Northeast Fisheries Science Center Reference Document (in review)

2014 Operational Assessments for

Georges Bank Winter Flounder, Gulf of Maine Winter Flounder, Pollock

by

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Preface

This document represents the findings of an Operational Assessment of Georges Bank winter flounder, Gulf of Maine winter flounder, and Pollock. The meeting was held August 11-13, 2014 at the Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA. The Terms of Reference, following the guidance of the Assessment Oversight Panel, are restricted to updating the catch and survey data for each stock and application of the model used in the last benchmark assessment. For these assessments there were no changes in the previously used model formulation.

The values of biological reference points were updated in response to revised estimates of average weights at age, maturity at age, selectivity, and recruitment, but the basis of the reference points was unaltered. The review panel provided commentary on the implementation of the Operational Assessment for each stock and also provided comments on the process itself. Their conclusions are included in their entirety as part of this report.

I wish to thank the assessment scientists and colleagues in the Population Dynamics Branch for their efforts to implement the operation assessments of these three stocks. I also thank the review panel and especially the Chair, for their timely and insightful reviews. This document is part of an overall program to streamline the stock assessment process and provide more timely information to the New England and Mid Atlantic Fishery Management Councils. I thank the executive staff of the NEFMC for their efforts to identify, coordinate and support the peer review panel.

This report will become a Center Reference Document and published by the NEFSC. The reports herein have been checked for accuracy but there may be minor editorial and formatting changes before these reports are finalized. However, the reports have been peer reviewed for scientific content and should be considered sufficient for providing scientific advice. Any formatting problems associated with the merging of the individual reports are my responsibility and will be corrected when this report is finalized by the Center.

Paul Rago, Chief
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October 5, 2014

A_Georges Bank Winter Flounder – Review Panel Summary

The panel and workshop participants reviewed a draft report that updated the stock assessment using the methods from SAW52 (NEFSC 2011) with fishery data through 2013 and survey data through spring 2014. The panel identified some new research publications that were not available at SAW52. Although those publications were not reviewed by all participants, the Panel evaluated SAW52 data and model decisions in the context of new research. The panel requested additional sensitivity projections, minor additions to the report and revisions of the draft text, and recommended some topics for the research track.

Terms of Reference

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

The panel confirmed that there were no changes to the data protocols or modeling methods developed for SAW52. The data patterns recognized at SAW52 continued. Data quality improved since the last assessment. For example, precision of the U.S. discards and precision of the US landings improved during 2011-2013. US catches continued to be well-sampled, but similar to SAW52, no length or age samples were available for the Canadian fisheries and no age data were available from the Canadian spring surveys. Since 2006, most catch has continued to come from statistical area 522, Cultivator Shoals. Although recent survey trends were somewhat inconsistent among surveys (e.g., increasing NEFSC spring survey indices during 2012-2014, but fluctuating NEFSC fall and Canadian survey indices), age compositions of all three surveys showed expansion of age structure since 2009. The Panel also noted that the decreasing trend in weight-at-age continued during 2010-2013, and that this trend is common among several species in the region, possibly a result of warming temperatures.

The Panel requested information on statistical distribution (e.g., proportion of positive tows) and geographic distribution of recent NEFSC survey data. The GARM III assessment (NEFSC 2008) reported survey distributions through 2007. The statistical distribution of the Bigelow survey should be different from the Albatross survey, because of increased catchability. Therefore, the Panel requested distributional information for the entire Bigelow series (2009-2013).

The assessment update assumed 100% discard mortality as in previous assessments. At GARM III (NEFSC 2008), a review of the existing discard mortality rate studies for Northeast groundfish stocks was conducted and it was decided that discard mortality rates would be set at 100% unless an adequate discard mortality study was available to do otherwise. The Panel recommends that the results of a recent discard mortality study by Barkley and Cadrin (2012) and any other relevant discard mortality studies be considered during the next benchmark assessment.

Recently published information on stock structure confirms SAW52 conclusions about stock definition. An interdisciplinary review of winter flounder stock structure (DeCelles and Cadrin 2011) found that the Georges Bank stock definition was supported by an examination of life history traits, seasonal movement patterns as indicated by tagging, parasite characteristics and meristics. However, they also concluded that there is some uncertainty regarding the stock structure of winter flounder in the Great South Channel and on Nantucket

Shoals, which is close to the western boundary of the Georges Bank management unit, and further research is needed to examine the stock identity of these individuals. Wirgin et al. (2014) used microsatellite DNA analysis of young-of-the year and adult winter flounder collected throughout the range of the species to conclude that winter flounder from Georges Bank was marginally distinct from the inshore collections from the Gulf of Maine and Southern New England/Mid-Atlantic stocks, but the genetic differences were less pronounced than would have been expected based on the differences in life history characteristics that have been reported. On a related topic, the Panel discussed the use of survey data from stratum 23 (in the Great South Channel), which was well justified by SAW52.

Recent publications also confirm the SAW52 method for deriving maturity at age from moving averages of macroscopic data. McBride et al. (2013) compared maturity assignment by macroscopic and microscopic methods and demonstrated that results from both methods were compatible for Georges Bank winter flounder, justifying the continued use of macroscopic data. McElroy et al. (2013) found skipped spawning of winter flounder, but did not observe skipped spawning in Georges Bank samples, so that macroscopic maturity is not a biased approach to determining maturity. Winton et al. (2014) found greater variation in size- and age-at-maturity within than between existing stock areas, justifying the use of a moving average.

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

The panel confirmed that there were no changes to the VPA methodology developed for SAW52 for the updated assessment. The updated model fit was similar to the SAW52 application, with patterns in survey residuals. The Panel questioned the equal weighting of survey indices, but was satisfied that VPA results were relatively insensitive to the alternative weightings considered by SAW52.

The retrospective pattern of the updated assessment was worse than the SAW52 assessment, with a tendency for SSB to decrease as data are added, and for F to increase as data are added. The retrospective-adjusted estimates of SSB and F are just within the 90% confidence limits of the unadjusted point estimates of SSB and F. Based on the criteria developed by GARM III (NEFSC 2008), , retrospective adjustments should not be applied. However, the panel noted that the retrospective pattern is worth considering as a source of uncertainty (approximately 20% for SSB and F). The panel noted that a retrospective pattern is a nonrandom error, whereas bootstrapped confidence limits of point estimates quantify random errors. The panel discussed the possibility of estimating bootstrap confidence limits for retrospective-adjusted F and SSB.

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

The Panel confirmed that the updated assessment includes the information needed to recommend ABC (e.g., stock status, stochastic projections at F_{MSY}, projections and 75%F_{MSY} and stochastic rebuilding projections). Although the bootstrap analysis quantifies much of the uncertainty in the assessment, the Panel also suggested that the emergence of a retrospective pattern in the updated assessment should be considered in the evaluation of uncertainty.

Although Canadian catch has been a small portion of the total catch, Canadian catch is not explicitly accounted for in the determination of the US catch limit. The Panel suggests that the PDT consider recommending that Canadian catch be considered somehow in the US Annual Catch Limit to account for all removals.

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

The SAW52 method of deriving F_{MSY} based on a stock-recruitment relationship assuming fixed steepness (h=0.78) was updated. The updated estimate of F_{MSY} is 0.44, slightly greater than the SAW52 estimate of 0.42. The long-term projection method developed at SAW52 was also updated and produced an estimate of SSB_{MSY}=8,100 mt, which is considerably less than the SAW52 estimate (11,800 mt). The Panel concluded that the revised estimates of MSY reference points were appropriate because of continued reductions in weight-at-age and the updated 3-year moving window of maturity-at-age and fishery selectivity.

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

The Panel accepts the stock status determined by updated VPA results (2013 F=0.30, 2013 SSB=6,950 mt) and updated MSY reference points (F_{MSY}=0.44, SSB_{MSY}=8,100 mt). Therefore, the stock was not overfished or experiencing overfishing in 2013.

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

Short-term projections assuming 75%F_{MSY} did not achieve the rebuilding target of SSB_{MSY} by 2017 with 75% probability. Therefore, $F_{rebuild}$ was iteratively derived as 0.27.

The Panel recognized that SAW52 projections indicated that the stock should have been rebuilt, with 78% probability by 2012 and 93% probability by 2017, based on an SSB_{MSY} of 11,800 mt and fishing at 75% of F_{MSY} (=0.315), during 2012-2017, with an assumed catch of 2,118 mt in 2011. The 2011-2013 U.S. catches were similar to SAW52 projections, so the apparently slower rebuilding is primarily a result of the retrospective pattern (i.e., decreased estimates of 2011 abundance from the updated assessment) and reduced weight-at-age in recent years. Therefore, if the retrospective pattern continues, the updated projections will also be optimistic. The Panel recommends that a sensitivity projection with retrospective adjustment be provided by the PDT. The Panel recommended that performance of all groundfish projections should be evaluated in the 2015 assessment updates, similar to the evaluations provided by the 2012 update assessments (NEFSC 2012).

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

The Panel recommends that a statistical catch at age model should be considered at the next benchmark assessment of Georges Bank winter flounder. A statistical catch at age model could estimate stock-recruitment relationships and MSY reference points within the model and include information on stock productivity before 1982.

The Panel recommends that the criterion for retrospective adjustment should be re-considered in a research track assessment. Specifically, incorporating retrospective inconsistency and adjustment in the bootstrap analysis might be a more statistically appropriate approach.

The Panel also noted that the approach of fixing steepness in the estimation of F_{MSY}, and the relationship between steepness and natural mortality should be considered for a research track topic.

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

The panel concluded that the updated assessment is a reliable basis for fishery management and alternative approaches are not necessary at this time.

References

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A. Update of the Georges Bank Winter Flounder Stock Assessment through 2013

Terms of Reference

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

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

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

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

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

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

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

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

1.0 Background

Winter flounder on Georges Bank reach a maximum age of 19 years and fish on Georges Bank reach larger sizes and have much faster growth rates than the Gulf of Maine and Southern New England/Mid-Atlantic stocks (NEFSC 2011a).

A portion of the Georges Bank stock (2-17% of the total catch during 2004-2013) is not regulated by the U.S., yet is susceptible to fishing (i.e., incidental catches) by the Canadian scallop dredge and groundfish bottom trawl fleets. Winter flounder discards in the latter fleet are unknown and the precision of the estimated discards from the scallop dredge fleet are unknown because observer sampling coverage is very low; one trip per month during 2004-2007 and two trips per month during 2008-2013.

The Georges Bank winter flounder stock was most recently assessed in June, 2011 at SAW/SARC 52 (NEFSC 2011a; NEFSC 2011b) using an ADAPT Virtual Population Analysis (VPA) model (Gavaris 1988) that included U.S. and Canadian catch-at-age data (ages 1-7+) for 1982-2010, M = 0.3, and a maturity schedule based on a three-year moving window that incorporated data from 1981 to 2010. The VPA model was tuned with minimum population size estimates derived from NEFSC spring (ages 1-7+, 1982-2010) and fall bottom trawl surveys (1981-2009, ages 0-6 lagged forward one year and age) and Canadian spring bottom trawl surveys (ages 1-7+, 1987-2010). Model diagnostics indicated trends in residuals patterns for a number of ages for each of the three tuning indices, with variability by age and year. Retrospective patterns for terminal year estimates of fishing mortality and spawning stock biomass, during 2001-2009, were considered very mild and did not require adjustment. There was no retrospective pattern for terminal year estimates of age-1 recruitment, but terminal year estimates were highly variable.

The existing biological reference points (BRPs) were estimated during SARC 52. FMSY (= 0.42) was estimated from a Beverton-Holt stock-recruitment model with an unfished steepness parameter that was fixed at 0.78. SSBMSY (= 11,800 mt) and MSY (= 4,400 mt) were estimated as the median values from a 100-year stochastic projection with an assumed constant harvest rate of 0.42, the FMSY value from the Beverton-Holt model, and 2006-2010 averages of the proportions mature-at-age, mean weights, and fishery selectivity patterns-at-age. Based on the SARC 52 BRPs, the stock was not overfished and overfishing was not occurring in 2010. However, the stock was subject to a rebuilding plan with a regulatory requirement for rebuilding to SSBMSY, with at least 75% probability, by 2017. Under the assumptions of the stochastic projection conducted for 2011-2017, the stock was predicted to be rebuilt by 2012 with 78% probability and by 2017 with 93% probability.

2.0 Fisheries

Commercial Landings

Statistical Areas used for reporting commercial fishery data for the Georges Bank winter flounder stock include: 522-525, 542, 551-552, and 561-562 (Figure A1). There is no recreational fishery for the stock. Commercial landings data were available for 1964-2013 and the data collection methodology changes are discussed in SARC 52 assessment (NEFSC 2011a). Since 1964, total landings have been predominately from the U.S groundfish trawl fleet, but landings have also been reported for the Canadian groundfish trawl fisheries, as bycatch in the haddock and cod fisheries (Heath Stone pers. comm.). During 1965-1977, landings were also reported by the former USSR andreached a peak of 1,699 mt in 1972 (Table A1, Figure A2). Canadian landings generally comprised a low percentage (1-2 %) of the total landings until 1994, at which time Canadian landings increased rapidly from 6 % of the total to a peak of 24 % in 2001 (529 mt). The increasing trend in Canadian landings occurred primarily during the second half of the year because, since 1994, Canadian groundfish fisheries on Georges Bank have, for the most part, been closed during January-May (Van Eeckhaute and Brodziak 2005). After 2001, Canadian landings declined rapidly to 1% in 2007 (12 mt) and ranged between 1% and 4% of the total landings during 1982-2013.

Total landings increased during 1964-1972, reaching a peak of 4,509 mt in 1972, then declined to 1, 892 mt in 1976 (Figure A2, Table A1). A sustained period of high landings occurred during 1977-1984, ranging from 3,061-4,009 mt. After 1984, landings gradually declined to the lowest level in the time series, 783 mt in 1995, but then increased again to 3,139 mt in 2003. Thereafter, landings declined rapidly and reached the second lowest level on record in 2007 (807 mt). During 1982-2013, total landings averaged 1,948 mt and were slightly below average in 2013 (1,687 mt).

Most of the U.S. landings (92-100%) are harvested with bottom trawls and most of the remainder is harvested by the scallop dredge fleet (Table A2). During most years since 1982, landings harvested by the scallop dredge fleet comprised less than 1% of the total U.S. landings. However, a high period of landings by the scallop dredge fleet (4-8% of the total landings) occurred during 1988-1993 and in 2005-2006 (6% and 3%, respectively, of the total landings).

The spatial distribution of winter flounder landings on Georges Bank has largely been affected by complex management regulations. During 1982-1993, prior to the implementation of groundfish Closed Areas I and II (Figure A3), most of the Georges Bank landings of winter flounder were taken in the two northern SAs, 522 and 562. Since 1994, portions of the four SAs where most of the landings occur (522, 525, 561 and 562) have been closed, for the most part, to groundfish bottom trawl fishing (Figure A4). During 1994-2001, most of the landings occurred in SA 522 (37-69%), but then shifted to SA 562 during 2002-2005, where 38-54% of the landings occurred (Figure A4). With implementation of the Eastern (SAs 561 and 562) and Western US/CA Areas (SAs 522 and 525) in May of 2004, which was linked to the establishment of total allowable catches (TACs) for cod, haddock and yellowtail for the US versus CA within their respective EEZs, landings began increasing again in SAs 522 and 525. The shift in where the predominant landings occurred (from the Eastern to the Western U.S./CA Area), after 2004, may have been attributable, in part, to the 2005 requirement to use a haddock separator trawl when fishing in the Eastern U.S./CA Area as well as closures of this Area when cod, haddock or yellowtail quotas were reached. The haddock separator trawl was designed to catch haddock but to reduce incidental catches of other demersal finfish species. During 2006-2013, most of the landings occurred in SA 522 (Figure A4).

Precision (Proportional Standard Error, reported as a %) of the U.S. landings, due to allocation of the landings to Statistical Area using Vessel Trip Reports, averaged 0.9% during 1995-2013 and was much lower during 2012 (0.3 %) and 2013 (0.5%, Table A3).

Discards

U.S. Fisheries

U.S. discard estimates were updated for 2011-2013 using data from the Northeast Fisheries Observer Program (NEFOP) Database and the Commercial Fisheries Database, for the large-mesh bottom trawl (codend mesh size >= 5.5 inches), small-mesh bottom trawl (codend mesh size < 5.5 inches), and sea scallop dredge fleets (Table A4 and Figure A5), according to the combined ratio method (Wigley et al 2008) used in the previous Georges Bank winter flounder stock assessment (NEFSC 2011a).

U.S. discards of Georges Bank winter flounder were much higher during 1964-1991 (average = 195 mt) than during 1992-2013 (average = 70 mt). During 1964-1975, U.S. discards were predominately (49-87%) attributable to the large-mesh groundfish trawl fleet (listed in Table A4 as the small-mesh fleet because the minimum codend mesh size prior to 1982 was less than 5.5 in.), but were primarily attributable to the scallop dredge fleet thereafter. Total U.S. discards, primarily from the scallop dredge fleet, were highest during 1976-1991 (ranging between 142 mt and 348 mt), but then declined to a very low level in 1992 (Table A4, Figure A5). This trend follows the trend in fishing effort (days fished) for the U.S. scallop dredge fleet (NEFSC 2010). After 1991, discards were lower and continued to track the trend in scallop fleet fishing effort. During 1992-2003 discards were low, between 9 and 85 mt, but thenincreased to 188 mt in 2007. U.S. discards of winter flounder declined from 138 mt in 2010 to 47 mt in 2013 (Table A4). During most years since 2005, when trip sampling rates increased substantially in the scallop dredge and large-mesh bottom trawl fleets, precision of the U.S. discard estimates greatly improved (averaging 0.15 during 2005-2013) and was lowest during 2011-2013, ranging between 0.07 and 0.11 (Table A4).

Canadian Fisheries

The Canadian sea scallop fishery operating with dredges on the Canadian portion of Georges Bank closes when the annual TAC is caught. There are two Canadian sea scallop management areas on Georges Bank (based on depth and productivity) with different TACs. Landings of groundfish bycatch in the sea scallop fishery have been prohibited since 1996, so presumably all winter flounder bycatch in the fishery is discarded. Observer coverage of the scallop dredge fleet has been very low and has consisted of one trip per month during 2004-July of 2007 and two trips per month thereafter. Observer discard data for winter flounder caught in the Canadian sea scallop fishery were only available for September 2004-December 2013 and discards were estimated by staff from the CA Division of Fisheries and Oceans (DFO) using the method of Garvaris and VanEeckhaute (2007). The 2004-2010 average of the proportions of Georges Bank winter flounder discards to sea scallop landings by the Canadian scallop fleet (0.029) was multiplied by the sea scallop landings in the Canadian scallop fleet (CSAS 2010; J. Sameoto, pers. comm. 2011) in order to obtain hindcast winter flounder discard estimates for 1982-2003.

Winter flounder discards in the Canadian sea scallop fishery averaged 128 mt during 2004-2013 and declined between 2009 and 2013, from 252 mt to 29 mt, respectively (Table A1). Hindcast discard estimates for the fleet during 1982-2003 ranged between 58 and 199 mt. The associated precision of the discard estimates is unknown.

Estimates of winter flounder discards in the Canadian bottom trawl fisheries were not available from the CA DFO. Since most of the Canadian landings of Georges Bank winter flounder occur as bycatch in bottom trawl fisheries targeting haddock and cod in (H. Stone pers. comm.), presumably some winter flounder discards also occur in these fisheries, and possibly other, bottom trawl fisheries that operate on Georges Bank. Since the mid-1980's, discarding of groundfish in the Canadian groundfish fisheries on Georges Bank (NAFO Division 5Zj) has been prohibited. However, although there is no discarding of groundfish during observed trips, observer coverage of the groundfish bottom trawl fleet is very low and there is no doubt that discarding of winter flounder occurs because discards for species that are more highly sought after in the Georges Bank Canadian groundfish fisheries (e.g., cod, haddock and yellowtail flounder) have been estimated (Gavaris et al. 2010).

Total Discards

During 1982-2013, discards of winter flounder on Georges Bank were higher in the U.S. fisheries prior to 1991 and higher in the Canadian scallop dredge fishery thereafter (Figure A6). Total discards were much higher during 1982-1991, than thereafter, but total discards slowly increased from 59 mt in 1995 to 343 mt in 2009 then declined to 76 mt in 2013 (Table A1, Figure A6). During 1982-2013, total discards averaged 12% of the total catch (Table A1).

Catches

Total catches were dominated (69-95%) by the U.S. landings,primarily from the groundfish bottom trawl fleet, during 1964-2013 (Table A1). Catches from Canadian fleets, landings in the haddock and cod fisheries and discards from the scallop dredge fleet, represented 2-17% of the total catch during 1982-2013, but discards in the bottom trawl fleets and the precision of the Canadian discard estimates is unknown. The Canadian percentage of the total catches declined from 13% in 2009 to 2% in 2013. The U.S. percentage of total catches also declined from a peak of 22% during 2006 and 2007 to 4% in 2013.

Historical catches were likely higher than those observed since 1964 because the U.S. landings alone reached a peak of 4,089 mt in 1945, close to the magnitude of the peak catch during 1964-2013 (4,608 mt), and without the inclusion of discards which presumably would have been substantial prior to 1964 becausecodend mesh sizes were much smaller (Figure A7).

Landings-at-age

Length and age composition data are not collected from either the landings or discards of Canadian fleets that fish on Georges Bank. Length and age composition samples from the U.S. landings were available, by market category and quarter, for 1982-2013. Since 1982, landings of Georges Bank winter flounder have been reported, depending on the port of landing, for eight market categories (Lemon Sole = 1201, Extra Large = 1204, Large = 1202, Large /Mixed = 1205, Medium = 1206, Small = 1203, Peewee = 1207, and Unclassified = 1200). However, 85% of the landings during 1982-2013 were comprised of only three market categories (Lemon Sole, Large, and Small). After comparing the length frequencies by market category, across years, the data were binned into the following market category groups: Lemon Sole (1201 and 1204), Large (1202 and 1205) and Small (1203, 1206 and 1207).

During 1982-2013, the annual sampling intensity of lengths of landed fish, consisting of approximately 100 fish per sample, ranged between 15 mt and 271 mt per sample (Table A5). Sampling intensity was lowest during 1996-2000, but particularly during 1998 and 1999 when sampling intensity was 271 mt per sample and 192 mt per sample, respectively. After 2000, sampling intensity improved substantially and has been highest since 2005 (Table A5, Figure A8). During 1982-2002, landings were dominated by the Large and Medium/Small market category groups, but during 2002-2008, landings were dominated by larger fish (Lemon Sole and Large, Tables A6 and A7), which was reflected in the increased sampling intensity of these larger fish. Landings of Medium/Small fish increased after 2007, as the 2006 year class moved through the fishery, and constituted the predominant market category during 2009-2013 (Figure A9). Landings of Lemon Sole and Extra Large fish declined after 2003 and were very low during 2010-2013.

During most years, biological sampling of the U.S. landings was adequate to construct the landings-at-age (LAA) matrix by applying commercial age-length keys to corresponding landings length frequency data, on either a quarterly or half-year basis, by market category group for ages 1-7+ (Table A8). The LAA matrix from the most recent assessment (NEFSC 2011a) was updated to include data for 2011-2013 (Table A9). The U.S. Unclassified market category samples were prorated and the Canadian landings were assumed to have the same age compositions as the sampled U.S. landings, and therefore, the U.S. LAA were adjusted by a raising factor to incorporate the Canadian landings. The minimum size limit for winter flounder landings in the U.S. bottom trawl fishery was 28 cm during 1986-April, 1994 and has been 30 cm since then.

Landings-at-age (numbers in thous.) during 1982-2013 were computed for ages 1-7+. Large year classes were traceable in the landings-at-age matrix. For example, landings of large numbers of fish from the 1994 cohort can be tracked through age 3 in 1997. Age 0 fish do not appear in the landings and landings of age 1 fish were insignificant during most years (Table A9). The landings were dominated by age 3-5 fish during 1982-1984 and were dominated by age 2-4 fish during 1985-2000. Since 2001, the landings have returned to a predominance of age 3-5 fish. In part, this change was due to a codend mesh size increase (to 6.5 in. square or diamond mesh) that was required in the Georges Bank bottom trawl fishery for groundfish beginning in August, 2002.

Discards-at-age

The annual numbers of lengths sampled from winter flounder discards in the U.S. bottom trawl and scallop dredge fisheries were inadequate to characterize discard length compositions during 1989-2001 and 1989-2003 (with the exception of 1997), respectively (Table A10). Length and age composition data for winter flounder discards in the Canadian fisheries are not collected. For years lacking adequate length composition data, U.S. bottom trawl discards-at-age were characterized based on the assumption that fish smaller than the U.S. minimum regulatory size limits were discarded. The minimum size limit for winter flounder landings by the U.S. bottom trawl fishery was 28 cm during 1986-April, 1994 and has been 30 cm since then. Examination of survey length-at-age data indicates that fish of this size are one year old in the NEFSC fall surveys and two years old in the spring surveys. Therefore, discards-at-age for the U. S. bottom trawl fleet, during 1982-2001, were estimated by dividing the estimated discard weight of winter flounder by the bottom trawl fleet, during January-June, by the annual mean weights of age 2 fish from the NEFSC spring surveys. Likewise, winter flounder discard weights for July-December were divided by the annual mean weights of age 1 fish from the NEFSC fall surveys. Discards-at-age for the U.S. bottom trawl fleet, during 2002-2013, were estimated by using the discard numbers at length from the NEFOP Database, binned as January-June and July-December, to characterize the proportion discarded at length and ages were determined by applying the NEFSC spring and fall survey age-length keys and length-weight relationships, respectively. Length compositions of discarded fish in the U.S. bottom trawl fishery indicate that for most years during 2002-2013, discarding of all sizes of winter flounder occurred (NEFSC 2011a), particularly when Georges Bank winter flounder trip limits were in place during May, 2006 - July 6 of 2009 (5,000 lbs per trip). As of October of 2010, all NE multispecies permit holders that fished on a sector trip were prohibited from discarding legal-sized fish (must land all winter flounder > 30 cm TL).

Length samples of winter flounder discarded in the U.S. scallop dredge fishery were inadequate to characterize discard length compositions during 1989-2003, with the exception of 1997 (Table A10). The post-2003 discard length composition data suggested that, in general, all sizes of winter flounder were discarded in the U.S. scallop dredge fishery, but that catches of winter flounder smaller 30 cm were very low (Figure B15). Similar types of scallop dredges are used by the Canadian scallop dredge fleet (H. Stone, pers. comm.). The Canadian scallop dredge fleet has been prohibited from landing groundfish since 1996 and winter flounder is a low-value species in CA in relation to cod, haddock and yellowtail flounder (there is no existing directed fishery for winter flounder). Given these considerations, discards-at-age for the both the U.S. and Canadian scallop dredge fisheries, during 1982-2003, were estimated by scaling up the LAA by the ratio of total scallop dredge discards to total landings. During years when sufficient numbers of length samples of winter flounder discards were available, 1997 and 2004-2013, the annual discard length frequency distributions were used to characterize the proportion of discards-at-length for both the U.S. and Canadian scallop dredge fleets. The NEFSC fall survey age-length keys and length-weight relationships were applied to the combined annual discard weights (U.S. and CA) because most of the U.S. discards occurred during the second half of the year.

Discards-at-age (numbers in thous.) were computed for ages 1-7+. Discards occurred across all age categories because they are primarily driven by discarding in the U.S. and Canadian scallop dredge fleets. Numbers of discarded fish shifted primarily from age 2-4 fish during 1982-1997 to age 3-5 fish during 1998-2003 (Table B11). The total numbers of fish discarded were consistently much lower during 2004-2010, when the fishing in Closed Areas I and II was mostly prohibited for groundfish trawlers and limited for scallop fishing. However, the range of ages that were discarded broadened to include mostly ages 2-5. Discards of age 1 fish, which occur primarily in bottom trawl rather than scallop dredge fisheries, were highest during 1982-1985; a time when there was no minimum landings size limit in effect and the minimum codend mesh size was smallest (5.5 inches) for groundfish trawlers. During 1982-2010, the numbers of age 1 discards decreased, presumably because the minimum codend mesh size required in groundfish bottom trawls was increased to 6.5 inches.

Catch-at-age

Catch-at-age (CAA, numbers in thous.) during 1982-2013 was computed for ages 1-7+. Components of the CAA consisted of the combined U.S. and Canadian landings-at-age, discards-at-age for the U.S. large-mesh and small-mesh bottom trawl fleets, and the U.S. and Canadian scallop dredge fleets (Table A12). During 1982-1984, the CAA contained a broad range of ages, but was dominated by ages 2-5 and had the highest numbers of fish aged 6 and older (Table A13, Figure A10). The CAA changed from this more stable age composition to one dominated by ages 2-4, during 1985-1996. During 2000-2005, the catch composition changed back to a predominance of age 3-5 fish and contained more older fish (ages 6 and older), but not at the higher levels observed during 1980-1984. Catches were dominated by age 3-4 fish during 2008-2013 as the 2006 year-class moved through the fishery (Table A13, Figure A10).

Mean weights-at-age in the catch remained relatively stable during 1985-1996 across most ages, but then declined to a lower level during 1997-2001, for ages 3-5 possibly due, in part, to poor sampling of large fish during part of this time period (Figure A11, Table A14). Mean weights-at-age, for ages 3-7+, reached their highest levels during 2003-2007, but then declined through 2013 to some of the lowest levels since 1982 (Figure A11).

3.0 Research Bottom Trawl Surveys

Biomass and Abundance Indices

Relative abundance and biomass indices were derived for Georges Bank winter flounder with data from NEFSC spring (April, 1982-2014) and fall (1981-2013) bottom trawl surveys (offshore strata 13-23, Figure A12). Indices were also were derived from Canadian stratified random bottom trawl surveys, conducted in strata 5Z1-4 (Figure A13) during February by Maritimes Region staffs from the CA Division of Fisheries and Oceans (DFO), were also included in the assessment. Survey design and sampling protocols for the Canadian surveys are provided in Chadwick et al. (2007).

Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices are presented for the NEFSC spring (April, 1968-2014) and fall (October, 1963-2013) bottom trawl surveys, as well the Canadian spring bottom trawl surveys conducted during February, 1987-2013 (Table A15, Figure A14). NEFSC survey indices prior to 1985 were standardized for gear changes (weight = 1.86 and numbers = 2.02, Sissenwine and Bowman 1978) and trawl door changes (weight = 1.39 and numbers = 1.4, Byrne and Forrester 1991). A stock-specific, calibration factor for numbers-at-length (combined seasons) was to convert post-2008 RSV *H.B. Bigelow* survey abundance indices of Georges Bank winter flounder to R/V *Albatross IV* units (NEFSC 2011a).

Despite considerable inter-annual variability, the NEFSC fall survey relative abundance indices showed an increasing trend during the 1970’s, followed by a declining trend during the 1980s to a time series low in 1991 (Figure A14). Thereafter, fall relative abundance increased through 2001 then declined to a level below the 1963-2009 median during 2005-2007. In 2009, fall relative abundance reached the second highest point in the time series, but declined and was slightly below the median in 2013. Trends in the NEFSC spring survey relative abundance indices exhibited more inter-annual variability and were msot similar to the fall survey indices during 1982-2008, but the two time series varied from one another thereafter (Figure A14). NEFSC spring survey abundance indices were at record low levels during 2004-2007. Spring relative abundance increased steadily after 2011 and was well above the median in 2014. Relative abundance trends in the Canadian spring surveys were similar to those in the NEFSC spring survey during most years but were of greater magnitude during 1988-1990 and 1993-1997. Unlike the NEFSC spring indices, the Canadian spring indices remained stable at some of the lowest levels in the time series during 2008-2014.

The distribution of winter flounder on Georges Bank (kg per tow) during the 2011-2014 NEFSC spring surveys and the 2011-2013 NEFSC fall bottom trawl surveys was not unusual based on the distribution pattern for 2001-2010 (Appendix A1).

In order to estimate catchability coefficients (*q*) for each survey within the VPA model, minimum population size estimates were computed based on swept-area estimates of wingspread (= 0.011 nmi^2 for NEFSC surveys conducted by the R/Vs *Albatross IV* and *Delaware II* and 0.012 nmi^2 for the CA surveys). During NEFSC and CA surveys, tows are conducted for 30 minutes, between winch lock and re-engage, at a target speed of 3.5 knots (Azarovitz 1981; Chadwick et al 2007). Minimum population sizes-at-age (000's) included in the VPA included: the U.S. fall (1981-2013, ages 0-6 lagged forward one year and age, Table A16) and spring bottom trawl surveys (1982-2014, Table A17) and the Canadian spring bottom trawl surveys (1987-2014, Table A18).

Age samples of winter flounder are not collected during Canadian bottom trawl surveys, so the NEFSC spring survey age-length keys were used to partition stratified mean numbers-at-length from the Canadian surveys into numbers-at-age. Although the numbers-at-age were highly variable, large cohorts appeared to track through the numbers-at-age matrices, for the NEFSC surveys, for the 1980, 1987, 1994, 1998-2001, and 2006 cohorts (Figure A15). Age truncation occurred between 1983 and 1997, during which time the population was dominated by two to four age groups rather than seven or more. During 1998-2004, the age structure improved but then became truncated again. Both the U.S. and Canadian spring surveys showed reduced numbers of age 1-3 fish (and age 4 fish in the CA surveys) during 2000-2007. The Canadian spring survey did not show the same magnitudinal increase in the numbers of age 1-6 fish that were evident in the NEFSC spring surveys during 2008-2010. Population age structure has expanded since 2009 in the NEFSC spring and fall surveys, but not in the Canadian surveys (Figure A15).

Maturity Schedule

Georges Bank winter flounder spawn during March-May, with a peak in April (Smith 1985). As in the previous assessment (NEFSC 2011a), the maturity schedule was estimated as a 3-year moving window based on an adjustment of the female maturity-at-age data from the NEFSC spring surveys. The 1982-2010 maturity schedules were updated with data for 2011-2014. The average of the median age-at-maturity (A50), during 1982-2013, was 2.4 years (Figure A16).

4.0 Assessment

The current assessment update utilizes the VPA model formulation from SARC 52 (NEFSC 2011a) with the addition of catch-at-age (CAA) data for 2011-2013 and survey tuning indices for 2011-2014. Version

3.4.5 of the ADAPT/VPA software available from the NOAA Fisheries Toolbox (NOAA 2014) was utilized. Retrospective analyses, for terminal years 2006-2012, were conducted for each model run and Mohn's rho values were computed to determine the need for adjustments to terminal year estimates of average F, SSB and age-1 recruitment values. Input data to the VPA model are presented in Table A19.

Similar to SARC 52, trends in the residuals patterns, both positive and negative, were evident for a number of ages within each of the three sets of VPA calibration indices, with variability by age and year. For example, residuals trends from NEFSC spring surveys were the worst for age 2 and age 3 fish (Figure A17). The Canadian spring survey indices for ages 2-4 showed major residuals trends (Figure A18), also both positive and negative, but the patterns differed from those evident in the NEFSC spring surveys. Residuals trends for the NEFSC fall survey abundance indices were the worst for older fish, ages 5-7+ (actually ages 4-6 lagged forward one year and age, Figure A19).

VPA estimates of survey catchability coefficients (*q*), by age, were similar to those from SARC 52 and indicated that catchabilities for all three surveys generally increased with age (Figure A20). Catchabilities-at-age were higher for the NEFSC fall surveys than for the NEFSC spring surveys but were not significantly different between surveys for ages 4-7+. Catchabilities for the Canadian spring surveys can be compared across ages but not between surveys because the vessels and gear were different. For all three surveys, catchabilities of age 1-3 fish were significantly lower than for age 5-7+ fish (Figure A20).

Fishing mortality, spawning stock biomass and recruitment

VPA estimates-at-age of Jan. 1 stock sizes (numbers in thousands), average fishing mortality rates (ages 4-6), and SSB are presented in Tables A20-A22. Fishing mortality rates were highest during 1984-1993, ranging between 0.572 and 1.175, but then declined to between 0.310 and 0.510 during 1994-1998 (Figure A21, Table A23). Fishing mortality rates were low (0.263-0.276) during 1999 and 2000, then increased rapidly to 0.887 in 2003, but declined again to the second lowest level in the time series (0.255) in 2006. Fishing mortality rates declined from 0.399 in 2011 to 0.299 (90% confidence limits based on 1,000 bootstrap iterations = 0.222, 0.428) in 2013 (Tables A23 and A24).

SSB declined rapidly from a time series peak of 17,380 mt in 1982 to 6,256 mt in 1985, and then gradually declined further to a time series low of 3,420 mt in 1995 (Figure A21, Table A23). SSB subsequently increased to 13,685 mt in 2000, but then declined to 4,533 mt in 2005 and remained stable at this low level through 2008. SSB has been increasing since 2008 and totaled 6,947 mt in 2013 (90% confidence limits based on 1,000 bootstrap iterations = 5,525, 9,274, Table A25).

Trends in age-1 recruitment showed two periods of rise-and-fall, during 1983-1993 and during 1993-2005, with a peak of 26.3 million fish in 1988 (Figure B21, Table B23). After reaching a time series low of 4.1 million fish in 2005, recruitment increased to 15.2 million fish in 2009 and ranged between 7.7 and 16.8 million fish during 2010-2013. The 2014 recruitment value (9.9 million fish) is uncertain (Table A26) because it represents the geometric mean of the 2006-2012 recruitment values.

Retrospective analyses

Unlike the SARC 52 assessment results, the retrospective patterns in F, SSB and age-1 R were uni-directional for the 2014 assessment. The 2006-2012 terminal year estimates of fishing mortality were underestimated and spawning stock biomass estimates were overestimated (Figures A22 and A23). There was no retrospective pattern for terminal year age-1 recruitment, but the estimates were highly variable (Figures A22 and A23).

Averages of the relative differences in the estimates of average F and SSB during terminal years 2006-2012, Mohn's rho values (Mohn 1999), were computed (F = -0.1639 and SSB = 0.2565) and retrospective adjustment factors (1/(1+rho)) of 1.196 and 0.796 were applied to the 2013 F and SSB estimates, respectively,and this retrospective-adjusted 2013 point estimate was compared with the 90% confidence interval of the unadjusted 2013 F and SSB point estimate to determine whether retrospective error adjustments were necessary for the stochastic projections described in Section 6.0. The 2013 retrospective-adjusted point estimate (F2013 = 0.358, SSB2013 = 5,529 mt) fell within the 90% confidence interval of the unadjusted 2013 point estimate but was very close to the lower limit (Table A30, Figure A25). Therefore, based on the guidance provided at GARM III (NEFSC 2008), retrospective error adjustments of the terminal year F and SSB values were not necessary.

5.0 Biological Reference Points

The existing BRPs were estimated at SARC52 (NEFSC 2011a). FMSY (= 0.42) was estimated from a Beverton-Holt stock-recruitment model using the Stock-Recruitment Fitting Model (SRFIT) software (version 7.0.1) available in the NOAA Fisheries Toolbox (NOAA 2010). The model incorporated R (age 1, 1982-2012 year-classes) and SSB estimates from the final VPA model with a fixed prior on unfished steepness (h = 0.78). At SARC 52, the Review Panel noted that the stock-recruitment data for the Georges Bank stock was less informative than the SNE/MA data for predicting recruitment at low spawner levels, making direct estimation of the spawner-recruit relationship difficult without external information. The SARC Review Panel also concluded that steepness values should be similar between winter flounder stocks and used the steepness log-likelihood profiles of the two stocks to select fixed values for steepness with which to estimate FMSY for each stock. Steepness values that were within two units of the minimum AIC were considered to be realistic values for each stock and fixed steepness values of 0.61 and 0.78 were recommended for the SNE/MA and Georges Bank stocks, respectively.

The SARC 52 formulation of the Beverton-Holt model (steepness fixed at 0.78) was updated with R and SSB estimates from the updated VPA model for year-classes 1982-2012. Additional input data included the most recent five-year averages (2009-2013) of fishery selectivity-at-age, proportion mature-at age, and weights-at-age from the udpated VPA model (Table A27). A sensitivity analysis was conducted to re-evaluate the log-likelihood profile of the fixed steepness parameter. Parameter estimates from the updated run of the model are shown in Table A28. Similar to the SARC 52 results, the steepness parameter for the model could not be estimated (h=1) without assuming a prior. The steepness and FMSY values, when estimated with a steepness prior of 0.80, were also similar to the estimates from SARC 52. Again, the steepness log-likelihood profile indicated that the steepness prior was highly influential in determining the FMSY estimate (Table A29). The updated FMSY estimate resulting from fixing steepness at 0.78 was 0.44. Precision estimates for FMSY were not possible due to fixing the steepness parameter. Results from the model fit and standardized residuals are shown in Figure B24. Similar to the SARC 52 model results, trends in the residuals alternate between positive and negative for most of the time series.

SSBMSY and MSY, and their associated precision, were estimated using the same method that was used in SARC 52; medians of 100-year stochastic projections that incorporated the parameter estimates and variance from the Beverton-Holt model and the most recent five-year averages (2009-2013) of fishery selectivity-at-age, weights-at-age, and proportions mature-at-age (Table A27). Existing and updated BRPs are presented in Table A30. The updated BRPs were used to determine the status of the Georges Bank winter flounder stock during 2013 and were: FMSY (Fthreshold) = 0.44; SSBMSY (Btarget) = 8,100 mt; ½ SSBMSY (Bthreshold) = 4,050 mt and MSY = 3,200 mt. Based on these BRPs, overfishing was not occurring in 2013 because the 2013 fishing mortality rate (= 0.299) was below the updated value of FMSY (= 0.44, Figure A25). The stock was also not overfished in 2013 because spawning stock biomass in 2013 (= 6,947 mt) was above the SSBMSY threshold (= 4,050 mt, Figure A25).

The results of a bootstrap analysis (1,000 iterations) suggested that there was a 90% probability that the 2013 F estimate (0.299) was between 0.222 and 0.428 and that the 2013 SSB estimate (6,947 mt) was between 5,525 mt and 9,274 mt (Figure A26, Table A30).

6.0 Projections

Stochastic projections of future stock status, during 2014-2017, were conducted based on results from the updated VPA model run and the updated BRPs using AGEPRO software (v. 4.2.2) from the NOAA Fisheries Toolbox (NOAA 2014). The projections incorporated uncertainty in the current population estimate, via bootstrap replicates (N=1,000), and input data included the the parameter and variance estimates from the updated Beverton-Holt stock-recruitment model and the 2009-2013 proportions mature-, mean weights-, and fishery selectivity patterns-at-age to reflect current conditions in the stock and fishery (Table A27). The regulations require rebuilding of the Georges Bank stock, with at least 75% probability, by 2017. Two sets of projections were run. Both sets assumed an Annual Catch Limit of 1,522 mt in calendar year 2014. The first projection included fishing at 75% of FMSY (= 0.330) during 2015-2017.

The first set of projection results indicated that rebuilding to SSBMSY (= 8,100 mt) occurred by 2017, but the probability of being rebuilt was 60% rather than the required 75% (Figure A27). Therefore, an iterative series of projection runs were conducted to determine Frebuild. The second set of projection results indicated that rebuilding to SSBMSY is expected to be achieved with 76% probability in 2017 when fishing at Frebuild = 0.270 with an assumed Annual Catch Limit of 1,522 mt in 2014 (Figure A28). The projected median estimate of SSB in 2017 was 9,221 mt (6,909, 12,803) and median catches during 2015-2017 were 2,124 mt, 2,222 mt, and 2,294 mt, respectively (Figure A29).

7.0 Summary

Update biological reference points (BRPs) for the stock are:

FMSY = 0.44
SSBMSY = 8,100 mt
MSY = 3,200 mt

Stock Status in 2013

Retrospective bias adjustments were not required for the determination of stock status in 2013, because the bias-adjusted 2013 point estimate of SSB and average F was within the 90% confidence interval of the unadjusted 2013 point estimate of these values (Table A35, Figure A36). SSB in 2013 (6,947 mt) was above the new reference point biomass threshold (½ SSBMSY = 4,050 mt), and therefore, the stock was not overfished in 2013. F in 2013 (0.299) was below the new reference point FMSY threshold (= 0.44), and therefore, overfishing was not occurring during 2013. The stock is predicted to rebuild to SSBMSY (= 8,100 mt), with 76% probability, in 2017 based on stochastic projections that assumed an annual Catch Limit of 1,522 mt and fishing at an Frebuild = 0.27 during 2015-2017.

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Table A1. Landings, discards, and catches (mt) of Georges Bank winter flounder, 1964-2013.

YEAR	522-525 561-562 USA[1] (mt)	5Ze[2] (521-526 and 541-562) CA (mt)	5Ze[2] (521-526 and 541-562) USSR (mt)	5Z (521-562) CA (mt)	5Z (521-562) USSR (mt)	TOTAL LANDINGS (mt)	DISCARDS USA (mt)	DISCARDS CA[3] (mt)	TOTAL CATCH (mt)
1964	1,370			146		1,516	231		1,747
1965	1,175			199	312	1,686	165		1,851
1966	1,876			164	156	2,196	137		2,333
1967	1,916			83	349	2,348	106		2,454
1968	1,569	57	372			1,998	140		2,138
1969	2,165	116	235			2,516	117		2,633
1970	2,613	61	40			2,714	109		2,824
1971	3,089	62	1,029			4,180	105		4,286
1972	2,802	8	1,699			4,509	98		4,608
1973	2,267	14	693			2,974	94		3,068
1974	2,123	12	82			2,217	98		2,315
1975	2,407	13	515			2,935	118		3,053
1976	1,876	15	1			1,892	142		2,034
1977	3,569	15	7			3,591	207		3,798
1978	3,183	65				3,248	262		3,510
1979	3,042	19				3,061	257		3,319
1980	3,928	44				3,972	255		4,227
1981	3,990	19				4,009	281		4,290
1982	2,959	19				2,978	246	114	3,338
1983	3,894	14				3,908	225	70	4,203
1984	3,927	4				3,931	195	56	4,182
1985	2,151	12				2,163	158	111	2,432
1986	1,761	25				1,786	182	142	2,110
1987	2,637	32				2,669	272	197	3,138
1988	2,804	55				2,859	293	126	3,278
1989	1,880	11				1,891	316	136	2,343
1990	1,898	55				1,953	338	151	2,442
1991	1,814	14				1,828	314	168	2,310
1992	1,822	27				1,849	29	178	2,056
1993	1,662	21				1,683	11	179	1,873
1994	931	65				996	10	145	1,150
1995	729	54				783	1	58	842
1996	1,370	71				1,441	26	87	1,554

Table A1 (cont.)

YEAR	522-525 561-562 USA[1]	5Ze[2] (521-526 and 541-562) CA	USSR	5Z (521-562) CA	USSR	TOTAL LANDINGS (mt)	DISCARDS (mt) USA	CA[3]	TOTAL CATCH (mt)
1997	1,226	143				1,369	69	124	1,562
1998	1,308	93				1,401	52	116	1,569
1999	939	104				1,043	85	107	1,235
2000	1,603	161				1,764	65	198	2,027
2001	1,674	529				2,203	11	199	2,413
2002	2,100	244				2,344	20	193	2,558
2003	2,829	310				3,139	9	179	3,328
2004	2,660	191				2,851	69	105	3,026
2005	2,012	73				2,085	118	145	2,347
2006	825	55				880	110	135	1,125
2007	795	12				807	188	44	1,039
2008	947	20				967	143	69	1,179
2009	1,658	12				1,670	91	252	2,013
2010	1,252	45				1,297	138	109	1,544
2011	1,801	52				1,853	129	88	2,070
2012	1,911	83				1,994	113	79	2,185
2013	1,675	12				1,687	47	29	1,763

[1] USA landings prior to 1985 include those from Statistical Areas 551 and 552, and since May of 1994, landings have been self-reported by dealers and were allocated to statistical areas based on Vessel Trip Report data.
[2] Includes landings from Statistical Areas 521, 526, and 541 which are outside of the Georges Bank winter flounder stock area.
[3] Only includes discards from the CA scallop dredge fleet during 1982-2013 because discards from the CA bottom trawl fleets were not provided by the CA Department of Fisheries and Oceans. The 2004 CA discard estimate is based on at-sea observer data from August to December because no data were collected during January-July.

Table A2. USA landings (mt) of Georges Bank winter flounder, by major gear type, during 1964-2013.

	USA Landings (mt)				
Year	Bottom Trawl	Scallop Dredge	Other	Total	% Bottom Trawl
1964	1,359	11.2	0.0	1,370	99.2
1965	1,174	0.9	0.0	1,175	99.9
1966	1,872	4.2	0.0	1,876	99.8
1967	1,914	1.8	0.0	1,916	99.9
1968	1,564	4.6	0.0	1,569	99.7
1969	2,163	1.8	0.0	2,165	99.9
1970	2,609	4.4	0.0	2,613	99.8
1971	3,085	4.8	0.0	3,089	99.8
1972	2,795	7.9	0.0	2,802	99.7
1973	2,264	3.4	0.1	2,267	99.8
1974	2,115	7.7	0.0	2,123	99.6
1975	2,407	0.0	0.0	2,407	100.0
1976	1,875	1.0	0.0	1,876	99.9
1977	3,568	1.1	0.0	3,569	100.0
1978	3,165	17.9	0.0	3,183	99.4
1979	3,018	24.9	0.0	3,042	99.2
1980	3,885	42.5	0.3	3,928	98.9
1981	3,934	53.5	2.5	3,990	98.6
1982	2,917	41.2	0.0	2,959	98.6
1983	3,868	25.4	0.8	3,894	99.3
1984	3,908	18.4	0.4	3,927	99.5
1985	2,148	3.1	0.0	2,151	99.9
1986	1,725	36.0	0.0	1,761	98.0
1987	2,559	77.9	0.0	2,637	97.0
1988	2,697	106.4	0.0	2,804	96.2
1989	1,760	119.7	0.0	1,880	93.6
1990	1,780	118.1	0.1	1,898	93.8
1991	1,673	141.1	0.0	1,814	92.2
1992	1,685	136.3	0.0	1,822	92.5
1993	1,546	115.4	0.0	1,662	93.1
1994	894	21.6	15.3	931	96.0
1995	716	8.5	4.5	729	98.2
1996	1,365	4.6	0.7	1,370	99.6
1997	1,212	12.0	2.0	1,226	98.9
1998	1,293	13.3	1.8	1,308	98.8
1999	925	11.2	2.5	939	98.5
2000	1,577	23.1	3.4	1,603	98.3
2001	1,667	6.3	0.3	1,674	99.6
2002	2,092	1.0	7.1	2,100	99.6
2003	2,826	0.4	3.2	2,829	99.9
2004	2,627	4.5	28.7	2,660	98.8
2005	1,892	111.8	7.8	2,012	94.1
2006	778	21.9	25.8	825	94.2
2007	785	8.8	1.3	795	98.7
2008	944	0.7	2.1	947	99.7
2009	1,656	0.7	2.0	1,658	99.8
2010	1,251	0.1	0.6	1,252	99.9
2011	1,794	3.7	3.9	1,801	99.6
2012	1,902	6.8	2.0	1,911	99.5
2013	1,673	1.4	0.7	1,675	99.9

Table A3. Proportional standard errors (PSE) for the 1995-2013 total landings of Georges Bank winter flounder. Canadian landings average 7% during this period and were assumed to have precision estimates similar to the U.S. landings. The PSE (in percent) due to allocation to statistical area using Vessel Trip Reports for 1995 and later years.

Year	Landings (mt)	PSE
1995	783	1.1
1996	1,441	0.9
1997	1,369	1.0
1998	1,401	1.3
1999	1,043	1.2
2000	1,764	1.0
2001	2,203	1.0
2002	2,345	0.7
2003	3,139	0.7
2004	2,851	0.8
2005	2,085	0.7
2006	880	0.8
2007	807	1.0
2008	967	0.8
2009	1,670	0.9
2010	1,297	1.3
2011	1,853	0.8
2012	1,994	0.3
2013	1,687	0.5

Table A4. U.S. discards (mt) of Georges Bank winter flounder in the large mesh (codend mesh ≥ 5.5 in.) and small mesh (codend mesh < 5.5 in.) bottom trawl (BT) fleets and the scallop dredge fleet during 1964-2013. Discards during 1982-1988, 1964-1988, and 1964-1991 were hindcast for the large and small mesh bottom trawl (BT) fleets and the scallop dredge fleet, respectively.

	U.S. Discards (mt)				
Year	Large mesh BT	Small mesh BT	Scallop dredge	Total	CV
1964		112.1	118.4	230.5	
1965		135.4	29.7	165.1	
1966		118.9	18.2	137.1	
1967		82.0	24.0	106.0	
1968		74.1	65.9	140.0	
1969		74.8	42.2	117.0	
1970		72.6	36.8	109.4	
1971		69.5	35.9	105.4	
1972		61.4	36.7	98.1	
1973		61.1	32.8	94.0	
1974		59.7	38.3	97.9	
1975		60.4	57.6	118.0	
1976		48.8	93.0	141.9	
1977		68.3	138.8	207.0	
1978		77.0	184.9	261.9	
1979		75.8	181.7	257.4	
1980		83.1	171.6	254.7	
1981		97.3	184.0	281.3	
1982	11.4	72.3	162.6	246.3	
1983	39.8	21.8	163.6	225.3	
1984	47.3	3.3	144.5	195.1	
1985	28.9	1.6	127.7	158.2	
1986	23.3	1.6	156.6	181.5	
1987	24.8	1.9	245.5	272.1	
1988	28.3	6.4	258.3	293.0	
1989	13.8	0.1	302.4	316.2	
1990	15.7	0.0	322.3	338.0	
1991	1.9	0.0	311.9	313.8	
1992	8.5	0.0	20.3	28.8	0.22
1993	2.5	0.0	8.1	10.6	0.49
1994	2.3	0.9	6.4	9.5	0.16
1995	1.1	0.0	0.0	1.1	0.56
1996	8.3	0.0	17.4	25.7	0.31
1997	0.0	0.0	69.2	69.2	---
1998	0.1	0.0	51.5	51.7	0.01
1999	44.0	0.0	41.2	85.2	0.46
2000	16.7	0.1	48.2	64.9	0.31
2001	2.4	0.0	8.3	10.7	0.15
2002	3.1	0.0	16.5	19.7	0.13
2003	6.5	0.9	2.1	9.5	0.34
2004	46.6	15.4	7.3	69.3	0.48
2005	15.0	15.3	87.5	117.9	0.09
2006	26.3	14.9	68.8	110.0	0.12
2007	50.1	16.0	122.2	188.3	0.23
2008	70.2	0.15	72.6	143.0	0.14
2009	37.5	6.36	46.9	90.8	0.14
2010	29.0	94.2	14.3	137.6	0.44
2011	11.5	7.0	110.3	128.7	0.09
2012	4.6	0.4	107.5	112.5	0.11
2013	7.4	14.1	25.3	46.9	0.07

Table A5. Numbers of Georges Bank winter flounder sampled for length, by year and market category group, and sampling intensity (mt landed per 100 lengths) during 1982-2013.

Year	N lengths by market category					Sampling intensity (mt landed per 100 lengths)
	Unclassified (1200)	Lemon/XL (1201, 1204)	Large/Lg mix (1202, 1205)	Med/small (1203, 1206, 1207)	Total	
1982	350	724	1,019	807	2,900	102
1983		625	1,768	2,100	4,493	87
1984		518	1,435	902	2,855	138
1985	68	728	1,675	1,456	3,927	55
1986	124	389	1,125	1,184	2,822	62
1987		603	1,068	1,437	3,108	85
1988		478	1,034	1,447	2,959	95
1989		167	566	737	1,470	128
1990	399	27	1,285	1,758	3,469	55
1991	103	136	1,603	1,295	3,137	58
1992		131	1,420	1,483	3,034	60
1993		336	509	590	1,435	116
1994		183	632	556	1,371	68
1995		103	279	469	851	86
1996		370	484	138	992	138
1997		43	518	443	1,004	122
1998			79	403	482	271
1999	94		121	274	489	192
2000		486	160	697	1,343	119
2001	102	670	990	804	2,566	65
2002	274	699	1,458	424	2,855	74
2003	268	1,589	2,863	625	5,345	53
2004		1,579	4,643	188	6,410	42
2005	161	1,987	3,790	576	6,514	31
2006	100	1,978	3,196	293	5,567	15
2007		1,659	1,381	161	3,201	25
2008		1,688	2,815	819	5,322	18
2009		2,060	2,383	2,065	6,509	25
2010	456	1,346	3,906	2,686	8,394	15
2011	352	1,296	3,818	3,207	8,673	21
2012	69	637	2,421	2,210	5,337	36
2013		288	2,182	1,838	4,308	39

Table A6. Summary of U.S. winter flounder landings, from Georges Bank (Statistical Areas 522-525, 551-562), sampled for length and age compositions, during 1982-2013. Unless footnoted, total sample numbers do not include unclassified market category samples collected in: 1980 (1), 1981 (2), 1982 (4), 1985 (1), 1986 (1), 1990 (4), 1991 (1), 1999 (1), 2001 (1), 2002 (3), 2003 (4), 2005 (3), 2006 (1), and 2012 (1).

				Number of Samples by Market Category and Quarter															Annual Sampling Intensity (mt landed/100 lengths)		
				Lemon Sole: Lemon Sole (1201), Extra-Large (1204)					Large: Large (1202), Large/Mixed (1205)					Small: Small (1203), Medium (1206), Pee-Wee (1207)					1201 1204	1202 1205	1203 1206 1207
Year	N Samples	N Lengths	N Ages	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Lemon	Large	Small
1982	26	2,900	739	0	1	6	2	**9**	0	1	6	3	**10**	0	1	5	1	**7**	76	168	69
1983	36	4,493	874	0	3	2	1	**6**	2	5	6	2	**15**	2	3	9	1	**15**	58	100	81
1984	24	2,855	593	0	1	3	1	**5**	3	3	4	3	**13**	1	2	0	3	**6**	73	142	151
1985	38	3,927	827	1	2	5	1	**9**	2	4	9	1	**16**	2	3	7	1	**13**	37	64	50
1986	29	2,822	563	1	1	0	3	**5**	2	3	3	2	**10**	1	6	3	4	**14**	46	66	56
1987	33	3,108	618	2	1	1	2	**6**	4	3	3	1	**11**	5	3	4	4	**16**	40	96	87
1988	34	2,959	693	2	2	1	2	**7**	4	3	3	1	**11**	4	4	4	4	**16**	34	96	103
1989	16	1,470	280	1	1	0	0	**2**	3	2	0	1	**6**	1	3	3	1	**8**	66	127	126
1990	34	3,469	737	0	0	0	1	**1**	3	3	4	3	**13**	6	7	3	4	**20**	265	49	62
1991	35	3,137	698	1	1	1	1	**4**	6	6	2	2	**16**	6	3	3	3	**15**	40	42	72
1992	35	3,034	688	1	2	1	1	**5**	5	4	3	3	**15**	6	5	3	1	**15**	50	47	63
1993	16	1,435	338	1	2	0	1	**4**	3	2	0	0	**5**	1	5	0	1	**7**		125	139
1994	14	1,371	276	0	2	1	0	**4**	1	2	2	1	**6**	1	2	1	1	**5**	33	59	83
1995	9	851	215	1	0	0	1	**2**	1	0	0	2	**3**	2	1	0	1	**4**	43	93	78
1996	10	992	218	0	2	1	1	**4**	0	2	1	1	**4**	0	0	1	1	**2**	18	92	457
1997	13	1,004	232	0	0	0	1	**1**	1	2	1	1	**5**	2	2	0	3	**7**	101	84	81

				Number of Samples by Market Category and Quarter															Annual Sampling Intensity (mt landed/100 lengths)		
				Lemon Sole					Large					Small[2]					1201 1204	1202 1205	1203[2] 1206 1207
				Lemon Sole (1201) Extra-Large (1204)					Large (1202) Large/Mixed (1205)					Small (1203) Medium (1206) Pee-Wee (1207)							
Year	N Samples[1]	N Lengths	N Ages	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Lemon	Large	Small
1998	6	482	70	0	0	0	0	**0**	0	1	0	0	**1**	0	1	1	3	**5**	-----	624	193
1999	6	395	78	0	0	0	0	**0**	0	0	0	1	**1**	2	0	0	3	**5**	-----	313	178
2000	17	1,343	283	0	0	1	4	**5**	0	0	0	2	**2**	2	4	1	3	**10**	24	412	111
2001	27	2,464	606	2	2	1	3	**8**	1	5	3	1	**10**	1	0	2	6	**9**	29	82	73
2002	33	2,485	753	2	4	3	2	**11**	0	9	5	3	**17**	1	1	0	3	**5**	53	81	98
2003	60	4,864	1,396	2	7	4	5	**18**	5	17	8	5	**35**	1	1	0	5	**7**	64	49	52
2004	78	6,343	1,862	1	5	6	5	**17**	6	15	22	13	**56**	1	2	1	1	**5**	37	39	123
2005	75	6,353	1,561	3	9	8	4	**24**	4	17	13	6	**40**	1	4	4	2	**11**	20	35	47
2006	68	5,467	1,458	5	13	4	6	**28**	4	17	9	5	**35**	0	3	1	1	**5**	11	15	35
2007	45	3,201	931	4	7	5	6	**22**	7	7	3	1	**18**	3	0	2	0	**5**	8	35	87
2008	77	5,322	1,463	3	12	7	9	**31**	4	9	9	8	**30**	0	3	9	4	**16**	7	20	30
2009	100	6,509	1,734	4	15	7	15	**41**	2	8	10	4	**24**	2/1	6/3	8/4	10/1	**35**	4	32	38
2010	140	8,394	2,521	2	14	12	23	**51**	4	20	7	11	**42**	0/0	13/7	1/8	10/3	**42**	2	11	28
2011	141	8,673	2,543	8	15	7	10	**40**	11	19	6	6	**42**	6/4	23/5	8/3	4/2	**55**	2	19	31
2012	83	5,268	1,144	2	11	6	7	**26**	3	11	6	5	**25**	0/1	5/5	9/5	5/2	**32**	3	34	45
2013	64	4,308	1,094	0	6	3	4	**13**	3	10	4	6	**23**	0/0	10/5	4/2	5/2	**28**	6	34	50

1 Includes Unclassified samples; 5 length and 4 age samples during 2010 and 4 length and age samples during 2011.

2 Samples and sampling intensities during 2009-2013 are indicated as N Small/Peewee combined / N Medium.

Table A7. Percentage of U.S. landings, during 1982-2013, by market category group.

	U.S. Landings by Market Category Group (%)			
	Lemon/XL	Large/LG Mix	Med/Small	Unclassified
Year	1201	1202	1203	1200
1982	18.6	57.9	18.9	4.7
1983	9.3	45.5	43.4	1.8
1984	9.6	51.7	34.8	3.9
1985	12.4	50.1	33.9	3.5
1986	10.1	42.0	37.5	10.4
1987	9.2	38.9	47.4	4.5
1988	5.9	35.5	53.3	5.3
1989	5.9	38.1	49.2	6.7
1990	3.8	33.1	57.3	5.9
1991	3.0	37.5	51.2	8.3
1992	3.6	36.9	51.2	8.3
1993	5.3	38.2	49.3	7.1
1994	6.5	40.3	49.4	3.8
1995	6.1	35.4	50.3	8.2
1996	4.8	32.6	46.1	16.6
1997	3.6	35.5	29.2	31.7
1998	4.0	37.7	56.4	1.9
1999	4.8	40.4	51.8	2.9
2000	7.3	41.1	48.4	3.3
2001	11.4	48.7	34.9	4.9
2002	17.6	56.5	19.8	6.0
2003	35.9	49.3	11.6	3.2
2004	22.3	67.9	8.7	1.2
2005	20.0	65.6	13.4	1.0
2006	25.3	59.4	12.3	3.0
2007	16.9	60.4	17.7	5.1
2008	12.1	59.5	26.0	2.4
2009	5.3	45.8	47.2	1.7
2010	1.9	34.9	60.0	3.3
2011	1.4	39.9	55.4	3.2
2012	1.2	42.5	52.2	4.2
2013	1.0	44.4	54.5	0.1

Table A8. Data pooling procedures used to apply length frequency samples to landings, by market category, to estimate landings-at-age of Georges Bank winter flounder, during 1982-2013. An “X” indicates that the time bin applies to all market categories unless otherwise noted.

<table>
<tr><th>Year</th><th>Quarter 1</th><th>Quarter 2</th><th>Quarter 3</th><th>Quarter 4</th><th>Market Category Groups</th></tr>
<tr><td>1982</td><td colspan="2">Pooled each mkt cat group</td><td>X</td><td>X</td><td rowspan="12">Pooled 1204 (Extra Large) and 1201 Lemon Sole

Pooled 1205 (Large/Mixed) and 1202 (Large)

Pooled 1206 (Medium), 1207 (Peewee) and 1203 (Small)</td></tr>
<tr><td>1983</td><td colspan="2">Pooled each mkt cat group</td><td>X</td><td>X</td></tr>
<tr><td>1984</td><td colspan="2">Pooled each mkt cat group</td><td colspan="2">Pooled each mkt cat group</td></tr>
<tr><td>1985</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1986</td><td>X</td><td>X</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1987</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1988</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1989</td><td>X</td><td>X</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1990</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1991</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1992</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1993</td><td>X</td><td colspan="3">Pooled each mkt category group</td></tr>
<tr><td rowspan="2">1994</td><td colspan="2">Pooled Lemon/Lg</td><td colspan="2">Pooled Lemon/Lg</td><td rowspan="7">Pooled 1201 (Lemon Sole), 1204 (Extra Large), 1202 (Large), and 1205 (Large/Mixed)

Pooled 1206 (Medium), 1207 (Peewee) and 1203 (Small)</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td rowspan="2">1995</td><td colspan="2">Pooled Lemon/Lg</td><td colspan="2">Pooled Lemon/Lg</td></tr>
<tr><td>X</td><td>X</td><td colspan="2">Pooled Med/Sm/Peewee</td></tr>
<tr><td rowspan="2">1996</td><td colspan="2">Pooled Lemon/Lg</td><td>X</td><td>X</td></tr>
<tr><td colspan="4">Pooled Med/Sm</td></tr>
<tr><td>1997</td><td>X</td><td>X</td><td colspan="2">Pooled Lemon/Lg
Pooled Med/Sm/Peewee</td></tr>
<tr><td>1998</td><td colspan="4">Pooled across all mkt categories</td><td rowspan="2">Pooled all market categories and included all kept lengths from otter trawl observer trips</td></tr>
<tr><td>1999</td><td colspan="4">Pooled across all mkt categories</td></tr>
</table>

Table A8 (cont.).

<table>
<tr><th>Year</th><th>Quarter 1</th><th>Quarter 2</th><th>Quarter 3</th><th>Quarter 4</th><th>Market Category Groups</th></tr>
<tr><td>2000</td><td colspan="2">Pooled across all mkt categories</td><td colspan="2">Pooled Lemon/Lg
Pooled Med/Sm/Peewee</td><td>Pooled market categories as in 1994-1997 and included kept lengths from otter trawl observer trips (months 1-6)</td></tr>
<tr><td>2001</td><td colspan="2">Pooled Med/Sm/Peewee</td><td>X</td><td>X</td><td rowspan="9">Pooled 1204 (Extra Large) and 1201 Lemon Sole

Pooled 1205 (Large/Mixed) and 1202 (Large)

Pooled 1206 (Medium), 1207 (Peewee) and 1203 (Small)</td></tr>
<tr><td>2002</td><td>X</td><td>X</td><td colspan="2">Pooled Med/Sm/Peewee</td></tr>
<tr><td>2003</td><td>X</td><td>X</td><td colspan="2">Pooled Med/Sm/Peewee</td></tr>
<tr><td>2004</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>2005</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>2006</td><td colspan="2">Pooled Med/Sm/Peewee</td><td>X</td><td>X</td></tr>
<tr><td rowspan="2">2007</td><td colspan="2">Pooled Med/Sm/Peewee</td><td colspan="2">Pooled Med/Sm/Peewee</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>2008</td><td colspan="2">Pooled Med/Sm/Peewee</td><td>X</td><td>X</td></tr>
<tr><td>2009</td><td colspan="2">Pooled Med, pooled Sm/Peewee</td><td colspan="2">Pooled Med</td><td rowspan="6">Pooled 1204 (Extra Large) and 1201 Lemon Sole
Pooled 1205 (Large/Mixed) and 1202 (Large)
1206 (Medium)
Pooled 1207 (Peewee) and 1203 (Small)</td></tr>
<tr><td>2010*</td><td colspan="2">Pooled Lemon/XL, pooled Sm/Peewee, pooled Med.</td><td colspan="2">Pooled Sm/Peewee</td></tr>
<tr><td>2011*</td><td colspan="2">Pooled Lemon/XL</td><td colspan="2">Pooled Sm/Peewee, pooled Med.</td></tr>
<tr><td>2012</td><td colspan="2">Pooled Lemon/XL, pooled Sm/Peewee, pooled Med.</td><td>X</td><td>X</td></tr>
<tr><td rowspan="2">2013</td><td colspan="4">Pooled Lemon/XL</td></tr>
<tr><td colspan="2">Pooled Sm/Peewee, pooled Med.</td><td>X</td><td>X</td></tr>
</table>

* Pooled 1200 (Unclassified) across year

Table A9. Total landings-at-age (numbers, in thousands) of Georges Bank winter flounder during 1982-2013.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	0	353	1707	1,048	511	258	281	4,157
1983	10	787	2,902	1,454	551	206	528	6,438
1984	0	282	570	1,371	1,408	635	920	5,186
1985	20	805	693	812	491	112	100	3,031
1986	0	665	1,328	235	229	131	88	2,675
1987	0	1,294	1,681	899	133	89	121	4,217
1988	0	835	2,774	843	197	90	93	4,832
1989	0	1,381	1,222	509	147	107	61	3,427
1990	0	295	2,032	668	185	46	17	3,241
1991	0	593	1,270	951	136	38	60	3,047
1992	0	796	756	727	468	92	61	2,902
1993	37	301	1,143	451	320	163	47	2,461
1994	0	367	635	360	97	50	45	1,554
1995	371	701	172	142	105	32	41	1,563
1996	0	1,319	423	185	95	98	88	2,208
1997	0	355	993	444	176	79	87	2,135
1998	0	10	1,426	826	131	43	12	2,447
1999	0	296	786	521	147	20	20	1,790
2000	0	646	1,108	369	254	186	160	2,723
2001	11	372	1,280	801	586	158	99	3,307
2002	0	121	927	757	445	236	189	2,675
2003	0	259	694	925	455	252	400	2,987
2004	0	62	579	844	520	234	367	2,606
2005	0	224	529	752	362	142	217	2,227
2006	0	25	283	278	122	55	113	876
2007	0	108	135	217	167	73	84	784
2008	0	191	372	303	203	102	95	1,265
2009	0	671	1,097	556	198	91	90	2,702
2010	0	628	803	546	198	68	50	2,294
2011	3	147	786	1,064	521	142	82	2,745
2012	0	126	943	1,114	710	156	124	3,174
2013	0	166	777	585	497	276	101	2,402

Table A10. Number of Georges Bank winter flounder lengths sampled by fishery observers (and at-sea monitors during May1, 2010-2013) from the discards of the bottom trawl and scallop dredge fleets during 1989-2013.

	N lengths sampled from discards	
Year	Bottom trawl	Scallop dredge
1989	70	0
1990	22	0
1991	5	0
1992	15	1
1993	5	3
1994	6	35
1995	11	0
1996	39	2
1997	1	417
1998	1	84
1999	2	111
2000	4	15
2001	1	0
2002	88*	1
2003	89	1
2004	293	137
2005	420	804
2006	437	413
2007	827	887
2008	1,966	640
2009	909	743
2010	1,336	133*
2011	430	1,041
2012	105*	1,199
2013	239	254*

*Due to low sample sizes, combined bottom trawl discard length composition samples for 2002 and 2003 and for 2012 and 2013. Length composition samples from scallop dredges were combined with 2009 for 2010 and with 2012 for 2013.

Table A11. U.S. discards-at-age (numbers, in thousands) for Georges Bank winter flounder during 1982-2013.

	Age								
Year	0	1	2	3	4	5	6	7+	Total
1982	0	116	706	1,843	1,131	551	278	303	4,928
1983	0	137	1,051	3,053	1,530	580	217	556	7,123
1984	0	138	431	595	1,432	1,471	663	961	5,690
1985	0	67	987	768	899	544	124	111	3,499
1986	0	38	816	1,522	270	262	150	101	3,159
1987	0	99	1,556	1,912	1,022	151	101	138	4,980
1988	0	72	1,049	3,044	925	216	98	102	5,507
1989	0	34	1,655	1,428	595	172	125	71	4,079
1990	0	36	392	2,400	789	218	54	20	3,909
1991	0	2	710	1,505	1,127	161	45	72	3,621
1992	0	23	842	778	749	482	95	63	3,031
1993	0	43	317	1,184	467	331	169	49	2,558
1994	0	8	416	706	400	108	55	51	1,744
1995	0	394	742	182	149	111	34	43	1,655
1996	0	35	1,417	450	197	101	104	94	2,397
1997	0	6	145	74	33	7	2	2	268
1998	0	0	11	1,561	904	143	47	13	2,680
1999	0	70	425	887	588	165	22	23	2,180
2000	0	52	749	1,225	408	281	206	177	3,099
2001	0	16	410	1,393	872	638	172	108	3,608
2002	0	0	127	970	793	466	247	198	2,802
2003	0	0	273	729	972	479	266	421	3,141
2004	0	4	33	29	39	18	15	18	156
2005	0	5	42	26	44	26	44	29	217
2006	0	5	24	52	57	58	11	14	220
2007	0.2	23	44	30	41	62	17	13	230
2008	0.4	15	135	87	27	24	16	9	313
2009	0.4	7	124	145	102	34	22	18	453
2010	0.1	3	36	94	79	31	22	22	288
2011	0	12	23	91	81	41	11	18	277
2012	0	2	17	66	55	20	20	22	203
2013	0	4	27	32	21	8	9	14	116

Table A12. Georges Bank winter flounder catch-at-age components.

Catch-at-age component	Years	Time Period	Length data	Age data
U.S. landings	1982-2013		Commercial	Commercial
CA landings	1982-2013		None available, scaled-up the U.S. LAA	None available
U.S. BT discards (lg & sm mesh)				
≤ MLS as discard /mean wt-at-age in NEFSC surveys	1982-2001	Half yr est.	No discard L-F	discard ages unavailable; MLS 1st half yr = age 2 spring and 2nd half yr = age 1 fall
	2002-2013	Half yr est.	U.S. BT discards	NEFSC spring and fall L-W and A/L keys
CA BT discards				
No discard est. provided, assumed zero				
U.S. scallop dredge discards				
	1982-1996 & 1998-2003		No discard L-F; scaled-up LAA	
	1997 & 2004-2013		Annual U.S. scallop dredge discards	NEFSC fall survey L-W and A/L keys
CA scallop dredge discards				
Avg. 2004-2010 rate x annual CA scallop landings	1982-1996 & 1998-2003		None collected by CA ; scaled up LAA	None collected by CA
Estimated by CA DFO	2004-2013		Annual U.S. scallop dredge discards	None collected by CA; 1st half yr = NEFSC spr survey A/L keys & L-W 2nd half yr = NEFSC spring survey

Table A13. Catch-at-age (numbers, in thousands) for Georges Bank winter flounder during 1982-2013. Age 0 fish were not included in the VPA runs.

	Age								
Year	0	1	2	3	4	5	6	7+	Total
1982	0	116	1,058	3,550	2,179	1,061	536	584	9,086
1983	0	147	1,838	5,954	2,983	1,131	423	1,084	13,561
1984	0	138	713	1,165	2,803	2,879	1,298	1,880	10,876
1985	0	87	1,791	1,461	1,711	1,034	235	211	6,530
1986	0	38	1,481	2,850	505	491	281	189	5,834
1987	0	99	2,850	3,593	1,921	285	189	259	9,196
1988	0	72	1,884	5,818	1,767	413	188	196	10,339
1989	0	34	3,035	2,650	1,104	319	231	131	7,506
1990	0	36	687	4,431	1,457	402	99	36	7,150
1991	0	2	1,302	2,775	2,077	297	83	132	6,668
1992	0	23	1,638	1,534	1,476	950	187	124	5,932
1993	0	80	617	2,327	918	650	332	95	5,019
1994	0	8	783	1,341	760	206	105	96	3,298
1995	0	765	1,443	354	291	217	66	83	3,218
1996	0	35	2,737	872	381	196	203	182	4,605
1997	0	2	407	1020	456	179	80	87	2,231
1998	0	0	21	2,987	1,730	274	91	26	5,127
1999	0	70	720	1,673	1,109	312	42	43	3,970
2000	0	52	1,395	2,333	777	536	392	337	5,823
2001	0	27	782	2,673	1,673	1,223	330	207	6,915
2002	0	0	249	1,896	1,551	910	483	387	5,477
2003	0	0	533	1,423	1,897	934	518	821	6,127
2004	0	3	87	594	861	525	238	374	2,682
2005	0	4	265	548	771	373	160	229	2,350
2006	0	4	37	306	301	146	61	122	978
2007	0.2	23	152	165	258	230	90	96	1,014
2008	0.4	15	325	459	330	226	118	104	1,577
2009	0.4	7	786	1235	662	231	113	107	3,141
2010	0.1	3	233	961	704	242	97	73	2,313
2011	0	14	170	877	1,145	562	153	100	3,021
2012	0	2	143	1,009	1,169	730	176	147	3,376
2013	0	4	194	809	606	505	285	115	2,518

Table A14. Mean weights-at-age (kg) for catches of Georges Bank winter flounder during 1982-2013.

	Age							
Year	1	2	3	4	5	6	7+	All ages
1982	0.216	0.234	0.444	0.779	1.041	1.228	1.615	0.647
1983	0.149	0.260	0.451	0.668	0.899	0.991	1.340	0.576
1984	0.110	0.281	0.467	0.585	0.744	0.891	1.266	0.719
1985	0.191	0.386	0.522	0.782	1.050	1.366	1.720	0.683
1986	0.197	0.392	0.617	0.778	1.029	1.194	1.589	0.650
1987	0.081	0.375	0.549	0.868	1.107	1.217	1.724	0.606
1988	0.145	0.327	0.510	0.760	1.149	1.323	1.761	0.567
1989	0.123	0.355	0.459	0.826	1.076	1.332	1.742	0.538
1990	0.110	0.432	0.510	0.757	0.992	1.339	2.021	0.588
1991	0.190	0.415	0.479	0.702	0.985	1.438	1.751	0.594
1992	0.137	0.386	0.494	0.744	0.906	1.185	1.465	0.627
1993	0.246	0.382	0.537	0.758	0.941	1.294	1.900	0.680
1994	0.200	0.413	0.543	0.803	0.954	1.380	1.618	0.651
1995	0.285	0.387	0.590	0.666	0.999	1.267	1.652	0.501
1996	0.120	0.444	0.649	0.892	1.223	1.467	1.763	0.639
1997	0.000	0.342	0.527	0.691	0.981	1.243	1.440	0.652
1998	0.178	0.244	0.486	0.631	0.809	1.322	1.829	0.572
1999	0.215	0.337	0.452	0.703	1.040	1.569	1.778	0.534
2000	0.119	0.416	0.478	0.568	1.003	1.277	1.627	0.628
2001	0.238	0.306	0.488	0.750	0.827	1.241	1.821	0.664
2002	0.137	0.481	0.554	0.845	1.071	1.340	1.812	0.878
2003	0.124	0.404	0.608	0.968	1.254	1.540	1.893	1.052
2004	0.132	0.475	0.705	0.967	1.223	1.455	1.763	1.096
2005	0.157	0.379	0.595	0.937	1.170	1.495	1.760	0.959
2006	0.170	0.465	0.647	0.937	1.262	1.568	1.887	1.024
2007	0.154	0.375	0.699	0.963	1.277	1.566	1.991	1.035
2008	0.157	0.361	0.583	0.768	0.998	1.193	1.640	0.747
2009	0.117	0.359	0.551	0.760	0.975	1.231	1.624	0.637
2010	0.287	0.320	0.497	0.726	0.899	1.133	1.512	0.604
2011	0.177	0.328	0.497	0.690	0.877	1.091	1.448	0.691
2012	0.385	0.436	0.428	0.650	0.793	1.014	1.224	0.649
2013	0.181	0.372	0.581	0.675	0.807	0.979	1.281	0.710

Table A15. Georges Bank winter flounder relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices from the U.S. spring (1968-2013) and autumn (1963-2013) bottom trawl surveys (derived using offshore survey strata 13-23), conducted by the Northeast Fisheries Science Center, and from the Canadian spring (1987-2013) bottom trawl surveys conducted on Georges Bank (derived using strata 5Z1-5Z4). U.S. survey indices for 1963-1984 were multiplied by standardization coefficients (numbers = 1.46 and weight = 1.39) to account for a trawl door change in 1985 and U.S. spring survey indices for 1973-1981 were divided by standardization coefficients (numbers = 2.02 and weight = 1.86) to account for a net change during 1973-1981.

