B. Stock Assessment of Georges Bank Atlantic Cod (*Gadus morhua*) for 2012

SAW 55 Terms of Reference

Terms of Reference

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data and take into account the recommendations and subsequent work from the March 2012 MRIP workshop. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.

2. Present the survey data and calibration information being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Consider model-based (e.g. GLM) as well as design-based analyses of the survey data in developing trends in relative abundance. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Summarize the findings of recent workshops on stock structure of cod of the Northeastern US and Atlantic Canada.

4. Investigate the evidence for natural mortality rates which are time- and/or age-specific. If appropriate, integrate these into the stock assessment (TOR 5).

5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Consider feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets, and whether to use domed or flat selectivity-at–age for the NEFSC surveys. Provide a summary of steps in the model building process. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. Consider alternative parametric models of the stock recruitment relationship. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and any "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from Cod TOR-6).

8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass.

Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations

Executive Summary

ToR 1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data and take into account the recommendations and subsequent work from the March 2012 MRIP workshop. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.

Total Georges Bank (GB) cod commercial landings taken by USA and Canadian fleets, and Distant Water Fleets are available from 1893-2011 and total catch is available from 1960-2011. Total USA commercial landings ranged between 11,000 mt to 40,000 mt during 1960-1993, averaging about 21,000 mt. As stock biomass declined and year round closures were implemented in Dec 1994, landings declined, ranging between 3,000 mt – 15,000 mt during 1994-2011, averaging about 6,000 mt. Total Canadian landings ranged between 19 mt to 18,000 mt during 1960-1993 and after large quota restrictions in 1993, CA landings ranged between 600 mt to 8,500 mt with an average of about 1,600 mt during 1994-2011. Total USA and Canadian commercial landings of GB cod were 4,454 mt in 2011, a 13% increase from 2010. In 2011, the USA accounted for 83% of the total landings and Canada the remaining 17%.

Atlantic cod discarded on Georges Bank by the USA commercial fisheries were estimated from the NEFSC 1989-2011 observer data (NEFOP) and the 2010-2011 at-sea monitoring (ASM) data. Uncertainty estimates presented as coefficients of variation (CV) varied between 8% and 53% for the total GB discard estimates. Estimates of discards in the large mesh otter trawl fishery during 1978-1988 were hindcasted using a survey filter method. The Northern Demersal Working Group (WG) agreed that 'Delphi' determined mortality rates were to be applied to the final estimates of USA discards included in this assessment. In 2011, the USA commercial fisheries discarded 122 mt (CV = 12%) and the Canadian fisheries discarded 42 mt. USA discards accounted for 3% of the total catch and Canadian discards accounted for 1% of the total catch in 2011.

USA recreational catch of GB cod were estimated using data provided by the NOAA Marine Recreational Fisheries Statistics Survey (MRFSS, 1981-2003), and NOAA Marine Recreational Information Program (MRIP, 2003-2011). Recreational catch accounts for 1%-10% of the total catch since 1981, and in the past five years averaged 2% of the catch. In 2011 recreational catch was 219 mt, 5% of the total catch.

Total catch ranged between 11,000 mt to 62,000 mt during 1960-1993, averaging about 35,000 mt. After the year round closures were implemented in Dec 1994, catches declined, ranging between 4,000 mt – 16, 000 mt during 1994-2011, averaging about 8,400 mt. Total combined USA and Canadian catch of GB cod was 4,472 mt in 2011, a 13% increase from 3,950 mt caught in 2010. USA catches accounted for 83% and Canadian catches accounted for 17% of the total catch in 2011. The total catch at age for ages 1-10+ is summarized across all components: the USA commercial landings and discards, USA recreational landings and discards, and Canadian commercial landings and discards during 1978-2011. The total catch during 2011 was dominated by age 3 and age 4 fish of the 2008 and 2007 year class.

SEE Fishery Section for details.

ToR2.
Present the survey data and calibration information being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Consider model-based (e.g. GLM) as well as design-based analyses of the survey data in developing trends in relative abundance. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

NEFSC spring and autumn research bottom trawl surveys have been conducted off the Northeast coast of the USA since 1968 and 1963, respectively. Indices of abundance (stratified mean number per tow) and biomass (stratified mean weight per tow (kg)) were estimated from both the spring and autumn surveys for Georges Bank cod during 1963-2012. The indices were standardized for differences in fishing power of the *FRV Albatross IV* and the *FRV Delaware II,* for differences between catchability of BMV and polyvalent doors, introduced in 1985, and for the calibration of the *FSV H.B. Bigelow* catches to *FRV Albatross IV* units. Spring surveys were conducted with a Yankee #41 trawl during 1973-1981, and with a Yankee #36 for all other years through 2008, however, no fishing power coefficients are available for standardization. NEFSC spring and autumn catch per tow biomass and abundance indices show similar trends throughout the time series. Survey indices were variable but relatively stable between 1963 and the early 1980s, then gradually declined until about 1995 and have remained low since that time.

Canadian research bottom trawl surveys have been conducted in February on Georges Bank since 1986. Survey abundance indices have fluctuated and generally declined during 1990-2004 and have been increasing until 2010. Both the 1999 and 2000 indices increased primarily due to the recruitment of the 1996 year class.

The WG considered a GLM model to investigate the utility of model-based survey indices of abundance for the NEFSC spring and autumn survey data compared to the design based indices described above. The negative binominal model with factors of year, stratum, and time of day gave the best fit to the data for both spring and autumn. Overall, the model and design – based abundance and biomass trends are very similar. The WG concluded that the GLM is acting as a time series smoother and thus to best reflect uncertainty in the survey data, the WG recommends use of the design-based indices. The CVs from the GLM can be compared to those generated during the stage two iterative re-weighting process (in the ASAP model diagnostics) as the latter incorporates both observation and process error, similar to what the GLM produces.

A general linear model (GLM), first conducted in the 1993 assessment was repeated in the current assessment to estimate USA standardized fishing effort and commercial landings-per-unit-effort (LPUE) for Georges Bank cod during 1978-2011. The LPUE index indicates a declining trend from 1980 through 1995, a gradual increase to 2002 with another decline through 2006, then an increasing trend to 2011. The LPUE index was last estimated in the 1998 assessment but was not used as an index of abundance in the 1998 assessment or in any subsequent assessments. At that time, the post-1994 effort data was no longer considered to be equivalent to the historic 1978-1993 effort series due to increased management restrictions. The SAW 55 WG reviewed the updated analysis and recommended that the standardized LPUE not

be used in the SAW 55 assessment model for several reasons. The LPUE does not represent the entire stock for the entire time series since the index incorporates only the USA landings and effort data in the western part of the stock area since 1985. This was illustrated in a series of quarterly distribution maps of commercial LPUE during 1978-1994 and annual distribution maps of LPUE during 1994-2011. The Canadian fishery contributes about an average 25% to the overall landings and that is not accounted for in the GLM. In addition, there have been significant regulatory changes since 1994 and most recently the implementation of sector management, all resulting in spatial shifts in the fishery. All of these factors detract from the utility of the index as a measure of abundance. The WG recommendation to not utilize the index is consistent with the findings of the recent NEFSC-sponsored LPUE workshop.

A log-normal general linear model (GLM) was applied to recreational data to estimate an LPUE index (cod landed/angler hour) for Georges Bank cod during 1994-2011. The standardized LPUE index indicates a variable but declining trend from 1994 to 2002 and then a variable but increasing trend from 2003-2011. The WG had several concerns with respect to the applicability of the LPUE index. At the beginning of the time series, there is uncertainty whether the data reported was in pounds or in numbers (as required). There were a limited number of party/charter boats involved in the fishery (17), but only a few vessels (4) consistently fished over the time series. In addition, the fishery was conducted primarily in the westernmost part of the stock area. The WG concluded that the recreational LPUE index was not representative of the stock and should not be included in the assessment model.

SEE Stock Abundance and Biomass Indices Section for details

ToR 3. Summarize the findings of recent workshops on stock structure of cod of the Northeastern US and Atlantic Canada.

A work plan on the topic of Atlantic cod stock structure in the Northeast United States/Scotian Shelf region was recommended by the New England Fishery Management Council's Scientific and Statistical Committee. The work plan laid out a three-phase process for re-evaluating, and possibly revising, the spatial basis for assessment and management of Atlantic cod. The first phase was to review data (genetic, life history, tagging, etc.) in order to evaluate the "null hypothesis" of the status quo management units.

The NEFSC sponsored a public workshop on cod stock structure, held June 12-14, 2012, facilitated by the Gulf of Maine Research Institute to address Phase I. Invited participants from the fishing and scientific communities presented on a range of topics with opportunities for discussion. The full workshop report is available at http://www.gmri.org/mini/index.asp?ID=52&p=149.

Many of the workshop participants felt that there was compelling evidence that the current management units need to be revised. The Workshop did not reach any conclusions on what the most appropriate management units might be. This will require further data analysis and modeling in order to complete Phase I of the SSC recommended process. The workshop report also identifies gaps in the data and analyses and recommended action to address them.

The Workshop did not explicitly address and propose the next steps in the process. The Steering Committee recommended that an inclusive but focused Working Group meeting be held involving a small group of Canadian and US scientists to consider the results of the Workshop. This Working Group should be provided the short-term data and analyses identified as missing by the Workshop. Using that information, as well as the conclusions from the Workshop, the Working Group should determine the most appropriate representations of biological stock structure to complete Phase I of the process. The results from this Working Group meeting should be evaluated through an independent peer-review process.

Since the phased review process of cod stock structure that was recommended by the SSC has not been completed, no changes to stock structure were incorporated into this assessment.

SEE Background section

ToR4. Investigate the evidence for natural mortality rates which are time- and/or age-specific. If appropriate, integrate these into the stock assessment (TOR 5).

Instantaneous natural mortality (M) has been assumed to be 0.2, constant and age-invariant, in all previous assessments of Georges Bank cod. In this benchmark review, the WG investigated several life-history analyses and also tagging results to evaluate the M assumption. In the meta-analysis of life history-based estimates, M estimates ranged between 0.21 - 0.45. These variable estimates and the conflicting result of a decrease in condition in the spring but not the autumn, as evidenced by both the Fulton's K and the differences in seasonal length – weight equations, make it difficult to make a definitive conclusion on a hypothesis for a shift in life history parameters. It should be noted that maximum age as high as 15 has been observed in the commercial fishery as recently as 2011, and age 12 in the more recent years, which suggests comparable natural mortalities relative to earlier in the time series.

The method of Lorenzen (1996) was used to provide an aged-based estimate of M. This method, which is based upon the relationship between body weight and M across a wide range of species, was used in SAW 54 to provide age-based estimates of M for Southern New England – Mid Atlantic Bight yellowtail flounder. The peer review panel of SAW 54 (O'Boyle 2012) considered that applying an inter-species relationship to infer within-species dynamics was an over-interpretation of the method. While M no doubt may be age-specific, the pattern estimated from the Lorenzen method may not be appropriate. Recent work performed by Jon Deroba (NEFSC) and Amy Shueller (SEFSC) (*https://afs.confex.com/afs/2012/webprogram/Paper10183.html*) indicated that using constant or age varying mortality would have similar impacts on the assessment. The SAW 55 WG thus concluded that the parsimonious approach is for the SAW 55 assessment models to use a single *M* for all ages.

Two working papers considered the predator field of cod in the Gulf of Maine-Georges Bank area. Link (2012) noted that directed piscivory of cod by other fish was not common, with less than 200 cod in over 550,000 stomachs observed the survey time series. Similarly, the evidence for cannibalism is weak with only 20 cod found in over 20,000 stomachs. Studies to date suggest that M due to fish predation is likely low and is focused on juvenile and smaller size groups. Waring (2012) considered marine mammals as a potential source of elevated M in the Gulf of

Maine area. Firm estimates on the size of the current herds are not available. Notwithstanding this, the food habit research suggests that cod mortality due to seals is low. Additionally, while seals are known to prey on cod, they are generalist feeders and the importance of cod in the diet of Gulf of Maine area grey seals is unknown. There is limited information that suggests that cod represent only a minor component of harbor seal diet along the Maine coast.

An analysis of tagging data collected during 2003 – 2006 to jointly estimate natural and fishing mortality was undertaken during GARM III. This analysis was updated for SAW 55 and contrary to the earlier work, this analysis was not length-based. Estimates of M ranged from 0.4 to 0.7 for Georges Bank cod tag returns of greater than 50 cm. The analysis provided evidence of significant cod movements between GM and GB and area 4X on the order of 4.1% to 29.7%. While M was relatively high compared to current estimates, fishing mortality (F) was comparatively low, prompting discussion on whether or not it was representative of the fishery due to local effects. The results were highly sensitive to the assumed return rate of high-reward tags. High-reward return rates on the order of 50% were associated with Georges Bank cod M estimates of 0.4, with M increasing as the high-reward tag rate increased. Model preference (based on log-likelihood function) was for assumptions of near-100% on reporting rates of the high-reward tags. Estimates of F were inversely related to the M response with F declining with higher assumptions of high-reward tags reporting rates. Across all ranges total mortality (Z) was estimated about 0.8-0.9.

Concerns were raised with the tagging conducted in the Cape Cod area, which represented over 50% of the data in the database, which prompted the greater than 50 cm analysis. The tagging had been conducted employing a wide range of expertise with mostly small cod being tagged. This in combination with the warm water in the area may have resulted in higher tag induced mortality than assumed in the model. There were additional concerns with the assumed tag reporting rate (100%) for high reward tags. There is evidence to suggest differential reporting rates among some sectors of the commercial fishery, most notably the reporting rate by gillnet vessels was five times lower than that of trawl vessels. It is unknown if these same reporting trends also apply to the high-reward tags. There was also discussion on the age groups of cod represented by the study. Within the subset of greater than 50 cm fish, only about 10% of the released cod were greater than 80 cm. GB cod at 50 cm are 2 years old on average, implying that the estimates of M are for ages 2 to 5 fish but weighted towards the younger ages.

The SAW 55 WG discussed how best to use these estimates of M. It was hesitant to conclude that M was in the range of 0.6 – 0.7 and to recommend that these estimates be directly included in the assessment models. Rather, the tagging analysis is another form of modeling that should be considered. The WG discussed the availability of historical tagging to which the current estimates could be compared. It was reported that tagging work conducted in the Gulf of Maine area (with a smaller percentage of tagging done on GB) during the 1970s and 1980s suggested M estimates in the order of 0.2 – 0.3 whereas tagging in the 1990s was suggestive of M similar to the more recent results. These observations are based upon unpublished work that could not be corroborated at the meeting. Much of the historical work had been focused on cod movements and did not provide estimates of natural, fishing or total mortality. Further, concerns were raised that there was no obvious mechanism (e.g. predation) that could explain a recent increase in M, although it was countered that no mechanism has been identified for the current M estimate of

0.2, though this estimate is supported by life history parameters. The SAW 55 WG recommended profiling natural mortality across both the historical and more recent periods of the assessment to inform the discussion as to whether or not there has been a long-term change in M. The WG agreed that an option (M-ramp) with an M change should be considered as an alternate to a base model which would assume no change in M (i.e. M = 0.2).

See Life History- Natural mortality section

ToR5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Consider feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets, and whether to use domed or flat selectivity-at–age for the NEFSC surveys. Provide a summary of steps in the model building process. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.

The Georges Bank cod stock assessment has historically been assessed as an age-based assessment employing virtual population analysis (VPA). Given the biased retrospective pattern observed in recent assessments the 2012 benchmark assessment review presented the opportunity to explore a new model formulation to mitigate the retrospective bias. The WG chose to use a forward projecting model, ASAP (Age Structured Assessment Program). To bridge between the previous VPA formulation and the ASAP model formulation the following models were presented: a VPA updated through 2012, a VPA-like ASAP formulation, and the final accepted BASE ASAP formulation.

BASE ASAP
The catch at age includes combined USA and Canadian landings and discards, and USA recreational landings from 1978-2011 for ages 1-10+. Swept-area estimates of abundance were used to calibrate the model include the NEFSC 1978-2011 spring survey indices for ages 1-10, the NEFSC autumn survey indices for ages 1-6, and the Canadian DFO 1986-1992, and 1995-2011 survey indices for ages 1-10. Input to the Base ASAP model includes the MRIP equivalents and the application of ‘delphi’ discard mortality rates.

A multinomial distribution was assumed for both fishery catch at age and survey age compositions. The survey time series were *not* split between 1994/1995 as in the VPA. Since exploratory runs indicated similar trends in spawning stock biomass (SSB) and F between formulations with the survey time series split or not split, the WG agreed to proceed with no split in the survey time series.

Both survey and fishery selectivity were flat-topped. Examination of the logistic fit of the four fishery blocks clearly indicated only 2 blocks are appropriate given the similarities between blocks 1 and 2 (1978-1982, 1983-1993) and blocks 3 and 4 (1994-1999, and 2000-2011). The final effective sample size (ESS) was based on the stage 2 multiplier as described by Francis (2011) for both catch and survey age composition.

Fully recruited F (unweighted, ages 5-8), not adjusted for retrospective bias was estimated at 0.23 in 2011, a 21% decrease from 2010. SSB in 2011, not adjusted for retrospective bias, was estimated at 22,217 mt, a 29% increase from 2010. Recruitment (millions of age 1 fish) of the 2003 year class (7.0 million), not adjusted for retrospective bias, is now estimated to be smaller than the 1998 year class (11.9 million). The 2008 year class (8.0 million) and 2009 (8.1 million) are similar in size to the 2003 year class.

A retrospective analysis was performed to evaluate how well ASAP calibration would have estimated F, SSB, and recruits at age 1 for seven years (2004-2010) prior to the terminal year, 2011. While the magnitude of the retrospective bias is slightly less than that of the VPA, the pattern of over estimating SSB and underestimating F relative to the terminal year continues in this model. The WG agreed to address the retrospective bias in the BASE ASAP by adjusting the terminal year results by applying the 7-year rho factor.

MCMC simulation was performed to obtain posterior distributions of the SSB and average F_{5+} time series. The 2011 SSB estimate, not adjusted for retrospective bias, of 22,217 mt has a 90% PI of 15,809 mt – 31,993 mt and the 2011 average $F_{5+} = 0.23$, not adjusted for retrospective bias, has a 90% PI of 0.15- 0.34.

Alternative ASAP Models
Given the continued retrospective bias in the ASAP model results and the discussion of possible shifts in M in recent years based on tagging data, the WG agreed to explore two alternative models. Both of the alternatives address the issue of losses due to unaccounted for mortality (i.e. 'missing catch'), either from unaccounted for natural mortality, or from unaccounted for removals from the fishery (undocumented discard mortality (e.g. mortality experienced by fish escaping the gear during commercial operations), unreported/missing dealer or logbook statistics, biased or underestimated discards).

See Assessment Model Formulation Section

ToR 6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, and MSY) and provide estimates of their uncertainty. Consider alternative parametric models of the stock recruitment relationship. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and any "new" (i.e., updated, redefined, or alternative) BRPs.

The current non-parametric biological reference points (BRP) for GB cod, based on $F_{40\%}$ were revised in February 2012 based on VPA model results are as follows:

SSB_{MSY} proxy= 140,424 mt,
F_{MSY} proxy ($F_{40\%}$) = 0.23,
MSY proxy= 28,774 mt.

Base Model-SARC 55 accepted model
The GARM III BRP Panel selected $F_{40\%}$ from the non-parametric yield-per-recruit (YPR)

analysis as the basis for the estimation of BRPs for GB Atlantic cod. The SAW 55 WG evaluated various proxies for F_{MSY} to determine if $F_{40\%}$ was still appropriate by comparing estimated SSB and recruitment ratios with expected spawning biomass per recruit over a range of fishing mortalities (F=20% to F80% in 5% increments) to investigate the potential for replacement under equilibrium assumptions (i.e. constant harvest rate and biology over the lifespan). An analysis of replacement lines under recent productivity (approximately last 10 years) indicated that 90% of the years were above the $F_{40\%}$ replacement line for the Base ASAP model thus $F_{40\%}$ was still an appropriate F_{MSY} proxy.

Non-parametric estimates of MSY and SSB_{MSY} based on $F_{40\%}$ from YPR analysis were estimated using the 33-year time series mean recruitment as:
$F_{40\%}$ = 0.18, MSY = 17,391 mt, SSB_{MSY} = 107,291 mt.

Long term stochastic projections out to 100 years at F_{MSY} = 0.18, provided the following non-parametric biomass reference points:

$F_{40\%}$= 0.18,
MSY = 30,622 mt, (80% CI: 25,450- 36,302),
SSB_{MSY} = 186,535 mt (80% CI: 155,398 - 220,756)

The WG determined that the relationship between stock and recruitment during 1978-2011 did not provide support for use of either a Ricker or Beverton-Holt (BH) function. When a BH was estimated within the BASE ASAP model, the relationship was relatively linear with unexploited SSB and unexploited recruitment being estimated essentially to infinity. For this reason, the WG agreed that BRPs for GB cod continue to be based upon BMSY proxies.

See Biological Reference Points Section

ToR 7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

Status of Stock – VPA
Based on the updated 2012 VPA model results, unadjusted for retrospective bias, the stock is overfished (SSB_{2011} = 12, 532 < ½ SSB_{MSY}) and overfishing is occurring (F_{2011} = 0.69 > $F_{40\%}$). The stock is not rebuilt. MSY proxy BRPs continue to be appropriate for this model given that the relationship between stock and recruitment does not support the use of a parametric model.

See Biological Reference Points Section

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from Cod TOR-6).

Status of Stock – BASE ASAP
Based on the accepted BASE ASAP model results, adjusted for retrospective bias, the stock is overfished (SSB_{2011} = 13,216 mt < ½ SSB_{MSY}) and overfishing is occurring (F_{2011} = 0.43 > $F_{40\%}$). The stock is not rebuilt. The WG agreed that MSY proxy BRPs are appropriate for this model given that the relationship between stock and recruitment does not support the use of a parametric model

See Biological Reference Points Section

ToR 8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

Short term stochastic projections under F = 75%F_{MSY} were performed for the BASE model results to estimate landings and SSB during 2013-2015. Recruitment was estimated from a 2-stage cumulative distribution function (CDF) associated with a SSB breakpoint of 50,000 mt. Catch in 2012 was estimated based on year-to-date catch (commercial and recreational landings and discards) and assumed catch for the remainder of the year.

The results of the short term projections indicate that for the BASE ASAP, under an 75%F_{MSY} = 0.14, catch is projected to initially decrease but then increase by 2015 to a catch higher than that in 2012, and SSB is projected to increase in each year through 2015. The rebuilding plan for GB cod requires that the stock reach SSB_{MSY} by 2026, however, the Frebuild projection was not conducted at this time.

See Projections Section

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
Consequence Analysis
The risks associated with management actions taken during 2013 – 2015 were examined by undertaking stock projections under the competing assumptions of the state of nature. For instance, if the true state of nature is that natural mortality has remained unchanged at 0.2 and that stock productivity is best reflected by the M = 0.2 model, then the consequences of management actions taken by setting projected catch according to 75% F_{MSY} based on the two alternative states of nature ("M ramp" and "Catch Multiplier") were examined.

When management actions are correctly based upon a particular state of nature an increase in SSB is projected until 2015 for the three options, this particularly the case for Catch Mult. If the management actions are correctly based upon the 'true' state of nature, the base and catch mult

models indicate that, in 2013, the stock is in an overfished state. In contrast, the MRamp model indicates that the stock would not be in an overfished state in 2013.
In regards to the consequences of mis-specifying the state of nature, there is little impact on the absolute estimate of SSB (but not status), although assuming an M ramp when increased recent catch is true results in less than 'planned' growth in SSB. Assuming an Mramp when either of the other models is true also has significant implications for 2013 F_{FULL} and catch. In each case, catch would be higher than 'planned', resulting in higher than 'planned' catch. The consequences of assuming the base and catch mult models when Mramp is true are relatively modest in absolute terms. However, due to the changes in the reference points, the 2013 status changes depending on the basis of the management action and the state of nature.

If the Base model is the true state of nature, assuming increased recent catch when setting catch will result in the same status (overfished but not overfishing) while assuming Mramp when setting catch will result in being overfished and overfishing. If the Mramp is the true state of nature, assuming either of the other options when setting 2013 – 2015 catch will not change status (not overfished and no overfishing). If catch mult is the true state of nature, while status does not change if setting catches is based upon the base option (not overfished and no overfishing), status changes to overfished and overfishing if catch are based upon the M ramp option.

In summary, the Base option is the most sensitive of the three to setting 2013 -2015 catch according to the alternate states, while the Mramp option is the least sensitive.

See Appendix Section

c.Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

Productivity of the stock is low with two decades of poor recruitment and a truncated age structure. Natural mortality may have increased in recent years, thus accounting for the low productivity although evidence for such an increase is lacking in the food habits data. However, the analysis of 2003-2006 tagging data suggests M was high during the years tagged cod were released. Cod have been shown to have low hatching rate for 1st and 2nd time spawners (13% and 62%) (Trippel 1998), suggesting that an age structure of older repeat spawners would likely be more productive, under favorable environmental conditions. Given the uncertainty in the magnitude of M and the overfished state of the stock, at 7% of SSB_{MSY} the stock is vulnerable to an allowable biological catch (ABC) quota that is too high.

See Summary Section

ToR 9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

The WG reviewed the status of previous research recommendations and proposed new ones to address issues raised during the three WG meetings, indicating priorities (High, Medium, Low)

as it felt appropriate. Some of these recommendations were felt to be common to both Gulf of Maine and GB cod.

The SAW 55 WG reviewed the status of previous research recommendations and proposed new ones to address issues raised during the three WG meetings. The WG proposed six new research recommendations which primarily focus on improving estimates of natural mortality and the survival of post-capture fish as well as advances in assessment methods. All new research recommendations proposed by the SAW 55 WG have been assigned relative priorities as appropriate. Many of these recommendations were felt to be common to both the Gulf of Maine and Georges Bank Atlantic cod stocks and are labeled as 'general'.

See Recommendations Section.

B. Georges Bank Atlantic Cod *Gadus morhua*

Background

Distribution and Stock Structure
The Atlantic cod, *Gadus morhua*, is a demersal gadoid species found on both sides of the North Atlantic. In the Northwest Atlantic, cod occur from Greenland to North Carolina (Collette and Klein–MacPhee 2002). In US waters (Figure B1), cod are assessed and managed as two stocks: (i) Gulf of Maine and (ii) Georges Bank and southward (Serchuk et al. 1994)

Recent reviews of historical and contemporary tagging studies (O'Brien et al. 2005, Tallack 2007, Loehrke and Cadrin 2007) suggest that there is movement of fish between the Gulf of Maine and Georges Bank stocks with the degree of mixing < 30% (Hunt et al. 1999, Tallack 2009, Miller 2012). The SAW 55 WG reviewed some preliminary analyses evaluating possible impacts of stock mixing on assessment results (Chen and Cao 2012). Overall, the results indicated that the lack of consideration of inter-stock mixing had little impact on the Gulf of Maine cod assessment results. By inference, little impact would be expected for the GB cod stock model results. The importance of the quality of the catch information was highlighted. The WG expressed several concerns and possible areas of improvement in the analysis. While the study is a work in progress with many assumptions and issues to be resolved, it highlighted the value of undertaking modeling to explore complex spatial processes influencing cod in the Gulf of Maine – Georges Bank region.

Several meta-analyses of the life history parameters of Atlantic cod in the region have been conducted over the last four decades that generally support the current stock boundaries. These investigations have highlighted differences in both the growth and maturity rates between the Gulf of Maine and Georges Bank stocks (Pentilla and Gifford 1976, Begg et al. 1999).

A work plan on the topic of Atlantic cod stock structure in the Northeast United States/Scotian Shelf region was recommended in 2012 by the New England Fishery Management Council's Scientific and Statistical Committee. The work plan laid out a three-phase process for re-evaluating, and possibly revising, the spatial basis for assessment and management of Atlantic cod. The first phase was to review data (genetic, life history, tagging, etc.) in order to evaluate the "null hypothesis" of the status quo management units.

The NEFSC sponsored a public workshop on cod stock structure, held June 12-14, 2012, facilitated by the Gulf of Maine Research Institute to address Phase I. Invited participants from the fishing and scientific communities presented on a range of topics with opportunities for discussion. The full workshop report is available at http://www.gmri.org/mini/index.asp?ID=52.

Many of the workshop participants felt that there was compelling evidence that the current management units need to be revised. The Workshop did not reach any conclusions on what the most appropriate management units might be. This will require further data analysis and modeling in order to complete Phase I of the SSC recommended process. The workshop report also identifies gaps in the data and analyses and recommended action to address them.

The Workshop did not explicitly address and propose the next steps in the process. The Steering Committee recommended that an inclusive but focused Working Group meeting be held involving a small group of Canadian and US scientists to consider the results of the Workshop. This Working Group should be provided the short-term data and analyses identified as missing by the Workshop. Using that information, as well as the conclusions from the Workshop, the Working Group should determine the most appropriate representations of biological stock structure to complete Phase I of the process. The results from this Working Group meeting should be evaluated through an independent peer-review process.

Since the phased review process of cod stock structure that was recommended by the SSC has not been completed, no changes to stock structure were incorporated into this assessment.

Assessment History

The Georges Bank (GB) Atlantic cod *Gadus morhua* stock was last assessed and peer reviewed in February 2012 (O'Brien et al. 2012) . Georges Bank cod assessments were first conducted during the International Convention for the Northwest Atlantic Fisheries (ICNAF) era. In all contemporary assessments the age-structured Virtual Population Analysis (VPA) model has been applied. Since the inception of the SARC/SAW process the GB cod stock has been assessed in 1985 (Anthony and Murawski 1985), 1986 (Serchuk and Wigley 1986), 1988 (Serchuk 1988), 1990 (Serchuk and Wigley 1990), 1991 (Serchuk et al. 1991), 1992 (Serchuk et al 1992), 1993 (Mayo et al. 1994), 1994 (Serchuk et al. 1994), and 1997 (O'Brien 1999). The stock was assessed in the Transboundary Resources Assessment Committee (TRAC) in 1998 (O'Brien and Cadrin 1999), 2000 (O'Brien and Munroe 2000), and 2001 (O'Brien and Munroe 2001). The stock was next assessed by the Groundfish Assessment Review Meeting (GARM) in 2002 (O'Brien et al. 2002), 2005 (O'Brien et al 2006), and 2008 (O'Brien et al. 2008). The 2012 assessment (this document) is being assessed by SARC 55.

Serchuk and Wigley (1992) provide a very thorough and comprehensive historical review of GB cod assessments and fishery. More recently, in 2002, the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish established biological reference points (BRPs) for GB cod based on a Beverton-Holt stock recruit relationship with an assumed prior for the unfished recruitment from the VPA data (NEFSC 2002). The BRPs were: F_{MSY} = 0.175, MSY = 35,200 mt and SSB_{MSY} = 217,000 mt. The MSY included commercial landings only and did not include recreational landings or discards. In 2008, BRPs for GB cod were re-established by the GARM III BRP Review Panel (O'Boyle 2008). Based on a non-parametric YPR analysis the F_{MSY} proxy was set as $F_{40\%}$ of maximum spawning potential, and SSB_{MSY} and MSY were estimated based on long-term projections at $F_{40\%}$.

BRPs for recent assessments:

Stock Assessment		$F_{0.1}$	$F_{40\%}$	F MSY	B_{MSY} (mt)
SAW	2000	0.18			108,000
SAW	2001	0.18			108,000
GARM I	2002			0.18	217,000
GARM II	2005			0.18	217,000
GARM III	2008		0.25		
Update	2012, Feb		0.23		

In the 2008 assessment (O'Brien et al. 2008), fully recruited F shifted from age 4, as seen in previous assessments, to fully recruited F at age 5. This was due, in part, to increases in minimum mesh size requirements to 6.5 inch square or diamond mesh that were established in May 2002. From 1999 to 2002, mesh requirements had been 6.5 inch square or 6.0 inch diamond mesh. To address the retrospective bias all survey times series of abundance used for calibration were split between 1994/1995. The split lessened the retrospective bias and the perceived 'change in catchability' was considered to alias an unknown mechanism that is the cause of the retrospective bias.

Fishery

Management

Georges Bank Atlantic cod is a transboundary stock that historically had been harvested by both USA and Canadian fishing fleets. Since October 1984, with implementation of the Hague Line by the International Court of Justice, delimiting the EEZ boundary, neither country has had access to the full stock, only those portions within their respective waters.

Since 1970, two areas of GB have been closed to USA fishing during some or all of the months from February-May. In December of 1994, these areas, designated Closed Areas I and II were closed year-round (Figure B1). Also since 1994, the Canadian fishery for GB cod (SA 551-552) has been closed from January through May, and since 2005, February through May.

Prior to 1977, GB cod was managed by quota allocation within ICNAF. Since 1977, USA commercial and recreational fisheries for cod have been managed under the New England Fishery Management Council's (NEFMC) Northeast Multispecies Fishery Management Plan (FMP). Under this FMP, cod were included in a complex of 16 groundfish species managed by time/area closures, gear restrictions, and minimum size limits. Starting in 1994, this complex was managed using direct effort controls, including a moratorium on permits and days-at-sea restrictions under Amendments 5, 7, and 13 to the FMP. Trip limits were in effect for both Gulf of Maine and Georges Bank cod. Amendment 9 established initial biomass rebuilding targets (NEFMC 1998) and defined control rules which specify target fishing mortality rates and corresponding rebuilding time horizons. Amendment 13 implemented formal rebuilding plans within specified time frames, based on revised biomass and fishing mortality targets derived by the Working Group on Re-evaluation of Biological Reference Points for New England Groundfish (2002) for 18 groundfish stocks reviewed at the 2002 Groundfish Assessment Review Meeting (GARM) (NEFSC 2002a, 2002b). The goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to initially rebuild above minimum biomass thresholds and, ultimately, to remain at or near target biomass levels. Framework 42 was implemented in 2006, establishing B_{MSY} targets and F_{MSY} thresholds, as well as formal rebuilding plans for overfished stocks, reviewed at the 2005 Groundfish Assessment Review Meeting (GARM II) (NEFSC 2005). In addition, a formal quota-sharing agreement was implemented in 2004 between Canada and the USA to share the harvest of cod in the transboundary eastern GB cod management unit. The agreement includes total allowable catch quotas for each country as well as in-season monitoring of the USA catch of cod on eastern Georges Bank. The Canadian fishery on Georges Bank is managed under an individual quota

system.

In 2010, the domestic groundfish fishery experienced a major management change with the passage of Amendment 16. Amendment 16, with the introduction of annual catch limits (ACLs), represented a return to the use of hard TACs. Additionally, 17 new groundfish sectors were approved and those vessels not members of a groundfish sector were subject to additional cuts in DAS and restrictive trip limits. Vessels fishing under the sector management were exempt from DAS restrictions and instead, each sector was given a share of the total commercial groundfish sub-ACL. How the catch was divided up amongst sector vessels or how catch was allocated throughout the year was left to the sole discretion of the sector. One of the requirements of Amendment 16 was an increase in the overall level of observer coverage. This was accomplished using observers trained through the existing Northeast Fisheries Observer Program (NEFOP) as well as a new class of observers termed At-Sea Monitors (ASMs). The data collection protocols for ASMs were restricted to catch estimation and the collection of limited biological information (e.g., lengths). The recent shift to a catch share system in 2010 appears to have dramatically reduced discards but it is too soon to fully understand the overall impacts of the sector management system. Details of USA management measures, not totally inclusive, are in Appendix B1. Table 1 and Canadian management measures are listed in Appendix B1. Table 2.

Commercial Data Collection

The collecting and processing of the commercial fishery and landings data has been conducted using two methods during the time series. Prior to 1994, information of the catch quantity, by market category, was derived from reports of landings transactions submitted voluntarily by processors and dealers. More detailed data on fishing effort and location of fishing activity were obtained for a subset of trips from personal interviews of fishing captains conducted by port agents in the major ports of the Northeast. Information acquired from the interview was used to augment the total catch information obtained from the dealer.

In 1994, a mandatory reporting system was initiated requiring anyone fishing for or purchasing regulated groundfish in the Northeast to submit either vessel trip reports (VTR; logbooks) or dealer reports, respectively (Power *et al.* 1997 WP). Information on fishing effort (number of hauls, average haul time) and catch location were now obtained from logbooks submitted to NMFS by vessel captains instead of personal interviews. Estimates of total catch by species and market category were derived from mandatory dealer reports submitted on a trip basis to NMFS. Since 1994, catches by market category were allocated to area fished using a multi-tier trip-based allocation procedure as described at the GARM III data meeting (Wigley et al. 2008). Dealer electronic reporting was implemented in May 2004, however, this did not result in any changes to the allocation procedure. The uncertainty in allocation of landings to an area, the random component of the allocation, estimated for yellowtail flounder and haddock stocks (Legault et al 2008) indicated very low magnitude of uncertainty. The conclusion is that this source of uncertainty is not of consequence within NEFSC stock assessments.

Commercial Catch

Commercial Landings

Total GB cod commercial landings taken by USA and Canadian fleets, and Distant Water Fleets

(DWF) are available from 1893-2011 (Figure B2a) and total catch is available from 1960-2011 (Table B1, Figure B2b). Landings data were reported by area (e.g. Georges Bank and Gulf of Maine) only since 1932 (Serchuk and Wigley 1992) thus the landings prior to that time have been prorated to stock area. USA cod landings are generally highest in the second calendar quarter (April-June) and are taken predominantly from the western part of Georges Bank (statistical areas (SA) 521-522, 525-526, 537-539, and Subarea 6) throughout the year (Table B2a-b). Landings from SA 537-539 and Subarea 6 contribute a small percentage to total landings. The majority of the landings from the eastern part of Georges Bank (SA 561-562) are taken in the first and second calendar quarter (Table B2a-b). USA cod landings are taken primarily by otter trawl gear and gill net gear (Table B3). Landings are classified into several market categories but are primarily landed as either: 'scrod', 'market' or 'large'. The 'market' category followed by the 'scrod' category generally represents the majority of landings (Figure B3).

Since 1994, the Canadian fishery for GB cod (SA 551-552) has been closed from January through May, and since 2005, February through May. Canadian landings are taken primarily during the third quarter (July-September) by long line and otter trawl gear.

Total USA commercial landings ranged between 11,000 mt to 40,000 mt during 1960-1993, averaging about 21,000 mt. As stock biomass declined and year round closures were implemented in December 1994, landings declined, ranging between 3,000 mt – 15,000 mt during 1994-2011, averaging about 6,000 mt. Total Canadian landings ranged between 19 mt to 18,000 mt during 1960-1993 and after large quota restrictions in 1993, CA landings ranged between 600 mt to 8,500 mt with an average of about 1,600 mt during 1994-2011.

Total USA and Canadian commercial landings of GB cod were 4,454 mt in 2011, a 13% increase from 2010. In 2011, the USA accounted for 83% of the total landings and Canada the remaining 17%.

Commercial Discards

Atlantic cod discarded on Georges Bank by the USA commercial fisheries were estimated from the NEFSC 1989-2011 observer data (NEFOP) and the 2010-2011 at- sea monitoring (ASM) data using the Standardized Bycatch Reporting Methodology (SBRM) as recommended by the GARM III Data meeting (GARM 2007, Wigley et al. 2007). Comparison of the NEFOP and ASM data showed no significant differences, so the data was used in combination. Using observed tows only, a ratio of discarded cod to total kept of all species (d:k) was estimated on a trip basis by gear, quarter, and area (western GB, eastern GB, and Southern New England). Discard estimates were derived for the large and small mesh otter trawl, large mesh gillnet, longline, and scallop gears. Large and small mesh was defined by mesh greater or lesser than 5½ inches, respectively. If there were insufficient trips per quarter (less than 2) d:k was imputed from the half year or full year estimate. Total discards by weight for each gear (Table B4) were estimated from the product of d:k and total commercial landings of all species in the gear/quarter/area stratum. Uncertainty estimates presented as coefficients of variation varied between 8% and 53% for the total GB cod discard estimates (Table B4). Estimates of cod discarded in the large mesh otter trawl fishery during 1978-1988 were hindcasted using a survey filter method (O'Brien and Esteves 2001, Mayo *et al*. 1992, Palmer et al. 2008).

A NEFSC sponsored workshop was held in July 2012 to determine the mortality of discarded cod caught in gear off the coast of New England. The Northern Demersal Working Group (WG) agreed that the following 'Delphi' determined mortality rates were to be applied to the final estimates of USA discards included in this assessment.

Mortality Rate (%)					
	Otter trawl	Gillnet	Longline	Hook and line	Recreational
25TH PERCENTILE	70	68	26	13	20
MEDIAN	75	80	33	20	30
75TH PERCENTILE	80	86	39	25	35

Cod discards in the Canadian fishery are not expected given the regulation that prohibits discarding of undersized fish. However, discards in the groundfish fishery have been estimated with the ratio of sums method, using the difference in ratio of cod to haddock from observed and unobserved trips. There is a lack of observer data for both mobile and fixed gear prior to 1997; however, estimates of cod discards in the groundfish fishery are provided for 1997-1999, 2005-2006, 2008-2011 (Wang and O'Brien 2012). The Canadian scallop fishery has been prohibited from landing cod since 1996. Discards in this fishery were estimated using the ratio of discards to scallop effort from 1978-2004 (Van Eeckhaute et al. 2005) and using a 3-month moving window estimation of discard rate per hour to monthly effort in hours since 2005 (Gavaris et al. 2007) (Table B1).

In the USA fishery, otter trawl gear accounts for the majority of the discarded fish in western and eastern Georges Bank and in Southern New England. Discards have ranged between 100 mt - 600 mt, representing 5% of the USA commercial catch on average (Table B1). In the Canadian fishery, discards represent about 9% of the Canadian catch on average (Table B1).

In 2011, the USA commercial fisheries discarded 122 mt (CV = 12%) of GB cod and the Canadian fisheries discarded 42 mt of GB cod. USA discards accounted for 3% and Canadian discards accounted for 1% of the total GB cod catch in 2011 (Table B1, Figure B2b).

Recreational Catch
Landings and Discards
USA recreational landings (a + b1) and discards (b2) of GB cod were estimated using data provided by the NOAA Marine Recreational Fisheries Statistics Survey (MRFSS) from 1981-2003, and from the NOAA Marine Recreational Information Program (MRIP) from 2004-2011. Interview data from all ports south of Massachusetts were considered to be from the GB stock. Data collected from Massachusetts was assigned to the Gulf of Maine (GM) or GB stock based on the port landed; any data from ports on the south side of Cape Cod were considered to be from the GB stock while those on the north side were assigned to the GM stock.

A MRIP/MRFSS ratio of means for 2004-2011 was applied to the 1981-2003 MRFSS numbers to convert to MRIP equivalents. The ratio of 1.01 was applied to numbers landed (a + b1) by half year and the ratio of .65 to numbers discarded (b2) by half year (Table B5a). The uncertainty of the recreational catch estimates, measured as percent standard error (PSE), is generally less than 20% for Massachusetts catch, but more variable and higher for Rhode Island and New York

catches (Table B5b).

Recreational catch accounts for 1%-10% of the total catch since 1981, and in the past five years averaged 2% of the catch. In 2011 recreational catch was 219 mt, 5% of the total catch.

Total Catch
Total catch ranged between 11,000 mt to 62,000 mt during 1960-1993, averaging about 35,000 mt. After the year round closures were implemented in December 1994, catches declined, ranging between 4,000 mt – 16, 000 mt during 1994-2011, averaging about 8,400 mt.

Total combined USA and Canadian catch of GB cod was 4,472 mt in 2011, a 13% increase from 3,950 mt caught in 2010. USA catches accounted for 83% of the total catch in 2011 and Canadian catches accounted for remaining 17%.

Sampling intensity
The numbers of samples taken to characterize the length and age composition of the USA and Canadian commercial cod landings from GB are summarized in Tables B6a and B6b. In the USA fishery, sampling intensity by market category has improved since 1978, in part due to the decline in landings over time. Sampling intensity has been relatively high since 2003, ranging between one sample per 4 mt to 1 sample per 53 mt (Table B6a). These estimates are biased, however, since samples are usually less than the recommended 100 fish/sample, particularly for the 'large' market category. In the USA fishery the average number of fish measured per sample was 57 and the average number of fish aged per sample was 15 during 2011. In the Canadian fishery, sampling since 2003 has ranged between one sample per 2 mt to one sample per 16 mt. The average number of fish measured per sample was 212 and the average number of fish aged per sample was 35 in the Canadian fishery during 2011 (Table B6b).

Age and Size Composition

USA Commercial Landings at Age
For the 2008 cod benchmark, the age and size composition of the 1978-2007 USA landings, dis-aggregated into eastern (SA 561-562) and western Georges Bank (SA 521-522, 525-526, 537-539) was estimated, by market category, from length frequency and age samples pooled by calendar quarter (O'Brien et al. 2008). In some years samples were pooled semi-annually or annually within a market category or samples were 'borrowed' from adjacent areas, due to an insufficient number of samples within a quarter.

Landed mean weights were estimated by applying seasonal length-weight equations based on 1992-2007 spring and autumn research survey data to the quarterly length frequency samples, by market category,by area:

Statistical areas: 521,522,525,526,561,562 (Georges Bank)
Quarter 1 and 2 : ln weight (kg,live) = -11.6913 + 3.0291 ln length (cm), (1)
Quarter 3 and 4: ln weight (kg,live) = -11.9883 + 3.1221 ln length (cm), (2)

Statistical areas: 537,538,539 (Southern New England)
Quarter 1 and 2 : ln weight (kg,live) = -12.4143 + 3.2341 ln length (cm), (3)

Quarter 3 and 4: ln weight (kg,live) = -12.4027 + 3.2319 ln length (cm) (4).

Numbers of fish landed, by quarter, were estimated by dividing the mean weight into the quarterly landings, by market category, and prorating the total numbers by the corresponding market category sample length frequency. Quarterly age-length keys were then applied to the numbers-at-length to estimate numbers landed at age. Annual estimates of landings at age were obtained by summing values over market category and quarter. Derivation of landings at age by quarter, rather than by month, was performed since not all months had at least two length frequency samples per market category (i.e., minimum desired for monthly catch estimates).

In 2012, the age and size composition of the 2008-2011 USA landings was estimated as described above. A comparison of the 1992-2007 length-weight relationship with an updated 1992-2011 length-weight relationship indicated minimal differences (see Length-Weight section), therefore, the 1992-2007 length-weight relationship continued to be used in the estimation of 2008-2011 age and size composition of commercial landings.

Uncertainty in estimation of landings at age, measured as the coefficient of variation (CV) are lower for younger ages, less than 20%, compared to the older ages, where fewer samples are available (Table B7).

The eastern and western Georges Bank landings-at-age were combined to obtain the landings-at-age matrix in numbers (Figure B4), weight, mean weight, and mean length during 1978-2011 (Table B8a). The 2011 landings were dominated by age 3 and age 4 fish of the 2008 and 2007 year class (Table B8a). The 2003 year class was the most recent year class of note but still below the long term average. This year class's contribution to the fishery is now minimal, however, the number of age 8 fish in 2011 is the highest since the 1996 year class at this age.

Canadian Commercial Landings at Age

Canadian landings-at-age data from the Northeast Peak of Georges Bank (SA 551-552) were obtained from Y. Wang, (Department of Fisheries and Oceans (DFO), St. Andrews NB) for 1978-2011 (Wang and O'Brien 2012). Size and age composition of the landings was estimated from pooled port and at-sea samples by quarter and gear type (otter trawl, gillnet, and longline), rather than by market category as in the USA. Seasonal length-weight equations, based on 1995-2000 observer data (Wang et al. 2009) were applied to quarterly length frequency samples, by gear:

Quarter 1 and 2 : ln weight (kg,live) = -11.4689 + 2.9832 ln length (cm) (5)
Quarter 3 : ln weight (kg,live) = -11.0922 + 2.9069 ln length (cm) (6)
Quarter 4 : ln weight (kg,live) = -11.3264 + 2.9775 ln length (cm) (7)

The Canadian landings-at-age matrix in numbers (Figure B5), weight (mt), mean weight (kg) and mean length (cm) for 1978-2011 are presented in Table B8b. The 2011 landings were dominated by age 4 and age 5 fish of the 2007 and 2006 year class (Table B8b).

USA Commercial Discards at Age

The age and size composition of cod discarded in the commercial fishery during 1989-2011 were estimated similarly to that described above for commercial landings by applying combined survey and commercial age-length keys, by half year, to observer length frequency data, and using the 1992-2011 length weight equation derived from spring and autumn research survey data:

Quarter 1 and 2 : ln weight (kg,live) = -11.7019 + 3.0269 ln length (cm) (8)
Quarter 3 and 4: ln weight (kg,live) = -12.0190 + 3.1313 ln length (cm) (9).

In the large mesh otter trawl fishery, a higher proportion of larger fish and a lower proportion of smaller fish were discarded on eastern GB compared to western over the time series (Figure B6). In the western GB area, a higher proportion of smaller fish were discarded in the latter half of the year and a high proportion of larger fish discarded in the first half of the year (Figure B6). Thus, discards at age for large mesh otter trawl were estimated by half-year, for eastern and western GB. Also, given the generally lower amount of large mesh otter trawl discards in the Southern New England (SNE) area, these data were added to western GB. Summarization of length sampling data by gear indicated a combination of low or sporadic sampling over the time series (Table B9), particularly for small mesh otter trawl and scallop dredge. Comparison of length frequency samples by gear indicated that the length range of discards was similar between the gears. Therefore, discards at age for all gears were estimated by prorating large mesh otter trawl discard estimates at age to total discards (mt) of all gears combined. Estimates of total annual discards at age during 1989-2011 were obtained by summarizing across half-years and areas (eastern GB and western GB+SNE).

The age and size composition of discards for 1978-1988 was initially presented at the 2008 benchmark review (O'Brien et al. 2008). Using the hindcasted discards at length for large mesh otter trawl estimated by the survey filter method (O'Brien and Esteves 2001, Mayo *et al*. 1992, Palmer et al. 2008), discards at age were estimated by applying autumn research survey proportions at age and the historical length-weight equation:

ln weight (kg,live) = -11.7231+ 3.0521 ln length (cm) (10).

Equation 10 had been used historically before the current survey length-weight data became available after 1992.

The total USA commercial discards-at-age in numbers, weight (mt), mean weight (kg) and mean length (cm) for 1978-2011 are presented in Table B10a. The commercial discards are generally dominated by age 2 and age 3 fish during the time series (Table B10a).

Canadian Commercial Discards at Age

Discards from the Canadian groundfish fishery were assumed to have the same size and age composition as the fishery landings. The size composition of discards from the scallop fishery was estimated using observer length frequency and age data (Wang and O'Brien 2012). The total Canadian commercial discards-at-age in numbers, weight (mt), mean weight (kg) and mean length (cm) for 1978-2011 are presented in Table B10b. The commercial discards are generally

dominated by age 2 and age 3 fish during the time series (Table B10b).

Combined USA and Canadian discards at age indicate that ages 2 and 3 are primarily discarded in recent years (Figure B7).

USA Recreational Landings and Discards at Age

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 the limited samples available indicated a length range similar to that observed in the NEFSC survey. Assuming that recreationally captured fish are caught in proportion to the population age structure, a combined commercial and survey age-length key, and research survey length frequencies and length-weight relationships (Eq. 8 and 9) were applied by half-year to the number of fish caught to obtain the recreational landings and discards at age for 1981-2011.

Landings and discard length frequencies were differentiated by applying a length cutoff to the survey length frequency. The length cutoff corresponded to the minimum size regulation in effect at the time and the minimum size observed in length samples taken by MRFSS/MRIP:

1981-1985: 30 cm
1986: 38 cm
1987: 43 cm
1988: 43 cm
1989: 48 cm
1996: 51 cm
2002-2011: 58 cm

For 1978-1980, MRFSS data was not collected, therefore, the magnitude and size composition of the recreational catches in those years were assumed to be equivalent to the 1981 estimates.

The recreational catch at age, in numbers, weight (mt), mean weight (kg) and mean length (cm) during 1981-2011 are presented in Table B11a for landings and Table B11b for discards. The recreational catch would appear to be dominated by ages 4-5 in the landings component and ages 2-3 in the discard component in recent years (Table B10b, Figure B8).

Recreational catch represents 1%-20% of the total USA catch of cod during 1981-2011. In 2011, recreational catch accounted for 5% of the total GB cod catch (Table B1, Figure B2b).

Total Catch at Age

The total catch at age is summarized across all components during 1978-2011: USA commercial landings and discards, USA recreational landings and discards, and Canadian commercial landings and discards and is presented for numbers (000s), weight (mt), mean weight (kg) and mean length (cm) of fish at age in Table B12. The total catch numbers at age will be input to the assessment model formulation.

The total catch during 2011 was dominated by age 3 and age 4 fish of the 2008 and 2007 year

class (Table B12, Figure B9).

Catch Mean Weight and Length at Age
Mid-year mean weights at age for ages 1-10+ are summarized for USA (Table B8a) and Canadian landings (Table B8b) and total catch (Table B12). Although there does not appear to be a trend in January 1 mean weight for ages 1-3 during the 34-year time series, there does appear to be a declining trend in mean weight for ages 4-9 (Figure B10a). The mean weight for age 10+ has been increasing, however, since 2007. The trend in mean lengths at age (Figure 10b) is similar to the trend in mean weight suggesting that there has not been a decline in condition for commercially and recreationally caught GB cod.

Stock Abundance and Biomass Indices

Commercial Catch Rates
A general linear model (GLM), first conducted in the 1993 assessment (Mayo et al. 1994a; Mayo *et al.* 1994b) was repeated in the current assessment to estimate USA standardized fishing effort and commercial landings-per-unit-effort (LPUE; mt/day fished) for Georges Bank cod during 1978-2011. Prior to the 1994 assessment, trends in fishing effort and LPUE had been estimated but these were not standardized estimates (Serchuk et al. 1993). Factors included in the GLM were year, statistical area (521,522,561,562,525,526), calendar quarter, tonnage class (TC 31, 32, 33, 41) and depth code (1 =1-30 fathom, 2=31-60 fm, 3=61-100 fm). The specific factors used for standardization were year 1978, area 521, quarter 2, TC 33, and depth code 3. Landings data included all USA interviewed otter trawl trips landing cod during 1978-1993 and any otter trawl trips that reported landing cod on the VTR during 1994-2011 from the Georges Bank area. The LPUE index indicates a declining trend from 1980 through 1995, a gradual increase to 2002 with another decline through 2006, then an increasing trend to 2011(Figure B11).

Standardized effort and LPUE were last estimated in the 1998 assessment (O'Brien and Cadrin 1999). In 1998, under the management restrictions of days at sea (DAS), larger mesh sizes, closed areas since December of 1994, mandatory logbooks for collection of effort data implemented in May 1994, and other management measures, the post 1994 effort data was no longer considered to be equivalent to the historic 1978-1993 effort series. The LPUE series was, therefore, not used as an index of abundance in the 1998 assessment (O'Brien and Cadrin 1999) or in any subsequent assessments.

The WG reviewed the analysis and recommended that the standardized 1978-2011 LPUE series not be used in the SAW 55 assessment model for several reasons. The LPUE does not represent the entire stock because the index incorporates only the USA landings and effort data and since 1985, only from the western part of the stock area. This was illustrated in a series of quarterly distribution maps of commercial LPUE during 1978-1994 (WP 17a-c) and annual distribution maps of LPUE during 1994-2011 (WP 16). The Canadian fishery contributes about an average 25% to the overall landings and that is not accounted for in the GLM. In addition, there have been significant regulatory changes since 1994 as described above and most recently the implementation of sector management since May 2010, all resulting in spatial shifts in the fishery. All of these factors detract from the utility of the index as a measure of abundance. The WG recommendation to not utilize the index is consistent with the findings of the recent

NEFSC-sponsored LPUE workshop.

Recreational Catch Rates
A log-normal general linear model (GLM) was applied to recreational data to estimate an LPUE index (cod landed/angler hour) for Georges Bank cod during 1994-2011 (WP 11). The link function was the 'identity' and factors used in the standardization included year, month, area, permit, and fishing category (party vs. charter). Zero-inflated models were fit and there were no significant differences in trend compared to the log-normal. The standardized LPUE index indicates a variable but declining trend from 1994 to 2002 and then a variable but increasing trend from 2003-2011 (Figure B11).

The WG had several concerns with respect to the applicability of the LPUE index. At the beginning of the time series, there is uncertainty whether the data reported was in pounds or in numbers (as required). There were a limited number of party/charter boats involved in the fishery (17), but only a few vessels (4) consistently fished over the time series. In addition, the fishery was conducted primarily in the westernmost part of the stock area. The WG concluded that the recreational LPUE index was not representative of the stock and should not be included in the assessment model.

Survey Biomass and abundance indices

USA Surveys
NEFSC spring and autumn research bottom trawl surveys have been conducted off the Northeast coast of the USA since 1968 and 1963, respectively (Azarovitz 1981). Indices of abundance (stratified mean number per tow) and biomass (stratified mean weight per tow (kg)) were estimated from both the spring and autumn surveys for Georges Bank cod (offshore strata 13-25, Figure B12a) during 1963-2012. The indices were standardized for differences in fishing power of the *FRV Albatross IV* and the *FRV Delaware II,* for differences between catchability of BMV and polyvalent doors, introduced in 1985, and for the calibration of the *FSV H.B. Bigelow* catches to *FRV Albatross IV* units. The fishing power coefficients of 0.79 and 0.67 to convert *Delaware II* to *Albatross IV* equivalents and the door conversion coefficients of 1.56 and 1.62 were both applied to abundance and biomass indices, respectively (NEFSC 1991). Spring surveys were conducted with a Yankee #41 trawl during 1973-1981, and with a Yankee #36 for all other years through 2008. No fishing power coefficients are available, however, for adjusting the Yankee #41 to Yankee #36 equivalents. Since 2009, for both seasons, length-based conversion coefficients (Brooks et al. 2010, Table B13) and a constant weight conversion coefficient of 1.579 (Miller et al. 2010) have been applied to the *Bigelow* catch per tow data to standardize to *Albatross IV* units.

NEFSC spring and autumn catch per tow biomass and abundance indices show similar trends throughout the time series (Tables B14, Figures B13a-B13b). Survey indices were variable but relatively stable between 1963 and the early 1980s, then gradually declined until about 1995 and have remained low since that time.

Survey abundance indices for age 1 in the autumn survey indicate above-average recruitment of the 1966, 1971, 1975, 1977, 1980, 1983,1985, 1988, and 2008 year classes (Figure B14). The

2008 is the first year class, as age 1, to be above the time series average in 20 years. As 2 year old fish, the 1993 year class was above average, and the 1996 year class was average. Although the 2006, 2007, 2008, and 2009 year classes as age 2 fish are each below average they are all about the same magnitude. The magnitude of an above-average year class has been declining over time, particularly noticeable in the recruits at age 1. Standardized catch per tow at age in numbers for NEFSC spring and autumn surveys are presented in Tables B15a-B15b and Figure B15).

Canadian Surveys

Canadian research bottom trawl surveys have been conducted in February-March on Georges Bank (strata 5Z1-5Z8, Figure 12b) since 1986. Survey abundance indices have fluctuated and generally declined during 1990-2004 and have been increasing until 2010 (Figure B13b). Both the 1999 and 2000 indices increased primarily due to the recruitment of the 1996 year class (Table 15c, Figure B16). Abundance indices for ages 1 and 2 indicate above average recruitment of the 1985, 1987,1988, 1990, and 2003 year classes (Figure B16). In 1993, 1994, and 2012 the DFO survey did not sample the western part of Georges Bank (DFO strata 5Z5 - 5Z7), therefore, the indices of stratified mean number per tow at age in those years were not used in the assessment model formulation. Standardized catch per tow at age in number for DFO spring surveys are presented in Table B15c and Figure B17.

Model-Based Abundance Indices

The WG considered a GLM model to investigate the utility of model-based survey indices of abundance for the NEFSC spring and autumn survey data compared to the design based indices described above. The factors included in the model were year, stratum, temperature, depth, and time of day (WP 7). The negative binominal model with factors of year, stratum, and time of day gave the best fit to the data for both spring and autumn.

Overall, the model and design – based abundance and biomass trends are very similar. The WG concluded that the GLM is acting as a time series smoother and thus to best reflect uncertainty in the survey data, the WG recommends use of the design-based indices. The CVs from the GLM are comparable to those generated during the stage two iterative re-weighting process (in the ASAP model diagnostics) as the latter incorporates both observation and process error, similar to what the GLM produces.

Ageing Precision

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

The precision for aging of cod otoliths is high; During 2008-2011 the percent agreement ranged between 85.9%- 100% with CVs less than 5.5%.

Life-History

Length-Weight Relationship

In 1992, NEFSC research survey protocols were modified thus enabling the collection of individual weight at length for all fish sampled for age structures and maturity. Prior to that time, the length-weight (LW) equation available for analyses was equation 10, described above. In 2008, seasonal LW equations of the form: weight= a*Length^b were estimated using cod survey data from Georges Bank (offshore strata 13-25) and SNE (offshore strata 5-10) with combined sexes and the years 1992-2007 combined (equations 1-4 above). These equations were applied to analyses in the 2008 benchmark assessment (O'Brien et al. 2008).

In this assessment, the LW equation has been updated through 2011 for GB and SNE, however, additional strata (offshore 5-10 plus offshore 61-76 and inshore 1-51, 53) have been included in the SNE estimation. The updated 1992-2011 LW equation is compared to the 1992-2007 and historical equations (Figure B18). In both the spring and the autumn, in both areas, the two equations are nearly identical, and the 95% confidence intervals for the 1992-2011 equations are slightly narrower or equivalent to the 95% confidence intervals of the 1992-2007 equations (Figure B18). For Georges Bank, the two contemporary equations show greater weight at length in the autumn, primarily for fish greater than 80 cm, whereas in the spring, the contemporary equations show smaller weight at length when compared to the historical equation (Figure B19). For SNE, both contemporary equations show greater weight at length in both seasons relative to the historical equation (Figure B19). For the GB cod stock, with a truncated age structure and relatively few large fish in the population, these differences are not a concern for the short term. Also, the historical equation is within the confidence bounds of both contemporary equations in the two areas and two seasons.

Length-weight equations for each season and area were estimated by 5-year time blocks and compared to the two time series relationships (Figure B20). For GB in the spring the 1992-1996 time block had greater weight at length and the 2007-2011 time block had smaller weight at length relative to the 1997-2001 and 2002-2006 time blocks and the two times series relationships. In the autumn, all six relationships were very similar for GB (Figure B20). The differences between seasons is likely related to feeding and spawning condition during the spring spawning season compared to fish in the autumn that have been feeding throughout the summer. The SNE pattern was opposite to that of GB with the spring 5-year spring equations being very similar to the time series equations for lengths less than about 100 cm. In the autumn, the 1992-1995 5-year block had greater weight at length than the two time series relationships, whereas the other 5-year blocks had smaller weight at length (Figure B20). Spawning occurs in the latter part of the autumn in the SNE area, which may contribute to the variability between time blocks.

Growth

Age and length (cm) data from the spring and autumn NEFSC research bottom trawl survey were fit to the von Bertalanffy growth equation for three time periods : 1970-2011, and the earliest and latest decade in the time series, 1970-1979, and 2001-2011. The form of the equation (Ricker 1975) was:

$$L_t = L_\infty (1 - e^{-K(t-to)}) \quad (11)$$

where L_t = length at age t,
L_∞ = asymptotic length,
K = growth coefficient,
t = age.

Spring and autumn data were combined by assigning a decimal age to each record depending on the month the fish was captured, i.e. age = age + (month/12).

The asymptotic length (L_∞) was 114 cm for the time series, 118 cm for the first decade and 92 cm for the last decade (Figure B21). The growth coefficient, inversely proportional to L_∞, was the highest at 0.28 in the 2001-2011 decade. The number of large fish in the sample for the last decade was minimal with only 2 fish in the 10+ age group, contributing to the low L_∞.

VB parameters	years	Linf	k	to	N 10+ fish
GB	1970-2011	114.10	0.22	0.17	149
GB	1970-1979	117.50	0.21	0.19	101
GB	2001-2011	91.63	0.28	0.32	2

Mean Length and Weight at Age
Mean length and mean weight at age were estimated for ages 0-9 from the NEFSC spring and autumn research bottom trawl surveys during 1970-2011. Mean weights for data from 1970-1991 were estimated using the historical LW relationship (equation 10). Mean length and weight are variable over the time series but appear to be declining for ages 4 and older in both the spring and autumn (Figure B22a-B22b).

Condition
Fulton's condition factor ((K) Ricker 1975) was estimated from spring and autumn research bottom trawl survey data. Condition factor was estimated from individual length (l_i) and weight (w_i) data for females and sexes combined during 1992-2011 as :

$$K_i = ((w_i/l_i^3) \times 100) \quad (12).$$

Individual K estimates, averaged within a year indicate a decline in K over time for the spring, however, the decline was not observed for the autumn K (Figure B23). This seasonal difference was observed in the LW relationships, and suggests that food availability or spawning condition are influencing the weight of fish in the spring relative to the autumn.

Maturity ogives
Logistic regression analysis was used to estimate female maturity ogives from NEFSC spring research survey data during 1970- 2012. 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, 2012, has only 3 years of data (2010, 2011, and 2012). 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) (Table B16, Figure B24).

Median maturity for females declined from about age 2.6 in the early 1970s to age 1.8 in 1988 and has since increased and is currently age 2.4 in 2011 (Table B16).

Total Mortality

Estimates of instantaneous total mortality (Z) were derived from catch per tow abundance indices for the NEFSC spring and autumn surveys, and the DFO survey (Tables B15a-c). Annual mortality in each survey was estimated as:

$$\ln\left(\Sigma \text{ age 4+ for years i to j} / \Sigma \text{ age 5+ for years i+1 to j+1}\right) \qquad (13).$$

To compare the estimates between surveys within a year, the time of year that each survey was conducted was added to each survey year (DFO = 0.16, spring=0.25, autumn =0.75) and a three year moving average was fit to the time series of combined survey mortality estimates (Figure B25). The estimates are highly variable throughout the time series but are without trend. The average total Z over each survey time series was 0.60 for DFO, 0.67 for NEFSC spring and 0.88 for NEFSC autumn (see text table below). During 1978-2011, which corresponds to the assessment model time series, the average total Z across all three surveys was 0.78. Comparison of Z for each survey with overlapping years indicates that Z increases from early winter to autumn.

Average of Annual Z ln(4+/5+)				
Year	DFO	Spring	Autumn	Total
1964-2011			0.88	
1968-2011		0.67	0.88	
1986-2011	0.60	0.75	0.99	
1978-2011		0.72	0.98	
1978-2011				**0.78**
1963-2011				0.74

Natural Mortality

Instantaneous natural mortality (M) has been assumed to be 0.2 in all previous assessments of Georges Bank cod e.g. Serchuk et al. (1977) as this was the convention for many stocks in the Northwest Atlantic (Paloheimo and Koehler 1968, Pinhorn 1975, Minet 1978). In this benchmark review, the WG investigated several life-history analyses and also tagging results to evaluate the M assumption.

Hoenig (1983) demonstrated that natural mortality can be estimated as a function of the maximum observed age (t_{max}) in a population:

$$\ln (Z) = \exp (a + b^* \log(t_{max})) \ , \qquad a=1.46,\ b= -1.01, \qquad (14).$$

Using a maximum age =18 from early in the survey time series or age = 10 for the more recent survey years, results in e^Z = M= 0.23 or 0.42.

Hewitt and Hoenig (2005) refined the Hoenig (1983) approach:

$$M = 4.22/ t_{max} \qquad (15)$$

which give the same results as above, of M = 0.42 and 0.23 for t_{max} = 18 or 10, respectively. Maximum age in the commercial fishery in recent years has been between 12 and 15, resulting in M values of 0.35 and 0.28, respectively.

Given that the Georges Bank cod stock has been heavily exploited , i.e. overfished during the assessment times series (post 1978, O'Brien et al. 2012), and age samples are only available from the 1970s, M values in the range of 0.23 to 0.42 estimated from maximum age likely overestimate the true M for this stock.

An alternative approach relies on the gonadosomatic index (GSI), the ratio of gonad weight to somatic weight (Gunderson 1997) in the following relationship:

$$M= 1.79 * GSI \qquad (16).$$

The general premise is that M is positively correlated with reproductive effort, specifically, female reproductive effort. Estimates of GSI were not readily available from NEFSC survey data for Georges Bank cod; however using a GSI value of 0.117 reported for Georges Bank cod by McIntyre and Hutchings (2003) results in an M estimate of 0.21. Pauly (1980) first showed that M is proportional to the von Bertalanffy growth parameter, K. Using a variant of the relationship (Jensen 1996):

$$M = gK \qquad (17)$$

and an estimate of g=1.598 (Gunderson et al. 2003) results in estimates of M= 0.35, 0.34, or 0.45 depending on whether the K value is taken from the growth parameters estimated from data during 1970-2011, 1970-1979, or 2001-2011.

In this meta-analysis of life history-based estimates, M estimates range between 0.21 - 0.45. These variable estimates and the conflicting result of a decrease in condition in the spring but not the autumn, as evidenced by both the Fulton's K and the differences in seasonal LW equations make it difficult to make a definitive conclusion on a hypothesis for a shift in life history parameters. It should be noted that maximum age as high as 15 has been observed in the commercial fishery as recently as 2011, and age 12 in the last several years, which suggests comparable natural mortalities relative to earlier in the time series.

