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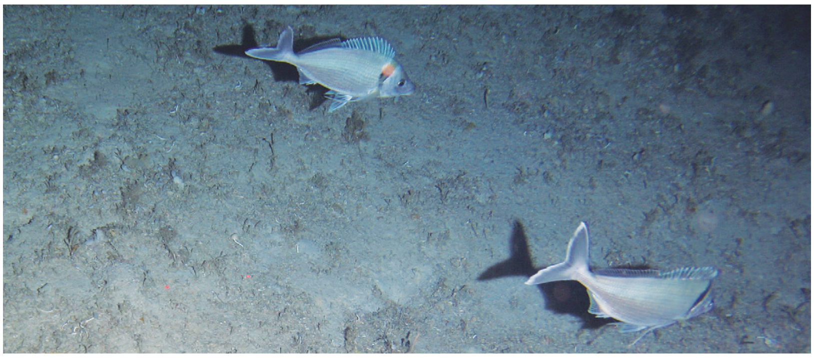
Australian Government
Australian Fisheries Management Authority

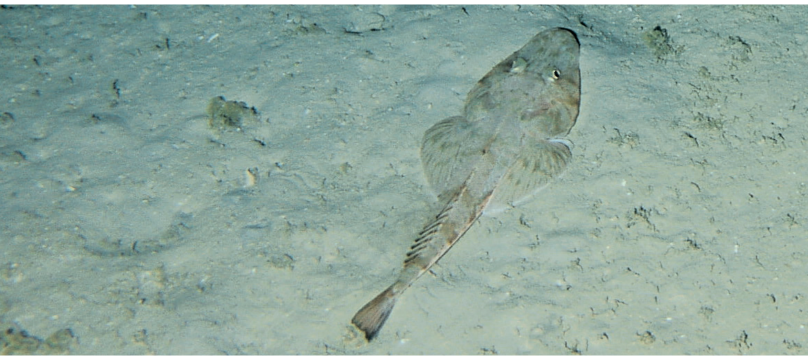
2017/0824 June 2020

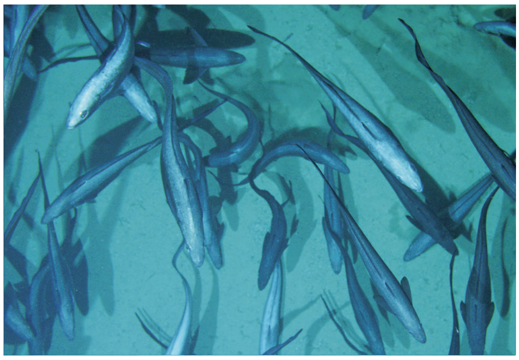
Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2018 and 2019

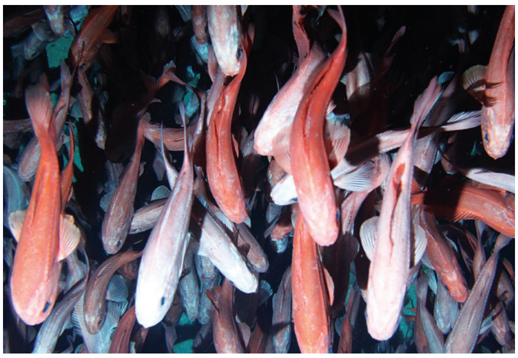


PART 1

2019







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All authors wish to thank the science, management and industry members of the south east, GAB and shark resource assessment groups for their contributions to the work presented in this report. Authors also acknowledge support from Fish Ageing Services (for fish ageing data) and AFMA (for the on-board and port length-frequencies, and in particular John Garvey, for the log book data). Toni Cracknell is greatly thanked for her assistance with the production of this report.

Cover photographs

Front cover, jackass morwong, orange roughy, blue grenadier, and flathead.

Report structure

Part 1 of this report describes the Tier 1 assessments of 2019. Part 2 describes the Tier 3 and Tier 4 assessments, catch rate standardisations and other work contributing to the assessment and management of SESSF stocks in 2019.

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2018 and 2019

Part 1: 2019

G.N. Tuck
June 2020
Report 2017/0824

Australian Fisheries Management Authority

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2019

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6. Tiger flathead (*Neoplatycephalus richardsoni*) stock assessment based on data up to 2018 – development of a preliminary base case

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6.1 Executive Summary

This document presents a suggested base case for an updated quantitative Tier 1 tiger flathead (*Neoplatycephalus richardsoni*) assessment for presentation at the first SERAG meeting in 2019. The last full assessment was presented in Day (2016). The preliminary base case has been updated by the inclusion of data up to the end of 2018, which entails an additional 3 years of catch, discard, CPUE, length and age data and ageing error updates since the 2016 assessment and incorporation of survey results from the Fishery Independent Survey (FIS) from 2016. This document describes the process used to develop a preliminary base case for tiger flathead through the sequential updating of recent data used by the stock assessment, using the stock assessment package Stock Synthesis (SS-V3.30.14).

Changes to the last stock assessment include: incorporation of conditional age-at-length data for 2008 from the FIS; improvement to the method of estimating the bias ramp and using an updated tuning method.

Results show reasonably good fits to the catch rate data, length data and conditional age-at-length data. This assessment estimates that the projected 2020 spawning stock biomass will be 34% of virgin stock biomass (projected assuming 2018 catches in 2019), compared to 43% at the start of 2017 from the 2016 assessment (Day 2016) and 50% at the start of 2014 from the 2013 assessment (Day and Klaer 2013). This change in stock status is largely due to below average newly estimated recruitment events, particularly in 2013 but also in 2014, and a revision to the previously estimated 2012 recruitment event. The 2013 poor recruitment is supported both by the age and length data and by the recent index data, and the updated assessment fits all of these data sources well.

6.2 Introduction

6.2.1 *Bridging from 2016 to 2019 assessments*

The previous full quantitative assessment for tiger flathead was conducted in 2016 (Day, 2016) using Stock Synthesis (version SS-V3.24Z, Methot and Wetzel, 2013, Methot, 2015). The 2019 assessment uses the current version of Stock Synthesis (version SS-V3.30.14.05, Methot, 2019), which includes some changes from SS_V3.24Z.

As a first step in the process of bridging to a new model, the model was translated from version SS-V3.24Z (Methot, 2015) to version SS-V3.30.14.05 (Methot et. al, 2019) using the same data and model structure used in the 2016 assessment. Once this translation was complete, improved features unavailable in SS-V3.24Z were incorporated into the SS-V3.30 assessment. These included allowing smaller lower bounds on minimum sample sizes and estimating a parameter that tunes the standard deviation to abundance indices. Following this step, the model was re-tuned using the most recent tuning protocols, thus allowing the examination of changes to both assessment practices and the tuning procedure on the previous model structure. These changes to software and tuning practices are likely to lead to changes to key model outputs, such as the estimates of depletion and the trajectory of spawning biomass. This initial bridging phase (Bridge 1) highlights changes that have occurred since 2016 simply through changes to software and assessment practices. The subsequent bridging exercise (Bridge 2) then sequentially updates the model with new data through to 2018.

The second part of the bridging analysis includes updating historical data (up to 2015), followed by including the data from 2016-2018 into the model. These additional data included new catch, discard, CPUE, FIS abundance indices, length composition data, conditional age-at-length data and an updated ageing error matrix. Additional SESSF FIS data were also included: 2016 FIS abundance index; 2016 FIS length frequencies; and 2008 FIS conditional age-at-length data. The last year of recruitment estimation was extended to 2015 (changed from 2012 in the 2016 assessment).

The use of updated software and the inclusion of additional data resulted in some differences in the fits to CPUE, conditional age-at-length data and length composition data. The usual process of bridging to a new model by adding new data piecewise and analysing which components of the data could be attributed to changes in the assessment outcome was conducted with the details outlined below.

6.2.2 *Update to Stock Synthesis SSV-3.30 and updated catch history (Bridge 1)*

The 2016 tiger flathead assessment (Flathead2015_3.24Z) was initially converted to the most recent version of the software, Stock Synthesis version SS-V3.30.14.05 (Flathead2015_3.30.14). Figure 6.1 shows that the differences in the assessment results from this step were minimal.

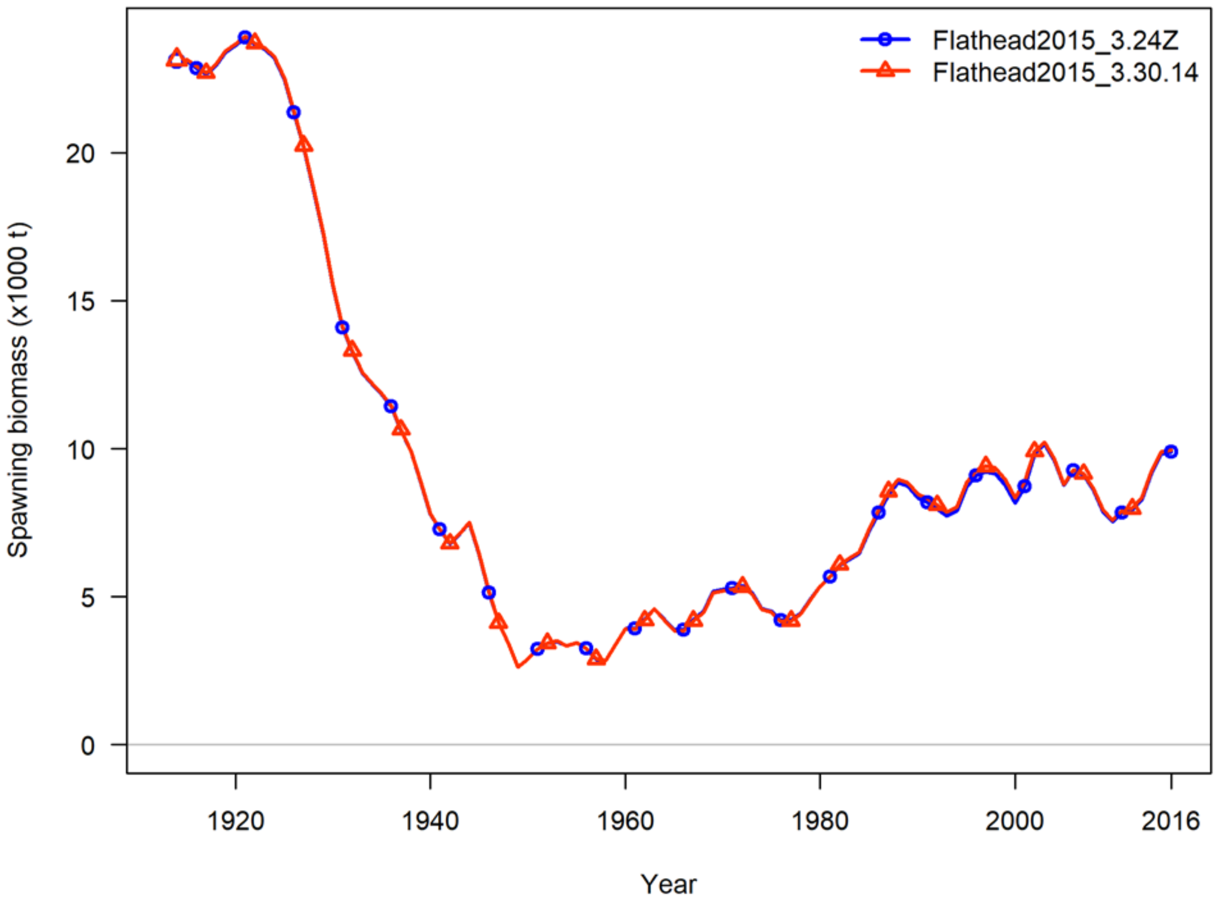

Figure 6.1. Comparison of the time-series of absolute spawning biomass from the 2016 assessment (Flathead2015_3.24Z – in blue) and a model converted to SS-V3.30 (Flathead2015_3.30.14 – in red).

New features available in the new version of Stock Synthesis, such as allowing smaller lower bounds on minimum sample sizes and estimating additional standard deviation to abundance indices were then incorporated (Flathead2015_3.30New), followed by retuning using the latest tuning protocol (Flathead2015_3.30Tuned). Details of the tuning procedure used are listed in Section 1.2.1. Revisions to the historical catches, between 2001 and 2015, including some corrections to allocations of catches between fleets and updates to recent state catches, and replacing the estimated 2016 catch with the actual 2016 catch, were then added to this tuned version of the 2016 model (Flathead2015_3.30ReviseCatch). This process demonstrates the outcomes that could theoretically have been achieved with the last assessment if we had the latest software, tuning protocols and corrected data available in 2016. This initial bridging step, Bridge 1, does not incorporate any data after 2015 or any structural changes to the assessment.

When these time series are plotted together (Figure 6.2 and Figure 6.3), there are minor changes due to incorporating new features in Stock Synthesis. The new tuning procedures result in an improved fit to the steam trawl index, largely through allowing more flexibility in early recruitment (prior to 1930) which alters the predicted biomass series, especially in the 1920s. The additional changes through catch revisions to 2015 are minimal.

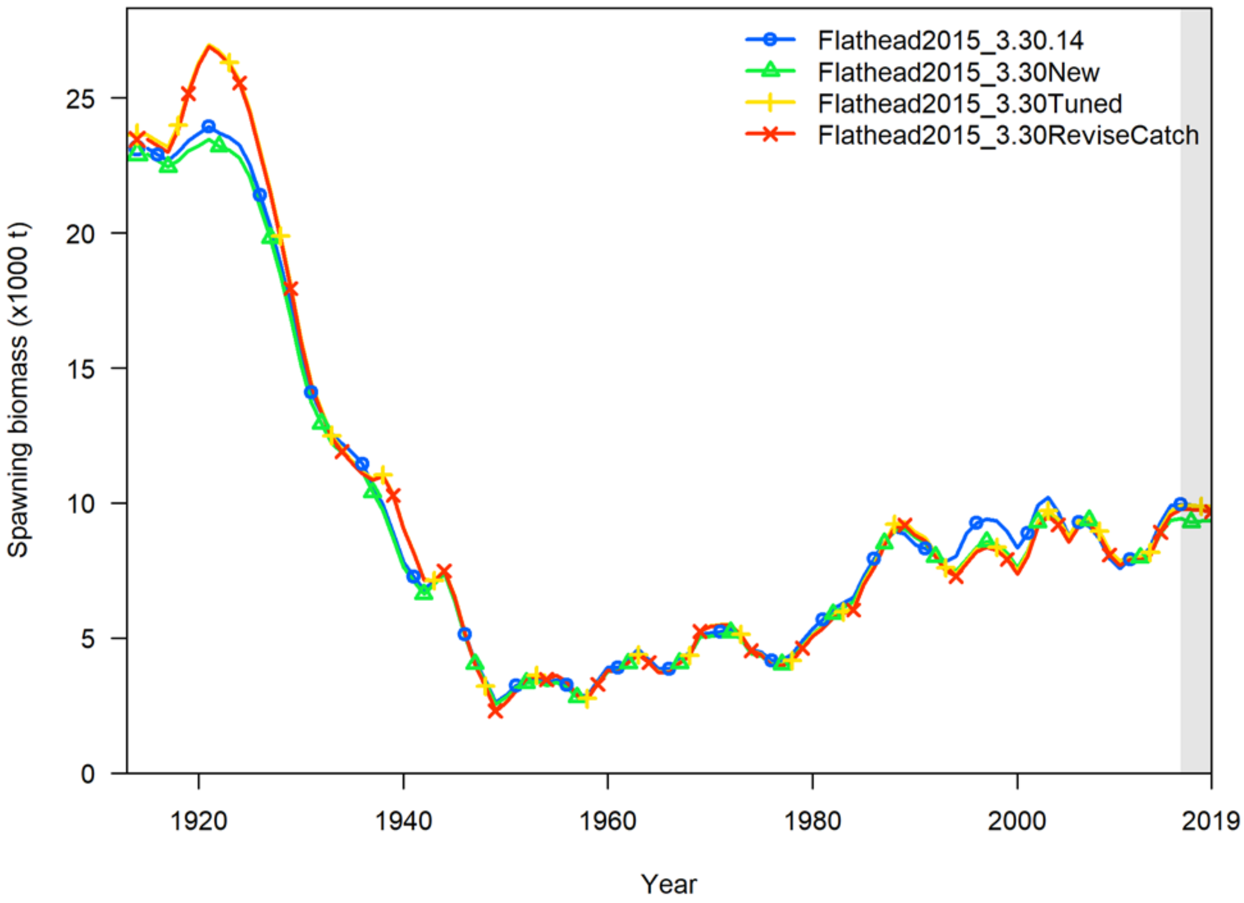

Figure 6.2. Comparison of the time-series of absolute spawning biomass from the 2016 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

The results of Bridge 1 suggest that the stock was marginally more depleted in 2017 than the 2016 assessment indicated (43% of SSB_0), although the stock was still estimated to be above the target reference point of 40% of SSB_0. These changes are small enough to be well within the confidence bounds of the 2016 assessment results and the fits are generally improved through these revisions.

Fits to the abundance indices (Figure 6.4 to Figure 6.8) show changes through this process, mostly with small improvements to the fit during Bridge 1. However, the FIS indices show less noticeable change to fits (Figure 6.9 to Figure 6.10). The estimated recruitment series shows little change in broad trends during Bridge 1 (Figure 6.11), although there are several minor changes resulting from the new tuning procedures. In particular, the new tuning procedures allow for greater variation in recruitment prior to 1950, which in turn allows for better fits to the early CPUE data.

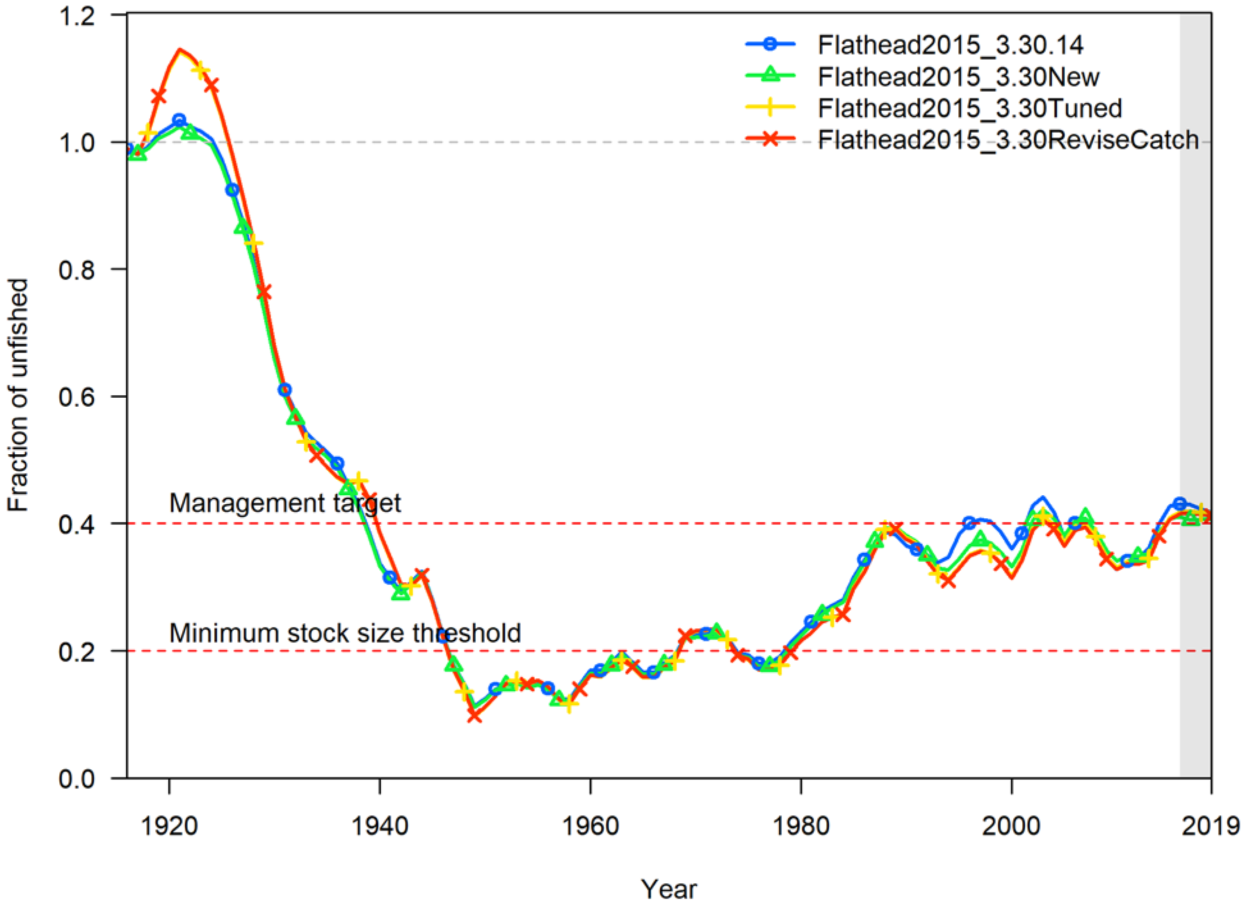

Figure 6.3. Comparison of the time-series of relative spawning biomass from the 2016 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red). Note that the section shaded in grey indicates a few years of future projections, beyond the period covering data used in the assessment, which stops in 2015 in this case.

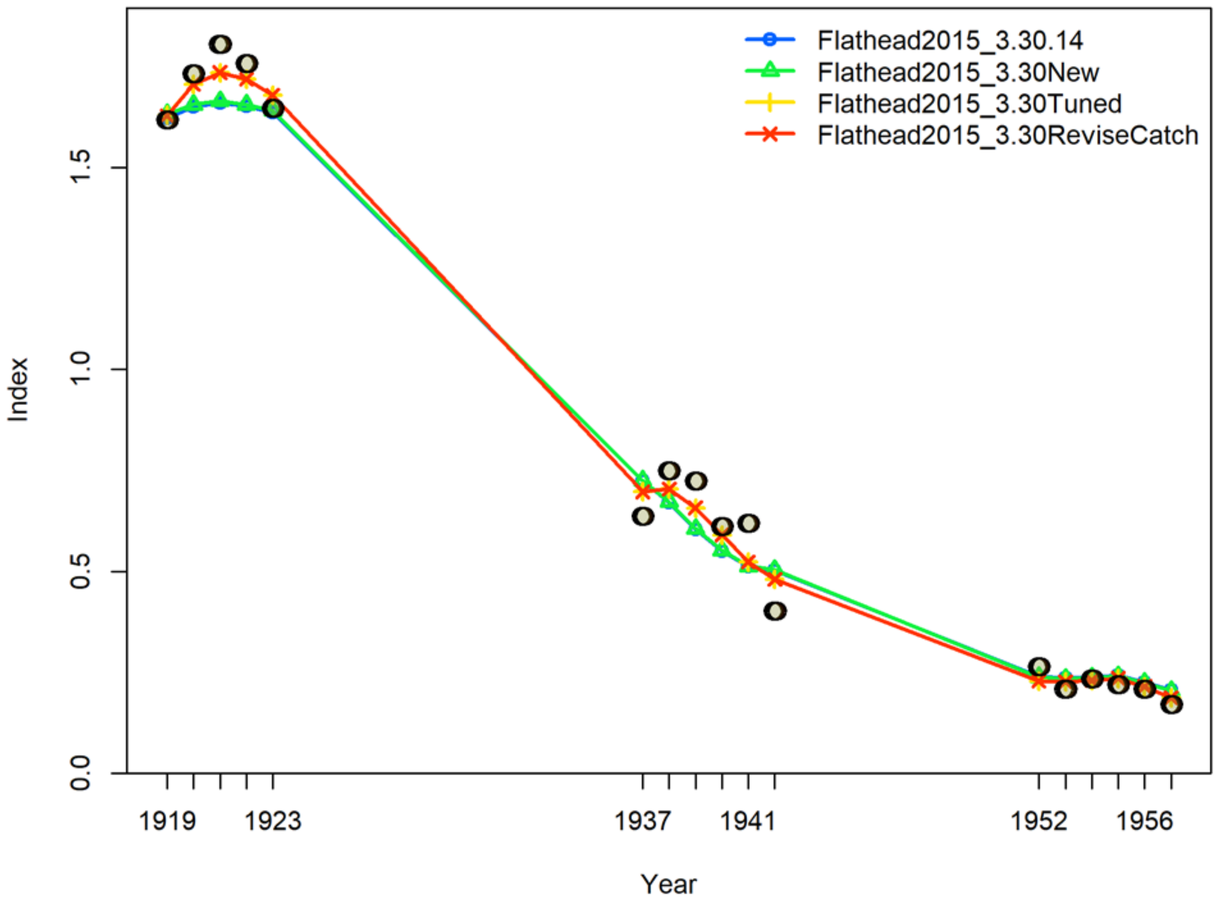

Figure 6.4. Comparison of the fit to the steam trawl CPUE index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

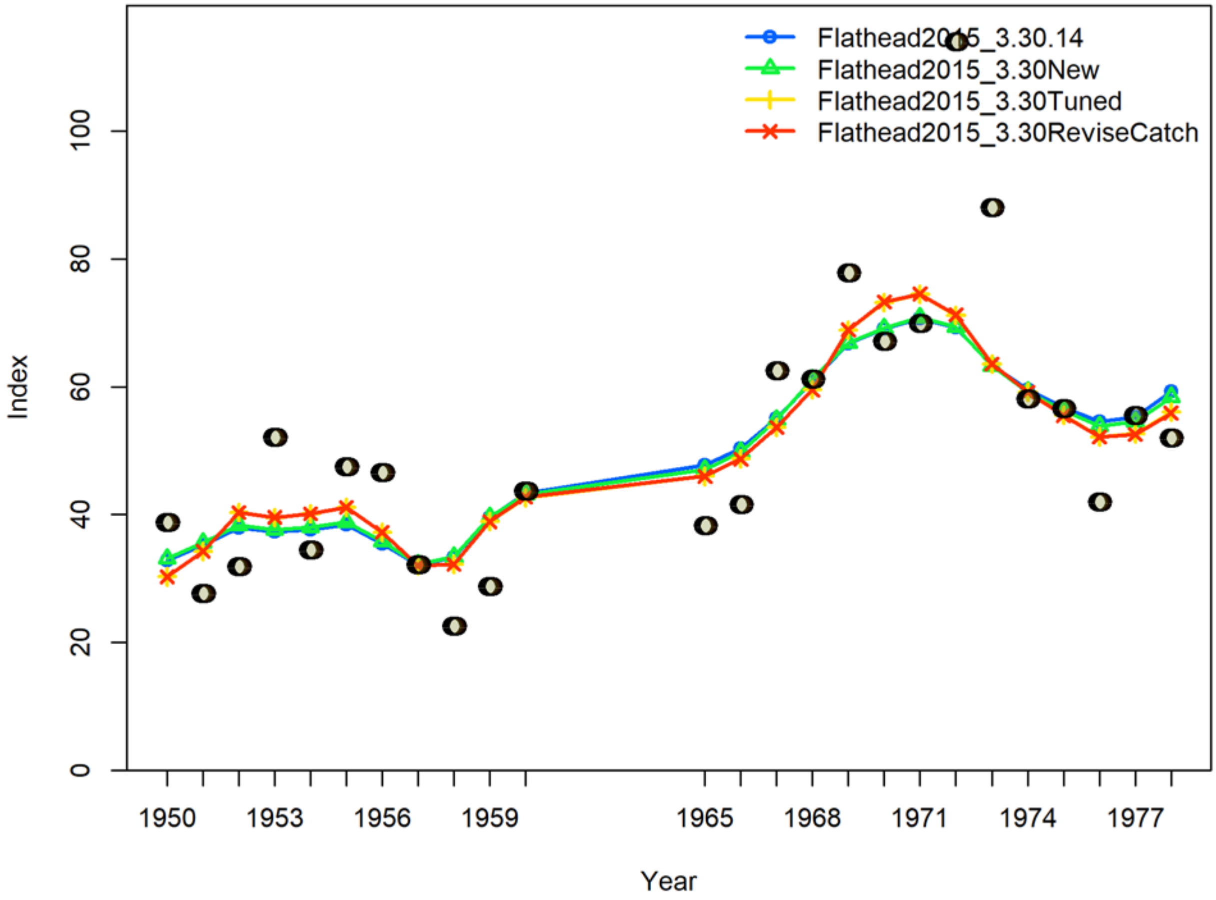

Figure 6.5. Comparison of the fit to the old Danish seine CPUE index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

