B. STOCK ASSESSMENT OF TILEFISH IN THE MID-ATLANIC/SOUTHERN NEW ENGLAND REGION FOR 2014

Executive Summary

The SAW Demersal Working Group prepared this report. The Working Group met December 2-5, 2013 at the NEFSC in Woods Hole, MA to conduct a stock assessment of Golden Tilefish for review by SARC 58 in January 2014. The following scientists, managers, and fishermen participated in the meeting:

Jon Deroba	NMFS NEFSC
Dan Farnham	MAFMC Industry Advisory Panel
Chris Legault	NMFS NEFSC
Richard McBride	NMFS NEFSC
Jose´ Montañez	MAFMC Staff
Paul Nitschke	NMFS NEFSC, Lead Assessment Scientist
John Nolan	MAFMC Industry Advisory Panel
Lauri Nolan	MAFMC Member
Loretta O'Brien	NMFS NEFSC
Michael Palmer	NMFS NEFSC
Douglas Potts	NMFS NERO
Katherine Sosebee	NMFS NEFSC
Mark Terceiro	NMFS NEFSC, SAW Working Group Chair
Douglas Vaughn	MAFMC SSC Member
Susan Wigley	NMFS NEFSC

B. Tilefish

Terms of Reference (TOR)

1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the magnitude of uncertainty in these sources of data.

2. Characterize commercial LPUE as a measure of relative abundance. Consider the utility of recreational data for this purpose. Characterize the uncertainty and any bias in these sources of data.

3. For the depth zone occupied by tilefish, examine the relationship between bottom temperature, tilefish distribution and thermal tolerance.

4. Use assessment models to estimate annual fishing mortality and stock size for the time series, and estimate their uncertainty. Include a historical retrospective to allow a comparison with previous assessment results.

5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY or for their proxies) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.
6. Evaluate stock status with respect to the existing ASPIC model (from previous peer reviewed accepted assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.
    a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
    b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-4).

7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
    a. Provide numerical annual projections (2-3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

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

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

Summary by TOR

1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the magnitude of uncertainty in these sources of data.

Total commercial landings (live weight) increased from less than 125 metric tons (mt) during 1967-1972 to more than 3,900 mt in 1979 and 1980 during the development of the directed longline fishery. Landing pior to the mid 1960s was landed as a bycatch through the trawl fishery. Annual landings have ranged between 666 and 1,838 mt from 1988 to 1998. Landings from 1999 to 2002 were below 900 mt (ranging from 506 to 874 mt). An annual quota of 905 mt was implemented in November of 2001. Landings in 2003 and 2004 were slightly above the quota at 1,130 mt and 1,215 mt respectively. Landing from 2005 to 2009 have been at or below the quota. Landings in 2010 were slightly above the quota at 922 mt. Landings in 2011 and 2012 were 864 mt ant 834 mt respectively.

During the late 1970s and early 1980s Barnegat, NJ was the principal tilefish port; more recently Montauk, NY has accounted for most of the landings. Most of the commercial landings are taken by the directed longline fishery. Discards in the trawl and longine fishery are a minor component of the catch. Recreational catches also appears to be a minor component of the total removals.

2. Characterize commercial LPUE as a measure of relative abundance. Consider the utility of recreational data for this purpose. Characterize the uncertainty and any bias in these sources of data.

A fishery independent index of abundance does not exist for tilefish. Three different series of longline effort data were analyzed. The first series was developed by Turner (1986) who used a general linear modeling approach to standardize tilefish effort during 1973-1982 measured in kg per tub (0.9 km of groundline with a hook every 3.7 m) of longline fished obtained from logbooks of tilefish fishermen. Two additional CPUE series were calculated from the NEFSC Weighout (1979-1993) and the VTR (1995-2013) systems. The NEFSC Weighout and VTR CPUE series were standardized using a general linear model (GLM) incorporating year and individual vessel effects (Appendix B1). The number of vessels targeting tilefish has declined over the time series; during 1994-2003, five vessels accounted for more than 70 percent of the total tilefish landings. The length of a targeted tilefish trip had been generally increasing until the mid 1990s. At the time of the 2005 assessment trip lengths have shorten to about 5 days. Trip length has increased slightly until 2008 and has subsequently declined until 2011. There was a slight increase in the trip length in 2012 to about 7 days.

Seven market categories exist in the database. They are: small-kitten, small, kitten, medium, large and extra large as well as an unclassified category. The proportion of landings in the kittens and small market categories increased in 1995 and 1996. Evidence of several strong recruitment events can be seen tracking through the market category proportions. The proportion of the large market category has been relatively low in the 1990s until around 2004. The proportion of larges has increase since 2005. Commercial length sampling has been inadequate over most of the time series. However some commercial length sampling occurred in the mid to late 1990s. More recently there has been a substantial increase in the commercial length sampling from 2003 to 2013.

More recently changes in the CPUE can be generally explained with evidence of strong incoming year classes that track through the landings size composition over time. Since the SARC 48 assessment there appear to be increases in CPUE due to a strong 2004 year class. In general, strong year classes appear to persist longer in the fishery after the FMP and after the constant quota management came into effect which is evident in both the CPUE and size composition data. The decrease in the CPUE in 2012 and 2013 is consistent with the ageing of the last strong year class.

3. For the depth zone occupied by tilefish, examine the relationship between bottom temperature, tilefish distribution and thermal tolerance.

There is very limited data to address this term of reference. Only a few fish per survey are caught during NEFSC bottom trawl surveys. The working group examined spatial distribution plots and bottom temperatures where tilefish were caught during the spring, winter, and fall NEFSC bottom trawl surveys. The probability of occurrence was also calculated for tilefish from the spring and fall surveys. Examination of temporal changes is not possible with the limited numbers of tilefish caught in the surveys. The literature states that tilefish have a narrow temperature preference of 9 to 14 C. The temperature distribution from the surveys also suggests the species is limited to this narrow temperature range. However, there were several tows which did catch tilefish at temperatures lower than 9 degrees C. The working group also found some evidence of small amounts of tilefish being caught in a non directed tilefish longline fishery in the Gulf of Maine.

4. Use assessment models to estimate annual fishing mortality and stock size for the time series, and estimate their uncertainty. Include a historical retrospective to allow a comparison with previous assessment results.

In this SARC 58 assessment the working group updated the ASPIC surplus production model and explored the use of forward projecting size (SCALE) and age (ASAP) structured models. The SARC 58 working group concentrated on the development of size/age structure models due to the continued concerns with process error issues from year class effects within the surplus production model and to include more realistic life history information on size and growth within the model. In general, all models show increases in biomass and decreases in fishing mortality since the implementation of the fishery management plan in 2001. However, the working group concluded that the ASPIC production model no longer adequately characterize the recent population and tilefish fishery trends, and therefore the ASPIC results are no longer sufficient to evaluate the status of the stock. There was relatively little difference in the results among the different SCALE and ASAP model configurations. Comparisons were also done to past assessments. Flattop selectivity runs showed an unrealistic truncation in the population age structure in comparison to the number of tilefish aged for both the SCALE and ASAP models at the end of the time series. In addition, there were reasons to believe that a dome-shaped selectivity pattern is appropriate for the directed tilefish longline fishery. Further development of the SCALE model was not persuaded due to the inability in modeling dome shaped selectivity patterns. The ASAP model that estimated dome shaped selectivity patterns was used as the best model for stock status determination. However general concerns still remain with the lack of data and reliance on commercial CPUE in this assessment.

5. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY or for their proxies) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.

The existing stock status determination is based on the ASPIC surplus production model from SARC 48. SARC 48 concluded overfishing was not occurring and the stock was not overfished. In SARC 48 the ASPIC model indicated that the stock was above B_{MSY}. However, SARC 48 concluded that the stock was not yet rebuilt based on concerns with the catch size distributions and process error cause by year class effects within the ASPIC model.

Biological reference points were redefined in this assessment based on the ASAP model. The working group did not develop stock recruitment based biological based reference points due to the uncertainty in the recruitment and SSB estimates during the 1980s and 1990s. Therefore the working group based biological reference points on a percent SPR proxy. The long life span and relatively low M would suggest that a fishing mortality rate reference point of F40% or higher %MSP would be appropriate. However, information provided by fishing industry advisors and ASAP model results indicate that it is likely that the fishery selection curve for tilefish is strongly dome-shaped. Further, under the constant landings quota of 905 mt since implementation of the FMP in 2002, the stock has increased to the new estimate of SSB_{MSY}. In general, improvements to the stock have occurred under the 905 mt quota implemented in November of 2001 which is evident in the raw catch size and fishery CPUE data. Fishing mortality rates have averaged 0.367 since 2002, and the new yield per recruit analysis shows that this fishing rate corresponds to about $F_{25\%}$. Given these factors, the WG recommends that $F_{MSY} = F_{25\%} = 0.370$ and the corresponding SSB_{MSY} = 5,153 mt, $SSB_{THRESHOLD}$ = 2,577 mt, and MSY = 1,029 mt be adopted as the new biological reference point proxies for this assessment.

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

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

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-4).

The reference points from the previous 2009 SAW 48 assessment are based on the ASPIC surplus production model and cannot be compared to the current assessment ASAP model results and reference points. The current assessment using an updated ASPIC model provides the following updated reference points: B_{MSY} = 12,950 mt, F_{MSY} = 0.139 and MSY = 1,800 mt. Based on the current ASPIC model results and updated reference points, F in 2012 is estimated to be 0.053, 38% of F_{MSY} and stock biomass in 2012 is estimated to be 15,150 mt, 17% above B_{MSY}. With respect to the existing reference points from the 2009 SAW 48 assessment, fishing mortality in 2012 was estimated to be 0.053, 33% of F_{MSY} = 0.16, and total biomass in 2012 was estimated to be 15,150 mt, 133% of B_{MSY} = 11,400 mt. With regards to this term of reference, note that for the ASPIC surplus production model it may not be appropriate to compare stock status relative to biological reference points from a different model run. All ASPIC model results suggest the stock is rebuilt. However, the SARC 48 review panel accepted the ASPIC model but concluded that the ASPIC model is likely over optimistic and that the stock has not rebuilt above B_{MSY}.

The SCALE model was not accepted for stock status determination in SARC 48. In addition the updated SCALE model for this assessment was also not used for status determination due to the inability for modeling a dome-shaped selectively pattern within the model.

The Golden Tilefish stock was not overfished and overfishing was not occurring in 2012 relative to the new biological reference points. The tilefish stock was slightly above the SSB_{MSY} estimate in 2012. A new model (ASAP statistical catch at age) is used in this assessment to incorporate newly available length and age data and better characterize the population dynamics of the stock. Comparison of ASAP model biological reference points to ASPIC model biological reference points was not done since the measure of fishing mortality (F_{MULT}) and biomass (SSB) has changed with the new model.

The fishing mortality rate was estimated to be 0.275 in 2012, below the new reference point F_{MSY} proxy = $F_{25\%}$ = 0.370. There is a 90% probability that the fishing mortality rate in 2012 was between 0.198 and 0.372. SSB was estimated to be 5,229 mt in 2012, about 101% of the new reference point SSB_{MSY} proxy = $SSB_{25\%}$ = 5,153 mt. There is a 90% chance that SSB in 2012 was between 3,275 and 7,244 mt. The average recruitment from 1971 to 2012 is 1.24 million fish at age-1. Recent large year classes have occurred in 1998 (2.35 million), 1999 (2.39 million) and 2005 (1.85 million).

7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

a. **Provide numerical annual projections (2-3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).**
b. **Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.**
c. **Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.**

The 905 ACL was assumed for the removals in the two bridge years of the projections (2013-2014). The SARC 58 review panel concluded that there was no information to inform estimates of age-1 recruitment in the last three years of the final ASAP model (2010-2012) since fishery independent measure of abundance are lacking and since age-1 and -2 are not selected and age-3 possessing a low selection of 0.05 in the commercial fishery (Appendix B2). In the absence of information to inform recruitment at the end of the time series the SARC concluded that the model estimated geometric mean would be a better approximation of the recruitment from 2010 to 2012. Recruitment for the last three years (2010-2012) was adjusted to the time series geometric mean through the use of Mohn's rho adjustment within the AGEPRO projections. Projections were made at the constant 905 mt and at $F_{MSY} = F_{25} = 0.37$. The estimated fishing mortality assuming a 905 mt catch remain below F_{MSY} in the adjusted AGEPRO projections. The CV on the 2015 OFL was estimated at 30%. The adjusted recruitment projections done during the SARC meeting are shown in Appendix B2 which can be compared to the original unadjusted working group projections which are shown in the main report.

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

Two new research recommendations were developed by the working group (industry based survey and increase maturity sampling). Past research recommendations were reviewed and summarized as new, pending, or completed.

Introduction

Golden tilefish, *Lopholatilus chamaeleonticeps*, inhabit the outer continental shelf from Nova Scotia to South America, and are relatively abundant in the Southern New England to Mid-Atlantic region at depths of 80 to 440 m. Tilefish have a narrow temperature preference of 9 to 14 ºC. Their temperature preference limits their range to a narrow band along the upper slope of the continental shelf where temperatures vary by only a few degrees over the year. The middle Atlantic-Southern New England stock boundary is shown in Figure B1. They are generally found in and around submarine canyons where they occupy burrows in the sedimentary substrate. Tilefish are relatively slow growing and long-lived, with a maximum observed age of 46 years and a maximum length of 110 cm for females and 39 years and 112 cm for males (Turner 1986). At lengths exceeding 70 cm, the predorsal adipose flap, characteristic of this species, is larger in males and can be used to distinguish the sexes. Tilefish of both sexes are mature at ages between 5 and 7 years (Grimes et. al. 1988).

Golden Tilefish was first assessed at SARC 16 in 1992 (NEFSC 1993). The Stock Assessment Review Committee (SARC) accepted a non-equilibrium surplus production model (ASPIC). The ASPIC model estimated biomass-based fishing mortality (F) in 1992 to be 3-times higher than F_{MSY}, and the 1992 total stock biomass to be about 40% of B_{MSY}. The intrinsic rate of increase (r) was estimated at 0.22.

The Science and Statistical Committee (SSC) reviewed an updated tilefish assessment in 1999 based on a ASPIC surplus production model. Total biomass in 1998 was estimated to be 2,936 mt, which was 35% of B_{MSY} = 8,448 mt. Fishing mortality was estimated to be 0.45 in 1998, which was about 2-times higher than F_{MSY} = 0.22. The intrinsic rate of increase (r) was estimated to be 0.45. These results were used in the development of the Tilefish Fishery Management Plan (Mid-Atlantic Fishery Management Council 2000). The Mid-Atlantic Fishery Management Council implemented the Golden Tilefish Fishery Management Plan (FMP) in November of 2001. Rebuilding of the tilefish stock to B_{MSY} was based on a ten-year constant harvest quota of 905 mt.

SARC 41 reviewed a benchmark tilefish assessment in 2005. The surplus production model indicated that the tilefish stock biomass in 2005 has improved since the assessment in 1999. Total biomass in 2005 is estimated to be 72% of B_{MSY} and fishing mortality in 2004 is estimated to be 87% of F_{MSY}. Biological reference points did not change greatly from the 1999 assessment. B_{MSY} is estimated to be 9,384 mt and F_{MSY} is estimated to be 0.21. The SARC concluded that the projections are too uncertain to form the basis for evaluating likely biomass recovery schedules relative to B_{MSY}. The TAC and reference points were not changed based on the SARC 41 assessment.

The last benchmark tilefish stock assessment in SARC 48 (2009) was also based on the ASPIC surplus production model. The model is calibrated with CPUE series, as there are no fishery-independent sources of information on trends in population abundance. While the SARC expressed concern about the lack of fit of the model to the VTR CPUE index at the end of the time series, they agreed to accept the estimates of current fishing mortality and biomass and associated reference points. The instability of model results in the scenario projections was also a source of concern. It was noted that the bootstrap uncertainty estimates do not capture the true uncertainty in the assessment. The SARC concluded the overfishing was not occurring and the stock was not overfished. The ASPIC model indicated that the stock was rebuilt. However, SARC 48 concluded that the stock was not yet rebuilt due to concerns regarding the process error from year class effects within the ASPIC model.

In this SARC 58 assessment the working group updated the ASPIC surplus production model and explored the used of size and age structured forward projecting models. The working group put forward an age structured model in ASAP as the best estimate of stock status determination due to the continued concerns with process error within the surplus production model and to include more realistic life history information on size and growth into a single model framework.

TOR 1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the magnitude of uncertainty in these sources of data.

Data Sources

Commercial catch data

Total commercial landings (live weight) increased from less than 125 metric tons (mt) during 1967-1972 to more than 3,900 mt in 1979 and 1980 during the development of the directed longline fishery. Landing prior to the mid 1960s was landed as a bycatch through the trawl fishery. Annual landings have ranged between 666 and 1,838 mt from 1988 to 1998. Landings from 1999 to 2002 were below 900 mt (ranging from 506 to 874 mt). An annual quota of 905 mt was implemented in November of 2001. Landings in 2003 and 2004 were slightly above the quota at 1,130 mt and 1,215 mt respectively. Landing from 2005 to 2009 have been at or below the quota. Landings in 2010 were slightly above the quota at 922 mt. Landings in 2011 and 2012 were 864 mt ant 834 mt respectively (Table B1, Figure B2).

Over 75% of the landings came from Statistical Areas 537 and 616 since 1991 (Table B2, Figure B3). In the 1980s a greater proportion of the landings came from 526. It is not clear if the higher portion of the landings was partly an artifact of the low interview coverage in the Weighout system that was made up of mostly New Jersey vessels. Nevertheless perhaps a higher proportion of the landings were coming from 526 in the 1980s relative to 2000s. Since the 1980s, over 85% of the commercial landings of tilefish in the MA-SNE region have been taken in the longline fishery (Table B3, Figure B4). Over the last 4 years the percent of the landing coming from longline gear has increased to over 95%. During the development of the directed longline fishery in the late 1970s and early 1980s Barnegat, NJ was the principal tilefish port; more recently Montauk, NY has accounted for most of the landings (Figure B5). The shift in landings can be seen in the proportion of the landings by state in Table B4 and Figure B6. In the late 1970s and early 1980s a greater proportion of the landings were taken in quarters 1 and 2 (Table B5, Figure B7). Recent landings have been relatively constant over the year.

Commercial discard data

Discards were estimated following the SBRM approach (discard/kept all species ratio x kept all total) for small and large mesh trawl and for gillnet fisheries (Wigley et al. 2007). The number of observed trips, discard ratios, CVs, and estimated discards are summarized in Table B6. In general the discard of tilefish in other commercial fisheries appears to low (several metric tons per gear type). Very little discarding (< 1%) of tilefish was reported in the vessel trip report (VTR) from longline vessels that target tilefish (SARC 48). The small number of observed directed tilefish longline trips also suggest that discards of tilefish is minimal. The tilefish working group concluded that discarding of tilefish is a minor component of the total removals and was not included as a component of the total catch in the modeling.

Recreational catch data

A small recreational fishery occurred briefly in the mid 1970s (< 100 mt annually, Turner 1986) but subsequent recreational catches appear to have been low for the last 30 years in the Marine Recreational Information Program (MRIP) (Table B7). The tilefish catch in the MRIP survey is likely below detection levels of the survey judging from the sporadic estimates in the survey. However there a several party charter vessels which make on a few targeted tilefish trips a year. Party and charter boat vessel trip reports also show relatively low numbers of tilefish being caught although there is an increase in numbers of fish reported (6400 fish) at the end of the time series in 2012 (Table B8). However this increase may be more a reflection of recent increases in reporting rate. Most of the report landing was coming from New Jersey (Table B8). It appears that a greater proportion of the reported recreational catch and effort is further south in statistical area 622 relative to the commercial longline fleet that fishes more in 537 (Tables B9 and B10). The working group was not able to produce a reliable time series of recreational catches. However the working group also concluded that the recreational removals are likely a minor component of the catch.

TOR 2. Characterize commercial LPUE as a measure of relative abundance. Consider the utility of recreational data for this purpose. Characterize the uncertainty and any bias in these sources of data.

Only a few fish per survey are caught during NEFSC bottom trawl surveys. This survey time series is not useful as an index of abundance for tilefish. The tilefish stock assessment relies on a fishery dependent commercial CPUE as an index of abundance.

Commercial CPUE data

A fishery independent index of abundance does not exist for tilefish. Analyses of catch (landings) and effort data were confined to the longline fishery since directed tilefish effort occurs in this fishery (e.g. the remainder of tilefish landings are taken as bycatch in the trawl fishery). Most longline trips that catch tilefish fall into two categories: (a) trips in which tilefish comprise greater than 90% of the trip catch by weight and (b) trips in which tilefish accounted for less than 10% of the catch. Effort was considered directed for tilefish when at least 75% of the catch from a trip consisted of tilefish.

Three different series of longline effort data were analyzed. The first series was developed by Turner (1986) who used a general linear modeling approach to standardize tilefish effort during 1973-1982 measured in kg per tub (0.9 km of groundline with a hook every 3.7 m) of longline obtained from logbooks of tilefish fishermen. Two additional CPUE series were calculated from the NEFSC Weighout (1979-1993) and the VTR (1995-2012) systems. Effort from the Weighout data was derived by port agents' interviews with vessel captains whereas effort from the VTR systems comes directly from mandatory logbook data. In the SARC 48 assessment and in the 1998 and 2005 tilefish assessments we used Days absent as the best available effort metric. In the 1998 assessment an effort metric based on Days fished (average hours fished per set / 24 * number of sets in trip) was not used because effort data were missing in many of the logbooks and the effort data were collected on a trip basis as opposed to a haul by haul basis. For this assessment effort was calculated as:

Effort = days absent (time & date landed - time & date sailed) – one day per trip.

For some trips, the reported days absent were calculated to be a single day. This was considered unlikely, as a directed tilefish trip requires time for a vessel to steam to near the edge of the continental shelf, time for fishing, and return trip time. Thus, to produce a realistic effort metric based on days absent, a one day steam time for each trip (or the number of trips) was subtracted from days absents and therefore only trips with days absent greater than one day were used.

The number of vessels targeting tilefish has declined since the 1980s (Table B11, Figure B8); during 1994-2003 and 2005-2012, five vessels accounted for more than 70 percent of the total tilefish landings. The number of vessels targeting tilefish has remained fairly constant since the assessment in 2005. The length of a targeted tilefish trip had been generally increasing until the mid 1990s. At the time of the 2005 assessment trip lengths have shorten to about 5 days. Trip length has increased slightly until 2008 and has subsequently declined until 2011. There was a slight increase in the trip length in 2012 to about 7 days (Figure B8). In the Weighout data the small number of interview is a source of concern; very little interview data exists at the beginning of the time series (Table B11, Figure B9). The 5 dominant tilefish vessels make up most of the VTR reported landings (Table B12, Figure B10).

In some years there were higher total landings reported in the VTR data than the Dealer data for the 5 dominant tilefish vessels. After the FMP was implemented the IVR (Interactive Voice recorder) database was developed to monitor the quota. In 2005 the IVR database had the highest landings level despite that this system only applies to the limited access tilefish fishery (Figure B10). The IVR 2005 total was assumed to be a better estimate of the total landings in that year then the other data sources. The IVR total landing in 2005 was used as the total removals in all tilefish modeling. The IVR system was no longer used for monitoring after the development of a ITQ fishery in 2009 and was therefore not updated in this assessment.

The number of targeted tilefish trips declined in the early 1980s while trip length increased at the time the FMP was being developed in 2000 (Figures B11 and B12). During the last assessment in 2005 the number of trips became relatively stable as trip length decreased. Since the last assessment trip length has increased. The interaction between the number of vessels, the length of a trip and the number of trips can be seen in the total days absent trend in Figure B8. Total days absent remained relatively stable in the early 1980s, but then declined at the end of the Weighout series (1979-1994). In the beginning of the VTR series (1994-2004) days absent increased through 1998 but declined to 2005. Since 2005 total days absent has increase somewhat. Figure B11 also shows that a smaller fraction of the total landings in the Weighout series were included in the calculation of CPUE in comparison to the VTR series. Expanding effort to the total dealer landings shows a greater decline in effort (days absent and number of trips) over the time series (Figure B12).

Figure B13 illustrates difference between the nominal CPUE and vessel standardized (GLM) CPUE with the Weighout and VTR data combined. CPUE trends are very similar for most vessels that targeted tilefish (Figure B14). A sensitivity test of the GLM using different vessel combinations was done in SARC 41. The SARC 41 GLM was found not to be sensitivity to different vessels entering the CPUE series.

Very little CPUE data exist for New York vessels in the 1979-1994 Weighout series despite the shift in landing from New Jersey to New York before the start of the VTR series in 1994. The small amount of overlap between the Weighout and VTR series is illustrated in Figures B15 and B16 which were taken from SARC 48. Splitting the Weighout and VTR CPUE series can be justified by the differences in the way effort was measured and difference in the tilefish fleet between the series. In breaking up the series we omitted 1994 due to the lack of CPUE data for that year. The sparse 1994 data that existed came mostly from the Weighout system in the first quarter of the year. Very similar trends exist in the four years of overlap between Turner (1986) CPUE and the Weighout series (Figure B17). For this assessment additional logbook data for three New York vessels was collected from New York fishermen from 1991-1994 and added to the VTR series. This was done to provide more information (years of overlap) in the modeling between the Weighout and the VTR series (Figure B18).

Since 1979, the tilefish industry has changed from using cotton twine to steel cables for the backbone and from J hooks to circle hooks. The gear change to steel cable and snaps started on New York vessels in 1983. In light of possible changes in catchability associated with these changes in fishing gear, the working group considered that it would be best to use the three available indices separately rather than combined into one or two series. The earliest series (Turner 1986) covered 1973-1982 when gear construction and configuration was thought to be relatively consistent. The Weighout series (1979-1993) overlapped the earlier series for four years and showed similar patterns (Figure B17) and is based primarily on catch rates from New Jersey vessels. The VTR (1991-2013) series is based primarily on information from New York vessels using steel cable and snaps.

In SARC 41 a month vessel interaction was significant but explained only a small amount of the total sum of squares (6%*)*. Adding a month - vessel interaction term to the GLM model had very little influence on the results at SARC 41 and was not updated for this assessment. The GLM output for the Weighout and the VTR CPUE series standardized for individual vessel effects can be seen in Appendix B1.

In the SARC 48 assessment the sensitivity of the assumed error structure used in VTR GLM CPUE index was explored. The nominal VTR CPUE data distribution does appear over-dispersed relative to normal or lognormal distribution, suggesting that a model with poisson or negative binomial distribution may be more appropriate (SARC 48). However the GLM CPUE indices using different error assumptions showed very little differences in the CPUE trends. Therefore the lognormal error distribution was retained.

The NEFSC Weighout and VTR CPUE series were standardized using a general linear model (GLM) incorporating year and individual vessel effects. The CPUE was standardized to an individual longline vessel and the year 1984; the same year used in the last assessment. For the VTR series the year 2000 was used as the standard. Model coefficients were back-transformed to a linear scale after correcting for transformation bias. However, the updated GLM model that accounted of individual vessel effects appears to show more of an overall increasing trend in CPUE in comparison to the nominal series (figure B19). A similar pattern was seen when the additional New York logbook data from 1991-1994 was added to the VTR series (Figure B20).

More recently changes in the CPUE can be generally explained with evidence of strong incoming year classes that track through the landings size composition over time (See below). Since the SARC 48 assessment there appear to be increases in CPUE due to one or two new strong year classes. In general, strong year classes appear to persist longer in the fishery after the FMP and after the constant quota management came into effect which is evident in both the CPUE and size composition data. The small decrease in the CPUE in 2012 and 2013 is consistent with the ageing of the last strong year class.

Commercial market category and size composition data

Seven market categories exist in the database. They are: small-kitten (aka extra small, tiny or kk), small, kitten, medium, large and extra large as well as an unclassified category. Differences in the naming convention among ports tend to cause some confusion. For example small and kitten categories reflect similar size fish. Smalls is the naming convention used in New Jersey whereas the kitten market category is used primarily in New York ports. In 1996 and 1997, the reporting of tilefish by market categories increased, with the proportion of unclassified catch declining to less than 20% (Table B13, Figure B21). The proportion of landings in the small and kitten market categories increased in 1995 and 1996. However, the proportion of small fish in the catch may have increased prior to 1995. The size composition of the catch in the late 1980s and early 1990s is uncertain due to the high proportion of unclassified fish in the catch. Small and kitten market categories have similar length distributions and samples from 1995 to 1999 were combined. Evidence of several strong recruitment events can be seen tracking through the market category proportions (Figures B22). The proportion of the large market category has been relatively low in the 1990s until around 2004 (Figure B22). The proportion of larges has increase since 2005. The strong year class tracking through the small kitten and mediums in the late 1990s did not materialized into the large market category. However two strong year classes in the 2000s appear to have contributed to increases of the large market category since 2005.

Extensive size sampling was conducted in 1976-1982 (Grimes *et al.* 1980, Turner 1986) however that data are not available by market category (Figure B23). Since then commercial length sampling has been inadequate in most years (Table B14). However some commercial length sampling occurred in the mid to late 1990s which required some pooling of samples. More recently there has been a substantial increase in the commercial length sampling in 2003 to 2013. Commercial length sampling in New York has also increased since the last assessment in 2005 (Table B14). Expanded length frequency distributions from 1995 to 1999 are shown in Figure B24. In this assessment expanded length frequency distributions were estimated form 2002 to 2013 (Figures B25 through B27). The stratification used in the expansion can be seen in Table B14. The large market category length frequencies appear to have been relatively stable for years when more than 100 fish were measured. However the small market category exhibits shifts in the size distribution in certain years as a strong year class moves through the fishery (Figure B28). The tracking of a year classes can be seen as the cohort grows over the year in 2003 and 2004 (Figure B28). This strong 1998 and/or 1999 year class can be seen tracking over the years in the expanded commercial length frequency distributions (Figure B25).

Commercial length frequencies were expanded for years where sufficient length data exist (1995-1999 and 2002-2013) (Table B14). The large length frequency samples from 1996 to 1998 were used to calculate the 1995 to 1999 expanded numbers at length while the large length samples from 2001 and 2003 were used to calculate the 2002 expanded numbers at length. Evidence of strong 1992/1993, 1998/1999 and a 2005 year classes can be seen in the expanded numbers at length in the years when length data existed (1995-1999 and 2002-2013) (Figure B25). The matching of modes in the length frequency with ages was done using available growth information (Turner's (1986) and 2007-2013 catch at age). In 2004 and 2005 the 1998/1999 year class can be seen growing into the medium market category and in 2006 and 2007 the year class has entered the large market category. From 2002 to 2007 it appears that most of the landings were comprised of this year class. A similar pattern occurred with the 2005 year class from 2009-2013. An increase in the landings and CPUE can be seen when the 1992/1993, 1998/1999 and 2005 year classes recruit to the longline fishery. As the year classes gets older the catch rates decline (Figure B18). At this point the catch also gets more widely distributed over multiple year classes. This can be seen in 2007-2008 and 2012-2013. CPUE appear to decline as the strong year classes get older then about 6 years. However, biomass frequencies at length show that most of the biomass in the catch is still comprised of the larger heavier fish which is why the quota can still be taken (Figure B27).

There is additional market category in the fishery called large-mediums which makes up a relatively small component of the catch. A code does not exist for this market category which likely results in some error in several years in the expanded size distributions. Like the name suggests the large-medium category falls between the medium and the large sizes. Figure B29 compares medium and large length distributions with distributions that had a comment from the port sampler indicating that the sample came from a dealer large-medium category. Some of the samples are put into the large market code while some where coded as mediums. It is not clear how each dealer is reporting the catch from this category but it appears that most of these fish could be coded as unclassified. It can be seen that the proportion of unclassified tend to increase in years when we would expect the large year class to grow into the large-medium sizes (Figure B25). This does seem to cause some error in the expansions in those years (2005-2006, 2011-2012) since unclassified fish are distributed across all size categories (Figure B25). A database large-medium code is now being developed for commercial dealers and the biological port sampling. The working group acknowledges this issue and recommended continued work on developing a code but concluded that this additional error effect should be relatively minor.

Concern was expressed at SARC 48 with little evidence of an incoming year class, catch rates declining and the mismatch between the biomass trends predicted by the surplus production model in comparison to the observed CPUE at the end of the time series. However, since the last 2009 assessment there is evidence of a strong year class (2005) tracking through the landings size distributions. In 2012 that year class is entering the large market category and as expected there is a decline in the CPUE relative to 2011. However, there is also some evidence of a broader size distribution of the fish being caught from 2011to 2013 which suggests the fishery is less reliant on a single year class. Nevertheless, like in SARC 48 there are some concerns on whether another strong year class will increase CPUE and stock biomass in the future. Industry indicated that signs of another large year class has just recently entered the catch but are not yet reflected in the data or projections used for this assessment.

Commercial AGE data

For SARC 58 the Northeast Fisheries Science Center (NEFSC) aged commercial age samples (otoliths) from 2007-2012. The new age and growth data is summarized in table B15. Catch at age was estimated for 2007 and 2008 through 2012. Catch at age could not be developed for 2008 due to missing age data from the first half of the year which resulted in missing ages for smaller fish. A Pooled age length key was developed for all years combined and von Bertalanffy growth curve was also estimated using the NEFSC age data.

TOR 3. For the depth zone occupied by tilefish, examine the relationship between bottom temperature, tilefish distribution and thermal tolerance.

There is very limited data to address this term of reference. Only a few fish per survey are caught during NEFSC bottom trawl surveys. The working group examined spatial distribution plots and bottom temperatures where tilefish were caught during the spring, winter and fall NEFSC bottom trawl surveys (Figures B30 through B34). Examination of temporal changes is not possible with the limited numbers of tilefish caught in the surveys. In general, survey distributions seem to match information for the directed longline fishery (Figure B3). The fishery tends to be concentrated in an area in the Mid-Atlantic southern New England region where the stock is most abundant and where the stock is more widely distributed across the shelf break. The stock appears to occupy a narrower band to the north along the south edge of Georges Bank and to the south towards Cape Hatteras. The literature states that tilefish have a narrow temperature preference of 9 to 14 C. The temperature distribution from the surveys also suggests the species is limited to this narrow temperature range. However, there were several tows which did catch tilefish at temperatures lower than 9 C (Figure B30).

The probability of occurrence was calculated for tilefish from the spring and fall surveys (Figure B31). The confidence intervals tend to be wide due to the limited data but the analysis shows that tilefish occur at temperatures between 10-15 degrees C. The probability of occurrence is calculated as follows. The quotient analysis splits temperature into bins (1 degree C in this case). In each bin the following calculation is made:

$$Q_i = \frac{N_i n}{N\, n_i}$$

where Q is the quotient index for temperature bin *i*, N_i is the number of tilefish occurrences in the bin and *N* is the number of tilefish occurrences overall; n_i is the number of stations sampled in the bin and n is number of stations sampled overall). The following standardization is made:

$$Q_i^s = \frac{Q_i}{\sum Q_i}$$

which gives the probability of occurrence in each temperature bin. In essence this provides an empirical probability density function, which is corrected for potentially unequal sampling across temperature bins. Bootstrapping is used to estimate the confidence intervals. For tilefish, the confidence intervals are wide, because there are relatively few tilefish in the survey.

The probability of occurrence analysis gives a first-order analysis of the realized thermal niche of tilefish. This could be used as a starting point to see whether the tilefish stock could be impacted if bottom water temperatures change beyond this range. A critical dimension of tilefish realized niche is substrate suitability; tilefish construct burrows and require habitat with suitable substrate characteristics. This factor should be considered in future evaluations to determine whether shifts in distribution are possible if bottom temperatures do change beyond the range of estimated thermal niche.

In general, tilefish is a warm water species and are potentially quite vulnerable to cold water intrusions in their shelf break habitat. They principally occupy a relatively narrow temperature band at the shelf break bathed in relatively stable warm water influenced by the Gulf Stream. A massive tilefish die-off was recorded however in 1882 (Collins 1884; Bigelow and Schroeder 1953) and attributed to deep penetration of cold Labrador Current water into the region (Cushing 1982; Marsh et al. 1999). Collins (1884) estimated that as many as one billion tilefish may have perished in this massive ecological event. The deep water sea robin (*Peristedion miniatum*) was also affected. This cold water intrusion has in turn, been connected to the North Atlantic Oscillation which reached a very low point in the winters of 1880-1881 and 1881-1882 (Marsh et al. 1999). The affects of change in the NAO on the hydrography of the region is typically felt about 12-18 months later. A sharp drop in the NAO could provide an early-warning signal to look for strong input of Labrador Slope water with possible repercussions for the tilefish stock.

The working group also examined a distribution plot using point location data from the commercial fishery VTR (logbook) data for longline gear (Figure B35). This plot does show that most of the tilefish catch comes from the central part of the stock in 537 and 616 where the directed tilefish longline fishery occurs. Perhaps more interesting, the plot also suggests a small amount of non directed catch coming from the deep eastern part of the Gulf of Maine. Further investigation of some of these VTR trips and some limited observed trips did suggest that small amounts of tilefish are caught in the Gulf of Maine in other longline (non-tilefish directed) commercial fisheries. This is surprising since this tilefish population component was not detected in the bottom trawl surveys. The small Gulf of Maine population is likely below detection levels of the trawl surveys due to the low catch rates.

TOR 4. Use assessment models to estimate annual fishing mortality and stock size for the time series, and estimate their uncertainty. Include a historical retrospective to allow a comparison with previous assessment results.

In this SARC 58 assessment the working group updated the ASPIC surplus production model and explored the use of forward projecting size (SCALE) and age (ASAP) structured models. The SARC 58 working group concentrated on the development of size/age structure models due to the continued concerns with process error issues from year class effects within the surplus production model and to include more realistic life history information on size and growth within the model. However concerns with the general lack of data over the time series with more advance data hungry models remains a source of concern. All modeling was initially done through 2013 to make use of all available data. However carrying models through 2013 requires some assumption to be made for the terminal year. The working group assumed the calendar year removals would be at the quota of 905 mt in 2013. Landing in the past 10 years have been relatively close to the 905 mt quota. The working group also assumed the 2013 size at length distribution and the 2013 commercial CPUE estimate which included data through August

2013 would not change significantly when it is updated through the end of the calendar year. After all model exploration and examination was completed, the working group concluded that the final model terminal year should be 2012 to avoid questions regarding the incomplete 2013 data.

ASPIC Surplus production model

The ASPIC surplus production model (Prager 1994; 1995) was used to determine fishing mortality, stock biomass and biological reference points (F_{MSY}, and B_{MSY}) for the development of the tilefish FMP in 2001. SARC 41 in 2005 and SARC 48 in 2009 accepted the ASPIC model as a basis for stock status determination. However, the SARC 48 surplus production model suggested that the stock was rebuilt and SARC 48 concluded that the stock was not yet rebuilt due to process error concerns within the surplus production model caused by year class effects. The catch size distributions and reductions in CPUE as year classes age also suggested that the stock has not yet rebuilt.

The three commercial fishery CPUE index series (Turner 1973-1982; NEFSC Weighout 1982-1993; and VTR 1995-2013) as configured in the 2009 SAW 48 assessment were updated for the SARC 58 ASPIC model configuration in run 2. Comparison of the updated ASPIC model to historical assessments can be seen in Figure B36 and Table B16. The updated ASPIC model estimates higher biomass and lower F relative to models from SARC 41 and SARC 48. Biomass in 2014 was estimated to be 1.66 of B_{MSY} and F was estimated to be 0.28 of F_{MSY}. The updated model also suggests the stock was not overfished during the implementation of the fishery management plan (stock was above one half B_{MSY} in 1999 for this run). A retrospective analysis also reveals that the surplus production model tends to underestimate B_{MSY} and overestimates fishing mortality as years are omitted from the model (Figure B37). The updated ASPIC run maintained the same B1 ratio assumption as in the last assessment. The B1 ratio parameter is the ratio of biomass in the first year of the model to K (carrying capacity of the stock). In past assessments this ratio was fixed at B_{MSY} since the model tends to estimate biomass much higher than K in the first year. Sensitivity runs were made to further evaluate the impact of different model configurations (Table B17, Figures B37 and B39). The influence of the B1 assumption on the model results can be seen in the sensitivity analysis. Run 3 estimates the B1 ratio at 1.3 of k. This does lower the estimate of B/B_{MSY} at the end of the time series from 1.66 to 1.56. Run 4 used the nominal CPUE series for the VTR CPUE index and run 5 combine the Weighout and VTR series into a single series. Combining the two CPUE series also resulted in a lower B/B_{MSY} ratio in the terminal year. This suggests that in the separate series runs the fishery is becoming less efficient when comparing the VTR q to the Weighout q (Figure B40). It is the relative shift in the q between the two CPUE series which resulting in higher biomass as years get added to the model. Reasoning on why the fishery would be less efficient in the VTR series relative to the older Weighout series is difficult to justify.

Expanded landing length frequency distributions and trends in the VTR CPUE show recent strong year class effects tracking through the fishery. As in past assessments the strong 1998/1999 and 2005 year classes result in process error with the fit to the VTR series in the ASPIC model since the surplus production model does not consider changes in recruitment, or cohort effects (Figure B40). The increase in error is reflected in the residual pattern of the vtr series. All ASPIC sensitive runs suggest the stock is above B_{MSY}. Some runs suggest the biomass is closer to the carrying capacity where density depend processes should be occurring (Figure B41). However, in general catch at size and age distributions suggest the fishery relies on periodic strong year classes. The fishery is not fishing on a stable size distribution of mostly larger fish across years as expected when density dependent processes would be occurring.

The working group developed run 6 as the preferred run using ASPIC model (Table B17, Figure B42). Run 6 incorporated the 1991-1994 logbook data from NY vessels into the VTR series, had a terminal year of 2012 and fixed the B1 ratio at k. Fixing the B1 ratio at K seems to be more in line with the initial development of the longline fishery in the early 1970s. However the working group did not bring forward the surplus production model as the preferred model for stock status determination due to the concerns described above. The working group concluded that the ASPIC production model does not adequately characterize the recent population and tilefish fishery trends, and therefore the ASPIC results are no longer sufficient to evaluate the status of the stock.

SCALE Model

The working group investigated the use of an age and size structured forward projection model (SCALE) for assessing the tilefish stock due to the inability of the ASPIC surplus production model in fitting the observed year class effects. The SCALE model was first examined in the last assessment in SARC 48. The working group investigated the use of the SCALE model for this assessment using the new commercial age data available.

Incomplete or lack of age-specific catch and survey indices often limits the application of a full age-structured assessment (e.g. Virtual Population Analysis). Stock assessments will often rely on the simpler size/age aggregated models (e.g. surplus production models) when age-specific information is lacking. However the simpler size/age aggregated models may not utilize all of the available information for a stock assessment. Knowledge of a species growth and lifespan, along with total catch data, size composition of the removals, recruitment indices and indices on numbers and size composition of the large fish in a survey can provide insights on population status using a simple model framework.

SCALE Model Description

The Statistical Catch At LEngth (SCALE) model, is a forward projecting age-structured model tuned with total catch (mt), catch at length or proportional catch at length, recruitment at a specified age (usually estimated from first length mode in the survey), survey indices of abundance of the larger/older fish (usually adult fish) and the survey length frequency distributions (NOAA Fisheries Toolbox 2008a). The SCALE model was developed in the AD model builder framework. The model parameter estimates are fishing mortality and recruitment in each year, fishing mortality to produce the initial population (Fstart), logistic selectivity parameters for each year or blocks of years and Qs for each survey index.

The SCALE model was developed as an age-structured model that does NOT rely on age-specific information on a yearly basis. The model is designed to fit length information, abundance indices, and recruitment at age which can usually be estimated by using survey length slicing. However a fishery independent survey does not exist for this tilefish stock. The model does require an accurate representation of the average overall growth of the population which is input to the model as mean lengths at age. Growth can be modeled as sex-specific growth and natural mortality or growth and natural mortality can be model with the sexes combined. The SCALE model will allow for missing data.

The SCALE model assumes growth follows the mean input length at age with predetermined input error in length at age. Therefore a growth model or estimates of mean length at age are essential for reliable results. The model assumes static growth and therefore population mean length/weight at age are assumed constant over time.

The SCALE model estimates logistic parameters for a flattop selectivity curve at length in each time block specified by the user for the calculation of population and catch age-length matrices or the user can input fixed logistic selectivity parameters. Presently the SCALE model cannot account for the dome shaped selectivity pattern.

The SCALE model computes an initial age-length population matrix in year one of the model as follows. First the estimated populations numbers at age starting with age-1 recruitment get normally distributed at one cm length intervals using the mean length at age with the assumed standard deviation. Next the initial population numbers at age are calculated from the previous age at length abundance using the survival equation. An estimated fishing mortality (Fstart) is also used to produce the initial population. This F can be thought of as the average fishing mortality that occurred before the first year in the model. Now the process repeats itself with the total of the estimated abundance at age getting redistributed according to the mean length at age and standard deviation in the next age (age+1).

This two step process is used to incorporate the effects of length specific selectivities and fishing mortality. The initial population length and age distribution is constructed by assuming population equilibrium with an initial value of F, called Fstart. Length specific mortality is estimated as a two step process in which the population is first decremented for the length specific effects of mortality as follows:

$$N^*_{a,len,y_1} = N_{a-1,len,y_1} e^{-\left(PR_{len}F_{start}+M\right)}$$

In the second step, the total population of survivors is then redistributed over the lengths at age *a* by assuming that the proportions of numbers at length at age *a* follow a normal distribution with a mean length derived from the input growth curve (mean lengths at age).

$$N_{a,len,y_1} = \pi_{len,a} \sum_{len=0}^{L_\infty} N^*_{a,len,y_1}$$

where

$$\pi_{len,a} = \Phi\left(len + 1 \mid \mu_a, \sigma_a^2\right) - \Phi\left(len \mid \mu_a, \sigma_a^2\right)$$

where

$$\mu_a = L_\infty \left(1 - e^{-K(a - t_0)}\right)$$

Mean lengths at age can be calculated from a von Bertalanffy model from a prior study as shown in the equation above or mean lengths at age can be calculated directly from an age-length key. Variation in length at age a = σ_s^2 can often be approximated empirically from the growth study used for the estimation of mean lengths at age. If large differences in growth exist between the sexes then growth can be input as sex-specific growth with sex-specific natural mortality. However catch and survey data are still fitted with sexes combined.

This SCALE model formulation does not explicitly track the dynamics of length groups across age because the consequences of differential survival at length at age a do not alter the mean length of fish at age a+1. However, it does more realistically account for the variations in age-specific partial recruitment patterns by incorporating the expected distribution of lengths at age.

In the next step the population numbers at age and length for years after the calculation of the initial population use the previous age and year for the estimate of abundance. Here the calculations are done on a cohort basis. Like in the previous initial population survival equation the partial recruitment is estimated on a length vector.

$$N^*_{a,len,y} = N_{a-1,len,y-1} e^{-\left(PR_{len} F_{y-1} + M\right)}$$

second stage

$$N_{a,len,y} = \pi_{len,a} \sum_{len=0}^{L_\infty} N^*_{a,len,y}$$

Constant M is assumed along with an estimated length-weight relationship to convert estimated catch in numbers to catch in weight. The standard Baranov's catch equation is used to remove the catch from the population in estimating fishing mortality.

$$C_{y,a,len} = \frac{N_{y,a,len} F_y PR_{len} \left(1 - e^{-\left(F_y PR_{len} + M\right)}\right)}{(F_y \quad PR_{len}) + M}$$

Catch is converted to yield by assuming a time invariant average weight at length.

$$Y_{y,a,len} = C_{y,a,len} W_{len}$$

The SCALE model results in the calculation of population and catch age-length matrices for the starting population and then for each year thereafter. The model is programmed to estimate recruitment in year 1 and estimate variation in recruitment relative to recruitment in year 1 for each year thereafter. Estimated recruitment in year one can be thought of as the estimated average long term recruitment in the population since it produces the initial population. The residual sum of squares of the variation in recruitment $\sum(\text{Vrec})^2$ is then used as a component of the total objective function. The weight on the recruitment variation component of the objective function (Vrec) can be used to penalize the model for estimating large changes in recruitment relative to estimated recruitment in year one.

The model requires an age-1 recruitment index for tuning or the user can assume relatively constant recruitment over time by using a high weight on Vrec. Usually there is little overlap in ages at length for fish that are one and/or two years of age in a survey of abundance. The first mode in a survey can generally index age-1 recruitment using length slicing. In addition numbers and the length frequency of the larger fish (adult fish) in a survey where overlap in ages at a particular length occurs can be used for tuning population abundance. The model tunes to the catch and survey length frequency data using a multinomial distribution. The user specifies the minimum size (cm) for the model to fit. Different minimum sizes can be fit for the catch and survey data length frequencies.

The number of parameters estimated is equal to the number of years in estimating F and recruitment plus one for the F to produce the initial population (Fstart), logistic selectivity parameters for each year or blocks of years, and for each survey Q. The total likelihood function to be minimized is made up of likelihood components comprised of fits to the catch, catch length frequencies, the recruitment variation penalty, each recruitment index, each adult index, and adult survey length frequencies:

$$\mathrm{L_{catch}} = \sum_{years}\left(l\,\mathrm{n}(Y_{\mathrm{obs,y}} + 1) - \ln\left(\sum_{a}\sum_{len} \mathrm{Y_{pred,len,a,y}} + 1 \right) \right)^2$$

$$L_{catch\_lf} = -N_{eff} \sum_{y} \left(\sum_{inlen}^{L_\infty} \left((C_{y,len} + 1) \ln\left(1 + \sum_{a} C_{pred,y,a,len} \right) - \ln(C_{y,len} + 1) \right) \right)$$

$$\mathrm{L_{vrec}} = \sum_{y=2}^{Nyears} (Vrec_y)^2 = \sum_{y=2}^{Nyears} (R_1 - R_y)^2$$

$$\sum L_{rec} = \sum_{i=1}^{Nrec} \left[\sum_{y}^{Nyears} \left(\ln\left(I_{rec_i,inage_i,y}\right) - \ln\left(\sum_{len}^{L_\infty} N_{y,inage_i,len} * q_{rec\,i} \right) \right)^2 \right]$$

$$\sum L_{adult} = \sum_{i=1}^{Nadult} \left[\sum_{y}^{Nyears} \left(\ln\left(I_{adult_i,inlen+_i,y}\right) - \left(\sum_{a} \sum_{inlen_i}^{L_\infty} \ln\left(N_{pred,y,a,len} * q_{adult\,i} \right) \right) \right)^2 \right]$$

$$\sum L_{lf} = \sum_{i=1}^{Nlf} \left[-N_{eff} \sum_{y} \left(\sum_{inlen_i}^{L_\infty} \left((I_{lf_i,y,len} + 1) \ln\left(1 + \sum_{a} N_{pred,y,a,len} \right) - \ln(I_{lf_i,y,len} + 1) \right) \right) \right]$$

In equation L_{catch_lf} calculations of the sum of length are made from the user input specified catch length to the maximum length for fitting the catch. Input user specified fits are indicated with the prefix "in" in the equations. LF indicates fits to length frequencies. In equation L_{rec} the input specified recruitment age and in L_{adult} and L_{lf} the input survey specified lengths up to the maximum length are used in the calculation.

$$Obj\ fcn = \sum_{i=1}^{N} \lambda_i L_i$$

Lambdas represent the weights to be set by the user for each likelihood component in the total objective function.

Tilefish SCALE Model Configuration and results

Three growth studies are available for golden tilefish (Figure B36 and B37). Turner's aging study was done during the development of the longline fishery (1978-1982). Vidal growth study collected fish in 2008. Von Bertalanffy growth curves from Turner and Vidal were used in the SARC 48 SCALE model. For SARC 58 new age data from the 2007-2012 commercial fishery was used for the development of the updated SCALE model (Figure B43). Von Bertalanffy growth from the updated age information was very similar to the growth curve that Turner estimated (Figure B44). The lack of older fish (> 22 years) in Vidal study made the estimation of L-infinity more difficult. In SARC 48 sex specific models were examined since growth and longevity appears to differ between the sexes with males getting larger but not living as long as females. However, in general model results did not differ greatly between the sex specific and the combined sex models in SARC 48. A total of 3,579 fish were aged from 2007-2012 (Table B15, Figures B43). The estimated growth curve appears to be relatively stable. The estimated von Bertalanffy growth curve did not differ greatly when some of the oldest fish (> 26 year) were omitted from the growth model (Figure B45). However sex information is not available for commercial ages since the fish are landed dressed. Individual annual growth models also did not differ greatly (Figure B46).

Inferences on the assumed natural mortality were made using Turner's aging work since landings were relativity low before this period. Natural mortality may be higher on male than females judging from the number of older fish seen by sex in Turner's sample (Table B18). In general Turner saw fewer older males than females during his study. The oldest fish age in the recent 2007-2012 age data was a 76 cm 36 year old fish in 2008. Twenty-seven fish were aged older than 20 years when all years (2007-2012) were combined. At SARC 48 a natural mortality rate of 0.15 was assumed for males and 0.1 on females. For the south Atlantic stock and the Gulf of Mexico golden tilefish stock an assumption using the Lorenzen m scaled to 0.1 is done in the modeling. The SARC 58 working group concluded that natural mortality was between 0.1 and 0.15 for this assessment. Initial comparison of virgin length frequency distributions and length distributions from Turner's length distributions during the development of the directed fishery seem to suggest m is closer to 0.15 (Figure B47). The base runs were first developed using a natural mortality assumption of 0.15 with sensitivity runs done at 0.1.

The assumed variation around the mean lengths at age was also estimated from the pooled (2007-2012) age length data (Figure B48 and B49). A centered 5 year moving average was used to estimate the increase in the variation at age. The variation at age was held constant at age 17 where the lack of age data causes the estimated variation to decline.

The SCALE model was dimensioned from ages 1-45, lengths 1-140 cm from years 1971-2013 with a combined sex von Bertalanffy mean lengths at age from 2007-2012. The two selectivity blocks (1971-1981, 1982-2008) were initially retained from the SARC 48 assessment. A recruitment index does not exist for tilefish so a straight line index (constant recruitment index) was used as a proxy for the age index. A low penalty weight (0.05) on recruitment variation was use in fitting the recruitment. However with a straight line proxy for the index the weight on the index can also be thought of as a penalty on recruitment variation. The SCALE model did pick up a recruitment signal from the commercial expanded length frequency distributions. The CPUE indices were fit to fish sizes that were approximate according to the landing length frequency distributions. Turner's CPUE series was fit to 47+ cm fish and the Weighout and VTR series were fit to 37+ cm fish.

The working group discovered an error in the SARC 48 SCALE configuration. The NOAA toolbox SCALE model is designed to fit numbers at age indices. The model was recoded to fix biomass indices since commercial CPUE indices are in biomass. This did appear to aid in the model's ability in fitting the VTR CPUE trends cause by year class effects (Figure B50).

The catch length frequency distributions are an important component of the SCALE model. Turner collected landing length frequency information in 1974 and from 1976 to 1982. Note that Turner's length frequency data is only available in 5 cm blocks. NEFSC expanded landing size information exist from 1995 to 1999 and from 2002 to 2013. There appears to be a shift to smaller fish sizes between 1981 and 1982 in Turner's size distributions. Two selectivity blocks were assumed in the SCALE model (1971-1981, 1982-2008). The sensitivity of assuming a single selectivity block (run 3) over the time series was also tested. The working group also decided to shift the second selectivity block by one year so that the second block starts in 1983 (see ASAP model section below).

The SCALE model time series starts in 1971 at the beginning of the directed tilefish longline fishery. The SCALE model tends to estimate a low Fstart which is expected since this is the equilibrium F that is assumed to occur before the beginning the time series before the directed longline fishery started.

Relatively little differences are seen in the results among the different model configurations (Table B19, Figure B51). The models generally suggest the large decline in the biomass with the development of the directed longline fishery and then a small increase in the stock since the mid 1990s. Unlike the surplus production model the SCALE model results in a large shift in the q between the Weighout and VTR series which produces a large decline in the stock (Figure B52). This is likely the result of fitting the year class dynamics in the vtr series along with the tracking of cohorts information through the catch at length. Addition CPUE data from three vessels were collected from NY fishermen logbooks to extend the VTR series further in the past due to concerns that the model may be estimating a unrealistic increase in efficiency because of the lack of information during the mid-1990s. Adding this CPUE data from 1991-1994 did lower the change in q from the Weighout to the VTR series (Figure B53). In addition a sensitivity run which combines the Weighout and VTR series also prevents a change in q which results in higher biomass and lower F at the end of the time series.

Run 10 is the final working group run which was configured similar to the final ASPIC and final ASAP run (Table B19). Final runs had a terminal year of 2012 and included the additional 1991-1994 New York CPUE data in the VTR series. Results of the final SCALE runs are summarized in Figures B54 through B59. A comparison of the final SARC 48 and SARC 58 ASPIC and SCALE models and the new SARC 58 final ASAP model (see below) is shown in Figure B60. The size and age structure models result in similar estimates of biomass and fishing mortality relative to the more optimistic ASPIC model results.

There is a general concern with the lack of data and with the data independence used in the SCALE model. A general lack of tuning information may result in little difference between the sensitivity runs. The strongest evidence for the model estimating unrealistic low biomass and high fishing mortality came from a comparison of the estimated population numbers of older fish (10+ 15+ and 20+) with the actually number of fish aged in the commercial sampling program (Table B20). It seems unrealistic that the age sample accounted for over 25% of the entire population for age 20+ fish.

Tilefish fishing industry advisors participating in the working group meeting stated that large tilefish (in the extra large market category and larger, mainly larger/older than 75 cm/age 8) are not often targeted by the commercial longline fleet. The largest tilefish are worth a lower price than smaller fish, due mainly to lower relative meat yield per fish. The largest tilefish are known to occupy habitat that is a) difficult to fish due to bottom characteristics (e.g., burrows in canyon walls) or located in deeper water that is harder to fish efficiently and b) presents availability issues due to conflicts with lobster fishing gear. The largest tilefish also have an increased chance to escape the longline gear due to pulled hooks and leader breakage. All of these factors combine to make it likely that the fishery selection curve for tilefish is strongly dome-shaped. The current version of SCALE does not have the ability to incorporate a dome shape selection pattern. Therefore the working group did not accept the SCALE model basis for stock status determination and pursued the development of an ASAP model which directly fits the catch at age data.

ASAP Model

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

ASAP Model Inputs and Formulation

Maturity at age estimates came from McBride et al. (2013). Maturity at age was estimated using a logistic model from 58 female fish which that had maturation determined through histology (Figure B61). SARC 48 used at maturation curve based on macroscopic determination at length from Vidal. Conversion of the maturity at length curve to age was similar to the new update histological maturity at age curve (Figure B61). The A50 is slightly older the 5 years.

Four different ASAP formulation were initially developed, 1) catch at age to 20+ with year specific catch at age expansions for years where age data exists (2007, 2009-2012), 2) catch at age to 20+ with pooled age length key used for all years in the model, 3) catch at age to 10+ with year specific catch at age expansions for years where age data exists (2007, 2009-2012), 4) catch at age to 10+ with pooled age length key used for all years in the model. Relatively small differences in the catch at age exist between using the pool age length key and using year specific keys for years where age data exists (Figure B62). There is some evidence that year specific expansion show a slightly stronger 2005 year class tracking through the catch at age relative to using the pooled age length key. The marginal improvement in the tracking of the 2005 year class in the raw age data suggests that the uses of a pool age length key is not producing a large change in the model results. These may be partly a reflection of the difficultly in aging tilefish. Strong year class effects are seen in the catch at length and CPUE data but the error in the aging of tilefish plus or minus a year could result in the smearing of year class effects. Therefore there may not be a significant improvement in model results through production aging to produce a year specific catch at age for this stock.

Year specific expansion could not be estimated in 2008 due to missing age information for the smaller size fish in that year. Mean weight at age show variability increases for ages older than 20 due to the limit number of 20+ fish aged (Figures B63). Like the SCALE model the ASAP model time series was estimated from 1971 to 2013. For all four model formulations the average mean weights at age for years which possessed data was used in years which had missing information (1971-1973, 1975, 1983-1994, 2000-2001) (Table B21, Figures B64 and B65).

Initial runs assumed a flattop selectivity pattern (estimating selective at age while fixing 7+ fish at full selectivity 1971-1981 and 6+ for 1982-2013). Initial working group exploratory runs are shown in Table B22 and Figures B66 and B67. Runs 1 through 4 illustrate the effect of the 4 different initial model formulations describe above (Figure B66). There was very little difference between runs that used a pooled age length key for all years verse runs that used year specific keys when age exists. Comparison of 10+ verse 20+ formulations also show little difference between runs in years where length data exist at the end of the time series. However recruitment, SSB and fishing mortality did differ in the 1980s and early 1990s where significant data gaps exist. The working group was therefore concerned with a possible over interpretation of stock recruit based biological reference points that relied on unstable estimates of SSB and recruitment. Therefore the working group developed proxy based biological reference points.

Sensitivity runs 5 through 13 were developed from run 2 (20+ using year specific keys when data exists with m=0.15). Run 5 tested the effect of m=0.1. Run 6 combined the Weighout and VTR CPUE series and run 7 tested the effect of including the 1991 to 1994 data in the VTR series. The combing of the Weighout and VTR series had a similar effect as seen in the SCALE model which resulted in higher biomass at the end of the time series. The affects on the change in q was similar as observed with the SCALE model (Figure B68). However there is little justification for the combining of the Weighout and VTR series. The combining of the two series also results in some tension in the model which is reflected in the increase in the retrospective pattern of run 6 (Figures B69 and B70). Run 9 had a terminal year of 2012 and runs 10-12 tested the effect of three different fixed dome shaped selectivity patterns (Figure B71). Run 13 tested the effect of using a single selectivity block.

In general the ASAP model flattop selectivity results were very similar to the SCALE model results despite the different approaches for modeling growth. In addition, the fitting of catch at age data directly in the ASAP model did not result of in significantly more 20+ fish in the population at the end of the time series. Therefore flattop selectivity runs using ASAP also did not appear to be very believable when comparing the proportion of the population in the age sample (Table B23). Failure in passing this believability test and commercial fishing practice described above led the working group to the development of a dome shaped ASAP models.

The working group developed two different dome formulations using the pooled age length key for the catch at age in all years and a natural mortality rate of 0.15. One formulation (run 14, 17-22, 26-27) modeled the catch at age to 10+ with estimation of selectivity at each age for the older ages (7-10+) and the other formulation (run 16 and 25) expanded the catch at age out to 20+ and modeled selectivity as a double logistic curve (Table B24, Figure B72). Twelve of the working group dome shaped selectivity runs including the preferred working group final run 27b are summarized in table B24 and Figure B73. In general similar results were seen between the 10+ and 20+ runs. In general, the 20+ run tend to have more convergence issues then the 10+ formulation. Initial SSB was sensitive to changes in the selectivity blocks and to changes in fitting the length frequency data in 1974. Information on when the second selectivity block should start was lacking due to missing length data from 1983-1994. The last year in Turner's length data (1983) suggests a greater proportion of smaller fish in the catch. However information is lacking on whether this could have been due to an increase in recruitment or a shift in selectivity. The working group decided to put the second selectivity block after the last year of Turner's length data in 1983. The working group also decided not to fit the 1974 length data since this distribution was very different then the other years in the 1970s and since a limited sample size exists for this year with only 194 fish measured. Starting the model in 1995 (run 26) scaled the biomass lower at the end of the time series. Combining the Weighout and VTR series also did not produce as large an increase in biomass at the end of the time series as seen with the flattop SCALE and ASAP runs. This may be a function of the increased flexibility with the dome shape models through changes in selectivity between the blocks. The input, diagnostics, and results for the working group final ASAP model 27b are summarized in Figures B74 to B91. As expected the final dome shaped model did produce more older fish in the population relative to the fat-topped models (Table B25). A profile on m of the final ASAP model suggests an assume m=0.15 is appropriate (Figure B92).

Preferred ASAP Model Results

Fishing mortality (F_{MULT}) increased with the development of the directed longline fishing from near zero in 1971 to 1.2 in 1987. Fishing mortality was relatively high but fluctuated from 0.3 to 1.3 from 1987 to 1997. Fishing mortality has been decreasing since 1997 to 0.26 in 2011 and 0.27 in 2012. F_{MULT} MCMC 90% confidence intervals were 0.201 – 0.37 in 2012; (Table B26; Figures B93 and B94).

