C. Gulf of Maine (GOM) WINTER FLOUNDER STOCK ASSESSMENT FOR 2011

[SAW52 Editor's Note: The SARC-52 peer review panel concluded that no ASAP model run provided a suitable basis for management advice. A swept-area biomass method was accepted instead, and it is described in Appendix C1.]

The Southern Demersal Working Group (SDWG) prepared the stock assessment. The SDWG met during April 19-21, April 26-28, and May 3-5, 2011 at the Northeast Fisheries Science Center, Woods Hole, MA, USA.

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SAW 52 Terms of Reference

C. Winter flounder (Gulf of Maine Stock)

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data.

2. Present survey data being considered and/or used in the assessment (e.g., regional indices of abundance, recruitment, state and other surveys, age-length data, etc.). Characterize uncertainty in these sources of data.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-5), and estimate their uncertainty. Include area-swept biomass estimates. Investigate if implied survey gear or catchability estimates are reasonable. Include a historical retrospective analysis to allow a comparison with previous assessment results.

4. Perform a sensitivity analysis which examines the impact of allocation of catch to stock areas on model performance (in TOR-3).

5. Examine the effects of incorporating environmental factors in models of population dynamics (e.g., spring water temperatures in an environmentally-explicit stock recruitment function).

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, BTHRESHOLD, and FMSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status (overfished and overfishing) with respect to the "new" BRPs (from TOR 6), and with respect to the existing BRPs (from a previous accepted peer review) whose values have been updated.

8. Develop and apply analytical approaches and data that can *be used for conducting* single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs) under a set of alternative harvest scenarios. If the stock needs to be rebuilt, take that into account in these projections.

a. Provide numerical short-term projections (3-5 yrs, or through the end of the rebuilding period, as appropriate). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).

b. Take into consideration uncertainties in the assessment and the species biology to describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming or remaining overfished, and how this could affect the choice of ABC.

c. Develop plausible hypotheses (e.g., mixing among the three stocks) which might explain any conflicting trends in the data and undertake scenario analyses to evaluate the consequences of these alternate hypotheses on ABC determination.

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

Executive Summary

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data.

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. Recreational landings reached a peak in 1981 with 2,554 mt but declined substantially thereafter. Recreational landings have generally been less than 100 mt since 1994, with exception of 2008 were the landings was estimated at 103 mt. A discard mortality of 15% was assumed for recreational discards. Discards were estimated for the large mesh trawl (1982-2010), gillnet (1986-2010), and northern shrimp fishery (1982-2010). A discard mortality of 50% was assumed for commercial fishery. In general the total discards are a small percentage (time series average 11%) of the total catch. There has been a substantial decline in the total catch compared to the early 1980s (recent catch is roughly 5% of the 1980s catch).

2. Present survey data being considered and/or used in the assessment (e.g., regional indices of abundance, recruitment, state and other surveys, age-length data, etc.). Characterize uncertainty in these sources of data.

The spring and fall NEFSC, Massachusetts DMF (MDMF) and the Maine New Hampshire (MENH) surveys were used in the Gulf of Maine winter flounder assessment. In general the survey indices are relative flat over the time series in comparison to the catch trends. All of the indices generally show a slight decrease in the population in the late 1980s from a high in the early 1980s with low abundance remaining through the early 1990s. All of the indices show signs of increase abundance starting in 1998 and 1999. Since 2001 all indices indicate some decrease in abundance. However there have been recent increases in the indices at age for the older fish. Length base conversions were use in 2009 and 2010 when the new survey vessel was used in the NEFSC survey.

The SARC accepted GOM winter flounder assessment is based on an empirical swept-area model utilizing data from the 2010 NEFSC fall survey, the MADMF fall survey, and the Maine-New Hampshire fall inshore surveys. Using an efficiency value of 0.6 the estimated stock biomass in 2010 of fish greater than 30 cm was 6,341 mt (80% CI 4,230 - 8,800 mt) (Appendix C1).

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-5), and estimate their uncertainty. Include area-swept biomass estimates. Investigate if implied survey gear or catchability estimates are reasonable. Include a historical retrospective analysis to allow a comparison with previous assessment results.

The base and split VPA were updated from the GARM III assessment. The SDWG changed the

assumed natural mortality from 0.2 to 0.3 in this assessment. Diagnostics still imply major sources for concern surrounding the VPA model formulation for GOM winter flounder. The SDWG developed a new assessment in ASAP (Age Structured Assessment Program) which provides more flexibility in the weighting of data sources. The population models have difficulty with 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 weight imposed on the catch at age compositions. The ASAP model allowed errors in the fit to the catch at age and improved fit to the survey indices without the split. However this resulted in a lack of fit to the plus group in the catch at age composition. The combined survey 30+ biomass area swept estimate was used to inform the optimal weighting for the preferred model formulation. The resulting final SDWG model weighting formulation considered both the tradeoff between retrospective bias and feasible biomass estimates at the end of the time series. The within model uncertainty did not capture the uncertainty in this assessment considering how sensitive the results were to the model formulation and weighting. ***The SARC concluded that the ASAP assessment model was too unreliable to be a basis for management.***

The accepted assessment of GOM winter flounder stock is based on an empirical swept-area model utilizing data from the 2010 NEFSC fall survey, the MADMF fall survey, and the Maine-New Hampshire fall inshore surveys. Using an efficiency value of 0.6 the estimated stock biomass in 2010 of fish greater than 30 cm was 6,341 mt (80% CI 4,230 - 8,800 mt). Exploitation rate in 2010 was estimated at 0.03 (80% CI 0.02 - 0.05) based on the ratio of 2010 catch (195 mt) to survey based swept area estimate of biomass for winter flounder exceeding 30 cm in length (6,341 mt). The biomass estimate for 2010 is 16% lower than that for 2009 using the same survey methods but this difference is not statistically significant (Appendix C1).

4. Perform a sensitivity analysis which examines the impact of allocation of catch to stock areas on model performance (in TOR-3).

The SDWG interpretation of TOR4 is that the variance of the commercial landings due to the 1995 and later area-allocation scheme should be used as the basis for the magnitude of landings that might be lost or gained from the stock-specific assessments, and then perform an exercise to run the assessment model with those potential biases and report the results. Additional work was done to estimate the error in the commercial landings due to misreporting of commercial landings to statistical area at allocation level A. Given the magnitude of these errors, the SDWG elected to run the final GOM winter flounder ASAP model, with an additional 5% PSE in commercial landings added to the estimated PSE over the 1995-2010 time series.

The commercial landings have a calculated Proportional Standard Error (PSE; due to the commercial landings area-allocation procedure; available for 1995 and later years, with the mean of those years substituted for 1982-1994) ranging from 5.3% to about 6.5%; the commercial discard (trawl and gillnet) PSEs range from 16-177% (available for 1994-2010, mean of those years substituted for 1982-1993); and the recreational landings PSEs range

from 17-50%. Because the PSEs for the commercial landings are low, and the commercial landings account for about two-thirds of the total catch, the total catch weighted-average annual PSEs range from 7-30%, and averages 11.7% (unweighted) for the 1981-2010 time series.

The catch in the final assessment model was increased and decreased by the annually varying PSE and models were re-run to provide an additional measure of uncertainty of assessment estimates. For the final ASAP multi model, the fishing mortality estimate in 2010 did not change greatly (0.01 to 0.034). The 2010 SSB range was 4,700 to 6,900 mt, was similar to the MCMC estimate of uncertainty. However the assessment modeling was not accepted by the SARC as a basis for management.

5. Examine the effects of incorporating environmental factors in models of population dynamics (e.g., spring water temperatures in an environmentally-explicit stock recruitment function).

To develop environmentally-explicit stock recruitment relationships, three specific types of data are required: spawning stock biomass, recruitment, and environmental data. Spawning stock biomass and recruitment data from the final 2011 SAW 52 assessment models were used in the analysis. For the GOM stock, recruitment (lagged by 1 year) and spawning stock biomass pairs were used from the ASAP multi model. Two general types of temperature data were used: air temperatures and coastal water temperature. In addition to temperature, four large-scale forcing indices were included in the analyses. The North Atlantic Oscillation (NAO) is the dominant mode of winter climate variability in the North Atlantic region and has been related to numerous physical and biological variables across the North Atlantic (Ottersen et al. 2001, Visbeck et al. 2003). The Atlantic Multidecadal Oscillation (AMO) is a natural mode of climate variability and represents a detrended multi-decadal pattern of sea surface temperatures across the North Atlantic with a period of 60-80 years (Kerr 2005). Finally, the Gulf Stream index is a measure of the northern extent of the Gulf Stream south of the northeast U.S. shelf ecosystem. The Gulf Stream position is related to the larger basin-wide circulation, which in turn is related to NAO and AMO. Two Gulf Stream indices are used here (Joyce and Zhang 2010, Taylor and Stephens 1998).

For the Gulf of Maine stock, increased winter air temperatures are related to lower recruitment, but the strength of this environmental forcing is less than for the Southern New England stock. This result makes sense in the context of the distribution of winter flounder; the southern stock is most affected by warmer temperatures.

One use of the environmentally-explicit models is to develop short-term and long-term forecasting models. Based on this work, there is no trend in winter temperature over the past 30 years and thus short-term forecasts can be developed using the environmentally-explicit models assuming winter temperatures to be at their mean state. It may also be useful to develop short-term forecasts under warm temperatures and short temperatures to provide managers with a tangible understanding of the effect of temperature on the stocks. The environmentally-explicit models could also be used to develop longer-term forecasts following the approach of Hare et al. (2010). These forecasts would provide an assessment of the

sustainability of the winter flounder fishery on the 30-100 time scale. Work is underway within the SDWG to incorporate environmentally-explicit stock-recruitment models into the NFT standard software used to fit stock-recruitment models and to perform projections of stock and fishery catch. However, this work has not been developed sufficiently to be made available for peer-review at this time (see new Research Recommendation 10).

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, BTHRESHOLD, and FMSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

The 2008 GARM III assessment was not accepted and the overfished and overfishing status of the GOM winter flounder stock is currently unknown. For the new 2011 assessment, the SDWG split VPA estimated higher percent maximum spawning potential (MSP) proxies relative to the ASAP model because the VPA estimated selectivity was shifted to older fish. The SDWG ASAP multi run estimated a F40% FMSY proxy at 0.34 using the 2006-2010 average mean weights and selectivity as input to the YPR analysis. The F40% SSBmsy was estimated from a long term projection (100 years) using the CDF of recruitment from the entire model time series (1982-2010) and the estimated YPR F40%. The SSBmsy using the FMSY = F40% proxy was estimated at 3,287 mt with a SSBmsy threshold estimate of 1,644 mt and MSY equal to 1,080 mt for the ASAP multi run. The Beverton Holt stock recruitment Fmsy using the Pleuronectids steepness prior from Myers et al. (1999; 0.8 mean and CV = 0.09) was estimated at 0.57. The stock recruit SSBmsy was estimated at 2,167, SSBmsy threshold = 1,084 mt, and MSY = 1,152. The MSY estimates did not vary greatly with SSBmsy from the mcmc in the stock recruitment analysis. The SDWG expressed concern with the stock recruitment estimate of SSBmsy being estimated in the lower end of the range of past SSB observations. However SARC 52 did not accept the SDWG model and the overfished status remains as unknown since biomass based reference points could not be estimated.

The SARC accepted a proxy value of the overfishing threshold which was derived from a length-based yield per recruit analysis that assumes all fish above 30 cm are fully recruited to the fishery and that natural mortality is 0.3. Using $F_{40\%}$ (0.31) as a proxy for Fmsy, the threshold exploitation rate is 0.23 and 75%$F_{40\%}$ exploitation was 0.17 with M=0.3. The reference points were converted to exploitation rates to be consistent with the swept area biomass approach.

7. Evaluate stock status (overfished and overfishing) with respect to the "new" BRPs (from TOR 6), and with respect to the existing BRPs (from a previous accepted peer review) whose values have been updated.

The 2008 GARM III assessment was not accepted and the overfished and overfishing status of GOM winter flounder stock is currently unknown. In the new 2011 assessment, stock status evaluation was consistent regardless of the model formulation (VPA and ASAP). Both the split

VPA model and the SDWG preferred ASAP multi model indicate that the stock is not overfished and overfishing is not occurring. However spawning stock biomass relative to the SSBmsy varied widely between the VPA and preferred ASAP multi model. SSB in 2010 to SSBmsy ratios varied from the stock recruit Split VPA estimate of 0.52 to the stock recruit estimate of 3.09 from the ASAP multi with no prior on steepness. All models show that fishing mortality in 2010 were well below their respective Fmsy reference points. Fishing mortality in 2010 to Fmsy ratios varied from the stock recruitment split VPA ratio estimate of 0.47 to the stock recruitment estimated ratio of 0.05 from the ASAP multi run with no prior on steepness. The SDWG ASAP multi run using the Fmsy = F40% proxy estimated the SSB2010/SSBmsy ratio at 1.77 and the F2010/F40 at 0.09. The stock recruitment priors did lower the estimated steepness which lowered the SSB2010/SSBmsy ratio to 2.74 and increased the F2010/Fmsy ratio to 0.06.

All GOM winter flounder models have diagnostic issues due to the conflicting signals in the data. The SDWG preferred the ASAP multi model as the best fit to all data sources including considerations for reasonable estimates of biomass in 2009 and 2010 in comparisons to the survey area swept biomass estimates. However the SDWG questioned the feasibility of the estimated SSB relative to the SSBmsy reference points for both the F40% proxy and the stock recruit estimates (1.77 to 2.68). In general the trends and biomass estimated by the model seem appropriate. Surveys and anecdotal feedback from fishermen suggest a shift in the population to deeper water which can help explain the lack of catch in the recreational fishery. However questions remain with the lack of higher catches as the stock rebuilds during the late 1990s and early 2000s when effort in the groundfish fishery was high. In addition, there is little evidence of a change in the size structure or stock range expansion to waters off the coast of Maine which traditionally had higher catches. Considerable uncertainty remains with regards to the comparison of the 2010 SSB relative to the SSBmsy biological reference points. The SARC concluded that the population models are too uncertain as a based from stock status determination.

The overfished status remains as unknown since an analytical model was not accepted and a biomass reference point could not be estimated. *The SARC concluded that in 2010 overfishing was not occurring for the stock. A proxy value of the overfishing threshold was derived from a length-based yield per recruit analysis that assumes all fish above 30 cm are fully recruited to the fishery and that natural mortality is 0.3. Using F40% (0.31) as a proxy for Fmsy, the threshold exploitation rate is 0.23. Exploitation rate in 2010 was estimated at 0.03 (80% CI 0.02 - 0.05) which was based on the ratio of 2010 catch (195 mt) to survey based swept area estimate of biomass for winter flounder exceeding 30 cm in length (6,341 mt).*

8. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs) under a set of alternative harvest scenarios. If the stock needs to be rebuilt, take that into account in these projections.

a. Provide numerical short-term projections (3-5 yrs, or through the end of the rebuilding period, as appropriate). Each projection should estimate and report annual probabilities of

exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).

SDWG Ten year AGEPRO projections assumed that the ACL of 230 mt will be taken in 2011. Projections were done using 1000 bootstrap iterations from the split VPA and 1000 mcmc iterations from the preferred ASAP multi run. SSB, catch, and fishing mortality with 80 confidence intervals were estimated from the split VPA at the Fmsy proxy of F40% = 0.43 (derived from the updated split VPA) and 75% of the F40% proxy = 0.32. Projections for the ASAP multi model were also run assuming the F40% proxy = 0.34 and 75% of the F40% = 0.26. Short term projections using the stock recruit reference point with the prior on steepness for the ASAP multi run were also done at Fmsy = 0.57 and 75%Fmsy = 0.42. All projections show relatively high catch in 2012 compared to model time series of catches. The projected VPA SSB increases towards SSBmsy after lower estimates of SSB in 2013 and 2014. The low SSB estimate in 2013 and 2014 is due to the low recruitment estimated in 2009 and 2010 which was influenced by the length based survey calibration. Therefore substantial uncertainty exists with the estimated recruitment in 2009 and 2010. The ASAP multi short term projections result in fishing of the SSB down to SSBmsy. The estimated catch in 2012 shows a large increase relative to the assumed catch in 2011 of 230 mt for both the split VPA and ASAP formulations. The ASAP multi run estimated 2012 catch varies from 1,700 mt from the 75% F40 projection to the stock recruit Fmsy projection estimate of 3,080 mt. However catch declines quickly after 2012 as the stock approaches SSBmsy. Consideration could be given to the overestimation of the plus group in the ASAP model projections. For example a plus group residual adjustment within AGEPRO can be approximated using an assumed plus group discard proportion.

The SARC did not accept the analytical modeling. Therefore projections are not possible.

b. Take into consideration uncertainties in the assessment and the species biology to describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming or remaining overfished, and how this could affect the choice of ABC.

Uncertainties that were not accounted for by assessment and reference point models were evaluated using model diagnostics. Standard model diagnostics (e.g., residual analyses, retrospective analyses) were used for model validation. Vulnerabilities that were not accounted for by assessment and reference point models were evaluated using exploratory modeling, habitat observations and testing the influence of environmental factors on recruitment dynamics. Additional considerations of vulnerability and productivity are the implications of shifts in distribution, recruitment dynamics and increased natural mortality. Nye et al. (2009) found an annual increase in mean depth (0.8 m per year) of the winter flounder distribution, which may have productivity and vulnerability implications. Apparent decreases in estuarine spawning or shifts toward coastal spawning (e.g., DeCelles and Cadrin 2010) may also have implications for vulnerability (e.g., less availability to recreational fisheries) and productivity (less larval retention). Consumption of winter flounder by other fishes, birds and mammals may be increasing as these predator populations increase. The GOM assessment indicates that the stock is well above B_{MSY} and experiencing low fishing

mortality. However, the GOM assessment is the most uncertain of the three (from a "feasibility" perspective, if not from a "statistical precision" perspective). The apparent shift in distribution to deeper habitat may be adding uncertainty to the stock assessment reference points that assume stationarity in vital rates. Therefore, it may be vulnerable to overfishing if managed at a catch level close to the nominally projected catch in the near term.

c. Develop plausible hypotheses (e.g., mixing among the three stocks) which might explain any conflicting trends in the data and undertake scenario analyses to evaluate the consequences of these alternate hypotheses on ABC determination.

Major conflicting signals exist between the catch at age data and survey data within the modeling work. The split VPA is weighted towards the catch at age information while the preferred ASAP multi run has a greater weight on the survey information. Survey trends 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 where there is no survey coverage. This hypothesis could possible explain why the survey indices are relatively flat with little apparent response to the change in catch. However there is very limited data on the extent of estuarine residing populations in the 1980s. Therefore this hypothesis remains simply as speculation. The consequences of the split VPA being a better reflection of the true dynamics can be evaluated by assuming the catch or ABC from the preferred ASAP projection is taken within the split VPA projection formulation.

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

About ten of the previous fourteen research recommendations have been partially addressed. Twelve new research recommendations have been developed by the SDWG for SAW52.

Introduction and Assessment History

Gulf of Maine winter flounder is the smallest of the three winter flounder stocks (Figure C1). 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 is unknown.

TOR 1: Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data.

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 C1, Figure C2). The primary gear used was the otter trawl from 1964-1985 that accounted for an average of 95% of the landings. Otter trawl accounted for an average of 74% of the landings from 1986- 2010 with an increase in the proportion of the landings coming from gillnets (26% from 1986-2010) (Table C2). Since 1999 around 95% percent of the landings are taken in Massachusetts from statistical area 514 (Figures C3 and C4). 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 C4). The proportion of the landings coming from the medium market category has decreased since 2004 (Figures C4).

Recreational landings reached a peak in 1981 with 2,554 mt but declined substantially thereafter (Table C4, Figure C5). Recreational landings have generally been less than 100 mt since 1994, with exception of 2008 were the landings was estimated at 103 mt. The PSE of the recreational landing averaged 29% over the time series. Recreational landing weight was re-estimated using the expanded numbers at length and the length weight relationship by half year for input to the VPA, SCALE, and ASAP models.

In the commercial fishery, annual sampling intensity varied from 6 to 310 mt landed per sample during 1982-2007. Overall sampling intensity was adequate, however temporal and market category coverage in some year was poor (Table C4). Samples were pooled by half year when possible. In 1982 mediums were pooled with unclassified by half year, in 1985, 1995, 2005, 2006, and 2007, smalls were pooled with mediums, and the large samples from adjacent years were used for the lack of samples in 1996, 1999, and 2001. Sampling coverage may have been poor but length frequency samples appeared relatively constant over time and

there was a substantial amount of overlap between market categories which help justify the pooling used in the assessment. Lengths of kept fish from observer data were used to supplement length data of unclassified fish. Kept fish lengths taken from gillnet trips in the observer data were used to characterize the gillnet proportion of the landings (Table C5). In 2002 gillnet landings also shifted from occurring mostly in the first half of the year to a greater proportion coming from the second half. In general there has been an increase in the sampling intensity from the commercial ports. However the decline in landings has made it difficult to get samples from the medium and large market categories in recent years. As in GARM III catch at age and catch at length was estimated using observe kept length measurements by gear supplemented with unclassified port lengths by gear from 1999 to 2010. Characterization of the landings using the observer data produced expanded catch at length distributions similar to the length expansions using the port samples by market category for years which had relatively good port sampling (Figures C6 and C7). Size distributions of the landings have been very stable over the past 10 years (Figure C7).

Discards were estimated for the large mesh trawl (1982-2010), gillnet (1986-2010), and northern shrimp fishery (1982-2010) (Table C6 through C7). The survey method was used in estimating both the discard and proportion discards at length for the large mesh trawl fishery from 1982-1988 (Mayo et al. 1992). Observer discard to landings of all species ratios were applied to corresponding commercial fishery landings to estimate discards in weight from 1989 to 2010 for the large mesh trawl fishery. (Wigley et al. 2008)The Fishery Observer length frequency samples were judged inadequate to characterize the proportion discarded at length from 1989 to 1998 for the large mesh trawl fishery and the length proportion from the survey method was used to characterize the size distribution of discarded fish. Observer discard length sampling increased in 2001 and was used to characterize the large mesh trawl discards from 2001 to 2010 (Table C8). The observer sum discarded to landing of all species ratios were used for estimating gillnet discard rates. Observer sum discarded to days fished ratios were used for the northern shrimp fishery since landing of winter flounder in the shrimp fishery is prohibited. The observer length frequency data for gillnet and the northern shrimp fishery were used to characterize the proportion discarded at length. The sample proportion at length, converted to weight, was used to convert the discard estimate in weight to numbers at length. Data from the small mesh trawl fishery was judged as inadequate to estimate discards over the time series (Tables C7 and C9). Observer coverage has improved in the small mesh fishery over the last ten years. The small mesh discard estimates suggests that the discards are small from this fishery. However the estimate in 2010 did showed an increase. As in the southern New England stock (NEFSC 1999), a 50% mortality rate was applied to all commercial discard data (Howell et al., 1992). Numbers at ages were determined using NEFSC/MDMF spring and NEFSC fall survey age-length keys.

A discard mortality of 15% was assumed for recreational discards (B2 category from MRFSS data), as assumed in Howell et al. (1992). Discard losses peaked in 1982 at 140,000 fish. Discards have since declined to an average of about 8,000 fish from 2000 to 2010 (Table C3, Figure C5). Since 1997, irregular sampling of the recreational fisheries by state fisheries agencies has indicated that the discard is usually of fish below the minimum landing size of 12 inches (30 cm). For 1982-2006, the recreational discard has been assumed to have the same

length frequency as the catch in the MDMF survey below the legal size and above an assumed hookable fish size (13 cm). Since 2007 lengths of B2 released catch have been collected by the MRFSS program on party charter vessels which were used to characterize the size of the B2 catch. The recreational discard for 1982-2010 is aged using NEFSC/MDMF spring and NEFSC fall survey age-length keys.

A summary of how the catch at age was constructed can be seen in Table C10. Predicted landings using the same discard method was used as a diagnostic of the discard estimates (Table C11). The predicted landings using the kept to landing of all species ratio are variable but on the same order of magnitude with the dealer landings (Table C1). Decreases in the catch and the catch at age components are shown in Table C12 through C16 and Figures C8 and C9. Mean weights at age and the total catch at age are given in Table C17 and Figure C10. Declines in the mean weights at age were observed for most ages in the catch at age over the last four years.

TOR 2: Present survey data being considered and/or used in the assessment (e.g., regional indices of abundance, recruitment, state and other surveys, age-length data, etc.). Characterize uncertainty in these sources of data.

Mean number per tow indices for the NEFSC and the Massachusetts Division of Marine Fisheries (MDMF) spring and fall time series are presented in Table C18 and Figures C9 through C15. 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 Northeast Fisheries Science Center (NEFSC). There are many differences in the vessel operation, gear, and towing procedures between the new and old research platforms (NEFSC Vessel Calibration Working Group 2007). For most flatfishes there is evidence for differences in selectivity at length between the two survey vessels. The SDWG used the estimated length based calibration by stock to convert the survey indices in 2009 and 2010 into Albatross equivalent units (Figure C16). Details on the estimation of length based calibration coefficients at length is outlined in a working paper by Miller entitled "Winter Flounder Length-based Survey Calibration". Both the length based and published peer reviewed aggregate calibration effects can be seen in Figures C11 and C12 (Miller 2011, Miller et al., 2010). The survey length and calibrated lengths can be seen in Figures C17 and C18.

All of the indices generally show a slight decrease in the population in the late 1980s from a high in the early 1980s with low abundance remaining through the early 1990s. All of the indices show signs of increase abundance starting in 1998 and 1999. Since 2001 all indices indicate a decrease in abundance (Figure C15). The MDMF survey catchability is on the order of 60 to 100 fish per tow while NEFSC survey catchability is on the order of 4 to 14 fish per tow. Age data for the MDMF fall survey are not available. The NEFSC fall ages were used to age the MDMF fall index.

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 of 2010 (Figure C19). The MENH

survey catches relatively few fish over 30 cms (Figures C20 and C21). Age modes for the younger fish are also not clearly seen in the size data. However the increase in the fall of 2010 could be due to an incoming stronger year class. A more defined mode at 9cm can be seen in the fall of 2010 (Figures C21). The working group examined some preliminary age information from the spring MENH index. It was noted that growth from inshore Maine and New Hampshire appears to be slower relative to the MDMF and NEFSC surveys. The MENH indices at age were not included in the models for this assessment due to time constraints and missing age data for some years. However the MENH survey was used in the direct biomass area swept estimate.

Normandeau Associates, Inc. monitored entrainment of winter flounder larvae through the Pilgrim Nuclear power plant since 1975. In general this data suggests a higher abundance of winter flounder larvae since 1997 relative to the 1980s and early 1990s (Figure C22).

An examination of the survey catch per tow at length was conducted to determine the ability of the survey in tracking cohorts. Survey catch per tow at length were plotted with alternating spring and fall surveys over time (Figures C23 through C25). Year classes modes were approximated using growth information. The growth and tracking of cohorts in the younger ages can be seen in the MDMF spring and fall surveys. The younger length modes are more difficult to observe in the NEFSC survey which has a lower catchability for the smaller fish. The raw length frequency data suggests the occurrence of a strong 1998 yearclass evident in both the MDMF and NEFSC surveys. However the detection of this yearclass as it growths above legal size is more difficult to discern (Figure C23 and C24). The strong 1998 yearclass is not estimated in the VPA model. However the tracking of year classes is more difficult to observe in the indices at age (Figures C26 through C28).

Some evidence for a change in the spatial distribution can be seen in the MDMF and NEFSC surveys. There appears to be a shift in abundance for all sizes from shallow water in early 1980s to deeper strata at the end of the time series (Figure C29). Offshore stratum 26 which contains Stellwagon bank also shows increase abundance starting in 1999 while the northern offshore strata off the coast of Maine show no signs of recent increases (Figures C30 and C31). Input from fishermen at the SMAST Fishermen input meeting also reiterated this observation. It is not clear how this shift effects the interpretation of the survey indices. Speculation on a reason for why the survey trends are relatively flat over the time series could be due to a greater proportion of the population residing within the estuaries during the 1980s during the height of the recreational fishery. Fish that reside within the estuaries are not covered by any survey.

TOR 3: Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-5), and estimate their uncertainty. Include area-swept biomass estimates. Investigate if implied survey gear or catchability estimates are reasonable. Include a historical retrospective analysis to allow a comparison with previous assessment results.

[SAW52 Editor's Note: The SARC-52 peer review panel concluded that no ASAP model run provided a suitable basis for management advice. A swept-area biomass method was accepted instead, and it is described in Appendix C1. The ASAP model and results are included below in this report to document the ASAP modeling runs that the SAW Working Group provided to the SARC for peer review.]

Instantaneous Natural Mortality (M)

The SDWG adopted a change in the instantaneous rate of natural mortality (M) for the winter flounder stocks. The value of M previously used in all assessments was 0.2 for all ages and years, and was based on the ICES 3/Tmax "rule-of-thumb" using observed maximum ages for winter flounder (Tmax) of about 15. The current observed Tmax values for the three stock units are GOM = 15 years, GBK = 18 years, and SNE/MA = 16 years (see Growth and Maturity section, above). The adopted change increases this rate to 0.3 for all stocks, ages and years. Evidence can be found in the literature and current model diagnostics to support the increase.

Literature values of M from tagging studies and life history equations indicate M for winter flounder is likely higher than 0.2. Dickie and McCraken (1955) carried out a tagging study in St. Mary Bay, Nova Scotia, Canada (GOM Stock) and estimated a percentage natural mortality rate to be 30% (M = 0.36). Saila et al. (1965) applied Ricker's equilibrium yield equation to winter flounder from Rhode Island waters (Tmax = 12) and using F values from Berry et al. (1965) calculated M to be 0.36. Poole (1969) analyzed tagging data from New York waters from five different years and estimated values for M of 0.54 (1937), 0.33 (1938), 0.5 (1964), 0.52 (1965), and 0.52 (1966). Finally, an analysis of tagging data from a large scale study along the coast of Massachusetts provided a percentage natural mortality rate of 27%, or M = 0.32 (Howe and Coates 1975). For this assessment, a re-analysis of the Howe and Coates (1975) tagging data was conducted using a contemporary tagging model to estimate natural mortality (Wood WP 15). The tagging model fit to the data was the instantaneous rates formulation of the Brownie et al. (1985) recovery model (Hoenig et al. 1998). This work provided an M of 0.30 with 95% confidence interval from 0.259 to 0.346.

Values derived from life history equations found in the literature also support a higher estimate of M for winter flounder. Three equations were used along with a maximum age (Tmax) of 16 to derive estimates of M equal to 0.28, 0.26, and 0.19 (the equations from Hoenig 1983, Hewitt

and Hoenig 2005, and ICES, respectively). A newly proposed method from Gislason et al. (2010), based on SNE/MA stock mean size at age (Ages 1-16) and von Bertalanffy growth parameters, estimated M to be 0.37 (see text table below).

Values of Natural Mortality (M) for winter flounder found in the

literature and derived using life-history equations.

Study	**Method**	**M**
ICES rule-of-thumb	Equation: 3/Tmax	0.19
Hewett and Hoenig 2005	Equation: 4.22/Tmax	0.26
Hoenig 1983	Equation: 1.44-0.982*ln(Tmax)	0.28
Howe and Coates 1975	Analysis of Tagging Data	0.32
Wood 2011 WP15	Re-analysis of Howe and Coates 1975	0.30
Poole 1969	Analysis of Tagging Data from 1938	0.33
Dickie and McCraken 1955	Analysis of Tagging Data	0.36
Saila et al. 1965	Ricker Equil. Yield Equation and Tmax	0.36
Gislason et al. 2010	Equation: Mean size at age and VBG	0.37
Poole 1969	Analysis of Tagging Data from 1964	0.50
Poole 1969	Analysis of Tagging Data from 1965	0.52
Poole 1969	Analysis of Tagging Data from 1966	0.52
Poole 1969	Analysis of Tagging Data from 1937	0.54

Preliminary assessment population model run diagnostics also in general support a higher value for M. Profiles in mean squared residual for ADAPT VPA SNE/MA stock models indicate best fits for M in the range of 0.2 to 0.3. The likelihood profile of initial ASAP SCAA model runs for the SNE/MA stock indicates a best fit for M= 0.6. Model runs from Rademeyer and Butterworth SCAA (ASPM) model (2011) at M equal to 0.2, 0.3, and 0.4 also reveal decreasing negative log-likelihood as M is increased for GOM and SNE/MA stock models (see text table below).

Results of SCAA for the **Gulf of Maine winter flounder** for each combination of 3 levels of natural mortality (*M*=0.2, 0.3 and 0.4, constant throughout the assessment period) and 3 weightings of the survey CAA likelihood (*w*=0.1, 0.3 and 0.5). The runs with w=0.3 and 0.5 have both commercial and survey selectivities flat at older ages, while the runs with w=0.1 have only the commercial selectivity flat. Displayed values are the negative log-likelihoods of each model.

	M		
Weighting	0.2	0.3	0.4
0.1	-123.2	-126.6	-129.1
0.3	-156.9	-177.2	-196.1
0.5	-255.6	-263.2	-280.8

Results of SCAA for the **SNE/MA winter flounder** for 3 levels of natural mortality for Base Case 2. Displayed values are the negative log-likelihoods of each model.

	M		
	0.2	0.3	0.4
-LL	-123.2	-126.6	-129.1

The SDWG also considered other evidence that might justify an increase in M for winter flounder. The NEFSC's food habits database (Smith and Link 2010) was examined to identify the major fish predators of winter flounder. These predators include Atlantic cod, sea raven, monkfish (goosefish), spiny dogfish, winter skate and little skate. A preliminary examination was undertaken to determine the prominence of winter flounder in the diets of these predators, across all seasons, years, size classes of predator, sizes of prey, and geographic locales. The overall frequency of occurrence of winter flounder in the stomachs is not a common or high occurrence (see text table below), always less than 0.15%.

Occurrence of winter flounder in their major fish predators.

	Number of stomachs	Occurrences of winter flounder	% Freq. of occurrence
Spiny dogfish	67,565	27	0.040%
Winter skate	17,708	6	0.034%
Little skate	28,725	6	0.021%
Atlantic cod	20,142	27	0.134%
Sea raven	7,968	10	0.126%
Goosefish	10,742	12	0.112%

Further, the contribution of winter flounder to the diets of these predators species is also notably small (see text table below), usually less than 0.4%.

Contribution of winter flounder to the diet of their major fish predators.

	% Diet composition of winter flounder,	95% CI
Spiny dogfish	0.2049%	0.10678
Winter skate	0.1454%	0.16008
Little skate	0.0124%	0.01618
Atlantic cod	0.3172%	0.24032
Sea raven	0.8831%	0.78407
Goosefish	0.2492%	0.25947

Understandably the temptation exists to evaluate these relatively low contributions of diet with respect to consumptive removals of winter flounder as compared to winter flounder stock abundance and (relatively low) landings, initially using *ad hoc* or proxy methods. Yet just as one would not do so when assessing the status of a stock without a fuller exploration of all the sensitivities, uncertainties and caveats of the appropriate estimators and parameters, the SDWG did not recommend doing so for scoping winter flounder predatory removals at this time. The SDWG also noted that for percentages as low as observed, when allocated to the three winter flounder stocks and explored seasonally or as a time series, there are going to be large numbers of zeroes and attendant uncertainties and variances that would logically offset any potentially high individual predator total population-level consumption rates. Thus, the SDWG does not

provide comment as to the merit of exploring or relative magnitude of the issue, but recommends that the topic should be forwarded as an important research recommendation. Other sources of increased natural mortality may come from perceived increases in seal populations along the New England coast, which are known to be predators of winter flounder (Ampela 2009). Population size was estimated at 5600 seals in 1999 (Waring et al. 2007) and a current survey is being conducted to estimate the size of the seal population. However, no time series of seal abundance or consumption of winter flounder is available.

Stock Assessment Models

Abundance indices at age were available from several research surveys: NEFSC spring bottom trawl ages 1-8+, NEFSC fall ages 1-8+ (advanced to tune January 1 abundance of ages 2-8+), Massachusetts spring ages 1-8+, and Massachusetts fall ages 0-8+ (advanced to tune January 1 abundance of ages 1-8+) (Figures C32). The influence of the length based conversion on the indices at age can be seen in Figure C33. The survey mean lengths at age also showed a slight decline at the end of the time series (Figure C34).

There was little change in the female 3 year moving average maturity using MDMF spring survey (Figure C35). A logistic maturity estimate using all years combined (1982-2010) from the spring MDMF survey did not change from the maturity schedule estimated (1982-2007) from GARM III (Figure C36). A histological maturation study described in the working paper by McBride et al 2011 indicated that the MDMF survey macroscopic maturation estimate was appropriate for this stock.

The base and split VPA with assumed natural mortality equal to 0.2 was updated from the GARM III assessment. Differences between the split VPA m=0.2 and m=0.3 can be seen in Figure C37. There was little difference in retrospective pattern between the split model with m=0.2 to the split model m=0.3. All subsequent model runs were done with m=0.3 based on the SDWG conclusion above. As in GARM III the base case VPA run showed a severe pattern in the residuals (Figure C38) and exhibits a severe retrospective pattern in F, recruitment, and a large overestimation of SSB (Figures C39 and C40). Splitting the surveys allows the model to estimate further declines in abundance with higher Fs at the end of the time series. The split survey model is less constrained by the conflicting signals between the large decline in the catch and the survey abundance of the older fish (4+) at the end of the time series. As in GARM III, splitting all of the surveys between 1993 and 1994 did improve the retrospective pattern (Figures C41 and C42). The survey split in the updated assessment appears to have reduced the retrospective bias further then what was observed in the GARM III split VPA model. In addition the update split model estimates for 2007 was similar to the terminal year estimates from the GARM III split VPA which can be seen in the historical retrospective plots in Figures C43 and C44. However other diagnostics still imply major sources for concern surrounding the VPA model formulation for GOM winter flounder. 1) A significant residual pattern in the survey exists for the first half of the model (1982-1993), however the residual pattern seems to have improved for the second half (1994-2010) (Figure C38). 2) Forward and

backward diagnostic calculations of the plus group suggest that the plus group estimates are not well determined (Table C19). 3) Area swept Q estimates suggest efficiencies greater than one in both the base and split model runs indicating that the area swept survey population estimate is higher than what is estimated by the model (Figures C45 and C46). 4) The split model results in a large change in the Q estimate. Many of the survey Qs more than tripled in the split VPA run. 5) Biological reasons for a strong dome shape pattern in the Q at age from the surveys is difficult to understand (Figures C45 and C46). However this dome shape concern in the surveys also exists in the forward projecting age structured models.

The SCALE model is a simple forward projecting model that tunes to age data for the younger recruitment ages (age 1, 2, and 3) and length data for the larger adult fish (30+ cm). The SCALE model assumes an overall time invariant growth curve with assumed input variation around the mean lengths at age. The model also assumes flat-topped selectivity in the surveys. The Base SCALE model run possessed a similar retrospective pattern as the VPA. The split SCALE model results were sensitive to the weighting on the recruitment indices. The SDWG did a brief exploration of the SCALE model for this assessment. The SCALE model appeared to possess similar diagnostic issues as observed during GARM III. The estimated selectivity and fishing mortality was sensitive to the assumed input variation on the growth (mean lengths at age). The SDWG concentrated on developing the assessment in ASAP (Age Structured Assessment Program) since there appeared to be greater dynamics present in the indices at age relative to the apparent lack of change in the size structure over time. In addition ASAP allows for the estimation of dome shape selectivity patterns in the surveys.

Preliminary runs were first developed in ASAP similar to the base and split VPA configuration. Indices were input as indices at age. This preliminary runs had a relatively high weight on fitting the catch at age compositions (150 effective sample size). The preliminary runs showed similar results as the VPA with similar diagnostic issues (Figure C47). However, the split ASAP model possessed a severe retrospective pattern (Figure C48). The split in ASAP did not reduce the retrospective pattern as observed with the split VPA model.

Reducing the weight on fitting the catch at age composition (50 effective sample size) in the ASAP base model allows a better fit to the survey indices. Trends in the estimated stock numbers at age can be seen in Figure C49. The estimated biomass over the last decade increases as the weight on the catch at age composition is lowered. This results in further overestimation of the plus group relative to the run with a higher weight (150) on the catch at age composition (Figures C50 and C51). The retrospective pattern with an effective sample size weight of 50 compared to a weight of 150 also showed a reduction in the retrospective pattern (Figure C52 and C53). Similar results were seen with the modeling of Gulf of Maine winter flounder done in an Age-Structured Production Model (ASPM) which is described in Rademeyer and Butterworth MS 2011. The 50 weight model showed a similar dome shaped pattern in Qs as the split VPA (Figure C54).

The SDWG also explored an ASAP model formulation which fit the aggregated survey indices and survey age structure as a multinomial. This formulation does allow for fixing the assumptions on survey selectivity. In general both ASAP formulations produced similar results. The multinomial (ASAP multi run) formation did produce some difference in estimated biomass trends at the start of the model (1980s) and a lower estimate of biomass at the end of the time series. The SDWG did some further refinement to the final multi run through the estimate of a separate selectivity block from 1998 to 2010. This did result in a slight shift in the selectivity to older fish for the second time block as observed in the catch at age. Fits to catch at age composition, estimated survey selectivity, fits to the aggregate survey indices, predicted stock numbers at age, and the retrospective pattern can be seen in Figures C55 to C60. The difficulties in estimating population scale can be seen when comparing the results from different models (VPA and ASAP) and for models with different weighting on the data sources (Figure C61).

The combined survey area swept 30+ biomass estimates are described in Appendix C1. The fall survey biomass estimates were judge more appropriate since a greater proportion of the population should be within the survey area during the fall because the fish are not spawning within the estuaries at that time. The area swept 30+ biomass for the fall between 2009 and 2010 ranged from 6,300 mt to 7,600 mt assuming a gear efficiency of 60 percent (q=0.6). This survey based biomass estimate was used to inform the weighting on the catch at age composition used in the model. Therefore the 30+ biomass estimate at the end of the time series was important for judging the feasibility of the model results. For example the ASAP which used dome shape fishery selectivity had desirable diagnostic properties but the biomass estimates were unfeasibly high at the end of the time series (over 20,000 mt). The 30+ cm biomass estimate from the survey estimate is comparable to the 4+ biomass, exploitable biomass, and the SSB in 2009 and 2010 from the SDWG multi ASAP run (Figures C62 and C63).

Age Structured Assessment Program (ASAP) Description

ASAP (Age Structured Assessment Program v2.0.20, Legault and Restrepo 1998) and the technical manual can be obtained from the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/). ASAP is an age-structured model that uses forward computations assuming separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance. Discards can be treated explicitly. The separability assumption is partially relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change in blocks of years. Weights are input for different components of the objective function which allows for configurations ranging from relatively simple age-structured production models to fully parameterized statistical catch at age models.

The objective function is the sum of the negative log-likelihood of the fit to various model components. In the SDWG preferred ASAP multi run the catch at age and survey age composition are modeled assuming a multinomial distribution, while most other model

components are assumed to have lognormal error. Specifically, lognormal error is assumed for: total catch in weight by fleet, survey indices, stock recruit relationship, and annual deviations in fishing mortality. Recruitment deviations are also assumed to follow a lognormal distribution, with annual deviations estimated as a bounded vector to force them to sum to zero (this centers the predictions on the expected stock recruit relationship).

ASAP Model Inputs and Formulation

The ASAP model formulation used a composite catch by a directed fleet starting in 1982. Commercial landings do exist prior to 1982. However recreational landings are unknown prior to 1981. All models included the NEFSC spring and fall as well as the Massachusetts state surveys for both the spring and fall. Minimum swept area abundances and an assumed CV of 0.4, as well as age composition for each survey were used in the model. The working group focused initial scrutiny on models that treated the survey indices by age, similar to a VPA model formulation but due to difficulties to reconcile model diagnostics, the multinomial formulation was preferred by the working group. The preferred ASAP multi model used a plus group at age 7. Exploratory runs examined model sensitivity to estimating a stock recruit function versus estimating an average recruitment with annual deviations; estimating age-specific selectivity for the surveys versus forcing the survey to have a flat-topped selectivity; "breaking" the survey time series into two separate series or maintaining a continuous time series; and adding or removing selectivity "blocks" to the directed and bycatch fleets. In considering these various model iterations, diagnostics were examined to determine if the fit improved. Specifically, the pattern of residuals in age composition for catch and indices, residuals in the fit to total catch and annual index values, components of the objective function in addition to total objective function and number of estimated parameters, as well as the "feasibility " of the estimated selectivity patterns were examined. With regard to the last criterion ("feasibility" of estimated selectivity), the models tended towards solutions with sharply domed selectivities for both the directed fleet and the surveys. As there was nothing biological to suggest that fish at ages 5 and beyond would have very low catchability (i.e., no known behavioral aspects, no strong swimming capabilities), nothing gear related that would suggest lower catchability (no outswimming otter trawls, no other known gear interactions), and no known market conditions that would favor smaller fish. The SDWG found it hard to reconcile selectivities of 0.10 on the 7+ group.

Model formulations for both the indices at age and the multinomial model were examined. Although the objective function values were not directly comparable between these two model treatments, owing to differences in the underlying data, residual diagnostics, overall fits, and retrospective patterns were compared. The working group agreed to the following preferred multi configuration: A model that did not split the survey indices, two selectivity blocks for the directed fleet (the break occurred between 1997 and 1998), forced with a selectivity = 1 for ages 4 and older. With all models considered, there was a strong correlation between the selectivity estimated for the directed fleet and the selectivity of the surveys. Forcing a flattop for the survey indices caused the selectivity estimates for the directed fleet to be also flattopped. Similarly, allowing a dome in the survey led to dome selectivity in the directed fishery. For this reason, a flattop was assumed for the directed fleet fishery. For this

selectivity pattern, the age composition residuals showed some patterning, particularly in the plus age category and the overall index as well as the total catch showed some time trends in the fit to the residuals. In contrast, when a dome selectivity is estimated in the fishery, there was an improvement in both the residual age composition and residual fit the overall index and total catch. However, the estimates of spawning stock biomass and recruitment were unreasonably high due to cryptic biomass that was generated from the dome selectivity pattern. Although the flattop configuration did not provide the best diagnostics, the estimates of spawning stock biomass and recruitment were within reason. This is a fairly consistent trade-off seen in many of the model diagnostics, wherein improvements in the fit to the catch at age, including the total data (catch or total index values) results in a different perception of the stock. Thus, selecting the 'best' model depended to some extent on the amount of confidence that one had in the age composition data as well as the total catch and the indices. Complete diagnostic output plots can be found in the Appendix C2 ("Multi models diagnostics_2_Block_Fishery_Selectivity").

Preferred ASAP Multi model Retrospective Pattern

A retrospective analysis on the ASAP multi model using a seven year peel was conducted to examine the stability of the model estimate for fishing mortality, recruitment and spawning stock biomass (Figures C59 and C60). Due to the change in selectivity block beginning in 1998, it was difficult to interpret the earliest peels because there was an imbalance in the number of parameters being estimated versus number of years with additional data. However, it was noted that the model that estimated a dome in the directed fleet had the lowest retrospective while the preferred multi model exhibited higher retrospective averages.

Preferred ASAP Multi model Sensitivity Analyses

For completeness, sensitivity to the model decisions adopted in the base model are summarized in Table C20. Seven additional runs were explored including assuming survey flattop selectivity, lowering or increasing the age to fix survey selectivity, allowing a dome in the fishery and removing time blocks in the fishery selectivity. Due to convergence problems in some of the sensitivity runs, only four of the seven sensitivity runs were reported. Only one of the four runs reported assumed no time blocks in the directed fishery selectivity. The motivation for introducing selectivity blocks, and the year that they were introduced, was an attempt to account for changes in the fishery composition and pertinent regulations (mesh size and minimum sizes changes). While this model offered similar diagnostics as in the ASAP multi run, the retrospective estimates were improved for spawning stock biomass, recruitment and Fishing mortality. The overall objective function for the single block directed fishery was 3480 while for the base model, it was 3453. Thus, the multi run which estimated an additional block of selectivity improved the objective function by 27 points at the cost adding four additional parameters to the model.

The remaining three models were based on the two block selectivity in the fishery. Lowering the age to fix the survey selectivity suggested improvement in the likelihood components of the model. However, the model had problem converging, possibly due to parameter boundary

issue as hessian was obtained for the model. Assuming flattop in the survey did not improve the overall objective likelihood function neither did it provide improved diagnostic in comparison to the ASAP multi run. Additionally, survey catchability for the Massachusetts state survey was greater than one and the retrospective estimates deteriorate substantially.

Preferred ASAP multi Model Results

Fishing mortality on ages 3+ varied between 0.359and 0.648 from 1982 to 1989 then decreased consistently since 1990 from 0.586 to 0.102 in 1999. Fishing mortality Varied slightly between 0.138 and 0.058 from 2000 to 2009. The fishing mortality rate in 2010 is estimated to be 0.032 (80% confidence interval 0.026 – 0.038; Figures C63 and C64).

Recruitment has been relatively stable throughout the time series. Mean recruitment was around 8.1million for age1 recruits. Several abundant year classes were produced in 1982-1983, 1985, 2004,-2007 ranging from 10 million to 11.9 million. Recruitment in 2010 is estimated to be 4.7 million, lowest in the time series (80% Confidence interval 3.2 million – 6.2million).

Spawning stock biomass declined substantially early in the time series from 12,506 metric tons in 1982 to 1,487 metric tons in 1993, lowest in the time series. Thereafter, SSB has steadily increased from 1,664 metric tons in 1994 to 5,817 metric tons in 2009. Spawning stock biomass in 2010 is estimated to be 5,803 metric tons (80% confidence interval 4,901 – 6,705 metric tons; Figures C63 and C64).

SDWG Stock Assessment Model Discussion and Conclusions

The population models have difficulty with 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. These conflicting signals were identified in GARM III and results in a severe retrospective pattern in the modeling. Splitting of the survey indices did help reduce the retrospective bias in the models. However the magnitude of the change in q estimated from the split that was required for the model to fit the lack of older fish in the catch at age was no longer believable. Area swept q estimates (2-3 second half) which exceeded 1 suggested that model estimates of biomass was far lower then what was observed in the surveys. At GARM III stock status determination changed from not overfished and not overfishing to overfished and overfishing with the split. Examination of an alternative forward projecting model (SCALE) that tunes to length data produced similar results and had similar diagnostic issues as the VPA. Status determination from the SCALE model was also sensitive the weighing of different data components. The lack of fit to the survey indices in the GARM III VPA resulted in high uncertainty in the status determination which led to rejection of the models.

Conflicting trends in the data still exist in this assessment. However there are several changes that contribute to change in the estimated population trends and status determination relative to

the GARM III models. 1) The change in assumed natural mortality from 0.2 to 0.3. 2) Trends at the end of the assessment during the GARM III where difficult to interpret due to the declining catch with declines in the survey index for older fish (4+) at the end of the time series in 2007. This assessment added three more years (2008-2010) to the GARM assessment. 3) There have been increases in the indices at age for the older fish (5,6 7+) since the GARM assessment. 4) The biggest change that contributed to the change in population trends was the switch in the modeling of the stock to ASAP which allowed errors in the fit to the catch at age and a better fit to the surveys indices without the split.

Population scale is poorly determined within the modeling due to the conflicting data trends. The scaling of the population estimates was sensitive to the weight imposed on the catch at age compositions. The conflicting trends in the data produce a bifurcation in the model results. This was observed in both the ASAP and ASPM modeling work from Rademeyer and Butterworth MS 2011. Forward projections models that are forced to fit the catch at age cannot fit the survey indices and result in similar trends as seen in the VPA. Tension within the model is lowered, retrospective bias is reduced, and population estimates are scaled higher with larger increases at the end of the time series as the fit on the catch at age composition in ASAP and ASPM models is relaxed. Preferred ASAP and ASPM models assumed a flat-topped selectivity pattern. This results in an overestimation of fish in the plus group as the fit to the catch at age composition is lowered. Allowing both models to fit a dome shape selectivity pattern further releases the tension within the model and allows the estimation of the strong dome shaped pattern with unrealistically high biomass estimates at the end of the time series.

The SDWG developed a table outlining the reasons why the ASAP multi model was the preferred model in this assessment (Table C21). The split VPA lack of fit to the overall survey indices with estimates on biomass far below the minimum area swept numbers made it difficult for the SDWG to accept this model formulation. The ASAP model formulation did not require a split survey configuration to adjust for the retrospective pattern. The combined survey 30+ biomass area swept estimate was used to inform the optimal weighting for the preferred model formulation. The resulting final model weighting formulation considered both the tradeoff between retrospective bias and feasible biomass estimates at the end of the time series. A retrospective pattern did exist in the preferred ASAP multi run but the SDWG noted that the last two years of the model appeared to be consistently estimated. The within model uncertainty will not capture the uncertainty in this assessment considering how sensitivity the results are to the model formulation and weighting.

The SARC concluded that the assessment model were too unreliable as a basis for management. The accepted assessment of GOM winter flounder stock is based on an empirical swept-area model utilizing data from the 2010 NEFSC fall survey, the MADMF fall survey, and the Maine-New Hampshire fall inshore surveys which is summarized in apppendex C1. Using an efficiency value of 0.6 the estimated stock biomass in 2010 of fish greater than 30 cm was 6,341 mt (80% CI 4,230 - 8,800 mt).

TOR 4: Perform a sensitivity analysis which examines the impact of allocation of catch to stock areas on model performance (in TOR-3).

The SDWG interpretation of TOR4 is that the variance of the commercial landings due to the 1995 and later area-allocation scheme should be used as the basis for the magnitude of landings that might be lost or gained from the stock-specific assessments, and then perform an exercise to run the assessment model with those potential biases and report the results. Additional work was done to estimate the error in the commercial landings due to misreporting of commercial landings to statistical area at allocation level A, the initial reporting level in mandatory Vessel Trip Reports (VTRs; Palmer and Wigley MS 2011). Vessel monitoring system (VMS) positional data from northeast United States fisheries for 2004-2008 were used to validate the statistical area fished and stock allocation of commercial landings derived from the VTRs. The accuracy of the VMS method relative to the VTRs was assessed using haul locations and catch data recorded by at-sea observers. This work was performed for several New England groundfish species. The perceived under-reporting of statistical areas in the VTR data led to minor (< 5%) differences in the overall species allocations; only nine stocks in the five year time-series exhibited differences in stock allocations exceeding 2.0% (2004: northern and southern silver hake, ± 3.0%; 2006: northern and southern windowpane flounder, ± 4.7%; 2007: Georges Bank winter flounder, 2.4%; 2008: Georges Bank winter flounder, 2.4%, Southern New England/Mid-Atlantic winter flounder, -3.2%, and northern and southern windowpane flounder, ± 3.4%). Given the magnitude of these errors, the SDWG elected to run the final GOM winter flounder ASAP model, with an additional 5% PSE in commercial landings added to the estimated PSE over the 1995-2010 time series.

For the GOM stock the total catch consists of 4 components. The commercial landings have a calculated Proportional Standard Error (PSE; due to the commercial landings area-allocation procedure; available for 1995 and later years, with the mean of those years substituted for 1982-1994) ranging from 5.3% to about 6.5%; the commercial discard (trawl and gillnet) PSEs range from 16-177% (available for 1994-2010, mean of those years substituted for 1982-1993); and the recreational landings PSEs range from 17-50%. Because the PSEs for the commercial landings are low, and the commercial landings account for about two-thirds of the total catch, the total catch weighted-average annual PSEs range from 7-30%, and averages 11.7% (unweighted) for the 1981-2010 time series.

The catch in the final assessment model was increased and decreased by the annually varying PSE and models re-run to provide an additional measure of uncertainty of assessment estimates. For the final ASAP multi model, the fishing mortality estimate in 2010 did not change greatly (0.01 to 0.034). The 2010 SSB range was 4,700 to 6,900 mt, was similar to the MCMC estimate of uncertainty (Figures C63 and C65).

TOR 5: Examine the effects of incorporating environmental factors in models of population dynamics (e.g., spring water temperatures in an environmentally-explicit stock recruitment function).

This TOR is addressed in a separate working paper from Hare MS 2011 entitled "Development of environmentally-explicit stock-recruitment models for three stocks of winter flounder (Pseudopleuronectes americanus) along the northeast coast of the United States**".**

To develop environmentally-explicit stock recruitment relationships, three specific types of data are required: spawning stock biomass, recruitment, and environmental data. Spawning stock biomass and recruitment data from the final 2011 SAW 52 assessment models were used in the analysis. For the GOM stock, recruitment (lagged by 1 year) and spawning stock biomass pairs were used from the ASAP multi model. Two general types of temperature data were used: air temperatures and coastal water temperature. In addition to temperature, four large-scale forcing indices were included in the analyses. The North Atlantic Oscillation (NAO) is the dominant mode of winter climate variability in the North Atlantic region and has been related to numerous physical and biological variables across the North Atlantic (Ottersen et al. 2001, Visbeck et al. 2003). The Atlantic Multidecadal Oscillation (AMO) is a natural mode of climate variability and represents a detrended multi-decadal pattern of sea surface temperatures across the North Atlantic with a period of 60-80 years (Kerr 2005). Finally, the Gulf Stream index is a measure of the northern extent of the Gulf Stream south of the northeast U.S. shelf ecosystem. The Gulf Stream position is related to the larger basin-wide circulation, which in turn is related to NAO and AMO. Two Gulf Stream indices are used here (Joyce and Zhang 2010, Taylor and Stephens 1998).

In summary, for the Gulf of Maine stock, increased winter air temperatures are related to lower recruitment, but the strength of this environmental forcing is less than for the Southern New England stock. This result makes sense in the context of the distribution of winter flounder; the southern stock is most affected by warmer temperatures.

One use of the environmentally-explicit models is to develop short-term and long-term forecasting models. Based on the this work, there is no trend in winter temperature over the past 30 years and thus short-term forecasts can be developed using the environmentally-explicit models assuming winter temperatures to be at their mean state. It may also be useful to develop short-term forecasts under warm temperatures and short temperatures to provide managers with a tangible understanding of the effect of temperature on the stocks. The environmentally-explicit models could also be used to develop longer-term forecasts following the approach of Hare et al. (2010). These forecasts would provide an assessment of the sustainability of the winter flounder fishery on the 30-100 time scale.

Work is underway within the SDWG to incorporate environmentally-explicit stock-recruitment models into the NFT standard software used to fit stock-recruitment models and to perform projections of stock and fishery catch. However, this work has not been developed sufficiently to be made available for peer-review at this time (see new Research Recommendation 10).

TOR 6: State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, BTHRESHOLD, and FMSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

The 2008 GARM III assessment was not accepted and the overfished and overfishing status of the GOM winter flounder stock is currently unknown. However GARM III stated that it is highly likely that biomass is below B_{MSY}, and that there is a substantial probability that it is below the ½ B_{MSY} threshold. A rebuilding schedule was not developed for this stock since GARM III stock status was considered unknown and the GARM I and II assessments did not considered the stock overfished.

The estimated biological reference points are summarized in table C22. The split VPA estimated higher percent maximum spawning potential (MSP) proxies relative to the ASAP model because the VPA estimated selectivity was shifted to older fish (Figure C66). The preferred SDWG ASAP multi run estimated a F40 FMSY proxy at 0.34 using the 2006-2010 average mean weights and selectivity as input to the YPR analysis (Table C23; Figure C67). The F40 SSBmsy was estimated from a long term projection (100 years) using the CDF of recruitment from the entire model time series (1982-2010) and the estimated YPR F40. The SSBmsy using the FMSY = F40 proxy was estimated at 3,287 mt with a SSBmsy threshold estimate of 1,644 mt and a MSY equal to 1,080 mt for the ASAP multi run. Stock recruit relationships from the split VPA and ASAP multi run can be seen in figures C68 and C69. The split in the VPA results in a trend in the estimated recruitment which produces a lower steepness and a stronger relationship in the stock recruit curve. Performing a likelihood profile on steepness and a MCMC on the stock recruit model suggests that the steepness, SSBmsy and Fmsy was not well determined from the ASAP multi run (Table C24; Figure C70). The SDWG Beverton Holt stock recruitment Fmsy using the Pleuronectids steepness prior from Myers et al. (1999; 0.8 mean and CV = 0.09) was estimated at 0.57. The stock recruit SSBmsy was estimated at 2,167, SSBmsy threshold = 1,084 mt, and MSY = 1,152. The MSY estimate did not vary greatly with SSBmsy from the MCMC in the stock recruitment analysis (Figure C71). The SDWG expressed concern with the stock recruitment estimate of SSBmsy being estimated in the lower end of the range of past SSB observations.

The SDWG developed a unified response to TOR6, taking into consideration the assessment results for all three stocks. The fishing mortality and biomass Biological Reference Points (BRPs) discussed below are from the Final models accepted for the stocks. As defined in the Magnuson Act, 'overfishing' means "a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis" (i.e., FMSY). The guidelines allow for the projected catch associated with the overfishing limit (OFL) to be based on FMSY proxies. Many proxies are used to define overfishing in situations when FMSY is not well determined. The SDWG interpreted these guidelines to mean that best practice is to use a FMSY estimate instead of a proxy when FMSY can be reliably estimated. The SDWG estimated FSMY for the winter flounder stocks as well as proxies in the form of

F40%. The SDWG developed consensus on some aspects of the FMSY estimates (relative magnitude across stocks), but also had some disagreement about the reliability of FMSY estimates (related to the perceived reliability of the respective assessments). The SDWG could not come to consensus on the preferred MSY reference points for the three winter flounder stocks. Updated estimates of F40% were provided as the existing overfishing definitions and as alternatives to FMSY and SSBMSY estimates. Estimates of F40% and SSB40% were provided as potential overfishing definitions based on the precedence offered by GARM-III (NEFSC 2008), instead of other potential %MSP alternatives.

Appropriateness of FMSY Estimates

The SDWG estimates of FMSY utilize data and prior information in a statistical framework. Estimation of the steepness parameters (*h*) in the stock-recruitment relationships used the available stock-recruitment estimates and a prior distribution of *h* from other Pleuronectid flatfishes (Myers et al. 1999), as was used in previous assessments of SNE/MA winter flounder (NEFSC 2002).

Steepness was estimated to be:

- 0.84 for Gulf of Maine winter flounder
- 0.85 for Georges Bank winter flounder
- 0.64 for SNE/MA winter flounder

The SDWG estimates of *h* for winter flounder stocks are realistic. They are compatible with both the estimates of *h* for Pleuronectids that were used as priors, and with the distribution of all of the estimates in Myers et al. (1999). Uncertainty in FMSY is estimable based on stock-recruitment relationships, but not all sources of uncertainty are included in the SDWG evaluation (e.g., uncertainty in assumed natural mortality, precision and accuracy of stock-recruit estimates are not considered).

Concerns about the reliability of the estimates FMSY

There are aspects of using a prior for steepness for these stocks that are problematic. If no prior is applied, two of the three resulting stock-recruit relationships are not theoretically feasible (e.g., the linear increase in SNE/MA recruitment as a function of spawning stock size; the constant recruitment even at low spawning stock size for GBK winter flounder). There are several concerns with the prior on *h* from Myers et al. (1999) meta-analysis for Pleurinectid flatfishes. The prior is not well understood, because the original data was not available at the SDWG. Many of the stocks used to form the prior have $M < 0.2$. The appropriateness of this prior for the U.S. winter flounder stocks, with assumed $M = 0.3$, is therefore unknown. The number of Pleuronectid stocks in the Myers et al. (1999) study is limited (n=14), and there were no winter flounder stocks included. Derivation of the precision estimate of *h* (0.09; NEFSC 2002) is not clearly documented. The assumed normal error structure for the prior may not be appropriate for a parameter bounded by 0.2 and 1. Myers et al. (1999) stated that "the family-level estimates (shown in boldface) should be used with caution." FMSY estimates depend on both mean and precision of steepness, but the SDWG did not have

information on how well the Myers et al. (1999) values were estimated.

The precision of steepness (*h*) estimates show a moderate range of possible values and an associated moderate range in estimates of FMSY(see text table below):

Estimates of steepness (h), FMSY and %MSP with 80% confidence intervals and CVs.

Stock	h	CV	10%	90%	FMSY	CV	10%	90%	%MSP	10%	90%
GOM	0.84	0.08	0.75	0.92	0.565	0.19	0.43	0.77	28	34	21
GBK	0.85	0.08	0.75	0.94	0.500	0.22	0.39	0.69	29	35	22
SNE/MA	0.64	0.08	0.57	0.76	0.310	0.07	0.27	0.43	42	46	32

The implied maximum lifetime reproductive rate [$4h/(1-h)$] is quite variable among the stock (h=0.64 implies ahat=7.1 while h=0.84 implies ahat=21.0), where ahat represents the number of spawners produced by each spawner over its lifetime at very low spawner abundance (i.e., assuming absolutely no density dependence). With similar growth, maturity and natural mortality rates, it is not clear why the implied reproductive rates are so different.

The %MSP associated with the range of FMSYestimates suggests that F40% is compatible with FMSY for SNE/MA winter flounder, but those ranges suggest that F40% is not compatible with FMSY for the GOM and GBK stocks. The %MSP associated with FMSY estimates range from 28% to 42%, but it is again unclear why the %MSP values are up to 50% different for stocks with similar biology and fishery characteristic, when only the stock-recruitment steepness differs.

The SDWG had several concerns about the use of F40% as an overfishing definition. F%MSP ignores any information from stock and recruitment estimates, and therefore may be inconsistent with FMSY estimates that use such information. The performance of F40% for achieving MSY has not been evaluated specifically for winter flounder stocks. The SDWG recognized the logical difference between "data-based" inferences involved in estimates of FMSY vs. “hypothesis-based” expectations of inter-stock similarities, based on analogy to justify F40%.

In summary, from a comparative approach to MSY reference points, F40% is similar for all three stocks. The estimate of FMSY for GOM winter flounder is similar to that for the GBK stock but twice that for the SNE/MA stock. This two-fold range in FMSY among the three stocks is due to the differing patterns in the estimated stock-recruitment data (see text table below). The SNE/MA stock has a low steepness estimate that is driven by estimates of strong recruitment and high spawning stock size from the 1980s. Unlike the situation for SNE/MA winter flounder, for GOM and GBK winter flounder there is no pattern in the stock-recruitment estimates that supports inferences of lower steepness. The influence of environmental conditions that limit recruitment success (e.g., warmer temperatures and subsequent larval predation effects) is a possible explanation of the lower steepness of the SNE/MA stock (and subsequently lower FMSY). The SDWG noted that this explanation

assumes no local and complete adaptation to environmental conditions among the stocks.

Stock	F_{MSY}	h	SSB_{MSY}	SSB_0	SSB_0/SSB_{MSY}	MSY	F_{40}	SSB_{40}	MSY_{40}
GOM	0.565	0.84	2,167	8,887	4.10	1,152	0.340	3,287	1,080
GBK	0.500	0.85	8,260	31,478	3.81	4,200	0.320	11,300	3,200
SNE/MA	0.310	0.64	33,820	92,657	2.74	9,763	0.327	29,045	8,903

Implications of Reference Point Decisions

Despite the uncertainty in reference point estimation for SNE/MA Atlantic winter flounder, the determination of stock status and rebuilding conclusions are robust. All candidate reference points lead to a conclusion that the stock cannot rebuild to Bmsy by 2014, even at F=0.

Major uncertainty persists in the GOM winter flounder stock assessment, and estimates of current biomass are much greater than all candidate estimates of BMSY or BMSY proxies. However, the relatively low estimates of F and conclusion that overfishing is not occurring are consistent with recent regulations and restrictions on catch. The estimate of SSBMSY corresponding to *h*=0.84 for GOM winter flounder is close to the lower end of the range of past SSB estimates, in contrast to the situation for GBK winter flounder, where it is close to the middle of this range. The minimum observed GOM SSB was 1487 mt, and the 80% confidence interval of SSB_{MSY} is 1640 to 2700 mt. Although the 80% confidence intervals for *h* for each of these two stocks are similar, this feature of the GOM estimates renders them less reliable than those for the GBK stock. While there were disagreements within the SDWG on the BRPs to use as the overfishing definition, the SDWG reached consensus that the current model and associated reference points for Gulf of Maine winter flounder were acceptable and the best that could be determined at this time.

