.076	0.022	0.000	0.000	0.000
1998	0.000	0.080	0.046	0.000	0.062	0.009	0.000	0.000	0.000	0.000
1999	0.000	3.724	0.087	0.162	0.029	0.227	0.039	0.000	0.000	0.000
2000	0.000	1.037	1.188	0.968	0.145	0.084	0.053	0.136	0.000	0.000
2001	0.000	0.073	0.131	1.040	0.525	0.167	0.227	0.065	0.048	0.090
2002	0.000	3.299	0.207	0.605	1.418	0.081	0.036	0.022	0.036	0.000
2003	0.000	0.359	0.203	0.093	0.109	1.990	0.204	0.144	0.036	0.054
2004	0.000	0.115	0.000	0.154	0.033	0.095	0.621	0.029	0.000	0.015
2005	0.000	0.010	0.172	0.000	0.070	0.083	0.225	0.274	0.000	0.029
2006	0.000	0.179	0.092	1.678	0.272	0.104	0.022	0.211	0.548	0.047
2007	0.000	0.156	0.085	0.028	0.252	0.000	0.028	0.029	0.034	0.159
2008	0.000	0.036	0.659	0.411	0.000	0.334	0.000	0.028	0.057	0.324

Table R20. Stratified mean numbers-at-age per tow of Gulf of Maine haddock from the Northeast Fisheries Science Center (NEFSC) autumn survey, 1963 – 2007. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9^+
1963	35.602	12.183	1.704	3.012	6.942	4.938	1.669	1.318	1.041	1.142
1964	0.081	5.904	1.848	0.706	0.975	1.820	1.754	0.984	0.000	0.103
1965	0.054	0.367	7.991	5.064	0.253	1.450	1.205	0.663	0.333	0.054
1966	0.019	0.000	0.525	6.597	2.181	0.284	0.616	0.403	0.083	0.034
1967	0.000	0.000	0.000	1.542	7.995	1.801	0.528	0.125	0.149	0.046
1968	0.000	0.000	0.000	0.000	0.193	6.265	1.452	0.217	0.319	0.117
1969	0.000	0.000	0.000	0.037	0.028	0.037	4.119	0.931	0.138	0.161
1970	0.000	0.048	0.000	0.000	0.000	0.126	0.136	1.946	0.606	0.057
1971	0.268	0.000	0.000	0.000	0.016	0.000	0.122	0.169	2.029	0.276
1972	0.000	1.190	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.770
1973	1.129	0.022	0.960	0.000	0.356	0.026	0.022	0.038	0.022	1.592
1974	0.022	1.660	0.209	0.429	0.000	0.000	0.000	0.000	0.000	0.368
1975	0.888	0.227	1.916	0.558	1.388	0.000	0.045	0.045	0.000	0.466
1976	1.633	1.794	0.077	1.275	0.149	0.902	0.000	0.189	0.000	0.016
1977	0.104	3.085	3.401	0.137	1.028	0.192	0.255	0.000	0.000	0.094
1978	0.174	0.087	1.716	5.523	0.201	0.640	1.204	0.126	0.000	0.104
1979	0.781	0.421	0.084	1.123	2.854	0.509	0.326	0.063	0.000	0.013
1980	3.953	0.509	0.320	0.000	0.298	1.068	0.650	0.157	0.105	0.093
1981	0.000	0.614	0.562	1.013	0.314	0.855	0.681	0.170	0.183	0.064
1982	0.386	0.056	0.682	0.855	0.306	0.055	0.000	0.112	0.048	0.128
1983	0.000	0.557	0.053	0.638	0.603	0.312	0.172	0.068	0.161	0.034
1984	0.000	0.202	0.541	0.000	0.282	0.000	0.408	0.000	0.034	0.228
1985	0.000	0.089	0.471	2.725	0.017	0.182	0.150	0.395	0.000	0.051
1986	0.000	0.015	0.000	0.069	0.351	0.085	0.018	0.025	0.059	0.000
1987	0.029	0.000	0.127	0.114	0.190	0.061	0.238	0.146	0.000	0.130
1988	0.000	0.000	0.000	0.032	0.023	0.101	0.000	0.041	0.137	0.000
1989	0.000	0.059	0.059	0.019	0.012	0.031	0.052	0.052	0.000	0.000
1990	0.009	0.024	0.000	0.056	0.000	0.000	0.000	0.038	0.019	0.000
1991	0.053	0.047	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.145	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.099	0.467	0.219	0.037	0.030	0.015	0.000	0.000	0.000	0.000
1994	0.206	0.047	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.036
1995	0.000	0.094	0.604	0.185	0.036	0.036	0.000	0.000	0.000	0.023
1996	0.043	0.115	0.227	1.043	0.618	0.068	0.114	0.070	0.036	0.073
1997	0.214	1.328	0.025	0.378	0.584	0.083	0.075	0.000	0.000	0.000
1998	1.466	0.241	0.431	0.131	0.423	0.297	0.070	0.048	0.025	0.000
1999	0.542	3.231	0.620	0.817	0.278	0.477	0.525	0.131	0.051	0.058
2000	0.333	0.806	11.209	1.604	1.265	0.446	0.618	0.222	0.088	0.000
2001	0.196	0.240	2.288	4.821	0.756	0.866	0.287	0.192	0.271	0.045
2002	0.014	0.121	0.014	0.482	2.521	0.365	0.135	0.000	0.205	0.065
2003	0.853	0.000	0.280	0.073	0.486	2.494	0.350	0.048	0.000	0.150
2004	0.073	0.348	0.029	0.559	0.262	0.812	3.215	0.124	0.168	0.116
2005	0.188	0.110	1.579	0.088	0.143	0.314	0.427	1.117	0.076	0.091
2006	0.230	0.282	0.088	1.762	0.028	0.219	0.107	0.285	0.841	0.068
2007	0.015	1.042	0.850	0.221	2.157	0.066	0.014	0.162	0.122	0.504

Table R21. Summary of the number of individual length and age measurements taken during the Northeast Fisheries Science Center spring and autumn bottom trawl surveys, 1963 – 2008.

Year	Lengths		Ages	
	Spring	Autumn	Spring	Autumn
1963		2347		320
1964		412		140
1965		609		142
1966		356		140
1967		316		162
1968	189	260	108	232
1969	134	161	94	148
1970	36	74	36	69
1971	39	72	38	50
1972	37	53	34	51
1973	50	142	44	112
1974	61	114	26	58
1975	280	365	132	175
1976	919	363	154	164
1977	498	660	150	181
1978	68	887	29	78
1979	219	603	19	145
1980	105	331	59	117
1981	199	151	115	28
1982	106	101	76	64
1983	159	102	64	99
1984	35	59	34	59
1985	92	194	65	137
1986	27	29	26	29
1987	5	35	5	27
1988	10	13	9	12
1989	10	22	10	21
1990	2	9	1	9
1991	4	9	4	6
1992	9	11	9	8
1993	25	64	19	34
1994	24	16	20	10
1995	31	55	21	33
1996	10	91	10	66
1997	98	115	60	74
1998	11	225	11	90
1999	278	517	77	216
2000	207	809	83	157
2001	209	468	72	184
2002	333	151	119	98
2003	236	233	118	130
2004	56	312	41	113
2005	49	197	33	117
2006	232	288	95	167
2007	48	251	38	125
2008	126		57	

Table R22. Summary of virtual population analysis (VPA) configuration runs for Gulf of Maine haddock. The BRP1 configuration was accepted by the Biological Reference Point Panel.

VPA run description	**BRP1**	**BASE**	**ALT1**
Survey indices			
1977 - 2008 NEFSC Spring ages	1-6+	1-6+	1-9+
1976 - 2007 NEFSC Autumn ages (projected +1)	1-8+	1-8+	1-9+
Discards			
1977 - 1988 hindcast	Yes	Yes	Yes
1989 - 2007 estimated from observer	Yes	Yes	Yes
Recreational catch			
1981 - 2007 MRFSS	Yes	Yes	Yes
Diagnostics			
Sum of squares	316.5	327.6	474.7
Mean squared residuals	0.978	0.905	1.141
Retrospective calculations			
Recruitment (age 1, T+1) relative difference			
2000		1.06	0.85
2001		7.12	9.85
2002		0.58	0.62
2003		-0.40	-0.41
2004		-0.49	-0.50
2005		-0.19	-0.21
2006		-0.51	-0.52
Average (Mohn's rho)		1.02	1.38
Avg F (6-8) relative difference			
2000		1.11	0.98
2001		1.05	0.94
2002		1.03	0.93
2003		0.93	1.55
2004		0.32	0.76
2005		0.11	0.43
2006		0.01	0.37
Average (Mohn's rho)		0.65	0.85
SSB relative difference			
2000		-0.09	-0.05
2001		0.27	0.31
2002		0.31	0.35
2003		0.21	0.17
2004		-0.04	-0.21
2005		-0.06	-0.21
2006		-0.01	-0.13
Average (Mohn's rho)		0.08	0.03

Table R23. Virtual population analysis (VPA) uncertainty measures in terminal year + 1 (2008) numbers at age estimates for Gulf of Maine haddock.

Output variable	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
NLLS Estimate	219	2924	1411	251	1793	142	196	29
Bootstrap mean	299	3312	1510	270	1904	155	200	34
Bootstrap std. error	279	1820	680	107	628	60	65	31
C.V. for NLLS soln.	0.93	0.55	0.45	0.40	0.33	0.39	0.32	0.93
Bias estimate	80	389	98	19	111	13	3	5
Bias std. error	9	59	22	3	20	2	2	1
Percent bias	36.7	13.3	7.0	7.6	6.2	9.1	1.6	16.4
NLLS estimate corrected for bias	139	2535	1313	232	1682	129	193	24
CV for corrected estimate	2.01	0.72	0.52	0.46	0.37	0.47	0.33	1.29
Lower 80% CI	74	1495	796	154	1165	90	121	1
Upper 80% CI	594	5670	2407	405	2711	232	290	77

Table R24. Virtual population analysis (VPA) uncertainty measures in terminal year (2007) biomass estimates for Gulf of Maine haddock.

Output variable	**Jan-1 biomass**	**Mean biomass**	**Spawning stock biomass**
NLLS Estimate	7350	7340	5850
Bootstrap mean	7817	7755	6089
Bootstrap std. error	1470	1355	1084
C.V. for NLLS soln.	0.19	0.17	0.18
Bias estimate	466	420	244
Bias std. error	49	45	35
Percent bias	6.3	5.7	4.2
NLLS estimate corrected for bias	6885	6915	5602
CV for corrected estimate	0.21	0.20	0.19
Lower 80% CI	5970	6080	4690
Upper 80% CI	9710	9460	7520

Table R25. Virtual population analysis (VPA) uncertainty measures in terminal year (2007) fishing mortality estimates for Gulf of Maine haddock.

Output variable	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Avg $F_{6\text{-}8}$	N-weighted $F_{6\text{-}8}$
NLLS Estimate	0.00	0.00	0.01	0.03	0.14	0.07	0.22	0.86	0.33	0.33	0.47	0.35
Bootstrap mean	0.00	0.00	0.01	0.03	0.14	0.07	0.24	1.47	0.34	0.34	0.68	0.39
Bootstrap std. error	0.00	0.00	0.00	0.01	0.05	0.03	0.08	1.22	0.09	0.09	0.41	0.12
C.V. for NLLS soln.	0.25	0.53	0.42	0.40	0.32	0.39	0.33	0.83	0.26	0.26	0.60	0.31
Bias estimate	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.61	0.01	0.01	0.21	0.04
Bias std. error	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.00
Percent bias	0.80	14.42	11.21	7.47	3.99	5.41	7.99	71.49	3.07	3.07	45.47	12.87
NLLS estimate corrected for bias	0.00	0.00	0.01	0.03	0.13	0.06	0.20	0.24	0.32	0.32	0.26	0.30
CV for corrected estimate	0.26	0.71	0.53	0.47	0.35	0.43	0.39	5.00	0.28	0.28	1.61	0.41
Lower 80% CI	0.00	0.00	0.00	0.02	0.09	0.04	0.16	0.42	0.24	0.24	0.31	0.26
Upper 80% CI	0.00	0.00	0.01	0.05	0.20	0.10	0.34	3.66	0.45	0.45	1.40	0.55

Table R26. Gulf of Maine haddock fishing mortality (F) at age estimated from the virtual population analysis (VPA), 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Avg F_{6-8}	N-weighted F_{6-8}
1977	0.00	0.10	0.15	0.03	0.20	0.51	0.42	5.00	0.42	0.42	1.94	0.42
1978	0.00	0.00	0.10	0.25	0.14	0.27	0.87	0.15	0.47	0.47	0.50	0.54
1979	0.01	0.01	0.06	0.21	0.28	0.23	0.13	0.45	0.16	0.16	0.25	0.16
1980	0.02	0.02	0.18	0.11	0.42	0.44	0.30	0.25	0.28	0.28	0.28	0.28
1981	0.01	0.05	0.34	0.20	0.40	0.36	0.32	0.20	0.30	0.30	0.27	0.30
1982	0.10	0.15	0.18	0.56	0.25	0.20	0.41	0.45	0.44	0.44	0.43	0.44
1983	0.00	0.05	0.05	0.38	0.74	0.50	0.47	0.69	0.59	0.59	0.58	0.59
1984	0.00	0.02	0.09	0.12	0.49	0.39	0.41	0.34	0.40	0.40	0.38	0.40
1985	0.00	0.02	0.04	0.39	0.34	0.69	0.45	0.56	0.51	0.51	0.51	0.52
1986	0.06	0.09	0.00	0.41	1.05	0.72	0.61	0.67	0.63	0.63	0.64	0.63
1987	0.02	0.07	0.02	0.22	0.47	0.49	1.11	0.79	0.89	0.89	0.93	0.89
1988	0.00	0.03	0.00	0.09	0.19	0.55	0.91	1.10	0.94	0.94	0.98	0.94
1989	0.00	0.01	0.06	0.06	0.57	0.57	0.45	1.48	0.64	0.64	0.86	0.72
1990	0.01	0.01	0.01	0.50	0.03	0.58	2.57	2.02	2.19	2.19	2.26	2.22
1991	0.01	0.02	0.11	0.19	0.44	0.45	1.40	5.00	1.44	1.44	2.62	1.56
1992	0.00	0.03	0.07	0.64	0.21	0.30	0.10	0.60	0.17	0.17	0.30	0.19
1993	0.01	0.01	0.06	0.15	0.46	0.15	0.13	0.42	0.19	0.19	0.25	0.20
1994	0.02	0.04	0.02	0.15	0.10	0.08	0.12	0.19	0.14	0.14	0.15	0.14
1995	0.00	0.02	0.04	0.12	0.37	0.12	0.22	0.10	0.14	0.14	0.15	0.14
1996	0.02	0.01	0.02	0.10	0.11	0.11	0.06	0.35	0.12	0.12	0.18	0.13
1997	0.00	0.00	0.01	0.11	0.24	0.18	0.18	0.11	0.15	0.15	0.15	0.15
1998	0.01	0.01	0.02	0.03	0.10	0.31	0.18	0.25	0.19	0.19	0.21	0.19
1999	0.00	0.00	0.00	0.04	0.11	0.10	0.16	0.16	0.16	0.16	0.16	0.16
2000	0.00	0.00	0.01	0.04	0.11	0.16	0.22	0.23	0.22	0.22	0.22	0.22
2001	0.00	0.00	0.01	0.03	0.13	0.13	0.29	0.17	0.22	0.22	0.23	0.22
2002	0.00	0.00	0.00	0.01	0.04	0.15	0.23	0.19	0.22	0.22	0.21	0.22
2003	0.00	0.00	0.01	0.01	0.03	0.10	0.17	0.20	0.18	0.18	0.19	0.18
2004	0.00	0.00	0.00	0.01	0.10	0.09	0.17	0.20	0.18	0.18	0.18	0.18
2005	0.00	0.00	0.00	0.02	0.10	0.36	0.23	0.27	0.26	0.26	0.26	0.26
2006	0.00	0.00	0.00	0.02	0.02	0.13	0.56	0.18	0.27	0.27	0.34	0.27
2007	0.00	0.00	0.01	0.03	0.14	0.07	0.22	0.86	0.33	0.33	0.47	0.35

Table R27. Gulf of Maine haddock January 1 numbers (000's) at age estimated from the virtual population analysis (VPA), 1977 to 2008.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1977	2,349	6,599	13,777	1,888	2,204	588	463	1	5	20	27,894
1978	8,591	1,916	4,908	9,666	1,500	1,476	289	250	0	16	28,611
1979	8,488	7,024	1,565	3,627	6,151	1,065	920	99	176	0	29,116
1980	4,915	6,908	5,688	1,203	2,417	3,823	691	658	52	114	26,469
1981	744	3,955	5,545	3,878	886	1,301	2,022	417	418	54	19,221
1982	2,119	606	3,090	3,223	2,594	484	742	1,203	279	186	14,524
1983	1,002	1,573	426	2,117	1,514	1,661	323	405	625	217	9,863
1984	186	818	1,219	333	1,183	593	826	166	166	340	5,831
1985	348	152	660	911	242	592	328	449	96	104	3,882
1986	179	285	122	517	507	141	243	170	210	28	2,403
1987	771	138	214	100	280	145	57	108	72	34	1,919
1988	579	618	106	172	65	143	73	15	40	9	1,821
1989	449	474	490	86	129	44	68	24	4	2	1,771
1990	457	368	385	379	67	60	20	35	4	0	1,776
1991	845	370	297	314	189	53	28	1	4	3	2,103
1992	1,845	683	296	217	213	99	28	6	0	8	3,394
1993	3,235	1,506	541	225	94	142	60	20	3	4	5,830
1994	3,739	2,634	1,222	416	159	49	100	43	11	8	8,382
1995	1,586	3,007	2,076	979	294	118	37	73	30	27	8,225
1996	2,618	1,298	2,417	1,629	712	166	86	24	54	8	9,011
1997	2,796	2,101	1,054	1,947	1,206	525	121	66	14	14	9,843
1998	15,057	2,289	1,717	855	1,434	775	357	83	48	48	22,665
1999	2,999	12,230	1,862	1,382	679	1,061	466	245	53	46	21,022
2000	951	2,454	10,006	1,524	1,092	499	784	324	172	85	17,891
2001	1,278	778	2,004	8,146	1,204	798	349	517	210	134	15,418
2002	524	1,045	635	1,620	6,476	869	574	215	356	385	12,699
2003	5,764	429	854	519	1,310	5,106	614	373	146	478	15,594
2004	579	4,719	351	695	422	1,038	3,792	423	249	374	12,642
2005	2,606	474	3,856	287	562	314	778	2,613	285	393	12,167
2006	4,369	2,134	387	3,142	231	416	179	504	1,628	285	13,275
2007	267	3,573	1,738	316	2,509	185	300	83	343	1,461	10,776
2008	1,445	219	2,924	1,411	251	1,793	142	196	29	1,062	9,472

Table R28. Gulf of Maine haddock spawning stock biomass (mt) at age estimated from the virtual population analysis (VPA), 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total (mt)
1977	0	12	1,905	1,290	3,587	1,218	1,171	1	23	99	9,306
1978	0	3	379	6,497	1,922	2,897	614	847	0	69	13,228
1979	0	15	116	2,423	7,925	1,909	2,097	243	593	0	15,321
1980	0	10	584	876	3,069	6,755	1,657	1,719	154	441	15,265
1981	0	5	406	2,943	1,171	2,457	4,971	1,341	1,389	181	14,864
1982	0	2	197	1,736	4,061	982	1,784	3,534	961	647	13,904
1983	0	3	45	1,260	1,543	3,146	753	1,049	1,892	752	10,443
1984	0	2	85	202	1,429	1,021	1,942	494	551	1,198	6,924
1985	0	1	75	529	316	976	688	1,246	324	367	4,522
1986	0	1	17	370	452	235	482	390	614	101	2,662
1987	0	0	33	80	362	230	100	245	195	134	1,379
1988	0	1	9	145	81	272	132	34	123	34	831
1989	0	1	36	89	149	71	142	44	14	7	553
1990	0	1	43	327	146	97	28	58	8	0	708
1991	0	1	39	245	305	142	49	1	10	7	799
1992	0	1	36	206	318	226	75	13	0	20	895
1993	0	3	55	198	140	285	165	59	8	16	929
1994	0	3	119	359	252	107	253	139	37	31	1,300
1995	0	4	115	717	445	264	108	246	120	138	2,157
1996	0	2	116	1,055	932	316	228	62	153	23	2,887
1997	0	6	122	1,427	1,371	961	283	191	38	48	4,447
1998	0	8	159	747	2,377	1,317	838	235	139	132	5,952
1999	0	22	171	1,153	977	1,751	881	582	156	141	5,834
2000	0	7	775	906	1,407	809	1,331	624	383	259	6,501
2001	0	2	198	5,330	1,348	1,223	628	1,020	458	310	10,517
2002	0	2	43	1,135	8,009	1,262	1,028	477	757	954	13,667
2003	0	1	64	231	1,410	6,857	984	741	344	1,115	11,747
2004	0	12	24	341	438	1,313	5,603	755	494	763	9,743
2005	0	1	274	157	500	396	1,029	4,077	521	834	7,789
2006	0	6	25	1,502	171	490	242	717	2,585	537	6,275
2007	0	9	97	142	2,090	160	404	108	498	2,338	5,846

Table R29. Input values for Gulf of Maine haddock biological reference point calculations based on 2002 to 2006 average values from the VPA base run.

Age	Fishery selectivity	Natural mortality	Stock weights (kg)	Catch weights (kg)	Spawning stock weights (kg)	Proportion mature (%)
1	0.007	1.0	0.086	0.151	0.086	0.032
2	0.016	1.0	0.271	0.531	0.271	0.259
3	0.063	1.0	0.645	0.863	0.645	0.787
4	0.258	1.0	1.002	1.117	1.002	0.975
5	0.536	1.0	1.292	1.424	1.292	0.998
6	1.000	1.0	1.598	1.688	1.598	1.000
7	1.000	1.0	1.836	1.863	1.836	1.000
8	1.000	1.0	2.053	2.037	2.053	1.000
9	1.000	1.0	2.228	2.228	2.228	1.000

Table R30. Output from yield and biomass per recruit analyses of Gulf of Maine haddock.

Reference point	F	Yield per recruit	SSB per recruit	Total biomass per recruit	Mean age	Mean generation time	Expected spawnings
F_0	0.00	0.00	5.37	6.00	5.52	9.07	2.35
$F_{0.1}$	0.32	0.46	2.47	3.08	3.40	5.77	1.65
F_{max}	1.66	0.56	1.11	1.69	2.54	4.18	0.92
$F_{40\%\ MSP}$	**0.43**	**0.50**	**2.15**	**2.75**	**3.19**	**5.39**	**1.51**

Table R31. Gulf of Maine haddock spawning stock biomass (SSB) and catch projections for 2009 under assumptions of $F_{40\%}$ and N-weighted $F_{6\text{-}8,2007}$. Catch in 2008 is assumed to be equal to 2007 catch (1,368 mt).

Scenario	F	SSB (mt)	$\%SSB_{MSY}$	Catch (mt)	% MSY
$F_{40\%}$	0.43	6,000	1.02	1,450	1.07
$F_{2007\ N\text{-}weighted}$	0.35	6,090	1.03	1,200	0.88

11.0 Figures

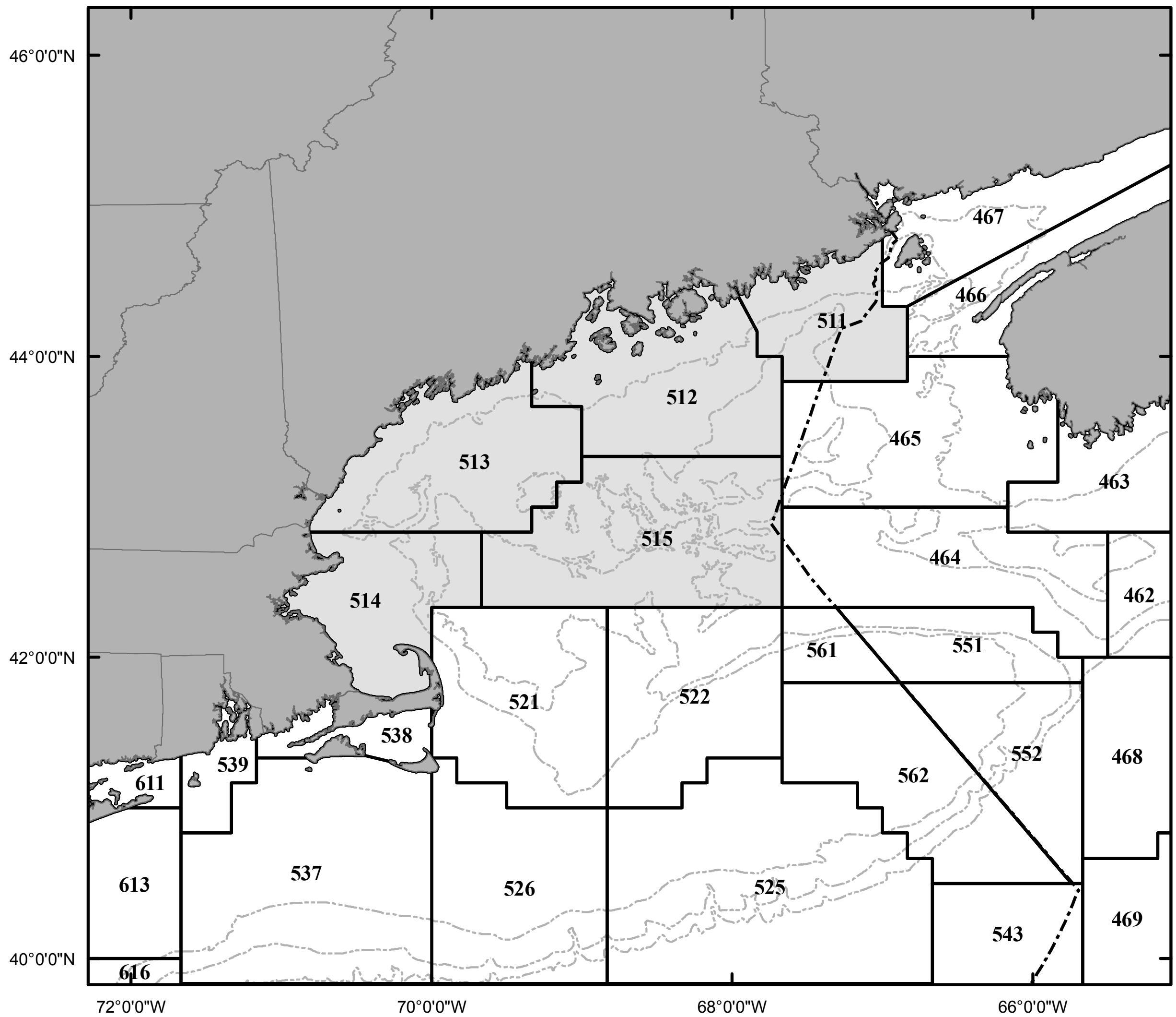


Figure R1. Statistical areas included in the Gulf of Maine haddock management unit (light grey). Northeast Atlantic Fisheries Organization (NAFO) division 5Y is composed of United States statistical areas 511 – 515. Bathymetric contours corresponding to the 50, 100, and 500 fa contour lines are shown in light grey. Dashed line represents the United Sates Exclusive Economic Zone.

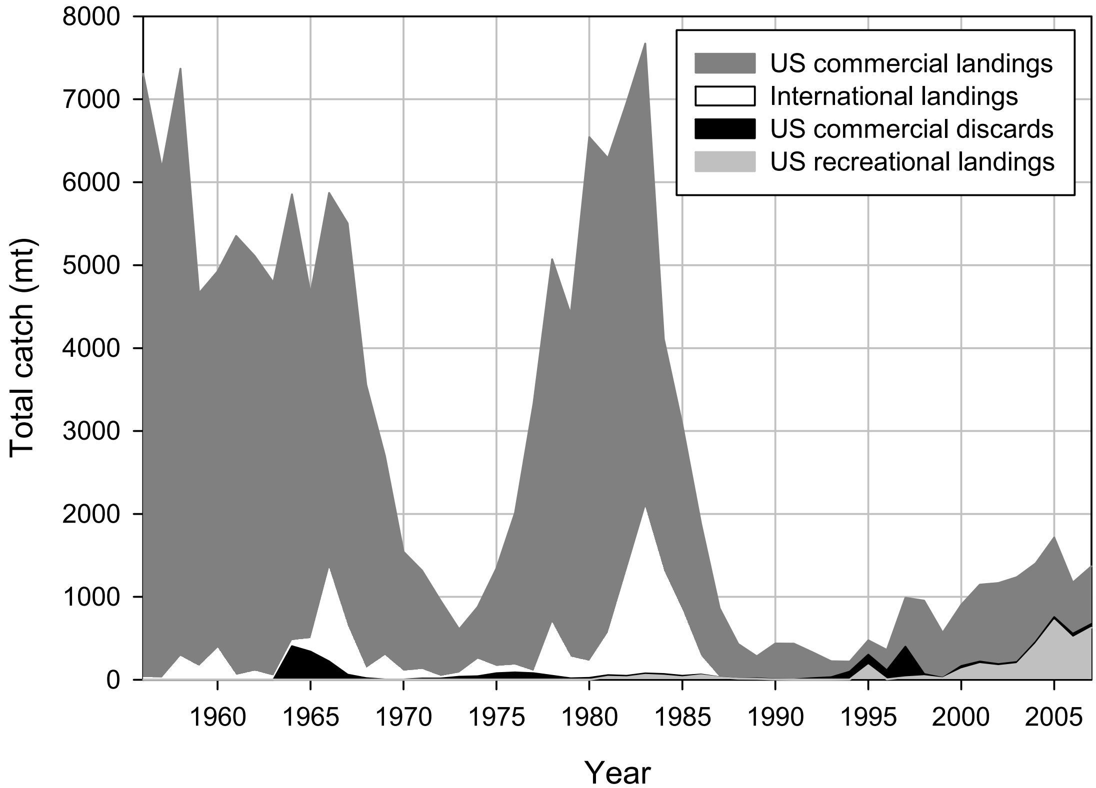


Figure R2. Total catch (mt) of Gulf of Maine haddock, 1956 – 2007.