	U.S. Spring Survey				U.S. Autumn Survey				Canadian Spring Survey	
Year	**Number**	**CV**	**Kg**	**CV**	**Number**	**CV**	**Kg**	**CV**	**Number**	**Kg**
1963					1.94	44.9	3.02	41.0		
1964					1.75	56.4	2.77	51.8		
1965					2.70	36.8	3.03	28.2		
1966					4.79	40.2	5.26	33.7		
1967					1.78	42.3	2.11	35.9		
1968	2.66	51.1	2.99	53.1	1.92	23.1	1.83	28.1		
1969	2.95	20.8	4.02	20.9	2.59	33.2	2.53	32.5		
1970	1.81	21.8	2.20	24.5	7.02	47.3	7.73	47.7		
1971	1.71	20.6	2.04	26.1	1.53	37.5	1.32	36.2		
1972	4.71	34.8	4.90	34.0	1.64	31.4	1.56	27.8		
1973	1.34	36.7	1.73	39.4	2.56	35.9	2.30	33.5		
1974	3.19	33.8	3.16	31.9	1.36	37.7	1.55	42.6		
1975	0.92	37.6	0.72	60.0	3.74	52.3	2.09	34.8		
1976	2.23	27.5	1.57	27.4	5.52	36.7	3.63	40.7		
1977	1.95	43.6	0.90	40.7	4.81	25.0	3.97	22.5		
1978	3.25	35.9	2.52	36.8	4.22	17.9	3.47	17.6		
1979	0.79	26.8	1.09	28.1	5.06	24.8	4.08	23.9		
1980	1.63	43.9	1.45	38.4	2.03	24.8	2.32	25.8		
1981	1.92	35.8	2.00	36.5	5.50	25.3	4.41	20.5		
1982	2.42	29.0	1.57	34.7	5.61	18.6	3.32	20.2		
1983	8.29	35.8	6.93	36.4	3.03	31.9	2.89	35.9		
1984	5.12	27.2	5.22	26.0	4.90	41.5	3.28	40.8		
1985	3.54	43.4	2.44	39.2	1.98	32.8	1.18	32.9		
1986	2.10	34.2	1.26	31.3	3.31	45.0	2.00	43.0		
1987	2.61	30.8	1.16	29.6	0.96	33.6	1.03	42.6	1.24	1.74
1988	2.68	37.5	1.51	33.7	3.90	58.5	1.29	32.1	4.31	2.75
1989	1.25	33.3	0.73	35.9	1.43	45.2	0.96	40.1	4.05	1.95
1990	2.65	47.0	1.48	49.3	0.51	32.7	0.34	37.4	4.93	2.64
1991	2.21	35.0	1.21	28.6	0.31	38.7	0.24	44.0	1.98	1.38
1992	1.34	26.0	0.83	30.5	0.69	35.9	0.38	37.2	0.51	0.59

Table A15.
(cont.)

	U.S. Spring Survey				U.S. Autumn Survey				Canadian Spring Survey	
Year	**Number**	**CV**	**Kg**	**CV**	**Number**	**CV**	**Kg**	**CV**	**Number**	**Kg**
1993	1.00	30.1	0.58	25.6	1.22	36.2	0.78	30.9	3.53	1.76
1994	1.25	48.9	0.56	46.9	0.85	34.3	0.56	31.1	5.10	2.01
1995	2.42	37.8	1.38	44.5	2.74	30.3	1.62	28.6	5.63	1.96
1996	2.12	32.7	1.38	28.0	1.48	24.5	1.68	25.1	4.12	2.30
1997	1.48	78.8	1.09	72.5	1.78	20.7	1.55	21.5	4.58	3.09
1998	0.78	34.9	0.71	36.0	3.50	28.1	3.40	30.5	1.14	1.21
1999	3.56	46.2	3.21	50.4	2.45	36.4	2.47	42.0	1.25	1.89
2000	4.25	36.8	3.55	39.2	4.60	57.8	4.82	52.7	1.48	2.22
2001	1.25	38.7	1.16	37.8	6.08	36.6	4.85	31.4	2.28	2.54
2002	4.73	35.6	4.82	32.6	4.67	36.5	5.60	44.2	3.17	3.85
2003	1.22	47.4	1.30	46.2	2.36	38.3	2.96	45.7	1.09	1.31
2004	0.42	33.5	0.51	33.6	5.01	46.3	4.06	44.8	2.10	1.79
2005	1.00	56.8	0.80	64.3	1.94	31.4	2.11	30.9	1.19	1.23
2006	0.58	35.4	0.49	36.9	1.36	28.8	1.42	26.4	0.36	0.39
2007	0.75	29.8	0.68	29.5	2.13	40.1	2.00	50.6	0.18[1]	0.27
2008	7.35	57.8	5.42	66.8	4.58	31.0	2.70	25.5	1.07	0.65
2009	2.68	51.9	1.36	42.1	6.58	26.8	5.20	29.0	0.70	0.56
2010	2.08	28.0	1.36	26.1	2.38[2,4]	36.3	1.83	36.7	0.79	0.66
2011	1.86	26.5	1.15	23.5	5.48	32.1	4.64	36.7	0.69	0.42
2012	2.60	28.6	2.01	30.7	5.24	27.2	4.44	28.0	1.01	0.73
2013	3.37	34.2	2.55	37.8	2.11	52.0	1.90	49.8	1.19	0.57
2014	4.34[5]	38.8	3.45	39.6					0.56	0.37
Median	2.11		1.42		2.57		2.40		1.25	1.74

[1] No tows conducted in the northwest portion of stratum 5Z3 due to adverse weather conditions.
[2] One station in each of strata 16 and 19 were not sampled due to vessel mechanical problems.
[3] For U.S. survey indices from 2009 onward, length-based conversion factors were applied to the FSV *H. B. Bigelow* numbers-at-length to obtain RV *Albatross IV* equivalents and kg per tow indices were computed by applying the respective seasonal survey length-weight equations for 1982-2007.
[4] Stations located on the Canadian side of Georges Bank were not sampled during the fall of 2010 because of severe weather delays during previous survey legs.
[5] The 2014 U.S. spring survey occurred on Georges Bank during May, instead of April, due to vessel mechanical problems.

Table A16. NEFSC fall survey minimum population size-at-age (thous. of fish) for Georges Bank winter flounder (offshore strata 13-23), during 1981-2013, lagged forward one year and age.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
1982	0	2,396	674	814	1,082	504	135	244	147	63	6,059
1983	284	2,094	2,178	583	542	283	184	0	33	0	6,181
1984	27	70	568	1,347	619	236	264	95	57	57	3,339
1985	239	654	1,189	1,391	1,408	368	113	26	12	0	5,401
1986	110	341	885	550	80	190	27	0	0	0	2,182
1987	145	1,160	1,627	370	205	48	24	23	0	48	3,652
1988	36	53	239	256	208	99	80	62	27	0	1,061
1989	49	2,958	620	468	139	9	25	25	0	0	4,293
1990	24	97	1,072	73	143	74	58	9	27	0	1,577
1991	24	61	44	376	0	52	0	0	0	0	557
1992	109	46	0	81	53	18	36	0	0	0	344
1993	0	53	509	158	9	27	0	0	0	0	757
1994	0	592	192	283	213	27	0	18	0	18	1,343
1995	0	167	424	224	86	33	0	0	0	0	934
1996	18	937	1,115	685	187	57	0	0	18	0	3,018
1997	0	124	344	614	259	131	94	63	0	0	1,628
1998	18	79	648	758	344	79	30	3	0	0	1,960
1999	91	273	386	1,713	1,109	190	66	27	0	0	3,854
2000	18	388	796	381	367	608	88	27	24	0	2,697
2001	18	53	1,286	1,666	753	902	270	56	69	0	5,073
2002	18	599	1,536	2,442	1,276	322	332	100	53	25	6,703
2003	0	206	496	1,053	1,309	1,148	410	477	23	23	5,146
2004	309	176	27	352	770	652	209	80	21	0	2,597
2005	231	326	1,353	1,377	1,328	282	349	230	44	0	5,520
2006	97	55	167	493	464	297	358	132	18	58	2,139
2007	0	101	179	307	380	422	72	42	0	0	1,502
2008	231	313	317	307	428	613	91	34	18	0	2,351
2009	90	1,152	1,612	1,202	286	346	224	48	0	88	5,047
2010	0	190	1,509	2,401	1,882	665	363	72	46	121	7,249
2011	38	31	487	941	696	211	134	28	15	42	2,623
2012	25	585	464	1,528	1,887	1,024	25	86	58	128	6,037
2013	117	252	936	1,098	1,799	949	348	140	31	103	5,774
2014	0	58	348	489	459	389	267	183	31	100	2,324

Table A17. NEFSC spring survey minimum population size-at-age (thous. of fish) for Georges Bank winter flounder (offshore strata 13-23) during 1982-2014.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
1982	74	903	555	660	191	151	41	18	36	36	2,665
1983	27	1,037	3,704	1,555	692	796	608	424	125	169	9,135
1984	36	168	2,107	1,635	390	379	477	280	27	146	5,644
1985	0	1,701	821	636	402	223	47	24	49	0	3,902
1986	255	752	857	192	170	85	0	0	0	0	2,310
1987	163	1,647	670	275	91	0	24	0	0	0	2,871
1988	73	556	1,433	692	117	42	18	0	27	0	2,958
1989	49	560	293	251	157	18	0	53	0	0	1,381
1990	129	653	1,611	357	99	74	0	0	0	0	2,923
1991	273	349	834	587	278	36	24	0	49	0	2,430
1992	73	652	302	141	148	111	0	24	27	0	1,477
1993	172	291	362	175	0	47	33	24	0	0	1,105
1994	127	604	436	96	66	45	0	0	0	0	1,374
1995	150	790	1,295	297	103	30	0	0	0	0	2,664
1996	38	1,233	436	494	70	27	43	0	0	0	2,339
1997	24	194	542	677	115	24	27	0	24	0	1,627
1998	0	24	218	468	125	0	27	0	0	0	861
1999	225	548	675	1,313	896	200	53	18	0	0	3,927
2000	18	620	1,069	697	1,155	734	200	120	71	0	4,685
2001	0	73	335	314	197	193	268	0	0	0	1,380
2002	113	167	245	1,935	772	784	701	312	159	26	5,215
2003	52	27	163	231	367	320	154	27	0	0	1,341
2004	0	36	27	63	215	73	24	28	0	0	465
2005	98	188	130	315	212	132	0	27	0	0	1,101
2006	43	0	188	210	88	81	0	24	0	0	634
2007	91	128	67	159	180	100	56	23	19	0	822
2008	945	1,280	1,513	1,945	1,427	386	94	504	0	0	8,094
2009	43	1,258	831	456	161	145	22	28	0	13	2,957
2010	7	153	901	693	242	230	25	18	3	25	2,297
2011	39	104	507	837	426	92	11	0	7	31	2,054
2012	37	200	184	890	1,012	295	107	17	22	97	2,862
2013	93	326	602	497	627	926	305	131	54	155	3,716
2014	16	317	907	1,278	343	691	579	397	143	107	4,777

Table A18. Canadian spring survey (February) minimum population size-at-age (thous. of fish) for Georges Bank winter flounder during 1987-2014.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+	Total
1987	0	68	153	202	255	102	0	0	0	0	780
1988	102	386	1,396	653	101	46	0	23	0	0	2,708
1989	54	1,244	623	448	141	27	4	6	0	0	2,547
1990	0	88	683	1,991	262	42	25	3	0	0	3,094
1991	44	57	412	577	129	29	0	0	0	0	1,247
1992	0	17	38	131	48	86	0	3	0	0	323
1993	746	419	595	282	85	48	41	3	0	0	2,219
1994	10	2,083	705	155	234	1	11	10	0	0	3,207
1995	992	1,544	799	134	57	8	2	0	0	0	3,534
1996	562	792	589	408	136	50	48	2	3	4	2,594
1997	11	609	990	1,102	120	23	9	17	0	0	2,880
1998	11	19	100	382	180	21	0	0	0	0	714
1999	32	154	146	252	145	36	12	4	4	0	784
2000	6	0	7	87	82	227	227	120	121	54	932
2001	150	49	121	147	276	92	232	348	10	11	1,437
2002	0	58	136	51	729	256	270	284	126	83	1,993
2003	29	135	37	53	80	131	86	126	7	2	686
2004	331	113	59	138	136	327	101	96	17	0	1,319
2005	55	100	55	104	107	107	102	63	37	17	748
2006	0	3	3	50	62	33	68	2	3	1	226
2007	0	0	3	0	8	39	24	21	8	9	112
2008	260	123	48	54	75	26	32	54	0	0	671
2009	11	75	184	68	25	35	5	21	0	16	439
2010	0	8	133	210	81	45	1	18	0	0	495
2011	48	40	54	170	90	20	3	0	0	7	432
2012	26	19	27	175	164	60	15	0	11	39	637
2013	244	94	121	65	55	80	42	17	13	17	747
2014	70	46	32	67	14	49	37	24	9	2	350

Table A19. Input data and descriptions of the final VPA model run conducted for the 2014 assessment update of Georges Bank winter flounder. Catch-at-age data was included for 1982-2013 for ages 1-7+.

Description of Abbreviations	Catch-at-age	Tuning Indices (swept-area nos.)	M	Maturity	2011 stock estimates	R in 2014	Avg. F	Recruits	Selectivity
US bottom trawl (BT) and scallop dredge (SD) discards	Ages 1-7+, US BT and SD discards-at-age; CA SD discards-at-age; US landings-at-age; US landings bumped up by CA landings	US spr & CA spr surveys, ages 1-7+; US fall svy, ages 0-6 (lagged forward 1 yr and age)	Constant across all ages at 0.3	1981-2014 3-yr moving window for 1982-2013	Ages 3-6	Geom. Mean, 2006-2012	Ages 4-6	Age 1	Flat-topped, full at age 4

Table A20. VPA estimates of January 1 stock sizes (nos. in 000's), by year and age, for Georges Bank winter flounder during 1982-2014.

AGE	1982	1983	1984	1985	1986
1	13763.	8338.	17881.	16791.	21914.
2	21622.	10097.	6051.	13129.	12365.
3	15683.	15111.	5913.	3873.	8197.
4	8440.	8597.	6164.	3387.	1634.
5	3016.	4400.	3842.	2206.	1073.
6	1897.	1336.	2298.	479.	764.
7	2066.	3426.	3329.	430.	515.
Total	66488.	51305.	45478.	40296.	46461.

AGE	1987	1988	1989	1990	1991
1	15542.	26316.	14912.	9880.	13235.
2	16202.	11429.	19434.	11018.	7288.
3	7895.	9572.	6860.	11807.	7574.
4	3659.	2822.	2240.	2842.	4999.
5	782.	1099.	619.	731.	882.
6	382.	339.	465.	191.	205.
7	521.	353.	263.	70.	327.
Total	44983.	51930.	44793.	36538.	34511.

AGE	1992	1993	1994	1995	1996
1	6422.	5200.	7308.	22770.	16283.
2	9803.	4738.	3784.	5407.	16213.
3	4289.	5865.	2983.	2136.	2780.
4	3263.	1879.	2379.	1080.	1281.
5	1950.	1174.	620.	1118.	553.
6	402.	646.	325.	285.	644.
7	267.	186.	298.	361.	577.
Total	26397.	19688.	17698.	33157.	38330.

AGE	1997	1998	1999	2000	2001
1	16181.	18634.	18185.	14200.	8626.
2	12033.	11985.	13803.	13412.	10474.
3	9677.	8565.	8861.	9609.	8743.
4	1320.	6297.	3816.	5138.	5134.
5	625.	592.	3195.	1886.	3144.
6	244.	311.	208.	2100.	942.
7	268.	88.	212.	1806.	591.
Total	40347.	46472.	48280.	48150.	37654.

AGE	2002	2003	2004	2005	2006
1	6654.	5155.	4354.	4074.	6559.
2	6367.	4929.	3819.	3223.	3014.
3	7091.	4504.	3196.	2754.	2161.
4	4210.	3642.	2129.	1861.	1574.
5	2385.	1807.	1106.	850.	728.
6	1295.	997.	555.	378.	315.
7	1037.	1581.	874.	542.	625.
Total	29039.	22614.	16033.	13682.	14976.

AGE	2007	2008	2009	2010	2011
1	10481.	14949.	15182.	7851.	8828.
2	4856.	7745.	11062.	11241.	5814.
3	2201.	3467.	5459.	7523.	8128.
4	1339.	1490.	2176.	2993.	4752.
5	909.	772.	823.	1051.	1619.
6	415.	478.	380.	413.	572.
7	444.	425.	361.	312.	375.
Total	20645.	29325.	35443.	31385.	30088.

AGE	2012	2013	2014
1	8671.	16789.	9909.
2	6528.	6422.	12434.
3	4161.	4713.	4591.
4	5272.	2224.	2801.
5	2547.	2910.	1133.
6	723.	1267.	1725.
7	604.	511.	977.
Total	28506.	34836.	33570.

Table A21. VPA estimates of average fishing mortality rates (ages 4-6), by year and age, for Georges Bank winter flounder during 1982-2013.

AGE	1982	1983	1984	1985	1986
1	0.0098	0.0206	0.0089	0.0060	0.0020
2	0.0582	0.2351	0.1461	0.1711	0.1486
3	0.3012	0.5968	0.2570	0.5630	0.5066
4	0.3513	0.5053	0.7276	0.8498	0.4365
5	0.5145	0.3495	1.7823	0.7608	0.7339
6	0.3918	0.4498	1.0157	0.8138	0.5440
7	0.3918	0.4498	1.0157	0.8138	0.5440

AGE	1987	1988	1989	1990	1991
1	0.0074	0.0032	0.0027	0.0042	0.0002
2	0.2262	0.2105	0.1983	0.0748	0.2303
3	0.7287	1.1525	0.5811	0.5594	0.5421
4	0.9026	1.2171	0.8195	0.8699	0.6412
5	0.5372	0.5610	0.8774	0.9732	0.4856
6	0.8278	0.9861	0.8318	0.8902	0.6163
7	0.8278	0.9861	0.8318	0.8902	0.6163

AGE	1992	1993	1994	1995	1996
1	0.0041	0.0179	0.0012	0.0396	0.0025
2	0.2137	0.1627	0.2716	0.3653	0.2161
3	0.5254	0.6023	0.7160	0.2114	0.4451
4	0.7222	0.8079	0.4552	0.3695	0.4171
5	0.8044	0.9838	0.4769	0.2523	0.5189
6	0.7522	0.8719	0.4597	0.3082	0.4467
7	0.7522	0.8719	0.4597	0.3082	0.4467

AGE	1997	1998	1999	2000	2001
1	0.0001	0.0001	0.0045	0.0043	0.0037
2	0.0399	0.0020	0.0622	0.1279	0.0901
3	0.1297	0.5085	0.2449	0.3268	0.4309
4	0.5023	0.3784	0.4050	0.1913	0.4667
5	0.3970	0.7456	0.1196	0.3940	0.5869
6	0.4672	0.4051	0.2648	0.2418	0.5107
7	0.4672	0.4051	0.2648	0.2418	0.5107

AGE	2002	2003	2004	2005	2006
1	0.0001	0.0001	0.0007	0.0013	0.0007
2	0.0462	0.1332	0.0267	0.0999	0.0144
3	0.3664	0.4491	0.2407	0.2597	0.1784
4	0.5458	0.8915	0.6182	0.6388	0.2489
5	0.5720	0.8810	0.7738	0.6926	0.2628
6	0.5552	0.8880	0.6687	0.6553	0.2533
7	0.5552	0.8880	0.6687	0.6553	0.2533

AGE	2007	2008	2009	2010	2011
1	0.0025	0.0011	0.0005	0.0004	0.0019
2	0.0370	0.0498	0.0856	0.0243	0.0344
3	0.0904	0.1657	0.3009	0.1593	0.1329
4	0.2508	0.2937	0.4280	0.3149	0.3237
5	0.3423	0.4094	0.3891	0.3073	0.5056
6	0.2868	0.3317	0.4172	0.3129	0.3669
7	0.2868	0.3317	0.4172	0.3129	0.3669

AGE	2012	2013
1	0.0003	0.0003
2	0.0257	0.0355
3	0.3264	0.2203
4	0.2941	0.3746
5	0.3983	0.2229
6	0.3269	0.2988
7	0.3269	0.2988

Table A22. VPA estimates of spawning stock biomass (mt), by year and age, for Georges Bank winter flounder during 1982-2013.

AGE	1982	1983	1984	1985	1986
1	53.	20.	0.	0.	34.
2	707.	438.	143.	593.	1086.
3	4057.	3698.	1639.	1396.	3566.
4	5282.	4155.	2587.	1747.	957.
5	2593.	3245.	1653.	1535.	796.
6	1880.	1111.	1477.	425.	715.
7	2807.	3806.	3033.	560.	663.
Total	17380.	16474.	10533.	6256.	7817.

AGE	1987	1988	1989	1990	1991
1	8.	28.	0.	0.	0.
2	1270.	603.	487.	253.	228.
3	2989.	2987.	2321.	4436.	2664.
4	2159.	1353.	1240.	1417.	2561.
5	643.	949.	455.	504.	669.
6	336.	311.	449.	180.	213.
7	678.	450.	346.	105.	455.
Total	8082.	6682.	5298.	6895.	6790.

AGE	1992	1993	1994	1995	1996
1	0.	0.	0.	0.	0.
2	474.	175.	0.	105.	510.
3	1518.	2106.	1151.	1015.	1316.
4	1684.	970.	1430.	578.	861.
5	1258.	756.	460.	921.	473.
6	350.	571.	337.	289.	712.
7	301.	263.	399.	512.	844.
Total	5585.	4841.	3778.	3420.	4716.

AGE	1997	1998	1999	2000	2001
1	0.	0.	0.	0.	0.
2	489.	24.	1449.	1403.	666.
3	4550.	3310.	2996.	3598.	3415.
4	759.	3245.	2051.	2438.	2840.
5	511.	358.	2641.	1455.	1896.
6	249.	322.	240.	2225.	905.
7	321.	135.	327.	2566.	879.
Total	6878.	7393.	9703.	13685.	10601.

AGE	2002	2003	2004	2005	2006
1	0.	0.	0.	0.	0.
2	24.	14.	0.	0.	242.
3	2838.	2056.	823.	1333.	1086.
4	2510.	2276.	1457.	1285.	1148.
5	1879.	1528.	976.	740.	742.
6	1242.	1042.	611.	423.	401.
7	1518.	2223.	1210.	751.	1038.
Total	10011.	9139.	5077.	4533.	4656.

AGE	2007	2008	2009	2010	2011
1	0.	0.	0.	0.	0.
2	116.	124.	89.	81.	34.
3	1246.	1416.	1872.	2456.	1851.
4	1015.	962.	1291.	1734.	2559.
5	908.	639.	637.	778.	1107.
6	527.	494.	371.	390.	504.
7	738.	593.	490.	423.	459.
Total	4550.	4229.	4749.	5862.	6514.

AGE	2012	2013
1	0.	20.
2	209.	399.
3	1069.	1880.
4	2734.	1120.
5	1638.	1952.
6	605.	1013.
7	632.	563.
Total	6887.	6947.

Table A23. VPA model estimates of average fishing mortality rates and spawning stock biomass, during 1982-2013, and age 1 recruitment, during 1982-2014, for Georges Bank winter flounder.

Year	Avg F (ages 4-6)	Spawning Stock Biomass (mt)	Recruitment (nos. in thousands)
1982	0.419	17,380	13,763
1983	0.435	16,474	8,338
1984	1.175	10,533	17,881
1985	0.808	6,256	16,791
1986	0.572	7,817	21,914
1987	0.756	8,082	15,543
1988	0.921	6,682	26,316
1989	0.843	5,298	14,912
1990	0.911	6,895	9,880
1991	0.581	6,790	13,235
1992	0.760	5,585	6,422
1993	0.888	4,841	5,200
1994	0.464	3,778	7,308
1995	0.310	3,420	22,770
1996	0.461	4,716	16,283
1997	0.456	6,878	16,181
1998	0.510	7,393	18,634
1999	0.263	9,703	18,185
2000	0.276	13,685	14,200
2001	0.521	10,601	8,626
2002	0.558	10,011	6,654
2003	0.887	9,139	5,155
2004	0.687	5,077	4,354
2005	0.662	4,533	4,074
2006	0.255	4,656	6,559
2007	0.293	4,550	10,481
2008	0.345	4,229	14,949
2009	0.411	4,749	15,182
2010	0.312	5,862	7,851
2011	0.399	6,514	8,828
2012	0.340	6,887	8,671
2013	0.299	6,947	16,789
2014			9,909

Table A24. Bootstrapped estimates of the 2013 fishing mortality rates-at-age, from the final VPA run, and the associated precision and bias estimates for Georges Bank winter flounder.

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AVG F	0.2988	0.3100	0.061479	0.1983
N WTD	0.2906	0.2913	0.057402	0.1970
B WTD	0.2831	0.2847	0.056876	0.1998
C WTD	0.3042	0.3156	0.063701	0.2018

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AVG F	0.011242	0.001976	3.7627	0.2875	0.2138
N WTD	0.000695	0.001815	0.2390	0.2899	0.1980
B WTD	0.001553	0.001799	0.5486	0.2816	0.2020
C WTD	0.011355	0.002046	3.7322	0.2929	0.2175

	LOWER 90. % CI	UPPER 90. % CI
AVG F	0.222185	0.427749
N WTD	0.209589	0.395203
B WTD	0.207446	0.387621
C WTD	0.225519	0.434803

Table A25. Bootstrapped estimates of the 2013 spawning stock biomass (mt) and 2014 January 1 mean biomass estimates, from the final VPA run, and the associated precision and bias estimates for Georges Bank winter flounder.

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
JAN-1	13237.	13732.	2224.	0.1620
MEAN	11136.	11637.	1924.	0.1653
SSB	6947.	7255.	1147.	0.1580

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
JAN-1	495.	72.	3.7429	12741.	0.1746
MEAN	501.	63.	4.4985	10635.	0.1809
SSB	308.	38.	4.4288	6639.	0.1727

	LOWER 90. % CI	UPPER 90. % CI
JAN-1	10444.	17608.
MEAN	8775.	14973.
SSB	5525.	9274.

Table A26. Bootstrapped estimates of the 2014 stock sizes-at-age (in thousands), from the final VPA run, and associated precision and bias estimates for Georges Bank winter flounder.

NLLS	Bootstrap Estimate	Bootstrap Mean	C.V. For Std Error	NLLS Soln.
N 3	4591.	5069.	2293.	0.4523
N 4	2801.	3012.	1253.	0.4158
N 5	1133.	1203.	437.	0.3630
N 6	1725.	1825.	618.	0.3389

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 3	478.	74.	10.4024	4114.	0.5573
N 4	211.	40.	7.5386	2590.	0.4836
N 5	70.	14.	6.2179	1062.	0.4111
N 6	99.	20.	5.7642	1626.	0.3804

	LOWER 90. % CI	UPPER 90. % CI
N 3	2241.	9451.
N 4	1413.	5328.
N 5	644.	2015.
N 6	971.	2946.

Table A27. Input data to stochastic projection software used to compute median estimates of catch (mt) and spawning stock biomass (mt) of Georges Bank winter flounder during 2015-2017. The data are 2009-2013 averages from the final VPA model. Selectivity-, stock weights-, catch weights-, and proportions mature-at-age data were also used in the Beverton-Holt stock-recruitment model to estimate FMSY.

Age	Selectivity on F	Selectivity on M	Stock weights	Catch weights	Spawning stock weights	Proportion mature
1	0.002	1	0.275	0.241	0.238	0.003
2	0.116	1	0.264	0.368	0.319	0.073
3	0.641	1	0.443	0.518	0.473	0.745
4	1.000	1	0.616	0.699	0.647	1.000
5	1.000	1	0.809	0.870	0.830	1.000
6	1.000	1	1.024	1.092	1.043	1.000
7+	1.000	1	1.464	1.431	1.431	1.000

Table A28. Summary of Beverton-Holt stock-recruitment model fits for Georges Bank winter flounder based on updated input data from the VPA model (1982-2012 year-classes). The updated FMSY reference point (= 0.44) was estimated from the model run with steepness (*h*) fixed at 0.78. Note that only the FMSY estimate from this model was used as a biological reference point.

	No prior	Prior on *h*[1]	Final Model Fixed *h*[2]
FMSY	2.0	0.53	0.44
SSBMSY (mt)	1,832	5,745	6,828
MSY (mt)	3,157	2,825	2,807
Fmax	N/A	N/A	N/A
h	1.00	0.84	0.78
R_0	12,632	14,257	15,234
NegLL	311.785	310.897	306.660
AIC	630.460	631.457	632.187

[1] Steepness prior (*h*) set to 0.80 and SE set to 0.09 based on values for Pleuronectids reported in Myers et al. (1999)

[2] See text regarding rationale for fixing *h* at 0.78

Table A29. Log-likelihood profile for fixed unfished steepness (*h*) values from Beverton-Holt stock-recruitment models (1982-2012 year-classes) for Georges Bank winter flounder. The steepness parameter was fixed at 0.78 in the final model run.

Fixed unfished steepness (*h*)	F_{MSY}	SSBMSY (mt)	MSY (mt)	Bias-corrected AIC	NLL
0.60	0.27	12,196	3,119	636.717	308.926
0.70	0.35	8,660	2,852	633.648	307.391
0.78	0.44	6,828	2,807	632.187	306.660
0.80	0.47	6,411	2,809	631.917	306.525

Table A30. Existing biological reference points (and 80% confidence limits) and updated biological reference points (and 90% confidence limits) in relation to the 2013 F and SSB estimates (and 90% confidence limits) used to determine the stock status of Georges Bank winter flounder during 2013.

	Existing	Updated
FMSY[1]	0.42	0.44
SSBMSY (mt)	11,800 (8,500, 16,800)	8,100 (5,890, 11,300)
MSY (mt)	4,400 (3,200, 6,100)	3,200 (2,340, 4,460)
F2013		0.299 (0.222, 0.428)
SSB2013 (mt)		6,947 (5,525, 9,274)

[1] Precision estimates were not possible because the steepness parameter (*h*) from the Beverton-Holt stock-recruitment model was fixed at 0.78

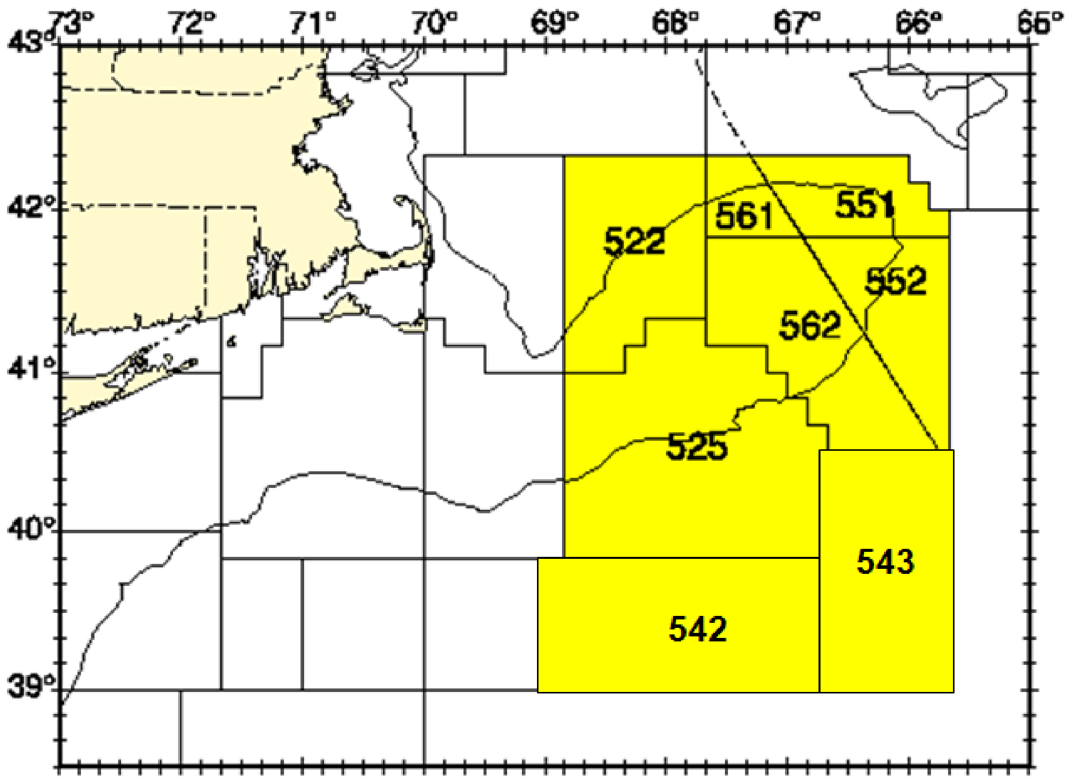


Figure A1. Statistical Areas used for reporting fishery data for the Georges Bank winter flounder stock.

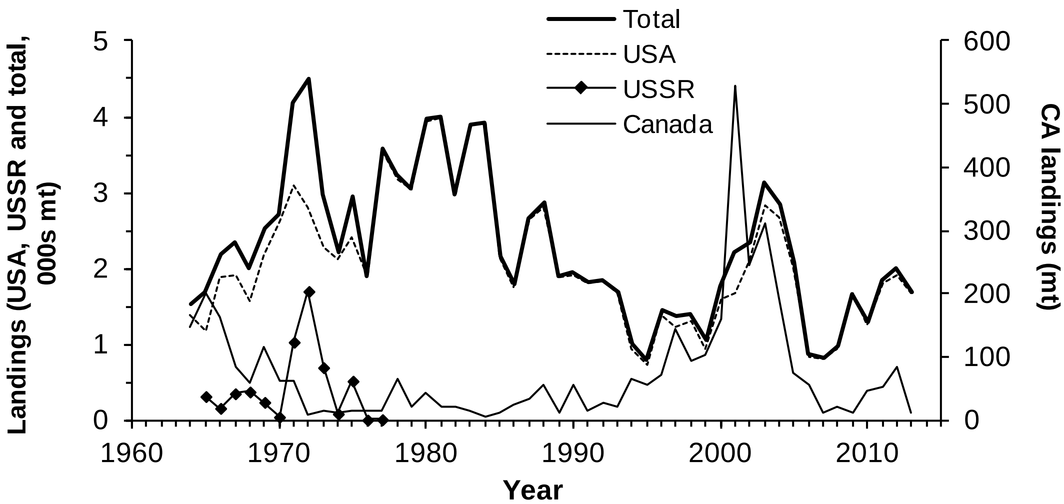


Figure A2. Landings (mt) of Georges Bank winter flounder, by country, during 1964-2013.

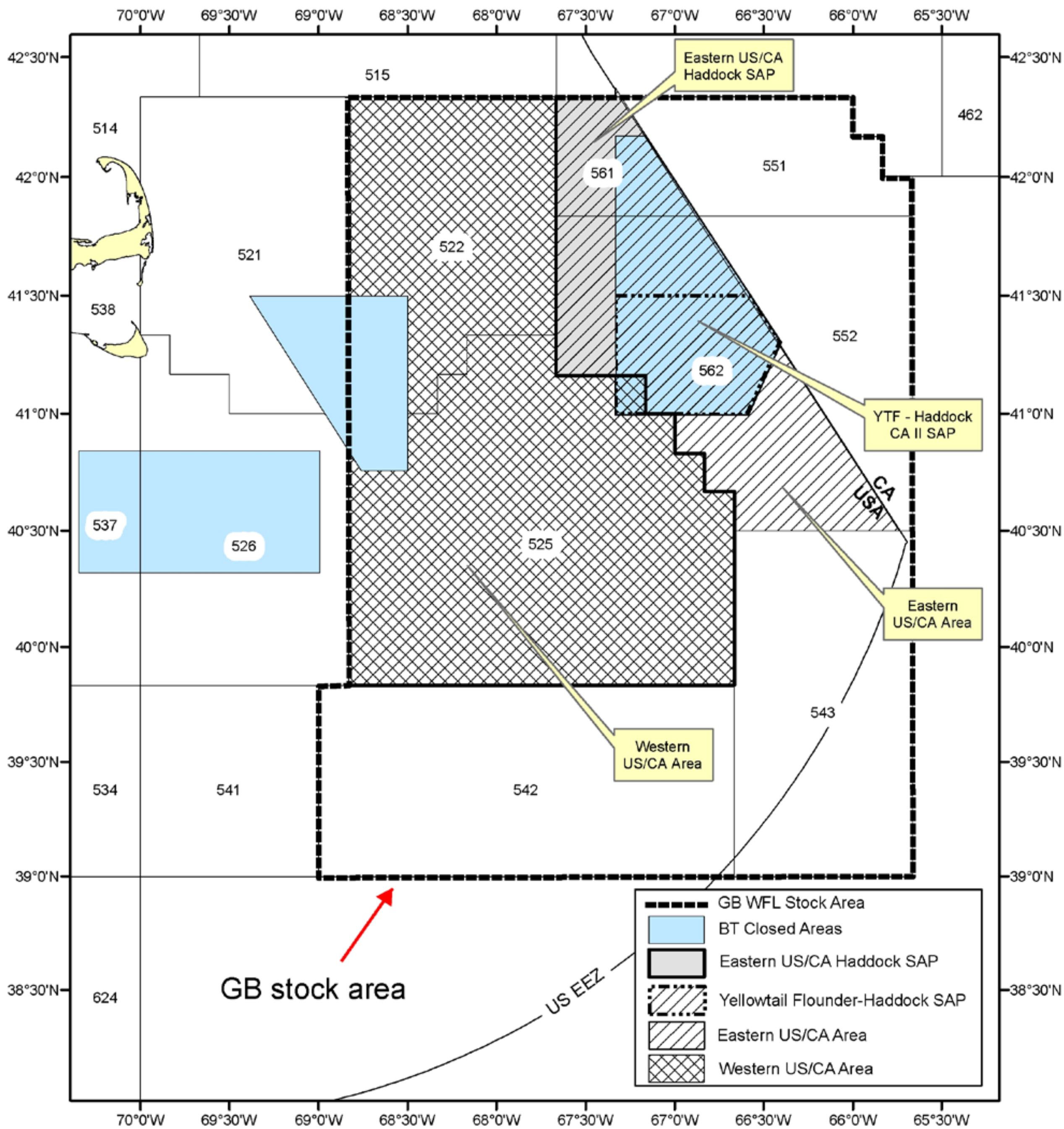


Figure A3. Fishery management areas that may affect the Georges Bank winter flounder stock. Blue polygons have been closed, since 1994, to bottom trawl vessels but have been open to scallop dredge vessels with fishery closures dependent on scallop and yellowtail flounder bycatch limits. The US/CA areas were implemented beginning in May of 2004 and involve jointly managed cod, haddock and yellowtail flounder stocks.

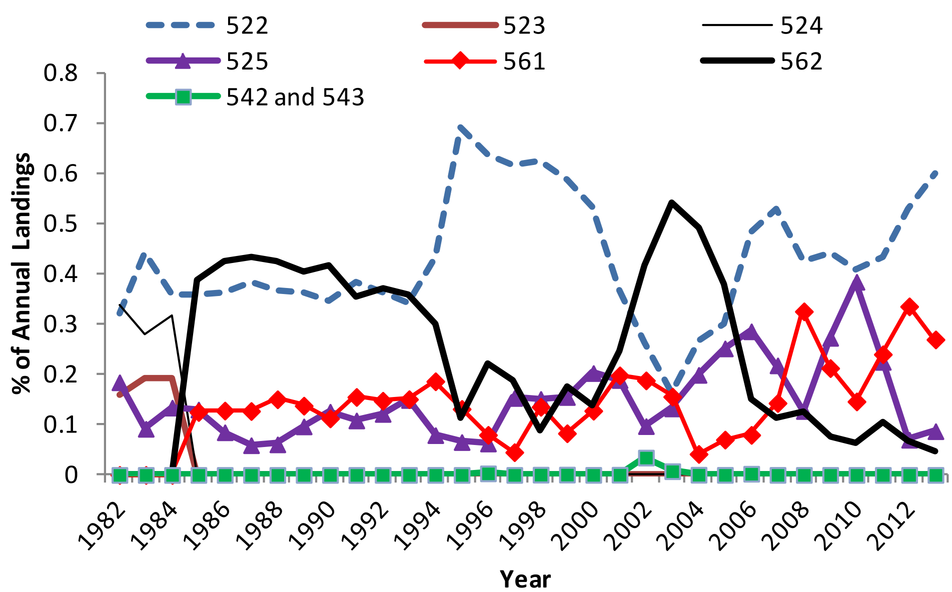


Figure A4. U.S. landings of Georges Bank winter flounder, by Statistical Area, during 1982-2013.

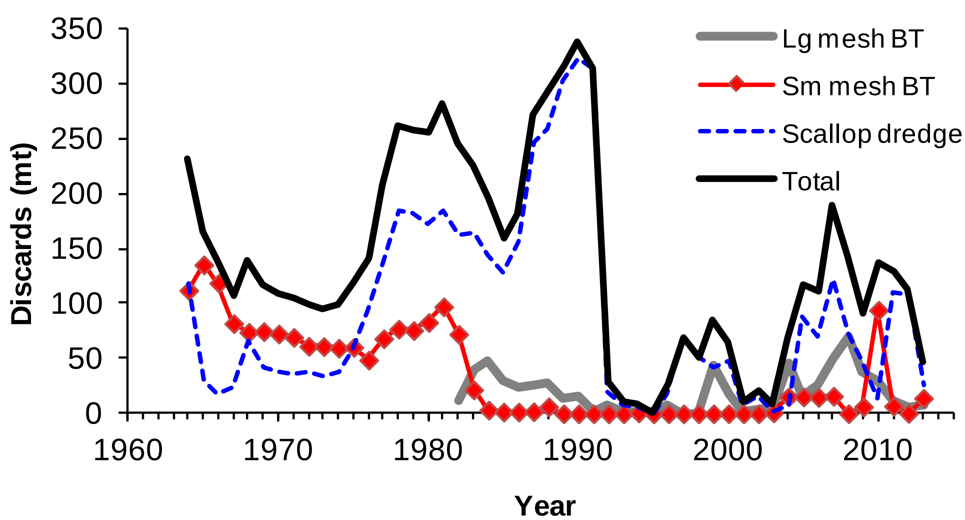


Figure A5. U.S. discards (mt) of Georges Bank winter flounder, by major gear type, during 1964-2013.

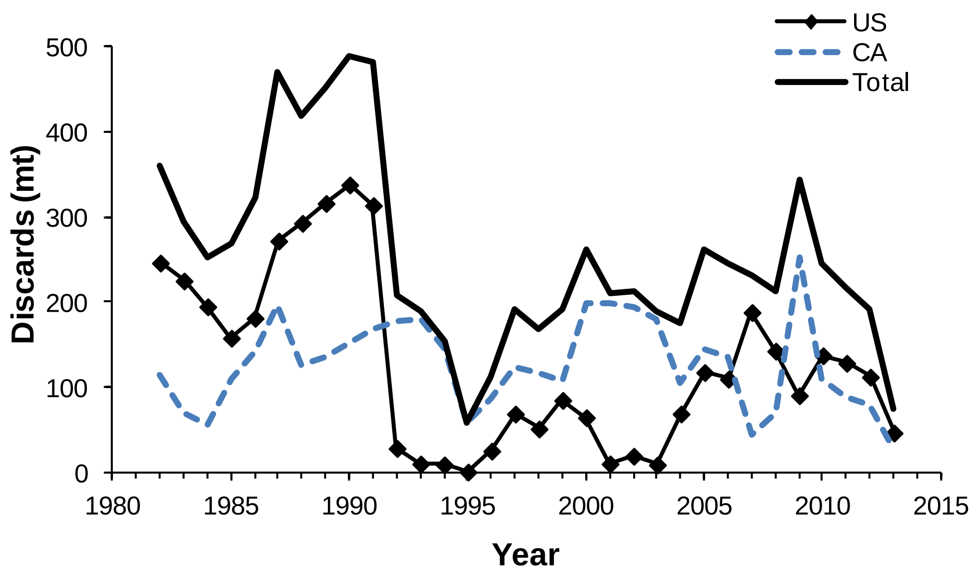


Figure A6. Estimates of total discards (mt) of Georges Bank winter flounder, by country, during 1982-2013.

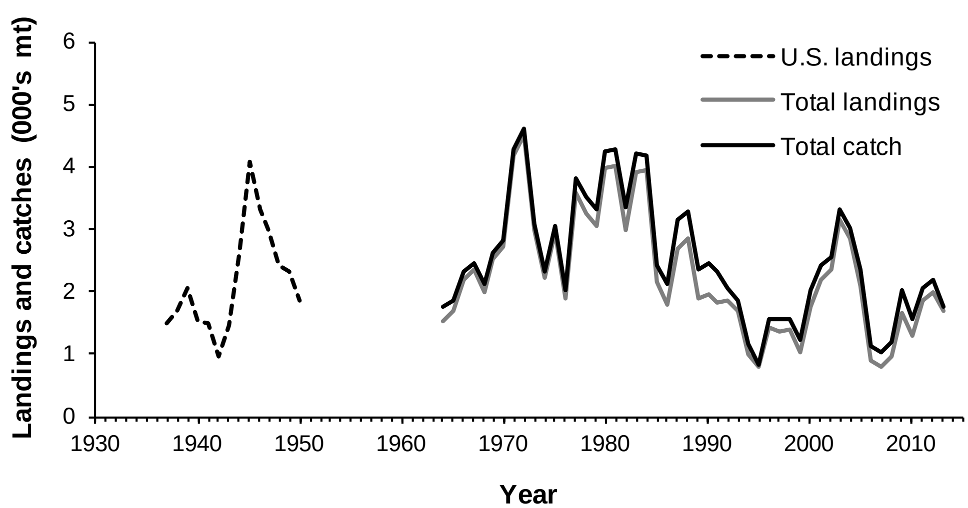


Figure A7. Historical U.S. landings of winter flounder from Georges Bank, during 1937-1950, in relation to total landings and catches during 1964-2013.

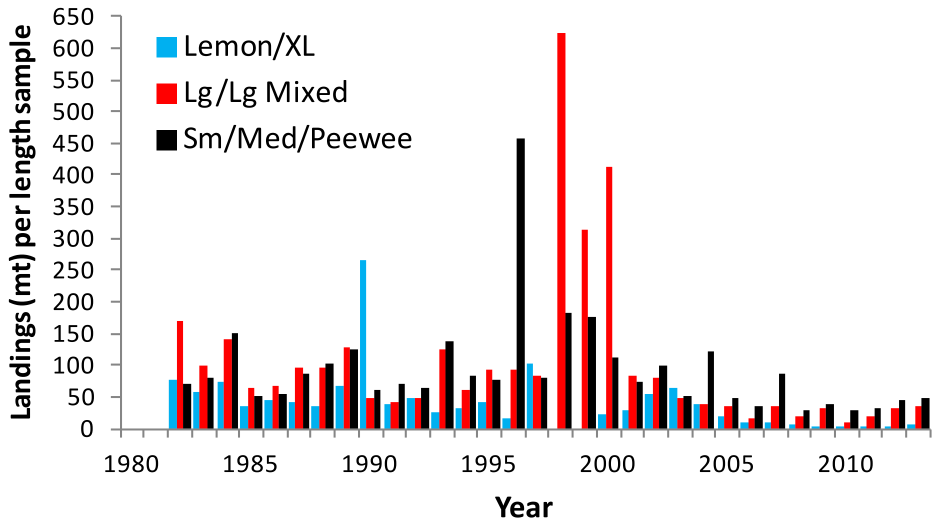


Figure A8. Landings of Georges Bank winter flounder per length sample (approximately 100 lengths per sample), by market category group, during 1982-2013.

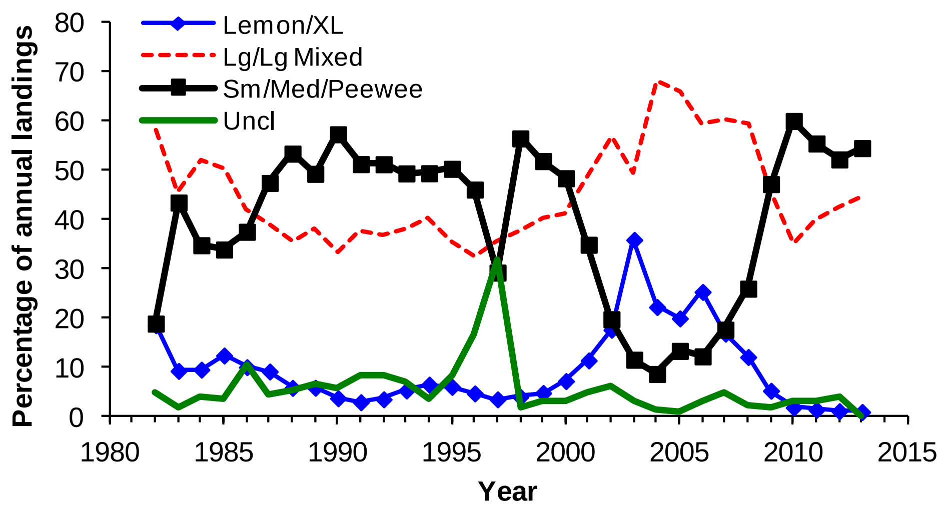


Figure A9. U.S. landings of Georges Bank winter flounder, by market category group, during 1982-2013.

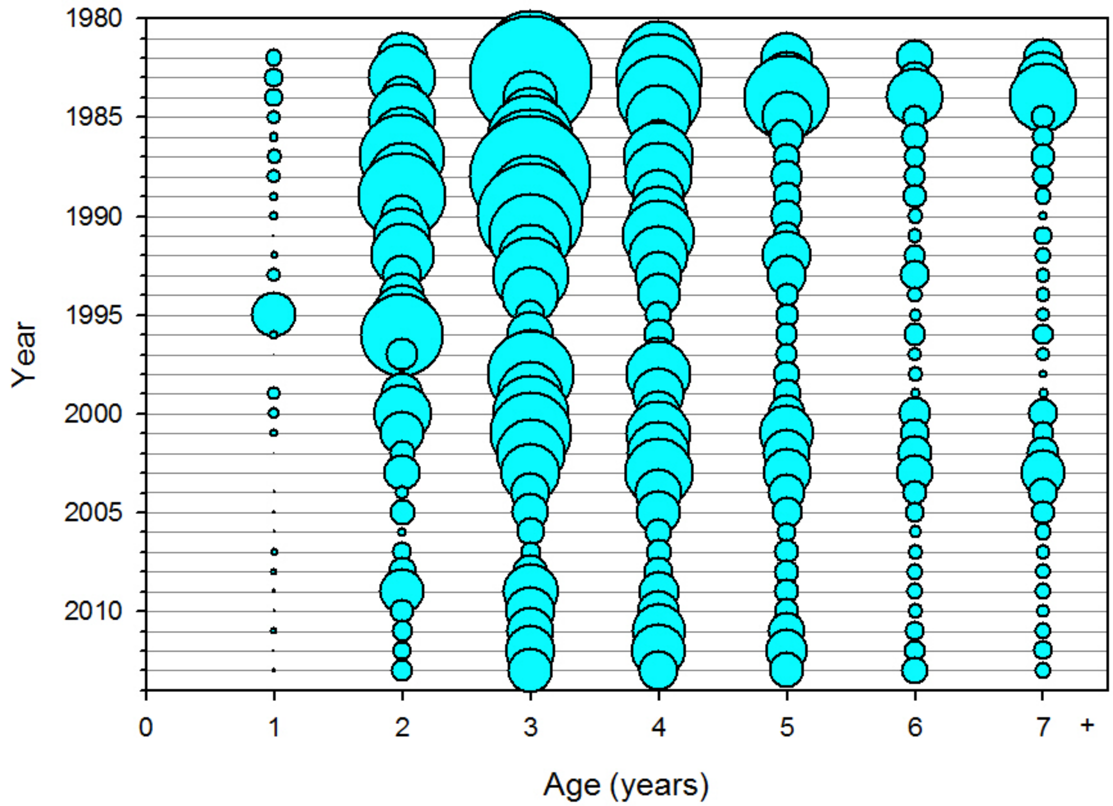


Figure A10. Georges Bank winter flounder catch-at-age during 1982-2013. Catches increase with circle size.

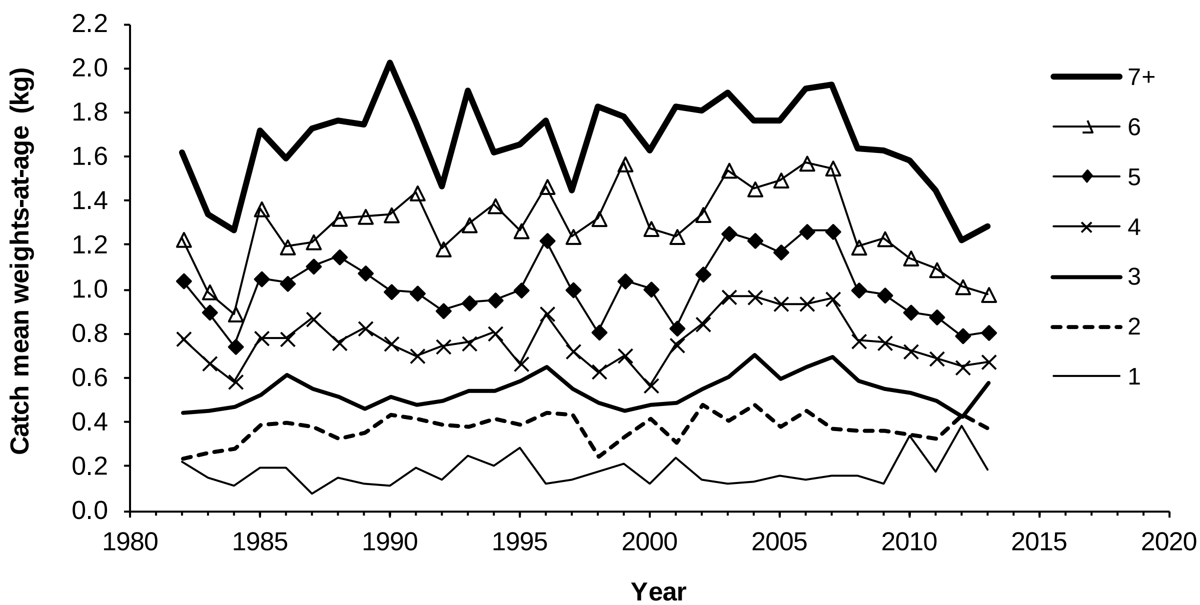


Figure A11. Trends in mean weights-at-age (kg) of GB winter flounder catches, 1982-2013.

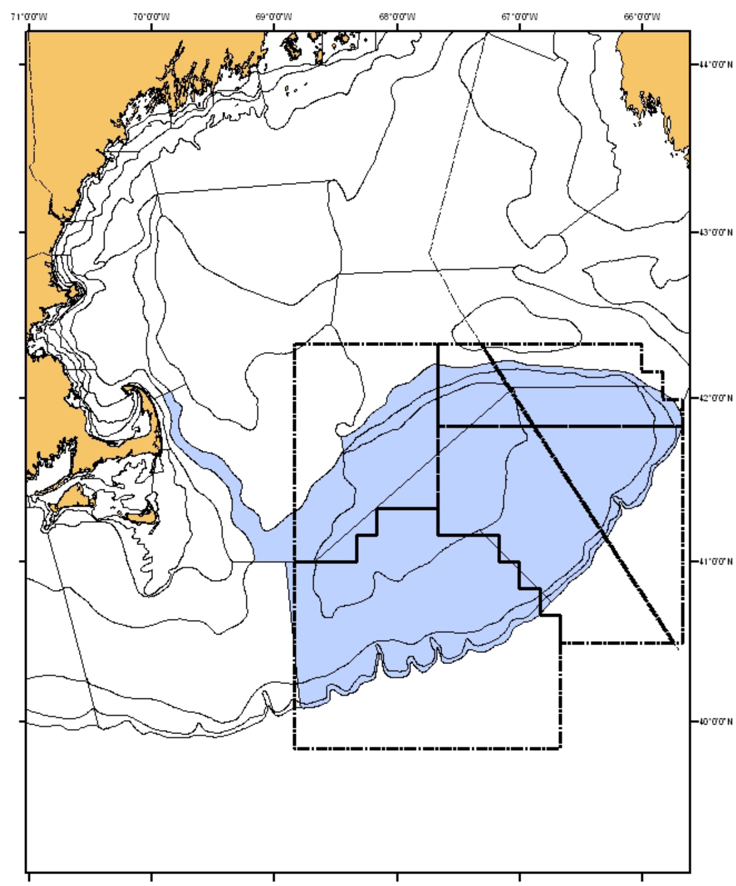


Figure A12. NEFSC survey strata (13-23) included in the assessment of Georges Bank winter flounder in relation to fishery Statistical Areas for the stock.

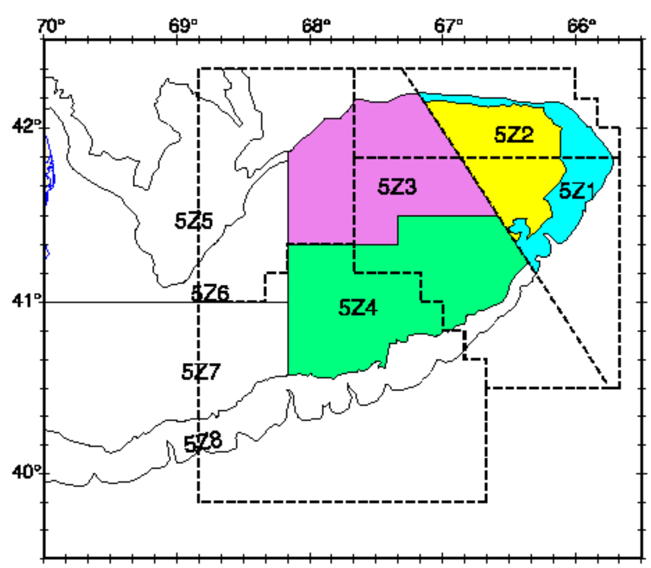
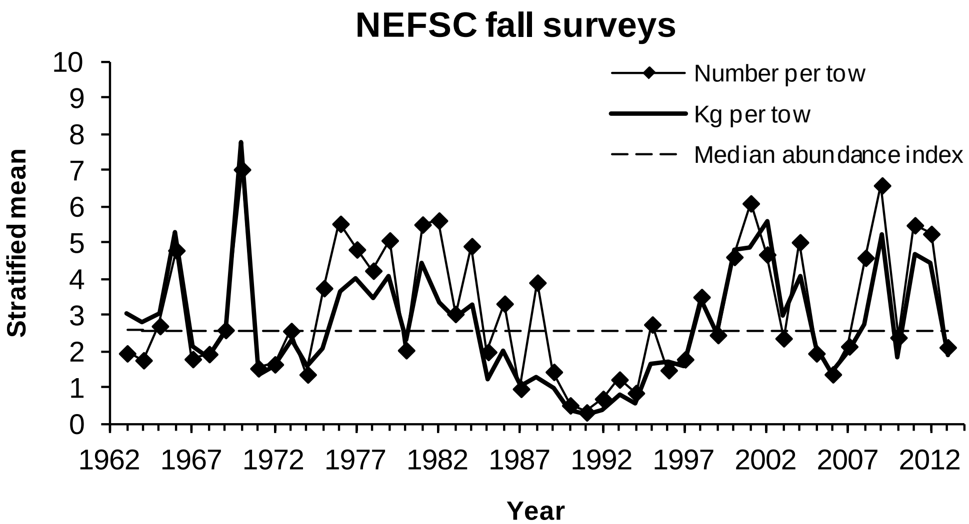


Figure A13. Strata (5Z1-5Z4) from the Canadian spring survey included in the assessment of Georges Bank winter flounder in relation to fishery Statistical Areas for the stock.



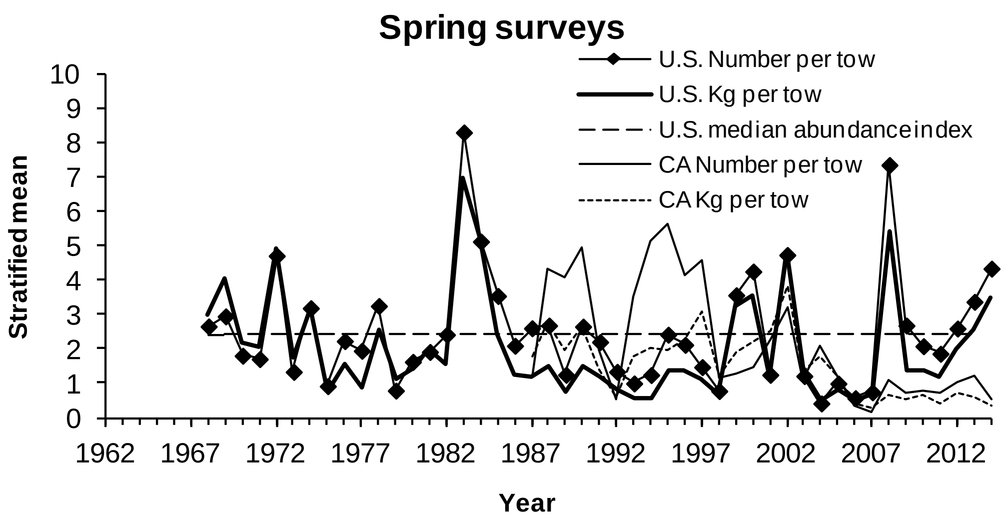


Figure A14. Relative biomass (stratified mean kg per tow) and abundance (stratified mean numbers per tow) indices for Georges Bank winter flounder caught during (top) NEFSC fall (1963-2013) bottom trawl surveys and (bottom) NEFSC spring (1968-2014) and Canadian spring (1987-2014 strata 5Z1-5Z4) bottom trawl surveys. NEFSC survey indices include strata 13-23 and were standardized for gear changes (weight = 1.86 and numbers = 2.02) and trawl door changes (weight = 1.39 and numbers = 1.46) prior to 1985. NEFSC indices for the SRV *H.B. Bigelow*, from 2009 onward, were converted to SRV *Albatross* equivalents using length-based conversion factors.

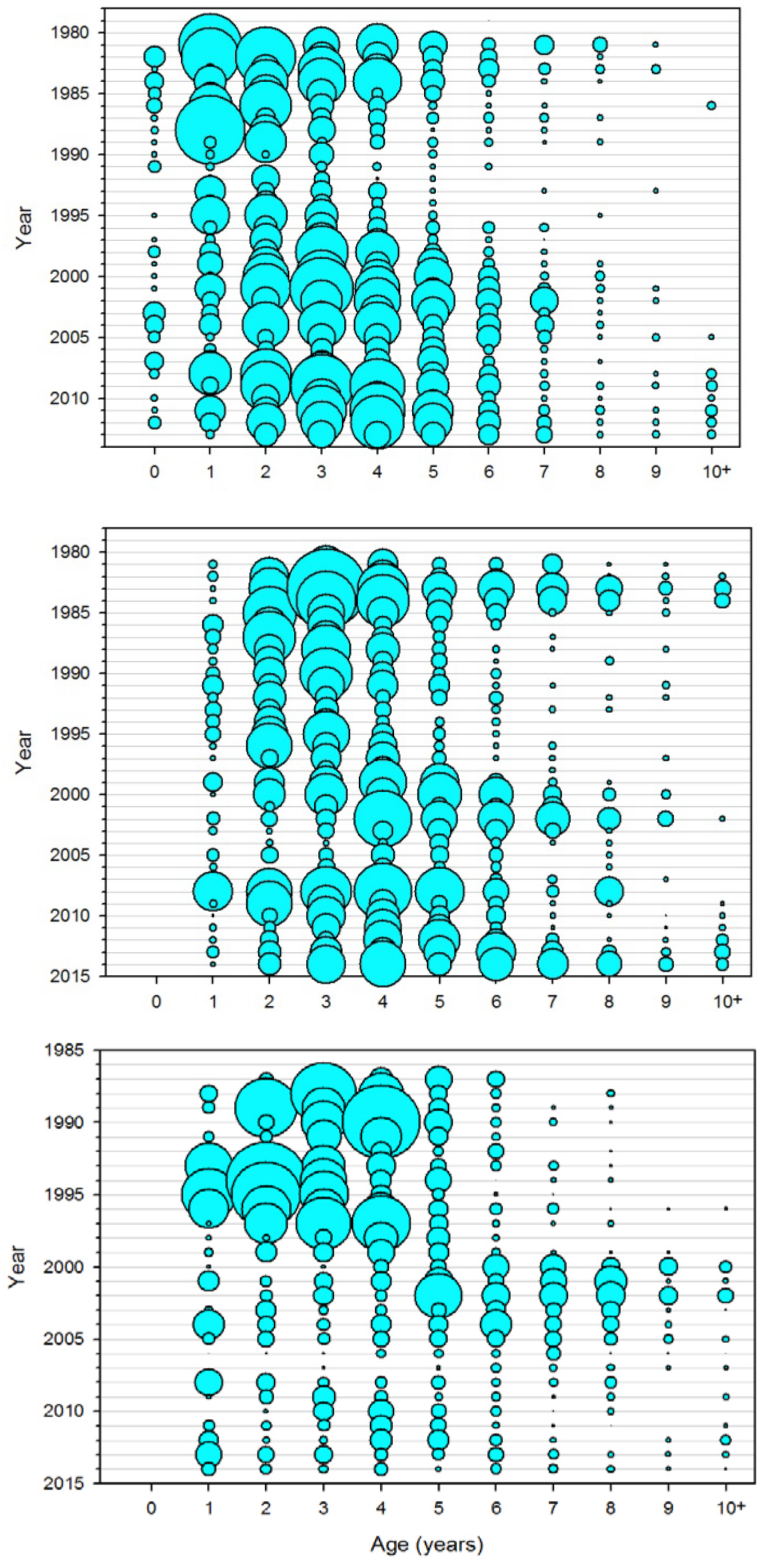


Figure A15. Stratified mean number per tow-at-age indices for (top) NEFSC fall bottom trawl surveys (1981-2013), (middle) NEFSC spring surveys (1982-2014) and (bottom) CA spring surveys (1987-2014). Relative abundance increases with circle size.

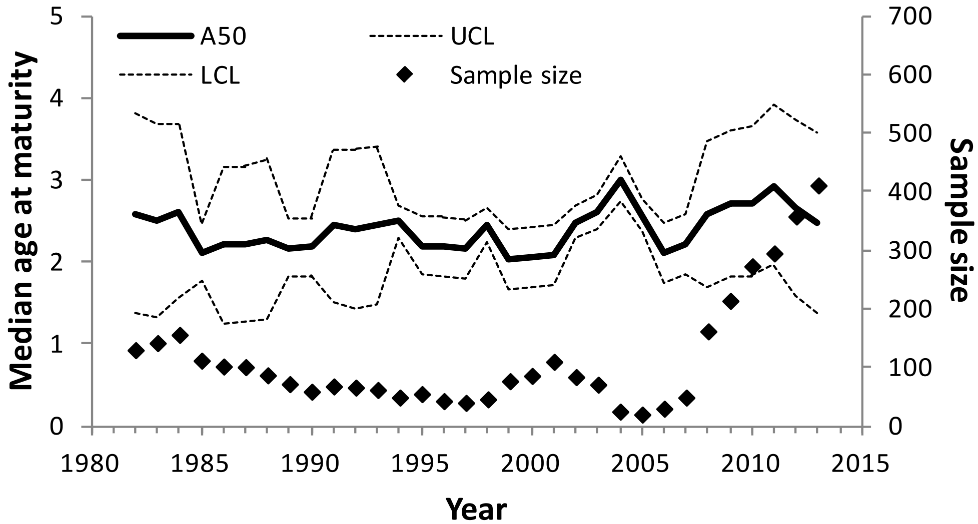


Figure A16. Three-year moving window (NEFSC spring survey data for 1981-2014) of female A50 values (median age-at-maturity) for Georges Bank winter flounder during 1982-2013.

Figure A17. Weighted residuals, plotted as Z scores, from the NEFSC spring bottom trawl survey indices (ages 1-7+, 1982-2014) used to calibrate the VPA model for Georges Bank winter flounder.

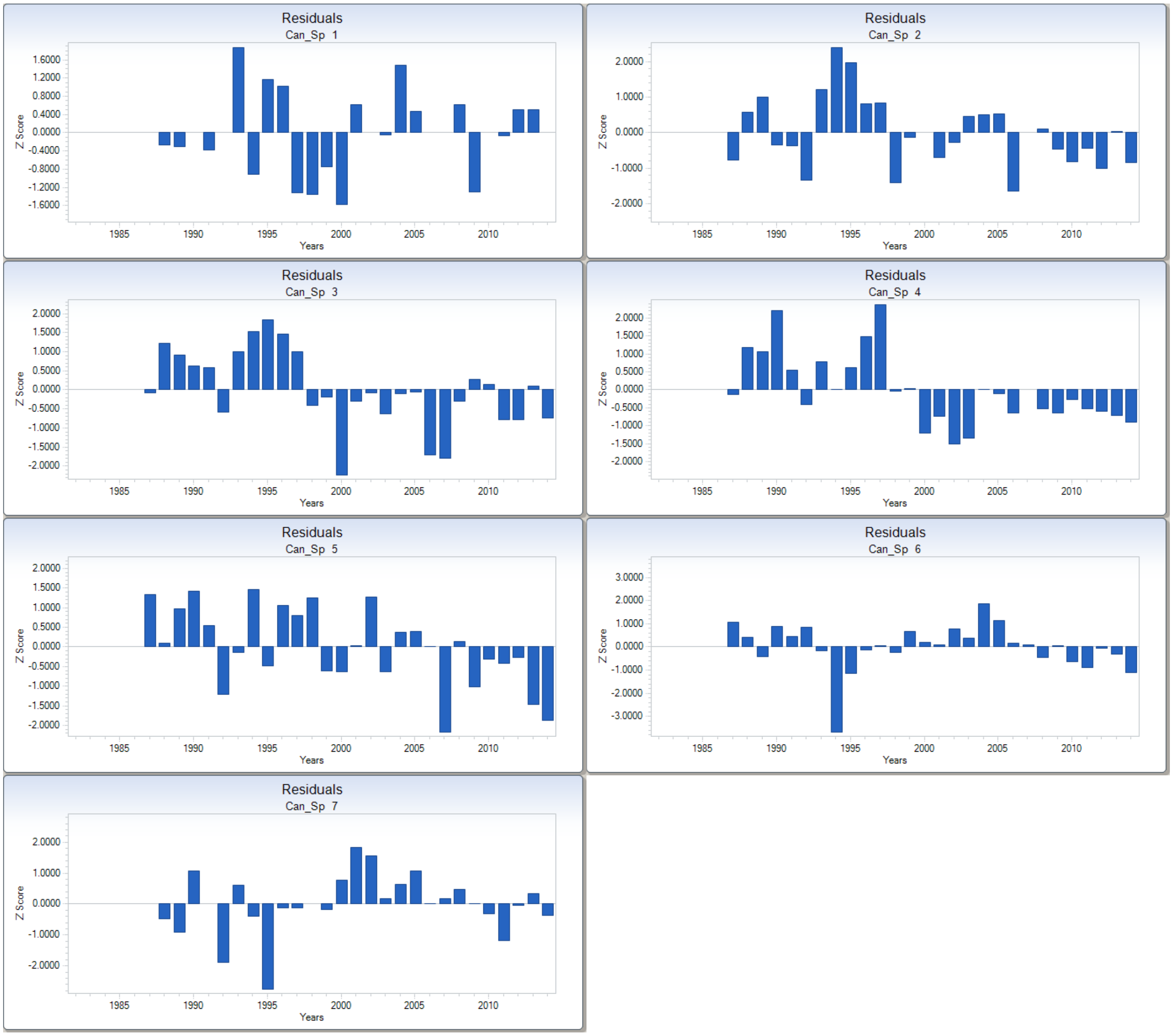


Figure A18. Weighted residuals, plotted as Z scores, from the Canadian spring bottom trawl survey indices (ages 1-7+, 1987-2014) used to calibrate the VPA model for Georges Bank winter flounder.

Figure A19. Weighted residuals, plotted as Z scores, from the US fall bottom trawl survey indices (ages 1-7+, 1982-2014; data for ages 0-6 during 1981-2013 were lagged forward by one year and age) used to calibrate the VPA model for Georges Bank winter flounder.

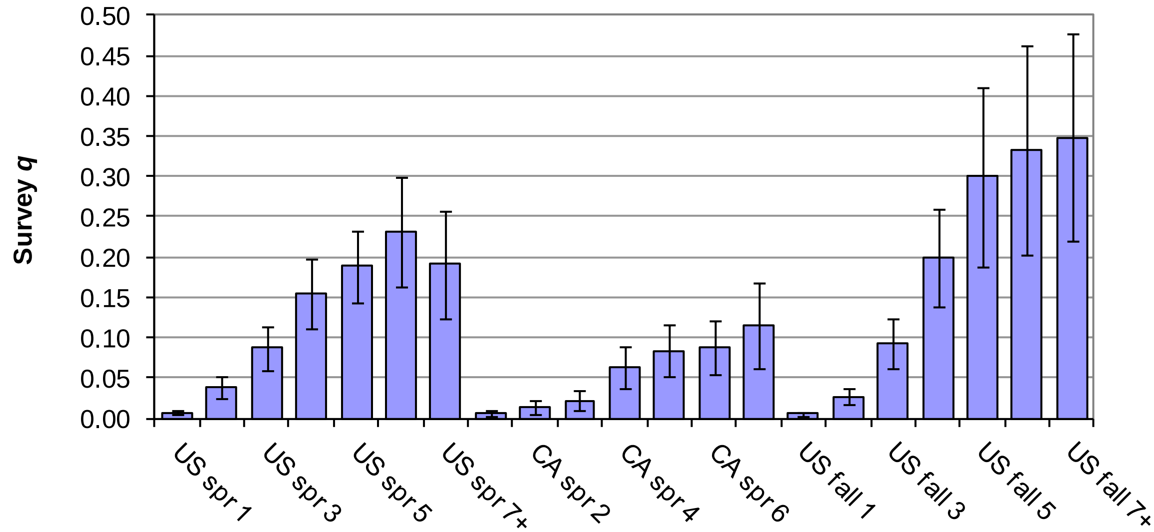


Figure A20. Estimates of swept-area survey catchability coefficients (+/- 2 SE) for the final VPA model run, by age, for Georges Bank winter flounder caught during the US spring (1982-2014, ages 1-7+), Canadian spring (1987-2014, ages 1-7+), and US fall (1981-2013, ages 0-6 lagged forward one year and age) bottom trawl surveys.

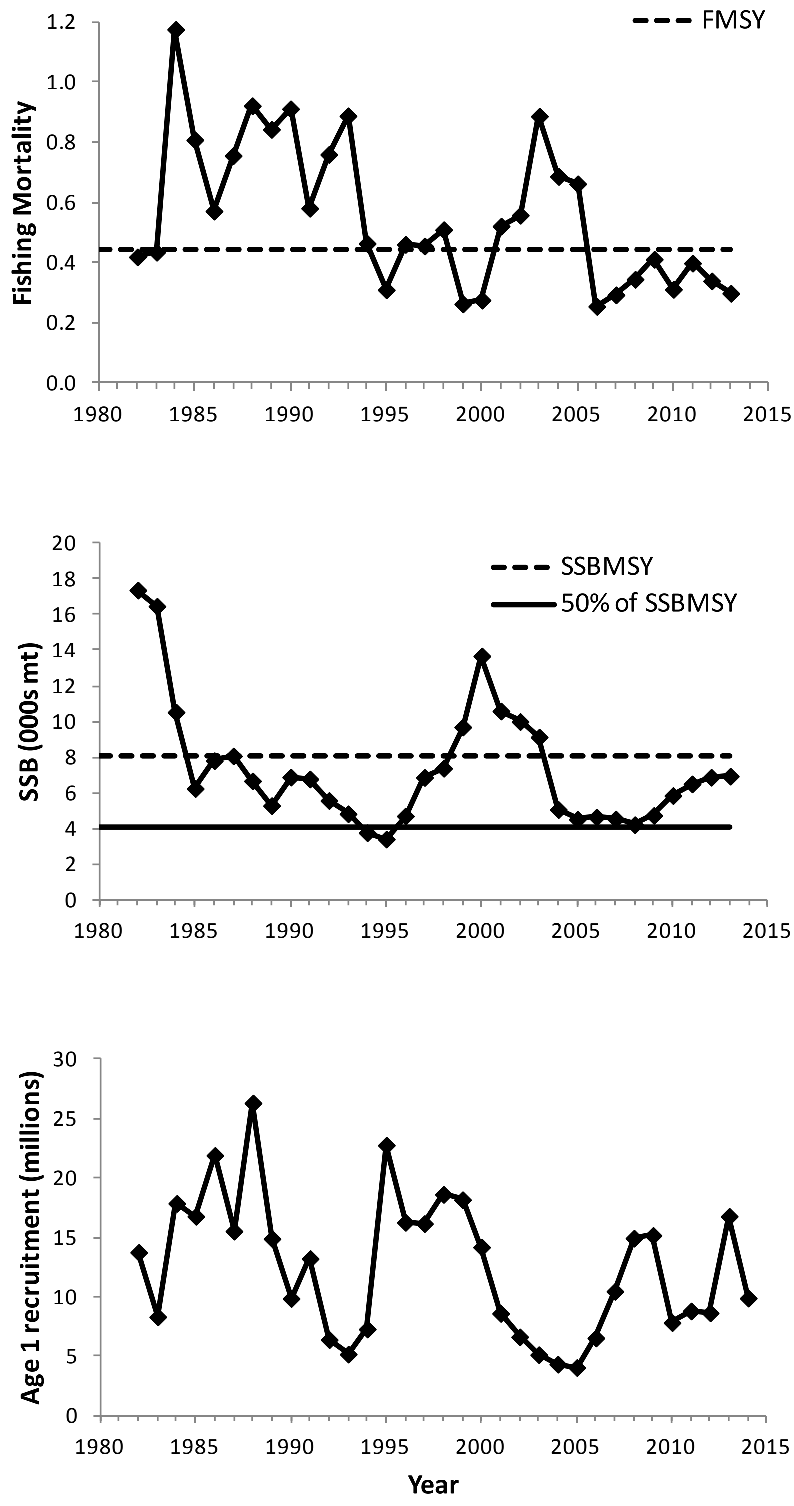


Figure A21. Final VPA model estimates of average fishing mortality rate (ages 4-6, top panel), spawning stock biomass (000's mt, middle panel), during 1982-2013, and age 1 recruitment (numbers in thousands), during 1982-2014 (bottom panel), for the Georges Bank winter flounder stock. The updated reference point thresholds, FMSY and 50% of SSBMSY, and SSBMSY are also shown. The 2014 recruitment estimate is solely based on survey data (2006-2013 geometric mean of recruitment).