The method of Lorenzen (1996), that applies mean weight at age (Table B17a) in the following

relationship, was used to provide an aged-based estimate of M (Table B17b, Figure B26):

$$M_w = M_u W^b \qquad (18)$$

where M_w = natural mortality associated with fish of weight, W,
Mu = natural mortality at unit weight, (3.69, consistent with Lorenzen ocean ecosystem constant)
W = weight (g),
b = allometric scaling factor (-0.305, consistent with Lorenzen ocean ecosystem constant)

This method, which is based upon the relationship between body weight and M across a wide range of species, was used in SAW 54 to provide age-based estimates of M for Southern New England – Mid Atlantic Bight yellowtail flounder. The peer review panel of SAW 54 (O'Boyle 2012) considered that applying an inter-species relationship to infer within-species dynamics was an over-interpretation of the method. While M no doubt may be age-specific, the pattern estimated from the Lorenzen method may not be appropriate. Recent work performed by Jon Deroba (NEFSC) and Amy Shueller (SEFSC) (*https://afs.confex.com/afs/2012/webprogram/Paper10183.html*) indicated that using constant or age varying mortality would have similar impacts on the assessment. The SAW 55 WG thus concluded that the parsimonious approach for the SAW 55 assessment models was to use a single M for all ages.

Two working papers considered the predator field of cod in the Gulf of Maine-Georges Bank area (Link 2012, Waring 2012). Link (2012) noted that directed piscivory of cod by other fish was not common, with less than 200 cod in over 550,000 stomachs observed the survey time series. Similarly, the evidence for cannibalism is weak with only 20 cod found in over 20,000 stomachs. Studies to date suggest that M due to fish predation is likely low and is focused on juvenile and smaller size groups (Smith and Link 2010). Waring (2012) considered marine mammals as a potential source of elevated M in the Gulf of Maine area. Four species of seals (harbor, grey, harp and hooded) are found in New England with harbor and grey seals being the most numerous. The harbor seal population, which was about 38,000 individuals in 2001, has been growing at an annual rate 6.6%. The grey seal herd has increased from tens of animals in the early 1980s to thousands of animals in the late 2000s. Firm estimates on the size of the current herds are not available. Notwithstanding this, the food habit research suggests that cod mortality due to seals is low. Additionally, while seals are known to prey on cod, they are generalist feeders and the importance of cod in the diet of Gulf of Maine area grey seals is unknown. There is limited information that suggests that cod represent only a minor component of harbor seal diet along the Maine coast (Wood 2001).

An analysis of tagging data collected during 2003 – 2006 to jointly estimate natural and fishing mortality was undertaken during GARM III (Miller and Tallack 2007). This analysis was updated for SAW 55 (Miller 2012). Contrary to the earlier work, this analysis was not length-based. Estimates of M ranged from 0.4 to 0.7 for Georges Bank cod tag returns of greater than 50 cm. The analysis provided evidence of significant cod movements between GM and GB and area 4X on the order of 4.1% to 29.7%. While M was relatively high compared to current estimates, F was comparatively low, prompting discussion on whether or not it was representative of the fishery due to local effects. The results were highly sensitive to the assumed

return rate of high-reward tags. High-reward return rates on the order of 50% were associated with Georges Bank cod M estimates of 0.4, with M increasing as the high-reward tag rate increased. Model preference (based on log-likelihood function) was for assumptions of near-100% on reporting rates of the high-reward tags. Estimates of fishing mortality, F, were inversely related to the M response with F declining with higher assumptions of high-reward tags reporting rates. Across all ranges total mortality (Z) was estimated about 0.8-0.9.

Concerns were raised with the tagging conducted in the Cape Cod area, which represented over 50% of the data in the database, which prompted the greater than 50 cm analysis. The tagging had been conducted employing a wide range of expertise with mostly small cod being tagged. This in combination with the warm water in the area may have resulted in higher tag induced mortality than assumed in the model. There were additional concerns with the assumed tag reporting rate (100%) for high reward tags. There is evidence to suggest differential reporting rates among some sectors of the commercial fishery, most notably the reporting rate by gillnet vessels was five times lower than that of trawl vessels (Tallack 2006). It is unknown if these same reporting trends also apply to the high-reward tags. There was also discussion on the age groups of cod represented by the study. Within the subset of greater than 50 cm fish, only about 10% of the released cod were greater than 80 cm. GB cod at 50 cm are 2 years old on average, implying that the estimates of M are for fish of ages 2 to 5 but weighted towards the younger ages.

The SAW 55 WG discussed how best to use these estimates of M. It was hesitant to conclude that M was in the range of 0.6 – 0.7 and to recommend that these estimates be directly included in the assessment models. Rather, the tagging analysis is another form of modeling that should be considered. The WG discussed the availability of historical tagging to which the current estimates could be compared. It was reported that tagging work conducted in the Gulf of Maine area (with a smaller percentage of tagging done on GB) during the 1970s and 1980s suggested M estimates in the order of 0.2 – 0.3 whereas tagging in the 1990s was suggestive of M similar to the more recent results. These observations are based upon unpublished work that could not be corroborated at the meeting. Much of the historical work (e.g. Hunt et al. 1999) had been focused on cod movements and did not provide estimates of natural, fishing or total mortality. Further, concerns were raised that there was no obvious mechanism (e.g. predation) that could explain a recent increase in M, although it was countered that no mechanism has been identified for the current M estimate of 0.2, though this estimate is supported by life history parameters. The SAW 55 WG recommended profiling natural mortality across both the historical and more recent periods of the assessment to inform the discussion as to whether or not there has been a long-term change in M. The WG agreed that an option (M-ramp) with an M change should be considered as an alternate to a base model which would assume no change in M (i.e. M = 0.2).

Assessment Model Formulation

The Georges Bank cod stock assessment has historically been assessed as an age-based assessment employing virtual population analysis (VPA). Given the biased retrospective pattern observed in recent assessments (O'Brien et al. 2012) the 2012 benchmark assessment review presented the opportunity to explore a new model formulation to mitigate the retrospective bias. The WG chose to explore a forward projecting model, ASAP (Age Structured Assessment Program v3.0.6, Legault and Restrepo 1998), which can be obtained from the NOAA Fisheries

Toolbox (http://nft.nefsc.noaa.gov/).) To bridge between the previous VPA formulation and a proposed ASAP model formulation the following models are presented: comparisons of two VPA models with data modifications since February 2012, a VPA updated through 2012, a VPA-like ASAP formulation, and the final proposed ASAP formulation.

Bridge VPA
Since the update assessment review in February 2012 (O'Brien et al. 2012), input data to the assessment has been modified by converting 1978-2003 MRFSS recreational statistics to MRIP equivalents and discard mortality rate of cod has changed to values less than 100% , the value previously applied (see text table above).

Comparing a VPA with the MRIP time series and 100% discard mortality to a VPA with both the MRIP time series and the Delphi mortality rates applied indicate minimal effect of changing the mortality rate (Figure B27). The SSB of the reduced mortality run is marginally greater in recent years and conversely, F is slightly less when compared to the MRIP only run.

Comparing the February 2012 run (O'Brien 2012) which used MRFSS data and 100% mortality rate to the MRIP only and MRIP+Delphi runs indicate an effect of the MRIP equivalents prior to about 1994. The SSB is estimated to be higher from 1978-1994 for the MRIP equivalent run compared to the February 2012 run (Figure B28). The effect on F is more variable, with F from the MRIP run being both above and below F compared to the February 2012 run (Figure B28). An examination of the retrospective bias indicated that the magnitude of the bias was similar for SSB and F across all three models.

The WG agreed to go forward with the MRIP equivalent time series and to apply the 'delphi' discard mortality rates in further model development.

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 F in 2011 and beginning year stock sizes in 2012. A retrospective analysis was performed for terminal year F, SSB, and age 1 recruitment. The accepted benchmark model from GARM III (O'Brien et al. 2008) was applied in the February 2012 update through 2010 (O'Brien 2012), and in the current assessment to update the VPA through 2011. As described above the updated data includes the MRIP equivalents and the application of 'Delphi' discard mortality rates.

The base ADAPT formulation provided stock size estimates for ages 1-8 in 2012 and corresponding F estimates for ages 1-7 in 2011. Assuming full recruitment at age 5, the F on age 9 in the terminal year was estimated as the average of the F on ages 5-8. The F on age 9 in all years prior to the terminal year was derived from weighted estimates of Z for ages 5-8. For all years, the F on age 9 was applied to the 10+ age group. Spawning stock size estimates were estimated with female maturity ogives derived from NEFSC spring research survey data for 1978- 2012 as described above.

The catch at age (Table B12, Figure B9) includes combined USA and Canadian landings and discards, and USA recreational landings and discards from 1978-2011 for ages 1-10+. Swept-area estimates (Appendix B2) were used to calibrate the VPA and were estimated from indices of abundance that included the NEFSC 1978-2012 spring survey indices for ages 1-8 (Table B15a), the NEFSC 1977-2011 autumn survey indices for ages 0-5 (Table B15b) and the Canadian DFO 1986-1992, and 1995-2011 survey indices for ages 1-8 (Table B15c). The DFO survey indices for 1993, 1994, and 2012 were not included in the model because the survey did not sample the entire GB area in those years. The NEFSC spring survey was dis-aggregated into two series based on the use of the Yankee #36 or Yankee #41 trawl. The NEFSC employed the #41 trawl during 1973 to 1981; the spring indices were split into a series from 1978-1981 for the #41 trawl and a series from 1982-2011 for the #36 trawl. The survey has been conducted by the *Bigelow* since 2009 and the survey abundance indices were converted to *Albatross IV* equivalents as described above. The NEFSC time series of survey indices have also been standardized for door and vessel changes prior to 2008, described above. The autumn survey abundance indices were shifted forward one age and one year to match cohorts in the spring survey in the subsequent year. In addition the survey time series were split between 1994 and 1995 for all three surveys (not Yankee #41). This 'split-run' was introduced in the 2008 assessment (O'Brien et al. 2008) to address the retrospective bias. While there was no reason to expect the survey catchability to have changed between those time periods, the split initially improved the retrospective pattern, and was understood to alias an unknown mechanism that introduced the retrospective bias (e.g. change in M, unaccounted for mortality from discards or landings).

The model results from the February 2012 VPA (O'Brien et al. 2012) are presented as run A in Table B18. Run B is an updated Run A that includes terminal year 2011 catch estimates and the NEFSC spring 2012 and autumn 2011 survey indices. In addition, the age 1 stock numbers for terminal year (t) + 1 are derived as the geometric mean of age 1 estimated for 2005-2009 rather than being estimated as in Run A. Results of Run B are presented Table B18.

The final 2012 VPA (Run B) compared to Run A resulted in a 53% increase in F from 0.45 in 2010 to an F= 0.69 in 2011 and an 11% increase in SSB from 11, 289 mt in 2010 to 12,532 in 2011 (Table B18). These results were not adjusted for retrospective bias.

Diagnostics – 2012 Split VPA (Run B)
The ADAPT calibration results for estimates of terminal year stock size and catchability (q) estimates, with corresponding standard error and CVs are presented in Table B18. Stock size estimates were more precise for ages 2-6, (CVs from 27% - 38%) than for age 7 (CV=59%), and age 8 (CV=74%). Comparison of precision estimates of catchability-at- age, pre- and post-split, generally showed higher CVs for the post-split indices (Table B18). The q estimates for post-split indices were higher than pre-split for all surveys. Estimates of q increased with age and were generally asymptotic, approaching a 'flat-top'.

Results – 2012 Split Model (Run B)
Fully recruited fishing mortality (unweighted, ages 5-8) was estimated at 0.69 in 2011 (Table B19a, Figure B29), a 25% increase from 2010. SSB in 2011 was estimated at 12,531 mt, a 23% increase from 2010 (Table B19b, Figure B29). Recruitment (millions of age 1 fish) of the 2003 year class (6.5 million age 1 fish) is now estimated to be smaller than the 1998 year class (12.4 million age 1 fish) (Table B19b). The 2008 year class (6.2 million age 1 fish) is similar in size to

the 2003 year class. The last year class (1990-20.7 million age 1 fish) above the time series average (12.9 million age 1 fish) occurred over two decades ago.

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, 2011.

Although there is no distinct mechanism (e.g. change in reporting and sampling systems, closed areas, life-history or environmental effect) to motivate splitting the survey time series, when the series are split in the mid-1990s (1994/1995), the result is a weaker retrospective pattern relative to a VPA with the surveys not split (Figure B30). This difference was more apparent in the 2008 benchmark (O'Brien et al. 2008) than it is now in the current assessment. The pattern of over estimating SSB and underestimating F relative to the terminal year continues as in the previous assessment (O'Brien 2012).

ASAP
Model description
The WG chose to use the forward projecting model ASAP (Age Structured Assessment Program, Legault and Restrepo 1998) as the basis for a proposed benchmark model for Georges Bank cod, rather than continuing with the VPA model. As described at the NFT software website (http://nft.nefsc.noaa.gov/), ASAP is an age-structured model that uses forward computations assuming separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance. Discards can be treated explicitly. The separability assumption is partially relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change in blocks of years. Weights are input for different components of the objective function which allows for configurations ranging from relatively simple age-structured production models to fully parameterized statistical catch at age models.

The objective function is the sum of the negative log-likelihood of the fit to various model components. Catch at age composition is modeled assuming a multinomial distribution. Surveys can be treated as either "West Coast style" in the same manner as the catch data with a total survey time series and survey catch at age composition modeled assuming a multinomial distribution, or "East Coast style" with the survey indices at age entered as separate series. Most other model components are assumed to have lognormal error. Specifically, lognormal error is assumed for: total catch in weight by fleet, survey indices, stock recruit relationship, and annual deviations in fishing mortality. Recruitment deviations are also assumed to follow a lognormal distribution, with annual deviations estimated as a bounded vector to force them to sum to zero (this centers the predictions on the expected stock recruit relationship). For more detail, the reader is referred to the technical manual (Legault 2008).

VPA-like ASAP
Input data for this ASAP model formulation was the same as described for the VPA except for the exclusion of the 2012 NEFSC spring survey. The survey calibration indices were split into two times series as in the VPA: 1978-1994 and 1995-2011. A multinomial distribution was

assumed for fishery catch at age and the survey indices at age were entered as separate series. The calibration indices at age for NEFSC spring and DFO surveys were compared to population numbers of the same age at the beginning of the same year. The NEFSC autumn calibration indices at age were compared to population numbers one year older at the beginning of the next year.

The model was formulated with four fishery selectivity blocks for the commercial fleet based on changes in codend mesh size regulations (text table below): 1978-1982, 1983-1993, 1994-1999, and 2000-2011.

years	codend mesh inches
1973-1976	4.50
1977-1982	5.13
1983-1993	5.50
1994-1999	6.00
2000-2011	6.50

Survey selectivity was modeled by age with selectivity fixed at one for ages 8-10.

The final objective function and contribution of individual components are presented in Table B20. A comparison with the VPA results indicates a similar trend in SSB, whereas, the trend in F is similar but more variable (Figure 31). The retrospective pattern (Figure B32) did not improve in this formulation of ASAP compared to the split-survey VPA (Figure B30).

The WG agreed that further exploration of the ASAP model with a multinomial assumption for the survey age composition would be more beneficial than pursuing this VPA-like ASAP model with lognormal error for the age-specific survey time series.

BASE ASAP

Input to the Base ASAP model is essentially the same as described for the VPA. The catch at age is for the combined landings and discards of USA and Canadian fishing fleets (Table B12, Figure B9) for ages 1-10+ during 1978-2011. Swept-area estimates derived from indices of abundance included additional ages: NEFSC 1978-2011 standardized estimates for ages 1- 10+ (Table B15a), NEFSC 1978-2011 standardized autumn estimates for ages 1-6 (Table B15b) and Canadian DFO 1986-1992, and 1995-2011 estimates for ages 1- 10+ (Table B15c). The DFO survey data for 1993 and 1994 were not included in the model because the survey did not sample the entire GB area in those years. The NEFSC spring survey was dis-aggregated into two series based on the use of the Yankee #36 or Yankee #41 otter trawl as described in the VPA section. A five-year moving average of age-specific and time varying maturity at age was used in the model as described in the VPA section. Natural mortality was age and time invariant and was assumed to be 0.2 as in previous assessments (O'Brien et al. 2012).

About 50 ASAP model formulations were explored to inform this final base model formulation, however, none of those model results will be presented, although they may be referenced.

A multinomial distribution was assumed for both fishery catch at age and survey age compositions. The survey time series were *not split* between 1994/1995 as in the VPA. Since exploratory runs indicated similar trends in SSB and F between formulations with the survey time series split or not split, the WG agreed to proceed with no split in the survey time series. The catch CV was set equal to 0.05 and the recruitment CV set equal to 0.5, however, the recruitment deviations were set with lambda = 0, so the deviations did not contribute to the objective function. The CV for each survey was initially set at the value generated from either the bootstrap analysis of the survey indices of abundance from the NEFSC SAGA (Survey Analysis Graphical Assistant) software package or from the DFO survey indices of abundance.

Model estimates of selectivity at age were initially freely estimated for the surveys and the fisheries with no restriction for flat-topped or dome-shaped results. Starting with the survey selectivity, the catchability (q) for each age was initially set based on values estimated by the VPA-like ASAP. Age 7 was fixed at 1 in the DFO survey, age 6 was fixed at age 1 in the NEFSC autumn, and age 8 was fixed at 1 in the NEFSC spring survey. The results of the fit indicated that the survey catchability was essentially 'flat-topped' (Table 21). The CVs associated with each estimate at age were high for ages 9 and 10+ in both the DFO and NEFSC spring survey, indicating a poor fit (Table B21). The CVs for all other ages were .25 or less for all three surveys. In each survey, selectivity was estimated at 1 for other ages in addition to the age that had been fixed at 1, i.e. ages 5 and 6 in DFO, age 4 in NEFSC autumn, and age 5 and 6 in the NEFSC spring. Given these results the NEFSC spring and DFO survey selectivities were fit using a single logistic. For the autumn survey, further comparison of selectivity at age vs. logistic fit indicated better diagnostics with selectivity for age 3 fixed at 1 (Figure B33).

For the fishery selectivity, when selectivity was freely estimated for both the survey and the fishery, each of the four fishery blocks appeared to have a moderate dome. Selectivity was fixed at age 1 for ages 3, 4, 5, and 5 in blocks 1978-1982, 1983-1993, 1994-1999, and 2000-2011. Examination of the fit statistics for the older ages indicated high CVs for ages 9 and 10+ (0.78-2.92) in all blocks and for age 8 (CV=0.79) in the 1978-1982 block. These results indicated that a flat-topped selectivity was more appropriate. When the survey selectivities were fit with a logistic and the fishery selectivity blocks were freely estimated, the fishery indicated flat-topped selectivity in the 3rd block (1994-1999) and a weak dome in the other 3 blocks, again with high CVs for the older ages. In each of the blocks selectivity was estimated at 1 for at least one other age (Table B22). Given these results, a logistic was fit to all 4 fishery blocks (Figure B34). Examination of the logistic fit of the four blocks clearly indicates only 2 blocks are appropriate given the similarities between blocks 1 and 2 (1978-1982, 1983-1993) and blocks 3 and 4 (1994-1999, and 2000-2011). A model with two fishery blocks (objective function (OF) = 2713, 91 parameters) is more parsimonious than a 4 block model (OF=2712, 95 parameters) with only 1 point increase in the OF with 4 less parameters (Figure B35).

The effective sample size (ESS) estimated for the catch at age data (treated as multinomial) was compared to the input ESS and was adjusted iteratively until the ESS specified generally matched the mean model estimated value. The final ESS was set at 64 based on the stage 2 multiplier as described by Francis (2011). An annual CV of 0.05 was assumed for the total catch.

The CV for each survey was initially set at the value from either the bootstrap analysis of the NEFSC survey abundance indices of abundance or the DFO estimate associated with the stratified mean abundance index. For the NEFSC spring the CVs averaged 0.43, with a range of 0.30-0.93, for the NEFSC autumn survey the CVs averaged 0.54, with a range of 0.34-0.86, and for the DFO survey the CVs averaged 0.38, with a range of 0.1-1.1. Further examination of the model fits to the survey indices resulted in adding the following constant to each survey CV vector: 0.2 (NEFSC spring and autumn) and 0.1 (DFO). The input ESS for the survey catch at age was manually adjusted until the model estimate was close to the input value. The final ESS was based on the stage 2 multiplier as described by Francis (2011) and was set for each of the surveys as: DFO = 9, NEFSC autumn = 14, NEFSC spring 41=40 and NEFSC spring 36 = 37.

Base Model Results

Model results, including the objective function (OF), number of parameters, components to the OF, the root mean square error (RMSE), computed from standardized residuals, and the 2011 SSB and F estimates are summarized in Table B20.

Catch

As a result of the small CVs assigned to the commercial catch, the model fit the observed catch very closely (Figure B36). The residuals of the catch age composition did not exhibit any strong patterning (Figure B37). The magnitude of the input ESS are appropriate given that the predicted mean age of the catch is generally within the 95% confidence interval (CI) of the observed mean ages (Figure B38) and the RMSE (0.98) is nearly 1.0 (Francis 2011).

Indices

The fit of the predicted indices through the observed DFO survey indices was better during the period 1995-2000 than before or after that period (Figure B39). A pattern of negative residuals in the older age groups during 1986-1995 and in the younger ages during 2000-2011 is apparent in the age composition (Figure B40). The DFO ESS was the lowest of the 3 surveys, with the predicted mean age fitting well in the middle of the time series but above the observed mean age earlier and later in the time series (Figure B41, RMSE=0.92).

The fit of the predicted indices through the NEFSC autumn survey indices did not show any strong patterning (Figure B42). Although there is not a pattern of residuals in the age composition, age 1 residuals are large compared to the other age groups (Figure B43). The input ESS =14 is appropriate given that the predicted mean age fit well through almost all the observed mean age CIs (Figure B44, RMSE=1.04).

The model fit diagnostics for the NEFSC spring (Yankee #41) are presented in Figures B45-B47. With only 4 years of survey indices, no patterns are easily described or evaluated.

The fit of the predicted indices through the NEFSC spring (Yankee #36) survey indices during the late 1990s and early 2000s, similar to the DFO survey, showed a series of negative residuals in the late 1980s to 1994 and a series of positive residuals in the mid-2000s (Figure B48). This pattern does not appear strongly in the residuals of the age composition at age, however (Figure B49). The input ESS =37 is appropriate given that the predicted mean age fit well through almost all the observed mean age CIs (Figure B50, RMSE=0.97).

Fishing mortality, SSB, and recruitment (not adjusted for retrospective bias)
Fully recruited F (unweighted, ages 5+) was estimated at 0.23 in 2011 (Tables B23a-b, Figure B51a), a 21% decrease from 2010. SSB in 2011 was estimated at 22,217 mt, a 29% increase from 2010 (Table B23a, Figure B51a-b). Recruitment (millions of age 1 fish) of the 2003 year class (7.0 million) is now estimated to be smaller than the 1998 year class (11.9 million) (Tables B23a-b, Figures B51a-b). The 2008 year class (8.0 million) and 2009 (8.1 million) are similar in size to the 2003 year class.

Retrospective analysis
A retrospective analysis was performed to evaluate how well ASAP calibration would have estimated F, SSB, and recruits at age 1 for seven years (2004-2010 prior to the terminal year, 2011. While the magnitude of the retrospective bias is slightly less than that of the VPA, the pattern of over estimating SSB and underestimating F relative to the terminal year continues in this model (Figure B52). The retrospective rho value, the average of the last 7 years of retrospective bias, was 0.681 for SSB and -0.459 for F_{5+} and 0.429 for recruitment.

The WG as well as the SAW 55 review panel agreed to address the retrospective bias in the BASE ASAP by adjusting the terminal year results by applying the 7-year average rho factor for SSB and F. Applying the retrospective bias adjustment results in SSB_{2011} = 13,216 mt, F_{2011} = 0.43 and 2011 age 1 recruitment, i.e. 2010 year classs = 5.131 million age 1 fish. These adjusted results will be used for GB cod status determination.

MCMC
MCMC simulation was performed to obtain posterior probability distributions of the SSB and average F_{5+} time series. Two MCMC chains of initial length of 2.5 million were simulated with every 2,500th value saved. The trace of each chain's saved draws suggests good mixing (Figures B53 and B54). The lagged autocorrelations showed decreasing correlation with increased lag with correlations $\leq$ 0.1 beyond lag 1 (Figures B55 and B56). From the MCMC distributions, a 90% probability interval (PI) was calculated to provide a measure of uncertainty for the model point estimates for SSB and average F_{5+}. Time series plots of the 90% PIs as well as plots of the posterior probability distributions for SSB_{2011} and average F_{5+} are shown in Figures B57 through B60. Prior to applying the retrospective bias adjustment, the 2011 SSB estimate of 22,217 mt has a 90% PI of 15,809 mt – 31,993 mt and the 2011 average F_{5+} = 0.23 has a 90% PI of 0.15- 0.34.

Envelope Analysis
An 'envelope analysis' was presented to the WG as a simple method to bound reasonable abundance estimates. Based on Baranov's catch equation, with swept area estimates of biomass from the NEFSC spring, NEFSC autumn, and DFO surveys, plausible assumptions are made on upper and lower bounds of catchability (q) and F to estimate population biomass for each survey. Specific details can be found in WP 26 (Rago 2012). The composite envelope results indicate that the ASAP results of the Base model are not unreasonable (Figure B51c).

Alternative ASAP Models
Given the continued retrospective bias in the ASAP model results and the discussion of possible shifts in M in recent years based on the tagging data, the WG agreed to explore two alternative

models. Both of the alternatives address the issue of losses due to unaccounted for mortality (i.e. 'missing catch'), either from unaccounted for natural mortality, or from unaccounted for removals from the fishery (undocumented discard mortality (e.g. mortality experienced by fish escaping the gear during commercial operations), mis-reported/unreported/missing dealer or logbook statistics, biased or underestimated commercial discards and/or recreational catch).

Given that the SARC 55 Panel chose the ASAP BASE model as new benchmark model, the alternative model formulations, 'M Ramp' and 'Catch Multiplier', are described in Appendix B3 along with the model results, yield-per-recruit analyses, support for and against alternative models, and consequence analysis.

Other Sensitivity Runs

A number of sensitivity analyses were considered by the WG. Assuming upper and lower bounds on the Bigelow / Albatross calibration changed post -2005 population estimates only marginally. Assuming 100% discards rates compared to those used in the Base model resulted in little change. In a run conducted with commercial LPUE included, biomass declined faster than that of the Base model until about 1994 after which it remained relatively flat but higher than in the Base model. Splitting the survey time series in 1994 did not improve the retrospective pattern. Splitting the NEFSC spring time series to account for the change in net type (Yankee 41 to 36) did result in a modest change in historical biomass, compared to the Base model and the WG agreed to include this split in the final formulation. A run which included two fleets (Canada and US) resulted in a stronger retrospective pattern and thus the one fleet model was retained for the final formulation. Runs using a range of CVs on the catch suggested a value of 0.1 which was initially accepted by the WG but later reduced to 0.05 after consideration of the CV used in the GOM cod model, which improved the fit to the GB 1978-1988 catch data.

Biological Reference Points

The current non-parametric biological reference points (BRP) for GB cod, based on $F_{40\%}$ were revised in February 2012 (O'Brien 2012), based on VPA model results and are as follows:

SSB_{MSY} proxy= 140,424 mt, F_{MSY} proxy ($F_{40\%}$) = 0.23 and MSY proxy= 28,774 mt.

Based on the updated VPA model results, (not adjusted for retrospective bias), the stock is overfished (SSB_{2011} = 12, 531 < ½ SSB_{MSY}) and overfishing is occurring (F_{2011} = 0.69 > $F_{40\%}$). MSY proxy BRPs continue to be appropriate for this model given that the relationship between stock and recruitment does not support the use of a parametric model.

Yield per Recruit Analysis

Base Model

A YPR analysis was conducted using the methods of Thompson and Bell (1934). Input data (Table B24) for catch and stock weights (ages 1-10+) were derived from an average of the most recent five years (2007-2011). The partial recruitment (PR) was based on a normalized arithmetic mean of 2007-2011 total fishing mortality from the Base ASAP model. The maturity ogive is the 2010 vector, estimated in the 5-year moving average analysis as described above, thus the 2010 ogive is based on the combined data of 5 years: 2008-2012 (Table B16). Results

of the BASE ASAP YPR analysis are presented in Table B25 and Figure B61.

The GARM III BRP Panel (NEFSC 2008) selected $F_{40\%}$ from the non-parametric YPR analysis as the basis for the estimation of BRPs for GB Atlantic cod. The SAW 55 WG evaluated various proxies for F_{MSY} to determine if $F_{40\%}$ was still appropriate by comparing estimated SSB and recruitment ratios with expected spawning biomass per recruit over a range of fishing mortalities (F=20% to F80% in 5% increments) to investigate the potential for replacement under equilibrium assumptions (i.e. constant harvest rate and biology over the lifespan). An analysis of replacement lines under recent productivity (approximately last 10 years) indicated that 90% of the years were above the $F_{40\%}$ replacement line for the Base ASAP model thus indicating that $F_{40\%}$ was still an appropriate F_{MSY} proxy (Figure B62).

Non-parametric estimates of MSY and SSB_{MSY} based on $F_{40\%}$ were estimated using the 33-year time series mean recruitment (13.596 million age 1 fish), Y/R (1.28) and SSB/R (7.89) (Table B26 as: $F_{40\%}$ = 0.18 , MSY = 17,391 mt , SSBmsy = 107,291 mt.

MSY Biological Reference Points

Long term (100 years) stochastic projections were run using the same input data as the YPR with F_{MSY} = 0.18. Following the GARM III benchmark recommendation (NEFSC 2008) recruitment was estimated from a 2 stage CDF based on either 21 low estimates or 12 high estimates of age 1 recruitment. When SSB is < 50,000 mt, recruitment is drawn from the low recruitment CDF, and when SSB > 50,000 mt then recruitment is drawn from the high recruitment CDF (Figure B63). The WG reviewed the stock –recruit data and agreed that the 50,000 mt cutpoint was still appropriate. The long term projection provided the following non-parametric biomass reference points (Table B26):

$F_{40\%}$= 0.18,

MSY = 30,622 mt, (80% CI: 25,450- 36,302),

SSB_{MSY} = 186,535 mt (80% CI: 155,398-220,756)

Status of Stock

Based on the WGs proposed BASE ASAP model as the new benchmark model, the model results, not adjusted for retrospective bias, indicate stock status as overfished (SSB_{2011} = 22,217 mt < ½ SSB_{MSY}) and overfishing is occurring (F_{2011} = 0.23 > $F_{40\%}$) (Figure B64). The WG agreed that MSY proxy BRPs are appropriate for this model given that the relationship between stock and recruitment does not support the use of a parametric model.

The SARC 55 Panel chose the ASAP BASE Model (M=0.2) adjusted for retrospective bias as the new benchmark model for determination of stock status and catch projections. Based on this accepted benchmark model and applying retrospective bias adjustments, the stock is overfished (SSB_{2011} = 13,216 mt < ½ SSB_{MSY}) and overfishing is occurring (F_{2011} = 0.43 > $F_{40\%}$) (Figure B64).

Parametric Stock-Recruit Biological Reference Points

The relationship between stock and recruitment during 1978-2011 did not provide support for use of either a Ricker or Beverton-Holt (BH) function. When a BH was estimated within the BASE ASAP model, the relationship was relatively linear with unexploited SSB and unexploited

recruitment being estimated essentially to infinity. For this reason, the WG agreed that BRPs for GB cod continue to be based upon B_{MSY} proxies.

Projections

Short term stochastic projections under F = 75%F_{MSY} were performed from the BASE model results to estimate landings and SSB during 2013-2015. The input values for mean catch and stock weights, PR, and maturity are the same as described above for the YPR analysis. Recruitment was estimated from the 2-stage CDF described above and associated with a SSB breakpoint of 50,000 mt. Catch in 2012 was estimated based on year-to-date catch (commercial and recreational landings and discards) and assumed catch for the remainder of the year (pers. comm. Tom Nies, NEFMC).

The results of the short term projections (Table B27) indicate that for the BASE ASAP, the proposed new model, under an 75%F_{MSY} = 0.14 catch is projected to initially decrease but then increase by 2015 to catch higher than 2012, and SSB is projected to increase in each year through 2015 (Table B27). The rebuilding plan for GB cod requires that the stock reach SSB_{MSY} by 2026, however, the Frebuild projection was not conducted at this time.

Recommendations

The WG reviewed the status of previous research recommendations and proposed new ones to address issues raised during the three WG meetings, indicating priorities (High, Medium, Low) as it felt appropriate. Some of these recommendations were felt to be common to both GOM and GB cod and are indicated as 'General'

GARM III

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.

- Based upon the SAW 53 analysis on GOM cod, it was considered that taking the assessment back beyond the start of age data was not productive due to issues in the catch information

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

- Analyses to evaluate the impact of data and model formulations on status and RPs were conducted during SAW 55.

Feb 2012 update

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

There is currently a NOAA funded FATE (Fisheries and the Environment) proposal with NEFSC co-PIs that is attempting to model environmental effects on biological parameters utilized in

projections.

SAW 55 WG

- Canadian discard information is available for its scallop fishery since 1978 while only since 1997 for the groundfish (mostly longline) fishery. There is a lack of observer data for both the mobile and fixed gear fleets prior to 1997. The WG queried whether or not hindcasting of discards could be conducted for 1978 – 1996 in a similar fashion as done for the US fishery. A request was made to the Transboundary Resource Assessment Committee (TRAC) through the US TRAC co-chair (L. O'Brien) to have this analysis undertaken as part of the spring 2013 benchmark assessment of eastern Georges Bank cod. For the SAW 55, the Canadian discards were used as presented. DFO replied that it didn't consider that there is a need to do an analysis of hindcasting prior to 1996.

- On the premise that retrospective bias is likely due to unaccounted for mortality, i.e. unaccounted 'catch' (from natural mortality, fishing mortality, underestimated / unobservable discard mortality) the following is recommended to address the retrospective pattern
    - Conduct 'forensic accounting' analysis of 'missing catch' i.e. lost/unreported VTRs, lost/unreported dealer data, underestimated discards. This would include summarization of such work done to date (re: Wigley, Palmer). Request/require formal involvement of NMFS regional office to further progress on this issue.
    - Require near 100% observer coverage (for 3-5 years) of the fisheries that either target GB cod or have cod as bycatch to ascertain potential underestimation of GB cod discards.
    - Conduct designed discard mortality study of cod that pass through the trawl via trouser trawl experiment, including blood analysis to determine stress levels compared to control group. (H – general)

- The WG noted that there may be advantages to inclusion of the tagging analysis formally within the stock assessment model. This would allow consideration of the factors affecting tagging estimates of F and M, including age/size based processes. This would be a longer-term project given the complexity of integrating the two analyses (H – General)

- The WG discussed at length the appropriate means to weight the proportions at age data within the ASAP model. The current error assumption (multinomial) assumes that the standardized variance on the proportions at age is constant. Analyses were presented to the WG that indicated that the variance on the proportions at age was not constant and that in order to properly account for this in the model fitting process, it was necessary to employ an age-dependent weighting, as the adjusted log-normal and sqrt(p) SCAA formulations do. While use of the multinomial would not produce biased estimates, it would likely result in the variance being over-estimated. Further, the AIC criterion would not be valid in model selection, although it was countered that the ASAP uses a penalized likelihood. This issue

- could not be fully resolved by the WG and further work is required to explore the appropriate weighting of the proportions at age data (M - General)

- The WG considered an approach that incorporated the Bigelow/Albatross calibration coefficients within the assessment model. This allowed re-estimation of the coefficients as data on year-classes was updated. While the effect in this assessment was small, the approach has merit and should be considered for incorporation into the ASAP software (M - General)

- The WG considered that exploration of a random errors approach to the internal fitting of stock – recruitment relationships had merit. This would require extensive software changes to ASAP code (M – General)

- The WG recommended that simulations (conditioned on data) of the internal estimation of stock - recruitment functions be used to explore potential bias in the fitting of these relationships (M – General)

Summary

Based on model results of the proposed BASE ASAP, accepted by the 55th SAW with retrospective bias adjustments included, the Georges Bank Atlantic cod stock is overfished (SSB_{MSY} =186,617) and overfishing is occurring ($F_{40\%}$ = 0.18). Fishing mortality (unweighted, ages 5-8) in 2011 was estimated to be about 0.23 and when adjusted for retrospective bias, F_{2011}= 0.43. SSB was estimated at 22,217 mt in 2011, 12% of SSB_{MSY} and adjusted for retrospective bias SSB_{2011} = 13,216 mt, 7% of SSB_{MSY}. The last year class that was above the time series average (13.6 million age 1 fish) occurred almost 2 decades ago in 1990. The survey time series of biomass and abundance declined in the mid 1980s and has remained low and variable since the mid 1990s.

Productivity of the stock is low with two decades of poor recruitment and a truncated age structure. Natural mortality may have increased in recent years, thus accounting for low productivity; however, evidence for such an increase is lacking in the food habits data. The analysis of 2003-2006 tagging data suggests M was high during the years tagged cod were released, however, there is no similar tagging analysis of the earlier years. Cod have been shown to have a low hatching rate for 1st and 2nd time spawners (13% and 62%) (Trippel 1998), suggesting that an age structure of older repeat spawners would likely be more productive under favorable environmental conditions. Given the uncertainty in the magnitude of M and the overfished status, the stock is vulnerable to an allowable biological catch (ABC) quota that is too high.

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B. Tables

Table B1. Total commercial and recreational catch (metric tons, live) of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and1 Subarea 6), 1960-2011.

	USA					Canada			Distant Water Fleet				Total	
	Commercial		Recreational		Total			Total						
Year	Landings	Discards	Landings	Discards	Catch	Landings	Discards	Catch	USSR	Spain	Poland	Other	Landings	Catch
1960	10834				10834	19		19	-	-	-	-	10853	10853
1961	14453				14453	223		223	55	-	-	-	14731	14731
1962	15637				15637	2404		2404	5302	-	143	-	23486	23486
1963	14139				14139	7832		7832	5217	-	-	1	27189	27189
1964	12325				12325	7108		7108	5428	18	48	238	25165	25165
1965	11410				11410	10598		10598	14415	59	1851	-	38333	38333
1966	11990				11990	15601		15601	16830	8375	269	69	53134	53134
1967	13157				13157	8232		8232	511	14730	-	122	36752	36752
1968	15279				15279	9127		9127	1459	14622	2611	38	43136	43136
1969	16782				16782	5997		5997	646	13597	798	119	37939	37939
1970	14899				14899	2583		2583	364	6874	784	148	25652	25652
1971	16178				16178	2979		2979	1270	7460	256	36	28179	28179
1972	13406				13406	2545		2545	1878	6704	271	255	25059	25059
1973	16202				16202	3220		3220	2977	5980	430	114	28923	28923
1974	18377				18377	1374		1374	476	6370	566	168	27331	27331
1975	16017				16017	1847		1847	2403	4044	481	216	25008	25008
1976	14906				14906	2328		2328	933	1633	90	36	19926	19926
1977	21138				21138	6173		6173	54	2	-	-	27367	27367
1978	26579	223	5021	3	31823	8777	98	8875	-	-	-	-	35356	40700
1979	32645	403	5021	3	38068	5979	103	6082	-	-	-	-	38624	44153
1980	40053	426	5021	3	45500	8066	83	8149	-	-	-	-	48119	53652
1981	33849	775	5021	2.6	39644	8508	98	8606	-	-	-	-	42357	48252
1982	39333	739	4113	1.7	44185	17827	71	17898	-	-	-	-	57160	62085
1983	36756	492	4517	7.6	41765	12131	64	12196	-	-	-	-	48887	53968
1984	32915	74	1549	1.5	34537	5761	68	5829	-	-	-	-	38676	40368
1985	26828	262	5414	6.0	32504	10442	103	10545	-	-	-	-	37270	43055
1986	17490	343	988	2.2	18821	8504	51	8555	-	-	-	-	25994	27378
1987	19035	200	1373	11.5	20608	11844	76	11920	-	-	-	-	30879	32540
1988	26310	242	3103	11.0	29655	12741	83	12824	-	-	-	-	39051	42491
1989	25056	628	1239	19.5	26942	7895	76	7971	-	-	-	-	32951	34913
1990	28110	454	1489	19.2	30072	14364	70	14435	-	-	-	-	42474	44507
1991	24219	358	1203	7.5	25788	13467	65	13532	-	-	-	-	37687	39320
1992	16899	505	641	15.9	18061	11667	71	11738	-	-	-	-	28566	29800
1993	14590	284	2570	73.3	17517	8526	63	8588	-	-	-	-	23116	26105
1994	9737	159	744	31.1	10670	5277	63	5339	-	-	-	-	15013	16009
1995	7026	84	1613	60.5	8784	1102	38	1140	-	-	-	-	8128	9924
1996	7261	108	453	23.4	7845	1924	56	1980	-	-	-	-	9185	9825
1997	7548	100	1283	38.1	8969	2919	486	3404	-	-	-	-	10467	12373
1998	7041	99	859	62.0	8061	1907	365	2272	-	-	-	-	8948	10333
1999	8313	86	400	26.6	8825	1818	338	2156	-	-	-	-	10131	10982
2000	7600	137	832	53.6	8623	1572	69	1641	-	-	-	-	9172	10263
2001	10749	306	345	19.8	11420	2143	143	2286	-	-	-	-	12892	13705
2002	9472	168	311	34.4	9986	1278	94	1372	-	-	-	-	10750	11357
2003	6852	229	299	32.2	7413	1317	200	1517	-	-	-	-	8169	8930
2004	3509	130	262	12.3	3913	1112	145	1258	-	-	-	-	4621	5171
2005	2754	395	927	95.0	4171	630	228	859	-	-	-	-	3384	5030
2006	2700	230	56	3.9	2990	1096	349	1445	-	-	-	-	3796	4435
2007	3699	727	10	2.8	4439	1108	114	1221	-	-	-	-	4807	5660
2008	3255	308	66	1.0	3630	1390	139	1529	-	-	-	-	4645	5160
2009	2999	384	46	5.0	3434	1003	207	1210	-	-	-	-	4002	4643
2010	2688	253	146	22.6	3110	748	92	840	-	-	-	-	3436	3950
2011	3387	122	201	18.0	3728	702	42	744	-	-	-	-	4089	4472

Table B2a. Distribution of USA commercial Atlantic cod landings by quarter and area (Georges Bank, Georges Bank West, Georges Bank East) in metric tons, 1978-2011 (SA=statistical area).

	Landings (metric tons, live)														
	Georges Bank (Division 5Z and Subarea 6)					Georges Bank West SA 521-522, 525-526, 537-539 & Subarea 6					Georges Bank East SA 561-562				
Year	Quarter					Quarter					Quarter				
	1	2	3	4	TOTAL	1	2	3	4	TOTAL	1	2	3	4	TOTAL
1978	5494	8435	5925	5603	25456	3519	6523	5130	4783	19955	1975	1912	795	820	5502
1979	4480	10067	10136	7074	31756	2729	8019	8569	6032	25349	1751	2048	1567	1042	6408
1980	7104	13078	12111	6735	39028	3755	11366	11101	6388	32610	3349	1712	1010	347	6418
1981	7482	11047	9027	5471	33028	4037	9178	7035	4686	24936	3445	1869	1992	785	8091
1982	6801	10936	12204	8502	38443	3500	8768	9691	7918	29877	3301	2168	2513	584	8566
1983	7655	10793	10617	6870	35935	4528	8822	8258	5755	27363	3127	1971	2359	1115	8572
1984	8907	9820	8252	5058	32037	3895	7100	6226	4266	21487	5012	2720	2026	792	10550
1985	6725	8537	5756	5077	26095	3206	7064	4719	4465	19454	3519	1473	1037	612	6641
1986	6234	5526	3207	2309	17275	2625	3759	3012	2184	11580	3609	1767	195	125	5696
1987	4089	6326	4334	4006	18754	2651	4012	3976	3322	13961	1438	2314	358	684	4794
1988	7235	7305	5714	5781	26036	3641	4500	5255	4993	18389	3594	2805	459	788	7646
1989	5653	8814	6218	4369	25056	3707	5683	5809	3405	18604	1907	3084	354	838	6183
1990	6043	9125	7070	5871	28110	3616	5650	6553	5610	21429	2333	3452	459	171	6415
1991	6454	9845	4279	3641	24219	4275	6070	4120	3172	17637	2048	3758	144	403	6353
1992	4562	5561	3282	3494	16899	2574	3340	3068	2711	11693	1954	2174	190	762	5080
1993	3613	5166	2556	3255	14590	2242	3148	2314	2709	10413	1311	1992	233	491	4027
1994	2585	3454	2098	1600	9737	2478	2927	1880	1453	8738	107	527	218	146	998
1995	1438	2365	2102	1122	7026	1316	2023	2058	1086	6483	122	342	43.7	36.1	544
1996	1356	2923	1945	1037	7261	1203	2476	1913	992	6585	153	446	31.7	45.2	676
1997	1159	3449	1856	1084	7548	1067	3024	1842	1066	6999	92.6	425	13.7	17.8	549
1998	1335	2920	1493	1293	7041	1280	2370	1457	1255	6361	54.4	550	36.7	38	679
1999	1675	3807	1770	1061	8313	1463	2893	1743	1019	7118	212	914	26.3	41.8	1195
2000	1716	2798	1695	1391	7600	1502	2307	1665	1355	6829	214	491	29.9	36.2	772
2001	2350	3815	2418	2166	10749	2101	2733	2355	2073	9262	249	1082	63.3	93.1	1488
2002	2841	3834	1621	1175	9472	2408	2761	1513	1102	7784	434	1073	108	73.4	1688.1
2003	1751	2893	1308	900	6852	1304	1717	1234	746	5002	447	1175	74.1	154	1850.5
2004	912.9	1532	524.9	539	3509	679	797	497	529	2503	234	735	27.6	10.1	1006
2005	677.1	1191	528.9	358	2754	659	1076	492	357	2584	18.5	115	36.9	0.52	171
2006	449.4	821	548.5	881	2700	449	714	543	863	2569	0.68	107	5.15	18.4	131
2007	517.6	1255	1020	906	3699	494.1	1068	1014	878.67	3455	13.2	188	5.78	27.2	234
2008	711	1109	722.4	713	3255	706.8	1062	669.1	593.76	3031	4.2	47.6	53.3	119	224
2009	778.9	959.5	723.6	537	2999	702.2	778.5	589.6	480.56	2551	61.9	181	134	56.4	433
2010	642	923.8	411.2	711	2688	589.4	750.1	372.8	618.49	2331	52.5	174	38.5	92.4	357
2011	681	1133	801	773	3387	653.1	946.8	761.7	758.94	3120	27.9	186	39.3	13.7	267

Table B2b . Distribution of USA commercial Atlantic cod landings by quarter and area (Georges Bank, Georges Bank West, Georges Bank East) by percentage of total landings, 1978-2011 (SA=statistical area).

	Percentage of Annual Landings														
	Georges Bank (Div. 5Z and 6)					Georges Bank West SA 521-522, 525-526, 537-539 and Div. 6					Georges Bank East SA 561-562				
Year	Quarter					Quarter					Quarter				
	1	2	3	4	TOTAL	1	2	3	4	TOTAL	1	2	3	4	TOTAL
1978	21.6	33.1	23.3	22.0	100.0	13.8	25.6	20.2	18.8	78.4	7.8	7.5	3.1	3.2	21.6
1979	14.1	31.7	31.9	22.3	100.0	8.6	25.3	27.0	19.0	79.8	5.5	6.4	4.9	3.3	20.2
1980	18.2	33.5	31.0	17.3	100.0	9.6	29.1	28.4	16.4	83.6	8.6	4.4	2.6	0.9	16.4
1981	22.7	33.4	27.3	16.6	100.0	12.2	27.8	21.3	14.2	75.5	10.4	5.7	6.0	2.4	24.5
1982	17.7	28.4	31.7	22.1	100.0	9.1	22.8	25.2	20.6	77.7	8.6	5.6	6.5	1.5	22.3
1983	21.3	30.0	29.5	19.1	100.0	12.6	24.6	23.0	16.0	76.1	8.7	5.5	6.6	3.1	23.9
1984	27.8	30.7	25.8	15.8	100.0	12.2	22.2	19.4	13.3	67.1	15.6	8.5	6.3	2.5	32.9
1985	25.8	32.7	22.1	19.5	100.0	12.3	27.1	18.1	17.1	74.6	13.5	5.6	4.0	2.3	25.4
1986	36.1	32.0	18.6	13.4	100.0	15.2	21.8	17.4	12.6	67.0	20.9	10.2	1.1	0.7	33.0
1987	21.8	33.7	23.1	21.4	100.0	14.1	21.4	21.2	17.7	74.4	7.7	12.3	1.9	3.6	25.6
1988	27.8	28.1	21.9	22.2	100.0	14.0	17.3	20.2	19.2	70.6	13.8	10.8	1.8	3.0	29.4
1989	22.6	35.2	24.8	17.4	100.0	14.8	22.7	23.2	13.6	74.3	7.6	12.3	1.4	3.3	24.7
1990	21.5	32.5	25.2	20.9	100.0	12.9	20.1	23.3	20.0	76.2	8.3	12.3	1.6	0.6	22.8
1991	26.6	40.6	17.7	15.0	100.0	17.7	25.1	17.0	13.1	72.8	8.5	15.5	0.6	1.7	26.2
1992	27.0	32.9	19.4	20.7	100.0	15.2	19.8	18.2	16.0	69.2	11.6	12.9	1.1	4.5	30.1
1993	24.8	35.4	17.5	22.3	100.0	15.4	21.6	15.9	18.6	71.4	9.0	13.7	1.6	3.4	27.6
1994	26.6	35.5	21.5	16.4	100.0	25.5	30.1	19.3	14.9	89.7	1.1	5.4	2.2	1.5	10.3
1995	20.5	33.7	29.9	16.0	100.0	18.7	28.8	29.3	15.5	92.3	1.7	4.9	0.6	0.5	7.7
1996	18.7	40.3	26.8	14.3	100.0	16.6	34.1	26.3	13.7	90.7	2.1	6.1	0.4	0.6	9.3
1997	15.4	45.7	24.6	14.4	100.0	14.1	40.1	24.4	14.1	92.7	1.2	5.6	0.2	0.2	7.3
1998	19.0	41.5	21.2	18.4	100.0	18.2	33.7	20.7	17.8	90.4	0.8	7.8	0.5	0.5	9.6
1999	20.2	45.8	21.3	12.8	100.0	17.6	34.8	21.0	12.3	85.6	2.6	11.0	0.3	0.5	14.4
2000	22.6	36.8	22.3	18.3	100.0	19.8	30.3	21.9	17.8	89.8	2.8	6.5	0.4	0.5	10.2
2001	21.9	35.5	22.5	20.2	100.0	19.5	25.4	21.9	19.3	86.2	2.3	10.1	0.6	0.9	13.8
2002	30.0	40.5	17.1	12.4	100.0	25.4	29.2	16.0	11.6	82.2	4.6	11.3	1.1	0.8	17.8
2003	25.6	42.2	19.1	13.1	100.0	19.0	25.1	18.0	10.9	73.0	6.5	17.2	1.1	2.2	27.0
2004	26.0	43.7	15.0	15.4	100.0	19.4	22.7	14.2	15.1	71.3	6.7	20.9	0.8	0.3	28.7
2005	24.6	43.2	19.2	13.0	100.0	23.9	39.1	17.9	13.0	93.8	0.7	4.2	1.3	0.0	6.2
2006	16.6	30.4	20.3	32.6	100.0	16.6	26.4	20.1	31.9	95.1	0.0	4.0	0.2	0.7	4.9
2007	14.0	33.9	27.6	24.5	100.0	13.4	28.9	27.4	23.8	93.4	0.4	5.1	0.2	0.7	6.3
2008	21.8	34.1	22.2	21.9	100.0	21.7	32.6	20.6	18.2	93.1	0.1	1.5	1.6	3.7	6.9
2009	26.0	32.0	24.1	17.9	100.0	23.4	26.0	19.7	16.0	85.1	2.1	6.0	4.5	1.9	14.4
2010	23.9	34.4	15.3	26.4	100.0	21.9	27.9	13.9	23.0	86.7	2.0	6.5	1.4	3.4	13.3
2011	20.1	33.4	23.6	22.8	100.0	19.3	27.9	22.5	22.4	92.1	0.8	5.5	1.2	0.4	7.9

Table B3. Distribution of USA commercial landings (metric tons, live; percentage) of Georges Bank Atlantic cod (Division 5Z), by gear type,1965-2011. Data only reflect cod landings that could be identified by gear type.

NOT ALL LANDINGS HAVE A GEAR CODE

	Landings (metric tons,live)						Percentage of Annual Landings					
	Otter trawl	Sink Gill net	Line Trawl	Handline	Other gear	Total	Otter trawl	Sink Gill net	Line Trawl	Handline	Other gear	Total
1965	10251	0	582	505	9	11347	90.3	-	5.1	4.5	0.1	100
1966	10206	0	787	757	19	11769	86.7	-	6.7	6.4	0.2	100
1967	10915	0	894	704	9	12522	87.2	-	7.1	5.6	0.1	100
1968	12084	0	936	524	<1	13544	89.2	-	6.9	3.9	-	100
1969	13194	0	1371	387	<1	14952	88.2	-	9.2	2.6	-	100
1970	11270	0	1676	404	<1	13350	84.4	-	12.6	3	-	100
1971	12436	0	2334	230	2	15002	82.9	-	15.6	1.5	-	100
1972	10179	0	2071	217	10	12477	81.6	-	16.6	1.7	0.1	100
1973	12431	3	2185	206	21	14846	83.7	-	14.7	1.4	0.2	100
1974	14078	3	2548	11	9	16649	84.6	-	15.3	0.1	-	100
1975	12069	0	2435	84	4	14592	82.7	-	16.7	0.6	-	100
1976	12257	4	1519	153	5	13938	88	-	10.9	1.1	-	100
1977	18529	30	912	83	22	19576	94.7	0.2	4.7	0.4	0.1	100
1978	22412	141	1594	1184	126	25456	87.8	0.3	6.6	5	0.3	100
1979	27248	769	2709	870	161	31756	85.9	2	8.8	2.8	0.5	100
1980	33032	4612	1103	6	276	39028	84.7	11.7	2.9	-	0.7	100
1981	28216	3901	122	587	202	33028	86.2	10.9	0.4	1.8	0.6	100
1982	34065	3149	385	627	216	38443	88.9	7.8	1	1.7	0.6	100
1983	32392	2174	833	447	89	35935	90.7	5.3	2.4	1.3	0.3	100
1984	27470	3203	382	755	227	32037	87.1	8.6	1.2	2.5	0.6	100
1985	22070	3094	468	298	165	26095	86.4	10	1.8	1.1	0.7	100
1986	14198	1853	799	329	96	17275	83	10.3	4.2	1.9	0.6	100
1987	14976	1624	1757	293	105	18754	79.9	8.9	9.5	1.3	0.4	100
1988	21333	2053	2158	290	202	26036	83	7.6	8	0.9	0.5	100
1989	19293	3549	1785	160	267	25056	78.4	13.8	6.9	0.5	0.4	100
1990	23162	2701	1360	518	369	28110	84.1	9.0	4.9	1.5	0.5	100
1991	18836	2614	2003	357	409	24219	79.7	9.7	8.5	1.3	0.8	100
1992	12475	2208	1851	206	158	16899	75.7	11.3	11.1	1.2	0.7	100
1993	11366	1584	1460	79	102	14590	79.7	9.7	9.6	0.4	0.6	100
1994	6899	1375	1193	238	31	9737	70.9	14.1	12.3	2.4	0.3	100
1995	3897	1380	1353	369	27	7026	55.5	19.6	19.3	5.3	0.4	100
1996	4158	1611	1007	463	22	7261	57.3	22.2	13.9	6.4	0.3	100
1997	4475	1652	901	497	23	7548	59.3	21.9	11.9	6.6	0.3	100
1998	4035	959	1374	633	41	7041	57.3	13.6	19.5	9.0	0.6	100
1999	4724	1556	1528	460	44	8313	56.8	18.7	18.4	5.5	0.5	100
2000	4545	1770	830	415	42	7600	59.8	23.3	10.9	5.5	0.5	100
2001	7134	1579	1089	890	57	10749	66.4	14.7	10.1	8.3	0.5	100
2002	6683	1362	773	529	124	9472	70.6	14.4	8.2	5.6	1.3	100
2003	5143	1209	231	233	36	6852	75.1	17.7	3.4	3.4	0.5	100
2004	2771	410	107	154	67	3509	79.0	11.7	3.0	4.4	1.9	100
2005	2273	236	130	53	63	2754	82.5	8.6	4.7	1.9	2.3	100
2006	2130	311	63	65	130	2700	78.9	11.5	2.3	2.4	4.8	100
2007	2982	585	80	34	18	3699	80.6	15.8	2.2	0.9	0.5	100
2008	2568	583	63	25	16	3255	78.9	17.9	1.9	0.8	0.5	100
2009	2379	453	109	38	20	2999	79.3	15.1	3.6	1.3	0.7	100
2010	2103	242	115	18	210	2688	69.3	16.3	9.1	4.4	1.0	100
2011	2763	189	102	28	305	3387	69.2	16.4	8.9	4.5	1.0	100

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

Table B4. Commercial discards (mt) of Atlantic cod in Georges Bank otter trawl, gill net, longline, and scallop fisheries with coefficient of variation (cv) and number of trips, 1989-2011. Delphi mortality rate not yet applied.

WESTERN

	WGB large mesh trawl			WGB small mesh traw		WGB gillnet, large			WGB longline			WGB Scallop			**Western GB Total**	
Year	mt	cv	# trips	mt	cv	mt	cv	# trips	mt	cv	# trips	mt	cv	# trips	mt	cv
1989	606.7	0.28	25	31.1	0.53										637.9	0.27
1990	431.8	0.35	23	1.6	0.49										433.4	0.35
1991	302.8	0.48	28	0.8	0.73				55.2	0.84	16			1	358.8	0.42
1992	147.5	0.52	26	0.1	3.94				580.6	0.18	23	33.9	0.84	10	762.0	0.17
1993	254.5	0.31	14	11.5	1.13							15.9	0.35	11	281.9	0.29
1994	87.1	0.86	19	11.7	0.00	71.9	0.42	13			1	30.0	1.01	6	200.7	0.43
1995	52.9	0.48	41	1.2	1.33	54.0	0.35	39				0.3	0.71	6	108.4	0.29
1996	20.4	0.42	16	0.8	0.00	89.8	0.71	17				24.7	0.48	13	135.6	0.49
1997	19.1	0.30	16	0.5	0.00	77.0	0.45	13				23.6	0.54	10	120.2	0.31
1998	6.6	0.56	5	6.0	0.00	57.5	0.80	33				43.3	0.40	9	113.4	0.43
1999	35.3	0.56	11	0.0		44.2	0.44	30				24.9	0.45	36	104.4	0.29
2000	66.7	1.04	20	7.5	0.42	77.6	0.30	44				3.3	0.15	179	155.1	0.47
2001	150.8	0.59	34	8.0	0.42	41.9	0.52	27				7.3	0.28	17	207.9	0.44
2002	75.5	0.33	68	15.0	0.34	61.4	0.63	22	113.7	0.56	7	5.1	0.43	11	270.7	0.29
2003	116.9	0.21	140	20.1	0.72	43.9	0.24	88	6.5	4.68	5	4.5	0.31	12	191.9	0.22
2004	51.1	0.19	192	5.2	0.35	32.1	0.32	174	12.1	0.36	111	0.4	0.73	25	100.9	0.15
2005	225.2	0.12	645	8.0	0.19	6.3	0.44	161	37.4	0.51	224	2.0	0.32	81	278.9	0.12
2006	155.7	0.18	342	2.5	0.47	11.0	0.43	45	15.1	0.60	57	4.3	0.23	102	188.6	0.16
2007	563.9	0.11	345	8.2	0.97	12.8	0.37	106	5.2	0.61	51	4.4	0.21	177	594.3	0.11
2008	354.8	0.10	445	3.1	0.63	19.8	0.52	61	4.7	0.46	54	2.1	0.19	210	384.5	0.09
2009	250.6	0.13	379	1.9	1.16	33.0	0.35	48	3.3	0.23	44	0.7	0.37	59	289.5	0.12
2010	160.8	0.11	435	3.8	0.66	9.1	0.25	434	2.6	0.29	112	2.4	0.33	93	178.7	0.10
2011	95.2	0.10	537	0.3	0.95	5.1	0.34	367	13.1	0.37	33	2.3	0.20	117	116.1	0.09

Georges Bank Total

Year	mt	cv
1989	837.1	0.212
1990	605.8	0.534
1991	508.1	0.368
1992	998.7	0.164
1993	372.0	0.245
1994	207.7	0.415
1995	108.7	0.293
1996	137.4	0.486
1997	127.0	0.292
1998	126.4	0.389
1999	117.4	0.256
2000	176.7	0.419
2001	402.7	0.408
2002	282.5	0.281
2003	299.5	0.222
2004	170.9	0.218
2005	535.4	0.085
2006	314.3	0.132
2007	953.3	0.132
2008	411.7	0.088
2009	511.6	0.105
2010	361.0	0.244
2011	190.4	0.093

EASTERN

	EGB large mesh trawl			EGB scallop dredge		EGB small mesh otter			**Eastern GB Total**	
Year	mt	cv	# trips	mt	cv	mt	cv	# trips	**mt**	**cv**
1989	100.2	0.45	12	0.00		12.4	0.00	3	112.6	0.40
1990	91.8	0.38	10	0.00		0.0		1	91.8	0.38
1991	148.7	0.74	4	0.00		0.0			148.7	0.74
1992	231.9	0.42	11	3.34	0.00	0.0			235.3	0.41
1993	66.6	0.62	13	2.28	0.00	0.0			68.9	0.60
1994	5.0	1.17	15	1.24	0.00	0.0		1	6.3	0.94
1995	0.3	0.61	15	0.00		0.0			0.3	0.61
1996	1.5	0.38	9	0.00		0.0			1.5	0.38
1997	0.0			6.40	0.00	0.0			6.4	0.00
1998	1.6	0.00	2	5.76	0.00	0.0			7.3	0.00
1999	11.7	0.00	4	1.29	0.86	0.0			13.0	0.09
2000	20.9	0.45	9	0.69	0.22	0.0		2	21.6	0.43
2001	194.8	0.70	11	0.00		0.5	0.00	2	195.3	0.70
2002	11.8	0.49	21	0.00		0.5	1.37	6	12.3	0.47
2003	103.8	0.51	68	1.82	0.00	6.4	0.00	4	112.1	0.47
2004	69.0	0.51	67	0.28	0.43	7.2	0.66	7	76.5	0.47
2005	253.8	0.13	93	0.52	0.70	11.0	0.60	14	265.4	0.12
2006	125.0	0.23	40	0.56	0.59	0.0		5	125.5	0.23
2007	354.2	0.31	48	0.73	0.49	17.2	1.02	11	372.1	0.30
2008	25.8	0.19	122	0.90	0.26	0.2	0.76	5	26.9	0.18
2009	193.7	0.19	116	1.10	0.43	0.5	0.53	14	195.3	0.19
2010	141.1	0.52	87	0.07	0.00	0.3	0.77	22	141.4	0.51
2011	36.2	0.15	136	1.08	0.54	0.0	0.33	*19*	37.3	0.15

SOUTHERN NEW ENGLAND

	SNE large mesh trawl			EGB scallop dredge		**SNE Total**	
Year	mt	cv	# trips	mt	cv	**mt**	**CV**
1989	41.9	0.00	12	44.7	0.56	86.6	0.29
1990	28.8	0.61	10	51.7	5.48	80.6	3.53
1991	0.0		4	0.6	0.61	0.6	0.61
1992	0.9	0.83	11	0.5	1.05	1.4	0.65
1993	7.4	0.00	13	13.8	0.67	21.2	0.44
1994	0.0		15	0.8	1.00	0.8	1.00
1995	0.0		15	0.0		0.0	
1996	0.3	0.51	9	0.0		0.3	0.51
1997	0.4	0.75		0.0	15.34	0.4	1.09
1998	0.0		2	5.6	0.00	5.6	0.00
1999	0.0		4	0.0		0.0	
2000	0.0		9	0.0		0.0	
2001	0.0		11	0.0		0.0	
2002	0.0		21	0.0		0.0	
2003	0.0		68	1.9	0.45	1.9	0.45
2004	0.4	0.68	67	0.3	0.46	0.7	0.42
2005	1.1	0.60	93	1.1	0.57	2.2	0.41
2006	0.2	1.04	40	0.0		0.2	1.04
2007	2.2	1.11	48	1.8	0.54	4.0	0.66
2008	0.1	0.95	122	0.4	0.48	0.5	0.43
2009	25.8	0.79	116	1.5	0.44	27.3	0.74
2010	41.2	1.12	43	0.0	1.28	41.2	1.12
2011	36.7	0.36	36	0.3	0.64	37.0	0.35

Table B5a. Estimated numbers (000s) of Atlantic cod recreational catch as estimated by the Marine Recreational Information Program (MRIP) from the Georges Bank and South stock during 1981-2011. Catch from 1981-2003 are Marine Recreational Fisheries Statistics Survey (MRFSS) estimates adjusted to MRIP estimates. Delphi mortality of 30% applied.

	Catch	Landings		Discards	
Year		Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec
1981	1761	1322	420	15	4
1982	1521	1145	363	10	3
1983	1746	1292	410	35	9
1984	475	349	111	12	3
1985	1943	1451	461	24	6
1986	306	226	72	7	2
1987	488	354	112	18	5
1988	1181	868	276	30	8
1989	433	302	96	28	7
1990	492	349	111	25	6
1991	399	287	91	17	4
1992	231	157	50	20	5
1993	884	584	185	90	23
1994	365	222	70	57	15
1995	612	392	125	76	20
1996	183	115	36	26	7
1997	407	255	81	56	15
1998	353	208	66	63	16
1999	166	97	31	31	8
2000	376	222	70	67	17
2001	124	76	24	19	5
2002	126	71	23	26	7
2003	126	72	23	24	6
2004	90	33	38	10	10
2005	378	222	38	97	20
2006	20	3	11	1	4
2007	6	1	2	2	1
2008	23	17	4	1	0
2009	23	14	1	7	0
2010	73	42	6	24	1
2011	86		19	17	4

Table B5b. Percent standard error of estimated numbers (000s) of Atlantic cod recreational catch as estimated by the Marine Recreational Information Program from the Georges Bank and South stock during 1981-2011.

Year	CT	DE	MD	MA	NJ	NY	NC	RI	VA
1981	100			23.4		15.6		25.2	
1982				39.1		29.2		29.1	
1983		58		13.6		29.6		29.8	
1984	60.8			13.9		28.3		22.4	
1985	32.5	64.3		23.3		26		70.8	
1986	45.2	46.2		22.6	44.6	31.8		24.7	
1987	63.3			14.3	75	26.6		25.9	
1988	46.3	91.3		10.6	47.1	19.4	75.9	23.4	
1989				14.6	40.1	16.3		28	
1990	40.2			11.2	69.3	14.8		18.3	
1991	64.7	100.5		9.5	100	21		24	
1992	54.6			13.5	33	16.6		43.2	31
1993	62.9	71		13.1	40.2	15.4		37	70.1
1994		100		9.2	44.6	23.6		34.9	
1995	62.3			11.2	100	19.6		15.8	
1996			105.9	13.2	36.7	33.2		32.8	100.6
1997		100		17.6	63.6	21.9		28.4	
1998	63.1	100	77.7	17.4	34.1	45.1		20.7	
1999	72.1			17.7	100			34.8	
2000		100.2		14.5		33		18.9	
2001				8	102.8	43.8		23.2	
2002	100			9.1				35.7	
2003	60.6	100		9.5	100	52.4		48.1	
2004	14.3			19.7	90.9	31.8		26.7	
2005			117.1	15.1	30.2	66		22	
2006	2.2	100.5		13.9	23.9	70.2		17.6	
2007				16.8	97.5	67.2		42.8	
2008				17.7	113.5	52.1		3	
2009		99.3	83.7	18	38.3	51.3		14.8	117.4
2010		38.4	57.2	17.6	53.3	15.6		90.9	100
2011		53	33.6	12	27.8	13.1		69.5	80.2
2012			101.1	22	83.3	57.9		85.9	

Table B6a. USA sampling of commercial Atlantic cod landings, by market category, for the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2011.