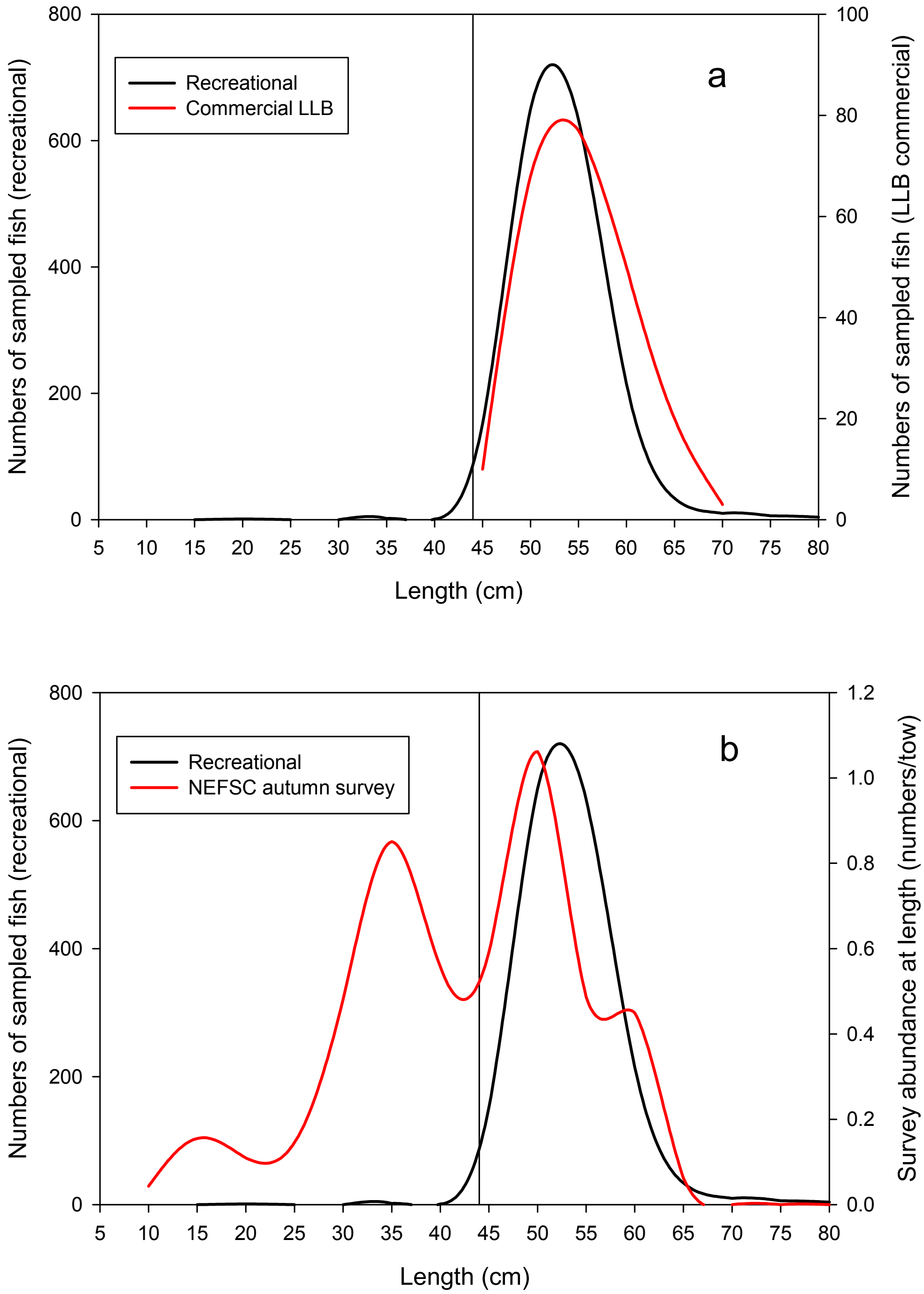


Figure R3. Selectivity of the recreational fishery relative to the commercial longline fishery (a) and Northeast Fisheries Science Center bottom trawl survey (b). Solid vertical lines indicate minimum legal size for recreational fishery. Data shown are from 2005.

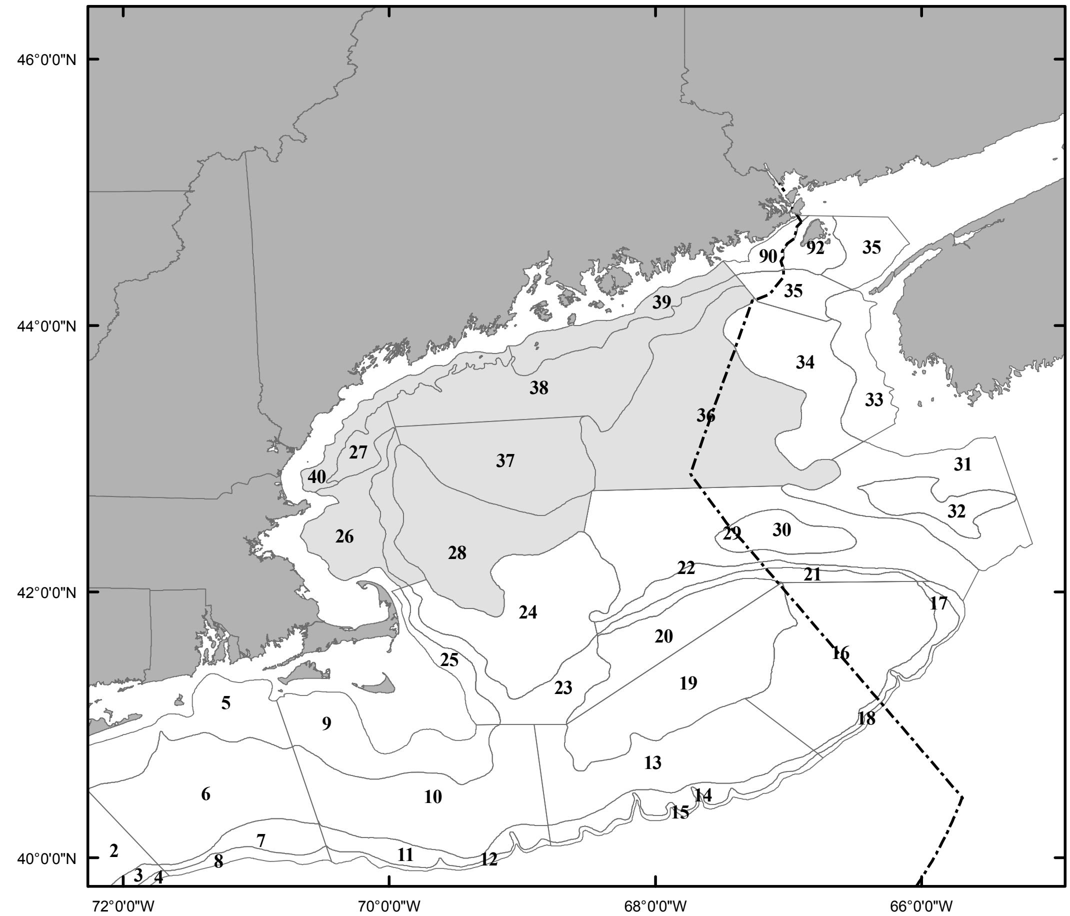


Figure R4. Northeast Fisheries Science Center (NEFSC) bottom trawl survey strata used to calculate the Gulf of Maine survey indices. Dashed line represents the United Sates Exclusive Economic Zone.

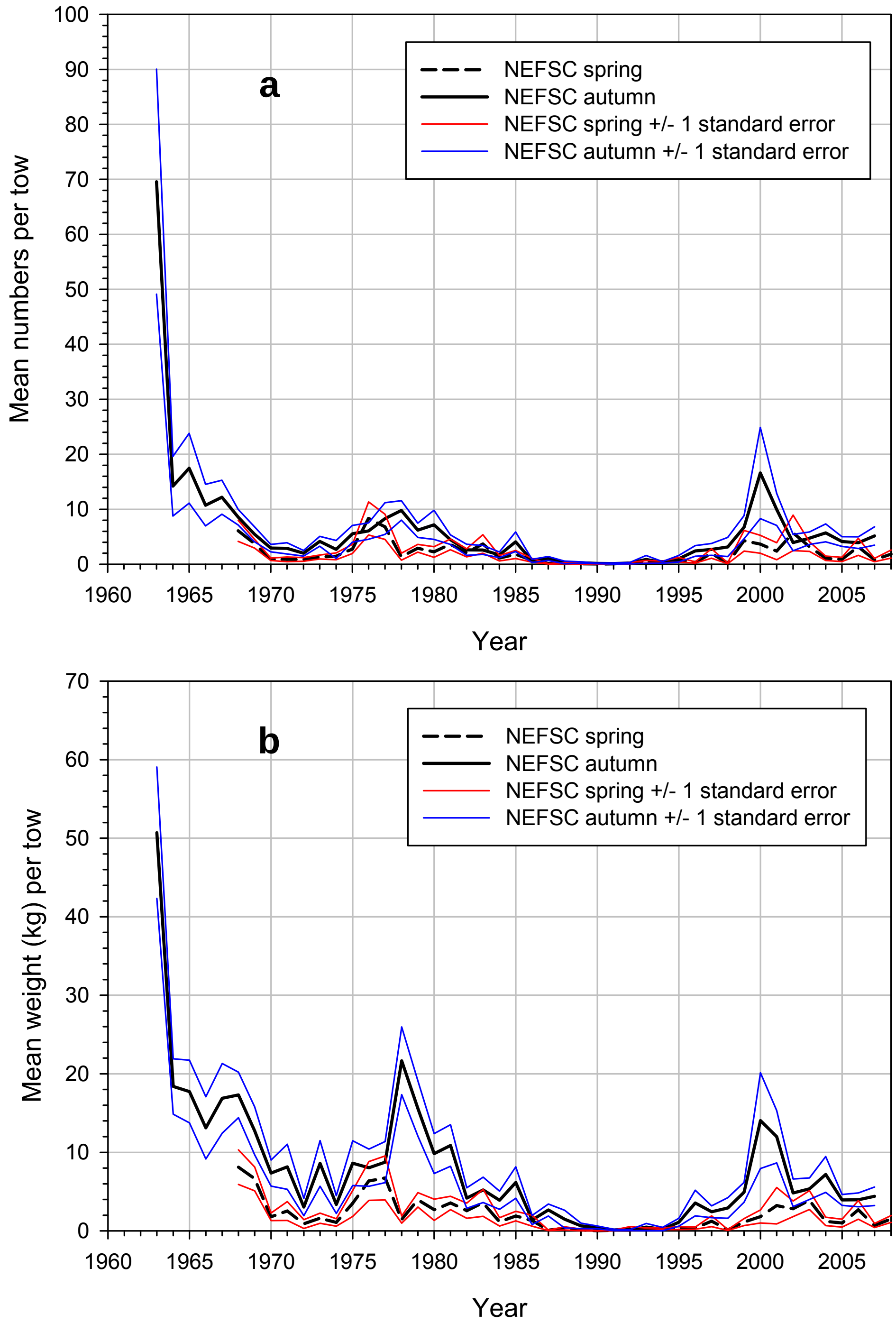


Figure R5. Northeast Fisheries Science Center (NEFSC) bottom trawl survey abundance (stratified mean numbers per tow) (a), and biomass (stratified mean weight (kg) per tow) (b) for Gulf of Maine haddock, 1963 – 2008 (autumn 2008 survey has not been conducted). Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

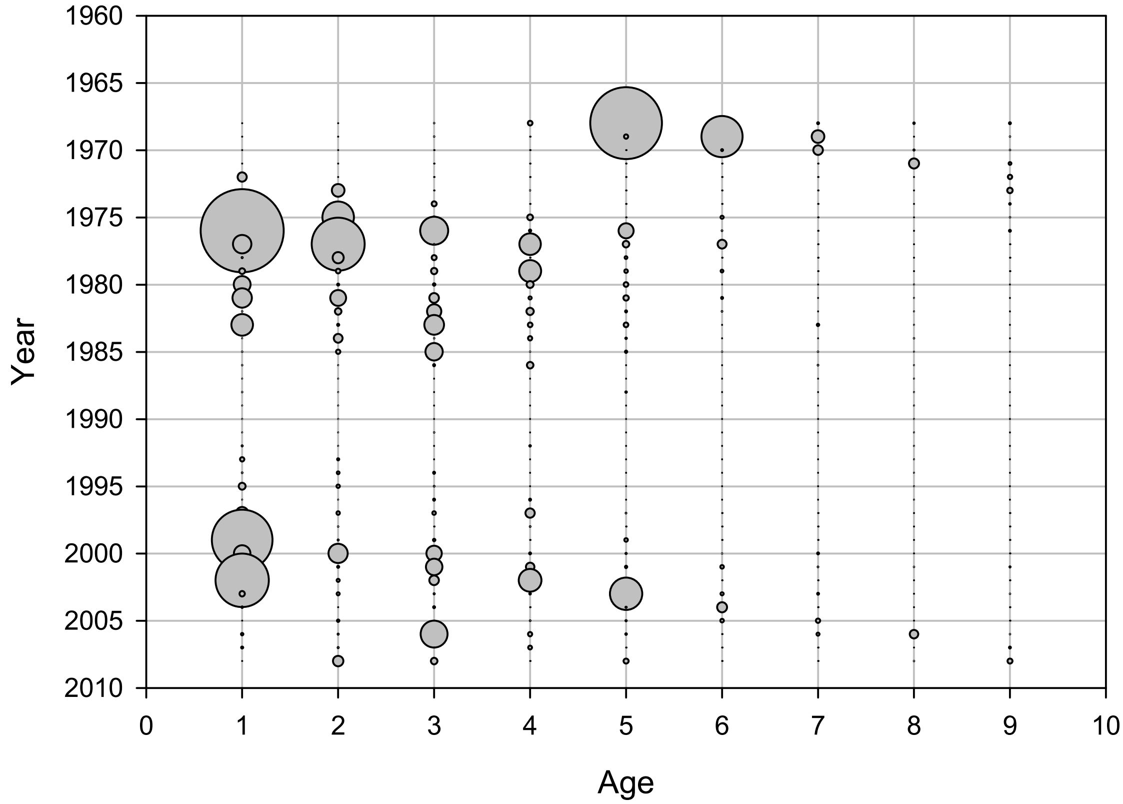


Figure R6. Age structure of the Gulf of Maine haddock population as indicated by the NEFSC spring bottom trawl survey indices of abundance, 1968 – 2008.

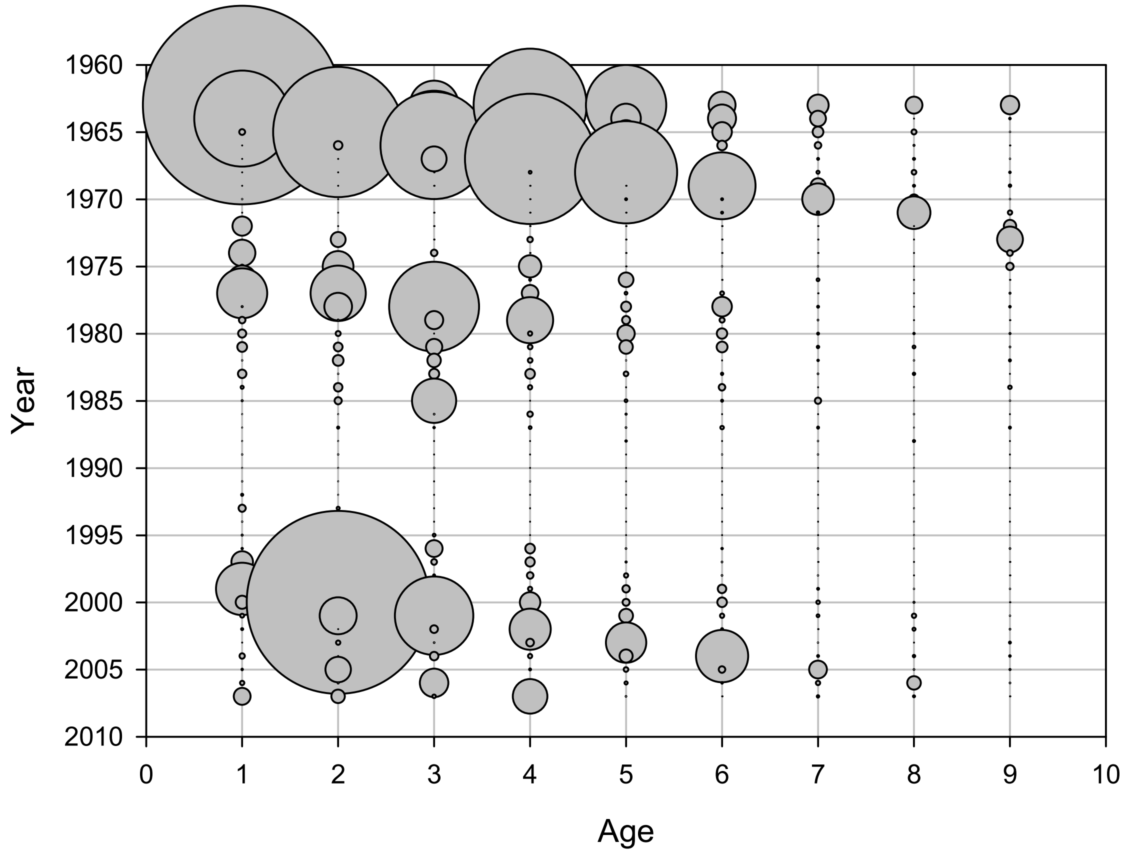


Figure R7. Age structure of the Gulf of Maine haddock population as indicated by the NEFSC autumn bottom trawl survey indices of abundance, 1963 – 2007.

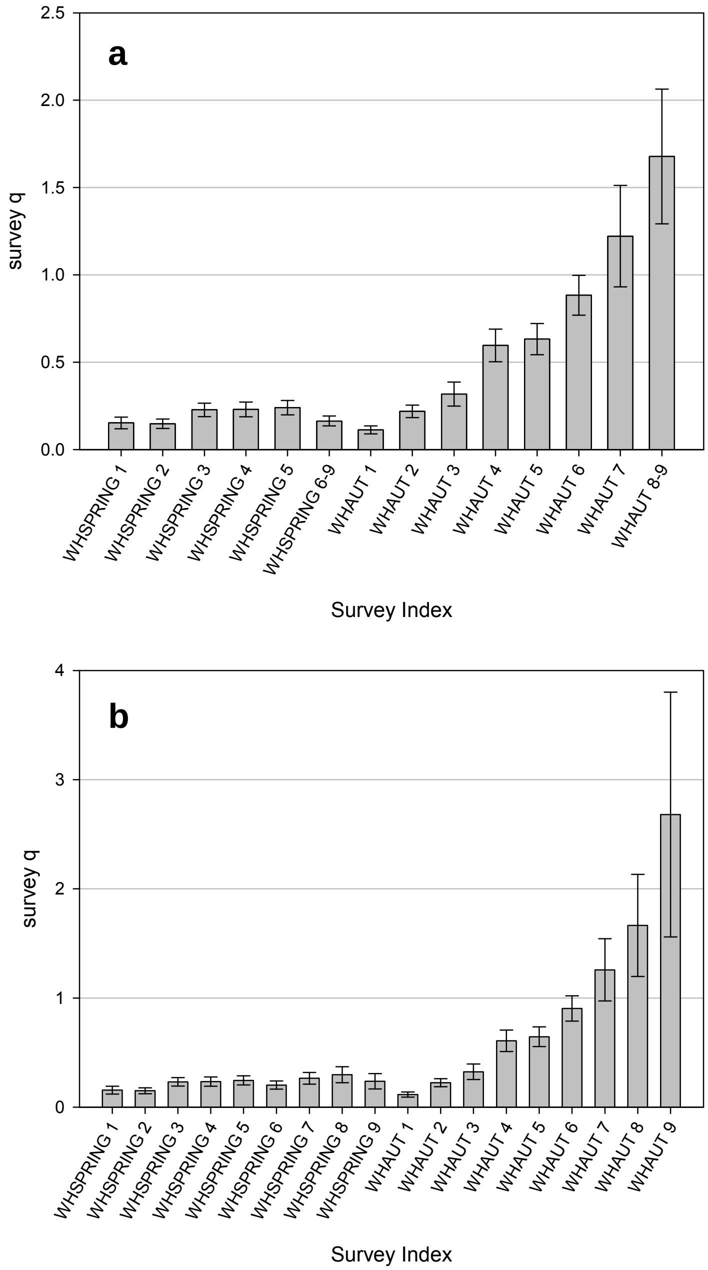


Figure R8. Comparison of swept area (absolute N) survey index catchability coefficients (q) fo the BASE (a) and ALT1 (b) virtual population analysis (VPA) run configurations; error bars are +/- 1 standard error.

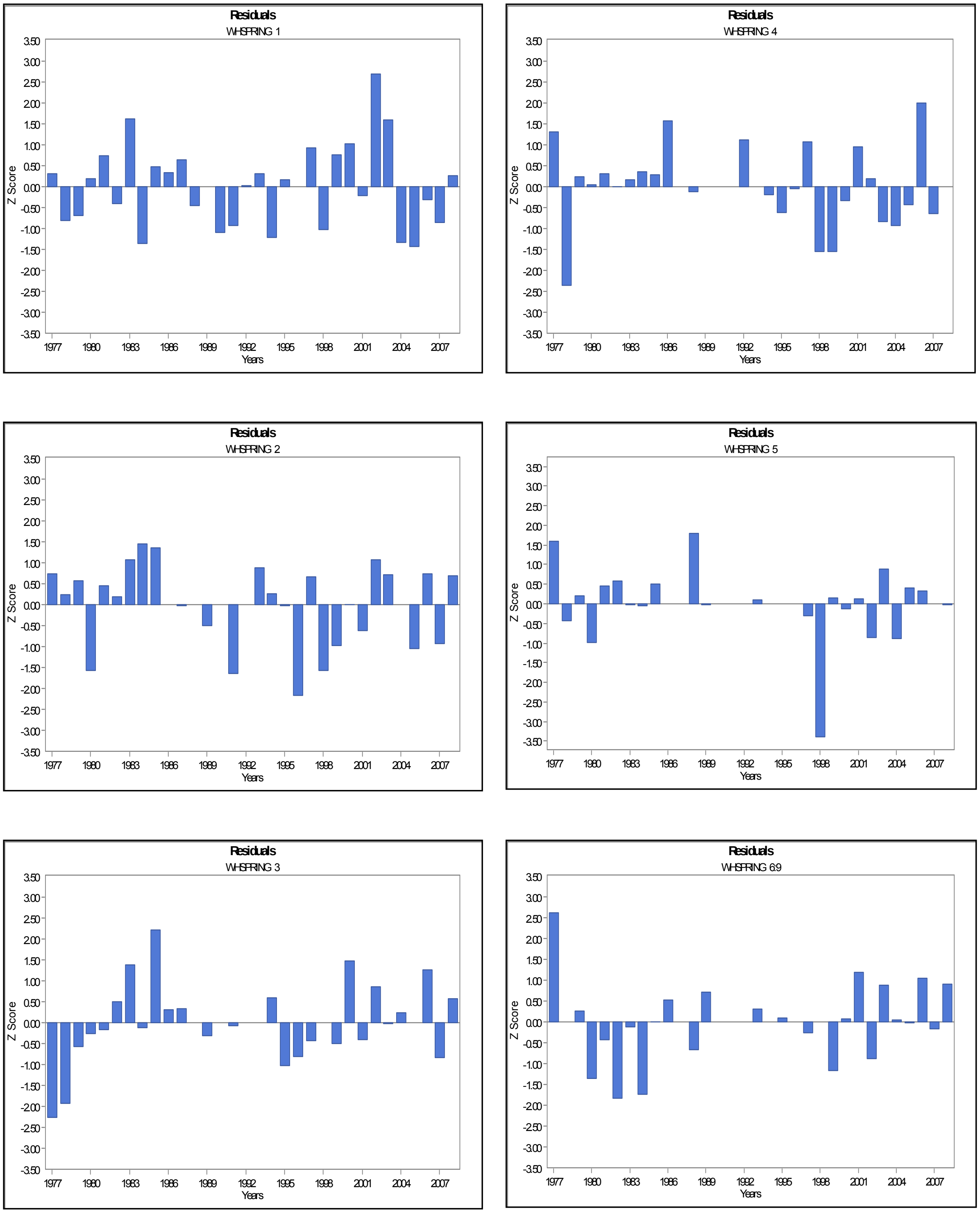


Figure R9. Standardized residuals for the age 1 through 6:9+ spring survey indices used to tune the BASE virtual population analysis run for Gulf of Maine haddock.

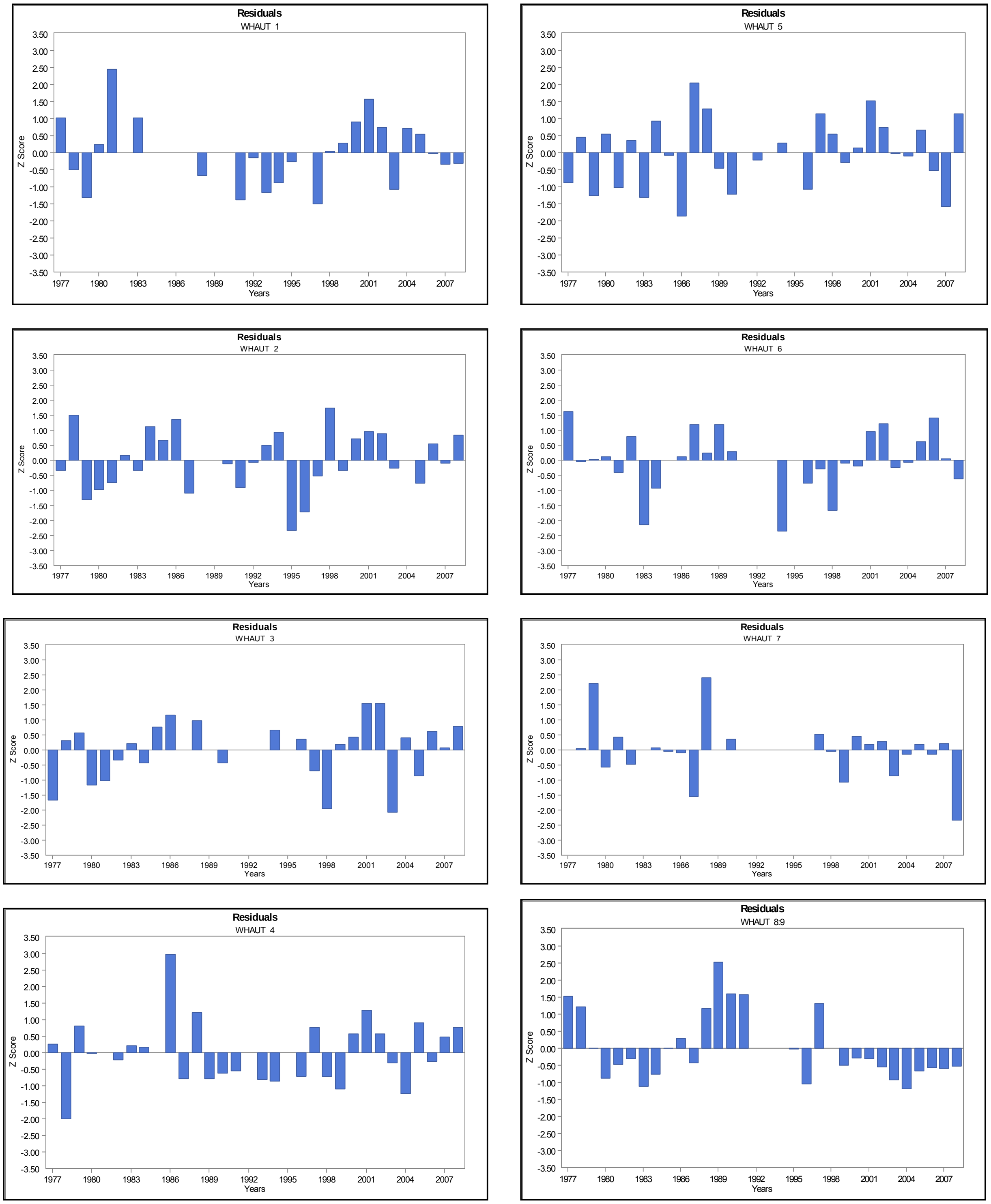


Figure R10. Standardized residuals for the age 1 through 8:9^{+} autumn survey indices used to tune the BASE virtual population analysis run for Gulf of Maine haddock.