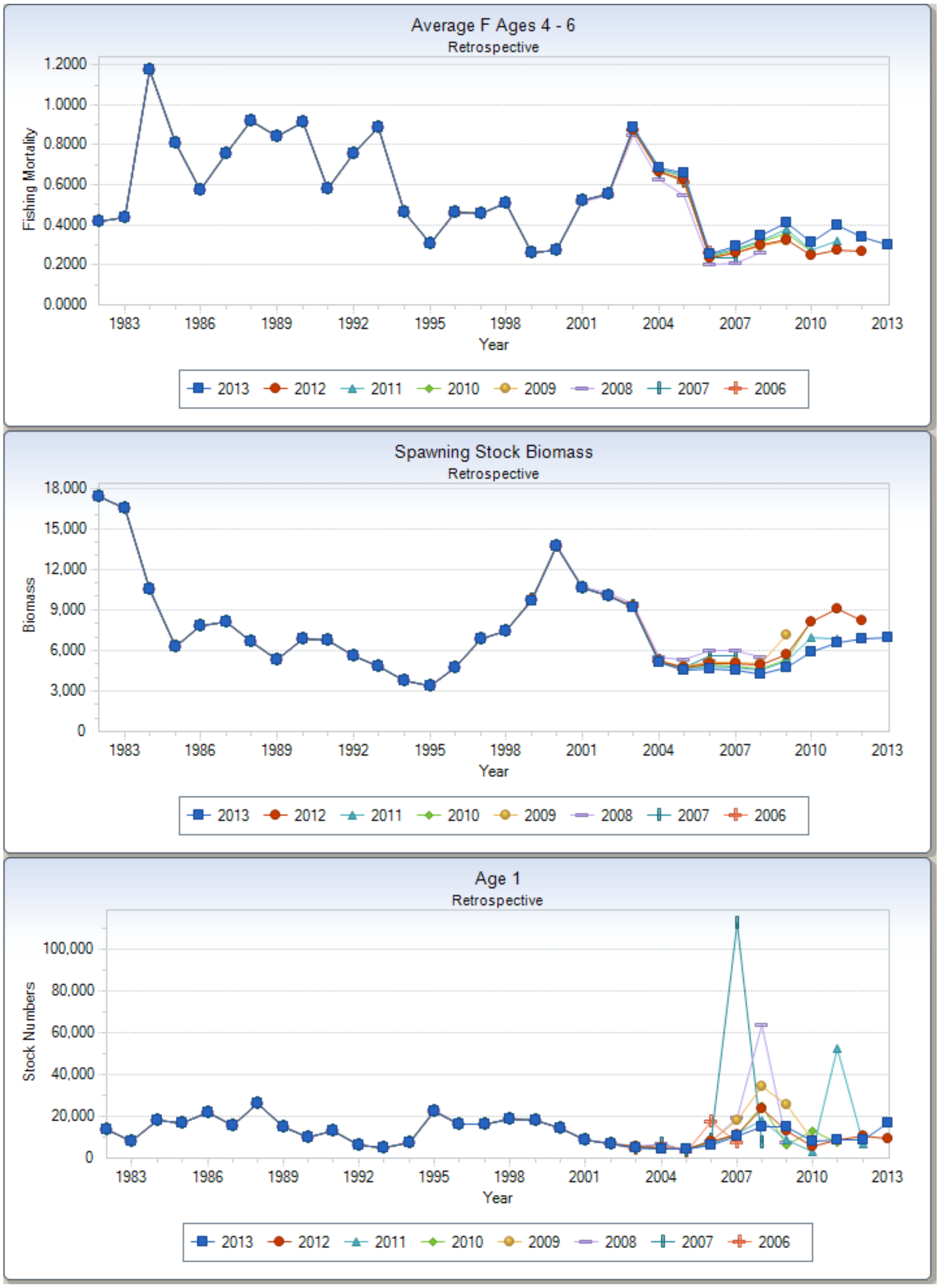


Figure A22. VPA retrospective analysis results for terminal years 2006-2012: average fishing mortality rates (F at ages 4-6, top panel), spawning stock biomass (mt, middle panel), and age 1 recruitment (numbers in thousands, bottom panel) for Georges Bank winter flounder.

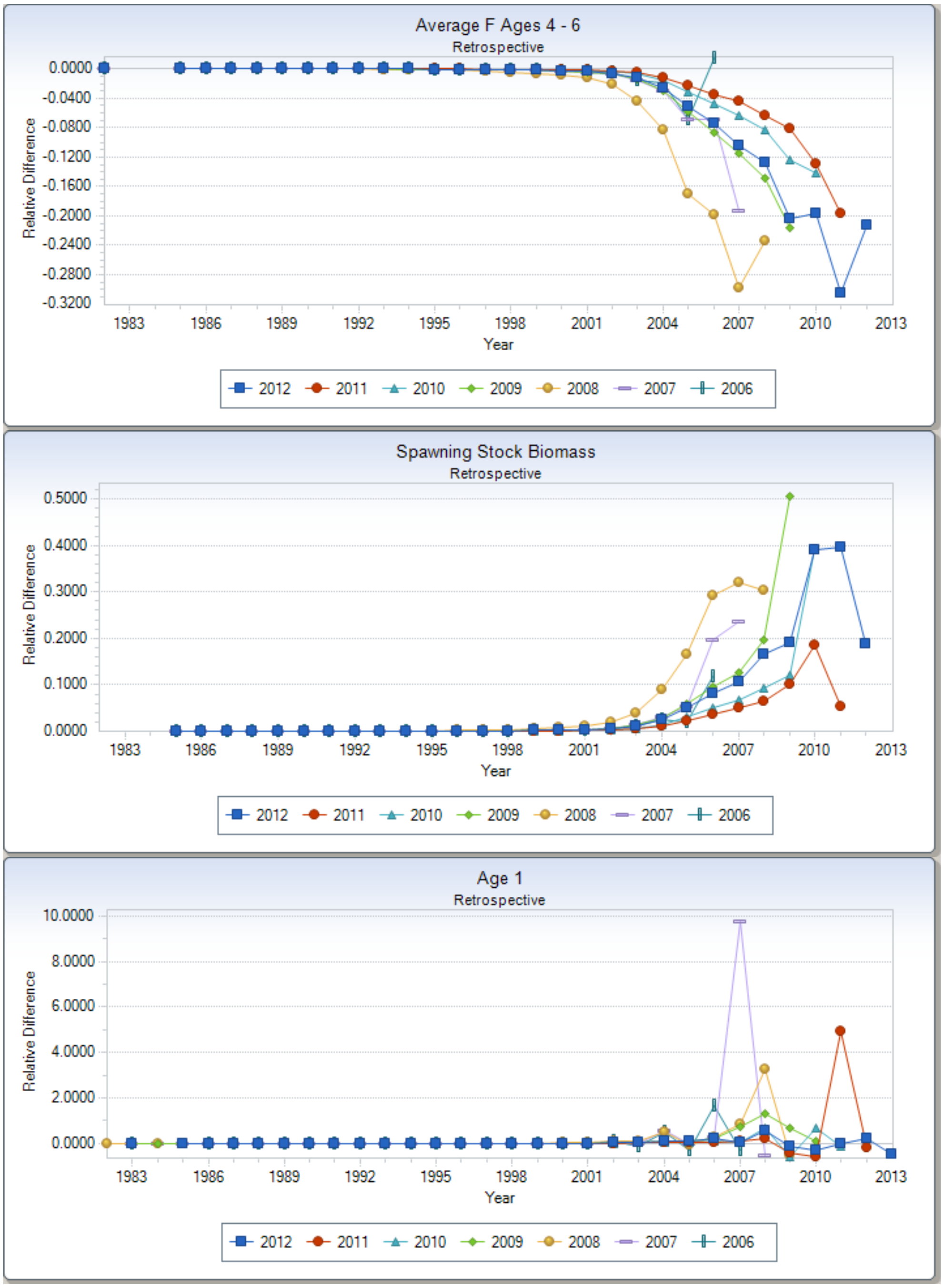


Figure A23. VPA retrospective analysis results for relative differences, between terminal years 2006-2012 and 2013, of average F (ages 4-6, top panel), spawning stock biomass (mt, middle panel), and age 1 recruitment (bottom panel) for Georges Bank winter flounder.

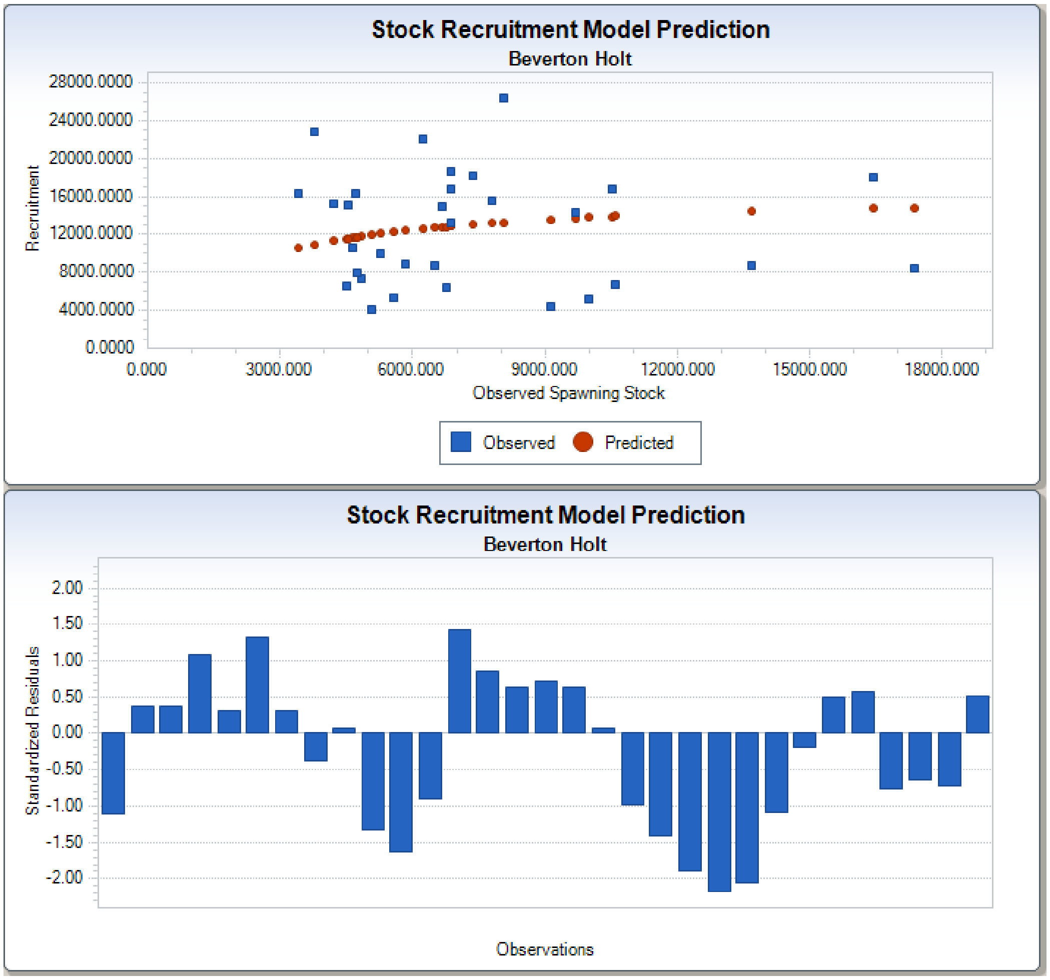


Figure A24. Results from a Beverton-Holt stock-recruitment model fit to Georges Bank winter flounder estimates of recruitment (age 1 numbers in thousands, 1982-2012 year classes) and spawning stock biomass (mt) from the final VPA model (top panel). The model was fit assuming a fixed value of 0.78 for unfished steepness (*h*). The bottom panel shows the standardized residuals from the model.

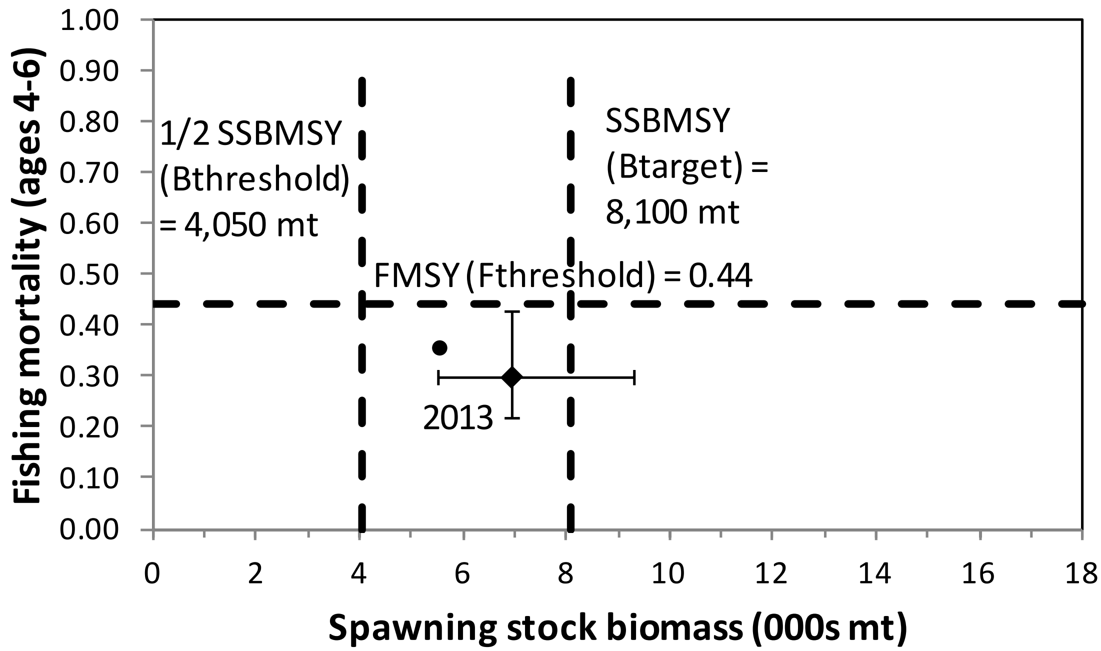
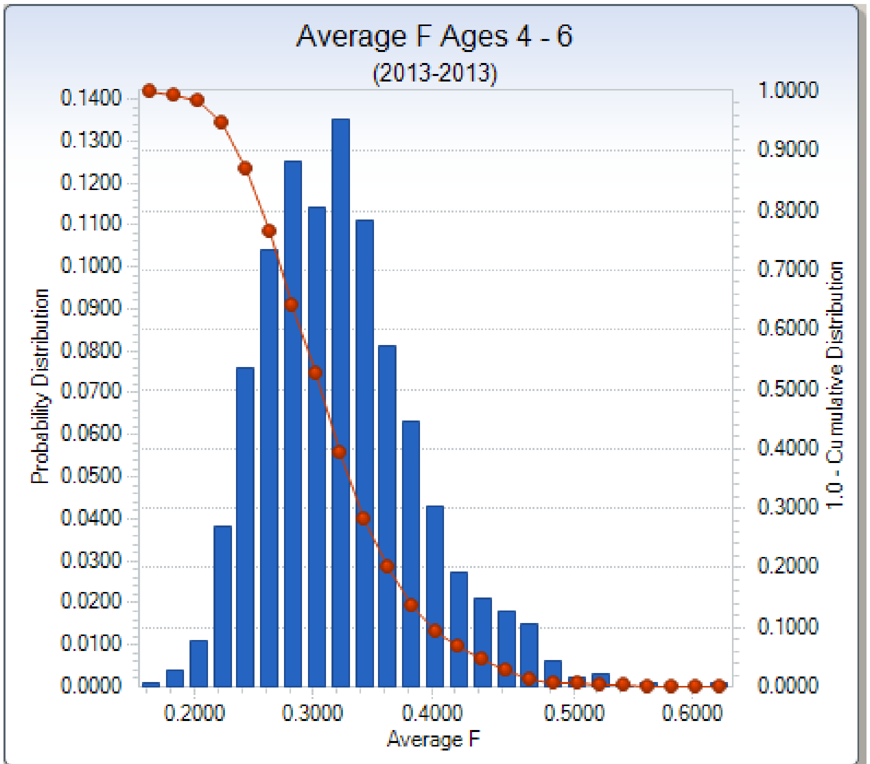


Figure A25. Stock status for Georges Bank winter flounder, during 2013, based on updated FMSY and SSBMSY reference points. The diamond is the 2013 F and SSB point estimate, with 90% confidence intervals, and the triangle is the 2013 F and SSB point estimate adjusted for retrospective error.



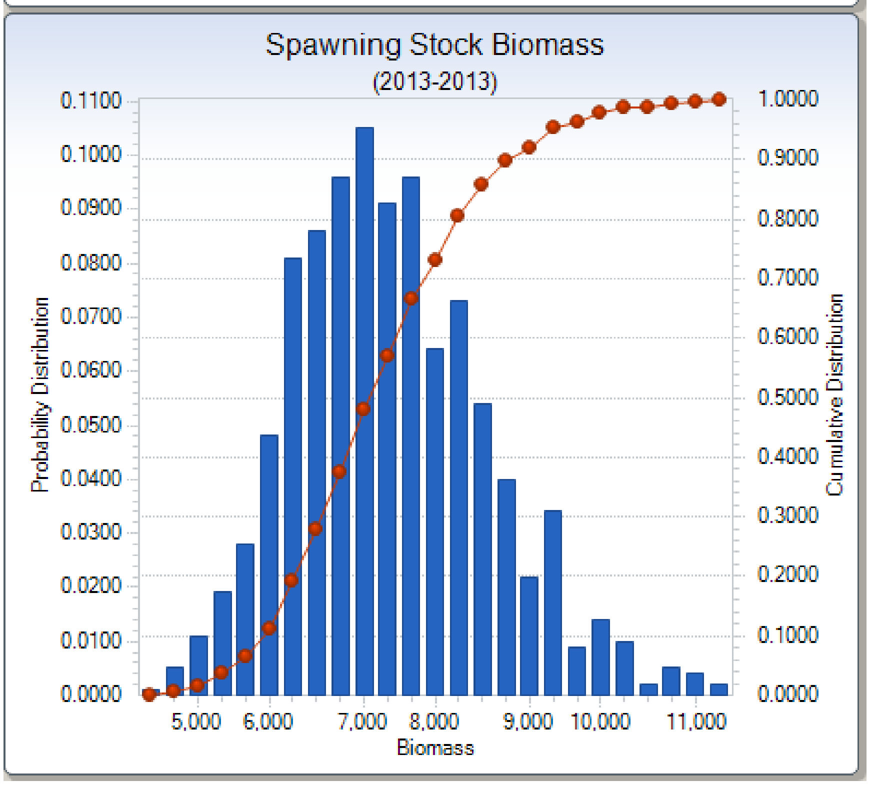


Figure A26. Precision (based on 1,000 bootstrap iterations) of the 2013 estimates of average fishing mortality rate (ages 4-6) and spawning stock biomass (mt) from the final VPA model for Georges Bank winter flounder.

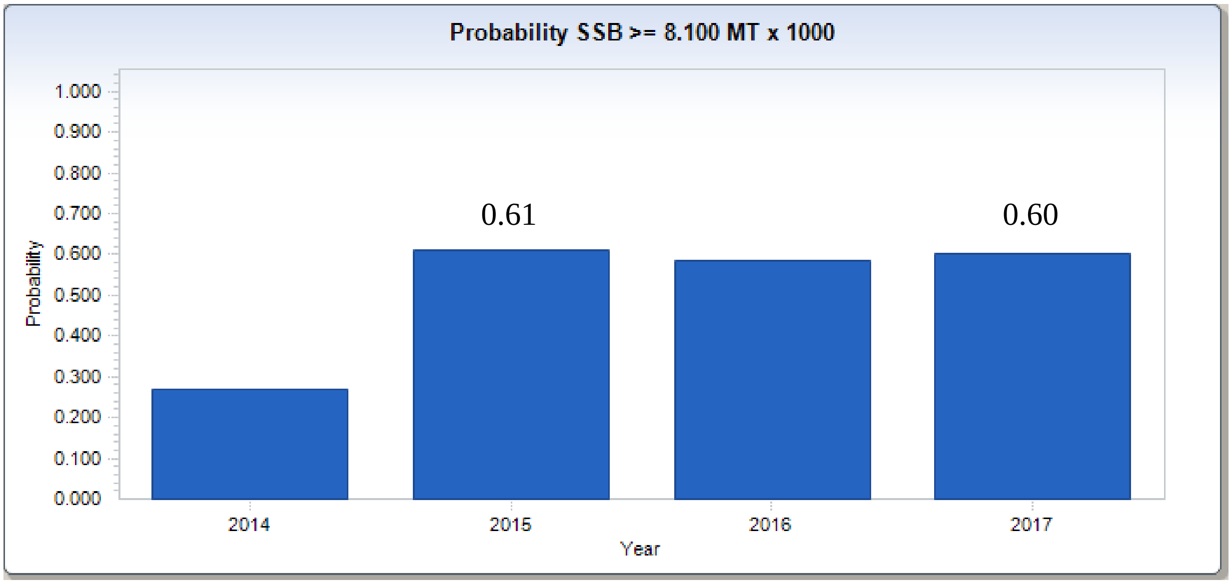


Figure A27. Probability of the Georges Bank winter flounder stock being rebuilt to SSBMSY (= 8,100 mt by 2017 based on a 2014 Annual Catch Limit of 1,522 mt and fishing at 75% of the updated FMSY value (= 0.330). The regulations require a probability of being rebuilt of at least 75% by 2017.

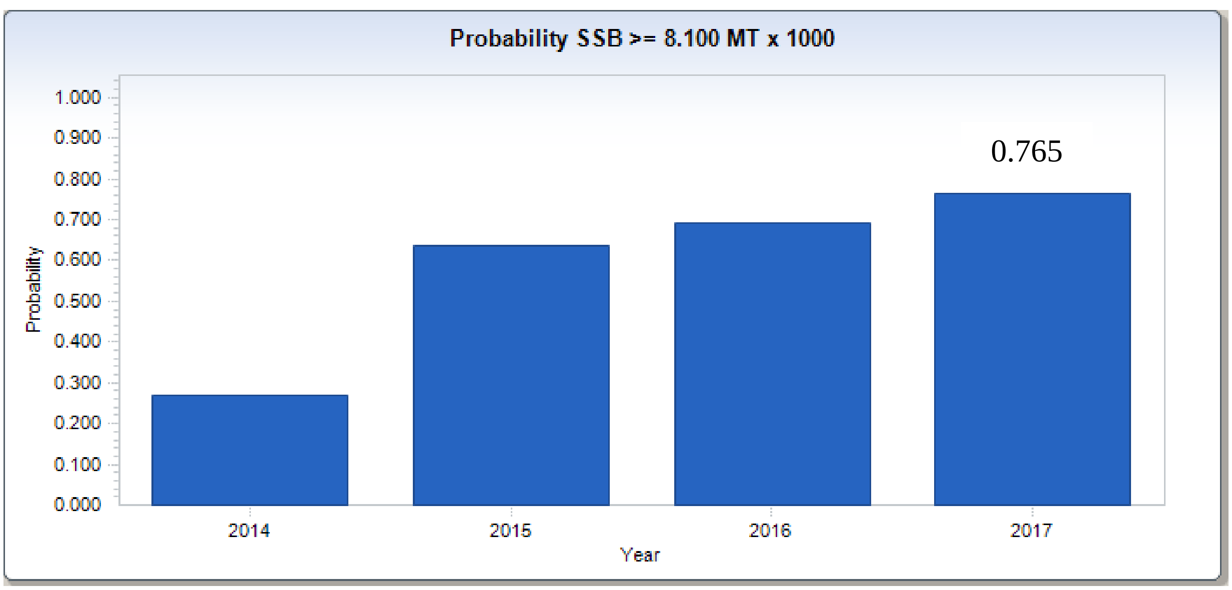


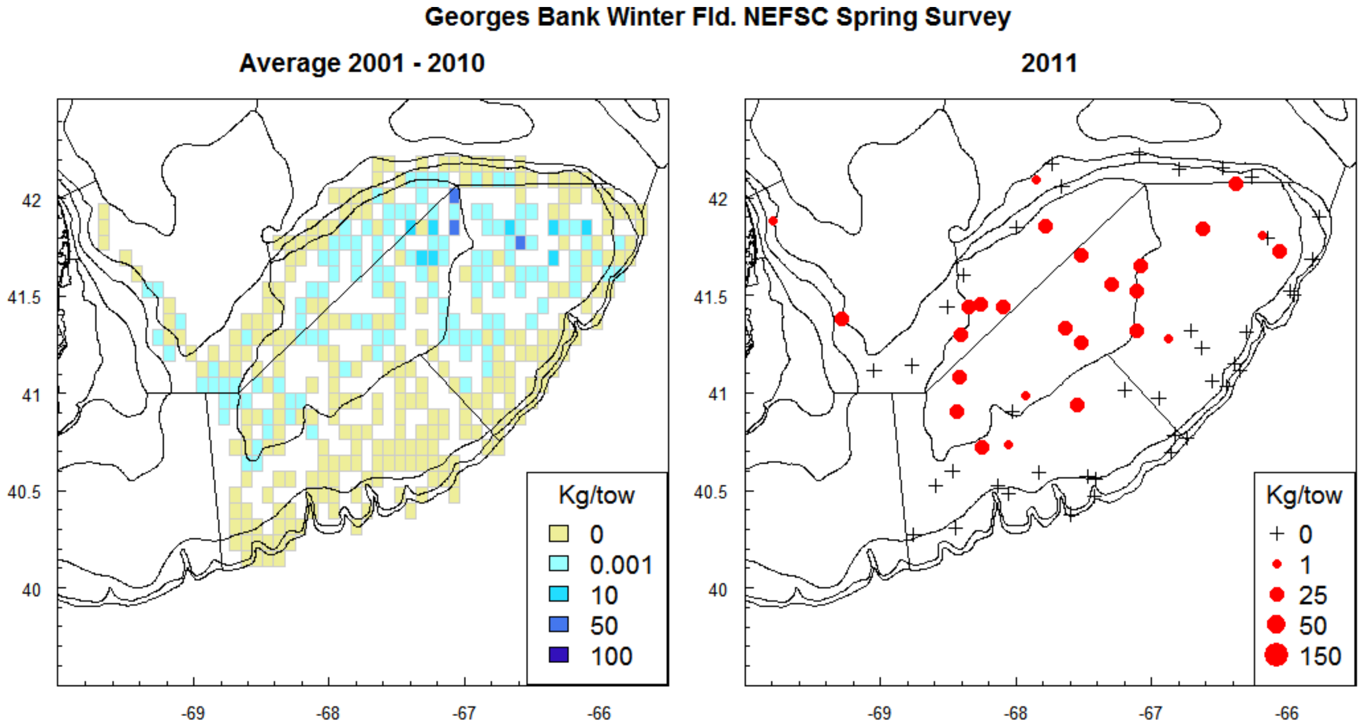
Figure A28. The probability of the Georges Bank winter flounder stock being rebuilt to the updated SSBMSY value (= 8,100 mt) by 2017 is 76% when assuming a 2014 Annual Catch Limit of 1,522 mt and fishing mortality rate of 0.270 during 2015-2017. The regulations require a probability of being rebuilt of at least 75% by 2017.

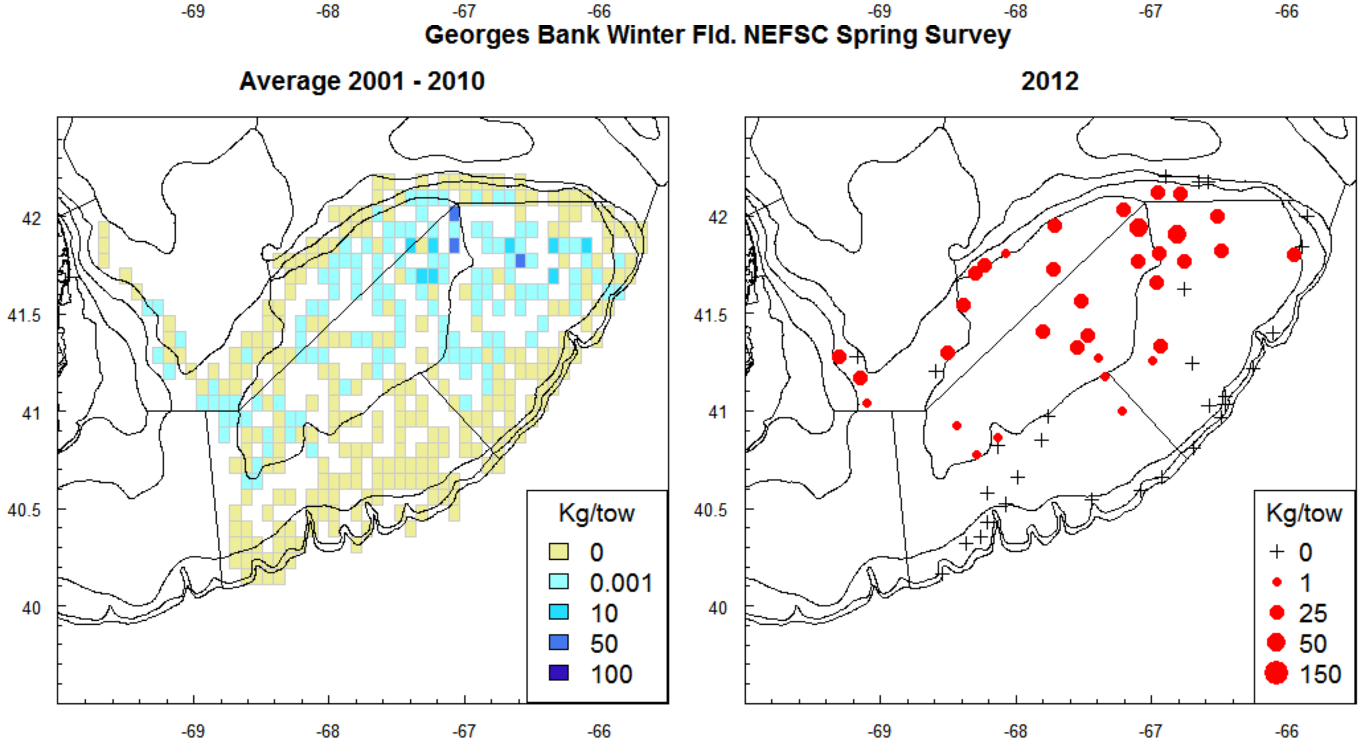
	1	2	3	4
Median	2014	2015	2016	2017
	7.261	8.672	8.862	9.221
95% CI	2014	2015	2016	2017

	1	2	3	4
	1.522	1.516	1.675	1.732
Median	2014	2015	2016	2017
	1.522	2.124	2.222	2.294

Figure A29. Projected median spawning stock biomass (000's mt, top panel) and catches (000's mt, bottom panel), for Georges Bank winter flounder during 2015-2017 (deadline for rebuilding is 2017), based on an assumed 2014 Annual Catch Limit of 1,522 mt and fishing at Frebuild = 0.270. Projected SSB in 2017 is 9,221 mt (6,909, 12,803). Dashed lines represent the 5% and 95% confidence limits.

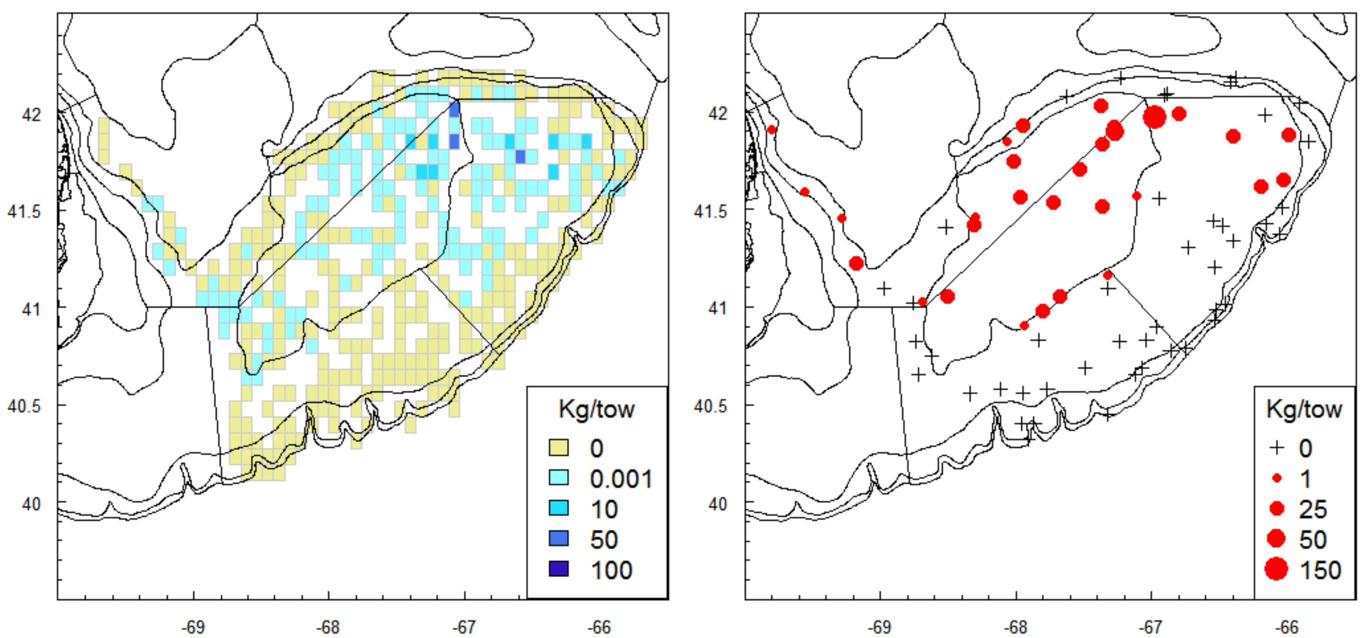
Appendix A1. Distribution maps of Georges Bank winter flounder during NEFSC spring and fall bottom trawl surveys during 2001-2010 (average kg per tow by ten-minute square) and annual maps (kg per tow) during 2011-2013 (2014 for the spring survey).





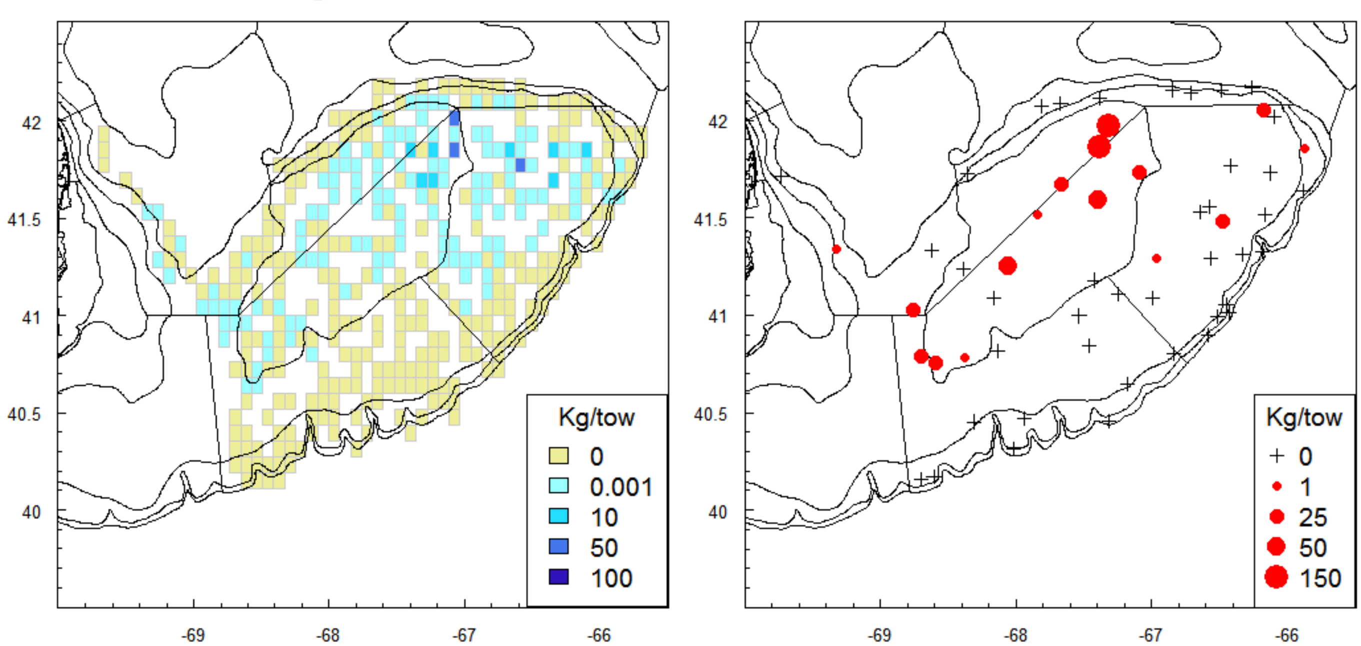
Georges Bank Winter Fld. NEFSC Spring Survey

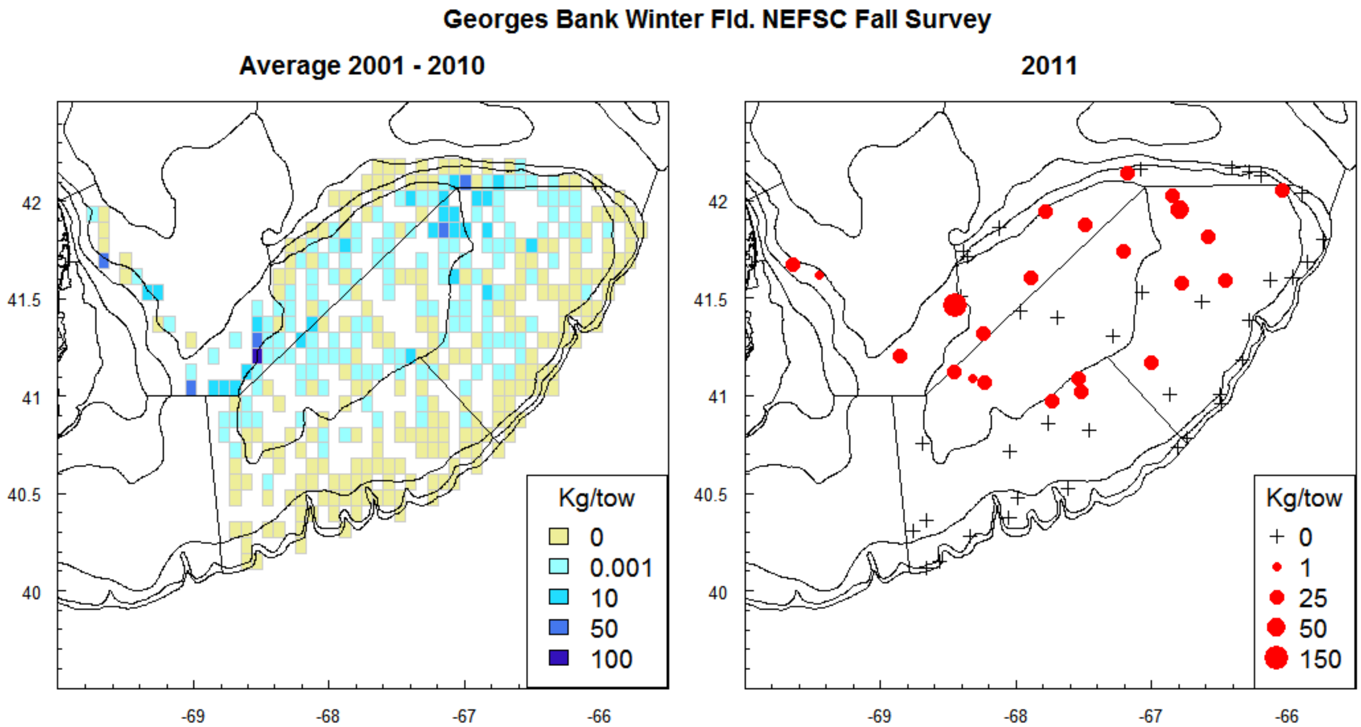
Average 2001 - 2010 **2013**

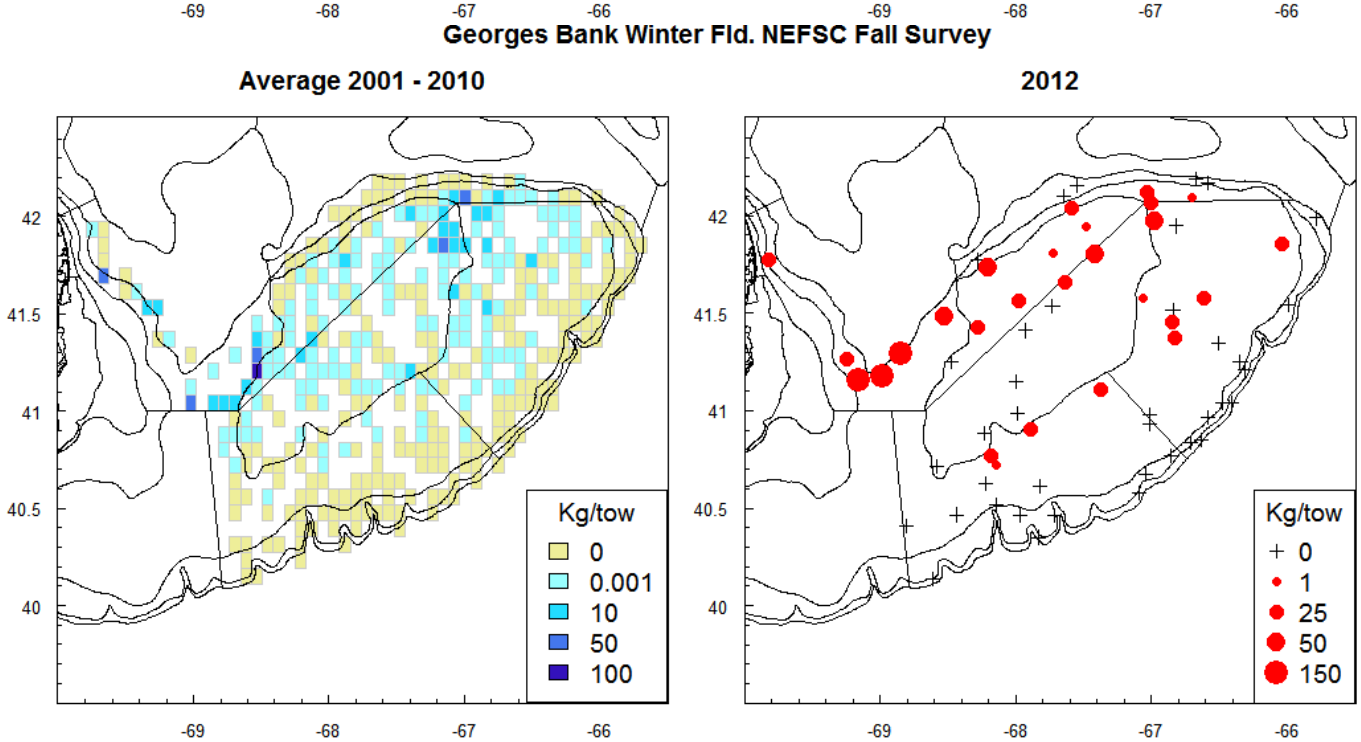


Georges Bank Winter Fld. NEFSC Spring Survey

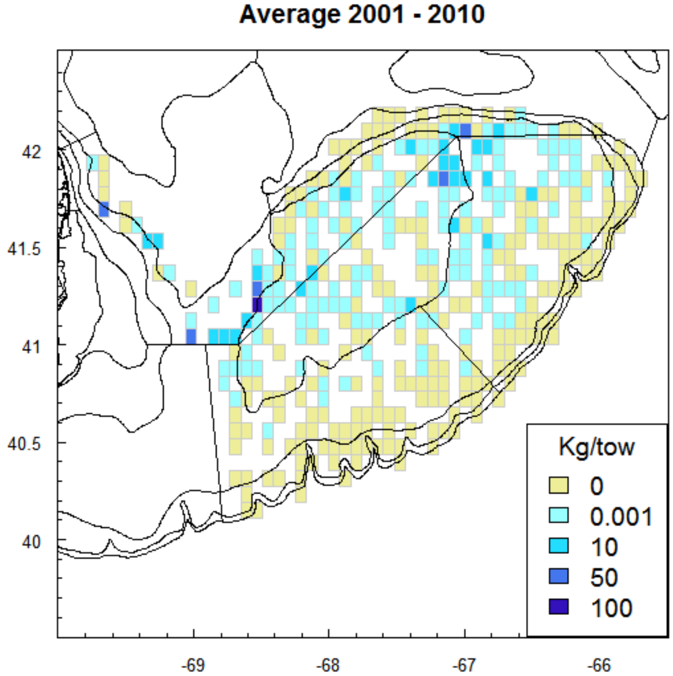
Average 2001 - 2010 **2014**

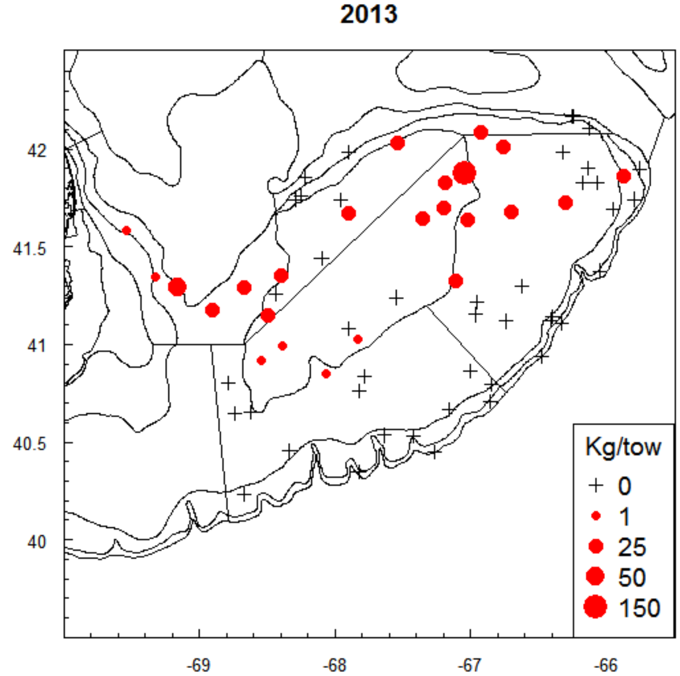



Georges Bank Winter Fld. NEFSC Fall Survey
Average 2001 - 2010
2011
42
41.5
41
40.5
40
-69
-68
-67
-66
Kg/tow
0
0.001
10
50
100
Kg/tow
0
1
25
50
150


Georges Bank Winter Fld. NEFSC Fall Survey
Average 2001 - 2010
2012
42
41.5
41
40.5
40
-69
-68
-67
-66
Kg/tow
0
0.001
10
50
100
Kg/tow
0
1
25
50
150

Georges Bank Winter Fld. NEFSC Fall Survey





B_Gulf of Maine Winter Flounder – Review Panel Summary

The Panel and workshop participants reviewed a draft report that updated the methods from SAW52 (NEFSC 2011) with fishery data through 2013 and survey data through spring 2014. The panel identified some new research publications that were not available at SAW52. Although those publications were not reviewed by all participants, the Panel evaluated SAW52 data and model decisions in the context of new research. The panel requested minor additions to the report and revisions of the draft text and recommended some topics for the research track.

Terms of Reference

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

The panel confirmed that there were no changes to the data protocols or modeling methods developed for SAW52. Recent catches remain low with a low discard rate and little recreational catch. Although a small portion of the annual catch limit was caught, industry participants reported that the low catch resulted from a large reduction in the inshore fleet and constraints in multispecies effort from catch limits of other species (e.g., yellowtail flounder, American plaice) and changes in mobile gear fishing patterns because of an increase in fixed gear in areas where the fleet would target winter flounder.

There were some conflicting recent survey trends, with general decreases in the NEFSC and MADMF indices (e.g., the 2014 MADMF spring index is the lowest on record), but stable or increasing MENH survey trends (e.g., the 2014 MENH spring index is the highest on record). A recent study documented shifting distributions of Gulf of Maine winter flounder to deeper and more northerly habitats (e.g., Nye et al. 2009). Recent field studies (Fairchild et al. 2009, DeCelles and Cadrin 2010) have also documented more frequent coastal spawning and less estuarine spawning than previously reported. The updated survey and catch data reflect the previous trends in distribution reported by SAW52. For example, the most recent spring survey estimate of biomass is greater than the fall survey biomass estimate, which may have resulted from more of the stock being in coastal waters during the spawning season. The Panel requested information on length distributions from recent surveys to investigate the possibility of more larger, mature fish in coastal strata in spring.

The decline in recreational catch may also result from less availability in estuaries. The recent increase in the MENH survey and decrease in MADMF and NEFSC surveys may have resulted from a continued northward shift. Contrary to the apparent northerly shifts in distribution, the majority of the fishery catch continues to come from statistical area 514 (Massachusetts Bay). The Panel recognized that the apparent shifts in distribution may have resulted from changes in survey timing (e.g., a general trend toward fall surveys extending later into November and the 2014 NEFSC spring survey being the latest ever).

The Panel noted that the survey designs assume random sampling within strata, but sampling may not be truly random because of fixed gear or hard bottom. Some of these issues may be addressed by examining the research vessel logs. The Panel requested information on geographic distribution of recent survey data. The statistical distribution of the Bigelow survey data should be different than that of the Albatross survey data because of increased catchability. Therefore, the Panel requested distributional information for the entire Bigelow series (2009-2013). Issues of interference from fixed gear and hard bottom avoidance can be examined empirically from the research vessel logs (ie SHG/TOGA codes, failure to sample target sites etc.)

Recently published information on stock structure confirms SAW52 conclusions about stock definition. An interdisciplinary review of winter flounder stock structure (DeCelles and Cadrin 2011) found that the Gulf of Maine stock definition was supported by an examination of life history traits, seasonal movement patterns as indicated by tagging, parasite characteristics and meristics. Wirgin et al. (2014) used microsatellite DNA analysis of young-of-the year and adult winter flounder collected throughout the range of the species to conclude that winter flounder from the Gulf of Maine was marginally distinct from the collections from Georges Bank and Southern New England/Mid-Atlantic stocks, but the genetic differences were less pronounced than would have been expected based on the differences in life history characteristics that have been reported.

Recent publications also confirm the SAW52 method for deriving maturity at age from the time series average of MADMF macroscopic data. McBride et al. (2013) compared maturity assignment by macroscopic and microscopic methods and demonstrated that MADMF data more accurately represents onset of maturity than NEFSC data. McElroy et al. (2013) studied showed skipped spawning of winter flounder, but only found low (2%) incidence of skipped spawning in inshore winter flounder stocks, so that macroscopic maturity is not a biased approach to determining maturity.

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

The panel confirmed that there were no changes to assessment methodology developed for SAW52. This approach derives an estimate of 30+ cm biomass from combined NEFSC, MADMF and MENH fall surveys, assuming a wingspread catchability of 0.6, which is based on the Georges Bank winter flounder VPA. The SAW52 diagnostic test of comparing area-swept biomass estimates from overlapping MADMF and NEFSC inshore strata was updated. Unlike the SAW52 results, which had comparable biomass estimates from the two surveys, the MADMF fall surveys produced significantly greater biomass estimates than NEFSC fall surveys in recent years. Although the survey-based assessment approach may be robust to shifting distributions within the selected survey strata, movement out of the selected strata or to unsampled habitats would not be accounted for. Such shifts would also present problems for analytical stock assessment approaches.

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

The Panel confirms that the updated assessment includes the information needed to recommend ABC (e.g., estimates of exploitable biomass and measures of uncertainty). The Panel recommends continued application of the SAW52 approach for determining catch advice.

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

The SAW52 estimate of $F_{40\%}$ (0.31, 0.23 exploitation rate) from length-based spawner-per-recruit analysis was not revised. The Panel accepted that no new information was available to update the estimate.

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

The Panel accepts the stock status determined by updated assessment results (2013 exploitable biomass = 2,932 mt and 2013 exploitation rate=0.09) and the SAW52 estimate of $F_{40\%}$ (0.23). Therefore, the stock is not experiencing overfishing. The overfished status is unknown, but the Panel is concerned that recent biomass estimates substantially decreased despite relatively low catch. Reasons for the apparent decline in biomass are not well understood.

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

Short-term projections are not possible using the area-swept survey biomass approach.

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

Recent developments in the empirical approach of estimating exploitable biomass from area-swept survey data by the 2014 Transboundary Resources Assessment Committee (TRAC) should be reconciled with the approach developed by SAW52 for Gulf of Maine winter flounder. For example, the TRAC approach uses area swept based on doorspread to account for herding between the trawl doors and wings and an assumed 0.37 whole-net efficiency based on flatfish surveys in other regions. The SAW52 method addresses selectivity by estimating biomass of fully-selected sizes, but the TRAC method does not explicitly address selectivity. The Panel recommends that the empirical approach be considered in a research track assessment to reconcile methodological differences among assessments, consider estimates of catchability from field experiments, and to potentially improve the approach as a basis for fishery management.

The Panel discussed the possibility that catch rates in the commercial and recreational fisheries might help to reflect catch trends, but quantifying fishing effort targeted at winter flounder would be difficult.

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

The panel concluded that the updated assessment is a reliable basis for fishery management and alternative approaches are not necessary at this time.

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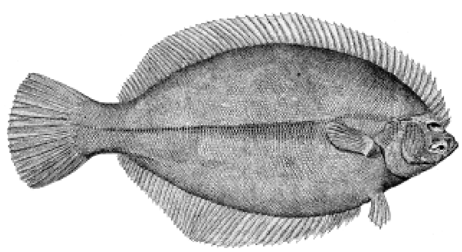
B_Gulf of Maine (GOM) Winter Flounder
Operational Update 2014



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1.0 Background and Assessment History

Historically the Gulf of Maine winter flounder stock was the smallest of the three winter flounder stocks (Figure B1). Gulf of Maine winter flounder was first assessed in SARC 21 (1995) as an index based assessment. It was noted at that assessment that survey indices were low and relatively few large fish were seen in the survey size distributions. Survey Z estimates were high (1978-1993 mean of 1.21) and the stock was thought to be overexploited. The SARC 36/GARM 1 assessment in 2001 was the first analytical assessment (ADAPT VPA) for this stock. The stock was considered rebuilt and overfishing was not occurring. In GARM II the ADAPT VPA model was updated through 2004 (NEFSC 2005). The GARM II assessment also concluded that the stock is not overfished and overfishing is not occurring. Spawning stock biomass was estimated to be at 3,400 mt and fully recruited F = 0.13 in 2004. SSB at B_{msy} was estimated to be at 4,100 mt and F_{msy} = 0.43. The GARM II VPA developed a severe retrospective pattern in F and a large overestimation of SSB. GARM II concluded that VPA results were too uncertain as a basis for performing projections.

In GARM III the review panel was unable to determine the stock's status relative to the BRPs, but stated that trends in the population were very troubling (NEFSC 2008). The Review Panel generally agreed that the stock biomass was highly likely to be less than the B_{MSY} proxy, and that there is a substantial probability that it was below the minimum stock size threshold. The split VPA model estimated spawning stock biomass in 2007 at 1,100 mt or about 29% of the B_{MSY} proxy (3,792 mt) and fishing mortality in 2007 was 0.42 or about 147% of $F_{40\%}$ = 0.28. The base case VPA and a split forward projection model (SCALE) which put higher weight on the recruitment indices suggested that the stock was not overfished and overfishing was not occurring. However the base case VPA had a severe retrospective pattern. The VPA showed greater reductions in biomass than observed in the survey biomass trends. All models had difficulty fitting the relatively flat age 1 and age 2 recruitment indices and the decrease in adult indices with the large decline in the catch at the end of the time series. The models were not accepted as a basis for status determinations. Therefore the stock status was unknown.

The next benchmark assessment occurred at SARC 52 in June 2011. The population models still had difficulty estimating population scale due to the conflicting data trends within the assessment, specifically the large decrease in the catch over the time series with very little change in the indices or age structure in both the catch and surveys. The scaling of the population estimates was sensitive to the weighting imposed on the catch at age compositions. The ASAP model did allow errors in the fit to the catch at age and improved fit to the surveys indices without the split in survey catchability. However this resulted in a lack of fit to the plus group in the catch at age composition. Survey trends possibly may not reflect the population changes in response to the large decline in the catch over time if a greater proportion of the population historically remained within the estuaries in the early 1980s. However there is very limited data on the extent of estuarine residing populations in the 1980s. The SARC-52 peer review panel concluded that ASAP, VPA or SCALE models runs were not a suitable basis for management advice. Instead a 30+ cm swept-area biomass method using the MENH, MDMF, and NEFSC surveys was used to estimate exploitable biomass and the exploitation rate. Comparison of this exploitation rate to the estimated length based $F_{40\%}$ F_{MSY} proxy with a knife edge 30+ cm selectivity was used for the development of management advice. Exploitation rates based on 30+ area swept biomass assuming a q=0.6 were low and indicated that overfishing was not occurring ($F_{2010}/F_{40\%}$ = 0.13). Biomass based biological based reference points could not be estimated using this method and remained unknown.

2.0 Fishery

Landings

Commercial landings were near 1,000 mt from 1964 to the mid-1970s. Thereafter commercial landings increased to a peaked of 2,793 mt in 1982, and then steadily declined to 350 mt in 1999. Landings have been near 650 mt from 2000 to 2004 and about 300 mt from 2005 to 2009. Landings have declined to a record low of 140 mt in 2010 (Table B1, Figure B2). The primary gear used was the otter trawl from 1964-1985 that accounted for an average of 95% of the landings (Table B2, Figure B2). Otter trawl accounted for an average of 80% of the landings from 1986- 2013 with an increase in the proportion of the landings coming from gillnets (20% from 1986-2013) (Table B2). Since 1999 around 95% percent of the landings are taken in Massachusetts from statistical area 514 (Figures B3). GOM winter flounder are landed throughout the year. However a greater proportion of the landings have been coming from quarter three over the last ten years (Figure B3).

Recreational landings reached a peak in 1981 with 2,554 mt but declined substantially thereafter (Table B3). Recreational landings have generally been less than 100 mt since 1994, with exception of 2008 were the landings was estimated at 103 mt.

Discards

Discards were estimated for the large mesh trawl (1982-2013), gillnet (1986-2013), and northern shrimp fishery (1982-2013). Observer discard to landings of all species ratios were applied to corresponding commercial fishery landings to estimate discards in weight from 2004 to 2013 for the large mesh trawl, gillnet, and shrimp fishery for this assessment update (Table B4). As in the southern New England stock (NEFSC 1999), a 50% mortality rate was applied to all commercial discard data.

A discard mortality of 15% was assumed for recreational discards (B2 category from MRIP data). Discards have been low, about 3,000 fish in 2012 and 2013 (Table B5, Figure B4). Discards in weight have been estimated using a length weight relationship and a sampled length distribution of 10 fish measured in 2008. Length sampling of the B2 in recent years are inadequate for weight determination.

3.0 Research Surveys

Mean number per tow indices for the Northeast Fisheries Science Center (NEFSC) and the Massachusetts Division of Marine Fisheries (MDMF) spring and fall time series are presented in Table B6 and Figures B5 through B9. In 2009, the *NOAA SHIP Henry B. Bigelow* replaced the *R/V Albatross IV* as the primary vessel for conducting spring and fall annual bottom trawl surveys for the NEFSC. There are many differences in the vessel operation, gear, and towing procedures between the new and old research platforms. For most flatfishes there is evidence for differences in selectivity at length between the two survey vessels. The SARC 52 estimated length based gulf of Maine winter flounder calibration was used to convert the survey indices from 2009 to 2013 into Albatross equivalent units.

All of the indices generally show a slight decrease in the population in the late 1980s from a high in the early 1980s with low abundance remaining through the early 1990s. All of the indices show signs of increase abundance starting in 1998 and 1999. More recently there are decreases in abundance seen in the NEFSC fall, MDMF spring and MDMF fall surveys while the NEFSC spring survey remained more stable (Figure B5).

Maine and New Hampshire (MENH) have been conducting an inshore bottom trawl survey in the spring since 2001 and in the fall since 2000. These survey indices are relatively flat over the time series with slightly higher abundance in the fall 2010 (Figure B9). However the MENH survey catches relatively few fish over 30 cms (Figure B10).

Gulf of Maine winter flounder inshore and offshore NEFSC survey spatial distribution plots, 30+ cm NEFSC and MDMF length frequency distributions and percent positive tows by strata are shown in appendix B1.

4.0 Assessment

Gulf of Maine winter flounder exploitation rates using 30+ cm biomass from survey area swept estimates

Direct estimates of exploitable biomass through area swept estimates are now possible with the recent improvements in fishery independent data sources. The NEFSC (RV Bigelow series), MDMF, and MENH surveys catch significant numbers of winter flounder per tow (Figures B5 through B9). The change in the NEFSC survey vessel and gear to the Bigelow in 2009 has resulted in higher catch efficiency relative to the Albatross series. In addition the sampling intensity has also increased in most of the NEFSC inshore strata for the Gulf of Maine. The MENH survey covers a large area of this stock that was previous missing prior to 2000. Exploitation rates can be estimated from using a range of assumed survey efficiencies (Q) along with consideration of survey stock area coverage. Possible bounds on the likely recent exploitation rate can also be determined. The range of the estimates using different assumptions may help show what the likely exploitation rates are under different catches. A knife edge approximation of exploitable biomass was assumed as legal sized 30+ cm numbers converted to weight from a length-weight equation. Exploitable biomass was estimated as;

Exploitable Biomass = (30+ cm biomass index per tow /1000) x (total survey Area/tow footprint) x (1/q)

and exploitation rate as;

Exploitation rate = catch / 30+ cm biomass

Estimated area swept biomass from non-overlapping strata from three different surveys (NEFSC, MENH, MDMF) was used to determine the exploitation rate and overfishing status for Gulf of Maine winter flounder (Table B7 and B8, Figure B11). However determination on whether the stock is overfished cannot be made since biomass reference points remain unknown.

Exploitable 30+ cm biomass and exploitation rates with the associated error distribution were estimated from 2009 to spring 2014 and fall 2013 (Table B9 and B10, Figure B12) using the Survey Area Graphical Analysis (SAGA) and the updated Bigelow TOGA tow criteria (123x) which considers net performance sensor data for tow evaluation. The 80 percent confidence intervals were plotted to evaluate the inter-annual variation for each survey component (Figure B12). An analysis limited to strata which overlapped both the NEFSC Bigelow and MDMF survey was also updated in this assessment. Slightly lower biomass estimates in the NEFSC Fall in 2011 to 2013 are seen relative to the area adjusted (area overlap difference) MDMF biomass estimate (Table B8, Figures B13 through B15). The exact reasons for larger differences between the surveys in recent years are unknown. More recently the MDMF fall survey suggests a higher relative area swept estimate in comparison to the NEFSC fall survey. A comparison of the survey components used in the combined estimate (MDMF, MENH, and NEFSC surveys) between the spring and the fall surveys shows that a higher proportion of the stock is closer to shore in the spring (Table B9, Figure B16). In SARC 52 the fall 2010 survey estimate was used for exploitation determination since a lower overall 30+ biomass estimates in the spring may be a function of unavailable fish to the surveys that are residing inside the estuaries during the spring spawning season. However recent reductions in the update fall indices now indicate that total fall 30+ cm biomass indices are similar or lower than the spring estimates. Note that the large reduction in the 2014 MDMF spring index was offset by an increase in the MENH 2014 spring index. Updated surveys show fairly stable spring survey estimates from 2009-2013 relative to the fall indices that showed a larger reduction in biomass since 2010. Also remember the combined fall 2010 estimate from SARC 52 was based on a different strata set among the surveys since the MDMF strata in Cape Cod Bay were used to account for the missing inshore strata coverage in the NEFSC fall 2010 survey (Table B8).

At the SARC 52 SMAST Fishermen's input meeting fishermen suggested that herding between the doors and ground cable is important for the catchability of winter flounder. However questions still remain whether this may be more important in the commercial fishery targeted flatfish tows were tow speeds tend to be about a knot slower than the survey tows (3 knots). Area swept estimates using the doors for the footprint calculation was also done as a sensitivity analysis (Table B10). Area swept estimates coming from the Georges Bank empirical yellowtail benchmark assessment based the area swept estimates on doors spread and an average q estimate taken form the literature (q=0.37) (Somerton et al. 2007; Harden Jones et al. 1977). Gulf of Maine winter flounder area swept estimates using the doors and a q = 0.37 estimates a similar biomass as assuming 100% efficiency on the wing spread (Q=0.37 door spread fall 2013 biomass = 1,852 mt and Q=1.0 wing spread fall 2013 biomass = 1,759 mt) (Tables B9 and B10).

Biological Reference Points

As in SARC 52 biomass based biological reference points remain unknown. The $F_{40\%}$ F_{MSY} poxy was not updated for this assessment due limited new data to inform the reference points. At SARC 52 a proxy value of the overfishing threshold was derived for the 2011 assessment from a length-based yield per recruit (NFT2011) analysis that assumes all fish above 30 cm are fully recruited to the fishery and that natural mortality is 0.3 (Figure B17). Von Bertalanffy parameters were estimated from the spring and fall NEFSC survey age data (n = 2,035) and the maturity at length information was estimated from the spring MDMF survey (L_{50}=29cm). The reference points were converted to exploitation rates to be consistent with the swept area biomass approach. An $F_{40\%}$ exploitation rate was estimated at 0.23 and 75%$F_{40\%}$ exploitation was 0.17 with M=0.3.

Uncertainty Estimates

Methods

The sampling distributions of biomass and fishing mortality are approximated by integrating over the factors which constitute the primary sources of uncertainty. These factors include the sampling variability in NEFSC, MADMF, and MENH spring and fall bottom surveys updated from 2011 through fall 2013 and spring 2014. The second major source of variability for the survey estimates is the variation in the size of the area swept by an average tow. The sample means and variances for each of these factors were used to parameterize their respective normal distributions. Sampling theory and boot-strapping analyses for other species suggests that the survey means should be asymptotically normal. We exploit this feature to simplify the estimation of the sampling distribution of biomass and exploitation rate.

The estimator of total stock size can be written as

$$B_{Tot} = A_{NEFSC}\frac{I_{NEFSC}}{e\ a_{NEFSC}} + A_{MADMF}\frac{I_{MADMF}}{e\ a_{MADMF}} + A_{MENH}\frac{I_{MENH}}{e\ a_{MENH}} \quad \text{(Eq. 1)}$$

Where **A** represents the total stratum area, **I** represents the mean index of abundance (kg/tow) for winter flounder greater than 30 cm, and **a** represents the average area swept per tow, and **e** represents the trawl efficiency (probability of capture given encounter). Each of the measures of survey abundance and swept area are measured with uncertainty. In this exercise it is assumed that the total stratum area A is constant and measured without error. The gear efficiency **e** is unknown but cannot be greater than one unless significant herding occurs. If herding does occur the maximum efficiency is approximately equal to the ratio of the trawl door width to the wing width. For the purposes of this exercise, gear efficiency was examined over a range of values between 0.6 and 1.0. The sampling distribution B_{tot} can be estimated by integrating over all possible sources of variation. In this exercise there are six normally distributed random variables to consider I_{NEFSC}, I_{MADMF}, I_{MENH}, a_{NEFSC}, a_{MADMF}, and a_{MENH}. The means and variances of these variables are summarized in Table B11. The variance of the footprints for the MADMF and MENH survey were not measured. It was assumed that the CV of these estimates was equal to the estimates for the NEFSC survey. All NEFSC survey estimates were conducted on the FSV Bigelow.

The sampling distribution of each of the Fs described above was evaluated by integrating over each of the normal distributions for average weight I, survey footprint ***a*.** The density **I** and footprint a parameters were evaluated over 40 equal probability intervals. The full evaluation of the six sources of variability required 40^6 = 4,096,000,000 evaluations. The proposed method is sometimes known as a Latin hypercube approach because it samples each of the distributions over equal probability intervals. In contrast, a parametric bootstrap sampling randomly from each of the component distributions may not adequately characterize the underlying variability. This of course could be tested and compared with the Latin hypercube approach.

Let Φ = Normal cumulative distribution function. The inverse of Φ, denoted as Φ^{-1}, allows the evaluation of a set of values over a specified range, say α_{min} and α_{max}, over equal probability intervals. The value of the random variable X associated with the α level is defined as:

$$I_{\alpha}^{'} = \Phi^{-1}(\alpha \mid \bar{I}, S_I^2) \qquad \text{(Eq. 2)}$$

The step size between successive values of α was set as δ = 1/40 (0.975-0.025), where α_{min} = 0.025 and α_{max} = 0.975. An equivalent approach was used for evaluation of the footprint parameter **a** where $a \sim N(\mu_a , \sigma_a^2)$.

This property can be illustrated for the biomass estimates by substituting Equation 2 into Eq. 1 and integrating over all possible step sizes. Let i, j, k, l, m, n represent the indices for survey and footprint components, and let a prime denote the value of each component that is derived by evaluating Eq. 2. corresponding the α probability level.

The expected value of $\boldsymbol{B_{tot}}$ is obtained by summing over the sampling distributions of ***X*** and ***a*** as follows:

$$E[B_{Tot}] = \sum_{i=1}^{40}\sum_{j=1}^{40}\sum_{k=1}^{40}\sum_{l=1}^{40}\sum_{m=1}^{40}\sum_{n=1}^{40}\left[A_{NEFSC}\frac{I'_i}{e\ a'_j} + A_{MADMF}\frac{I'_k}{e\ a'_l} + A_{MENH}\frac{I'_m}{e\ a'_n}\right]\delta^6$$

(Eq .3)

The sampling distribution of ***Btot*** can be constructed by noting that the each element within the brackets of the rhs of Equation 3 has a probability weight of δ =(1/40).

The sampling distribution of F is simply the assumed value of the quota divided by the estimate of the biomass in Equation 3. This approximation of the multidimensional integration provides reasonable assurance that the sampling distribution of the F and B will be appropriately estimated.

Results of Uncertainty Analyses

Summary statistics for the biomass estimates are provided in Tables B12 and B13 and plotted in Figures B18 and B19. Under the null hypothesis that the distribution is normally distributed, the sample statistics for skewness and kurtosis estimates have expected values of zero. Values of skewness greater than zero indicate positive skewing (i.e, a longer tail on the right or in a positive direction from the mean). Values of kurtosis greater than zero provide evidence that the sampling distribution is more peaked than a normal distribution with a comparable mean and variance.

Exploitation rate distributions relative to exploitation rate biological reference points are shown in Table B14 and Figures B20 through B24. Comparison between the SARC 52 and this operational update of the probability of exceeding candidate biological reference points are provided graphically in Figures B21 through B24.

5.0 Survey Area Swept Biomass and Exploitation Rate Conclusions

At SARC 52 the use of a survey efficiency value (q) of 0.6 was supported by comparison of VPA estimates of efficiency for Georges Bank winter flounder while making the assumption that the same fraction of each stock is available to the respective surveys. The NEFSC fall survey (expressed in Albatross equivalents) had an efficiency estimate of 0.3. Calibration experiments between the FSV Bigelow and the R/V Albatross revealed a biomass conversion coefficient of ~2. Thus an efficiency estimate for the Bigelow survey estimate in 2010 of 0.6 was supported.

SARC 52 concluded that the best estimate of 30+ cm biomass and recent (2010) exploitation was based on use of the TOGA tow criteria for the most recent fall 2010 surveys assuming an efficiency q of 0.6. In this 2014 operational update the catch increased slightly from 195 in 2010 to 253 mt in 2013 and the survey based swept area estimate of biomass for winter flounder exceeding 30 cm in length decreased from 6,341 mt in 2010 to 2,932 mt in 2013 based on the fall surveys. Therefore exploitation rate increased from 0.03 (80% CI 0.02 - 0.05) in 2010 to 0.09 (80% CI 0.05 - 0.18) in 2013 (Figure B25). However overfishing is still not occurring (F_{2013}/F_{40} ratio = 0.32, Figure B26) in 2013 based on a q=0.6 using the wing spread area swept estimates. Estimated exploitation rates would be higher (0.14) but the overfishing status would not have changed if area swept biomass estimates had been based on a q of 0.37 using the door spread which was used for the recent 2014 Georges Bank yellowtail empirical benchmark assessment. In addition, biomass estimates were similar between the spring and fall surveys for both 2012 and 2013 (not statistically different) and therefore the results would not differ greatly between surveys. The difficulty is with the rational on why recent biomass estimates decreased to less than half of the estimates from 2010 when the catch remained far below the overfishing level of 1,458 mt (F_{40}). Questions remain on why increases in biomass were not realized with the low removals ranging from 217 mt to 380 mt in the last three years (Figure B26).

Biomass and exploitation rate estimates are sensitive to the assumed survey q (Figure B27). Therefore the estimated OFLs and ABC will also be sensitive to this assumption. Updated OFLs and ABCs based strictly on the SARC 52 method (q=0.6 on the wing spread) decreased from 1,458 mt to 688 mt and from 1,078 mt to 510 mt respectively using the 2010 and 2013 fall surveys. Survey efficiency studies are needed to better determine the true efficiency (Q) in the surveys. The Q assumption that was used in the Georges Bank yellowtail assessment would translate into a higher efficiency on the wing spread and lower biomass than what was used in the SARC 52 GOM winter flounder assessment. However, catch advice (ABCs) would still have resulted in high catch limits than the removals that occurred if the SARC 52 catch advice was instead based on the Georges Bank yellowtail Q assumption.

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Table B1. Winter flounder commercial landings (metric tons) for the Gulf of Maine stock (U.S. statistical reporting areas 511 to 515). Landings from 1964-1977 is taken from SARC 21, 1982-1993 is estimated from the WODETS data, 1994-2013 is estimated using the trip based allocated AA tables.

Year	metric tons	Year	Metric tons
1964	1,081	1990	1,116
1965	665	1991	1,008
1966	785	1992	825
1967	803	1993	611
1968	864	1994	543
1969	975	1995	707
1970	1,092	1996	606
1971	1,113	1997	569
1972	1,085	1998	643
1973	1,080	1999	350
1974	885	2000	535
1975	1,181	2001	700
1976	1,465	2002	694
1977	2,161	2003	755
1978	2,194	2004	623
1979	2,021	2005	336
1980	2,437	2006	201
1981	2,407	2007	254
1982	2,793	2008	288
1983	2,096	2009	283
1984	1,699	2010	140
1985	1,582	2011	173
1986	1,188	2012	348
1987	1,140	2013	218
1988	1,250		
1989	1,253		

Table B2. Gulf of Maine winter flounder commercial landings (metric tons) by gear.

Year	Trawl	Shrimp	Gillnet	Other	Total
1982	2,485	151	59	99	2,793
1983	1,819	142	54	80	2,096
1984	1,438	139	26	96	1,699
1985	1,446	62	16	59	1,582
1986	912	69	164	42	1,188
1987	848	97	135	60	1,140
1988	1,016	61	161	12	1,250
1989	1,008	58	138	48	1,253
1990	857	25	214	21	1,116
1991	868	22	94	25	1,008
1992	632	17	160	16	825
1993	460	1	138	13	611
1994	438	0	100	5	543
1995	511	1	184	10	706
1996	464	0	135	6	606
1997	426	0	134	9	569
1998	461	0	176	6	643
1999	248	0	101	1	350
2000	412	0	122	1	535
2001	531	0	160	9	700
2002	596	0	82	15	694
2003	565	0	185	5	755
2004	427	0	137	59	623
2005	230	0	67	38	336
2006	133	0	47	21	201
2007	163	0	53	38	254
2008	196	0	57	35	288
2009	202	0	67	14	283
2010	83	0	49	7	139
2011	112	0	50	12	173
2012	248	0	57	43	348
2013	177	0	32	9	218

Table B3. Estimated number (000's) and weight for Gulf of Maine winter flounder caught, landed, and discarded in the recreational fishery. MRFSS estimates from 1981-2003 and MRIP estimates from 2004-2013.

	Numbers (000's)				Metric tons
	Catch	Landed	Released	15% Release	Landed
year	A+B+B2	A+B1	B2	Mortality	A+B1
1981	6,200	5,433	767	115	2,554
1982	8,207	7,274	933	140	1,876
1983	2,169	1,988	181	27	868
1984	2,477	2,285	191	29	1,300
1985	3,694	3,220	474	71	1,896
1986	946	691	255	38	523
1987	3,070	2,391	679	102	1,809
1988	953	841	111	17	345
1989	1,971	1,678	294	44	620
1990	786	652	134	20	370
1991	213	154	59	9	91
1992	186	137	48	7	90
1993	398	249	150	22	140
1994	232	145	88	13	83
1995	150	83	67	10	40
1996	183	98	86	13	56
1997	192	64	129	19	43
1998	109	65	44	7	30
1999	109	65	44	7	33
2000	146	59	87	13	32
2001	173	72	102	15	45
2002	101	61	40	6	42
2003	86	52	34	5	32
2004	62	46	16	2	29
2005	82	40	42	6	23
2006	75	50	25	4	34
2007	75	49	26	4	28
2008	249	179	70	10	124
2009	190	97	94	14	60
2010	154	88	65	10	40
2011	138	80	58	9	37
2012	66	47	19	3	22
2013	63	42	20	3	28

Table B4. Gulf of Maine winter flounder estimated large mesh trawl, shrimp and gillnet discard ratios (discard/sum all species kept), estimated discard CVs, and estimated discards in metric tons.

	Discard Ratio			CV			Metric Tons		
	trawl			trawl			trawl		
year	lg mesh	shrimp	gillnet	lg mesh	shrimp	gillnet	lg mesh	shrimp	gillnet
2004	0.0022	0.0035	0.0011	0.28	0.27	0.27	60.61	3.83	7.65
2005	0.0025	0.0063	0.0003	0.27	0.41	0.22	46.95	5.52	2.21
2006	0.0019	0.0012	0.0001	0.32	0.33	0.42	20.89	1.49	0.85
2007	0.0032	0.0010	0.0002	0.33	0.33	0.39	29.73	2.08	1.33
2008	0.0015	0.0018	0.0002	0.24	0.26	0.43	17.12	3.40	1.76
2009	0.0015	0.0046	0.0003	0.19	0.33	0.29	16.19	5.62	2.31
2010	0.0004	0.0016	0.0001	0.26	0.42	0.16	4.80	5.61	0.82
2011	0.0005	0.0001	0.0001	0.11	0.00	0.09	5.95	0.36	0.90
2012	0.0013	0.0008	0.0002	0.11	0.29	0.08	17.08	1.41	1.16
2013	0.0009	0.0070	0.0001	0.17	0.32	0.18	9.74	1.36	0.45

Table B5. Gulf of Maine winter flounder composition of the catch by weight (mt). A 50% mortality rate is assumed on gillnet, large mesh, and shrimp discards while a 15% mortality rate is assumed on recreational discards.

