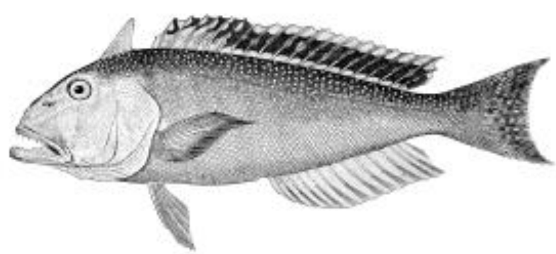
Golden Tilefish, *Lopholatilus chamaeleonticeps,* stock assessment update through 2016 in the Middle Atlantic-Southern New England Region



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State of Stock: This assessment of Golden tilefish is an update through 2016 of commercial fishery landings and size data, CPUE indices of abundance, and the analyses of those data. The Golden tilefish stock was not overfished and overfishing was not occurring in 2016 relative to the newly updated biological reference points (Figure 1).

The SARC 58 (NEFSC 2014) ASAP model was updated with landings, size/age distributions, and commercial CPUE data from 2013-2016 (Figures 2 to 6). During this update process the SARC 58 ASAP model was found to have the likelihood constants turned on. Since the SARC 58 assessment, it was determined that incorporation of likelihood constants into the objective function can cause biases in assessment models (Deroba and Miller 2016). This bias can result in reductions in the estimated recruitment and biomass. These biases also tend to occur more often at the end of the time series in models with limited data and dome-shaped selectivity assumptions (Legault 2015). In this 2017 update the likelihood constants were turned off and are no longer used, which tends to shift recruitment and SSB trends higher and fishing mortality lower, especially at the end of the time series relative to the SARC 58 assessment (Figure 1). This change in the standard ASAP model configuration requires, for this assessment model update only, that the biological reference points be updated following the procedure used in the SARC 58 assessment.

The F_{MSY} proxy was updated using the new average of the fishing mortality during 2002-2012 (a period when the stock was rebuilding under constant quota = 905 mt), providing an updated F_{MSY} proxy of 0.310 (equal to $F_{38\%}$), compared to the SARC 58 value of 0.370 (equal to $F_{25\%}$). The SSB_{MSY} and MSY proxies were also updated using the same procedures as in the SARC 58 assessment. The updated SSB target = SSB_{MSY} = $SSB_{38\%}$ = 9,492 mt (compared to the SARC 58 $SSB_{25\%}$ = 5,153 mt) and the updated SSB threshold = one-half $SSB_{38\%}$ = 4,746 mt (compared to the SARC 58 one-half $SSB_{25\%}$ = 2,577 mt). The updated $MSY_{38\%}$ = 957 mt (compared to the SARC 58 $MSY_{25\%}$ = 1,029 mt).

Based on the ASAP model 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 1998. Since the implementation of constant landings quota of 905 mt in 2002, the stock has increased approaching the biomass target reference point (SSB_{MSY} proxy).

The fishing mortality rate was estimated to be 0.249 in 2016, below the updated reference point F_{MSY} proxy = 0.310. There is a 90% probability that the fishing mortality rate in 2016 was between 0.179 and 0.359 (Figures 7 and 8). SSB was estimated to be 8,479 mt in 2016, 89% of the updated biomass target reference point SSB_{MSY} proxy = 9,492 mt. There is a 90% chance that SSB in 2016 was between 4,061 and 12,888 mt (Figures 7 and 8). Average recruitment from 1971 to 2016 was 1.42 million fish at age 1. Recent large year classes occurred in 1998 (2.35 million), 1999 (2.39 million) and 2005 (1.85 million). A recent large year class is estimated at 2.85 million in 2013. This year class should recruit to the small and kitten market categories in 2017. The updated 2017 final run had a minor retrospective pattern in fishing mortality (Mohn's Rho = -0.15), spawning stock biomass (Mohn's Rho = -0.06) and age-1 recruitment (Mohn's Rho = +0.24) (Figures 9-11).

Catch: Total commercial landings (live weight) increased from less than 125 metric tons (mt) during 1967-1972 to more than 3,900 mt in 1979 during the development of the directed longline fishery (Figure 2). Landings prior to the mid-1960s were landed as a bycatch in the trawl fishery. Annual landings ranged between 454 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. Landings from 2005 to 2009 were at or below the quota, while landings in 2010 at 922 mt were slightly above the quota (Figure 2). Since 2010 landings have been below the quota and decreased to an estimated 502 mt in 2016. The Total Allowable Landings (TAL) was reduced for the first time in 2015 to 796 mt from the TAL of 905 mt which was in place from 2001-2014. The TAL in 2016 and 2017 was increased to 856 mt based on projections from the SARC 58 assessment.

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 longline fishery appear to be a minor component of the catch. Recreational catches are estimated to be low and were not included as a component of the removals in the assessment model.

Catch and Status Table: Golden Tilefish. Landings, SSB, Recruitment (age-1), and Fishing Mortality (FMULT) (weights in '000 mt live, recruitment in millions)

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Max[1]	Min[1]	Mean[1]
Commercial landings	0.8	0.7	0.9	0.9	0.9	0.8	0.8	0.8	0.6	0.5	4.0	0.1	1.3
SSB	7.9	8.1	8.7	8.3	8.4	8.4	7.9	8.1	8.4	8.5	28.6	2.6	8.9
Recruitment	1.5	1.0	0.9	0.8	0.8	0.5	1.0	2.9	1.5	1.2	3.9	0.5	1.4
Fishing mortality	0.36	0.37	0.34	0.29	0.26	0.28	0.35	0.40	0.30	0.25	1.18	0.01	0.46

[1] Over period 1971-2016.

Commercial CPUE, market category and size composition data: Changes in the CPUE can be generally explained by the impact of strong incoming year classes that track through the landings size composition over time. Since the SARC 58 assessment there appear to be increases in CPUE due to one or two new strong year classes. In general, strong year classes and proportion of larger fish in the catch appear to persist longer in the fishery after the FMP’s quota based management came into effect, which is evident in both the CPUE and size composition data. The continued decrease in the CPUE since 2011 is consistent with the ageing of the last strong year class in 2005.

More recently, evidence of a new strong 2013 year class is beginning to enter the fishery. The 2016 data update showed a mode of very small tilefish (31 cm) in the 2015 catch at length from the unclassified market category (Figures 5 and 6). Now the update of the 2016 catch at length provides further evidence of this strong 2013 year class, which has just begun to enter the directed fishery in the extra small market category. A broad size distribution and market category proportions show evidence of small fish from the strong 2013 year class while also showing the presence of larger fish in the catch. CPUE is expected to increase from a 10 year low as the strong 2013 year class further recruits to the fishery. This year class is projected to enter the small/kitten market categories at age 4 during 2017 (Figure 4). However, the exact strength of this year class is still uncertain since it is estimated to be only 5% recruited to the fishery in 2016. The model suggests a 50% selection at age 4 in 2017 and full selection at age 5 in 2018.

Projections: The projections are conditioned on the 2017 ABC being taken (861 mt) in 2017 and fishing at the F_{MSY} proxy = 0.310 from 2018 to 2020. Overfishing is projected to occur in 2017 at a 58% probability with the removals of 861 mt.

Catch, Fishing Mortality (F), Spawning Stock Biomass (SSB),
Probability of $F>F_{MSY}$ and $SSB<SSB_{MSY}/2$
Catch and SSB in metric tons

Year	Total Catch	F	SSB	$P(F>F_{MSY})$	$P(SSB<SSB_{MSY}/2)$
2017	861	0.327	6,983	0.577	0.127
2018	1,058	0.310	7,407	-	0.094
2019	1,030	0.310	7,824	-	0.055
2020	944	0.310	7,856	-	0.047

Stock Distribution and Identification: 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 relatively narrow temperature preference of 9 to 14 °C. The Virginia- North Carolina border defines the boundary between the northern and southern Golden Tilefish management units.

