A closer look at the 2018 stock assessment model for Pacific bluefin tuna

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Summary

This working paper provides potential areas of improvement for the 2018 Pacific bluefin tuna stock assessment model. The 2018 assessment model was revisited, and an alternative model or approach is recommended for each aspect as follows: 1) improved fit to size composition data for two age-0 fleets by using less constrained selectivity parameterization for these fleets, 2) use of the US recreational length compositions to account for the increased number of size classes in the data observed since 2014 in the eastern Pacific Ocean, 3) relaxation of the assumption of asymptotic selectivity, 4) simplified selectivity parameterization to reduce the number of estimated parameters, 5) convergence issue with the steepness, and 6) transition of the 2018 assessment model to Stock Synthesis 3.30. Given the complexity of the parametrization, we evaluated each alternative model as one-off changed from the 2018 stock assessment model. Also, there could be other alternatives within each aspect that were not explored in the paper.

Introduction

The Pacific Bluefin tuna Working Group (PBFWG) of the International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean (ISC) is tasked to conduct a benchmark stock assessment in 2020. The PBFWG completed a benchmark stock assessment in 2016 (ISC 2016) and an updated of the 2016 assessment in 2018 (ISC 2018).

In these assessments, dynamic models were able to capture the signal of observed catches in adult indices (based on the age-structured production diagnostics). Additionally, the recruitment index used provided a reliable measure of age-0 abundance (as shown in an unpublished study). In this well-defined system, all data used indicated a consistent population scale (based on the R0 profile analysis). The assessment model estimated both length-based contact selectivity (the probability that a fish of a given size is caught by the fleet) and age-based selectivity as proxy of the age-based availability (the probability that a fish of a given age is available to the fleet) based on the simulation study (Lee et al., 2017). For fleets without CPUE information, selectivities were often modeled as time-varying to capture primarily changes in spatial availability. Given the complexity of the selectivity parametrization, the number of estimated parameters increased to 316 with a resulting run time (including the Hessian matrix) of 50 minutes.

The current assessment model has performed well, however, we have revisited some aspects of the model as potential areas for improvement: 1) improved fit to size composition data, 2) use of the US recreational length compositions, 3) relaxation of the assumption of asymptotic selectivity, 4) simplified selectivity parameterization, 5) convergence issue with the steepness, and 6) transition of the 2018 assessment model to Stock Synthesis 3.30. Because of the complexity of the current stock assessment, we evaluated each alternative model as one-off changes from the 2018 stock assessment model. Therefore, the impact on the results of interactions of a combination of more than 1 of the evaluated changes is unknown.

1. Positive residuals for size-at-age 0 fish

Status: The goodness-of-fits to the size composition data from the 2018 stock assessment model generally captured the size modes when the data were aggregated by fleet across seasons and years (Figure 1-1). However, there were noticeable positive residuals (observed > expected) from the two fleets caught age-0 fish (Fleet 2: Japan small pelagic purse seine fisheries in the East China Sea for the seasons 1, 3 and 4, and Fleet 6: Japan troll fisheries for the seasons 2-4; left panels in Figure 1-2).

Alternative: These positive residuals were hypothesized to be the results of differences in the timing of the recruits and/or constraints of the parameterization for the length-based contact selectivity. For fleet 2, the positive residuals were greatly reduced (upper panels in Figure 1-2) by estimating the parameter for the selectivity in the last length bin (P6) of the double normal function. This parameter was fixed in the 2018 stock assessment model (Appendix 1-1). For fleet 6, the positive residuals were reduced (lower panels in Figure 1-2) by estimating the parameters for both selectivity at the first (P5) and last (P6) length bins of double normal function. These parameters were fixed in the 2018 stock assessment model (Appendix 1-2). Both models converge with 317 and 318 parameters estimated for fleet 2 and fleet 6 models, respectively.

Conclusion: The PBFWG should consider using the less constrained selectivity parameterization for these age-0 fleets (fleets 2 and 6) to reduce the large positive residuals without considerably impacting the population dynamics (Figure 1-3).

2. Fit the US recreational length compositions

Status: Size samples of the US recreational catch were collected by the Inter-American Tropical Tuna Commission (IATTC) from 1993 to 2011 and have been collected by Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS) since 2014. The catch from these recreational fleets has increased due to increased abundance and warmer than average waters in recent years, and the fisheries have caught larger fish compared to the size of fish caught before

2011 (Figure 2-1). These size composition data were not used as a likelihood component in the 2016 and 2018 stock assessments.

Alternative: To better account for the size of removals of the US Sport fleet (fleet 15), especially given the increased size classes observed since 2014 in the eastern Pacific Ocean, two alternative models were conducted to fit these size compositions. All six parameters of the double normal function that describes a dome shape for length-based contact selectivity were estimated (Figure 2-2; Appendix 2-1). Two time blocks were set for 1) prior to 2014 and 2) 2014-2016 for the length-based selectivity to reflect different sampling designs between IATTC and NMFS. The first alternative model assumed that the change of annual spatial age-class availability due to movement and contact selectivity varies yearly from 2014 to 2016, where four out of six dome shape parameters (beginning size for the plateau (P1), width of the plateau (P2), descending width (P4), and selectivity at last bin (P6)) were time-varying (top panel in Appendix 2-1). The second alternative model assumed that the change of annual spatial age-class availability due to movement and contact selectivity varies yearly not only from 2014 to 2016, but also from 1993 to 2011. Additional additive time-varying deviations were estimated from 1993 to 2011 for three out of six dome shape parameters (width of the plateau (P2), ascending width (P3), and descending width (P4)) (bottom panel in Appendix 2-1). Both models converge with 334 and 391 parameters estimated in the model 1 and 2, respectively. The alternative model 1 has fewer parameters estimated with worse goodness-of-fits to the size compositions for fleet 15 compare to the alternative model 2 (Figure 2-3).

Conclusion: To reflect the nature of the recent increase in catch-at-size in the eastern Pacific Ocean, we recommend the 2020 stock assessment model fit the size compositions for fleet 15 without impacting the population dynamics (Figure 2-4).

3. <u>Asymptotic or dome shape (contact) length-based selectivity for Taiwan longline fisheries</u>

Status: The 2016 and 2018 stock assessment models assumed asymptotic length-based selectivity for the Taiwan longline fleet (F12), which caught the largest size classes of fish. This assumption was intentionally made to stabilize parameter estimation. However, the large size of fish may not be always fully available to the fleet due to the incomplete mixing of large individuals in the area or/and heterogeneity of fishing gears.

Alternative: An alternative model was conducted by estimating the dome shape (contact) length-based selectivity for the Taiwan longline fleet (F12) (Figure 3-1). Five out of six dome shape parameters (beginning size for the plateau (P1), the width of the plateau (P2), ascending width (P3), descending width (P4), and selectivity at last bin (P6)) were estimated (Appendix 3-1). The alternative model converged with 319 parameters estimated. The goodness-of-fits to the size compositions for fleet 12 by assuming dome shape performed as well as those by assuming asymptotic (Figure 3-2). This alternative model estimated a larger population compared to the 2018 stock assessment model (Figure 3-3).

Conclusion: Specifying an asymptotic selectivity for this fleet is an assumption made to stabilize parameter estimates. That assumption may not be necessary due to the strong information in the model. The PBFWG should consider using a selectivity parameterization that allows a range from asymptotic to domed shape. A penalized likelihood could be used to constrain the shape of the pattern.

<u>4. Simplified selectivity parameterization</u>

Status: The 2016 and 2018 stock assessment models assumed that each fleet represents a combination of gear and area with its own selectivity pattern estimated (i.e., fleets-as-areas) to account for both spatial processes (estimating age-based selectivity) and contact selectivity of the gear (estimating length-based selectivity). For the fleets catching non-migrating age-classes (ages 0 or 6 and older for fleets 1, 2, 6, 12, 17, and 19), time-invariant length-based contact selectivity assuming either an asymptotic pattern or a dome shape was estimated, but age-based selectivity was not estimated (left panel in Appendix 4-1). For the fleets catching migrating age-classes (ages 1-5 for fleets 4, 5, 8, 9, 10, 13, 14, and 18), either time-varying length-based contact selectivity or time-varying age-based selectivity was estimated (left panel in Appendix 4-1 and top panel in Appendix 4-2) to account for both contact selectivity and the annual spatial age-class availability. The number of estimated parameters were increased since the 2016 assessment model from 293 to 316 parameters. This rate of increase in the number of parameters will slow down the run time in the future assessment model and take longer to maintain the same quality of the assessment process.

Alternative: An alternative model that simplifies the selectivity parameterization and makes more use of the concept that age-based movement is represented by the selectivity and is used for all fleets on the same side of the Pacific Ocean was conducted. The fleets-as-areas approach was also used. Instead of estimating time-varying age-based selectivity for each fleet catching migrating age-classes, a shared time-varying age-based selectivity was estimated among all fleets in in the western Pacific Ocean and separately in the eastern Pacific Ocean (right panel in Appendix 4-1 and bottom panel in Appendix 4-2). In the western Pacific Ocean, the time-varying age-based selectivity was shared among fleets 4, 5, 8, 9, 10, and 18, where selectivity from age 3 to 6 was time-varying and selectivity for age 1, 2, 7, 8, 9, and 10 was time-invariant (left panel in Figure 4-1). In the eastern Pacific Ocean, the time-varying age-based selectivity was shared among fleets 13 and 14, where selectivity from age 2 to 5 was time-varying and selectivity for age 1 was time-invariant (right panel in Figure 4-1). Fish age 6 and older were not selected by the fleets in the eastern Pacific Ocean. This alternative model converged with 285 parameters estimated. The goodness-of-fits to the aggregated size compositions for all the fleets in the alternative model generally performed worse than those in the 2018 stock assessment model (Figure 4-2), in particular, for fleets 4, 5, 8, 9, 13, and 14. The goodness-of-fits to the CPUE indices in the alternative model generally performed similarly to those in the 2018 stock assessment model (Figure 4-3). The alternative model that simplified selectivity parameterization estimated a smaller population compared to the 2018 stock assessment model (Figure 4-4) although the difference in biomass is minimal after 1980.

Conclusion: The PBFWG may want to consider the trade-off between fewer parameters and smaller population estimates before 1980. The simplified modeling of age-based availability could theoretically be applied to only a part of the history (e.g., the earliest years). This consideration will become more important as additional years of data (or new fleets) are added to the model. The age-based selectivities used as a proxy for movement should be connected such that fish can only be on one side of the Pacific Ocean or the other, but this is not currently possible in Stock Synthesis. An alternative would be to explicitly model the movement in a two-stock model. Consideration should be given to further simplifying the model by fixing selectivity at one or zero on the respective sides of the ocean where appropriate.

5. Convergence issue with the steepness

Status: Steepness was fixed at 0.999 in the 2016 and 2018 stock assessment models based on independent estimates of steepness that incorporated the biological and ecological characteristics of the species (ISC 2016; 2018). Both assessment models did not converge with steepness fixed at values < 0.999 (ISC 2016; 2018. The PBFWG concluded that the models are fine-tuned to explain data under the current assumption of steepness and changes to this model process likely required tuning again to achieve a positive definite Hessian. However, criticisms about the failure of convergence warrant further scrutiny.

Alternative: The convergence to a global minimum was further investigated using random perturbation by changing 1) the starting values of all parameters by 10% and 2) the order of parameter phases used in the optimization of likelihood components. The range of steepness fixed was explored from 0.96 to 0.99. Ten random perturbations of starting values of all parameters were conducted for each steepness scenario. None of the runs converged. Also, ten random perturbations of the order of phases were conducted for each steepness scenario. The model with steepness fixed at 0.98 or 0.99 converged.

Conclusion: There still appears to be a degree of fine-tuning affecting convergence with steepness fixed at lower levels. However, the convergence issue was also due to the model ending a search very close to, but not at, the global minimum. Random perturbation of the order of parameter phases should be investigated for any base model or sensitivity that failed to converge.

6. Convert the 2018 stock assessment model to Stock Synthesis 3.30

Status: The 2016 and 2018 stock assessment models used Stock Synthesis 3.24f. The new version of Stock Synthesis 3.30 (SS3.30) has been released since 2016 (Methot et al., 2019). With a growing number of users utilizing new features in Stock Synthesis 3.30, it was recommended to explore the 2018 stock assessment using the new version. The new features include, but are not limited to, finer temporal steps (e.g., months verses seasons), user-specific settlement events, Sheperd spawner-recruitment relationship, growth cessation model, standard deviation of selectivity temporal deviations as a parameter, two-dimensional auto-regressive selectivity, etc.

Alternative: To convert the 2018 stock assessment model to SS3.30.14, the transition program provided was used (Methot et al., 2019). There are few issues to be manually dealt with as follows.

1) The super-period feature in the data file was not converted correctly.

2) There were size observations for fleet 13 with zero sample size.

3) SD of prior (as -1) for autocorrelation parameter in the spawner-recruitment relationship caused a fatal error in the transition.

4) The R1_offset parameter is the regime parameter in SS3.30. This regime parameter is fixed at 0. Instead, a time-varying offset to the regime parameter was estimated (i.e., one-year time block).

The 2018 stock assessment model converged with 317 parameters estimated in SS3.30. The one additional parameter, one year of forecast recruitment, compared to the SS3.24f was automatically created with a value of 0. The goodness-of-fits to the aggregated size compositions for all the fleets in the SS3.30 model generally performed similarly to those in the SS3.24 model (Figure 6-1). The difference of likelihood for the two versions is within < 1 likelihood unit except for fleet 13 with 6 likelihood units better than the SS3.24 (Table 6-1). The goodness-of-fits to the CPUE indices in the SS3.30 model generally performed similarly to those in the SS3.24 model (Figure 6-2). The difference of likelihood for the two versions is within < 1 likelihood unit for all indices (Table 6-1). Use of SS3.30 in the 2018 stock assessment model estimated a very similar population size and trajectory to SS3.24 (Figure 6-3).

Conclusion: Given the similarity between the SS3.24 and SS3.30.14 using the 2018 stock assessment, the PBFWG should consider using the SS3.30.14.