SARC 52 did not accept the SDWG model and the overfished status remains as unknown since biomass based reference points could not be estimated. The SARC accepted a proxy value of the overfishing threshold which was derived from a length-based yield per recruit analysis that assumes all fish above 30 cm are fully recruited to the fishery and that natural mortality is 0.3. Using $F_{40\%}$ (0.31) as a proxy for Fmsy, the threshold exploitation rate is 0.23 and 75%$F_{40\%}$ exploitation was 0.17 with M=0.3. The reference points were converted to exploitation rates to be consistent with the swept area biomass approach (Appendix C1).

TOR 7: Evaluate stock status (overfished and overfishing) with respect to the "new" BRPs (from TOR 6), and with respect to the existing BRPs (from a previous accepted peer review) whose values have been updated.

BRPs for GOM winter flounder from the GARM-III assessment in 2008 (NEFSC CRD08-15) were based on F40%, a proxy for FMSY. SSBMSY and MSY were estimated with the AGEPRO projection model, including the model's CDF of age-1 recruitment and the estimate of F40%. Although BRP's were estimated in GARM-III (F40% = 0.283, SSBMSY = 3,792 mt, and MSY = 917 mt), the GARM-III Review Panel concluded that the assessment did not give "a clear picture of the status of the resource" and that "the proposed analysis could not be

used to provide management advice nor stock projections". Therefore, the 2008 assessment was not accepted and the overfished and overfishing status of the GOM winter flounder stock is currently unknown.

Stock status evaluation was consistent regardless of the model formulation (VPA and ASAP) which is summarized in Table C22. Both the split VPA model and the SDWG preferred ASAP multi model indicate that the stock is not overfished and overfishing is not occurring. However spawning stock biomass relative to the SSBmsy varied widely between the VPA and preferred ASAP multi model. SSB in 2010 to SSBmsy ratios varied from the stock recruit Split VPA estimate of 0.52 to the stock recruit estimate of 3.09 from the ASAP multi with no prior on steepness. All models show that fishing mortality in 2010 were well below their respective Fmsy reference points. Fishing mortality in 2010 to Fmsy ratios varied from the stock recruitment split VPA ratio estimate of 0.47 to the stock recruitment estimated ratio of 0.05 from the ASAP multi run with no prior on steepness. The SDWG ASAP multi run using the Fmsy = F40 proxy estimated the SSB2010/SSBmsy ratio at 1.77 and the F2010/F40 at 0.09. The stock recruitment priors did lower the estimated steepness which lowered the SSB2010/SSBmsy ratio to 2.74 and increased the F2010/Fmsy ratio to 0.06.

All GOM winter flounder models have diagnostic issues due to the conflicting signals in the data. The SDWG preferred the ASAP multi model as the best fit to all data sources including considerations for reasonable estimates of biomass in 2009 and 2010 in comparisons to the survey area swept biomass estimates. However the SDWG questioned the feasibility of the estimated SSB relative to the SSBmsy reference points for both the F40 proxy and the stock recruit estimates (1.77 to 2.68). In general the trends and biomass estimated by the model seem appropriate. Surveys and anecdotal feedback from fishermen suggest a shift in the population to deeper water which can help explain the lack of catch in the recreational fishery. However questions remain with the lack of higher catches as the stock rebuilds during the late 1990s and early 2000s when effort in the groundfish fishery was high. In addition, there is little evidence of a change in the size structure or stock range expansion to waters off the coast of Maine which traditionally had higher catches. Considerable uncertainty remains with regards to the comparison of the 2010 SSB relative to the SSBmsy biological reference points.

The SARC concluded that the population models are too uncertain as a based from stock status determination. The overfished status remains as unknown since an analytical model was not accepted and a biomass reference point could not be estimated. The SARC concluded that in 2010 overfishing was not occurring for the stock. A proxy value of the overfishing threshold was derived from a length-based yield per recruit analysis that assumes all fish above 30 cm are fully recruited to the fishery and that natural mortality is 0.3. Using F40% (0.31) as a proxy for Fmsy, the threshold exploitation rate is 0.23. Exploitation rate in 2010 was estimated at 0.03 (80% CI 0.02 - 0.05) which was based on the ratio of 2010 catch (195 mt) to survey swept area estimate of biomass for winter flounder exceeding 30 cm in length (6,341 mt).

TOR 8: Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs) under a set of alternative harvest scenarios. If the stock needs to be rebuilt, take that into account in these projections.

a. Provide numerical short-term projections (3-5 yrs, or through the end of the rebuilding
period, as appropriate). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).

b. Take into consideration uncertainties in the assessment and the species biology to describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming or remaining overfished, and how this could affect the choice of ABC.

c. Develop plausible hypotheses (e.g., mixing among the three stocks) which might explain any conflicting trends in the data and undertake scenario analyses to evaluate the consequences of these alternate hypotheses on ABC determination.

A. Ten year AGEPRO projections assumed that the ACL of 230 mt will be taken in 2011. Projections were done using 1000 bootstrap iterations from the split VPA and 1000 mcmc iterations from the preferred ASAP multi run. Plots with 80 confidence intervals are shown for SSB, catch, and fishing mortality for the split VPA at the Fmsy proxy F40 = 0.43 and 75% of the F40 proxy = 0.32 (Figures C72 and C73). Projections for the ASAP multi model were also run assuming the F40 proxy = 0.34 and 75% of the F40 = 0.26 (Figures C74 and C75). Short term projections using the stock recruit reference point with the prior on steepness for the ASAP multi run were also done at Fmsy = 0.57 and 75%Fmsy = 0.42 (Figures C76 and C77). All projections show relativity high catch in 2012 compared to model time series of catches. The VPA SSB increases towards SSBmsy after low estimates of SSB in 2013 and 2014. The low SSB estimate in 2013 and 2014 is due to the low recruitment estimated in 2009 and 2010 which was influenced by the length based survey conversion. Therefore substantial uncertainty exists with the estimated recruitment in 2009 and 2010. The ASAP multi short term projections result in fishing of the SSB down to SSBmsy. The estimated catch in 2012 shows a large increase relative to the assumed catch in 2011 of 230 mt for both the split VPA and ASAP formulations. The ASAP multi run estimated 2012 catch varies from 1,700 mt from the 75% F40 projection to the stock recruit Fmsy projection estimate of 3,080 mt. However catch declines quickly after 2012 as the stock approaches SSBmsy.

Consideration in the projections could be given to the overestimation of the plus group in the ASAP model. For example a plus group residual adjustment within AGEPRO can be approximated using an assumed plus group discard proportion (Table C25). The effect of the plus group adjustment can be seen in table C25.

B. The Working Group accounted for vulnerability, productivity and susceptibility using conventional MSY reference points, and evaluated uncertainty using model estimates of precision and qualification of other uncertainties. Age-based analytical stock assessment models and associated MSY reference point evaluations provide a relatively comprehensive and synthetic evaluation of vulnerability that is entirely consistent with stock status determination and projection. Vulnerability and susceptibility were accounted for in both aspects of status determination (estimation of F and F_{MSY}) and projections as the magnitude of fishing mortality and recent selectivity at age. All components of productivity (reproduction, individual growth, and survival) were also explicitly accounted for in stock status determination and projections. Reproduction was monitored as age-1 recruitment, and projected as a function of SSB (the product of abundance, weight and maturity at age). Individual growth was monitored as empirical size at age, and projected as recent mean size at age. Survival was accounted for based on model estimates of fishing mortality and selectivity as well as assumed natural mortality, which was informed by tagging analysis. Uncertainties that were not accounted for by assessment and reference point models were evaluated using model diagnostics. Standard model diagnostics (e.g., residual analyses, retrospective analyses) were used for model validation. Retrospective inconsistencies that were outside the bounds of model precision estimates were addressed through selection of alternative models.

Vulnerabilities that were not accounted for from assessment and reference point models were evaluated using exploratory modeling, habitat observations and testing the influence of environmental factors on recruitment dynamics. All three winter flounder stocks are harvested in mixed-stock fisheries, but bycatch and discards are monitored and managed through Annual Catch Limits with Accountability Measures for exceeding those limits.

Additional considerations of vulnerability and productivity are the implications of shifts in distribution, recruitment dynamics and increased natural mortality. Nye et al. (2009) found an annual increase in mean depth of the winter flounder distribution, which may have productivity and vulnerability implications. Apparent decreases in estuarine spawning or shifts toward coastal spawning (e.g., DeCelles and Cadrin 2010) may also have implications for vulnerability (e.g., less availability to recreational fisheries, decreasing vulnerability to that fishery) and productivity (possibly less larval retention). Consumption of winter flounder by other fishes, birds and mammal predators may be increasing as those predator populations increase.

The GOM assessment indicates that the stock is well above B_{MSY} and experiencing low fishing mortality. However, the GOM assessment is the most uncertain of the three (from a "feasibility" perspective, if not from a "statistical precision" perspective). The apparent shift in distribution to deeper habitat may be adding uncertainty to the stock assessment reference points that assume stationarity in vital rates. Therefore, it may be vulnerable to overfishing if managed at a catch level close to the nominally projected catch in the near term.

C. Major conflicting signals exist between the catch at age data and survey data within the

modeling work. The split VPA is weighted towards the catch at age information while the preferred ASAP multi run has a greater weight on the survey information. Survey trends 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 where there is no survey coverage. This hypothesis could possible explain why the survey indices are relatively flat with little apparent response to the change in catch. However there is very limited data on the extent of estuarine residing populations in the 1980s. Therefore this hypothesis remains simply as speculation. The consequences of the split VPA being a better reflection of the true dynamics can be evaluated by assuming the catch or ABC from the preferred ASAP projection as taken within the split VPA projection formulation. Figure C78 is an example of the consequence of the split VPA model being true and assuming the catch from the 75% Fmsy ASAP multi projection.

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

SDWG SAW 52 New Research Recommendations

1) Update and investigate migration rates between stock and movement patterns. The most recent comprehensive tagging study was completed in the 1960s (Howe and Coates), and a new large scale effort is warranted. Further investigate localized structure/genetics within the stocks.

2) Investigate the feasibility of port samplers collecting otoliths from large and lemon sole instead of scales because of problems under-ageing larger fish.

3) Investigate use of periodic gonad histology studies as a check to make ensure maturity estimates are accurate, with particular attention to obtaining sufficient samples from the Georges Bank stock.

4) Investigate the skipped spawning percentage for each stock, and estimate interannual variation when sufficient data have been collected.

5) Investigate ways to improve compliance to help VTR reporting. Currently about 300 of the 1500 permitted vessels consistently under-report the number of statistical area fished.

6) Encourage support for Industry Based Surveys, which can provide valuable information on stock abundance, distribution, and catchability in research surveys that is independent of and supplemental to NMFS efforts.

7).Explore use of a more complex Stock Synthesis model with small rates of migration between stocks.

8) Develop time series of winter flounder consumption by the major fish predators of winter

flounder.

9) Conduct studies to better understand recruitment processes of winter flounder, particularly in the GOM and on GBK.

10) Revise the NEFSC assessment software to include the ability to model S-R functions including environmental factors with errors/probabilities.

11) Further explore the relationship between large scale environmental forcing (e.g., temperature, circulation, climate) for effects on life history, reproduction, and recruitment in the Georges Bank stock.

12) Explore development of an index of winter flounder larval abundance based on MARMAP, GLOBEC, etc. time series.

Research Recommendations from GARM III

Assessment approaches needs to be explored that consider all three Winter Flounder stocks as a stock complex within which there is significant interaction amongst the individual stock components.

Working paper addressed by Terceiro MS (2011.) examined

Research Recommendations from SARC 36

1) The MADMF fall survey does collect winter flounder otoliths and scales, so ageing such material should be undertaken.

The MADMF fall survey has not been aged.

2) Increase the number of tows and/or consistently sample inshore strata in the NEFSC bottom trawl survey.

The number of tows in inshore Massachusetts strata conducted with the RV Bigelow starting in 2009 has increased from 1-2 tows to about 2-3 tows per strata with the exception of the fall 2010 survey which lacked sampling in Cape Cod bay. In addition stratum 64 appears to be more consistently sampled with the RV Bigelow and could possibly be included in the index in the future. However depth constraints prevents the sampling of stratum 58.

3) Increase MRFSS length sampling intensity in the recreational fishery.

Length sampling of the winter flounder B2 catch now occurs in the recreational fishery and was used in this assessment.

4) Increase temporal and market category coverage of length sampling in the commercial landings.

Biological length sampling in the ports has improved for all species. However the decline in commercial landings for Gulf of Maine winter flounder has made length sampling coverage by market category difficult. Unclassified sampling in the ports and observer sampling of the kept fish appears to have provided an adequate characterization of the size structure. However, regardless of increased observer coverage in 2010 the length sampling appears to have suffered from the decline in landings in 2010.

5) Increase the intensity of observer sampling especially with small- and large-mesh trawl gear.

Observer sampling has improved in the small and large mesh trawl fishery.

6) Examine the sources of discrepancy between NEFSC and MA survey maturity estimates.

Reasons for the discrepancy between NEFSC and MA survey maturity was examined by McBride et a.l MS 2011.

7) Initiate periodic maturity staging workshops, involving State and NEFSC trawl survey staff.

A maturity staging workshop was done with state and NEFSC staff. Education on how to stage maturity for winter flounder will need to continue as an ongoing process in the maturity workshops.

8) Incorporate the results from the MEDMR research trawl survey (begun in 2001) into the assessment as they become available.

Preliminary ME/NH survey winter flounder age data was examined by the SAW 52 SDWG. The ME/NH survey was included in the area swept estimates of 30+ biomass for this assessment.

9) Investigate derivation of stock-specific parameters for the next assessment.

It is not entirely clear on the intension of this research recommendation. Sensitivity of the assumed natural mortality was explored in this assessment.

10) Attempt use of a forward projection (statistical catch at age model) in the next assessment.

The forward projection ASAP model was developed and used in this assessment.

Research Recommendations prior to SARC 36

1) Examine the implications of anthropogenic mortalities caused by pollution and power plant entrainment in estimating yield per recruit, if feasible.

This research recommendation was not done. It is not clear how this research

recommendation could be addressed.

2) Examine growth variations within the Gulf of Maine, using results from the Gulf of Maine Biological Sampling Survey (1993-1994).

This research recommendation is perhaps not needed with the aging of the relatively new ME/NH survey.

3) Further examine the stock boundaries to determine if Bay of Fundy winter flounder should be included in the Gulf of Maine stock complex.

This research recommendation has not been done. The Bay of Fundy seems to be an appropriate natural break for the stock complex. See working paper by DeCelles MS 2011.

References

DeCelles GR, Cadrin SX. MS 2011. An interdisciplinary assessment of winter flounder (*Pseudopleuronectes americanus*) stock structure. Stock Assessment Workshop Southern Demersal Working Group 52 Working Paper 1.

DeCelles GR and Cadrin SX. MS 2010. Movement Patterns of winter flounder(*Pseudopleuronectes americanus)* in the southern Gulf of Maine: observations with the use of passive acoustic telemetry. Fish. Bull., 108: 407-419.

Hare JA. MS 2011. Development of environmentally-explicit stock-recruitment models for three stocks of winter flounder (*Pseudopleuronectesamericanus*) along the northeast coast of the United States. Stock Assessment Workshop Southern Demersal Working Group 52 Working Paper 13.

Hare JA, Alexander M, Fogarty MJ, Williams E, Scott J. 2010. Forecasting the dynamics of a coastal fishery species using a coupled climate-population model. Ecological Applications 20:452-464.

Howell, P., A. Howe, M. Gibson and S. Ayvasian. 1992. Fishery management plan for inshore stocks of winter flounder. Atlantic States Marine Fisheries Commission. Fisheries Management Report No. 21. May, 1992.

Mayo, R.K., L. O'Brien, and N. Buxton. 1992. Discard estimates of American plaice, *Hippoglossoides platessoides*, in the Gulf of Maine northern shrimp fishery and the Gulf of Maine-Georges Bank large-mesh otter trawl fishery. SAW 14 Res. Doc. 14/3. 40 pp.

McBride RS, Wuenschel MJ, McElroy D, Rowinski Y, Thornton G, Nitschke P. MS 2011. Classifying winter flounder maturity during NEFSC resource surveys: comparing at-sea,

macroscopic classifications with results from a gonad histology method. Stock Assessment Workshop Southern Demersal Working Group 52 Working Paper 8.

Miller TJ. MS 2011. Winter flounder length-based survey calibration. Stock Assessment Workshop Southern Demersal Working Group 52 Working Paper 7.

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

Myers RA, Bowen KG, Barrowman NJ. 1999. Maximum reproductive rate of fish at low population sizes. Can. J. Fish. Aquat. Sci. 56: 2404-2419.

NEFSC. 2003 Report of the 36th Northeast Regional Stock Assessment Workshop (36th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Ref. Doc 03-06. February 2003.

NEFSC. 2005. Assessment of 19 Northeast groundfish stocks through 2004. 2005 Groundfish Assessment Review Meeting (2005 GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts. 15-19 August 2005. Northeast Fish. Sci. Cent. Ref. Doc. 05-13. 508 p.

Palmer MC, Wigley SE. MS 2011. Using positional data from vessel monitoring systems (VMS) to validate the logbook-reported area fished and the stock allocation of commercial fisheries landings, 2004-2008. Stock Assessment Workshop Southern Demersal Working Group 52 Working Paper 9.

Rademeyer RA, Butterworth DS. MS 2011. Initial applications of statistical catch-at-age assessment methodology to the Gulf of Maine winter flounder resource. 28 p.

Terceiro M. MS 2011. Response to SNE/MA winter flounder TOR 4. Stock Assessment Workshop Southern Demersal Working Group 52 Working Paper 5.

Wigley SE, Palmer MC, Blaylock J, Rago PJ. 2008. A brief description of the discard estimation for the National Bycatch Report. NEFSC Ref. Doc. 08-02. 35 p.

Table C1. Winter flounder commercial landings (metric tons) for Gulf of the Maine stock (U.S. statistical reporting areas 511 to 515). Landings from 1964-1977 is taken from SARC 21, 1982-1993 is re-estimated from the WODETS data, 1994-2010 is estimated using the trip based allocated AA tables.

Year	metric tons	Year	Metric tons
1964	1,081	1990	1,116
1965	665	1991	1,008
1966	785	1992	825
1967	803	1993	611
1968	864	1994	543
1969	975	1995	707
1970	1,092	1996	606
1971	1,113	1997	569
1972	1,085	1998	643
1973	1,080	1999	350
1974	885	2000	535
1975	1,181	2001	698
1976	1,465	2002	683
1977	2,161	2003	754
1978	2,194	2004	623
1979	2,021	2005	335
1980	2,437	2006	199
1981	2,407	2007	254
1982	2,793	2008	287
1983	2,096	2009	283
1984	1,699	2010	140
1985	1,582		
1986	1,188		
1987	1,140		
1988	1,250		
1989	1,253		

Table C2. Gulf of Maine winter flounder commercial landings (metric tons) by gear.

Year	Trawl	*Shrimp*	Gillnet	Other	Total
1982	2,485	151	59	99	2,793
1983	1,819	142	54	80	2,096
1984	1,438	139	26	96	1,699
1985	1,446	62	16	59	1,582
1986	912	69	164	42	1,188
1987	848	97	135	60	1,140
1988	1,016	61	161	12	1,250
1989	1,008	58	138	48	1,253
1990	857	25	214	21	1,116
1991	868	22	94	25	1,008
1992	632	17	160	16	825
1993	460	1	138	13	611
1994	438	0	100	5	543
1995	511	1	184	10	706
1996	464	0	135	6	606
1997	426	0	134	9	569
1998	461	0	176	6	643
1999	248	0	101	1	350
2000	412	0	122	1	535
2001	529	0	160	9	698
2002	585	0	82	15	682
2003	564	0	185	5	754
2004	427	0	137	59	623
2005	230	0	67	38	335
2006	133	0	47	19	199
2007	162	0	53	38	254
2008	195	0	57	35	287
2009	202	0	67	14	283
2010	83	0	49	7	140

Table C3. Estimated number (000's) and MRFSS estimated weight and predicted weight (mt) from length frequencies for Gulf of Maine winter flounder caught, landed, and discarded in the recreational fishery.

	Number (000's)				Metric tons	
	Catch A+B1+B2	Landed A+B1	Released B2	15% Release Mortality	MRFSS Landed A+B1	Predicted Landed
1981	6,200	5,433	767	115	2,554	2,270
1982	8,207	7,274	933	140	1,876	3,024
1983	2,169	1,988	181	27	868	817
1984	2,477	2,285	191	29	1,300	1,103
1985	3,694	3,220	474	71	1,896	1,629
1986	946	691	255	38	523	411
1987	3,070	2,391	679	102	1,809	1,443
1988	953	841	111	17	345	537
1989	1,971	1,678	294	44	620	1,035
1990	786	652	134	20	370	344
1991	213	154	59	9	91	86
1992	186	137	48	7	90	77
1993	398	249	150	22	140	134
1994	232	145	88	13	83	77
1995	150	83	67	10	40	40
1996	183	98	86	13	56	52
1997	192	64	129	19	43	32
1998	109	65	44	7	30	27
1999	109	65	44	7	33	34
2000	146	59	87	13	32	31
2001	173	72	102	15	45	37
2002	101	61	40	6	42	35
2003	86	52	34	5	32	29
2004	61	41	20	3	19	29
2005	79	40	39	6	25	24
2006	94	53	41	6	34	35
2007	74	48	26	4	28	26
2008	243	168	74	11	104	103
2009	214	115	100	15	65	67
2010	168	107	61	9	48	48

Table C4. Number of lengths, samples, and metric tons per sample for Gulf of Maine winter flounder. Number of samples and calculations of metric tons per sample does not include observer data or gillnet landings from 1990-2007. * = redistributed according to market category and half year proportions. Bold numbers have additional lengths from observer trawl data but are not included in the number of samples.

	Number of lengths.						Number of samples						mt/samples					
year	half	lg	sm	med	un	total	half	lg	sm	med	un	total	half	lg	sm	med	un	total
1982	1	102	101		455		1	1	1		4		1	838	453		46	
	2	84	81		106	929	2	1	1		1	9	2	396	691		231	310
1983	1	380	100	99	407		1	4	1	1	4		1	120	510		53	
	2	115	1344		106	2551	2	2	11		1	24	2	125	44	64	95	87
1984	1	438	503		221		1	5	4		2		1	74	95			
	2	126	813	100		2201	2	1	6	1		19	2	189	67	114	124	89
1985	1	665	735				1	6	5				1	54				
	2	121			80	1601	2	2			1	14	2	87		182	176	113
1986	1	237	109	109	266		1	3	1	1	3		1		242	126	48	
	2		500	193	89	1503	2		6	2	1	17	2	113	37	31	56	70
1987	1				113		1				1		1					
	2	47	251	272		683	2	1	3	3		8	2	257	137	75	249	143
1988	1	102	258	706	*		1	1	3	7	*		1		108	23		
	2		169	107	*	1342	2		2	1	*	14	2	340	164	96		89
1989	1	113		91	**234**		1	1		1	**1**		1			168		
	2		95	220	**32**	785	2		1	2		6	2	313	435	42	**254**	209
1990	1	328	301		102		1	3	4		1		1	64	48			
	2	117	197	97		1142	2	1	2	1		12	2	83	90	144	111	75
1991	1	188	254	205	**143**		1	2	2	2	**2**		1	91	72			
	2	236	349			1375	2	3	3			14	2	32	62	95	57	65
1992	1	246	100	93	**107**		1	3	1	1			1					
	2	57	74	253		930	2	1	1	3		10	2	54	126	35		66
1993	1	100		288	**91**		1	1		3			1	84		17		
	2	80	55	157	**51**	822	2	1	1	2		8	2	47	178	30		59

Table C4. Continued.

	Number of lengths.						Number of samples						mt/samples					
year	half	lg	sm	med	un	total	half	lg	sm	med	un	total	half	lg	sm	med	un	total
1994	1		71	92			1		1	1			1			57		
	2	94		235	*	492	2	1		3		6	2	118	157	18		64
1995	1	101		474	**33**	474	1	1		5			1			29		
	2			414	**609**	1631	2			4		10	2	94		59		52
	↑																	
1996	1		378				1		4				1		29			
	2		795	338	**112**	1623	2		7	4		15	2		23	16		31
	↓																	
1997	1		127	75	*		1		2	1	*		1		34	33		
	2	407	1014	218	*	1841	2	5	11	3	*	22	2	20	11	19		18
1998	1		299	280	*		1		5	3	*		1		16	16		
	2	69	746	110	*	1504	2	1	9	1	*	19	2	51	12	32		17
	↑						↑											
1999	1			275	**122**		1			3			1					
	2		80		**430**	907	2		2			5	2		42	15		50
	↓					552												
2000	1	104	4331	250	**1046**		1	1	59	4			1	19	1			
	2	244	344		**130**	6449	2	4	6		**1**	75	2	7	20	24		6
	↑																	
2001	1		89	474	**795**		1		1	6			1		66	10		
	2		254	250	**1756**	3618	2		3	3		13	2		35	47		41
	↓																	
2002	1	28	507	173	**573**		1	1	7	2	**1**		1		7	34	**59**	
	2		982	133	**2734**	5130	2		14	2	**2**	29	2	57	14	48	**35**	21
2003	1		744		**2410**		1	1	10	1	**2**		1		11		**48**	
	2	384	818	110	**914**	5380	2	12	19	1	**6**	52	2	3	9	28	**18**	11
2004	1	223	692	86	**1915**		1	7	14	1	**6**		1		6		**12**	
	2	7	706		**2955**	6584	2	1	12		**4**	45	2	18	9	48	**6**	11
2005	1		269		**3202**		1		4		**11**		1		16.8		**3**	
	2	600	807		**5696**	10574	2	10	7		**11**	43	2	11	10		**2**	9
2006	1		732		**2330**		1		3		**11**		1		7		**1**	
	2	341	281		**823**	4507	2	4	3		**9**	30	2	14	14		**13**	9
2007	1		296		**1316**		1		3		**3**		1		11.3		**6**	
	2	15	272		**831**	2730	2	1	3		**3**	13	2	54	24.7		**4**	15

Table C5. Number of kept observer lengths, trips, and gillnet metric tons landed per 100 lengths sampled for Gulf of Maine winter flounder by half year.

Year	half	lengths	trips	gillnet landings	Mt/100 lengths
1990	1	500	90	185	
	2	78	1	29	
		578	91	215	37
1991	1	167	6	85	
	2	30	8	12	
		197	14	97	49
1992	1	1925	39	135	
	2	172	25	25	
		2097	64	160	8
1993	1	1990	63	97	
	2	375	20	42	
		2365	83	139	6
1994	1	330	22	75	
	2	207	10	25	
		537	32	100	19
1995	1	1132	20	156	
	2	275	23	28	
		1407	43	184	13
1996	1	930	26	114	
	2	118	17	22	
		1048	43	136	13
1997	1	656	18	105	
	2	42	4	29	
		698	22	134	19
1998	1	1163	19	145	
	2	431	8	31	
		1594	27	176	11
1999	1	747	5	84	
	2	538	12	17	
		1285	17	101	8
2000	1	911	8	104	
	2	259	4	18	
		1170	12	122	10

year	half	lengths	trips	gillnet landings	Mt/100 lengths
2001	1	862	15	124	
	2	42	2	36	
		904	17	160	18
2002	1	237	13	37	16
	2	691	31	45	7
		928	44	82	9
2003	1	1702	41	89	5
	2	3041	47	96	3
		4743	88	185	4
2004	1	2255	59	62	3
	2	4605	145	75	2
		6860	204	137	2
2005	1	635	31	26	4
	2	3982	134	41	1
		4617	165	67	1
2006	1	385	16	25	6
	2	174	14	21	12
		559	30	47	8
2007	1	651	20	26	4
	2	875	22	27	3
		1526	42	52	3
2008	1	165	14	31	3
	2	134	26	26	3
		499	40	57	6
2009	1	288	40	29	10
	2	476	58	38	8
		764	49	67	8
2010	1	689	15	19	3
	2	147	26	30	20
		836	49	49	6

Table C6. Gulf of Maine winter flounder estimated discard ratios in the shrimp fishery (total discard kg / total days fished) estimated from NEFSC and MA Observer data by shrimp season. Ratio for 1982-1988 is the average ratio from 1989-1992. Total shrimp fishery days fished and estimated discards are also shown. A 50% mortality is used for estimating dead discards. Dotted line indicates the introduction of the Nordmore grate.

Year	trips	tows	ratio	Shrimp df	discard wt (kg)	dead discards (kg)
1982			*13.5*	970	13,120	6,560
1983			*13.5*	1157	15,646	7,823
1984			*13.5*	1754	23,721	11,860
1985			*13.5*	2081	28,149	14,074
1986			*13.5*	2395	32,391	16,196
1987			*13.5*	3708	50,149	25,075
1988			*13.5*	2815	38,072	19,036
1989	12	24	3.5	2840	10,023	5,011
1990	25	53	13.1	3205	41,853	20,927
1991	38	94	16.3	2588	42,265	21,132
1992	72	225	21.2	2313	48,978	24,489
1993	63	178	7.0	1902	13,401	6,700
1994	63	183	5.8	1982	11,586	5,793
1995	58	136	4.8	3376	16,186	8,093
1996	40	92	4.0	3243	13,126	6,563
1997	21	55	7.5	3661	27,391	13,695
1998	3	6	3.9	2204	8,526	4,263
1999	4	5	1.4	1217	1,696	848
2000	4	10	7.7	793	6,091	3,046
2001	4	6	6.1	673	4,095	2,048
2002	1	2	2.4	246	581	291
2003	18	36	8.7	532	4,628	2,314
2004	11	47	8.5	304	2,588	1,294
2005	17	47	15.9	313	4,973	2,486
2006	17	55	12.7	170	2,162	1,081
2007	14	60	4.1	470	1,931	966
2008	19	72	8.1	620	5,049	2,524
2009	12	49	17.7	333	5,905	2,953
2010	15	45	5.6	708	4,000	2,000

Table C7. Gulf of Maine winter flounder re-estimated large and small mesh trawl and gillnet discard ratios (discard/sum all species kept), estimated discard CVs, and estimated discards in metric tons.

	Discard Ratio			CV			Metric Tons		
	trawl			trawl			trawl		
year	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet
1989	0.0011	0.0032	0.0006	0.53	0.55	0.34	21.94	5.73	8.96
1990	0.0004	0.0001	0.0027	0.54	1.00	0.44	10.70	0.30	44.79
1991	0.0011	0.0010	0.0005	0.45	0.60	0.23	34.18	2.38	6.37
1992	0.0005	0.0002	0.0020	0.38	0.86	0.14	14.37	0.46	26.13
1993	0.0003	0.0040	0.0023	0.79	0.95	0.17	7.90	9.99	38.13
1994	0.0000	0.0000	0.0008			1.66	0.00		10.78
1995	0.0009	0.0092	0.0016	0.55	0.43	0.45	15.12	20.67	23.86
1996	0.0002	0.0008	0.0008	1.77	0.28	0.59	4.23	2.28	10.99
1997	0.0001	0.0105	0.0058	0.62	0.01	0.61	1.61	19.89	71.29
1998	0.0011	0.0000	0.0010	0.45		0.46	14.93		13.15
1999	0.0017	0.0081	0.0010	0.34	0.29	0.51	18.67	13.98	7.85
2000	0.0004	0.0000	0.0029	0.87		0.39	6.06		23.28
2001	0.0016	0.0023	0.0008	0.39	1.32	0.66	26.33	3.21	5.65
2002	0.0022	0.0087	0.0015	0.36	0.41	0.41	34.31	11.22	9.82
2003	0.0014	0.0016	0.0008	0.33	0.50	0.32	25.40	0.84	5.15
2004	0.0023	0.0081	0.0011	0.29	0.30	0.27	60.78	3.15	7.65
2005	0.0025	0.0100	0.0003	0.27	0.69	0.22	46.95	3.14	2.21
2006	0.0019	0.0038	0.0001	0.32	0.43	0.42	20.89	1.75	0.85
2007	0.0032	0.0052	0.0002	0.33	0.42	0.39	29.73	3.37	1.33
2008	0.0015	0.0015	0.0002	0.24	0.49	0.43	17.12	1.12	1.76
2009	0.0015	0.0137	0.0003	0.19	0.42	0.29	16.19	9.57	2.31
2010	0.0004	0.0228	0.0001	0.26	0.35	0.16	4.74	25.70	0.83

Table C8. Gulf of Maine winter flounder observer numbers of lengths

year	Kept			Discards			
	lg mesh trawl	sm mesh trawl	gillnet	shrimp	lg mesh trawl	sm mesh trawl	gillnet
1989	56	4	76	426	78	183	2
1990	-	-	578	126	-	-	331
1991	42	-	197	1,144	9	-	35
1992	107	-	2,097	1,013	17	-	371
1993	51	91	2,379	1,687	12	43	437
1994	-	-	537	980	-	-	141
1995	642	-	1,438	716	30	258	209
1996	100	-	1,393	301	5	184	91
1997	-	10	849	155	2	-	67
1998	-	-	1,594	-	-	-	70
1999	552	-	1,285	-	-	231	112
2000	1,100	1	1,170	-	90	-	220
2001	2,615	-	904	-	192	-	42
2002	2,845	41	930	-	924	481	52
2003	2,497	175	4,751	265	1,535	168	246
2004	2,857	950	6,864	278	1,549	779	532
2005	6,222	189	4,618	168	3,074	393	131
2006	2,348	37	559	268	955	74	19
2007	2,097	-	1,526	17	2,188	162	44
2008	3,352	-	499	214	1,714	1	47
2009	1,629	-	764	53	643	520	58
2010	270	-	836	49	270	437	21

Table C9. Gulf of Maine winter flounder updated number of trips in the large and small mesh trawl and gillnet fishery in the dealer and observer data.

	Large Mesh Trawl						Small Mesh Trawl						Gillnet					
	Dealer trips		Ob trips		Dealer	Ob	Dealer trips		Ob trips		Dealer	Ob	Dealer trips		Ob trips		Dealer	Ob
YEAR	half 1	half 2	half 1	half 2	sum	sum	half 1	half 2	half 1	half 2	sum	sum	half 1	half 2	half 1	half 2	sum	sum
1989	6,561	5,992	16	21	12,553	37	192	1,570	7	16	1,762	23	4,140	5,616		84	9,756	84
1990	6,258	6,283	10	16	12,541	26	77	1,750		8	1,827	8	3,771	6,349	64	56	10,119	120
1991	7,181	6,705	12	36	13,886	48	59	1,574		29	1,633	29	3,488	5,365	153	648	8,853	801
1992	7,682	6,396	33	11	14,078	44	66	2,079	3	12	2,145	15	3,576	5,302	357	539	8,878	896
1993	6,548	6,153	9	8	12,700	17	86	1,913	2	4	1,999	6	3,431	5,801	251	309	9,232	560
1994	6,633	5,688	4	2	12,321	6	154	2,323			2,476		3,661	6,719	55	30	10,380	85
1995	6,171	4,983	17	7	11,154	24	639	1,191		30	1,829	30	4,448	5,884	23	46	10,332	69
1996	5,813	4,677	8	3	10,490	11	54	1,436	2	38	1,489	40	3,308	4,983	21	25	8,292	46
1997	4,814	3,860	4	1	8,674	5	142	1,075	3		1,216	3	3,015	4,187	13	20	7,201	33
1998	5,445	4,226	6		9,671	6	37	754			791		3,120	4,005	29	49	7,125	78
1999	3,441	4,007	1	21	7,448	22	28	769		11	797	11	1,981	2,540	18	55	4,521	73
2000	4,245	4,923	48	32	9,168	80	55	595			649		2,169	3,271	41	40	5,440	81
2001	4,321	4,977	36	75	9,297	111	71	600	1	3	671	4	2,325	3,382	25	22	5,707	47
2002	3,617	5,247	28	121	8,863	149	42	571	1	33	614	34	1,632	3,963	23	57	5,595	80
2003	3,142	5,274	116	135	8,416	251	44	270	7	12	313	19	2,156	3,912	93	202	6,068	295
2004	2,768	4,203	68	182	6,971	250	17	216	13	55	233	68	1,980	3,282	156	619	5,262	775
2005	2,369	3,600	171	328	5,969	499	29	160	20	49	189	69	1,500	4,010	138	513	5,509	651
2006	2,100	3,132	141	62	5,232	203	21	223	14	10	244	24	1,578	3,869	74	54	5,447	128
2007	2,484	2,817	100	125	5,302	225	41	406	1	15	447	16	1,920	4,554	32	86	6,474	118
2008	3,200	2,802	102	152	6,002	254	182	384		12	567	12	2,778	5,111	42	108	7,889	150
2009	2,950	3,319	196	214	6,269	410	10	412		22	422	22	2,783	5,606	120	156	8,389	276
2010	2,839	1,354	168	440	4,193	608	220	487	1	29	707	30	3,423	3,341	259	980	6,764	1,239

Table C10. SARC 52 Gulf of Maine winter flounder catch at age construction summary.

Catch at age Component	years	Half yr	length data	age data
trawl and other commercial landings	82-98	mix	commercial and observer (unclassified)	commercial
trawl and other commercial landings	99-10	Whole (99-01) Half yr (02-10)	Observer (Trawl kept) Com unclassified trawl	commercial
gillnet commercial Landings	90-10	whole (99-01) Half yr (02-10)	observer (gillnet kept) Com unclassified gillnet	commercial
recreational Landings	82-10	Half yr	MRFSS/MRIP	combine NEFSC and MA DMF ages by half yr
Recreational Discards	82-06	Half yr	spr & fall MA DMF	combine NEFSC and MA DMF ages by half yr
Recreational Discards	07-10	whole yr	MRFSS	combine NEFSC spr & fall survey
Large mesh trawl Discards (survey filter)	82-88	whole yr	survey method (spr & fall MA DMF)	Combine NEFSC spr & fall survey
large mesh trawl disc (obs disc/keptall)	89-10	whole yr	survey method (89-00) observer disc (01-10)	combine NEFSC spr & fall survey
gillnet discards (*obs* disc/keptall)	86-10	Whole yr	observer discards	combine spr NEFSC and MA DMF ages for 1986-2001 (combine NEFSC spr & fall survey for 2002-2010)
shrimp discards (obs disc/days fished)	82-10	shrimp season	observer (discards)	combine spr NEFSC and MA DMF ages

Table C11. Gulf of Maine winter flounder large and small mesh trawl and gillnet kept ratios (kept/sum all species kept), estimated discard CVs, and estimated landings in metric tons.

	Kept Ratio			CV			Metric Tons		
	trawl			trawl			trawl		
year	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet
1989	0.006	0.015	0.007	0.39	0.44	0.38	128	27	107
1990	0.002	0.000	0.015	0.46	0.73	0.43	43	1	246
1991	0.019	0.001	0.003	0.44	0.51	0.22	573	2	42
1992	0.008	0.001	0.013	0.49	0.58	0.12	228	4	170
1993	0.004	0.026	0.014	0.76	0.54	0.14	93	65	236
1994	0.001	0.000	0.005	0.88		1.00	13	0	73
1995	0.031	0.000	0.005	1.05		0.28	542	0	84
1996	0.016	0.000	0.007	2.45		0.42	288	0	94
1997	0.001	0.043	0.020	1.05	0.03	0.53	12	81	249
1998	0.005	0.000	0.009	0.42		0.39	65	0	126
1999	0.107	0.000	0.007	0.31		0.46	1213	0	56
2000	0.011	0.000	0.021	0.42		0.41	168	0	168
2001	0.025	0.000	0.011	0.25		0.74	409	0	81
2002	0.029	0.006	0.046	0.29	0.47	0.39	457	8	302
2003	0.020	0.012	0.033	0.19	0.54	0.18	368	7	220
2004	0.031	0.039	0.026	0.20	0.58	0.12	837	15	183
2005	0.022	0.018	0.012	0.15	0.30	0.14	407	6	78
2006	0.019	0.002	0.002	0.27	0.39	0.41	216	1	11
2007	0.012	0.002	0.013	0.19	0.35	0.37	114	2	94
2008	0.012	0.001	0.002	0.20	0.71	0.33	135	1	21
2009	0.012	0.000	0.004	0.19		0.23	123	0	39
2010	0.004	0.000	0.004	0.30	0.93	0.12	40	0	26

Table C12. Gulf of Maine winter flounder composition of the catch by number (000's).

	Landings		Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1982	7,274	5,282	140		1,397	56	14,149
1983	1,988	3,842	27		428	67	6,353
1984	2,285	3,992	29		249	102	6,657
1985	3,220	2,965	71		340	121	6,717
1986	691	2,055	38	45	253	139	3,221
1987	2,391	2,086	102	45	308	216	5,146
1988	841	2,210	17	45	406	164	3,682
1989	1,678	2,329	44	16	42	61	4,171
1990	652	1,981	20	84	20	113	2,870
1991	154	1,844	9	12	64	165	2,247
1992	137	1,620	7	44	27	241	2,078
1993	249	1,440	22	70	16	83	1,880
1994	145	1,153	13	24	23	86	1,443
1995	83	1,501	10	31	29	94	1,748
1996	98	1,228	13	21	8	59	1,427
1997	64	1,101	19	128	18	175	1,504
1998	65	1,147	7	24	28	53	1,323
1999	65	605	7	7	31	11	725
2000	59	940	13	39	11	38	1,100
2001	72	1,160	15	9	52	25	1,333
2002	61	1,126	6	11	72	3	1,279
2003	51	1,257	5	8	52	25	1,398
2004	41	996	3	12	137	15	1,203
2005	40	551	6	4	94	26	721
2006	53	317	6	1	40	10	426
2007	48	412	4	2	57	9	531
2008	168	477	11	2	34	20	712
2009	115	471	15	3	29	26	659
2010	107	219	9	1	7	22	365

Table C13. Gulf of Maine winter flounder composition of the catch by weight (mt).

	Landings		Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1981	2,270						
1982	3,024	2,793	11		343	7	6,178
1983	817	2,096	2		112	8	3,035
1984	1,103	1,699	3		67	12	2,883
1985	1,629	1,582	8		93	14	3,327
1986	411	1,185	5	12	63	16	1,692
1987	1,443	1,140	12	12	81	25	2,713
1988	537	1,250	2	12	106	19	1,927
1989	1,035	1,253	6	4	11	5	2,315
1990	344	1,116	3	22	5	21	1,511
1991	86	1,008	1	3	17	21	1,136
1992	77	825	1	12	7	24	947
1993	134	611	3	19	4	7	778
1994	77	543	2	6	6	6	640
1995	40	707	1	12	8	8	776
1996	52	606	2	6	2	7	674
1997	32	569	3	38	5	14	660
1998	27	643	1	7	7	4	689
1999	34	350	1	4	9	1	399
2000	31	535	2	12	3	3	587
2001	37	698	3	3	14	2	756
2002	35	682	1	5	17	0	740
2003	29	754	1	3	13	2	801
2004	29	623	0	4	31	1	687
2005	24	335	1	1	23	2	387
2006	35	199	1	0	10	1	247
2007	26	254	1	1	15	1	297
2008	103	287	3	1	9	3	405
2009	67	283	5	1	8	3	367
2010	48	140	3	0	2	2	195

Table C14. Gulf of Maine winter flounder landing at age (000's).

year	1	2	3	4	5	6	7	8+
1982	40	2,097	4,551	3,468	1,401	617	276	104
1983	93	748	1,680	1,799	856	362	158	133
1984	12	765	1,935	1,829	852	348	312	225
1985	0	137	1,335	2,039	1,922	398	218	136
1986	0	327	731	812	359	353	102	62
1987	0	312	1,626	1,161	792	311	138	136
1988	2	337	848	1,046	359	248	123	89
1989	0	162	1,309	1,462	774	212	51	38
1990	0	216	721	950	496	172	49	29
1991	0	186	782	580	232	119	57	41
1992	0	207	657	569	205	72	28	18
1993	0	132	688	644	145	68	9	3
1994	0	8	466	608	149	44	16	7
1995	0	8	291	744	387	120	16	18
1996	0	176	706	336	76	13	7	11
1997	0	150	499	382	92	22	8	12
1998	0	26	232	458	328	115	40	12
1999	0	0	61	229	224	101	29	27
2000	0	5	59	375	371	140	34	15
2001	0	0	52	358	425	239	101	56
2002	0	3	135	364	401	185	65	34
2003	0	5	140	378	415	246	78	46
2004	0	32	125	328	248	194	64	47
2005	0	12	120	239	135	53	17	16
2006	0	2	79	149	86	27	14	12
2007	0	7	68	173	130	57	16	9
2008	0	1	51	171	201	115	66	40
2009	0	1	25	133	216	144	41	26
2010	0	0	11	62	114	83	40	16

Table C15. Gulf of Maine winter flounder discards at age (000's).

year	1	2	3	4	5	6	7	8+
1982	72	786	716	19	0	0	0	0
1983	42	167	275	38	0	0	0	0
1984	11	151	142	72	4	0	0	0
1985	31	151	263	83	3	0	0	0
1986	49	178	196	39	14	0	0	0
1987	53	174	378	63	2	0	0	0
1988	22	134	340	131	3	1	0	0
1989	24	77	43	16	3	1	0	0
1990	9	47	114	58	8	0	0	0
1991	18	117	82	30	2	0	0	0
1992	44	182	77	15	1	0	0	0
1993	28	64	70	25	4	0	0	0
1994	18	73	37	15	3	0	0	0
1995	27	62	44	22	5	2	1	0
1996	16	41	27	14	2	0	0	0
1997	19	136	93	66	26	0	0	0
1998	20	38	32	16	4	0	1	0
1999	7	13	18	11	3	2	1	1
2000	17	24	30	19	9	2	0	0
2001	13	21	32	26	7	3	0	0
2002	4	28	32	20	6	2	0	0
2003	9	36	28	11	4	1	0	1
2004	10	57	77	17	2	2	1	0
2005	15	42	46	20	4	2	0	0
2006	7	12	25	11	2	0	0	0
2007	5	16	25	21	5	0	0	0
2008	8	20	24	10	3	1	0	0
2009	6	22	29	13	3	0	0	0
2010	6	10	8	8	5	2	0	0

Table C16. Gulf of Maine winter flounder total catch at age (000's).

year	1	2	3	4	5	6	7	8+
1982	112	2,883	5,267	3,487	1,402	617	276	104
1983	135	915	1,955	1,838	857	362	158	133
1984	23	916	2,077	1,901	856	348	312	225
1985	31	288	1,598	2,122	1,925	398	218	136
1986	49	505	928	851	373	353	102	62
1987	53	486	2,004	1,224	794	311	138	136
1988	23	471	1,188	1,177	361	248	123	89
1989	24	238	1,353	1,478	777	213	51	38
1990	9	263	836	1,008	504	172	49	29
1991	18	304	864	610	234	119	57	41
1992	44	390	734	585	207	72	28	18
1993	28	197	758	669	149	69	9	3
1994	18	81	503	623	152	44	16	7
1995	27	70	335	765	392	122	18	18
1996	16	217	733	350	79	13	7	11
1997	19	286	592	449	117	22	8	12
1998	20	64	264	474	333	115	41	12
1999	7	13	79	240	227	103	29	28
2000	17	29	89	394	380	142	34	15
2001	13	21	84	384	432	242	101	56
2002	4	31	167	383	408	187	65	34
2003	9	41	168	390	419	247	78	46
2004	10	89	202	345	250	195	64	47
2005	15	54	165	259	139	55	17	16
2006	7	14	104	160	89	27	14	12
2007	5	23	93	193	135	57	16	9
2008	8	21	75	181	205	116	66	40
2009	6	22	54	146	219	144	41	26
2010	6	10	20	70	120	84	40	16

Table C17. Gulf of Maine winter flounder mean weights at age.

year	1	2	3	4	5	6	7	8+
1982	0.084	0.224	0.375	0.487	0.595	0.802	0.943	2.037
1983	0.123	0.257	0.358	0.502	0.644	0.795	0.946	1.164
1984	0.082	0.264	0.306	0.401	0.543	0.708	0.855	1.115
1985	0.043	0.174	0.312	0.447	0.584	0.809	0.927	1.122
1986	0.050	0.309	0.410	0.510	0.664	0.813	1.005	1.221
1987	0.035	0.259	0.392	0.527	0.690	0.858	1.070	1.284
1988	0.038	0.396	0.426	0.487	0.648	0.754	1.022	1.204
1989	0.040	0.229	0.427	0.582	0.629	1.004	1.175	1.397
1990	0.034	0.301	0.421	0.538	0.625	0.763	0.979	1.226
1991	0.038	0.277	0.451	0.583	0.599	0.695	0.744	0.929
1992	0.027	0.227	0.406	0.533	0.638	0.788	1.051	1.465
1993	0.028	0.238	0.367	0.439	0.645	0.667	1.115	1.453
1994	0.028	0.090	0.369	0.470	0.610	0.747	1.068	1.229
1995	0.038	0.105	0.341	0.421	0.535	0.635	0.833	1.563
1996	0.028	0.321	0.454	0.541	0.643	0.722	0.767	1.321
1997	0.038	0.240	0.421	0.512	0.628	0.889	0.784	0.921
1998	0.029	0.202	0.392	0.472	0.615	0.755	0.910	1.557
1999	0.039	0.114	0.377	0.487	0.542	0.665	0.838	1.219
2000	0.041	0.146	0.353	0.473	0.581	0.698	0.817	1.030
2001	0.034	0.115	0.319	0.448	0.538	0.693	0.852	1.194
2002	0.050	0.182	0.415	0.496	0.593	0.705	0.882	1.285
2003	0.035	0.156	0.366	0.482	0.560	0.704	0.889	1.436
2004	0.035	0.207	0.352	0.494	0.628	0.763	0.923	1.269
2005	0.042	0.172	0.380	0.505	0.669	0.895	1.038	1.346
2006	0.048	0.138	0.404	0.535	0.715	0.811	1.032	1.365
2007	0.043	0.200	0.386	0.487	0.639	0.815	0.964	1.476
2008	0.046	0.153	0.375	0.474	0.549	0.671	0.784	1.097
2009	0.043	0.155	0.329	0.449	0.565	0.678	0.692	1.115
2010	0.031	0.065	0.314	0.427	0.507	0.604	0.717	0.947

Table C18. 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 in 2009 and 2010. NEFSC fall 2010 (bold) did not sample Cape Cod Bay. MA DMF uses strata 25-36.

	NEFSC spring		NEFSC fall		MA spring		MA fall	
year	number	weight	number	weight	number	weight	number	weight
1978					98.556	20.772	59.152	12.741
1979	4.487	1.730	6.003	2.602	71.834	15.787	134.251	32.837
1980	5.586	2.391	13.141	6.553	72.142	19.108	83.805	17.868
1981	6.461	2.122	4.179	3.029	106.341	30.383	50.847	13.595
1982	7.670	3.022	4.201	1.924	61.612	14.713	108.203	24.418
1983	12.367	5.653	10.304	3.519	112.487	28.984	76.658	15.143
1984	5.155	1.979	7.732	3.106	68.949	16.716	39.541	12.212
1985	3.469	1.418	7.638	2.324	54.210	15.302	48.677	8.288
1986	2.342	0.998	2.502	0.938	68.984	16.352	44.646	6.920
1987	5.609	1.503	1.605	0.488	85.180	18.640	54.434	8.018
1988	6.897	1.649	3.000	1.030	54.039	11.266	38.419	8.237
1989	3.717	1.316	6.402	2.013	64.696	13.940	39.249	8.602
1990	5.415	2.252	3.527	1.177	82.125	14.375	67.661	13.218
1991	4.517	1.436	7.035	1.467	46.630	11.513	101.716	17.580
1992	3.932	1.160	10.447	3.096	79.000	15.356	87.581	15.089
1993	1.556	0.353	7.559	1.859	78.018	12.051	93.527	15.109
1994	3.481	0.891	4.870	1.319	72.578	9.779	67.789	13.246
1995	12.185	3.149	4.765	1.446	89.361	14.960	76.736	15.092
1996	2.736	0.732	10.099	3.116	70.494	12.082	77.006	13.144
1997	2.806	0.664	10.008	2.950	85.396	12.959	78.402	14.438
1998	2.001	0.527	3.218	0.987	77.771	13.473	98.450	15.454
1999	6.510	1.982	10.921	3.269	80.776	14.957	125.742	23.204
2000	10.383	2.885	12.705	5.065	162.190	34.160	99.953	25.100
2001	5.242	1.663	8.786	3.133	89.743	24.510	81.072	17.743
2002	12.066	3.692	10.691	4.003	91.083	22.391	65.812	16.264
2003	7.839	2.544	10.182	4.315	83.693	17.323	90.477	15.801
2004	3.879	1.103	2.763	0.867	79.115	11.201	107.591	14.091
2005	6.920	2.056	8.807	2.314	94.044	11.980	78.591	11.812
2006	4.173	1.211	7.117	2.346	85.548	14.434	86.985	15.463
2007	2.500	0.717	6.378	1.820	53.583	10.060	76.669	11.599
2008	11.543	2.177	13.319	4.692	46.863	8.424	90.919	18.085
2009	6.846	2.100	13.176	4.721	71.316	12.277	108.996	22.677
2010	5.023	1.425	***12.046***	***3.922***	68.235	13.676	104.672	18.612

Table C19. Forward and backward calculation Plus group diagnostic report from the split VPA for Gulf of Maine winter flounder.

Year	Population Backward	Population Forward	F Forward	F Backward	Ratio
1982	255	255	0.63	0.63	1.00
1983	403	369	0.53	0.47	0.89
1984	569	381	1.09	0.60	0.55
1985	238	416	0.47	1.04	2.22
1986	183	293	0.28	0.49	1.75
1987	263	301	0.72	0.88	1.22
1988	188	190	0.76	0.77	1.01
1989	64	155	0.33	1.10	3.33
1990	50	104	0.39	1.05	2.73
1991	71	74	0.98	1.06	1.09
1992	33	46	0.60	0.94	1.58
1993	6	34	0.11	0.91	8.40
1994	17	27	0.35	0.61	1.76
1995	24	30	1.10	1.72	1.57
1996	43	15	1.73	0.35	0.20
1997	56	14	2.60	0.28	0.11
1998	27	21	1.00	0.72	0.72
1999	98	39	1.64	0.39	0.24
2000	45	56	0.36	0.48	1.31
2001	129	76	1.69	0.68	0.40
2002	85	97	0.51	0.61	1.20
2003	90	108	0.66	0.87	1.31
2004	89	89	0.91	0.91	1.00
2005	47	63	0.35	0.50	1.44
2006	87	55	0.29	0.17	0.60
2007	51	94	0.12	0.23	1.95
2008	167	115	0.50	0.32	0.64
2009	108	199	0.16	0.32	1.97
2010	101	217	0.09	0.20	2.26
2011	232	318	N/A	N/A	

Table C20. Summary results of GOM Winter Flounder ASAP model runs. Run 2 is the preferred ASAP multi run.

Model Run #	1	2	3	4	5
Year	1982-2010	1982-2010	1982-2010	1982-2010	1982-2010
Model Desc.	No Time Blocks in Selectivity; Weighting = 50	Two Block Fishery Selectivity fixed at Ages 5 in B1 and Age5 in B2; Weighting = 50	Two Block Fishery Selectivity fixed at Ages 4 in B1 and Age5 in B2; Weighting = 50; Modify ages fixed in Survey Selectivity_VERSION2; Lower Fixed Ages in Fishery Selectivity	**Run 3 + Force a Flat in the Survey**	**Run3 + Allow a dome to estimated in the fishery; Fixed at Age 5**
Model	No Split M = 0.3	No Split M = 0.3	No Split M = 0.3	No Split M = 0.3	No Split M = 0.3
Converge	Y	Y	N	Y	Y
S-R (Yes/No)	NO	NO	NO	NO	NO
Survey Selectivity	Survey Fixed Ages (NEFSC Fall = 3 , NEFSC SPR=2, MassFALL = 3 , MASS Spr = 2); All other ages estimated	Survey Fixed Ages (NEFSC Fall = 3 , NEFSC SPR=2, MassFALL = 3 , MASS Spr = 2); All other ages estimated	Survey Fixed Ages (NEFSC Fall = 3 , NEFSC SPR=3, MassFALL = 1 , MASS Spr = 2); All other ages estimated	Assumed Flattop Survey ; Fixed Ages (NEFSC Fall = 3+ , NEFSC SPR=2+, MassFALL = 3+ , MASS Spr = 2+); All other ages estimated	Survey Fixed Ages (NEFSC Fall = 3 , NEFSC SPR=2, MassFALL = 3 , MASS Spr = 2); All other ages estimated
Fishery Slectivity	Assume Flattop; Single Block Fishery Selectivity; Fixed at Age 4 and Older	**Assume Flattop; 2 blocks (1982-1998 and 1999-2010); fixed @ Age 5+ in Block 1 and Age 5+ in Block 2**	Assume Flattop; 2 blocks (1982-1998 and 1999-2010); fixed @ Age 3+ in Block 1 and Age 4+ in Block 2	Assume Flattop; 2 blocks (1982-1998 and 1999-2010); fixed @ Age 5+ in Block 1 and Age 5+ in Block 2	2 Blocks (1982-1998; 1999-2010, both fixed at age 5 and older)
Avg F	3-5	3-5	3-5	3-5	3-5
Objective Fxn	3480	3453	**3347**	3617	3352
Total Index_LL	1112	1120	1117	1174	**1098**
Index Age Comp_LL	1447	1447	**1329**	1588	1420
Total Catch_LL	142	142	142	154	**138**
Catch Age Comp_LL	428	397	416	325	**324**
NEFSC_q_fall	0.292	0.314	0.306	0.423	0.096
NEFSC_q_spr	0.167	0.179	0.235	0.247	0.055
Mass_q_fall	0.693	0.738	0.716	0.806	0.245
Mass_q_spr	0.923	0.982	0.928	1.145	0.326
Fleet 1 Sel	Flat Top	Flat Top	Flat Top	Flat Top	Dome
NEFSC_Fall_Surv_Sel	dome	dome	dome	Flat Top	Dome
NEFSC_Spr_Surv_Sel	dome	dome	dome	Flat Top	Dome
MASS_Fall_Surv_Sel	Stronger dome	Stronger dome	Stronger dome	Flat Top	Dome
MASS_Spr_Surv_Sel	Stronger dome	Stronger dome	Stronger dome	Flat Top	Dome
SSB (mt)	1,480-12,453	1,437-12,505	1,593-12,820	778-7,242	14,122-61,875
Rec (000's)	4,800-11,869	4,673-11,989	4,928-12,366	3,344-12,490	12,273-35,005
F	0.027-0.709	0.03-0.648	0.028-0.562	0.064-0.964	0.011-0.139
Retro_SSB (Rho)	19%	37%	**No Convergence**	110%	5%
Retro_Rec (Rho)	30%	37%	**No Convergence**	75%	28%
Retro_F (Rho)	-12%	-25%	**No Convergence**	-43%	-4%

Table C21. SDWG Pros and cons table for the final ASAP multi Gulf of Maine winter flounder assessment model

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Aspect of model	Pro	Con
Retrospective Patterns	Consistent F and SSB in last two years	Retrospective pattern before the last 2 years
Absolute Magnitude of Stock Biomass	Assessment 2010 biomass is greater [but not substantially greater] than the Survey based minimum area-swept biomass for 2010	
Survey Indices	In general, follows NEFSC and MADMF survey index trends	
Survey catchability (q)	Generally q < 1	Dome-shaped pattern in q at age
Fishery Catch	Model has flexibility to accommodate some degree of error in the catch at age	Significant residual error, particularly for age 8+ fish; requires constraint on fishery selectivity to provide feasible results
Stock Status	Current low F consistent with current low catch; recent trends and magnitude of catch and MSY estimate is consistent with the exploitation history	The assessment SSB time series is mostly >Bmsy, inferring that the stock has rarely experienced overfishing. Assessment results indicate that current SSB is at about 2/3 of unfished SSB. However, current fishery and survey evidence suggest fish are not abundant in historical inshore habitats
Stock-Recruitment Model	Provides FMSY	Poorly defined relationship

Table C22. Non-parametric empirical (F30, F35, F40) and stock recruit based (Fmsy) biological reference points and stock status (SSB2010/SSBmsy and F2010/Fmsy ratios) for Gulf of Maine winter flounder from the split VPA, ASAP indices at age, and ASAP multi run models. Projected long term SSBmsy and MSY reference point equivalents for parametric based reference points are given in parentheses.

		Indices at Age		ASAP Multi
	Split VPA	ASAP Base	ASAP Multi	with h-prior
F_{30}	0.68	0.44	0.51	-
F_{35}	0.54	0.36	0.42	-
F_{40}	0.43	0.30	0.34	-
F_{MSY}	0.40	0.49	0.66	0.57
Steepness	0.66	0.85	0.88	0.84
F_{max}	N/A	1.43	1.63	-
Mean Recruits (000s)	5,687	10,209	8,148	8,148
MSY (mt) F30	780	1,470	1,191	-
MSY (mt) F35	752	1,403	1,139	-
MSY (mt) F40	720	1,329	1,080	-
MSY (mt) Fmsy	942	1,405	1,158 (1181)	1,128 (1152)
SSB_{MSY} (mt) F30	1,691	3,290	2,464	-
SSB_{MSY} (mt) F35	1,989	3,837	2,874	-
SSB_{MSY} (mt) F40	2,292	4,388	3,287	-
SSB_{MSY} (mt) Fmsy	3,193	2,796	1,876 (1913)	2,121 (2167)
SSB_{10} (mt)	1,667	8,464	5,803	5,803
F_{10}	0.19	0.02	0.03	0.03
SSB_{10}/SSB_{MSY} F30	0.99	2.57	2.36	-
SSB_{10}/SSB_{MSY} F35	0.84	2.21	2.02	-
SSB_{10}/SSB_{MSY} F40	0.73	1.93	1.77	-
SSB_{10}/SSB_{MSY} Fmsy	0.52	3.03	3.09 (3.03)	2.74 (2.68)
F_{10}/F_{MSY} F30	0.28	0.05	0.06	-
F_{10}/F_{MSY} F35	0.35	0.06	0.08	-
F_{10}/F_{MSY} F40	0.44	0.07	0.09	-
F_{10}/F_{MSY} Fmsy	0.47	0.04	0.05	0.06

Table C23. Yield per recruit input from the ASAP multi run.

age	ASAP Multi selectivity	proportion mature	avg catch weight	avg stock weight
1	0.013	0.000	0.042	0.025
2	0.054	0.040	0.142	0.079
3	0.261	0.350	0.362	0.243
4	0.885	0.880	0.474	0.422
5	1.000	0.990	0.595	0.540
6	1.000	1.000	0.716	0.670
7	1.000	1.000	0.975	0.975

Table C24. Likelihood profile on steepness for the split VPA and the ASAP indices at age run.

	Split VPA			
AIC	steepness	MSY	Fmsy	SSBmsy
128.65	0.55	1,332	0.29	6,062
126.87	0.60	1,088	0.34	4,299
126.24	0.65	964	0.39	3,378
126.38	0.70	893	0.45	2,742
126.99	0.75	851	0.53	2,298
127.88	0.80	827	0.63	1,937
128.92	0.85	815	0.76	1,634

	ASAP Indices at Age			
AIC	steepness	MSY	Fmsy	SSBmsy
137.40	0.65	1,304	0.28	4,563
134.36	0.70	1,318	0.32	4,032
132.40	0.75	1,341	0.37	3,591
131.36	0.80	1,371	0.43	3,148
131.08	0.85	1,408	0.50	2,745
131.38	0.90	1,455	0.61	2,340
132.09	0.95	1,517	0.80	1,855

Table C25. Example of a possible plus group residual adjustment within AGEPRO as assumed plus group discards from the ASAP Indices at age run.

Plus group residual considerations	**ASAP**
F_{40}	0.30
MSY (mt) F40	1,329
MSY (mt) 25% plusgroup	1,279
MSY (mt) 50% plusgroup	1,228
MSY (mt) 75% plusgroup	1,178
25% 8+ never seen	50
50% 8+ never seen	101
75% 8+ never seen	151
SSB_{MSY} (mt) F40	4,388

C. GOM Winter Flounder Figures

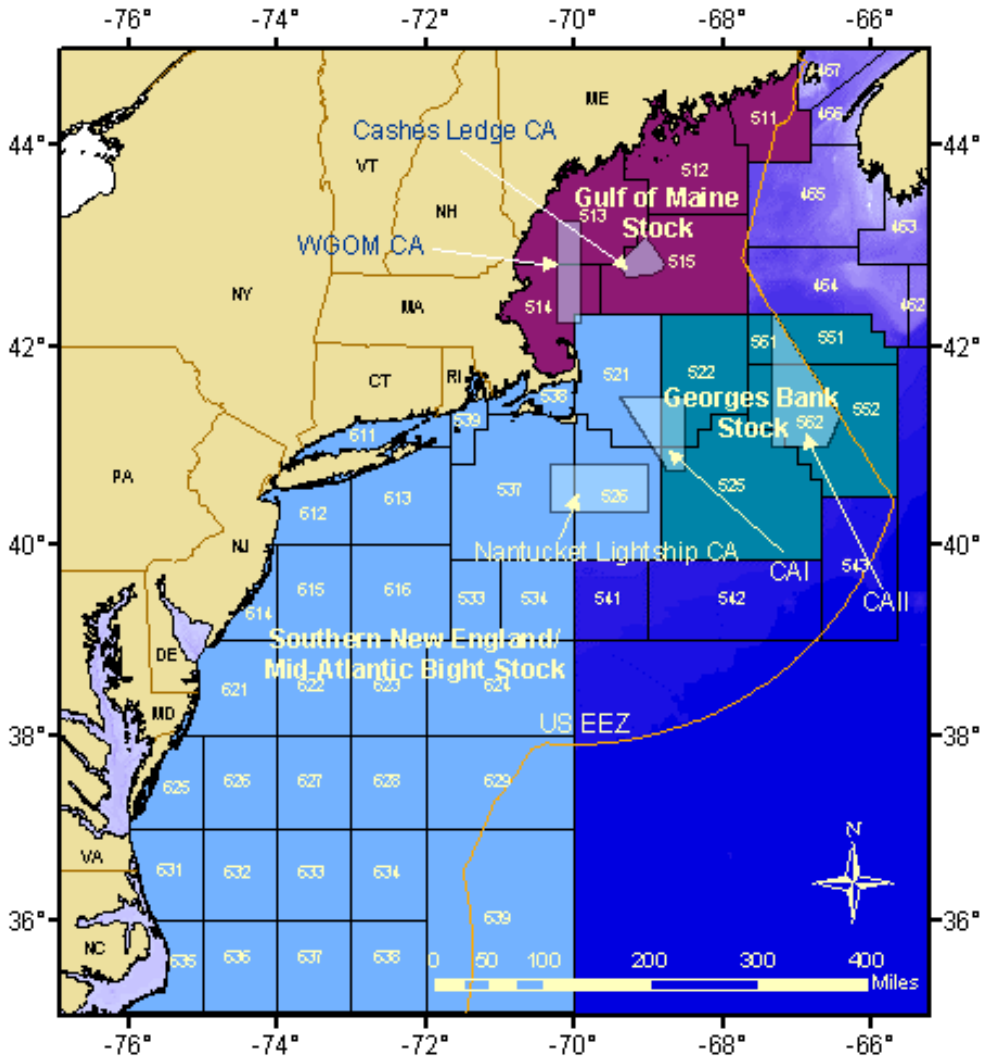


Figure C1. Statistical areas used to define winter flounder stocks. The Gulf of Maine stock includes area 511-515.

