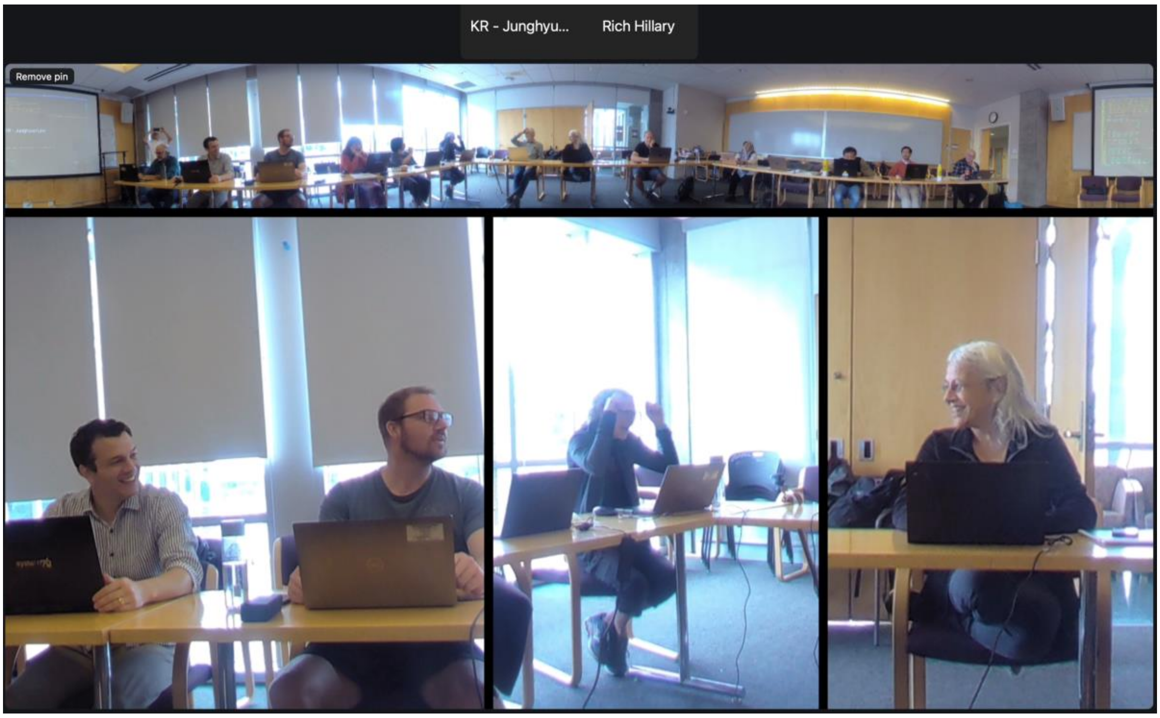
Commission for the Conservation of Southern Bluefin Tuna

みなみまぐろ保存委員会

Report of the Fourteenth Operating Model and Management Procedure Technical Meeting



24 – 28 June 2024
Seattle, USA

Report of the Fourteenth Operating Model and Management Procedure Technical Group

24 – 28 June 2024

Seattle, USA

Opening

1. The Chair of the Fourteenth Operating Model and Management Procedure Technical Meeting (OMMP14), Dr Ana Parma, opened the meeting and welcomed participants (**Attachment 1**). The Chair noted that the terms of reference are to discuss, implement, and evaluate changes to the Operating Model (conditioning and projections), and to continue to provide training on the use of the new software being developed by Dr Darcy Webber using the TMB-Stan platform.
2. The draft agenda was discussed and amended, and the adopted agenda is shown in **Attachment 2**.
3. The list of documents for the meeting is shown in **Attachment 3**.
4. Rapporteurs were appointed and agreed to co-ordinate the preparation of the report along with the consultant and the Advisory Panel members. Subsequent report sections are based on the adopted agenda.