References

ISC. 2016. 2016 Pacific Bluefin tuna stock assessment. http://isc.fra.go.jp/pdf/ISC16/ISC16_Annex_09_2016_Pacific_Bluefin_Tuna_Stock_Assessment.pdf

ISC. 2018. Stock assessment of Pacific bluefin tuna (*Thunnus orientalis*) in the Pacific Ocean in 2018. http://isc.fra.go.jp/pdf/ISC18/ISC_18_ANNEX_14_Pacific_Bluefin_Tuna_Stock_Assessment_2018_FINAL.pdf

Lee, H.H., Piner, K.R., Maunder, M., Taylor I. G., Methot, Jr. R.D. 2017. Evaluation of alternative modelling approaches to account for spatial effects due to age-based movement. Can. J. Fish. Aquat. Sci. 74(11): 1832-1844

Methot, Jr. R.D., Wetzel, C.R., Taylor, I.G., Doering K. 2019. Stock Synthesis user manual version 3.30.14.

Table 6-1. Likelihood estimates for each data component between SS3.24f and SS3.30.14 using the 2018 stock assessment model for Pacific bluefin tuna, where the highlight cell represent the difference of likelihood for the two versions is greater than 2 units.

		SS3.24f	SS3.30.14
Fleet 1	SizeFreq	125.706	124.825
Fleet 2	SizeFreq	211.798	211.939
Fleet 4	SizeFreq	113.811	113.73
Fleet 5	SizeFreq	25.085	25.1938
Fleet 6	SizeFreq	231.771	232.111
Fleet 8	SizeFreq	336.336	336.359
Fleet 9	SizeFreq	86.5491	86.4998
Fleet 10	SizeFreq	44.4207	44.3645
Fleet 12	SizeFreq	35.8094	35.7174
Fleet 13	SizeFreq	178.941	172.926
Fleet 14	SizeFreq	33.6946	33.6698
Fleet 17	SizeFreq	2.58818	2.58649
Fleet 18	SizeFreq	44.5771	44.5613
Fleet 19	SizeFreq	59.7055	59.7104
Fleet 20	Survey	-11.2851	-11.1803
Fleet 21	Survey	-23.0306	-23.266
Fleet 22	Survey	-25.1625	-25.417
Fleet 24	Survey	-43.275	-42.9898
Fleet 28	Survey	-9.63729	-9.73461

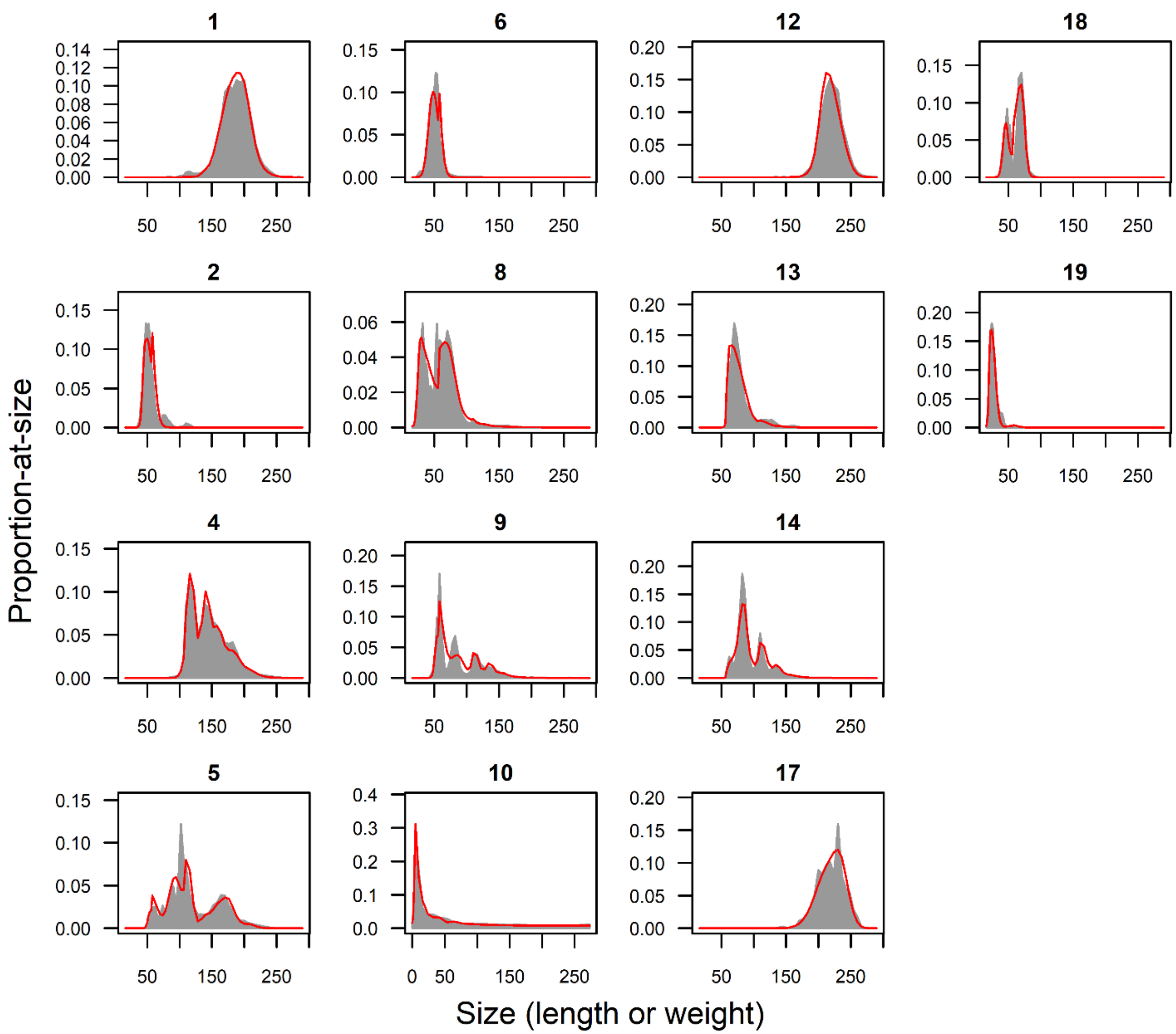


Figure 1-1. The overall fits of the size composition data by fleet across years and seasons (red lines) in the 2018 stock assessment model for Pacific bluefin tuna, where the grey areas represent the aggregated observations.

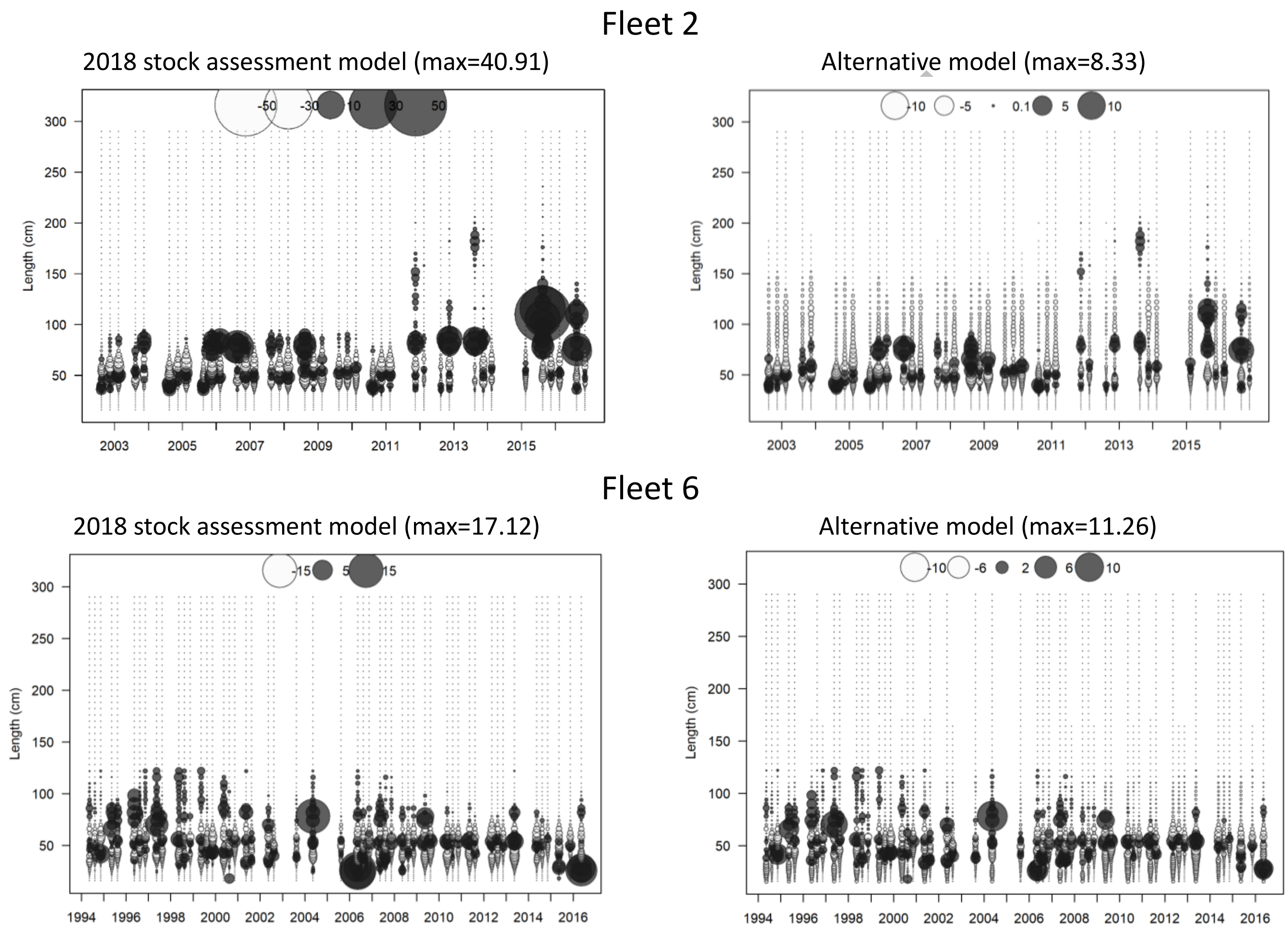
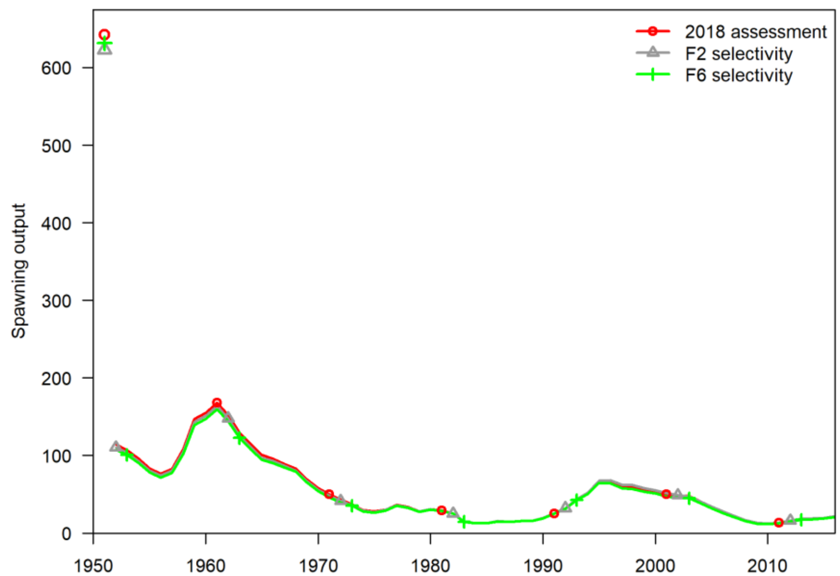


Figure 1-2. Pearson residual plots of the size composition data from fleet 2 (top panels) and fleet 6 (bottom panels) fit in the 2018 stock assessment model (left panels) and the alternative models (right panels; see Appendix 1-1 and 2-1 for detail) for Pacific bluefin tuna. The closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). The areas of the circles are proportional to the absolute values of the residuals.



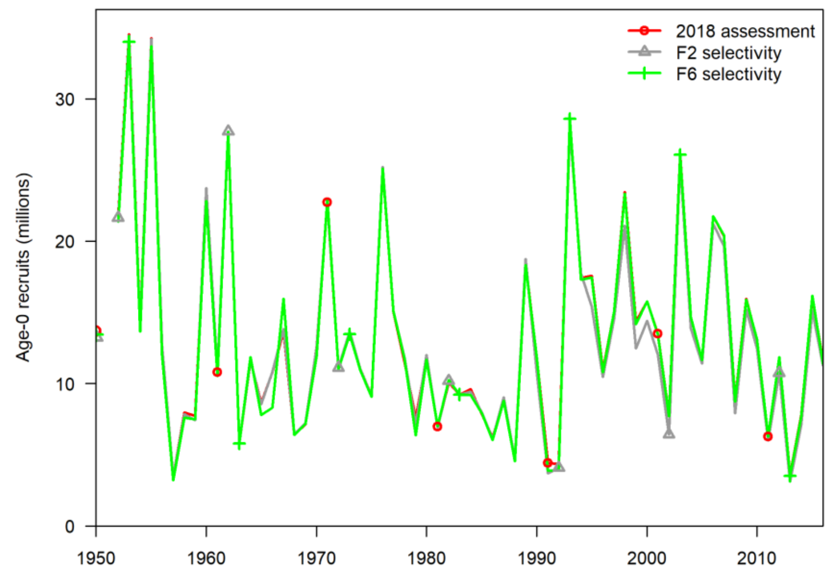


Figure 1-3. Estimated spawning stock biomass (left panel) and recruitment (right panel) in the 2018 stock assessment model (red lines) and two alternative models that reduce the positive residuals for fleet 2 (grey lines) and fleet 6 (green lines) for Pacific bluefin tuna.