	Landings		Dead Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1981	2,270						
1982	3,024	2,793	11		343	7	6,178
1983	817	2,096	2		112	8	3,035
1984	1,103	1,699	3		67	12	2,883
1985	1,629	1,582	8		93	14	3,327
1986	411	1,188	5	12	63	16	1,696
1987	1,443	1,140	12	12	81	25	2,713
1988	537	1,250	2	12	106	19	1,927
1989	1,035	1,253	6	4	11	5	2,315
1990	344	1,116	3	22	5	21	1,511
1991	86	1,008	1	3	17	21	1,136
1992	77	825	1	12	7	24	947
1993	134	611	3	19	4	7	777
1994	77	543	2	6	6	6	640
1995	40	707	1	12	8	8	777
1996	52	606	2	6	2	7	675
1997	32	569	3	38	5	14	660
1998	27	643	1	7	7	4	690
1999	34	350	1	4	9	1	399
2000	31	535	2	12	3	3	587
2001	37	700	3	3	14	2	759
2002	35	694	1	5	17	0	752
2003	29	755	1	3	13	2	803
2004	29	623	1	4	30	2	689
2005	23	336	2	1	23	3	388
2006	34	201	1	0	10	1	248
2007	28	254	1	1	15	1	300
2008	124	288	3	1	9	2	426
2009	60	283	4	1	8	3	359
2010	40	140	3	0	2	3	188
2011	37	173	2	0	3	0	217
2012	22	348	1	1	9	1	380
2013	28	218	1	0	5	1	253

Table B6. NEFSC and MDMF survey indices of abundance for Gulf of Maine winter flounder. Indices are stratified mean number and mean weight (kg) per tow. NEFSC indices are for inshore strata (58,59,60,61,65,66) and offshore strata (26,27,38,39,40). NEFSC indices are calculated with trawl door conversion factors where appropriate. NEFSC GOM Length based conversions were applied from 2009-2014. NEFSC fall 2010 (bold) did not sample Cape Cod Bay. MDMF uses strata 25-36.

	NEFSC spring		NEFSC fall		MA spring		MA fall	
year	number	weight	number	weight	number	weight	number	Weight
1978					98.258	20.430	57.454	12.217
1979	4.487	1.730	6.003	2.602	71.834	15.787	134.251	32.837
1980	5.586	2.391	13.141	6.553	72.142	19.108	83.805	17.868
1981	6.461	2.122	4.179	3.029	106.341	30.383	50.847	13.595
1982	7.670	3.022	4.201	1.924	61.612	14.713	108.203	24.418
1983	12.367	5.653	10.304	3.519	112.487	28.984	76.658	15.143
1984	5.155	1.979	7.732	3.106	68.949	16.716	39.541	12.212
1985	3.469	1.418	7.638	2.324	54.210	15.302	48.677	8.288
1986	2.342	0.998	2.502	0.938	68.984	16.352	44.646	6.920
1987	5.609	1.503	1.605	0.488	85.180	18.640	54.434	8.018
1988	6.897	1.649	3.000	1.030	54.039	11.266	38.419	8.237
1989	3.717	1.316	6.402	2.013	64.696	13.940	39.249	8.602
1990	5.415	2.252	3.527	1.177	82.125	14.375	67.661	13.218
1991	4.517	1.436	7.035	1.467	46.630	11.513	101.716	17.580
1992	3.932	1.160	10.447	3.096	79.000	15.356	87.581	15.089
1993	1.556	0.353	7.559	1.859	78.018	12.051	93.527	15.109
1994	3.481	0.891	4.870	1.319	72.578	9.779	67.789	13.246
1995	12.185	3.149	4.765	1.446	89.361	14.960	76.736	15.092
1996	2.736	0.732	10.099	3.116	70.494	12.082	77.006	13.144
1997	2.806	0.664	10.008	2.950	85.396	12.959	78.402	14.438
1998	2.001	0.527	3.218	0.987	77.771	13.473	98.450	15.454
1999	6.510	1.982	10.921	3.269	80.776	14.957	125.742	23.204
2000	10.383	2.885	12.705	5.065	162.190	34.160	99.953	25.100
2001	5.242	1.663	8.786	3.133	89.743	24.510	81.072	17.743
2002	12.066	3.692	10.691	4.003	91.083	22.391	65.812	16.264
2003	7.839	2.544	10.182	4.315	83.693	17.323	90.477	15.801
2004	3.879	1.103	2.763	0.867	79.115	11.201	107.591	14.091
2005	6.920	2.056	8.807	2.314	94.044	11.980	78.591	11.812
2006	4.173	1.211	7.117	2.346	85.548	14.434	86.985	15.463
2007	2.500	0.717	6.378	1.820	53.583	10.060	76.669	11.599
2008	11.543	2.177	13.319	4.692	46.863	8.424	90.919	18.085
2008	11.543	2.177	13.319	4.692	46.863	8.424	90.919	18.086
2009	6.846	1.528	13.176	3.163	71.316	12.277	108.996	22.677
2010	5.023	1.178	**12.046**	**2.561**	68.235	13.676	104.672	18.612
2011	3.345	0.767	10.352	2.714	66.492	9.134	152.607	25.434
2012	7.237	1.509	8.111	1.845	71.541	10.876	83.228	14.090
2013	5.465	1.157	4.533	1.287	58.518	10.415	47.838	9.610
2014	7.877	1.690			30.879	5.348		

TableB7. Survey total area coverage, average tow footprint, expansion factors, tow duration and average numbers per tow for non-overlapping strata used in the combined estimate.

	Combined Survey Estimate		
	NEFSC	MDMF	MENH
survey area (nm2)	2,990	309	3,475
Avg tow (wing area swept)	0.00700	0.00385	0.00462
Total area/tow footprint	427,143	80,343	752,154
Tow duration	20 min	20 min	20 min
Numbers per tow	34-65	80	35

Table B8. Survey total area coverage, average tow footprint, kg/tow expansion factors and tow during for the different surveys and survey non overlapping components (NEFSC combined, MDMF near shore, MENH state waters). NEFSC combined (offshore (39,40,26) = 2322 nm^2 + NEFSC inshore overlap (59,60,61,64,65,66) = 668 nm^2), MDMF overlap (27,28,29,30,34,35,36) = 484 nm^2, MDMF near shore (25,26,31,32,33) = 309 nm^2.

A. Wing spread

	NEFSC (Bigelow)			Gloria Michele (MDMF)			MENH
	inshore overlap	Fall 2010	combined	overlap	Fall 2010	near shore	state waters
survey area (nm2)	**668**	**2,638**	**2,990**	**484**	**633**	**309**	**3,475**
Avg tow (area swept)	**0.0070**	**0.0070**	**0.0070**	**0.0038**	**0.0038**	**0.0038**	**0.0046**
Total area/tow footprint	**95,429**	**376,857**	**427,143**	**125,845**	**164,587**	**80,343**	**752,165**
Tow duration	**20 min**	**20 min**	**20 min**	**20 min**	**20 min**	**20 min**	**20 min**

B. Door spread

	NEFSC (Bigelow)			Gloria Michele (MDMF)			MENH
	inshore overlap	Fall 2010	combined	overlap	Fall 2010	near shore	state waters
survey area (nm2)	**668**	**2,638**	**2,990**	**484**	**633**	**309**	**3,475**
Avg tow (area swept)	**0.0173**	**0.0173**	**0.0173**	**0.0125**	**0.0125**	**0.0125**	**0.0123**
Total area/tow footprint	**38,657**	**152,662**	**173,032**	**38,758**	**50,690**	**24,744**	**282,469**
Tow duration	**20 min**	**20 min**	**20 min**	**20 min**	**20 min**	**20 min**	**20 min**

Table B9. A range of estimated 30+ cm biomass based on WING spread and exploitation rates for the combined survey estimate using Bigelow spring 2009 to 2014 and Bigelow fall 2009 to 2013 using a range of qs assumptions (0.6, 0.8, & 1.0) and a range of assumed catch (mt) (2013=253, 2012=380, SARC 52 ABC=1078, OFL=1,458) based on an TOGA criteria of 132x. The proportion of the biomass in each survey area is also shown. * Fall 2010 estimate is based on a different strata set since the NEFSC fall survey did not cover Cape Cod bay strata.

Q = 1.0				Total	2013	2012	abc	OFL
	NEFSC	MDMF	MENH	30+ biomass	253	380	1078	1458
Spring 2009	0.56	0.25	0.19	3,212	0.08	0.12	0.34	0.45
Spring 2010	0.45	0.33	0.21	2,594	0.10	0.15	0.42	0.56
Spring 2011	0.40	0.33	0.28	1,536	0.16	0.25	0.70	0.95
Spring 2012	0.66	0.21	0.13	2,336	0.11	0.16	0.46	0.62
Spring 2013	0.51	0.33	0.16	1,931	0.13	0.20	0.56	0.75
Spring 2014	0.58	0.12	0.30	2,533	0.10	0.15	0.43	0.58
2012-2014 avg	0.58	0.22	0.20	2,267	0.11	0.17	0.48	0.65
Fall 2009	0.90	0.06	0.03	4,567	0.06	0.08	0.24	0.32
Fall 2010*	0.69	0.26	0.05	3,804	0.07	0.10	0.28	0.38
Fall 2011	0.81	0.14	0.05	3,999	0.06	0.10	0.27	0.36
Fall 2012	0.82	0.09	0.09	2,002	0.13	0.19	0.54	0.73
Fall 2013	0.73	0.11	0.16	1,759	0.14	0.22	0.61	0.83
2011-2013 avg	0.79	0.11	0.10	1,881	0.13	0.20	0.57	0.78

Q = 0.8				Total	2013	2012	abc	OFL
	NEFSC	MDMF	MENH	30+ biomass	253	380	1078	1458
Spring 2009	0.56	0.25	0.19	4,015	0.06	0.09	0.27	0.36
Spring 2010	0.45	0.33	0.21	3,243	0.08	0.12	0.33	0.45
Spring 2011	0.40	0.33	0.28	1,920	0.13	0.20	0.56	0.76
Spring 2012	0.66	0.21	0.13	2,920	0.09	0.13	0.37	0.50
Spring 2013	0.51	0.33	0.16	2,414	0.10	0.16	0.45	0.60
Spring 2014	0.58	0.12	0.30	3,166	0.08	0.12	0.34	0.46
2012-2014 avg	0.58	0.22	0.20	2,833	0.09	0.14	0.39	0.52
Fall 2009	0.90	0.06	0.03	5,709	0.04	0.07	0.19	0.26
Fall 2010*	0.69	0.26	0.05	4,756	0.05	0.08	0.23	0.31
Fall 2011	0.81	0.14	0.05	4,999	0.05	0.08	0.22	0.29
Fall 2012	0.82	0.09	0.09	2,503	0.10	0.15	0.43	0.58
Fall 2013	0.73	0.11	0.16	2,199	0.12	0.17	0.49	0.66
2011-2013 avg	0.79	0.11	0.10	2,351	0.11	0.16	0.46	0.62

Q = 0.6				Total	2013	2012	abc	OFL
	NEFSC	MDMF	MENH	30+ biomass	253	380	1078	1458
Spring 2009	0.56	0.25	0.19	5,354	0.05	0.07	0.20	0.27
Spring 2010	0.45	0.33	0.21	4,324	0.06	0.09	0.25	0.34
Spring 2011	0.40	0.33	0.28	2,559	0.10	0.15	0.42	0.57
Spring 2012	0.66	0.21	0.13	3,894	0.06	0.10	0.28	0.37
Spring 2013	0.51	0.33	0.16	3,219	0.08	0.12	0.33	0.45
Spring 2014	0.58	0.12	0.30	4,221	0.06	0.09	0.26	0.35
2012-2014 avg	0.58	0.22	0.20	3,778	0.07	0.10	0.29	0.39
Fall 2009	0.90	0.06	0.03	7,612	0.03	0.05	0.14	0.19
Fall 2010*	0.69	0.26	0.05	6,341	0.04	0.06	0.17	0.23
Fall 2011	0.81	0.14	0.05	6,666	0.04	0.06	0.16	0.22
Fall 2012	0.82	0.09	0.09	3,337	0.08	0.11	0.32	0.44
Fall 2013	0.73	0.11	0.16	2,932	0.09	0.13	0.37	0.50
2011-2013 avg	0.79	0.11	0.10	3,135	0.08	0.12	0.34	0.47

Table B10. A range of estimated 30+ cm biomass based on DOOR spread and exploitation rates for the combined survey estimate using Bigelow spring 2009 to 2014 and Bigelow fall 2009 to 2013 using an assumed q=0.37 (literature value used for GB yellowtail) and a range of assumed catch (mt) (2013=253, 2012=380, SARC 52 ABC=1078, OFL=1,458) based on an TOGA criteria of 132x. The proportion of the biomass in each survey area is also shown. * Fall 2010 estimate is based on a different strata set since the NEFSC fall survey did not cover Cape Cod bay strata.

	NEFSC	MDMF	ME/NH	Total 30+ biomass	2013 253	2012 380	abc 1078	OFL 1458
Spring 2009	0.60	0.21	0.19	3,255	0.08	0.12	0.33	0.45
Spring 2010	0.50	0.28	0.22	2,569	0.10	0.15	0.42	0.57
Spring 2011	0.44	0.28	0.29	1,516	0.17	0.25	0.71	0.96
Spring 2012	0.70	0.17	0.13	2,403	0.11	0.16	0.45	0.61
Spring 2013	0.56	0.27	0.17	1,923	0.13	0.20	0.56	0.76
Spring 2014	0.61	0.10	0.29	2,630	0.10	0.14	0.41	0.55
2012-2014 avg	0.62	0.18	0.19	2,319	0.11	0.16	0.46	0.63
Fall 2009	0.92	0.05	0.03	4,912	0.05	0.08	0.22	0.30
Fall 2010*	0.74	0.21	0.05	3,893	0.06	0.10	0.28	0.37
Fall 2011	0.84	0.11	0.05	4,216	0.06	0.09	0.26	0.35
Fall 2012	0.85	0.07	0.08	2,132	0.12	0.18	0.51	0.68
Fall 2013	0.76	0.09	0.15	1,852	0.14	0.21	0.58	0.79
2011-2013 avg	0.82	0.09	0.09	1,992	0.13	0.19	0.54	0.73

Table B11. Summary of uncertainty model input data for estimation of updated swept area biomass estimates for Gulf of Maine winter flounder.

Survey	Season	Year	Total Survey Area in	Area per tow in nm^2 (SE)	Survey in kg/tow (SE)
NEFSC	Fall	2011	2990	0.006974755 0.000835526	7.58160 1.89494
MADMF			309	0.003846 0.0004607	6.95300 1.36203
ME-NH			3475	0.00462 0.000553443	0.26902 0.03428
NEFSC	Fall	2012	2990	0.006974755 0.000835526	3.86460 0.51401
MADMF			309	0.003846 0.0004607	2.22835 0.86196
ME-NH			3475	0.00462 0.000553443	0.22957 0.04138
NEFSC	Fall	2013	2990	0.006974755 0.000835526	3.00956 1.91193
MADMF			309	0.003846 0.0004607	2.47407 0.42430
ME-NH			3475	0.00462 0.000553443	0.36564 0.05090
NEFSC	spring	2011	2990	0.006974755 0.000835526	1.42612 0.43308
MADMF			309	0.003846 0.0004607	6.23390 1.29496
ME-NH			3475	0.00462 0.000553443	0.56596 0.24210
NEFSC	spring	2012	2990	0.006974755 0.000835526	3.60241 1.00922
MADMF			309	0.003846 0.0004607	6.23518 1.34671
ME-NH			3475	0.00462 0.000553443	0.39419 0.14960
NEFSC	spring	2013	2990	0.006974755 0.000835526	2.29905 0.37989
MADMF			309	0.003846 0.0004607	7.87736 1.12588
ME-NH			3475	0.00462 0.000553443	0.42051 0.08807
NEFSC	spring	2014	2990	0.006974755 0.000835526	3.42422 1.20931
MADMF			309	0.003846 0.0004607	3.90166 0.70399
ME-NH			3475	0.00462 0.000553443	1.00579 0.68373

Table B12. Summary of estimated sampling distribution of biomass estimates for Gulf of Maine winter flounder for spring surveys from 2011 to 2014 under assumed efficiency estimates of 1.0, 0.8 and 0.6.

	Spring 2011			Spring 2012			Spring 2013			Spring 2014		
	Q=1.0	Q=0.8	Q=0.6	Q=1.0	Q=0.8	Q=0.6	Q=1.0	Q=0.8	Q=0.6	Q=1.0	Q=0.8	Q=0.6
Minimum	760	960	1300	1210	1530	2060	1300	1630	2200	730	940	1290
Maximum	2530	3150	4170	3930	4880	6470	2780	3460	4590	4850	6020	7820
Range	1770	2190	2870	2720	3350	4410	1480	1830	2390	4120	5080	6530
Mean	1553.6	1945.7	2599.3	2369.8	2965.9	3959.0	1945.1	2435.0	3251.7	2587.588	3238.1	3509.5
Std Dev	264.2	329.8	439.1	440.4	549.7	731.6	216.3	270.1	359.6	665.777	830.9	639.2
C.V.	0.17	0.169	0.169	0.186	0.185	0.185	0.111	0.111	0.111	0.257	0.257	0.182
Skewness(G1)	0.172	0.171	0.169	0.263	0.262	0.259	0.246	0.244	0.242	0.165	0.162	-0.621
Kurtosis(G2)	-0.172	-0.181	-0.19	-0.266	-0.274	-0.284	-0.113	-0.124	-0.134	-0.26	-0.27	0.078
Percentiles												
1%	990	1240	1660	1490	1870	2500	1490	1870	2500	1180	1480	1830
5%	1130	1420	1900	1680	2110	2820	1610	2010	2690	1520	1910	2310
10%	1220	1520	2040	1810	2260	3020	1670	2090	2800	1730	2170	2590
20%	1320	1660	2220	1980	2480	3310	1760	2200	2940	2010	2510	2950
25%	1370	1710	2290	2050	2570	3430	1790	2240	3000	2110	2650	3090
30%	1410	1760	2350	2110	2650	3530	1820	2280	3050	2210	2770	3210
40%	1480	1850	2470	2230	2790	3730	1880	2350	3140	2390	3000	3420
50%	1550	1940	2590	2350	2940	3920	1940	2420	3240	2570	3210	3610
60%	1610	2020	2700	2470	3090	4120	1990	2490	3330	2740	3430	3790
70%	1690	2120	2830	2590	3250	4330	2050	2570	3430	2930	3670	3950
75%	1730	2170	2890	2670	3340	4450	2090	2610	3490	3040	3800	4030
80%	1780	2230	2970	2750	3440	4590	2130	2660	3560	3160	3950	4110
90%	1900	2380	3180	2960	3700	4940	2230	2790	3730	3470	4340	4270
95%	2000	2510	3350	3130	3920	5230	2320	2900	3870	3720	4650	4350
99%	2190	2740	3660	3450	4310	5740	2480	3100	4140	4180	5220	4410

Table B13. Summary of estimated sampling distribution of biomass estimates for Gulf of Maine winter flounder for fall surveys from 2011 to 2013 under assumed efficiency estimates of 1.0, 0.8, and 0.6.

	Fall 2011			Fall 2012			Fall 2013		
	Q=1.0	Q=0.8	Q=0.6	Q=1.0	Q=0.8	Q=0.6	Q=1.0	Q=0.8	Q=0.6
Minimum	2160	2720	3660	1280	1610	2170	250	320	440
Maximum	6830	8490	11200	3030	3780	5010	4130	5160	6850
Range	4670	5770	7540	1750	2170	2840	3880	4840	6410
Mean	4060.211	5077.898	6774.045	2018.999	2527.355	3374.759	1799.57	2252.689	3007.586
Std Dev	799.455	997.124	1325.803	271.025	338.508	450.829	735.99	919.321	1223.498
C.V.	0.197	0.196	0.196	0.134	0.134	0.134	0.409	0.408	0.407
Skewness(G1)	0.308	0.304	0.299	0.331	0.329	0.328	0.217	0.217	0.212
Kurtosis(G2)	-0.287	-0.298	-0.314	-0.133	-0.139	-0.147	-0.467	-0.468	-0.476
Percentiles									
1%	2520	3150	4210	1480	1850	2470	380	480	640
5%	2820	3540	4720	1600	2010	2680	620	780	1050
10%	3040	3800	5080	1680	2100	2810	830	1050	1400
20%	3340	4180	5590	1780	2230	2980	1130	1420	1900
25%	3470	4340	5790	1820	2280	3050	1260	1570	2100
30%	3590	4490	5990	1860	2330	3110	1370	1710	2290
40%	3800	4760	6350	1930	2420	3230	1570	1970	2630
50%	4010	5020	6700	2000	2510	3350	1770	2220	2960
60%	4230	5290	7060	2070	2590	3460	1970	2470	3290
70%	4470	5580	7450	2150	2690	3600	2190	2740	3660
75%	4600	5750	7670	2200	2750	3670	2310	2890	3860
80%	4750	5930	7910	2250	2810	3760	2440	3060	4080
90%	5140	6420	8560	2380	2980	3980	2800	3500	4660
95%	5460	6820	9090	2500	3120	4170	3070	3840	5120
99%	6030	7530	10030	2700	3380	4510	3530	4410	5870

Table B14. Summary of estimated probabilities of exceeding reference points in 2013, based on fall survey for alternative quotas.

	Efficiency = 0.6		Efficiency = 0.8		Efficiency = 1.0	
Quota	P(F>0.17)	P(F>0.23)	P(F>0.17)	P(F>0.23)	P(F>0.17)	P(F>0.23)
100	0.003781	0.000023	0.021372	0.003293	0.039872	0.016458
200	0.063437	0.028328	0.125578	0.06142	0.208417	0.104862
217	0.077379	0.035885	0.15144	0.074986	0.24953	0.126734
253	0.111159	0.053915	0.214021	0.107824	0.346014	0.179886
300	0.164444	0.081777	0.309905	0.159633	0.483373	0.262422
380	0.277783	0.141996	0.495235	0.270059	0.707052	0.427969
400	0.309905	0.159633	0.542411	0.301441	0.754741	0.471812
500	0.483373	0.262422	0.754741	0.471812	0.922046	0.681964
600	0.655255	0.384643	0.897895	0.642626	0.987622	0.843385
700	0.797832	0.515677	0.970956	0.786553	0.99967	0.940382
800	0.897895	0.642626	0.995716	0.889487	1	0.985183
900	0.958225	0.754150	0.999982	0.952958	1	0.99821
1000	0.987622	0.843385	1	0.985183	1	1
1078	0.996547	0.896309	1	0.995504	1	1
1100	0.997786	0.908775	1	0.99704	1	1
1200	0.999982	0.952958	1	0.999907	1	1
1300	1	0.979511	1	1	1	1
1400	1	0.992872	1	1	1	1
1458	1	0.996634	1	1	1	1
1500	1	0.998210	1	1	1	1

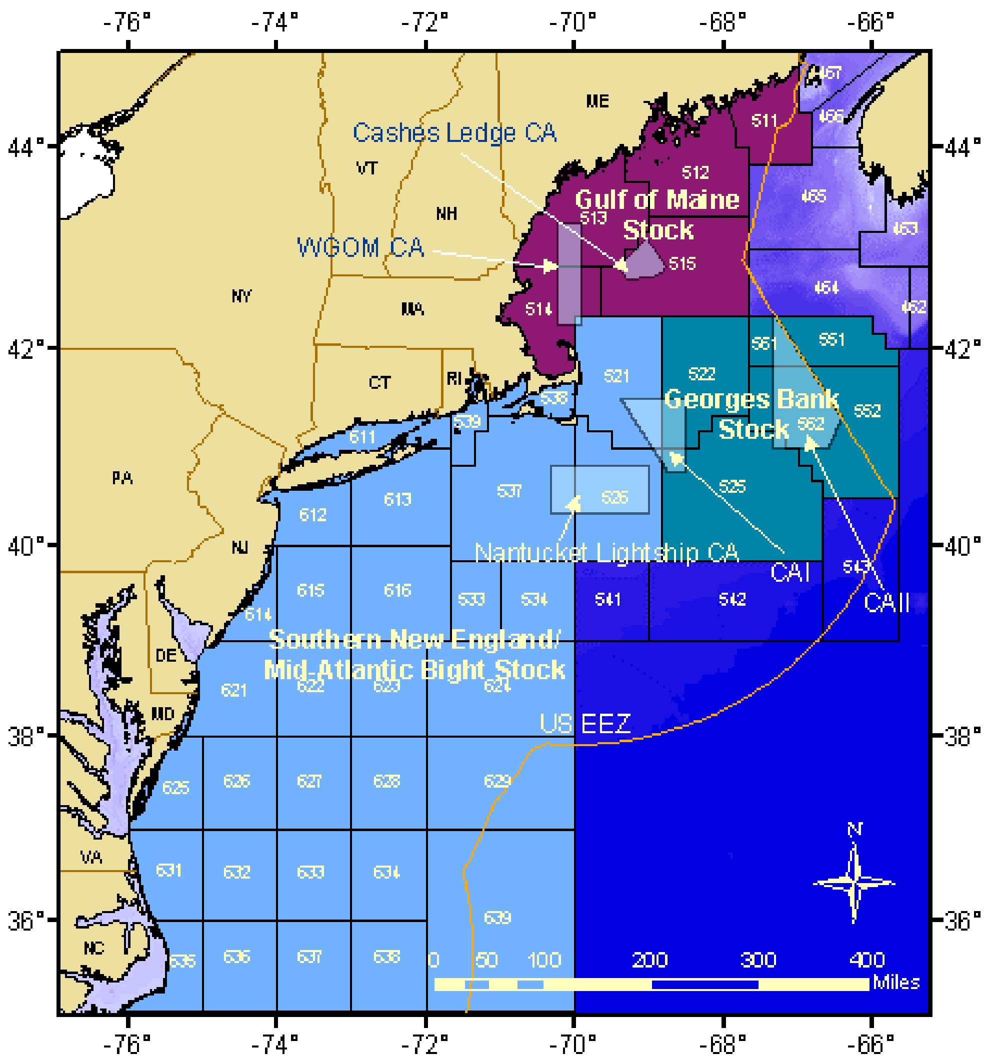


Figure B1. Statistical areas used to define winter flounder stocks. The Gulf of Maine stock includes area 511-515.

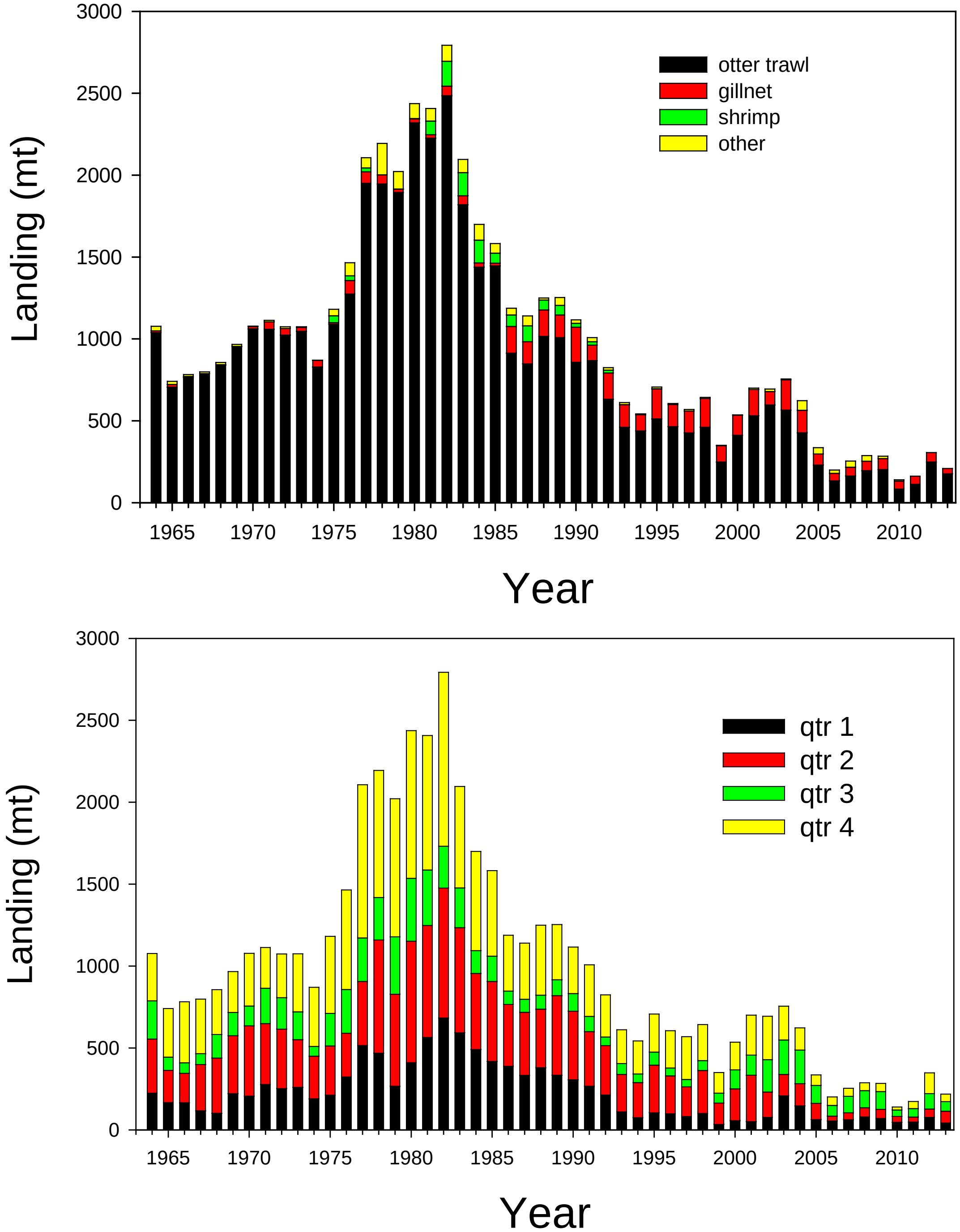


Figure B2. Gulf of Maine winter flounder commercial landings by gear (top) and quarter (bottom) 1964-2013.

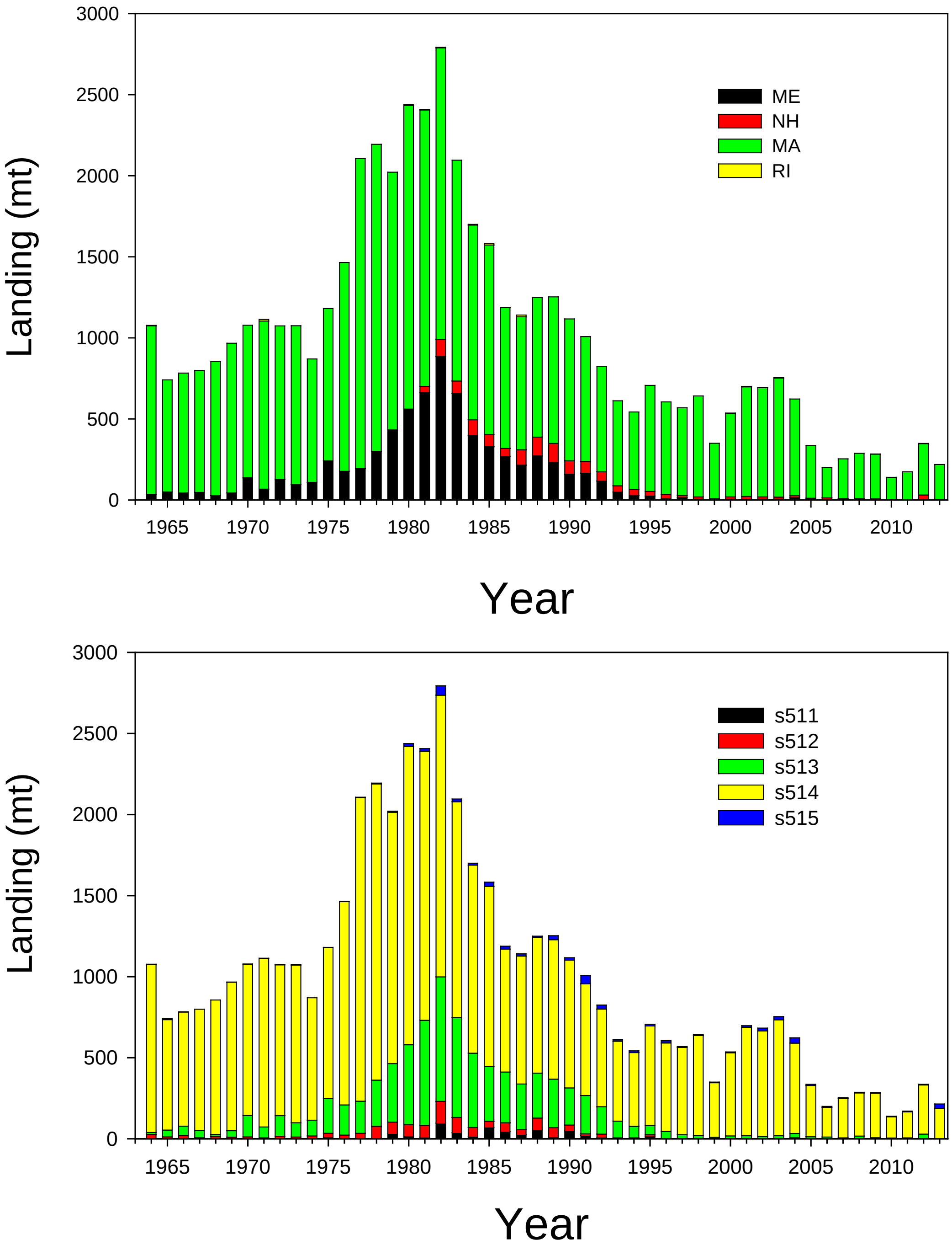


Figure B3. Gulf of Maine winter flounder commercial landings by state (top) and statistical area (bottom) 1964-2013.

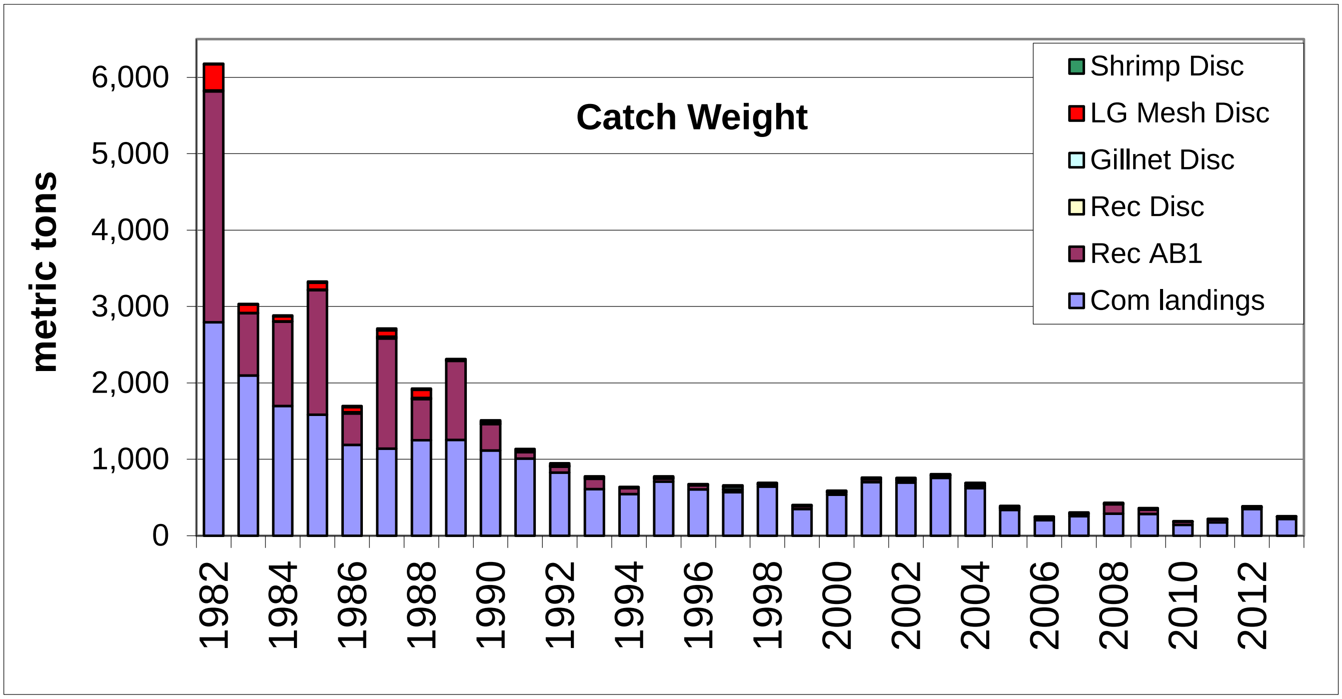


Figure B4. Gulf of Maine winter flounder composition of the catch by weight 1982-2013.

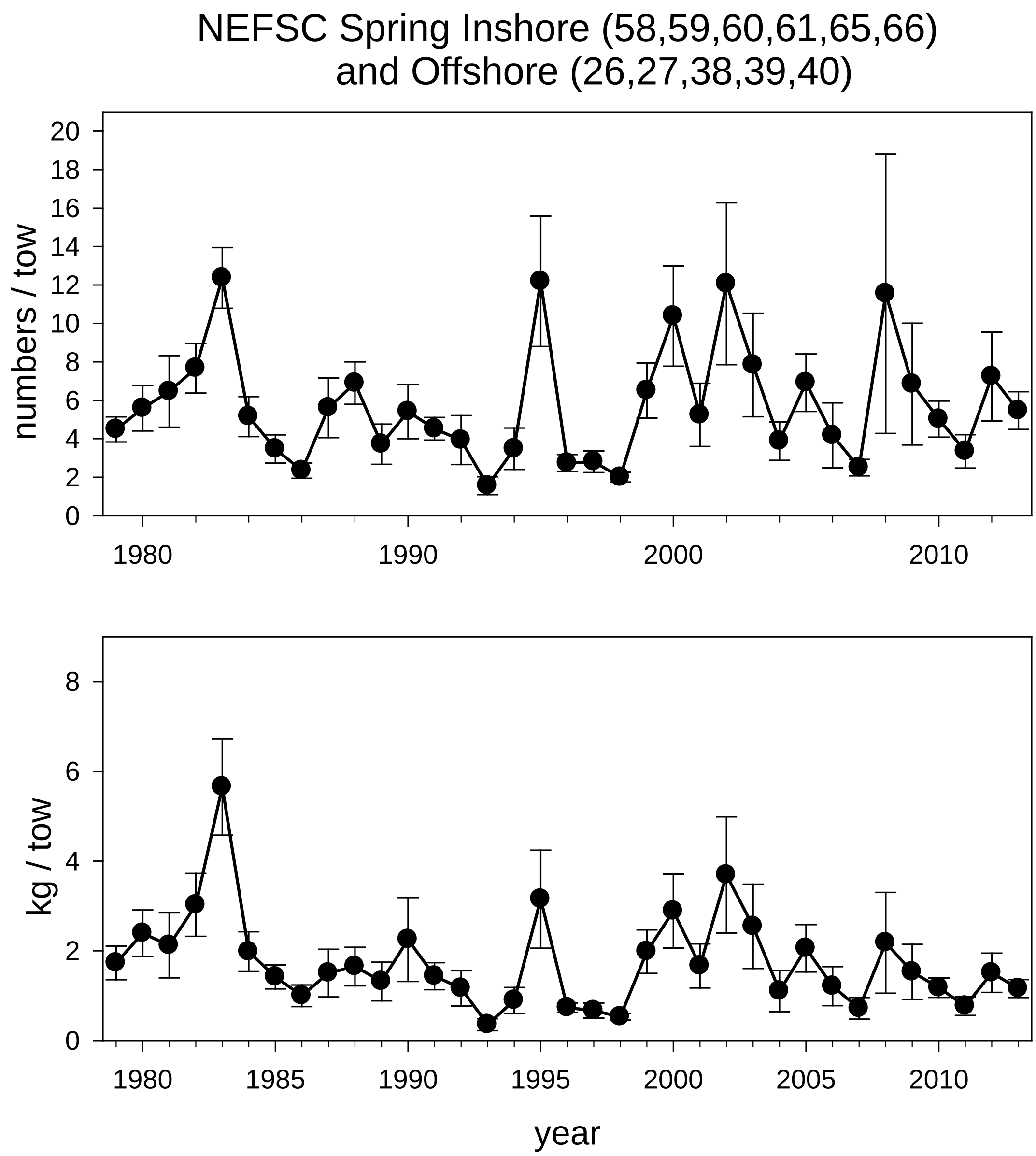


Figure B5. NEFSC spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Estimated standard error is also shown. Trawl door and FV Bigelow conversion factors are use where appropriate.

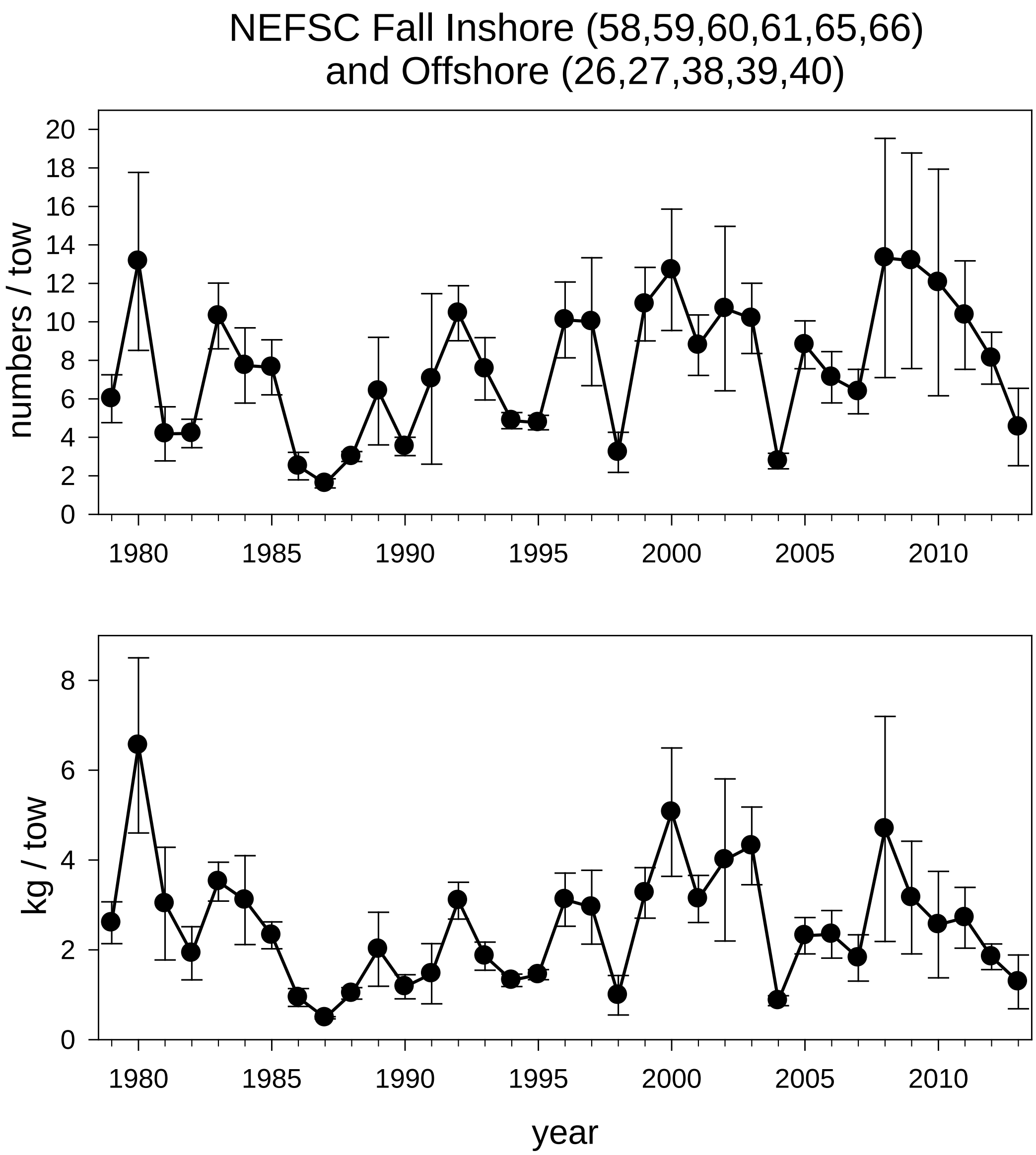


Figure B6. NEFSC fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Estimated standard error is also shown. Trawl door and FV Bigelow conversion factors are use where appropriate.

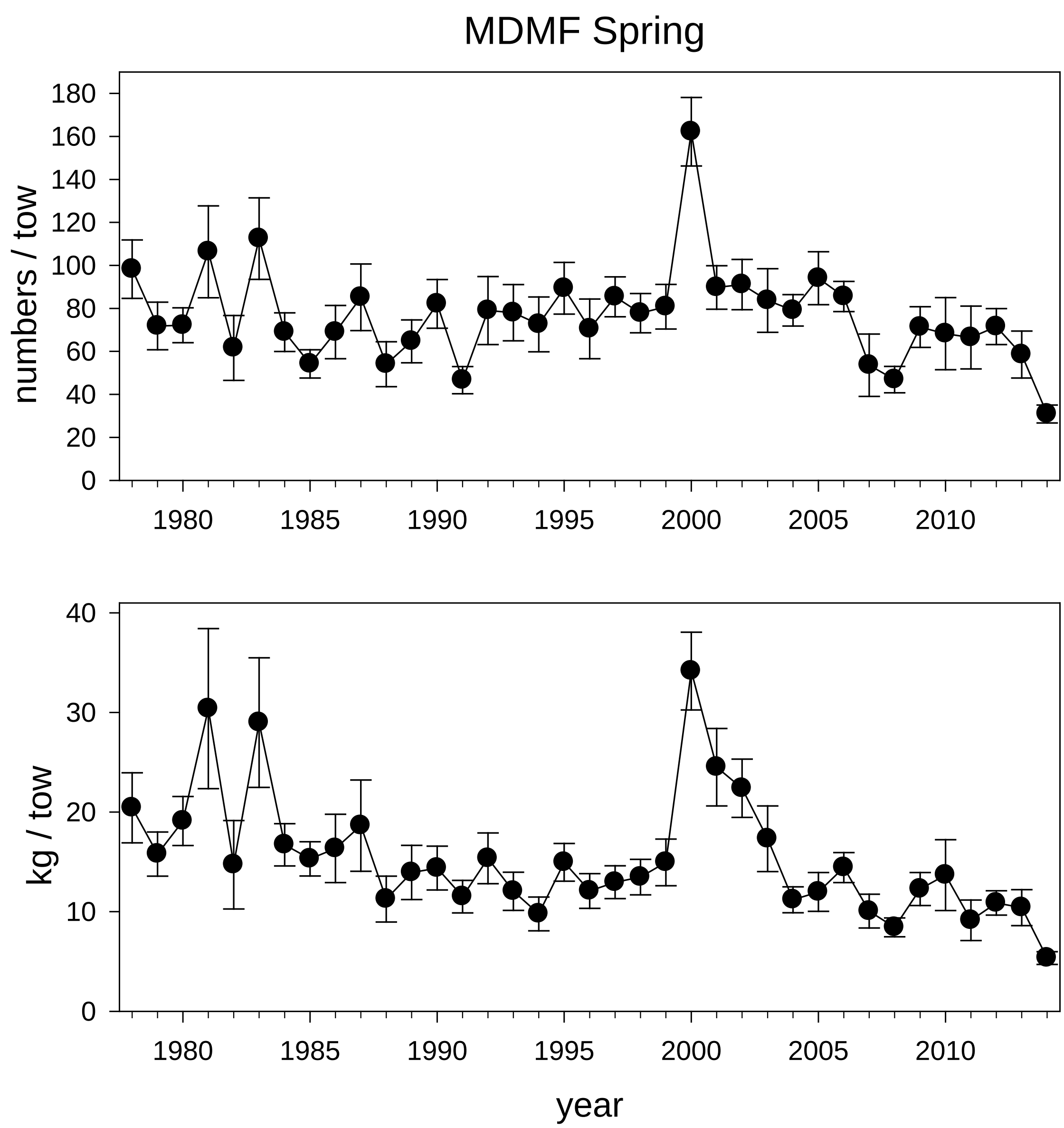


Figure B7. MDMF spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Estimated standard error is also shown.

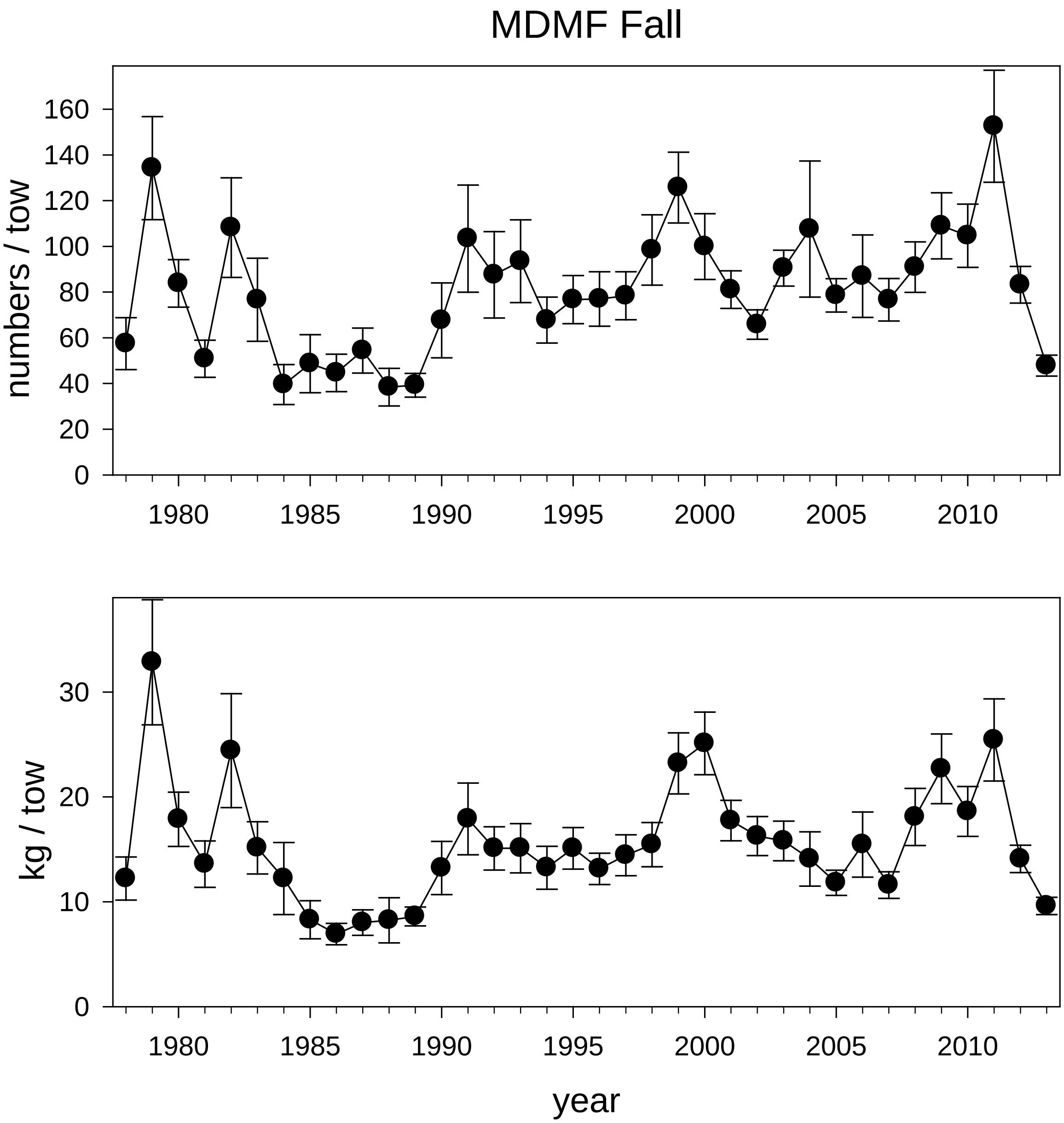
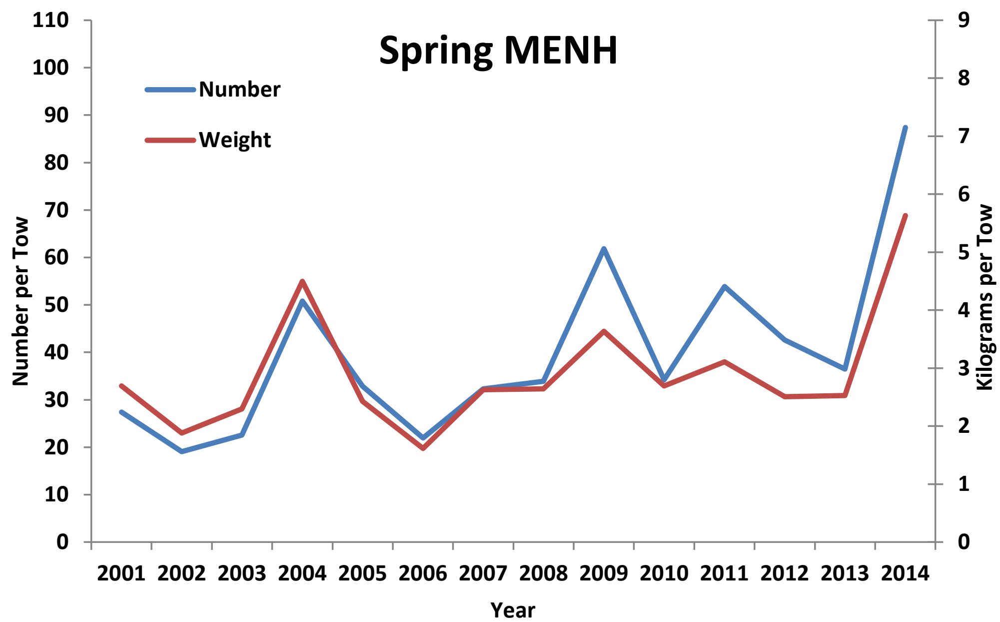


Figure B8. MDMF fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Estimated standard error is also shown.



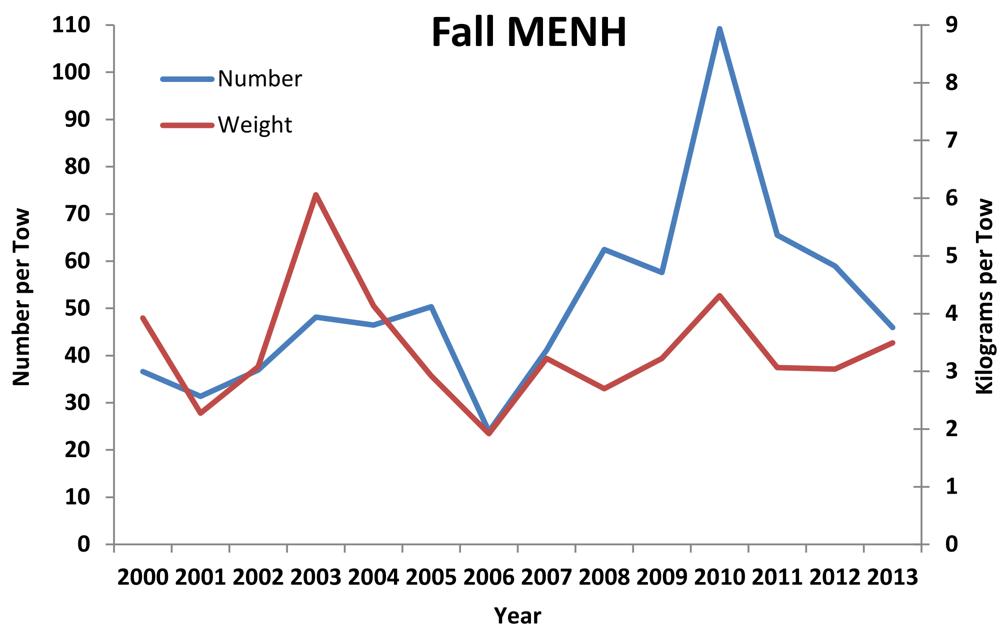
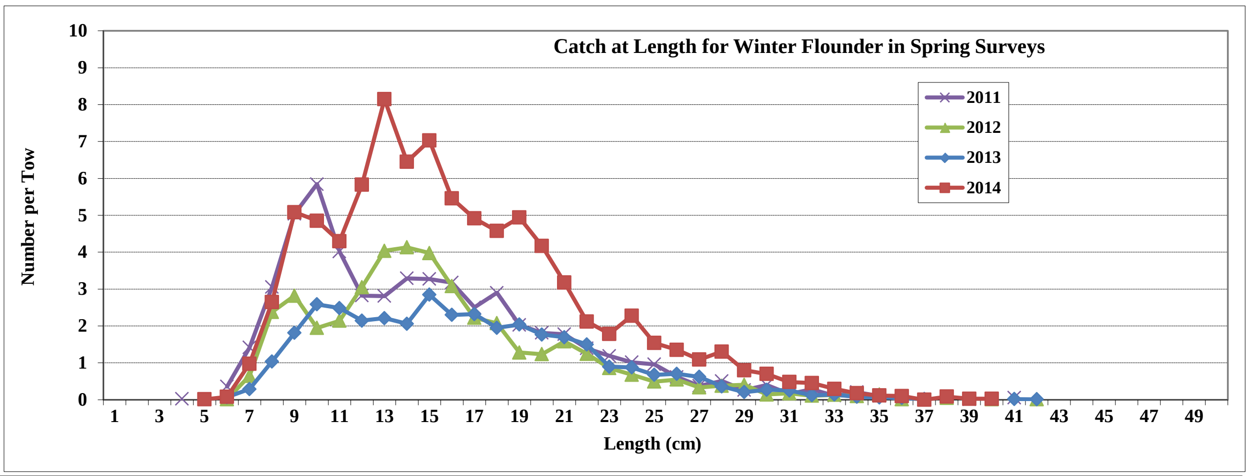


Figure B9. MENH spring and fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.



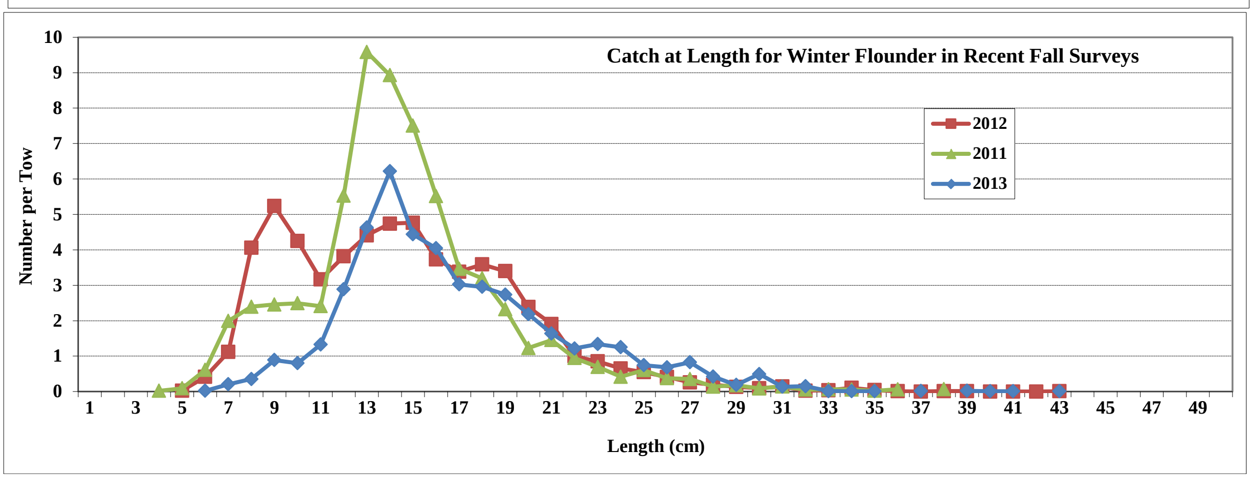


Figure B10. Numbers per tow at length from the inshore MENH survey. Relatively few fish 30 cm and greater are caught in the MENH survey.

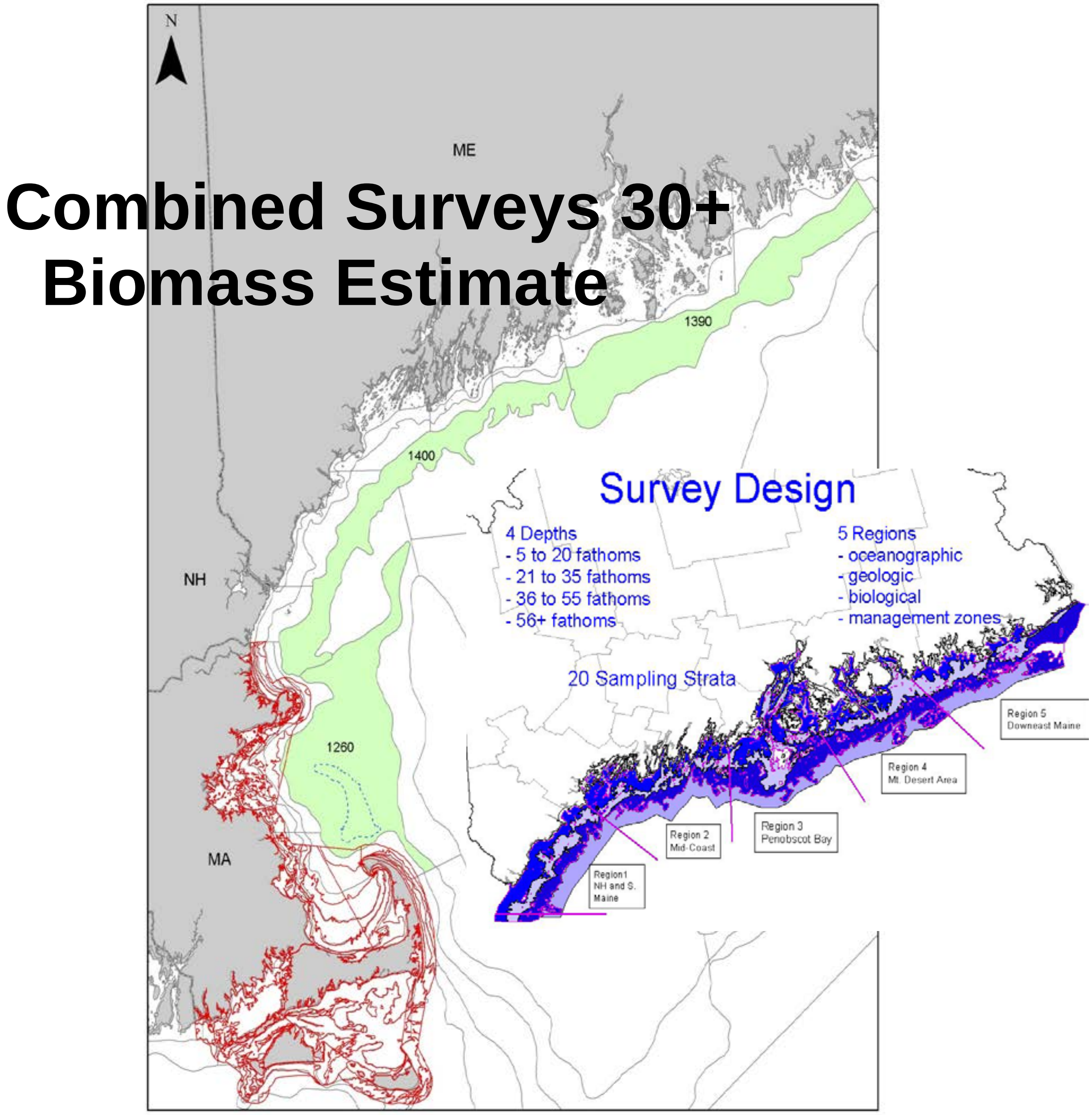
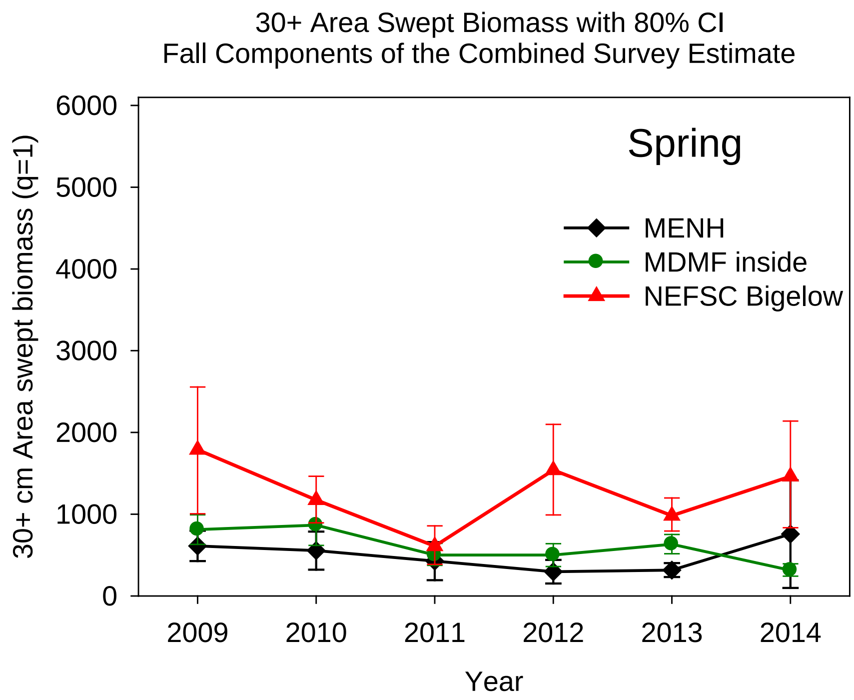


Figure B11. NEFSC, MDMF, and MENH survey areas used in the combined survey 30+ cm biomass estimate. Green shaded areas are the NEFSC offshore strata used for the 30+ biomass estimate.



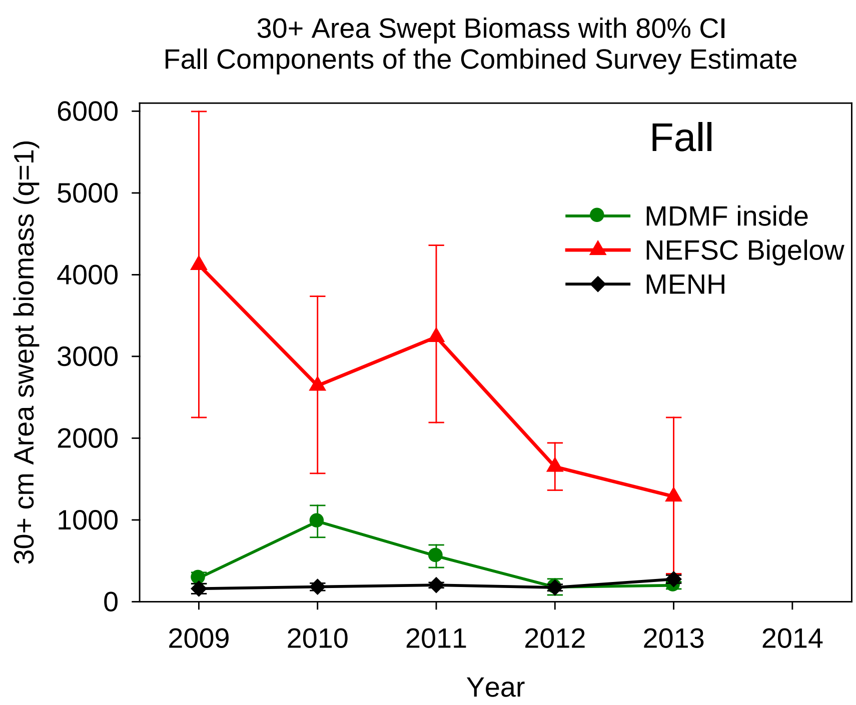


Figure B12. Bigelow spring and fall area swept (Q=1) exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals for the non-overlapping strata used in the combine biomass estimate.

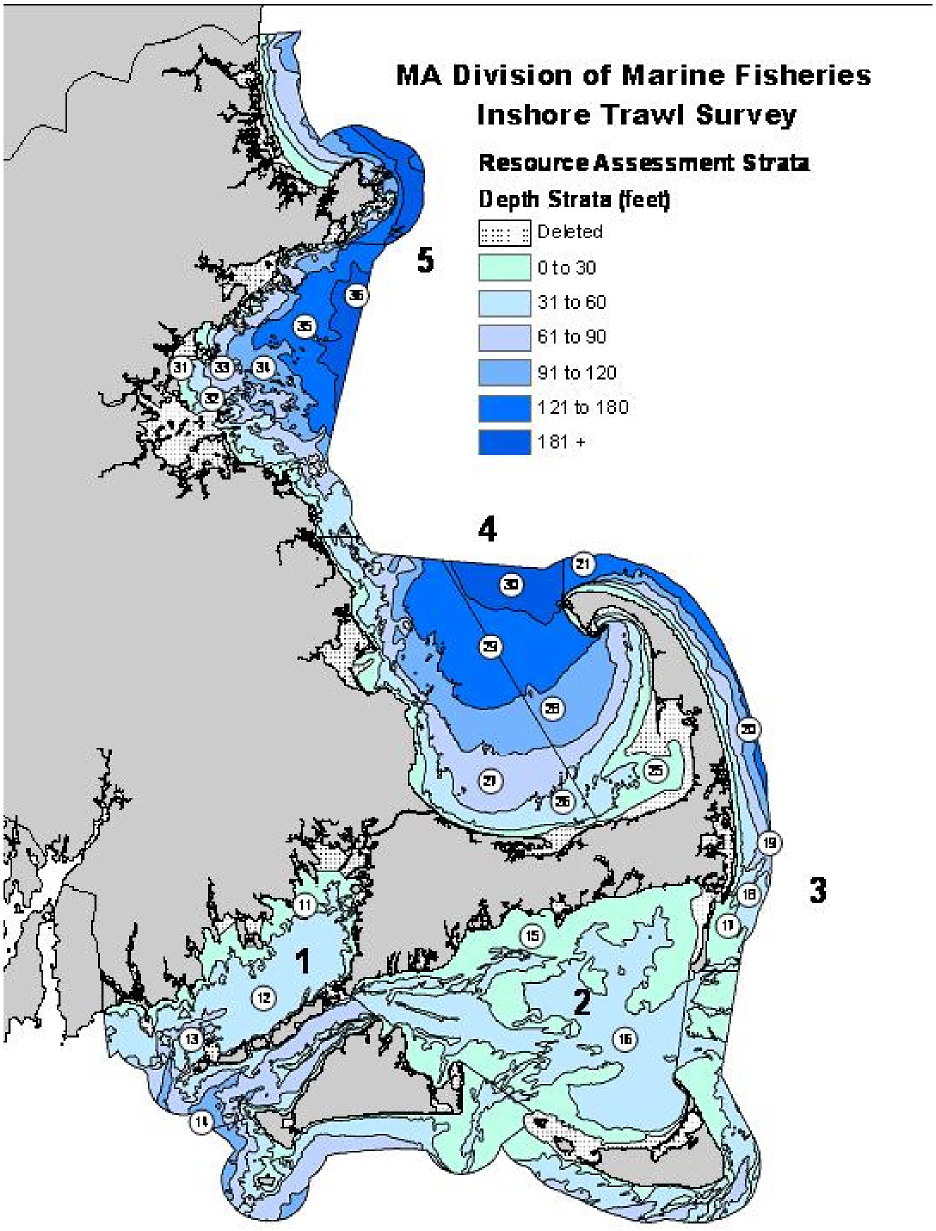


Figure B13. MDMF survey strata. The gulf of Maine winter flounder stock uses strata north of Cape Cod. Strata 25, 26, 31, 32 and 33 are used for the combined non-overlapping biomass estimate.

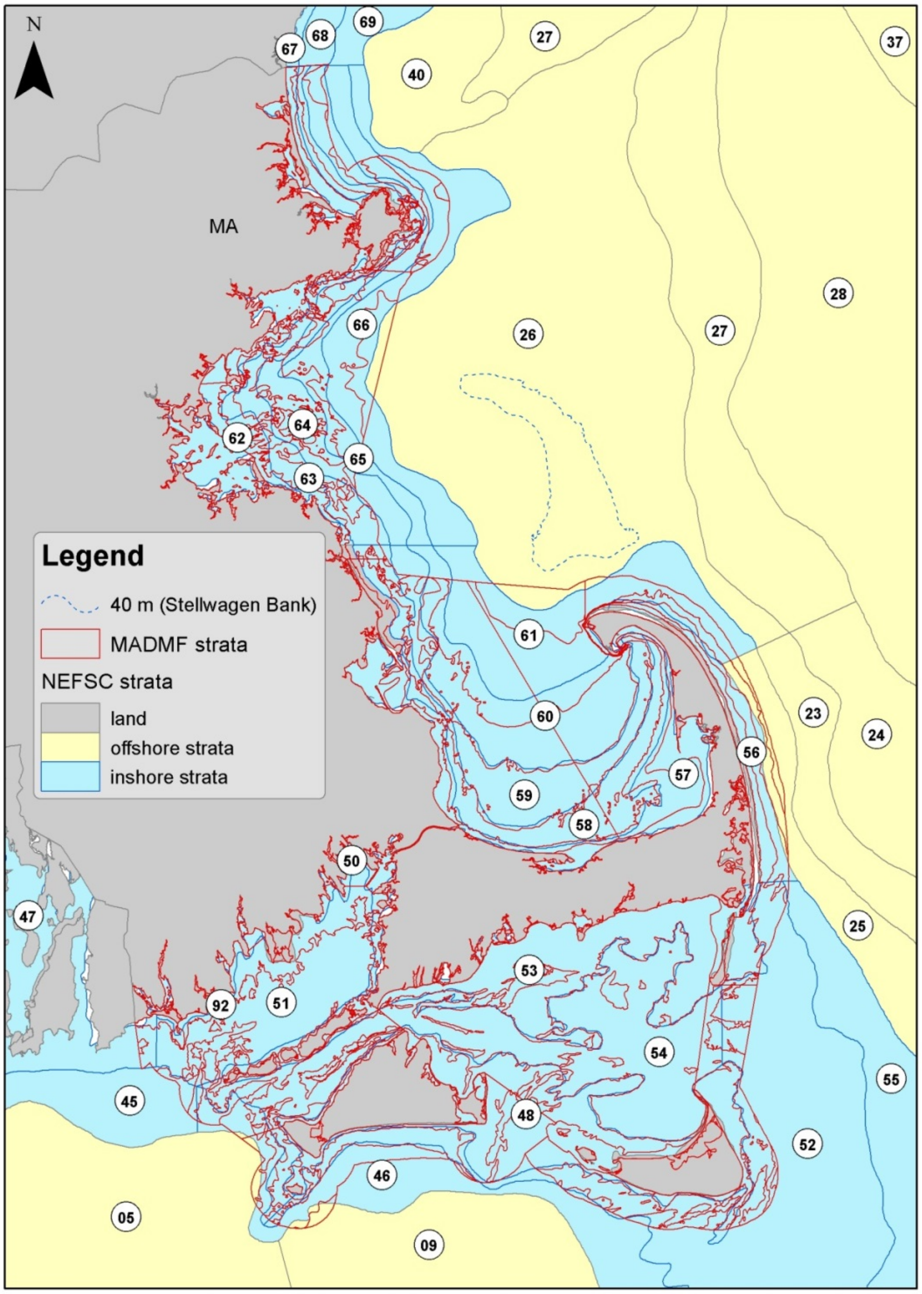


Figure B14. Gulf of Maine winter flounder inshore survey overlap between the NEFSC and MDMF surveys.

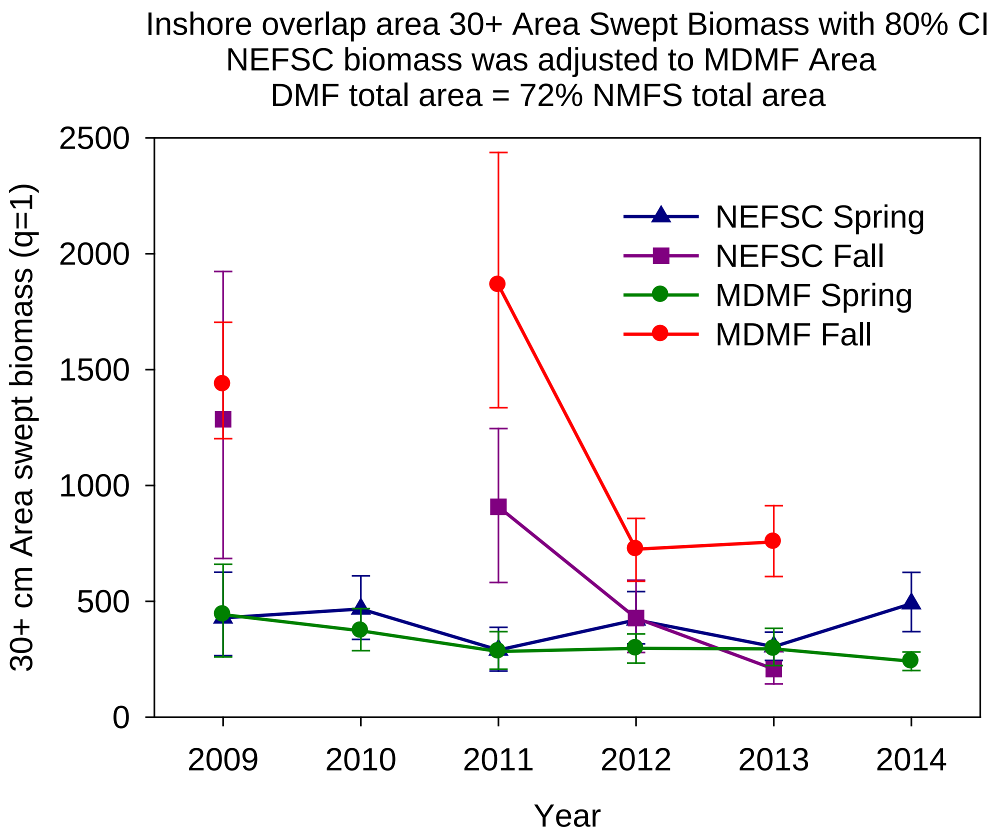


Figure B15. Minimum area adjusted area swept (q=1.0) exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals limited to the overlap strata between the NEFSC and MDMF surveys. NEFSC overlap strata equals 72% of the total DMF overlap area. NEFSC fall 2010 is missing due to lack of coverage for Cape Cod bay inshore strata.

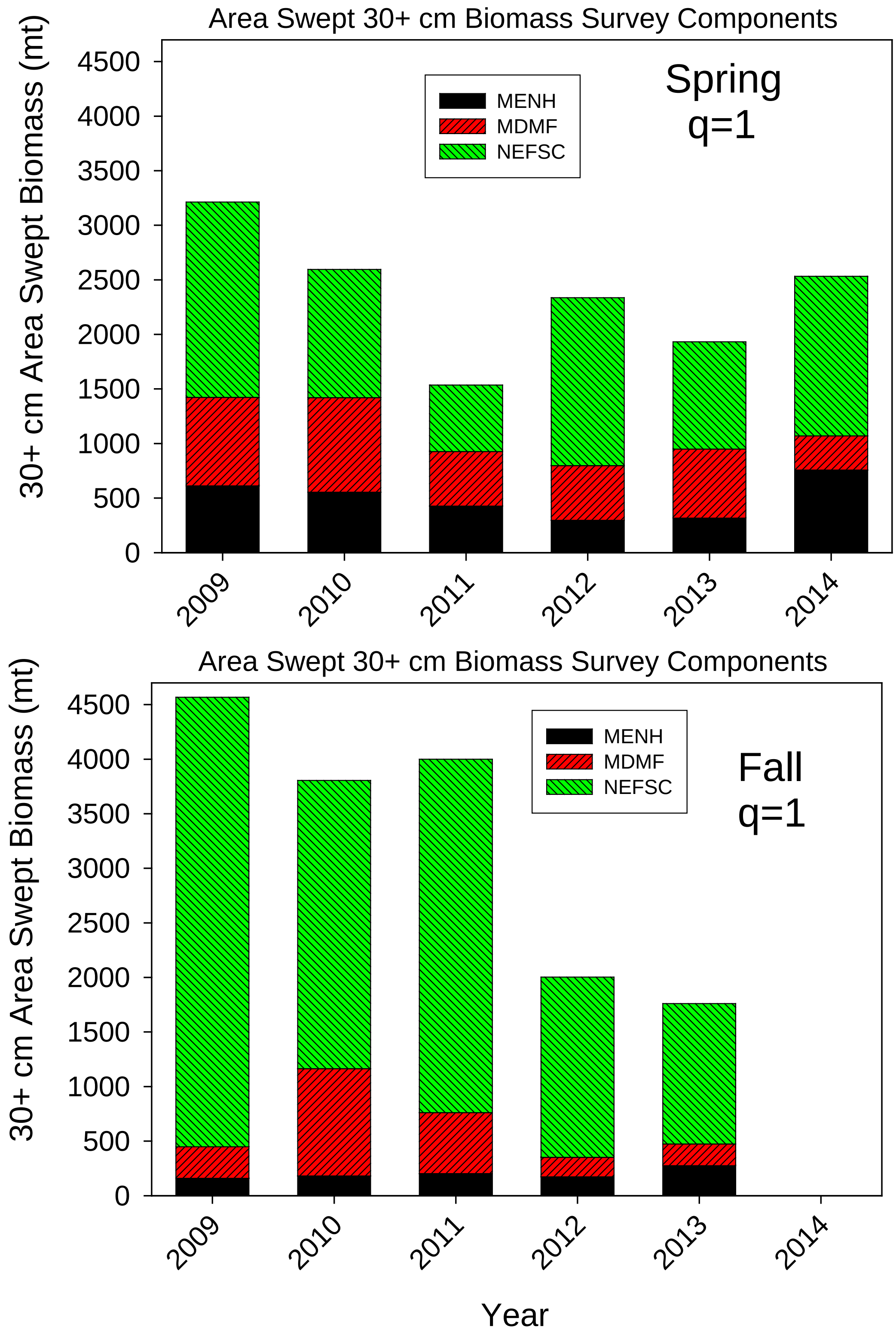


Figure B16. 30+ cm area swept biomass estimates for each survey (MENH, MDMF, NEFSC) for the spring (top; 2009-2014) and fall (bottom; 2009-2013) surveys assuming q=1.0.

