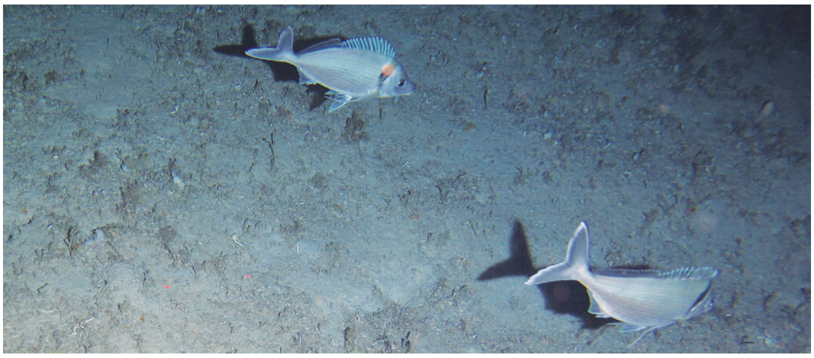
Cite as:
Day, J. and Castillo-Jordán, C. (2018) Eastern Jackass Morwong (*Macruronus novaezelandiae*) stock assessment based on data up to 2017 - development of a preliminary base case. pp 8 - 85 *in* Tuck, G.N. (ed.) 2020. *Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2018 and 2019*. Part 1, 2018. Australian Fisheries Management Authority and CSIRO Oceans and Atmosphere, Hobart. 526p.

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
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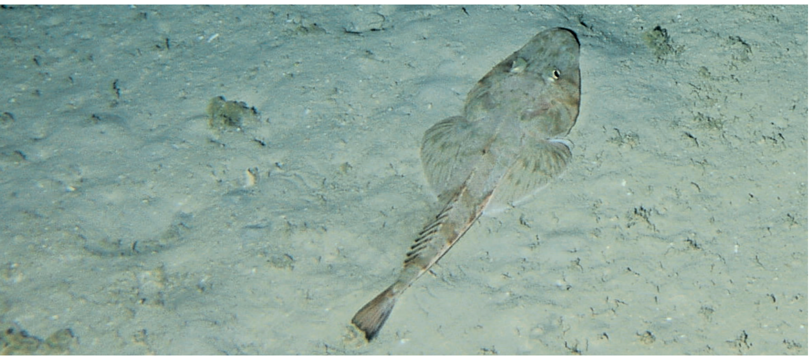

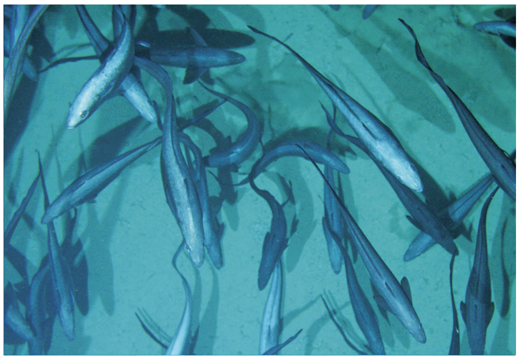

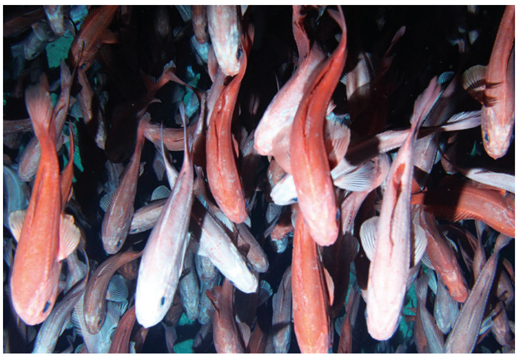

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Stock Assessment for the southern and eastern scalefish and shark fishery 2018 and 2019. Report ref# 2017/0824. By PI: Tuck, G.N. June 2020 - ONLINE

ISBN 978-1-925994-07-0

Preferred way to cite this report

Tuck, G.N. (ed.) 2020. Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2018 and 2019. Part 1, 2018. Australian Fisheries Management Authority and CSIRO Oceans and Atmosphere, Hobart. 526p.

Acknowledgements

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 2018. 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 2018.

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

Part 1: 2018

G.N. Tuck
June 2020
Report 2017/0824

Australian Fisheries Management Authority

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

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1. Non-Technical Summary

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

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OBJECTIVES:

- Provide quantitative and qualitative species assessments in support of the four SESSFRAG assessment groups, including RBC calculations within the SESSF harvest strategy framework
- 2018: Provide Tier 1 assessments for Blue grenadier, Jackass morwong (east and west), School shark, and Silver warehou; Tier 3 assessment for Alfonsino; Tier 4 assessments for Blue eye trevalla and Deepwater shark (east and west); and Tier 5 for Smooth oreo.
- 2019: Provide Tier 1 assessments for Deepwater flathead, Tiger flathead, Western gemfish, and Gummy shark; and Tier 4 for Mirror Dory

Outcomes Achieved - 2018

The 2018 assessments of stock status of the key Southern and Eastern Scalefish and Shark fishery (SESSF) species are based on the methods presented in this report. Documented are the latest quantitative assessments for the SESSF quota species. Typical assessment results provide indications of current stock status, in addition to an application of the recently introduced Commonwealth fishery harvest control rules that determine a Recommended Biological Catch (RBC). These assessment outputs are a critical component of the management and Total Allowable Catch (TAC) setting process for these fisheries. The results from these studies are being used by SESSFRAG, industry and management to help manage the fishery in accordance with agreed sustainability objectives.

1.1 Slope, Shelf and Deepwater Species

Jackass Morwong

The 2015 Tier 1 assessment of eastern and western jackass morwong (*Nemadactylus macropterus*) was updated to provide estimates of stock status in the SESSF at the start of 2019. The assessment was performed using the stock assessment package Stock Synthesis (version V3.30.12.00). The 2015 stock assessment has been updated with the inclusion of data up to the end of 2017, comprising an additional three years of catch, discard, CPUE, length and age data and ageing error updates, including revisions to historical catch series, length frequencies and discard rates. One additional year in the abundance index (2016) for the Fishery Independent Survey (FIS) was included.

The base-case assessment for eastern jackass morwong estimates that current spawning stock biomass is 35% of unexploited stock biomass (SSB_0). Under the agreed 20:35:48 harvest control rule, the 2019 recommended biological catch (RBC) is 261 t, with the long-term yield (assuming average recruitment in the future) of 356 t. The average RBC over the three-year period 2019-2021 is 270 t and over the five-year period 2019-2023, the average RBC is 279 t. Exploration of model sensitivity showed variation in spawning biomass across all sensitivities ranging from 18% to 52% of SSB_0 with greatest sensitivity to natural mortality. Excluding this sensitivity to natural mortality, the other sensitivities showed a much narrower range, from 29% to 40% of SSB_0.

The base-case assessment for western jackass morwong estimates that current spawning stock biomass is 68% of unexploited stock biomass (SSB_0). Under the agreed 20:35:48 harvest control rule, the 2019 recommended biological catch (RBC) is 235 t, with the long-term yield (assuming average recruitment in the future) of 158 t. The average RBC over the three-year period 2019-2021 is 223 t and over the five-year period 2019-2023, the average RBC is 212 t. Exploration of model sensitivity showed variation in spawning biomass across all sensitivities ranging from 33% to 102% of SSB_0 with greatest sensitivity to natural mortality. Excluding this sensitivity to natural mortality, the other sensitivities showed a much narrower range, from 60% to 75% of SSB_0. As in the 2015 assessment, results show poor fits to the abundance data (catch rate and Fishery Independent Survey (FIS)), but acceptable fits to the length composition and conditional age-at-length data.

Blue grenadier

The base case Tier 1 assessment for blue grenadier (*Macruronus novaezelandiae*) was updated from the last full assessment in 2013. Relative to the 2013 assessment, the base case is updated by the inclusion of data to the end of 2017, which entails an additional five years of catch, discard, CPUE, length-composition and conditional age-at-age data and ageing error.

The base case specifications agreed in 2013 were generally maintained in the final base case. The main differences are: separating length-composition into onboard- and port- collected components, assigning stage-1 weights to length-compositions by shots (onboard) and trips (port); and using the latest methods for assigning final weights to the various data sources and the extent of variation in recruitment. The estimated time series of recruitment under the base-case parameter set shows the typical episodic nature of blue grenadier recruitment, with strong year-classes in 1979, the mid-1980s, 1994, and 2003, with relatively low recruitment between these years. However, recent estimated recruitments are more stable than has been observed before. The fit to the discard mass has improved compared to the 2013 assessment result. As has been noted in previous blue grenadier assessments, the fit to the standardized non-spawning catch-rate index is generally poor; the model is unable to fit to the high early catch rates and over-estimates catch rates during the early 2000s.

The estimated spawning biomass in 2019 which is used in the harvest control rule, is approximately 122% SSB_0. The optimistic outlook from this assessment is largely being driven by the addition of 5 further years of data and the substantial estimates of recruitment since 2010. While a promising sign for the fishery, some caution should be exercised regarding these recruitment estimates and its implication on future stock status, until clear further indications of its existence (and magnitude) are evident in future years' data. For the base case model, the 2019 recommended biological catch (RBC) under the 20:35:48 harvest control rule is 13,260t. The long-term retained catch is 4,899t. The retained portion of the RBC for 2019 is estimated to be 12,671t.

Silver warehou

A quantitative Tier 1 assessment of silver warehou (*Seriolella punctata*) in the SESSF using data up to 31 December 2017 was updated from the last assessment in 2015. The 2018 assessment has been updated by the inclusion of data up to the end of 2017, which entails an additional three years of catch, discard, CPUE, length-composition and conditional age-at-length data and ageing error updates.

Agreed changes to the 2018 base case included: the use of a re-estimated discard fractions split between the eastern and western trawl fleets, accounting for the observed discarding practices of factory trawlers, the inclusion of conditional age-at-length data for the western onboard trawl fleet, removal of length data from the small pelagic fishery (SPF) and inclusion of non-trawl catches in the existing eastern and western trawl fleets.

This assessment has seen a continuation of below average recruitment noted in the last two assessments with the last 11 years of estimated recruitment all below average. While the current assessment estimates that spawning biomass in 2019 will be 31% of unfished levels, previous assessments have shown that optimistic recent recruitments have been revised downwards in subsequent assessments. A retrospective assessment suggested that the increase in spawning biomass seen in the most recent years of the 2018 assessment may be overly optimistic and that the stock may currently be near the limit reference point.

This assessment estimates that the projected 2019 spawning stock biomass will be 31.3% of virgin stock biomass. The recommended biological catch (RBC) from the base case model for 2019 is 942t for the 20:35:48 harvest control rule, increasing to 1,353t in 2020 and 1,420t in 2021. The long-term yield is 1,772t. At its November 2018 meeting, SERAG agreed to recommend a TAC for silver warehou based on the assumption that recruitment will remain below average in the next few years. SERAG chose to assume that recruitment would remain at the mean of the last five years of estimated recruitments in the base case model (2010 – 2014). Projections assuming this low recruitment were run for scenarios of constant landed catch that were between the catch in the most recent year for which data is available (348 t) and the RBCs from the base case model which assumes average recruitment (942 t in 2019). Scenarios with constant annual catches of 750 t or more led to the estimated spawning biomass declining under the low recruitment scenario. Under the low recruitment scenario with constant annual catches between 348 t and 600 t, spawning biomass is predicted to increase, albeit more slowly than the base case which assumes average recruitment.

Eastern orange roughy

A cross-catch risk assessment for eastern orange roughy was presented based upon the model structure of the last full quantitative assessment in 2017. Two models are considered that differ only by the assumed value of natural mortality, M. The base-case model has M=0.04 and an alternative has M=0.032. The alternative value for natural mortality was chosen to define a low productivity model, and used the value with highest likelihood from the likelihood profile. The catches input to the two model structures were the predicted projected catches from each model, and a fixed 3-year catch series proposed by industry; thus three projected catch scenarios associated with each natural mortality were used. The purpose of the risk assessment was to identify if any of the catch series led to biomass trajectories that may be perceived as a risk to the long-term sustainability of the stock. The consequent six scenarios (2 models × 3 catch series) were projected 55 years into the future.

Results showed that the model with lower productivity (the M=0.032 model) and with the highest catches (from the M=0.04 model) had the lowest long-term biomass series (in terms of annual tonnage of female spawning biomass). This series stabilised at approximately 30% of virgin biomass. All other scenarios had biomass levels that were considerably greater than this. As far as short-term catches and depletion were concerned, the differences between biomass trajectories across catch series were minimal within a model structure (i.e. for a particular value of M). For example, by 2025, the depletion ranged between 0.40 and 0.42 for the M=0.04 models, whereas the depletion ranged between 0.31 and 0.34 for the M=0.032 model.

1.2 Shark Species

School shark

Sampling for the school shark close kin project is complete, with approximately 3,000 sharks collected and genetically sequenced. A total of 3 parent offspring pairs (POPs, two mothers and one father) were found along with 34 full sibling pairs (FSPs) and 65 half sibling pairs (HSPs, i.e. two offspring with one parent in common) of which 27 were paternal and 38 maternal. The ratio of full to half siblings is relatively high, suggesting a large “litter effect” whereby some cohorts have unusually high survival due (possibly) to favourable environmental conditions (these are not expected to bias our estimates of abundance). There also seem to be a modest proportion of litters that have more than one father. All animals sequenced were also aged by counting vertebral “rings”. Relatively large ageing error was found (CV 0.08) and mature animals are known to have slower growth rates and to accumulate less than one vertebral ring per year of age.

Simple analyses of the proportion of half sibling pairs born since 2000, based on the facts that (1) each animal had exactly one mother and one father at birth, and (2) mothers and fathers may die over time, give a ballpark estimate for recent adult abundance. We constructed an age-structured population dynamics model that uses commercial catch and discard data, length frequencies from port measured gillnet catches (although these were given negligible weight), estimates of gear selectivity and several biological parameters used by the sharkRAG stock assessment model for school shark, as well as the close kin data. The model follows the same approach used for close kin mark recapture (CKMR) for Southern Bluefin Tuna (SBT) and several other species, whereby the probability that each pairwise comparison of two animals will prove to be a close kin pair is computed based on the working values of the population dynamics parameters, taking account of the ring counts, years of capture, and sex of the two animals concerned. The actual outcome of that comparison (e.g. that it was a maternal half sibling pair) is then compared with the computed probability, and parameters are adjusted to give the best fit between observed and expected values. Probability distributions were constructed for the age of each animal, given its ring count and accounting for ageing error and ring deposition rates at age.

Compared with the 2012 projection of the stock assessment model for school shark, which assumed catches of 225t after 2011, the analyses and the close kin model both estimate a substantially lower adult abundance. The assessment projection and the close kin model (as well as the simple approaches) both indicate an upward trend in abundance since 2000, of a similar rate (although the confidence interval on trend is quite wide).

The close kin model requires assumptions which may not hold far back into the history of this fishery, particularly those regarding density dependence. We therefore restricted attention (for now) to the 2000-2017 period, when most of the close kin samples were born and where the information content is strongest. This was done by restricting the (estimated) age of included samples, leaving out the oldest. This did reduce the “sample size” (to 1,627 out of 2,438 original samples, and 29 out of 40 maternal half-sibling pairs, and a shorter window). The restriction led to satisfactory model fits, but more uncertainty about abundance than might be obtained with the complete dataset. In addition, because we had no prior estimates of whether male fecundity varies much through adulthood, and not enough POPs to estimate it, we took a conservative approach, of not considering the 27 paternal half siblings and the single father-offspring pair. If the model can be expanded to include the historical data adequately and include more of the samples, the CVs will improve.

The stock assessment model used by sharkRAG has been limited by the absence of an index of relative abundance after 1997, and has never been able to disentangle abundance from productivity without the use of a prior based on “expert opinion”. Close kin data provides a fishery-independent estimate of absolute abundance, productivity, and spawning stock trend, and can thus obviate the need for the prior.

KEYWORDS: fishery management, southern and eastern scalefish and shark fishery, stock assessment, trawl fishery, non-trawl fishery

2. Background

The Southern and Eastern Scalefish and Shark Fishery (SESSF) is a Commonwealth-managed, multi-species and multi-gear fishery that catches over 80 species of commercial value and is the main provider of fresh fish to the Sydney and Melbourne markets. Precursors of this fishery have been operating for more than 85 years. Catches are taken from both inshore and offshore waters, as well as offshore seamounts, and the fishery extends from Fraser Island in Queensland to south west Western Australia.

Management of the SESSF is based on a mixture of input and output controls, with over 20 commercial species or species groups currently under quota management. For the previous South East Fishery (SEF), there were 17 species or species groups managed using TACs. Five of these species had their own species assessment groups (SAGs) – orange roughy (ORAG), eastern gemfish (EGAG), blue grenadier (BGAG), blue warehou (BWAG), and redfish (RAG). The assessment groups comprise scientists, fishers, managers and (sometimes) conservation members, meeting several times in a year, and producing an annual stock assessment report based on quantitative species assessments. The previous Southern Shark Fishery (SSF), with its own assessment group (SharkRAG), harvested two main species (gummy and school shark), but with significant catches of saw shark and elephantfish.

In 2003, these assessment groups were restructured and their terms of reference redefined. Part of the rationale for the amalgamation of the previous separately managed fisheries was to move towards a more ecosystem-based system of fishery management (EBFM) for this suite of fisheries, which overlap in area and exploit a common set of species. The restructure of the assessment groups was undertaken to better reflect the ecological system on which the fishery rests. To that end, the assessment group structure now comprises:

- SESSFRAG (an umbrella assessment group for the whole SESSF)
- South East Resource Assessment Group (Slope, Shelf and Deep RAG)
- Shark Resource Assessment Group (Shark RAG)
- Great Australian Bight Resource Assessment Group (GAB RAG)

Each of the depth-related assessment groups is responsible for undertaking stock assessments for a suite of key species, and for reporting on the status of those species to SESSFRAG. The plan for the resource assessment groups (South East, GAB and Shark RAGs) is to focus on suites of species, rather than on each species in isolation. This approach has helped to identify common factors affecting these species (such as environmental conditions), as well as consideration of marketing and management factors on key indicators such as catch rates.

The quantitative assessments produced annually by the Resource Assessment Groups are a key component of the TAC setting process for the SESSF. For assessment purposes, stocks of the SESSF currently fall under a Tier system whereby those with better quality data and more robust assessments fall under Tier 1, while those with less reliable available information are in Tiers 3 and 4. To support the assessment work of the four Resource Assessment Groups, the aims of the work conducted in this report were to develop new assessments if necessary (under all Tier levels), and update and improve existing ones for priority species in the SESSF.

3. Need

A stock assessment that includes the most up-to-date information and considers a range of hypotheses about the resource dynamics and the associated fisheries is a key need for the management of a resource. In particular, the information contained in a stock assessment is critical for selecting harvest strategies and setting Total Allowable Catches.

4. Objectives

These Objectives include a description of the SESSFRAG agreed changes to the assessment schedule:

- Provide quantitative and qualitative species assessments in support of the four SESSFRAG assessment groups, including RBC calculations within the SESSF harvest strategy framework
- 2018: Provide Tier 1 assessments for Blue grenadier, Jackass morwong (east and west), School shark, and Silver warehou; Tier 3 assessment for Alfonsino (removed); Tier 4 assessments for Blue eye trevalla (addition of T5 for seamounts) and Deepwater shark (east and west); and Tier 5 for Smooth oreo (removed).
- 2019: Provide Tier 1 assessments for Deepwater flathead, Tiger flathead, Western gemfish (moved to T4), Bight redfish (addition) and Gummy shark (delayed); and Tier 4 for Mirror Dory

5. Eastern Jackass Morwong (*Nemadactylus macropterus*) stock assessment based on data up to 2017 – development of a preliminary base case

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5.1 Executive Summary

This document presents a suggested base case for an updated quantitative Tier 1 assessment of eastern jackass morwong (*Nemadactylus macropterus*) for presentation at the first SERAG meeting in 2018. The last full assessment was presented in Tuck et al. (2015). The preliminary base case has been updated by the inclusion of data up to the end of 2017, which entails an additional three years of catch, discard, CPUE, length-composition and conditional age-at length data and updates to the ageing error matrices since the 2015 assessment. One additional abundance index (2016) for the Fishery Independent Survey (FIS) was included. This document describes the process used to develop a preliminary base case for jackass morwong through the sequential updating of recent data to the stock assessment, using the stock assessment package Stock Synthesis (SS-V3.30.12).

Changes to the last stock assessment include: improvement to the method of estimating the bias ramp and using an updated tuning method.

Results show good fits to the abundance data (catch rate and FIS), and good fits to the length composition and conditional age-at-length data. This assessment estimates that the projected 2019 spawning stock biomass will be 35% of virgin stock biomass (projected assuming 2017 catches in 2018), a slightly lower relative biomass level than the depletion of 37% at the start of 2016 obtained from the last assessment (Tuck et al., 2015).

5.2 Introduction

5.2.1 *Bridging from 2015 to 2018 assessments*

The previous full quantitative assessment for eastern jackass morwong was conducted during 2015 (Tuck et al., 2015) using Stock Synthesis (version SS-V3.24U, Methot and Wetzel, 2013). The 2018 assessment uses the current version of Stock Synthesis (version SS-V3.30.12, Methot et. al, 2018), which includes some changes from SS-V3.24U.

As a first step in the process of bridging to a new model, the model was translated from version SS-V3.24U (Methot and Wetzel, 2013) to version SS-V3.30.12 (Methot et. al, 2018) using the same data and model structure used in the 2015 assessment. Once this translation was complete, improved features unavailable in SS-V3.24U were incorporated into the SS-V3.30.12 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 2015 simply through changes to software and assessment practices. The subsequent bridging exercise (Bridge 2) then sequentially updates the model with new data through to 2017.

The second part of the bridging analysis includes updating historical data (up to 2014), followed by including the data from 2015-2017 into the model. These additional data included new catch, discard, CPUE, FIS abundance indices, length composition data, conditional age-at-length data, an updated ageing error matrix and an additional CPUE index (trawl). The last year of recruitment estimation was extended to 2012 (2011 in the 2015 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.

5.2.2 *Update to Stock Synthesis SS-V3.30.12 and updated catch history (Bridge 1)*

The 2015 eastern jackass morwong assessment (East2015_24U) was initially translated to the most recent version of the software, Stock Synthesis version SS-V3.30.12 (East2015_30_12). Figure 5.1 shows that the differences in the assessment results from this step were minimal.

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 (East2015_30_12New), followed by retuning using the latest tuning protocol (East2015_30_12Tuned). Details of the tuning procedure used are listed in Section 5.2.2.1. Revisions to the historical catches, up to 2014, and replacing the estimated 2015 catch with the actual 2015 catch were then added to this tuned version of the 2015 model (East2015_30_12ReviseCatch). 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 2015. This initial bridging step, Bridge 1, does not incorporate any data after 2014 or any structural changes to the assessment.

When these time series are plotted together, there are relatively minor changes in the translation to SS-V3.30.12, largely due to differences in implementation of regime shifts in the new version, but considerable changes when the new features were added, and further changes when the model was retuned using current model tuning protocols. Revising the catch history to 2014 had very little effect (Figure 5.2 and Figure 5.3).

The results of Bridge 1 suggest that the stock was more depleted in 2016 than the 2015 assessment indicated. This is almost entirely due to changes in parameters that can be tuned, including variances that can be estimated internally and in the tuning procedure itself, rather than changes to the data or to the software.

Fits to the abundance indices (Figure 5.4 to Figure 5.8) show changes through this process, most with small improvements to the fit during Bridge 1. However the FIS indices show very little noticeable change to fits (Figure 5.9 to Figure 5.10). The estimated recruitment series shows little change in broad trends from using the new features in Stock Synthesis and using the new tuning procedure (Figure 5.11). However, while most of the recent recruitment estimates are largely unchanged, those in 2009 and 2010 have been notably revised downwards during Bridge 1.

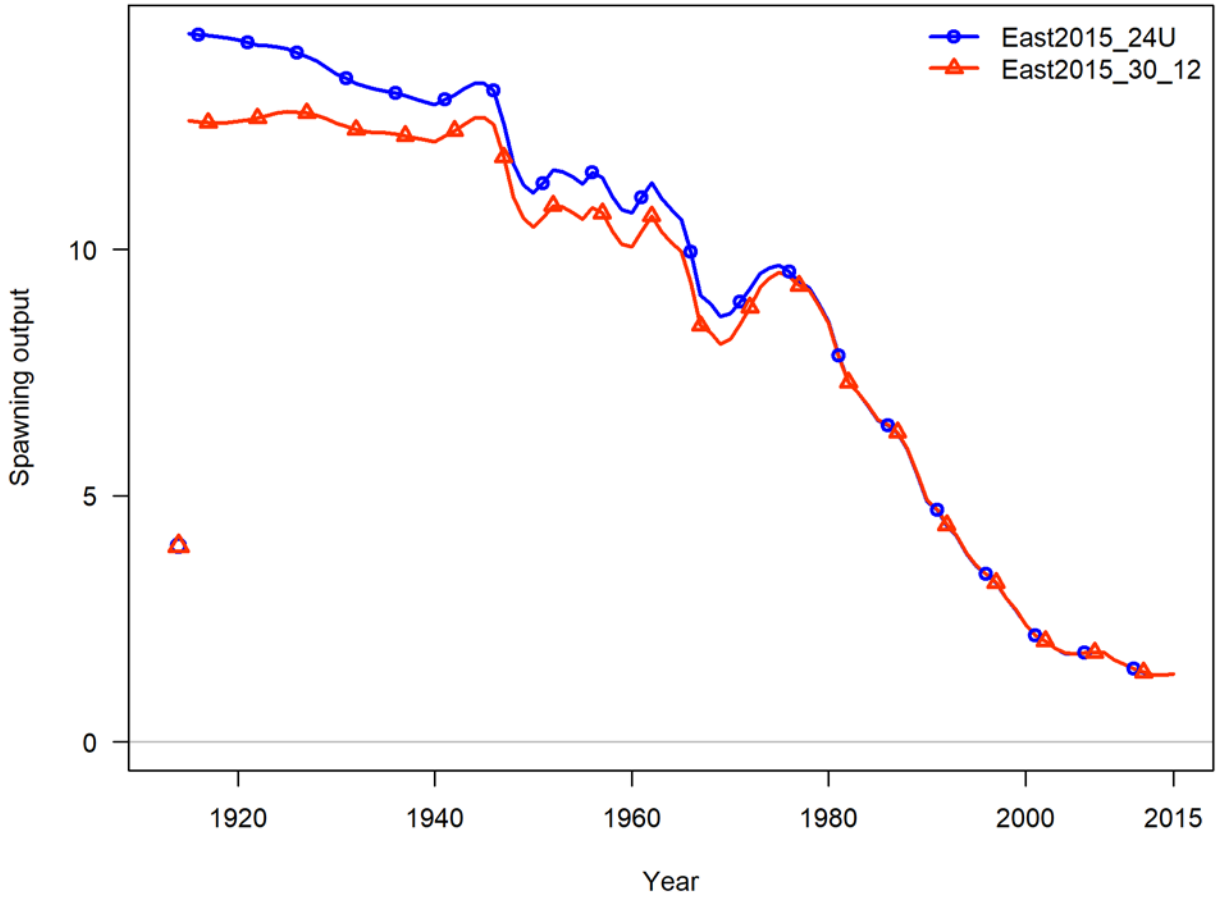

Figure 5.1. Comparison of the time series of absolute spawning biomass from the 2015 assessment (East2015_24U – in blue), and a model with the same data converted to SS-V3.30 (East2015_30_12 – in red). The changes shown are largely due to changes in the implementation of a regime shift in the updated version of Stock Synthesis.

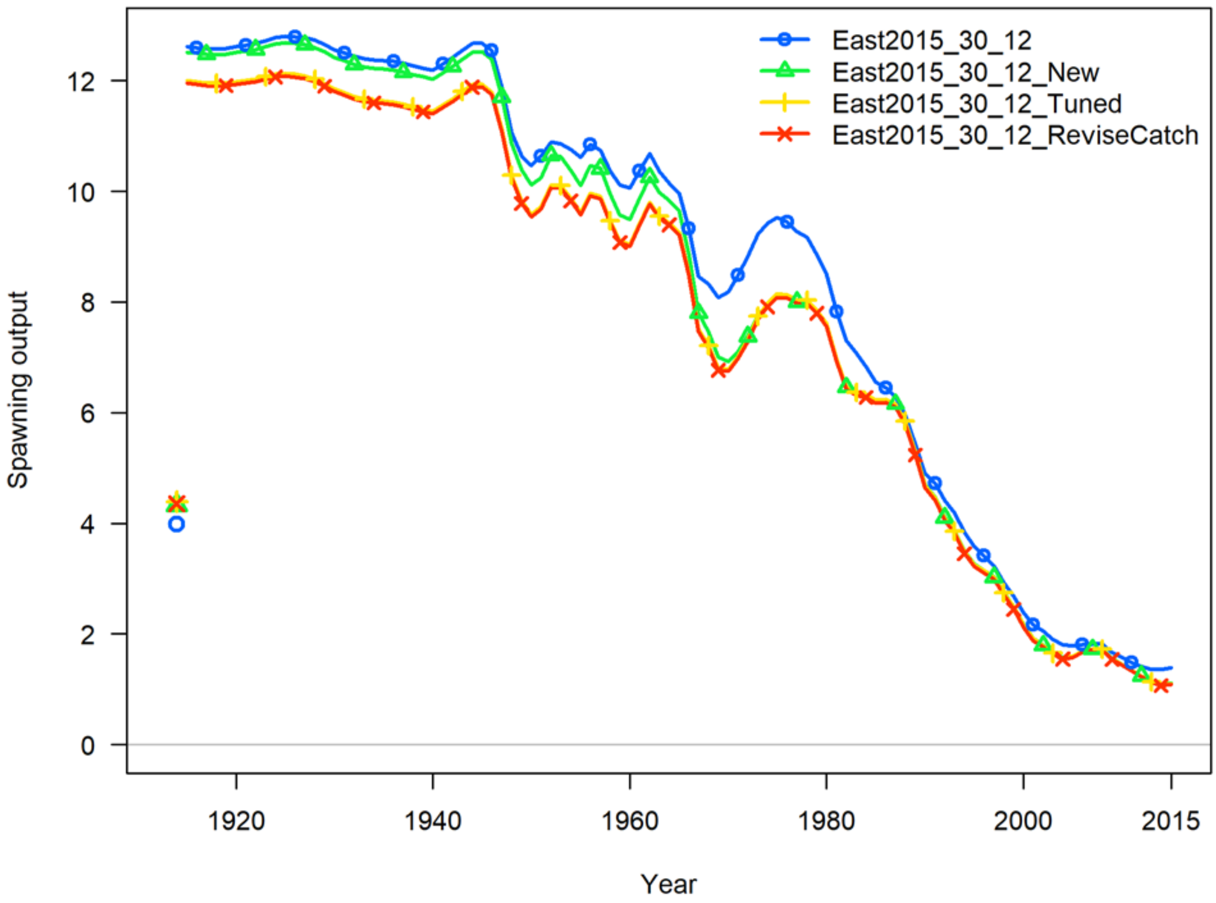

Figure 5.2. Comparison of the time-series of absolute spawning biomass from the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

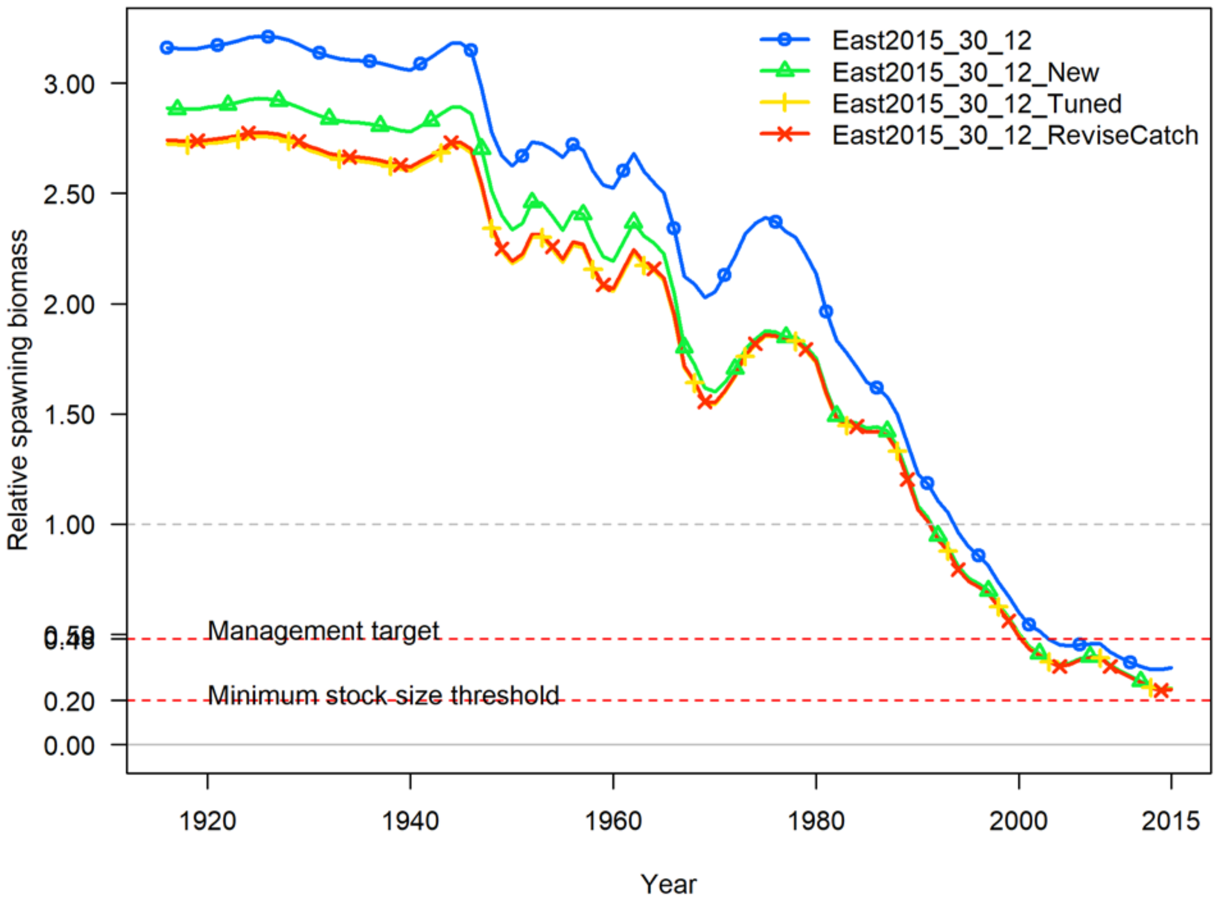

Figure 5.3. Comparison of the time-series of relative spawning biomass from the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