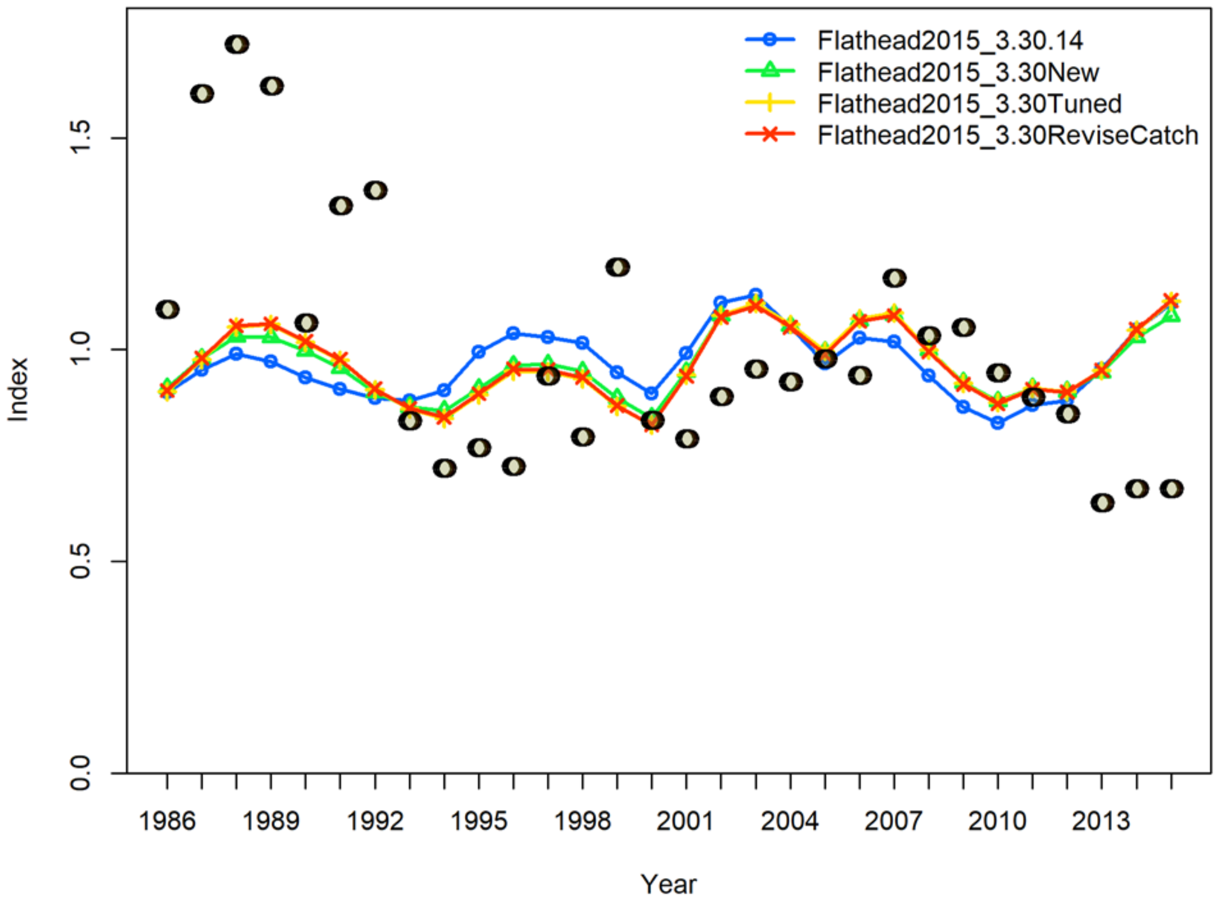

Figure 6.6. Comparison of the fit to the Danish seine CPUE index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

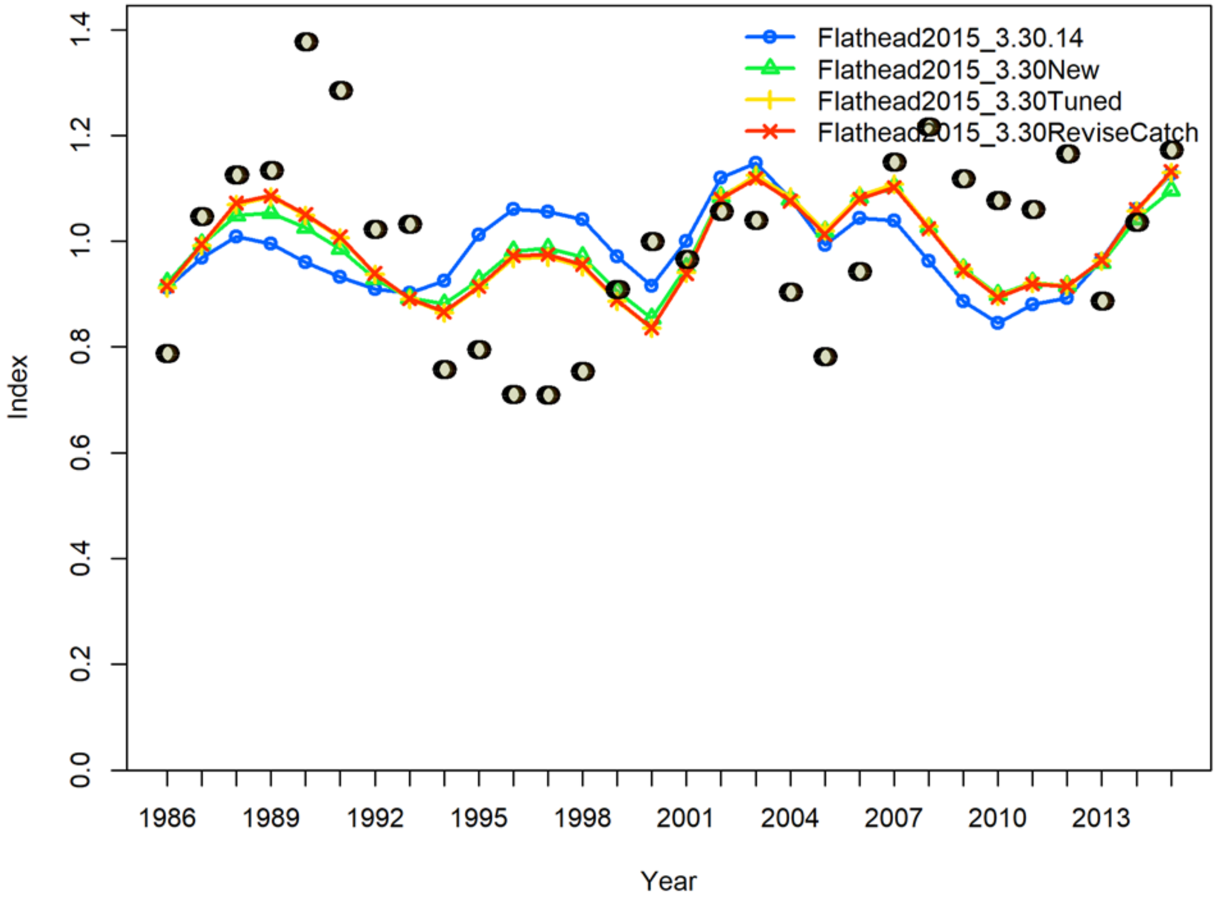

Figure 6.7. Comparison of the fit to the Eastern trawl CPUE index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

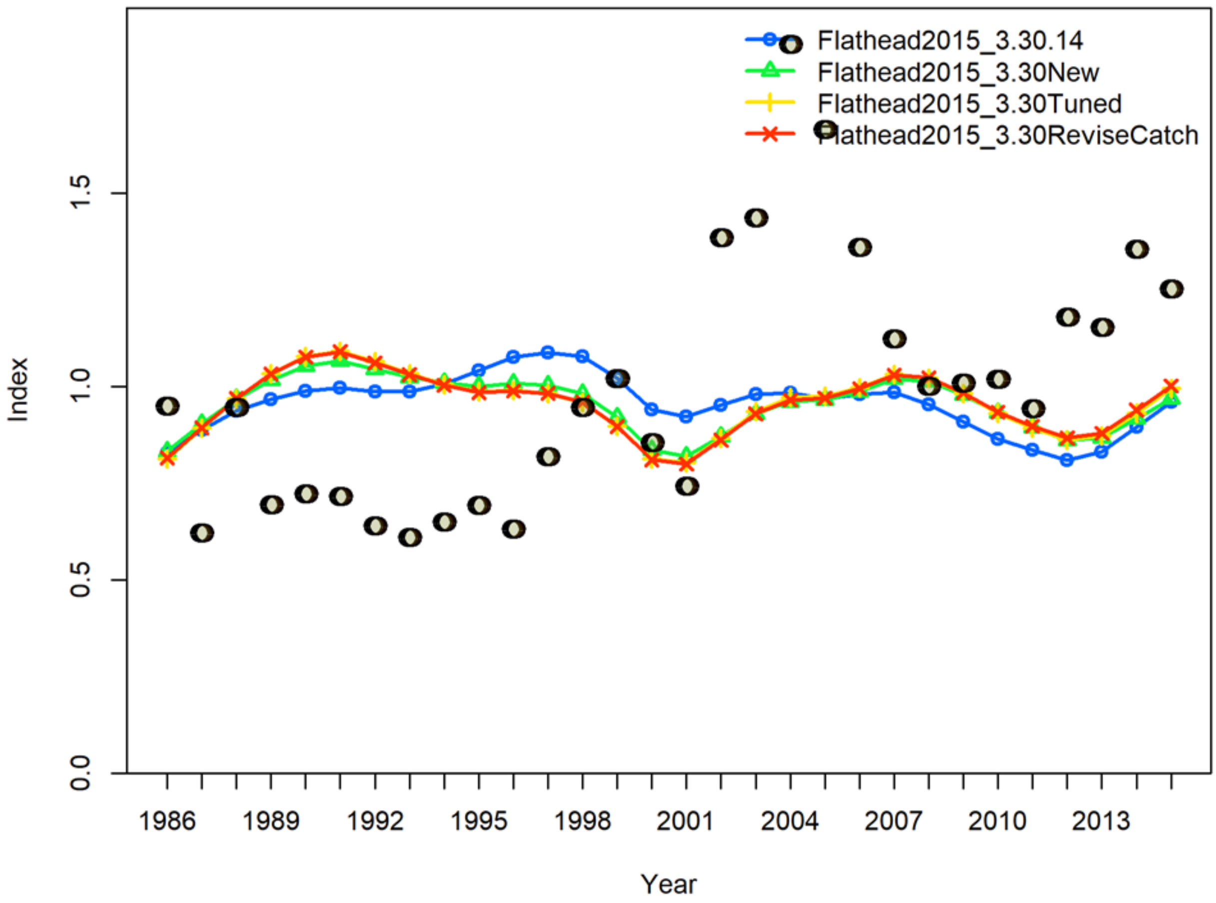

Figure 6.8. Comparison of the fit to the Tasmanian trawl CPUE index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

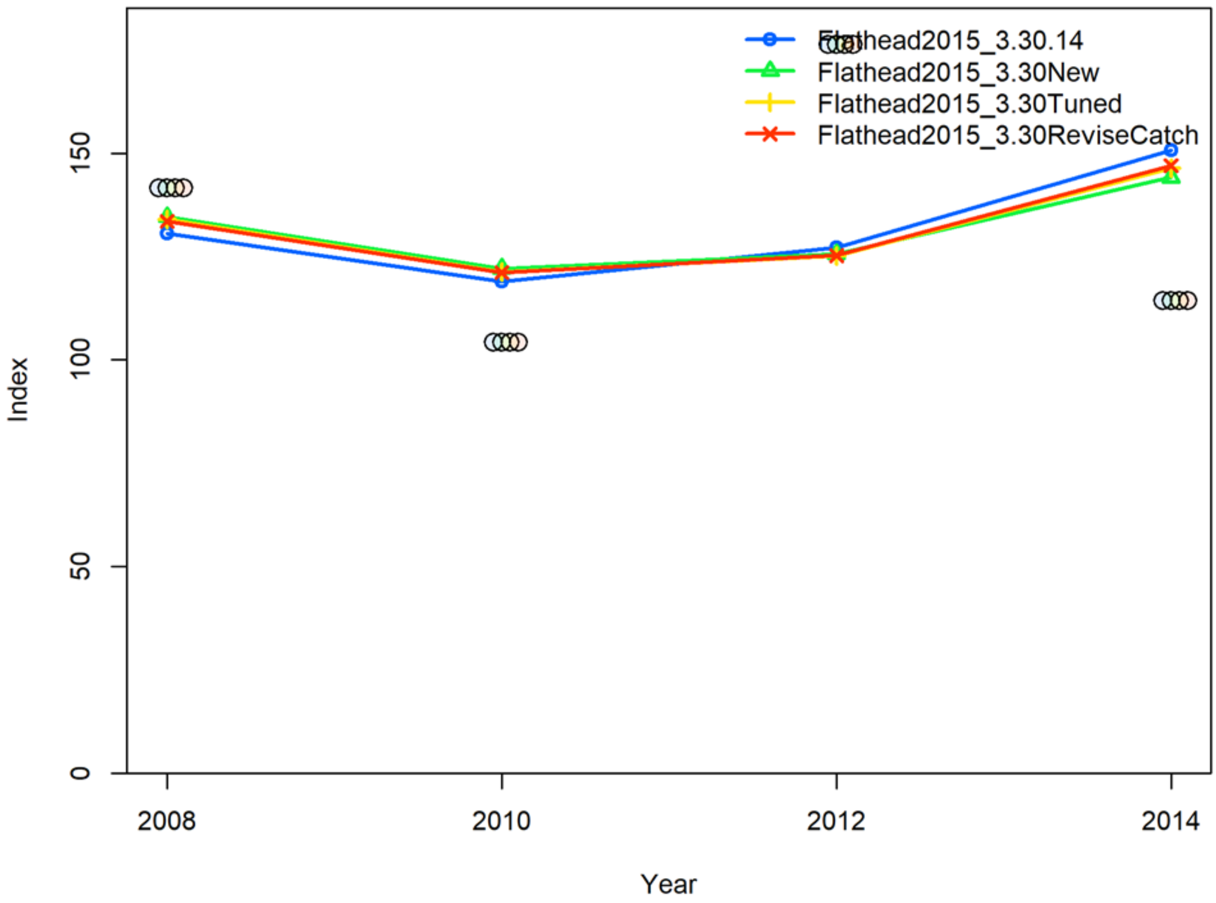

Figure 6.9. Comparison of the fit to the FIS_East (zones 10 and 20) abundance index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

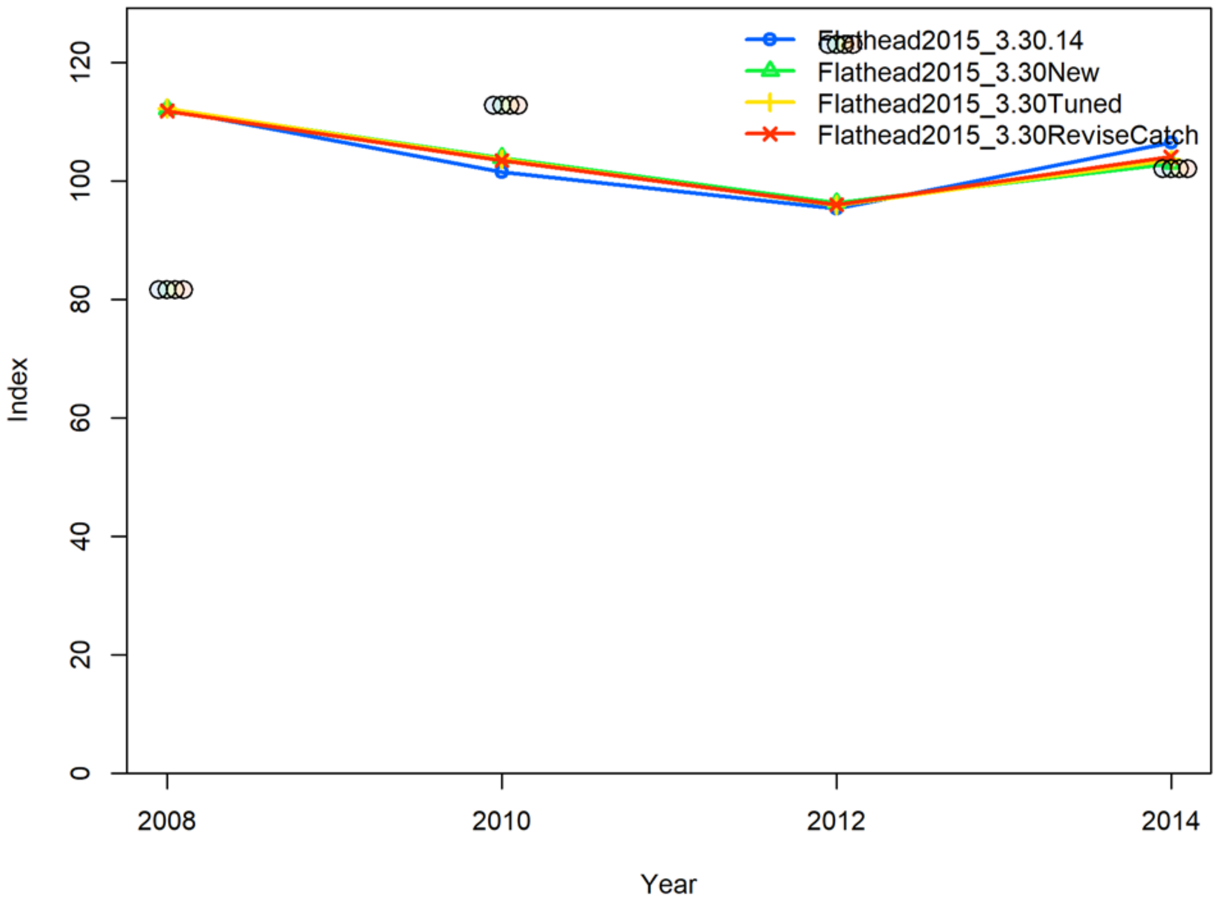

Figure 6.10. Comparison of the fit to the FIS_Tas (zone 30) abundance index for the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

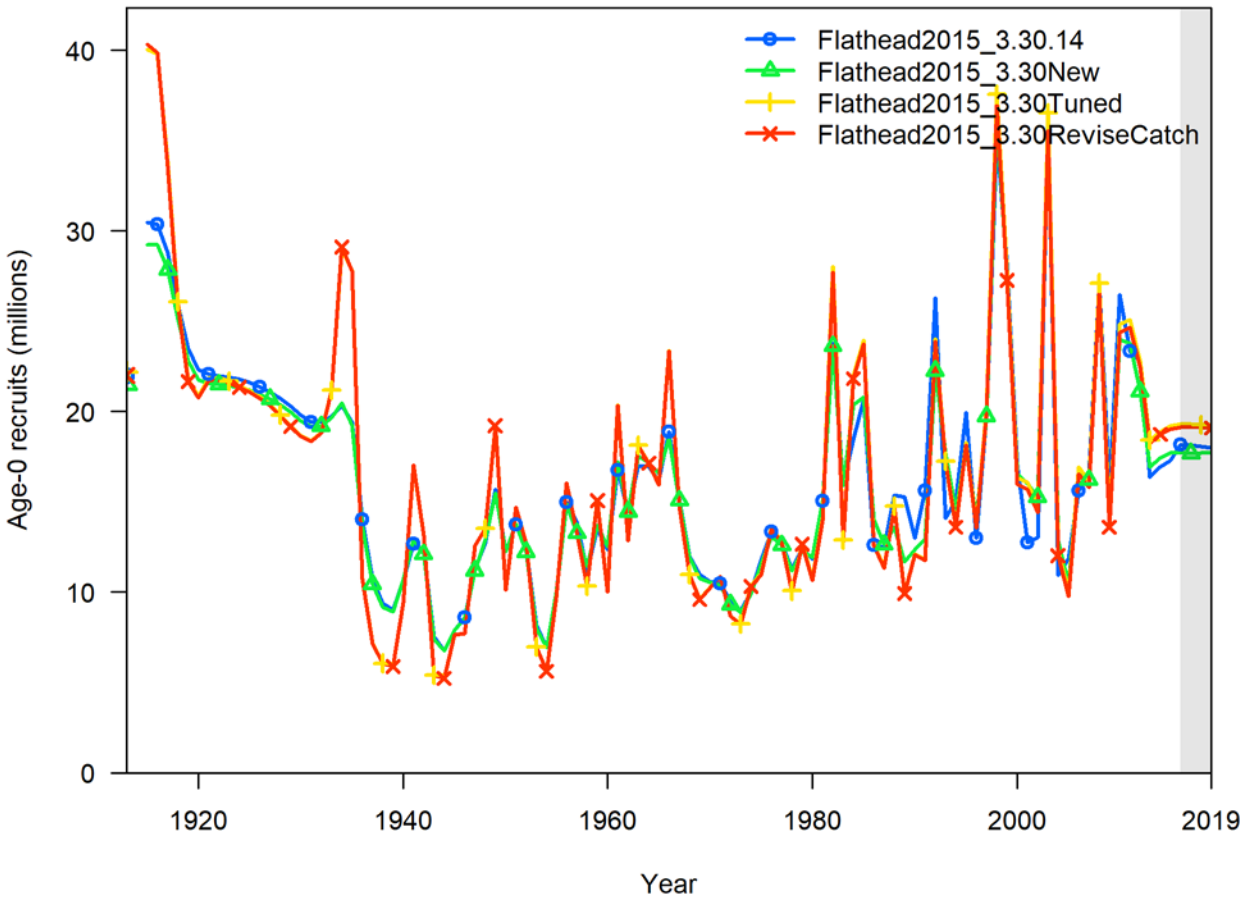

Figure 6.11. Comparison of the time series of recruitment from the 2015 assessment (Flathead2015_3.30.14 – in blue), incorporating new features (Flathead2015_3.30New – in green), retuning the model using the latest tuning protocols (Flathead2015_3.30Tuned – in yellow) and revising the historical catch to 2015 and the projected catch in 2016 (Flathead2015_3.30ReviseCatch – in red).

6.2.2.1 Tuning method

Iterative rescaling (reweighting) of input and output CVs or input and effective sample sizes is a repeatable method for ensuring that the expected variation of the different data streams is comparable to what is input (Pacific Fishery Management Council, 2018). Most of the indices (CPUE, surveys and composition data) used in fisheries underestimate their true variance by only reporting measurement or estimation error and not including process error.

In iterative reweighting, the effective annual sample sizes are tuned/adjusted so that the input sample size is equal to the effective sample size calculated by the model. In SS-V3.30 it is possible to estimate an additional standard deviation parameter to add to the input CVs for the abundance indices (CPUE).

1. Set the standard error for the log of relative abundance indices (CPUE or FIS) to the standard deviation of a loess curve fitted to the original data - which will provide a more realistic estimate to that obtained from the original statistical analysis. SS-V3.30 then allows an estimate to be made for an additional adjustment to the relative abundance variances appropriately.

An automated iterative tuning procedure was used for the remaining adjustments. For the recruitment bias adjustment ramps:

2. Adjust the maximum bias adjustment and the start and finish bias adjustment ramps as predicted by SS-V3.30 at each step.

For the age and length composition data:

3. Multiply the stage-1 (initial) sample sizes for the conditional age-at-length data by the sample size multipliers using the approach of Punt (2017).
4. Similarly multiply the initial samples sizes by the sample size multipliers for the length composition data using the 'Francis method' (Francis, 2011).
5. Repeat steps 2 - 4, until all are converged and stable (with proposed changes < 1 – 2%).

This procedure constitutes current best practice for tuning assessments.

6.2.3 *Inclusion of new data: 2016-2018 (Bridge 2)*

Starting from the translated, retuned 2016 base case model with updated data to 2015 (previously referred to as "Flathead2015_3.30ReviseCatch" but simplified to "Flathead2015_3.30Updated" from here on), additional data from 2016-2018 were added sequentially to build a preliminary base case for the 2019 assessment:

1. Change final assessment year to 2018, add catch to 2018 (Flathead2019_addCatch2018).
2. Add CPUE to 2018 (from Sporcic (2019a, 2019b)) (Flathead2019_addCPUE2018), and the FIS abundance index for 2016 (Knuckey et al 2017) (Flathead2019_addFIS1_2016).
3. Add new discard fraction estimates from 1994 to 2018 (Flathead2019_addDiscards2018).
4. Add updated length frequency data to 2018 (Flathead2019_addLength2018).
5. Add updated age error matrix and conditional age-at-length data to 2018 and FIS conditional age-at-length data from 2008 (Flathead2019_addAge2018FIS).
6. Change the final year for which recruitments are estimated from 2012 to 2015 (Flathead2019_extendRec2015).
7. Retune using current tuning protocols, including Francis weighting on length-compositions and conditional age-at-length data (Flathead2019_Tuned).

Inclusion of the new data resulted in a series of changes to the estimates of recruitment and the time-series of absolute and relative spawning biomass (Figure 6.12 and Figure 6.13), with relatively small changes to these series as more data is added. Some changes are reversed from one step to the next, as additional data continues to be added (e.g. adding new catch data seems to have an effect that is largely cancelled out in the next step by updating the abundance indices). The most important change is extending the final year for which recruitment is estimated, resulting in a revision downwards of the 2012 recruitment (which was the last year of recruitment estimated in the 2016 assessment) and estimated below average recruitment for the newly estimated 2013 and 2014 recruitments (Figure 6.13), which in turn flows through to a reduction in the estimated stock biomass in 2019 (Figure 6.12). These below average recruitment events appear to be supported by the recent length and age data.

Fits to the early CPUE indices (Figure 6.14 and Figure 6.15) show little change as no new data is added in this period. Fits to the more recent CPUE (Figure 6.16 to Figure 6.18) show larger changes, especially in the last four years, 2015-2018, with extending the final year for which recruitment is estimated producing the largest change out of each of the steps shown. The largest improvement in fit is to the most recent four years of the CPUE time series for eastern trawl (Figure 6.17) with recruitment estimated to 2015. Changes in fits to the FIS indices are relatively minor (Figure 6.19 and Figure 6.20). Given the variability from point to point and the short time series, it would be hard to get better fits to the FIS series, especially given the species biology and the rest of the data included in the assessment. It appears that the fits to the much longer recent trawl CPUE indices are still much more influential. The fits to the historic CPUE indices are generally reasonable and the fit to the eastern trawl CPUE series matches the changes seen in the last six data points.