	Number of Samples, by Market Category & Quarter															Annual Sampling Intensity			
	Scrod					Market					Large					No. of Tons Landed/Sampled			
Year	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Q1	Q2	Q3	Q4	∑	Scrd	Mkt	Lge	∑
1978	17	15	6	3	41	9	12	13	9	43	1	0	1	2	4	69	374	1922	302
1979	2	5	14	8	29	6	19	11	8	44	2	0	4	1	7	88	407	1742	408
1980	7	10	13	4	34	12	14	5	1	32	3	0	0	0	3	136	588	5546	580
1981	4	10	11	3	28	6	9	10	2	27	2	0	0	0	2	149	634	6283	594
1982	5	9	32	9	55	6	20	27	13	66	8	8	9	5	30	156	279	410	260
1983	4	12	17	10	43	12	19	22	14	67	2	15	16	3	36	185	291	259	252
1984	6	8	8	7	29	8	15	8	11	42	18	5	3	3	29	138	441	358	329
1985	6	7	16	5	34	11	11	12	8	42	4	8	7	5	24	201	299	310	268
1986	6	7	7	6	26	8	10	10	11	39	6	5	10	8	29	142	215	186	186
1987	7	8	6	8	29	6	8	9	10	33	6	6	4	2	18	240	220	267	238
1988	8	6	7	5	26	13	7	9	9	38	4	4	3	1	12	283	331	532	346
1989	2	7	9	9	27	7	8	8	7	30	3	4	1	1	9	210	450	660	380
1990	8	9	10	4	31	10	13	9	8	40	4	4	4	0	12	295	315	538	340
1991	6	11	7	5	29	12	13	8	8	41	4	6	3	5	18	158	293	423	275
1992	6	7	7	10	30	8	10	6	9	33	5	5	3	1	14	149	215	377	219
1993	5	16	7	6	34	10	10	7	9	36	6	1	3	2	12	126	173	339	178
1994	3	9	8	2	22	5	11	7	4	27	1	4	3	1	9	92	187	290	167
1995	2	3	13	2	20	2	4	10	2	18	0	1	0	1	2	83	181	880	167
1996	6	2	12	3	23	5	6	11	6	28	0	2	1	1	4	59	143	400	127
1997	3	11	3	10	27	5	16	9	9	39	3	6	0	5	14	50	105	148	94
1998	3	7	23	5	38	10	10	15	3	38	1	2	1	0	3	44	92	573	88
1999	5	3	10	3	21	7	14	10	7	38	2	5	2	0	9	80	118	205	121
2000	21	19	16	27	83	20	14	13	16	63	2	2	2	2	8	18	72	192	49
2001	11	9	13	3	36	9	10	8	10	37	6	12	6	10	34	72	163	55	99
2002	5	7	7	1	20	8	10	11	6	35	14	8	6	3	31	80	153	63	109
2003	4	8	6	10	28	7	16	10	6	39	5	11	10	4	30	21	113	52	70
2004	8	11	4	10	33	14	6	8	13	41	25	13	2	11	51	8	53	20	28
2005	6	12	4	5	27	5	10	12	8	35	7	11	7	11	36	7	52	19	27
2006	11	16	8	14	49	13	15	10	13	51	25	28	7	18	78	6	38	6	15
2007	14	10	10	11	45	22	18	9	10	59	20	27	15	15	77	10	47	6	20
2008	13	11	10	16	50	21	12	9	11	53	40	20	17	18	95	9	44	4	16
2009	15	21	16	13	65	18	20	13	5	56	31	25	11	10	77	5	42	4	15
2010	32	22	15	23	92	32	27	11	19	89	30	12	10	17	69	4	23	4	11
2011	28	18	8	10	64	29	21	6	6	62	34	9	6	13	62	8	39	7	18

Table B6b. USA and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978 - 2011.

	USA					Canada				
	Length Samples			Age Samples		Length Samples			Age Samples	
Year	No.	# Fish Measured		No.	# Fish Aged	No.	# Fish Measured		No.	# Fish Aged
1978	88	6841		76	1463	28	7684		27	1364
1979	80	6973		79	1647	11	3103		11	591
1980	69	4990		67	1119	10	2784		10	536
1981	57	4304		57	1231	17	4147		16	897
1982	151	11970		147	2579	17	4705		17	858
1983	146	12544		138	2945	15	3822		14	604
1984	100	8721		100	2431	7	1889		7	385
1985	100	8366		100	2321	27	7031		20	958
1986	94	7515		94	2222	22	5890		19	888
1987	80	6395		79	1704	31	9133		24	1236
1988	76	6483		76	1576	40	11350		36	1927
1989	66	5547		66	1350	32	8726		30	1561
1990	83	7158		83	1700	109	31974		35	1672
1991	88	7708		88	1865	98	27869		37	1782
1992	77	6549		77	1631	89	29082		44	1856
1993	82	6636		82	1598	99	31588		47	2146
1994	58	4688		54	1064	111	27972		27	1268
1995	40	2879		40	778	33	6660		13	548
1996	55	4600		54	1080	125	26069		20	828
1997	80	6638		80	1581	103	31617		29	1216
1998	80	7076		81	1545	115	26180		53	1643
1999	68	5987		67	1503	85	26232		29	880
2000	154	12421		154	3043	97	20582		41	1374
2001	108	8389		108	2421	98	19055		39	1505
2002	86	6400		86	2179	80	16119		32	1252
2003	92	6116		90	2135	94	19757		29	1070
2004	125	8749		107	2755	132	18392		37	1357
2005	98	4705		86	1681	153	23937		42	786
2006	178	9431		2798	163	307	44708		31	812
2007	181	9200		171	2697	521	141607		48	1191
2008	198	9747		160	2493	257	64387		48	1214
2009	198	9447		174	2595	188	48335		54	1479
2010	250	12289		239	3549	151	30647		27	1022
2011	188	10678	57	163	2374	15 193	40936	212	32	1119

Table B7. Coefficient of variation for USA western and eastern Georges Bank commercial Atlantic cod landings at age estimated for 1996- 2011. Values for earlier years are estimable but not readily available; 1997 for western Georges Bank not available.

GB cod West (521,522,525,526,537,538,539,600+)

ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1996		0.17	0.09	0.06	0.17	0.18	0.61	0.50	0.43						
1997															
1998	0.98	0.07	0.08	0.10	0.12	0.16	0.40	0.97	1.25						
1999		0.20	0.06	0.08	0.18	0.22	0.20	0.54	1.12						
2000	0.42	0.04	0.06	0.04	0.11	0.16	0.21	0.20	1.11						
2001	1.38	0.18	0.06	0.12	0.14	0.22	0.27	0.30	0.25	0.87	1.38				
2002		0.41	0.09	0.05	0.13	0.12	0.18	0.38	0.35	0.42	0.81	1.61			
2003		0.26	0.10	0.08	0.06	0.14	0.17	0.29	0.50	0.85	1.29				
2004		0.16	0.04	0.10	0.07	0.08	0.14	0.13	0.28	0.33	0.52	0.65	0.81		
2005		0.24	0.14	0.06	0.16	0.12	0.16	0.18	0.25	0.51	0.34	1.38			
2006		0.32	0.04	0.08	0.06	0.15	0.14	0.14	0.29	0.29	0.69	0.87	1.01	0.86	
2007		0.14	0.11	0.03	0.16	0.14	0.29	0.29	0.46	0.88	1.11				
2008		0.10	0.05	0.13	0.07	0.22	0.27	0.36	0.39	0.49	1.24	1.05	1.01		
2009		0.18	0.05	0.04	0.13	0.12	0.28	0.36	0.60	0.60	1.28	0.84			
2010		0.21	0.06	0.04	0.09	0.22	0.12	0.97	0.57	0.92	0.88				
2011		0.07	0.06	0.03	0.03	0.03	0.05	0.05	0.18	0.31	0.43	0.38	0.60	0.55	1.05

GB cod East (561-562)

ages	1	2	3	4	5	6	7	8	9	10	11	12	13
1996	3.41	0.38	0.15	0.08	0.22	0.24	0.90	0.56	0.39		1.95		
1997		0.40	0.40	0.28	0.11	0.22	0.30	0.15	0.23	0.29	0.32	0.90	
1998		0.40	0.22	0.20	0.17	0.18	0.40	0.99	1.18				
1999		0.28	0.15	0.20	0.30	0.57	0.38	0.95	1.28	1.73			
2000		0.11	0.15	0.12	0.33	0.48	0.83	5.60	5.65				
2001		0.22	0.12	0.19	0.20	0.35	0.77	0.58	0.61	1.11	3.85	9.78	
2002		0.30	0.16	0.10	0.21	0.26	0.31	0.36	0.72	0.57	0.75	2.36	
2003		0.15	0.24	0.14	0.08	0.24	0.22	0.52	0.47	0.86	1.33		
2004		0.23	0.19	0.25	0.15	0.14	0.33	0.22	0.50				
2005		0.29	1.32	0.22	0.20	0.36	0.31	0.20	0.26	0.35			0.91
2006		0.32	0.26	0.14	0.28	0.41	0.32		31.62		31.62		
2007		0.90	0.32	0.07	0.41	0.29	0.46	0.60	0.75	1.14	1.87		
2008		0.22	0.12	0.27	0.12	0.57	0.38	1.00	1.11	1.13			
2009		0.15	0.22	0.26	0.29	0.40	0.38	0.37	0.96				
2010		0.54	0.16	0.14	0.17	0.54	0.23	0.95	1.25				
2011		0.07	0.06	0.06	0.03	0.06	0.12	0.15					

Table B8a. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2011.

	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	226	1108	1345	201	59	96	29	14	4	3081
1995	0	341	1006	570	310	27	19	19	5	1	2299
1996	0	211	753	947	191	137	8	9	10	0	2267
1997	0	399	539	674	566	75	60	11	6	3	2332
1998	8	693	979	349	258	190	24	8	2	0	2510
1999	0	256	1663	606	211	86	112	15	2	0	2951
2000	9	721	627	865	205	58	30	29	2	0	2546
2001	1	508	2302	616	457	111	34	15	11	1	4056
2002	0	32	1001	1293	310	285	68	13	8	5	3016
2003	0	74	279	650	707	117	94	17	4	2	1944
2004	0	30	272	153	228	158	34	26	6	3	912
2005	0	22	96	358	100	77	55	8	4	2	721
2006	0	12	441	129	185	29	15	13	2	2	827
2007	0	114	168	793	43	65	6	4	3	1	1198
2008	0	162	521	112	301	6	16	0	1	0	1118
2009	0	36	360	355	72	96	4	4	0	0	927
2010	0	21	295	401	102	13	47	1	2	0	881
2011	0	33	376	340	228	67	10	16	3	1	1073

Table B8a - continued. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2011.

	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	1350	36756
1984	72	2151	8080	10435	2887	2823	3279	396	1614	1178	32915
1985	118	5857	3475	4051	6910	2009	1563	1603	194	1048	26828
1986	126	1638	7325	1606	2036	2796	508	510	594	351	17490
1987	16	6849	2014	5556	1147	1290	1309	338	240	275	19035
1988	0	2533	12755	2313	5556	1021	733	851	201	347	26310
1989	0	2750	5861	11937	1288	2274	406	262	241	37	25056
1990	0	7087	7638	4488	6723	782	1013	175	101	102	28110
1991	50	1799	6990	6616	4246	3412	498	383	137	88	24219
1992	1	3423	3094	2961	4202	1571	1251	174	165	59	16899
1993	0	1171	6787	2020	1526	1625	638	629	150	43	14590
1994	0	306	2306	4593	965	427	670	261	140	67	9737
1995	0	511	2005	2151	1627	231	175	234	66	27	7026
1996	0	320	1821	3022	910	900	79	94	113	2	7261
1997	0	629	1260	2378	2219	429	447	83	68	34	7548
1998	4	1020	2203	1240	1240	1059	192	57	23	2	7041
1999	0	394	3525	1995	987	503	758	126	22	2	8313
2000	10	1225	1534	3029	977	340	225	242	18	0	7600
2001	0	782	5198	1810	1909	599	220	118	101	13	10749
2002	0	60	2167	3847	1226	1486	439	105	80	63	9472
2003	0	152	663	1944	2783	570	560	123	37	22	6852
2004	0	61	745	507	922	791	196	197	56	34	3509
2005	0	41	246	1226	410	386	313	65	40	29	2754
2006	0	24	1112	465	749	139	89	89	14	18	2700
2007	0	232	419	2515	171	281	31	27	17	5	3699
2008	0	335	1330	344	1107	39	84	5	7	4	3255
2009	0	70	883	1222	300	466	26	26	4	2	2999
2010	0	42	726	1240	393	52	218	6	10	2	2688
2011	0	65	932	1043	843	311	55	91	31	17	3387

Table B8a - continued. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2011.

	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	0.896	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	10.370	3.264
2007	0.000	2.027	2.495	3.169	3.947	4.299	5.363	7.038	6.646	7.777	3.088
2008	0.000	2.074	2.552	3.075	3.682	6.351	5.387	10.318	8.839	13.714	2.910
2009	0.000	1.924	2.451	3.447	4.158	4.860	7.296	6.649	8.818	13.092	3.235
2010	0.000	2.010	2.463	3.097	3.855	4.155	4.587	5.649	4.890	14.043	3.052
2011	0.000	1.957	2.480	3.072	3.703	4.661	5.487	5.609	11.422	15.053	3.158

Table B8a - continued. USA commercial landings (thousands of fish; metric tons), mean weight (kg) and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978- 2011.

	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	97.8	67.6
2007		58.1	62.5	67.7	72.5	74.7	80.3	87.9	86.2	89.6	66.8
2008		58.6	63.2	67.4	71.5	85.8	79.7	100.1	95.2	103.2	65.6
2009		57.6	62.4	70.1	74.6	78.6	89.2	87.4	94.9	110.4	68.0
2010		58.0	62.4	67.4	72.6	74.0	76.8	80.6	76.5	108.9	66.8
2011		57.6	62.3	66.9	71.6	77.4	81.5	82.0	105.5	115.5	67.2

Table B8b. Canadian commercial landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Landings in Numbers (000's) at Age						
1978	1.4	71.4	2341.1	719.5	216.2	76.1	56.8	11.7	10.7	6.1	3511
1979	4.5	553.3	532.1	793.7	267.2	57.3	15.2	11.9	1.9	2.7	2240
1980	0.7	705.1	1078.5	200.6	499.1	135.3	31.3	14.1	26.3	16.5	2707
1981	2.8	272.1	888.3	637.3	183.9	278.4	93.1	42.6	27.7	10.6	2437
1982	6.8	2200.4	1455.2	900.5	689.5	154.0	233.9	104.6	29.9	32.5	5807
1983	15.5	411.3	1429.8	863.2	290.3	218.8	89.8	126.6	70.0	24.1	3539
1984	0.0	25.1	133.5	379.8	257.7	156.3	95.3	18.1	35.2	27.9	1129
1985	2.5	2162.4	960.2	403.5	553.8	155.1	45.9	50.1	12.9	11.7	4358
1986	9.6	244.3	1358.7	395.7	156.8	239.7	37.6	22.0	11.9	3.6	2480
1987	20.1	3057.2	604.6	764.2	98.9	81.9	115.5	24.8	15.2	6.7	4789
1988	18.4	229.1	2726.3	344.7	410.7	62.6	71.5	129.0	43.3	27.9	4064
1989	1.2	389.6	340.0	927.7	135.6	200.3	35.0	26.4	41.4	23.5	2121
1990	8.4	429.1	2108.1	702.0	834.1	88.2	92.9	7.0	9.5	25.7	4305
1991	34.5	688.2	654.3	1301.1	582.1	480.5	67.1	49.1	15.4	23.6	3896
1992	43.7	1747.3	917.6	293.4	549.7	204.2	216.3	38.3	27.6	9.8	4048
1993	4.9	269.3	1158.9	624.4	192.9	247.0	97.4	73.2	19.2	16.8	2704
1994	2.7	148.8	357.8	640.2	228.7	37.7	50.0	25.0	17.0	1.9	1510
1995	0.7	40.9	163.2	62.5	56.6	11.8	4.7	2.5	2.0	0.0	345
1996	1.3	27.6	170.0	282.9	55.4	38.1	10.7	2.6	1.6	0.2	590
1997	3.3	104.5	148.0	273.1	244.5	61.2	26.4	9.5	2.9	1.0	874
1998	0.3	57.6	209.6	101.5	94.8	80.3	15.7	8.7	2.9	1.7	573
1999	4.3	41.4	263.2	177.0	48.3	28.4	25.9	7.4	1.1	0.5	597
2000	0.0	30.0	59.3	238.2	94.9	23.4	14.2	8.1	2.1	0.6	471
2001	0.0	8.8	185.5	113.6	212.7	61.1	18.1	8.9	2.8	0.3	612
2002	0.0	2.7	34.9	144.6	42.3	76.4	14.0	4.7	2.1	1.5	323
2003	0.0	4.7	55.7	72.6	141.6	28.5	39.5	9.2	2.1	1.1	355
2004	0.0	2.6	60.5	64.4	53.8	73.0	17.5	18.7	4.1	1.6	296
2005	0.0	5.8	12.4	83.4	23.7	18.3	20.8	8.4	4.1	1.2	178
2006	0.0	2.6	112.0	43.9	124.2	32.2	13.5	13.7	1.8	1.5	345
2007	0.0	17.2	28.8	235.6	19.2	56.4	10.0	6.2	6.0	0.4	380
2008	0.0	17.6	96.2	47.9	201.0	13.3	28.6	3.8	1.9	0.8	411
2009	0.0	12.5	87.2	67.8	22.6	91.9	7.5	8.4	1.1	0.6	300
2010	0.0	7.7	46.8	129.5	45.4	10.3	20.4	2.4	1.4	0.4	264
2011	0.0	19.8	49.9	57.0	81.5	16.9	9.9	5.5	0.2	0.2	241

Table B8b continued. Canadian commercial landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Landings in Weight (Tons) at Age						
1978	1.0	88.4	4997.5	1908.2	735.9	425.7	336.9	109.3	89.4	84.6	8777
1979	5.8	815.8	814.3	2590.4	1117.5	317.8	135.0	125.0	19.0	38.3	5979
1980	0.4	876.8	2461.0	611.6	2370.4	844.2	210.5	173.3	294.2	223.6	8066
1981	2.3	346.8	1840.9	2037.2	869.1	1824.0	744.3	388.2	280.8	174.4	8508
1982	3.8	2971.8	3100.5	3322.7	3491.3	1038.2	1992.9	1041.0	350.8	513.8	17827
1983	14.1	570.1	3026.7	2673.2	1388.9	1338.0	716.3	1282.1	800.9	320.9	12131
1984	0.0	36.5	335.7	1446.6	1275.5	946.9	775.4	175.0	380.1	389.0	5761
1985	1.7	2836.2	1751.2	1312.1	2507.3	923.0	351.0	462.1	134.9	162.8	10442
1986	7.1	376.2	3623.5	1425.4	810.2	1621.2	298.6	195.6	109.9	36.2	8504
1987	12.4	4559.0	1482.5	3089.9	552.5	592.0	1034.8	240.3	177.9	102.6	11844
1988	12.7	260.6	6023.5	1153.8	2040.0	395.6	628.9	1333.1	494.7	398.5	12741
1989	0.9	451.8	677.9	3467.6	709.6	1284.2	247.0	264.0	457.0	334.9	7895
1990	6.3	731.7	5465.8	2387.4	3975.4	540.5	722.4	73.1	108.6	353.1	14364
1991	28.1	1084.3	1627.1	4184.5	2418.2	2664.4	497.2	478.9	147.9	336.8	13467
1992	40.3	2525.2	2150.6	1022.1	2416.2	1199.3	1508.5	335.8	319.2	149.7	11667
1993	3.9	388.7	2511.7	1797.1	822.4	1360.7	647.4	624.3	169.3	200.2	8526
1994	2.2	202.5	800.4	2276.9	1030.7	245.1	364.7	201.6	130.4	21.9	5277
1995	0.3	54.6	367.4	214.3	295.0	76.4	47.6	25.3	20.4	0.4	1102
1996	1.2	40.4	380.0	887.6	275.1	228.0	70.2	22.7	16.4	2.5	1924
1997	3.0	152.3	314.2	823.9	963.1	336.1	200.8	81.7	33.3	10.4	2919
1998	0.2	81.6	467.8	304.9	381.5	442.1	104.4	70.9	30.5	23.7	1907
1999	2.5	57.3	566.1	579.7	190.2	168.2	175.1	59.8	12.3	7.2	1818
2000	0.0	43.9	125.6	721.1	396.9	114.6	84.1	58.9	19.0	7.6	1572
2001	0.0	13.3	432.3	340.9	852.5	310.7	92.7	70.1	26.0	4.1	2143
2002	0.0	3.7	80.3	450.8	184.2	389.3	96.3	38.3	18.8	16.4	1278
2003	0.0	6.2	124.1	203.4	543.2	125.2	224.6	64.8	16.0	9.6	1317
2004	0.0	3.5	121.6	182.1	182.5	333.7	96.8	137.7	37.5	16.8	1112
2005	0.0	7.2	20.7	209.9	89.3	88.8	108.4	59.7	34.1	11.8	630
2006	0.0	2.9	211.2	107.6	435.8	147.7	85.8	80.8	13.1	11.4	1096
2007	0.0	21.2	52.6	579.2	62.8	238.5	63.3	43.7	42.0	4.4	1108
2008	0.0	22.4	204.3	133.3	741.7	66.7	168.7	29.9	15.1	7.7	1390
2009	0.0	14.3	166.3	203.5	78.6	421.5	43.1	57.6	11.6	6.5	1003
2010	0.0	9.3	89.4	322.5	150.8	35.7	108.6	14.5	13.0	4.0	748
2011	0.0	24.5	88.8	146.6	286.9	74.5	41.9	34.0	2.1	2.3	702

Table B8b continued. Canadian commercial landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Landings Mean Weight (kg) at Age						
1978	0.688	1.237	2.135	2.652	3.403	5.595	5.933	9.311	8.358	13.840	2.500
1979	1.299	1.474	1.530	3.264	4.182	5.543	8.908	10.535	9.766	14.313	2.669
1980	0.552	1.244	2.282	3.049	4.750	6.237	6.717	12.312	11.195	13.581	2.979
1981	0.831	1.275	2.072	3.197	4.727	6.553	7.996	9.118	10.138	16.498	3.492
1982	0.563	1.351	2.131	3.690	5.064	6.742	8.520	9.947	11.734	15.805	3.070
1983	0.912	1.386	2.117	3.097	4.784	6.114	7.979	10.126	11.443	13.292	3.427
1984	0.000	1.457	2.515	3.809	4.949	6.058	8.136	9.675	10.800	13.926	5.103
1985	0.649	1.312	1.824	3.252	4.527	5.950	7.653	9.219	10.438	13.934	2.396
1986	0.742	1.540	2.667	3.602	5.168	6.764	7.933	8.905	9.270	9.952	3.429
1987	0.614	1.491	2.452	4.043	5.588	7.231	8.956	9.697	11.682	15.420	2.473
1988	0.692	1.138	2.209	3.348	4.967	6.319	8.789	10.330	11.429	14.257	3.136
1989	0.802	1.159	1.994	3.738	5.233	6.410	7.050	10.005	11.041	14.282	3.723
1990	0.758	1.705	2.593	3.401	4.766	6.132	7.779	10.437	11.470	13.750	3.337
1991	0.814	1.576	2.487	3.216	4.154	5.545	7.413	9.761	9.621	14.288	3.457
1992	0.923	1.445	2.344	3.484	4.395	5.872	6.973	8.759	11.556	15.243	2.882
1993	0.795	1.443	2.167	2.878	4.263	5.508	6.646	8.523	8.829	11.902	3.153
1994	0.793	1.361	2.237	3.556	4.507	6.500	7.295	8.062	7.666	11.354	3.494
1995	0.435	1.334	2.250	3.430	5.214	6.480	10.218	10.055	10.251	13.004	3.194
1996	0.918	1.464	2.235	3.137	4.963	5.982	6.563	8.874	10.395	11.747	3.259
1997	0.907	1.457	2.123	3.017	3.938	5.492	7.621	8.567	11.644	10.833	3.338
1998	0.693	1.418	2.232	3.003	4.024	5.505	6.656	8.109	10.351	14.082	3.328
1999	0.590	1.383	2.151	3.275	3.938	5.928	6.770	8.084	11.187	15.055	3.044
2000	0.710	1.465	2.119	3.027	4.181	4.900	5.940	7.288	8.921	13.228	3.339
2001	0.000	1.507	2.331	3.001	4.007	5.085	5.128	7.857	9.344	14.642	3.502
2002	0.692	1.361	2.299	3.118	4.359	5.096	6.879	8.092	8.742	11.070	3.953
2003	0.000	1.326	2.227	2.801	3.835	4.397	5.686	7.063	7.698	8.664	3.710
2004	0.704	1.360	2.011	2.827	3.391	4.571	5.527	7.354	9.040	10.328	3.753
2005	0.000	1.248	1.676	2.517	3.766	4.842	5.215	7.114	8.407	9.796	3.539
2006	0.048	1.105	1.886	2.449	3.509	4.579	6.342	5.919	7.278	7.543	3.174
2007	0.175	1.236	1.825	2.459	3.264	4.226	6.321	7.007	7.008	10.101	2.916
2008	0.000	1.276	2.123	2.784	3.691	5.011	5.895	7.955	7.961	9.092	3.381
2009	0.000	1.144	1.908	3.000	3.474	4.588	5.781	6.846	10.220	10.840	3.348
2010	0.551	1.199	1.912	2.490	3.321	3.450	5.321	6.075	9.451	11.284	2.829
2011	0.348	1.242	1.779	2.573	3.521	4.401	4.216	6.168	10.038	9.629	2.912

Table B8b continued. Canadian commercial landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	Canadian Commercial Landings Mean Length (cm) at Age										
1978	39.5	48.1	58.4	62.6	67.9	79.7	80.5	97.1	93.2	110.9	60.7
1979	49.0	51.6	52.7	68.0	74.3	80.8	95.8	101.7	99.4	113.6	61.8
1980	36.7	48.9	59.8	66.3	77.1	83.9	86.3	106.9	103.4	110.7	63.1
1981	42.6	49.2	58.1	67.4	77.2	86.6	92.2	96.4	98.8	112.7	66.9
1982	36.8	49.9	58.1	70.3	78.6	86.8	94.3	98.6	105.4	116.3	62.8
1983	43.7	50.7	58.7	66.8	77.4	84.5	92.7	100.3	104.7	110.3	66.4
1984	0.0	52.1	62.5	72.0	78.3	84.2	92.8	98.5	102.5	111.2	77.7
1985	39.1	49.6	55.5	67.7	75.7	83.5	91.1	96.3	100.2	111.1	58.4
1986	40.8	52.6	63.6	70.5	79.2	86.8	92.3	95.9	96.4	99.6	67.7
1987	38.4	52.0	61.5	72.8	81.5	89.0	95.9	98.6	105.6	115.3	59.3
1988	39.8	47.7	59.6	68.6	78.2	85.0	95.8	101.1	104.6	112.8	64.7
1989	41.6	48.6	57.7	71.2	79.7	85.5	88.0	100.3	103.5	113.2	68.5
1990	41.0	54.3	62.9	68.7	77.0	83.5	91.1	101.8	105.1	111.7	67.2
1991	41.2	53.0	62.0	67.3	73.4	80.5	89.7	99.2	97.7	112.9	67.4
1992	43.7	51.6	60.5	69.2	74.8	82.8	87.3	94.3	104.6	115.7	62.4
1993	41.3	51.1	59.1	65.0	73.6	81.1	86.5	94.6	94.2	106.1	65.2
1994	42.9	50.1	59.5	69.7	75.2	85.0	89.2	91.8	89.4	103.9	67.8
1995	33.0	50.5	59.7	68.5	79.5	85.4	100.6	99.5	99.8	109.1	65.4
1996	43.9	51.2	59.2	66.5	77.5	83.2	84.8	93.4	100.7	105.9	66.3
1997	43.7	51.4	58.6	65.7	72.1	80.7	91.0	94.6	105.4	102.2	66.8
1998	40.0	50.7	59.3	65.4	72.5	80.9	86.3	92.4	101.1	111.8	66.3
1999	37.7	50.4	58.5	67.6	71.6	82.7	87.0	92.1	103.7	114.6	64.5
2000	40.0	51.3	58.4	65.6	73.1	76.9	82.3	88.2	94.6	109.1	66.9
2001	0.0	51.7	59.8	65.2	72.1	78.0	77.9	90.6	96.8	111.4	67.9
2002	40.0	49.8	59.3	66.0	74.2	78.1	86.6	90.9	93.7	101.0	70.7
2003	0.0	48.8	58.9	63.7	71.0	74.4	81.2	87.5	90.3	92.5	69.3
2004	40.1	49.8	56.9	64.1	67.9	75.1	80.3	88.6	95.0	99.3	69.0
2005	0.0	48.4	53.9	61.4	70.5	77.4	78.8	86.6	93.1	97.9	67.5
2006	16.0	46.0	55.7	60.8	68.7	75.4	84.8	82.9	89.2	90.2	65.3
2007	25.0	48.1	55.1	60.9	67.0	73.2	84.2	87.7	87.5	99.4	63.6
2008	0.0	49.0	58.2	63.7	70.0	77.3	82.1	91.1	91.6	95.9	67.1
2009	0.0	46.9	56.2	65.3	68.3	75.2	81.2	86.5	99.9	102.3	66.3
2010	37.0	47.9	56.2	61.3	67.6	68.5	79.5	83.1	97.6	103.9	63.2
2011	31.2	48.3	54.7	61.7	69.1	74.4	72.9	83.3	99.1	96.4	63.6

Table B9. Number of length samples, by gear of discarded Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1989-2011.

	Number of lengths sampled																	
	Otter Trawl Large Mesh				Otter Trawl Small Mesh						Gill Net - Large Mesh		Longline		Scallop Dredge			
	West/sne		East		West		East		SNE		West		West		West		East	
	Q12	Q34	Q12	Q34	Q12	Q34	Q12	Q34	Q12	Q34	Q12	Q34	Q12	Q34	Q12	Q34	Q12	Q34
1989	1095	699	135	66	486	131			447									
1990	776	399	285	63		18			200									
1991	178	6	170															
1992	46	160	202	327	2								627					
1993	46	298	216			6									3		1	
1994	70	1	149	4								16			21	25	2	
1995	134	40	5	1	1	4					26	36						
1996	35	7	10						1		37	8			1	3		
1997	6	66									25	12				1	21	7
1998	9	2	1	5							29	45			3	21	25	
1999	0	49	9								56	2			1	56	4	2
2000	42	10	9	9	1	7	7				59	110				8		
2001	17	0	42		61						104	22						
2002	69	598	52	40	2	358	10	5			32			28		7		
2003	810	813	406	75	1	165	61	3	1	5	181	311	5		7	2		
2004	396	1112	461	119	78	30	205	3	9		831	122		306		8	4	2
2005	6197	3370	1456	241	158	295	5	93	5	15	21	129	306	242	8	18		
2006	2344	2472	717	17	15	2	16			1	44	70	34	65	22	17	5	2
2007	6015	4523	1622	176	11	17	6				15	55		34	19	29		1
2008	6058	4119	29	1161	19	13		4	3		159	317	53	178	15	3	6	1
2009	3926	998	380	1015	9	27					53	410	383	64	8	5	3	13
2010	3322	633	344	123	1	9		10	1	2	130	1176	72	273	28	13	2	
2011	2866	2151	604	261		7			15		32	105	29	366	15	12		5

Table B10a. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				USA Commercial Discards in Numbers (000's) at Age							
1978	112	49	90	7	6	0	0	0	0	0	264
1979	173	247	11	10	2	0	0	0	0	0	443
1980	178	278	55	2	0	0	0	0	0	0	513
1981	433	397	46	0	0	0	0	0	0	0	877
1982	154	507	40	15	0	0	0	0	0	0	717
1983	128	283	77	3	0	0	0	0	0	0	491
1984	43	66	8	0	0	0	0	0	0	0	117
1985	9	217	11	0	0	0	0	0	0	0	236
1986	330	126	26	13	0	0	0	0	0	0	495
1987	12	142	40	4	1	0	0	0	0	0	200
1988	57	154	53	6	0	0	0	0	0	0	270
1989	385	331	179	10	0	0	0	0	0	0	906
1990	25	359	108	11	4	0	0	0	0	0	507
1991	54	263	57	22	1	1	0	0	0	0	397
1992	14	465	23	7	1	0	0	0	0	0	509
1993	9	269	71	0	0	0	0	0	0	0	350
1994	6	64	41	5	0	0	0	0	0	0	116
1995	3	38	26	2	0	0	0	0	0	0	69
1996	7	20	18	6	0	0	0	0	0	0	51
1997	11	49	5	4	2	0	0	0	0	0	72
1998	6	23	13	2	1	1	0	0	0	0	46
1999	11	58	12	1	0	0	0	0	0	0	82
2000	14	90	15	5	0	0	0	0	0	0	124
2001	5	152	147	4	0	0	0	0	0	0	309
2002	3	14	67	17	3	0	0	0	0	0	104
2003	0	40	42	38	12	2	0	0	0	0	134
2004	19	16	47	6	4	2	0	0	0	0	96
2005	1	146	45	69	9	5	4	0	0	0	279
2006	5	18	105	12	21	2	0	0	0	0	164
2007	1	225	74	160	10	14	1	0	0	0	486
2008	9	124	87	15	7	0	0	0	0	0	242
2009	9	85	129	16	4	4	0	0	0	0	248
2010	6	78	73	21	3	0	1	0	0	0	183
2011	4	48	46	9	0	0	0	0	0	0	107

Table B10a - continued. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	USA Commercial Discards in Weight (Tons) at Age										
1978	65	45	97	9	7	0	0	0	0	0	125
1979	114	262	13	12	2	0	0	0	0	0	403
1980	101	253	70	3	0	0	0	0	0	0	426
1981	281	435	58	0	0	0	0	0	0	0	775
1982	104	568	48	19	0	0	0	0	0	0	739
1983	87	313	88	4	0	0	0	0	0	0	492
1984	20	46	7	0	0	0	0	0	0	0	74
1985	4	243	15	0	0	0	0	0	0	0	262
1986	214	88	28	14	0	0	0	0	0	0	343
1987	7	140	47	4	1	0	0	0	0	0	200
1988	35	139	62	6	0	0	0	0	0	0	242
1989	164	277	164	20	1	1	0	0	0	0	628
1990	11	303	107	19	12	1	1	0	0	0	454
1991	30	238	58	28	2	2	0	0	0	0	358
1992	15	454	27	7	1	0	0	0	0	0	505
1993	4	215	66	0	0	0	0	0	0	0	284
1994	6	96	51	5	0	0	0	0	0	0	159
1995	3	50	29	2	0	0	0	0	0	0	84
1996	22	53	26	7	0	0	0	0	0	0	108
1997	25	47	8	11	7	1	0	0	0	0	100
1998	23	42	16	10	6	3	0	0	0	0	99
1999	12	61	11	1	0	0	0	0	0	0	86
2000	14	102	15	5	0	0	0	0	0	0	137
2001	5	144	152	5	0	0	0	0	0	0	306
2002	4	23	110	27	5	0	0	0	0	0	168
2003	0	60	69	65	26	5	2	0	0	0	229
2004	4	21	67	13	12	8	2	2	0	0	130
2005	0	129	58	141	30	18	16	1	0	0	395
2006	2	18	143	23	39	5	1	1	0	0	230
2007	0	257	104	295	26	38	4	2	1	0	727
2008	5	141	125	22	14	0	0	0	0	0	308
2009	6	106	204	39	12	16	1	1	0	0	384
2010	2	79	110	42	11	2	6	0	0	0	253
2011	1	45	62	14	1	0	0	0	0	0	122

Table B10a - continued. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
				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	0.508	0.878	0.983	2.049	2.512	3.291	3.397	0.000	0.000	0.000	0.756
1990	0.523	0.935	1.035	1.761	3.440	3.963	4.196	5.729	0.000	0.000	0.975
1991	0.690	0.957	1.160	1.299	3.020	2.864	3.614	0.000	0.000	0.000	0.975
1992	0.633	0.869	1.104	1.053	1.352	0.000	0.000	0.000	0.000	0.000	0.877
1993	0.453	0.855	0.933	1.095	0.000	0.000	0.000	0.000	0.000	0.000	0.860
1994	0.432	0.896	1.048	1.074	0.000	0.000	0.000	0.000	0.000	0.000	0.933
1995	0.555	0.883	0.968	0.900	0.000	0.000	0.000	0.000	0.000	0.000	0.903
1996	0.560	0.930	1.045	1.030	0.000	0.000	0.000	0.000	0.000	0.000	0.930
1997	0.493	0.692	0.998	1.714	2.275	4.951	4.951	0.000	0.000	0.000	0.805
1998	0.341	0.838	0.961	2.990	4.236	4.539	4.951	3.458	0.000	0.000	1.026
1999	0.499	0.808	0.917	1.024	0.000	0.000	0.000	0.000	0.000	0.000	0.783
2000	0.546	0.887	0.997	1.007	0.000	0.000	0.000	0.000	0.000	0.000	0.866
2001	0.906	0.923	1.033	1.060	0.000	0.000	0.000	0.000	0.000	0.000	0.977
2002	0.614	0.896	1.272	1.393	1.386	1.999	0.000	0.000	0.000	0.000	1.225
2003	0.214	1.180	1.465	1.575	2.229	2.272	5.729	7.493	8.441	0.000	1.505
2004	0.194	1.138	1.373	2.215	2.844	4.172	5.703	8.493	8.272	9.518	1.310
2005	0.275	0.933	1.314	2.060	3.392	3.602	4.046	8.203	9.121	9.754	1.446
2006	0.390	1.047	1.390	1.832	1.894	2.665	4.557	5.653	6.436	8.582	1.440
2007	0.299	1.346	1.507	1.871	2.626	2.712	3.675	5.100	4.854	6.147	1.617
2008	0.602	1.287	1.466	1.459	2.189	2.263	3.872	0.000	0.000	0.000	1.362
2009	0.689	1.287	1.599	2.534	3.028	3.625	4.945	2.460	4.769	0.000	1.579
2010	0.432	1.104	1.539	2.077	3.473	3.544	4.657	0.000	2.684	0.000	1.441
2011	0.416	1.011	1.411	1.505	1.717	2.509	2.543	0.000	0.000	0.000	1.206

Table B10a - continued. USA commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					USA Commercial Discards Mean Length(cm) at Age						
1978	38.5	45.0	47.5	51.8	47.6	0.0	0.0	0.0	0.0	0.0	43.3
1979	40.2	47.1	49.1	49.5	50.0	0.0	0.0	0.0	0.0	0.0	44.6
1980	38.3	44.7	50.3	53.0	0.0	0.0	0.0	0.0	0.0	0.0	43.1
1981	40.0	47.7	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0
1982	40.7	48.1	49.1	50.2	0.0	0.0	0.0	0.0	0.0	0.0	46.6
1983	40.6	47.8	48.5	53.0	0.0	0.0	0.0	0.0	0.0	0.0	46.0
1984	35.7	41.2	43.7	53.0	0.0	0.0	0.0	0.0	0.0	0.0	39.4
1985	36.1	48.1	52.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.8
1986	40.0	40.9	47.0	47.4	0.0	0.0	0.0	0.0	0.0	0.0	40.8
1987	38.9	45.8	49.0	47.0	53.0	0.0	0.0	0.0	0.0	0.0	46.1
1988	39.3	44.3	48.9	47.6	0.0	0.0	0.0	0.0	0.0	0.0	44.2
1989	35.5	43.9	45.8	58.5	63.3	69.7	70.5	0.0	0.0	0.0	40.9
1990	36.6	44.6	46.3	54.5	70.4	74.3	76.0	86.0	0.0	0.0	45.0
1991	39.3	45.6	48.0	49.8	67.1	66.6	74.0	0.0	0.0	0.0	45.4
1992	38.8	44.1	48.4	47.6	52.1	0.0	0.0	0.0	0.0	0.0	44.2
1993	34.6	43.5	45.4	50.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6
1994	34.5	44.0	47.2	48.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8
1995	37.2	43.7	45.8	45.0	0.0	0.0	0.0	0.0	0.0	0.0	44.3
1996	37.1	45.5	47.8	47.7	0.0	0.0	0.0	0.0	0.0	0.0	45.4
1997	35.2	41.1	46.5	52.7	58.4	80.0	80.0	0.0	0.0	0.0	41.9
1998	31.0	44.1	45.7	65.3	75.2	77.7	80.0	71.0	0.0	0.0	44.9
1999	36.0	43.0	45.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	42.4
2000	36.9	44.4	46.6	46.9	0.0	0.0	0.0	0.0	0.0	0.0	43.9
2001	44.0	44.8	47.5	48.1	0.0	0.0	0.0	0.0	0.0	0.0	46.1
2002	38.5	43.6	50.0	51.8	51.9	59.4	0.0	0.0	0.0	0.0	49.2
2003	27.5	47.8	52.2	53.5	59.8	59.6	83.2	91.9	96.4	0.0	52.1
2004	25.3	47.0	50.9	59.8	64.9	74.1	82.2	96.3	95.2	100.7	47.0
2005	30.0	43.8	50.2	58.2	69.4	70.6	73.0	94.3	97.8	100.1	50.1
2006	32.7	45.5	50.9	56.4	56.8	64.1	77.0	83.0	85.2	96.9	51.1
2007	30.9	49.9	52.5	56.4	62.9	63.4	71.0	80.1	79.1	86.0	53.1
2008	38.1	49.2	52.4	52.4	58.9	57.7	70.8	0.0	0.0	0.0	50.4
2009	39.5	49.0	53.7	61.8	65.8	70.3	79.3	61.8	80.0	0.0	52.6
2010	34.0	46.9	53.1	58.5	70.2	70.9	77.5	0.0	65.1	0.0	51.0
2011	33.6	45.3	51.6	53.3	55.3	64.8	65.0	0.0	0.0	0.0	48.3

Table B10b. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	Canadian Commercial Discards in Numbers (000's) at Age										
1978	6.9	0.2	19.5	3.2	2.4	0.6	2.2	0.1	0.1	0.1	35
1979	8.5	13.0	1.0	12.7	3.5	1.0	0.5	0.6	0.1	0.0	41
1980	5.6	8.5	9.9	0.6	6.2	1.1	0.3	0.3	0.1	0.1	33
1981	22.5	12.6	13.2	5.6	0.2	1.7	0.7	0.2	0.0	0.4	57
1982	8.2	12.4	4.5	4.3	2.6	0.0	1.2	0.3	0.0	0.0	34
1983	1.6	7.0	13.9	1.9	1.3	0.7	0.2	0.4	0.0	0.2	27
1984	9.3	1.5	5.9	8.5	0.8	1.6	0.6	0.1	0.8	0.0	29
1985	5.5	30.0	5.5	2.6	3.1	0.9	0.4	0.4	0.2	0.5	49
1986	29.6	4.3	6.4	0.7	1.2	1.2	0.2	0.2	0.3	0.0	44
1987	2.0	20.5	4.2	5.1	0.4	0.7	0.9	0.3	0.2	0.2	35
1988	4.3	2.2	20.1	2.3	3.3	0.2	0.3	0.6	0.1	0.1	33
1989	3.6	12.9	3.2	9.7	1.4	1.6	0.3	0.2	0.3	0.3	33
1990	2.3	3.4	9.2	2.6	4.1	0.6	0.8	0.2	0.1	0.2	23
1991	12.0	5.7	6.4	3.6	3.0	1.7	0.2	0.2	0.0	0.2	33
1992	4.1	18.3	5.6	0.9	2.4	1.3	0.9	0.2	0.2	0.0	34
1993	2.9	5.6	11.8	2.3	0.6	1.5	0.5	0.5	0.2	0.1	26
1994	1.8	7.3	6.1	6.9	1.7	0.8	1.2	0.1	0.3	0.0	26
1995	0.5	2.1	6.7	2.5	2.2	0.6	0.4	0.1	0.1	0.0	15
1996	3.6	1.8	7.0	8.7	1.8	1.2	0.3	0.1	0.1	0.0	25
1997	3.1	28.6	34.8	49.6	44.9	8.2	2.8	1.1	0.3	0.1	174
1998	2.8	27.8	61.3	23.3	19.1	10.6	1.3	1.2	0.1	0.1	148
1999	2.1	14.0	71.5	37.4	11.1	4.6	3.0	0.7	0.2	0.1	145
2000	1.9	8.3	4.9	9.7	4.2	1.0	0.4	0.2	0.0	0.0	31
2001	3.2	5.5	24.6	4.2	11.4	3.6	1.4	0.7	0.7	0.2	56
2002	0.4	3.2	6.1	18.4	2.6	3.7	1.0	0.2	0.1	0.1	36
2003	0.0	5.2	21.2	22.5	18.9	2.6	3.4	0.6	0.1	0.0	74
2004	19.0	4.4	23.4	12.5	9.6	6.8	0.9	1.3	0.2	0.0	78
2005	0.6	18.2	15.6	55.1	9.0	4.9	4.8	1.0	0.4	0.0	110
2006	2.0	16.0	74.8	20.9	39.4	7.1	1.9	1.8	0.2	0.2	164
2007	0.1	13.6	13.2	44.7	3.5	3.2	0.2	0.1	0.1	0.0	79
2008	0.9	12.8	12.1	5.0	19.6	1.3	3.1	0.4	0.2	0.1	55
2009	0.5	10.2	34.5	17.6	4.9	16.9	1.2	1.1	0.1	0.1	87
2010	1.2	5.8	10.8	20.8	6.0	1.4	1.4	0.1	0.0	0.0	48
2011	4.2	13.3	7.8	4.2	3.5	0.6	0.2	0.2	0.0	0.0	34

Table B10b continued. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Canadian Commercial Discards in Weight (Tons) at Age						
1978	2.7	0.4	44.3	11.8	12.3	4.2	18.2	1.3	1.0	1.4	98
1979	3.1	16.5	2.1	45.7	16.6	5.8	5.1	7.0	0.8	0.0	103
1980	2.0	8.1	22.1	2.1	33.8	7.2	1.9	3.4	0.9	1.6	83
1981	6.2	17.1	28.7	19.7	1.3	12.2	5.5	2.6	0.0	4.5	98
1982	4.5	18.4	10.5	14.1	10.7	0.0	10.3	2.4	0.4	0.0	71
1983	0.7	9.3	33.2	4.7	4.5	4.4	1.8	3.4	0.0	3.6	65
1984	2.2	1.3	14.6	27.3	2.5	6.8	3.4	1.3	8.9	0.0	68
1985	2.3	41.0	14.3	9.4	12.3	5.7	3.8	4.2	2.3	7.0	102
1986	13.2	3.8	12.3	2.3	6.0	6.9	1.7	1.6	2.7	0.2	51
1987	0.5	29.5	9.1	14.3	2.4	5.1	6.8	2.1	2.0	4.4	76
1988	1.4	2.3	41.7	7.7	16.9	1.5	2.6	7.0	1.0	1.1	83
1989	1.3	14.9	6.2	27.6	5.2	10.7	2.3	1.5	3.3	3.3	76
1990	1.0	4.1	21.4	8.2	19.3	3.7	6.5	1.8	0.8	3.6	70
1991	4.1	8.2	14.1	11.5	11.0	8.2	1.5	2.2	0.3	3.4	65
1992	2.2	23.4	11.8	2.4	10.8	8.6	6.9	1.8	2.6	0.7	71
1993	1.1	6.2	25.0	7.1	3.1	9.4	4.0	3.4	2.0	1.3	63
1994	0.5	6.2	11.3	20.8	6.6	4.3	7.0	1.3	3.9	0.7	63
1995	0.1	2.4	13.0	6.6	8.3	2.4	2.4	0.8	1.4	0.8	38
1996	1.3	2.2	12.5	23.1	6.4	6.4	1.5	0.8	1.0	0.4	56
1997	1.6	40.6	72.2	136.5	160.8	41.4	19.3	9.0	2.9	1.5	486
1998	2.2	36.4	124.9	62.3	68.5	51.6	8.1	8.2	1.2	1.5	365
1999	1.1	18.0	134.2	100.7	33.4	22.2	18.3	5.8	2.4	1.7	338
2000	1.1	10.5	8.7	26.1	14.0	3.6	2.8	1.9	0.1	0.3	69
2001	0.7	5.4	41.0	14.1	41.8	17.4	8.7	6.3	5.8	1.9	143
2002	0.1	3.3	9.3	47.3	9.1	15.4	5.0	2.1	0.8	1.3	94
2003	0.0	6.2	47.4	62.0	56.1	7.9	15.8	3.7	0.7	0.0	200
2004	4.4	4.3	37.7	30.2	29.6	25.0	4.0	8.0	1.7	0.5	145
2005	0.1	13.4	22.4	117.0	27.3	19.8	20.1	5.1	2.8	0.4	228
2006	0.2	8.3	124.0	44.6	119.0	28.5	11.3	10.1	1.4	1.5	349
2007	0.0	9.1	13.8	72.8	7.3	9.1	0.9	0.4	0.3	0.0	114
2008	0.1	9.8	20.4	11.9	67.6	6.3	18.2	2.9	1.4	0.8	139
2009	0.1	7.8	54.8	44.8	14.7	69.5	6.0	7.1	1.1	0.7	207
2010	0.5	5.1	16.6	43.2	16.3	4.1	5.6	0.5	0.2	0.0	92
2011	1.1	8.7	10.1	8.3	9.4	2.1	0.8	1.2	0.1	0.0	42

Table B10b continued. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Canadian Commercial Discards Mean Weight (kg) at Age						
1978	0.391	1.641	2.275	3.689	5.209	6.783	8.445	8.985	10.222	14.998	2.765
1979	0.362	1.276	2.022	3.603	4.811	5.776	10.371	10.937	10.799	0.000	2.516
1980	0.360	0.960	2.220	3.667	5.457	6.502	5.894	12.954	11.735	13.451	2.546
1981	0.274	1.354	2.181	3.542	5.333	7.018	8.205	12.670	0.000	12.401	1.711
1982	0.550	1.489	2.328	3.263	4.163	0.000	8.340	8.842	10.764	0.000	2.128
1983	0.413	1.324	2.385	2.491	3.300	5.952	8.174	7.476	0.000	16.207	2.387
1984	0.242	0.916	2.483	3.206	3.070	4.394	5.931	8.985	10.471	0.000	2.352
1985	0.418	1.367	2.615	3.662	3.933	6.458	8.786	9.867	14.048	15.347	2.086
1986	0.445	0.893	1.942	3.217	4.920	5.733	7.439	8.988	10.684	18.000	1.153
1987	0.260	1.440	2.188	2.817	5.672	7.487	7.480	6.659	10.100	20.219	2.209
1988	0.323	1.057	2.077	3.371	5.062	6.268	9.325	11.369	11.973	17.117	2.484
1989	0.360	1.157	1.938	2.837	3.818	6.597	7.615	7.813	11.320	12.723	2.279
1990	0.446	1.193	2.316	3.158	4.731	5.903	8.589	10.114	13.493	16.278	2.997
1991	0.343	1.441	2.208	3.151	3.614	4.895	7.544	10.059	9.973	14.584	1.946
1992	0.548	1.279	2.088	2.672	4.476	6.379	7.420	8.474	11.803	19.671	2.091
1993	0.365	1.110	2.117	3.137	5.101	6.191	8.169	7.289	9.450	11.783	2.412
1994	0.278	0.853	1.866	2.993	3.786	5.528	5.710	8.661	11.246	17.373	2.374
1995	0.159	1.109	1.938	2.628	3.757	4.056	6.801	7.920	11.753	16.693	2.500
1996	0.369	1.223	1.782	2.667	3.642	5.412	4.294	12.028	11.920	15.163	2.264
1997	0.519	1.421	2.074	2.751	3.578	5.052	6.798	8.328	11.495	12.537	2.799
1998	0.794	1.309	2.037	2.673	3.591	4.854	6.070	7.125	9.531	12.366	2.471
1999	0.525	1.285	1.875	2.692	3.025	4.807	6.110	8.327	9.672	15.349	2.333
2000	0.584	1.271	1.785	2.700	3.322	3.676	6.397	7.722	11.523	13.972	2.257
2001	0.208	0.978	1.668	3.334	3.674	4.802	6.142	8.514	8.022	10.533	2.574
2002	0.338	1.020	1.542	2.574	3.500	4.114	4.899	8.436	10.001	12.169	2.618
2003	0.000	1.190	2.231	2.752	2.971	3.065	4.692	6.014	7.661	0.000	2.682
2004	0.230	0.979	1.612	2.411	3.085	3.666	4.207	6.085	8.596	11.353	1.857
2005	0.114	0.737	1.437	2.122	3.026	4.090	4.212	5.071	7.578	7.752	2.084
2006	0.086	0.518	1.658	2.135	3.023	4.003	5.879	5.605	6.516	8.008	2.124
2007	0.161	0.669	1.042	1.628	2.080	2.821	4.670	6.636	5.277	0.000	1.444
2008	0.130	0.765	1.679	2.363	3.452	4.999	5.928	7.543	7.758	8.682	2.514
2009	0.191	0.764	1.590	2.551	3.009	4.123	5.041	6.413	9.700	11.622	2.377
2010	0.418	0.884	1.539	2.077	2.699	2.892	4.080	4.206	6.413	7.901	1.935
2011	0.254	0.655	1.302	1.976	2.703	3.705	3.464	5.002	7.581	9.336	1.231

Table B10b continued. Canadian commercial discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Canadian Commercial Discards Mean Length (cm) at Age						
1978	34.5	54.9	60.7	71.5	80.6	87.3	94.6	97.0	101.2	115.0	60.8
1979	33.2	50.1	58.7	70.8	78.3	83.0	100.9	103.3	100.0	0.0	58.0
1980	33.9	45.6	60.5	70.6	81.8	86.8	83.6	106.2	106.0	110.9	58.1
1981	30.0	51.2	60.1	70.8	80.8	89.1	94.1	108.7	0.0	104.5	49.1
1982	38.7	53.0	61.8	69.0	75.1	0.0	93.8	96.5	103.0	0.0	56.3
1983	34.3	51.2	61.7	63.0	69.3	84.4	94.0	89.9	0.0	118.0	59.7
1984	29.4	44.5	62.6	67.9	67.3	76.1	84.5	97.0	101.8	0.0	55.3
1985	35.5	51.5	63.6	71.3	73.5	86.1	96.3	100.1	112.5	114.4	55.7
1986	36.0	44.5	58.1	68.9	81.2	85.2	97.6	97.0	108.3	118.0	44.1
1987	30.4	52.1	61.4	68.6	82.0	90.1	92.8	97.5	100.4	121.2	57.7
1988	31.3	45.6	59.4	68.8	77.0	79.1	96.7	103.5	103.5	120.6	58.8
1989	32.6	48.1	58.1	65.7	71.1	83.6	88.2	96.4	105.2	107.5	56.7
1990	35.8	49.2	60.7	67.2	75.9	83.6	92.5	98.0	106.0	111.1	62.5
1991	32.4	52.0	60.5	65.3	68.9	78.6	90.8	98.5	94.8	116.6	51.9
1992	37.0	49.7	59.4	64.1	75.2	84.7	88.2	92.0	100.9	119.6	55.1
1993	33.8	48.0	58.7	67.6	79.8	84.3	91.1	90.7	95.0	103.5	58.1
1994	29.1	43.6	56.7	66.4	71.0	80.3	81.0	98.4	101.1	132.6	57.5
1995	24.3	47.0	57.6	64.7	72.8	73.5	87.1	86.5	105.4	109.6	60.5
1996	33.3	49.3	55.7	63.7	69.3	81.1	73.5	100.8	102.7	109.3	57.5
1997	36.9	51.1	58.2	63.9	70.0	78.3	87.5	93.0	104.5	105.9	63.1
1998	42.9	49.2	57.8	63.3	70.1	77.6	84.1	89.0	97.8	104.7	60.3
1999	36.1	49.2	56.2	63.8	66.4	77.6	84.2	92.1	97.8	114.0	59.5
2000	37.3	49.6	55.4	64.2	68.7	70.1	86.0	93.7	101.6	108.4	58.6
2001	28.4	46.1	54.7	68.6	72.2	78.7	85.4	94.4	93.4	99.3	60.5
2002	32.1	45.3	53.4	62.9	70.7	74.9	80.1	93.4	98.5	103.9	62.1
2003	0.0	46.4	60.8	63.9	67.2	67.3	79.6	84.5	91.8	0.0	63.6
2004	24.6	44.3	52.7	61.2	66.7	70.7	73.9	84.3	94.6	100.5	51.0
2005	22.1	40.2	51.1	58.5	66.1	73.8	73.7	77.8	89.5	91.2	56.5
2006	22.0	35.7	52.9	57.7	65.5	71.9	82.2	81.1	86.2	91.7	56.0
2007	24.2	40.1	46.9	54.2	58.6	64.9	77.1	87.1	80.7	0.0	51.2
2008	22.1	40.8	53.9	60.2	68.6	77.3	82.5	90.0	91.2	95.0	58.7
2009	25.8	40.9	53.2	62.1	65.6	73.0	77.9	85.1	99.0	104.6	58.8
2010	33.6	43.7	52.9	58.6	64.0	65.7	73.8	74.4	84.9	92.0	56.2
2011	28.2	39.0	49.6	56.8	63.4	70.8	68.8	79.0	91.3	97.3	45.8

Table B11a. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	USA Recreational Landings in Numbers (000's) at Age										
1978											
1979											
1980											
1981	184.7	428.9	539.3	309.9	19.2	170.2	44.0	23.5	0.0	22.5	1742
1982	67.7	434.9	367.5	308.9	232.3	9.4	70.2	13.1	2.9	1.2	1508
1983	139.0	495.6	645.7	148.2	124.5	75.9	7.1	38.0	0.0	28.0	1702
1984	30.9	65.2	108.8	140.3	41.0	40.0	14.2	0.2	18.0	1.3	460
1985	49.5	861.9	209.9	278.7	333.0	62.2	40.9	38.0	8.1	30.0	1912
1986	48.2	26.0	114.9	20.6	32.2	38.2	4.1	6.7	5.6	1.7	298
1987	1.7	237.6	57.0	110.4	9.0	23.5	19.4	2.1	3.4	2.0	466
1988	13.9	130.2	728.3	89.9	145.3	11.5	8.8	15.7	0.0	0.0	1144
1989	0.0	73.1	74.5	174.3	24.7	32.8	5.2	3.7	5.2	4.2	398
1990	0.0	52.1	205.7	75.0	95.5	13.2	14.1	1.2	1.5	2.0	460
1991	0.0	47.8	131.6	97.6	55.6	34.9	5.7	4.4	0.0	0.0	378
1992	0.4	64.6	56.3	20.4	29.9	15.8	14.8	2.0	2.1	0.0	206
1993	0.0	40.6	517.6	71.1	37.5	51.6	9.7	11.3	15.2	15.4	770
1994	0.0	21.9	113.5	105.6	19.5	4.0	19.2	0.5	8.3	0.0	293
1995	0.0	65.4	177.9	102.5	106.0	18.5	37.9	5.0	3.9	0.0	517
1996	0.0	12.5	46.3	66.9	11.6	11.7	1.4	0.9	0.0	0.0	151
1997	0.0	26.7	45.1	119.8	97.1	12.4	30.3	4.4	0.0	0.0	336
1998	0.5	36.7	82.9	58.5	51.2	35.6	6.7	2.3	0.0	0.0	274
1999	0.0	5.8	40.8	45.6	19.9	8.6	4.6	1.7	0.5	0.0	128
2000	0.0	45.0	76.6	117.0	40.1	9.1	2.2	1.8	0.0	0.0	292
2001	0.0	7.4	46.3	9.8	22.5	10.9	1.7	1.1	0.7	0.0	100
2002	0.0	0.3	15.1	48.6	12.9	13.4	2.3	0.0	0.0	1.6	94
2003	0.0	2.2	15.8	35.3	35.1	2.2	4.2	0.5	0.0	0.0	95
2004	0.0	0.9	13.1	17.6	18.7	13.9	3.2	2.6	0.1	0.5	71
2005	0.0	3.0	16.3	113.2	56.5	39.8	26.5	5.2	0.0	0.0	260
2006	0.0	0.3	6.7	1.1	3.9	0.9	1.2	0.4	0.2	0.0	15
2007	0.0	0.4	0.3	1.7	0.2	0.2	0.0	0.0	0.0	0.0	3
2008	0.0	1.4	3.2	2.9	12.6	0.7	0.8	0.0	0.0	0.0	22
2009	0.0	0.1	3.2	4.4	2.4	4.4	0.3	0.2	0.2	0.0	15
2010	0.0	0.7	7.2	25.3	7.7	1.5	5.5	0.0	0.4	0.0	48
2011	0.0	0.0	10.7	26.8	18.4	6.2	0.8	1.9	0.0	0.0	65

Table B11a - continued. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				USA Recreational Landings in Weight (Tons) at Age							
1978											
1979											
1980											
1981	91.8	504.6	1182.5	1079.9	70.0	1212.6	345.1	205.0	0.0	329.0	5021
1982	40.7	556.6	847.3	914.5	980.3	48.2	563.1	108.4	28.2	26.0	4113
1983	76.6	593.3	1558.9	474.2	498.9	428.5	57.1	414.5	0.0	414.6	4517
1984	13.3	47.7	263.7	510.9	201.6	222.1	92.5	2.9	175.8	18.0	1549
1985	22.6	922.8	454.6	972.5	1469.5	368.0	326.5	370.7	94.7	412.1	5414
1986	30.8	28.5	237.4	68.3	177.6	239.3	36.8	71.2	72.4	26.2	988
1987	1.6	327.1	149.5	446.4	42.4	156.5	164.9	24.1	31.0	29.9	1373
1988	11.9	170.4	1554.0	300.0	714.9	80.3	96.6	174.9	0.0	0.0	3103
1989	0.0	112.8	158.5	517.9	106.6	183.0	27.5	32.9	51.0	48.5	1239
1990	0.0	85.3	458.3	251.0	451.1	79.0	112.9	10.8	12.3	27.8	1489
1991	0.0	80.5	346.7	305.6	210.2	179.0	36.0	45.0	0.0	0.0	1203
1992	0.7	97.2	122.2	69.7	118.0	98.9	96.8	13.7	23.7	0.0	641
1993	0.0	56.1	1126.1	202.8	181.8	362.2	81.8	89.2	211.8	257.8	2570
1994	0.0	32.3	218.7	279.5	62.4	18.3	49.1	7.6	75.6	0.0	744
1995	0.0	105.3	312.3	301.3	442.2	58.2	292.8	52.8	48.4	0.0	1613
1996	0.0	20.9	104.1	192.4	57.9	66.9	6.3	4.3	0.0	0.0	453
1997	0.0	51.0	118.4	388.3	392.9	60.0	251.6	21.3	0.0	0.0	1283
1998	0.7	67.0	180.1	173.4	189.3	161.4	72.5	14.6	0.0	0.0	859
1999	0.0	11.5	90.8	145.1	77.1	43.4	18.1	9.6	4.3	0.0	400
2000	0.0	84.6	169.6	360.0	159.2	29.1	14.0	15.7	0.0	0.0	832
2001	0.0	14.5	93.1	31.3	98.3	77.9	15.3	9.6	4.9	0.0	345
2002	0.0	0.7	38.0	141.2	44.4	61.7	10.0	0.0	0.0	15.2	311
2003	0.0	5.2	40.6	100.7	121.8	9.3	19.1	2.5	0.0	0.0	299
2004	0.0	2.1	37.5	54.9	67.0	60.6	18.3	15.1	0.7	6.2	262
2005	0.0	6.4	44.3	337.8	214.2	142.2	130.7	51.7	0.0	0.0	927
2006	0.0	0.6	17.4	4.5	12.4	3.7	14.8	1.8	1.0	0.0	56
2007	0.0	1.1	0.8	6.1	1.0	1.4	0.1	0.1	0.0	0.0	10
2008	0.0	3.1	9.3	6.5	39.4	4.2	3.4	0.0	0.0	0.0	66
2009	0.0	0.2	7.4	11.7	7.2	16.0	1.5	0.7	1.0	0.0	46
2010	0.0	1.7	15.5	68.9	29.1	5.2	24.7	0.0	1.0	0.0	146
2011	0.0	0.0	29.0	76.8	57.9	23.7	2.7	10.6	0.0	0.0	201

Table B11a - continued. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
	USA Recreational Landings Mean Weight (kg) at Age										
1978											
1979											
1980											
1981	0.497	1.177	2.193	3.486	3.640	7.125	7.847	8.721	0.000	14.592	2.882
1982	0.602	1.280	2.306	2.960	4.220	5.143	8.016	8.271	9.656	21.217	2.727
1983	0.551	1.197	2.414	3.200	4.006	5.646	8.022	10.919	0.000	14.833	2.654
1984	0.431	0.732	2.424	3.641	4.922	5.555	6.519	14.875	9.782	13.641	3.367
1985	0.456	1.071	2.166	3.490	4.413	5.917	7.980	9.762	11.744	13.726	2.831
1986	0.640	1.095	2.067	3.309	5.515	6.259	9.004	10.705	12.965	15.209	3.316
1987	0.979	1.377	2.624	4.046	4.728	6.672	8.487	11.499	9.129	15.206	2.948
1988	0.861	1.309	2.133	3.335	4.921	6.957	10.932	11.143	0.000	0.000	2.713
1989	0.000	1.543	2.128	2.971	4.320	5.575	5.319	8.843	9.869	11.499	3.115
1990	0.000	1.637	2.228	3.347	4.723	5.968	8.014	8.814	8.022	14.219	3.233
1991	0.000	1.684	2.634	3.132	3.779	5.135	6.334	10.283	0.000	0.000	3.186
1992	1.512	1.505	2.170	3.412	3.947	6.253	6.536	6.904	11.499	0.000	3.106
1993	0.000	1.381	2.176	2.854	4.843	7.021	8.479	7.871	13.948	16.779	3.338
1994	0.000	1.476	1.926	2.646	3.205	4.546	2.557	16.182	9.080	0.000	2.542
1995	0.000	1.612	1.755	2.938	4.174	3.152	7.719	10.551	12.503	0.000	3.121
1996	0.000	1.675	2.247	2.877	4.985	5.705	4.545	4.768	0.000	0.000	2.993
1997	0.000	1.908	2.624	3.240	4.046	4.841	8.293	4.901	0.000	0.000	3.821
1998	1.512	1.827	2.173	2.964	3.697	4.535	10.770	6.245	0.000	0.000	3.131
1999	0.000	1.982	2.226	3.179	3.870	5.025	3.929	5.597	8.022	0.000	3.133
2000	0.000	1.878	2.213	3.076	3.970	3.191	6.278	8.584	0.000	0.000	2.850
2001	0.000	1.966	2.012	3.183	4.359	7.161	9.105	8.814	6.585	0.000	3.435
2002	0.000	2.314	2.524	2.905	3.452	4.604	4.394	0.000	0.000	9.656	3.308
2003	0.000	2.345	2.578	2.852	3.473	4.181	4.513	4.768	0.000	0.000	3.139
2004	0.000	2.370	2.852	3.116	3.585	4.370	5.727	5.725	6.585	11.386	3.712
2005	0.000	2.115	2.719	2.986	3.795	3.574	4.937	9.916	0.000	0.000	3.561
2006	0.000	2.115	2.595	3.945	3.170	4.337	12.316	4.848	4.299	0.000	3.819
2007	0.000	2.431	2.719	3.487	5.202	6.770	3.475	5.331	0.000	0.000	3.611
2008	0.000	2.257	2.925	2.253	3.123	5.760	4.010	0.000	0.000	0.000	3.046
2009	0.000	2.303	2.319	2.632	2.980	3.616	4.795	3.849	5.545	0.000	2.997
2010	0.000	2.279	2.150	2.730	3.772	3.463	4.506	0.000	2.543	0.000	3.025
2011	0.000	0.000	2.709	2.859	3.147	3.853	3.323	5.590	0.000	0.000	3.096

Table B11a - continued. Recreational landings (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
	USA Recreational Landings Mean Length (cm) at Age										
1978											
1979											
1980											
1981	36.8	48.9	60.5	70.7	70.3	89.4	92.7	95.7	0.0	114.6	61.9
1982	39.1	49.6	62.3	67.4	75.9	82.0	93.7	95.1	101.0	131.0	62.7
1983	38.0	49.3	62.3	68.2	73.8	83.9	95.0	104.1	0.0	113.3	60.7
1984	35.1	41.5	62.4	71.9	79.9	82.2	87.9	110.0	100.8	107.0	66.2
1985	35.9	46.6	60.2	70.2	76.2	85.3	94.4	100.4	107.5	112.3	61.1
1986	40.1	47.7	59.4	70.3	83.2	86.4	96.9	102.5	109.7	108.4	64.8
1987	46.0	51.6	64.6	74.3	77.7	88.7	96.2	107.0	98.9	112.1	63.6
1988	44.3	50.7	60.0	69.6	78.2	86.6	103.9	102.0	0.0	0.0	63.0
1989	0.0	53.5	60.3	66.9	75.9	82.7	80.5	97.9	101.3	107.0	66.4
1990	0.0	54.5	60.4	69.1	77.8	84.6	92.9	98.0	95.0	111.3	66.9
1991	0.0	54.8	64.0	68.4	72.5	80.5	86.8	102.3	0.0	0.0	67.5
1992	53.0	53.3	60.3	69.0	73.5	85.9	87.5	90.4	107.0	0.0	65.5
1993	0.0	52.0	60.2	65.9	79.1	89.0	96.2	94.2	107.0	120.3	66.2
1994	0.0	52.4	57.8	64.6	67.9	77.2	63.9	113.0	98.0	0.0	62.4
1995	0.0	53.9	56.2	67.6	75.7	69.3	92.9	104.0	110.0	0.0	66.2
1996	0.0	55.2	60.4	66.6	77.8	83.8	74.7	80.0	0.0	0.0	66.1
1997	0.0	56.9	63.2	68.7	74.8	77.8	93.4	79.8	0.0	0.0	71.5
1998	53.0	56.1	60.1	66.9	72.1	77.1	103.3	85.0	0.0	0.0	66.7
1999	0.0	58.0	60.6	67.8	72.3	80.3	74.8	81.4	95.0	0.0	67.1
2000	0.0	56.8	61.1	67.6	73.9	68.7	86.7	97.1	0.0	0.0	65.4
2001	0.0	57.4	58.8	69.0	75.8	90.3	98.2	98.0	89.0	0.0	68.2
2002	0.0	60.7	62.9	66.7	70.5	77.9	77.5	0.0	0.0	101.0	69.0
2003	0.0	60.8	63.6	66.2	70.8	73.6	77.6	80.0	0.0	0.0	68.1
2004	0.0	61.5	64.6	67.8	70.5	75.0	80.5	83.5	89.0	101.0	70.7
2005	0.0	59.0	63.9	67.3	73.3	72.0	78.4	101.0	0.0	0.0	70.8
2006	0.0	59.0	62.6	72.0	67.8	75.2	101.8	77.9	74.0	0.0	69.1
2007	0.0	61.6	64.2	69.0	77.9	84.5	71.5	83.0	0.0	0.0	69.2
2008	0.0	60.2	65.9	62.3	68.1	78.6	74.8	0.0	0.0	0.0	67.1
2009	0.0	60.5	62.1	65.2	67.9	71.9	80.0	66.7	83.6	0.0	67.4
2010	0.0	60.4	60.7	65.8	72.7	71.4	78.2	0.0	65.0	0.0	67.6
2011	0.0	0.0	64.2	66.1	68.5	74.0	71.0	83.0	0.0	0.0	67.8