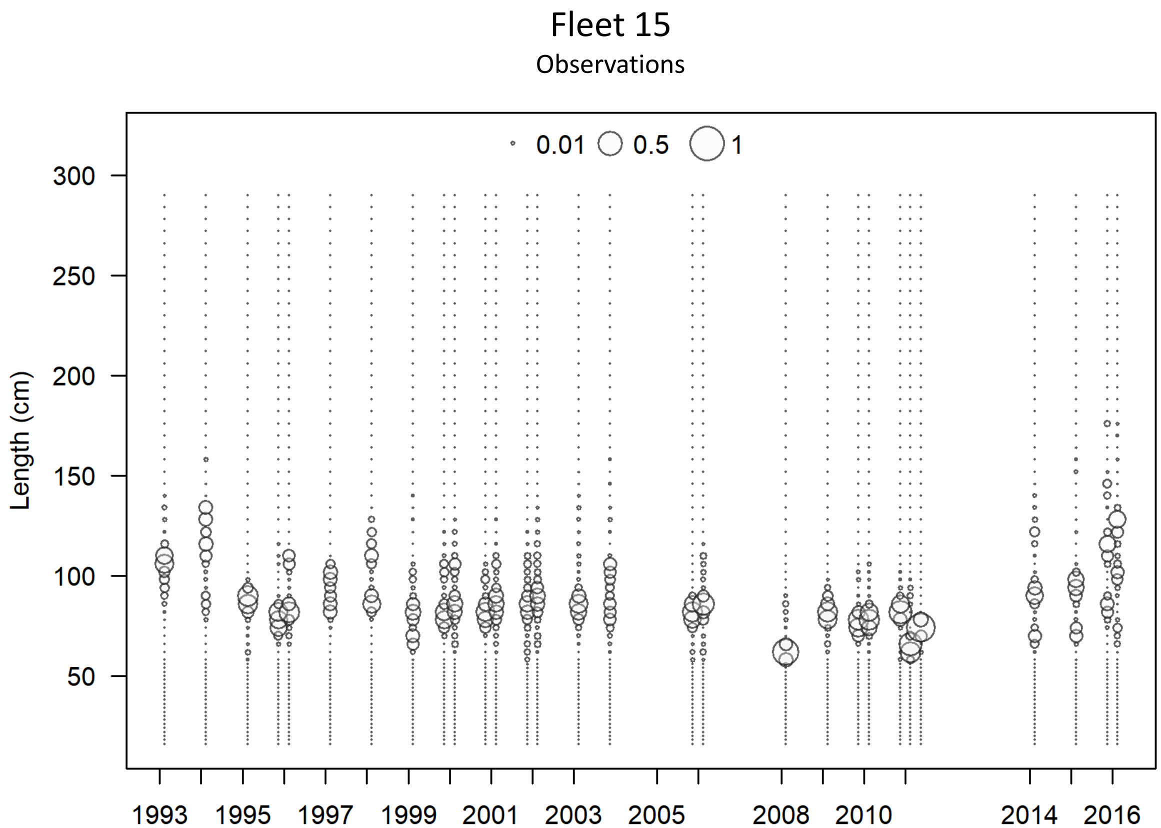


Figure 2-1. Observed size composition data from fleet 15 for Pacific bluefin tuna.

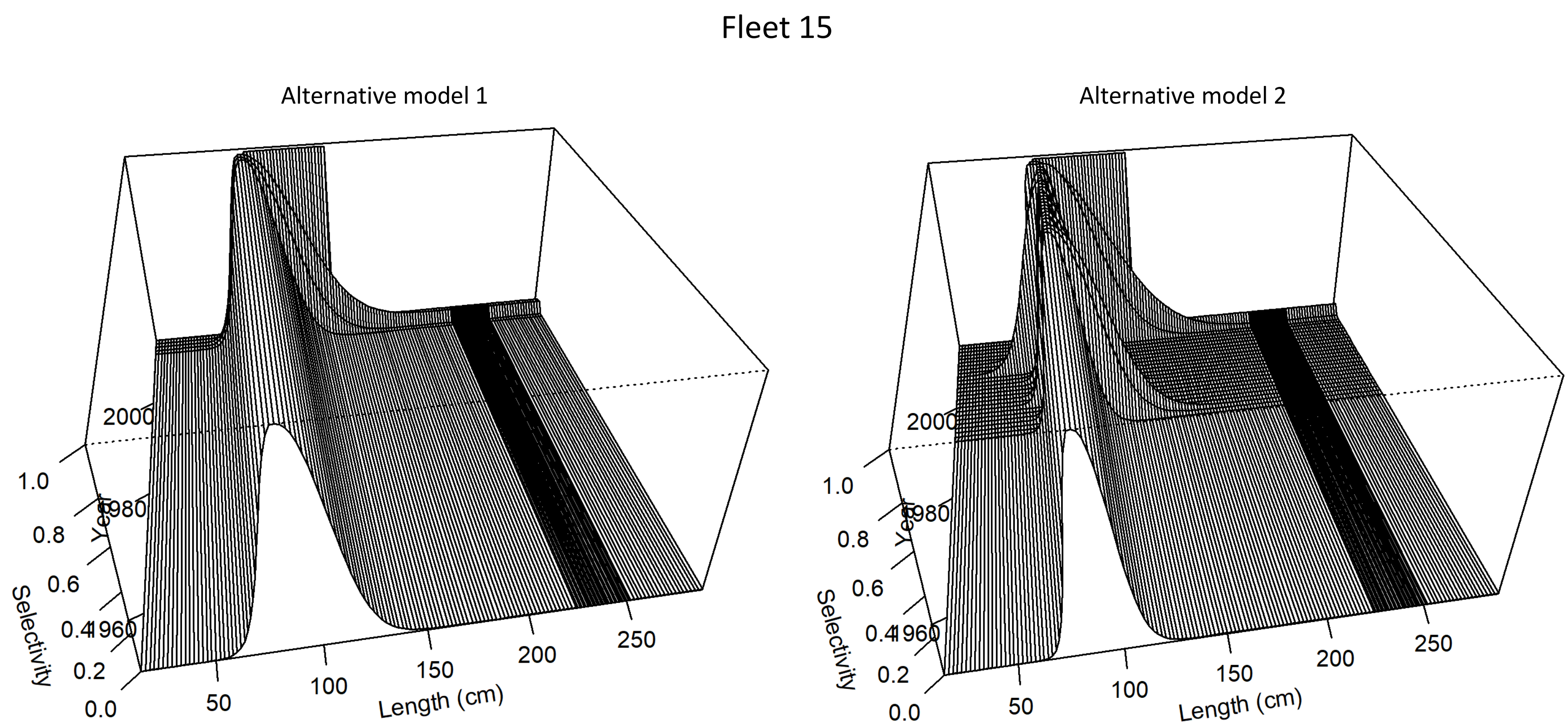


Figure 2-2. Estimated time-varying selectivity for fleet 15 in the alternative model 1 (left panel; see Appendix 2-1 for detail) and 2 (right panel; see Appendix 2-1 for detail) for Pacific bluefin tuna.

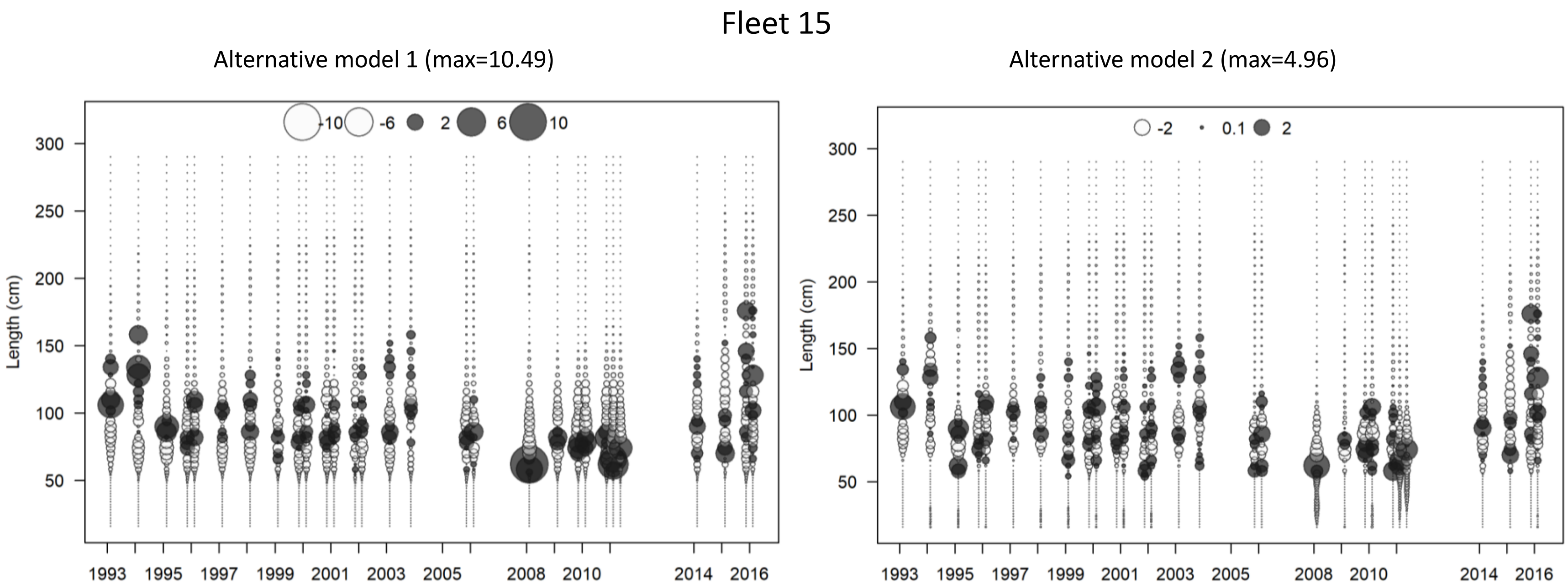


Figure 2-3. Pearson residual plots of the size composition data for fleet 15 fit in the alternative model 1 (left panel; see Appendix 2-1 for detail) and 2 (right panel; see Appendix 2-1 for detail) for Pacific bluefin tuna. The closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected), where the areas of the circles are proportional to the absolute values of the residuals.

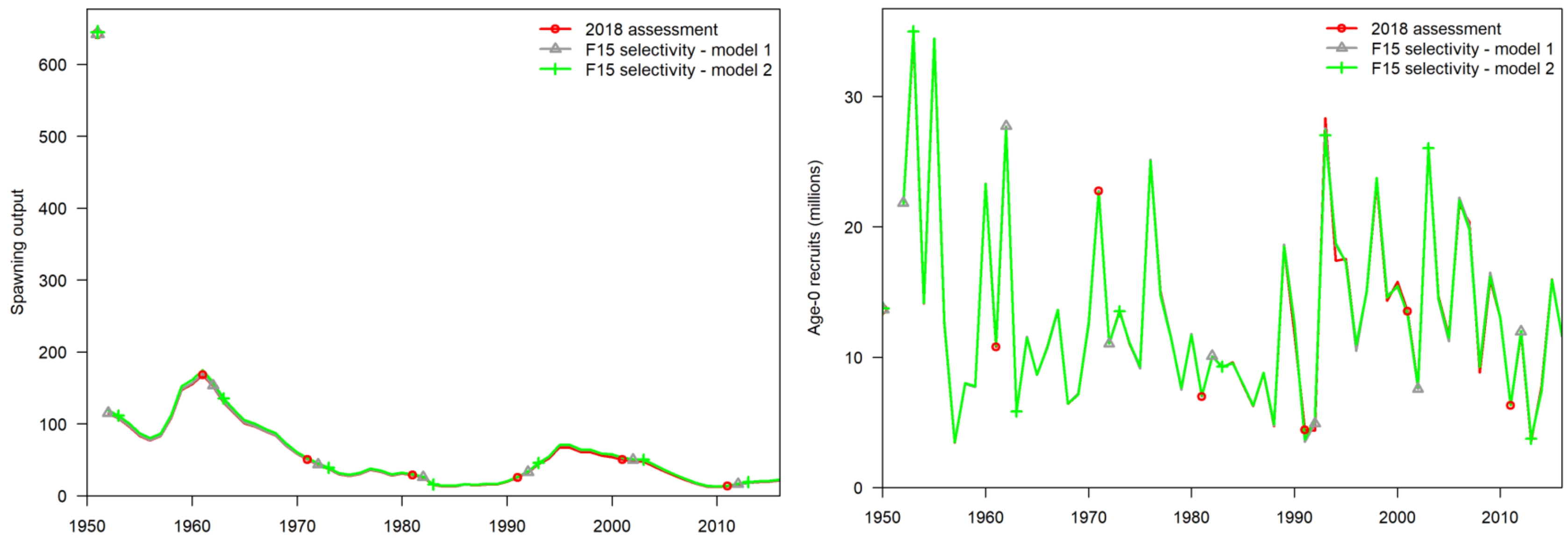


Figure 2-4. Estimated spawning stock biomass (left panel) and recruitment (right panel) in the 2018 stock assessment model (red lines), the alternative model 1 (grey lines), and the alternative model 2 (green lines) that fit the size composition data for fleet 15 for Pacific bluefin tuna.