Inclusion of the new data had considerable impacts on the estimates of recruitment and the spawning biomass time series. With recruitment estimated up until 2015, this resulted in the 2012 recruitment (previously estimated in the 2016 assessment) to be revised down, compared to the 2016 assessment. Of the three new years of estimated recruitment (2013, 2014 and 2015), the first two are estimated to be below average, with 2013 having the lowest estimated recruitment deviation for over 50 years. The 2015 recruitment is estimated to be slightly above average, but this is the least informed estimate of these three new estimated recruitment events. These recruitment events appear to be supported by the recent length and age data and have resulted in an estimate of the depletion at the start of 2020 of 34% of unexploited stock biomass, SSB_0. While the most recent recruitments are well estimated, they should be treated with some caution as it is possible for future data to result in modifications to estimates of recent recruitment events, as occurred with the 2012 recruitment estimates from the 2015 assessment. Since 2005, various values have been used for the target and the breakpoint in the Tier 1 harvest control rule. In 2009, AFMA directed that the 20:35:40 (B_{lim}: B_{MSY}: F_{targ}) form of the harvest control rule be used for tiger flathead.

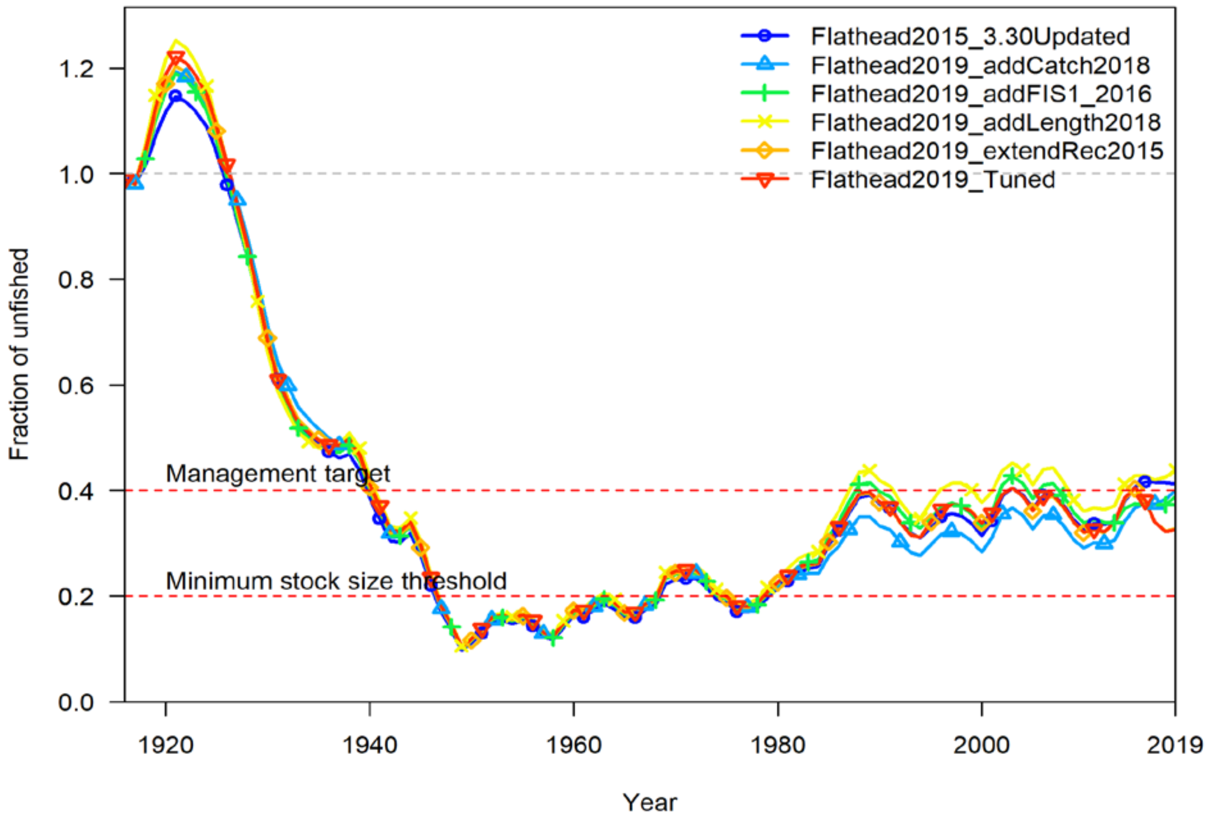

Figure 6.12. Comparison of the time series of relative spawning biomass for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

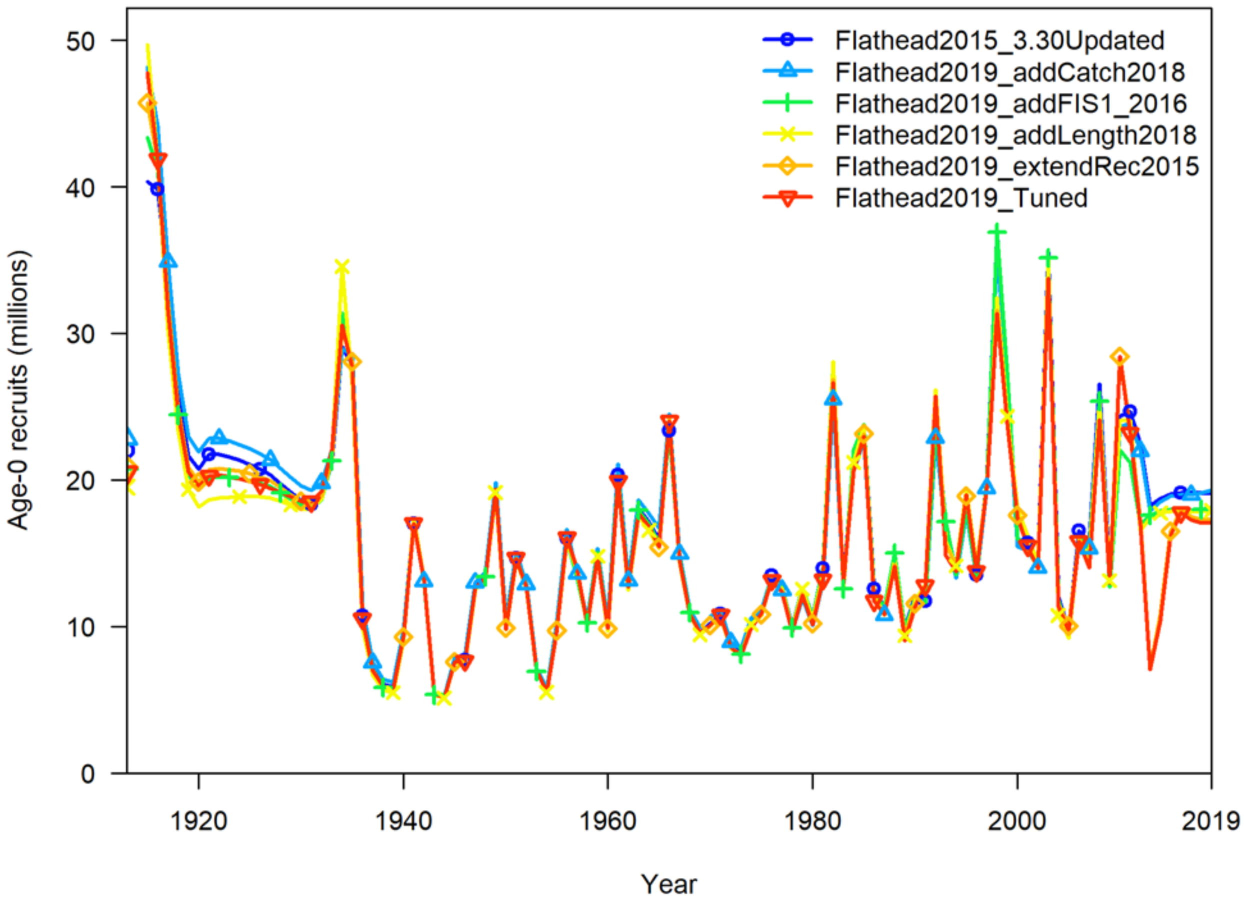

Figure 6.13. Comparison of the time series of recruitment from the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

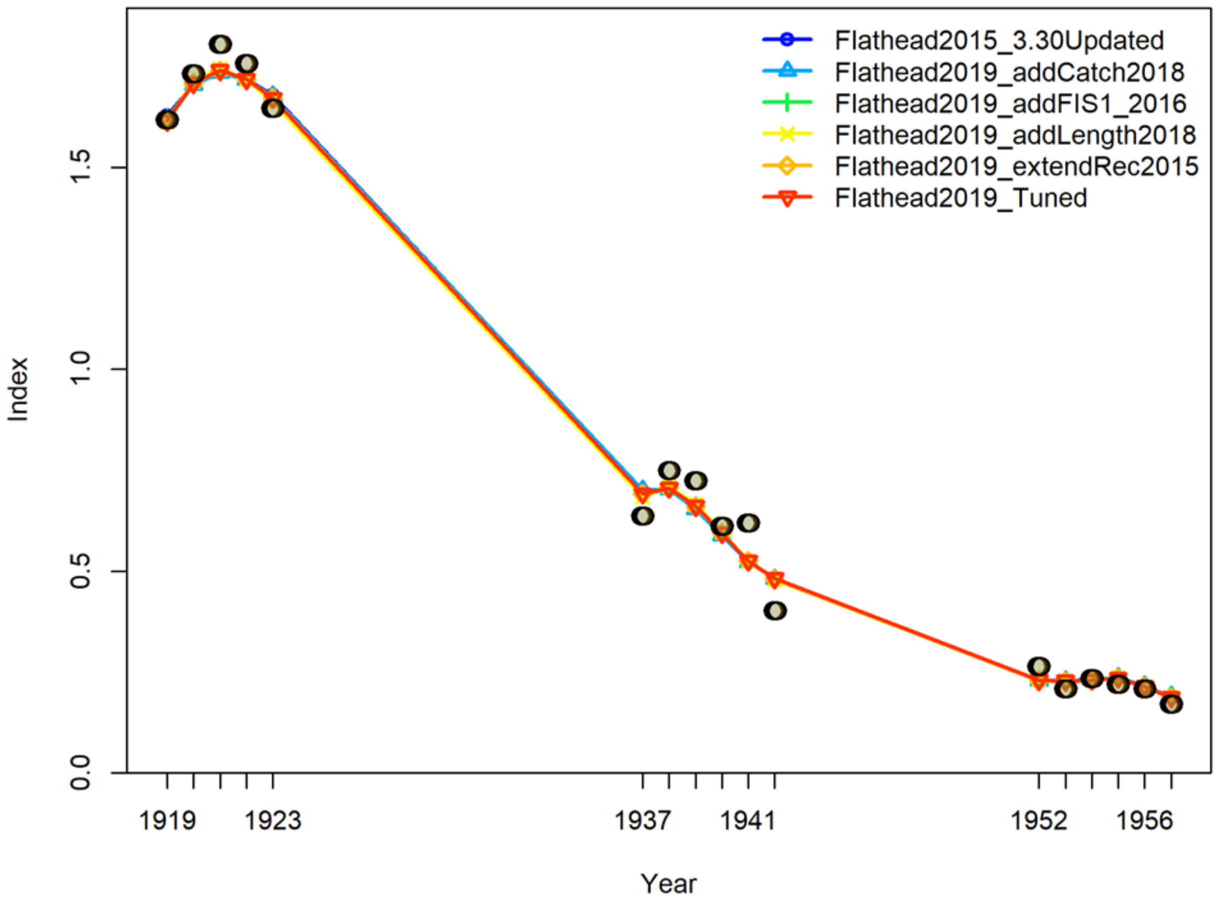

Figure 6.14. Comparison of the fit to the steam trawl CPUE index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

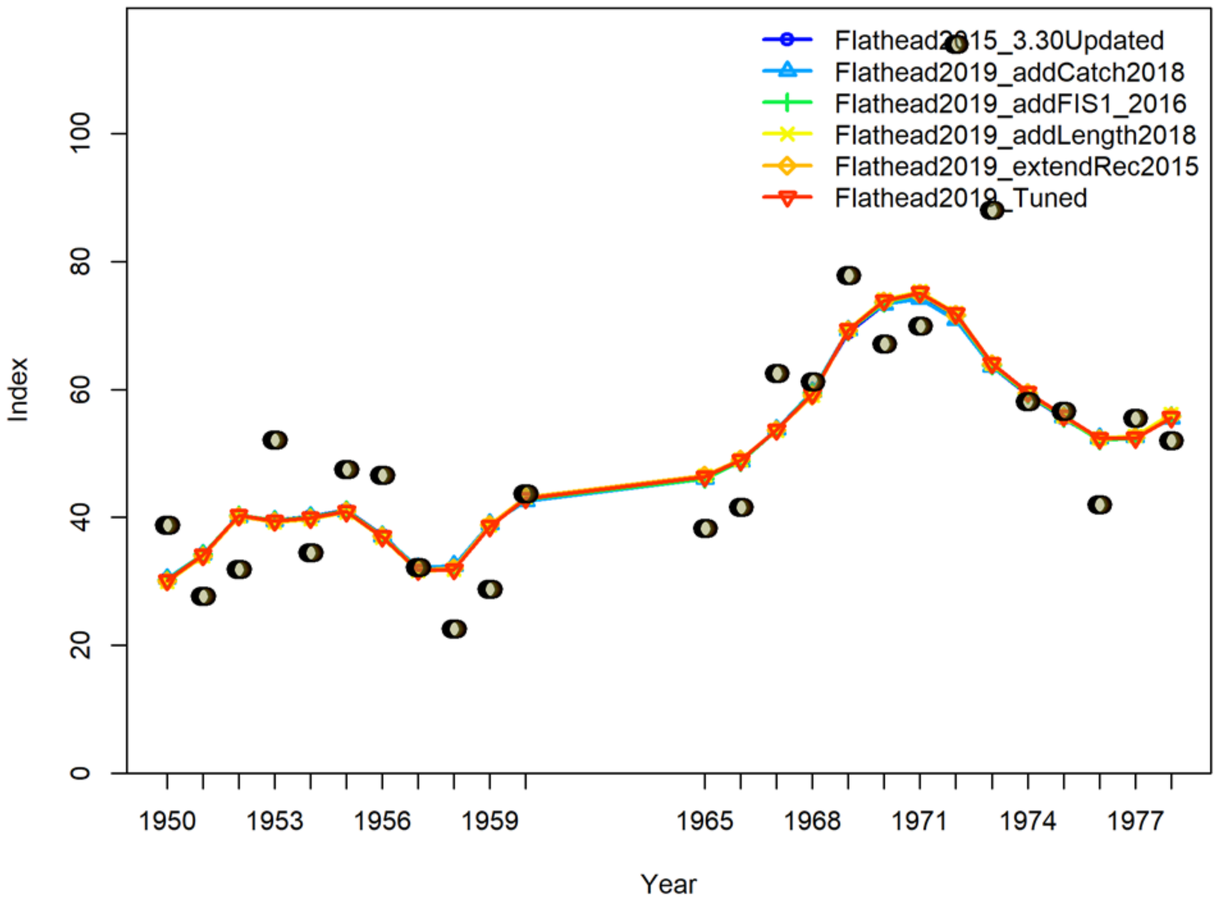

Figure 6.15. Comparison of the fit to the steam trawl CPUE index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

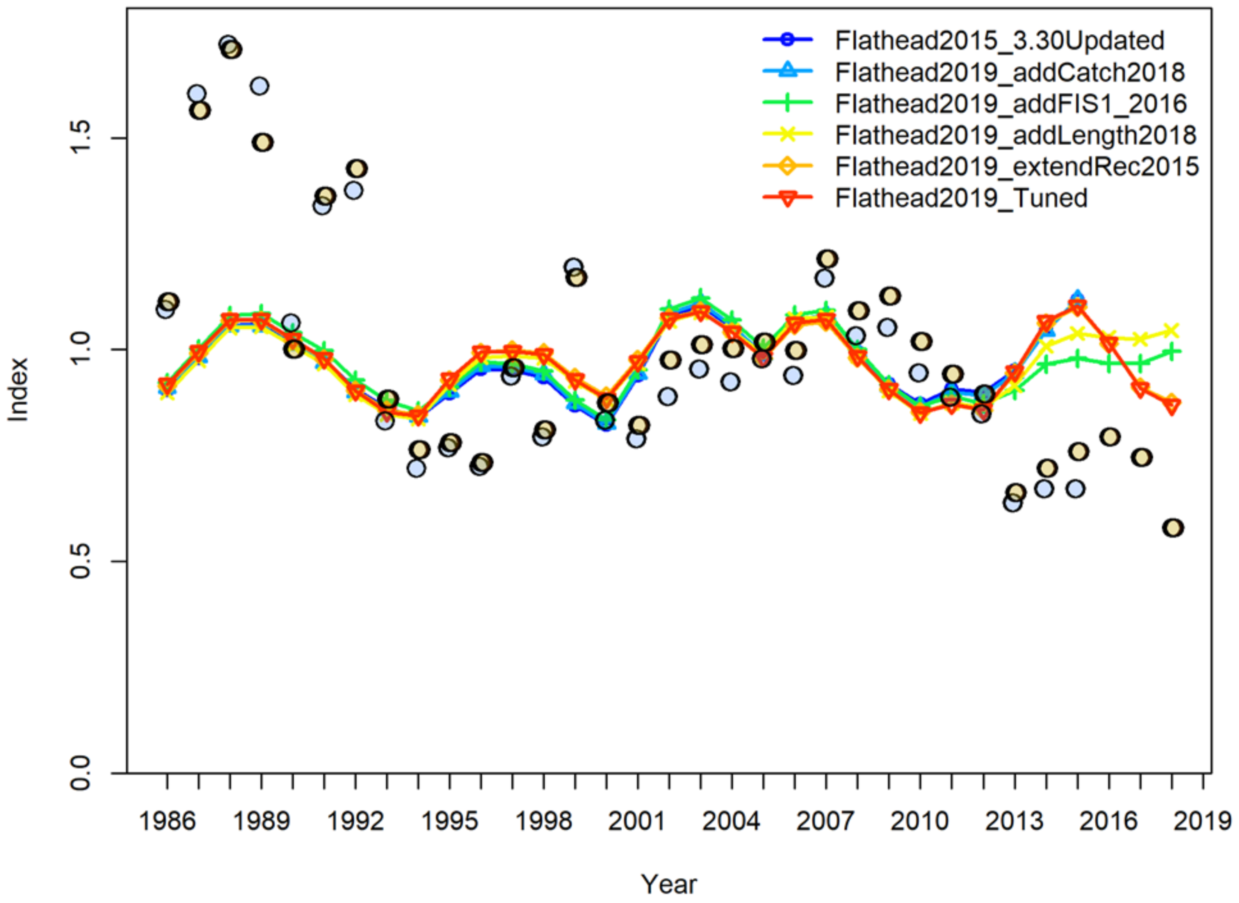

Figure 6.16. Comparison of the fit to the Danish seine CPUE index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

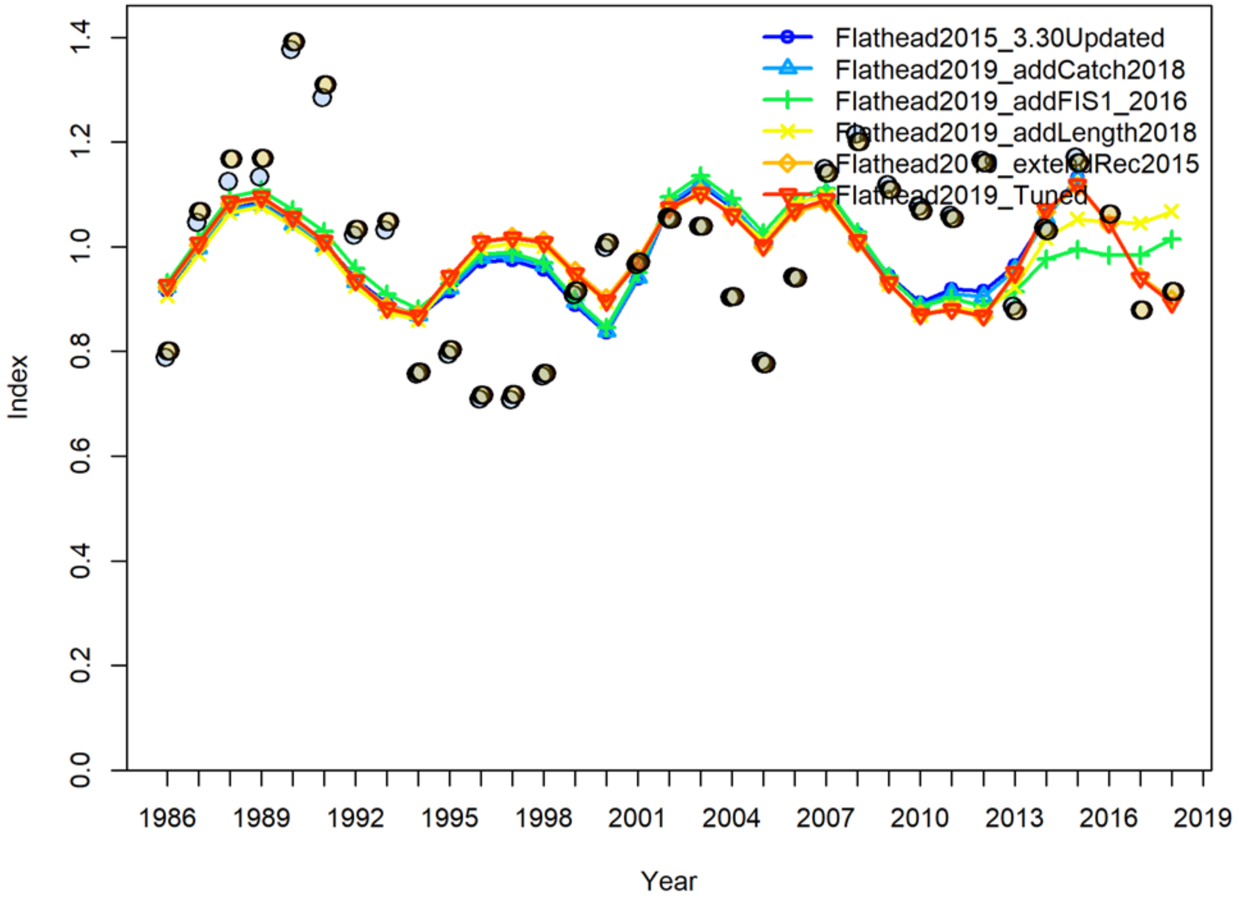

Figure 6.17. Comparison of the fit to the eastern trawl CPUE index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

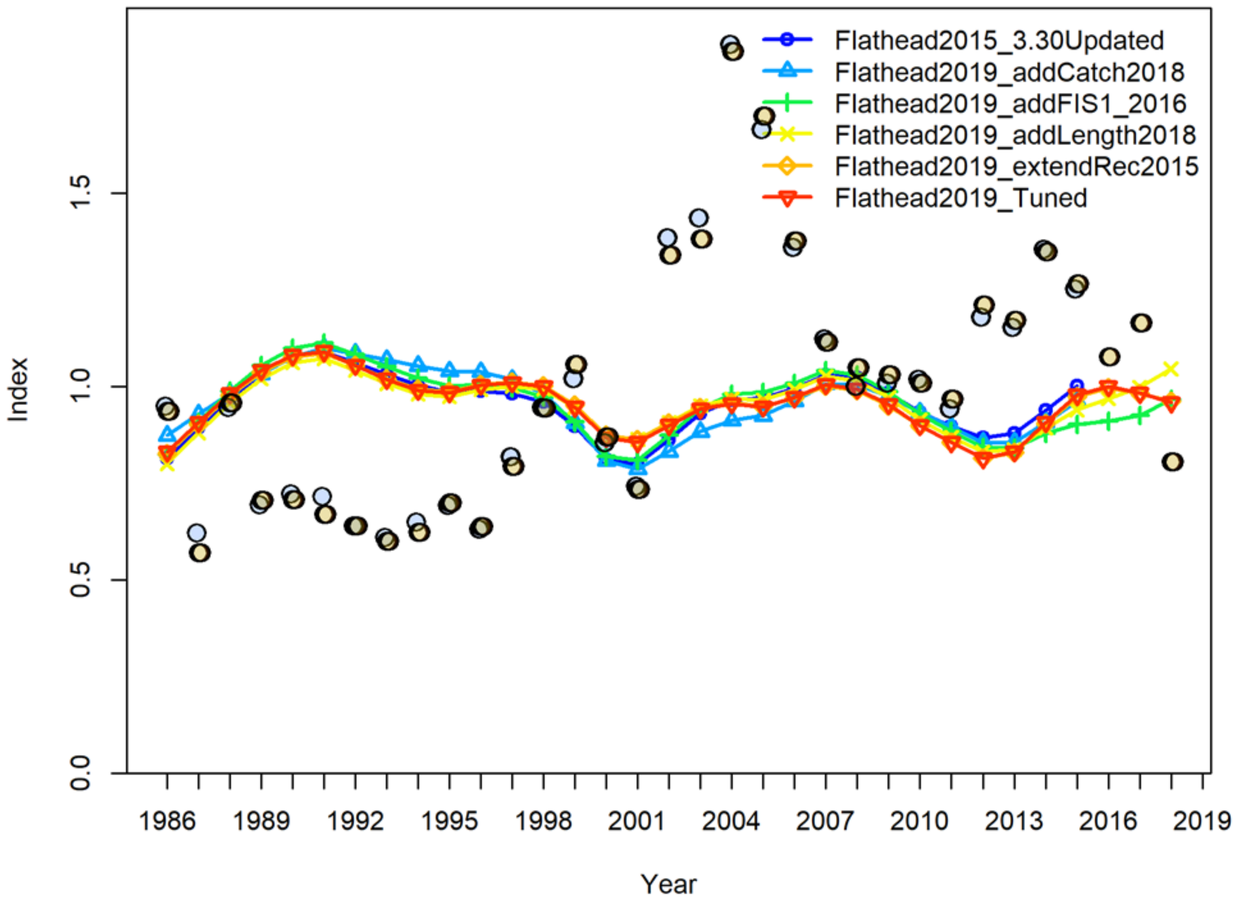

Figure 6.18. Comparison of the fit to the Tasmanian trawl CPUE index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