Agenda Item 1. Summary progress report on the Operating Model Specification and Software Upgrade project

1.1. Review of project components and progress

5. The CCSBT Consultant, Dr Darcy Webber, presented the related part of CCSBT-OMMP/2406/04.
6. Dr Webber provided an introduction to the project and a summary of the Tokyo workshop (**Attachment 4**). The ADMB Operating Model (OM) specifications, code, and software present challenges for:
   - communicating the population dynamics and statistical assumptions underpinning the SBT model;
   - addressing uncertainty within each element of the OM grid; and
   - revising and implementing alternative hypotheses in stock assessments and future Management Procedure (MP) evaluations.
7. Upgrading to modern software will improve the flexibility, utility and understanding of the southern bluefin tuna (SBT) operating and assessment models for all CCSBT participants. Improvements to model structural and statistical procedures will potentially result in better presentation and understanding of historical, current and future SBT stock status, its associated uncertainty and MP performance.

8. Prior to the Tokyo meeting, the OM was coded into Template Model Builder (TMB). The model was integrated into an R package named sbt, and the R package was made available on GitHub.

1.2. Matching of ADMB and TMB likelihoods and results

9. Version 1 (V1) of the TMB code has been tested to ensure that it mimics the last version of the ADMB code. It was locked as V1 and is provided only for future reference.

Agenda Item 2. Handling of uncertainty and Bayesian Inference

2.1. Comparison of uncertainty approximated by sampling the grid versus MCMC[1]

10. In the approach used with ADMB, uncertainty was approximated using a reference set of models (a grid of 108 combinations of parameter values for steepness (4 levels), ψ (3 levels), M0 (3 levels) and M10 (3 levels), and sampling using prior weights for steepness and ψ, and objective-function likelihood-based weights for M0 and M10 (see CCSBT-ESC/2308/16 for further details)**.** The same full grid was run with the new TMB code using the version that matched the ADMB results (V1), and R code for sampling the grid was developed during the workshop to obtain a sample of size equal to 2000 from the reference set of models.

11. The new TMB software allows uncertainty to be evaluated by applying MCMC. A reduced grid was set up for checking purposes, which used the same fixed values of steepness and ψ as specified in the full grid but estimated M0 and M10 within the MCMC together with the rest of the model parameters. Because M0 and M10 were sampled using objective-function weights in the ADMB grid approach, the new reduced MCMC grid would allow for a consistent comparison of the level of uncertainty estimated by the two methods.

12. With four steepness values and three values for ψ, the group ran 12 separate (reduced-grid) MCMCs. The respective posteriors were combined for estimating the overall uncertainty around the total reproductive output (TRO). The resulting uncertainty was larger than that obtained by sampling the fixed grid of 108 cells.

13. While running the 108-cell grid using version 2 (V2) of the sbt TMB code (see section 3 below), except for the changes made to treat two of the fisheries (LL3 and LL4) as direct removals, some convergence problems were encountered and it was noted that a large number of iterations were required to achieve convergence. This did not appear to be an issue for ADMB. The comparison of the uncertainty estimated by the two approaches was therefore repeated after further changes were introduced to the sbt code including the treatment of LL3 and LL4 fisheries as direct removals (see section 3.2). The group also refined the optimiser settings, which lead to better convergence.

14. The uncertainty around TRO obtained using the final version (V2) of the sbt TMB code based on the two approaches (sampling from the 12 MCMC runs

[1] MCMC: Markov Chain Monte Carlo simulations

compared to integration across the 108-cell grid of fixed parameter values) showed similar results to what was observed prior to making those last model modifications (see Figure 1). The group concluded that the uncertainty approximated by sampling the maximum posterior densities obtained with the 108-cell grid was underestimating the parameter uncertainty in the sbt assessment.

2.2. Evaluation of possible reduced grid structures for applying MCMC

15. The group considered possible reduced grid structures to replace the full grid of 108 cells for going forward with MCMC. It was decided that, at the least, M0 and M10 should be estimated by MCMC to better reflect their uncertainty.

16. The question of whether ψ could be estimated instead of treating it as a grid axis was evaluated by conducting four MCMC runs conditioned on the four fixed steepness values while estimating ψ. The prior for ψ used in the ADMB code was carried over for this run. The marginal posterior distribution of ψ for the two MCMC runs corresponding to the most extreme steepness values (0.55 and 0.8) were examined and found to perform adequately. It was noted however that the posterior distributions were constrained by the bounds placed on ψ (log(1.5) and log(2)), so that the suggestion was made to explore performance after widening those bounds to log(0.5) and log(3).