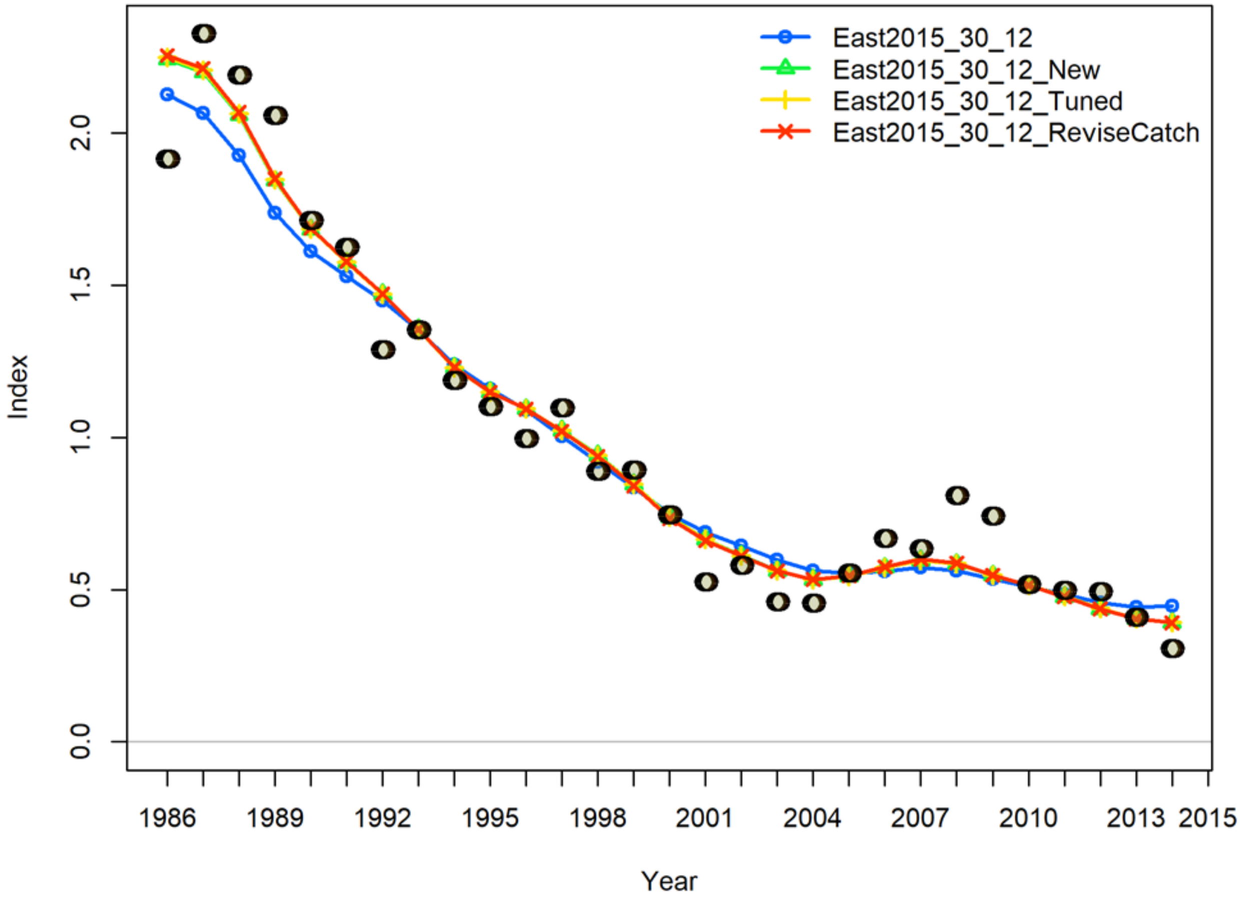

Figure 5.4. Comparison of the fit to the Eastern trawl CPUE index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

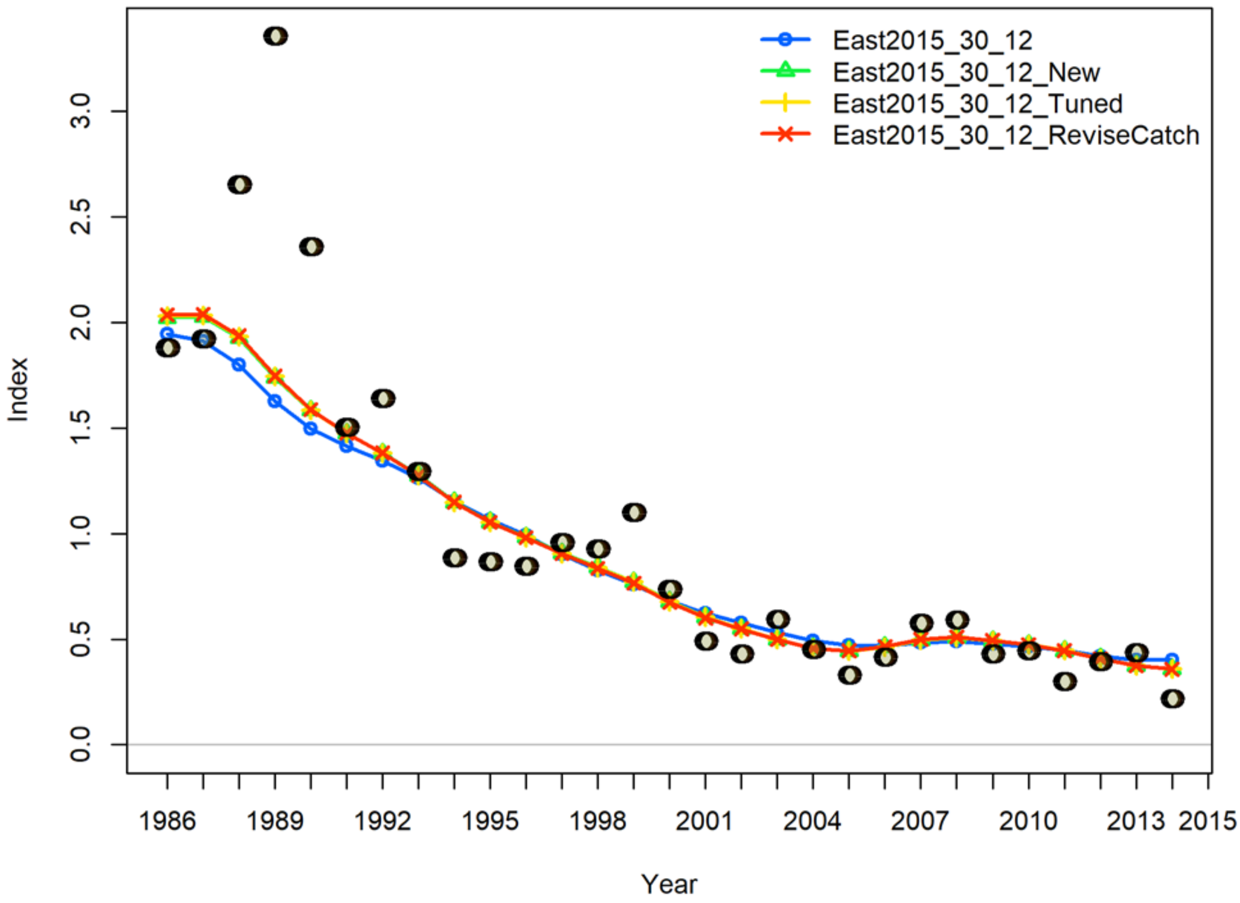

Figure 5.5. Comparison of the fit to the Tasmanian trawl CPUE index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

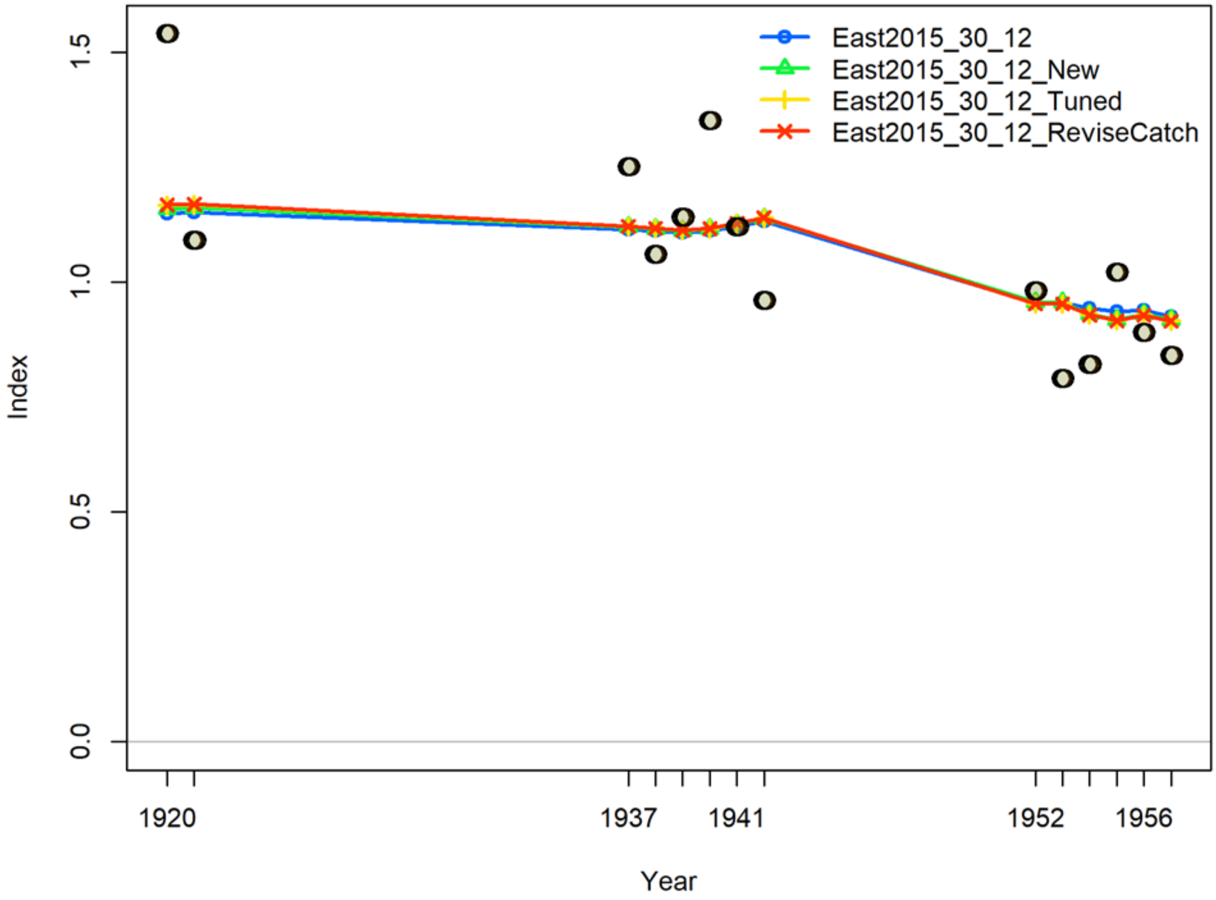

Figure 5.6. Comparison of the fit to the Steam trawl CPUE index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

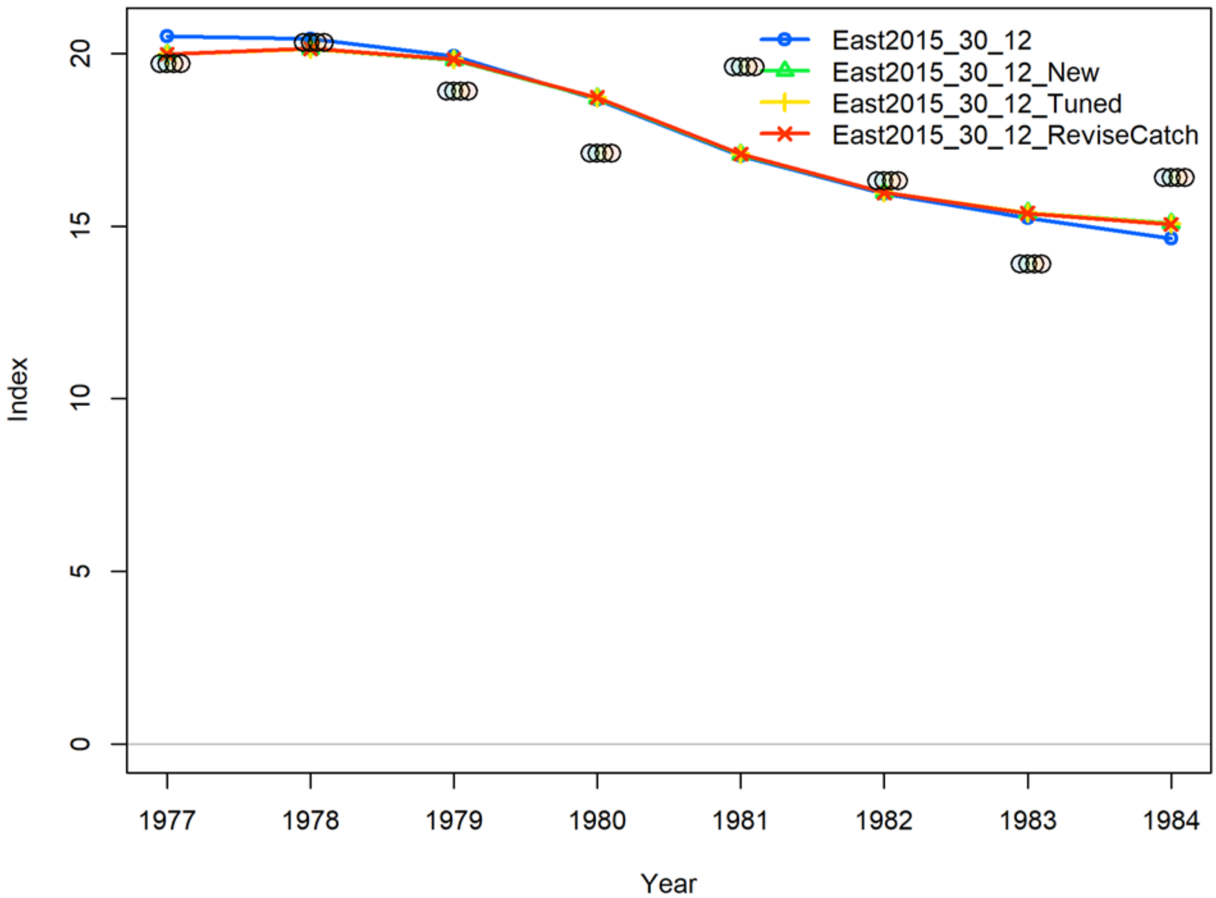

Figure 5.7. Comparison of the fit to the mixed CPUE index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

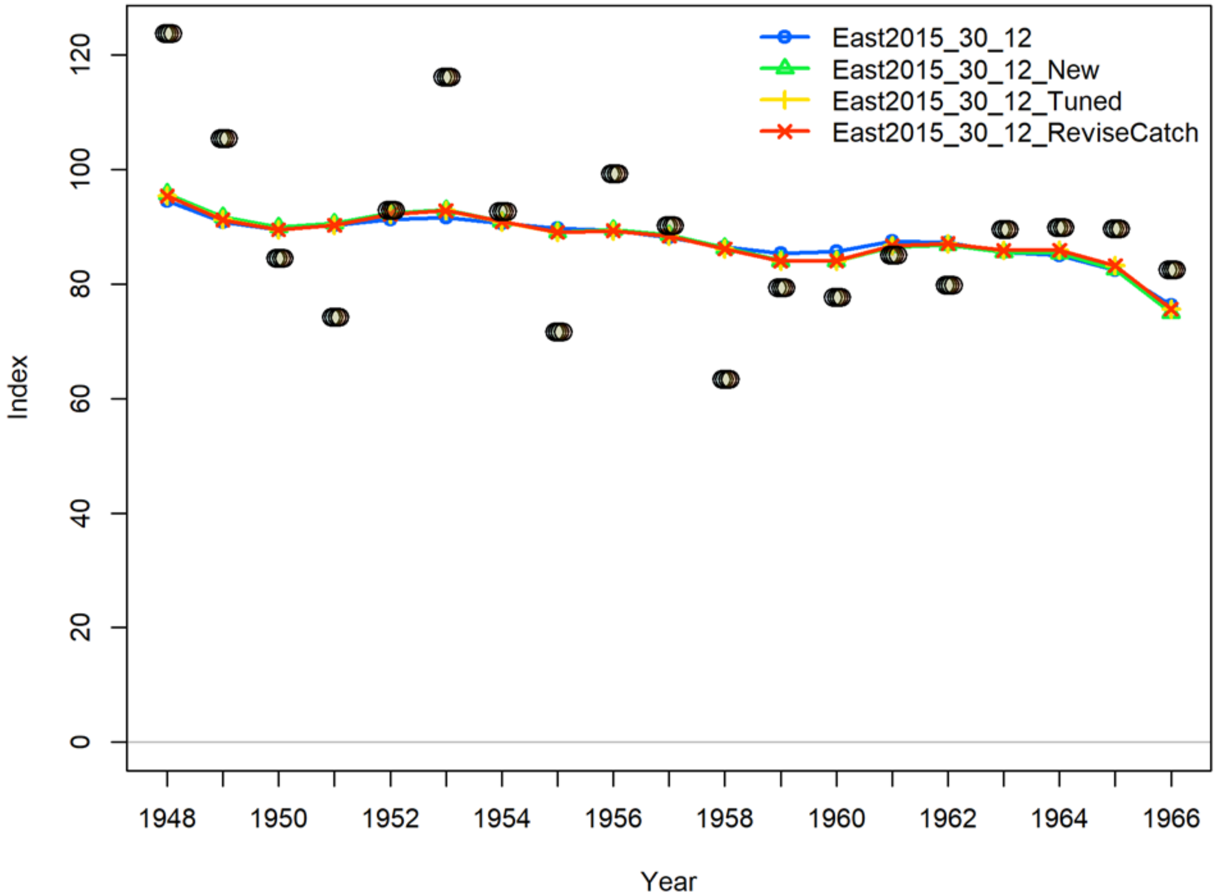

Figure 5.8. Comparison of the fit to the Smith CPUE index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

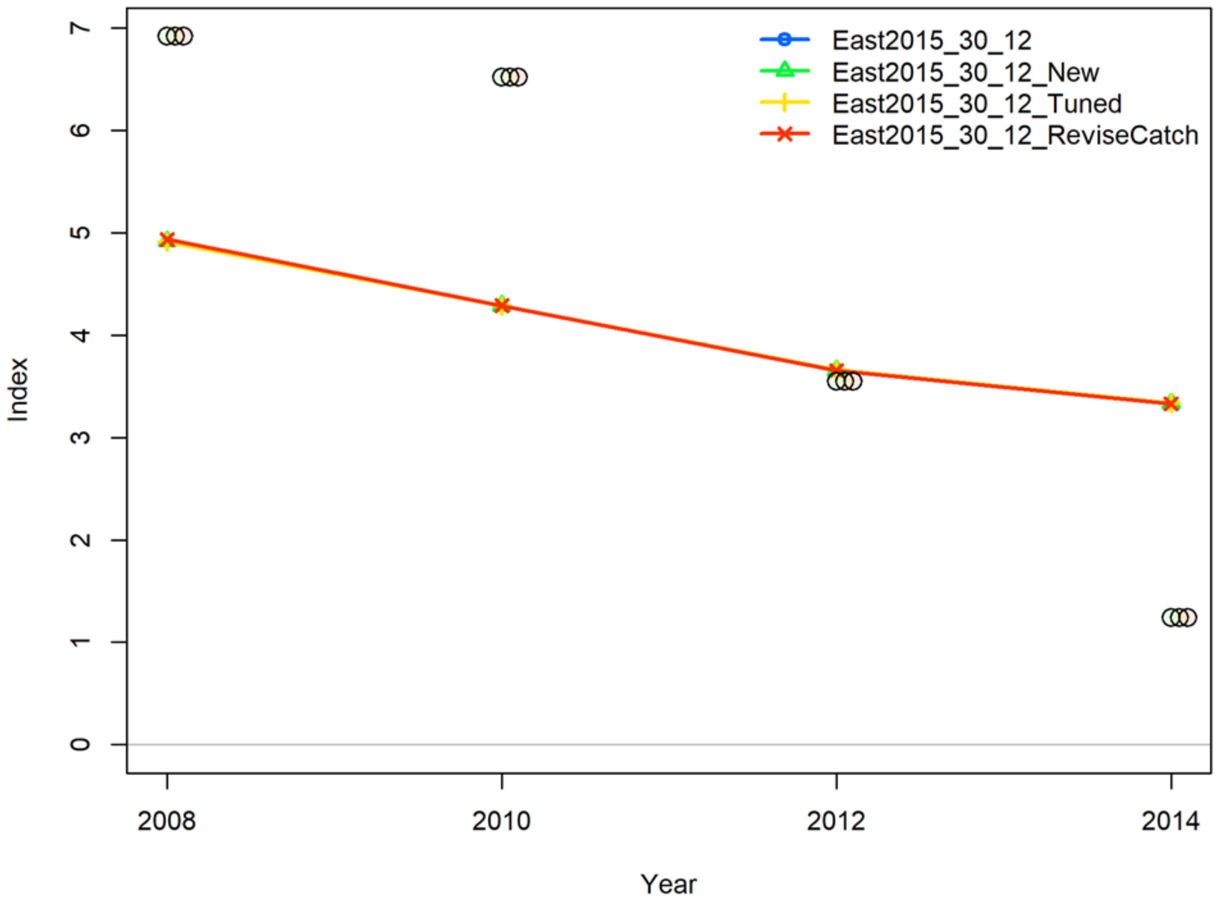

Figure 5.9. Comparison of the fit to the FIS_East (zones 10 and 20) abundance index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

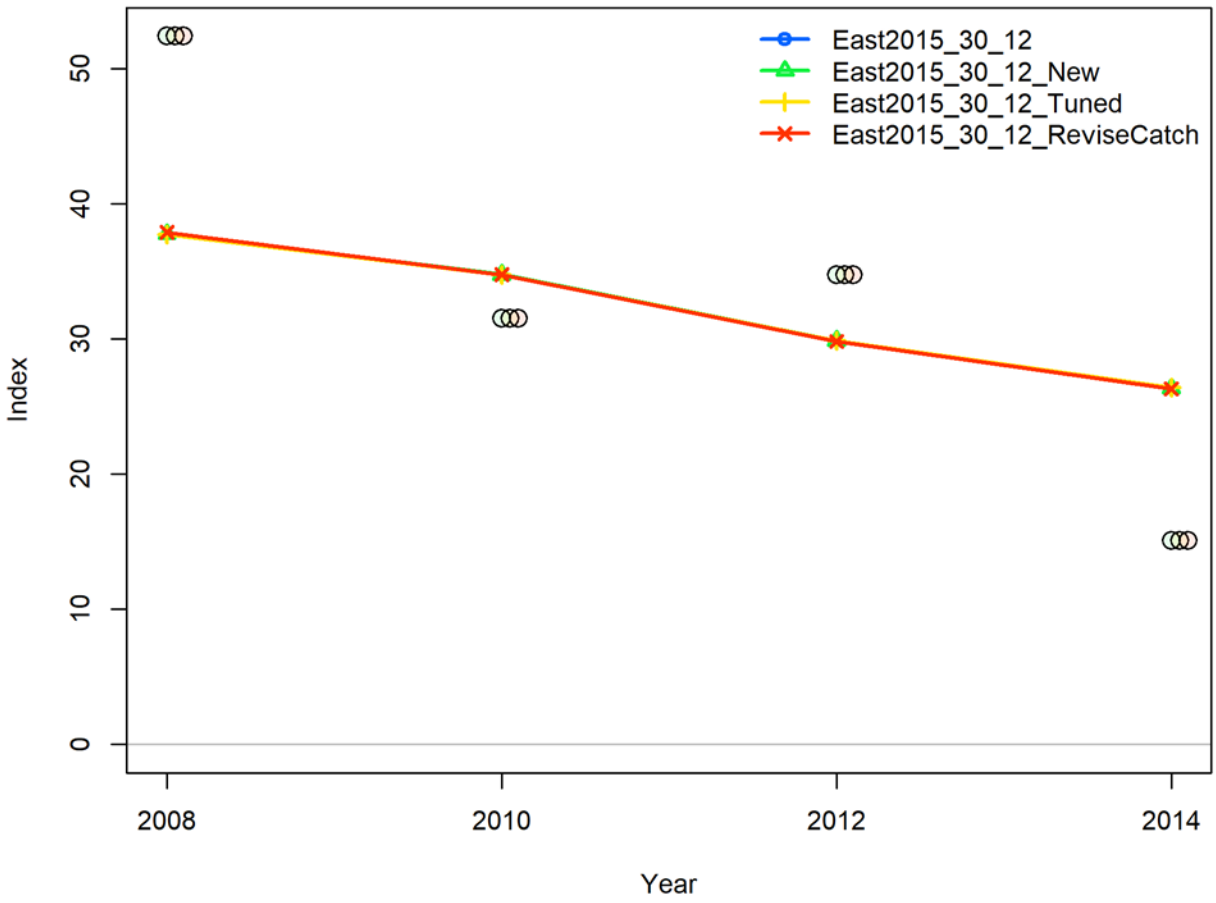

Figure 5.10. Comparison of the fit to the FIS_Tas (zone 30) abundance index for the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

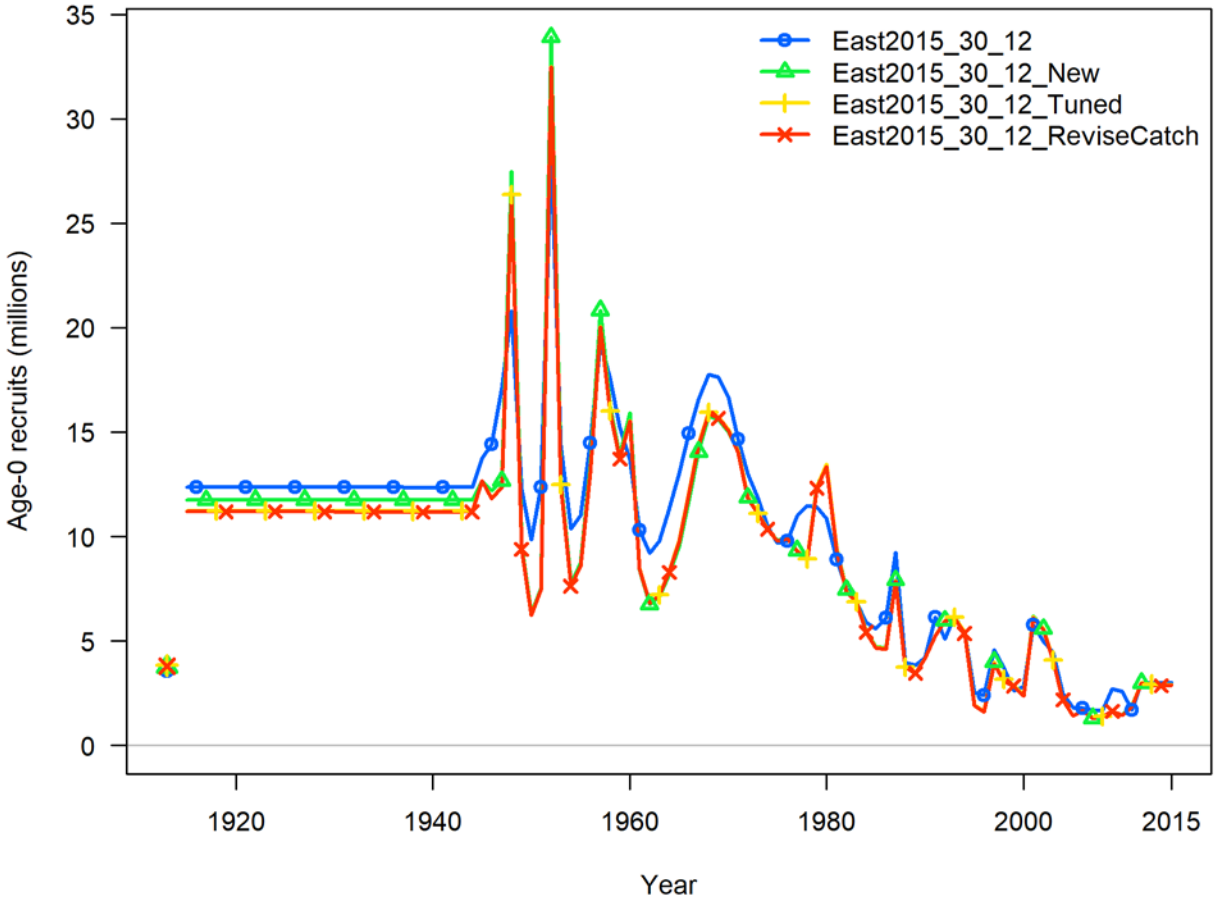

Figure 5.11. Comparison of the time series of recruitment from the 2015 assessment (East2015_30_12 – in blue), incorporating new features (East2015_30_12_New – in green), retuning the model using the latest tuning protocols (East2015_30_12_Tuned – in yellow) and revising the historical catch to 2014 and the projected catch in 2015 (East2015_30_12_ReviseCatch – in red).

5.2.2.1 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 their estimated standard errors 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.

5.2.3 *Inclusion of new data: 2015-2017*

Starting from the translated, retuned 2015 base case model with updated data to 2014 (previously referred to as “East2015_30_12ReviseCatch”, but simplified to “East2015_30_12Updated” from here on), additional data from 2015-2017 were added sequentially to build a preliminary base case for the 2018 assessment:

1. Change final assessment year to 2017, add catch to 2017 (East2018_addCatch2017).
2. Add CPUE to 2017 (from Sporcic and Haddon (2018b)), and the FIS abundance index for 2016 (Knuckey et al 2017) (East2018_addCPUE2017).
3. Add new discard fraction estimates from 1994 to 2017 (East2018_addDiscards2017).
4. Add updated length frequency data to 2017 (East2018_addLength2017).
5. Add updated age error matrix and conditional age-at-length data to 2017 (East2018_addAge2017).
6. Change the final year for which recruitments are estimated from 2011 to 2012 (East2018_extendRec2012).
7. Retune using current tuning protocols, including Francis weighting on length-compositions and conditional age-at-length data (East2018_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 5.12, Figure 5.13 and Figure 5.14), with relatively small changes to these series as more data is added. The most significant change to the absolute biomass series relates to the estimate of 1988 equilibrium spawning biomass (post productivity shift), see the lower left points in Figure 5.12. These changes are amplified in the initial depletion level in 1914, which is shown relative to the 1988 equilibrium spawning biomass in Figure 5.13, which changes slightly as data is added, effectively producing a pivot point around the 1988 equilibrium spawning biomass. Fits to the CPUE indices (Figure 5.15 to Figure 5.19) and the FIS abundance index (Figure 5.20 and Figure 5.21) feature minor changes as data is added, and with minimal changes to the historical fleets which have no new data. Both the Eastern trawl and Tasmanian trawl improve marginally as more data is added. Adding discard data appears to have the largest influence, most likely due to changes to the methods for calculating discard estimates. The fits to the FIS abundance index (Figure 5.20 and Figure 5.21) are not very good. Given the variability from point to point, it would be hard to get good fits to these series, and to fit the species biology and the rest of the data in the assessment. It appears that the fits to the much longer recent trawl CPUE indices are much more influential. The fits to the historic CPUE indices are reasonable and the fit to the eastern trawl CPUE series even matches the increase seen in the last 3 data points

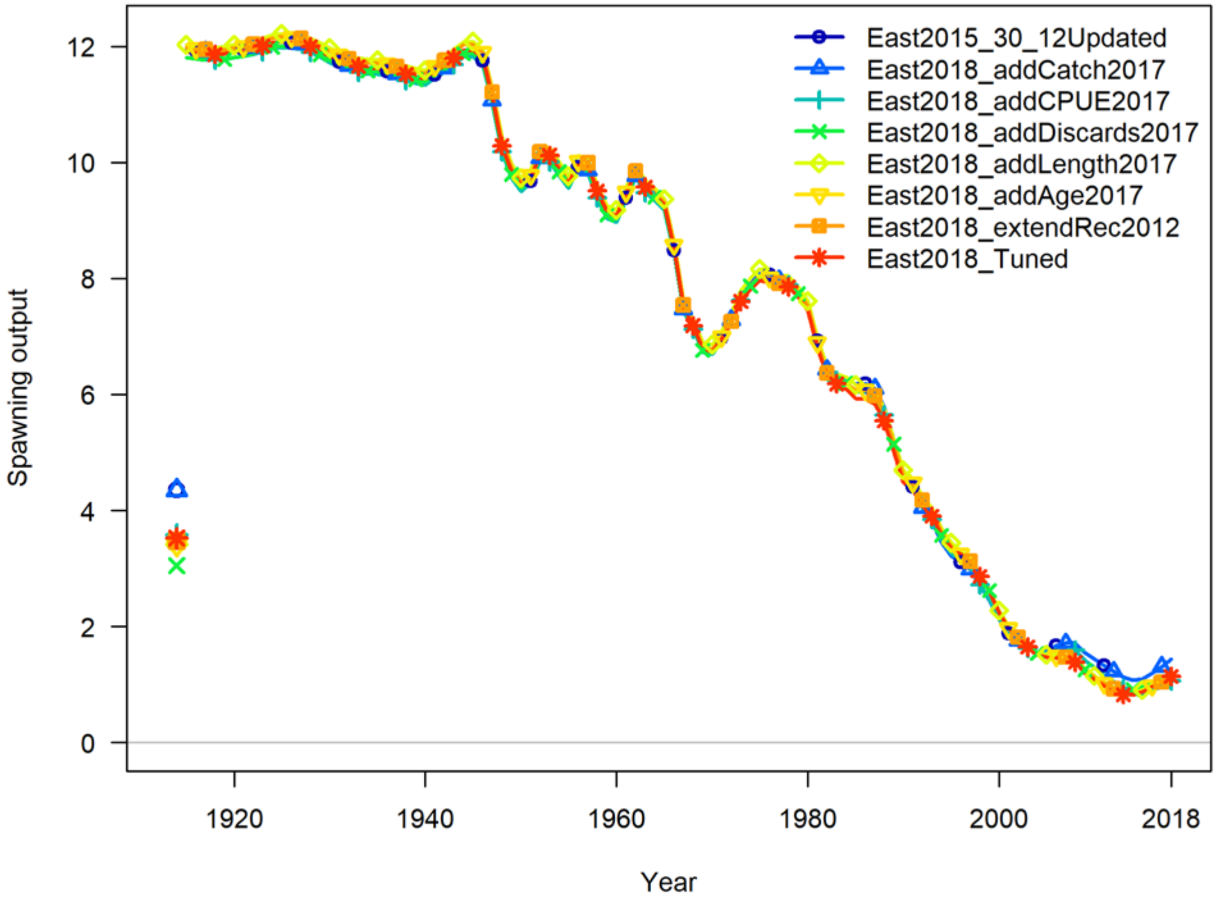

Figure 5.12. Comparison of the time series of absolute spawning biomass for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated- blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

Since the 2015 assessment, standard changes to the procedures used in the Stock Synthesis assessments in the SESSF include:

1. Revised tuning procedures, still including use of Francis weighting for length-composition and conditional age-at-length data, but tuning the weight assigned to the CPUE series within Stock Synthesis, and
2. Improvements to how the recruitment bias ramp adjustment is calculated.