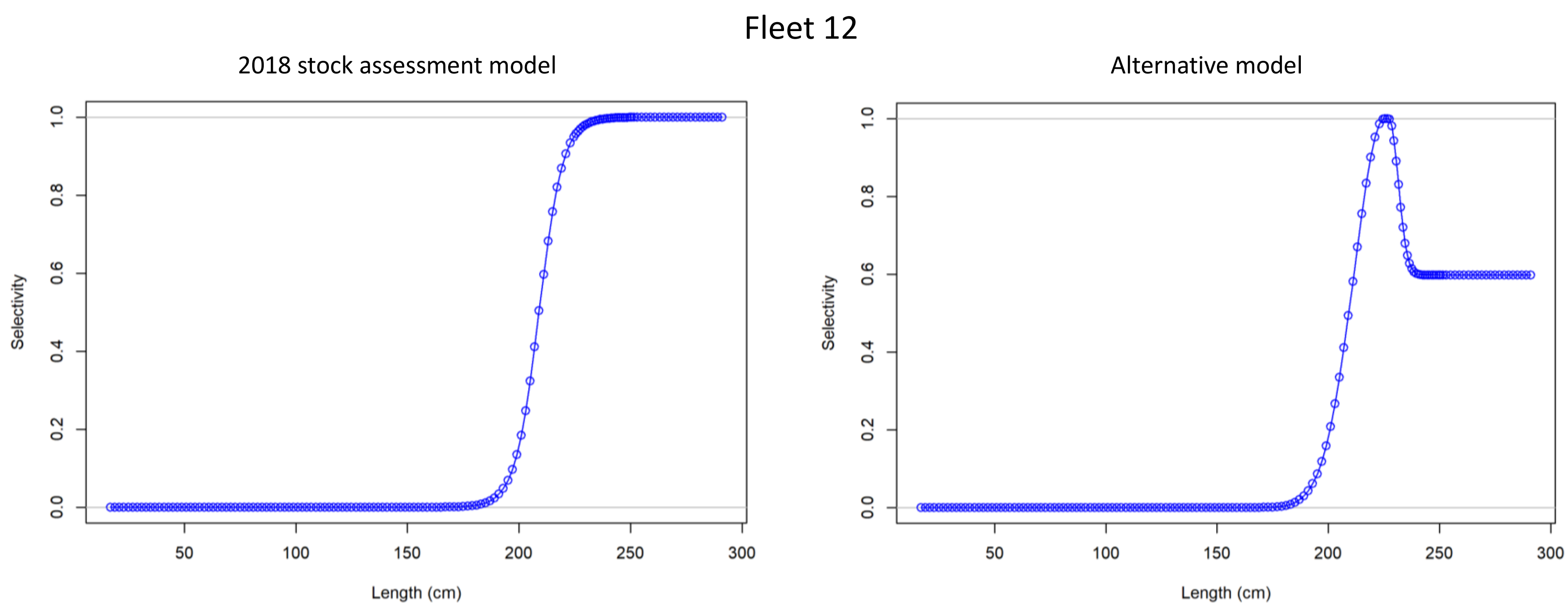


Figure 3-1. Estimated selectivity for fleet 12 in the 2018 stock assessment model (left panel; see Appendix 2-1 for detail) and the alternative model (right panel; see Appendix 2-1 for detail) for Pacific bluefin tuna.

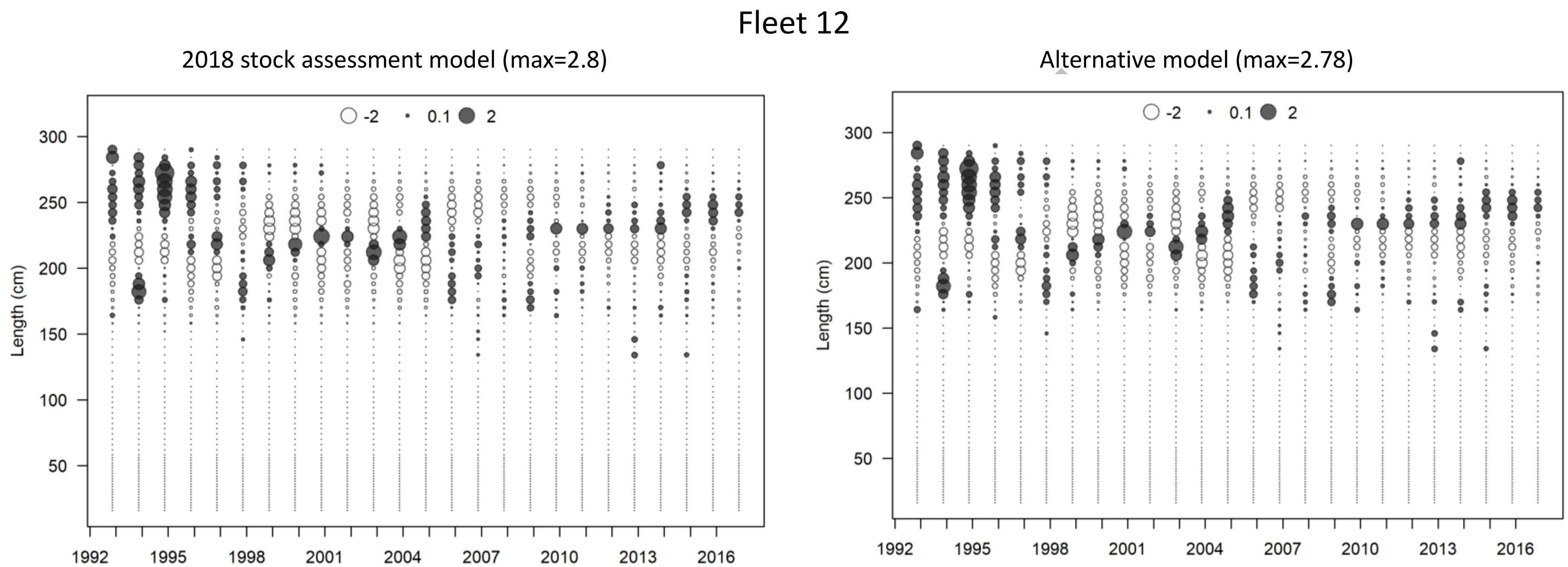


Figure 3-2. Pearson residual plots of the size composition data for fleet 12 fit in the 2018 stock assessment model (left panel; see Appendix 3-1 for detail) and the alternative model (right panel; see Appendix 3-1 for detail) for Pacific bluefin tuna. The closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected), where the areas of the circles are proportional to the absolute values of the residuals.

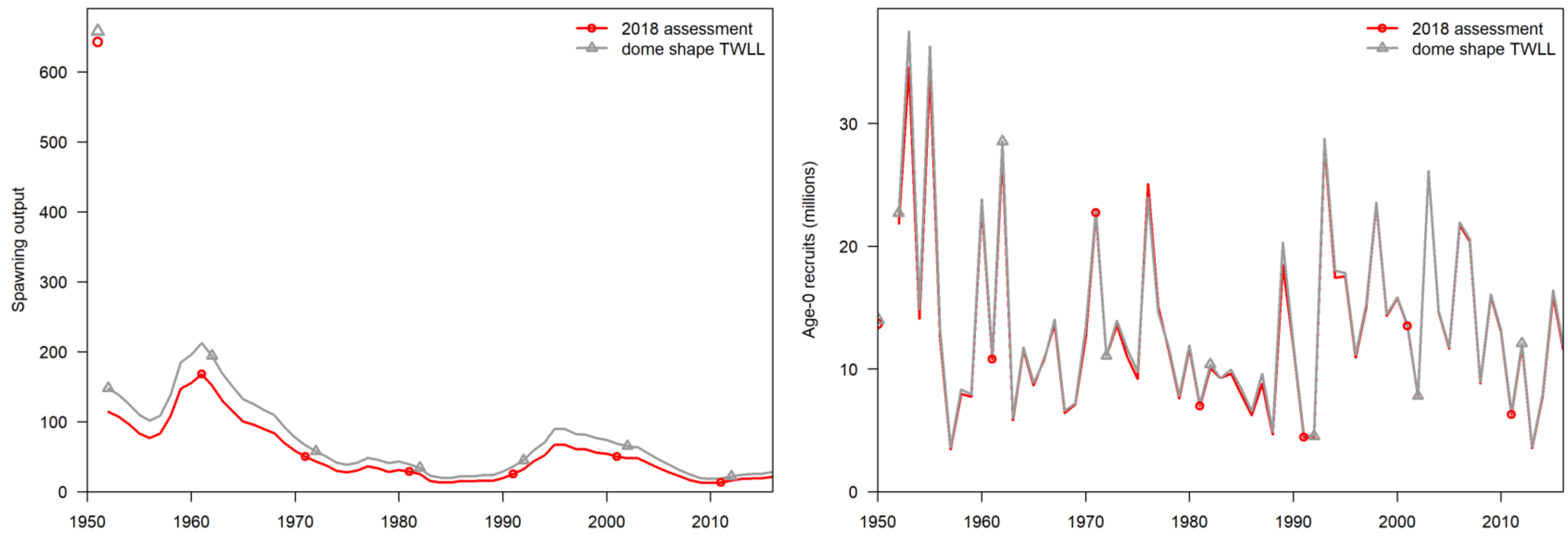


Figure 3-3. Estimated spawning stock biomass (left panel) and recruitment (right panel) in the 2018 stock assessment model (red lines) and the alternative model (grey lines), which assumed the asymptotic and dome shape selectivity for fleet 12 for Pacific bluefin tuna, respectively.

Shared age-based selectivity for the fleets 4, 5, 8, 9, 10, and 18 in the western Pacific Ocean

Shared age-based selectivity for the fleets 13 and 14 in the eastern Pacific Ocean

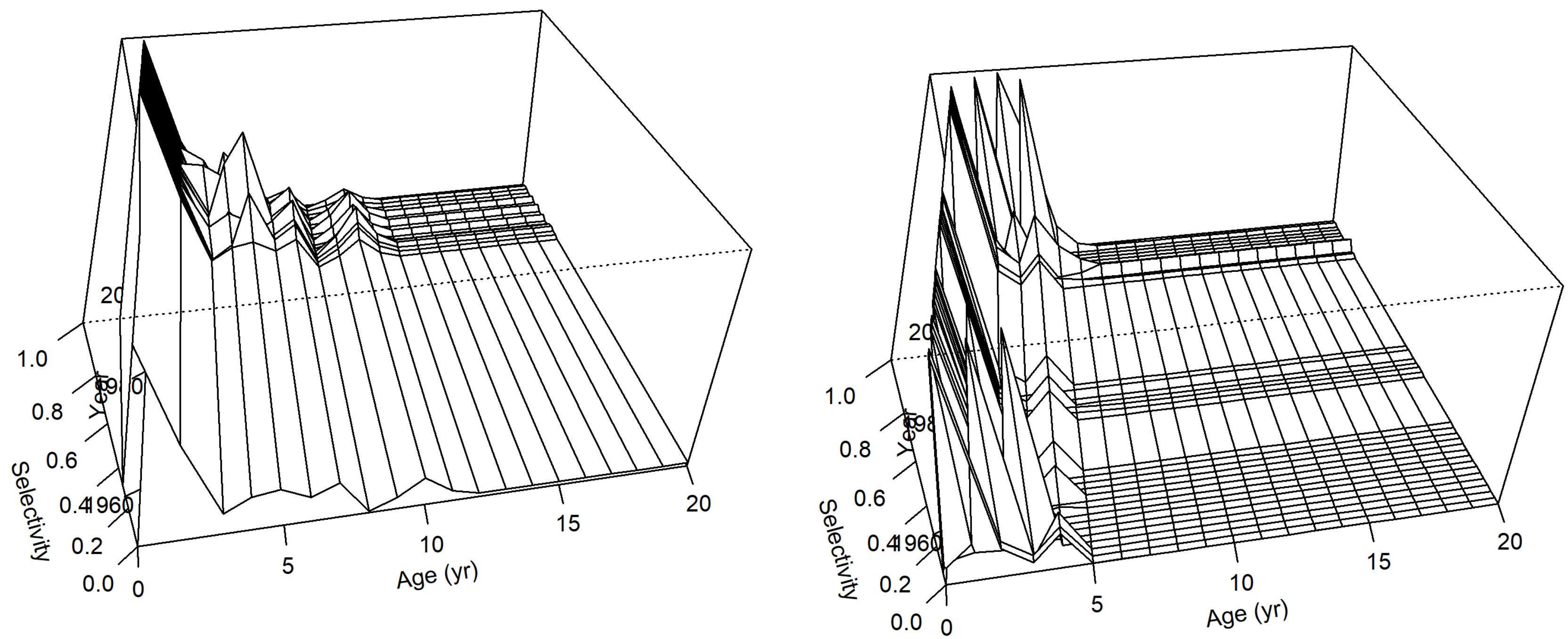


Figure 4-1. Estimated time-varying age-based selectivity for the fleets in the western Pacific Ocean (left panel; see Appendix 4-1 and 4-2 for detail) and the fleets in the eastern Pacific Ocean (right panel; see Appendix 4-1 and 4-2 for detail) in the alternative model that simplified selectivity parameterizations for Pacific bluefin tuna.