Table B11b. Recreational discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
	USA Recreational Discards in Numbers (000's) at Age										
1978											
1979											
1980											
1981	18.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19
1982	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13
1983	44.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44
1984	14.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
1985	21.3	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30
1986	7.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
1987	4.8	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22
1988	26.5	9.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37
1989	14.5	19.9	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	36
1990	5.9	20.8	4.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	31
1991	16.2	4.1	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	21
1992	4.9	19.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	25
1993	17.3	75.0	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	114
1994	25.3	45.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72
1995	11.7	58.9	23.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0	95
1996	9.5	8.0	12.5	2.2	0.0	0.0	0.0	0.0	0.0	0.0	32
1997	28.6	36.6	4.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	71
1998	11.1	45.0	22.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	79
1999	14.0	13.7	10.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0	38
2000	23.9	51.8	6.2	2.5	0.0	0.0	0.0	0.0	0.0	0.0	84
2001	2.9	10.3	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
2002	4.0	5.3	13.7	8.7	0.5	0.1	0.0	0.0	0.0	0.0	32
2003	3.1	13.0	5.4	5.1	2.8	1.3	0.0	0.0	0.0	0.0	31
2004	11.4	1.4	6.0	0.3	0.5	0.0	0.0	0.0	0.0	0.0	20
2005	2.9	75.4	17.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	117
2006	2.4	0.8	1.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	5
2007	0.4	1.2	0.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	3
2008	0.4	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1
2009	3.1	1.8	2.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	7
2010	2.6	14.5	6.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	25
2011	3.7	9.9	4.5	3.1	0.2	0.0	0.0	0.0	0.0	0.0	21

Table B11b continued. Recreational discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				USA Recreational Discards in Weight (Tons) at Age							
1978											
1979											
1980											
1981	2.53	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
1982	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
1983	7.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
1984	1.39	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
1985	4.12	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
1986	1.88	0.26	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
1987	1.76	9.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12
1988	5.65	4.74	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
1989	5.08	13.32	0.95	0.19	0.00	0.00	0.00	0.00	0.00	0.00	20
1990	1.44	13.87	3.33	0.53	0.00	0.00	0.00	0.00	0.00	0.00	19
1991	3.74	3.14	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	8
1992	1.63	13.80	0.24	0.24	0.00	0.00	0.00	0.00	0.00	0.00	16
1993	3.34	50.73	19.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73
1994	5.46	24.79	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
1995	2.69	39.04	17.64	1.08	0.00	0.00	0.00	0.00	0.00	0.00	60
1996	2.74	5.77	12.63	2.24	0.00	0.00	0.00	0.00	0.00	0.00	23
1997	6.90	25.85	3.95	1.38	0.00	0.00	0.00	0.00	0.00	0.00	38
1998	4.26	34.50	22.36	0.00	0.93	0.00	0.00	0.00	0.00	0.00	62
1999	4.36	11.52	10.10	0.00	0.59	0.00	0.00	0.00	0.00	0.00	27
2000	5.88	39.62	5.57	2.52	0.00	0.00	0.00	0.00	0.00	0.00	54
2001	0.55	8.00	11.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20
2002	0.87	4.62	16.65	11.56	0.54	0.14	0.00	0.00	0.00	0.00	34
2003	1.16	9.77	7.27	7.66	4.34	1.96	0.00	0.00	0.00	0.00	32
2004	1.81	1.27	8.02	0.47	0.75	0.00	0.00	0.00	0.00	0.00	12
2005	0.86	42.76	20.16	31.25	0.00	0.00	0.00	0.00	0.00	0.00	95
2006	0.70	0.79	2.11	0.14	0.15	0.01	0.00	0.00	0.00	0.00	4
2007	0.11	0.91	0.39	1.29	0.06	0.05	0.00	0.00	0.00	0.00	3
2008	0.11	0.48	0.24	0.08	0.13	0.01	0.00	0.00	0.00	0.00	1
2009	0.46	1.06	3.08	0.28	0.12	0.00	0.00	0.00	0.00	0.00	5
2010	0.55	11.05	8.64	2.40	0.00	0.00	0.00	0.00	0.00	0.00	23
2011	0.64	6.09	6.10	4.85	0.28	0.00	0.00	0.00	0.00	0.00	18

Table B11b continued. Recreational discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
	USA Recreational Discards Mean Weight (kg) at Age										
1978											
1979											
1980											
1981	0.135	0.221	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.136
1982	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.130
1983	0.172	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172
1984	0.099	0.221	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.104
1985	0.194	0.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.196
1986	0.248	0.423	0.501	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.262
1987	0.370	0.564	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.522
1988	0.213	0.477	0.526	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.292
1989	0.351	0.670	0.876	0.953	0.000	0.000	0.000	0.000	0.000	0.000	0.549
1990	0.246	0.667	0.798	0.953	0.000	0.000	0.000	0.000	0.000	0.000	0.611
1991	0.231	0.766	0.953	0.953	0.000	0.000	0.000	0.000	0.000	0.000	0.359
1992	0.333	0.716	0.953	0.953	0.000	0.000	0.000	0.000	0.000	0.000	0.645
1993	0.193	0.677	0.895	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.644
1994	0.216	0.542	0.781	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.431
1995	0.230	0.663	0.762	0.781	0.000	0.000	0.000	0.000	0.000	0.000	0.635
1996	0.289	0.724	1.013	1.001	0.000	0.000	0.000	0.000	0.000	0.000	0.727
1997	0.242	0.705	0.912	1.049	0.000	0.000	0.000	0.000	0.000	0.000	0.537
1998	0.382	0.767	1.016	0.000	0.953	0.000	0.000	0.000	0.000	0.000	0.784
1999	0.312	0.842	0.990	0.000	1.150	0.000	0.000	0.000	0.000	0.000	0.692
2000	0.246	0.764	0.896	1.007	0.000	0.000	0.000	0.000	0.000	0.000	0.634
2001	0.189	0.774	1.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.825
2002	0.217	0.873	1.215	1.324	1.150	1.386	0.000	0.000	0.000	0.000	1.065
2003	0.375	0.750	1.357	1.492	1.570	1.499	0.000	0.000	0.000	0.000	1.048
2004	0.158	0.918	1.328	1.362	1.620	0.000	0.000	0.000	0.000	0.000	0.626
2005	0.295	0.567	1.186	1.422	0.000	0.000	0.000	0.000	0.000	0.000	0.810
2006	0.289	0.943	1.299	1.415	1.546	1.620	0.000	0.000	0.000	0.000	0.767
2007	0.268	0.782	1.052	1.212	1.393	1.163	0.000	0.000	0.000	0.000	0.907
2008	0.249	0.848	1.251	1.286	1.419	1.371	0.000	0.000	0.000	0.000	0.775
2009	0.149	0.600	1.386	1.421	1.620	0.000	0.000	0.000	0.000	0.000	0.678
2010	0.211	0.762	1.339	1.473	0.000	0.000	0.000	0.000	0.000	0.000	0.900
2011	0.172	0.616	1.345	1.550	1.371	0.000	0.000	0.000	0.000	0.000	0.837

Table B11b continued. Recreational discards (thousands of fish; metric tons), mean weight (kg), and mean length, at age, of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Subarea 6), 1981-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
	USA Recreational Discards Mean Length (cm) at Age										
1978											
1979											
1980											
1981	23.9	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.9
1982	23.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.7
1983	26.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.1
1984	21.4	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.7
1985	26.6	28.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1
1986	28.7	35.8	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.3
1987	32.7	39.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.9
1988	26.4	36.6	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5
1989	31.6	41.2	45.7	47.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5
1990	27.9	40.9	43.8	47.0	0.0	0.0	0.0	0.0	0.0	0.0	39.0
1991	27.6	43.1	47.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3
1992	31.1	42.3	47.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	40.1
1993	26.7	41.4	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0
1994	26.3	37.6	44.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.7
1995	26.9	40.9	43.3	44.0	0.0	0.0	0.0	0.0	0.0	0.0	39.8
1996	29.8	42.3	47.6	47.4	0.0	0.0	0.0	0.0	0.0	0.0	41.0
1997	28.1	41.5	46.0	48.5	0.0	0.0	0.0	0.0	0.0	0.0	36.5
1998	32.6	42.9	47.8	0.0	47.0	0.0	0.0	0.0	0.0	0.0	42.9
1999	29.5	44.4	47.3	0.0	50.0	0.0	0.0	0.0	0.0	0.0	39.8
2000	29.2	42.9	45.6	47.7	0.0	0.0	0.0	0.0	0.0	0.0	39.4
2001	26.4	42.4	48.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.0
2002	25.8	44.1	50.4	51.9	50.0	51.5	0.0	0.0	0.0	0.0	46.7
2003	32.6	41.4	52.4	54.4	55.3	54.5	0.0	0.0	0.0	0.0	46.4
2004	23.3	44.5	51.3	52.7	56.0	0.0	0.0	0.0	0.0	0.0	34.7
2005	30.8	37.8	50.0	53.4	0.0	0.0	0.0	0.0	0.0	0.0	42.3
2006	29.5	44.8	50.5	52.2	54.2	56.0	0.0	0.0	0.0	0.0	39.7
2007	29.3	42.4	47.3	50.4	53.2	50.1	0.0	0.0	0.0	0.0	44.2
2008	28.1	42.0	51.0	51.5	53.2	53.0	0.0	0.0	0.0	0.0	40.1
2009	24.9	39.8	53.0	53.5	56.0	0.0	0.0	0.0	0.0	0.0	38.0
2010	26.7	43.1	52.3	54.1	0.0	0.0	0.0	0.0	0.0	0.0	44.5
2011	23.9	39.5	52.2	55.1	53.0	0.0	0.0	0.0	0.0	0.0	41.9

Table B12. Catch (thousands of fish; metric tons), mean weight (kg), and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				Catch in Numbers (000's) at Age							
1978	324	840	9002	2806	931	349	288	46	41	32	14660
1979	438	2785	1694	4935	1194	623	201	331	11	57	12270
1980	489	4512	6443	841	2569	1165	462	97	151	43	16773
1981	701	3964	5212	2969	374	1352	433	157	162	77	15401
1982	678	10719	4684	2979	2152	294	752	213	83	92	22648
1983	417	4658	7805	2390	1297	954	182	320	126	134	18281
1984	168	1500	3531	3393	871	620	484	58	199	113	10936
1985	214	7439	2823	1716	2233	532	278	242	37	117	15631
1986	558	1543	4701	897	565	670	98	79	62	29	9202
1987	60	8348	1520	2263	313	269	290	61	39	27	13191
1988	120	2205	9020	1138	1619	223	168	235	61	52	14841
1989	349	2464	3219	4413	416	587	90	58	70	31	11697
1990	37	5479	5744	2070	2338	228	230	24	20	36	16206
1991	151	2160	3685	3265	1471	1079	138	96	28	30	12103
1992	78	4673	2338	1083	1522	478	409	59	45	13	10697
1993	34	1411	4898	1306	519	583	191	156	50	35	9183
1994	43	552	1634	2103	451	101	167	54	40	6	5150
1995	17	563	1407	741	475	58	62	27	11	1	3364
1996	53	320	1014	1315	260	188	20	13	12	0	3196
1997	81	658	778	1123	955	157	119	26	9	4	3910
1998	63	910	1369	535	426	317	48	20	5	2	3694
1999	45	407	2061	867	290	128	146	24	4	1	3973
2000	61	972	789	1237	345	92	47	39	4	1	3586
2001	12	695	2717	748	704	186	55	26	15	2	5160
2002	11	66	1153	1532	372	378	85	18	11	8	3634
2003	3	149	423	827	917	154	142	28	6	3	2653
2004	51	58	424	254	315	254	56	49	11	5	1477
2005	4	264	201	700	198	145	111	23	9	4	1658
2006	9	48	739	208	373	72	31	29	4	3	1516
2007	1	342	281	1235	76	139	17	10	9	1	2112
2008	9	305	719	183	540	22	48	5	3	1	1834
2009	12	143	616	460	106	213	13	14	2	1	1580
2010	9	122	437	598	164	26	76	3	4	1	1441
2011	11	121	493	440	332	90	21	24	3	1	1536

Table B12- continued. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					Catch in Weight (Tons) at Age						
1978	163	1016	21169	9365	3628	2188	1929	391	395	457	40702
1979	259	3801	3274	20496	5757	4421	1858	3379	108	801	44154
1980	281	6254	15397	2933	14135	7889	3802	947	1407	609	53654
1981	425	5589	12005	10172	1788	9583	3653	1489	2241	1310	48256
1982	438	14728	11603	10813	11086	1950	6867	2110	1046	1443	62083
1983	280	6605	18478	7948	6204	6053	1498	3367	1447	2086	53964
1984	110	2283	8702	12419	4367	3999	4150	575	2179	1586	40369
1985	153	9900	5711	6345	10900	3306	2244	2441	426	1630	43055
1986	393	2134	11227	3116	3030	4663	845	778	778	414	27378
1987	40	11914	3702	9111	1745	2043	2516	604	451	411	32538
1988	67	3109	20435	3781	8328	1499	1461	2367	697	747	42490
1989	172	3620	6869	15970	2110	3753	683	560	753	422	34912
1990	20	8227	13694	7154	11181	1406	1855	261	223	488	44508
1991	117	3213	9037	11145	6887	6265	1033	908	286	430	39321
1992	61	6537	5406	4063	6748	2878	2863	525	511	208	29802
1993	12	1887	10535	4027	2532	3358	1371	1346	534	502	26105
1994	14	668	3388	7176	2065	695	1092	473	349	88	16007
1995	6	762	2745	2677	2373	368	517	313	135	28	9924
1996	27	442	2356	4135	1250	1202	156	121	130	5	9824
1997	37	944	1776	3739	3743	867	919	195	104	46	12370
1998	35	1282	3014	1790	1886	1717	377	151	54	27	10332
1999	20	554	4337	2822	1288	737	970	202	41	11	10981
2000	32	1506	1858	4144	1547	487	326	318	37	8	10263
2001	7	967	5928	2201	2901	1005	337	204	137	18	13704
2002	5	95	2421	4524	1468	1953	551	145	99	96	11357
2003	1	240	951	2383	3535	719	822	194	54	31	8930
2004	10	93	1016	788	1214	1218	317	360	97	58	5170
2005	1	239	412	2063	771	655	588	183	78	42	5032
2006	3	55	1610	644	1356	324	202	183	29	31	4435
2007	0	521	591	3469	268	568	99	73	61	9	5660
2008	5	512	1690	517	1970	117	275	37	23	13	5159
2009	6	198	1319	1521	413	989	78	92	18	10	4644
2010	3	148	966	1720	600	99	363	20	25	7	3951
2011	3	149	1128	1293	1198	411	100	137	34	19	4472

Table B12 - continued. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Catch Mean Weight (kg) at Age						
1978	0.502	1.209	2.352	3.337	3.895	6.265	6.706	8.494	9.673	14.074	2.776
1979	0.592	1.365	1.932	4.153	4.820	7.094	9.239	10.207	9.861	14.006	3.599
1980	0.575	1.386	2.390	3.486	5.502	6.774	8.234	9.738	9.316	14.045	3.199
1981	0.607	1.410	2.303	3.426	4.777	7.088	8.435	9.503	13.815	17.096	3.133
1982	0.646	1.374	2.477	3.629	5.151	6.638	9.129	9.914	12.580	15.629	2.741
1983	0.672	1.418	2.368	3.325	4.783	6.347	8.244	10.530	11.507	15.576	2.952
1984	0.653	1.522	2.464	3.660	5.016	6.451	8.567	9.979	10.974	14.052	3.691
1985	0.715	1.331	2.023	3.697	4.882	6.216	8.071	10.070	11.597	13.936	2.755
1986	0.704	1.383	2.388	3.474	5.363	6.964	8.599	9.817	12.524	14.269	2.975
1987	0.669	1.427	2.436	4.026	5.583	7.594	8.682	9.849	11.449	15.042	2.467
1988	0.556	1.410	2.265	3.323	5.145	6.708	8.674	10.051	11.462	14.488	2.863
1989	0.493	1.469	2.134	3.619	5.071	6.388	7.611	9.608	10.824	13.526	2.985
1990	0.527	1.502	2.384	3.456	4.782	6.156	8.080	10.879	11.245	13.525	2.746
1991	0.773	1.488	2.452	3.414	4.681	5.804	7.487	9.486	10.242	14.429	3.249
1992	0.788	1.399	2.313	3.753	4.435	6.023	7.000	8.873	11.305	15.712	2.786
1993	0.366	1.338	2.151	3.084	4.882	5.757	7.189	8.604	10.624	14.309	2.843
1994	0.323	1.210	2.073	3.413	4.582	6.867	6.557	8.720	8.807	15.728	3.108
1995	0.323	1.353	1.950	3.610	5.000	6.306	8.374	11.745	11.934	18.917	2.950
1996	0.514	1.379	2.323	3.145	4.802	6.379	7.737	9.532	11.024	10.844	3.074
1997	0.454	1.435	2.283	3.330	3.917	5.529	7.697	7.639	11.374	11.734	3.164
1998	0.551	1.408	2.201	3.349	4.430	5.418	7.834	7.629	11.086	13.599	2.797
1999	0.451	1.361	2.104	3.253	4.436	5.774	6.643	8.285	10.450	13.985	2.764
2000	0.521	1.550	2.356	3.350	4.488	5.321	6.953	8.081	8.404	13.254	2.862
2001	0.547	1.391	2.182	2.942	4.121	5.392	6.108	7.874	9.136	11.532	2.656
2002	0.462	1.435	2.101	2.952	3.948	5.162	6.495	8.085	9.293	11.500	3.125
2003	0.356	1.605	2.246	2.881	3.854	4.680	5.788	7.007	8.365	10.139	3.365
2004	0.203	1.619	2.397	3.100	3.851	4.799	5.606	7.396	8.785	11.293	3.501
2005	0.266	0.907	2.044	2.947	3.901	4.526	5.321	8.044	8.764	11.381	3.035
2006	0.295	1.128	2.179	3.100	3.632	4.519	6.434	6.382	7.383	9.001	2.925
2007	0.276	1.524	2.106	2.810	3.519	4.078	5.798	6.946	6.849	8.694	2.680
2008	0.537	1.680	2.351	2.831	3.646	5.391	5.696	8.140	8.177	10.268	2.812
2009	0.531	1.387	2.143	3.307	3.887	4.633	6.115	6.622	9.366	11.419	2.940
2010	0.365	1.214	2.208	2.875	3.654	3.759	4.769	5.889	6.182	12.270	2.742
2011	0.273	1.231	2.289	2.941	3.613	4.551	4.778	5.730	11.302	14.110	2.912

Table B12 - continued. Catch (thousands of fish; metric tons), mean weight (kg) , and mean length (cm), at age, of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978-2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
					Catch Mean Length (cm) at Age						
1978	36.6	49.0	60.5	67.6	70.6	84.2	85.5	94.2	96.5	112.3	62.7
1979	38.5	50.9	57.0	72.9	76.9	87.9	96.5	99.4	98.7	111.3	67.0
1980	38.2	51.1	60.9	69.7	80.5	86.7	92.1	97.0	96.1	112.4	64.4
1981	38.8	51.3	60.3	68.8	77.1	88.1	93.5	97.2	109.5	117.7	63.6
1982	39.5	51.0	61.4	69.8	78.9	86.0	95.9	98.3	106.8	114.4	60.8
1983	39.7	51.7	60.8	67.9	76.8	84.8	93.0	100.9	103.9	114.4	63.1
1984	38.7	52.6	61.7	70.4	78.2	85.3	93.6	98.6	102.0	109.9	68.3
1985	40.6	50.3	57.6	70.7	77.6	84.4	92.1	99.1	104.1	110.5	60.9
1986	41.0	50.9	61.1	68.9	79.7	87.5	94.1	98.2	106.0	110.1	63.1
1987	39.9	51.6	61.4	72.6	81.2	90.4	94.4	98.5	103.8	112.7	59.2
1988	36.8	51.7	60.2	67.9	78.7	86.1	94.4	99.4	104.1	112.1	63.1
1989	35.2	52.1	58.9	70.0	78.3	84.5	89.4	98.4	102.4	111.1	63.7
1990	36.2	52.7	60.9	68.8	76.7	83.3	91.6	101.8	103.5	110.5	62.3
1991	40.6	52.3	61.6	68.4	76.0	81.6	89.5	96.7	99.1	112.6	65.9
1992	41.3	51.3	60.6	71.1	75.2	83.3	87.9	94.8	104.1	116.5	62.0
1993	31.5	50.3	59.3	66.7	77.5	82.3	89.3	95.1	99.4	112.8	63.0
1994	30.0	48.5	58.4	68.9	76.0	87.1	86.1	95.0	95.0	115.4	65.1
1995	29.8	50.6	57.4	70.1	79.4	83.9	94.9	105.3	106.6	121.3	63.7
1996	35.9	51.0	60.5	67.0	77.0	86.2	88.6	97.9	102.7	103.0	65.2
1997	34.0	51.4	60.3	68.2	72.3	81.6	91.6	91.1	104.8	105.9	65.6
1998	37.0	51.4	59.7	69.0	75.9	81.5	92.0	91.2	103.5	110.4	63.0
1999	34.1	50.7	59.0	68.4	76.0	83.1	87.6	93.5	101.5	111.7	63.2
2000	35.7	52.8	61.2	68.8	75.8	80.2	88.0	93.4	94.1	109.1	63.8
2001	35.7	51.1	59.5	65.7	73.5	80.7	83.9	91.8	97.4	104.3	62.4
2002	33.7	51.0	58.7	66.1	72.6	79.5	86.0	92.2	96.9	104.9	66.2
2003	32.0	52.7	60.0	65.4	72.3	76.9	82.9	88.3	93.4	99.3	68.1
2004	24.8	53.0	60.7	67.0	72.3	77.7	81.8	90.0	95.2	103.4	67.8
2005	29.4	43.1	57.7	65.7	73.1	76.7	80.4	92.1	94.8	103.6	64.5
2006	29.5	45.5	58.8	66.4	70.2	75.5	85.3	85.5	88.8	94.2	64.0
2007	29.8	52.0	58.5	64.4	69.2	72.7	81.9	87.5	86.9	93.5	62.7
2008	36.0	53.8	61.1	64.9	70.6	79.6	81.2	91.9	92.5	97.7	63.8
2009	35.2	50.3	59.1	68.7	72.4	76.4	83.1	85.8	96.9	104.3	64.7
2010	31.8	48.3	59.8	65.4	70.8	71.2	77.6	82.1	82.4	105.6	63.5
2011	28.3	47.9	60.3	65.7	70.7	76.6	76.9	82.4	105.0	112.2	64.5

Table B13. Length based calibration coefficients and coefficient of variation (CV) applied to spring and autumn survey Atlantic cod data to standardize *H.B.Bigelow* catches to *Albatross IV* units.

cm	calibration coefficient	CV
< 20	5.7237	0.16
21	5.6002	0.16
22	5.4767	0.16
23	5.3532	0.16
24	5.2297	0.15
25	5.1062	0.15
26	4.9827	0.15
27	4.8592	0.14
28	4.7357	0.14
29	4.6122	0.14
30	4.4887	0.14
31	4.3652	0.13
32	4.2417	0.13
33	4.1182	0.13
34	3.9947	0.12
35	3.8712	0.12
36	3.7477	0.11
37	3.6242	0.11
38	3.5007	0.11
39	3.3772	0.10
40	3.2537	0.10
41	3.1302	0.10
42	3.0067	0.09
43	2.8832	0.09
44	2.7597	0.09
45	2.6362	0.09
46	2.5127	0.09
47	2.3892	0.09
48	2.2657	0.10
49	2.1422	0.11
50	2.0187	0.12
51	1.8952	0.14
52	1.7717	0.16
53	1.6482	0.18
54	1.6016	0.20
> 55	1.6016	0.20

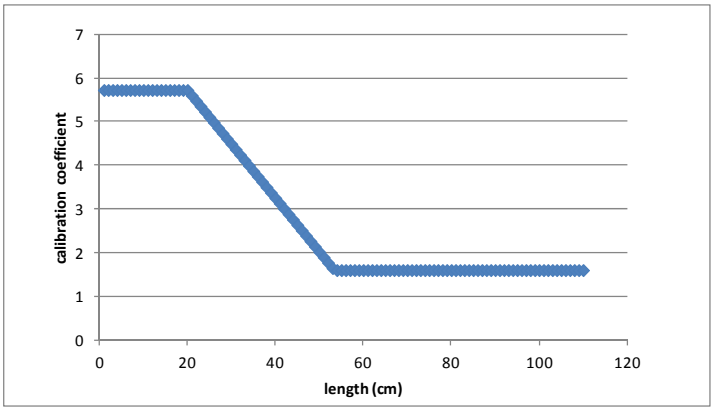


Table B14. Georges Bank Atlantic cod standardized stratified mean catch per tow in numbers and weight (kg) in NEFSC offshore spring and autumn research vessel bottom trawl surveys (strata 13-25), 1963 - 2012.

	Spring				Autumn			
Year	No/Tow	No. CV	Wt/Tow	Wt CV	No/Tow	No. CV	Wt/Tow	Wt. CV
1963	-		-		4.4	28.3	17.8	27.2
1964	-		-		2.8	22.1	11.4	29.5
1965	-		-		4.3	29.4	11.8	31.7
1966	-		-		4.9	25.3	8.2	22.9
1967	-		-		10.3	25.7	13.6	22.7
1968	4.7	21.2	12.7	19.7	3.3	24.1	8.5	25.1
1969	4.6	15.7	17.8	15.2	2.2	18.3	8.0	20.1
1970	4.3	19.0	15.8	19.8	5.1	17.1	12.6	18.7
1971	3.4	16.0	14.3	22.4	3.2	21.5	9.8	25.5
1972	9.2	16.1	19.3	13.6	13.1	23.7	23.0	36.4
1973	57.6	67.7	94.1	58.0	12.3	23.7	30.8	29.3
1974	14.7	18.1	36.4	16.6	3.5	21.3	8.2	21.3
1975	6.9	36.9	26.1	34.1	6.4	50.4	14.1	41.1
1976	7.1	18.8	18.6	14.7	10.4	31.2	17.7	23.9
1977	6.3	12.3	15.4	13.5	5.4	16.1	12.5	14.1
1978	12.3	17.4	31.2	15.4	8.6	15.4	23.3	15.3
1979	5.0	14.2	16.2	14.1	5.9	19.4	16.5	12.9
1980	7.7	24.8	24.1	21.1	2.9	18.2	6.7	24.6
1981	10.4	17.1	26.1	15.6	9.1	41.9	20.3	43.5
1982	33.0	75.4	101.9	84.3	3.3	40.5	6.1	41.5
1983	7.7	23.7	23.5	18.2	4.1	35.0	7.4	30.3
1984	4.1	16.7	15.3	20.4	4.7	29.9	10.0	31.8
1985	7.0	22.3	21.7	19.2	2.3	40.0	3.1	45.7
1986	5.0	13.9	16.7	15.4	3.0	43.8	3.7	27.5
1987	3.2	15.7	9.9	16.7	2.3	28.6	4.4	30.2
1988	5.9	19.3	13.5	18.2	3.1	28.6	5.6	34.4
1989	4.8	20.0	10.9	18.3	4.8	39.8	4.7	29.2
1990	4.8	22.0	11.7	18.4	4.8	31.4	11.5	41.7
1991	4.3	11.2	8.9	13.8	1.0	25.2	1.4	30.4
1992	2.7	18.0	7.4	20.8	1.7	25.6	3.0	31.7
1993	2.4	26.5	7.0	25.4	2.1	64.4	2.2	34.4
1994	0.9	27.0	1.2	27.7	1.8	27.2	3.3	33.4
1995	3.3	26.2	8.4	38.6	3.6	48.4	5.6	47.4
1996	2.7	25.2	7.5	23.2	1.1	27.4	2.7	27.7
1997	2.3	17.5	5.2	26.7	0.9	44.8	1.9	48.6
1998	4.4	34.4	11.7	36.1	1.9	23.7	2.8	21.3
1999	2.1	16.0	4.7	19.5	1.0	31.9	3.0	43.0
2000	3.6	25.7	8.2	24.0	1.3	65.5	1.4	36.8
2001	1.9	26.1	5.5	33.2	1.0	33.3	2.1	34.7
2002	2.1	23.4	5.0	19.9	4.7	37.3	11.3	45.0
2003	2.0	36.9	4.2	39.8	1.2	42.9	2.1	32.4
2004	5.4	50.3	14.3	59.4	4.2	41.7	5.9	70.4
2005	2.0	17.7	4.5	19.4	1.0	30.8	1.6	30.2
2006	3.2	27.0	6.1	24.3	1.4	43.1	2.6	45.3
2007	3.4	25.1	5.1	24.2	0.6	29.4	1.1	37.1
2008	3.6	31.6	4.3	22.5	3.6	74.6	2.9	34.1
2009	2.3	24.5	3.5	22.3	2.5	50.3	4.2	39.8
2010	1.9	21.2	3.8	19.5	1.6	34.9	2.5	34.0
2011	1.0	21.0	1.9	23.9	1.8	30.4	3.0	36.7
2012	1.7	24.3	3.5	23.7				

Table B15a. Georges Bank Atlantic cod standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) in NEFSC offshore spring bottom trawl surveys (strata 13-25), 1963 - 2012.

					AGE							
Year	0	1	2	3	4	5	6	7	8	9	10+	No./tow
SPRING												
1968	0.51	0.14	1.62	0.83	0.67	0.39	0.25	0.14	0.08	0.06	0.06	4.72
1969	0.00	0.12	0.55	1.78	0.89	0.45	0.33	0.22	0.13	0.07	0.11	4.64
1970	0.00	0.38	0.81	0.48	1.30	0.16	0.66	0.27	0.06	0.16	0.06	4.34
1971	0.01	0.20	0.75	0.56	0.25	0.56	0.14	0.35	0.33	0.08	0.15	3.39
1972	0.06	3.01	1.87	2.67	0.52	0.12	0.32	0.12	0.23	0.11	0.13	9.16
1973	0.06	0.52	42.12	6.36	6.36	0.65	0.50	0.37	0.04	0.20	0.41	57.58
1974	0.00	0.44	4.68	5.84	0.76	1.97	0.49	0.10	0.26	0.05	0.14	14.74
1975	0.00	0.06	0.38	2.04	3.10	0.25	0.69	0.13	0.11	0.13	0.00	6.89
1976	0.11	1.30	1.95	0.92	0.66	1.60	0.16	0.26	0.03	0.00	0.07	7.06
1977	0.00	0.01	3.46	1.11	0.59	0.28	0.71	0.06	0.07	0.00	0.02	6.30
1978	3.31	0.37	0.19	5.53	0.97	0.81	0.11	0.71	0.05	0.14	0.11	12.31
1979	0.11	0.42	1.29	0.28	1.87	0.53	0.22	0.09	0.13	0.01	0.04	4.99
1980	0.10	0.03	2.21	2.70	0.21	1.73	0.38	0.15	0.03	0.03	0.10	7.68
1981	0.30	2.30	1.85	2.82	1.70	0.11	0.85	0.26	0.13	0.00	0.11	10.44
1982	0.17	0.51	5.44	9.50	8.32	6.21	0.29	1.87	0.37	0.25	0.03	32.96
1983	0.08	0.33	1.95	3.02	0.80	0.70	0.44	0.03	0.22	0.00	0.14	7.70
1984	0.00	0.40	0.43	0.76	1.24	0.42	0.40	0.21	0.00	0.21	0.00	4.08
1985	0.24	0.11	2.65	0.66	1.11	1.41	0.27	0.19	0.18	0.04	0.16	7.03
1986	0.09	0.87	0.41	1.84	0.37	0.54	0.62	0.06	0.13	0.10	0.02	5.04
1987	0.00	0.02	1.61	0.38	0.76	0.06	0.18	0.14	0.03	0.03	0.02	3.24
1988	0.18	0.72	0.61	3.15	0.41	0.64	0.06	0.04	0.05	0.00	0.01	5.87
1989	0.00	0.31	1.41	0.67	1.58	0.24	0.35	0.05	0.04	0.05	0.09	4.79
1990	0.04	0.17	0.92	1.74	0.67	0.91	0.13	0.14	0.01	0.02	0.03	4.79
1991	0.19	1.03	0.53	0.69	0.93	0.48	0.33	0.05	0.04	0.00	0.04	4.31
1992	0.00	0.12	1.25	0.47	0.17	0.27	0.14	0.16	0.02	0.04	0.03	2.67
1993	0.11	0.01	0.40	1.31	0.21	0.09	0.14	0.03	0.03	0.02	0.05	2.40
1994	0.03	0.12	0.27	0.20	0.22	0.03	0.01	0.04	0.00	0.02	0.00	0.95
1995	0.48	0.05	0.38	0.85	0.53	0.60	0.11	0.22	0.04	0.02	0.00	3.29
1996	0.00	0.07	0.21	0.74	1.25	0.17	0.21	0.03	0.02	0.00	0.00	2.70
1997	0.30	0.29	0.44	0.17	0.49	0.42	0.05	0.13	0.02	0.00	0.00	2.31
1998	0.02	0.11	0.67	1.30	0.85	0.75	0.53	0.10	0.03	0.00	0.00	4.36
1999	0.07	0.21	0.29	0.61	0.51	0.24	0.12	0.06	0.02	0.01	0.00	2.15
2000	0.05	0.22	0.81	0.83	1.14	0.37	0.10	0.03	0.02	0.00	0.00	3.57
2001	0.00	0.06	0.23	0.79	0.16	0.38	0.18	0.02	0.02	0.01	0.00	1.86
2002	0.02	0.06	0.09	0.38	0.99	0.24	0.22	0.04	0.00	0.00	0.03	2.08
2003	0.00	0.02	0.21	0.26	0.61	0.71	0.08	0.08	0.01	0.00	0.00	1.98
2004	0.00	0.64	0.06	0.58	1.41	1.35	0.89	0.18	0.26	0.01	0.00	5.38
2005	0.06	0.01	0.48	0.14	0.63	0.27	0.21	0.13	0.03	0.00	0.00	1.96
2006	0.01	0.18	0.23	1.31	0.33	0.72	0.21	0.12	0.05	0.00	0.00	3.17
2007	0.00	0.13	0.64	0.38	1.79	0.18	0.21	0.03	0.02	0.00	0.00	3.37
2008	0.13	0.63	0.83	0.58	0.35	0.96	0.04	0.05	0.00	0.00	0.00	3.57
2009	0.00	0.62	0.35	0.58	0.28	0.15	0.25	0.02	0.01	0.01	0.00	2.26
2010	0.00	0.10	0.58	0.37	0.58	0.14	0.03	0.12	0.00	0.01	0.00	1.94
2011	0.00	0.07	0.26	0.18	0.28	0.14	0.05	0.01	0.02	0.00	0.00	1.02
2012	0.00	0.03	0.34	0.52	0.57	0.14	0.10	0.02	0.00	0.00	0.00	1.72
Average	0.25	0.39	1.97	1.53	1.10	0.66	0.28	0.17	0.09	0.07	0.09	6.42

Table B15b. Georges Bank Atlantic cod standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) in NEFSC offshore autumn bottom trawl surveys (strata 13-25), 1963 - 2011.

	AGE											
Year	0	1	2	3	4	5	6	7	8	9	10+	No./tow
AUTUMN												
1963	0.0	0.7	0.8	0.9	0.9	0.4	0.3	0.2	0.1	0.0	0.07	4.37
1964	0.0	0.6	0.7	0.6	0.5	0.1	0.1	0.1	0.1	0.0	0.08	2.98
1965	0.2	1.3	1.0	0.7	0.5	0.2	0.2	0.1	0.1	0.0	0.02	4.25
1966	1.0	1.7	1.0	0.5	0.3	0.1	0.1	0.1	0.0	0.0	0.02	4.81
1967	0.1	7.6	1.3	0.5	0.4	0.1	0.1	0.1	0.1	0.0	0.07	10.39
1968	0.1	0.3	1.6	0.8	0.3	0.1	0.1	0.0	0.0	0.0	0.05	3.30
1969	0.0	0.3	0.6	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.06	2.20
1970	0.43	1.70	1.36	0.53	0.70	0.15	0.00	0.03	0.06	0.05	0.10	5.12
1971	0.40	0.60	0.63	0.40	0.31	0.48	0.16	0.04	0.09	0.00	0.07	3.19
1972	0.91	7.48	1.34	1.73	0.40	0.24	0.55	0.14	0.16	0.02	0.11	13.09
1973	0.19	1.76	6.03	1.26	1.94	0.24	0.19	0.21	0.06	0.14	0.25	12.28
1974	0.46	0.41	0.65	1.52	0.16	0.09	0.13	0.00	0.06	0.00	0.00	3.49
1975	2.34	1.03	0.42	0.63	1.68	0.11	0.16	0.00	0.00	0.00	0.04	6.41
1976	0.00	6.14	2.07	0.76	0.28	0.74	0.05	0.27	0.04	0.05	0.02	10.43
1977	0.14	0.12	3.55	0.70	0.25	0.22	0.35	0.01	0.03	0.00	0.08	5.44
1978	0.38	1.87	0.25	4.17	0.98	0.35	0.16	0.33	0.05	0.03	0.01	8.59
1979	0.12	1.61	1.68	0.16	1.69	0.32	0.18	0.03	0.11	0.01	0.03	5.95
1980	0.28	0.82	0.56	0.77	0.05	0.27	0.05	0.07	0.02	0.00	0.00	2.91
1981	0.26	3.53	2.20	1.52	0.76	0.06	0.60	0.09	0.04	0.00	0.09	9.15
1982	0.38	0.56	1.91	0.24	0.07	0.12	0.00	0.06	0.00	0.00	0.00	3.34
1983	1.28	0.85	1.09	0.74	0.07	0.03	0.00	0.00	0.02	0.00	0.04	4.14
1984	0.18	1.91	0.68	0.93	0.83	0.02	0.06	0.04	0.00	0.04	0.04	4.73
1985	1.00	0.18	0.84	0.07	0.11	0.07	0.01	0.02	0.00	0.00	0.00	2.31
1986	0.10	2.26	0.13	0.31	0.03	0.05	0.07	0.02	0.00	0.01	0.02	2.99
1987	0.20	0.41	1.35	0.11	0.20	0.03	0.01	0.00	0.00	0.00	0.01	2.33
1988	0.55	0.87	0.44	0.90	0.06	0.19	0.00	0.01	0.04	0.00	0.00	3.07
1989	0.25	2.80	1.05	0.16	0.51	0.05	0.02	0.01	0.00	0.00	0.00	4.84
1990	0.16	0.36	1.62	1.81	0.41	0.29	0.04	0.02	0.03	0.01	0.02	4.78
1991	0.04	0.41	0.18	0.27	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.96
1992	0.04	0.41	0.95	0.17	0.10	0.04	0.01	0.00	0.00	0.00	0.00	1.72
1993	0.18	0.97	0.53	0.38	0.02	0.03	0.02	0.00	0.00	0.02	0.00	2.15
1994	0.07	0.41	0.66	0.43	0.15	0.07	0.02	0.00	0.01	0.00	0.00	1.82
1995	0.16	0.24	1.81	1.25	0.09	0.05	0.01	0.00	0.00	0.00	0.00	3.62
1996	0.02	0.24	0.20	0.41	0.14	0.06	0.03	0.00	0.00	0.00	0.00	1.10
1997	0.01	0.24	0.32	0.11	0.13	0.05	0.01	0.01	0.00	0.00	0.00	0.87
1998	0.07	0.34	1.03	0.35	0.04	0.04	0.00	0.00	0.00	0.00	0.00	1.87
1999	0.07	0.14	0.15	0.31	0.25	0.09	0.00	0.00	0.00	0.00	0.00	1.02
2000	0.02	0.58	0.53	0.07	0.08	0.03	0.00	0.00	0.00	0.00	0.00	1.31
2001	0.03	0.05	0.38	0.46	0.06	0.05	0.01	0.01	0.00	0.00	0.00	1.04
2002	0.23	0.48	0.71	1.40	1.63	0.12	0.13	0.01	0.00	0.00	0.00	4.70
2003	0.33	0.14	0.33	0.21	0.16	0.08	0.00	0.01	0.00	0.00	0.00	1.25
2004	1.69	0.74	0.14	0.71	0.25	0.32	0.25	0.06	0.02	0.00	0.02	4.21
2005	0.05	0.06	0.58	0.13	0.18	0.03	0.00	0.01	0.00	0.00	0.00	1.02
2006	0.10	0.43	0.16	0.51	0.03	0.12	0.01	0.04	0.01	0.01	0.00	1.44
2007	0.07	0.11	0.21	0.05	0.13	0.01	0.01	0.00	0.00	0.00	0.00	0.59
2008	2.22	0.39	0.62	0.18	0.01	0.11	0.04	0.01	0.00	0.00	0.00	3.57
2009	0.12	1.29	0.64	0.36	0.07	0.03	0.04	0.00	0.01	0.00	0.00	2.55
2010	0.31	0.38	0.59	0.13	0.14	0.06	0.00	0.00	0.00	0.00	0.00	1.61
2011	0.10	0.47	0.69	0.27	0.17	0.09	0.01	0.00	0.00	0.00	0.00	1.81
Average	0.37	1.19	0.99	0.66	0.38	0.14	0.11	0.06	0.05	0.03	0.06	3.90

Table B15c. Georges Bank Atlantic cod stratified mean catch per tow at age (numbers) in Canadian Department of Fisheries and Oceans (DFO) February research bottom trawl survey, 1986-2012.

	AGE											
Year	1	2	3	4	5	6	7	8	9	10+	No./ tow	CV
SPRING												
1986	0.60	2.27	2.81	0.37	0.65	0.44	0.26	0.04	0.07	0.03	7.54	0.35
1987	0.25	2.13	0.92	1.09	0.33	0.12	0.21	0.07	0.03	0.07	5.22	0.26
1988	0.28	0.99	4.67	0.59	1.02	0.13	0.08	0.17	0.04	0.05	8.02	0.24
1989	1.52	2.70	1.35	2.81	0.36	0.42	0.05	0.10	0.12	0.07	9.49	0.16
1990	0.45	2.62	3.85	2.11	3.89	0.42	0.93	0.12	0.12	0.35	14.86	0.17
1991	1.17	1.16	1.84	2.14	1.04	1.30	0.16	0.22	0.03	0.09	9.15	0.13
1992	0.11	2.86	1.77	0.80	0.98	0.60	0.43	0.12	0.07	0.02	7.76	0.18
*1993	0.05	0.60	2.83	1.04	0.62	1.23	0.44	0.42	0.07	0.12	7.42	0.23
*1994	0.02	0.80	0.89	1.65	0.60	0.23	0.45	0.11	0.15	0.04	4.94	0.39
1995	0.07	0.67	1.50	0.86	0.60	0.19	0.04	0.05	0.02	0.02	4.02	0.26
1996	0.14	0.49	2.31	4.02	1.09	0.79	0.33	0.08	0.11	0.03	9.39	0.26
1997	0.32	0.53	0.55	1.25	1.23	0.27	0.06	0.03	0.02	0.01	4.27	0.19
1998	0.01	0.67	0.95	0.35	0.35	0.28	0.07	0.02	0.00	0.02	2.72	0.19
1999	0.33	0.32	1.49	1.09	0.41	0.26	0.15	0.01	0.02	0.01	4.06	0.19
2000	0.10	0.44	1.05	3.89	1.74	0.79	0.39	0.24	0.01	0.02	8.69	0.49
2001	0.00	0.06	0.64	0.42	1.11	0.52	0.26	0.17	0.16	0.05	3.39	0.33
2002	0.01	0.09	0.57	2.05	0.68	1.22	0.40	0.17	0.05	0.08	5.32	0.26
2003	-	0.02	0.30	0.65	1.21	0.32	0.34	0.16	0.01	-	3.01	0.15
2004	0.54	0.10	0.39	0.42	0.45	0.39	0.07	0.12	0.02	0.01	2.50	0.18
**2005	0.02	1.43	0.62	2.69	1.21	0.53	0.32	0.03	0.01	-	6.86	0.44
2006	-	0.04	1.40	0.62	1.59	0.66	0.19	0.19	0.07	0.05	4.81	0.32
2007	0.14	0.52	0.94	2.94	0.39	0.60	0.10	0.08	0.04	0.00	5.75	0.20
2008	0.01	0.32	0.90	0.59	2.18	0.14	0.28	0.03	0.00	0.01	4.47	0.24
2009	0.03	0.27	2.24	1.99	0.42	2.38	-	0.07	-	0.01	7.40	0.53
2010	0.00	0.14	1.10	4.68	2.07	0.82	2.12	0.07	0.10	0.00	11.12	0.62
2011	0.13	0.44	0.67	0.78	1.00	0.19	0.05	0.08	0.01	0.00	3.34	0.19
*2012	0.01	0.22	0.51	0.44	0.25	0.21	0.01	0.02	0.01	-	1.67	0.17
average	0.30	0.89	1.45	1.63	1.08	0.57	0.32	0.10	0.05	0.04	6.37	0.28

** not used in assessment calibration; entire Bank not surveyed;5Z5,6,7 missing*

***R/V Teleost (R/V Needler indices not used since entire GB not surveyed)*

Table B16. Georges Bank Atlantic cod female median age at maturity (A50) and maturity ogives for ages 1-10+ from the NEFSC spring research survey data, 1970- 2012.

	AGE										
YEAR	1	2	3	4	5	6	7	8	9	10+	A50
1970	0.03	0.20	0.69	0.95	0.99	1.00	1.00	1.00	1.00	1.00	2.6
1971	0.03	0.20	0.69	0.95	0.99	1.00	1.00	1.00	1.00	1.00	2.6
1972	0.02	0.20	0.73	0.97	1.00	1.00	1.00	1.00	1.00	1.00	2.6
1973	0.02	0.19	0.70	0.96	1.00	1.00	1.00	1.00	1.00	1.00	2.6
1974	0.02	0.17	0.68	0.96	1.00	1.00	1.00	1.00	1.00	1.00	2.7
1975	0.05	0.25	0.67	0.93	0.99	1.00	1.00	1.00	1.00	1.00	2.6
1976	0.06	0.28	0.71	0.94	0.99	1.00	1.00	1.00	1.00	1.00	2.5
1977	0.09	0.34	0.73	0.94	0.99	1.00	1.00	1.00	1.00	1.00	2.4
1978	0.08	0.33	0.75	0.95	0.99	1.00	1.00	1.00	1.00	1.00	2.4
1979	0.07	0.34	0.78	0.96	0.99	1.00	1.00	1.00	1.00	1.00	2.3
1980	0.09	0.38	0.79	0.96	0.99	1.00	1.00	1.00	1.00	1.00	2.3
1981	0.09	0.38	0.79	0.96	0.99	1.00	1.00	1.00	1.00	1.00	2.3
1982	0.08	0.36	0.79	0.96	0.99	1.00	1.00	1.00	1.00	1.00	2.3
1983	0.08	0.41	0.85	0.98	1.00	1.00	1.00	1.00	1.00	1.00	2.2
1984	0.13	0.49	0.87	0.98	1.00	1.00	1.00	1.00	1.00	1.00	2.0
1985	0.18	0.59	0.91	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.8
1986	0.16	0.58	0.91	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.8
1987	0.20	0.59	0.89	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.8
1988	0.25	0.64	0.90	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.7
1989	0.20	0.61	0.91	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.8
1990	0.12	0.46	0.85	0.97	1.00	1.00	1.00	1.00	1.00	1.00	2.1
1991	0.13	0.53	0.89	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.9
1992	0.09	0.47	0.89	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.1
1993	0.04	0.43	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.1
1994	0.04	0.41	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.1
1995	0.04	0.50	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.0
1996	0.05	0.48	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.0
1997	0.10	0.57	0.94	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.9
1998	0.09	0.56	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.9
1999	0.07	0.51	0.93	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.0
2000	0.07	0.51	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.0
2001	0.08	0.50	0.93	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.0
2002	0.07	0.43	0.88	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.1
2003	0.04	0.33	0.84	0.98	1.00	1.00	1.00	1.00	1.00	1.00	2.3
2004	0.07	0.38	0.83	0.98	1.00	1.00	1.00	1.00	1.00	1.00	2.2
2005	0.06	0.36	0.83	0.98	1.00	1.00	1.00	1.00	1.00	1.00	2.3
2006	0.05	0.35	0.84	0.98	1.00	1.00	1.00	1.00	1.00	1.00	2.3
2007	0.04	0.37	0.88	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.2
2008	0.04	0.35	0.86	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.3
2009	0.03	0.31	0.87	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.3
2010	0.02	0.27	0.85	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.4
2011	0.02	0.25	0.83	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.4
2012	0.02	0.21	0.82	0.99	1.00	1.00	1.00	1.00	1.00	1.00	2.5

Table B17a. Georges Bank Atlantic cod January 1 stock weights at age, 1978-2011.

	Age									
stock waa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1978	0.3048	0.9566	1.7695	2.777	2.8866	5.1593	5.4354	7.8834	9.0644	14.0744
1979	0.3866	0.8281	1.5285	3.1251	4.0109	5.2565	7.6079	8.2732	9.1521	14.0065
1980	0.3673	0.9055	1.8061	2.5954	4.7801	5.7141	7.6426	9.4851	9.7511	14.0451
1981	0.403	0.9004	1.7866	2.8614	4.081	6.2448	7.5589	8.8461	11.5989	17.096
1982	0.4358	0.9129	1.8687	2.8914	4.2008	5.6315	8.0441	9.1448	10.9339	15.6291
1983	0.4461	0.9569	1.8036	2.8699	4.1665	5.7176	7.3979	9.8044	10.6807	15.5762
1984	0.4576	1.0108	1.8692	2.9437	4.0841	5.5548	7.374	9.0704	10.7499	14.0524
1985	0.5138	0.9323	1.7546	3.0181	4.2271	5.5839	7.2158	9.2882	10.7579	13.9359
1986	0.4943	0.9941	1.7827	2.651	4.4526	5.8309	7.3113	8.9014	11.2299	14.2689
1987	0.4609	1.0023	1.8353	3.1007	4.4038	6.382	7.7757	9.203	10.6012	15.0424
1988	0.3422	0.9714	1.7981	2.8454	4.551	6.1198	8.1159	9.3412	10.6247	14.488
1989	0.2821	0.9038	1.7347	2.8634	4.1052	5.733	7.1453	9.129	10.4303	13.526
1990	0.3133	0.86	1.8712	2.7158	4.1602	5.5872	7.1845	9.0993	10.3944	13.525
1991	0.5748	0.8852	1.919	2.8526	4.0224	5.2684	6.789	8.7547	10.5554	14.4293
1992	0.6044	1.0401	1.855	3.0336	3.8909	5.3099	6.3741	8.1504	10.3556	15.7121
1993	0.2012	1.0266	1.7347	2.6707	4.2804	5.0529	6.5803	7.761	9.7092	14.3095
1994	0.1575	0.6652	1.6656	2.7093	3.7594	5.7903	6.1439	7.9178	8.7052	15.7281
1995	0.1564	0.6608	1.5358	2.736	4.1309	5.3755	7.5832	8.7756	10.2014	18.9171
1996	0.3077	0.6676	1.773	2.4766	4.1639	5.6477	6.9847	8.934	11.3789	10.8441
1997	0.2577	0.859	1.7745	2.7812	3.51	5.1528	7.0073	7.6875	10.4119	11.7344
1998	0.3506	0.7995	1.7774	2.7649	3.841	4.6068	6.5813	7.6632	9.2023	13.5989
1999	0.2433	0.8661	1.7214	2.6761	3.8543	5.0577	5.9993	8.0562	8.9291	13.9853
2000	0.3191	0.836	1.7908	2.6553	3.8212	4.8583	6.3362	7.3264	8.3444	13.254
2001	0.3379	0.8514	1.8389	2.6324	3.7159	4.9193	5.7007	7.399	8.5923	11.5319
2002	0.2479	0.8862	1.7091	2.538	3.408	4.6124	5.9175	7.0272	8.5539	11.5002
2003	0.167	0.8613	1.7953	2.4601	3.3729	4.2986	5.4659	6.746	8.2242	10.1391
2004	0.0963	0.7593	1.9617	2.6385	3.3308	4.3003	5.1223	6.5429	7.8459	11.2934
2005	0.1294	0.4293	1.819	2.6579	3.4776	4.1748	5.0532	6.7156	8.0512	11.3806
2006	0.1297	0.5481	1.4055	2.5173	3.2717	4.1987	5.3964	5.8277	7.7064	9.0013
2007	0.1122	0.6703	1.5414	2.4741	3.3031	3.8488	5.1184	6.685	6.6114	8.6937
2008	0.3346	0.6815	1.8927	2.4415	3.2005	4.3555	4.8198	6.8698	7.5365	10.2684
2009	0.3508	0.8636	1.8974	2.7881	3.3172	4.11	5.7415	6.1416	8.7314	11.4192
2010	0.1986	0.8026	1.7502	2.4822	3.4761	3.8224	4.7009	6.0012	6.3982	12.2702
2011	0.1112	0.6703	1.667	2.5482	3.223	4.0777	4.2376	5.2278	8.1584	14.1104

Table B17b. Georges Bank Atlantic cod Lorenzen (1996) age based natural mortality (M) estimates derived from January 1 stock weights at age with annual and time series mean, 1978-2011.

Lorenzen M	AGE										
	1	2	3	4	5	6	7	8	9	10+	Mean
1978	0.64	0.45	0.38	0.33	0.32	0.27	0.27	0.24	0.23	0.20	0.33
1979	0.60	0.48	0.39	0.32	0.29	0.27	0.24	0.24	0.23	0.20	0.33
1980	0.61	0.46	0.37	0.34	0.28	0.26	0.24	0.23	0.22	0.20	0.32
1981	0.59	0.46	0.38	0.33	0.29	0.26	0.24	0.23	0.21	0.19	0.32
1982	0.58	0.46	0.37	0.32	0.29	0.26	0.24	0.23	0.22	0.19	0.32
1983	0.57	0.45	0.37	0.33	0.29	0.26	0.24	0.22	0.22	0.19	0.32
1984	0.57	0.45	0.37	0.32	0.29	0.27	0.24	0.23	0.22	0.20	0.32
1985	0.55	0.46	0.38	0.32	0.29	0.27	0.25	0.23	0.22	0.20	0.32
1986	0.56	0.45	0.38	0.33	0.28	0.26	0.24	0.23	0.21	0.20	0.32
1987	0.57	0.45	0.37	0.32	0.29	0.25	0.24	0.23	0.22	0.20	0.31
1988	0.62	0.45	0.38	0.33	0.28	0.26	0.24	0.23	0.22	0.20	0.32
1989	0.66	0.46	0.38	0.33	0.29	0.26	0.25	0.23	0.22	0.20	0.33
1990	0.64	0.47	0.37	0.33	0.29	0.27	0.25	0.23	0.22	0.20	0.33
1991	0.53	0.47	0.37	0.33	0.29	0.27	0.25	0.23	0.22	0.20	0.32
1992	0.52	0.44	0.37	0.32	0.30	0.27	0.26	0.24	0.22	0.19	0.31
1993	0.73	0.45	0.38	0.33	0.29	0.27	0.25	0.24	0.22	0.20	0.34
1994	0.79	0.51	0.38	0.33	0.30	0.26	0.26	0.24	0.23	0.19	0.35
1995	0.79	0.51	0.39	0.33	0.29	0.27	0.24	0.23	0.22	0.18	0.35
1996	0.64	0.51	0.38	0.34	0.29	0.26	0.25	0.23	0.21	0.22	0.33
1997	0.68	0.47	0.38	0.33	0.31	0.27	0.25	0.24	0.22	0.21	0.34
1998	0.62	0.48	0.38	0.33	0.30	0.28	0.25	0.24	0.23	0.20	0.33
1999	0.69	0.47	0.38	0.33	0.30	0.27	0.26	0.24	0.23	0.20	0.34
2000	0.64	0.47	0.38	0.33	0.30	0.28	0.26	0.24	0.23	0.20	0.33
2001	0.62	0.47	0.37	0.33	0.30	0.28	0.26	0.24	0.23	0.21	0.33
2002	0.69	0.47	0.38	0.34	0.31	0.28	0.26	0.25	0.23	0.21	0.34
2003	0.77	0.47	0.38	0.34	0.31	0.29	0.27	0.25	0.24	0.22	0.35
2004	0.92	0.49	0.37	0.33	0.31	0.29	0.27	0.25	0.24	0.21	0.37
2005	0.84	0.58	0.37	0.33	0.31	0.29	0.27	0.25	0.24	0.21	0.37
2006	0.84	0.54	0.40	0.34	0.31	0.29	0.27	0.26	0.24	0.23	0.37
2007	0.87	0.51	0.39	0.34	0.31	0.30	0.27	0.25	0.25	0.23	0.37
2008	0.63	0.50	0.37	0.34	0.31	0.29	0.28	0.25	0.24	0.22	0.34
2009	0.62	0.47	0.37	0.33	0.31	0.29	0.26	0.26	0.23	0.21	0.34
2010	0.73	0.48	0.38	0.34	0.31	0.30	0.28	0.26	0.25	0.21	0.35
2011	0.88	0.51	0.38	0.34	0.31	0.29	0.29	0.27	0.24	0.20	0.37
Mean	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	

Table B18. Selected VPA diagnostics, including predicted beginning year stock numbers for ages 1-8, standard error and CV, and catchability estimates of each survey index, with standard error and CV for Model comparison Run A (terminal year 2010) and Run B (terminal year 2011) for the Georges Bank Atlantic cod stock.

RUN A

FEB 2012 TY 2010

RSS 384.38

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

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

RUN B

NOV 2012 TY 2011

RSS 389.3

age	N	std err	cv	F2012
1				0.00
2	5639	2001	0.35	0.16
3	2379	691	0.29	0.43
4	2851	776	0.27	0.70
5	681	237	0.35	0.75
6	439	165	0.38	0.90
7	54	32	0.59	0.95
8	20	15	0.74	0.97
F 5-8				0.69
SSB				12532

Survey Index	Catchability q	Std. Err	CV
spr_36_us_1	0.02	0.01	0.34
spr_36_us_2	0.09	0.01	0.12
spr_36_us_3	0.16	0.03	0.18
spr_36_us_4	0.21	0.04	0.20
spr_36_us_5	0.25	0.05	0.22
spr_36_us_6	0.25	0.05	0.20
spr_36_us_7	0.26	0.05	0.18
spr_36_us_8	0.31	0.06	0.19
post-spr_36_us_1	0.04	0.01	0.21
post-spr_36_us_2	0.12	0.01	0.11
post-spr_36_us_3	0.24	0.03	0.14
post-spr_36_us_4	0.50	0.08	0.16
post-spr_36_us_5	0.67	0.11	0.17
post-spr_36_us_6	0.71	0.11	0.15
post-spr_36_us_7	0.75	0.14	0.19
post-spr_36_us_8	0.80	0.16	0.20
spr_41_us_1	0.01	0.01	0.76
spr_41_us_2	0.08	0.02	0.31
spr_41_us_3	0.17	0.05	0.30
spr_41_us_4	0.15	0.02	0.16
spr_41_us_5	0.19	0.05	0.28
spr_41_us_6	0.16	0.04	0.26
spr_41_us_7	0.25	0.09	0.37
spr_41_us_8	0.23	0.12	0.53
spr_dfo_1	0.03	0.01	0.32
spr_dfo_2	0.18	0.04	0.21
spr_dfo_3	0.31	0.04	0.11
spr_dfo_4	0.35	0.04	0.13
spr_dfo_5	0.55	0.07	0.12
spr_dfo_6	0.52	0.11	0.21
spr_dfo_7	0.66	0.19	0.28
spr_dfo_8	0.80	0.22	0.27
post-spr_dfo_1	0.01	0.01	0.35
post-spr_dfo_2	0.09	0.02	0.24
post-spr_dfo_3	0.43	0.07	0.16
post-spr_dfo_4	1.07	0.16	0.15
post-spr_dfo_5	1.71	0.27	0.16
post-spr_dfo_6	2.45	0.44	0.18
post-spr_dfo_7	2.31	0.55	0.24
post-spr_dfo_8	2.50	0.49	0.20
aut_1	0.02	0.00	0.20
aut_2	0.07	0.01	0.16
aut_3	0.11	0.02	0.15
aut_4	0.12	0.02	0.18
aut_5	0.09	0.02	0.22
aut_6	0.09	0.01	0.15
post-aut_1	0.03	0.01	0.42
post-aut_2	0.10	0.02	0.19
post-aut_3	0.21	0.03	0.15
post-aut_4	0.24	0.04	0.17
post-aut_5	0.22	0.04	0.19
post-aut_6	0.30	0.06	0.18

Table B19a. Beginning year stock size (thousands of fish) and instantaneous fishing mortality (F) of Georges Bank cod, estimated from virtual population analysis (**VPA)**, calibrated using split survey swept area estimates for the commercial catch at age ADAPT formulation, 1978-2011.

Stock Numbers (Jan 1) in thousands

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	10161	11123	8626	18647	8600	4958	13202	5143	22742	8503	8955	5183	3401	11921	4727	1975	904
2	6757	21844	20502	16770	33392	14713	8703	22325	7881	37587	14577	18960	12361	7816	17553	6337	5353
3	48971	7695	34032	25511	21643	36072	15536	9966	23322	9318	41989	17845	27730	12914	9787	16745	6195
4	24383	45623	6770	27725	20377	15256	27658	11048	5686	20155	7997	31638	15103	19949	6768	5971	9544
5	9751	18738	36030	5639	22157	12945	9066	19695	6526	4190	14998	5284	21225	10876	10939	3687	2518
6	8763	10158	15729	24165	4479	13682	7695	5798	10625	4431	3059	7195	3806	11005	4802	4785	1416
7	7426	8189	7829	9166	15739	2871	8154	4188	2750	6937	2658	1499	3614	2397	4770	2072	1584
8	798	7113	6642	3770	5531	9104	1411	4388	2021	2021	4395	1078	833	1810	1349	1929	701
9	1522	382	3974	5633	2281	3251	5092	815	1918	1217	1326	1828	464	564	868	802	564
10+	1876	3050	1642	3923	3620	5051	3784	3364	1139	1197	1532	1064	1096	823	386	825	144
Total	120407	133915	141776	140950	137819	117903	100299	86731	84611	95557	101487	91573	89633	80075	61949	45128	28923

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	532	1590	2010	1409	2784	1834	679	733	195	610	180	456	521	1144	2217	760	794	772
2	3354	2148	4363	6326	3331	8288	4020	1493	2516	728	2257	624	1899	2577	2364	4088	2055	4185
3	9371	6784	4446	7040	10986	5424	13707	5589	2405	4880	1336	5756	1367	3724	5332	3651	6708	4158
4	4365	9170	6152	3601	5363	8880	4599	9225	4076	1881	4365	1053	6630	1150	2693	4354	3344	7257
5	4201	2679	6501	3100	2268	3308	6057	2597	5420	2063	1234	2348	520	3491	738	1321	2900	2249
6	805	2309	1514	3062	1425	1083	1969	3253	1257	2150	941	481	981	265	1690	334	670	1777
7	833	492	1167	664	1569	740	574	954	1315	524	925	305	155	408	174	688	203	267
8	557	312	304	238	320	618	397	234	381	463	226	301	123	66	162	81	272	127
9	248	321	179	89	70	91	291	178	93	168	120	57	111	43	33	59	64	160
10+	61	12	86	54	22	20	41	187	54	113	70	58	18	26	20	16	43	51
Total	24328	25817	26722	25584	28138	30283	32334	24443	17711	13582	11656	11439	12325	12894	15422	15351	17053	21003

Fishing Mortality

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.01	0.02	0.03	0.02	0.04	0.05	0.01	0.02	0.02	0.00	0.01	0.03	0.00	0.01	0.01	0.00	0.01
2	0.14	0.13	0.25	0.28	0.40	0.41	0.22	0.42	0.25	0.28	0.18	0.14	0.55	0.31	0.36	0.30	0.07
3	0.44	0.46	0.47	0.51	0.58	0.56	0.62	0.78	0.50	0.40	0.55	0.42	0.55	0.91	0.66	0.81	0.65
4	0.43	0.46	0.44	0.41	0.62	0.67	0.50	0.72	0.61	0.48	0.58	0.57	0.52	0.71	0.75	1.01	1.04
5	0.36	0.33	0.47	0.35	0.59	0.61	0.56	0.74	0.55	0.45	0.77	0.44	0.69	0.90	0.89	1.06	1.30
6	0.26	0.44	0.62	0.48	0.52	0.57	0.67	0.82	0.51	0.55	0.67	0.71	0.46	0.83	0.86	1.10	0.60
7	0.26	0.23	0.68	0.50	0.55	0.71	0.65	0.74	0.34	0.44	0.82	0.63	0.69	0.56	0.90	1.07	1.20
8	0.69	0.55	0.17	0.51	0.49	0.47	0.52	0.82	0.48	0.37	0.79	0.77	0.34	0.70	0.50	1.14	1.09
9	0.31	0.34	0.52	0.46	0.57	0.60	0.61	0.75	0.51	0.47	0.76	0.57	0.66	0.84	0.88	1.08	1.09
10+	0.31	0.34	0.52	0.46	0.57	0.60	0.61	0.75	0.51	0.47	0.76	0.57	0.66	0.84	0.88	1.08	1.09
F 5-8	0.39	0.39	0.48	0.46	0.53	0.59	0.60	0.78	0.47	0.45	0.76	0.64	0.54	0.75	0.79	1.09	1.05

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.12	0.10	0.14	0.12	0.11	0.11	0.17	0.04	0.05	0.07	0.06	0.05	0.16	0.10	0.06	0.03	0.05
3	0.29	0.34	0.43	0.48	0.44	0.34	0.51	0.48	0.42	0.21	0.36	0.22	0.43	0.51	0.27	0.26	0.15
4	0.71	0.49	0.81	0.59	0.64	0.52	0.63	0.62	0.78	0.50	0.63	0.78	0.70	0.55	0.73	0.47	0.46
5	0.71	0.58	0.82	0.85	0.77	0.57	0.64	0.76	0.97	0.81	0.93	0.84	0.75	0.78	0.73	0.64	0.52
6	0.55	0.70	0.87	0.73	0.68	0.60	0.71	0.88	0.85	0.81	1.18	1.13	0.90	0.49	0.83	0.40	0.91
7	0.94	0.38	1.48	0.73	0.93	0.58	0.90	0.85	1.02	0.91	1.06	0.92	0.95	0.97	0.61	0.83	0.65
8	0.61	0.51	1.20	1.18	1.10	0.71	0.75	0.88	0.77	1.35	1.32	0.92	0.97	0.73	0.85	0.33	0.69
9	0.71	0.61	0.87	0.79	0.78	0.58	0.66	0.82	0.96	0.82	1.03	0.87	0.85	0.77	0.79	0.64	0.69
10+	0.71	0.61	0.87	0.79	0.78	0.58	0.66	0.82	0.96	0.82	1.03	0.87	0.85	0.77	0.79	0.64	0.69
F 5-8	0.71	0.54	1.09	0.87	0.87	0.61	0.75	0.84	0.90	0.97	1.12	0.95	0.89	0.74	0.76	0.55	0.69

Table B19b. Spawning stock biomass (mt) and female percent mature (5-year moving window) of Georges Bank cod, estimated from virtual population analysis (**VPA**), calibrated using split survey swept area estimates for the commercial catch at age ADAPT formulation, 1978-2011.