Figure B17. SARC 52 length based yield per recruit analysis using updated von Bertalanffy parameters estimated from the spring and fall 2006-2010 NEFSC surveys, maturity at length from the MDMF survey and assuming a natural mortality of 0.3. F40% was estimated at 0.31.

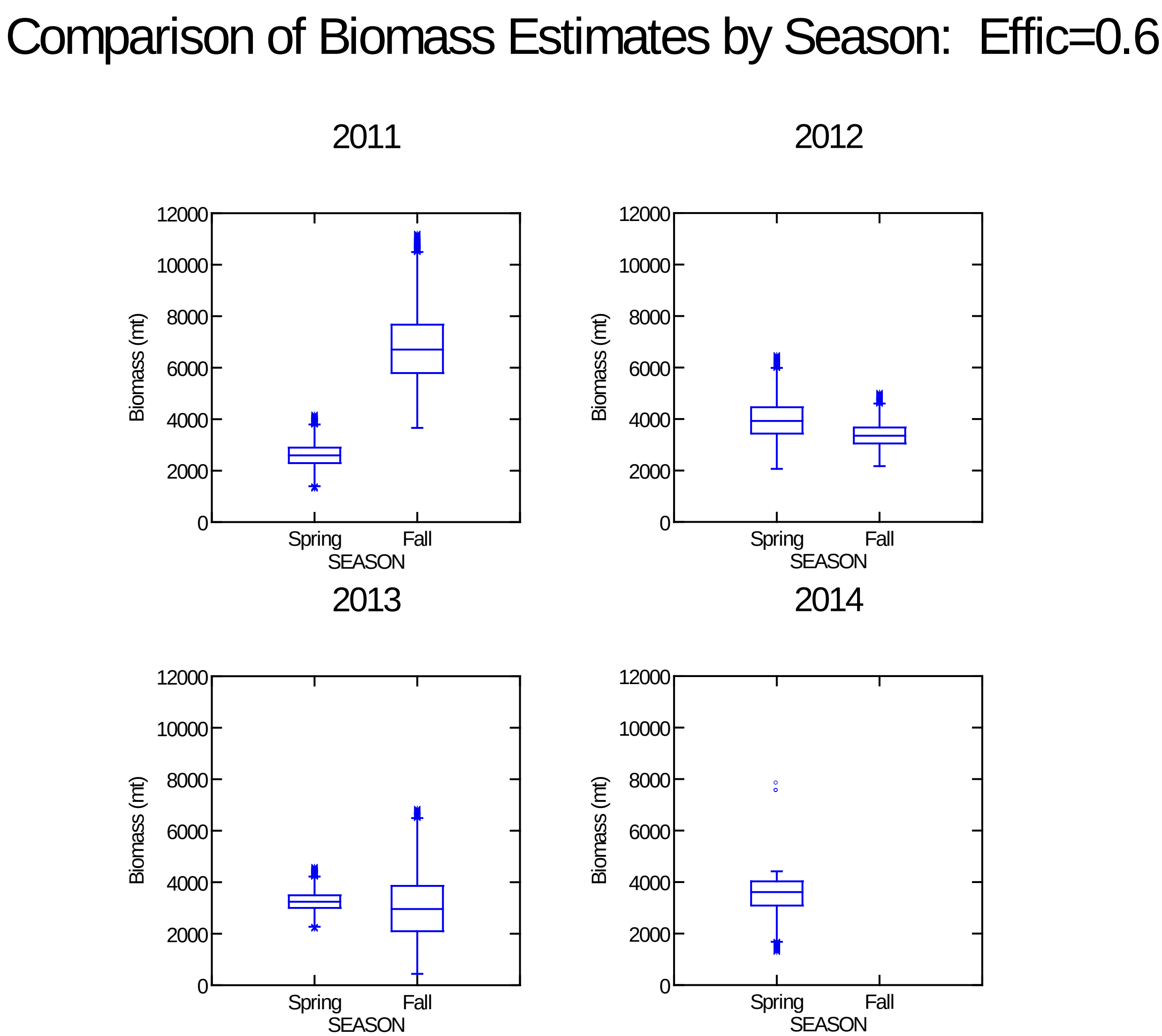
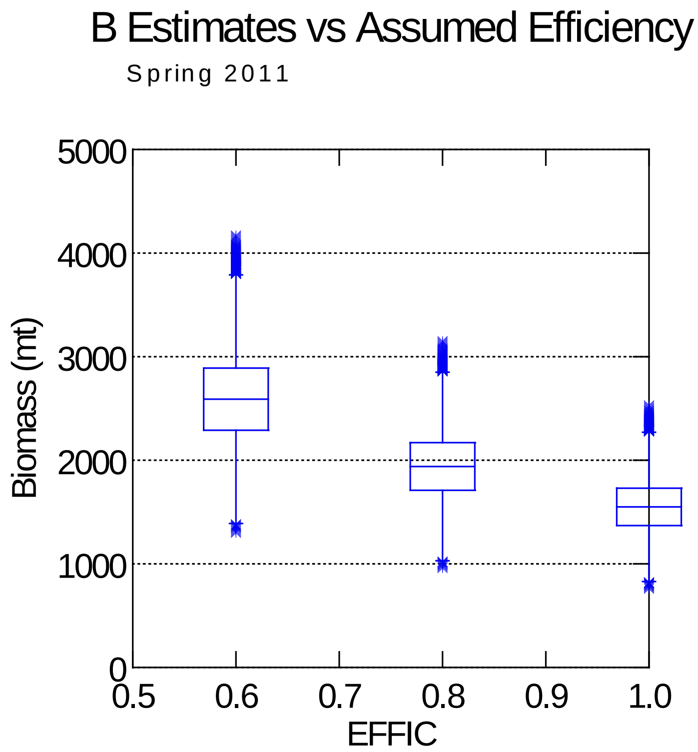


Figure B18. Gulf of Maine winter flounder seasonal (spring and fall) swept area biomass estimates comparison assuming trawl efficiency = 0.6.



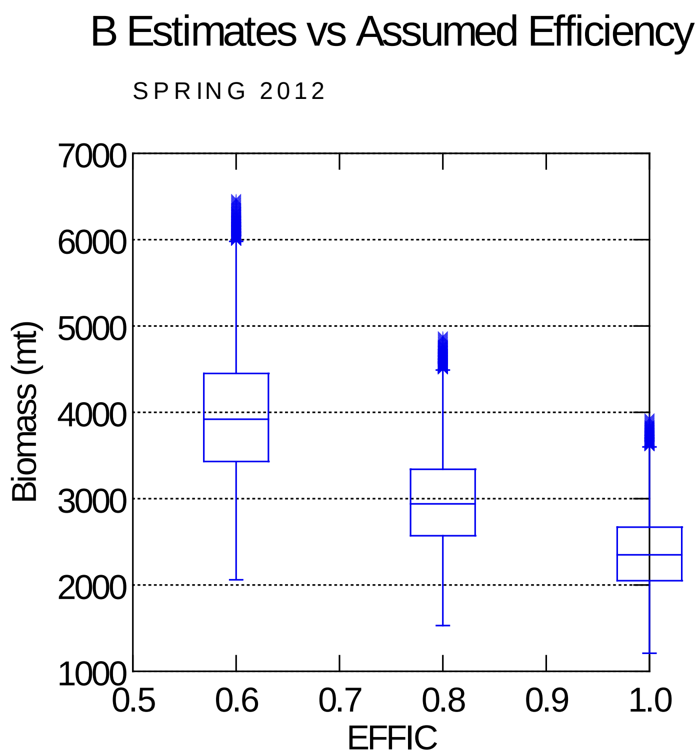
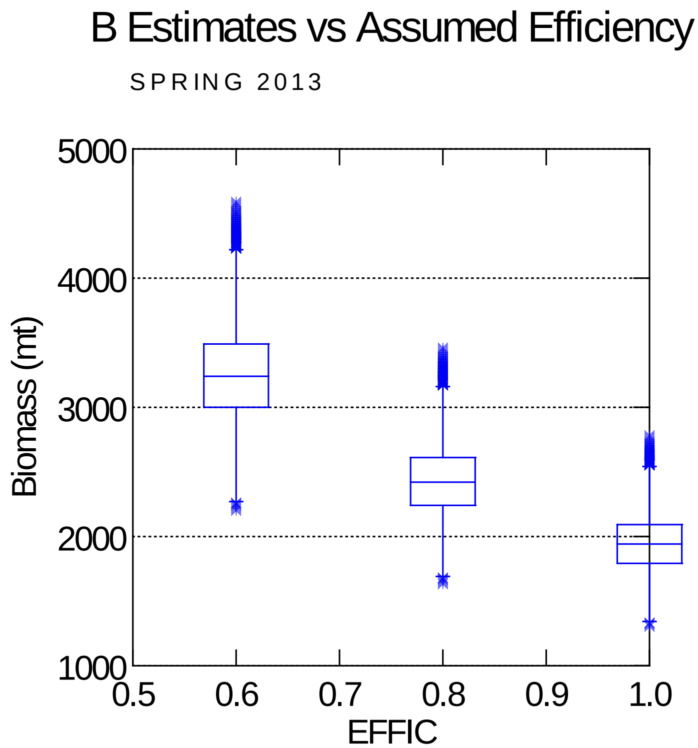


Figure B19. Swept area biomass estimates for Gulf of Maine winter flounder for varying seasons (spring and fall) and years under three alternative assumed values of trawl efficiency (0.6, 0.8 and 1.0).



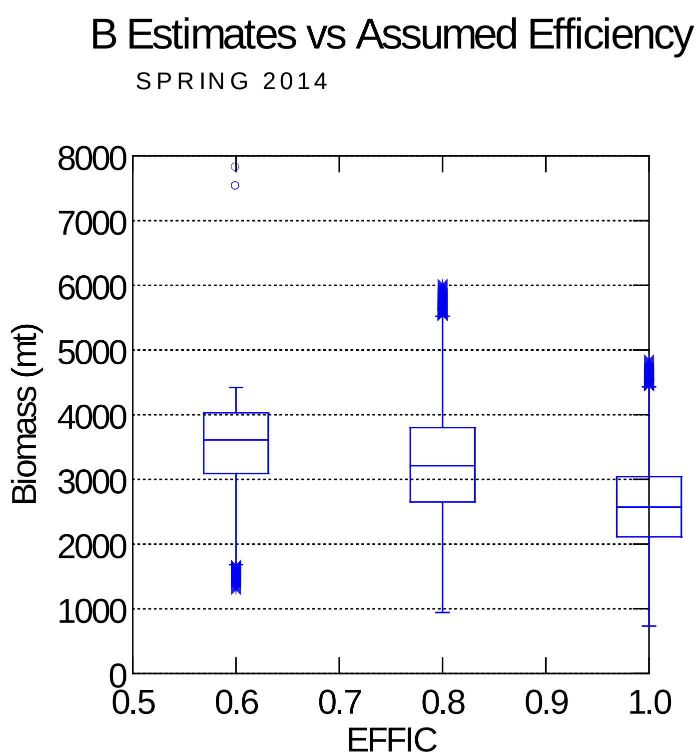
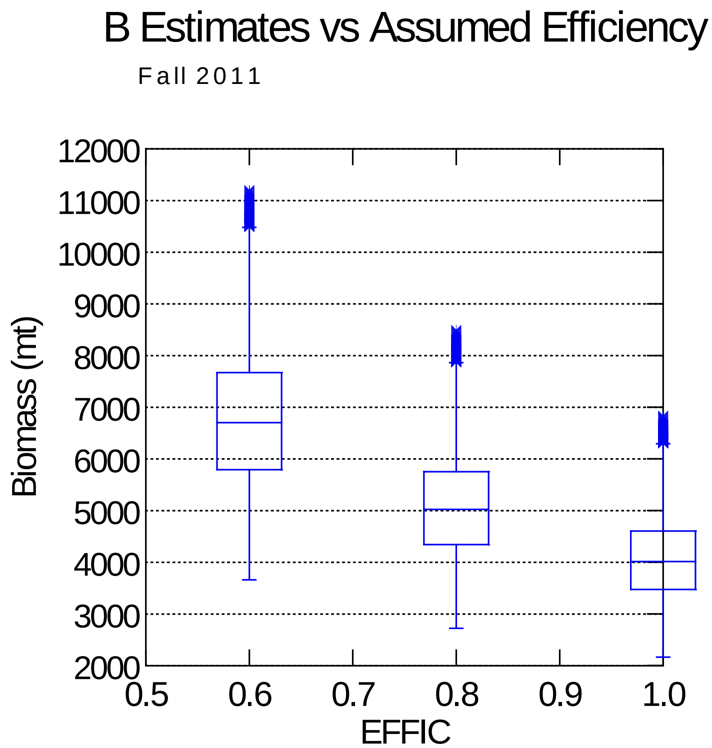
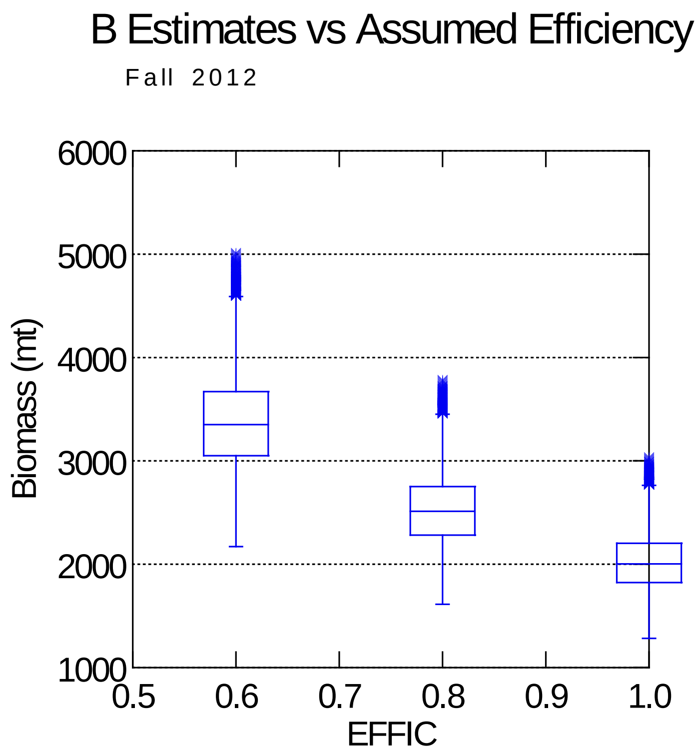


Figure B19. Cont.





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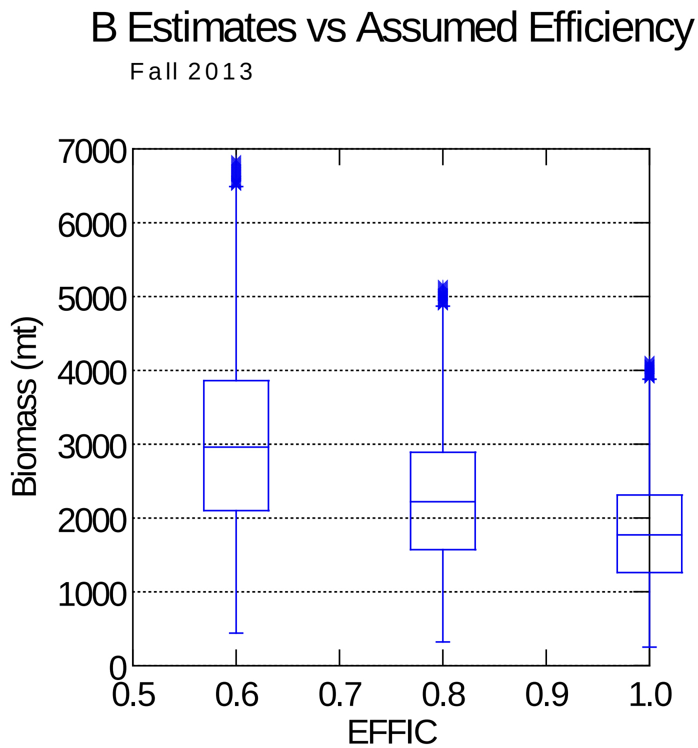
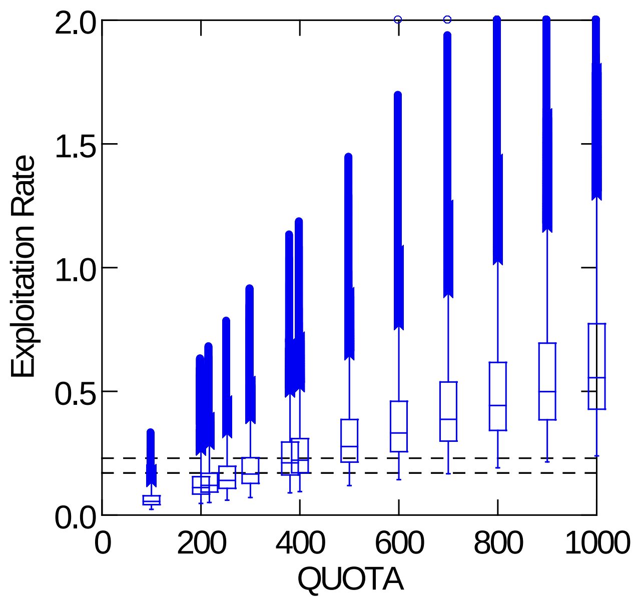


Figure B19. Cont.

Exploitation Estimates: Fall 2013, Efficiency=1.0



Exploitation Estimates: Fall 2013, Efficiency=0.8

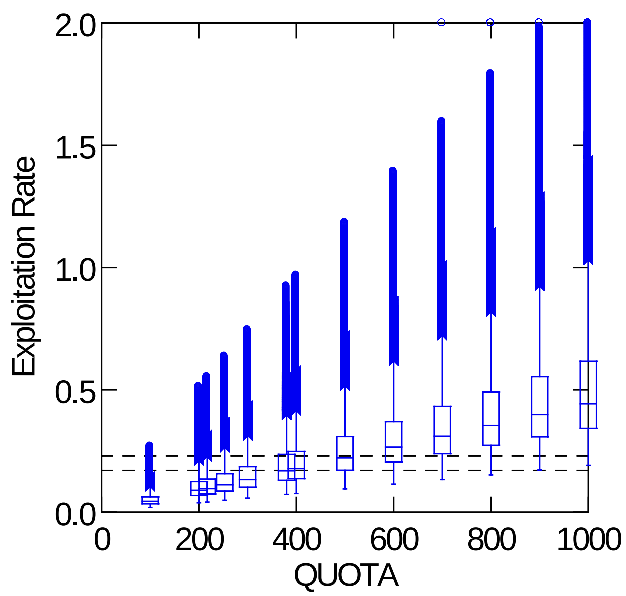


Figure B20. Estimated exploitation rates for Gulf of Maine winter flounder for fall 2009 based on three assumed estimates of gear efficiency (0.6, 0.8, and 1.0) under various quotas. Dashed lines represent length based estimates of F40% (0.19) and 75% of F40% (0.1425). SSB per recruit is derived using GOM winter flounder growth and maturation relationships and an assumed knife edge selection curve at 30 cm.

Exploitation Estimates: Fall 2013, Efficiency=0.6

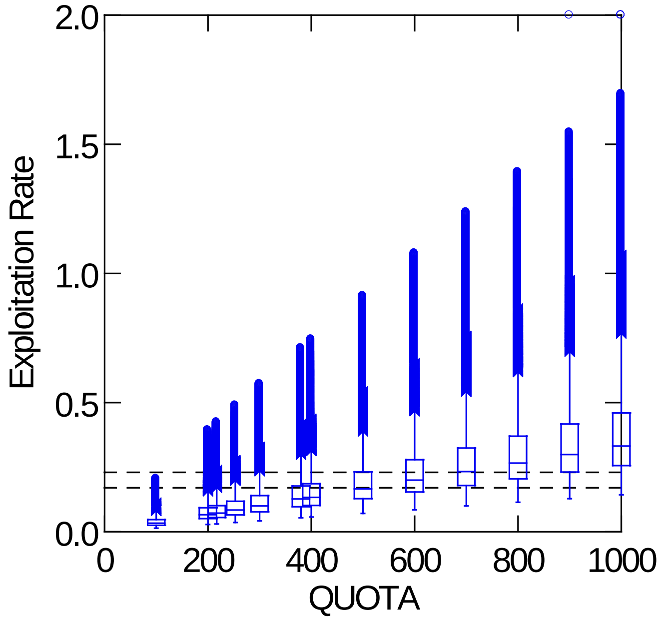


Figure B20. Cont.

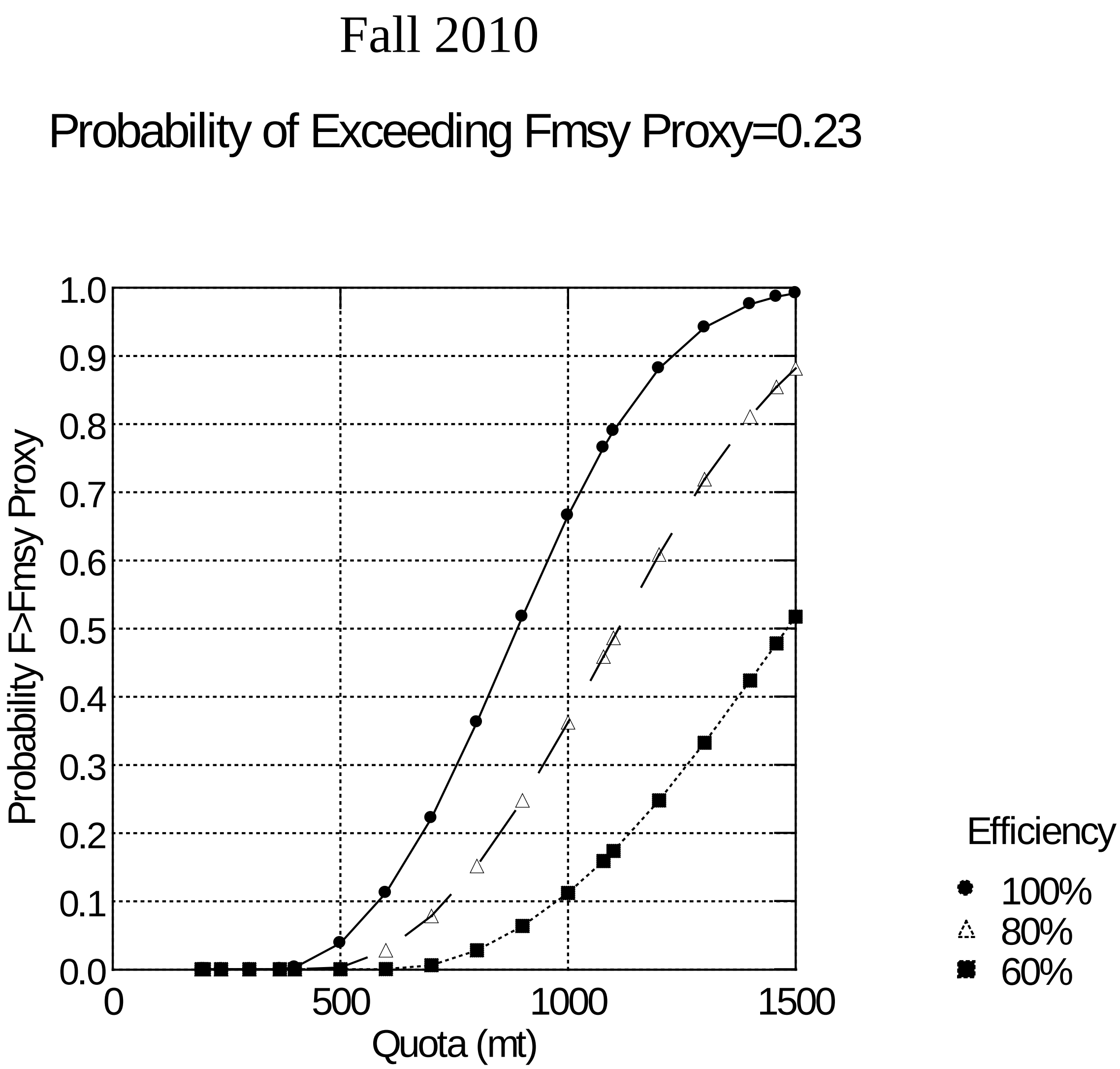


Figure B21. Estimated probability of exceeding F_{MSY} proxy (F40%), expressed as an exploitation rate of 0.23, and assuming efficiencies of 60%, 80% and 100% from SARC 52 based on the fall 2010 survey across a range of quotas.

Fall 2013

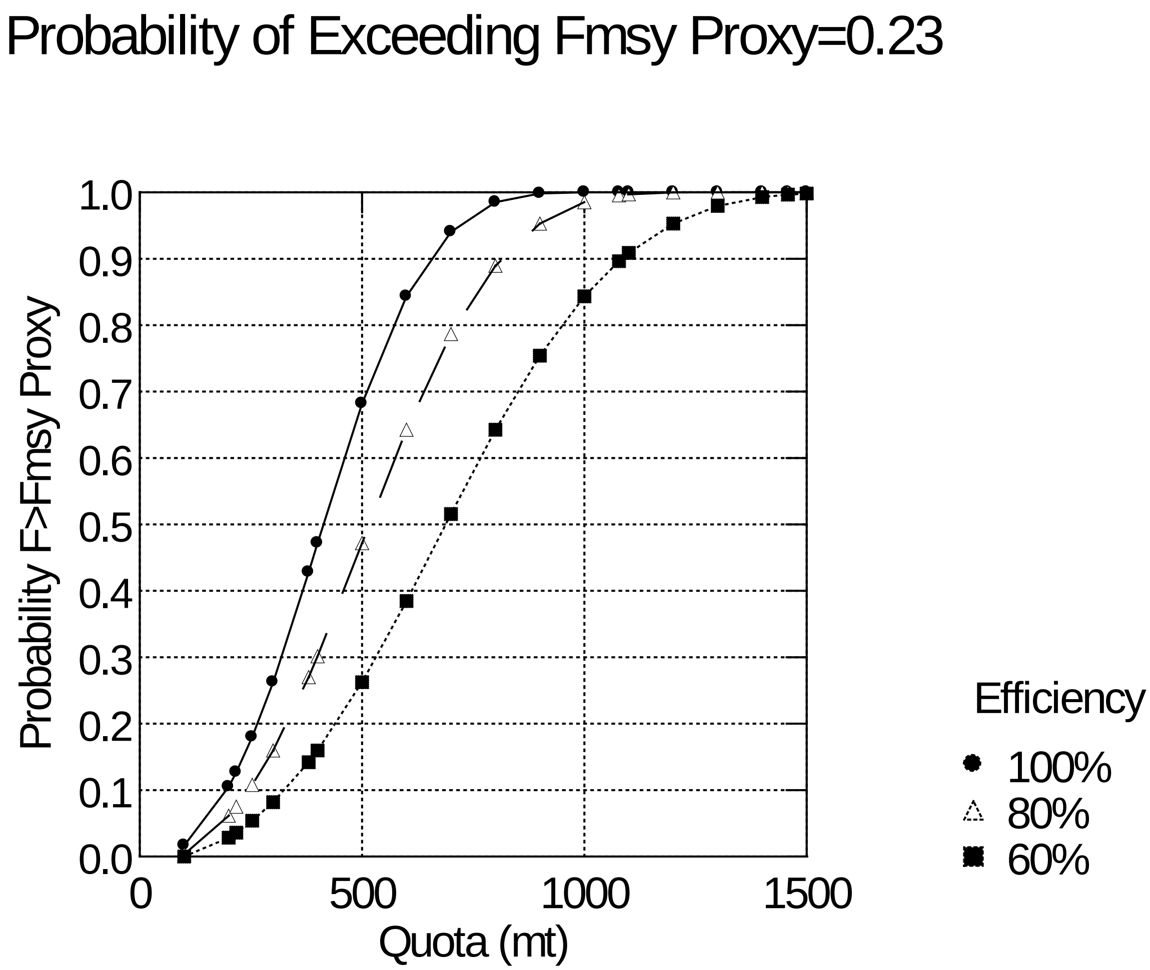


Figure B22. Updated estimated probability of exceeding F_{MSY} proxy (F40%), expressed as an exploitation rate of 0.23, and assuming efficiencies of 60%, 80% and 100% based on the fall 2013 survey across a range of quotas.

Fall 2010

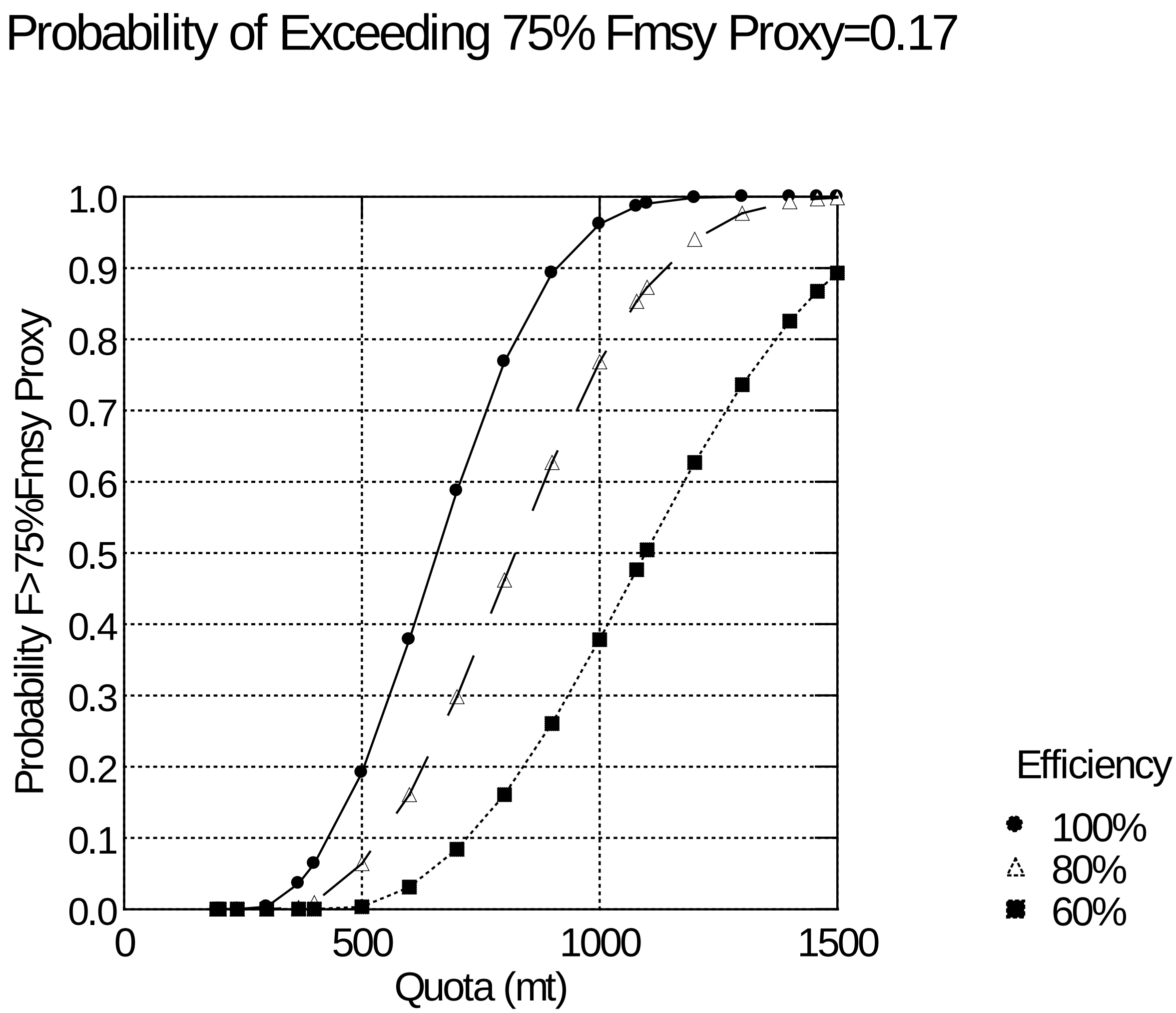


Figure B23. Estimated probability of exceeding 75% of F_{MSY} proxy (F40%), expressed as an exploitation rate of 0.17, and assuming efficiencies of 60%, 80% and 100% from SARC 52 based on the fall 2010 survey across a range of quotas.

Fall 2013

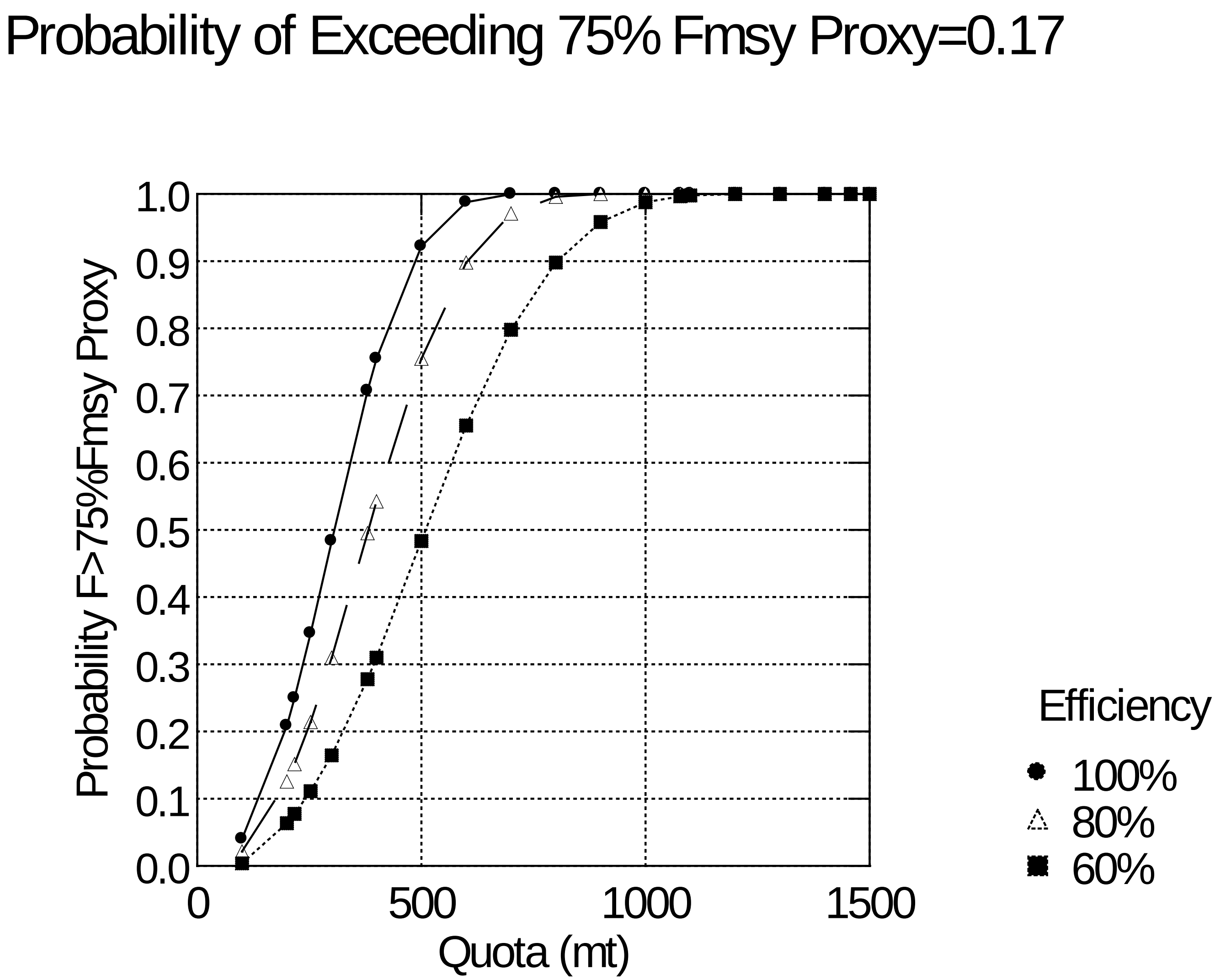


Figure B24. Updated estimated probability of exceeding 75% of F_{MSY} proxy (F40%), expressed as an exploitation rate of 0.17, and assuming efficiencies of 60%, 80% and 100% based on the fall 2013 survey across a range of quotas.

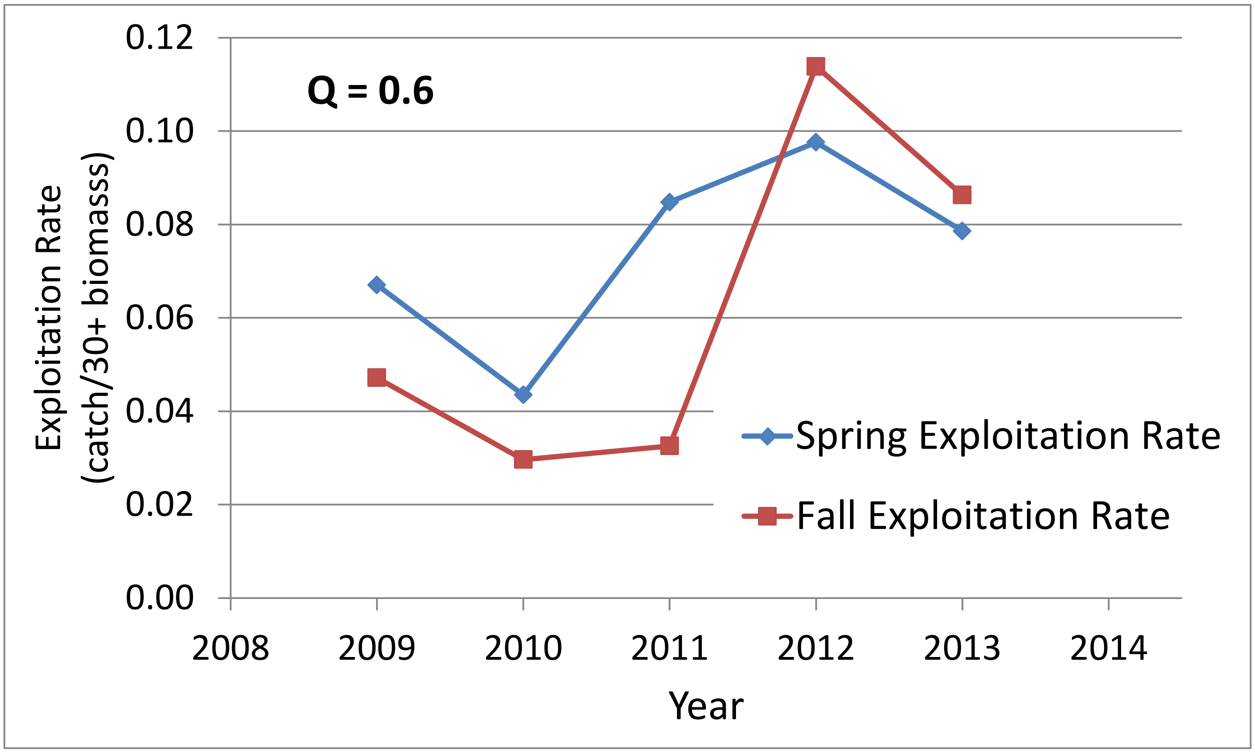


Figure B25. Estimated exploitation rates (catch/ 30+ cm biomass) from 2009-2013 using the spring and fall surveys assuming q=0.6 on wing spread.

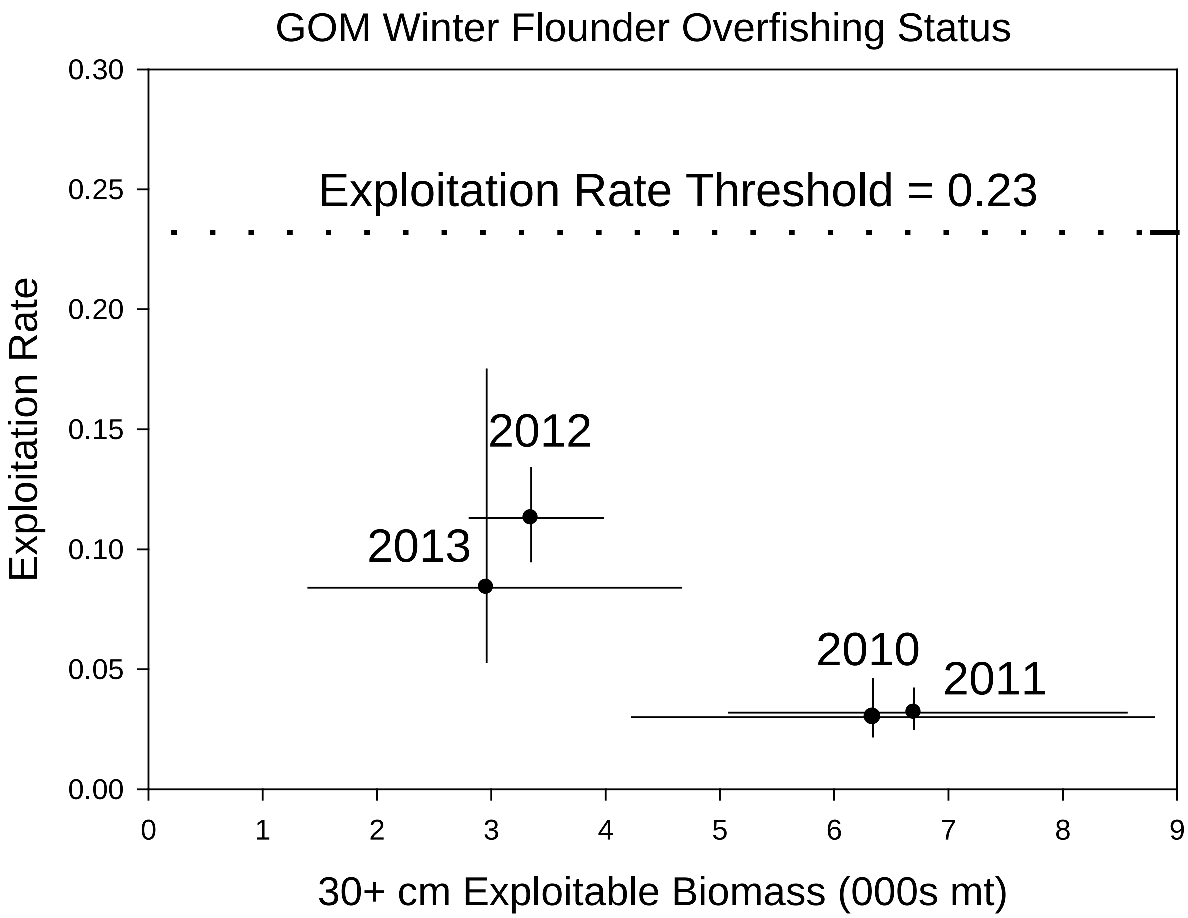


Figure B26. Stock status for Gulf of Maine winter flounder from 2010 through 2013 with respect to the F_{MSY} proxy. 80% confidence intervals are shown for biomass and exploitation rate from 2010 and 2013. F40% = 0.31, which corresponds to an exploitation rate of 0.23.

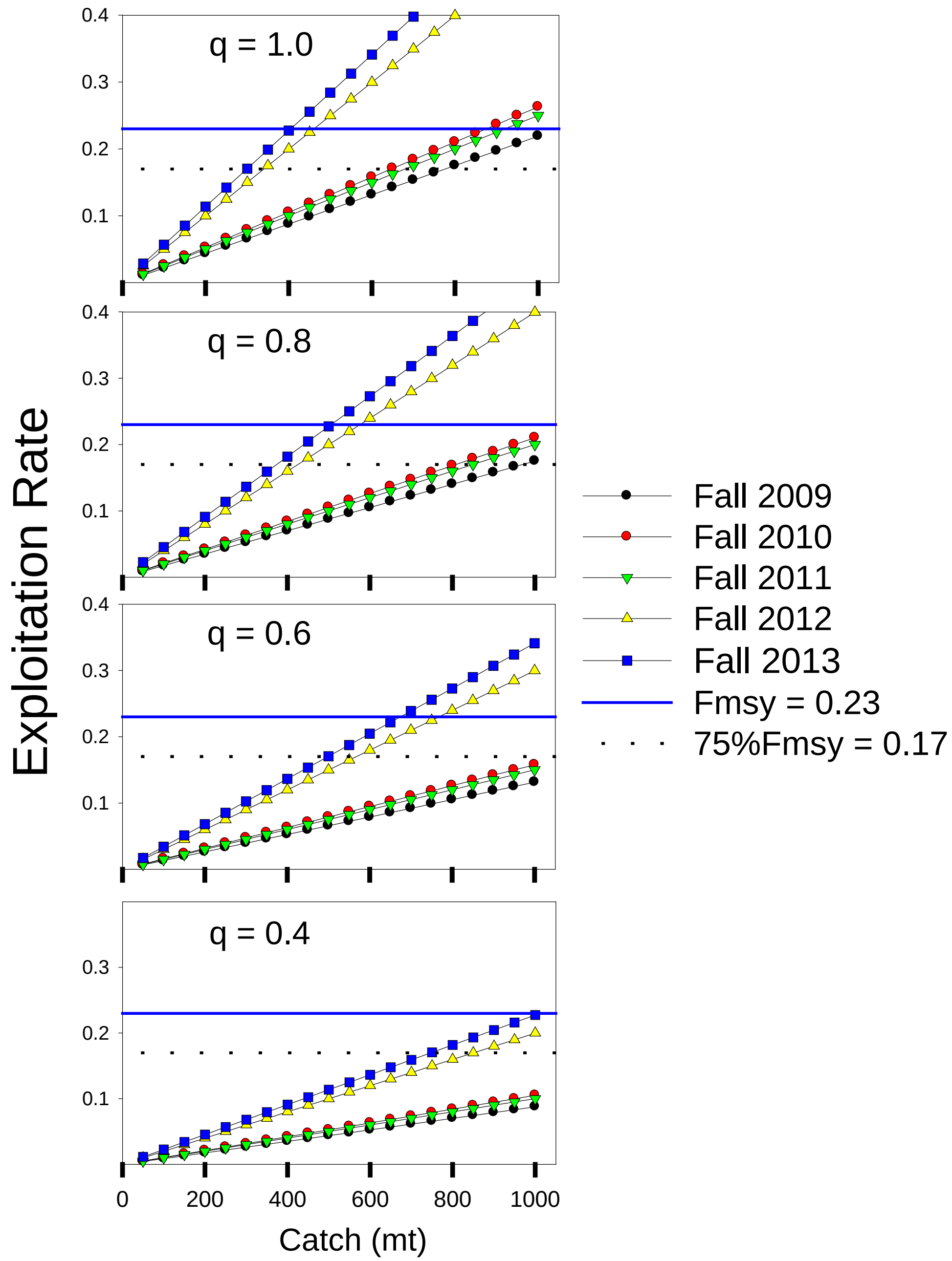
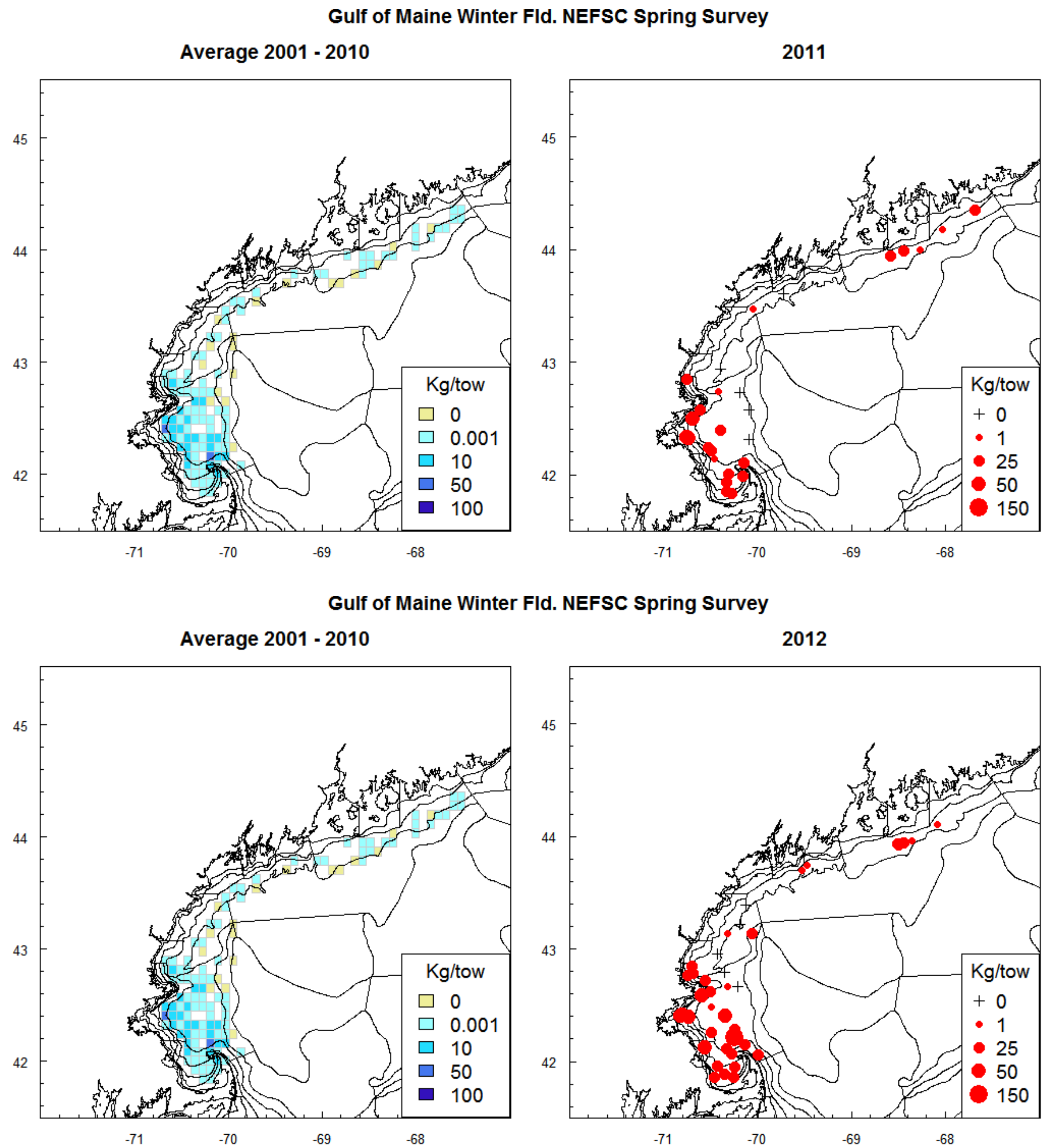
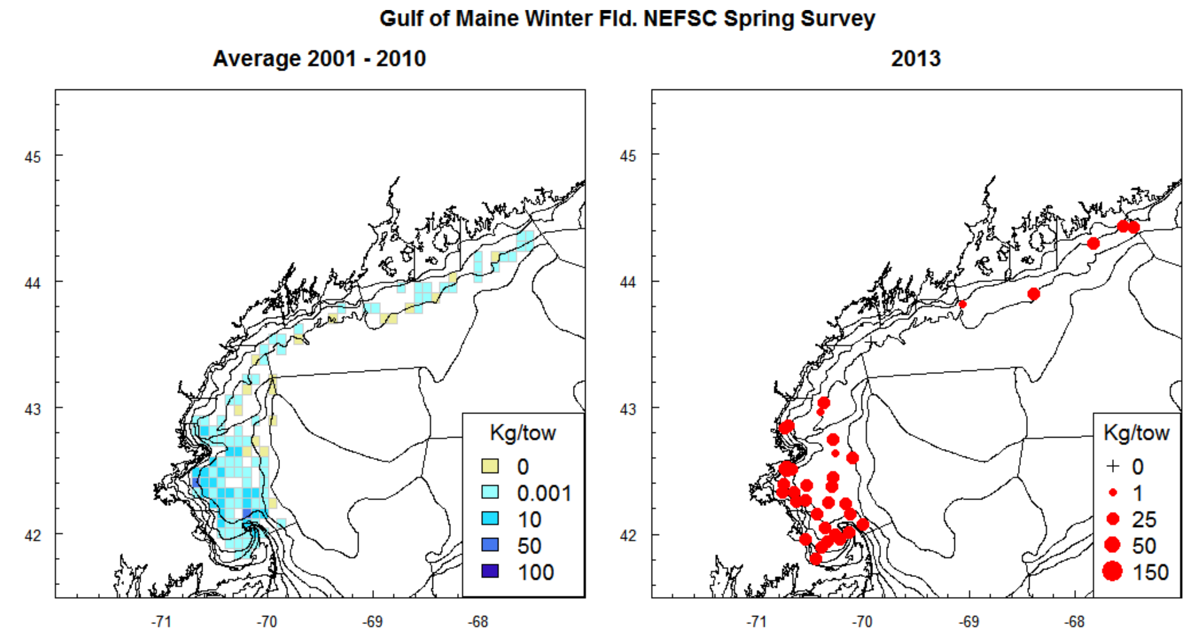


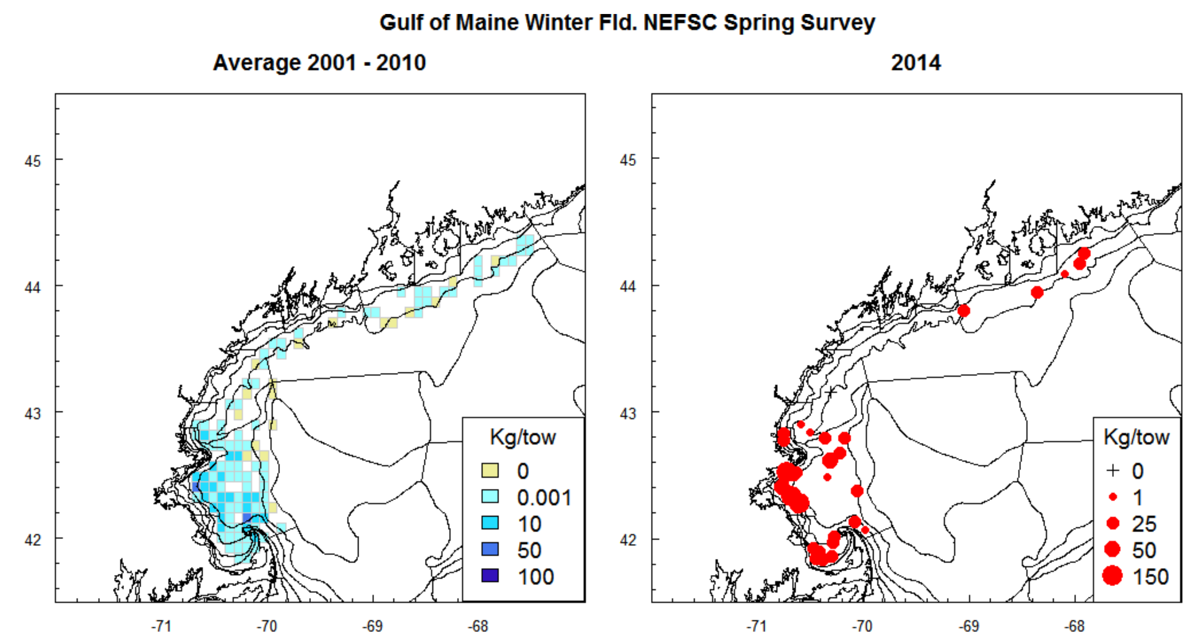
Figure B27. Exploitation rate (catch over survey biomass) for a range of catches using the combined fall surveys from 2009 through 2013 assuming different efficiencies (0.4, 0.6, 0.8 1.0) using wing spread. Solid blue line is exploitation rate at F_{MSY} = 0.23 proxy and the dashed black line is the exploitation rate at 75% F_{MSY} = 0.17.

Appendix B1. Gulf of Maine winter flounder operational update 2014 survey distribution plots, length frequency distributions and percent positive tows by strata plots.

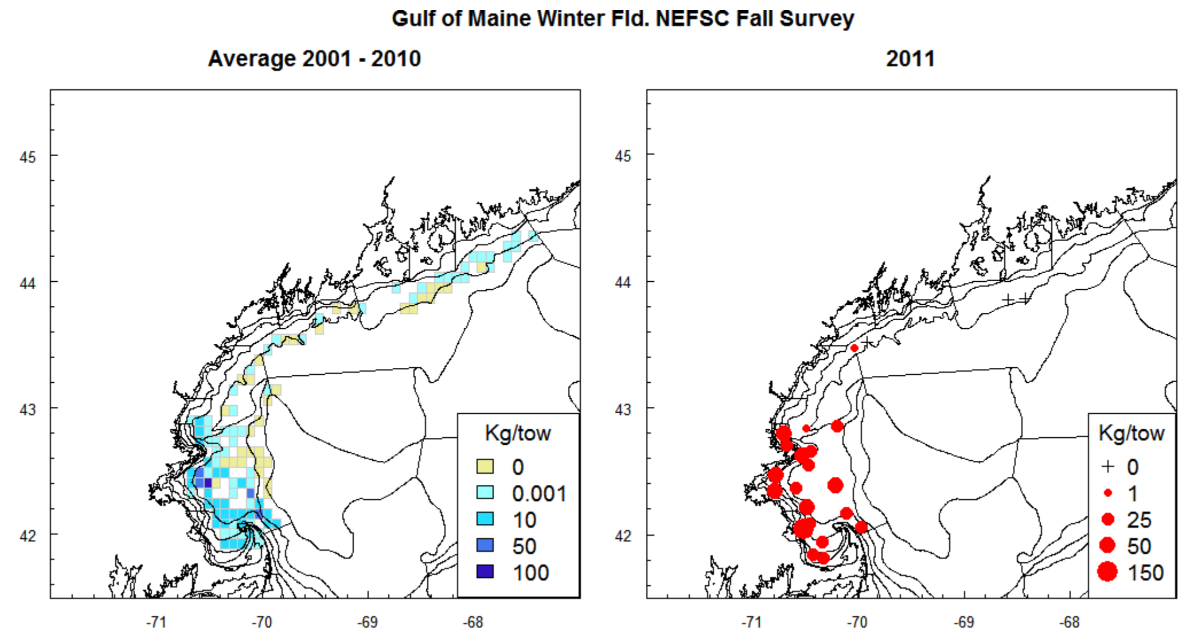


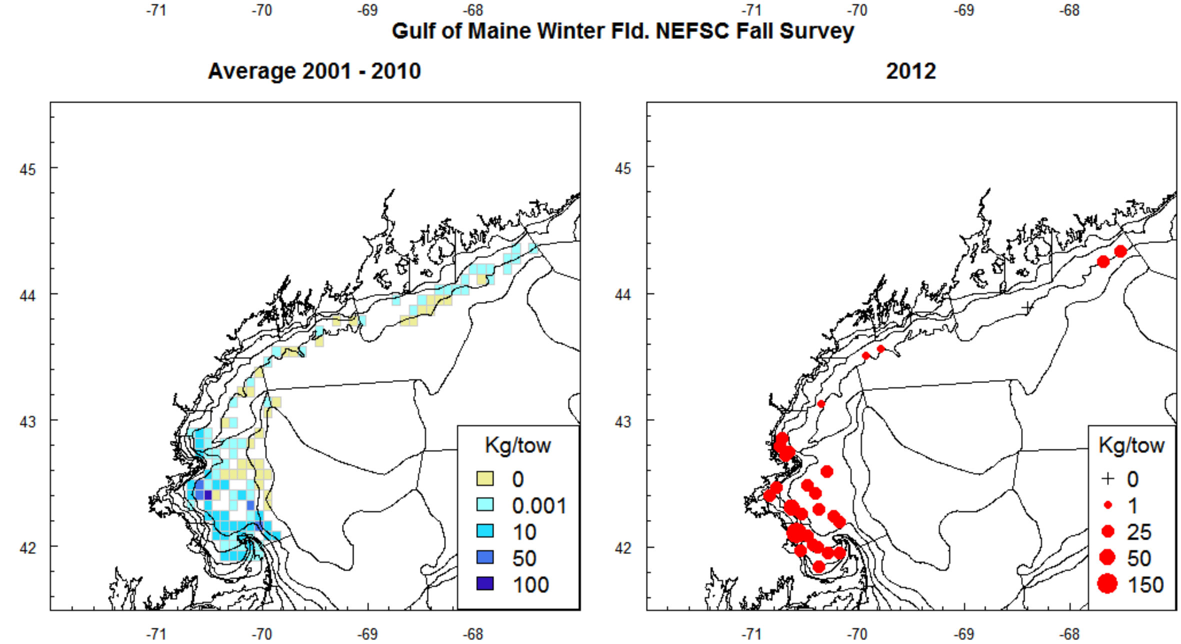
Appendix B1 Figure B1. Gulf of Maine winter flounder NEFSC spring 2011-2014 and fall 2011-2013 spatial survey distributions in Kg/tow (right panel). Plots on the left show the kg/tow average from 2001 to 2010.



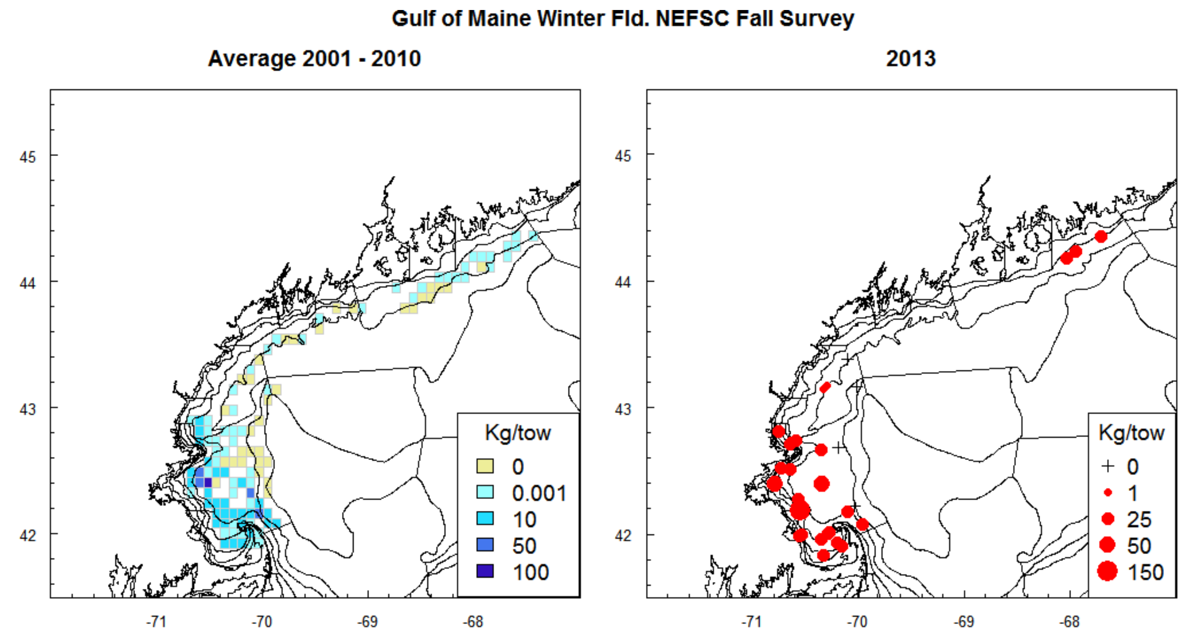


Appendix B1 Figure B1. Cont.

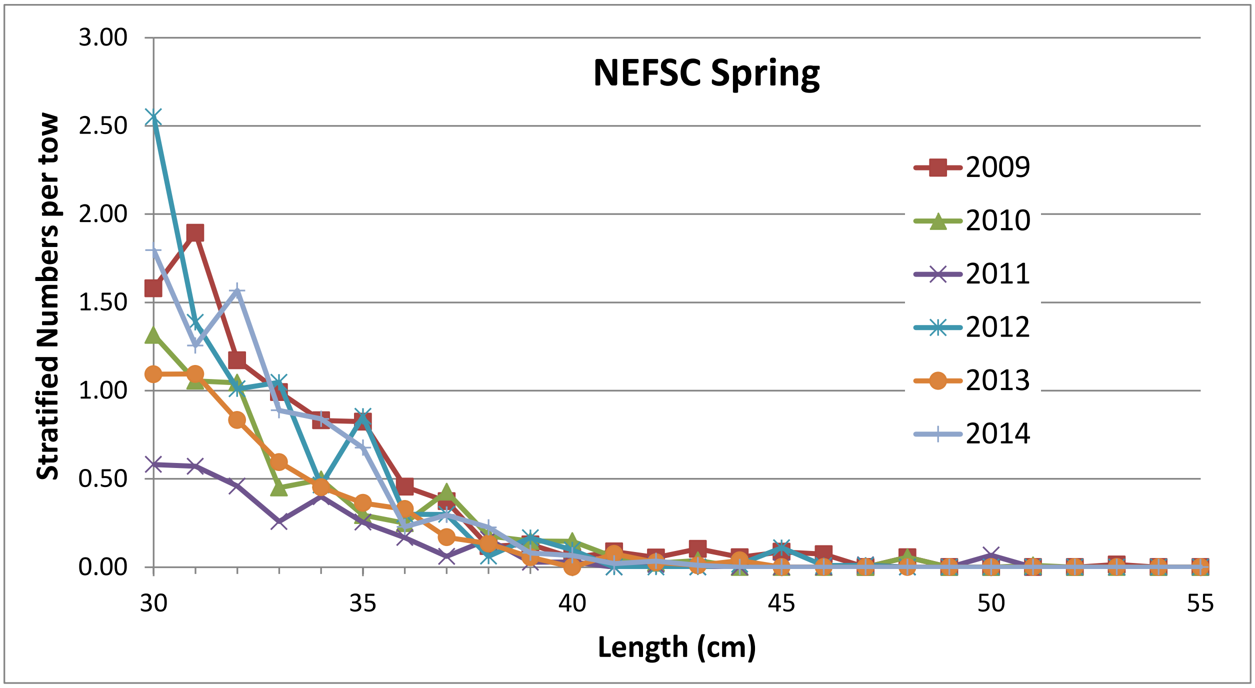


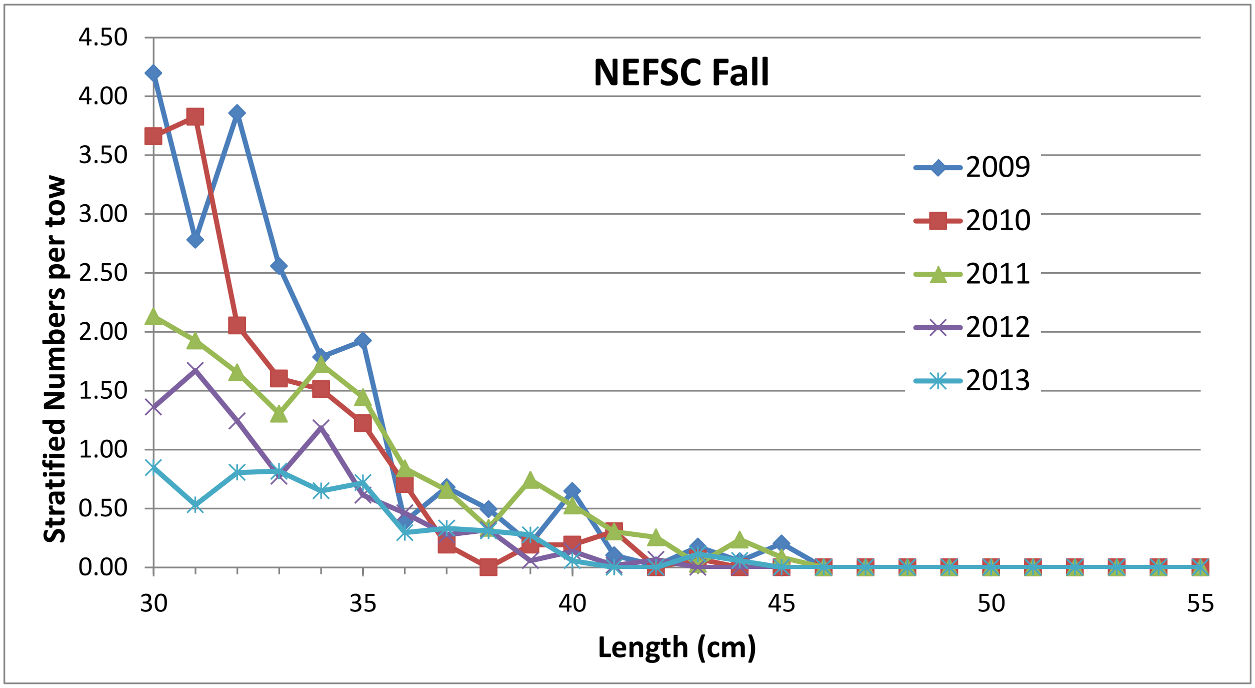


Appendix B1 Figure B1. Cont.

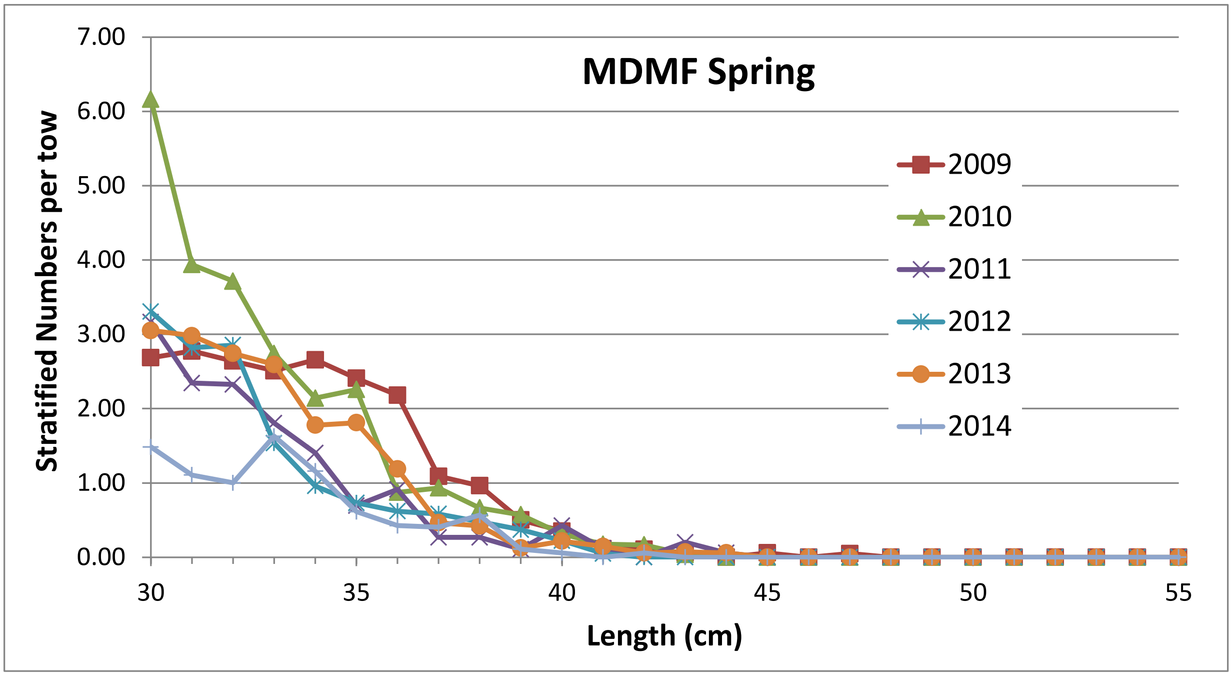


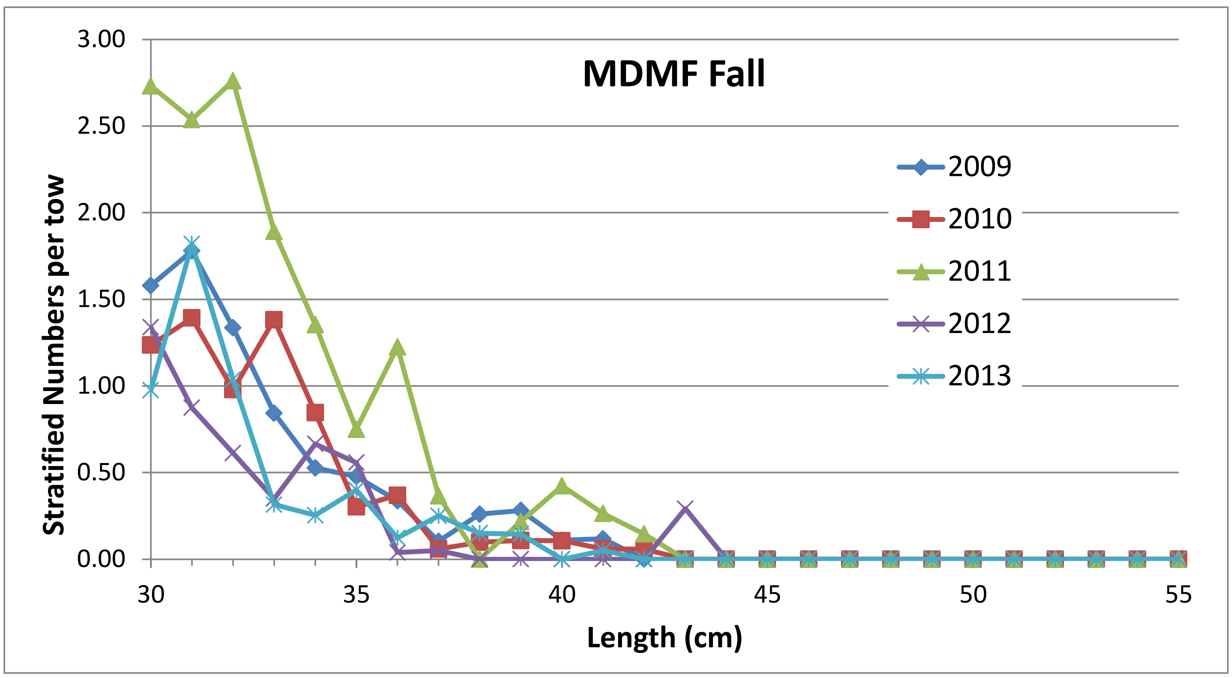
Appendix B1 Figure B1. Cont.



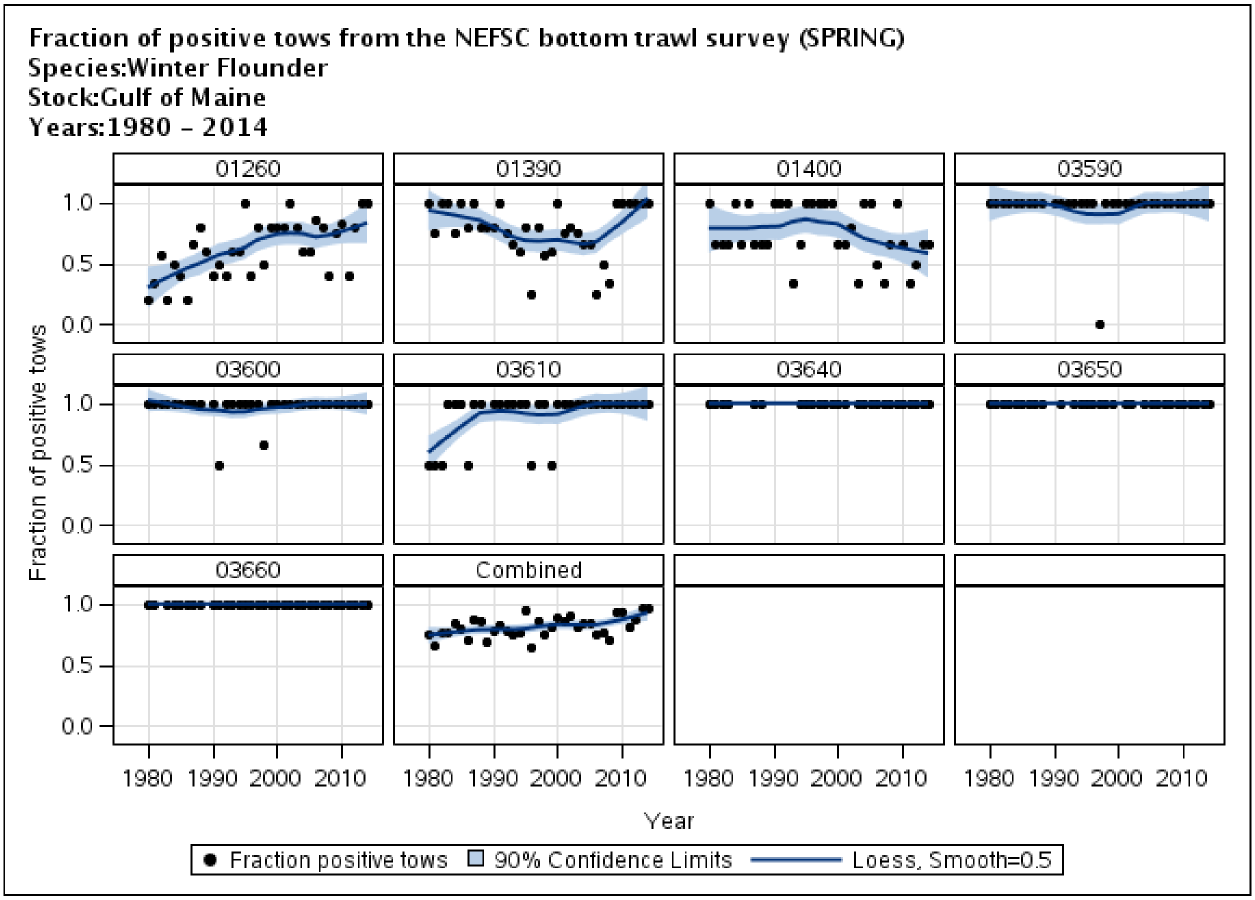


Appendix B1 Figure B2. NEFSC 30+ cm stratified numbers per tow size distribution for the spring 2009 to 2014 and the fall 2009 to 2013 surveys (offshore strata 39,40,26 and inshore strata 59,60,61,64,65,66).