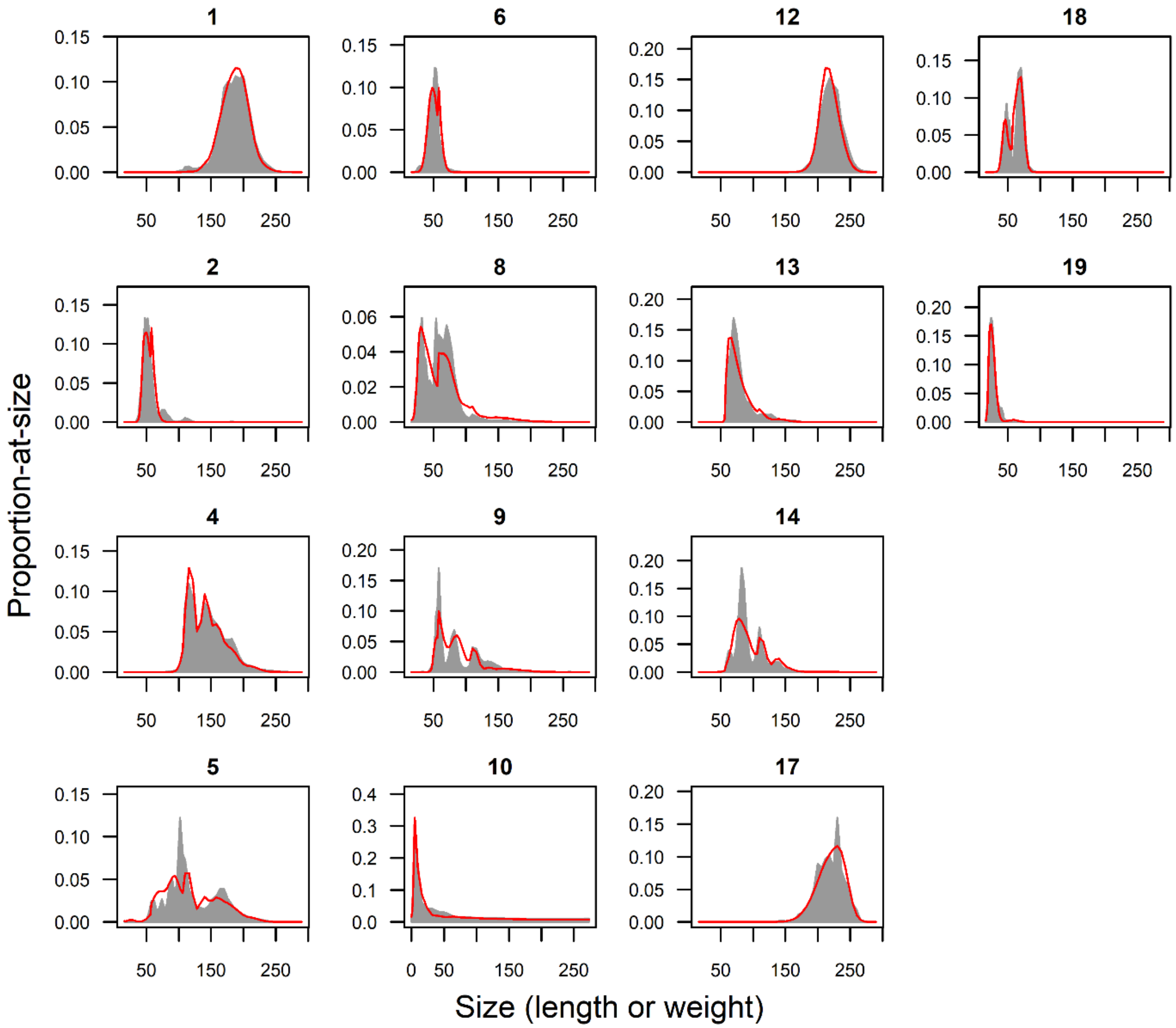


Figure 4-2. The overall fits of the size composition data by fleet across years and seasons (red lines) in the alternative model that simplified selectivity parameterizations for Pacific bluefin tuna, where the grey areas represent the aggregated observations.

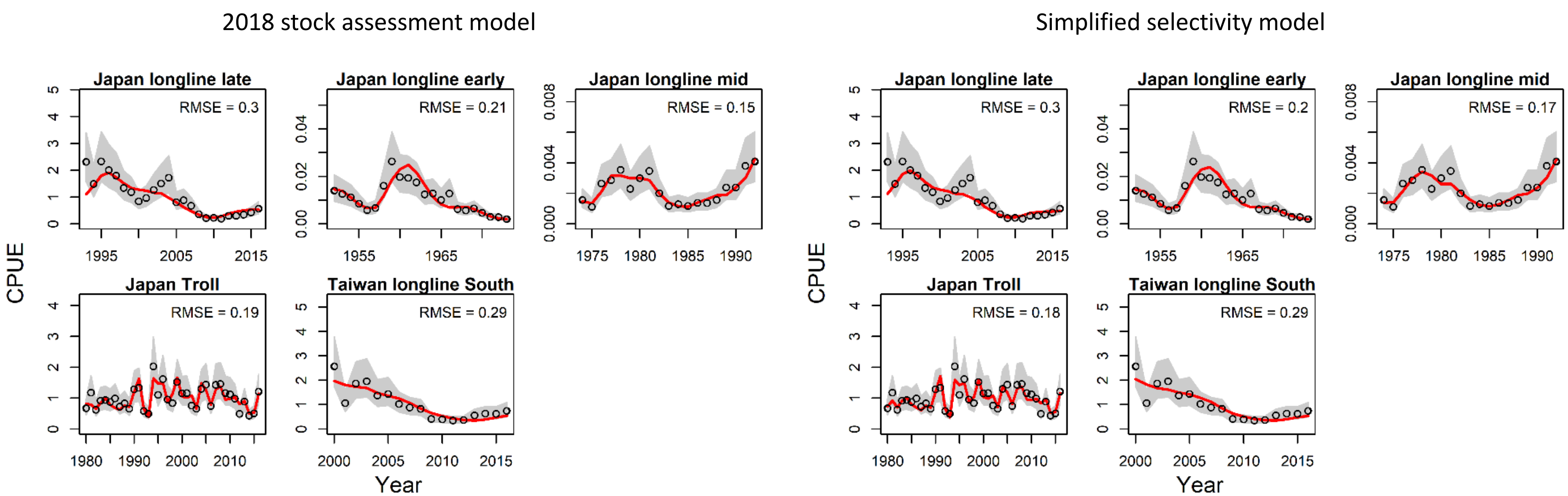


Figure 4-3. The overall fits of CPUE indices (red lines) in the 2018 stock assessment model (left panel) and the alternative model that simplified selectivity parameterizations (right panel) for Pacific bluefin tuna, where the circles represent the observations and grey areas represent the 95% confidence intervals.

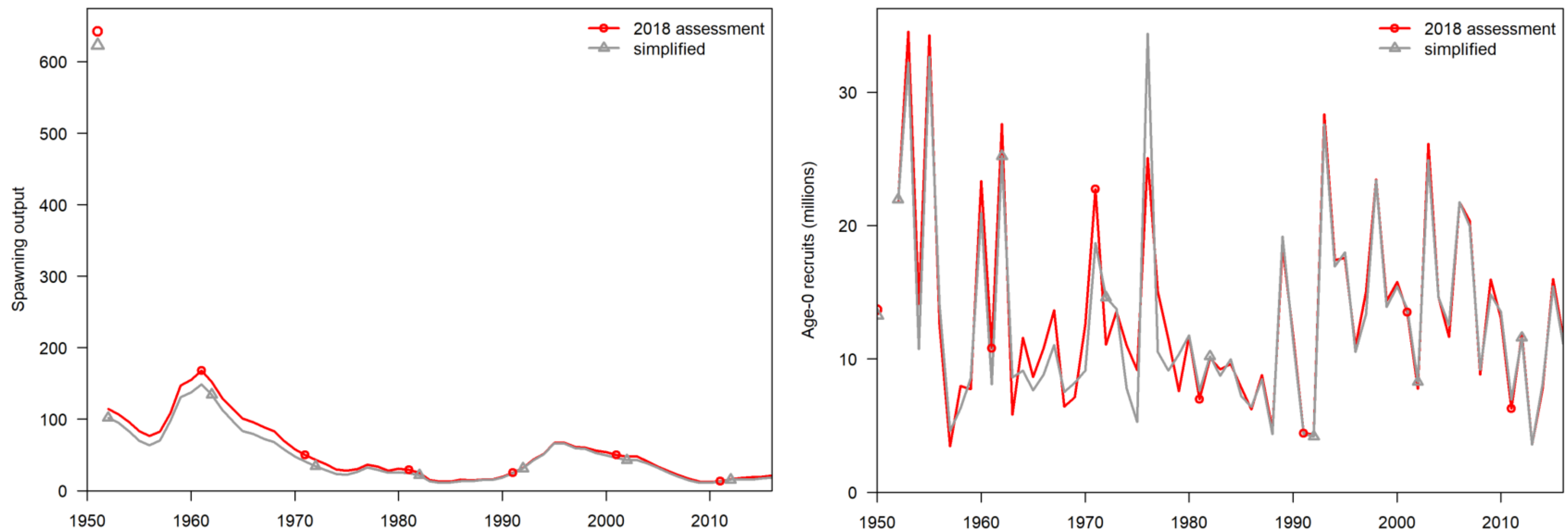


Figure 4-4. Estimated spawning stock biomass (left panel) and recruitment (right panel) in the 2018 stock assessment model (red lines) and the alternative model that simplified selectivity parameterizations (grey lines) for Pacific bluefin tuna.

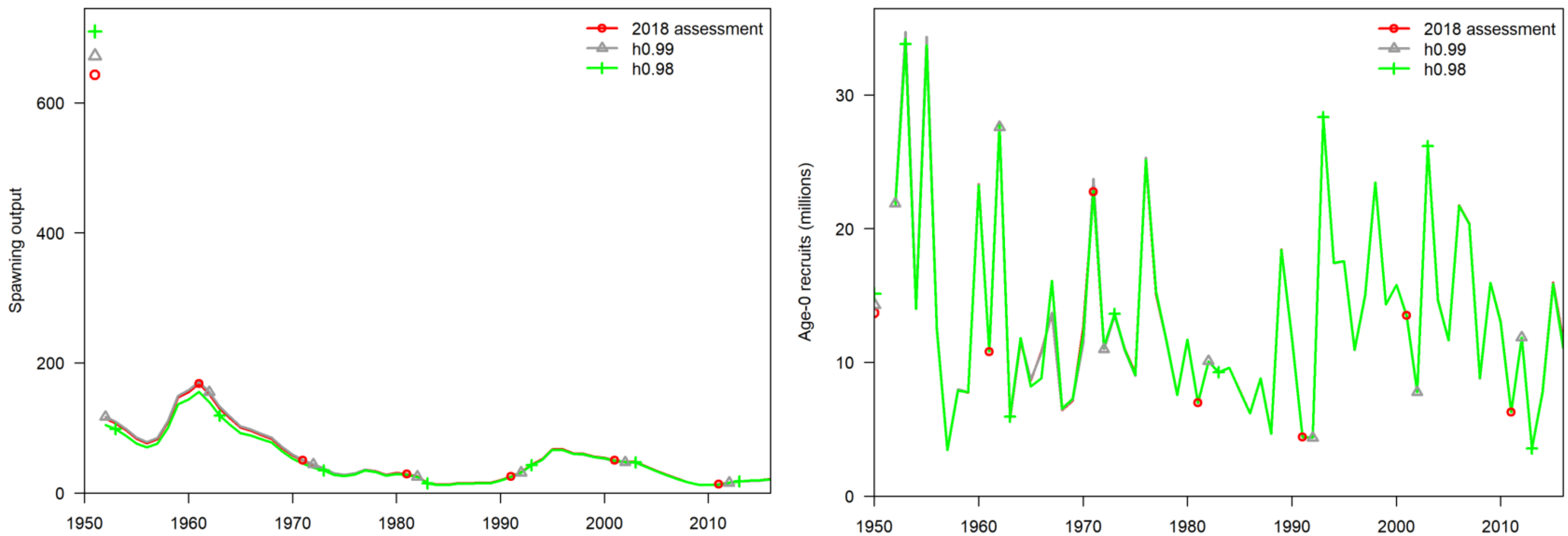


Figure 5-1. Estimated spawning stock biomass (left panel) and recruitment (right panel) in the 2018 stock assessment model (red lines), the alternative model 1 assumed steepness at 0.99 (grey lines), and the alternative model 2 assumed steepness at 0.98 (green lines) for Pacific bluefin tuna.

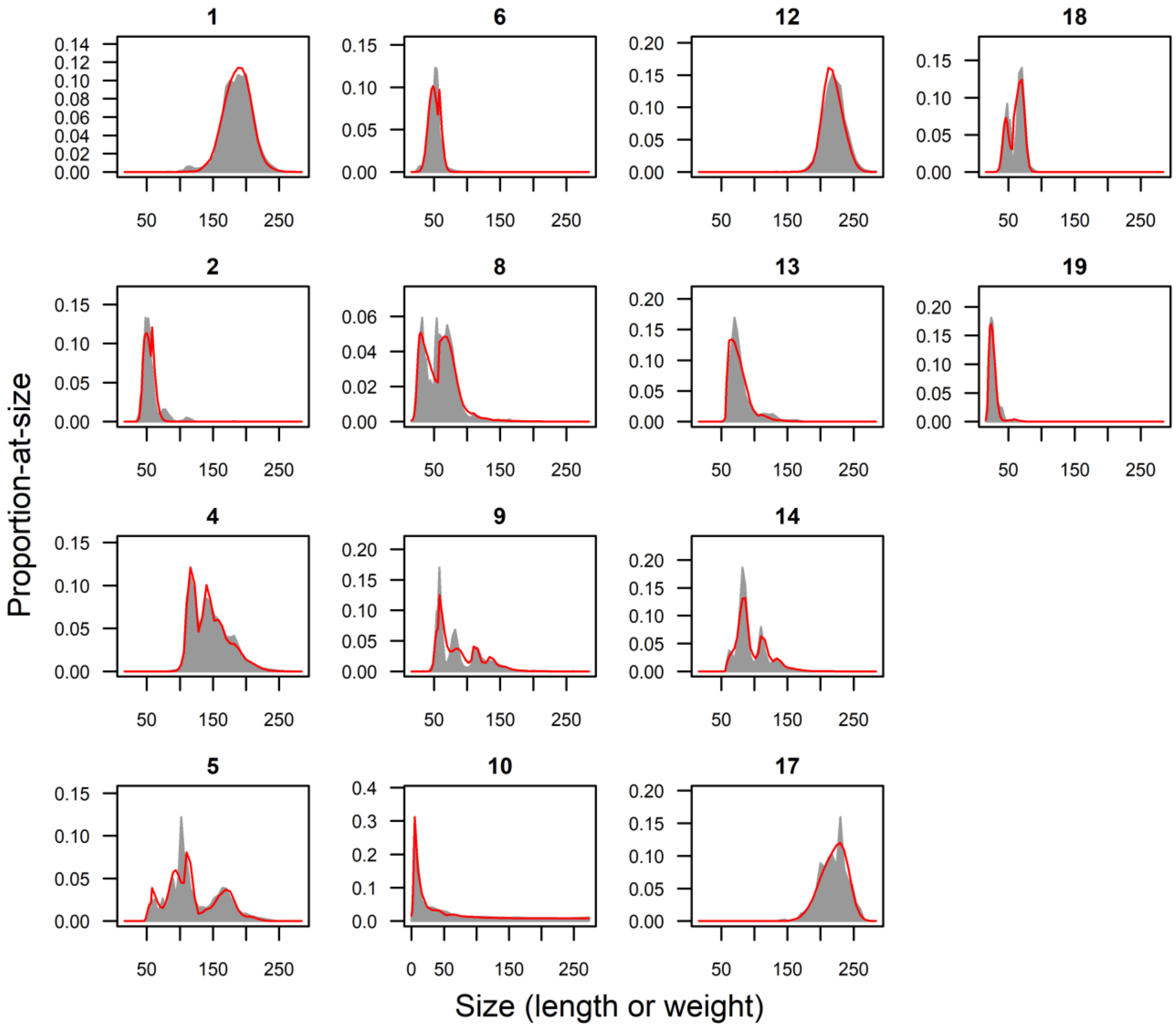


Figure 6-1. The overall fits of the size composition data by fleet across years and seasons (red lines) in the 2018 stock assessment model using Stock Synthesis 3.30.14 for Pacific bluefin tuna, where the grey areas represent the aggregated observations.