Data, Assessment Model and Model Sensitivity Runs: The surplus production model ASPIC was used to assess the Golden Tilefish stock in assessments previous (Nitschke et al. 1998, NEFSC 2005, 2009) to SARC 58 (NEFSC 2014). The availability of length and age data facilitated application of a forward projecting age-structured model ASAP (Legault and Restrepo 1998; NFT 2013c) using a pooled age length key in the SARC 58 stock assessment. The same pooled age length key was used in this 2017 model update. However, new age data was available for 2007, 2014 and 2015. A sensitivity model run was done using 2014 and 2015 ages to estimate year specific catch at age for these two years and a pooled 2014 and 2015 key was used to estimate 2016 (Figure 12). An additional sensitivity run was done by pooling all the age data available and develop a new pooled age length key for the whole time series which was then used to re-estimate the time series catch and weight at age. In general there was little difference between the updated 2017 model using the pooled key from SARC 58 with the two sensitivity runs. Incomplete year specific age information in 2016 likely was responsible for the failure to estimate a strong 2013 year class in the year specific run. However, there is evidence of a strong 2013 year class in the catch at length. Note that the use of a pooled age length key will also contribute to the uncertainty in year class strength and in turn influence projected catches.

There are no fishery independent surveys available for this stock, so commercial catch per unit effort is relied upon for indications of population abundance. Over the last fifteen 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 (Figure 3). The 2005 year class has now passed through the fishery, and fishery CPUE has continued to decline to the terminal year in 2016 with the dome-shaped selectivity pattern. Review of commercial fishery practices and markets justified the use of a dome-shaped selectivity pattern used in the assessment model developed at SARC 58.

Biological Reference Points (BRPs): Golden Tilefish are estimated to live about 40 years, and this information along with the SARC 58 likelihood profiles of the ASAP model indicated that a value for instantaneous natural mortality (M) of 0.15 was appropriate (NEFSC 2014). The long lifespan and relatively low M would suggest that a fishing mortality rate BRP of $F_{40\%}$ or higher %MSP would be appropriate. Under a management regime using a constant landings quota of 905 mt from 2002-2012, with actual landings close to the quota each year, the stock increased to 8,388 mt in 2012. SARC 58 (NEFSC 2014) therefore recommended using the average of the fishing mortality during 2002-2012, a period when the stock was rebuilding under constant quota = 905 mt, as the F_{MSY} proxy for Golden Tilefish.

This update indicates that fishing mortality rates have averaged 0.310 from 2002-2012, and the updated yield per recruit analysis shows that this fishing rate now corresponds to $F_{38\%}$, compared to the $F_{25\%}$ estimate calculated in SARC 58. Therefore, the updated BRPs proxies using the same average F calculations as in SARC 58 produced a F_{MSY} proxy = 0.310 (overfishing threshold), with corresponding SSB_{MSY} proxy = 9,492 mt (SSB target), one-half SSB_{MSY} = 4,746 mt (SSB threshold), and MSY = 957 mt. SSB_{MSY} was calculated from median estimates of long term (100 years) stochastic projections fishing at the F_{MSY} proxy = 0.310 which resampled from the CDF of empirical recruitment from 1971-2016.

Fishing Mortality: Fishing mortality on the fully selected age class (age 5, F_{MULT}) increased with the development of the directed longline fishing from near zero in 1971 to 1.179 in 1987 (Figure 7). Fishing mortality then remained relatively high through the 1990s. Fishing mortality has been lower since 1999 and was estimated to be 0.249 in 2016. F_{MULT} 90% confidence intervals were 0.179 and 0.359 in 2016 (Figure 8).

Spawning Stock Biomass: Spawning stock biomass decreased substantially early in the time series from 28,608 mt in 1974 to 2,591 mt in 1998, lowest in the time series (Figure 7). SSB has since increased to 8,479 mt in 2016. Spawning stock biomass 90% confidence intervals were 4,061 and 12,888 mt in 2016 (Figure 8).

Recruitment: Average recruitment from 1971 to 2016 was 1.4 million fish. Recent large year classes have occurred in 1998 (2.93 million), 1999 (3.02 million) and 2005 (2.05 million) (Figure 1). A new recent large year class was estimated in 2013 (2.85 million). However, this year class has just started to enter the directed longline fishery in 2016, and so this estimate has higher uncertainty than those prior.

References and Further Information:

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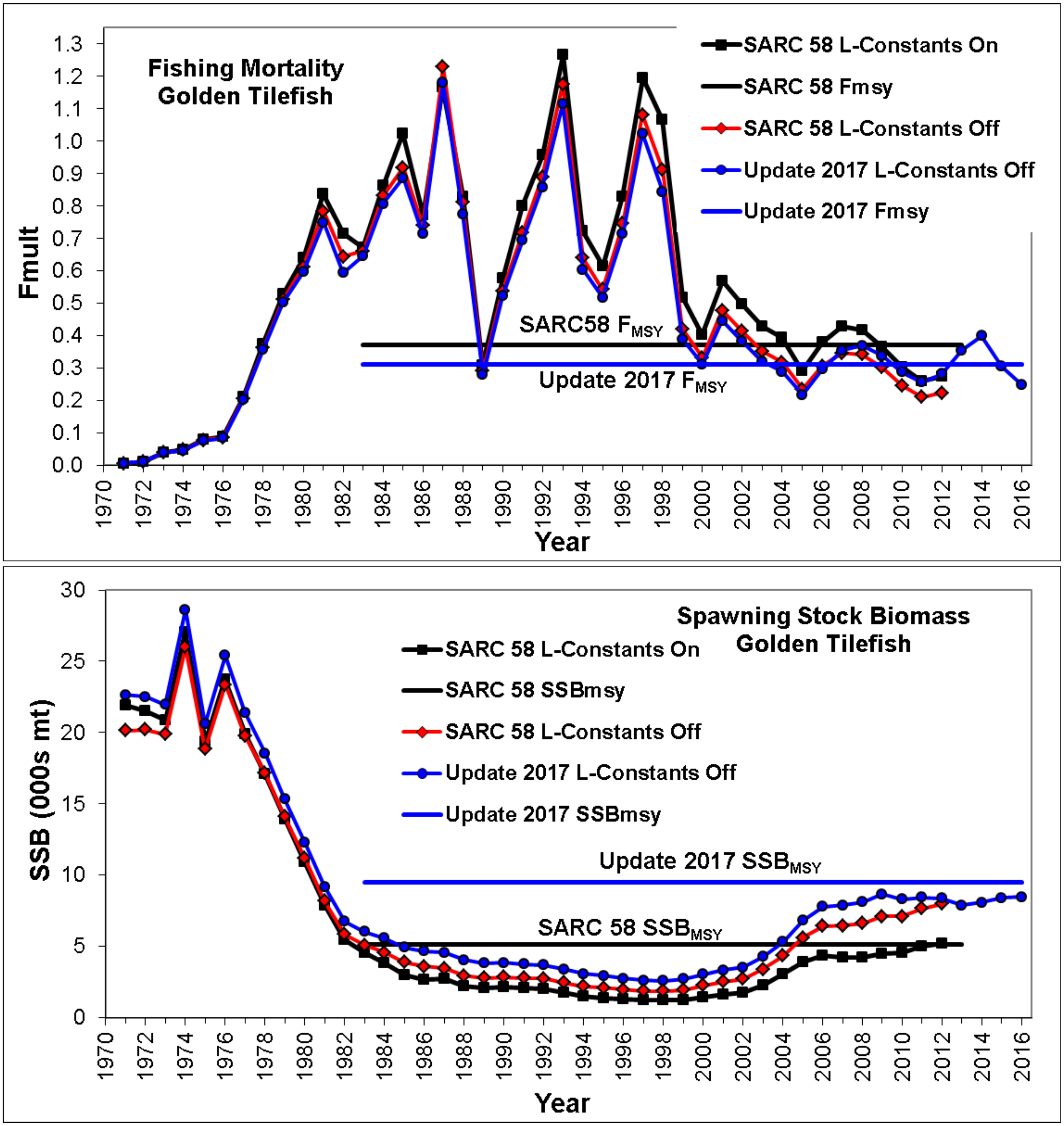


Figure 1. F_{MULT}, spawning stock biomass (SSB), and age-1 recruitment comparison of the SARC 58 final ASAP model (terminal year 2012) with the likelihood constants on, the SARC 58 model (terminal year 2012) with the likelihood constants turned off and the final update 2017 model (terminal year 2016) with the likelihood constants turned off. The SARC 58 and 2017 updated estimated F_{MSY} and SSB_{MSY} biological reference points are also shown for comparison.

