

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

1.0 Background

Witch flounder, *Glyptocephalus cynoglossus*, is assessed as a unit stock from the Gulf of Maine southward (Figure F1). An analytical assessment was last conducted for this species in 2008 at the Groundfish Assessment Review Meeting (GARM 2008; Wigley and Col 2008). Witch flounder was overfished and overfishing occurred in 2007. The 2008 assessment indicated average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.70 in 1988, declined to 0.23 in 1992, increased to 1.14 in 1996, then declined to 0.29 in 2007. Spawning stock biomass declined steadily from 16,903 mt in 1982 to 3,877 mt in 1996 and then increased to 6,874 mt in 2000 and declined to 3,434 mt in 2007. Since 1982, recruitment at age 3 has ranged from approximately 2 million fish (2002 year class) to 26 million fish (2004 year class) with a mean (1979 – 2005 year classes) of 11.1 million fish. The retrospective analysis indicates a pattern of overestimation of average F prior to 2003 and then underestimation for average F from 2003 onward. A similar ‘flip’ pattern was also evident for spawning stock biomass. Spawning stock biomass was underestimated prior to 2001 and then overestimated from 2001 onward. The retrospective analysis for Age 3 recruits indicated an overestimation prior to 2001 and then an underestimation from 2002 onward. NEFSC bottom trawl survey indices generally declined from the early 1960s to record low levels in the late 1980s and early 1990s. Since then survey indices increased but have exhibited a declining trend since 2001. Biological reference points were estimated. A yield and spawning stock per recruit analysis was performed using 5-year (2003-2007) averages for partial recruitment, stock weights, catch weights and maturity (2004-2008). Based on yield and SBB per recruit analysis, a proxy of F_{MSY} was F_{40%MSY} = 0.20. A long-term stochastic projection estimated SSB_{MSY} = 11,447 mt and MSY = 2,352 mt. The long-term projections used a constant F scenario (F = F_{MSY} = 0.20), estimates of Age 3 recruitment derived by re-sampling the cumulative density functions based on empirical observations during 1982 to 2008 (1997 to 2005 year classes), proportions of F and M which occur before spawning (0.1667; March 1) and M = 0.15 (Wigley and Col 2008).

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

2.0 Fishery

Commercial landings

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

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

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

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

<http://www.nefsc.noaa.gov/fbp/QA-QC/index.html>.

Discard estimation

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

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

The estimation of large-mesh otter trawl discards is based upon two methods. For 1982 to 1988, a method which filters survey length frequency data through a commercial gear retention ogive and a culling ogive was used and then a semi-annual ratio estimator of survey-filtered 'kept' index to semi-annual numbers landed was used to expand the estimated 'discard' survey index to

numbers of fish discarded at length (Wigley et al. 2003). For 1989 to 2010¹, an annual combined ratio of witch flounder discard weight to kept weight of all species ratios (d/k_{all}) was calculated from observer data. Total discard weight was derived by multiplying the d/k_{all} ratio by the commercial large-mesh otter trawl landings. Observed discard length frequencies are used to estimate discarded fish at length. Semi-annual numbers of fish discarded were apportioned to age using the corresponding seasonal NEFSC survey age/length key. Discards from the large-mesh otter trawl fishery account for the majority of total discards (Table F6). Witch flounder discarded in the large-mesh otter trawl fishery range in age from 0 to 6, with the majority at ages 4 to 5. Discards at age and mean weights at age from the large-mesh otter trawl and northern shrimp trawl fleets are presented in Tables F7 and F8 and Figure F4.

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

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

3.0 Research Vessel Surveys

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

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

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

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

NEFSC Survey conversion factors: 1963 to 2008

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

NEFSC Survey conversion factors: 2009 - 2011

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

4.0 Assessment

Input Data and analysis

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

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

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

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

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

Selection of a final VPA run

The precision of the stock size estimates are similar between all the formulations. Among the four VPA runs (Runs D, E, F and G), the SPLIT RUN had best model fit with the lowest values of residual sums of squares and mean square residual and the least retrospective pattern (Table F13). The VPA runs had similar retrospective patterns indicating that average F was underestimated, SSB was overestimated and Age 3 recruitment exhibited a ‘flip’ (change in direction) pattern (overestimated than underestimated). The Mohn rho statistics (described below) of the VPA SPLIT run indicate that the retrospective pattern is less severe than the other model formulations (Table F14) for average F , SSB and Age 3. In addition to the summary of terminal year estimates (Table F13), comparisons of trends in F , SSB and Age 3 recruit from the GARM 2008 (Run A), SPLIT RUN (Run D), and NO SPLIT (Run E) are given in Appendix Figure F5 and from the SPLIT RUN (Run D), SPLIT LCF1 (Run F) and SPLIT LCF2 (Run G)

are given in Appendix Figure F6. The combination of: 1) the contraction of the age structure observed in the survey indices at age and the commercial catch at age; 2) the low NEFSC survey abundance and biomass indices in recent years; and 3) the magnitude of the 2004 year class at age 3 relative to the age 3 abundance indices over the entire time series (Appendix Figure F4), indicating a strong 2004 cohort but not exceptional year class, all seem to suggest that the VPA SPLIT RUN more accurately characterizes the witch flounder population. The VPA SPLIT RUN is used for biological reference point calculations and for stock status determination.

VPA SPLIT RUN results

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

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

Mohn rho statistic (Mohn 1999; GARM 2008) was derived by taking the average of seven (2003 – 2009) relative differences between the quantity (e.g. F, SSB and Age 3) from the reduced time series assessment and the same quantity from the full assessment. The SPLIT RUN Mohn rho statistics for F, SSB and Age 3 was -0.33, 0.61 and 0.06, respectively (Table F14).

The precision of the 2011 stock size at age, F at age in 2010, and SSB in 2010 from the VPA SPLIT RUN was evaluated using bootstrap techniques (Efron 1982). Bootstrap results of the SPLIT RUN suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 19% and 12%, respectively. The 80% confidence interval for $F_{2010}=0.47$ was 0.38 and 0.61, and for $SSB_{2010} = 4,099$ mt the 80% confidence interval was 3,614 mt and 4,874 mt. The range of the bootstrap estimates and the probability of the individual values are presented in Figure F17.

5.0 Biological Reference Points

For this assessment, yield and spawning stock per recruit analyses (YPR v2.7) were updated using 5-year (2006-2010) averages for partial recruitment, stock weights, catch weights and maturity (2007-2011; Table F17). Based on yield and SSB per recruit analyses, a proxy of

F_{msy} is $F40\%MSP = 0.27$ for the SPLIT Run (Table F18).

A long-term (100 year) stochastic projection (AGEPRO v4.2) was performed to estimate spawning stock biomass and MSY under equilibrium conditions. The same partial recruitment, mean weights at age and maturity vectors used in the yield and SSB per recruit analysis were also used in the projections. A constant F scenario was used ($F = F_{msy} = 0.27$). Estimates of Age 3 recruitment used in the projections were derived by re-sampling the cumulative density function based on the empirical observations during 1982 to 2009 (1979 to 2006 year classes) from the SPLIT RUN (Table F17). The proportions of F and M which occurs before spawning equals 0.1667 (March 1); M equals 0.15. Comparisons of GARM 2008 and updated biological references points are given in Table F18.

Trends of the age structure of the spawning stock biomass and the age structure under MSY conditions are given in Figure F18. As reported above, SSB in 2010 is well below SSB_{msy}, and the distribution of spawning biomass at age is concentrated at younger ages in 2010, indicating a truncated age structure.

6.0 Projections

Short term projections of catch and spawning stock biomass in 2011 through 2017 were conducted under four F scenarios using the bootstrapped VPA SPLIT RUN calibrated stock sizes in 2011. The partial recruitment, maturity ogive, and mean weights at age (Table F19) are the same as described for biological reference points (using 5 year average mean weight and the 1982 – 2009 series (1979 – 2006 year classes) of Age 3 recruitment and an assumed natural mortality of 0.15.

Short-term median estimates of catch and spawning stock biomass for 2011 through 2017 are given in Table F19. If 2010 fishing mortality is held at F status quo ($F=0.47$), then 2017 catch is forecast to be 2,323 mt and spawning stock biomass is forecast to be 5,212 mt. If fishing mortality is held at F_{msy} ($F=0.27$), then 2017 catch is forecast to be 1,991 mt and spawning stock biomass is forecast to be 9,653 mt. If fishing mortality is held at F75%msy ($F= 0.20$), then 2017 catch is forecast to be 1,770 and spawning stock biomass is forecast to be 10,921 mt. Projections to estimate $F_{rebuild}$ in 2011- 2017 that will rebuild the spawning biomass to SSB_{msy} = 10,051 mt by 2017 indicate that $F_{rebuild} = 0.18$ (attaining 11,233 mt with a 75% confidence; Table F19).

When the 2006-2010 geometric mean is used to estimate Age 3 in 2011 then the estimated stock size is 6.079 million fish rather than 16.044 million fish (61% CV) estimated via the survey tuning indices (Run D, SPLIT RUN; Table F16). If the fishing mortality is held at F75%msy ($F= 0.20$) and 2011 stock sizes with the 2006-2010 geometric mean for Age 3 is used, then the 2012 to 2017 median catches and SSB are lower than the median catches and SSB from the projection using the 2011 stock sizes with Age 3 estimated via the survey tuning indices (Table F19).

7.0 Summary

Based on the VPA SPLIT RUN, witch flounder fishing mortality and spawning stock biomass in 2010 are summarized relative to the biological reference points (Figure F19). The 2010 spawning stock biomass was 4,099 mt, 41% below SSB_{msy} (10,051 mt) and 2010 fishing mortality was 0.47, 173% above F_{msy} ($F=0.27$); therefore, witch flounder was overfished and overfishing occurred in 2010 (Figure F19).

The 2010 witch flounder assessment reveals that discards continue to be a minor component of the total catch. Total catch has declined in recent years and is below the time series average. Fishing mortality has declined substantially since 1996; however, F in 2010 is about twice as high as the estimated fishing mortality in the early 1990s. Spawning stock biomass has shown a general declining trend over the time series. Age 3 recruits have averaged 9.8 million fish over the time series. The 2004 year class appears strong (above the time series average) while the 2005 – 2007 year classes are below the time series average.

Based on yield per recruit analyses, $F_{msy} = F40\%MSP = 0.27$. SSB_{msy} and MSY were estimated using a long-term stochastic projection. SSB_{msy} = 10,051 mt and MSY = 2,075 mt. The 2010 spawning stock biomass age structure remains truncated compared to the conditions under MSY (Figure F18).

Changes from last assessment

Changes from the last assessment were: minor revisions to 2007 catches, software updates and three additional years for data.

Sources of Uncertainty

- Low frequency of samples across market category and quarter results in imprecise mean weights at age and estimates of numbers at age in some years.
- Lack of data to support direct estimates of discards at age requires use of various surrogate survey-based methods.
- The research bottom trawl survey catches very few witch flounder; in many years, the stratified mean number per tow of witch flounder is less than 5 fish. Abundance of witch flounder in the late 1980s and early 1990's may have gone below levels that provide reliable estimates of trends in abundance and biomass.

8.0 Conclusions:

Status of Stock for Witch flounder

SSB in 2010 is estimated to be 4,099 mt.

F in 2010 is estimated to be 0.47.

Updated estimates of the biological reference points are:

SSB_{msy} proxy = 10,051 mt,
F_{msy} proxy = 0.27, and
MSY proxy = 2,075 mt.

Based on these results, witch flounder is overfished and overfishing is occurring. The stock is below the biomass target. This is the same status as reported in GARM-III.

The results are based on the same model (ADAPT VPA) used in GARM-III (NEFSC 2008, CRD#08-15), which includes splitting the time series between 1994 and 1995.

The BRPs are based on the following updates: average of the recent five year partial recruitment, mean weights at age, and maturity, as well as estimates of recruitment from the VPA for years 1982 to 2009.

Witch Flounder. Summary of Assessment Information

Witch Flounder	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg	Min	Max	YrRange
Landings (mt)	3227	3162	2935	2662	1871	1086	1012	963	765		2700	765	6675	1937-2010
Discards(mt)	225	334	309	150	87	97	63	104	89		162	25	339	1982-2010
Catch (mt)	3413	3458	3226	2802	1950	1173	1071	1058	848		2951	848	6760	1982-2010
SSB (mt)	6168	5504	4221	3756	2757	2710	3194	3900	4099	-	6555	2710	16903	1982-2010
F age 8-9	0.54	0.75	0.93	0.84	0.85	0.521	0.55	0.41	0.47	-	0.60	0.23	1.14	1982-2010
Recruitment, Age 3 millions	11.213	8.476	5.106	3.702	4.521	2.438	7.277	3.962	5.119	16.044	9.390	2.438	17.706	1982-2011

Panel Comments

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

The GARM III assessment used the split series model to reduce the retrospective pattern, but it did not eliminate the retrospective pattern. This update assessment also uses the split series model to reduce but not remove the retrospective pattern. The remaining retrospective pattern in this assessment is larger than in the GARM III assessment. Although the split leads to a reduction in retrospective bias, it does not identify the underlying causes or imply its persistence. This situation is similar to other stocks for which the split was used to remove a retrospective pattern.

The sensitivity run that used a 5 year geometric mean in stock projections indicated that recruitment in terminal year of current assessment is likely to be substantially overestimated. When the 2006-2010 geometric mean is used to estimate Age 3 in 2011, the estimated stock size is 6.079 million fish rather than 16.044 million fish estimated via the survey tuning indices. The projected SSB and median catches are substantially lower when the 5-year geometric mean recruitment is used compared to the estimates using terminal year estimates of recruitment.

The Panel discussed the declining trends in mean weights at age for the middle and older ages. Possible causes of the declines are the imprecise estimation of mean weights at age in the earlier time series, selective fishery removals, or an actual decline in growth rates of older fish. The issue of changing weights in age has been noted in a number of groundfish stocks, and research into its cause should be continued. This has been identified as a source of uncertainty. Concern was expressed that if there is a difference in the weight at age in commercial samples and survey samples, using only the commercial catch mean weights at age as population mean weights could lead to the overestimation of population biomass.

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

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

9.0 Acknowledgments

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Table F1. Witch flounder landings, discards and catch (metric tons, live) by country, 1937-2010 [1937-1959 provisional landings reported in Lange and Lux, 1978; 1960-1963 reported to ICNAF/NAFO (Burnett and Clark, 1983)].

Year	LANDINGS						USA Discards	USA Catch
	USA Subarea 4, 5 & 6	USA Subarea 3	USA Total	CAN	Other	Total		
1937			5000			5000		
1938			3600			3600		
1939			3100			3100		
1940			3000			3000		
1941			2000			2000		
1942			1800			1800		
1943			1000			1000		
1944			1000			1000		
1945			1000			1000		
1946			1500			1500		
1947			1500			1500		
1948			1000			1000		
1949			3600			3600		
1950			3000			3000		
1951			2600			2600		
1952			3700			3700		
1953			4200			4200		
1954			4000			4000		
1955			2400			2400		
1956			2000			2000		
1957			1000			1000		
1958			1000			1000		
1959			1000			1000		
1960	1255		1255			1255		
1961	1022		1022	2		1024		
1962	976		976	1		977		
1963	1226		1226	27	121	1374		
1964	1381		1381	37		1418		
1965	2140		2140	22	502	2664		
1966	2935		2935	68	311	3314		
1967	3370		3370	63	249	3682		
1968	2807		2807	56	191	3054		
1969	2542		2542		1310	3852		
1970	3112		3112	19	130	3261		
1971	3220		3220	35	2860	6115		
1972	2934		2934	13	2568	5515		
1973	2523		2523	10	629	3162		
1974	1839		1839	9	292	2140		
1975	2127		2127	13	217	2357		
1976	1871		1871	5	6	1882		
1977	2469		2469	11	13	2493		
1978	3501		3501	18	6	3525		
1979	2878		2878	17		2895		
1980	3128		3128	18	1	3147		
1981	3442		3442	7		3449		

continued.

Table F1 continued. Witch flounder landings, discards and catch (metric tons, live).

Year	LANDINGS						USA Discards	USA Total Catch
	USA Subarea 4, 5 & 6	USA Subarea 3	USA Total	CAN	Other	Total		
1982	4906		4906	9		4915	48	4954
1983	6000		6000	45		6045	162	6162
1984	6660		6660	15		6675	100	6760
1985	6130	255	6385	46		6431	61	6191
1986	4610	539	5149	67		5216	25	4635
1987	3450	346	3796	23		3819	47	3497
1988	3262	358	3620	45		3665	60	3322
1989	2068	297	2365	13		2378	76	2144
1990	1465	2	1467	12		1479	96	1561
1991	1777		1777	7		1784	217	1994
1992	2227		2227	7		2234	212	2439
1993	2601		2601	10		2611	224	2825
1994	2670		2670	34		2704	339	3009
1995	2209		2209	11		2220	203	2412
1996	2087		2087	10		2097	207	2294
1997	1772		1772	7		1779	209	1981
1998	1848		1848	10		1858	198	2046
1999	2121		2121	19		2140	277	2398
2000	2439		2439	53		2492	178	2617
2001	3020		3020	32		3052	307	3327
2002	3188		3188	39		3227	225	3413
2003	3124		3124	38		3162	334	3458
2004	2917		2917	18		2935	309	3226
2005	2652		2652	10		2662	150	2802
2006	1863		1863	8		1871	87	1950
2007	1076		1076	11		1086	97	1173
2008	1009		1009	3		1012	63	1071
2009	954		954	9		963	104	1058
2010	759		759	6		765	89	848

Table F2. Percentage of witch flounder landings (metric tons, live) by gear type, 1964-2010.

YEAR	Otter Trawl	Shrimp Trawl	Gillnet	Unknown	Other	Total
1964	99.9	.	.	.	0.1	100.0
1965	99.8	.	.	.	0.2	100.0
1966	99.7	.	.	.	0.3	100.0
1967	100.0	.	.	.	0.0	100.0
1968	99.9	.	.	.	0.1	100.0
1969	100.0	.	.	.	0.0	100.0
1970	100.0	.	0.0	.	0.0	100.0
1971	97.7	.	0.0	.	2.3	100.0
1972	97.4	.	0.0	.	2.6	100.0
1973	98.6	.	0.0	.	1.3	100.0
1974	99.7	.	0.0	.	0.3	100.0
1975	97.0	2.5	0.1	.	0.4	100.0
1976	98.8	0.8	0.1	.	0.3	100.0
1977	97.2	1.5	0.1	.	1.3	100.0
1978	98.0	.	0.1	.	1.8	100.0
1979	97.8	0.2	0.4	.	1.7	100.0
1980	96.6	0.6	0.2	.	2.6	100.0
1981	97.2	0.8	0.2	.	1.8	100.0
1982	96.8	0.8	0.4	.	2.0	100.0
1983	95.9	0.6	0.1	.	3.4	100.0
1984	96.1	0.4	0.0	.	3.4	100.0
1985	95.0	1.1	0.1	.	3.8	100.0
1986	95.4	1.1	0.2	.	3.3	100.0
1987	95.4	1.1	0.8	.	2.8	100.0
1988	96.0	0.8	0.6	.	2.6	100.0
1989	95.3	0.4	1.4	.	2.9	100.0
1990	92.8	0.6	2.5	.	4.1	100.0
1991	94.9	0.4	1.0	.	3.7	100.0
1992	96.1	0.1	0.9	.	2.9	100.0
1993	94.1	0.0	2.9	.	3.0	100.0
1994	96.1	0.0	2.6	0.2	1.1	100.0
1995	96.5	0.0	2.1	0.5	1.0	100.0
1996	97.1	0.0	2.0	0.2	0.8	100.0
1997	96.9	0.3	1.4	0.0	1.4	100.0
1998	97.1	0.1	1.5	0.0	1.3	100.0
1999	97.3	0.1	2.1	0.1	0.4	100.0
2000	97.7	0.0	1.6	0.0	0.7	100.0
2001	98.3	0.0	1.2	0.1	0.3	100.0
2002	97.4	0.0	1.2	0.8	0.6	100.0
2003	97.6	0.0	1.3	0.0	1.1	100.0
2004	95.2	0.0	1.0	2.0	1.8	100.0
2005	90.4	0.0	1.7	5.3	2.6	100.0
2006	94.1	0.1	1.5	1.9	2.3	100.0
2007	97.0	0.1	1.7	1.0	0.3	100.0
2008	95.0	0.6	3.2	1.0	0.2	100.0
2009	94.0	0.1	3.7	1.7	0.6	100.0
2010	95.3	0.0	3.0	0.7	1.0	100.0

Dealer Electronic Reporting (DER) was implemented in 2004;

For 2010, Otter Trawl (95.3%) includes Haddock Separator Trawl (3.1%) and Ruhle Trawl (0.1%).

Table F3. Summary of USA commercial witch flounder landings (mt), number of length samples (n), number of fish measured (len) and number of age samples (age) by market category and quarter for all gear types, 1981 - 2010. The sampling ratio represents the amount of landings per length sample.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio
	Small	Med.	Large											
1981 mt	260	7	517	269	32	694	242	13	607	230	0	453	3324	
n	.	.	.	.	1	1	.	1	.	1	.	1	5	665
len	.	.	.	.	101	103	.	89	.	105	.	100	498	
age	.	.	.	.	26	.	25	.	25	.	25	.	101	
1982 mt	348	1	726	342	73	886	287	170	739	278	201	669	4720	
n	5	2	6	1	2	2	2	2	6	3	4	2	37	128
len	527	194	626	126	209	216	189	210	514	307	393	189	3700	
age	128	55	150	30	55	50	50	50	150	81	105	50	954	
1983 mt	475	250	910	471	286	1037	298	154	758	257	169	613	5678	
n	5	2	3	5	1	5	8	3	8	6	3	.	49	116
len	680	232	265	685	96	520	1008	123	981	677	344	.	5611	
age	135	30	55	131	16	125	152	0	159	180	75	.	1058	
1984 mt	462	322	1036	513	393	1000	403	248	653	429	286	586	6331	
n	5	9	4	7	1	7	8	1	2	4	2	1	51	124
len	804	1112	400	970	117	775	1045	106	191	615	243	91	6469	
age	154	250	76	186	25	180	210	28	53	105	44	25	1336	
1985 mt	465	377	613	697	453	850	526	291	553	433	310	408	5976	
n	12	1	2	5	4	7	7	7	6	8	2	4	65	92
len	1530	105	229	657	426	698	795	800	684	824	264	349	7361	
age	319	29	50	106	77	153	97	138	113	161	25	29	1297	
1986 mt	384	309	356	654	421	595	375	238	354	312	212	238	4448	
n	6	3	5	5	4	5	4	3	4	5	3	2	49	90
len	662	307	515	558	410	413	302	364	406	416	337	233	4923	
age	123	60	89	106	97	129	63	75	100	87	75	52	1056	
1987 mt	349	211	228	432	317	387	296	203	247	298	203	202	3373	
n	1	1	2	4	2	3	5	5	4	2	3	2	34	69
len	85	145	200	323	228	316	354	583	400	204	261	178	3277	
age	25	25	50	77	47	76	78	113	95	48	64	51	749	
1988 mt	424	304	271	436	393	389	184	176	208	140	140	131	3196	
n	5	4	5	5	5	3	5	4	3	3	4	3	49	65
len	335	407	465	344	544	429	396	359	295	229	402	356	4561	
age	70	89	106	71	110	77	70	100	75	61	95	69	993	
1989 mt	230	174	148	255	264	251	98	145	156	85	107	103	2016	
n	1	2	2	2	2	1	2	2	1	1	2	.	18	112
len	94	201	222	230	236	27	150	206	100	125	202	.	1793	
age	25	50	49	50	46	25	40	51	25	25	47	.	433	