Inclusion of three years of new data resulted in relatively small changes to estimates of recruitment and the spawning biomass time series, although the time series of spawning biomass now appears to have shifted a little lower in recent years with a minimum stock biomass level in 2013 and 2014 of around 23% but with an apparent recovery since then, with stronger recruitment and low fishing pressure in recent years. Recruitment was only able to be estimated for one additional year, despite using three more years of additional data, with upward revisions to the recruitment estimates from 2010 and 2011 and slightly higher than average recruitment estimated for 2012. These latest recruitment estimates may be further revised with the inclusion of additional data in future assessments, with new data that may help inform these recruitment estimates. The 2015 assessment estimated the depletion at the start of 2016 at 37%. This provisional base case has an estimate of depletion at the start of 2019 (projected assuming 2017 catches in 2018) of 35% of unexploited stock biomass, SSB_0. The equilibrium female spawning biomass in 1988 (post productivity shift) equilibrium female spawning biomass of 3,523 t (reduced from 3,977 t from the 2015 assessment) and in 2019 the female spawning biomass is projected to be 1,237t.

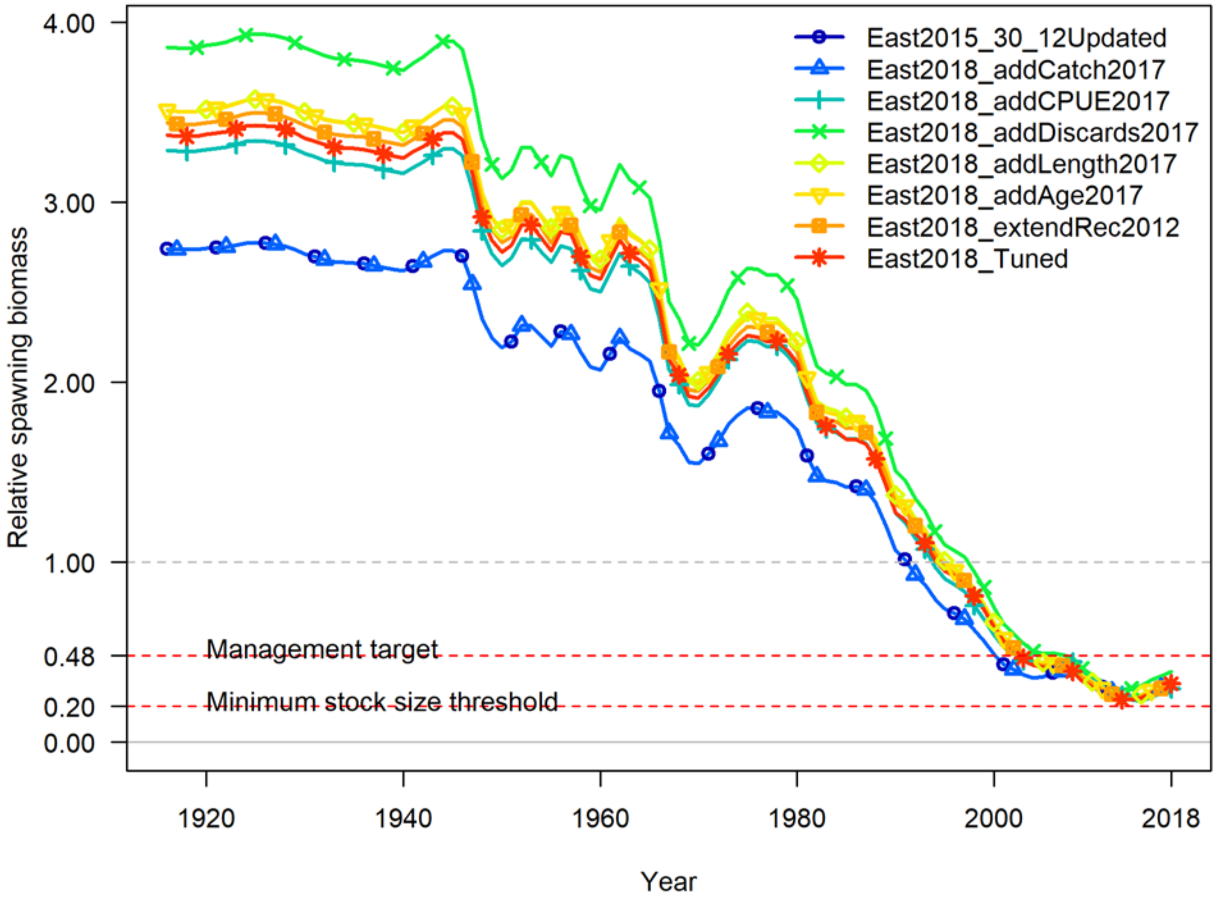

Figure 5.13. Comparison of the time series of relative spawning biomass for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

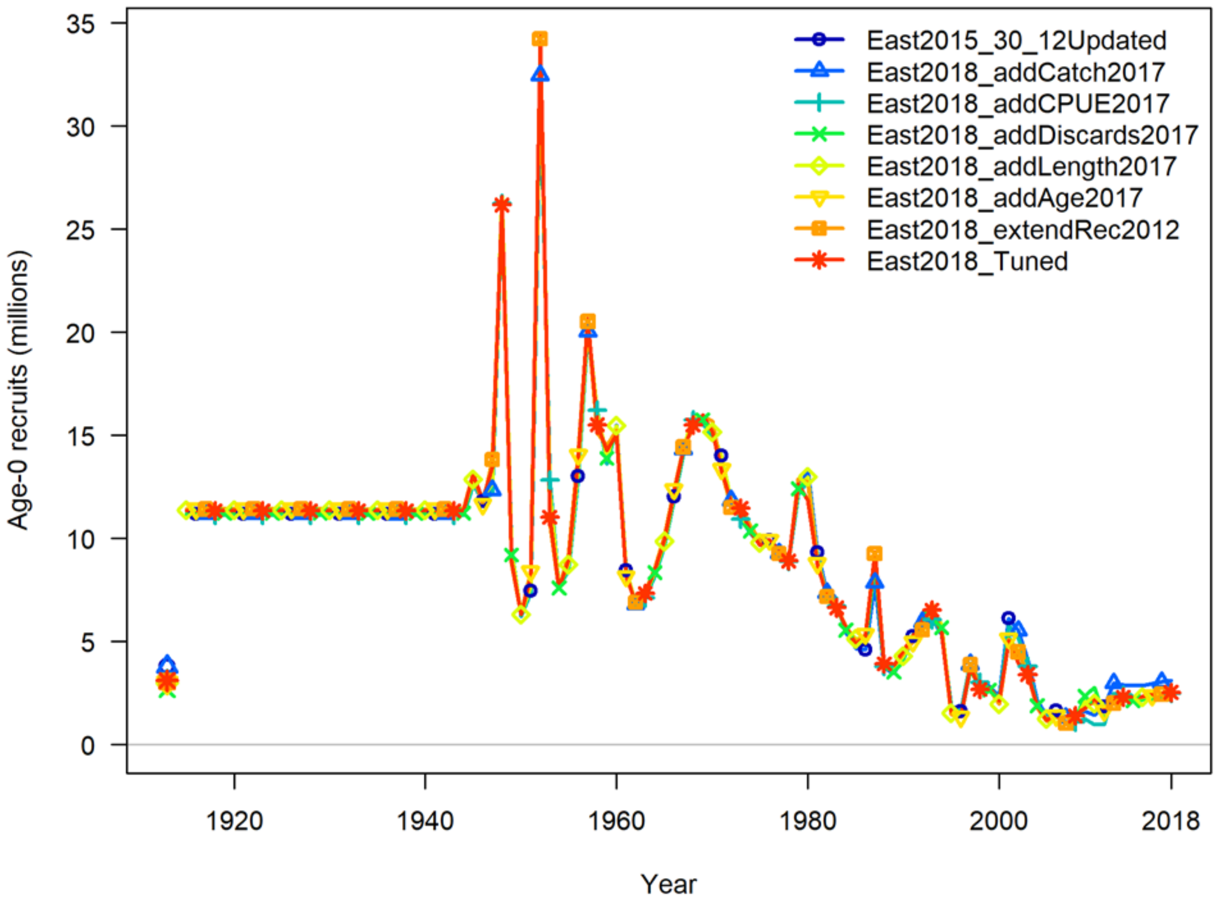

Figure 5.14. Comparison of the time series of recruitment from the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

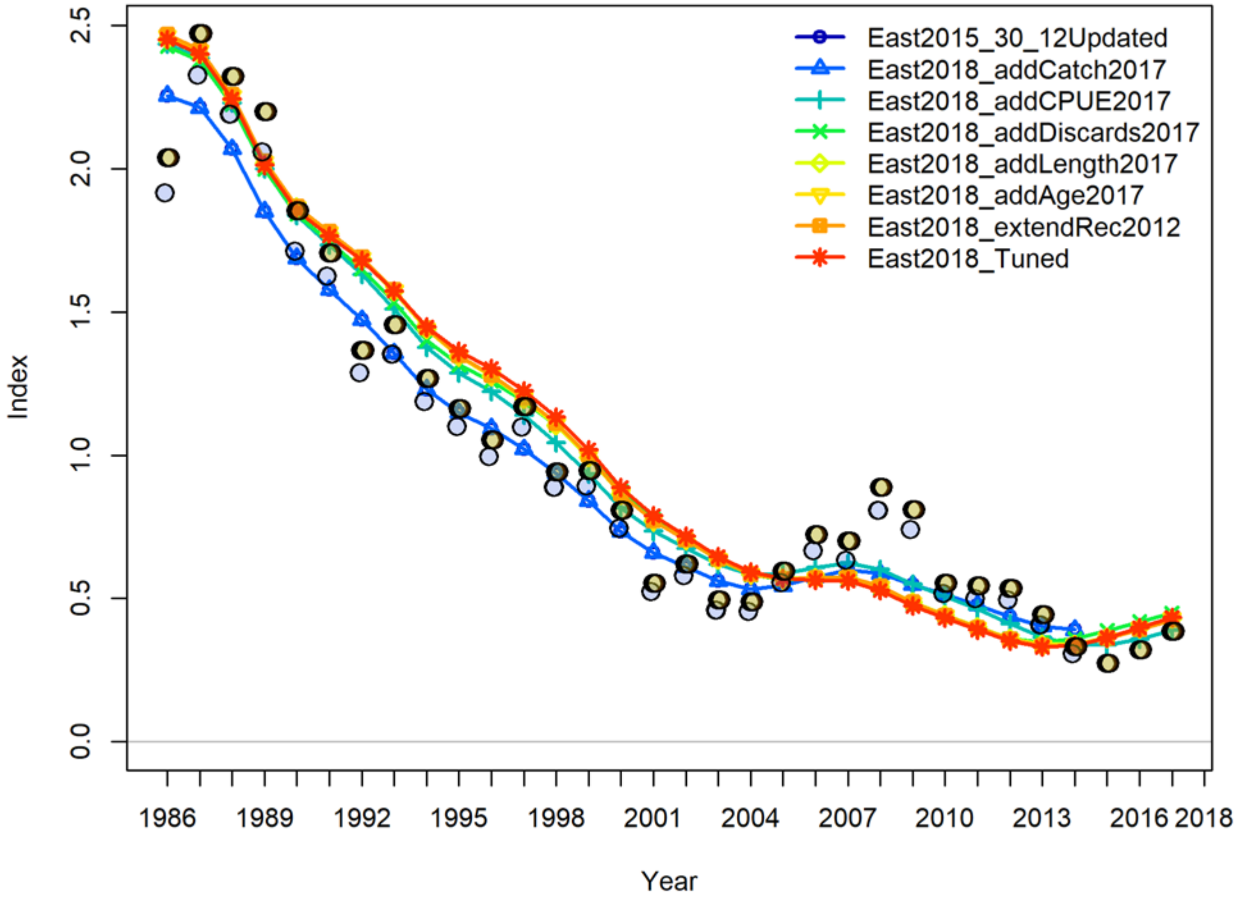

Figure 5.15. Comparison of the fit to the eastern trawl CPUE index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

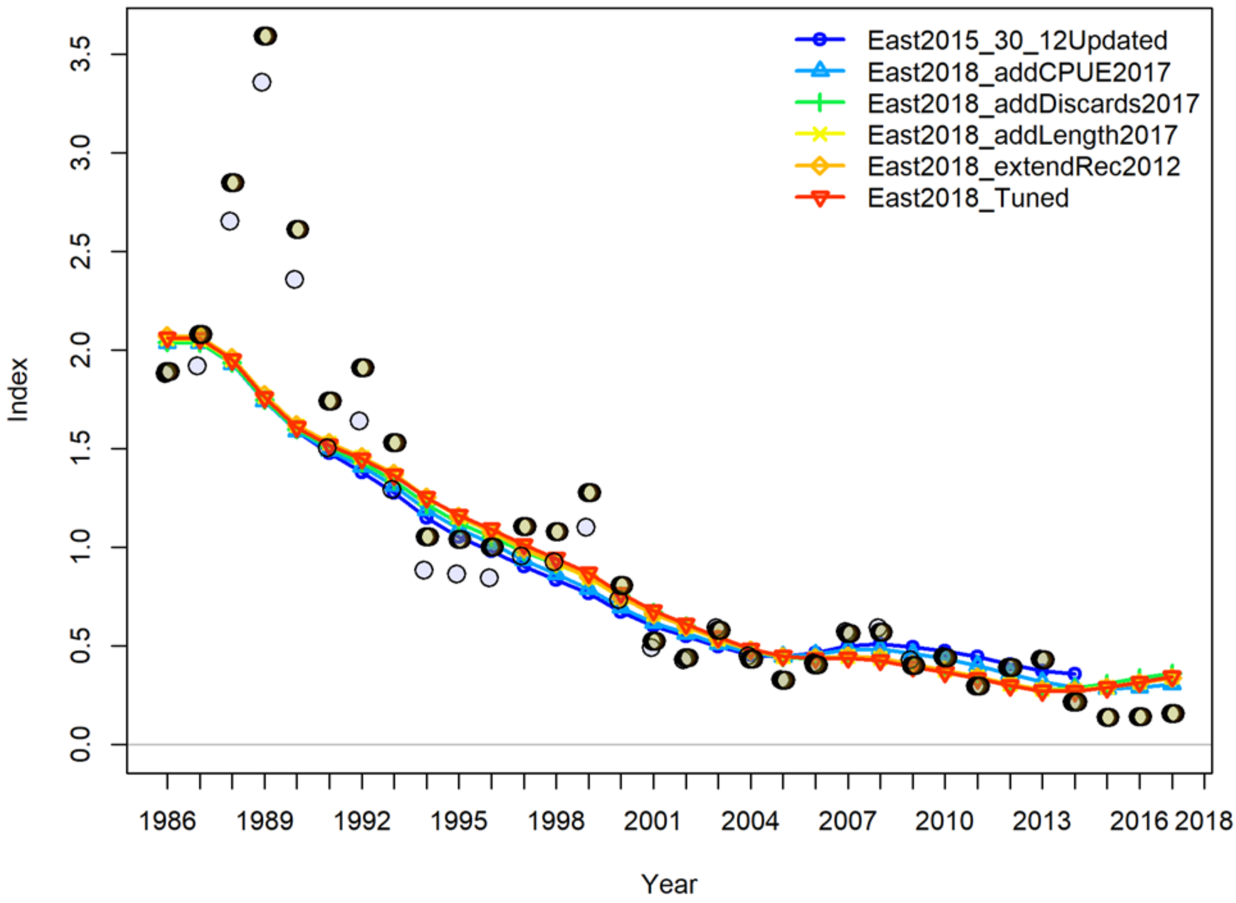

Figure 5.16. Comparison of the fit to the Tasmanian trawl CPUE index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

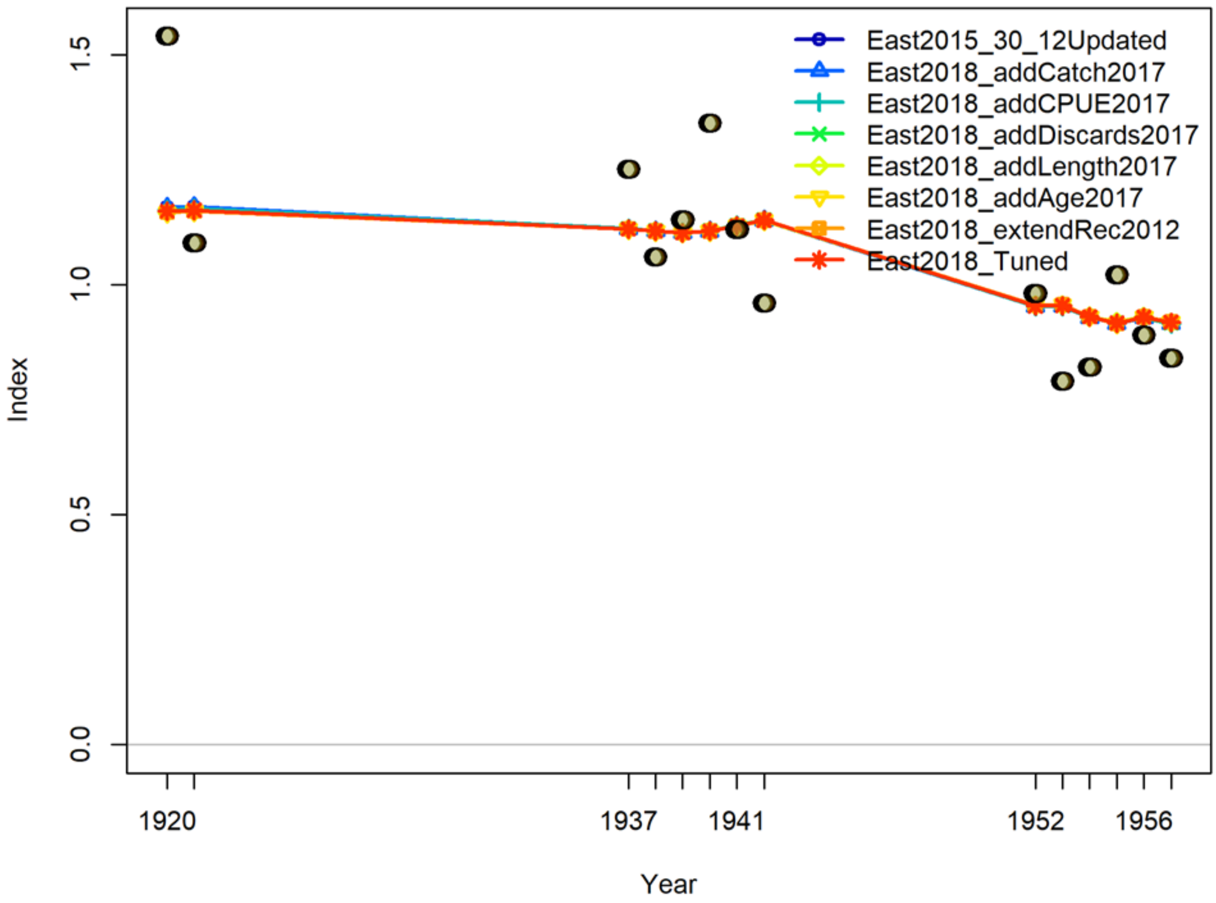

Figure 5.17. Comparison of the fit to the steam trawl CPUE index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

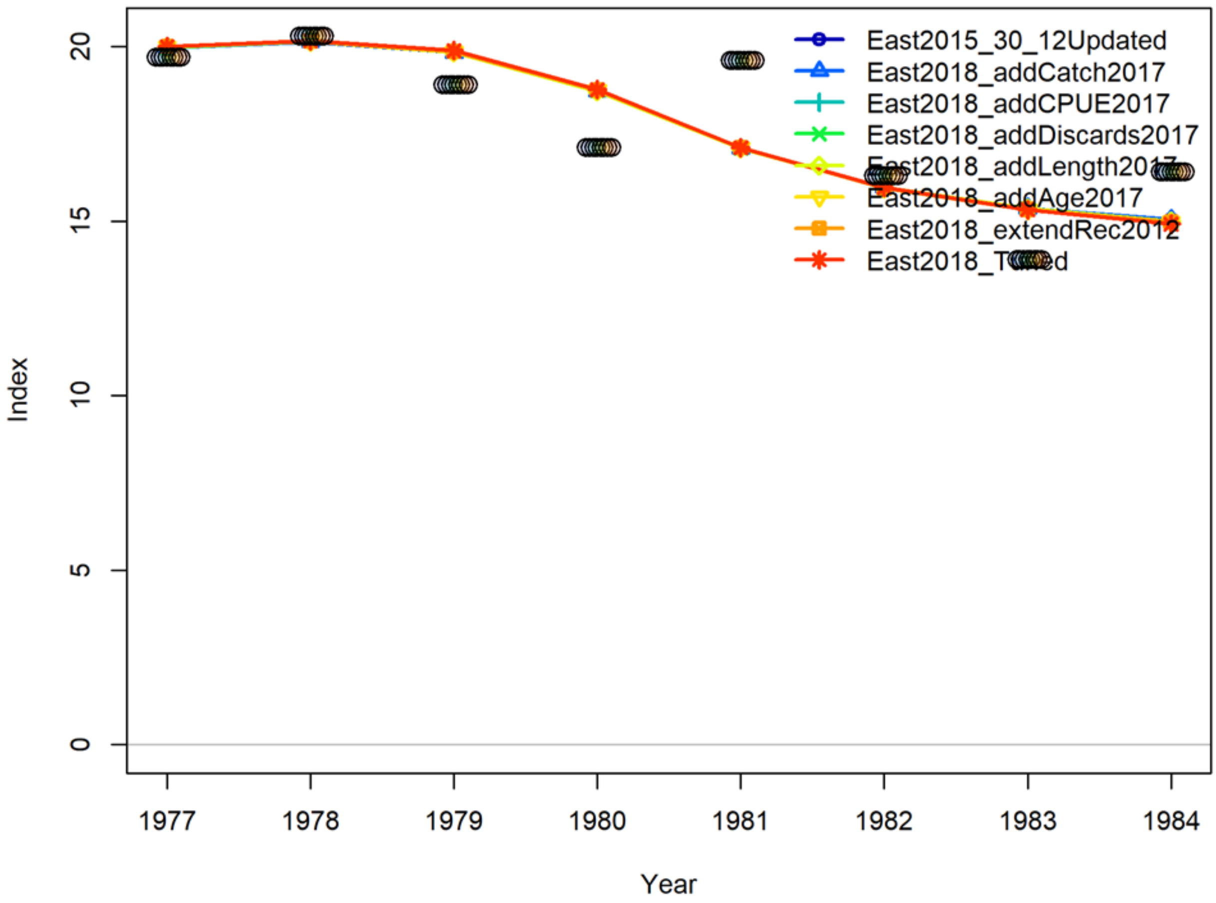

Figure 5.18. Comparison of the fit to the mixed CPUE index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

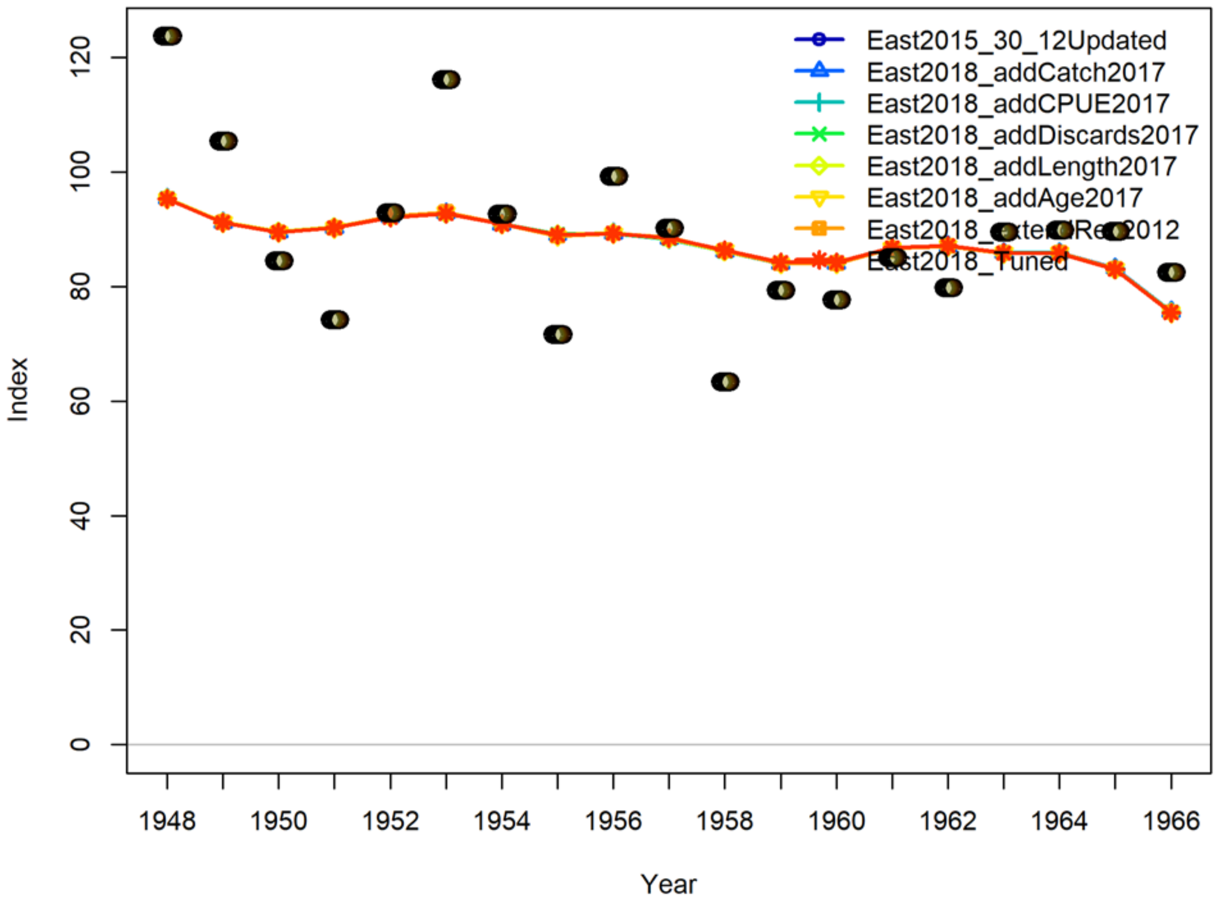

Figure 5.19. Comparison of the fit to the Smith CPUE index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

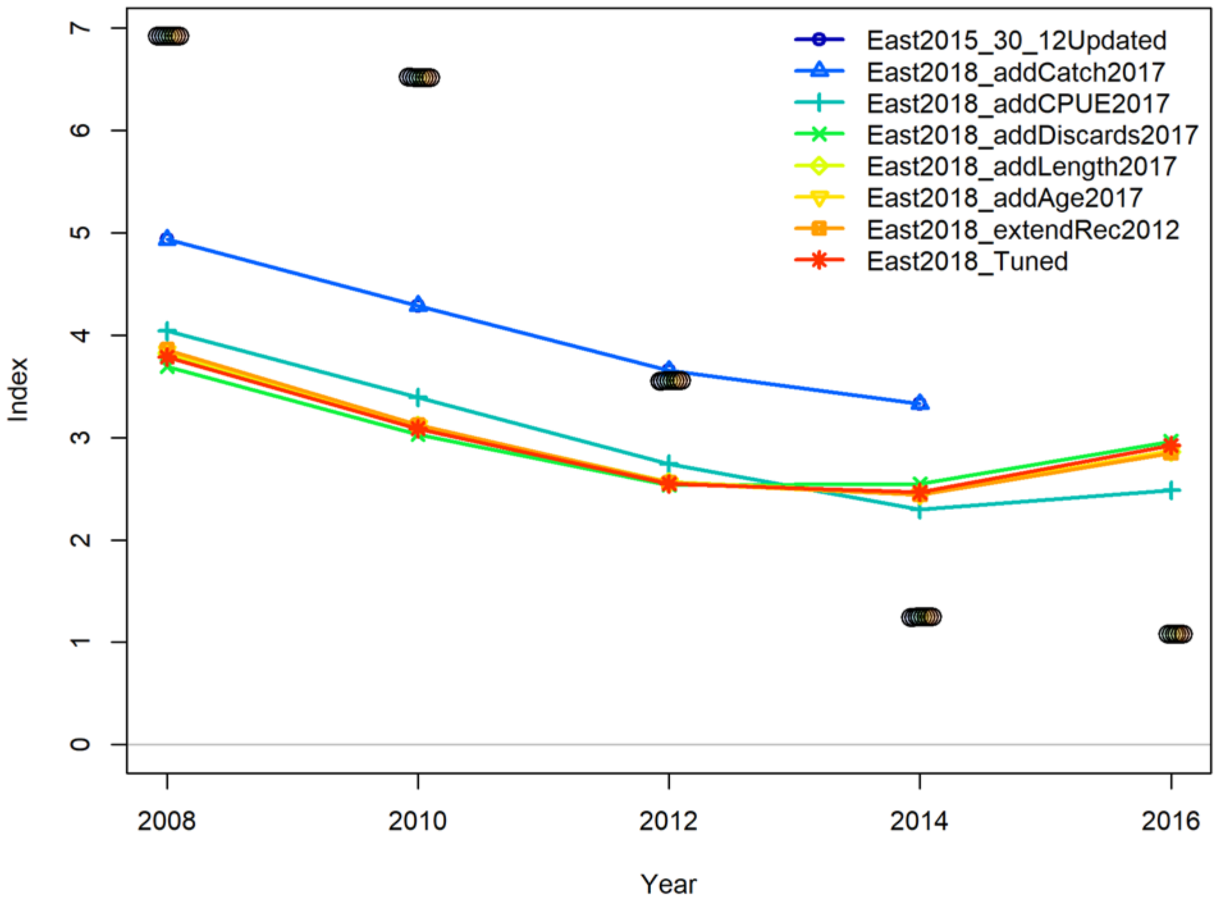

Figure 5.20. Comparison of the fit to the FIS east (Zones 10 and 20) index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

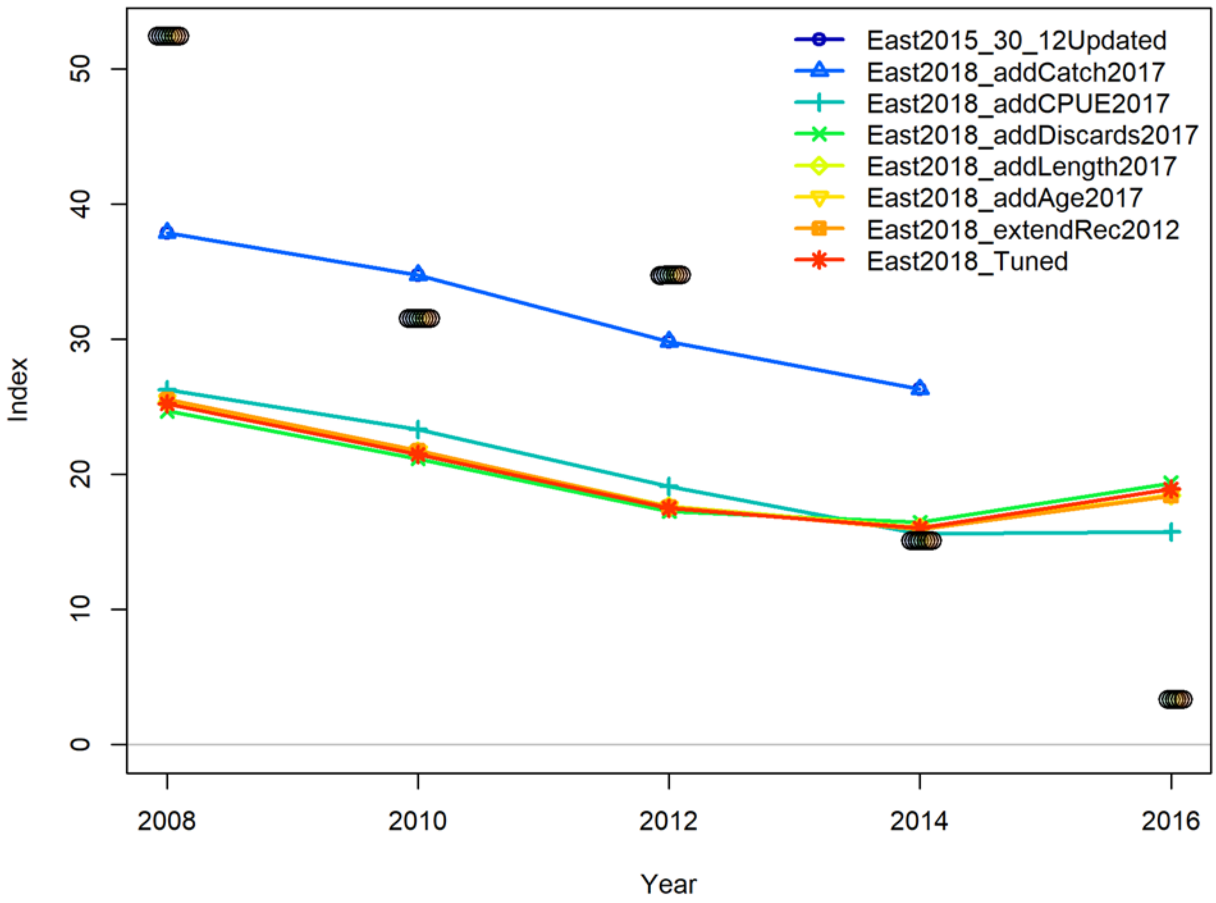

Figure 5.21. Comparison of the fit to the FIS Tas (Zone 30) index for the updated 2015 assessment model converted to SS-V3.30.12 (East2015_30_12_updated - blue) with various bridging models leading to a proposed 2018 base case model (East2018_Tuned - red).