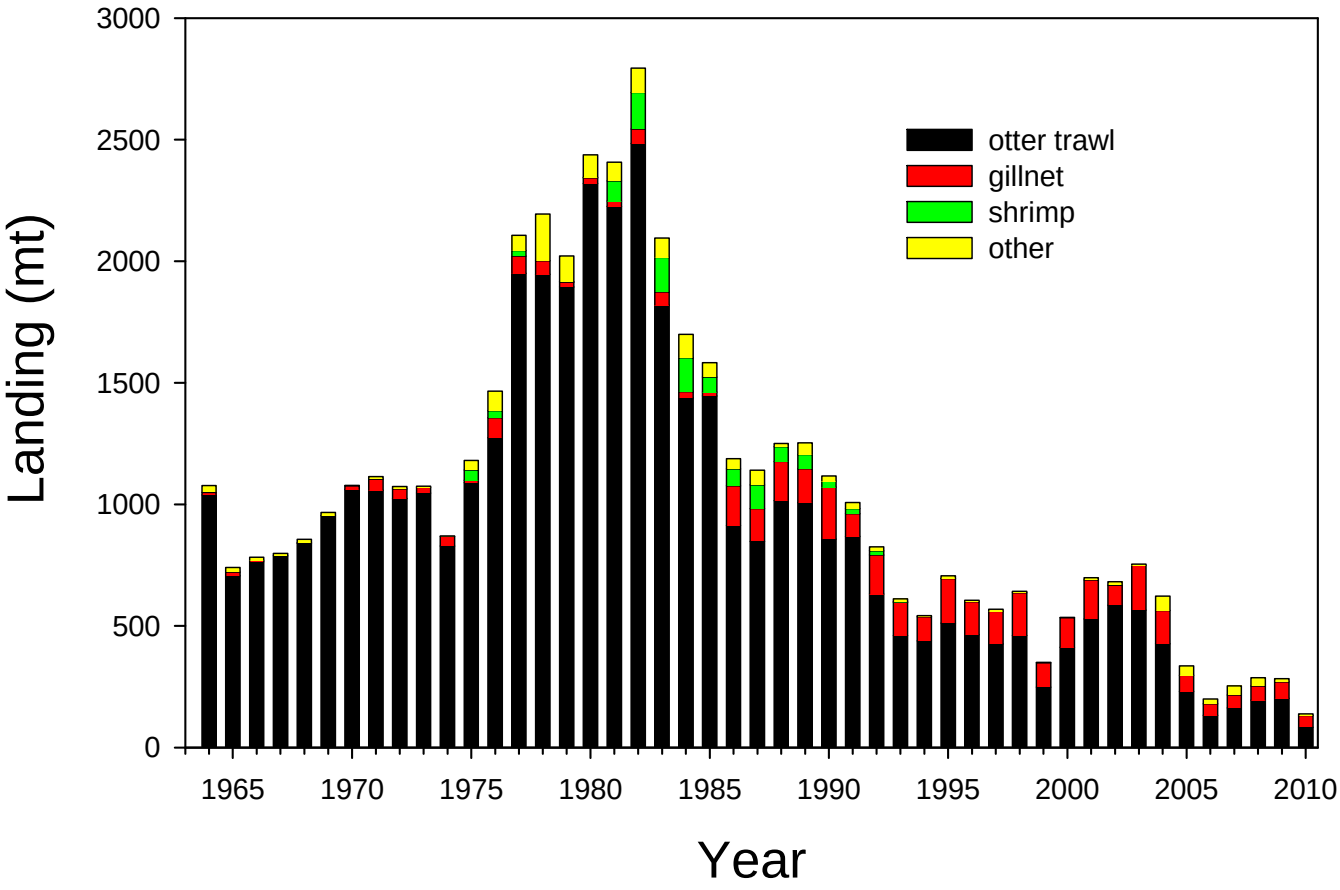


Figure C2. Commercial landings by gear 1964-2010.

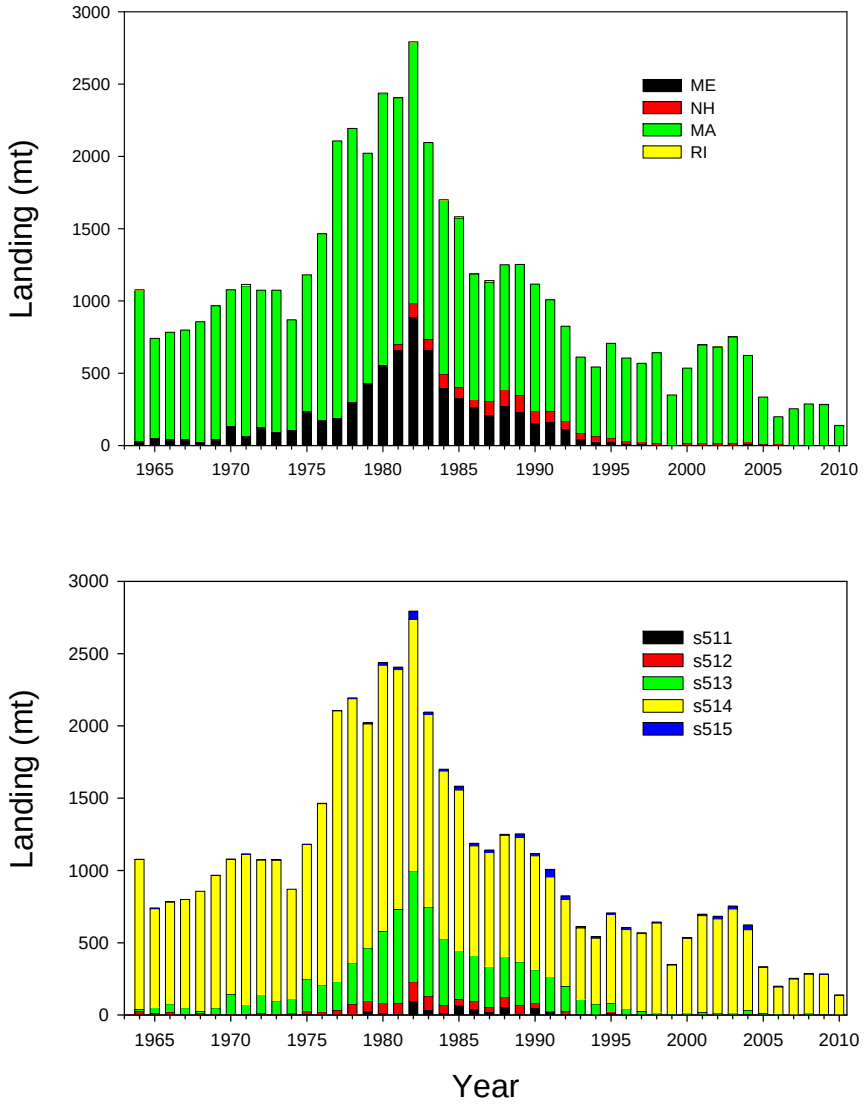
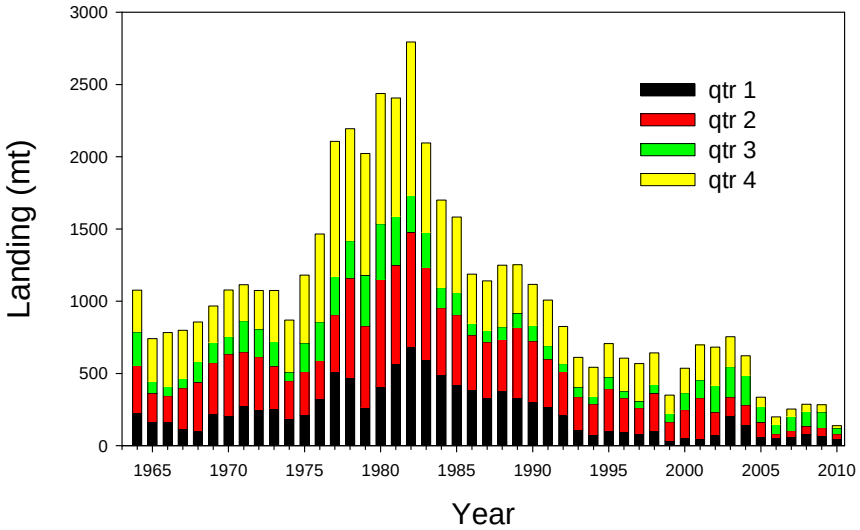


Figure C3. Commercial landings by state (top) and statistical area (bottom) 1964-2010.



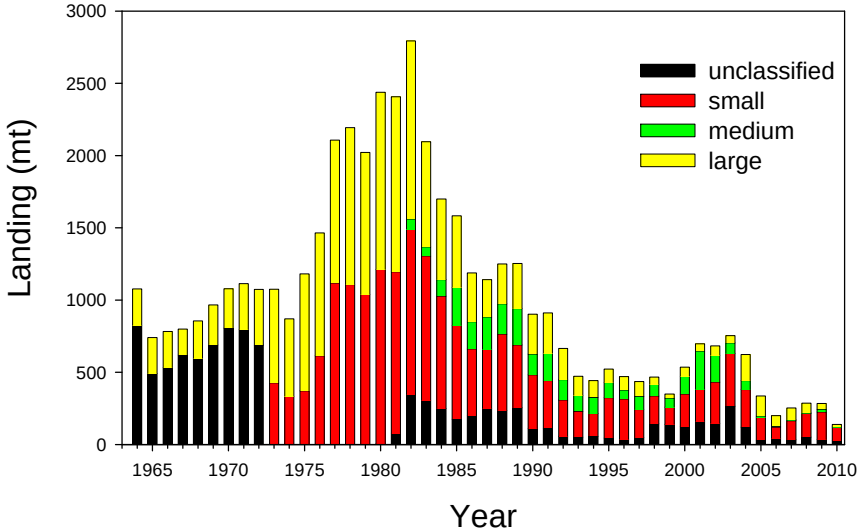


Figure C4. Commercial landings by quarter (top) and market category (bottom) 1964-2010.

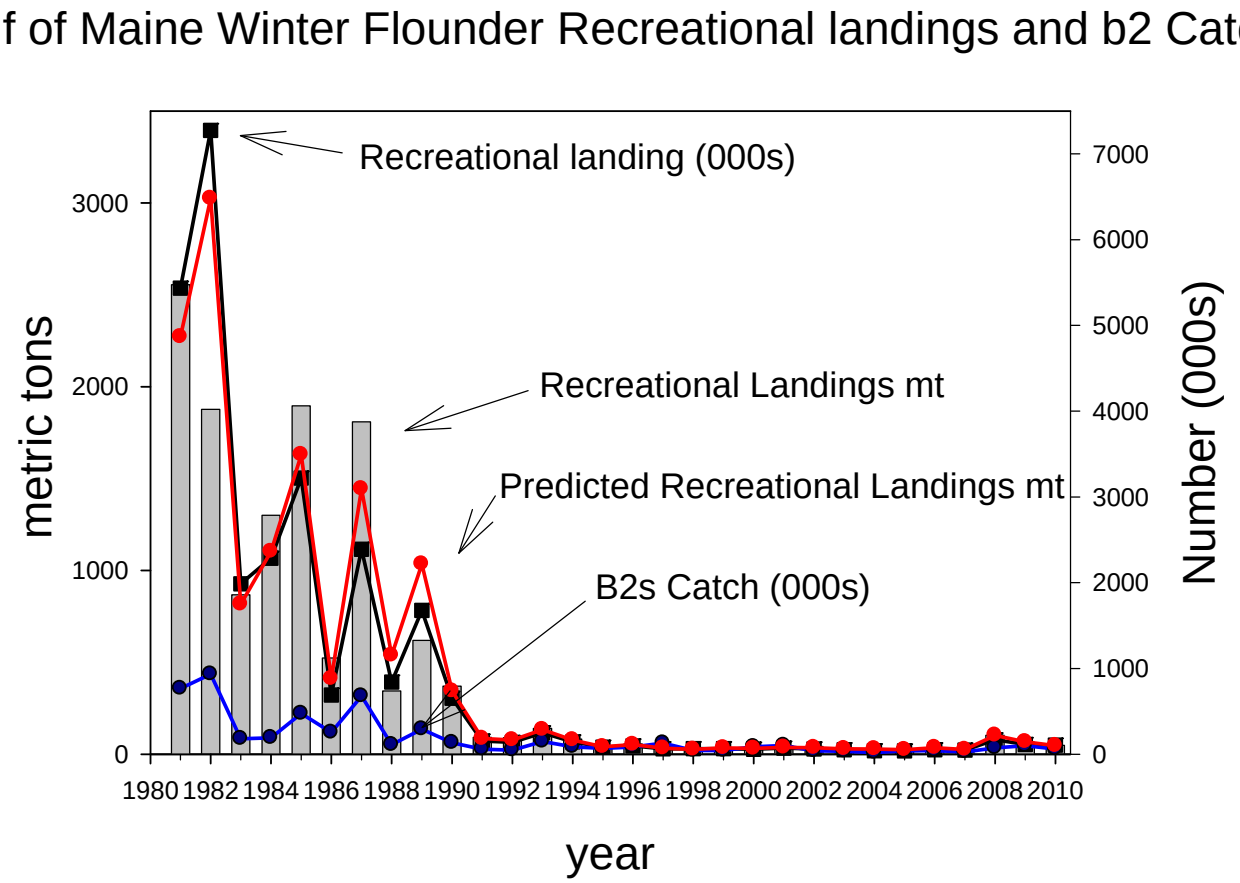


Figure C5 Recreational landings in numbers and metric tons for Gulf of Maine winter flounder. B2 catch in numbers is also shown.

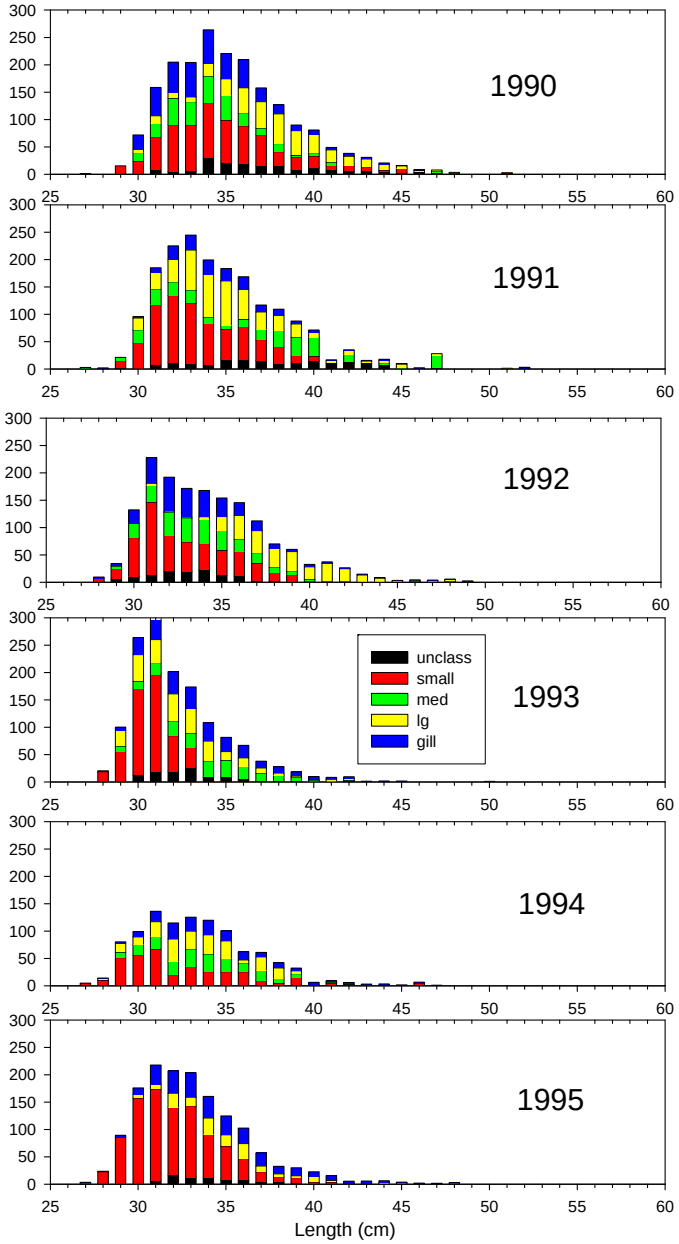


Figure C6. Expanded landing length distribution using port sampling data.

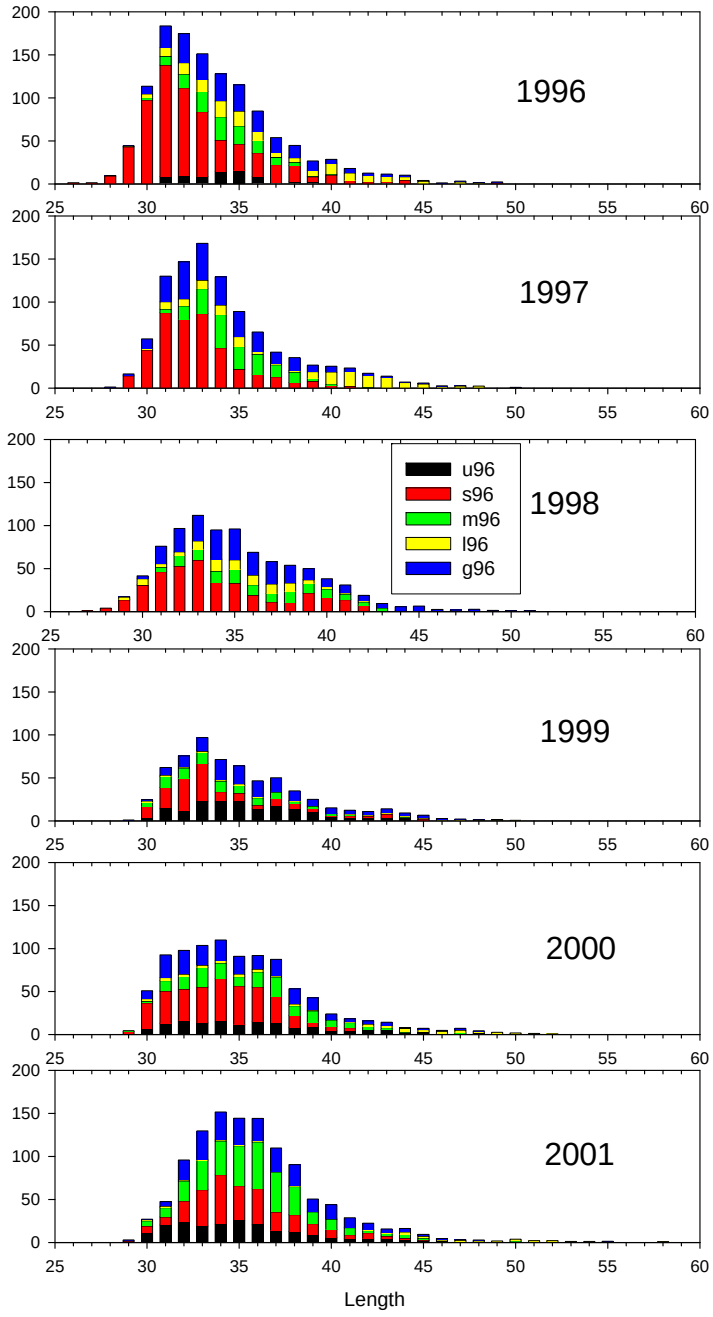


Figure C6. Cont.

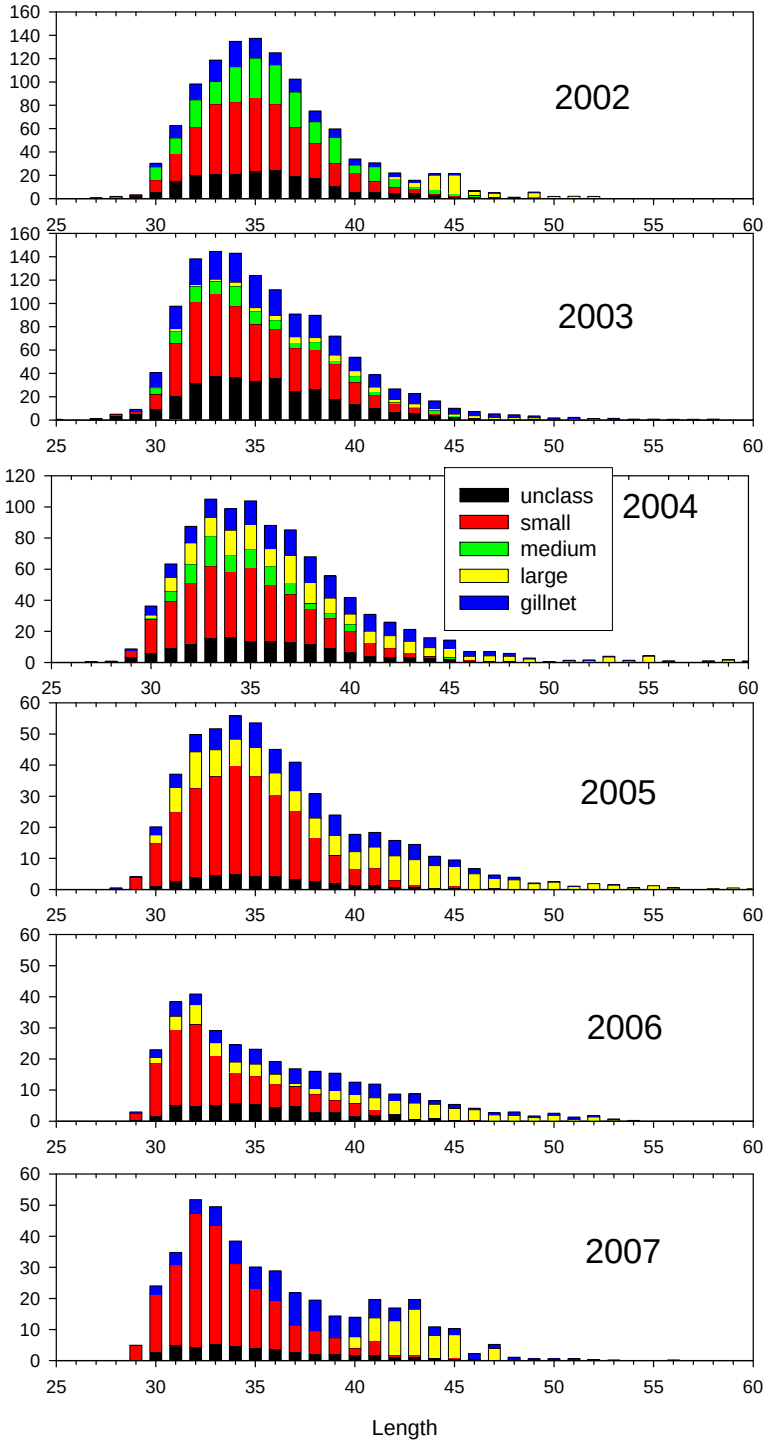


Figure C6. Cont.

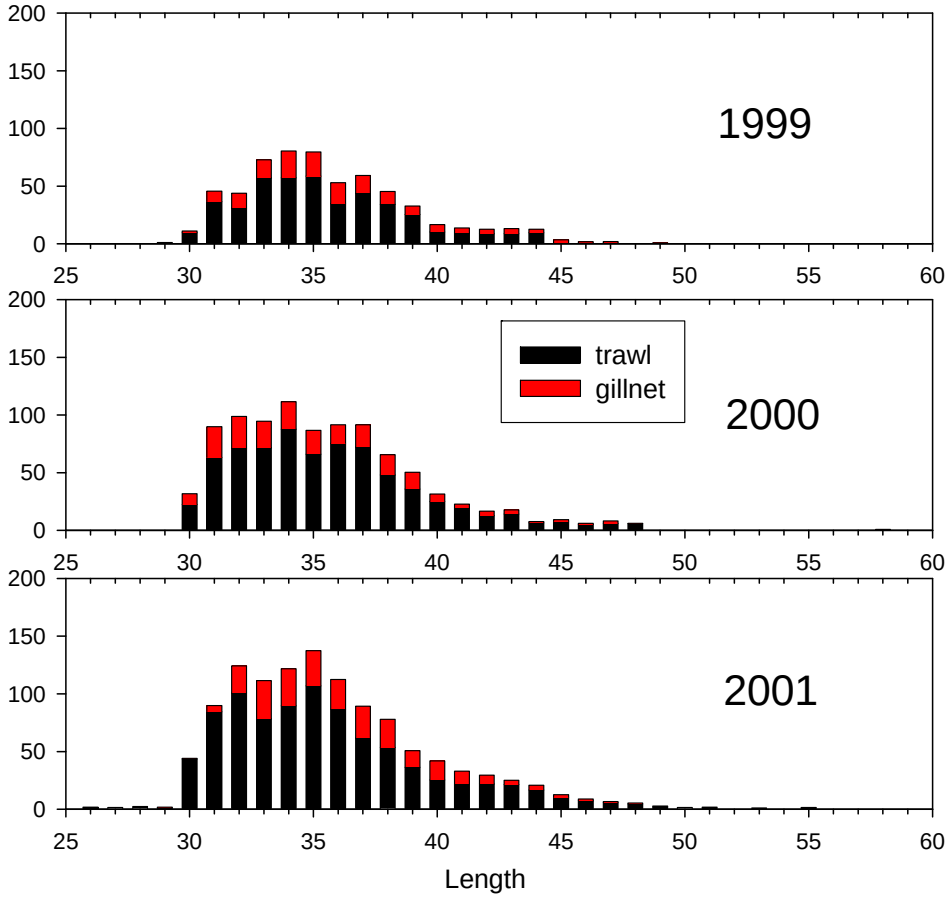


Figure C7. Expanded landing length distribution using observer data.

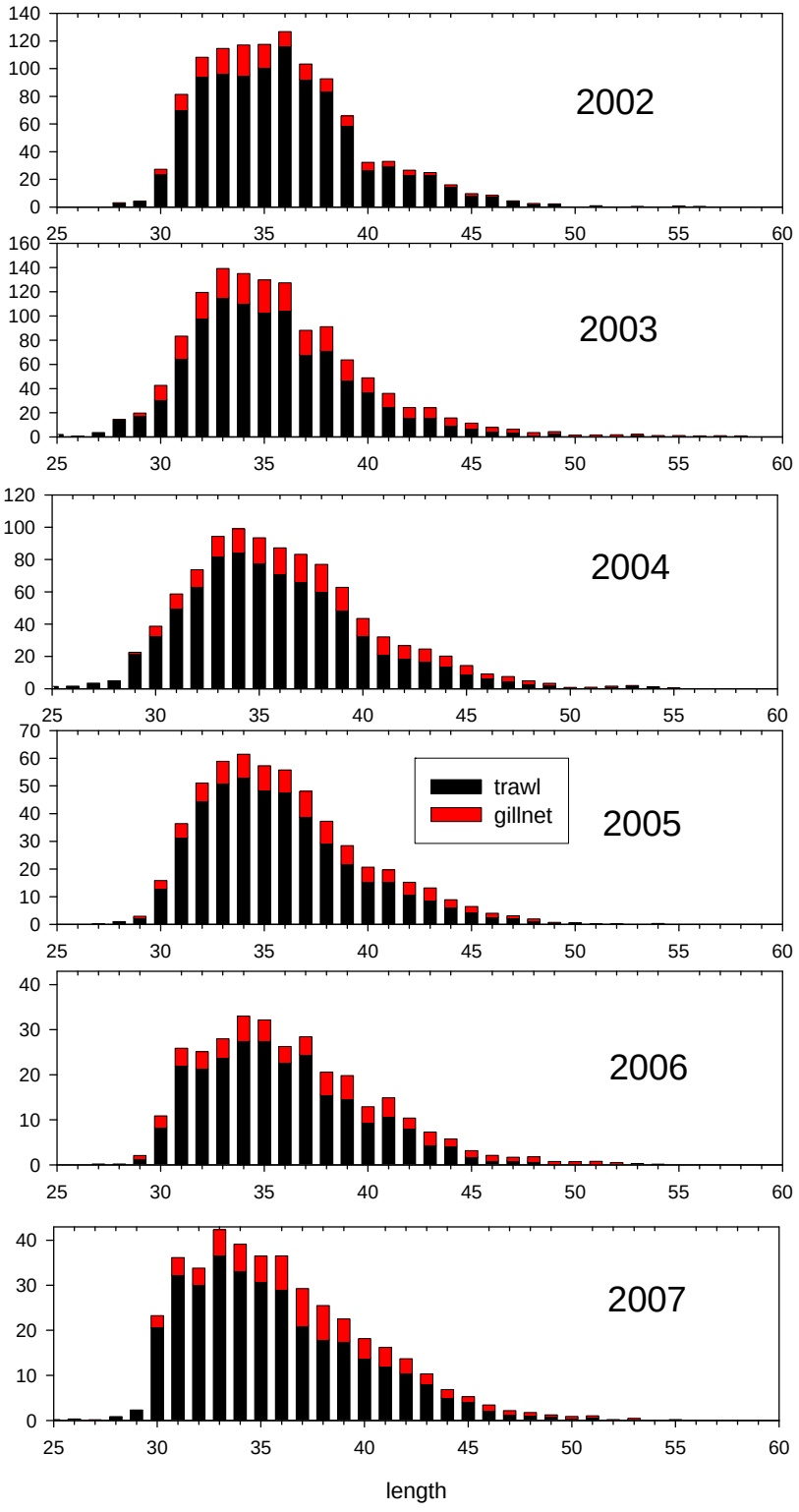


Figure C7. Cont.

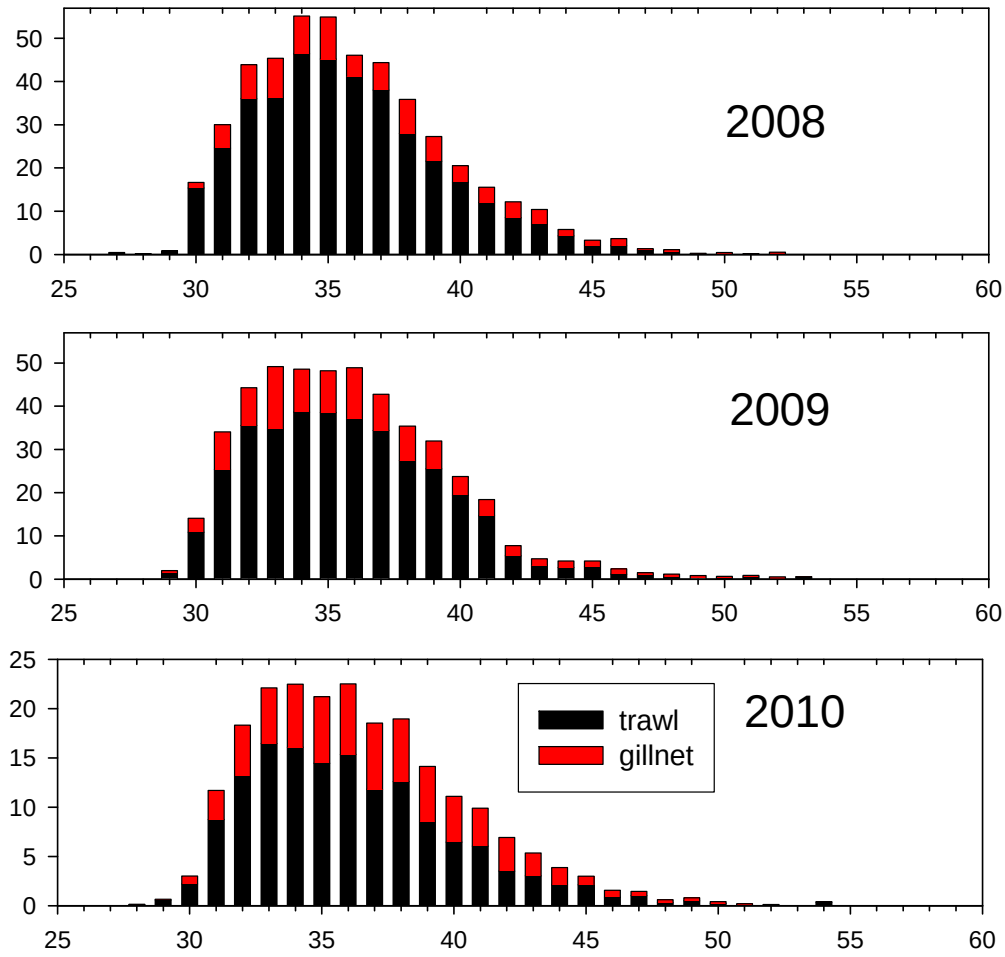
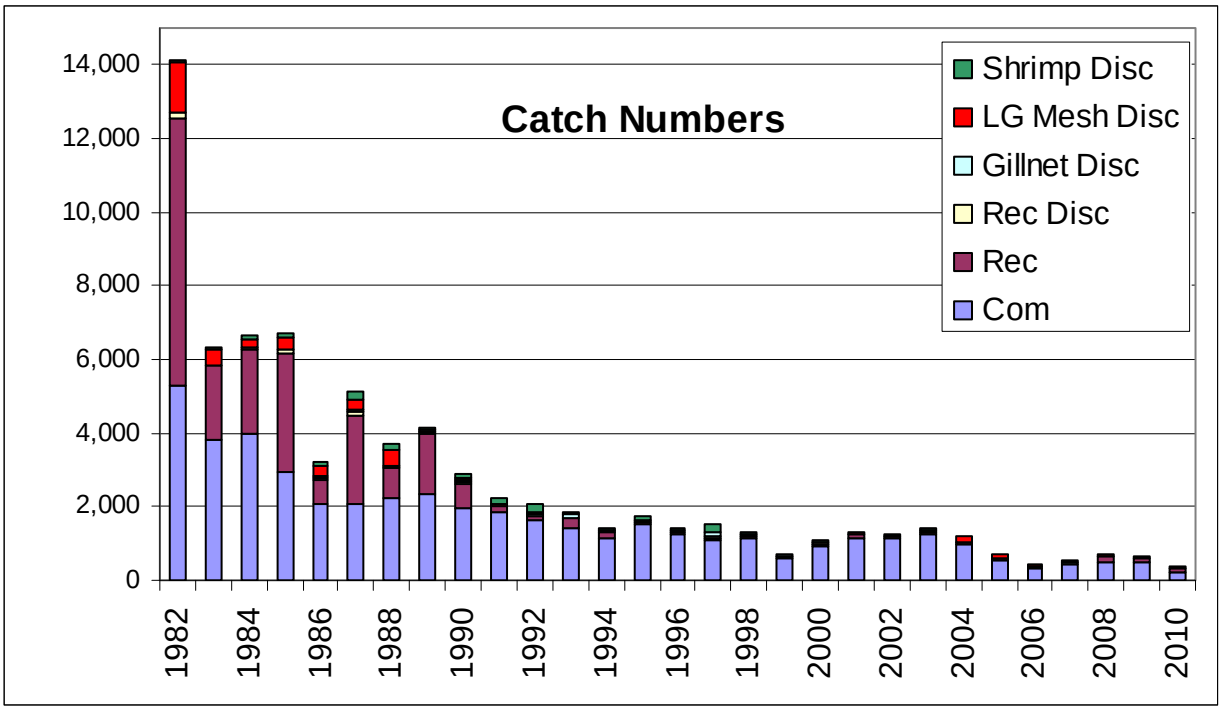


Figure C7. Cont.



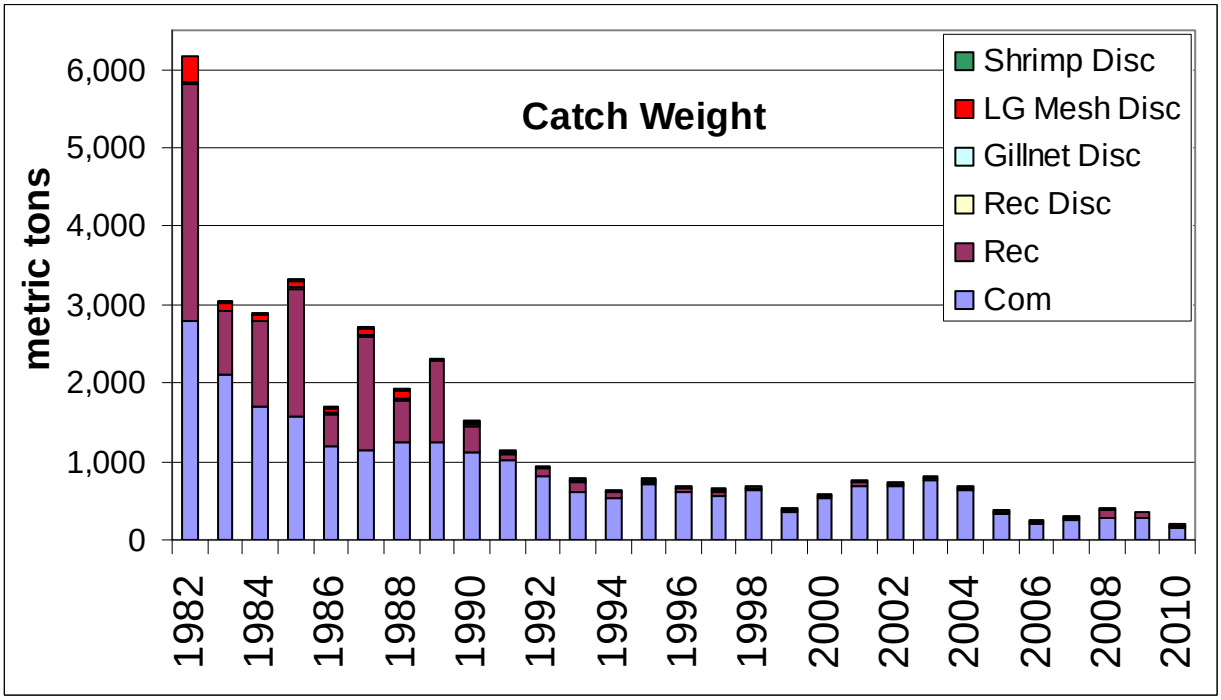


Figure C8. Gulf of Maine winter flounder composition of the catch by numbers and weight.

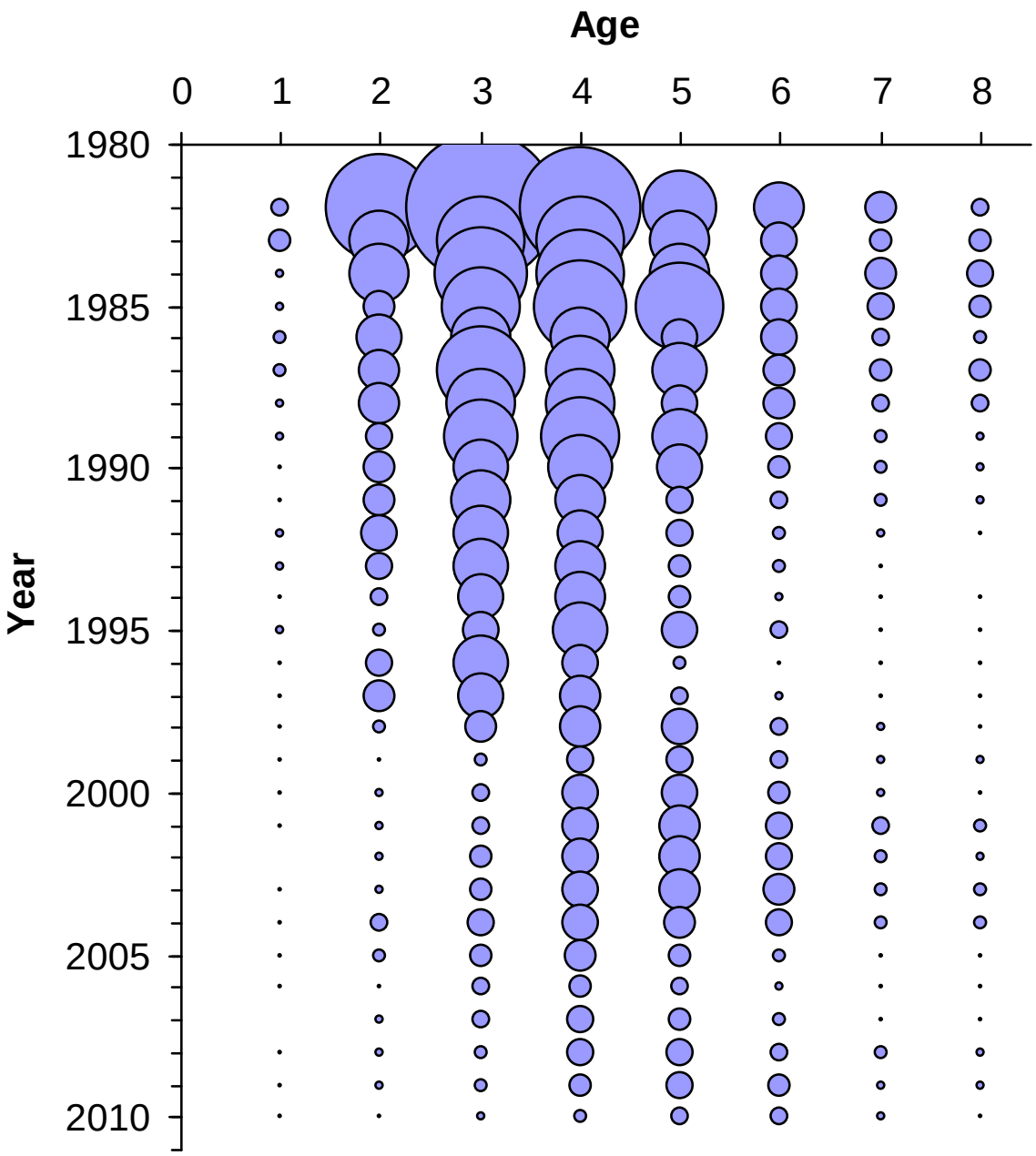


Figure C9. Gulf of Maine winter flounder bubble plot of the catch at age.

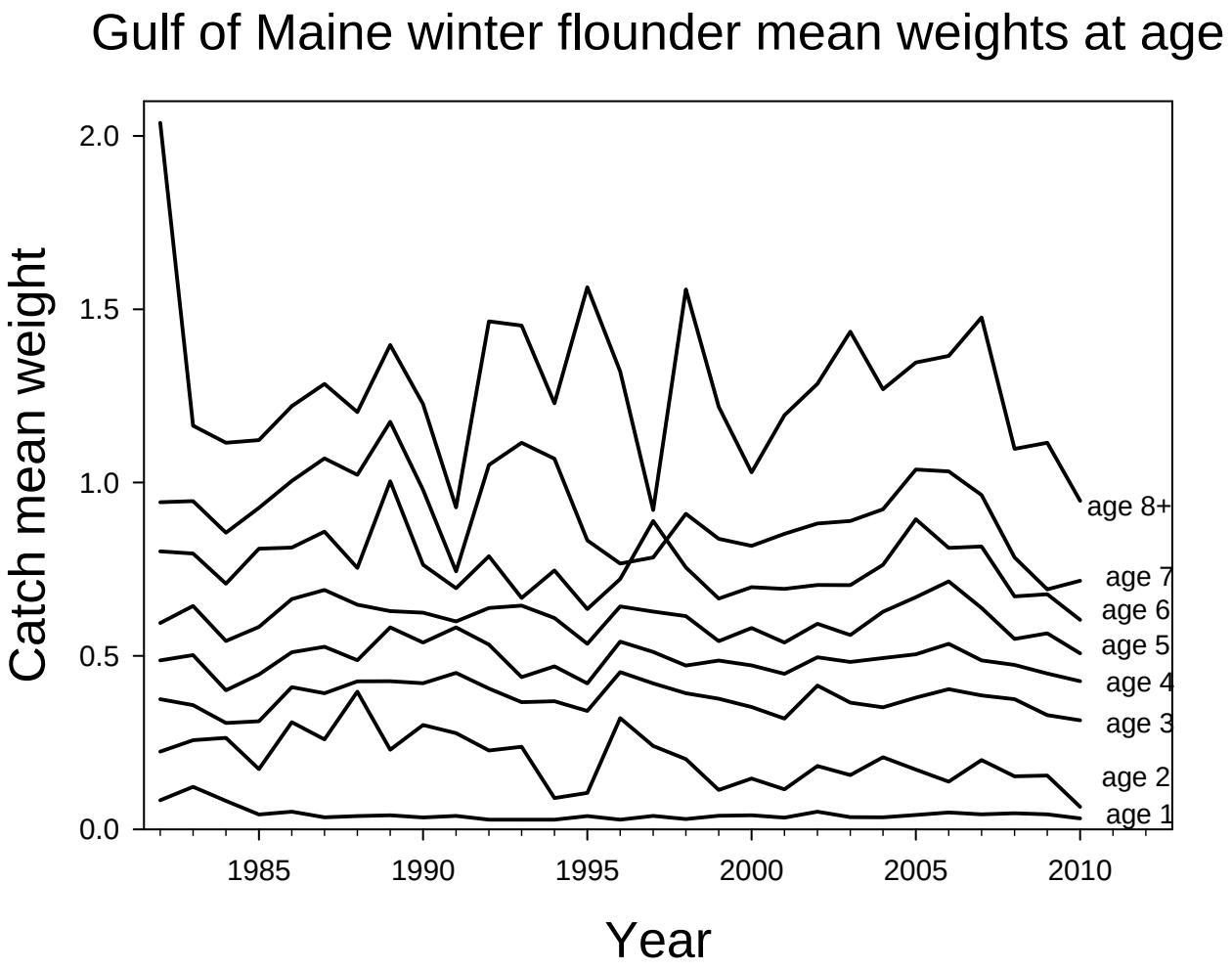


Figure C10. Gulf of Maine winter flounder mean catch weights at age (kg).

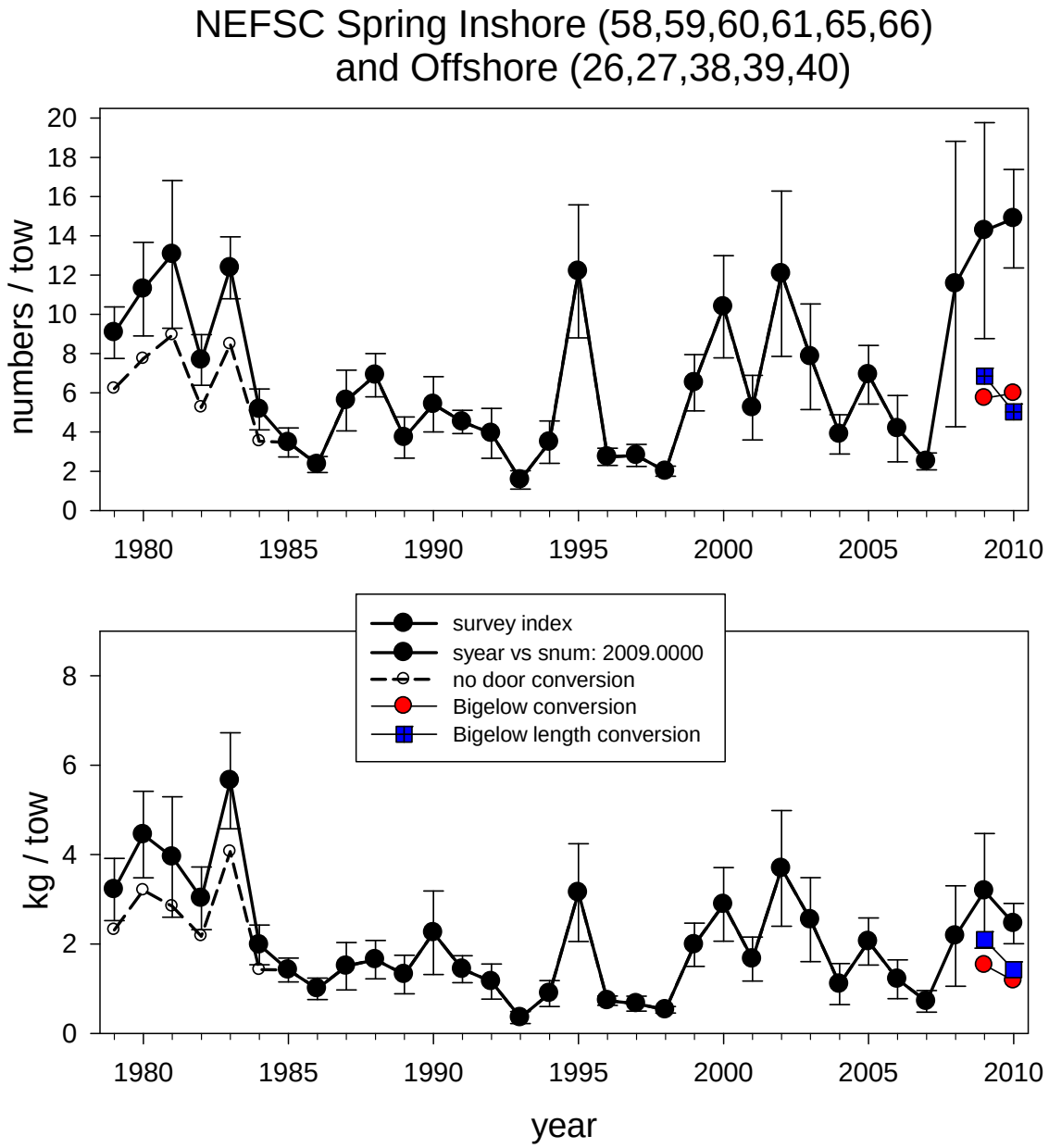


Figure C11. NEFSC spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are use where appropriate. Dotted lines are unconverted door indices. Bigelow aggregate (red dots) and length based conversion (blue squares) are also shown.

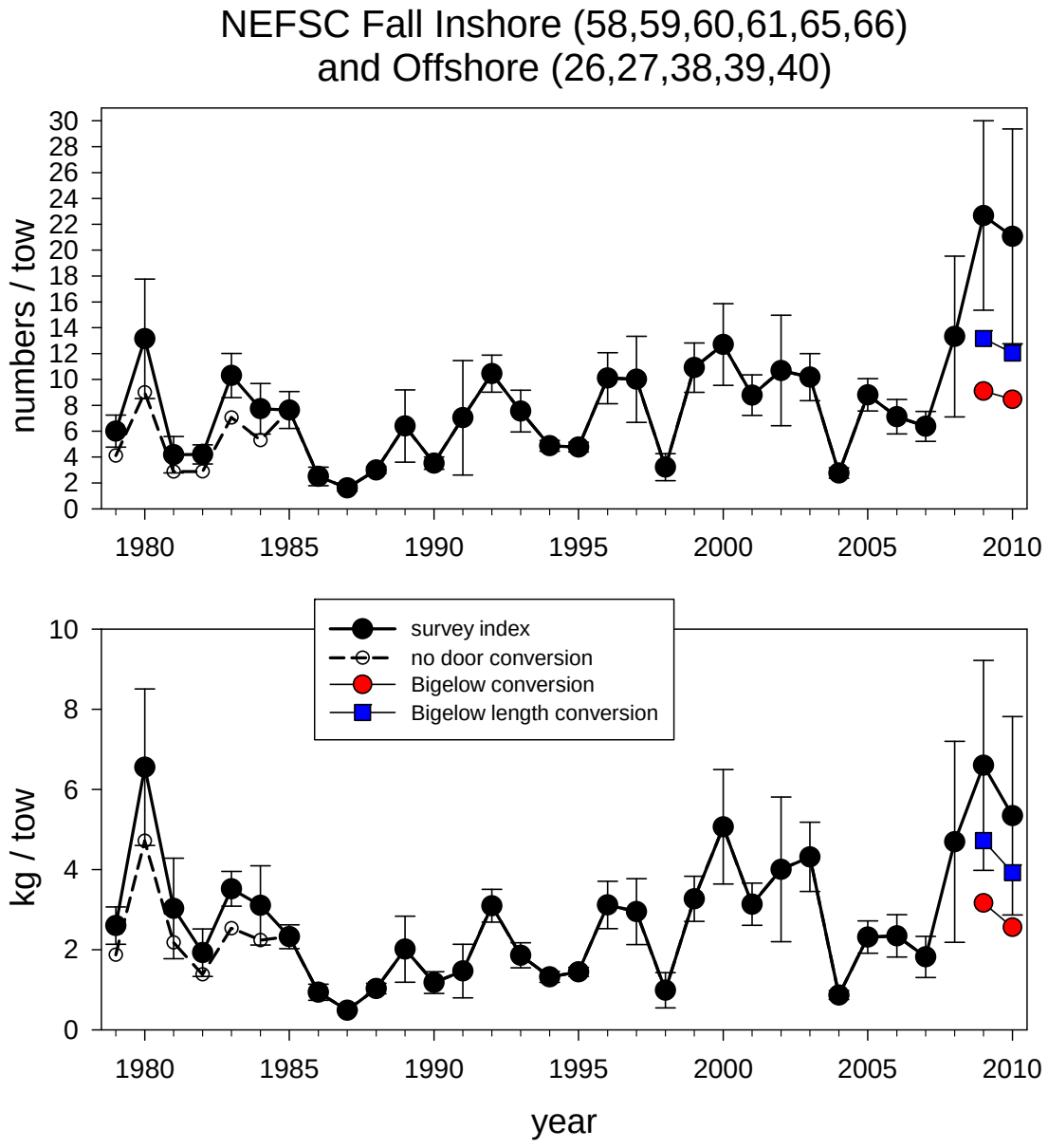


Figure C12 NEFSC fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are use where appropriate. Dotted lines are unconverted door indices. Bigelow aggregate (red dots) and length based conversion (blue squares) are also shown. The 2010 index did not have Cape Cod Bay strata sampled.

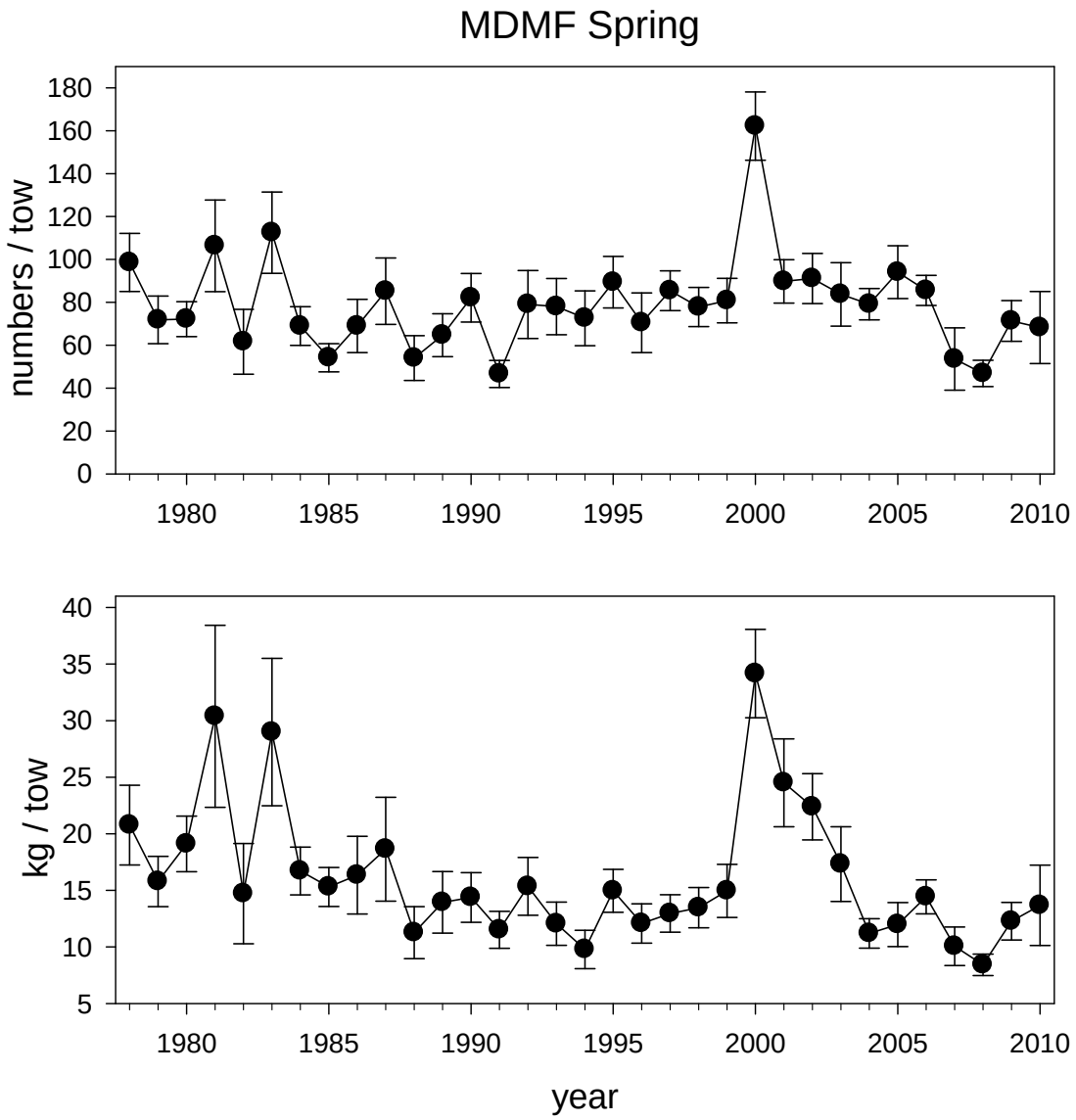


Figure C13. Massachusetts Division of Marine Fisheries (MDMF) spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

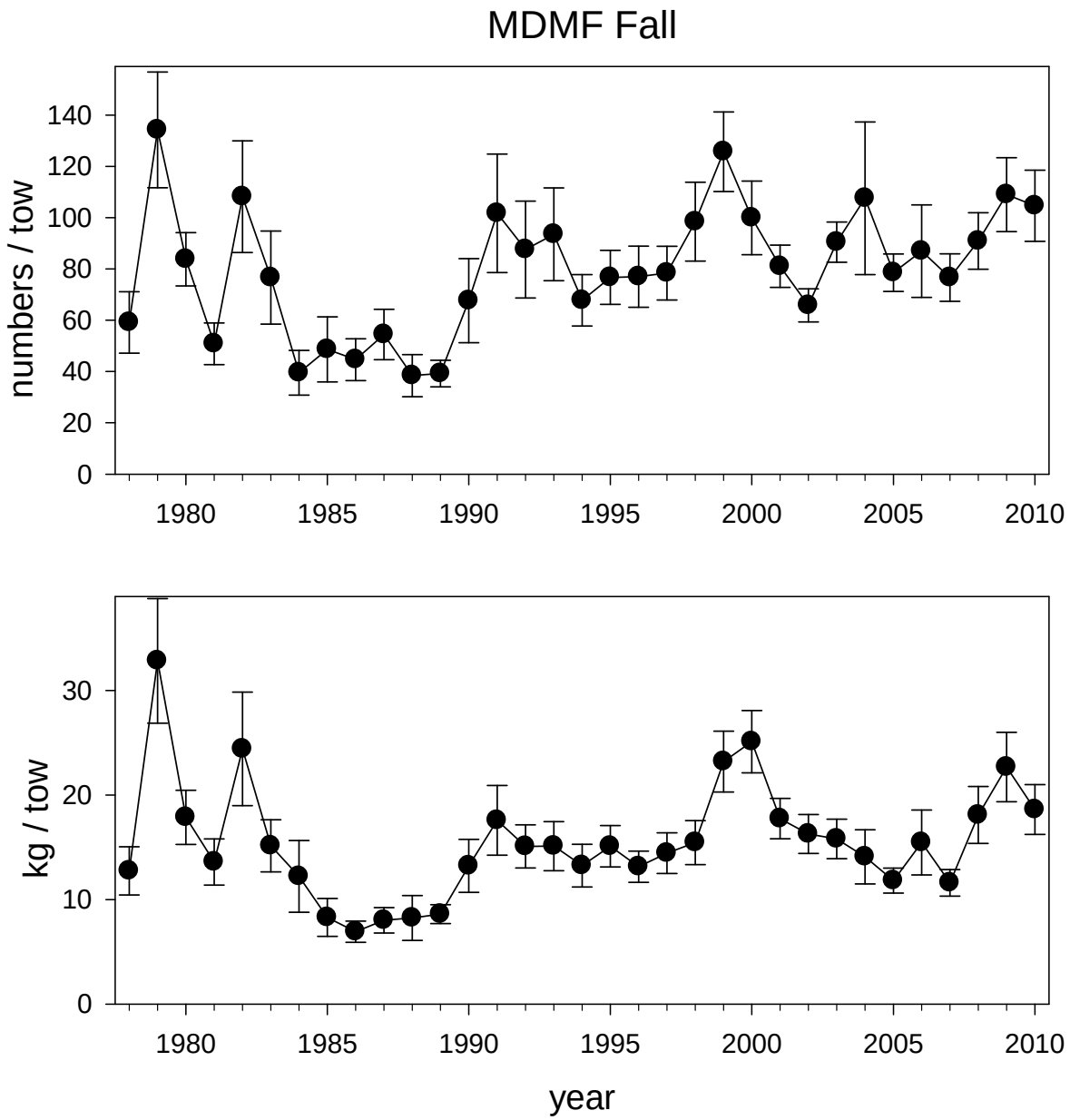


Figure C14. Massachusetts Division of Marine Fisheries (MDMF) fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

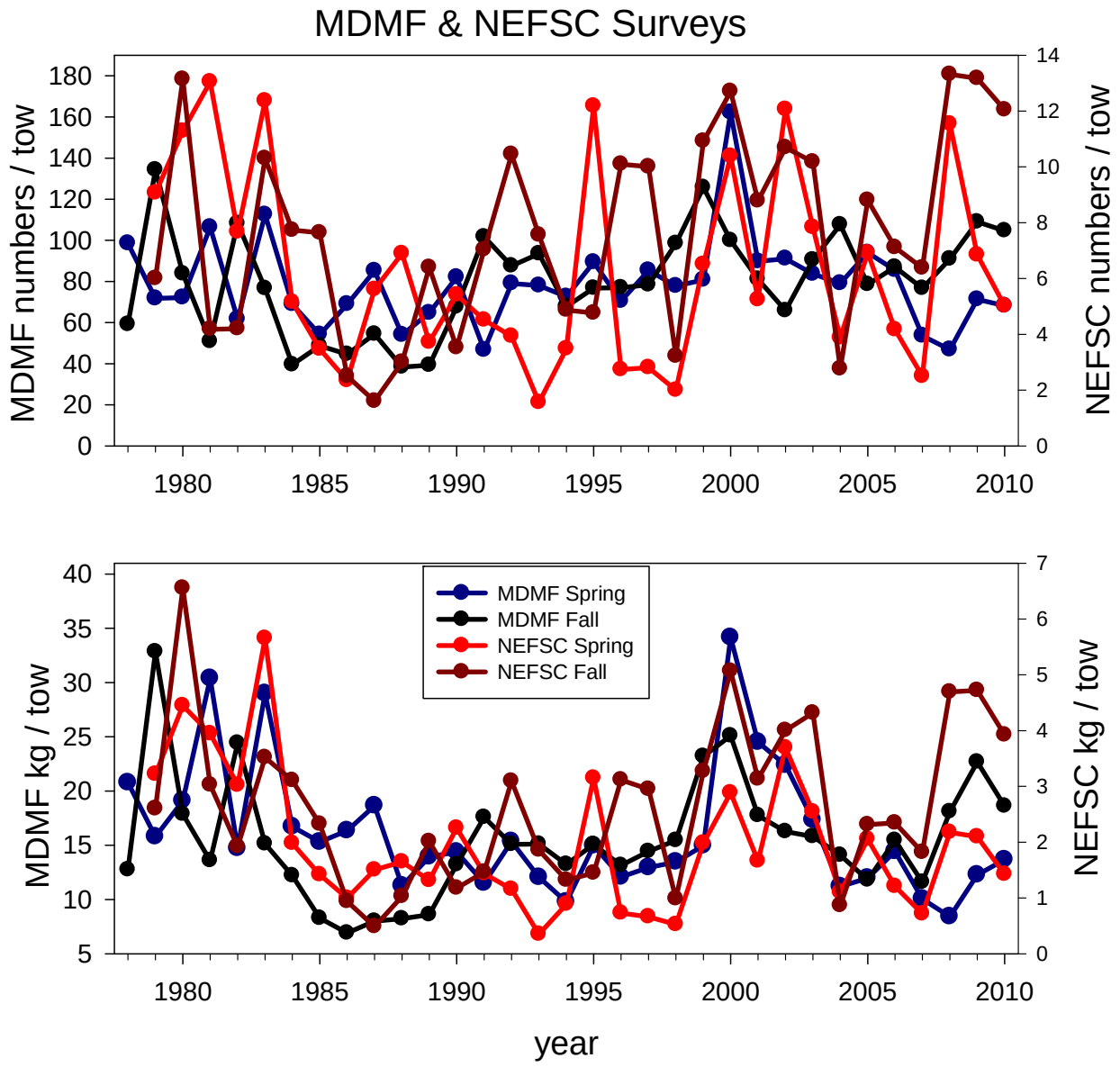


Figure C15. All four survey stratified mean numbers and mean weight (kg) per tow trends for Gulf of Maine winter flounder.

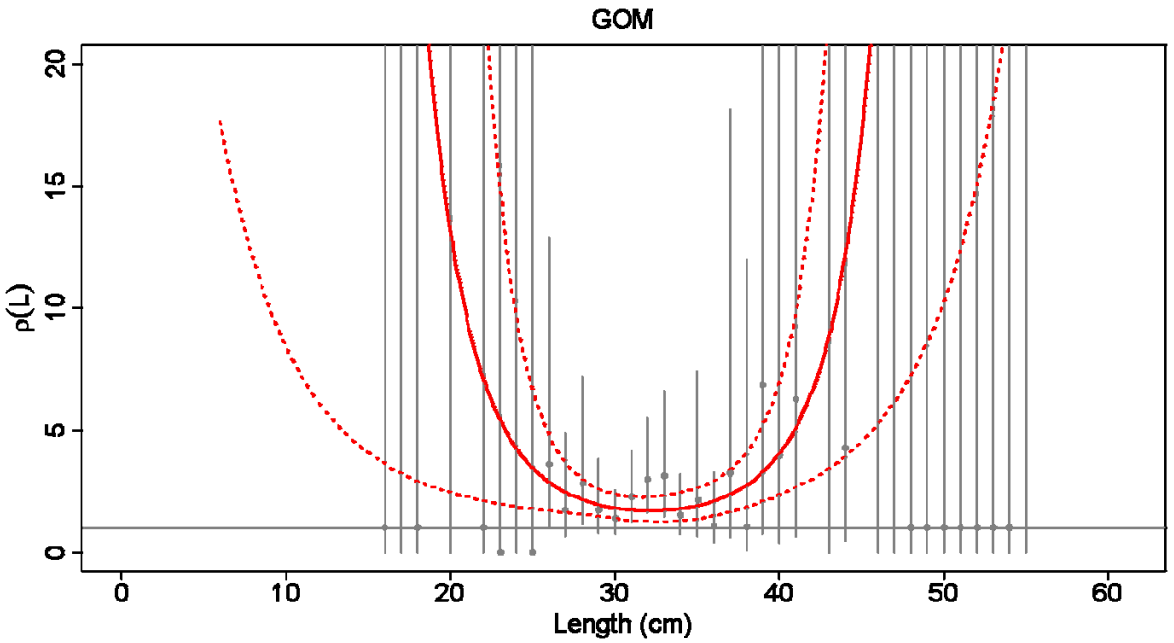


Figure C16. Estimated Length based calibration coefficients for Gulf of Maine winter flounder.

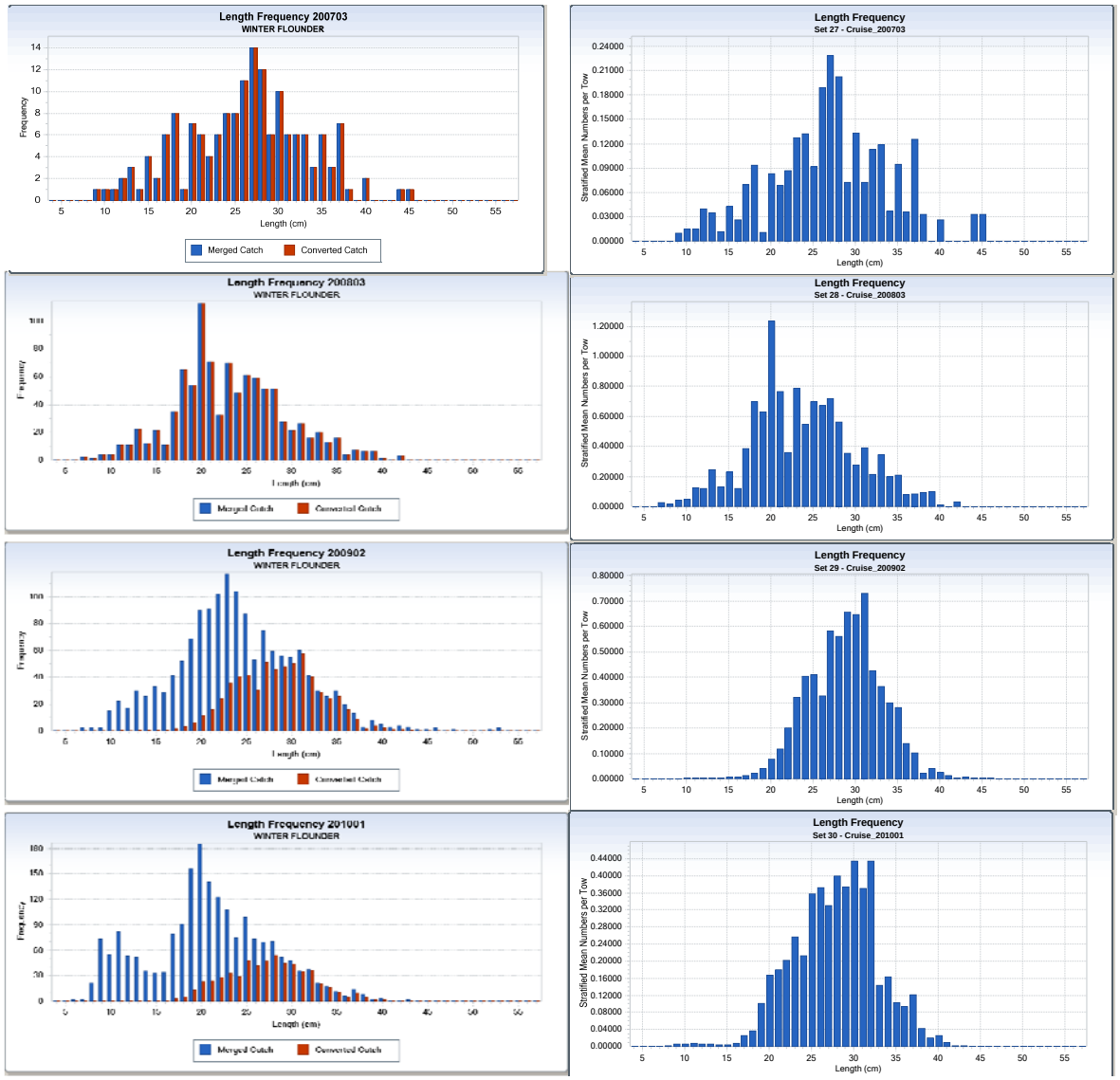


Figure C17. Spring raw and converted survey length distributions in 2009 and 2010. Albatross distributions are shown for 2008 and 2009 for comparison. Stratified converted length distributions are shown on the right.