SSB at start of spawning season

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	883	858	581	1618	743	381	1020	644	3949	1315	1731	1248	657	1382	593	172	35
2	2170	6825	6463	5888	11487	4782	3329	9873	4317	20125	8073	11465	6655	3300	8477	2742	2199
3	32126	5170	23746	17907	15007	25119	11514	7369	18886	7676	32982	14485	22263	9130	7548	12601	5001
4	20632	38814	5846	24047	17063	12660	24110	9295	4916	17816	6878	27256	13122	16623	5659	4836	7759
5	8793	16985	31916	5091	19227	11200	7987	16842	5762	3763	12768	4752	18289	9061	9124	2989	1962
6	8121	9137	13719	21568	3974	12029	6656	4895	9432	3909	2647	6178	3411	9274	4027	3852	1239
7	6874	7622	6765	8163	13900	2465	7076	3581	2514	6235	2243	1306	3116	2113	3969	1677	1254
8	688	6281	6249	3347	4933	8137	1251	3703	1804	1840	3728	916	762	1557	1202	1542	565
9	1397	349	3525	5050	2006	2846	4447	695	1704	1089	1130	1608	402	474	724	648	455
10+	1723	2787	1456	3517	3183	4420	3305	2871	1013	1070	1306	936	949	692	322	666	116
Total	83407	94828	100266	96196	91524	84040	70697	59769	54297	64837	73486	70150	69626	53605	41645	31725	20585

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	21	61	97	136	242	124	46	57	13	24	12	26	25	44	86	22	15
2	1303	1022	1980	3420	1771	4015	1926	717	1038	230	822	216	626	908	792	1220	533
3	7941	5949	3803	5911	9282	4610	11442	4640	1907	3830	1010	4453	1033	2911	4237	2940	5383
4	3752	8171	5202	3123	4662	7798	4005	7971	3426	1641	3727	877	5593	1004	2282	3856	2967
5	3609	2351	5481	2601	1929	2909	5267	2214	4462	1744	1022	1976	443	2967	631	1149	2573
6	710	1988	1267	2621	1231	949	1692	2719	1055	1819	747	386	816	236	1423	302	557
7	688	447	882	568	1299	650	477	801	1072	436	749	253	128	336	152	580	176
8	487	278	240	189	258	531	339	196	324	357	175	250	101	56	136	74	235
9	213	280	150	76	59	80	252	151	77	142	98	47	93	36	28	51	55
10+	52	10	72	46	19	17	35	158	45	96	57	48	15	22	17	14	37
Total	18777	20557	19174	18691	20753	21681	25482	19623	13418	10317	8420	8531	8875	8521	9783	10208	12531

Percent mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.08	0.07	0.09	0.09	0.08	0.08	0.13	0.18	0.16	0.20	0.25	0.20	0.12	0.13	0.09	0.04	0.04
2	0.33	0.34	0.38	0.38	0.36	0.41	0.49	0.59	0.58	0.59	0.64	0.61	0.46	0.53	0.47	0.43	0.41
3	0.75	0.78	0.79	0.79	0.79	0.85	0.87	0.91	0.91	0.89	0.90	0.91	0.85	0.89	0.89	0.93	0.92
4	0.95	0.96	0.96	0.96	0.96	0.98	0.98	0.99	0.99	0.98	0.98	0.98	0.97	0.98	0.99	1.00	1.00
5	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.04	0.05	0.10	0.09	0.07	0.07	0.08	0.07	0.04	0.07	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.02
2	0.50	0.48	0.57	0.56	0.51	0.51	0.50	0.43	0.33	0.38	0.36	0.35	0.37	0.35	0.31	0.27	0.25	0.21
3	0.96	0.95	0.94	0.94	0.93	0.94	0.93	0.88	0.84	0.83	0.83	0.84	0.88	0.86	0.87	0.85	0.83	0.82
4	1.00	1.00	0.99	1.00	0.99	1.00	0.99	0.99	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table B20. ASAP model diagnostics for the VPA-like, BASE, MRamp, and Catch Multiplier model formulations: number of parameters, total objective function (OF) value, contribution to the OF by components, root mean square error (RMSE) of the standardized residuals, and the spawning stock biomass (SSB 2011) and fishing mortality of unweighted ages 5+ (F2011 for terminal year 2011).

Model		vpa like	BASE	Mramp	CatMult
number of parameters		158	94	94	94
objective function		5989	2269	2271	2298
components of	catch total	280	260	260	279
obj. function	index fit total	4991	840	833	848
	catch age composition	344	430	431	430
	Index age composition	0	739	747	741
	Recruit deviations	374	0	0	0
RMSE	Catch fleet	1.09	0.14	0.08	0.18
	DFO		0.92	0.84	1.14
	Autumn		1.01	0.94	1.07
	Spring 41		1.11	1.11	1.10
	Spring 36		0.92	0.79	0.94
	Index total		0.96	0.87	1.05
SSB 2011		13109	22217	21536	36323
F 2011 (age 5+)		0.51	0.23	0.26	0.45

Table B21. ASAP model with freely estimated selectivity at age for the DFO, NEFSC autumn and NEFSC spring surveys (and freely estimated fleet selectivity).

Run 15w	value	std dev	cv		
index_sel_	0.04	0.01	0.25	**dfo**	1
index_sel_	0.16	0.03	0.17		2
index_sel_	0.38	0.06	0.15		3
index_sel_	0.80	0.11	0.14		4
index_sel_	1.00	0.00	0.00		5
index_sel_	1.00	0.00	0.00		6
index_sel_	0.90	0.22	0.24		7
index_sel_	0.39	0.22	0.55		9
index_sel_	0.02	0.04	1.62		10
index_sel_	0.19	0.03	0.15	**autumn**	1
index_sel_	0.54	0.06	0.12		2
index_sel_	0.86	0.10	0.11		3
index_sel_	1.00	0.00	0.00		4
index_sel_	0.93	0.14	0.15		5
index_sel_	0.11	0.02	0.19	**spr**	1
index_sel_	0.32	0.05	0.15		2
index_sel_	0.63	0.09	0.14		3
index_sel_	0.88	0.12	0.14		4
index_sel_	1.00	0.00	0.00		5
index_sel_	0.99	0.19	0.19		6
index_sel_	0.84	0.21	0.25		7
index_sel_	0.43	0.23	0.54		9
index_sel_	0.01	0.03	1.88		10

Table B22. ASAP results of freely estimated selectivity at age for four fishery blocks.

run16w	value	std	cv		
sel_params[1]	0.04	0.02	0.36	1978	age1
sel_params[2]	0.46	0.08	0.18		2
sel_params[3]	0.97	0.17	0.18		3
sel_params[5]	0.87	0.22	0.25		5
sel_params[6]	1.00	0.00	0.00		6
sel_params[7]	0.89	0.37	0.42		7
sel_params[8]	1.00	0.01	0.01		8
sel_params[9]	0.97	0.97	1.00		9
sel_params[10]	0.55	0.77	1.40		10
sel_params[11]	0.02	0.01	0.34	1983	1
sel_params[12]	0.45	0.07	0.15		2
sel_params[13]	0.93	0.13	0.14		3
sel_params[14]	0.98	0.16	0.16		4
sel_params[16]	0.94	0.21	0.23		6
sel_params[17]	0.95	0.30	0.31		7
sel_params[18]	0.79	0.34	0.43		8
sel_params[19]	1.00	0.01	0.01		9
sel_params[20]	0.85	0.80	0.94		10
sel_params[21]	0.01	0.00	0.67	1994	1
sel_params[22]	0.13	0.03	0.20		2
sel_params[23]	0.52	0.08	0.16		3
sel_params[24]	0.87	0.15	0.17		4
sel_params[26]	0.87	0.26	0.30		6
sel_params[27]	1.00	0.00	0.00		7
sel_params[28]	1.00	0.00	0.00		8
sel_params[29]	1.00	0.00	0.00		9
sel_params[30]	1.00	0.03	0.03		10
sel_params[31]	0.01	0.00	0.48	2000	1
sel_params[32]	0.13	0.02	0.17		2
sel_params[33]	0.54	0.07	0.13		3
sel_params[34]	0.90	0.12	0.13		4
sel_params[35]	1.00	0.00	0.00		5
sel_params[36]	0.99	0.18	0.18		6
sel_params[38]	0.68	0.30	0.44		8
sel_params[39]	0.41	0.33	0.82		9
sel_params[40]	0.06	0.08	1.29		10

Table B23a. ASAP BASE model results for January 1 biomass, spawning stock biomass (SSB), average F (unweighted, ages 5+), and recruitment (000s, age 1 fish), 1978-2011.

Year	Biomass Jan. 1	(mt) SSB	Favg. age 5-8	Recruitment Age 1 (000s)
1978	118945	83600	0.40	29399
1979	130430	93607	0.41	27836
1980	136837	96864	0.52	22073
1981	134210	90633	0.51	44386
1982	131938	85290	0.69	20472
1983	110035	75533	0.68	10357
1984	94391	64591	0.62	29539
1985	81683	55094	0.87	9211
1986	80074	49640	0.58	47147
1987	89884	59852	0.55	16436
1988	94936	68021	0.64	26484
1989	85008	64395	0.54	18656
1990	83209	63060	0.73	11028
1991	76140	47513	0.89	24732
1992	59873	38311	0.85	8319
1993	44115	30554	0.93	9970
1994	28960	20581	1.10	7082
1995	25102	19220	0.68	3913
1996	27254	21311	0.60	7142
1997	28706	20202	0.87	10299
1998	27481	20042	0.79	4766
1999	29153	21636	0.76	11895
2000	30976	22256	0.62	6106
2001	32877	25624	0.83	2605
2002	25761	20459	0.76	3962
2003	19435	14960	0.80	1256
2004	15164	11860	0.54	6959
2005	13465	10121	0.65	1526
2006	13471	10441	0.50	3985
2007	14835	10970	0.65	5848
2008	17117	11520	0.58	5327
2009	22168	14725	0.42	8079
2010	24447	17168	0.29	8136
2011	29077	22217	0.23	7334

Table B23b. ASAP BASE model results for stock numbers (000s) and fishing mortality (F,unweighted, average ages 5+) at age, 1978-2011.

Stock Numbers (Jan 1) in thousands

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	29399	27836	22073	44386	20472	10357	29539	9211	47147	16436	26484	18656	11028	24732	8319	9970	7082
2	5140	23844	22573	17853	35906	16492	8346	23835	7389	38080	13285	21359	15081	8876	19829	6677	7986
3	29224	3495	16172	14538	11541	21379	9878	5133	13081	4631	24218	8088	13612	8826	4809	10961	3549
4	7538	16212	1929	8008	7256	4848	9092	4441	1817	6118	2234	10658	3918	5515	3042	1729	3631
5	3475	4131	8836	940	3935	2984	2019	4011	1531	835	2902	964	5077	1552	1850	1065	557
6	1061	1904	2251	4304	462	1617	1242	890	1382	703	396	1251	459	2011	520	647	343
7	1744	581	1037	1096	2114	190	673	548	307	635	333	171	596	182	674	182	208
8	158	955	317	505	538	869	79	297	189	141	301	144	81	236	61	236	59
9	313	87	520	154	248	221	362	35	102	87	67	130	68	32	79	21	76
10+	239	302	212	357	251	205	178	238	94	90	84	65	93	64	32	39	19
Total	78290	79345	75919	92142	82723	59162	61407	48637	73039	67756	70302	61484	50014	52026	39214	31527	23509

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	3913	7142	10299	4766	11895	6106	2605	3962	1256	6959	1526	3985	5848	5327	8079	8136	7334
2	5714	3174	5801	8335	3861	9641	4958	2109	3211	1018	5657	1238	3241	4746	4327	6577	6635
3	5821	4352	2440	4333	6276	2917	7392	3717	1594	2417	787	4326	961	2476	3654	3388	5221
4	1662	3367	2631	1285	2372	3492	1743	3963	2070	871	1501	464	2744	565	1508	2412	2391
5	1102	734	1609	984	515	978	1633	672	1636	826	437	686	241	1245	273	842	1517
6	153	458	333	557	367	198	433	585	260	609	395	188	341	103	572	147	516
7	93	63	206	114	206	140	87	154	224	96	289	169	93	145	47	306	90
8	57	38	28	71	42	79	62	31	59	83	45	124	84	40	66	25	187
9	16	23	17	10	26	16	35	22	12	22	39	19	61	36	18	35	15
10+	26	17	18	12	8	13	13	17	15	10	15	23	21	35	32	27	38
Total	18556	19371	23384	20467	25569	23580	18960	15233	10337	12910	10690	11223	13636	14718	18577	21895	23946

Fishing Mortality

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.01
2	0.19	0.19	0.24	0.24	0.32	0.31	0.29	0.40	0.27	0.25	0.30	0.25	0.34	0.41	0.39	0.43	0.12
3	0.39	0.39	0.50	0.49	0.67	0.66	0.60	0.84	0.56	0.53	0.62	0.52	0.70	0.87	0.82	0.90	0.56
4	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.86	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	0.99
5	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.09
6	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.10
7	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.10
8	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.10
9	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.10
10+	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.10
F 5+	0.40	0.41	0.52	0.51	0.69	0.68	0.62	0.87	0.58	0.55	0.64	0.54	0.73	0.89	0.85	0.93	1.10

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
2	0.07	0.06	0.09	0.08	0.08	0.07	0.09	0.08	0.08	0.06	0.07	0.05	0.07	0.06	0.04	0.03	0.02
3	0.35	0.30	0.44	0.40	0.39	0.32	0.42	0.39	0.40	0.28	0.33	0.26	0.33	0.30	0.22	0.15	0.12
4	0.62	0.54	0.78	0.72	0.69	0.56	0.75	0.68	0.72	0.49	0.58	0.45	0.59	0.53	0.38	0.26	0.21
5	0.68	0.59	0.86	0.79	0.75	0.61	0.83	0.75	0.79	0.54	0.64	0.50	0.65	0.58	0.42	0.29	0.23
6	0.69	0.60	0.87	0.79	0.76	0.62	0.84	0.76	0.80	0.54	0.65	0.50	0.66	0.58	0.42	0.29	0.23
7	0.69	0.60	0.87	0.80	0.76	0.62	0.84	0.76	0.80	0.55	0.65	0.50	0.66	0.58	0.43	0.29	0.23
8	0.69	0.60	0.87	0.80	0.76	0.62	0.84	0.76	0.80	0.55	0.65	0.50	0.66	0.59	0.43	0.29	0.23
9	0.69	0.60	0.87	0.80	0.76	0.62	0.84	0.76	0.80	0.55	0.65	0.50	0.66	0.59	0.43	0.29	0.23
10+	0.69	0.60	0.87	0.80	0.76	0.62	0.84	0.76	0.80	0.55	0.65	0.50	0.66	0.59	0.43	0.29	0.23
F 5+	0.68	0.60	0.87	0.79	0.76	0.62	0.83	0.76	0.80	0.54	0.65	0.50	0.65	0.58	0.42	0.29	0.23

Table B24. Input data for yield-per-recruit and projection analysis computed from 5-year averages of 2007-2011 data.

Age	ASAP selectivity	selx on M	stk wt	catch	spw stk wt	% mature
1	0.01	1	0.221	0.397	0.221	0.02
2	0.11	1	0.738	1.407	0.738	0.27
3	0.51	1	1.750	2.219	1.750	0.85
4	0.90	1	2.547	2.953	2.547	0.99
5	0.99	1	3.304	3.664	3.304	1.00
6	1.00	1	4.043	4.482	4.043	1.00
7	1.00	1	4.924	5.431	4.924	1.00
8	1.00	1	6.185	6.666	6.185	1.00
9	1.00	1	7.487	8.375	7.487	1.00
10	1.00	1	11.352	11.352	11.352	1.00

Table B25. Yield-per-recruit (YPR) analysis results: spawning stock biomass per recruit (SSB/R), total stock weight per recruit (TSB/R), mean age and mean generation time (mn gen) at four fishing mortality rates for the BASE ASAP model.

BASE

Reference	F	YPR	SSB/R	TSB/R	mean age	mn gen
F zero	0.00	0.00	19.72	21.24	5.52	7.29
F-01	0.18	1.28	7.81	9.14	3.54	4.98
F-Max	0.46	1.43	3.75	4.96	2.70	3.91
F40%	0.18	1.28	7.89	9.22	3.55	5.00

Table B26. Biological reference points based on yield-per-recruit (YPR) analysis and long term projection of F_{MSY} proxies for the BASE ASAP model results.

BASE

Model	F40%	Y/R	SSB / R	Recruitment	SSBmsy	MSY
YPR	0.18	1.28	7.89	13,596	107,291	17,391
Projection (CDF >50K)	12 values			24,327	186,535	30,622

Table B27. Projection of spawning stock biomass (SSB), fishing mortality (F), and catch during 2013 -2015 of Georges Bank Atlantic cod for F= F75% for the Base ASAP preferred model.

Year	Catch	SSB	F
2012	2.910	18.184	0.17
2013	2.584	20.174	0.14
2014	2.816	21.415	0.14
2015	3.265	26.005	0.14

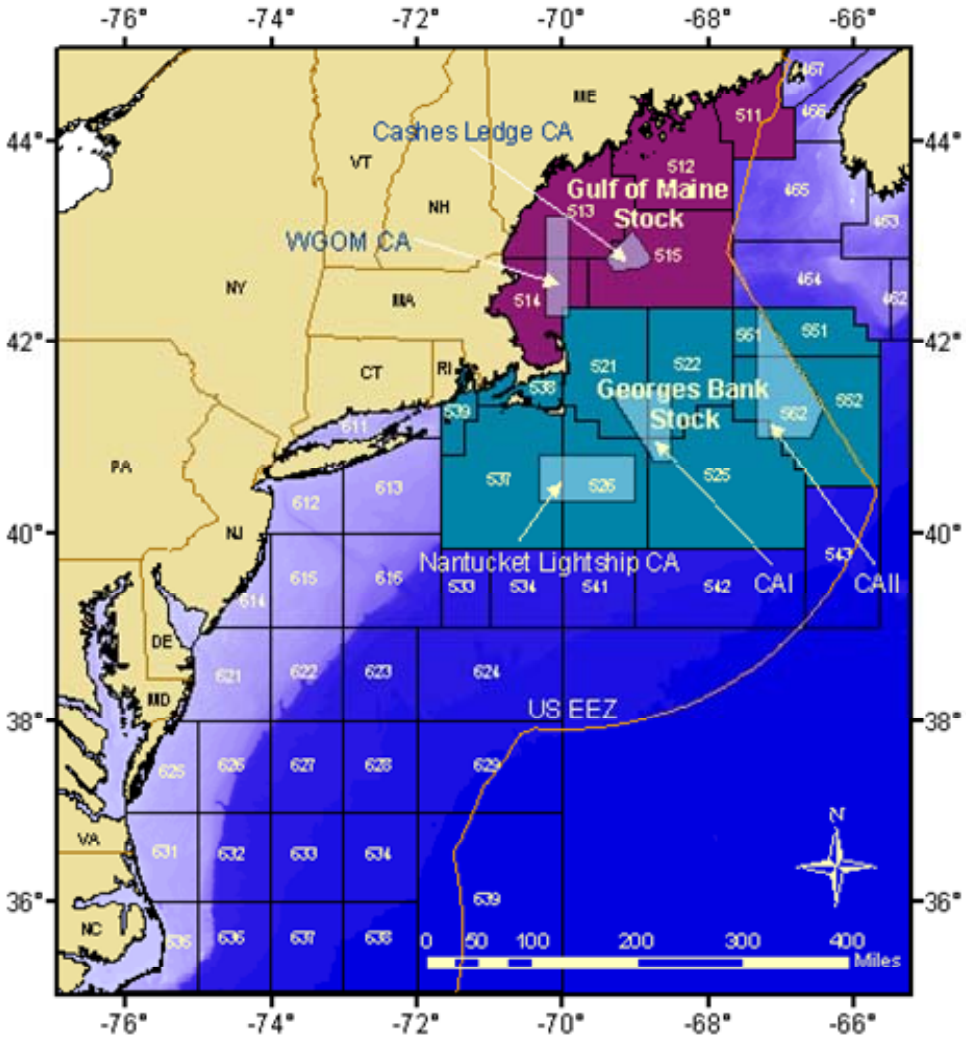


Figure B1. Stock area of Georges Bank cod as defined by Northwest Atlantic Fisheries Organization (NAFO) Div 5Z and Subarea 6 (NMFS statistical areas: 521-526, 551-552, 561-562, 537-539 and south.

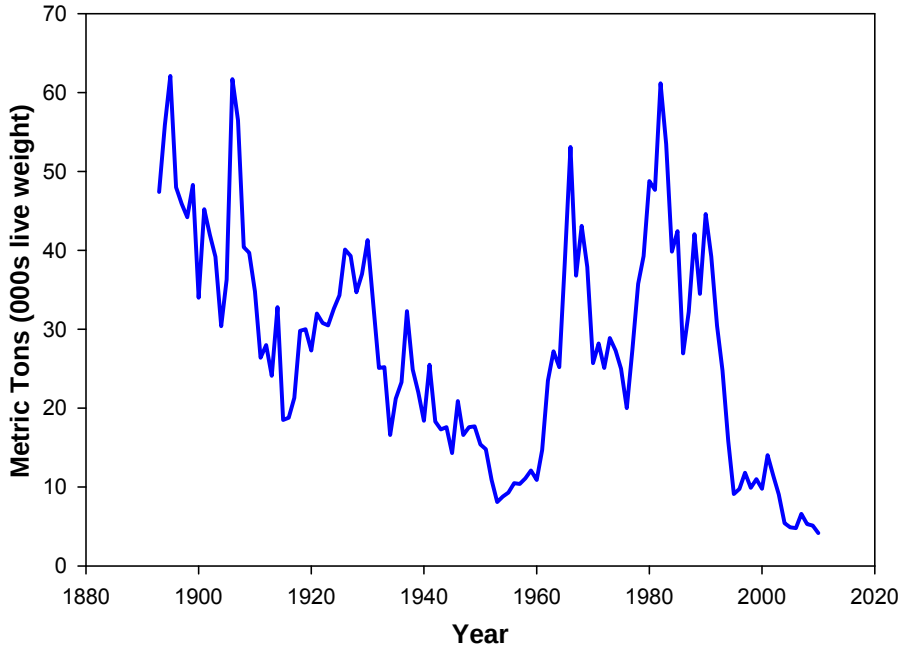


Figure B2a. Total commercial landings (1893-1977) and catch (1978-2011) of Georges Bank and South Atlantic cod (NAFO Div. 5Z and Subarea 6).

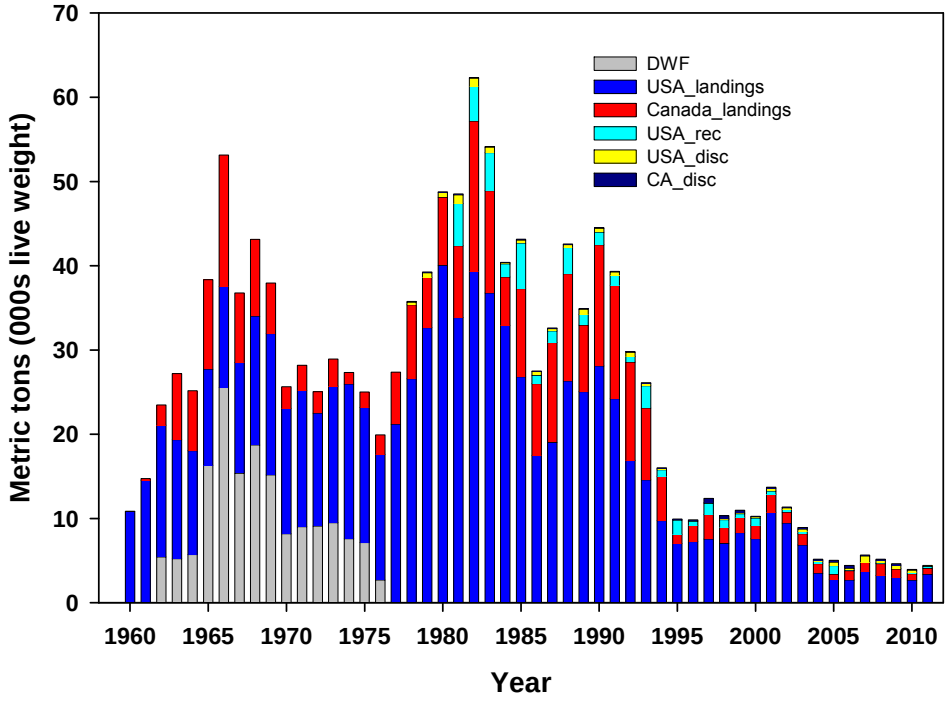


Figure B2a. Total catch of Georges Bank Atlantic cod including USA commercial and recreational landings and discards and Canadian commercial landings and discards, 1960-2011.

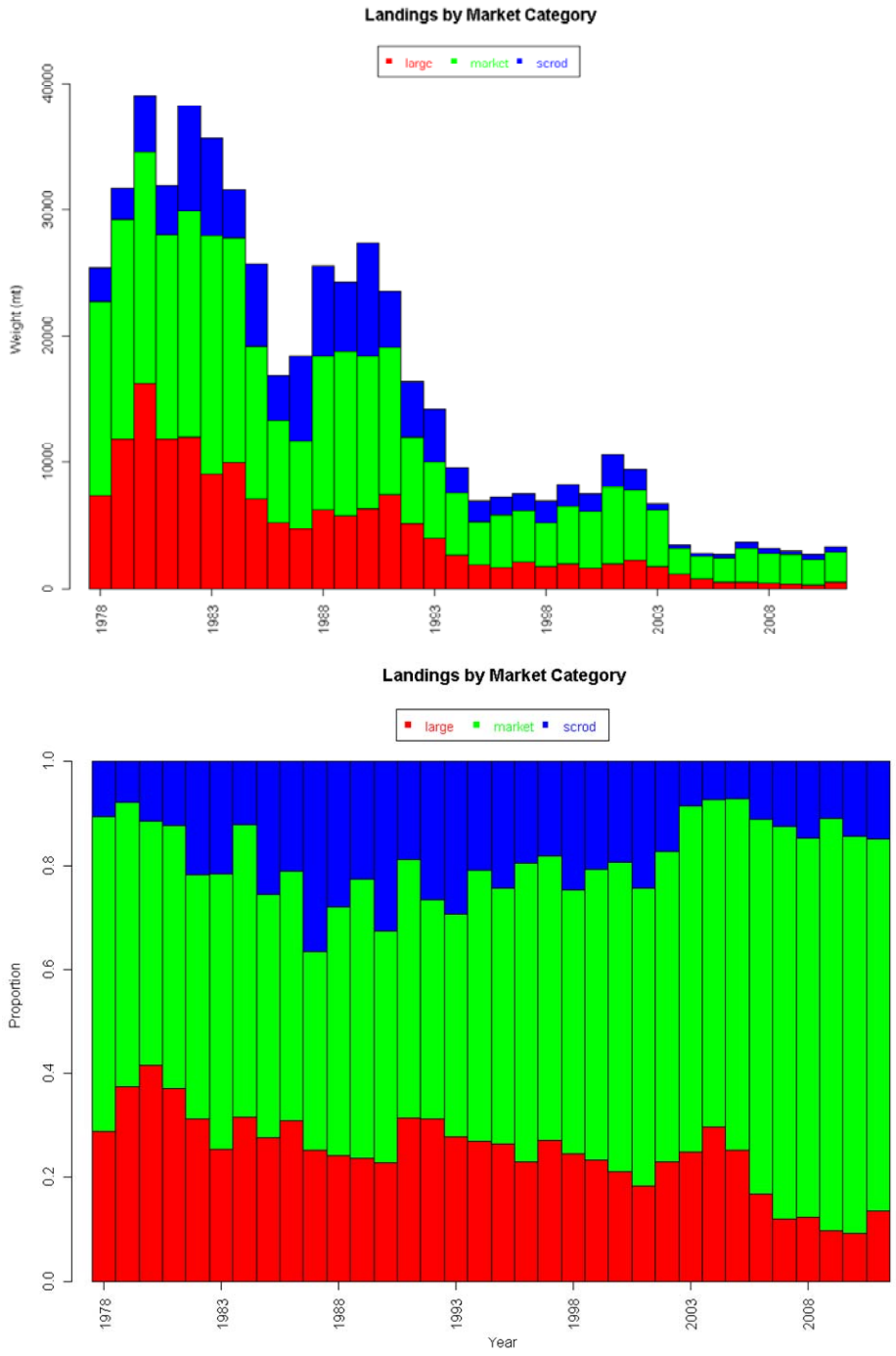


Figure B3. Landings of Georges Bank cod by market category by metric ton (upper panel) and percent of total landings (lower panel).

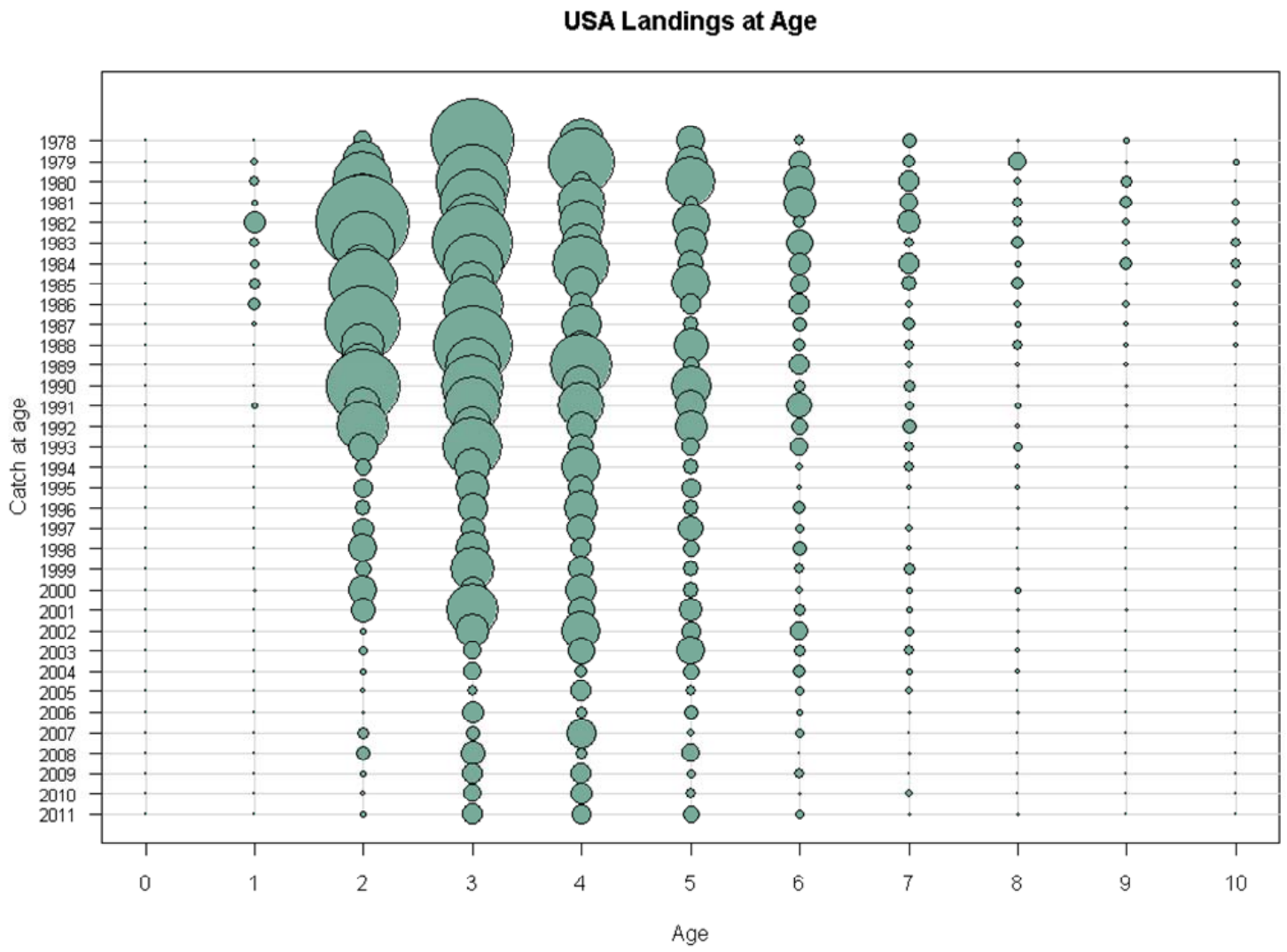


Figure B4. USA landings at age of Atlantic cod, 1978-2011

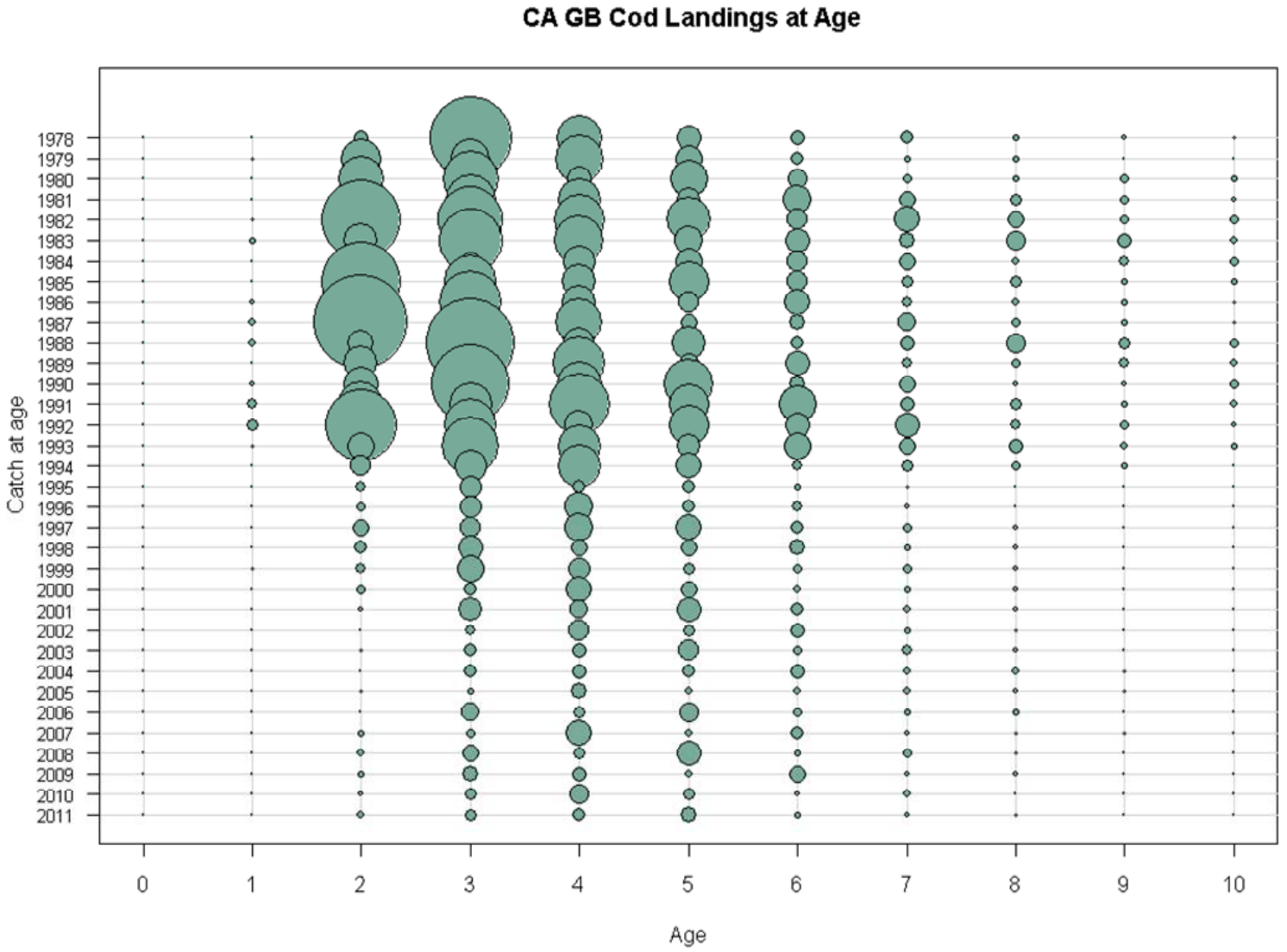


Figure B5. Canadian landings (SA 551,552) at age of Atlantic cod, 1978-2011

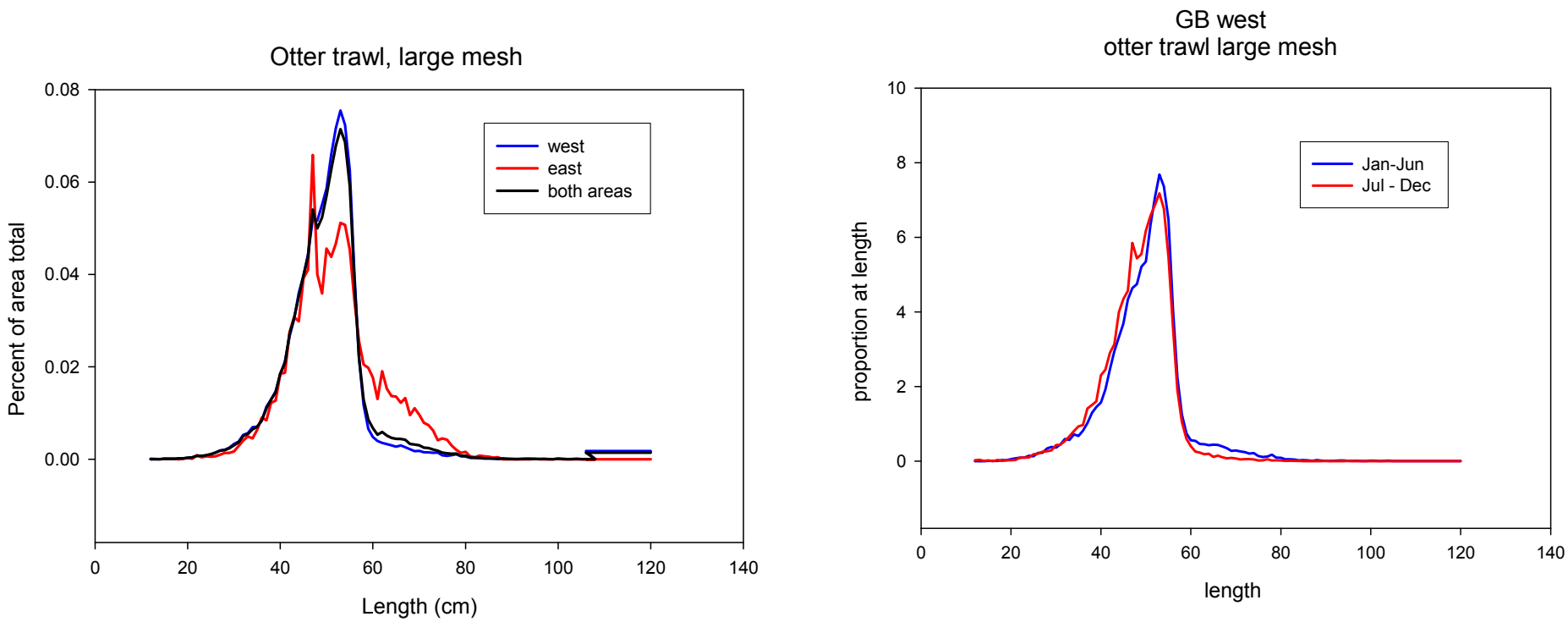


Figure B6. Proportion at length of USA otter trawl discards in western and eastern Georges Bank (left panel) and the proportion at length by half year for large mesh otter trawl discards in western Georges Bank for Atlantic cod, 1989-2011.

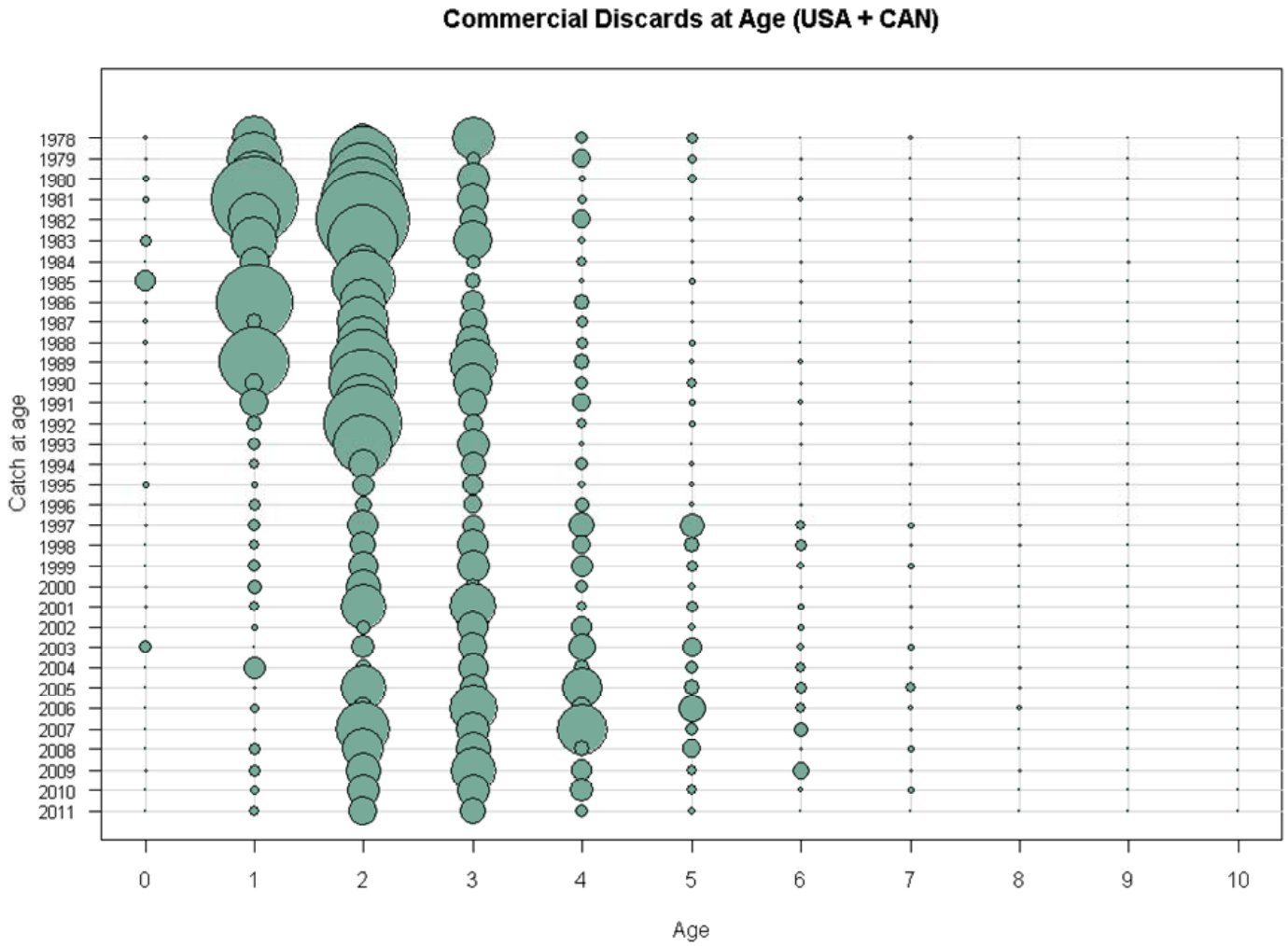


Figure B7. Georges Bank Atlantic cod combined USA and Canadian discards at age (SA 521-522,561-562,551-552,525-526), 1978-2011.

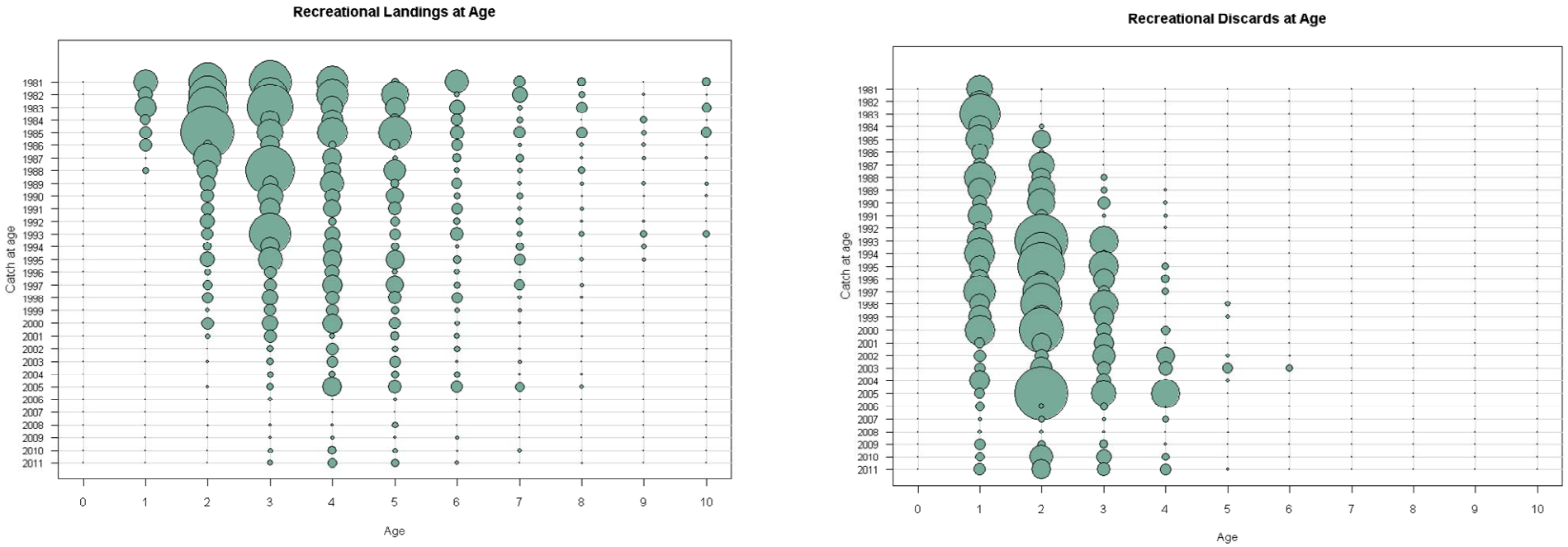


Figure B8. USA recreational landings and discards at age of Georges Bank Atlantic cod, 1981-2011.

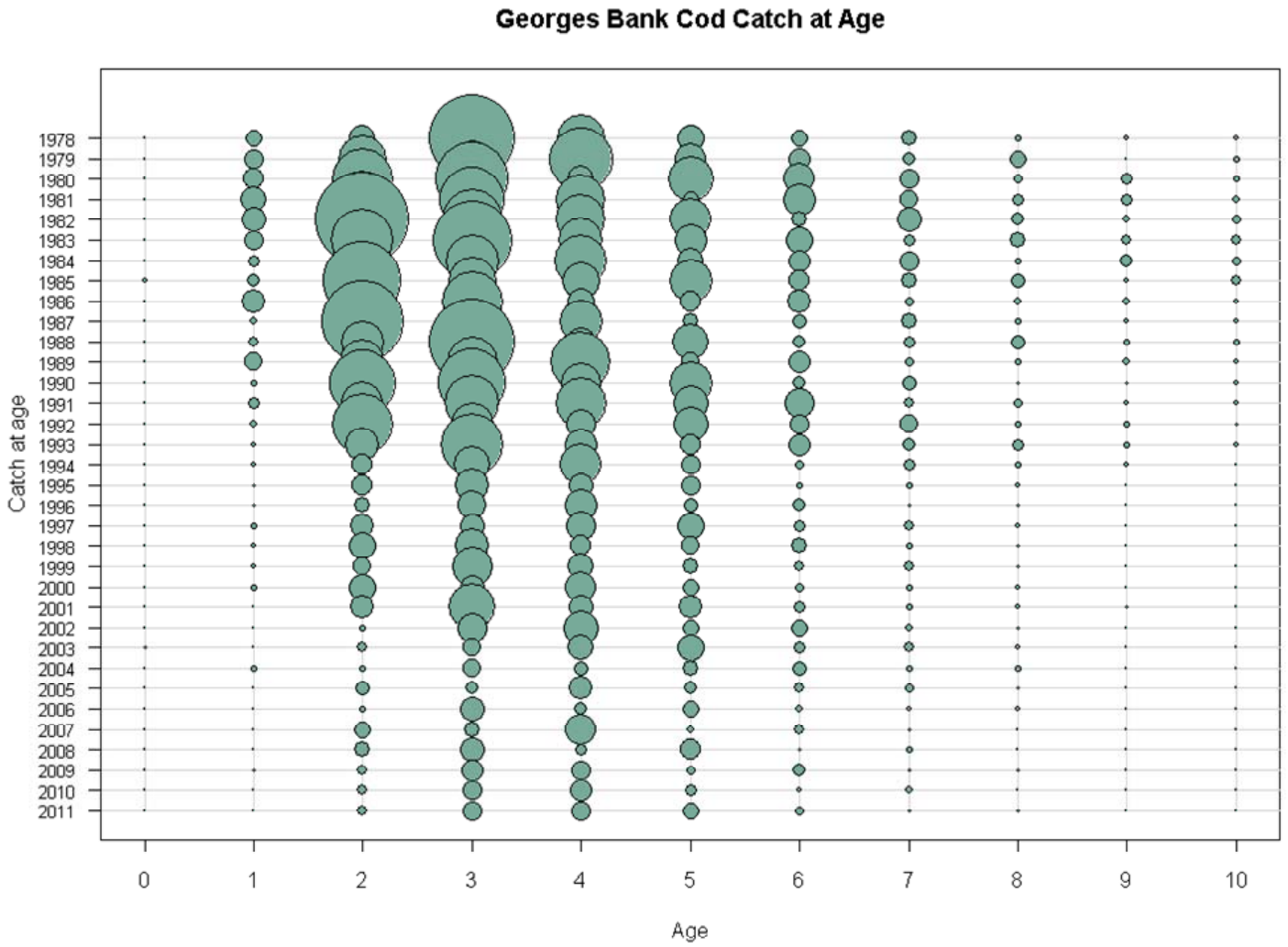


Figure B9. Georges Bank Atlantic cod total catch at age: combined USA and Canadian commercial landings and discards and USA recreational landings and discards, 1978-2011.

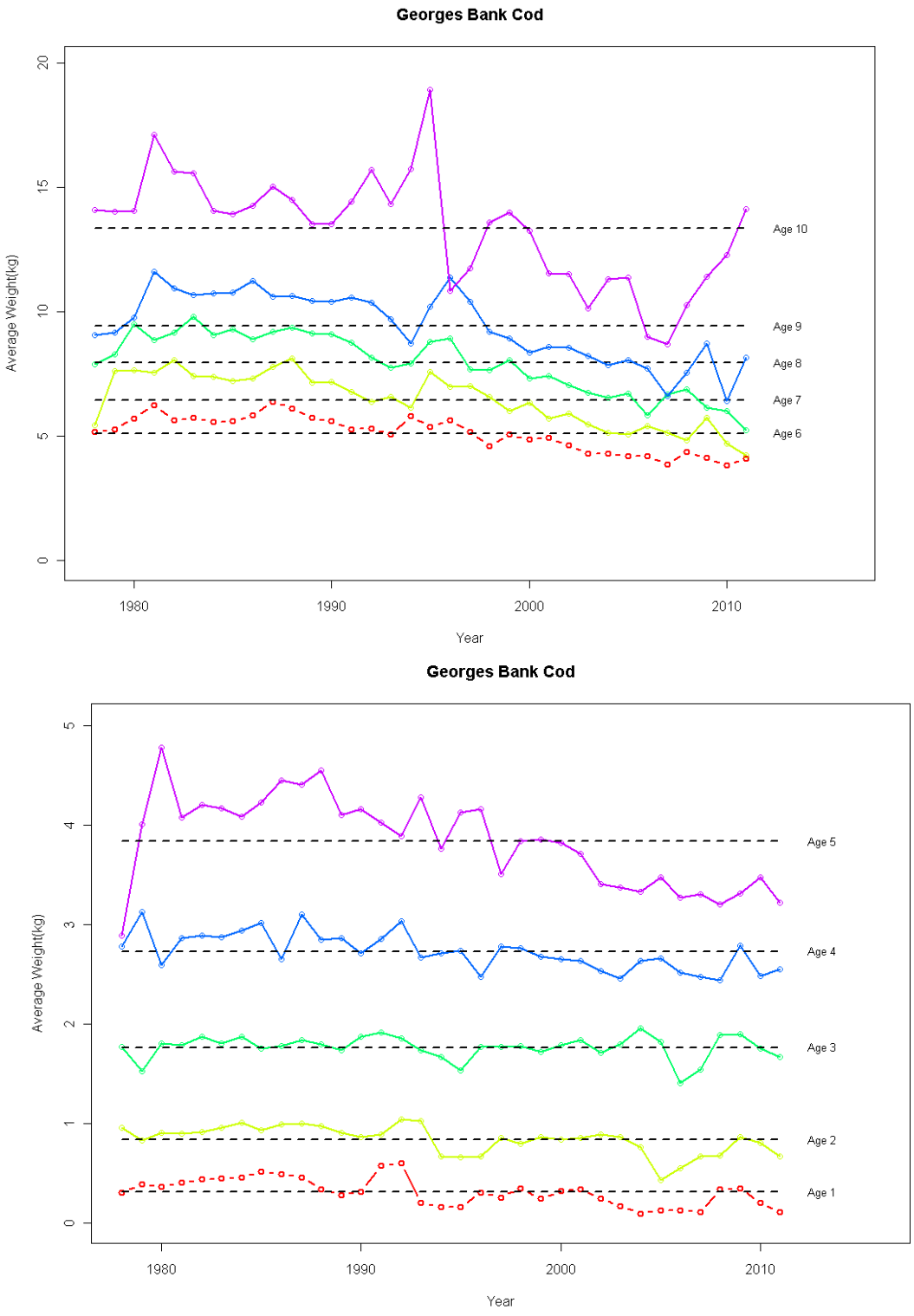


Figure B10a. Georges Bank Atlantic cod January 1 mean weight at age (1-10+) for the total catch at age: combined USA and Canadian commercial landings and discards and USA recreational landings and discards, 1978-2011.

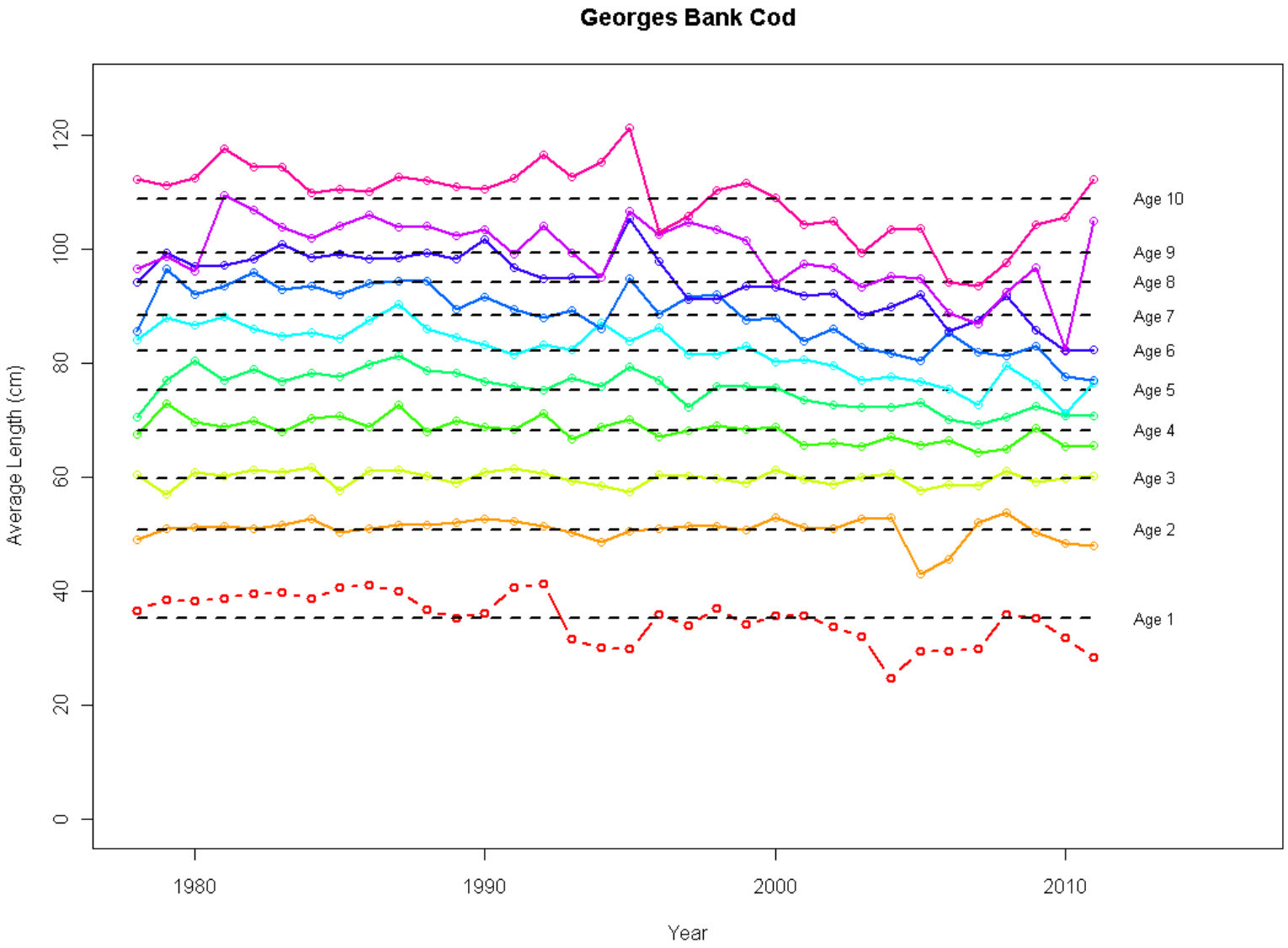


Figure B10b. Georges Bank Atlantic cod mean length at age (1-10+) for the total catch at age: combined USA and Canadian commercial landings and discards and USA recreational landings and discards, 1978-2011.

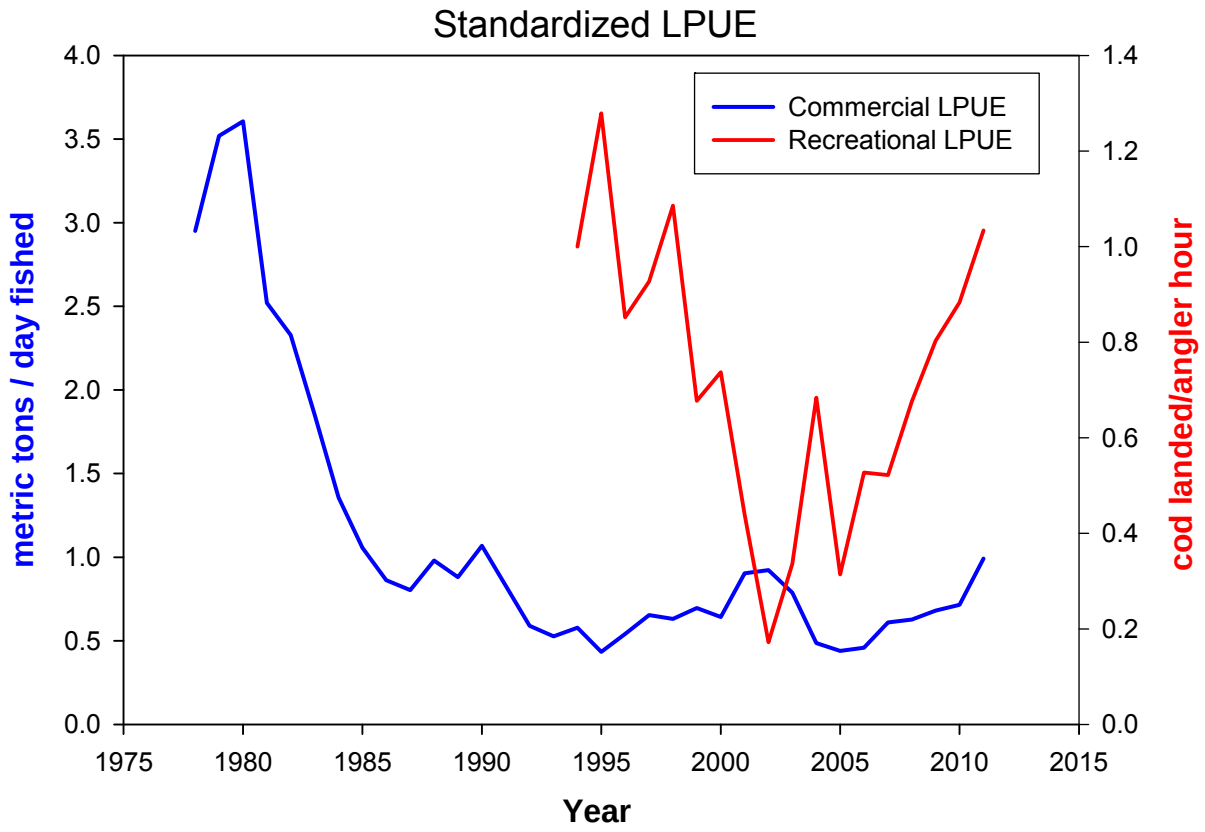


Figure B11. Georges Bank Atlantic cod standardized landings per unit effort for commercial landings (landings (mt)/day fished (24 hours)) and recreational landings (number cod landed/angler hour), 1978-2011.

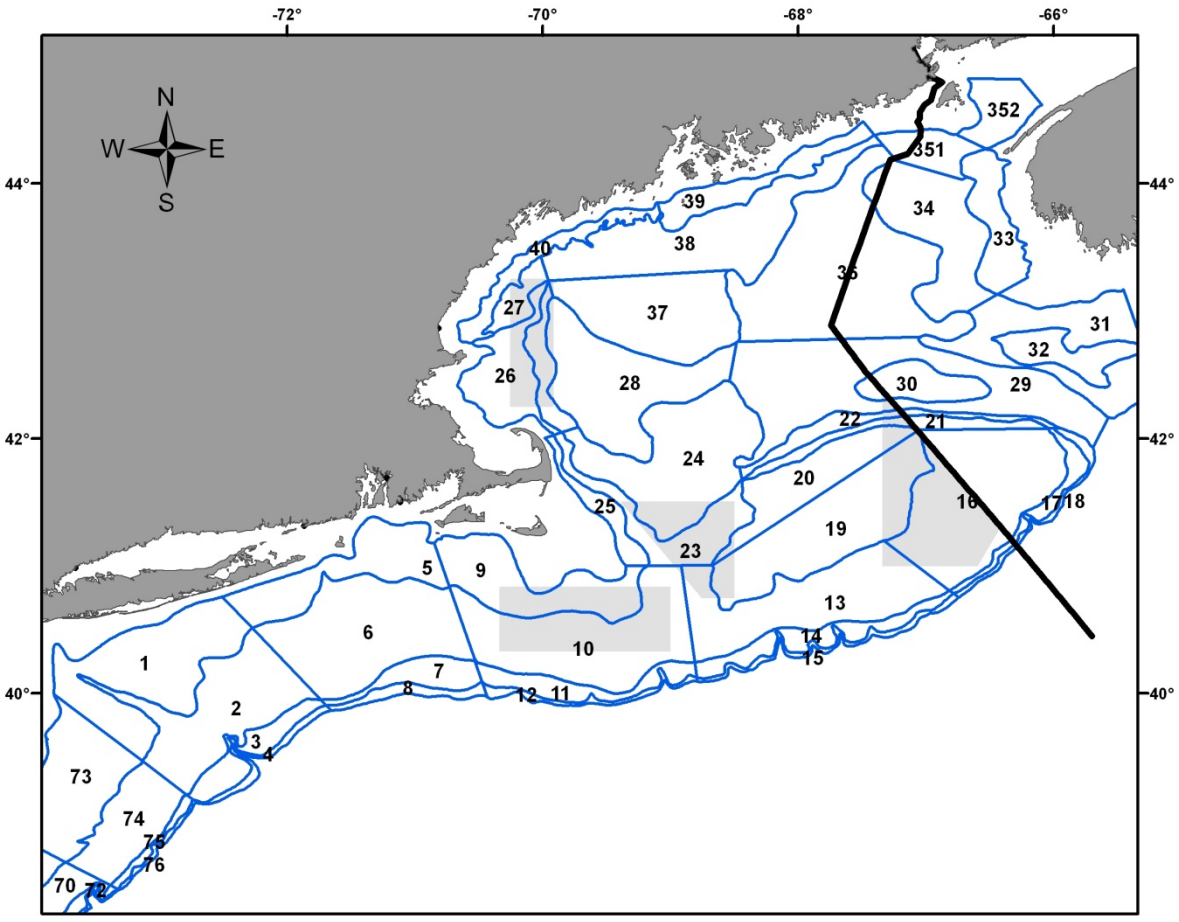


Figure B12a. NEFSC offshore strata for the Gulf of Maine, Georges Bank and southern New England area. The black line is the Hague Line, delineating the USA and CA exclusive economic zone (EEZ). Shaded boxes are year round closed areas - west to east: Nantucket Lightship Area (NLA), Closed Area I, Closed Area II, and north of Cape Cod, the Western Gulf of Maine Closure.

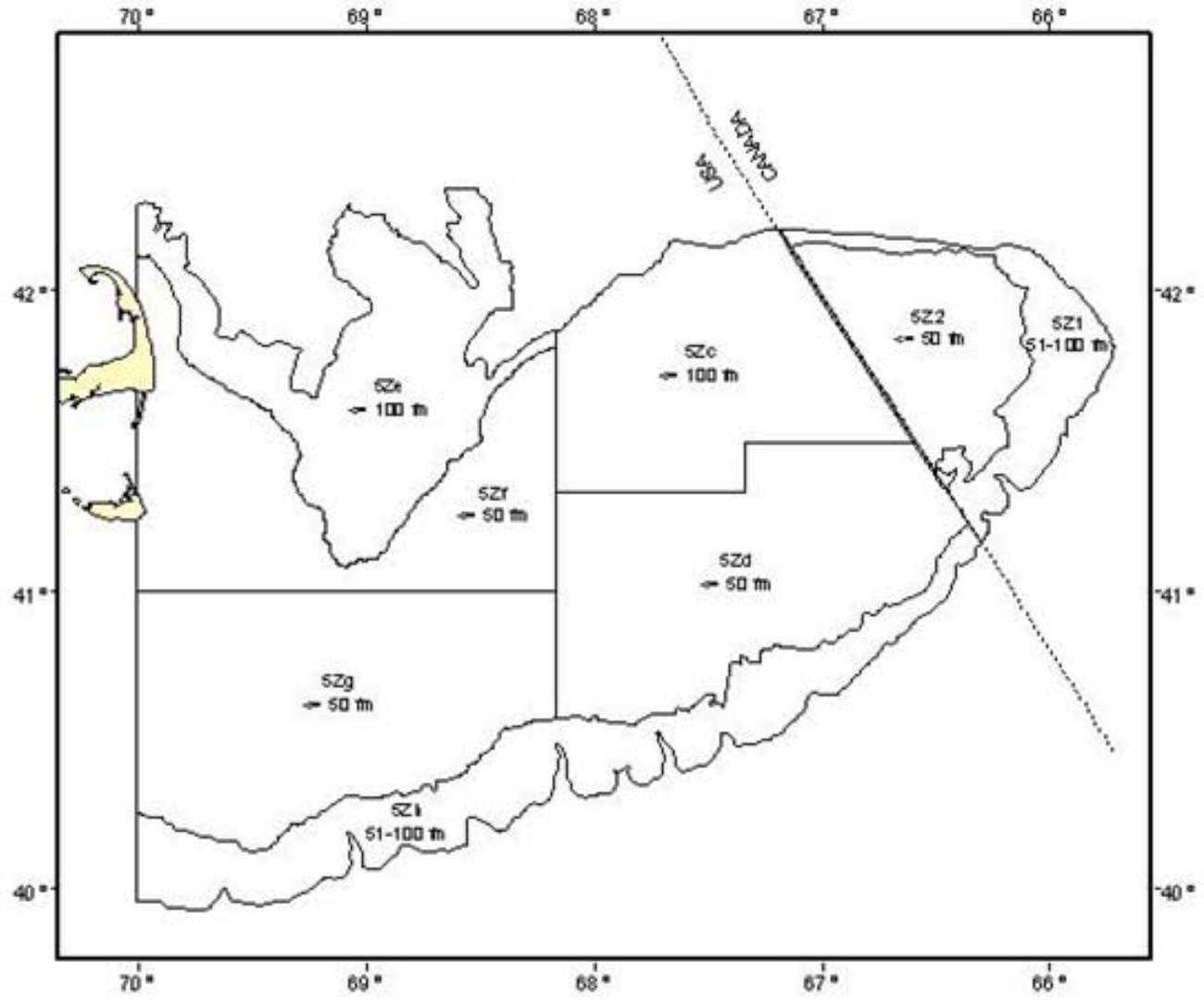


Figure B12b. DFO strata area on Georges Bank

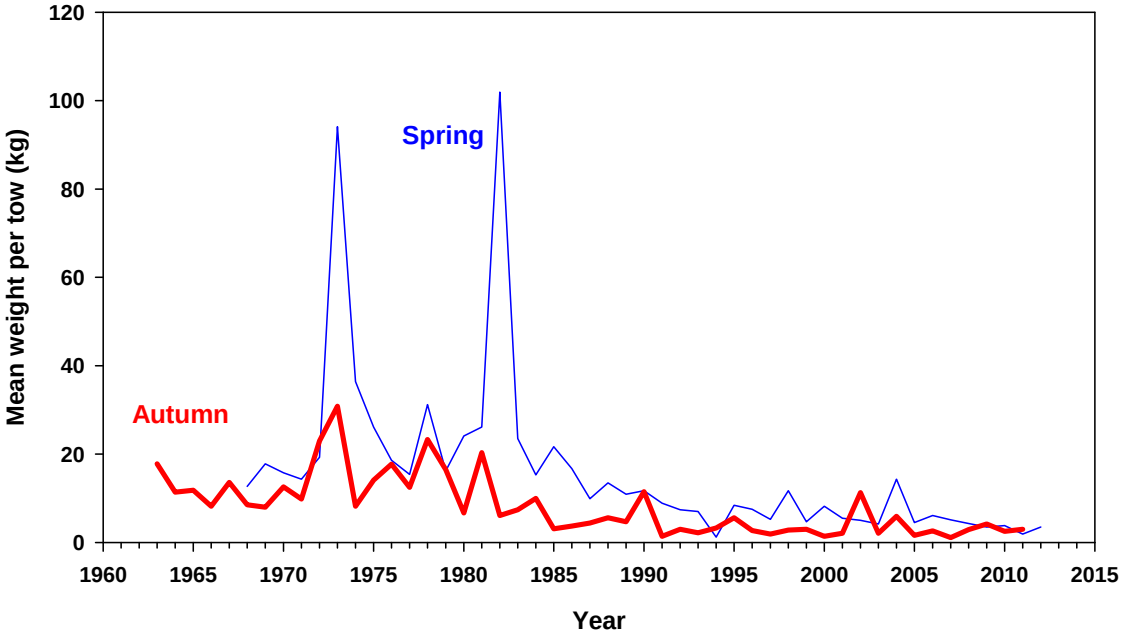


Figure B13a. Georges Bank Atlantic cod standardized stratified mean catch per tow (kg) in the NEFSC spring and autumn research survey vessel bottom trawl surveys (strata 13-25), 1963-2012.