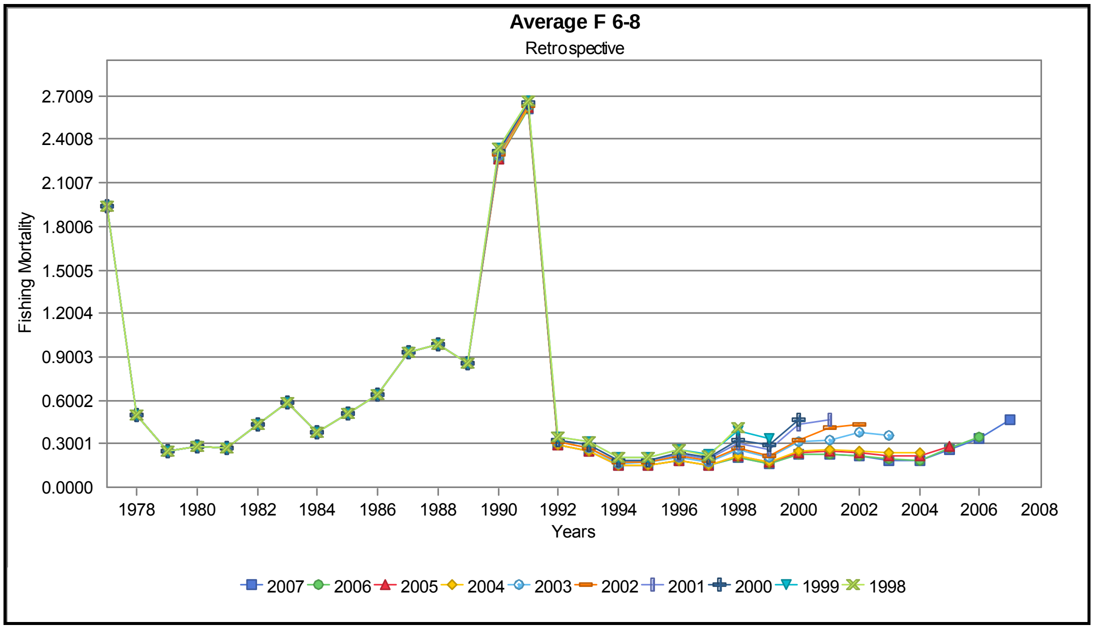


Figure R11. Retrospective plot of the virtual population analysis (VPA) estimates of fully recruited F for Gulf of Maine haddock ($F_{6\text{-}8}$).

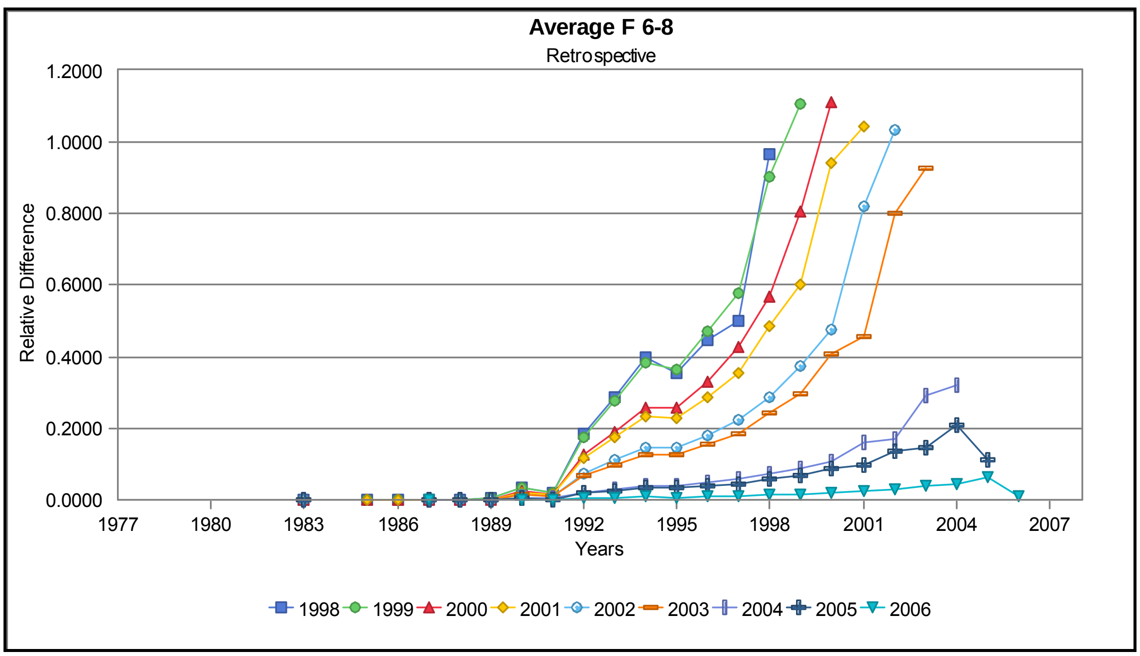


Figure R12. Relative difference of annual virtual population analysis (VPA) “peels” compared to the 2007 base run estimates of fully recruited F for Gulf of Maine haddock ($F_{6\text{-}8}$).

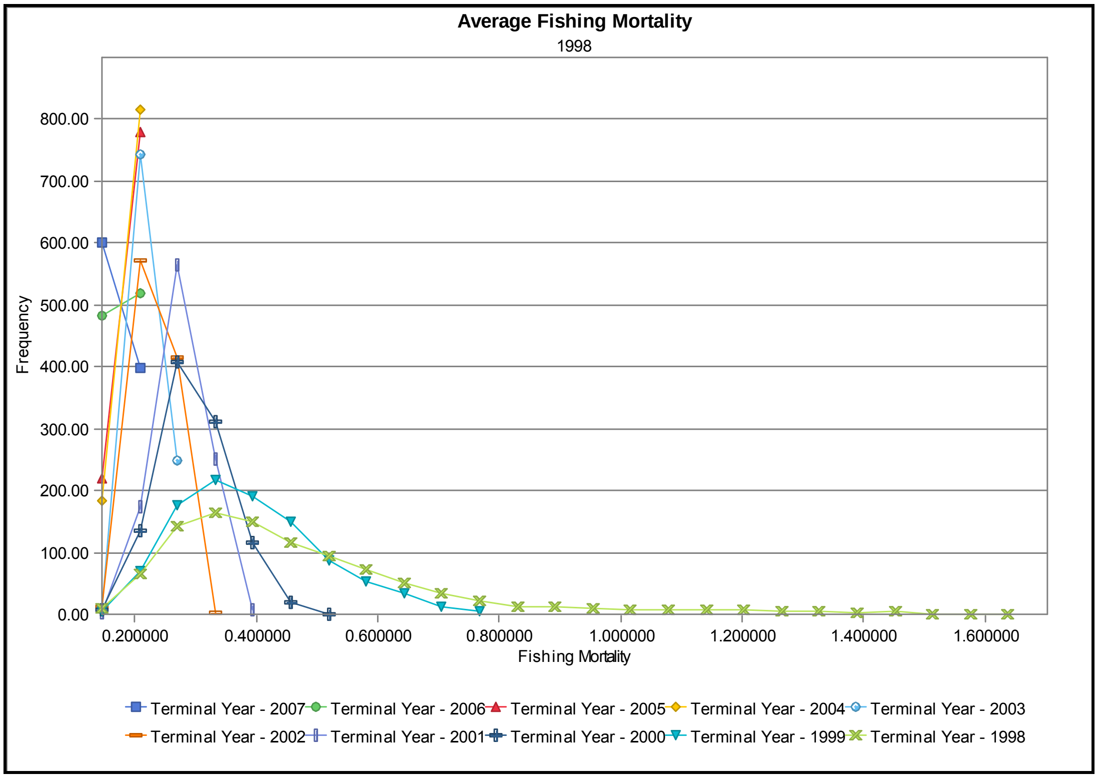


Figure R13. Distributions of terminal year fishing mortality estimates resulting from 1000 bootstrap iterations.

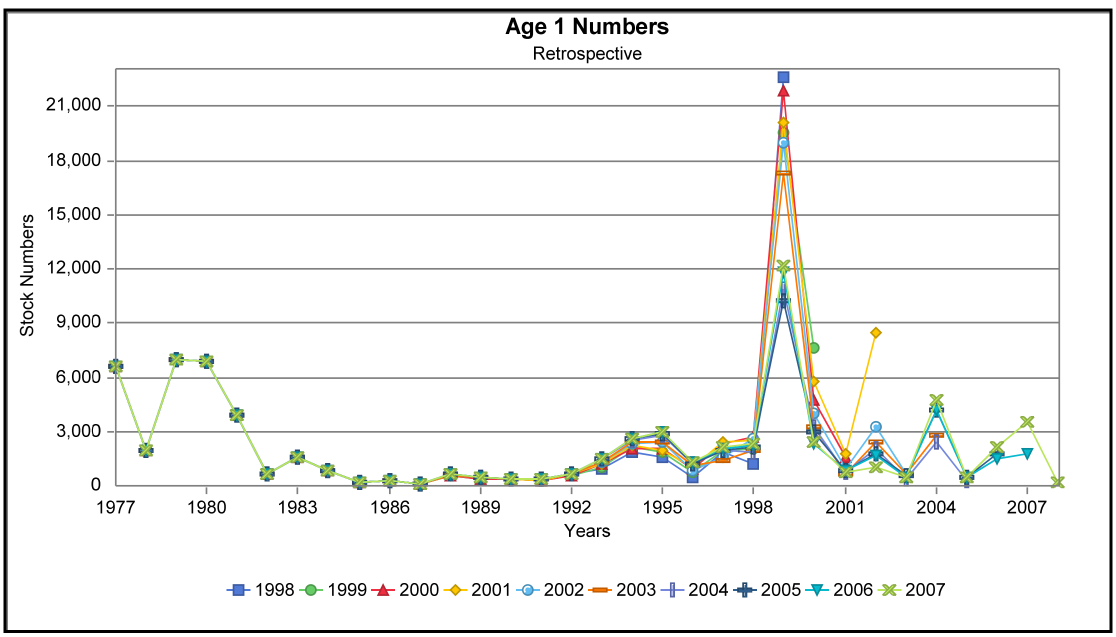


Figure R14. Retrospective plot of the virtual population analysis (VPA) estimates of age 1 recruitment for Gulf of Maine haddock.

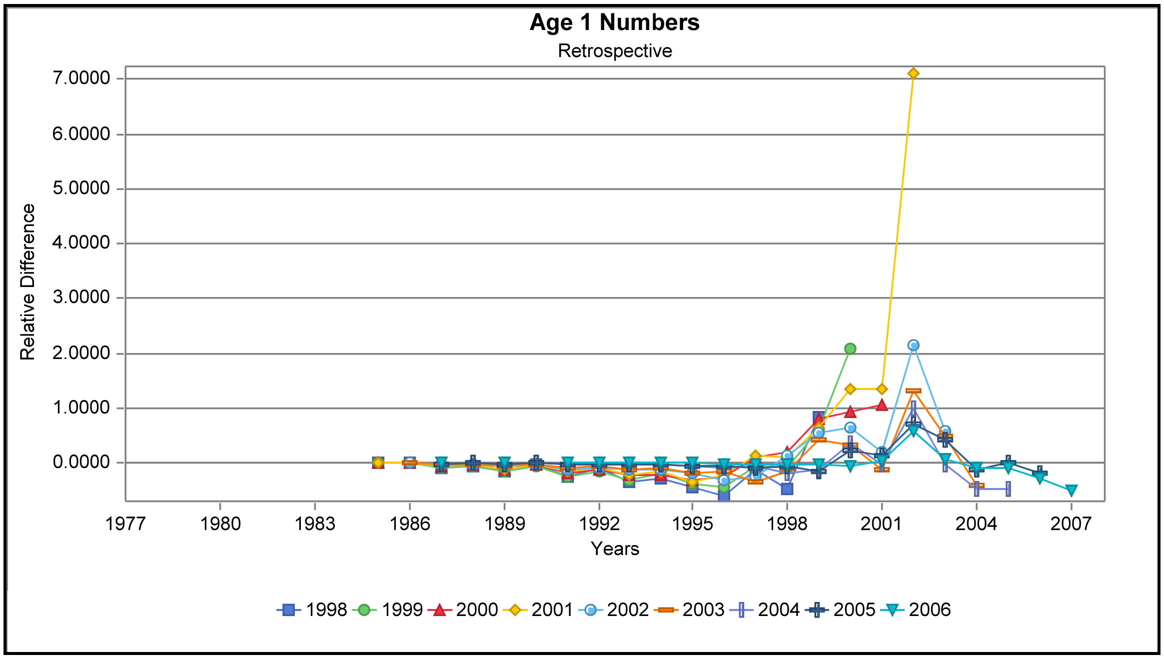


Figure R15. Relative difference of annual virtual population analysis (VPA) "peels" compared to the 2007 base run estimates of age 1 recruitment for Gulf of Maine haddock.

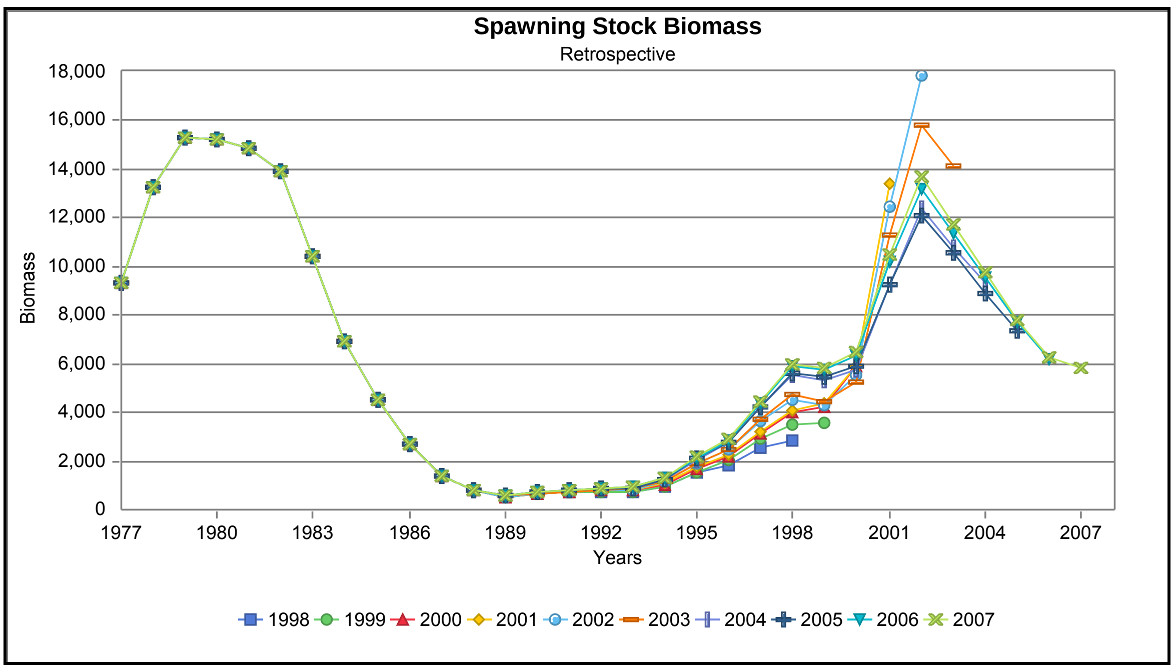


Figure R16. Retrospective plot of the virtual population analysis (VPA) estimates of spawning stock biomass for Gulf of Maine haddock.

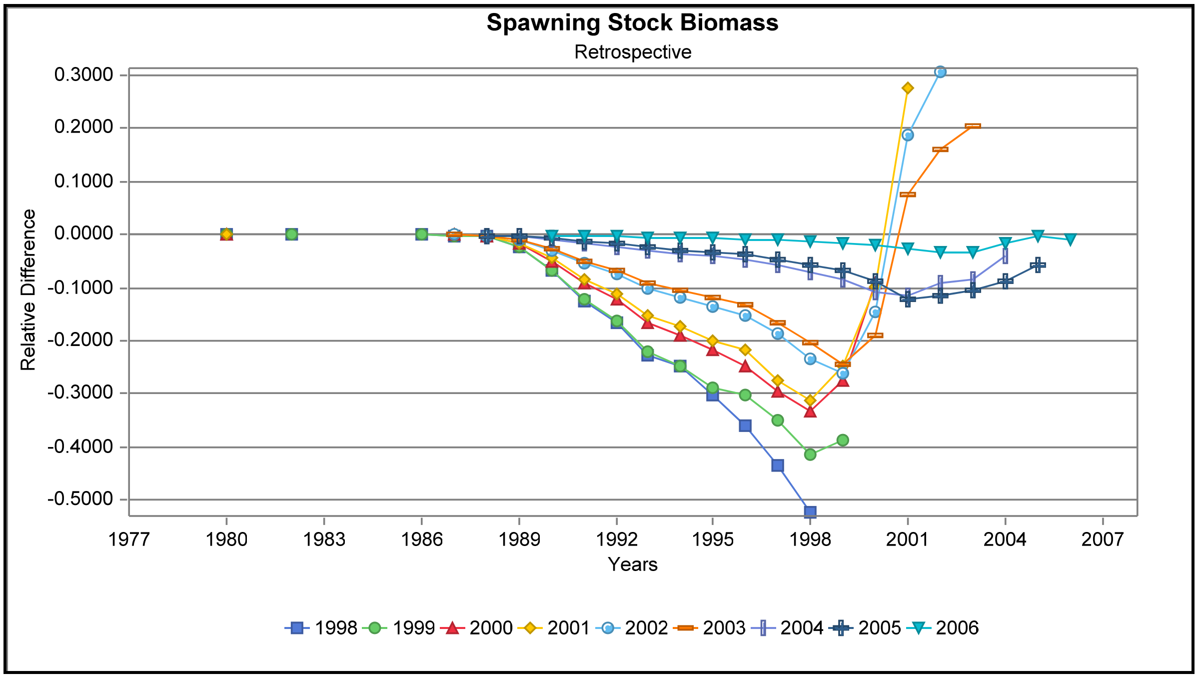


Figure R17. Relative difference of annual virtual population analysis (VPA) "peels" compared to the 2007 base run estimates of spawning stock biomass for Gulf of Maine haddock.

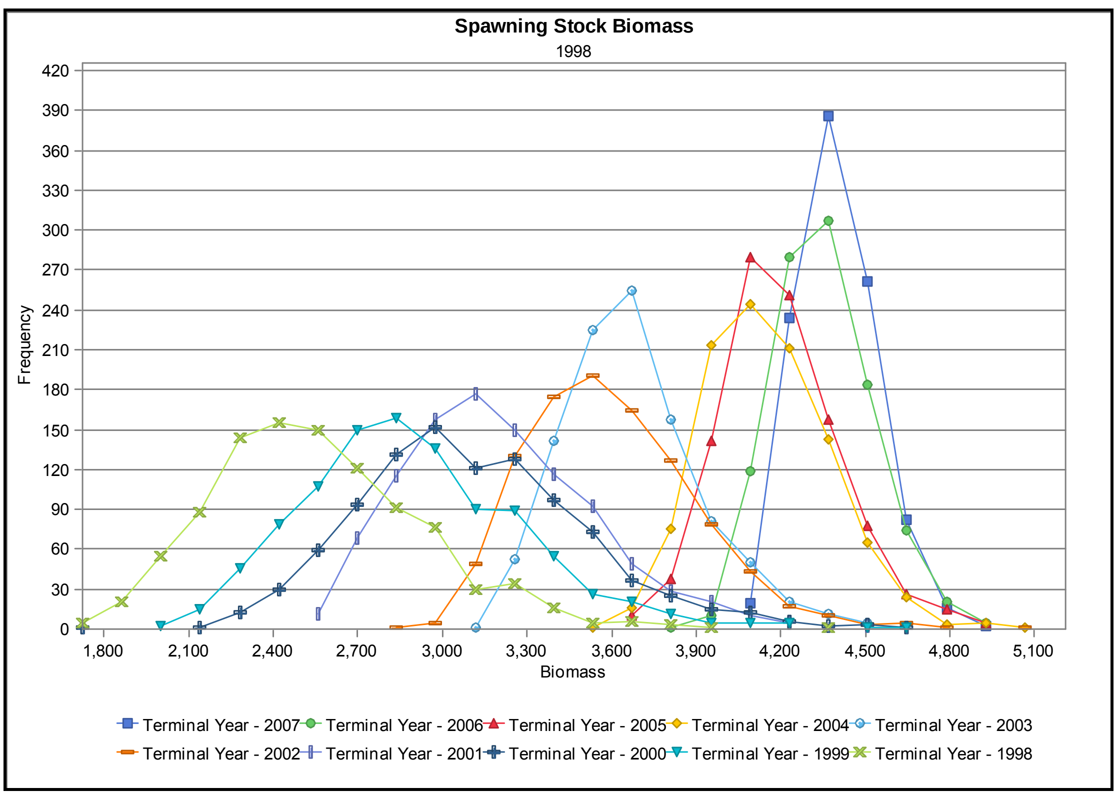


Figure R18. Distributions of terminal year spawning stock biomass estimates resulting from 1000 bootstrap iterations.

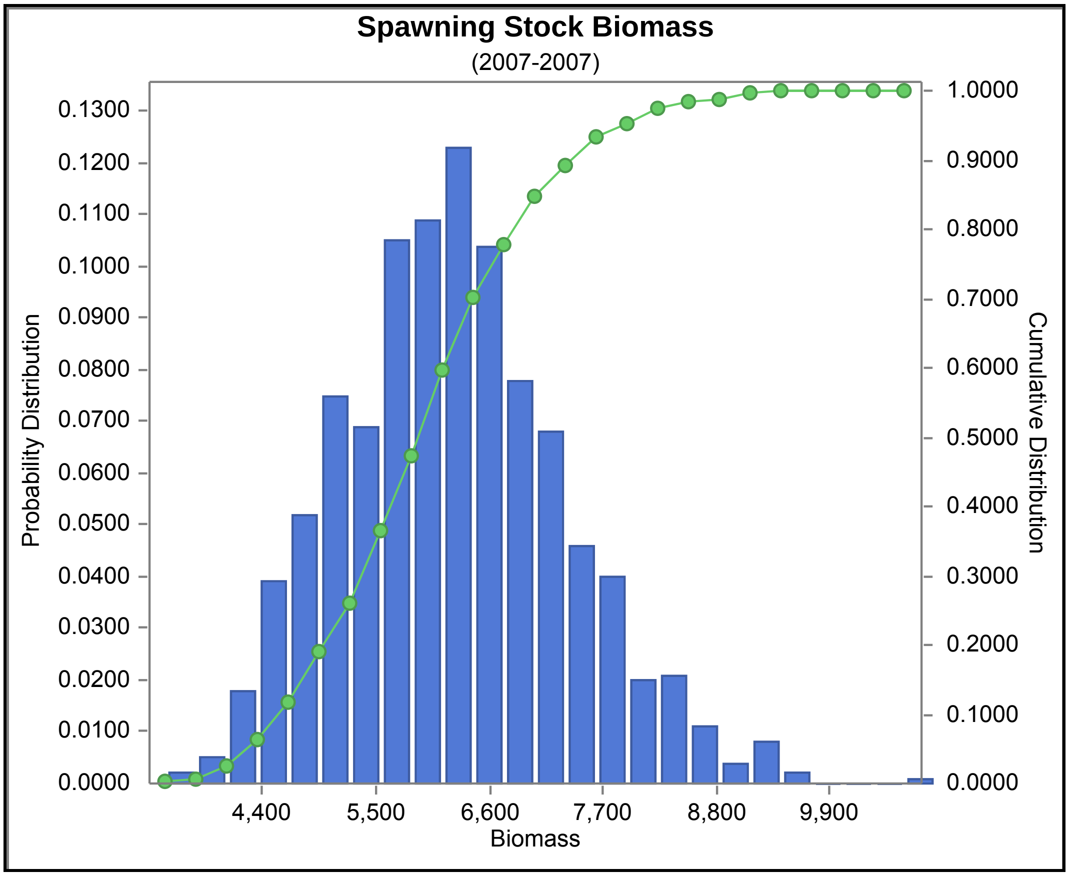
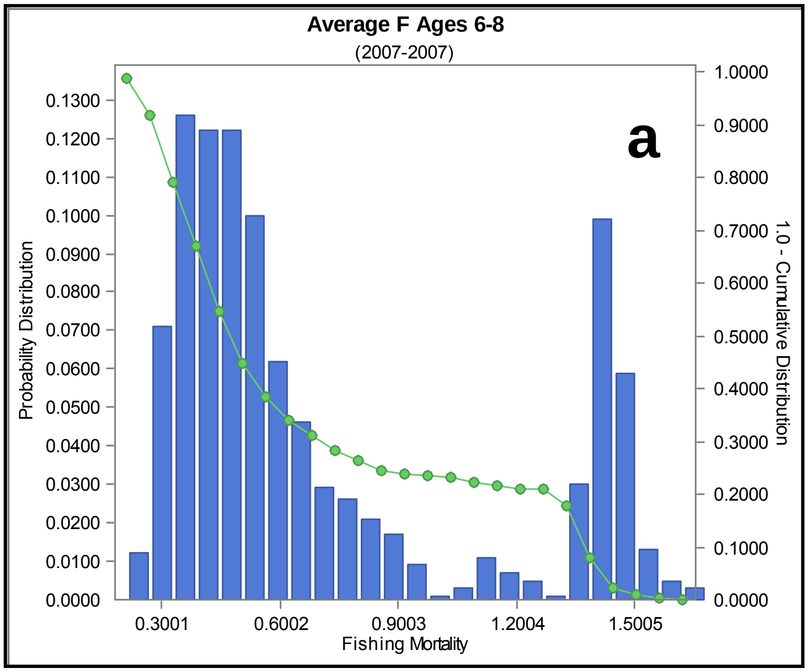


Figure R19. Bootstrap distribution of 2007 fishing mortality; unweighted avg. $F_{6\text{-}8}$ (a), and N-weighted avg. $F_{6\text{-}8}$ (b). The vertical bars provide the probability distribution of values of SSB from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.



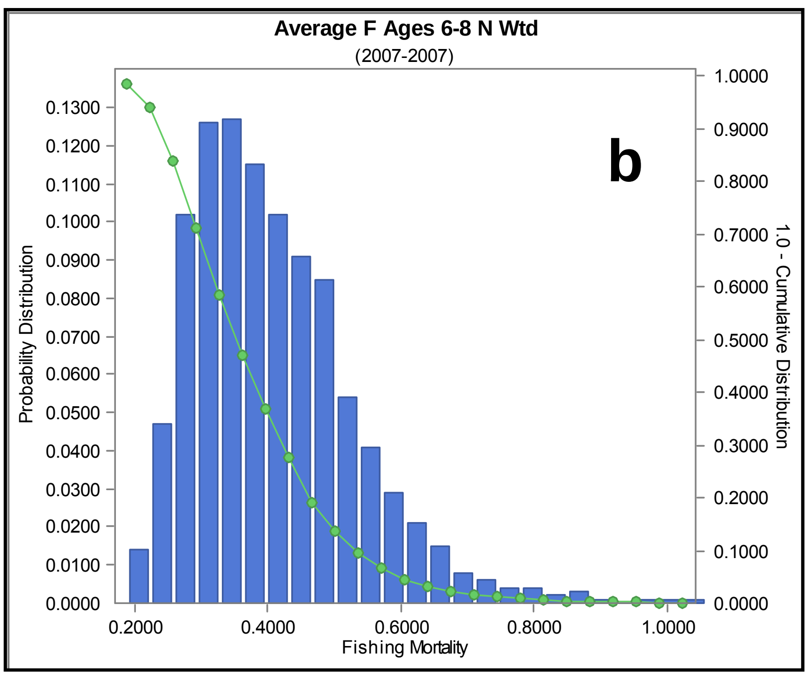


Figure R20. Bootstrap distribution of 2007 fishing mortality; unweighted avg. $F_{6\text{-}8}$ (a), and N-weighted avg. $F_{6\text{-}8}$ (b). The vertical bars provide the probability distribution of values of $F_{6\text{-}8}$ from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.

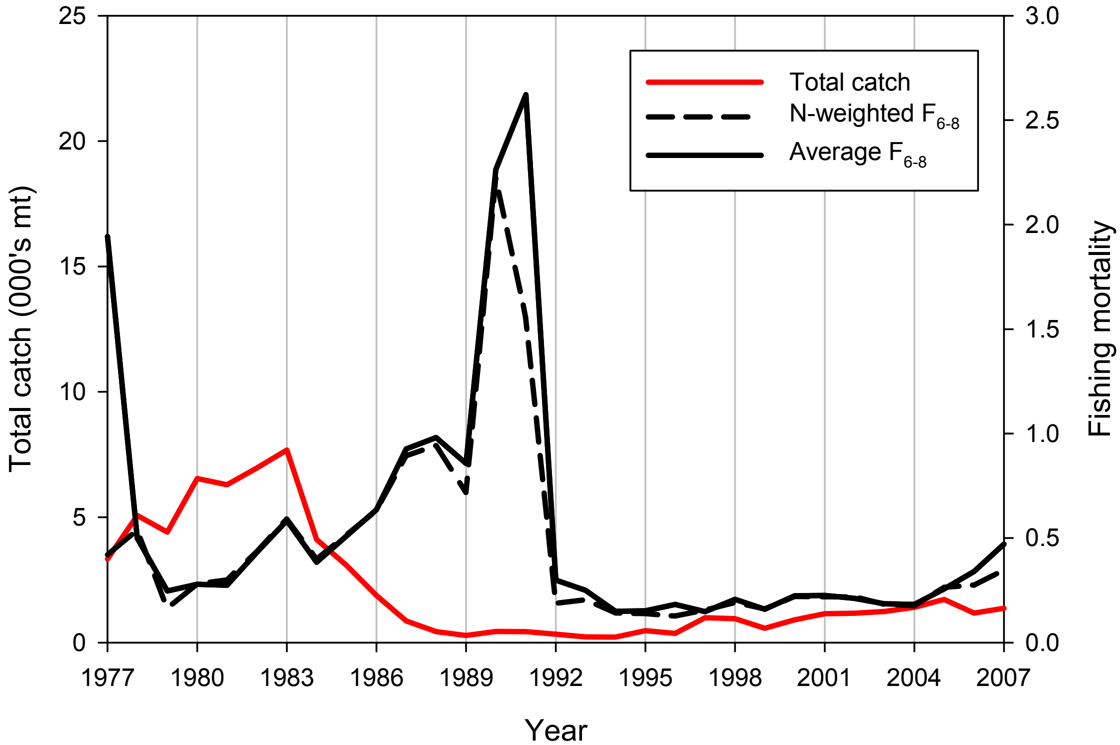


Figure R21. Trends in total catch (commercial landings, discards and recreational landings, 000's mt), fully recruited average $F_{6\text{-}8}$ and N-weighted $F_{6\text{-}8}$, 1977 to 2007.