Table F3 continued. Summary of commercial sampling for witch flounder.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio
	Small	Med.	Large											
1990 mt	113	125	107	147	168	147	100	119	129	84	79	85	1403	
n	1	2	3	6	3	1	6	2	2	7	2	.	35	40
len	134	199	199	335	296	100	349	247	145	381	201	.	2586	
age	15	40	45	81	70	25	69	41	50	103	48	.	587	
1991 mt	71	56	58	219	151	167	192	142	184	168	108	121	1637	
n	5	2	3	7	2	1	4	2	3	5	4	3	41	40
len	262	224	401	537	239	125	212	165	249	300	410	274	3398	
age	53	50	80	93	45	25	49	49	52	66	97	58	717	
1992 mt	180	86	82	466	163	174	205	115	138	212	97	116	2034	
n	4	2	2	7	1	2	7	1	1	2	.	1	30	68
len	259	241	185	501	125	235	477	121	117	129	.	46	2436	
age	42	46	52	78	25	25	86	25	25	27	.	23	454	
1993 mt	350	112	110	442	192	161	263	122	150	331	96	106	2435	
n	7	1	.	7	1	1	9	1	5	.	.	.	32	76
len	830	100	.	741	107	100	728	85	499	.	.	.	3190	
age	55	25	.	56	27	26	74	.	73	.	.	.	336	
1994 mt	403	143	98	505	183	154	390	122	117	383	91	80	2669	
n	.	.	.	3	5	6	5	5	1	5	3	4	37	72
len	.	.	.	560	532	749	356	648	105	342	368	407	4067	
age	.	.	.	59	104	134	44	113	26	56	60	82	678	
1995 mt	336	91	77	586	117	100	399	61	70	304	48	40	2229	
n	3	3	3	6	3	5	.	.	.	2	.	1	26	85
len	208	348	347	459	367	517	.	.	.	217	.	94	2557	
age	53	84	89	81	75	135	.	.	.	27	.	25	569	
1996 mt	313	57	36	545	86	60	458	56	44	363	42	28	2088	
n	5	2	3	5	2	1	5	4	4	5	3	3	42	50
len	504	218	292	331	240	127	494	464	468	343	277	348	4106	
age	59	45	78	53	50	26	59	86	101	60	70	69	756	
1997 mt	313	40	25	478	86	41	398	55	27	265	31	16	1775	
n	6	3	3	9	4	3	9	3	1	9	1	1	52	34
len	557	350	351	812	418	309	783	308	107	505	128	50	4678	
age	77	68	70	108	73	77	98	81	20	73	18	23	786	
1998 mt	372	39	19	587	79	31	380	40	20	239	26	14	1846	
n	5	2	1	4	1	1	5	3	1	.	.	.	23	80
len	339	206	128	238	88	135	484	186	100	.	.	.	1904	
age	45	50	19	30	.	29	47	22	.	.	.	.	242	
1999 mt	386	48	19	616	79	31	436	67	30	353	38	18	2121	
n	3	.	.	4	.	.	17	2	3	11	1	.	41	51
len	282	.	.	308	.	.	1110	201	306	775	109	.	3091	
age	15	.	.	62	.	.	143	.	32	91	16	.	359	

Table F3 continued. Summary of commercial sampling for witch flounder.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio	
	Small	Med.	Large												
2000	mt	477	53	17	583	93	27	555	89	28	451	50	16	2439	
	n	31	2	.	47	.	.	17	1	.	5	5	2	110	22
	len	2253	91	.	2445	.	.	994	105	.	308	558	217	6971	
	age	393	10	.	463	.	.	224	20	.	67	92	51	1320	
2001	mt	583	71	17	824	99	30	699	98	28	507	50	13	3019	
	n	8	4	2	3	3	2	8	2	3	5	3	.	43	70
	len	744	422	134	237	352	159	594	209	213	313	232	.	3609	
	age	125	64	42	48	48	64	126	34	46	61	49	.	707	
2002	mt	740	79	18	774	103	26	849	114	29	400	45	9	3186	
	n	5	1	2	3	5	3	5	2	3	3	2	2	36	89
	len	363	121	107	212	518	209	389	150	194	262	226	115	2866	
	age	75	16	50	65	73	64	88	34	62	49	30	49	655	
2003	mt	603	70	17	684	108	30	865	125	36	533	43	10	3124	
	n	4	6	6	10	5	10	11	6	16	7	7	13	101	31
	len	324	423	162	881	482	433	943	531	552	654	632	525	6542	
	age	57	93	60	131	64	174	172	91	246	99	120	191	1498	
2004	mt	609	76	16	598	90	23	758	113	30	546	45	13	2917	
	n	5	13	23	8	5	8	5	5	2	19	5	15	113	26
	len	480	1244	1813	675	549	576	541	356	48	1838	420	83	8623	
	age	73	226	505	151	96	169	58	95	10	49	72	.	1504	
2005	mt	603	69	14	639	101	18	618	96	21	433	34	6	2652	
	n	15	8	11	10	7	9	8	8	12	9	8	15	120	22
	len	727	525	309	798	523	288	542	369	329	512	422	445	5789	
	age	78	65	104	117	113	93	130	92	165	92	99	229	1377	
2006	mt	619	67	14	418	52	8	367	46	12	232	24	4	1863	
	n	9	6	14	11	5	16	11	5	26	11	5	29	148	13
	len	501	538	765	837	433	255	584	268	392	577	444	334	5928	
	age	90	114	246	146	118	119	129	75	282	119	106	238	1782	
2007	mt	264	27	5	267	37	7	227	40	8	173	19	3	1076	
	n	10	6	40	12	2	12	11	15	24	10	5	19	166	6
	len	516	480	400	653	203	304	605	279	237	605	232	177	4691	
	age	106	144	343	132	51	172	136	133	189	107	76	159	1748	

Table F3 continued. Summary of commercial sampling for witch flounder.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio
	Small	Med.	Large											
2008	mt	274.8	33.9	7.2	233	28.1	5.1	216.6	32.9	7.2	148.2	18.1	3.7	1009
	n	13	4	22	13	10	24	13	7	12	13	8	16	155
	len	649	243	410	819	329	237	578	417	104	749	459	166	5160
	age	152	83	229	155	190	236	130	69	95	153	178	159	1829
2009	mt	271.1	31.1	5.2	207.8	23.4	3.9	224.7	32.1	8	126.6	16.2	4	954
	n	12	8	15	14	10	20	10	4	18	10	5	4	130
	len	642	393	269	722	299	123	575	246	193	572	317	17	4368
	age	150	163	136	151	139	83	113	100	150	127	74	11	1397
2010	mt	256.7	30.6	5.1	151.5	16.5	2.8	136.9	18.5	6	118.3	13.9	2.6	759
	n	10	6	18	12	15	28	12	7	15	13	4	9	149
	len	537	355	147	656	376	197	685	221	129	672	200	132	4307
	age	114	106	119	147	178	157	146	134	117	147	77	105	1547

Table F4. USA commercial landings at age (thousands of fish), of witch flounder, 1982 – 2010.

Year	USA Commercial Landings in Numbers (1000's) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.000	0.000	117.900	826.600	1119.900	1454.300	665.200	656.000	399.500	239.400	1578.400
1983	0.000	0.000	0.000	219.800	768.600	1033.700	1567.300	1590.200	977.800	737.700	510.400	1675.500
1984	0.000	0.000	0.000	90.600	1012.400	1808.700	1734.300	1486.500	1497.500	696.700	375.100	1718.800
1985	0.000	0.000	0.000	0.000	985.100	2026.800	1933.800	1524.900	1247.900	606.000	400.400	1359.200
1986	0.000	0.000	0.000	6.300	298.500	1441.600	2772.600	1566.900	834.900	412.700	222.800	758.200
1987	0.000	0.000	0.000	0.000	81.500	321.600	1276.000	1574.700	870.900	480.600	252.400	489.400
1988	0.000	0.000	0.000	0.000	50.800	176.000	654.700	1382.700	1154.100	401.500	266.700	597.500
1989	0.000	0.000	0.000	0.000	7.290	49.690	314.330	759.350	882.120	349.650	123.390	348.000
1990	0.000	0.000	0.000	0.000	181.570	574.320	255.610	273.860	471.070	333.930	81.350	177.490
1991	0.000	0.000	0.000	0.000	179.540	732.880	519.430	235.770	244.550	292.110	313.560	257.770
1992	0.000	0.000	0.000	0.000	509.310	839.430	935.490	716.980	201.640	177.880	120.040	377.010
1993	0.000	0.000	0.000	0.000	422.170	1022.890	917.660	597.190	585.560	218.770	278.530	390.480
1994	0.000	0.000	0.000	0.000	201.639	1431.828	1288.414	828.243	197.021	540.057	113.680	324.838
1995	0.000	0.000	0.000	0.000	23.690	763.000	1597.430	848.700	267.450	97.220	269.490	156.840
1996	0.000	0.000	0.000	0.000	45.790	467.720	1263.830	1430.480	263.230	215.480	57.050	113.620
1997	0.000	0.000	0.000	0.000	212.263	528.139	1049.873	1014.449	591.550	83.179	49.808	70.112
1998	0.000	0.000	0.000	0.000	18.090	487.960	1213.510	1583.010	370.510	141.350	15.540	70.300
1999	0.000	0.000	0.000	0.000	185.149	585.733	1391.764	1178.302	763.150	251.266	31.571	54.361
2000	0.000	0.000	0.000	0.000	75.400	261.550	1072.960	1671.410	1004.050	558.090	93.130	234.600
2001	0.000	0.000	0.000	0.000	18.818	379.952	931.284	1683.679	1455.521	632.495	427.485	309.590
2002	0.000	0.000	0.000	0.000	169.070	648.660	1233.240	2107.400	1269.990	640.020	94.100	201.150
2003	0.000	0.000	0.000	0.000	56.790	517.680	1222.550	1760.820	1535.500	741.010	433.590	347.010
2004	0.000	0.000	0.000	0.000	188.530	696.460	1221.100	1403.550	1122.510	785.000	313.390	285.050
2005	0.000	0.000	0.000	0.000	75.118	637.827	1702.245	1746.227	818.771	408.738	234.635	132.335
2006	0.000	0.000	0.000	0.000	36.197	177.392	571.614	1519.138	869.397	355.919	132.599	73.028
2007	0.000	0.000	0.000	0.000	15.084	48.668	220.213	852.105	594.940	167.497	96.950	42.708
2008	0.000	0.000	0.000	4.215	58.171	84.173	270.632	578.017	449.391	312.074	111.419	66.505
2009	0.000	0.000	0.000	0.000	35.417	223.433	246.701	476.561	436.345	320.804	73.851	76.973
2010	0.000	0.000	0.000	0.000	0.000	111.778	304.427	275.523	394.735	176.211	231.944	45.576

Table F5. USA commercial landings mean weight (kg) at age of witch flounder, 1982 – 2010.

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982	-	-	-	0.216	0.275	0.345	0.424	0.550	0.727	0.886	0.983	1.406
1983	-	-	-	0.195	0.257	0.322	0.410	0.518	0.613	0.795	0.977	1.357
1984	-	-	-	0.212	0.268	0.346	0.422	0.539	0.664	0.817	0.922	1.339
1985	-	-	-	-	0.253	0.311	0.429	0.565	0.691	0.842	0.964	1.326
1986	-	-	-	-	0.227	0.306	0.408	0.533	0.676	0.853	0.975	1.321
1987	-	-	-	-	0.272	0.342	0.434	0.561	0.686	0.828	0.980	1.303
1988	-	-	-	-	0.310	0.367	0.435	0.538	0.668	0.819	0.980	1.326
1989	-	-	-	-	0.260	0.344	0.425	0.574	0.682	0.818	0.968	1.358
1990	-	-	-	-	0.308	0.323	0.438	0.586	0.688	0.849	1.049	1.454
1991	-	-	-	-	0.286	0.371	0.443	0.578	0.702	0.836	0.974	1.420
1992	-	-	-	-	0.328	0.383	0.459	0.614	0.739	0.822	0.882	1.243
1993	-	-	-	-	0.292	0.364	0.432	0.535	0.666	0.882	1.023	1.335
1994	-	-	-	-	0.308	0.357	0.430	0.534	0.691	0.832	0.909	1.266
1995	-	-	-	-	0.284	0.367	0.448	0.561	0.690	0.911	0.974	1.243
1996	-	-	-	-	0.260	0.355	0.435	0.554	0.708	0.856	0.974	1.232
1997	-	-	-	-	0.318	0.357	0.407	0.495	0.628	0.871	1.037	1.293
1998	-	-	-	-	0.235	0.331	0.382	0.492	0.585	0.871	0.978	1.206
1999	-	-	-	-	0.325	0.355	0.406	0.516	0.584	0.628	0.917	0.872
2000	-	-	-	-	0.319	0.326	0.376	0.455	0.535	0.624	0.704	0.915
2001	-	-	-	-	0.291	0.325	0.384	0.468	0.550	0.645	0.647	0.840
2002	-	-	-	-	0.355	0.344	0.416	0.477	0.553	0.652	0.826	0.941
2003	-	-	-	-	0.275	0.315	0.355	0.433	0.507	0.567	0.621	0.810
2004	-	-	-	-	0.288	0.317	0.369	0.451	0.543	0.613	0.698	0.873
2005	-	-	-	-	0.291	0.327	0.371	0.449	0.558	0.634	0.725	0.909
2006	-	-	-	-	0.290	0.327	0.372	0.465	0.551	0.655	0.719	0.932
2007	-	-	-	-	0.292	0.323	0.394	0.480	0.564	0.679	0.742	0.906
2008	-	-	-	0.304	0.313	0.383	0.436	0.485	0.544	0.599	0.649	0.823
2009	-	-	-	-	0.284	0.330	0.402	0.462	0.562	0.622	0.727	0.677
2010	-	-	-	-	-	0.313	0.353	0.442	0.502	0.658	0.620	0.821
Mean												
2006-2010	-	-	-	-	0.294	0.338	0.395	0.468	0.556	0.638	0.712	0.849
1982-2010	-	-	-	-	0.288	0.341	0.410	0.514	0.623	0.757	0.867	1.129

Table F6. The number of observed trips, witch flounder discards (in metric tons) and coefficient of variation (CV) by the large-mesh otter trawl, small-mesh otter trawl and northern shrimp trawl fleets, 1982 – 2010.

YEAR	Large-mesh Otter Trawl			Small-mesh Otter Trawl			Shrimp Trawl		Total		used in VPA
	trips	mt	CV	trips	mt	CV	trips	mt	mt	CV	
1982		42						6	48		
1983		149						13	162		
1984		89						11	100		
1985		49						12	61		
1986		12						13	25		
1987		26						22	47		
1988		26						34	60		
1989	55	56	0.46	45	2	0.44	36	19	76	0.45	
1990	46	55	0.41	22	12	0.92	47	29	96	0.37	
1991	72	184	0.42	41	3	0.87	62	29	217	0.41	
1992	62	193	0.31	28	1	5.29	110	18	212	0.31	
1993	29	215	0.39	11	0	3.41	104	9	224	0.39	
1994	25	318	0.50	2	5			98	16	339	0.49
1995	48	159	0.16	34	10	0.25	88	34	203	0.15	
1996	23	144	0.56	44	50	0.38	50	14	207	0.43	
1997	19	191	0.38	7	5	13.15	28	13	209	0.49	
1998	9	117	1.51	1	62			18	198	0.99	
1999	32	146	0.53	16	120	0.67		12	277	0.42	
2000	93	126	0.24	7	44	0.61		8	178	0.24	
2001	139	239	0.17	14	63	0.37		4	307	0.16	
2002	205	211	0.18	51	13	0.84		1	225	0.18	
2003	372	281	0.12	43	53	0.22	15	0	334	0.11	
2004	425	288	0.12	96	20	0.39	12	0	309	0.11	
2005	1097	126	0.07	157	24	0.18	17	0	150	0.07	
2006	519	72	0.09	48	15	0.34	20	1	87	0.10	
2007	527	48	0.14	32	43	0.31	14	2	97	0.16	
2008	678	61	0.10	20	1.57	0.92	16	0	63	0.10	
2009	731	100	0.13	50	3.75	0.91	7	1	104	0.13	
2010	877	80	0.09	68	8.54	0.32	11	1	89	0.08	

Due to small sample sizes in 1994 and 1998 in the small-mesh otter trawl fleet, the boxed values represent an average discard weight of the preceding and following years.

Table F7. Witch flounder discards at age (thousands of fish) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2010.

Year	Discards in Numbers (1000's) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.030	0.060	1.719	72.590	237.874	87.770	21.102	0.000	0.000	0.000	0.000	0.000
1983	0.000	0.020	4.283	117.310	577.567	487.062	7.822	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.334	0.884	56.013	453.907	194.004	5.286	0.000	0.000	0.000	0.000	0.000
1985	0.000	0.338	3.470	123.580	191.020	91.412	2.437	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.532	3.859	16.649	78.567	75.193	2.745	0.000	0.000	0.000	0.000	0.000
1987	2.084	18.918	79.933	22.250	99.755	145.459	4.060	0.000	0.000	0.000	0.000	0.000
1988	0.417	14.659	130.291	600.271	89.115	88.302	3.567	0.000	0.000	0.000	0.000	0.000
1989	0.737	11.107	52.609	89.660	303.471	104.106	0.000	0.000	0.396	0.000	0.000	0.000
1990	1.187	5.176	116.983	303.232	200.684	200.585	0.000	0.000	0.000	0.000	0.000	0.000
1991	2.958	17.794	78.958	496.264	450.987	348.944	129.780	0.000	0.000	0.000	0.000	0.000
1992	2.706	43.408	136.916	161.856	460.095	273.947	130.037	12.009	0.000	0.000	0.000	0.000
1993	112.060	78.837	108.179	86.473	584.190	395.440	5.872	2.206	0.000	0.000	0.000	0.000
1994	8.058	1368.463	498.455	67.221	439.211	629.888	59.437	119.237	2.287	2.786	0.000	7.859
1995	2.680	49.949	658.585	640.868	354.387	278.294	108.050	2.413	0.993	0.284	0.000	0.000
1996	5.206	32.683	51.477	141.832	327.193	418.024	61.442	0.000	0.000	0.000	0.000	0.000
1997	8.683	74.911	106.806	124.289	485.868	366.753	155.794	5.404	1.367	0.781	0.000	0.248
1998	49.780	392.321	278.498	220.996	283.455	240.982	70.956	10.156	0.318	0.238	0.000	0.000
1999	32.110	253.018	188.874	146.512	275.888	340.571	51.780	15.455	1.912	0.804	0.000	0.000
2000	21.610	169.950	121.192	122.168	291.153	297.891	74.732	17.516	2.878	0.000	0.000	0.000
2001	12.330	96.960	66.280	65.071	310.455	645.812	176.741	43.068	0.143	0.143	0.000	0.000
2002	2.320	19.121	15.755	32.539	406.974	471.164	125.103	34.891	5.906	2.781	1.127	1.068
2003	0.000	1.429	6.686	31.990	226.211	585.743	379.425	120.428	23.726	6.433	1.328	1.408
2004	0.000	0.148	9.622	32.951	169.061	476.762	383.720	116.846	31.664	15.111	13.510	7.967
2005	0.000	5.920	14.598	15.318	109.137	196.146	158.955	53.816	9.365	4.596	1.313	0.854
2006	0.000	2.524	18.810	45.398	35.729	61.004	136.814	36.592	9.802	3.726	2.121	1.770
2007	0.000	2.076	20.100	71.185	70.247	53.408	37.778	18.282	2.009	1.905	0.000	0.543
2008	0.000	0.100	4.907	25.718	131.668	89.504	42.413	15.279	4.267	0.284	0.103	0.793
2009	0.000	0.367	17.170	26.611	129.873	214.695	53.182	20.865	17.681	2.291	0.542	0.334
2010	0.000	3.393	50.873	28.559	63.017	117.131	138.653	16.523	3.624	1.710	0.359	1.113

Table F8. Witch flounder discard mean weight (kg) at age in the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2010.

Year	Discards Mean Weight (kg) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.002	0.038	0.048	0.126	0.127	0.181					
1983		0.009	0.038	0.064	0.130	0.158	0.248					
1984		0.017	0.040	0.053	0.141	0.162	0.253					
1985		0.017	0.023	0.128	0.153	0.166	0.231					
1986		0.017	0.026	0.090	0.125	0.173	0.229					
1987	0.006	0.015	0.033	0.081	0.125	0.201	0.232					
1988	0.004	0.006	0.017	0.045	0.142	0.200	0.276					
1989	0.010	0.012	0.032	0.058	0.145	0.225						
1990	0.004	0.010	0.032	0.049	0.134	0.191						
1991	0.004	0.014	0.038	0.057	0.154	0.235	0.239					
1992	0.003	0.007	0.021	0.067	0.178	0.264	0.292					
1993	0.003	0.009	0.022	0.096	0.199	0.235	0.316					
1994	0.005	0.004	0.019	0.083	0.179	0.226	0.364					
1995	0.005	0.007	0.025	0.052	0.151	0.222	0.253	0.473	0.595	0.702		
1996	0.004	0.019	0.031	0.064	0.134	0.208	0.251					
1997	0.004	0.023	0.034	0.065	0.157	0.197	0.245	0.498	0.471	0.702		
1998	0.003	0.006	0.024	0.061	0.161	0.203	0.222	0.230	0.355	0.370		
1999	0.003	0.006	0.024	0.067	0.162	0.219	0.283	0.407	0.423	0.495		
2000	0.003	0.006	0.025	0.070	0.146	0.185	0.253	0.238	0.256			
2001	0.003	0.006	0.023	0.084	0.166	0.207	0.227	0.257	0.309	0.309		
2002	0.003	0.007	0.030	0.099	0.172	0.201	0.231	0.259	0.427	0.556	0.566	0.404
2003		0.008	0.039	0.069	0.136	0.195	0.237	0.263	0.317	0.416	0.422	0.681
2004		0.009	0.053	0.099	0.156	0.205	0.241	0.289	0.407	0.527	0.510	0.776
2005		0.020	0.065	0.114	0.171	0.211	0.251	0.299	0.390	0.486	0.504	0.754
2006		0.012	0.052	0.098	0.164	0.203	0.232	0.271	0.343	0.351	0.523	0.694
2007		0.015	0.037	0.108	0.177	0.220	0.245	0.304	0.449	0.607		0.815
2008	0.000	0.004	0.049	0.115	0.171	0.208	0.237	0.288	0.390	0.616	0.570	0.966
2009		0.042	0.044	0.102	0.187	0.218	0.252	0.299	0.300	0.490	0.427	0.798
2010	0.000	0.010	0.026	0.115	0.180	0.218	0.233	0.263	0.367	0.416	0.598	0.579
mean												
2006-2010		0.017	0.042	0.108	0.176	0.213	0.240	0.285	0.370	0.496	0.529	0.770
1982-2010	0.004	0.012	0.033	0.079	0.156	0.203	0.250	0.309	0.387	0.503	0.515	0.718

Table F9. Total USA commercial catch [landings + shrimp trawl discards + small-mesh otter trawl discards + large-mesh otter trawl discards] in numbers (thousands of fish) at age of witch flounder, 1982 - 2010.

Year	USA Commercial Catch in Numbers (1000's) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.030	0.060	1.719	190.490	1064.474	1207.670	1475.402	665.200	656.000	399.500	239.400	1578.400
1983	0.000	0.020	4.283	337.110	1346.167	1520.762	1575.122	1590.200	977.800	737.700	510.400	1675.500
1984	0.000	0.334	0.884	146.613	1466.307	2002.704	1739.586	1486.500	1497.500	696.700	375.100	1718.800
1985	0.000	0.338	3.470	123.580	1176.120	2118.212	1936.237	1524.900	1247.900	606.000	400.400	1359.200
1986	0.000	0.532	3.859	22.949	377.067	1516.793	2775.345	1566.900	834.900	412.700	222.800	758.200
1987	2.084	18.918	79.933	22.250	181.255	467.059	1280.060	1574.700	870.900	480.600	252.400	489.400
1988	0.417	14.659	130.291	600.271	139.915	264.302	658.267	1382.700	1154.100	401.500	266.700	597.500
1989	0.738	11.117	52.657	89.743	311.047	153.938	314.619	760.049	883.329	349.972	123.504	348.320
1990	1.196	5.217	117.916	305.651	385.304	781.087	257.649	276.045	474.828	336.594	81.999	178.906
1991	2.963	17.822	79.083	497.048	631.523	1083.533	650.236	236.142	244.936	292.571	314.055	258.177
1992	2.707	43.434	137.000	161.955	970.000	1114.061	1066.182	729.437	201.764	177.989	120.114	377.241
1993	112.072	78.845	108.190	86.482	1006.466	1418.479	923.630	599.459	585.622	218.793	278.559	390.521
1994	8.071	1370.806	499.308	67.336	641.947	2065.247	1350.159	949.103	199.650	543.772	113.875	333.267
1995	2.691	50.156	661.314	643.523	379.643	1045.609	1712.546	854.639	269.556	97.908	270.607	157.490
1996	5.321	33.404	52.613	144.961	381.212	905.284	1354.510	1462.038	269.037	220.234	58.309	116.127
1997	8.704	75.092	107.065	124.590	699.825	897.063	1208.592	1022.328	594.355	84.164	49.929	70.531
1998	51.345	404.651	287.250	227.941	311.022	751.852	1324.834	1643.237	382.483	146.038	16.028	72.509
1999	33.799	266.329	198.811	154.220	485.292	975.036	1519.487	1256.558	805.310	265.331	33.232	57.221
2000	21.975	172.823	123.241	124.233	372.750	568.899	1167.096	1717.480	1023.952	567.525	94.705	238.566
2001	12.569	98.839	67.565	66.332	335.655	1045.644	1129.500	1760.213	1483.876	644.900	435.770	315.590
2002	2.329	19.195	15.816	32.664	578.257	1124.127	1363.562	2150.523	1280.799	645.271	95.593	202.995
2003	0.000	1.451	6.790	32.491	287.431	1120.695	1627.050	1910.694	1583.632	759.142	441.725	353.872
2004	0.000	0.000	9.684	33.162	359.881	1180.736	1615.099	1530.134	1161.566	805.236	328.994	294.894
2005	0.000	5.972	14.727	15.452	185.874	841.300	1877.554	1815.860	835.412	416.966	238.021	134.359
2006	0.000	2.544	18.956	45.751	72.486	240.250	713.937	1567.829	886.037	362.442	135.768	75.379
2007	0.00	2.16	20.87	73.91	88.60	105.98	267.86	903.70	619.79	175.88	100.66	44.91
2008	0.00	0.10	4.91	29.98	190.12	173.93	313.51	594.17	454.33	312.82	111.69	67.40
2009	0.00	0.37	17.23	26.71	165.88	439.68	300.95	499.19	455.64	324.24	74.66	77.58
2010	0.00	3.43	51.39	28.85	63.66	231.23	447.58	295.01	402.41	179.73	234.66	47.16

Table F10. USA commercial catch mean weight (kg) at age of witch flounder, 1982 - 2010.