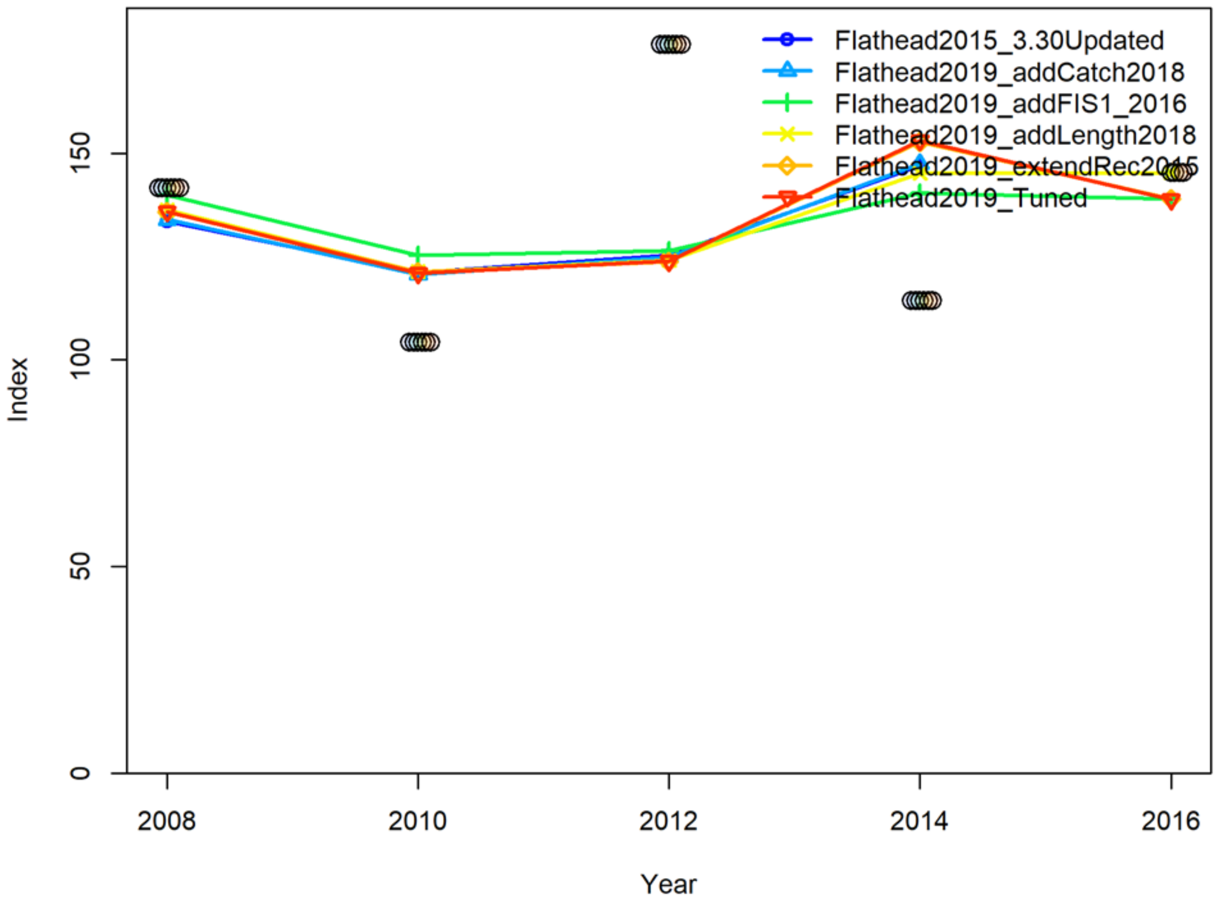

Figure 6.19. Comparison of the fit to the FIS_East (zones 10 and 20) abundance index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

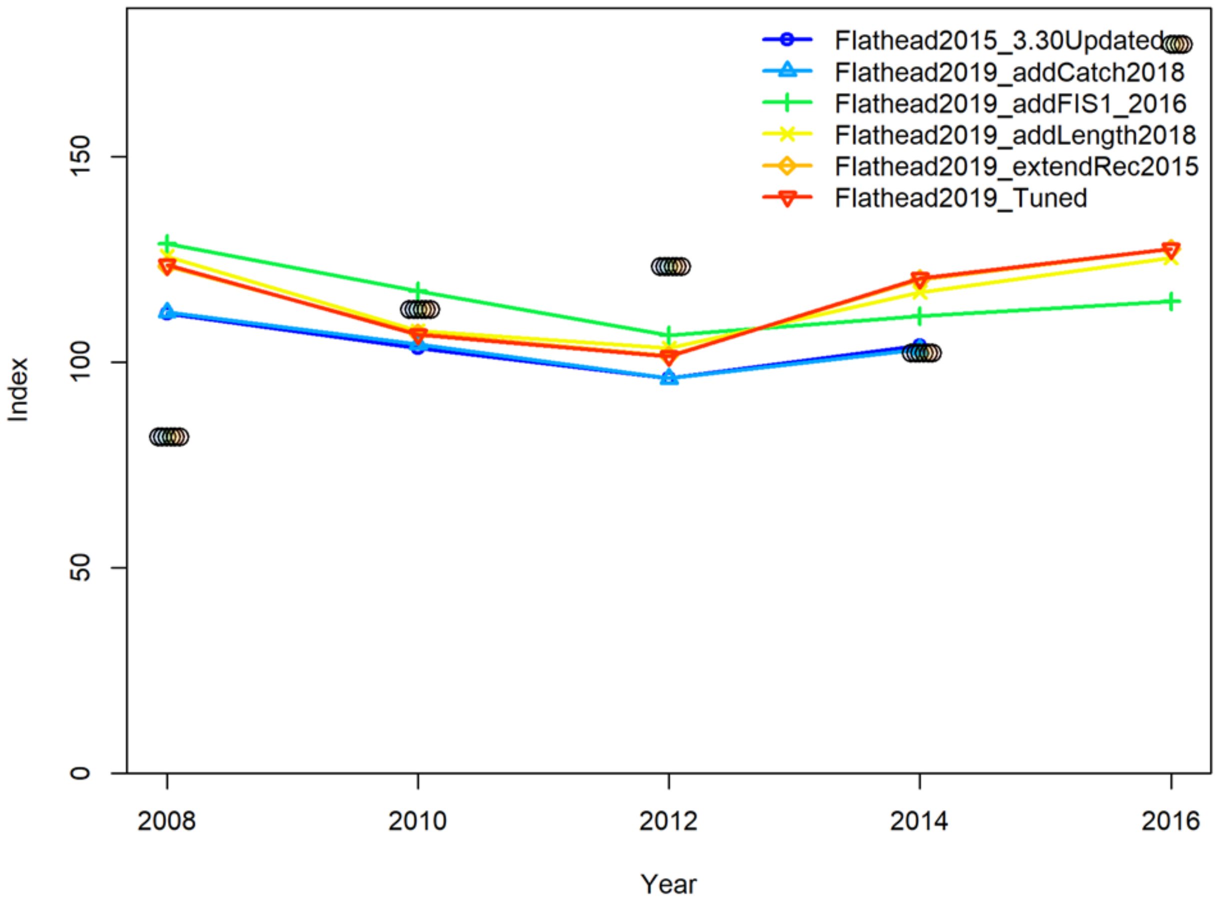

Figure 6.20. Comparison of the fit to the FIS_Tas (zone 30) abundance index for the updated 2016 assessment model converted to SS-V3.30.14 (Flathead2015_3.30Updated - blue) with various bridging models leading to a proposed 2019 base case model (Flathead2019_Tuned- red).

6.2.4 *Likelihood profiles*

As stated by Punt (2018), likelihood profiles are a standard component of the toolbox of applied statisticians. They are most often used to obtain a 95% confidence interval for a parameter of interest. Many stock assessments "fix" key parameters such as *M* and steepness based on *a priori* considerations. Likelihood profiles can be used to evaluate whether there is evidence in the data to support fixing a parameter at a chosen value. If the parameter is within the entire range of the 95% confidence interval, this provides no support in the data to change the fixed value. If the fixed value is outside the 95% confidence interval, it would be reasonable for a review panel to ask why the parameter was fixed and not estimated, and if the value is to be fixed, on what basis and why should what amounts to inconsistency with the data be ignored. Integrated stock assessments include multiple data sources (e.g., commonly catch-rates, length-compositions, and age-compositions) that may be in conflict, due for example to inconsistencies in sampling, but more commonly owing to incorrect assumptions (e.g., assuming that catch-rates are linearly related to abundance), i.e. model-misspecification. Likelihood profiles can be used as a diagnostic to identify these data conflicts (Punt, 2018).

Standard parameters to consider are natural mortality (*M*), steepness (*h*) and the logarithm of the unfished recruitment (lnR_0).

For tiger flathead, the likelihood profile for natural mortality, *M*, a parameter fixed in the model, is shown in Figure 6.21 with the total likelihood shown in black and components of the total likelihood from different data sources shown in a range of colours. This likelihood profile suggests that there is little information in the model that can be used to inform this parameter (fixed at 0.27 in the model). The index and length data (which suggest higher mortality) and the recruitment and discard data (which suggest lower mortality) are in conflict and the likelihood profile suggests higher values of mortality are preferred. However, this likelihood profile is essentially uninformative when the biological consequences of mortality values of 0.3, or greater, are considered.

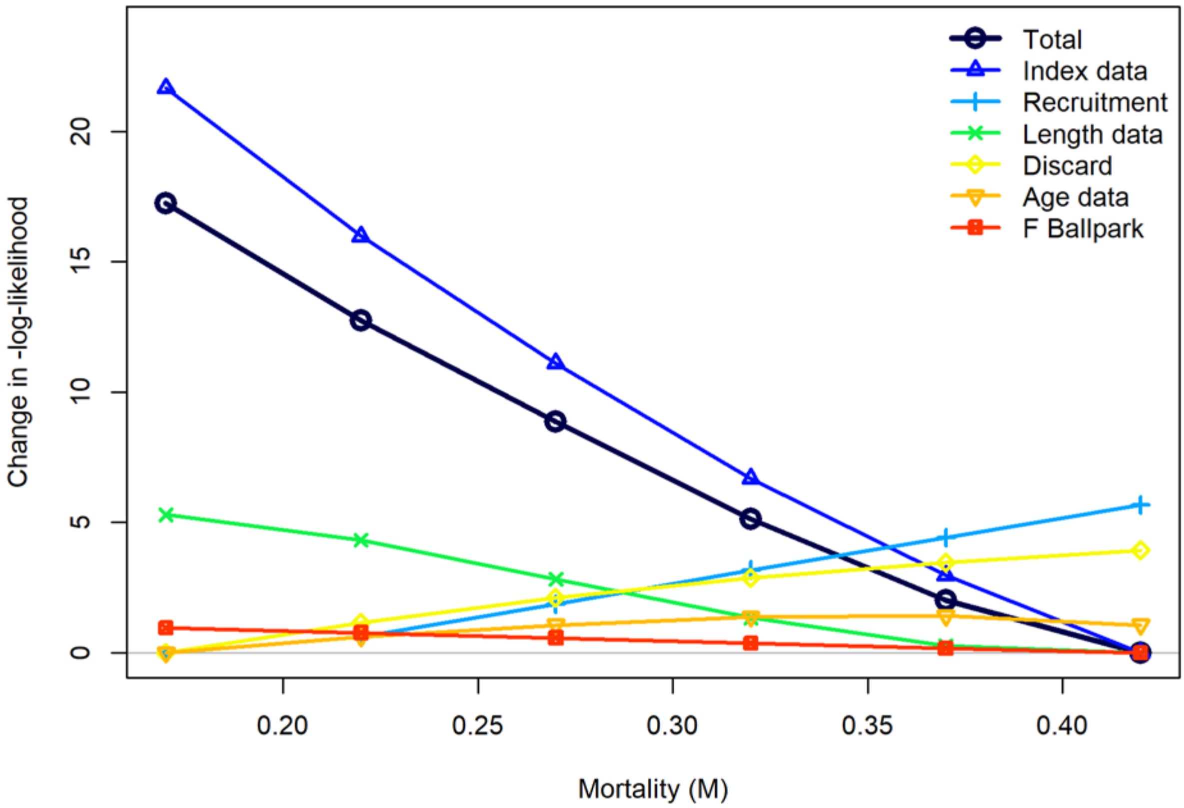

Figure 6.21. The likelihood profile for natural mortality, with *M* ranging from 0.17 to 0.42. The fixed value for *M* is 0.27yr^{-1}.

A likelihood profile for virgin spawning biomass (SSB_0) is shown in Figure 6.22 with the total likelihood shown in black and components of the total likelihood from different data sources shown in a range of colours. SSB_0 is a derived parameter which is linked to the estimated parameter R_0, which is the average equilibrium recruitment and constructing this likelihood profile requires some additional steps. To construct a likelihood profile on SSB_0 requires setting up an additional "fleet" with a single data point (in 1915) with very low standard error, essentially adding a "highly precise survey" of spawning biomass, setting the selectivity type to 30 (an index of *SSB*) and then allowing this spawning biomass value to vary between runs. This likelihood profile suggests a broad range of plausible values for SSB_0 ranging between around 15,000 and 29,000t with the most likely value at around 22,000t. The important data sources in providing information on SSB_0 are the index data and recruitment deviations. SSB_0 needs to be sufficiently high to enable the historical catches to be sustained, so this results in the recruitment component of the likelihood providing a lower bound on SSB_0 and the fits to the index data deteriorate with larger values of SSB_0. A likelihood profile for current spawning biomass and depletion would be useful additions to this analysis

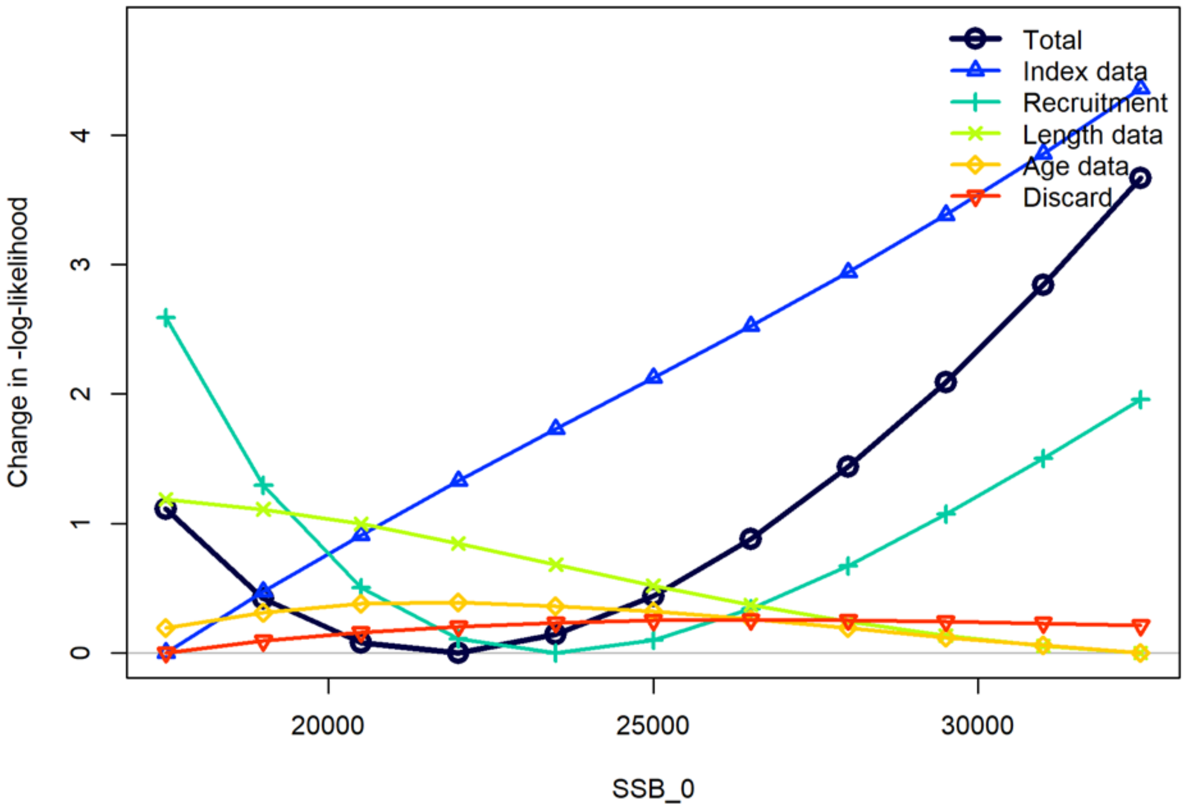

Figure 6.22. The likelihood profile for virgin spawning biomass, with SSB_0 ranging from 17,500 to 32,500t. The estimated value for SSB_0 is 21,715t.

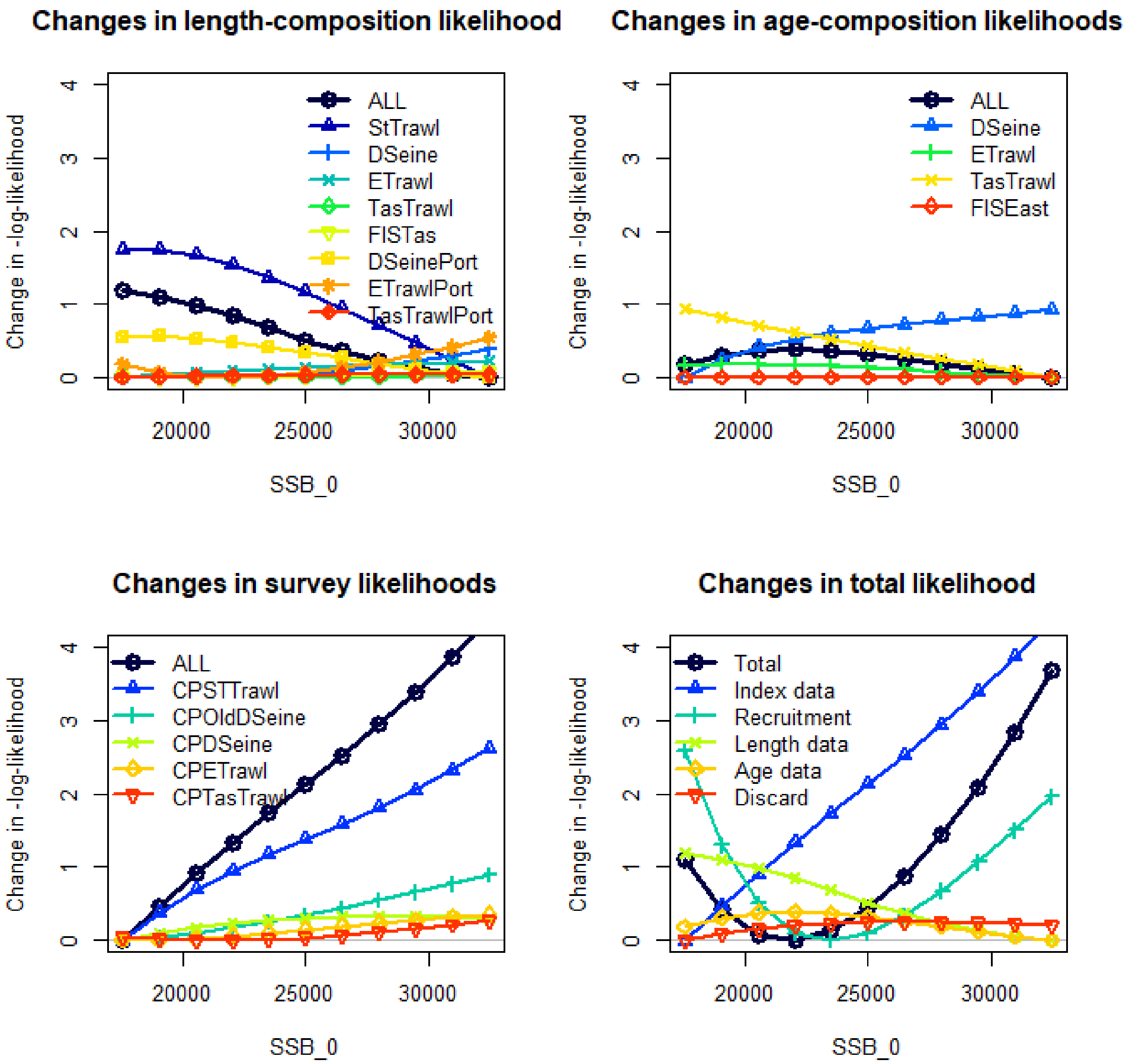

Figure 6.23. Piner plot for the likelihood profile for virgin spawning biomass, showing components of the change in likelihood for length, age and indices (CPUE) in addition to the changes in the total likelihood.

6.2.5 *Retrospectives*

A retrospective analysis was completed, starting from the most recent year of data, working backward in time and removing successive years of data from the assessment. This analysis can highlight potential problems and instability in an assessment, or some features that appear from the data.

A retrospective analysis for absolute spawning biomass is shown in Figure 6.24, with the data after 2017 removed initially (shown in light blue), then successive years of data removed back to 2013 (shown in red). The same analysis is plotted in terms of relative spawning biomass in Figure 6.25. In both cases the changes are minor with the largest change at the end of the retrospectives deleting all data after 2014 (orange, minor change) and 2013 (red, slightly larger change), at the end of both time series. These show a slight downward revision of the relative spawning biomass in the period 2010-

2015, as more years of additional data are added to the assessment. However, the effect is relatively small, and is only shown for these two retrospectives where a lot of data is removed.

When this retrospective analysis is applied to the recruitment time series (Figure 6.26), the more recent data results in a downward revision to the recruitment estimate in 2012. This recruitment is first estimated in the retrospective to 2015 (which corresponds to the data used in the 2016 assessment, shown in yellow), and this revision downwards is supported by data in 2016, 2017 and 2018. The first estimate of the 2013 recruitment is made in the 2016 retrospective (green) and is well below average. This estimate of 2013 recruitment is revised further downwards when data from 2017 and 2018 is added.

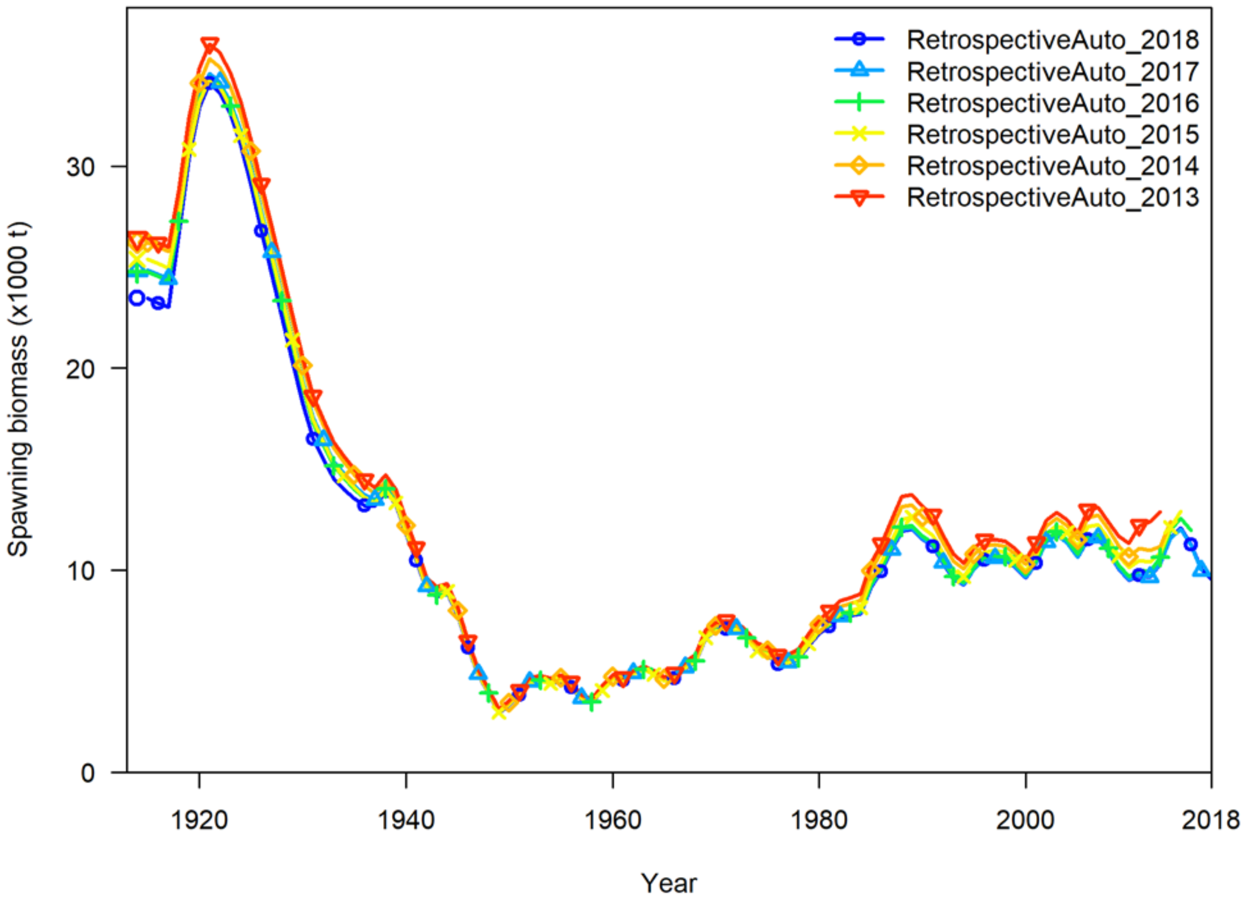

Figure 6.24. Retrospectives for absolute spawning biomass for tiger flathead, with data removed back to 2017 (light blue) and then successive years removed back to 2013 (red).

These retrospective analyses do not reveal any pathological patterns or apparent biases in the estimates at the end of the time series due to the addition of new data, which provides additional confidence in the stability of this assessment.