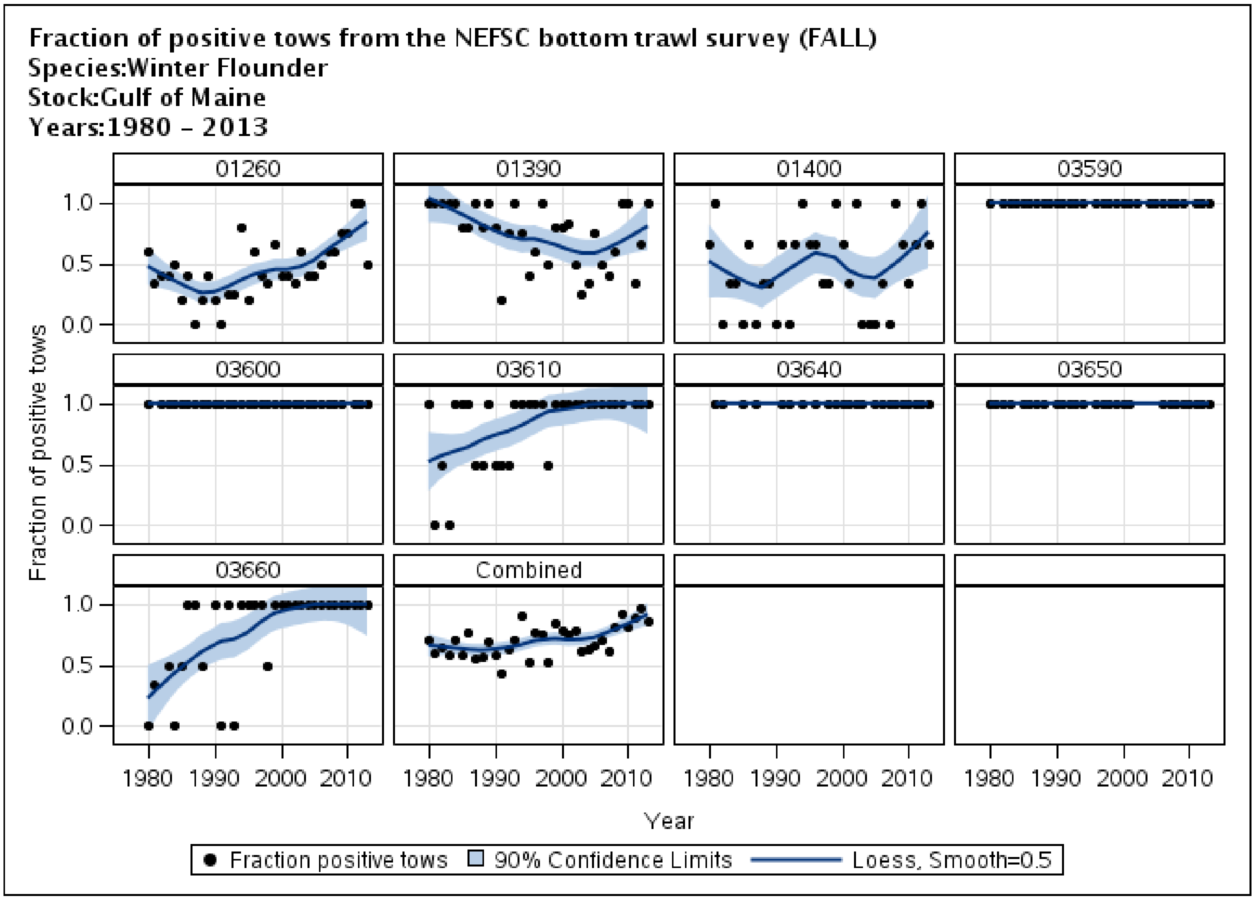




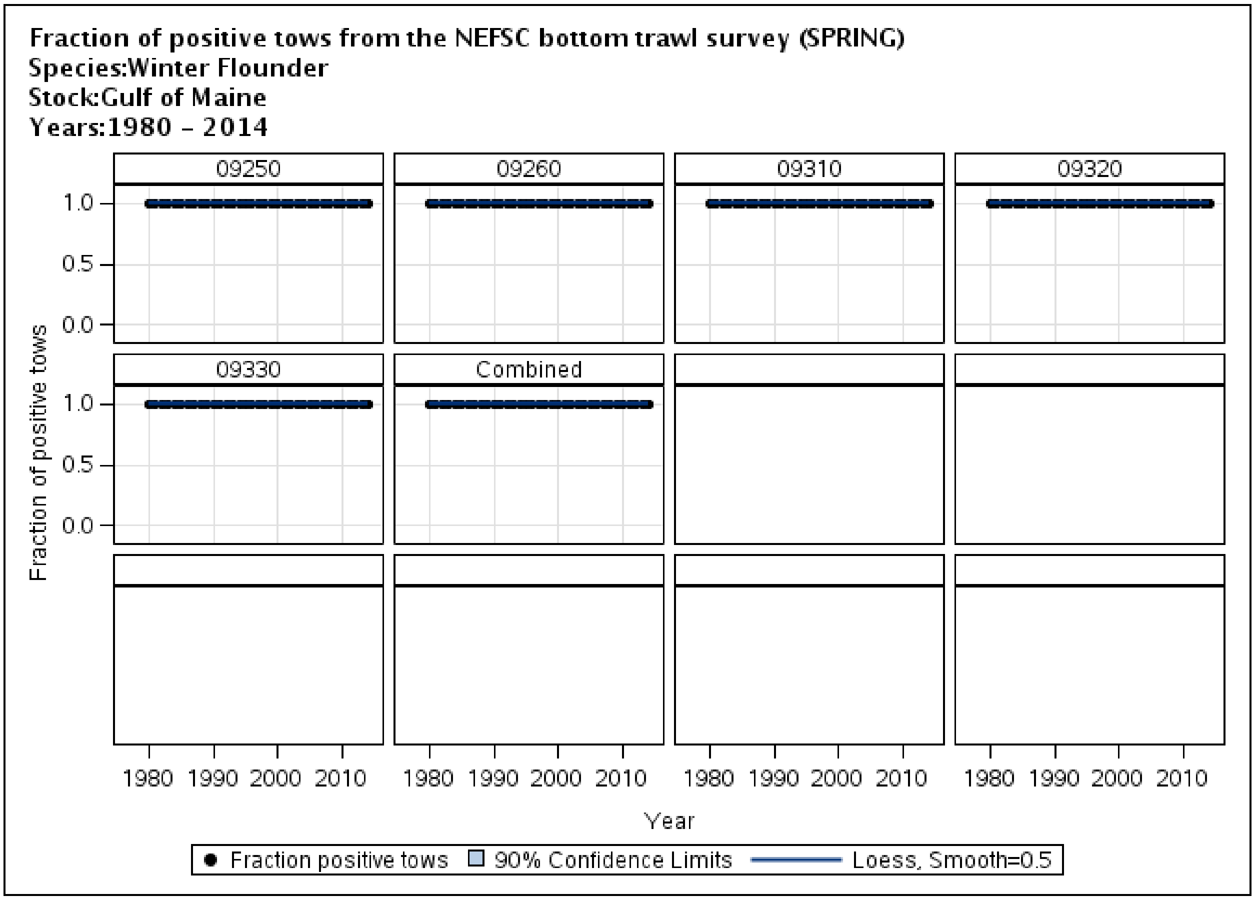
Appendix B1 Figure B3. MDMF 30+ cm stratified numbers per tow size distribution for the spring 2009 to 2014 and the fall 2009 to 2013 surveys (strata 25,26,31,32,33).



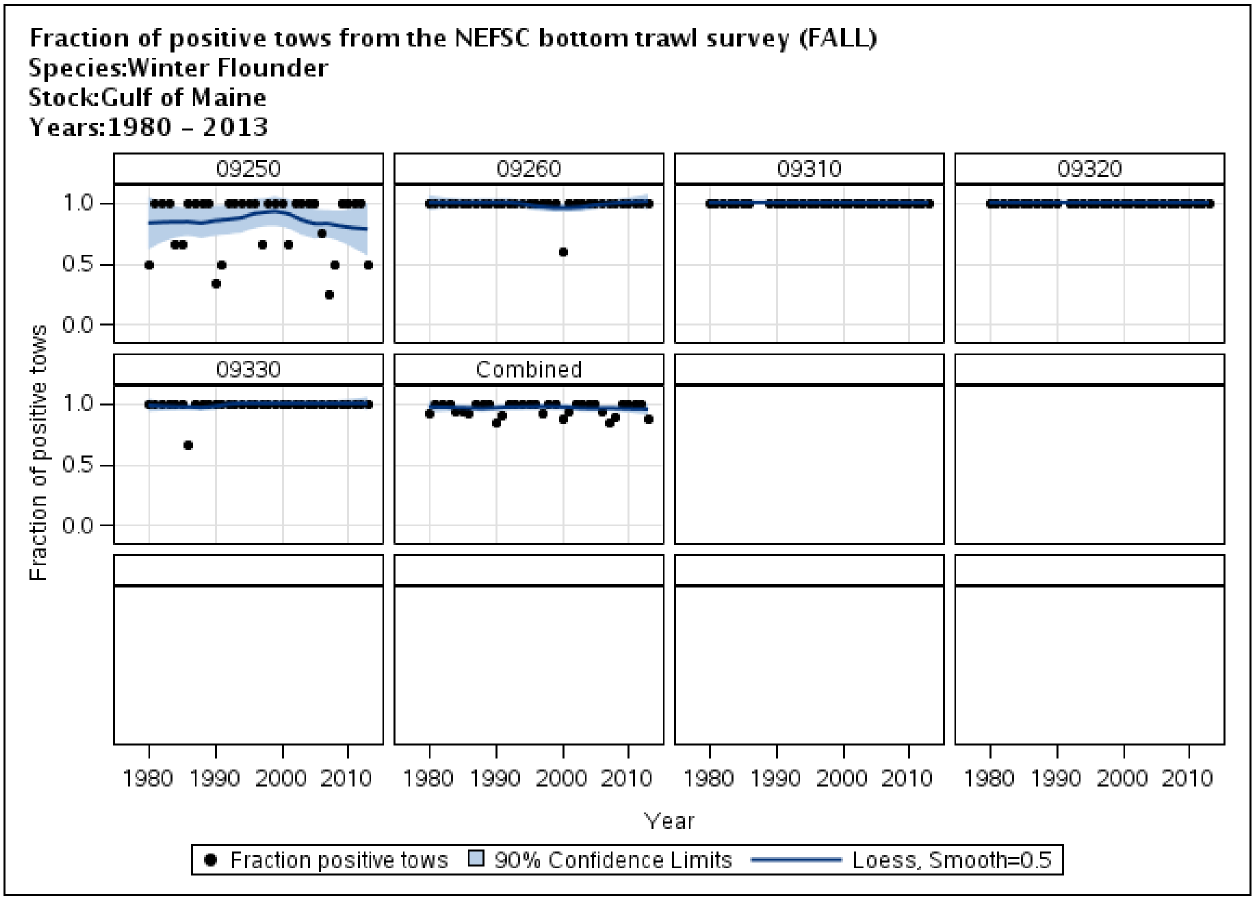
Appendix B1 Figure B4. NEFSC and MDMF spring 1980 to 2014 and fall 1980 to 2013 percent of positive winter flounder tows by strata. A combined strata and loess smooth is also shown.



Appendix B1 Figure B4. Cont.



Appendix B1 Figure B4. Cont.



Appendix B1 Figure B4. Cont.

Pollock – Review Panel Summary

The panel and workshop participants reviewed a draft report that updated the methods from SAW50 (NEFSC 2010) with fishery data through 2013 and survey data through spring 2014. The panel requested additional sensitivity analyses and projections as well as minor additions to the report and revisions of the draft text, and recommended some topics for the research track.

Terms of Reference

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

The update assessment report documents several revisions from the SAW50 data: recreational catch estimates, precision of recreational discards and commercial discard-at-age estimates for 2001-2008. Estimates of recreational catch for 2004 to 2013 were derived from the newly developed Marine Recreational Information Program (MRIP), replacing the SAW50 estimates for 2004-2009, and previous estimates (1970-2003) were converted to be compatible with the new series using a conversion factor developed by NMFS (2012). The conversion was approximately 10% less landed weight and 5% less discarded weight. The intended method of deriving commercial discards-at-age by SAW50 used combined survey and fishery age-length keys, but fall survey data were unintentionally excluded for estimates from 2001 to 2008 since 2001, so that omission was corrected. Both data changes produced only slight changes in the assessment because both catch components are relatively small. The updated assessment used the average of annual precision estimates from SAW50 for recreational discards (average CV=0.68) and commercial discards (average CV=0.3) because the recreational precision estimates could not be replicated.

The updated catch was approximately 8,000 mt per year, with an increasing proportion of recreational landings and a recent expansion of the age structure. Surveys continued to be noisy because of patchy Pollock catches (e.g., one or two large survey tows in the 2011 spring and fall surveys).

The Panel requested information on weight-at-age data to be included in the report. The information showed a general decrease in weight-at-age for older ages in the most recent five years. A constant maturity schedule was assumed for the entire assessment time series, and maturity-at-age estimates were not revised with recent data for the updated assessment, but the Panel recommends that potential changes in maturity-at-age should be investigated in the next update assessment. Although the age proportions have several periods of adjacent strong yearclasses and weight-at-age values have abrupt and large decreases for some old ages, quality assurance information from age processing suggests that age determination is not a major source of uncertainty.

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

The panel confirmed that there were no changes to ASAP methodology developed by SAW50 for the updated assessment.

The retrospective pattern of the updated assessment was worse than the SAW50 assessment, with a tendency for SSB to decrease as more data are added and for F to increase as more data are added. The retrospective pattern of the updated assessment was stronger than the SAW52 assessment, with a tendency for SSB to decrease as data are added, and for F to increase as data are added. The retrospective-adjusted estimates of SSB and F are just within the 90% confidence limits of the unadjusted point estimates of SSB and F. Based on the criteria developed by GARM III (NEFSC 2008), , retrospective adjustments should not be applied. However, the panel noted that the retrospective pattern is worth considering as a source of uncertainty (approximately 29% for SSB and 25% for F). The panel noted that retrospective error is a nonrandom error, whereas MCMC-based confidence limits of point estimates quantify random errors. The panel discussed the possibility of estimating MCMC-based confidence limits for retrospective-adjusted F and SSB.

Although several periods of selectivity were assumed for the commercial and recreational fleets by the SAW50 assessment, residual patterns do not suggest recent changes in selectivity, and recent management changes were not expected to cause changes in selectivity. Survey selectivity was assumed to be domed in the SAW50 base ASAP, with 50% selectivity of the oldest age. The assumed dome-shaped selectivity implies that a large portion of the stock is in the oldest age group and is only partly vulnerable to the fishery. A SAW50 sensitivity analysis assuming full selectivity of the oldest age was also updated. The sensitivity run had a greater retrospective pattern, outside the 90% confidence limits. The Panel requested comparison of the ASAP base model results with retrospective-adjusted results from the sensitivity run, and the comparison showed a considerable difference, such that the overfishing status was sensitive to the assumed survey selectivity.

The effective sample sizes for age compositions were assumed to be the same as SAW50, but a sensitivity analysis assumed re-weighted sample sizes, because the model expectation of sample sizes for the spring survey were much lower than the assumed values. The Panel requested comparison of the ASAP base model results with results from the reweighted sensitivity run. Summary plots showed that stock biomass estimates from the reweighted sensitivity run were considerably lower than those from the base run. The lower effective sample size estimated by the model may result from the patchy nature of survey catches. The Panel noted that the absolute stock biomass estimates tended to be sensitive to the model parameterization, but temporal trends of stock biomass tended to be robust with respect to alternative model parameterization. The Panel recommended continued sensitivity analyses in next update assessment and re-consideration of weighting in next benchmark assessment.

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

The Panel confirms that the updated assessment includes the information needed to recommend ABC (e.g., stock status and stochastic projections at F_{40} and 75%F_{40}).

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

The SAW50 estimate of $F_{40\%}$ (0.41) was updated, and the updated estimate was only slightly greater (0.42). The estimate of SSB_{MSY} proxy from SAW50 (90,700 mt) was also updated with long-term stochastic projection at $F_{40\%}$, using randomly selected age-1 recruitment from the series of ASAP estimates (1970-2011), excluding the 2012 and 2013 estimates because the abundance of recent yearclasses are uncertain. The updated estimate of the SSB_{MSY} proxy (76,900 mt) was considerably less than the SAW50 estimate, largely because of the recent decrease in weight-at-age. The estimate of steepness from the updated ASAP model (h=0.56) was lower than the SAW50 estimate (h=0.66), but the two estimates were not significantly different, because neither was precisely estimated. The large difference reflects both the uncertain estimate of steepness (justifying the use of a $F_{40\%}$ proxy for F_{MSY}) as well as the recent decrease in weight at age. The Panel concluded that the revised reference point estimates were appropriate because of the observed changes in weight-at-age.

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

The Panel accepts the stock status determined by updated assessment results (2013 SSB= 126,000 mt and 2013 F=0.1) and the updated estimate of $F_{40\%}$ (0.41) and the SSB_{MSY} proxy (76,900 mt). Therefore, the stock is not overfished and not experiencing overfishing. However, the overfishing status is sensitive to the assumed survey selectivity.

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

Short-term projections were provided for F_{40}, 75%F_{40} and status quo F. The Panel requested two sensitivity projections. The Panel discussed the influence that the apparently large 2011 yearclass would have on short-term projections. The Panel confirmed that the 2011 yearclass was not included in random draws for assumed future recruitment, but the yearclass is expected to recruit to the fishery over the next several years. The assessment is expected to be updated again in 2015, providing more information on the strength of the 2011 yearclass. However, a sensitivity projection was requested that reduced the 2011 yearclass by 50% which would decrease it to an approximately average yearclass. The second sensitivity projection requested was from the sensitivity analysis that assumed full selection of the oldest age in surveys.

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

The Panel discussed the convergence problems experienced for some alternative ASAP configurations, and the Panel recommended that reducing the number of estimated parameters may improve model performance. For example, combining fleets should be considered at the next benchmark assessment to investigate if the simplification of selectivity assumptions is worth the reduction in estimated parameters.

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

The panel concluded that the updated assessment is a reliable basis for fishery management and alternative approaches are not necessary at this time.

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C. Pollock

A. Background

The pollock stock was last assessed as part of the 50th Stock Assessment Review Committee (SARC 50; NEFSC 2010). That assessment was a benchmark, and all methods that were accepted by the SARC 50 review panel were used in this update. Four additional years of catch and index data are incorporated.

B. Fishery

Total catches of pollock have increased since the mid-1990s, reaching a peak of around 12,000 mt in 2008 (Table C1; Figure C1). Total catches have remained relatively constant since 2009 at about 8,500 mt. US commercial landings have decreased from around 7,500 mt in 2009 to around 5,000 mt in 2013, but still account for the majority (61%) of total catches in 2013. US commercial discards have remained relatively constant since 2009 at about 170 mt, and account for 2% of total catches in 2013. Recreational landings have increased from around 600 mt in 2009 to around 1,600 mt in 2013, and account for 20% of total catches in 2013. Recreational discards have increased from around 400 mt in 2009 to around 1,500 mt in 2013, and account for 17% of total catches in 2013.

Marine Recreational Information Program

The National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS) was replaced by the Marine Recreational Information Program (MRIP) in 2012 to provide improved recreational fishing statistics. The MRIP implemented a new statistical method for calculating recreational catch estimates, with many survey elements related to both data collection and analysis updated and refined to address issues such as data gaps, bias, consistency, accuracy, and timeliness. As part of the implementation of the MRIP, recreational fishery catch estimates for 2004-2011 have been directly replaced by those using the MRIP estimation methods. For earlier years, a constant “ratio of means” of the MRFSS and MRIP estimates has been used to adjust the recreational catch estimates (Table C2), based on the recommendations of the MRFSS/MRIP Calibration Workshop Ad-hoc Working Group (NMFS 2012).

Over all years (2004-2011), the cumulative recreational landings in numbers decreased by about 223,000 fish (-11%), ranging from a decrease of around 160,000 fish in 2010 (-30%) to an increase of around 29,000 fish in 2006 (+17%; Table C3). The average ratio between MRFSS and MRIP for this period was -11%, therefore, for the years 1981-2003, recreational landings numbers were decreased by 11% for this assessment. Over all years, the cumulative recreational landings in weight decreased by about 731 mt (-10%), ranging from a decrease of around 566 mt in 2010 (-30%) to an increase of around 122 mt in 2006 (+21%). Therefore, for the years 1981-2003, recreational landings weights were decreased by 10% for this assessment. Over all years, the cumulative recreational discards in numbers decreased by about 57,000 fish (-4%), ranging from a decrease of around 74,000 fish in 2010 (-21%) to an increase of around 60,000 fish in 2004 (+72%). Therefore, for the years 1981-2003, recreational discards numbers were decreased by 4% for this assessment. Over all years, the cumulative recreational discards in weight decreased by about 222 mt (-5%), ranging from a decrease of around 214 mt in 2010 (-21%) to an increase of around 144 mt in 2004 (+73%). Therefore, for the years 1981-2003, recreational discards weights were decreased by 5% for this operational assessment.

Age Structure

Port samples of size and age structure for the commercial catch are summarized in Table C4. Sampling intensity has been good since the early 1980s. Summaries of the Northeast Fisheries Science Center (NEFSC) Age and Growth Program’s ongoing QA/QC testing (http://www.nefsc.noaa.gov/fbp/QA-QC/) indicate that age estimation error is not likely an issue for the pollock stock. Landed catch at age shows some relatively strong year-classes in the 1970s and 1980s (Figure C2). The 2014 operational assessment begins in 1970, based on the availability of commercial catch at age data. This assessment models ages 1 to 9+, as was done in the SARC 50 final base model.

An issue was discovered with the 2001-2008 commercial discards at age used in SARC 50. In SARC 50, semi-annual age length keys were applied to discards at length. The age length keys were supposed to be constructed using commercial and survey data, with spring survey data used in the age length keys for the first half of the year and fall survey data used in the age length keys for the second half of the year. In actuality, the second half-year age length keys for 2001-2008 were constructed using only commercial data. Therefore, those age length keys contained no observations less than about 45 cm. For the operational assessment, those second half-year age length keys were reconstructed including fall survey data, and commercial discards at age for 2001-2008 were reestimated (Figure C3). The revised commercial discards at age show increases in the proportions of younger fish compared to the original SARC 50 commercial discards at age

(Table C5). The SARC 50 base model was rerun with the revised commercial discards at age, which resulted in little change to the estimates of SSB, average F, and recruitment (Table C6; Figure C4). The lack of difference in model results is due to the small magnitude of the commercial discards relative to the total catch.

The length-frequency of recreational discards was represented by samples of the recreational kept catch (A and B1) as was done in SARC 50. Recreational age samples are not available, so age length keys were constructed from commercial and survey data sources, which were applied to recreational catches at length.

C. Research Surveys

The NEFSC spring and fall surveys have large inter-annual variation (Tables C7, C8; Figure C5). The NEFSC fall survey series generally corresponds with the exploitation history: the survey index declines from high abundance in the late 1970s to extremely low abundance in the mid-1990s, consistent with total annual catches exceeding 20,000 mt during the same period; abundance increased in the late 1990s when catches were less than 6,000 mt; survey abundance decreased again in the late 2000s as catches approached 10,000 mt; with the exception of a spike in 2011, survey abundance has remained relatively constant since 2010 as catches have remained around 8,500 mt. The spring survey does not correspond as well with the exploitation history.

D. Assessment

Model
The final SARC 50 base model for pollock was performed with the NOAA Fisheries Toolbox (NFT) ASAP version 2.0.20. That input file was then run in ASAP version 3.0.17 to confirm that the results were identical. The additional data were then added and run with the same configuration as for SARC 50. Ages one through nine were modeled, with age class nine serving as a plus-group. The first year in the catch at age was 1970.

Maturity
The 'hit or miss' nature of the pollock catches in surveys results in highly variable estimates of maturity at age resulting from low sample sizes in many years. When maturity data is pooled across all years, age 3 appears to be an inflection point in the maturity ogive, with most fish younger than 3 immature and most fish older than 3 mature (Figure C6). A time-averaged maturity leads to more reliable estimates of maturity at age. In SARC 50, maturity at age was assumed to be constant over time, and was estimated using pooled-year data from the NEFSC fall survey.

Natural Mortality
As in SARC 50, a natural mortality of 0.2 was assumed for all ages (1-9+) and all years. No alternatives were explored.

Indices
The NEFSC spring and fall bottom trawl survey indices (numbers of fish/tow) were used in the operational assessment. Total annual indices and their associated coefficients of variation (CVs), as well as age-specific indices for ages 1-9+ were included as model inputs. As in SARC 50, the NEFSC indices were not calibrated to account for changes in door type and vessel.

ASAP Results
The base model estimates a starting spawning stock biomass (SSB) in 1970 of about 262,000 mt, which is approximately 33% above the deterministic, point estimate of unexploited spawning biomass (~197,000 mt). Spawning biomass decreased to the time series low (56,900 mt) in 1990 (Table C9, Figure C7). Since the 1990 low, spawning biomass increased steadily through 2006, with a decline to the present. The current estimate of spawning biomass is about 126,000 mt.

Two additional biomass measures were calculated from the estimated numbers at age (Table C10). Total population biomass was calculated with January 1 weights at age while exploitable biomass was calculated with mid-year catch weights at age and annual selectivity at age (Tables C11, C12; Figures C8, C9). Total population biomass follows the same trend as SSB (Table C13, Figure C7). Exploitable biomass ranges from 37% to 73% of spawning biomass over the time series (Table C14). Due to the estimated dome-shaped fishery selectivities, exploitable biomass will always be less than spawning biomass.

In any given year, the fishing mortality experienced by an age class depends on the selectivity and amount of catch of each fleet. To provide a consistent metric for expressing F over the whole time series, the unweighted average F for ages 5-7 ($F_{5\text{-}7}$) is reported (Table C15). In 1970, $F_{5\text{-}7}$ is estimated at 0.12, and mostly increased to its peak of 0.52 in 1986. Since then, $F_{5\text{-}7}$ steadily decreased to 2006, when it reached the time series low of 0.04. In the last three years, $F_{5\text{-}7}$ was 0.12, 0.10, and 0.10, respectively.

Mean recruitment was around 19 million age 1 recruits. Several abundant year-classes were produced in 1971, 1979, 1997, 1998, 1999, 2001, and 2011, with the estimated number at age ranging from 27 to 53 million (Figure C10). The model estimated steepness at 0.56 with a CV of 0.24 (Figure C11).

As a result of the small CVs assigned to the commercial landings (CV = 0.05), they were well fit (Figure C12). Commercial discards, which used the average of the CVs estimated from the data (CV = 0.30), had larger residuals compared to the landings (Figure C13). The residuals in the commercial age composition did not indicate a need for adding or adjusting selectivity blocks (Figure C14). The final SARC 50 input effective sample size (N = 50) approximately matches most of the model estimated effective sample sizes (Figure C15).

The CV assigned to the recreational landings was five times greater than the commercial landings CV (CV = 0.25), but they were still fit well (Figure C16). Recreational discards, which used the average of the CVs estimated from the data (CV = 0.68), had larger residuals compared to the landings (Figure C17). The residuals in the recreational age composition did not indicate a need for adding or adjusting selectivity blocks (Figure C18). The final SARC 50 input effective sample size (N = 35) does a reasonable job of matching most of the model estimated effective sample sizes (Figure C19).

As noted above, the indices show apparently strong year effects, but these years tended to have the largest CVs. Thus, in fitting the indices, the influence of these effects was not strong. The predicted spring index smoothes through the early and late part of the time series, but there is a stretch of positive residuals in the 1980s and 1990s (Figure C20). The residuals in the spring age composition show some persistent trends at age for several year blocks, although the year-age blocks with the trends do not appear to be related (Figure C21). The age composition of the indices was downweighted relative to the landings by having a lower effective sample size (N = 30). As in SARC 50, Figure C22 suggests that the indices could be downweighted further.

The predicted fall index smoothes through the time series until about 1990, when there is a run of positive residuals through 2006 (Figure C23). The residuals in the fall age composition show some persistent trends at age for several year blocks (Figure C24). Unlike for the spring, however, these residual blocks somewhat trace diagonals through the plot and may reflect cohort effects. As in SARC 50, Figure C25 suggests that the fall index could be downweighted further but not to the extent that was seen for the spring index.

MCMC simulation was performed to obtain posterior distributions of spawning stock biomass and $F_{5\text{-}7}$ time series. The traces of the MCMC chains were plotted, and indicated good mixing (Figure C26). Autocorrelations for $F_{5\text{-}7}$ ranged from 0.21 in 1970 to 0.27 in 2013 with a lag of 1, and were less than 0.11 with a lag of 2 or greater. Autocorrelation for SSB ranged from 0.20 to 0.32 with a lag of 1, and were less than 0.20 with a lag of 2 or greater. The decreasing autocorrelation with increasing lag is another good indicator that the MCMC chains have converged. Finally, the Gelman-Rubin potential scale reduction factor (psrf) was calculated for the time series of $F_{5\text{-}7}$ and SSB. All psrf were between 1.0 and 1.01, which again suggests convergence of the chains.

As the MCMC simulations appear to have converged, 90% Probability Intervals were calculated to provide a measure of uncertainty for the model point estimates (Figures C27, C28). Plots of the posterior for SSB_{1970}, SSB_{2013}, $F_{5\text{-}7(2007)}$, and $F_{5\text{-}7(2013)}$ are shown to characterize the uncertainty in the estimates (Figures C29, C30).

ASAP Retrospective Analysis

The average Mohn's rho was calculated for the seven retrospective relative differences in years 2006-2013 (Figure C31). The values for Mohn's rho were -0.25 for F, 0.29 for SSB, and 0.14 for age 1 recruitment.

ASAP Sensitivity Analysis

A sensitivity model was examined where selectivity in both the NEFSC spring and fall surveys was fixed at 1.0 for ages 6-9+. The effect of this was predictable, in that abundances were scaled lower (Table C6). Specifically, SSB in 1970 was 89,000 mt instead of 262,000 mt. Also, current biomass with flat survey selectivity dropped to 48,000 mt from 126,000 mt in the base model. Compared to the base model, the age composition residuals for both the indices and the fleets barely changed. However, the fits to the indices were worse, with the predicted indices dropping even further below the observed values from the 1990s and later. A retrospective run of the model with flat survey selectivities led to one year where the model did not run to completion (2010). For the remaining six years, the retrospective pattern had relative biases that were greater than the base case (Figure C32). The six year average Mohn's rho was -0.36 for F, 0.66 for SSB, and 0.35 for age 1 recruitment.

A sensitivity model was examined where CVs of both the NEFSC spring and fall surveys were doubled, annual recruitment deviation CVs were increased from 0.5 to 0.6, and input effective sample sizes for the fishery and survey age comps were adjusted to approximately equal the means of the estimated effective sample sizes from the assessment model to produce root mean square errors (RMSEs) closer to 1.0. The effect of the reweighting was that abundances were scaled lower (Table C6). Specifically, SSB in 1970 was 186,000 mt instead of 262,000 mt. Also, current biomass in the reweighted base model dropped to 56,000 mt from 126,000 mt in the base model. The RMSEs for the survey indices decreased from around 2.0 in the base model to 1.3 in the reweighted base model, while the RMSE for the annual recruitment deviations remained around 1.0. A retrospective run of the reweighted base model led to retrospective patterns where predicted F and SSB time series from the peels consistently crossed predicted F and SSB time series from the full model (Figure C33). The seven year average Mohn's rho was -0.26 for F, 0.25 for SSB, and 0.27 for age 1 recruitment.

E. Biological Reference Points (BRPs)

The NOAA Toolbox program YPR version 3.3 was used to calculate a deterministic value for the Fmsy proxy of $F_{40\%}$ given average vectors for the most recent 5 years (2009-2013) for SSB weights at age, catch weights at age, maturity at age (which is time invariant), and selectivity at age (Table C16). Expressed as the average F experienced at ages 5-7, the estimate is $F_{40\%5\text{-}7}$ = 0.27, which corresponds to a fully selected F of 0.42.

As was done for SARC 50, the NMFS Toolbox program AGEPRO was used to determine equilibrium, median values for SSB_{MSY} and MSY under the $F_{40\%}$ from the YPR analysis. The selectivity ogive and weights used in the determination of $F_{40\%}$ (Table C16) were applied to the population for 100 years and the median, 5th, and 95th percentiles of 1,000 bootstraps are reported for SSB and yield (Table C17). The recruitment option employed was to sample from the empirical cdf (Model 14 in AGEPRO version 4.2). The long-term median recruitment from this projection is 17.6 million age 1 fish, with 90% CI ranging from 8 million to 40 million fish. The estimates of equilibrium SSB_{MSY} and MSY are 76,900 mt and 14,800 mt, respectively. There is a 90% probability that SSB_{MSY} is between 59,100 and 102,500 mt, and that MSY is between 10,700 and 21,400 mt.

Biological Reference Points Sensitivity Analysis

To evaluate the sensitivity of reference points to the model estimated dome-shaped selectivities, results from the flat survey selectivity sensitivity model run were also used to estimate reference points. Following the same methodology, the average $F_{40\%}$ on ages 5 to 7 was 0.24, the proxy for SSB_{MSY} was 51,100 mt, and the proxy MSY was 10,500 mt. Thus, if the survey selectivity at ages 6-9 is fixed at 1.0, rather than having a dome shape, then the biomass reference points would be 29-34% lower.

F. Projections

Three projection scenarios were explored with the same AGEPRO configuration used to determine the biomass reference points: $F_{40\%}$ = 0.42 (equivalent to $F_{5\text{-}7}$ = 0.27), 0.75* $F_{40\%}$ = 0.32 (equivalent to $F_{5\text{-}7}$ = 0.20), and status-quo with F_{2013} = 0.15 (equivalent to $F_{5\text{-}7}$ = 0.10). For all three scenarios, total catch in 2014 was assumed to be 6,817 mt, which is the estimate of 2014 total catch provided by the Greater Atlantic Regional Fisheries Office (GARFO) for projections. Following the methods laid out in the 3rd Groundfish Assessment Review Meeting (GARM III; NEFSC 2008), base model projections were not Mohn's rho-adjusted, because the Mohn's rho-adjusted estimates of 2013 SSB and F fell within the 90% probability intervals of the unadjusted estimates of 2013 SSB and F.

Projections are summarized for various percentiles of spawning stock biomass and catch under all three scenarios in Table C18, C19. Under the $F_{40\%}$ and 0.75* $F_{40\%}$ scenarios, spawning biomass decreases from SSB_{2013}=126,000 mt to SSB_{2014} = 123,000 mt, increases to SSB_{2015} = 132,000 mt, and then decreases until it reaches equilibrium at the projected F. Projecting at

0.75*$F_{40\%}$, the median SSB equilibrates at 92,300 mt, while at $F_{40\%}$ the median SSB equilibrates at 76,900 mt (the proxy for SSB_{MSY}). Under $F_{status-quo}$, spawning biomass increases from SSB_{2014} = 123,000 mt, and the median SSB equilibrates at 130,000 mt.

Projected catch includes both commercial and recreational landings and discards. Under $F_{status-quo}$, median projected catch increases from 6,800 mt in 2014 to 11,300 mt in 2018, then decreases until equilibrating around 8,800 mt (Table C19). Projecting at 0.75*$F_{40\%}$, the median catch increases to 19,000 mt in 2017, then decreases until equilibrating around 13,300 mt. Projecting at $F_{40\%}$, median catch increases to 22,800 mt in 2017, then decreases until equilibrating around 14,800 mt (the proxy for MSY).

Projections Sensitivity Analysis

Three projection scenarios were explored for the flat survey selectivity sensitivity model with the same AGEPRO configuration used in the base model projections: $F_{40\%}$ = 0.41 (equivalent to F_{5-7} = 0.24), 0.75* $F_{40\%}$ = 0.31 (equivalent to F_{5-7} = 0.18), and status-quo with F_{2013} = 0.33 (equivalent to F_{5-7} = 0.20). Following the methods laid out in GARM III (NEFSC 2008), flat survey selectivity sensitivity model projections were Mohn's rho-adjusted, because the Mohn's rho-adjusted estimates of 2013 SSB and F fell outside the 90% probability intervals of the unadjusted estimates of 2013 SSB and F.

Projections are summarized for various percentiles of spawning stock biomass and catch under all three scenarios in Tables C20, C21. Under all three scenarios, spawning biomass increases from the Mohn's rho-adjusted SSB_{2013}=29,000 mt until it reaches equilibrium at the projected F. Projecting at $F_{status-quo}$, the median SSB equilibrates at 58,400 mt. Projecting at 0.75*$F_{40\%}$, the median SSB equilibrates at 60,300 mt, while at $F_{40\%}$ the median SSB equilibrates at 51,100 mt (the proxy for SSB_{MSY}).

Projected catch includes both commercial and recreational landings and discards. Projecting at $F_{status-quo}$, median projected catch decreases from 6,800 mt in 2014 to 5,200 mt in 2015, then increases until equilibrating around 9,800 mt (Table C21). Projecting at 0.75*$F_{40\%}$, the median catch decreases to 5,000 mt in 2015, then increases until equilibrating around 9,600 mt. Projecting at $F_{40\%}$, median catch decreases to 6,400 mt in 2015, then increases until equilibrating around 10,500 mt (the proxy for MSY).

Due to uncertainty in the high estimate of 2012 age 1 recruits (i.e., the 2011 year-class), the sensitivity of short term (i.e., 2015) projections to 2012 recruitment was explored by reducing the 2012 age 1 recruits by 50%, which brought 2012 recruitment more in line with mean recruitment. Three projection scenarios were explored for the reduced 2012 recruitment sensitivity run with the same AGEPRO configuration used in the base model projections: $F_{40\%}$ =

0.42 (equivalent to $F_{5\text{-}7}$ = 0.27), 0.75* $F_{40\%}$ = 0.32 (equivalent to $F_{5\text{-}7}$ = 0.20), and status-quo with F_{2013} = 0.15 (equivalent to $F_{5\text{-}7}$ = 0.10).

Projections are summarized for various percentiles of spawning stock biomass and catch under all 3 scenarios in Tables C22, C23. Under all three scenarios, spawning biomass increases from 121,000 mt in 2014 to 123,000 mt in 2015.

Projected catch includes both commercial and recreational landings and discards. Projecting at $F_{status\text{-}quo}$, median projected catch increases from 6,800 mt in 2014 to 8,000 mt in 2015 (Table C23). Projecting at 0.75*$F_{40\%}$, the median catch increases to 15,900 mt in 2015. Projecting at $F_{40\%}$, median catch increases to 20,600 mt in 2015.

G. Summary

Stock Status

Following the methods laid out in GARM III (NEFSC 2008), terminal year SSB and F estimates were not Mohn's rho-adjusted for stock status determination, because the Mohn's rho-adjusted estimates of 2013 SSB and F fell within the 90% probability intervals of the unadjusted estimates of 2013 SSB and F (Figure C34). The estimate of SSB_{2013} is 126,000 mt, which is greater than the median estimate of SSB_{MSY} (76,900 mt). Therefore, the pollock stock is not overfished. The estimate of average F on ages 5 to 7 in 2013 is 0.10, which is less than the F_{MSY} proxy (0.27), therefore overfishing is not occurring.

Stock Status Sensitivity Analysis

The sensitivity of stock status to the model estimated dome-shaped selectivities was evaluated by comparing current F and SSB estimates from the sensitivity model with flat survey selectivity for ages 6-9 to their corresponding reference points. Following the methods laid out in GARM III (NEFSC 2008), terminal year SSB and F estimates were Mohn's rho-adjusted for stock status determination, because the Mohn's rho-adjusted estimates of 2013 SSB and F fell outside the 90% probability intervals of the unadjusted estimates of 2013 SSB and F. The estimate of SSB_{2013} is 29,000 mt, which is less than the median estimate of SSB_{MSY} (51,100 mt), but greater than $B_{THRESHOLD}$ (25,600 mt). Therefore, the pollock stock is not overfished. The Mohn's rho-adjusted estimate of average F on ages 5 to 7 in 2013 is 0.30, which is greater than the F_{MSY} proxy (0.24), therefore overfishing is occurring. It was therefore concluded that stock status is sensitive to the shape of survey selectivity at older ages.

H. References

National Marine Fisheries Service (NMFS). 2012. MRFSS/MRIP Calibration Workshop Ad-hoc Working Group Report. May 16, 2012. 12 p.

Northeast Fisheries Science Center (NEFSC). 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii.

Northeast Fisheries Science Center (NEFSC). 2010. 50th Northeast Regional Stock Assessment Workshop (50th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-17; 844 p.

Table C1. Total catch (mt) of pollock in US areas 5&6 by commercial and recreational fisheries.

Year	US Landings	US Discards	Canadian Landings	Distant Water Fleet Landings	**Commercial Total mt**	Recreational Landings	Recreational Discards	**Recreational Total mt**	Total Catch (mt)
1960	8190	0	2211	0	10401	0	0	0	10401
1961	7861	0	359	0	8220	0	0	0	8220
1962	5550	0	601	0	6151	0	0	0	6151
1963	4673	0	953	615	6241	0	0	0	6241
1964	4764	0	1942	2298	9004	0	0	0	9004
1965	4903	0	2044	2040	8987	0	0	0	8987
1966	3232	0	4012	2664	9908	0	0	0	9908
1967	2741	0	5287	449	8477	0	0	0	8477
1968	2913	0	1740	499	5152	0	0	0	5152
1969	3521	0	2443	3872	9836	0	0	0	9836
1970	3586	0	853	7116	11555	0	0	0	11555
1971	4734	0	1636	7949	14319	0	0	0	14319
1972	5248	0	1366	6381	12995	0	0	0	12995
1973	5753	0	1727	5600	13080	0	0	0	13080
1974	7720	0	3539	755	12014	0	0	0	12014
1975	8190	0	4736	556	13482	0	0	0	13482
1976	9593	0	2116	1022	12731	0	0	0	12731
1977	11999	0	3413	104	15516	0	0	0	15516
1978	16758	0	4754	0	21512	0	0	0	21512
1979	14613	0	3032	0	17645	0	0	0	17645
1980	16567	0	5634	0	22201	0	0	0	22201
1981	17766	0	4050	0	21816	677	386	1063	22879
1982	13961	0	5373	1	19335	737	715	1452	20787
1983	13842	0	4383	0	18225	523	695	1218	19443
1984	17657	0	3290	0	20947	103	62	165	21112
1985	19192	0	1764	0	20956	233	55	288	21244
1986	24339	0	654	1	24994	129	32	161	25155
1987	20251	0	0	0	20251	104	178	282	20533
1988	14830	0	0	0	14830	150	385	535	15365
1989	10553	473	0	0	11025	233	224	457	11482
1990	9559	107	0	0	9666	140	110	250	9916
1991	7886	223	0	0	8109	90	274	364	8473
1992	7184	196	0	0	7380	45	45	90	7470
1993	5674	100	0	0	5774	47	55	102	5876
1994	3763	154	0	0	3918	228	192	420	4338
1995	3352	192	0	0	3544	222	488	710	4254
1996	2962	230	0	0	3192	305	212	517	3709
1997	4264	124	0	0	4388	177	163	340	4728

1998	5572	68	0	0	5640	116	176	292	5932
1999	4590	141	0	0	4730	80	134	214	4944
2000	4043	117	0	0	4160	219	338	557	4717
2001	4109	73	0	0	4182	424	830	1254	5436
2002	3580	68	0	0	3648	492	581	1073	4721
2003	4794	45	0	0	4839	449	448	897	5736
2004	5070	104	0	0	5174	558	343	901	6075
2005	6509	100	0	0	6609	425	216	641	7250
2006	6067	73	0	0	6140	700	270	970	7110
2007	8372	157	0	0	8529	591	188	779	9308
2008	10040	355	0	0	10395	929	915	1844	12239
2009	7504	279	0	0	7783	583	400	983	8766
2010	5153	97	0	0	5250	1338	805	2143	7393
2011	7211	174	0	0	7385	1450	926	2376	9761
2012	6742	108	0	0	6850	588	855	1443	8293
2013	5058	168	0	0	5226	1623	1455	3078	8304

Table C2. Estimated recreational landings (mt) and discards (mt) of pollock from the Marine Recreational Statistics Survey (MRFSS) and the Marine Recreational Information Program (MRIP). MRFSS estimates were converted to MRIP equivalents for 1981-2003.

Year	Recreational Landings MRFSS (mt)	Recreational Landings MRIP (mt)	Recreational Discards MRFSS (mt)	Recreational Discards MRIP (mt)
1981	752	677	407	386
1982	819	737	755	715
1983	581	523	733	695
1984	115	103	65	62
1985	259	233	58	55
1986	143	129	34	32
1987	115	104	187	178
1988	167	150	406	385
1989	259	233	236	224
1990	155	140	116	110
1991	100	90	289	274
1992	50	45	47	45
1993	52	47	58	55
1994	253	228	202	192
1995	247	222	514	488
1996	339	305	223	212
1997	196	177	172	163
1998	128	116	186	176
1999	89	80	141	134
2000	243	219	356	338
2001	471	424	875	830
2002	547	492	613	581
2003	499	449	472	448
2004	661	558	198	343
2005	509	425	266	216
2006	578	700	251	270
2007	537	591	227	188
2008	942	929	923	915
2009	562	583	468	400
2010	1904	1338	1019	805
2011	1613	1450	930	926
2012	---	588	---	855
2013	---	1623	---	1455

Table C3. Estimates of recreational landings (top row) and discards (bottomrow) of pollock in numbers (left column) and weight (right column) form the Marine Recreational Statistics Survey (MRFSS) and Marine Recreational Information Program (MRIP). Percentage difference between MRSS and MRIP estimates is (MRIP-MRFSS)/MRFSS. Positive % Delta value indicates MRIP estimate is greater than MRFSS estimate.

Landings (numbers of fish)				Landings (kg)			
Year	MRFSS	MRIP	% Delta	Year	MRFSS	MRIP	% Delta
2004	223,697	192,221	-14%	2004	661,003	557,713	-16%
2005	156,804	130,694	-17%	2005	509,185	425,177	-16%
2006	175,068	204,247	17%	2006	577,685	699,949	21%
2007	161,172	178,884	11%	2007	536,774	591,266	10%
2008	241,974	237,055	-2%	2008	941,977	928,900	-1%
2009	144,660	149,794	4%	2009	561,560	582,679	4%
2010	541,332	381,069	-30%	2010	1,904,304	1,338,195	-30%
2011	463,419	411,037	-11%	2011	1,613,170	1,450,284	-10%
Total	2,108,125	1,885,001	-11%	Total	7,305,658	6,574,164	-10%

Discards (numbers of fish)				Discards (kg)			
Year	MRFSS	MRIP	% Delta	Year	MRFSS	MRIP	% Delta
2004	83,932	144,348	72%	2004	198,299	342,606	73%
2005	97,328	79,907	-18%	2005	266,455	215,596	-19%
2006	103,168	111,393	8%	2006	250,954	269,787	8%
2007	77,864	66,042	-15%	2007	227,294	187,550	-17%
2008	256,483	253,565	-1%	2008	923,376	914,542	-1%
2009	142,950	125,798	-12%	2009	467,883	399,979	-15%
2010	350,715	277,109	-21%	2010	1,018,962	804,735	-21%
2011	315,558	312,681	-1%	2011	929,566	926,421	0%
Total	1,427,997	1,370,843	-4%	Total	4,282,788	4,061,216	-5%

Table C4. Port samples (sampling intensity) for pollock.

Year	Number of Fish Lengths	Number of Aged Fish	Commcial Landings (mt)	Lengths per mt	Ages per mt
1970	396	---	3586	0.11	---
1971	57	---	4734	0.01	---
1972	633	---	5248	0.12	---
1973	965	---	5753	0.17	---
1974	1053	---	7720	0.14	---
1975	548	---	8190	0.07	---
1976	497	60	9593	0.05	0.01
1977	4695	1099	11999	0.39	0.09
1978	2159	451	16758	0.13	0.03
1979	5716	1365	14613	0.39	0.09
1980	2412	548	16567	0.15	0.03
1981	5448	1346	17766	0.31	0.08
1982	5809	1314	13961	0.42	0.09
1983	9616	2415	13842	0.69	0.17
1984	7605	1811	17657	0.43	0.10
1985	7900	2050	19192	0.41	0.11
1986	9515	2438	24339	0.39	0.10
1987	8128	2162	20251	0.40	0.11
1988	9067	2128	14830	0.61	0.14
1989	7954	1853	10553	0.75	0.18
1990	6179	1429	9559	0.65	0.15
1991	6089	1418	7886	0.77	0.18
1992	6071	1405	7184	0.85	0.20
1993	4733	737	5674	0.83	0.13
1994	4466	1121	3763	1.19	0.30
1995	3043	753	3352	0.91	0.22
1996	3879	889	2962	1.31	0.30
1997	6738	1574	4264	1.58	0.37
1998	3198	822	5572	0.57	0.15
1999	4134	1168	4590	0.90	0.25
2000	3617	1006	4043	0.89	0.25
2001	5087	1385	4109	1.24	0.34
2002	3240	1133	3580	0.91	0.32
2003	9719	3360	4794	2.03	0.70
2004	8996	1640	5070	1.77	0.32
2005	7599	1598	6509	1.17	0.25
2006	8396	1985	6067	1.38	0.33
2007	7606	1802	8372	0.91	0.22

2008	7807	1558	10040	0.78	0.16
2009	8204	1612	7504	1.09	0.21
2010	10252	2445	5153	1.99	0.47
2011	9884	2198	7211	1.37	0.30
2012	9241	2081	6742	1.37	0.31
2013	8909	2447	5058	1.76	0.48

Table C5. Ratios of commercial discards at age for pollock from the revised SARC 50 base model (i.e., with revised commercial discards at age for 2001-2008) to commercial discards at age from the original SARC 50 base model. Ratios greater than 1.0 (blue shading) indicate a greater proportion at age for the revised SARC 50 base model. Empty cells result from division by zero.

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
1989	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1991	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1992	1.00	1.00	1.00	1.00	1.00				
1993	1.00	1.00	1.00	1.00	1.00				
1994	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1995	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1996	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1997	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1998	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1999	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2000		1.00	1.00	1.00	1.00	1.00	1.00	1.00	
2001		1.00	1.10	0.75	1.00	1.00	1.00		
2002		0.81	1.19	0.86	0.81	0.81	0.00	0.00	
2003		2.16	0.81	0.68	0.51	0.68	0.68	0.68	
2004	1.59	0.85	1.21	0.54	0.54	0.41	0.82	1.09	
2005	0.42	2.54	0.97	0.95	1.06	0.85	0.85	0.56	
2006	0.45		1.27	0.60	0.91	0.91	1.09	0.91	
2007	1.29	3.88	1.62	0.73	1.13	0.80	0.55	0.40	
2008	6.24	1.69	0.80	0.70	0.63	0.68	0.73	0.75	

Table C6. ASAP model results for the SARC 50 base model, revised SARC 50 base model (i.e., with revised commercial discards at age for 2001-2008), 2014 base model, 2014 base model with flat survey selectivity patterns, and reweighted 2014 base model. SSB0 is unexploited spawning biomass. The terminal year for the two SARC 50 models is 2009. The terminal year for the three 2014 models is 2013. Only the 2014 base model and 2014 base model with flat survey selectivity patterns use the same data. Therefore, only the likelihood components of those two models are directly comparable.

Model estimate	SARC 50 base	SARC 50 base revised	2014 base	2014 base w/ flat sel	2014 base reweighted
lk.total	4531	4537	**4316**	4349	4454
lk.catch.total	402	402	**453**	456	454
lk.discard.total	648	648	**-31**	-31	-32
lk.index.fit.total	168	168	**187**	240	142
lk.catch.age.comp	878	879	**970**	978	1310
lk.discards.age.comp	539	545	**656**	657	826
lk.index.age.comp	1475	1474	**1623**	1607	1304
lk.Recruit.devs	420	420	**459**	441	449
R0	26431	20573	**19249**	15435	15989
R1970	28663	28731	**26621**	19032	31185
mean.R	21358	21411	**19498**	13029	14831
SSB0	273763	213090	**197398**	158286	163959
SSB1970	297288	298156	**262338**	88937	186172
CV.SSB1970	0.14	0.14	**0.14**	0.11	0.18
SSB1970/SSB0	1.09	1.40	**1.33**	0.56	1.14
SSB2009	196339	196195	**151646**	56456	68210
CV.SSB2009	0.14	0.14	**0.14**	0.13	0.20
SSB2009/SSB0	0.72	0.92	**0.77**	0.36	0.42
SSB2013	--	--	**125879**	48138	55618
CV.SSB2013	--	--	**0.15**	0.16	0.26
SSB2013/SSB0	--	--	**0.64**	0.30	0.34
F1970	0.11	0.11	**0.12**	0.21	0.14
CV.F1970	0.13	0.13	**0.13**	0.11	0.13
F2009	0.07	0.07	**0.09**	0.18	0.18
CV.F2009	0.16	0.16	**0.14**	0.12	0.17
F2013	--	--	**0.10**	0.20	0.19
CV.F2013	--	--	**0.18**	0.19	0.27
steepness	0.66	0.60	**0.56**	0.62	0.53
CV.steepness	0.24	0.28	**0.24**	0.12	0.18
Spring.index.q	2.53E-05	2.53E-05	**2.92E-05**	5.66E-05	4.71E-05
Fall.index.q	1.36E-05	1.35E-05	**1.60E-05**	2.73E-05	2.30E-05

Table C7. NEFSC spring survey age structure for pollock .

			N/tow at age								
Year	N/tow	CV	1	2	3	4	5	6	7	8	9+
1970	1.09	0.24	0.070	0.035	0.108	0.059	0.033	0.061	0.090	0.163	0.383
1971	0.80	0.18	0.044	0.115	0.164	0.101	0.075	0.079	0.010	0.068	0.345
1972	3.38	0.50	0.157	0.473	0.193	0.008	0.018	0.006	0.016	0.035	0.096
1973	4.56	0.45	0.001	0.722	0.129	0.037	0.027	0.006	0.003	0.020	0.056
1974	1.34	0.25	0.000	0.048	0.424	0.121	0.042	0.107	0.050	0.016	0.192
1975	1.43	0.31	0.000	0.163	0.120	0.235	0.027	0.051	0.061	0.057	0.286
1976	1.69	0.19	0.029	0.059	0.099	0.102	0.151	0.067	0.102	0.103	0.289
1977	1.61	0.32	0.067	0.296	0.136	0.040	0.094	0.171	0.089	0.065	0.042
1978	1.94	0.50	0.000	0.139	0.213	0.265	0.162	0.060	0.045	0.024	0.093
1979	0.95	0.19	0.117	0.054	0.089	0.076	0.143	0.110	0.065	0.146	0.200
1980	1.43	0.32	0.070	0.127	0.065	0.206	0.174	0.108	0.166	0.038	0.047
1981	1.43	0.25	0.004	0.263	0.034	0.051	0.114	0.147	0.049	0.043	0.296
1982	3.96	0.46	0.027	0.382	0.216	0.185	0.031	0.067	0.029	0.029	0.034
1983	0.88	0.33	0.650	0.067	0.022	0.033	0.002	0.000	0.054	0.030	0.141
1984	1.03	0.27	0.167	0.124	0.112	0.119	0.112	0.099	0.044	0.037	0.185
1985	15.20	0.85	0.001	0.022	0.292	0.236	0.299	0.117	0.016	0.001	0.015
1986	1.88	0.42	0.026	0.079	0.036	0.105	0.054	0.222	0.203	0.069	0.207
1987	1.66	0.68	0.092	0.549	0.121	0.015	0.021	0.022	0.045	0.048	0.087
1988	0.78	0.23	0.517	0.031	0.100	0.018	0.000	0.039	0.028	0.072	0.195
1989	1.90	0.50	0.030	0.065	0.055	0.230	0.215	0.149	0.090	0.076	0.091
1990	0.65	0.34	0.000	0.038	0.369	0.143	0.050	0.080	0.064	0.051	0.206
1991	2.05	0.26	0.053	0.037	0.211	0.287	0.151	0.126	0.077	0.005	0.052
1992	1.75	0.30	0.408	0.111	0.083	0.081	0.094	0.047	0.051	0.022	0.104
1993	1.62	0.34	0.363	0.171	0.202	0.121	0.028	0.055	0.030	0.009	0.022
1994	0.58	0.20	0.005	0.079	0.171	0.220	0.128	0.123	0.147	0.082	0.045
1995	3.58	0.83	0.001	0.006	0.242	0.551	0.143	0.035	0.001	0.014	0.007

1996	0.64	0.43	0.372	0.033	0.012	0.110	0.241	0.129	0.070	0.034	0.000
1997	3.54	0.40	0.145	0.135	0.220	0.168	0.202	0.055	0.055	0.010	0.013
1998	2.66	0.37	0.284	0.098	0.367	0.068	0.022	0.065	0.061	0.026	0.011
1999	2.22	0.45	0.294	0.502	0.081	0.058	0.017	0.023	0.019	0.006	0.000
2000	1.40	0.38	0.524	0.076	0.084	0.060	0.110	0.076	0.039	0.020	0.011
2001	1.72	0.31	0.391	0.097	0.069	0.044	0.150	0.143	0.067	0.029	0.010
2002	0.72	0.28	0.055	0.029	0.054	0.303	0.203	0.253	0.079	0.024	0.000
2003	1.44	0.69	0.210	0.597	0.032	0.051	0.026	0.036	0.028	0.011	0.009
2004	0.47	0.40	0.141	0.411	0.097	0.020	0.063	0.133	0.062	0.026	0.048
2005	2.17	0.38	0.003	0.210	0.007	0.014	0.063	0.430	0.173	0.071	0.029
2006	0.94	0.25	0.091	0.020	0.023	0.008	0.058	0.331	0.402	0.054	0.012
2007	2.09	0.24	0.112	0.067	0.097	0.042	0.152	0.204	0.316	0.011	0.000
2008	2.04	0.23	0.049	0.011	0.003	0.030	0.100	0.124	0.360	0.121	0.202
2009	0.97	0.26	0.132	0.226	0.133	0.008	0.093	0.060	0.032	0.192	0.097
2010	1.21	0.43	0.549	0.056	0.173	0.087	0.076	0.026	0.084	0.102	0.057
2011	3.15	0.75	0.014	0.064	0.423	0.555	0.816	0.813	0.179	0.023	0.262
2012	0.82	0.45	0.366	0.037	0.039	0.011	0.034	0.015	0.093	0.021	0.208
2013	0.82	0.25	0.009	0.080	0.214	0.117	0.028	0.101	0.053	0.092	0.124

Table C8. NEFSC fall survey age structure for pollock.

			N/tow at age								
Year	N/tow	CV	1	2	3	4	5	6	7	8	9+
1970	0.55	0.20	0.129	0.162	0.011	0.191	0.168	0.125	0.081	0.053	0.080
1971	0.95	0.43	0.019	0.372	0.181	0.017	0.045	0.118	0.019	0.071	0.159
1972	1.48	0.26	0.231	0.198	0.142	0.062	0.053	0.063	0.057	0.050	0.143
1973	0.97	0.21	0.013	0.258	0.079	0.051	0.085	0.073	0.078	0.086	0.278
1974	1.01	0.35	0.002	0.077	0.320	0.234	0.096	0.084	0.112	0.000	0.075
1975	0.70	0.38	0.341	0.056	0.048	0.172	0.098	0.068	0.117	0.023	0.077
1976	4.30	0.48	0.009	0.007	0.039	0.135	0.451	0.152	0.081	0.049	0.077
1977	2.34	0.31	0.022	0.097	0.118	0.118	0.215	0.169	0.097	0.035	0.129
1978	1.06	0.21	0.031	0.207	0.042	0.047	0.103	0.077	0.162	0.076	0.257
1979	0.87	0.19	0.014	0.020	0.209	0.167	0.093	0.107	0.082	0.099	0.210
1980	0.49	0.21	0.115	0.013	0.022	0.100	0.194	0.062	0.096	0.099	0.300
1981	1.10	0.68	0.024	0.161	0.469	0.125	0.118	0.029	0.024	0.003	0.050
1982	0.79	0.36	0.104	0.279	0.281	0.067	0.023	0.072	0.060	0.000	0.116
1983	1.00	0.44	0.505	0.015	0.070	0.041	0.070	0.017	0.057	0.078	0.148
1984	0.28	0.36	0.371	0.440	0.059	0.014	0.009	0.071	0.009	0.009	0.019
1985	1.11	0.35	0.606	0.044	0.093	0.071	0.072	0.045	0.021	0.000	0.049
1986	0.42	0.28	0.319	0.194	0.075	0.091	0.099	0.102	0.091	0.018	0.013
1987	0.54	0.30	0.078	0.353	0.104	0.000	0.109	0.029	0.124	0.057	0.149
1988	3.96	0.66	0.024	0.029	0.279	0.341	0.109	0.113	0.020	0.048	0.036
1989	1.64	0.63	0.266	0.413	0.222	0.081	0.000	0.000	0.000	0.000	0.019
1990	0.70	0.33	0.013	0.116	0.318	0.196	0.161	0.012	0.029	0.044	0.113
1991	0.70	0.40	0.198	0.094	0.221	0.328	0.080	0.062	0.018	0.000	0.000
1992	0.91	0.53	0.334	0.221	0.146	0.145	0.125	0.018	0.011	0.000	0.000
1993	1.10	0.49	0.442	0.364	0.084	0.030	0.011	0.056	0.000	0.000	0.014
1994	0.37	0.37	0.000	0.136	0.366	0.263	0.189	0.047	0.000	0.000	0.000
1995	0.86	0.41	0.036	0.182	0.547	0.128	0.080	0.027	0.000	0.000	0.000

1996	1.01	0.40	0.285	0.306	0.045	0.210	0.133	0.015	0.006	0.000	0.000
1997	1.70	0.54	0.322	0.372	0.086	0.100	0.101	0.019	0.000	0.000	0.000
1998	2.06	0.66	0.602	0.159	0.154	0.045	0.013	0.017	0.010	0.000	0.000
1999	2.28	0.32	0.222	0.235	0.089	0.226	0.116	0.087	0.019	0.006	0.000
2000	2.45	0.74	0.143	0.795	0.038	0.007	0.011	0.007	0.000	0.000	0.000
2001	2.11	0.32	0.054	0.286	0.225	0.234	0.127	0.043	0.025	0.006	0.000
2002	3.18	0.43	0.064	0.041	0.290	0.217	0.261	0.103	0.024	0.000	0.000
2003	7.74	0.67	0.039	0.255	0.240	0.390	0.067	0.009	0.000	0.000	0.000
2004	3.11	0.55	0.037	0.084	0.535	0.135	0.116	0.065	0.028	0.000	0.000
2005	5.06	0.41	0.006	0.438	0.080	0.177	0.124	0.150	0.022	0.002	0.000
2006	1.67	0.66	0.168	0.477	0.069	0.031	0.061	0.092	0.100	0.004	0.000
2007	0.33	0.26	0.339	0.037	0.000	0.083	0.046	0.233	0.170	0.042	0.051
2008	1.01	0.58	0.151	0.260	0.229	0.079	0.043	0.025	0.047	0.047	0.119
2009	0.29	0.30	0.082	0.168	0.024	0.009	0.000	0.000	0.000	0.008	0.000
2010	1.88	0.55	0.076	0.664	0.296	0.099	0.211	0.168	0.091	0.115	0.164
2011	4.37	0.66	1.233	2.089	0.528	0.252	0.088	0.052	0.019	0.071	0.037
2012	1.59	0.44	0.482	0.429	0.300	0.078	0.154	0.077	0.043	0.009	0.013
2013	1.32	0.50	0.041	1.115	0.127	0.008	0.000	0.031	0.000	0.000	0.000

Table C9. Estimated spawning biomass (mt) at age per year from the ASAP base model (reported to 3 significant digits). Spawning weights were calculated as January 1 weights by applying the Rivard method to mid-year catch weights.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1970	43	496	1990	5840	12200	10400	17200	31900	182000	262000
1971	30	578	3620	6390	10900	15000	11400	18000	221000	287000
1972	96	654	5250	13600	12500	14800	16400	11700	202000	277000
1973	27	919	4850	15600	19000	13900	13800	15600	140000	224000
1974	29	461	7410	11700	20800	18700	11200	11100	137000	218000
1975	34	488	3530	27800	20200	24200	19800	11000	133000	240000
1976	34	419	3700	9450	41800	22700	22400	17500	121000	239000
1977	32	595	3130	9440	15100	46100	21300	21200	111000	228000
1978	12	520	4380	9570	15100	17800	45000	20100	104000	216000
1979	22	159	3740	10900	14800	17000	16800	41100	112000	217000
1980	68	373	1170	10100	16800	16300	14800	14600	129000	203000
1981	70	565	2770	3610	14900	16800	13200	12400	118000	182000
1982	17	391	3540	7190	5470	14800	13500	10800	113000	169000
1983	53	201	2190	11200	10100	4860	11900	11000	107000	159000
1984	30	444	1370	8190	17100	8100	3660	9340	83300	132000
1985	12	189	2640	3690	12100	16200	6100	2900	82300	126000
1986	35	203	1130	7740	4850	10600	12300	5250	68500	111000
1987	13	284	1470	4110	11700	3860	6490	7160	55800	90900
1988	31	133	1920	3980	5710	9550	2250	3670	44500	71700
1989	20	220	1070	6520	5780	4650	6040	1300	38800	64400
1990	13	102	1520	3780	9610	5400	3380	4150	28900	56900
1991	15	68	693	5930	5860	10000	4320	2430	28600	57900
1992	33	149	521	3000	10300	6630	8760	3540	26000	58900
1993	38	200	838	2400	4750	11900	6200	7490	25000	58800
1994	23	205	908	2410	3770	5500	11100	5480	28800	58200
1995	28	167	1420	3810	5560	4850	5410	10300	35200	66700
1996	40	251	1230	7270	11600	8730	5100	5030	35000	74300
1997	35	319	1440	5020	13800	15700	9430	4920	34400	85100
1998	59	186	1930	4740	8650	17300	15800	8970	33600	91200
1999	86	394	1230	7500	9480	10600	17800	15200	36600	98900
2000	90	402	1910	5620	15400	12100	11000	17200	41800	106000
2001	32	494	1940	7930	10400	19400	13400	10900	54500	119000
2002	35	212	3490	9260	20700	12900	20200	12900	53700	133000
2003	16	295	1240	16100	22600	25800	13900	20300	58500	159000
2004	9	110	2250	5320	27600	28900	26500	13000	70100	174000
2005	15	148	876	9810	11700	34600	30600	25100	67800	181000
2006	19	104	1310	3870	18100	14900	36900	29800	88300	193000

2007	38	278	690	4850	6780	23300	17000	35600	89300	178000
2008	58	359	2130	3100	10800	10300	26600	16100	96000	165000
2009	65	465	2210	6510	6190	13600	10700	21800	90100	152000
2010	22	223	2450	6790	11200	7690	13200	8660	88000	138000
2011	54	258	1030	7480	12300	14200	7830	11500	82700	137000
2012	100	368	1970	4620	14000	15000	13700	6410	72500	129000
2013	18	701	1960	6430	8840	17000	14400	11200	65400	126000

Table C10. Estimated numbers (thousands of fish) at age per year from the ASAP base model (reported to 3 significant digits).

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1970	26600	18200	8830	7370	6740	3910	4550	6310	25000	108000
1971	25000	21800	14700	6830	5380	4830	2800	3400	25000	110000
1972	53300	20500	17600	11300	4900	3770	3390	2060	22700	140000
1973	19500	43700	16600	13700	8350	3570	2750	2560	19900	131000
1974	20700	16000	35300	12800	9920	5920	2530	2040	18000	123000
1975	21200	16900	13000	27600	9550	7310	4360	1930	16100	118000
1976	24500	17300	13700	10200	20800	7070	5410	3330	14500	117000
1977	22600	20100	14100	10800	7650	15400	5240	4140	14400	114000
1978	7310	18500	16300	10900	7920	5530	11100	3940	14800	96300
1979	15400	5980	14900	12300	7570	5350	3730	7970	14800	88000
1980	34000	12600	4830	11300	8640	5200	3680	2710	17900	101000
1981	23300	27900	10100	3530	7360	5410	3260	2500	16200	99600
1982	9600	18600	21700	7140	2200	4420	3260	2160	14500	83600
1983	23900	7570	14300	15300	4460	1330	2680	2170	13000	84700
1984	9910	19000	5880	10200	9640	2710	809	1790	11800	71700
1985	10400	8070	15000	4130	6120	5530	1560	518	10500	61800
1986	17600	8390	6330	10400	2430	3420	3090	980	8540	61200
1987	10700	14000	6750	4750	6360	1250	1620	1460	6920	53800
1988	17000	8550	11200	5050	2910	3270	590	764	5960	55300
1989	7560	13400	6790	8400	3130	1540	1590	288	4900	47600
1990	6410	5960	10700	5150	5520	1820	838	871	3930	41200
1991	10400	5110	4780	8220	3520	3400	1060	490	3600	40600
1992	16700	8300	4110	3730	5850	2310	2150	672	3150	47000
1993	19100	13500	6740	3250	2730	4010	1530	1420	2960	55200
1994	11500	15500	11000	5360	2430	1940	2770	1060	3380	54900
1995	12800	9310	12500	8820	4240	1820	1350	1940	3510	56300
1996	20100	10400	7530	10100	6990	3200	1290	961	4280	64900
1997	13300	16300	8430	6100	8070	5390	2350	950	4200	65100
1998	26900	10800	13300	6850	4900	6220	3960	1730	4120	78800
1999	33200	22000	8830	10800	5500	3770	4540	2890	4650	96200
2000	40900	27100	17900	7190	8730	4280	2800	3380	6000	118000
2001	17700	33300	22100	14600	5780	6800	3210	2110	7490	113000
2002	28900	14300	27000	17800	11600	4480	5100	2420	7710	119000
2003	11500	23700	11700	22000	14400	9180	3430	3890	8140	108000
2004	15500	9410	19300	9560	17800	11400	7020	2620	9640	102000
2005	9060	12700	7690	15800	7770	14300	8890	5350	9760	91300
2006	15600	7410	10400	6280	12800	6240	11200	6750	11900	88600
2007	17000	12700	6060	8450	5100	10300	4880	8520	14800	87800

2008	20800	13900	10400	4940	6850	4070	7890	3600	18200	90700
2009	12500	17000	11400	8460	3970	5350	2980	5460	16800	83900
2010	18400	10200	13900	9250	6820	3120	3980	2110	17200	85000
2011	20600	15100	8300	11300	7430	5350	2330	2830	15100	88300
2012	50000	16900	12300	6720	9010	5750	3860	1570	13700	120000
2013	8990	40800	13700	9960	5400	7050	4240	2690	11900	105000

Table C11. January 1 weights at age (kg), assumed to reflect spawning weights at age, derived by applying the Rivard method to mid-year catch weights at age.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+
1970	0.08	0.35	0.87	1.34	2.11	2.78	3.81	5.07	7.29
1971	0.06	0.34	0.95	1.58	2.37	3.23	4.11	5.29	8.83
1972	0.09	0.41	1.15	2.03	2.97	4.09	4.88	5.70	8.92
1973	0.07	0.27	1.13	1.92	2.65	4.06	5.07	6.10	7.05
1974	0.07	0.37	0.81	1.55	2.45	3.29	4.46	5.43	7.64
1975	0.08	0.37	1.05	1.70	2.47	3.44	4.59	5.72	8.23
1976	0.07	0.31	1.04	1.57	2.35	3.34	4.18	5.25	8.32
1977	0.07	0.38	0.86	1.48	2.30	3.12	4.10	5.12	7.70
1978	0.08	0.36	1.04	1.48	2.23	3.35	4.09	5.12	7.01
1979	0.07	0.34	0.97	1.50	2.29	3.30	4.54	5.17	7.56
1980	0.10	0.38	0.94	1.50	2.27	3.26	4.07	5.42	7.21
1981	0.15	0.26	1.06	1.73	2.36	3.23	4.08	4.96	7.29
1982	0.09	0.27	0.63	1.70	2.90	3.49	4.17	5.03	7.77
1983	0.11	0.34	0.59	1.24	2.64	3.81	4.50	5.06	8.24
1984	0.15	0.30	0.90	1.36	2.07	3.11	4.57	5.23	7.07
1985	0.06	0.30	0.68	1.51	2.31	3.05	3.96	5.61	7.86
1986	0.10	0.31	0.69	1.26	2.33	3.22	4.03	5.37	8.03
1987	0.06	0.26	0.84	1.46	2.14	3.22	4.06	4.91	8.07
1988	0.09	0.20	0.66	1.33	2.29	3.04	3.85	4.82	7.47
1989	0.13	0.21	0.61	1.31	2.15	3.15	3.83	4.51	7.91
1990	0.10	0.22	0.55	1.24	2.03	3.09	4.08	4.77	7.36
1991	0.07	0.17	0.56	1.22	1.94	3.07	4.11	4.96	7.95
1992	0.10	0.23	0.49	1.36	2.05	2.98	4.12	5.28	8.25
1993	0.10	0.19	0.48	1.25	2.03	3.09	4.08	5.27	8.44
1994	0.10	0.17	0.32	0.76	1.81	2.95	4.06	5.17	8.53
1995	0.11	0.23	0.44	0.73	1.53	2.78	4.06	5.33	10.05
1996	0.10	0.31	0.63	1.22	1.94	2.84	4.00	5.25	8.17
1997	0.13	0.25	0.66	1.39	1.99	3.02	4.05	5.19	8.20
1998	0.11	0.22	0.56	1.17	2.06	2.90	4.04	5.19	8.17
1999	0.13	0.23	0.54	1.17	2.01	2.92	3.97	5.25	7.89
2000	0.11	0.19	0.41	1.32	2.06	2.95	3.98	5.10	6.97
2001	0.09	0.19	0.34	0.92	2.10	2.97	4.22	5.19	7.29
2002	0.06	0.19	0.50	0.88	2.08	3.00	4.01	5.33	6.97
2003	0.07	0.16	0.41	1.24	1.83	2.92	4.08	5.22	7.20
2004	0.03	0.15	0.45	0.94	1.81	2.65	3.81	4.97	7.28
2005	0.08	0.15	0.44	1.05	1.76	2.52	3.48	4.70	6.95
2006	0.06	0.18	0.49	1.04	1.65	2.49	3.34	4.42	7.40
2007	0.11	0.28	0.44	0.97	1.55	2.35	3.52	4.19	6.04

2008	0.14	0.33	0.79	1.06	1.84	2.63	3.40	4.47	5.29
2009	0.26	0.35	0.75	1.30	1.82	2.64	3.63	4.00	5.37
2010	0.06	0.28	0.68	1.24	1.92	2.56	3.35	4.12	5.13
2011	0.13	0.22	0.48	1.12	1.93	2.76	3.40	4.09	5.49
2012	0.10	0.28	0.62	1.16	1.81	2.72	3.57	4.08	5.29
2013	0.10	0.22	0.55	1.09	1.91	2.51	3.43	4.16	5.50

Table C12. Catch weights at age (kg), assumed to reflect mid-year weights at age.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+
1970	0.16	0.58	1.17	1.78	2.61	3.38	4.49	5.72	7.28
1971	0.16	0.71	1.56	2.12	3.16	4.00	4.99	6.24	8.83
1972	0.16	1.06	1.86	2.65	4.17	5.29	5.95	6.52	8.92
1973	0.16	0.46	1.21	1.98	2.65	3.96	4.86	6.25	7.05
1974	0.16	0.84	1.42	1.98	3.02	4.09	5.03	6.06	7.64
1975	0.16	0.86	1.31	2.04	3.07	3.92	5.14	6.51	8.23
1976	0.16	0.60	1.25	1.89	2.71	3.64	4.46	5.37	8.32
1977	0.16	0.88	1.22	1.75	2.80	3.58	4.62	5.88	7.70
1978	0.16	0.79	1.23	1.79	2.85	4.01	4.66	5.67	7.01
1979	0.16	0.71	1.20	1.83	2.94	3.82	5.15	5.73	7.56
1980	0.16	0.90	1.24	1.87	2.82	3.61	4.33	5.71	7.21
1981	0.20	0.43	1.24	2.42	2.98	3.70	4.61	5.67	7.28
1982	0.17	0.35	0.92	2.33	3.47	4.09	4.69	5.48	7.77
1983	0.18	0.67	0.99	1.66	2.98	4.19	4.95	5.45	8.24
1984	0.21	0.49	1.20	1.87	2.57	3.25	4.98	5.53	7.07
1985	0.14	0.43	0.94	1.91	2.84	3.61	4.83	6.31	7.86
1986	0.16	0.68	1.11	1.69	2.84	3.65	4.50	5.97	8.03
1987	0.11	0.41	1.03	1.91	2.71	3.66	4.51	5.35	8.07
1988	0.14	0.37	1.07	1.71	2.75	3.41	4.04	5.15	7.47
1989	0.17	0.32	1.01	1.60	2.69	3.61	4.30	5.04	7.91
1990	0.13	0.28	0.93	1.53	2.58	3.54	4.60	5.29	7.36
1991	0.13	0.23	1.12	1.59	2.46	3.64	4.76	5.35	7.94
1992	0.14	0.40	1.04	1.64	2.64	3.61	4.67	5.86	8.25
1993	0.13	0.27	0.57	1.51	2.50	3.61	4.62	5.95	8.44
1994	0.15	0.22	0.37	1.01	2.17	3.49	4.56	5.78	8.53
1995	0.18	0.35	0.89	1.44	2.33	3.57	4.73	6.22	10.05
1996	0.16	0.52	1.15	1.67	2.61	3.47	4.48	5.82	8.17
1997	0.17	0.39	0.83	1.68	2.36	3.50	4.73	6.01	8.20
1998	0.16	0.29	0.80	1.64	2.52	3.55	4.66	5.69	8.17
1999	0.16	0.33	1.00	1.70	2.46	3.38	4.44	5.92	7.89
2000	0.14	0.23	0.50	1.75	2.50	3.53	4.69	5.86	6.97
2001	0.13	0.25	0.51	1.70	2.52	3.53	5.05	5.74	7.29
2002	0.10	0.27	0.99	1.50	2.54	3.57	4.55	5.62	6.97
2003	0.10	0.27	0.61	1.54	2.23	3.35	4.66	5.98	7.20
2004	0.06	0.21	0.75	1.45	2.12	3.14	4.34	5.31	7.28
2005	0.12	0.36	0.91	1.47	2.13	2.99	3.85	5.09	6.95
2006	0.13	0.27	0.66	1.19	1.86	2.92	3.74	5.07	7.40
2007	0.19	0.58	0.73	1.42	2.02	2.96	4.24	4.69	6.04
2008	0.22	0.58	1.08	1.54	2.38	3.43	3.91	4.71	5.29

2009	0.27	0.56	0.96	1.57	2.14	2.92	3.83	4.10	5.37
2010	0.11	0.29	0.83	1.59	2.34	3.06	3.84	4.44	5.13
2011	0.19	0.44	0.79	1.50	2.33	3.25	3.78	4.35	5.49
2012	0.15	0.41	0.86	1.71	2.19	3.17	3.93	4.40	5.29
2013	0.15	0.32	0.73	1.39	2.13	2.88	3.72	4.40	5.50

Table C13. Estimated January 1 total biomass (mt) at age per year from the ASAP base model (reported to 3 significant digits). January 1 weights are the same as spawning weights and were calculated by applying the Rivard method to mid-year catch weights.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1970	2130	6360	7680	9870	14200	10900	17300	32000	182000	282000
1971	1500	7410	14000	10800	12700	15600	11500	18000	221000	313000
1972	4800	8390	20300	22900	14500	15400	16600	11800	203000	318000
1973	1370	11800	18700	26300	22100	14500	14000	15600	140000	264000
1974	1450	5910	28600	19800	24300	19500	11300	11100	137000	259000
1975	1690	6260	13600	47000	23600	25200	20000	11000	133000	281000
1976	1720	5370	14300	16000	48800	23600	22600	17500	121000	271000
1977	1580	7630	12100	16000	17600	48000	21500	21200	111000	257000
1978	585	6660	16900	16200	17700	18500	45500	20200	104000	246000
1979	1080	2030	14500	18400	17300	17600	16900	41200	112000	241000
1980	3400	4790	4540	17000	19600	17000	15000	14700	129000	225000
1981	3490	7240	10700	6100	17400	17500	13300	12400	118000	206000
1982	864	5020	13700	12100	6380	15400	13600	10900	113000	191000
1983	2620	2570	8450	19000	11800	5060	12100	11000	107000	180000
1984	1490	5690	5290	13800	19900	8430	3700	9360	83400	151000
1985	622	2420	10200	6230	14100	16900	6160	2910	82400	142000
1986	1760	2600	4370	13100	5650	11000	12500	5260	68600	125000
1987	644	3640	5670	6940	13600	4020	6560	7180	55800	104000
1988	1530	1710	7420	6720	6670	9940	2270	3680	44500	84400
1989	982	2820	4140	11000	6740	4840	6110	1300	38800	76700
1990	641	1310	5860	6390	11200	5620	3420	4160	28900	67500
1991	726	869	2680	10000	6830	10400	4370	2430	28600	66900
1992	1670	1910	2010	5070	12000	6900	8850	3550	26000	68000
1993	1910	2560	3230	4060	5540	12400	6260	7500	25000	68500
1994	1150	2630	3500	4070	4400	5720	11300	5490	28900	67200
1995	1410	2140	5500	6440	6490	5050	5470	10300	35200	78000
1996	2010	3220	4740	12300	13600	9080	5150	5040	35000	90100
1997	1730	4090	5560	8480	16100	16300	9530	4930	34400	101000
1998	2960	2380	7450	8010	10100	18100	16000	8990	33700	108000
1999	4320	5060	4770	12700	11100	11000	18000	15200	36700	119000
2000	4500	5160	7360	9490	18000	12600	11100	17200	41800	127000
2001	1590	6330	7500	13400	12100	20200	13500	10900	54600	140000
2002	1740	2720	13500	15600	24200	13500	20500	12900	53800	158000
2003	805	3780	4800	27300	26300	26800	14000	20300	58600	183000
2004	464	1410	8700	8990	32200	30100	26700	13000	70200	192000
2005	725	1900	3380	16600	13700	36000	30900	25100	67800	196000
2006	935	1330	5070	6530	21200	15500	37300	29800	88400	206000

2007	1870	3570	2670	8200	7910	24200	17200	35700	89400	191000
2008	2920	4600	8230	5240	12600	10700	26800	16100	96100	183000
2009	3240	5960	8530	11000	7220	14100	10800	21800	90200	173000
2010	1110	2850	9450	11500	13100	8000	13300	8680	88000	156000
2011	2680	3310	3980	12600	14300	14800	7910	11600	82800	154000
2012	5000	4720	7600	7800	16300	15600	13800	6430	72600	150000
2013	899	8980	7560	10900	10300	17700	14500	11200	65400	147000

Table C14. Estimated exploitable biomass at age per year from the ASAP base model (reported to 3 significant digits). Mid-year catch weights were multiplied by numbers at age, and the exploitable fraction was obtained by further multiplying by selectivity at age by year.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1970	0	905	4400	11300	17600	13200	14100	15000	23400	99900
1971	0	1330	9770	12500	17000	19300	9660	8850	28400	107000
1972	0	1860	13900	25800	20400	20000	13900	5610	26000	127000
1973	0	1730	8540	23500	22100	14100	9240	6680	18000	104000
1974	0	1150	21300	21800	30000	24200	8790	5150	17700	130000
1975	0	1250	7230	48700	29300	28700	15500	5230	17000	153000
1976	0	893	7300	16600	56200	25700	16700	7470	15500	146000
1977	0	1520	7300	16300	21400	55100	16700	10200	14200	143000
1978	0	1260	8520	16900	22600	22200	35800	9320	13300	130000
1979	0	365	7610	19400	22200	20400	13300	19000	14400	117000
1980	0	974	2550	18300	24400	18800	11000	6450	16600	99100
1981	376	1890	5850	7500	21900	19900	10300	5870	15200	88800
1982	203	1280	9800	14800	7630	17900	10400	4880	14700	81600
1983	426	885	6770	22400	13300	5500	9060	4880	13900	77100
1984	29	912	3060	16500	24800	8800	2780	4120	10700	71700
1985	42	388	6210	6850	17400	19900	5170	1360	10600	67900
1986	128	185	1110	9220	5820	12500	13900	4520	11100	58500
1987	61	220	1120	4790	14600	4570	7280	6040	9070	47800
1988	174	183	2100	4630	6790	11200	2380	3030	7260	37700
1989	118	323	1280	7280	7170	5540	6830	1120	6340	36000
1990	65	104	1760	4230	12100	6430	3840	3550	4720	36800
1991	117	83	981	7050	7360	12400	5040	2020	4660	39700
1992	130	139	701	3240	13100	8350	10000	3040	4230	42900
1993	163	185	653	2610	5780	14500	7070	6530	4070	41600
1994	103	251	400	1130	2960	6770	12200	3460	3620	30900
1995	163	284	1270	2840	5640	6480	6100	6700	4360	33800
1996	182	376	814	3420	10200	11100	5580	3160	4400	39200
1997	92	320	501	1860	10300	18900	10900	3290	4410	50600
1998	121	109	576	1840	6570	22100	18200	5750	4380	59600
1999	134	227	442	2950	7170	12700	19900	10000	4780	58300
2000	366	490	934	2690	12300	15100	12600	11100	5220	60800
2001	269	1200	2000	7100	8900	24000	15100	6380	6400	71300
2002	45	98	1390	4360	14900	15200	23200	8680	8660	76500
2003	13	118	296	5170	16200	29700	16000	14500	8900	90900
2004	11	45	635	1530	10200	23100	30500	12300	17700	96000
2005	10	84	255	2330	4290	27400	34200	24200	17100	110000
2006	24	46	299	826	6460	11800	41700	30200	22300	114000

2007	29	136	160	1200	2670	19600	20700	35400	22500	102000
2008	56	194	510	858	4460	9040	30900	14900	24300	85200
2009	34	196	435	1400	2250	10100	11400	19800	22800	68400
2010	38	103	728	2020	4810	6320	15300	8120	22400	59800
2011	65	205	371	2170	5040	11400	8800	10700	21000	59800
2012	95	171	491	1320	5430	11800	15200	6100	18400	59000
2013	31	546	747	2120	3670	13600	15800	10200	16700	63400

Table C15. Estimated total pollock fishing mortality at age (both fleets combined), and the unweighted average F for ages 5 to 7 from the ASAP base model.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Ave 5-7
1970	0.00	0.01	0.06	0.11	0.13	0.13	0.09	0.06	0.02	0.12
1971	0.00	0.01	0.07	0.13	0.15	0.15	0.11	0.06	0.02	0.14
1972	0.00	0.01	0.05	0.10	0.12	0.12	0.08	0.05	0.01	0.10
1973	0.00	0.01	0.06	0.12	0.14	0.14	0.10	0.06	0.02	0.13
1974	0.00	0.01	0.04	0.09	0.10	0.10	0.07	0.04	0.01	0.09
1975	0.00	0.01	0.04	0.09	0.10	0.10	0.07	0.04	0.01	0.09
1976	0.00	0.01	0.04	0.09	0.10	0.10	0.07	0.04	0.01	0.09
1977	0.00	0.01	0.05	0.11	0.12	0.12	0.09	0.05	0.02	0.11
1978	0.00	0.02	0.08	0.17	0.19	0.19	0.13	0.08	0.02	0.17
1979	0.00	0.01	0.07	0.15	0.17	0.17	0.12	0.07	0.02	0.16
1980	0.00	0.02	0.11	0.23	0.27	0.27	0.18	0.11	0.03	0.24
1981	0.02	0.05	0.14	0.27	0.31	0.31	0.21	0.13	0.04	0.28
1982	0.04	0.06	0.15	0.27	0.31	0.30	0.21	0.13	0.04	0.27
1983	0.03	0.05	0.14	0.26	0.30	0.29	0.20	0.12	0.04	0.27
1984	0.00	0.03	0.15	0.31	0.36	0.36	0.25	0.15	0.05	0.32
1985	0.01	0.04	0.17	0.33	0.38	0.38	0.26	0.16	0.05	0.34
1986	0.03	0.02	0.09	0.29	0.46	0.55	0.55	0.43	0.09	0.52
1987	0.03	0.02	0.09	0.29	0.46	0.55	0.55	0.42	0.09	0.52
1988	0.04	0.03	0.09	0.28	0.44	0.52	0.52	0.40	0.08	0.49
1989	0.04	0.03	0.08	0.22	0.35	0.41	0.40	0.31	0.07	0.39
1990	0.03	0.02	0.06	0.18	0.29	0.34	0.34	0.26	0.05	0.32
1991	0.02	0.02	0.05	0.14	0.22	0.26	0.26	0.20	0.04	0.25
1992	0.01	0.01	0.03	0.11	0.18	0.21	0.21	0.16	0.03	0.20
1993	0.01	0.01	0.03	0.09	0.14	0.17	0.17	0.13	0.03	0.16
1994	0.01	0.01	0.02	0.03	0.09	0.17	0.16	0.09	0.02	0.14
1995	0.01	0.01	0.02	0.03	0.08	0.14	0.14	0.08	0.02	0.12
1996	0.01	0.01	0.01	0.02	0.06	0.11	0.10	0.06	0.01	0.09
1997	0.00	0.01	0.01	0.02	0.06	0.11	0.11	0.06	0.01	0.09
1998	0.00	0.00	0.01	0.02	0.06	0.12	0.11	0.07	0.01	0.10
1999	0.00	0.00	0.00	0.02	0.05	0.10	0.10	0.06	0.01	0.08
2000	0.01	0.01	0.01	0.02	0.05	0.09	0.09	0.05	0.01	0.07
2001	0.01	0.01	0.02	0.03	0.05	0.09	0.08	0.05	0.01	0.07
2002	0.00	0.00	0.00	0.01	0.04	0.07	0.07	0.05	0.01	0.06
2003	0.00	0.00	0.00	0.01	0.04	0.07	0.07	0.04	0.01	0.06
2004	0.00	0.00	0.00	0.01	0.02	0.05	0.07	0.06	0.02	0.05
2005	0.00	0.00	0.00	0.01	0.02	0.05	0.07	0.07	0.02	0.05
2006	0.00	0.00	0.00	0.01	0.02	0.05	0.07	0.06	0.02	0.04
2007	0.00	0.00	0.00	0.01	0.03	0.07	0.10	0.09	0.03	0.07

2008	0.00	0.00	0.01	0.02	0.05	0.11	0.17	0.15	0.04	0.11
2009	0.00	0.00	0.01	0.02	0.04	0.10	0.15	0.13	0.04	0.09
2010	0.00	0.00	0.01	0.02	0.04	0.09	0.14	0.12	0.04	0.09
2011	0.00	0.01	0.01	0.02	0.06	0.13	0.19	0.17	0.05	0.12
2012	0.00	0.00	0.01	0.02	0.04	0.11	0.16	0.14	0.04	0.10
2013	0.00	0.01	0.01	0.02	0.05	0.10	0.15	0.13	0.04	0.10

Table C16. Input and output for the yield per recruit analysis.