Year	USA Commercial Catch Mean Weight (kg) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.002	0.038	0.152	0.242	0.329	0.421	0.550	0.727	0.886	0.983	1.406
1983		0.009	0.038	0.149	0.202	0.270	0.409	0.518	0.613	0.795	0.977	1.357
1984		0.017	0.040	0.151	0.229	0.328	0.421	0.539	0.664	0.817	0.922	1.339
1985		0.017	0.023	0.128	0.237	0.305	0.429	0.565	0.691	0.842	0.964	1.326
1986		0.017	0.026	0.089	0.206	0.299	0.408	0.533	0.676	0.853	0.975	1.321
1987	0.006	0.015	0.033	0.081	0.191	0.298	0.433	0.561	0.686	0.828	0.980	1.303
1988	0.004	0.006	0.017	0.045	0.203	0.311	0.434	0.538	0.668	0.819	0.980	1.326
1989	0.010	0.012	0.032	0.058	0.147	0.263	0.425	0.574	0.682	0.818	0.968	1.358
1990	0.004	0.010	0.032	0.049	0.217	0.289	0.438	0.586	0.688	0.849	1.049	1.454
1991	0.004	0.014	0.038	0.057	0.192	0.327	0.402	0.578	0.702	0.836	0.974	1.420
1992	0.003	0.007	0.021	0.067	0.257	0.354	0.439	0.610	0.739	0.822	0.882	1.243
1993	0.003	0.009	0.022	0.096	0.238	0.328	0.431	0.534	0.666	0.882	1.023	1.335
1994	0.005	0.004	0.019	0.083	0.219	0.317	0.427	0.527	0.690	0.833	0.909	1.264
1995	0.005	0.007	0.025	0.052	0.160	0.328	0.436	0.561	0.690	0.910	0.974	1.243
1996	0.004	0.019	0.031	0.064	0.149	0.286	0.426	0.554	0.708	0.856	0.974	1.232
1997	0.004	0.023	0.034	0.065	0.206	0.291	0.386	0.495	0.628	0.869	1.037	1.291
1998	0.003	0.006	0.024	0.061	0.165	0.289	0.373	0.490	0.585	0.870	0.978	1.206
1999	0.003	0.006	0.024	0.067	0.228	0.305	0.402	0.515	0.584	0.628	0.917	0.872
2000	0.003	0.006	0.025	0.070	0.182	0.251	0.368	0.453	0.534	0.624	0.704	0.915
2001	0.003	0.006	0.023	0.084	0.173	0.250	0.359	0.463	0.550	0.645	0.647	0.840
2002	0.003	0.007	0.030	0.099	0.226	0.284	0.399	0.473	0.552	0.652	0.823	0.938
2003	0.008	0.039	0.069	0.164	0.251	0.327	0.422	0.504	0.566	0.620	0.809	
2004		0.053	0.099	0.226	0.272	0.338	0.439	0.539	0.611	0.690	0.870	
2005	0.020	0.065	0.114	0.220	0.300	0.361	0.445	0.556	0.632	0.724	0.908	
2006	0.012	0.052	0.098	0.227	0.295	0.345	0.460	0.549	0.652	0.716	0.927	
2007	0.015	0.037	0.108	0.198	0.269	0.372	0.476	0.564	0.678	0.742	0.905	
2008	0.004	0.049	0.141	0.214	0.293	0.409	0.480	0.543	0.599	0.649	0.824	
2009	0.042	0.044	0.102	0.208	0.275	0.375	0.455	0.552	0.621	0.725	0.677	
2010	0.010	0.026	0.115	0.180	0.264	0.316	0.432	0.501	0.656	0.620	0.815	
mean												
2006-2010	0.017	0.042	0.113	0.206	0.279	0.363	0.461	0.541	0.641	0.690	0.830	
1982-2010	0.004	0.012	0.033	0.090	0.204	0.294	0.397	0.511	0.622	0.757	0.866	1.128

Table F11. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in **NEFSC offshore spring and autumn bottom trawl surveys** in Gulf of Maine-Georges Bank region (strata 22-30,36-40), 1963-2011.

Year	SPRING					AUTUMN						
	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow
1963	-		-		-	-	5.52	18.6	3.46	17.2	39.7	0.627
1964	-		-		-	-	2.89	13.6	2.09	17.2	44.2	0.724
1965	-		-		-	-	3.94	14.8	2.29	17.0	40.6	0.580
1966	-		-		-	-	7.89	17.0	4.61	16.2	41.2	0.585
1967	-		-		-	-	3.00	18.0	1.99	27.4	43.7	0.666
1968	4.71	17.8	3.27	21.1	42.3	0.693	4.82	18.2	3.52	19.0	44.8	0.731
1969	3.73	22.1	2.59	22.5	45.3	0.695	5.81	29.2	4.21	19.7	43.5	0.725
1970	6.39	14.3	4.50	13.5	44.7	0.705	4.89	10.7	3.68	12.8	45.0	0.753
1971	2.74	22.0	2.04	26.6	46.5	0.747	4.32	14.6	2.96	14.7	42.1	0.686
1972	5.35	20.1	4.01	21.3	45.8	0.749	3.24	15.3	2.42	16.7	43.9	0.747
1973	8.20	11.8	6.21	14.5	44.8	0.758	3.18	23.4	2.05	23.7	43.6	0.646
1974	6.23	17.9	3.62	18.3	39.3	0.581	2.38	16.7	1.58	19.9	41.0	0.666
1975	3.72	26.2	2.75	32.8	43.9	0.739	1.66	19.1	1.03	25.8	39.8	0.621
1976	5.50	16.8	3.70	22.0	42.3	0.673	1.34	23.6	0.94	21.1	41.9	0.699
1977	4.20	25.6	1.96	20.8	37.2	0.467	5.05	21.3	3.38	15.3	42.0	0.669
1978	3.87	21.4	2.56	18.5	41.7	0.662	4.04	12.3	2.94	10.6	42.8	0.727
1979	2.91	20.7	1.71	17.4	38.2	0.587	1.94	10.3	1.62	11.4	45.2	0.838
1980	8.46	29.8	3.89	15.9	36.0	0.460	2.62	13.8	2.04	16.4	43.7	0.777
1981	8.14	14.5	4.05	19.3	38.0	0.497	3.66	28.5	2.19	20.9	40.4	0.600
1982	3.64	22.2	1.87	17.2	37.2	0.513	0.99	40.5	0.83	40.5	44.7	0.842
1983	6.41	27.0	2.74	22.0	36.3	0.427	4.72	14.2	2.12	13.4	36.7	0.448
1984	3.00	16.1	1.66	17.0	39.9	0.554	4.37	13.9	2.33	16.1	39.7	0.534
1985	5.18	19.3	2.75	19.2	40.3	0.531	2.76	19.7	1.59	23.1	41.9	0.577
1986	2.07	15.8	1.35	17.0	44.1	0.650	1.59	15.5	1.09	14.7	43.3	0.683
1987	1.01	23.2	0.65	25.1	43.4	0.646	0.48	33.0	0.37	27.3	43.9	0.774
1988	1.43	23.3	0.85	27.5	42.3	0.590	1.38	17.3	0.57	19.6	35.2	0.414
1989	1.95	21.7	0.74	20.0	35.8	0.382	0.89	19.6	0.38	26.6	31.4	0.423
1990	0.63	30.3	0.24	30.6	35.2	0.378	2.00	16.4	0.40	18.4	24.7	0.200
1991	1.68	25.0	0.57	21.9	31.5	0.341	2.08	27.6	0.54	27.3	29.2	0.258
1992	1.26	18.2	0.48	23.1	34.8	0.383	0.94	30.0	0.24	37.6	29.5	0.254
1993	1.47	17.7	0.36	20.9	30.3	0.245	5.15	25.0	0.54	22.8	17.0	0.105
1994	3.13	22.6	0.53	28.5	27.4	0.170	2.21	16.4	0.42	26.5	24.9	0.191
1995	1.88	16.9	0.47	19.9	30.6	0.248	4.74	19.6	0.62	20.7	25.7	0.132
1996	1.36	16.9	0.28	19.4	30.5	0.204	5.38	19.1	1.02	21.1	29.7	0.189
1997	2.22	26.7	0.43	28.1	31.0	0.195	5.10	19.6	0.77	21.9	24.9	0.150
1998	4.27	17.5	0.77	18.8	29.0	0.179	3.70	20.1	0.47	23.2	24.2	0.127
1999	3.15	20.5	0.48	20.0	28.1	0.153	5.91	21.9	0.88	21.3	26.3	0.148
2000	3.45	14.0	0.52	12.4	27.3	0.151	6.63	15.2	1.11	17.3	27.1	0.167
2001	4.41	16.3	0.75	13.0	29.5	0.170	7.94	16.2	1.71	16.5	32.3	0.216
2002	8.10	20.3	1.61	16.5	31.4	0.199	4.31	19.0	1.06	20.0	33.2	0.246
2003	5.20	16.1	1.30	14.5	34.2	0.250	2.66	19.0	0.79	18.8	35.4	0.298
2004	3.80	12.6	1.08	13.5	35.5	0.283	3.82	31.8	1.03	31.9	33.3	0.271
2005	3.36	20.3	0.89	22.1	34.6	0.265	1.93	18.5	0.38	16.7	27.8	0.197
2006	3.09	13.9	0.72	11.0	32.2	0.235	2.03	19.3	0.46	20.7	30.5	0.226
2007	2.37	16.5	0.58	14.9	32.9	0.245	2.74	22.8	0.57	23.2	31.6	0.208
2008	7.45	25.0	1.40	21.7	31.28	0.188	2.78	17.1	0.64	19.5	31.2	0.233
*2009	2.20	18.5	0.50	18.6	31.74	0.227	2.08	19.0	0.45	21.0	29.6	0.217
*2010	2.49	17.8	0.54	18.1	30.44	0.218	1.99	16.9	0.36	20.9	28.4	0.182
*2011	2.72	16.0	0.55	17.0	30.21	0.201						

*For 2009 through 2011, constant conversion factors were applied (3.257177 for numbers and 3.257201 for weight). For 1963 through 2008, there are no significant survey conversion factors for witch flounder.

Table F12. Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys
 (Strata 22-30, 36-40), 1980 – 2011.

SPRING	AGE														Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	
1980	0.000	0.060	0.230	0.950	1.520	0.720	1.200	1.020	0.380	0.400	0.310	0.300	0.120	0.160	1.100	8.460
1981	0.000	0.000	0.050	0.820	0.930	2.000	1.020	0.760	0.670	0.420	0.130	0.200	0.240	0.220	0.900	8.400
1982	0.000	0.044	0.042	0.610	0.484	0.377	0.237	0.609	0.362	0.093	0.259	0.175	0.026	0.033	0.292	3.642
1983	0.000	0.000	0.071	0.531	1.262	1.293	0.541	0.716	0.632	0.475	0.214	0.166	0.075	0.054	0.376	6.407
1984	0.000	0.000	0.103	0.012	0.307	0.778	0.401	0.310	0.202	0.196	0.115	0.173	0.117	0.023	0.266	3.001
1985	0.000	0.000	0.000	0.017	0.459	1.057	1.199	0.908	0.412	0.148	0.149	0.044	0.072	0.027	0.691	5.182
1986	0.000	0.000	0.000	0.000	0.044	0.240	0.529	0.412	0.172	0.194	0.079	0.038	0.063	0.055	0.248	2.073
1987	0.000	0.000	0.000	0.000	0.059	0.114	0.133	0.259	0.185	0.009	0.061	0.023	0.000	0.000	0.163	1.007
1988	0.000	0.023	0.023	0.062	0.000	0.072	0.300	0.379	0.239	0.137	0.086	0.084	0.029	0.000	0.000	1.434
1989	0.000	0.023	0.013	0.036	1.004	0.105	0.073	0.081	0.327	0.081	0.015	0.056	0.056	0.019	0.056	1.945
1990	0.000	0.008	0.000	0.038	0.091	0.319	0.000	0.042	0.009	0.050	0.018	0.009	0.011	0.000	0.030	0.626
1991	0.000	0.042	0.000	0.781	0.108	0.087	0.209	0.033	0.101	0.083	0.138	0.018	0.022	0.000	0.064	1.684
1992	0.000	0.054	0.009	0.187	0.373	0.085	0.111	0.152	0.045	0.149	0.015	0.016	0.046	0.000	0.019	1.260
1993	0.000	0.149	0.112	0.137	0.472	0.320	0.058	0.085	0.000	0.015	0.015	0.000	0.068	0.000	0.037	1.469
1994	0.000	0.107	0.698	0.541	0.644	0.810	0.164	0.027	0.028	0.070	0.008	0.000	0.000	0.016	0.016	3.129
1995	0.000	0.041	0.120	0.581	0.316	0.179	0.312	0.116	0.110	0.042	0.000	0.038	0.028	0.000	0.000	1.883
1996	0.000	0.017	0.036	0.244	0.394	0.346	0.218	0.073	0.000	0.000	0.000	0.032	0.000	0.000	0.000	1.359
1997	0.000	0.072	0.066	0.152	0.693	0.617	0.437	0.084	0.083	0.014	0.000	0.000	0.000	0.000	0.000	2.219
1998	0.000	0.112	1.079	0.712	0.388	0.798	0.713	0.214	0.154	0.076	0.000	0.000	0.000	0.028	0.000	4.274
1999	0.000	0.106	0.376	0.974	0.797	0.482	0.164	0.182	0.031	0.014	0.023	0.000	0.000	0.000	0.000	3.149
2000	0.000	0.007	0.250	1.194	0.692	0.660	0.239	0.253	0.116	0.000	0.035	0.000	0.000	0.000	0.000	3.446
2001	0.000	0.105	0.099	0.713	1.476	1.020	0.401	0.293	0.163	0.113	0.028	0.000	0.000	0.000	0.000	4.409
2002	0.000	0.023	0.060	0.897	2.627	2.263	0.822	0.683	0.351	0.192	0.103	0.014	0.000	0.029	0.037	8.101
2003	0.000	0.000	0.000	0.150	0.808	1.646	1.017	0.869	0.387	0.197	0.046	0.060	0.000	0.016	0.009	5.204
2004	0.000	0.009	0.060	0.074	0.428	0.648	0.809	0.883	0.368	0.158	0.161	0.135	0.000	0.000	0.067	3.799
2005	0.000	0.011	0.160	0.146	0.220	0.737	0.760	0.574	0.383	0.245	0.086	0.018	0.000	0.021	0.000	3.362
2006	0.000	0.043	0.460	0.347	0.138	0.207	0.683	0.568	0.410	0.145	0.069	0.015	0.000	0.000	0.000	3.087
2007	0.000	0.000	0.178	0.571	0.263	0.241	0.228	0.546	0.154	0.158	0.000	0.031	0.000	0.000	0.000	2.370
2008	0.000	0.011	0.372	0.847	2.833	1.341	0.646	0.724	0.550	0.088	0.036	0.000	0.000	0.000	0.000	7.448
*2009	0.000	0.116	0.126	0.278	0.407	0.540	0.195	0.147	0.211	0.112	0.053	0.009	0.003	0.004	0.000	2.202
*2010	0.000	0.139	0.457	0.267	0.163	0.426	0.498	0.143	0.097	0.179	0.064	0.031	0.016	0.004	0.009	2.494
*2011	0.000	0.035	0.369	0.692	0.251	0.276	0.432	0.270	0.114	0.087	0.118	0.045	0.008	0.010	0.010	2.716

*Survey conversion factors applied.

Table F12 continued. Stratified mean number per tow at age of witch flounder.

AUTUMN	AGE														Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	
1980	0.040	0.000	0.020	0.000	0.200	0.260	0.280	0.360	0.170	0.150	0.270	0.040	0.160	0.120	0.570	2.620
1981	0.030	0.070	0.030	0.240	0.440	0.610	0.460	0.270	0.260	0.180	0.210	0.170	0.040	0.130	0.480	3.660
1982	0.020	0.000	0.000	0.058	0.013	0.027	0.076	0.241	0.132	0.015	0.027	0.032	0.009	0.039	0.301	0.991
1983	0.000	0.008	0.011	0.507	1.596	0.758	0.548	0.444	0.084	0.137	0.073	0.114	0.025	0.000	0.415	4.718
1984	0.000	0.000	0.000	0.093	0.943	0.991	0.605	0.535	0.310	0.149	0.126	0.073	0.041	0.132	0.375	4.373
1985	0.000	0.000	0.009	0.059	0.076	0.610	0.684	0.482	0.270	0.103	0.122	0.029	0.015	0.089	0.217	2.763
1986	0.009	0.000	0.000	0.000	0.051	0.266	0.353	0.309	0.160	0.112	0.009	0.010	0.021	0.052	0.237	1.590
1987	0.000	0.000	0.023	0.000	0.011	0.023	0.046	0.192	0.071	0.000	0.009	0.000	0.000	0.023	0.085	0.482
1988	0.000	0.007	0.000	0.725	0.055	0.012	0.036	0.215	0.048	0.046	0.045	0.079	0.011	0.043	0.055	1.376
1989	0.174	0.018	0.018	0.082	0.301	0.009	0.021	0.017	0.084	0.078	0.024	0.000	0.026	0.000	0.037	0.888
1990	0.481	0.088	0.137	0.380	0.507	0.219	0.024	0.023	0.023	0.025	0.000	0.000	0.009	0.055	0.034	2.005
1991	0.224	0.021	0.177	0.661	0.329	0.290	0.145	0.067	0.059	0.030	0.052	0.028	0.000	0.000	0.000	2.083
1992	0.097	0.029	0.109	0.259	0.224	0.054	0.061	0.000	0.000	0.019	0.009	0.019	0.000	0.019	0.042	0.940
1993	2.541	0.672	0.154	0.544	0.777	0.219	0.058	0.022	0.081	0.000	0.019	0.042	0.000	0.011	0.014	5.154
1994	0.432	0.156	0.287	0.532	0.165	0.395	0.037	0.106	0.000	0.043	0.009	0.000	0.005	0.000	0.042	2.209
1995	0.512	0.203	0.764	1.624	0.858	0.472	0.229	0.000	0.000	0.011	0.054	0.000	0.000	0.000	0.009	4.736
1996	0.232	0.092	0.261	0.785	1.988	1.386	0.441	0.066	0.065	0.037	0.000	0.033	0.000	0.000	0.000	5.384
1997	0.892	0.339	0.979	0.522	0.871	0.770	0.383	0.329	0.000	0.000	0.000	0.020	0.000	0.000	0.000	5.105
1998	0.639	0.082	0.520	1.363	0.465	0.303	0.165	0.110	0.043	0.012	0.000	0.000	0.000	0.000	0.000	3.701
1999	0.323	0.521	1.178	1.514	1.044	0.600	0.364	0.275	0.050	0.037	0.009	0.000	0.000	0.000	0.000	5.915
2000	0.943	0.096	0.719	1.408	1.746	0.674	0.589	0.229	0.152	0.049	0.000	0.000	0.026	0.000	0.000	6.630
2001	0.000	0.039	0.210	0.952	3.156	1.886	0.813	0.612	0.159	0.058	0.056	0.000	0.000	0.000	0.000	7.940
2002	0.000	0.000	0.275	0.431	1.475	0.997	0.532	0.331	0.148	0.071	0.000	0.046	0.005	0.000	0.000	4.311
2003	0.018	0.000	0.038	0.075	0.307	0.580	0.770	0.315	0.129	0.222	0.083	0.021	0.046	0.019	0.038	2.660
2004	0.276	0.072	0.014	0.086	0.453	0.987	0.826	0.498	0.355	0.054	0.105	0.072	0.000	0.000	0.019	3.816
2005	0.132	0.635	0.087	0.023	0.131	0.181	0.269	0.340	0.055	0.052	0.012	0.000	0.000	0.016	0.000	1.933
2006	0.066	0.103	0.540	0.322	0.046	0.104	0.298	0.286	0.138	0.071	0.042	0.014	0.000	0.000	0.000	2.030
2007	0.000	0.065	0.162	1.206	0.478	0.188	0.220	0.261	0.069	0.078	0.000	0.000	0.014	0.000	0.000	2.740
2008	0.275	0.021	0.095	0.422	0.794	0.273	0.254	0.235	0.302	0.014	0.057	0.000	0.000	0.008	0.000	2.748
*2009	0.092	0.391	0.178	0.189	0.349	0.420	0.146	0.133	0.111	0.065	0.004	0.008	0.000	0.000	0.000	2.084
*2010	0.037	0.377	0.453	0.190	0.218	0.176	0.265	0.050	0.115	0.061	0.019	0.021	0.002	0.000	0.000	1.986

*Survey conversion factors applied.

Table F13. Parameter estimates (with coefficient of variation), stock size (N) in '000 of fish, and estimates of terminal F from ADAPT VPA formulations for witch flounder. Note: *SPLIT survey indices are: 1982-1994 and 1995 - onward.*

RUN	A	B	C	D	E	F	G
	GARM 2008 SPLIT RUN	Update 2012 SPLIT RUN	Update 2012 SPLIT RUN	Update 2012 SPLIT RUN	Update 2012 NO SPLIT RUN	Update 2012 SPLIT RUN LCF1	Update 2012 SPLIT RUN LCF2
Software	NFT VPA 2.7.7	NFT VPA 3.1.1	NFT VPA 3.1.1	NFT VPA 3.1.1	NFT VPA 3.1.1	NFT VPA 3.1.1	NFT VPA 3.1.1
Catch-At-Age	1982-2007 3-11+	1982-2007 3-11+	1982-2007 w/ revised 2007 3-11+	1982-2010 3-11+	1982-2010 3-11+	1982-2010 3-11+	1982-2010 3-11+
Est.Ages	3-10	3-10	3-10	3-10	3-10	3-10	3-10
NMFS-s	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+
NMFS-a	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+	3-11+
Residual Sum Sq.	324.1	324.1	324.1	348.4	423.0	356.9	351.9
Mean Sq.Residual	0.730	0.730	0.730	0.700	0.849	0.716	0.706
N3 (cv)	11,992 (.63)	11,992 (.63)	11,992 (.63)	16,044 (.61)	33,879 (.67)	6,749 (.62)	6,891 (.61)
N4 (cv)	22,123 (.45)	22,123 (.45)	22,121 (.45)	4,380 (.44)	7,837 (.47)	2,207 (.44)	2,264 (.44)
N5 (cv)	5,433 (.37)	5,433 (.37)	5,432 (.37)	2,855 (.36)	4,966 (.39)	2,002 (.37)	2,036 (.36)
N6 (cv)	1,220 (.34)	1,220 (.34)	1,220 (.34)	4,273 (.32)	7,371 (.34)	3,476 (.33)	3,540 (.33)
N7 (cv)	1,442 (.35)	1,442 (.35)	1,442 (.35)	5,887 (.30)	10,022 (.31)	4,864 (.31)	4,973 (.31)
N8 (cv)	2,074 (.39)	2,074 (.39)	2,076 (.39)	1,427 (.32)	2,535 (.32)	1,070 (.35)	1,137 (.34)
N9 (cv)	957 (.44)	957 (.44)	959 (.44)	418 (.42)	813 (.37)	218 (.49)	292 (.46)
N10 (cv)	1,354 (.36)	1,354 (.36)	1,356 (.36)	479 (.38)	1,113 (.30)	225 (.46)	330 (.42)
F 3	0.003	0.003	0.003	0.006	0.003	0.012	0.012
F 4	0.015	0.015	0.015	0.021	0.012	0.029	0.029
F 5	0.077	0.077	0.077	0.049	0.029	0.060	0.059
F 6	0.159	0.159	0.159	0.068	0.041	0.082	0.080
F 7	0.339	0.339	0.338	0.175	0.102	0.227	0.215
F 8	0.470	0.470	0.467	0.635	0.374	0.990	0.818
F 9	0.114	0.114	0.113	0.297	0.139	0.551	0.407
F10	0.292	0.292	0.290	0.466	0.257	0.771	0.612
F11+	0.292	0.292	0.290	0.466	0.257	0.771	0.612
2007 Avg F 8-9	0.292 (.27)	0.292	0.290	0.52	0.43	0.58	0.55
2007 SSB(mt)	3,434 (.15)	3,434	3,750	2,710	3,476	2,392	2,513
2007 Age 3 in yr t	25,781	25,781	25,780	12,438	19,973	10,573	10,773
2010 Avg F 8-9				0.47 (.20)	0.26 (.35)	0.77	0.61
2010 SSB(mt)				4,099 (.12)	7,033 (.15)	3,108	3,350
2010 Age 3 in yr t				5,119	9,136	2,596	2,662
Mohn's rho F8-9	-0.02			-0.33	-0.55	-0.29	-0.33
Mohn's rho SSB	0.43			0.61	1.38	0.67	0.65
Mohn's rho Age 3	-0.13			0.06	0.52	0.16	0.13
Notes:	GARM 2008 accepted run	'Bridge Run' with updated software	"Bridge Run" with revised 2007 values	2008 thru 2010 added; constant conversion factors for surveys 2009+	Sensitivity run; no split in survey tuning indices	Sensitivity run: length-based CF for surveys 2009+	Sensitivity run: length-based CF 20-40 cm then constant for surveys 2009+

Table F14. Mohn rho statistic (average of relative differences of 7 ‘peels’) for fishing mortality (F 8-9), spawning stock biomass (SSB), and recruits (Age 3) for the SPLIT RUN and three sensitivity runs.