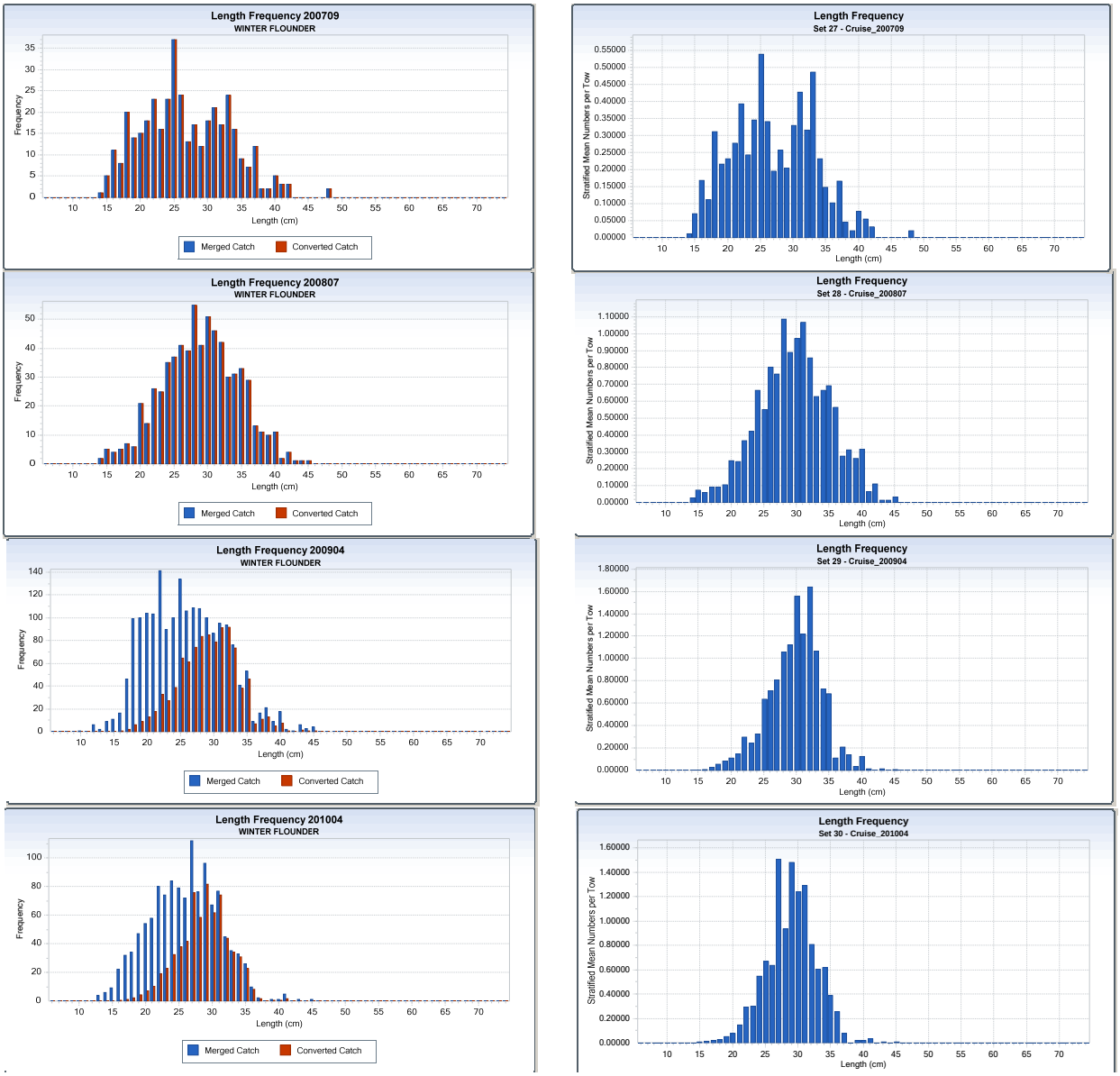
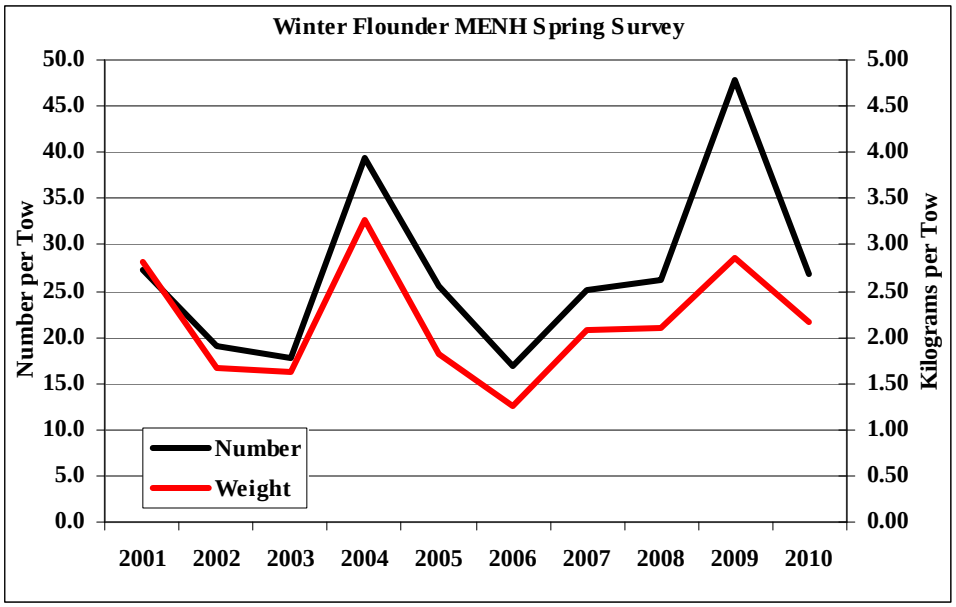


Figure C18. Fall raw and converted survey length distributions in 2009 and 2010. Albatross distributions are shown for 2008 and 2009 for comparison. Stratified converted length distributions are shown on the right.



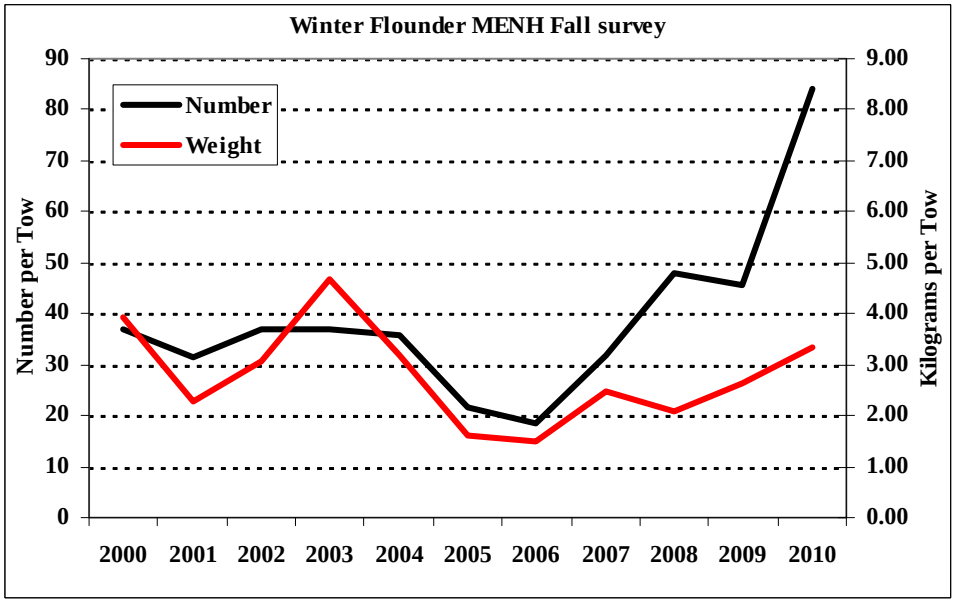


Figure C19. Spring and Fall MENH bottom trawl survey winter flounder abundance indices.

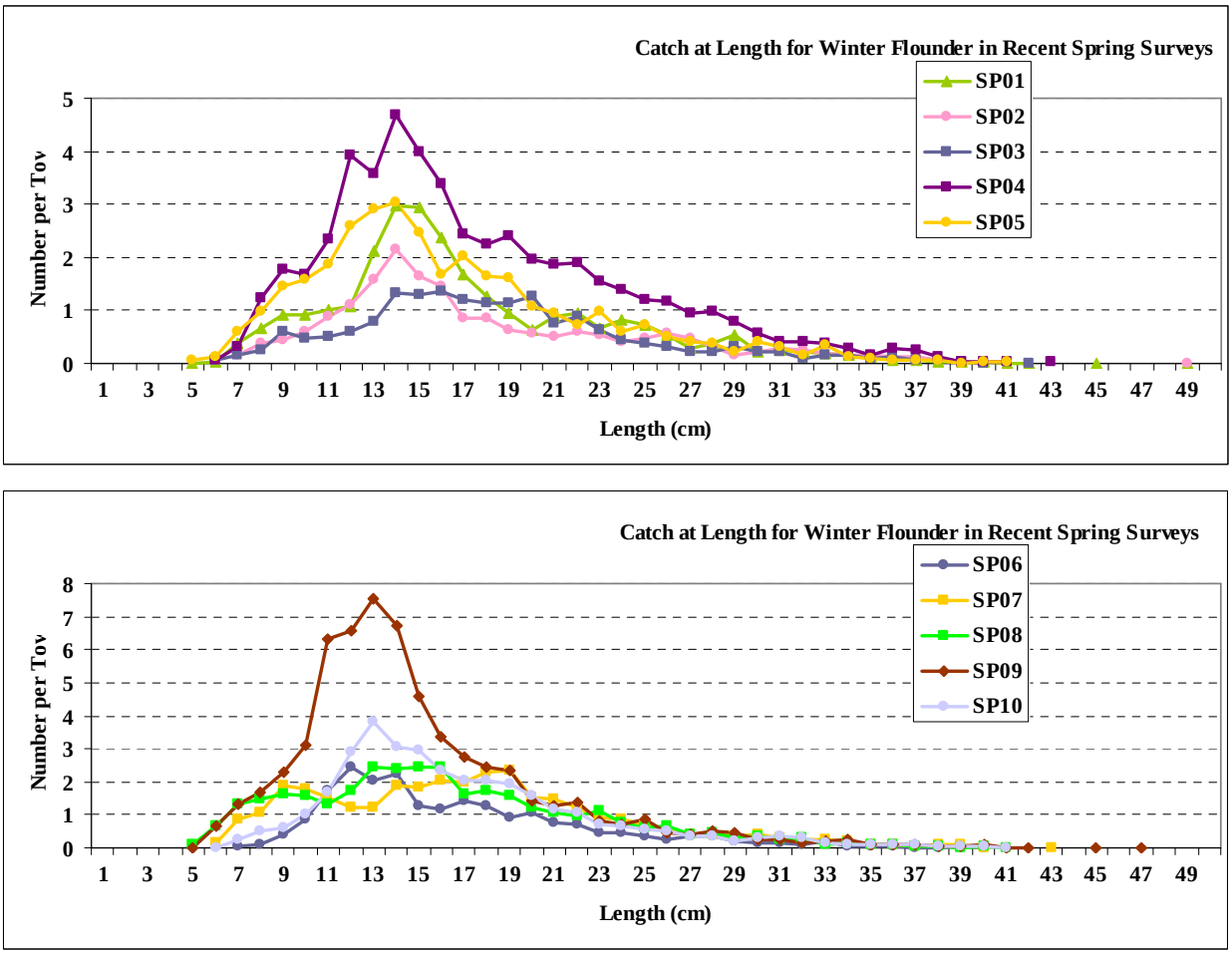
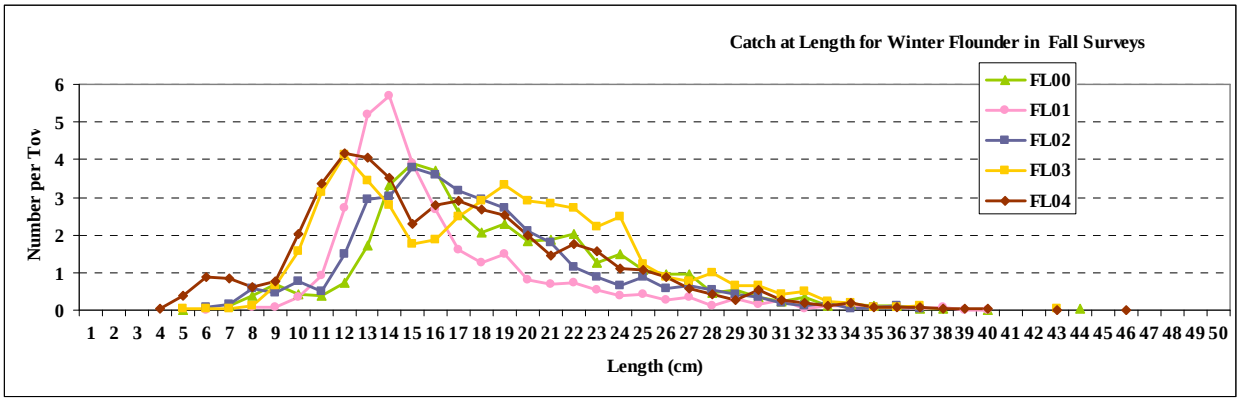


Figure C20. Spring MENH survey length distributions for Gulf of Maine winter flounder.



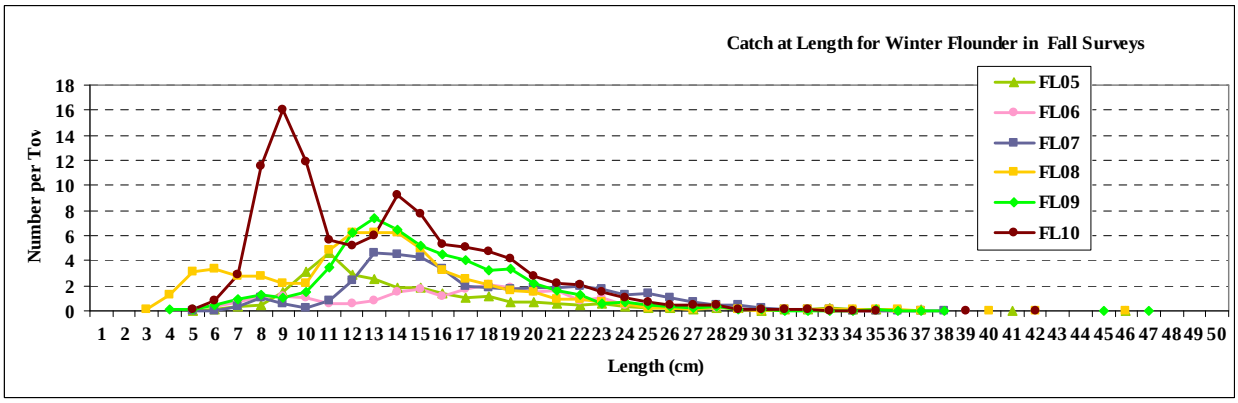


Figure C21. Fall MENH survey length distributions for Gulf of Maine winter flounder.

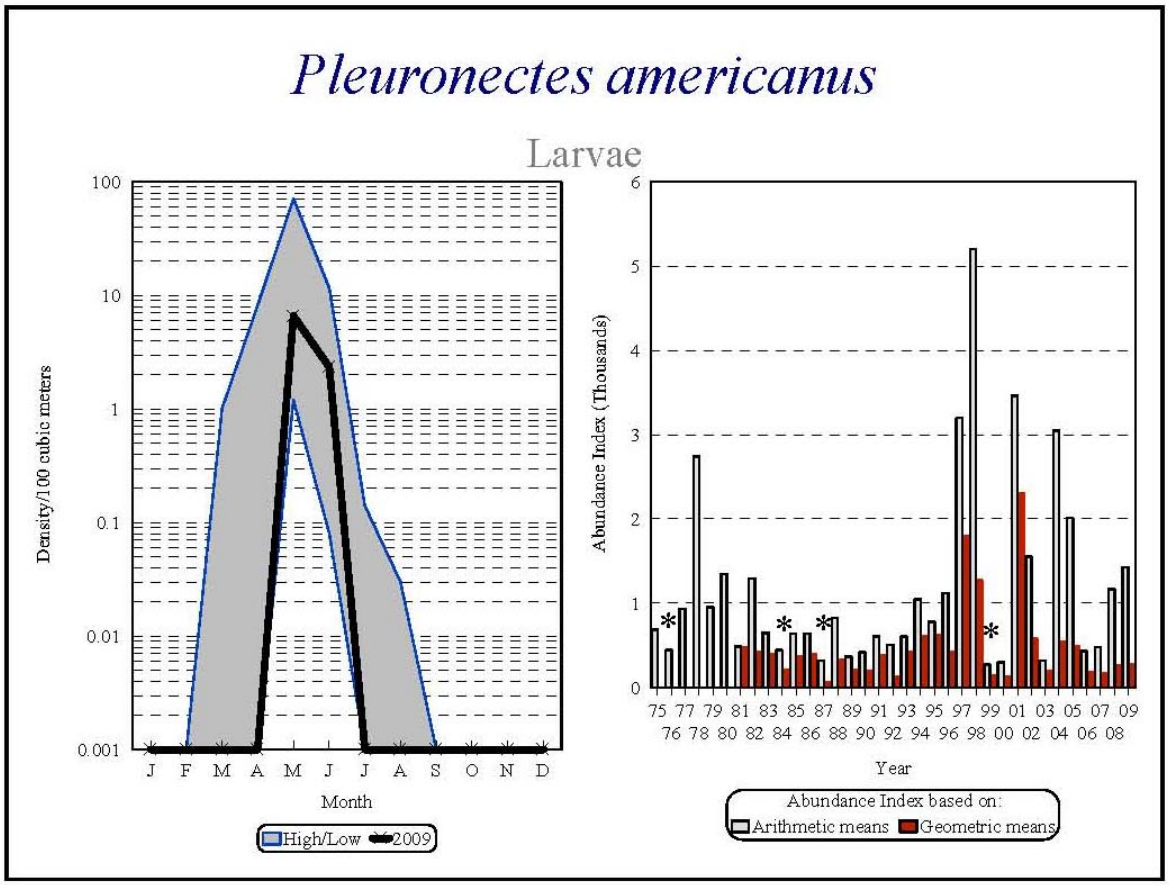


Figure C22. Entrainment monitoring of winter flounder larvae at the Pilgrim Nuclear power plant in Plymouth Massachusetts from 1975 to 2009.

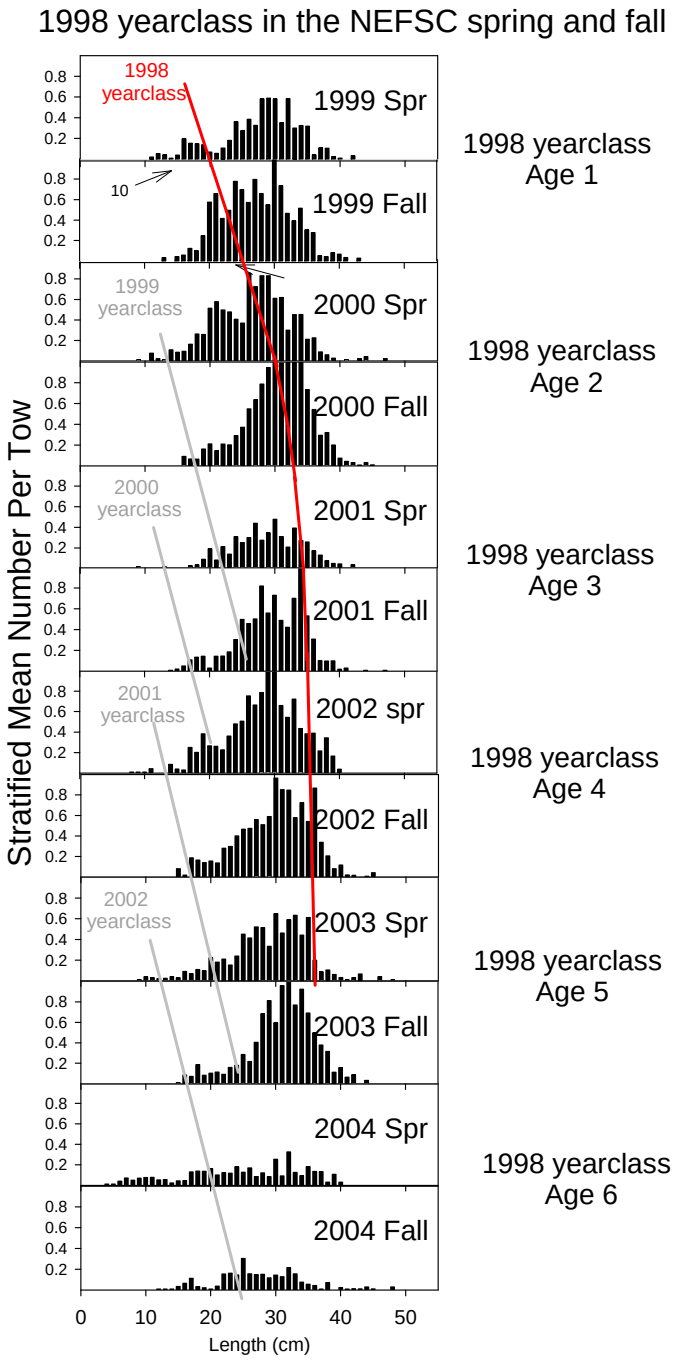


Figure C23. MDMF bottom trawl survey tracking of the 1998 yearclass in the Gulf of Maine winter flounder catch per tow at length (cm) distributions.

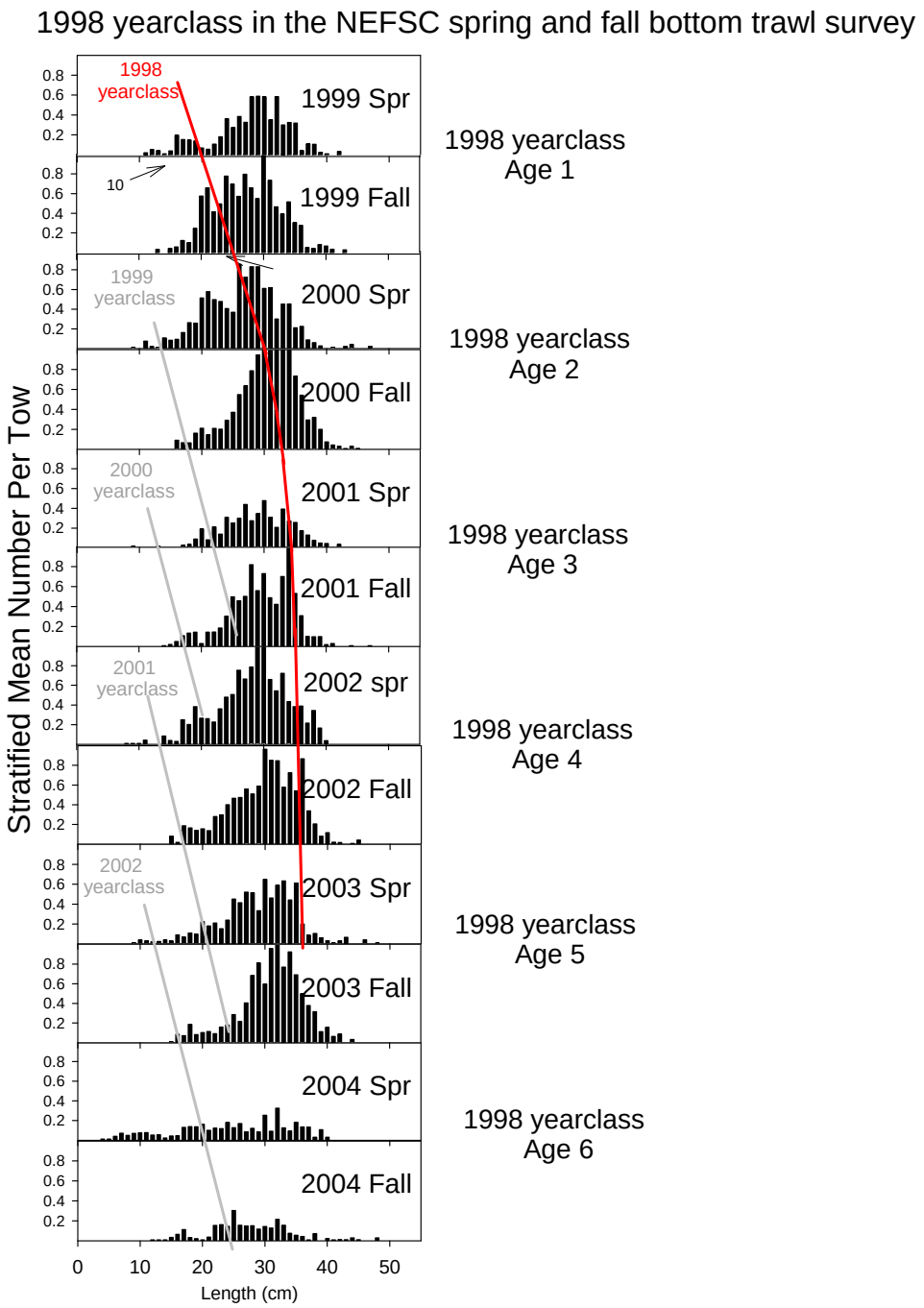


Figure C24. NEFSC bottom trawl survey tracking of the 1998 yearclass in the Gulf of Maine winter flounder catch per tow at length (cm) distributions.

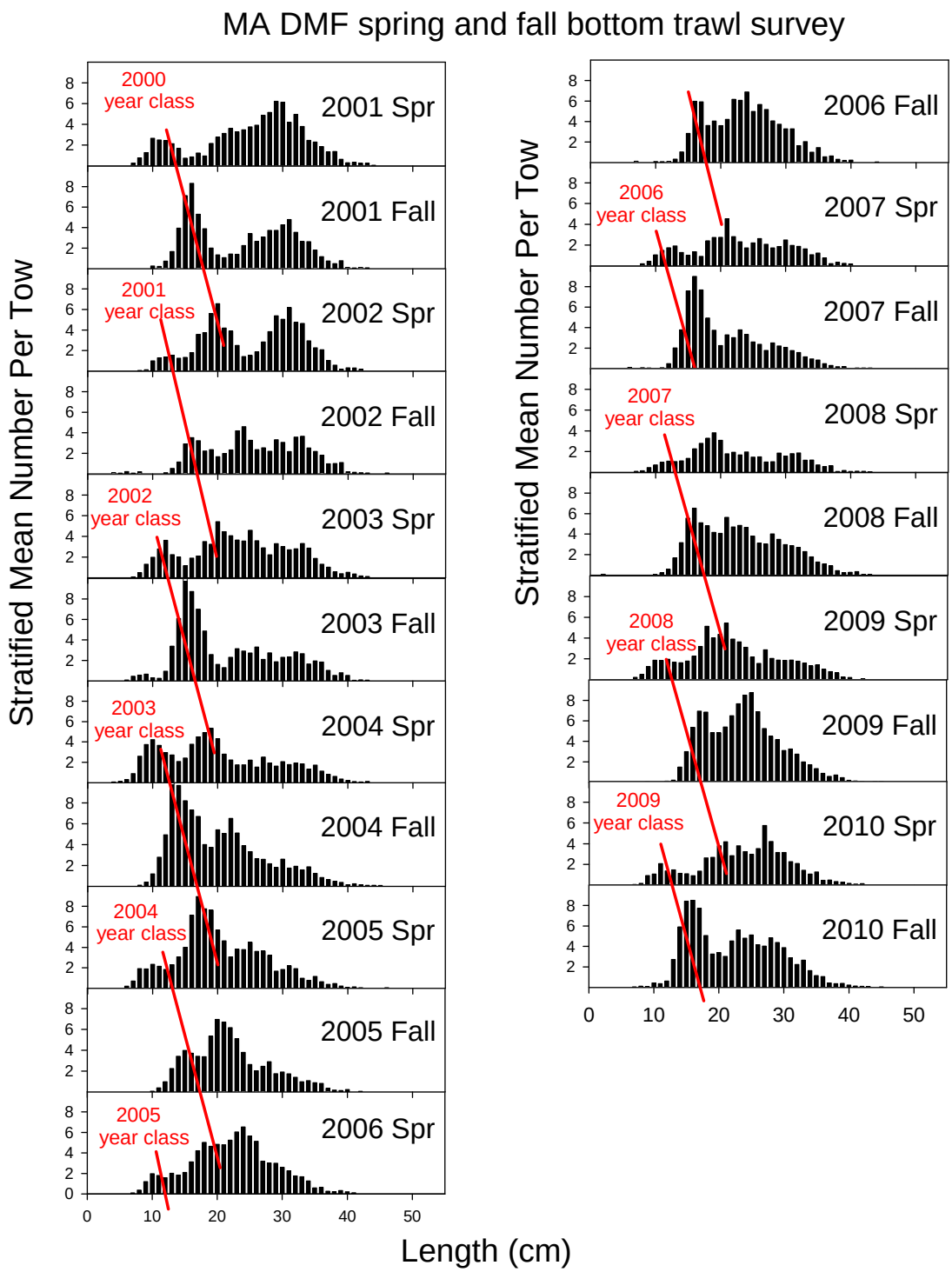


Figure C25. MDMF bottom trawl survey tracking of age modes in the catch per tow at length (cm) distributions from the spring and fall surveys for Gulf of Maine winter flounder.

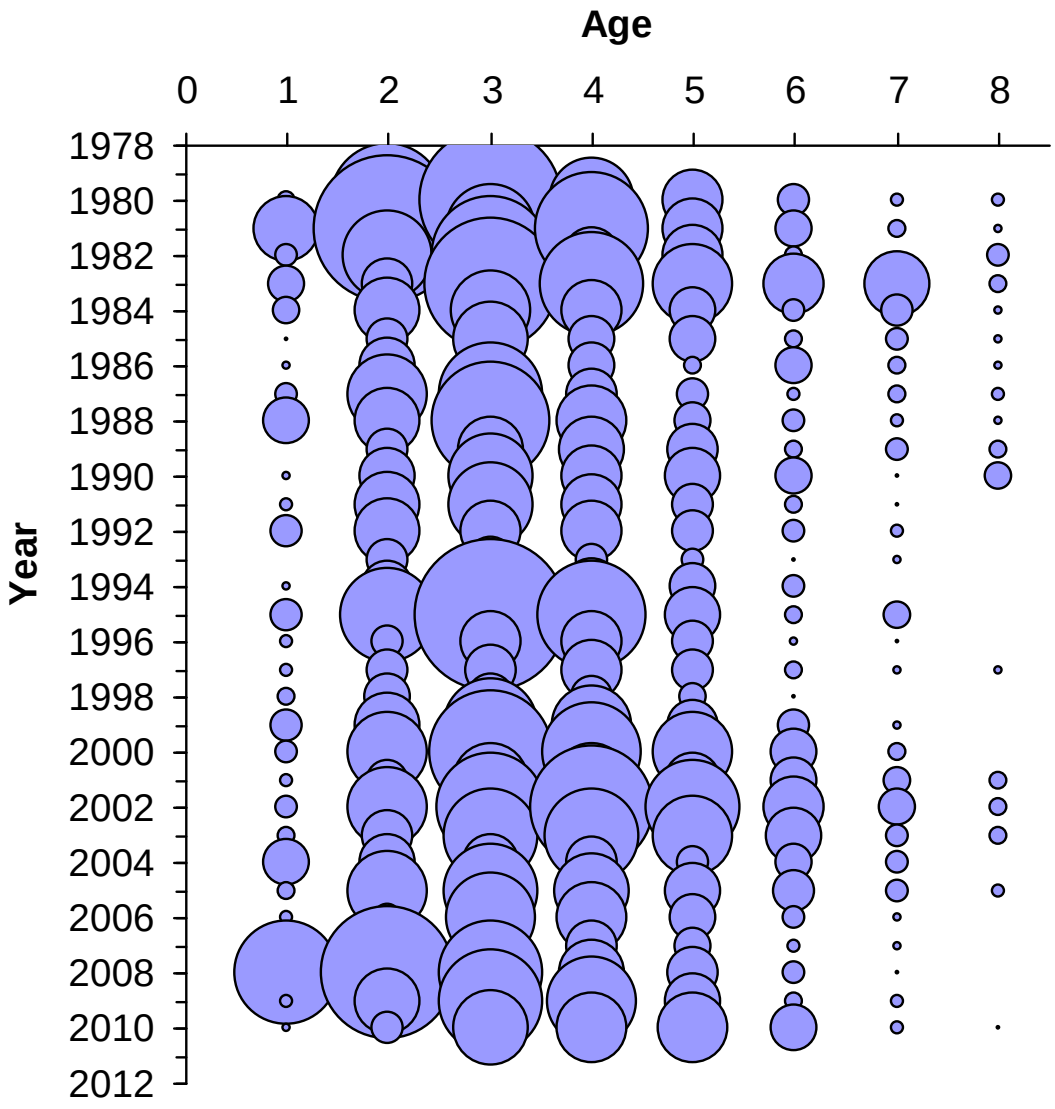


Figure C26. NEFSC Spring indices of abundance by age.

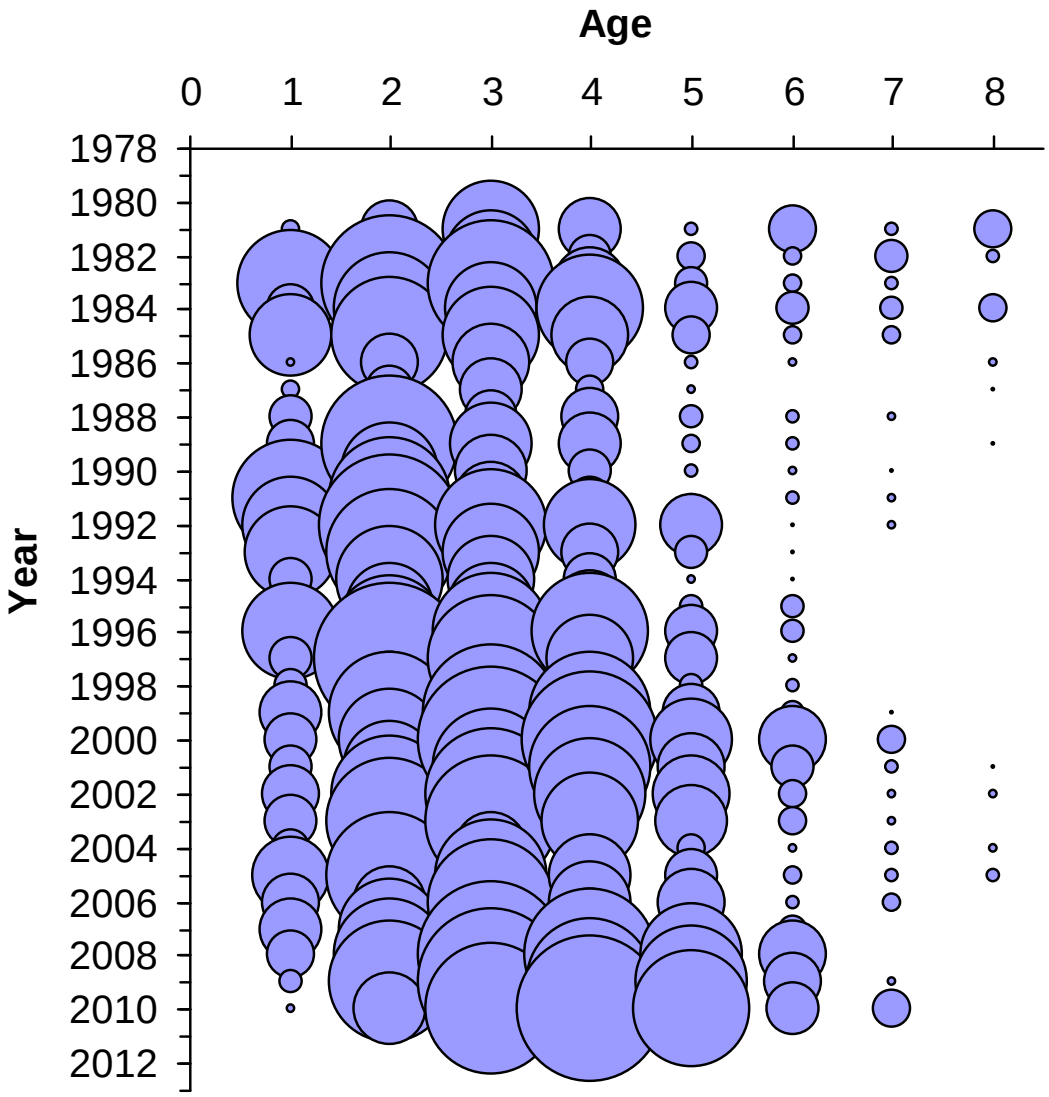


Figure C27. NEFSC Fall indices of abundance by age.

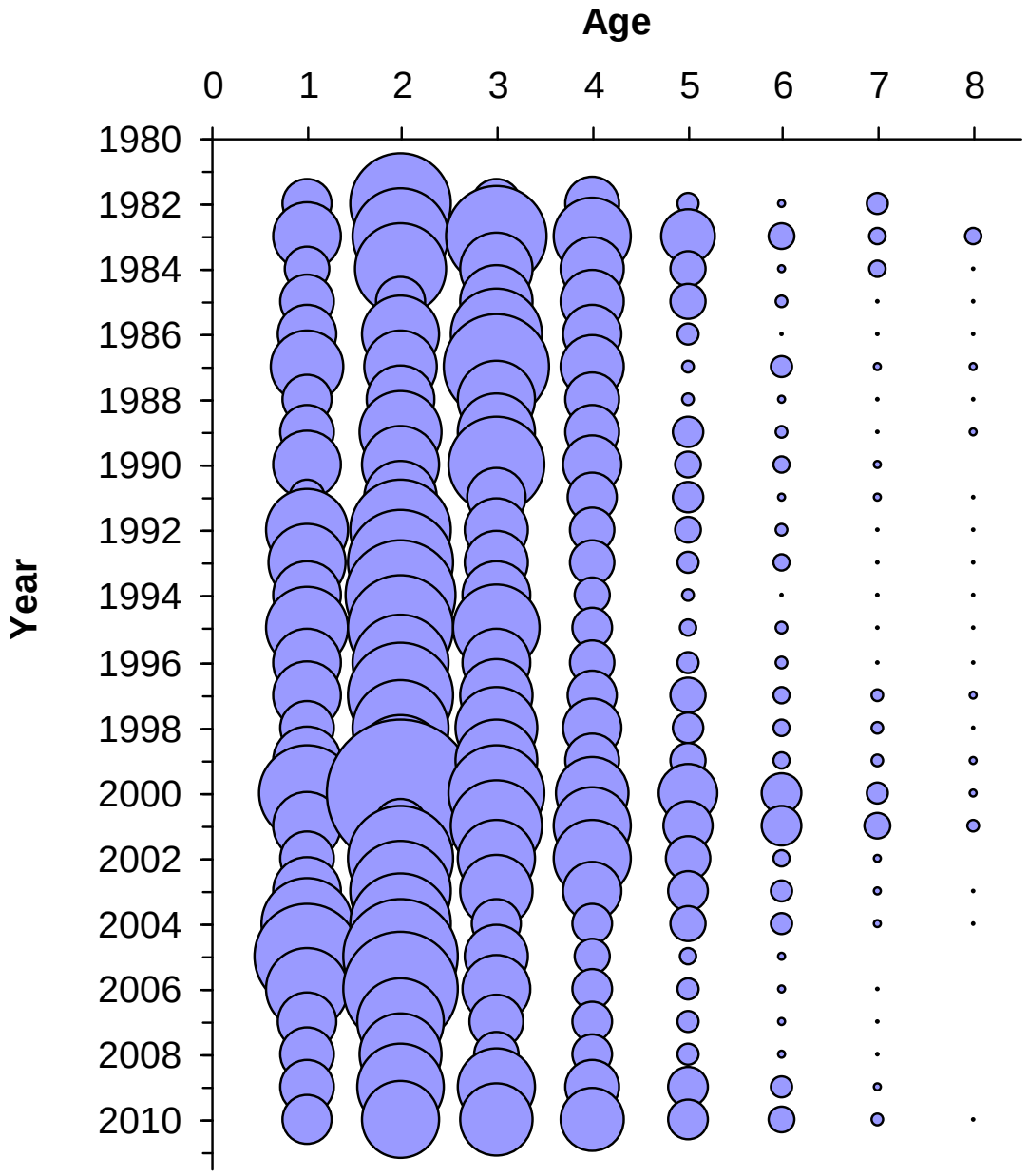


Figure C28. MDMF spring indices of abundance by age.

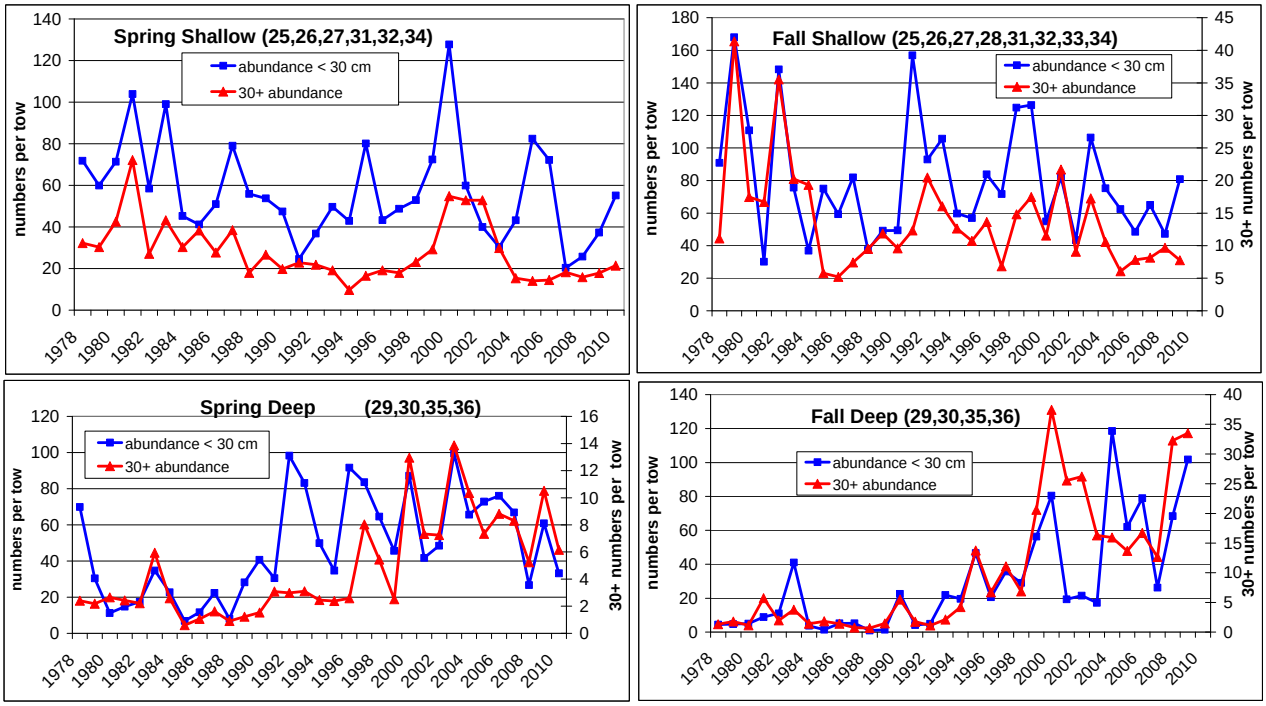


Figure C29. Stratified number per tow indices greater than and less than 30 cm from the Spring and Fall MDMF surveys by depth category (shallow and deep).

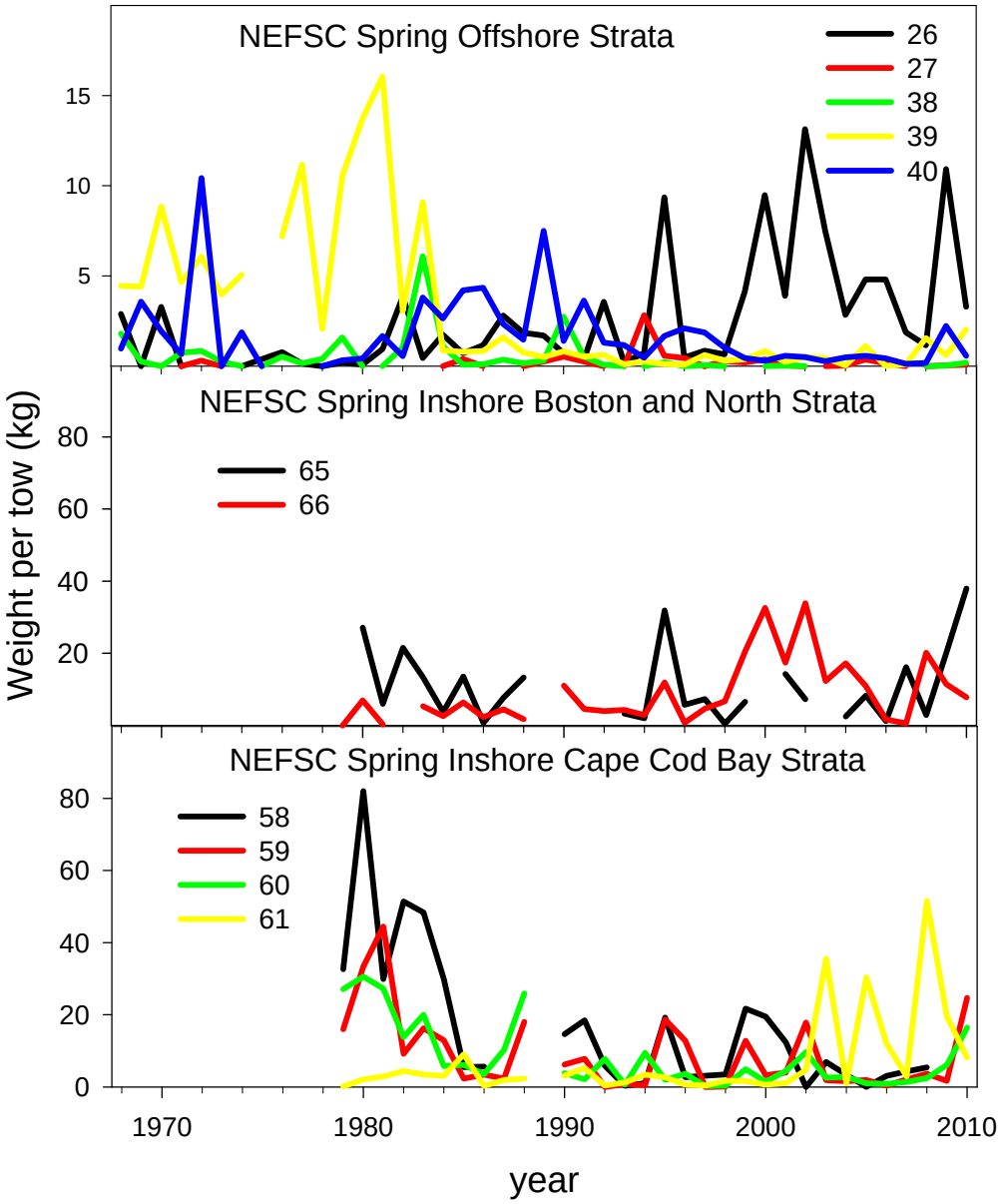


Figure C30. Spring NEFSC survey weight per tow by strata indices.

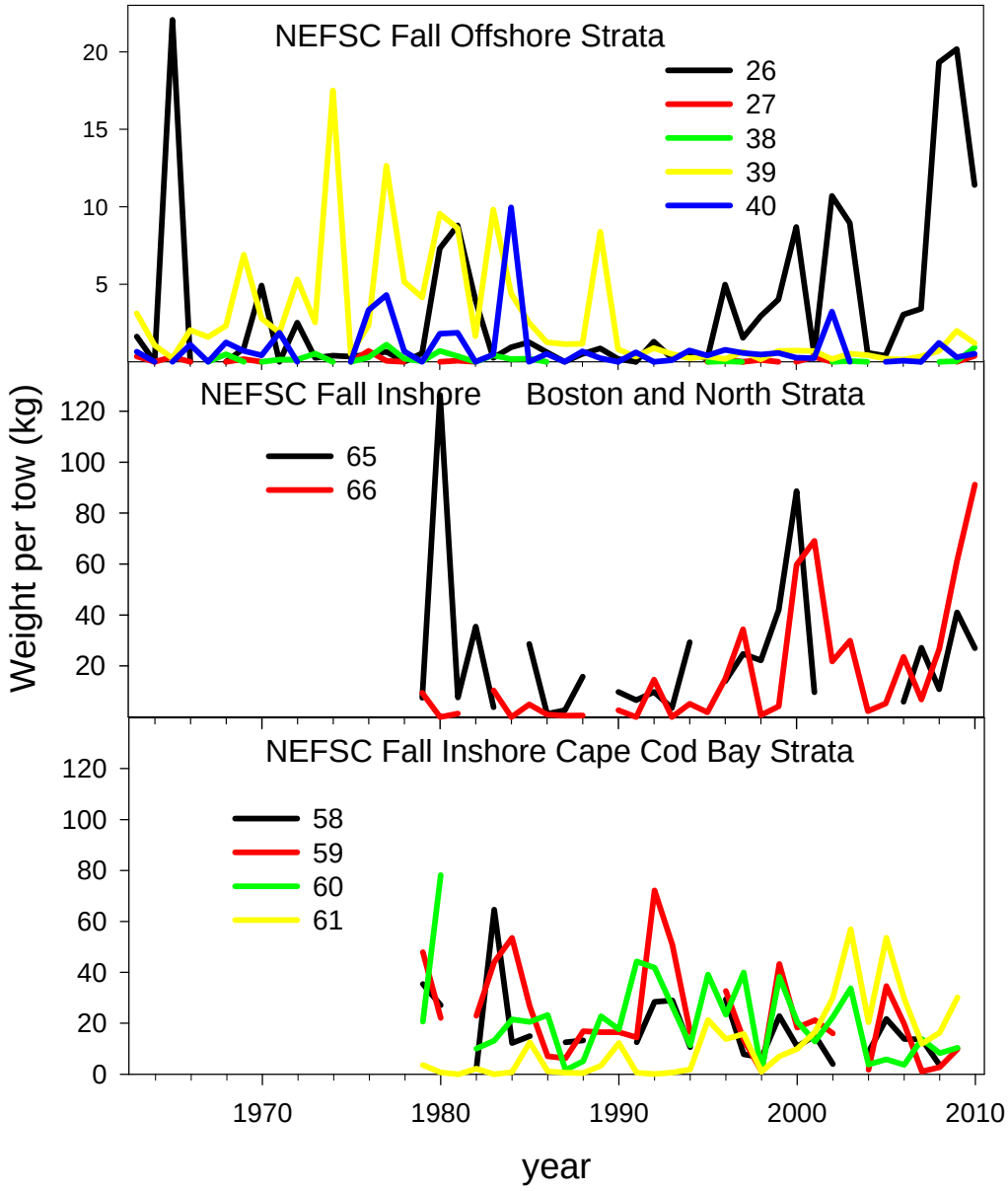


Figure C31. Spring NEFSC survey weight per tow by strata indices.

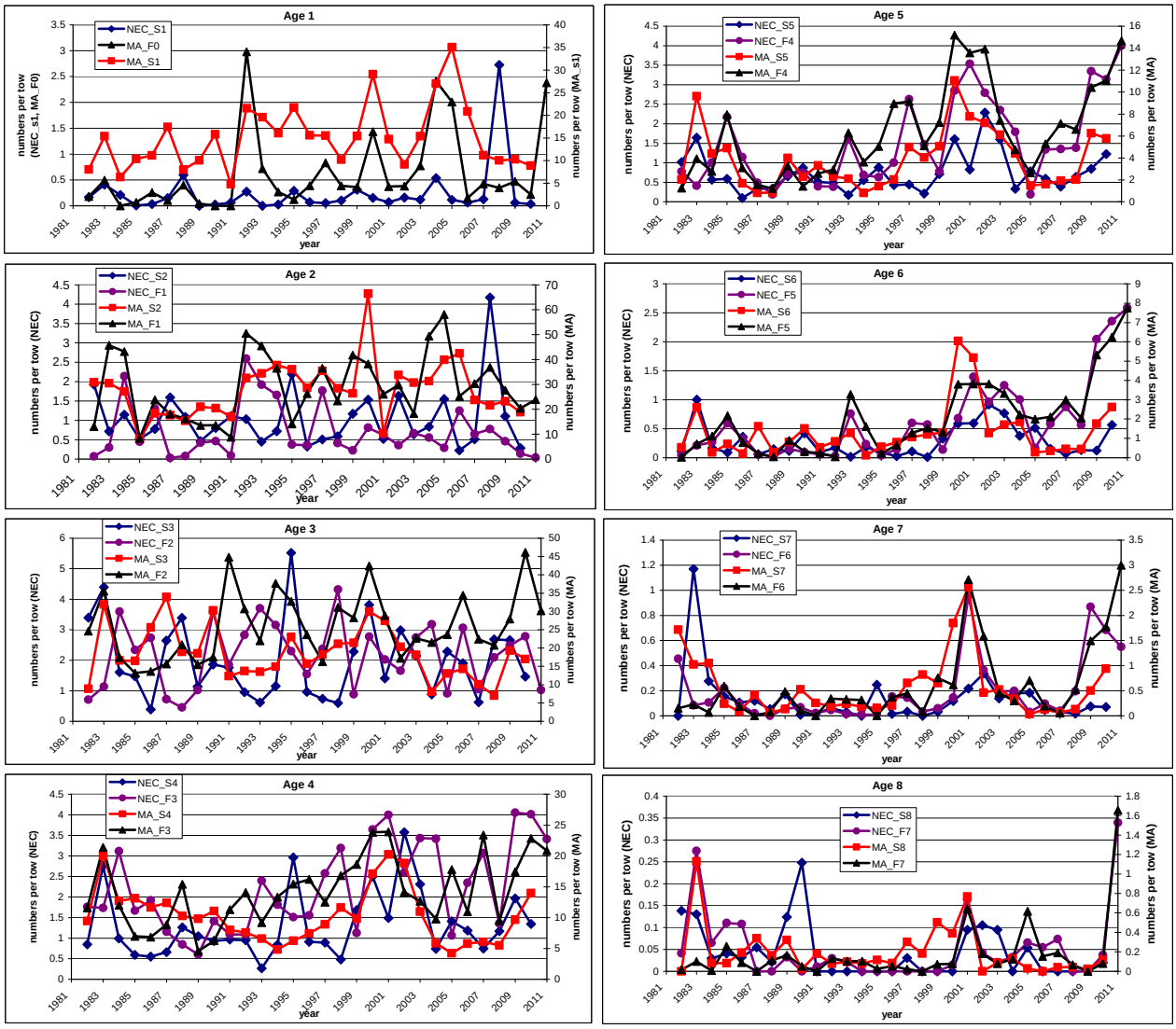


Figure C32. Indices at age from the spring and fall NEFSC and MDMF surveys.

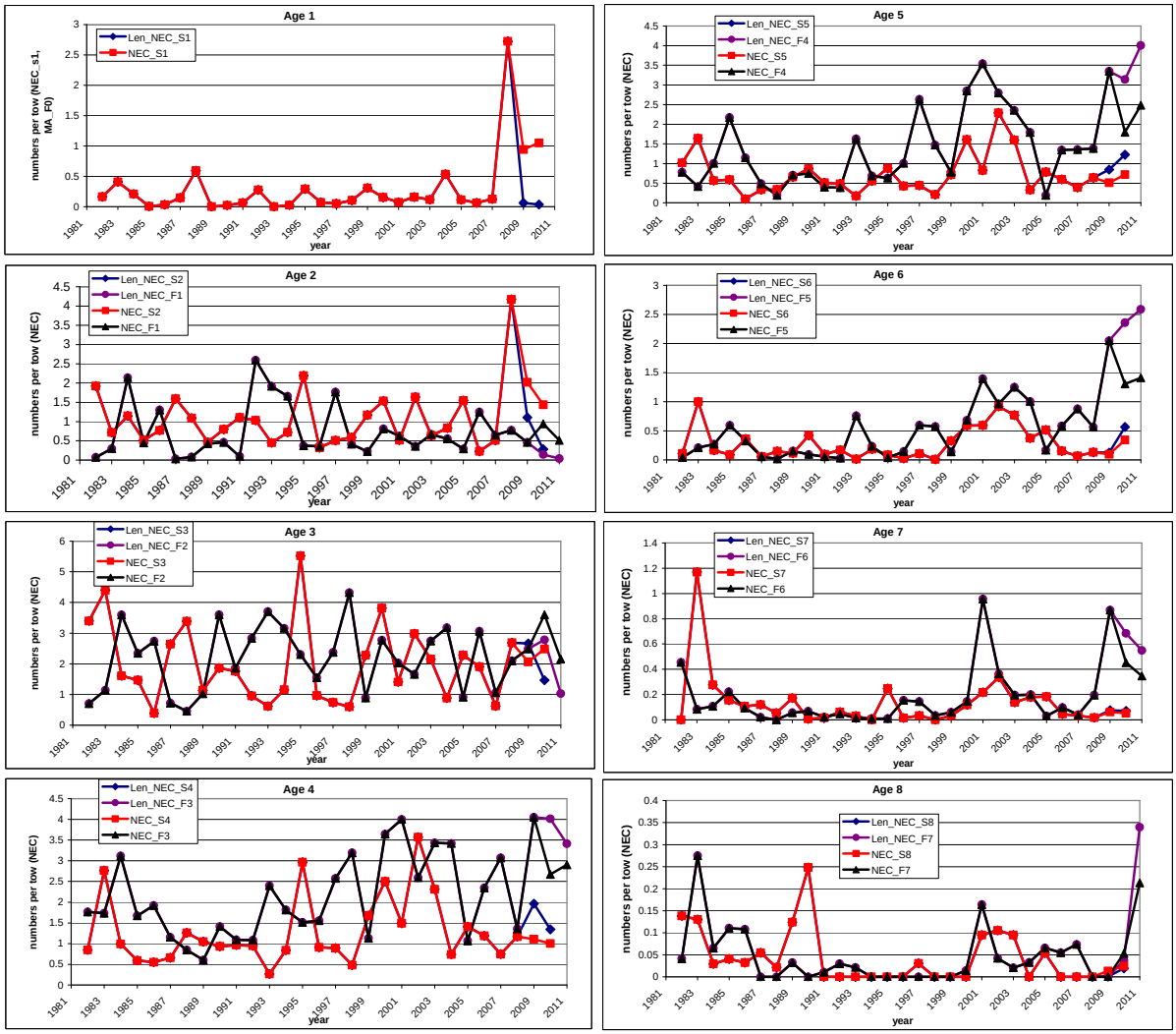


Figure C33. Aggregate and length based converted indices at age from the spring and fall NEFSC surveys.

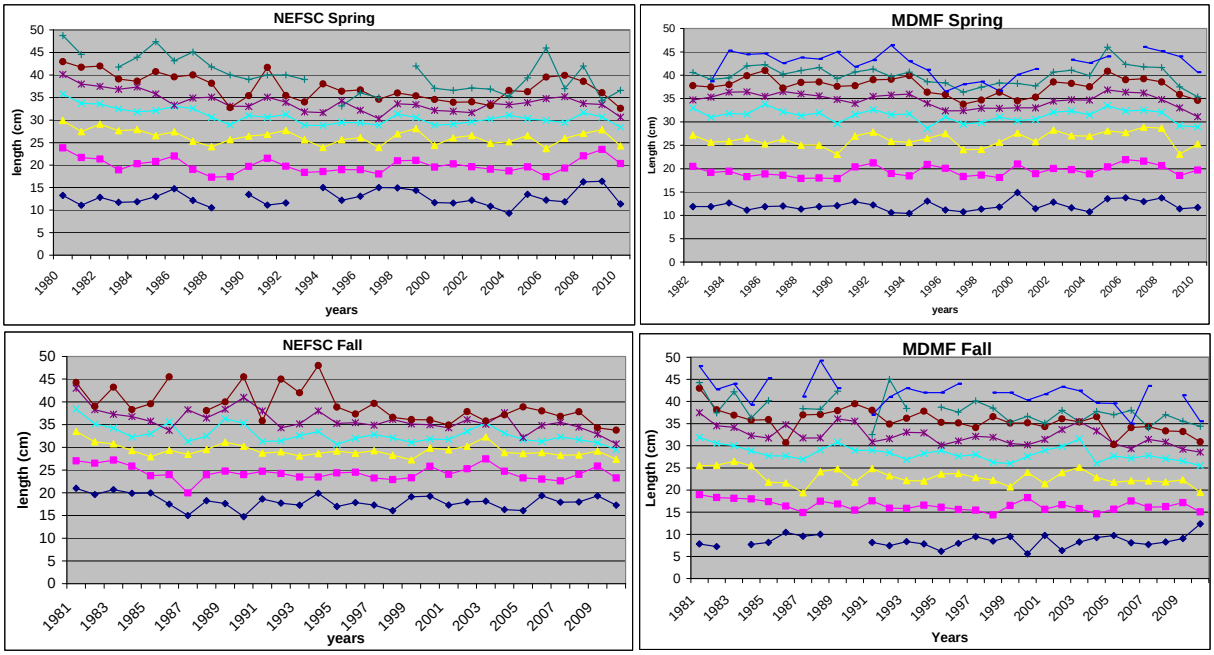


Figure C34. Mean lengths at age from the NEFSC and MDMF surveys.

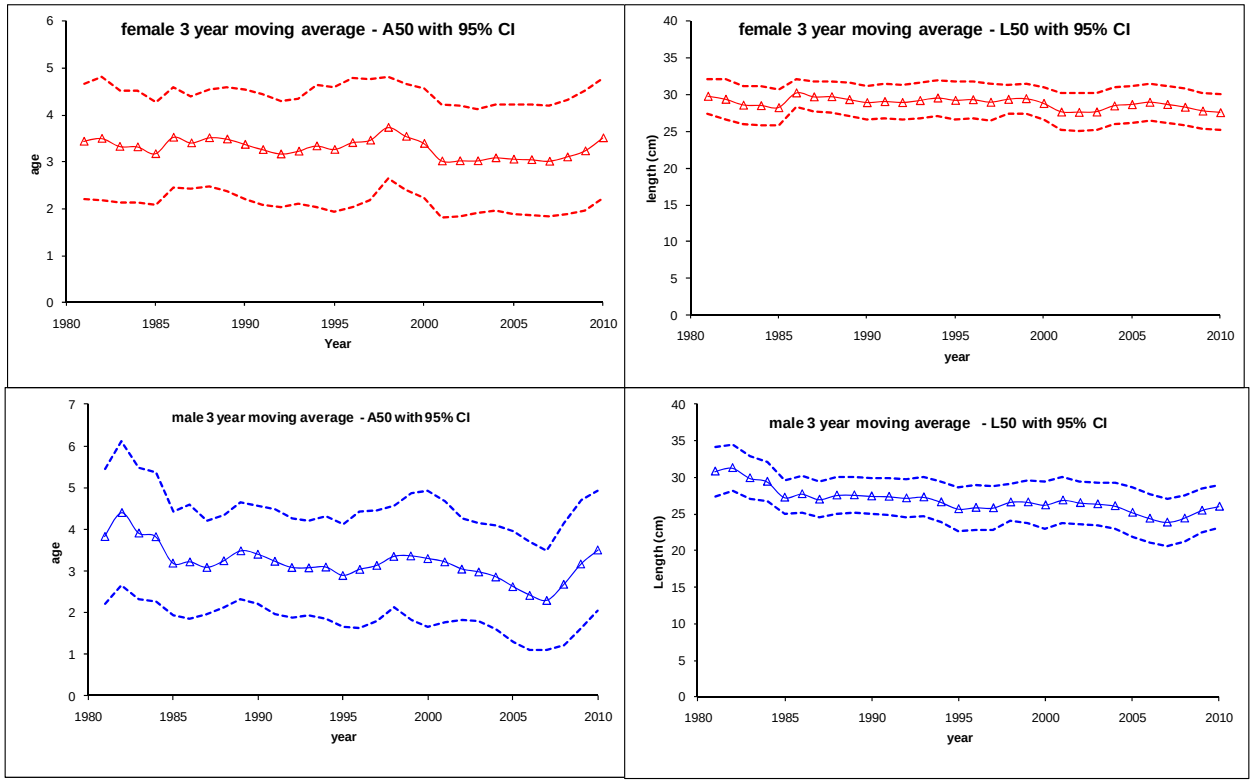


Figure C35. Male and female 3 year moving average L and A 50s from the MDMF survey.