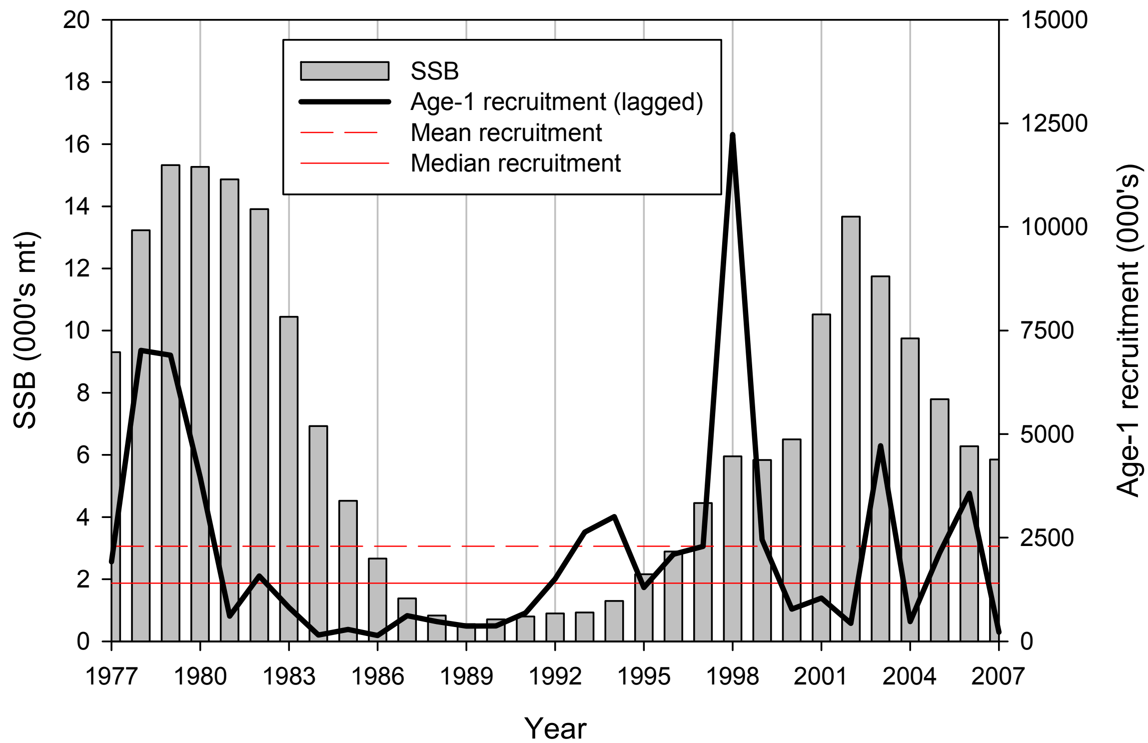


Figure R22. Trends in spawning stock biomass (000's mt) and age-1 recruitment (000's) for Gulf of Maine haddock, 1977 to 2007. The mean (2.3 million fish) and median (1.4 million) age 1 recruitment are indicated by the dashed and solid red lines, respectively.

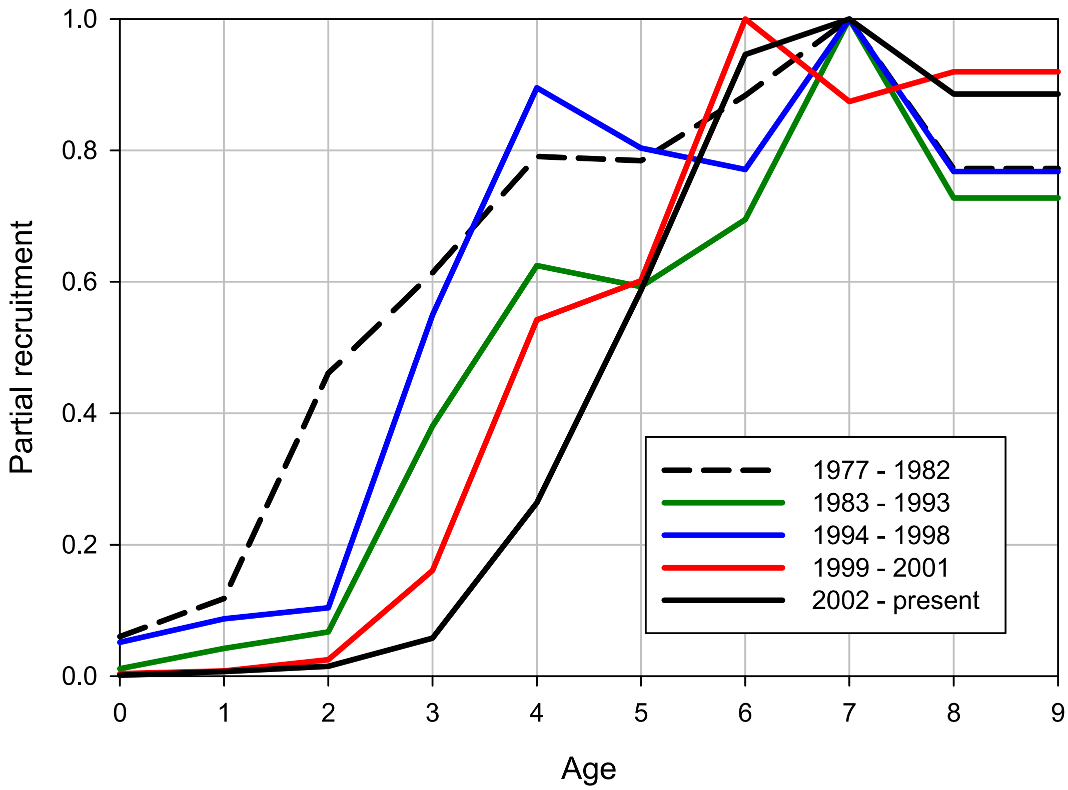


Figure R23. Partial recruitment patterns by age for Gulf of Maine haddock as estimated from the BASE run of the virtual population analysis (VPA) model. Years have been grouped based on changes to minimum mesh size (codend mesh size unless otherwise specified): 1977 – 1982 – 5.125”; 1983 – 1993 – 5.5”; 1994 – 1998 – 6.0”; 1999 – 2001 –6.5” for square nets, 6.0” for diamond nets; 2002 – present – 6.5” for all nets including gillnet (body mesh size can be 6.0” for diamond mesh).

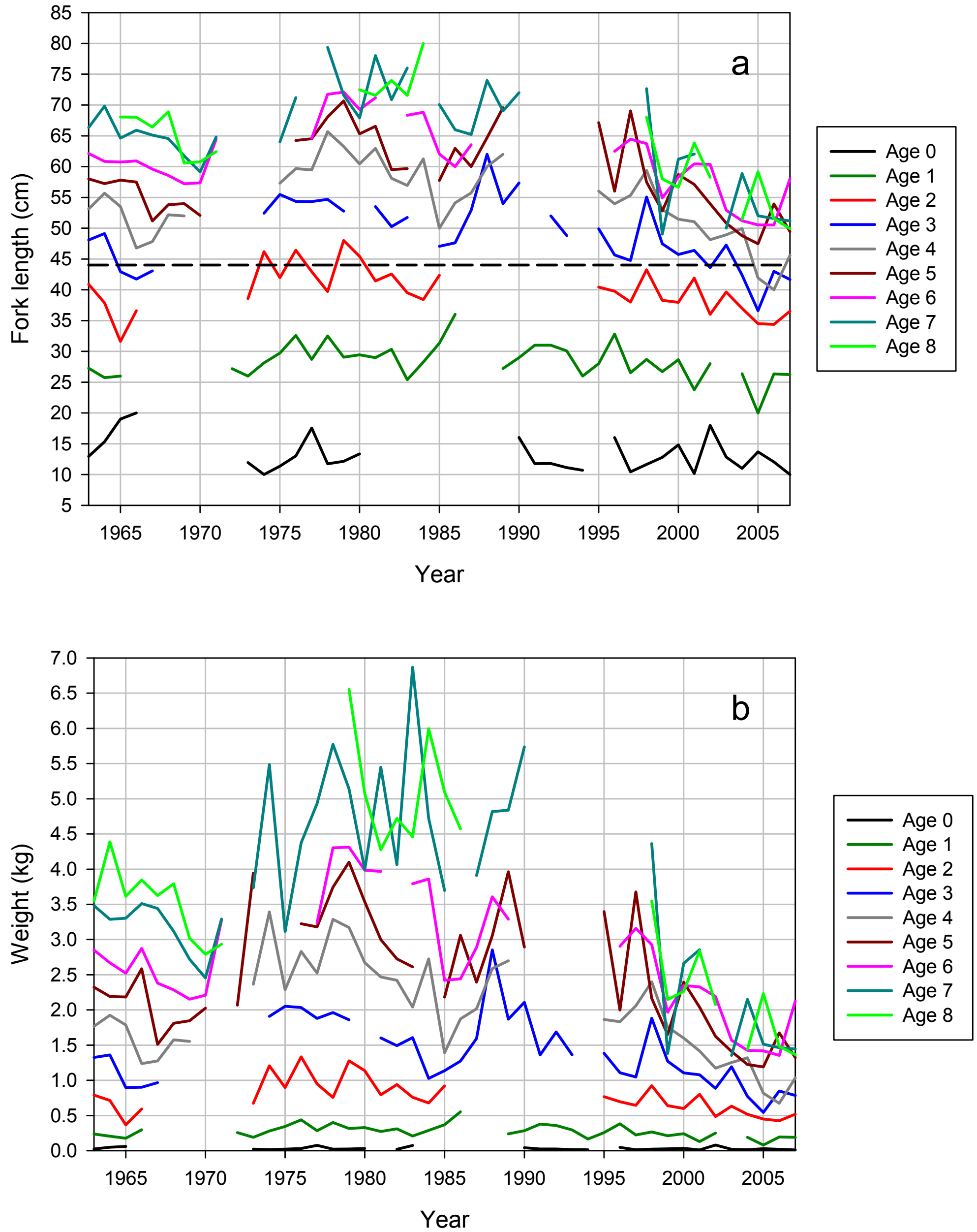


Figure R24. Mean length at age (a) and weight at age (b) of age 0 to 8 Gulf of Maine haddock caught in the Northeast Fisheries Science Center's autumn bottom trawl survey, 1963 to 2007. The dashed line in the length at age plot denotes the fork length equivalent of the current minimum size for both commercial and recreational fisheries of 19 inches.

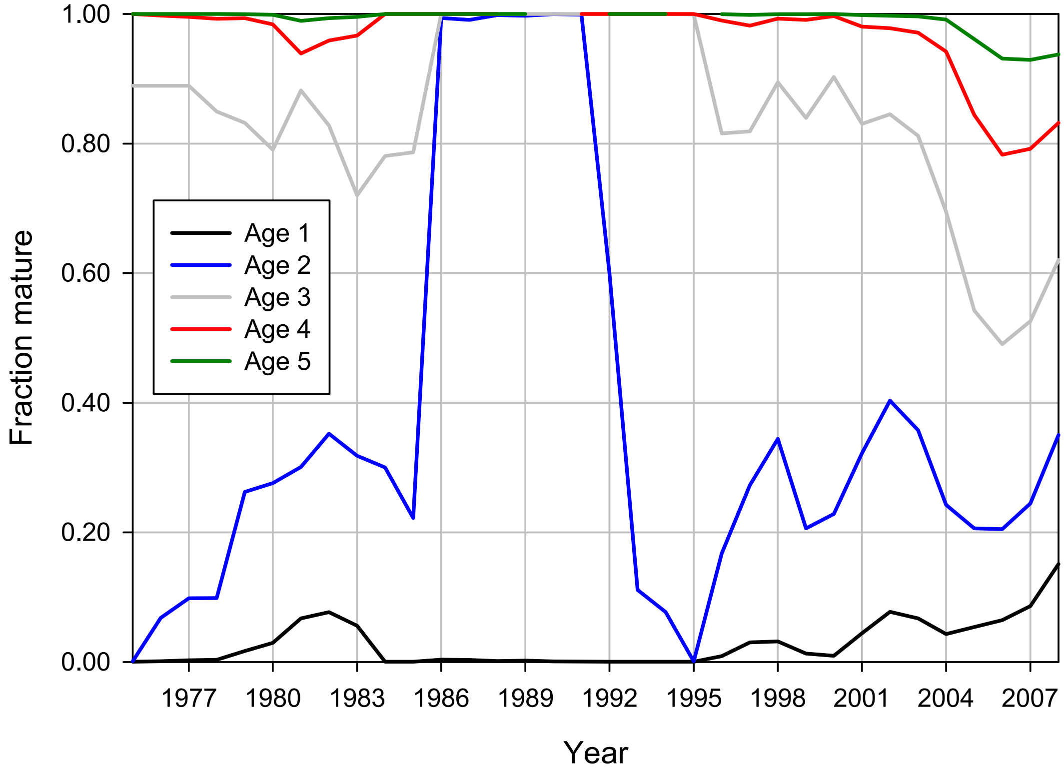


Figure R25. Proportion mature at age of female Gulf of Maine haddock using a 3-year moving window for ages 1-5 (upper panel). Data are from the Northeast Fisheries Science Center spring bottom trawl survey, 1975 to 2008.

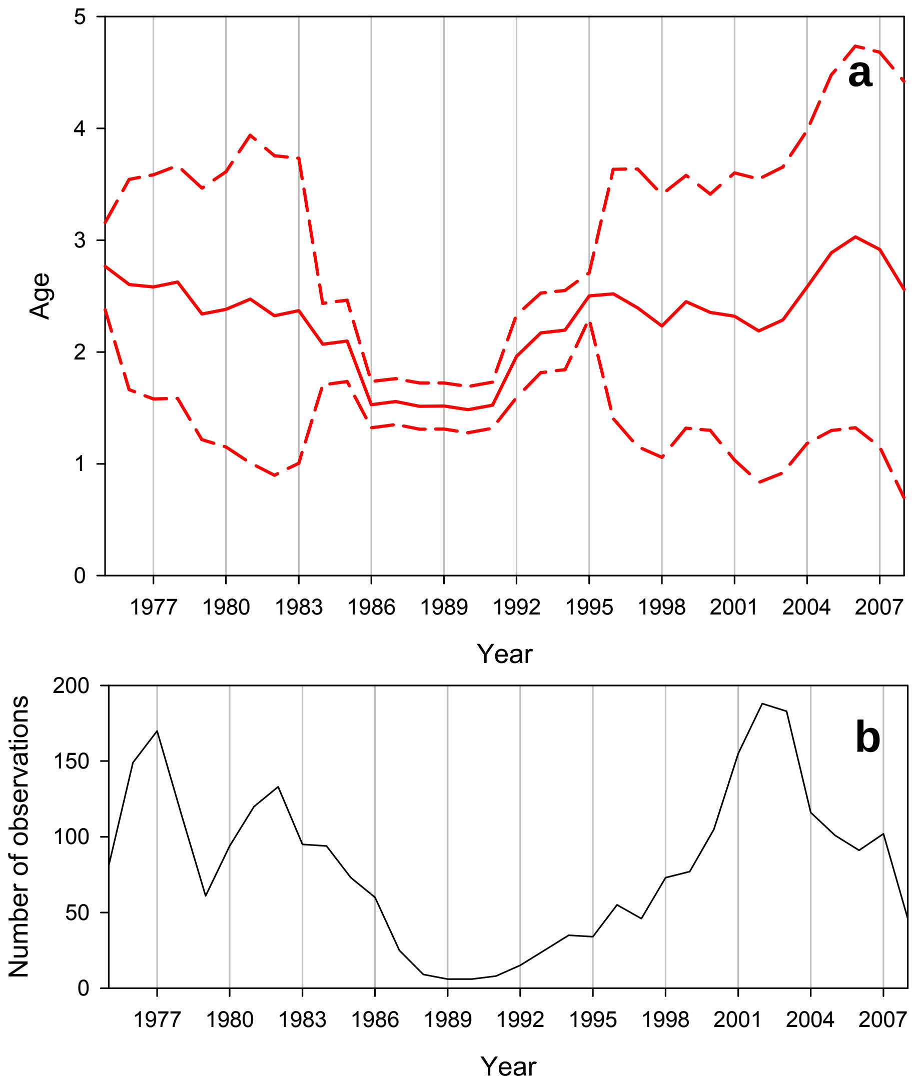


Figure R26. Median age at maturity (A_{50}) of females a) with 95% confidence intervals, and number of samples in the combined 3-year moving average (b). Data are from the Northeast Fisheries Science Center spring bottom trawl survey 1975 to 2008.

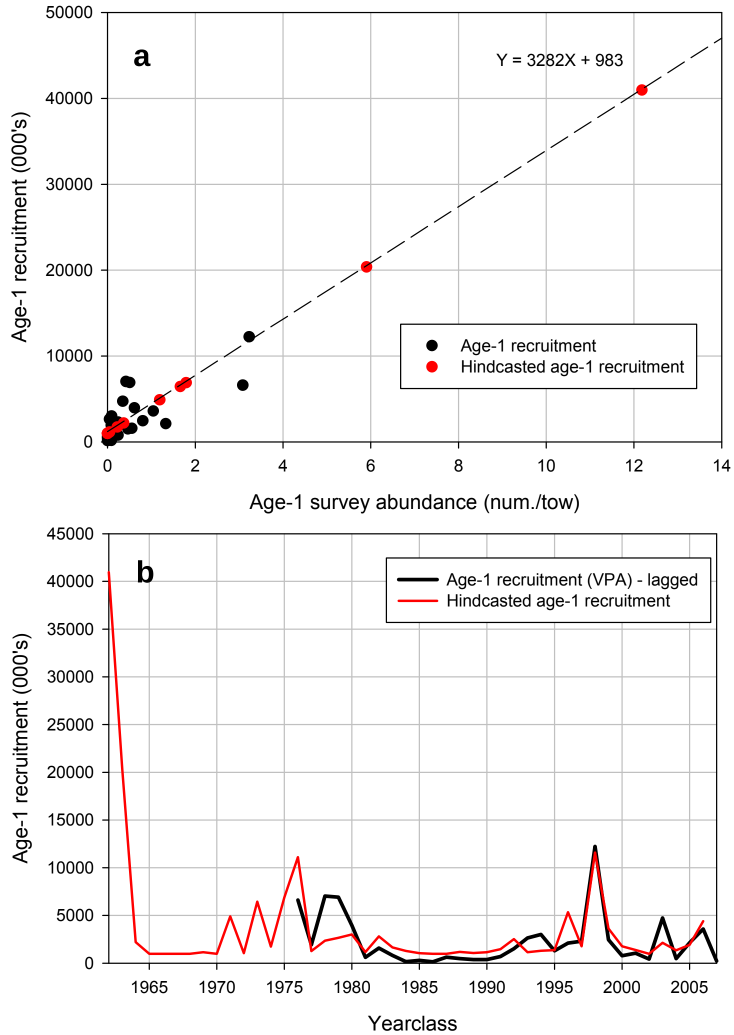


Figure R27. Regression of virtual population analysis (VPA) age 1 numbers on age-1 survey abundance index (a) and hindcasted estimates of age 1 recruitment using the Northeast Fisheries Science Center autumn survey age 1 numbers at age (b).

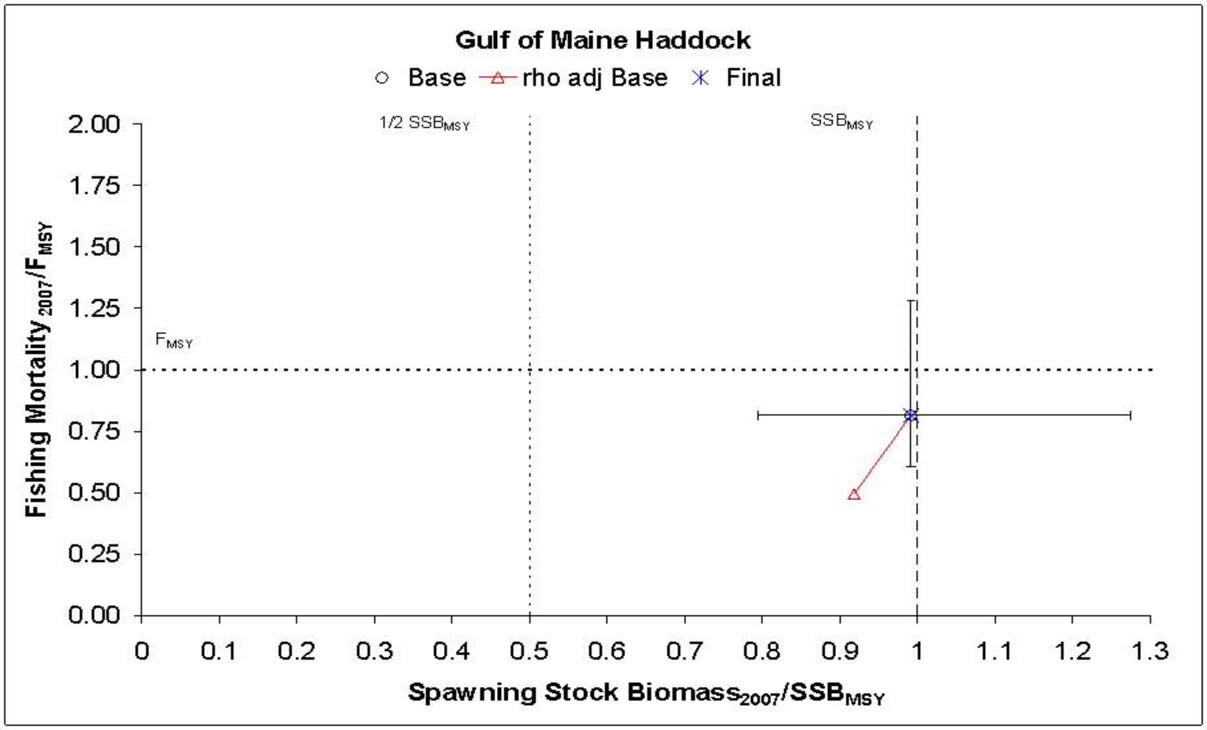


Figure R28. Gulf of Maine haddock stock status in 2007 with respect to GARM 2008 biological reference points; error bars represent the 80% confidence intervals. Stock status is based on the unweighted average $F_{6\text{-}8}$.

S. Atlantic halibut
by Laurel Col and Chris Legault

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

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). Atlantic halibut within the Gulf of Maine-Georges Bank region (NAFO Divisions 5Y and 5Z, Figure S1) have been exploited since the early 1800s, with major abundance declines noted as early as the 1870s (Goode 1886, Grasso 2008).

In previous index-based assessments (Brodziak and Col 2005, Brodziak 2002), 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 (Table S3, Figure S2). Reference points for Atlantic halibut were originally determined by the New England Fisheries Management Council (NEFMC 1998) using Canadian Atlantic halibut length-weight equations (McCracken 1958) and von Bertalanffy growth curves (Nielson and Bowering 1989) to perform yield-per-recruit (YPR) and biomass-per-recruit analyses. M was assumed to be 0.1 and an MSY proxy was chosen to be 300 mt, yielding a B_{MSY} proxy = 5400 mt, a ½ B_{MSY} proxy = 2700 mt, and an F_{MSY} proxy (threshold) = $F_{0.1}$ = 0.06. Based on the Groundfish Assessment Review Meeting (GARM) 2005 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).

In the Atlantic halibut assessment presented here, NEFSC survey and commercial fishery data were updated through 2007 and estimates of discards from the United States (US) commercial fishery were included in total catch estimates to reflect the GARM Data Meeting recommendations (GARM 2007). Reference points were re-evaluated by updating YPR analyses using recent estimates of growth (Sigourney 2002) and maturity parameters (Sigourney et al. 2006). The resulting F_{MSY} proxy was used to define the intrinsic rate of growth in a Replacement Yield Model as recommended by the GARM Biological Reference Points meeting panel (GARM 2008b). The Replacement Yield Model incorporates the entire time series of catch data, tunes to the autumn survey swept-area biomass index, and results in B_{MSY} and MSY proxy reference points, and annual estimates of biomass and relative fishing mortality.

2.0 Fishery

Commercial landings

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 S1, Figure S3). However, substantial landings occurred prior to this, since the halibut fishery experienced sharp declines during the late 1870s (Hennemuth and Rockwell 1987, Goode 1887).

Current US landings were extracted from the NEFSC commercial fisheries database (CFDBS) AA tables, and Canadian landings (Division 5Zc) were extracted from the NAFO 21A database[8].

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 per year during 1941-1976, and declined further to an average of 91 mt per year during 1977-2000 (Table S1, Figure S3). Total reported commercial landings of halibut increased somewhat from record lows of 17-20 mt during 1998-2000 to 52 mt in 2007. Of the 2007 landings, 22 mt (42%) were landed by US fishermen and 30 mt (58%) were landed by Canadian fishermen.

Commercial discards

Discards from the Northeast Fisheries Observer Program database were estimated for the period 1989 to 2007 based on the Standardized Bycatch Reporting Methodology combined ratio estimation (Wigley et al. 2007). The 1999 implementation of a one halibut per trip limit as well as a 91 cm minimum retention size increased the discard to kept ratio from 17% during 1989-1998 to 147% during 1999-2007 (Table S2, Figure S4). Due to the low occurrence of Atlantic halibut in the observer database, the 1989-1998 average discards were applied to the landings from 1893 to 1998 and the 1999-2007 average discards were applied to landings in those years. Including US discards, total catch increased from 18 mt in 1998 to 84 mt in 2007 (Table S1, Figure S4).

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, Table S3). Both indices have high interannual variability since the surveys capture low numbers of halibut, and in some years there are no halibut caught (Figure S5), indicating that halibut abundance is close to being below the detectability levels of the surveys. The autumn survey biomass and abundance indices are relatively flat (Figures S6a and b), whereas the spring survey biomass and abundance indices (Figures S6a and b) suggest a relative increase during the late 1970s to early 1980s, a decline during the 1990s, and an increase since the late 1990s. However, it is unknown whether survey trends in the Gulf of Maine-Georges Bank region have been influenced by changes in the seasonal distribution and availability of Atlantic halibut. Due to the lack of alternative population estimates, the autumn survey has been used in previous assessments to estimate biomass. The autumn survey was chosen over the spring survey because of the longer time series as well as possible environmental forcing in the spring survey indicated by a negative correlation with spring bottom water temperature anomalies. There are no conversion factors available for Atlantic halibut catchability differences due to vessel, net or door changes that have occurred throughout the NEFSC survey time series. In previous assessments a survey catchability coefficient of one was assumed for swept-area biomass estimates.

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[8] http://www.nafo.int/science/frames/research.html

4.0 Assessment

Input data and model formulation

YPR: The Gulf of Maine-Georges Bank region of the Atlantic halibut stock is severely data limited. Relatively few fish are encountered in either the commercial fishery or NEFSC bottom trawl surveys, and currently the NEFSC does not age samples from either source. Recent experimental halibut lonline data (Kanwit 2007), growth analyses (Sigourney 2002), and maturity analyses (Sigourney et al. 2006) have been used along with NEFSC length and weight data to update YPR analyses for Atlantic halibut.

Combined years (1992-2007) of NEFSC spring and autumn length and weight data over all strata were used to estimate length-weight parameters:
$W = \alpha L^{\beta}$

Where:
α was estimated to be 0.00415 and
β was estimated to be 3.23040.

Atlantic halibut from NEFSC spring and autumn surveys and the halibut experimental longline fishery were aged through 2001 and a von Bertalanffy growth equation was used to estimate length at age by sex (Sigourney 2002). The length-weight equation was then applied to the female lengths at age to determine weight-at-age inputs for YPR analyses (Table S4).

Maturity percentiles at age from Sigourney et al. (2006) were used to calculate a maturity ogive for female halibut:

$S(a) = (1+e^{(-\alpha - \beta a)})^{-1}$

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.

The resulting weight at age and maturity at age were used in YPR analyses with a plus group for ages 41 to 50 (Table S4). Sigourney et al. (2006) recorded halibut from the recent NEFSC survey time series up to age 40, and it is likely that larger halibut landed in the earlier part of the fishery time series were at least 50 years of age. No estimates of natural mortality rates for Atlantic halibut or Greenland halibut are included in previous assessments (Brodziak and Col 2005, DFO 2006, DFO 2007, DFO 2008). Pacific halibut has similar growth patterns and maximum age, and in recent reports, M was estimated to be 0.15 for Pacific halibut based on catch curve analysis and energetic models of growth and reproduction (Clark and Hare 2006). Therefore M was assumed to be 0.15 for the Gulf of Maine-Georges Bank Atlantic halibut, however it should be cautioned that this estimate is somewhat higher than using maximum age as a proxy to estimate M (using $-\ln(0.05)$/(max age of 50), M ~ 0.06).