SPLIT RUN

Run D	2003	2004	2005	2006	2007	2008	2009	Mean
F 8-9	-0.23	-0.43	-0.61	-0.71	-0.44	0.02	0.07	-0.33
SSB	0.90	1.30	0.74	0.76	0.38	0.11	0.06	0.61
Age 3	-0.67	-0.59	0.13	0.33	0.65	0.27	0.26	0.06

NO SPLIT

Run E	2003	2004	2005	2006	2007	2008	2009	Mean
F 8-9	-0.53	-0.64	-0.80	-0.84	-0.67	-0.33	-0.03	-0.55
SSB	2.09	2.64	1.98	1.92	1.28	-0.42	0.20	1.38
Age 3	-0.36	-0.20	0.89	1.01	1.21	0.60	0.52	0.52

SPLIT LCF1

Run F	2003	2004	2005	2006	2007	2008	2009	Mean
F 8-9	-0.23	-0.44	-0.62	-0.73	-0.50	0.13	0.33	-0.29
SSB	0.92	1.33	0.80	0.89	0.56	0.19	0.03	0.67
Age 3	-0.61	-0.52	0.35	0.57	0.99	0.32	-0.01	0.16

SPLIT LCF2

Run G	2003	2004	2005	2006	2007	2008	2009	Mean
F 8-9	-0.23	-0.44	-0.62	-0.72	-0.47	0.06	0.12	-0.33
SSB	0.91	1.32	0.77	0.84	0.48	0.17	0.06	0.65
Age 3	-0.64	-0.55	0.30	0.54	0.96	0.31	0.01	0.13

Table F15. Summary of witch flounder spawning stock biomass (mt), fully recruited fishing mortality (F8-9), recruitment (Age 3, millions fish), and year class from VPA **SPLIT RUN**, 1982 to 2010, with Age 3 recruits predicted in 2011.

Year	SSB (mt)	Avg F8-9	Recruits Age 3	Year Class
1982	16,903	0.26	15.409	1979
1983	13,439	0.50	17.706	1980
1984	11,542	0.63	16.371	1981
1985	10,433	0.68	7.670	1982
1986	9,550	0.50	5.437	1983
1987	8,950	0.60	3.137	1984
1988	8,312	0.70	9.301	1985
1989	7,360	0.44	6.070	1986
1990	6,334	0.25	7.541	1987
1991	6,950	0.25	8.659	1988
1992	7,052	0.23	12.156	1989
1993	5,833	0.45	8.905	1990
1994	4,350	0.60	13.104	1991
1995	4,068	0.62	11.837	1992
1996	3,871	1.14	15.676	1993
1997	4,141	1.08	13.896	1994
1998	5,160	0.66	14.774	1995
1999	6,070	0.54	12.596	1996
2000	6,794	0.56	11.448	1997
2001	6,688	0.91	12.134	1998
2002	6,168	0.54	11.213	1999
2003	5,504	0.75	8.476	2000
2004	4,221	0.93	5.106	2001
2005	3,756	0.84	3.702	2002
2006	2,757	0.85	4.521	2003
2007	2,710	0.52	12.438	2004
2008	3,194	0.55	7.277	2005
2009	3,900	0.41	3.962	2006
2010	4,099	0.47	5.119	2007
2011			16.044	2008
Min	2,710	0.23	3.137	
Max	16,903	1.14	17.706	
Mean	6,556	0.60	9.850	
Geomean			8.865	
Median			9.301	
Mean (1979 to 2006 year classes)			10.019	

Summary statistics for Recruits Age 3 exclude the 2011 estimate.

Table F16. Estimates of beginning year stock size ('000 of fish), instantaneous fishing mortality and spawning stock biomass (mt) for witch flounder estimated from the virtual population analysis, 1982-2010 **SPLIT RUN**.

Jan 1 Population Numbers

AGE	1982	1983	1984	1985	1986
3	15409.	17706.	16371.	7670.	5437.
4	12176.	13086.	14927.	13954.	6487.
5	9564.	9495.	10017.	11491.	10922.
6	7830.	7115.	6766.	6771.	7932.
7	4290.	5376.	4669.	4218.	4041.
8	2752.	3077.	3160.	2648.	2225.
9	2102.	1763.	1747.	1344.	1132.
10	1101.	1440.	839.	862.	600.
11	7260.	4728.	3844.	2927.	2040.
<hr/>					
Total	62485.	63786.	62339.	51884.	40817.
AGE	1987	1988	1989	1990	1991
3	3137.	9301.	6070.	7541.	8659.
4	4659.	2680.	7449.	5141.	6208.
5	5234.	3842.	2177.	6123.	4069.
6	7998.	4073.	3062.	1731.	4548.
7	4270.	5700.	2897.	2344.	1252.
8	2036.	2225.	3629.	1792.	1762.
9	1146.	951.	856.	2308.	1104.
10	594.	545.	449.	414.	1675.
11	1152.	1220.	1267.	904.	1377.
<hr/>					
Total	30226.	30535.	27856.	28300.	30653.
AGE	1992	1993	1994	1995	1996
3	12156.	8905.	13104.	11837.	15676.
4	6992.	10313.	7584.	11216.	9592.
5	4759.	5121.	7945.	5934.	9302.
6	2502.	3067.	3099.	4932.	4140.
7	3313.	1172.	1788.	1425.	2667.
8	859.	2178.	459.	668.	445.
9	1290.	553.	1334.	211.	327.
10	680.	946.	275.	648.	92.
11	2136.	1326.	804.	377.	183.
<hr/>					
Total	34686.	33581.	36391.	37248.	42424.

Table F16 continued.

AGE	1997	1998	1999	2000	2001
3	13896.	14774.	12596.	11448.	12134.
4	13358.	11845.	12505.	10698.	9738.
5	7903.	10849.	9907.	10314.	8863.
6	7169.	5972.	8642.	7624.	8350.
7	2315.	5053.	3916.	6033.	5483.
8	954.	1052.	2834.	2212.	3608.
9	136.	278.	553.	1696.	963.
10	80.	40.	105.	233.	937.
11	113.	183.	181.	586.	678.
Total	45925.	50046.	51239.	50845.	50754.

AGE	2002	2003	2004	2005	2006
3	11213.	8476.	5106.	3702.	4521.
4	10382.	9621.	7266.	4364.	3172.
5	8071.	8400.	8014.	5920.	3584.
6	6661.	5907.	6194.	5806.	4317.
7	6142.	4473.	3583.	3840.	3266.
8	3096.	3305.	2092.	1676.	1637.
9	1740.	1486.	1390.	736.	675.
10	240.	903.	582.	458.	251.
11	510.	724.	522.	259.	140.
Total	48055.	43296.	34749.	26762.	21564.

AGE	2007	2008	2009	2010	2011
3	12438.	7277.	3962.	5119.	16044.
4	3847.	10637.	6236.	3385.	4380.
5	2663.	3229.	8979.	5213.	2855.
6	2862.	2194.	2618.	7321.	4273.
7	3056.	2216.	1598.	1975.	5887.
8	1371.	1797.	1359.	915.	1427.
9	596.	610.	1127.	750.	418.
10	249.	351.	238.	671.	479.
11	111.	212.	247.	136.	435.
Total	27193.	28521.	26364.	25485.	36197.

Table F16 continued.

Fishing Mortality

AGE	1982	1983	1984	1985	1986
3	0.0134	0.0207	0.0097	0.0175	0.0046
4	0.0987	0.1172	0.1116	0.0950	0.0646
5	0.1459	0.1888	0.2416	0.2206	0.1616
6	0.2261	0.2713	0.3226	0.3661	0.4693
7	0.1823	0.3813	0.4172	0.4894	0.5357
8	0.2953	0.4162	0.7050	0.6995	0.5132
9	0.2282	0.5928	0.5561	0.6571	0.4945
10	0.2657	0.4770	0.6494	0.6850	0.5069
11	0.2657	0.4770	0.6494	0.6850	0.5069
AGE	1987	1988	1989	1990	1991
3	0.0077	0.0720	0.0160	0.0446	0.0638
4	0.0428	0.0578	0.0460	0.0841	0.1159
5	0.1009	0.0769	0.0791	0.1475	0.3363
6	0.1887	0.1907	0.1171	0.1743	0.1668
7	0.5020	0.3014	0.3305	0.1354	0.2264
8	0.6110	0.8055	0.3026	0.3344	0.1618
9	0.5944	0.6000	0.5750	0.1705	0.3344
10	0.6050	0.7394	0.3492	0.2388	0.2248
11	0.6050	0.7394	0.3492	0.2388	0.2248
AGE	1992	1993	1994	1995	1996
3	0.0144	0.0105	0.0055	0.0603	0.0100
4	0.1614	0.1109	0.0955	0.0371	0.0437
5	0.2893	0.3524	0.3268	0.2098	0.1105
6	0.6079	0.3897	0.6266	0.4649	0.4314
7	0.2696	0.7880	0.8344	1.0153	0.8773
8	0.2904	0.3402	0.6253	0.5648	1.0317
9	0.1605	0.5501	0.5725	0.6825	1.2541
10	0.2104	0.3793	0.5858	0.5918	1.1200
11	0.2104	0.3793	0.5858	0.5918	1.1200
AGE	1997	1998	1999	2000	2001
3	0.0097	0.0168	0.0133	0.0118	0.0059
4	0.0580	0.0287	0.0427	0.0382	0.0378
5	0.1302	0.0775	0.1119	0.0612	0.1356
6	0.1998	0.2719	0.2093	0.1797	0.1571
7	0.6383	0.4283	0.4212	0.3641	0.4215
8	1.0840	0.4926	0.3633	0.6817	0.5793
9	1.0673	0.8215	0.7168	0.4437	1.2393
10	1.0819	0.5529	0.4132	0.5714	0.6866
11	1.0819	0.5529	0.4132	0.5714	0.6866

Table F16 continued.

AGE	2002	2003	2004	2005	2006
3	0.0031	0.0041	0.0070	0.0045	0.0114
4	0.0618	0.0327	0.0548	0.0469	0.0251
5	0.1621	0.1548	0.1723	0.1657	0.0749
6	0.2482	0.3500	0.3280	0.4253	0.1956
7	0.4698	0.6098	0.6097	0.7028	0.7182
8	0.5839	0.7163	0.8947	0.7588	0.8601
9	0.5055	0.7868	0.9589	0.9242	0.8482
10	0.5550	0.7377	0.9199	0.8064	0.8566
11	0.5550	0.7377	0.9199	0.8064	0.8566
AGE	2007	2008	2009	2010	
3	0.0064	0.0044	0.0073	0.0061	
4	0.0251	0.0194	0.0291	0.0205	
5	0.0438	0.0597	0.0541	0.0489	
6	0.1061	0.1667	0.1319	0.0680	
7	0.3812	0.3390	0.4075	0.1750	
8	0.6596	0.3164	0.4449	0.6345	
9	0.3802	0.7915	0.3688	0.2974	
10	0.5664	0.4172	0.4097	0.4660	
11	0.5664	0.4172	0.4097	0.4660	

Table F16 continued.

Average Fishing Mortality For Ages 8-9

Year	Average F	N Weighted	Biomass Wtd	Catch Wtd
1982	0.2618	0.2663	0.2630	0.2699
1983	0.5045	0.4805	0.4919	0.4921
1984	0.6306	0.6520	0.6454	0.6577
1985	0.6783	0.6852	0.6833	0.6857
1986	0.5039	0.5069	0.5060	0.5071
1987	0.6027	0.6050	0.6042	0.6051
1988	0.7028	0.7439	0.7349	0.7525
1989	0.4388	0.3546	0.3635	0.3799
1990	0.2524	0.2421	0.2345	0.2664
1991	0.2481	0.2283	0.2353	0.2558
1992	0.2254	0.2124	0.2078	0.2295
1993	0.4452	0.3827	0.3913	0.3973
1994	0.5989	0.5860	0.5841	0.5867
1995	0.6236	0.5931	0.5994	0.5962
1996	1.1429	1.1259	1.1368	1.1318
1997	1.0756	1.0819	1.0813	1.0819
1998	0.6571	0.5613	0.5802	0.5835
1999	0.5400	0.4211	0.4274	0.4509
2000	0.5627	0.5784	0.5701	0.5968
2001	0.9093	0.7183	0.7369	0.7792
2002	0.5447	0.5557	0.5526	0.5576
2003	0.7516	0.7382	0.7403	0.7392
2004	0.9268	0.9203	0.9227	0.9210
2005	0.8415	0.8093	0.8153	0.8138
2006	0.8542	0.8566	0.8561	0.8566
2007	0.5199	0.5749	0.5639	0.5978
2008	0.5539	0.4369	0.4493	0.5101
2009	0.4069	0.4104	0.4081	0.4133
2010	0.4660	0.4828	0.4633	0.5305

Table F16 continued.

Spawning Stock Biomass

AGE	1982	1983	1984	1985	1986
3	20.	21.	38.	8.	6.
4	107.	132.	185.	127.	91.
5	376.	459.	580.	685.	994.
6	1116.	1241.	1244.	1585.	1918.
7	1544.	1884.	1715.	1720.	1638.
8	1634.	1544.	1559.	1388.	1219.
9	1632.	1172.	1088.	878.	781.
10	949.	1207.	629.	666.	487.
11	9525.	5779.	4505.	3376.	2416.
Total	16903.	13439.	11542.	10433.	9550.
AGE	1987	1988	1989	1990	1991
3	13.	31.	16.	13.	16.
4	176.	143.	188.	111.	98.
5	846.	703.	329.	552.	380.
6	2475.	1301.	969.	406.	941.
7	1796.	2526.	1308.	1004.	497.
8	1084.	1161.	2038.	1007.	1009.
9	758.	629.	561.	1648.	757.
10	479.	423.	368.	360.	1417.
11	1324.	1395.	1583.	1232.	1837.
Total	8950.	8312.	7360.	6334.	6950.
AGE	1992	1993	1994	1995	1996
3	25.	22.	31.	11.	11.
4	137.	162.	137.	163.	98.
5	473.	479.	685.	629.	857.
6	585.	712.	652.	1291.	1166.
7	1361.	422.	622.	546.	1060.
8	501.	1228.	235.	354.	228.
9	921.	393.	872.	146.	199.
10	550.	794.	217.	515.	70.
11	2500.	1621.	899.	414.	183.
Total	7052.	5833.	4350.	4068.	3871.
AGE	1997	1998	1999	2000	2001
3	6.	18.	20.	25.	36.
4	104.	155.	200.	160.	156.
5	581.	969.	766.	786.	595.
6	1820.	1302.	1859.	1426.	1381.
7	904.	1816.	1373.	1938.	1626.
8	458.	499.	1336.	939.	1451.
9	87.	173.	287.	909.	435.
10	62.	33.	86.	136.	513.
11	119.	196.	144.	475.	496.
Total	4141.	5160.	6070.	6794.	6688.

Table F16 continued.

AGE	2002	2003	2004	2005	2006
3	67.	28.	36.	35.	27.
4	235.	202.	167.	137.	79.
5	544.	590.	513.	512.	255.
6	1043.	811.	816.	860.	590.
7	1644.	1100.	789.	878.	726.
8	1191.	1145.	662.	569.	533.
9	869.	647.	570.	320.	303.
10	151.	476.	286.	244.	134.
11	425.	505.	380.	200.	109.
<hr/>					
Total	6168.	5504.	4221.	3756.	2757.
AGE	2007	2008	2009	2010	
3	74.	66.	33.	54.	
4	88.	299.	259.	111.	
5	204.	278.	990.	555.	
6	473.	421.	588.	1478.	
7	805.	690.	547.	655.	
8	519.	777.	602.	364.	
9	310.	294.	588.	410.	
10	149.	210.	141.	372.	
11	89.	159.	152.	100.	
<hr/>					
Total	2710.	3194.	3900.	4099.	

Table F17. Witch flounder input vectors for biological reference points (yield and spawning biomass per recruit analyses and long-term stochastic projections).

Age	Partial recruitment	Sel. on M	Mean	Mean	
			Stock wts	Catch wts	SpStock wts
3	0.011	1	0.087	0.113	0.087
4	0.039	1	0.152	0.206	0.152
5	0.091	1	0.244	0.279	0.244
6	0.427	1	0.322	0.363	0.322
7	0.603	1	0.414	0.461	0.414
8	1.000	1	0.501	0.541	0.501
9	1.000	1	0.595	0.641	0.595
10	1.000	1	0.662	0.690	0.662
11+	1.000	1	0.830	0.830	1.00

Age 3	
Year	('000 fish)
1982	15,409
1983	17,706
1984	16,371
1985	7,670
1986	5,437
1987	3,137
1988	9,301
1989	6,070
1990	7,541
1991	8,659
1992	12,156
1993	8,905
1994	13,104
1995	11,837
1996	15,676
1997	13,896
1998	14,774
1999	12,596
2000	11,448
2001	12,134
2002	11,213
2003	8,476
2004	5,106
2005	3,702
2006	4,521
2007	12,438
2008	7,277
2009	3,962
Mean	10,019

Table F18. Witch flounder yield and spawning stock biomass per recruit results and corresponding biological reference points estimated in GARM 2008 and Update 2012. The $F_{msy} = F_{40\%}MSP$ is based on yield per recruit analyses, while the SSB_{msy} and MSY estimates are based on long-term stochastic projections using the VPA SPLIT RUN. (*Note: mean Age 3 recruitment values are not used in the calculations of Update 2012 SSB_{msy} and MSY estimates*).

	F _{msy} F _{40%}	Y/R (kg)	SSB/R (kg)	Mean Age 3		Agepro Projections	
				Recruitment (fish,millions)	(mt)	SSB _{msy} (mt)	MSY (mt)
GARM 2008							
SPLIT RUN	0.20	0.1943	0.9346	11.1		11,447	2,352
Update 2012							
SPLIT RUN	0.27	0.2069	0.9970	10.0		10,051	2,075

Table F19. Short-term projected median estimates of catch (mt) and spawning stock biomass (mt) of witch flounder in 2011 through 2017 under four fishing mortality scenarios: F status quo, Fmsy, F75%msy [with Age 3 stock size estimated via survey tuning indices and via 2006-2010 geometric mean (GM)], and F-rebuild based on the VPA **SPLIT RUN**. Projections assumed 2011 catches = 2010 catches; initial 2011 stock sizes for ages 3 to 11+ are from the calibrated VPA, average 2006-2010 partial recruitment, average 2006-2010 mean weights and maturation ogive representing 2007-2011 maturities are given below.

Projection input vectors:

Age	Partial recruitment	Sel. on M	Mean	Mean	Mean	
			Stock wts	Catch wts	SpStock wts	Maturity
3	0.011	1	0.087	0.113	0.087	0.11
4	0.039	1	0.152	0.206	0.152	0.25
5	0.091	1	0.244	0.279	0.244	0.47
6	0.427	1	0.322	0.363	0.322	0.71
7	0.603	1	0.414	0.461	0.414	0.87
8	1.000	1	0.501	0.541	0.501	0.95
9	1.000	1	0.595	0.641	0.595	0.98
10	1.000	1	0.662	0.690	0.662	0.99
11+	1.000	1	0.830	0.830	0.830	1.00

Projection results based on SPLIT RUN:

Catch (mt)	GM Age 3 t+1				
	Fsq (0.47)	Fmsy (0.27)	F75%msy (0.20)	F75%msy (0.20)	Frebuild (0.18)
Year					
2011	848	848	848	848	848
2012	1,946	1,207	919	902	854
2013	1,800	1,273	1,017	976	955
2014	1,947	1,465	1,205	1,007	1,140
2015	2,105	1,660	1,393	1,129	1,324
2016	2,328	1,909	1,630	1,258	1,556
2017	2,323	1,991	1,734	1,414	1,663
Spawning Stock Biomass (mt)					
Year					
2011	5,212	5,212	5,212	5,103	5,212
2012	5,860	5,995	6,044	5,695	6,054
2013	6,016	6,819	7,135	6,160	7,207
2014	6,477	7,741	8,298	6,769	8,427
2015	7,002	8,719	9,527	7,668	9,722
2016	7,236	9,343	10,387	8,511	10,641
2017	7,211	9,653	10,921	9,260	11,233

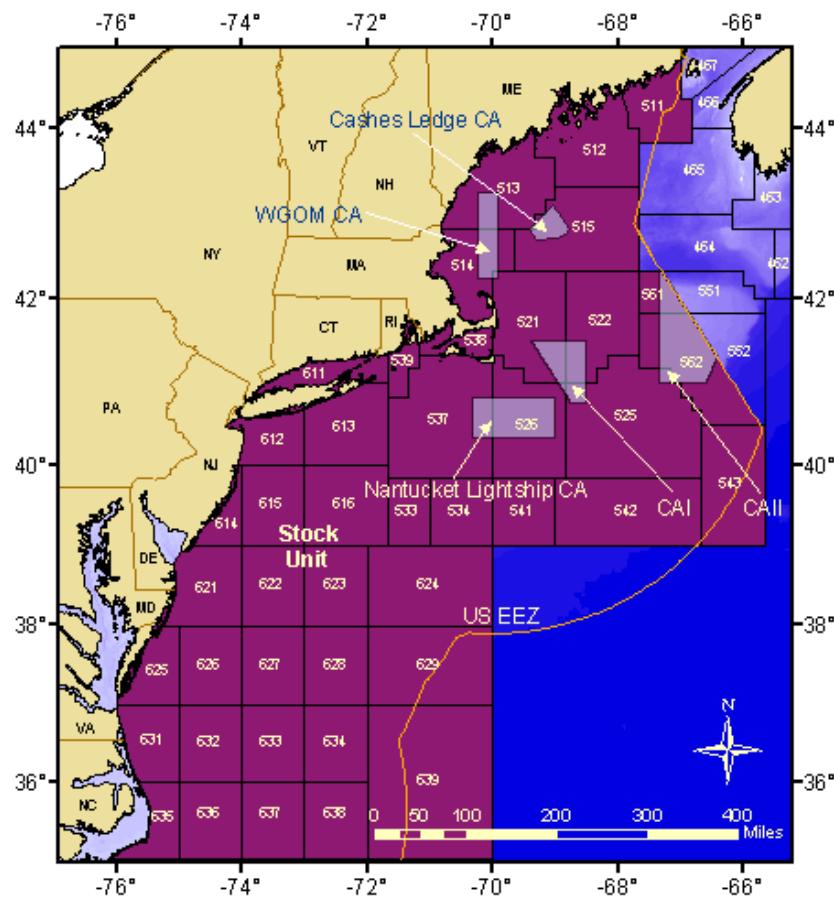


Figure 10.1. Statistical areas used to define the witch flounder stock.

Figure F1. Statistical areas used to define the witch flounder stock.

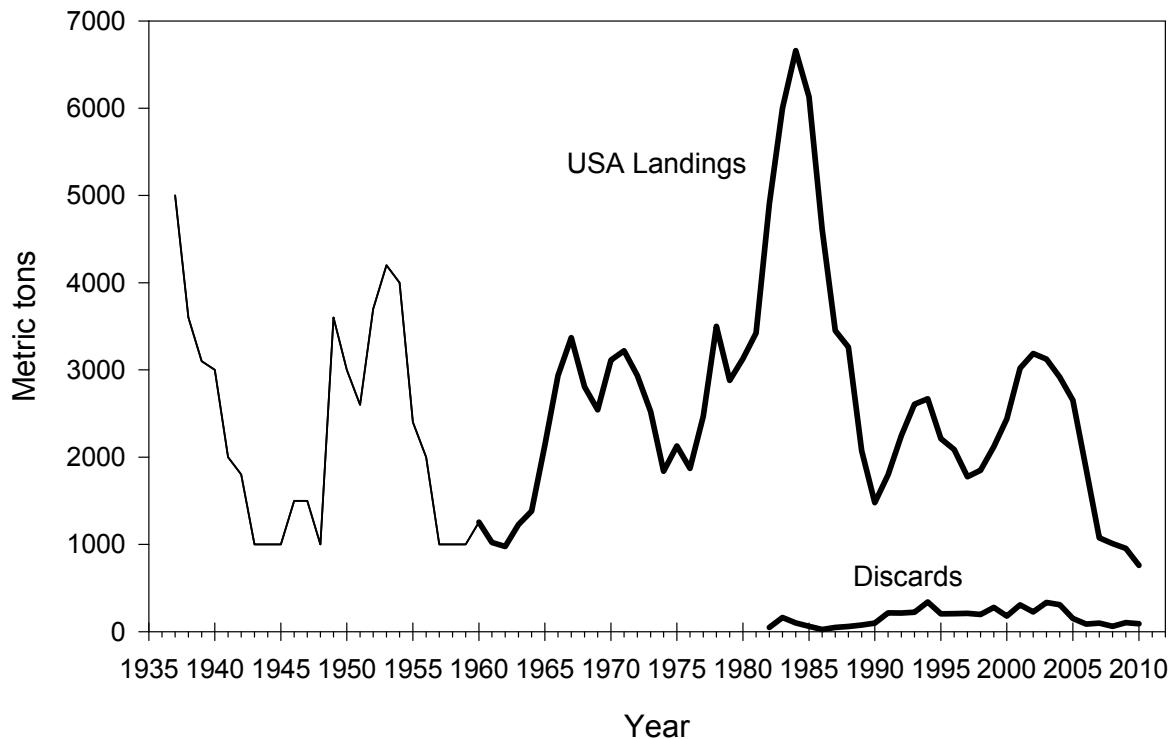


Figure F2. Historical USA witch flounder landings (mt), excluding USA landings from the Grand Banks in the mid-1980's. The thin line represents provisional landings data taken from Lange and Lux (1978). Discards are from the northern shrimp, small-mesh (<5.5 inch) otter trawl and large-mesh (>5.5 inch) otter trawl fisheries.