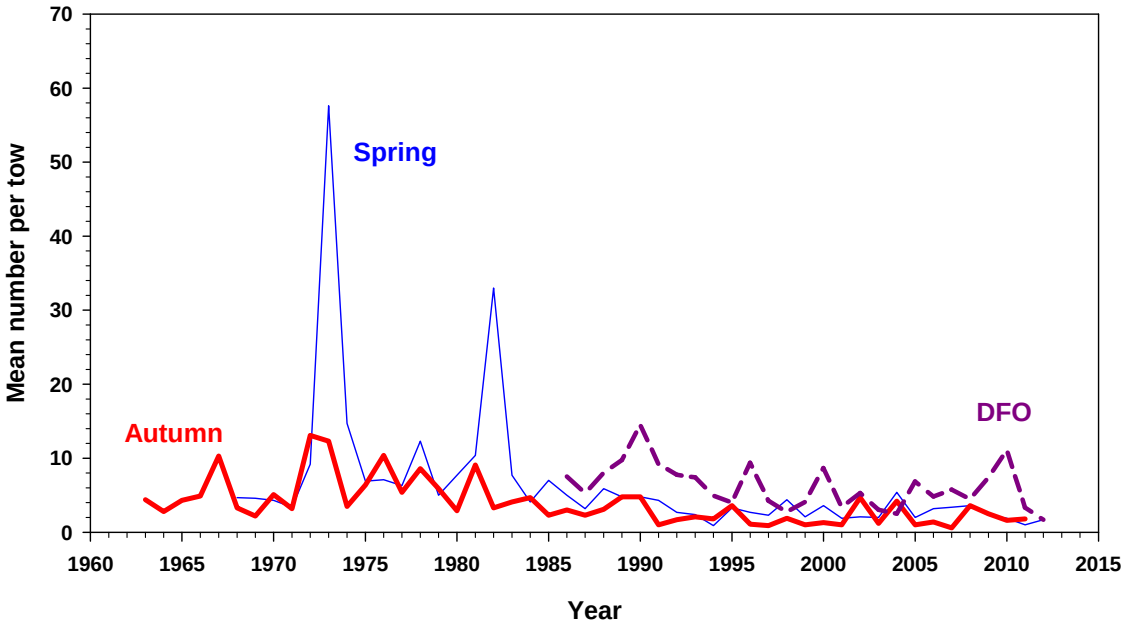


Figure B13b. Georges Bank Atlantic cod standardized stratified mean number per tow in the NEFSC spring, DFO, and NEFSC autumn research survey vessel bottom trawl surveys (NEFSC strata 13-25; DFO strata 5Z1-5Z8), 1963-2012.

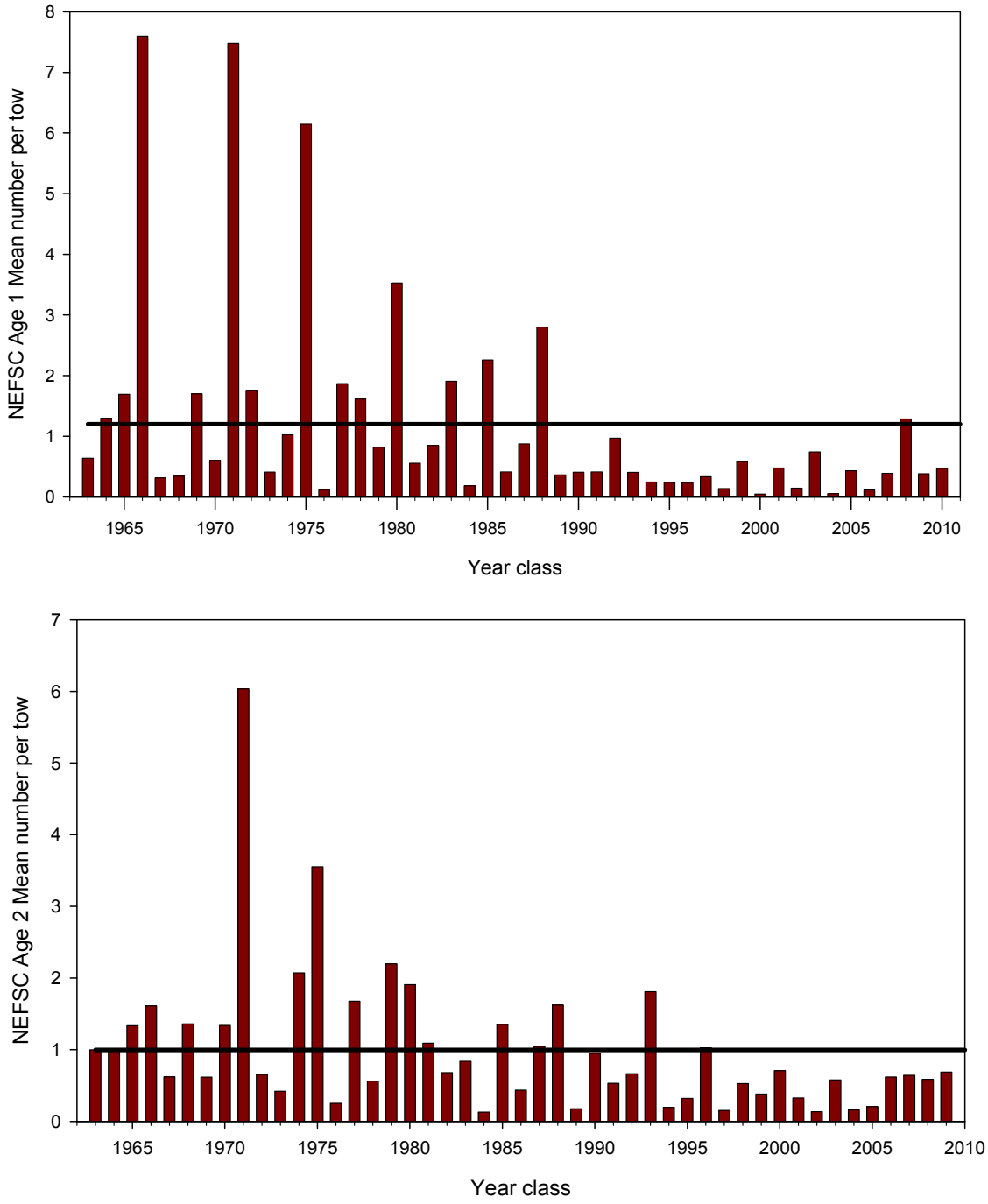


Figure B14. Georges Bank Atlantic cod relative year class strength of age 1 (upper panel) and age 2 (lower panel) (stratified mean numbers per tow) from NEFSC autumn research survey vessel bottom trawl surveys, 1963-2011.

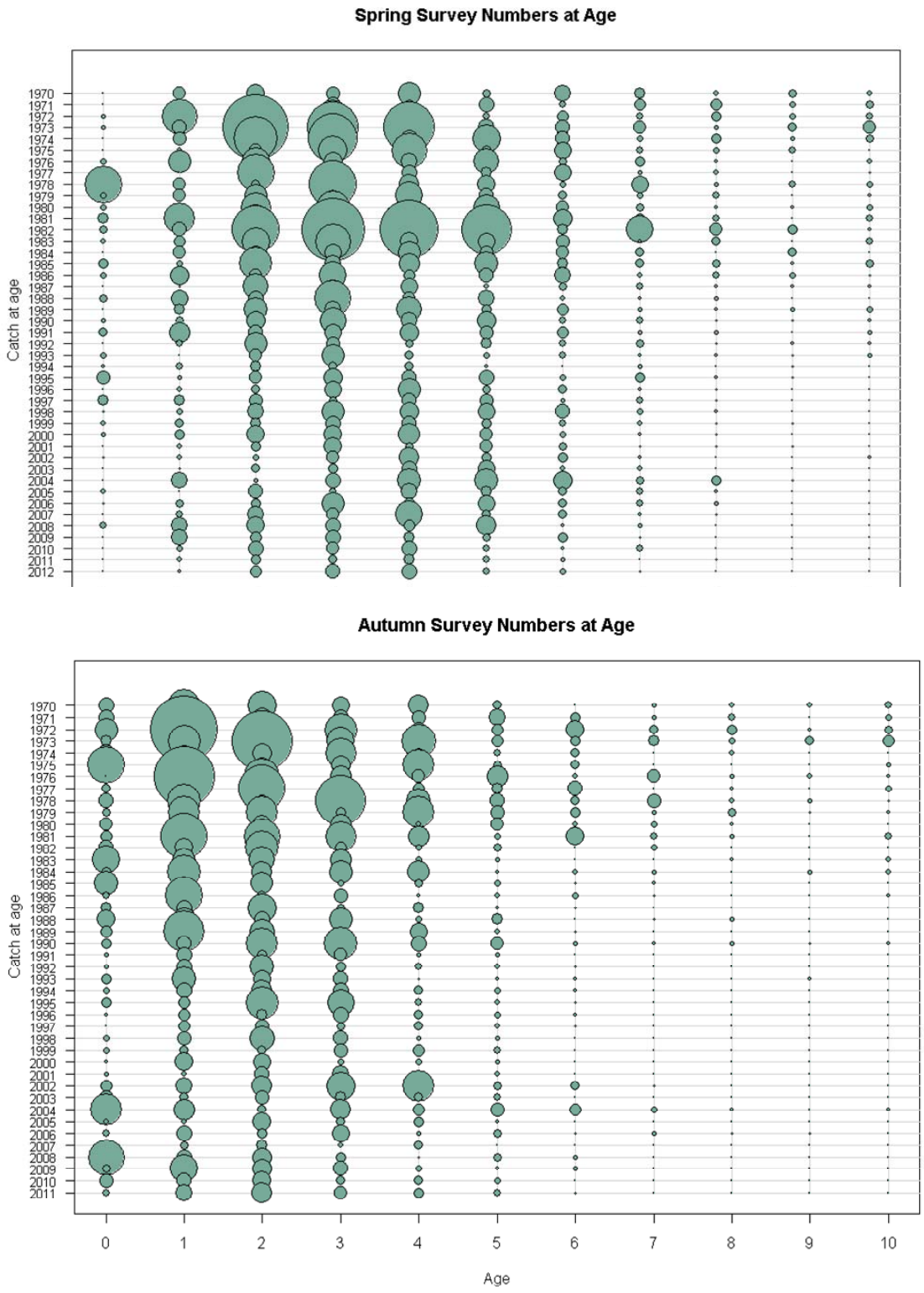


Figure B15. Georges Bank Atlantic cod standardized stratified mean catch per tow at age (numbers) in the NEFSC spring and autumn research survey bottom trawl surveys (strata 13-25), 1970-2012.

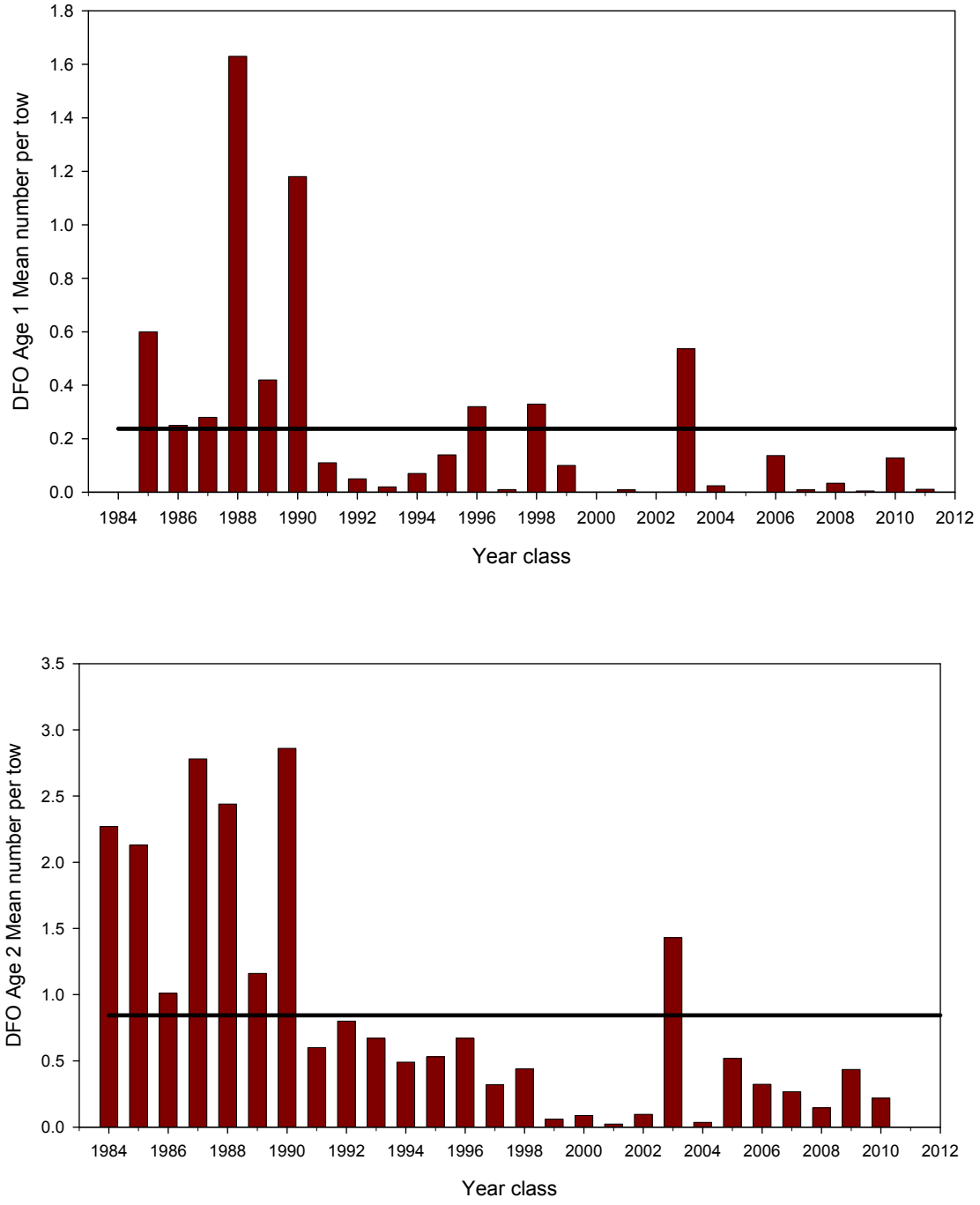


Figure B16. Georges Bank Atlantic cod relative year class strength of age 1 (upper panel) and age 2 (lower panel) (stratified mean numbers per tow) from DFO research survey vessel bottom trawl surveys, 1986-2012.

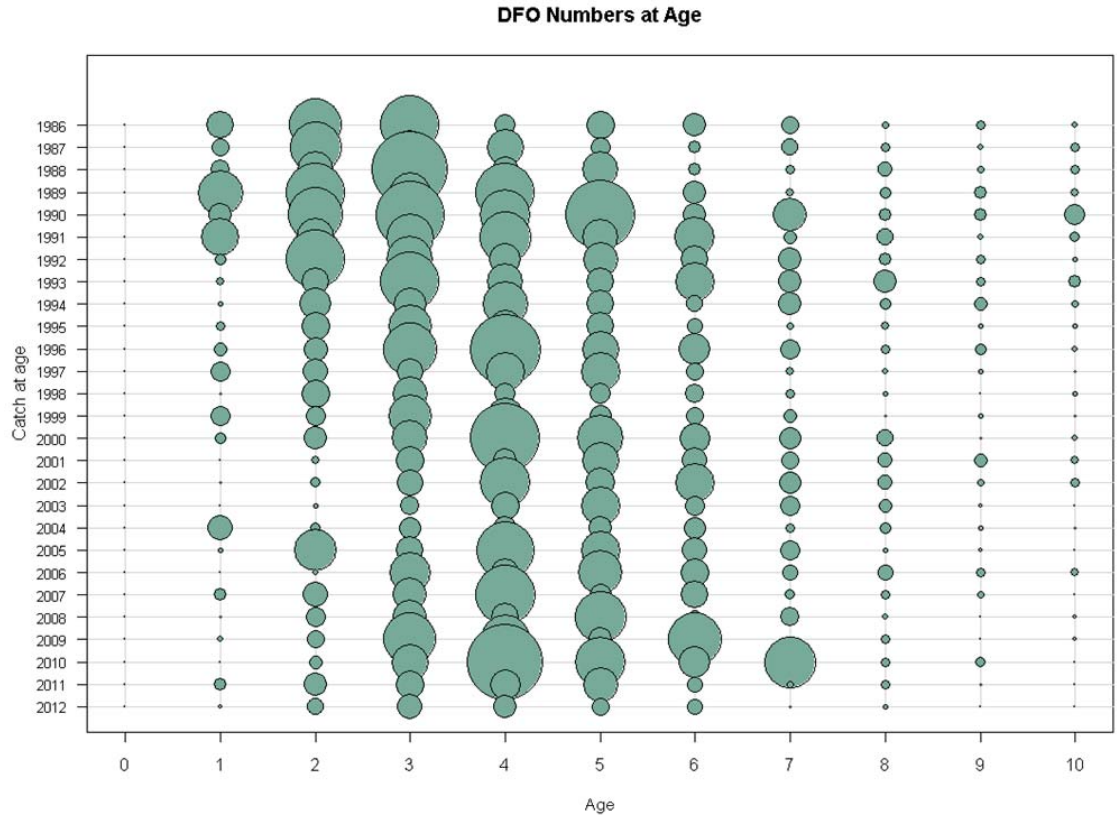
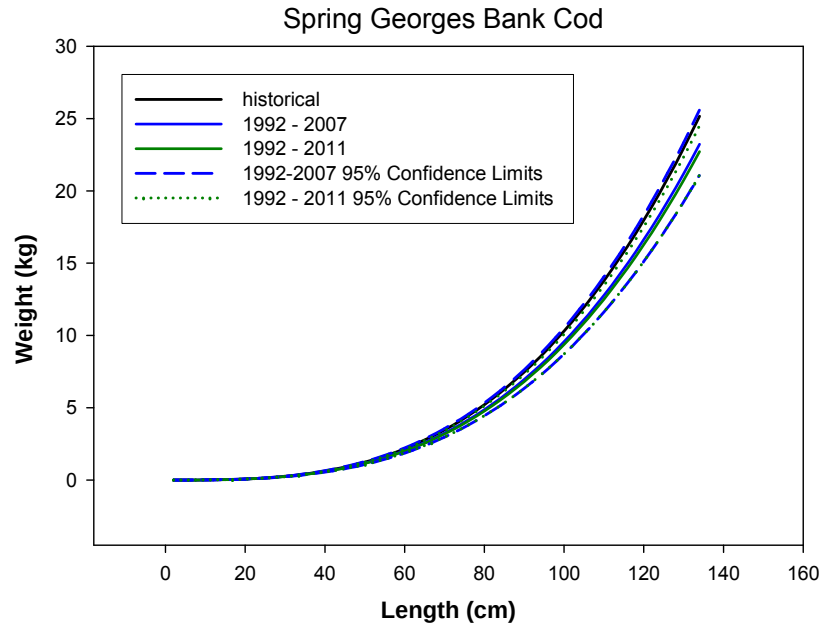
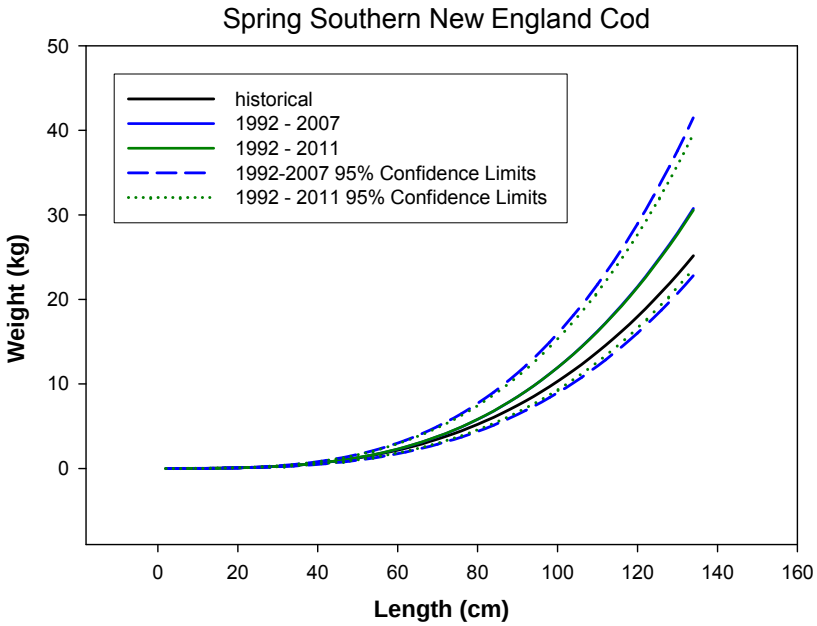
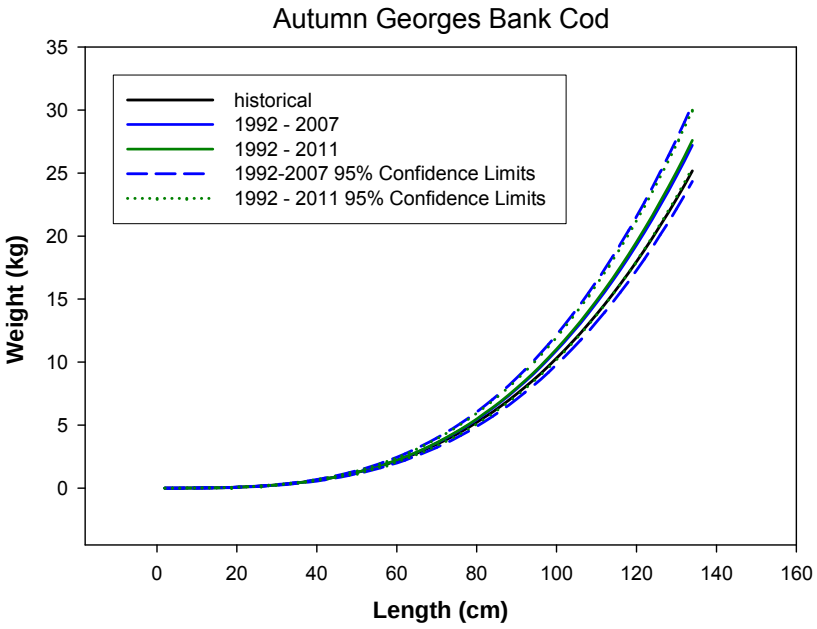


Figure B17. Georges Bank Atlantic cod standardized stratified mean catch per tow at age (numbers) in DFO research survey bottom trawl surveys (strata 5Z1-5Z8), 1986-2012.







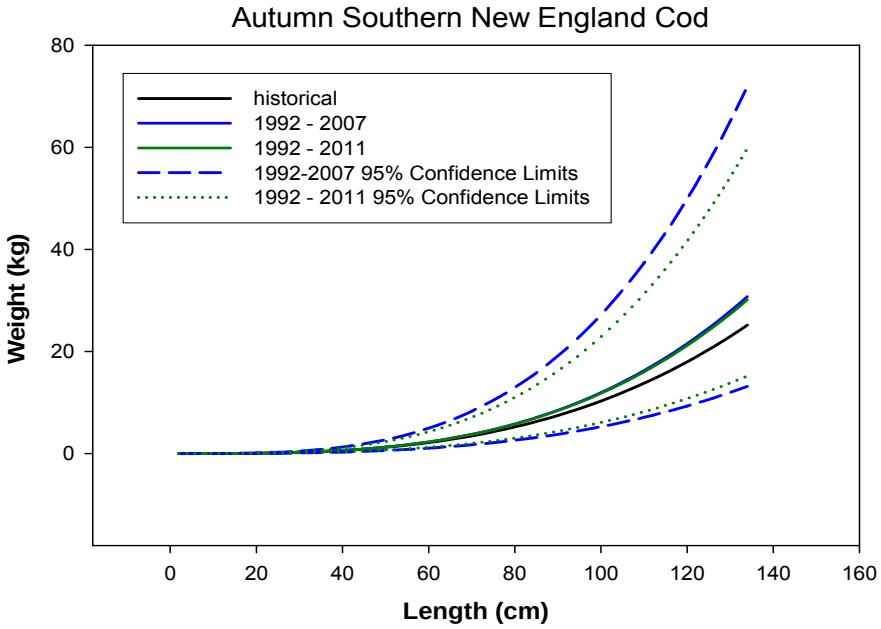
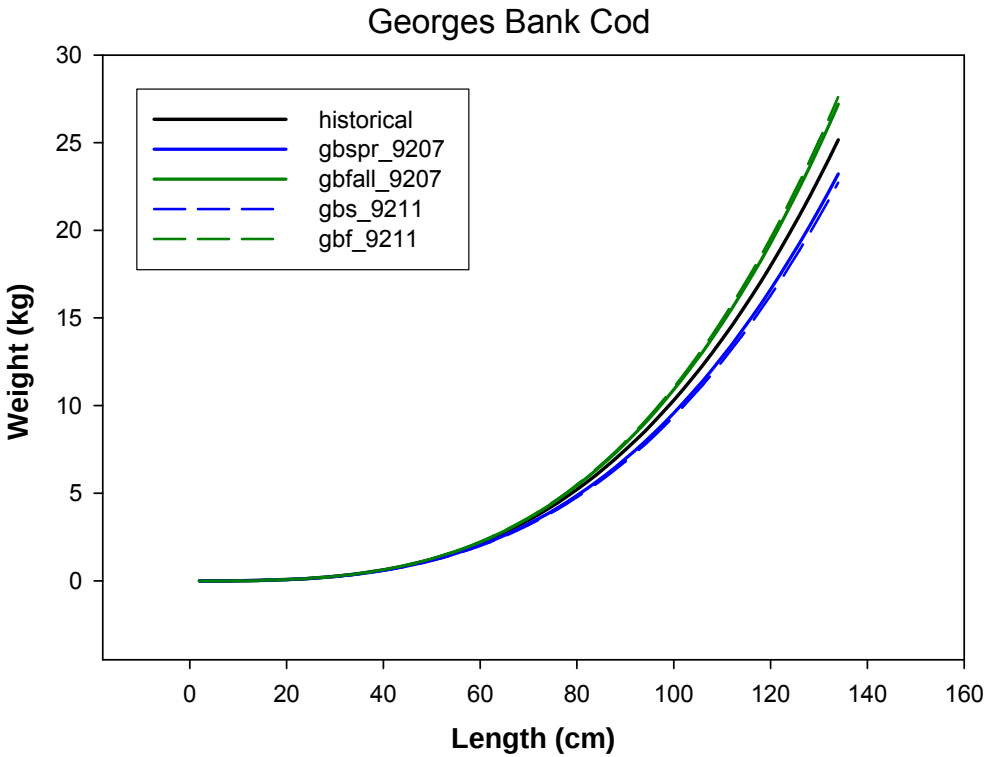


Figure B18. Length weight equations with 95% confidence intervals based on research survey data for cod from Georges Bank and Southern New England for spring and autumn during 1992-2007 and 1992-2011 compared to the historical length-weight relationship for cod.



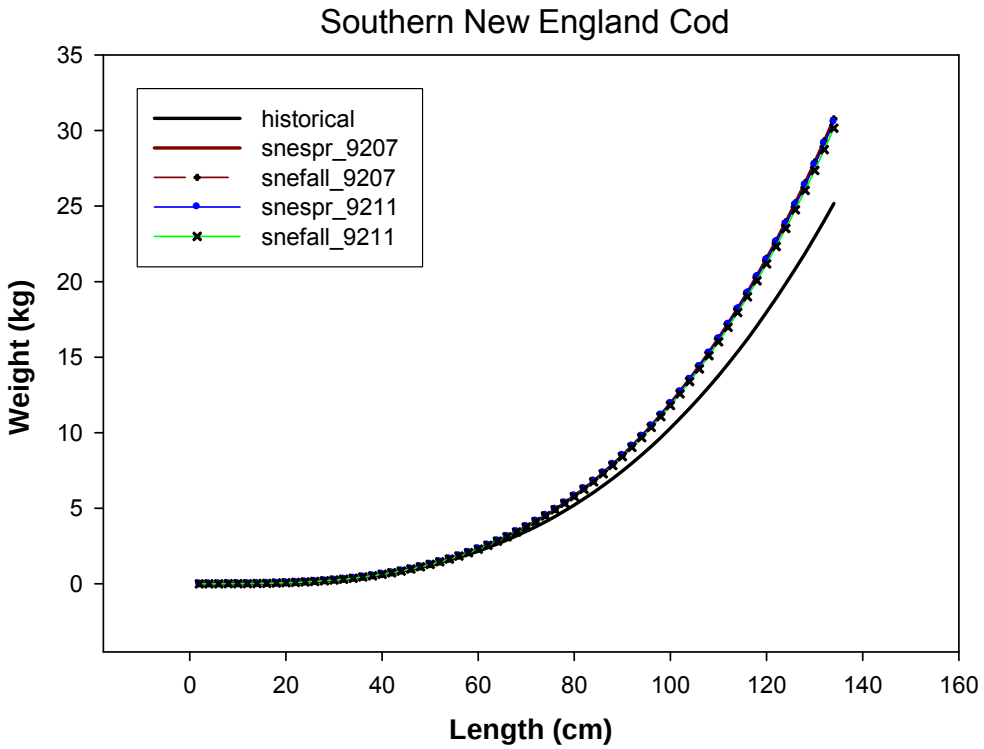


Figure B19. Length weight equations based on research survey data for cod from Georges Bank and Southern New England for spring and autumn during 1992-2007 and 1992-2011 compared to the historical length-weight relationship for cod.

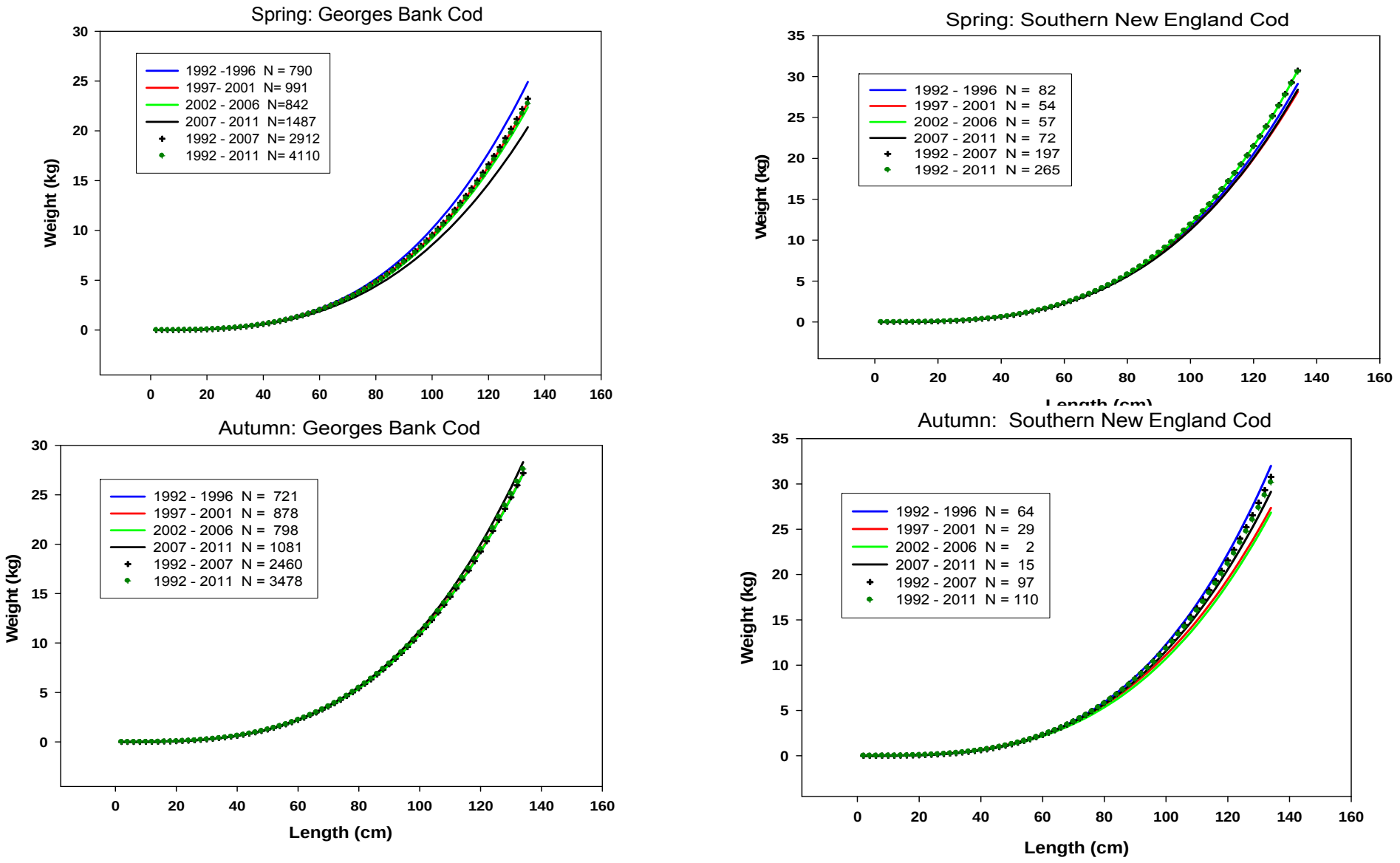


Figure B20. Length weight equations based on research survey data for cod from Georges Bank and Southern New England by 5-year blocks for spring and autumn during 1992-2011 compared to the 1992-2007 and 1992-2011 time series length-weight relationships. N=sample size.

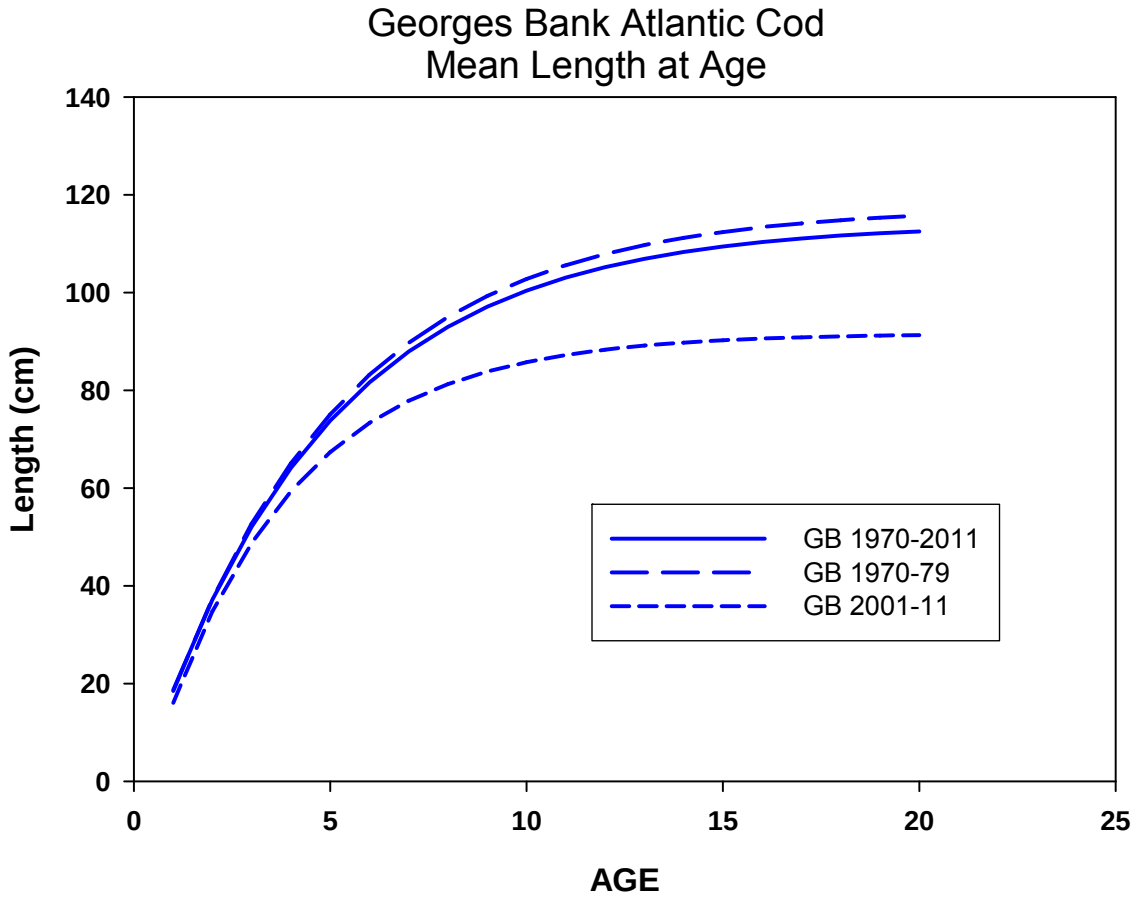


Figure B21. Von Bertalanffy growth curves fit to NEFSC spring and autumn research survey age and length data for Georges Bank cod during three time periods: 1970-2011, 1970-1979, and 2001-2011.

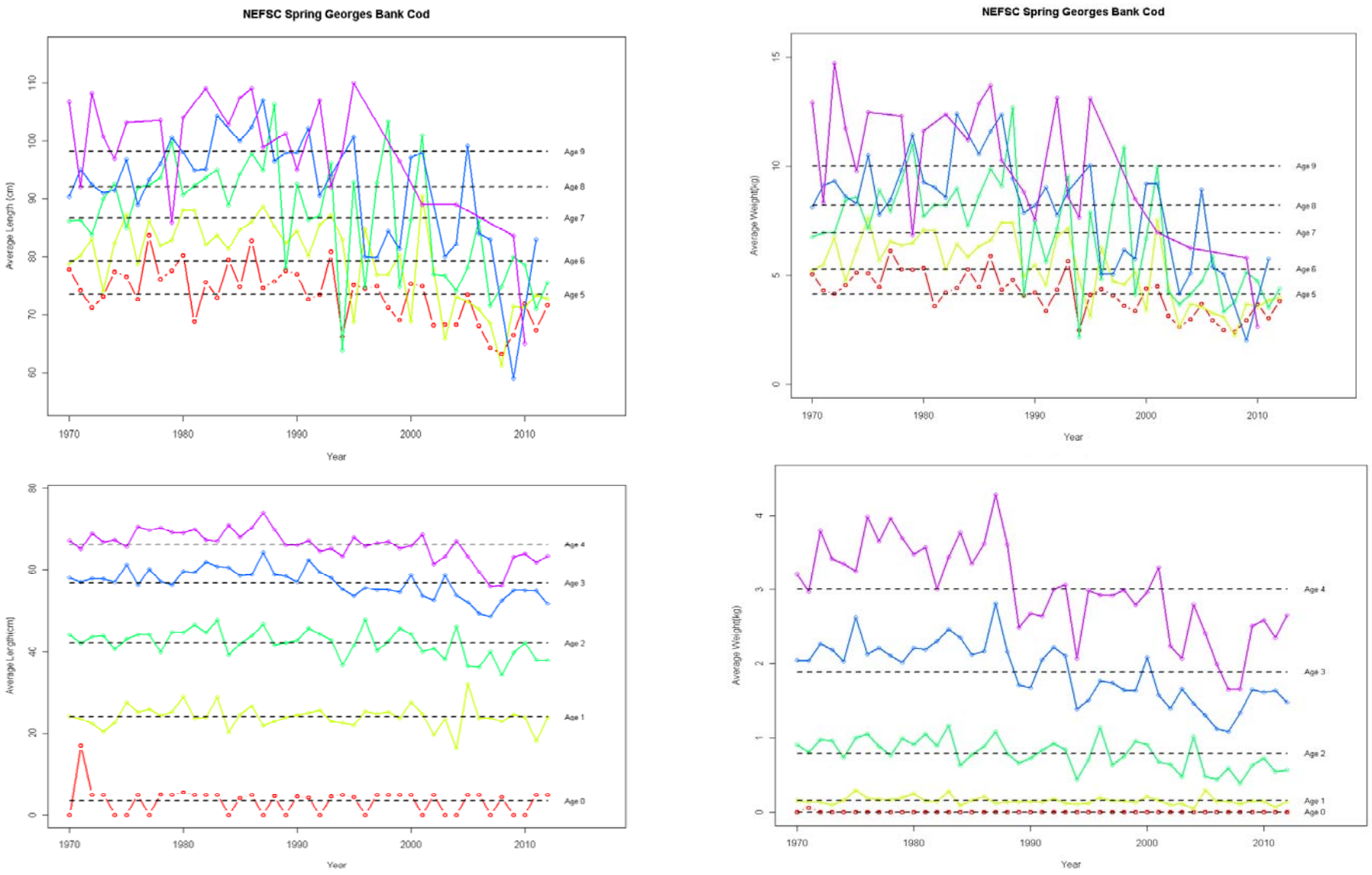
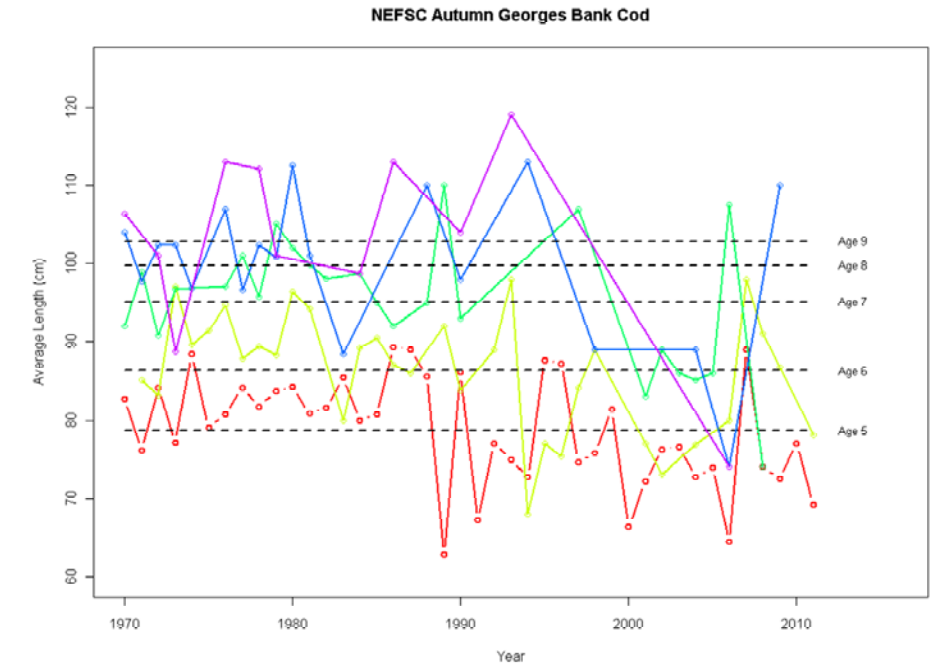
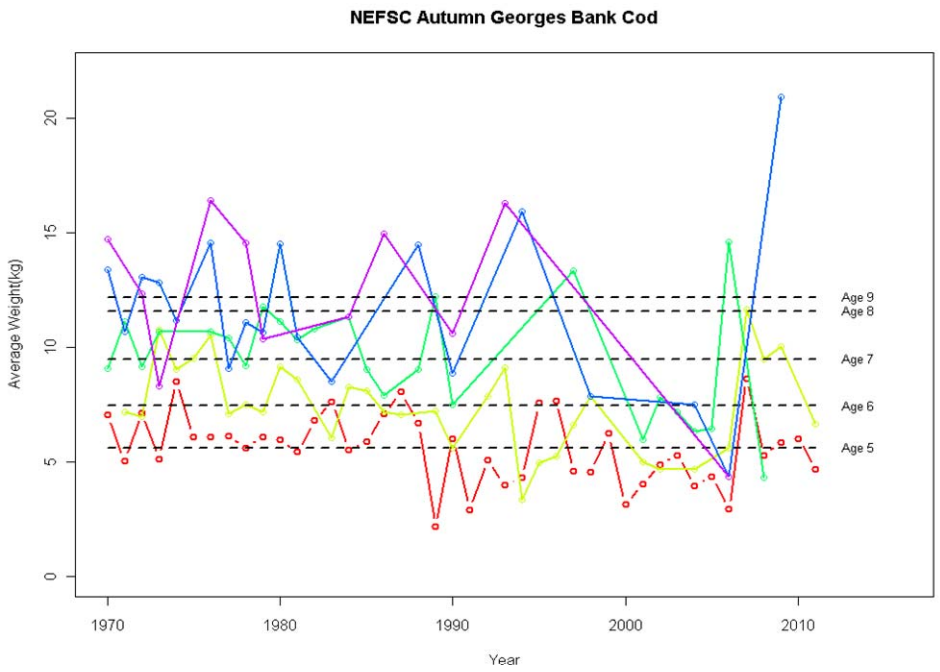
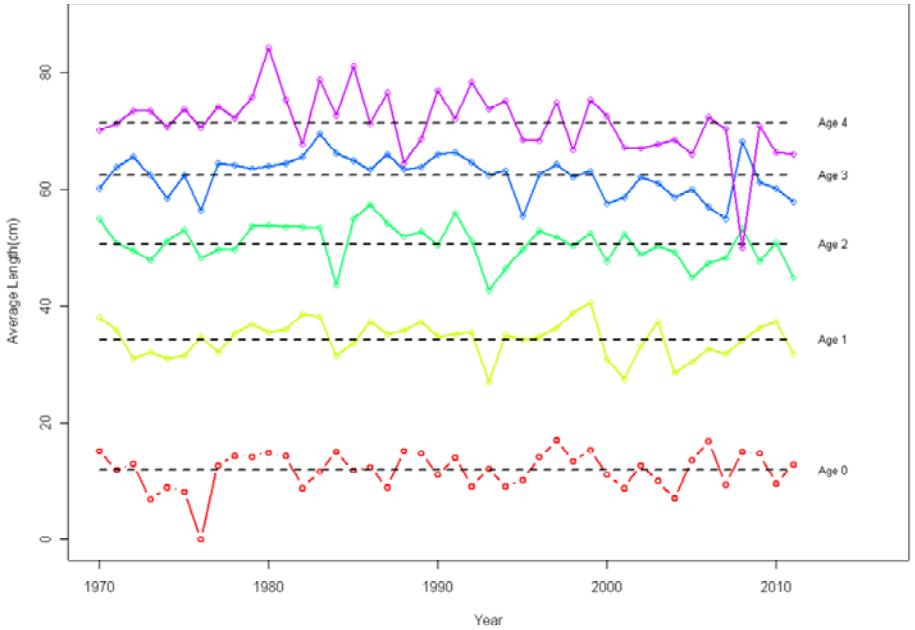


Figure B22a. Mean length and weight of Georges Bank cod from NEFSC spring research bottom trawl surveys for ages 0-9, 1970-2011.







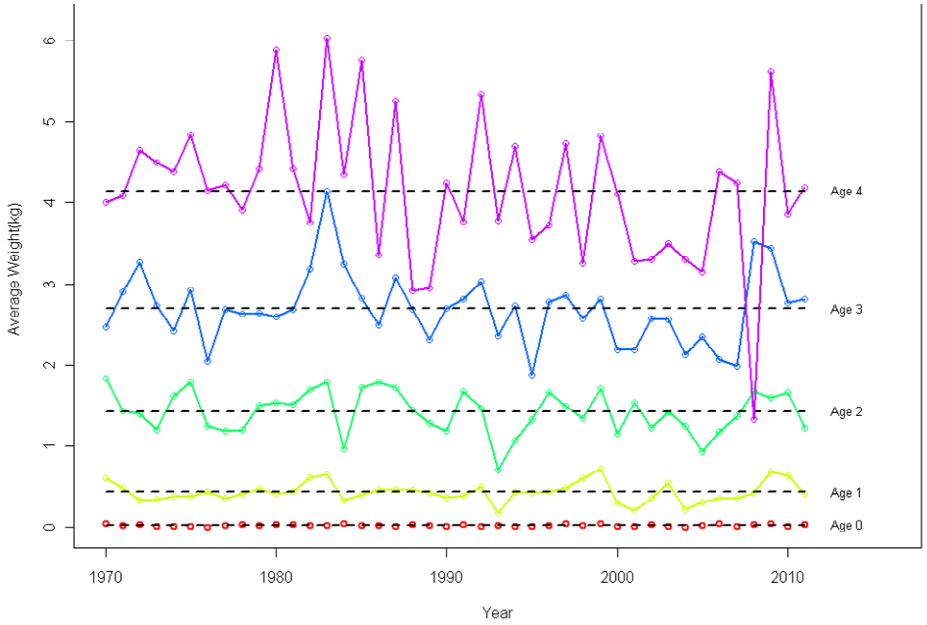


Figure B22b. Mean length and weight of Georges Bank cod from NEFSC autumn research bottom trawl surveys for ages 0-9, 1970-2011.

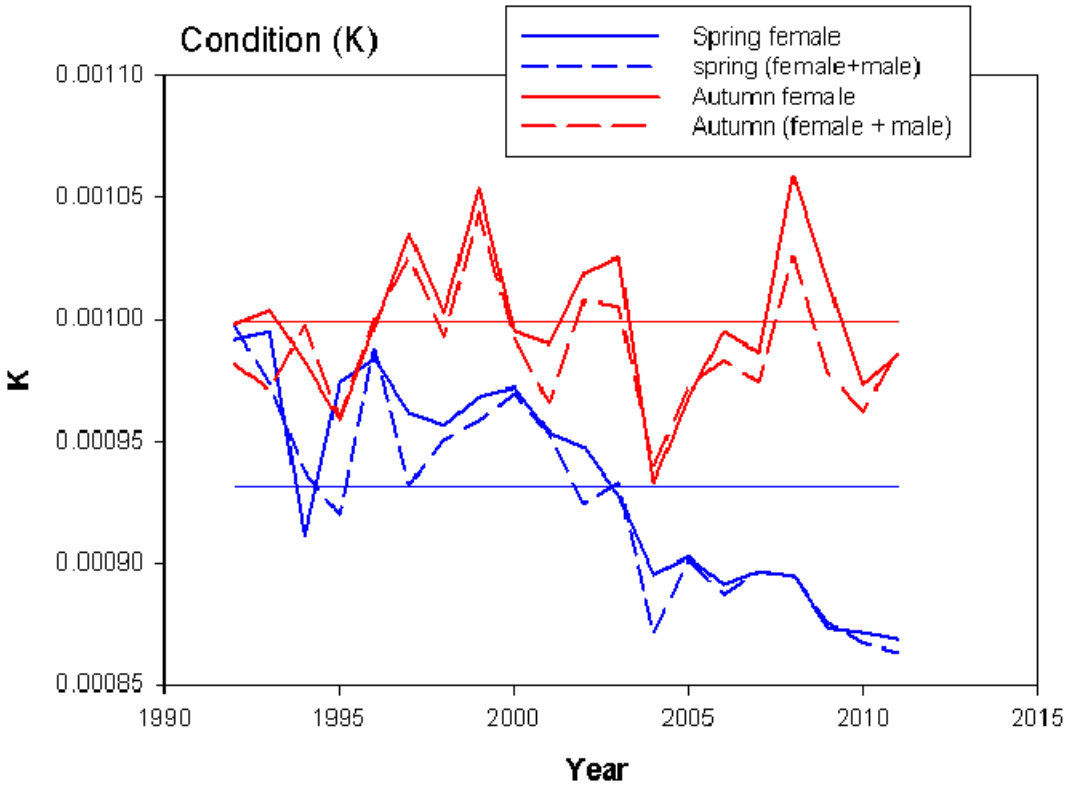


Figure B23. Fulton's condition factor (K) of Georges Bank cod for females and sexes combined from NEFSC spring and autumn research survey length and weight data, 1992-2011.

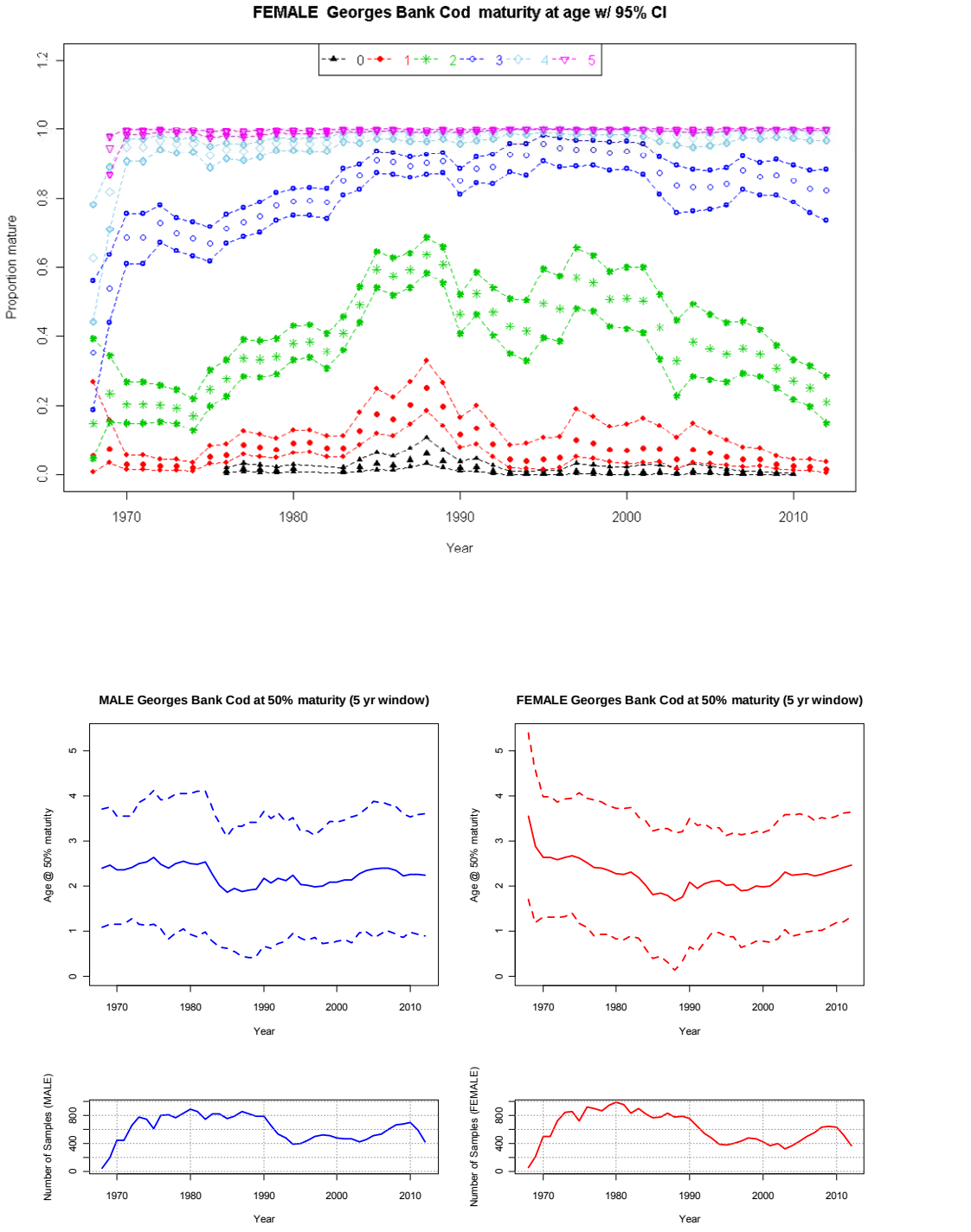


Figure B24. Proportion mature at age for ages 1-5 (upper panel) with 95% confidence intervals for female Georges Bank Atlantic cod using a 5-year moving window, median age at maturity (A50) for males (middle left panel) and females (middle right panel) with 95% confidence intervals, and number of samples in the combined 5-year moving average for males (lower left panel) and females (lower right panel).

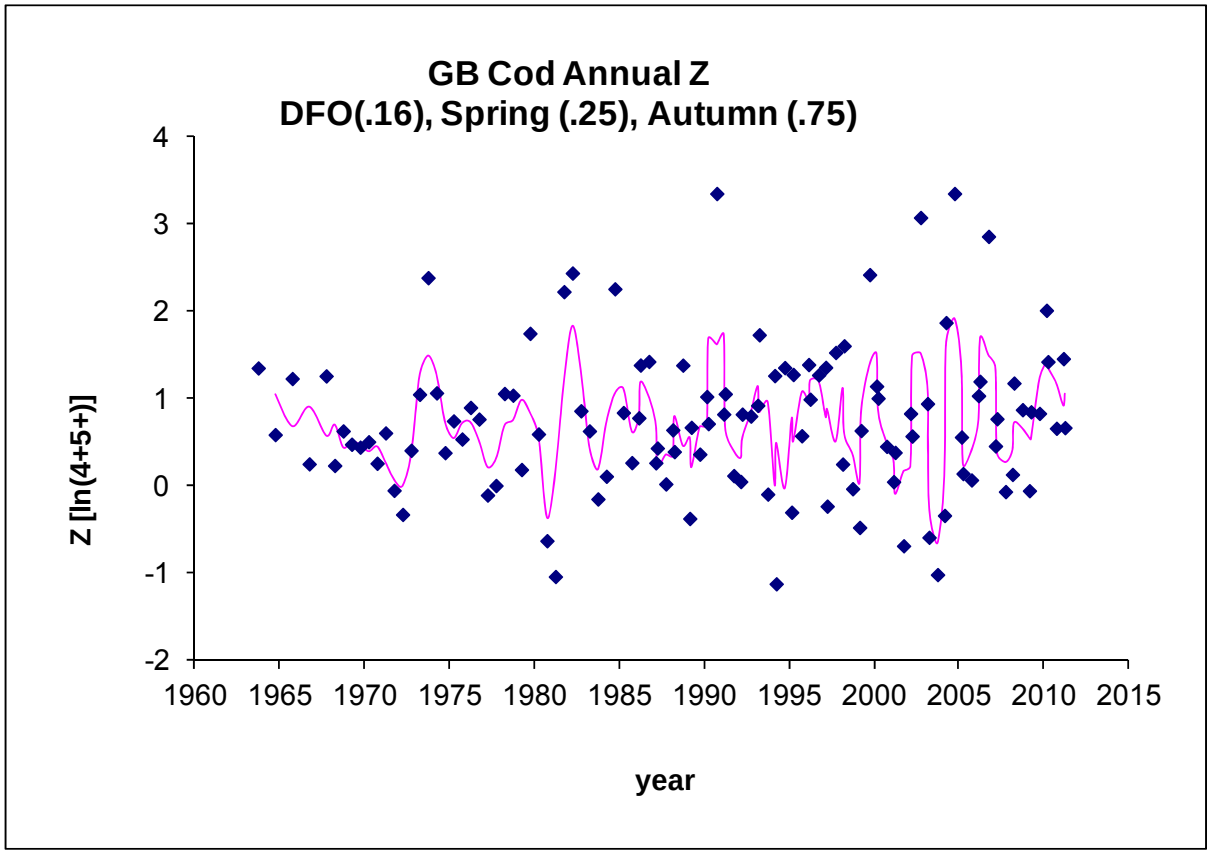


Figure B25. Annual total mortality (Z) estimated from DFO, NEFSC spring, and NEFSC autumn surveys, 1963-2011. Solid line is three-year centered moving average.

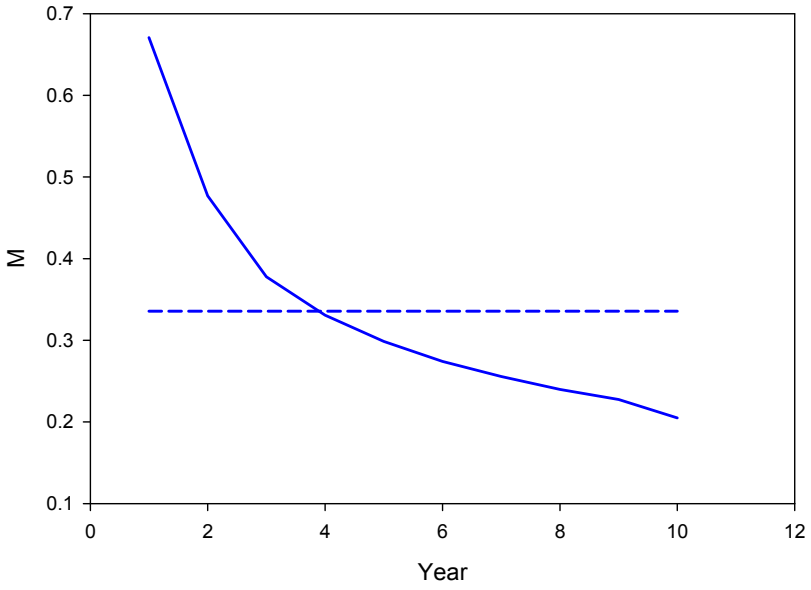
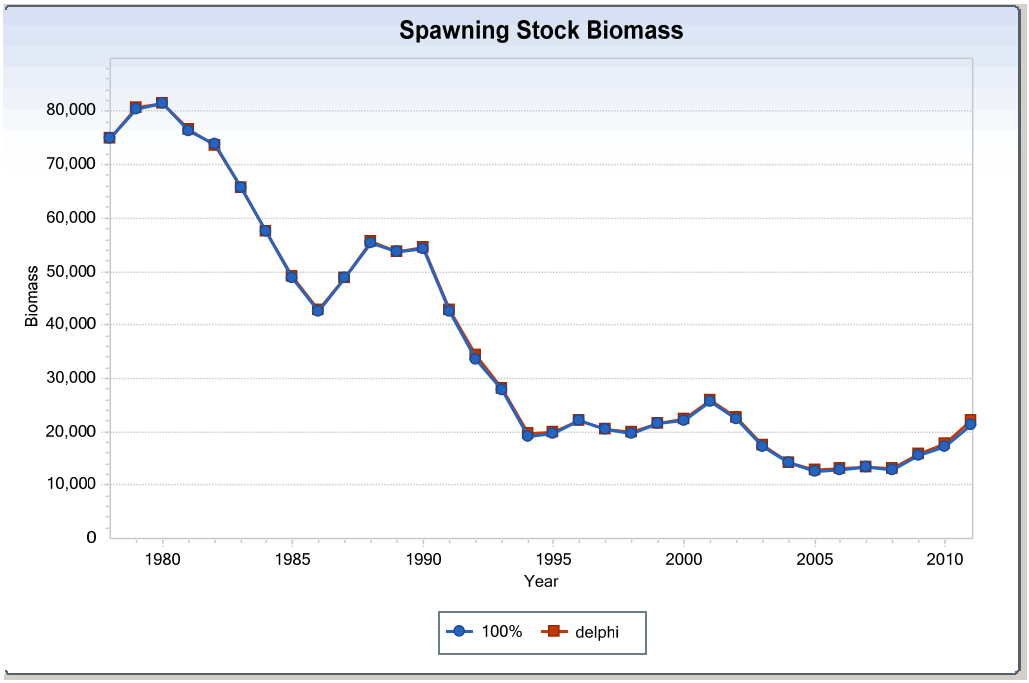


Figure B26. Lorenzen (1986) estimate of unadjusted- M based on times series average of January 1 stock weights of Georges Bank cod, 1978-2011. (Dashed line =0.336 total M)



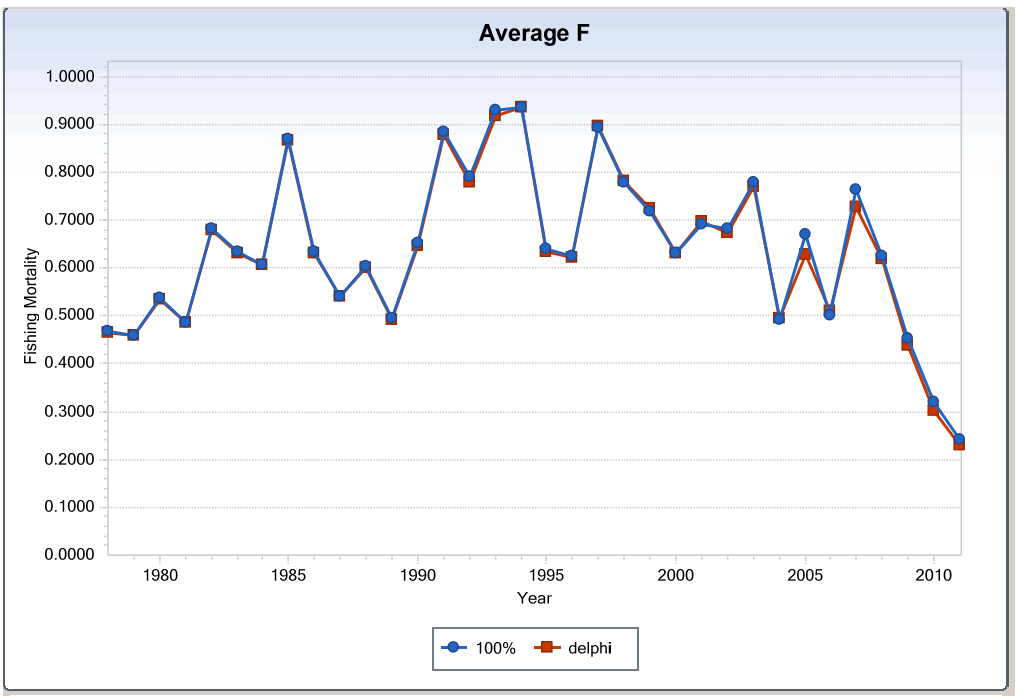
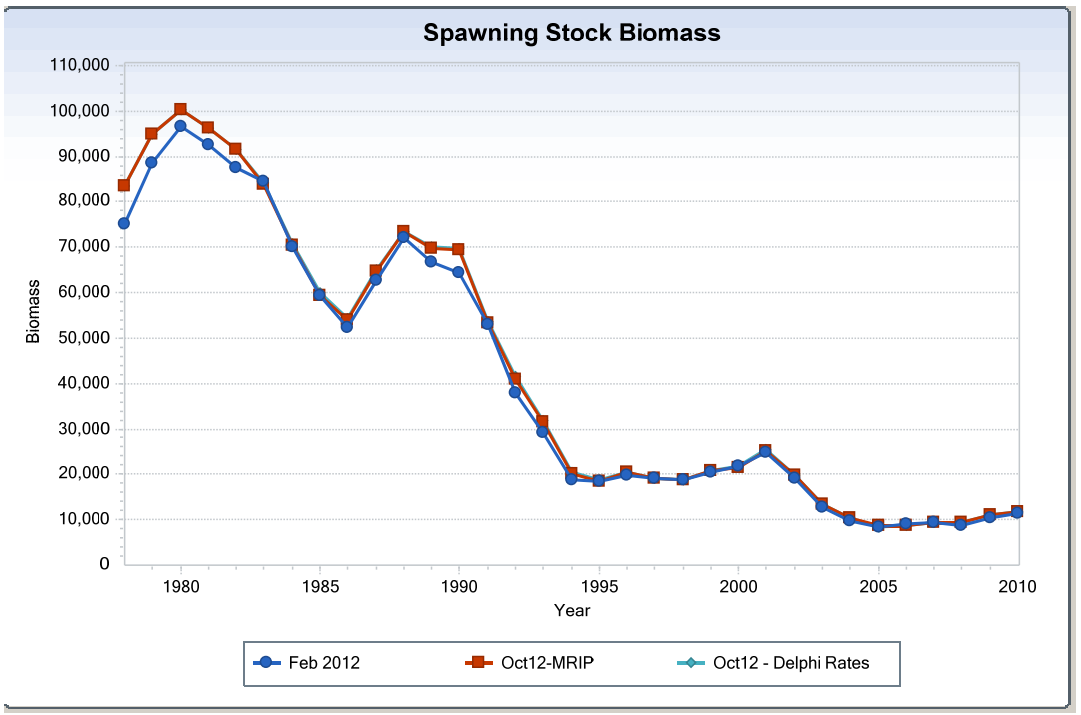


Figure B27. Comparison of spawning stock biomass (SSB) and fishing mortality (F) of an MRIP + 100 % discard mortality VPA (100%) with an MRIP+Delphi mortality rate (delphi) VPA.