As in the previous reference point determination (NEFMC 1998) a knife-edge selectivity at age 4 (~60cm and 2.4kg) was used for YPR analyses. Since Amendment 9 was implemented in 1999, regulations have prohibited landing halibut less than 91cm. However there is evidence from Northeast Fisheries Observer Program data that smaller halibut are continuing to be landed (Table S5). Kept halibut from observer data indicate that even after implementation, mean lengths of kept halibut generally ranged from 80-90cm (~ages 5.5-6.5), with minimum sizes of kept halibut generally ranging from 40-50cm (~ages 2.5-3.5, Table S5). Discarded halibut mean lengths have ranged from 27-70cm (~ages 2-5), with minimum discard lengths generally ranging from 20-40cm (~ages 1-3, Table S5). Survival of Atlantic halibut discarded from longline gear is estimated to be 77% whereas survival of discards from otter trawl gear was estimated to be substantially lower at 35% (Neilson et al. 1989). Thus, selectivity of Atlantic halibut likely starts around age 2 (30cm) for bottom trawl gear, which corresponds to the selectivity of other flatfish. Whereas selectivity from longline gear likely occurs at older ages around 6-7 years. This disparity in gear selectivity should be researched further, however with limited data to compare survey gear to commercial fishing gear, age 4 was chosen as a reasonable midpoint for knife-edged selectivity.

Replacement Yield Model

The resulting F_{MSY} proxy ($F_{0.1}$) from the YPR analysis was used to inform the intrinsic rate of growth (defined as $2*F_{0.1}$) for the Replacement Yield Model. Since Atlantic halibut catch predates reliable landings statistics beginning in 1893 (ICNAF 1953, Grasso 2008), a linear increase in catch was assumed from 1800-1893 following the advice of the GARM Biological Reference Points review panel (GARM 2008b, Table S7). Although this estimate is crude, it was considered to be better than assuming that 1893 biomass was representative of an unfished population and thus equal to carrying capacity.

A replacement yield model similar to that described in Brandao and Butterworth (2008a) was used to provide annual estimates of biomass, replacement yield and fishing mortality. 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,
C_{y-1} is the total catch in the previous year, and
R_{y-1} is the replacement yield 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).

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 roughly 0.5

Model selection process

Available models are limited for data poor species such as Atlantic halibut. An age-structured production model as described in Brandao and Butterworth (2008b) was not considered to be a reasonable approach given the lack of available data. A simplistic LOSS model without constraining the intrinsic rate of growth to YPR output or tuning to survey q yields a wide range of results with little information on which to inform model selection. By using $F_{0.1}$ to inform the intrinsic rate of growth in a Replacement Yield Model, and penalizing results that differ greatly from NEFSC autumn survey q, model results were considered to be more reliably estimated. This approach also incorporates the most data available for Atlantic halibut and was recommended by the GARM Biological Reference Points review panel (GARM 2008b).

Previous index-based assessments (Brodziak and Col 2005, Brodziak 2002) relied entirely on the expansion of NEFSC autumn survey indices to swept-area biomass estimates. This is particularly problematic with Atlantic halibut since the survey started roughly 100 years after the fishery collapsed, and encounter rates of halibut in consistently sampled survey strata are very low (Figure S5). Assuming a survey q of 1 for swept-area biomass estimates is likely high, and great uncertainty in previous MSY estimation leads to uncertainty in determining biomass reference points. Additionally, there have been changes in doors, nets and vessels throughout the time series which may affect catchability of Atlantic halibut over the time series. Since the surveys encounter so few halibut, conversion factors have not been estimable. The inability to calculate conversion factors for halibut will become a much larger problem in 2009 when the survey will change to the RV Henry Bigelow, which is likely to have vastly different catchabilities than the RV Albatross IV for most species. Therefore, relying entirely on the autumn survey index for the Atlantic halibut assessment is not recommended and the Replacement Yield Model is considered to be the preferred assessment method until further research can be performed.

An implicit assumption being made is that the current and historical productivity are similar. Given the long period of time being considered, this assumption is difficult to confirm.

Assessment results

NFT YPR version 2.7.2[9] was used to perform the YPR analysis, which resulted in an $F_{0.1}$ of 0.073. This is slightly higher than the previous $F_{threshold}$ of 0.06, using M = 0.1. The intrinsic

[9] http://nft.nefsc.noaa.gov/YPR.html NOAA Fisheries Toolbox Version 3.0, 2008. Age Based Yield per Recruit Version 2.7.2

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 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 1,300 mt in 2007 (Table S7, Figure S7). 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 0.065 in 2007 (Table S7, Figure S8). Replacement yield decreased sharply in the 1870s to a low of 500 mt in 1900, increased slightly to 700 mt around 1920, gradually decreased to 60 mt in the early 1990s, and is currently close to 190 mt (Table S7, Figure S9).

Diagnostics

No diagnostics are available for the previous index-based assessment. For the Replacement Yield Model, only the most recent 45 years can be included for residual pattern analyses, where survey swept-area biomass estimates are available. Figure S10 (Table S6) indicates that there is minor patterning in the residuals, with the Replacement Yield Model slightly overestimating biomass during the mid-1960s and greatly underestimating biomass in other years due to the high variability in the autumn survey index. However there are no periods of consistently strong residual patterns.

Sensitivity analyses

Two sensitivity analyses were run for the Replacement Yield Model based on panel recommendations from the GARM Biological Reference Points meeting (GARM 2008b). The first was to test using a parabolic increase of catch instead of a linear increase to represent 1800-1892 catch in the Replacement Yield Model. The resulting biomass estimates were essentially identical using either method, indicating that the Replacement Yield Model is not sensitive to the method of estimating historic catch.

The second sensitivity recommended by the review panel (GARM 2008b) was to test various natural mortality rates for Atlantic halibut in the Replacement Yield Model based on published values from halibut assessments in other regions. No alternative natural mortality rates were available from published assessments, however three natural mortality rates were tested in the YPR analyses to generate three $F_{0.1}$ estimates used to determine the intrinsic growth rates in Replacement Yield Models. The natural mortality estimate of 0.15 was the preferred M based on Pacific halibut estimates, resulting in $F_{0.1}$ = 0.073. A natural mortality estimate of 0.08 was tested based on a maximum age of 40 years, resulting in $F_{0.1}$ = 0.046. Finally, a natural mortality estimate of 0.10 was tested since this was used in the previous YPR analysis for Atlantic halibut (NEFSC 1998), resulting in $F_{0.1}$ = 0.053. However, it should be noted that the M of 0.10 that was used for the previous YPR analysis was based on Pacific halibut assessments at that time (NEFSC 1998).

The reference point tables below indicate that biomass reference points from Replacement Yield Models increased with decreasing natural mortality rates. Although initially counter-intuitive, this is due to the intrinsic rate of growth in the Replacement Yield Model being defined as 2*F_{MSY} proxy from the YPR analysis. As the intrinsic growth rate decreases with M, carrying capacity and thus biomass reference points have to be increased in the Replacement Yield Model in order to keep biomass from decreasing to zero over the time series of the catch.

Since biomass reference points increased proportionally with biomass, all sensitivity runs for natural mortality rates resulted in current biomass levels of 5-6% of ½ B_{MSY} proxies.

5.0 Biological Reference Points

The fishing mortality reference point was estimated to be F_{MSY} proxy ($F_{0.1}$) = 0.073 from updated YPR analyses described above, using M = 0.15 based on Pacific halibut estimates (Clark and Hare 2006). Since the Pacific halibut assessment is the only halibut assessment that assumes a natural mortality rate based on empirical research, this is the preferred M. Biomass reference points were based on Replacement Yield Model estimated carrying capacity (97,000 mt = estimated biomass in 1800), which was informed by the F_{MSY} proxy from the YPR analysis. Target biomass (B_{MSY} proxy) was defined as half of K (49,000mt) and threshold biomass (1/2 B_{MSY} proxy) was equal to 24,000 mt. 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. F_{MSY} proxies based on YPR analyses with alternative estimates of M are presented below with the resulting biomass reference points, MSY, current relative F and current biomass estimates from the Replacement Yield Model.

Replacement Yield Model Reference Points (M=0.15 based on Pacific halibut; Final BRPs):

	Threshold	**Target**	**Current Estimate**	**% Threshold**	**MSY**
Fishing mortality	**0.073**		**0.065**	**89%**	**3,500 mt**
Stock biomass	**24,000 mt**	**49,000 mt**	**1,300 mt**	**5%**	

Replacement Yield Model Reference Points (M=0.10 based on 1998 YPR):

	Threshold	Target	Current Estimate	% Threshold	MSY
Fishing mortality	0.053		0.038	72%	3,200 mt
Stock biomass	30,000 mt	60,000 mt	1,800 mt	6%	

Replacement Yield Model Reference Points (M=0.08 based on maximum age of 40):

	Threshold	Target	Current Estimate	% Threshold	MSY
Fishing mortality	0.046		0.043	93%	3,000 mt
Stock biomass	32,000 mt	65,000 mt	2,000 mt	6%	

In comparison to previous index-based assessments, B_{MSY}, MSY and current biomass from all of the Replacement Yield Model scenarios are substantially higher since they include the implied higher biomass levels that enabled large amounts of catch in the late 1800s. However current biomass as a percent of the threshold is similar for the two methods. Below are the biological reference points and 2007 estimates using the GARM 2005 index-based method.

Previous Index-Based Reference Points (M=0.10):

	Threshold	Target	Current Estimate	% Threshold	MSY
Fishing mortality	0.06	0.04	none	n/a	300 mt
Stock biomass	2,700 mt	5,400 mt	252 mt	9%	

6.0 Projection

$F_{REBUILD}$

Based on panel recommendations from the GARM III final meeting (August 4-8, 2008), 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 commenced 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 currently the $F_{REBUILD} = 0.044$.

There are a number of reasons to suggest that both the rebuilding time frame and the $F_{REBUILD}$ are highly optimistic, the first being that the Replacement Yield Model assumes maximum growth rate of the population at low abundance. There are currently no indications that Atlantic halibut are either reproducing or growing at their maximum potential in the currently depleted state. The second is that the Replacement Yield Model does not incorporate age structure. This is of particular concern for Atlantic halibut since the mean age of maturity for females is 7.3 years (Sigourney 2006), creating both a lag time of initial response to management measures and a slower rebuilding trajectory which are not realized in the current projections. The final source of concern for calculating rebuilding trajectories is that the currently assessed Gulf of Maine-Georges Bank region is likely a small portion of a larger US-Canadian Atlantic halibut stock (Kanwit 2007, see sources of uncertainty below). This substantially increases uncertainty in the current projections since the Replacement Yield Model does not incorporate the entire dynamics of the stock.

The $F_{REBUILD}$ for the current Replacement Yield Model is only slightly lower than the average model-estimated relative fishing mortality for the 1995-2007 period (0.052). Under this $F_{REBUILD}$ the projected biomass is estimated to roughly double over the next seven years and to continue with a roughly exponential growth throughout the rebuilding time period. This rate of increase has not been shown in the 200+ years of model estimated biomass and is thus unlikely to be biologically feasible. Further, there are no indications in the NEFSC survey indices that significant recent increases in population abundance or biomass are occurring. Therefore, both the rebuilding time frame and the $F_{REBUILD}$ from the Replacement Yield Model are highly optimistic.

2009 Catch Estimates

Three scenarios of relative F in 2009 were calculated for $F_{STATUS\ QUO}$, F_{MSY} and $F_{REBUILD}$. In each case the observed total catch for years 2004-2007 were used and catch in 2008 was set to equal the catch in 2007. The results for 2009 catch estimates based on the three scenarios were as follows: $F_{STATUS\ QUO}$: 100 mt, F_{MSY}: 112 mt, and $F_{REBUILD}$: 68 mt (Table S8).

7.0 Summary

Stock status

Using M = 0.15 in the YPR analysis resulted in a F_{MSY} proxy of 0.073. Current relative F from the Replacement Yield Model is 0.065 in 2007, indicating that overfishing is not occurring for Atlantic halibut, although relative F is 89% of the proxy F threshold. The 2007 estimated biomass from the Replacement Yield Model is 1,300 mt, or 5% of the biomass threshold, indicating that Atlantic halibut continues to be in an overfished condition (Figure S11).

Sources of uncertainty

Limited biological data lead to uncertainty in growth and maturity at age estimates for the YPR analysis, although recent research and the experimental halibut fishery have allowed for updated estimates to be based on Atlantic halibut in the Gulf of Maine-Georges Bank region. A lack of reported landings prior to 1893 lead to rough estimates of catch during 1800-1892, however the Replacement Yield Model does not appear to be highly sensitive to these estimates. A lack of available natural mortality estimates for Atlantic halibut necessitates the use of Pacific halibut estimates, and this leads to uncertainty in MSY and biomass reference point estimation in the Replacement Yield Model. However, the resulting status of Atlantic halibut being near overfishing levels and far below B_{MSY} levels remains regardless of M. Arguably the most problematic aspect of the Replacement Yield Model is providing informative tuning indices. Although the NEFSC autumn survey swept-area biomass index has been 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.

Another source of uncertainty is the stock boundary determination of Atlantic halibut. For management purposes the Gulf of Maine-Georges Bank region is considered to be a separate stock from Canadian Scotian Shelf-Southern Grand Banks and Gulf of St. Lawrence stocks. However, recent tagging information indicates that 28% of Atlantic halibut tagged off of the coast of Maine crossed into Canadian waters, and that some individuals traveled over 1,500 km north to Newfoundland (Kanwit 2007, Figure S12). This clearly indicates trans-boundary movement, and future assessments should consider combining the Gulf of Maine-Georges Bank region with Canadian stocks.

8.0 Panel Discussion/Comments

Conclusions

Consistent with the recommendations fo the GARM III ‘BRP’ review, the Panel accepted the replacement yield model and considered it sufficient for management purposes. This is a significant improvement from the previous assessment which was based on a relative index approach.

As recommended by the GARM III ‘BRP’ review, the Panel noted the further consideration of the estimate of M and agreed with the choice of 0.15 based upon estimates from Pacific Halibut. It also noted that the model results were relatively insensitive to assumptions on the trajectory of catches prior to 1893, an analysis suggested by the GARM III ‘BRP’ review.

Regarding uncertainties, it was noted that the research surveys do not provide a good estimate of abundance due to very low catch rates. The assessment suggests that, based upon this information, there has been an increase in abundance in recent years. However, the evidence for recovery is weak.

Another source of uncertainty is the stock definition with the tagging results presented at the meeting showing migration to the east into Canadian waters.

The Panel requested that a deterministic rebuilding projection be included in the assessment. $F_{REBUILD}$ was estimated to be 0.044.

Research Recommendations

There are a number of avenues that could be pursued to enhance the assessment. Further work on natural mortality is encouraged as is stock interactions with Atlantic Halibut in Canadian waters. In relation to the latter, joint work with Canadian halibut scientists is encouraged.

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Table S1. Reported catch (mt) of Atlantic halibut from the Gulf of Maine and Georges Bank (NAFO divisions 5Y and 5Z), 1893-2007.

Year	USA	US Discards	Canada	Other	Total Landings	Total Catch	Year	USA	US Discards	Canada	Other	Total Landings	Total Catch
1893	684	114	0	0	684	798	1951	154	26	0	0	154	180
1894	843	140	0	0	843	983	1952	123	20	0	0	123	143
1895	4200	699	0	0	4200	4899	1953	104	17	0	0	104	121
1896	4908	817	0	0	4908	5725	1954	125	21	0	0	125	146
1897	733	122	0	0	733	855	1955	74	12	0	0	74	86
1898	564	94	0	0	564	658	1956	62	10	0	0	62	72
1899	407	68	0	0	407	475	1957	80	13	0	0	80	93
1900	331	55	0	0	331	386	1958	73	12	0	0	73	85
1901	287	48	0	0	287	335	1959	59	10	0	0	59	69
1902	367	61	0	0	367	428	1960	63	10	0	0	63	73
1903	502	84	0	0	502	586	1961	79	13	5	0	84	97
1904	332	55	0	0	332	387	1962	86	14	35	25	146	160
1905	580	97	0	0	580	677	1963	94	16	88	1	183	199
1906	542	90	0	0	542	632	1964	115	19	120	1	236	255
1907	447	74	0	0	447	521	1965	128	21	153	18	299	320
1908	891	148	0	0	891	1039	1966	110	18	110	62	282	300
1909	193	32	0	0	193	225	1967	102	17	386	26	514	531
1910	329	55	0	0	329	384	1968	74	12	193	3	270	282
1911	389	65	0	0	389	454	1969	63	10	96	9	168	178
1912	460	77	0	0	460	537	1970	52	9	67	19	138	147
1913	402	67	0	0	402	469	1971	81	13	38	0	119	132
1914	329	55	0	0	329	384	1972	63	10	37	8	108	118
1915	336	56	0	0	336	392	1973	51	8	38	0	89	97
1916	478	80	0	0	478	558	1974	46	8	29	1	76	84
1917	293	49	0	0	293	342	1975	70	12	36	0	106	118
1918	375	62	0	0	375	437	1976	58	10	33	0	91	101
1919	498	83	0	0	498	581	1977	50	8	31	0	81	89
1920	896	149	0	0	896	1045	1978	84	14	50	0	134	148
1921	689	115	0	0	689	804	1979	125	21	29	0	154	175
1922	694	115	0	0	694	809	1980	80	13	88	0	168	181
1923	508	85	0	0	508	593	1981	80	13	118	0	198	211
1924	616	103	0	0	616	719	1982	85	14	116	0	201	215
1925	843	140	0	0	843	983	1983	72	12	131	0	203	215
1926	944	157	0	0	944	1101	1984	75	12	62	0	137	149
1927	831	138	0	0	831	969	1985	61	10	57	0	118	128
1928	781	130	0	0	781	911	1986	44	7	32	0	76	83
1929	570	95	0	0	570	665	1987	27	4	23	0	50	54
1930	716	119	0	0	716	835	1988	47	8	81	0	128	136
1931	511	85	0	0	511	596	1989	13	2	65	0	78	80
1932	443	74	0	0	443	517	1990	16	3	58	0	74	77
1933	279	46	0	0	279	325	1991	30	5	58	0	88	93
1934	192	32	0	0	192	224	1992	22	4	47	0	69	73
1935	292	49	0	0	292	341	1993	15	2	50	0	65	67
1936	374	62	0	0	374	436	1994	22	4	24	0	46	50
1937	187	31	0	0	187	218	1995	11	2	8	0	19	21
1938	146	24	0	0	146	170	1996	13	2	12	0	25	27
1939	124	21	0	0	124	145	1997	14	2	14	0	28	30
1940	499	83	0	0	499	582	1998	8	1	9	0	17	18
1941	145	24	0	0	145	169	1999	12	18	8	0	20	40
1942	250	42	0	0	250	292	2000	11	16	6	0	17	36
1943	76	13	0	0	76	89	2001	11	16	11	0	22	41
1944	77	13	0	0	77	90	2002	10	15	10	0	20	37
1945	55	9	0	0	55	64	2003	17	25	14	0	31	60
1946	124	21	0	0	124	145	2004	11	16	12	0	23	42
1947	198	33	0	0	198	231	2005	17	25	9	0	26	55
1948	156	26	0	0	156	182	2006	14	21	10	0	24	48
1949	157	26	0	0	157	183	2007	22	32	30	0	52	84
1950	116	19	0	0	116	135							

Table S2. Atlantic halibut United States discards (mt) based on Standardized Bycatch Reduction Methodology combined ratio estimation (1989-2007).

Year	US Discards (mt)	cv	# Hauls with Observed Halibut Discards	US Landings (mt)		Average Discards (mt)	Total US Catch (mt)
1989	3.4	0.525	25	13		2	15
1990	10.2	0.578	22	16		3	19
1991	5.2	0.348	48	30		5	35
1992	1.6	0.394	17	22		4	26
1993	1.3	0.444	11	15		2	17
1994	1.4	0.474	8	22		4	26
1995	2.8	1.319	12	11		2	13
1996	0.6	0.491	4	13	1989-1998 Average	2	15
1997	0.6	0.788	11	14	Discards/Landings=	2	16
1998	0.2	1.014	1	8	0.166	1	9
1999	76.1	0.702	4	12		18	30
2000	9.3	0.352	30	11		16	27
2001	9.4	0.271	22	11		16	27
2002	16.8	0.410	44	10		15	25
2003	15.7	0.212	123	17		25	42
2004	18.2	0.207	182	11		16	27
2005	14.0	0.114	533	17	1999-2007 Average	25	42
2006	14.3	0.171	243	14	Discards/Landings=	21	35
2007	9.5	0.123	192	22	1.465	32	54

Table S3. Atlantic halibut stratified mean weight (kg) and numbers per tow from NEFSC spring and autumn surveys (offshore strata 13-30, 36-40) and 5-year average swept-area biomass estimates.

Year	Spring Survey Weight (kg) per Tow	5-Year Average Spring Swept-Area Biomass (mt)	Spring Survey Numbers per Tow	Autumn Survey Weight (kg) per Tow	5-Year Average Autumn Swept-Area Biomass (mt)	Autumn Survey Numbers per Tow
1963				0.085	282	0.039
1964				0.067	252	0.022
1965				0.032	204	0.015
1966				0.004	156	0.003
1967				0.009	131	0.003
1968	0.129	428	0.046	0.233	229	0.013
1969	0.236	606	0.028	0.494	512	0.025
1970	0.105	520	0.015	0.000	491	0.000
1971	0.033	417	0.013	0.091	549	0.011
1972	0.005	337	0.006	0.018	555	0.013
1973	0.113	327	0.015	0.131	487	0.015
1974	0.112	244	0.052	0.014	169	0.004
1975	0.000	175	0.000	0.095	232	0.017
1976	0.644	580	0.031	0.378	422	0.038
1977	0.142	671	0.052	0.059	449	0.012
1978	0.163	704	0.025	0.294	558	0.028
1979	0.357	867	0.048	0.040	575	0.015
1980	0.563	1241	0.056	0.010	518	0.007
1981	0.066	857	0.027	0.321	481	0.024
1982	0.082	817	0.011	0.115	518	0.015
1983	0.611	1115	0.035	0.000	323	0.000
1984	0.022	892	0.009	0.124	378	0.005
1985	0.063	560	0.024	0.106	442	0.015
1986	0.000	516	0.000	0.313	437	0.029
1987	0.287	653	0.009	0.033	382	0.029
1988	0.023	262	0.039	0.004	385	0.006
1989	0.000	248	0.000	0.066	347	0.046
1990	0.064	248	0.026	0.060	316	0.045
1991	0.062	289	0.034	0.243	270	0.034
1992	0.037	123	0.031	0.201	381	0.018
1993	0.006	112	0.003	0.046	409	0.013
1994	0.017	123	0.008	0.000	365	0.000
1995	0.005	84	0.008	0.066	369	0.011
1996	0.013	52	0.009	0.053	243	0.004
1997	0.063	69	0.025	0.174	225	0.046
1998	0.017	76	0.016	0.103	263	0.060
1999	0.239	224	0.012	0.015	273	0.006
2000	0.000	220	0.000	0.021	243	0.006
2001	0.163	320	0.046	0.247	372	0.030
2002	0.128	363	0.013	0.004	259	0.003
2003	0.052	386	0.037	0.049	223	0.040
2004	0.168	339	0.025	0.112	287	0.047
2005	0.025	356	0.034	0.111	347	0.030
2006	0.383	502	0.113	0.031	204	0.021
2007	0.195	546	0.109	0.077	252	0.033
2008	0.100	578	0.062			

Table S4. Input data for Atlantic halibut yield-per-recruit analysis.

Age	Selectivity on Fishing Mortality	Natural Mortality Rate	Fraction Mature	Mean Weight (kg)
0	0	0.15	0.01	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 S5. Mean and minimum sizes of Atlantic halibut discarded and landed from Northeast Fisheries Observer Program data.

Discarded Atlantic Halibut

Year	Mean Length (cm)	Std Err	N	Minimum Length (cm)
1992	33.0	.	1	33
1993	31.3	13.3458	3	17
1994	42.4	5.1049	5	24
1995	27.2	5.4858	6	18
1997	36.3	2.1858	3	32
1999	62.0	.	1	62
2000	57.0	4.0778	13	18
2001	67.5	2.9518	13	48
2002	70.2	4.7648	13	38
2003	64.0	1.6363	91	31
2004	57.1	1.3502	87	26
2005	60.4	1.3042	160	33
2006	63.0	1.495	107	38
2007	64.3	1.9969	75	24

Landed Atlantic Halibut

Year	Mean Length (cm)	Std Err	N	Minimum Length (cm)
1990	46.6	2.0012	6	42
1991	92.0	.	1	92
1992	67.1	5.2457	11	29
1993	62.8	5.5333	10	42
1994	73.3	5.0781	16	46
1995	79.6	4.6356	29	42
1996	69.2	10.027	5	50
1997	67.5	11.3893	6	44
2001	118.0	6	2	112
2002	88.0	9.0738	6	52
2003	81.0	5.349	29	41
2004	83.9	3.9709	33	43
2005	76.4	2.5691	80	40
2006	84.9	3.5611	37	50
2007	90.5	4.225	33	49

Note: 1999-2007 average observed landed minimum size = 55cm
Minimum size regulation for 1999-present = 91cm

Table S6. Residuals of NEFSC survey swept-area biomass indices to estimated swept-area biomass indices from the Replacement Yield Model.

Year	Z-Score Residuals
1963	-0.324
1964	-0.492
1965	-0.768
1966	-0.940
1967	-0.838
1968	1.264
1969	3.544
1970	-0.574
1971	0.204
1972	-0.402
1973	0.545
1974	-0.453
1975	0.200
1976	2.569
1977	-0.131
1978	1.811
1979	-0.319
1980	-0.550
1981	2.091
1982	0.413
1983	-0.490
1984	0.623
1985	0.511
1986	2.279
1987	-0.068
1988	-0.325
1989	0.233
1990	0.190
1991	1.732
1992	1.396
1993	0.100
1994	-0.283
1995	0.263
1996	0.125
1997	1.113
1998	0.486
1999	-0.296
2000	-0.281
2001	1.575
2002	-0.512
2003	-0.188
2004	0.294
2005	0.219
2006	-0.520
2007	-0.214

Table S7. Atlantic halibut catch and resulting biomass, replacement yield, and relative F from Replacement Yield model (M=0.15). Note that reported landings begin in 1893 and 1800-1892 catch is assumed to be a linear increase.

Year	Total Catch (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F	Year	Total Catch (mt)	Biomass (mt)	Replacement Yield (mt)	Relative F
1800	10	97018	0	0.000	1852	3320	73579	2599	0.045
1801	20	97008	1	0.000	1853	3387	72858	2653	0.046
1802	30	96990	4	0.000	1854	3454	72123	2706	0.048
1803	37	96964	8	0.000	1855	3521	71375	2758	0.049
1804	104	96935	12	0.001	1856	3588	70612	2810	0.051
1805	171	96843	26	0.002	1857	3655	69834	2861	0.052
1806	238	96698	47	0.002	1858	3722	69040	2911	0.054
1807	305	96507	74	0.003	1859	3789	68229	2960	0.056
1808	372	96276	108	0.004	1860	3856	67400	3008	0.057
1809	439	96012	146	0.005	1861	3923	66552	3055	0.059
1810	506	95718	188	0.005	1862	3990	65684	3101	0.061
1811	573	95400	233	0.006	1863	4057	64796	3146	0.063
1812	640	95060	281	0.007	1864	4124	63885	3190	0.065
1813	707	94700	331	0.007	1865	4191	62951	3232	0.067
1814	774	94324	383	0.008	1866	4258	61992	3272	0.069
1815	841	93933	437	0.009	1867	4325	61006	3311	0.071
1816	908	93529	492	0.010	1868	4392	59992	3347	0.073
1817	975	93113	548	0.010	1869	4459	58947	3382	0.076
1818	1042	92686	605	0.011	1870	4526	57870	3414	0.078
1819	1109	92249	663	0.012	1871	4593	56758	3443	0.081
1820	1176	91803	722	0.013	1872	4660	55608	3470	0.084
1821	1243	91348	781	0.014	1873	4727	54418	3493	0.087
1822	1310	90886	840	0.014	1874	4794	53185	3513	0.090
1823	1377	90416	900	0.015	1875	4861	51904	3529	0.094
1824	1444	89938	960	0.016	1876	4928	50571	3540	0.097
1825	1511	89454	1020	0.017	1877	4995	49183	3545	0.102
1826	1578	88963	1080	0.018	1878	5062	47733	3545	0.106
1827	1645	88465	1140	0.019	1879	5129	46217	3538	0.111
1828	1712	87960	1201	0.019	1880	5196	44626	3523	0.116
1829	1779	87449	1261	0.020	1881	5263	42953	3500	0.123
1830	1846	86931	1321	0.021	1882	5330	41189	3465	0.129
1831	1913	86406	1382	0.022	1883	5397	39325	3419	0.137
1832	1980	85875	1442	0.023	1884	5464	37347	3358	0.146
1833	2047	85337	1502	0.024	1885	5531	35241	3281	0.157
1834	2114	84792	1562	0.025	1886	5598	32991	3183	0.170
1835	2181	84240	1622	0.026	1887	5665	30576	3061	0.185
1836	2248	83682	1682	0.027	1888	5732	27972	2910	0.205
1837	2315	83115	1741	0.028	1889	5799	25151	2724	0.231
1838	2382	82542	1801	0.029	1890	5866	22075	2493	0.266
1839	2449	81960	1860	0.030	1891	5933	18702	2207	0.317
1840	2516	81371	1919	0.031	1892	6000	14977	1852	0.401
1841	2583	80774	1977	0.032	1893	798	10828	1406	0.074
1842	2650	80168	2036	0.033	1894	983	11437	1475	0.086
1843	2717	79554	2094	0.034	1895	4899	11929	1530	0.411
1844	2784	78931	2151	0.035	1896	5725	8559	1141	0.669
1845	2851	78298	2209	0.036	1897	855	3975	557	0.215
1846	2918	77656	2266	0.038	1898	658	3678	517	0.179
1847	2985	77004	2323	0.039	1899	475	3537	498	0.134
1848	3052	76341	2379	0.040	1900	386	3561	502	0.108
1849	3119	75668	2435	0.041	1901	335	3677	517	0.091
1850	3186	74983	2490	0.042	1902	428	3859	542	0.111
1851	3253	74287	2545	0.044	1903	586	3973	557	0.147

Table S7 (cont.). Atlantic halibut catch and NEFSC autumn survey swept-area biomass index input and resulting biomass, replacement yield, and relative F from Replacement Yield model (M=0.15).