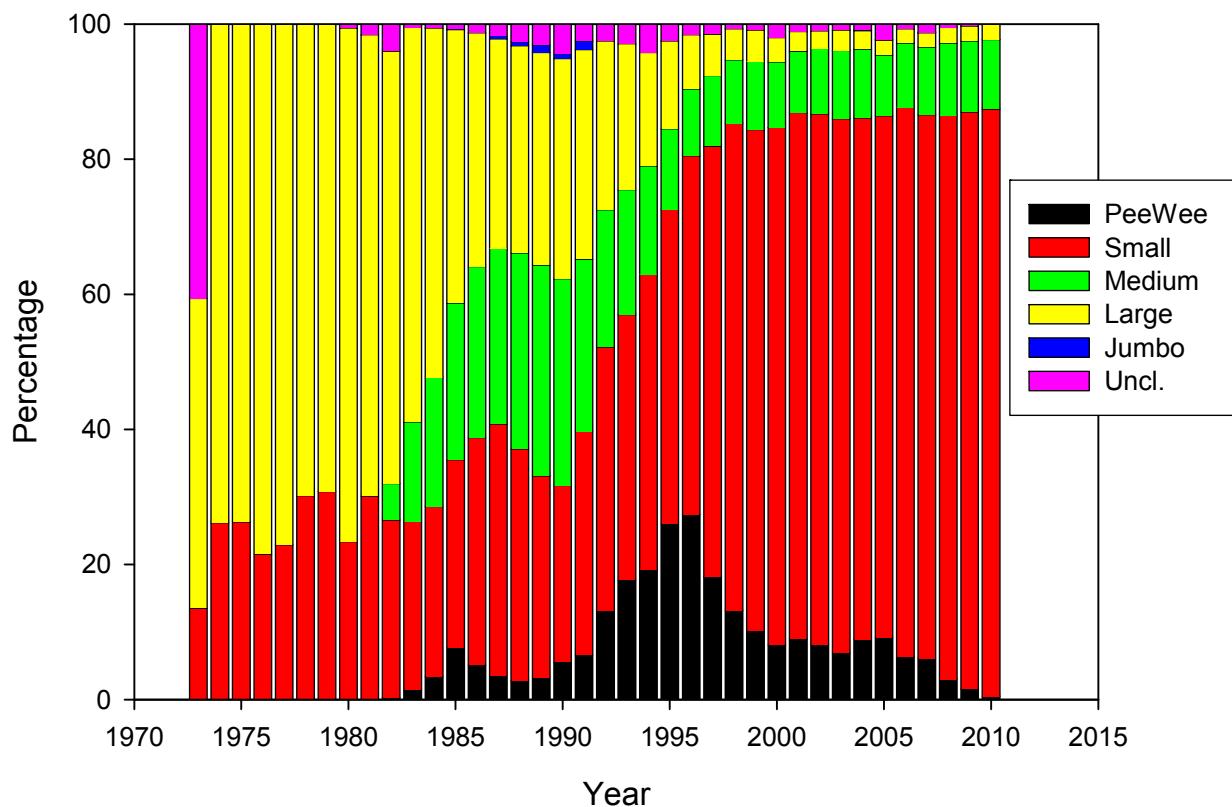


Figure F3. Percentage of witch flounder landings by market category for 1973 to 2010.

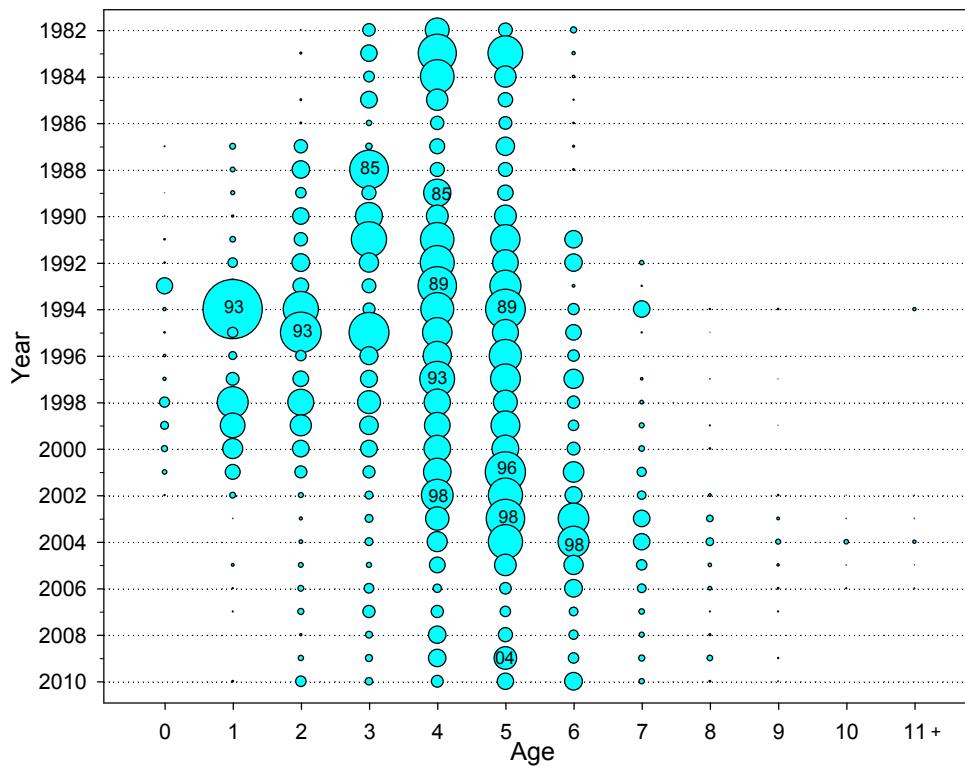


Figure F4. Witch flounder discards at age (in numbers) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 to 2010; selected cohorts are labeled.

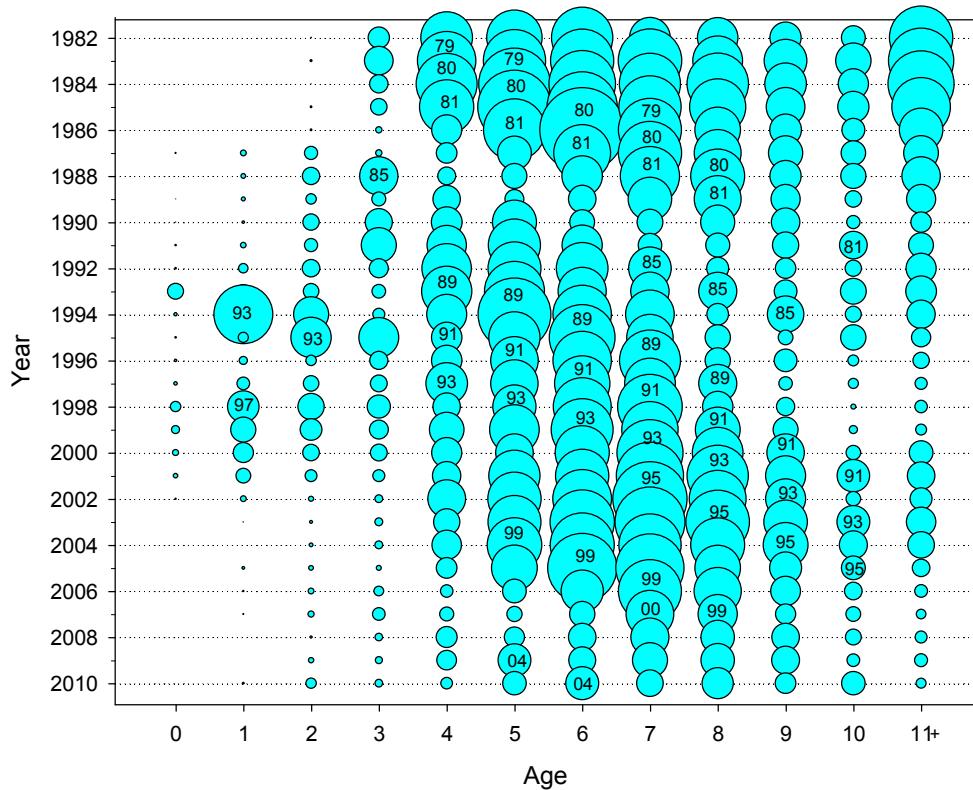


Figure F5. Witch flounder catch at age (in numbers), 1982-2010; selected cohorts are labeled.

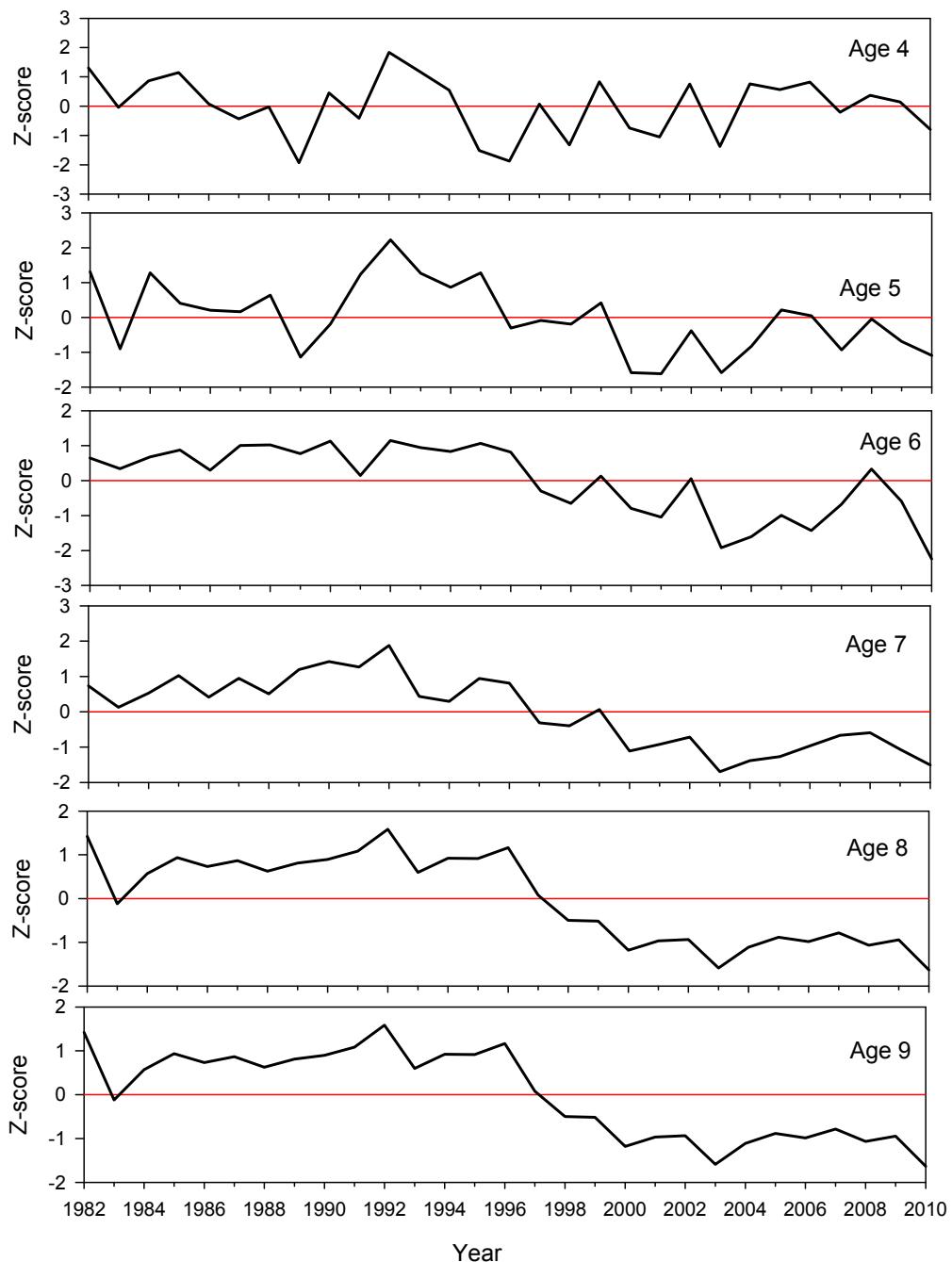


Figure F6. Z-scores of witch flounder mean weight at age in the catch for ages 4 to 9, 1982 - 2010.

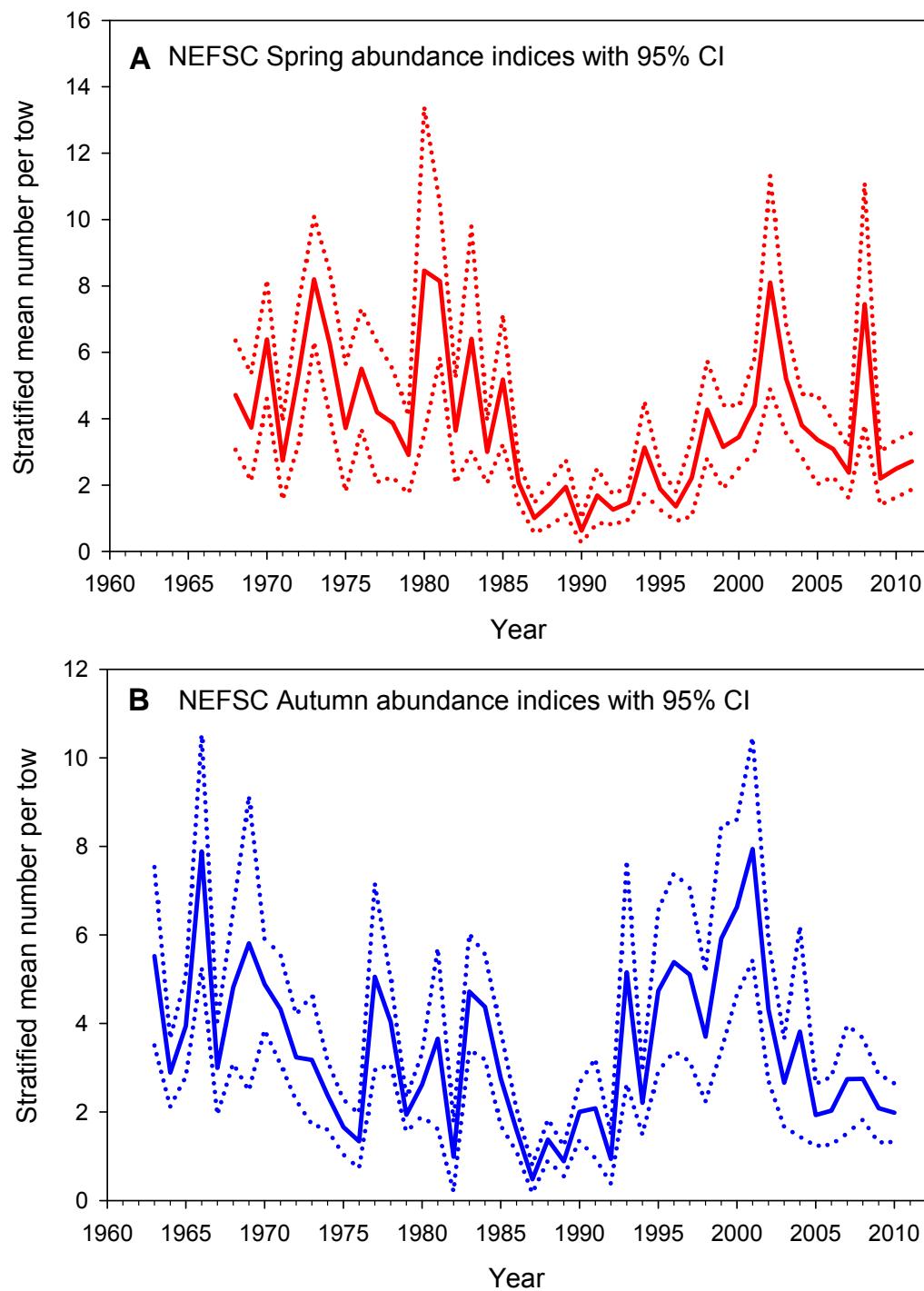


Figure F7. Stratified mean number per tow of witch flounder in the NEFSC spring (A) and autumn (B) bottom trawl surveys, 1963-2010, spring 2011.

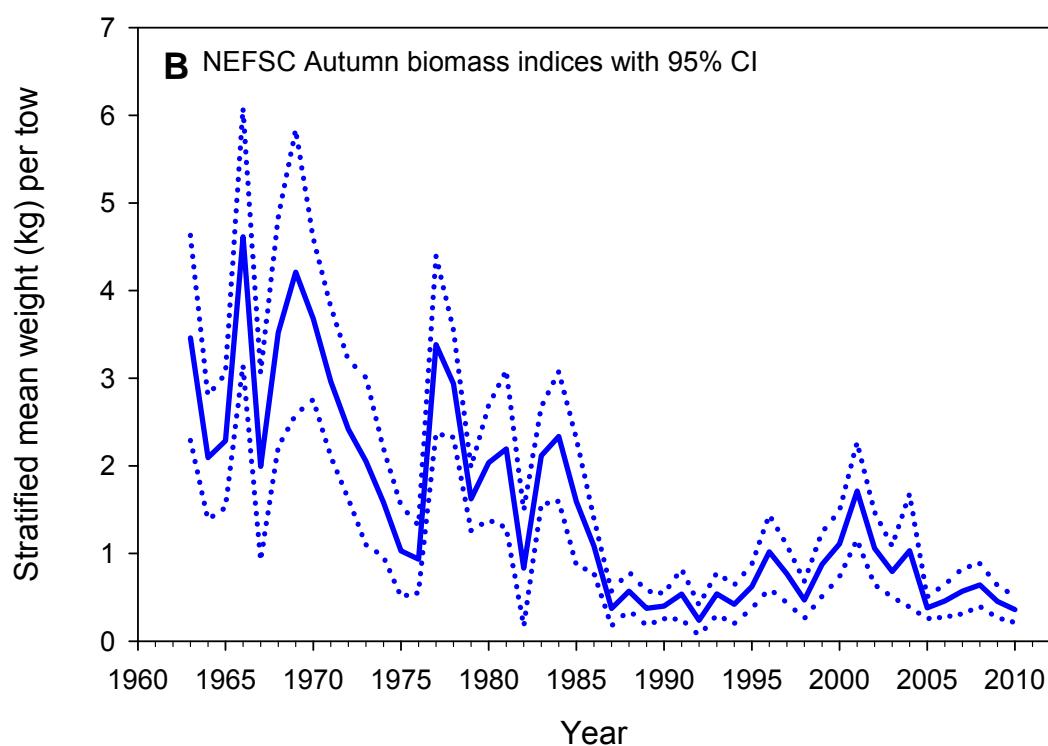
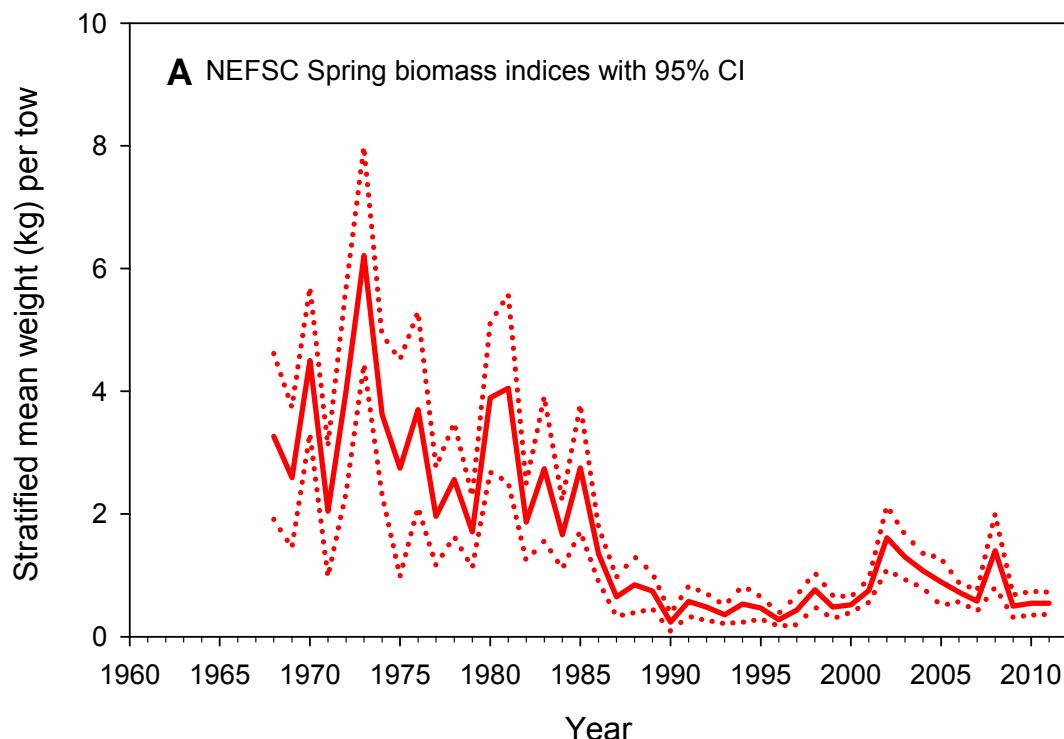


Figure F8. Stratified mean weight (kg) per tow of witch flounder in the NEFSC spring (A) and autumn (B) bottom trawl surveys, 1963-2010 and spring 2011.

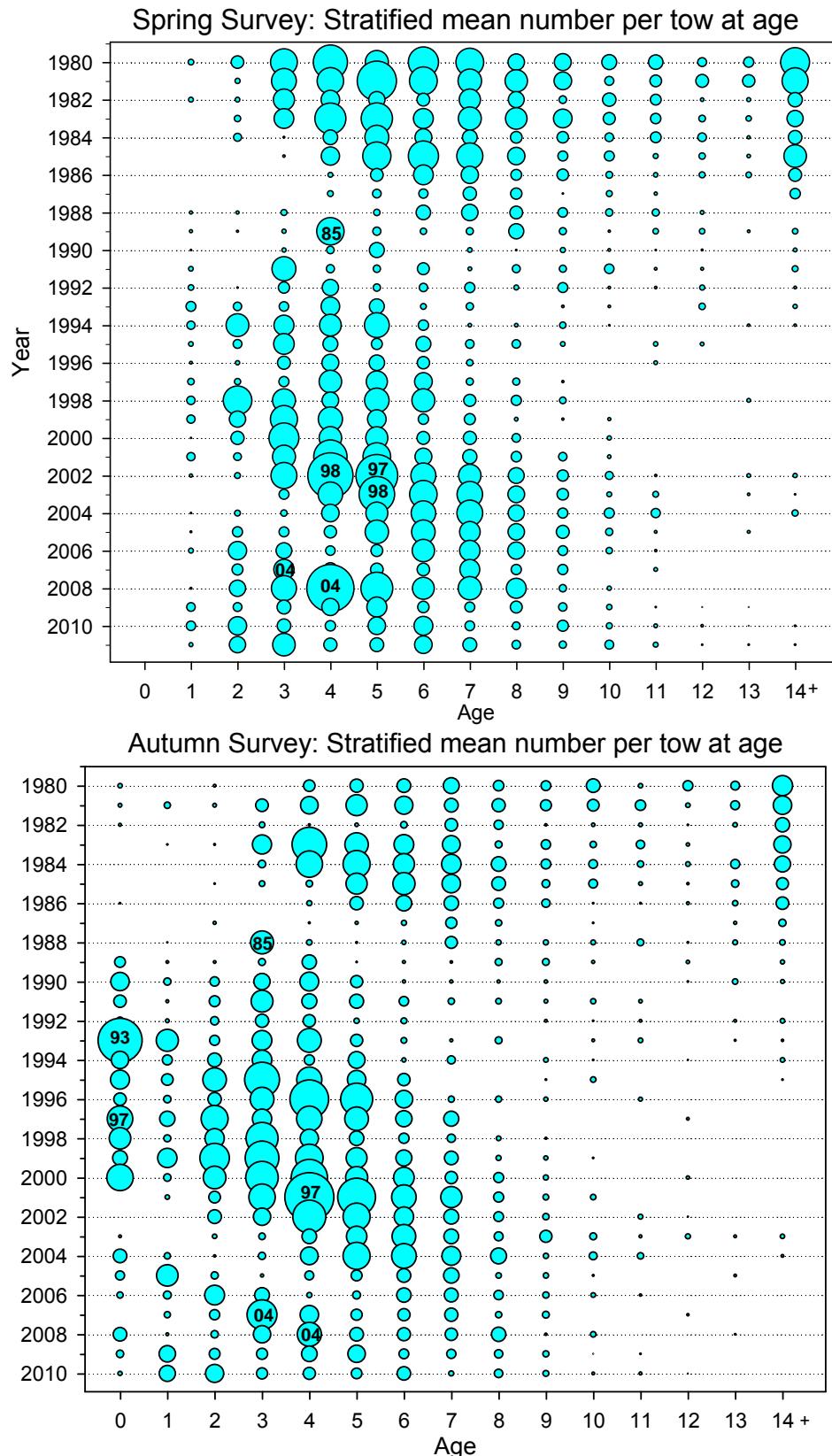


Figure F9. Stratified mean number of witch flounder per tow at age from NEFSC spring (top) and autumn (bottom) surveys, 1980 – 2011.