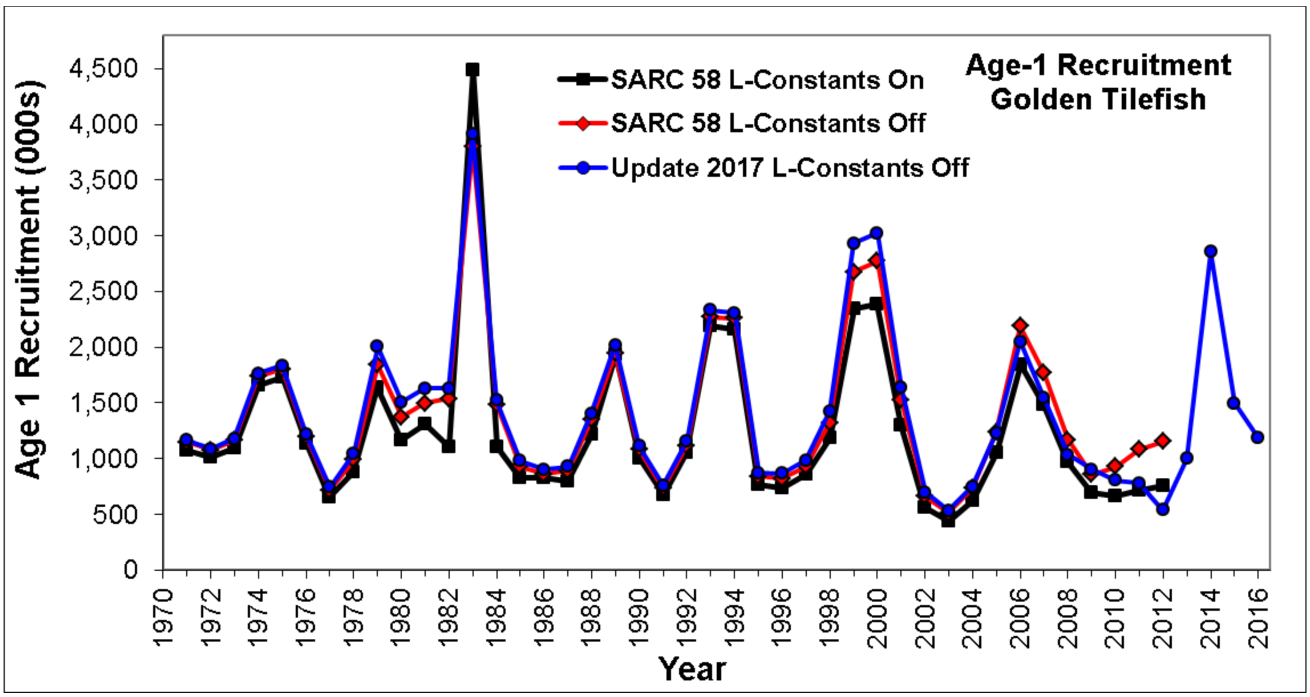


Figure 1. Cont. F_{MULT}, spawning stock biomass (SSB), and age-1 recruitment comparison of the SARC 58 final ASAP model (terminal year 2012) with the likelihood constants on, the SARC 58 model (terminal year 2012) with the likelihood constants turned off and the final update 2017 model (terminal year 2016) with the likelihood constants turned off. The SARC 58 and 2017 updated estimated F_{MSY} and SSB_{MSY} biological reference points are also shown for comparison.

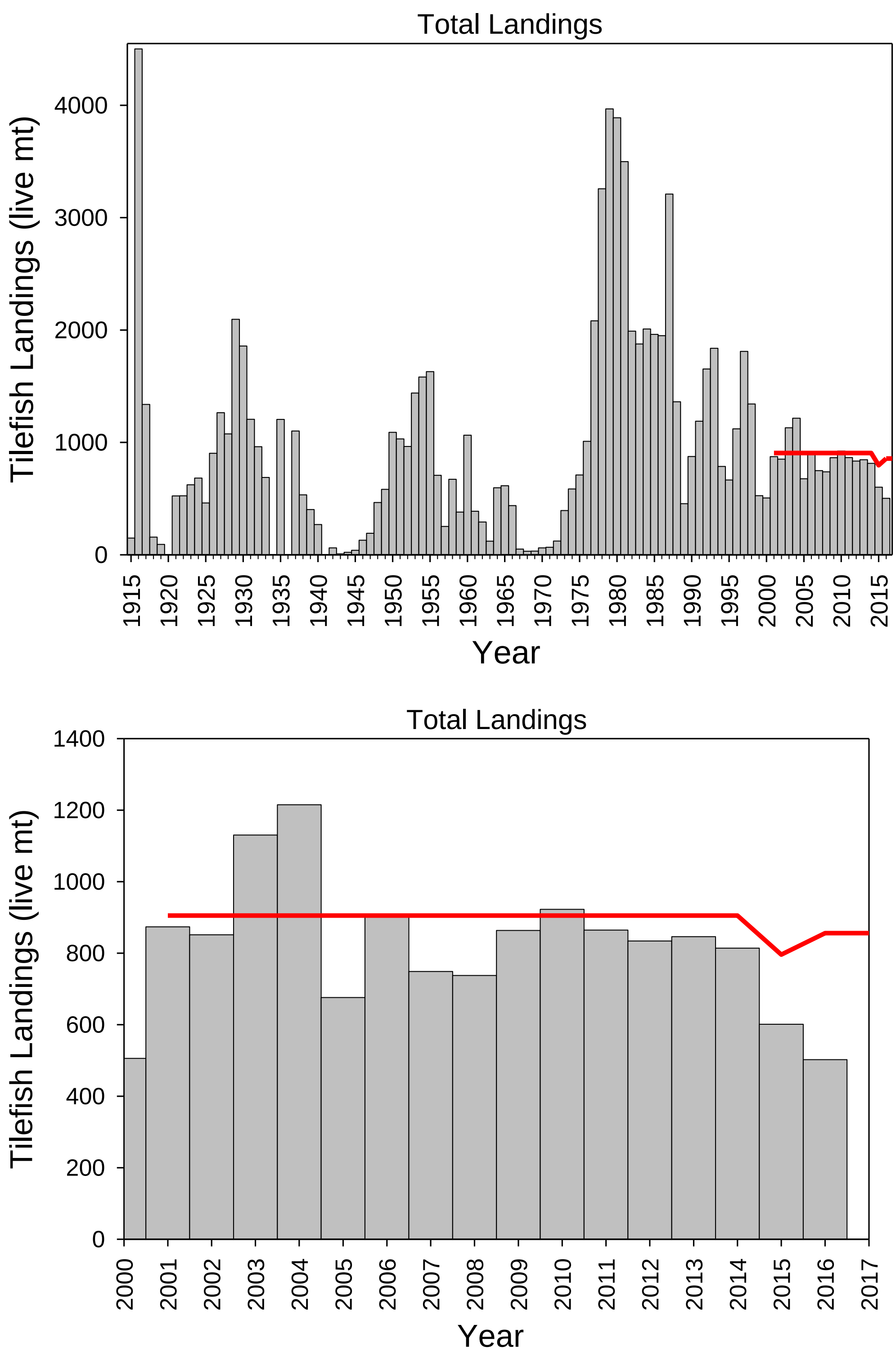


Figure 2. Landings of tilefish in metric tons from 1915-2016 (top) and from 2000-2016 (bottom). Landings in 1915-1972 are from Freeman and Turner (1977), 1973-1989 are from the general canvas data, 1990-1993 are from the weighout system, 1994-2003 are from the dealer reported data, and 2004-2016 is from dealer electronic reporting. Red line is the Total Allowable Landings (TAL) from 2001-2017.