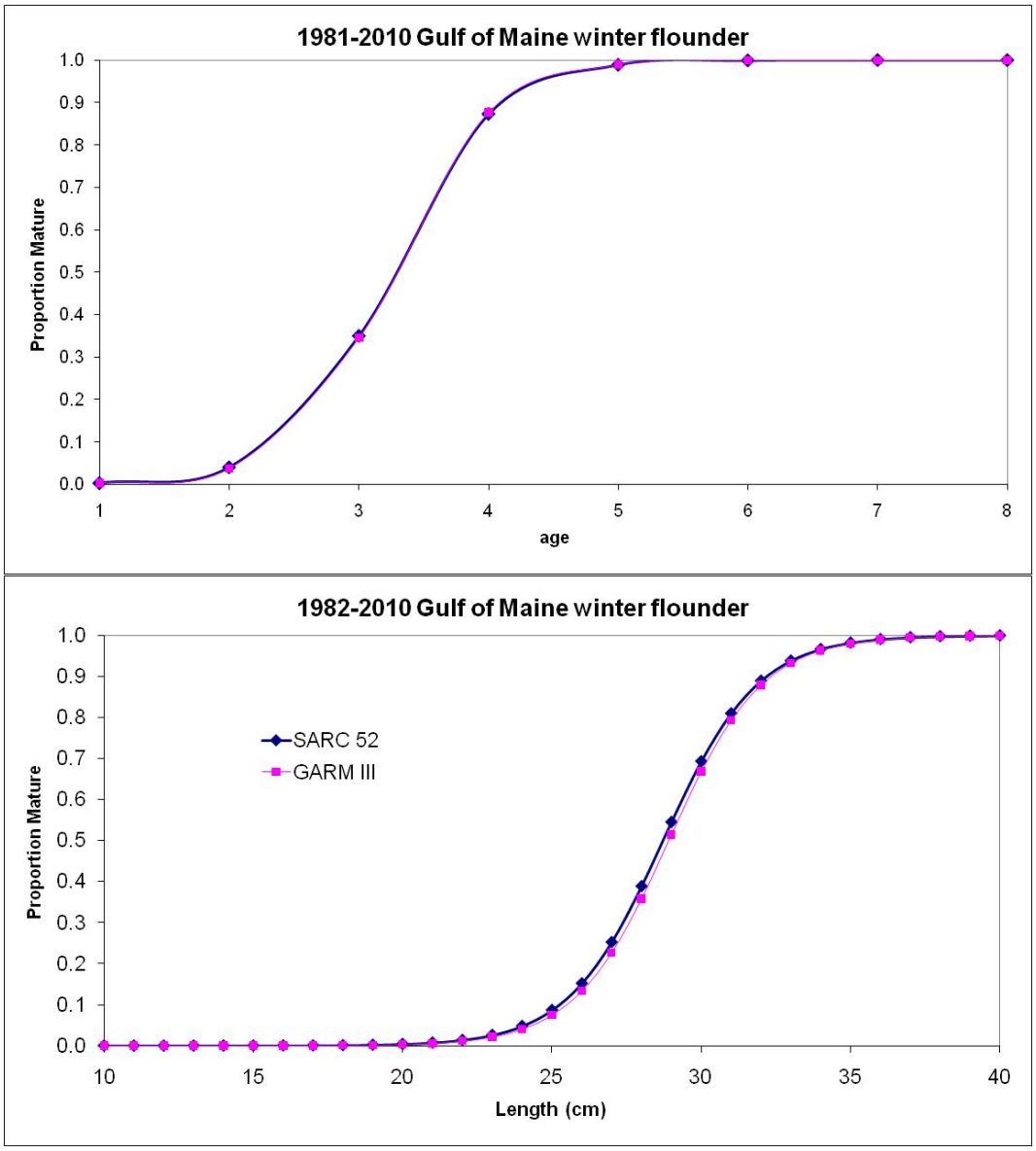
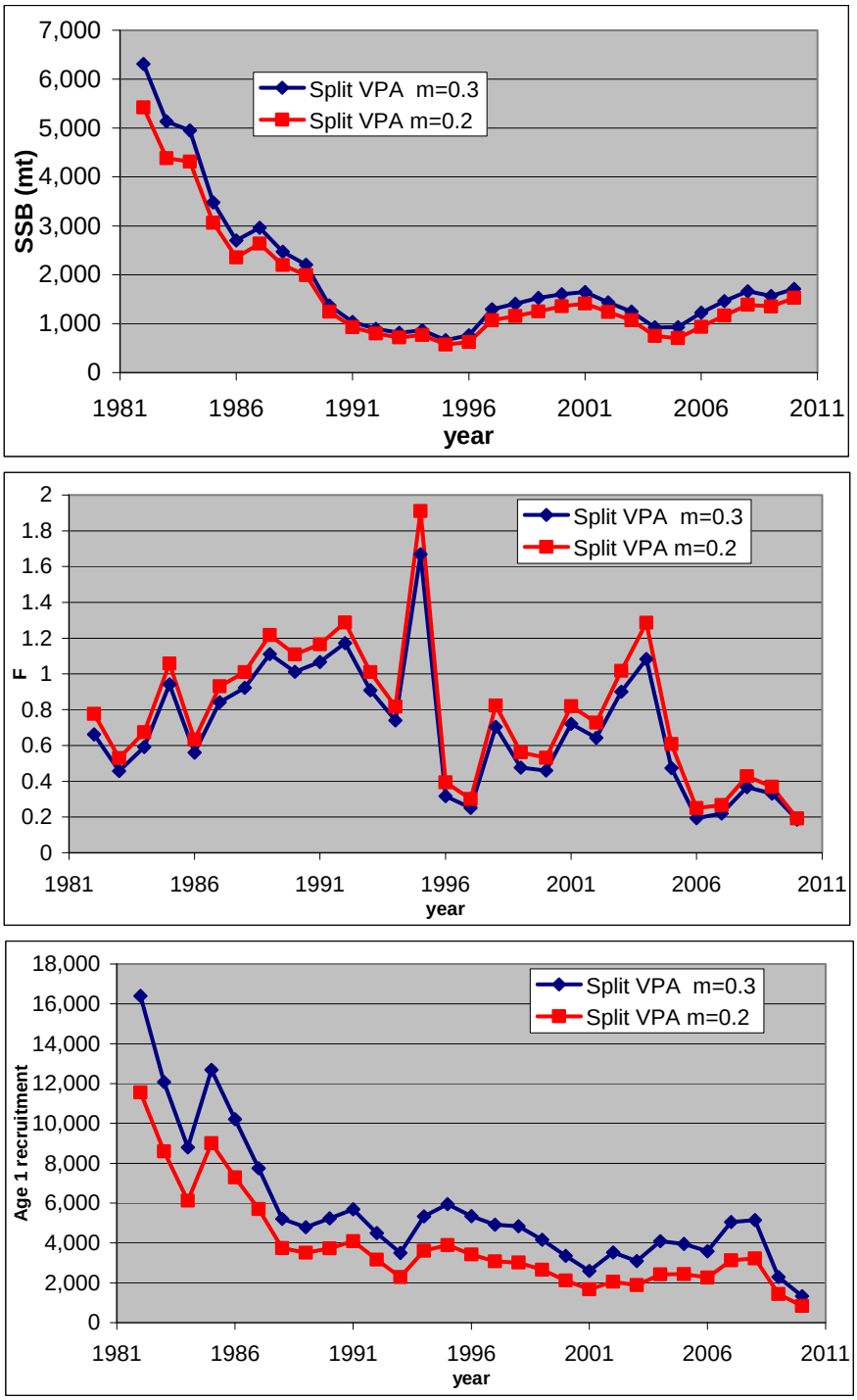


Figure C36. Female Gulf of Maine winter flounder logistic length and age maturity curves estimated from GARM III (1982-2007, n = 12,108) and with all years combine from the MDMF spring survey.



Figures C37. Split VPA SSB, F, and recruitment assuming m=0.2 and m=0.3.

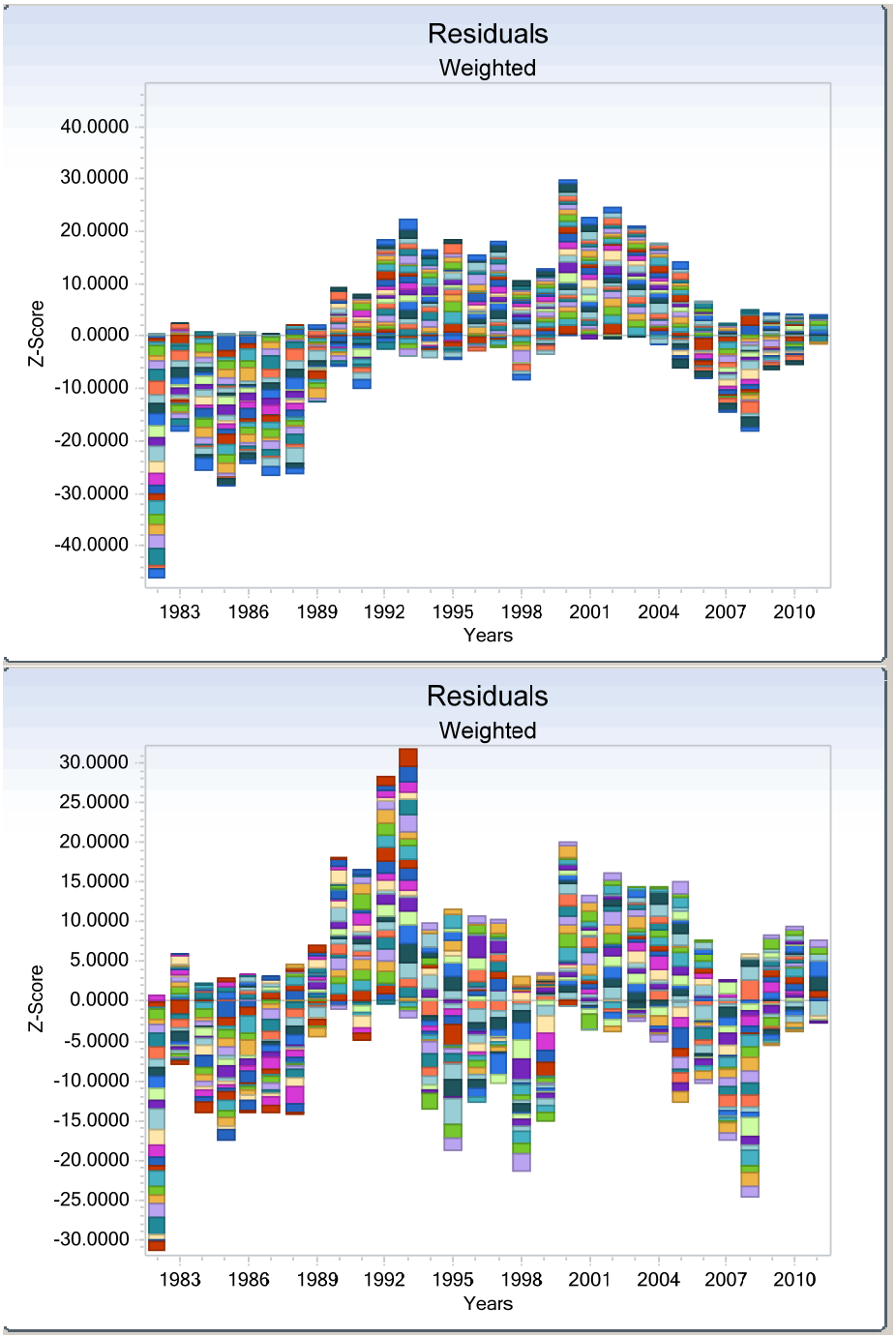


Figure C38. Base (top) and split (bottom) VPA residual pattern for all ages.

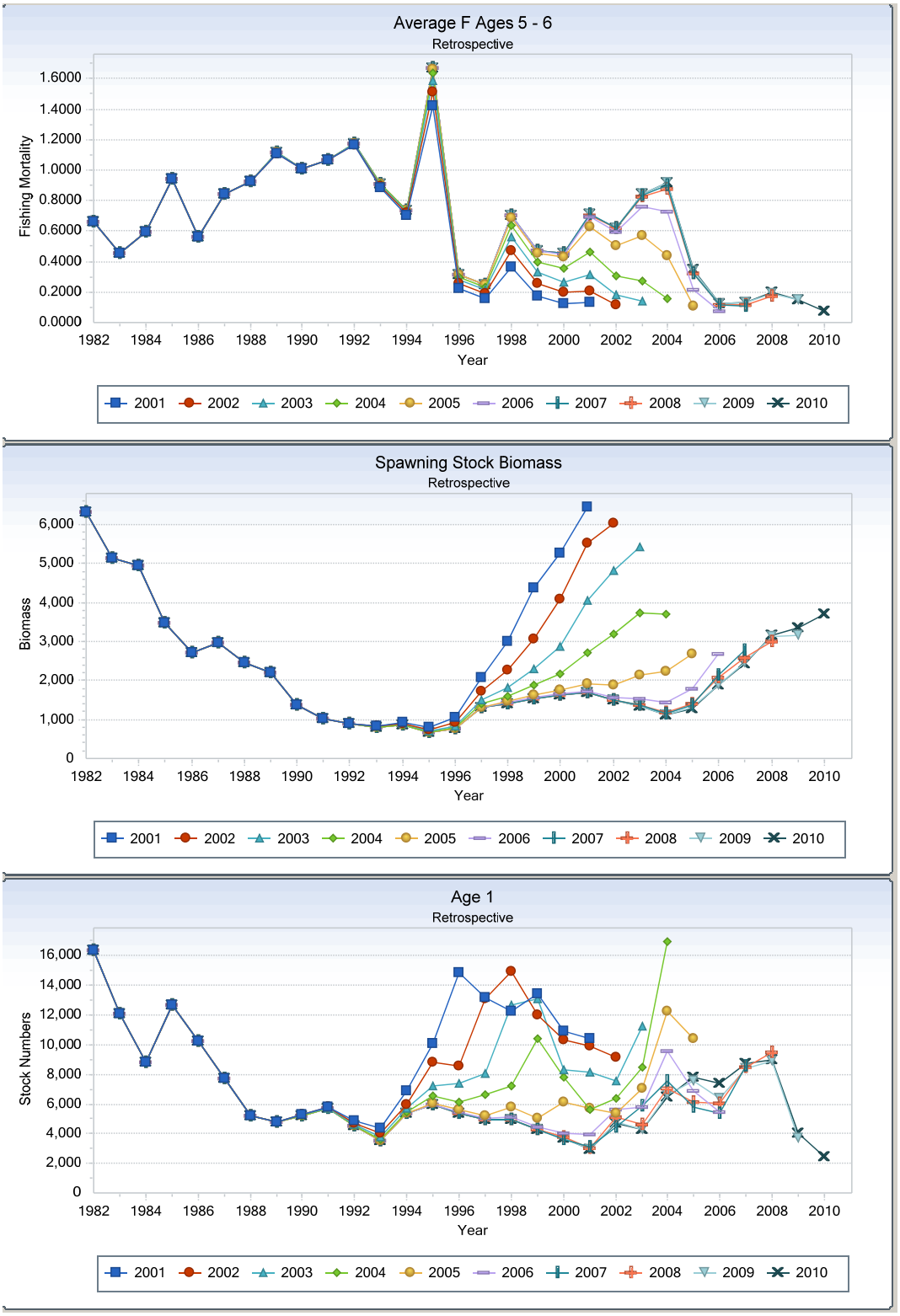


Figure C39. Gulf of Maine winter flounder Base VPA retrospective with m=0.3.

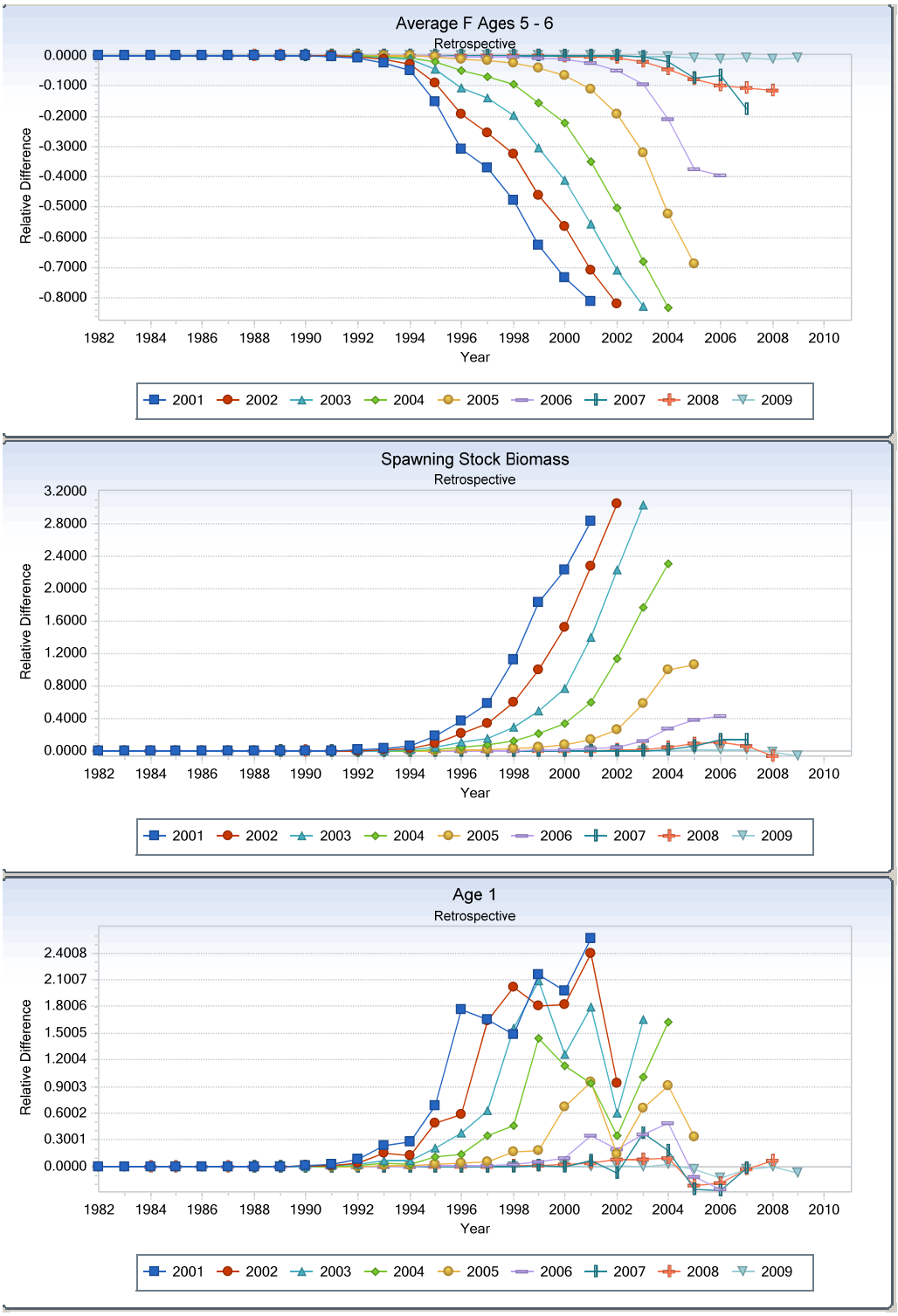


Figure C40. Gulf of Maine winter flounder Base VPA relative difference retrospective with m=0.3.

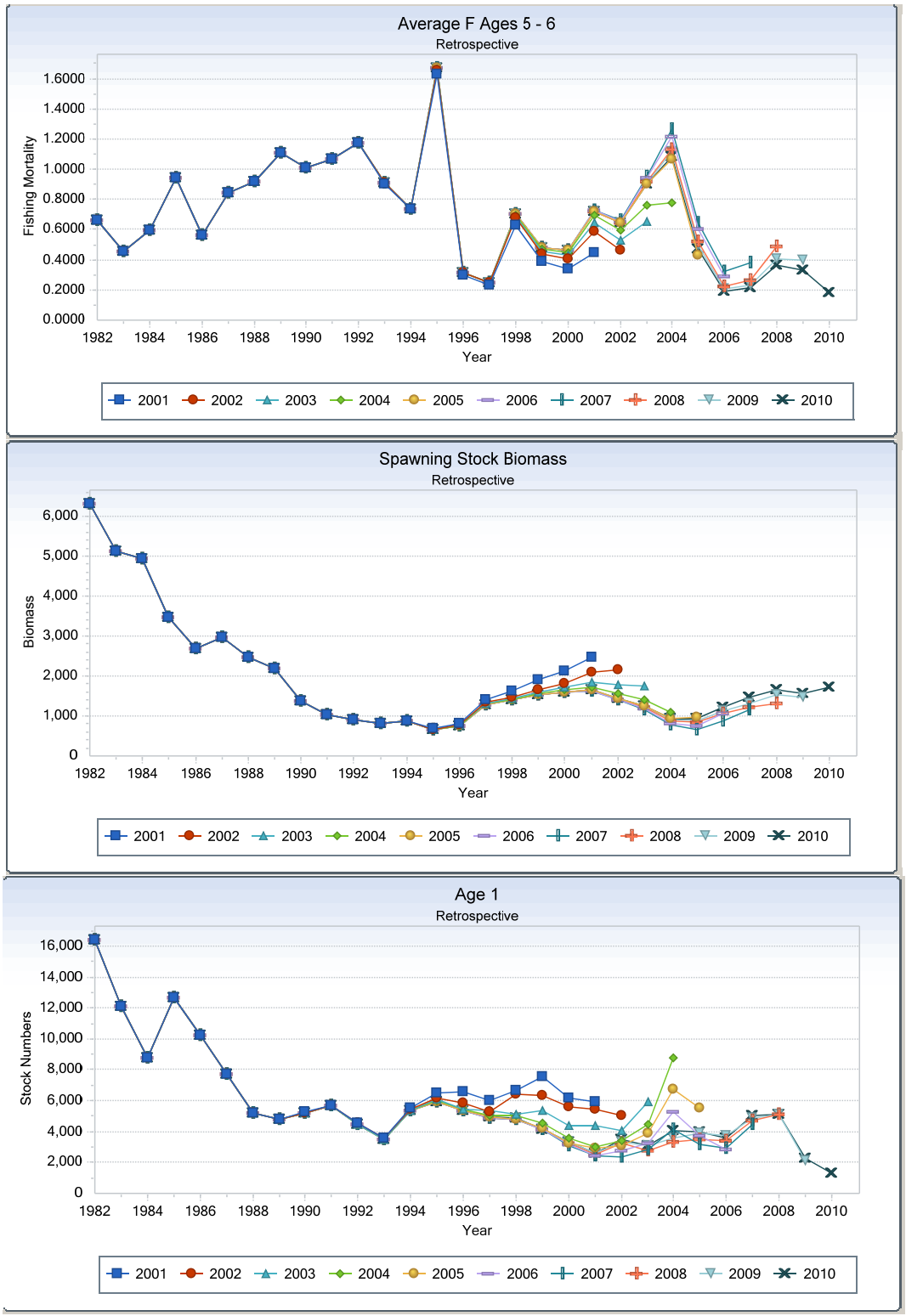


Figure C41. Gulf of Maine winter flounder split VPA retrospective with m=0.3.

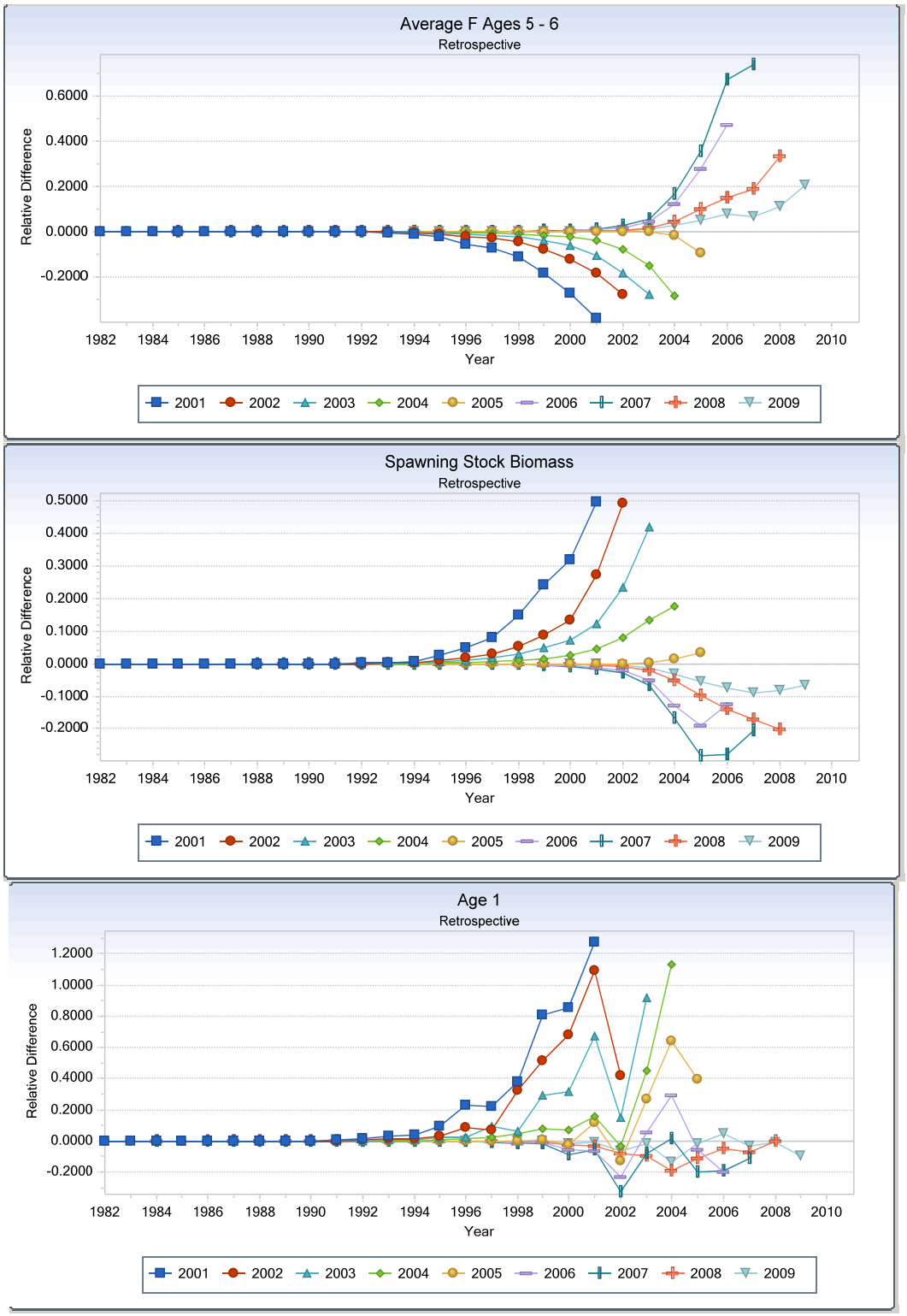


Figure C42. Gulf of Maine winter flounder split VPA relative difference retrospective with m=0.3.

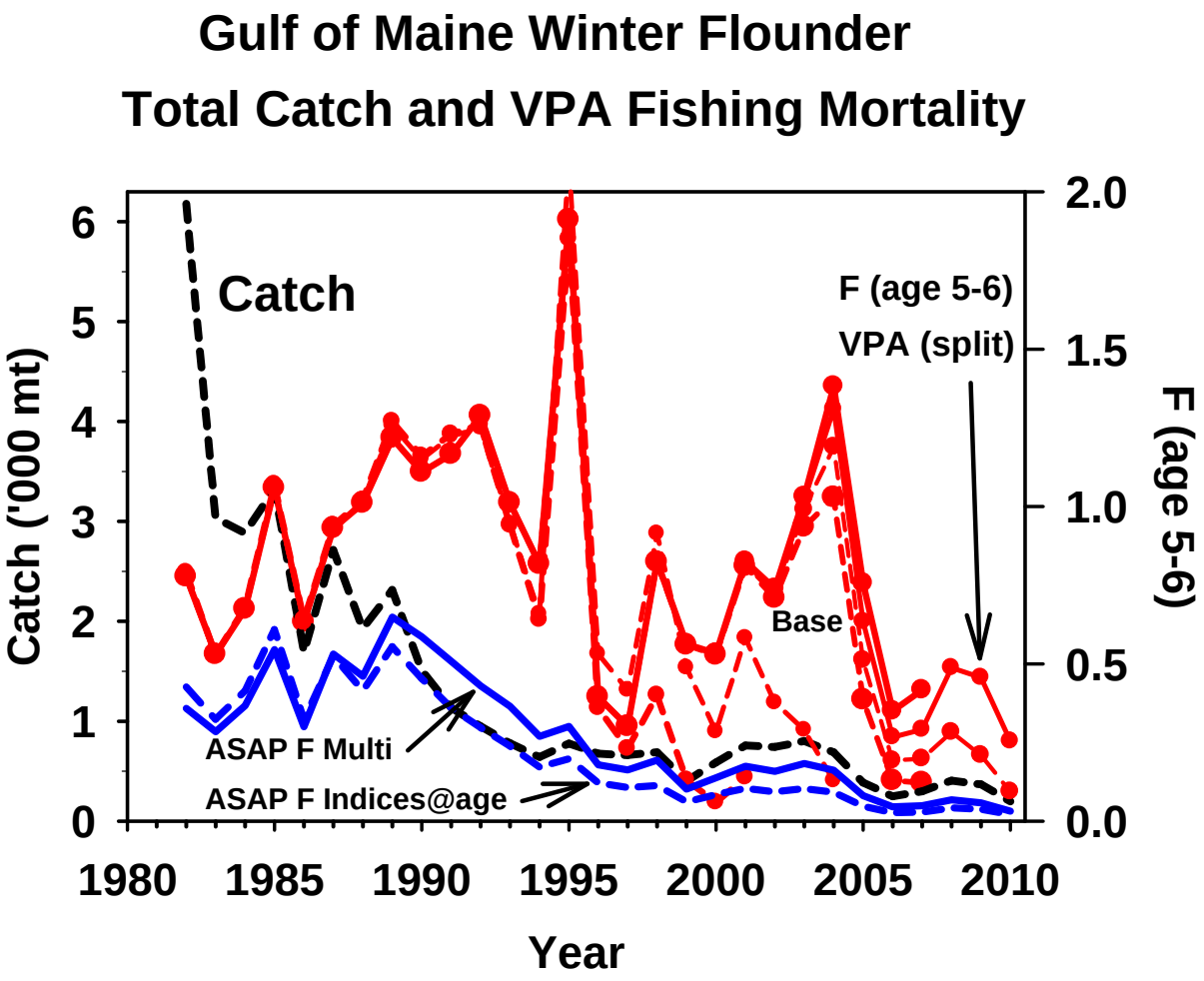


Figure C43. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (F, ages 5-6) from the split and base VPA runs from GARM I, II, and III, and this assessment for Gulf of Maine winter flounder. The ASAP indices at age and multi runs area also shown.

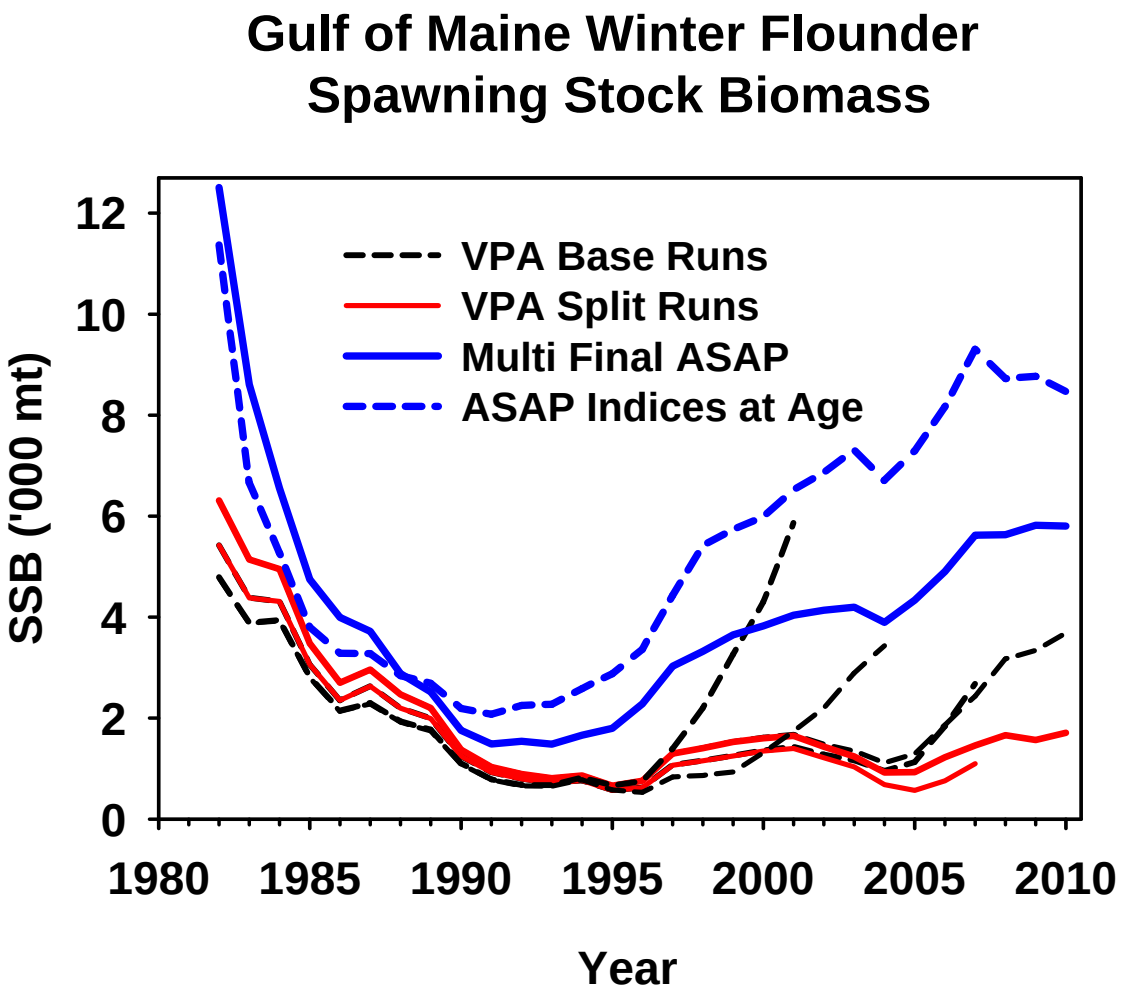


Figure C44. Spawning stock biomass from the split and base VPA runs from GARM I, II, III, and this assessment for Gulf of Maine winter flounder. The ASAP indices at age and multi runs area also shown.

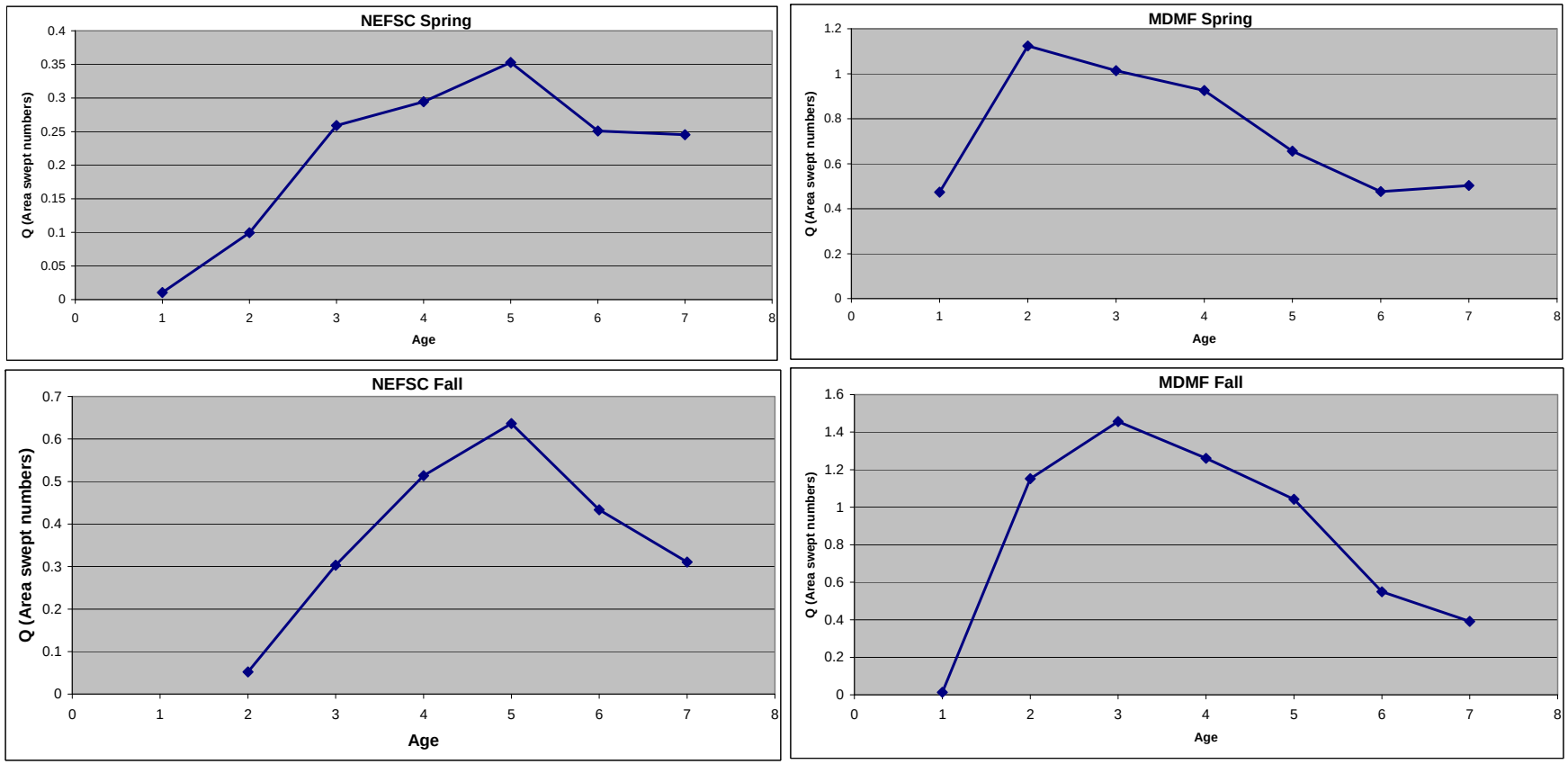


Figure C45. Estimated area swept Qs at age from the base VPA with m=0.3.

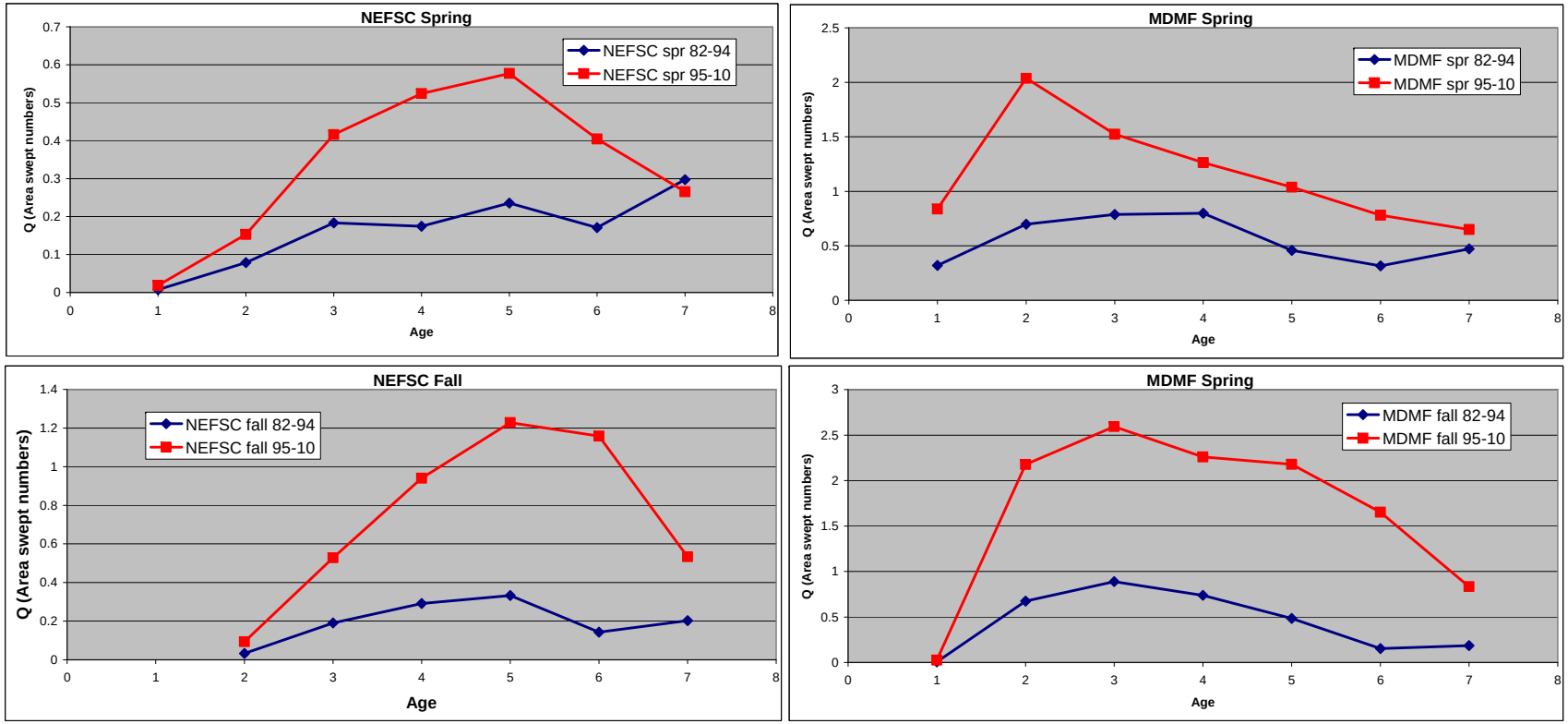


Figure C46. Estimated area swept Qs at age from the split VPA with m=0.3.

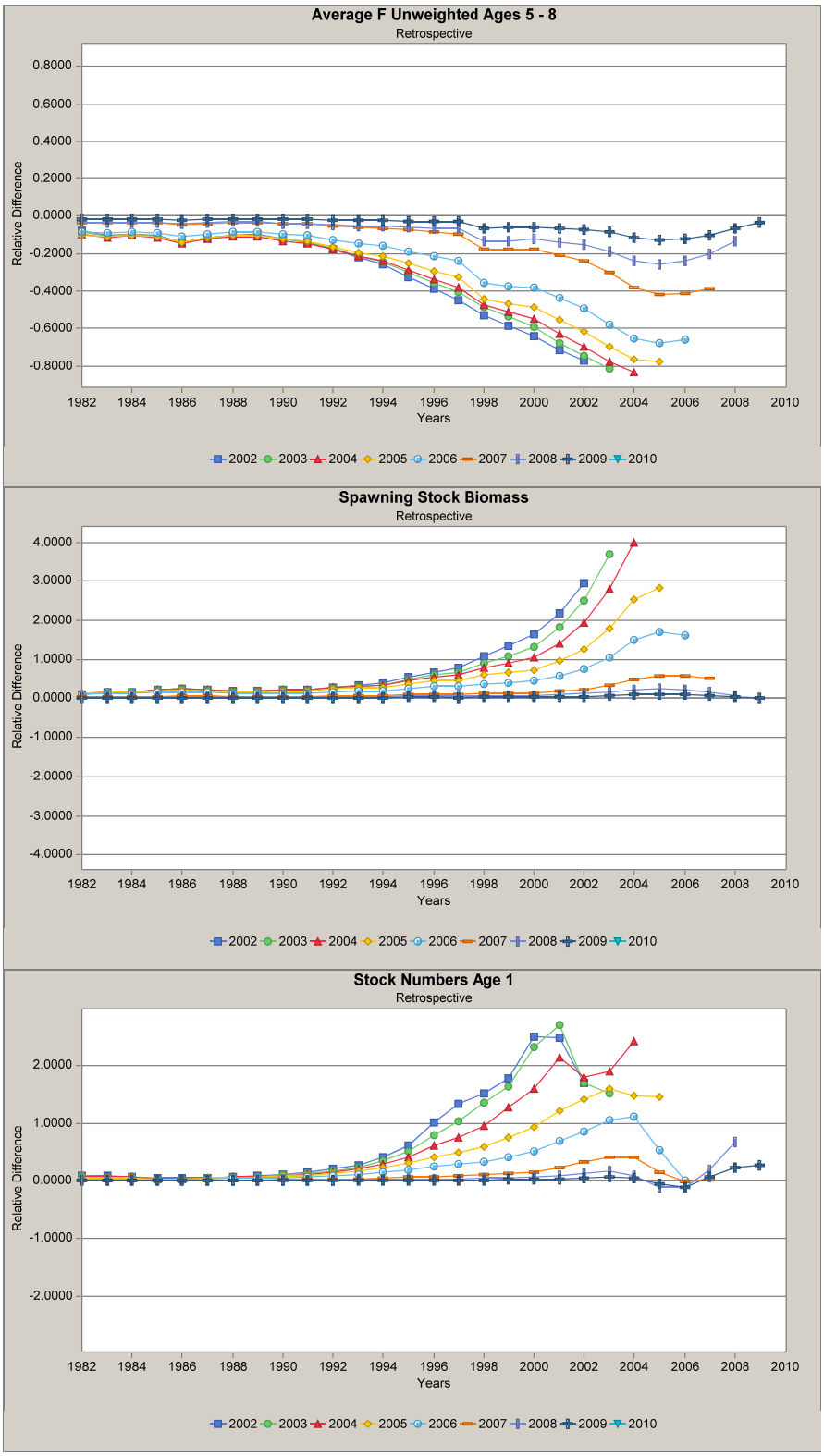


Figure C47. Relative retrospective pattern from ASAP indices at age run with a high effective sample size weight (ess 150) on the catch at age composition.

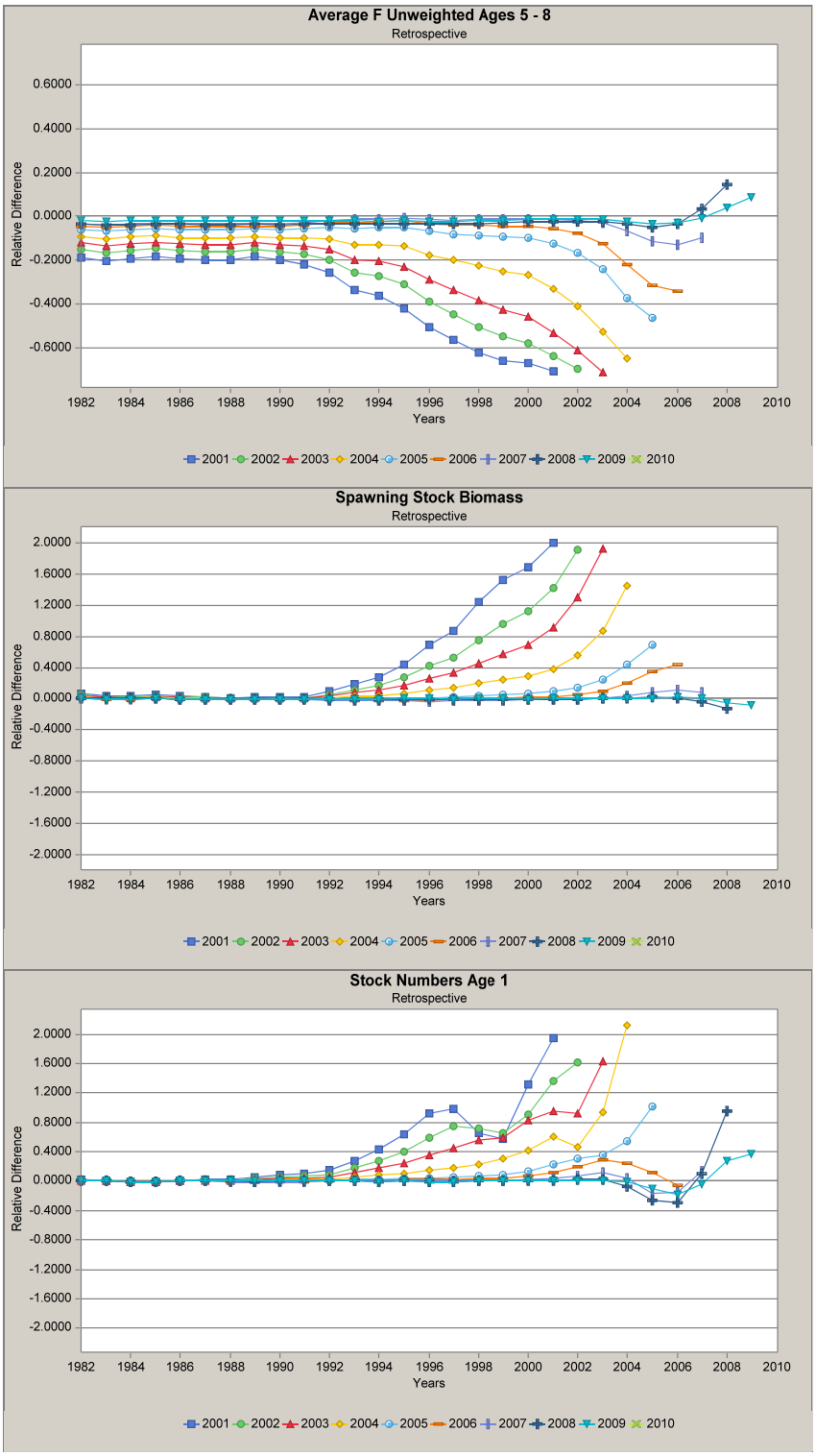


Figure C48. Relative retrospective pattern from the split ASAP indices at age run with a high effective sample size weight (ess 150) on the catch at age composition.

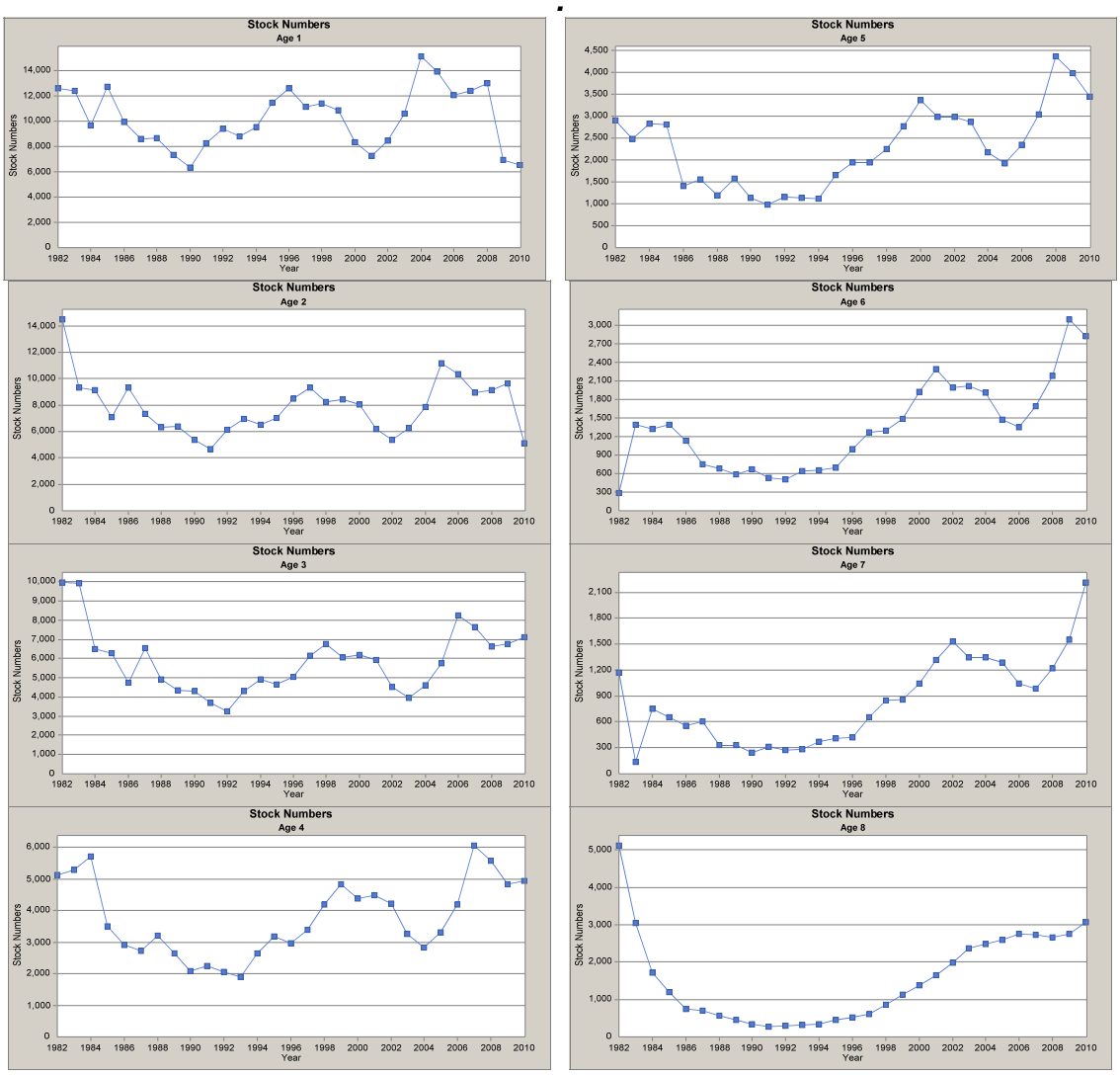
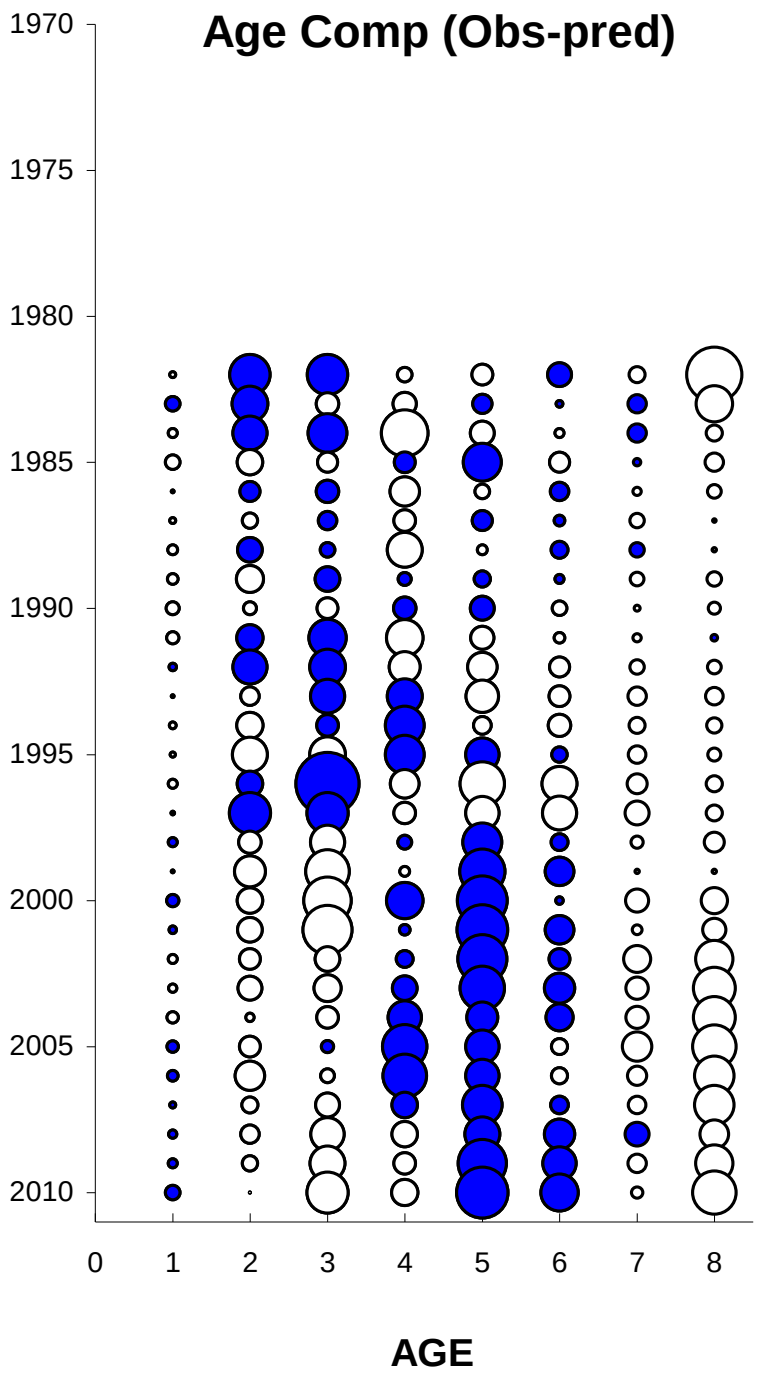


Figure C49. Estimated numbers at age from the ASAP indices at age run with a ESS weight of 50 on the catch at age composition.



Figures C50. Fit to catch at age composition with the ASAP indices at age run with a effective sample size weight of 150.

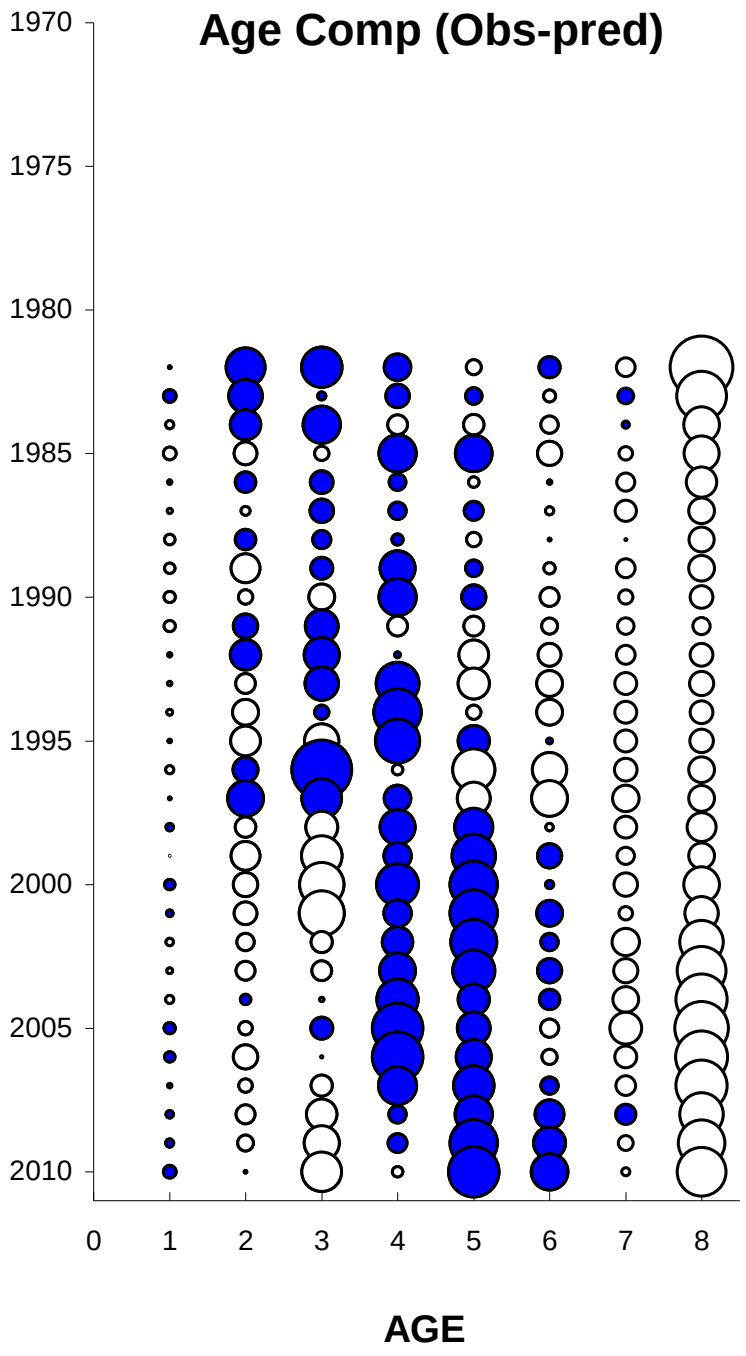


Figure C51. Fit to catch at age composition with the ASAP indices at age run with a effective sample size weight of 50.

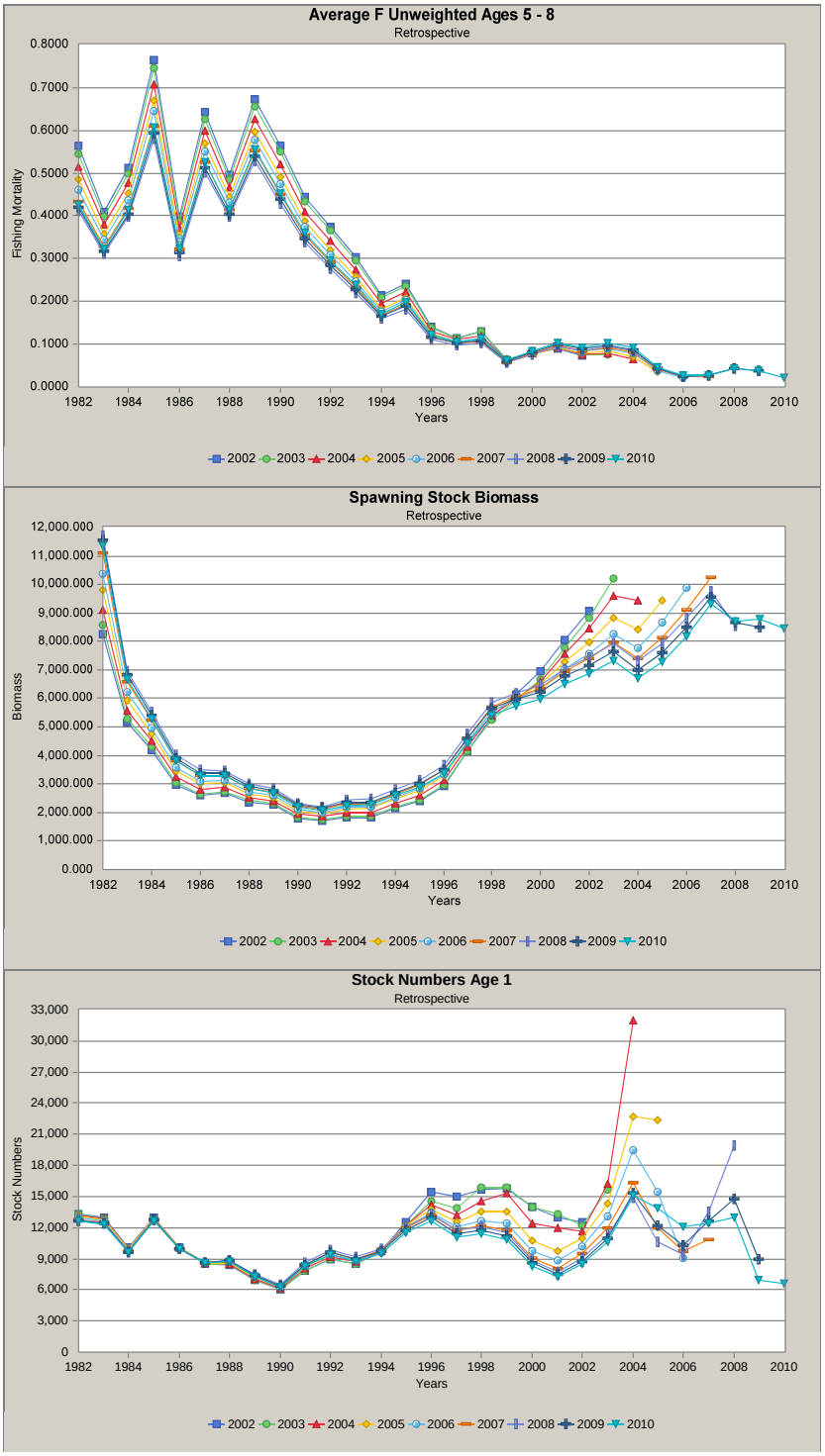
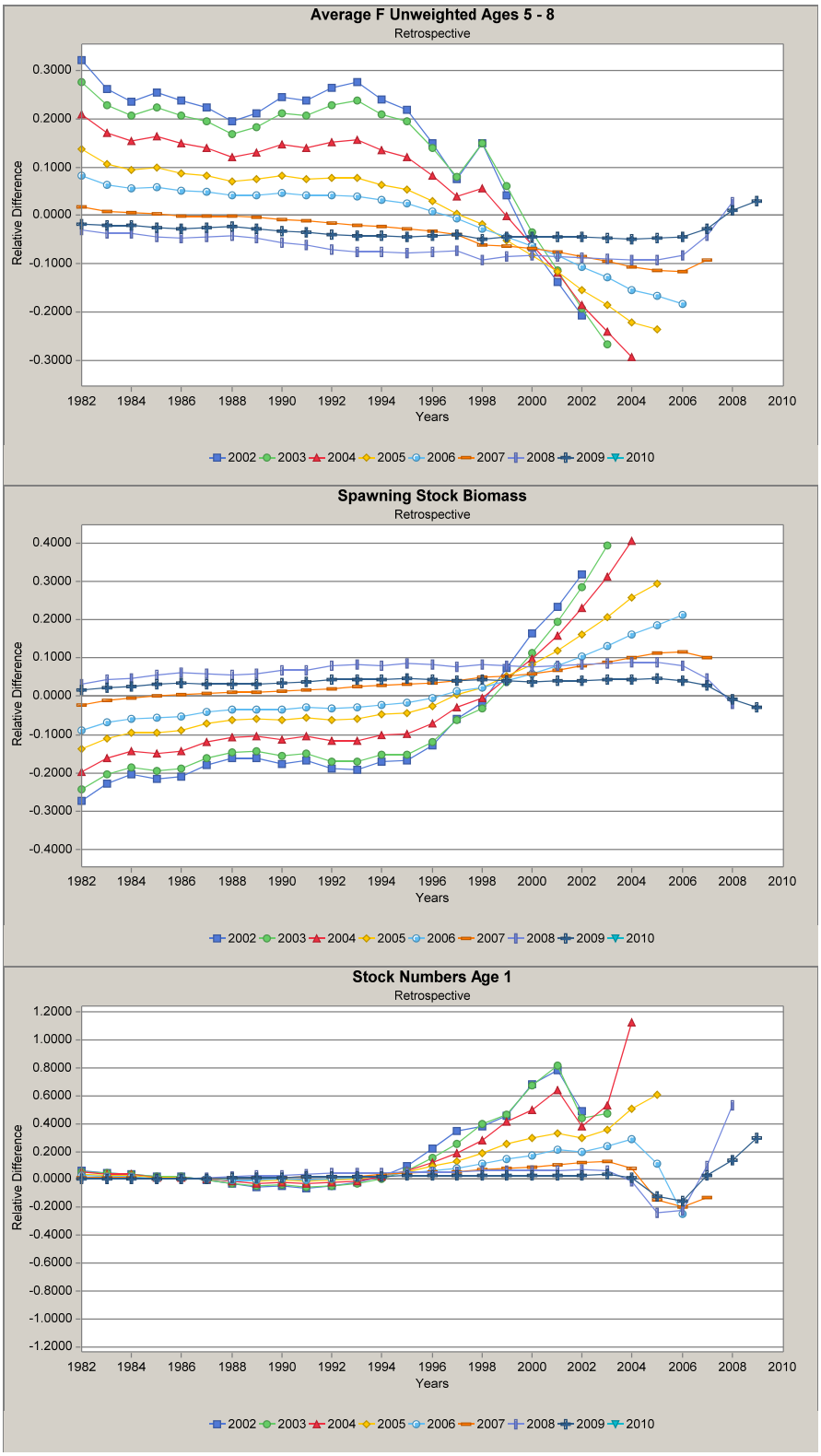
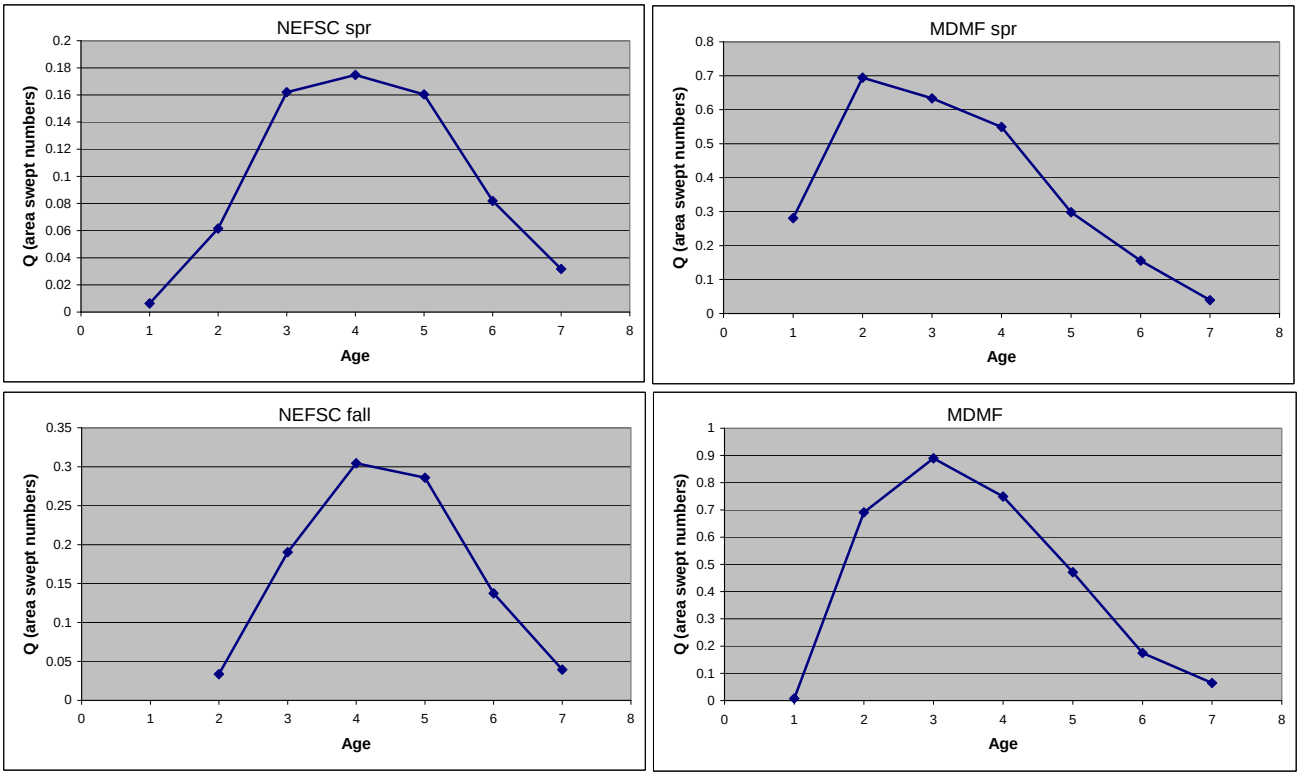


Figure C52. Retrospective pattern from ASAP indices at age run with an effective sample size weight of 50 on the catch at age composition.