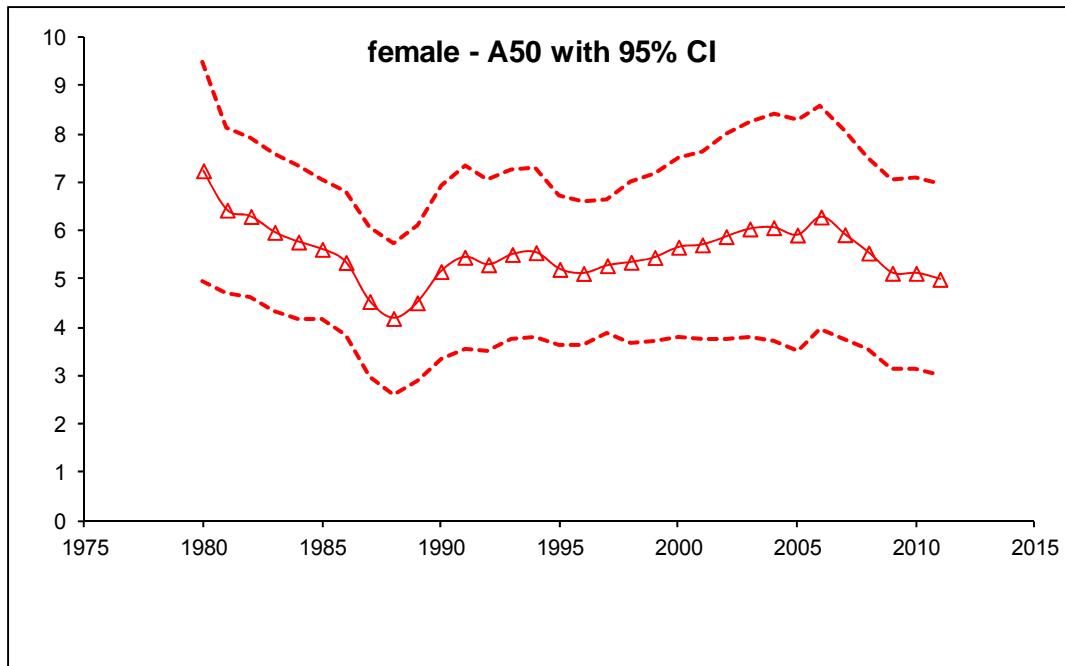


Figure F10. Annual estimates of median age (A50) of female witch flounder maturity derived from a five-year moving time block of maturity observations collected during the NEFSC spring survey, 1980 – 2011.

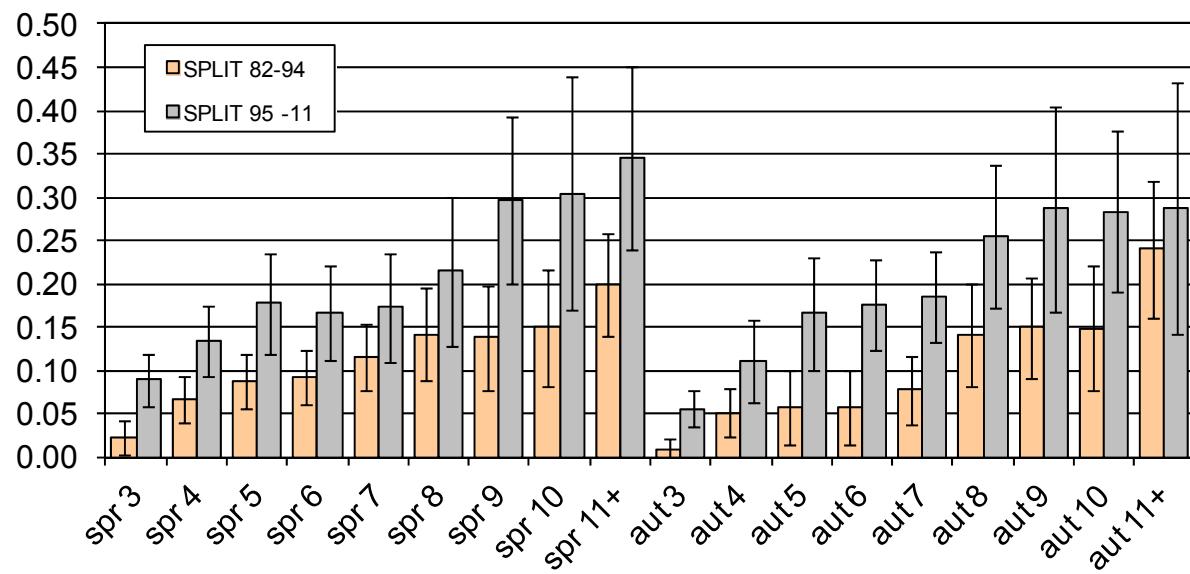


Figure F11. NEFSC swept-area survey catchabilities (q) by age (3 to 11+) and season (spring and autumn) from the VPA SPLIT RUN (survey tuning indices split between 1994 and 1995).

SPLIT RUN

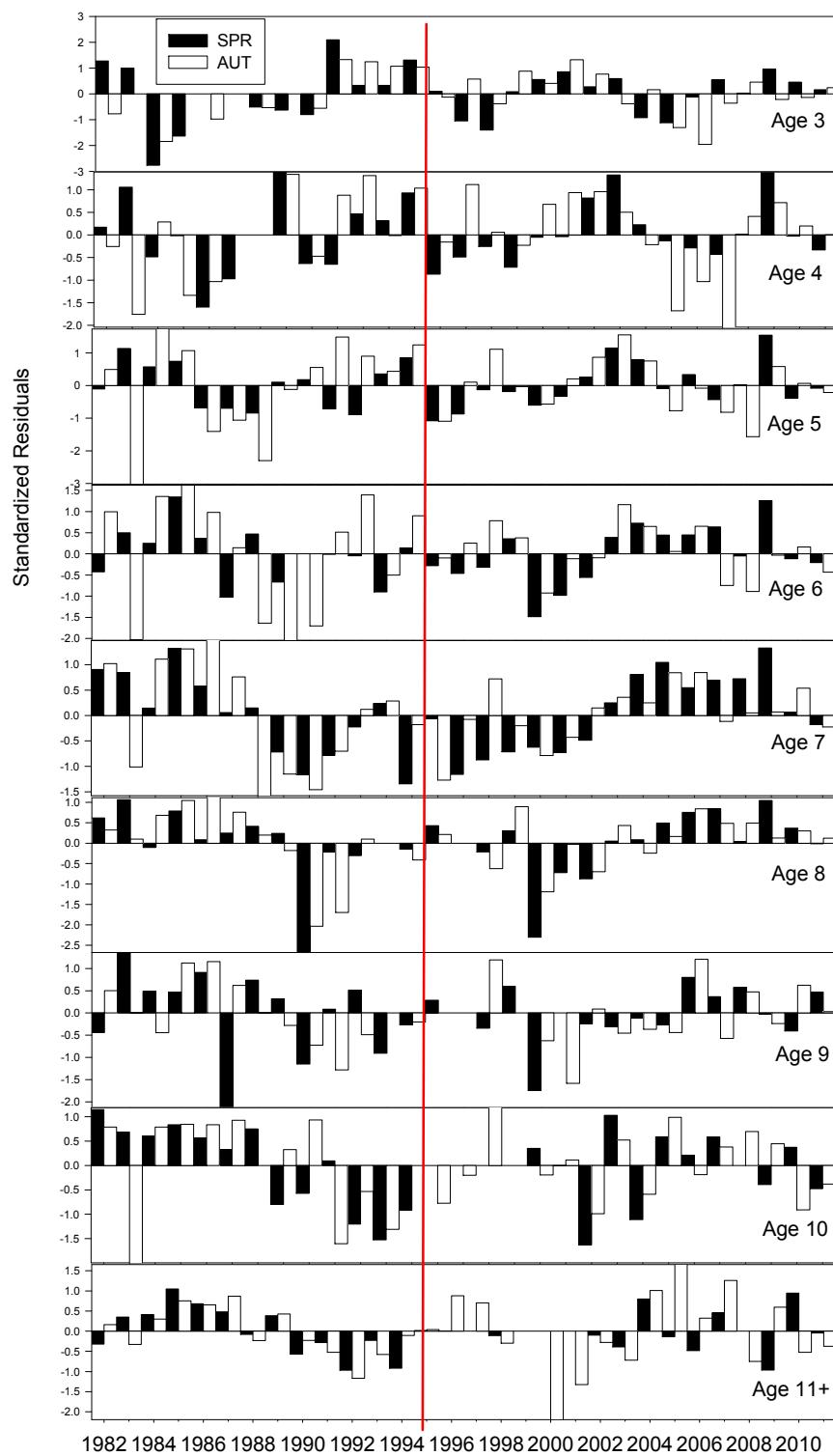


Figure F12. Witch flounder standardized residuals for NEFSC survey indices (spring solid bar and autumn open bar) at age from the VPA SPLIT RUN, 1982-2010. Red vertical line indicates the 1994 and 1995 split.

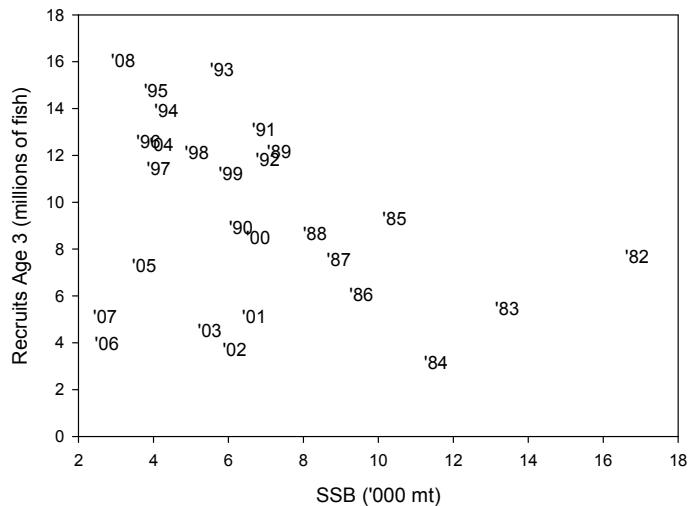
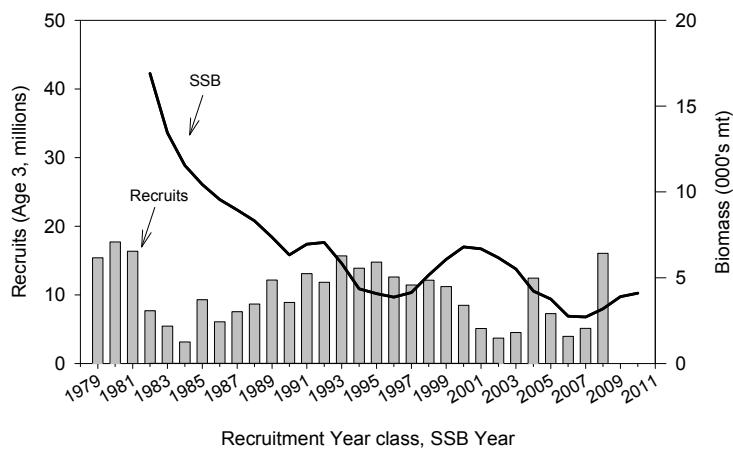
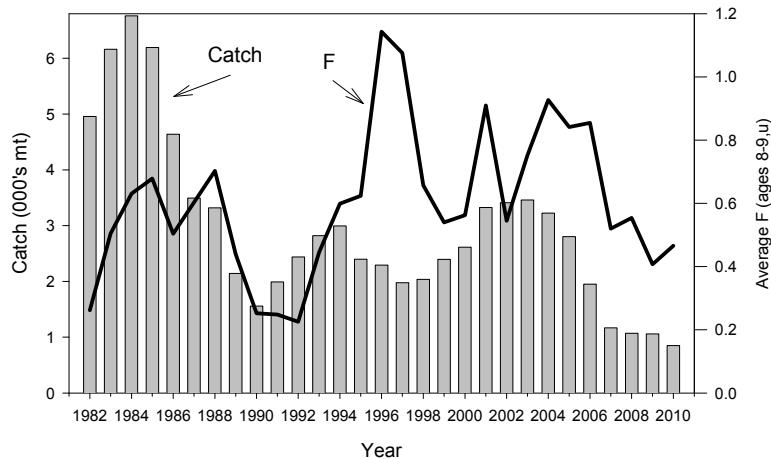


Figure F13. Trends of witch flounder total catch and fishing mortality (top), spawning stock biomass and Age 3 recruitment (middle), and spawning stock biomass (thousands, mt) and recruits (age 3, millions), 1982 – 2008 year classes (bottom) from VPA SPLIT RUN, 1982 -2010.

SPLIT RUN

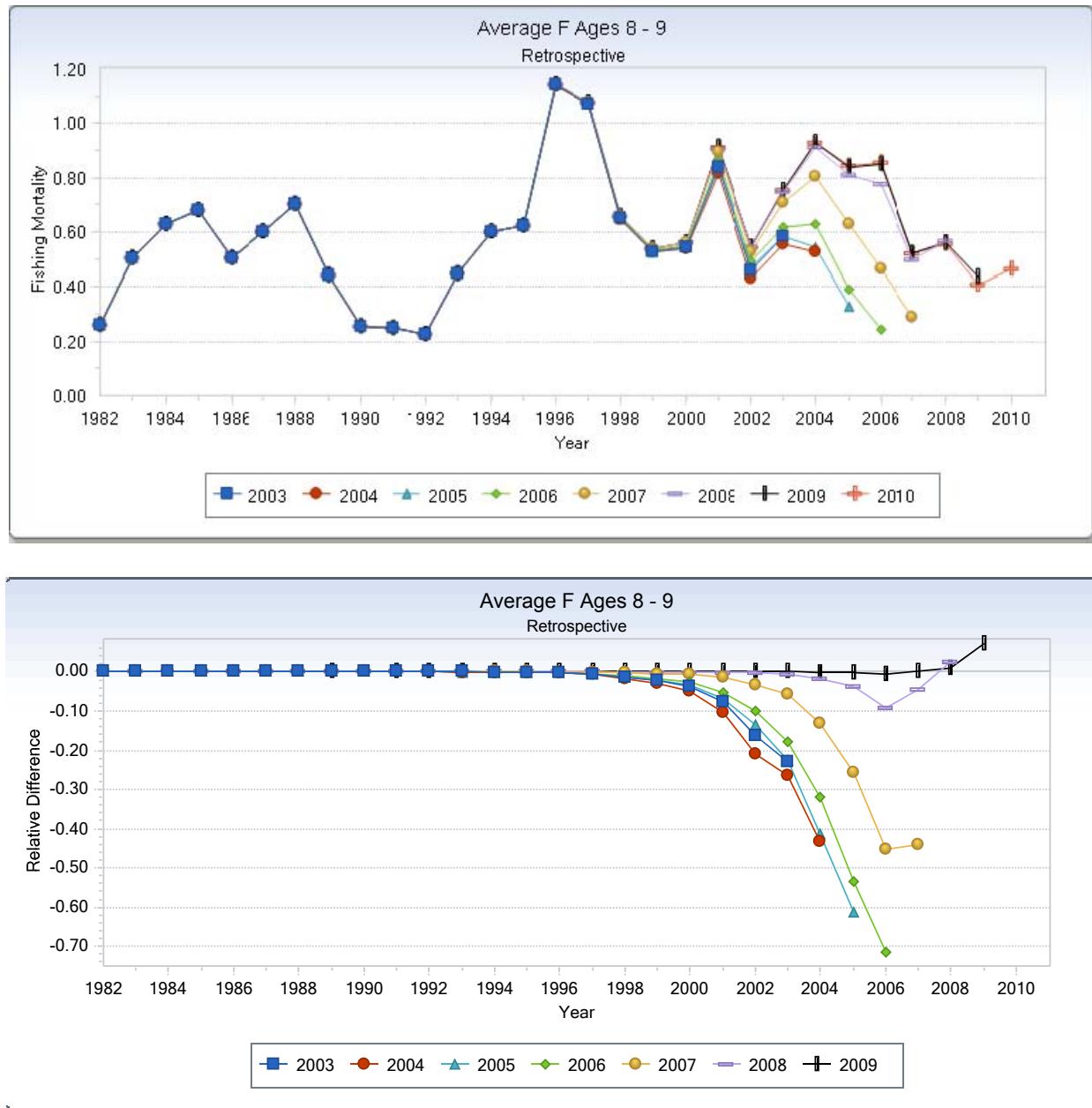


Figure F14. Retrospective analysis results of fishing mortality (top) and relative difference of fishing mortality from the terminal year (bottom) from VPA SPLIT RUN, 1982 – 2010.

SPLIT RUN

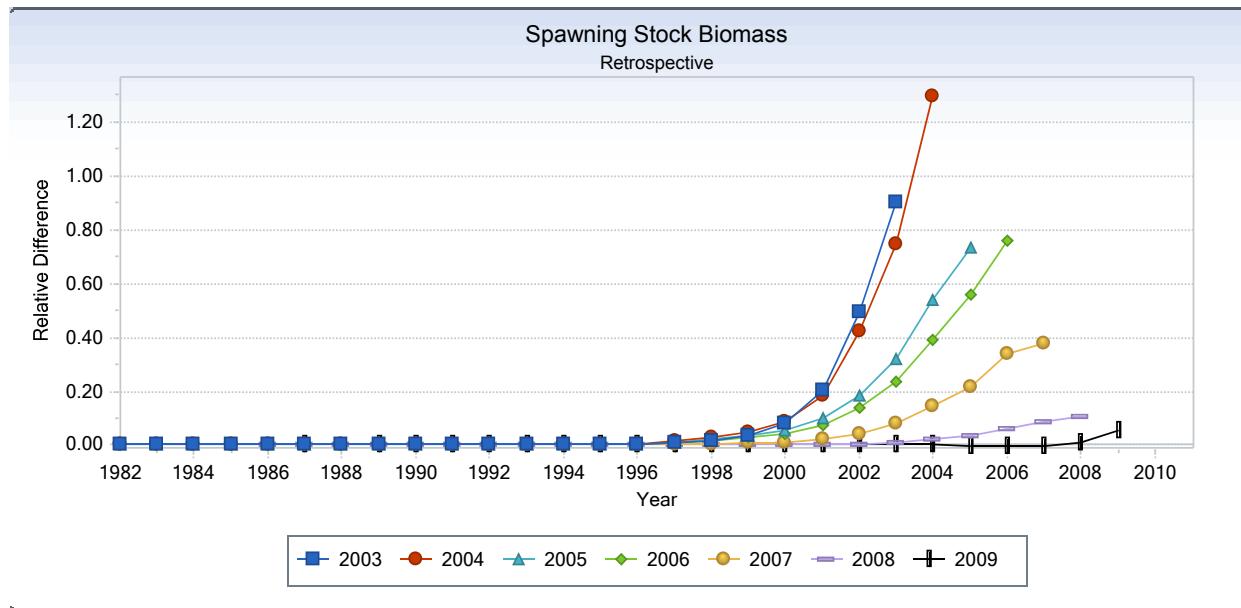
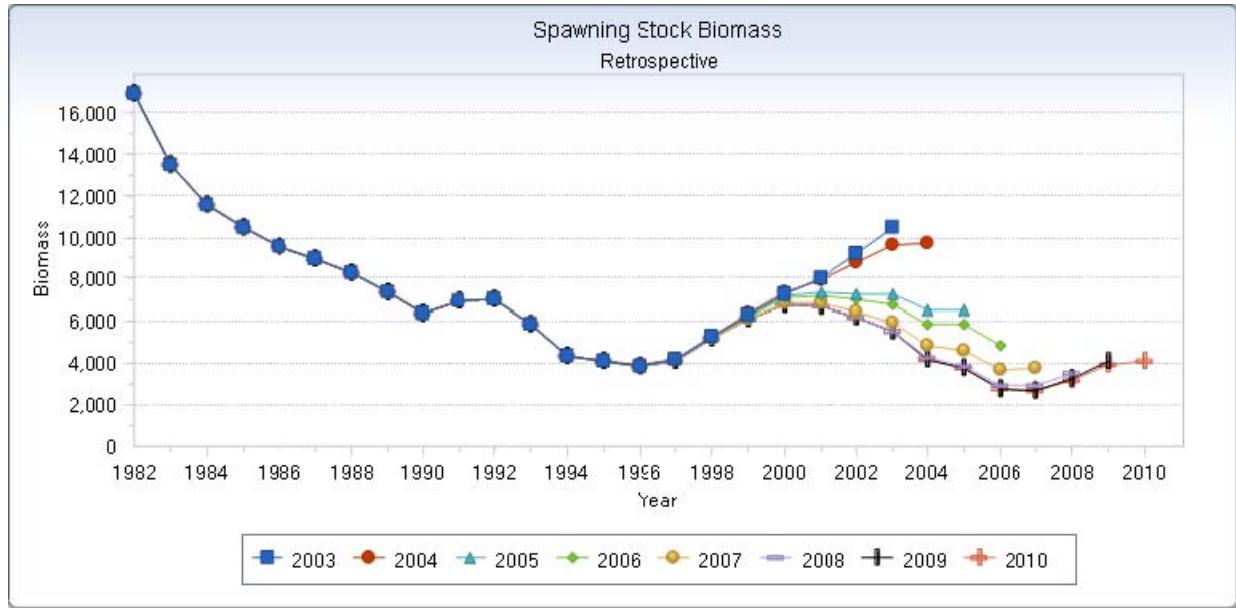


Figure F15. Retrospective analysis results of spawning biomass (top) and relative difference of spawning biomass from the terminal year (bottom) from VPA SPLIT RUN, 1982 – 2010.