Mean recruitment was around 1.2 million for age-1 recruits. Recruitment was estimated to be relatively low at the end of the time series (mean recruitment of 0.7 million from 2009-2002). Several stronger year classes were produced in 1982, 1988, 1992-1993, 1998-1999, and 2005. Large uncertainty surrounds the strength of the model estimated 1982 year class since very little data exists in the model in the 1980s and early 1990s. Aging error due to the difficultly in aging tilefish and the use of a pooled age length key may also contribute to the estimation of two consecutive year classes in 1982-1983 and 1998-1999 instead of the estimation of single year class for each period.

Spawning stock biomass declined substantially early in the time series from 27,044 metric tons in 1974 to 1,221 metric tons in 1999, lowest in the time series. Thereafter, SSB has increased to 5,229 metric tons in 2012. Spawning stock biomass MCMC 90% confidence intervals were 3,275 mt to 7,244 mt in 2012; (Table B26; Figures B93 and B94).

Summary of Working Group Meeting Conclusions

Over the last twenty years, the commercial length and more recent age data indicate that increases in fishery CPUE and model estimated biomass are predominantly due to the influence of strong year classes in 1999 and 2005. The 2005 year class has now passed through the fishery, and recently fishery CPUE has started to decline. Process error in the ASPIC model associated with the recent large year classes has increased at the end of the time series due to an assumed constant recruitment/growth parameter. The WG concluded that the ASPIC production model does not adequately characterize the recent population and fishery trends of tilefish, and therefore the ASPIC results are not sufficient to evaluate the status of the stock.

The WG also examined results obtained from an alternative forward projecting age/size structured model (SCALE), in order to include length and age data in modeling the dynamics of the stock. The SCALE model incorporates population growth and length information into the model framework. This allows for the estimation of strong recruitment events which can be seen in the commercial length frequency distributions over time. However the overall lack of data and issues with independence of the data sources is a source of concern with the SCALE model results. The lack of a recruitment index, inability to estimate uncertainty using MCMC, and the inability of the current SCALE model to incorporate a dome-shaped selection curve, are also sources of uncertainty. The SCALE model results suggest that the ASPIC surplus production model may have overestimate the productivity of the stock.

Tilefish fishing industry advisors participating in the WG meeting stated that large tilefish (in the extra large market category and larger, mainly larger/older than 75 cm/age 8) are not often targeted by the commercial longline fleet. The largest tilefish generally are worth a lower price than smaller fish, due mainly to lower relative meat yield per fish. The largest tilefish are known to occupy habitat that is a) difficult to fish due to bottom characteristics (burrows in canyon walls) and b) presents availability issues due to conflicts with lobster fishing gear. The largest tilefish also have an increased chance to escape the longline gear due to pulled hooks and leader breakage. All of these factors combine to make it likely that the fishery selection curve for tilefish is strongly dome-shaped.

In response to these noted concerns with the ASPIC surplus production and SCALE age-length model, the WG used the ASAP statistical catch at age model for stock status determination, since the ASAP has the ability to model recruitment, incorporate annual fishery age compositions directly, estimate uncertainty using MCMC, and model dome-shaped fishery selectivity .

TOR 5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY or for their proxies) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

The existing stock status determination is based on the ASPIC surplus production model from SARC 48. SARC 48 concluded overfishing was not occurring and the stock was not overfished. In SARC 48 the ASPIC model indicated that the stock was above B_{MSY}. However, SARC 48 concluded that the stock was not yet rebuilt based on concerns with the catch size distributions and process error cause by year class effects within the ASPIC model.

Biological reference points were redefined in this assessment based on the ASAP model. The working group did not develop stock recruitment based biological based reference points due to the uncertainty in the recruitment and SSB estimates during the 1980s and 1990s. Stock recruit based biological reference point would likely be sensitive to plus group decisions. Therefore the working group based biological reference points on a percent SPR proxy. Figure B95 shows yield per recruit and SPR curves for the final working group ASAP model run 27b. The long lifespan and relatively low M would suggest that a fishing mortality rate reference point of $F_{40\%}$ or higher %MSP would be appropriate. However, information provided by fishing industry advisors and ASAP model results indicate that it is likely that the fishery selection curve for tilefish is strongly dome-shaped. Further, under the constant landings quota of 905 mt since implementation of the FMP in November 2001, the stock has increased to the new estimate of SSB_{MSY}. In general, improvements to the stock have occurred under the 905 mt quota implemented in 2002 which is evident in the raw catch size and fishery CPUE data. Fishing mortality rates have averaged 0.367 since 2002, and the new yield per recruit analysis shows that this fishing rate corresponds to about $F_{25\%}$. Given these factors, the WG recommends that $F_{25\%}$ = 0.370 and the corresponding SSB_{MSY} = 5,153 mt, $SSB_{THRESHOLD}$ = 2,577 mt, and MSY = 1,029 mt be adopted as the new biological reference point proxies for this assessment. Working group dome-shaped run sensitivity runs, results and biological reference points are summarized in Table B27. Results for $F_{40\%}$ and $F_{30\%}$ associated reference points for the final run are also compared in Table B28. SSB_{MSY} was estimated from long term projections fishing at the F_{MSY} proxy and re-sampling from the CDF of recruitment using entire times series (1971-2013). The 90% confidence intervals from long term projections were 4,155 mt to 6,540 mt.

TOR 6. Evaluate stock status with respect to the existing ASPIC model (from previous peer reviewed accepted assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.

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

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-4).

The reference points from the previous 2009 SAW 48 assessment are based on the ASPIC surplus production model and cannot be compared to the current assessment ASAP model results and reference points. The current assessment using an updated ASPIC model provides the following updated reference points: B_{MSY} = 12,950 mt, F_{MSY} = 0.139 and MSY = 1,800 mt. Based on the current ASPIC model results and updated reference points, F in 2012 is estimated to be 0.053, 38% of F_{MSY} and stock biomass in 2012 is estimated to be 15,150 mt, 17% above B_{MSY}. With respect to the existing reference points from the 2009 SAW 48 assessment, fishing mortality in 2012 was estimated to be 0.053, 33% of F_{MSY} = 0.16, and total biomass in 2012 was estimated to be 15,150 mt, 133% of B_{MSY} = 11,400 mt. With regards to this term of reference, note that for the ASPIC surplus production model it may not be appropriate to compare stock status relative to biological reference points from a different model run. All ASPIC model results suggest the stock is rebuilt. However, the SARC 48 review panel accepted the ASPIC model but concluded that the ASPIC model is likely over optimistic and that the stock has not rebuilt above B_{MSY}.

The SCALE model was not accepted for stock status determination in SARC 48. In addition, the updated SCALE model for this assessment was also not used for status determination due to the inability for modeling a dome-shaped selectively pattern within the model. However flattop yield per recruit estimates were similar to flattop estimates using the ASAP model.

The Golden Tilefish stock was not overfished and overfishing was not occurring in 2012 relative to the new biological reference points. A new model (ASAP statistical catch at age) is used in this assessment to incorporate newly available length and age data and better characterize the population dynamics of the stock. Comparison of ASAP model biological reference points to ASPIC model biological reference points was not done since the measure of fishing mortality (F_{MULT}) and biomass (SSB) has changed with the new model.

The new model indicates that the stock was at high biomass and lightly exploited during the early 1970s. As the longline fishery developed during the late 1970s, fishing mortality rates increased and stock biomass decreased to a time series low by 1999. Since the implementation of constant landings quota of 905 mt in 2002, the stock has increased by 2012 to the new biomass reference point (SSB_{MSY} proxy).

The fishing mortality rate was estimated to be 0.275 in 2012, below the new reference point F_{MSY} proxy = $F_{25\%}$ = 0.370 (Figure B94). There is a 90% probability that the fishing mortality rate in 2012 was between 0.198 and 0.372. SSB was estimated to be 5,229 mt in 2012, about 101% of the new reference point SSB_{MSY} proxy = $SSB_{25\%}$ = 5,153 mt. $SSB_{THRESHOLD}$ was estimated to be 2,577 mt. There is a 90% chance that SSB in 2012 was between 3,275 and 7,244 mt. The average recruitment from 1971 to 2012 is 1.24 million fish at age-1. Recent large year classes have occurred in 1998 (2.35 million), 1999 (2.39 million) and 2005 (1.85 million).

TOR 7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

a. Provide numerical annual projections (2-3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

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

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

A five year average of stock and catch mean weights at age was used in the YRP and in all AGEPRO projections (Table B29). The 905 ACL was assumed for the removals in the two bridge years of the projections (2013-2014). Below is a description of the working group unadjusted recruitment projections. The SARC 58 panel concluded that projections should be done using 2010-2012 age-1 recruitment estimates adjusted to the time series geometric mean due to the lack of information to inform the estimate of recruitment at the end of the time series within the model. The adjusted projections from SARC 58 are described in Appendix B2.

In the unadjusted projections the fishing mortality in the bridge years increased to 0.28 in 2012 to 0.45 in 2013. Higher fishing morality in the bridge years and lower projected catches in 2014-2015 is a result of the assumed 905 catch in 2012-2013 and overall lower estimated recruitment at the end of the time series (2009-2012). The projected overfishing catch at F_{MSY} in 2015 is 759 mt. The estimated recruitment at the end of the times series is uncertain due to the lack of information to inform the recruitment estimate in the ASAP model (Figure B96). The 90% CI from projections assuming F_{MSY} = $F_{25\%}$ = 0.37 can be seen in Figure B97. The F_{MSY}

projection compared to a projections at F=0 and constant quota projections at 905 mt and 800 mt are summarized in Figure B98. A constant 905 mt projection suggests that overfishing would continue from 2013 to 2017.

ABC and OFL estimates that follow the Mid-Atlantic SSC p* approach from unadjusted projections are summarized in Table B30. The size of the uncertainty buffer between the OFL and the ABC is determined from the input uncertainty distribution on the OFL and the ratio of the SSB to SSB_{MSY}. Estimates assuming a 100% CV on the OFL and the model estimated 27% CV around the OFL in 2015 are also given in Table B30.

The new assessment model estimates a dome shaped selectivity based on probable refuge effects due to conflicts with lobster and trawl gear, unfished areas on the south flank of Georges Bank, effects of targeting incoming year classes, and avoiding the extra large fish due to price reductions. Uncertainty still surrounds the estimates of the extent of doming in the fishery selectivity since a fishery independent survey does not exist to help inform the shaped the selectivity curve. Unknown effects on tilefish CPUE due to competition/interference from increased dogfish abundance also introduce uncertainty in interpreting CPUE from this fishery as a measure of stock abundance.

The overall lack of data within the ASAP model and questions surrounding the estimates of selectivity are a general concern. However the ASAP model which incorporates the species lifespan, growth, and recruitment dynamics can more appropriately match the year class dynamics seen in the commercial size distributions and CPUE patterns which result in process error in the ASPIC model.

TOR 8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports. Identify new research recommendations.

New SARC 58

1) Develop an industry based survey using two or three designated fishing trips per year. Industry based survey trips would follow a design similar to a fishery independent survey and collect more intensive size and catch information on a haul by haul basis. However a reduction in catch rates likely occur on these survey trips relative to normal fishing operation. The benefits of a survey design to the stock assessment will likely surpass a more intensive and burdensome haul by haul data collection on trips during normal fishing operation. The WG suggests this science could be funded through the Cooperative Research Program, the habitat assessment improvement plan, or MAFMC research set-aside (RSA).

2) Increase the sampling of maturity at size and age and commercial landings at size and age.

Pending research recommendations from the 2013 MAFMC SSC, 2009 SARC 48, 2005 SARC 41, and 1999 MAFMC SSC Reviews

1). For the study fleet project and any potential semi fishery independent survey, include additional information on conflicts with lobster and trawl gear, the possibility of unknown effects on tilefish CPUE due to competition/interference from an increased abundance of dogfish, the unknown effects of bait type on tilefish CPUE (e.g., substitutes for the preferred squid).

No progress.

2). Develop protocols to ensure consistency between dealer, VTR, and IVR reports of the tilefish landings.

Work in progress. The IVR is no longer the principle data source for monitoring this fishery. The dealer reports are used to monitor the fishery and are consistent with the VTR data. The NERO has been working to integrate tilefish into the expanding QA/QC process, and inconsistencies between dealer and VTR reports are being identified and addressed more consistently. Removing the IVR requirement could however require a FMP amendment, as the IVR is not specifically mentioned in the list of framework-able issues. The NERO has discussed moving the IVR report to an online report through the Fish-Online webpage. So that might be another option if there is interest in keeping some form of dedicated IFQ report.

3). Develop protocols to ensure consistency in market category designation among fishing ports.

Work in progress in development of a large medium code in the dealer data and in the collection of biological information from the large medium market category. These changes are expected to be implemented in 2014. NERO should follow up with dealers regarding accurate and consistent market category reporting across all sizes. For example, industry noted inconsistency in the categorization of the smallest landed tilefish into different categories in NY (KK or tiny, meaning smaller than a kitten) and NJ (extra small).

4) Conduct a hook selectivity study to determine partial recruitment changes with hook size. Determine catch rates by hook size. Update data on growth, maturity, size structure, and sex ratios at length.

Hook selectivity study was not done. Funding was initially available, but subsequently rescinded. Updated growth, maturity, and size structure studies were completed during the 2009 SARC 48 assessment.

5) Develop a bioeconomic model to calculate maximum economic yield per recruit.

No progress.

6) Incorporate auxiliary data to estimate r independent of the ASPIC model.

No progress. The 2005 SARC 41 questioned if this can be done or should be done. However the 2009 SARC 48 SCALE results suggest that r is overestimated in the ASPIC model. The WG does not consider the ASPIC model to be sufficient to evaluate the status of the stock and has explored other models in this SARC 58 assessment.

7) Understand the role of tilefish in creating secondary habitats through their burrowing activity, thereby increasing diversity and the extent to which this diversity is compromised by the removal of these ecosystem engineers by the fishery.

No progress.

8) Understand the causes in the pattern and variability in recruitment.

No progress.

9) Quantify and understand the spatial dynamics of the stock and the fishery (specifically, assess historical changes in the distribution of fishing effort, develop haul-by-haul information on the spatial and temporal distribution of catch, and evaluate the potential of a rigorously-designed study fleet program).

Work in progress, through examination of the 2008 study fleet data and ongoing use of the VTR as the source of information for the fishery dependent CPUE index of stock abundance.

10) Assess the potential for and extent of local population structure.

No recent progress. The work of Katz et al. (1983) used significant differences in allelic frequencies to identify distinct stocks between mid-Atlantic and South Atlantic tilefish. Those authors also felt that certain aspects of golden tilefish distribution, life history and ocean circulation patterns supported their two stock hypothesis for the United States Atlantic.

11) Assess coherence between north and south Atlantic stocks and evaluate the effects of climate indices in driving stock dynamics.

No progress.

12) Evaluate the potential effect of time-varying catchability on assessment models that rely on commercial CPUE data.

Work in progress, through examination of catchability trends in SCALE and ASAP models developed for the SARC 58 assessment.

13) Evaluate the potential for a stakeholder survey to assess extent of population outside of normal fishing area.

No progress.

14). Explore the influence of water temperature and other environmental factors on trend in the commercial fishery CPUE index of stock abundance.

Work in progress, but note that extremely limited catch and temperature data are available to address this RR. Available data was examined in the SARC 58 assessment in TOR 3.

Completed Research Recommendations

1) Collect data on spatial distribution and population size structure. This can help answer the question of the existence of a possible dome shaped partial recruitment pattern where larger fish are less vulnerable to the fishery due to spatial segregation by size.

This research recommendation was completed in the study fleet data during the 2009 SARC 48 assessment.

2) Continue to develop the forward projecting catch-length model as additional length data becomes available. Investigate the influence of adding a tuning index of abundance and model estimated partial recruitment (logistic) to the catch-length model.

This research recommendation was completed during the 2009 SARC 48 assessment. The improved catch-length model was renamed as the SCALE model.

3) Collect appropriate effort metrics (number and size of hooks, length of main line, soak time, time of day, area fished) on a haul basis to estimate commercial CPUE.

This research recommendation was completed with the study fleet analysis during the 2009 SARC 48 assessment.

4) Initiate a study to examine the effects of density dependence on life history parameters between the 1978-82 period and present.

This research recommendation was completed with the updated growth and maturity study during the 2009 SARC 48 assessment.

5) Increased observer coverage in the tilefish fishery to obtain additional length data.

Consider completed due to increased port sampling to obtain sufficient lengths from the landings. Discards in the fishery are relatively small and adequately sampled.

6) Ensure that market category distributions accurately reflect the landings. Sampling of the commercial lengths has improved over the last six years. Small, kitten, and medium market category distributions can shift from one year to the next due to the growth of a strong year class. Intensive length sampling of the landings by market categories is needed to account for possible shifts in the distribution within a market category over time. Similar landings distributions were seen among the observer, study fleet, and commercial port sampling data sources.

Consider completed as progress has been made to address this research recommendation; superseded by new SARC 58 research recommendation 2.

7) Ensure that length frequency sampling is proportional to landings by market category.
Commercial length sampling has been sporadic during the beginning of the time series. In particular length samples from the large market category have been lacking. However commercial length sampling has greatly improved over the last six years with a higher proportion of the sampling coming from Montauk where most of the fish are landed.

Consider completed as progress has been made to increase port sampling intensity. Recommend that sampling remain at least at current levels in the future. See current research recommendations.

8) Increase and ensure adequate length sampling coverage of the fishery.

Consider completed, superseded by new SARC 58 research recommendations 1 and 2.

9) Update age- and length- weight relationships.

Consider completed for SARC 58.

10) Update the maturity-at-age, weight-at-age, and partial recruitment patterns.

Consider completed for SARC 58.

11) Develop fork length to total length conversion factors for the estimation of total length to weight relationships.

This work was completed in SARC 41.

References

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fish. Bull. Fish. Wildl. Serv. 53. 577pp.

Collins, J.W. 1884. History of the tilefish. U.S. Comm. Fish. Fisher., Rep. Comm, V (1882) 237-294.

Cushing, D.H. 1982. Climate and Fisheries. Academic Press, London, 373pp.

Freeman BL, Turner SC. 1977. Biological and fisheries data on tilefish, *Lopholatilus chamaeleonticeps* Goode and Bean. NEFSC Tech Rep. 5.

Grimes CB, Able KW, Turner SC. 1980. A preliminary analysis of the tilefish, *Lopholatilus chamaeleonticeps*, fishery in the Mid-Atlantic Bight. Mar Fish Rev. 42(11): 13-18.

Grimes CB, Idelberger CF, Able KW, Turner SC. 1988. The reproductive biology of tilefish, *Lopholatilus chamaeleonticeps*, Goode and Bean, from the United States Mid-Atlantic Bight, and the effects of fishing on the breeding system. Fish Bull. 86(4): 745-762.

Marsh, R.T., B. Petrie, C.R. Weidman, R.R. Dickson, J.W. Loder, C.G. Hannah, K. Frank, and K. Drinkwater. 1999. The 1882 tilefish kill - a cold event in shelf waters off the north-eastern United States? Fish. Oceanogr. 8:39-49

McBride RS, Vidal TE, Cadrin SX. 2013. Changes in size and age at maturity of northern stock of tilefish (*Lopholatilus chamaeleonticeps*) after a period of overfishing. Fish Bull. 111:161-174

Mid-Atlantic Fishery Management Council. 2000. Tilefish fishery management plan. NOAA award No. NA57FC0002.

NEFSC. 1993. Report of the 16th Northeast Regional Stock Assessment Workshop (16th SAW) Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref Doc. 93-18. 108 p.

Nitschke P, Shepherd G, Terceiro M. 1998. Assessment of tilefish in the middle Atlantic – southern New England region. NEFSC. 1-12.

Prager MH. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fish Bull. 92: 374-389

Prager MH. 1995. Users manual for ASPIC: a stock-production model incorporating covariates. SEFSC Miami Lab Doc. MIA-92/93-55.

Turner SC, Grimes CB, Able KW. 1983. Growth, mortality, and age/size structure of the fisheries for tilefish, *Lopholatilus chamaeleonticeps*, in the Middle Atlantic-Southern New England region. Fish Bull. 81(4): 751-763.

Turner SC. 1986. Population dynamics of and, impact of fishing on tilefish, *Lopholatilus chamaeleonticeps*, in the Middle Atlantic-Southern New England region during the 1970's and early 1980's. New Brunswick, N.J.: Rutgers University. Ph.D. dissertation.

Wigley SE, Rago, PJ, Sosebee, KA and Palka, DL. 2007. The analytic component to the Standardized Bycatch Reporting Methodology Omnibus Amendment: sampling design and estimation of precision and accuracy (2nd edition). U.S. Dep. Commer., NortheastFish. Sci. Cent. Ref. Doc. 07-09; 156 p. Available on-line: http://www.nefsc.noaa.gov/publications/crd/crd0709/index.htm

Tables

Table B1. Landings of tilefish in live metric tons from 1915-2008. Landings in 1915-1972 are from Freeman and Turner (1977), 1973-1989 are from the general canvas data, 1990-1993 are from the Weighout system, 1994-2003 are from the dealer reported data, and 2004-2012 is from Dealer electronic reporting. - indicates missing data.

year	mt	year	mt	year	mt
1915	148	1960	1,064	2005	676
1916	4,501	1961	388	2006	907
1917	1,338	1962	291	2007	749
1918	157	1963	121	2008	737
1919	92	1964	596	2009	864
1920	5	1965	614	2010	922
1921	523	1966	438	2011	864
1922	525	1967	50	2012	834
1923	623	1968	32		
1924	682	1969	33		
1925	461	1970	61		
1926	904	1971	66		
1927	1,264	1972	122		
1928	1,076	1973	394		
1929	2,096	1974	586		
1930	1,858	1975	710		
1931	1,206	1976	1,010		
1932	961	1977	2,082		
1933	688	1978	3,257		
1934	-	1979	3,968		
1935	1,204	1980	3,889		
1936	-	1981	3,499		
1937	1,101	1982	1,990		
1938	533	1983	1,876		
1939	402	1984	2,009		
1940	269	1985	1,961		
1941	-	1986	1,950		
1942	62	1987	3,210		
1943	8	1988	1,361		
1944	22	1989	454		
1945	40	1990	874		
1946	129	1991	1,189		
1947	191	1992	1,653		
1948	465	1993	1,838		
1949	582	1994	786		
1950	1,089	1995	666		
1951	1,031	1996	1,121		
1952	964	1997	1,810		
1953	1,439	1998	1,342		
1954	1,582	1999	525		
1955	1,629	2000	506		
1956	707	2001	874		
1957	252	2002	851		
1958	672	2003	1,130		
1959	380	2004	1,215		

Table B2. Percent landings by statistical area. Landings before 1990 are taken from the general canvas data. Percent landings after 1993 are estimated from the AA tables. Most of the other category comes from statistical area 613.

year	unknown	626	622	616	537	526	525	other
1962	100%	0%	0%	0%	0%	0%	0%	0%
1963	65%	0%	0%	0%	4%	28%	0%	3%
1964	83%	0%	0%	0%	4%	14%	0%	0%
1965	83%	0%	0%	0%	1%	16%	0%	0%
1966	97%	0%	0%	0%	0%	1%	1%	0%
1967	96%	0%	0%	0%	0%	4%	0%	0%
1968	96%	0%	0%	0%	1%	0%	0%	3%
1969	93%	0%	0%	0%	2%	4%	0%	1%
1970	87%	0%	0%	0%	8%	5%	0%	0%
1971	99%	0%	0%	0%	0%	0%	0%	0%
1972	92%	0%	0%	1%	1%	0%	0%	6%
1973	0%	0%	0%	62%	16%	0%	0%	21%
1974	0%	0%	0%	51%	27%	0%	0%	22%
1975	0%	0%	0%	48%	34%	8%	0%	10%
1976	0%	0%	0%	58%	28%	13%	0%	1%
1977	1%	0%	0%	44%	32%	22%	0%	1%
1978	0%	0%	0%	29%	40%	31%	0%	0%
1979	0%	0%	0%	18%	37%	45%	0%	0%
1980	0%	0%	0%	22%	34%	44%	0%	0%
1981	0%	0%	0%	28%	37%	35%	0%	0%
1982	0%	0%	0%	19%	52%	27%	0%	2%
1983	0%	1%	0%	22%	54%	23%	0%	0%
1984	0%	1%	3%	9%	53%	34%	0%	1%
1985	0%	0%	2%	25%	33%	38%	2%	1%
1986	0%	0%	1%	28%	44%	25%	3%	1%
1987	0%	0%	0%	12%	53%	32%	1%	2%
1988	0%	1%	2%	21%	41%	32%	0%	2%
1989	0%	0%	1%	63%	9%	26%	1%	1%
1990	0%	2%	0%	15%	14%	36%	0%	33%
1991	0%	0%	1%	64%	25%	1%	0%	10%
1992	0%	0%	1%	22%	70%	5%	1%	1%
1993	0%	0%	2%	14%	72%	7%	3%	2%
1994	0%	0%	3%	12%	32%	2%	25%	26%
1995	0%	0%	0%	8%	74%	4%	7%	7%
1996	0%	0%	0%	45%	40%	11%	0%	5%
1997	0%	0%	0%	39%	57%	0%	0%	3%
1998	0%	0%	0%	10%	78%	1%	2%	9%
1999	0%	0%	0%	39%	51%	0%	1%	9%
2000	0%	0%	0%	65%	31%	3%	1%	1%
2001	0%	0%	0%	59%	34%	6%	0%	1%
2002	0%	0%	0%	41%	43%	10%	1%	5%
2003	0%	0%	0%	42%	49%	2%	2%	5%
2004	0%	0%	0%	35%	56%	4%	2%	3%
2005	0%	27%	0%	24%	47%	1%	0%	1%
2006	0%	18%	0%	44%	31%	2%	0%	5%
2007	0%	0%	1%	33%	48%	0%	0%	17%
2008	0%	0%	5%	42%	32%	0%	0%	21%
2009	0%	0%	3%	35%	42%	0%	0%	20%
2010	0%	0%	1%	47%	43%	0%	0%	10%
2011	0%	0%	0%	41%	52%	0%	0%	7%
2012	0%	0%	0%	44%	52%	0%	0%	4%

Table B3. Landings of tilefish (mt, live) by gear. Number of length measurements are in parentheses. Landing before 1990 are from the general canvas data. Percent by gear per year are also given.

	Gear				Percent by Gear		
Year	longli	traw	othe	Total	longline	trawl	other
1962	0	167	2	169	0%	99%	1%
1963	0	121	0	121	0%	100%	0%
1964	0	596	0	596	0%	100%	0%
1965	0	614	0	614	0%	100%	0%
1966	0	437	0	437	0%	100%	0%
1967	0	51	0	51	0%	100%	0%
1968	0	30	0	30	0%	100%	0%
1969	0	30	0	30	0%	100%	0%
1970	0	57	1	58	0%	99%	1%
1971	0	62	1	62	0%	99%	1%
1972	93	26	2	121	77%	21%	2%
1973	370	24	1	394	94%	6%	0%
1974	531	33	22	586	91%	6%	4%
1975	588	111	11	710	83%	16%	2%
1976	950	58	1	1,010	94%	6%	0%
1977	1,772	309	1	2,082	85%	15%	0%
1978	2,938	309	10	3,257	90%	9%	0%
1979	3,362	449	156	3,968	85%	11%	4%
1980	3,794	94	0	3,889	98%	2%	0%
1981	3,366	128	5	3,499	96%	4%	0%
1982	1,935	49	6	1,990	97%	2%	0%
1983	1,857	8	11	1,876	99%	0%	1%
1984	2,003	6	1	2,009	100%	0%	0%
1985	1,929	31	0	1,961	98%	2%	0%
1986	1,874	76	0	1,950	96%	4%	0%
1987	3,029	180	0	3,210	94%	6%	0%
1988	1,319	42	0	1,361	97%	3%	0%
1989	421	33	0	454	93%	7%	0%
1990	852	22	0	874	98%	2%	0%
1991	1164	25	0	1,189	98%	2%	0%
1992	1497	155	0	1,653	91%	9%	0%
1993	1597	241	0	1,838	87%	13%	0%
1994	764	22	0	786	97%	3%	0%
1995	618	47	1	666	93%	7%	0%
1996	1005	111	4	1,121	90%	10%	0%
1997	1724	79	7	1,810	95%	4%	0%
1998	1198	134	10	1,342	89%	10%	1%
1999	486	28	11	525	92%	5%	2%
2000	461	38	7	506	91%	7%	1%
2001	822	52	0	874	94%	6%	0%
2002	767	83	2	851	90%	10%	0%
2003	1004	124	2	1,130	89%	11%	0%
2004	905	211	99	1,215	75%	17%	8%
2005	495	20	160	676	73%	3%	24%
2006	717	32	158	907	79%	3%	17%
2007	700	9	40	749	94%	1%	5%
2008	652	13	72	737	88%	2%	10%
2009	848	15	1	864	98%	2%	0%
2010	888	29	5	922	96%	3%	1%
2011	849	13	2	864	98%	2%	0%
2012	823	10	1	834	99%	1%	0%

Table B4. Landings of tilefish (mt, live) by state. Number of length measurements are in parentheses. Landings before 1990 are from general canvas data. Percent by state per year are also given.

														Percent by State					
Year	ME		MA		RI		NY		NJ		other	Total		ME	MA	RI	NY	NJ	other
1962	0		28		31		57		42		12	169		0%	16%	18%	34%	25%	7%
1963	0		42		46		13		14		6	121		0%	35%	38%	10%	12%	5%
1964	0		102		424		37		30		2	596		0%	17%	71%	6%	5%	0%
1965	0		106		478		20		9		2	614		0%	17%	78%	3%	1%	0%
1966	0		13		366		55		3		2	437		0%	3%	84%	13%	1%	0%
1967	0		2		27		8		8		5	51		0%	4%	54%	16%	17%	9%
1968	0		1		23		3		3		0	30		0%	4%	76%	9%	11%	0%
1969	0		2		13		4		10		0	30		0%	7%	44%	15%	35%	0%
1970	0		8		36		3		10		1	58		0%	13%	62%	5%	17%	2%
1971	0		0		21		25		15		1	62		0%	1%	34%	40%	24%	2%
1972	0		2		3		6		111		0	121		0%	1%	2%	5%	92%	0%
1973	0		51		17		3		323		0	394		0%	13%	4%	1%	82%	0%
1974	0		163		21		22		380		0	586		0%	28%	4%	4%	65%	0%
1975	0		174		101		2		434		0	710		0%	24%	14%	0%	61%	0%
1976	0		212		56		23		718		0	1,010		0%	21%	6%	2%	71%	0%
1977	0		84		354		314		1,331		0	2,082		0%	4%	17%	15%	64%	0%
1978	0		95		292		969		1,900		0	3,257		0%	3%	9%	30%	58%	0%
1979	0		22		432		1,365		2,148		0	3,968		0%	1%	11%	34%	54%	0%
1980	0		1		87	(37)	1,451		2,348		2	3,889	(37)	0%	0%	2%	37%	60%	0%
1981	0		6		126		1,284	(25)	2,083		1	3,499		0%	0%	4%	37%	60%	0%
1982	6		5		42	(87)	643		1,288		6	1,990	(87)	0%	0%	2%	32%	65%	0%
1983	0		12		7		844	(158)	1,001		12	1,876		0%	1%	0%	45%	53%	1%
1984	0		1		5		1,094		898	(116)	11	2,009	(116)	0%	0%	0%	54%	45%	1%
1985	2		10		207	(247)	958		777	(163)	6	1,961	(410)	0%	0%	11%	49%	40%	0%
1986	3		1		183	(70)	1,076	(107)	687		1	1,950	(177)	0%	0%	9%	55%	35%	0%
1987	0		7		269	(380)	1,996		924	(203)	9	3,205	(583)	0%	0%	8%	62%	29%	0%
1988	0		33		101	(98)	868		353		5	1,359	(98)	0%	2%	7%	64%	26%	0%
1989	0		1		28		249		174		1	454		0%	0%	6%	55%	38%	0%
1990	7		7		20		606		232		2	874		1%	1%	2%	69%	27%	0%
1991	4		1		19		720		444		1	1,189		0%	0%	2%	61%	37%	0%
1992	8		3		148		963	(36)	530		0	1,653	(36)	0%	0%	9%	58%	32%	0%
1993	59		14		276	(100)	1,003		485		1	1,838	(100)	3%	1%	15%	55%	26%	0%
1994	25		3		51		580		127		0	786		3%	0%	6%	74%	16%	0%
1995	8		1		20		560	(432)	76		1	666	(432)	1%	0%	3%	84%	11%	0%
1996	6	(108)	0		88	(219)	924		98	(328)	5	1,121	(655)	1%	0%	8%	82%	9%	0%
1997	13	(244)	0		54	(422)	1,577	(159)	82	(1,154)	82	1,810	(1,979)	1%	0%	3%	88%	5%	4%
1998	15		4		82	(320)	1,073	(74)	123	(606)	45	1,342	(1,000)	1%	0%	6%	80%	9%	3%
1999	3		2		75	(212)	377		40	(161)	29	525	(373)	1%	0%	15%	74%	8%	2%
2000	7		0		57		423	(143)	14		5	506	(143)	1%	0%	11%	84%	3%	1%
2001	0		0		33	(103)	833	(217)	4		4	874	(320)	0%	0%	4%	96%	0%	0%
2002	4		9		59	(482)	740	(850)	23		16	851	(1,332)	0%	1%	7%	88%	3%	1%
2003	2	(330)	12		104	(168)	848	(1,862)	157	(1,205)	7	1,130	(3,565)	0%	1%	9%	75%	14%	1%
2004	0	(31)	117	(19)	142	(388)	596	(789)	323	(2,159)	37	1,215	(3,386)	0%	10%	12%	49%	27%	3%
2005	0	(9)	3		12		454	(1,108)	122	(2,307)	85	676	(3,424)	0%	0%	2%	67%	18%	13%
2006	0	(14)	52	(446)	8	(55)	524	(2,176)	226	(3,076)	96	907	(5,767)	0%	6%	1%	58%	25%	11%
2007	1	(6)	0	(5)	5	(133)	615	(5,257)	124	(2,018)	3	749	(7,419)	0%	0%	1%	84%	14%	0%
2008	2		1		42	(579)	510	(3,752)	180	(1,469)	2	737	(5,800)	0%	0%	6%	69%	24%	0%
2009	0		1		6	(186)	651	(2,621)	204	(2,462)	2	864	(5,269)	0%	0%	1%	75%	24%	0%
2010	0		1		16		719	(6,353)	180	(4,997)	6	922	(11,350)	0%	0%	2%	78%	19%	1%
2011	0		3	(31)	7	(93)	690	(7,203)	162	(3,149)	2	864	(10,476)	0%	0%	1%	80%	19%	0%
2012	0		1		4		642	(4,860)	185	(2,583)	3	834	(7,443)	0%	0%	0%	77%	22%	0%

Table B5. Landings of tilefish (mt, live) by quarter. Number of length measurements are in parentheses. General canvas data are not included. Percent by quarter per year are also given.

	Quarter								
Year	1	2	3	4	Total	1	2	3	4
1977	1,017	961	93	12	2,082	49%	46%	4%	1%
1978	905	1,128	432	793	3,257	28%	35%	13%	24%
1979	1,351	1,055	538	1,024	3,968	34%	27%	14%	26%
1980	1,524	1,263	505	596	3,889	39%	32%	13%	15%
1981	1,352	1,091	474	581	3,499	39%	31%	14%	17%
1982	1,028	433	239	289	1,990	52%	22%	12%	15%
1983	577	726	289	284	1,876	31%	39%	15%	15%
1984	1,032	491	293	193	2,009	51%	24%	15%	10%
1985	551	632	496	281	1,961	28%	32%	25%	14%
1986	542	597	437	374	1,950	28%	31%	22%	19%
1987	1,048	873	723	565	3,210	33%	27%	23%	18%
1988	737	292	160	172	1,361	54%	21%	12%	13%
1989	147	61	78	167	454	32%	13%	17%	37%
1990	258	243	184	189	874	30%	28%	21%	22%
1991	326	437	182	244	1,189	27%	37%	15%	21%
1992	426	433	401	393	1,653	26%	26%	24%	24%
1993	634	664	267	273	1,838	34%	36%	15%	15%
1994	301	275	72	138	786	38%	35%	9%	18%
1995	214	148	108	195	666	32%	22%	16%	29%
1996	366	215	231	308	1,121	33%	19%	21%	28%
1997	442	574	373	421	1,810	24%	32%	21%	23%
1998	541	363	229	209	1,342	40%	27%	17%	16%
1999	163	146	120	96	525	31%	28%	23%	18%
2000	143	141	77	144	506	28%	28%	15%	28%
2001	190	236	224	224	874	22%	27%	26%	26%
2002	289	201	173	188	851	34%	24%	20%	22%
2003	314	314	242	260	1,130	28%	28%	21%	23%
2004	530	272	187	226	1,215	44%	22%	15%	19%
2005	178	119	170	209	676	26%	18%	25%	31%
2006	281	200	188	238	907	31%	22%	21%	26%
2007	192	172	169	216	749	26%	23%	23%	29%
2008	317	188	108	125	737	43%	25%	15%	17%
2009	190	286	226	161	864	22%	33%	26%	19%
2010	253	259	209	200	922	27%	28%	23%	22%
2011	234	260	185	185	864	27%	30%	21%	21%
2012	183	222	248	181	834	22%	27%	30%	22%

Table B6. Number of observed trips, discard ratios (discard/ sum all species kept), estimated CVs, and estimated discards in metric tons for large and small mesh trawl and gillnet gear.

	Observed trips			Discard Ratio			CV			Metric Tons		
	trawl			trawl			trawl			trawl		
year	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet	lg mesh	sm mesh	gillnet
1989	30	82	23	0.000227	0.000204	0.000000	0.54	0.74	-	14	11	0
1990	33	55	31	0.000000	0.000023	0.000000	-	0.68	-	0	1	0
1991	37	103	164	0.000017	0.000288	0.000000	1.38	0.68	-	1	15	0
1992	42	68	286	0.000010	0.000352	0.000000	1.13	0.82	-	1	18	0
1993	38	36	208	0.000000	0.000086	0.000000	-	0.43	-	0	5	0
1994	44	23	228	0.000016	0.000034	0.000000	0.63	0.60	-	1	2	0
1995	81	57	247	0.000061	0.000015	0.000019	1.05	1.97	0.99	3	1	0
1996	46	74	218	0.000035	0.000094	0.000000	1.22	0.91	-	2	5	0
1997	31	60	206	0.000004	0.000075	0.000045	1.88	2.42	0.87	0	4	1
1998	17	35	179	0.000016	0.000138	0.000000	1.32	0.69	-	1	8	0
1999	23	35	83	0.000117	0.000014	0.000000	0.76	0.94	-	6	1	0
2000	46	49	100	0.000057	0.000065	0.000000	1.22	0.70	-	3	2	0
2001	64	63	83	0.000654	0.000134	0.000000	0.68	0.71	-	36	5	0
2002	86	60	77	0.000000	0.000009	0.000000	-	0.80	-	0	0	0
2003	173	104	184	0.000012	0.000418	0.000018	0.62	0.59	0.87	1	11	0
2004	407	315	316	0.000130	0.000023	0.000143	0.50	0.42	0.42	8	1	3
2005	1033	328	339	0.000004	0.000626	0.000179	0.58	0.64	0.63	0	19	3
2006	517	179	121	0.000016	0.000147	0.000105	0.50	0.71	1.17	1	7	1
2007	601	234	206	0.000014	0.000010	0.000205	0.77	0.54	1.04	0	0	4
2008	663	166	147	0.000004	0.000203	0.000024	0.46	0.54	0.78	0	7	0
2009	651	379	132	0.000060	0.000060	0.000101	0.55	0.39	0.64	2	2	2
2010	731	480	636	0.000005	0.000098	0.000025	0.65	0.44	0.78	0	3	0
2011	949	426	608	0.000084	0.000034	0.000200	0.43	0.37	0.31	3	1	4
2012	719	296	502	0.000002	0.000058	0.000085	0.77	0.62	0.37	0	2	2

Table B7. Recreational Golden tilefish data from the Marine Recreational Information Program (MRIP).

	number	landed number A and B1		Released B2
year	fish measured	party/charter	private	private
1982	0	0	984	0
1983	0	0	0	0
1984	0	0	0	0
1985	0	0	0	0
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	0	0	0	0
1993	0	0	0	0
1994	0	608	0	0
1995	0	0	0	0
1996	0	6,842	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	148	0	0
2002	0	0	20,068	1,338
2003	18	721	0	0
2004	3	62	0	0
2005	0	0	0	0
2006	0	541	0	0
2007	2	1,329	0	0
2008	0	0	0	0
2009	0	177	0	0
2010	3	2,812	27514	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0

Table B8. Number of tilefish reported in the Party/charter vessel trip reports.

year	ME	NH	MA	RI	NY	NJ	DE	MD	VA	NC	Other	total
1994	275	636	0	0	0	0	0	0	0	0	0	911
1995	0	0	0	541	176	0	0	0	0	0	0	717
1996	0	0	0	0	81	0	0	0	0	0	0	81
1997	0	0	0	0	380	0	0	0	0	0	20	400
1998	0	0	0	102	121	0	0	0	0	52	20	295
1999	0	0	0	1	88	0	0	6	0	34	0	129
2000	0	0	0	0	108	39	0	0	0	139	0	286
2001	0	0	0	0	122	101	0	0	0	1,164	0	1,387
2002	0	0	0	0	439	423	0	0	0	0	0	862
2003	0	0	0	3	86	905	0	0	0	0	0	994
2004	0	0	0	0	12	631	0	0	254	0	0	897
2005	0	0	0	72	82	364	14	0	16	25	0	573
2006	0	0	0	0	265	66	2	133	12	30	0	508
2007	0	0	0	0	447	457	88	5	138	313	0	1,448
2008	0	0	0	3	488	545	22	32	10	60	0	1,160
2009	0	0	0	0	720	675	18	7	31	0	0	1,451
2010	0	0	0	0	586	1,194	19	23	48	0	0	1,870
2011	0	0	496	0	720	1,643	60	5	14	9	0	2,947
2012	0	0	0	1	1,116	5,144	42	23	98	12	0	6,436
2013	0	0	0	0	970	2,163	16	12	20	0	0	3,181

Table B9. Number of tilefish reported in the Party/charter vessel trip reports by statistical area.

year	631	632	626	621	622	616	537	526	525	other	total
1994	0	0	0	0	0	0	0	0	0	911	911
1995	0	0	0	0	0	32	144	0	0	541	717
1996	0	0	0	0	0	0	15	66	0	0	81
1997	0	0	0	0	0	20	200	0	0	180	400
1998	52	0	0	0	0	1	102	120	0	20	295
1999	0	0	6	0	0	0	85	0	0	38	129
2000	0	0	0	0	0	46	0	83	0	157	286
2001	27	242	0	0	0	101	122	0	0	895	1,387
2002	0	0	0	0	0	472	40	160	0	190	862
2003	0	0	0	0	4	868	64	0	0	58	994
2004	3	251	0	3		626	0	0	0	14	897
2005	0	13	3	0	17	357	60	75	0	48	573
2006	30	12	30	20	87	273	50	0	3	3	508
2007	313	58	80	22	92	433	67	300	0	83	1,448
2008	1	0	18	99	21	574	3	380	0	64	1,160
2009	0	2	36	166	26	588	0	625	0	8	1,451
2010	0	6	37	169	97	968	150	416	17	10	1,870
2011	0	0	14	339	587	676	369	607	0	355	2,947
2012	1	0	120	466	4,282	538	0	356	0	673	6,436
2013	0	0	32	18	1,815	706	0	110	0	500	3,181

Table B10. Number of trips that caught tilefish reported in the Party/charter vessel trip reports by statistical area.

year	631	632	626	621	622	616	537	526	525	other	total
1994	0	0	0	0	0	0	0	0	0	4	4
1995	0	0	0	0	0	2	2	0	0	2	6
1996	0	0	0	0	0	0	1	1	0	0	2
1997	0	0	0	0	0	1	1	0	0	1	3
1998	3	0	0	0	0	1	2	1	0	1	8
1999	0	0	3	0	0	0	3	0	0	5	11
2000	0	0	0	0	0	10	0	2	0	4	16
2001	2	7	0	0	0	15	2	0	0	10	36
2002	0	0	0	0	0	31	3	2	1	2	39
2003	0	0	0	0	2	17	3	0	0	3	25
2004	1	7	0	1	0	26	0	0	0	1	36
2005	0	2	1	0	4	20	3	1	0	4	35
2006	1	1	1	2	6	12	1	0	0	3	27
2007	12	1	3	2	10	29	2	2	1	2	64
2008	1	0	6	9	5	24	2	3	0	5	55
2009	0	2	12	9	7	18	0	5	0	2	55
2010	0	1	14	3	4	26	3	3	0	3	57
2011	0	0	3	10	13	14	4	5	0	7	56
2012	1	0	26	5	39	29	0	3	0	13	116
2013	0	0	9	2	26	9	0	1	0	3	50

Table B11. Total commercial and vessel trip report (VTR) landings in live mt and the commercial catch-per-unit effort (CPUE) data used for tilefish. Dealer landings before 1990 are from the general canvas data. CPUE data from 1979 to the first half of 1994 are from the NEFSC Weighout database, while data in the second half of 1994 to 2004 are from the vtr system (below the dotted line). Effort data are limited to longline trips which targeted tilefish (= or >75% of the landings were tilefish) and where data existed for the days absent. Nominal CPUE series are calculated using landed weight per days absent minus one day steam time per trip. Da represents days absent. * 2013 are preliminary estimates based on data retrieval in October 2013.

	Weighout		Commerical CPUE data subset								
year	& Dealer landings	vtr landings	interview landings	No. interviews	% interview trips	No. vessels	subset landings	days absent	No. trips	da per trip	nominal cpue
1979	3,968		0.0	0	0.0%	20	1,807	1,187	330	3.6	1.93
1980	3,889		0.8	1	0.3%	18	2,153	1,390	396	3.5	1.99
1981	3,499		35.0	4	1.2%	21	1,971	1,262	333	3.8	1.95
1982	1,990		90.7	13	5.7%	18	1,267	1,282	229	5.6	1.10
1983	1,876		85.8	16	8.9%	21	1,013	1,451	179	8.1	0.73
1984	2,009		140.1	25	18.2%	20	878	1,252	138	9.1	0.72
1985	1,961		297.1	64	30.6%	25	933	1,671	209	8.0	0.59
1986	1,950		120.7	31	16.5%	23	767	1,186	188	6.3	0.71
1987	3,210		198.5	38	18.5%	30	1,014	1,343	206	6.5	0.82
1988	1,361		148.2	30	19.4%	23	422	846	154	5.5	0.56
1989	454		92.8	11	15.7%	11	165	399	70	5.7	0.46
1990	874		32.4	8	11.9%	11	241	556	68	8.2	0.45
1991	1,189		0.8	3	2.8%	7	444	961	107	9.0	0.48
1992	1,653		58.0	9	8.6%	13	587	969	105	9.2	0.62
1993	1,838		71.9	11	10.5%	10	571	959	105	9.1	0.61
1994	-		0	0	0.0%	7	127	385	42	9.2	0.34
1994	786	30				4	53	150	18	8.3	0.37
1995	666	547				5	466	954	99	9.6	0.50
1996	1,121	865				8	822	1,318	134	9.8	0.64
1997	1,810	1,439				6	1,427	1,332	133	10.0	1.09
1998	1,342	1,068				9	1,034	1,517	158	9.6	0.70
1999	525	527				10	516	1,185	133	8.9	0.45
2000	506	446				11	421	932	110	8.5	0.47
2001	874	705				8	691	1,046	116	9.0	0.68
2002	851	724				8	712	951	114	8.3	0.78
2003	1,130	790				7	788	691	101	6.8	1.22
2004	1,215	1,153				12	1,136	811	134	6.1	1.54
2005	676	808				11	802	470	93	5.1	1.95
2006	907	870				12	852	682	105	6.5	1.35
2007	749	710				12	691	727	101	7.2	1.01
2008	737	675				14	672	1,119	124	9.0	0.62
2009	864	812				12	800	1,106	130	8.5	0.75
2010	922	871				11	853	694	108	6.4	1.33
2011	864	822				9	781	517	89	5.8	1.68
2012	834	799				12	795	651	100	6.5	1.32
*2013	-	-				9	481	449	64	7.0	1.15

Table B12. Dealer, VTR, and IVR tilefish total landings (live metric tons) compared to the total landings from the five dominant tilefish vessels. Percent of five dominant vessels to the total are also shown. IVR could not be updated from the SARC 48 assessment.

year	Dealer total (live mt)	Dealer top 5 vessels	Dealer % landing of top 5 vessels to total	VTR total (live mt)	VTR top 5 vessels	VTR % landing of top 5 vessels to total	IVR total (live mt)	IVR top 5 vessels	IVR % landing of top 5 vessels to total
1994	786	485	62%	31	17	57%	-	-	-
1995	666	522	78%	549	538	98%	-	-	-
1996	1,121	803	72%	865	799	92%	-	-	-
1997	1,810	1,292	71%	1,439	1,416	98%	-	-	-
1998	1,342	948	71%	1,068	1,003	94%	-	-	-
1999	525	399	76%	527	486	92%	-	-	-
2000	504	459	91%	446	428	96%	-	-	-
2001	871	817	94%	705	684	97%	-	-	-
2002	843	733	87%	724	687	95%	766	727	95%
2003	1,130	784	69%	790	732	93%	894	779	87%
2004	1,215	561	46%	1,153	688	60%	944	687	73%
2005	676	473	70%	808	596	74%	868	670	77%
2006	907	555	61%	870	569	65%	901	595	66%
2007	751	609	81%	710	601	85%	762	651	85%
2008	737	539	73%	675	502	74%	709	542	76%
2009	864	644	75%	812	617	76%	-	-	-
2010	922	711	77%	871	711	82%	-	-	-
2011	864	687	80%	822	664	81%	-	-	-
2012	833	642	77%	799	633	79%	-	-	-

Table B13. Tilefish Landing (metric tons) by market category from 1990-2012.

year	sm-kittens	small	kittens	medium	large	xl	unclassified	total
1990	0	24	14	103	46	0	687	874
1991	0	43	16	154	85	0	891	1189
1992	0	193	136	88	86	0	1,149	1653
1993	0	237	131	206	66	4	1,193	1838
1994	0	8	11	89	54	7	617	786
1995	0	26	73	88	91	2	386	666
1996	0	169	423	149	156	2	221	1121
1997	0	252	878	260	111	2	307	1810
1998	0	100	375	700	103	6	58	1342
1999	0	38	143	201	106	8	29	525
2000	0	17	193	153	115	8	20	506
2001	0	11	553	161	124	6	19	874
2002	0	28	341	311	128	3	40	851
2003	0	132	644	171	144	5	35	1130
2004	20	169	228	523	129	9	137	1215
2005	0	6	12	335	149	1	173	676
2006	1	8	8	233	369	1	287	907
2007	3	19	77	142	397	4	106	749
2008	17	49	100	195	299	17	60	737
2009	35	55	279	179	226	28	61	864
2010	16	28	240	373	166	17	81	922
2011	6	6	136	339	216	10	152	864
2012	8	10	84	308	285	17	121	834

Table B14. Number of lengths (1995-2013), samples (2002-2013), and metric tons landed per sample (2002-2013) for Golden tilefish. Number of lengths includes borrowing across years in bold. Trawl lengths were not used in the expansion. Large lengths used from 1995 to 1999 were taken from years 1996, 1997, and 1998. Large lengths in 2002 also used large lengths from 2003. Unclassified were redistributed according to market and quarter proportions.

Number of lengths.

year	half	sm	ki	med	lg	xl	total
1995	1		244	208	**332**		
	2						784
1996	1		312	100	**332**		
	2						744
1997	1		958	688	**332**		
	2						1978
1998	1		202	407	**332**		
	2						941
1999	1		211	155	**332**		
	2						698

Number of lengths.

year	half	sm	ki	med	lg	xl	total
2002	1		353	206	**492**		
	2						1051
2003	1	735	385	396	467	32	
	2		522	958			3495
2004	1	788	115	882	432		
	2	106	197	427			2947
2005	1		393	1378	825		
	2			763			3359
2006	1	112	346	1856	1284		
	2	218		1079	752		5647
2007	1	396	379	1128	898	25	
	2	220	1152	1871	1316		7385
2008	1	192	964	1456	1540	20	
	2		581	726			5479
2009	1	508	650	731	658	5	
	2	402	470	1024	322		4770
2010	1	1122	858	2363	1995	43	
	2	213	1081	2031	1140		10846
2011	1	852	1236	2682	2011	35	
	2		1104	1626	851		10397
2012	1	520	900	1342	1709	252	
	2		531	1100	1010		7364
2013	1	400	1200	1823	2575	369	
	2						6367

Number of samples

year	half	sm	ki	med	lg	xl	total
2002	1		6	2	**8**		
	2				↑		16
2003	1	5	4	3	7	2	
	2		6	5			32
2004	1	4	1	6	7		
	2	1	2	4			25
2005	1		6	10	12		
	2			8			36
2006	1	3	6	14	11		
	2	2		11	8		55
2007	1	4	4	12	12	1	
	2	1	5	9	8		56
2008	1	2	12	17	31	3	
	2		10	11			86
2009	1	5	11	13	11	2	
	2	4	8	17	11		82
2010	1	11	13	30	29	3	
	2	2	11	23	27		149
2011	1	10	17	32	29	3	
	2		12	18	11		132
2012	1	5	9	15	17	12	
	2		6	12	11		87
2013	1	6	12	19	32	13	
	2						82

mt/samples

year	half	sm	ki	med	lg	xl	total
2002	1		61	156	**19**		
	2						54
2003	1	26	98	22	21	3	
	2		42	21			34
2004	1	37	209	50	20		
	2	23	20	55			43
2005	1		3	19	12		
	2			18			14
2006	1	2	1	9	19		
	2	2		9	21		11
2007	1	1	6	6	18	4	
	2	12	11	8	23		12
2008	1	25	6	7	10	6	
	2		5	6			8
2009	1	9	8	8	14	14	
	2		25	5	6		9
2010	1	2	10	7	3	6	
	2		10	8	3		6
2011	1	1	4	6	4	3	
	2		6	8	9		5
2012	1	2	3	10	9	1	
	2		10	13	13		8
2013	1	2	8	11	7	1	
	2						7

Table B15. SARC 58 NEFSC commercial raw age data from 2007-2012.

Age	Year						Total
	2007	2008	2009	2010	2011	2012	
1	1					1	2
2	17		6	8	1	12	44
3	5		38	4	5	26	78
4	119	27	163	51	26	121	507
5	45	115	135	133	60	295	783
6	90	75	75	96	134	220	690
7	41	83	36	68	116	127	471
8	14	21	11	32	44	51	173
9	13	7	11	14	22	27	94
10	19	20	16	32	30	15	132
11	10	8	24	13	22	12	89
12	16	26	26	42	23	8	141
13	10	19	15	32	18	16	110
14	12	11	12	17	7	6	65
15	13	14	11	24	6	4	72
16	6	7	10	13	6	6	48
17	5	5	4	3	2	7	26
18	2	1	7	3	4	2	19
19	1		1	1	1	4	8
20	2		1	2		2	7
21	2	1		1			4
22			1		1		2
23		2				2	4
24			1				1
25		1	2				3
26		1				1	2
28		1		1			2
30					1		1
36		1					1
Total	443	446	606	590	529	965	3579

Table B16. Historical retrospective comparison of Golden tilefish assessments (ASPIC model).

				Run2 update	Run7 Final
assessment	SSC 2000	SARC 41	SARC 48	SARC 58	SARC 58
terminal year	1999	2004	2008	2013	2012
BMSY	8,448	9,384	11,400	10,620	10,420
FMSY	0.22	0.21	0.16	0.18	0.16
MSY	1,858	1,988	1,868	1,921	1,632
r	0.45	0.42	0.33	0.36	0.31
Turner q	0.009	0.010	0.009	0.009	0.007
Weightout q	0.222	0.225	0.175	0.180	0.156
VTR q	-	0.392	0.260	0.191	0.251
Biomass terminal yr	3,064	6,712	13,030	17,660	14,410
F terminal yr	0.450	0.184	0.059	0.052	0.059
B/Bmsy	0.36	0.72	1.14	1.66	1.38
F/Fmsy	2.05	0.88	0.37	0.29	0.38

Table B17. ASPIC surplus production model run comparison and sensitivity.

Run ID	0	1	2	3	4	5	6	7 (Final)
Description	SARC 48 Fix b1-ratio	Fix b1-ratio to Bmsy	Fix b1-ratio to Bmsy	Estimate b1-ratio	Estimate b1-ratio, nominal vtr series	Estimate b1-ratio, combine weighout-VTR series	Estimate b1-ratio, add 91-94 data to VTR series	Fix b1-ratio to K, add 91-95 data to VTR series, terminal year 2012
Terminal Year	2008	2012	2013	2013	2013	2013	2013	2012
Diagnostics								
RMSE	0.350	0.353	0.352	0.339	0.337	0.344	0.331	0.330
turner r2	0.22	0.22	0.15	0.60	0.63	0.61	0.61	0.53
Weighout r2	0.65	0.61	0.61	0.65	0.66	na	0.65	0.65
vtr r2	0.20	0.30	0.32	0.30	0.23	0.51	0.35	0.36
Turner q	0.009	0.009	0.009	0.007	0.006	0.006	0.007	0.007
Weighout q	0.175	0.169	0.180	0.166	0.094	na	0.152	0.156
VTR q	0.260	0.202	0.191	0.224	0.103	0.317	0.241	0.251
Results								
B1:K ratio	0.50	0.50	0.50	1.30	1.41	1.40	1.36	1.00
MSY (mt)	1,868	1,879	1,921	1,658	1,430	1,515	1,580	1,632
r	0.33	0.33	0.36	0.34	0.26	0.30	0.31	0.313
FMSY	0.16	0.17	0.18	0.17	0.13	0.15	0.16	0.16
K (mt)	22,790	22,700	21,240	19,290	22,430	20,480	20,210	20,840
BMSY (mt)	11,400	11,350	10,620	9,643	11,210	10,240	10,110	10,420
B2013/BMSY	na	1.56	1.65	1.54	1.19	1.13	1.41	1.38
F2012/FMSY	na	0.29	0.27	0.33	0.50	0.49	0.38	0.38
B2014/BMSY	na	na	1.66	1.56	1.23	1.19	1.44	na
F2013/FMSY	na	na	0.28	0.35	0.52	0.51	0.40	na

Table B18. Empirical mean lengths (top) at age and sample size from Turner et. al. (1983). Oldest fish aged (bottom) from Turner's PHD dissertation (1986) and Vidal's MS (2008).

	Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
female	empirical mean length	-	-	38	47	52	58	64	65	66	68		90	-	-	84	77	-	84	82	-	-	-	-	-	-	-	-	-	92	89	91	89	95	-	88
	n	-	-	14	47	61	40	65	52	11	1		1	-	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	1	1	1	3	1	-	2
male	empirical mean length	-	-	40	50	53	60	71	74	79	86	89	93	-	-	99	102	104	-	96	109	-	108	-	-	108	96	-	-	-	-	-	-	-	-	-
	n	-	-	4	51	55	17	44	41	23	5	1	1	-	-	5	1	1	-	2	2	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-

Dissertation 1986 S Turner		Number of females younger than 31	Number of females older than 31
oldest male: 39	1978	234	7
oldest female: 46	1979	87	4
	1980	177	3
	1982	194	21

	Number of males younger than 31	Number of males older than 31
1978	216	0
1979	148	1
1980	91	0
1982	187	1

T. Vidal (2008)
oldest male: 23
oldest female: 21

Table B19. Ten SCALE sensitivity runs. Under each run is a column for the weight or the input effective sample size, estimated q or input model fit at size and larger, and the residual or model estimates. resid = residuals, par = parameters.

Run		1			2			3			4			5	
Description		fit numbers			fit biomass			lower wt on age index			lower wt on catch			lower variation on len@age	
m		0.15			0.15			0.15			0.15			0.15	
selecivity		start 2nd block in 82			start 2nd block in 82			start 2nd block in 82			start 2nd block in 82			start 2nd block in 82	
	weight	q or fit	resid or par	weight	q or fit	resid or par	weight	q or fit	resid or par	weight	q or fit	resid or par	weight	q or fit	resid or par
Total Objective function			89.10			82.34			71.03			83.34			81.98
total catch	4		1.86	4		1.80	4		1.40	8		1.10	4		1.73
catch len freq 1+	400		49.87	400		47.07	400		43.77	400		47.39	400		47.32
Penalty of recruitment variation	0.05		0.42	0.05		0.51	0.05		0.99	0.05		0.52	0.05		0.48
Age 4	1	2.9E-06	8.37	1	3.0E-06	9.13	0.1	3.3E-06	1.92	1	3.0E-06	9.48	1	2.9E-06	8.76
Turner 47+ (1973-1982)	2	2.6E-02	1.31	2	6.6E-03	0.71	2	6.7E-03	0.72	2	6.5E-03	0.72	2	6.8E-03	0.76
Weighout 37+ (1979-1993)	2	3.5E-02	1.89	2	1.5E-02	1.09	2	1.5E-02	1.02	2	1.5E-02	1.14	2	1.5E-02	1.09
VTR 37+ (1995-2008)	4	8.9E-02	8.18	4	6.9E-02	4.08	4	7.2E-02	3.92	4	6.9E-02	4.99	4	6.7E-02	4.14
Turner (1973-1982) size fit		47			47			47			47			47	
Weighout (1979-1993) size fit		37			37			37			37			37	
VTR (1995-2008) size fit		37			37			37			37			37	
survey/catch len freq 65+	100		17.20	100		17.95	100		17.28	100		18.00	100		17.71
survey/catch len freq size fit		65			65			65			65			65	
Fstart			0.01			0.01			0.00			0.01			0.02
Recruitment year 1 (1971, 000s)			1106			1000			927			1011			1050
Selectivity Alpha (L50) 71-81			53.16			53.41			53.70			53.42			53.67
Selectivity Beta (slope) 71-81			0.36			0.35			0.32			0.35			0.33
Selectivity Alpha (L50) 82-08			40.87			40.92			41.10			40.91			40.74
Selectivity Beta (slope) 82-08			1.00			1.00			1.00			1.00			1.00
2012 F			0.16			0.24			0.25			0.24			0.23
2012 Biomass (000s mt)			6658			4767			4560			4772			4928
2013 F			0.16			0.24			0.26			0.24			0.23
2013 Biomass (000s mt)			7106			4860			4602			4870			5028

Table B19 cont.

Run	6			7			8			9			10 (final)		
Description	combine wo-vtr series			add 91-94 data to vtr			lower m to 0.1			increase wt on vtr			2012, 1974 off, 91-94 vtr		
m	0.15			0.15			0.1			0.15			0.15		
selecivity	start 2nd block in 82			start 2nd block in 82			start 2nd block in 82			start 2nd block in 82			start 2nd block in 83		
	weight	q or fit	resid or par	weight	q or fit	resid or par	weight	q or fit	resid or par	weight	q or fit	resid or par	weight	q or fit	resid or par
Total Objective function			87.82			86.06			83.16			80.06			81.81
total catch	4		3.21	4		2.51	4		1.98	4		1.09	4		2.74
catch len freq 1+	400		48.36	400		47.66	400		47.64	400		47.54	400		43.54
Penalty of recruitment variation	0.05		0.61	0.05		0.51	0.05		0.59	0.05		0.50	0.05		0.47
Age 4	1	2.8E-06	8.85	1	2.9E-06	8.61	1	3.6E-06	8.87	1	3.0E-06	9.04	1	2.8E-06	9.06
Turner 47+ (1973-1982)	2	8.3E-03	0.78	2	7.2E-03	0.72	2	7.5E-03	1.01	2	6.6E-03	0.71	2	8.3E-03	0.88
Weighout 37+ (1979-1993)	4	5.3E-01	6.98	2	1.8E-02	0.98	2	1.6E-02	1.11	2	1.5E-02	1.09	2	2.0E-02	0.94
VTR 37+ (1995-2008)			-	4	5.7E-01	6.14	4	7.8E-02	4.00	2	6.8E-02	2.57	4	5.7E-01	5.71
Turner (1973-1982) size fit		47			47			47			47			47	
Weighout (1979-1993) size fit		37			37			37			37			37	
VTR (1995-2008) size fit					37			37			37			37	
survey/catch len freq 65+	47		19.04	100		18.91	100		17.96	100		17.51	100		18.48
survey/catch len freq size fit		140			65			65			65			65	
Fstart			0.03			0.01			0.08			0.01			0.08
Recruitment year 1 (1971, 000s)			928			974			630			1002			1102
Selectivity Alpha (L50) 71-81			1.00			53.59			52.84			53.40			52.55
Selectivity Beta (slope) 71-81			140.00			0.34			0.37			0.35			0.24
Selectivity Alpha (L50) 82-08			1.00			40.84			40.89			40.89			40.83
Selectivity Beta (slope) 82-08			1.00			1.00			1.00			1.00			1.00
2012 F			0.17			0.19			0.28			0.23			0.17
2012 Biomass (000s mt)			6318			5752			4108			4815			6204
2013 F			0.17			0.19			0.28			0.24			-
2013 Biomass (000s mt)			6580			5959			4209			4932			-

Table B20. Comparison of final SCALE model run 10 estimated population numbers with the raw numbers of fish aged for 10+, 15+, and 20+ fish. Percent of the population numbers aged are also calculated.