5.2.4 *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. 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 ($\ln R_0$).

For jackass morwong east, the likelihood profile for natural mortality, *M*, a parameter fixed in the model, is shown in Figure 5.22, with the total likelihood shown in black and components of the total likelihood from different data sources shown in a range of colours. This shows that the fixed value chosen for *M* ($0.15yr^{-1}$) is outside the 95% confidence interval suggested by the likelihood profile (approximately 0.18-0.34). However, this is driven largely by the fits to the CPUE index, and in particular by the Eastern trawl fleet. In contrast the discard, age and length data all suggest a lower value of natural mortality than suggested by the fits to the CPUE index, albeit with lower contributions to the overall likelihood. This suggests that better fits to the eastern trawl CPUE index could be obtained with a higher value of natural mortality. This could be explained by changes in targeting practice or indeed a potential change in natural mortality in recent years, neither of which are incorporated in the model, or by suggesting that there is insufficient information in the data to be able to reliably inform an estimate of natural mortality. The maximum age observed in the data and the biology of jackass morwong should certainly be considered when making decisions on the value used for natural mortality.

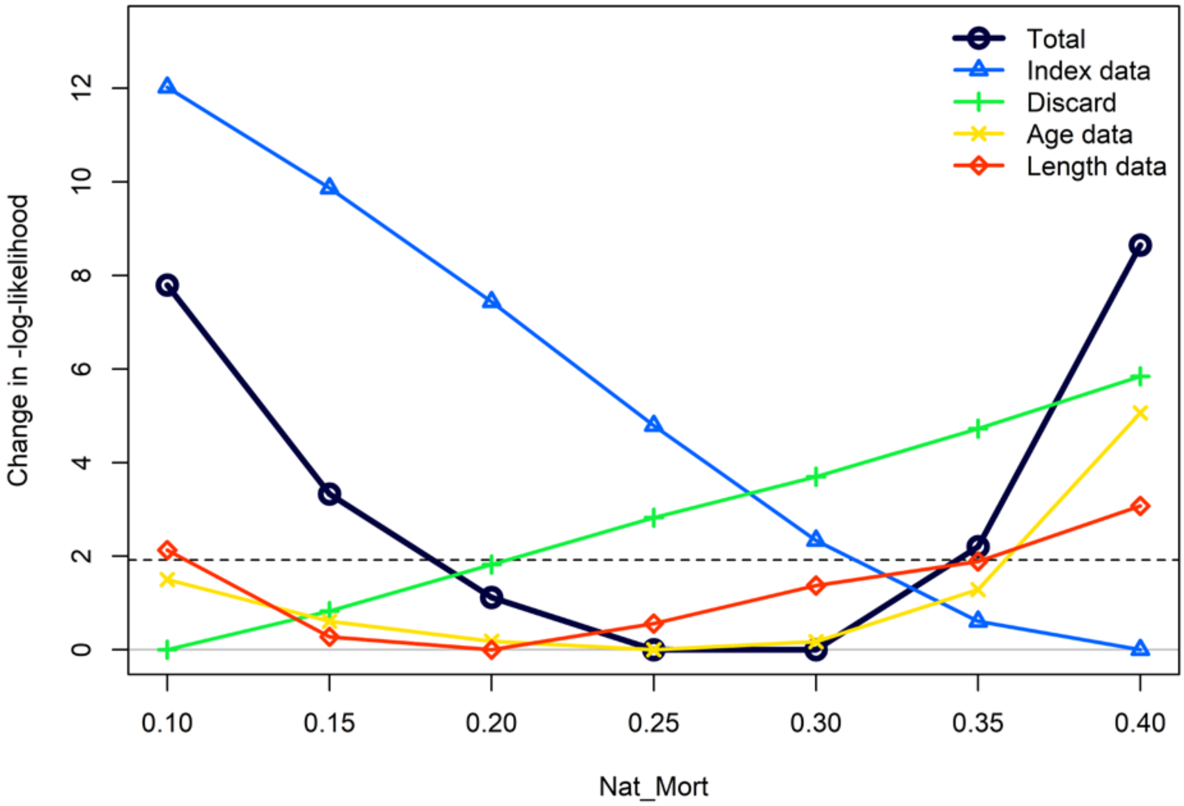

Figure 5.22. The likelihood profile for natural mortality. The fixed value for *M* is $0.15yr^{-1}$.

The likelihood profile for steepness, *h*, (Figure 5.23) suggests that there is little information in the model that can be used to inform this parameter (fixed at 0.7 in the model). The length data (higher steepness, but a small change in absolute value of likelihood) and recruitment data (lower steepness) are in conflict, and the likelihood profile, suggests lower values of steepness are preferred, but this is essentially uninformative when the biological consequences of a steepness of 0.3 or less are considered.

The likelihood profile for the logarithm of the unfished recruitment (lnR_0) would be a useful addition to this analysis.

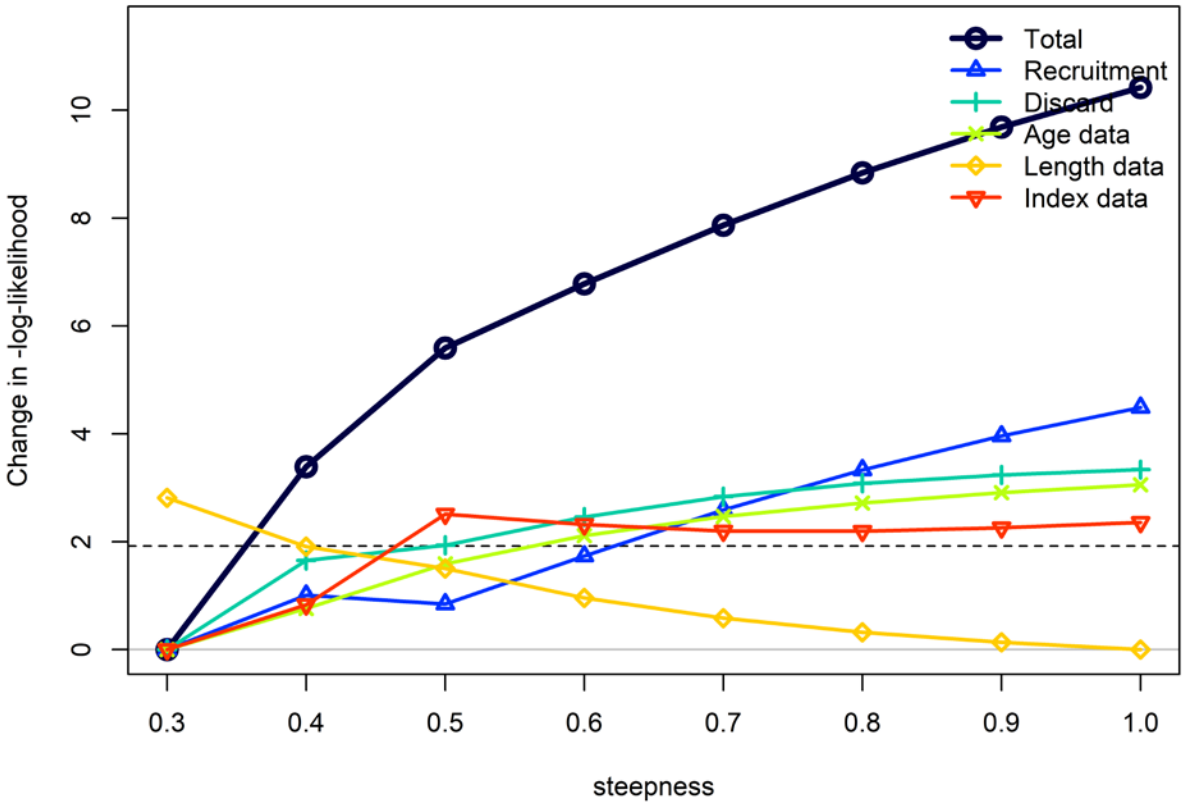

Figure 5.23. The likelihood profile for steepness. The fixed value for h is 0.7.

5.2.5 *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 5.24, with initially the data after 2017 removed (shown in blue), then successive years of data removed back to 2012 (shown in red). While these time series look very similar, the points in the lower left of the plot indicate changes in the 1988 equilibrium spawning biomass, which is used to determine the current stock status. This suggests that this value is not well determined as it is being decreased in a systematic way as more years of data are included in the assessment. This is clearer when this analysis is presented in terms of relative spawning biomass (Figure 5.25), with minor changes at the end of the series (up to 2018) but much larger changes at the start of the series, and perhaps a larger effect from removing the 2017 and 2016 data than removing earlier years. In this plot, the recent spawning biomass is plotted relative to the 1988 equilibrium spawning biomass, and the initial spawning biomass is also plotted relative to the 1988 equilibrium spawning biomass, and this is much greater than one due to the productivity shift implemented in this model. When this retrospective analysis is applied to the recruitment time series (Figure 5.26), the more recent data results in a revision downward to the recruitment estimates in the period 2009-2012. This analysis should probably have also included a change to the last year that recruitment is being estimated to prevent this pattern from occurring, and spurious recruitments being estimated at the end of the time series, with little data available to inform these estimates.

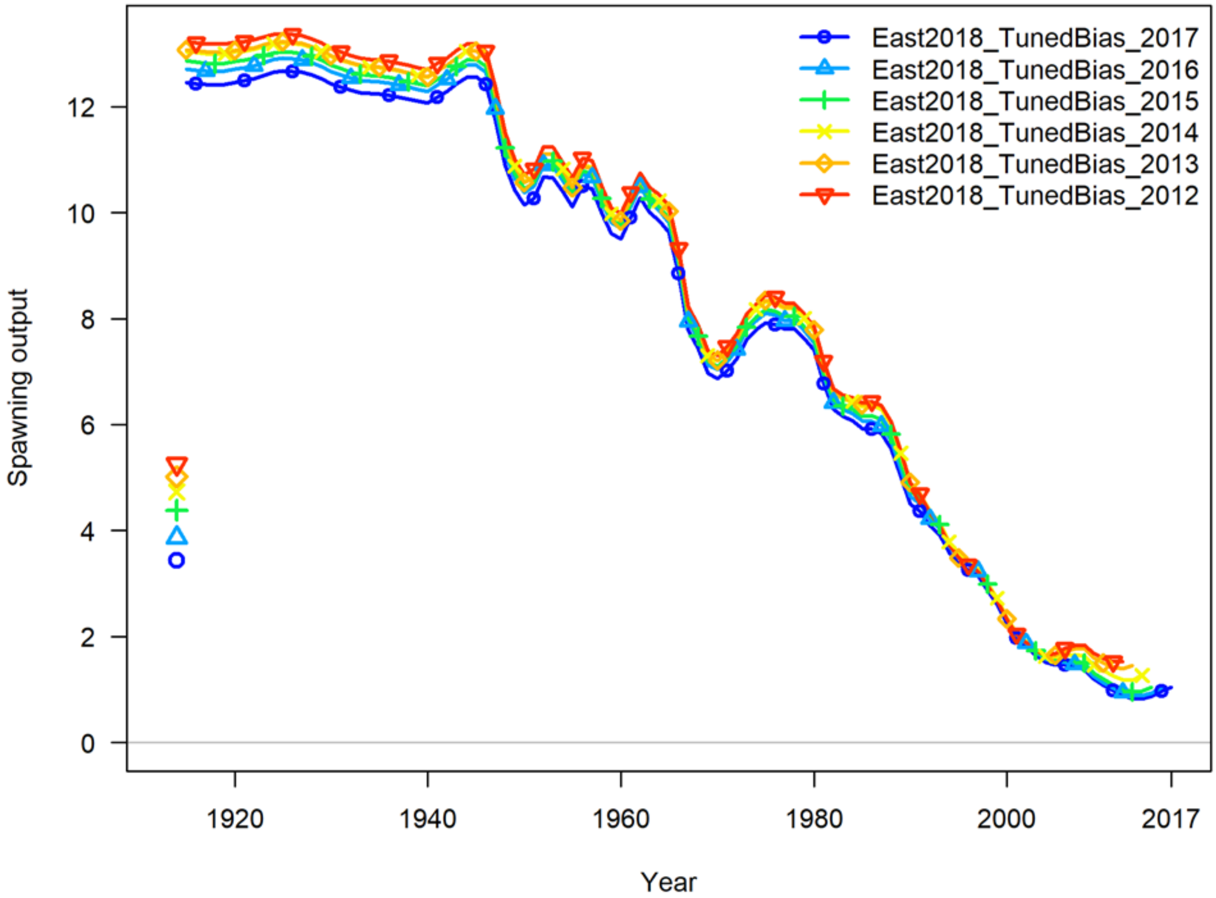

Figure 5.24. Retrospectives for absolute spawning biomass for eastern jackass morwong, with data removed back to 2017 (blue) and then successive years removed back to 2012 (red).

5.2.6 *Future work and unresolved issues*

There are some unresolved issues relating to recent state catches for the period 2015-2017, but these catches are relatively small and any future revisions are unlikely to have much influence on the assessment outcomes.

Two other sensitivities relating to the Fishery Independent Survey (FIS) would be useful.

1. Excluding all FIS data.
2. Including FIS length frequency data and estimating selectivity for the FIS fleet.

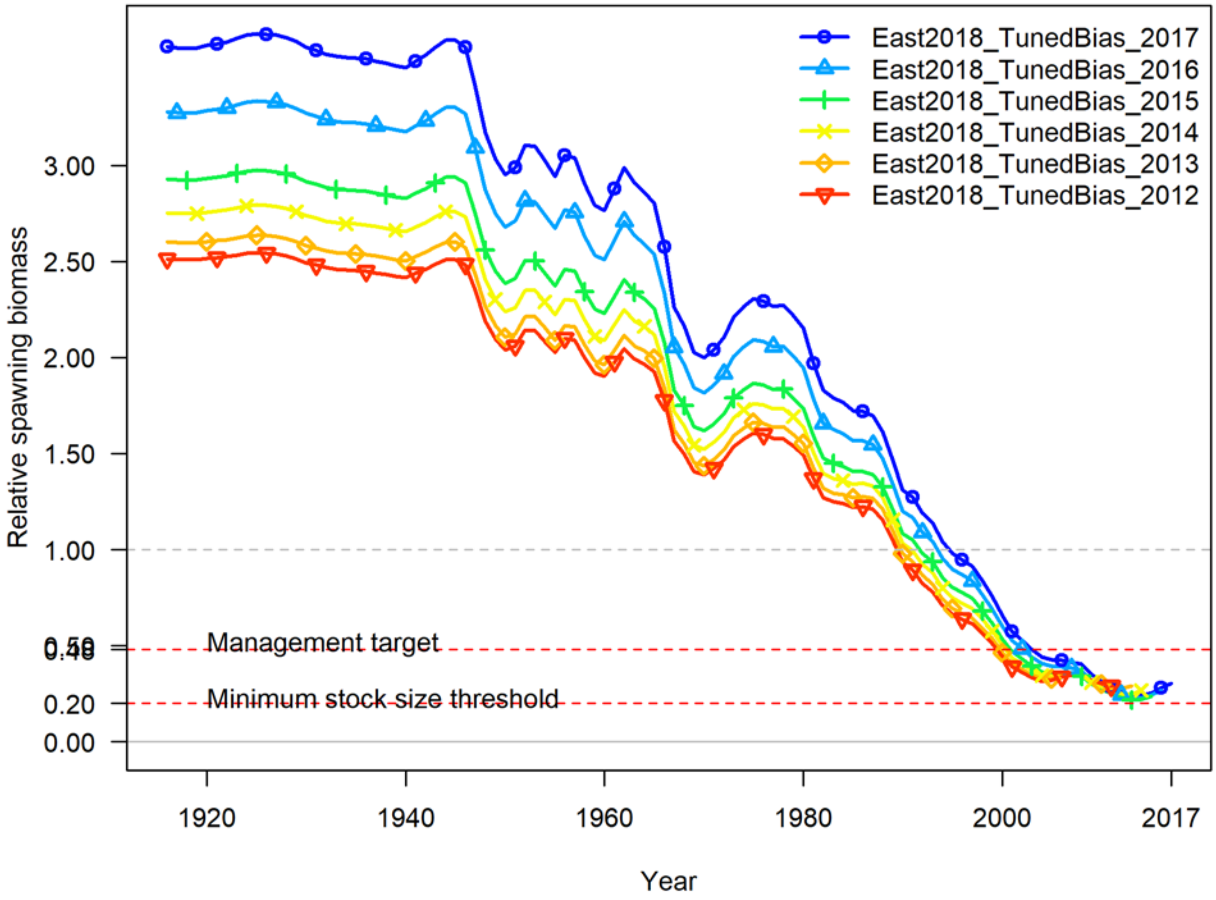

Figure 5.25. Retrospectives for relative spawning biomass for eastern jackass morwong, with data removed back to 2017 (blue) and then successive years removed back to 2012 (red).

Any results from this assessment should be treated with some caution given the recent data quality available for this assessment and the quality of the trawl CPUE data. Sporcic and Haddon (2018a) indicate that "the structural adjustment altered the effect of the vessel factor on the standardised result. However, log(CPUE) has also changed in character from 2014 - 2017, with spikes of low catch rates arising".

Note that the preliminary base case model fit to the FIS abundance indices are poor (Figure 5.20 and Figure 5.21), with additional CVs on these abundance series estimated within the model at 0.54 and 0.74 respectively. The additional CV estimated to the eastern trawl CPUE index was 0.09, with a negative value estimated for all other CPUE indices, indicating the initial CV values were too broad for these other fleets.

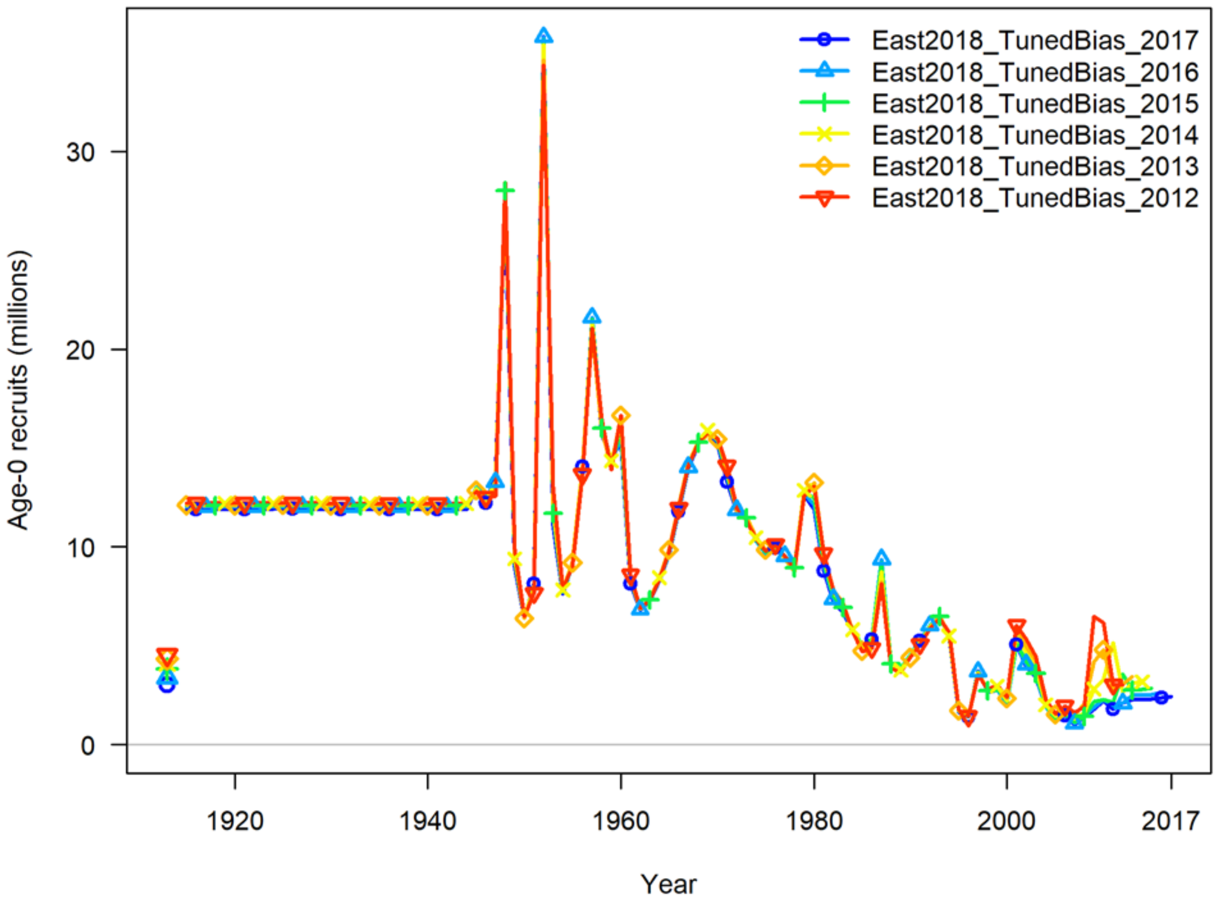

Figure 5.26. Retrospectives for recruitment for eastern jackass morwong, with data removed back to 2017 (blue) and then successive years removed back to 2012 (red).

5.3 Acknowledgements

Age data were provided by Kyne Krusic-Golub (Fish Ageing Services), ISMP and AFMA logbook and CDR data were provided by John Garvey (AFMA). Franzis Althaus, Mike Fuller, Roy Deng, Claudio Castillo-Jordán, and Paul Burch (CSIRO) pre-processed the data. André Punt, Geoff Tuck, Sandra Curin-Osorio, Paul Burch, Malcolm Haddon, Robin Thomson and Miriana Sporcic are thanked for helpful discussions on this work. Ian Taylor, Richard Methot and Chantel Wetzel (NOAA Fisheries) are thanked for all the Stock Synthesis support and advice. Malcolm Haddon provided useful code for auto-tuning, Athol Whitten provided useful R code for organising plots.

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5.5 Appendix A

A.1 Preliminary base case diagnositcs

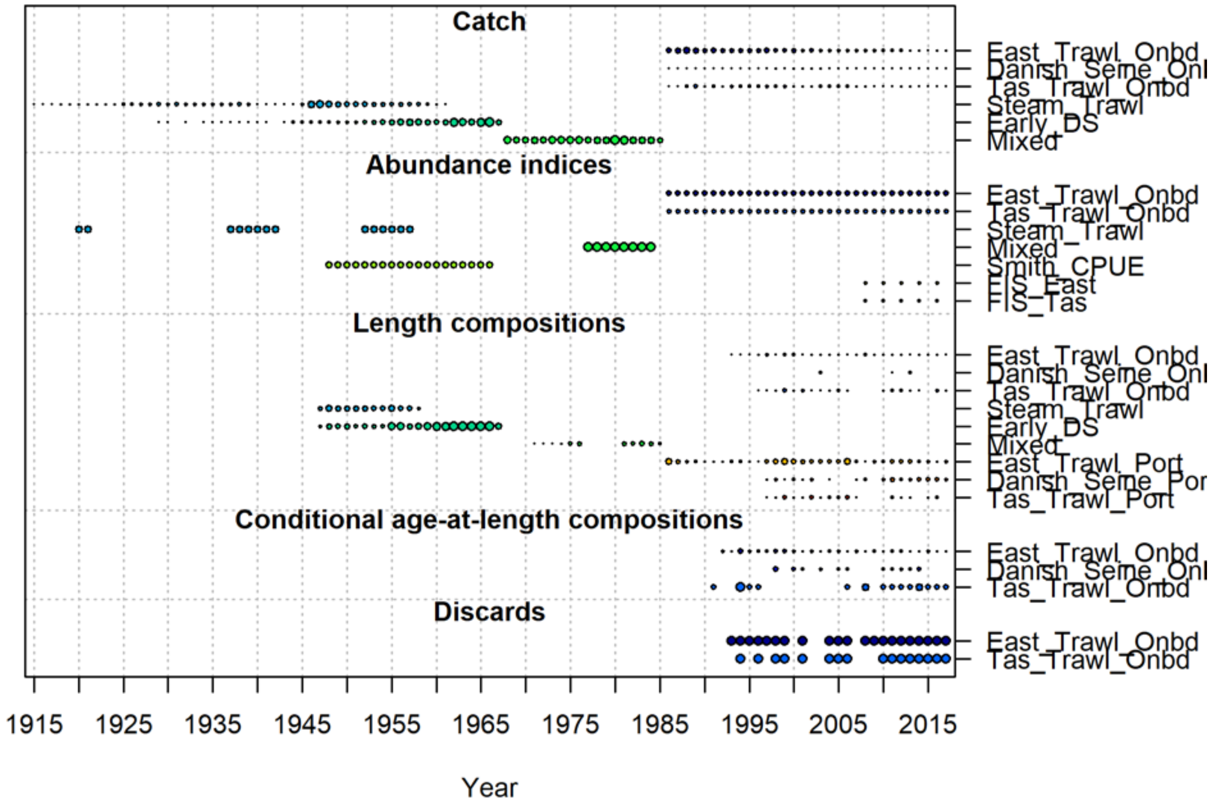


Figure A 5.1. Summary of data sources for eastern jackas morwong stock assessment.

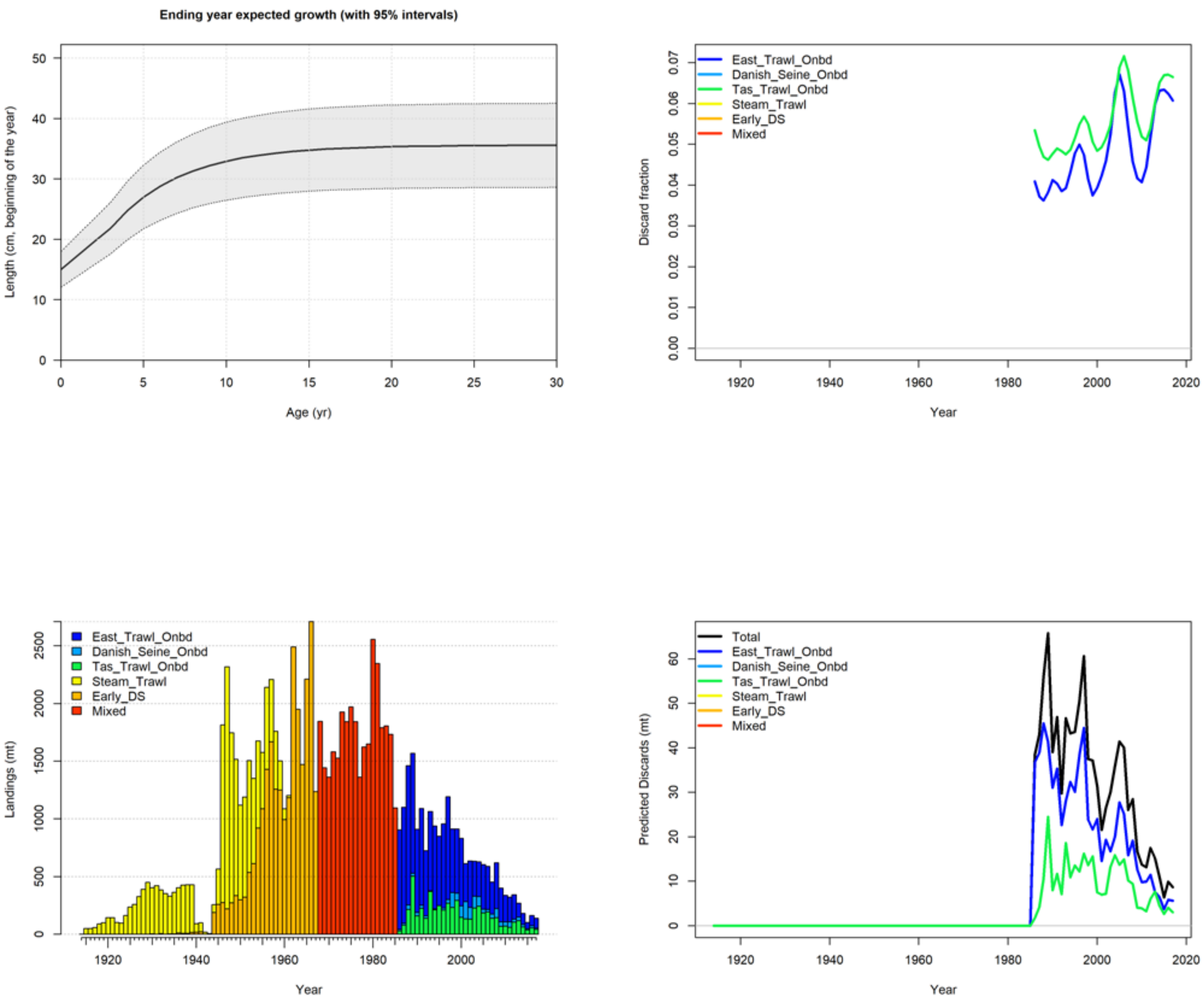


Figure A 5.2. Growth, discard fraction estimates, landings by fleet and predicted discards by fleet for eastern jackass morwong.

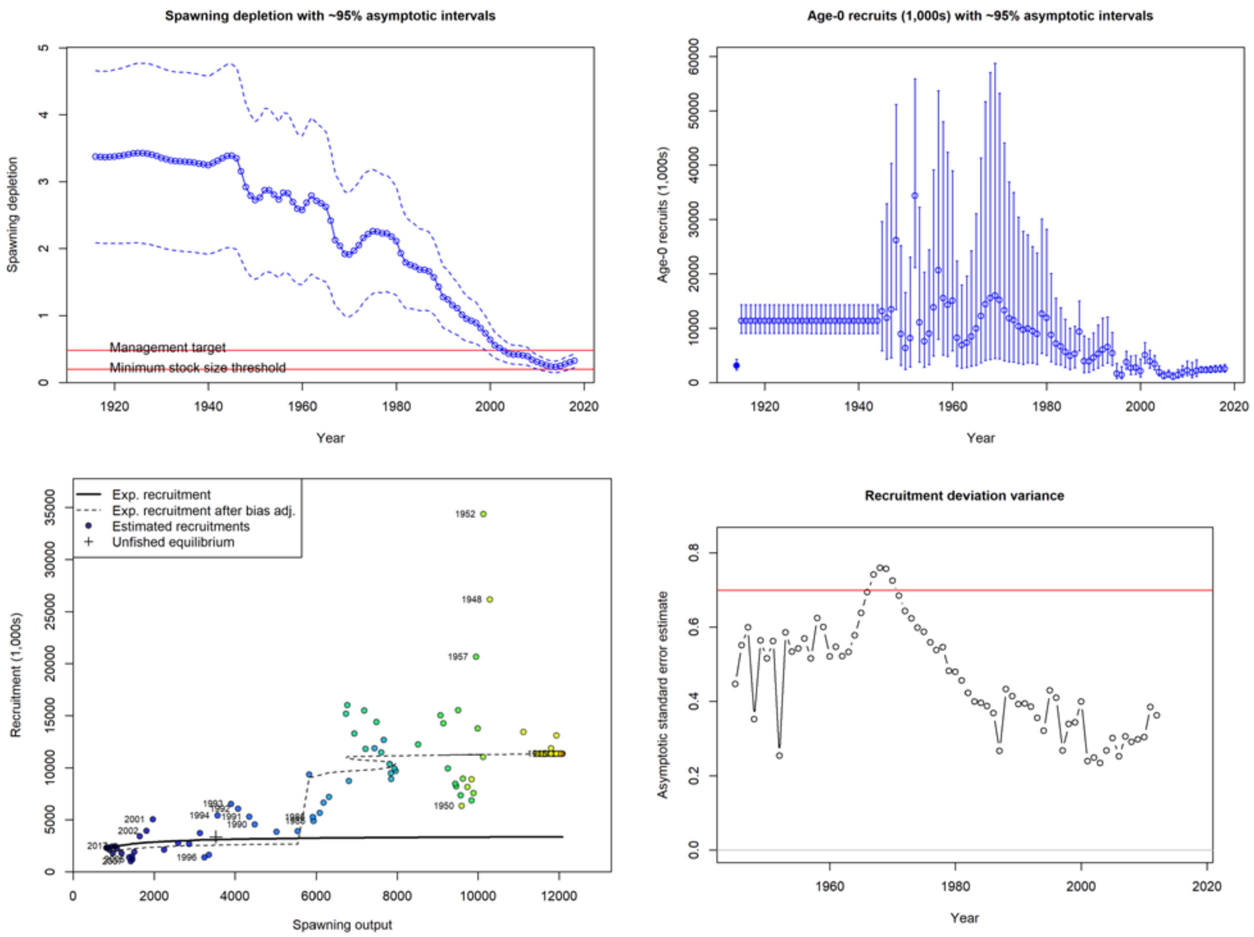
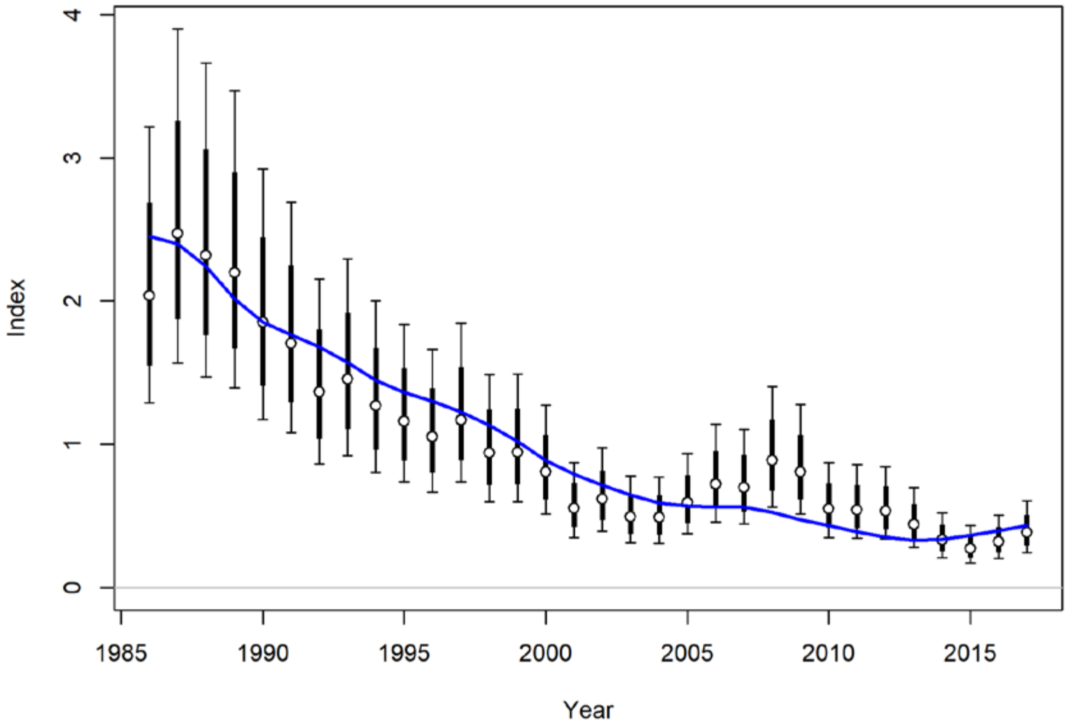


Figure A 5.3. Time series showing depletion of spawning biomass with confidence intervals, recruitment estimates with confidence intervals, stock recruitment curve and recruitment deviation variance check for eastern jackass morwong.