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
1904	387	3944	553	0.098	1956	72		982	142	0.0737
1905	677	4110	575	0.165	1957	93		1052	152	0.0887
1906	632	4009	562	0.158	1958	85		1110	160	0.0767
1907	521	3939	553	0.132	1959	69		1186	171	0.0580
1908	1039	3970	557	0.262	1960	73		1288	186	0.0570
1909	225	3488	492	0.065	1961	97		1400	202	0.0694
1910	384	3754	528	0.102	1962	160		1505	217	0.1065
1911	454	3898	547	0.116	1963	199	282	1561	225	0.1272
1912	537	3991	559	0.134	1964	255	222	1587	228	0.1607
1913	469	4014	563	0.117	1965	320	106	1561	224	0.2052
1914	384	4108	575	0.093	1966	300	13	1465	211	0.2050
1915	392	4299	601	0.091	1967	531	30	1375	198	0.3861
1916	558	4508	628	0.124	1968	282	773	1043	151	0.2708
1917	342	4579	638	0.075	1969	178	1640	911	132	0.1959
1918	437	4875	677	0.090	1970	147	0	865	125	0.1696
1919	581	5114	708	0.114	1971	132	302	843	122	0.1571
1920	1045	5242	725	0.199	1972	118	60	833	121	0.1422
1921	804	4922	683	0.163	1973	97	435	835	121	0.1167
1922	809	4801	667	0.169	1974	84	46	859	124	0.0974
1923	593	4659	648	0.127	1975	118	315	900	130	0.1308
1924	719	4714	656	0.152	1976	101	1255	912	132	0.1103
1925	983	4652	647	0.211	1977	89	196	944	137	0.0947
1926	1101	4316	603	0.255	1978	148	976	991	143	0.1493
1927	969	3818	536	0.254	1979	175	133	986	143	0.1772
1928	911	3385	478	0.269	1980	181	33	954	138	0.1900
1929	665	2951	418	0.225	1981	211	1065	911	132	0.2319
1930	835	2705	384	0.309	1982	215	382	832	121	0.2586
1931	596	2254	322	0.264	1983	215	0	737	107	0.2916
1932	517	1980	284	0.261	1984	149	412	629	91	0.2375
1933	325	1747	251	0.186	1985	128	352	571	83	0.2244
1934	224	1672	240	0.134	1986	83	1039	526	76	0.1584
1935	341	1688	243	0.202	1987	54	110	519	76	0.1049
1936	436	1590	229	0.274	1988	136	13	540	79	0.2514
1937	218	1383	199	0.158	1989	80	219	483	70	0.1660
1938	170	1364	197	0.125	1990	77	199	473	69	0.1620
1939	145	1390	200	0.104	1991	93	807	465	68	0.1999
1940	582	1446	208	0.403	1992	73	667	440	64	0.1652
1941	169	1072	155	0.158	1993	67	153	431	63	0.1565
1942	292	1058	153	0.276	1994	50	0	427	62	0.1164
1943	89	919	133	0.096	1995	21	219	439	64	0.0474
1944	90	964	140	0.093	1996	27	176	482	70	0.0563
1945	64	1014	147	0.063	1997	30	578	525	76	0.0578
1946	145	1096	158	0.132	1998	18	342	571	83	0.0321
1947	231	1110	160	0.208	1999	40	50	636	92	0.0633
1948	182	1039	150	0.175	2000	36	70	688	100	0.0517
1949	183	1008	146	0.182	2001	41	820	752	109	0.0539
1950	135	970	140	0.139	2002	37	13	821	119	0.0449
1951	180	975	141	0.184	2003	60	163	903	131	0.0661
1952	143	937	136	0.153	2004	42	372	974	141	0.0427
1953	121	929	135	0.131	2005	55	368	1073	155	0.0509
1954	146	942	136	0.155	2006	48	103	1174	170	0.0405
1955	86	933	135	0.093	2007	84	256	1296	187	0.0650

Table S8. Projected catch and Biomass in 2009 for Atlantic halibut under three relative F scenarios in 2009 (Fsq, F_{MSY} and $F_{REBUILD}$), assuming catch in 2008 equals catch in 2007.

F2009 = Fstatus quo = F2007 = 0.065

	2007	2008	2009
Relative F	0.065	0.060	0.065
Biomass (mt)	1,296	1,399	1,539
Catch (mt)	84	84	100

F2009 = Frebuild = 0.044

	2007	2008	2009
Relative F	0.065	0.060	0.044
Biomass (mt)	1,296	1,399	1,539
Catch (mt)	84	84	68

F2009 = Fmsy = 0.073

	2007	2008	2009
Relative F	0.065	0.060	0.073
Biomass (mt)	1,296	1,399	1,539
Catch (mt)	84	84	112

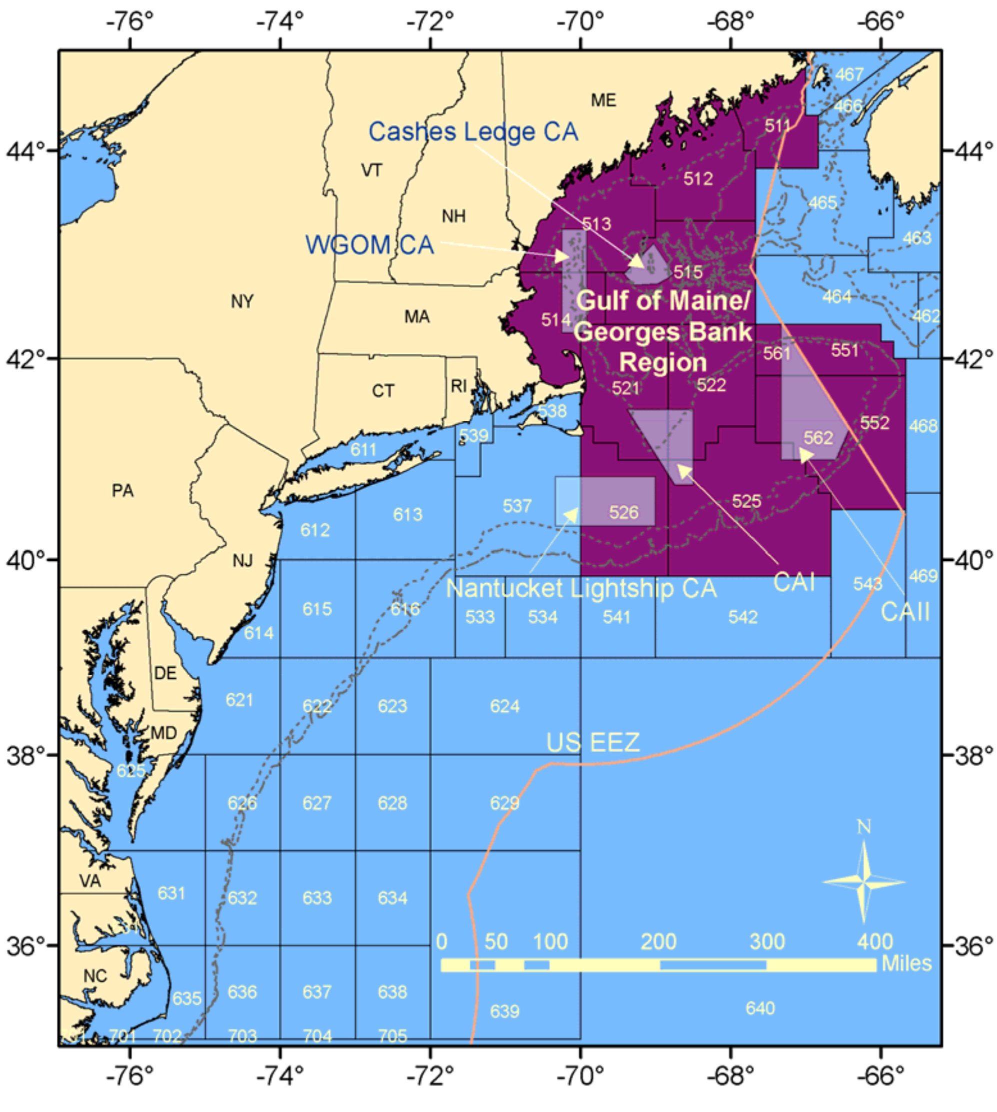

Figure S1. Statistical areas used to define United States commercial fishing catch for the Gulf of Maine-Georges Bank region of the Atlantic halibut stock.

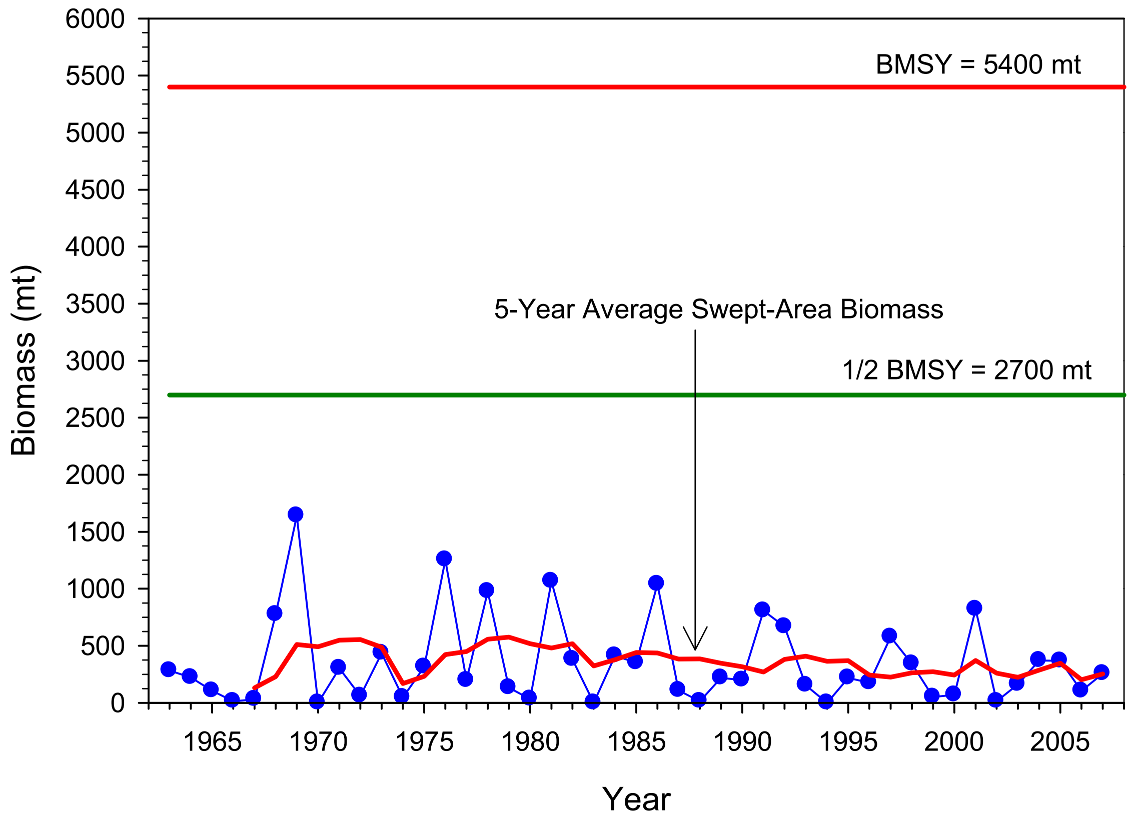

Figure S2. Trends in Atlantic halibut swept-area biomass indices from Northeast Fisheries Science Center autumn bottom trawl surveys and previous index-based assessment reference points.

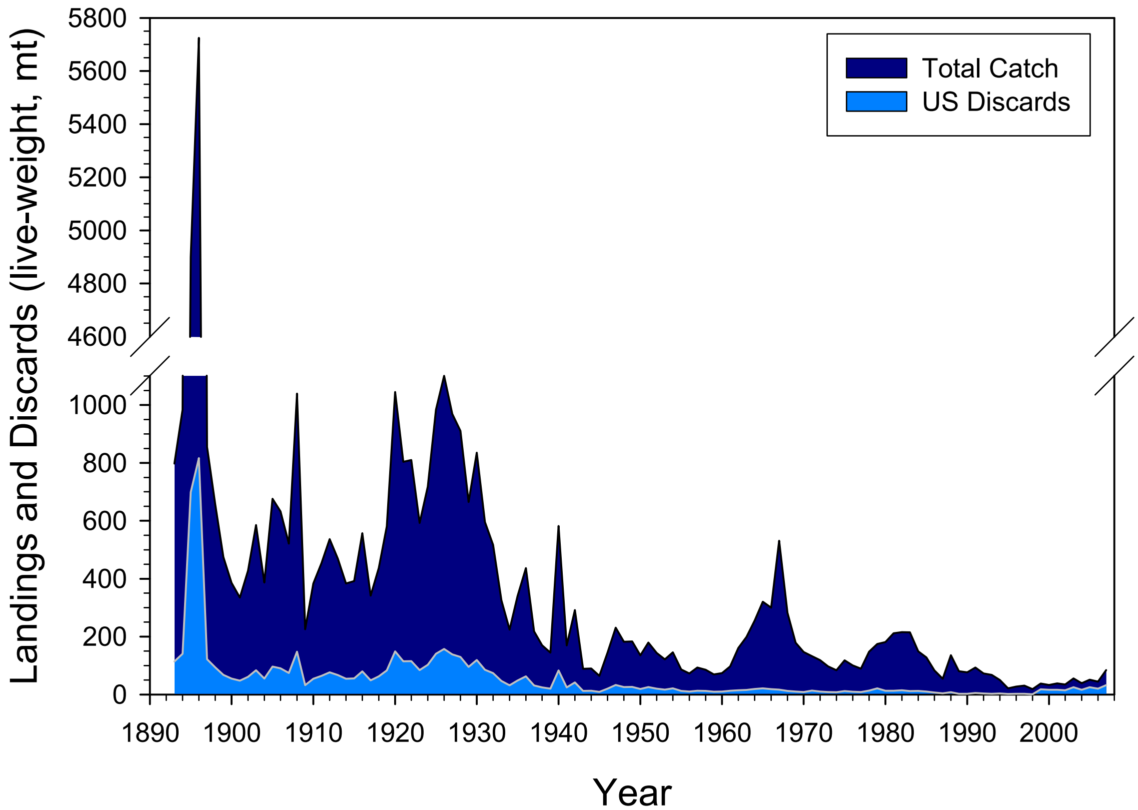

Figure S3. Atlantic halibut total catch (mt) from the Gulf of Maine-Georges Bank region (NAFO divisions 5Y and 5Z), 1893-2007.

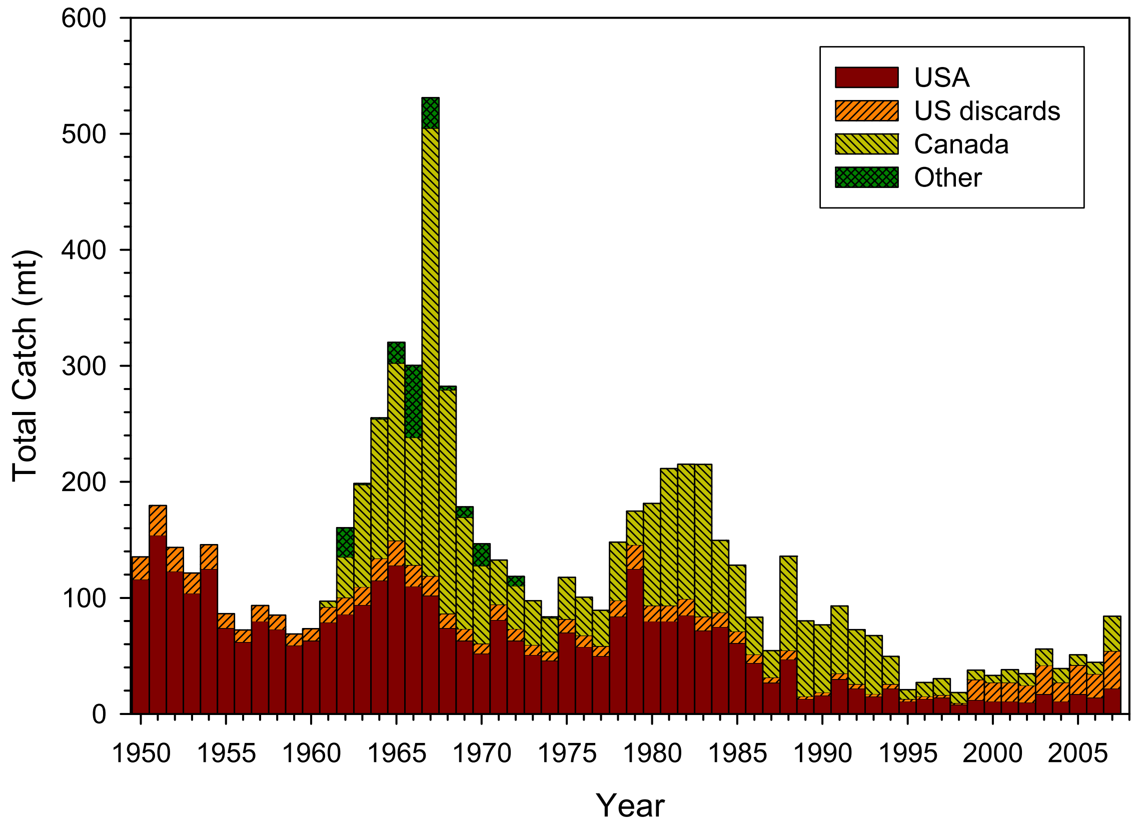

Figure S4. Atlantic halibut total catch (mt) by country, 1950-2007.

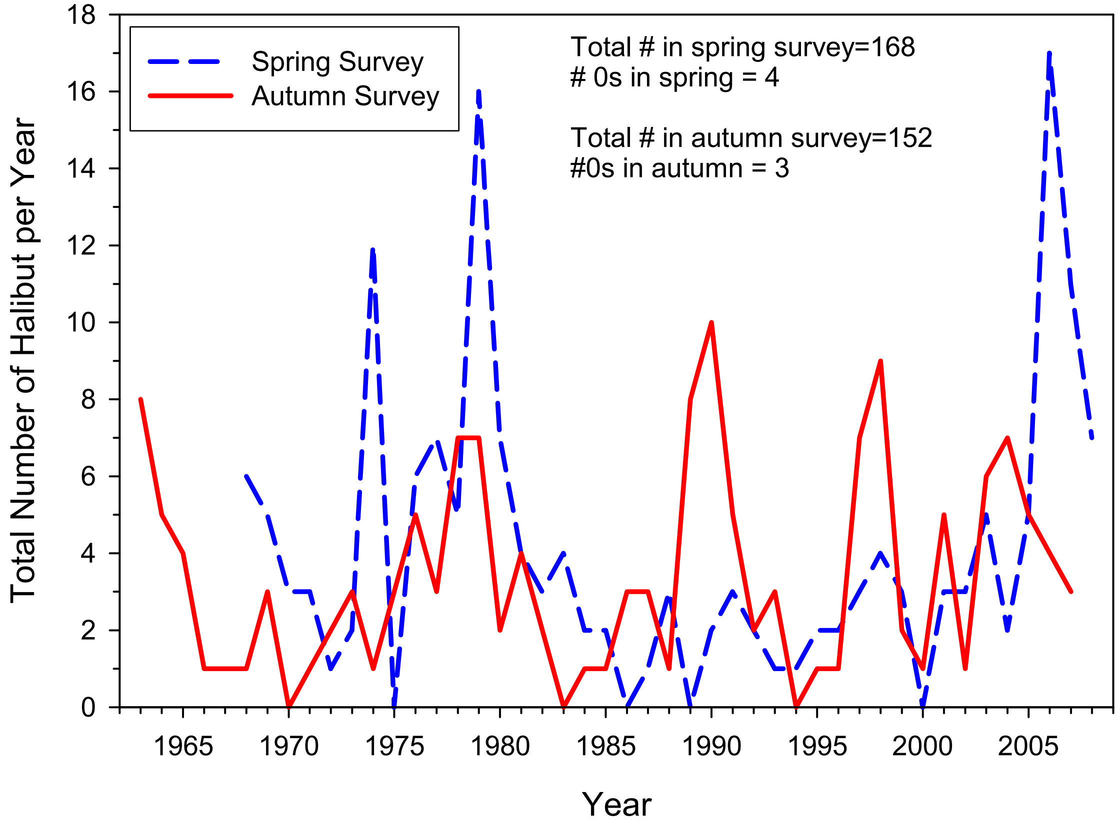

Figure S5. Total numbers of Atlantic halibut caught annually in Northeast Fisheries Science Center spring and autumn surveys.

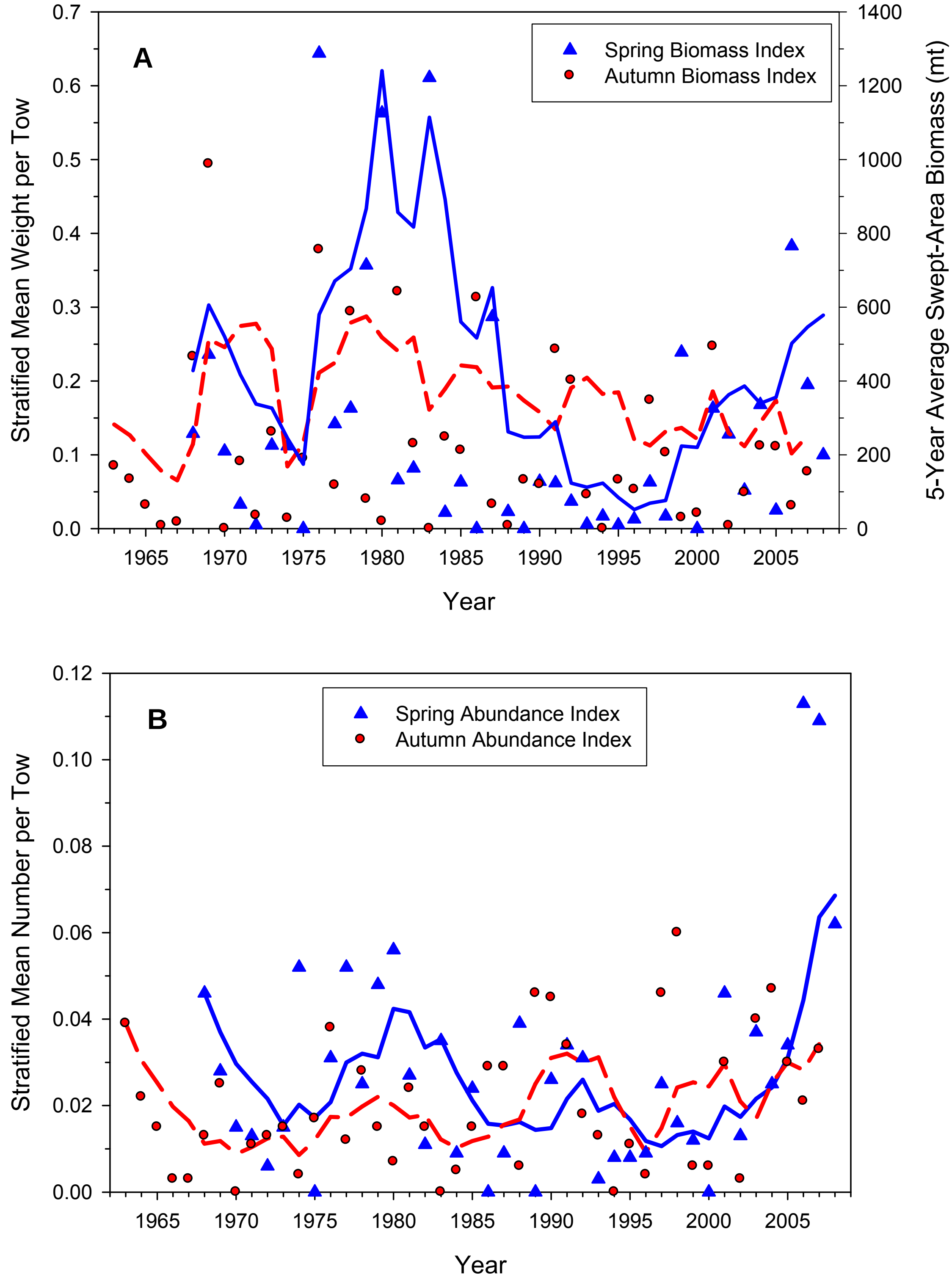

Figure S6. Northeast Fisheries Science Center spring and autumn survey trends for Atlantic halibut A) weight per tow indices and 5-year average swept-area biomass and B) number per tow indices and 5-year average number per tow from the Gulf of Maine-Georges Bank region, 1963-2008.

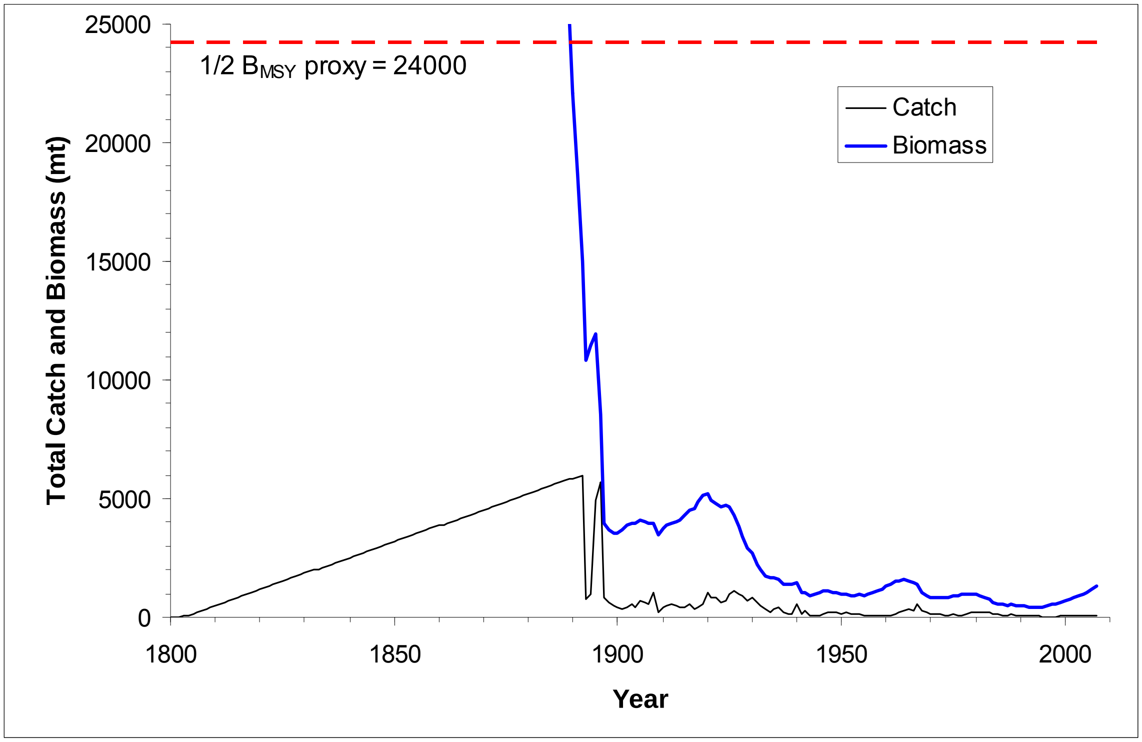

Figure S7. Atlantic halibut biomass and ½ B_{MSY} proxy from the Replacement Yield Model (M = 0.15).

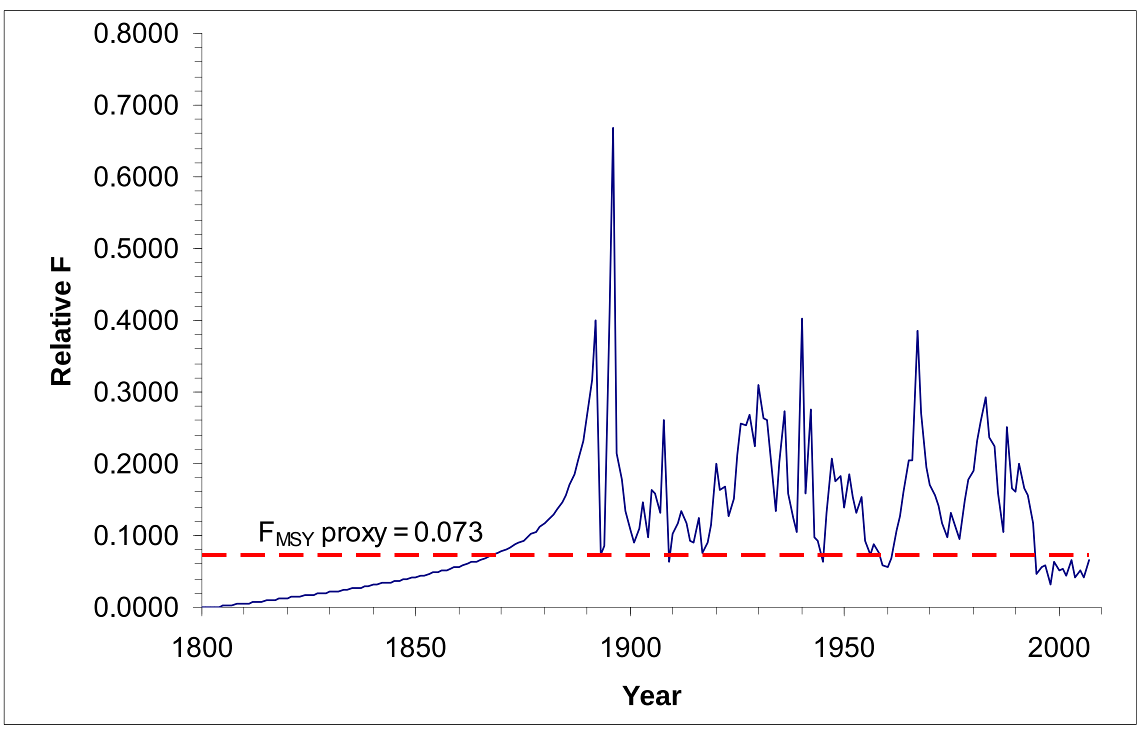

Figure S8. Atlantic halibut relative fishing mortality from the Replacement Yield Model (M = 0.15).