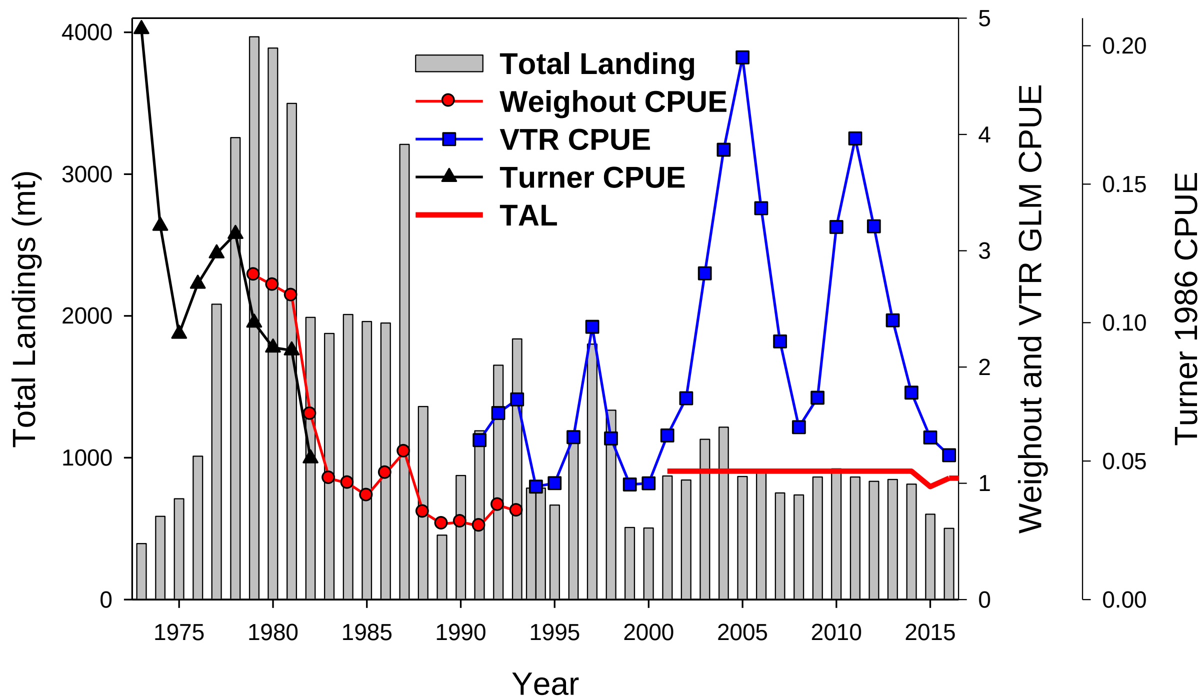


Figure 3. General Linear Model (GLM) Catch Per Unit Effort (CPUE) for the Weighout and Vessel Trip report (VTR) data split into two series with additional New York logbook CPUE data from three vessels (1991-1994) added to the VTR series. Four years of overlap between the Turner (1986) and Weighout CPUE series can also be seen. ASAP relative changes in qs among CPUE series were not incorporated into the plot. Assumed total landings are also shown. Landings in 2005 were taken from the Interactive Voice Reporting (IVR) system. Red line is the Total Allowable Landings (TAL).

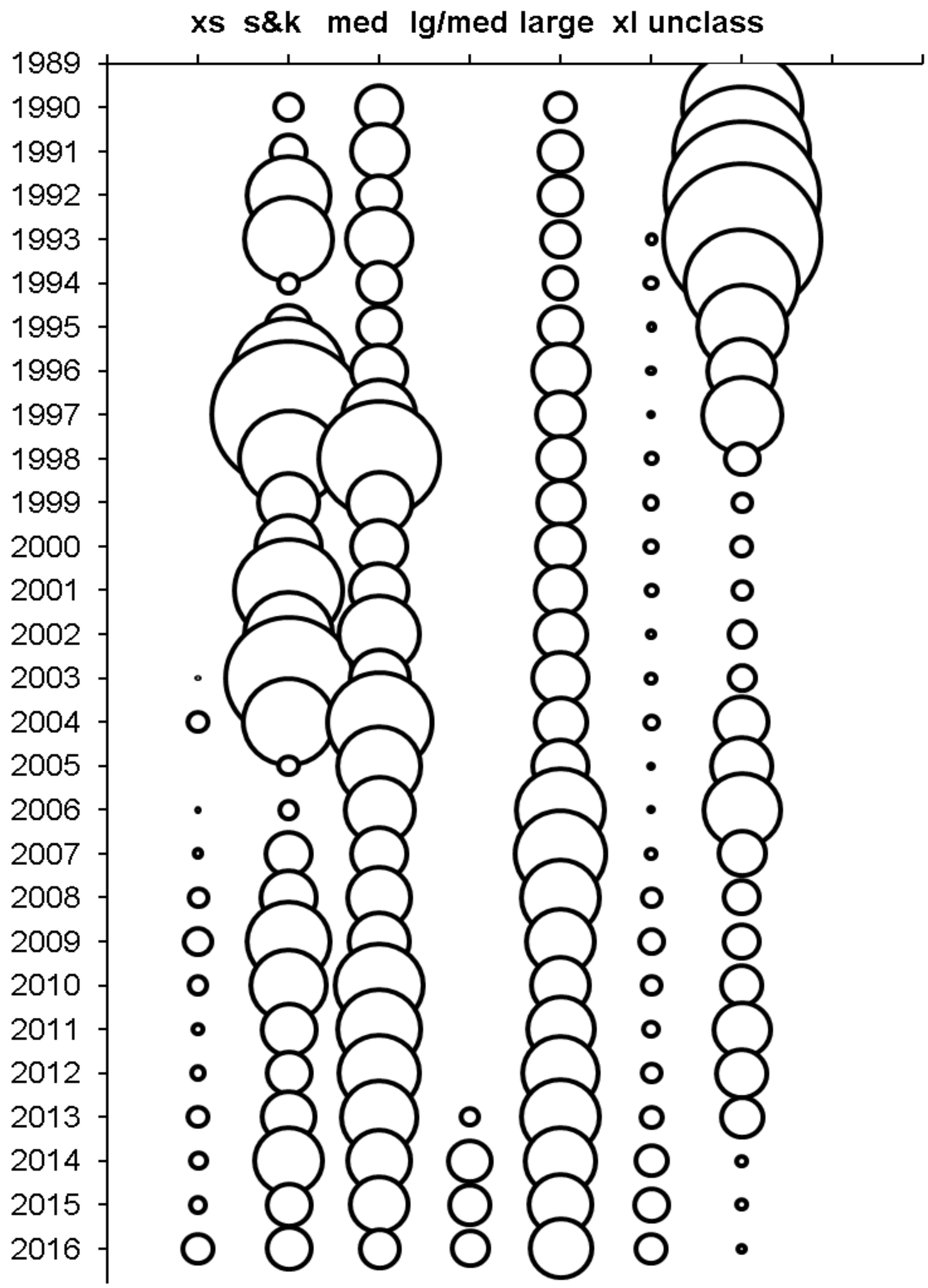


Figure 4. Bubble plot of Golden tilefish landings by market category. Large-medium market category code was added in 2013. Smalls and Kittens (s&k) were combined since these categories possess similar size fish.