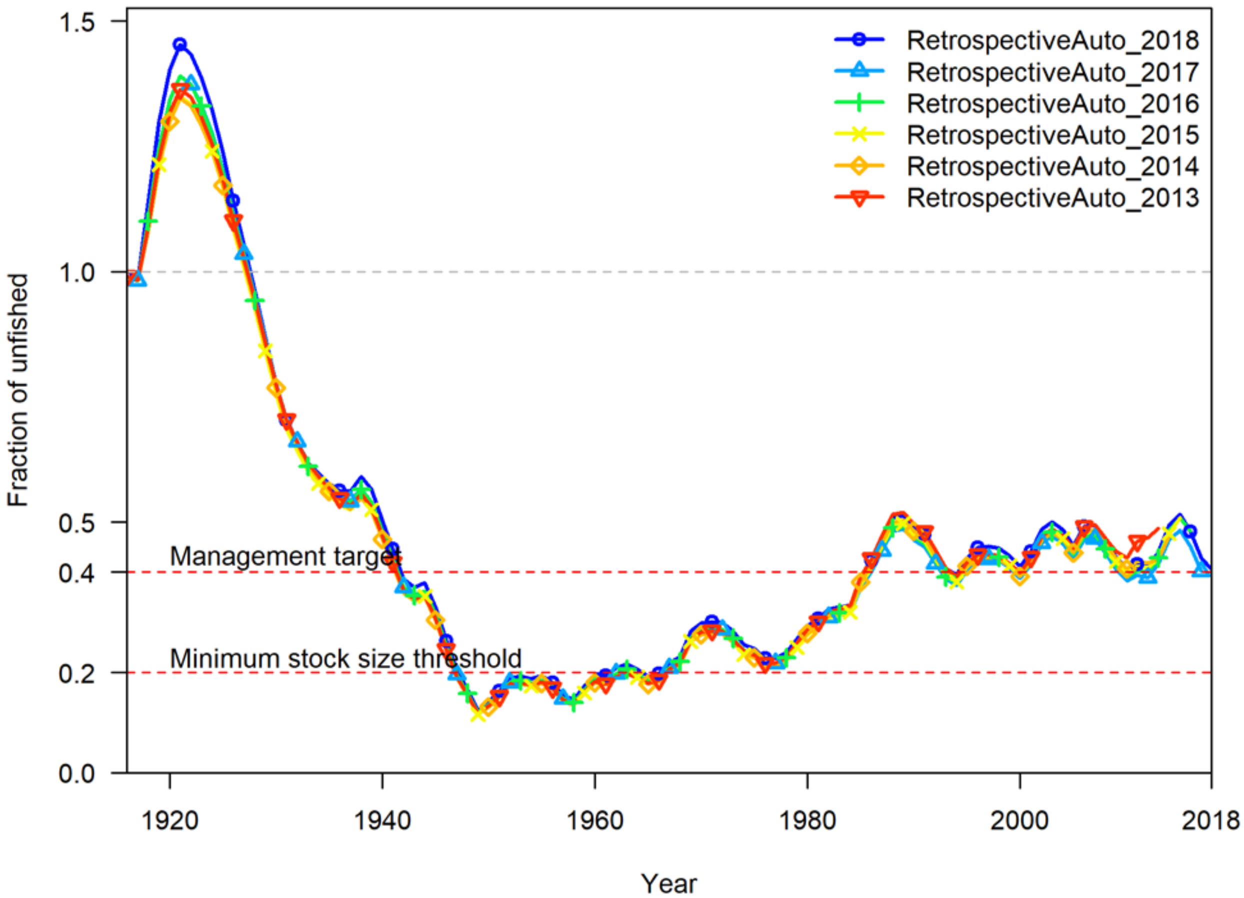

Figure 6.25. Retrospectives for relative spawning biomass for tiger flathead, with data removed back to 2017 (light blue) and then successive years removed back to 2013 (red).

6.2.6 *Future sensitivities*

Sensitivities to this potential base case have not yet been explored. In addition to the usual set of sensitivities (Day, 2016), (which includes sensitivities on mortality, maturity, fixing steepness and estimating mortality, σ_R and halving and doubling the weighting on length, age and CPUE data), there are some additional sensitivities that may be useful to explore. Two of these relate to the Fishery Independent Survey (FIS):

1. Incorporating all FIS3 abundance indices using reconditioned FIS abundance indices and adjusting for variations in catch rates within seasons (Sporcic et al 2019),
2. Incorporating Summer FIS length frequencies.

In addition, further sensitivities could be carried out on:

3. Excluding tiger flathead catches in the west (zones 40 and 50),
4. Using an alternative discard estimate series, reverting to a previously used method to calculate yearly discard rates.

Given the relatively small changes to the input data and the quantity of other data used in the assessment, it is unlikely that any of these additional sensitivities will produce results that are noticeably different to the base case.

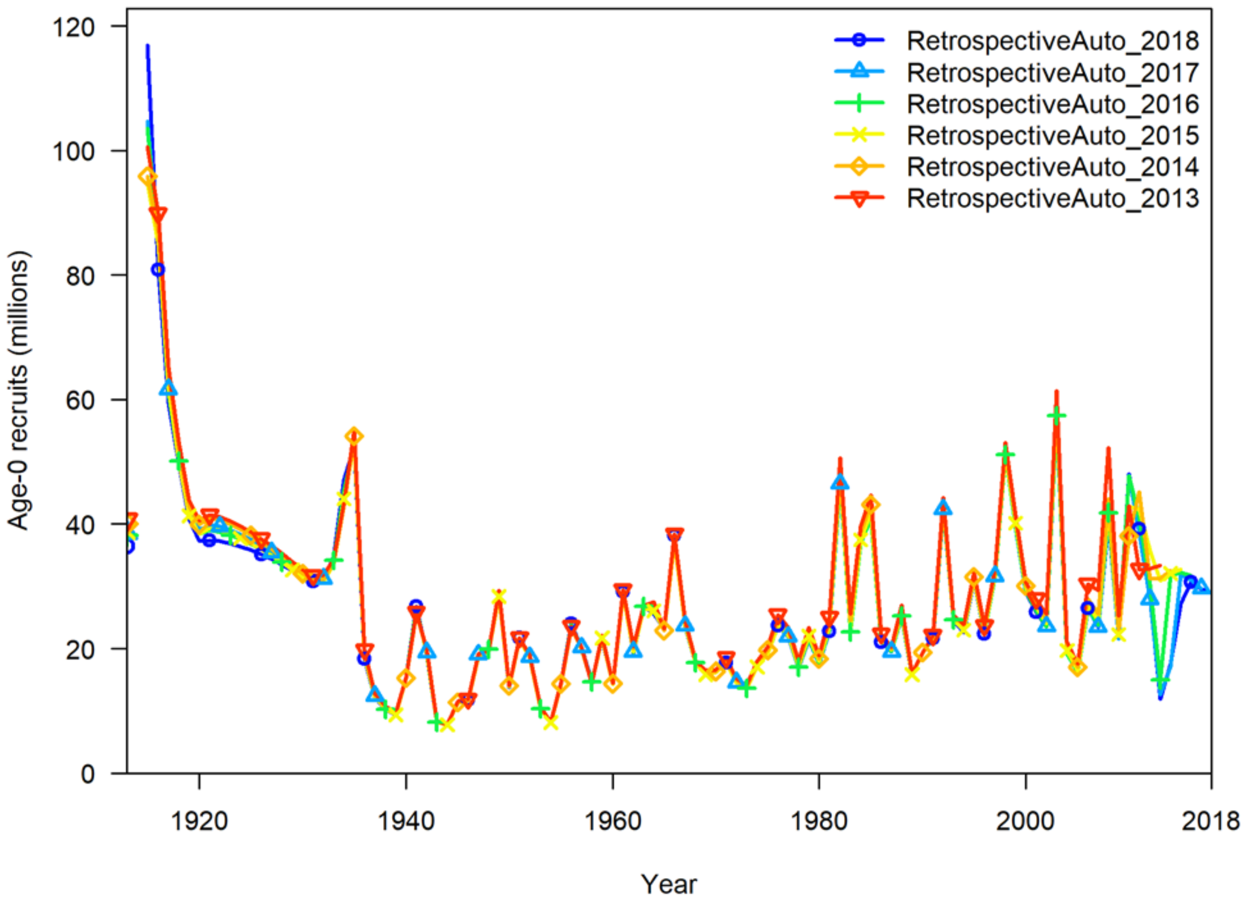

Figure 6.26. Retrospectives for recruitment for tiger flathead, with data removed back to 2017 (light blue) and then successive years removed back to 2013 (red).

For sensitivity 3 above, the western catches are already included in the assessment, as they are included in the CDRs, and allocated to the catches in the relevant eastern fleets in the same proportions as the eastern catches (from the logbook). To include these catches as a separate fleet would require a number of assumptions to be made (and agreed on by SERAG) and is unlikely to be a useful option given the absence of length frequency and age data from the west. Alternatively, this catch could be removed from the CDR in some fashion (requiring some scaling up of the western catch from the logbook to the CDRs and then removing the western portion from the CDR) but that would also require approval from SERAG.

6.3 Acknowledgements

Age data was provided by Kyne Krusic-Golub (Fish Ageing Services), ISMP and AFMA logbook and CDR data were provided by John Garvey (AFMA). Mike Fuller, Roy Deng, Franzis Althaus, Robin Thomson and Paul Burch (CSIRO) pre-processed the data. Geoff Tuck, Miriana Sporcic, Robin Thomson, Paul Burch, Malcolm Haddon (CSIRO), Claudio Castillo-Jordán (UW) and Ian Taylor (NOAA) are thanked for helpful discussions on this work. André Punt updated the ageing error matrix. Malcolm Haddon provided code for auto-tuning and Athol Whitten provided R code for organising plots.

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6.5 Appendix A

A.1 Preliminary base case diagnostics

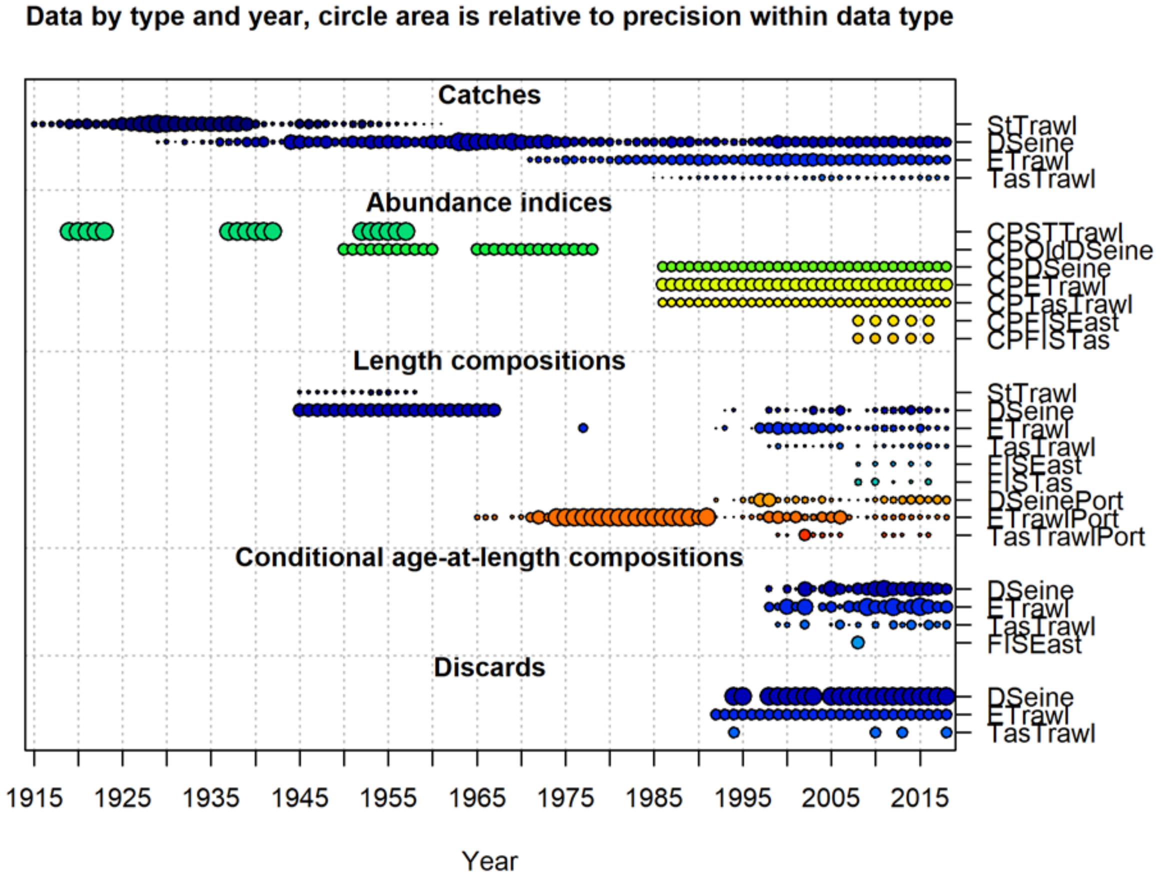

Figure A 6.1. Summary of data sources for tiger flathead stock assessment.

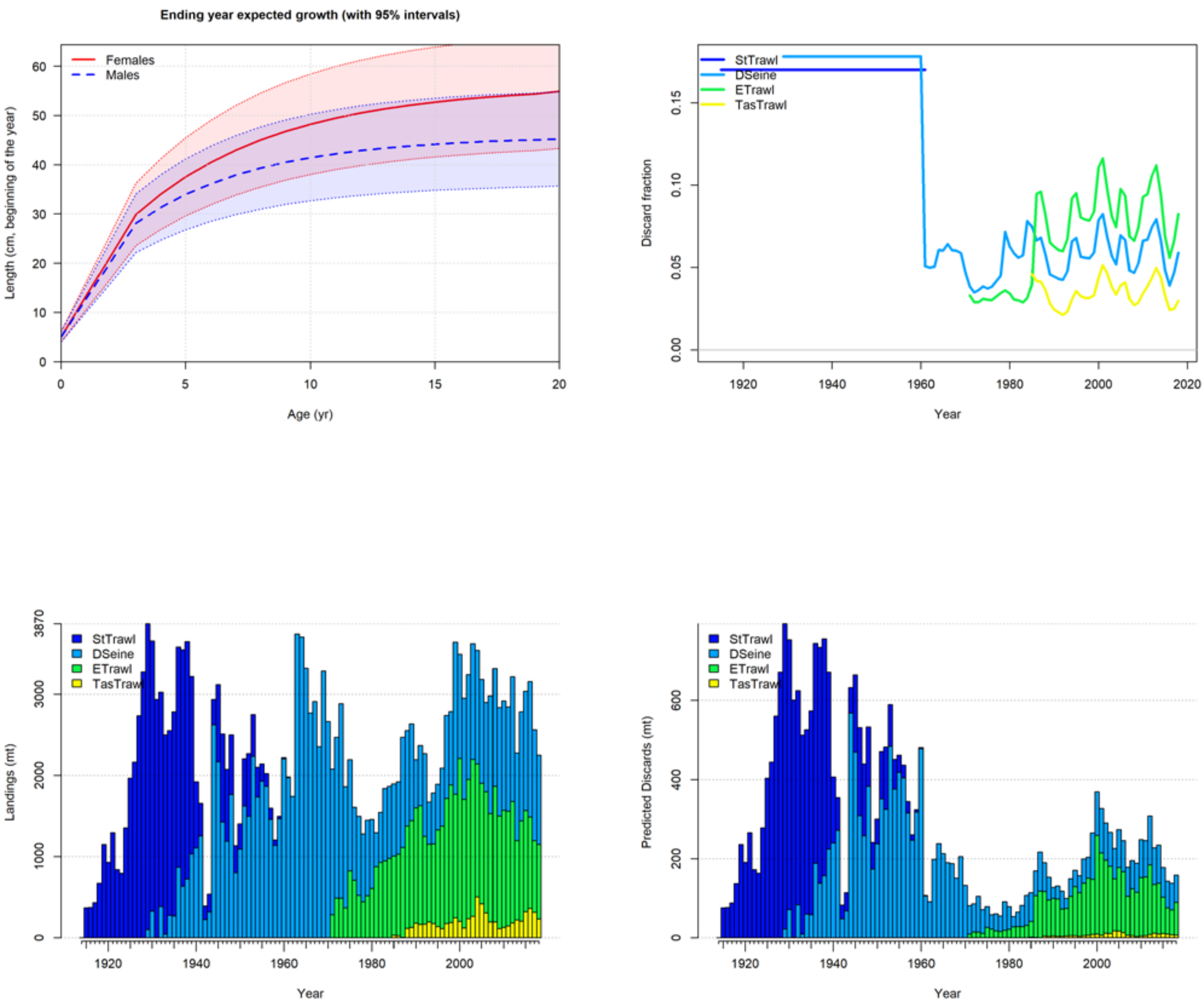

Figure A 6.2. Growth, discard fraction estimates, landings by fleet and predicted discards by fleet for tiger flathead.

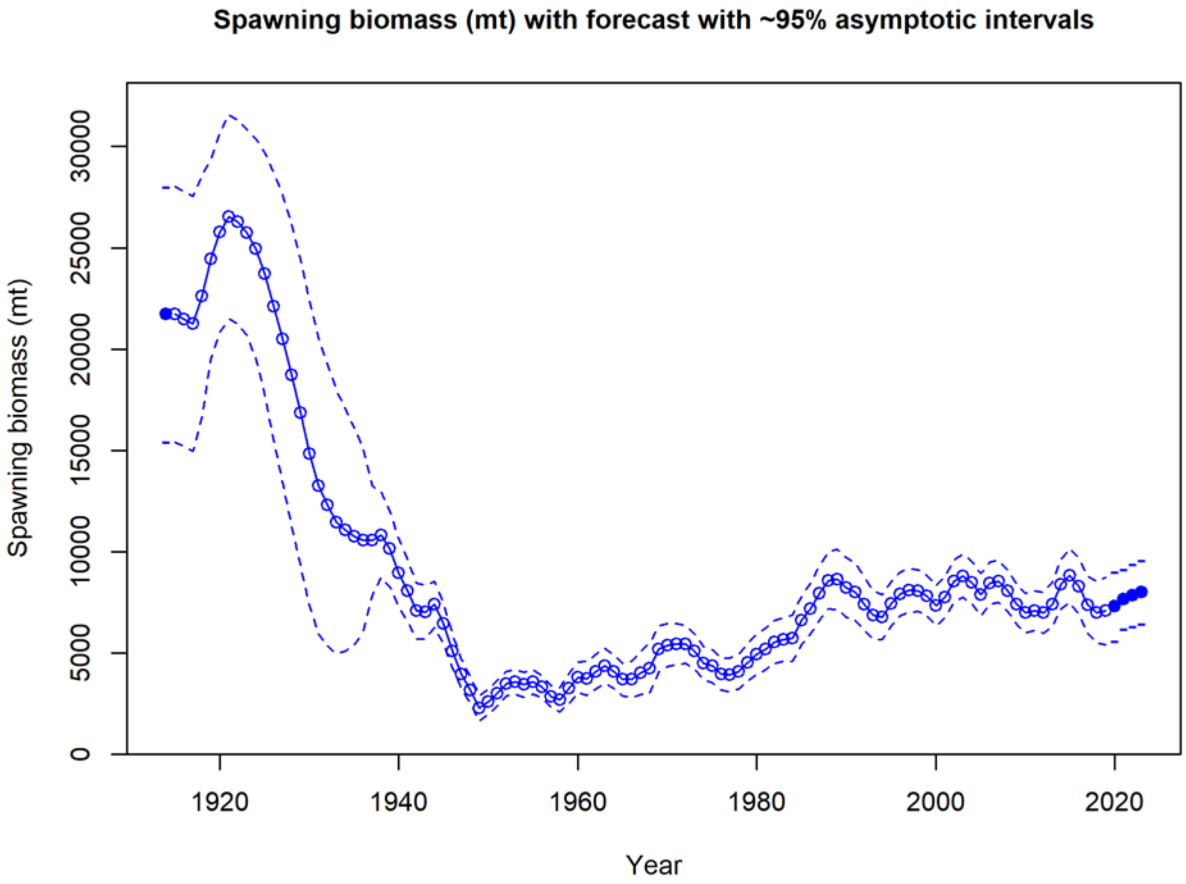

Figure A 6.3. Time series showing absolute spawning biomass with confidence intervals..

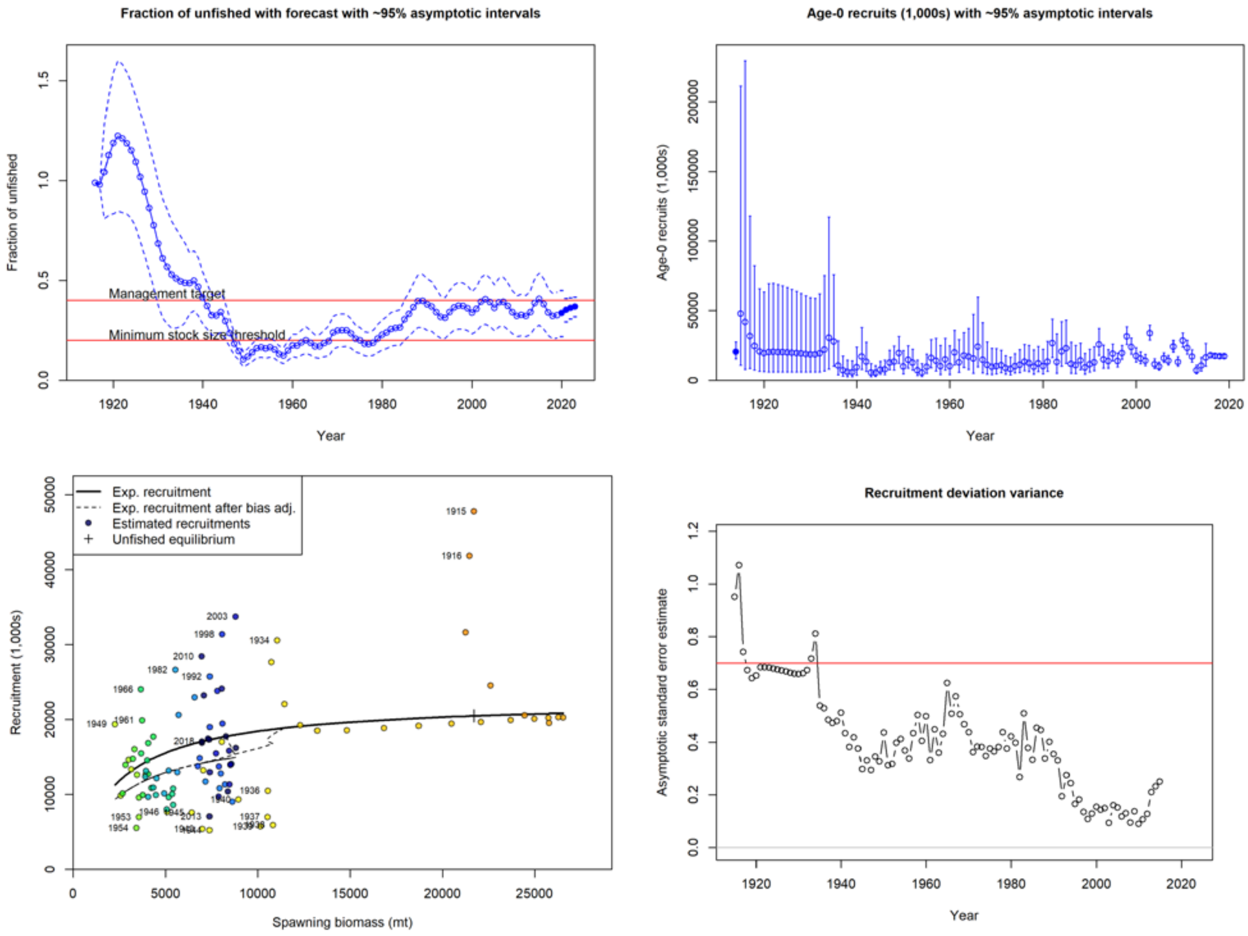

Figure A 6.4. Time series showing depletion of spawning biomass with confidence intervals, recruitment estimates with confidence intervals, stock recruitment curve and recruitment deviation variance check for tiger flathead.

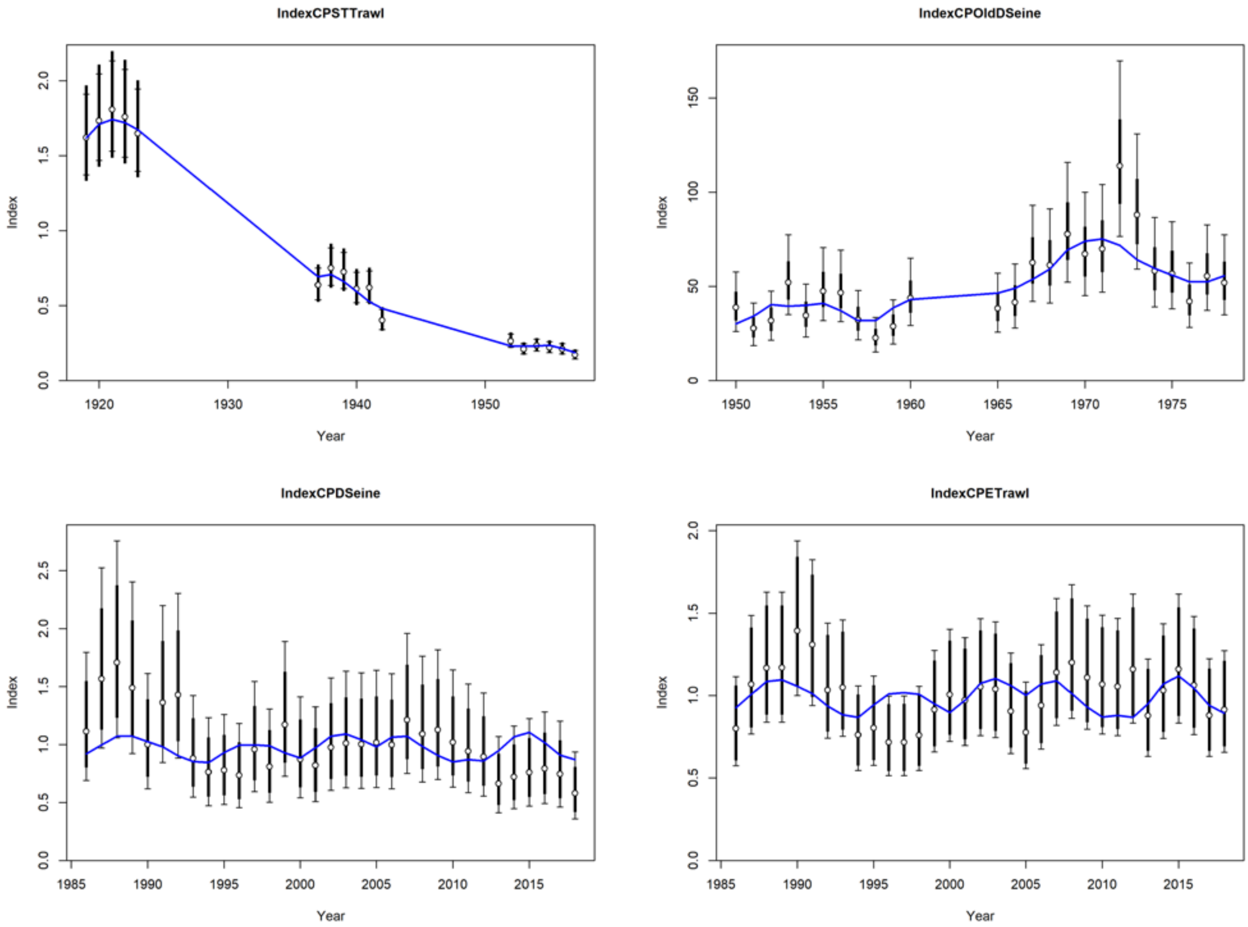

Figure A 6.5. Fits to CPUE by fleet for tiger flathead: steam trawl, old Danish seine, Danish seine, eastern trawl.