	10+			15+			20+		
	population numbers	raw age data	percent pop aged	population numbers	raw age data	percent pop aged	population numbers	raw age data	percent pop aged
2007	29,714	98	0.3%	222	31	14.0%	13	4	30.8%
2008	38,190	118	0.3%	1,038	34	3.3%	11	7	63.6%
2009	139,478	131	0.1%	965	38	3.9%	10	5	50.0%
2010	124,552	184	0.1%	1,706	48	2.8%	12	4	33.3%
2011	105,129	121	0.1%	2,303	21	0.9%	15	2	13.3%
2012	95,116	85	0.1%	3,262	28	0.9%	23	5	21.7%
total	532,179	737	0.1%	9,496	200	2.1%	84	27	32.1%

Table B21. Input mean weight example for 20+ catch at age using a pool age length key for all years. Shaded cells indicated cells where missing data was filled in with the average from years where data exists.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1971	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1972	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1973	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1974	0.107	0.225	0.639	1.257	2.109	2.707	3.311	4.851	6.412	7.390	7.971	8.550	9.491	9.391	10.125	10.139	12.098	11.788	15.007	15.749
1975	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1976	0.166	0.387	0.659	1.021	2.830	3.404	3.785	4.305	5.247	5.911	6.594	7.399	8.350	8.553	9.678	10.381	13.024	12.142	15.433	17.312
1977	0.166	0.387	0.802	1.068	2.427	3.400	3.780	4.271	5.137	5.811	6.562	7.409	7.967	8.236	8.641	9.028	10.275	11.339	13.064	17.578
1978	0.166	0.387	0.790	1.308	2.132	3.139	3.772	4.349	5.207	5.789	6.365	7.252	7.925	8.260	8.991	9.502	11.352	10.834	14.071	15.807
1979	0.166	0.387	0.766	1.440	2.278	2.880	3.381	3.786	5.164	5.867	6.284	7.290	7.636	7.991	8.711	9.216	10.931	9.685	13.820	15.238
1980	0.107	0.287	0.768	1.395	2.385	3.042	3.508	3.818	4.939	5.663	6.186	7.342	7.816	8.128	8.820	9.240	10.613	9.907	13.142	14.970
1981	0.225	0.342	0.723	1.128	2.403	3.294	3.796	4.297	5.105	5.656	6.257	7.189	7.911	8.165	8.919	9.402	10.706	10.609	13.078	14.416
1982	0.225	0.301	0.703	1.098	1.774	2.736	3.462	4.065	5.236	5.850	6.420	7.214	7.760	7.991	8.466	8.886	9.862	10.419	12.300	13.506
1983	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1984	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1985	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1986	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1987	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1988	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1989	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1990	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1991	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1992	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1993	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1994	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
1995	0.166	0.363	0.785	1.036	1.645	2.413	2.848	3.129	5.102	5.962	6.058	7.529	7.934	7.857	8.488	8.637	8.999	10.027	10.974	11.300
1996	0.166	0.378	0.929	0.981	1.398	1.890	2.441	2.817	4.731	5.596	5.823	7.529	7.935	7.857	8.488	8.637	8.999	10.029	10.976	11.304
1997	0.166	0.529	0.999	1.112	1.430	1.799	1.977	2.166	3.618	5.107	5.595	7.526	7.934	7.857	8.488	8.637	9.001	10.025	10.973	11.296
1998	0.166	0.378	1.185	1.416	1.809	2.136	2.356	2.360	3.339	4.287	3.897	7.514	7.933	7.857	8.486	8.636	8.997	10.026	10.974	11.300
1999	0.166	0.378	1.129	1.193	1.697	2.231	2.488	2.769	4.788	5.866	6.397	7.529	7.935	7.857	8.488	8.637	8.998	10.029	10.976	11.304
2000	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
2001	0.166	0.378	0.893	1.228	1.908	2.553	3.062	3.495	4.729	5.452	5.763	7.152	7.754	7.937	8.507	8.831	9.868	10.084	11.991	13.253
2002	0.166	0.435	0.768	0.929	1.360	2.069	2.938	3.465	4.394	4.915	5.672	6.972	7.936	8.015	8.649	8.983	11.801	9.904	12.487	17.259
2003	0.166	0.372	0.939	1.258	1.519	1.949	2.454	2.762	3.475	4.530	4.717	6.952	7.918	8.059	8.734	9.022	11.960	9.898	13.083	17.566
2004	0.166	0.378	1.285	1.548	1.796	2.093	2.473	2.725	3.804	4.276	3.664	6.742	7.802	7.995	8.492	8.722	9.089	9.563	10.788	12.644
2005	0.166	0.378	1.155	1.791	2.109	2.537	3.044	3.244	4.601	4.941	4.630	6.258	6.866	7.022	7.347	7.737	8.474	8.738	7.980	9.256
2006	0.166	0.318	0.736	1.243	2.307	2.951	3.532	3.943	4.891	5.253	5.459	5.890	6.315	6.836	6.989	7.138	7.515	8.146	9.490	10.679
2007	0.166	0.359	0.885	1.095	1.789	2.766	3.413	4.062	5.241	5.697	6.017	6.437	6.626	6.978	7.176	7.428	7.998	7.830	9.430	10.355
2008	0.166	0.396	0.636	0.988	1.655	2.561	3.263	3.839	5.069	5.690	6.157	6.997	7.356	7.518	7.896	8.394	8.169	8.788	11.967	11.792
2009	0.166	0.327	0.877	1.088	1.478	2.062	2.658	3.267	4.939	5.722	6.195	7.402	7.856	8.105	8.591	8.930	9.165	12.233	10.850	13.031
2010	0.166	0.378	1.060	1.300	1.716	2.138	2.516	2.753	3.763	4.836	5.056	7.530	8.139	8.404	8.864	9.165	9.667	10.592	11.001	10.866
2011	0.166	0.384	1.029	1.413	1.909	2.513	2.980	3.139	4.360	5.014	5.039	7.066	7.901	8.134	8.801	9.101	9.504	10.320	12.566	10.840
2012	0.166	0.468	1.034	1.264	1.902	2.595	3.235	3.592	4.724	5.185	5.292	6.782	7.701	8.016	8.639	9.005	10.187	10.109	12.416	12.808
2013	0.166	0.529	1.052	1.333	1.845	2.533	3.130	3.590	4.934	5.473	5.760	6.491	6.902	7.337	7.705	8.186	9.327	9.125	12.935	13.136

Table B22. Initial ASAP model sensitivity runs.

	Run	1	2	3	4	5	6	7	8	9	10	11	12	13
Description	plus group	20	20	10	10	20	20	20	20	20	20	20	20	20
	age data	pooled	actual	pooled	actual	actual	actual	actual	actual	actual	actual	actual	actual	actual
	m	0.15	0.15	0.15	0.15	0.1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	Description		base				combine wo-vtr cpue	add 91-94 to vtr cpue	wt vtr 91-13	terminal-yr 2012	fixed dome 1	fixed dome 2	fixed dome 3	1 selectivity block
	Total Objective function	1709.1	1726.0	1257.5	1278.7	1720.8	1840.2	1762.1	1851.3	1660.9	1717.0	1718.0	1729.6	1808.8
components of the objective function	catch fit	243.1	243.2	242.7	242.8	243.9	253.4	245.8	271.2	237.8	243.1	243.3	243.7	243.9
	index fit	10.1	10.5	-4.8	-4.7	10.9	72.4	37.2	78.3	9.8	9.1	8.3	8.8	7.0
	catch age comp	1006.8	1022.9	620.6	641.2	1023.7	1062.3	1029.1	1052.6	970.4	1017.0	1017.4	1016.9	1110.2
	N year 1	110.9	110.7	69.0	68.8	120.0	114.7	111.5	111.9	110.9	111.3	113.6	123.1	111.4
	recruit devs	338.3	338.7	330.0	330.6	322.3	337.3	338.5	337.3	332.0	336.5	335.4	337.1	336.3
RMSE	catch	0.41	0.42	0.39	0.39	0.45	0.81	0.54	1.22	0.43	0.41	0.42	0.44	0.45
	Turner 47+ (1973-1982)	0.71	0.70	0.61	0.60	0.77	0.59	0.68	0.65	0.70	0.66	0.61	0.57	0.61
	Weighout 37+ (1979-1993)	1.28	1.28	0.79	0.79	1.23	2.27	1.26	1.26	1.28	1.27	1.27	1.32	1.14
	VTR 37+ (1995-2008)	1.46	1.48	1.20	1.20	1.51	-	2.07	3.04	1.51	1.45	1.43	1.42	1.46
	index total	1.26	1.27	0.96	0.96	1.28	2.02	1.63	2.24	1.28	1.24	1.23	1.24	1.21
	stock numbers 1st year	0.41	0.41	0.99	0.99	0.95	0.54	0.42	0.44	0.41	0.44	0.63	1.14	0.51
	recruit devs	1.24	1.25	0.98	1.00	1.24	1.09	1.22	1.18	1.26	1.20	1.16	1.16	1.22
Results	SSB first year	17,721	17,901	20,039	20,205	12,090	15,910	17,579	17,010	17,931	22,571	30,773	65,208	22,952
	SSB terminal year	2,989	3,004	2,613	2,622	2,588	7,320	4,187	4,374	3,157	2,968	3,003	3,208	2,874
	F terminal year	0.31	0.31	0.37	0.36	0.36	0.12	0.22	0.21	0.26	0.31	0.30	0.29	0.33

Table B23. Comparison of ASAP flattop run 2 estimated population numbers with the raw numbers of fish aged for 10+, 15+, and 20+ fish. Percent of the population numbers aged are also calculated.

	10+			15+			20+		
	population numbers	raw age data	percent pop aged	population numbers	raw age data	percent pop aged	population numbers	raw age data	percent pop aged
2007	40,110	98	0.2%	1,170	31	2.6%	60	4	6.7%
2008	62,940	118	0.2%	2,040	34	1.7%	40	7	17.5%
2009	75,260	131	0.2%	1,970	38	1.9%	30	5	16.7%
2010	67,200	184	0.3%	2,090	48	2.3%	20	4	20.0%
2011	52,150	121	0.2%	2,130	21	1.0%	30	2	6.7%
2012	41,240	85	0.2%	2,660	28	1.1%	80	5	6.3%
total	338,900	737	0.2%	12,060	200	1.7%	260	27	10.4%

Table B24. Working group dome shaped ASAP model sensitivity runs. Run 27b is the final working group preferred run for stock status determination.

	Run	14	16	17	18	20	21	22	24	25	26	27	27b (final)
Discription	plus group	10	20	10	10	10	10	10	20	20	10	10	10
	age data	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
	m	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	selectivity	at age full at 6	double log	at age full at 6	at age full at 6	at age full at 6	at age full at 6	double log	double log	double log	at age full at 6	at age full at 6	full 7 1st blk full 5 2nd bll
	Selectivity start 2nd block	82	82	82	82	82	83	95	83	95	95	83	83
	terminal year	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013	2012
	Fit to LF 1974	yes	yes	No	yes	yes	yes	yes	yes	yes	yes	yes	no
	LF Effective Sample size	150	150	150	150	75	75	75	75	75	75	75	75
	Discription			add 91-94	add 91-94	add 91-94	add 91-94	add 91-94	add 91-94	add 91-94	Model start in 1995	combine wo - vtr	add 91-94
	Total Objective function	1170.0	1544.9	1057.6	1087.0	971.4	980.2	975.7	Did not converge	1303.9	553.1	993.1	932.4
components of the objective function	catch fit	242.3	242.4	241.8	241.8	240.8	240.9	241.2		242.1	104.2	240.9	235.2
	index fit	-8.3	-3.2	-10.0	-9.7	-17.1	-15.1	-16.4		-6.1	10.9	-2.6	-16.9
	catch age comp	537.5	862.0	432.2	457.1	351.0	356.8	356.2		625.7	246.4	356.7	325.4
	N year 1	68.7	115.8	65.4	69.8	68.7	68.5	69.0		114.5	51.7	68.8	66.0
	recruit devs	329.8	327.9	328.2	328.1	328.0	329.0	325.9		327.8	139.8	329.2	322.7
RMSE	catch	0.36	0.37	0.33	0.33	0.25	0.26	0.28		0.35	0.40	0.26	0.23
	Turner 47+ (1973-1982)	0.57	0.58	0.57	0.58	0.58	0.72	0.65		0.71	1.04	0.73	0.65
	Weighout 37+ (1979-1993)	0.71	0.67	0.40	0.40	0.50	0.68	0.58		0.83	1.04	0.90	0.63
	VTR 37+ (1995-2008)	1.09	1.33	1.08	1.09	1.01	0.99	0.99		1.27	0.69	0.87	0.98
	index total	0.87	0.99	0.83	0.83	0.80	0.85	0.81		1.04	0.00	0.86	0.82
	stock numbers 1st year	0.96	0.58	0.21	1.02	0.88	0.83	1.03		0.49	0.00	0.00	0.18
	recruit devs	0.97	0.84	0.85	0.86	0.85	0.86	0.91		0.86	0.86	0.86	0.84
Results	SSB first year	30,291	36,492	22,646	31,216	33,763	25,977	47,602		31,904	777	26,506	21,895
	SSB terminal year	2,913	2,948	3,974	3,806	3,993	3,963	2,682		3,883	2,249	4,342	5,229
	F terminal year	0.39	0.36	0.33	0.34	0.35	0.35	0.41		0.30	0.47	0.33	0.27

Table B25. Comparison of ASAP dome 20+ run 16 estimated population numbers with the raw numbers of fish aged for 10+, 15+, and 20+ fish. Percent of the population numbers aged are also calculated.

	10+			15+			20+		
	population numbers	raw age data	percent pop aged	population numbers	raw age data	percent pop aged	population numbers	raw age data	percent pop aged
2007	92,570	98	0.1%	18,610	31	0.2%	11,560	4	0.0%
2008	128,130	118	0.1%	21,400	34	0.2%	9,890	7	0.1%
2009	153,160	131	0.1%	21,420	38	0.2%	8,500	5	0.1%
2010	153,160	184	0.1%	21,420	48	0.2%	8,500	4	0.0%
2011	127,910	121	0.1%	22,910	21	0.1%	6,750	2	0.0%
2012	109,870	85	0.1%	25,240	28	0.1%	6,980	5	0.1%
total	764,800	737	0.1%	131,000	200	0.2%	52,180	27	0.1%

Table B26. Time series of fishing mortality (F), spawning stock biomass (SSB), and age-1 recruitment from the final working group run 27b.

year	F	SSB (mt)	Recruitment (000s)
1971	0.006	21,895	1,074
1972	0.012	21,540	1,011
1973	0.040	20,870	1,098
1974	0.048	27,044	1,657
1975	0.079	19,364	1,729
1976	0.089	23,744	1,135
1977	0.212	19,902	655
1978	0.375	17,106	880
1979	0.529	13,950	1,638
1980	0.639	10,941	1,165
1981	0.836	7,871	1,307
1982	0.715	5,476	1,110
1983	0.672	4,550	4,489
1984	0.863	3,828	1,106
1985	1.022	3,001	831
1986	0.773	2,657	831
1987	1.165	2,740	799
1988	0.829	2,246	1,219
1989	0.307	2,087	1,933
1990	0.577	2,157	998
1991	0.801	2,089	676
1992	0.956	2,047	1,052
1993	1.267	1,756	2,192
1994	0.722	1,486	2,161
1995	0.615	1,389	770
1996	0.828	1,307	736
1997	1.195	1,264	854
1998	1.067	1,250	1,191
1999	0.517	1,221	2,346
2000	0.403	1,453	2,390
2001	0.570	1,666	1,297
2002	0.497	1,777	561
2003	0.429	2,318	435
2004	0.395	3,039	624
2005	0.292	3,914	1,051
2006	0.379	4,378	1,847
2007	0.428	4,240	1,484
2008	0.418	4,241	973
2009	0.365	4,489	694
2010	0.302	4,540	661
2011	0.258	4,989	717
2012	0.275	5,229	751

Table B27. Summary of the working group meeting's dome shaped selectivity ASAP runs for tilefish. n/c = not calculated, selec yr is the start of 2nd selectivity block.

Run	**SSB_{1971}**	**SSB_{2013}**	**F_{1971}**	**F_{2013}**	**R1971**	**R_{2013}**	**F_{40}**	**SSB_{40}**	**MSY_{40}**	**Median R**	**$SSB2013/SSB_{40}$**	**$F2013/F_{40}$**	**Comment**
Run 21-10+, Selec 83	25,977	3,963	0.005	0.35	1,034	691	0.198	6,121	700	782	0.65	1.77	Acceptable Diagnostics, good retro
Run 22-10+, Selec 95	47,602	2,682	0.005	0.409	863	618	0.164	4,636	870	780	0.58	2.49	Acceptable Diagnostics, good retro
Run25-20+, Selec 95	31,904	3,883	0.004	0.299	1,120	661	0.174	7,963	730	851	0.49	1.67	Estimation issues, worse retro
Run 27a	22,057	5,186	0.006	0.351	1,070	746	0.236	8,189	893	1,060	0.63	1.49	Best diagnostics, best retro

F_{30}	**SSB_{30}**	**MSY_{30}**	**Median R**	**$SSB2012/SSB_{30}$**	**$F2012/F_{30}$**
0.319	6,138	984	1,060	0.85	1.1

Run	**SSB1983/1995**	**SSB2013**	**F1983/1995**	**F2013**	**R1983/1995**	**R2013**	**F_{40}**	**SSB_{40}**	**MSY_{40}**	**Median R**	**$SSB2013/SSB_{40}$**	**$F2013/F_{40}$**	**Comment**
Start in 1983	3,643	4,778	0.43	0.28	1,195	1,363	n/c	n/c	n/c	n/c	n/c	n/c	No advantage to shortening series, start up issues
run26, Start in 1995	777	2,249	0.75	0.47	710	514	n/c	n/c	n/c	n/c	n/c	n/c	Retro problems

Run 27b - Final WG run	**SSB1971**	**SSB2012**	**F1971**	**F2012**	**R1971**	**R2012**	**F_{40}**	**SSB_{40}**	**MSY_{40}**	**Median R**	**$SSB2012/SSB_{40}$**	**$F2012/F_{40}$**	**Comment**
	21,895	5,229	0.006	0.275	1,074	751	0.233	8,280	900	1,070	0.63	1.18	Run 27 B through 2012

Final Run 27b Properties

age 10+ , m=0.15
years 1971 - 2012
two selectivity blocks: 1971-1982 and 1983-2012
fix age 7 at 1 in sel block 1, fix age 5 at 1 in sel block 2
dropped 1974 catch at age proportions due to low sample size
survey CVs 0.4, 0.2, 0.2
catch input ESS 75
landings only (discards assumed minimal - zero actually)
recruitment years 1971-2012

F_{30}	**SSB_{30}**	**MSY_{30}**	**Median R**	**$SSB2012/SSB_{30}$**	**$F2012/F_{30}$**
0.315	6,208	993	1,070	0.87	0.84

F_{25}	**SSB_{25}**	**MSY_{25}**	**Median R**	**$SSB2012/SSB_{25}$**	**$F2012/F_{25}$**
0.37	5,153	1029	1,070	1.01	0.74

Table B28. Biological Reference Points from the final working group ASAP run 27b.

Final Working Group Run 27b

SSB_{2012}	5229 mt
F2012	0.275 (S= 1 at age 5)
R2012	751 (000s)

Proxy	F40%	F30%	F25%
SSB_{MSY}	8278	6208	5153
$SSB_{Threshold}$	4139	3104	2577
MSY	899	993	1029
FMSY	0.233	0.315	0.37
SSB/SSB_{MSY}	0.63	0.84	1.01
F/F_{MSY}	1.18	0.87	0.74

Table B29. Yield per recruit and AGEPRO projection inputs from the final ASAP run 27b. The five year average (2008-2012) was used for input mean weights. Rivard catch mean weights to Jan-1 were used for stock mean weights. Terminal year + 1 stock size at age is also shown.

age	Stock Size on 1 Jan 2012	Selectivity	Proportion Mature	Mean Weights Stock	Mean Weights Catch & SSB
1	751,400	0.000	0.000	0.101	0.166
2	617,010	0.004	0.000	0.262	0.417
3	489,370	0.045	0.010	0.627	1.010
4	436,610	0.479	0.110	1.088	1.280
5	464,710	1.000	0.570	1.463	1.770
6	460,170	0.775	0.930	2.024	2.368
7	373,920	0.527	0.990	2.622	2.904
8	141,320	0.245	1.000	3.092	3.268
9	59,750	0.115	1.000	3.877	4.544
10+	341,570	0.280	1.000	7.110	7.110

Table B30. Mid-Atlantic SSC OFL and ABC calculation using unadjusted projections and an assumed 100% CV on the OFL and a model estimated 27% CV on the OFL. Probability of overfishing or being overfished is also given.

	100% CV					probability	
year	OFL	ABC	SSB/SSB_{MSY}	ABC/OFL	F	overfishing	overfished
2015	759	552	0.89	0.73	0.26	0.13	0.04
2016	867	650	0.92	0.75	0.27	0.15	0.03
2017	973	744	0.94	0.76	0.28	0.13	0.03
rebuilt	1,029	833	1.00	0.81			

	27% CV					probability	
year	OFL	ABC	SSB/SSB_{MSY}	ABC/OFL	F	overfishing	overfished
2015	759	686	0.89	0.90	0.33	0.35	0.04
2016	844	767	0.91	0.91	0.33	0.37	0.04
2017	932	847	0.91	0.91	0.33	0.35	0.05
rebuilt	1,029	962	1.00	0.94			

Figures

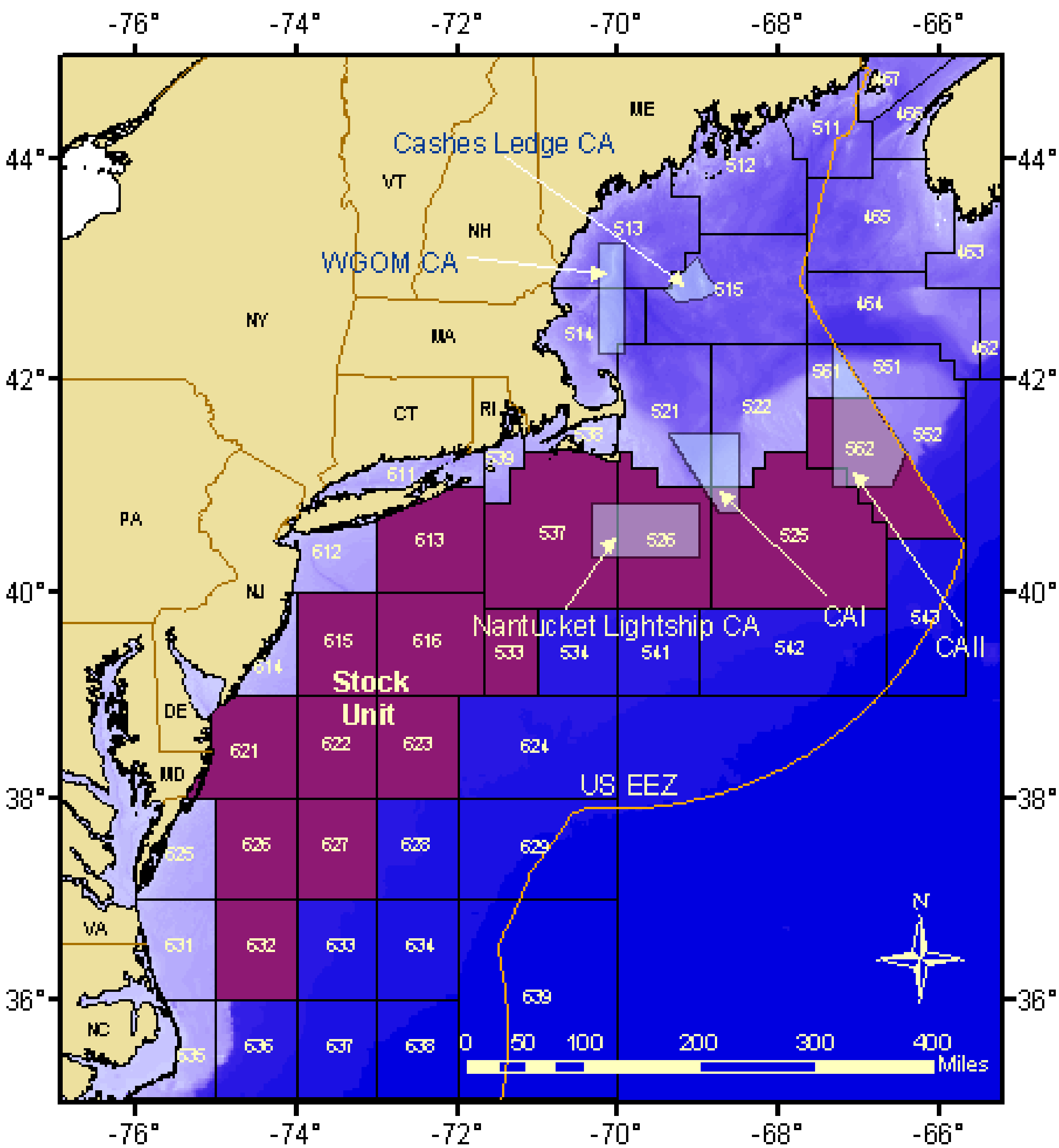


Figure B1. Middle Atlantic-Southern New England Golden tilefish stock boundary by statistical area.

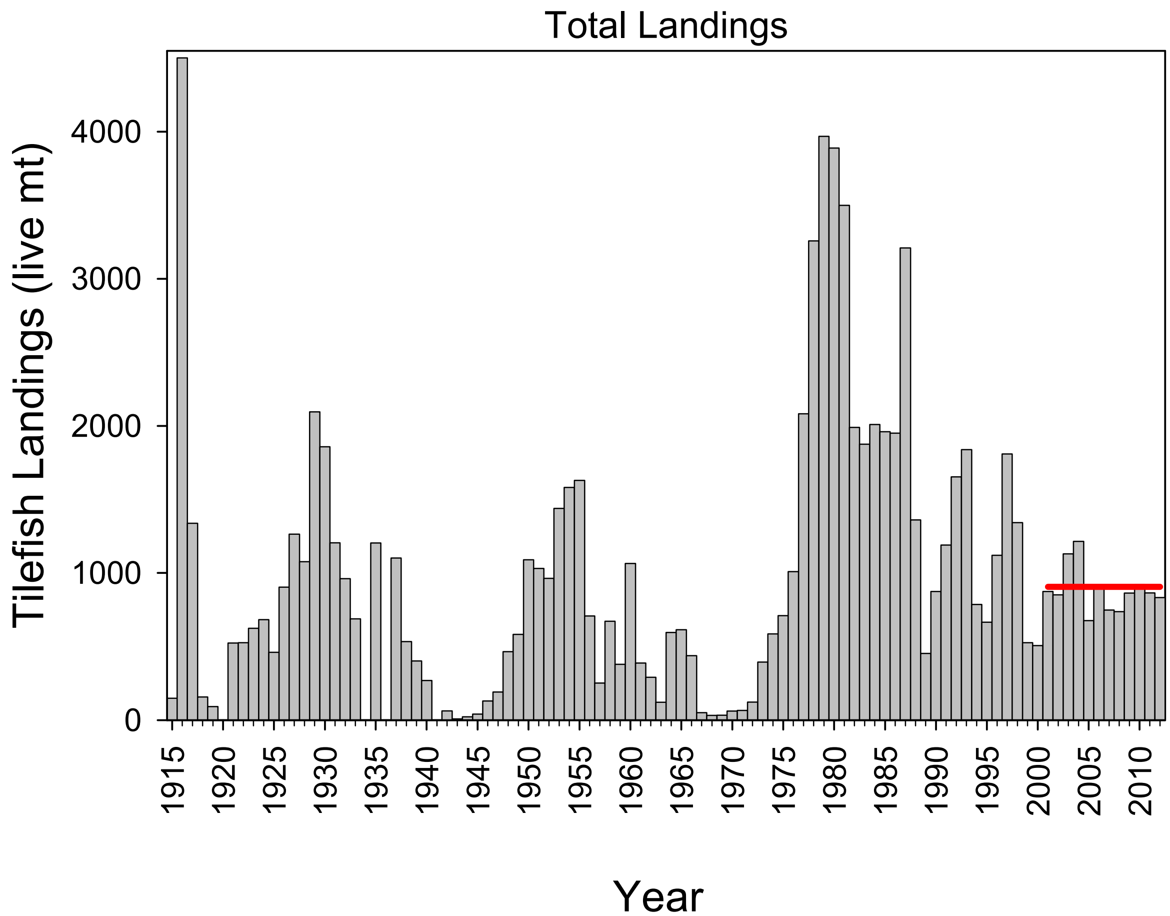


Figure B2. Landings of tilefish in metric tons from 1915-2004. Landings in 1915-1972 are from Freeman and Turner (1977), 1973-1989 are from the general canvas data, 1990-1993 are from the Weighout system, 1994-2003 are from the dealer reported data, and 2004-2012 is from dealer electronic reporting.

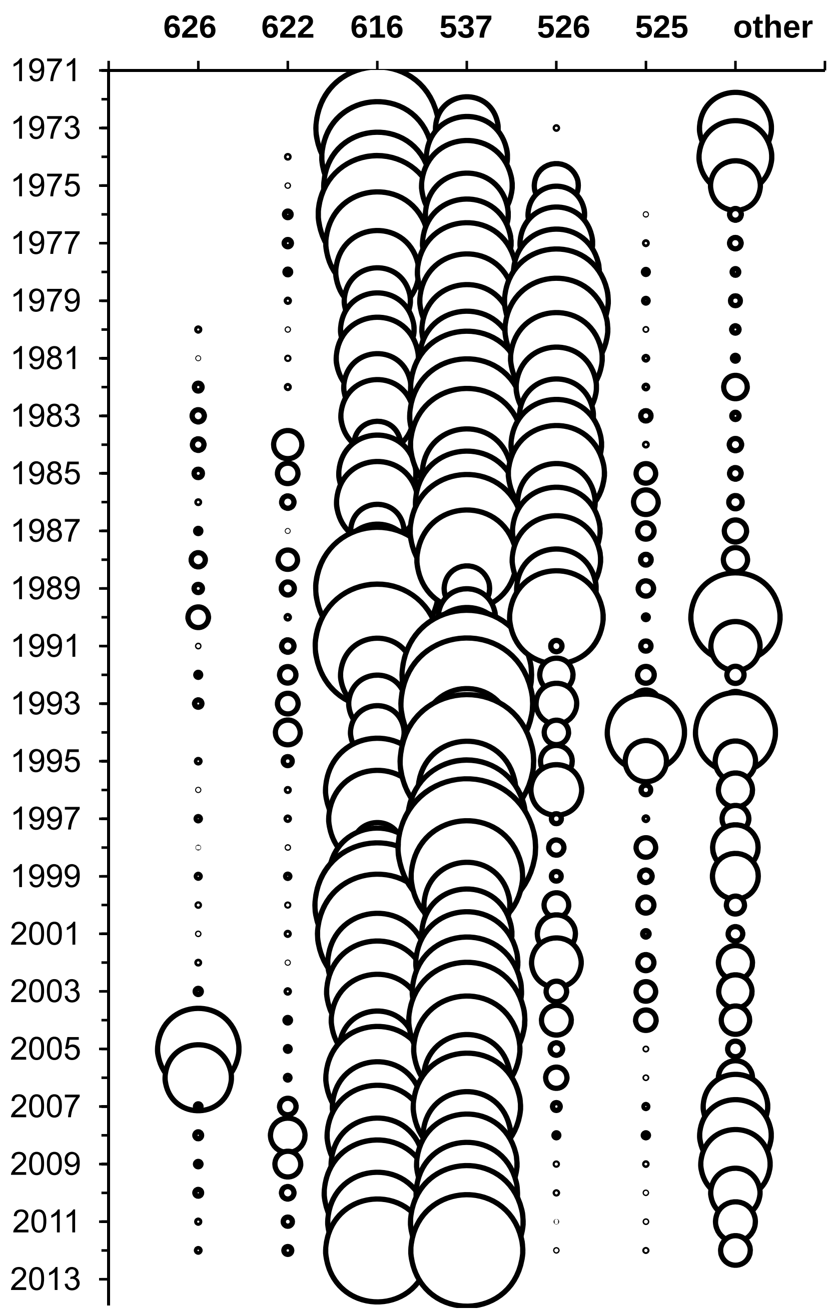


Figure B3. Bubble plot of Golden tilefish landings by statistical area.

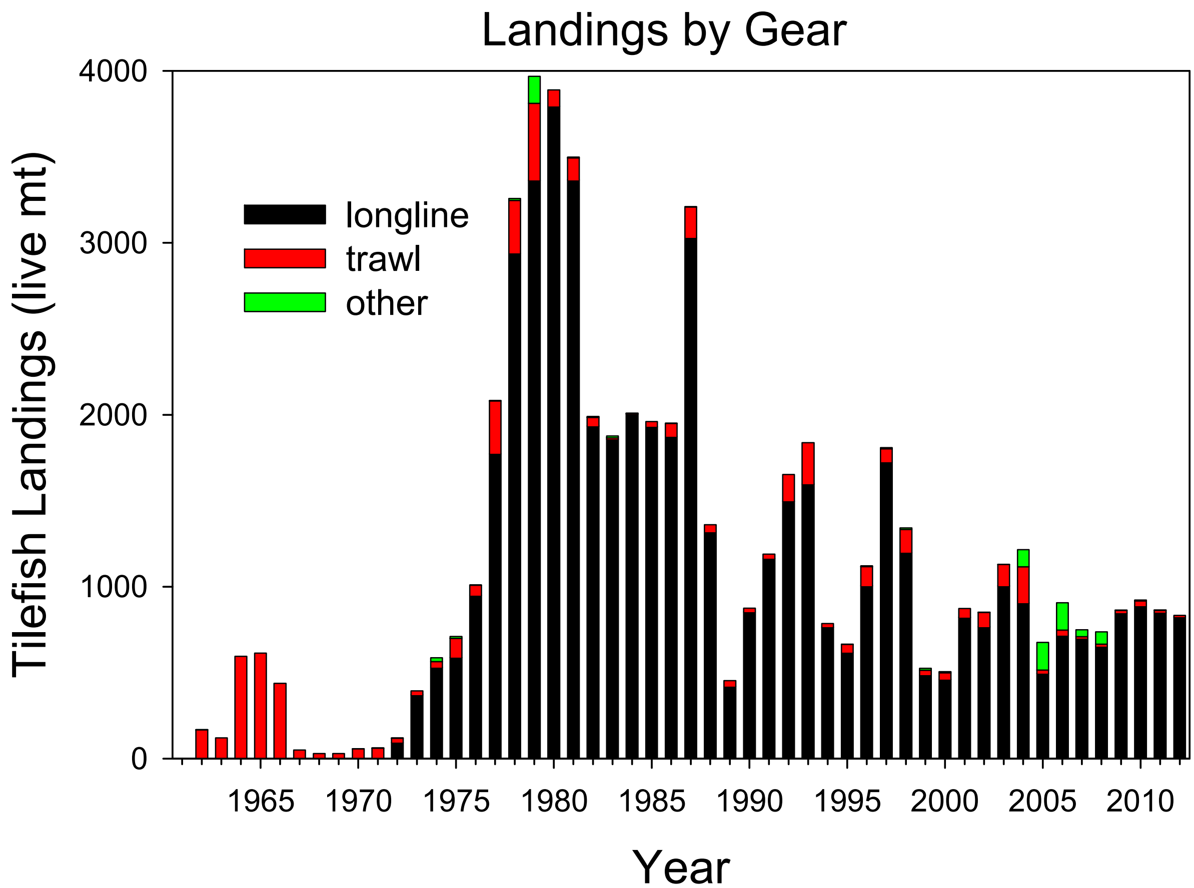


Figure B4. Landings of tilefish (mt, live) by gear. Landing before 1990 are from the general canvas data.

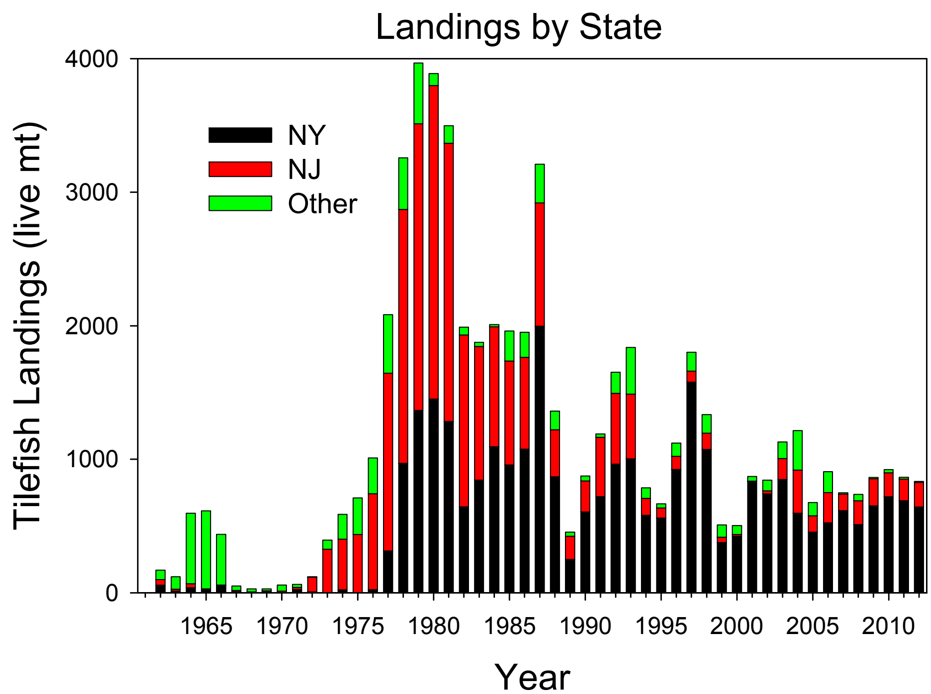


Figure B5. Landings of tilefish (mt, live) by State. Landings before 1990 are from the general canvas data.

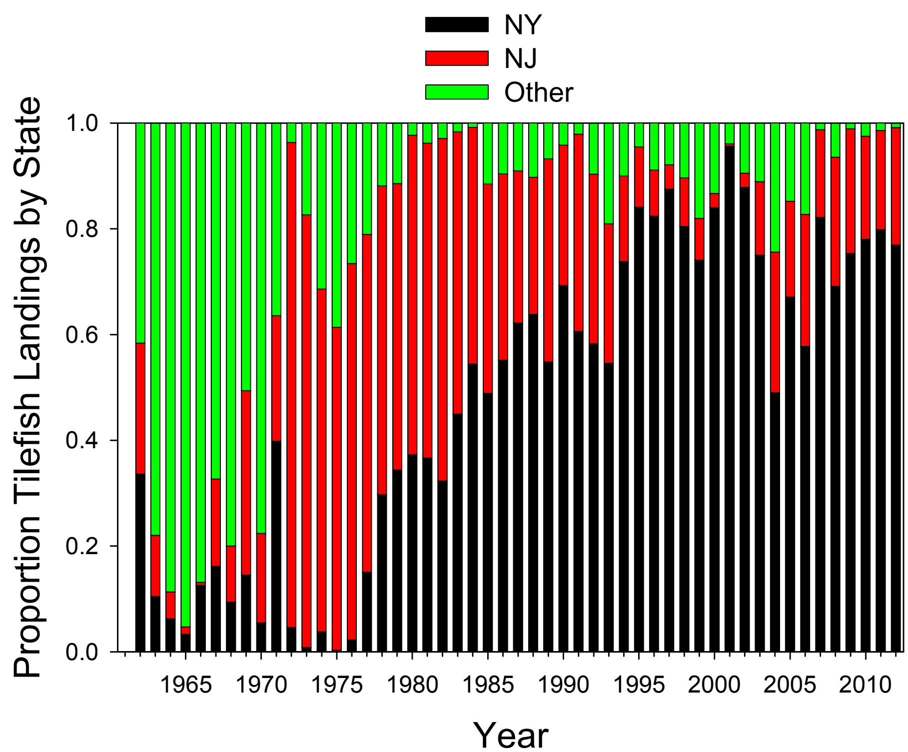


Figure B6. Landings of tilefish proportion by State. Landings before 1990 are from the general canvas data.

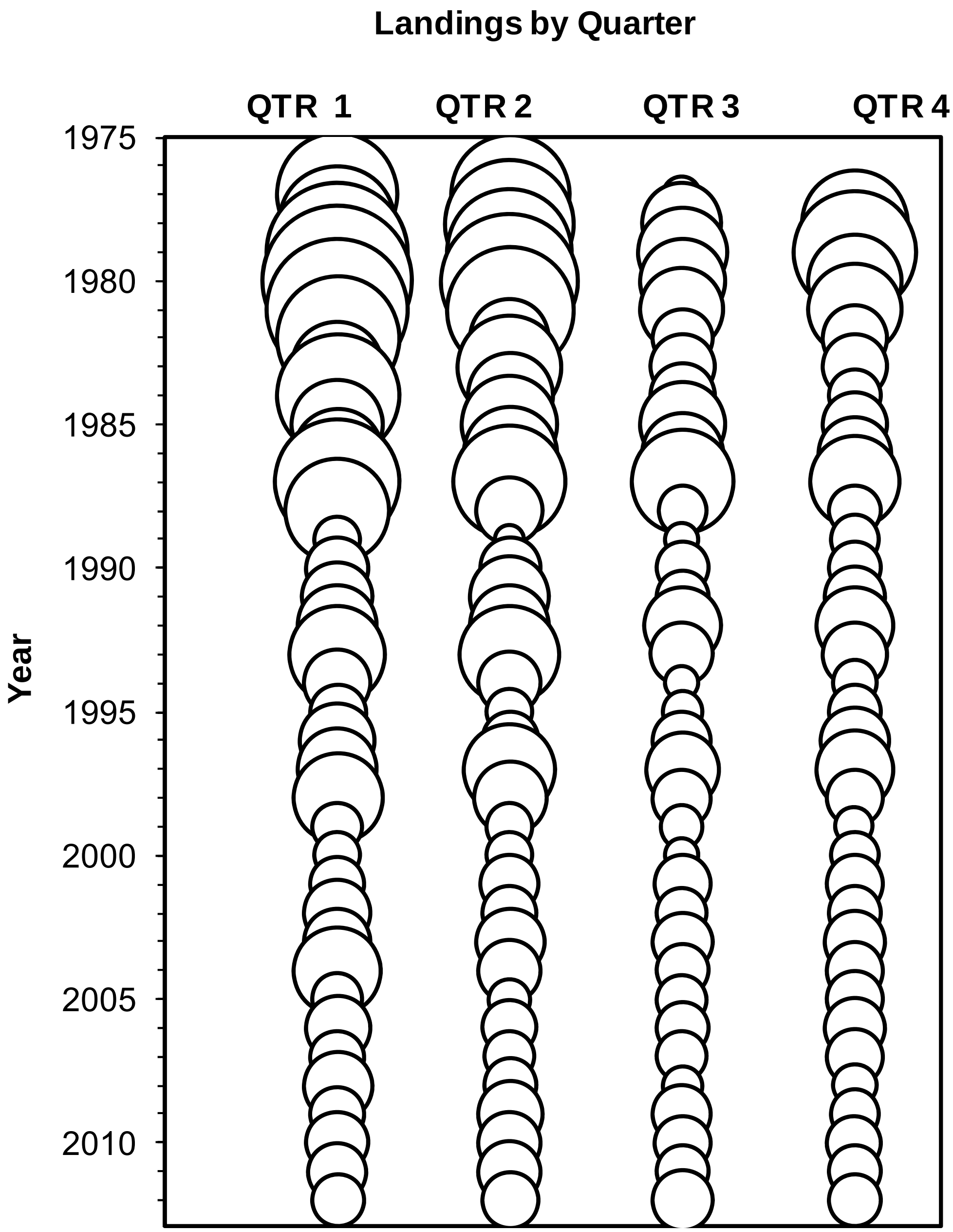


Figure B7. Bubble plot of Golden tilefish landings by quarter.

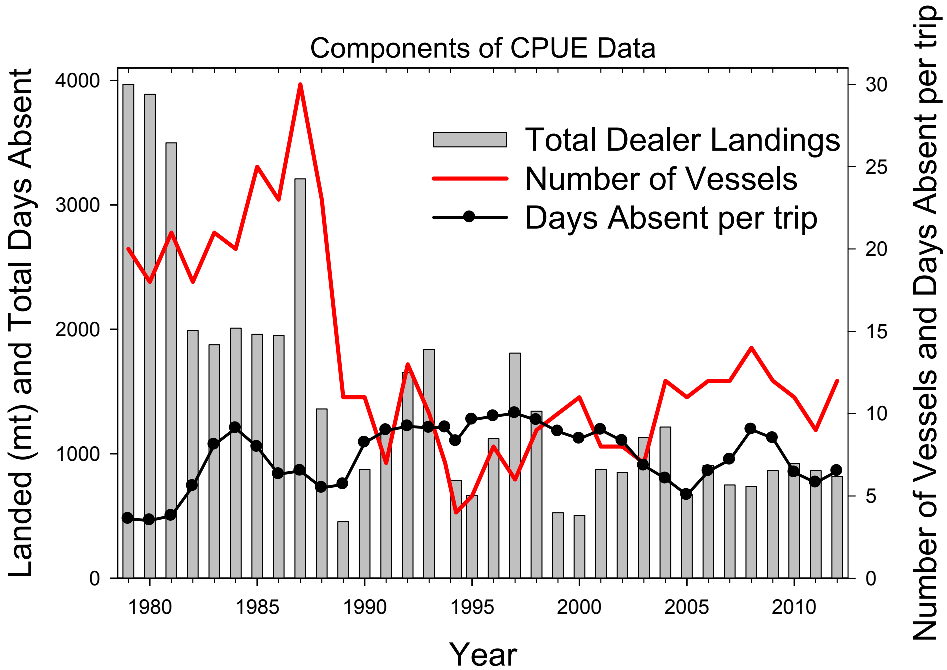


Figure B8. Number of vessels and length of trip (days absent per trip) for trips targeting tilefish (= or >75% tilefish) from 1979-2012. Total Dealer landings are also shown.

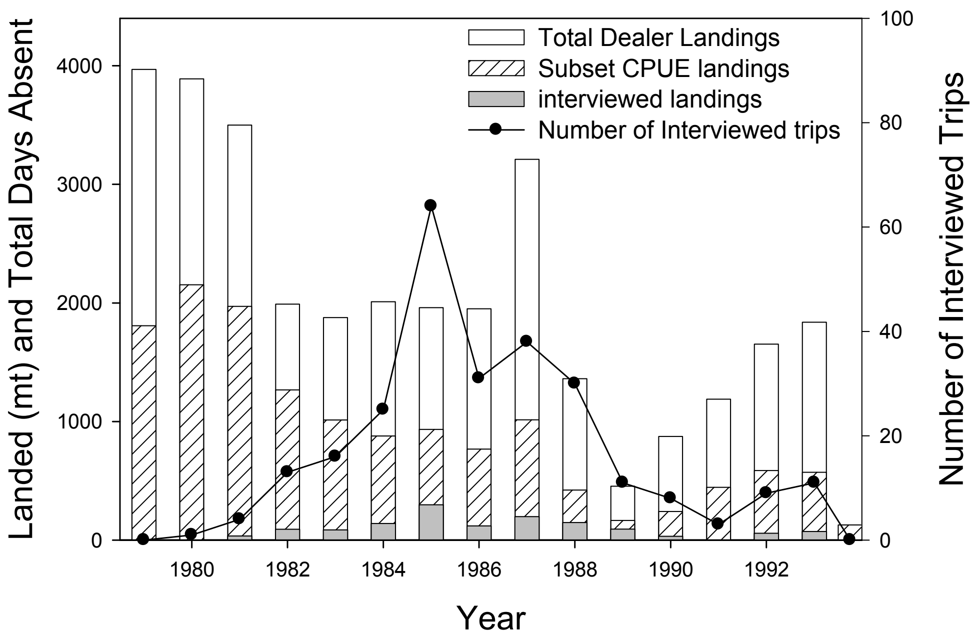


Figure B9. Number of interviewed trips and interviewed landings for trips targeting tilefish (= or >75% tilefish) for the Weighout data from 1979-1994. Total Weighout landings and the subset landings used in CPUE estimate are also shown.

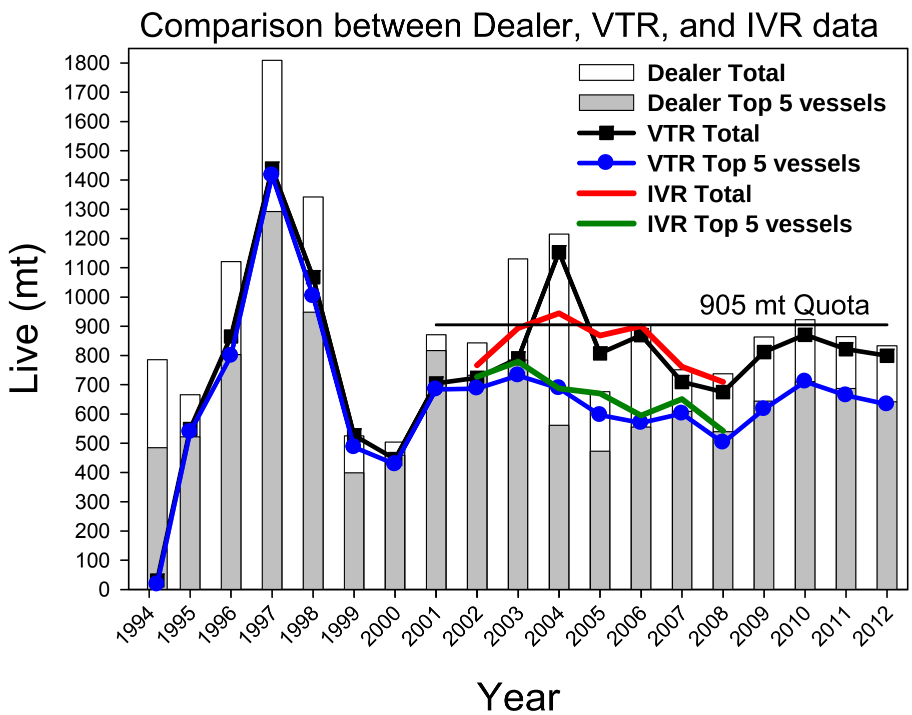


Figure B10. Comparison of dealer, VTR, and IVR total landings in live metric tons. Total landings limited to the top five dominant tilefish vessels are also shown.

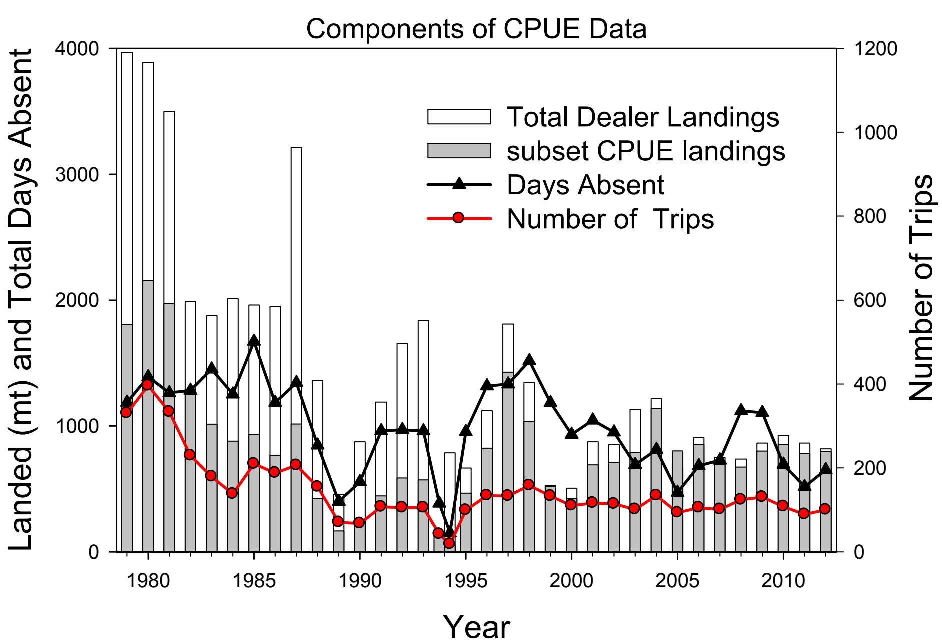


Figure B11. Total number of trips and days absent for trips targeting tilefish (= or >75% tilefish) from 1979-2012. Total Dealer and CPUE subset landings are also shown.

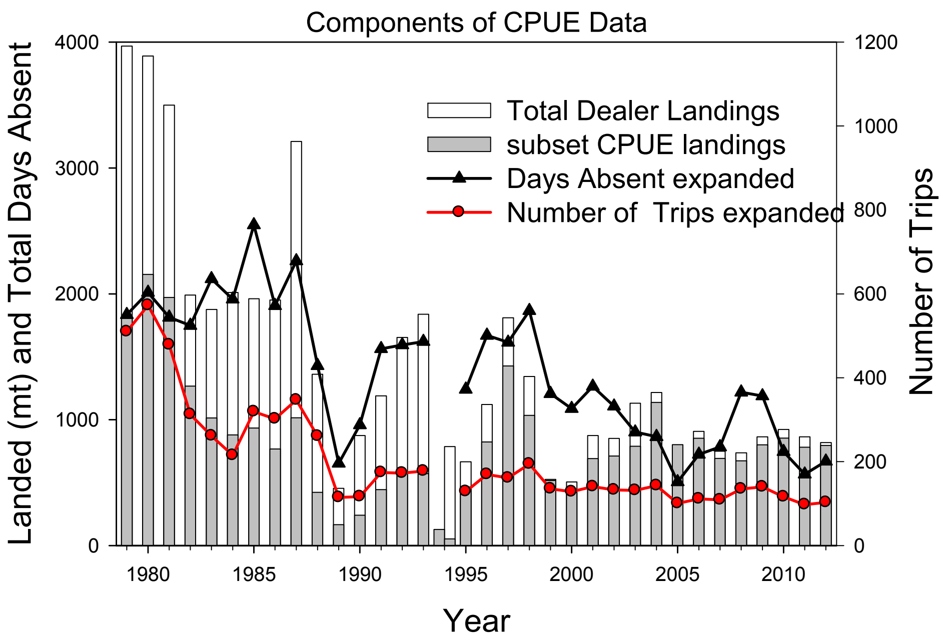


Figure B12. Total number of trips and days absent expanded to the total dealer landings from 1979-2012. Total Dealer and CPUE subset landings are also shown.

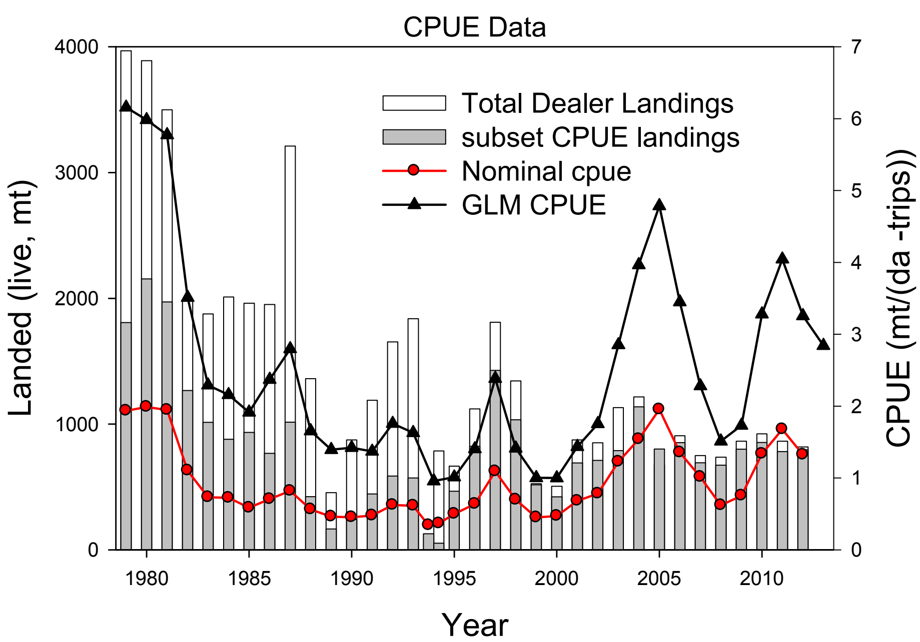


Figure B13. Nominal CPUE (1994 split by Weighout and VTR series) and vessel standard CPUE (GLM) for trips targeting tilefish (= or >75% tilefish) from 1979-2008. Total Dealer and CPUE subset landings are also shown.

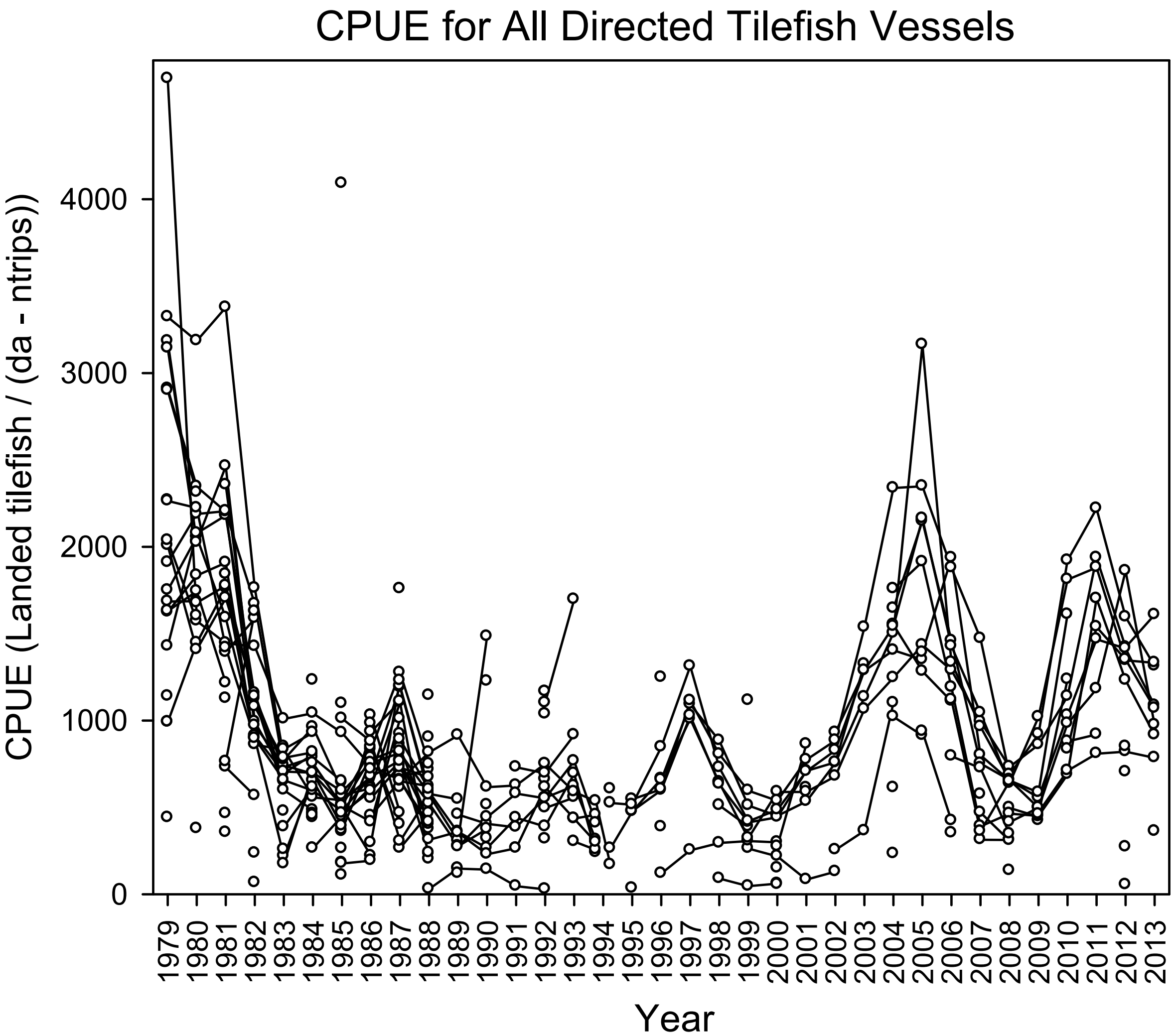


Figure B14. All individual tilefish vessel CPUE data for trips targeting tilefish (= or >75% tilefish) from 1979-2013.

Figure B15. Depiction of individual vessels (rows) targeting tilefish over the Weighout and VTR series. Year 1994 is split by the two series. Below the horizontal line are vessels which are predominantly found in the VTR series.

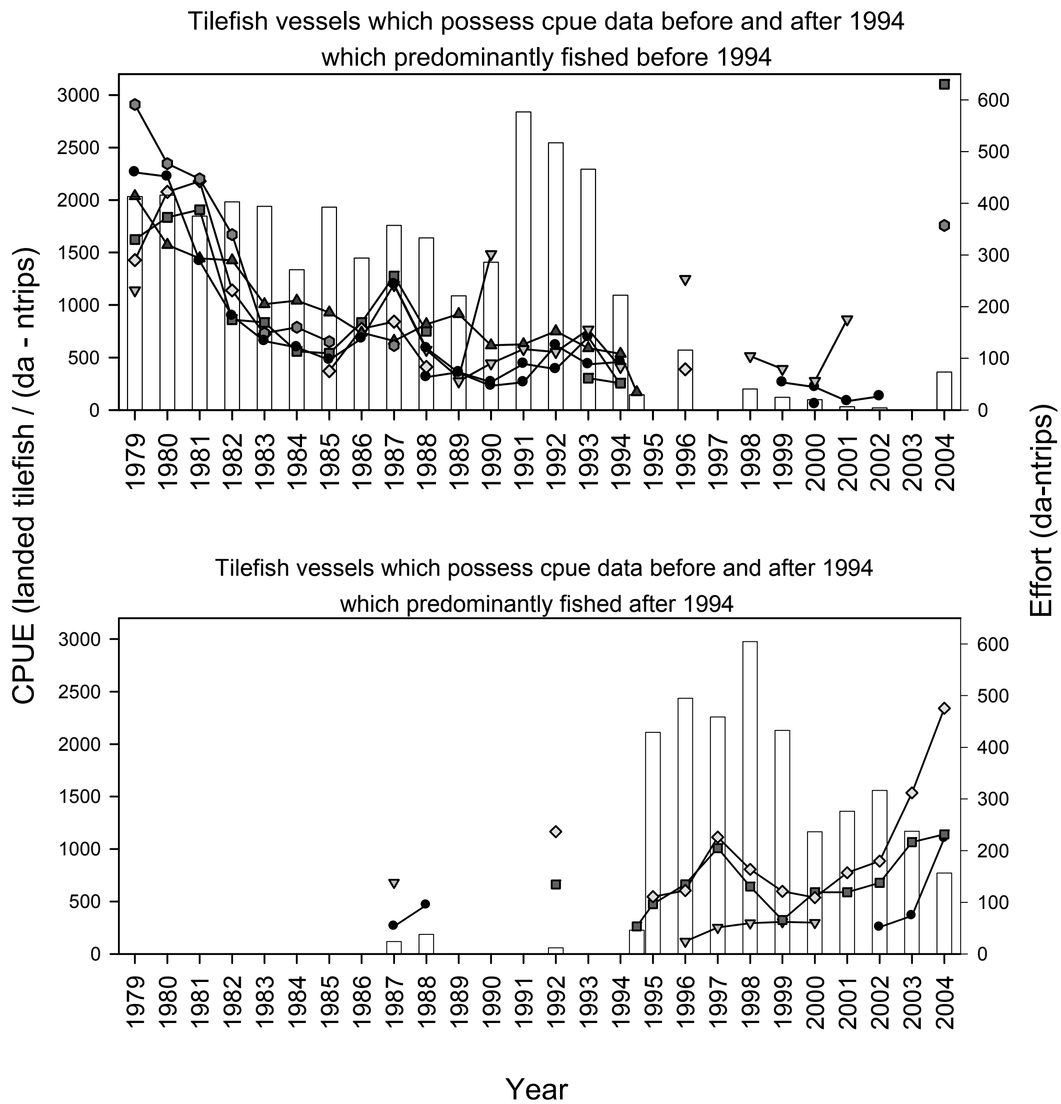


Figure B16. Individual tilefish vessel CPUE and effort data (Bars) for trips targeting tilefish (= or >75% tilefish) from 1979-2004 which are found in both the Weighout and VTR series. Top graph are vessels found predominantly in the Weighout series. Bottom graph are vessels found predominantly in the VTR series.