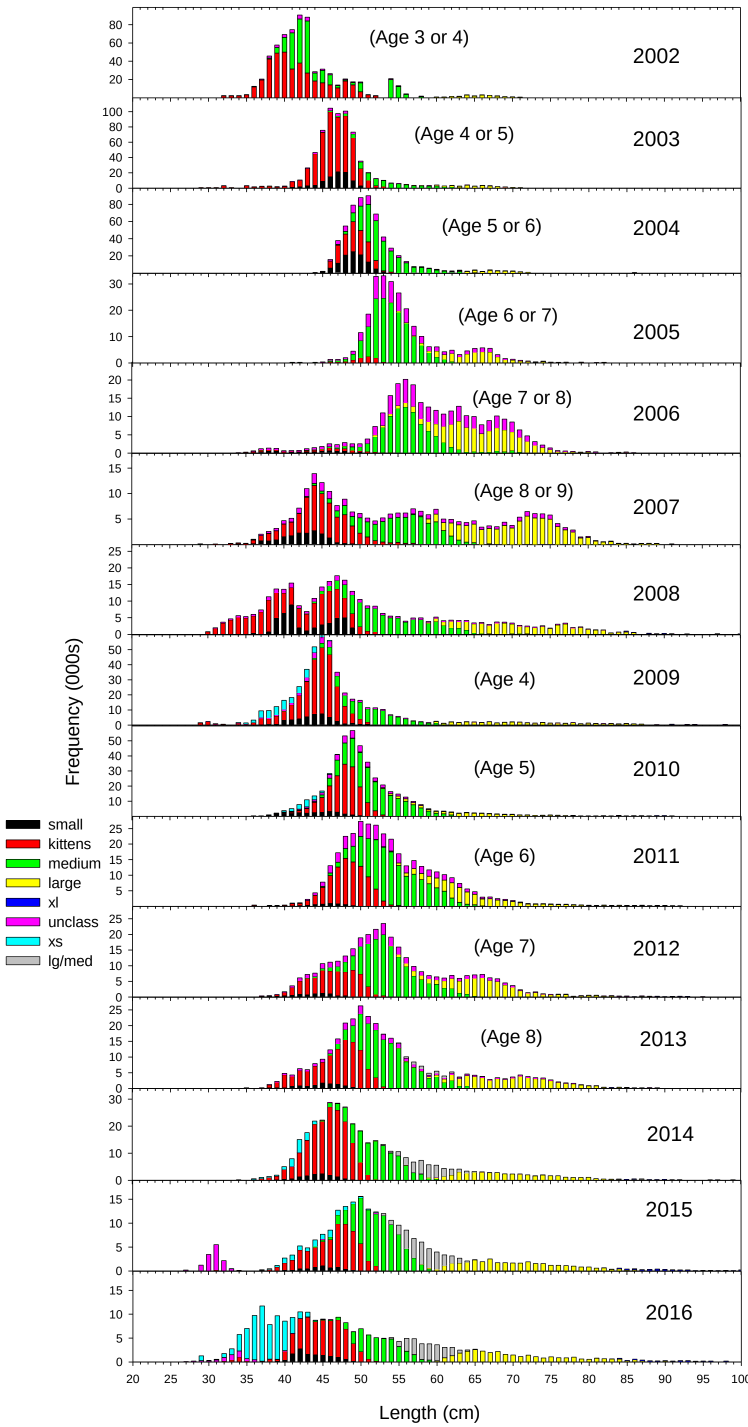


Figure 5. Expanded length frequency distributions from 2002 to 2016. Kittens lengths were used to characterize the extra small category in 2013. Y-axis is allowed to rescale.

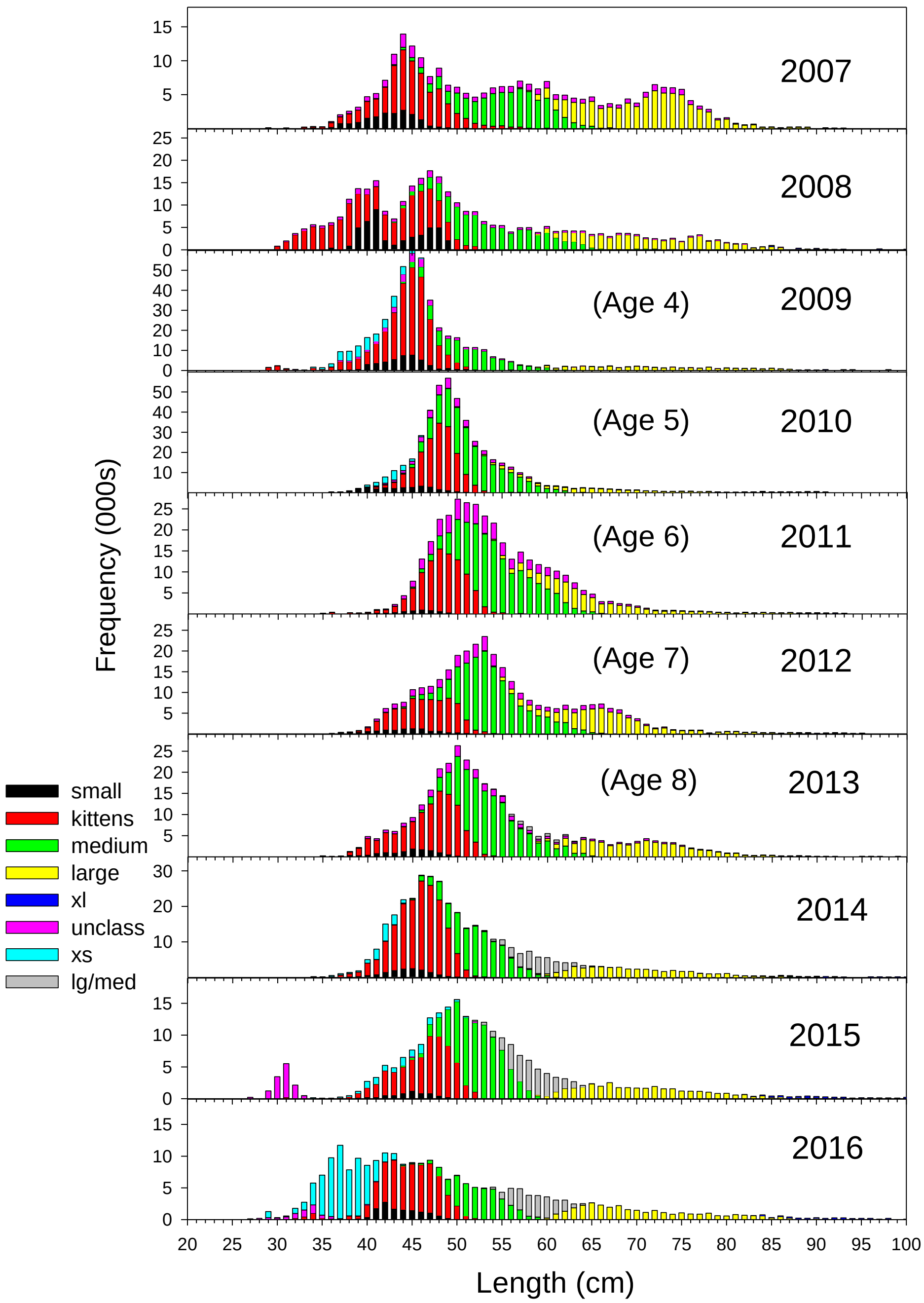
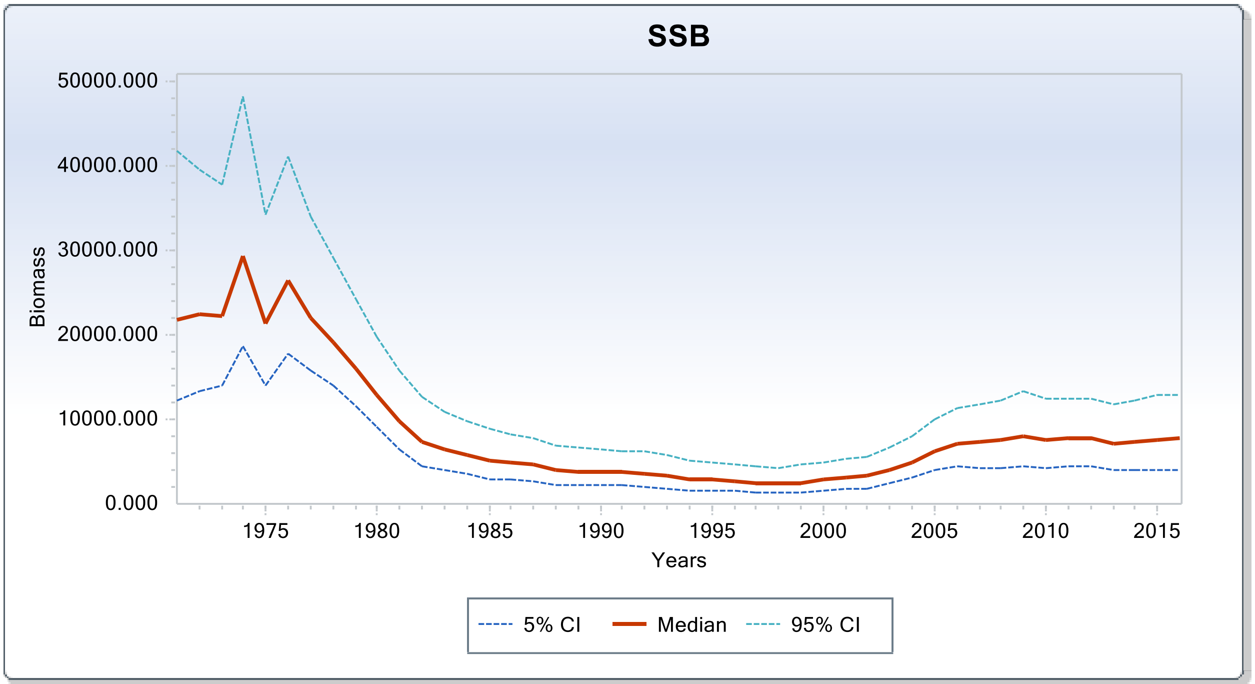


Figure 6. Expanded length frequency distributions from 2007 to 2016. No lengths for extra small (xs) exist in 2013. Kittens lengths were used to characterize the extra small category in 2013. No length samples for unclassified were used from 2007-2014. Unclassifieds in 2015 are based on two samples. Y-axis is allowed to rescale.