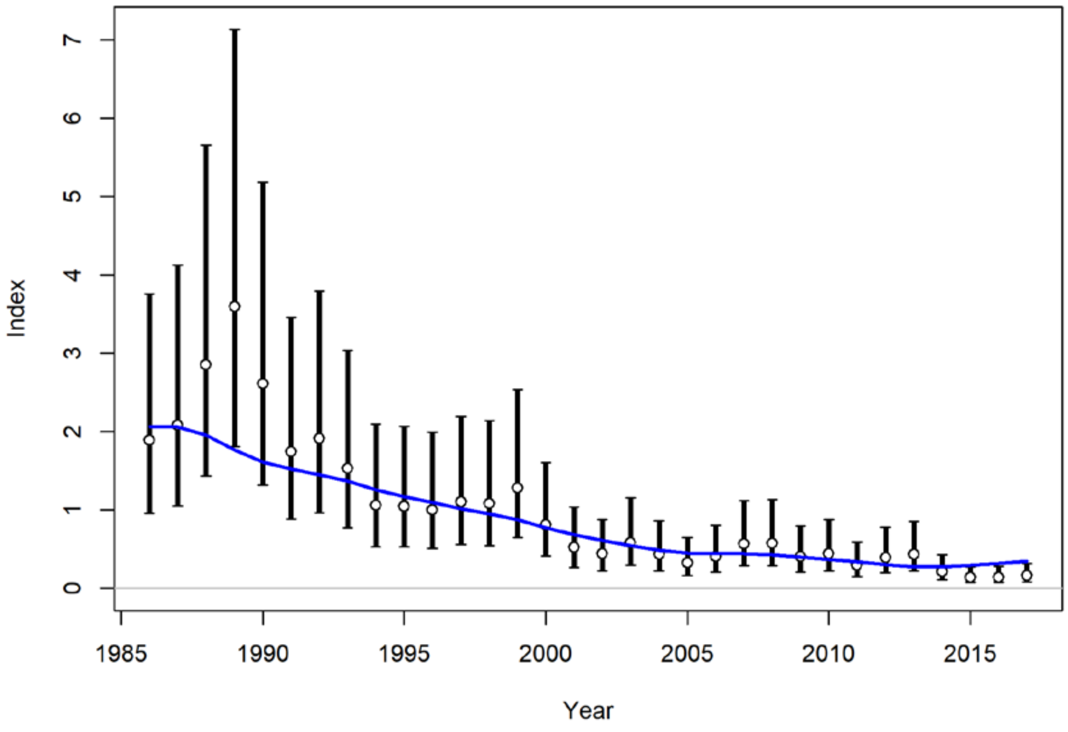
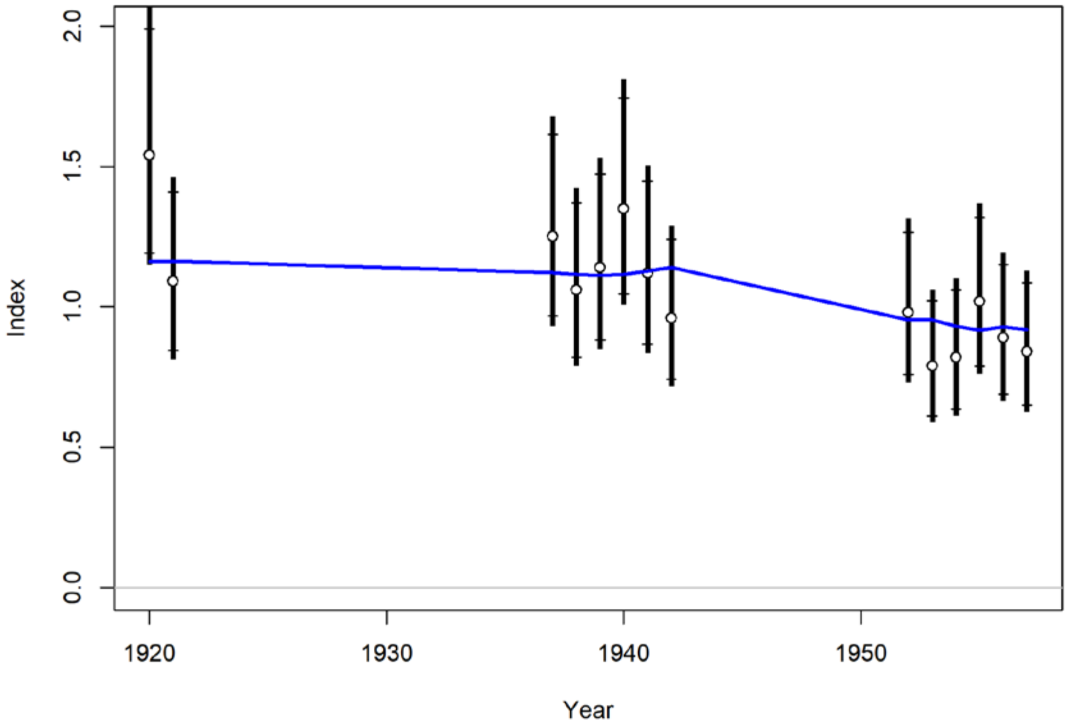


Figure A 5.4. Fits to CPUE by fleet for eastern jackass morwong: eastern trawl (top) and Tasmanian trawl (bottom).



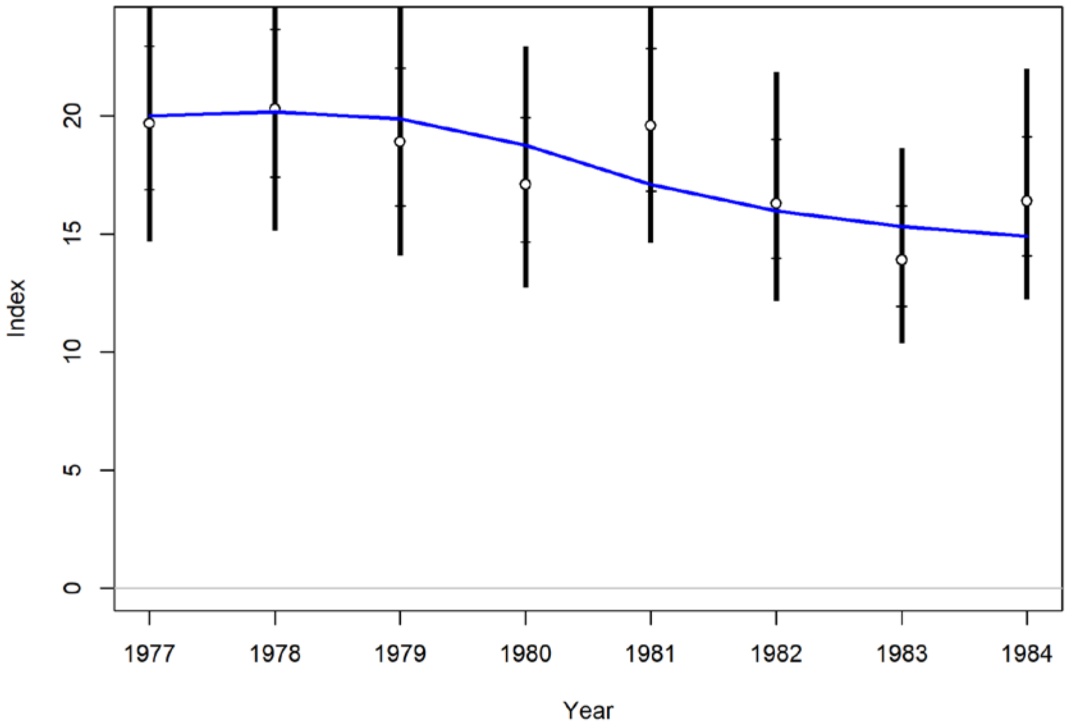


Figure A 5.5. Fits to CPUE by fleet for eastern jackass morwong: steam trawl (top) and mixed (bottom).

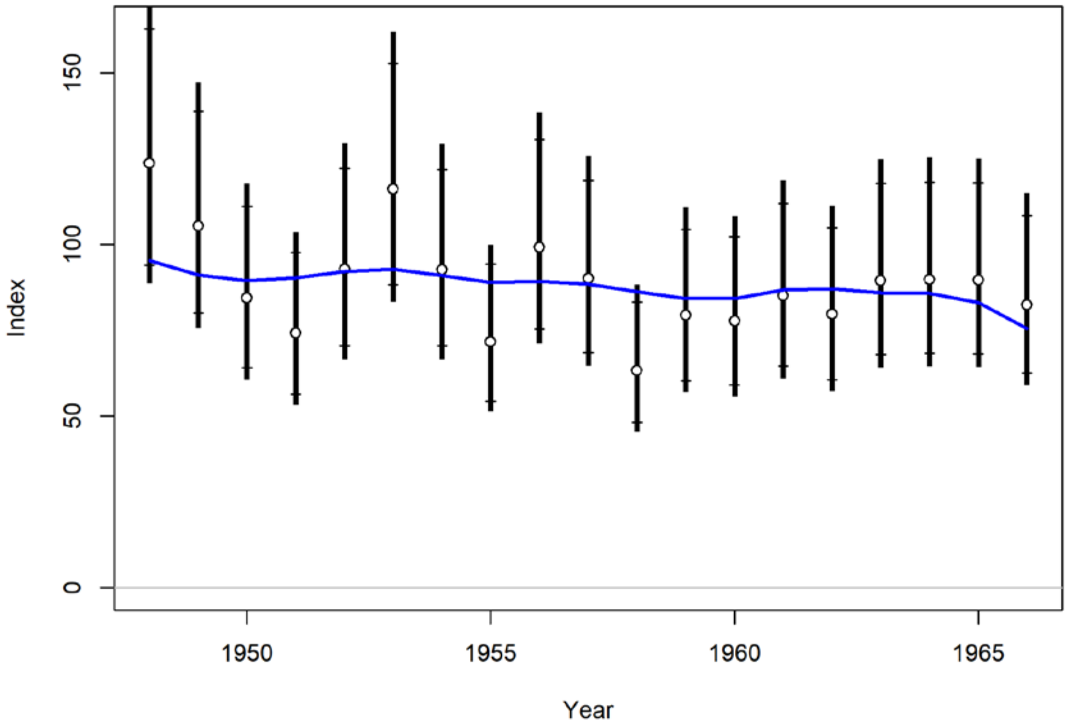


Figure A 5.6. Fits to CPUE by fleet for eastern jackass morwong: Smith CPUE.

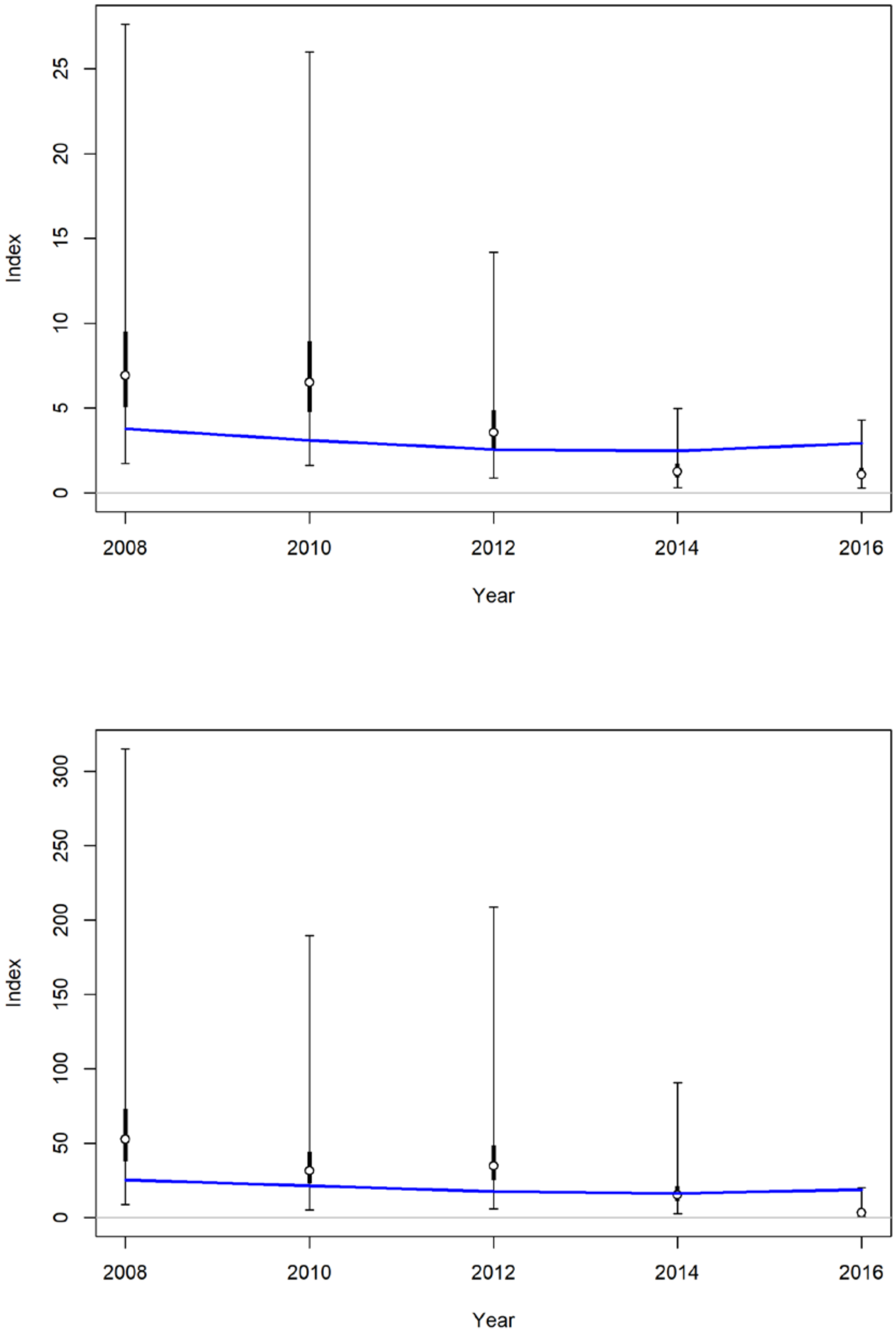
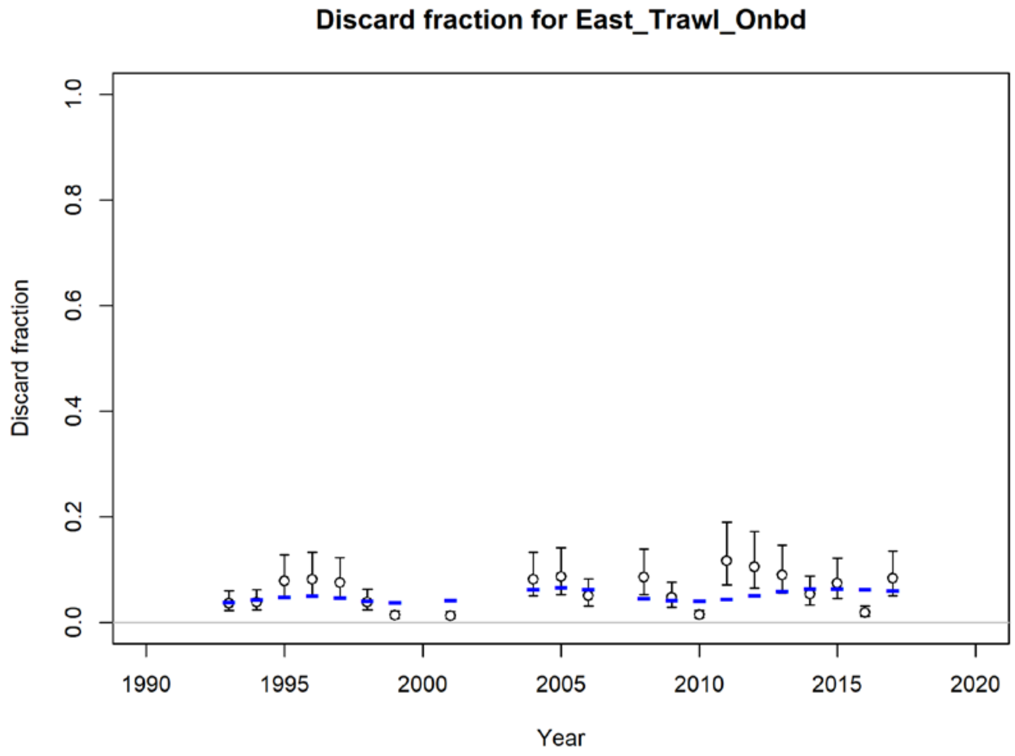


Figure A 5.7. Fits to FIS by fleet for eastern jackass morwong: eastern trawl (top) and Tasmanian trawl (bottom).



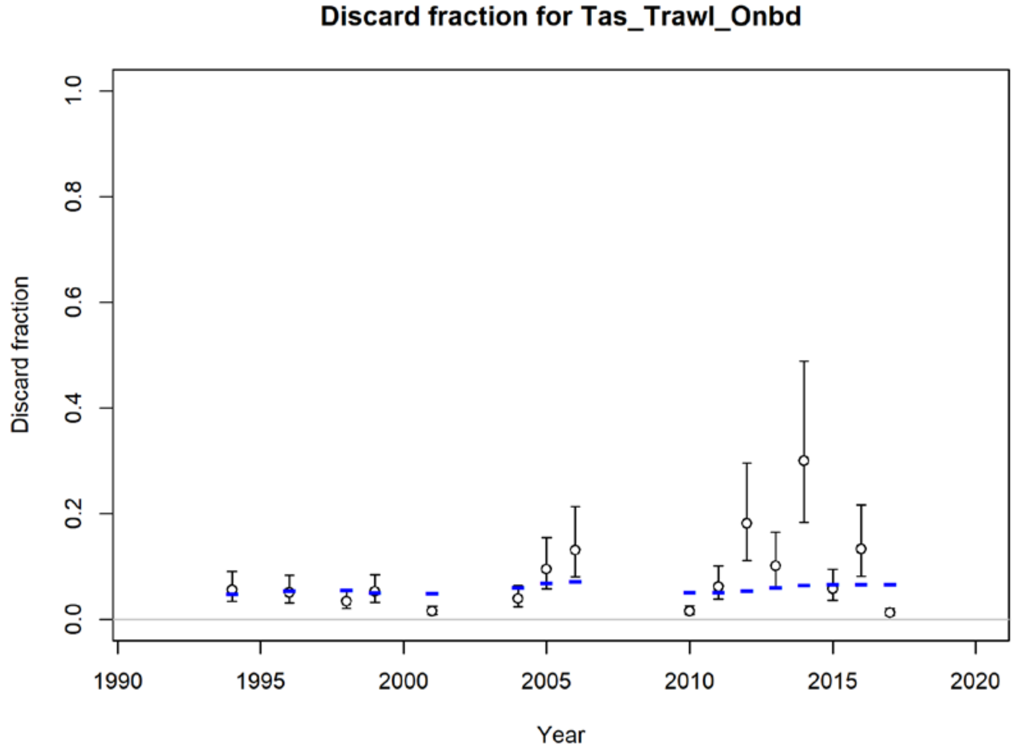


Figure A 5.8. Fits to discard rates for eastern trawl (top) and Tasmanian trawl (bottom) for eastern jackass morwong.

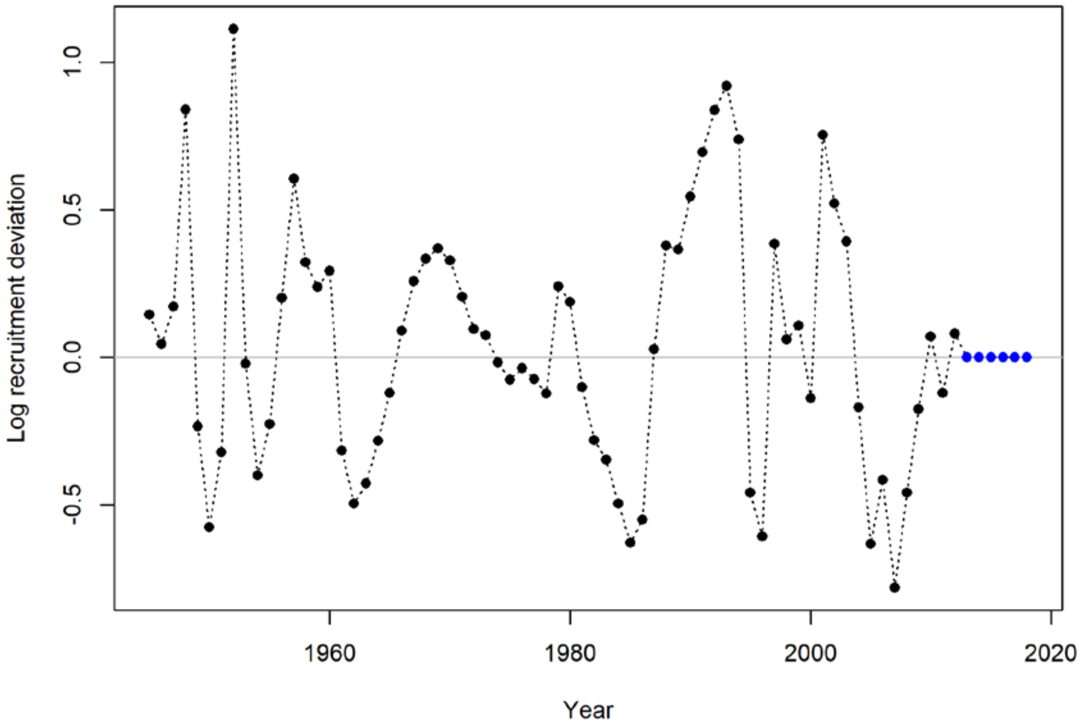


Figure A 5.9. Recruitment deviations for eastern jackass morwong.

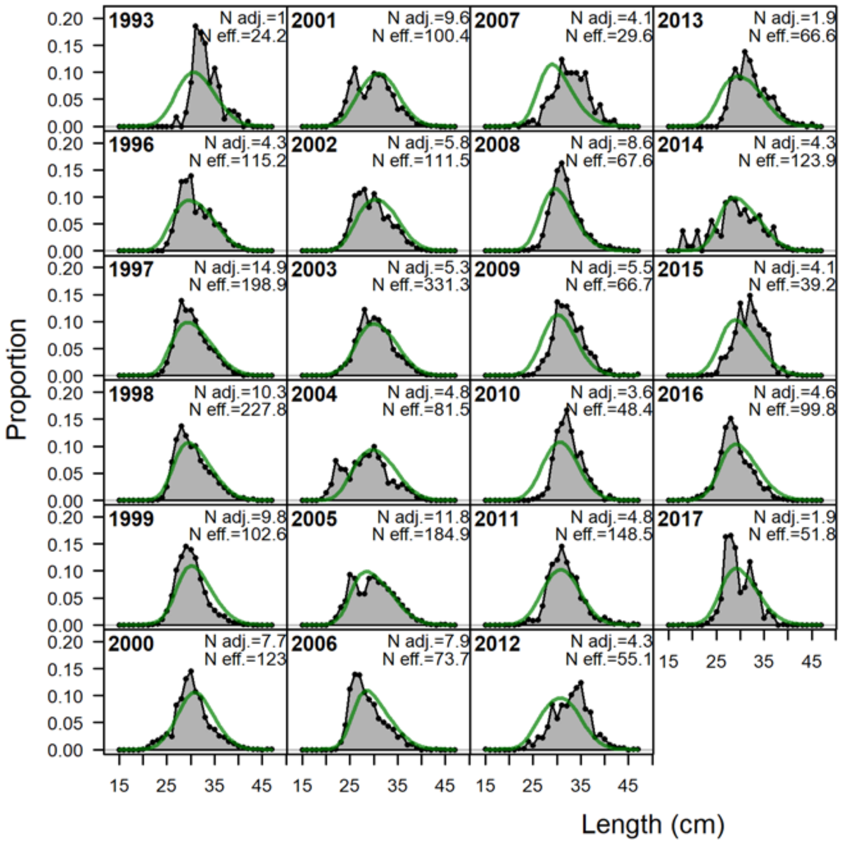


Figure A 5.10. Eastern jackass morwong length composition fits: eastern trawl onboard retained.

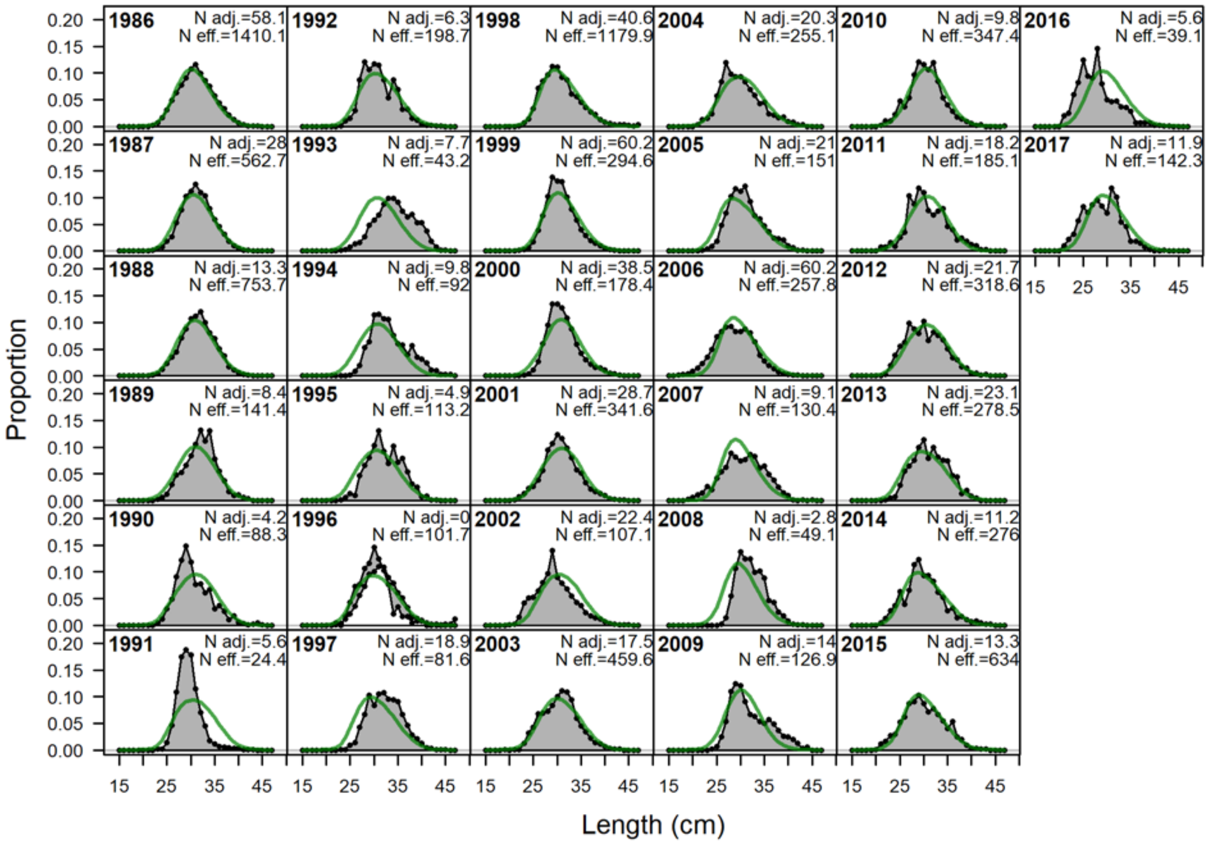


Figure A 5.11. Eastern jackass morwong length composition fits: eastern trawl port retained.

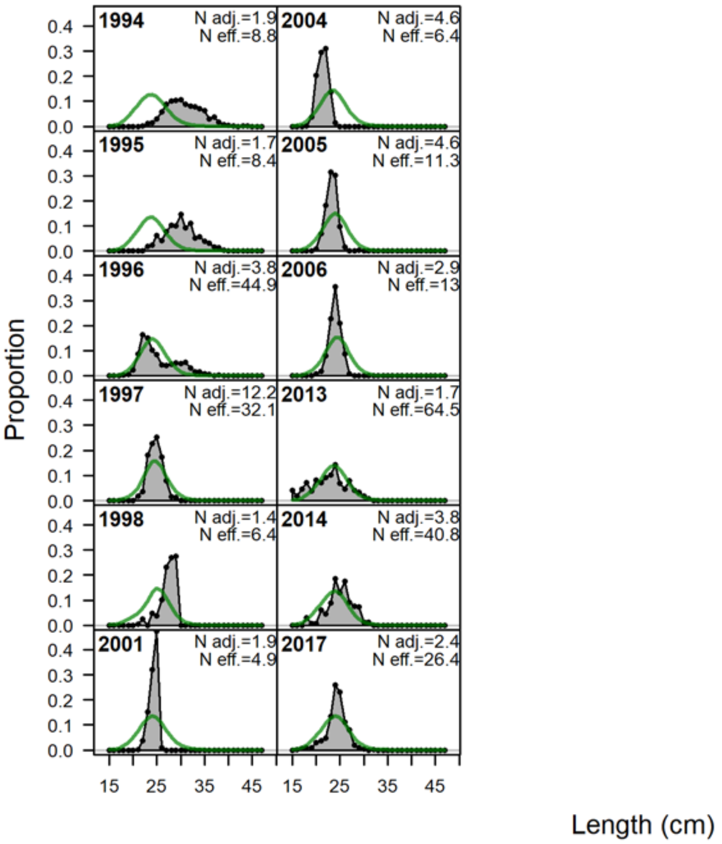


Figure A 5.12. Eastern jackass morwong length composition fits: eastern trawl discarded.

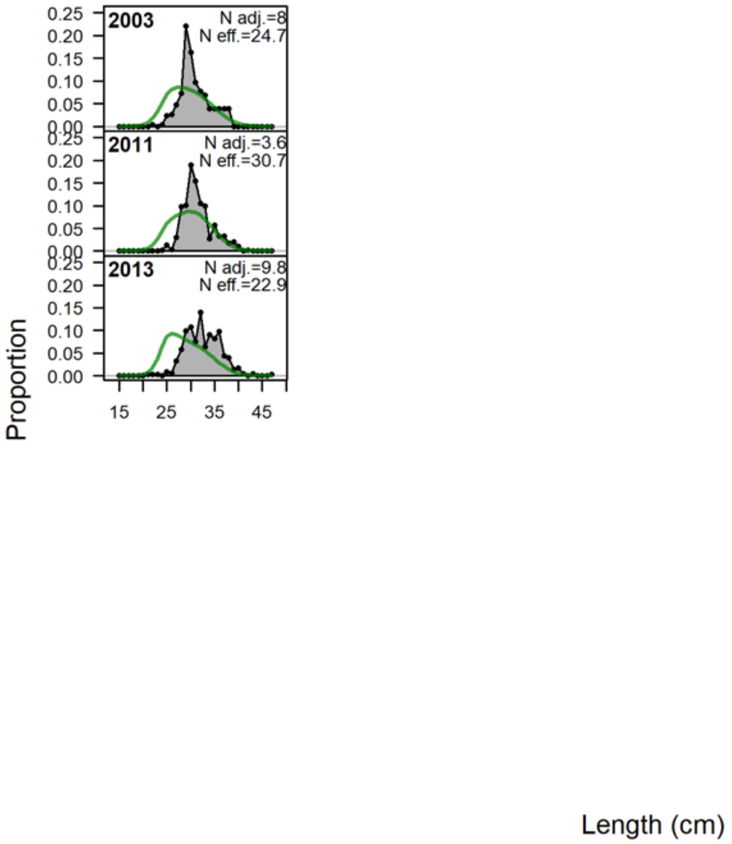


Figure A 5.13. Eastern jackass morwong length composition fits: Danish seine onboard retained.

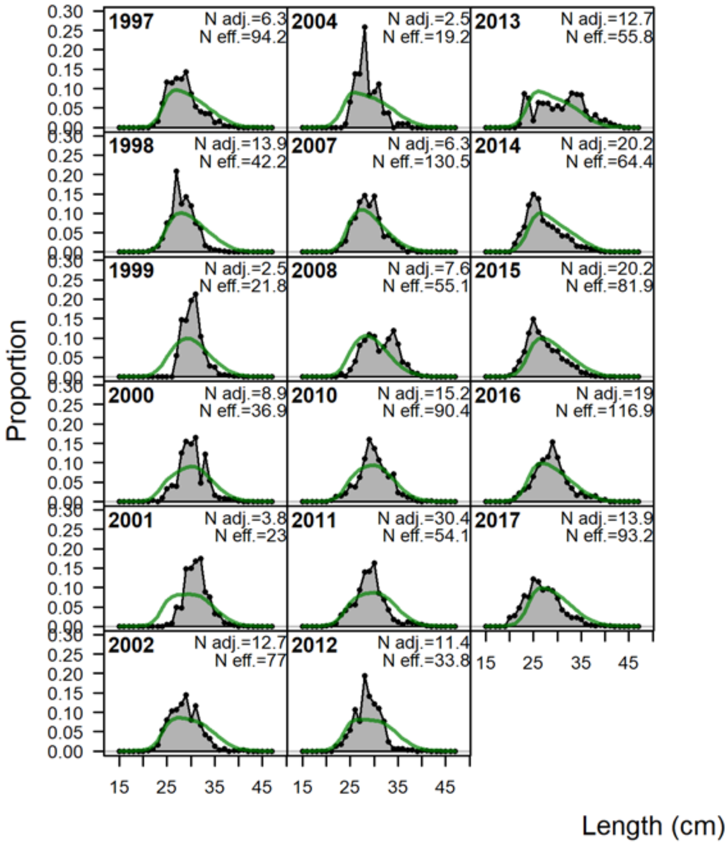


Figure A 5.14. Eastern jackass morwong length composition fits: Danish seine port retained.