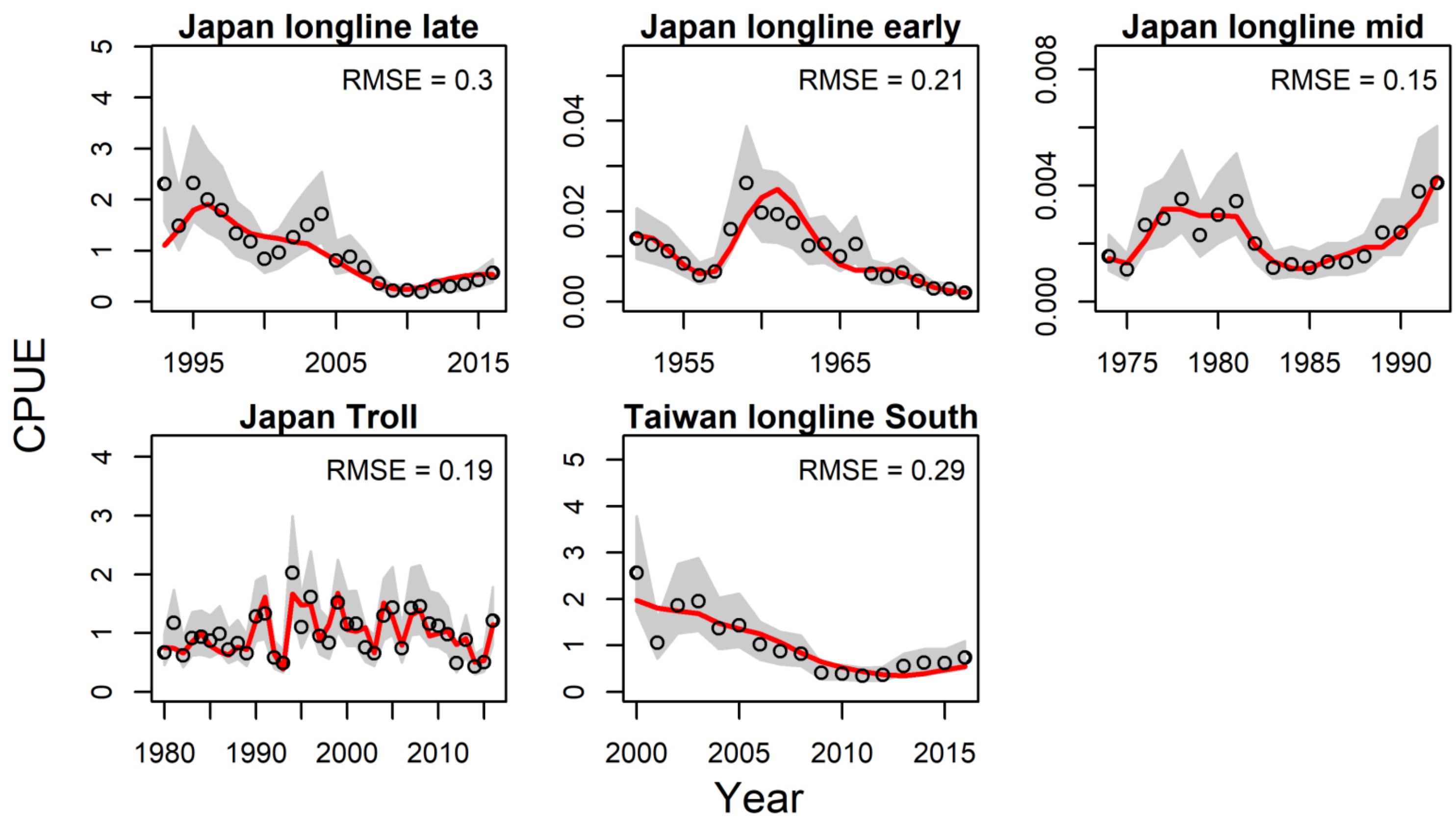


Figure 6-2. The overall fits of CPUE indices (red lines) in the 2018 stock assessment model using Stock Synthesis 3.30.14 for Pacific bluefin tuna, where the circles represent the observations and grey areas represent the 95% confidence intervals.

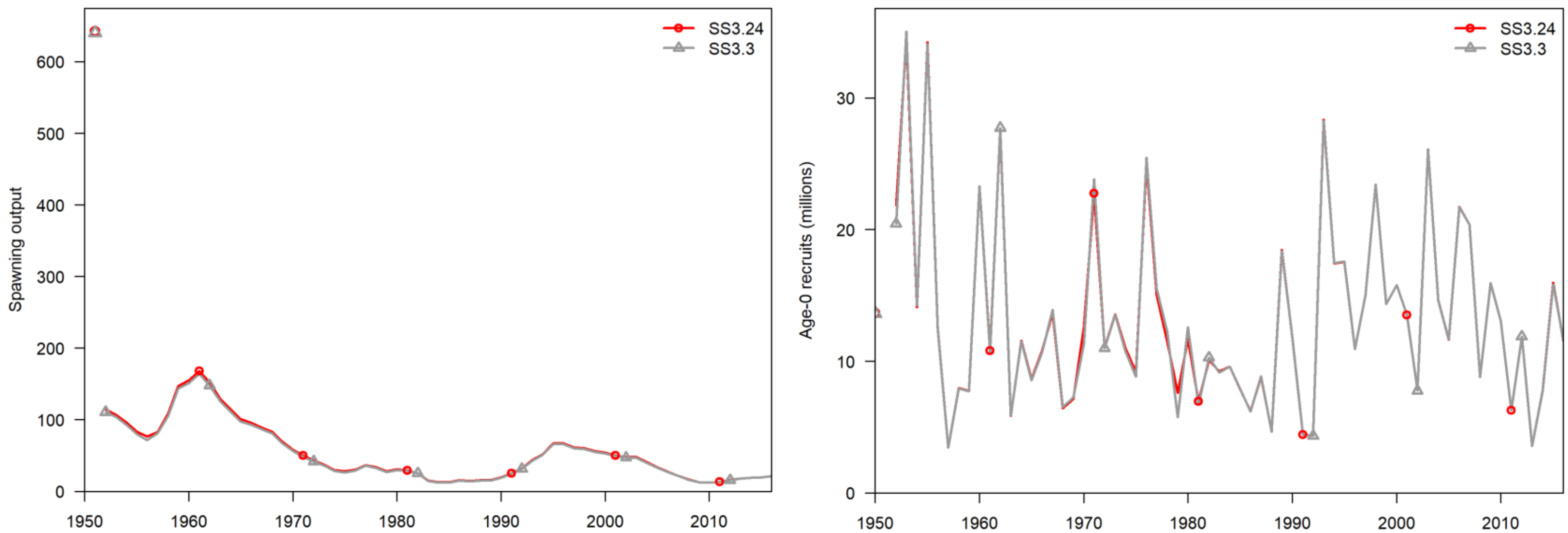


Figure 6-3. Estimated spawning stock biomass (left panel) and recruitment (right panel) in the 2018 stock assessment model using Stock Synthesis 3.24f (red lines) and Stock Synthesis 3.30.14 (grey lines) for Pacific bluefin tuna.

Appendix 1-1. Selectivity parameters (both length- and age-based) for fleet 2 used in the 2018 stock assessment model (top panel) and the alternative model (bottom panel) using Stock Synthesis 3.24f to reduce the positive residuals. The highlights represent the changes made in the models.

2018 stock assessment model

Length-based

21.2 284.1 47.164 44.8675 0 999 3 0 0 0 0 0 0 0 # SizeSel_2P_1_F2JSPPS(S1,3,4)
-15 4 -13.709 -6 0 999 3 0 0 0 0 0 0 0 # SizeSel_2P_2_F2JSPPS(S1,3,4)
-1 9 3.00781 2.33625 0 999 3 0 0 0 0 0 0 0 # SizeSel_2P_3_F2JSPPS(S1,3,4)
-1 9 5.37701 7.20306 0 999 5 0 0 0 0 0 0 0 # SizeSel_2P_4_F2JSPPS(S1,3,4)
-999 -999 -999 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_2P_5_F2JSPPS(S1,3,4)
-999 -999 -999 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_2P_6_F2JSPPS(S1,3,4)

Age-based

0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_2P_1_F2JSPPS(S1,3,4)
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_2P_2_F2JSPPS(S1,3,4)

Alternative model

Length-based

21.2 284.1 49.8415 44.8675 0 999 3 0 0 0 0 0 0 0 # SizeSel_2P_1_F2JSPPS(S1,3,4)
-15 4 -12.2092 -6 0 999 3 0 0 0 0 0 0 0 # SizeSel_2P_2_F2JSPPS(S1,3,4)
-1 9 3.55314 2.33625 0 999 3 0 0 0 0 0 0 0 # SizeSel_2P_3_F2JSPPS(S1,3,4)
-1 9 3.66869 7.20306 0 999 5 0 0 0 0 0 0 0 # SizeSel_2P_4_F2JSPPS(S1,3,4)
-999 -999 -999 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_2P_5_F2JSPPS(S1,3,4)
-5 9 -2.86145 -5 0 999 6 0 0 0 0 0 0 0 # SizeSel_2P_6_F2JSPPS(S1,3,4)

Age-based

0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_2P_1_F2JSPPS(S1,3,4)
0 5 3 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_2P_2_F2JSPPS(S1,3,4)

Appendix 1-2. Selectivity parameters (both length- and age-based) for fleet 6 used in the 2018 stock assessment model (top panel) and the alternative model (bottom panel) using Stock Synthesis 3.24f to reduce the positive residuals. The highlights represent the changes made in the models.

2018 stock assessment model

Length-based

-9 4 -9 -9 0 999 -2 0 0 0 0 0 0 0 # SizeSel_6P_2_F6JTroll(S2-4)
-1 9 4.87073 5.35469 0 999 3 0 0 0 0 0 0 0 # SizeSel_6P_3_F6JTroll(S2-4)
-1 9 4.36802 6.75769 0 999 6 0 0 0 0 0 0 0 # SizeSel_6P_4_F6JTroll(S2-4)
-999 -999 -999 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_6P_5_F6JTroll(S2-4)
-999 -999 -999 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_6P_6_F6JTroll(S2-4)

Age-based

0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_6P_1_F6JTroll(S2-4)
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_6P_2_F6JTroll(S2-4)

Alternative model

Length-based

19.2 284.1 53.5231 46.6534 0 999 4 0 0 0 0 0 0 0 # SizeSel_6P_1_F6JTroll(S2-4)
-9 4 -9 -9 0 999 -2 0 0 0 0 0 0 0 # SizeSel_6P_2_F6JTroll(S2-4)
-1 9 4.25508 5.35469 0 999 3 0 0 0 0 0 0 0 # SizeSel_6P_3_F6JTroll(S2-4)
-1 9 4.2958 6.75769 0 999 6 0 0 0 0 0 0 0 # SizeSel_6P_4_F6JTroll(S2-4)
-9 9 -3.93789 -5 0 999 6 0 0 0 0 0 0 0 # SizeSel_6P_5_F6JTroll(S2-4)
-9 9 -5.25936 -5 0 999 6 0 0 0 0 0 0 0 # SizeSel_6P_6_F6JTroll(S2-4)

Age-based

0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_6P_1_F6JTroll(S2-4)
0 5 2 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_6P_2_F6JTroll(S2-4)

Appendix 2-1. Selectivity parameters (both length- and age-based) for fleet 15 used in the 2018 stock assessment model (top panel), the alternative model 1 (middle panel), and the alternative model 2 (bottom panel) using Stock Synthesis 3.24f to reflect the catch at size from the sport fisheries in the Eastern Pacific Ocean. The highlights represent the changes made in the models.