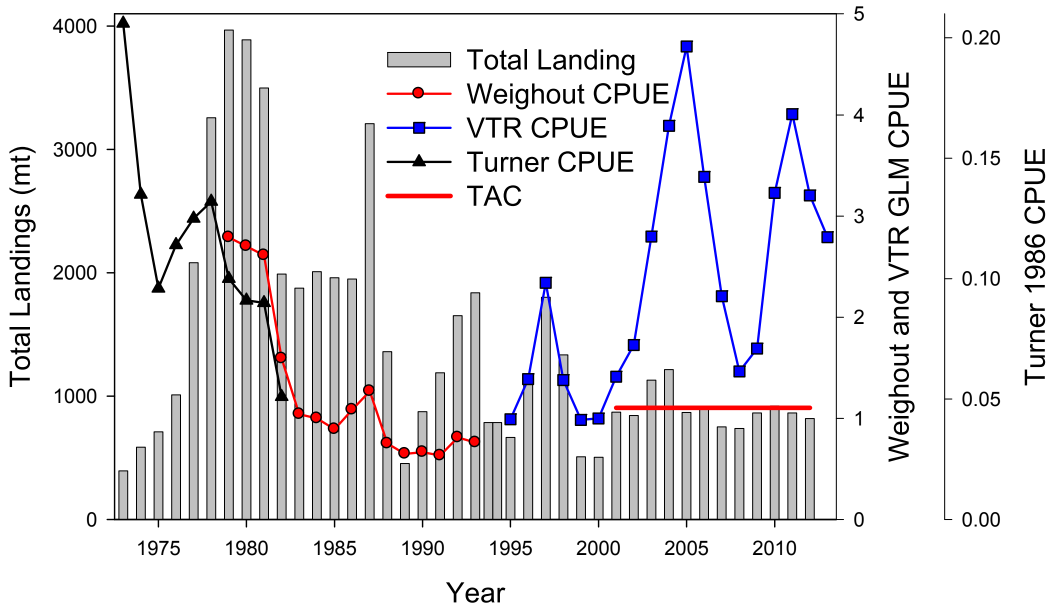


Figure B17. GLM CPUE for the Weighout and VTR data split into two series. Four years of overlap between Turner's and the Weighout CPUE series can be seen. Assumed total landings are also shown. Landing in 2005 was taken from the IVR system.

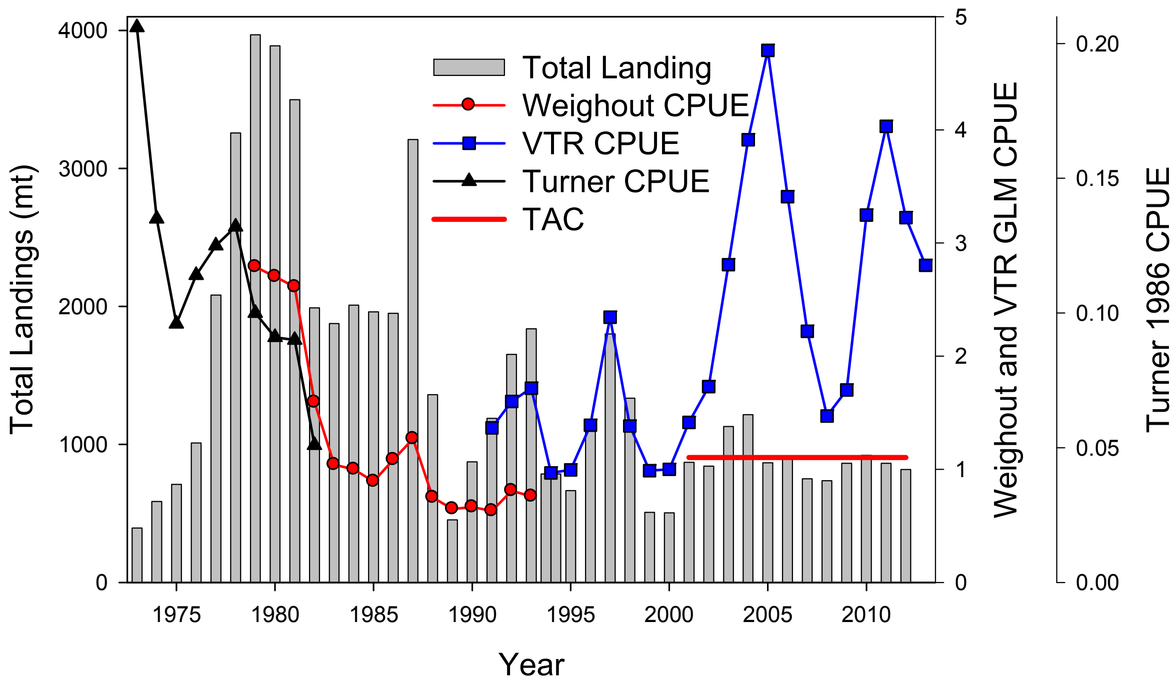


Figure B18. GLM CPUE for the Weighout and VTR data split into two series with additional New York logbook CPUE data from three vessels (1991-1994) added to the VTR series.

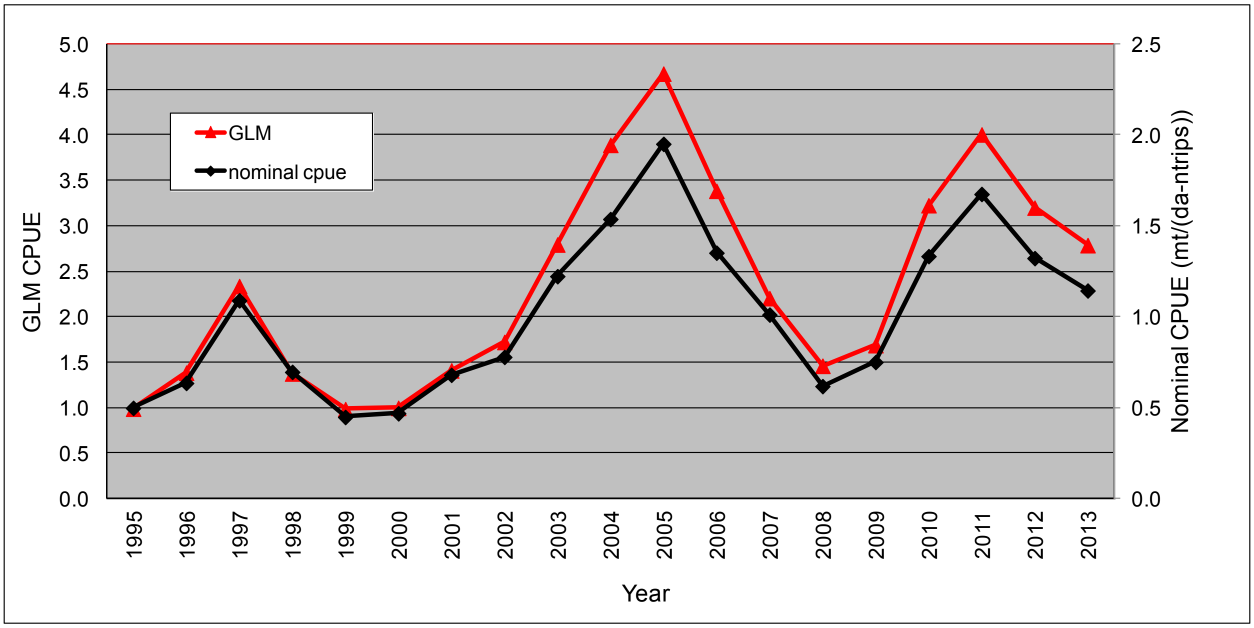


Figure B19. Comparison of nominal and GLM (vessel standardized) CPUE series from the VTR series.

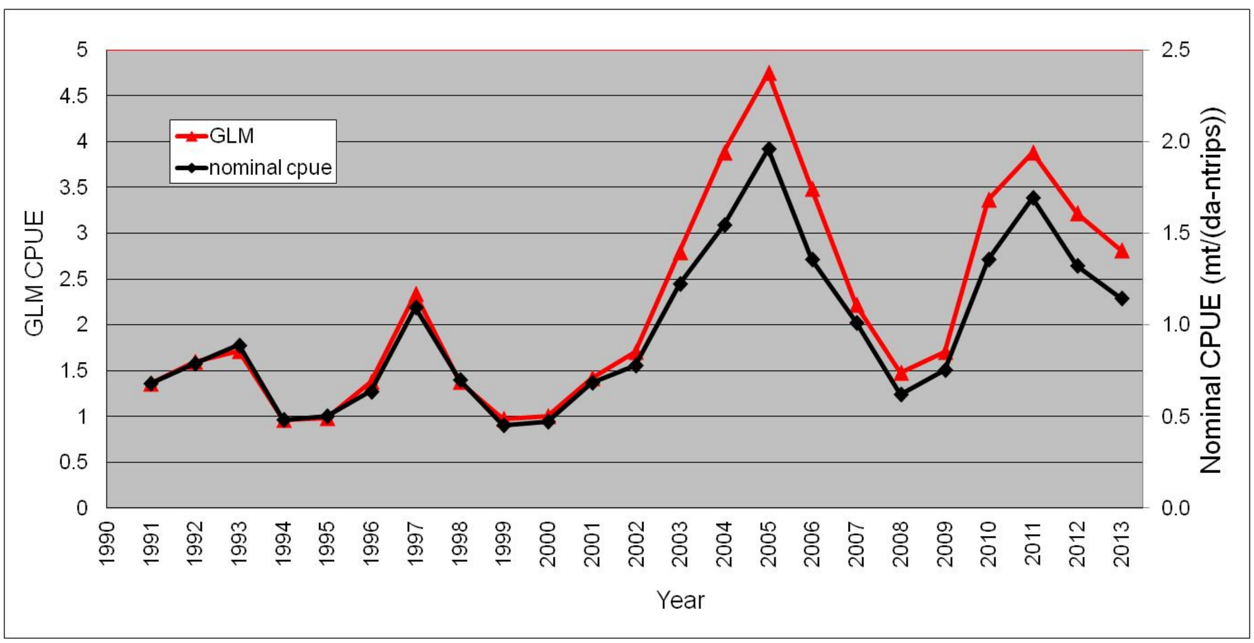


Figure B20. Comparison of nominal and GLM (vessel standardized) CPUE series from the VTR series with the additional 1991-1994 New York logbook CPUE data added to the series.

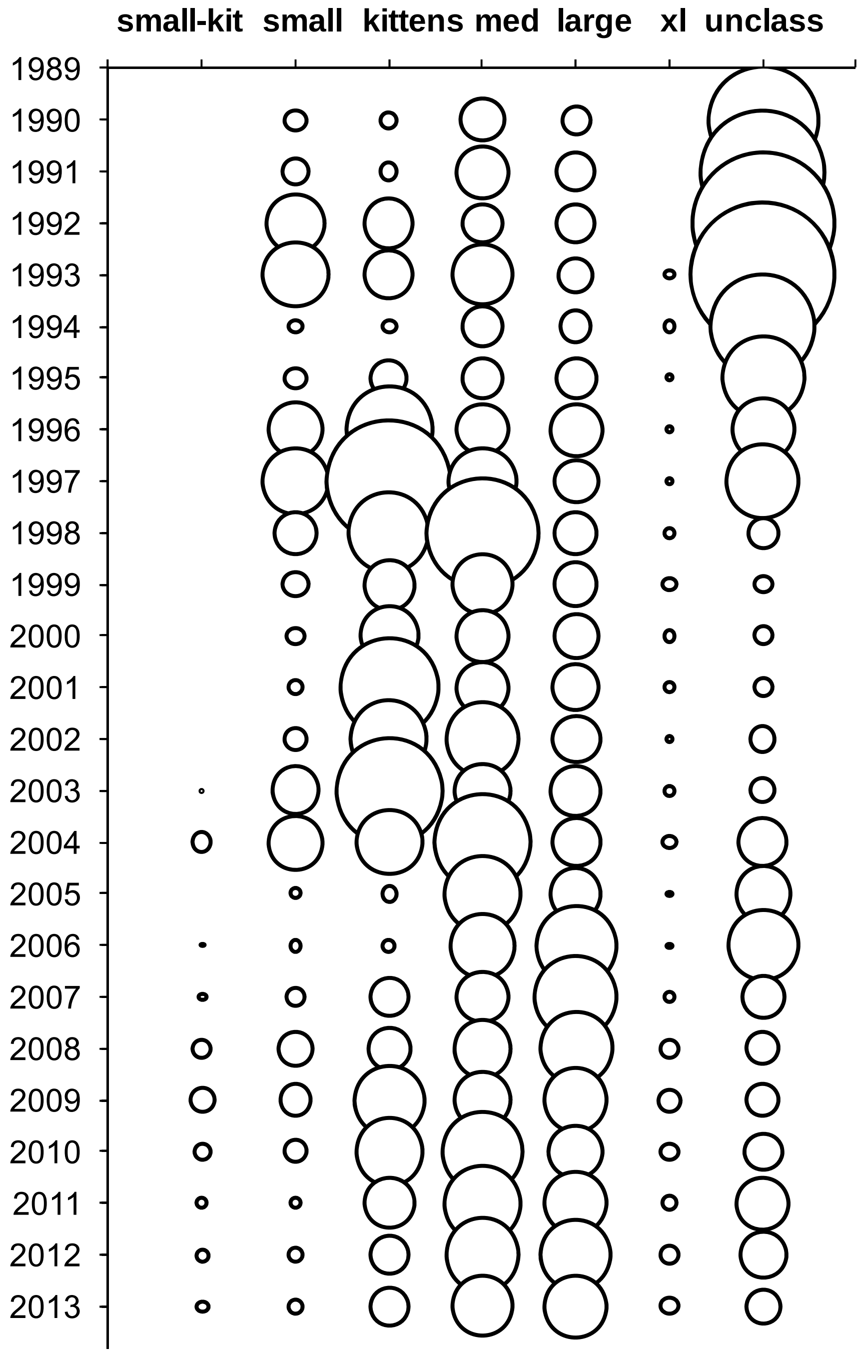


Figure B21. Bubble plot of Golden tilefish landings by market category.

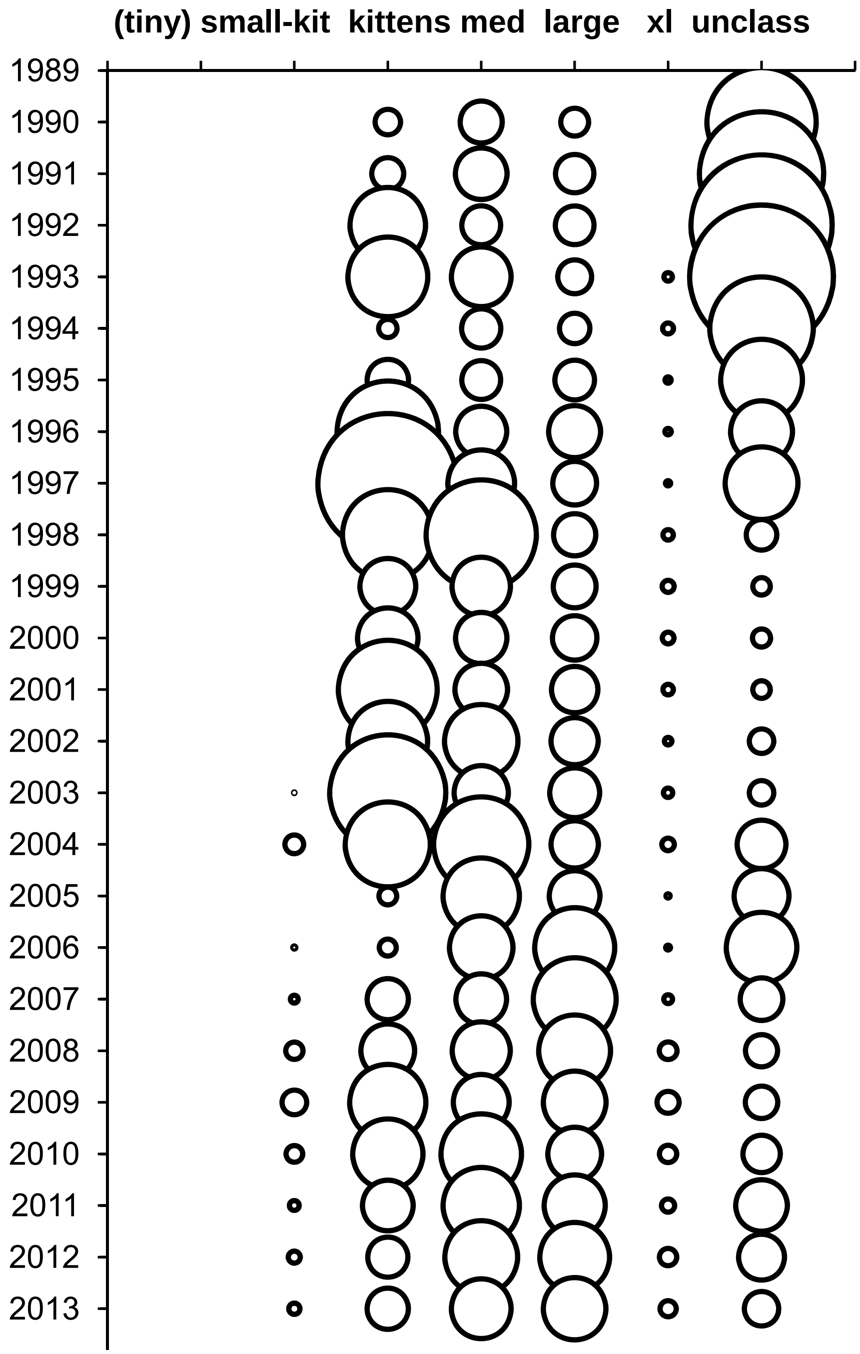


Figure B22. Bubble plot of Golden tilefish landings by market category where similar sized smalls and kittens market categories are combined into the kittens category.

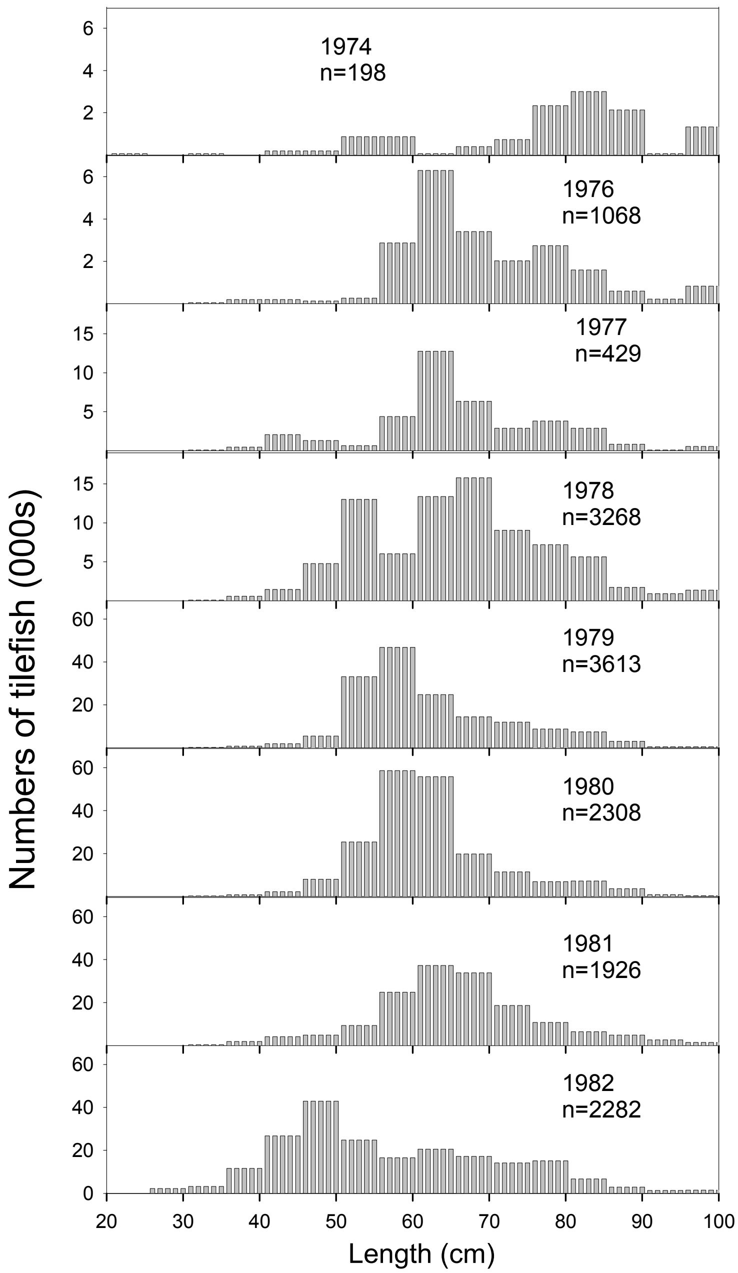


Figure B23. Expanded length frequency distributions using Turner (1986) length samples by 5 cm intervals. Hudson Canyon and Southern New England samples were combined.

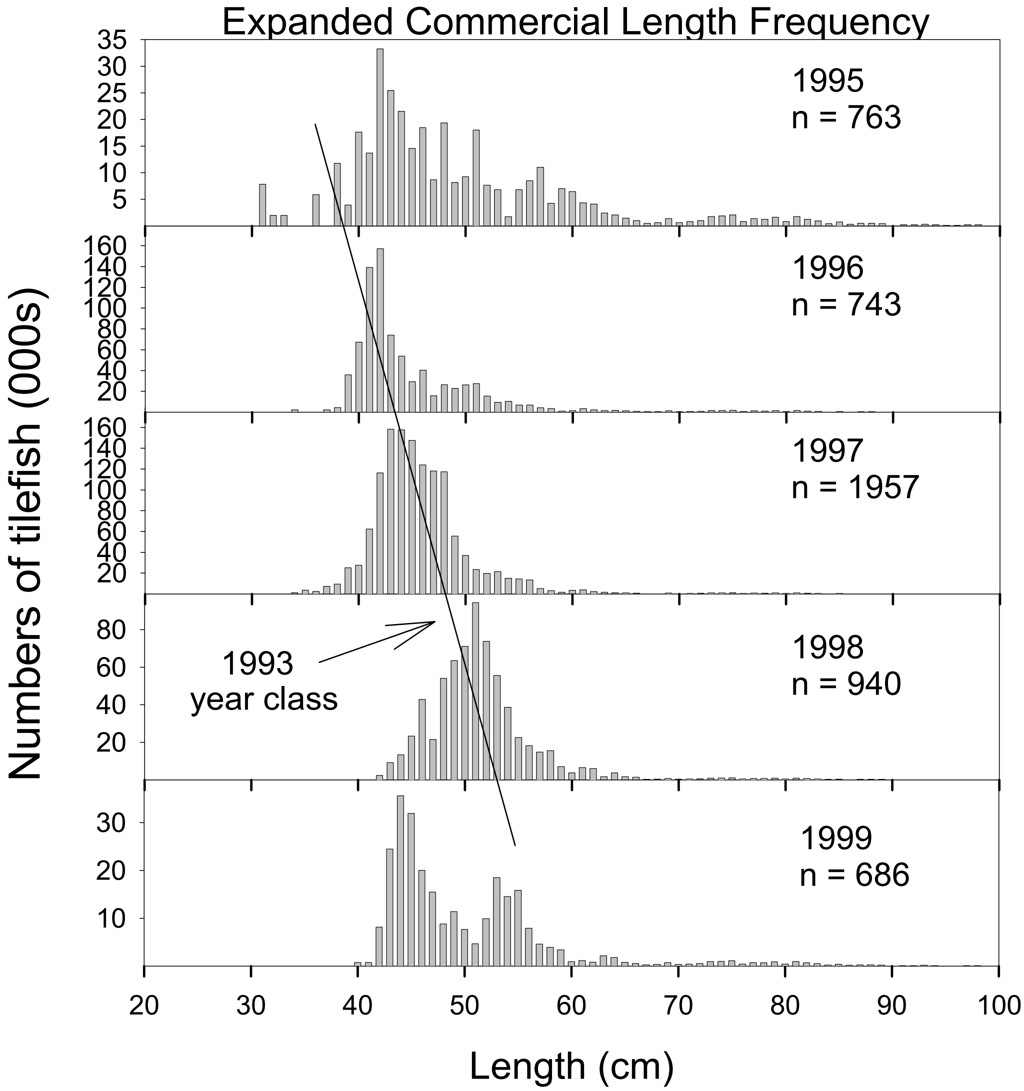


Figure B24. Expanded length frequency distributions by year. Large market category length used from 1995 to 1999 were taken from years 1996, 1998, and 1998. Smalls and kittens were combined and large and extra large were also combined.

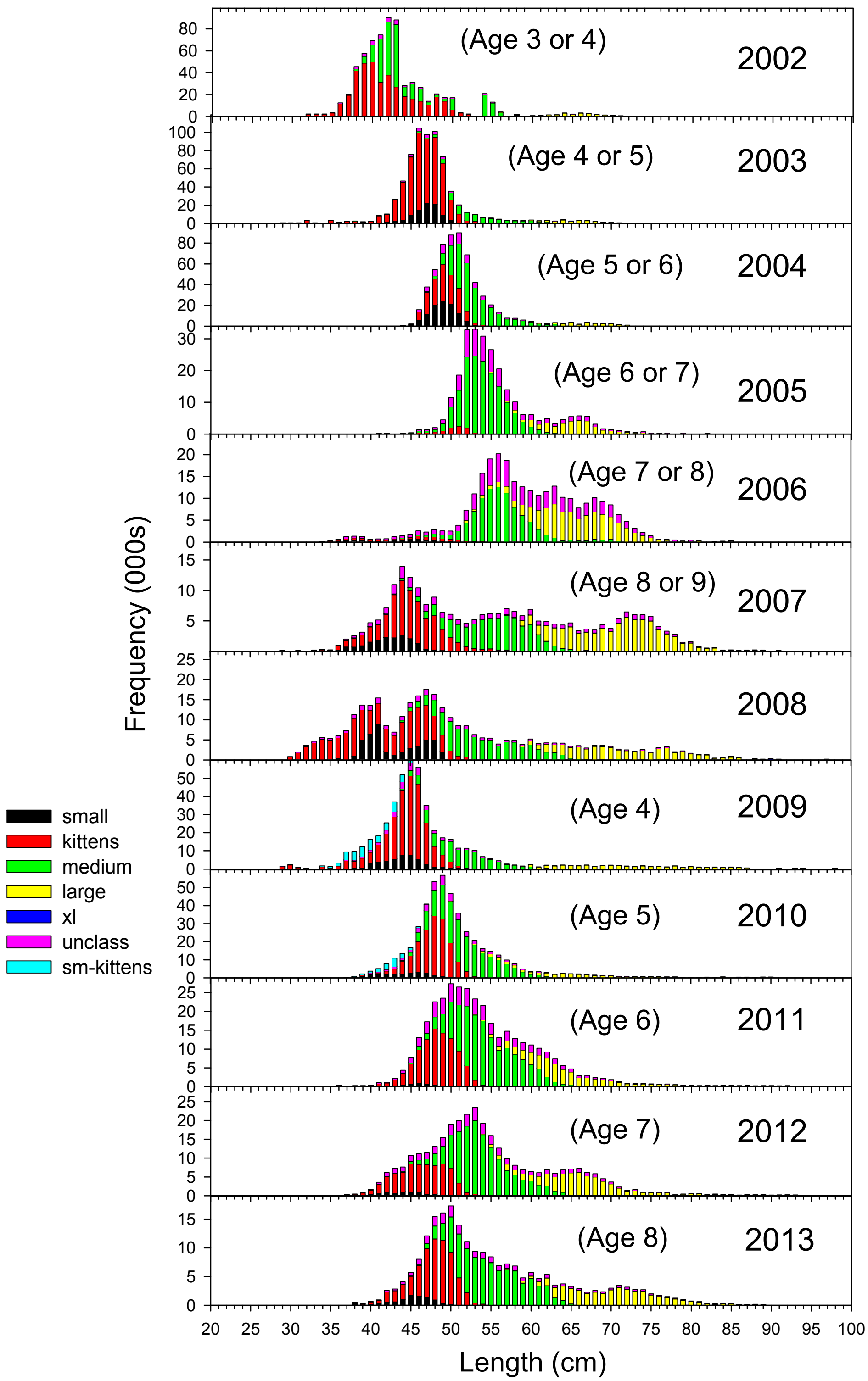


Figure B25. Expanded numbers length frequency distributions by year. Y-axis is allowed to rescale.

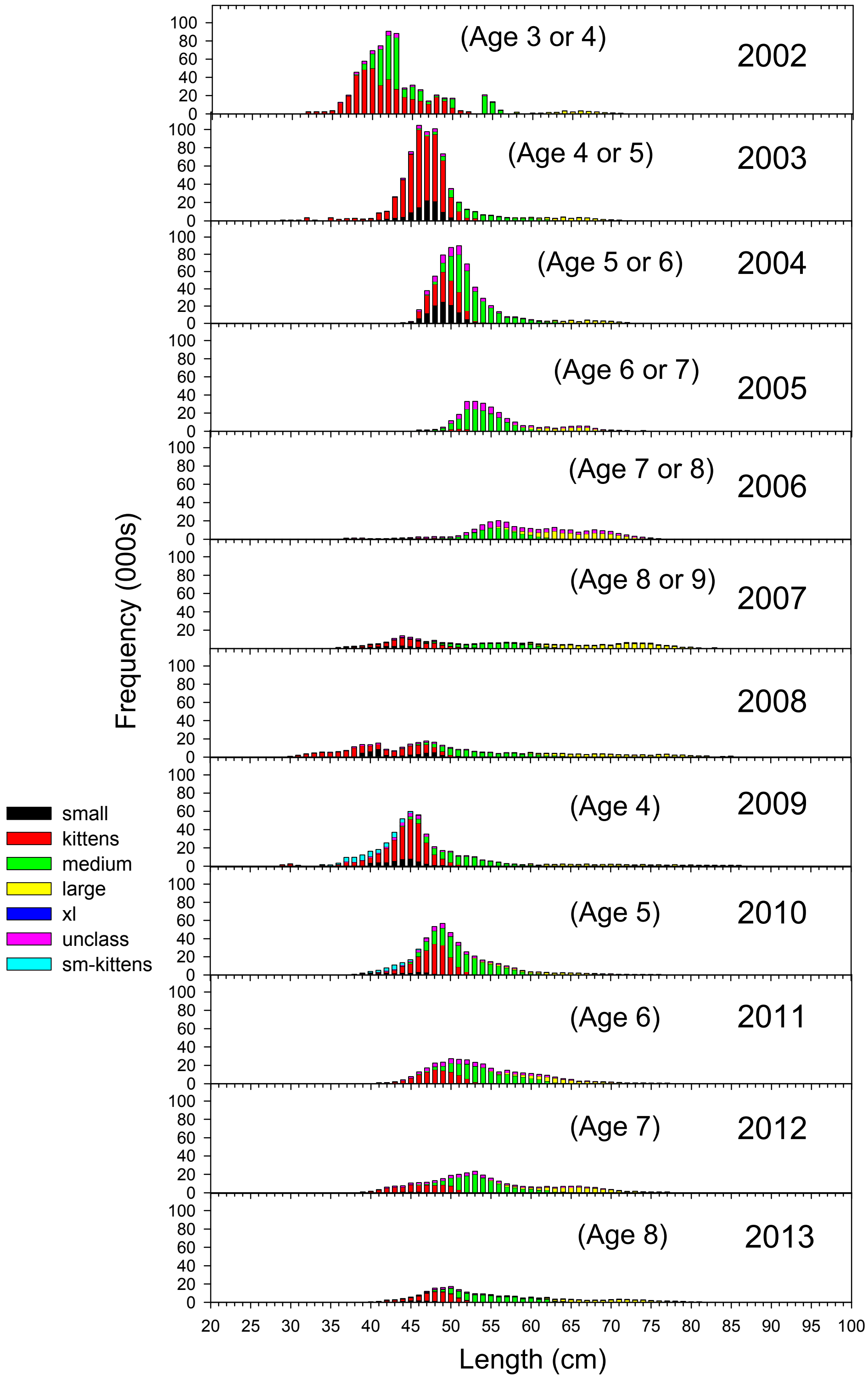


Figure B26. Expanded numbers length frequency distributions by year. Y-axis scale is fixed.

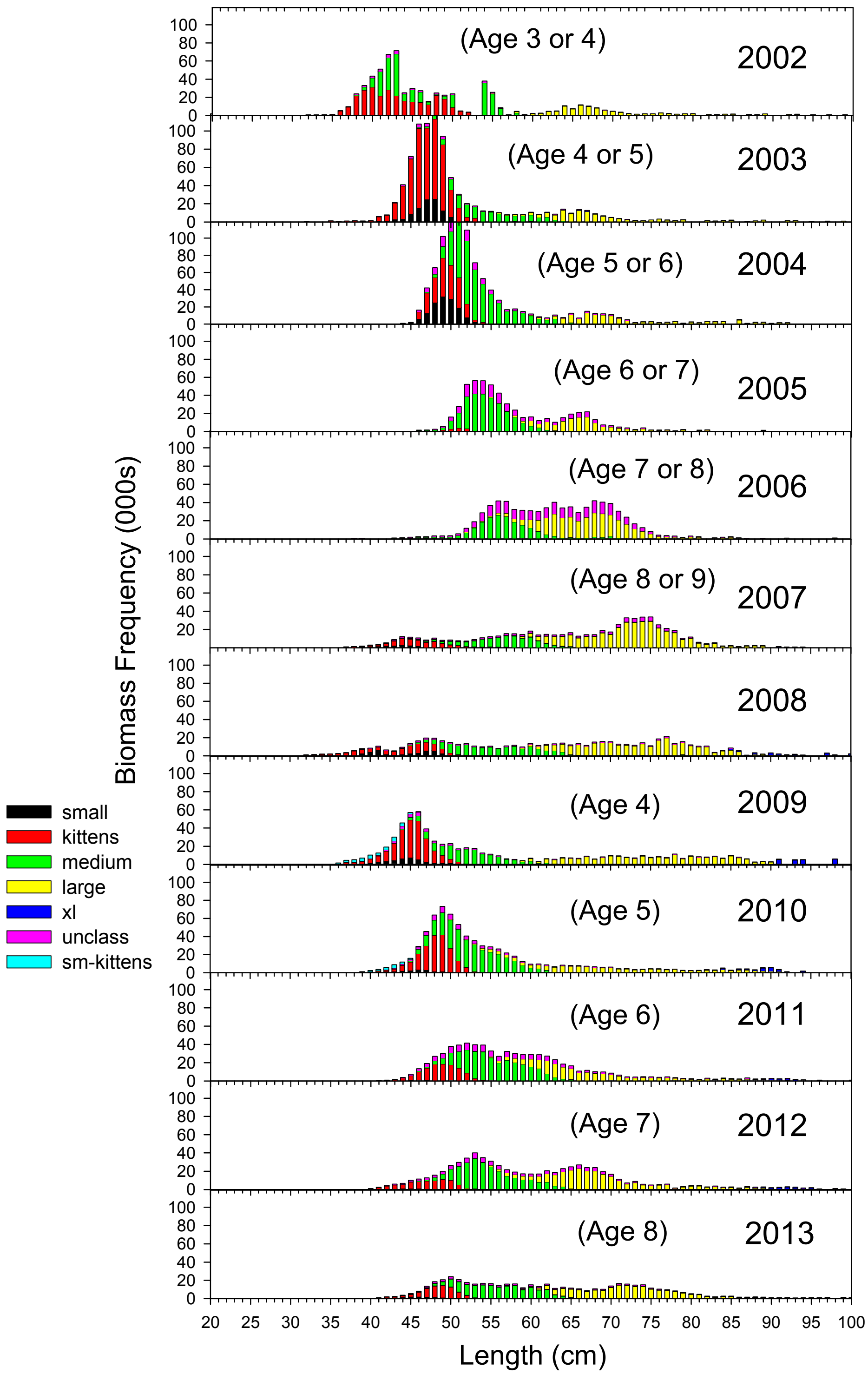


Figure B27. Expanded biomass length frequency distributions by year. Y-axis scale is fixed.

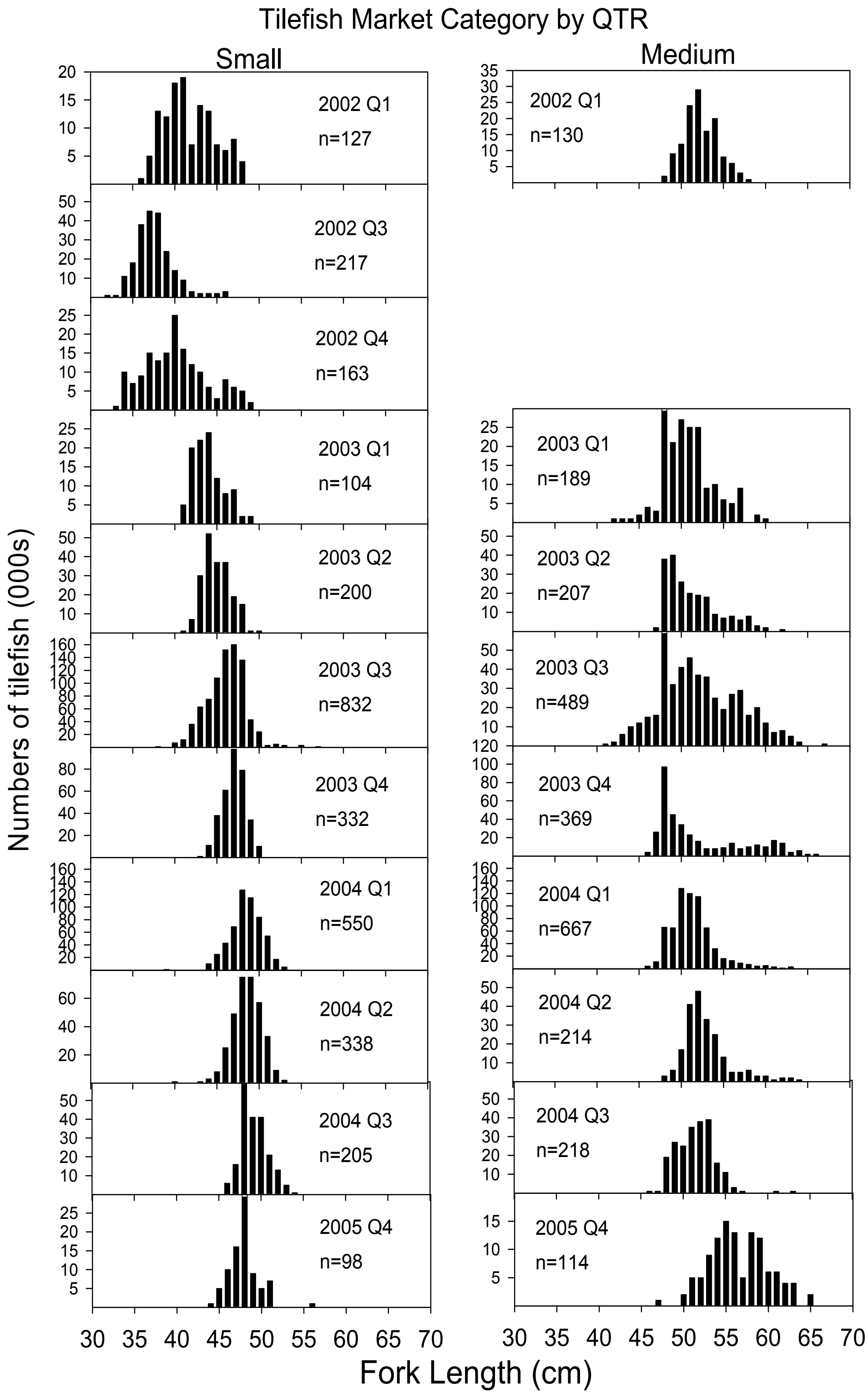


Figure B28. Small and medium tilefish market category length frequency distributions by quarter.

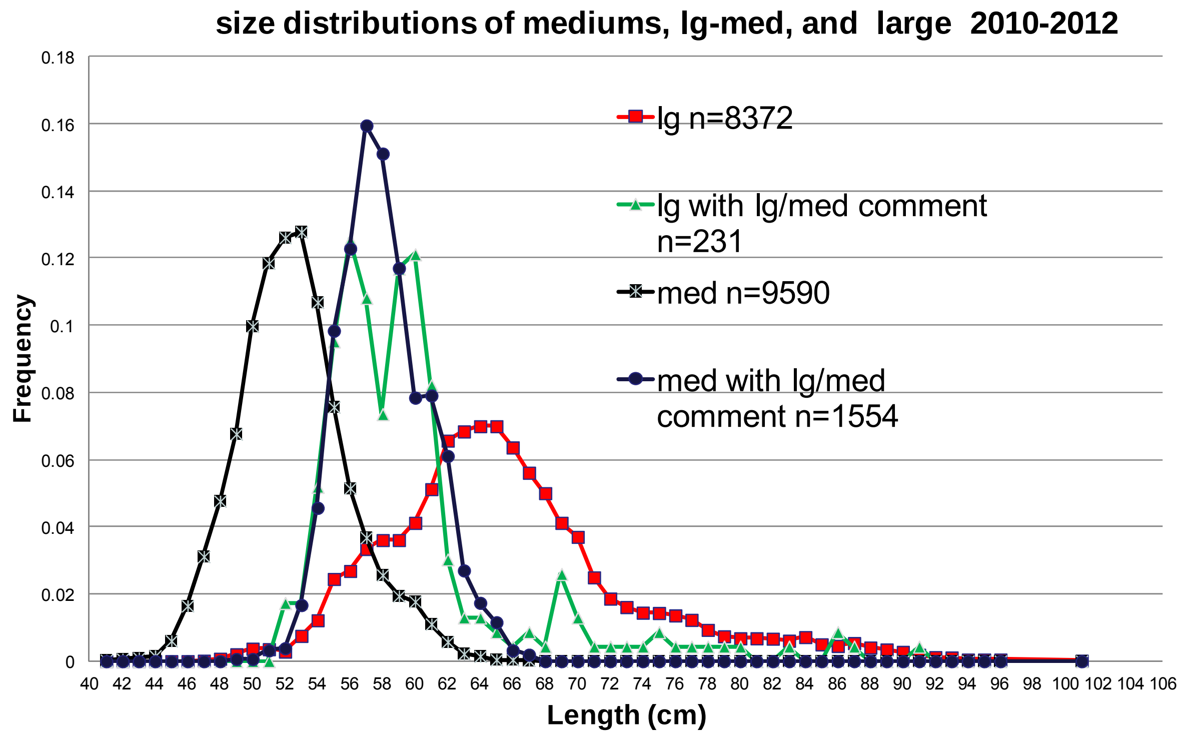


Figure B29. Comparison of medium and large length distributions with distributions that had a comment from the port sampler indicating that the sample came from a dealer large-medium category.

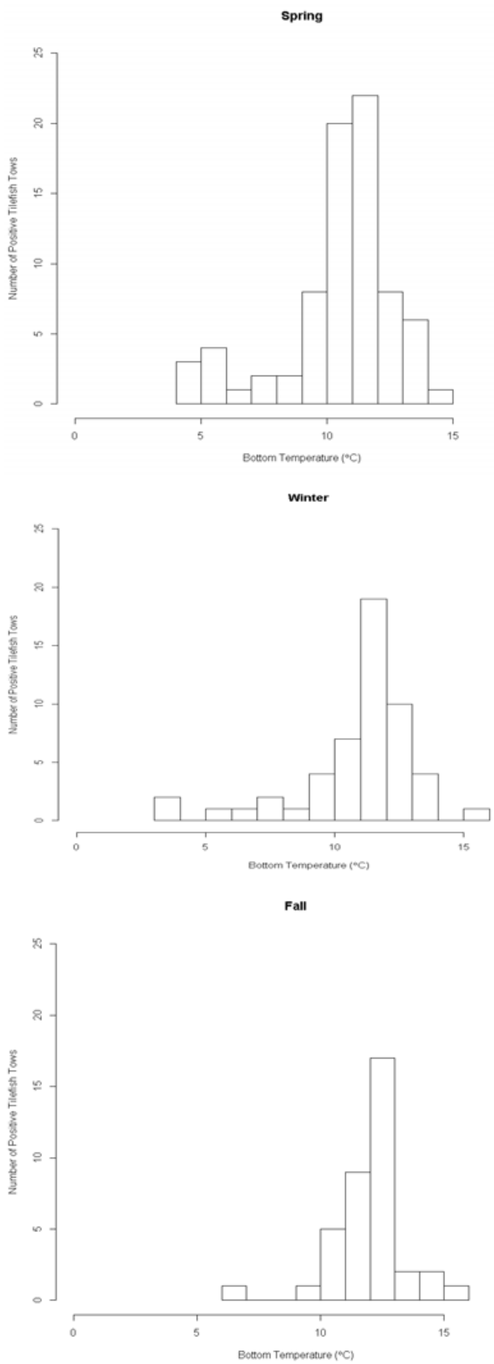


Figure B30. Temperature distributions from survey tows which caught tilefish over the entire time series for the NEFSC spring, winter and fall bottom trawl surveys.

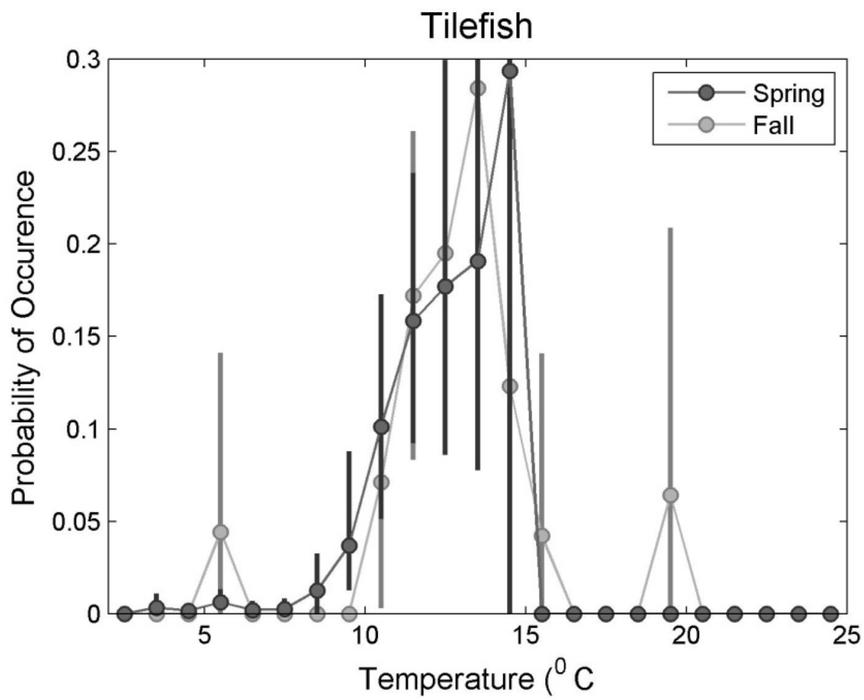


Figure B31. The probability of occurrence with temperature for tilefish from the spring and fall surveys. Confidence intervals were calculated from bootstrapping.

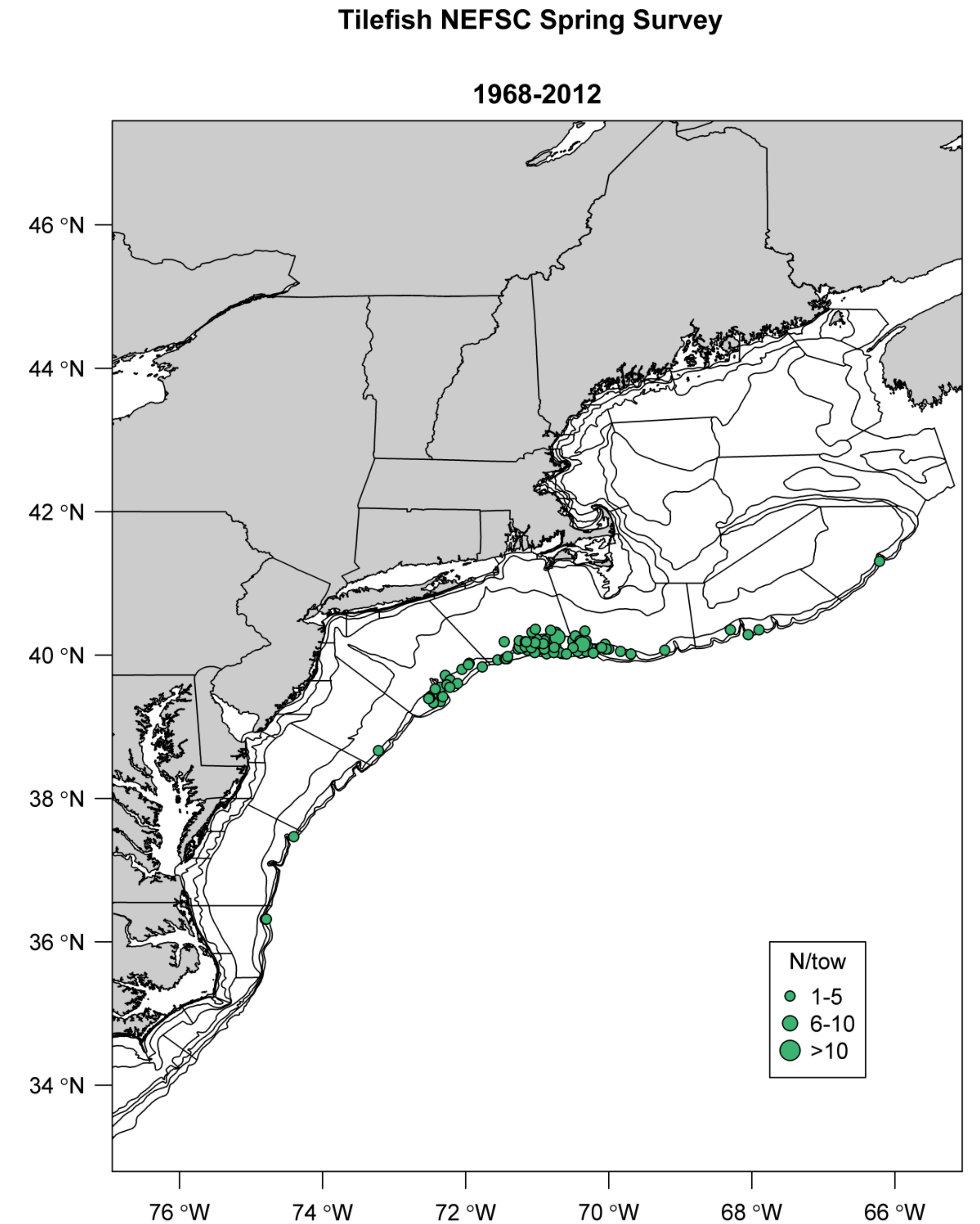


Figure B32. Spatial distribution for 138 tilefish caught in the Spring NEFSC bottom trawl survey over the entire 1968-2012 time series.

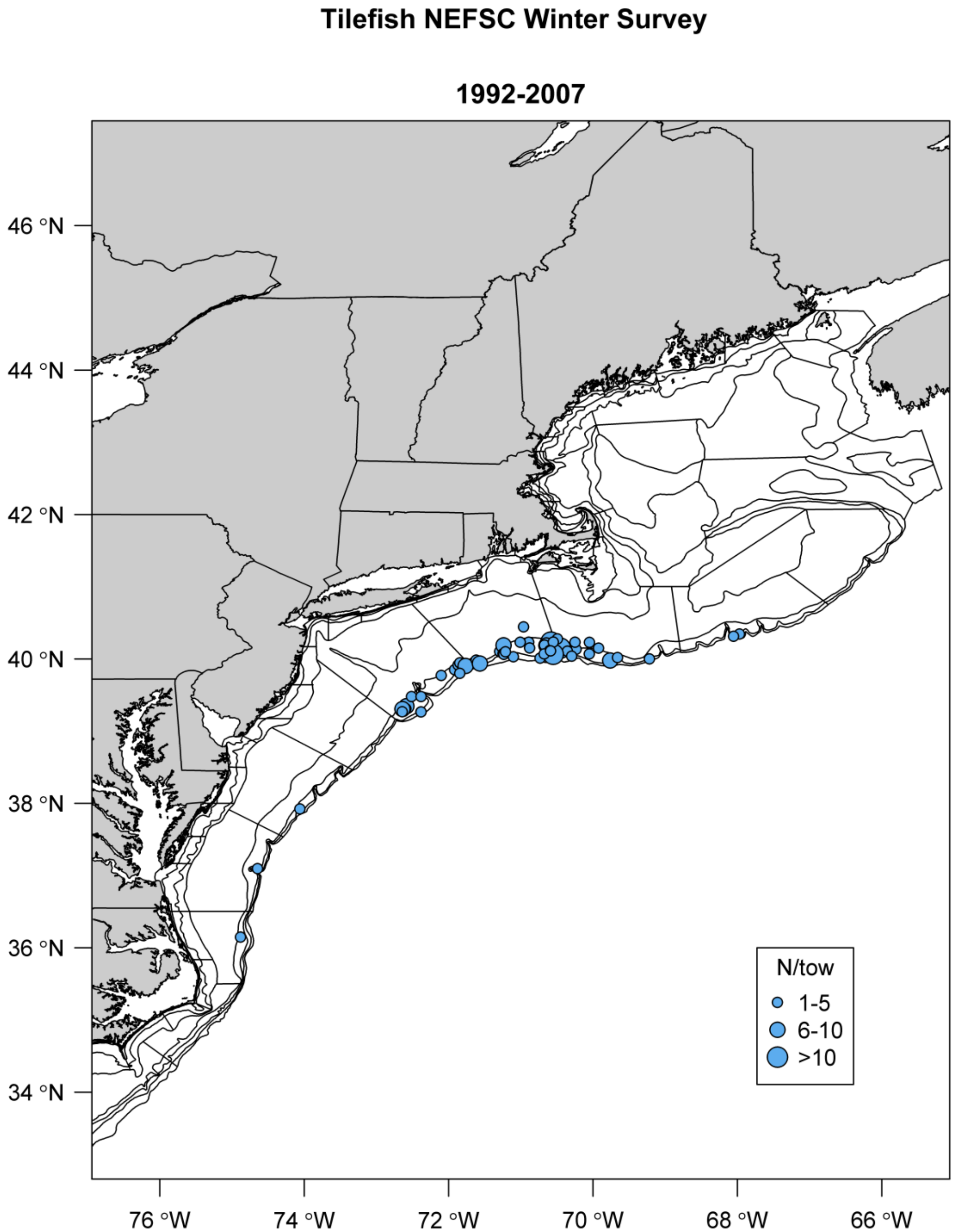


Figure B33. Spatial distribution for tilefish caught in the Winter NEFSC bottom trawl survey (flatfish net) over the entire 1992-2007 time series.

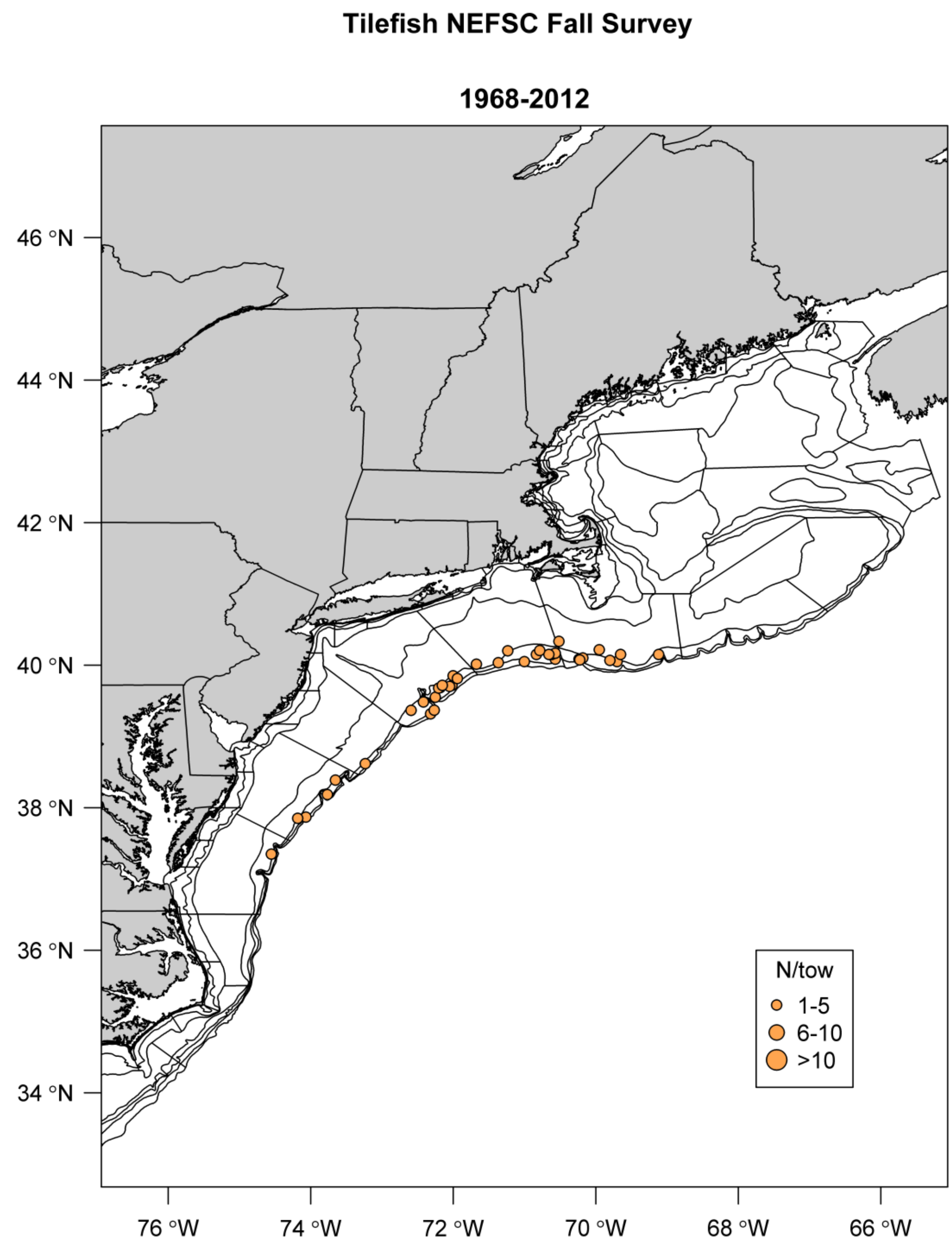


Figure B34. Spatial distribution for 47 tilefish caught in the Fall NEFSC bottom trawl survey over the entire 1963-2012 time series.

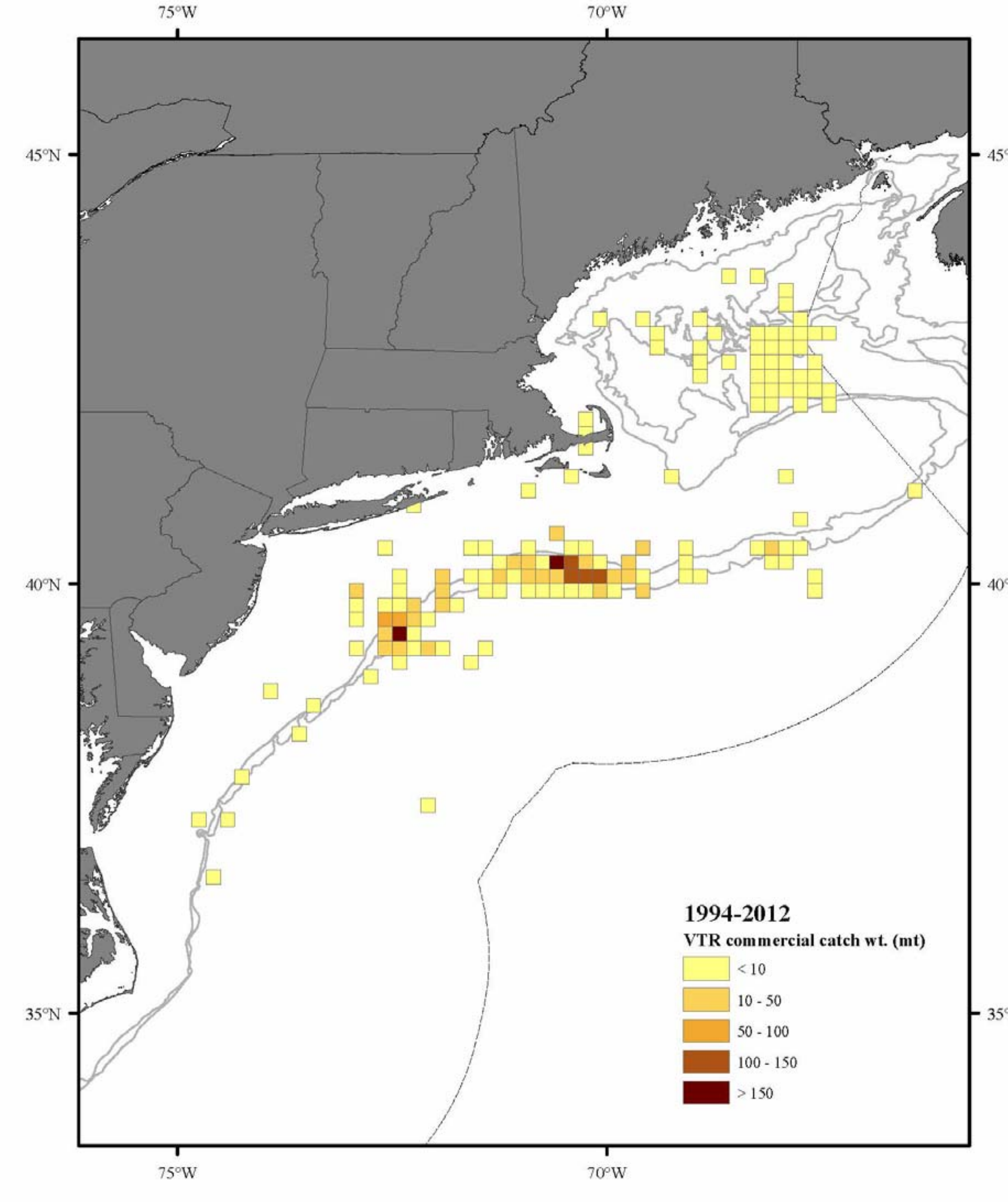


Figure B35. Spatial distribution for tilefish caught in all longline gear reported in the commercial VTR data from 1994-2012.