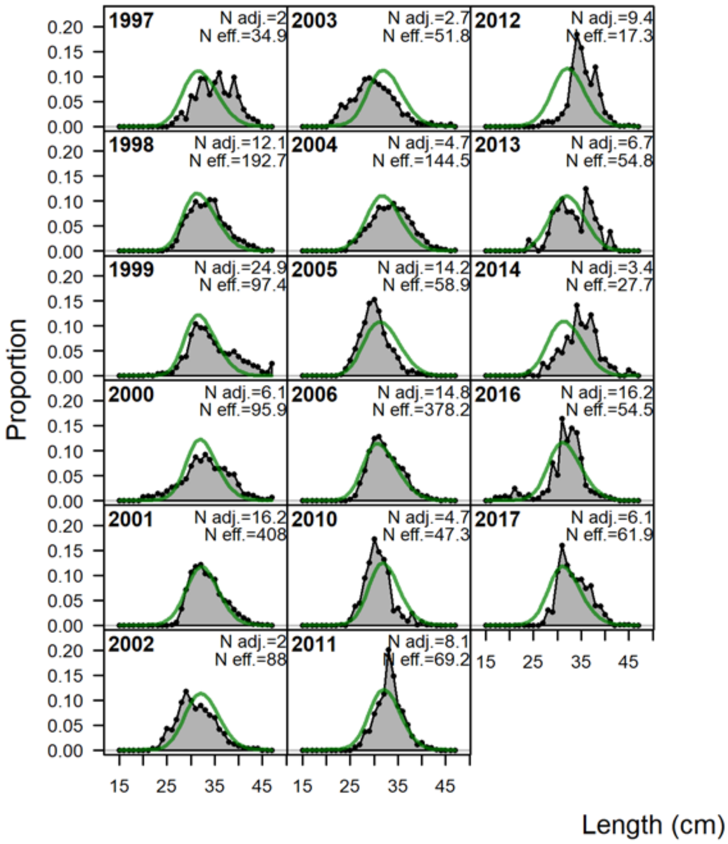


Figure A 5.15. Eastern jackass morwong length composition fits: Tasmanian trawl onboard retained.

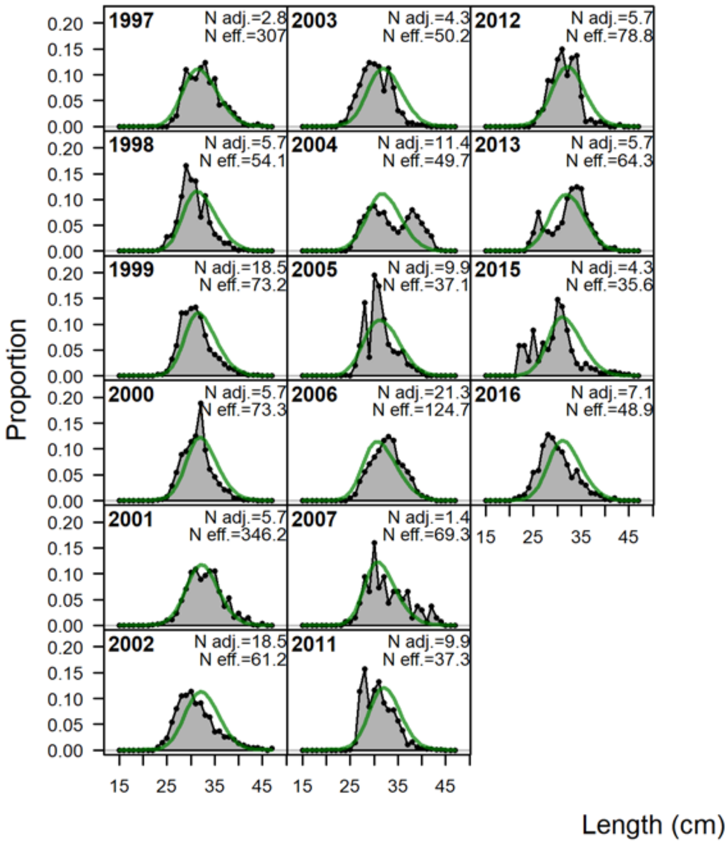


Figure A 5.16. Eastern jackass morwong length composition fits: Tasmanian trawl port retained.

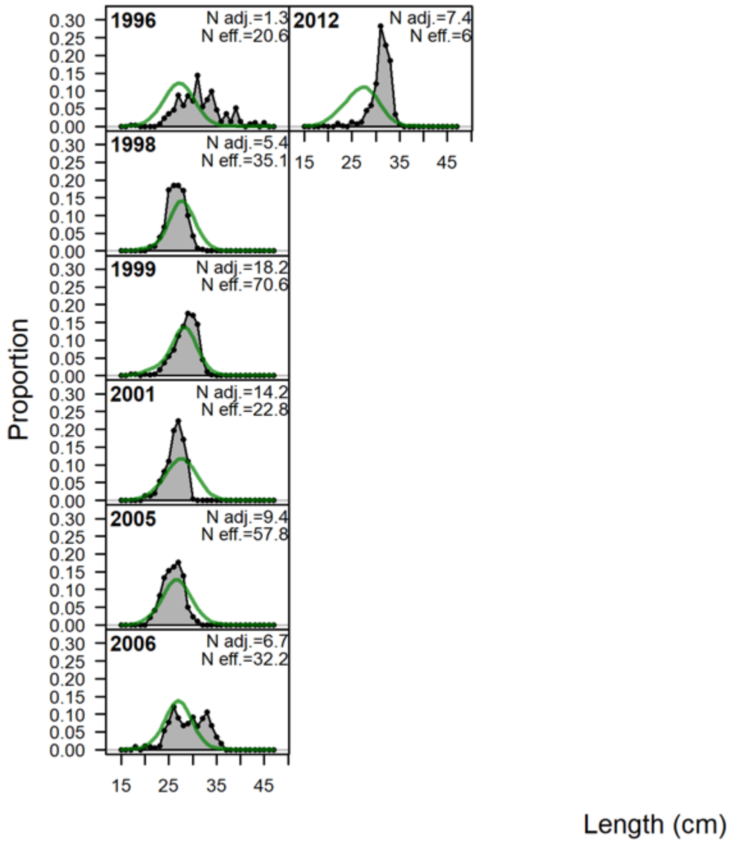


Figure A 5.17. Eastern jackass morwong length composition fits: Tasmanian trawl discarded.

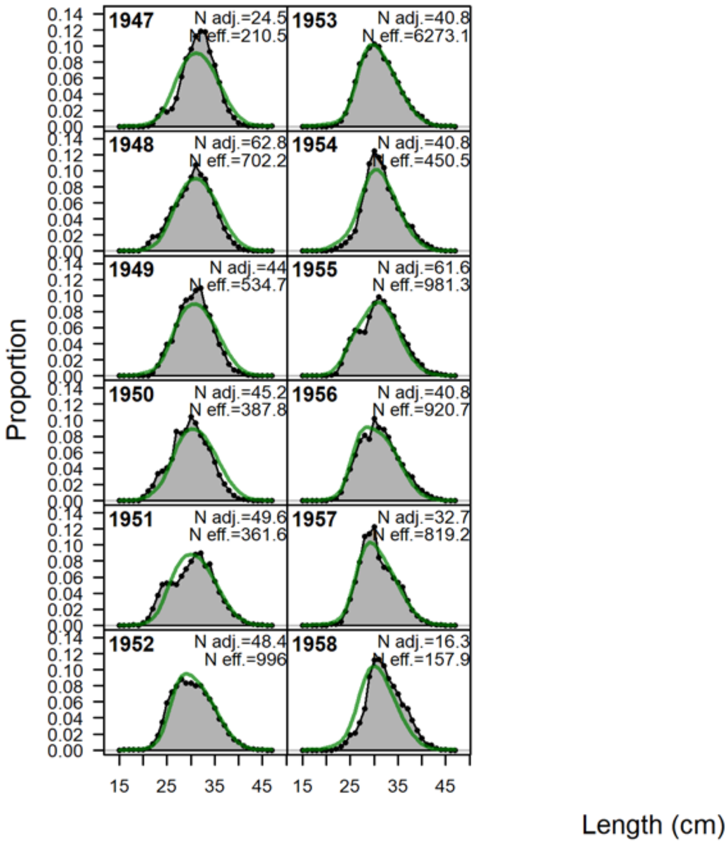


Figure A 5.18. Eastern jackass morwong length composition fits: steam trawl retained.

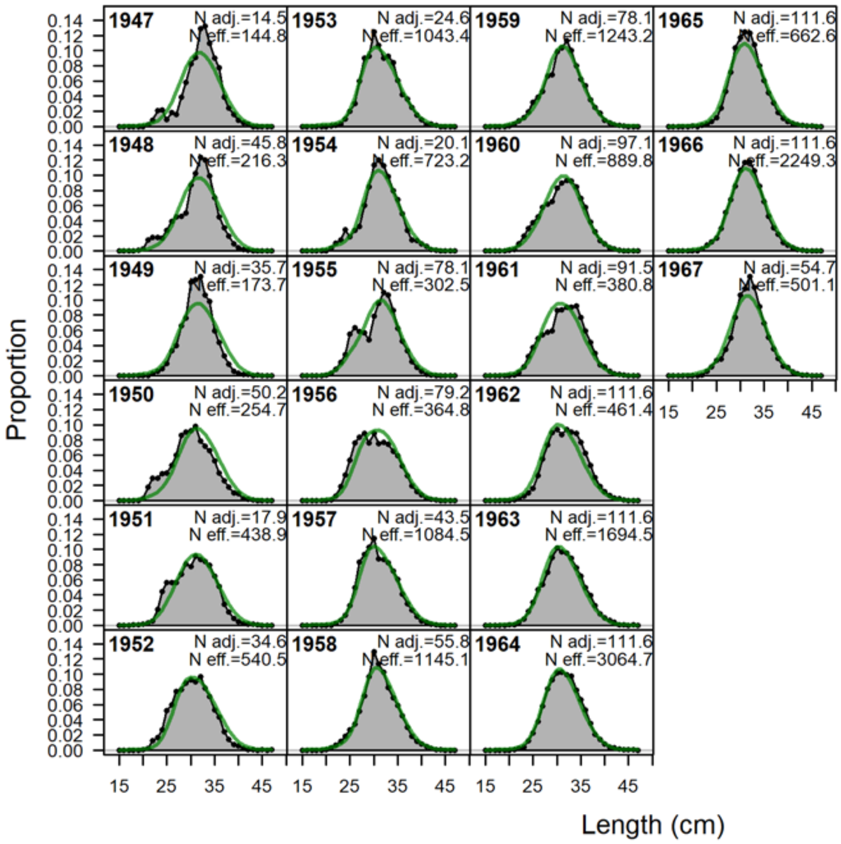


Figure A 5.19. Eastern jackass morwong length composition fits: early Danish seine retained.

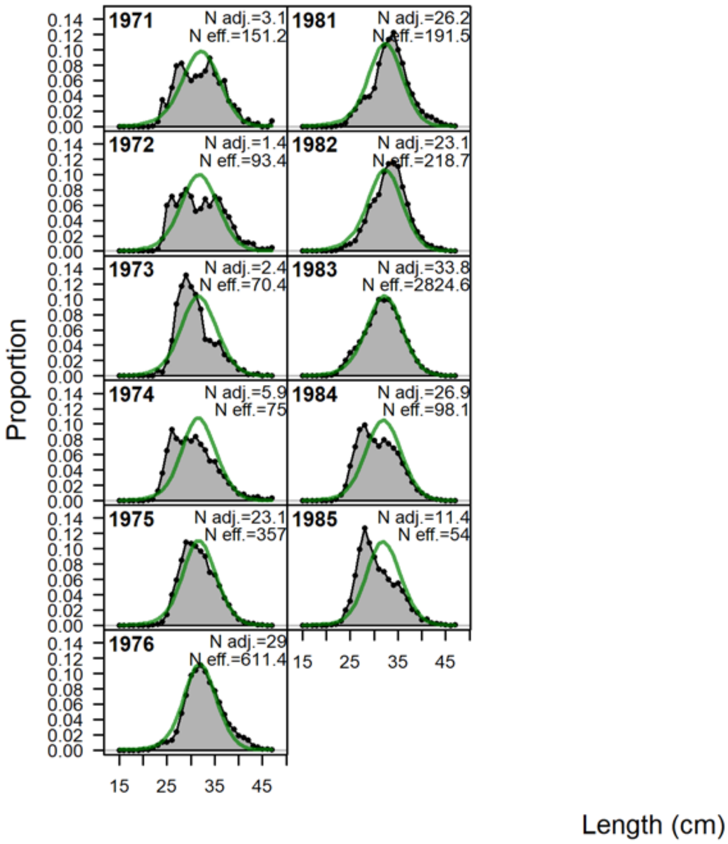


Figure A 5.20. Eastern jackass morwong length composition fits: mixed retained.

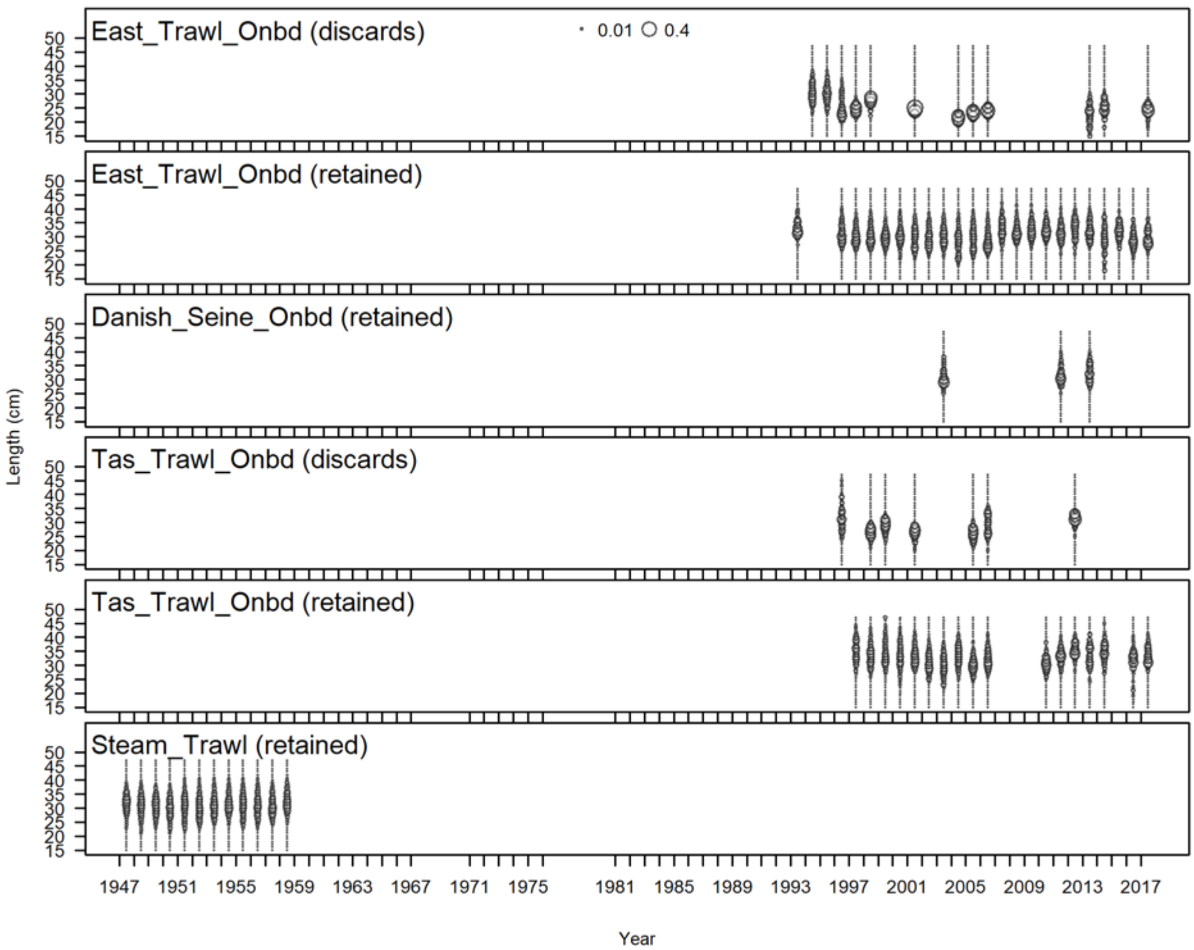


Figure A 5.21. Residuals from the annual length compositions (retained and discarded) for eastern jackass morwong displayed by year for trawl fleets.

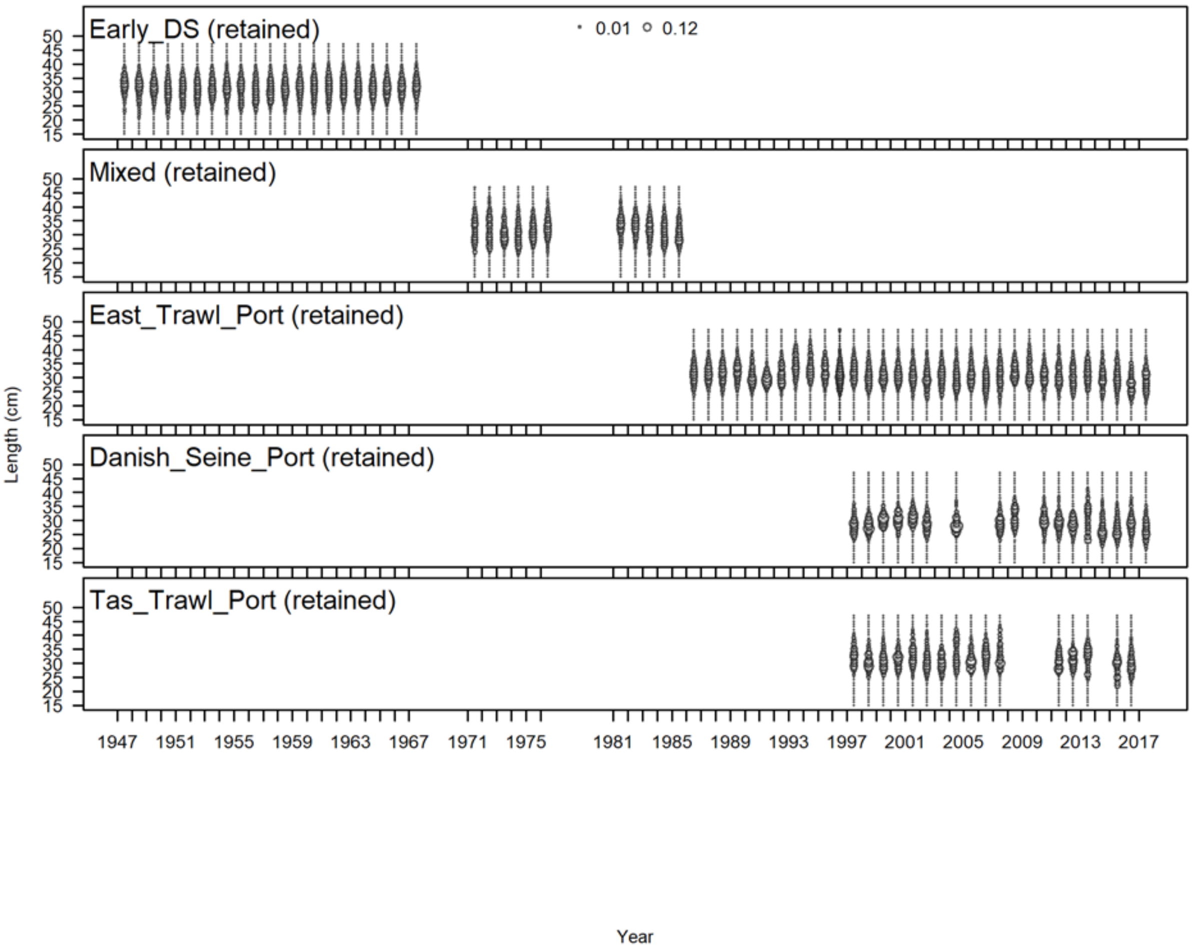


Figure A 5.22. Residuals from the annual length compositions (retained and discarded) for eastern jackass morwong displayed by year for trawl fleets.

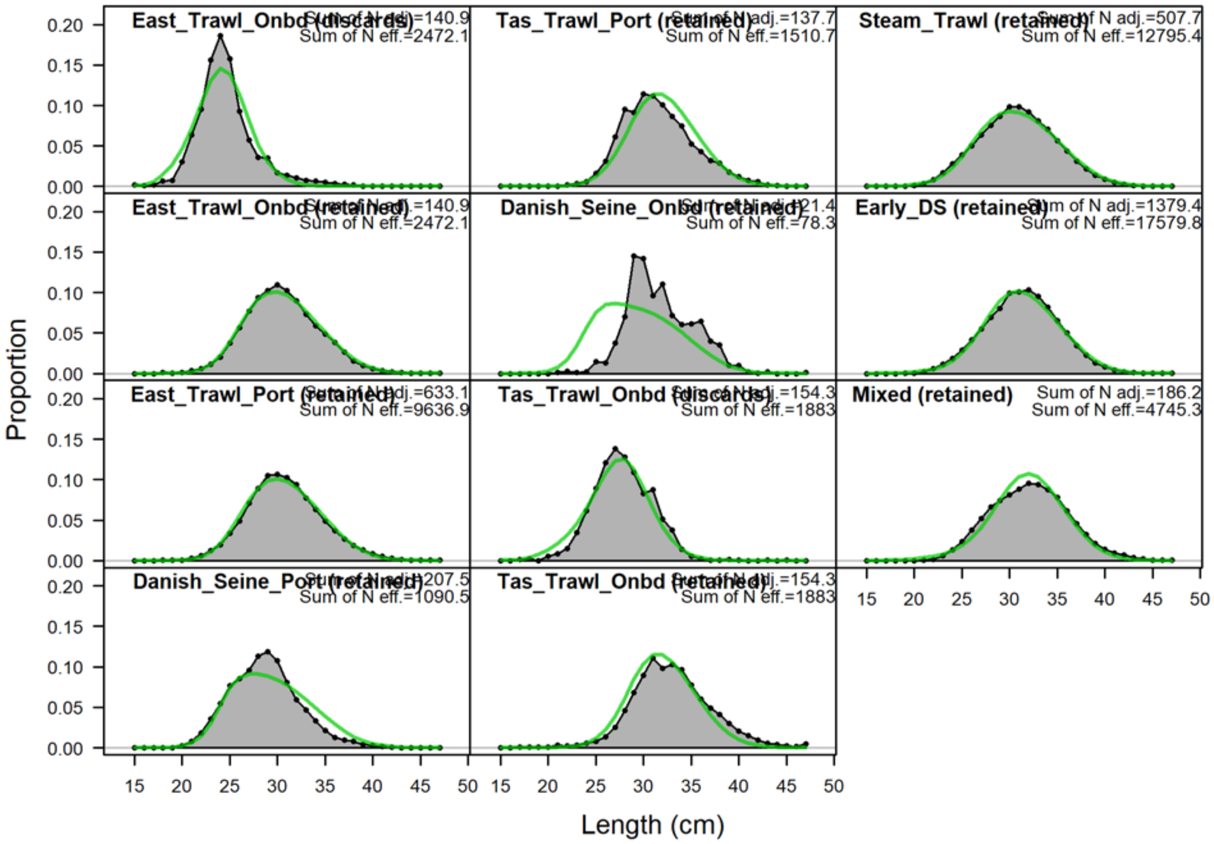


Figure A 5.23. Aggregated fits (over all years) to the length compositions for eastern jackass morwong displayed by fleet.

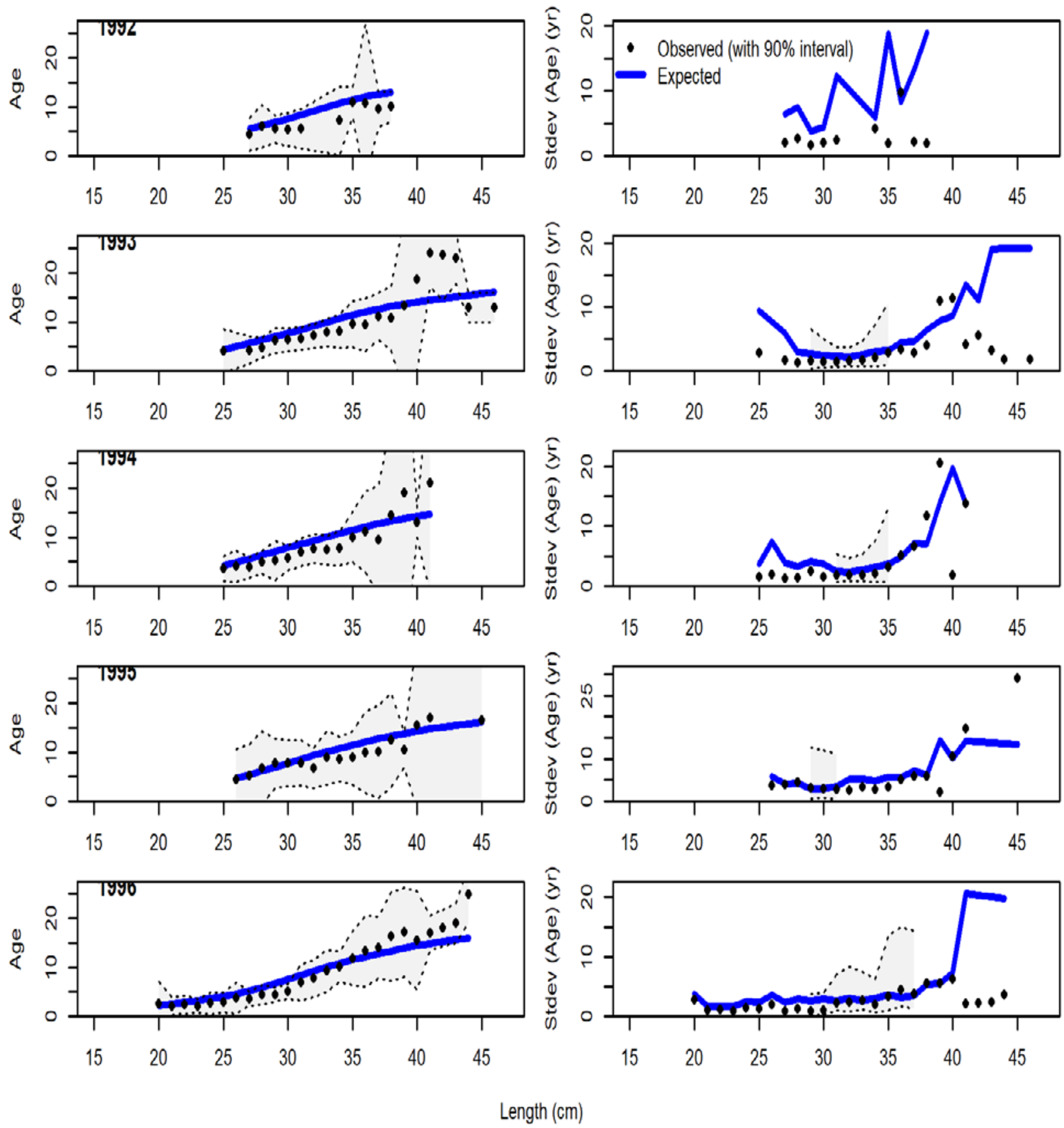


Figure A 5.24. Eastern jackass morwong conditional age-at-length fits: eastern trawl part 1.

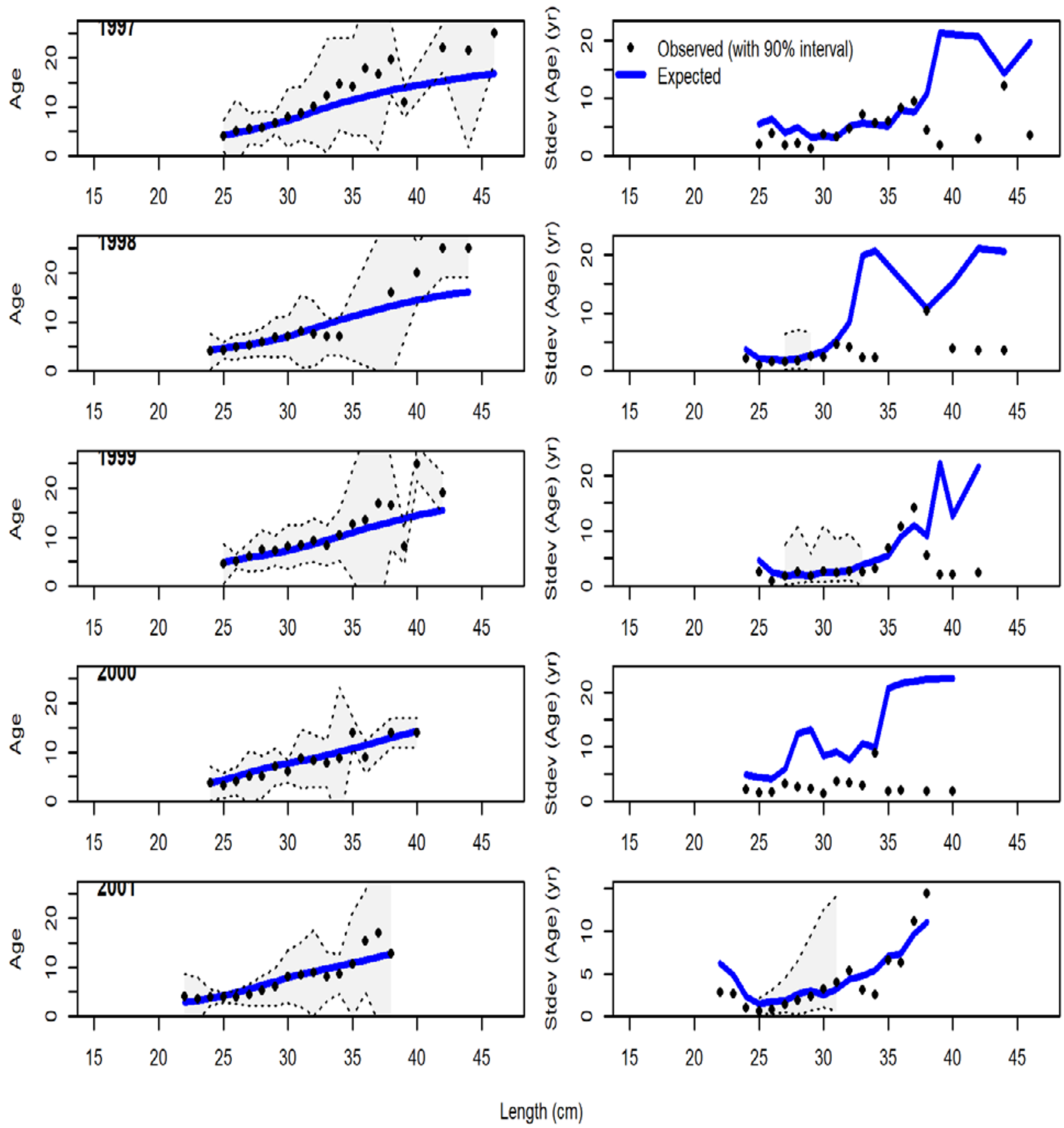


Figure A 5.25. Eastern jackass morwong conditional age-at-length fits: eastern trawl part 2.

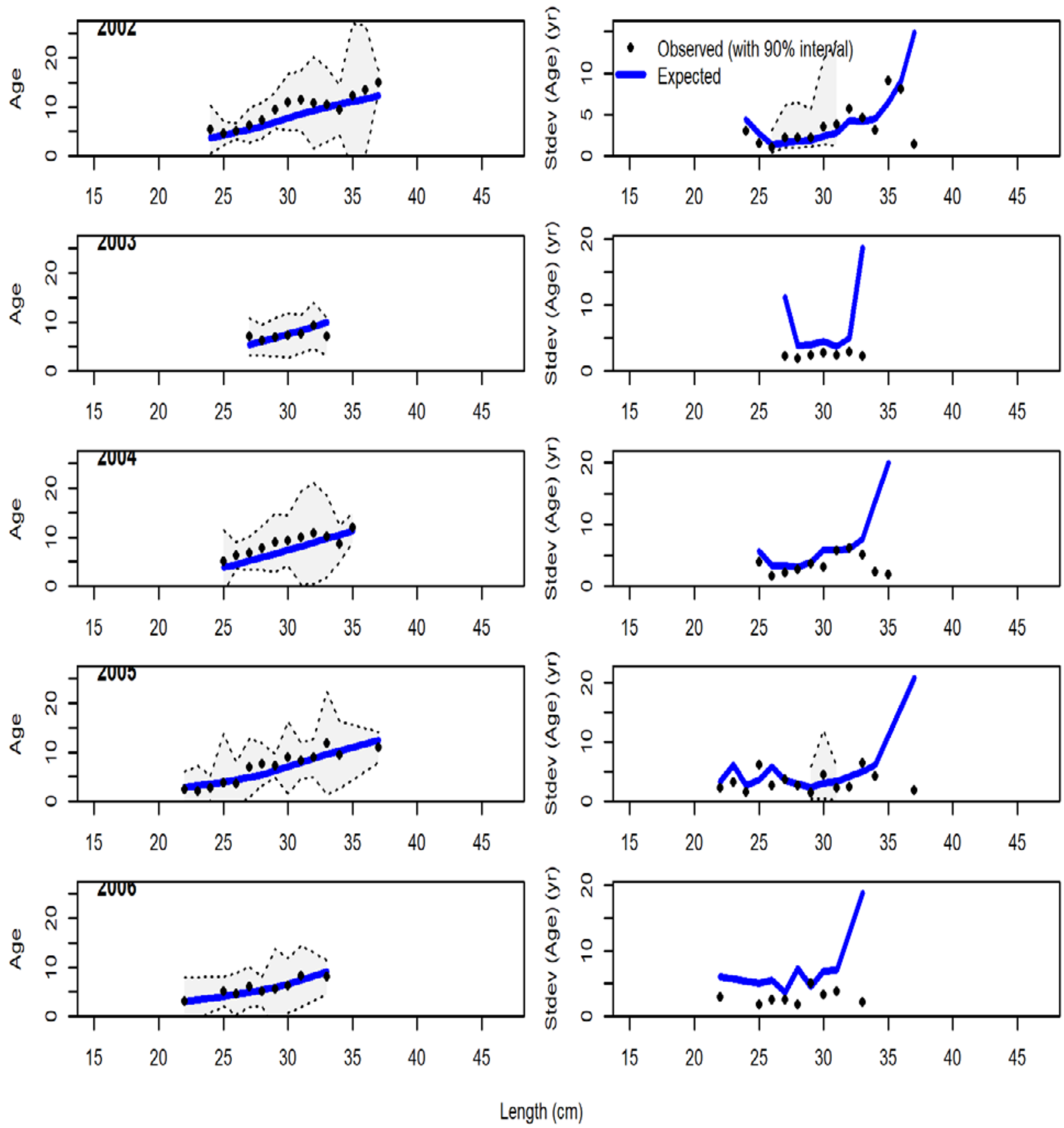


Figure A 5.26. Eastern jackass morwong conditional age-at-length fits: eastern trawl part 3.