2018 stock assessment model

Length-based
```
 1 14 1 1 0 25 -99 0 0 0 0 0.5 0 0 # SizeSel_15P_1_F15EPOSports
-5 0 -1 -1 0 25 -99 0 0 0 0 0.5 0 0 # SizeSel_15P_2_F15EPOSports
```
Age-based
```
 0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_15P_1_F15EPOSports
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_15P_2_F15EPOSports
```

Alternative model 1

```
3 #_blocks_per_pattern
2014 2014 2015 2015 2016 2016
```
Length-based
```
21.2 150.1 85.536 73.8791 0 999 4 0 0 0 0 0 5 2 # SizeSel_15P_1_F15EPOSports
-15 4 -12.693 -3.81522 0 999 3 0 0 0 0 0 5 2 # SizeSel_15P_2_F15EPOSports
-12 9 5.10558 4.689 0 999 6 0 0 0 0 0 0 0 # SizeSel_15P_3_F15EPOSports
-1 9 6.54864 6.07867 0 999 6 0 0 0 0 0 5 2 # SizeSel_15P_4_F15EPOSports
-15 9 -13.436 5 0 999 6 0 0 0 0 0 0 0 # SizeSel_15P_5_F15EPOSports
-15 9 -5.68769 5 0 999 6 0 0 0 0 0 5 2 # SizeSel_15P_6_F15EPOSports

21.2 150.1 84.7784 73.8791 0 999 4 # SizeSel_15P_1_F15EPOSports_BLK5repl_2014
21.2 150.1 84.7019 73.8791 0 999 4 # SizeSel_15P_1_F15EPOSports_BLK5repl_2015
21.2 150.1 89.0258 73.8791 0 999 4 # SizeSel_15P_1_F15EPOSports_BLK5repl_2016
-15 4 -9.3088 -3.81522 0 999 3 # SizeSel_15P_2_F15EPOSports_BLK5repl_2014
-15 4 -10.0571 -3.81522 0 999 3 # SizeSel_15P_2_F15EPOSports_BLK5repl_2015
-15 4 -1.13486 -3.81522 0 999 3 # SizeSel_15P_2_F15EPOSports_BLK5repl_2016
-1 9 7.28176 6.07867 0 999 6 # SizeSel_15P_4_F15EPOSports_BLK5repl_2014
-1 9 7.76081 6.07867 0 999 6 # SizeSel_15P_4_F15EPOSports_BLK5repl_2015
-1 9 -0.288052 6.07867 0 999 6 # SizeSel_15P_4_F15EPOSports_BLK5repl_2016
-15 9 -9.61078 5 0 999 6 # SizeSel_15P_6_F15EPOSports_BLK5repl_2014
-15 9 -2.73735 5 0 999 6 # SizeSel_15P_6_F15EPOSports_BLK5repl_2015
-15 9 -2.83085 5 0 999 6 # SizeSel_15P_6_F15EPOSports_BLK5repl_2016
```
Age-based
```
0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_15P_1_F15EPOSports
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_15P_2_F15EPOSports
```

Alternative model 2

```
3 #_blocks_per_pattern
2014 2014 2015 2015 2016 2016
```
Length-based
```
21.2 150.1 83.462 73.8791 0 999 4 0 0 0 0 0 5 2 # SizeSel_15P_1_F15EPOSports
-15 4 -13.3359 -3.81522 0 999 3 0 2 1993 2011 1 5 2 # SizeSel_15P_2_F15EPOSports
-12 9 4.19891 4.689 0 999 6 0 2 1993 2011 1 0 0 # SizeSel_15P_3_F15EPOSports
-1 9 5.80349 6.07867 0 999 6 0 2 1993 2011 1 5 2 # SizeSel_15P_4_F15EPOSports
```

```
-15 9 -10.9128 5 0 999 6 0 0 0 0 0 0 0 # SizeSel_15P_5_F15EPOSports
-15 9 -5.60132 5 0 999 6 0 0 0 0 0 5 2 # SizeSel_15P_6_F15EPOSports

21.2 150.1 77.526 73.8791 0 999 4 # SizeSel_15P_1_F15EPOSports_BLK5repl_2014
21.2 150.1 78.6889 73.8791 0 999 4 # SizeSel_15P_1_F15EPOSports_BLK5repl_2015
21.2 150.1 80.9452 73.8791 0 999 4 # SizeSel_15P_1_F15EPOSports_BLK5repl_2016
-15 4 -3.23327 -3.81522 0 999 3 # SizeSel_15P_2_F15EPOSports_BLK5repl_2014
-15 4 -9.60781 -3.81522 0 999 3 # SizeSel_15P_2_F15EPOSports_BLK5repl_2015
-15 4 -0.978794 -3.81522 0 999 3 # SizeSel_15P_2_F15EPOSports_BLK5repl_2016
-1 9 7.40311 6.07867 0 999 6 # SizeSel_15P_4_F15EPOSports_BLK5repl_2014
-1 9 8.22201 6.07867 0 999 6 # SizeSel_15P_4_F15EPOSports_BLK5repl_2015
-1 9 -0.287817 6.07867 0 999 6 # SizeSel_15P_4_F15EPOSports_BLK5repl_2016
-15 9 -9.60736 5 0 999 6 # SizeSel_15P_6_F15EPOSports_BLK5repl_2014
-15 9 -4.96479 5 0 999 6 # SizeSel_15P_6_F15EPOSports_BLK5repl_2015
-15 9 -2.73176 5 0 999 6 # SizeSel_15P_6_F15EPOSports_BLK5repl_2016
```

Age-based

```
0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_15P_1_F15EPOSports
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_15P_2_F15EPOSports
```

Appendix 3-1. Selectivity parameters (both length- and age-based) for fleet 12 used in the 2018 stock assessment model (top panel) and the alternative model (bottom panel) using Stock Synthesis 3.24f. The highlights represent the changes made in the models.

2018 stock assessment model

Length-based

60 230 208.918 206.5 0 999 4 0 0 0 0 0 0 0 # SizeSel_12P_1_F12TWLLSouth
0.1 50 15.6882 40 0 999 7 0 0 0 0 0 0 0 # SizeSel_12P_2_F12TWLLSouth

Age-based

0 10 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_12P_1_F12TWLLSouth
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_12P_2_F12TWLLSouth

Alternative model

Length-based

60 230 225.244 206.5 0 999 4 0 0 0 0 0 0 0 # SizeSel_12P_1_F12TWLLSouth
-9 4 -7.68746 -5 0 999 4 0 0 0 0 0 0 0 # SizeSel_12P_2_F12TWLLSouth
-1 9 5.92462 2.33625 0 999 3 0 0 0 0 0 0 0 # SizeSel_12P_3_F12TWLLSouth
-1 9 3.48745 7.20306 0 999 2 0 0 0 0 0 0 0 # SizeSel_12P_4_F12TWLLSouth
-999 -999 -999 -5 0 999 -6 0 0 0 0 0 0 0 # SizeSel_12P_5_F12TWLLSouth
-5 9 0.397097 -5 0 999 6 0 0 0 0 0 0 0 # SizeSel_12P_6_F12TWLLSouth

Age-based

0 10 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_12P_1_F12TWLLSouth
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_12P_2_F12TWLLSouth

Appendix 4-1. Types of selectivity parameters (both length- and age-based) assumed in the 2018 stock assessment model (left panel) and the alternative model that simplified selectivity parameterization (right panel) using Stock Synthesis 3.24f. The highlights represent the changes made in the models.

2018 stock assessment model	Alternative model
Length-based selectivity	
24 0 0 0 # 1 F1JLL	24 0 0 0 # 1 F1JLL
24 0 0 0 # 2 F2JSPPS(S1,3,4)	24 0 0 0 # 2 F2JSPPS(S1,3,4)
5 0 0 2 # 3 F3KOLPS	5 0 0 2 # 3 F3KOLPS
1 0 0 0 # 4 F4TPSJS	1 0 0 0 # 4 F4TPSJS
1 0 0 0 # 5 F5TPSPO	1 0 0 0 # 5 F5TPSPO
24 0 0 0 # 6 F6JTroll(S2-4)	24 0 0 0 # 6 F6JTroll(S2-4)
5 0 0 6 # 7 F7JPL	5 0 0 6 # 7 F7JPL
1 0 0 0 # 8 F8JSN(S1-3)	1 0 0 0 # 8 F8JSN(S1-3)
1 0 0 0 # 9 F9JSN(S4)	1 0 0 0 # 9 F9JSN(S4)
1 0 0 0 # 10 F10JSN(HK_AM)	1 0 0 0 # 10 F10JSN(HK_AM)
5 0 0 10 # 11 F11JOthers	5 0 0 10 # 11 F11JOthers
1 0 0 0 # 12 F12TWLLSouth	1 0 0 0 # 12 F12TWLLSouth
24 0 0 0 # 13 F13USCOMM(-2001)	1 0 0 0 # 13 F13USCOMM(-2001)
24 0 0 0 # 14 F14MEXCOMM(2002-)	1 0 0 0 # 14 F14MEXCOMM(2002-)
5 0 0 13 # 15 F15EPOSports	5 0 0 13 # 15 F15EPOSports
0 0 0 0 # 16 F16JTroll4Pen	0 0 0 0 # 16 F16JTroll4Pen
24 0 0 0 # 17 F17TWLLNorth	24 0 0 0 # 17 F17TWLLNorth
24 0 0 0 # 18 F18JSPPS(S2)	24 0 0 0 # 18 F18JSPPS(S2)
24 0 0 0 # 19 F19JTroll(S1)	24 0 0 0 # 19 F19JTroll(S1)
Types of age-based selectivity	
11 0 0 0 # 1 F1JLL	11 0 0 0 # 1 F1JLL
11 0 0 0 # 2 F2JSPPS(S1,3,4)	11 0 0 0 # 2 F2JSPPS(S1,3,4)
11 0 0 0 # 3 F3KOLPS	11 0 0 0 # 3 F3KOLPS
17 0 0 11 # 4 F4TPSJS	17 0 0 12 # 4 F4TPSJS
17 0 0 12 # 5 F5TPSPO	15 0 0 4 # 5 F5TPSPO
11 0 0 0 # 6 F6JTroll(S2-4)	11 0 0 0 # 6 F6JTroll(S2-4)
11 0 0 0 # 7 F7JPL	11 0 0 0 # 7 F7JPL
17 0 0 7 # 8 F8JSN(S1-3)	15 0 0 4 # 8 F8JSN(S1-3)
17 0 0 7 # 9 F9JSN(S4)	15 0 0 4 # 9 F9JSN(S4)
17 0 0 7 # 10 F10JSN(HK_AM)	15 0 0 4 # 10 F10JSN(HK_AM)
11 0 0 0 # 11 F11JOthers	11 0 0 0 # 11 F11JOthers
11 0 0 0 # 12 F12TWLLSouth	11 0 0 0 # 12 F12TWLLSouth
11 0 0 0 # 13 F13USCOMM(-2001)	17 0 0 7 # 13 F13USCOMM(-2001)
11 0 0 0 # 14 F14MEXCOMM(2002-)	15 0 0 13 # 14 F14MEXCOMM(2002-)
11 0 0 0 # 15 F15EPOSports	11 0 0 0 # 15 F15EPOSports
11 0 0 0 # 16 F16JTroll4Pen	11 0 0 0 # 16 F16JTroll4Pen
11 0 0 0 # 17 F17TWLLNorth	11 0 0 0 # 17 F17TWLLNorth
17 0 0 4 # 18 F18JSPPS(S2)	15 0 0 4 # 18 F18JSPPS(S2)
11 0 0 0 # 19 F19JTroll(S1)	11 0 0 0 # 19 F19JTroll(S1)

Appendix 4-2. Selectivity parameters (both length- and age-based) assumed in the 2018 stock assessment model (top panel) and the alternative model that simplified selectivity

parameterization (bottom panel) using Stock Synthesis 3.24f, where only the selectivity that has changed (highlighted fleets in Appendix 4-1) was shown.

2018 stock assessment model

Length-based

F13

21.2 150.1 65.6599 73.8791 0 999 4 0 0 0 0 0 2 2 # SizeSel_13P_1_F13USCOMM(-2001)
-9 4 -9 -3.81522 0 999 -3 0 0 0 0 0 0 0 # SizeSel_13P_2_F13USCOMM(-2001)
-12 9 3.45214 4.689 0 999 6 0 0 0 0 0 2 2 # SizeSel_13P_3_F13USCOMM(-2001)
-1 9 6.95756 6.07867 0 999 6 0 0 0 0 0 2 2 # SizeSel_13P_4_F13USCOMM(-2001)
-1014 -1014 -1014 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_13P_5_F13USCOMM(-2001)
-15 9 -15 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_13P_6_F13USCOMM(-2001)

21.2 150.1 63.2046 73.8791 0 999 2 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1954
21.2 150.1 80.1977 73.8791 0 999 5 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1955
21.2 150.1 66.0198 73.8791 0 999 6 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1956
21.2 150.1 87.0567 73.8791 0 999 3 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1958
21.2 150.1 85.0951 73.8791 0 999 3 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1959
21.2 150.1 60.976 73.8791 0 999 3 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1960
21.2 150.1 67.3217 73.8791 0 999 3 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1961
21.2 150.1 57.072 73.8791 0 999 6 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1963
21.2 150.1 62.8606 73.8791 0 999 6 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1965
21.2 150.1 61.0196 73.8791 0 999 7 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1976
21.2 150.1 74.3577 73.8791 0 999 7 # SizeSel_13P_1_F13USCOMM(-2001)_BLK2repl_1979
-9 9 2.26255 4.689 0 999 4 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1954
-9 9 2.31778 4.689 0 999 6 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1955
-9 9 2.54615 4.689 0 999 4 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1956
-9 9 5.53788 4.689 0 999 4 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1958
-9 9 5.06746 4.689 0 999 6 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1959
-9 9 -8.61838 4.689 0 999 2 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1960
-9 9 3.71586 4.689 0 999 6 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1961
-9 9 -7.13636 4.689 0 999 3 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1963
-9 9 2.51932 4.689 0 999 3 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1965
-12 9 -8.28916 4.689 0 999 2 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1976
-9 9 2.6677 4.689 0 999 4 # SizeSel_13P_3_F13USCOMM(-2001)_BLK2repl_1979
-1 12 8.23272 6.07867 0 999 4 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1954
-1 12 4.6347 6.07867 0 999 4 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1955
-1 12 6.65859 6.07867 0 999 3 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1956
-1 12 3.12244 6.07867 0 999 2 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1958
-1 12 6.67573 6.07867 0 999 5 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1959
-1 12 7.95279 6.07867 0 999 6 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1960
-1 12 5.72651 6.07867 0 999 3 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1961
-1 12 7.23068 6.07867 0 999 5 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1963
-1 12 5.83489 6.07867 0 999 7 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1965
-1 12 8.43017 6.07867 0 999 2 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1976
-1 12 4.43788 6.07867 0 999 3 # SizeSel_13P_4_F13USCOMM(-2001)_BLK2repl_1979

F14

21.2 150.1 87.2288 73.8791 0 999 5 0 0 0 0 0 3 2 # SizeSel_14P_1_F14MEXCOMM(2002-)

-9 4 -9 -3.81522 0 999 -3 0 0 0 0 0 0 0 # SizeSel_14P_2_F14MEXCOMM(2002-)
-9 9 4.44697 4.689 0 999 2 0 0 0 0 0 3 2 # SizeSel_14P_3_F14MEXCOMM(2002-)
-5 12 7.87924 6.07867 0 999 5 0 0 0 0 0 3 2 # SizeSel_14P_4_F14MEXCOMM(2002-)
-1014 -1014 -1014 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_14P_5_F14MEXCOMM(2002-)
-15 9 -15 -5 0 999 -4 0 0 0 0 0 0 0 # SizeSel_14P_6_F14MEXCOMM(2002-)