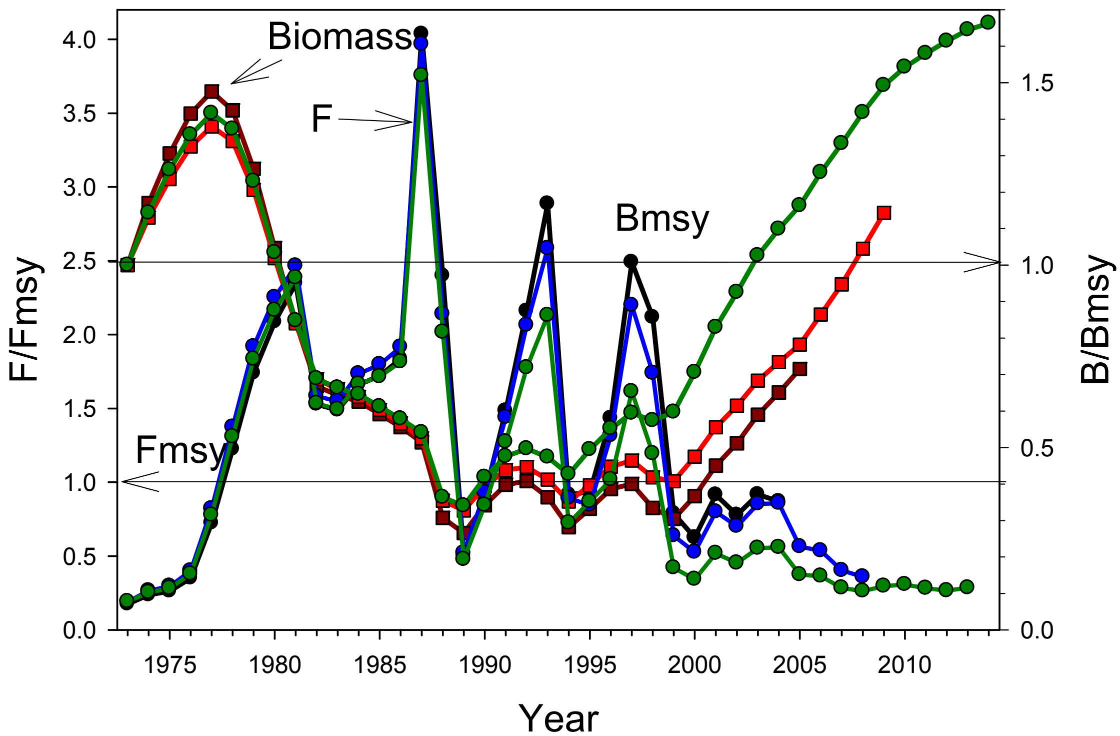


Figure B36. Comparison of the 2005 SAW 41, 2009 SARC 48 estimates of fishing mortality (F/FMSY) ratios and biomass (B/BMSY) ratios to the update model using the same configuration (run2 green).

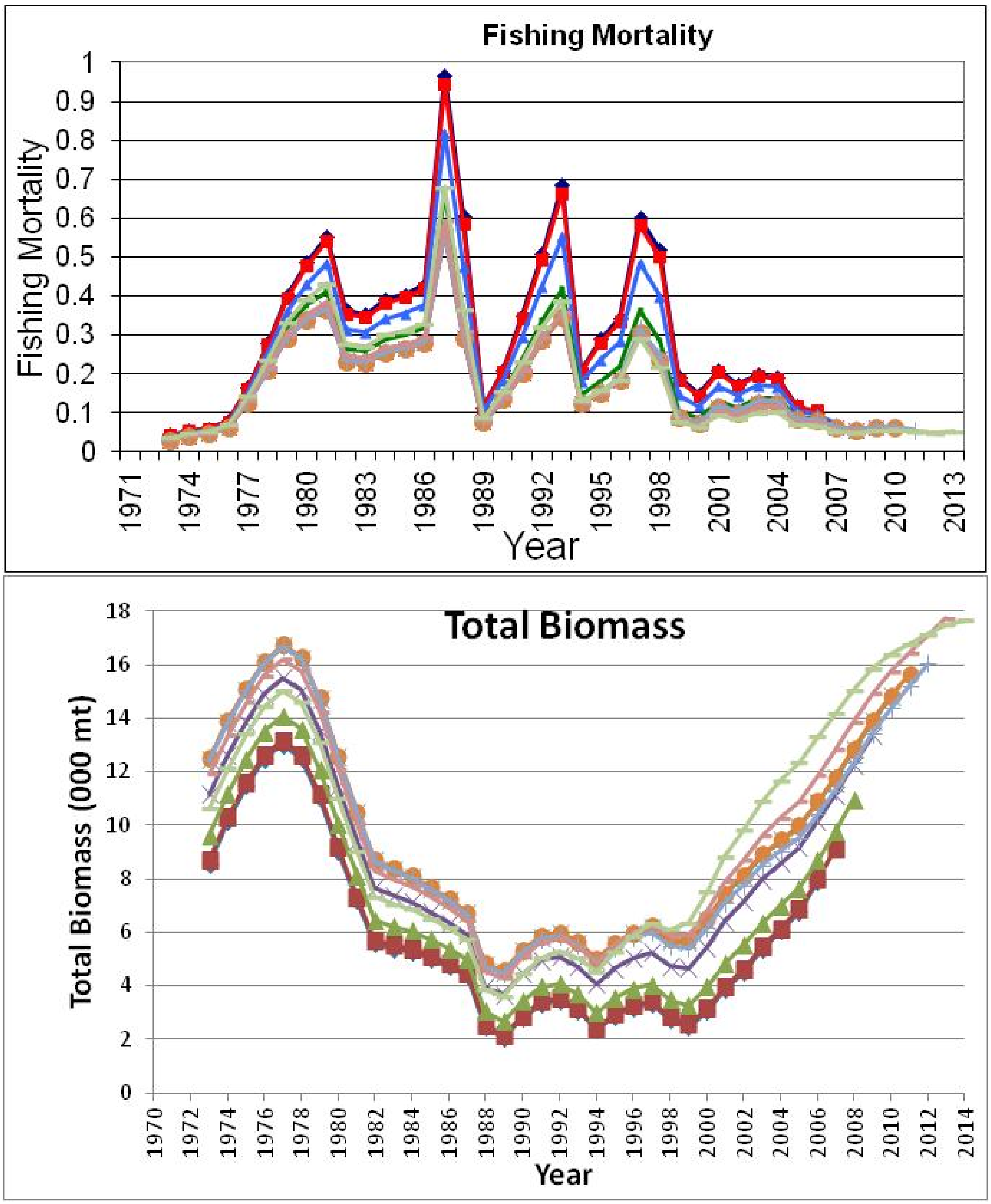
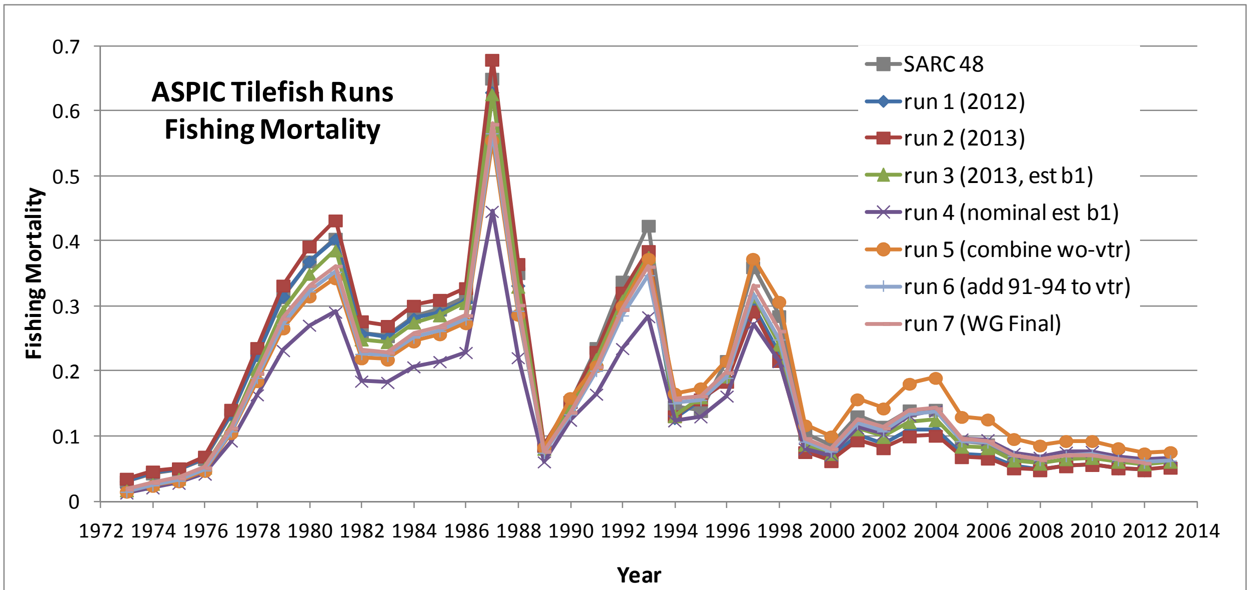


Figure B37. Retrospective analysis results for fishing mortality and biomass for the updated ASPIC run 2.



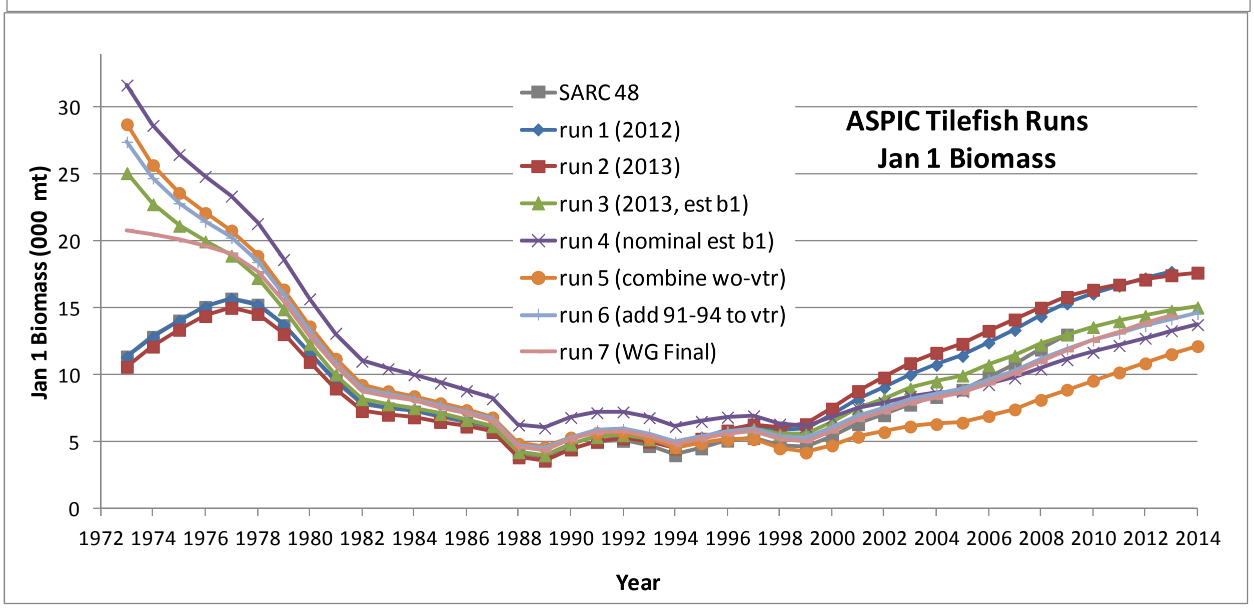


Figure B38. Sensitivity ASPIC runs for fishing mortality and total biomass.

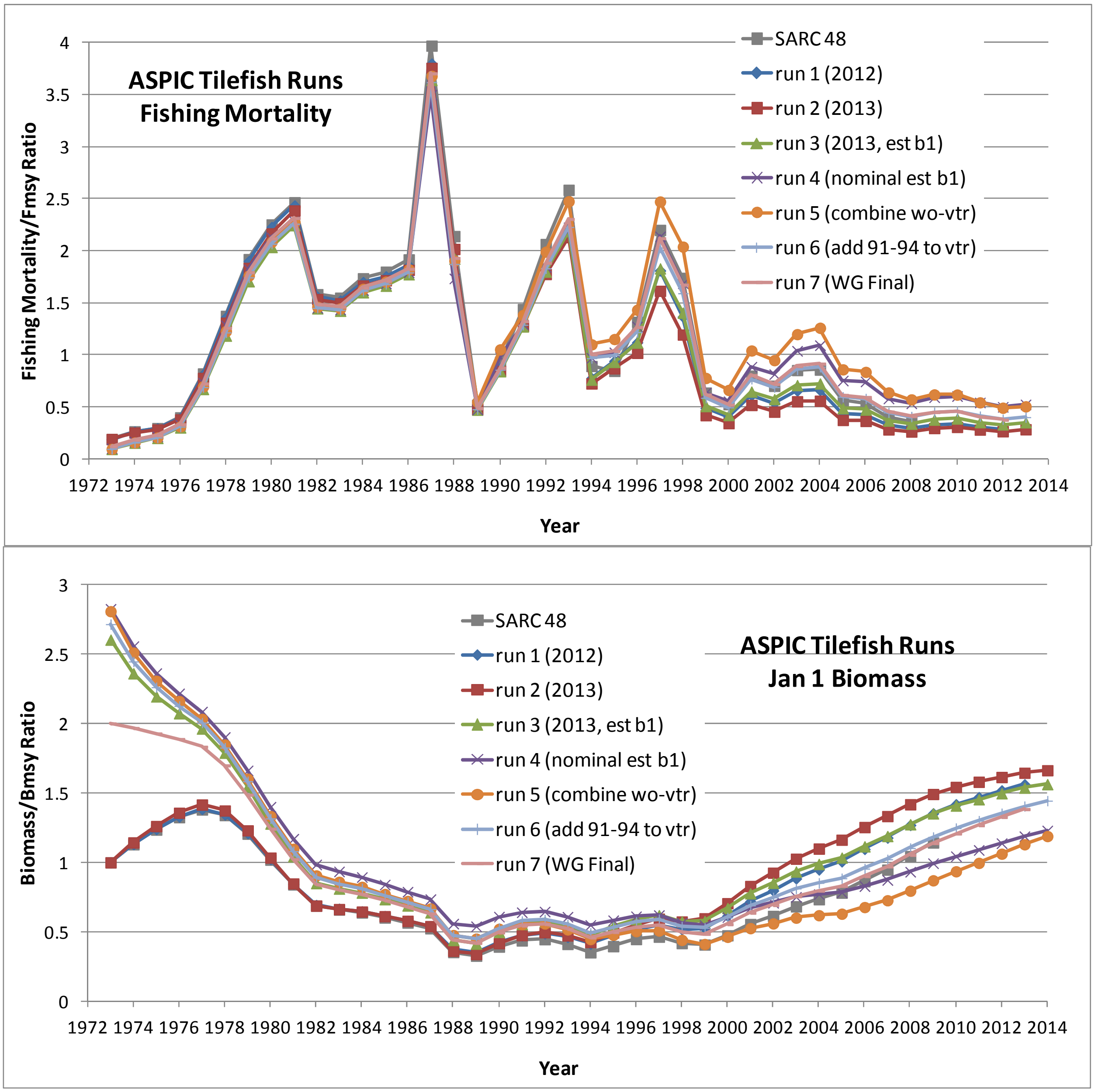
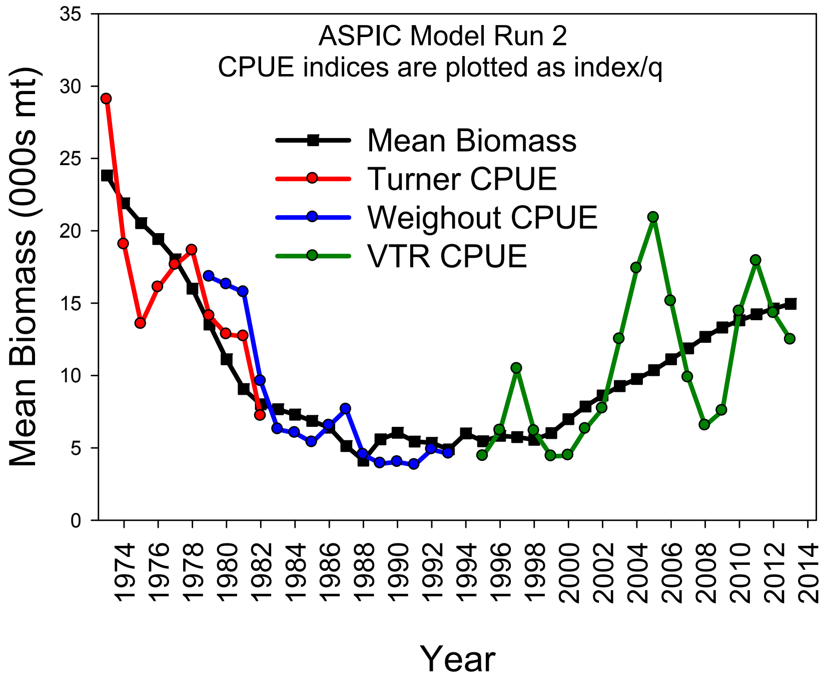


Figure B39. Sensitivity ASPIC runs for relative fishing mortality to F_{MSY} and relative biomass to B_{MSY}.



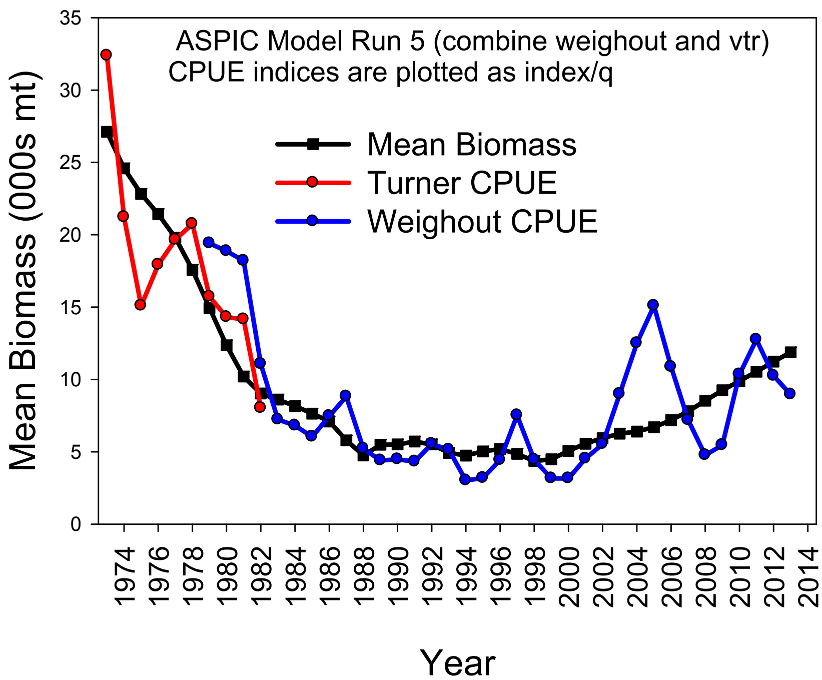


Figure B40. Fit of the ASPIC base run 1 with the three separate (Turner's, Weighout, and VTR) cpue series (top) and the fit of the ASPIC model to Turner's and the Weighout and VTR series combined.

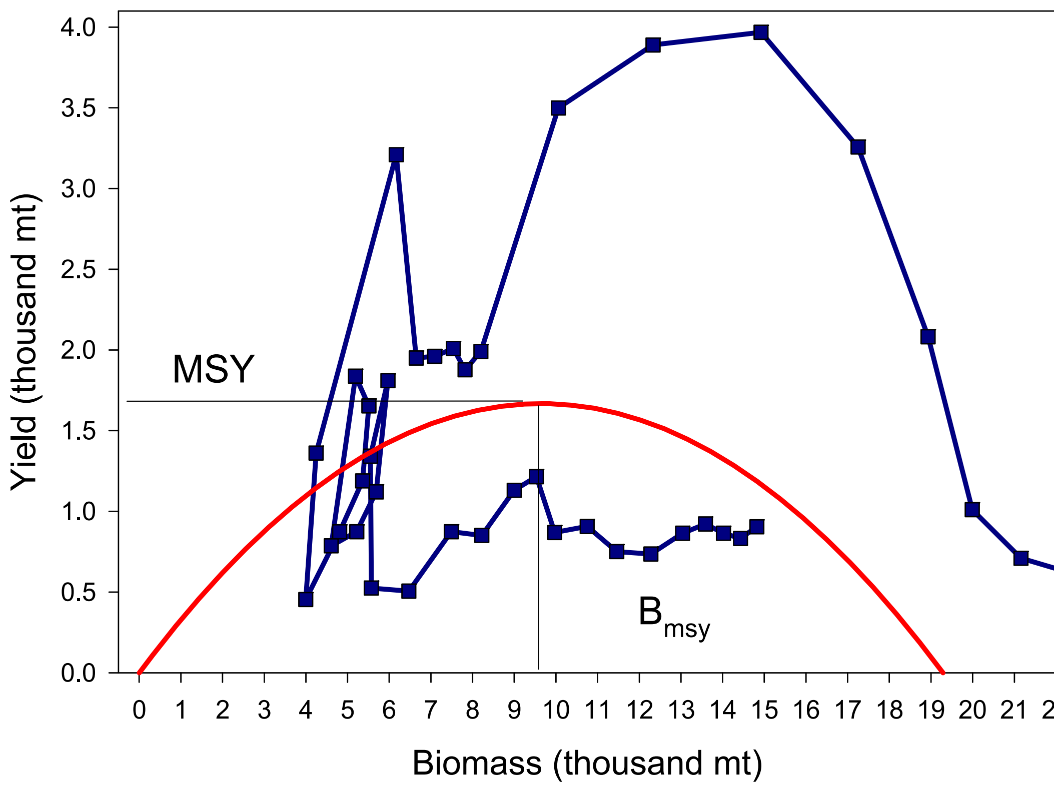


Figure B41. Time series of biomass and yield for ASPIC run 3. The beginning of the time series (1973) start at the right higher than the model estimated K and ends in 2013 above B_{MSY}.

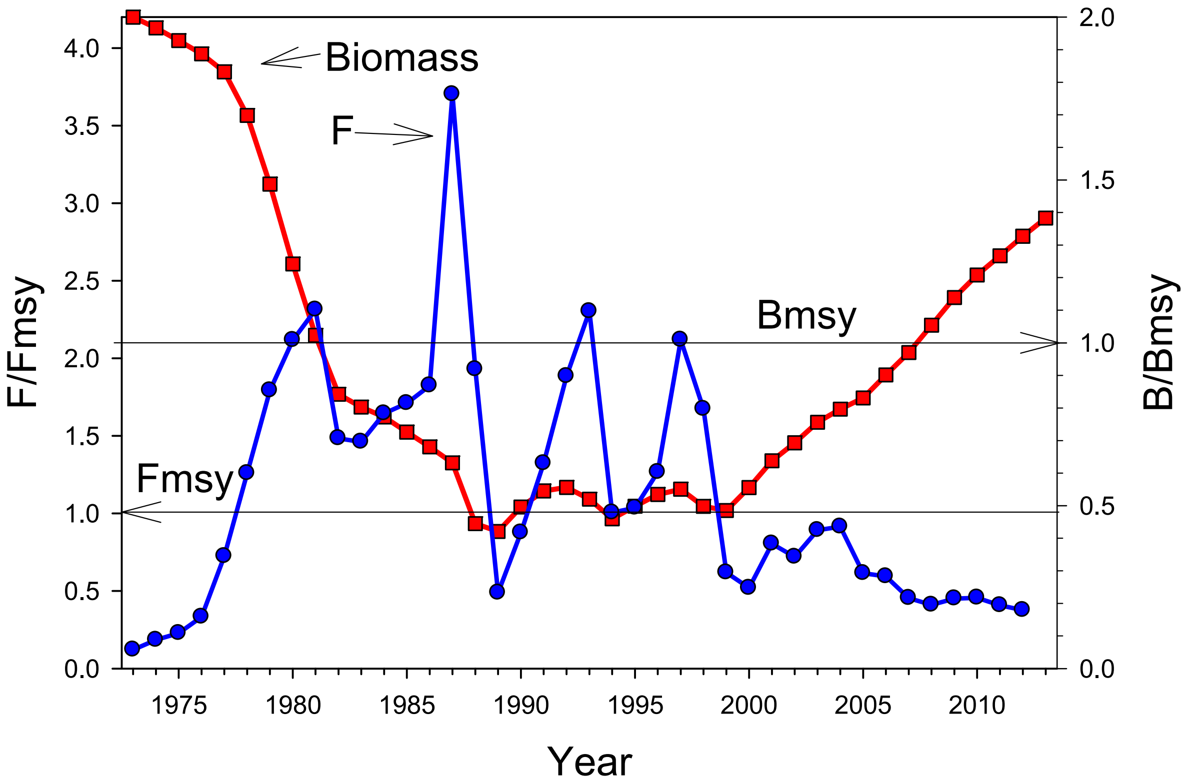


Figure B42. Working group final ASPIC model run which had a terminal year of 2012, added 1991-1994 data to the VTR series and fix the B1 ratio at K.

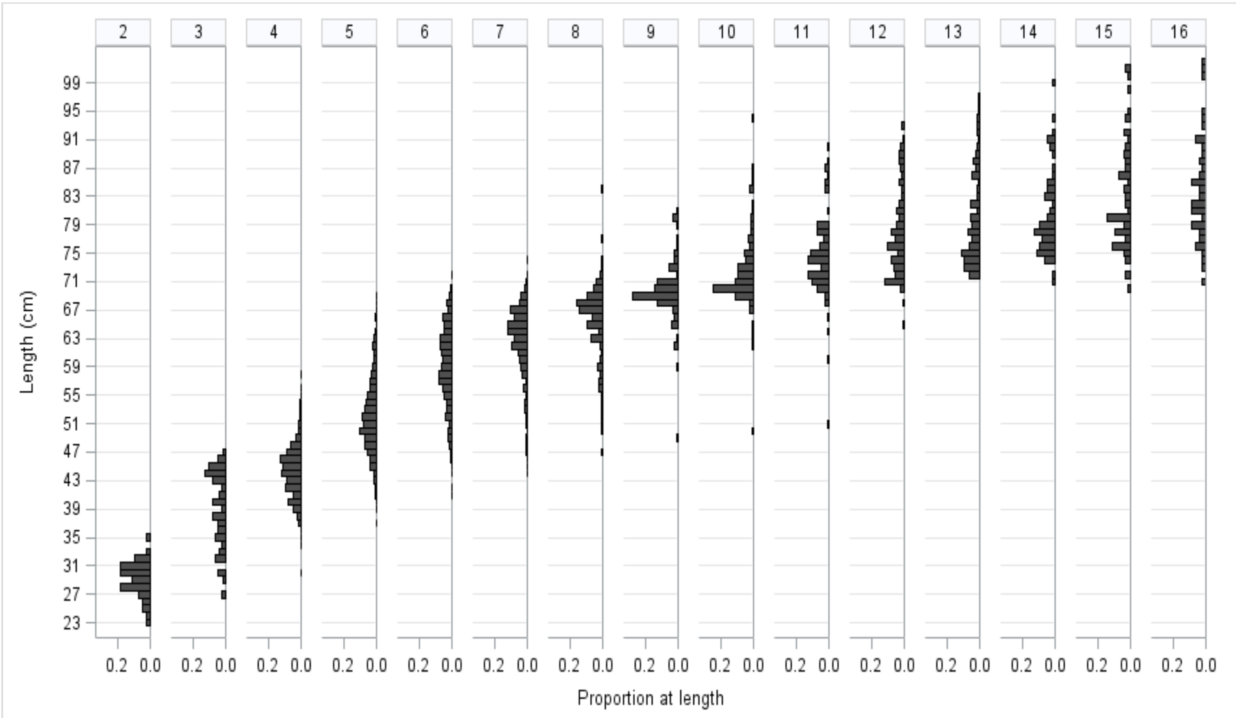


Figure B43. Distribution of lengths at age with all years combined.

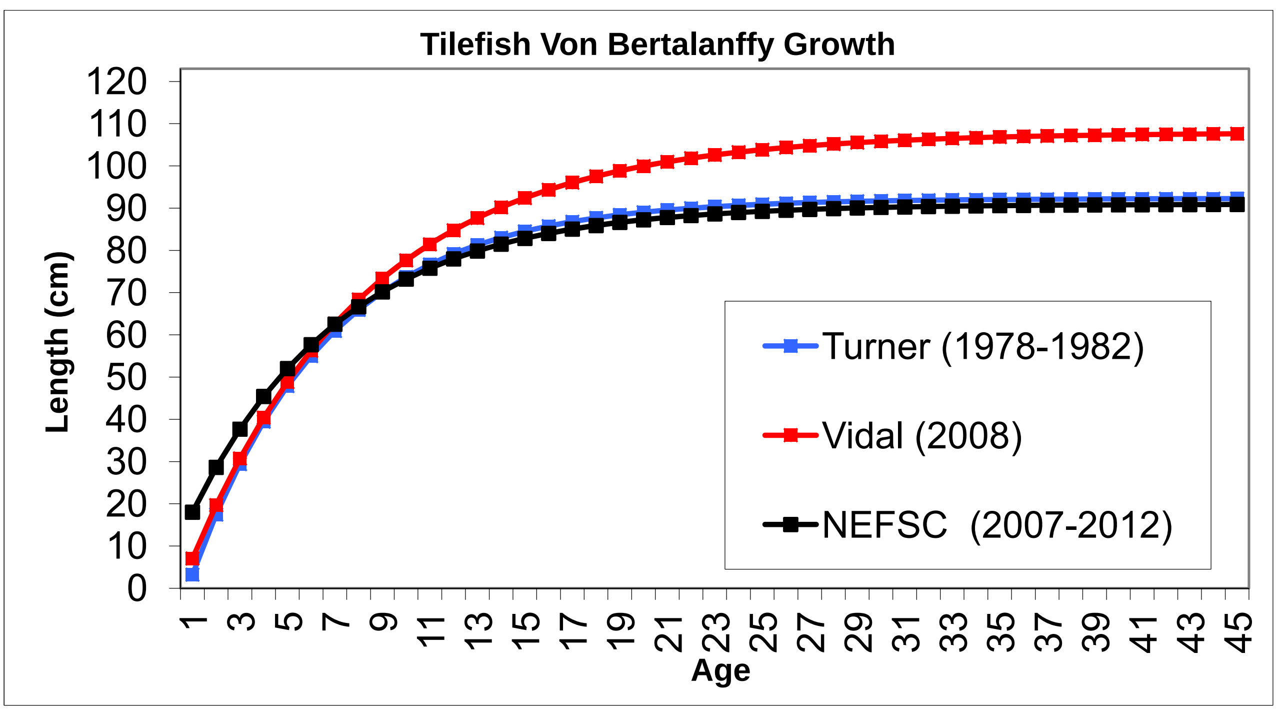


Figure B44. Comparison of von Bertalanffy growth curves from the three different growth studies.

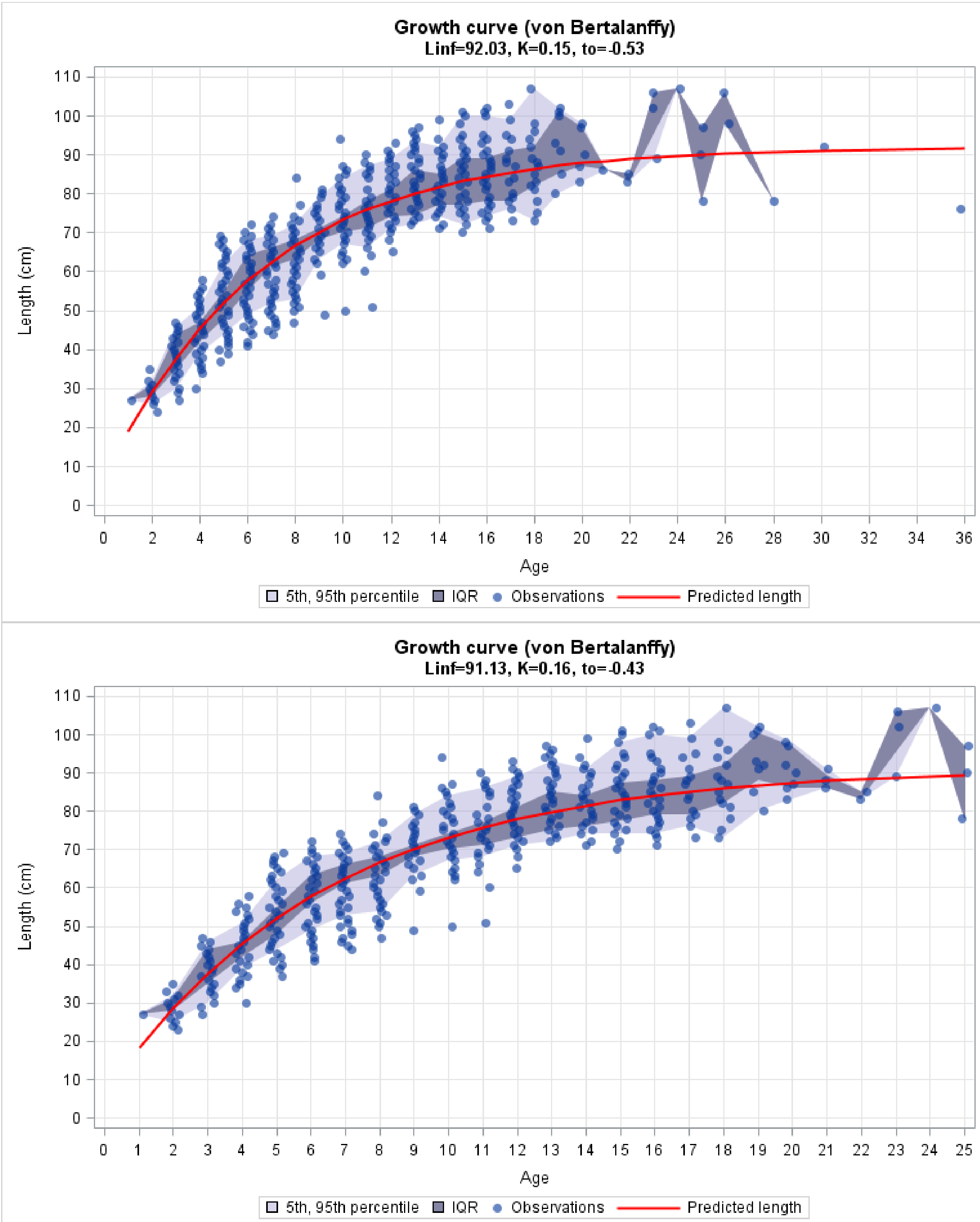


Figure B45. Estimated von Bertalanffy growth using all data (top) and data limited to fish younger the age 26 (bottom).

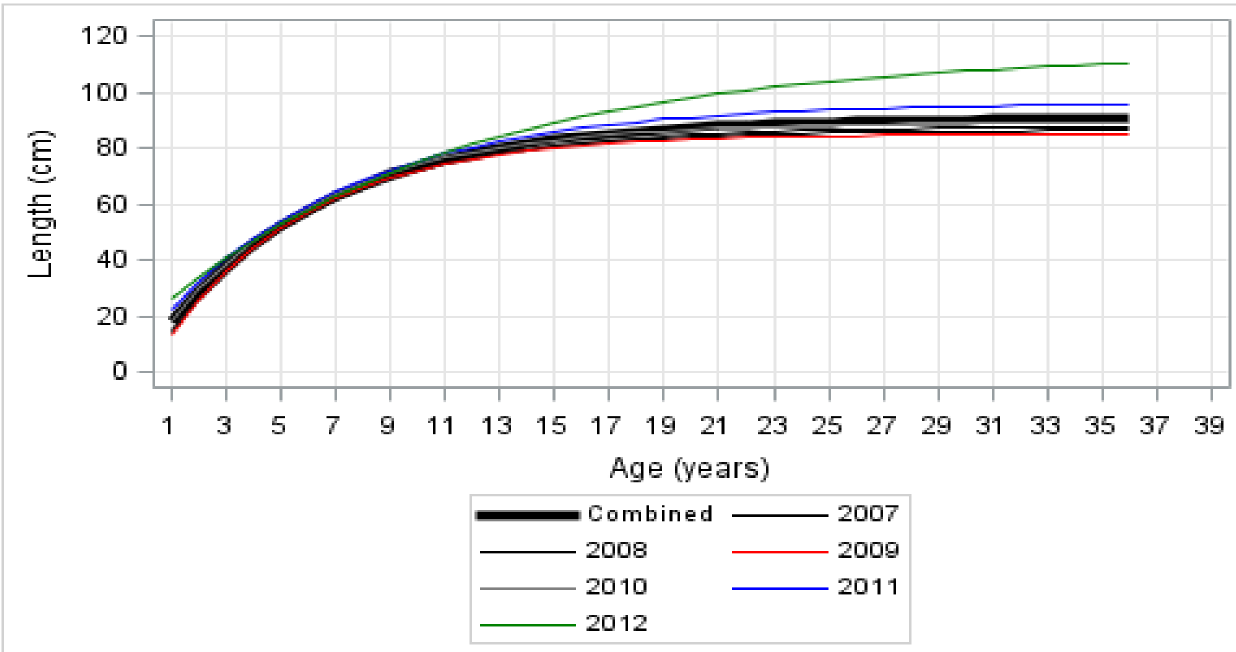


Figure B46. Comparison of annual von Bertalanffy growth curves.

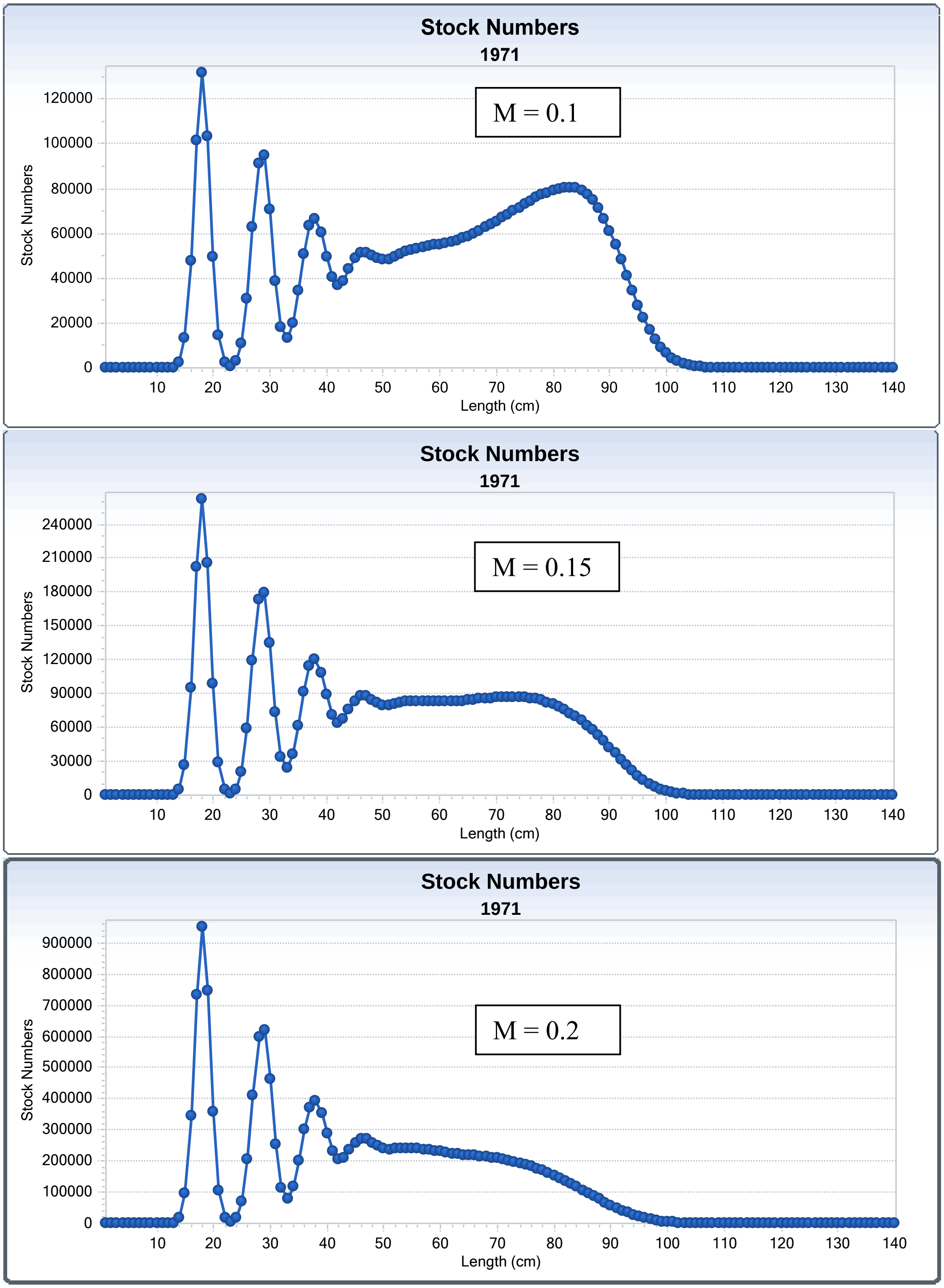
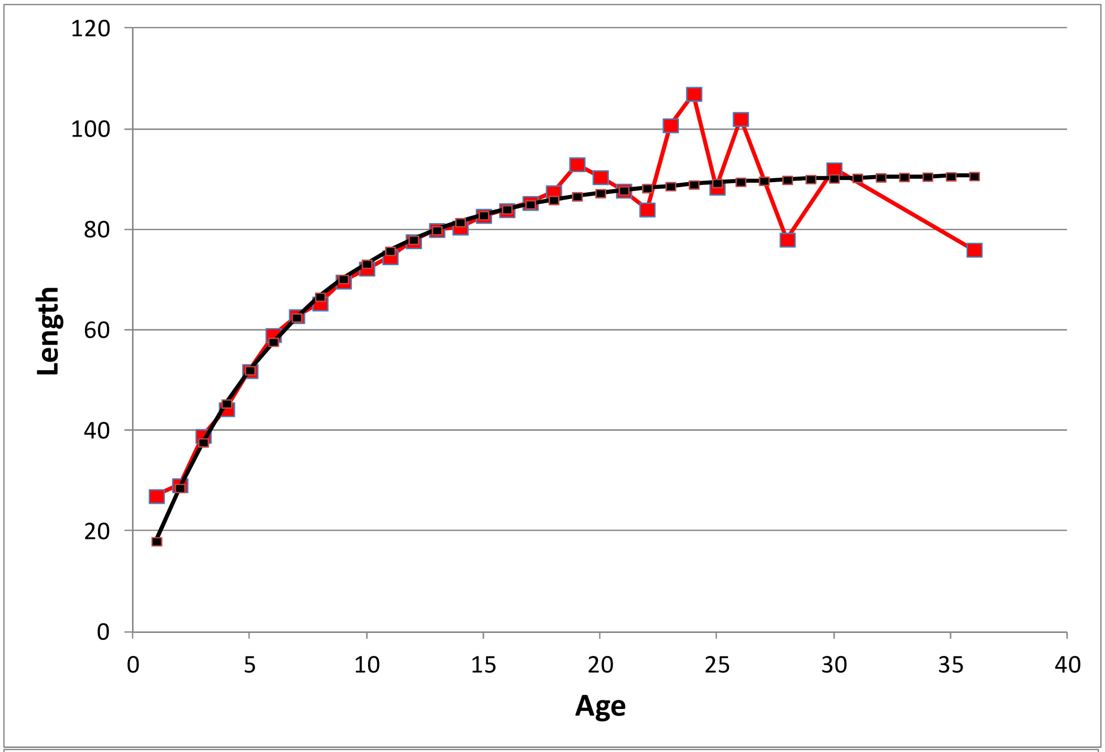


Figure B47. Equilibrium predicted virgin length distributions assuming no fishing and m=0.1, 0.15 and 0.2.



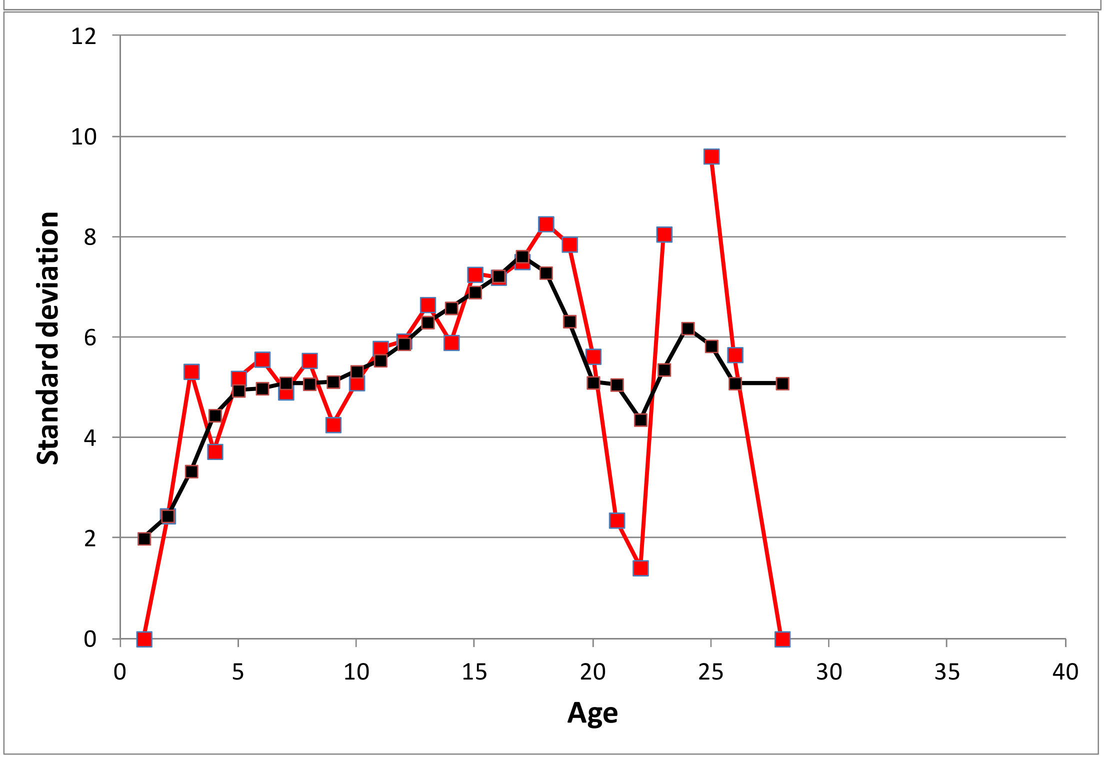


Figure B48. Comparison of the von Bertalanffy curve with the raw mean lengths at age (top) and the standard deviation at age with a centered 5 age moving average (bottom) for all years combined.

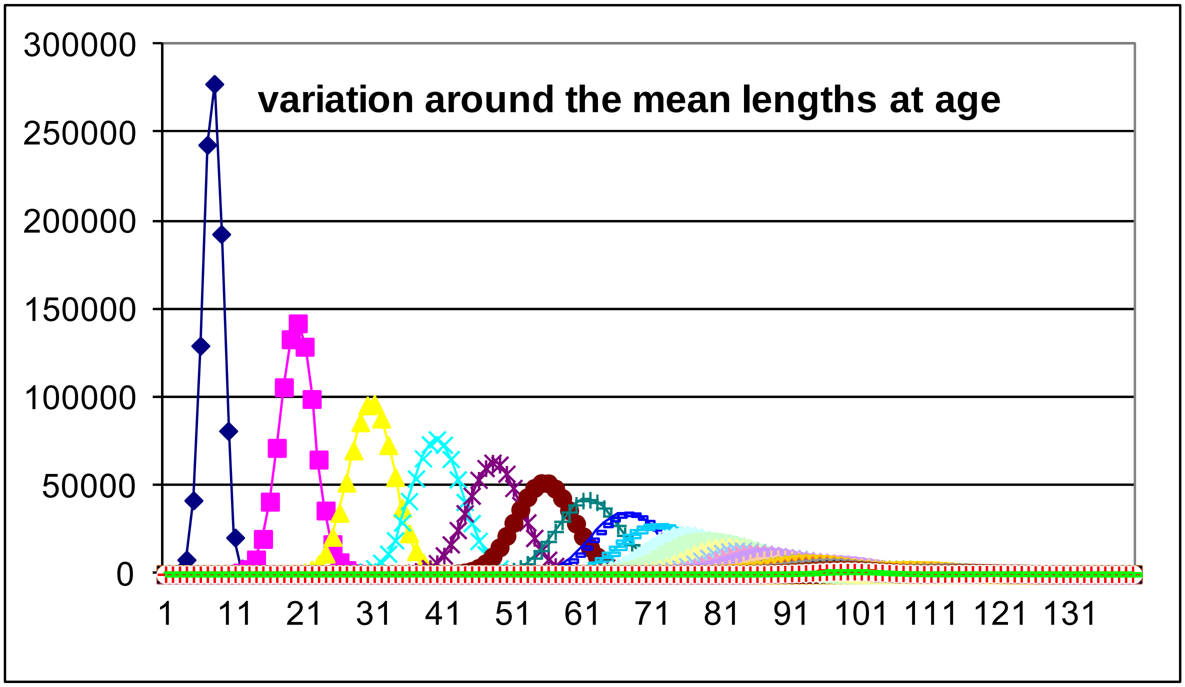


Figure B49. Resulting distributions at age from input variation on the mean lengths at age used in the SCALE model.

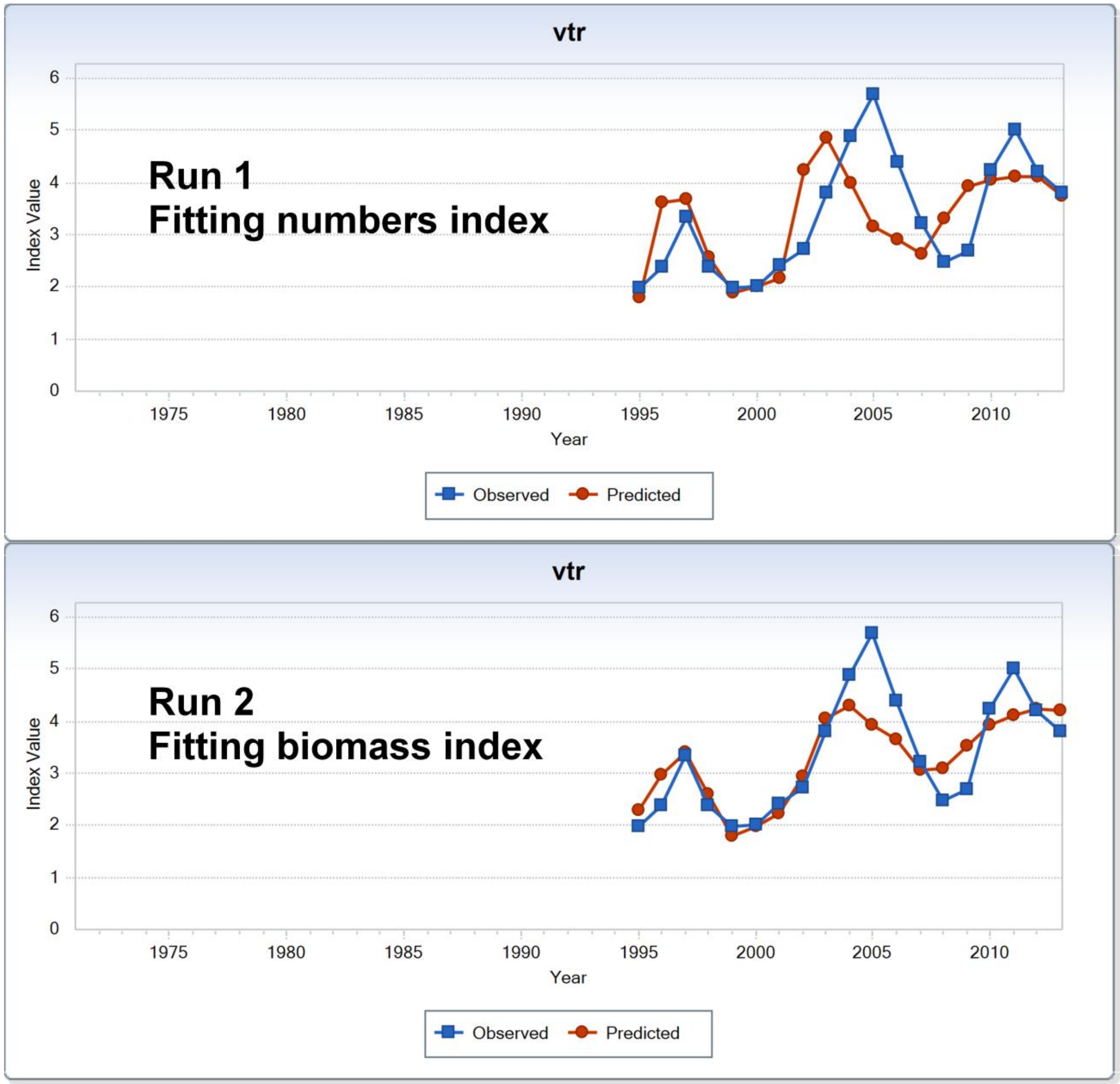


Figure B50. Comparison of fits using the incorrect numbers fit to the VTR biomass CPUE index (top) vs the correct fit to predicted biomass (bottom).

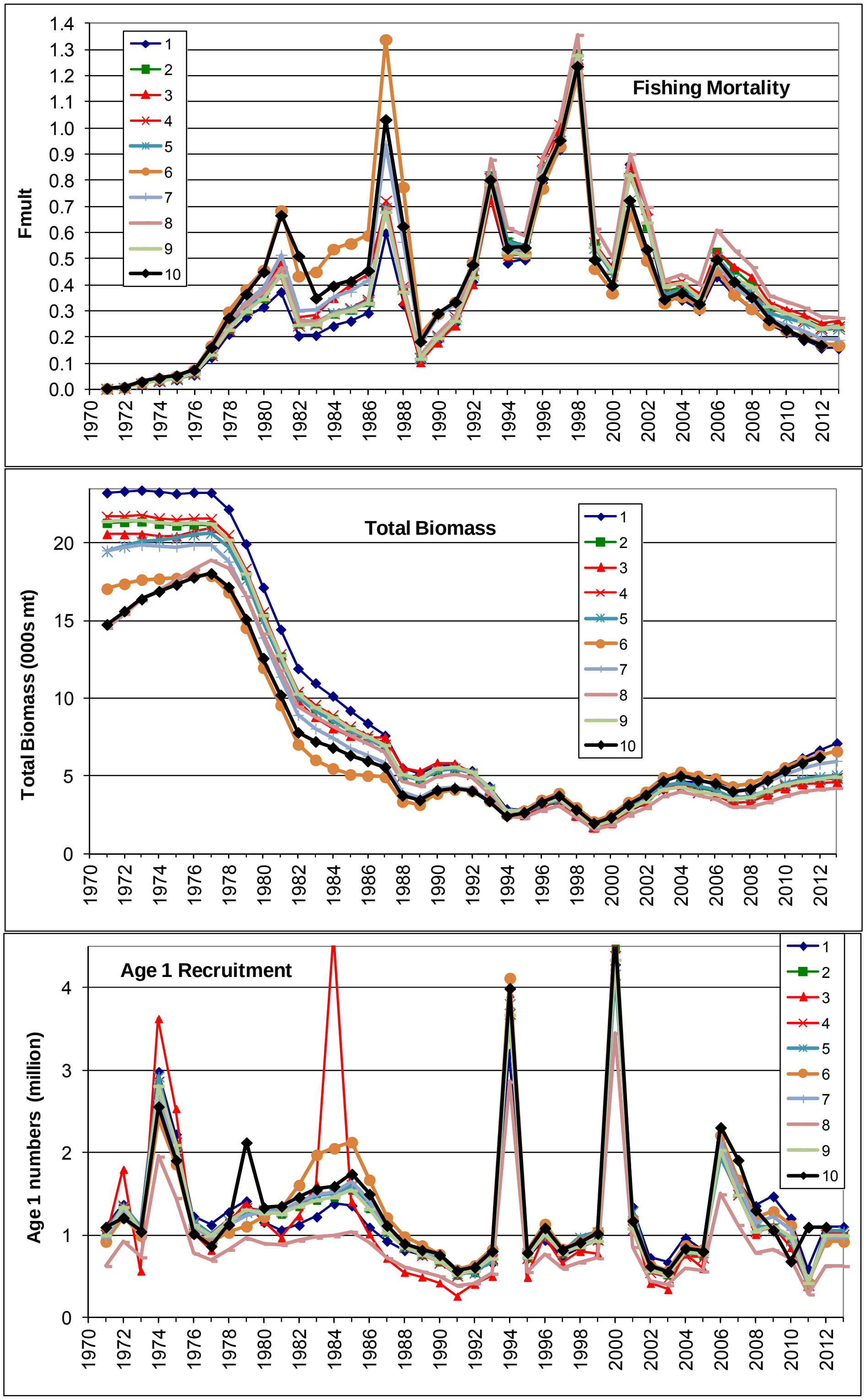


Figure B51. Sensitive SCALE runs comparing fishing mortality, total biomass, and age-1 recruitment.

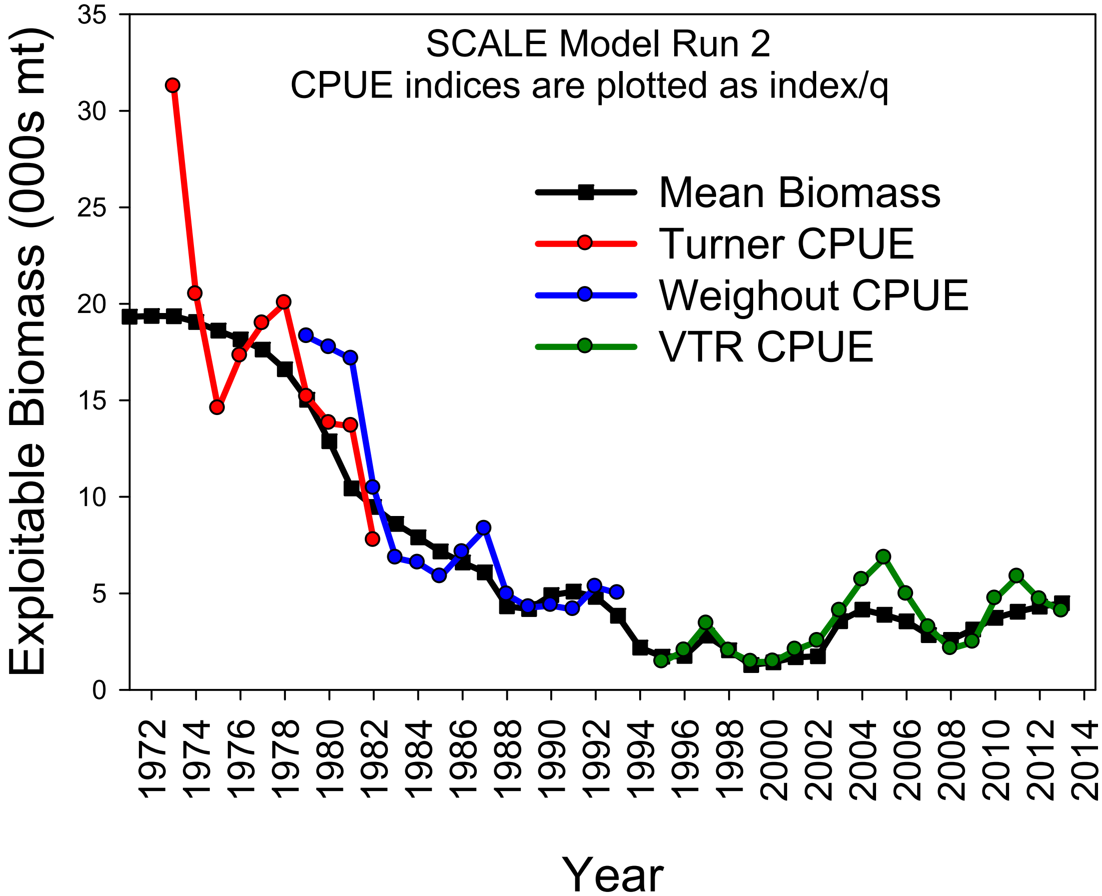


Figure B52. Comparison of the estimated exploitable biomass with the CPUE index / q for SCALE run2. A large change in q occurs between the Weighout and VTR series which results in lower biomass.

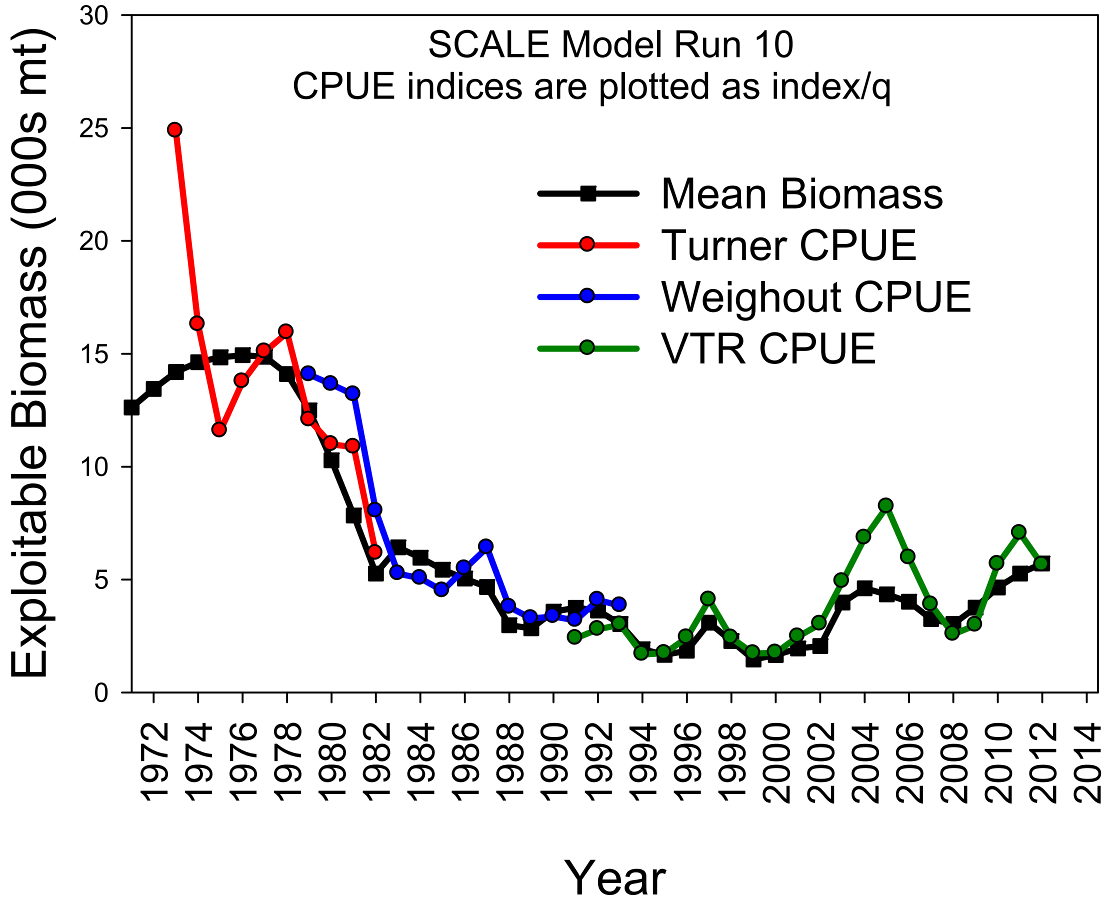


Figure B53. Comparison of the estimated exploitable biomass with the CPUE index / q for SCALE run10. The additional CPUE data form 1991-1994 results in less change in the q between the Weighout and VTR series.

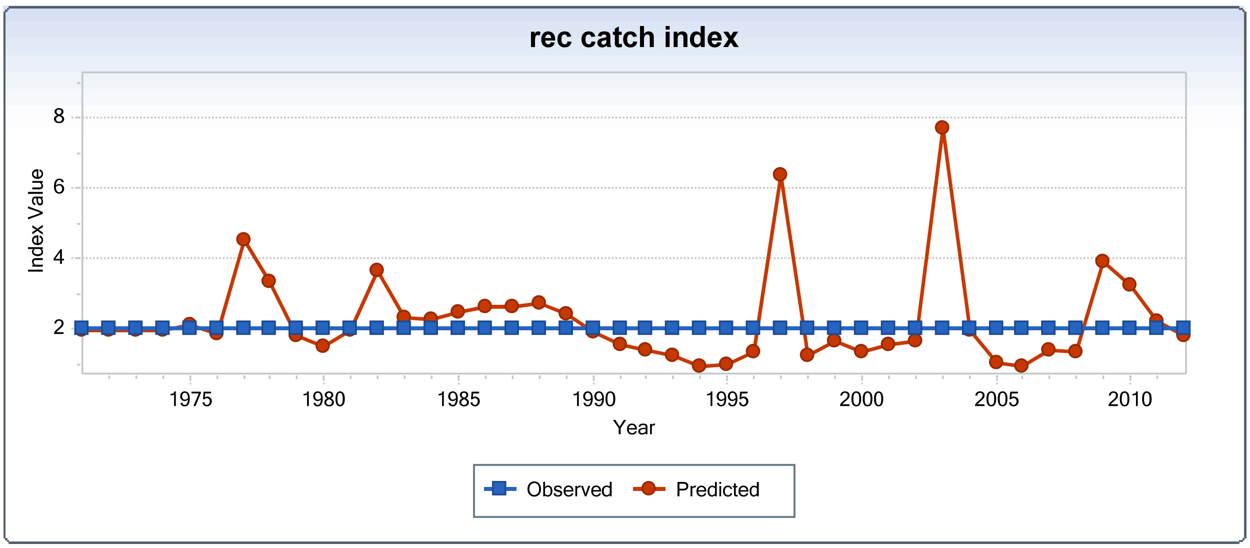


Figure B54. Working group final SCALE run 10 straight line age (recruitment) index which was used since an age index does not exist for this stock.