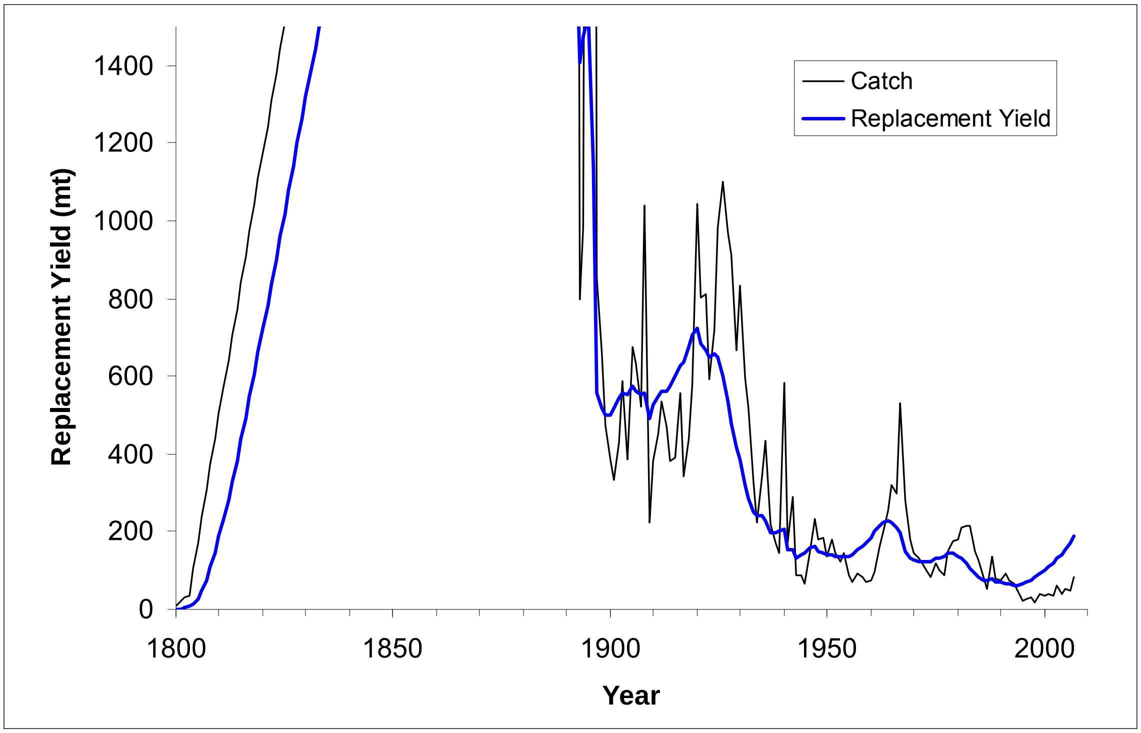

Figure S9. Atlantic halibut replacement yield from the Replacement Yield Model (M = 0.15).

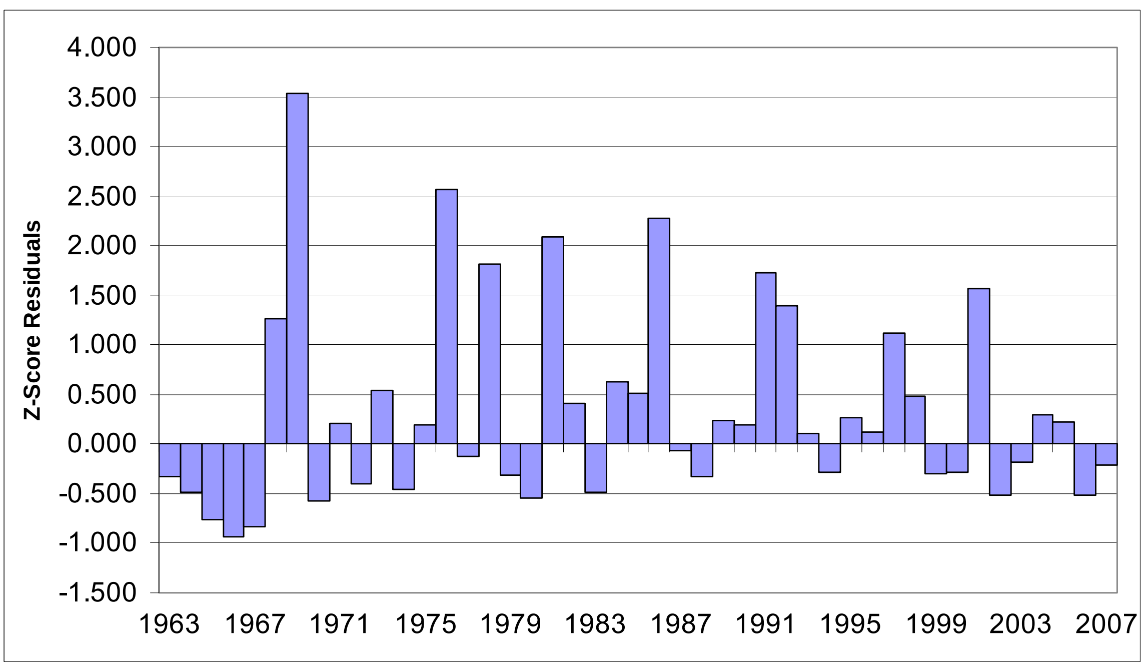

Figure S10. Z-score residuals of Atlantic halibut swept-area biomass estimates from the NEFSC autumn survey and predicted survey indices from the Replacement Yield Model.

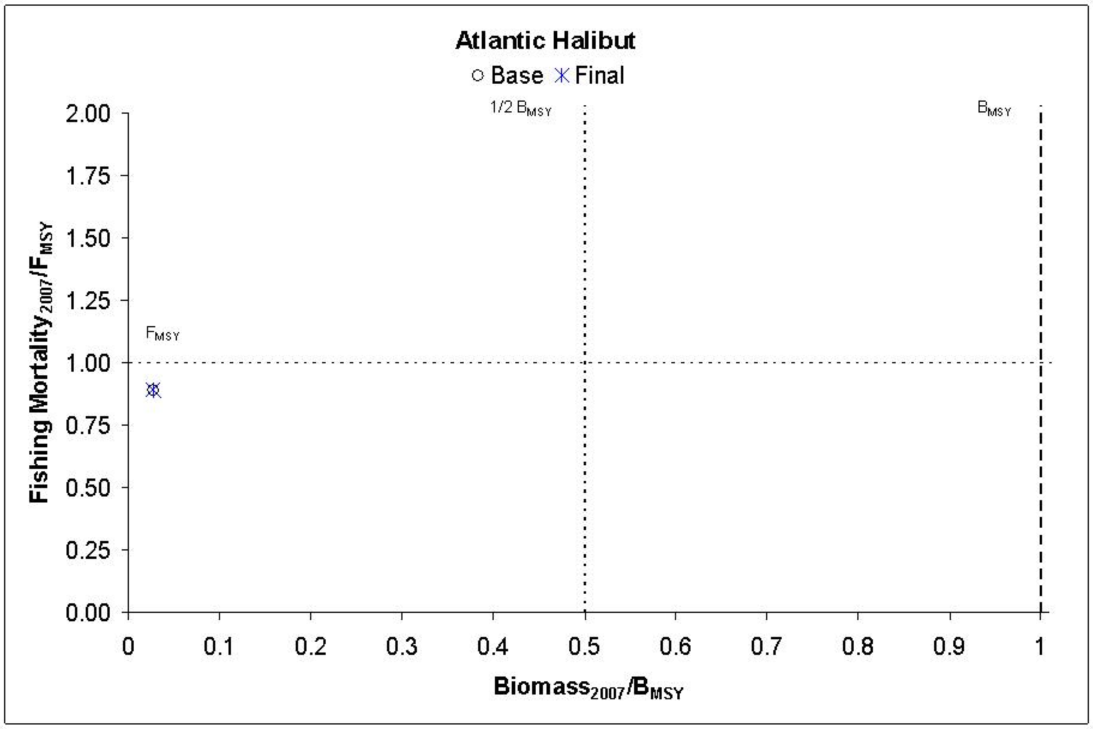

Figure S11. Status plot for Gulf of Maine-Georges Bank Atlantic halibut.

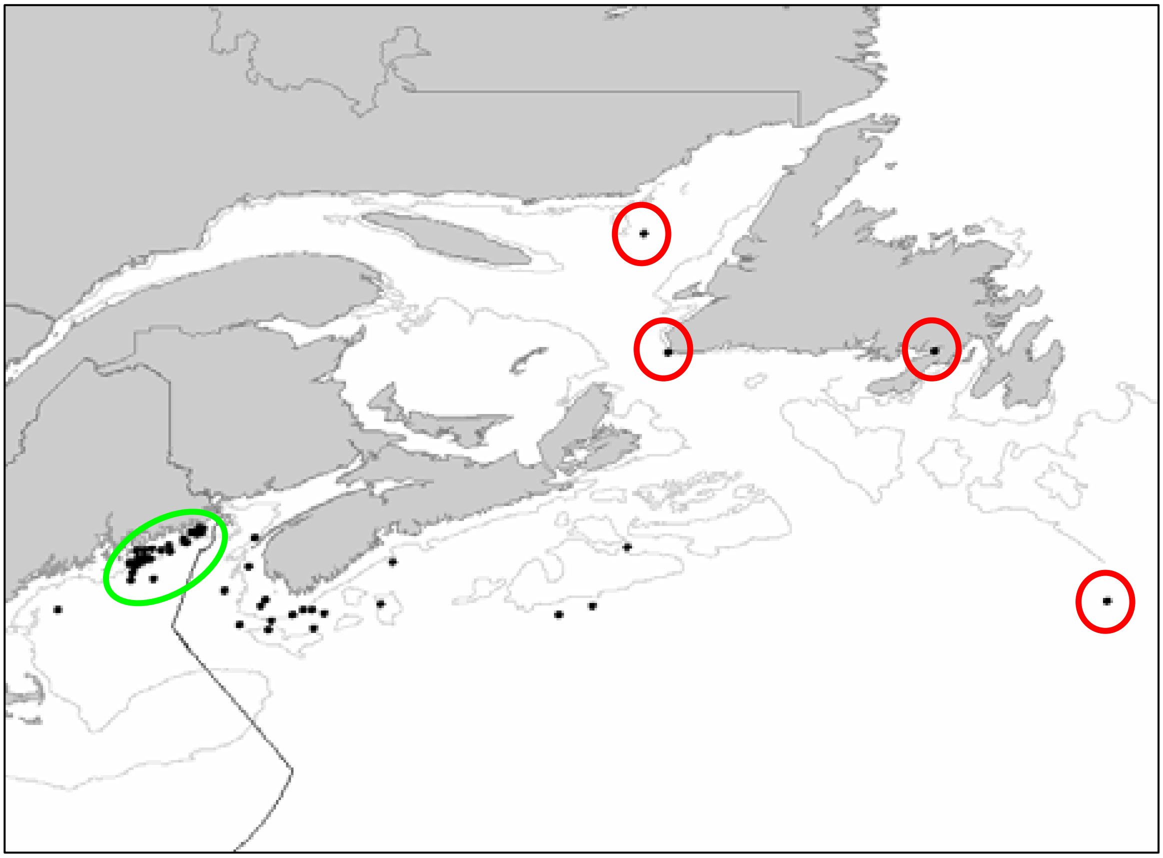

Figure S12. 2000-2004 Experimental Halibut Fishery tagging release location (green oval) and recapture locations (black dots). Red circles represent recapture locations where Atlantic halibut traveled more that 1,000 km.

Special Topics

Treatment of Historical Data

The Panel noted some inconsistencies in how historical data have been treated among assessments. Several stocks "hindcast" recruitment estimates in years when there were research survey indices of recruitment but no commercial catch at age estimates. However, hindcast recruitment estimates were not used for the Southern New England yellowtail flounder stock because "They extended well above the range of 'observed' recruitments and may not be representative of current stock productivity." (GARM III 'BRP' review). On the other hand, the Atlantic Halibut assessment included catch data going back to the late 1800's, and based biological reference point estimates on the results.The rationale for these apparent inconsistencies needs to be highlighted on a stock – specific basis.

Alternative Assessment Methods

Many different styles of stock assessment methods have been used at the NEFSC and these have been described in the GARM III 'models' review. The methods vary in terms of complexity and data requirements. The tendency appears to be to move toward age-structured methods with VPA as perhaps the ultimate goal. However, it is not clear in the scientific literature and in practice that this is necessarily the best way to proceed. There will be trade-offs between accuracy and precision among methods. Given that the NEFSC staff has considerable experience with this range of methods and that the methods appear to be backward compatible, i.e. that data poor methods could be used for data rich stocks, it would be informative to compare and contrast key model estimates among models applied to the same data/stock. This could also be tested in a management strategy evaluation framework. In this case, fishery performance could be measured relative to conservation and sustainable use objectives in closed loop simulations. Alternative assessment methods could be used in these simulations. It would be interesting to see if age-structured and VPA methods outperform "data-poor" methods.

ECOSYSTEM CONSIDERATIONS

2.1 Target Biological Reference Points, Worldwide Cross System Comparisons, and Aggregate Production Model Results for GARM Stocks.

by W.J. Overholtz, J.S. Link, M. Fogarty, L. Col, and C. Legault

1.0 Introduction:

This working paper addresses TOR 2: Ecosystem Data for use in stock assessments, (3. Identify candidate measures of system-level productivity). It provides analyses to determine if the Northeast Shelf LME (Large Marine Ecosystem) can support the reference point biomasses (summed BRPs) required for the GARM species (see NEFSC 2002) as well as the other demersal fish resources in the region. There has been some concern expressed by various stakeholders as to whether the US Northeast Shelf LME can support biomass at optimal levels (e.g., B_{MSY}) simultaneously for all 19 groundfish (GARM stocks), and more broadly, the entire fish community. The purpose of this working paper is to summarize current information on the BRPs for GARM species and other demersal fish components of the US Northeast Shelf LME. Here we summarize information for the demersal components of the LME and compare it to recent energy budget analyses for the region (Link et al. 2006). We then compare the data to other ecosystems by using energy budget density units (t/km2) as the common currency.

In addition an aggregate surplus production model will be fit using the ASPIC production model for all 19 GARM groundfish stocks. This approach will provide an estimate of the overall carrying capacity for this group of stocks as a whole. Estimates of BRPs (e.g., aggregate carrying capacity, B_{MSY}, MSY, F_{MSY}) will be calculated for the GARM stocks. The aim will be to calculate aggregate BRPs to compare to summations of single stocks BRPs.

2.0 Methods

Detailed descriptions of methods used in these analyses are available in working papers 3.1 and 3.2 (GARM BRP Meeting). The current analysis focuses only on the GARM stocks.

Results and Discussion

The estimated total MSY for the GARM species is 144,977* mt and B_{MSY} for this groundfish complex is 1,065,068 mt (Table 1). The current total biomass for the GARM stocks is 696,207 mt and the ratio of total current biomass to B_{MSY} for this group is 0.65 (Table 1). This analysis suggests that the GARM species are currently at 65% of their B_{MSY} target. The species with the largest B_{MSY} targets and lowest B/B_{MSY} ratios are GB cod, ocean pout, and white hake (Table 1). These are several of the major GARM stocks that still require rebuilding.

In terms of density units (t/km2), the total MSY for the GARM stocks is 0.59 t/km2 (Table 2). The summed value for GARM, elasmobranch, and other demersal components compares favorably, in terms of scale, with the values for these categories from other recent analyses for the entire LME (for example 11.77 t/km2 for demersal fishes; Link et al. 2006) (Table 3). The current target demersal biomass that the US Northeast Shelf LME needs to support is about 3.6 million mt (Table 3). This equates to a unit area biomass of 14.62 t/km2, about 24% higher than the 11.77 t/km2, estimated from a recent analysis for the 1996-2000 time period (Link et al. 2006) and compared to 10.6-17.04 t/km2 from historical studies for the

Georges Bank ecosystem (Cohen et al 1982; Sissenwine et al 1984). The other components of the ecosystem, excluding GARM species and elasmobranchs, comprise about 1/3 of the total biomass (Table 3).

The average demersal biomass for the nine temperate and boreal systems (from various ecosystem modeling studies) was 15.2 t/km2, with a range between 2.1-44.9 t/km2 (Table 4). The target biomass for the demersal component is moderately lower than the average for the nine systems and is higher than six of the individual systems (Table 4). However, for many of these other ecosystems the demersal component is depleted.

Landings of GARM stocks ranged from 49,000 mt to 289,000 mt during 1950-2005 (Table 5). Since landings either did not occur or were not recorded for several stocks during 1950-1959, only landings from 1960-2007 were used in the ASPIC analysis. Spring survey indices for the GARM stocks showed a major decline from over 80 kg/tow in 1973 to a series low of 10 kg/tow in 1994, recovering to over 50kg/tow in 2002 and fluctuating around this value through 2007(Figure 1). Most of the GARM stocks, although experiencing some declines from the 1970s to the early 1990s, were well represented in the survey catch during spring (Figure 2). Autumn survey indices also showed a pronounced decline during the late 1960s through the early 1990s, ranging from 110 kg/tow in 1964 to a series low of about 12 kg/tow in 1994, and recovering to about 50 kg/tow recently (Figure 3). GARM stocks were also well represented in the autumn survey catch in the 1963-2007 time-series (Figure 4).

Initial values from the previous ASPIC run (WP 3.2) for the GARM stocks were used to start a final ASPIC run, the model converged rapidly to a B1/K value of 1.0, an MSY of 139, and a K value of 1900 (Table 6). Residuals for both the spring and autumn series for this ASPIC run were reasonable and the biomass trajectory during 1960-2008 appeared plausible (Figures 5-7). Estimates of biological reference points were MSY= 139,000 mt, B_{MSY} = 950,000 mt, and F_{MSY} = 0.15 (Table 6; Figure 8). Bootstrap results for MSY and B_{MSY} suggest that the ASPIC model fit was reasonably precise for both parameters. 80% CIs for MSY are 128,800-141,900 mt and 836,000-1,059,000 mt for B_{MSY}. Relative bias for MSY was estimated at 3.0% and at 4.5% for B_{MSY}.

The estimates of MSY and B_{MSY} (139,000 mt and 950,000 mt) from ASPIC are similar to management targets (144,977 mt and 1,065,068) for the GARM single stock groups (Table 6). The new results for the GARM stocks are considerably lower for MSY and B_{MSY} than the previous estimates (Table 6). The system wide fishing rate on the GARM complex was estimated at F=0.15 (Table 6). When compared to the distribution of fully recruited Fs for the GARM stocks, the aggregate F_{MSY} is relatively much lower (Figure 8).

Conclusions

Results from this study suggest that on an ecosystem basis, current biomass management targets (B_{MSY}s) for GARM stocks are reasonable. The current targets compare favorably with the results of recent and historical studies in the region and are also in general agreement with results of many studies for other worldwide ecosystems. New summed BRPs for the GARM stocks are similar to BRPs from an aggregate surplus production model for these stocks. Aggregate model results suggest that the overall fishing mortality rate should be relatively low (F=0.15) to obtain MSY for this complex of GARM stocks.

Notes on GARM stock recovery and long-term advice

A 2nd Tier quota could be considered during recovery and for long-term maintenance of the GARM stock complex. Based on the results of the aggregate production model for the GARM stocks, system recovery is predicated on a low fishing rate (F_{MSY} = 0.15).
Weak stock management is an issue because there are several stocks in each eco-region that will constrain the overall recovery of this FMP complex (i.e. halibut, GB cod, GB Yt, white hake, SNE Yt). Unless stocks can somehow be targeted independently, a much lower fishing effort than is currently being employed will be required for full system recovery.

3.0 Panel Discussion/Comments

Conclusions

The Panel agreed that the exploration of ecosystem productivity for understanding future management scenarios is an important effort and should be pursued. It was noted that the sum of the GARM single species targets is close to the multispecies estimate of system productivity considering only those stocks. However, a concern was raised with the analysis that the single species reference points correct for survey catchability (through the assessment models) but the multispecies biomass dynamics model does not correct for the survey catchability of each species. This makes the direct comparison of the system biomass and reference points to single species estimates problematic and should be investigated in future.

Notwithstanding the problem noted above, the ecosystem estimates of productivity appears to be slightly less than the sum of species productivity and this implies that some tradeoffs between species may occur. If this is the case, it is likely that these tradeoffs are relatively minor under current conditions because many of the species are depleted. As rebuilding proceeds on more species, these tradeoffs may become more apparent and the difference between system potential productivity and single species summed potential may increase. The proposed analysis of the allocation of productivity among stocks (such as through a linear programming approach) is worth pursuing. Overall, a more complete management strategy evaluation or scenario analysis approach should be developed for this ecosystem. It was also noted that if differential exploitation of species can not be well managed then the overall fishing mortality rate for the entire system must be quite low ($F_{ecosystem}$ = 0.15) in order to obtain maximum sustainable yield for this ecosystem.

The Panel noted that in the new assessments, many of the biomass reference points for GARM species are lower than in previous assessments. The concern was raised that this may be an artifact of the depleted level of many resources. In most cases, reference points are estimated from the historic series of stock and recruitment. However, recent observations tend to be at low stock sizes (with low recruitment) or after commencement of high exploitation. This may result in lower estimated productivity. As rebuilding proceeds and recruitment at higher stock sizes are observed, it is likely that estimates of potential productivity (and the biomass reference points) will increase. This pattern has already been observed for some stocks (haddock, scallops), though the majority have not yet rebuilt sufficiently to confirm the pattern.

Table 1. Biological Reference Points (MSY, B_{MSY}), current biomass (from new assessments) and ratio of current biomass to B_{MSY} for GARM species.*

	GARM Stocks	MSY (mt)	Bmsy (mt)	Current B (mt)	B/Bmsy
1	GOM cod	10,431	60,104	33,878	0.56366
2	GB cod	31,159	148,084	17,672	0.11934
3	GOM haddock	1,360	5,900	5,846	0.99085
4	GB haddock	32,746	158,873	315,976	1.98886
5	Redfish	10,139	271,000	234,609	0.86572
6	Pollock[1]	6,491	33,201	12,517	0.37701
7	CC-GOM Yt	1,720	7,790	1,922	0.24673
8	GB Yt	9,400	43,200	9,526	0.22051
9	SNE-MA Yt	6,100	27,400	3,508	0.12803
10	Am plaice	4,011	21,940	11,106	0.50620
11	Witch fldr	2,352	11,447	3,434	0.29999
12	GOM Winter fldr	912	3,769	1,099	0.29159
13	GB Winter fldr	4,160	16,000	4,964	0.31025
14	SNE-MA Winter fldr	9,742	38,761	3,368	0.08689
15	GOM-GB Windowpane fldr[1]	700	5,599	2,550	0.45544
16	SNE-MA Windowpane fldr[1]	500	3,484	3,152	0.90471
17	Ocean Pout[1]	3,754	103,262	9,970	0.09655
18	White hake[1]	5,800	56,254	19,810	0.35215
19	Halibut	3,500	49,000	1,300	0.02653
total		144,977	1,065,068	696,207	0.65367

1 B_{MSY} based on area swept biomass and estimated Q for demersal species

Table 2. Biological Reference Points (MSY, and B_{MSY}, mt) for GARM stocks. expressed in energy budget density units (t/km^2) (based a total area of the continental shelf of 246,662 km^2) for direct comparison to other worldwide systems.*

	GARM Stocks	MSY (mt)	t/km^2	Bmsy (mt)	t/km^2
1	GOM cod	10,431	0.0423	60,104	0.243669672
2	GB cod	31,159	0.1263	148,084	0.600352385
3	GOM haddock[1]	1,360	0.0055	5,900	0.023919391
4	GB haddock	32,746	0.1328	158,873	0.644092437
5	Redfish	10,139	0.0411	271,000	1.098670325
6	Pollock[1]	6,491	0.0263	33,201	0.134601304
7	CC-GOM Yt	1,720	0.0070	7,790	0.031581704
8	GB Yt	9,400	0.0381	43,200	0.175138591
9	SNE-MA Yt	6,100	0.0247	27,400	0.111083273
10	Am plaice	4,011	0.0163	21,940	0.088947701
11	Witch fldr	2,352	0.0095	11,447	0.046407672
12	GOM Winter fldr	912	0.0037	3,769	0.015280031
13	GB Winter fldr	4,160	0.0169	16,000	0.064866145
14	SNE-MA Winter fldr	9,742	0.0395	38,761	0.15714229
15	GOM-GB Windowpane fldr[1]	700	0.0028	5,599	0.022699096
16	SNE-MA Windowpane fldr[1]	500	0.0020	3,484	0.014124603
17	Ocean Pout[1]	3,754	0.0152	103,262	0.418637989
18	White hake[1]	5,800	0.0235	56,254	0.228061256
19	Halibut	3500	0.0142	49,000	0.198652568
total	total	144,977	0.5878	1,065,068	4.31792843

* To complete this analysis in time for the GARM meeting it was necessary to get stock size and BRP estimates before they were finalized. Some of the values in Tables 1 and 2 (above) are not identical to the final values given in the individual species chapters and in the Executive Summary.

Table 3. Total biomass (mt) and energy budget density units (t/km^2) for GARM stocks, elasmobranchs, other demersal components, and medium pelagics (c.f. Link et al 2006) for the US Northeast Shelf LME.

Category	*Biomass (mt)*	*t/km^2*
GARM species	1065068.00	4.32
Elasmobranchs	1155731.00	4.69
demersal omnivores	15291.40	0.06
demersal piscivores	262902.49	1.07
demersal benthivores	850566.28	3.45
medium pelagics	256677.00	1.04
Total	**3606236.17**	**14.62**

Table 4. Energy budget density units (total t/km^2) and average (t/km^2) for nine worldwide systems for demersal fishes with proposed US Northeast Shelf LME BRP targets and current density.