SPLIT RUN

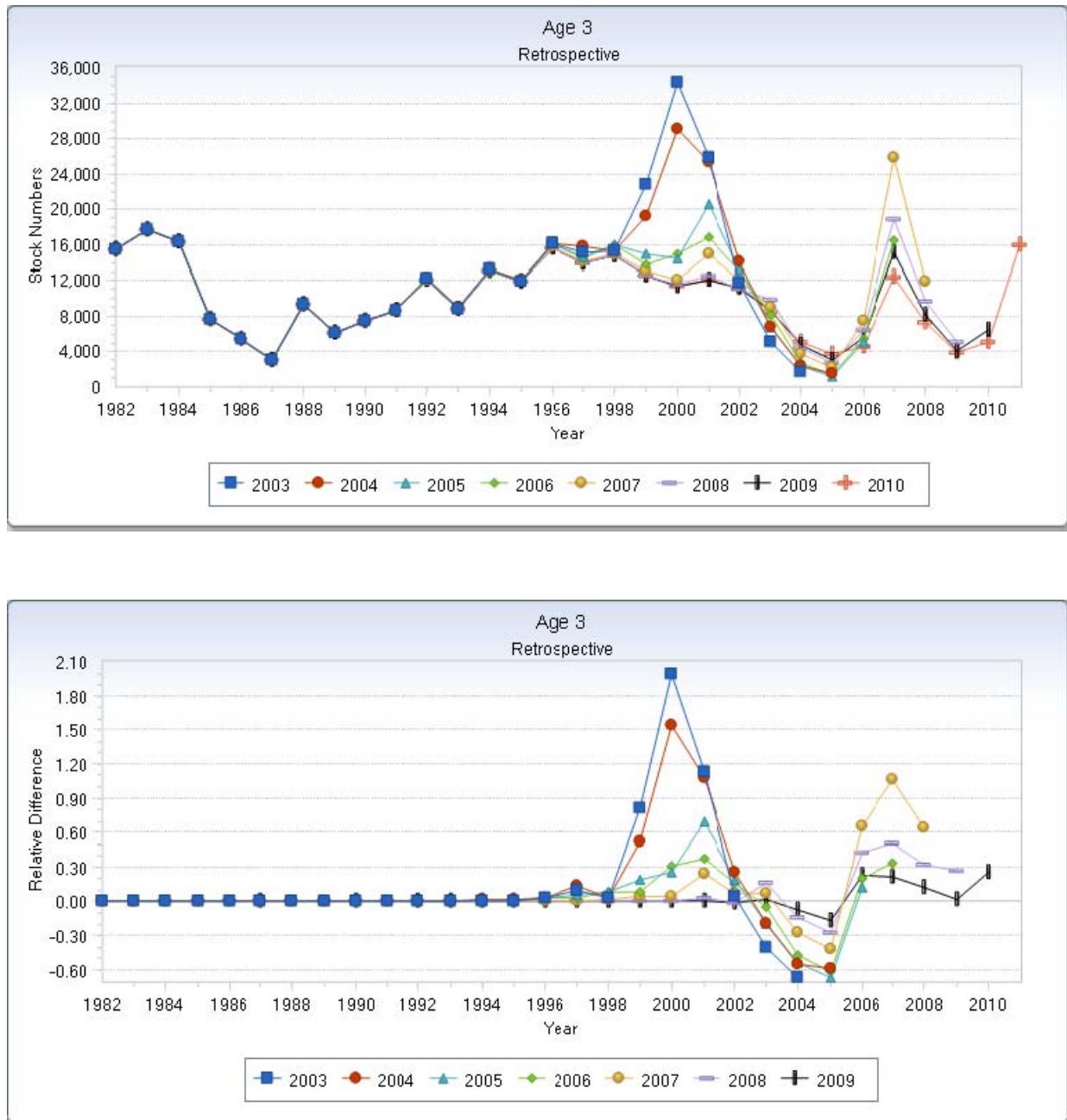


Figure F16. Retrospective analysis results of Age 3 recruitment (top) and relative difference of Age 3 recruitment from the terminal year (bottom) from VPA SPLIT RUN, 1982 – 2010.

SPLIT RUN

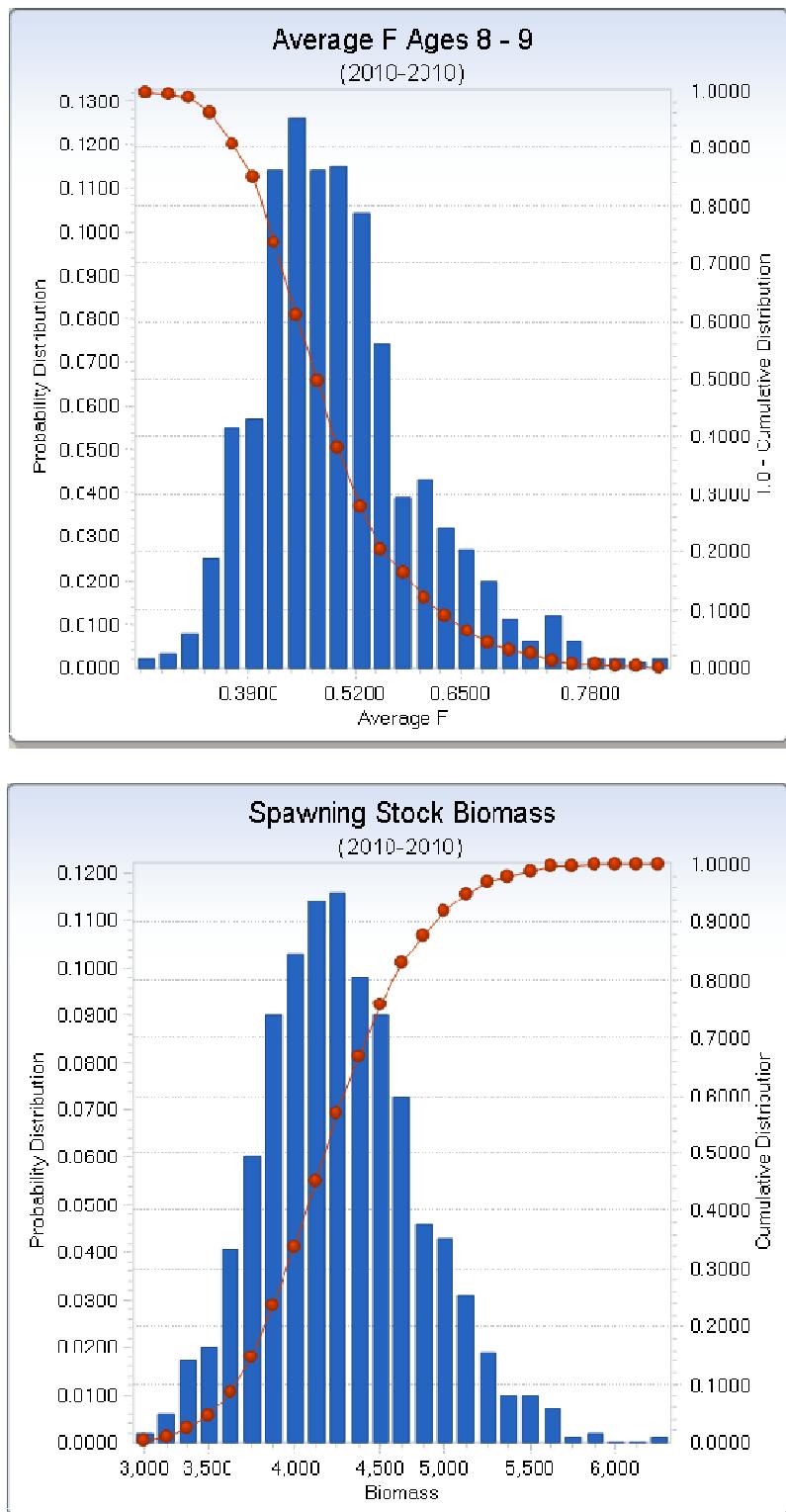


Figure F17. Precision estimates of fishing mortality (top) and spawning stock biomass (mt; bottom) in 2010 from the VPA SPLIT RUN. Vertical bars display both the range of the bootstrap estimates and the probability of the individual values in the range.

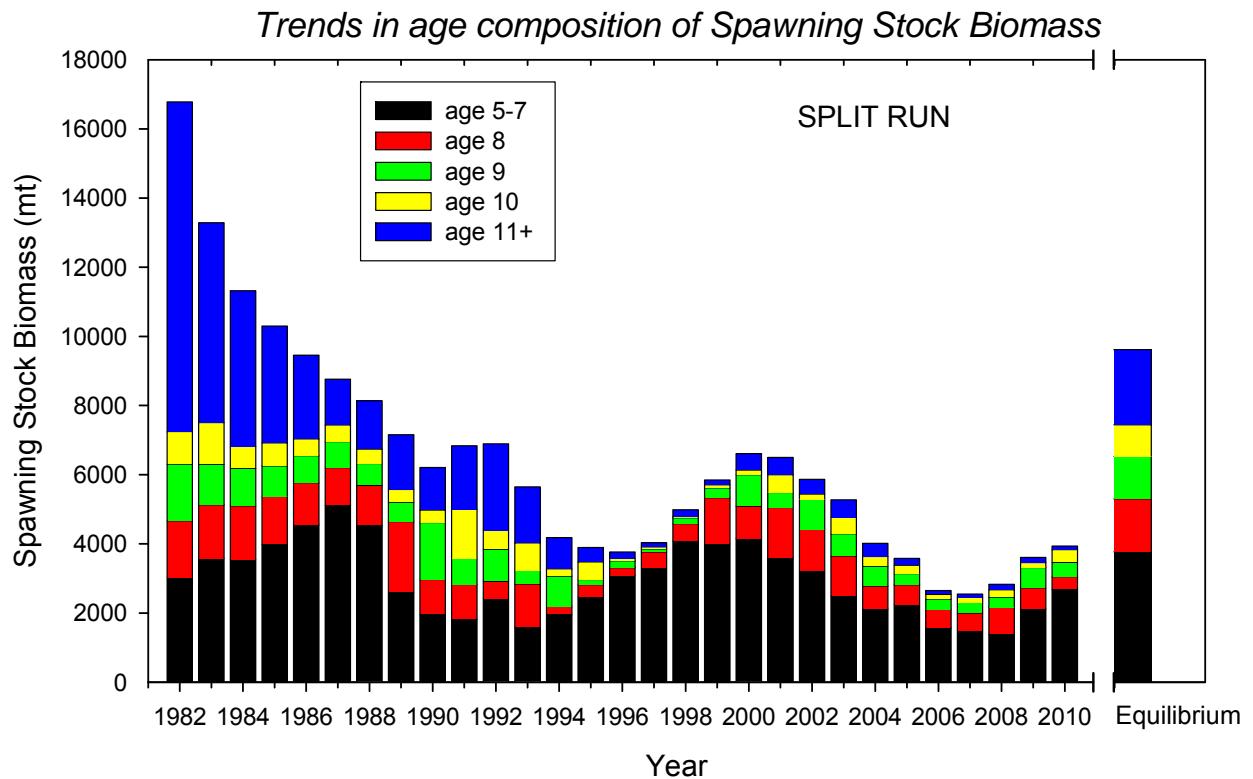


Figure F18. Age distribution of witch flounder spawning stock biomass, 1982-2010, and the expected age distribution at equilibrium, from VPA SPLIT RUN.

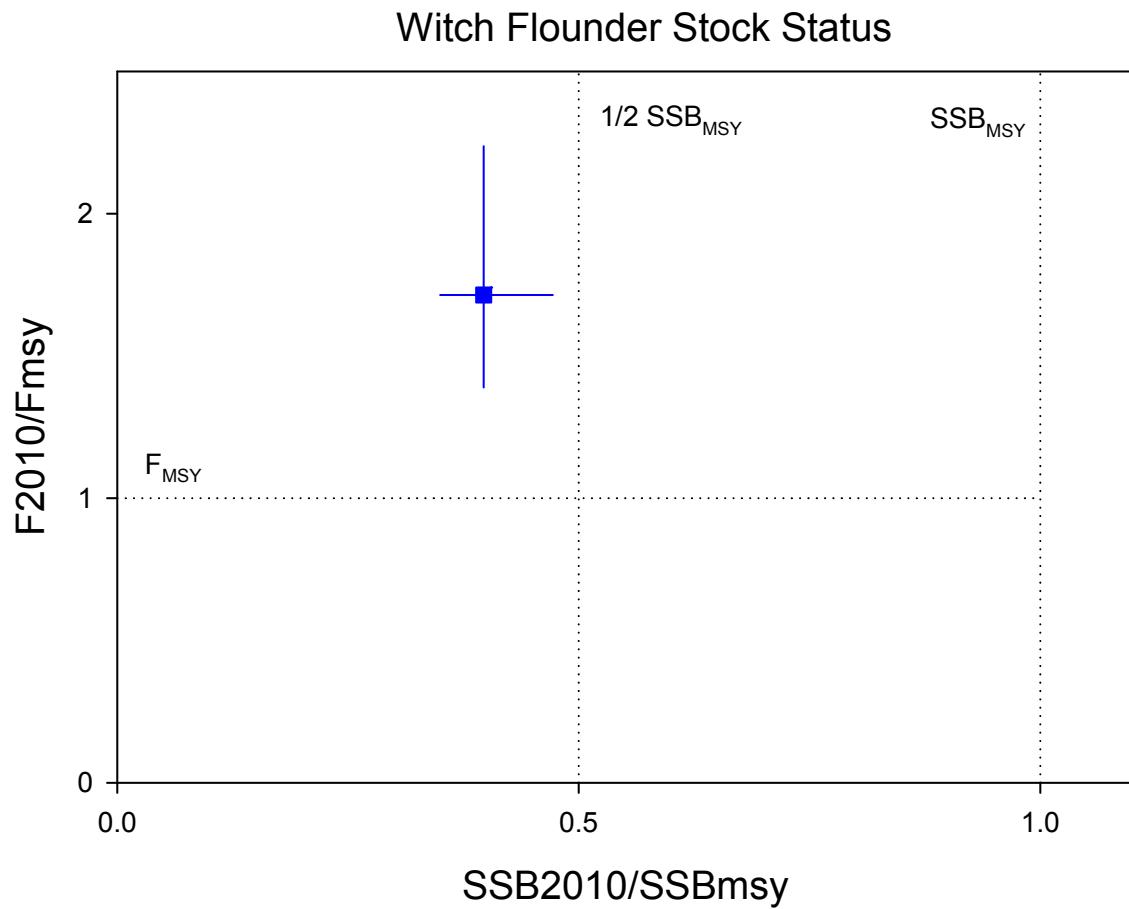


Figure F19. Witch flounder spawning stock biomass and fishing mortality (F8-9, u) with respect to the biological reference points, based on the VPA SPLIT RUN (square) with 80% confidence interval.

Appendix Table F1. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in **Massachusetts Division of Marine Fisheries inshore spring and autumn surveys** in the Cape Cod Bay and Mass. Bay region (Regions 4 and 5), 1978-2011.

Year	SPRING						AUTUMN					
	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow	Number per tow	CV	Weight per tow	CV	Length per tow	Avg. wt. per tow
1978	2.38	27.8	1.67	26.1	44.6	0.699	1.38	21.4	1.26	27.4	46.4	0.908
1979	1.26	30.4	1.32	36.7	48.3	1.046	1.52	60.0	1.08	56.0	42.9	0.708
1980	1.00	42.9	0.93	43.3	44.0	0.932	1.15	40.1	1.12	42.3	46.5	0.966
1981	2.44	44.0	1.83	49.5	40.2	0.747	0.39	91.7	0.23	86.5	41.2	0.589
1982	0.65	43.9	0.47	50.9	44.2	0.728	1.24	63.3	0.64	37.1	37.7	0.511
1983	1.97	40.9	1.02	23.5	36.8	0.519	2.22	35.7	1.46	33.3	44.6	0.658
1984	1.18	32.0	0.76	32.4	40.8	0.645	0.55	42.6	0.37	39.1	43.6	0.674
1985	1.01	25.3	0.73	28.3	43.4	0.720	0.76	51.4	0.50	46.0	43.6	0.655
1986	0.70	23.5	0.65	30.9	47.6	0.934	0.27	39.4	0.24	42.9	46.4	0.893
1987	0.88	48.1	0.73	42.0	45.1	0.821	0.19	39.2	0.13	41.6	44.6	0.713
1988	0.24	25.1	0.20	28.4	45.6	0.844	0.28	82.4	0.16	92.8	39.5	0.579
1989	0.13	46.9	0.05	47.9	34.9	0.369	0.13	56.4	0.06	52.7	38.1	0.491
1990	0.21	75.2	0.17	75.7	44.2	0.809	0.07	71.2	0.03	90.5	36.8	0.436
1991	0.11	58.6	0.04	77.6	34.1	0.393	0.35	39.6	0.21	40.2	41.1	0.602
1992	0.20	63.5	0.12	80.1	40.2	0.583	0.45	50.2	0.25	55.2	40.7	0.557
1993	0.03	100.0	0.01	100.0	33.0	0.200	0.30	47.8	0.15	52.9	40.9	0.5
1994	0.00	0.0	0.00	0.0	-	-	0.38	39.6	0.12	54.0	31.0	0.321
1995	0.10	36.0	0.06	62.6	36.0	0.613	2.41	77.8	0.41	53.0	26.7	0.172
1996	0.02	100.0	0.00	100.0	21.0	0.100	0.04	74.6	0.01	74.6	40.0	0.4
1997	0.05	0.0	0.01	100.0	31.5	0.250	0.51	83.3	0.15	88.9	36.0	0.3
1998	0.00	0.0	0.00	0.0	-	-	0.25	53.1	0.08	49.0	35.2	0.332
1999	0.02	100.0	0.00	0.0	11.0	-	0.67	37.2	0.17	43.6	33.7	0.251
2000	1.15	34.5	0.10	42.3	23.5	0.089	0.92	30.9	0.24	42.5	31.6	0.266
2001	0.07	46.8	0.02	65.2	33.0	0.250	0.43	22.1	0.12	33.2	33.2	0.275
2002	0.11	56.0	0.03	56.0	33.4	0.253	2.21	21.2	0.70	20.2	36.5	0.317
2003	0.19	15.3	0.04	22.0	30.2	0.217	1.19	30.2	0.53	32.1	39.8	0.445
2004	0.00	0.0	0.00	0.0	-	-	0.31	49.9	0.13	54.0	40.5	0.432
2005	0.05	71.0	0.03	75.1	45.5	0.675	0.51	33.1	0.19	31.6	37.8	0.369
2006	0.16	46.1	0.08	50.3	40.9	0.500	0.37	33.0	0.10	24.9	33.0	0.265
2007	0.46	43.6	0.13	49.8	34.6	0.286	0.51	40.9	0.15	33.7	36.8	0.295
2008	0.26	38.6	0.09	52.0	36.6	0.348	1.34	44.7	0.40	37.3	35.2	0.301
2009	0.44	73.1	0.08	65.1	31.1	0.185	1.27	29.6	0.40	44.7	33.4	0.311
2010	0.15	38.6	0.05	46.4	36.9	0.327	1.42	35.7	0.46	34.9	36.1	0.325
2011	0.35	78.9	0.12	76.8	34.9	0.348	3.51	30.9	0.97	30.4	35.1	0.277

Appendix Table F2. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in the **ASMFC summer shrimp surveys** in the Gulf of Maine (strata set 1,3,6,8), 1984 - 2010.

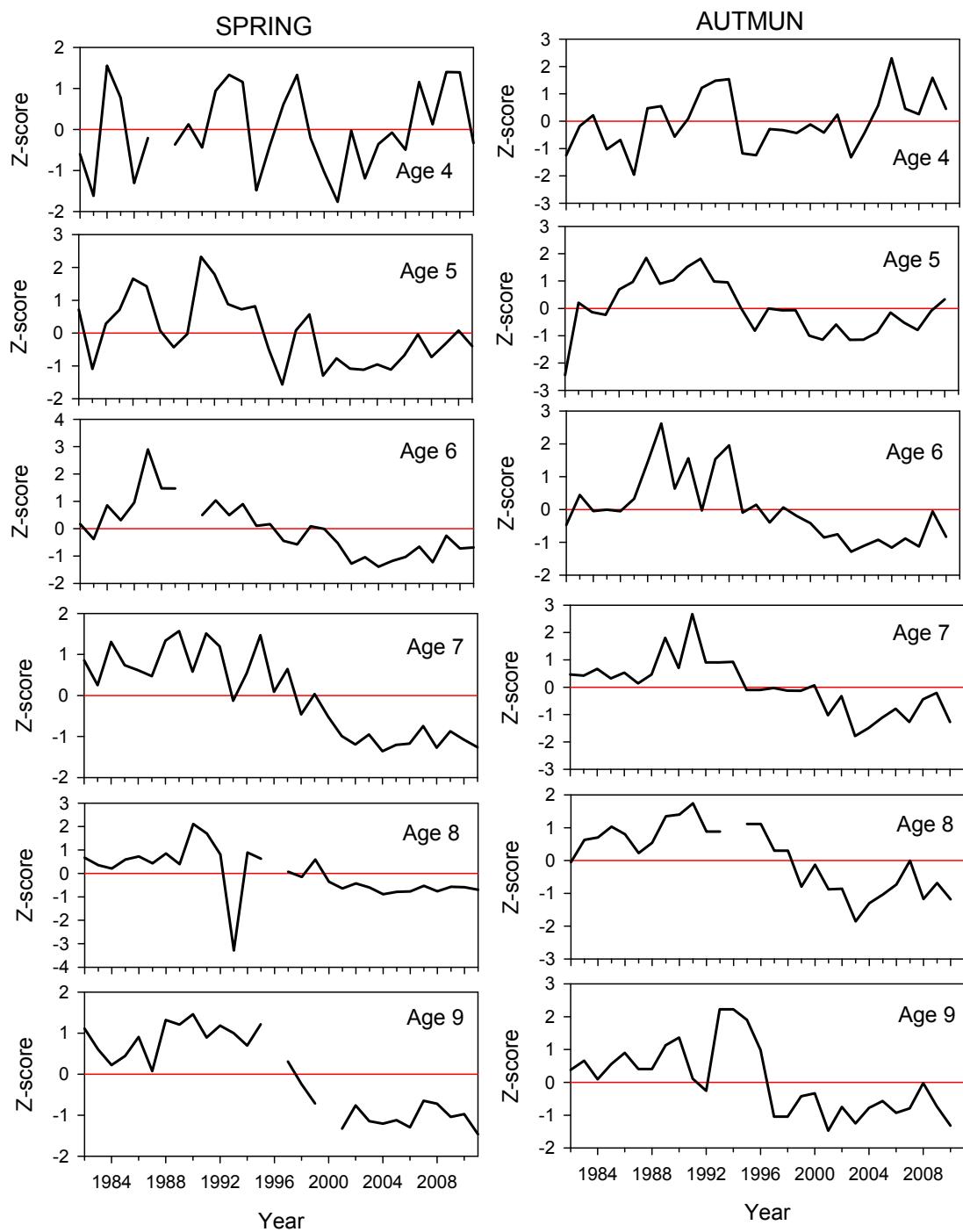
Year	Number		Weight		Length per tow	Avg. wt. per tow
	per tow	CV	per tow	CV		
1984	4.68	34.5	1.60	33.0	33.9	0.341
1985	6.19	18.7	2.52	15.4	36.0	0.408
1986	2.05	26.7	0.74	30.7	35.9	0.362
1987	4.87	28.4	1.50	28.5	26.5	0.307
1988	2.53	24.6	0.60	26.5	25.8	0.238
1989	2.92	32.3	0.31	29.4	22.8	0.105
1990	6.66	27.6	1.02	35.2	24.5	0.154
1991	14.94	34.6	1.20	30.0	19.6	0.080
1992	24.28	44.8	1.91	32.0	20.5	0.079
1993	21.42	27.4	0.50	18.2	12.8	0.023
1994	36.36	42.3	2.20	66.5	19.1	0.061
1995	17.95	37.9	1.48	40.9	22.6	0.082
1996	15.45	21.0	1.95	27.0	25.2	0.126
1997	23.19	43.2	1.42	22.1	19.1	0.061
1998	7.35	23.5	0.52	20.4	21.9	0.071
1999	110.07	23.3	5.93	22.6	18.7	0.054
2000	32.43	25.8	3.09	27.8	24.2	0.095
2001	41.52	33.3	5.57	34.2	27.2	0.134
2002	45.25	25.1	7.05	24.8	28.8	0.156
2003	24.06	22.5	4.46	21.3	30.6	0.185
2004	8.75	25.7	1.79	25.3	31.3	0.205
2005	19.77	23.0	2.00	26.4	21.6	0.101
2006	29.98	20.0	2.72	20.0	22.6	0.091
2007	23.10	21.6	2.49	23.5	25.1	0.108
2008	15.19	21.4	2.02	19.6	27.2	0.133
2009	23.21	23.4	3.88	37.3	27.1	0.167
2010	18.13	18.7	1.79	18.7	23.2	0.099

Appendix Table F3. Stratified mean number and weight (kg) per tow and associated standard error of witch flounder in the **ME-NH inshore spring and fall surveys** in the Gulf of Maine (strata set 1-4; regions 1-5), 2001 - 2011. Fixed stations are excluded; re-stratified for 2000, 2001 and 2002. *Indices provided by S. Sherman, ME DMR.*

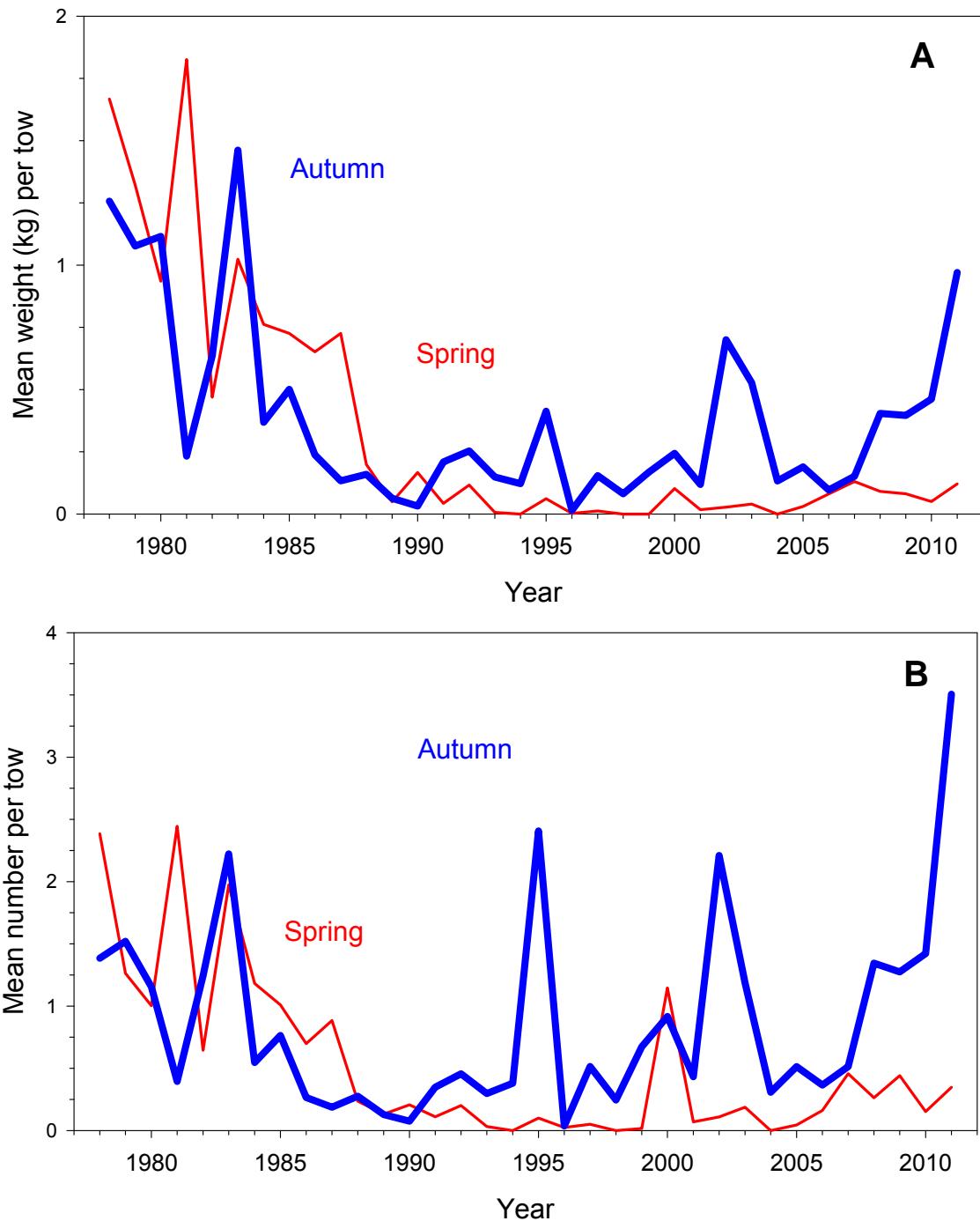
Year	SPRING				FALL			
	Number per tow	SE	Weight per tow	SE	Number per tow	SE	Weight per tow	SE
2000					3.89	0.56	0.22	0.03
2001	6.96	1.84	0.12	0.03	56.58	4.67	4.18	0.34
2002	4.58	0.86	0.41	0.15	6.29	0.93	0.65	0.13
2003	2.32	0.72	0.24	0.07	7.45	1.16	0.92	0.19
2004	1.42	0.21	0.10	0.02	11.73	1.94	1.41	0.20
2005	8.37	1.33	0.37	0.09	26.20	3.55	0.86	0.10
2006	5.17	1.11	0.24	0.06	12.83	1.37	0.83	0.07
2007	4.37	0.67	0.29	0.04	14.41	2.04	1.47	0.30
2008	4.25	0.60	0.38	0.08	14.78	1.79	1.31	0.23
2009	4.15	0.68	0.23	0.06	10.48	1.08	0.57	0.07
2010	5.17	0.91	0.31	0.06	16.22	1.74	0.81	0.10
2011	5.20	0.63	0.25	0.04				

Appendix Table F4. Summary of area (square nautical miles) of NEFSC survey strata (offshore strata 22-30; 36-40) used in the witch flounder stock assessment and the USA statistical areas associated with the witch flounder stock. The statistical areas that comprise approximately 96% of the landings are denoted with an asterisk (*).