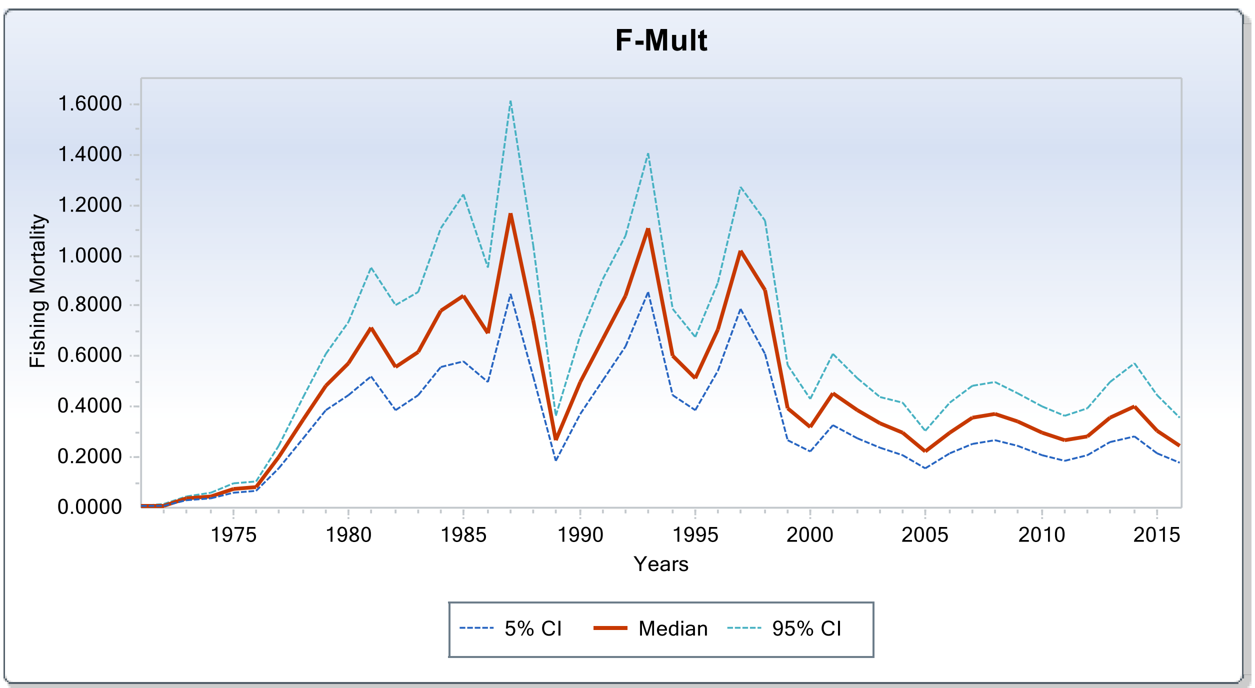


Figure 7. Updated 2017 ASAP model estimated fishing mortality (FMULT) and SSB with MCMC estimated 90% confidence intervals.

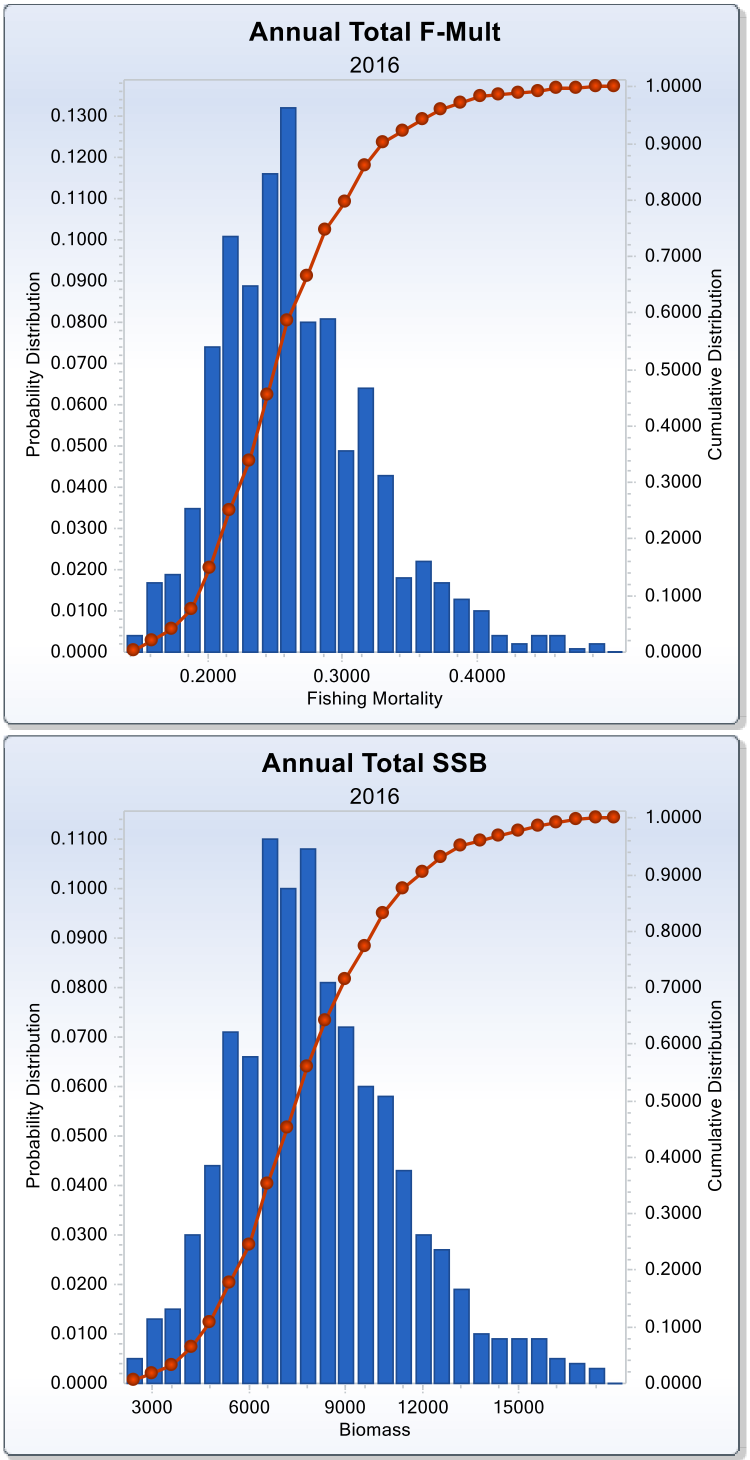


Figure 8. MCMC 2016 distributions for fishing mortality (FMULT) and SSB.The percent confidence intervals can be taken from the cumulative frequency. The 2016 point estimate for fishing mortality = 0.249 and SSB = 8,479 mt.