Figures C53. Relative retrospective pattern from ASAP indices at age run with an effective sample size weight of 50 on the catch at age composition.



Figures C54. Selectivity from ASAP indices at age run with an effective sample size weight of 50 on the catch at age composition.

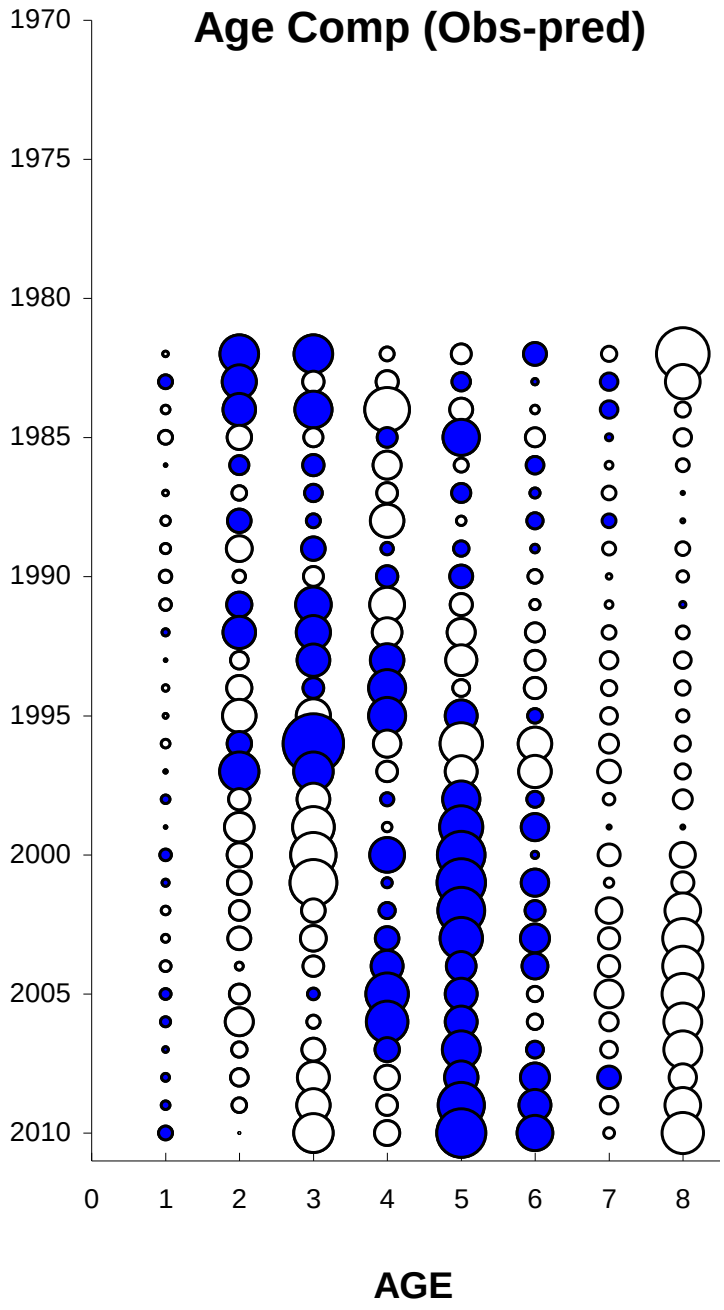


Figure C55. Fit to catch at age composition with the ASAP multi run with a effective sample size weight of 50.

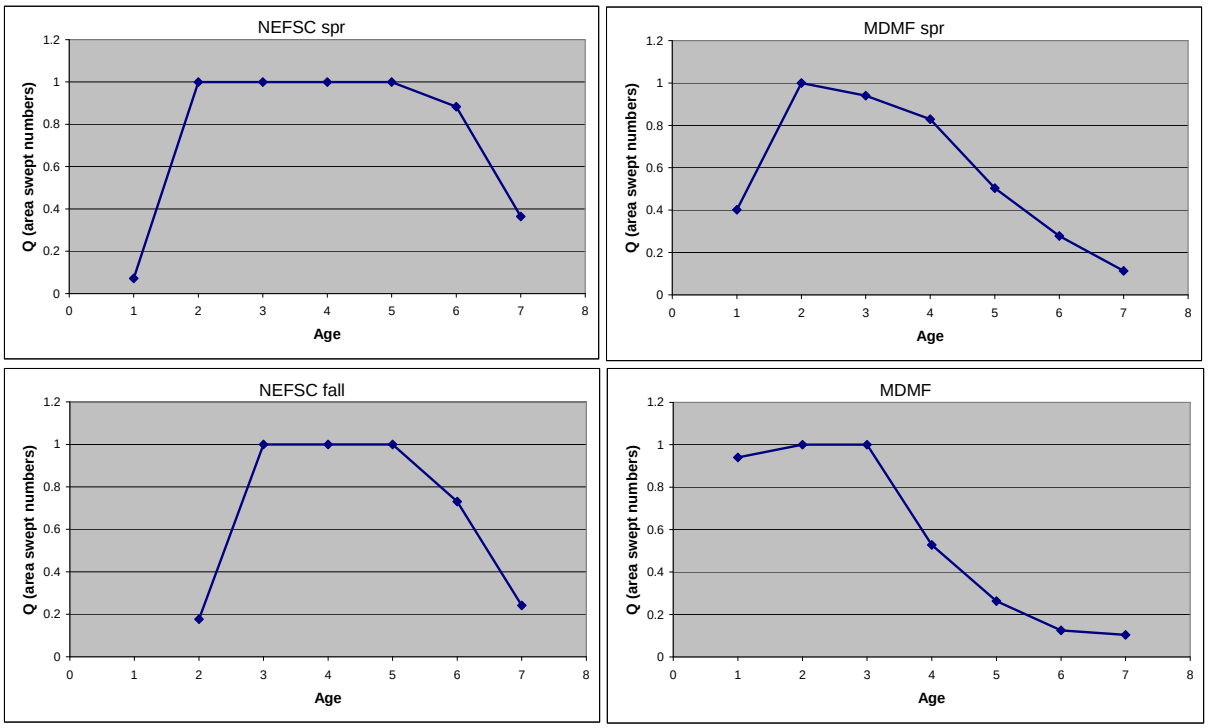


Figure C56. Selectivity from ASAP multi run with an effective sample size weight of 50 on the catch at age composition.

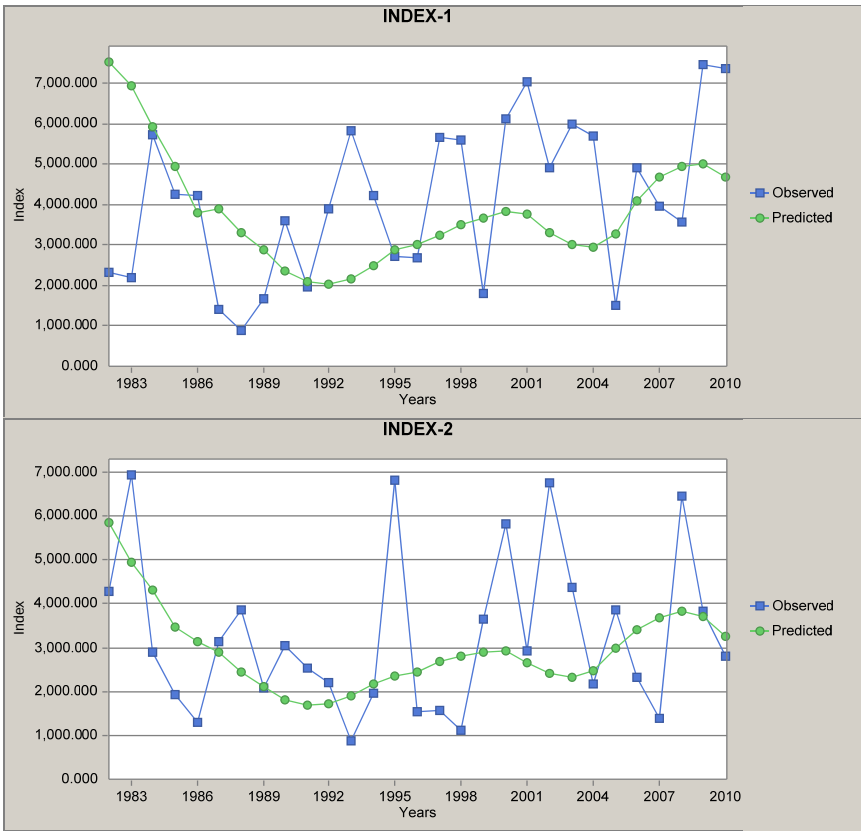
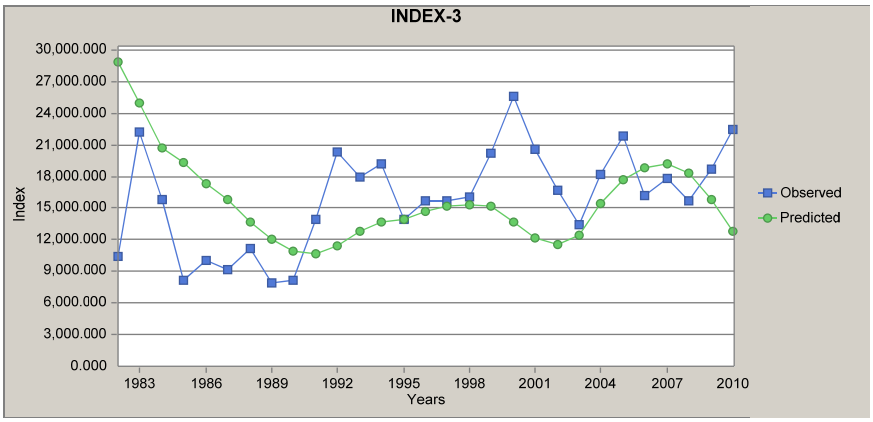


Figure C57. Fit to aggregate indices from the ASAP multi run with a effective sample size weight of 50.



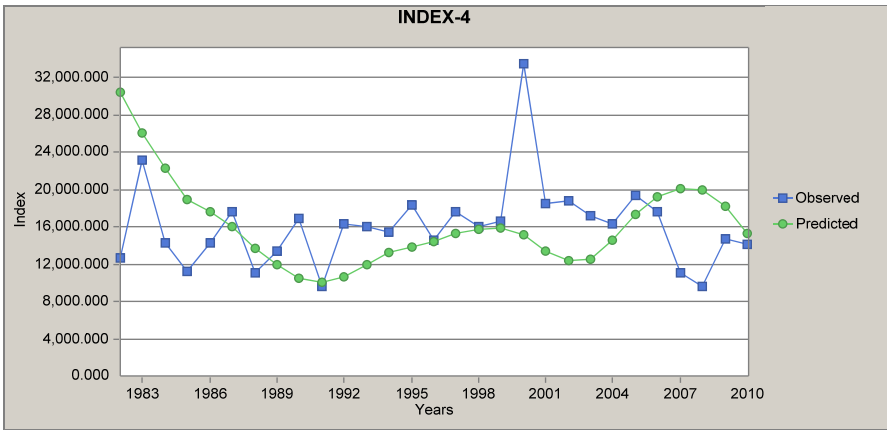
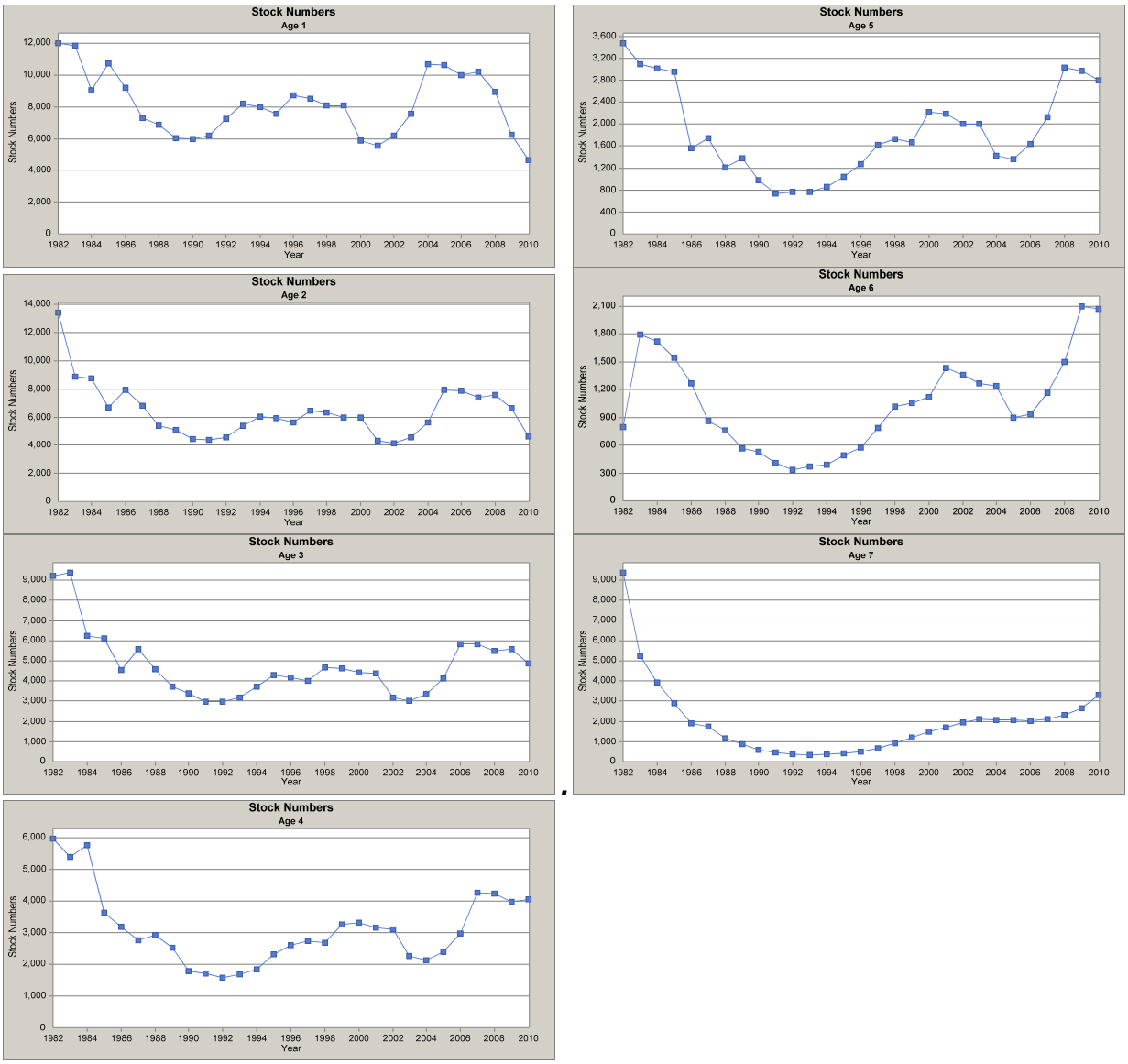


Figure C57. Cont.



Figures C58. Estimated numbers at age from the ASAP multi run with a ESS weight of 50 on the catch at age composition.

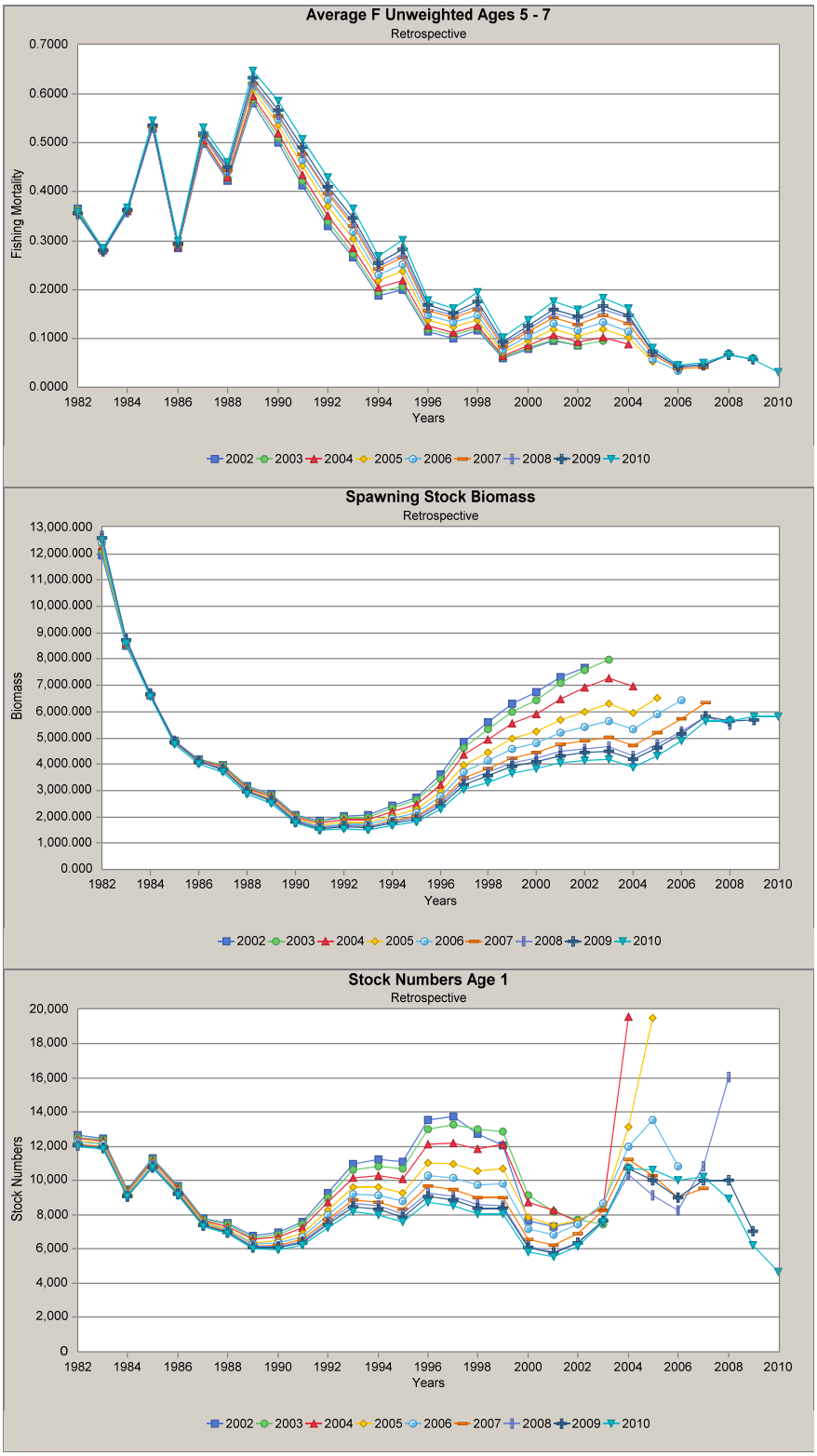
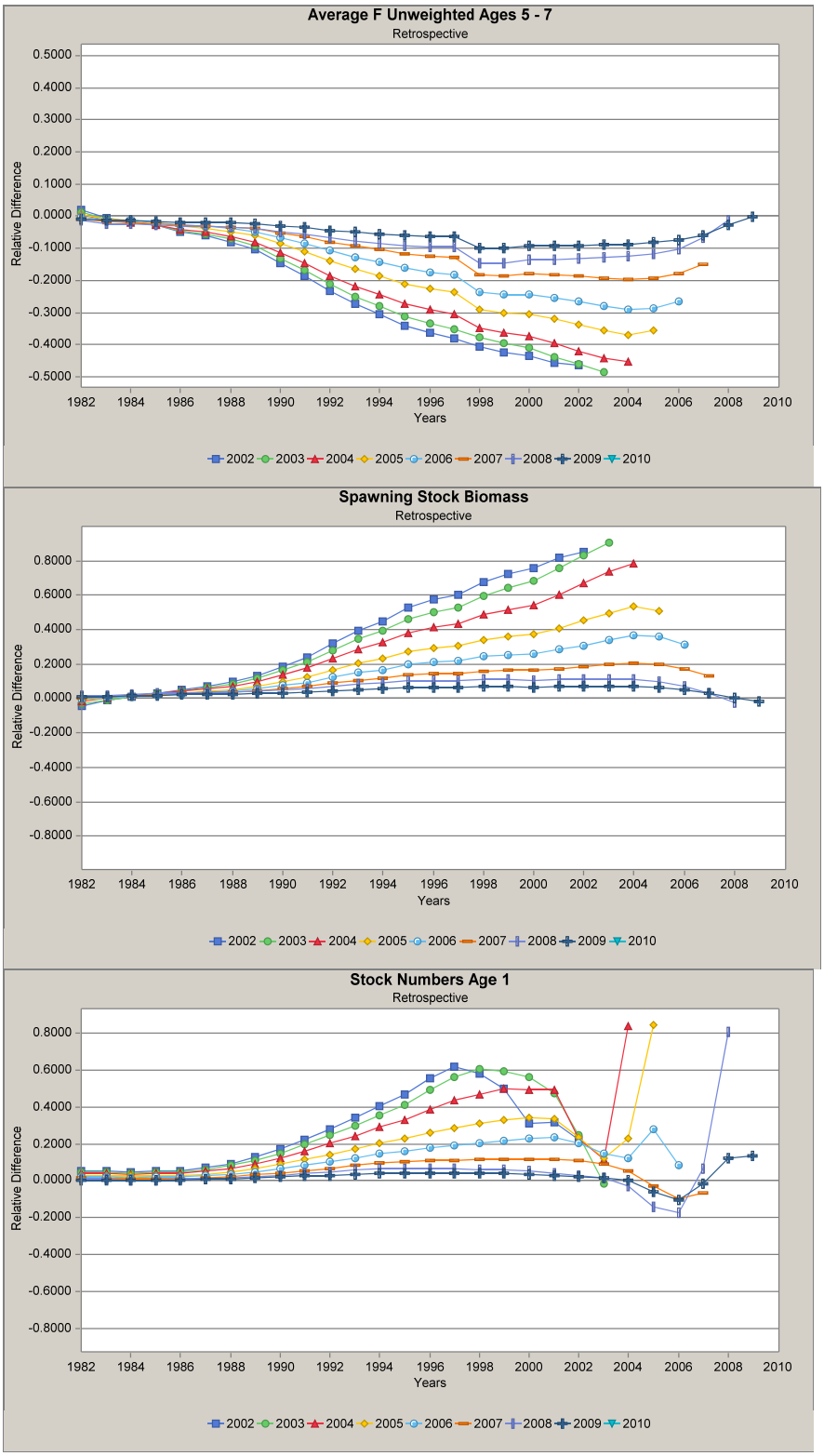
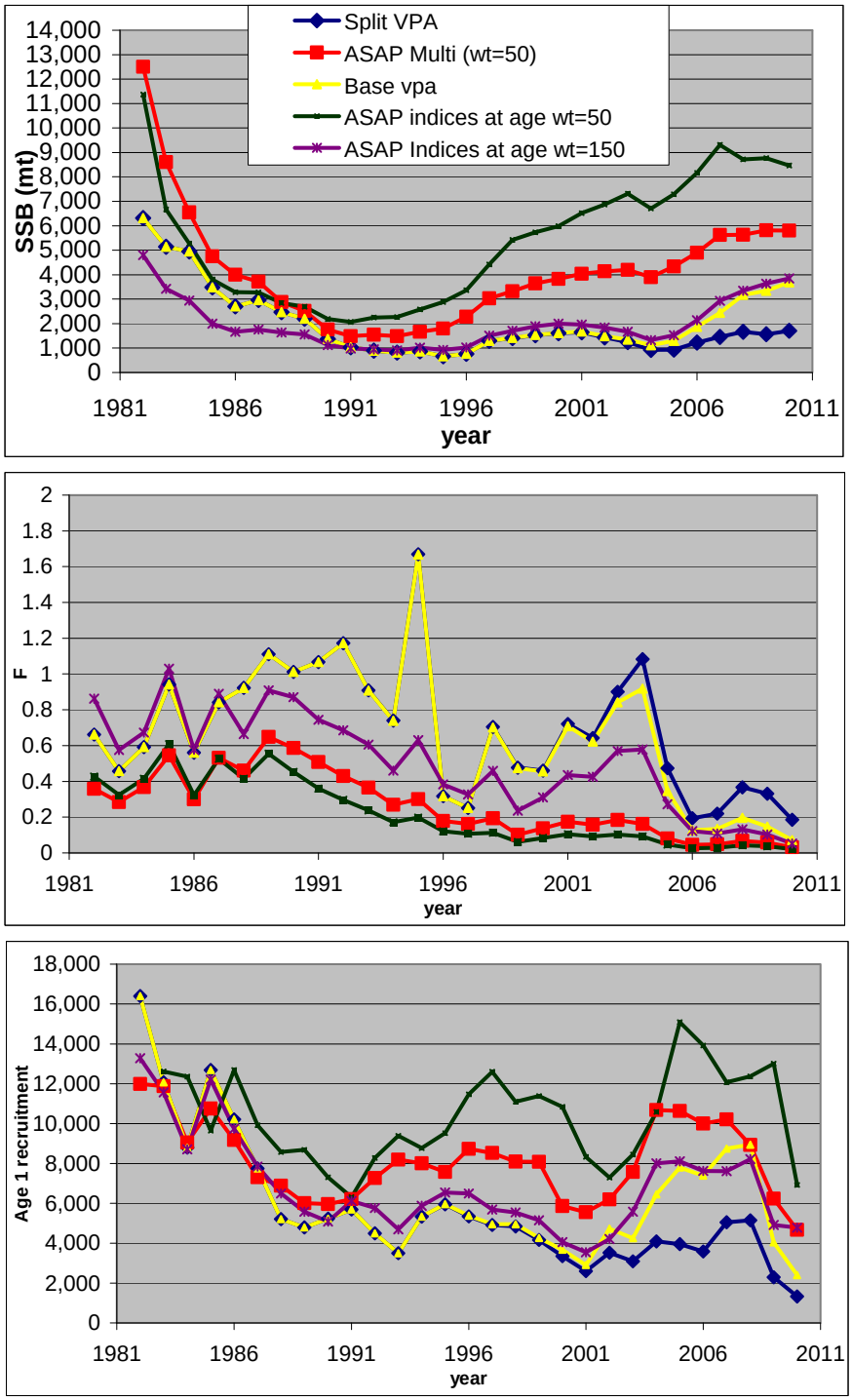


Figure C59. Retrospective pattern from ASAP multi run with an effective sample size weight of 50 on the catch at age composition.



Figures C60. Relative retrospective pattern from ASAP multi run with an effective sample size weight of 50 on the catch at age composition.



Figures C61. Comparison of different VPA and ASAP model runs for SSB, F and recruitment.

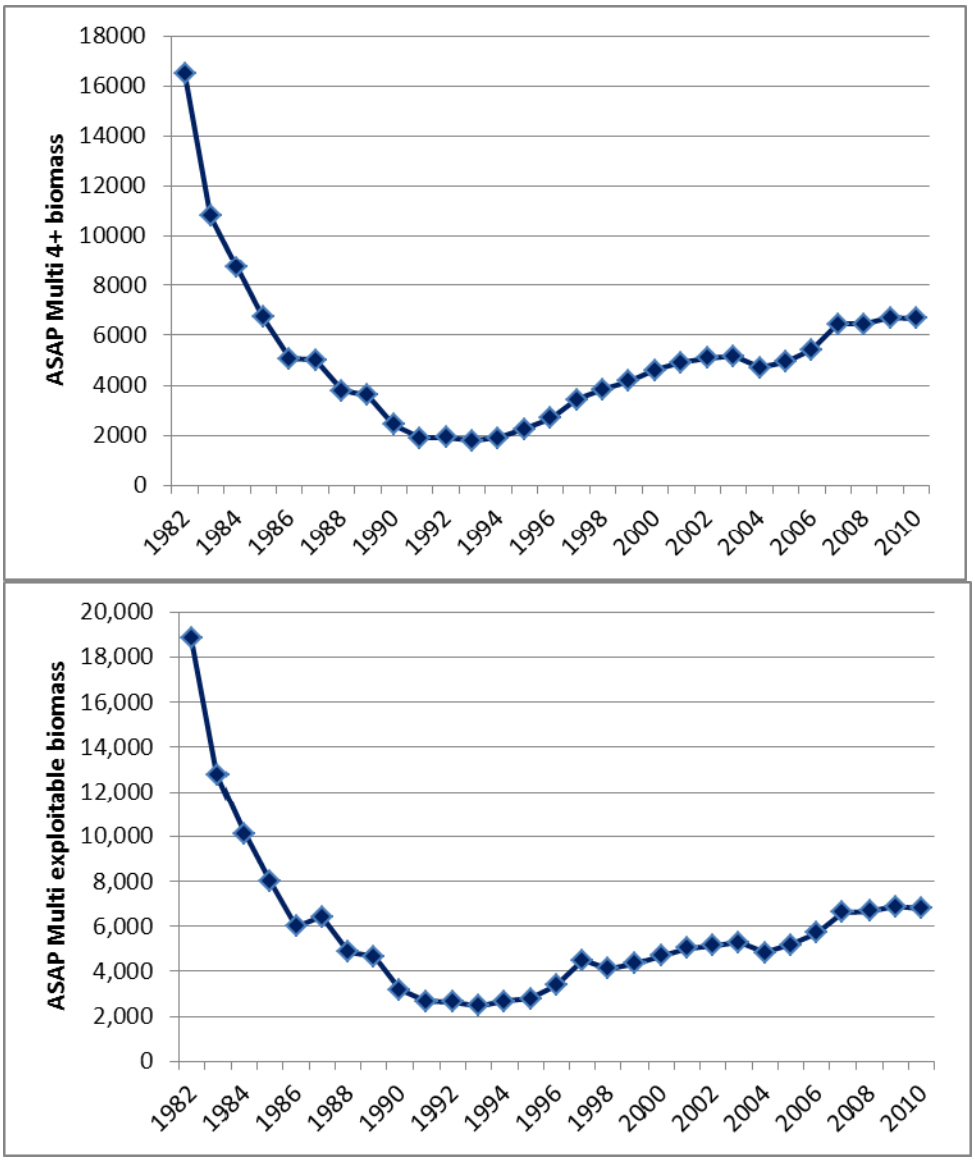
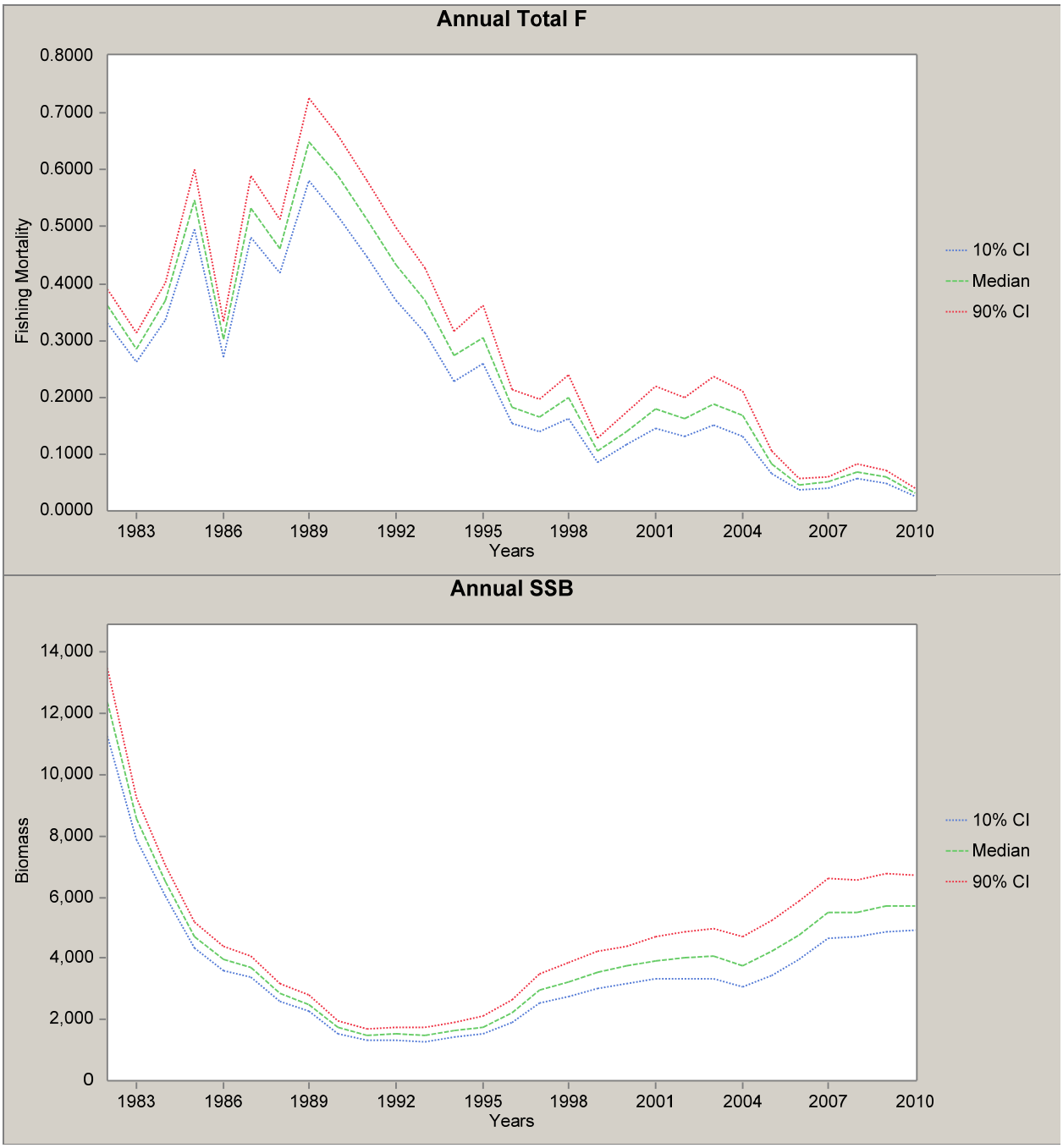


Figure C62. Estimated 4+ biomass and exploitable biomass from the preferred ASAP multi run.



Figures C63. Estimated fishing mortality and SSB with 80% confidence intervals from 1000 mcmc iterations for the preferred ASAP multi run.

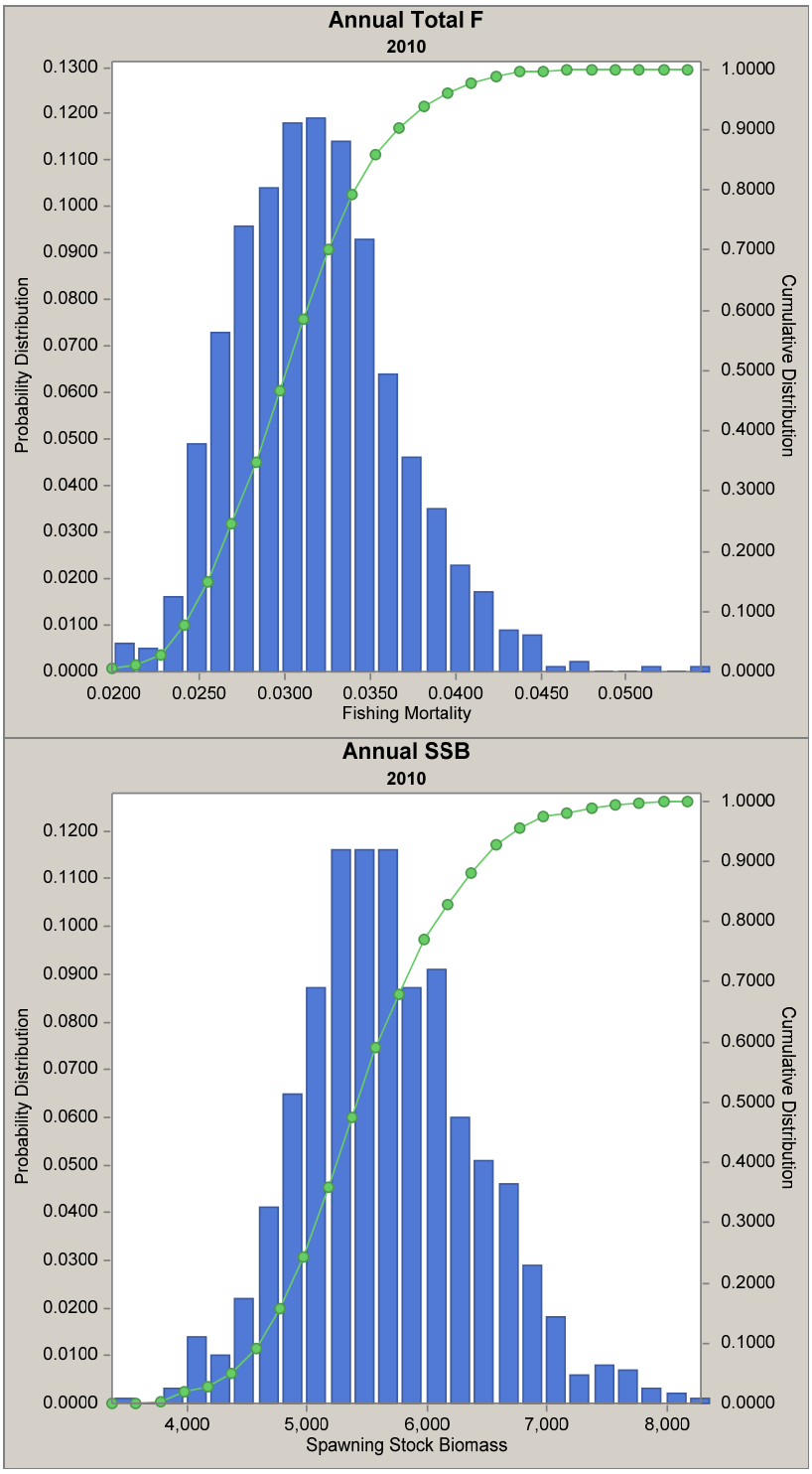


Figure C64. Estimated fishing mortality and SSB from 1000 mcmc iterations for the preferred ASAP multi run for 2010.

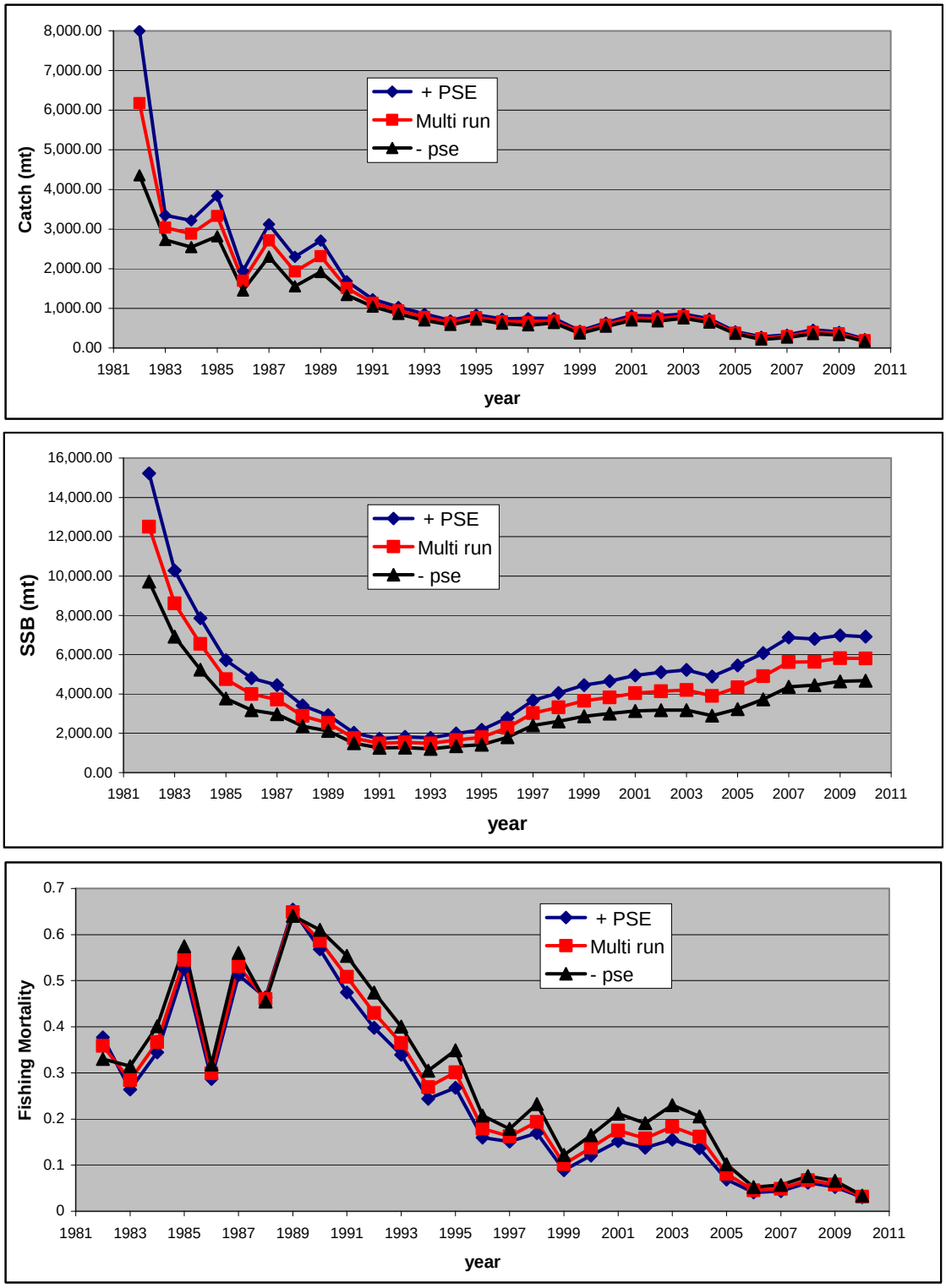


Figure C65. Assumed catch (top), SSB (middle) and fishing mortality (bottom) for the final ASAP multi model, the final multi model with the PSE added to the catch, and the PSE subtracted from the catch. This analysis was done to address TOR 4.

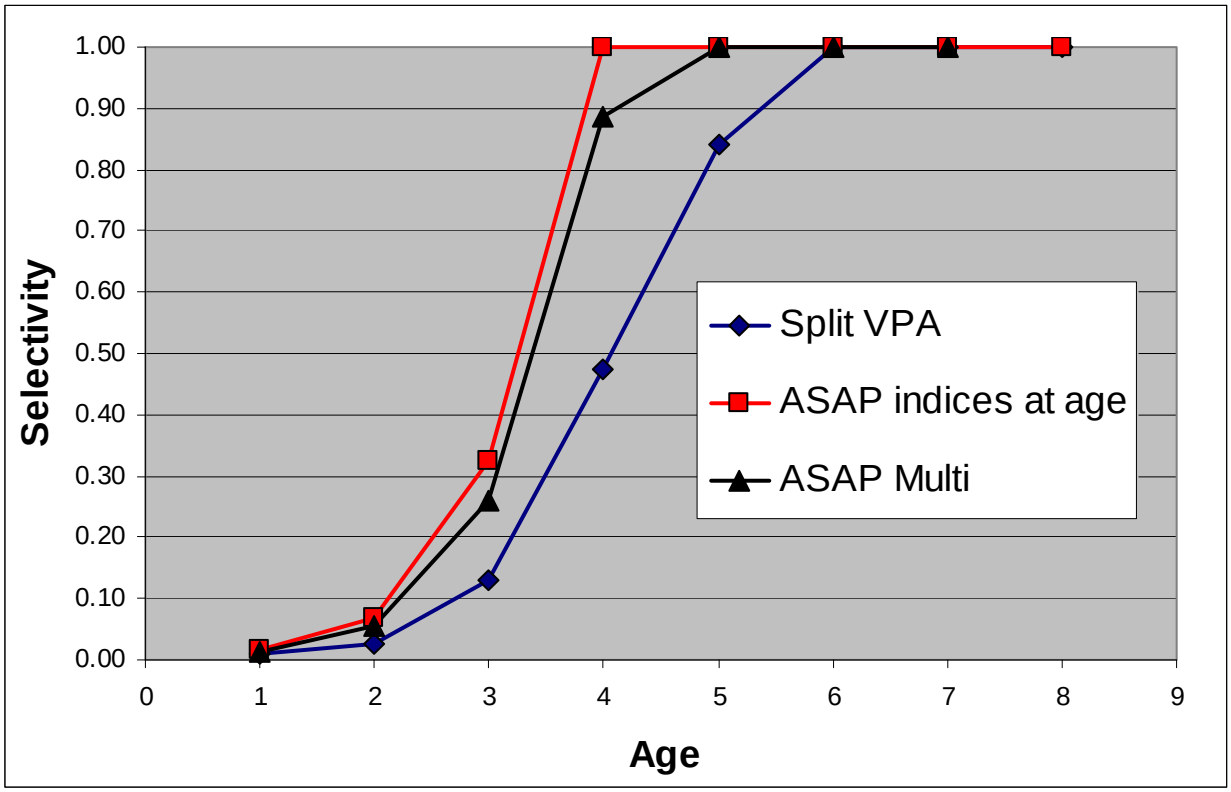


Figure C66. Comparison of estimated selectivity used for the estimation of biological reference point for the split VPA, ASAP indices at age and multi models.

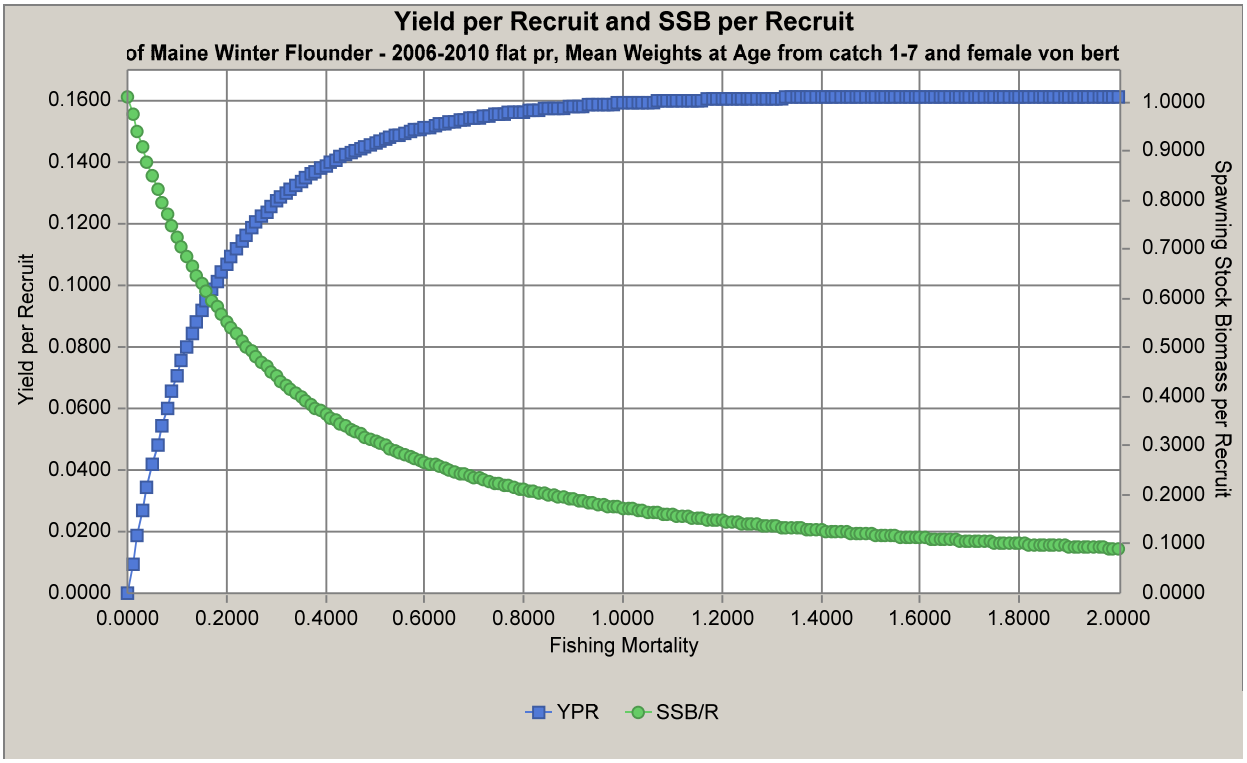
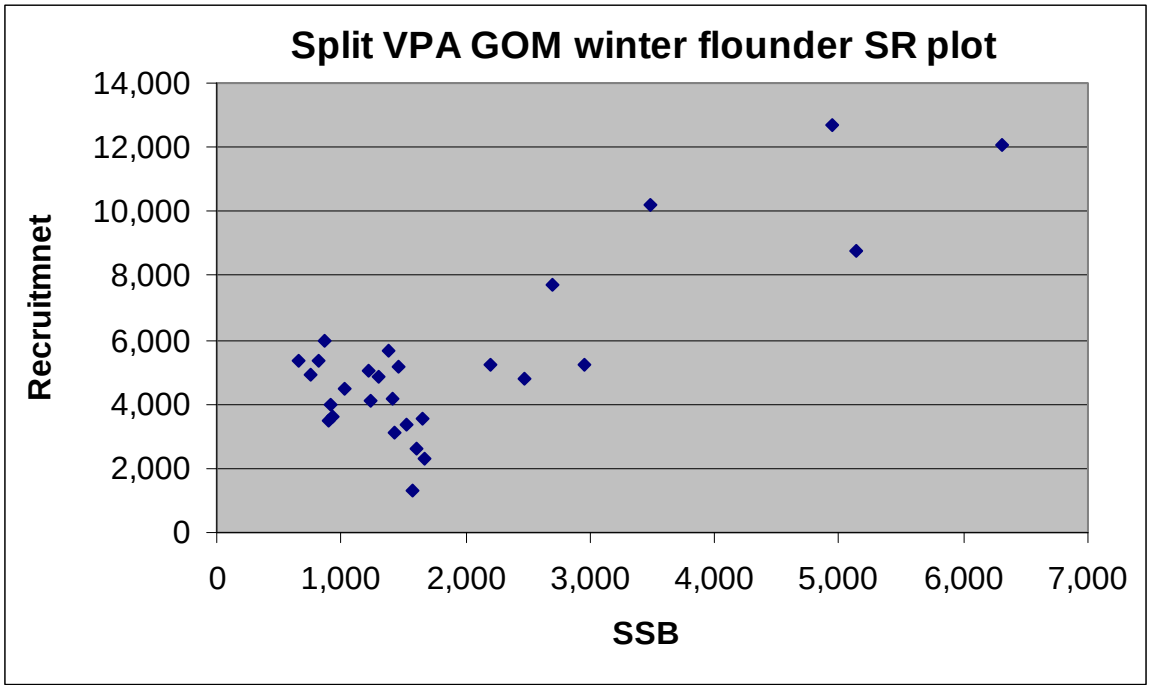


Figure C67. Yield per recruit analysis from the ASAP multi run.



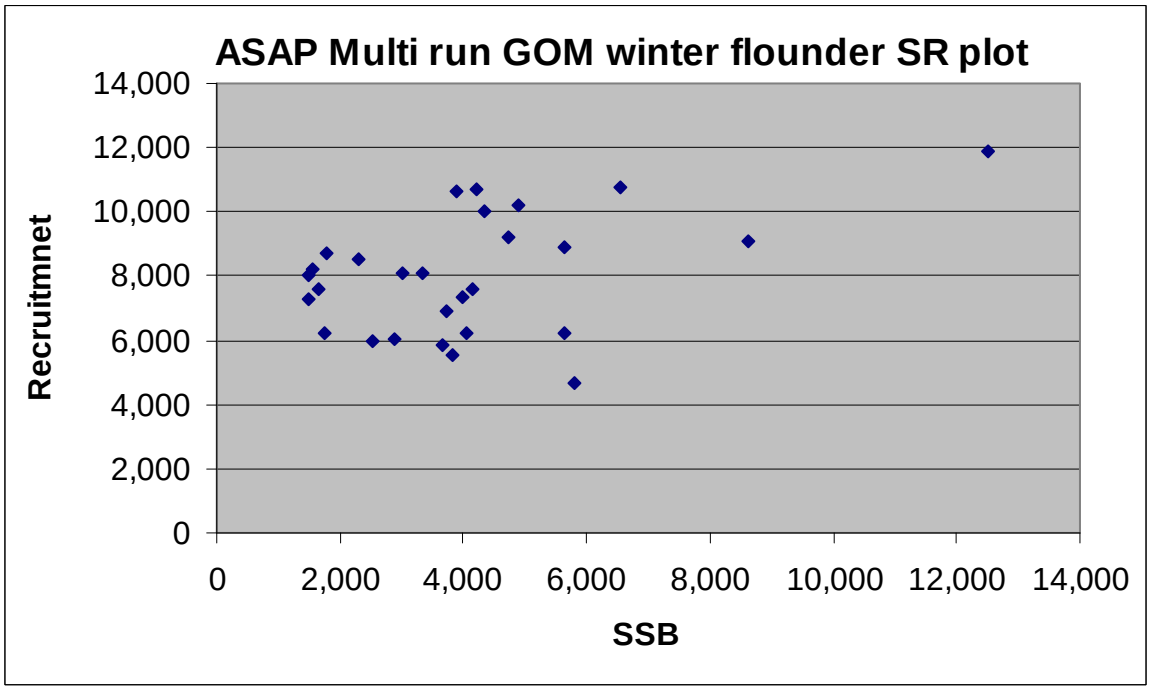
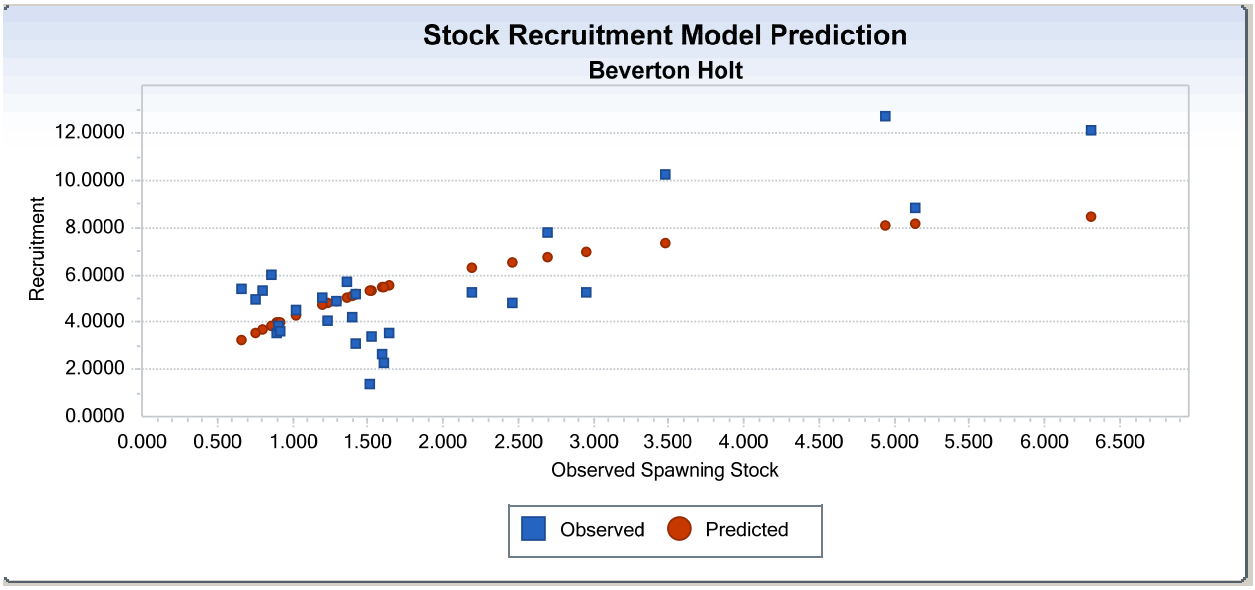


Figure C68. Stock recruit plots from the split VPA and ASAP multi runs.



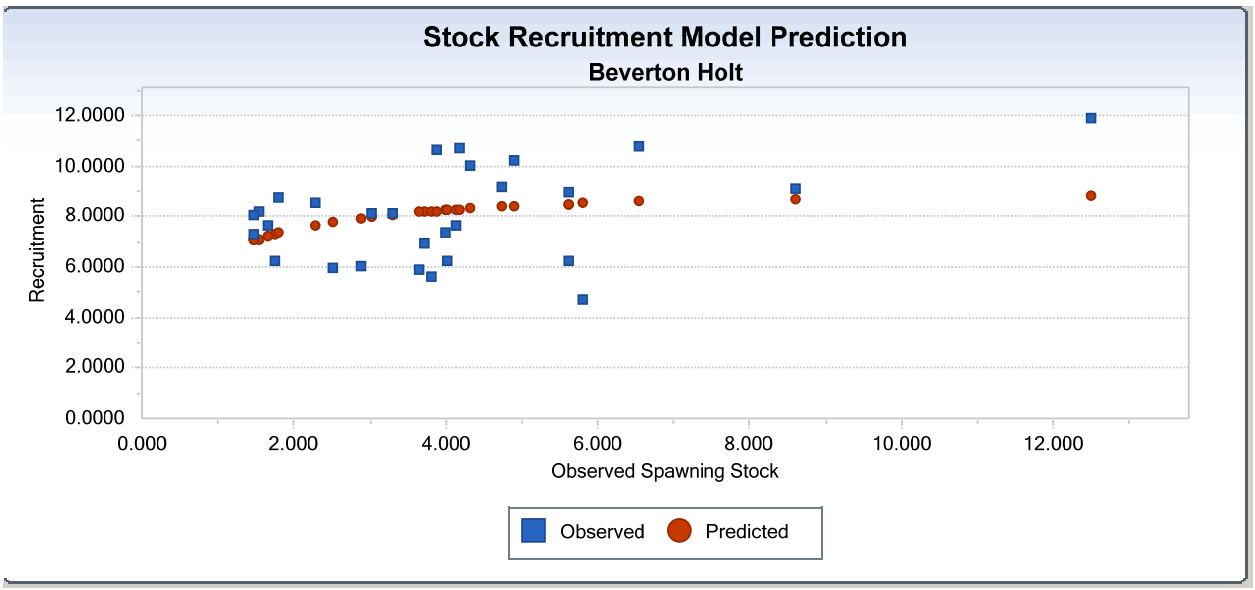


Figure C69. The estimated stock recruit curves from the split VPA and ASAP multi runs with a prior on steepness.

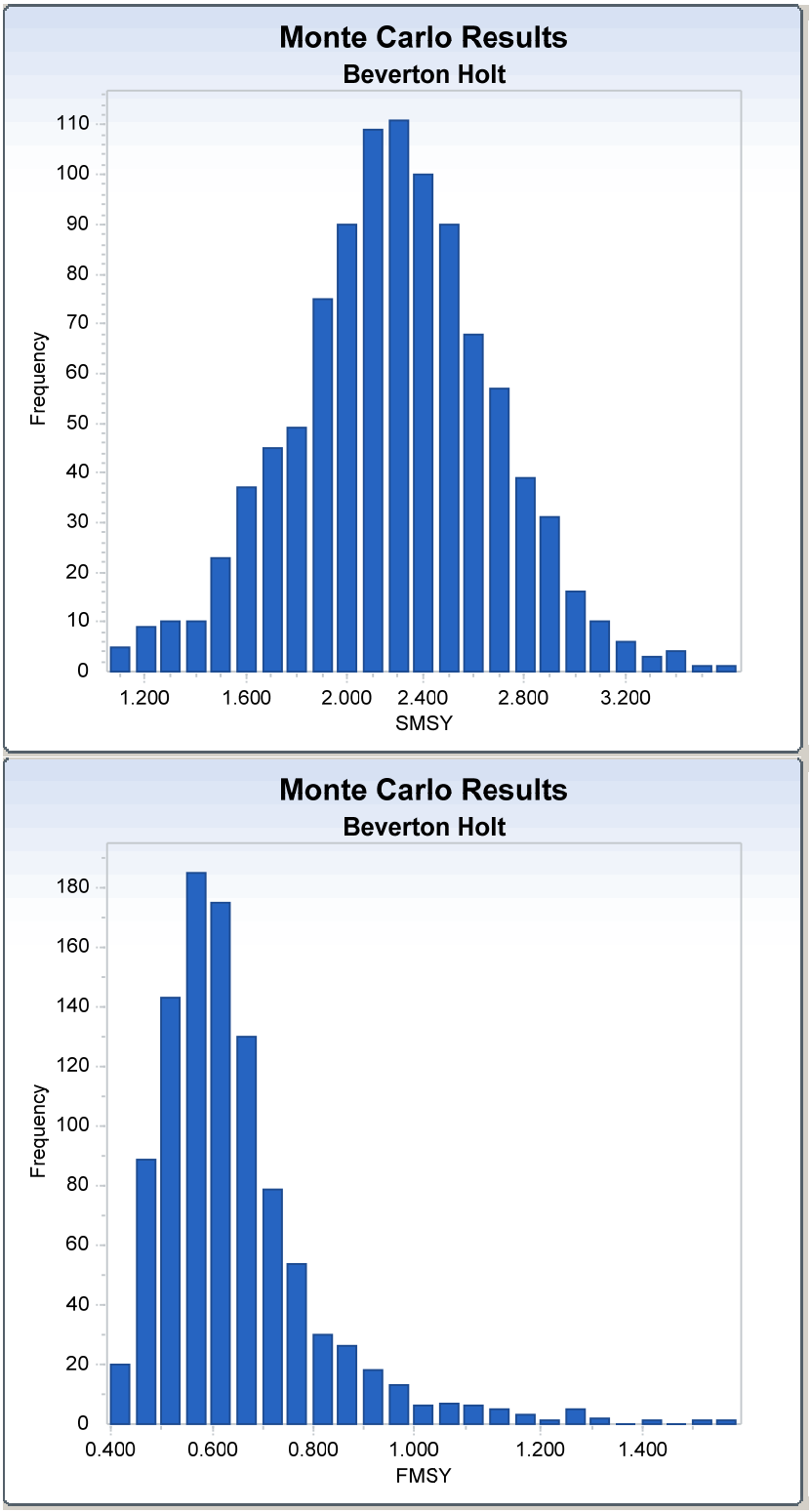


Figure C70. Estimated SSBmsy and Fmsy distribution from 1000 mcmc iterations for the preferred ASAP multi run with a prior on steepness.