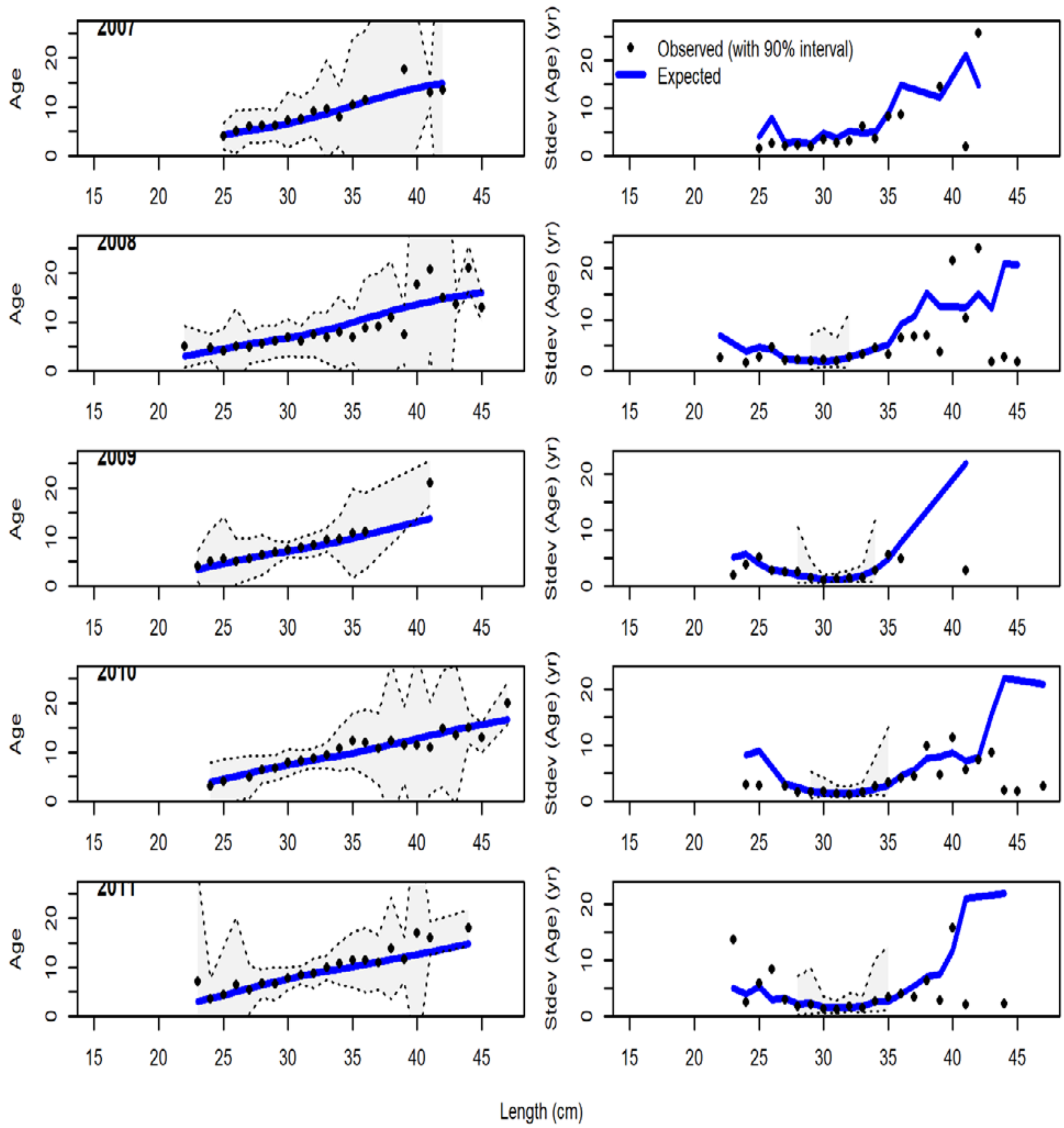


Figure A 5.27. Eastern jackass morwong conditional age-at-length fits: eastern trawl part 4.

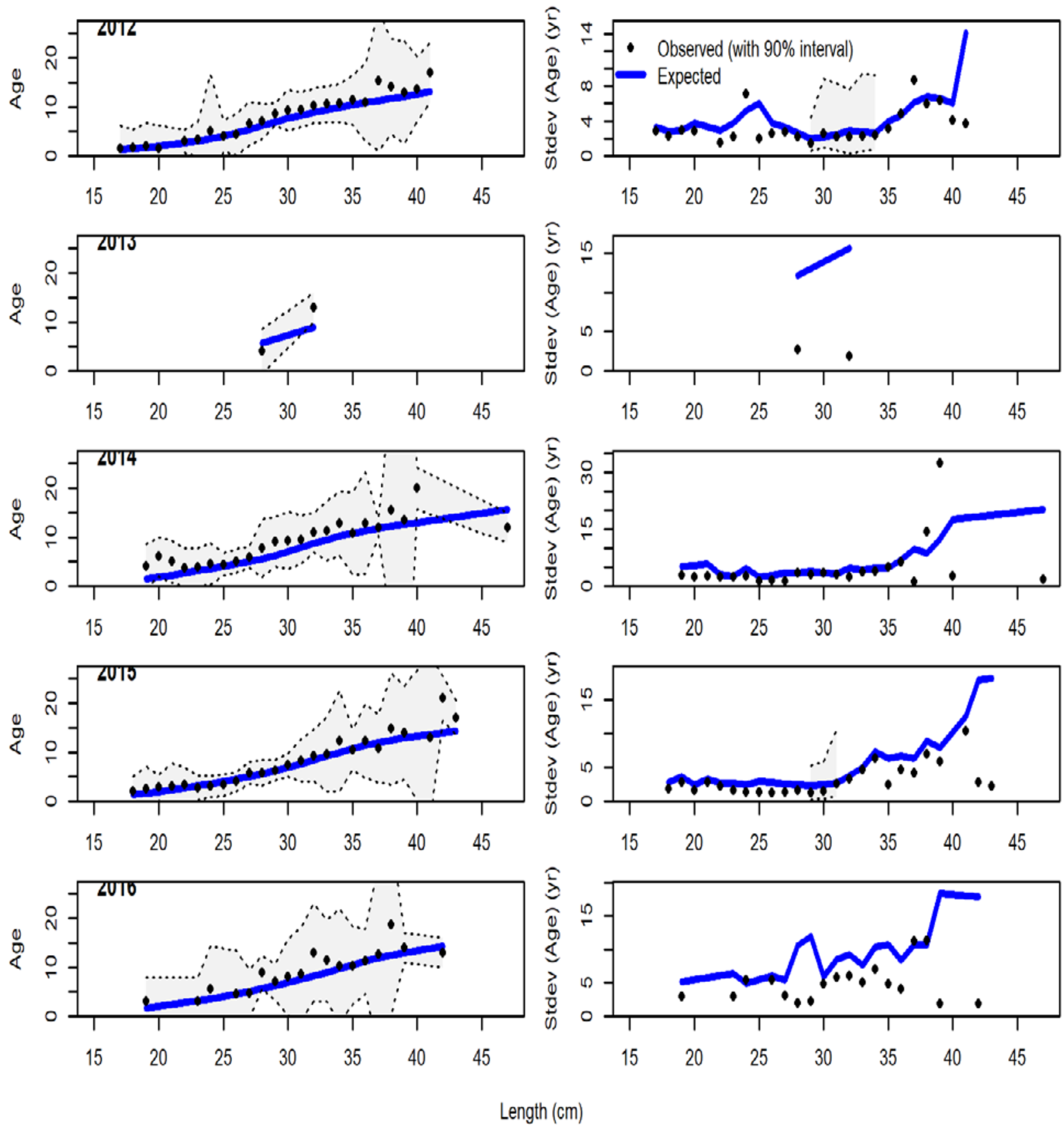


Figure A 5.28. Eastern jackass morwong conditional age-at-length fits: eastern trawl part 5.

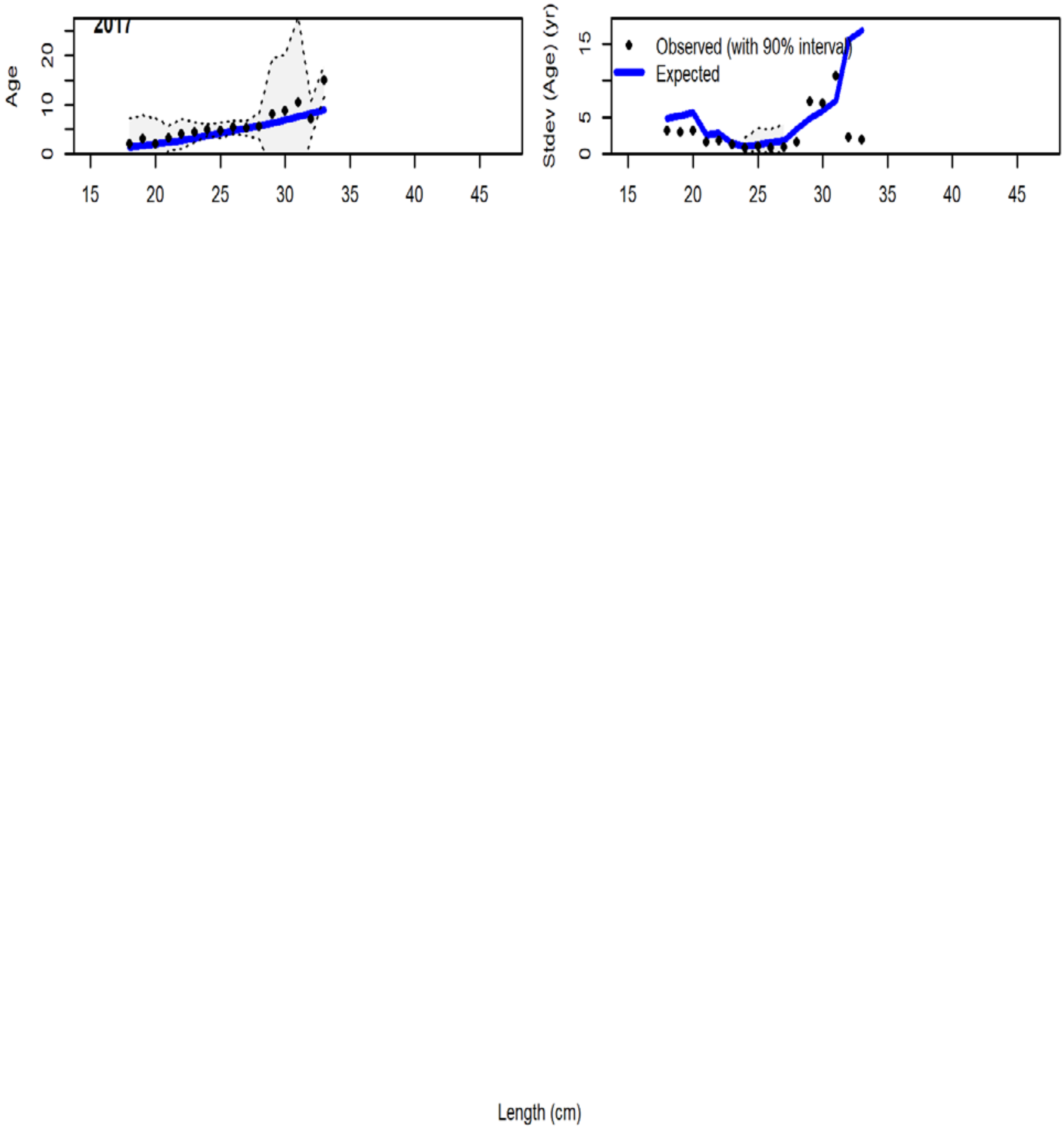


Figure A 5.29. Eastern jackass morwong conditional age-at-length fits: eastern trawl part 6.

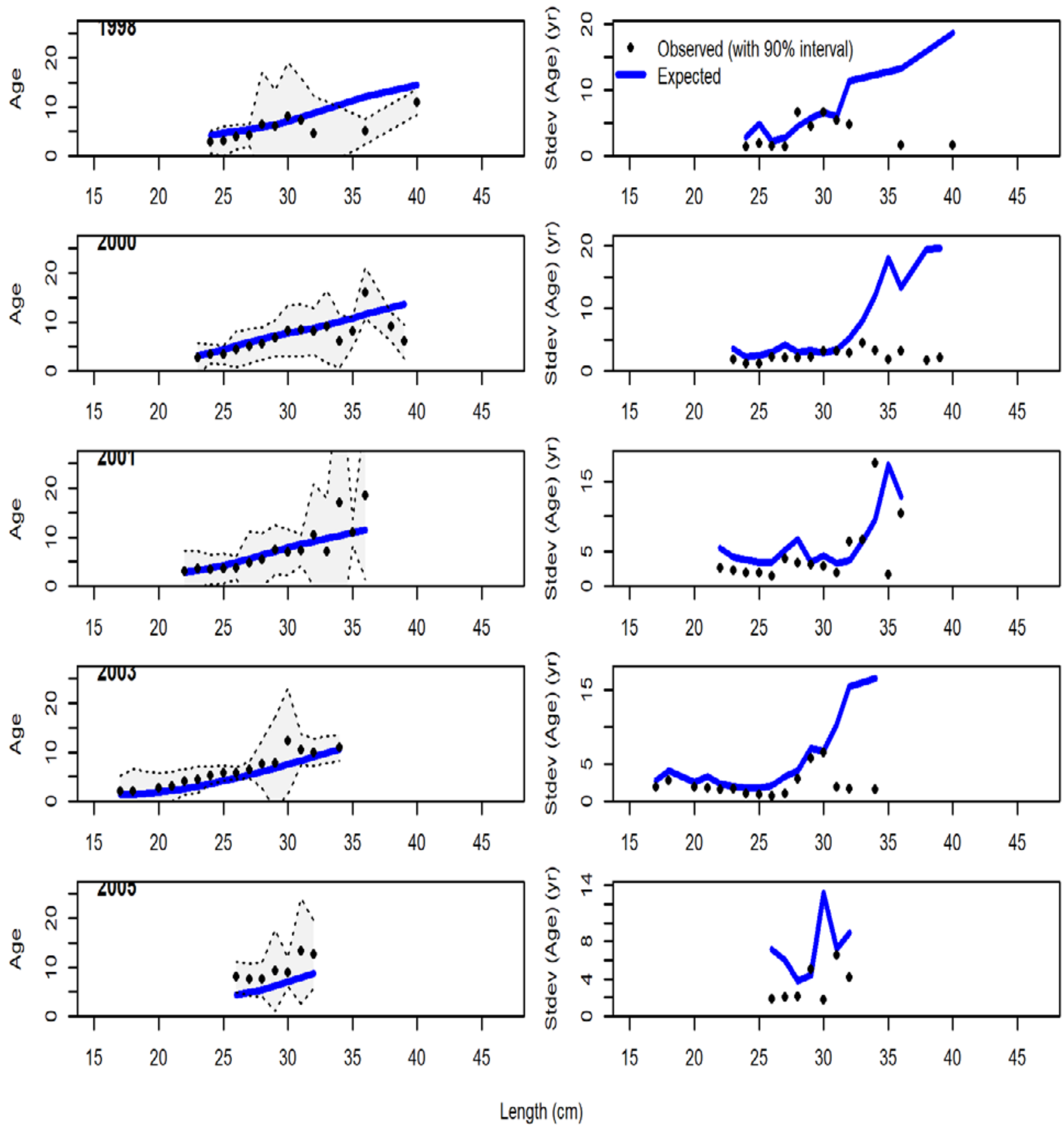


Figure A 5.30. Eastern jackass morwong conditional age-at-length fits: Danish seine part 1.

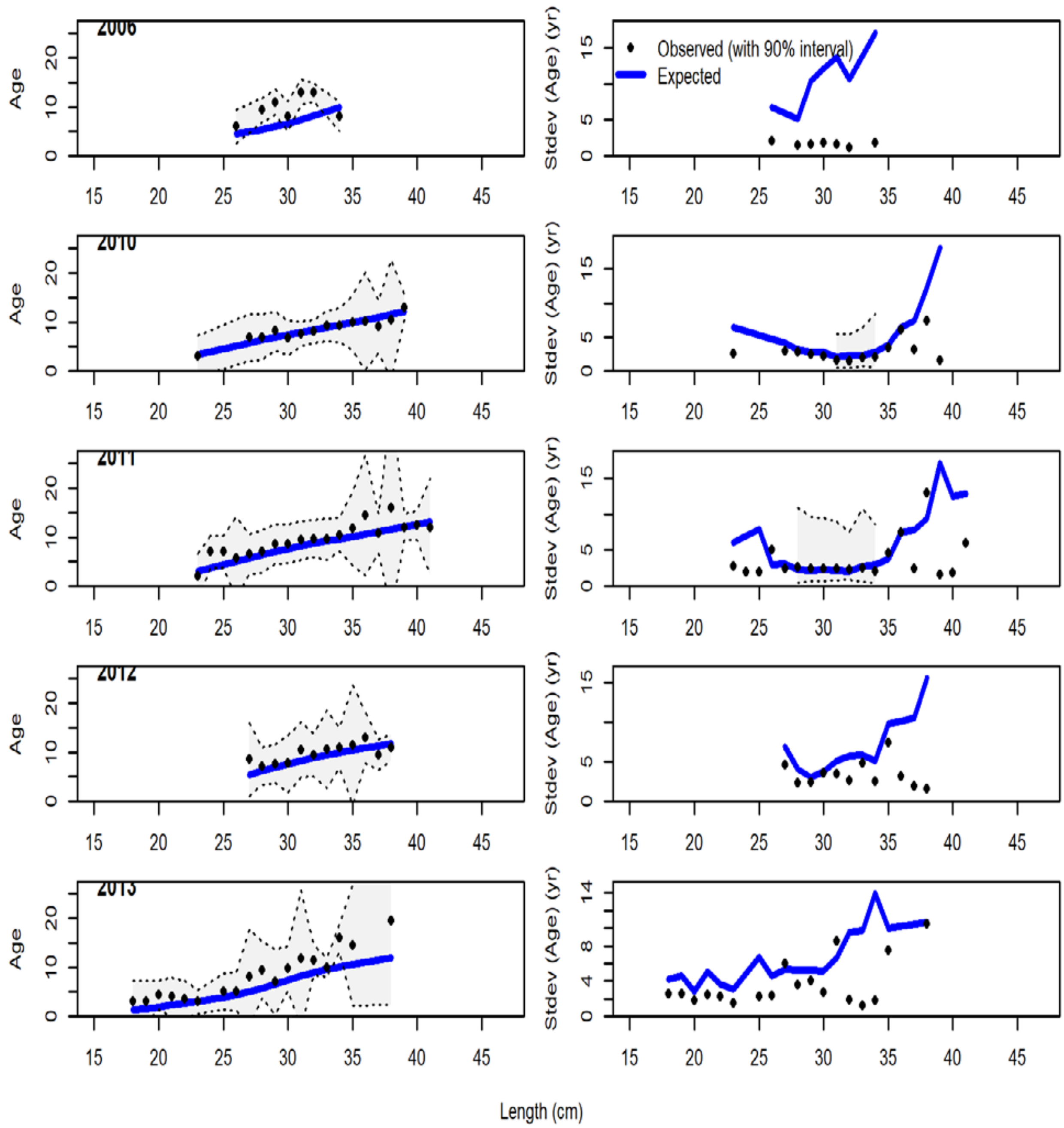


Figure A 5.31. Eastern jackass morwong conditional age-at-length fits: Danish seine part 2.

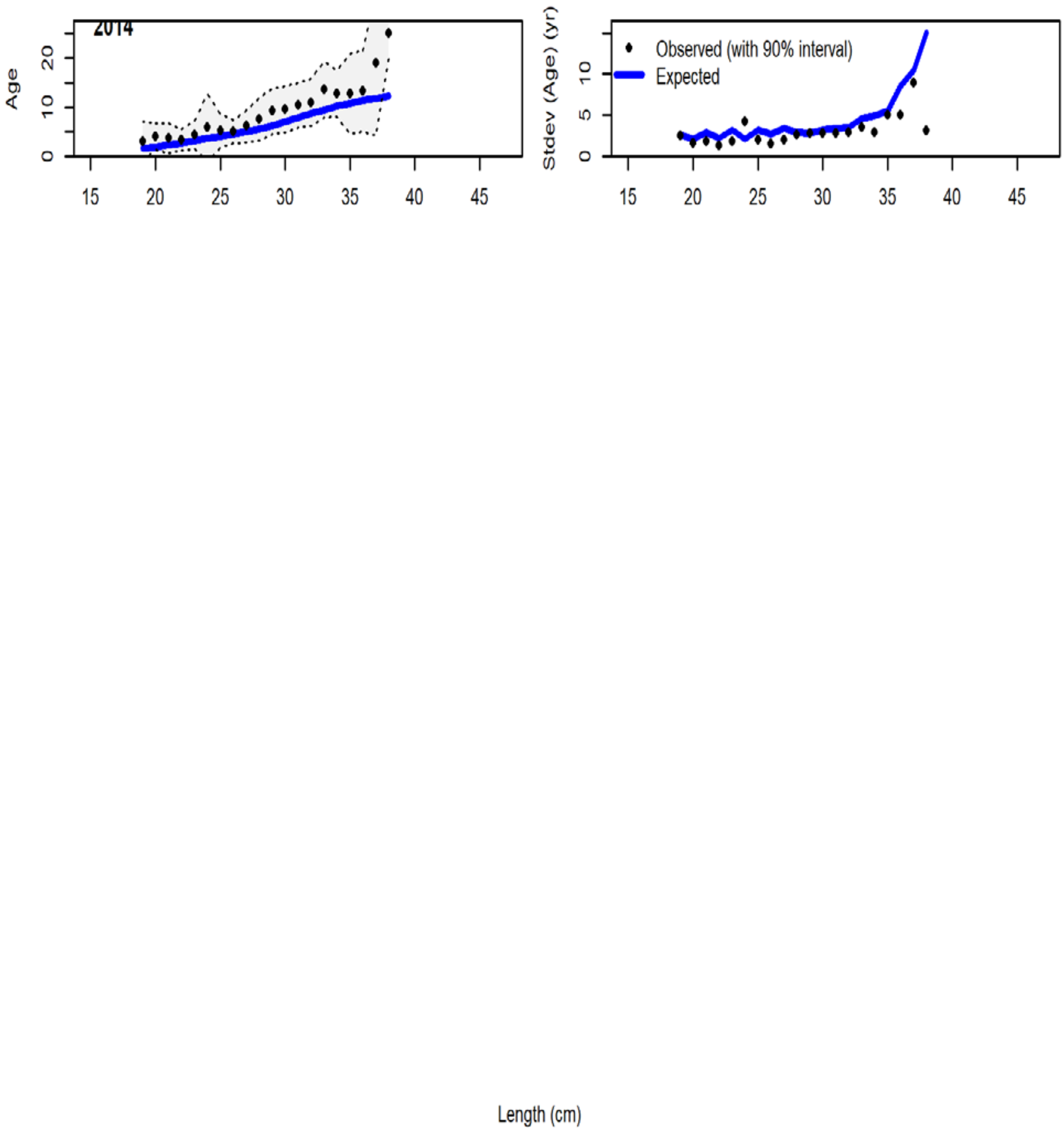


Figure A 5.32. Eastern jackass morwong conditional age-at-length fits: Danish seine part 3.

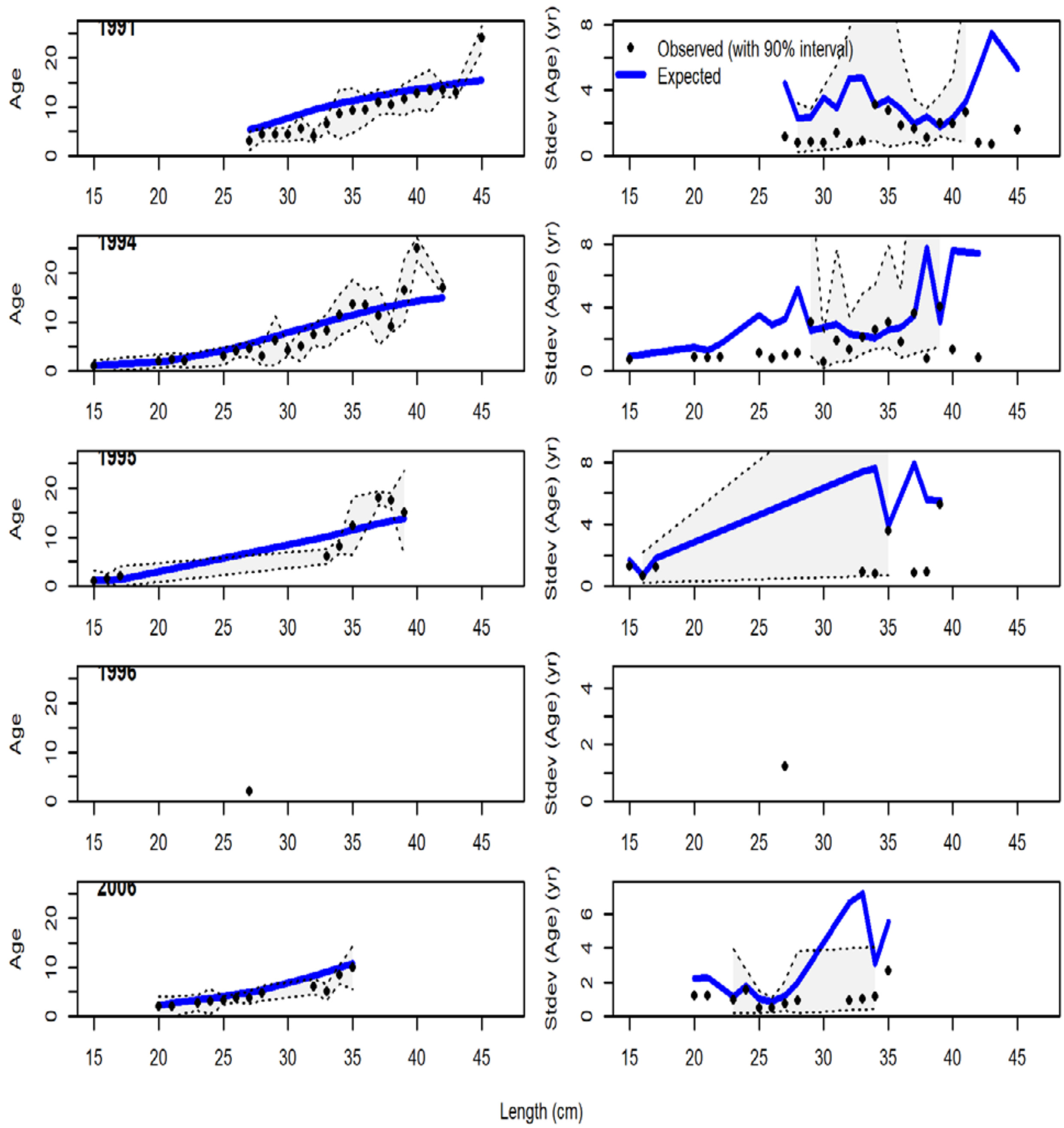


Figure A 5.33. Eastern jackass morwong conditional age-at-length fits: Tasmanian trawl part 1.

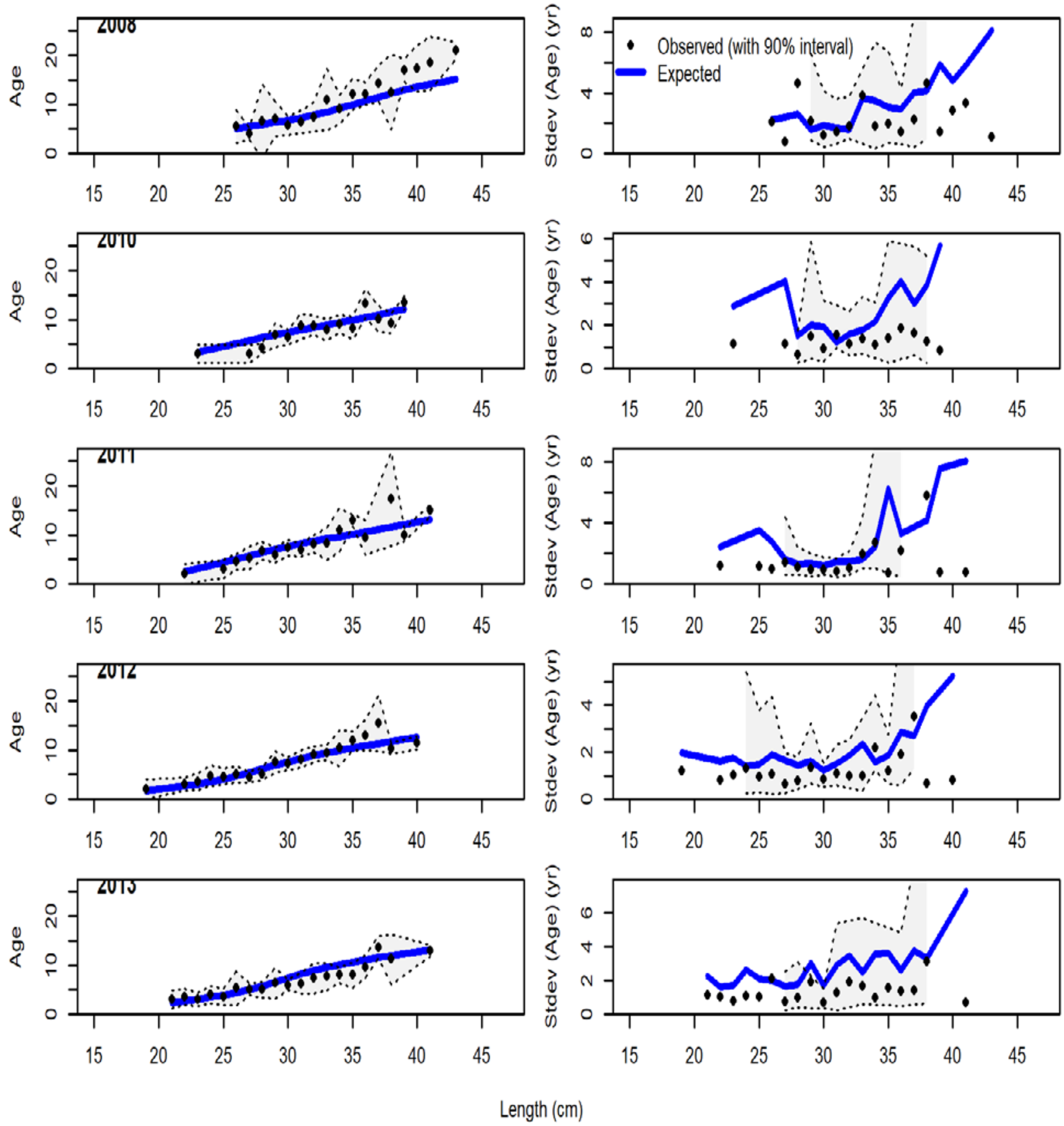


Figure A 5.34. Eastern jackass morwong conditional age-at-length fits: Tasmanian trawl part 2.

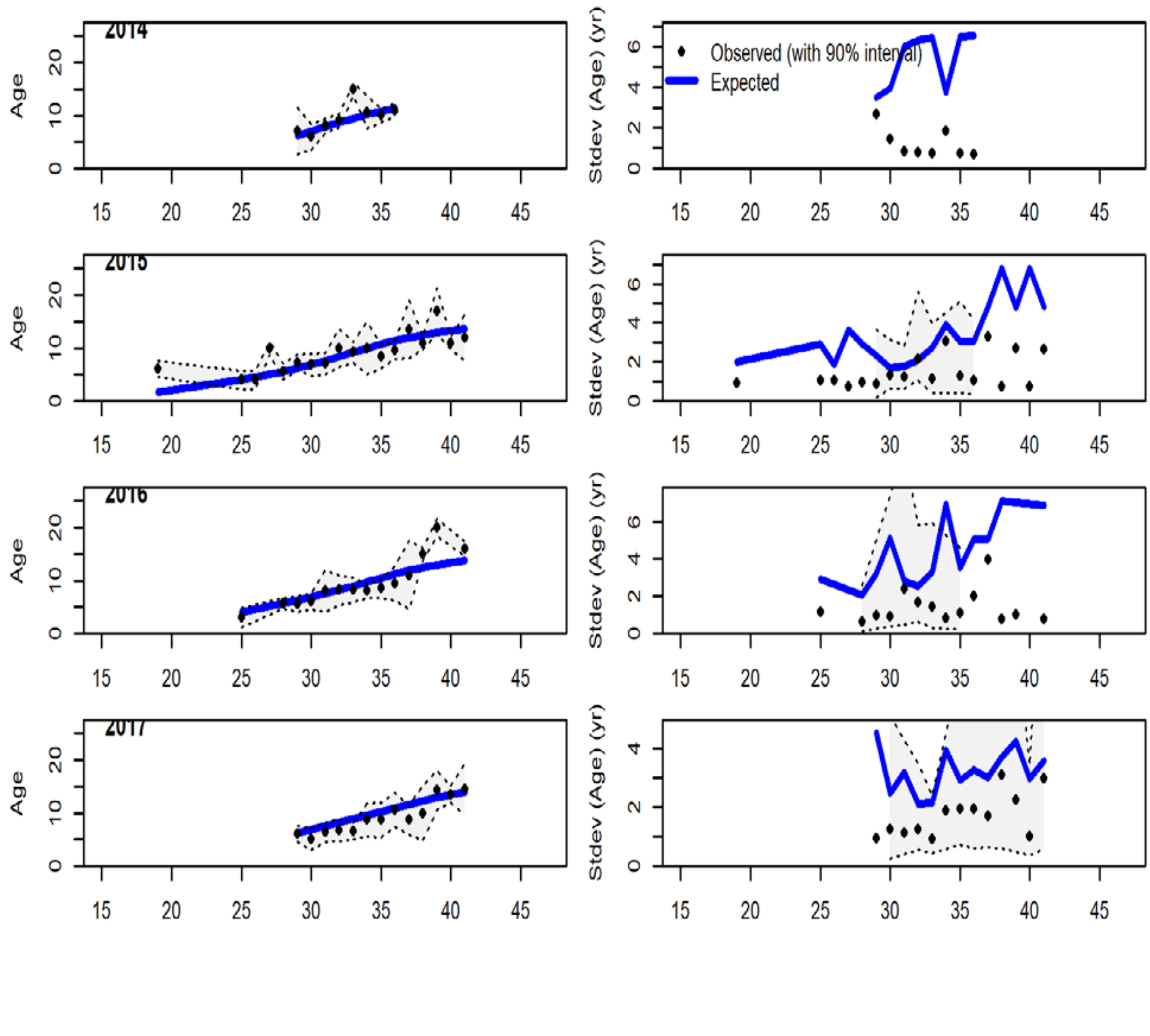


Figure A 5.35. Eastern jackass morwong conditional age-at-length fits: Tasmanian trawl part 3.