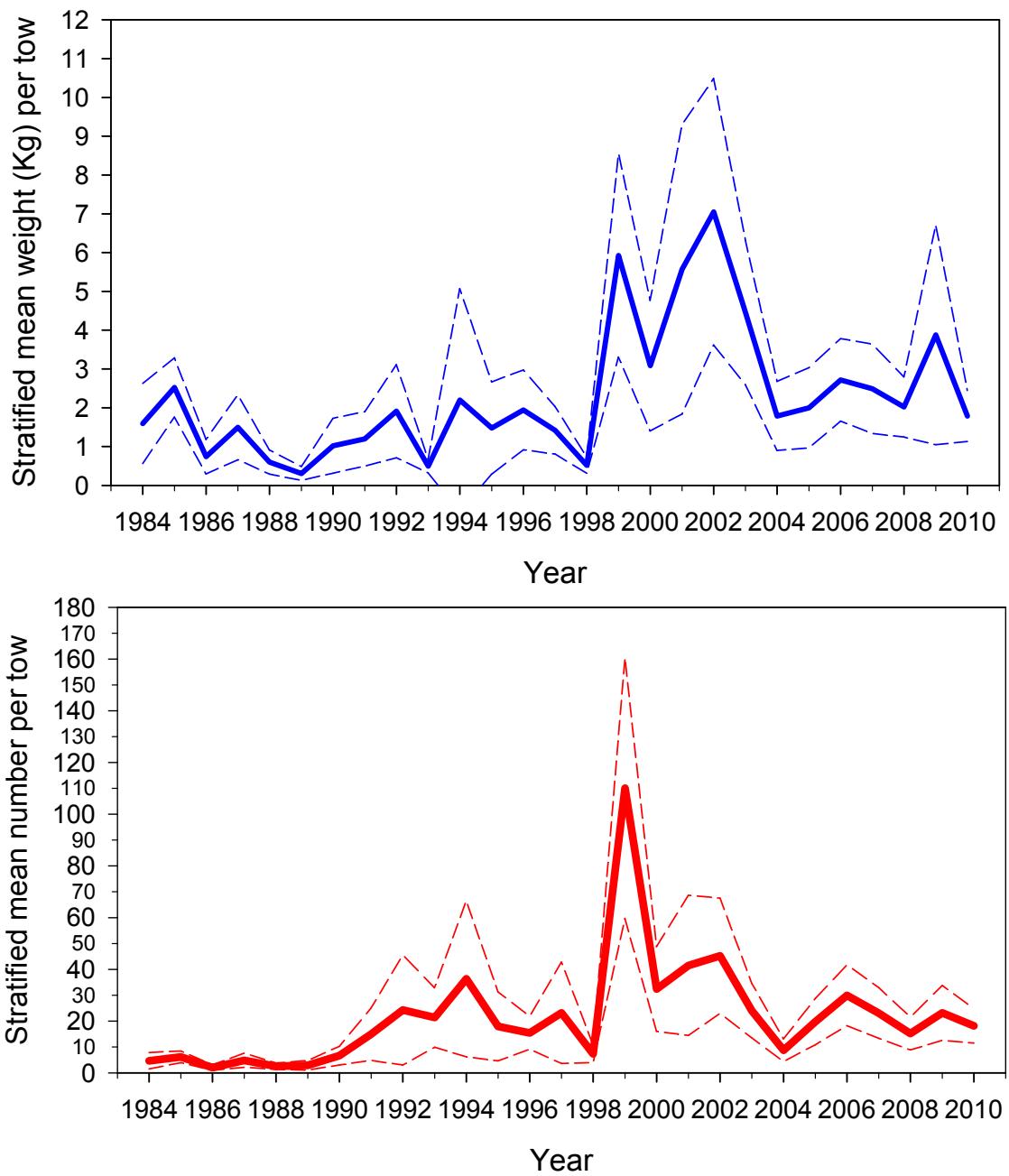
Survey Strata	Area	USA Stat	
		Areas	Area
22	454	464	208
23	1,016	465	258
24	2,569	467	75
25	390	511 *	1,313
26	1,014	512 *	3,652
27	720	513 *	3,567
28	2,249	514 *	2,573
29	3,245	515 *	4,603
30	619	521 *	3,853
36	4,069	522 *	3,663
37	2,108	525 *	7,461
38	2,560	526 *	4,029
39	730	533	1,547
40	578	534	2,320
Total	22,321	537	6,261
		538	800
		539	742
		541	2,320
		542	5,402
		543	2,281
		561 *	765
		562 *	3,562
		611	1,421
		612	1,893
		613	3,258
		614	1,131
		615	2,781
		616	3,707
		621	3,702
		622	2,820
		623	2,820
		624	5,638
		625	5,104
		626	2,858
		627	2,858
		628	2,858
		629	3,375
		631	3,115
		632	2,895
		633	2,895
		634	2,895
		635	3,485
		636	2,931
		637	2,931
		638	2,931
		639	3,508
		640	6,906
	Unit area		141,966
	* Areas		39,581



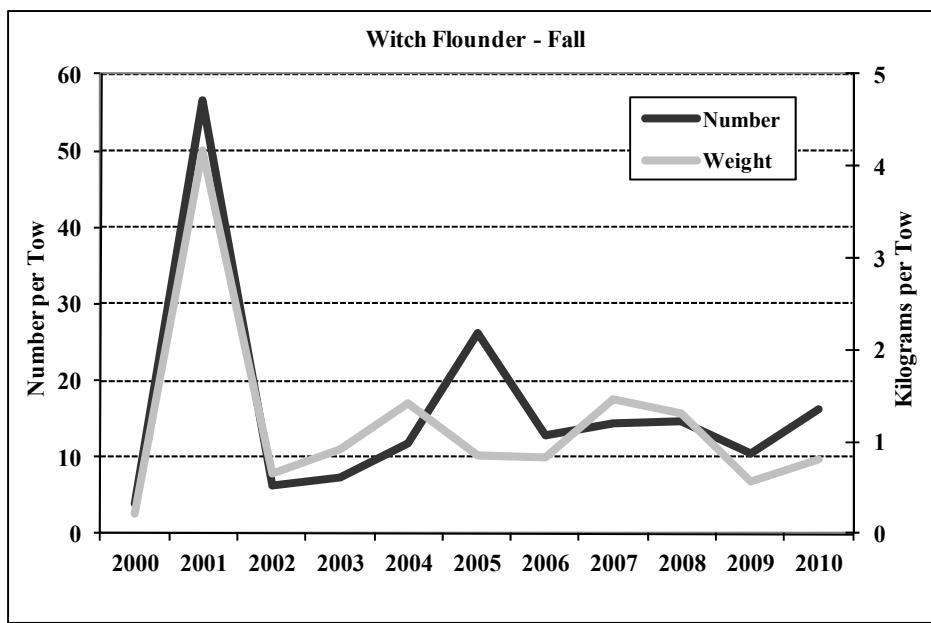
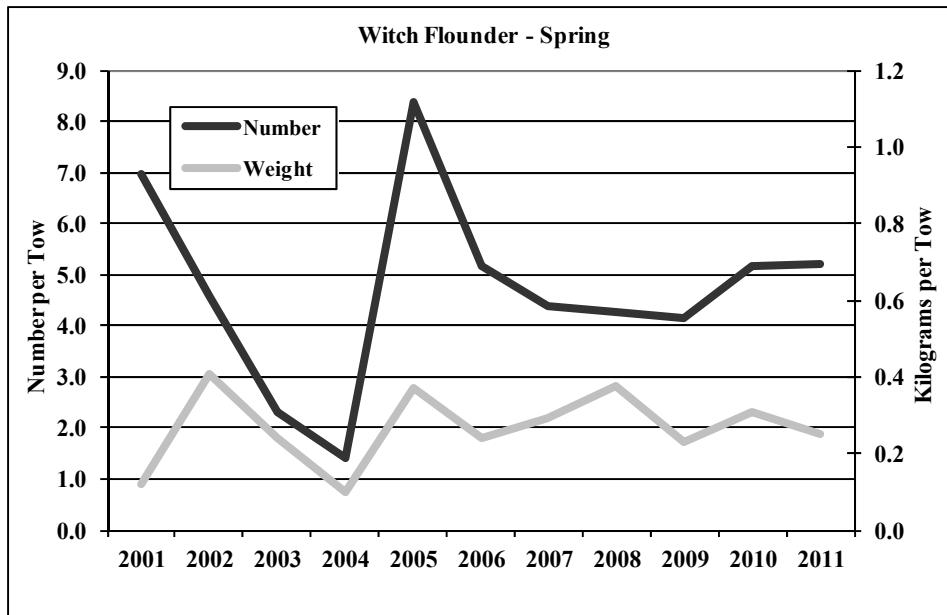
Appendix Figure F1. Z-scores of witch flounder mean weight at age (age groups 4 – 9) in the NEFSC spring survey (left), 1982-2011 and NEFSC autumn survey 1982 -2010 (right).



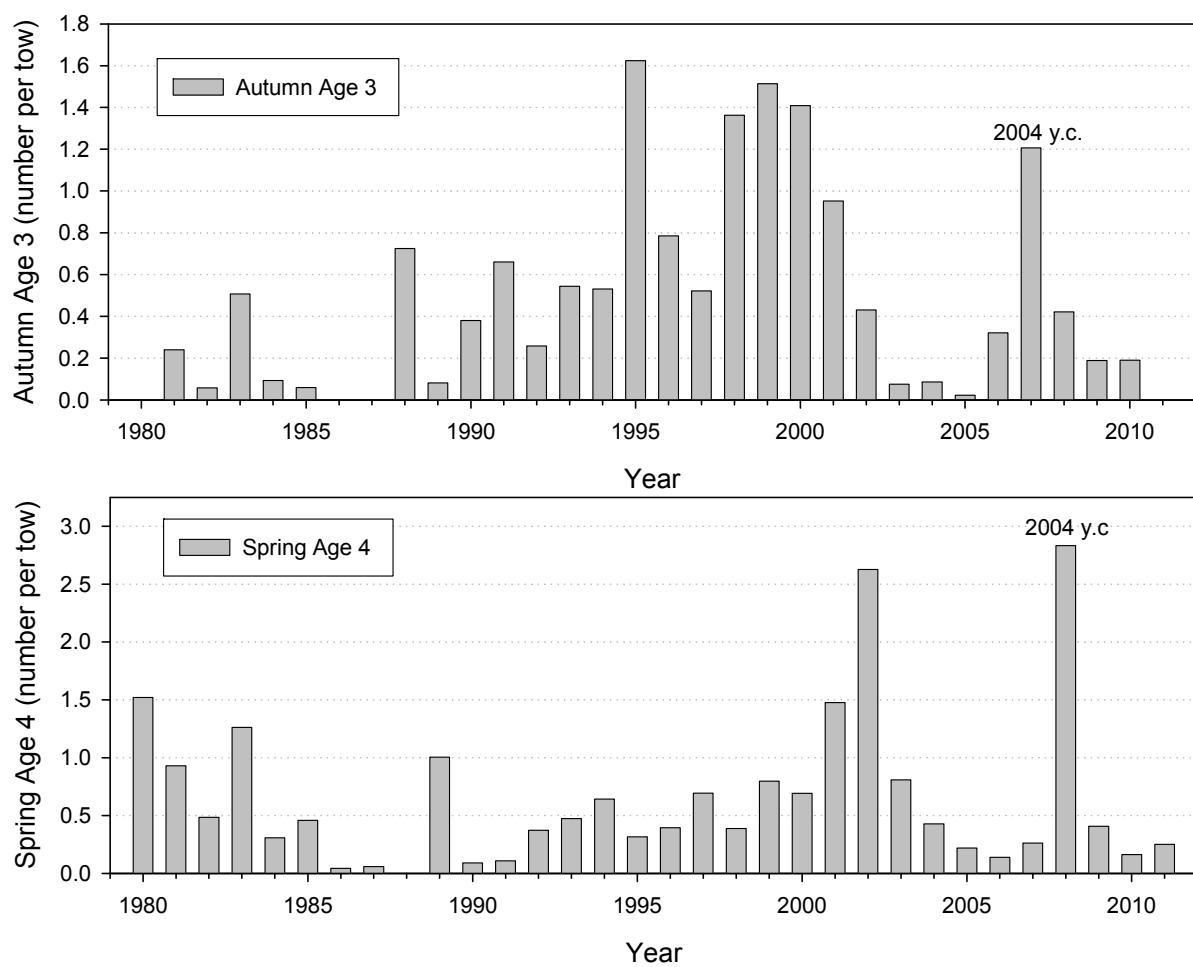
Appendix Figure F2. Stratified mean catch per tow, in weight (A) and number (B), of witch flounder in the Massachusetts Division of Marine Fisheries spring and autumn bottom trawl surveys in Cape Cod Bay – Mass Bay region (Regions 4 and 5), 1978 – 2010.



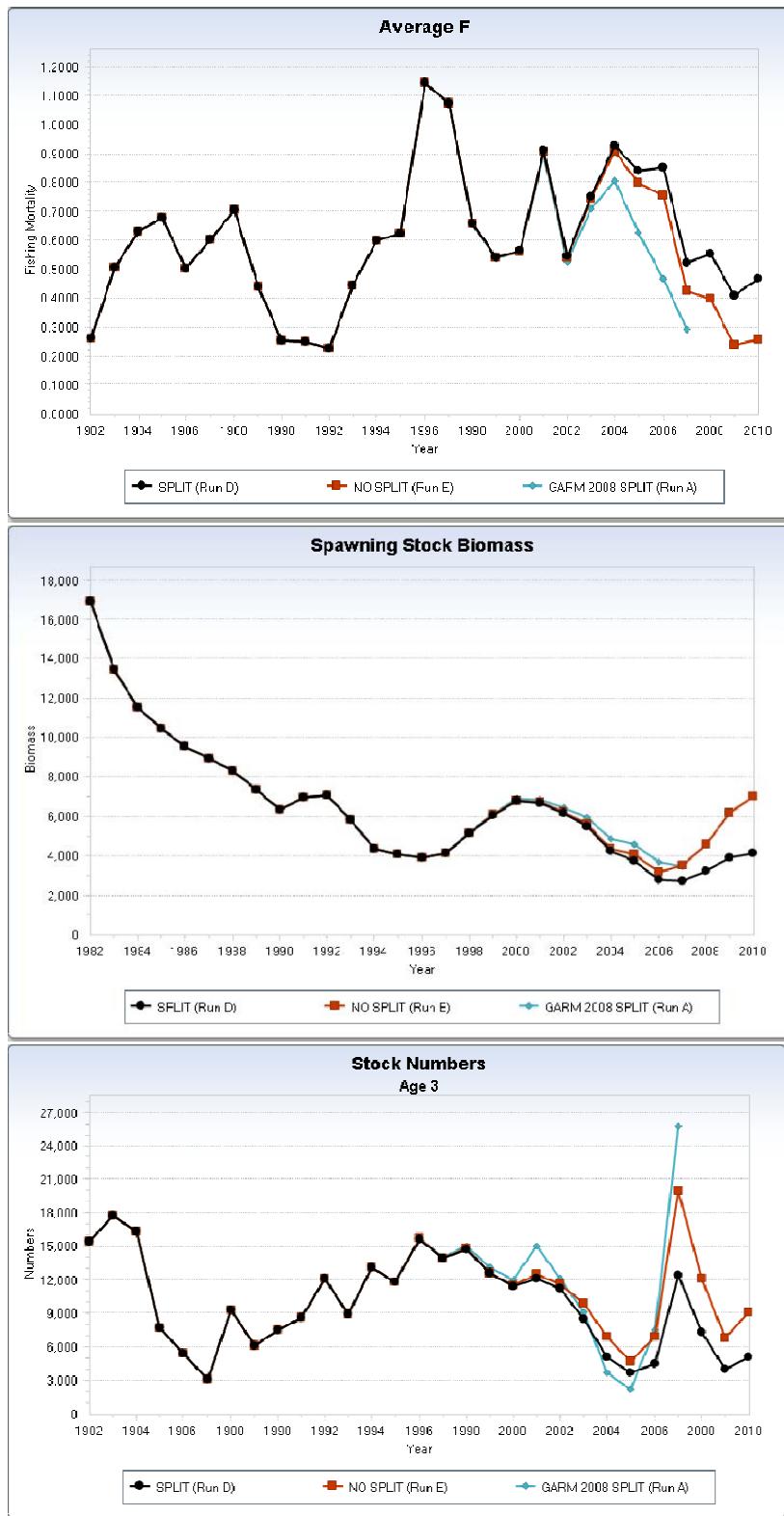
Appendix Figure F3. Stratified mean catch per tow, in weight (kg) and numbers, of witch flounder in the Atlantic States Marine Fisheries Commission summer northern shrimp survey (strata set 1,3,6,8) , 1984-2010. Dash line represents 95% confidence intervals.



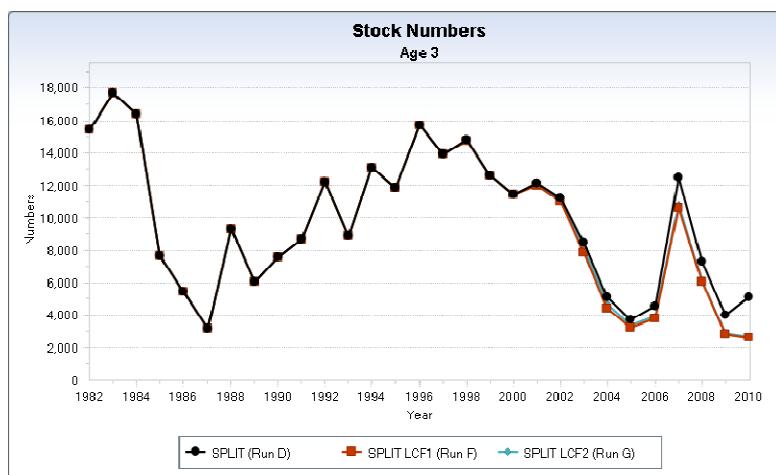
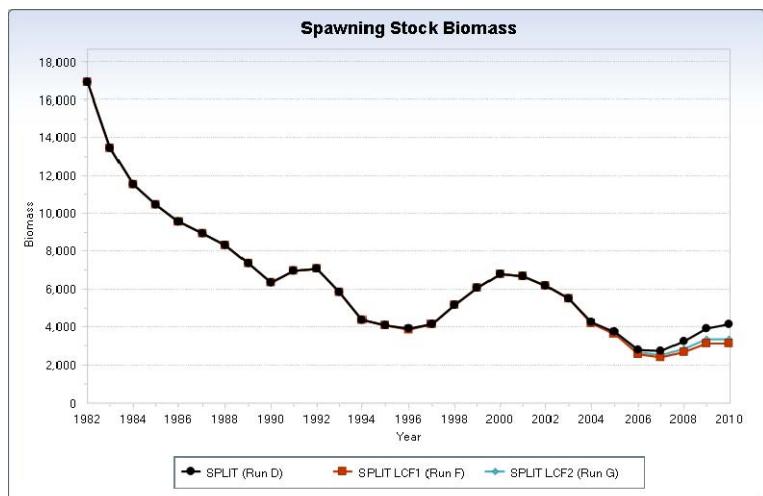
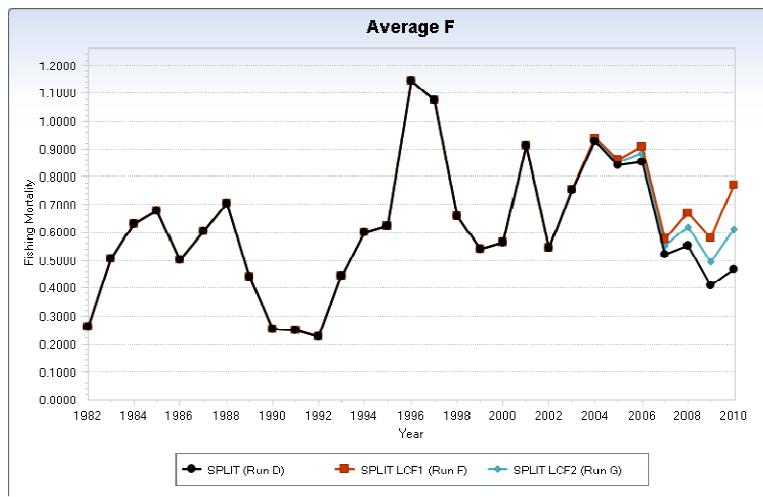
Appendix Figure F4. Stratified mean catch per tow, in weight (kg) and numbers, of witch flounder in the Maine-New Hampshire inshore spring and fall survey (strata 1 through 4; regions 1 to 5), 2000-2011. Fixed stations are excluded; re-stratified for 2000, 2001 and 2002. *Figure provided by S. Sherman, ME DMR.*



Appendix Figure F4. Stratified mean number per tow of age 3 witch flounder in the NEFSC autumn survey, 1980- 2010 (top), and age 4 witch flounder in the NEFSC spring survey, 1980 - 2011 (bottom). Constant conversion factor of 3.2572 applied to 2009 – 2011 surveys.



Appendix Figure F5. Model comparison of trends in Average F (top), SSB (middle) and Age 3 recruits (bottom) from VPA SPLIT RUN (Runs D; large black circle), NO SPLIT (Run E; red square) and VPA SPLIT RUN from GARM 2008 (Run A; small circle blue).



Appendix Figure F6. Model comparison of trends in Average F (top), SSB (middle) and Age 3 recruits (bottom) from VPA SPLIT RUN (Runs D; large black circle), SPLIT LCF1 (Run F; red square) and SPLIT LCF2 (Run G; small circle blue).