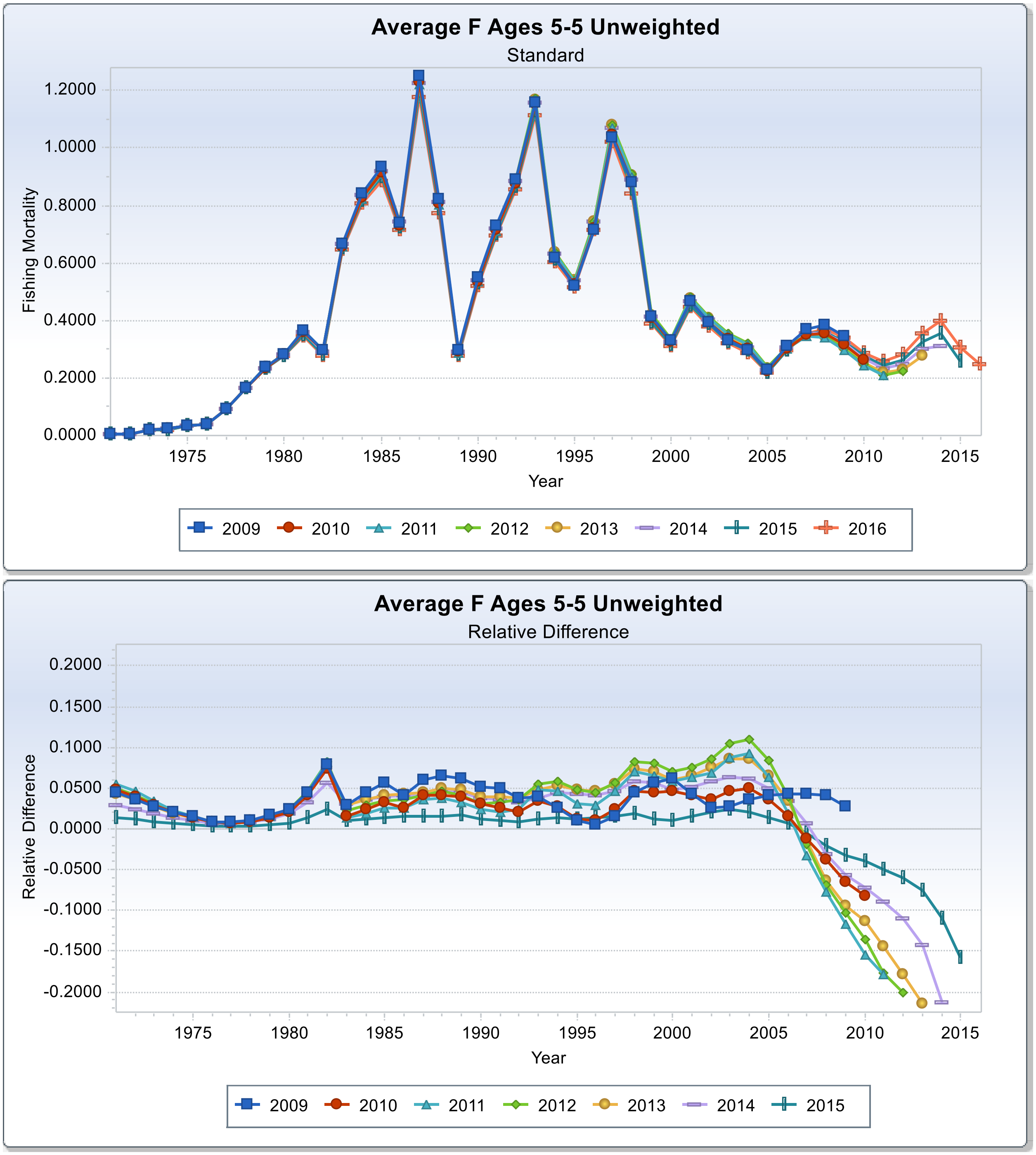


Figure 9. Updated 2017 model 7 peel retrospective analysis: fully recruited F age 5 = F_{Mult}; Mohn's Rho = -0.15.

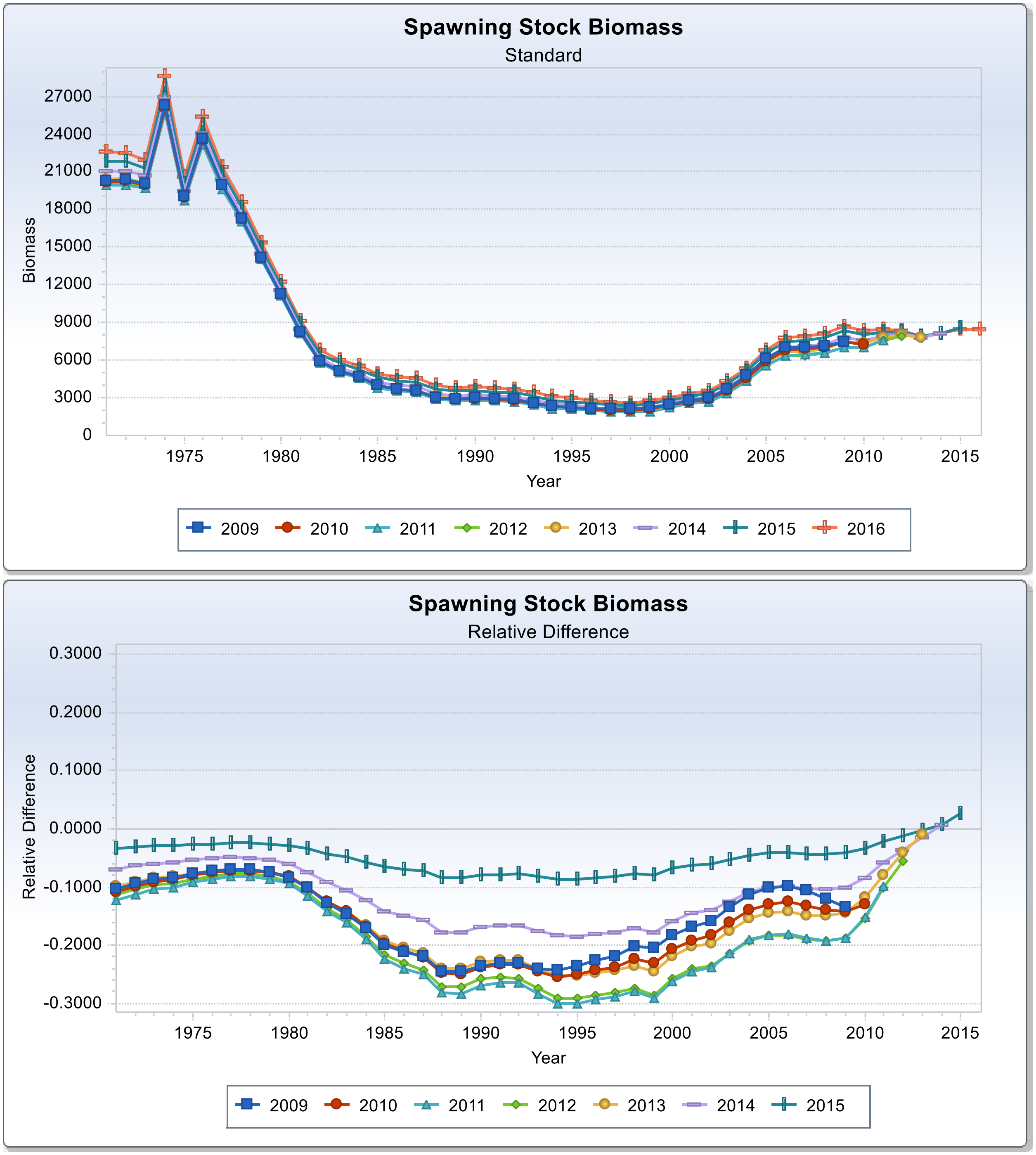
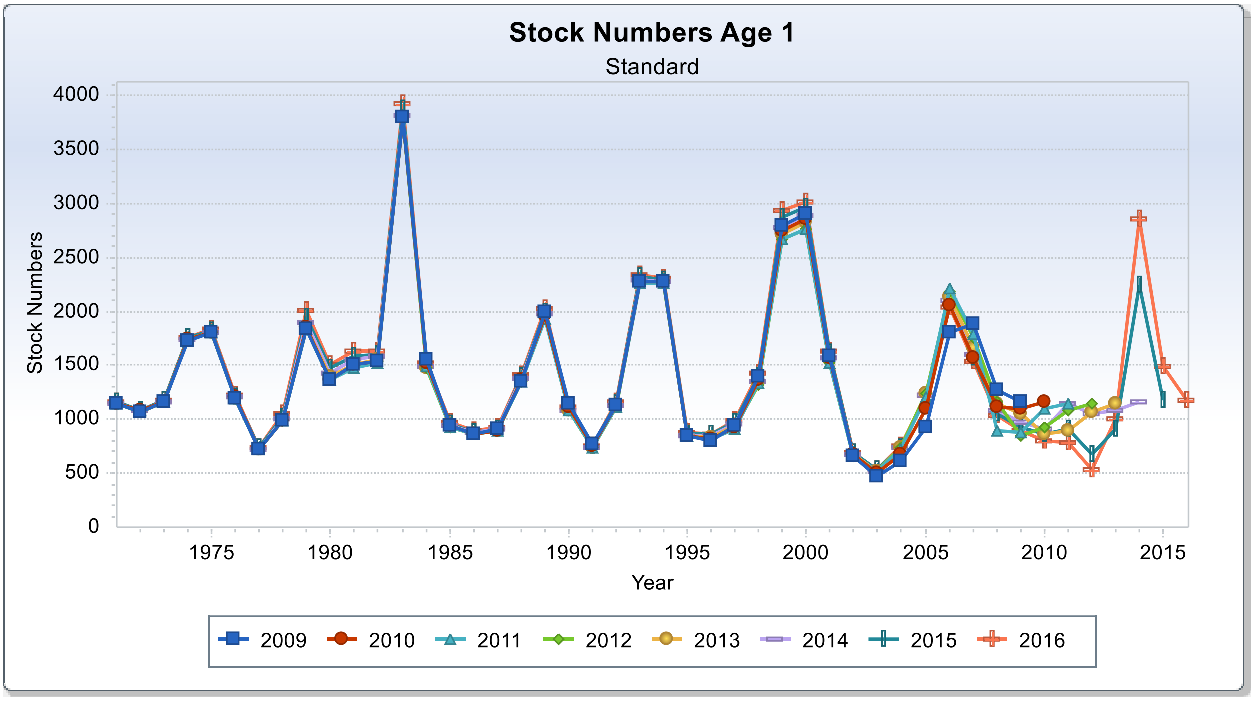


Figure 10. Updated 2017 model 7 peel retrospective analysis: Spawning Stock Biomass; Mohn's Rho = -0.06.