2014 Operational Assessment

Age	Selectivity	M	Stock wt	Catch wt	SSB wt	Maturity
1	0.02	0.20	0.13	0.17	0.13	0.02
2	0.03	0.20	0.27	0.40	0.27	0.08
3	0.06	0.20	0.62	0.83	0.62	0.26
4	0.13	0.20	1.18	1.55	1.18	0.59
5	0.29	0.20	1.88	2.23	1.88	0.86
6	0.66	0.20	2.64	3.06	2.64	0.96
7	1.00	0.20	3.48	3.82	3.48	0.99
8	0.87	0.20	4.09	4.34	4.09	1.00
9	0.25	0.20	5.36	5.36	5.36	1.00

	F	YPR	SSB/R
F40%	0.42	0.79	4.07

SARC 50

Age	Selectivity	M	Stock wt	Catch wt	SSB wt	Maturity
1	0.01	0.20	0.06	0.10	0.06	0.02
2	0.02	0.20	0.16	0.28	0.16	0.08
3	0.04	0.20	0.44	0.72	0.44	0.26
4	0.08	0.20	0.95	1.32	0.95	0.59
5	0.20	0.20	1.59	2.03	1.59	0.86
6	0.61	0.20	2.42	2.92	2.42	0.96
7	1.00	0.20	3.36	3.80	3.36	0.99
8	0.85	0.20	4.30	4.73	4.30	1.00
9	0.26	0.20	6.39	6.39	6.39	1.00

	F	YPR	SSB/R
F40%	0.41	0.80	4.41

Table C17. Updated reference points compared to SARC 50 estimates for pollock. SSB_{MSY} and MSY are in thousands of metric tons. Recruitment is in millions of age 1 fish.

2014 Operational Assessment

	Median	**5th**	**95th**
SSBmsy	76.9	59.1	102.5
MSY	14.8	10.7	21.4
Recruitment	17.6	7.7	39.7

SARC 50

	Median	**5th**	**95th**
SSBmsy	90.7	70.9	118.1
MSY	16.2	11.8	23.3
Recruitment	19.3	8.4	42.2

Table C18. Percentiles of pollock spawning stock biomass (000s mt) for projections at $F_{status-quo}$, 0.75* $F_{40\%}$, and $F_{40\%}$ from the base model.

	F-status-quo = 0.10 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	85.9	96.0	100.9	111.0	123.4	135.2	146.3	153.3	165.4
2015	93.9	102.6	109.0	119.2	131.6	144.5	157.0	163.7	179.0
2016	101.2	110.9	116.3	126.7	139.3	152.5	166.0	173.5	188.3
2017	103.1	112.9	118.3	128.8	141.1	153.7	166.9	173.9	190.4
2018	103.0	113.0	118.3	128.4	140.0	151.9	164.1	171.2	186.3
2019	101.5	110.9	116.2	125.4	136.3	148.0	159.2	166.3	180.1
2020	102.4	111.9	117.1	126.2	137.1	149.1	160.9	168.4	182.9
2021	100.3	109.3	114.4	123.3	134.3	146.5	159.0	166.7	182.2

	0.75*F40% = 0.20 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	85.9	96.0	100.9	111.0	123.4	135.2	146.3	153.3	165.4
2015	93.9	102.6	109.0	119.2	131.6	144.5	157.0	163.7	179.0
2016	95.4	104.5	109.4	119.4	131.3	143.6	156.3	163.4	178.0
2017	91.7	100.5	105.4	114.8	125.8	136.8	148.6	155.1	169.7
2018	86.2	94.6	99.1	107.6	117.2	127.2	137.3	143.3	155.9
2019	80.3	87.9	92.1	99.5	108.1	117.6	126.8	132.6	143.9
2020	78.0	85.2	89.3	96.4	105.0	114.7	124.7	130.8	143.3
2021	74.7	81.7	85.7	92.8	101.6	111.7	122.3	128.9	142.1

	F40% = 0.27 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	85.9	96.0	100.9	111.0	123.4	135.2	146.3	153.3	165.4
2015	93.9	102.6	109.0	119.2	131.6	144.5	157.0	163.7	179.0
2016	91.9	100.6	105.2	115.0	126.5	138.2	150.6	157.4	171.9
2017	85.3	93.6	98.2	107.0	117.2	127.4	138.4	144.5	158.1
2018	77.3	84.9	88.9	96.6	105.2	114.2	123.2	128.7	139.8
2019	69.9	76.5	80.2	86.6	94.3	102.6	110.9	116.1	126.4
2020	66.3	72.6	76.1	82.3	90.0	98.7	107.8	113.6	124.9
2021	62.9	68.9	72.4	78.7	86.5	95.8	105.5	111.6	123.9

Table C19. Percentiles of Pollock catch (000s mt) for projections at $F_{status\text{-}quo}$, 0.75* $F_{40\%}$, and $F_{40\%}$ from the base model.

	F-status-quo = 0.10 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	6.0	6.6	6.9	7.6	8.4	9.2	10.0	10.5	11.3
2016	6.7	7.3	7.7	8.3	9.1	10.0	10.9	11.2	12.2
2017	7.9	8.8	9.2	9.9	10.9	11.9	12.9	13.5	14.9
2018	8.0	9.1	9.5	10.4	11.3	12.4	13.4	14.1	15.5
2019	7.1	7.9	8.3	9.0	9.7	10.6	11.5	12.0	13.1
2020	6.0	6.6	6.9	7.5	8.2	9.0	9.9	10.5	11.6
2021	6.1	6.7	7.1	7.8	8.7	9.8	11.1	12.0	13.5

	0.75*F40% = 0.20 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	11.9	13.1	13.8	15.0	16.6	18.2	19.8	20.7	22.3
2016	12.4	13.5	14.1	15.4	16.9	18.4	20.0	20.8	22.6
2017	13.7	15.2	16.0	17.3	19.0	20.7	22.5	23.5	26.1
2018	13.1	14.8	15.6	16.9	18.5	20.1	21.9	23.1	25.2
2019	11.2	12.3	12.9	14.0	15.2	16.6	17.9	18.7	20.4
2020	9.4	10.3	10.9	11.8	13.0	14.3	15.9	17.0	19.1
2021	9.4	10.4	11.0	12.2	13.7	15.5	17.7	19.1	21.6

	F40% = 0.27 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	15.5	17.0	17.8	19.5	21.5	23.6	25.7	26.8	29.0
2016	15.4	16.7	17.6	19.1	20.9	22.8	24.9	25.8	28.1
2017	16.3	18.3	19.1	20.8	22.8	24.8	27.0	28.2	31.3
2018	15.1	17.0	17.9	19.5	21.2	23.2	25.1	26.5	29.0
2019	12.6	13.8	14.5	15.7	17.1	18.6	20.1	21.0	22.9
2020	10.7	11.7	12.3	13.4	14.8	16.4	18.2	19.7	22.2
2021	10.5	11.6	12.4	13.7	15.4	17.5	20.1	21.8	24.7

Table C20. Percentiles of Pollock spawning stock biomass (000s mt) for projections at $F_{status\text{-}quo}$, 0.75* $F_{40\%}$, and $F_{40\%}$ from Mohn's rho-adjusted flat survey selectivity sensitivity run.

	F-status-quo = 0.20 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	20.7	23.9	25.4	28.2	32.0	36.4	40.8	43.4	49.4
2015	21.2	24.5	26.3	29.8	34.1	39.2	44.9	47.4	53.5
2016	24.8	28.2	30.2	33.9	37.9	43.2	48.6	51.2	57.9
2017	26.9	30.2	32.2	36.0	39.9	44.7	49.9	52.7	58.4
2018	28.7	32.0	34.0	37.5	41.5	46.2	51.0	54.0	59.6
2019	29.8	33.1	35.1	38.6	43.1	48.2	53.7	57.2	64.0
2020	31.7	35.2	37.4	41.5	46.9	53.1	59.9	64.3	72.6
2021	32.7	36.6	39.1	43.8	49.9	57.2	64.8	69.6	78.8

	0.75*F40% = 0.18 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	20.7	23.9	25.4	28.2	32.0	36.4	40.8	43.4	49.4
2015	21.2	24.5	26.3	29.8	34.1	39.2	44.9	47.4	53.5
2016	24.9	28.4	30.4	34.2	38.2	43.5	49.0	51.6	58.3
2017	27.2	30.6	32.7	36.4	40.5	45.3	50.5	53.5	59.2
2018	29.2	32.6	34.7	38.2	42.3	47.1	52.0	55.1	60.8
2019	30.5	33.9	35.9	39.5	44.0	49.3	54.8	58.3	65.2
2020	32.5	36.2	38.3	42.5	48.0	54.4	61.1	65.6	74.0
2021	33.6	37.5	40.1	44.8	51.0	58.5	66.2	71.0	80.3

	F40% = 0.24 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	20.7	23.9	25.4	28.2	32.0	36.4	40.8	43.4	49.4
2015	21.2	24.5	26.3	29.8	34.1	39.2	44.9	47.4	53.5
2016	24.1	27.4	29.4	32.9	36.8	41.8	47.1	49.6	56.0
2017	25.5	28.6	30.5	34.1	37.8	42.2	47.1	49.9	55.2
2018	26.6	29.6	31.5	34.7	38.4	42.7	47.2	49.9	55.2
2019	27.0	30.0	31.8	35.0	39.2	44.0	49.2	52.6	59.0
2020	28.3	31.5	33.5	37.3	42.4	48.4	54.9	59.2	67.0
2021	29.0	32.6	34.9	39.3	45.1	52.1	59.4	63.9	72.7

Table C21. Percentiles of Pollock catch (000s mt) for projections at $F_{status-quo}$, 0.75* $F_{40\%}$, and $F_{40\%}$ from Mohn's rho-adjusted flat survey selectivity sensitivity run.

	F-status-quo = 0.20 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	3.1	3.7	4.0	4.5	5.2	6.1	6.9	7.4	8.4
2016	3.8	4.4	4.7	5.3	5.9	6.7	7.5	8.0	8.9
2017	4.8	5.4	5.7	6.4	7.1	7.9	8.9	9.4	10.5
2018	5.3	5.9	6.3	7.0	7.7	8.6	9.6	10.1	11.3
2019	5.0	5.5	5.9	6.5	7.1	7.9	8.7	9.3	10.2
2020	5.0	5.5	5.8	6.4	7.2	8.1	9.1	9.9	11.2
2021	5.3	5.9	6.3	7.2	8.3	9.7	11.3	12.4	14.3

	0.75*F40% = 0.18 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	2.9	3.5	3.8	4.3	5.0	5.7	6.5	7.0	7.9
2016	3.6	4.2	4.5	5.0	5.6	6.4	7.2	7.6	8.5
2017	4.6	5.2	5.5	6.1	6.8	7.6	8.5	9.0	10.1
2018	5.1	5.7	6.1	6.8	7.5	8.3	9.3	9.8	10.9
2019	4.9	5.4	5.7	6.3	6.9	7.7	8.5	9.0	9.9
2020	4.8	5.3	5.6	6.2	7.0	7.8	8.8	9.6	10.8
2021	5.2	5.8	6.2	7.0	8.1	9.4	10.9	12.0	13.8

	F40% = 0.24 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	3.8	4.5	4.9	5.5	6.4	7.4	8.4	9.0	10.2
2016	4.5	5.1	5.5	6.2	6.9	7.8	8.8	9.4	10.5
2017	5.5	6.2	6.6	7.3	8.1	9.1	10.2	10.8	12.0
2018	5.9	6.6	7.0	7.8	8.6	9.6	10.7	11.3	12.6
2019	5.5	6.1	6.4	7.1	7.8	8.7	9.6	10.1	11.2
2020	5.4	6.0	6.3	7.0	7.9	9.0	10.1	11.1	12.6
2021	5.7	6.4	6.9	7.8	9.1	10.7	12.5	13.7	15.8

Table C22. Percentiles of Pollock spawning stock biomass (000s mt) for projections at $F_{status-quo}$, 0.75* $F_{40\%}$, and $F_{40\%}$ from the reduced 2011 year-class sensitivity run.

	F-status-quo = 0.10 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	84.0	94.1	98.8	108.7	120.9	132.6	143.5	150.1	161.7
2015	85.8	95.1	101.0	110.6	122.6	135.1	146.5	152.9	166.7
2016	89.2	96.5	102.3	111.5	122.7	134.7	146.4	151.7	166.0
2017	88.3	95.9	100.7	109.8	120.4	131.3	142.3	148.0	161.5
2018	88.3	96.0	100.6	109.2	119.1	129.5	139.5	145.3	157.5
2019	88.6	96.5	101.1	109.3	118.9	129.3	139.1	145.4	157.8
2020	89.9	98.1	102.8	110.9	120.7	131.6	142.5	149.4	163.0
2021	89.9	98.1	102.7	111.0	121.3	132.9	144.8	152.4	167.3

	0.75*F40% = 0.20 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	84.0	94.1	98.8	108.7	120.9	132.6	143.5	150.1	161.7
2015	85.8	95.1	101.0	110.6	122.6	135.1	146.5	152.9	166.7
2016	83.4	90.4	95.9	104.4	114.9	126.2	137.1	142.1	155.8
2017	77.9	84.7	89.0	97.1	106.4	115.9	125.7	130.8	142.9
2018	73.7	80.3	84.2	91.5	99.7	108.4	116.7	121.6	132.0
2019	71.0	77.5	81.3	87.8	95.7	104.3	112.6	117.9	128.4
2020	69.9	76.5	80.2	86.8	94.8	104.0	113.5	119.5	131.4
2021	68.3	74.9	78.6	85.4	93.8	103.7	114.1	120.6	133.6

	F40% = 0.27 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	84.0	94.1	98.8	108.7	120.9	132.6	143.5	150.1	161.7
2015	85.8	95.1	101.0	110.6	122.6	135.1	146.5	152.9	166.7
2016	80.0	86.8	92.1	100.3	110.3	121.1	131.5	136.5	149.7
2017	72.1	78.5	82.5	90.0	98.6	107.4	116.5	121.2	132.6
2018	66.1	72.2	75.6	82.2	89.6	97.5	104.9	109.3	118.7
2019	62.3	68.1	71.4	77.2	84.3	91.9	99.6	104.4	114.1
2020	60.3	66.1	69.4	75.2	82.5	90.8	99.7	105.5	116.4
2021	58.2	63.9	67.3	73.3	81.0	90.1	99.7	105.8	117.9

Table C23. Percentiles of Pollock catch (000s mt) for projections at $F_{status\text{-}quo}$, 0.75* $F_{40\%}$, and $F_{40\%}$ from the reduced 2011 year-class sensitivity run.

	F-status-quo = 0.10 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	5.7	6.3	6.6	7.2	8.0	8.8	9.6	10.0	10.8
2016	6.0	6.5	6.9	7.5	8.2	9.0	9.8	10.1	11.0
2017	6.5	7.0	7.4	8.0	8.8	9.5	10.3	10.8	11.8
2018	6.1	6.7	7.1	7.7	8.4	9.1	9.9	10.3	11.4
2019	5.7	6.2	6.5	7.0	7.7	8.4	9.0	9.4	10.3
2020	5.5	6.1	6.4	6.9	7.6	8.4	9.2	9.9	11.0
2021	5.7	6.3	6.7	7.4	8.3	9.3	10.6	11.6	13.1

	0.75*F40% = 0.20 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	11.3	12.5	13.1	14.4	15.9	17.4	19.0	19.9	21.3
2016	11.0	11.9	12.6	13.8	15.1	16.4	17.9	18.5	20.1
2017	11.2	12.0	12.7	13.7	15.1	16.4	17.8	18.5	20.3
2018	10.1	11.0	11.6	12.6	13.7	14.9	16.2	16.9	18.6
2019	9.1	10.0	10.5	11.3	12.3	13.4	14.5	15.2	16.6
2020	8.9	9.7	10.2	11.1	12.3	13.6	15.1	16.3	18.3
2021	8.9	9.9	10.5	11.7	13.1	14.9	17.1	18.6	21.0

	F40% = 0.27 (average F on ages 5-7)								
YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2014	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
2015	14.7	16.2	17.0	18.6	20.6	22.6	24.6	25.7	27.6
2016	13.6	14.7	15.6	17.0	18.6	20.3	22.1	22.9	24.8
2017	13.3	14.3	15.1	16.3	17.9	19.4	21.1	22.0	24.1
2018	11.6	12.8	13.4	14.6	15.8	17.2	18.7	19.5	21.5
2019	10.4	11.4	12.0	13.0	14.1	15.4	16.7	17.4	19.1
2020	10.1	11.1	11.7	12.7	14.1	15.6	17.5	19.0	21.4
2021	10.0	11.1	11.9	13.2	14.9	17.0	19.6	21.3	24.2

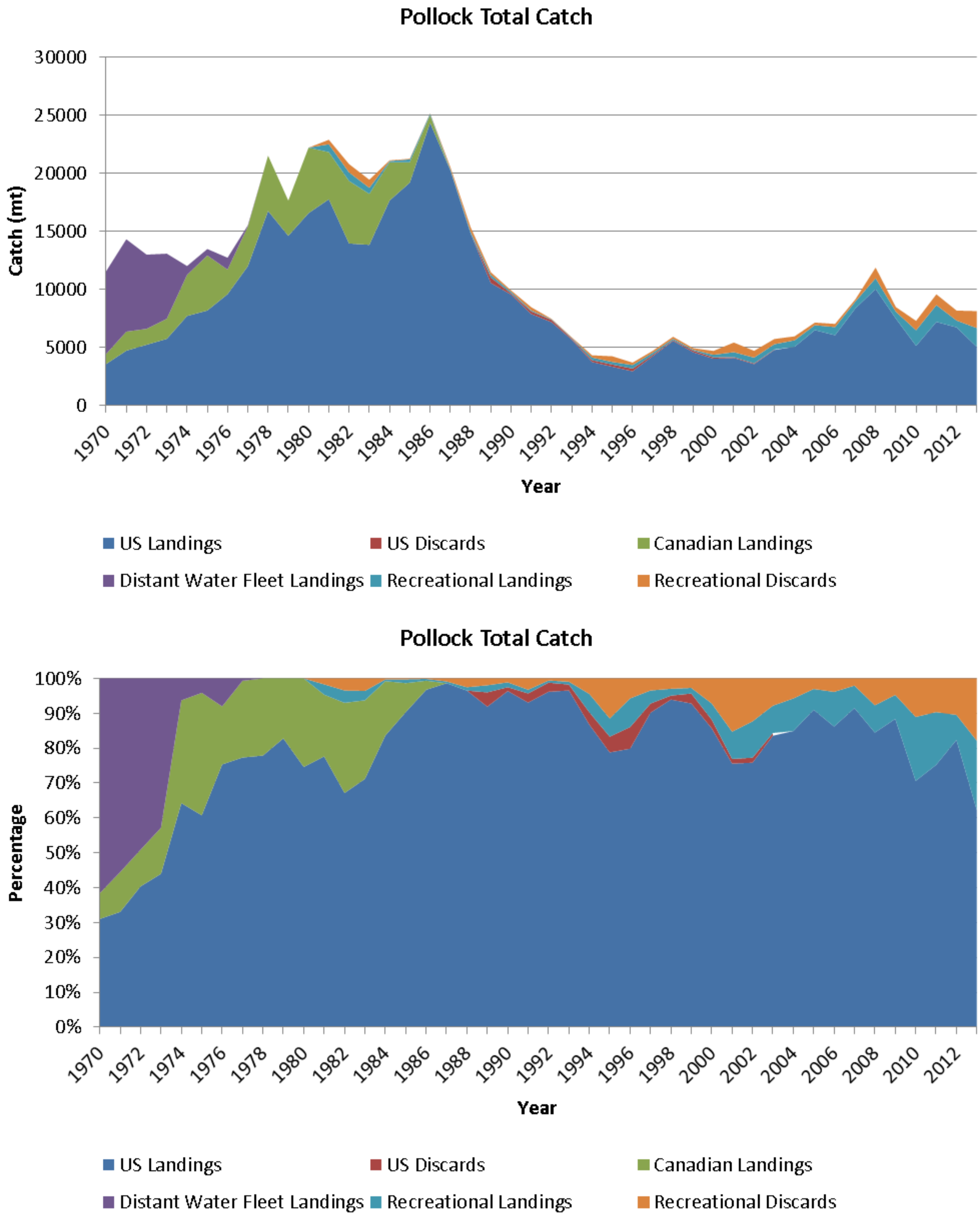

Figure C1. Total catch of pollock in US areas 5&6 by commercial and recreational fisheries in weight (mt; top panel) and in percentages (bottom panel).

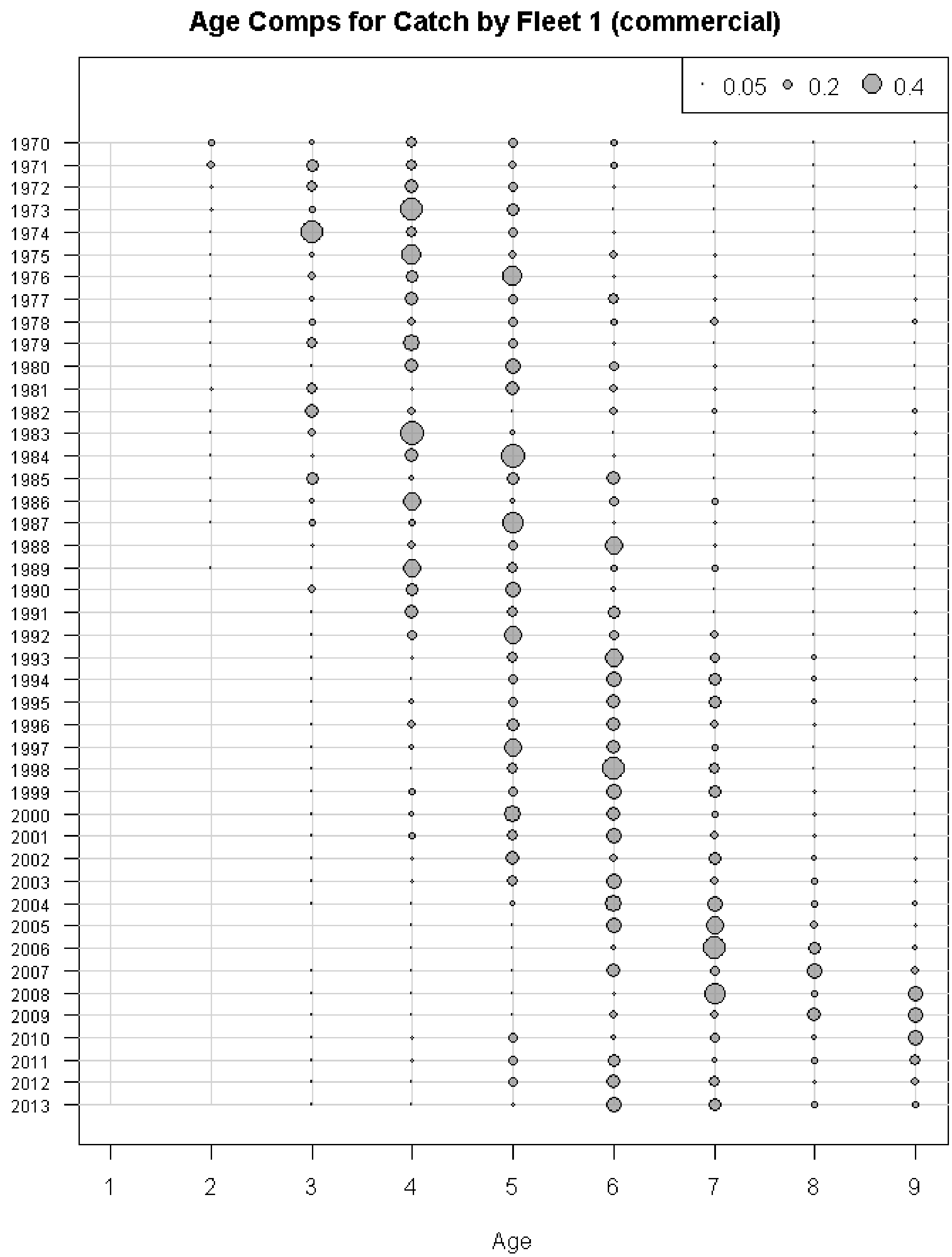

Figure C2. Total commercial landings at age of pollock expressed as a proportion of total annual landings.

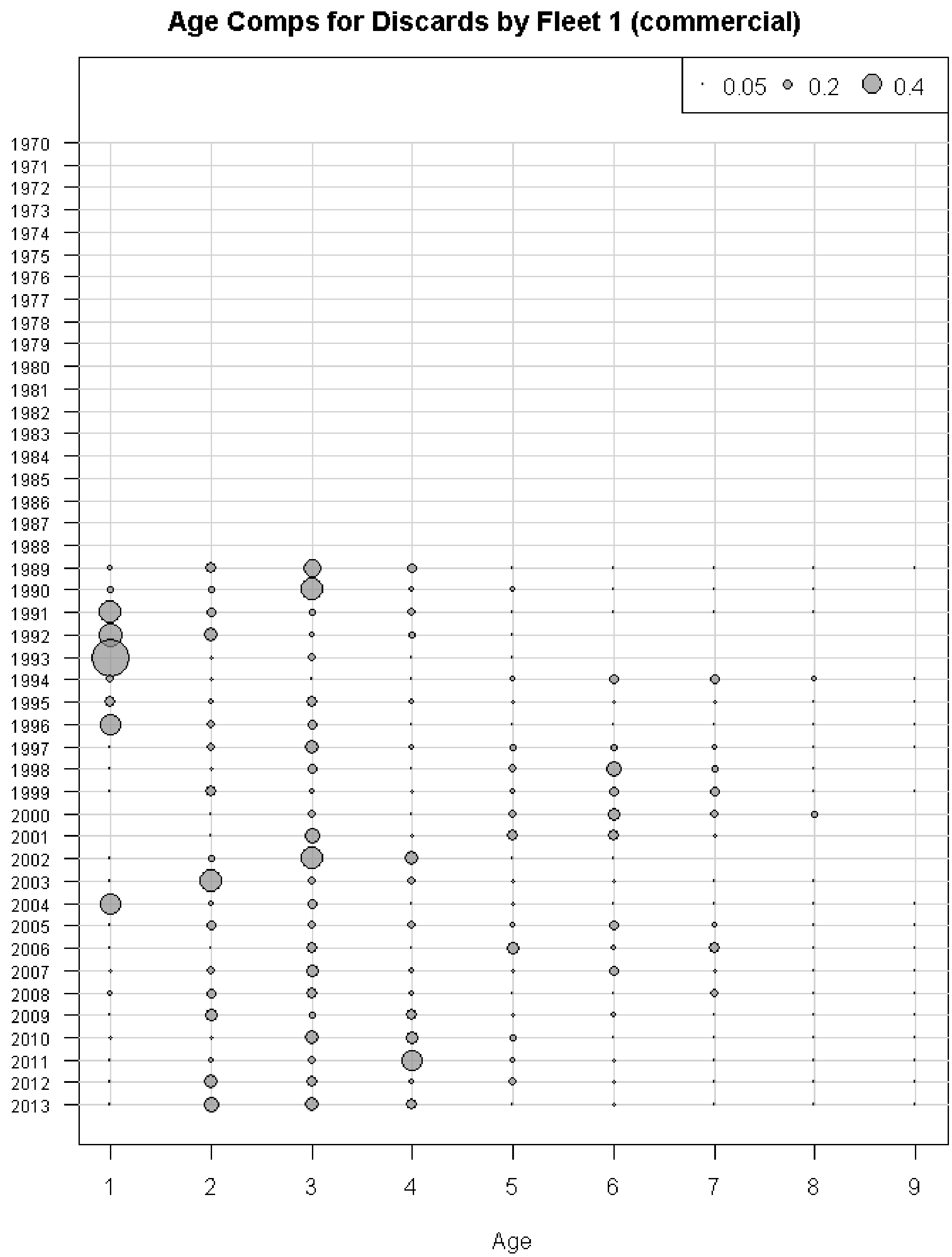

Figure C3. Total commercial discards at age of pollock expressed as a proportion of total annual discards.

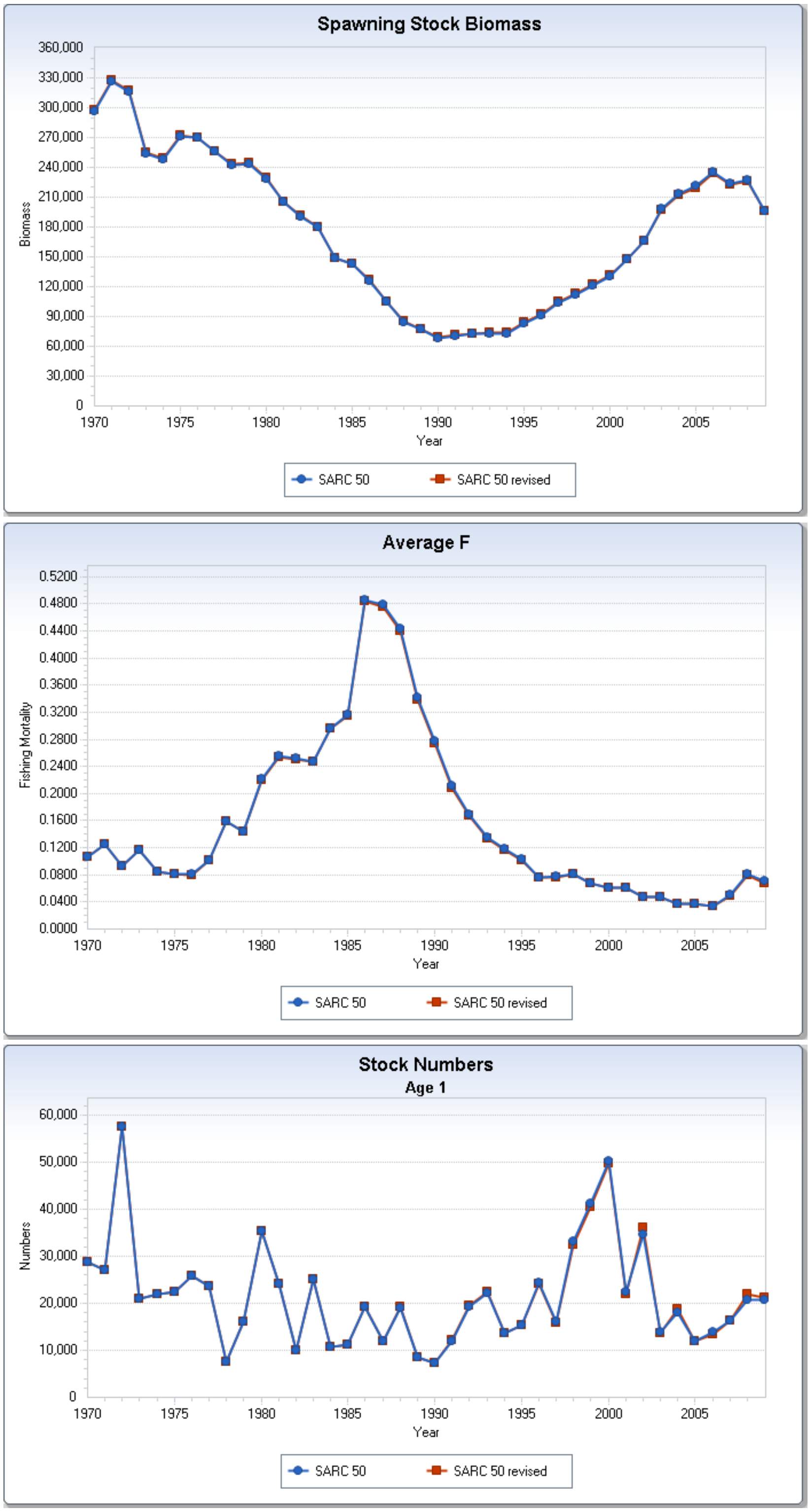

Figure C4. Estimated spawning stock biomass, average F (ages 5-7), and age 1 recruitment of pollock from the original SARC 50 base model and revised SARC 50 base model (i.e., with revised commercial discards at age for 2001-2008).

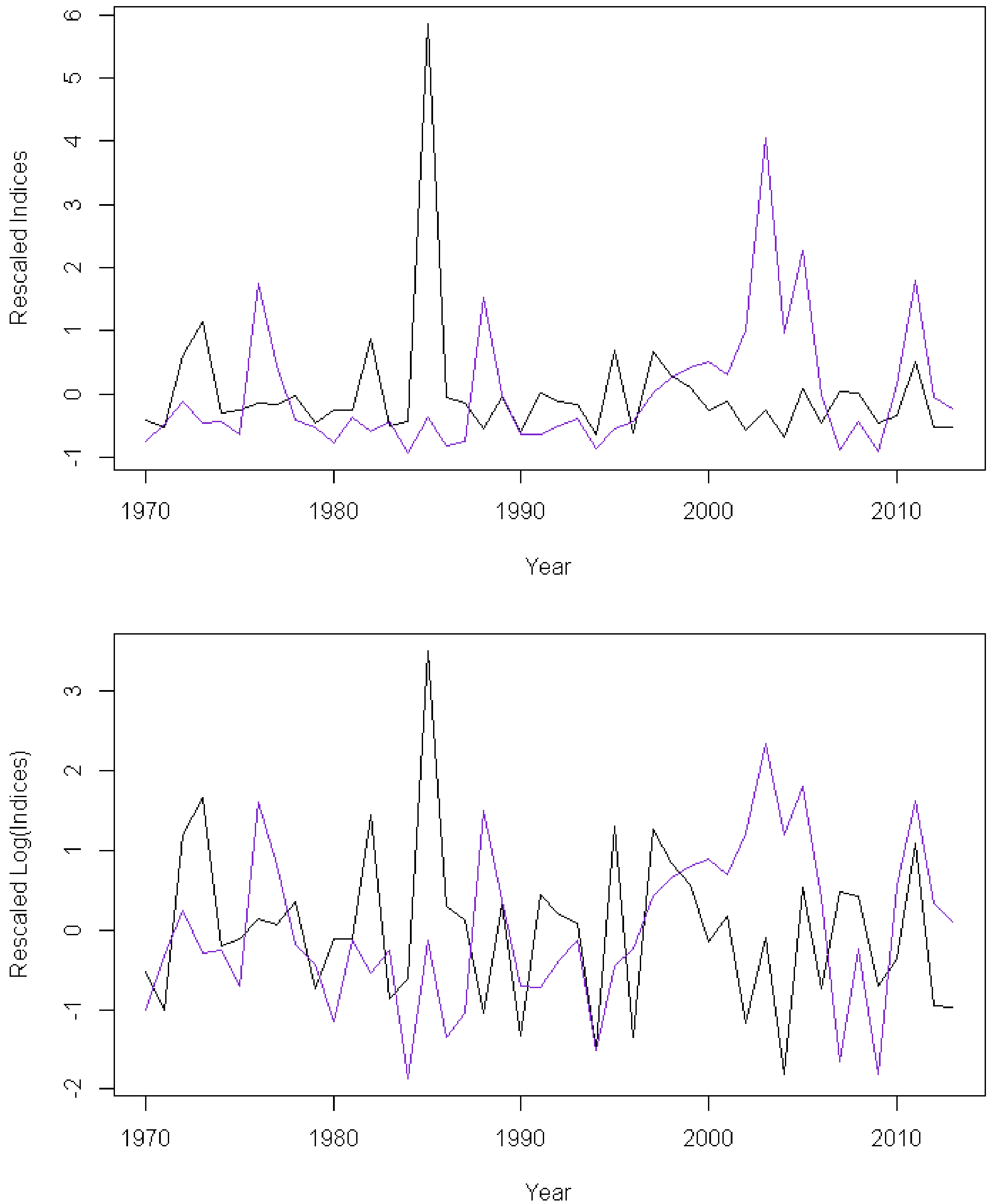

Figure C5. Rescaled NEFSC spring (black line) and fall (purple line) bottom trawl survey indices (top panel). Rescaled NEFSC spring (black line) and fall (purple line) bottom trawl survey log indices (bottom panel). Rescaled indices based on numbers of fish/tow.

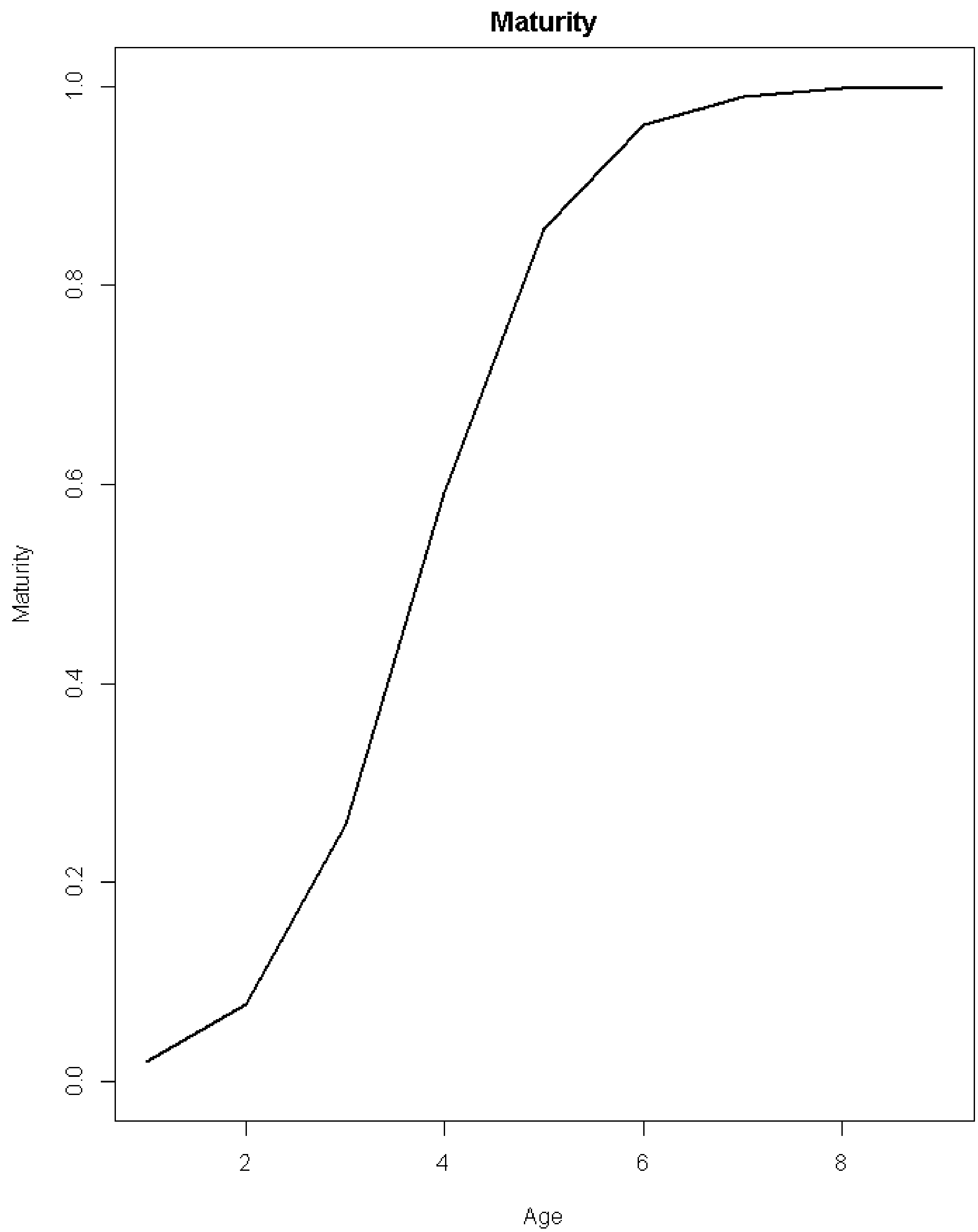

Figure C6. Pollock maturity at age, pooled across all years, from samples in the NEFSC fall bottom trawl survey.

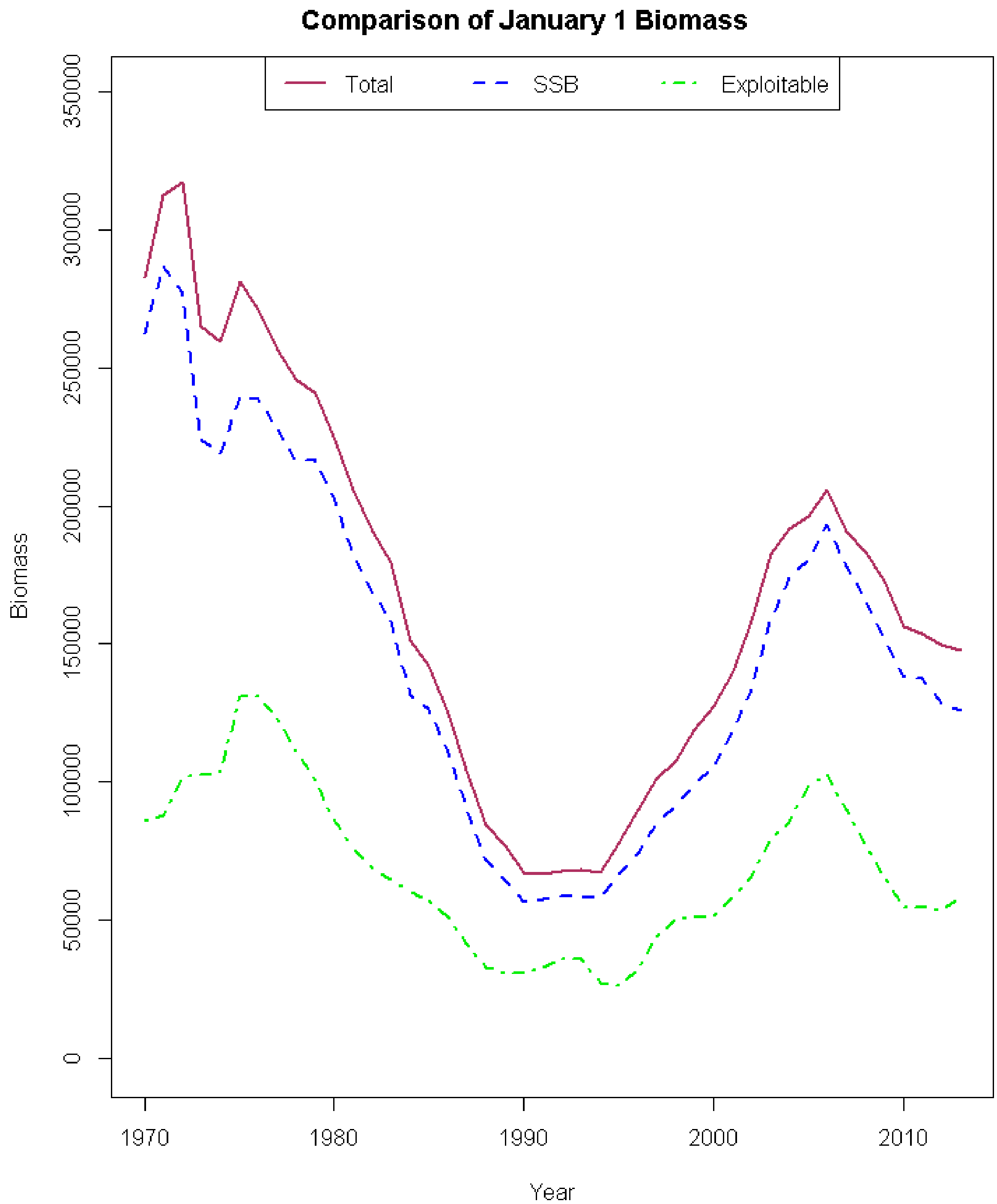

Figure C7. Annual estimates of biomass (mt) from the ASAP base model.

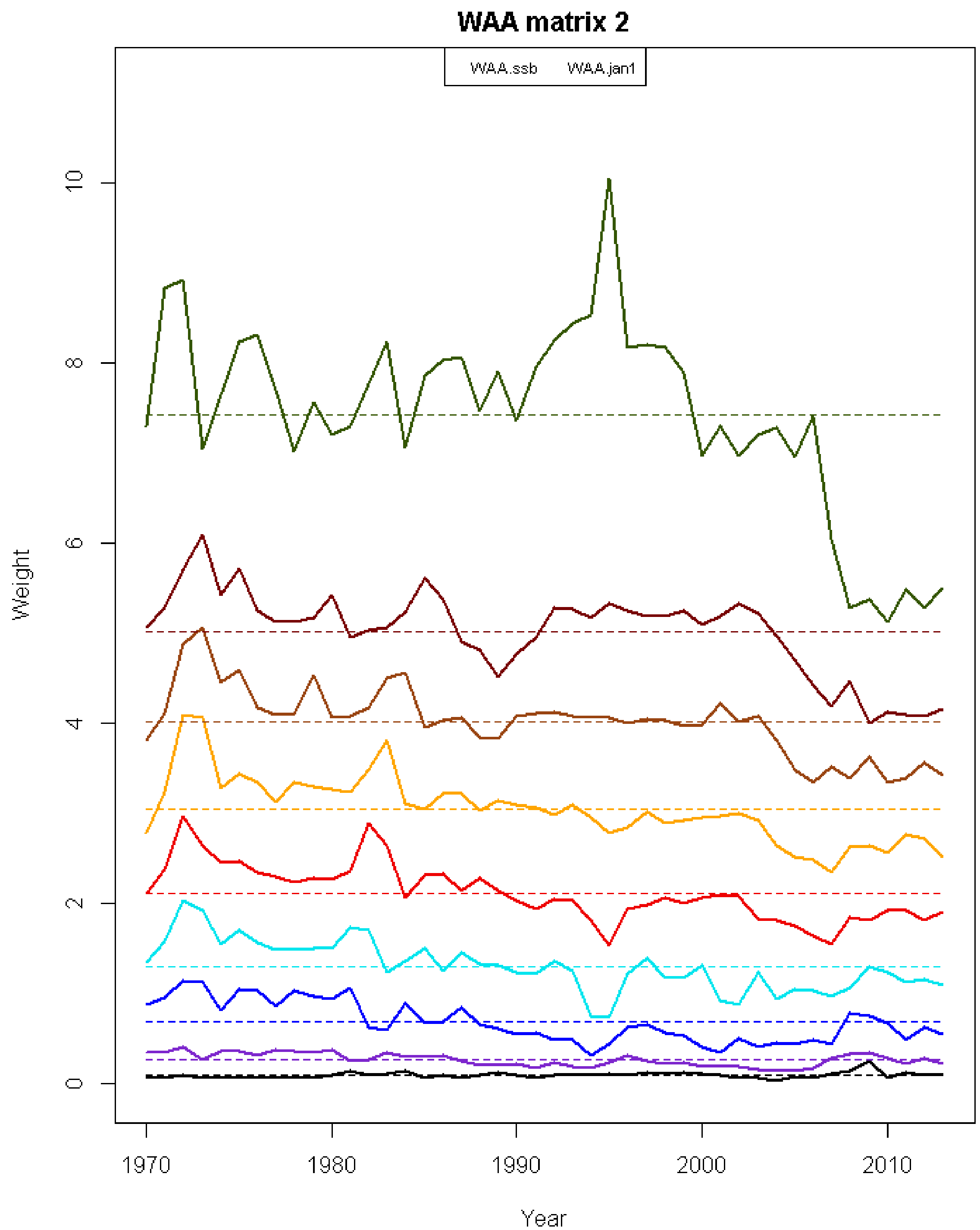

Figure C8. January 1 weights at age (kg), assumed to reflect spawning weights at age, derived by applying the Rivard method to mid-year catch weights at age.

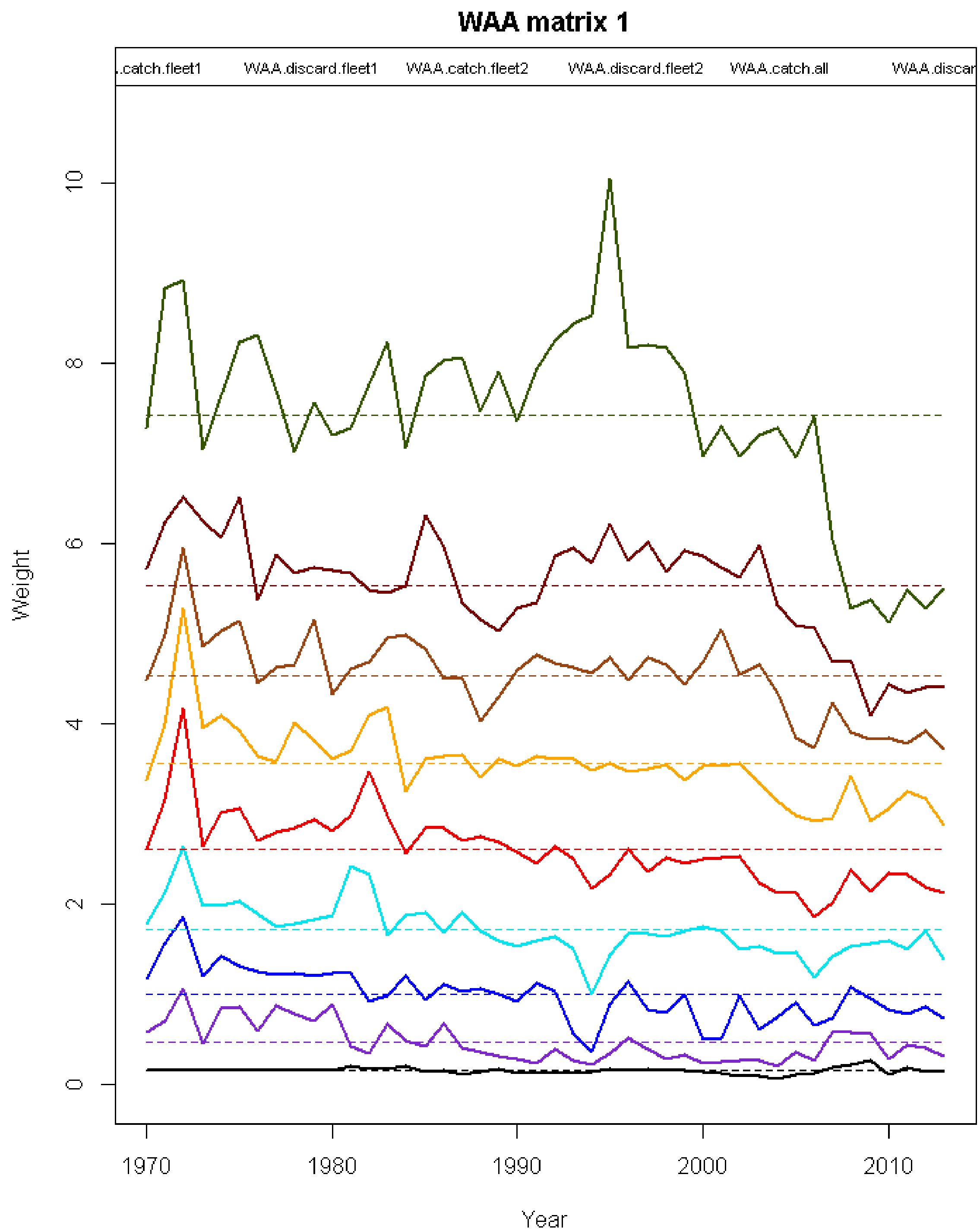

Figure C9. Catch weights at age (kg), assumed to reflect mid-year weights at age.

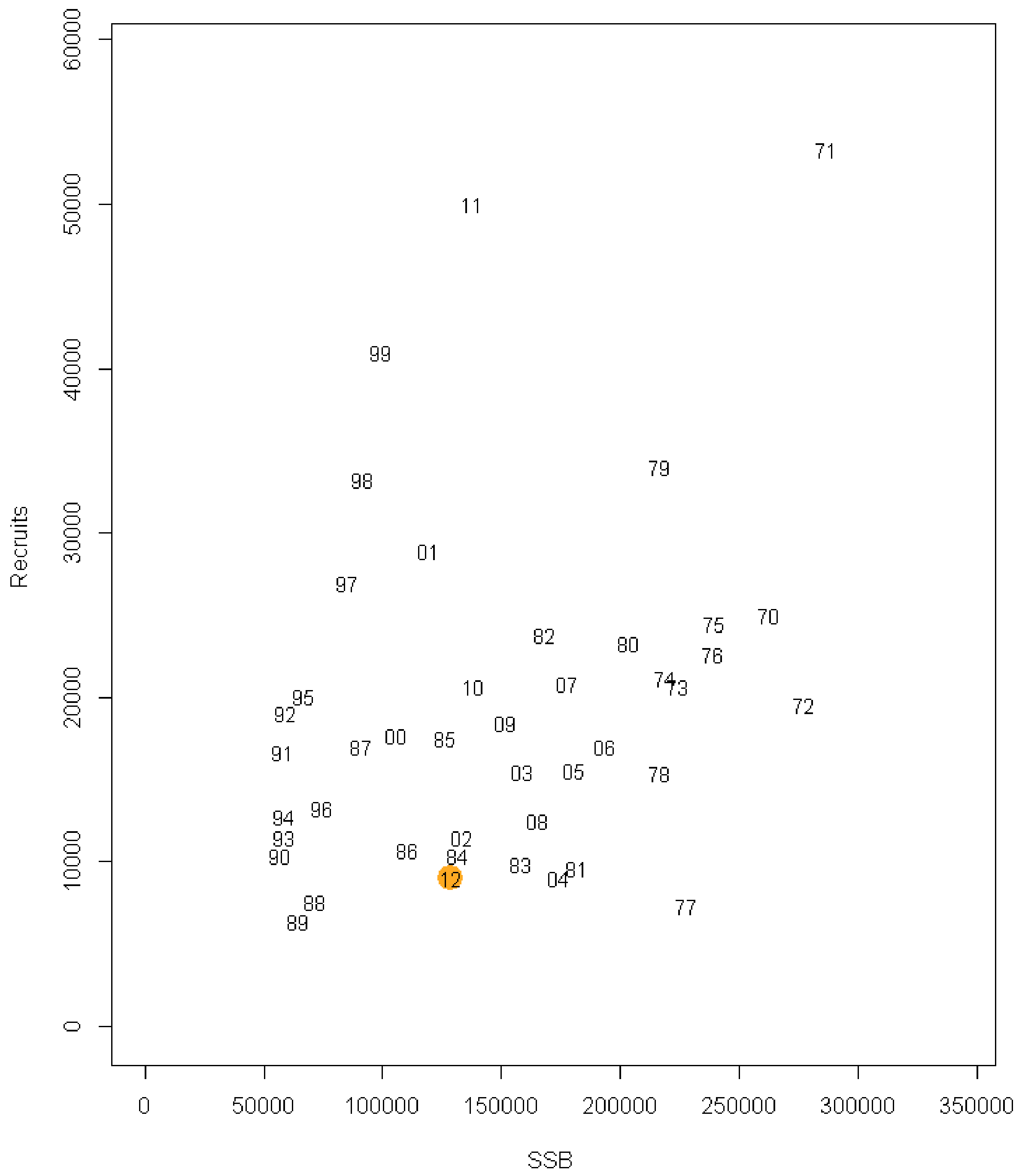

Figure C10. Scatterplot of ASAP base model estimates of spawning stock biomass (SSB, mt) versus recruitment at age 1 (thousands of fish). The symbol for each observation is the last two digits of the year-class (e.g. ‘70’ is the model estimate of age 1 recruitment in year 1971). The most recent age 1 recruitment estimate for 2013 (i.e., ‘12’) is highlighted by a filled orange circle.

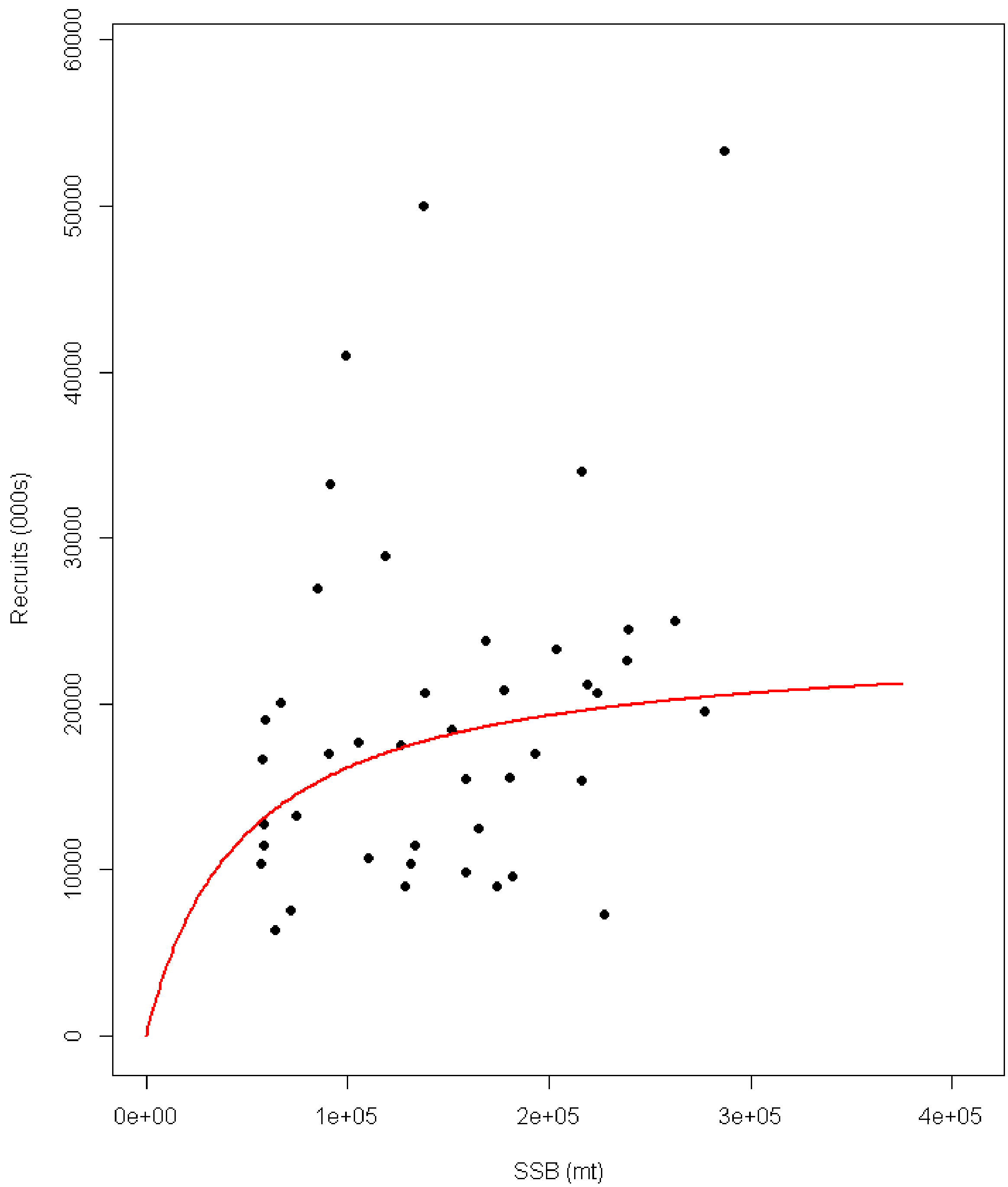

Figure C11. ASAP base model estimates of the predicted stock recruit relationship (solid red line) and the estimated spawning stock biomass (SSB mt) and age 1 recruits (in thousands of fish).

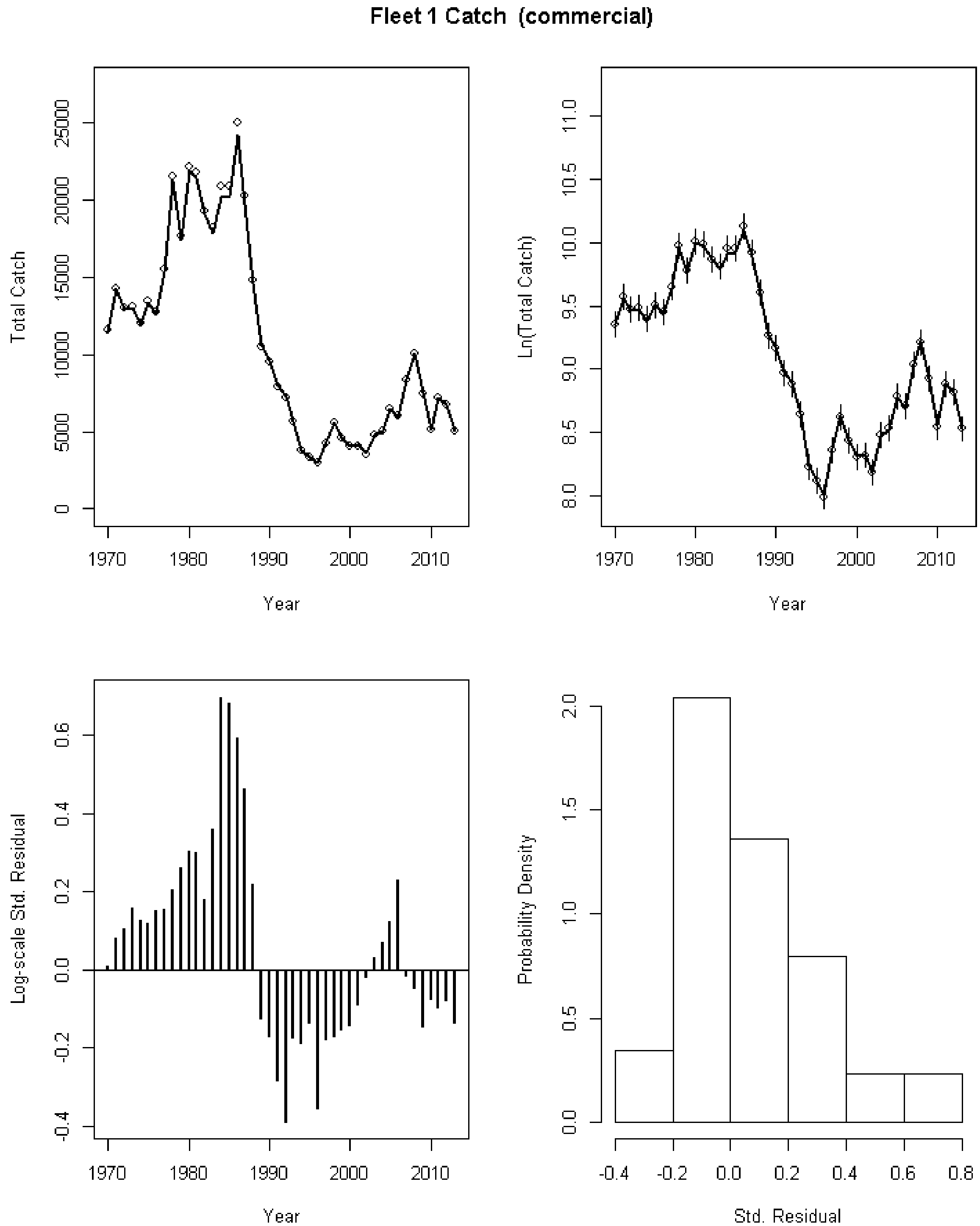

Figure C12. ASAP base model fit to commercial landings.

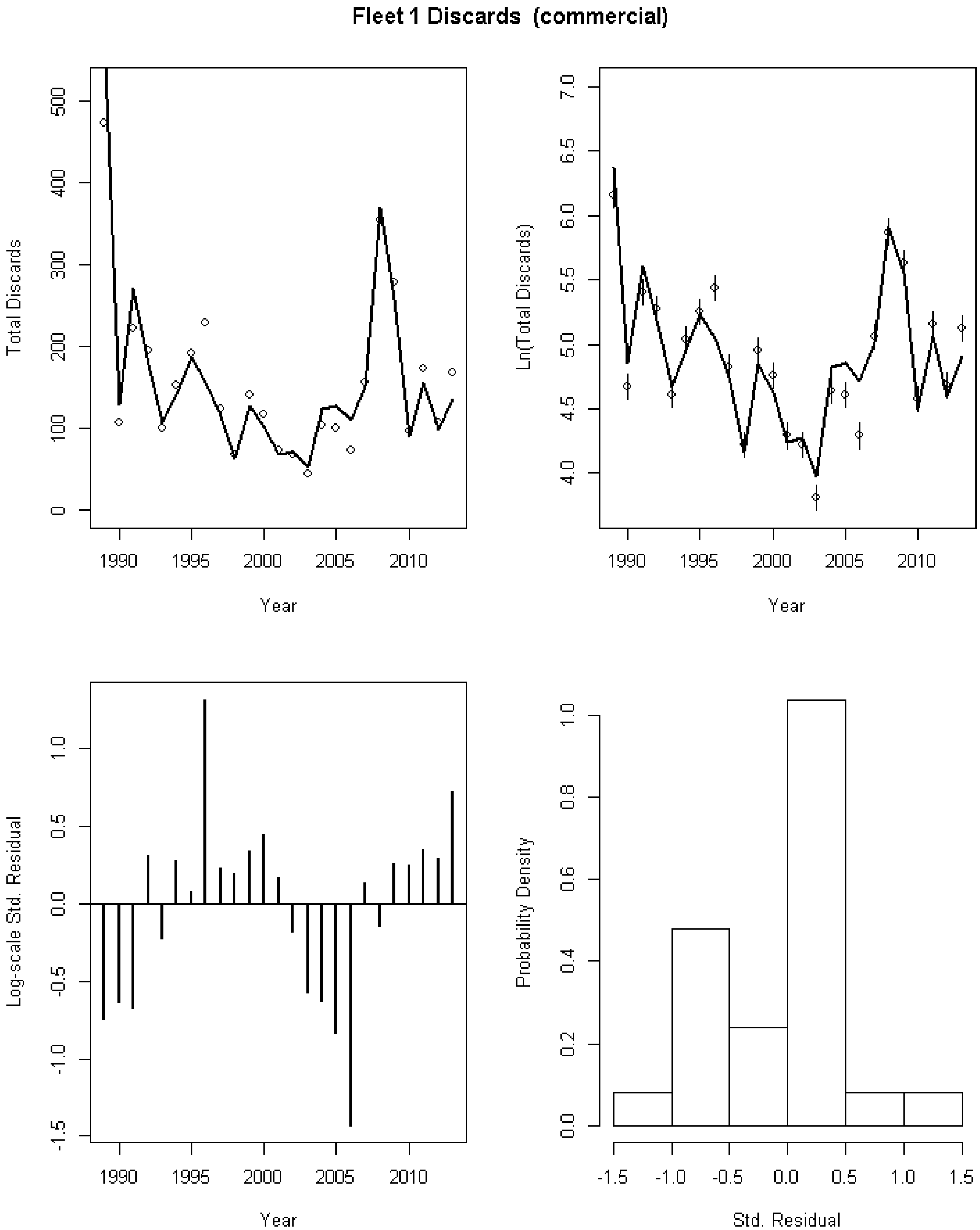

Figure C13. ASAP base model fit to commercial discards.