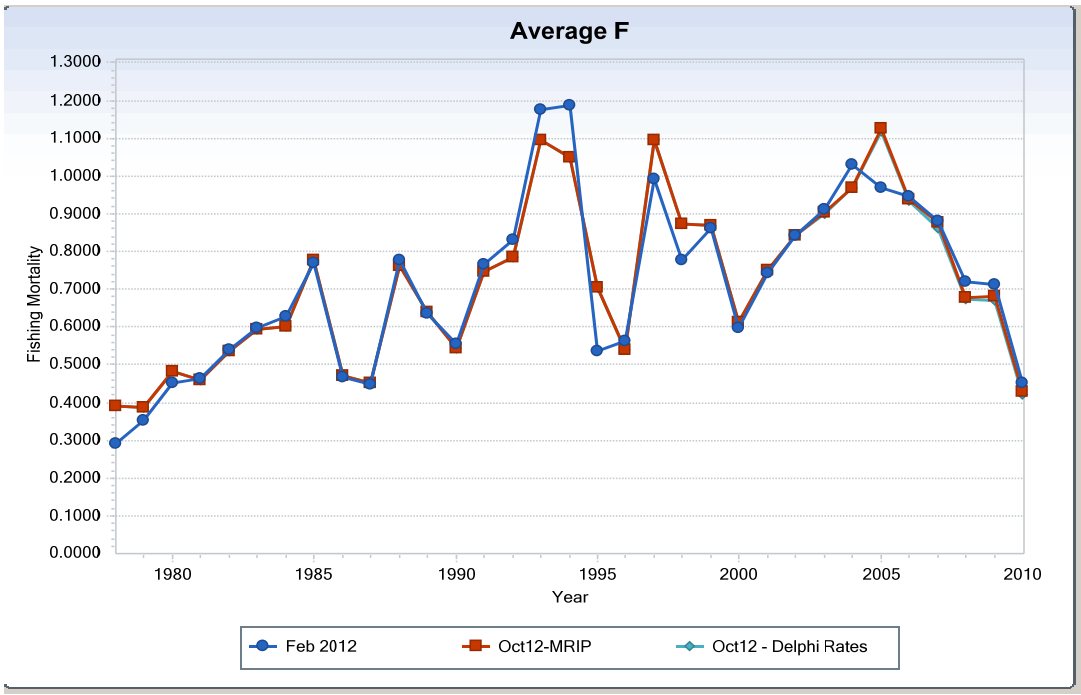
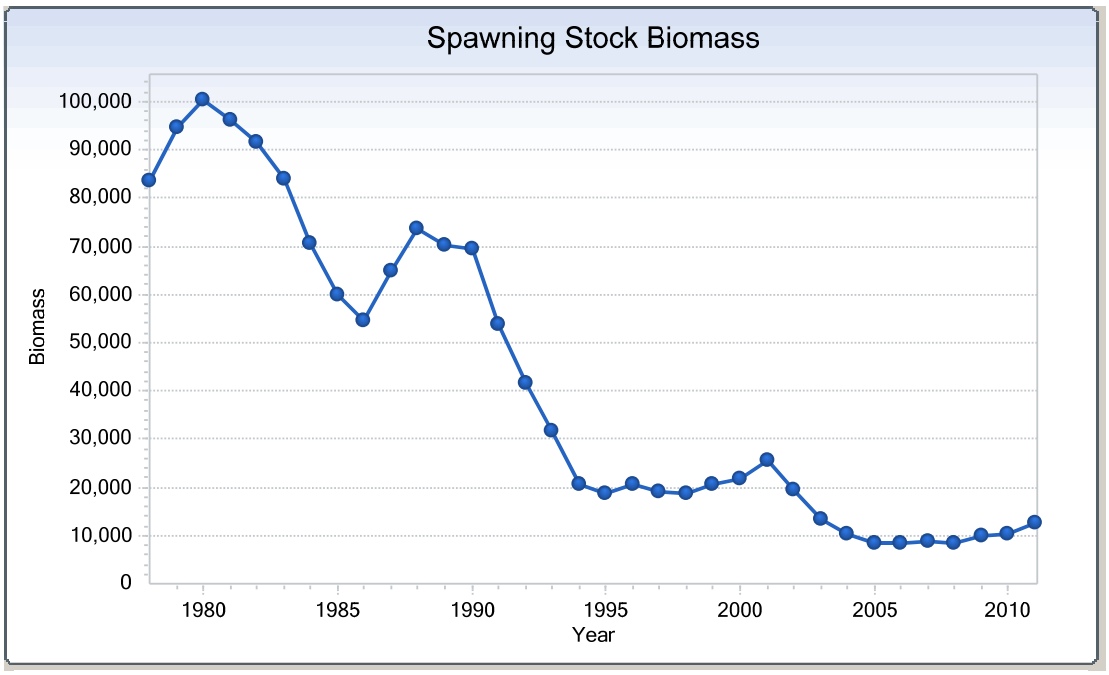


Figure B28. Comparison of spawning stock biomass (SSB) and fishing mortality (F) of the February 2012 VPA (Feb 2012), the MRIP + 100 % discard mortality VPA (Oct12-MRIP), and the MRIP+Delphi mortality rate VPA (Oct12-Delphi rates).



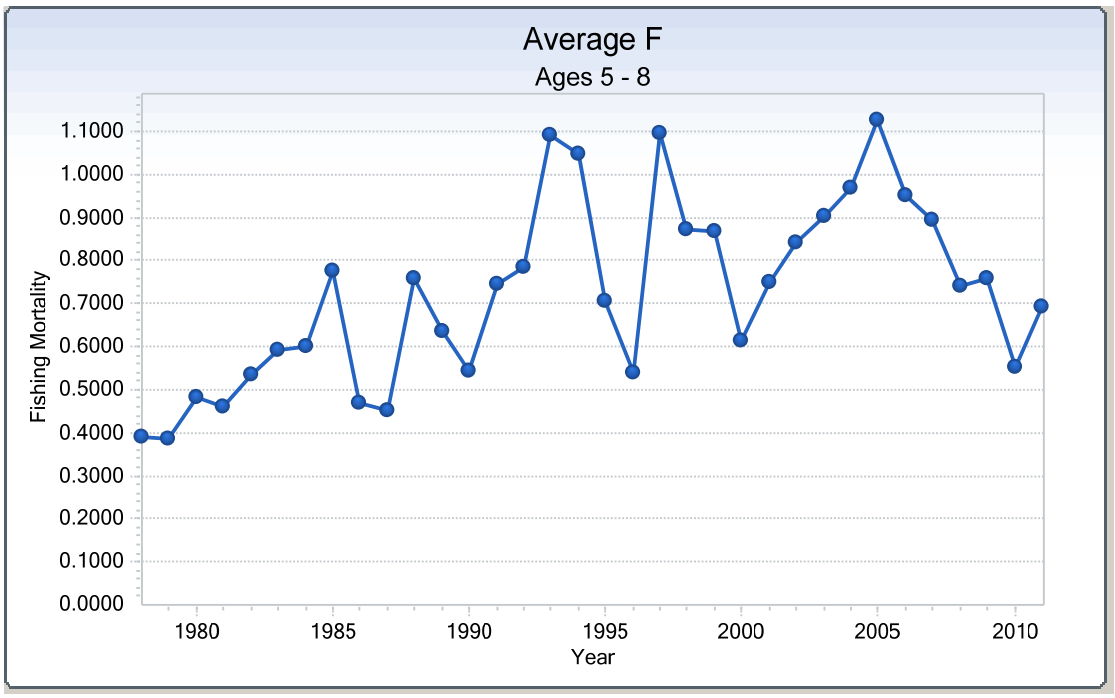


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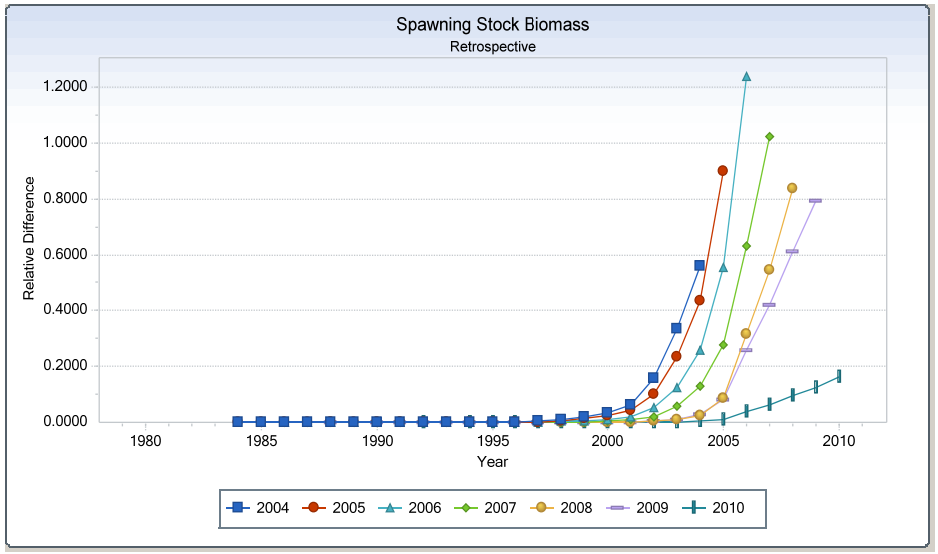
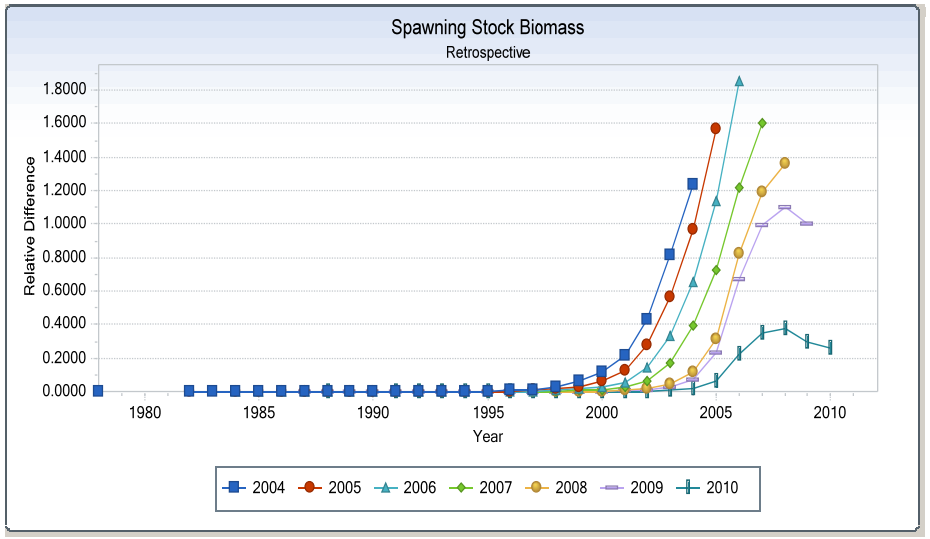
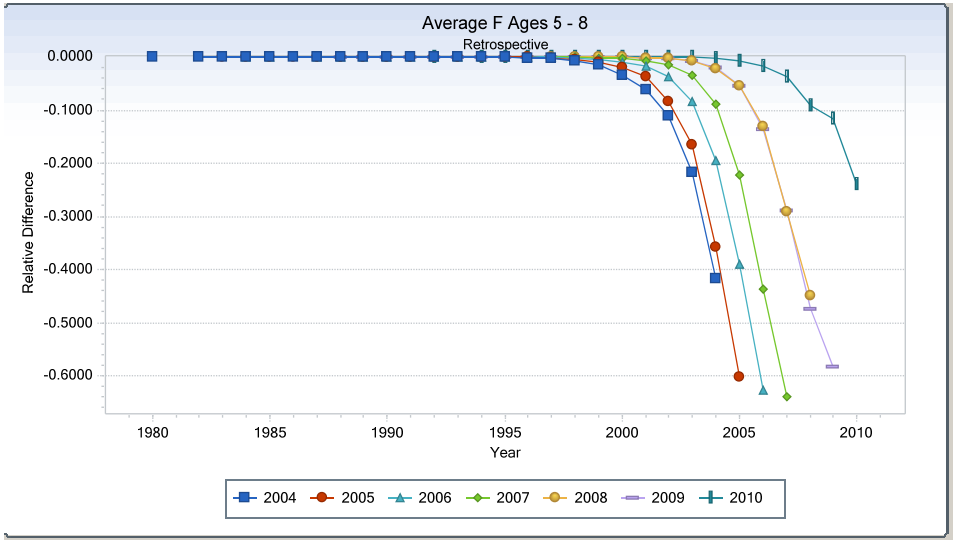
Figure B29. Spawning stock biomass (SSB) and fishing mortality (F) of terminal year 2011 VPA.







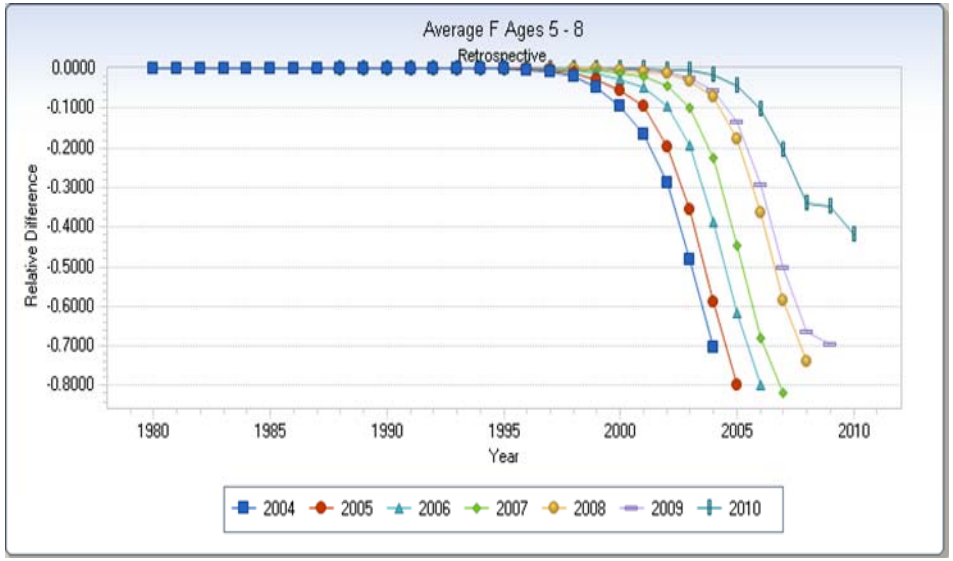
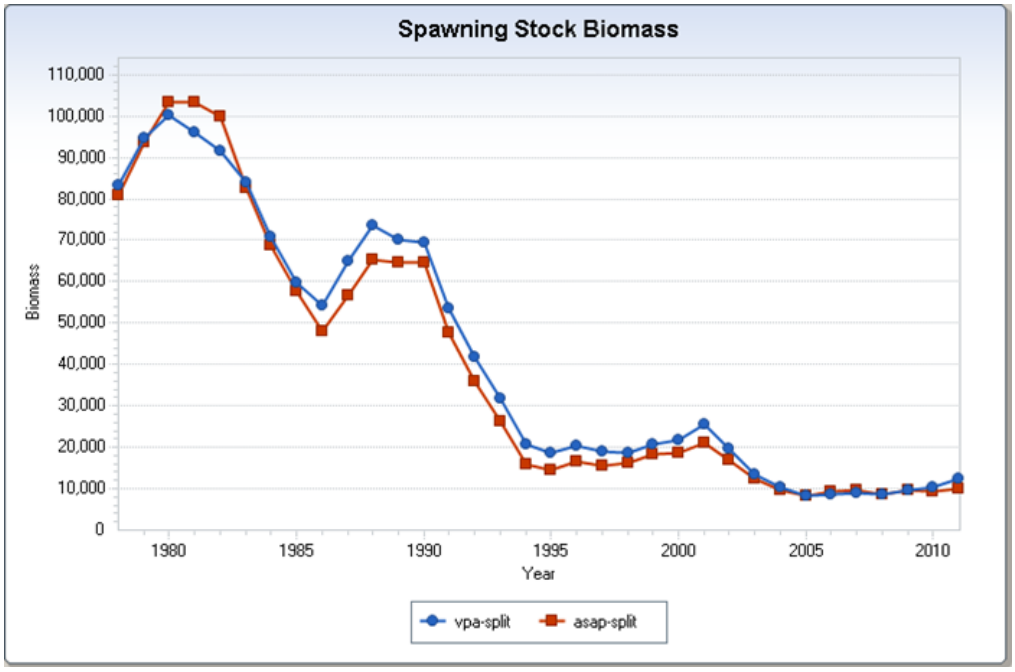


Figure B30. Retrospective bias of spawning stock biomass and fishing mortality of terminal year 2011 VPA for surveys split VPA (left) and survey not split VPA (right).



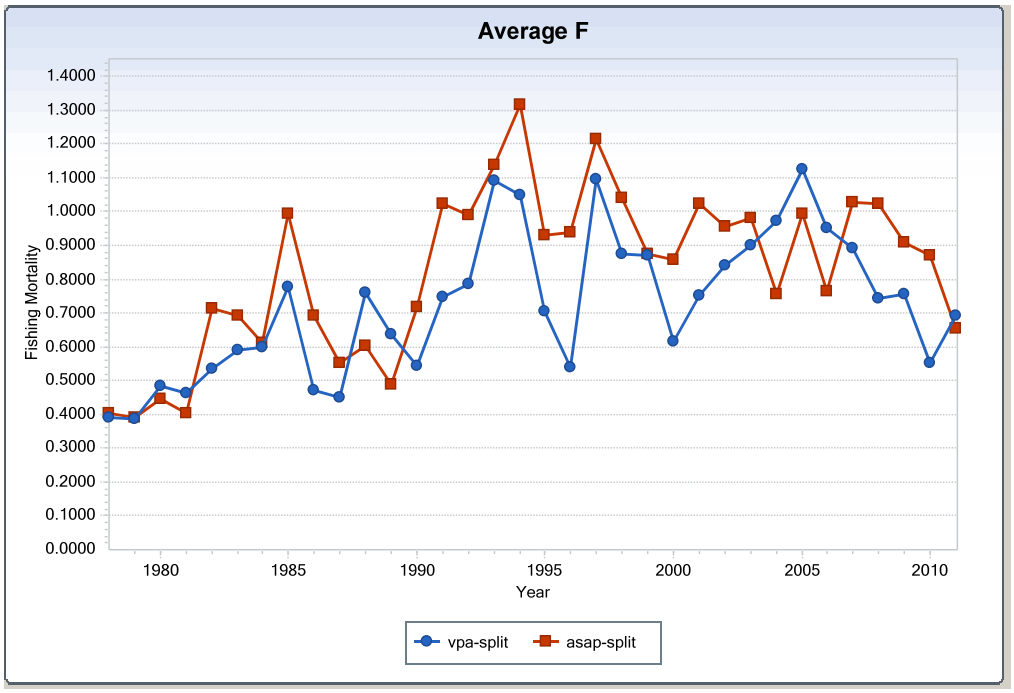
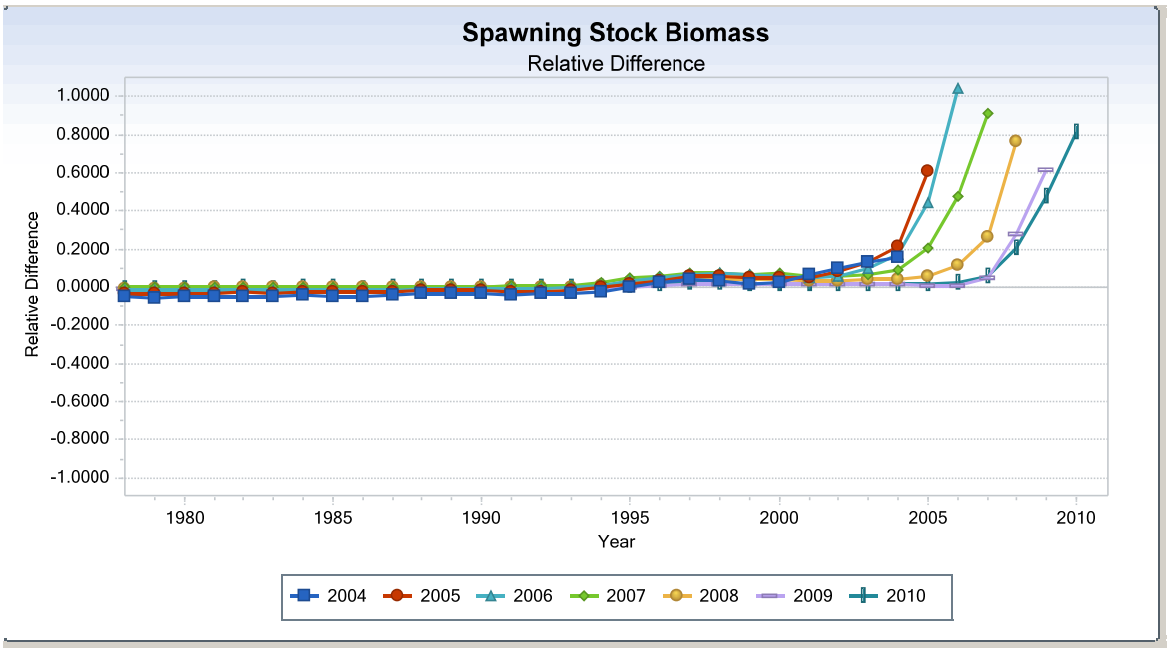


Figure B31. Comparison of spawning stock biomass and fishing mortality for VPA and VPA-like ASAP formulation, 1978-2011.



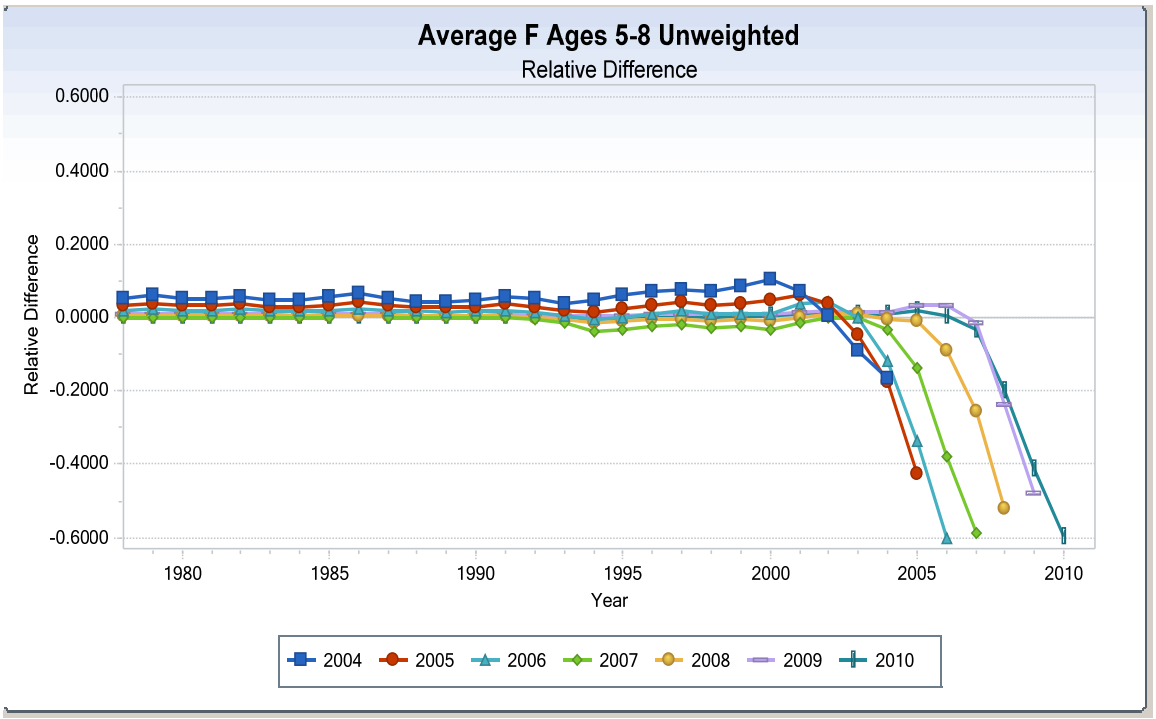


Figure B32. Spawning stock biomass and fishing mortality retrospective for VPA-like ASAP formulation, 1978-2011.

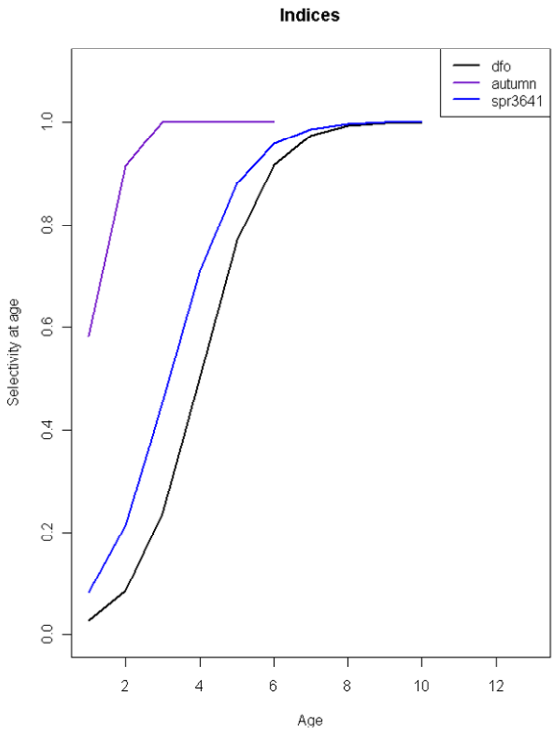


Figure B33. Survey selectivity at age (Run 42) for DFO (logistic), NEFSC spring (logistic) and autumn (fixed age 3=1) surveys.

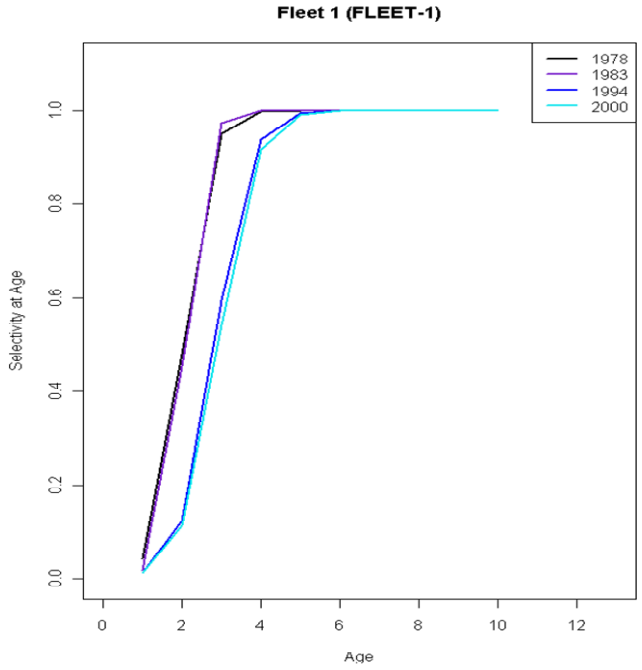


Figure B34. Fishery selectivity for four blocks (run 18).

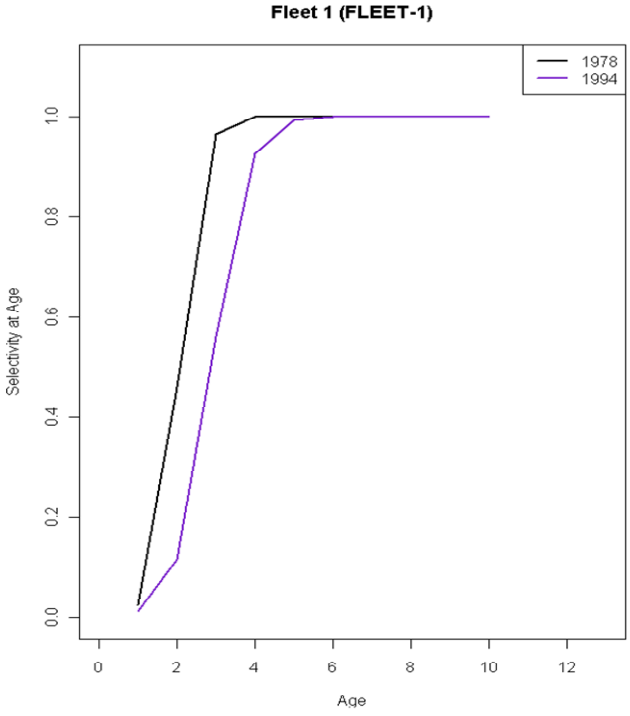


Figure B35. Fishery selectivity for two blocks (run 19).

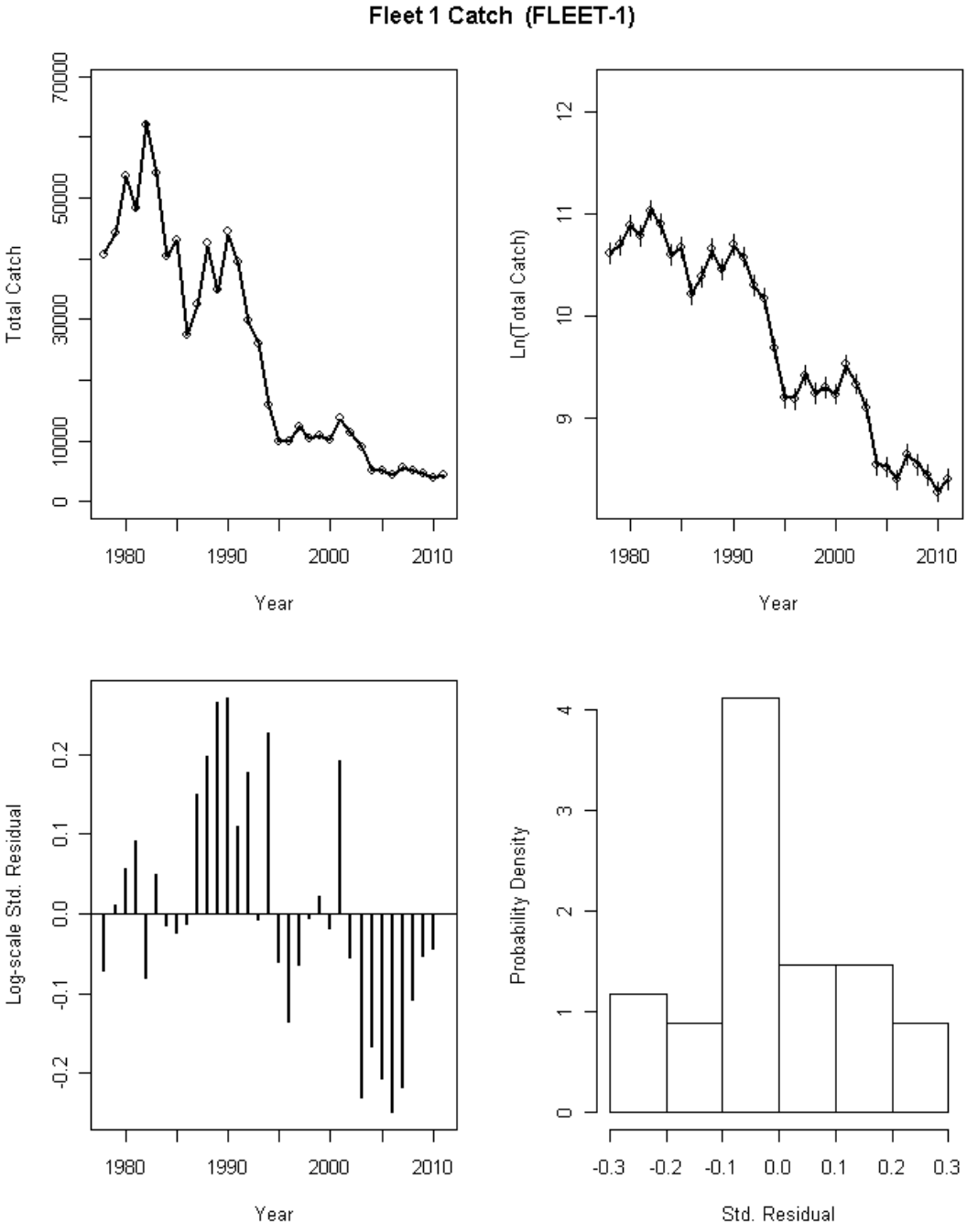


Figure B36. ASAP base model fit to total catch of Georges Bank cod, 1978-2011.

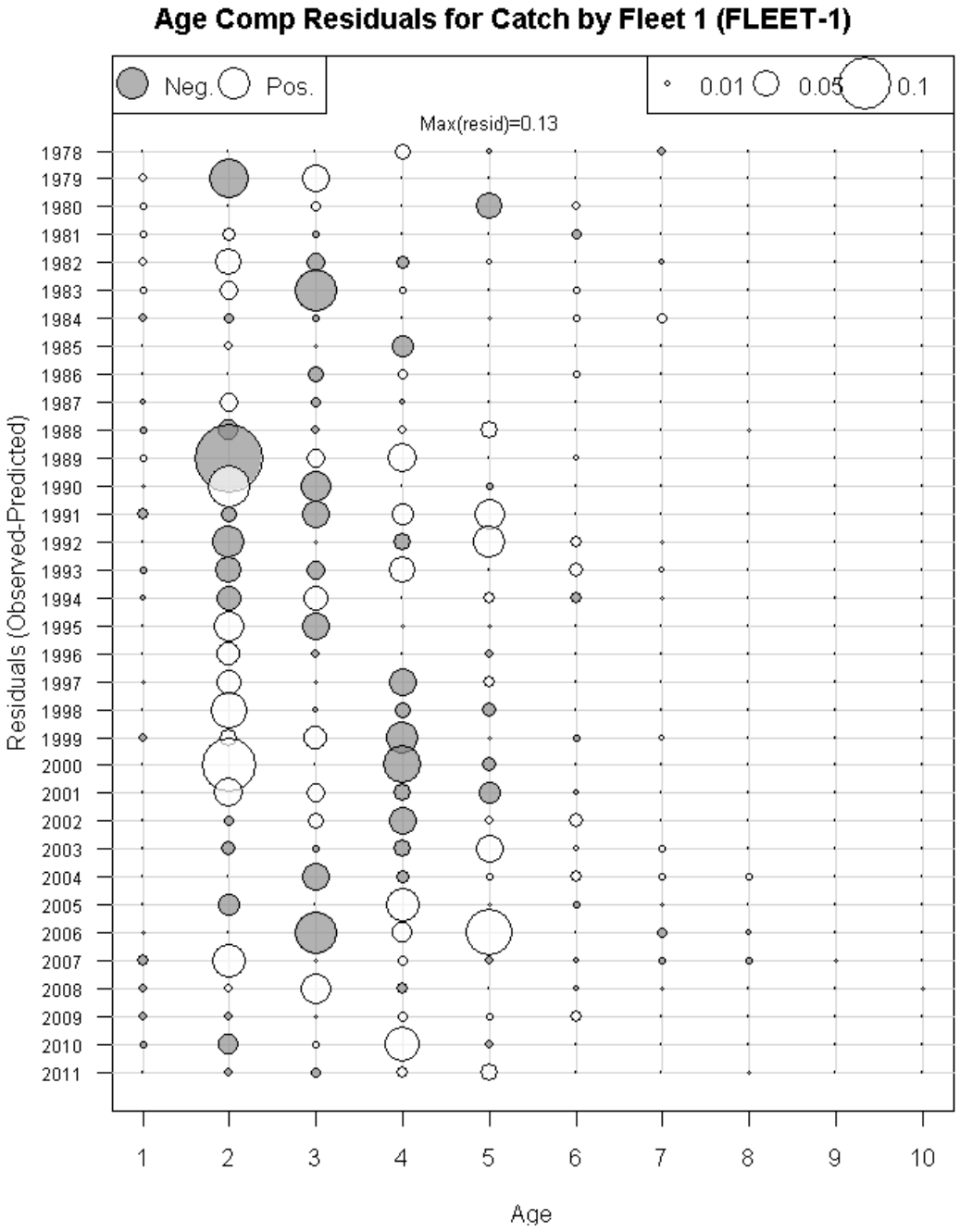


Figure B37. ASAP base model residuals for commercial catch age composition for Georges Bank cod, 1978-2011.

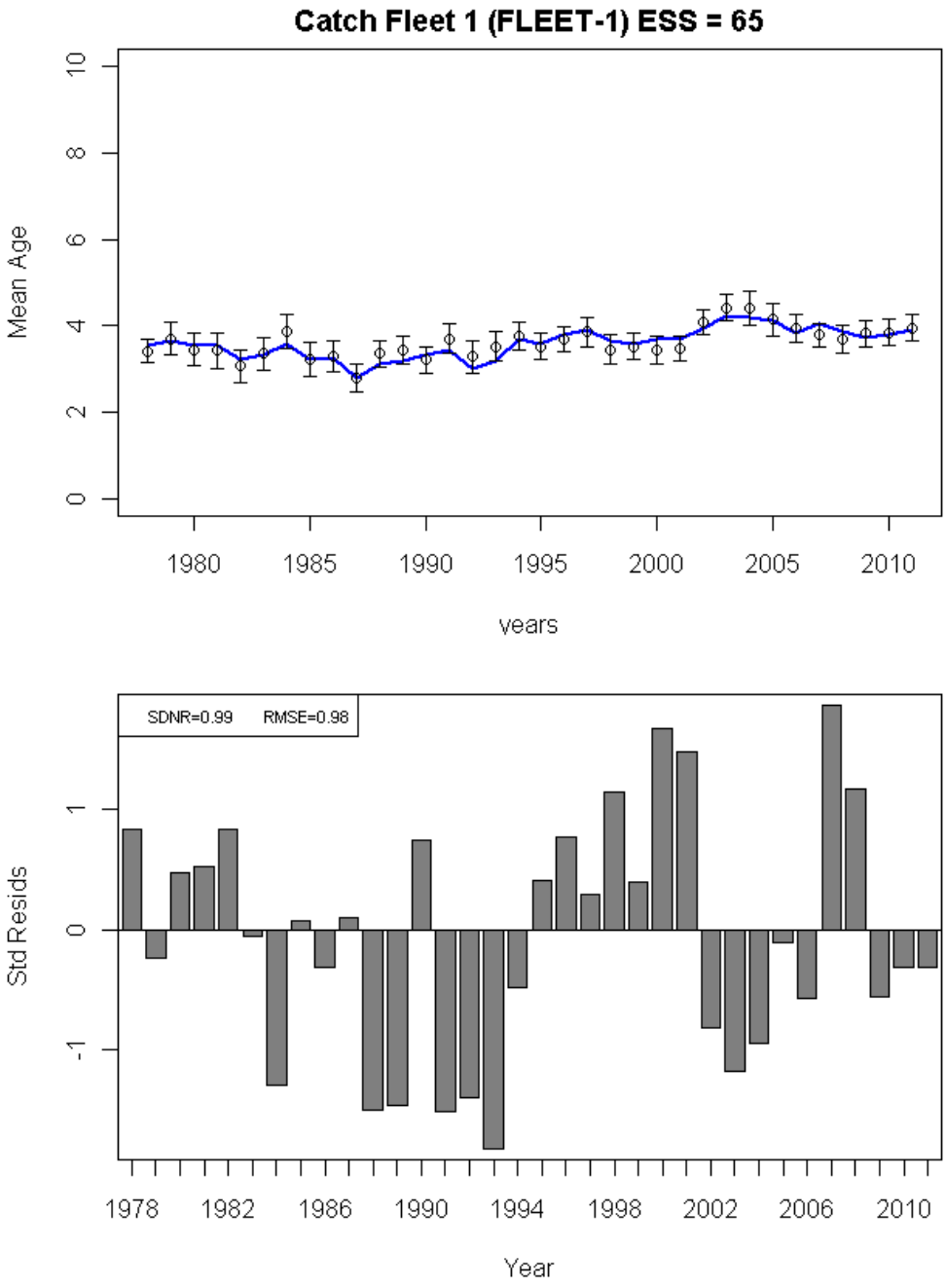


Figure B38. ASAP base model predicted mean age of Georges Bank cod in the total catch (blue line) compared to observed mean age (top plot) and the residuals about the mean (bottom plot).

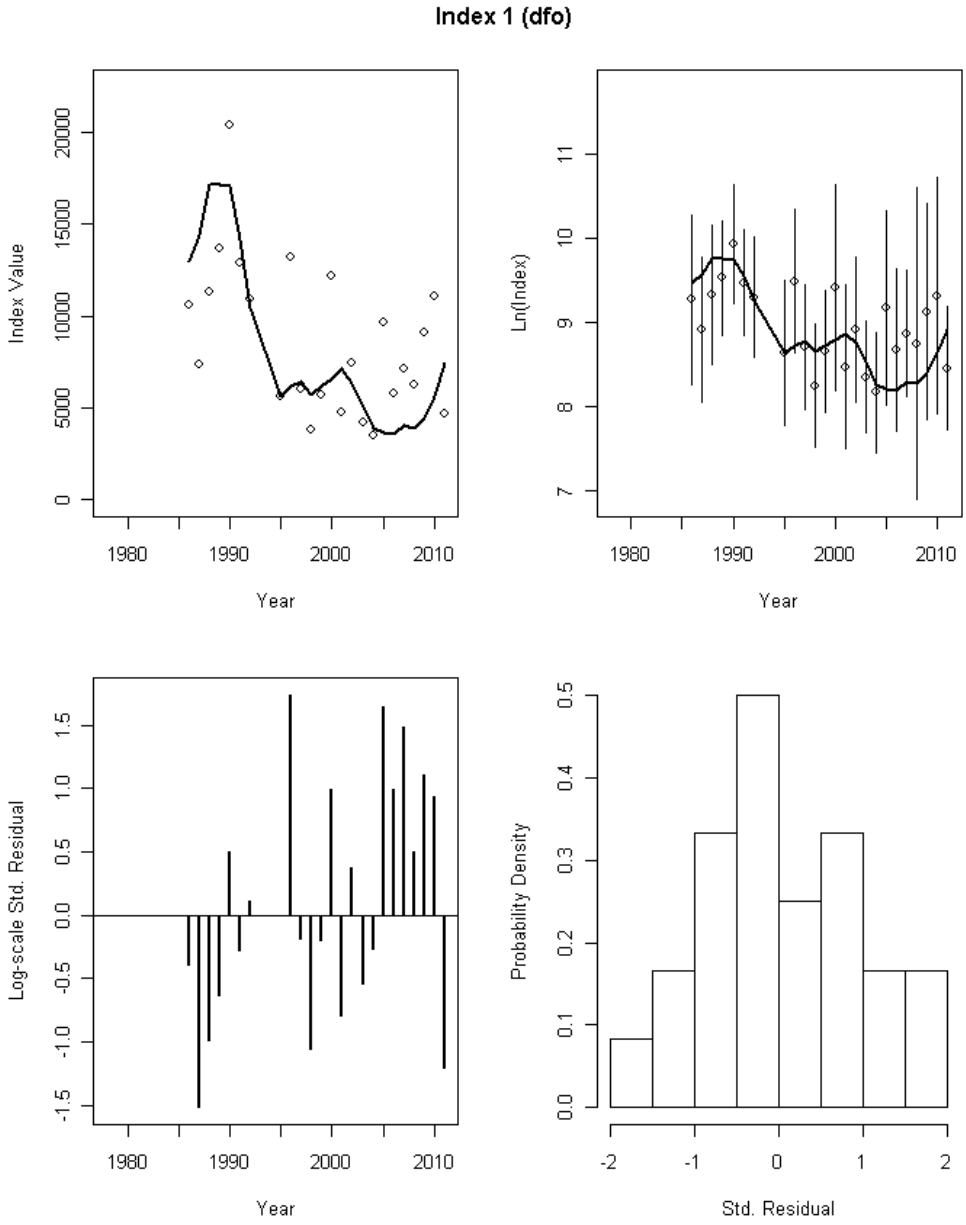


Figure B39. ASAP base model fit to DFO survey indices of Georges Bank cod, 1986-2011.

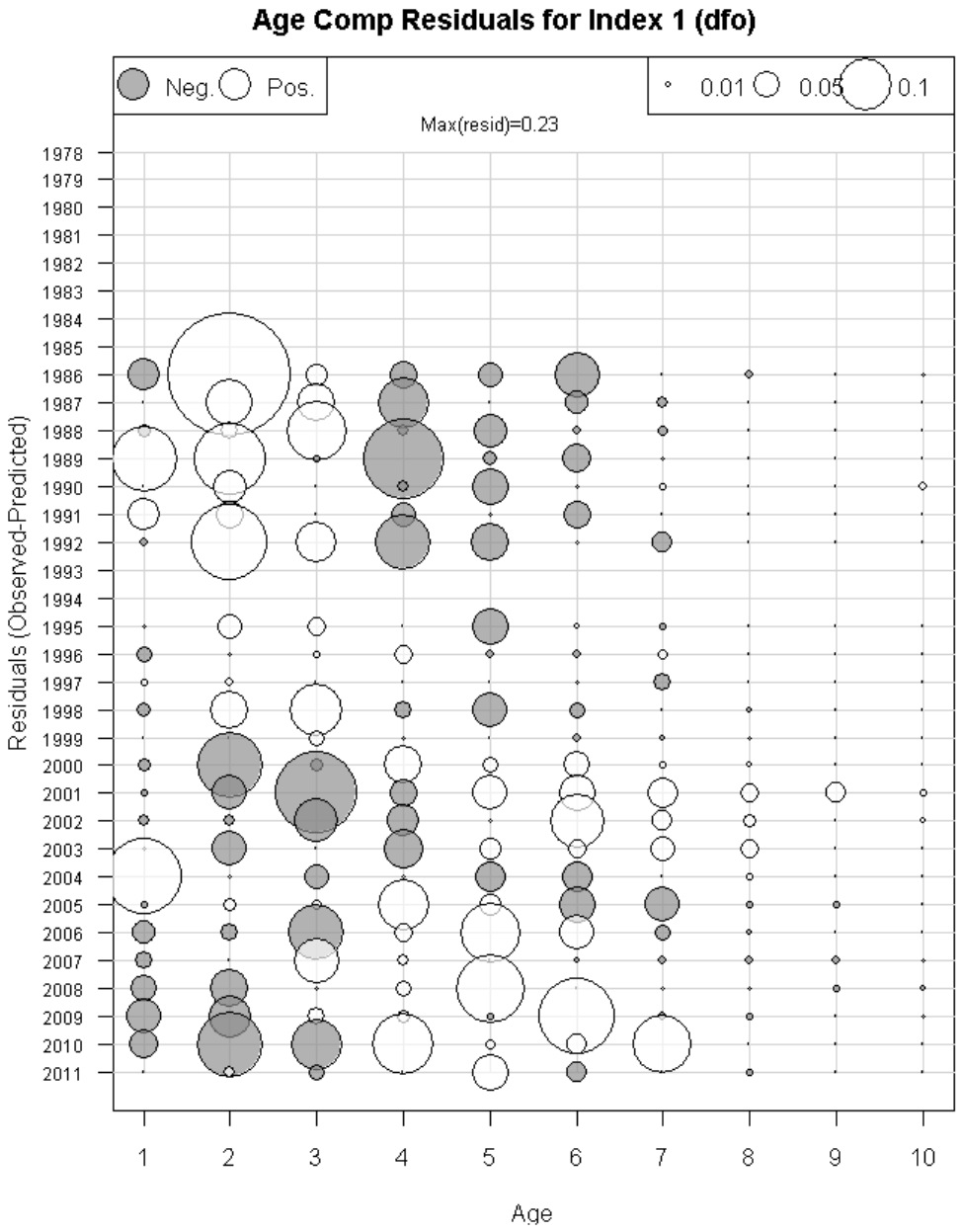


Figure B40. ASAP base model residuals for DFO survey index age composition for Georges Bank cod, 1986-2011.

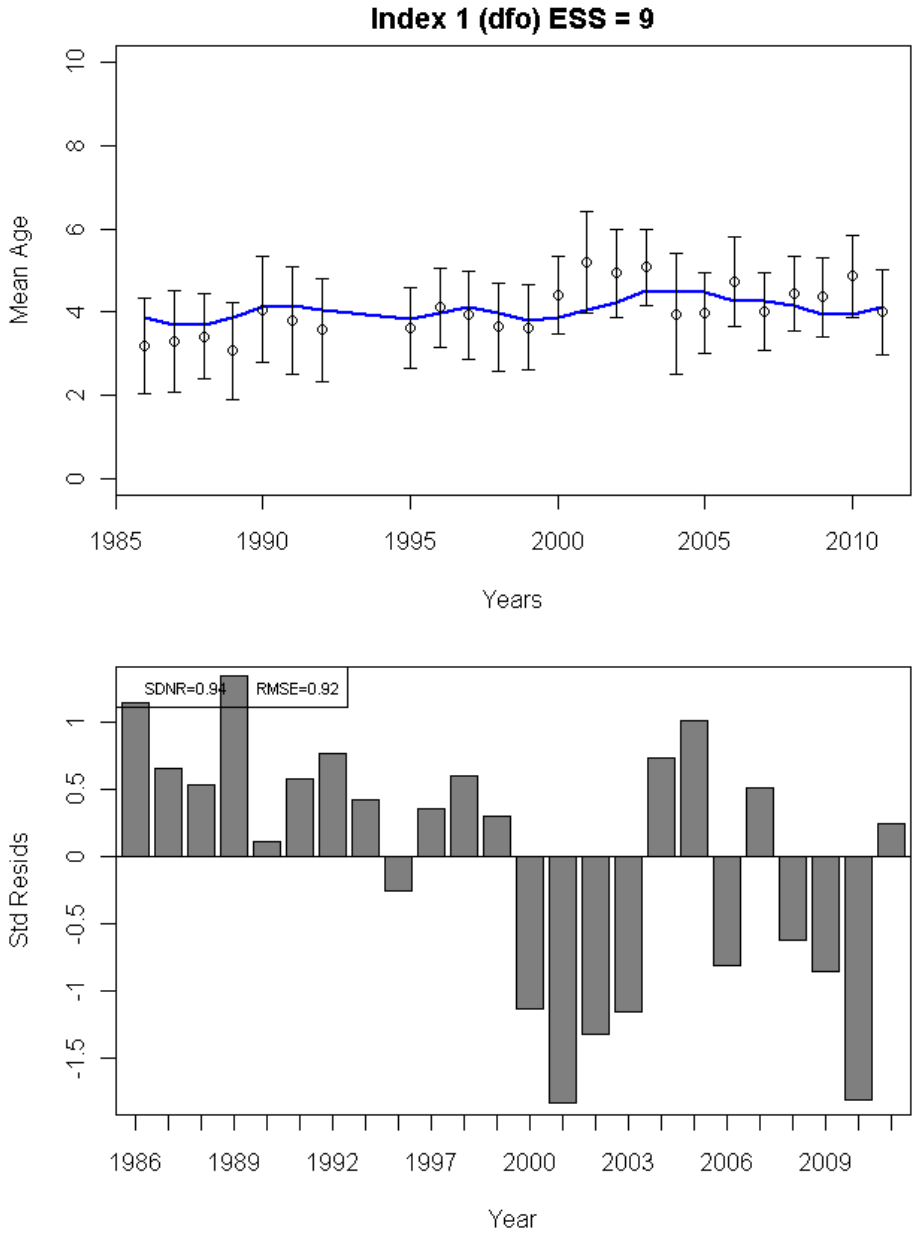


Figure B41. ASAP base model predicted mean age of Georges Bank cod in the DFO survey (blue line) compared to observed mean age (top plot) and the residuals about the mean (bottom plot).

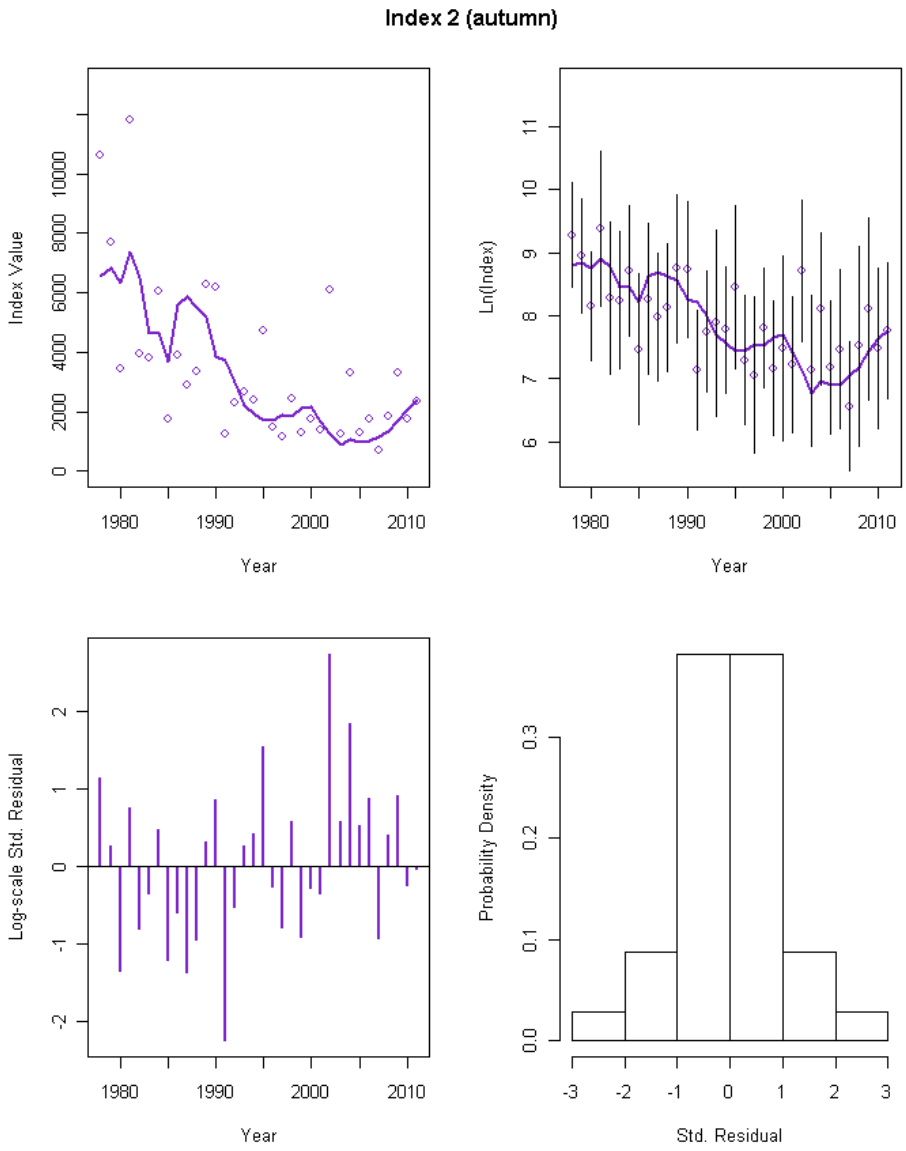


Figure B42. ASAP base model fit to autumn survey indices of Georges Bank cod, 1978-2011.

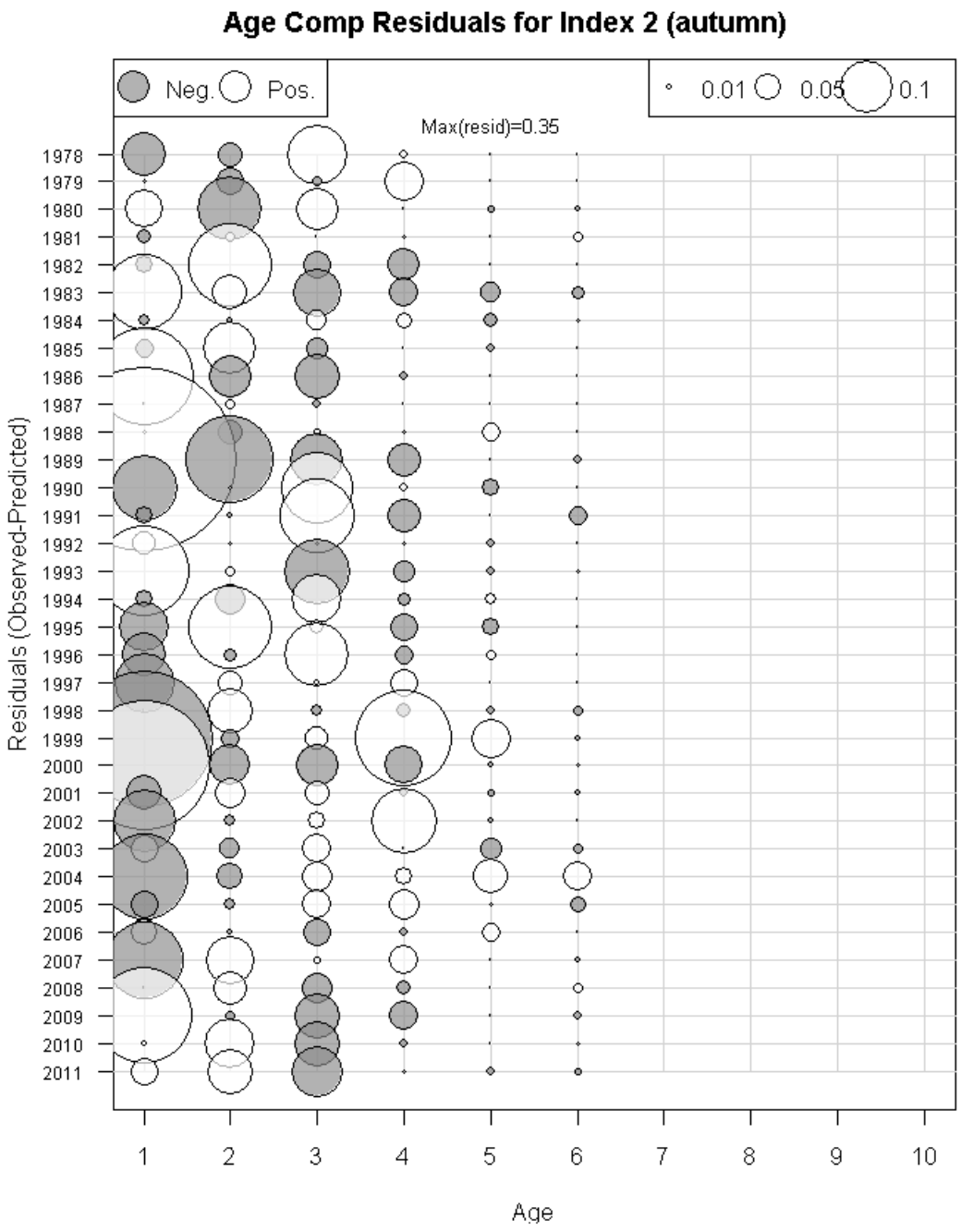


Figure B43. ASAP base model residuals for NEFSC autumn survey index age composition for Georges Bank cod, 1986-2011.

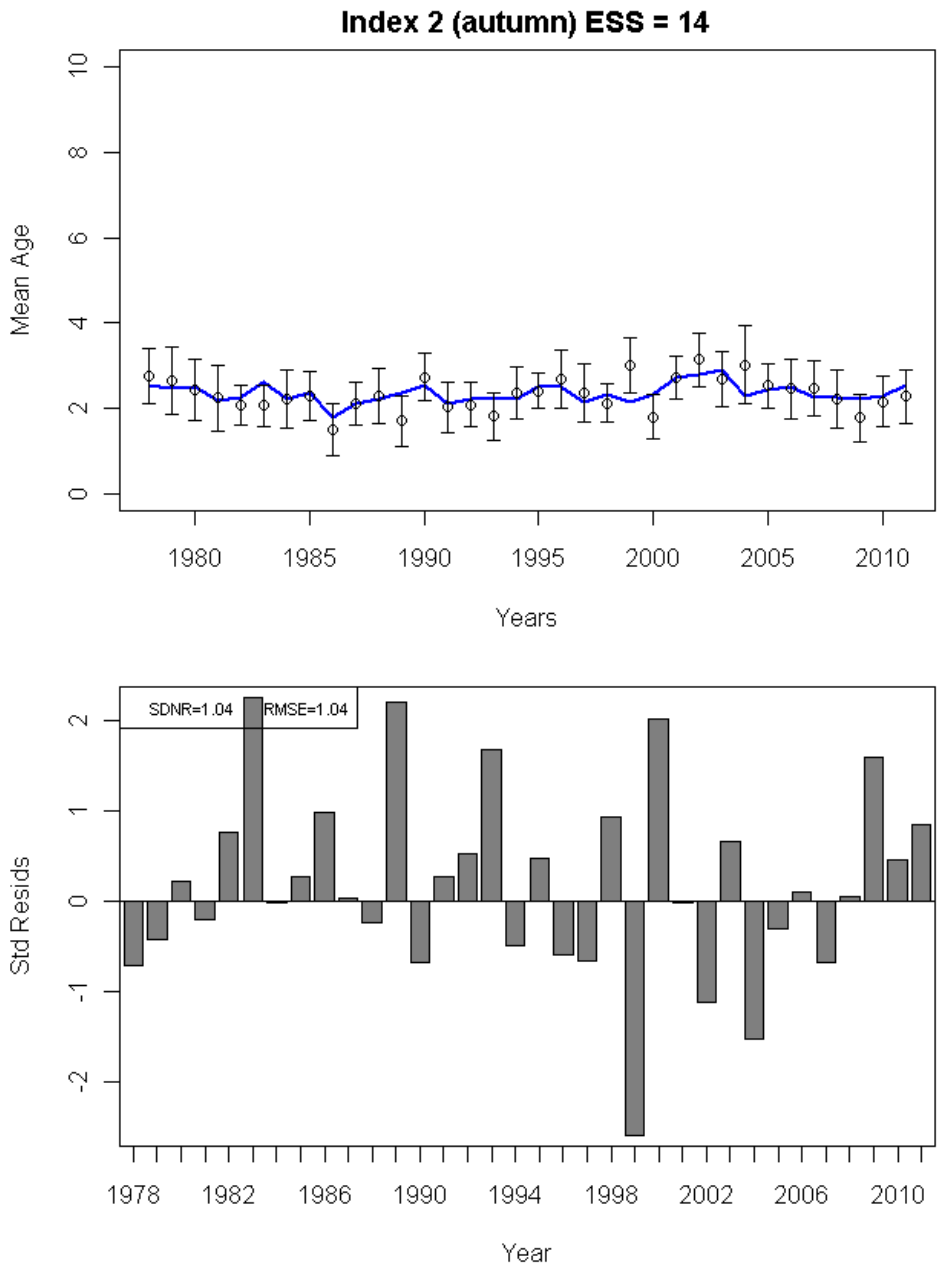


Figure B44. ASAP base model predicted mean age (blue line) of Georges Bank cod in the NEFSC autumn survey compared to observed mean age (top plot) and the residuals about the mean (bottom plot).

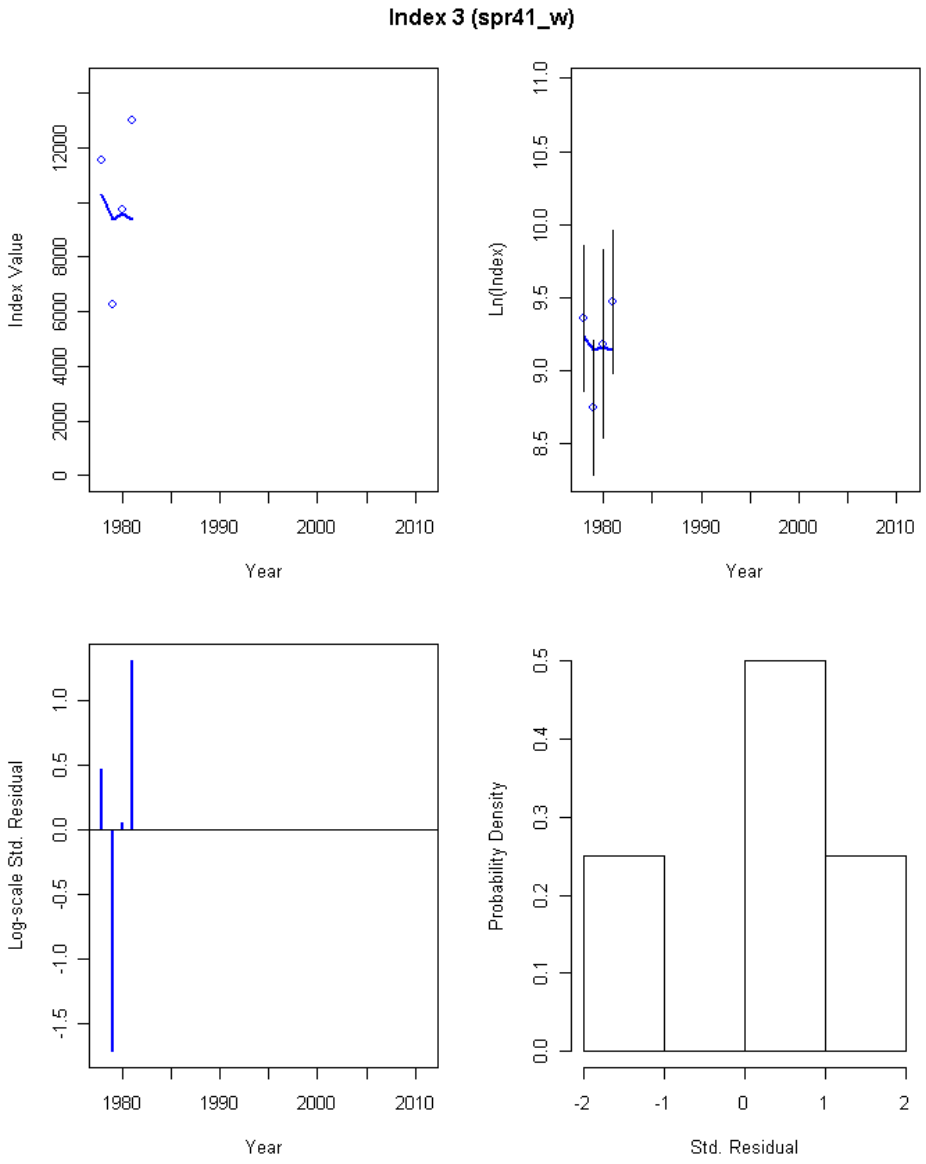


Figure B45. ASAP base model fit to NEFSC spring (Yankee #41) survey indices of Georges Bank cod, 1978-1981.

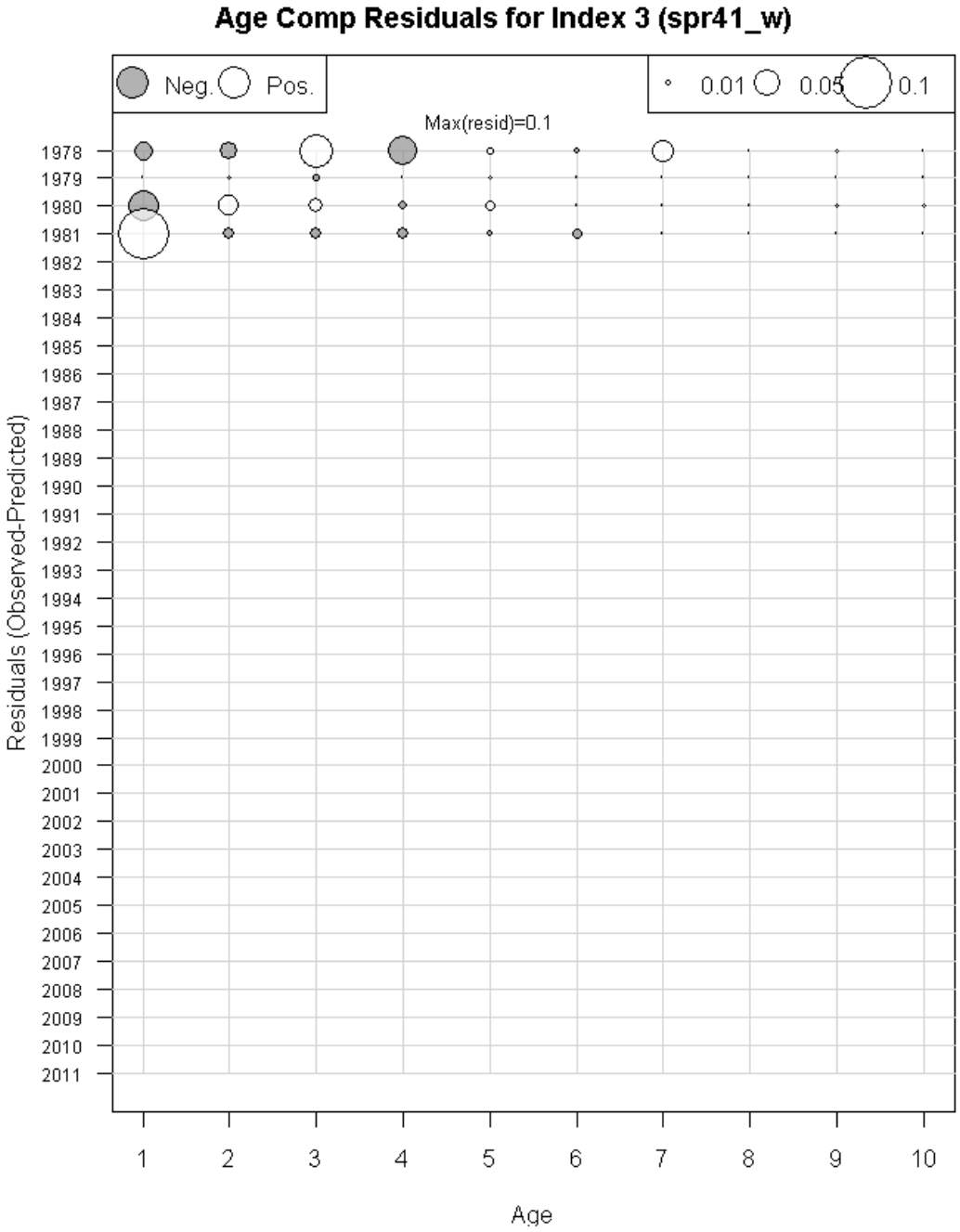


Figure B46. ASAP base model residuals for NEFSC spring (Yankee #41) age composition for Georges Bank cod, 1978-1981.