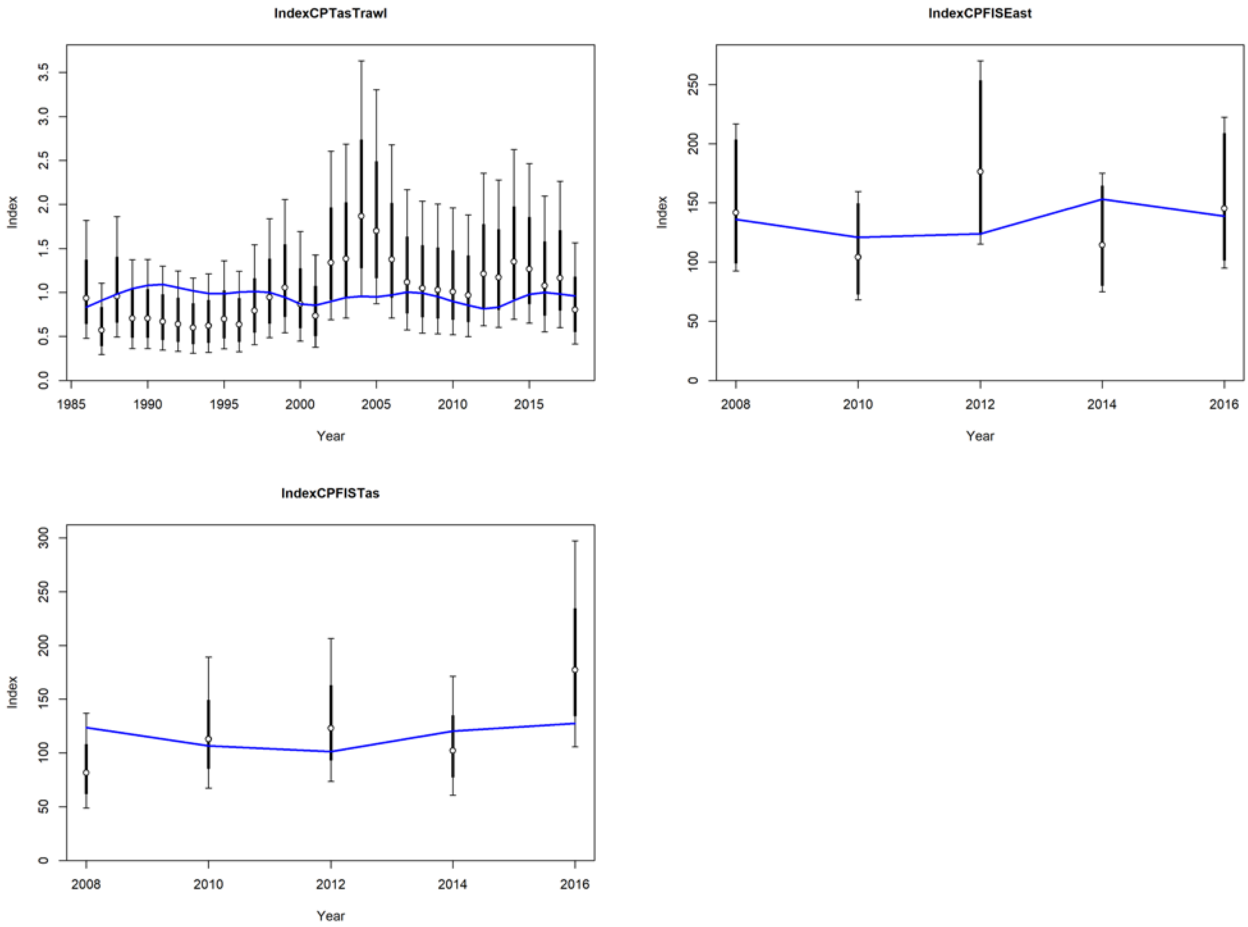

Figure A 6.6. Fits to CPUE by fleet for tiger flathead: Tasmanian trawl and the Fishery Independent Survey.

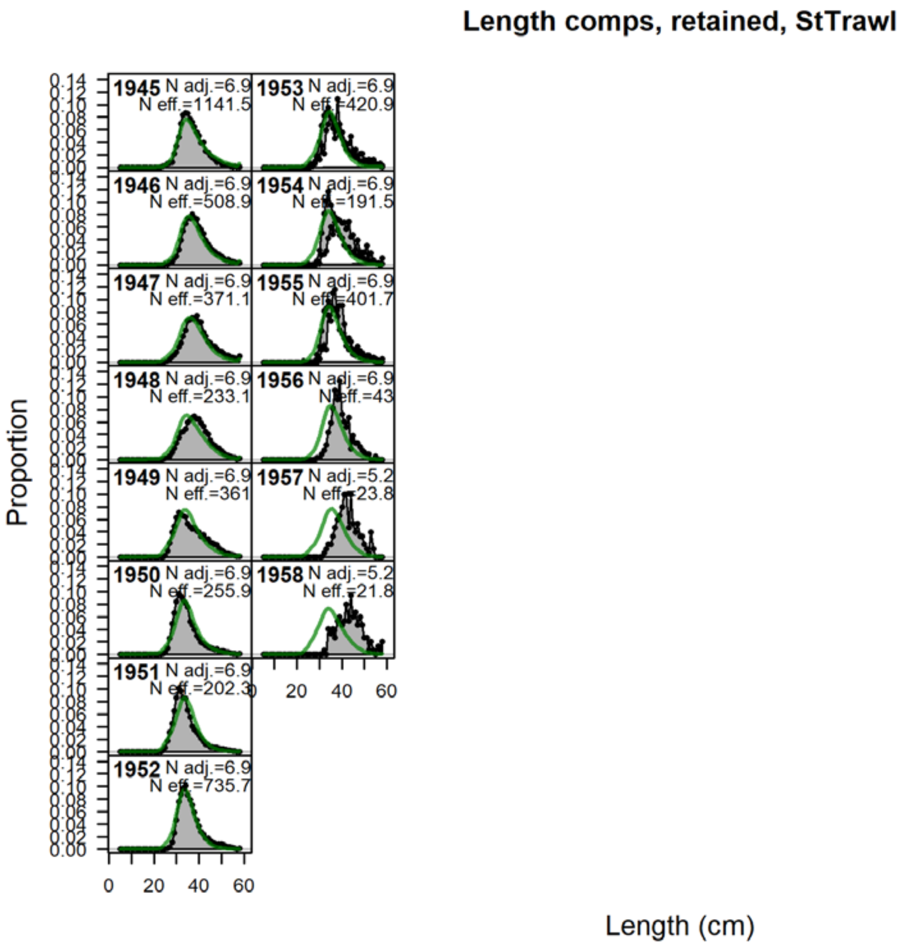

Figure A 6.7. Tiger flathead length composition fits: steam trawl retained.

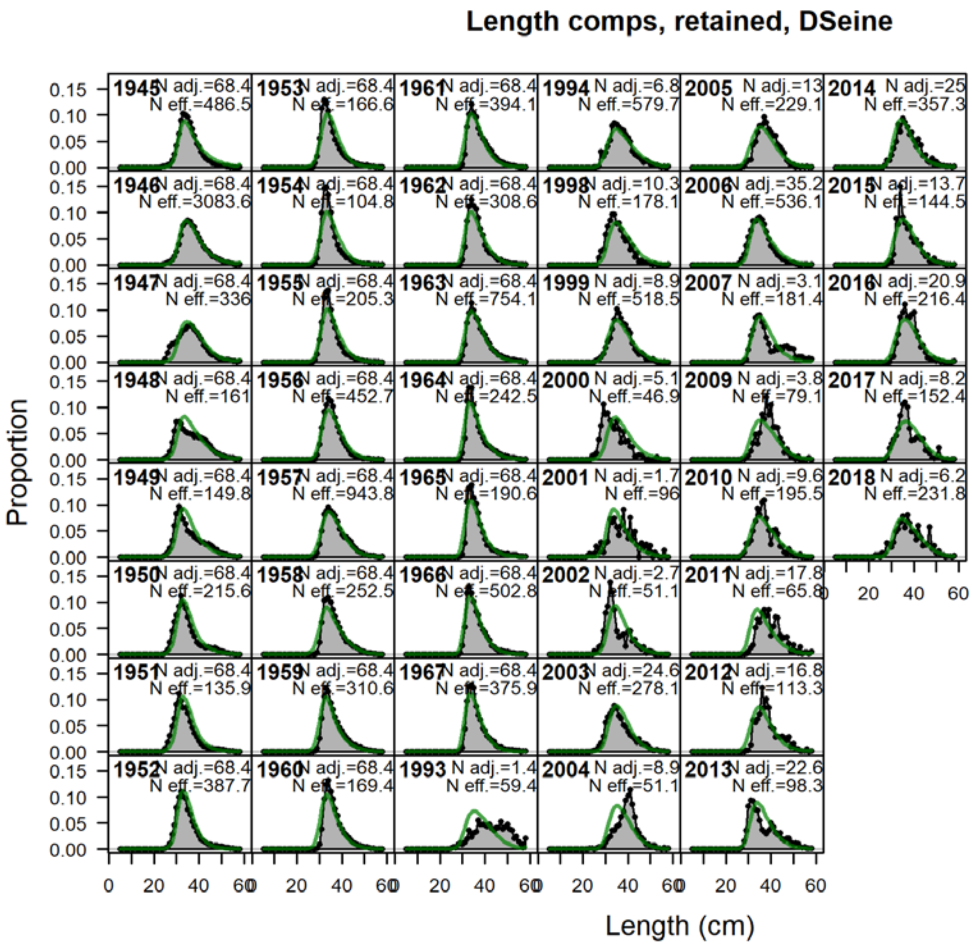

Figure A 6.8. Tiger flathead length composition fits: Danish seine retained.

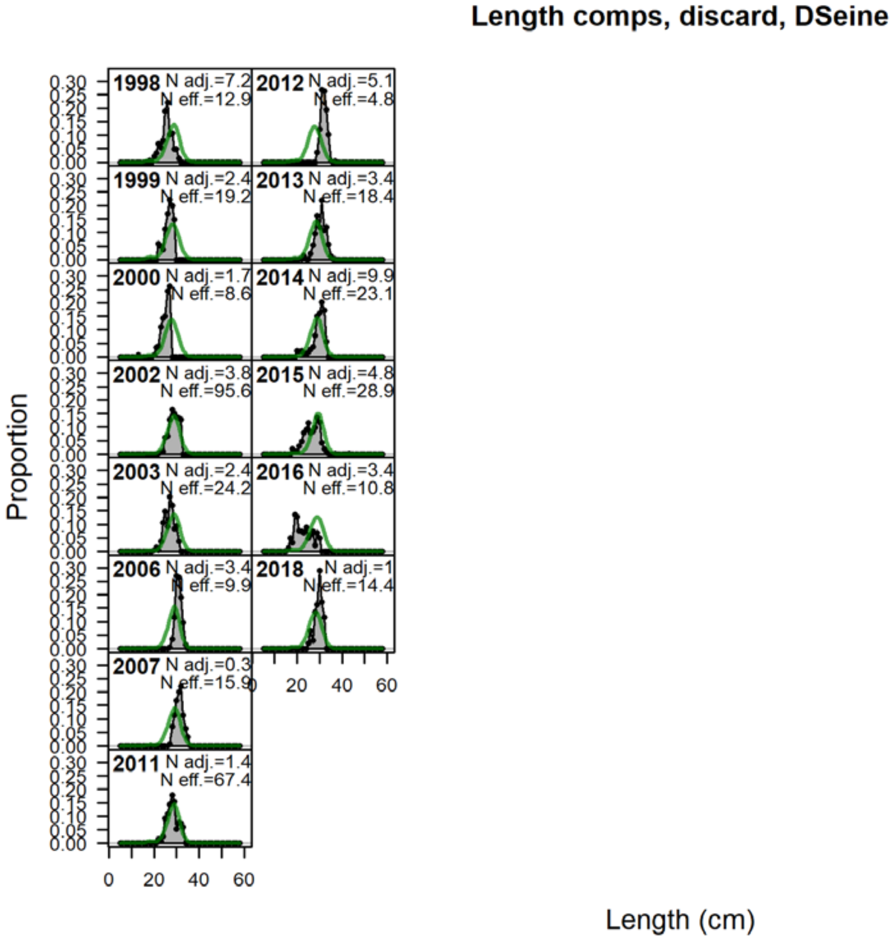

Figure A 6.9. Tiger flathead length composition fits: Danish seine discarded.

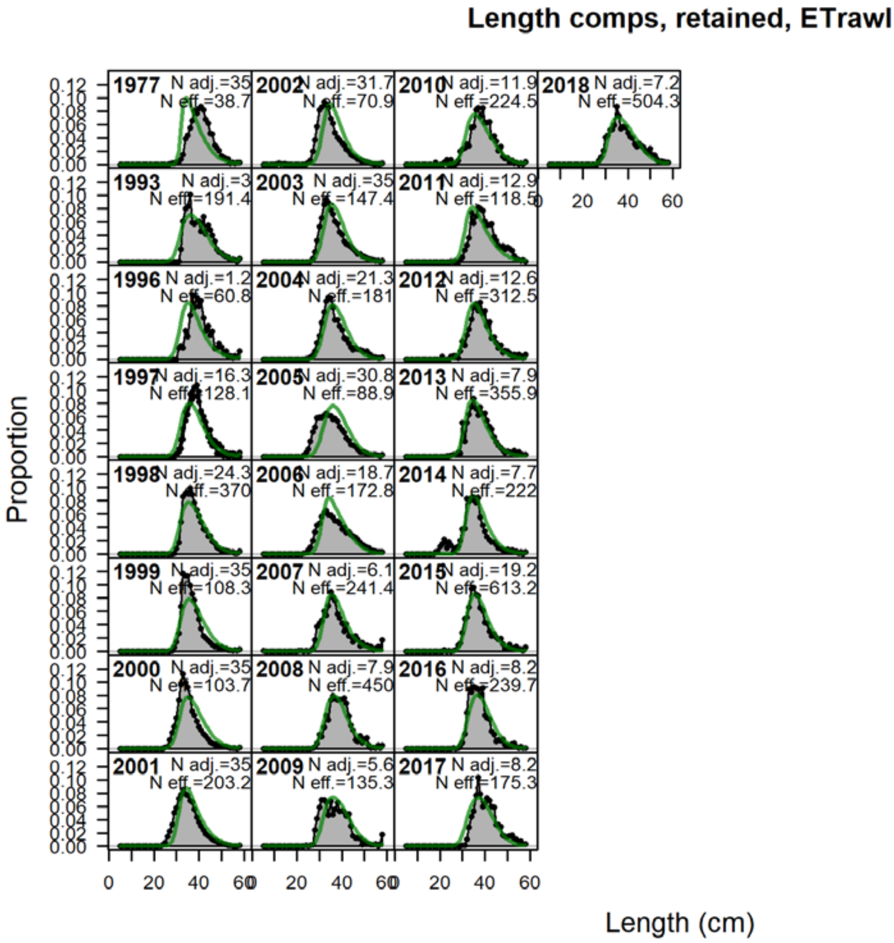

Figure A 6.10. Tiger flathead length composition fits: eastern trawl retained.

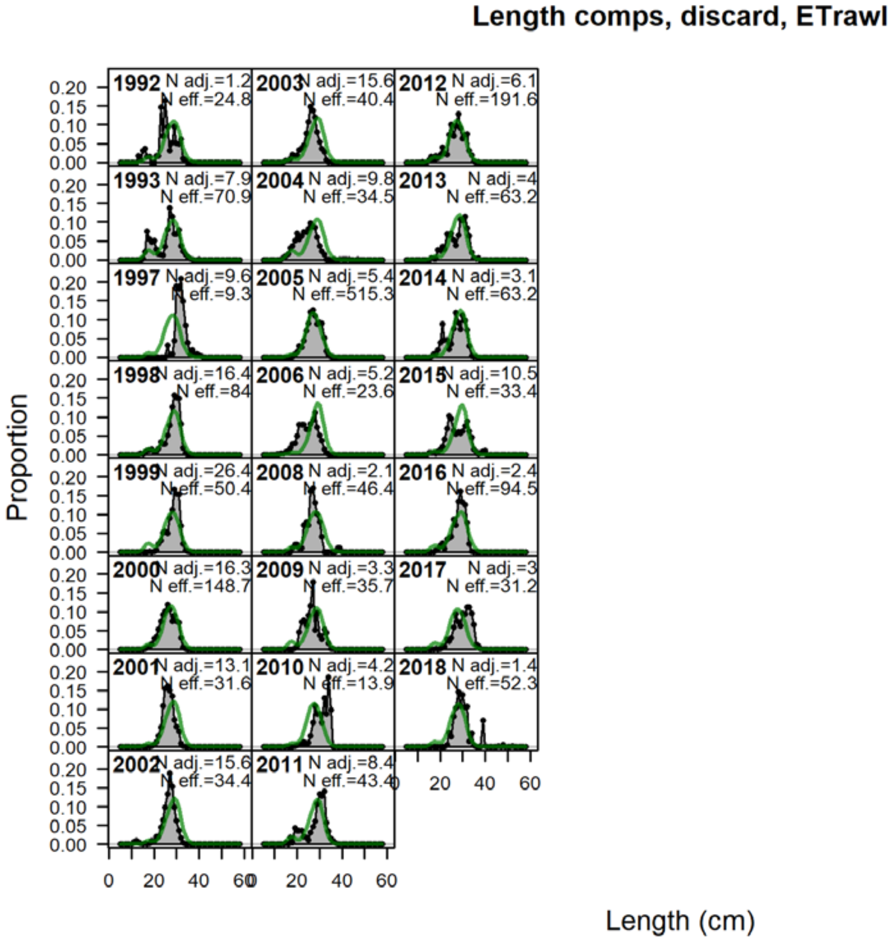

Figure A 6.11. Tiger flathead length composition fits: eastern trawl discarded.

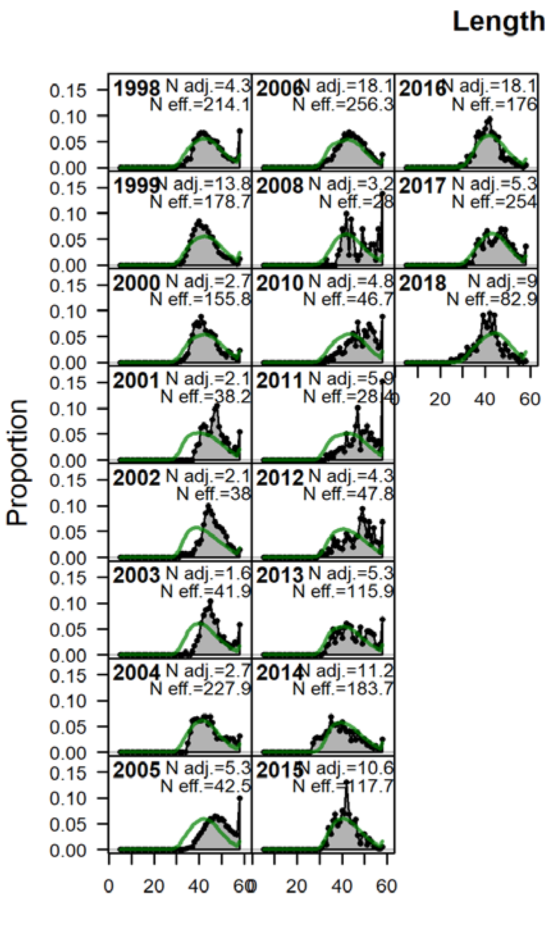

Figure A 6.12. Tiger flathead length composition fits: Tasmanian trawl retained.

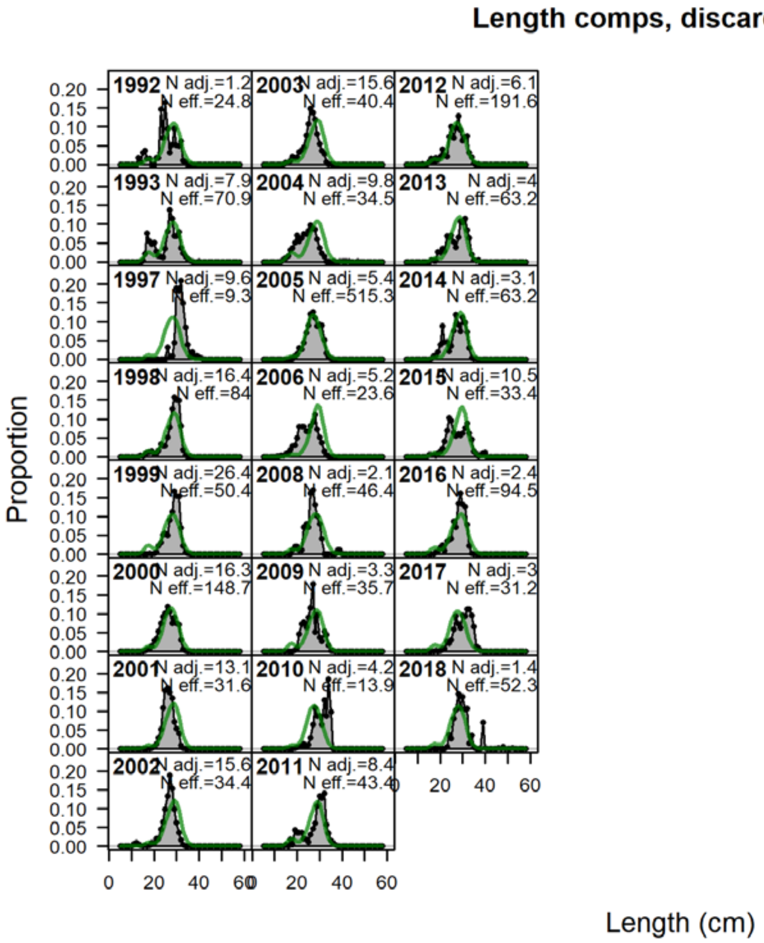

Figure A 6.13. Tiger flathead length composition fits: eastern trawl discarded.

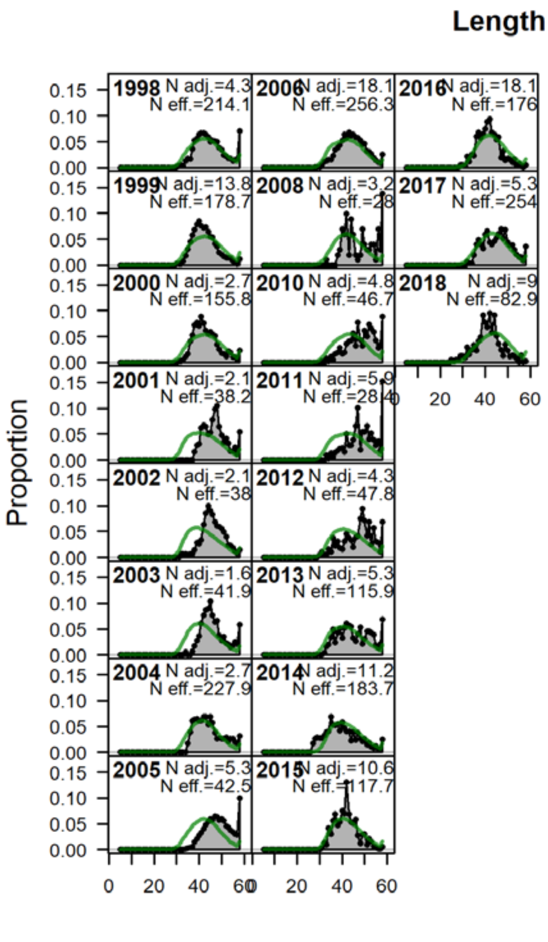

Figure A 6.14. Tiger flathead length composition fits: Tasmanian trawl retained.

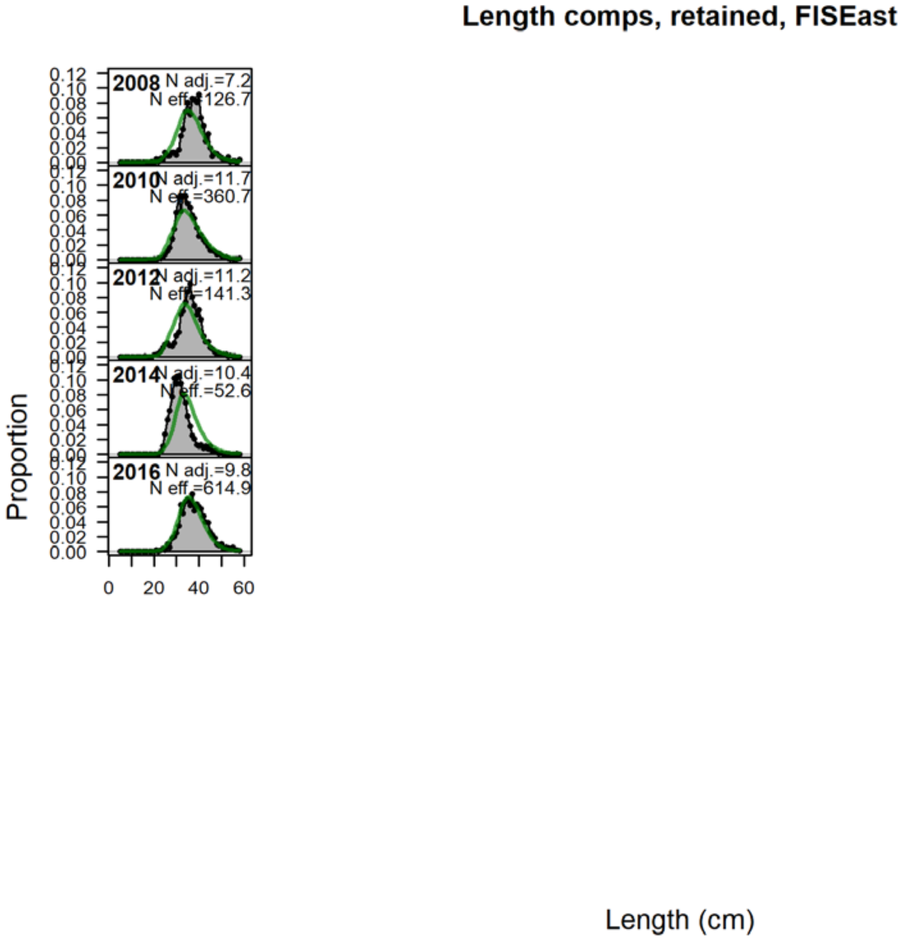

Figure A 6.15. Tiger flathead length composition fits: eastern FIS

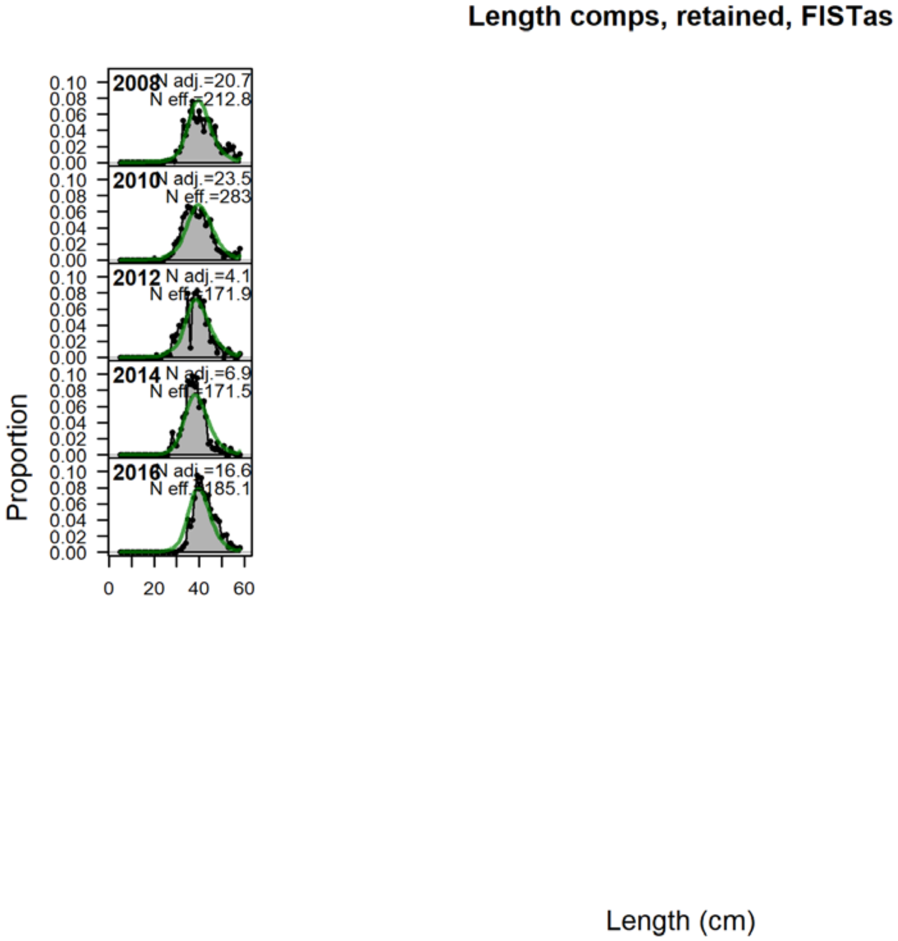

Figure A 6.16. Tiger flathead length composition fits: Tasmanian FIS.