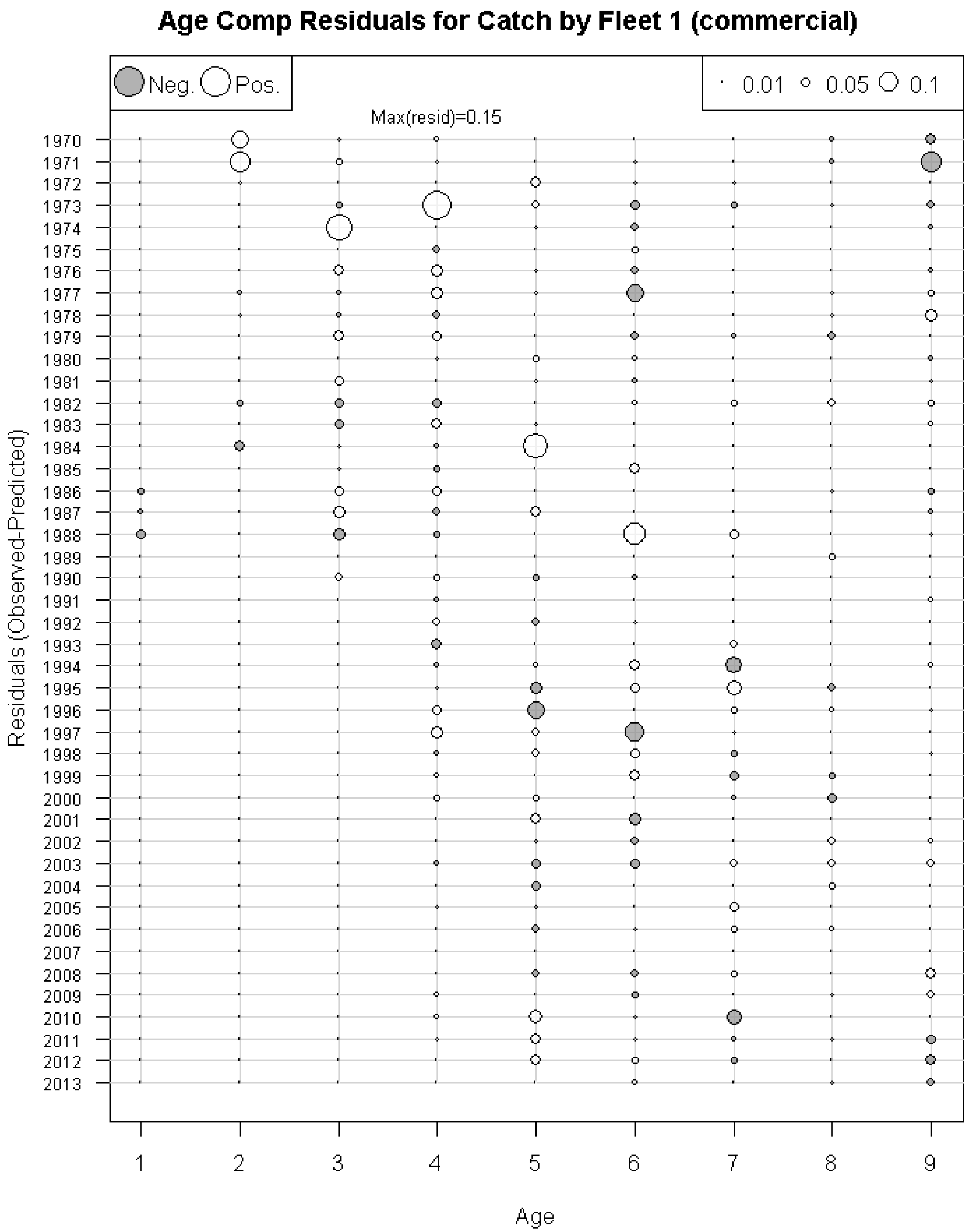

Figure C14. ASAP base model residuals for commercial catch age composition. Open circles are positive residuals, filled circles are negative residuals, calculated as (Observed-Predicted).

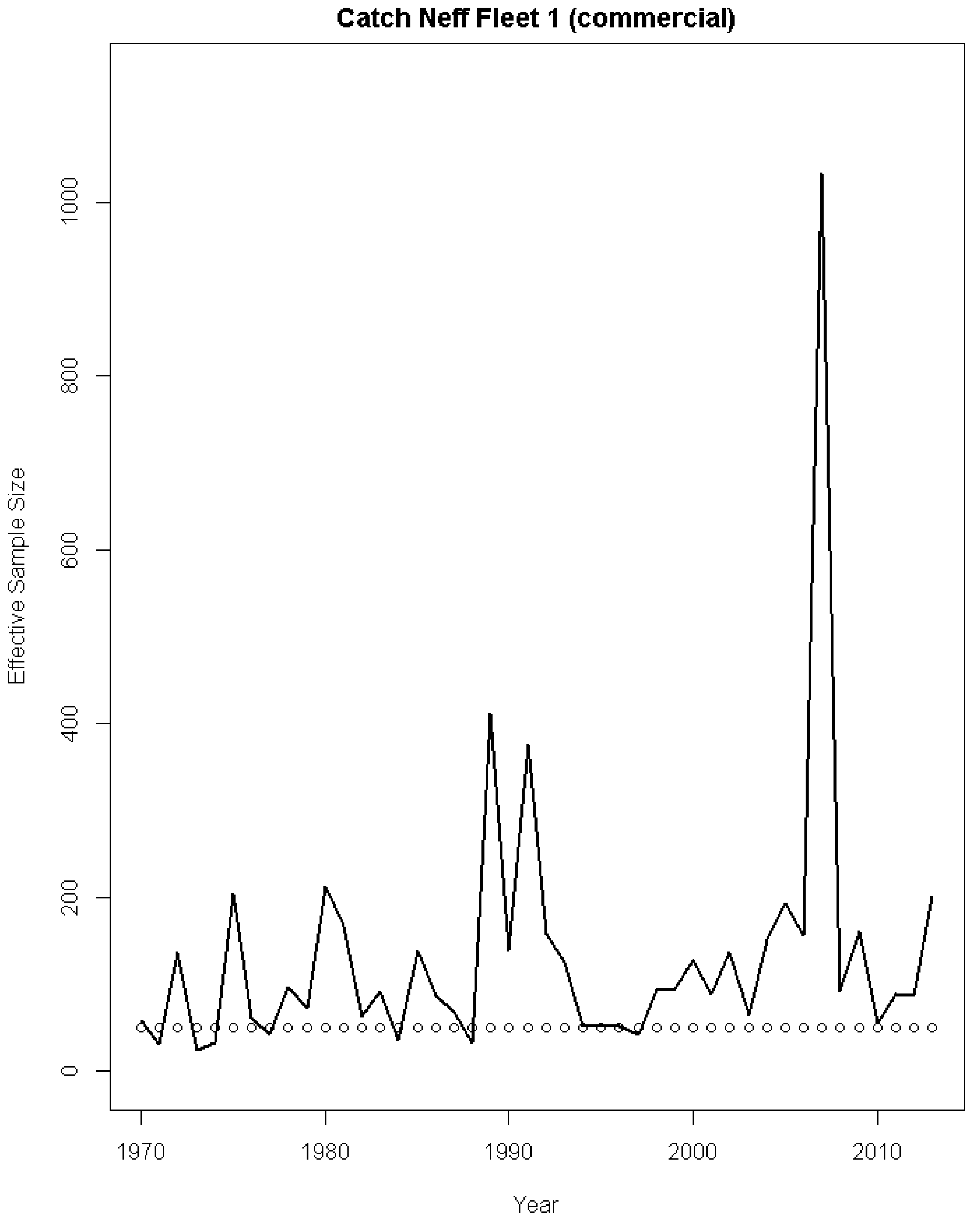

Figure C15. ASAP base model comparison of input effective sample size (circles) versus the model estimated effective sample size (line) for the commercial fleet.

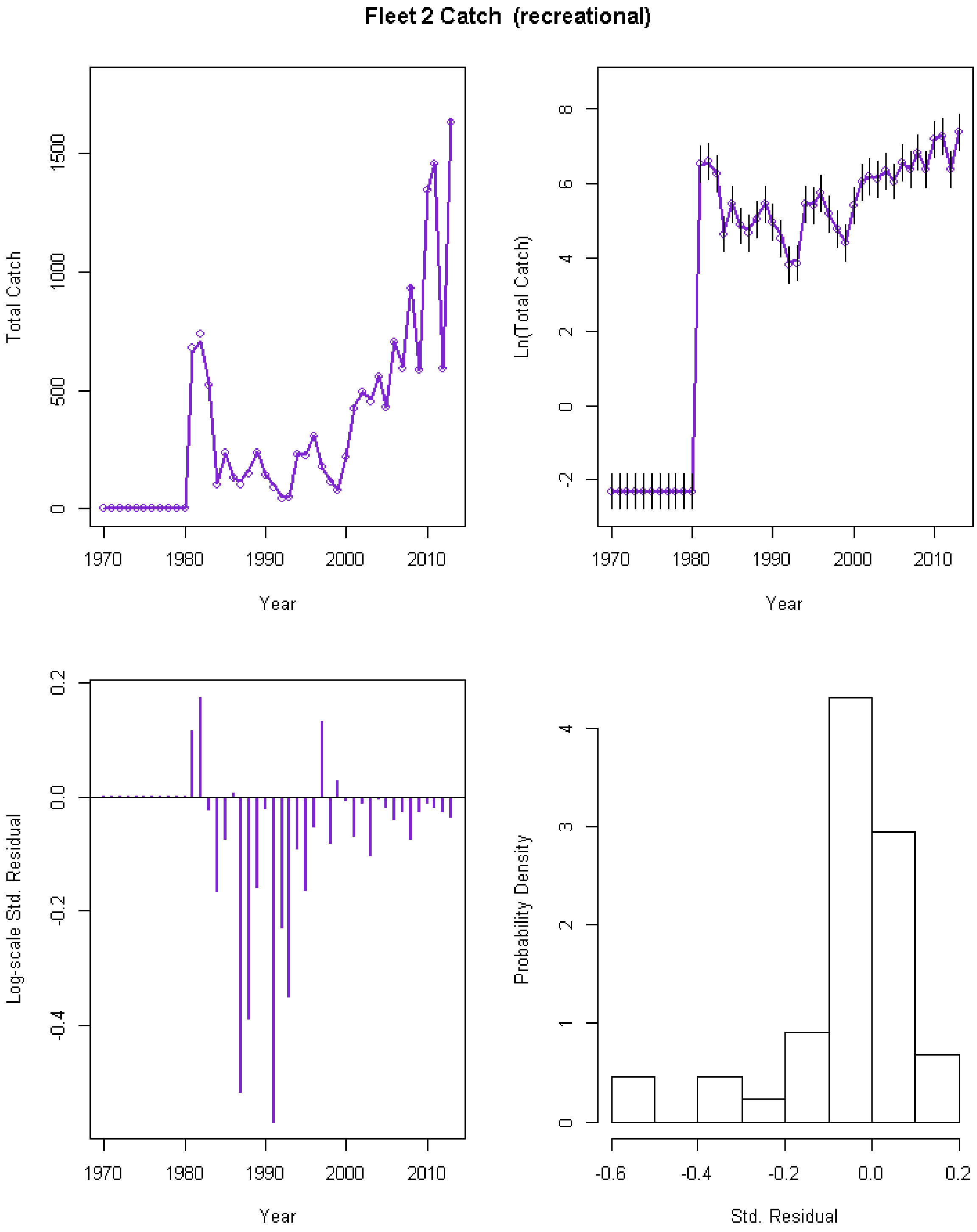

Figure C16. ASAP base model fit to recreational landings.

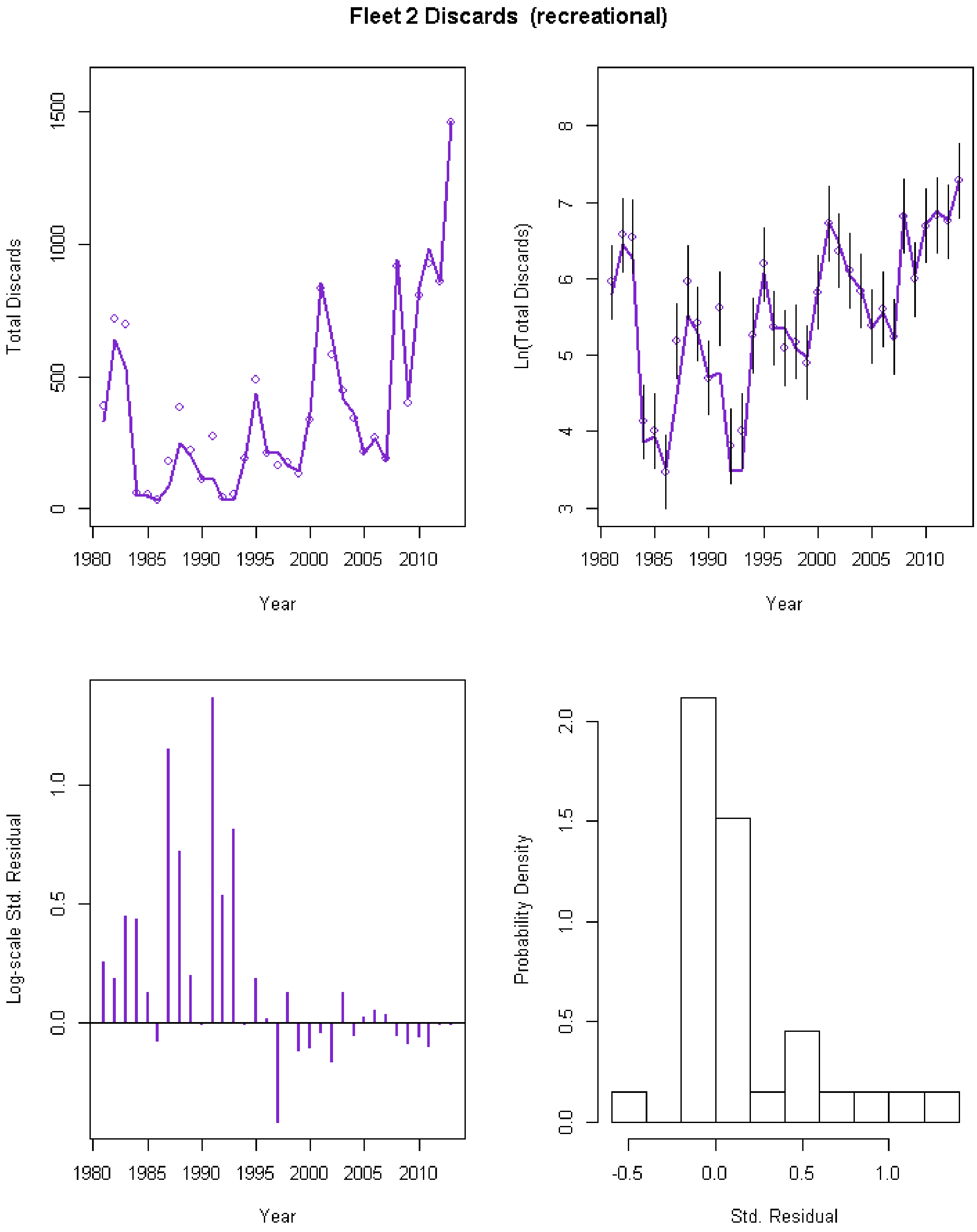

Figure C17. ASAP base model fit to recreational discards.

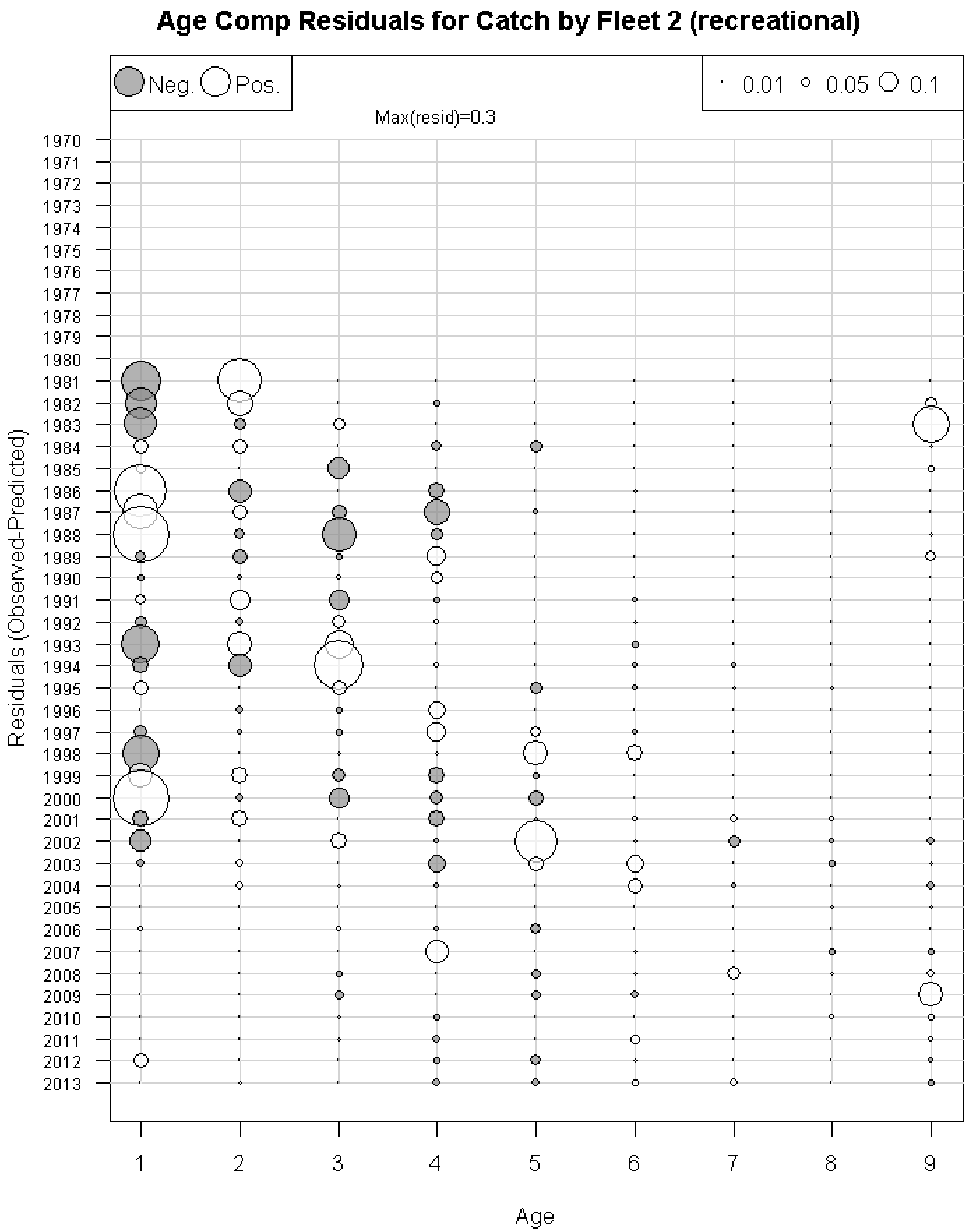

Figure C18. ASAP base model residuals for recreational catch age composition. Open circles are positive residuals, filled circles are negative residuals, calculated as (Observed-Predicted).

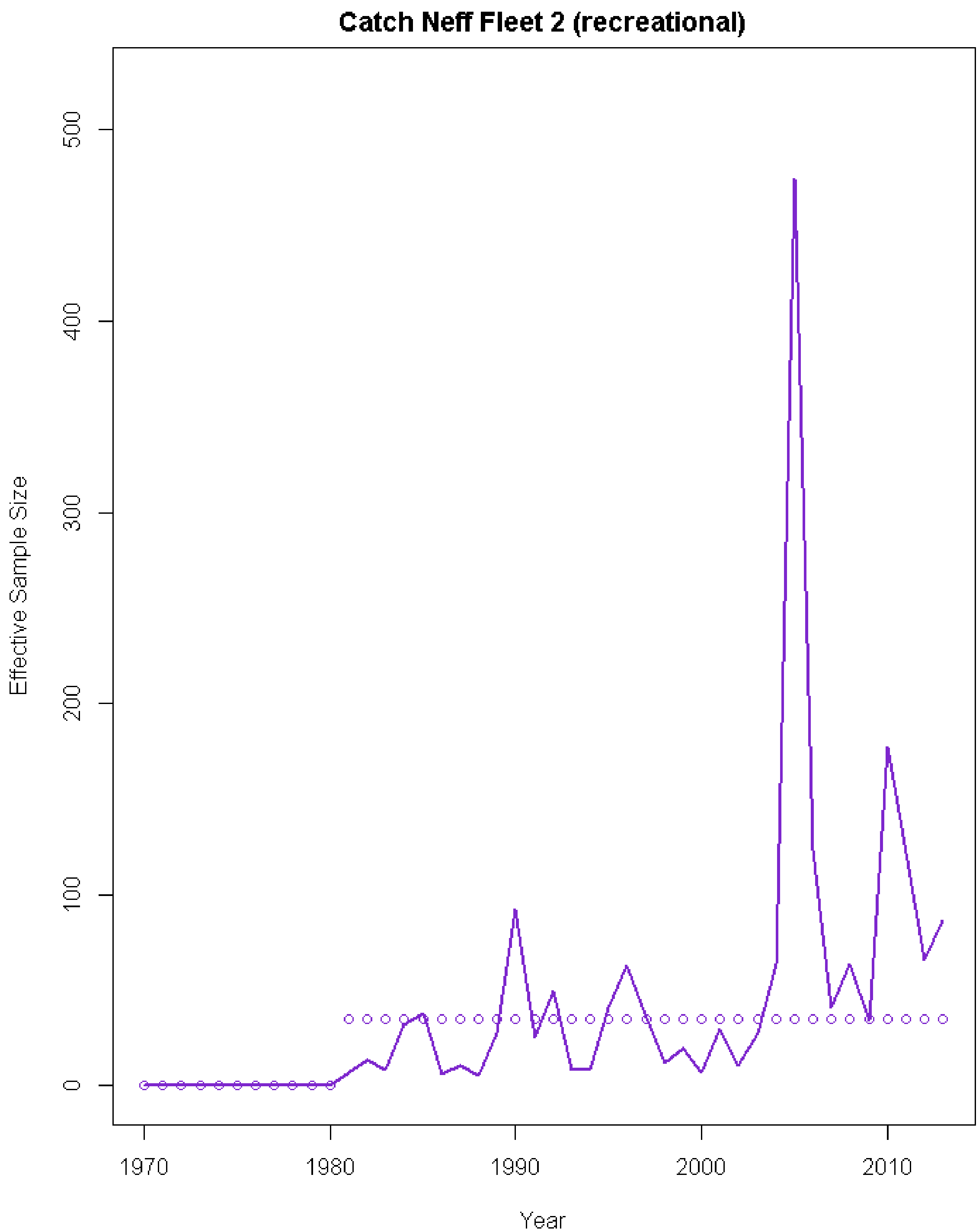

Figure C19. ASAP base model comparison of input effective sample size (circles) versus the model estimated effective sample size (line) for the recreational fleet.

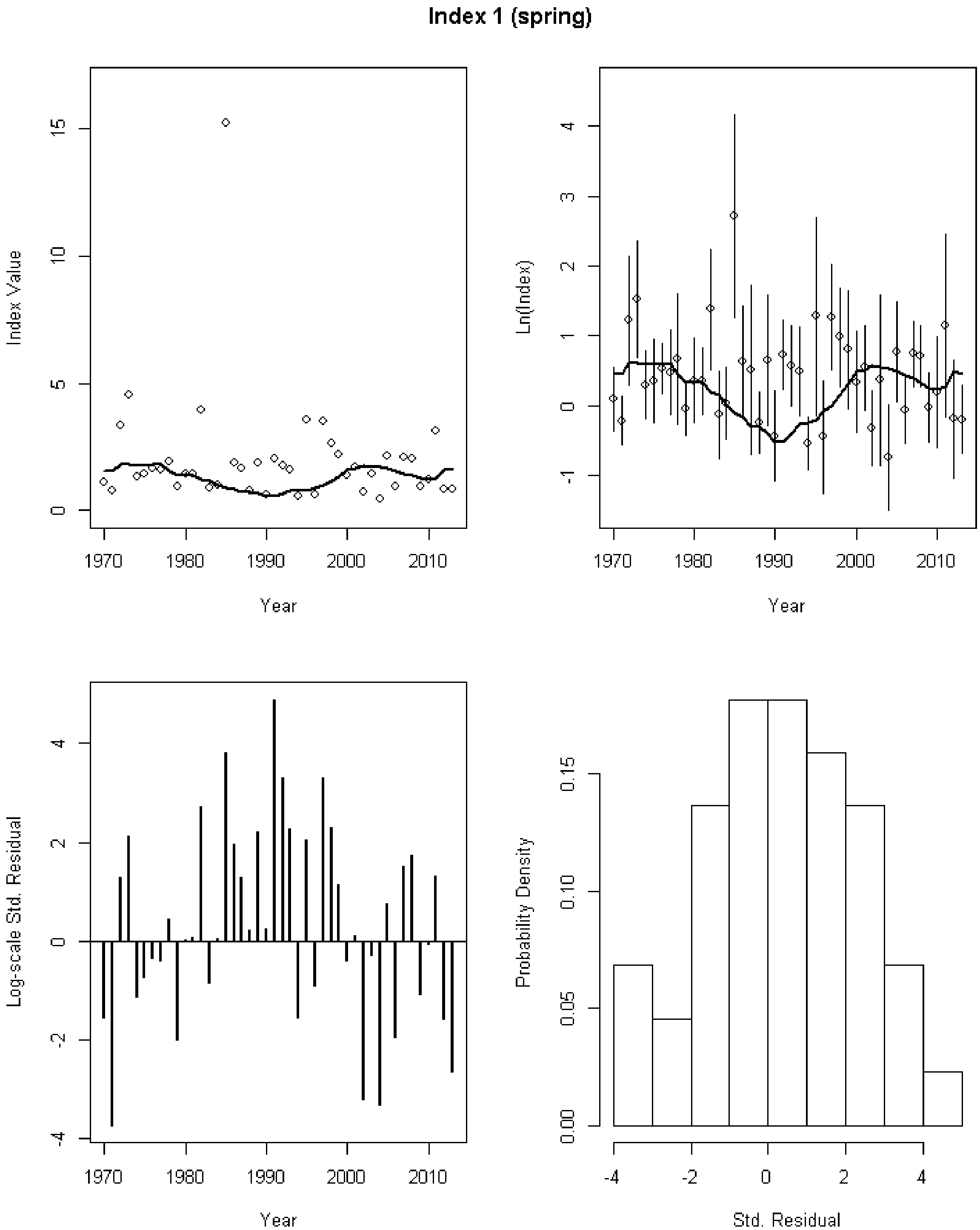

Figure C20. ASAP base model fit to the NEFSC spring index.

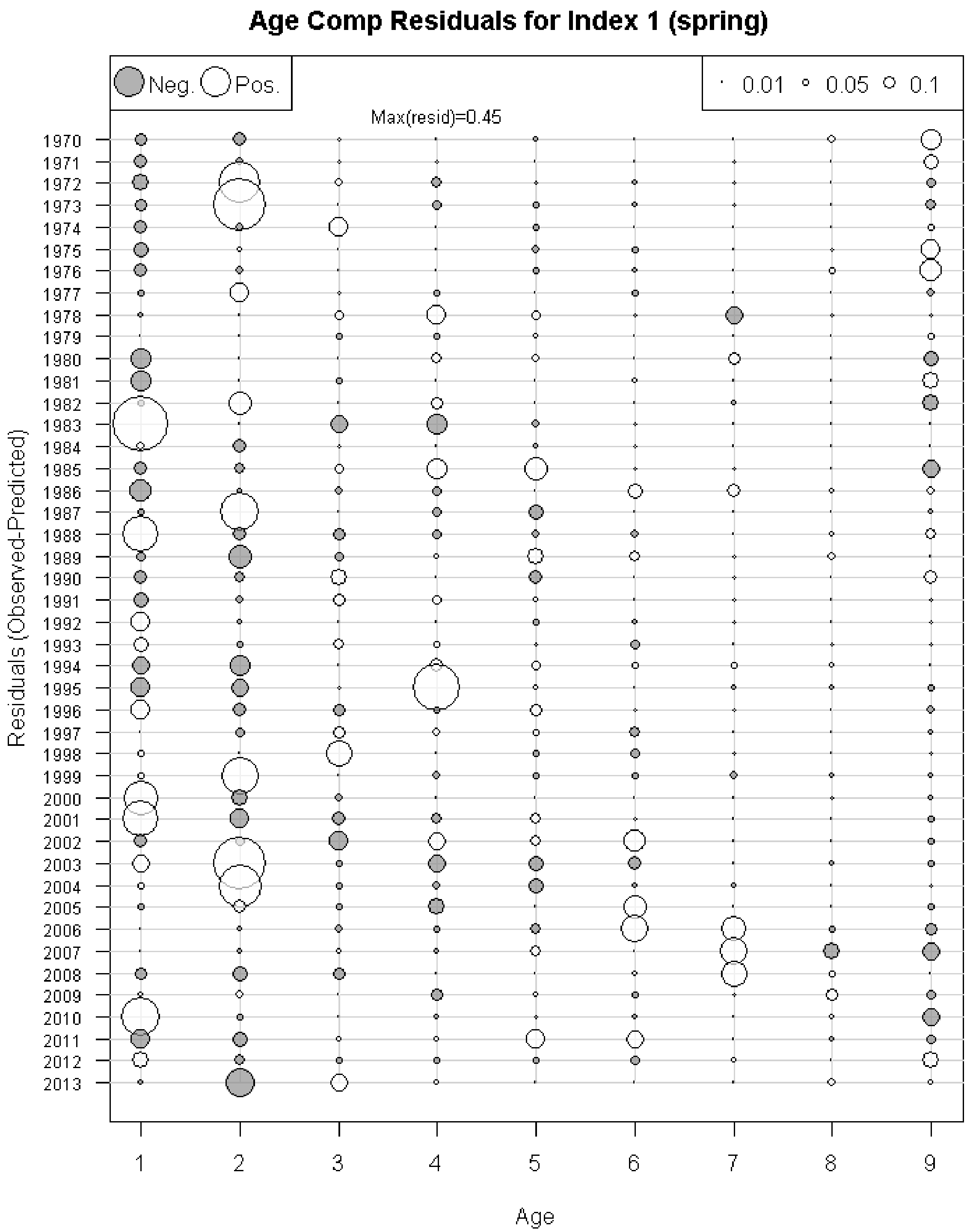

Figure C21. ASAP base model residuals for NEFSC spring index age composition. Open circles are positive residuals, filled circles are negative residuals, calculated as (Observed-Predicted).

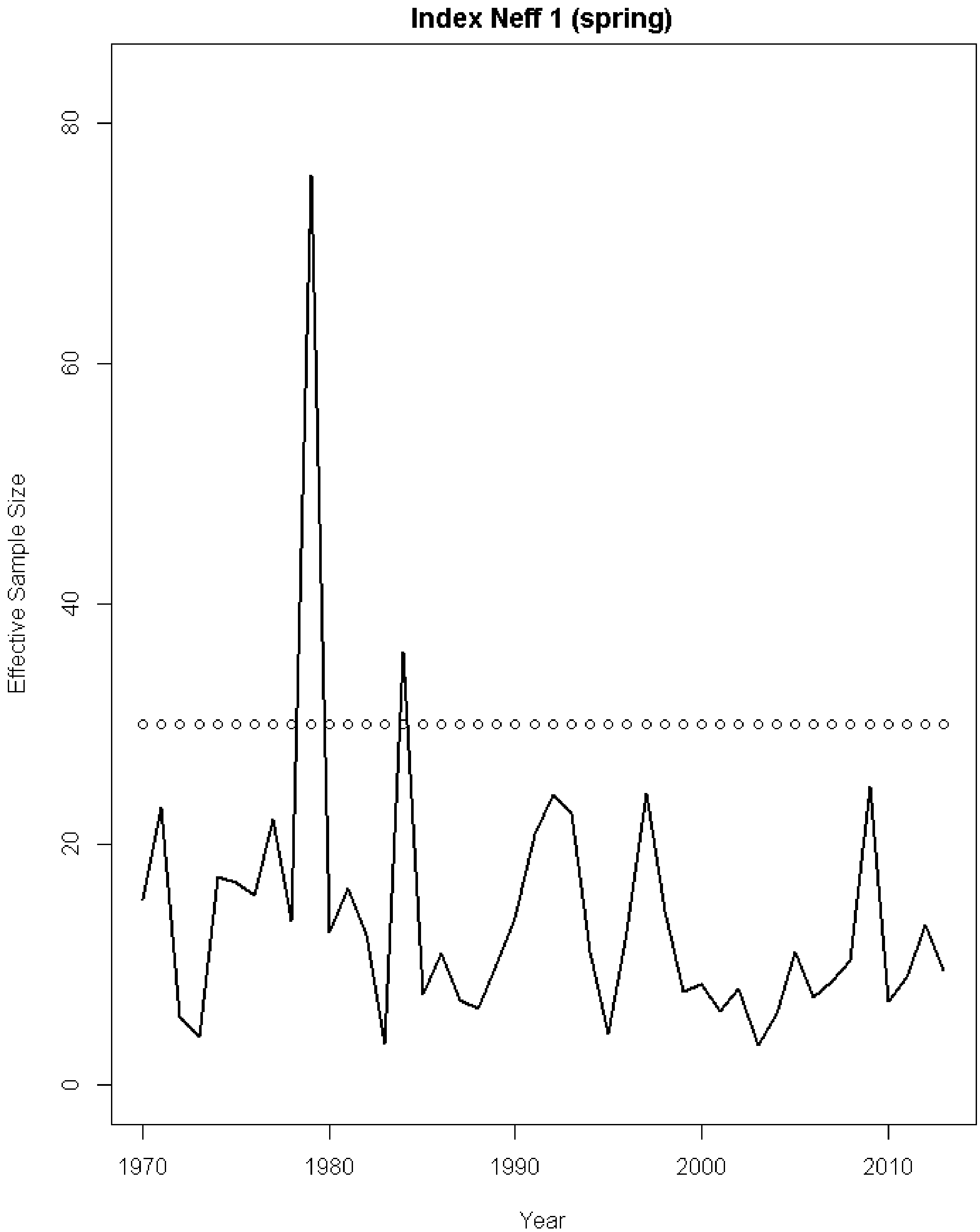

Figure C22. ASAP base model comparison of input effective sample size (circles) versus the model estimated effective sample size (line) for the NEFSC spring index.

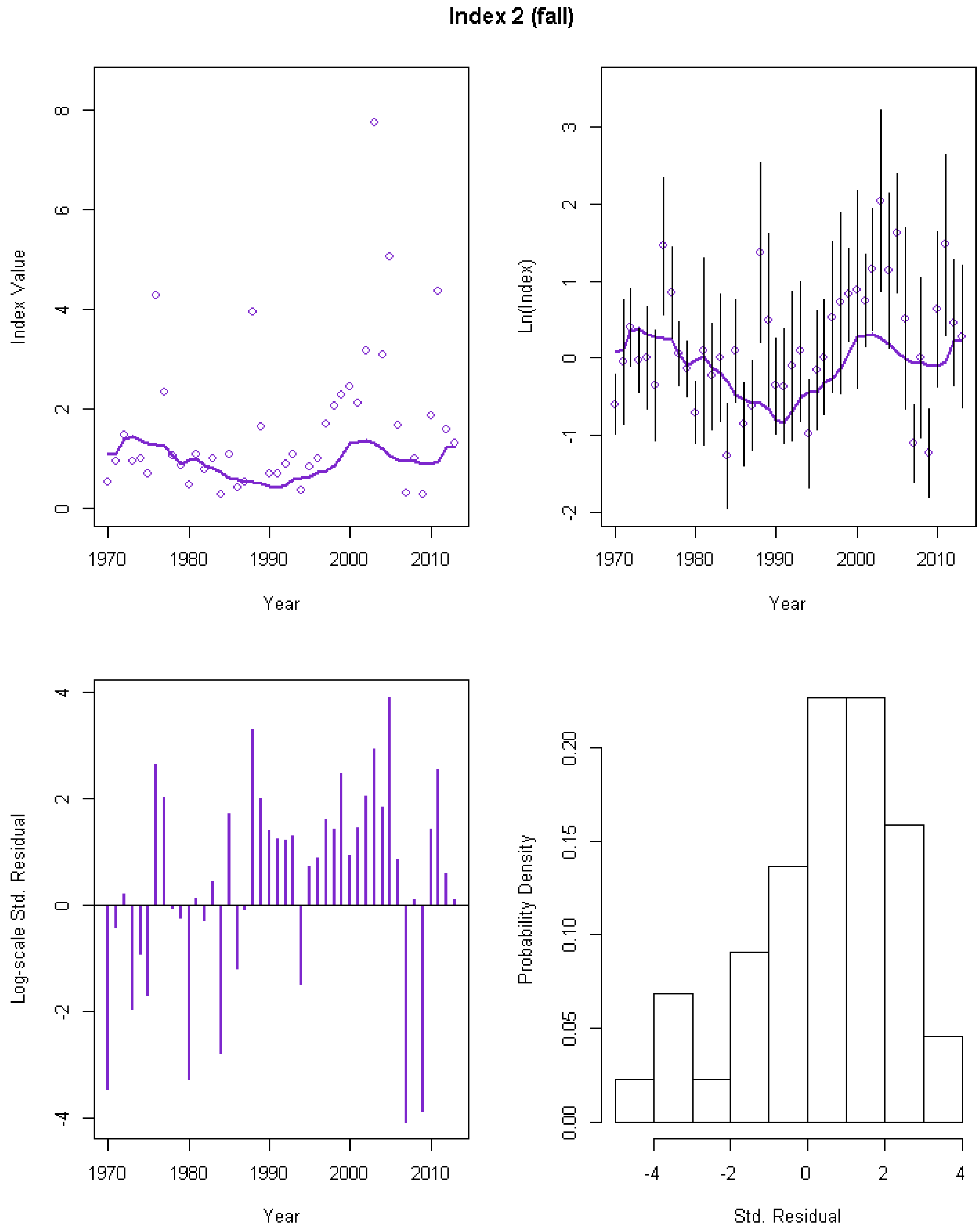

Figure C23. ASAP base model fit to the NEFSC fall index.

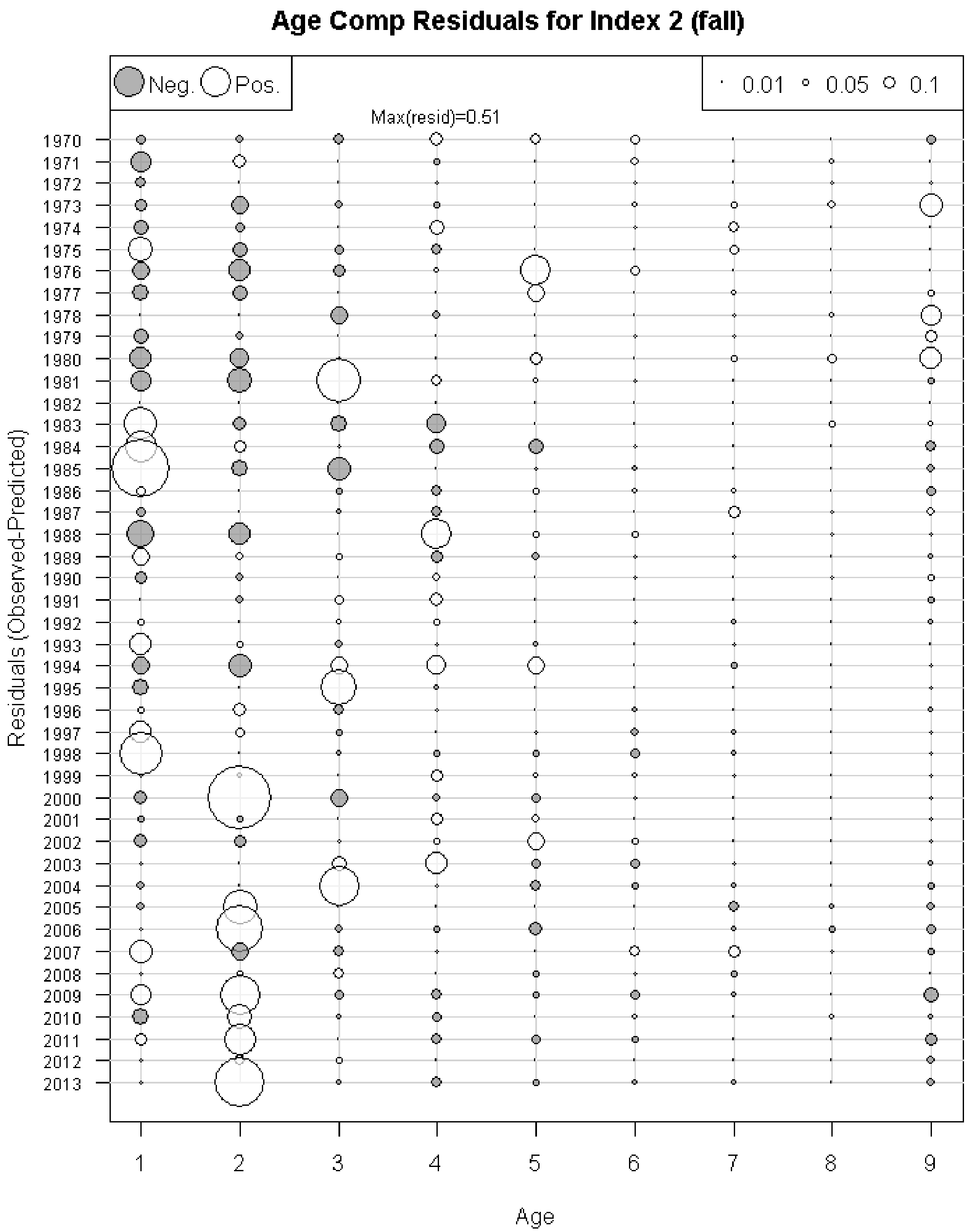

Figure C24. ASAP base model residuals for NEFSC fall index age composition. Open circles are positive residuals, filled circles are negative residuals, calculated as (Predicted-Observed).

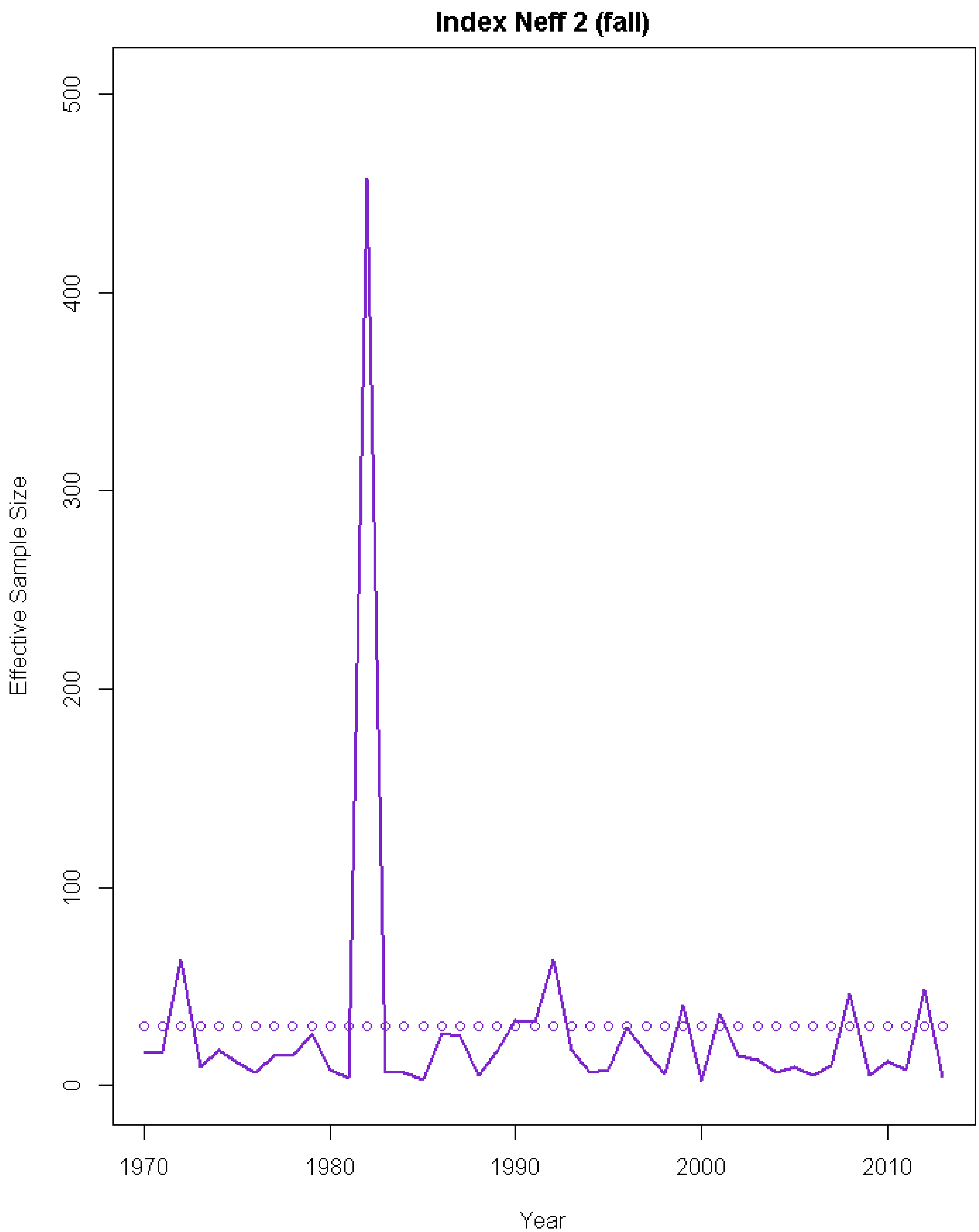

Figure C25. ASAP base model comparison of input effective sample size (circles) versus the model estimated effective sample size (line) for the NEFSC fall index.

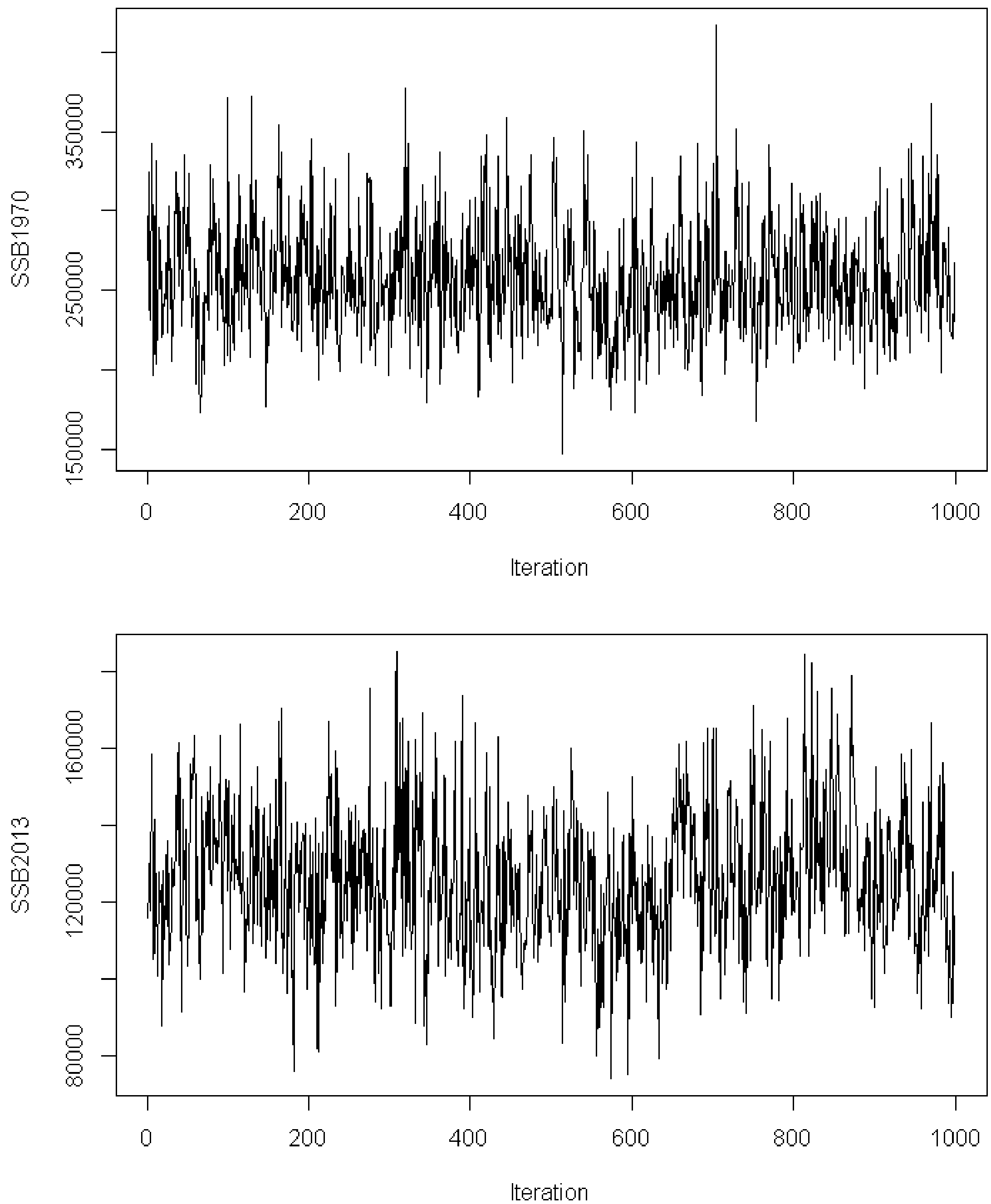

Figure C26. Trace of MCMC chains for SSB1970 (top panel) and SSB2013 (bottom panel), showing good mixing (ASAP base model). Each chain had initial length of 10 million; the first 5 million were dropped for burn-in, and the remaining 5 million were thinned at a rate of one out of every 5,000th. The final chain length was 1000 saved draws.

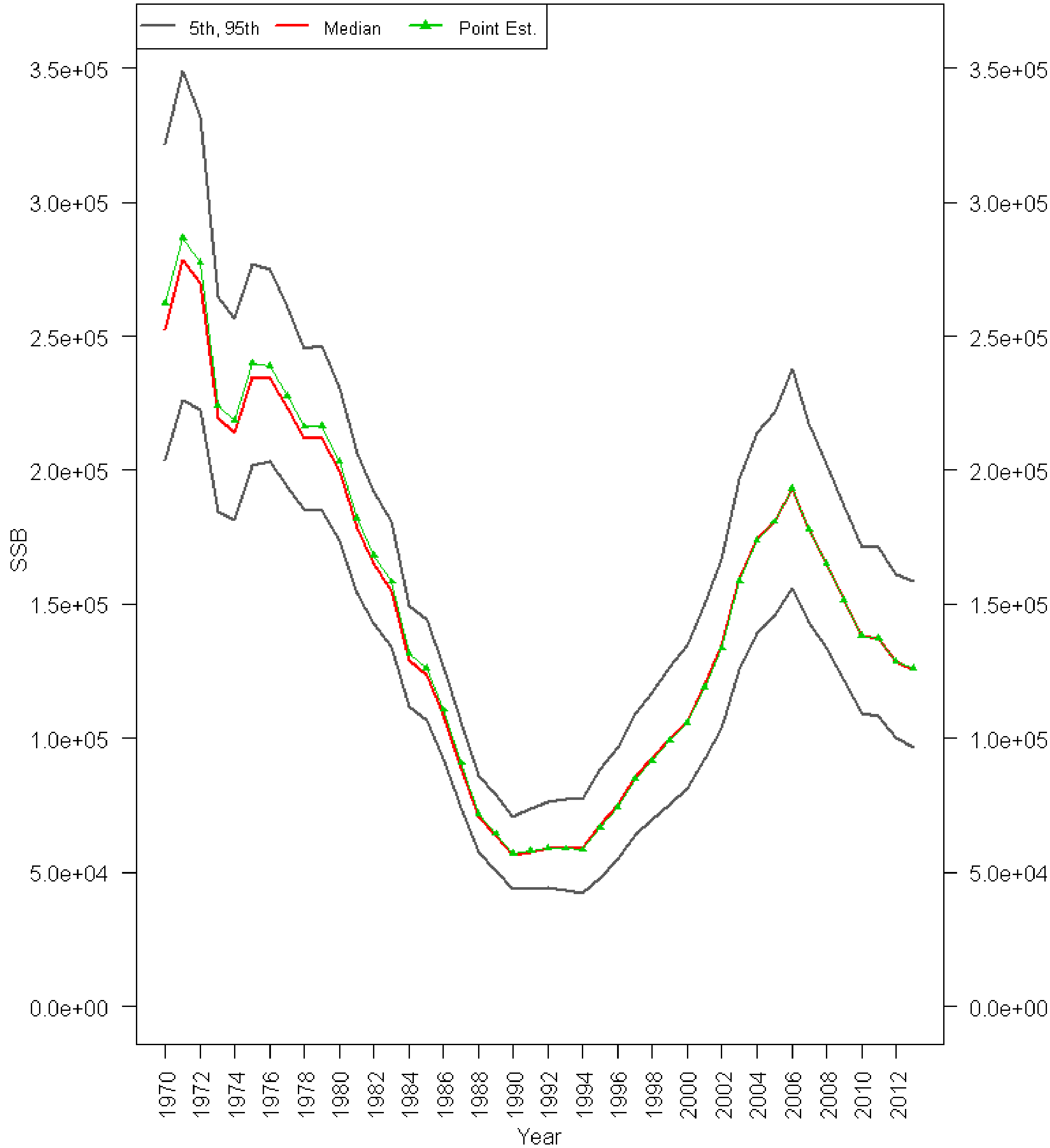

Figure C27. A 90% probability interval for pollock spawning stock biomass (SSB) in thousands of mt is plotted for the entire time series. The median value is in red, while the 5th and 95th percentiles are in dark grey. The point estimate from the base model (joint posterior modes) is shown in the thin green line with filled triangles. (ASAP base model)

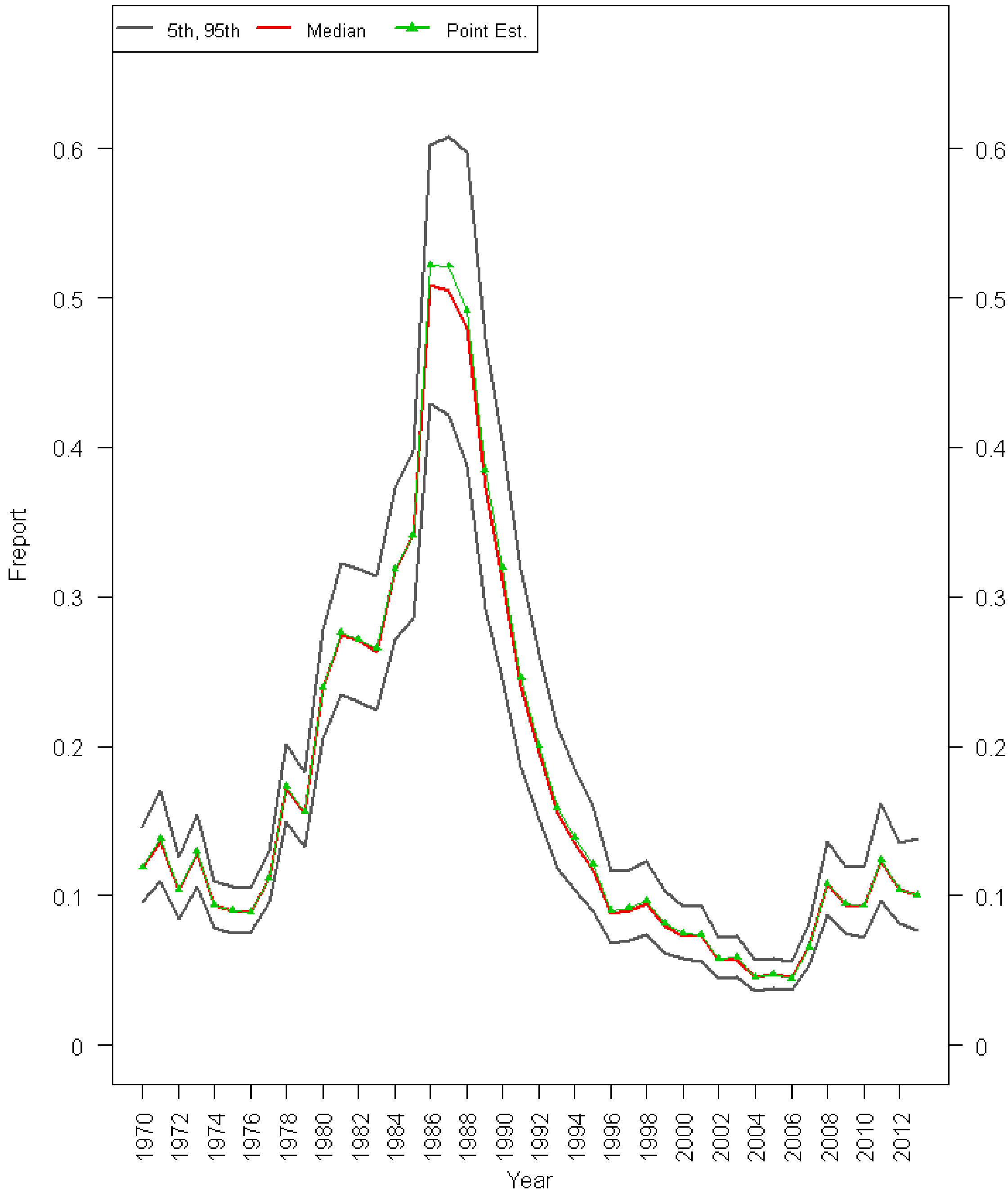

Figure C28. A 90% probability interval for the average F on ages 5-7 ($F_{5\text{-}7}$) for pollock is plotted for the entire time series. The median value is in red, while the 5^{th} and 95^{th} percentiles are in dark grey. The point estimate from the base model (joint posterior modes) is shown in the thin green lined with filled triangles. (ASAP base model)

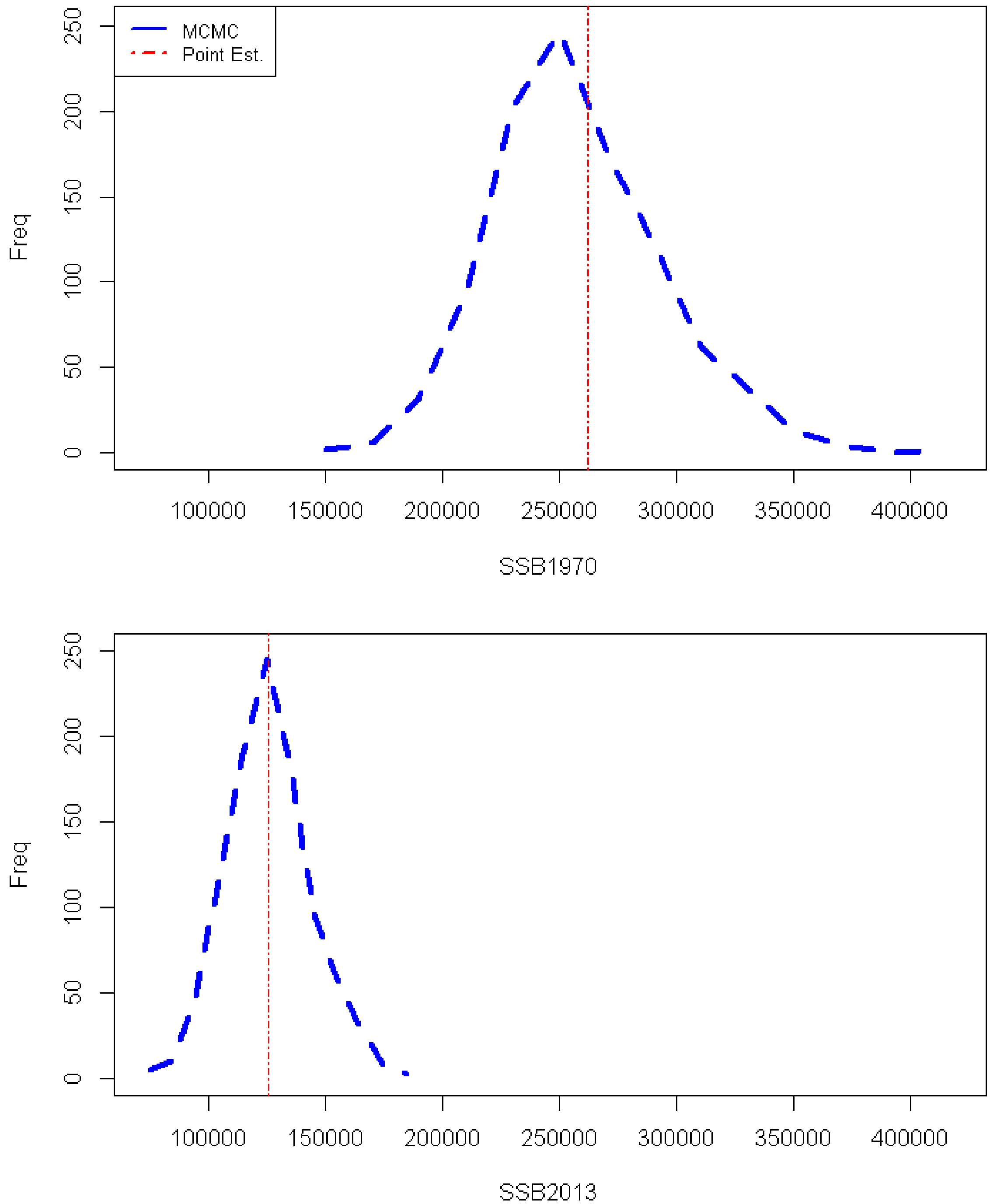

Figure C29. Posterior distribution for spawning stock biomass (SSB) in 1970 (top panel) and in 2013 (bottom panel). The vertical dashed red line indicates the point estimate. (ASAP base model)

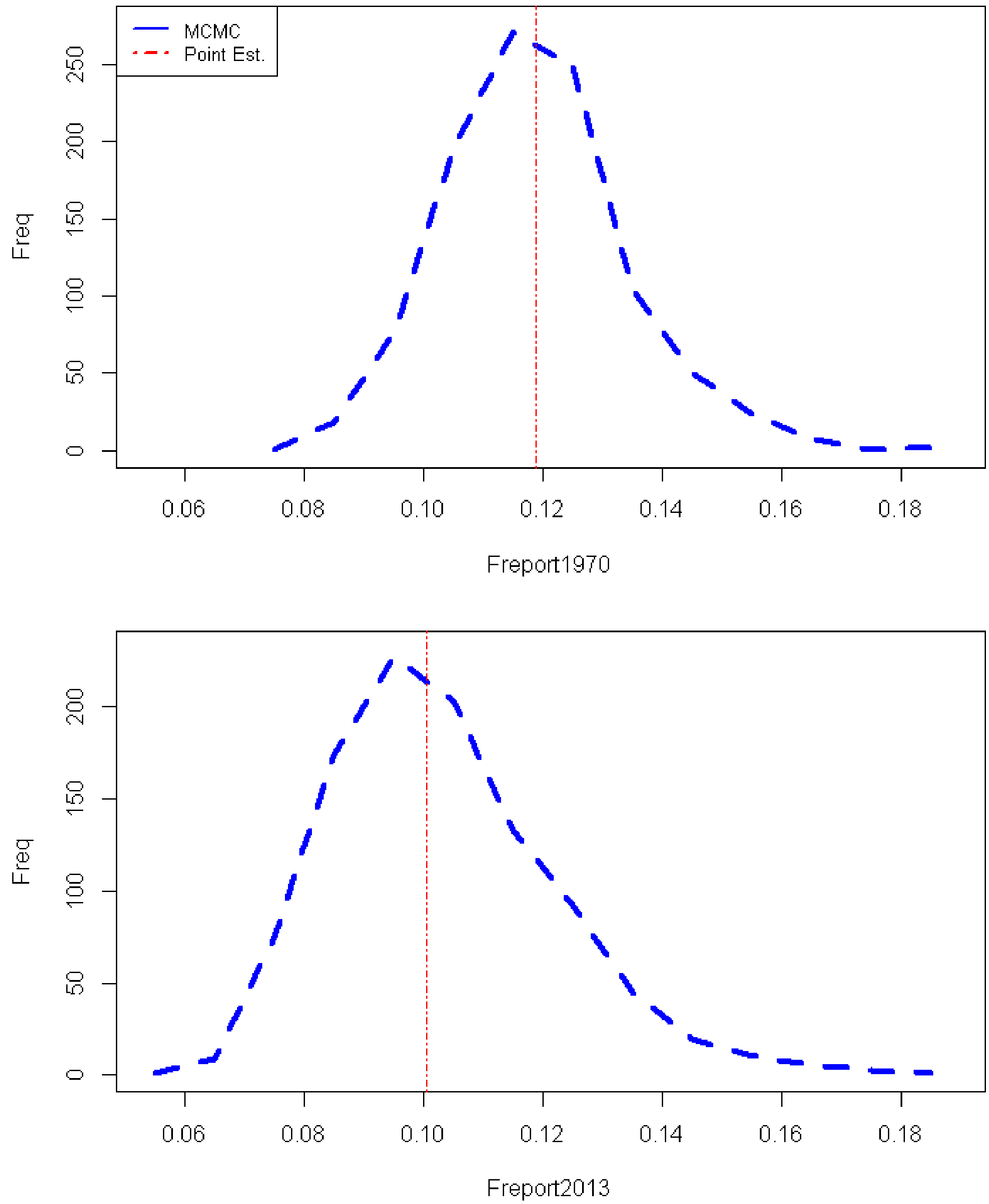

Figure C30. Posterior distribution for average F on ages 5-7 ($F_{5\text{-}7}$) in 1970 (top panel) and in 2013 (bottom panel). The vertical dashed red line indicates the point estimate. (ASAP base model)

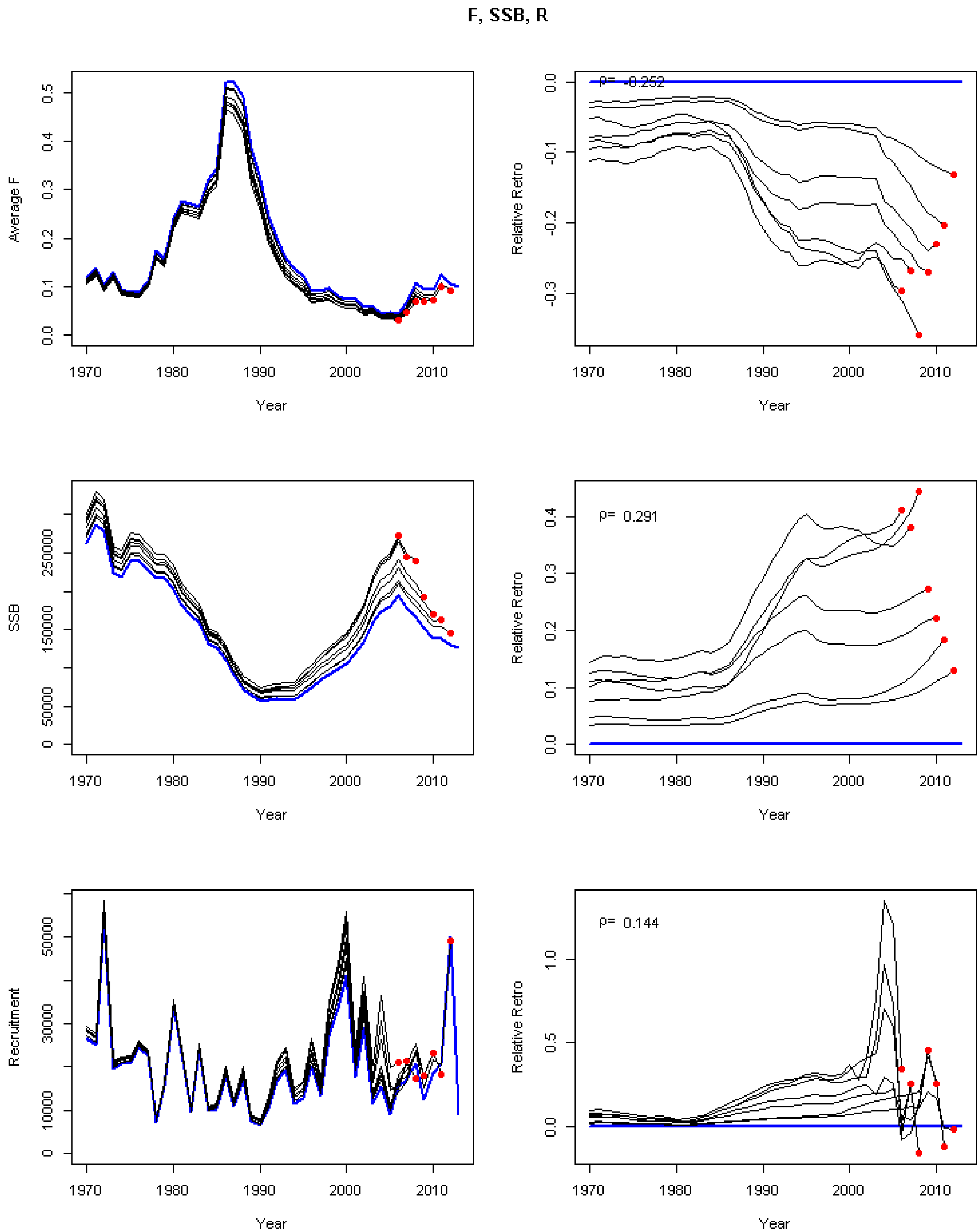

Figure C31. Retrospective analysis for the ASAP base model for years 2006-2012.

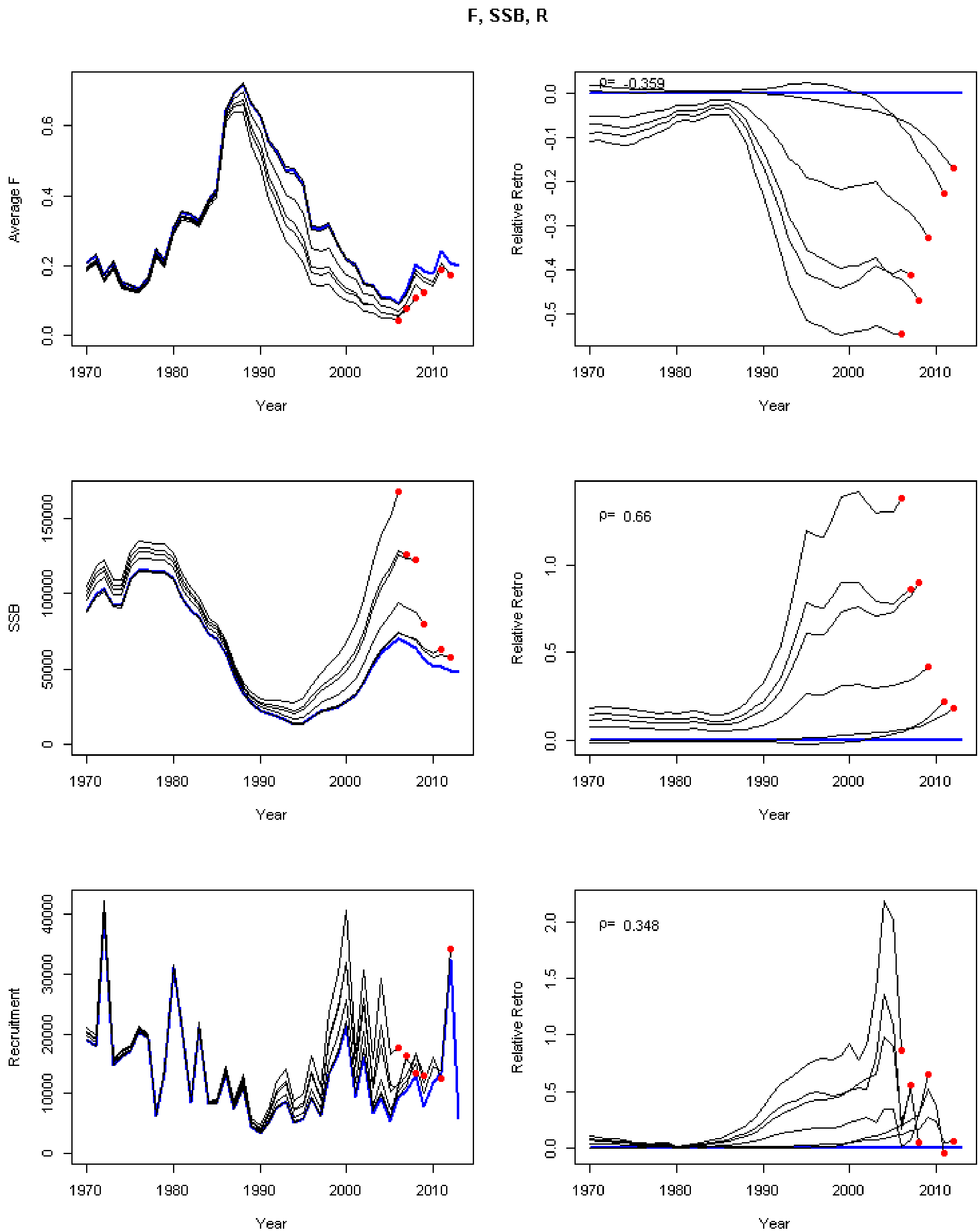

Figure C32. Retrospective analysis for years 2006-2012 for the ASAP sensitivity model with survey selectivity at ages 6-9+ fixed at 1.0. Relative biases are displayed for 2006-2009 and 2011-2012; the model did not successfully run for year 2010.

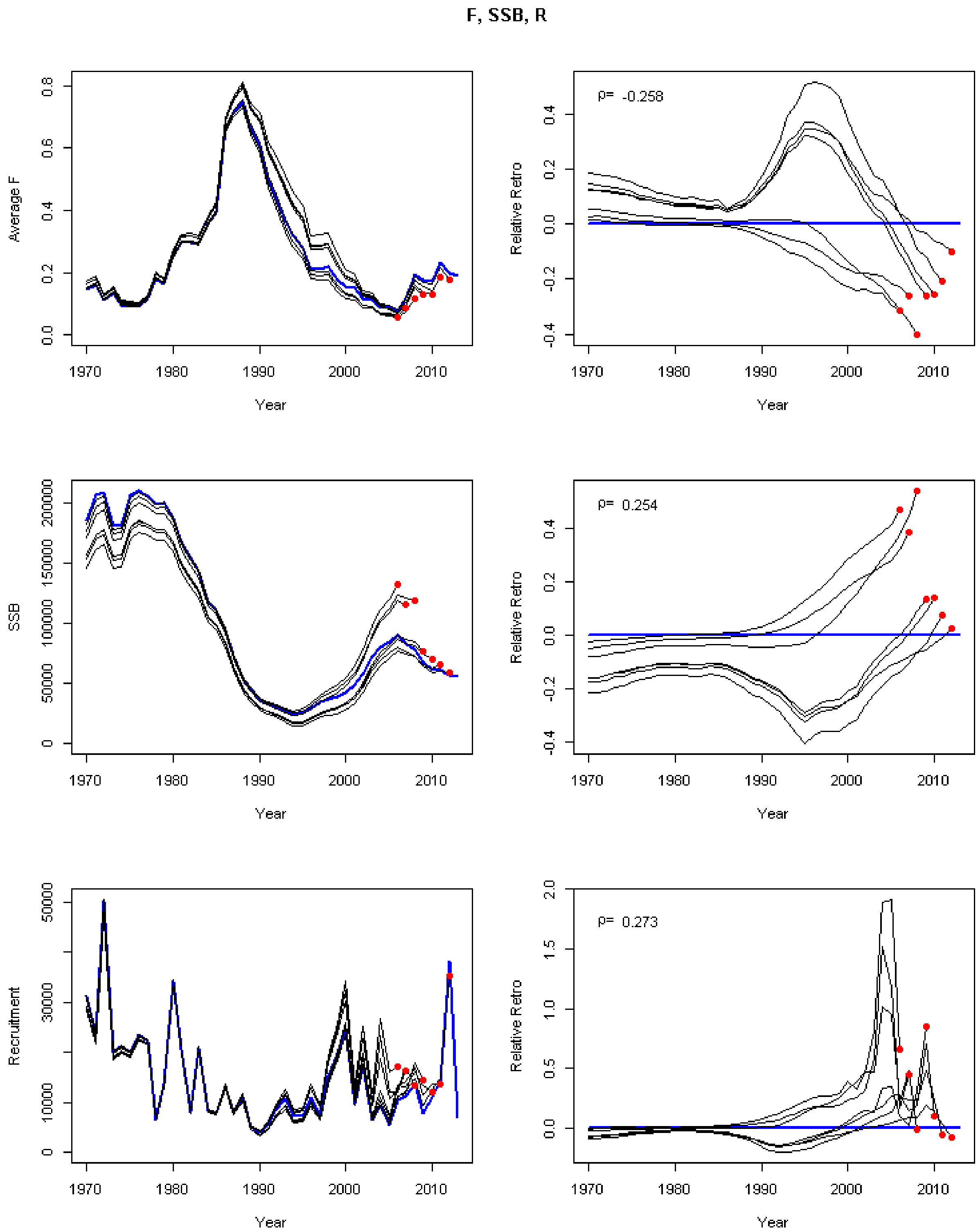

Figure C33. Retrospective analysis for the reweighted ASAP base model for years 2006-2012.

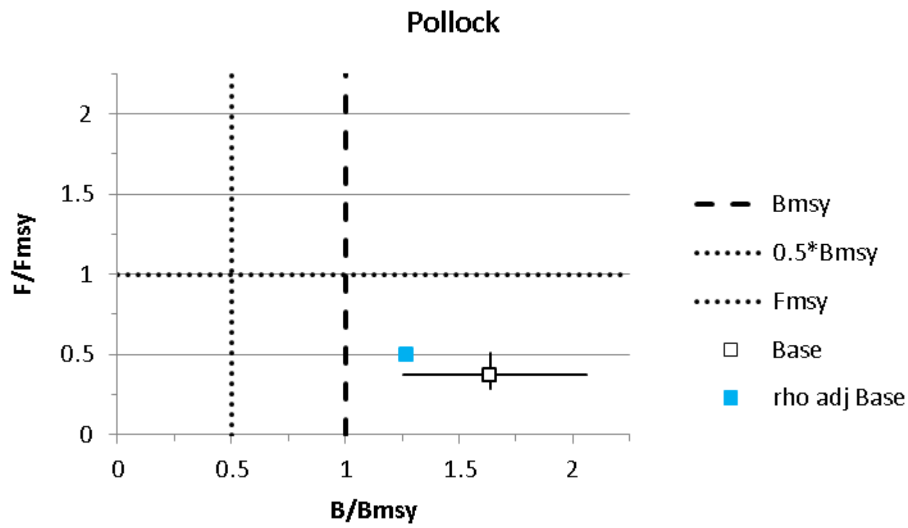

Figure C34. Stock status for pollock. The base model with 90% probability intervals and Mohn's rho-adjusted base model are plotted.

D_Operational Update Process – Review Panel Summary

As a relatively new process for reviewing assessment updates the Panel and participants reflected on the process to offer guidance for future implementations. Feedback was provided on documentation, scope, and standard content of an operational update assessment.

Some clarification on documentation is needed. The Operational Update Process specifies that "two reports will be provided to the appropriate PDT/TC. One report will summarize the results of the Integrated Peer Review (and authored by the Chair of the Integrated Peer Review). The second report will be the assessment document, which will be an NEFSC Reference Document, and will serve as the basis for the stock status determination (and will be authored by the stock's assessment scientist)." Full benchmark assessments include the detailed assessment document that explicitly addresses terms of reference, an assessment summary document that is completed during the meeting as a consensus of the entire workshop, and a review panel report that is completed after the open meeting.

In the spirit of an integrated review and transparency, the panel report for this operational update was completed at the meeting as a consensus of all participants and addressed each term of reference for each stock. Our approach deviates somewhat from the two previous operational updates. The 2012 groundfish updates included a chapter for each stock, and each chapter had an assessment document followed by a brief "Panel Discussion / Comments" that reported stock status and identified methodological changes since the last assessment (NEFSC 2012). The 2013 operational update of monkfish had a brief review panel report as one section of the frontmatter, followed by an executive summary that addressed each term of reference. For operational updates with more stocks (e.g., the 2015 groundfish updates), we suggest a brief Panel Report that addresses each term of reference for each stock.

The scope of operational updates was also considered. Although updating reference points increases the scope of an update, they may be appropriate in the context of recent changes in vital rates (weight-at-age, maturity-at-age) and possibly selectivity. If the update can document that there have been no such changes, updated reference points may not be necessary. We suggest that the Assessment Oversight Panel consider information on recent changes in vital rates and selectivity to determine if updated reference points are appropriate.

For the winter flounder stocks, the Panel identified several studies on maturity and stock structure that were published after the last benchmark assessment. The Panel concluded that reviewing recent studies are helpful for addressing the terms of reference. However, a comprehensive review of recent literature may not be feasible for operational updates of many stocks.

The Panel felt that the content provided in the draft assessment documents was sufficient to meet the terms of reference with few exceptions. The Panel recommends that geographic plots of fishery and survey data be provided to assist in the interpretation of model results. These plots are particularly

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informative for stocks that have had recent shifts in distributions. The Panel also requested statistical distributions of survey data (e.g., number of stations, proportion of stations with no catch).

References

NEFSC. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. NEFSC Ref Doc. 12-06.

NEFSC. 2013. 2013 monkfish operational assessment. NEFSC Ref Doc. 13-23.

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