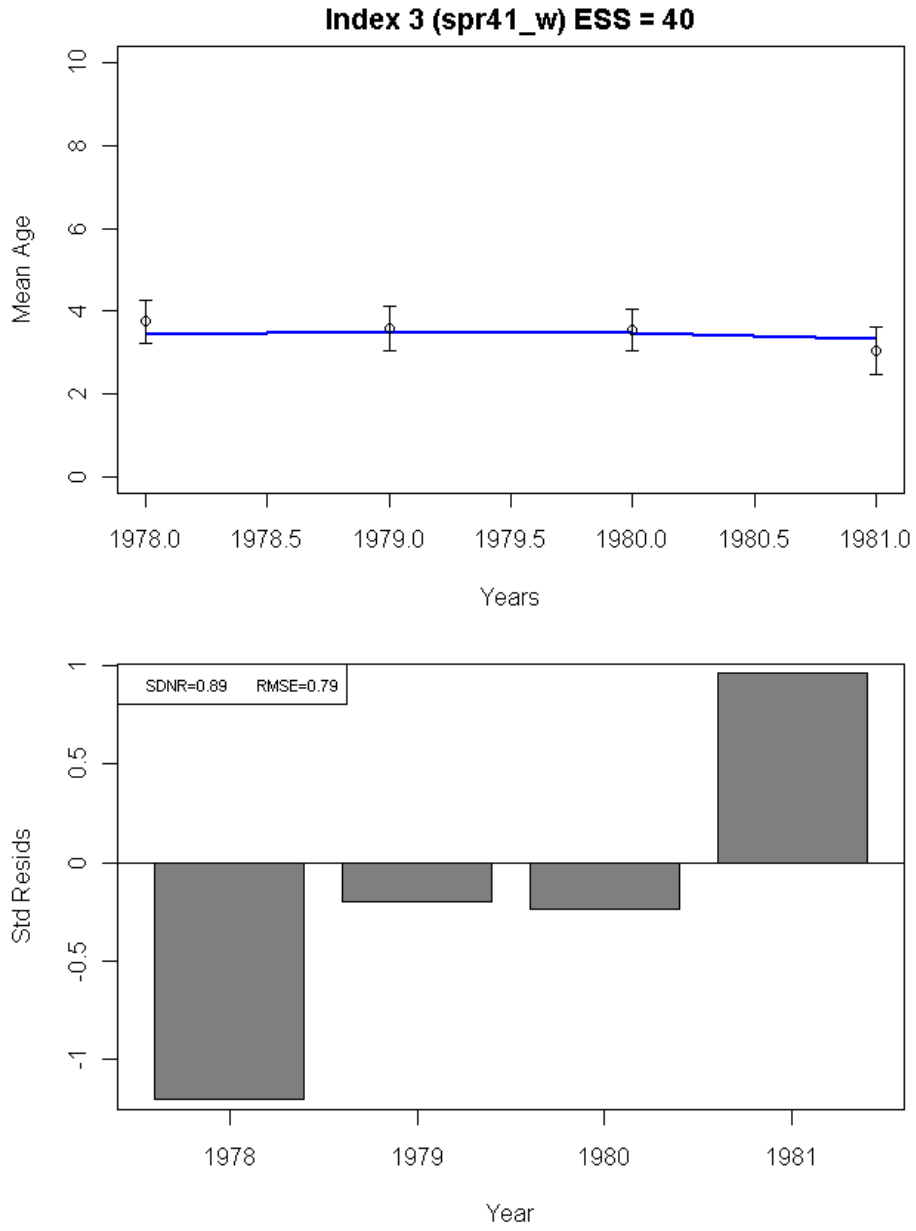


Figure B47. ASAP base model predicted mean age (blue line) of Georges Bank cod in the NEFSC spring (Yankee #41 compared to observed mean age (top plot) and the residuals about the mean (bottom plot).

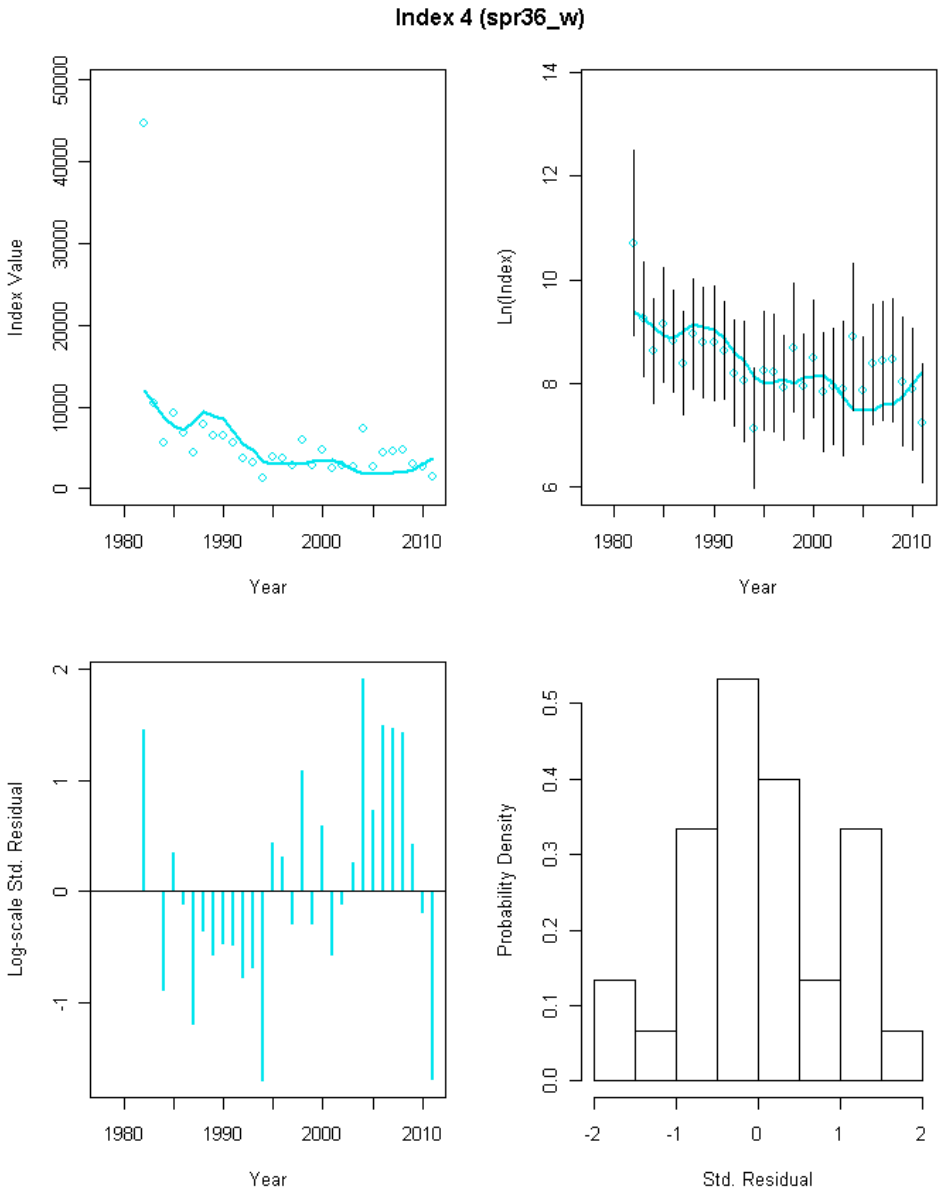


Figure B48. ASAP base model fit to NEFSC spring (Yankee #36) survey indices for Georges Bank cod, 1982-2011

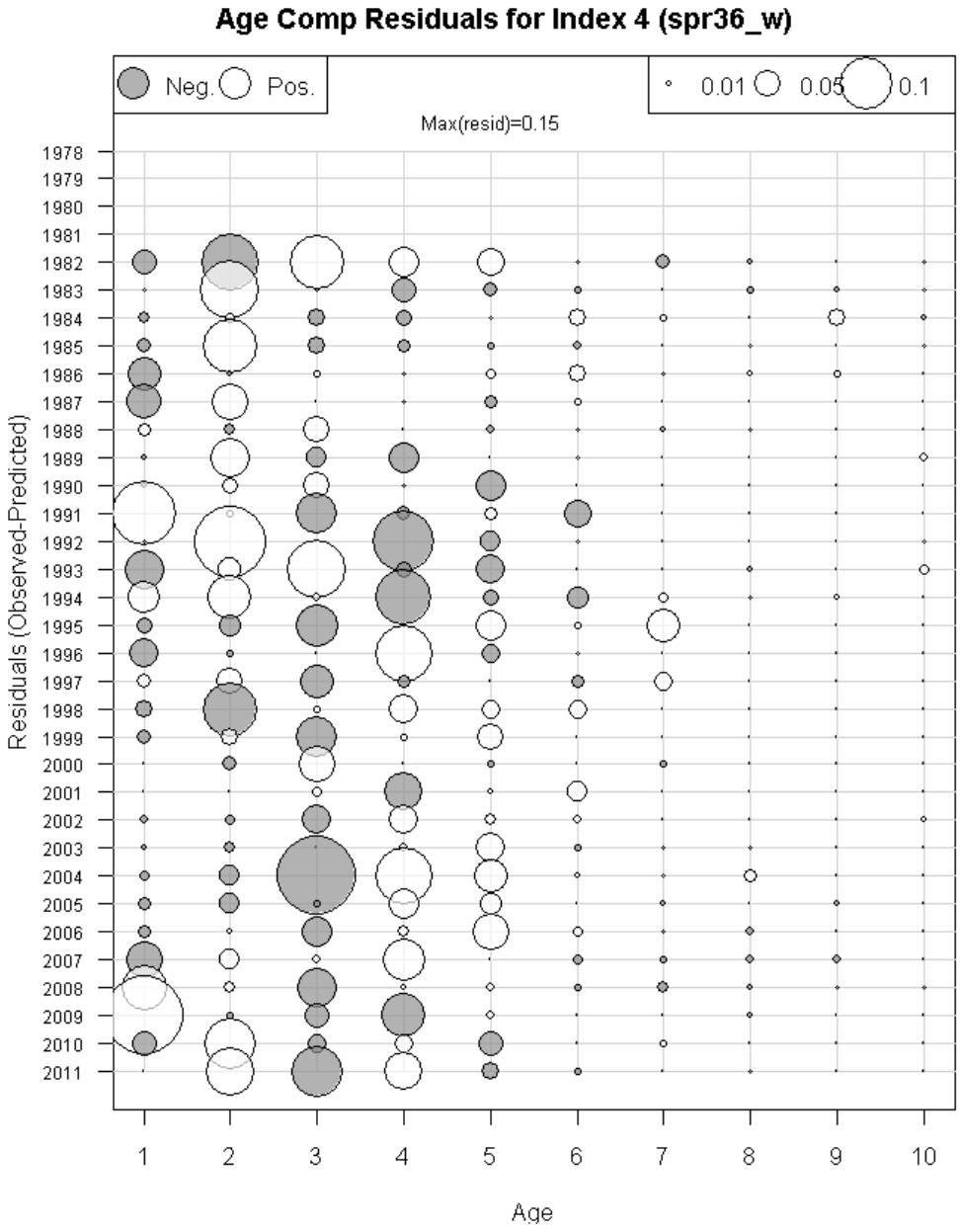


Figure B49. ASAP base model residuals for NEFSC spring (Yankee #36) survey index age composition for Georges Bank cod, 1982-2011.

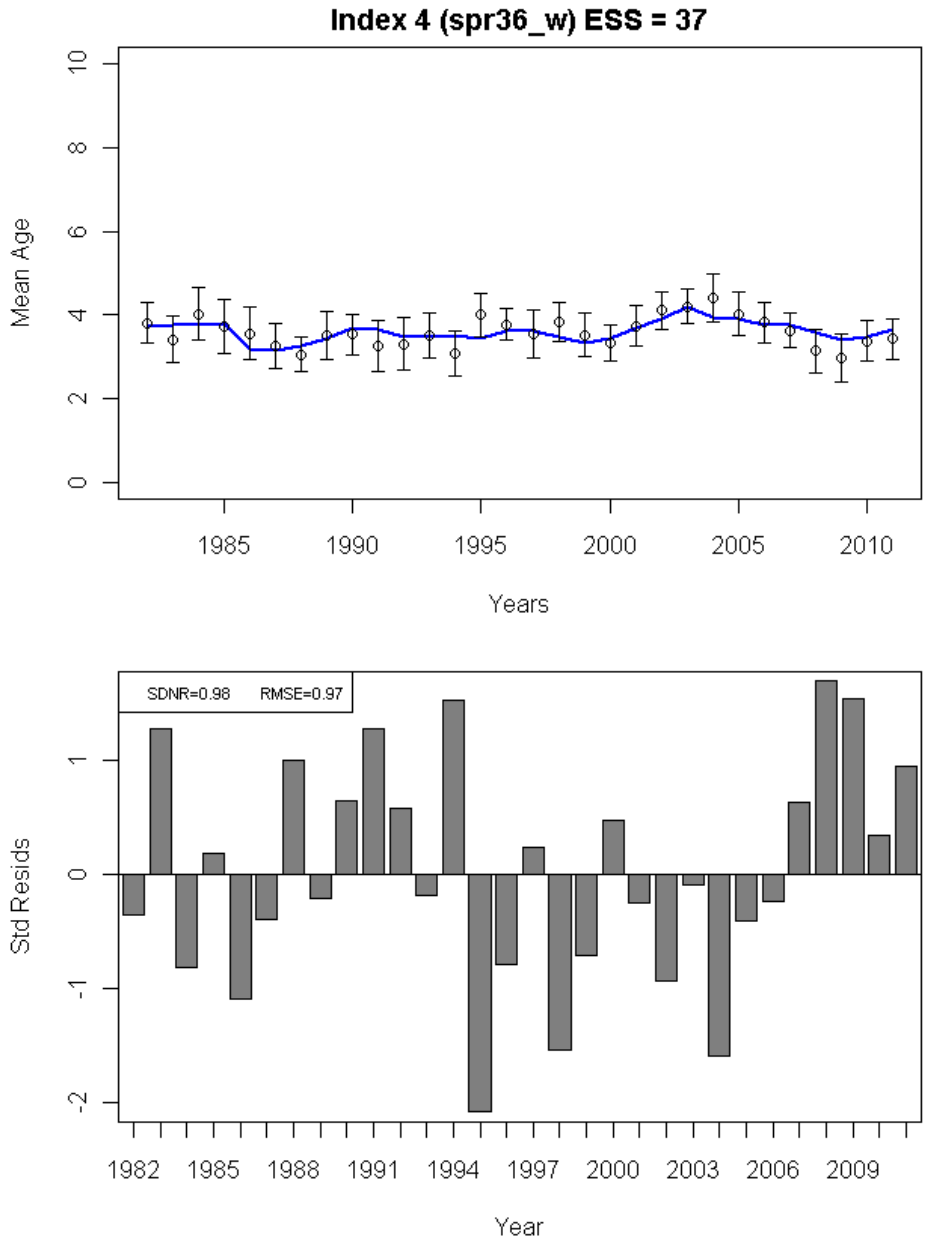


Figure B50. ASAP base model predicted mean age (blue line) of Georges Bank cod in the NEFSC spring (Yankee #36) survey compared to observed mean age (top plot) and the residuals about the mean (bottom plot).

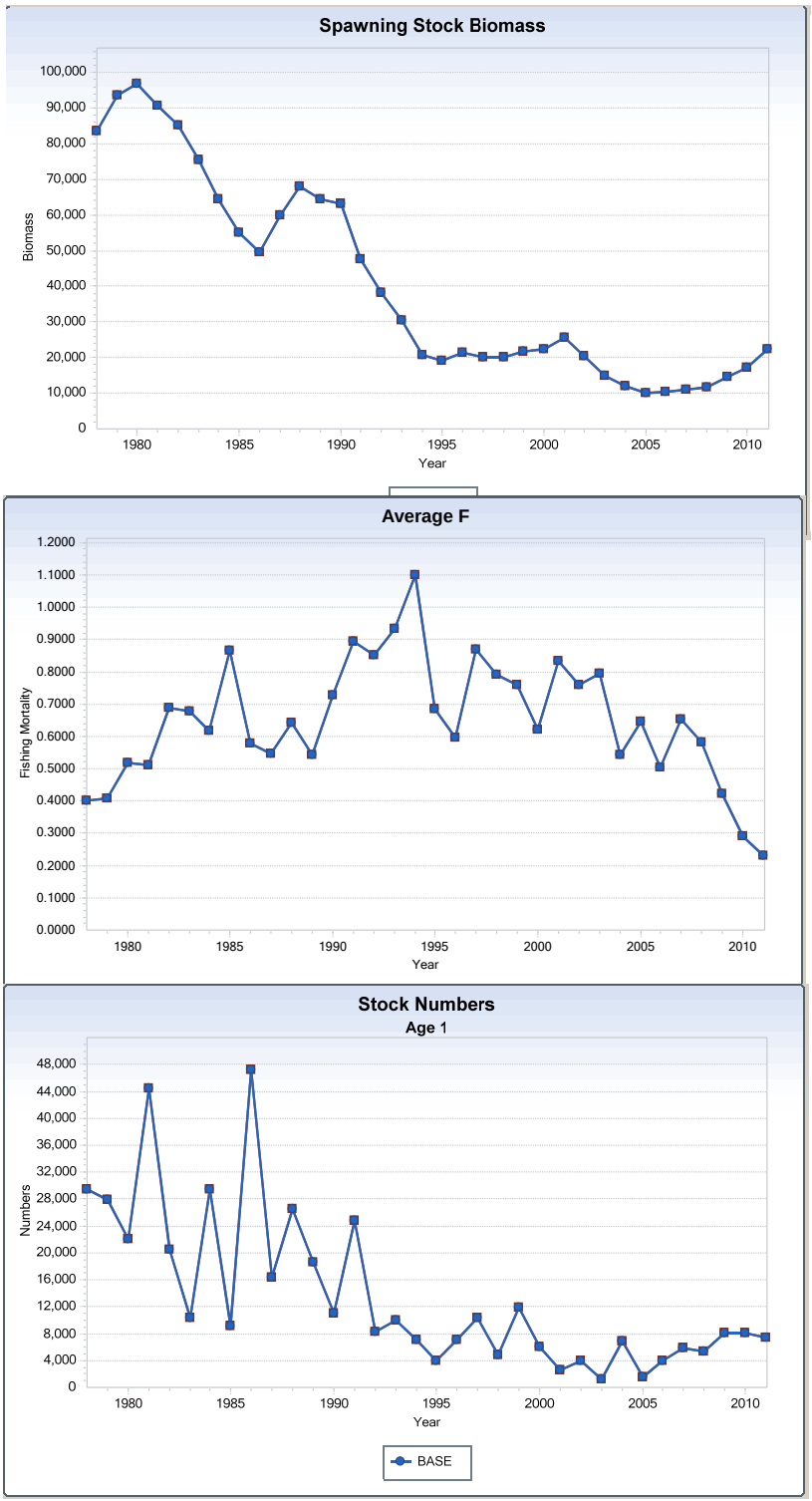


Figure B51a. BASE ASAP model results for spawning stock biomass,fishing mortality (ages 5-8), and recruitment (age 1, 000s), 1978-2011.

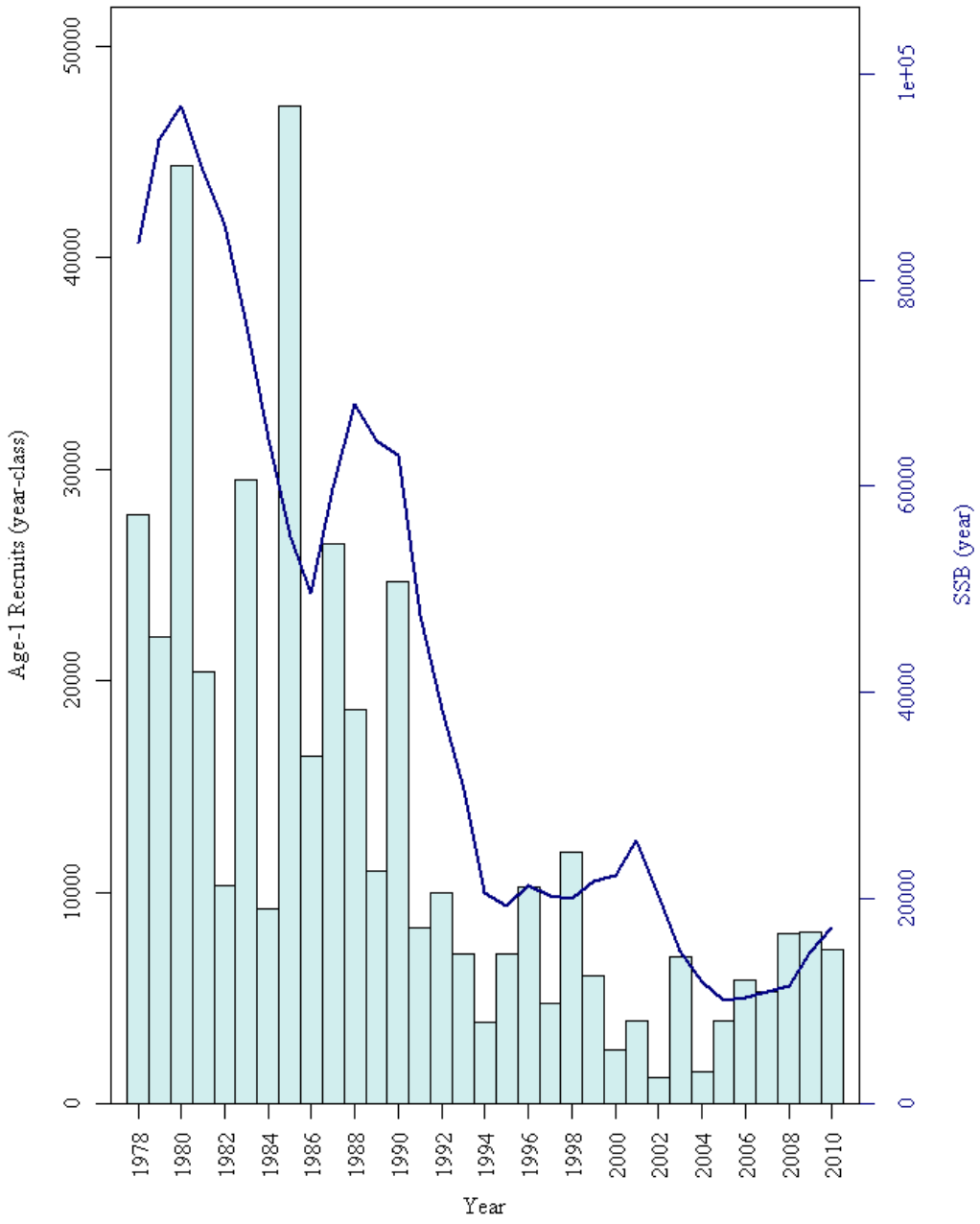


Figure B51b. BASE ASAP model results for spawning stock biomass and recruitment (age 1, 000s), 1978-2011.

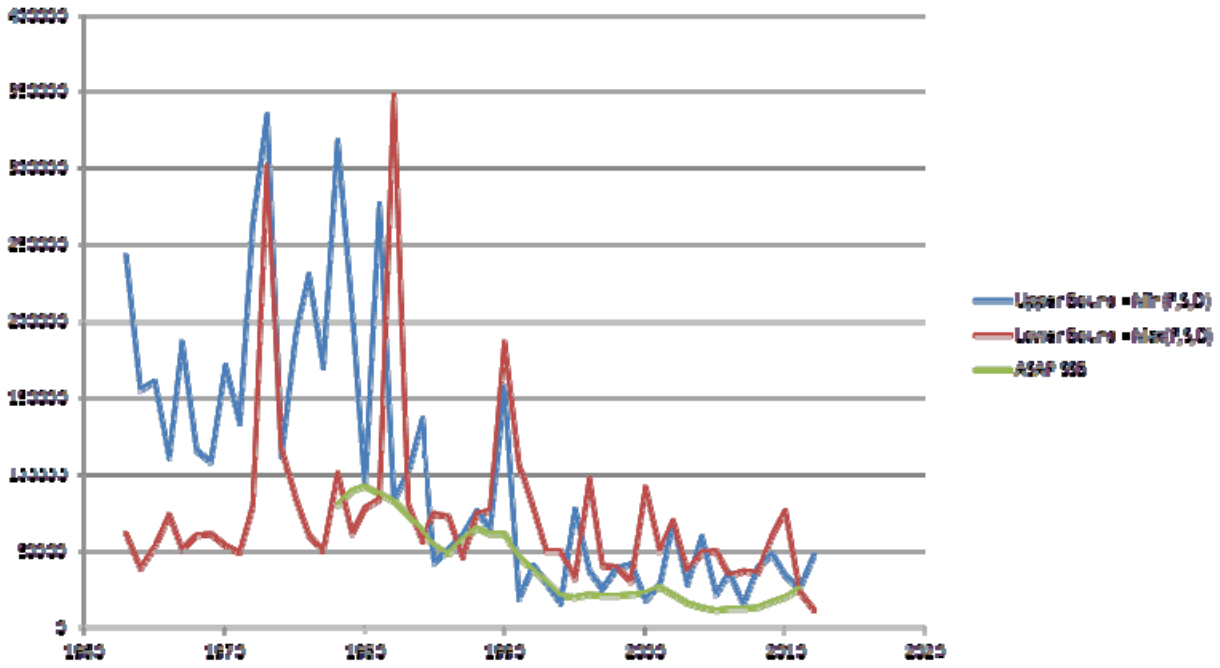


Figure B51c. Upper and lower bound estimates of total biomass from 'envelope analysis' with BASE ASAP spawning stock biomass estimate.

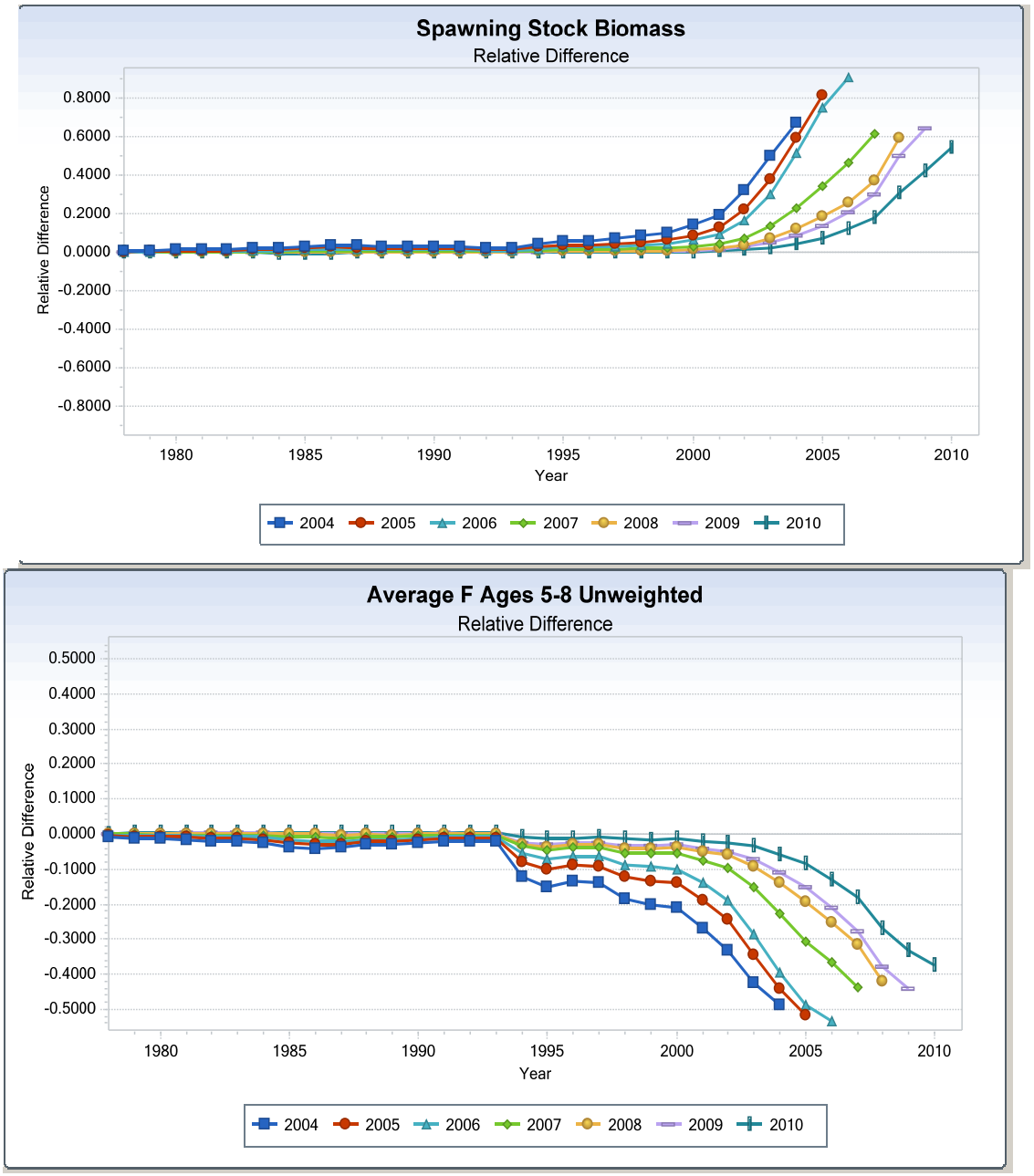


Figure B52. Retrospective bias of spawning stock biomass (SSB) and fishing mortality from BASE ASAP model. Retrospective rho for SSB = 0.681 and for F= -0.459.

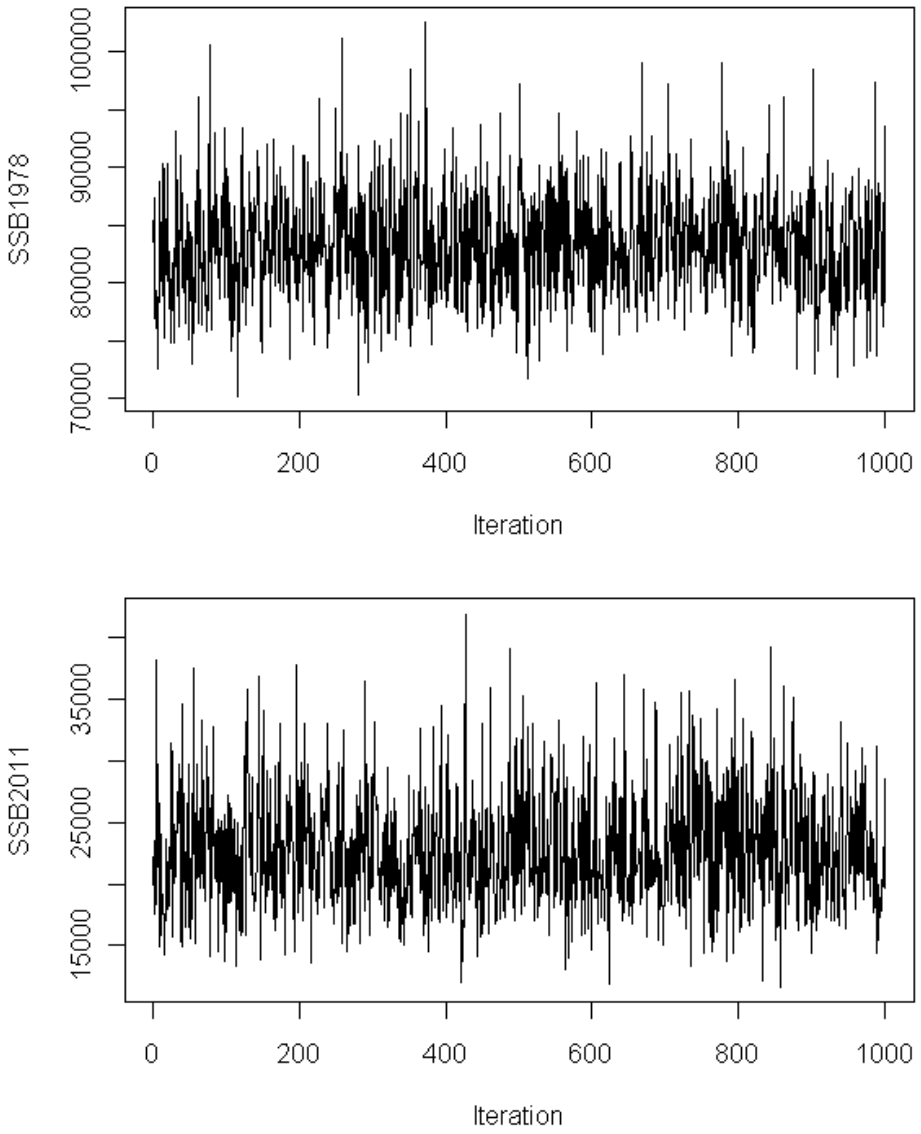


Figure B53. BASE ASAP trace of MCMC chains for Georges Bank Atlantic cod 1978 and 2011 spawning stock biomass. Each chain had initial length of 2,500,000 and was thinned at a rate of one out of every 2,500th resulting in a final chain length of 1000.

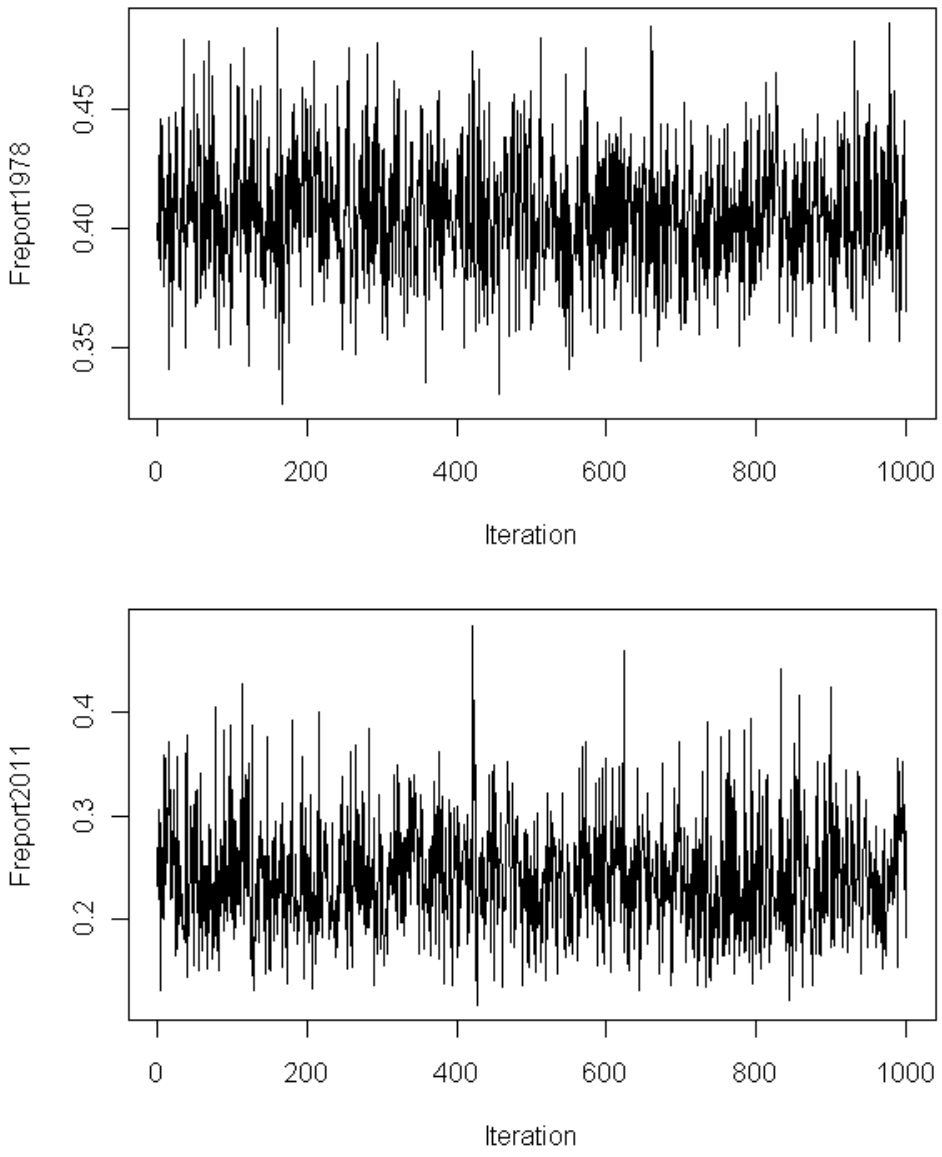


Figure B54. BASE ASAP trace of MCMC chains for Georges Bank Atlantic cod 1978 and 2011 fishing mortality (average 5-8). Each chain had initial length of 2,500,000 and was thinned at a rate of one out of every 2,500th resulting in a final chain length of 1000.

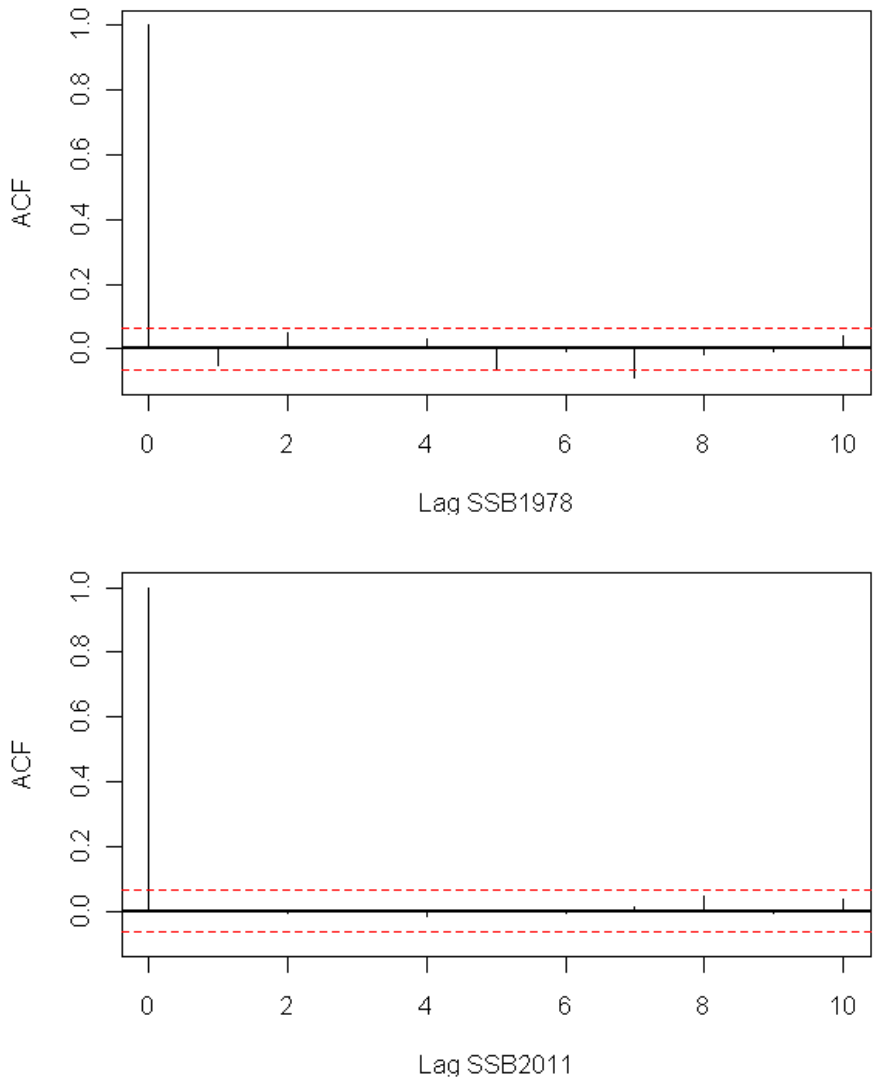


Figure B55. Autocorrelation within the 1978 and 2011 Georges Bank Atlantic cod spawning stock biomass (SSB) MCMC chains from the BASE ASAP model.

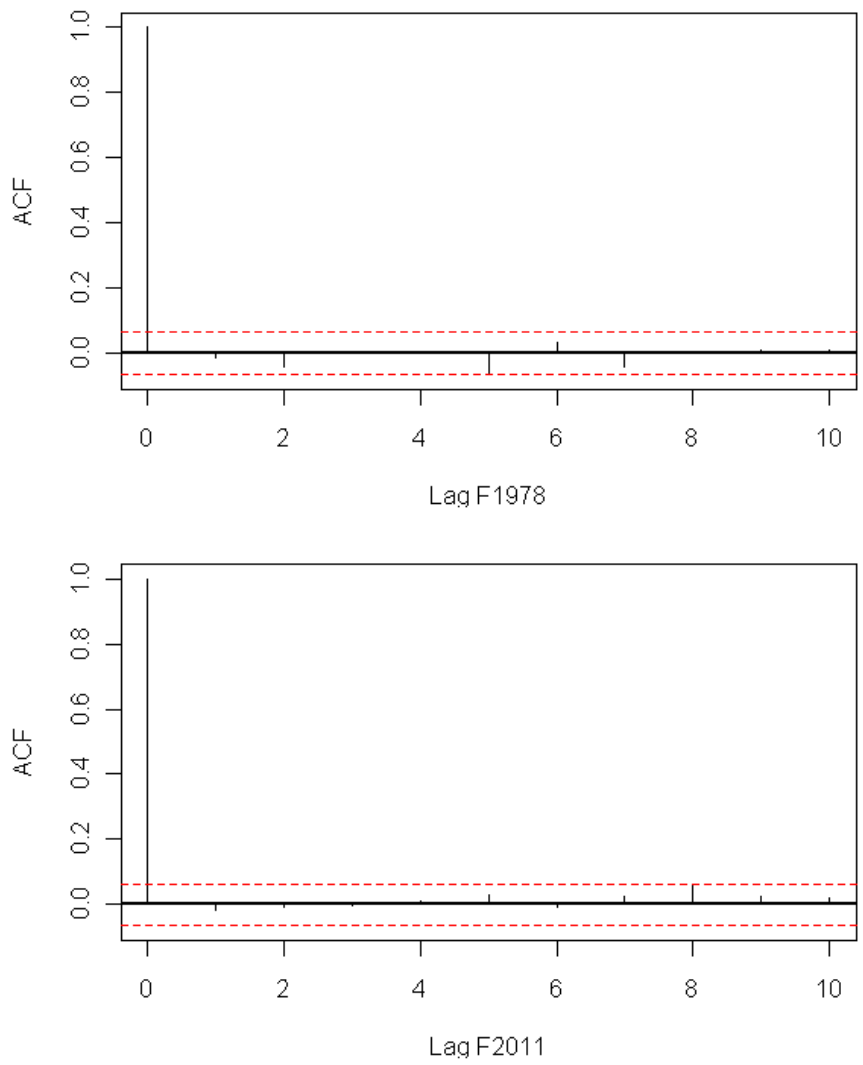


Figure B56. Autocorrelation within the 1978 and 2011 Georges Bank Atlantic cod fishing mortality (average, ages 5-8) MCMC chains from the BASE ASAP model.

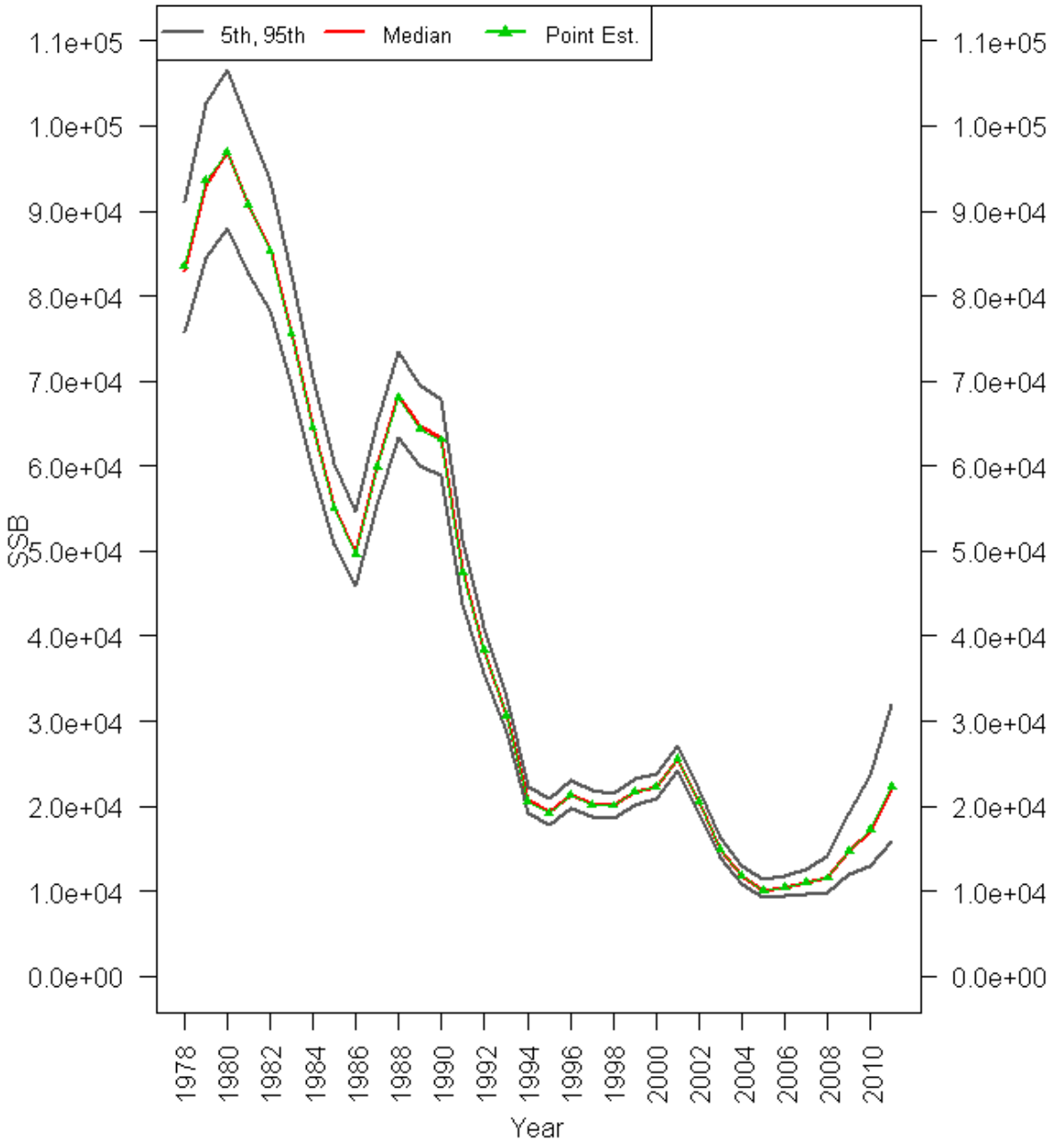


Figure B57. A 90% probability interval for Georges Bank Atlantic cod spawning stock biomass from the BASE ASAP model. The median value is in red, while the 5th and 95th percentiles are in dark grey. The point estimate from the base model (joint posterior modes) is shown in the thin green line with filled triangles.

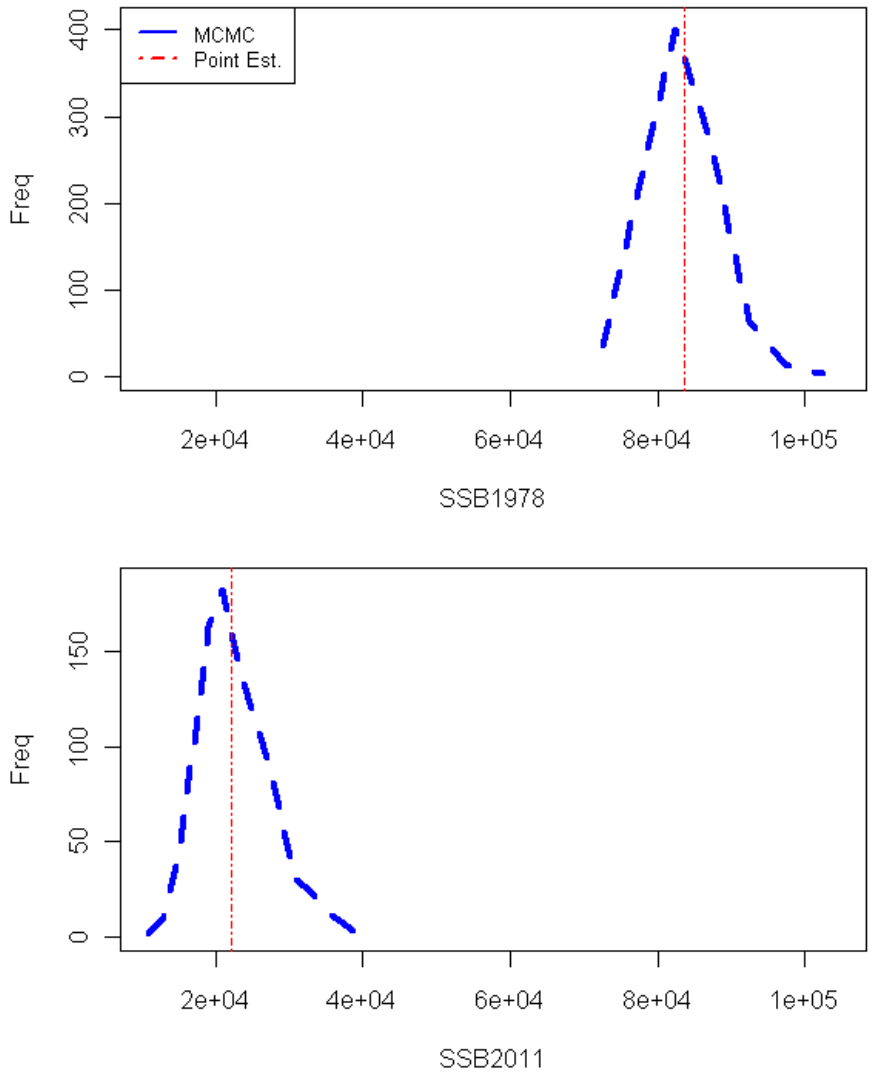


Figure B58. MCMC distribution of Georges Bank Atlantic cod spawning stock biomass in 1978 and 2011 estimated from the BASE ASAP model. The model point estimate is indicated by the dashed red line.

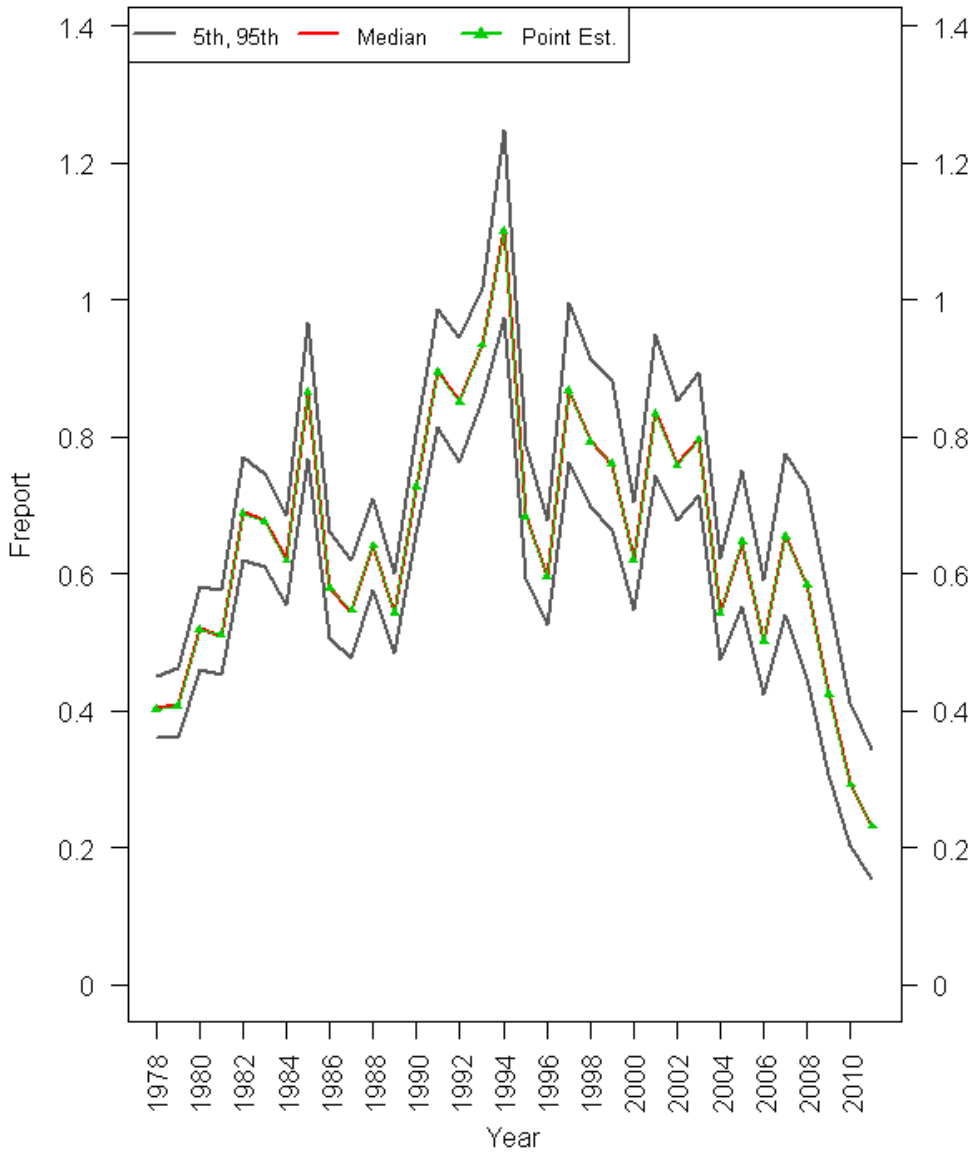


Figure B59. A 90% probability interval for Georges Bank Atlantic cod fishing mortality (average ages 5-8) from the BASE ASAP model. The median value is in red, while the 5th and 95th percentiles are in dark grey. The point estimate from the base model (joint posterior modes) is shown in the thin green line with filled triangles.

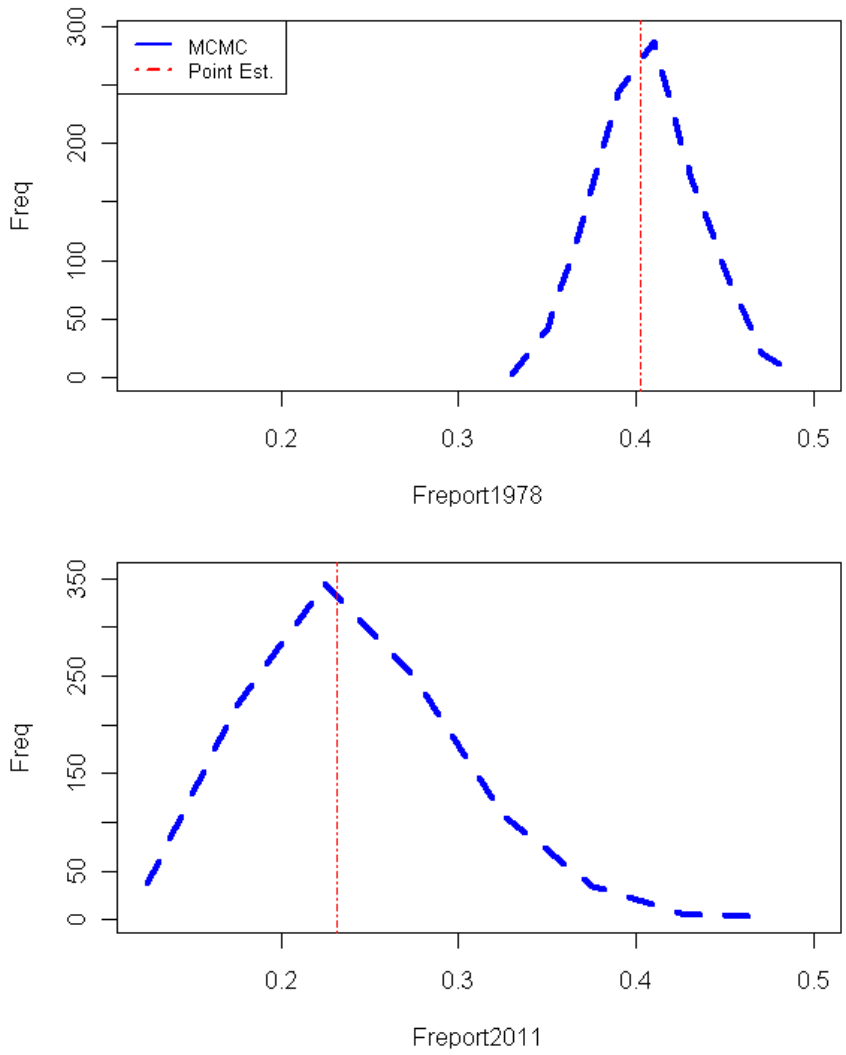


Figure B60. MCMC distribution of Georges Bank Atlantic cod fishing mortality (average ages 5-8) in 1978 and 2011 estimated from the BASE ASAP model. The model point estimate is indicated by the dashed red line.

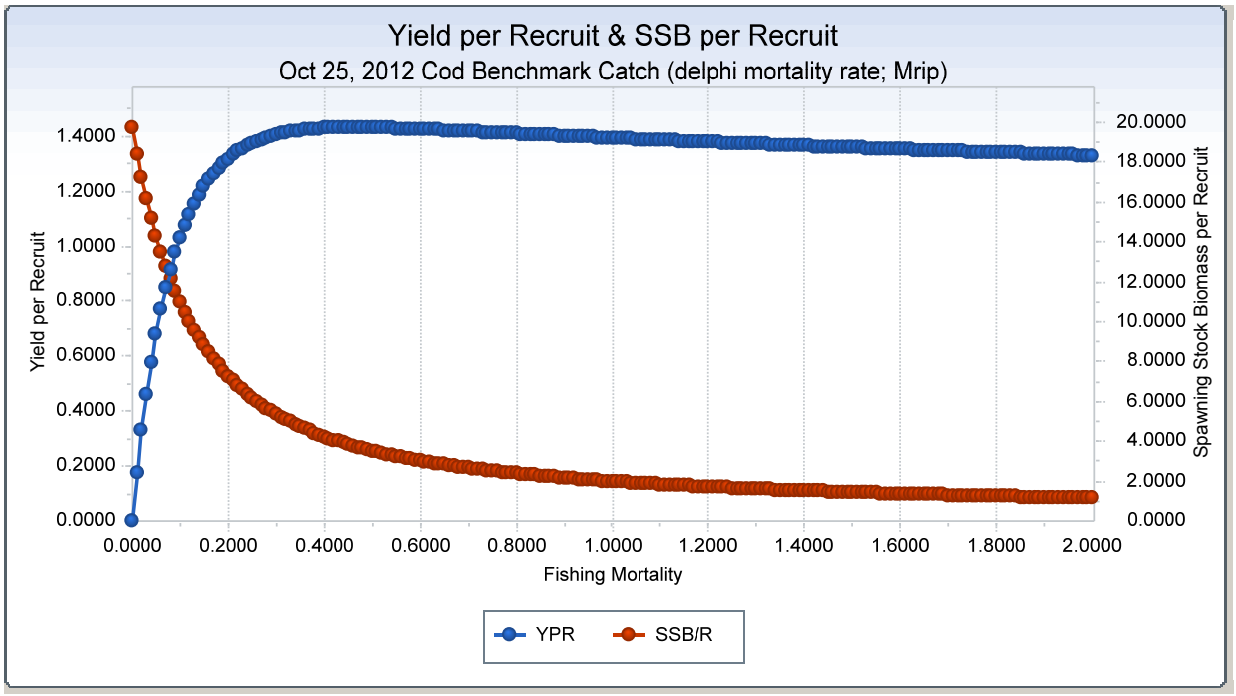


Figure B61. Yield- and Spawning Stock Biomass per-recruit analysis for Georges Bank Atlantic cod . $F_{0.1}$ =0.18 , F_{max} = 0.46 and $F_{40\%}$= 0.18.

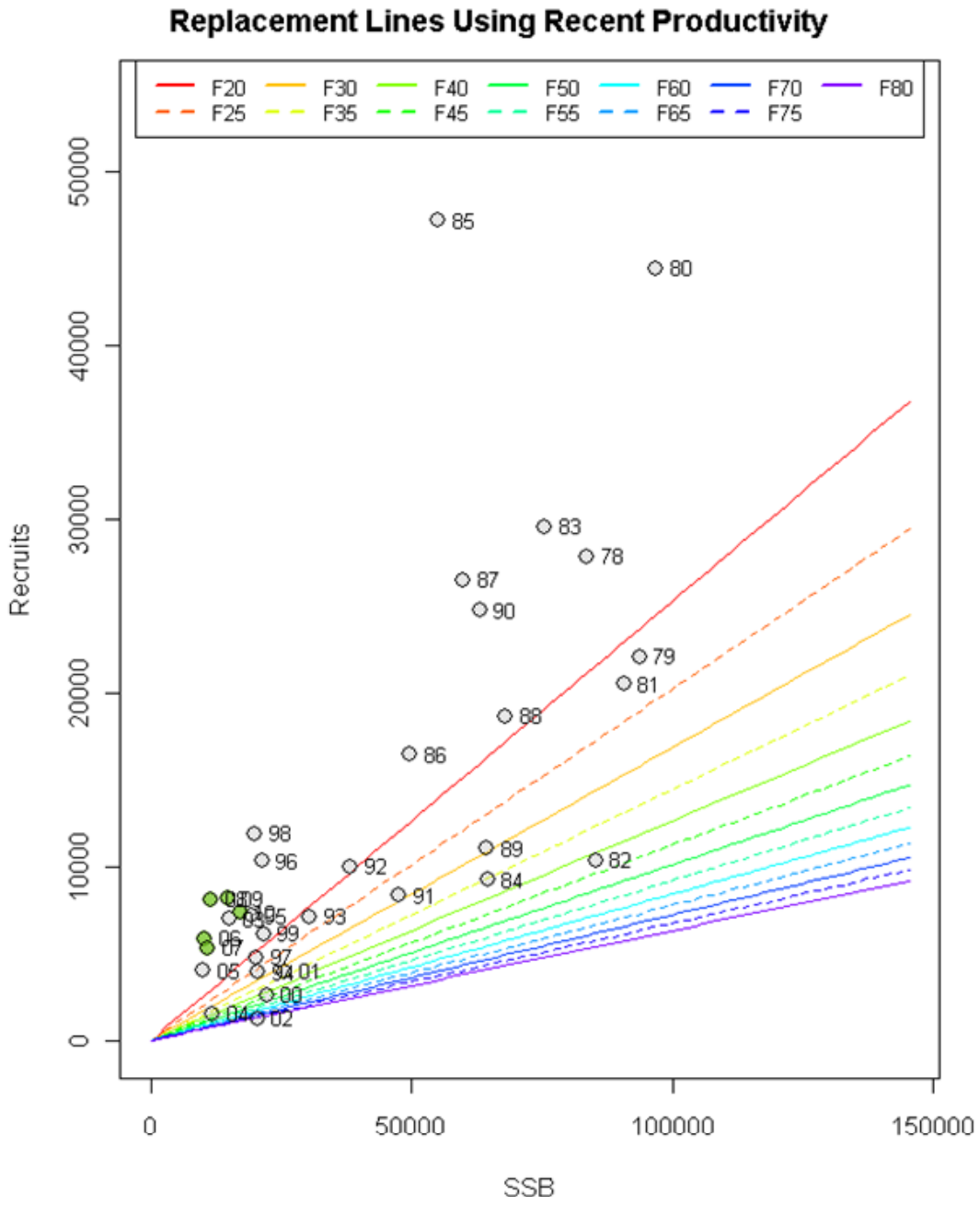


Figure B62. Replacement lines using recent productivity from the BASE ASAP model results for a range of fishing mortalities for Georges Bank Atlantic cod, 1978-2011.

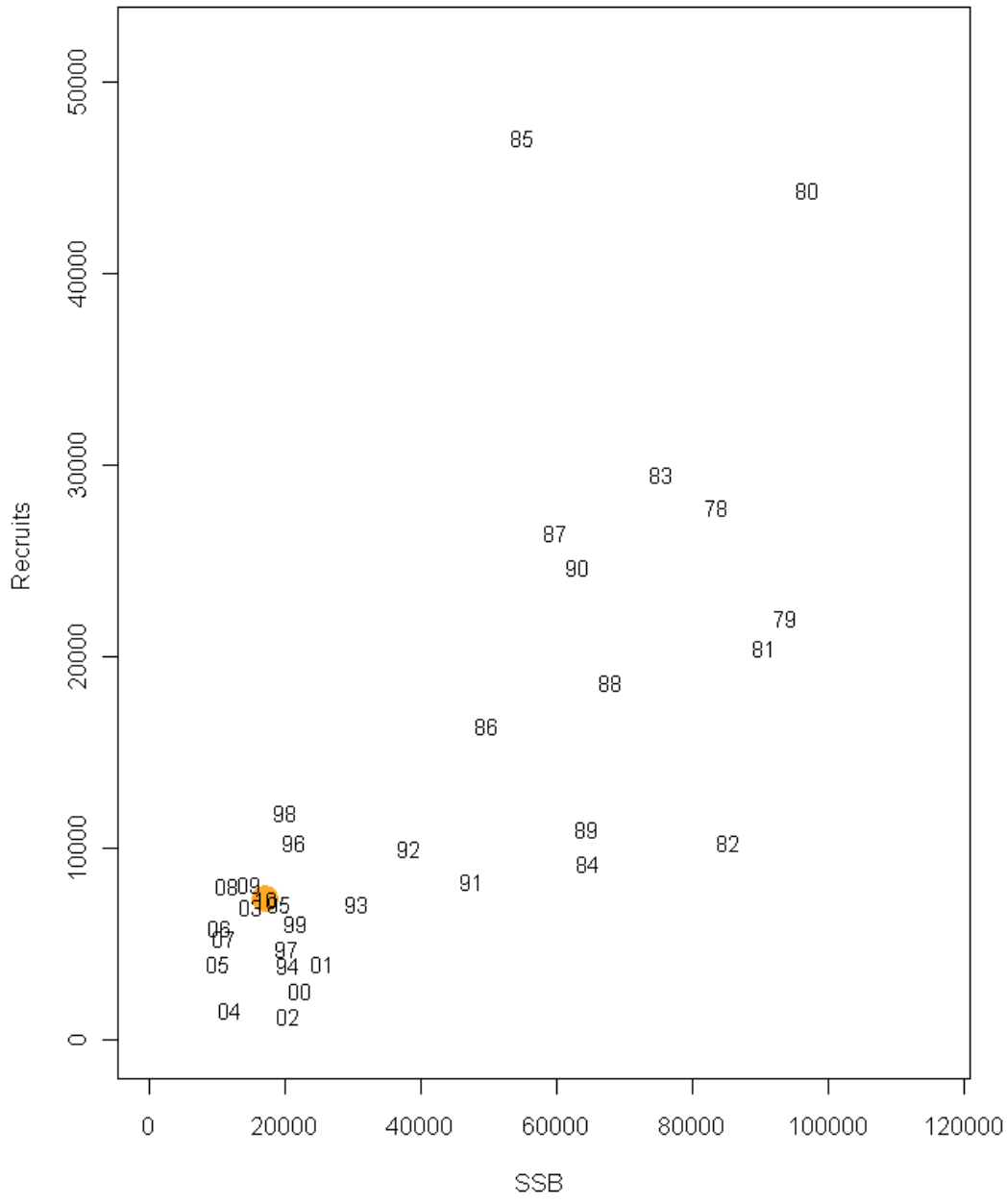


Figure B63. BASE ASAP spawning stock biomass – age 1 recruitment for Georges Bank Atlantic cod, 1978-2011.

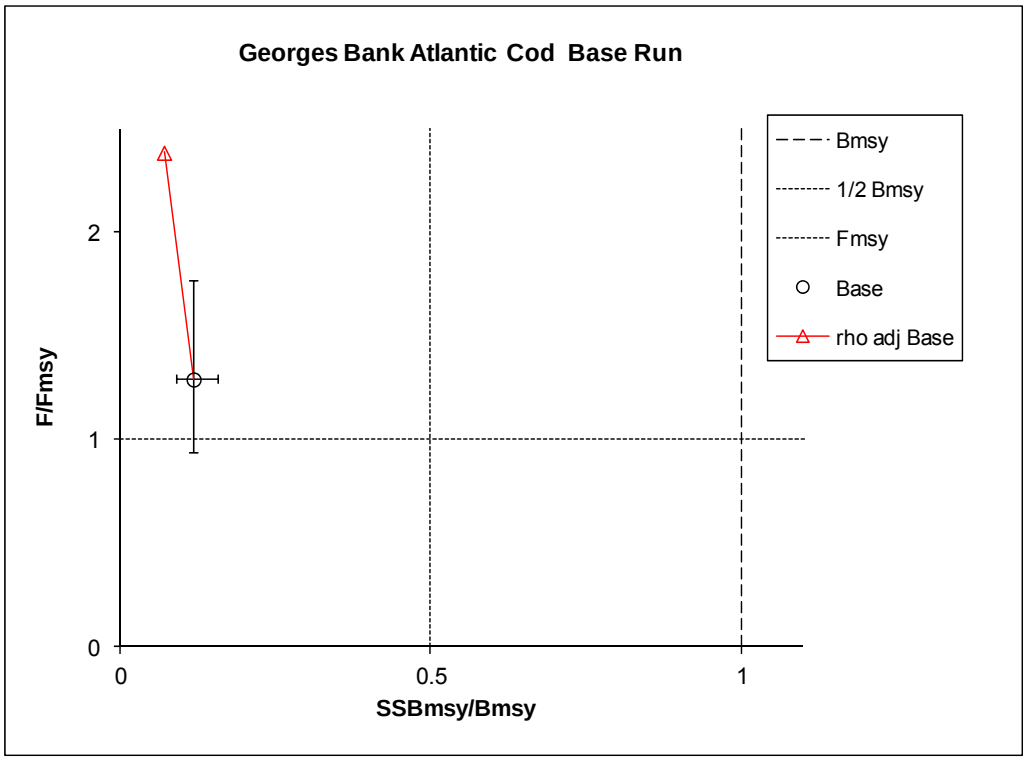


Figure B64. Status of 2011 fishing mortality (F) and spawning stock biomass (SSB) of Georges Bank Atlantic cod relative to F_{MSY} and SSB_{MSY} from ASAP BASE model results.