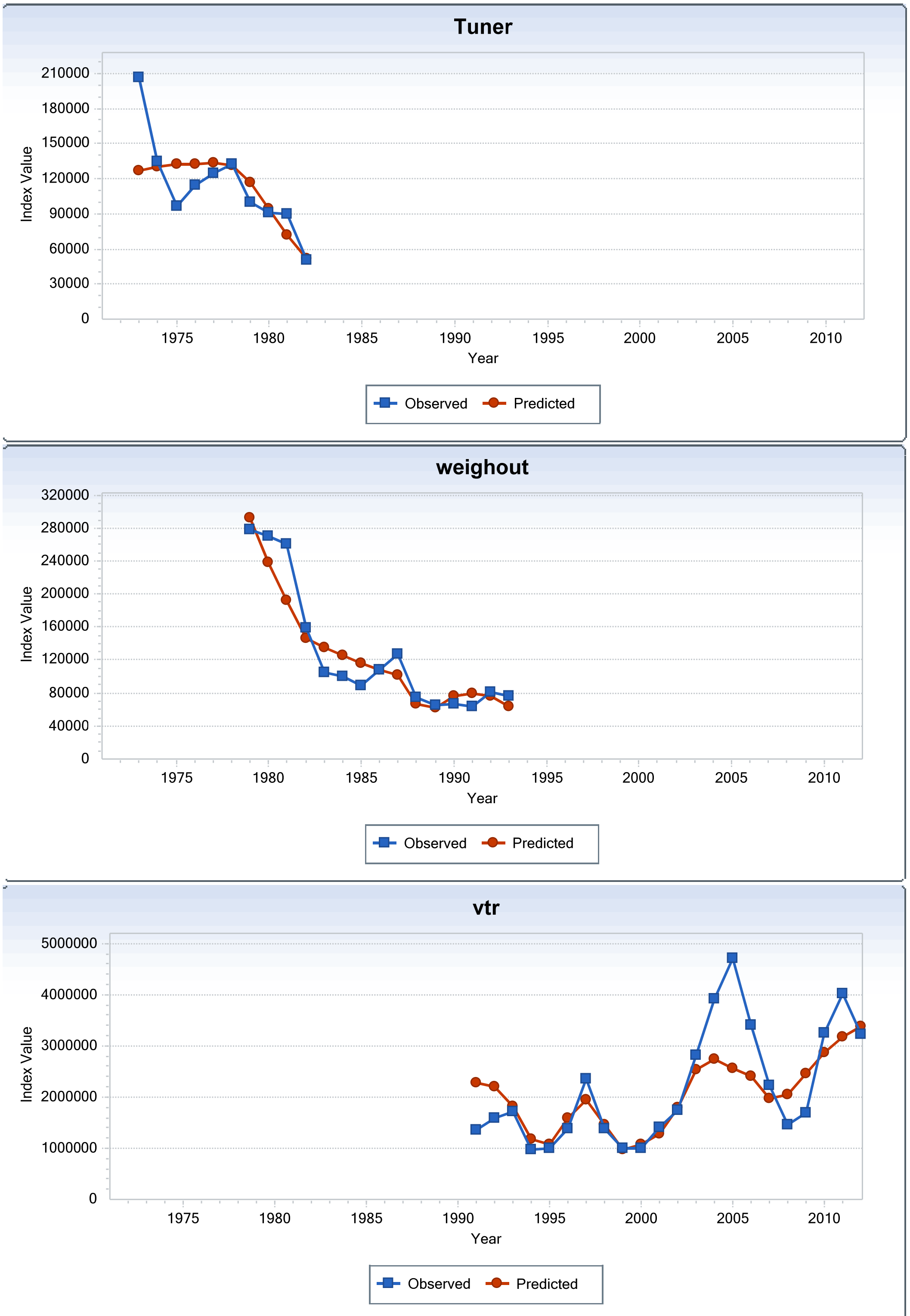


Figure B55. Working group final SCALE run 10 fit to the three CPUE indices.

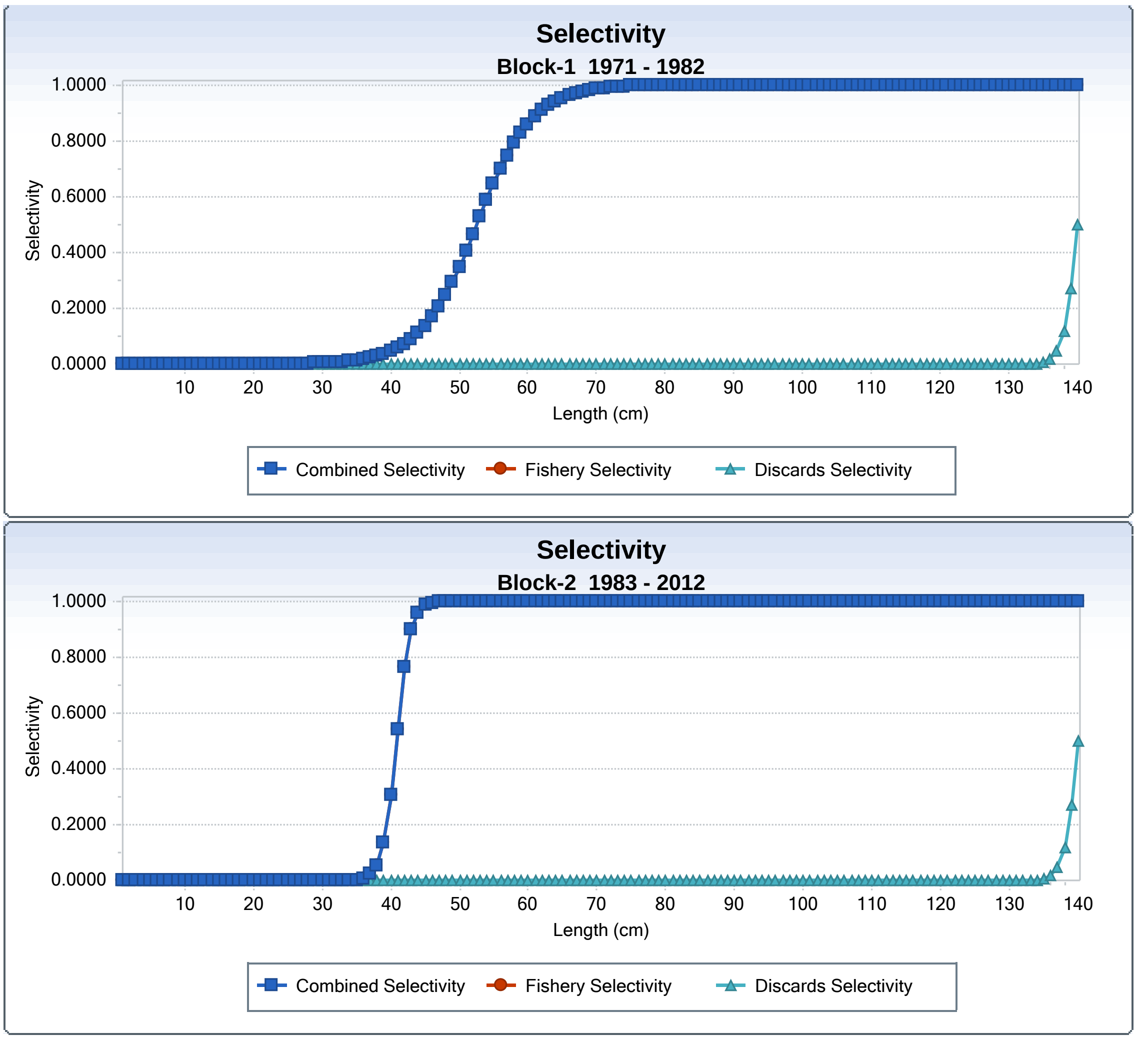


Figure B56. Working group final SCALE run 10 flattop estimated selectivity at length curves.

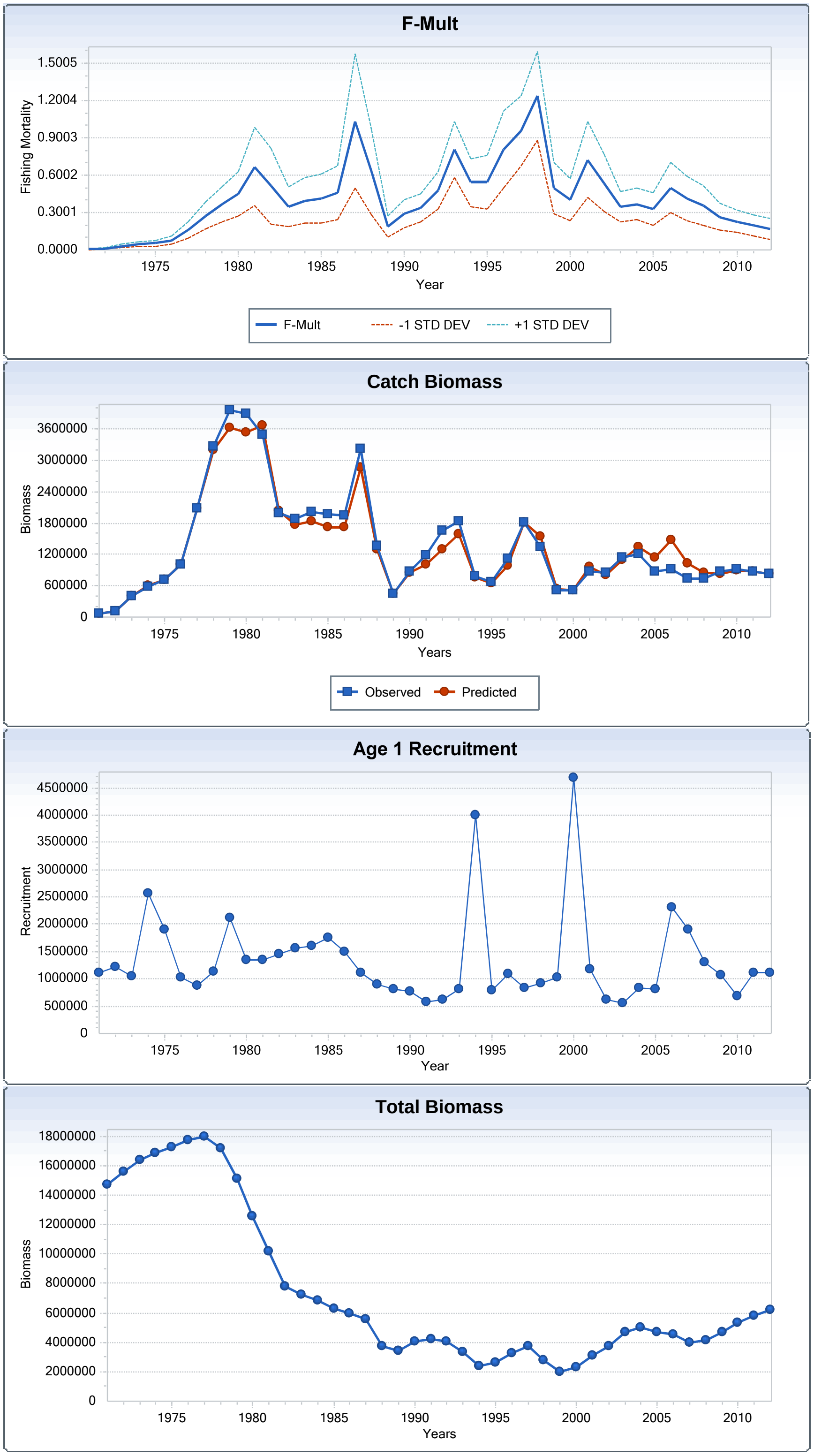


Figure B57. Working group final SCALE run 10 estimated F, fit to the catch, estimated recruitment, and total biomass.

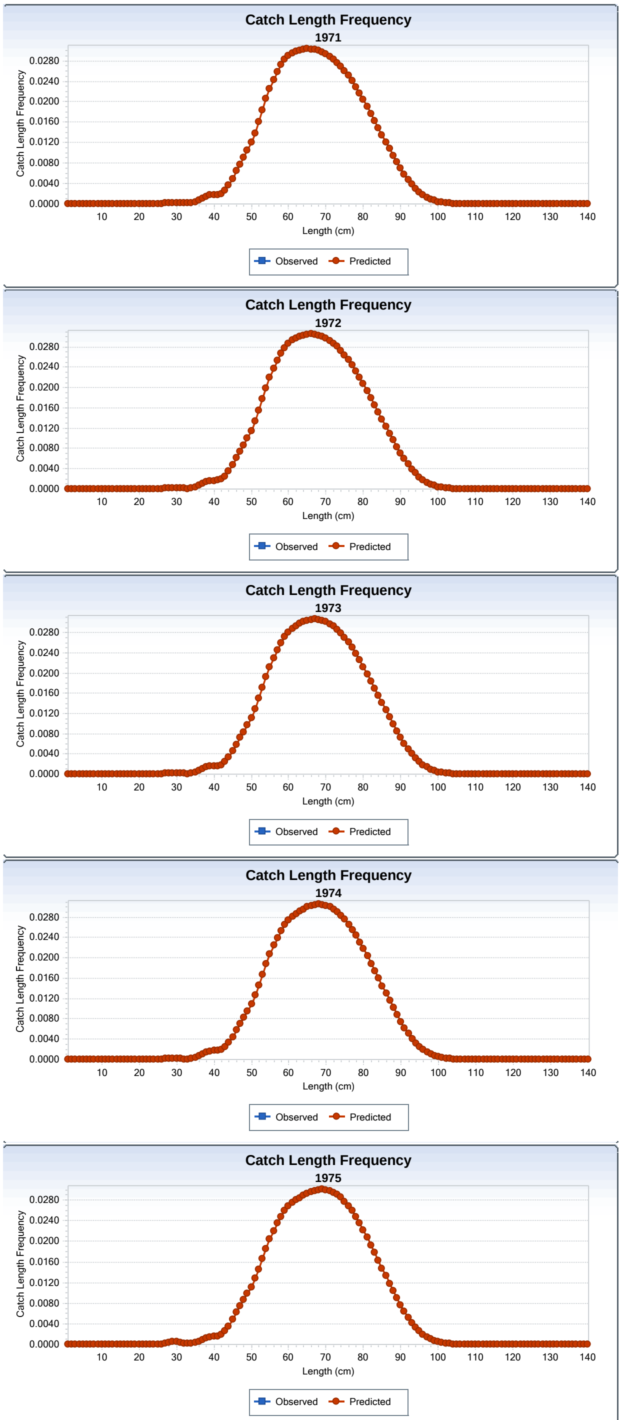


Figure B58. Working group final SCALE run 10 predicted (red) and observed (blue) catch distributions by year. Years which do not have data are also shown.

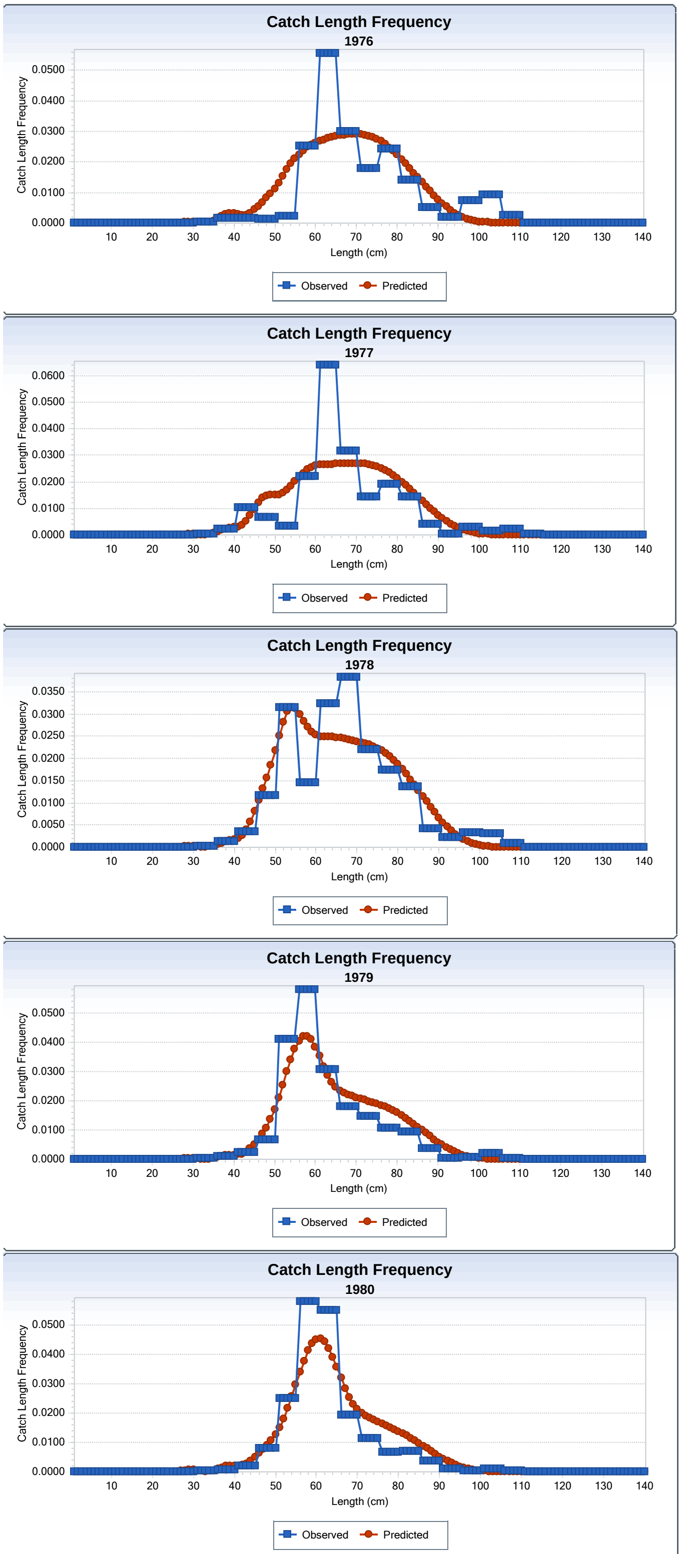


Figure B58. cont.

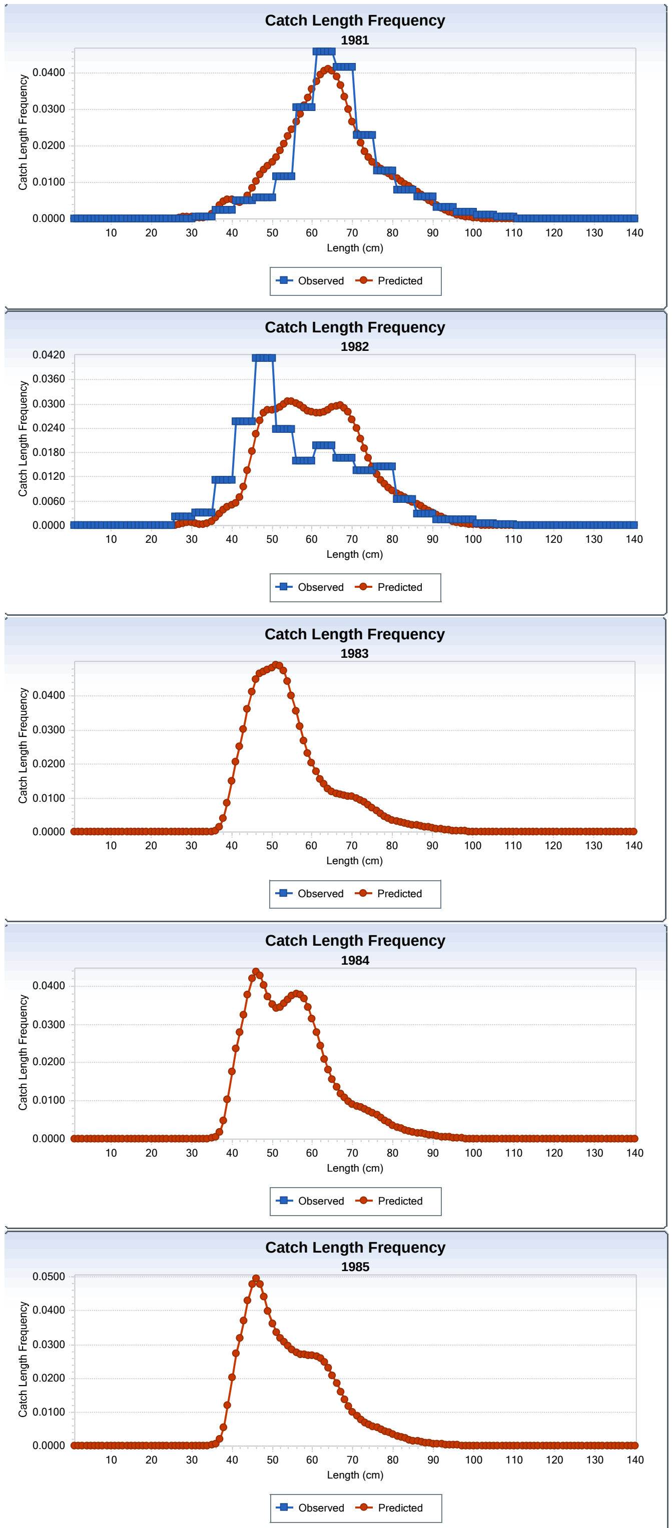


Figure B58. cont.

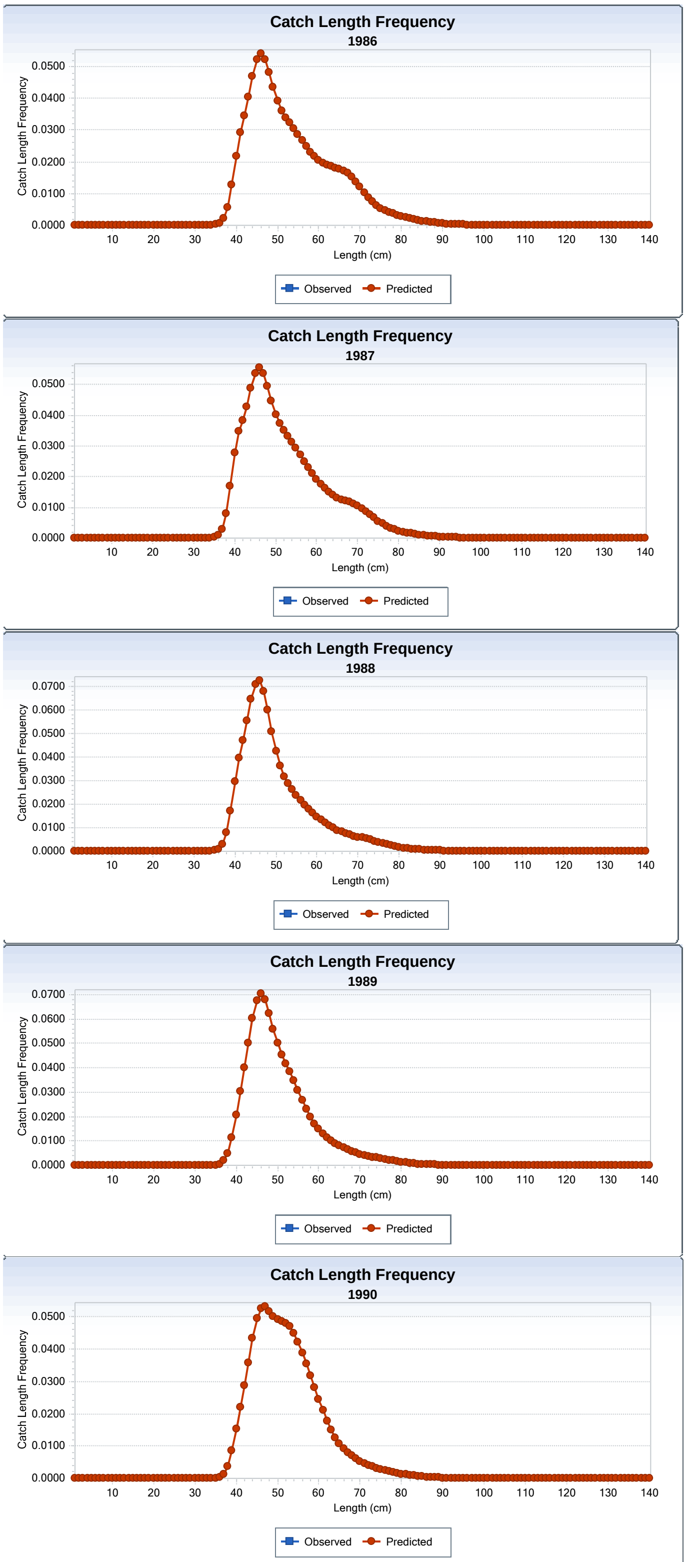


Figure B58. cont.

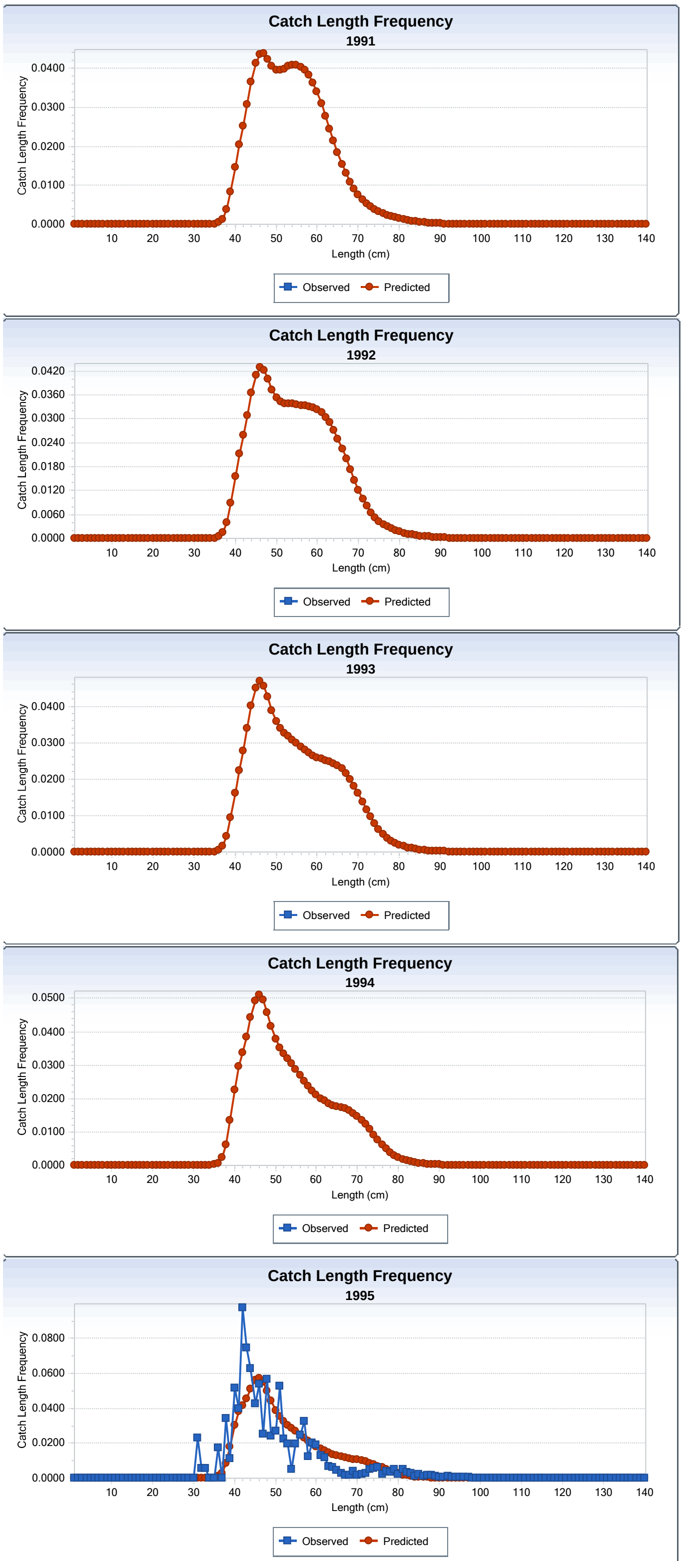


Figure B58. cont.

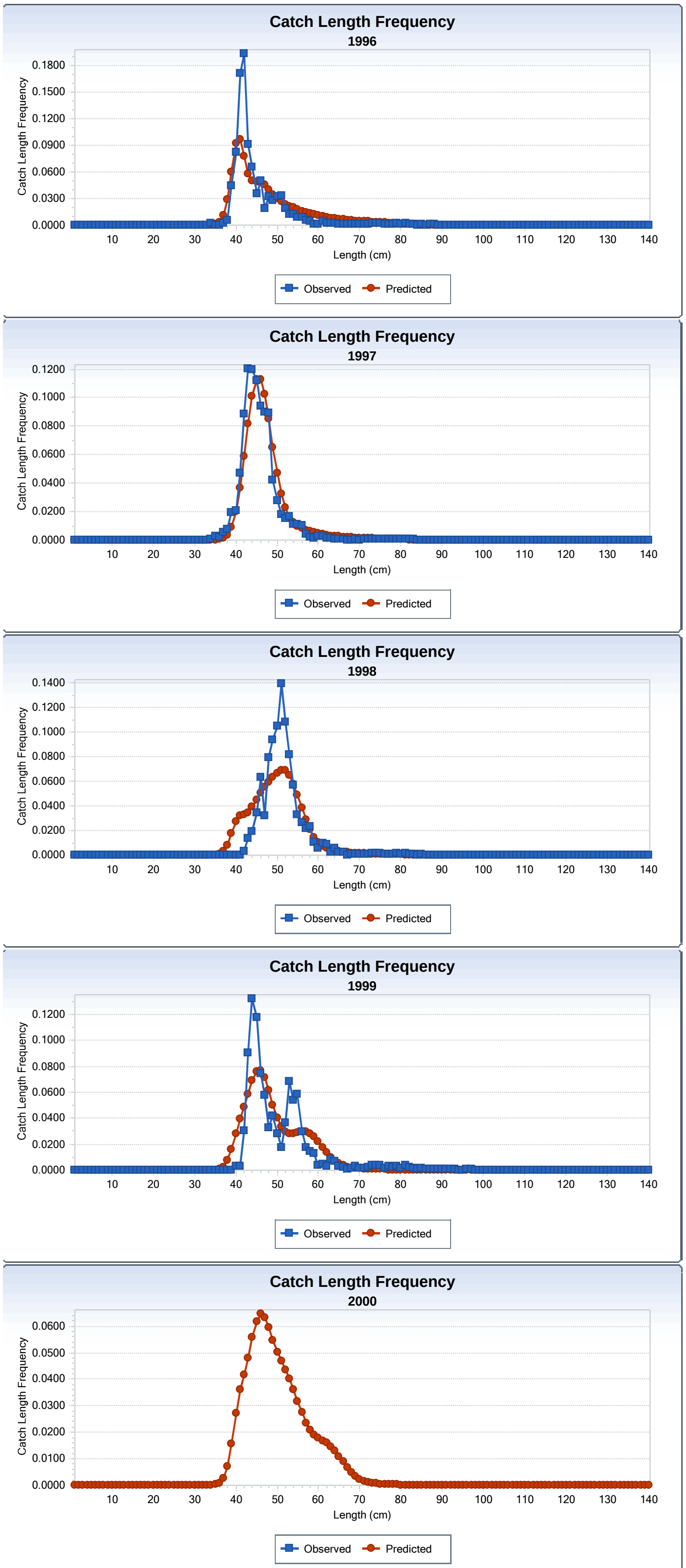


Figure B58. cont.

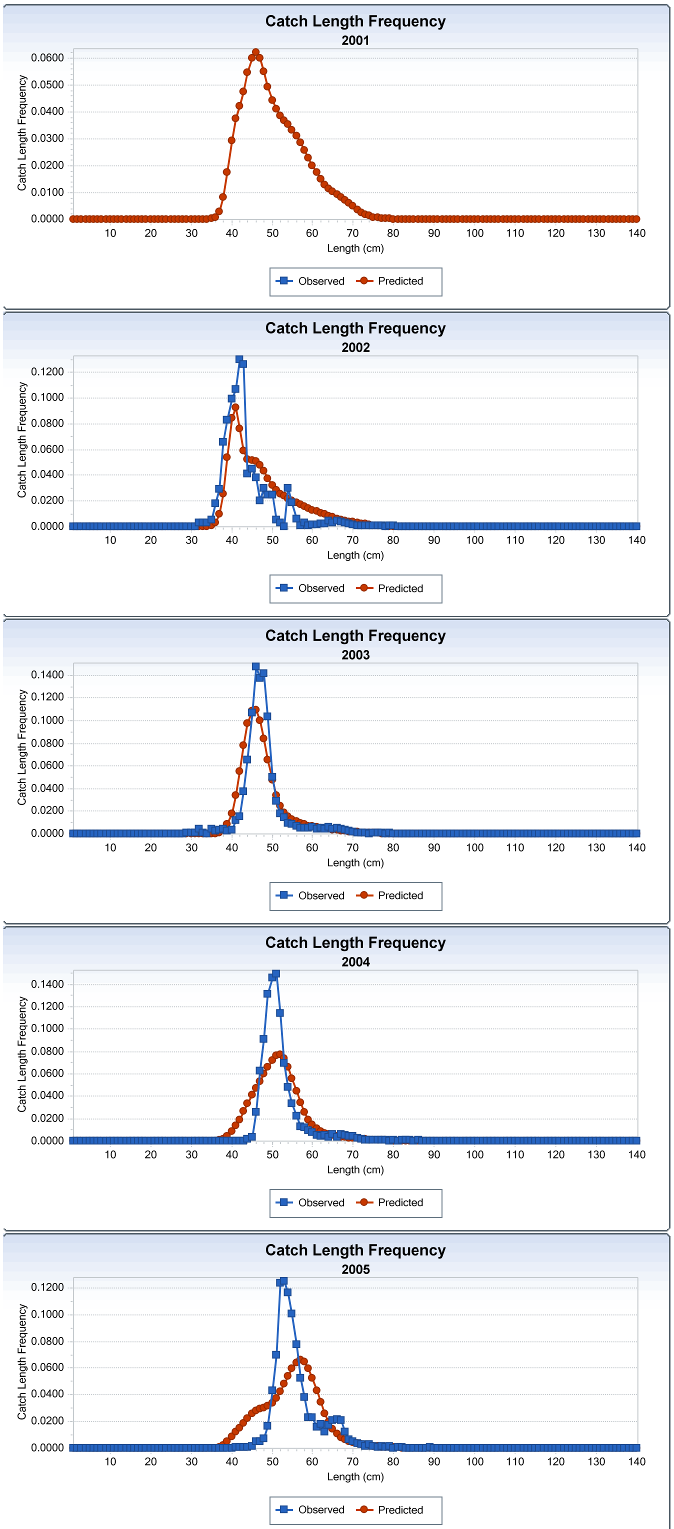


Figure B58. cont.

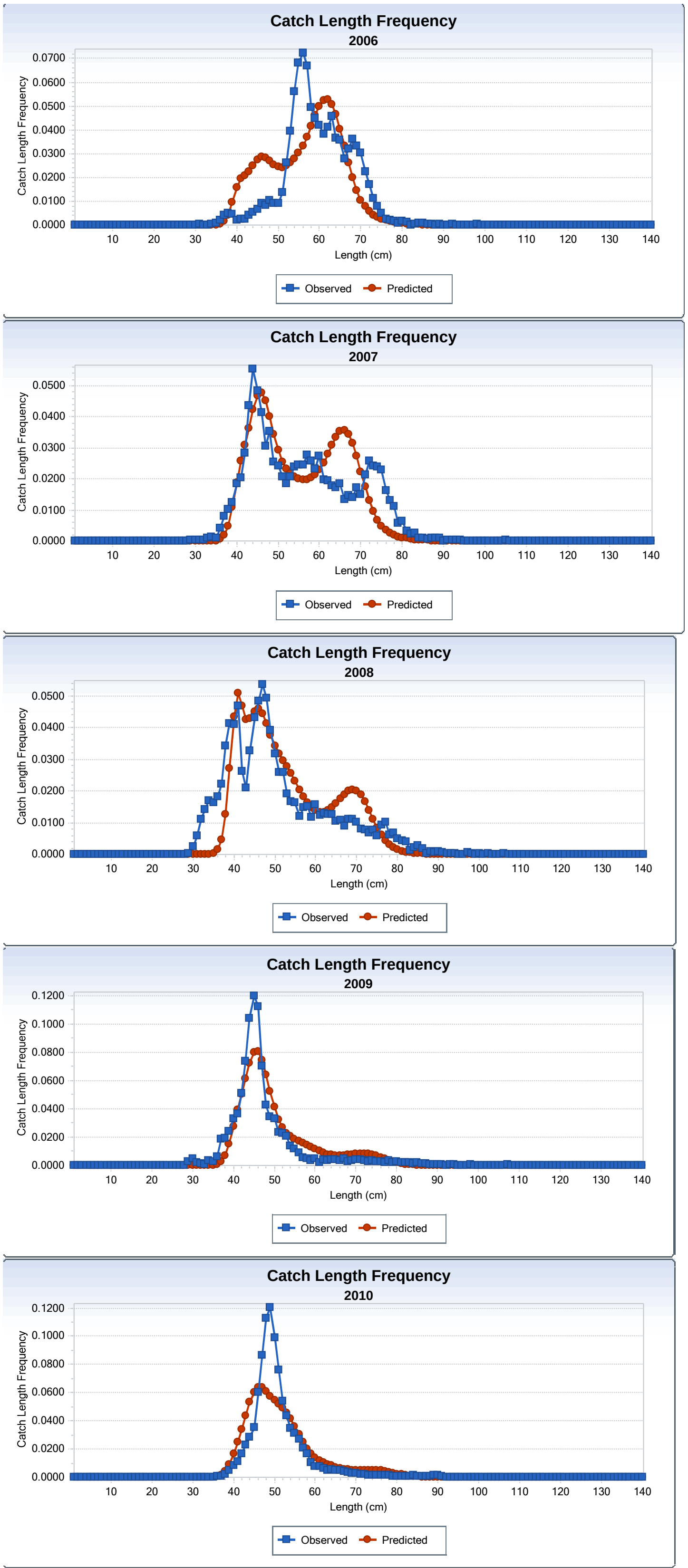
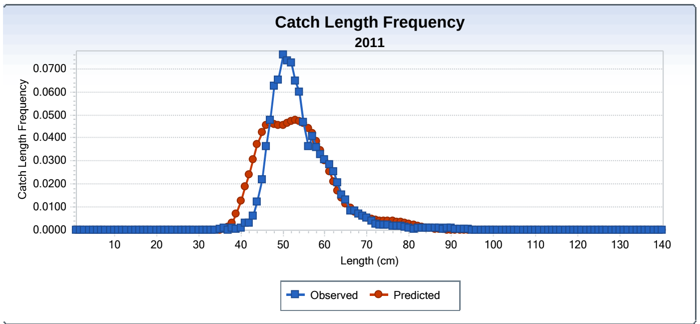


Figure B58. cont.

Catch Numbers Length Frequency, Year 1993



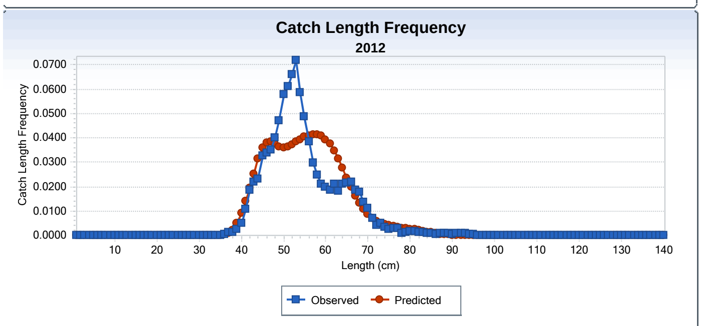


Figure B58. cont.

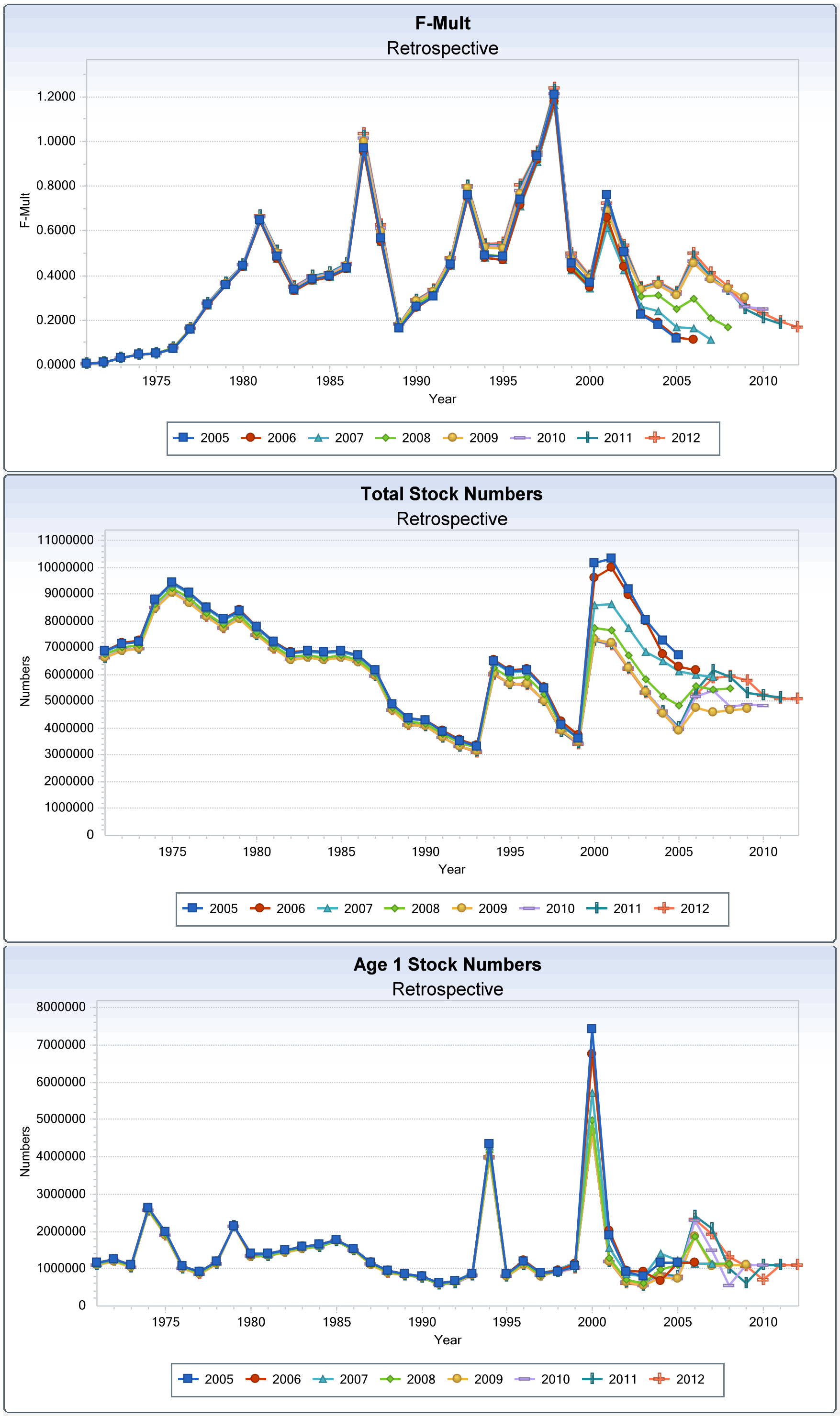


Figure B59. Working group final SCALE run 10 retrospective pattern.

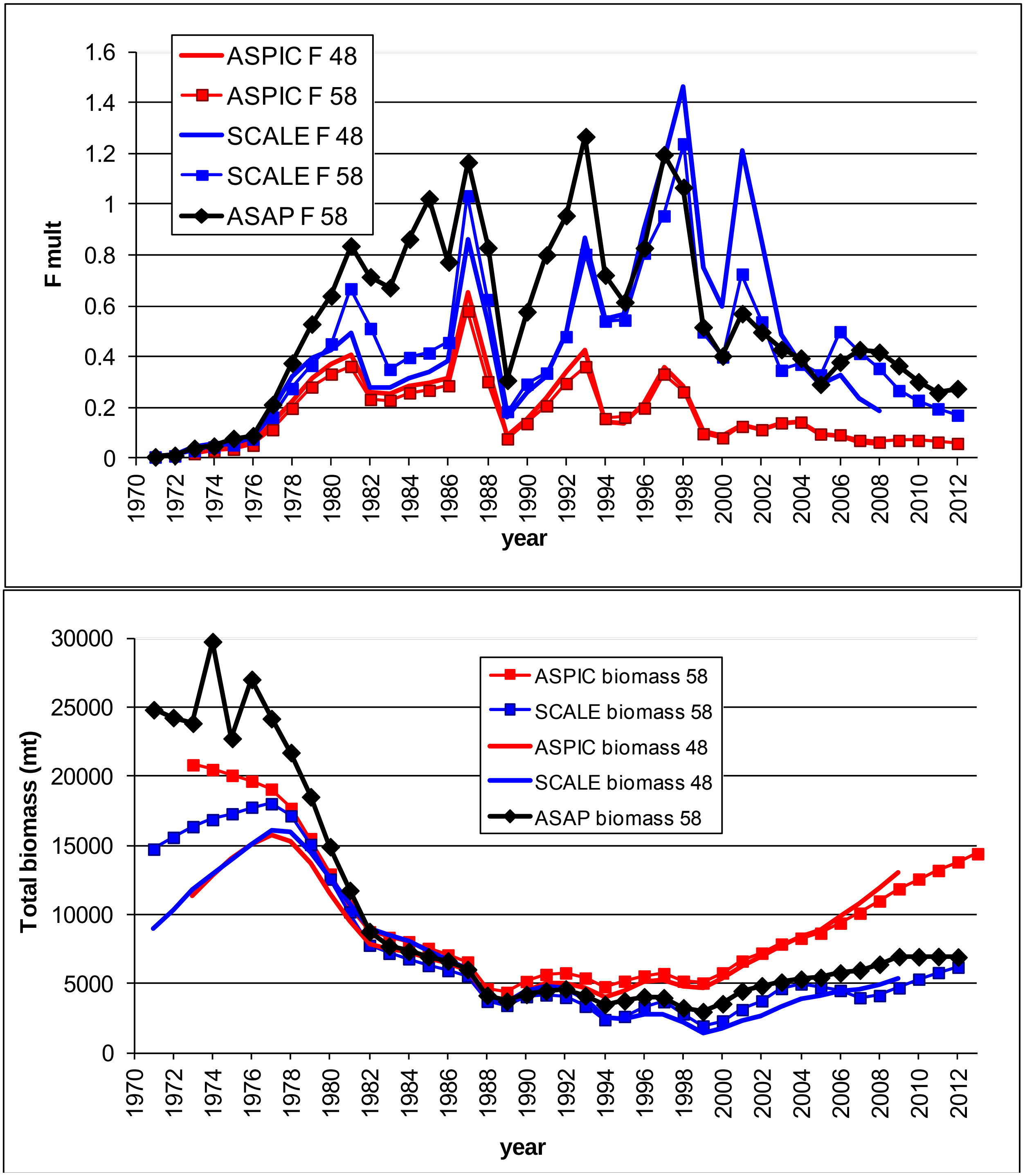


Figure B60. Comparison of the final SARC 48 and SARC 58 ASPIC and SCALE models and the new SARC 58 final ASAP model for total biomass and fishing mortality.

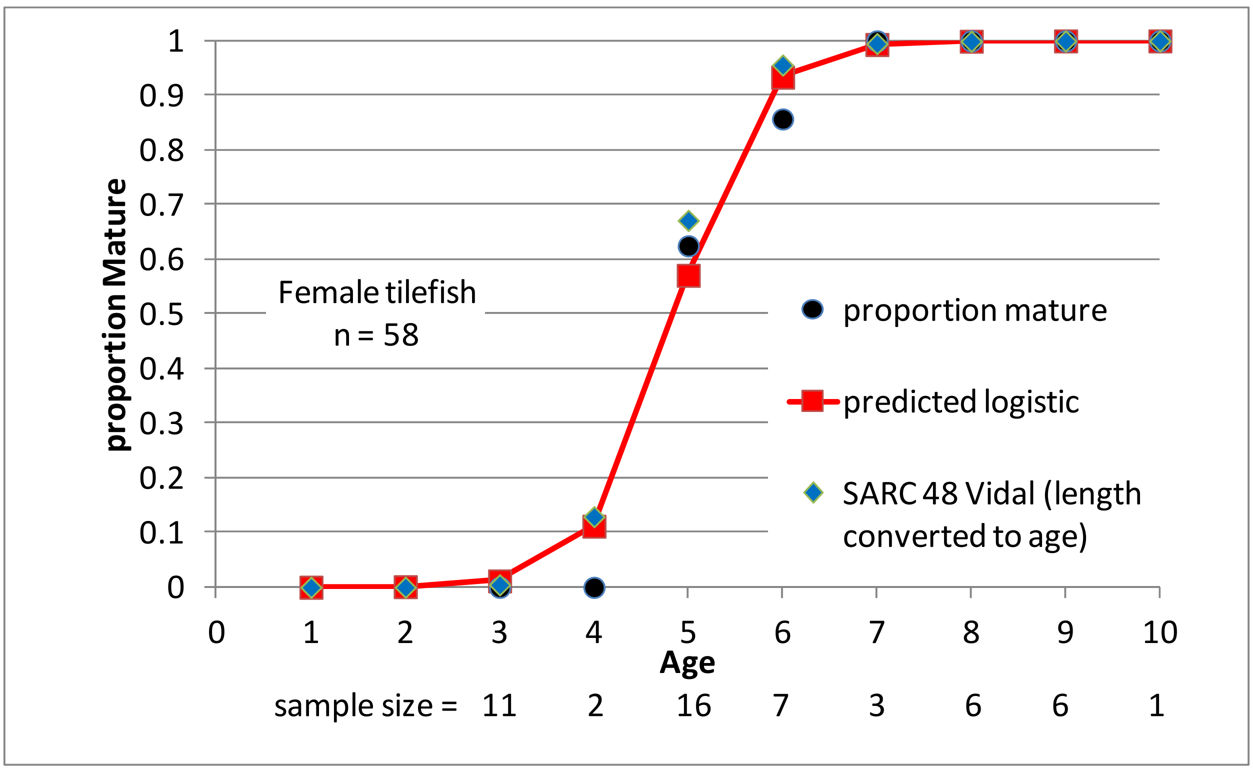


Figure B61. Maturity at age curves from Vidal (SARC 48) and McBridge et al. (2013).

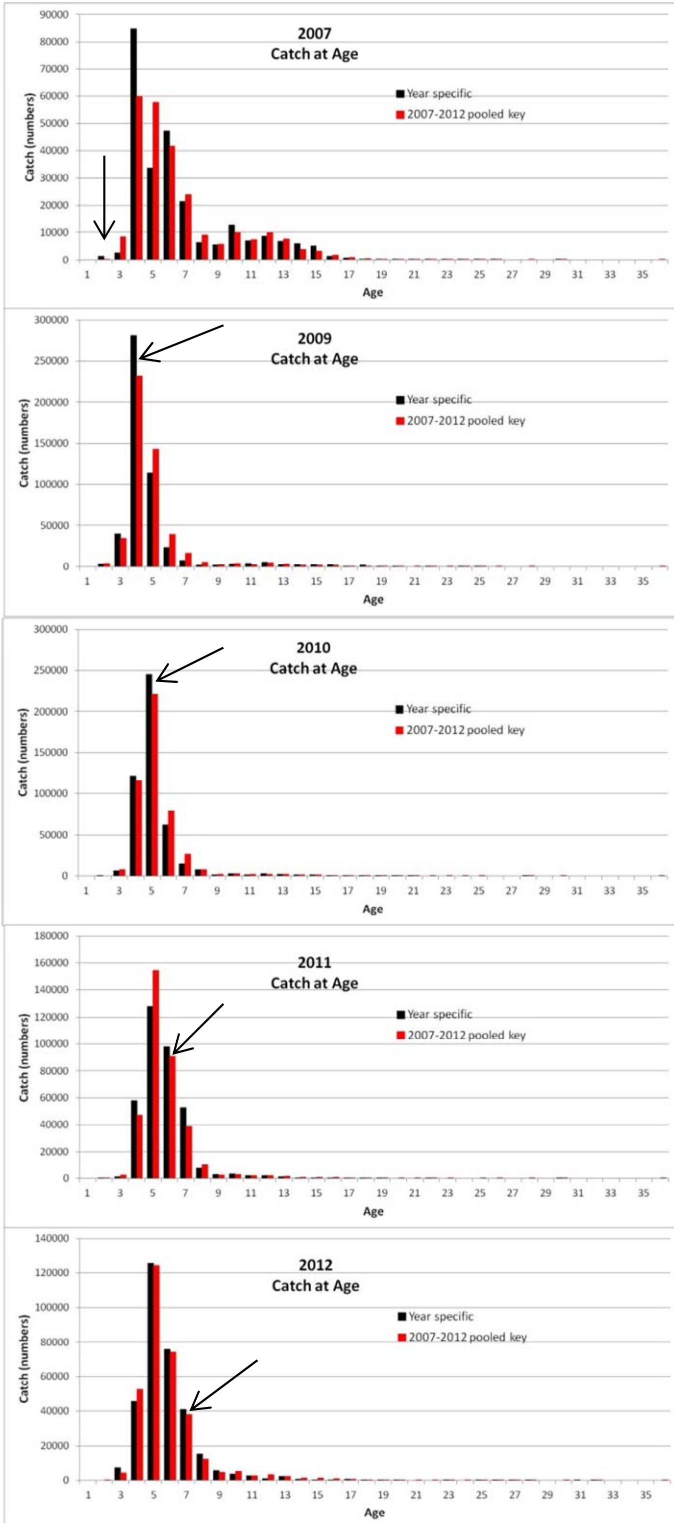


Figure B62. Comparison of catch at age using the pool age length key and using year specific keys for years where age data exists. 2008 did not have enough small fish aged to estimate a year specific catch at age. Arrows show the tracking of the 2005 year class.

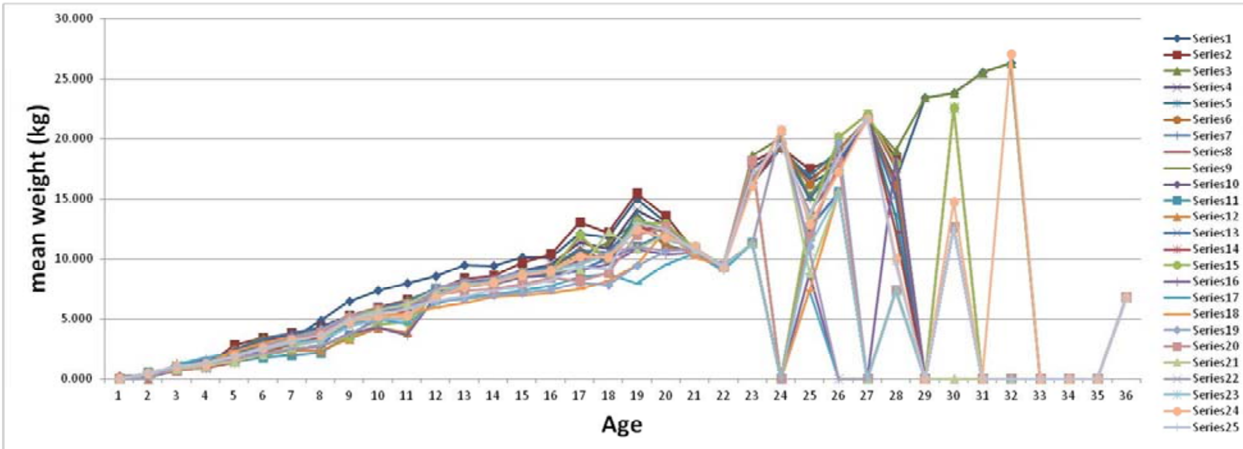
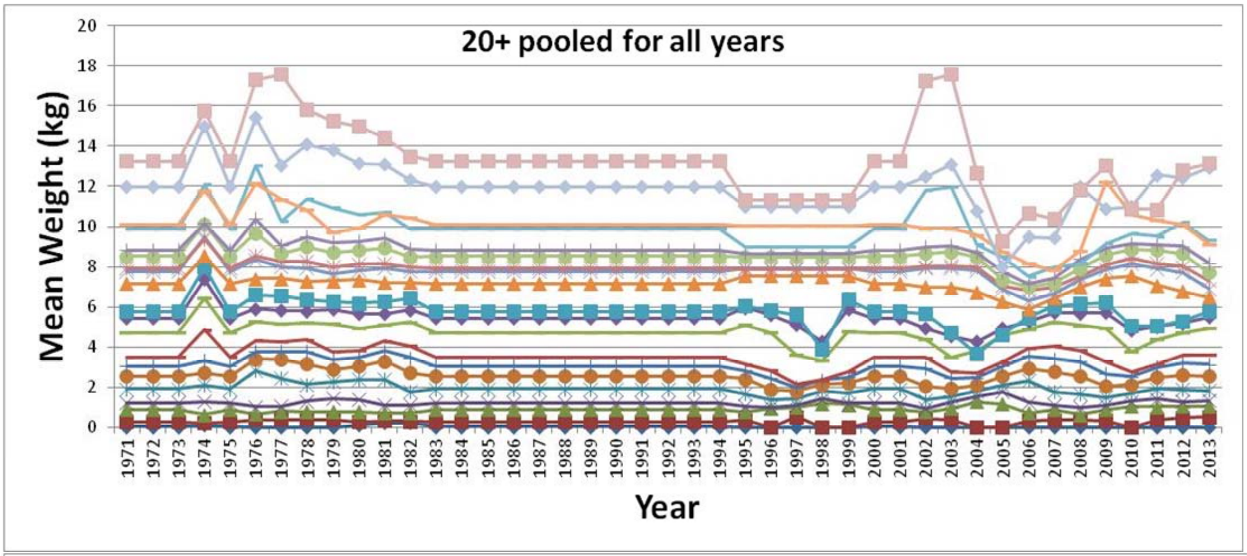


Figure B63. Mean weight at age. Each series represents a year in the time series. Estimates become variable at ages older than 20 where there is limited information.



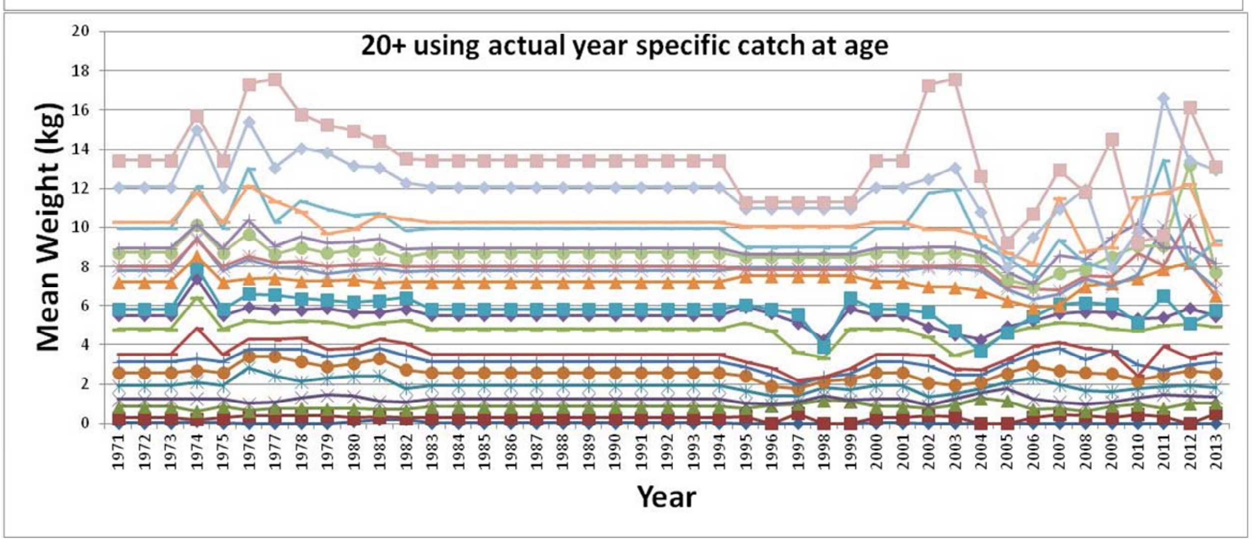
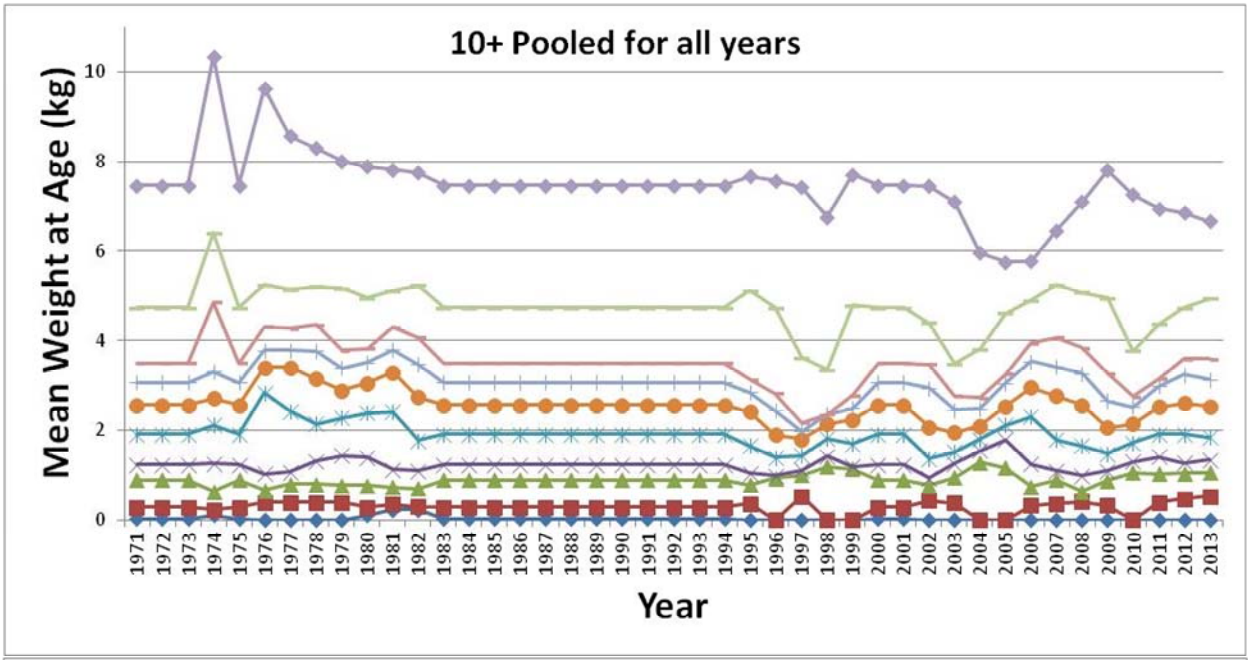


Figure B64. Mean weights at age of the 20+ formulation using a pool age length key for all years (top) and using year specific key in years were data exists (2007,2009-2012) (bottom). The average of years which have data was used for years with missing information.