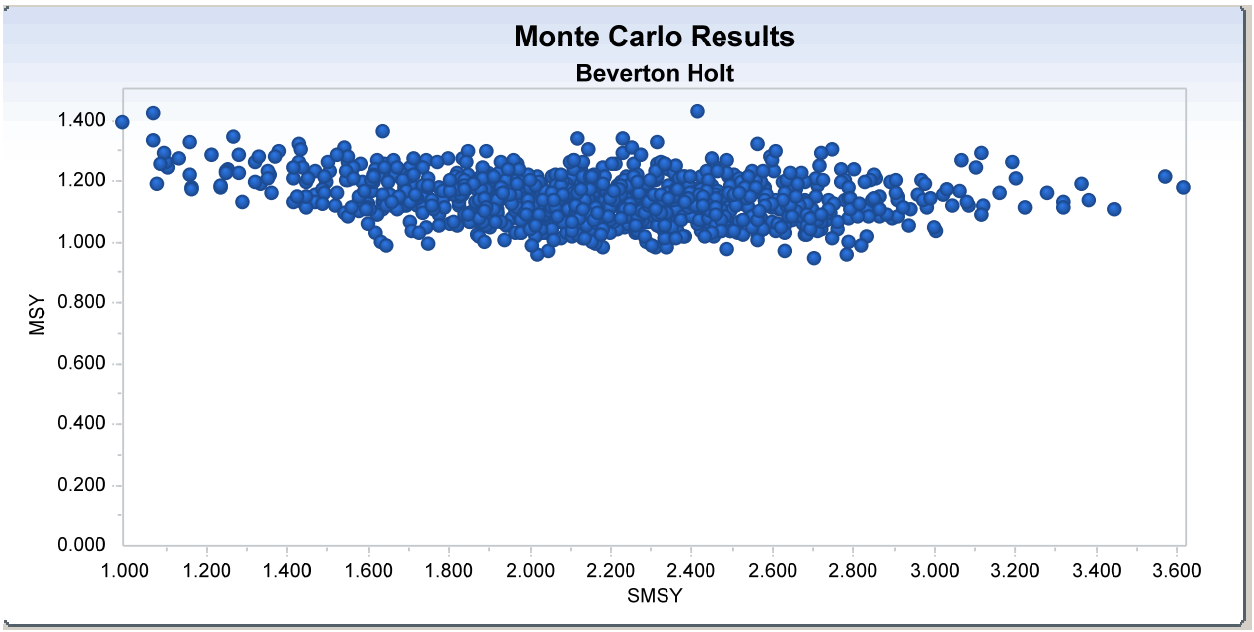
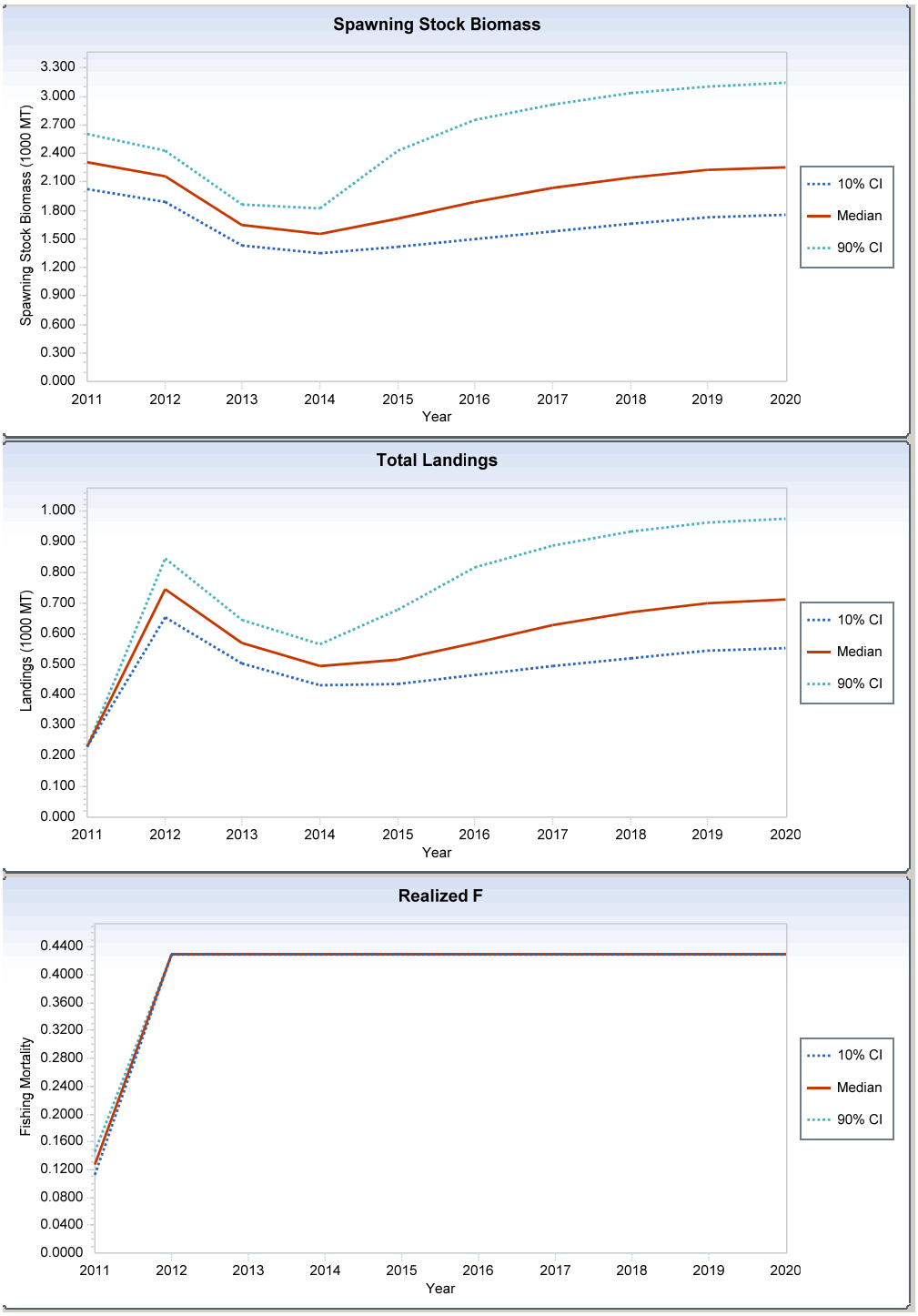
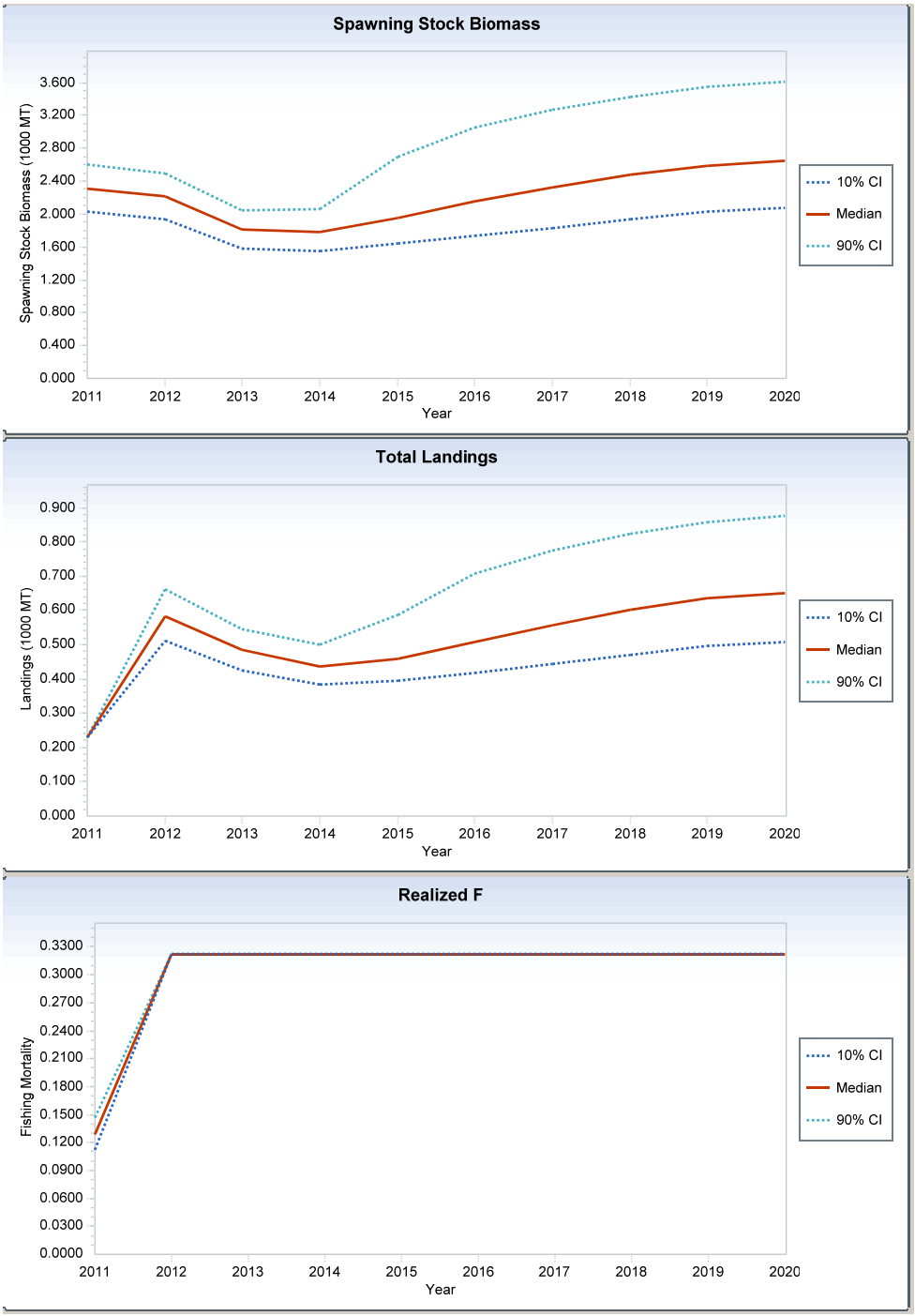


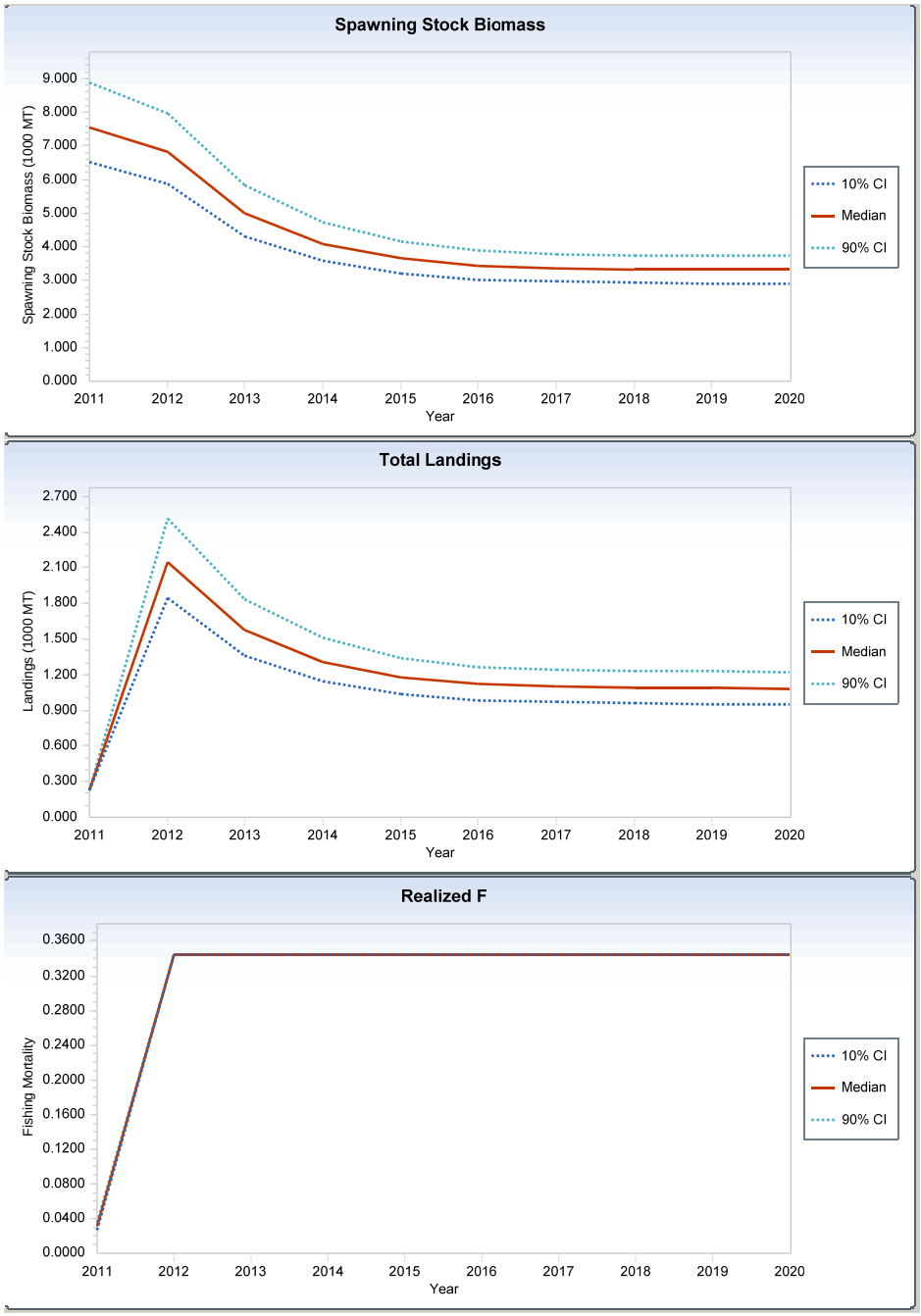
Figure C71. Variation of MSY with SSBmsy estimates from 1000 mcmc iterations for the preferred ASAP multi run with a prior on steepness.



Figures C72. SSB, catch, and fishing mortality assuming catch is 230 mt (ACL) in 2011 and the Fmsy proxy of F40% = 0.43 from 2012 to 2020 from the split VPA.



Figures C73. SSB, catch, and fishing mortality assuming catch is 230 mt (ACL) in 2011 and the 75% of the Fmsy proxy of F40% = 0.32 from 2012 to 2020 from the split VPA.



Figures C74. SSB, catch, and fishing mortality assuming catch is 230 mt (ACL) in 2011 and the Fmsy proxy of F40% = 0.34 from 2012 to 2020 from the ASAP multi run.

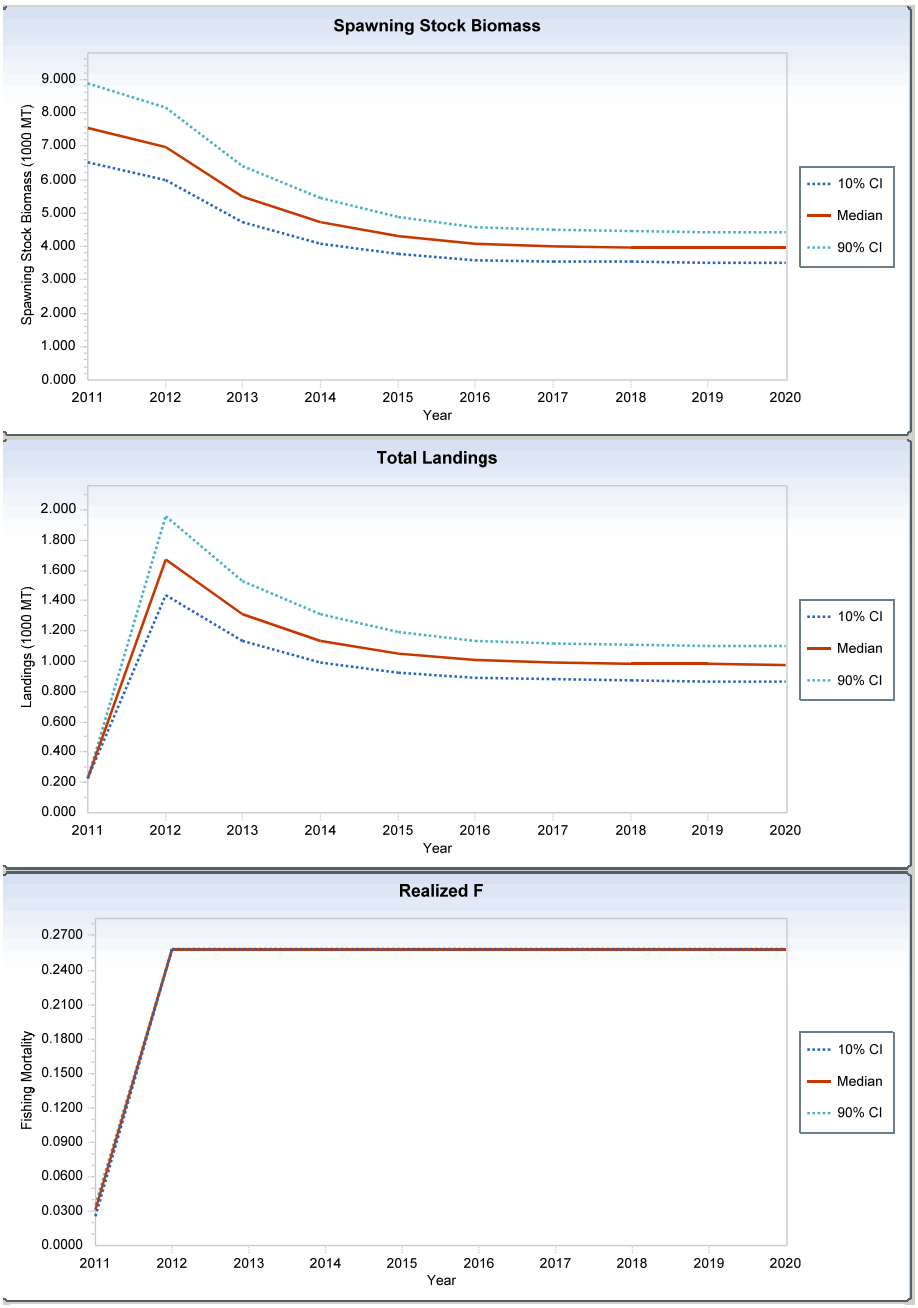


Figure C75. SSB, catch, and fishing mortality assuming catch is 230 mt (ACL) in 2011 and the 75% of the Fmsy proxy of F40% = 0.26 from 2012 to 2020 from the ASAP multi run.

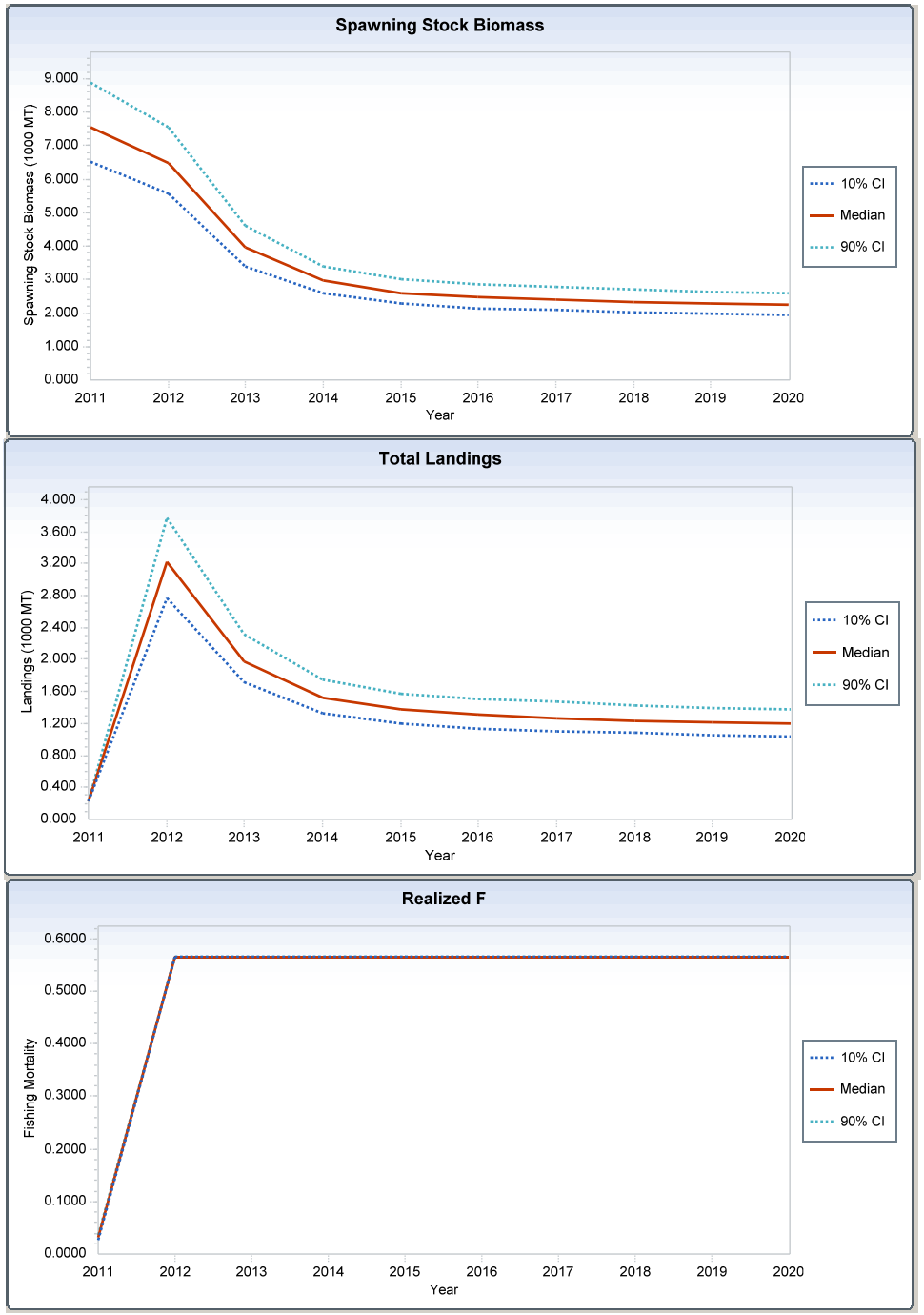
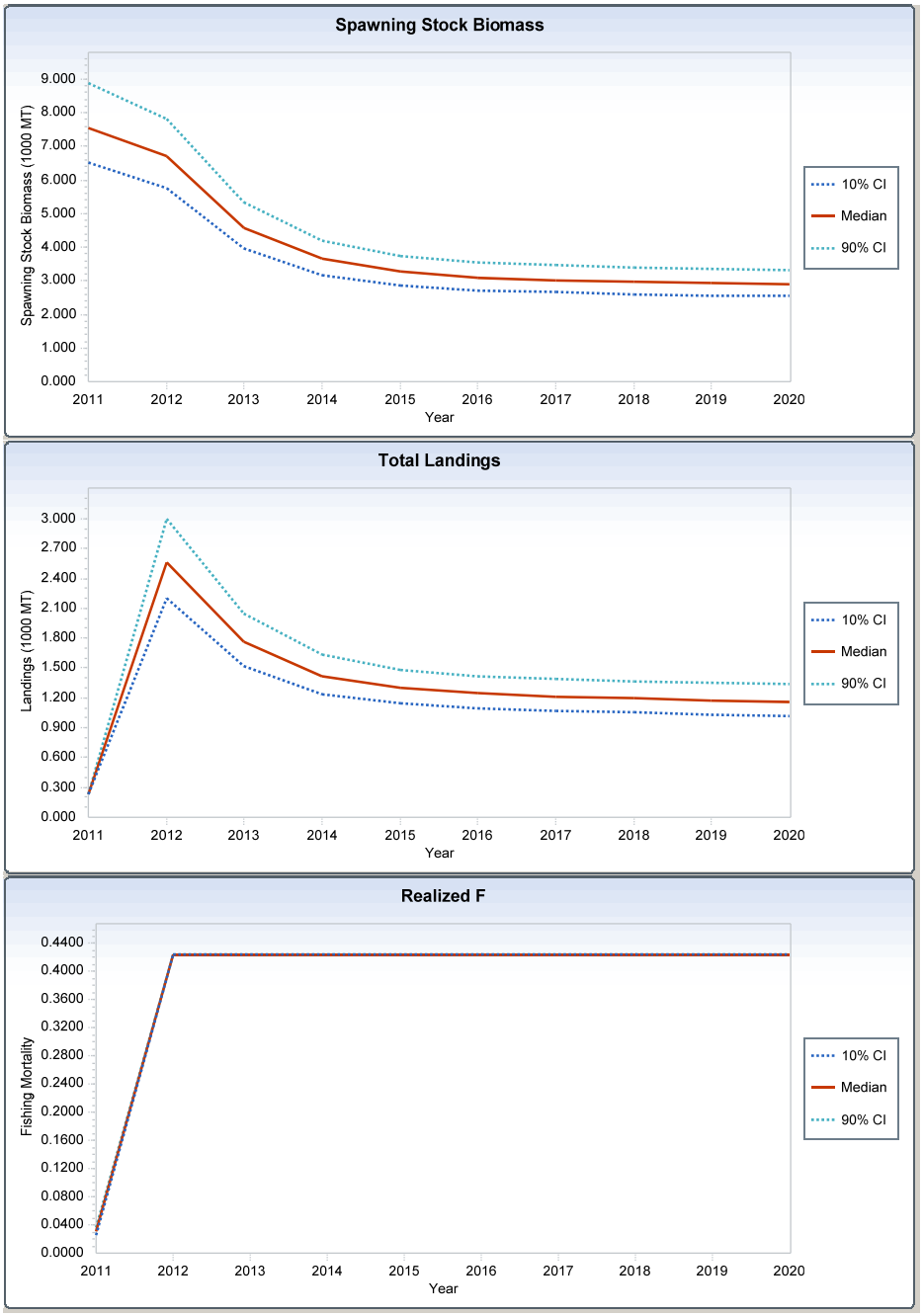


Figure C76. SSB, catch, and fishing mortality assuming catch is 230 mt (ACL) in 2011 and the stock recruit Fmsy = 0.57 from 2012 to 2020 from the ASAP multi run.



Figures C77. SSB, catch, and fishing mortality assuming catch is 230 mt (ACL) in 2011 and the 75% of the stock recruit Fmsy = 0.43 from 2012 to 2020 from the ASAP multi run.

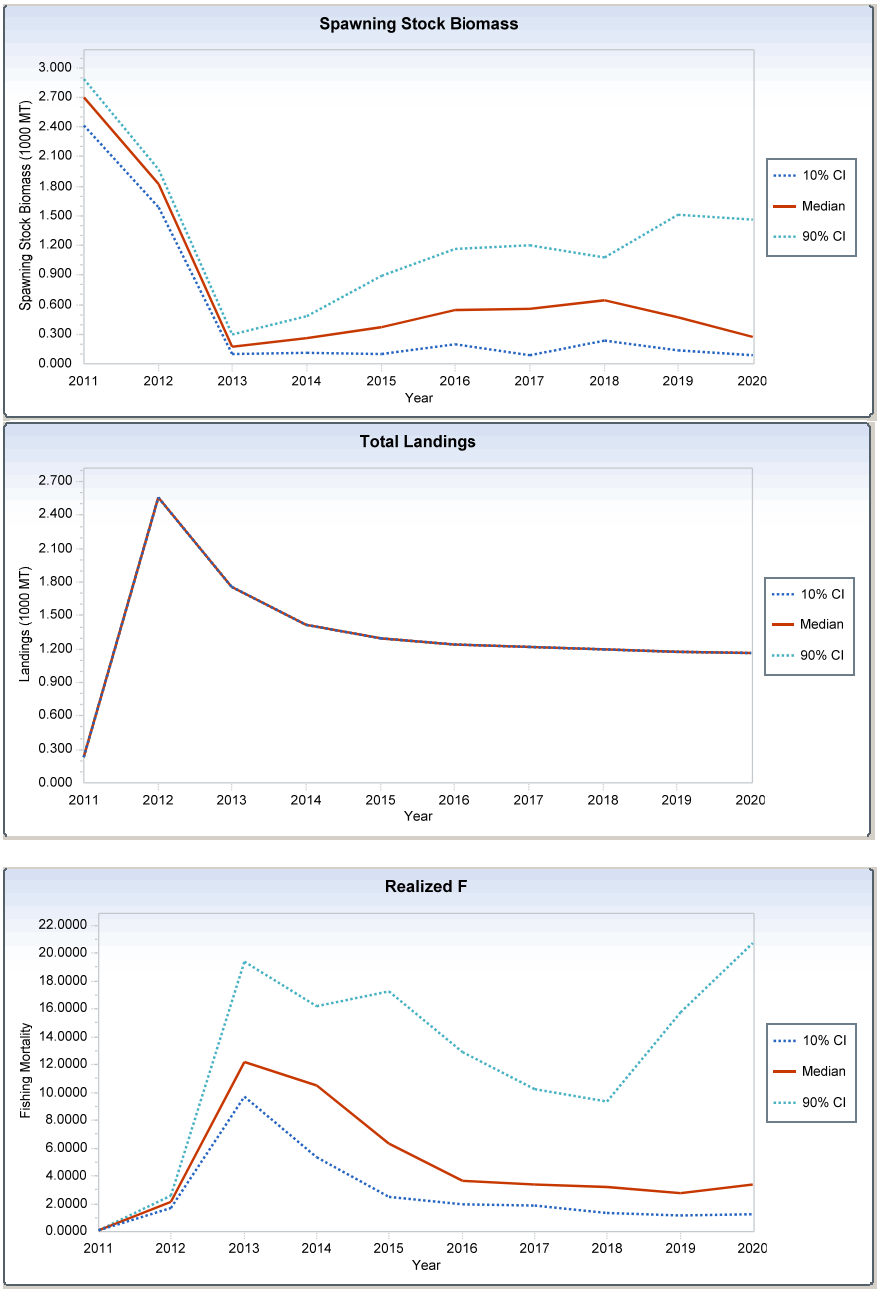


Figure C78. Consequence of the split VPA model reflecting the true when the 75% of Fmsy catch from the ASAP multi model is taken.

C. Assessment of Gulf of Maine (GOM) winter flounder
Appendix C1

[SAW52 Editor's Note: The SARC-52 peer review panel concluded that no ASAP model run provided a suitable basis for management advice. A swept-area biomass method was accepted instead, and it is described in Appendix C1.]

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

The NEFSC (RV Bigelow series), MDMF, and MENH surveys catch significant numbers of winter flounder per tow. 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 inshore strata for the Gulf of Maine. The MENH survey covers a large area of this stock that was previous missing prior to 2000. More direct estimates of exploitable biomass through area swept estimates are possible with the recent improvements in fishery independent data sources. Exploitation rates can be inferred from using a range of assumed survey efficiencies (Q) along with consideration of survey stock area coverage and different assumed catches. Possible bounds on the likely recent exploitation rate could 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

This method could possibly be used to determine the likely exploitation rate and overfishing status for Gulf of Maine winter flounder. However determination on whether the stock is overfished cannot be made since biomass reference points are unknown.

There are several important facts to take into consideration when interpreting the exploitation rate table (Table C1);

1. No single survey covers the entire stock (Appendix C1 Figures C1 to C4)).
2. Winter flounder is a shallow water species with a stock boundary from north of Cape Cod to the Canadian border.

3. Much higher survey catch rates are seen inshore verse offshore strata. However a significant proportion of the stock may be offshore due to the much larger strata area (offshore NEFSC 26, 40, 39).
4. The MENH survey catches significant numbers of fish. However relatively few exploitable 30+ cm fish are seen in the survey (Appendix C1 Figure C5). Updated age data suggests slower growth rates in Maine waters.
5. The most recent three year average biomass was used for the spring and fall MDMF surveys, two years for Bigelow spring survey and only one year for the Bigelow fall survey. The combined biomass estimate was calculated from non-overlapping strata from all three surveys.
6. Most of the catch is taken from statistical area 514 (Cape Cod Bay, Mass Bay, Ipswich Bay, Stellwagen bank). MDMF exploitation estimates conservatively assume that the entire stock is within Massachusetts state waters.
7. A Q equal to 1 conservatively assumes that the survey gear is 100% efficient.
8. The combined estimate using non-overlapping strata from all three surveys covers most of the stock area (Appendix C1 Table C2, Figure C4).

Exploitable 30+ cm biomass and exploitation rates with the associated error distribution were re-estimated from 2004 to 2010 (Appendix C1 Table C3, Figure C6 and C7) using the Survey Area Graphical Analysis (SAGA) program. The 80 percent confidence intervals were plotted to evaluate the inter-annual variation. The Bigelow to Albatross conversion coefficients were not incorporated into the calculations. However the use of the estimated Miller et al (2010) conversion of 2.086 Kg/tow would result in similar biomass estimates between the Albatross and Bigelow series (Appendix C1 Figure C6). Questions with regards to the relative low catchability and inshore sampling coverage in the Albatross series, uncertainty in the conversion coefficients for larger fish and possible effects of changes in stock size over time can be avoided by limiting the analysis to the most recent Bigelow time series (spring 2009 & 2010, fall 2009 & 2010). An analysis limited to strata which overlapped both the NEFSC Bigelow and Massachusetts DMF survey suggests there is relatively little difference in gear efficiency between the surveys (Appendix C1 Figure C8). Adjusting of the area difference in the overlapping strata between the MDMF and NEFSC surveys brings the estimates closer together (Appendix C1 Figure C9). A small difference in the survey gear efficiency helps justify the use of non-overlapping strata among the surveys as a single biomass estimate. A comparison of the survey components used in the combined estimate (MDMF near-shore, NEFSC inshore, NEFSC offshore) between the spring and the fall surveys shows that a higher proportion of the stock close to shore during the spring (Appendix C1 Table C4, Figures C10 and C11). The 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 spawning season. However survey information in the fall is also limited since no sampling occurred in Cape Cod bay in the NEFSC Fall 2010 survey. Note the combined fall 2010 estimate is based on a different strata set among the surveys (Appendix C1 Figure C12). The MDMF strata in Cape Cod Bay were used to account for the missing strata in the NEFSC survey. Sensitivity of the biomass estimates to the inclusion of the large deep offshore strata (27, 38) can be seen in Appendix C1 Figure C13. These deep offshore strata (27, 38) were not included in the final estimates due to the lack of fish seen in the deep central Gulf of Maine (Appendix C1 Figure C14).

At the SMAST Fishermen's input meeting fishermen suggested that herding between the doors and ground cable is important for the catchability of winter flounder. This may be more important in the commercial fishery targeted flatfish tows were tow speeds tend to be about a knot slower than a survey tow. Area swept estimates using the doors for the footprint calculation was done as a sensitivity analysis (Appendix C1 Table C5). Using the new TOGA criteria instead of SHG was also done as a sensitivity comparison. The wing based TOGA biomass estimates were slightly higher than estimates based on SHG (Appendix C1 Table C6).

A proxy value of the overfishing threshold (F40%) was derived from a length-based yield per recruit (NFT 2011) analysis that assumes all fish above 30 cm are fully recruited to the fishery and that natural mortality is 0.3 (Appendix C1 Figure C15). Von Bertalanffy parameters were estimated from the spring and fall NEFSC survey age data (n = 2,035) from 2006 to 2010. Maturity at length information is 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. Appendix C1 Table C7 and Figure C16 show estimated exploitation rates (catch over survey biomass) relative to the estimated exploitation based reference points over a range of catches using the combined surveys (spring and fall 2009 20010) assuming different efficiencies (0.2 to 1.0).

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 the Northeast Fisheries Science Center (NEFSC), Massachusetts Division of Marine Fisheries (MADMF), and Maine-New Hampshire (MENH) spring and fall bottom surveys for 2009 and 2010. 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 Appendix C1 Table C8. 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:

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

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~N(μ_a, σ_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 Appendix C1 Table C9 and plotted in Appendix C1 Figure C. 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 Appendix C1 Figures C18 through C21. The probability of exceeding candidate biological reference points are provided graphically in Appendix C1 Figures C22 and C23.

Survey Area Swept 30+ cm Exploitation Rates Conclusions

The use of an efficiency value of 0.6 was supported by comparison of VPA estimates of efficiency for the 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. An analysis of catch rates in overlapping areas by the NEFSC and MADMF surveys demonstrated similar catchabilities for winter flounder by the two surveys.

The SARC concluded that the best estimate of 30+ cm biomass and recent (2010) exploitation is based on use of the TOGA tow criteria for the fall 2010 surveys assuming an efficiency of 0.6 (Appendix C1 Tables C6 and C10 and Figure C14). The overfishing status is based on the ratio of 2010 catch (195 mt) to survey based swept area estimate of biomass for winter flounder exceeding 30 cm in length (6,341 mt). Exploitation rate in 2010 was estimated at 0.03 (80% CI 0.02 - 0.05) and therefore overfishing is not occurring (F2010/F40 ratio = 0.13, Appendix C1 Figure C24). This conclusion is robust to the range of uncertainty in the biomass estimate (Appendix C1 Figures C18 through C21). The biomass estimate for 2010 is 16% lower than that for 2009 using the same survey methods but this difference is not statistically significant (Appendix C1 Figure C17).

Appendix C1 Table C1. A range of estimated 30+ cm biomass and exploitation rates for different surveys using a range of assumed qs (1, 0.8, 0.6, 0.4) and assumed catch (mt) or ABCs (238, 344, 500, 800). A combined estimate using non-overlapping strata is also shown. Exploitation rates exceeding 0.2 are highlighted.

Q = 0.4	Catch	Bigelow Spring	Bigelow Fall	MDMF Spring	MDMF Fall	Combined Spring	Combined Fall
30+ Biomass		3,520	10,271	2,895	3,713	7,074	11,390
ABC 3yr avg	238	0.07	0.02	0.08	0.06	0.03	0.02
	344	0.10	0.03	0.12	0.09	0.05	0.03
	500	0.14	0.05	0.17	0.13	0.07	0.04
	800	0.23	0.08	0.28	0.22	0.11	0.07
Q = 0.6							
30+ Biomass		2,347	6,847	1,930	2,475	4,716	7,593
ABC 3yr avg	238	0.10	0.03	0.12	0.10	0.05	0.03
	344	0.15	0.05	0.18	0.14	0.07	0.05
	500	0.21	0.07	0.26	0.20	0.11	0.07
	800	0.34	0.12	0.41	0.32	0.17	0.11
Q = 0.8							
30+ Biomass		1,760	5,135	1,448	1,856	3,537	5,695
ABC 3yr avg	238	0.14	0.05	0.16	0.13	0.07	0.04
	344	0.20	0.07	0.24	0.19	0.10	0.06
	500	0.28	0.10	0.35	0.27	0.14	0.09
	800	0.45	0.16	0.55	0.43	0.23	0.14
Q = 1							
30+ Biomass		1,408	4,108	1,158	1,485	2,829	4,556
ABC 3yr avg	238	0.17	0.06	0.21	0.16	0.08	0.05
	344	0.24	0.08	0.30	0.23	0.12	0.08
	500	0.36	0.12	0.43	0.34	0.18	0.11
	800	0.57	0.19	0.69	0.54	0.28	0.18

Appendix C1 Table C2 - Survey total area coverage, average tow footprint, kg/tow and expansion factors for non-overlapping strata used in the combined estimate.

	Combined Survey Estimate		
	NEFSC	ME/NH	MDMF
survey area (nm2)	2,990	3,475	309
Avg tow (area swept)	0.007	0.00462	0.003846
Total area/tow footprint	427,143	752,154	80,343
Tow duration	20 min	20 min	20 min
Numbers per tow	34-65	35	80
Proportion of 30+ biomass	0.59	0.09	0.33

Appendix C1 Table C3 - Survey total area coverage, average tow footprint, kg/tow expansion factors and tow during for the different surveys and survey components. NEFSC 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							MDMF				MEHN
	Albatross			Bigelow				Gloria Michele				
	inshore overlap	offshore	combined	inshore overlap	offshore	Fall 2010	combined	state waters	near shore	Fall 2010	overlap	state waters
survey area (nm2)	668	2,322	2,990	668	2,322	2,638	2,990	793	309	633	484	3,475
Avg tow (area swept)	0.0112	0.0112	0.0112	0.007	0.007	0.007	0.007	0.003846	0.00385	0.003846	0.00385	0.00462
Total area/tow footprint	59,643	207,321	266,964	95,429	331,714	376,857	427,143	206,188	80,343	164,587	125,845	752,165
Tow duration	30 min	30 min	30 min	20 min	20 min	20 min	20 min	20 min	20 min	20 min	20 min	20 min

B. Door spread

	NEFSC				MDMF				MEHN
	Bigelow				Gloria Michele				
	inshore overlap	offshore	Fall 2010	combined	state waters	near shore	Fall 2010	overlap	state waters
survey area (nm2)	668	2,322	2,638	2,990	793	309	633	484	3,475
Avg tow (area swept)	0.0177	0.0177	0.0177	0.0177	0.0125	0.0125	0.0125	0.0125	0.0123
Total area/tow footprint	37,845	131,550	149,453	169,395	63,502	24,744	50,690	38,758	282,469
Tow duration	20 min	20 min	20 min	20 min	20 min	20 min	20 min	20 min	20 min

Appendix C1 Table C4 - A range of estimated 30+ cm biomass based on wing spread and exploitation rates for the combined survey estimate in spring 2009, spring 2010, fall 2009 and fall 2010 using a a range of qs assumptions (0.6, 0.8, & 1.0) and a range of assumed catch (mt) (238, 344, 400, 500, 800) based on an shg criteria of 136. 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				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.54	0.26	0.20	3,072	0.08	0.11	0.13	0.16	0.26
Spring 2010	0.45	0.33	0.21	2,587	0.09	0.13	0.15	0.19	0.31
Spring avg	0.49	0.30	0.21	2,829	0.08	0.12	0.14	0.18	0.28
Fall 2009	0.90	0.06	0.03	4,556	0.05	0.08	0.09	0.11	0.18
Fall 2010*	0.65	0.30	0.06	3,293	0.07	0.10	0.12	0.15	0.24

Q=0.8				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.54	0.26	0.20	3,840	0.06	0.09	0.10	0.13	0.21
Spring 2010	0.45	0.33	0.21	3,233	0.07	0.11	0.12	0.15	0.25
Spring avg	0.49	0.30	0.21	3,537	0.07	0.10	0.11	0.14	0.23
Fall 2009	0.90	0.06	0.03	5,695	0.04	0.06	0.07	0.09	0.14
Fall 2010*	0.65	0.30	0.06	4,116	0.06	0.08	0.10	0.12	0.19

Q=0.6				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.54	0.26	0.20	5,121	0.05	0.07	0.08	0.10	0.16
Spring 2010	0.45	0.33	0.21	4,311	0.06	0.08	0.09	0.12	0.19
Spring avg	0.49	0.30	0.21	4,716	0.05	0.07	0.08	0.11	0.17
Fall 2009	0.90	0.06	0.03	7,593	0.03	0.05	0.05	0.07	0.11
Fall 2010*	0.65	0.30	0.06	5,489	0.04	0.06	0.07	0.09	0.15

Appendix C1 Table C5 - A range of estimated 30+ cm biomass based on door spread and exploitation rates for the combined survey estimate in spring 2009, spring 2010, fall 2009 and fall 2010 using a a range of qs assumptions (0.6, 0.8, & 1.0) and a range of assumed catch (mt) (238, 344, 400, 500, 800) based on an shg criteria of 136. 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				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.43	0.16	0.40	1,516	0.16	0.23	0.26	0.33	0.53
Spring 2010	0.36	0.21	0.43	1,283	0.19	0.27	0.31	0.39	0.62
Spring avg	0.40	0.19	0.42	1,399	0.17	0.25	0.29	0.36	0.57
Fall 2009	0.87	0.05	0.08	1,877	0.13	0.18	0.21	0.27	0.43
Fall 2010*	0.64	0.23	0.14	1,328	0.18	0.26	0.30	0.38	0.60

A=0.8				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.43	0.16	0.40	1,895	0.13	0.18	0.21	0.26	0.42
Spring 2010	0.36	0.21	0.43	1,604	0.15	0.21	0.25	0.31	0.50
Spring avg	0.40	0.19	0.42	1,749	0.14	0.20	0.23	0.29	0.46
Fall 2009	0.87	0.05	0.08	2,347	0.10	0.15	0.17	0.21	0.34
Fall 2010*	0.64	0.23	0.14	1,660	0.14	0.21	0.24	0.30	0.48

				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.43	0.16	0.40	2,526	0.09	0.14	0.16	0.20	0.32
Spring 2010	0.36	0.21	0.43	2,139	0.11	0.16	0.19	0.23	0.37
Spring avg	0.40	0.19	0.42	2,332	0.10	0.15	0.17	0.21	0.34
Fall 2009	0.87	0.05	0.08	3,129	0.08	0.11	0.13	0.16	0.26
Fall 2010*	0.64	0.23	0.14	2,214	0.11	0.16	0.18	0.23	0.36

Appendix C1 Table C6 - A range of estimated 30+ cm biomass based on wing spread and exploitation rates for the combined survey estimate in spring 2009, spring 2010, fall 2009 and fall 2010 using a a range of qs assumptions (0.6, 0.8, & 1.0) and a range of assumed catch (mt) (238, 344, 400, 500, 800) 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				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.56	0.25	0.19	3,212	0.07	0.11	0.125	0.16	0.25
Spring 2010	0.45	0.33	0.21	2,594	0.09	0.13	0.154	0.19	0.31
Spring avg	0.50	0.29	0.20	2,903	0.08	0.12	0.138	0.17	0.28
Fall 2009	0.90	0.06	0.03	4,567	0.05	0.08	0.088	0.11	0.18
Fall 2010*	0.69	0.26	0.05	3,804	0.06	0.09	0.105	0.13	0.21

Q=0.8				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.56	0.25	0.19	4,015	0.06	0.09	0.100	0.12	0.20
Spring 2010	0.45	0.33	0.21	3,243	0.07	0.11	0.123	0.15	0.25
Spring avg	0.50	0.29	0.20	3,629	0.07	0.09	0.110	0.14	0.22
Fall 2009	0.90	0.06	0.03	5,709	0.04	0.06	0.070	0.09	0.14
Fall 2010*	0.69	0.26	0.05	4,756	0.05	0.07	0.084	0.11	0.17

Q=0.6				Total	Exploitation from assumed catch				
	NEFSC	MDMF	ME/NH	30+ biomass	238	344	400	500	800
Spring 2009	0.56	0.25	0.19	5,354	0.04	0.06	0.075	0.09	0.15
Spring 2010	0.45	0.33	0.21	4,324	0.06	0.08	0.093	0.12	0.19
Spring avg	0.50	0.29	0.20	4,839	0.05	0.07	0.083	0.10	0.17
Fall 2009	0.90	0.06	0.03	7,612	0.03	0.05	0.053	0.07	0.11
Fall 2010*	0.69	0.26	0.05	6,341	0.04	0.05	0.063	0.08	0.13

Appendix C1 Table C7 – Exploitation ratios at various levels of catch and assumed trawl efficiency using 30+ cm swept area biomass from combined surveys.

	catch	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Efficiency = 1	30+biomass																				
Spring 2009	3,212	0.016	0.031	0.047	0.062	0.078	0.093	0.109	0.125	0.140	0.156	0.171	0.187	0.202	0.218	0.233	0.249	0.265	0.280	0.296	0.311
Spring 2010	2,594	0.019	0.039	0.058	0.077	0.096	0.116	0.135	0.154	0.173	0.193	0.212	0.231	0.251	0.270	0.289	0.308	0.328	0.347	0.366	0.385
Spring avg	2,903	0.017	0.034	0.052	0.069	0.086	0.103	0.121	0.138	0.155	0.172	0.189	0.207	0.224	0.241	0.258	0.276	0.293	0.310	0.327	0.344
Fall 2009	4,567	0.011	0.022	0.033	0.044	0.055	0.066	0.077	0.088	0.099	0.109	0.120	0.131	0.142	0.153	0.164	0.175	0.186	0.197	0.208	0.219
Fall 2010	3,804	0.013	0.026	0.039	0.053	0.066	0.079	0.092	0.105	0.118	0.131	0.145	0.158	0.171	0.184	0.197	0.210	0.223	0.237	0.250	0.263
Fall avg	4,186	0.012	0.024	0.036	0.048	0.060	0.072	0.084	0.096	0.108	0.119	0.131	0.143	0.155	0.167	0.179	0.191	0.203	0.215	0.227	0.239
	catch	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Efficiency = 0.8	30+biomass																				
Spring 2009	4,015	0.012	0.025	0.037	0.050	0.062	0.075	0.087	0.100	0.112	0.125	0.137	0.149	0.162	0.174	0.187	0.199	0.212	0.224	0.237	0.249
Spring 2010	3,243	0.015	0.031	0.046	0.062	0.077	0.093	0.108	0.123	0.139	0.154	0.170	0.185	0.200	0.216	0.231	0.247	0.262	0.278	0.293	0.308
Spring avg	3,629	0.014	0.028	0.041	0.055	0.069	0.083	0.096	0.110	0.124	0.138	0.152	0.165	0.179	0.193	0.207	0.220	0.234	0.248	0.262	0.276
Fall 2009	5,709	0.009	0.018	0.026	0.035	0.044	0.053	0.061	0.070	0.079	0.088	0.096	0.105	0.114	0.123	0.131	0.140	0.149	0.158	0.166	0.175
Fall 2010	4,756	0.011	0.021	0.032	0.042	0.053	0.063	0.074	0.084	0.095	0.105	0.116	0.126	0.137	0.147	0.158	0.168	0.179	0.189	0.200	0.210
Fall avg	5,232	0.010	0.019	0.029	0.038	0.048	0.057	0.067	0.076	0.086	0.096	0.105	0.115	0.124	0.134	0.143	0.153	0.162	0.172	0.182	0.191
	catch	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Efficiency = 0.6	30+biomass																				
Spring 2009	5,354	0.009	0.019	0.028	0.037	0.047	0.056	0.065	0.075	0.084	0.093	0.103	0.112	0.121	0.131	0.140	0.149	0.159	0.168	0.177	0.187
Spring 2010	4,324	0.012	0.023	0.035	0.046	0.058	0.069	0.081	0.093	0.104	0.116	0.127	0.139	0.150	0.162	0.173	0.185	0.197	0.208	0.220	0.231
Spring avg	4,839	0.010	0.021	0.031	0.041	0.052	0.062	0.072	0.083	0.093	0.103	0.114	0.124	0.134	0.145	0.155	0.165	0.176	0.186	0.196	0.207
Fall 2009	7,612	0.007	0.013	0.020	0.026	0.033	0.039	0.046	0.053	0.059	0.066	0.072	0.079	0.085	0.092	0.099	0.105	0.112	0.118	0.125	0.131
Fall 2010	6,341	0.008	0.016	0.024	0.032	0.039	0.047	0.055	0.063	0.071	0.079	0.087	0.095	0.103	0.110	0.118	0.126	0.134	0.142	0.150	0.158
Fall avg	6,977	0.007	0.014	0.022	0.029	0.036	0.043	0.050	0.057	0.065	0.072	0.079	0.086	0.093	0.100	0.108	0.115	0.122	0.129	0.136	0.143
	catch	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Efficiency = 0.4	30+biomass																				
Spring 2009	8,030	0.006	0.012	0.019	0.025	0.031	0.037	0.044	0.050	0.056	0.062	0.068	0.075	0.081	0.087	0.093	0.100	0.106	0.112	0.118	0.125
Spring 2010	6,486	0.008	0.015	0.023	0.031	0.039	0.046	0.054	0.062	0.069	0.077	0.085	0.093	0.100	0.108	0.116	0.123	0.131	0.139	0.146	0.154
Spring avg	7,258	0.007	0.014	0.021	0.028	0.034	0.041	0.048	0.055	0.062	0.069	0.076	0.083	0.090	0.096	0.103	0.110	0.117	0.124	0.131	0.138
Fall 2009	11,419	0.004	0.009	0.013	0.018	0.022	0.026	0.031	0.035	0.039	0.044	0.048	0.053	0.057	0.061	0.066	0.070	0.074	0.079	0.083	0.088
Fall 2010	9,511	0.005	0.011	0.016	0.021	0.026	0.032	0.037	0.042	0.047	0.053	0.058	0.063	0.068	0.074	0.079	0.084	0.089	0.095	0.100	0.105
Fall avg	10,465	0.005	0.010	0.014	0.019	0.024	0.029	0.033	0.038	0.043	0.048	0.053	0.057	0.062	0.067	0.072	0.076	0.081	0.086	0.091	0.096
	catch	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Efficiency = 0.2	30+biomass																				
Spring 2009	16,061	0.003	0.006	0.009	0.012	0.016	0.019	0.022	0.025	0.028	0.031	0.034	0.037	0.040	0.044	0.047	0.050	0.053	0.056	0.059	0.062
Spring 2010	12,972	0.004	0.008	0.012	0.015	0.019	0.023	0.027	0.031	0.035	0.039	0.042	0.046	0.050	0.054	0.058	0.062	0.066	0.069	0.073	0.077
Spring avg	14,517	0.003	0.007	0.010	0.014	0.017	0.021	0.024	0.028	0.031	0.034	0.038	0.041	0.045	0.048	0.052	0.055	0.059	0.062	0.065	0.069
Fall 2009	22,837	0.002	0.004	0.007	0.009	0.011	0.013	0.015	0.018	0.020	0.022	0.024	0.026	0.028	0.031	0.033	0.035	0.037	0.039	0.042	0.044
Fall 2010	19,022	0.003	0.005	0.008	0.011	0.013	0.016	0.018	0.021	0.024	0.026	0.029	0.032	0.034	0.037	0.039	0.042	0.045	0.047	0.050	0.053
Fall avg	20,930	0.002	0.005	0.007	0.010	0.012	0.014	0.017	0.019	0.022	0.024	0.026	0.029	0.031	0.033	0.036	0.038	0.041	0.043	0.045	0.048

Appendix C1 Table C8 - Summary of model input data for estimation of swept area biomass estimates for GOM winter flounder.

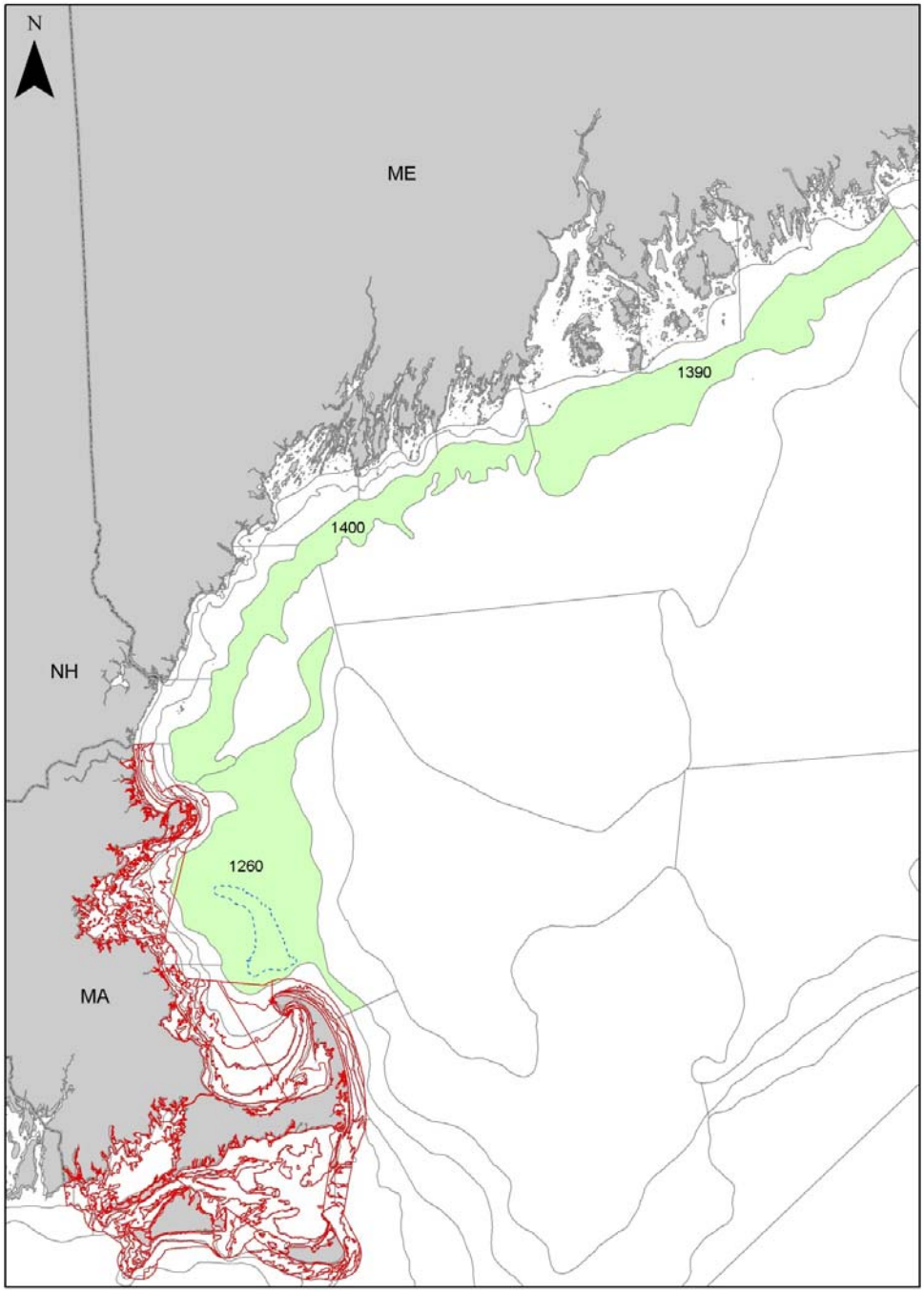
Survey	Season	Year	Total Survey Area in nm^2	Area per tow in nm^2 (SE)	Survey in kg/tow (SE)
NEFSC	Spring	2009	2990	0.006974755 (0.000835526)	4.18909 (1.68859)
MADMF			309	0.003846 (0.0004607)	10.0972 (1.63578)
ME-NH			3475	0.00462 (0.000553443)	0.81315 (0.13173)
NEFSC	Fall	2009	2990	0.006974755 (0.000835526)	9.6447 (4.10327)
MADMF			309	0.003846 (0.0004607)	3.59066 (0.627)
ME-NH			3475	0.00462 (0.000553443)	0.21176 (0.03698)
NEFSC	Spring	2010	2990	0.006974755 (0.000835526)	2.74878 (0.60754)
MADMF			309	0.003846 (0.0004607)	10.7822 (2.8331)
ME-NH			3475	0.00462 (0.000553443)	0.73656 (0.19354)
NEFSC	Fall	2010	2638	0.006974755 (0.000835526)	7.00897 (2.97247)
MADMF			633	0.003846 (0.0004607)	5.96533 (0.855255)
ME-NH			3475	0.00462 (0.000553443)	0.240953 (0.03455)

Appendix C1 Table C9 - Summary of estimated sampling distribution of biomass estimates for Gulf of Maine winter flounder for varying seasons, years and assumed survey efficiency estimates.

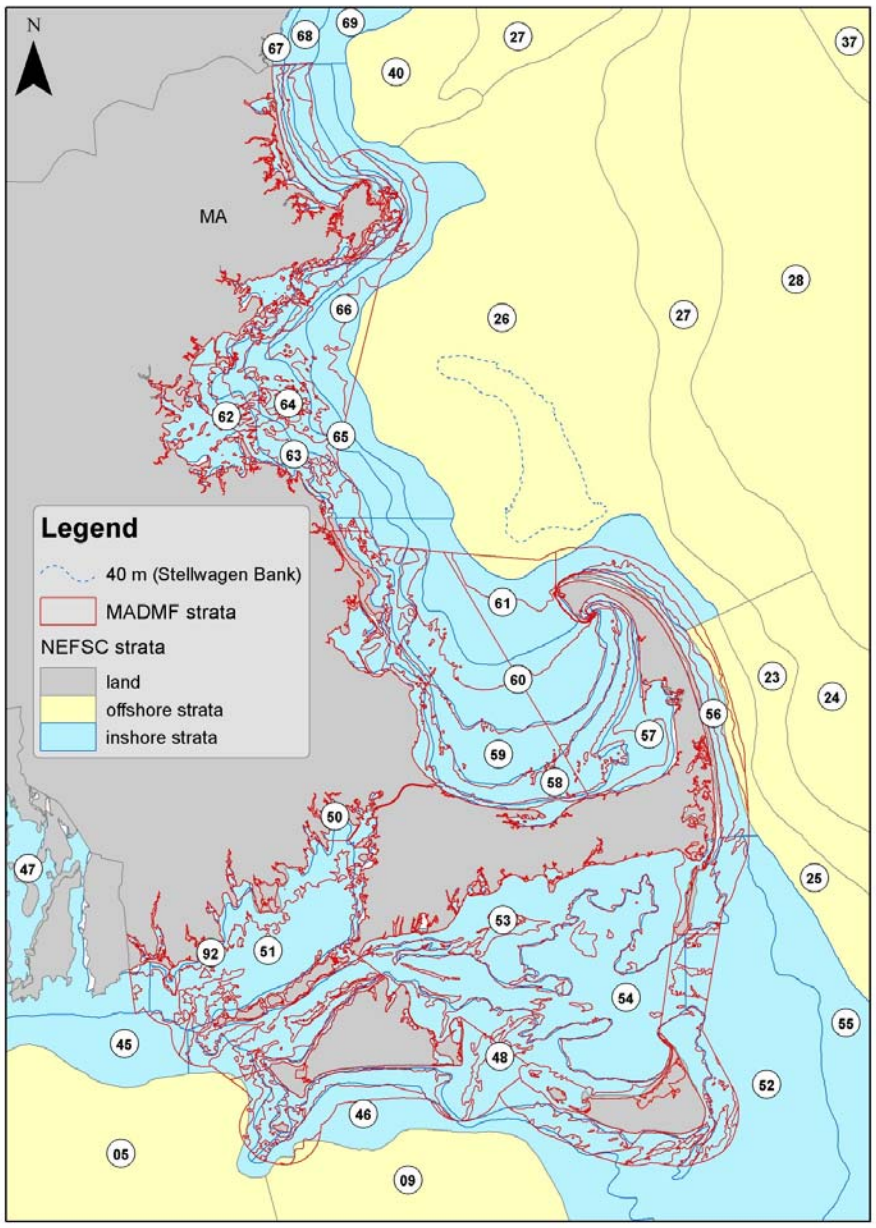
	Fall2009			*Spring2009*			*Spring2010*			*Fall2010*		
	0.6	***0.8***	***1***	***0.6***	***0.8***	***1***	***0.6***	***0.8***	***1***	***0.6***	***0.8***	***1***
Min	2,260	1,680	1,330	2,890	2,150	1,700	2,590	1,920	1,520	2,610	1,940	1,540
Max	15,690	12,400	9,930	8,240	6,230	5,010	6,540	4,940	3,970	11,870	8,990	7,240
Range	13,430	10,720	8,600	5,350	4,080	3,310	3,950	3,020	2,450	9,260	7,050	5,700
Mean	7,761	5,826	4,659	5,203	3,899	3,116	4,375	3,278	2,620	6,468	4,849	3,877
SD	2,643	1,995	1,599	913	686	550	612	460	368	1,721	1,295	1,037
CV	0.341	0.342	0.343	0.176	0.176	0.176	0.14	0.14	0.141	0.266	0.267	0.268
Skewness	0.231	0.248	0.249	0.242	0.246	0.249	0.191	0.195	0.195	0.237	0.242	0.245
Kurtosis	-0.471	-0.434	-0.432	-0.332	-0.32	-0.313	-0.178	-0.165	-0.157	-0.432	-0.422	-0.414
Percentiles												
1%	2,700	2,020	1,610	3,380	2,530	2,020	3,070	2,300	1,840	3,150	2,350	1,880
5%	3,560	2,670	2,130	3,770	2,820	2,250	3,400	2,550	2,030	3,750	2,800	2,240
10%	4,300	3,220	2,570	4,030	3,020	2,410	3,600	2,690	2,150	4,230	3,160	2,530
20%	5,360	4,020	3,210	4,390	3,290	2,630	3,840	2,880	2,300	4,910	3,680	2,940
25%	5,800	4,350	3,470	4,530	3,400	2,710	3,940	2,950	2,360	5,190	3,890	3,110
30%	6,200	4,650	3,710	4,670	3,500	2,800	4,030	3,020	2,410	5,450	4,090	3,270
40%	6,940	5,200	4,160	4,920	3,690	2,950	4,200	3,140	2,510	5,930	4,450	3,550
50%	7,650	5,740	4,590	5,160	3,870	3,090	4,350	3,260	2,610	6,390	4,790	3,830
60%	8,370	6,280	5,020	5,410	4,050	3,240	4,510	3,380	2,700	6,860	5,140	4,110
70%	9,150	6,870	5,490	5,670	4,250	3,400	4,690	3,510	2,810	7,370	5,530	4,420
75%	9,590	7,200	5,760	5,820	4,360	3,490	4,790	3,590	2,870	7,650	5,740	4,590
80%	10,080	7,570	6,050	5,990	4,490	3,590	4,890	3,670	2,930	7,970	5,980	4,780
90%	11,350	8,530	6,820	6,430	4,820	3,850	5,180	3,890	3,110	8,800	6,600	5,280
95%	12,350	9,290	7,430	6,780	5,090	4,070	5,420	4,070	3,250	9,450	7,090	5,680
99%	14,010	10,570	8,470	7,410	5,560	4,450	5,860	4,400	3,520	10,560	7,930	6,350

Appendix C1**Table C10. Summary of sampling distribution for exploitation rates for the Fall 2010 with an assumed efficiency of 0.6 and the 2010 catch of 195 mt for Gulf of Maine winter flounder.**

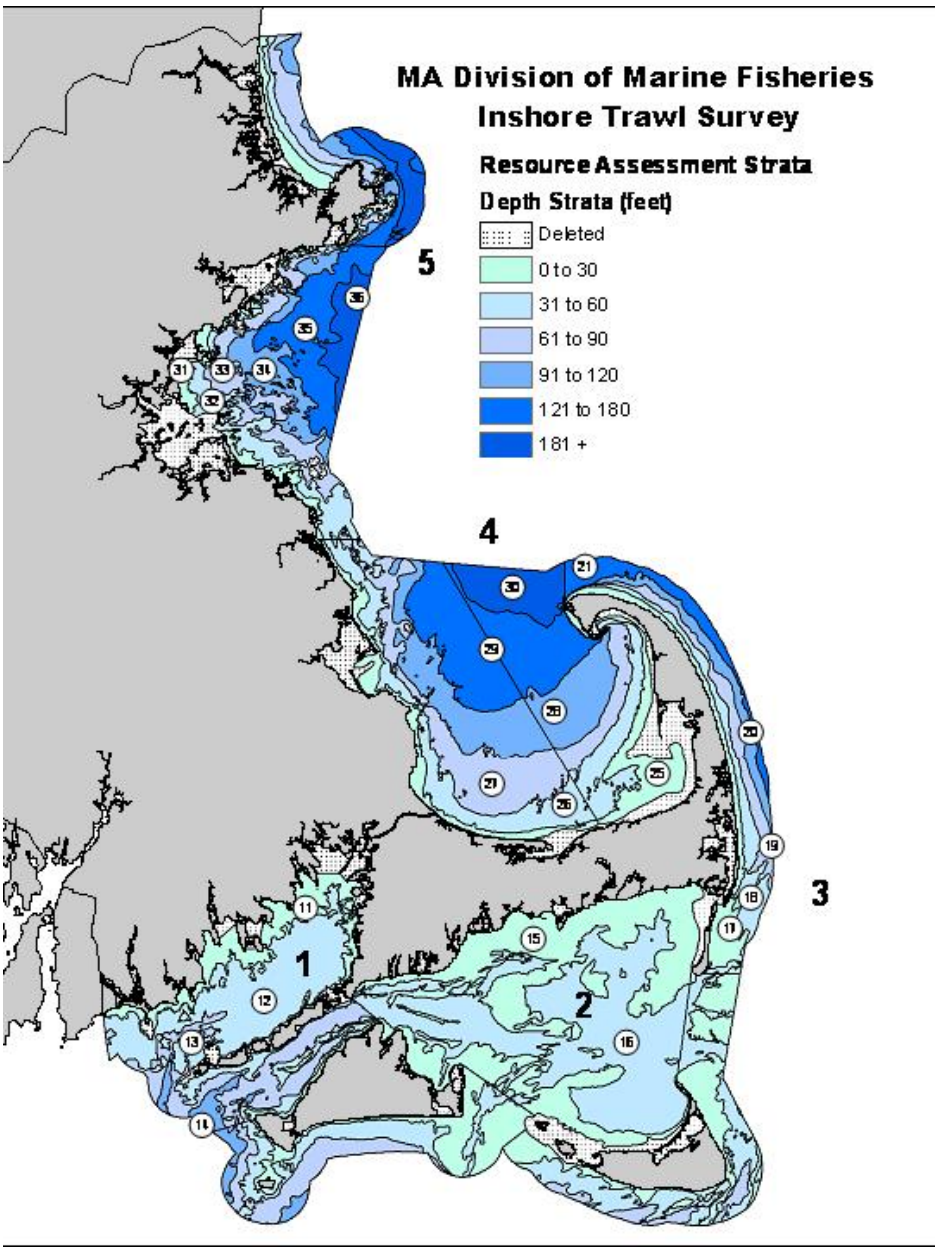
Minimum	**0.015**
Maximum	**0.076**
Range	**0.061**
Mean	**0.032**
Standard Dev	**0.010**
C.V.	**0.302**
Skewness(G1)	**1.057**
Kurtosis(G2)	**1.021**
Method = EMPCDF	
1 %	**0.018**
5 %	**0.020**
10 %	**0.022**
20 %	**0.024**
25 %	**0.025**
30 %	**0.026**
40 %	**0.028**
50 %	**0.030**
60 %	**0.032**
70 %	**0.035**
75 %	**0.037**
80 %	**0.039**
90 %	**0.046**
95 %	**0.051**
99 %	**0.061**



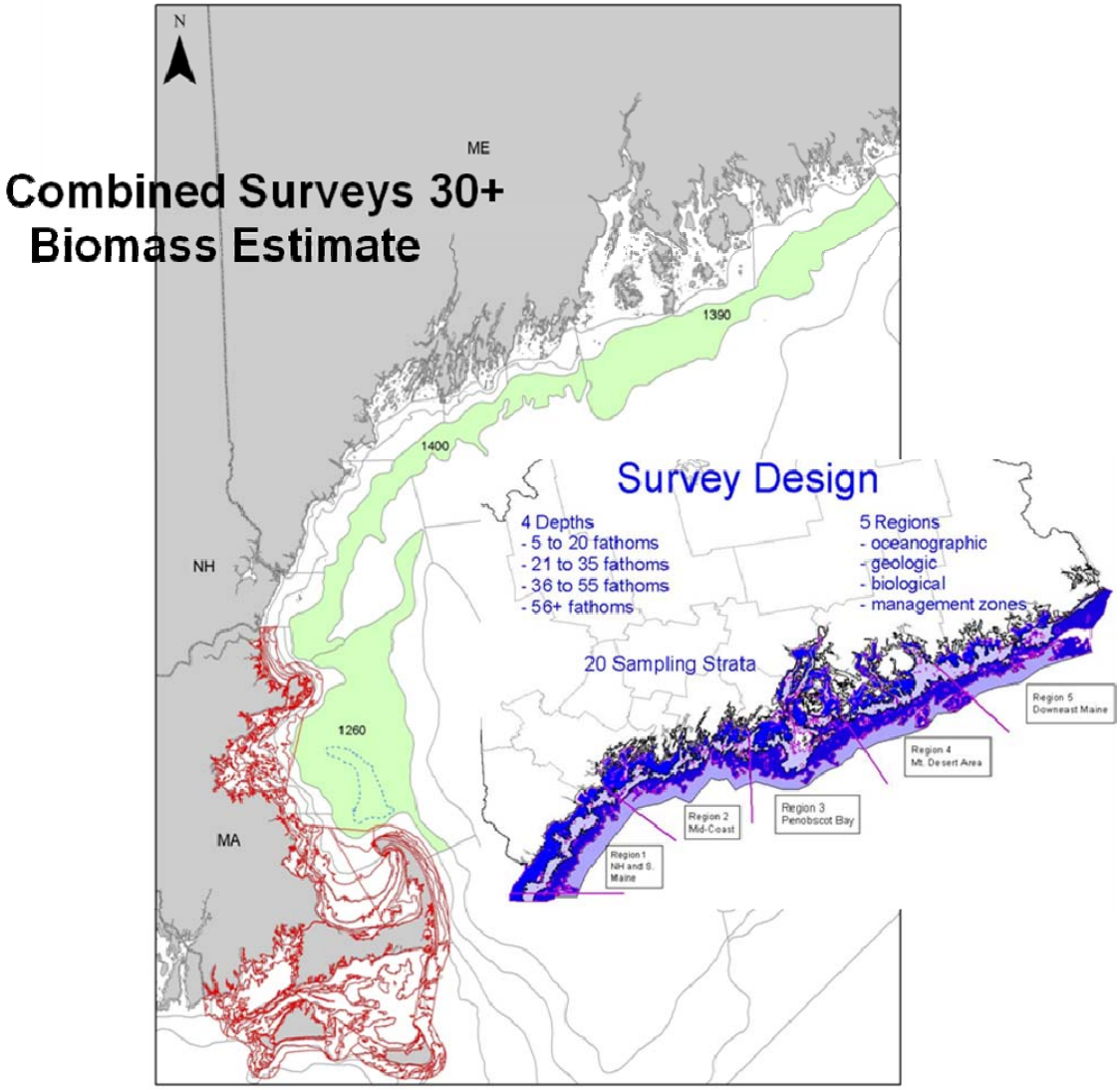
Appendix C1 Figure C1 - Gulf of Maine winter flounder inshore and offshore survey coverage map. Green shaded areas are the NEFSC offshore strata used for the 30+ biomass estimate.