System	Demersal B (t/km^2)
Gulf of Alaska	26.478
Bering Sea	44.852
Barents Sea	4.313
North Sea	8.868
Baltic Sea	2.130
Faroes	10.605
Newfoundland-Labrador	10.990
Gulf of St Lawrence	21.780
Scotian Shelf	6.849
Average	**15.207**
Northeast Shelf LME Target	**14.620**
Northeast Shelf LME Current	**13.123**

Table 5. Catch (t, recent years include discards) of GARM stocks during 1950-2007

Year	GOM cod	GB cod	GOM hadd	GB hadd	Yt	Window	A Plaice	Winter	Witch	Pollock	Redfish	O-pout	White_hake	Halibut	Total
1950	5062	15400		41273	13887						34307		5492	135	115557
1951	3567	14800		47318	10862						30077		5300	180	112104
1952	3011	10900		43252	10437						21377		5200	143	94320
1953	3121	8100		35926	8040						16791		5100	121	77200
1954	3411	8800		46388	7614						12988		5000	146	84346
1955	3171	9300		40851	9020						13914		4900	86	81243
1956	2693	10500	7307	51144	9526						14388		4800	72	100431
1957	2562	10400	6166	48561	14626						18490		4700	93	105598
1958	4670	11100	7367	37322	21339						16047		4600	85	102531
1959	3795	12100	4660	36051	18864						15521		4500	69	95559
1960	3448	10853	4924	40877	19939		1310		1255		11375		4400	73	98454
1961	3216	14731	5353	46650	25822		1522		1024		14101		4300	97	116816
1962	2989	23486	5110	54004	29000		1971		977		14134	0	4200	160	136031
1963	2595	27189	4789	54846	49490		2333		1374	6241	10046	20	4100	199	163222
1964	3226	25165	5853	64086	53580		3799	10302	1418	9008	8313	2123	3995	255	191124
1965	3780	38333	4654	150362	52371		3635	11194	2664	9000	8057	877	3434	320	288681
1966	4008	53134	5870	121274	44416		3867	15095	3314	9847	8569	13380	2051	300	285124
1967	5676	36752	5502	51469	53338		4473	12735	3682	8534	10864	7361	1498	531	202416
1968	6360	43136	3557	40923	55674		3777	10072	3054	5222	6777	16538	1699	282	197072
1969	8157	37939	2697	22252	67362		3939	11715	3852	9822	12455	30101	1815	178	212285
1970	7812	25652	1543	11300	51588		4329	12519	3261	11976	16741	9938	2799	147	159603
1971	7380	28179	1316	10862	37356		3061	12766	6115	15203	20034	7932	3801	132	154137
1972	6776	25059	955	5866	42351		2245	10883	5515	13013	19095	4849	4127	118	140852
1973	6069	28923	609	5429	33226		2087	9721	3162	13076	17360	6664	4462	97	130887
1974	7639	27331	878	4450	36657		2127	7459	2140	12393	10471	4866	5255	84	121749
1975	8903	25008	1343	5606	24702	2722	2596	8216	2357	13871	10572	994	5010	118	112017
1976	10172	19926	2013	4484	22369	2991	3536	6764	1882	13382	10696	1200	5641	101	105156
1977	12426	27367	3335	10994	19584	2770	7231	10372	2493	16273	13223	1987	7196	89	135340
1978	12426	35661	5071	22516	19500	3282	9610	12031	3525	22305	14083	2413	6630	148	169200
1979	11680	39162	4406	19647	21757	3086	11360	8883	2895	18452	14755	2181	5641	175	164080
1980	13528	48684	6542	27638	21727	2523	14442	17291	3147	23539	10183	2366	6630	181	198421
1981	12534	47543	6289	25011	17760	2864	13186	22460	3449	22820	7915	2994	8428	211	193464
1982	16713	61088	6961	17627	32320	4841	15567	23545	4954	20285	6903	4761	9112	215	224892
1983	16037	53404	7672	12009	36709	5836	13721	20750	6162	18397	5328	4897	9471	215	210607
1984	12187	39766	4109	10394	18890	6130	10761	22535	6760	20748	4793	5016	10195	149	172433
1985	12713	42298	3073	7943	9410	7736	7306	19539	6191	21328	4282	4665	10898	128	157511
1986	12768	26876	1878	6846	9666	7004	4796	12877	4635	26650	2929	4098	9270	83	130377
1987	11236	32112	860	6997	7856	6006	4312	15006	3497	23583	1894	4809	8362	54	126583
1988	9746	41976	430	6689	7170	6406	3839	13874	3322	17815	1177	4055	6976	136	123612
1989	12669	34340	282	4915	11687	6684	3536	11437	2144	12693	669	8729	7955	80	117821
1990	17737	44413	439	5574	26466	7520	3932	9801	1561	11674	639	10746	8154	77	148733
1991	20423	38810	435	6997	11246	7595	6060	10120	1994	10153	2039	6350	8215	93	130531
1992	11884	29686	331	6244	9740	2980	7034	7553	2439	10721	978	1994	12602	73	104257
1993	9607	24620	223	4668	6003	2449	6118	6782	2825	10290	1046	1578	10342	67	86618
1994	8951	15754	217	4827	6248	1856	5624	4737	3009	7585	546	1477	7108	50	67989
1995	7419	9068	476	2442	2989	1953	5444	4994	2412	4858	631	639	5791	21	49138
1996	7650	9718	360	4131	3941	1788	4829	5843	2294	4759	689	680	4108	27	50816
1997	5731	11784	988	3833	5127	1887	4634	6581	1981	5991	432	555	3391	30	52946
1998	4515	9888	954	5665	6347	1194	4383	5756	2046	7994	586	690	3724	18	53758
1999	4769	10991	565	6357	7801	630	3929	5272	2398	5815	383	804	4462	40	54216
2000	5939	9771	903	8711	10903	612	4583	7170	2617	5772	488	367	4375	36	62247
2001	8400	13584	1147	11788	11624	414	4800	8117	3327	6430	728	549	5998	41	76947
2002	7286	11368	1166	13258	8832	413	3764	6517	3413	5735	494	588	3763	37	66635
2003	7537	8901	1237	12827	9097	820	2802	6777	3458	6829	564	452	5081	60	66441
2004	5817	6292	1403	18253	8705	695	2023	5550	3226	7512	523	296	4229	42	64565
2005	5636	4404	1716	21814	5286	1270	1556	4152	2802	8687	665	205	3136	55	61383
2006	4536	4610	1172	15989	3151	1148	1338	3262	1950	7390	648	188	2256	48	47685
2007	5628	5956	1368	16815	2709	1422	1226	3254	1172	9400	1160	179	2163	85	52537

Table 6. Results for BRPs from aggregate production model (ASPIC), and summed single species BRPs for GARM stocks based on new and recent stocks assessments.

GROUP	***MSY***	***Bmsy***	***Fmsy***	***K***
New GARM SS Target	145	1065	na	na
New GARM Aggregate Results	139	950	0.15	1900
Old GARM SS Target	197	1424	na	na
Old GARM Aggregate Results	126	758	0.17	1513

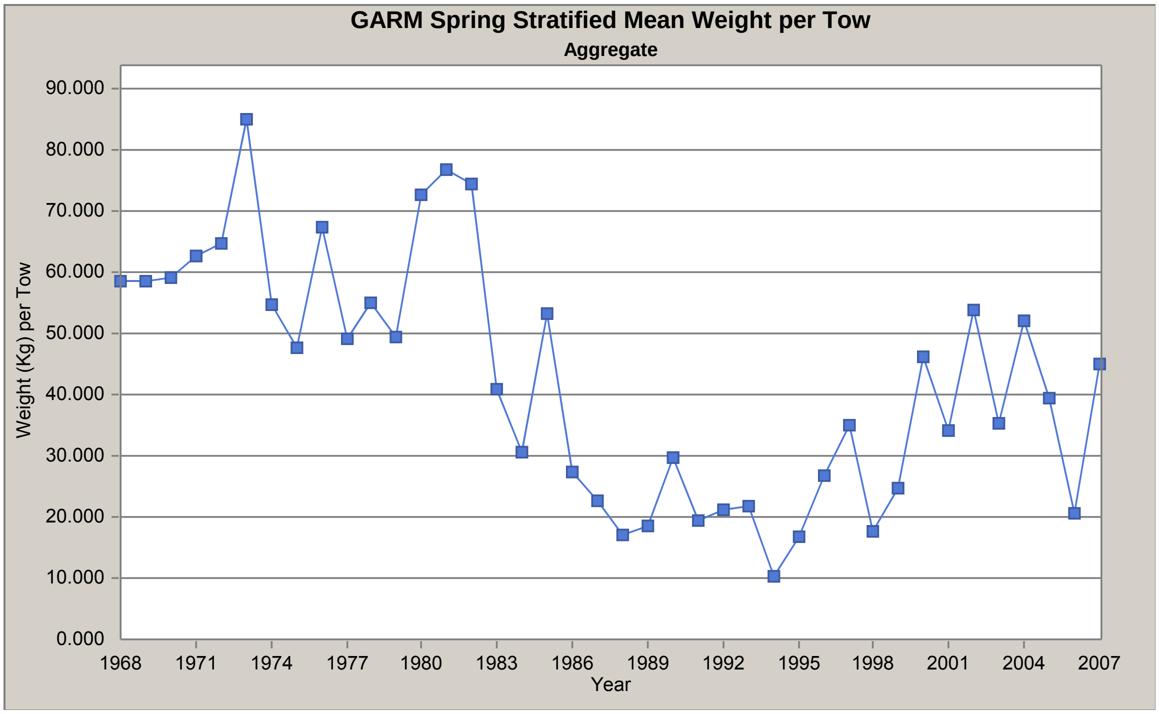

Figure 1. Spring stratified mean weight per tow (kg) for all GARM stocks during 1968-2007.

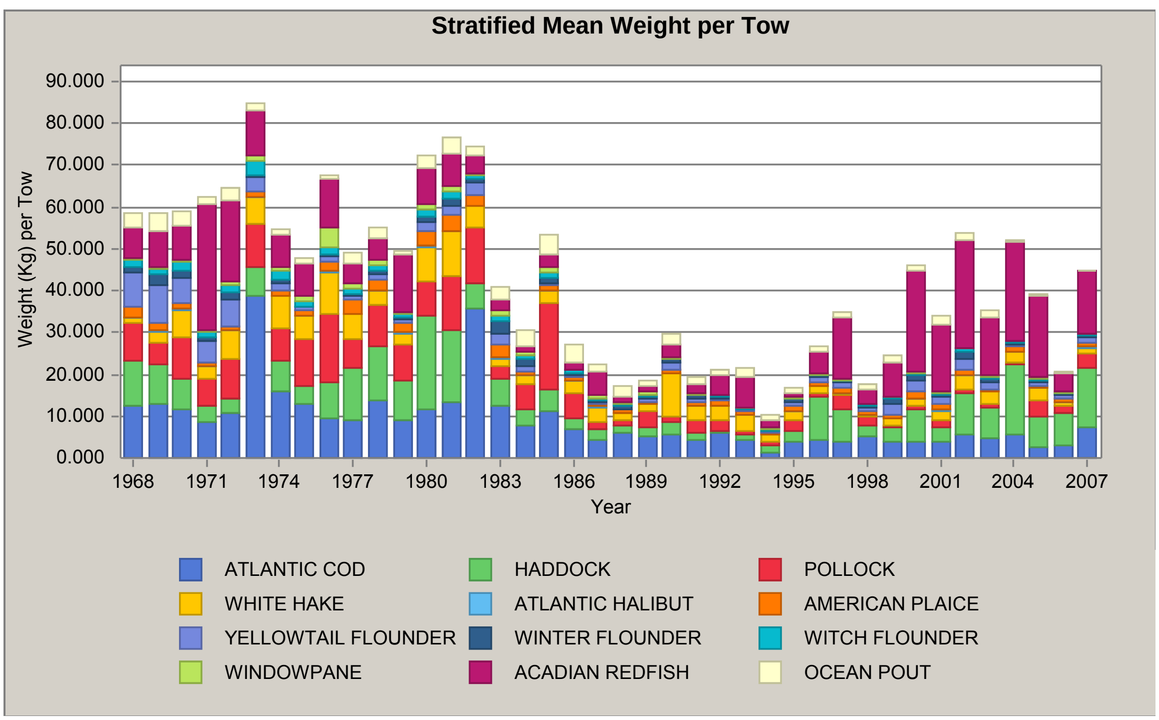

Figure 2. Catch composition of spring stratified mean weight per tow (kg) for all GARM stocks during 1968-2007.

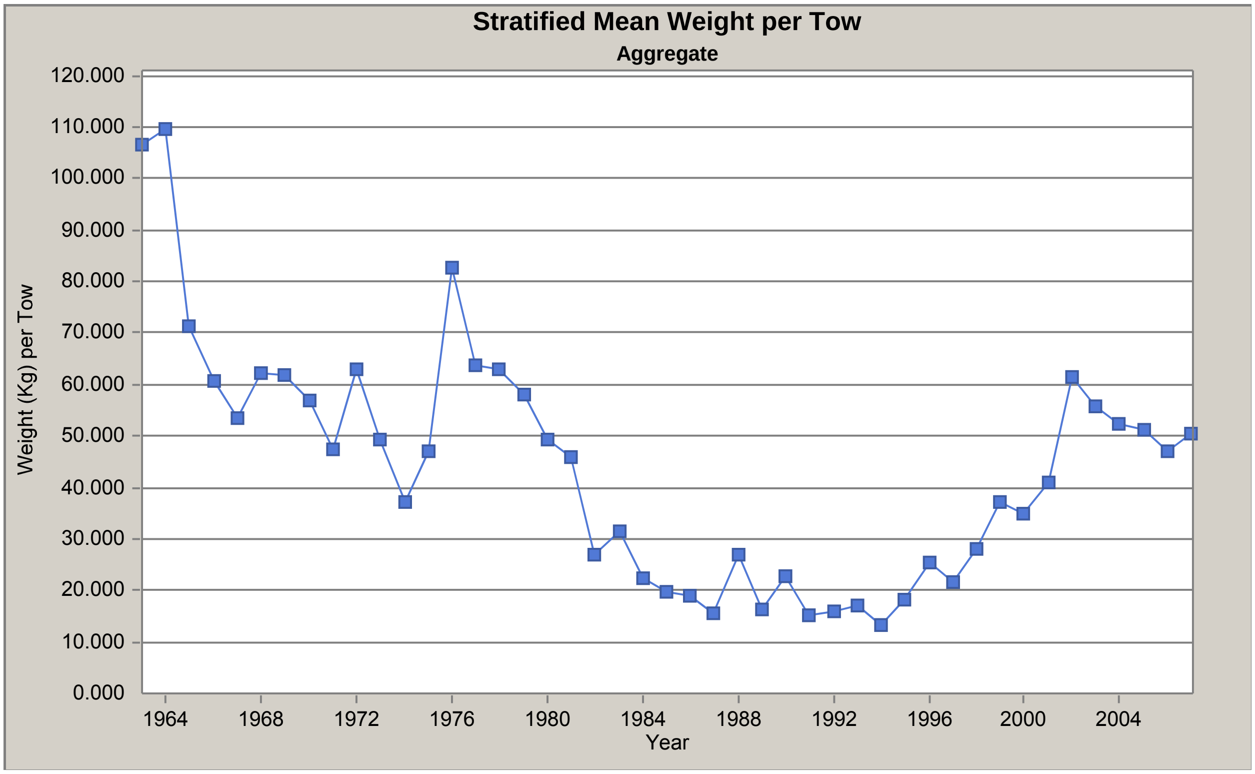

Figure 3. Autumn stratified mean weight per tow (kg) for all GARM stocks during 1963-2007.

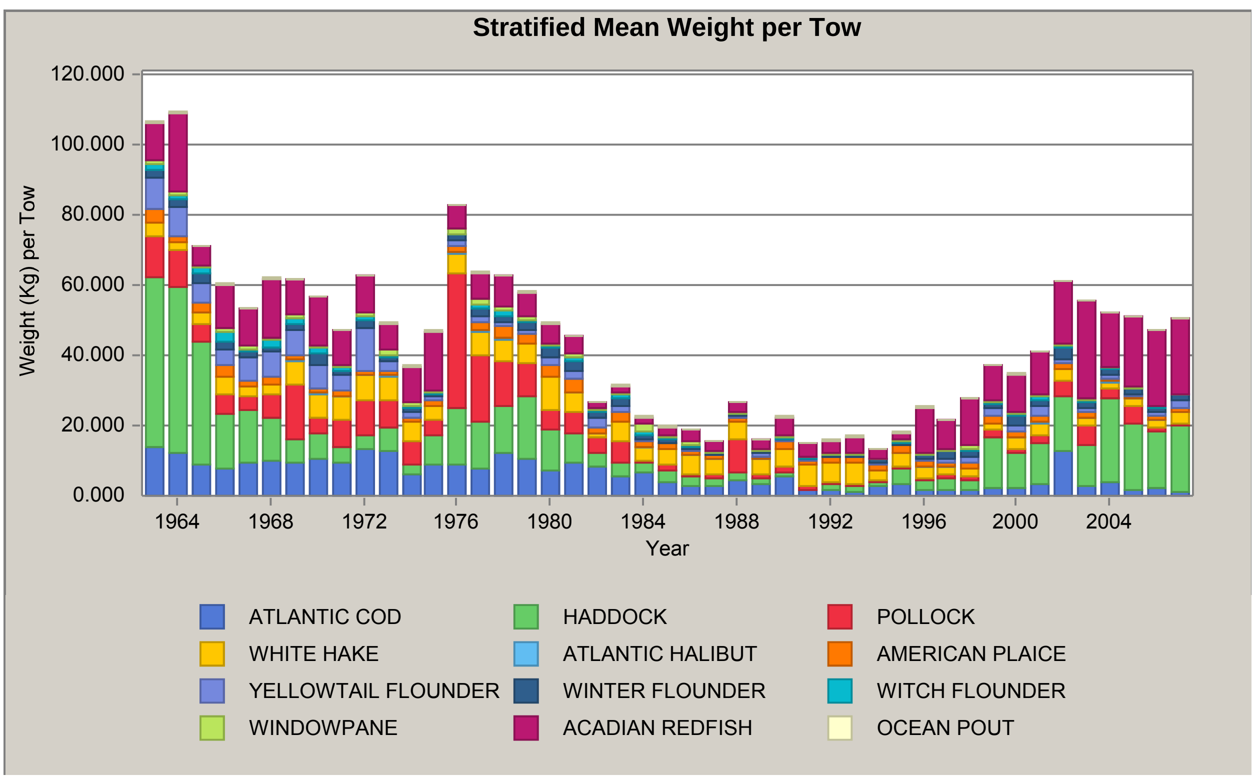

Figure 4. Catch composition of autumn stratified mean weight per tow (kg) for all GARM stocks during 1963-2007.

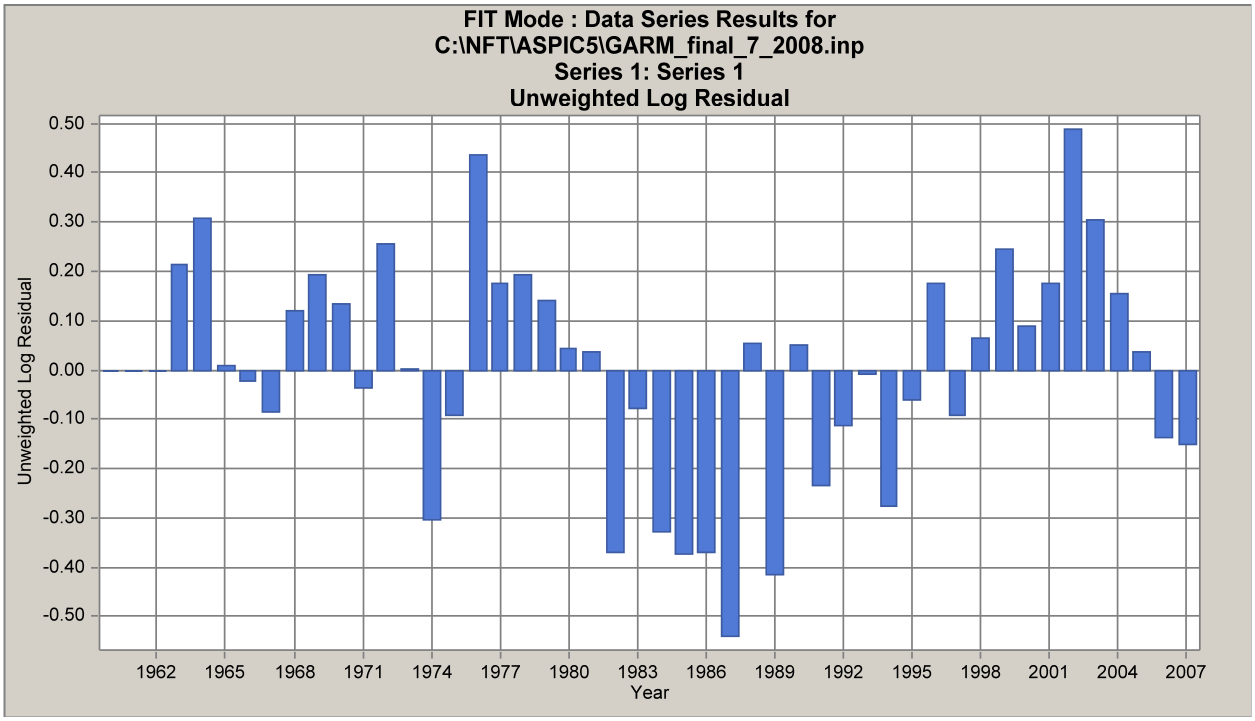

Figure 5. Residual plot from ASPIC model for autumn stratified mean weight per tow for the GARM stocks during 1963-2007.

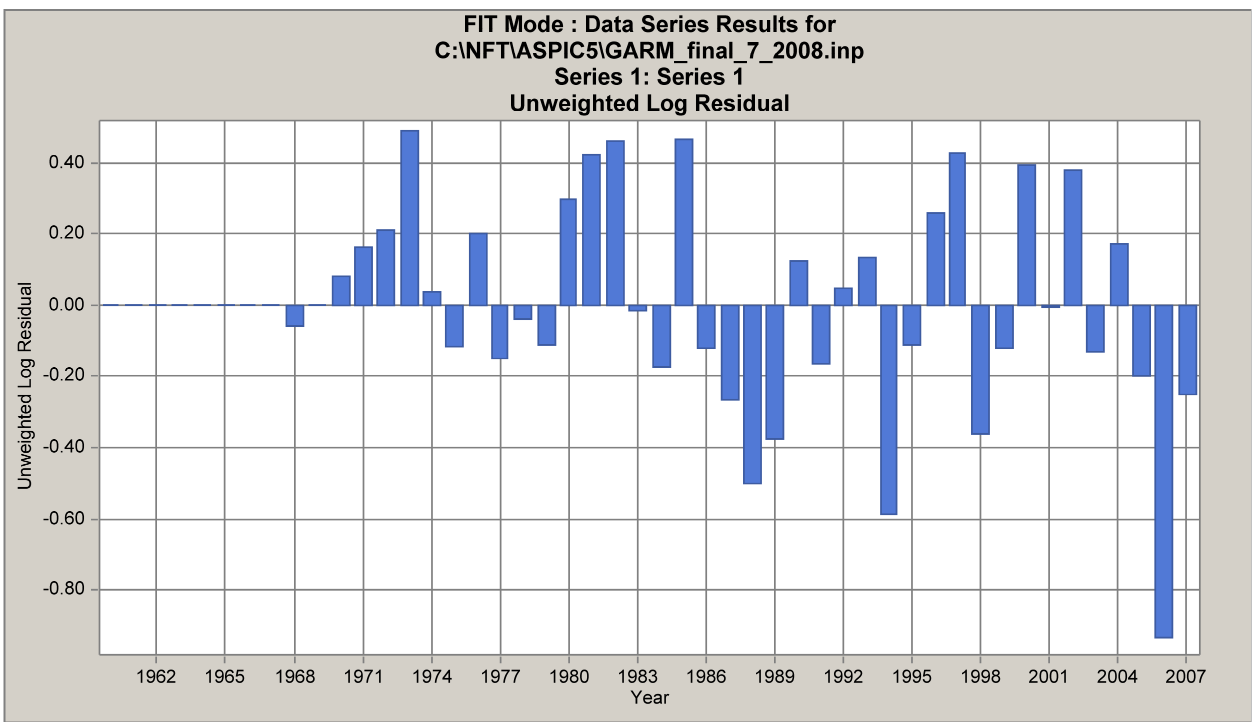

Figure 6. Residual plot from ASPIC model for spring stratified mean weight per tow for the GARM stocks during 1968-2007.

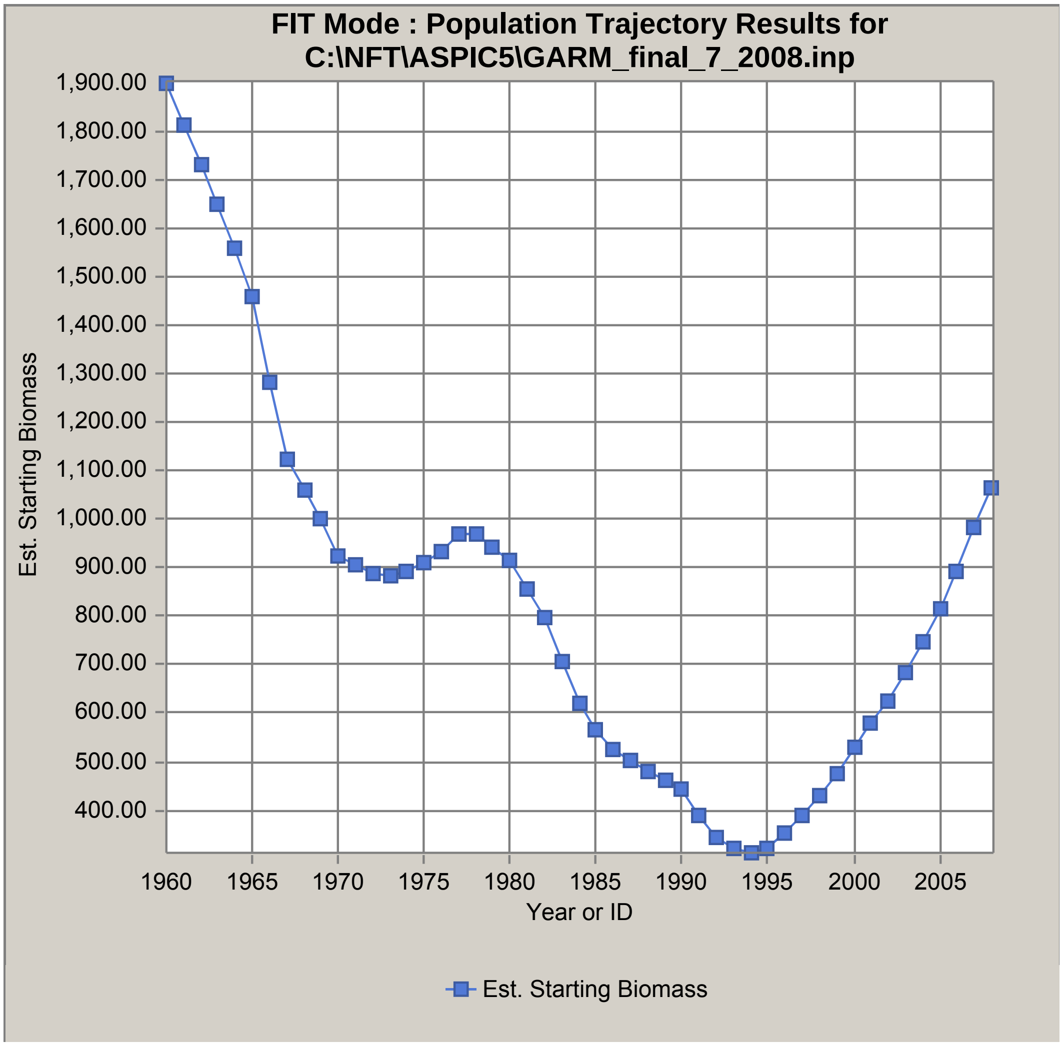

Figure 7. Biomass (000s mt) for GARM stocks from ASPIC model results during 1960-2007.

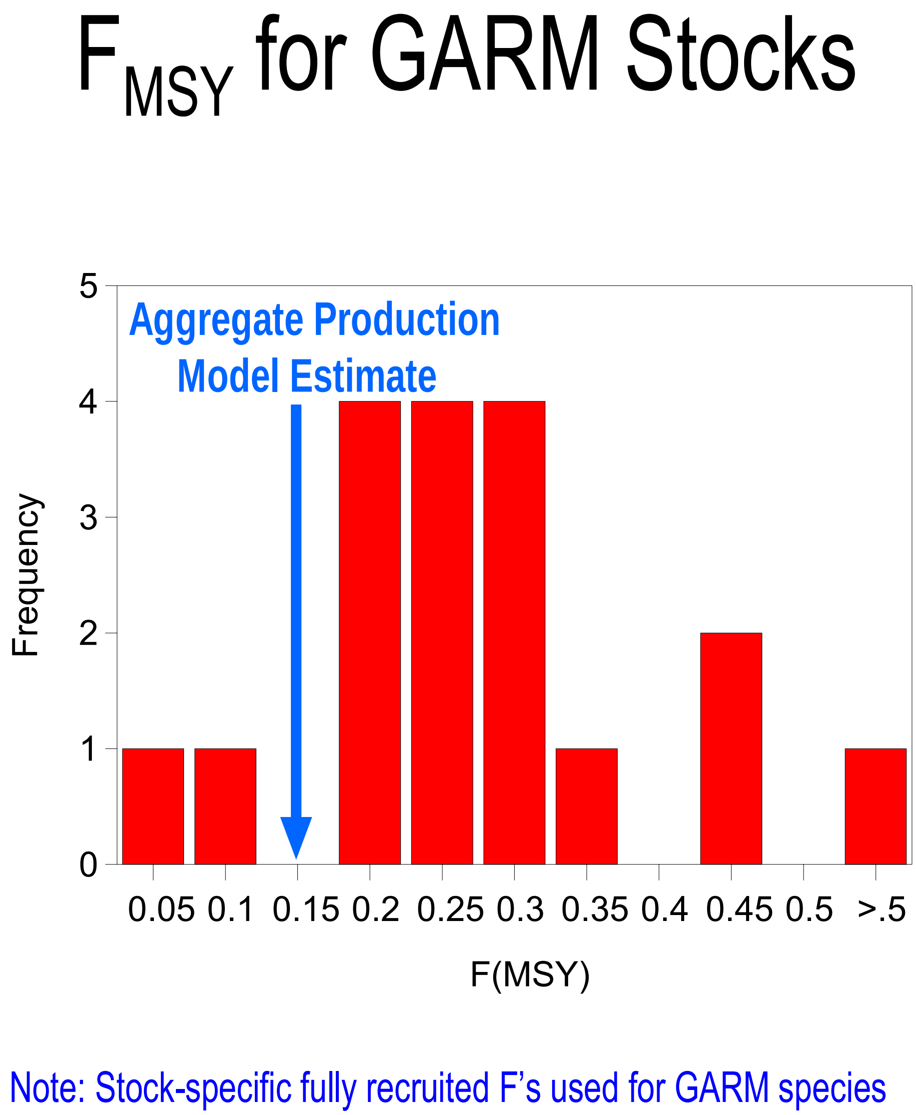

Figure 8. Comparison of GARM F_{MSY} from the aggregate ASPIC model with meta results for F_{MSY}s from the 19 GARM stocks.

CONCLUDING REMARKS (GARM Chair)

GARM III represents the culmination of work during November 2007 – August 2008 undertaken by the scientists at the NEFSC on the assessment of the status of 19 Northeast groundfish stocks. In aggregate, it is likely one of the most labor – intensive exercises undertaken by the Center, being an in-depth review of the data, models, assumptions and uncertainties involved in each assessment which has provided benchmarks which will be used until the next review. The GARM III was a very significant workload for the Center, which the Panel chairman acknowledges being of very high quality. He also would like to highlight the strong sense of 'team' and its leadership, particularly by Paul Rago, Jim Weinberg and Fred Serchuk that was evident throughout the review. Without this, the GARM III would not have been the success that it was. The Panel would like to acknowledge the invaluable contributions made at the meeting by all participants, particularly those of Doug Butterworth, who attended this and all the previous three GARM III reviews on behalf of the fishing industry. Finally, the Panel would like to thank Colleen Close and Andrea Strout for logistic support and Michele Traver, Andrea Strout and Laura Garner who assisted in report preparation. All these contributions made it possible for the GARM III 'assessment' review to meet its terms of reference.

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