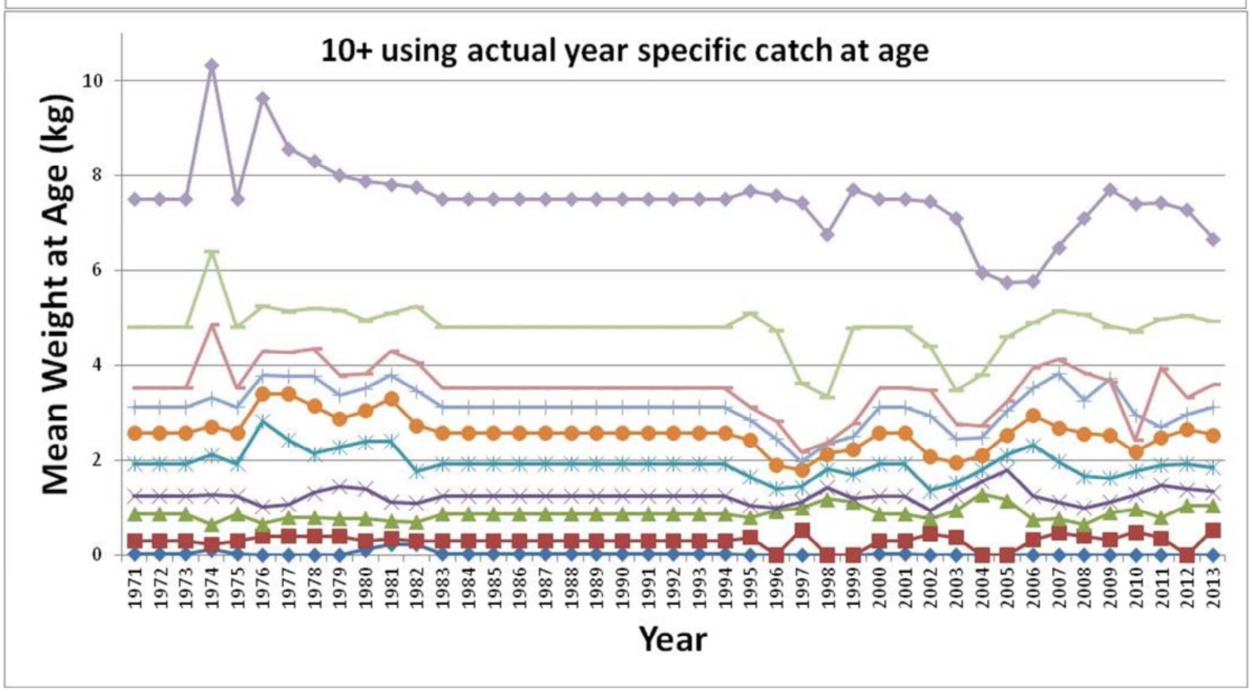


Figure B65. Mean weights at age of the 10+ formulation using a pool age length key for all years (top) and using year specific key in years were data exists (2007,2009-2012) (bottom). The average of years which have data was used for years with missing information.

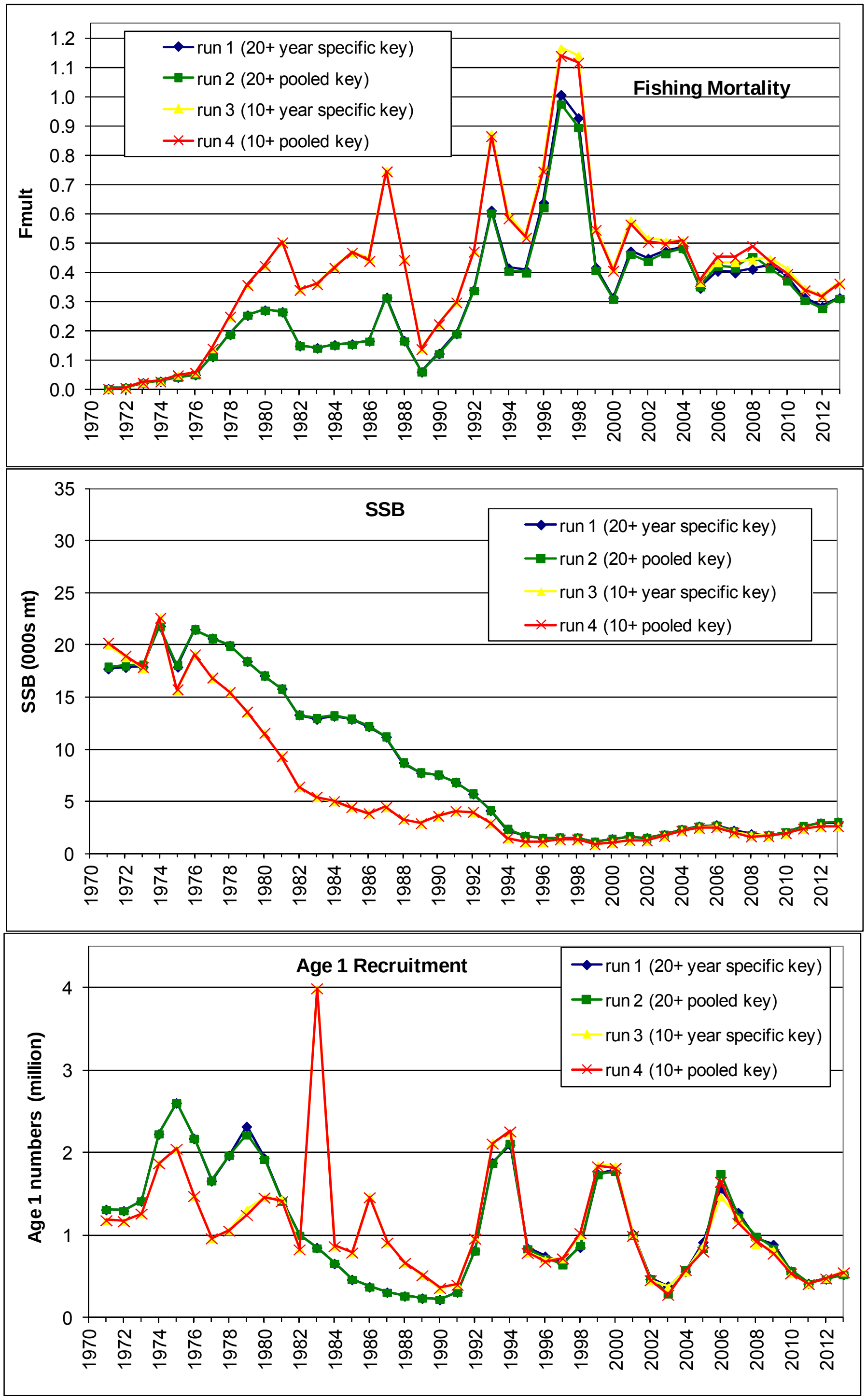


Figure B66. Results of initial four tilefish ASAP formulations for fishing mortality, SSB, and recruitment.

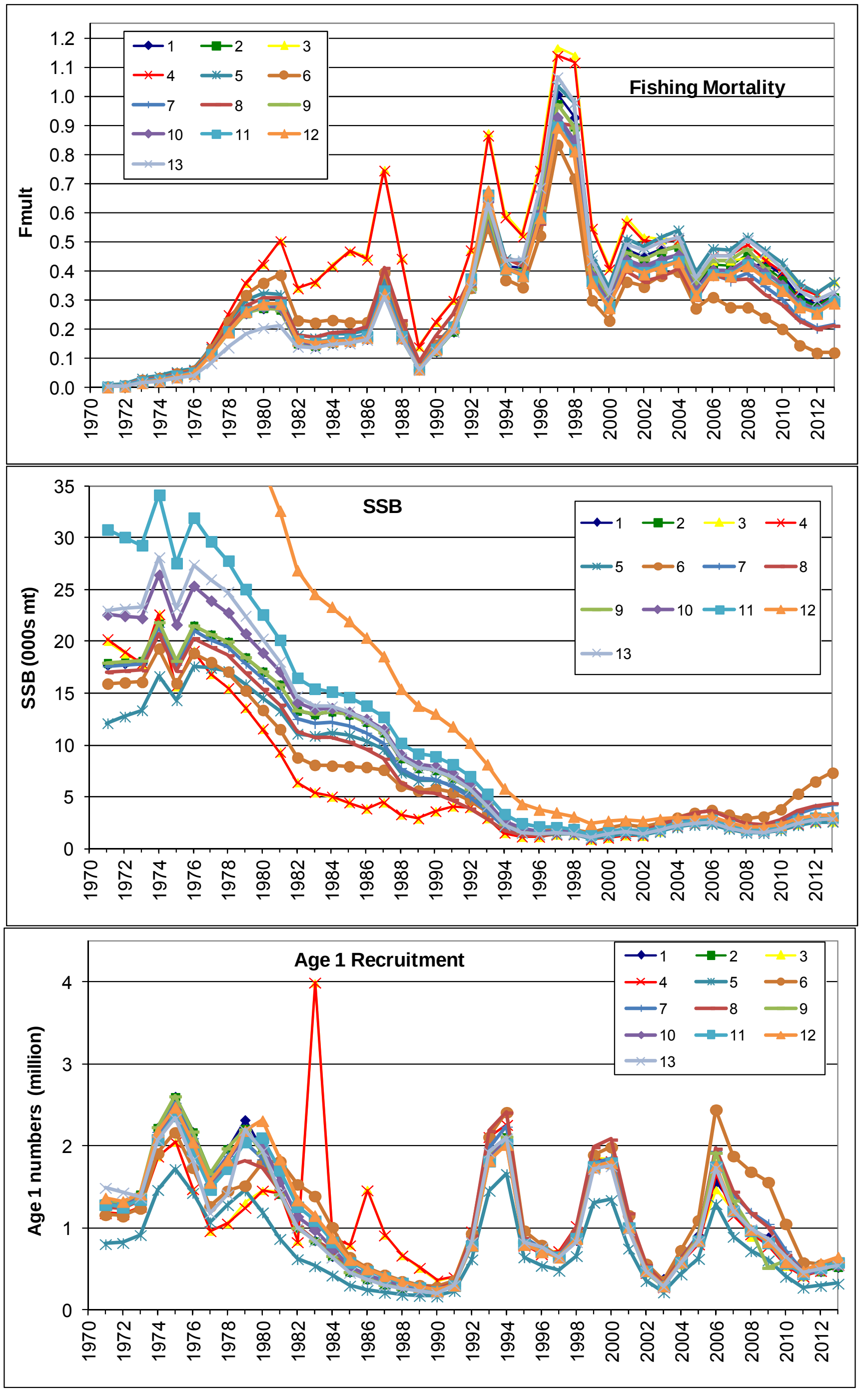
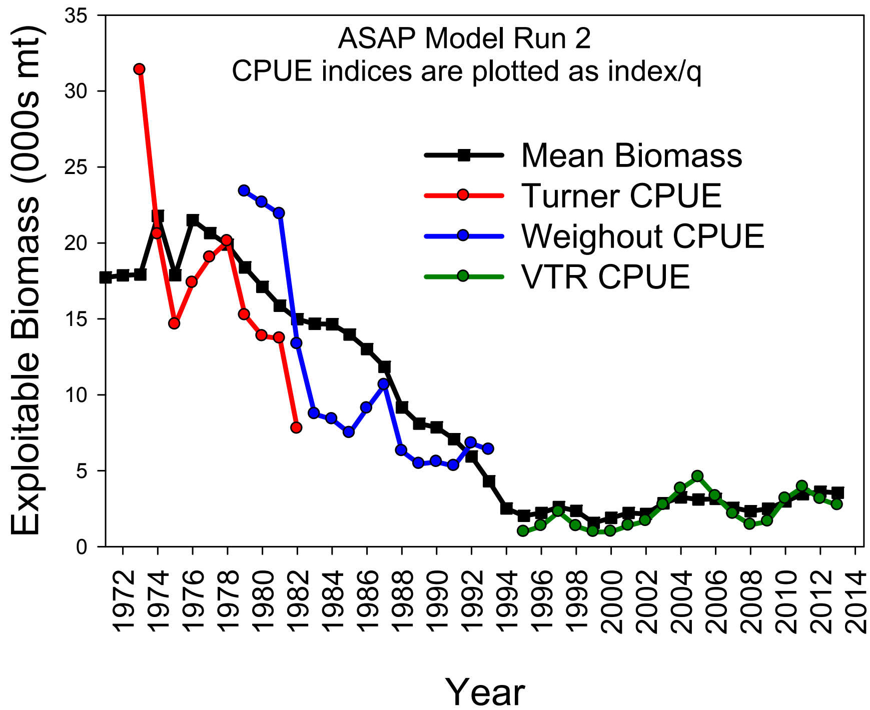


Figure B67. Initial tilefish sensitivity runs for fishing mortality, SSB, and recruitment.



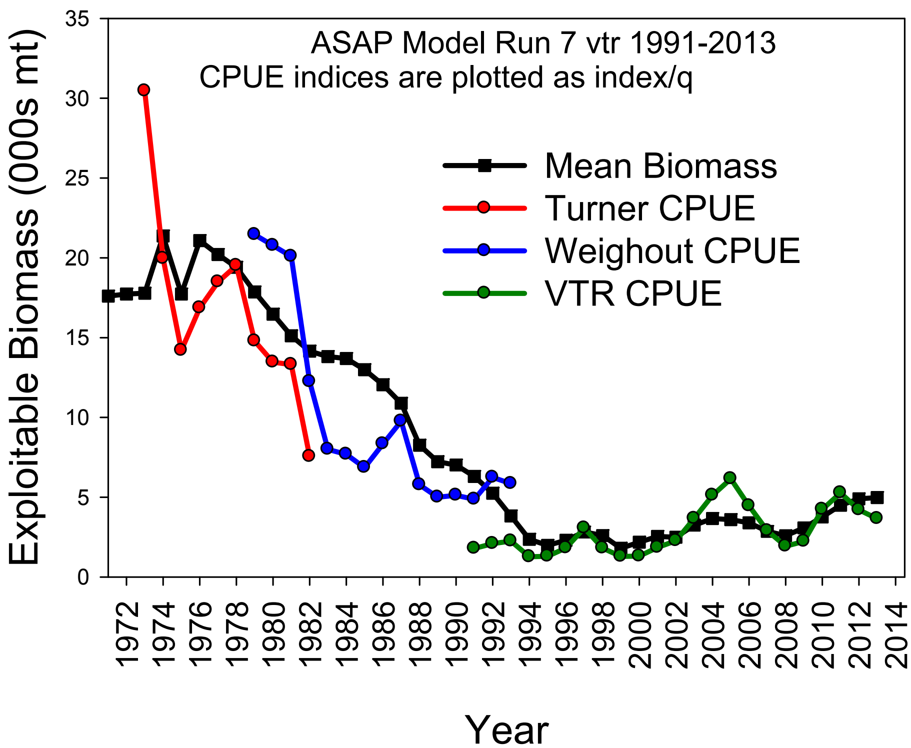


Figure B68. Depiction of the change in q between ASAP run 2 and ASAP run 7 which added the 1991-1994 New York CPUE data to the VTR series. Adding the 1991-1994 CPUE information in the past results in less change between the series.

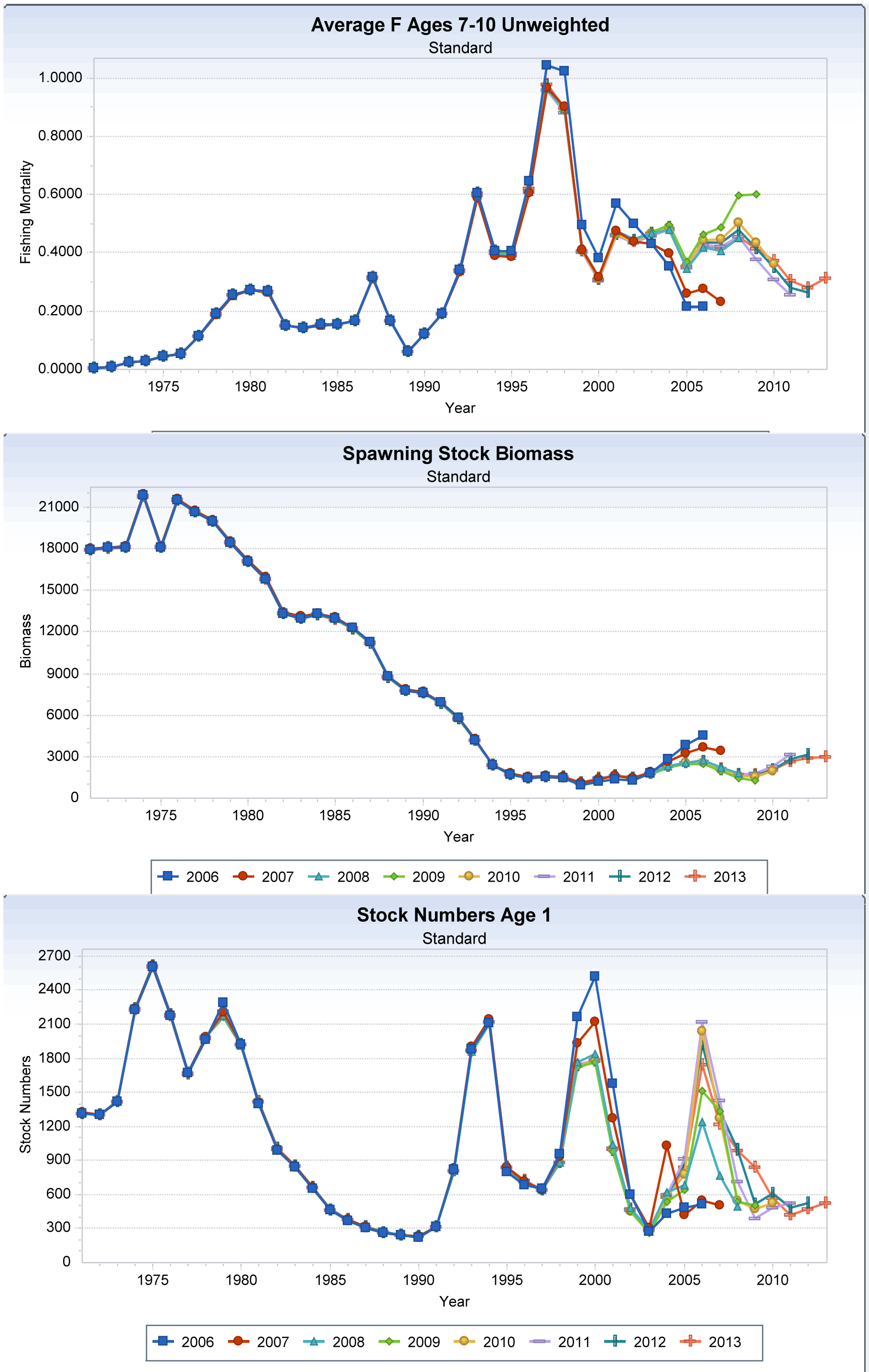


Figure B69. Tilefish ASAP run 2 retrospective analyses with 7 year peel.

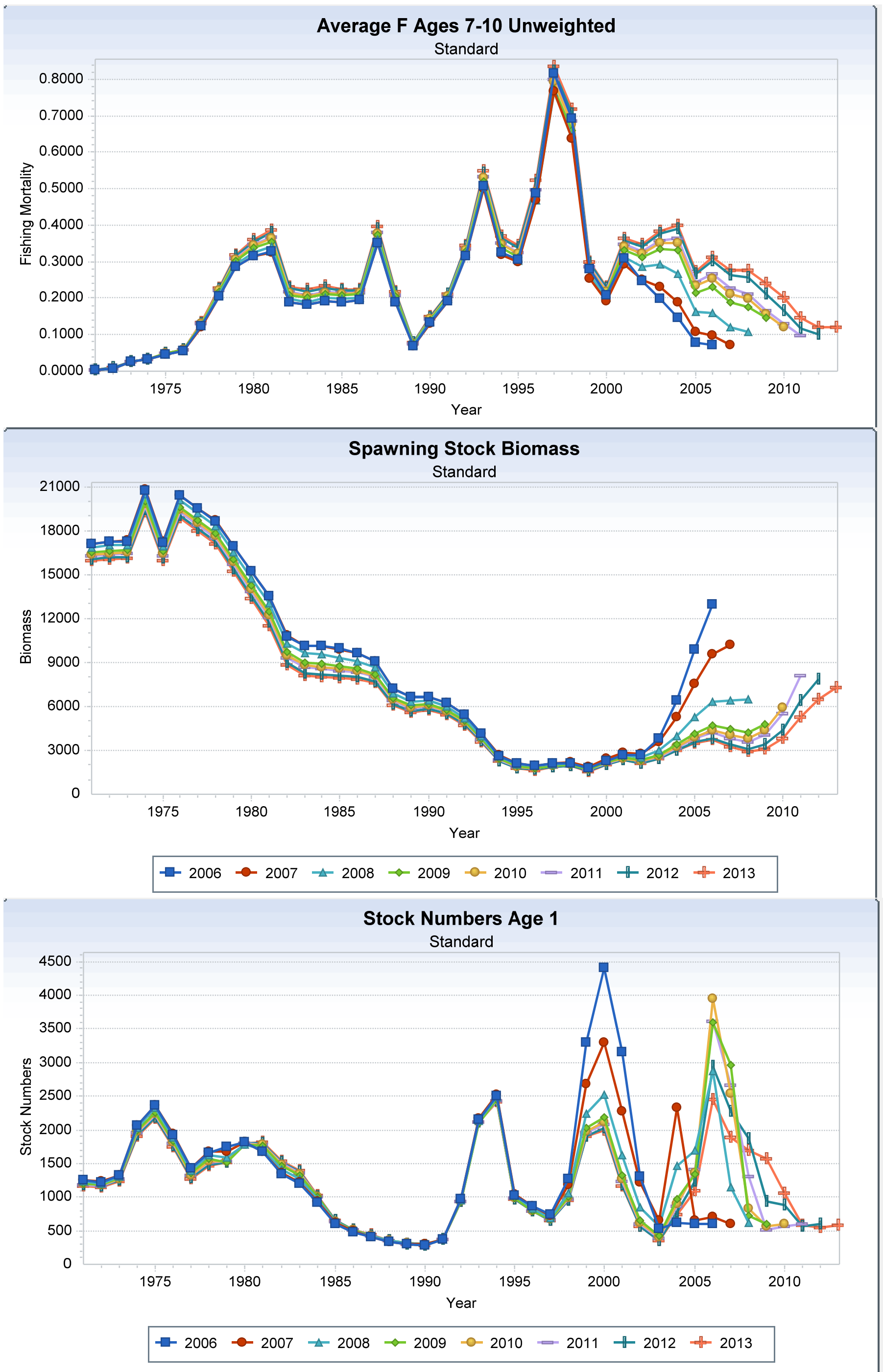


Figure B70. Tilefish ASAP run 6 (combine Weighout and VTR series) retrospective analyses with 7 year peel.

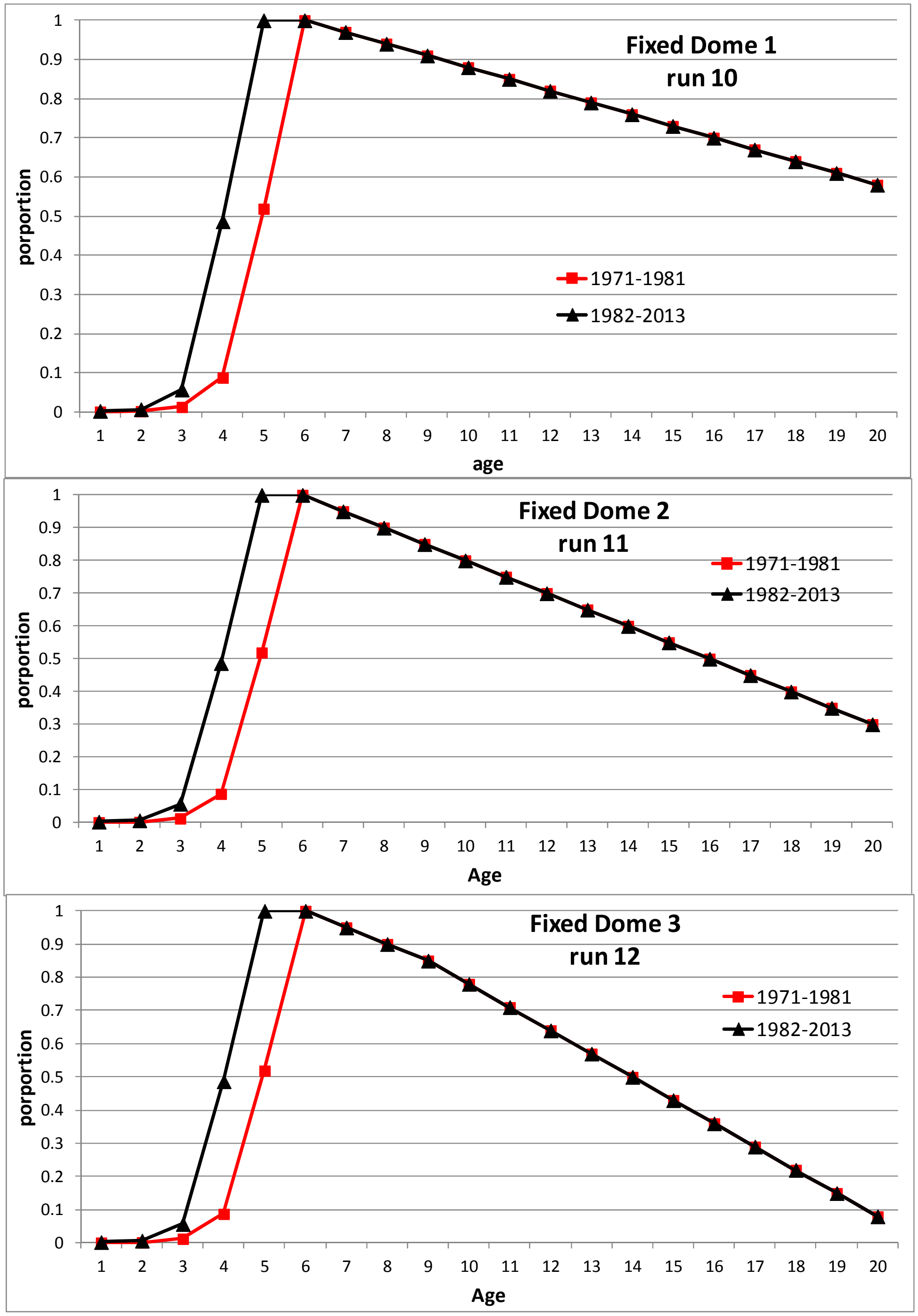


Figure B71. Fixed ASAP dome shaped (> age 5) selectivity which were used in sensitivity runs 10-12.

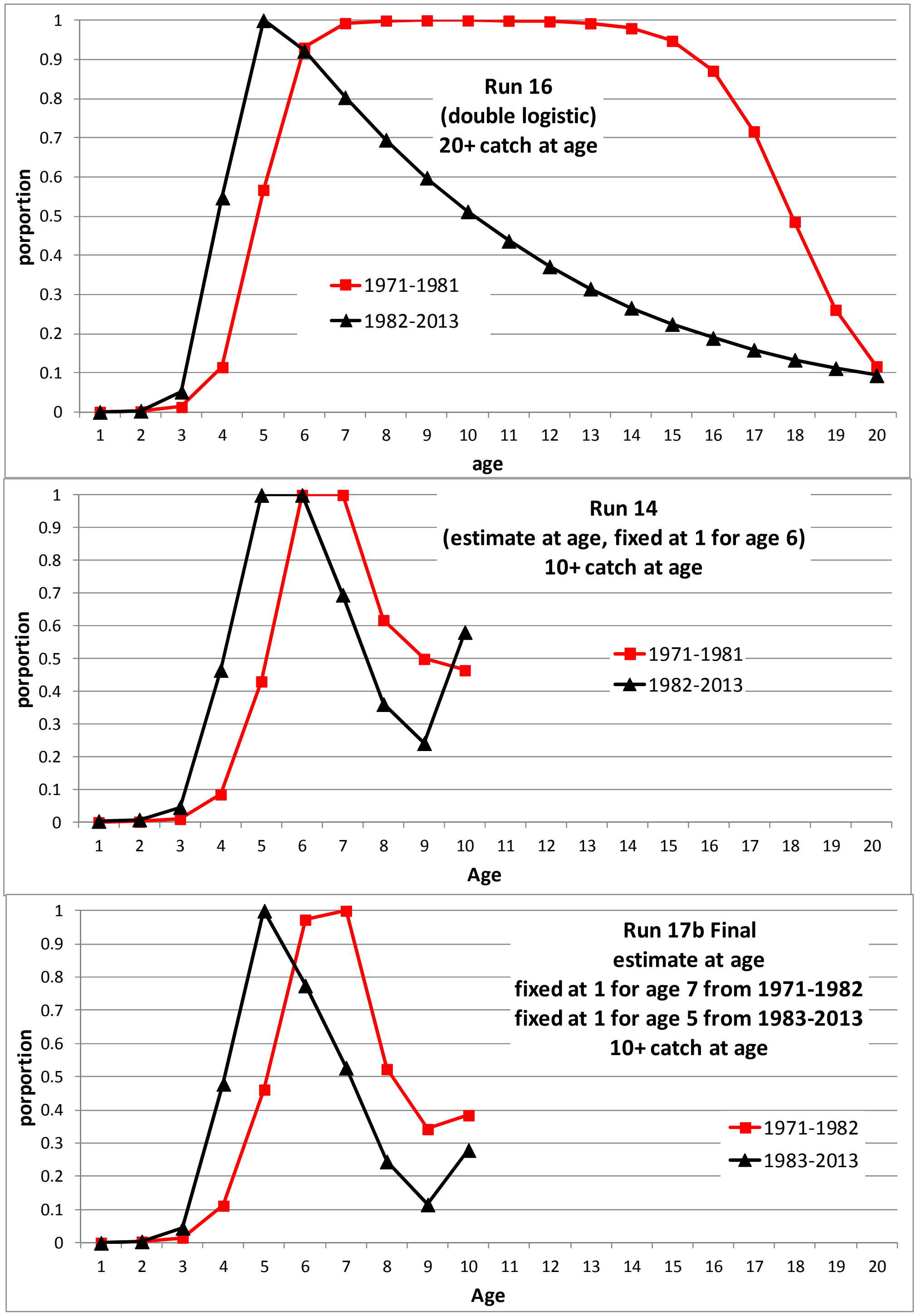


Figure B72. Estimated ASAP dome shaped selectivity from sensitivity runs 16 (20+ double logistic), run 14 (10+ at age), and the final run 27b (10+ at age).

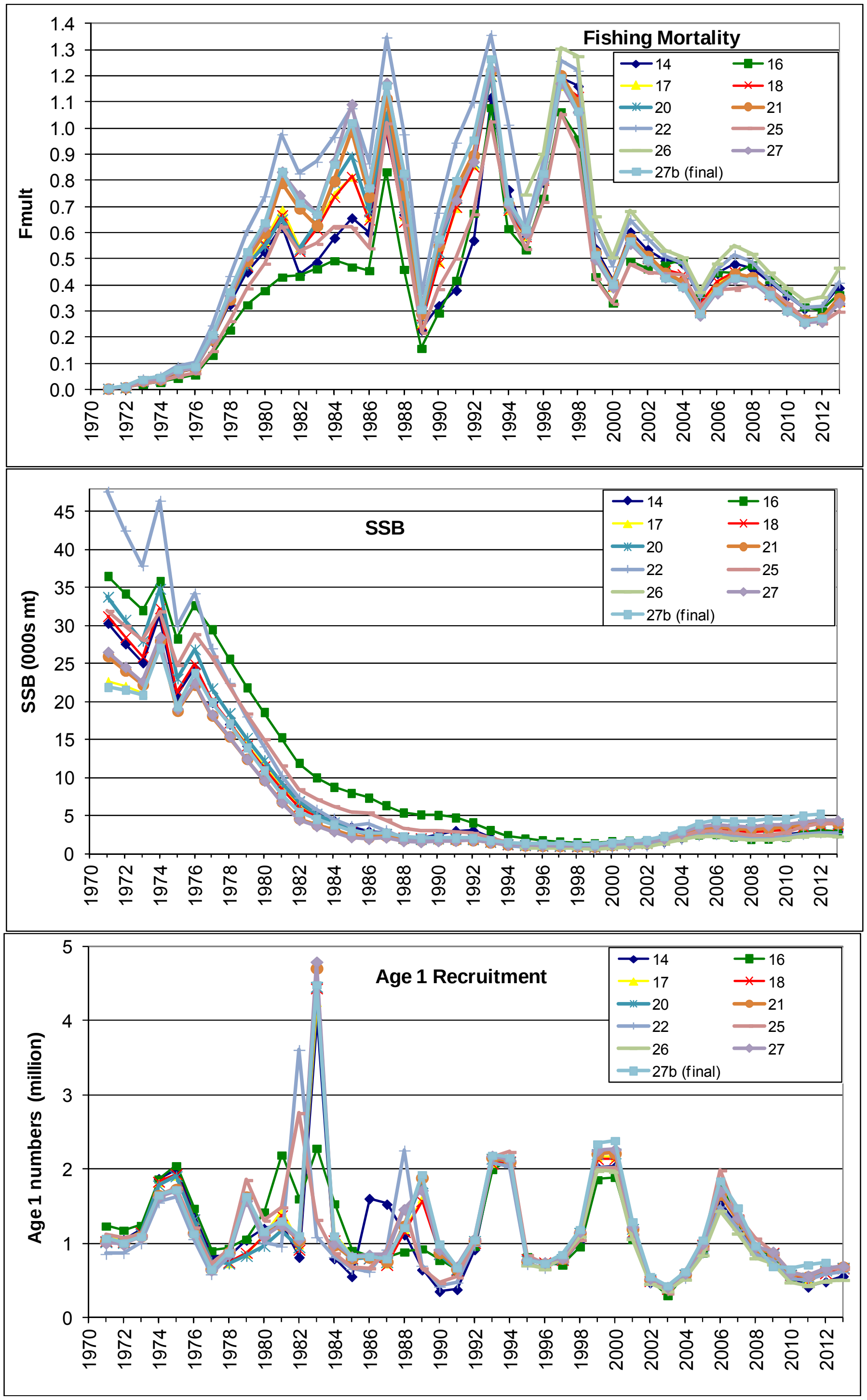


Figure B73. Working group tilefish dome shaped sensitivity runs for fishing mortality, SSB, and recruitment.

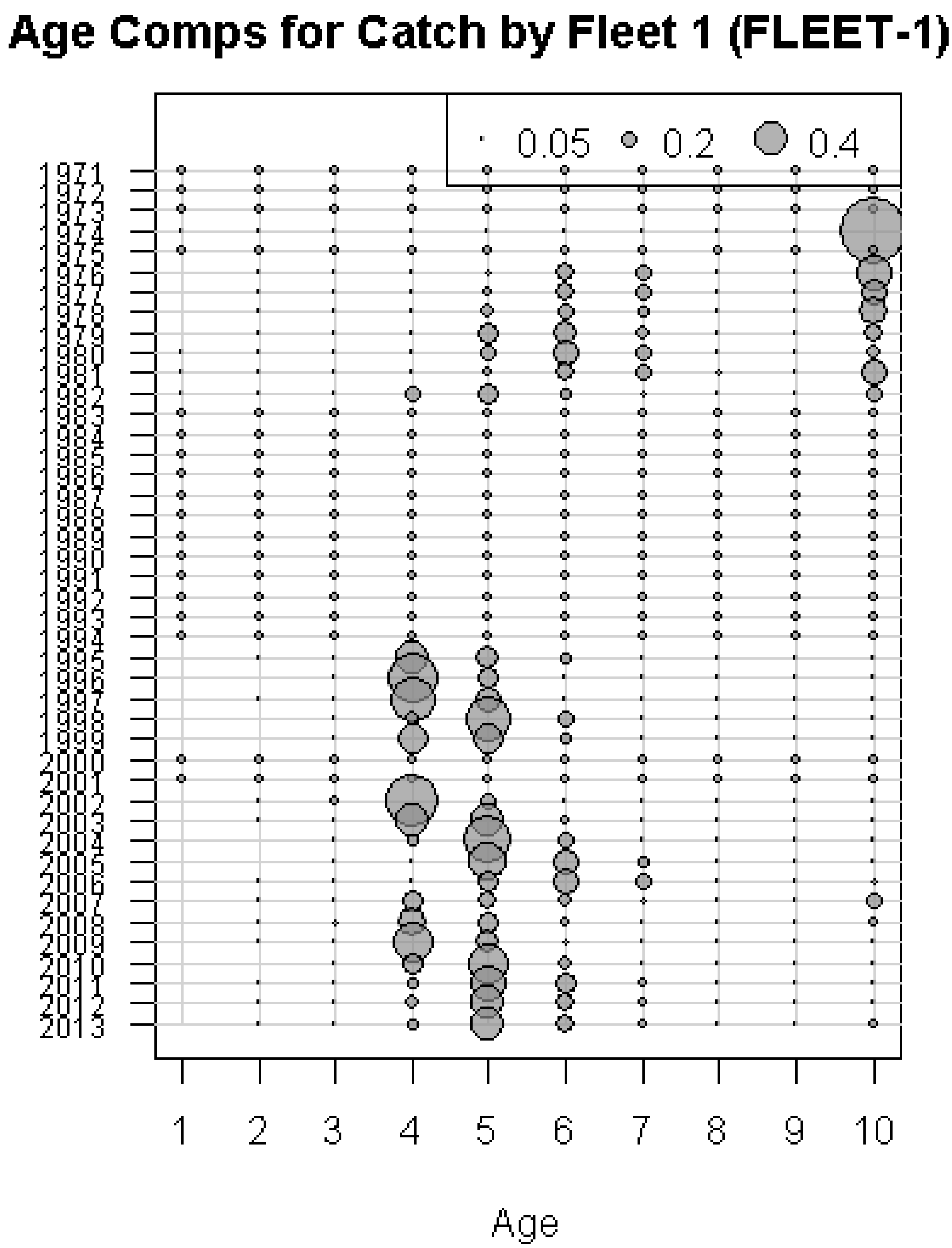


Figure B74. Working group final ASAP run 27b catch at age.

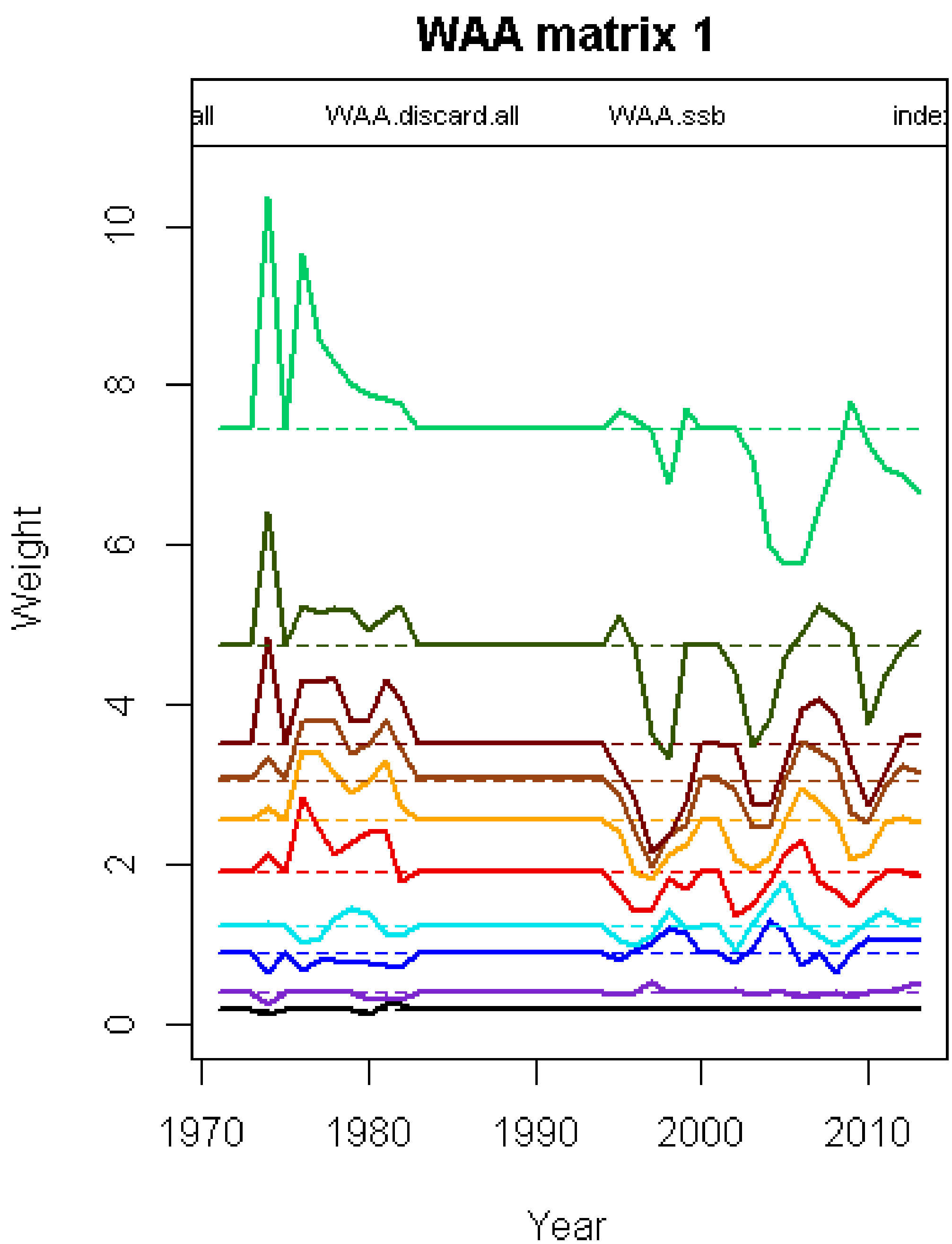


Figure B75. Working group final ASAP run 27b input mean weights at age.

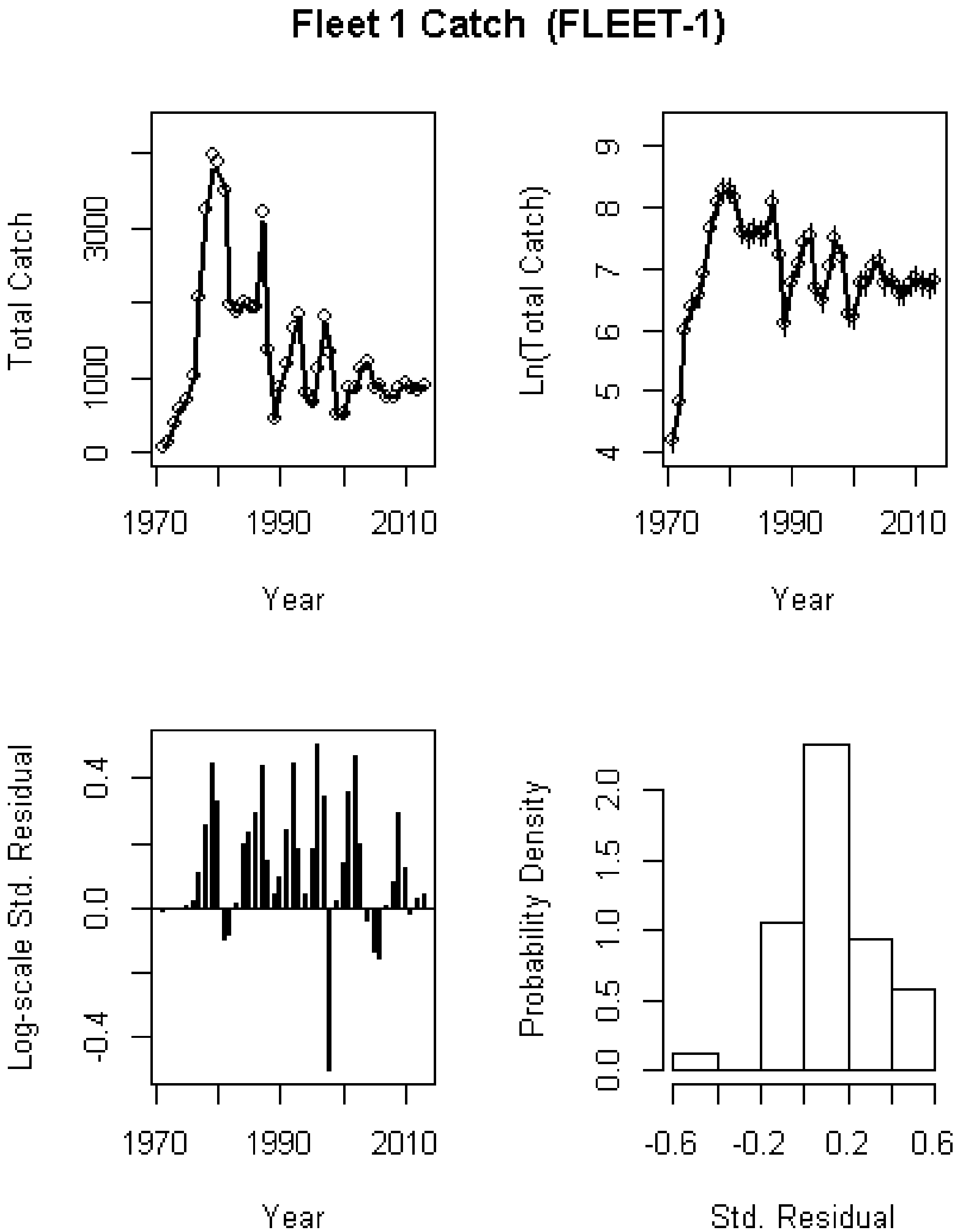


Figure B76. Working group final ASAP run 27b fit to the total catch.

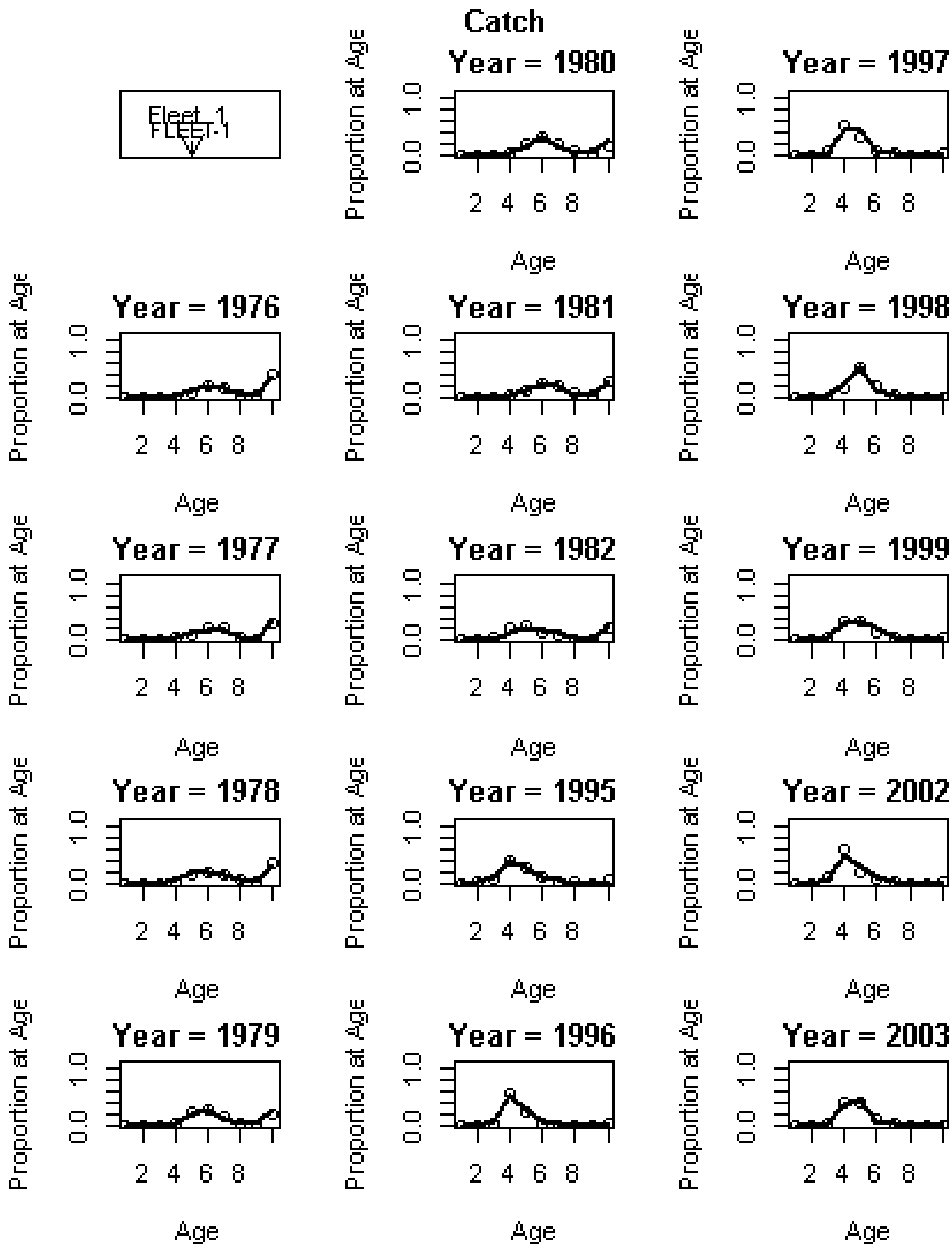


Figure B77. Working group final ASAP run 27b fit to catch at age.

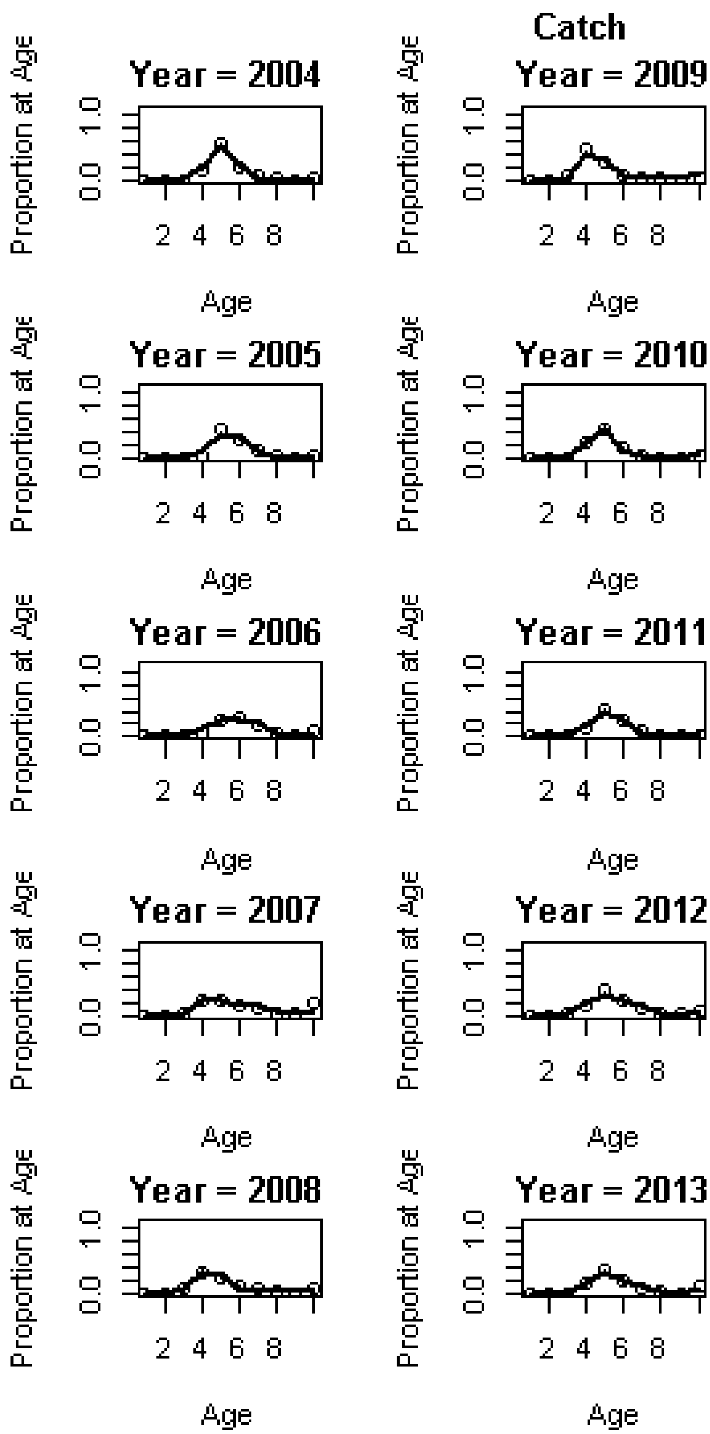


Figure B77. Cont.

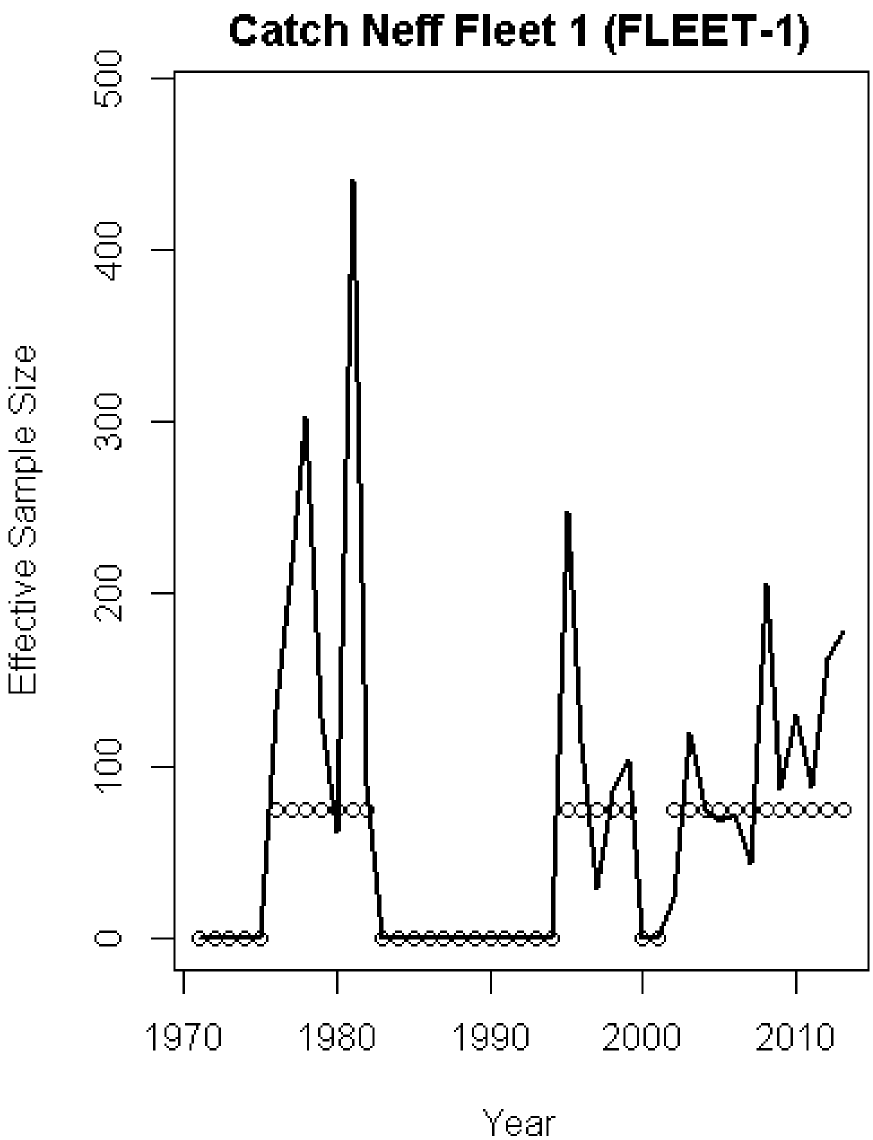


Figure B78. Working group final ASAP run 27b input and model estimated effective sample size on the catch at age.

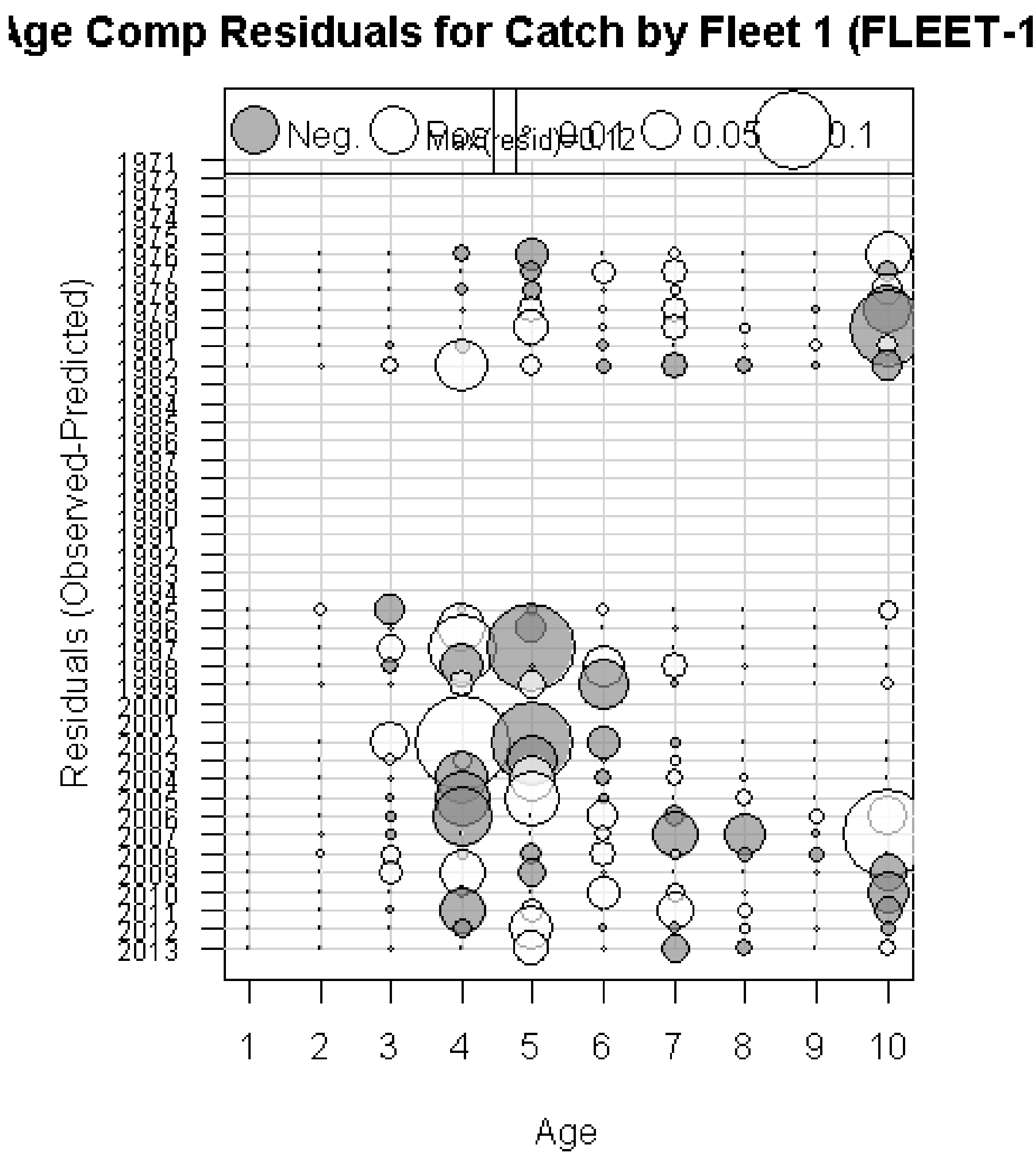


Figure B79. Working group final ASAP run 27b catch at age comp residuals.

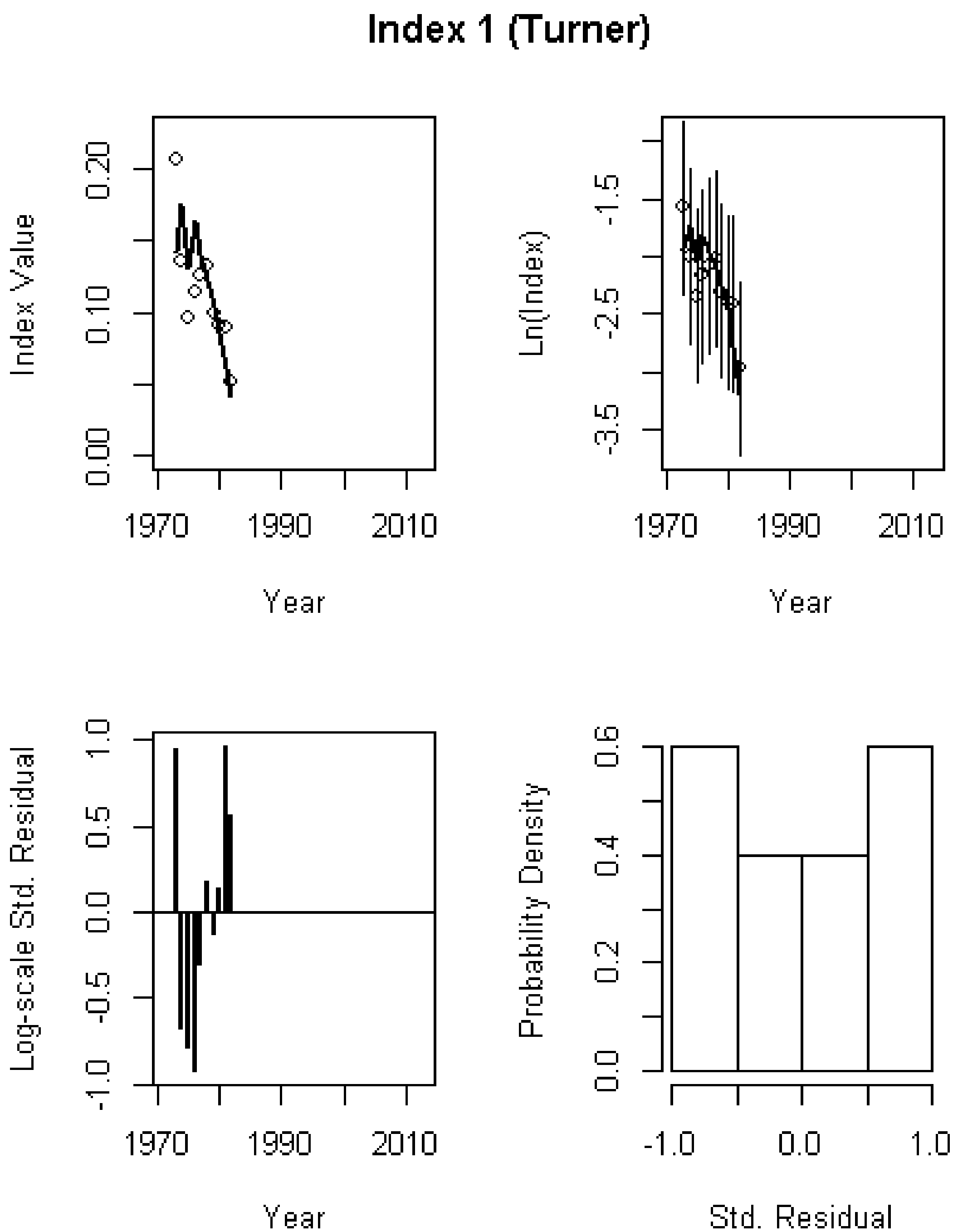


Figure B80. Working group final ASAP run 27b fit to Turner's CPUE index.