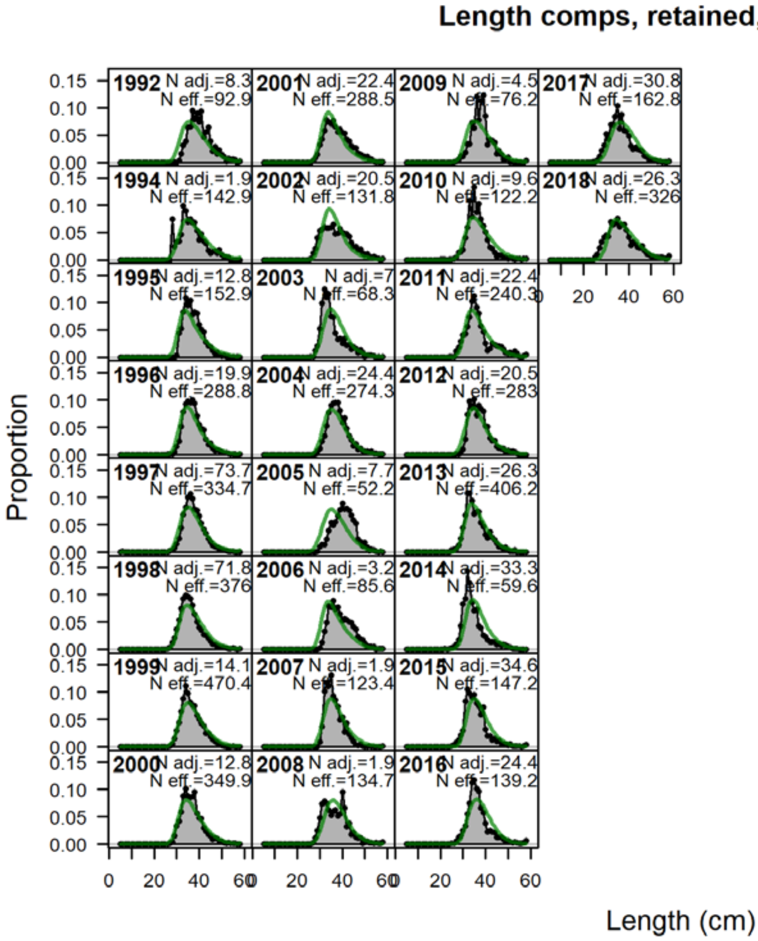

Figure A 6.17. Tiger flathead port length composition fits: Danish seine.

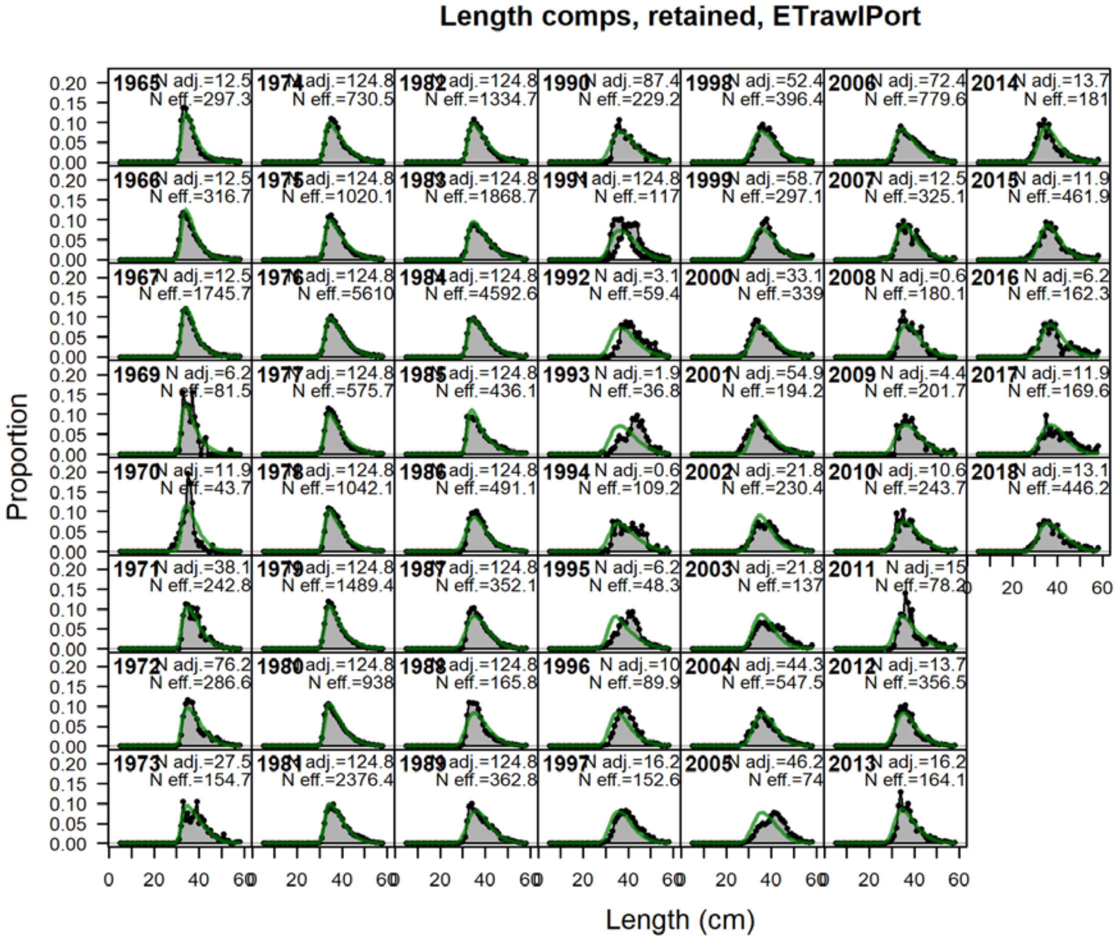

Figure A 6.18. Tiger flathead port length composition fits: eastern trawl.

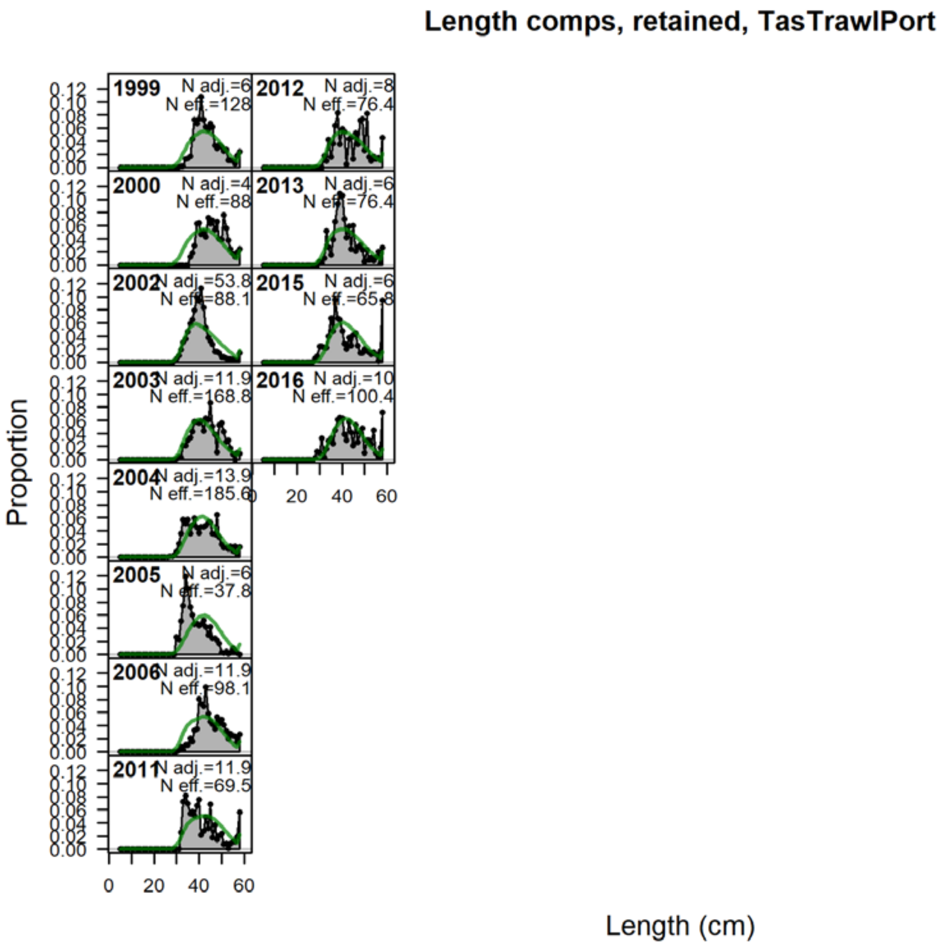

Figure A 6.19. Tiger flathead port length composition fits: Tasmanian trawl.

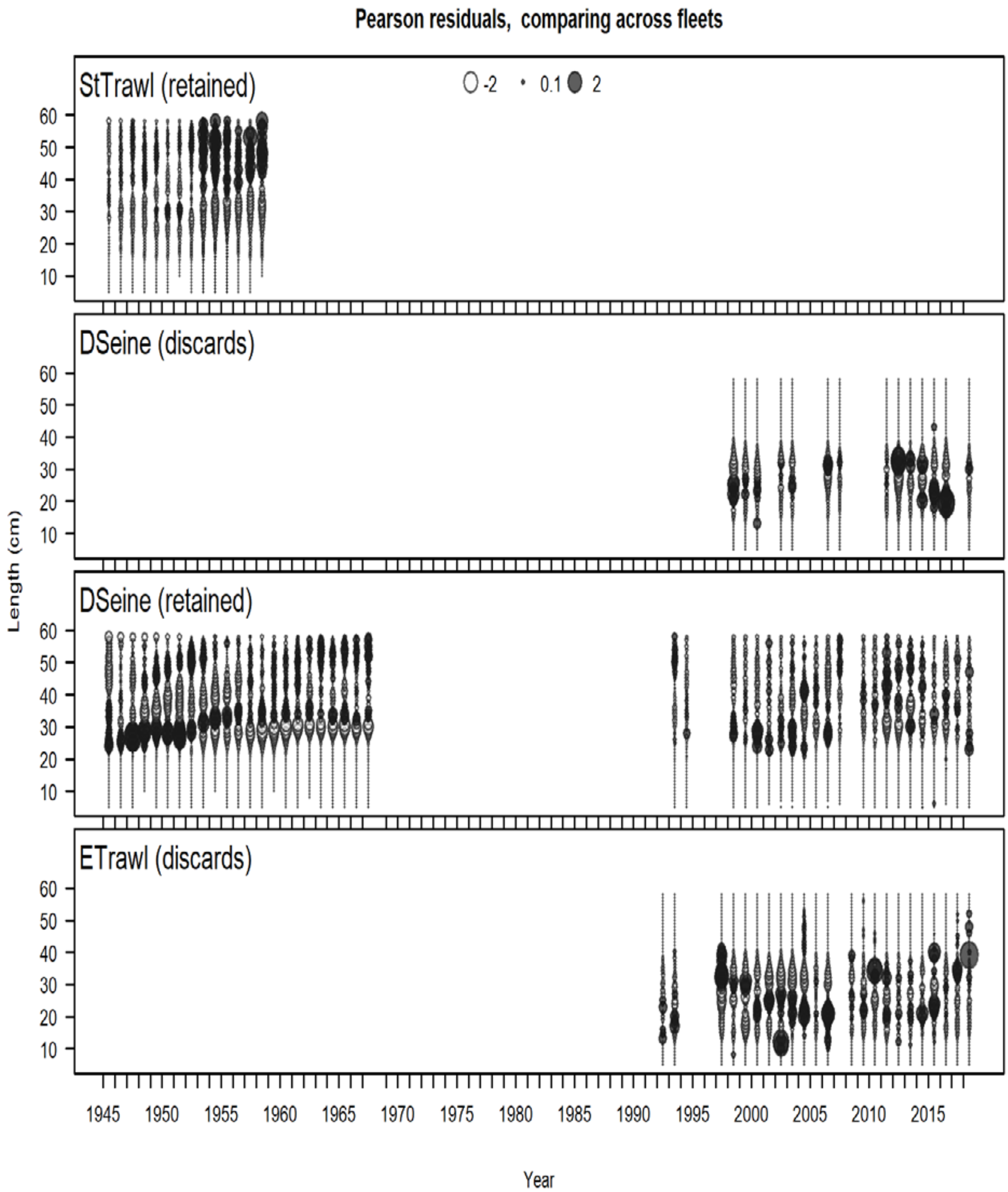

Figure A 6.20. Residuals from the annual length compositions (retained) for tiger flathead displayed by year and fleet.

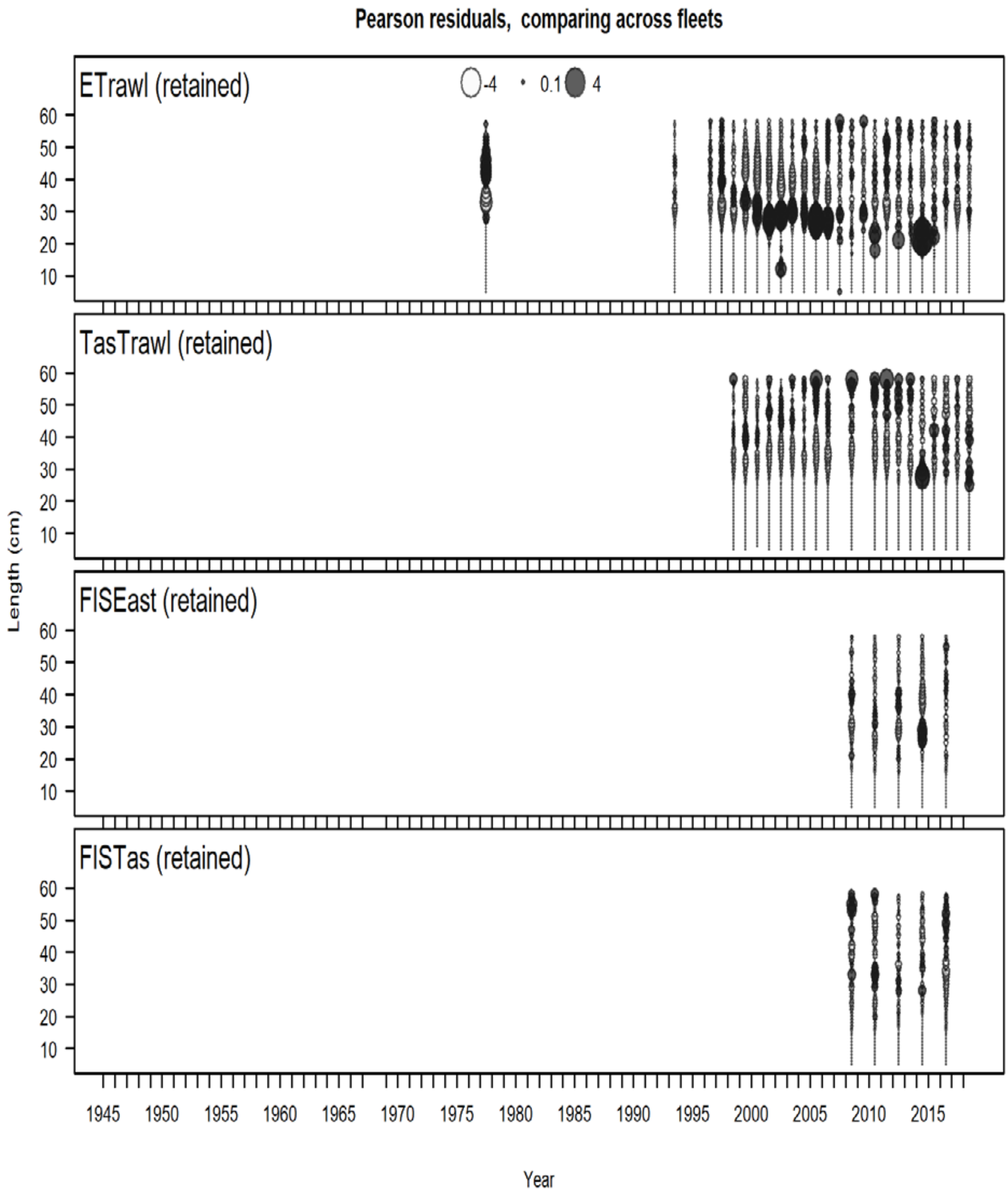

Figure A 6.21. Residuals from the annual length compositions (discarded) for tiger flathead displayed by year and fleet.

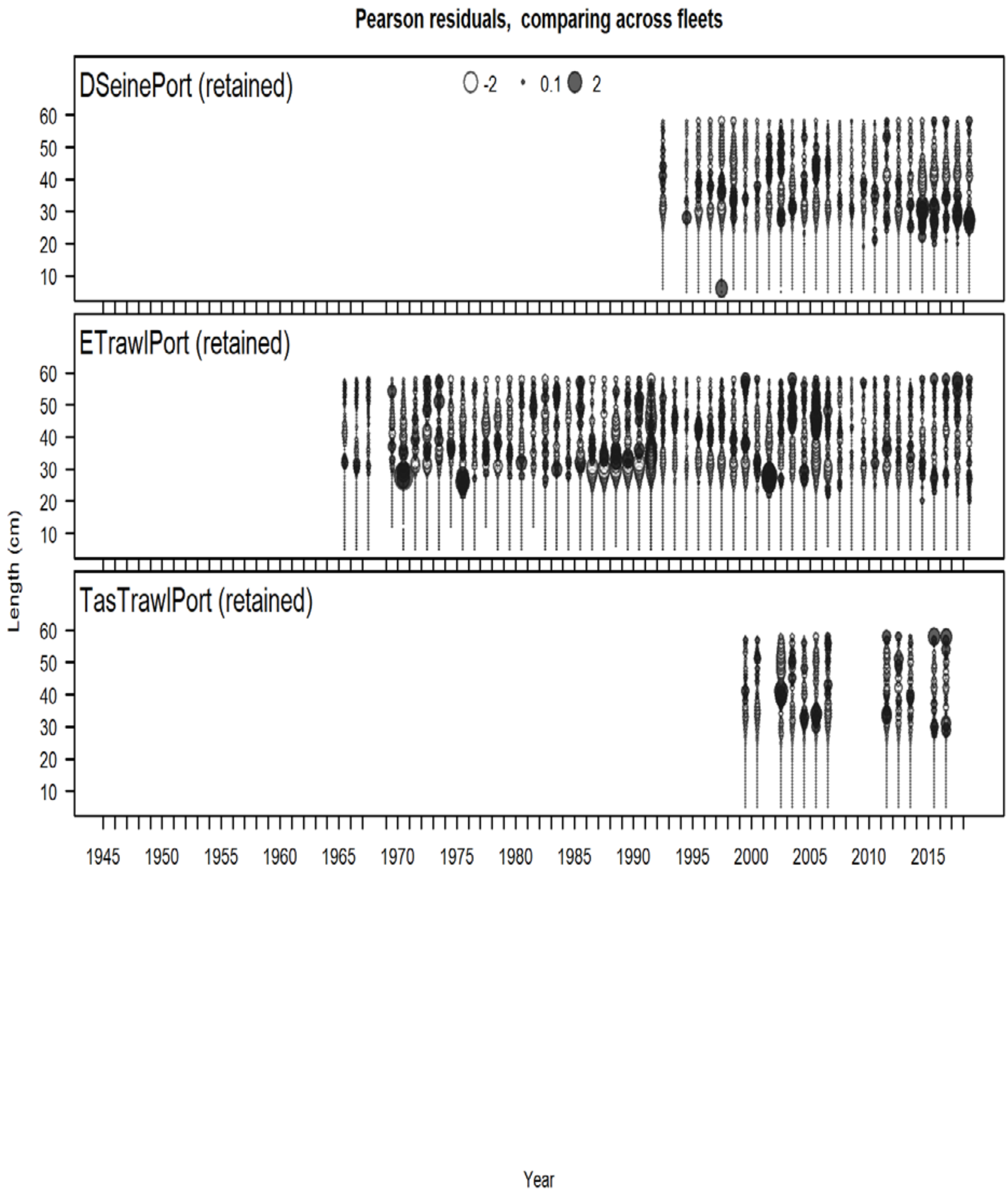

Figure A 6.22. Residuals from the annual length compositions (discarded) for tiger flathead displayed by year and fleet

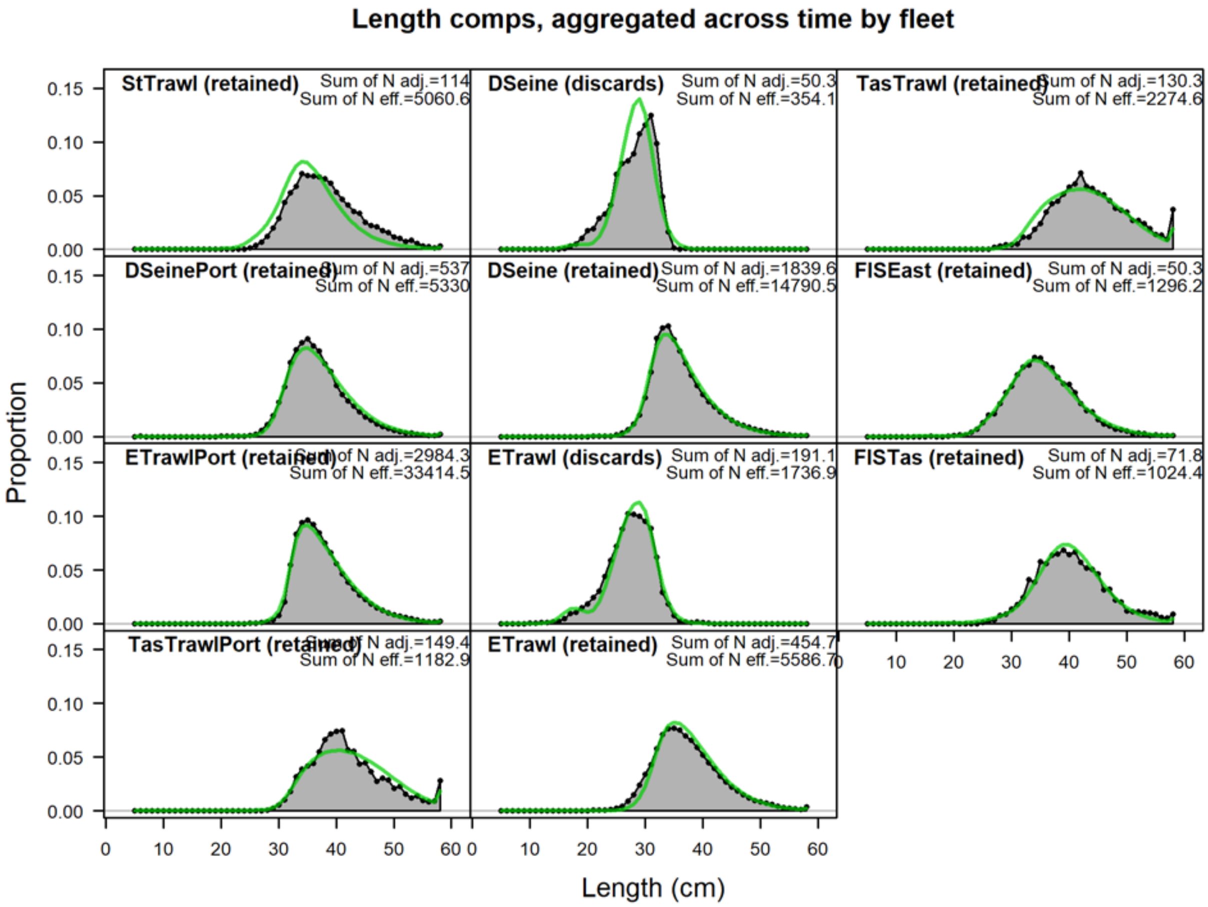

Figure A 6.23. Aggregated fits (over all years) to the length compositions for tiger flathead displayed by fleet.

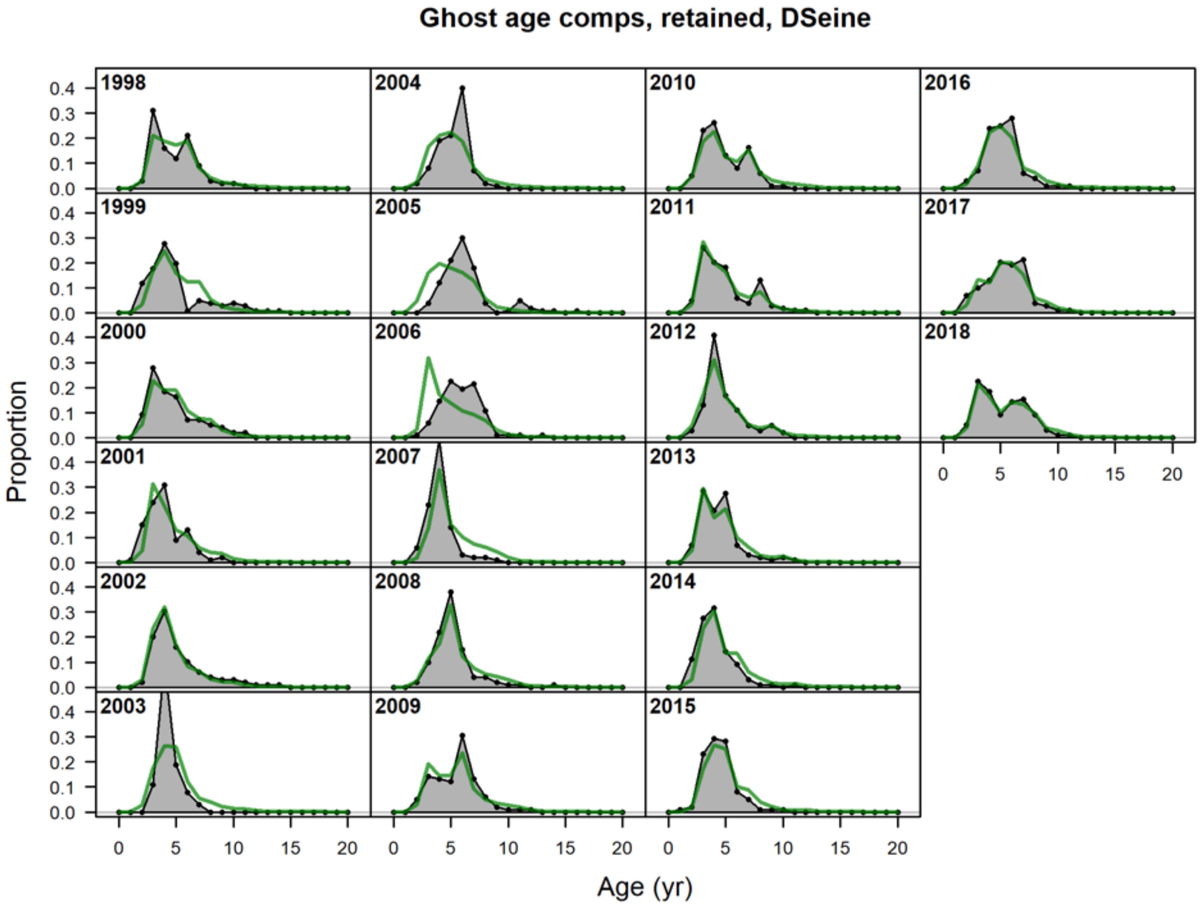

Figure A 6.24. Tiger flathead implied fits to age: Danish seine onboard retained.