17. An MCMC run that used the wider bounds on ψ and a value of steepness equal to 0.8 was completed during the meeting. MCMC diagnostics were examined in terms of the effective sample size and the $\widehat{R}$ statistic (Monnahan, 2024), which were all good. The traces for the two MCMC chains calculated were also good although there were a few divergences (14 of 2,000 transitions). The marginal posterior distributions and correlations between key model parameters were also satisfactory (Figure 2). It was noted that the posterior for ψ was somewhat shifted to lower values with respect to the prior, but this might change depending on the fixed value of steepness and should be further explored. The group was encouraged by these initial results which suggest that ψ could be estimated within MCMC together with the other model parameters.

18. A separate run was conducted where all the parameters were freely evaluated within the MCMC. This included the steepness value with an informative prior. In general, the posterior largely reflected the prior distribution. The group noted that the apparent information content about steepness depends on the assumption made that recruitment deviations are independent from year to year. The inclusion of autocorrelation in the model would result in higher uncertainty about steepness, as discussed in paper CCSBT-ESC/2008/13. The group decided that it was best to keep the range of fixed steepness values that has been used in the grid.

Agenda Item 3. Operating model changes specified at the Tokyo modelling workshop (November 2023)

19. During the Operating Model Specification and Software Upgrade Workshop held from 20 – 21 November 2023 in Tokyo, several changes to the model were specified, as described in the workshop report (submitted to this meeting as CCSBT-OMMP/2406/Info 01).

20. Dr Webber presented changes that were made to the TMB model since the Tokyo workshop (**Attachment 5**) so that they could be evaluated by the working group. These changes are implemented in Version 2 (V2) of the model, and include:

    - changes to the tag likelihood to remove the H* parameters (section 3.1),
    - addition of cohort slicing of LFs, and an option to specify direct removal of the catch (section 3.2),
    - addition of the Student-t distribution function, which will be used as a prior for sigma_r when this parameter is estimated in the model,
    - addition of an option to fit to LFs/AFs using a multinomial, Dirichlet, or Dirichlet-multinomial distribution (section 3.3),
    - changes to the POP likelihood to account for age uncertainty in the adults (section 3.4).

    Other changes were advanced during the meeting, including

    - an approach based on a Gaussian Markov random field to model time-varying selectivities for LL1, LL2, Indonesian and surface fisheries was implemented (section 3.5),
    - alternatives for keeping the harvest proportions at age below 0.9 were considered (section 3.6).

3.1. Changes to the tag likelihood

21. The ADMB OM included a large number of H* parameters that represent the harvest proportion of tagged fish in the same time period (year) that tagging occurred. These parameters were included to account for incomplete mixing of tagged fish within the wider population in the year of tagging. However, these parameters are not well estimated in the model. To resolve this issue (see https://github.com/quantifish/sbt/issues/17), the recaptures in a given year of tagging were removed from the number released that year after accounting for non-reporting. The probability of recapture in the year of tagging was then set to zero, so that the probability of a tagged fish surviving to the next year with at least one tag in place no longer needs to take into account the harvest proportion in that year but rather is a function of natural mortality and tag shedding parameters only. In addition, a Dirichlet-multinomial distribution function was coded in "short-hand" (following the R format) and used within the tagging likelihood to improve readability.

3.2. Treatment of LL3 and LL4 fisheries as removals by age

22. In the ADMB OM and version 1 of the TMB OM, the following four longline fisheries were distinguished:

Fishery	Catch data included	Pulse (season)	Actual period used for compiling statistics
LL1	Primarily Japanese LL areas 4-9 plus all LL catches not covered in LL2-LL5	(2) 1 July	Jan 1 through Dec 31
LL2	SBT caught in Taiwanese albacore LL fishery and Taiwanese gillnet catches	(2) 1 July	Jan 1 through Dec 31
LL3	Japanese LL in Area 2	(1) 1 Jan	Jan 1 through Dec 31
LL4	Japanese spawning fishery (Area 1)	(1) 1 Jan	July 1 through June 30

23. Selectivity at age was estimated for each fishery with variable specifications in order to fit the respective size compositions. Fisheries LL3 and LL4 had substantial catches in the past but not since about 1990. It was therefore decided to treat them as direct removals instead of modelling their selectivities, which reduces the number of parameters to be estimated. Time varying selectivity at age was estimated for the LL3 fishery while time invariant selectivity at age was estimated for the LL4 fishery. To implement the direct removal of catches, code was written to cohort slice length frequencies and transform them to age frequencies for the LL3 and LL4 fisheries outside of the TMB model code. This code slices all four longline fisheries, but the user can choose to fit to the original length frequencies or the sliced age frequencies for each fishery.