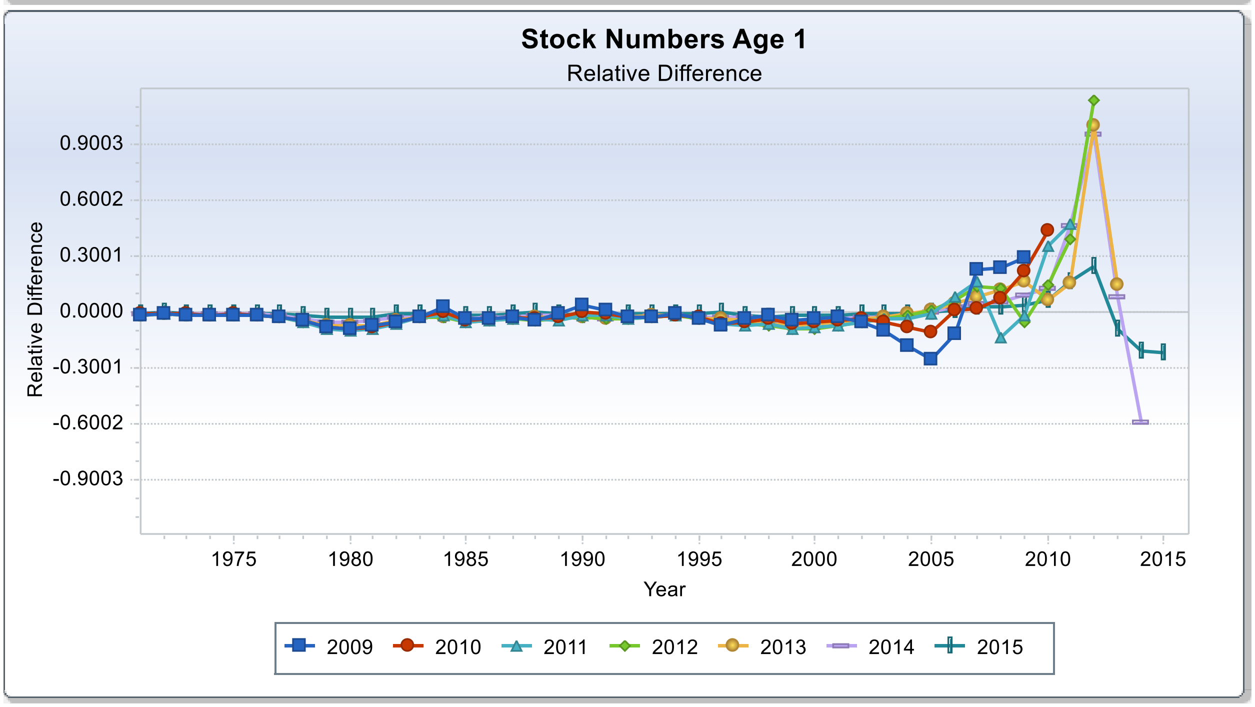


Figure 11. Updated 2017 model 7 peel retrospective analysis: Age-1 Recruitment; Mohn's Rho = +0.24.

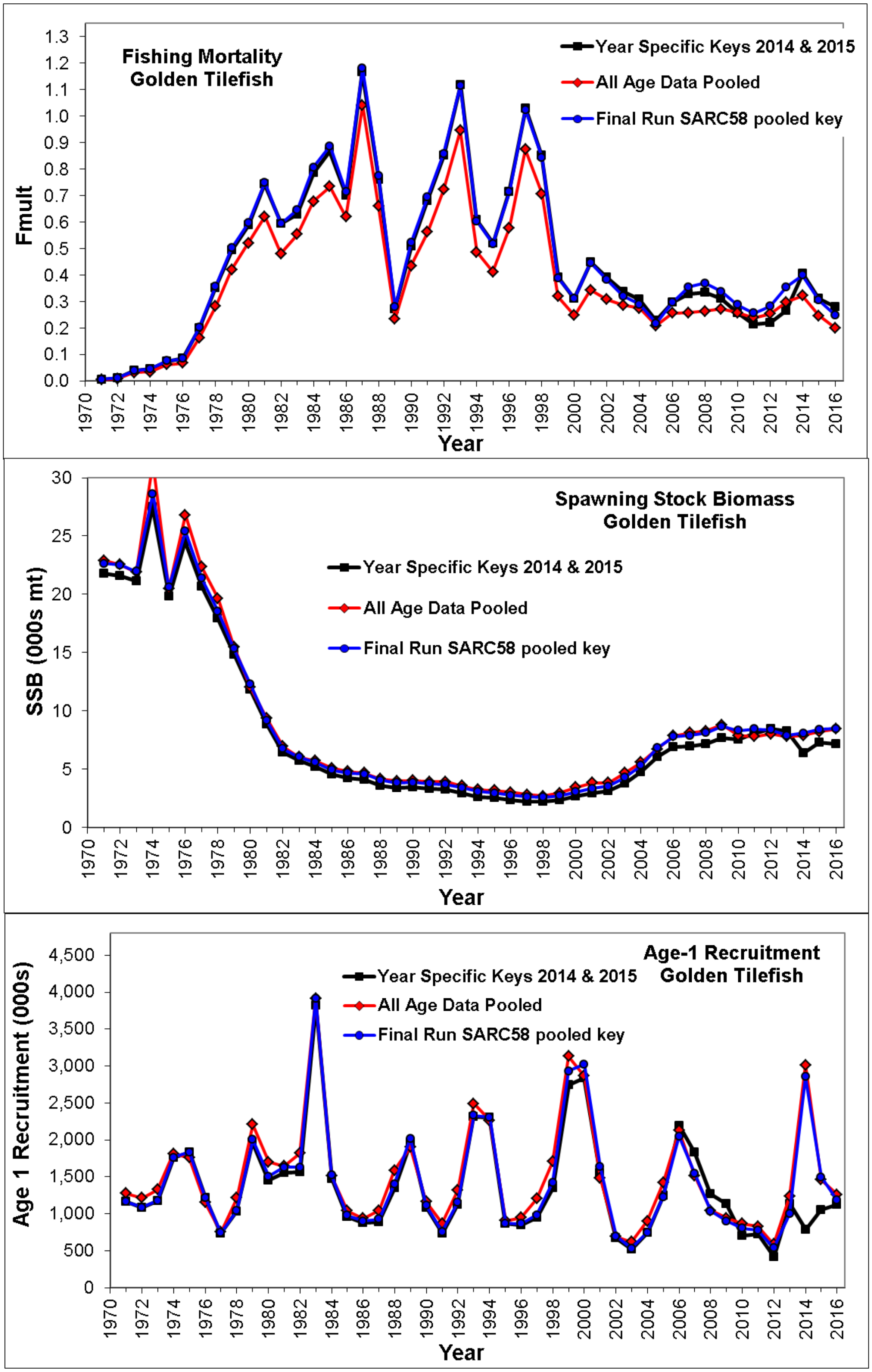


Figure 12. FMULT, spawning stock biomass (SSB), and age-1 recruitment comparison of the 2017 final update run using the SARC 58 pooled age length key to age 2013-2016 to a sensitivity run which used year specific keys in 2014 and 2015 and 2014-2015 pooled to age 2016 and a second sensitivity run which used all age data available 2007-2015 to estimate an update pooled age length key that was used to estimate the catch at age and weights at age in all years.