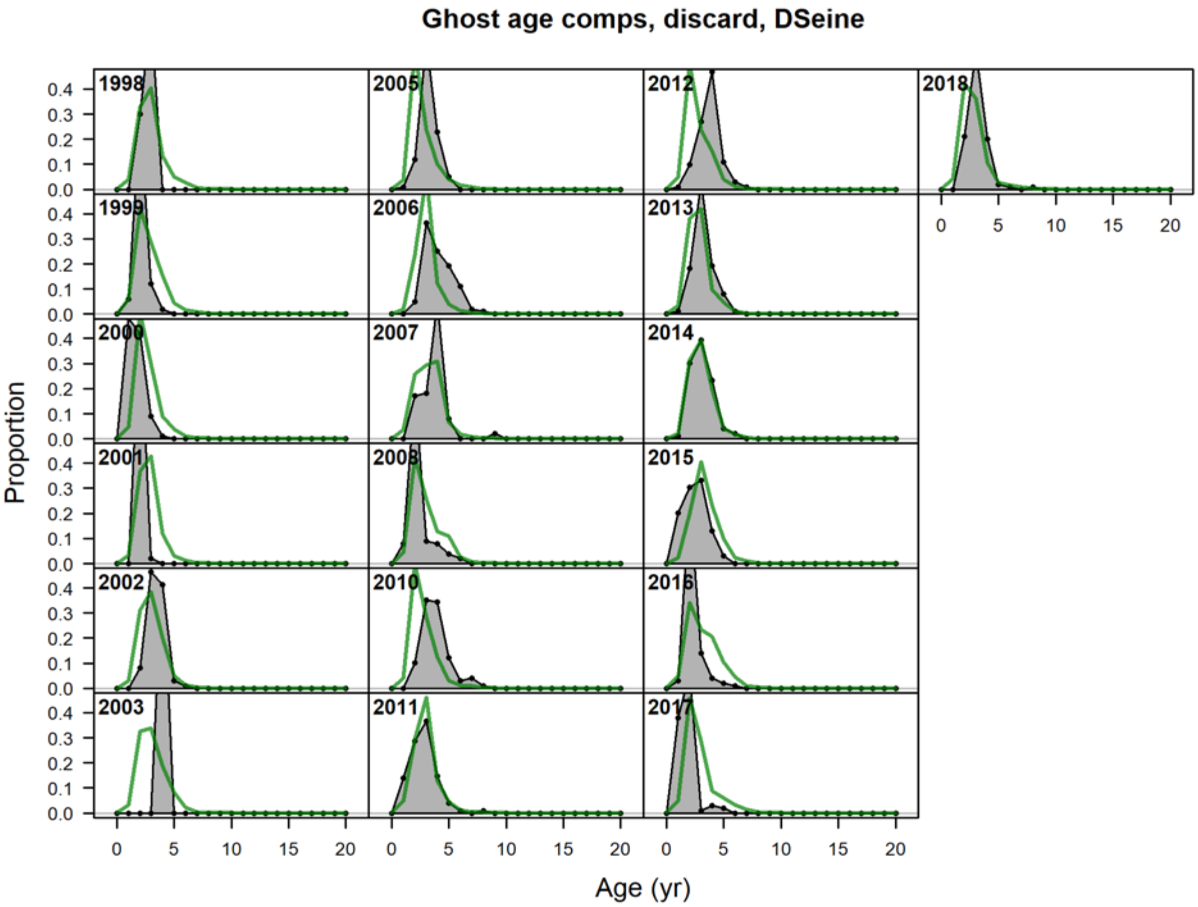

Figure A 6.25. Tiger flathead implied fits to age: Danish seine onboard discarded.

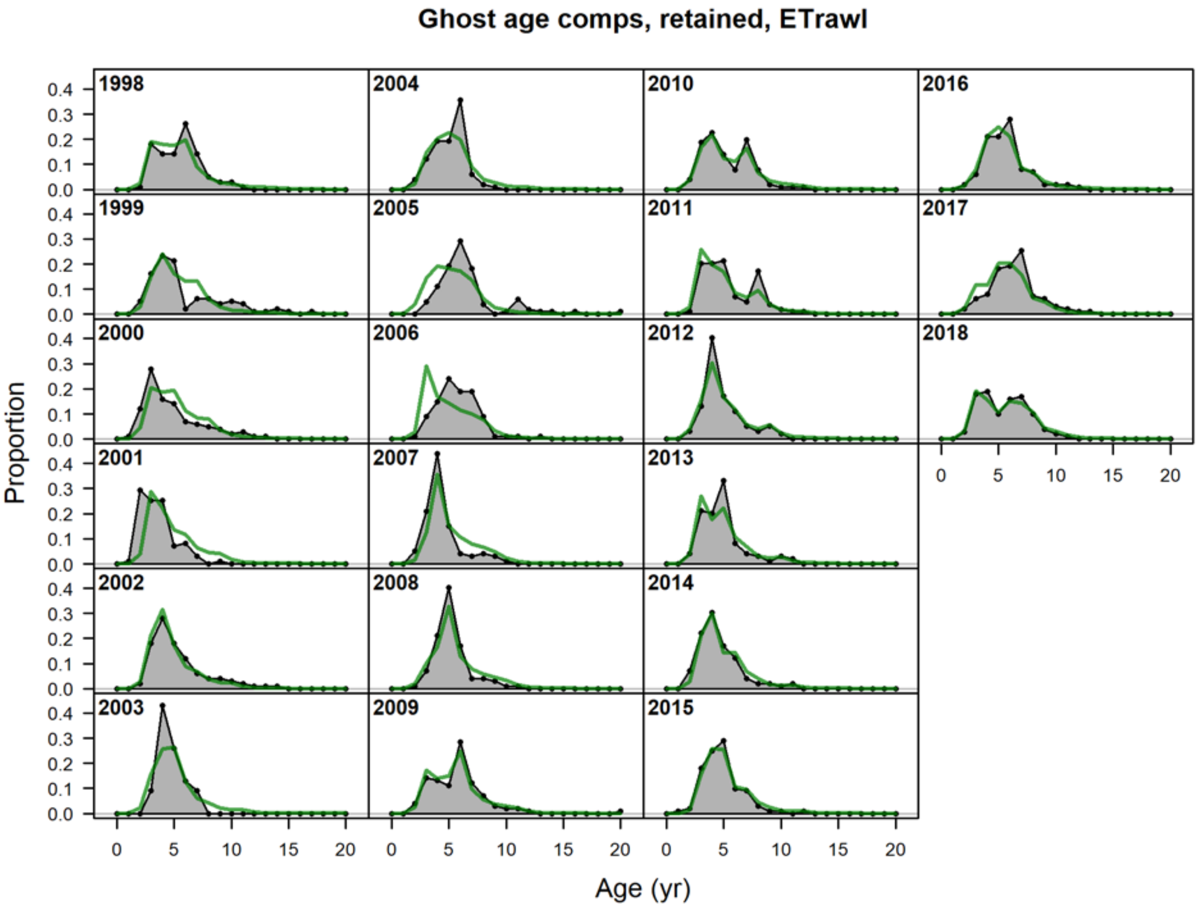

Figure A 6.26. Tiger flathead implied fits to age: Eastern trawl onboard retained.

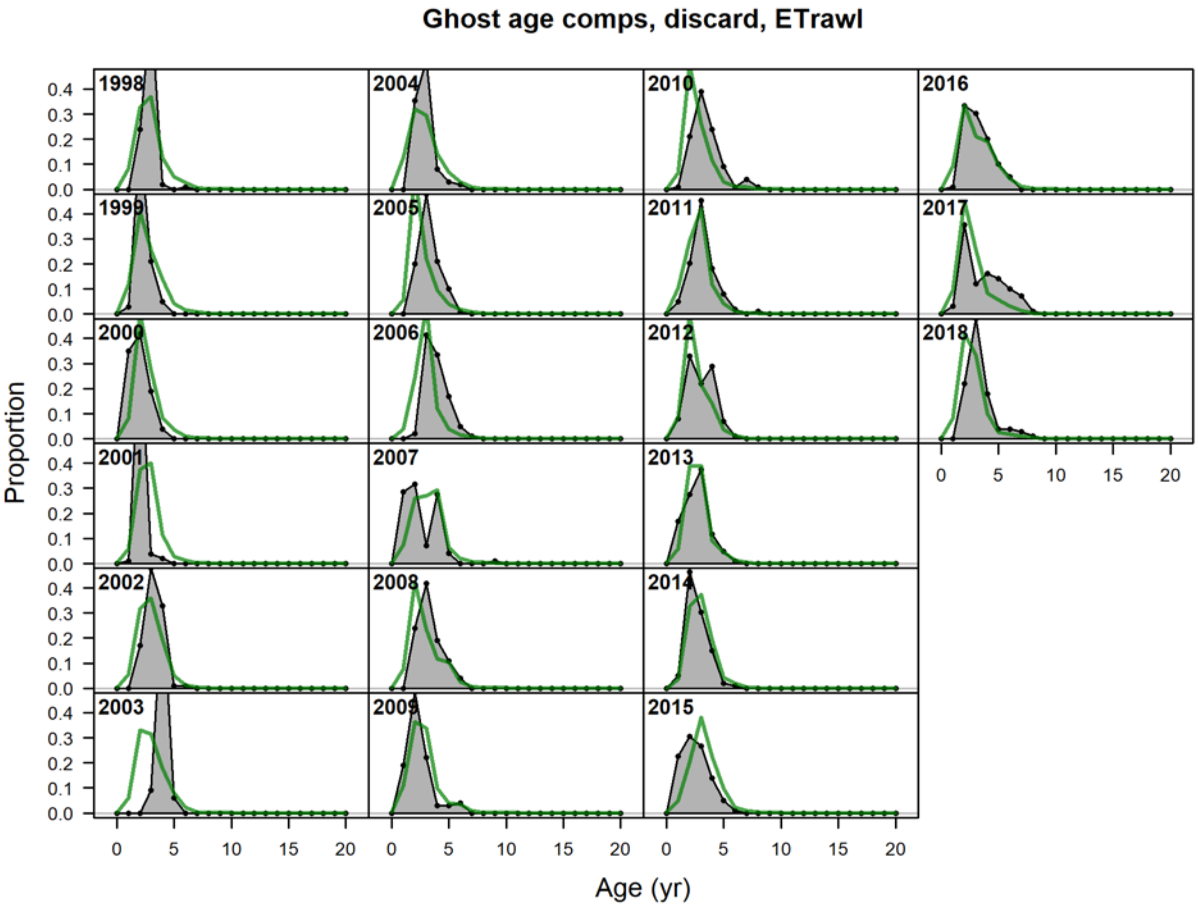

Figure A 6.27. Tiger flathead implied fits to age: Eastern trawl onboard discarded.

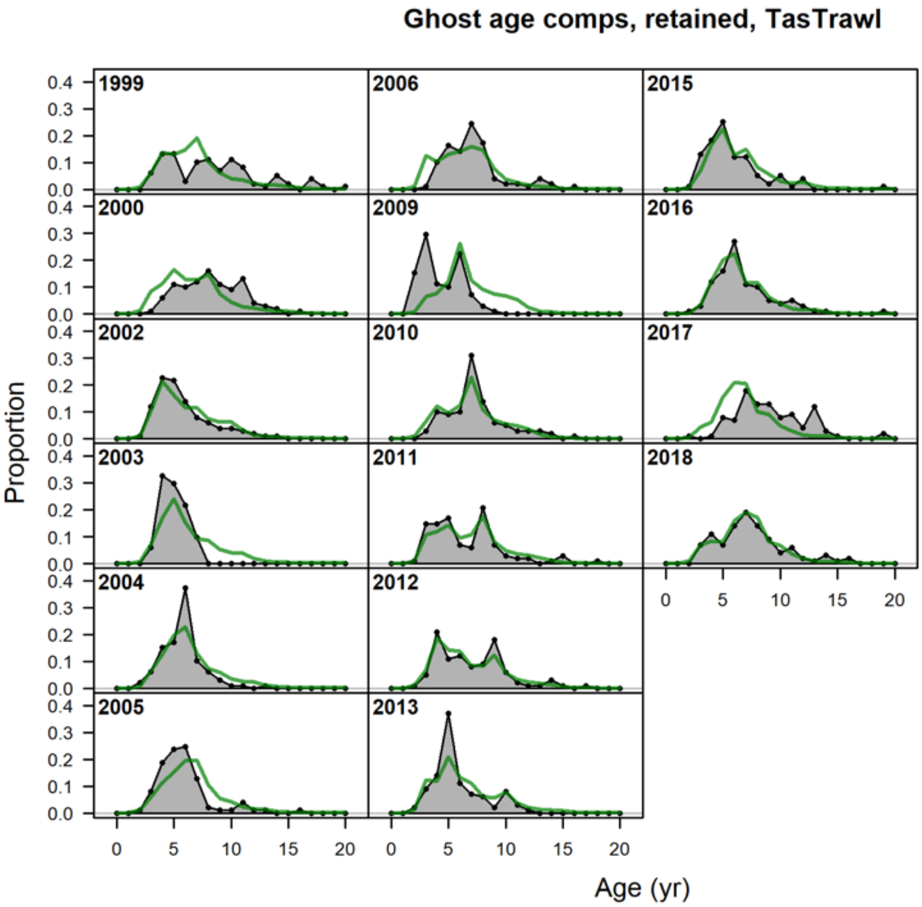

Figure A 6.28. Tiger flathead implied fits to age: Tasmanian trawl onboard retained.

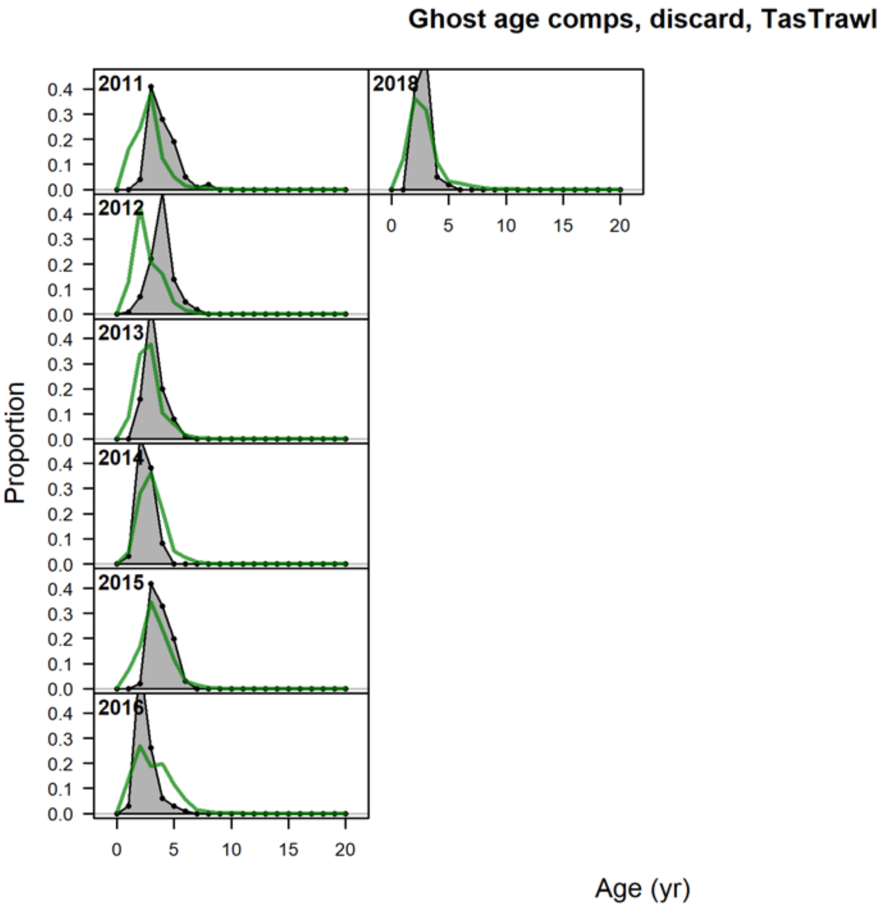

Figure A 6.29. Tiger flathead implied fits to age: Tasmanian trawl onboard discarded.

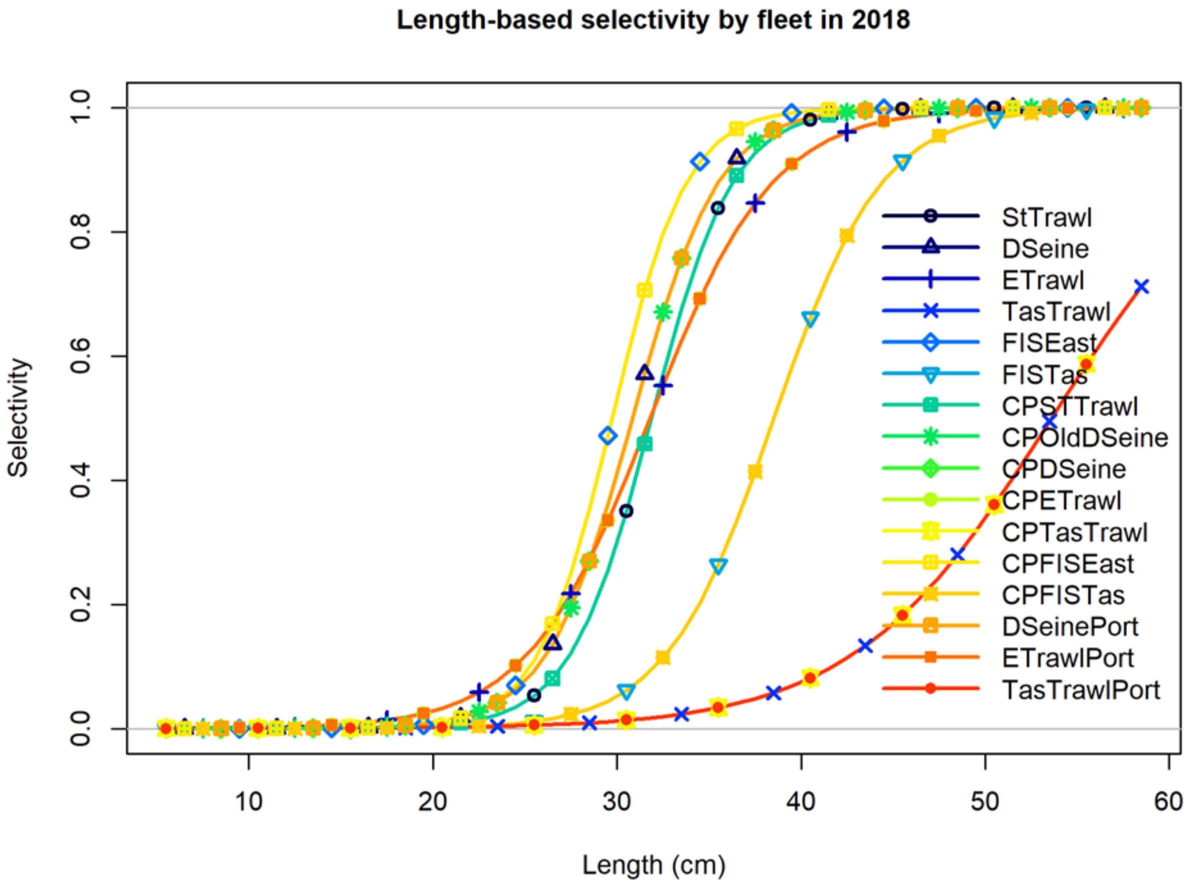

Figure A 6.30. Estimated selectivity curves for tiger flathead. There are only six different selectivity patterns listed here, with port and onboard fleets having the same selectivity and the “CP” fleets replicating the catch fleets. In some cases, the identical selectivity for three “fleets” are overwritten, as they actually represent only a single fleet.

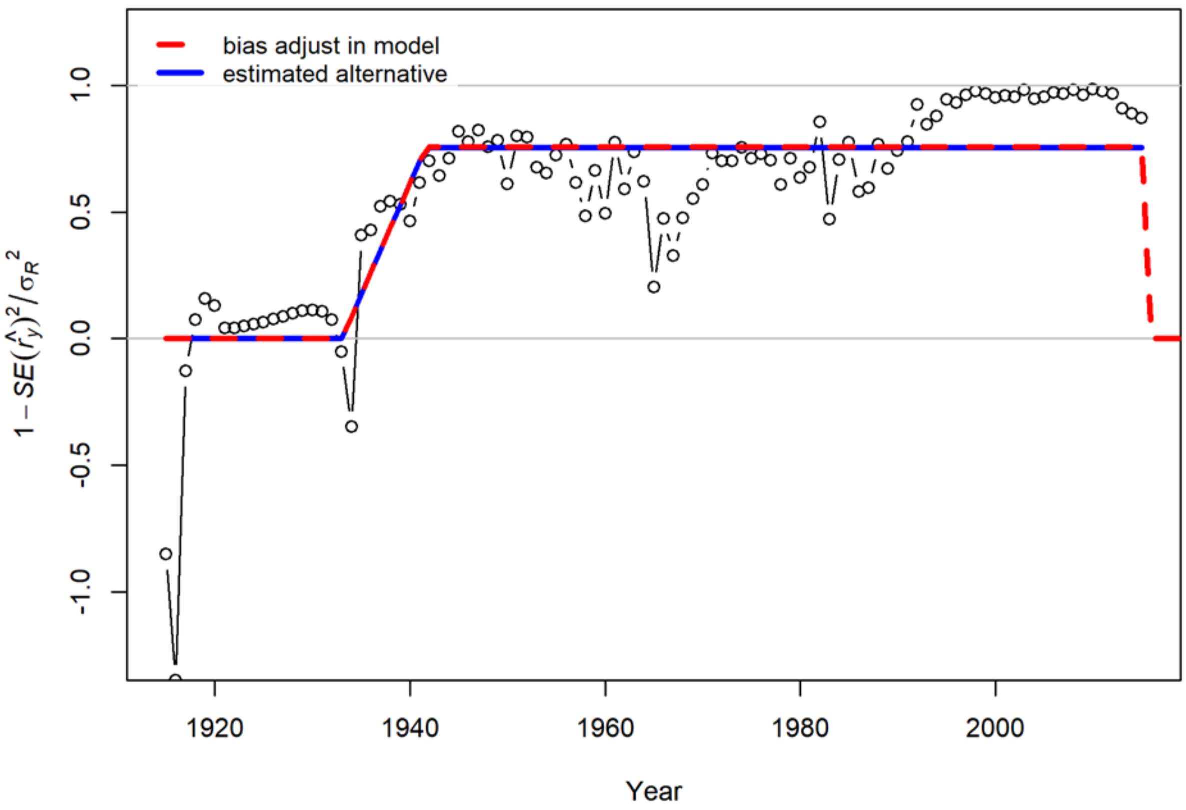

Figure A 6.31. Bias ramp adjustment for tiger flathead.

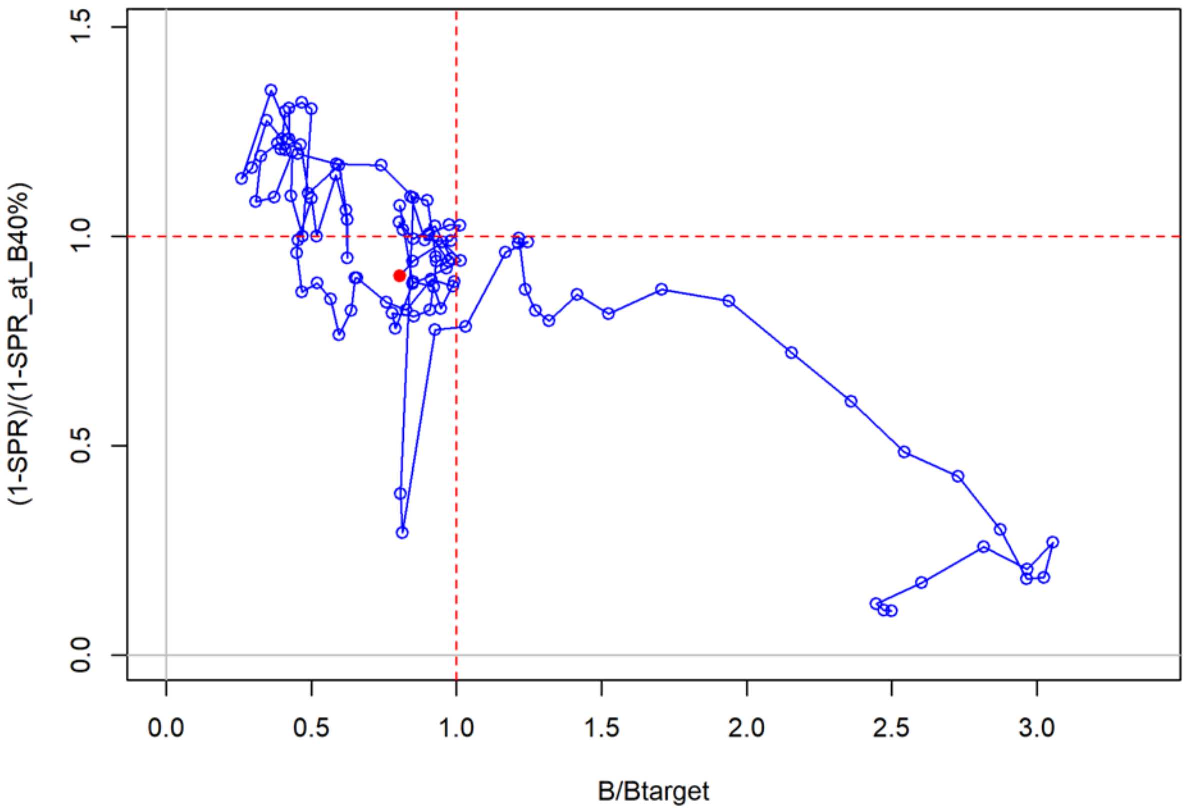

Figure A 6.32. Phase plot of biomass vs SPR ratio.