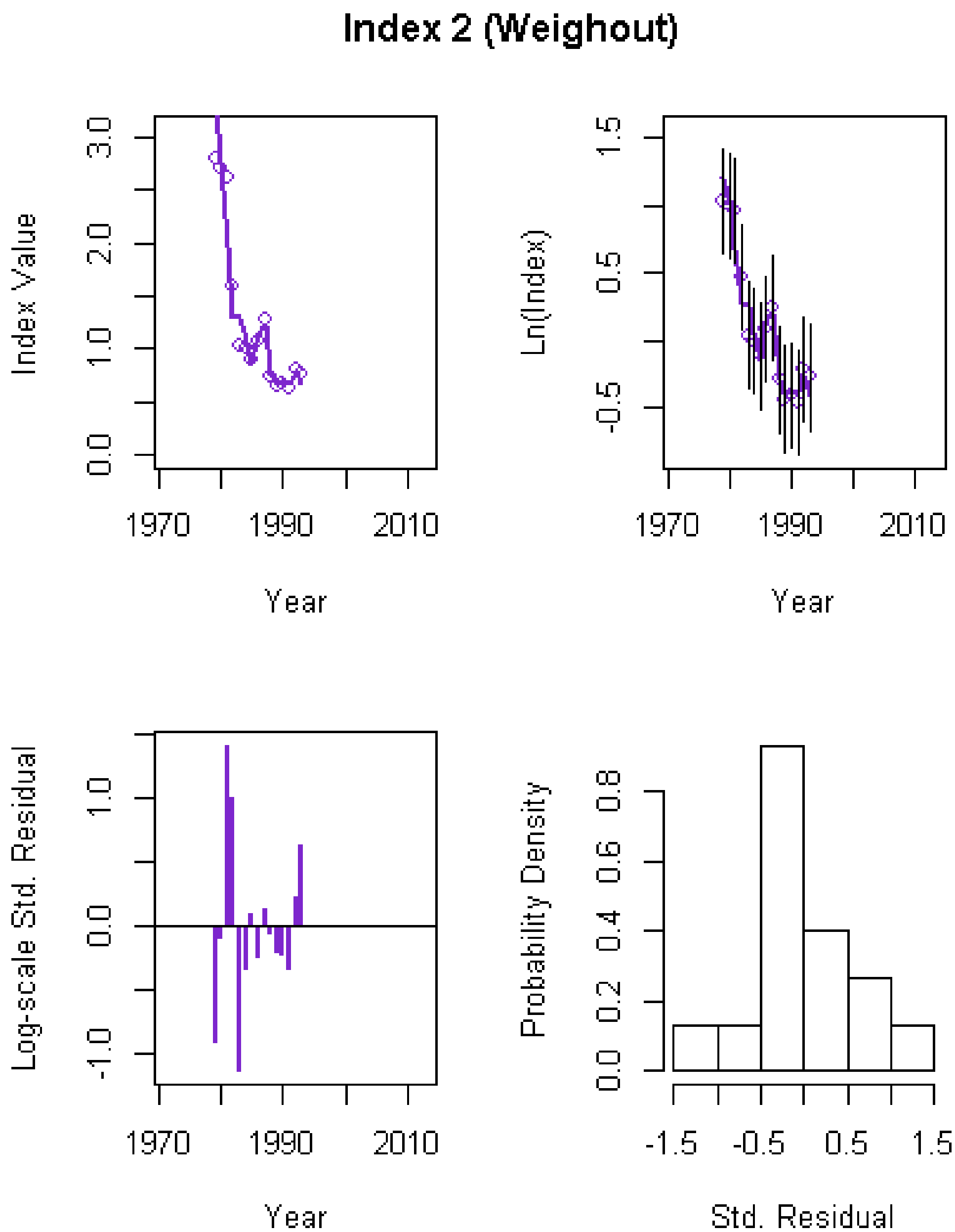


Figure B81. Working group final ASAP run 27b fit to the Weighout CPUE index.

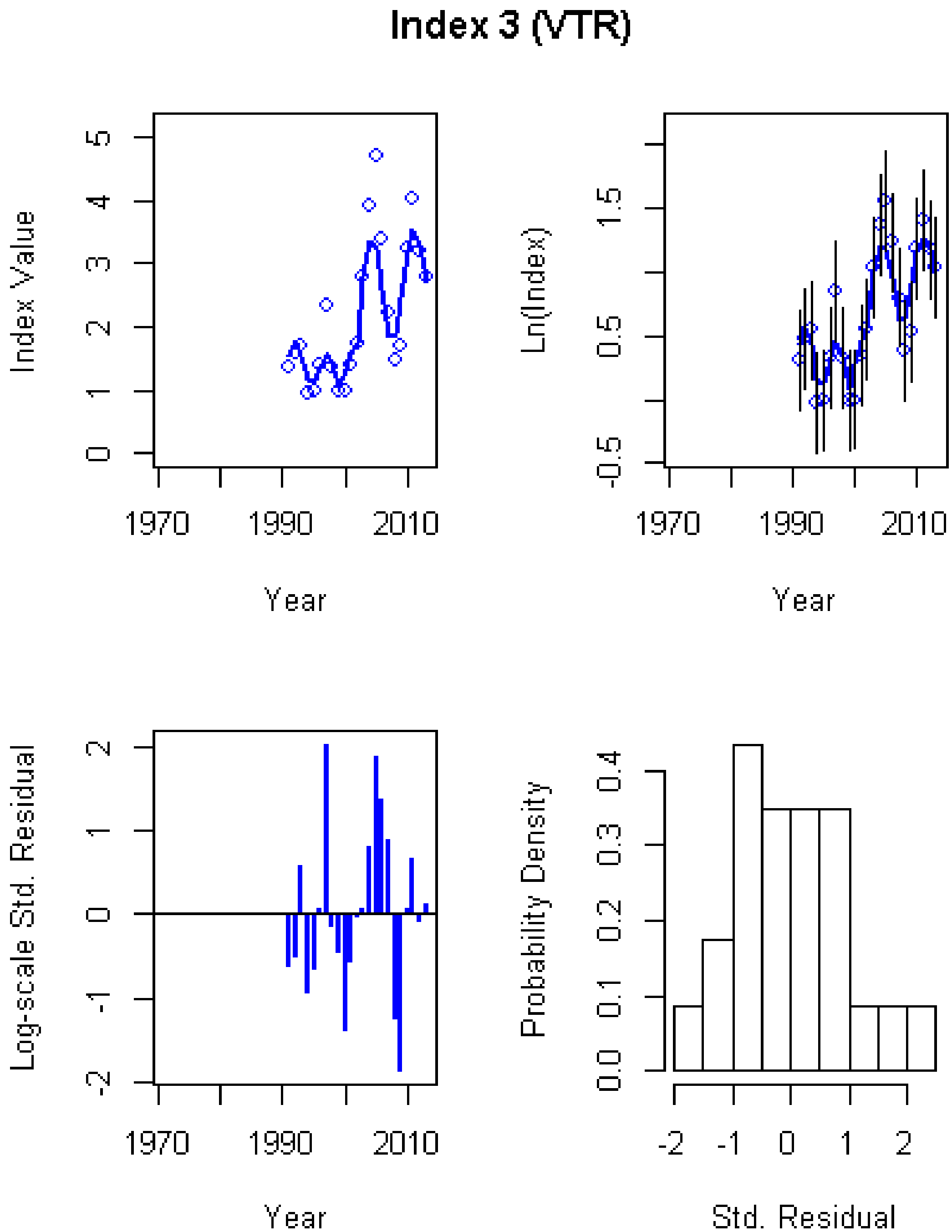


Figure B82. Working group final ASAP run 27b fit to VTR CPUE index.

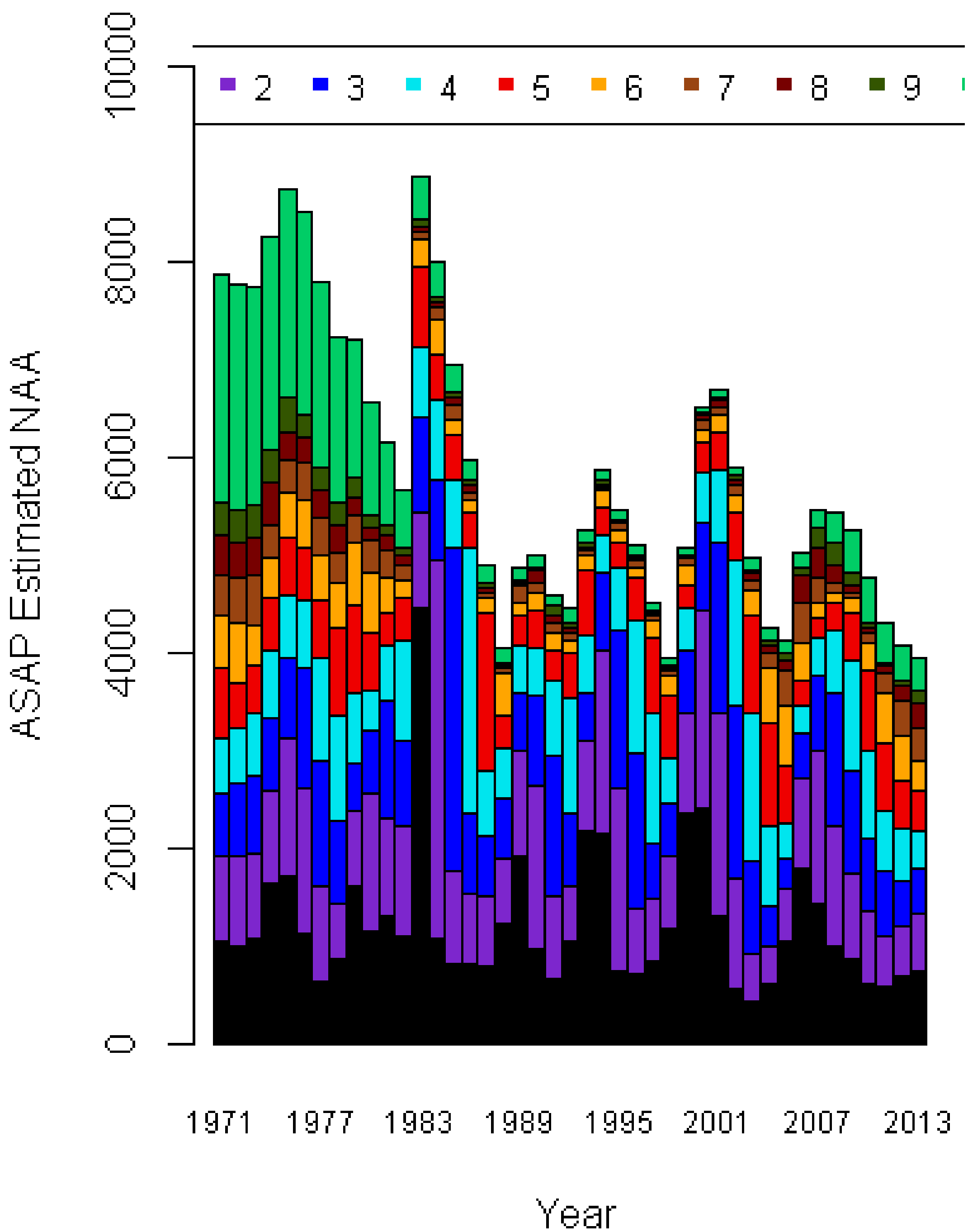


Figure B83. Working group final ASAP run 27b estimated numbers at age over the 1971-2012 time series.

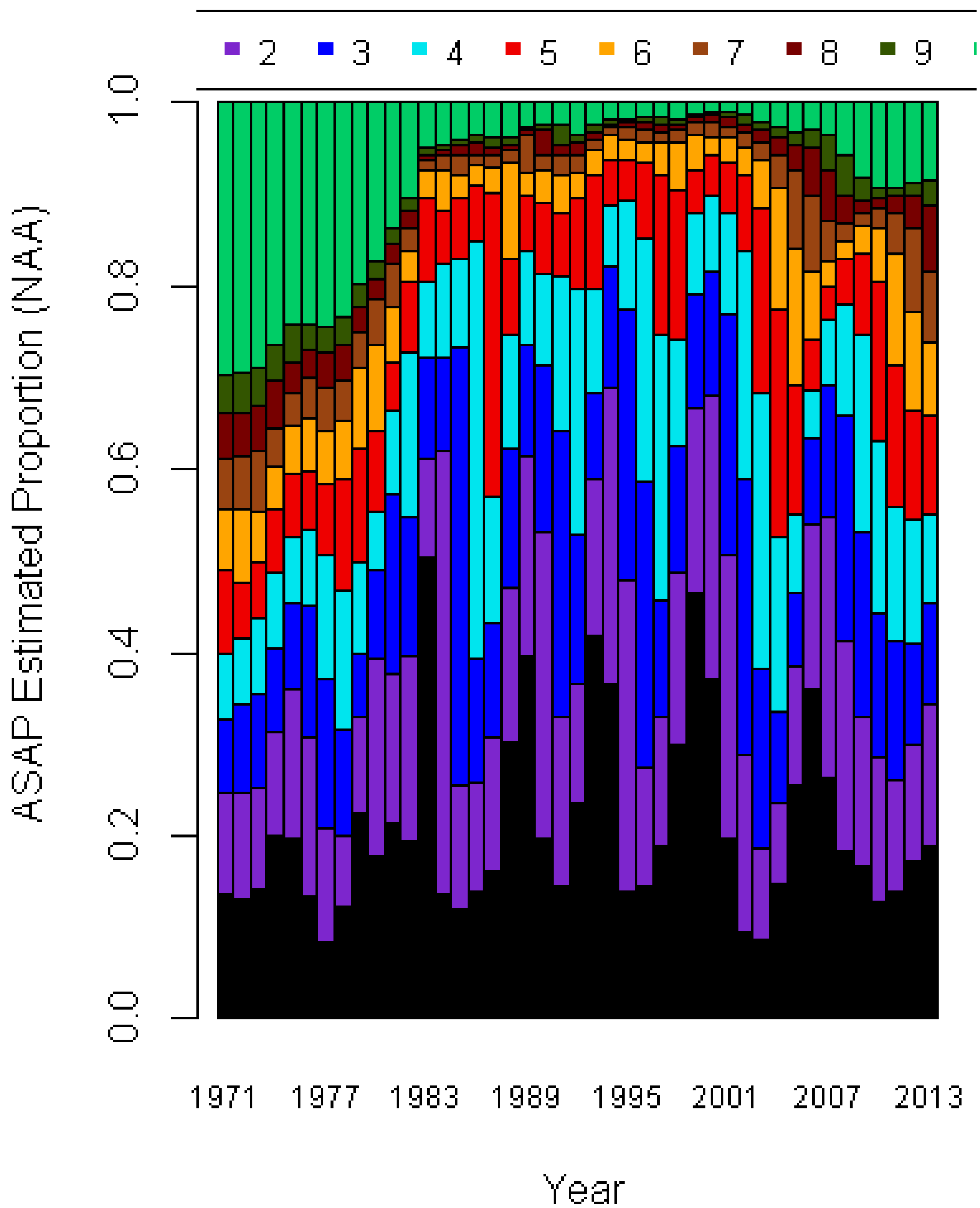


Figure B84. Working group final ASAP run 27b proportion of the numbers at age over the 1971-2012 time series.

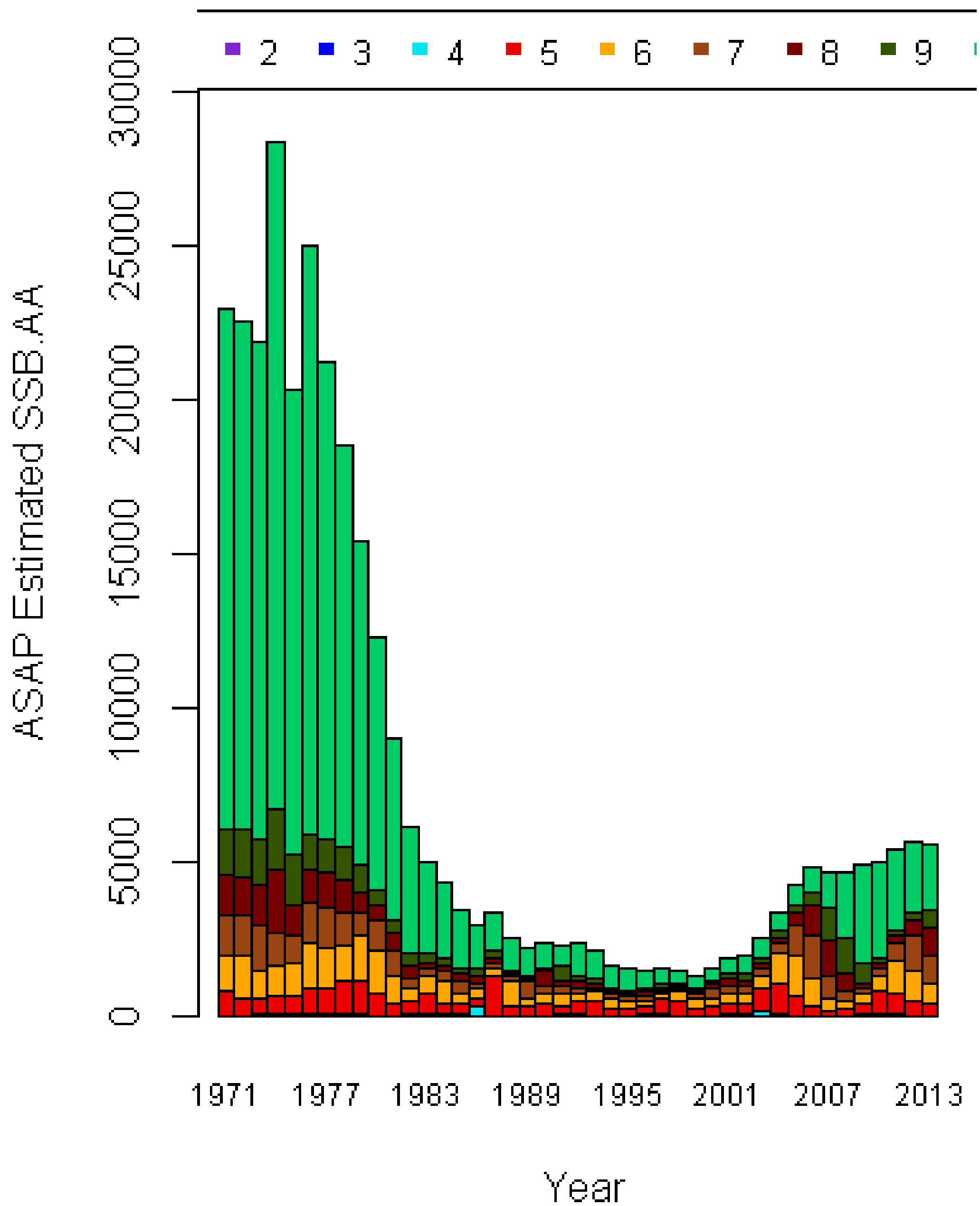


Figure B85. Working group final ASAP run 27b estimated SSB at age over the 1971-2012 time series.

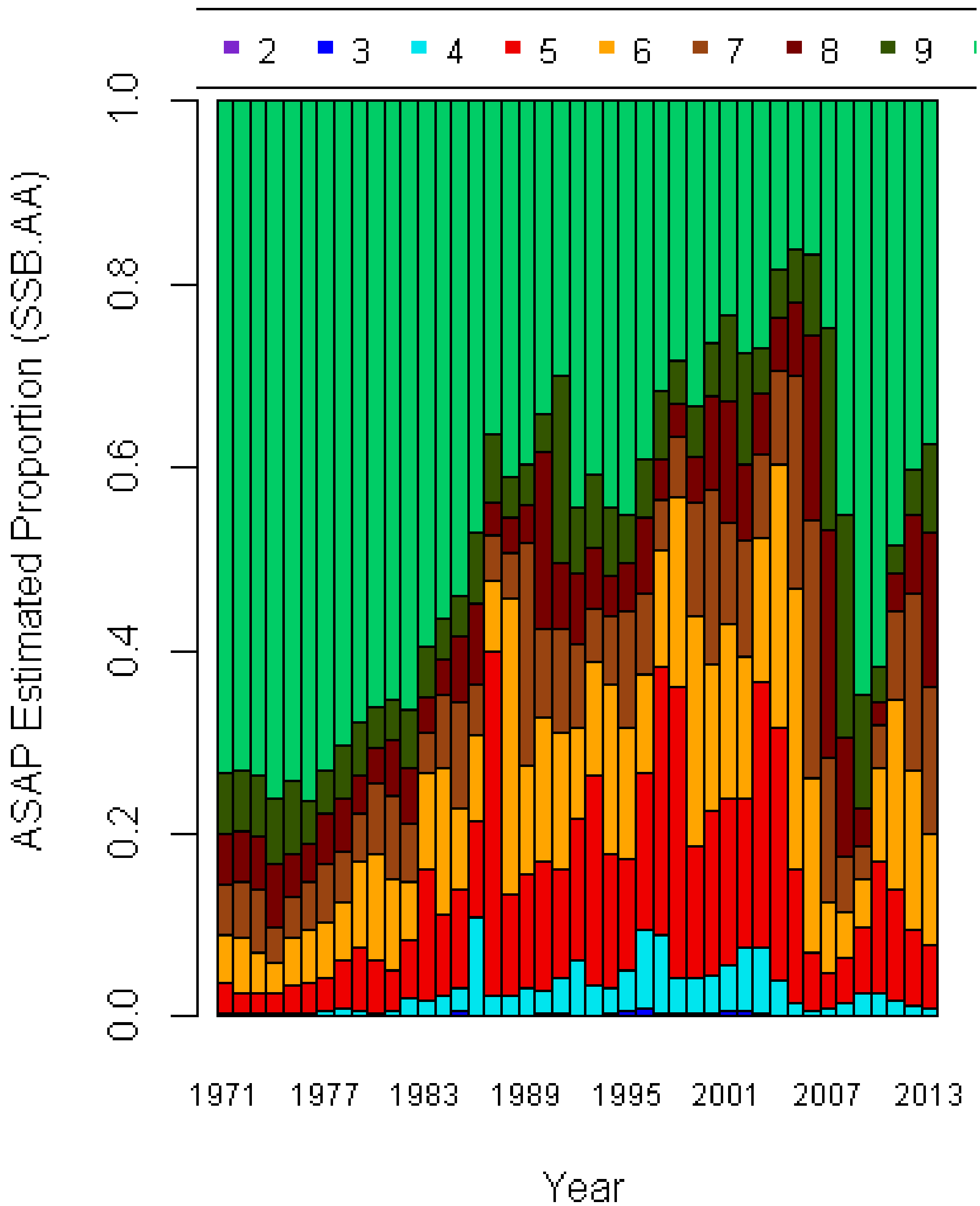


Figure B86. Working group final ASAP run 27b proportion of the SSB at age over the 1971-2012 time series.

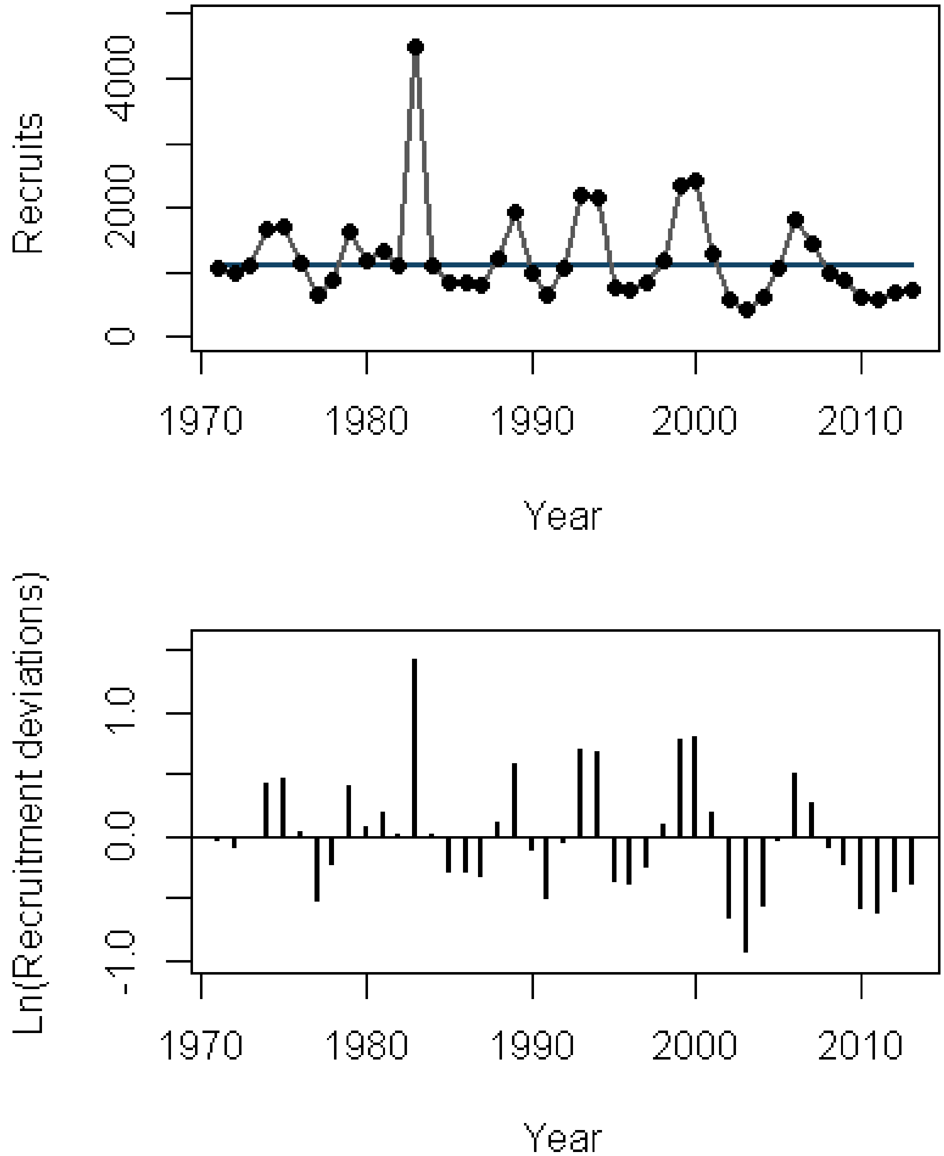


Figure B87. Working group final ASAP run 27b estimated age-1 recruitment deviations.

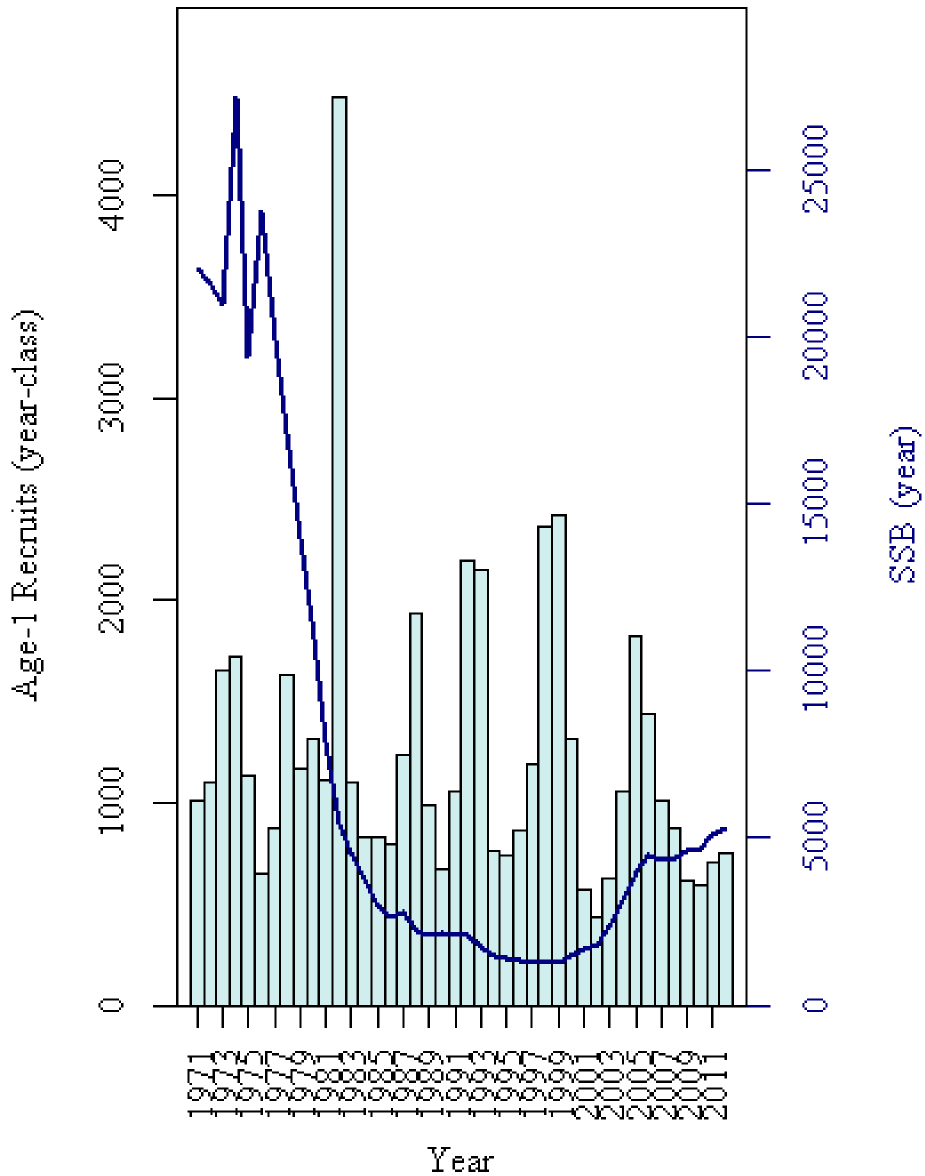


Figure B88. Working group final ASAP run 27b estimated age-1 recruitment and SSB.

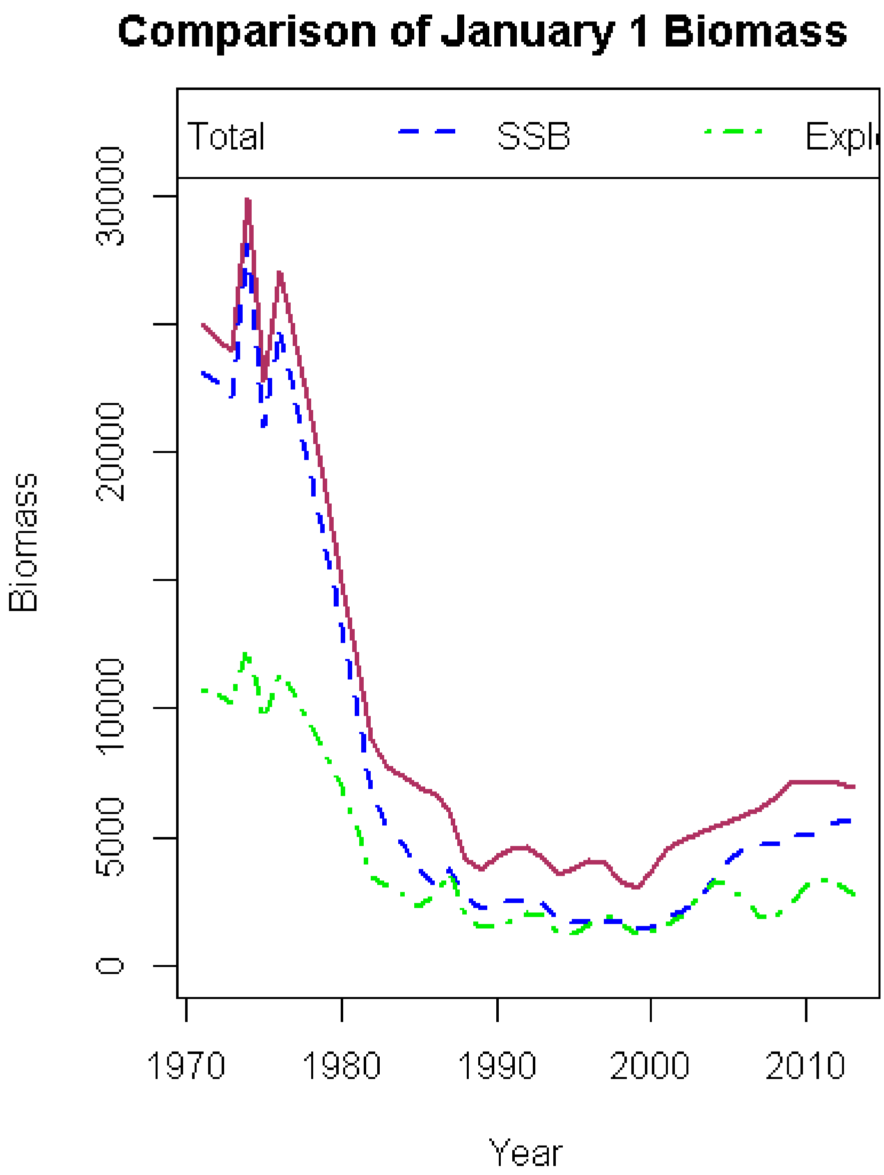


Figure B89. Working group final ASAP run 27b estimated total Jan-1 biomass, SSB, and exploitable biomass.

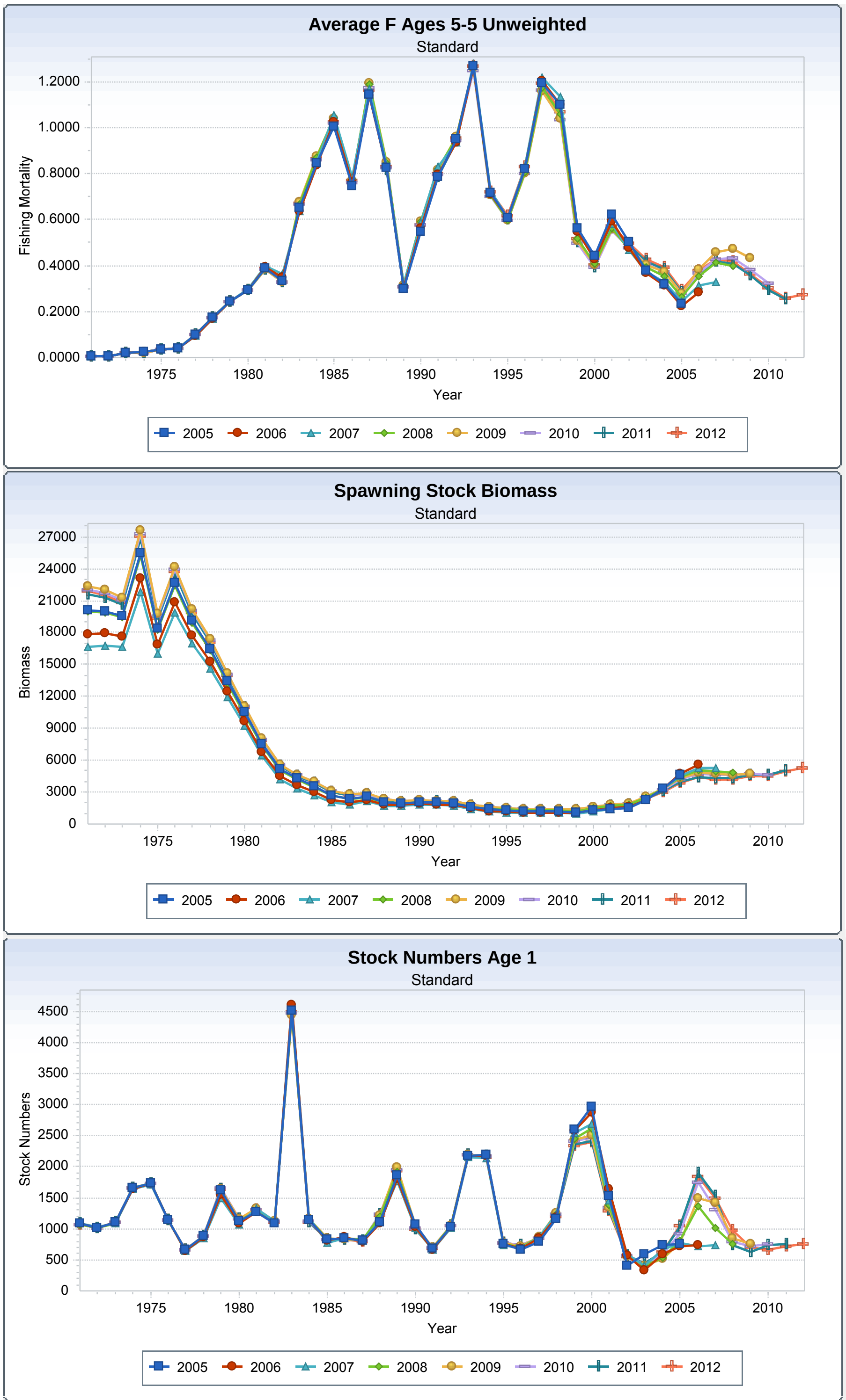


Figure B90. Working group final ASAP run 27b retrospective analysis using 7 year peel.

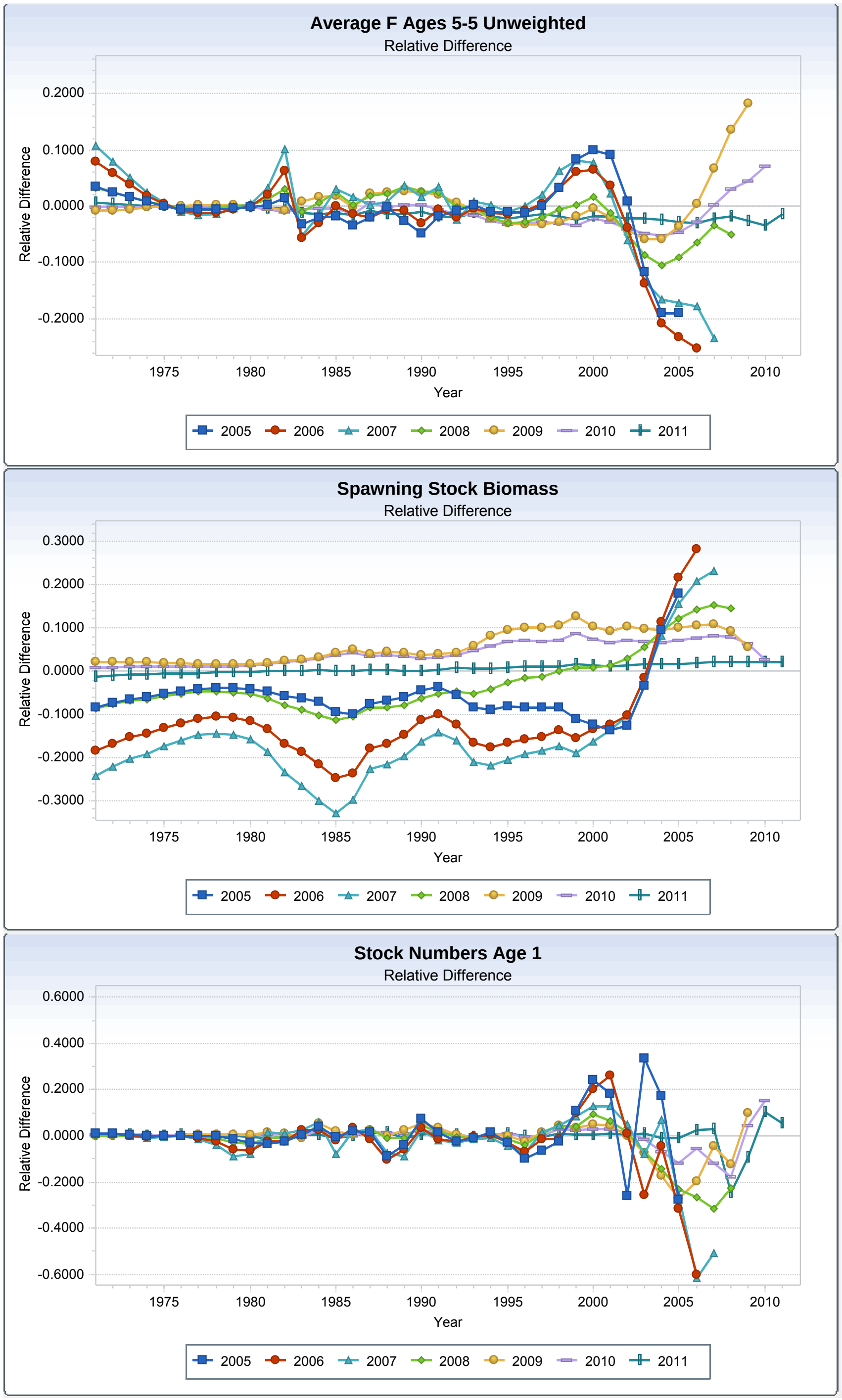


Figure B91. Working group final ASAP run 27b relative retrospective analysis using 7 year peel.

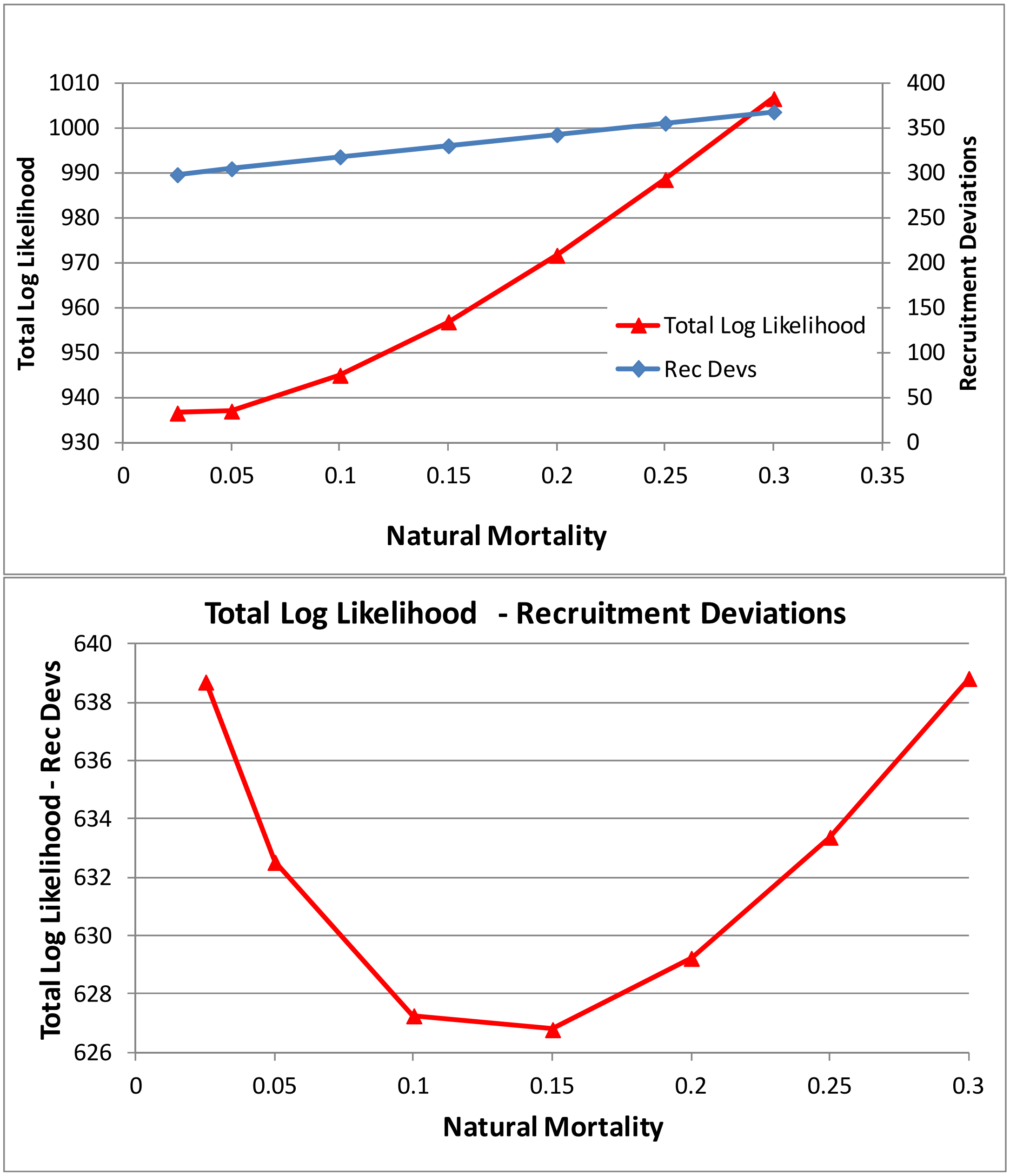


Figure B92. Working group final ASAP run 27b profile on natural mortality. Recruitment deviation residuals were subtracted from the total likelihood.

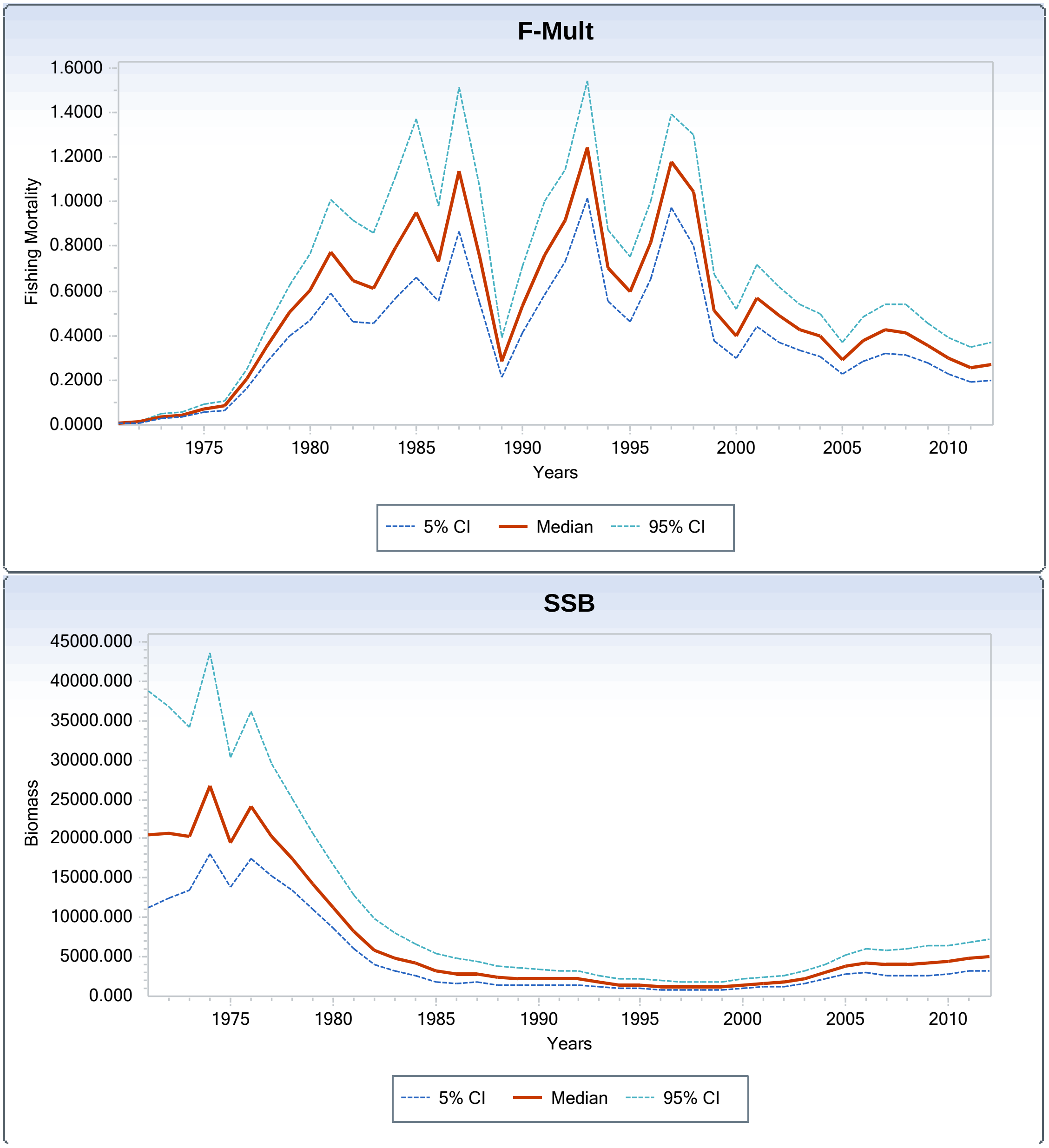


Figure B93. Working group final ASAP run 27b fishing mortality and SSB. 90% CI from NCMC are also shown.

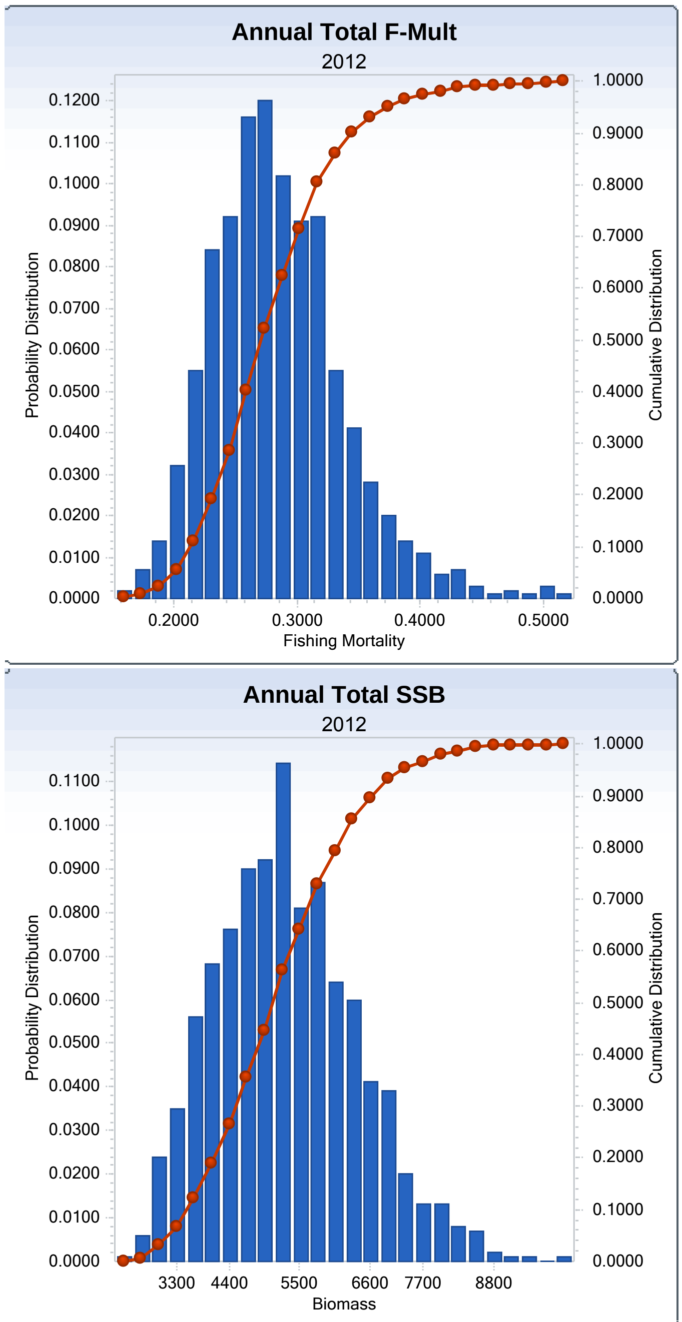


Figure B94. Working group final ASAP run 27b 2012 fishing mortality and SSB.

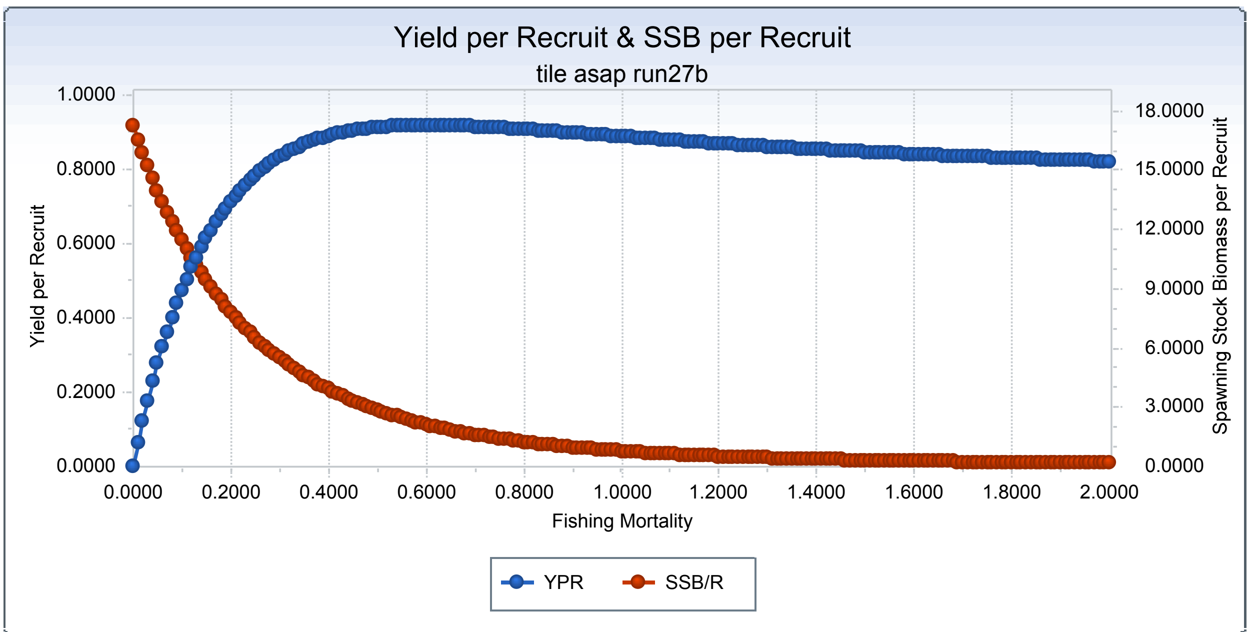


Figure B95. Yield per recruit and SPR curves for the final working group ASAP model run 27b.

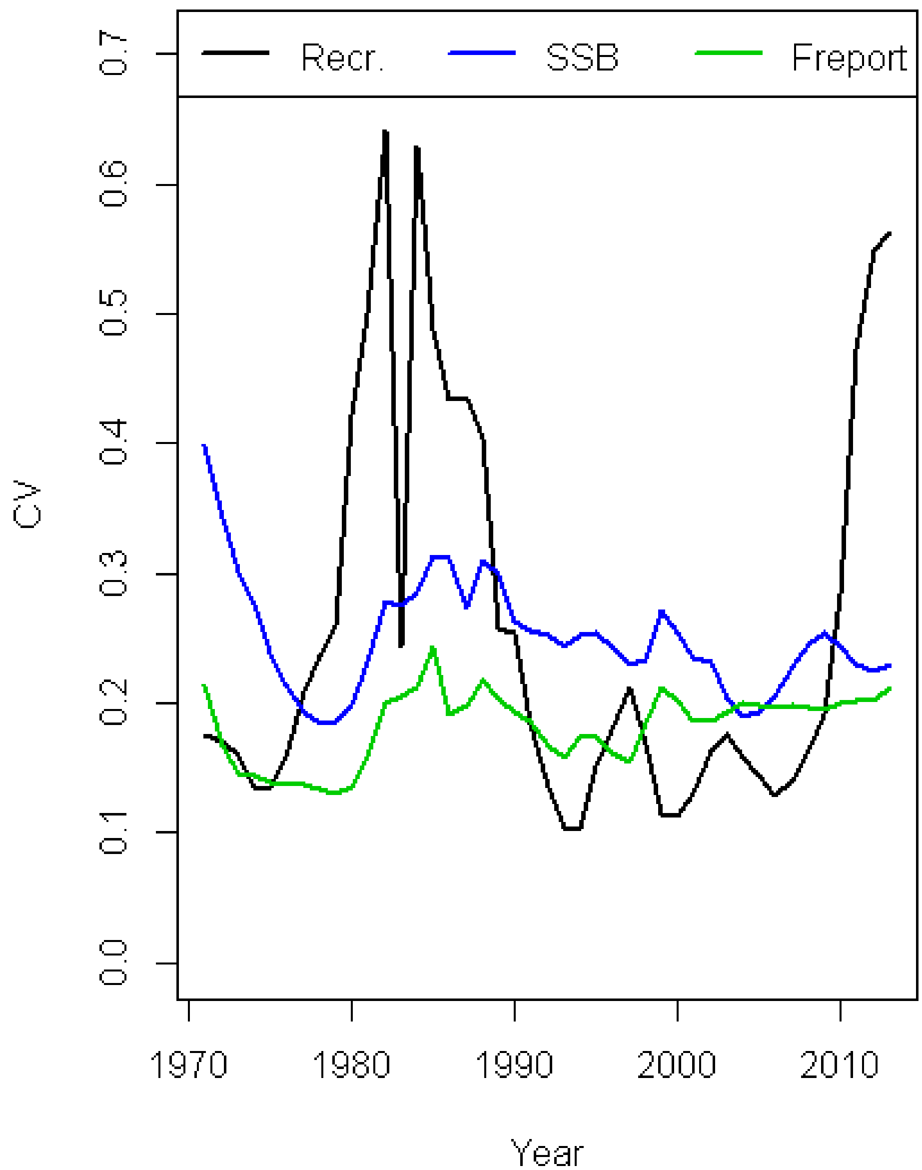


Figure B96. Estimated CVs from the final ASAP run 27b for age-1 recruitment, SSB, and fishing mortality.

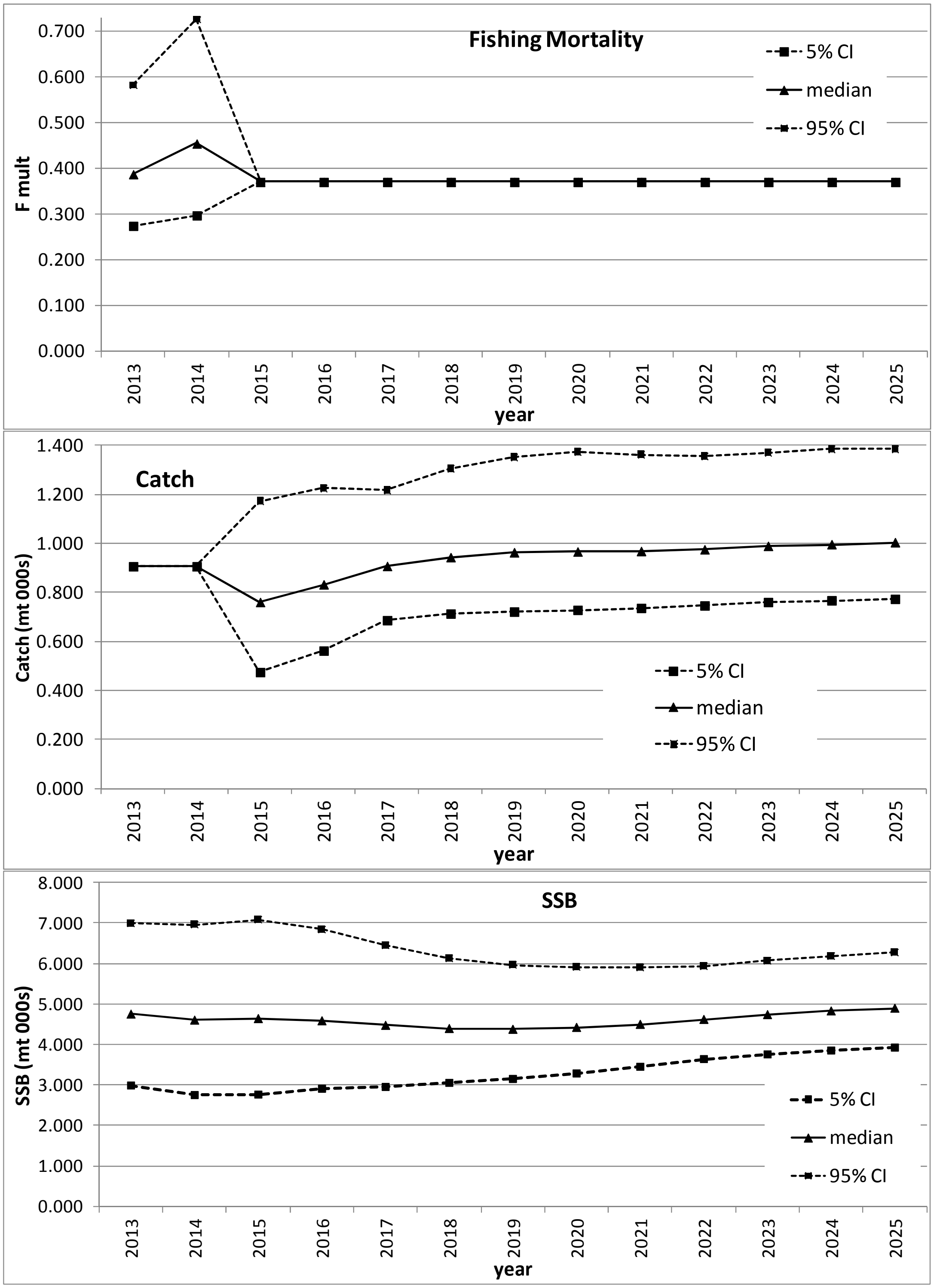


Figure B97. Final ASAP run 27b unadjusted AGEPRO $F_{MSY} = F_{25} = 0.37$ projections with 90% CIs. Removals of 905 mt was assumed in 2013 and 2014.

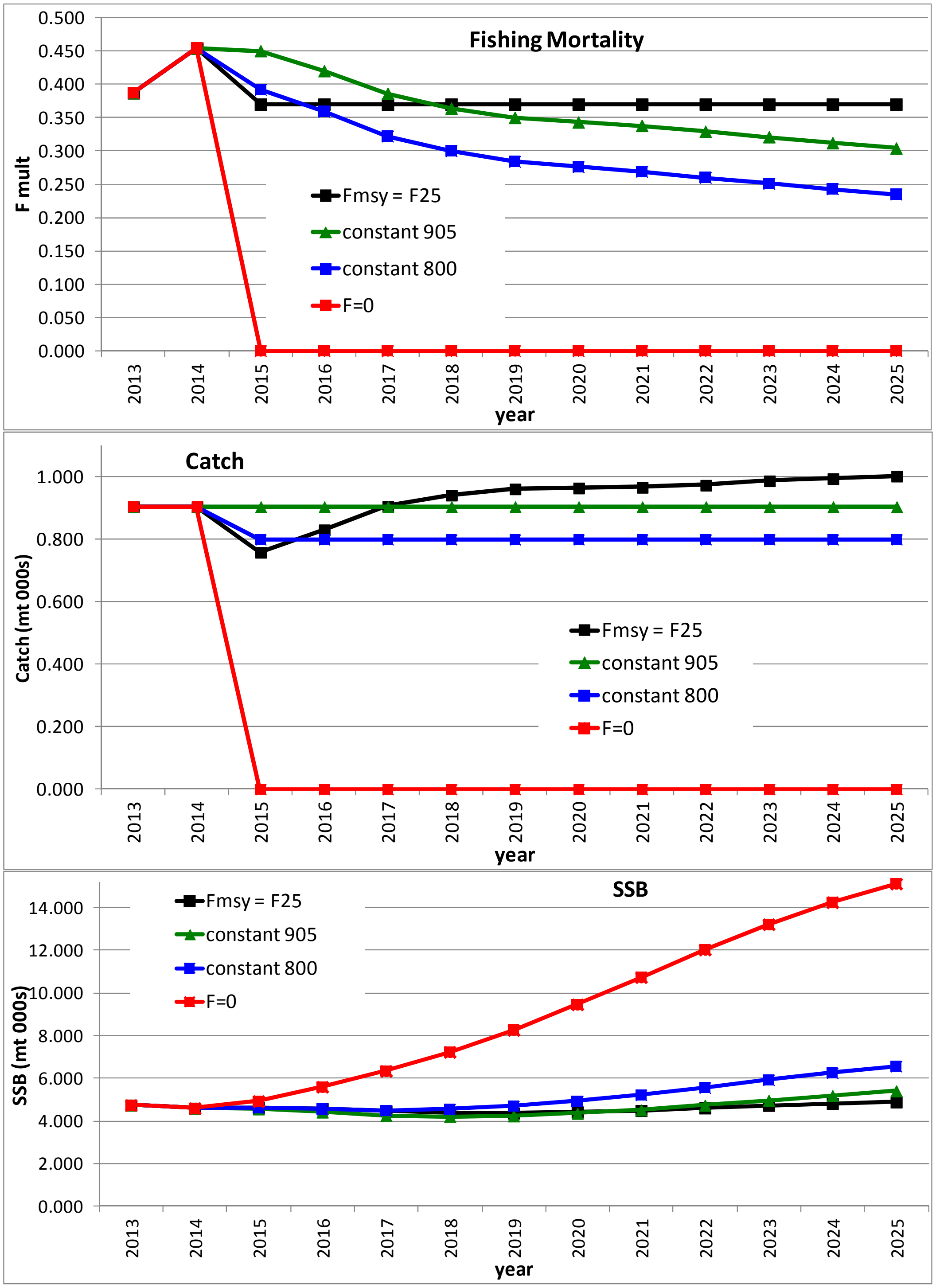


Figure B98. Final ASAP run 27b unadjusted AGEPRO projections at $F_{MSY} = F_{25} = 0.37$, constant catch of 905 mt, constant catch of 800 mt and F=0. A Catch of 905 mt was assumed in 2013 and 2014 bridge years.