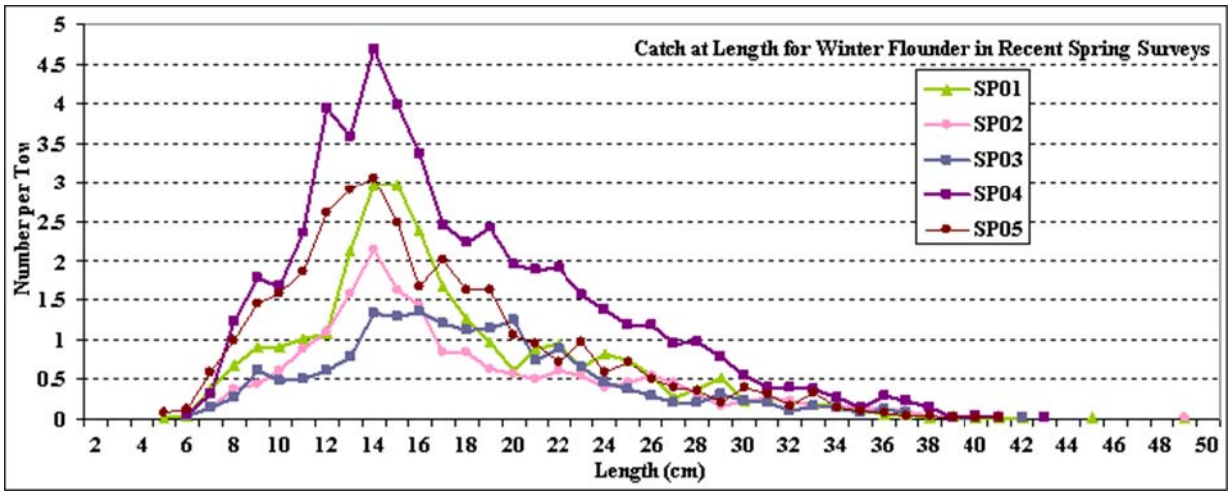
Appendix C1 Figure C2 - Gulf of Maine winter flounder inshore survey overlap between the NEFSC and MDMF surveys.



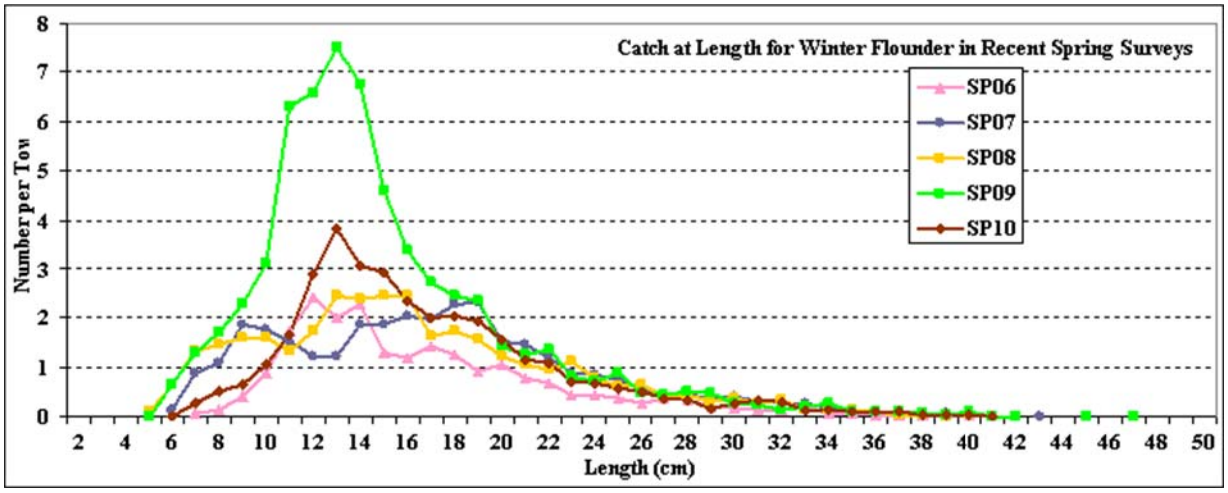
Appendix C1 Figure C3 - MDMF survey strata. The gulf of Maine winter flounder stock uses strata north of Cape Cod.



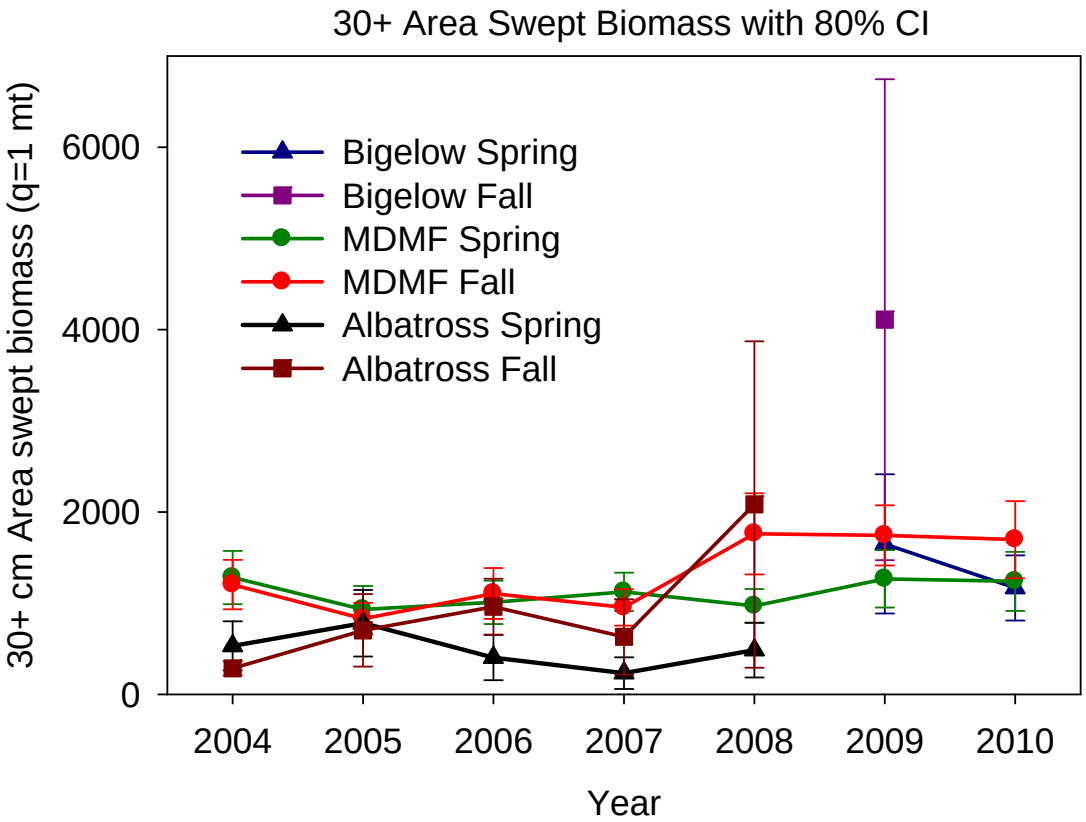
Appendix C1 Figure C4 - NEFSC, MDMF, and MENH survey areas used in the combined survey 30+ cm biomass estimate.



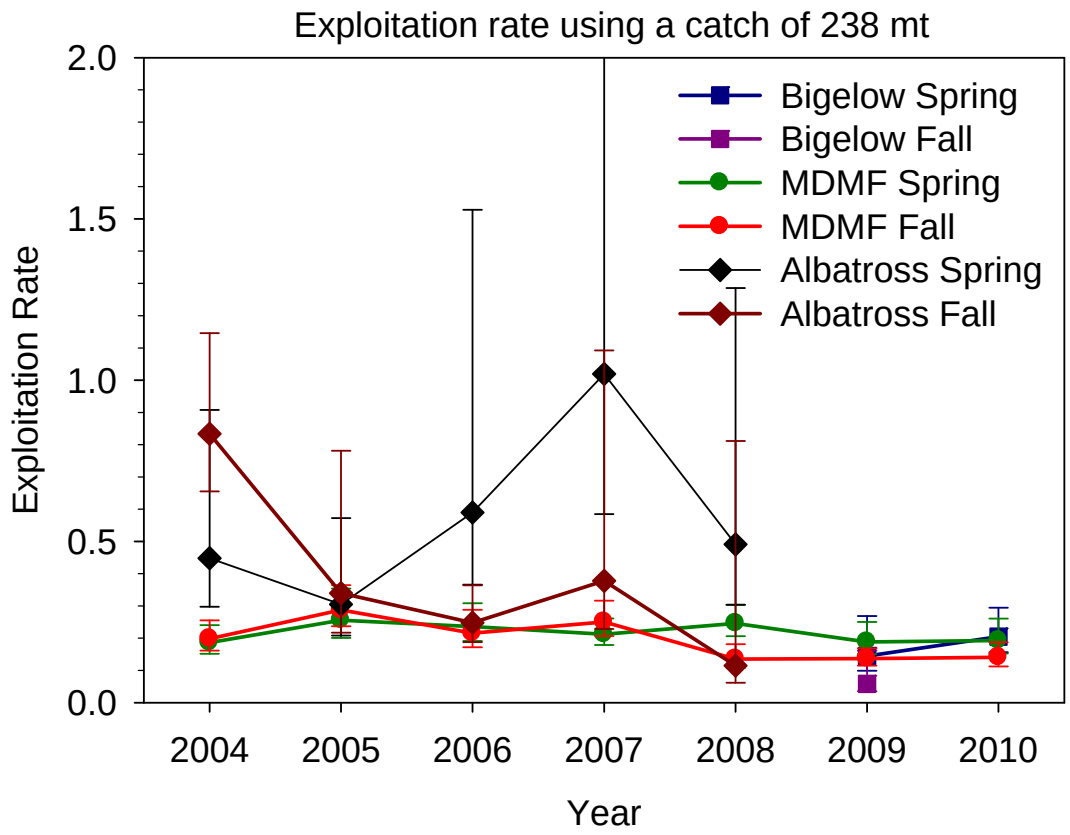
ME/NH Survey Spring



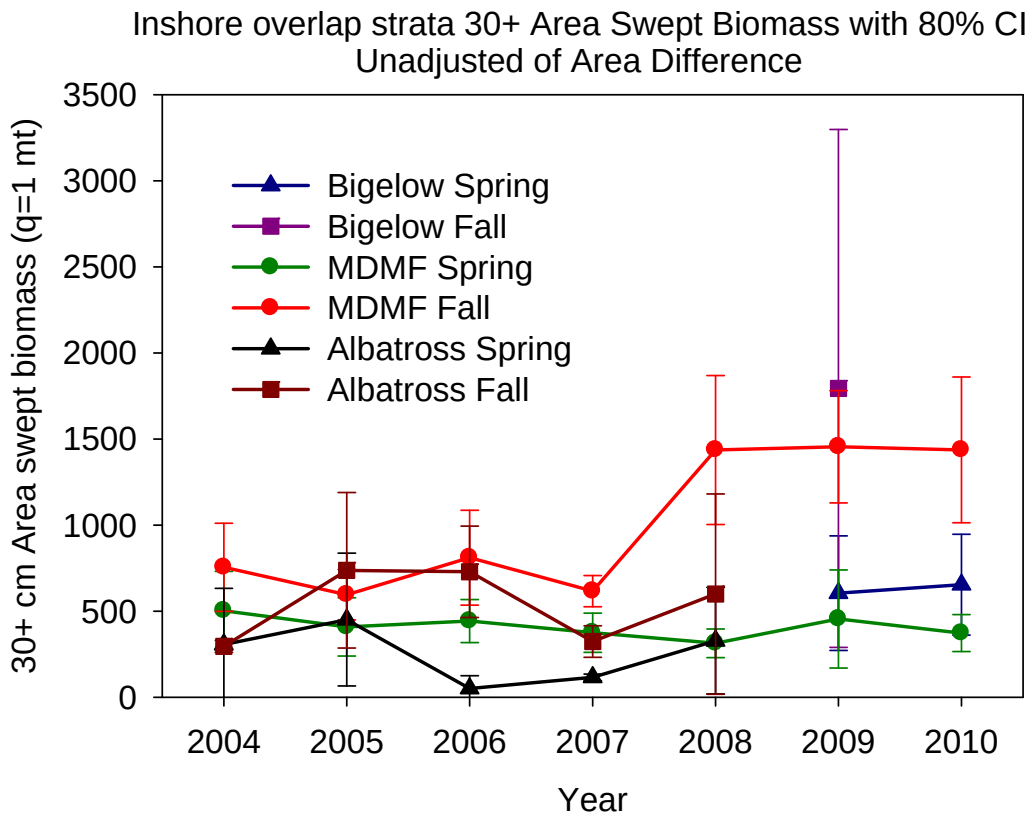
Appendix C1 Figure C5 - Numbers per tow at length from the inshore MENH survey. Relatively few fish 30 cm and greater are caught in the MENH survey.



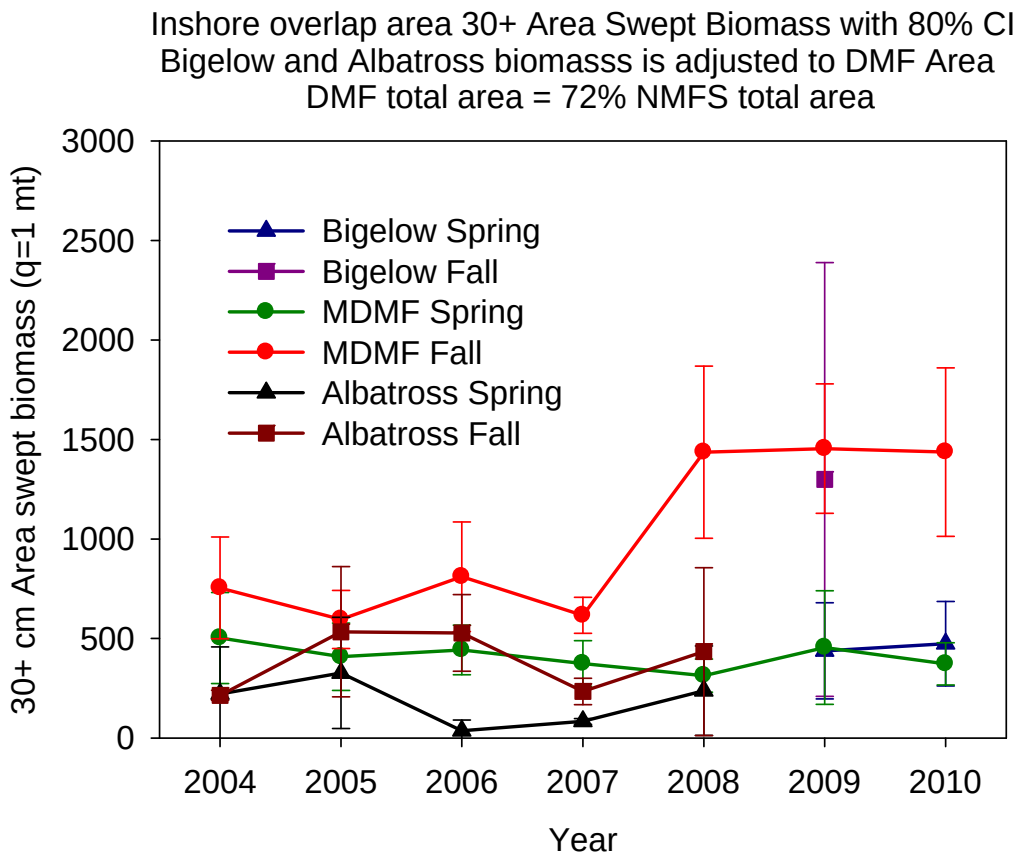
Appendix C1 Figure C6 - Minimum area swept exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals for the NEFSC (Albatross and Bigelow) and MDMF survey. Bigelow estimates were not adjusted to Albatross units.



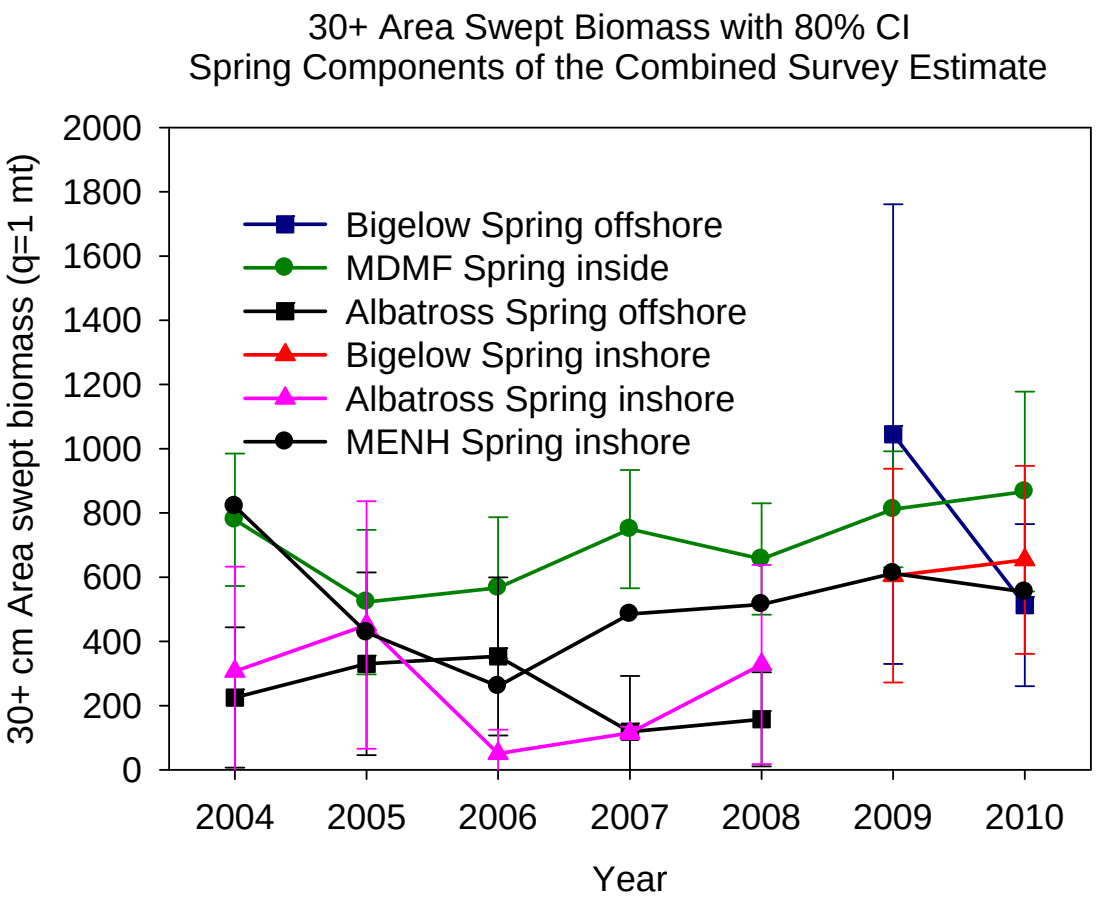
Appendix C1 Figure C7 - Exploitation rates assuming the ABC of 238 mt by year with the associated 80% confidence intervals for the NEFSC (Albatross and Bigelow) and MDMF surveys. Bigelow estimates were not adjusted to Albatross units.



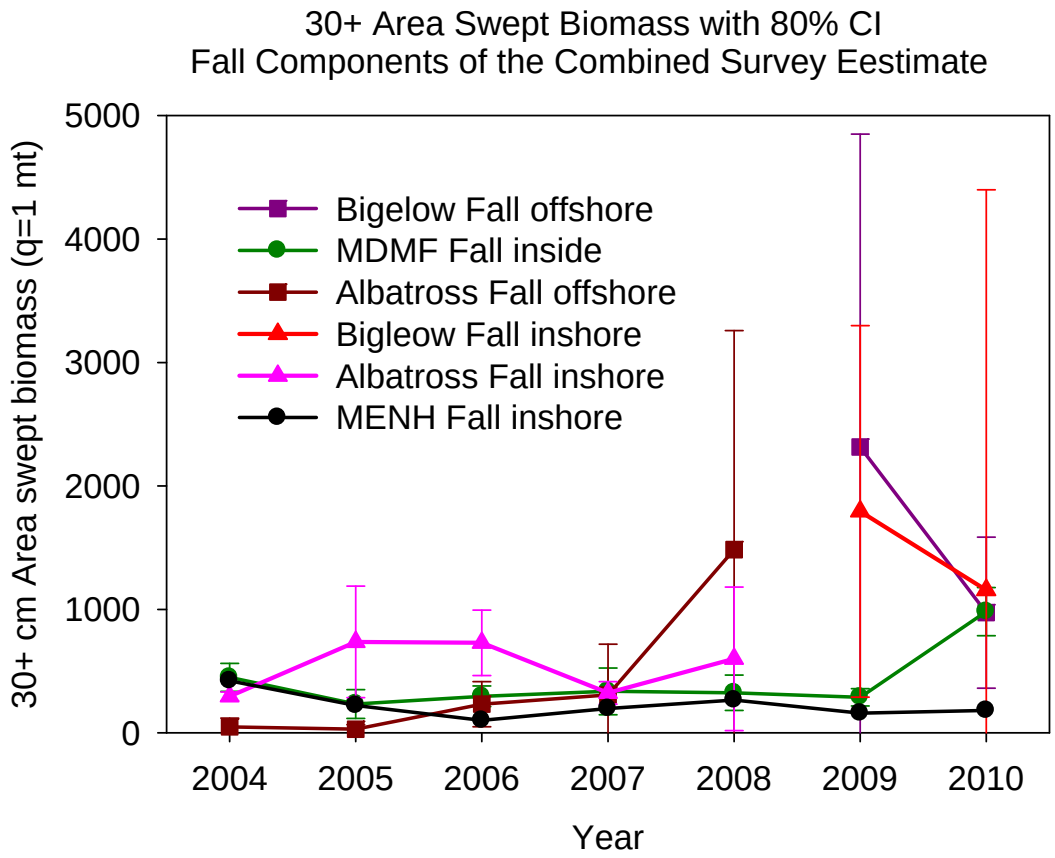
Appendix C1 Figure C8 - Minimum unadjusted area swept exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals limited to the overlap strata between the NEFSC (Albatross and Bigelow) and MDMF surveys. Bigelow estimates were not adjusted to Albatross units. NEFSC overlap strata equals 72% of the total DMF overlap area.



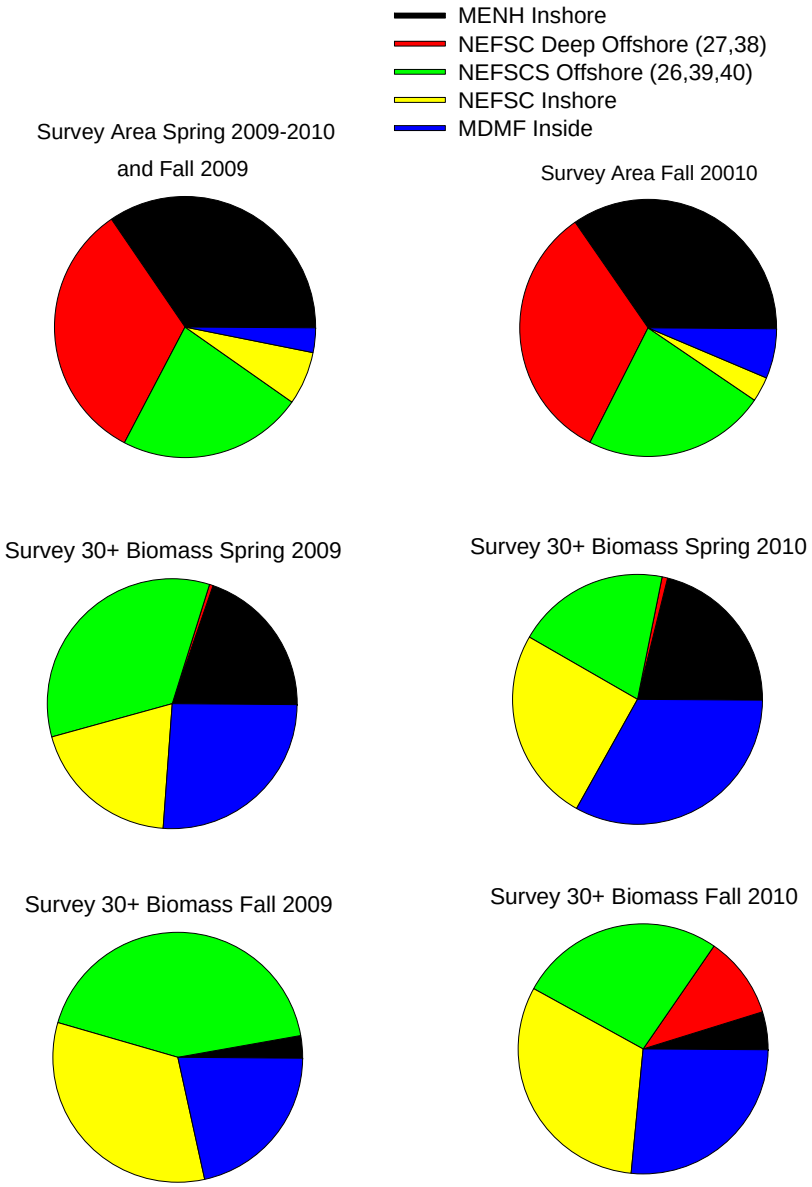
Appendix C1 Figure C9 - Minimum area adjusted area swept exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals limited to the overlap strata between the NEFSC (Albatross and Bigelow) and MDMF surveys. Bigelow estimates were not adjusted to Albatross units. NEFSC overlap strata equals 72% of the total DMF overlap area.



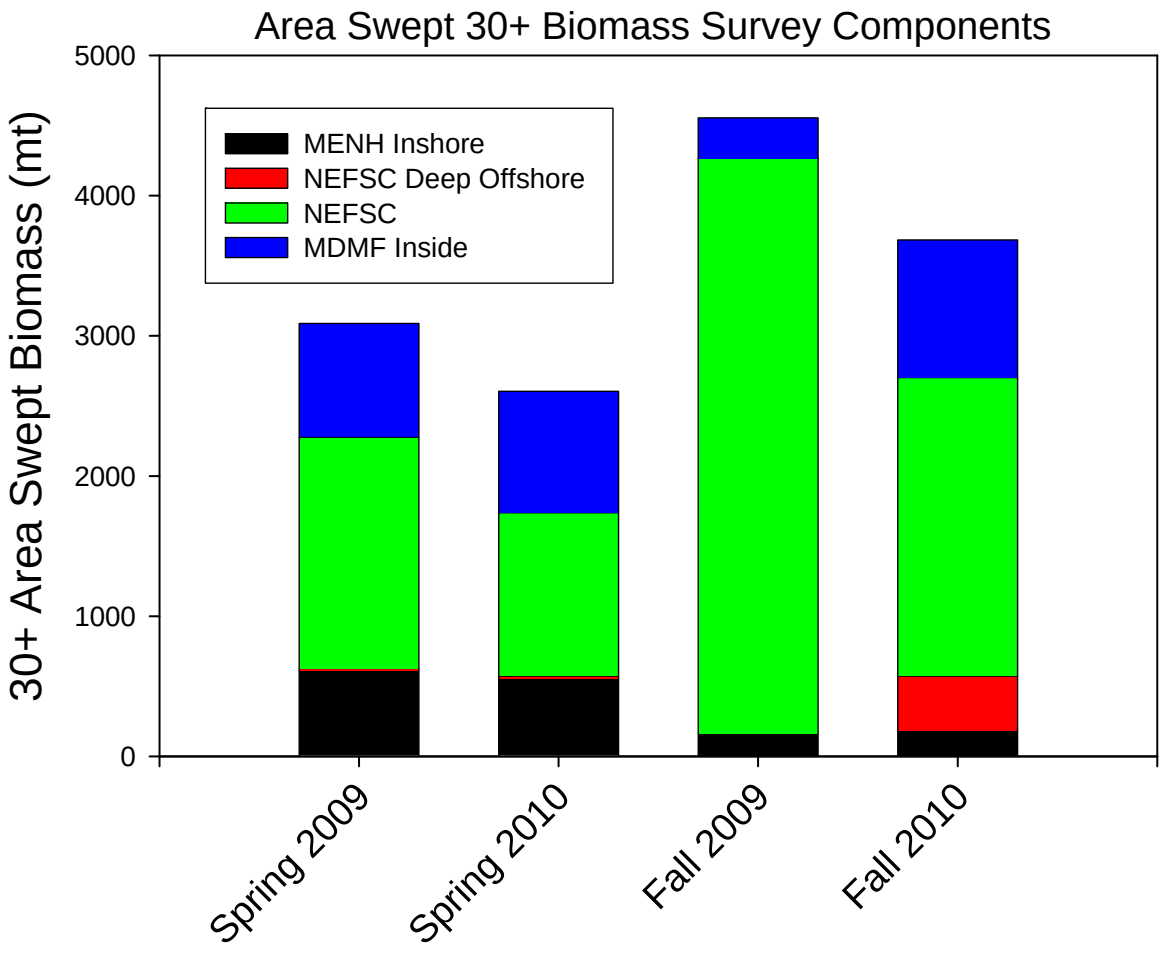
Appendix C1 Figure C10 - Spring minimum area swept exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals for the non-overlapping strata used in the combine biomass estimate. Bigelow estimates were not adjusted to Albatross units.



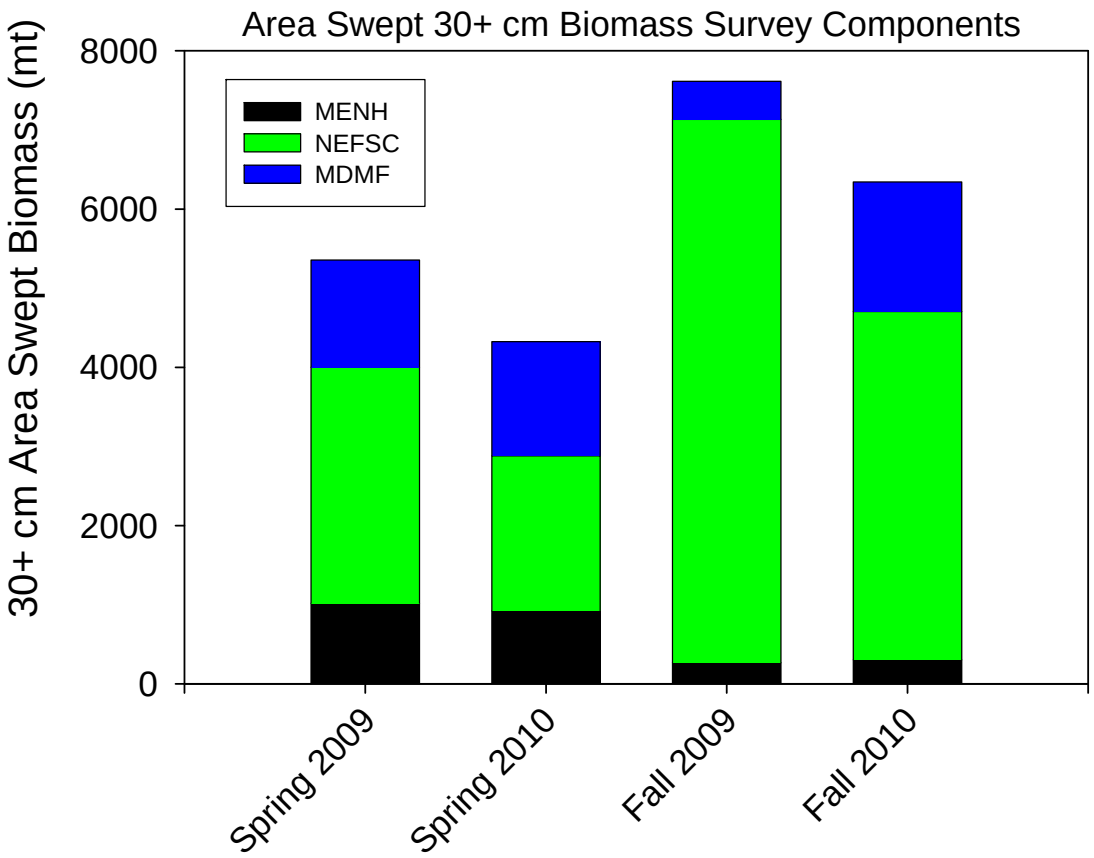
Appendix C1 Figure C11 - Fall minimum area swept exploitable biomass (30+cm) estimates by year with the associated 80% confidence intervals for the non-overlapping strata used in the combine biomass estimate. Bigelow estimates were not adjusted to Albatross units.



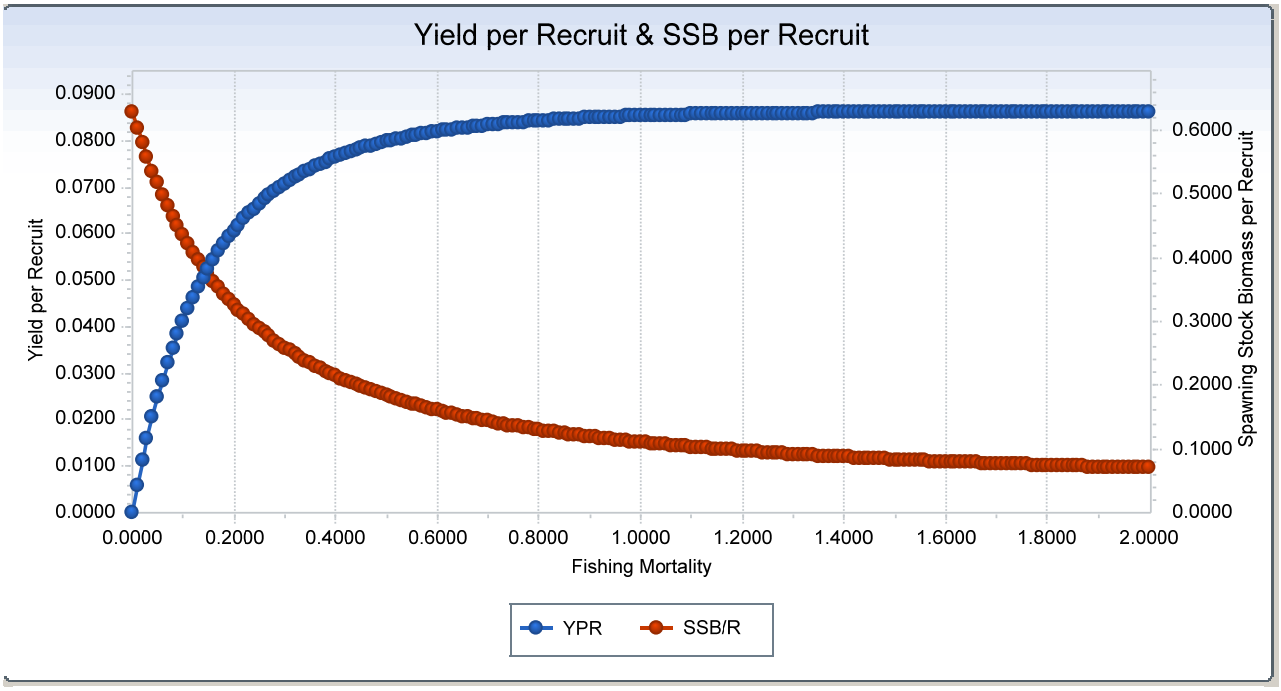
Appendix C1 Figure C12 –Pie charts of area coverage for each survey or NEFSC survey components (top). The Fall 2010 has a different area makeup due to the lack of coverage of Cape Cod Bay strata by the NEFSC survey. The estimated 30+ biomass for each component are shown for the spring 2009-2010 and fall 2009-2010 surveys.



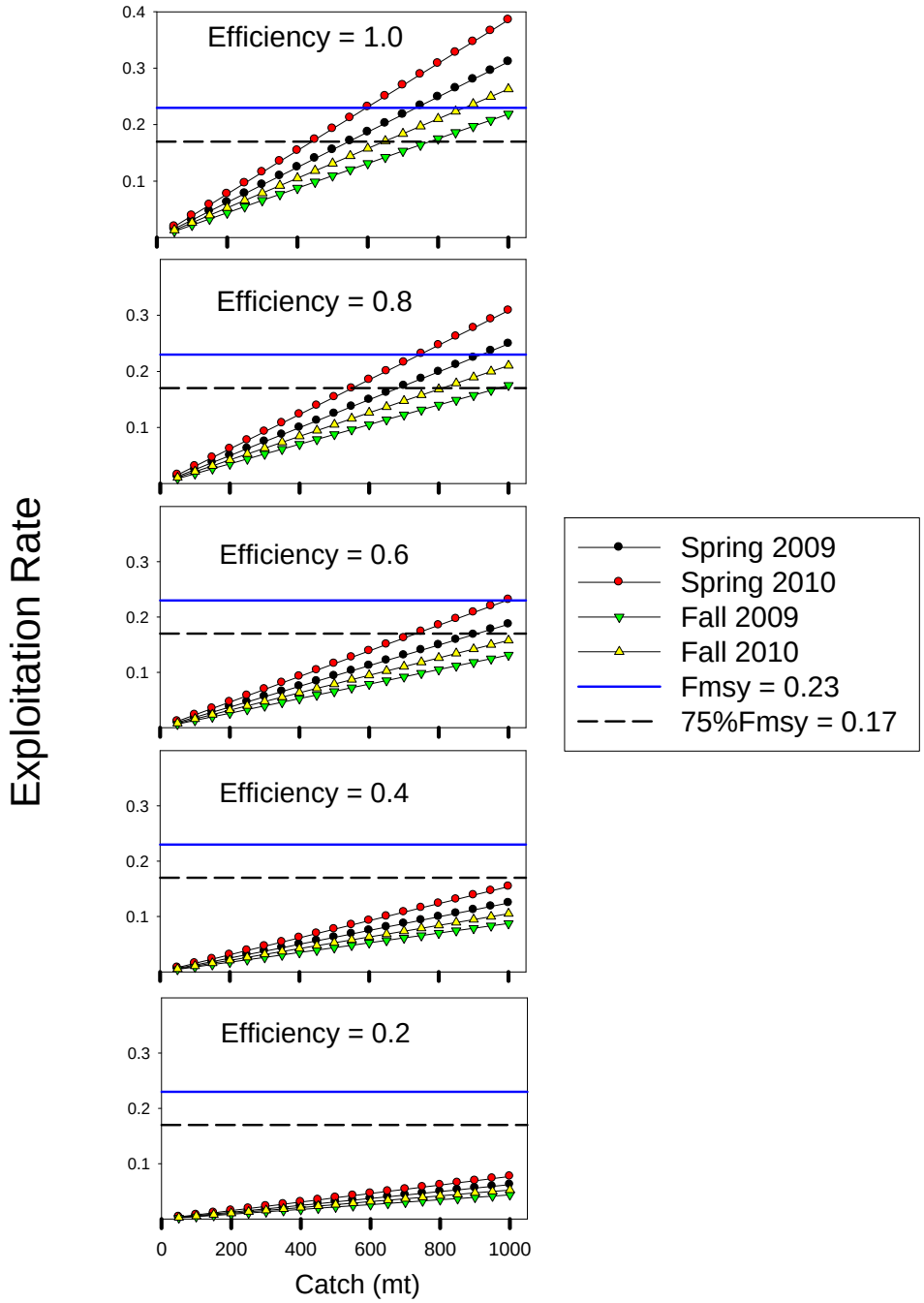
Appendix C1 Figure C13. 30+ area swept biomass estimates for the spring and fall surveys from 2009 to 2010 assuming efficiency is 1.0. The effect of using the NEFSC deep offshore strata (27, 38) can be seen in red. These strata were not used in the final estimates due to the lack of fish present in the deeper central part of the gulf of Maine.



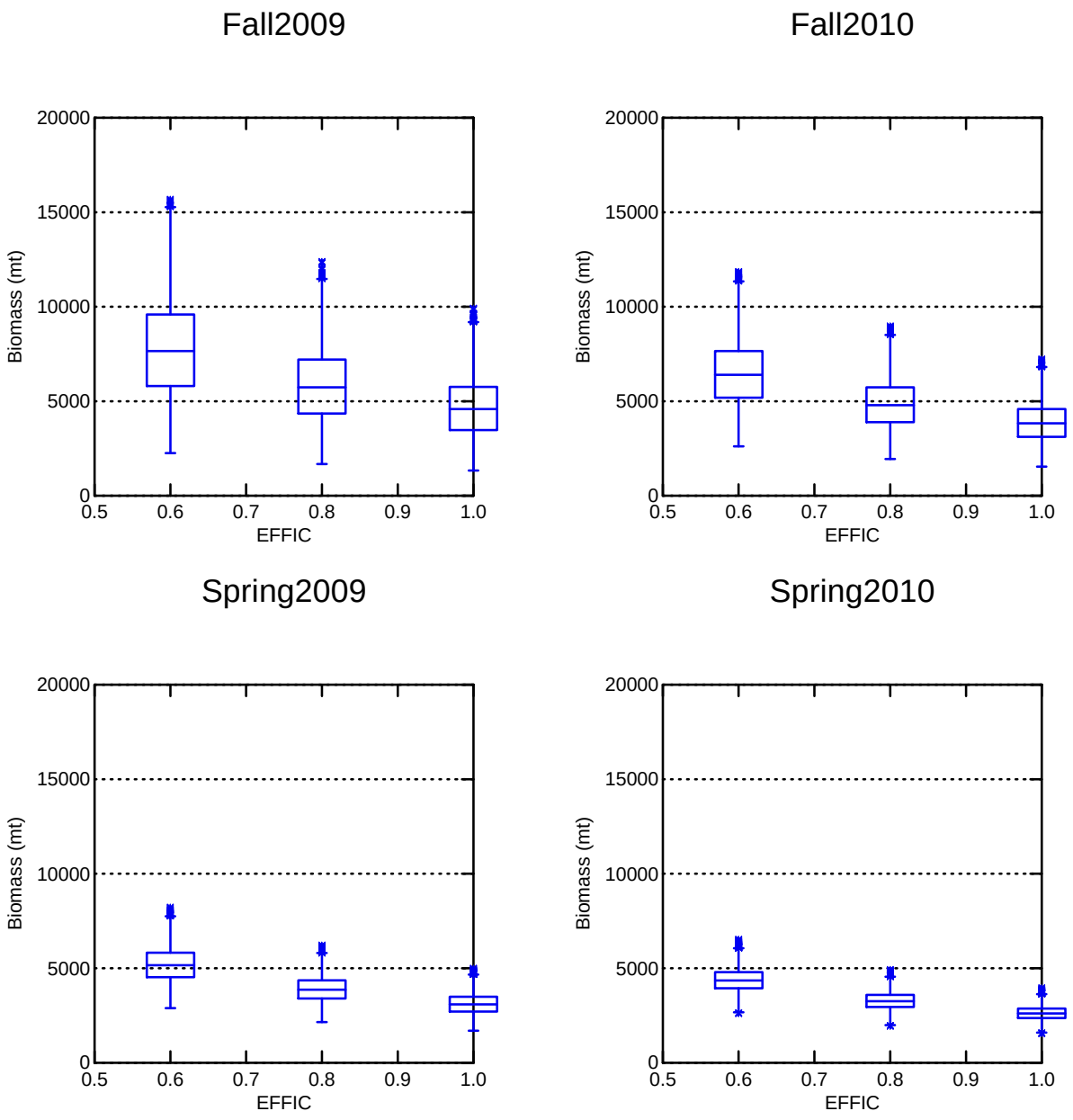
Appendix C1 Figure C14. The 30+ cm area swept biomass estimates for the spring and fall surveys from 2009 to 2010 assuming an efficiency of 0.6 which was used for overfishing status determination. The NEFSC survey used a TOGA tow criteria of 132x.



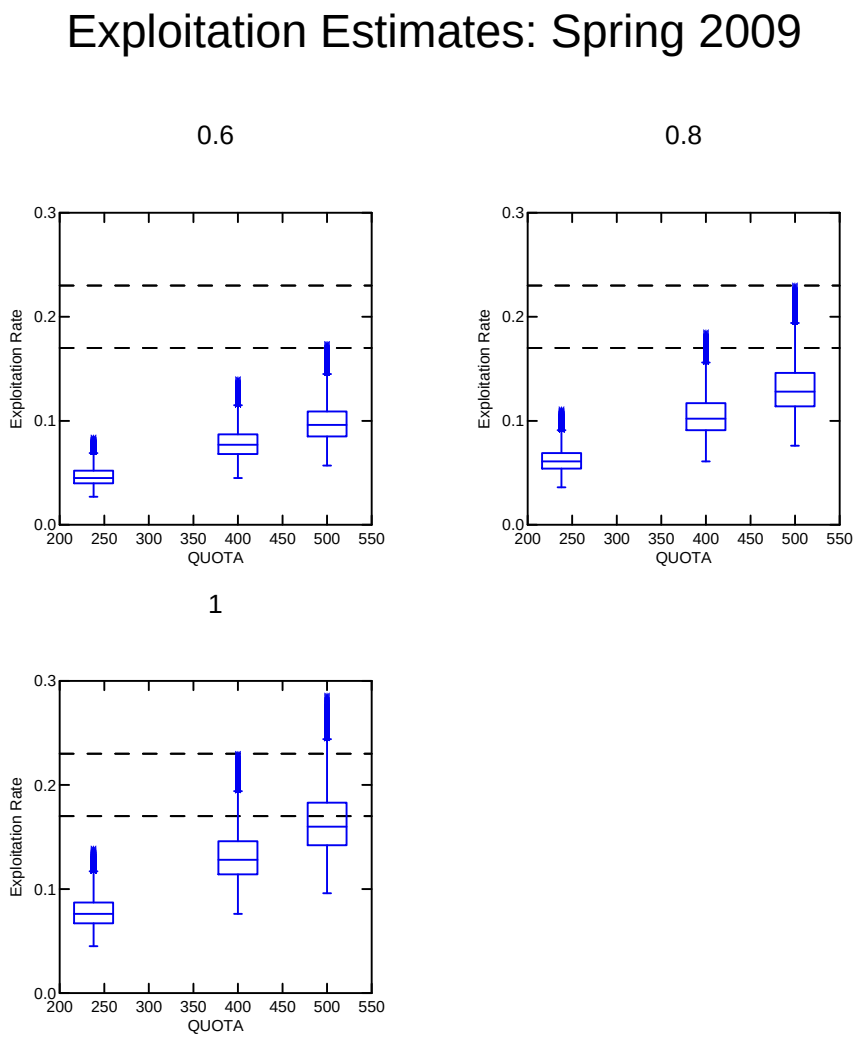
Appendix C1 Figure C15. Length based yield per recruit analysis using updated von Bertalanffy parameters estimated from the spring and fall 2006-2010 NEFSC surveys, maturity at length from the MDMF survey and assuming a natural mortality of 0.3. F40% was estimated at 0.31.



Appendix C1 Figure C16 - Exploitation rate (catch over survey biomass) for a range of catches using the combined surveys (spring and fall 2009 20010) assuming different efficiencies (0.2 to 1.0). Solid blue line is exploitation rate at Fmsy = 0.23 and the dashed black line is the exploitation rate at 75% F_{MSY} (0.17).

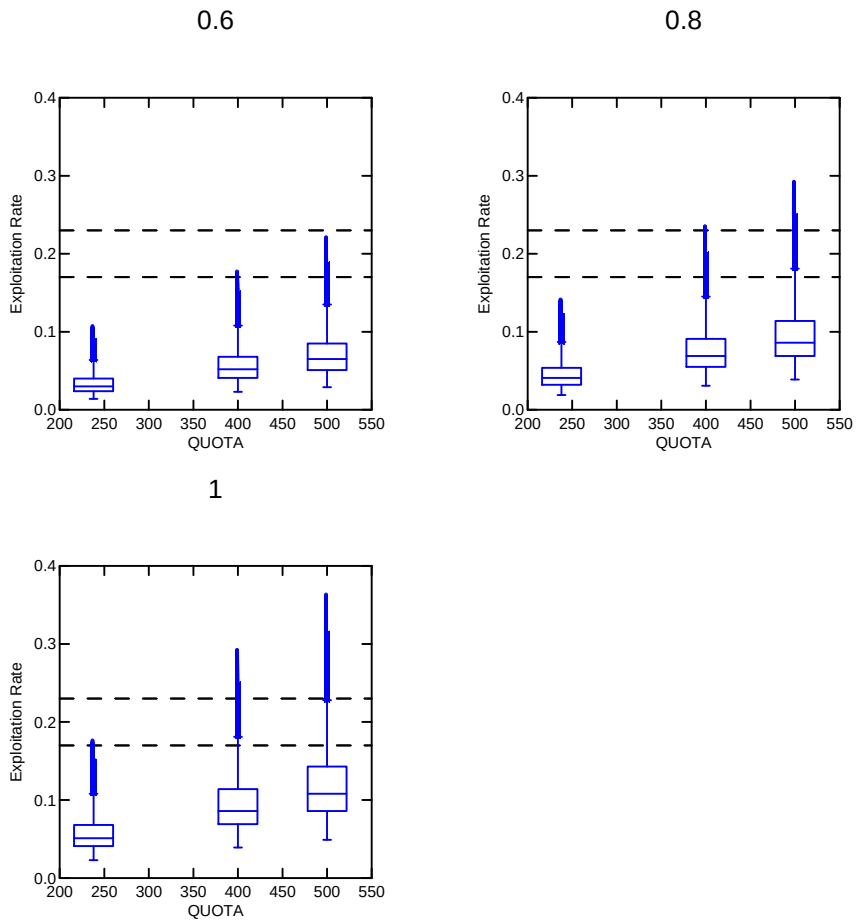


Appendix C1 Figure C17 - Sensitivity of swept area 30+ cm biomass estimates for Gulf of Maine winter flounder for varying seasons and years under three alternative assumed values of trawl efficiency for all three surveys.

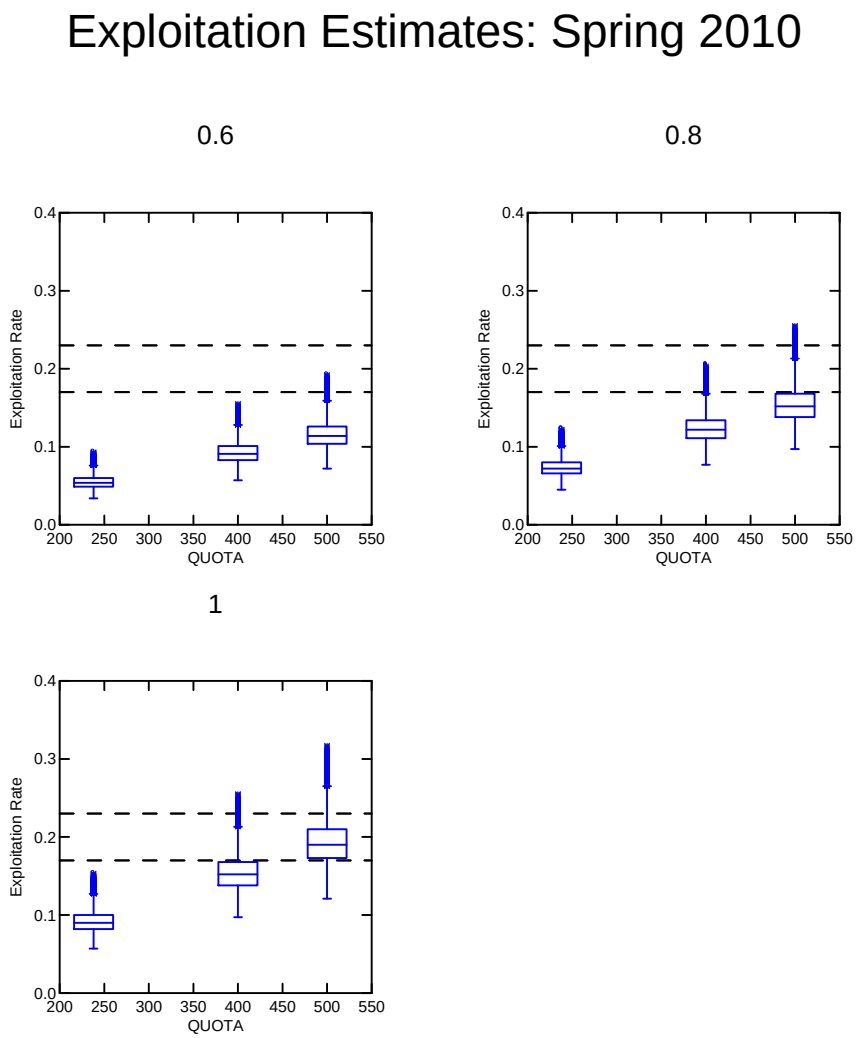


Appendix C1 Figure C18 - Estimated exploitation rates for Gulf of Maine winter flounder for spring 2009 based on three assumed estimates of gear efficiency (0.6, 0.8, and 1.0) and three assumed catch quotas of 238, 400, and 500 mt. Dashed lines represent length based estimates of F40% and 75% of F40% expressed as exploitation rates (0.23 and 0.17). 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 2009

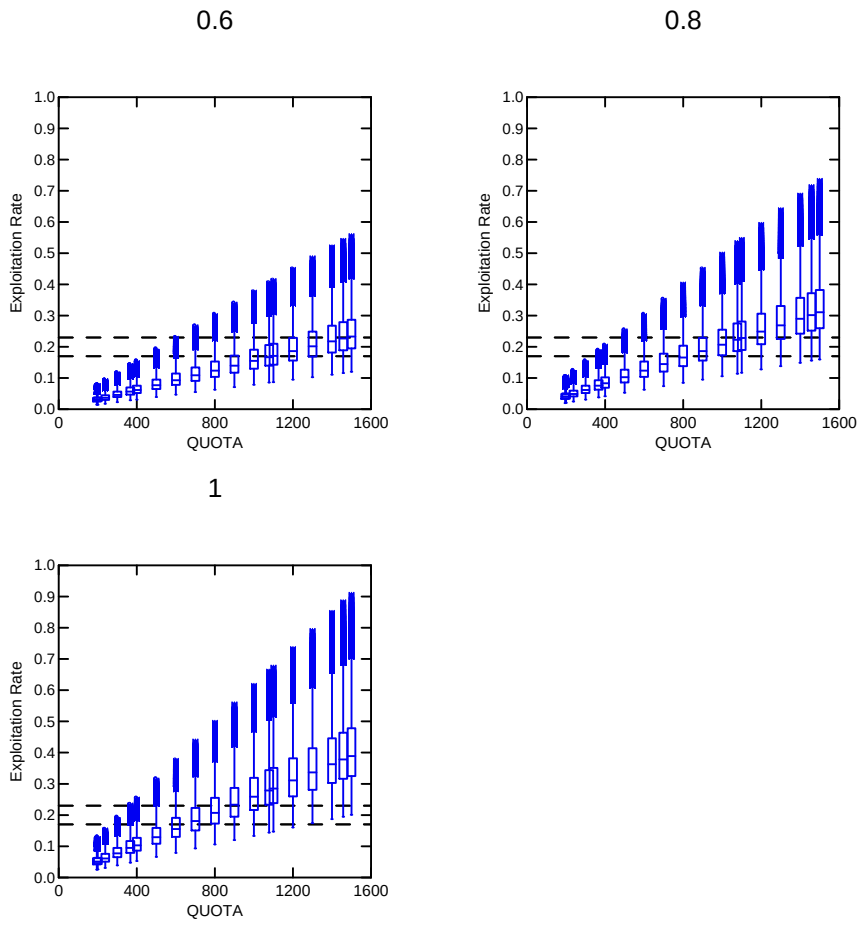


Appendix C1 Figure C19 - Estimated exploitation rates for Gulf of Maine winter flounder for Fall 2009 based on three assumed estimates of gear efficiency (0.6, 0.8, and 1.0) and three assumed catch quotas of 238, 400, and 500 mt. Dashed lines represent length based estimates of F40% and 75% of F40%expressed as exploitation rates (0.23 and 0.17). SSB per recruit is derived using GOM winter flounder growth and maturation relationships and an assumed knife edge selection curve at 30 cm.

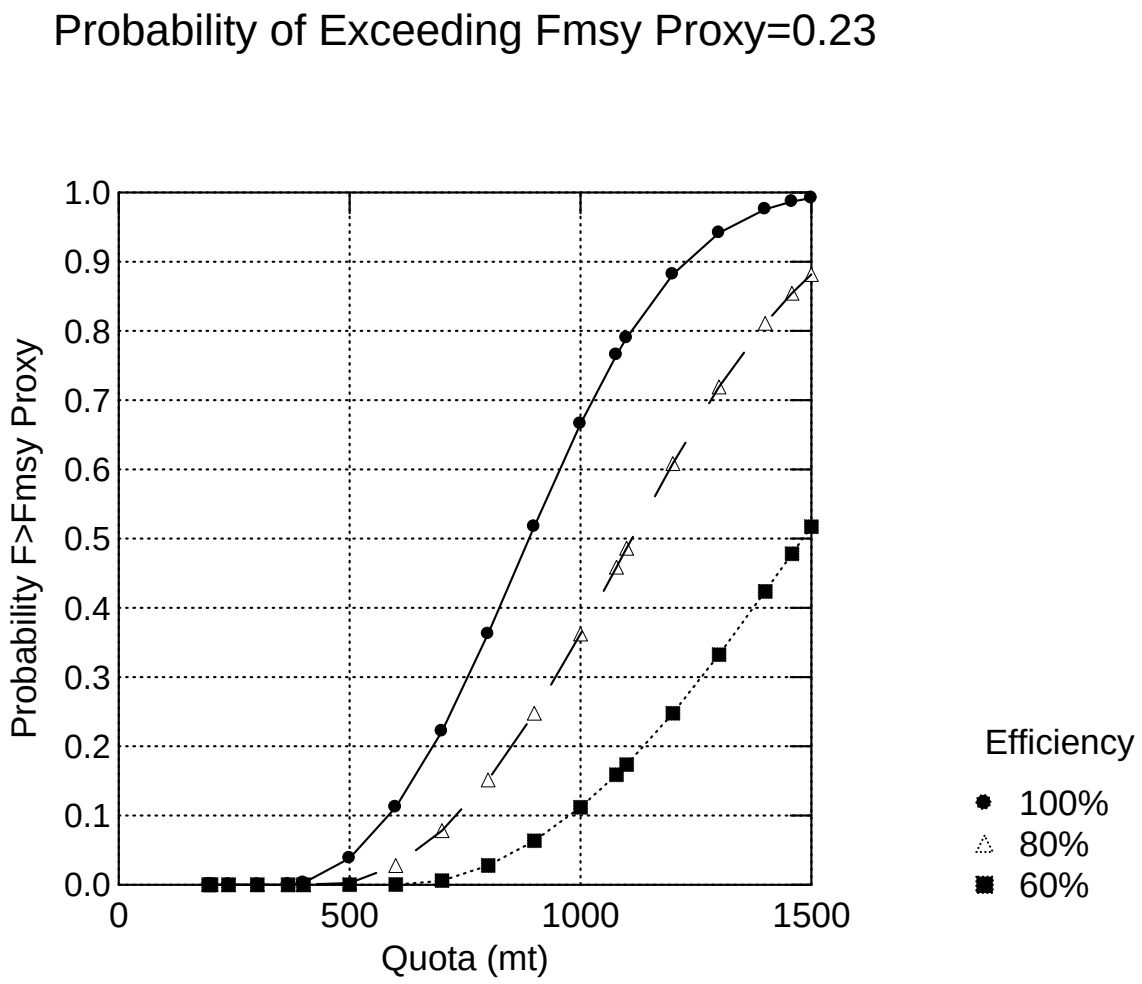


Appendix C1 Figure C20 - Estimated exploitation rates for Gulf of Maine winter flounder for Spring 2010 based on three assumed estimates of gear efficiency (0.6, 0.8, and 1.0) and three assumed catch quotas of 238, 400, and 500 mt. Dashed lines represent length based estimates of F40% and 75% of F40% expressed as exploitation rates (0.23 and 0.17). SSB per recruit is derived using GOM winter flounder growth and maturation relationships and an assumed knife edge selection curve at 30 cm.

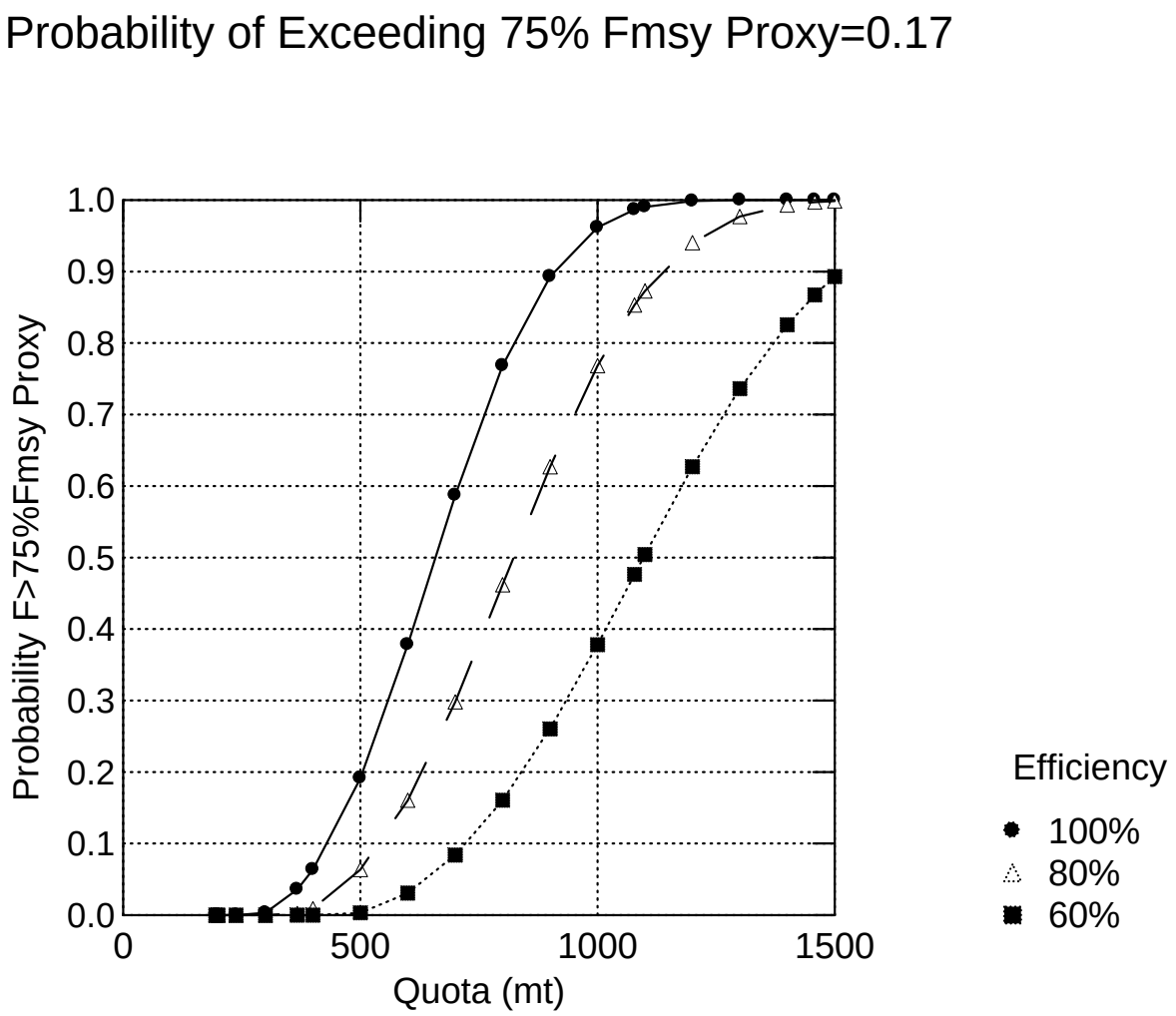
Exploitation Estimates: Fall 2010



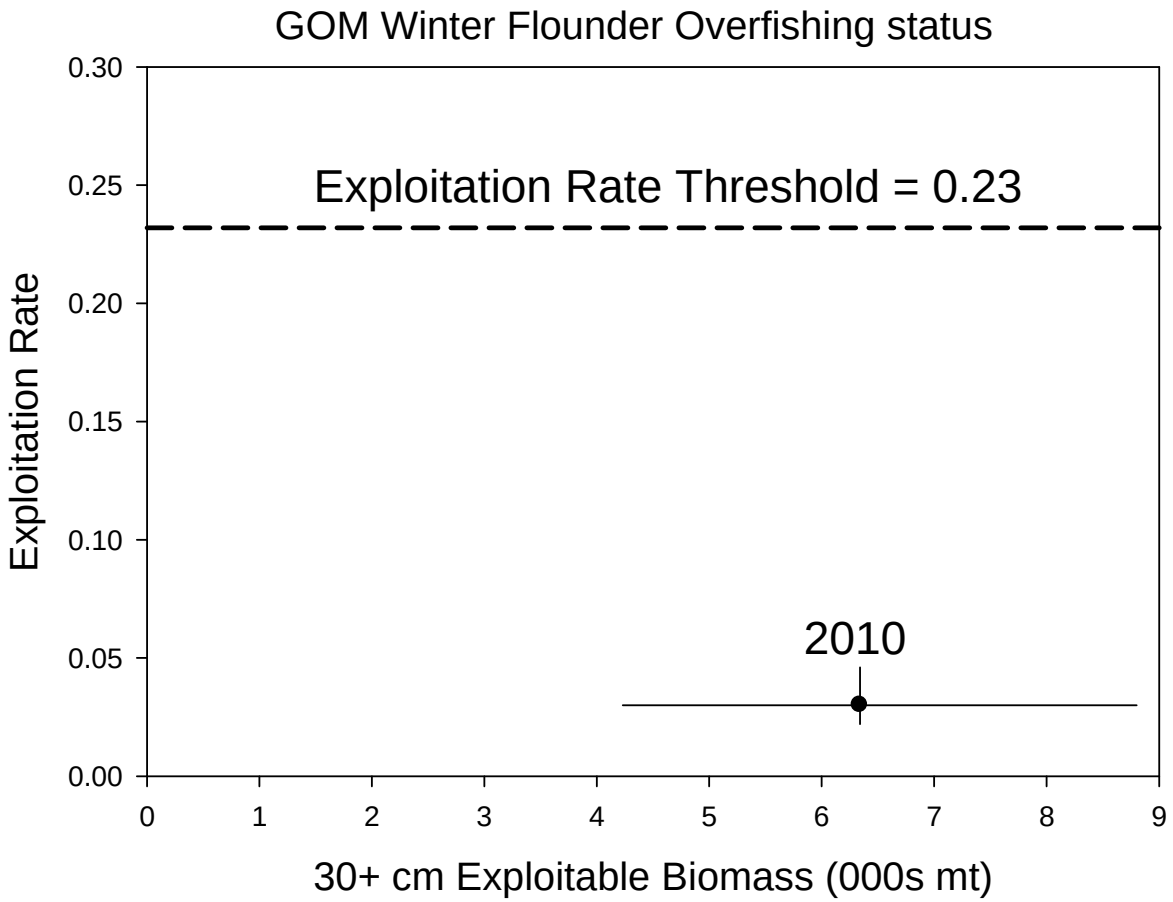
Appendix C1 Figure C21. Estimated exploitation rates for Gulf of Maine winter flounder for Fall 2010 based on three assumed estimates of gear efficiency (0.6, 0.8, and 1.0) and the 2010 catch of 195 mt, an assumed quota of 500 mt, 700 mt, 75% OFL of 1,078 mt and the OFL of 1,458 mt based on F40%. Dashed lines represent length based exploitation rate estimates of F40% (0.23) and 75% of F40% (0.17). SSB per recruit is derived using GOM winter flounder growth and maturation relationships and an assumed knife edge selection curve at 30 cm.



Appendix C1 Figure C22. Estimated probability of exceeding FMSY (F40 proxy) of 0.23 expressed as an exploitation rate assuming efficiencies of 60%, 80% and 100% base of the fall 2010 surveys across a range of quotas.



Appendix C1 Figure C23. Estimated probability of exceeding 75% of FMSY (F40 proxy) of 0.17 expressed as an exploitation rate assuming efficiencies of 60%, 80% and 100% base of the fall 2010 surveys across a range of quotas.



Appendix C1 Figure C24. Stock status for GOM winter flounder in 2010 with respect to MSY-based BRPs; error lines are 80% confidence intervals. F40% of 0.31 corresponds to an exploitation rate of 0.23.