Figure A 5.36. Eastern jackass morwong implied fits to age: eastern trawl onboard retained.

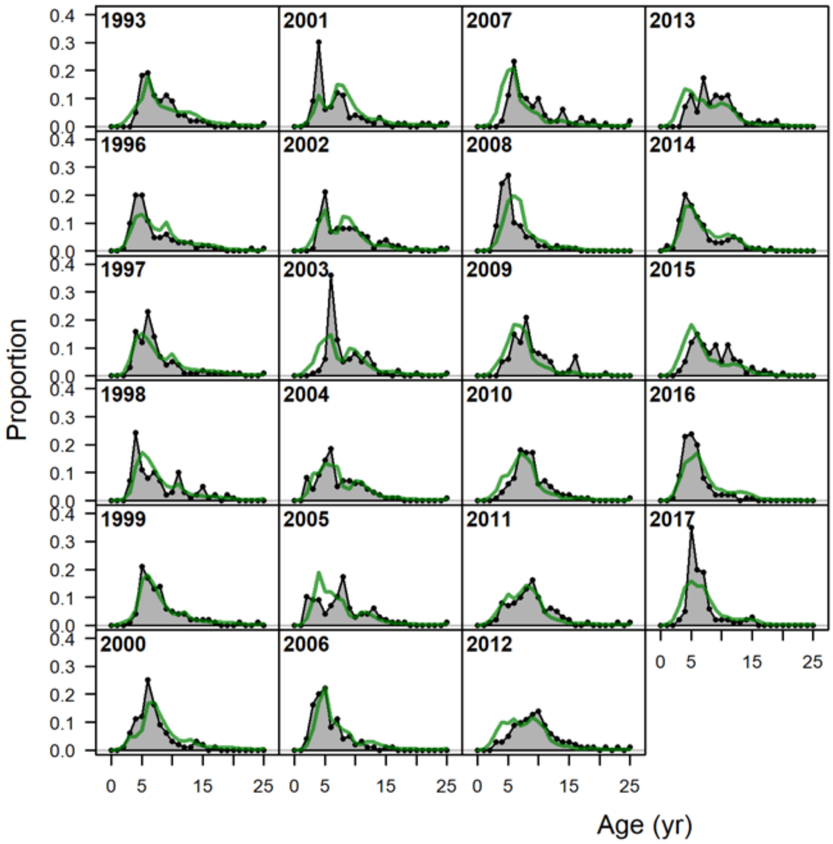


Figure A 5.37. Eastern jackass morwong implied fits to age: eastern trawl onboard retained.

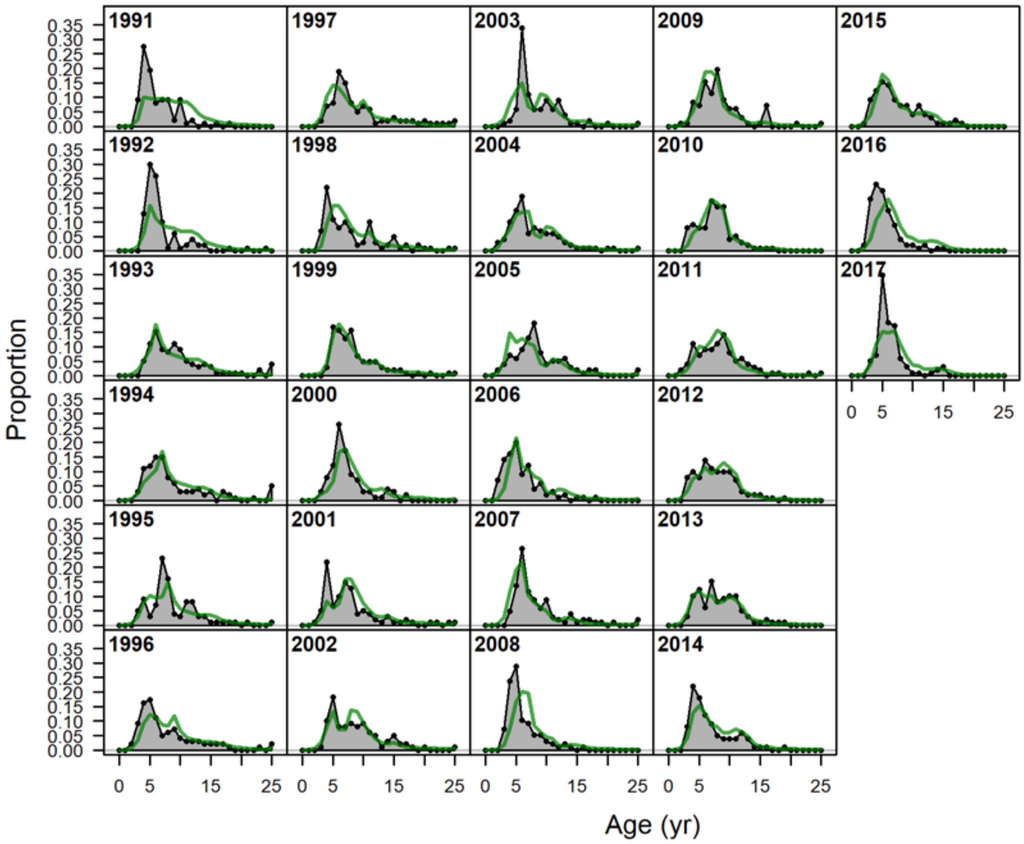


Figure A 5.38. Eastern jackass morwong implied fits to age: eastern trawl port retained.

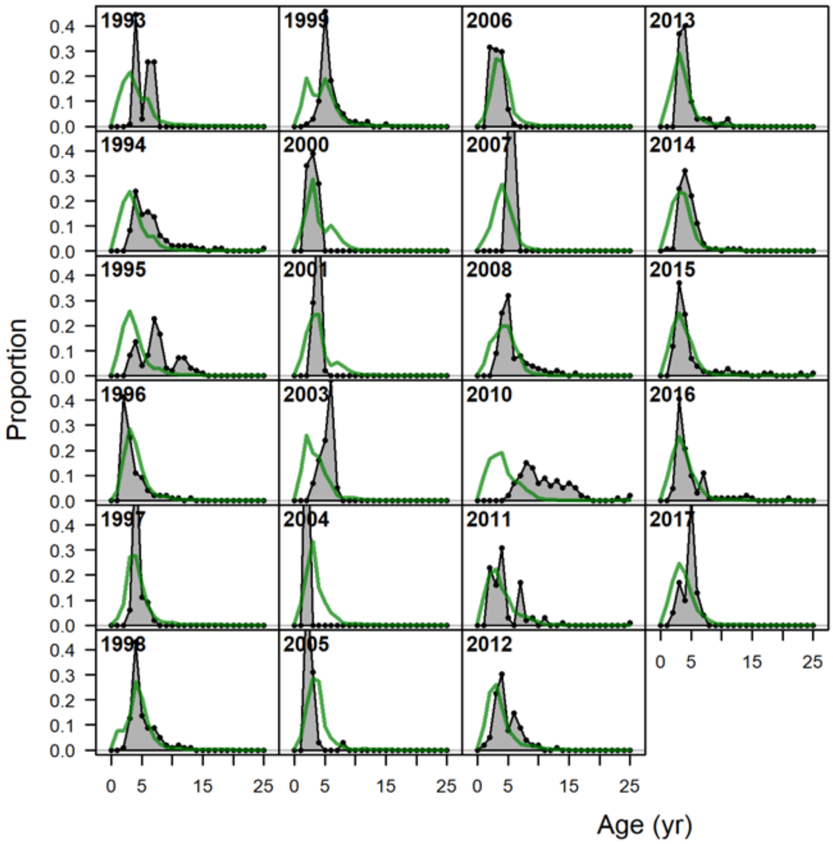


Figure A 5.39. Eastern jackass morwong implied fits to age: eastern trawl onboard discarded.

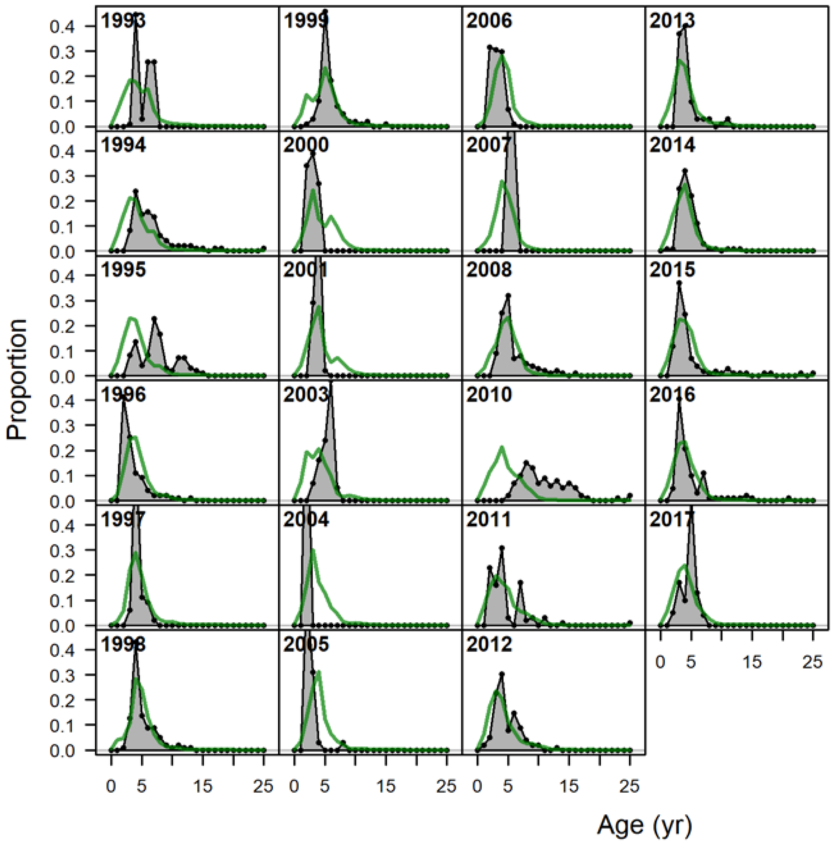


Figure A 5.40. Eastern jackass morwong implied fits to age: eastern trawl port discarded.

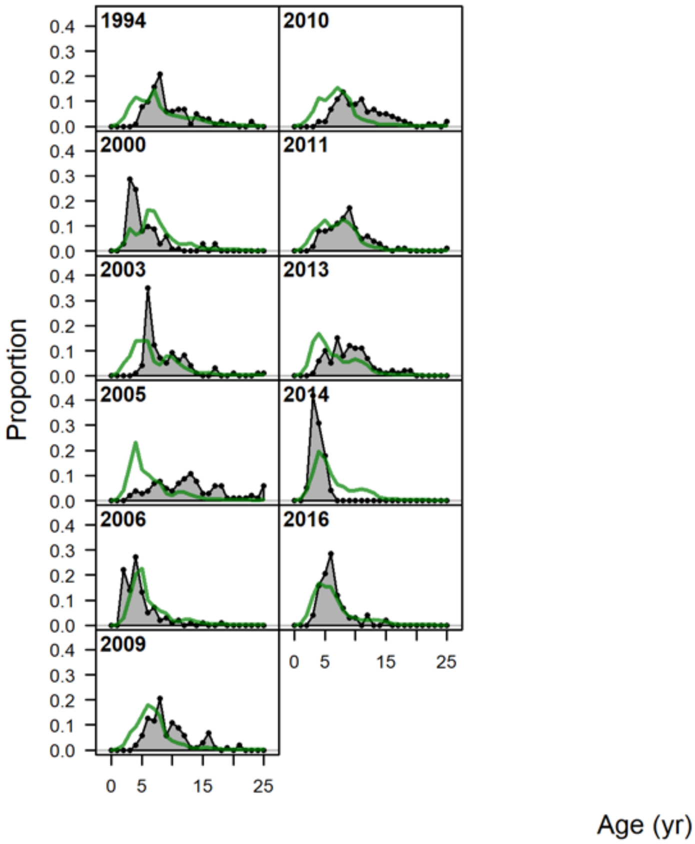


Figure A 5.41. Eastern jackass morwong implied fits to age: Danish seine onboard retained.

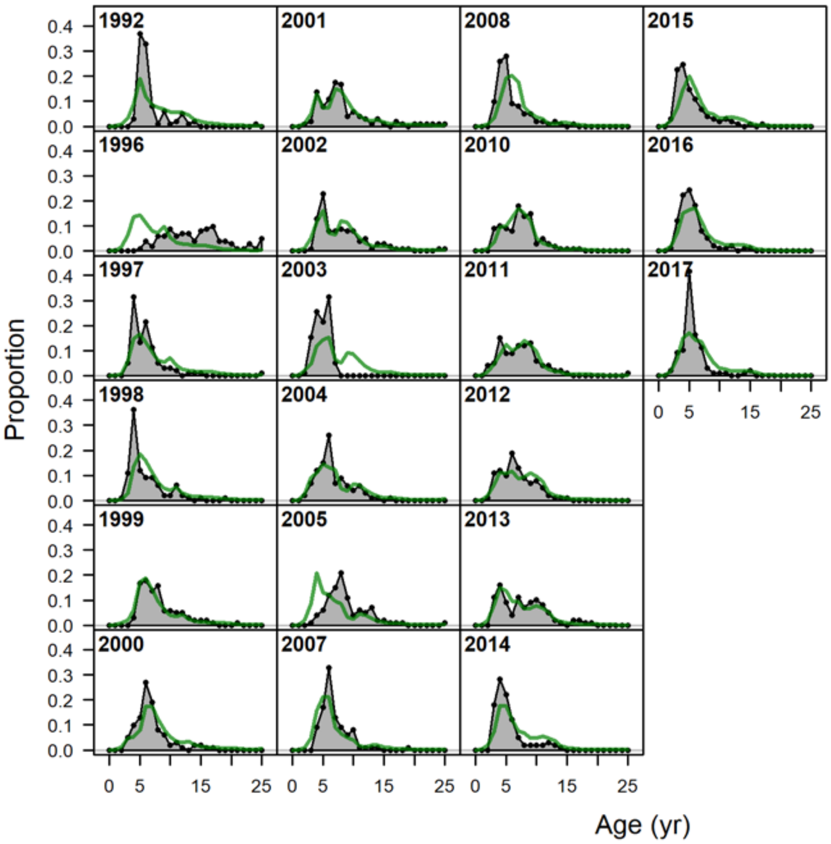


Figure A 5.42. Eastern jackass morwong implied fits to age: Danish seine port retained.

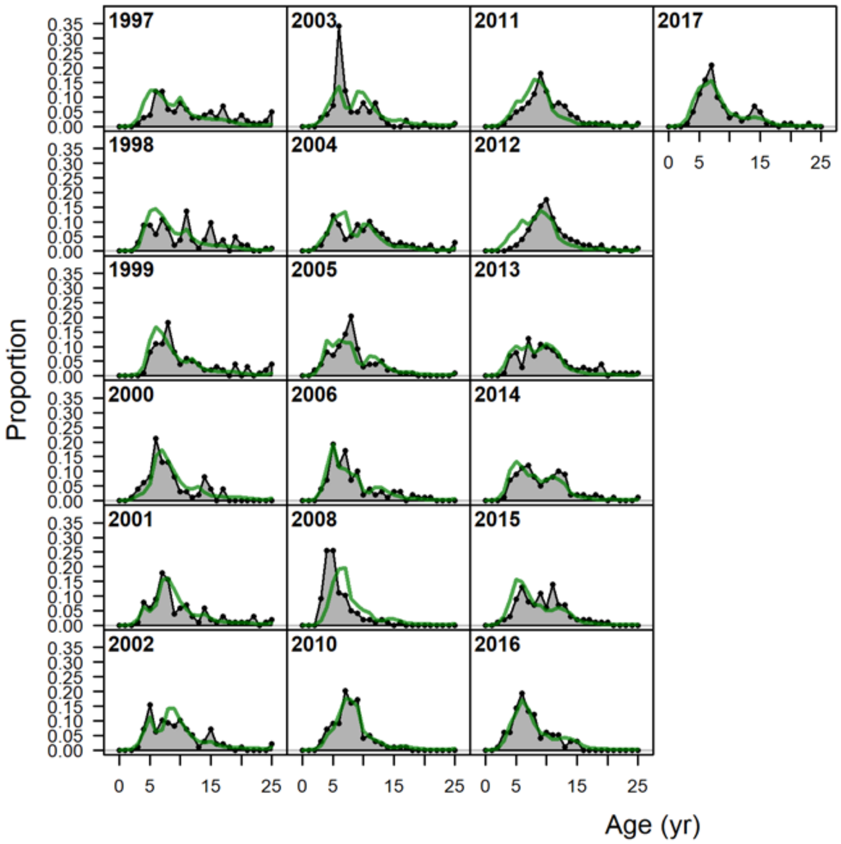


Figure A 5.43. Eastern jackass morwong implied fits to age: Tasmanian trawl onboard retained.

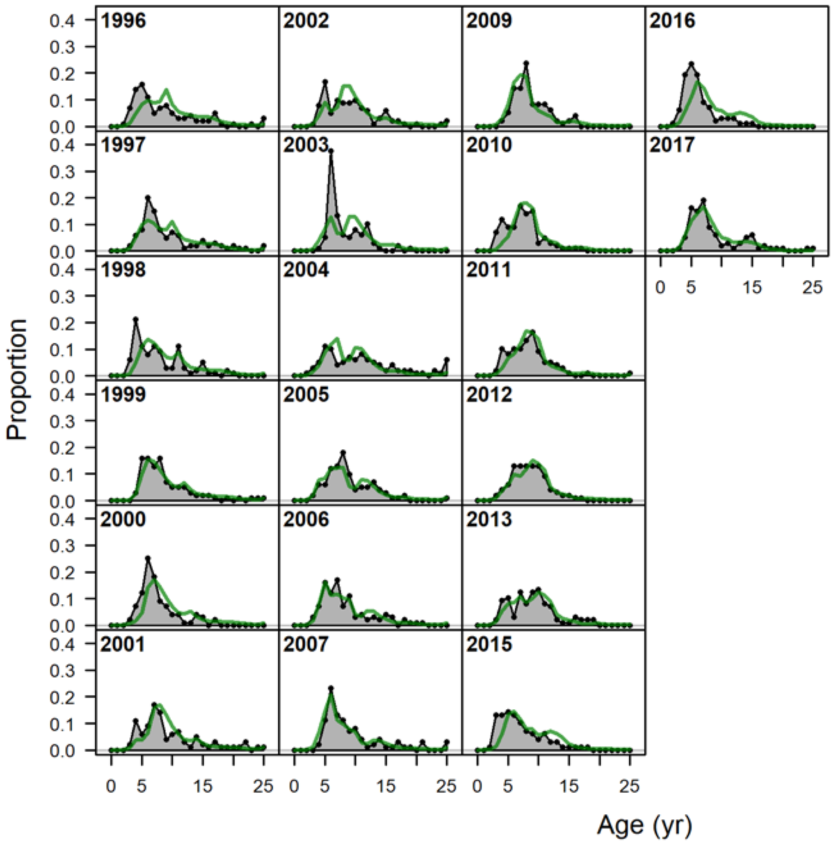


Figure A 5.44. Eastern jackass morwong implied fits to age: Tasmanian trawl port retained.

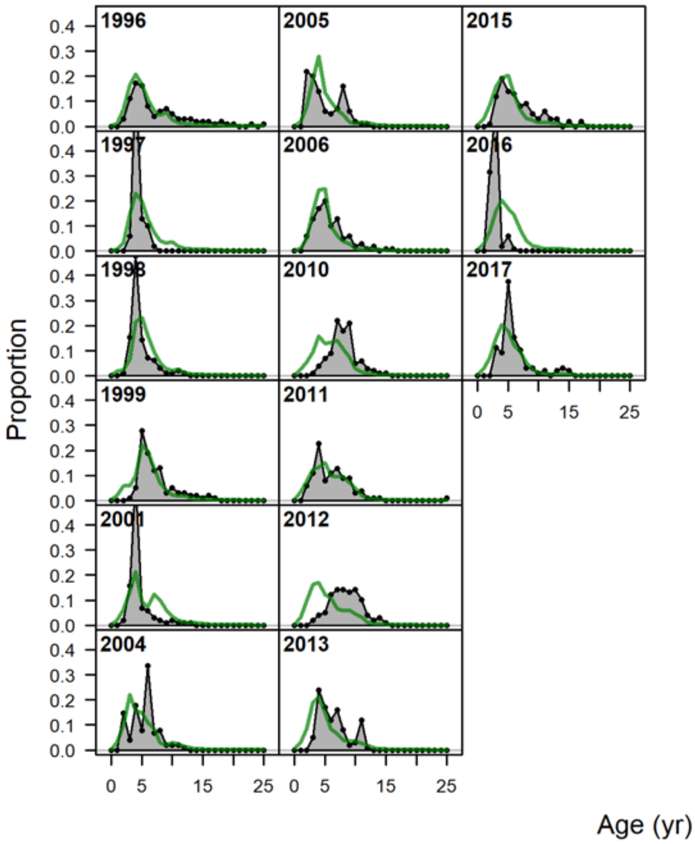


Figure A 5.45. Eastern jackass morwong implied fits to age: Tasmanian trawl onboard discarded.

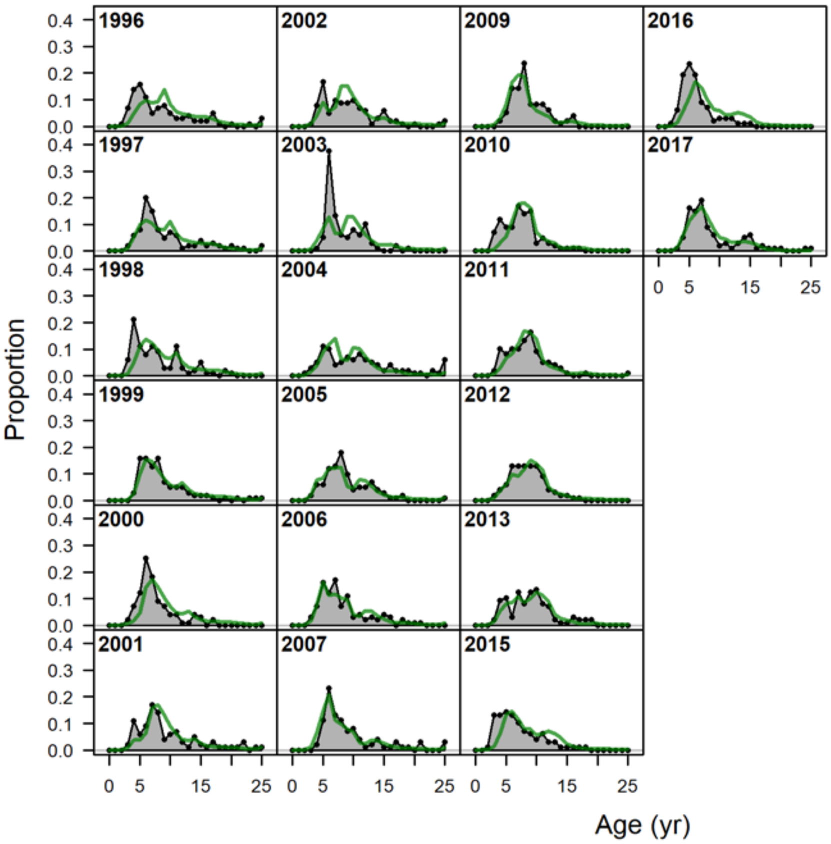


Figure A 5.46. Eastern jackass morwong implied fits to age: Tasmanian trawl port discarded.

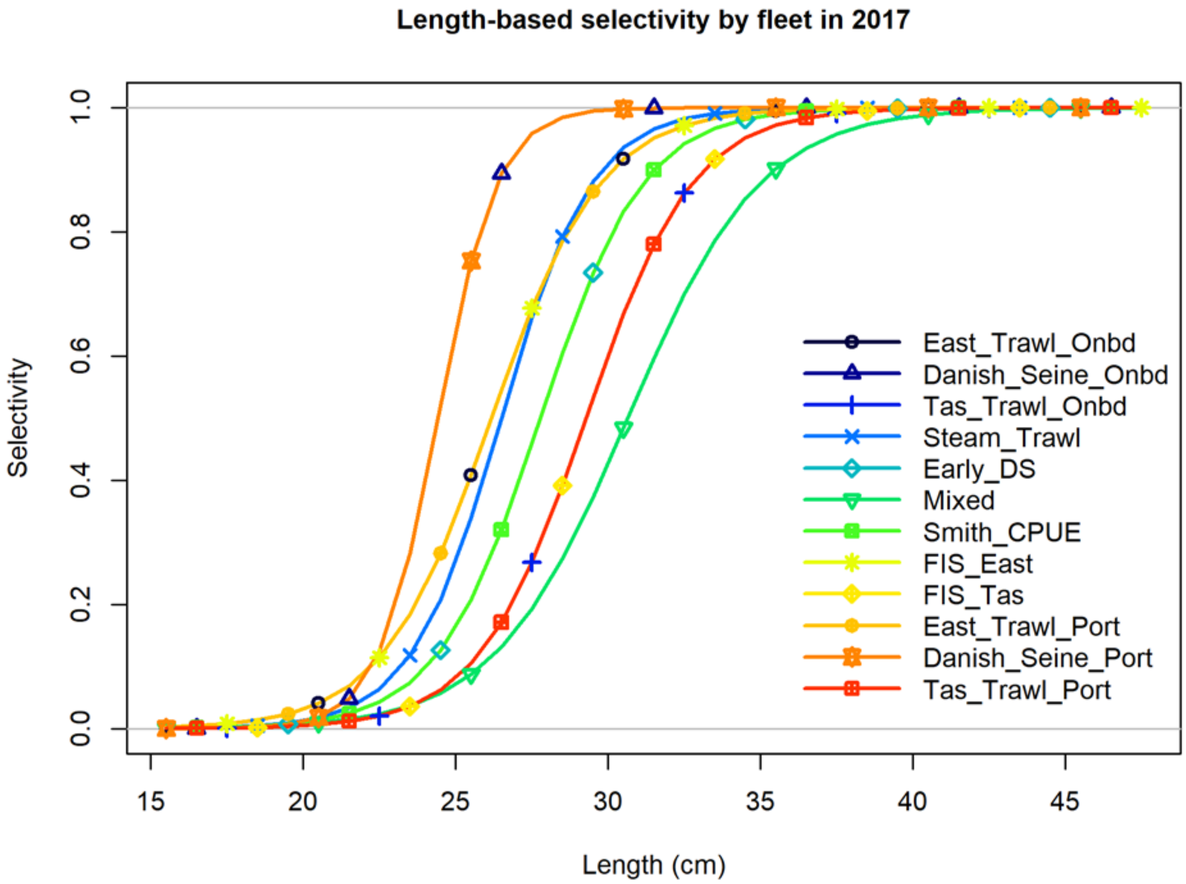


Figure A 5.47. Estimated selectivity and retention curves for eastern jackass morwong trawl fleet.

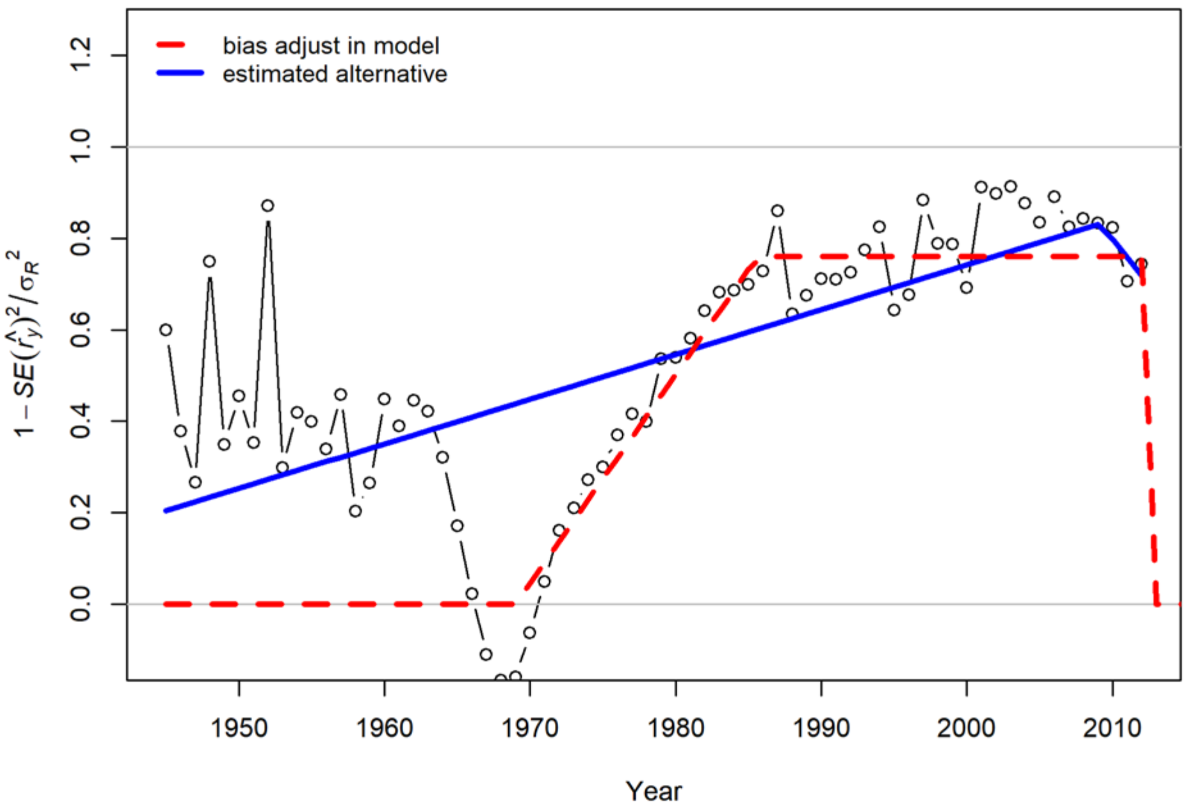


Figure A 5.48. Bias ramp adjustment for eastern jackass morwong.

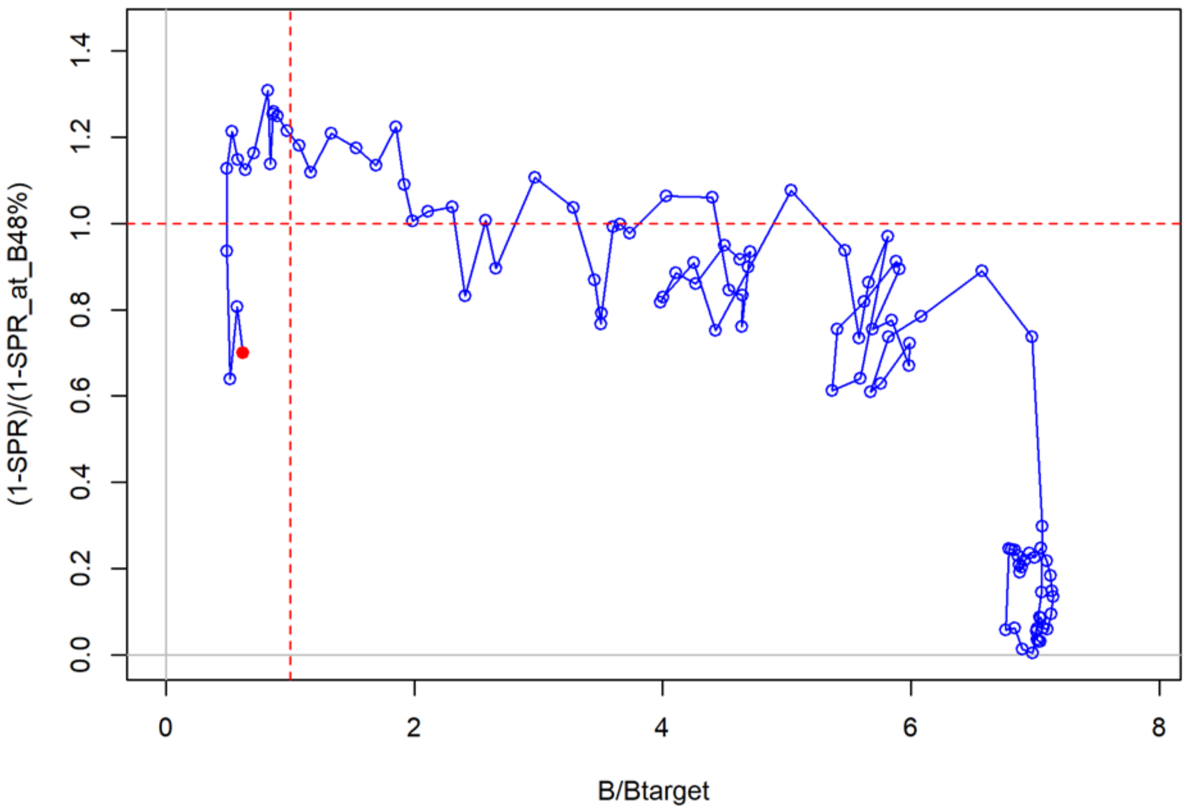


Figure A 5.49. Phase plot of biomass vs SPR ratio.