21.2 150.1 89.0913 73.8791 0 999 5 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2006
21.2 150.1 57.1153 73.8791 0 999 4 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2008
21.2 150.1 83.7981 73.8791 0 999 6 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2009
21.2 150.1 84.341 73.8791 0 999 7 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2010
21.2 150.1 66.1255 73.8791 0 999 5 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2011
21.2 150.1 83.2559 73.8791 0 999 4 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2012
21.2 150.1 86.7237 73.8791 0 999 6 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2013
21.2 150.1 105.04 73.8791 0 999 5 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2014
21.2 150.1 132.79 73.8791 0 999 6 # SizeSel_14P_1_F14MEXCOMM(2002-)_BLK3repl_2016
-9 9 4.92403 4.689 0 999 4 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2006
-9 9 -5.38987 4.689 0 999 2 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2008
-9 9 4.16619 4.689 0 999 3 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2009
-9 9 4.3848 4.689 0 999 4 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2010
-9 9 2.85464 4.689 0 999 4 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2011
-9 9 2.84946 4.689 0 999 7 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2012
-9 9 4.33275 4.689 0 999 4 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2013
-12 9 -7.98339 4.689 0 999 5 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2014
-9 9 5.53586 4.689 0 999 6 # SizeSel_14P_3_F14MEXCOMM(2002-)_BLK3repl_2016
-5 12 -4.66716 6.07867 0 999 2 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2006
-5 12 9.72976 6.07867 0 999 2 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2008
-5 12 9.04488 6.07867 0 999 7 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2009
-5 12 3.17497 6.07867 0 999 5 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2010
-5 12 8.48383 6.07867 0 999 6 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2011
-5 12 4.04779 6.07867 0 999 4 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2012
-5 12 8.17409 6.07867 0 999 4 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2013
-5 12 6.40844 6.07867 0 999 6 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2014
-5 12 6.98495 6.07867 0 999 2 # SizeSel_14P_4_F14MEXCOMM(2002-)_BLK3repl_2016

Age-based

F4

-1000 3 -1000 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_4P_1_F4TPSJS
-1000 3 -1000 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_4P_2_F4TPSJS
-15 15 0 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_4P_3_F4TPSJS
-15 15 -2.00047 0 0 999 3 0 2 2000 2016 1 0 0 # AgeSel_4P_4_F4TPSJS
-15 15 0.732794 0 0 999 6 0 2 2000 2016 1 0 0 # AgeSel_4P_5_F4TPSJS
-15 15 0.0195861 0 0 999 4 0 2 2000 2016 1 0 0 # AgeSel_4P_6_F4TPSJS
-15 15 -0.537083 0 0 999 4 0 2 2000 2016 1 0 0 # AgeSel_4P_7_F4TPSJS
-15 15 0.760479 0 0 999 5 0 2 2000 2016 1 0 0 # AgeSel_4P_8_F4TPSJS
-10 5 -5.04228 0 0 999 4 0 0 0 0 0 0 0 # AgeSel_4P_9_F4TPSJS
-10 5 4.84033 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_4P_10_F4TPSJS
-15 5 -1 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_4P_11_F4TPSJS
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_4P_12_F4TPSJS

F5

-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_5P_1_F5TPSPO

-15 15 0.0777344 0 0 999 6 0 0 0 0 0 4 2 # AgeSel_5P_2_F5TPSPO
-15 15 3.35159 0 0 999 3 0 0 0 0 0 0 0 # AgeSel_5P_3_F5TPSPO
-15 15 -2.8319 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_5P_4_F5TPSPO
-15 15 1.4058 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_5P_5_F5TPSPO
-15 15 0.451049 0 0 999 3 0 0 0 0 0 4 2 # AgeSel_5P_6_F5TPSPO
-15 15 0.842127 0 0 999 6 0 0 0 0 0 4 2 # AgeSel_5P_7_F5TPSPO
-15 15 -10.6426 0 0 999 6 0 0 0 0 0 4 2 # AgeSel_5P_8_F5TPSPO
-15 15 -0.185407 0 0 999 4 0 0 0 0 0 0 0 # AgeSel_5P_9_F5TPSPO
-15 15 8.60541 0 0 999 5 0 0 0 0 0 0 0 # AgeSel_5P_10_F5TPSPO
-15 15 -2.33758 0 0 999 2 0 0 0 0 0 0 0 # AgeSel_5P_11_F5TPSPO
-15 5 -1 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_5P_12_F5TPSPO
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_5P_13_F5TPSPO

-15 15 -3.46458 0 0 999 7 # AgeSel_5P_2_F5TPSPO_BLK4repl_2004
-15 15 1.15983 0 0 999 2 # AgeSel_5P_6_F5TPSPO_BLK4repl_2004
-15 15 -0.6587 0 0 999 5 # AgeSel_5P_7_F5TPSPO_BLK4repl_2004
-15 15 -6.94747 0 0 999 3 # AgeSel_5P_8_F5TPSPO_BLK4repl_2004

F8

-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_8P_1_F8JSN(S1-3)
-15 15 1.51827 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_8P_2_F8JSN(S1-3)
-15 15 -1.69425 0 0 999 3 0 0 0 0 0 0 0 # AgeSel_8P_3_F8JSN(S1-3)
-15 15 -0.988283 0 0 999 5 0 0 0 0 0 0 0 # AgeSel_8P_4_F8JSN(S1-3)
-15 15 -0.487775 0 0 999 7 0 0 0 0 0 0 0 # AgeSel_8P_5_F8JSN(S1-3)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_8P_6_F8JSN(S1-3)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_8P_7_F8JSN(S1-3)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_8P_8_F8JSN(S1-3)

F9

-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_9P_1_F9JSN(S4)
-15 15 0.262091 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_9P_2_F9JSN(S4)
-15 15 -0.0270432 0 0 999 5 0 0 0 0 0 0 0 # AgeSel_9P_3_F9JSN(S4)
-15 15 -0.12413 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_9P_4_F9JSN(S4)
-15 15 -0.481478 0 0 999 7 0 0 0 0 0 0 0 # AgeSel_9P_5_F9JSN(S4)
-15 15 -1.05058 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_9P_6_F9JSN(S4)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_9P_7_F9JSN(S4)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_9P_8_F9JSN(S4)

F10

-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_10P_1_F10JSN(HK_AM)
-3 3 1.74332 0 0 999 4 0 0 0 0 0 0 0 # AgeSel_10P_2_F10JSN(HK_AM)
-15 15 -0.65703 0 0 999 4 0 0 0 0 0 0 0 # AgeSel_10P_3_F10JSN(HK_AM)
-15 15 -0.334338 0 0 999 4 0 0 0 0 0 0 0 # AgeSel_10P_4_F10JSN(HK_AM)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_10P_5_F10JSN(HK_AM)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_10P_6_F10JSN(HK_AM)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_10P_7_F10JSN(HK_AM)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_10P_8_F10JSN(HK_AM)

F13

0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_13P_1_F13USCOMM(-2001)
10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_13P_2_F13USCOMM(-2001)

F14

0 1 0 1 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_14P_1_F14MEXCOMM(2002-)

10 20 20 142 0 25 -99 0 0 0 0 0.5 0 0 # AgeSel_14P_2_F14MEXCOMM(2002-)
F18
-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_18P_1_F18JSPPS(S2)
-15 15 0.962625 0 0 999 5 0 2 2004 2016 1 0 0 # AgeSel_18P_2_F18JSPPS(S2)
-15 15 -15 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_18P_3_F18JSPPS(S2)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_18P_4_F18JSPPS(S2)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_18P_5_F18JSPPS(S2)

Alternative model

Length-based
F13
21.2 150.1 59.9375 73.8791 0 999 4 0 0 0 0 0 0 0 # SizeSel_13P_1_F13USCOMM(-2001)
0.1 50 3.57666 40 0 999 6 0 0 0 0 0 0 0 # SizeSel_13P_2_F13USCOMM(-2001)
F14
21.2 150.1 79.0646 73.8791 0 999 5 0 0 0 0 0 0 0 # SizeSel_14P_1_F14MEXCOMM(2002-)
0.1 50 15.0922 40 0 999 6 0 0 0 0 0 0 0 # SizeSel_14P_2_F14MEXCOMM(2002-)
Age-based
F4
-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_4P_1_F4TPSJS
-15 15 1.16514 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_4P_2_F4TPSJS
-15 15 -0.765056 0 0 999 3 0 0 0 0 0 0 0 # AgeSel_4P_3_F4TPSJS
-15 15 -1.48109 0 0 999 6 0 2 2000 2016 1 0 0 # AgeSel_4P_4_F4TPSJS
-15 15 0.47078 0 0 999 6 0 2 2000 2016 1 0 0 # AgeSel_4P_5_F4TPSJS
-15 15 0.106571 0 0 999 3 0 2 2000 2016 1 0 0 # AgeSel_4P_6_F4TPSJS
-15 15 -0.404877 0 0 999 6 0 2 2000 2016 1 0 0 # AgeSel_4P_7_F4TPSJS
-15 15 0.365056 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_4P_8_F4TPSJS
-15 15 -3.34529 0 0 999 4 0 0 0 0 0 0 0 # AgeSel_4P_9_F4TPSJS
-15 15 2.23379 0 0 999 5 0 0 0 0 0 0 0 # AgeSel_4P_10_F4TPSJS
-15 15 0.879245 0 0 999 2 0 0 0 0 0 0 0 # AgeSel_4P_11_F4TPSJS
-15 5 -1 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_4P_12_F4TPSJS
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_4P_13_F4TPSJS
F13
-3 3 0 0 0 999 -2 0 0 0 0 0 0 0 # AgeSel_13P_1_F13USCOMM(-2001)
-15 15 2.832 0 0 999 6 0 0 0 0 0 0 0 # AgeSel_13P_2_F13USCOMM(-2001)
-15 15 -1.93471 0 0 999 5 0 0 0 0 0 5 2 # AgeSel_13P_3_F13USCOMM(-2001)
-15 15 -1.08218 0 0 999 6 0 0 0 0 0 5 2 # AgeSel_13P_4_F13USCOMM(-2001)
-15 15 1.29535 0 0 999 7 0 0 0 0 0 5 2 # AgeSel_13P_5_F13USCOMM(-2001)
-15 15 -10.1332 0 0 999 6 0 0 0 0 0 5 2 # AgeSel_13P_6_F13USCOMM(-2001)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_13P_7_F13USCOMM(-2001)
-999 5 -999 0 0 999 -5 0 0 0 0 0 0 0 # AgeSel_13P_8_F13USCOMM(-2001)

-15 15 2.17983 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1954
-15 15 -0.469712 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1955
-15 15 -1.53487 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1956
-15 15 -1.40854 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1958
-15 15 1.39461 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1959
-15 15 -1.75458 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1960
-15 15 -9.9509 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1961

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-15 15 -2.35954 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1963
-15 15 -2.45575 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1965
-15 15 -1.91391 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1976
-15 15 -11.6999 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_1979
-15 15 -3.64936 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2006
-15 15 -3.55469 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2008
-15 15 -1.60581 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2009
-15 15 -1.44985 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2010
-15 15 -1.62568 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2011
-15 15 -8.74363 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2012
-15 15 0.622283 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2013
-15 15 6.11732 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2014
-15 15 4.36431 0 0 999 6 # AgeSel_13P_3_F13USCOMM(-2001)_BLK5repl_2016
-15 15 -9.81769 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1954
-15 15 4.01426 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1955
-15 15 -10.2731 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1956
-15 15 -9.79184 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1958
-15 15 -1.91046 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1959
-15 15 -6.10114 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1960
-15 15 3.07935 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1961
-15 15 0.109622 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1963
-15 15 -7.97968 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1965
-15 15 -1.69246 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1976
-15 15 -1.00563 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_1979
-15 15 -5.74484 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2006
-15 15 -0.465274 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2008
-15 15 -0.789172 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2009
-15 15 -9.09213 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2010
-15 15 -2.24786 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2011
-15 15 7.6523 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2012
-15 15 -2.26673 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2013
-15 15 -2.02207 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2014
-15 15 1.58246 0 0 999 6 # AgeSel_13P_4_F13USCOMM(-2001)_BLK5repl_2016
-15 15 8.28385 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1954
-15 15 -10.3697 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1955
-15 15 3.40283 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1956
-15 15 -1.30008 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1958
-15 15 -8.76817 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1959
-15 15 4.18654 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1960
-15 15 -6.86313 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1961
-15 15 -8.10184 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1963
-15 15 -2.80076 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1965
-15 15 -0.0230717 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1976
-15 15 4.68053 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_1979
-15 15 6.6169 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2006
-15 15 -2.04952 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2008
-15 15 1.36423 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2009
-15 15 6.52986 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2010
-15 15 -1.38896 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2011
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-15 15 -3.02284 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2012
-15 15 4.38767 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2013
-15 15 -0.478409 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2014
-15 15 -0.447838 0 0 999 6 # AgeSel_13P_5_F13USCOMM(-2001)_BLK5repl_2016
-15 15 -8.53923 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1954
-15 15 -1.61246 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1955
-15 15 0.361252 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1956
-15 15 2.30955 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1958
-15 15 -1.48454 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1959
-15 15 -7.24849 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1960
-15 15 -2.26656 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1961
-15 15 -1.76546 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1963
-15 15 -0.843171 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1965
-15 15 -0.643301 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1976
-15 15 -3.02911 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_1979
-15 15 -0.533663 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2006
-15 15 1.08591 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2008
-15 15 -0.735726 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2009
-15 15 -5.69176 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2010
-15 15 -5.14575 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2011
-15 15 -7.29465 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2012
-15 15 -11.1858 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2013
-15 15 -2.5596 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2014
-15 15 -1.4437 0 0 999 6 # AgeSel_13P_6_F13USCOMM(-2001)_BLK5repl_2016
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