24. The process of cohort slicing for each length frequency involves taking the mean length at age for each year and season (ly,s,a), finding the midpoints between each length at age (and appending zero and infinity at start and end), and then cutting the length frequency at these midpoints.

25. An option has been set up in the OM for choosing to remove the catches using the standard method or direct removals of catches for all years for the selected fishery. When age or length frequency data were missing but catch was taken, an option was added in V2 to use the average size composition data to account for these removals. This occurred with fishery LL4 which lacked any length-composition data since 1990.

26. The equations for modelling the direct removals are specified in paper CCSBT-OMMP/2406/04. Implementation of this method required restructuring the model parameters in the TMB code, so that selectivity parameters for the different fisheries could be declared separately.

27. Stemming from discussions about size at age, the group recommended a future research project revisiting growth estimates to determine how they may have changed over time and among fisheries (age-length cut-points used in the assessment were estimated over a decade ago). It would also be useful to gather

the available information on weight at age to revisit length-weight parameters to determine whether or not they have been constant over time, as assumed in the model.

3.3. Evaluate the Dirichlet-multinomial likelihood for age/length composition data

28. An option was added to fit the AF and LF likelihoods using a multinomial, Dirichlet or Dirichlet-multinomial (D-M) distribution (a multinomial was used in the ADMB OM); this included coding the Dirichlet and D-M distributions in "short-hand" since they did not already exist in TMB. The D-M option has been run in investigations but is yet to be fully tested. An advantage of using the D-M distribution is that the likelihood weighting factors for the fisheries get estimated directly rather than needing to specify them, but the group noted the importance of checking that the estimates are sensible.

3.4. Incorporate the age-uncertainty for the adult part of the POP calculations (the possible ages given length)

29. A new way of evaluating the likelihood of POPs has been developed to include age uncertainty in the comparisons where the adults have not been aged and only the length is known. While the majority of the adults that were in a POP were aged (there are currently 22 adults with no ages and 96 adults that do have ages), this was not the case for the adults that were checked but were not part of a POP. For those with no ages, there is a range of ages that could be applied to the measured length. In V1, the expected age from the distribution of age at length was used, but now a procedure has been developed to integrate across all the possible ages an observed adult length could be via the distribution of age at length. This distribution has a time-dependence for two reasons: (1) the underlying distribution of length-at-age changes over time; and (2) given that the length distribution of sampled adults and the age composition of the population change from year to year, the prior age distribution (the distribution of possible ages the adult could be before measuring its observed length) will change also.

30. The group noted that the Indonesian age composition estimated in the model could be used to calculate the desired distribution of age given length, rather than estimating the prior age composition directly using the CK samples and applying Bayes theorem. The two approaches could be compared to evaluate if using the model might account better for the effects of variable year-class strength.

3.5. Time-varying selectivity for LL1, LL2, Indonesia, and surface fisheries

31. An approach based on a Gaussian Markov random field was proposed (see https://github.com/quantifish/sbt/issues/22).

32. A recent paper (Cheng et al. 2023) developed a methodology for allowing selectivity to vary over time using Gaussian Markov random fields (GMRF). Using this approach, selectivity can be modelled by age and year, with the selectivity parameters treated as random effects. The code has been written but has yet to be fully tested. It is difficult to implement as a switch, because it

requires changes to many parts of the code. It will be included as part of the next version.

3.6. Review harvest proportion function and determine if a penalty is required to keep it below 0.9 (currently there is no penalty in the sbt model)

33. The ADMB code used a function called posfun() to keep the annual harvest proportion below 1. It could also adjust (i.e. flatten) the selectivity of a given fishery when its catch for one or a few ages exceeded the abundance of those ages but the overall catch did not. TMB does not allow "if" statements that involve estimated parameters so that the posfun() cannot be used. A smooth penalty that increases rapidly as the limit (harvest proportion =0.9) is approached was explored but the performance of the maximum likelihood estimation became worse. The TMB conditional "ifelse" statement to constrain the harvest proportion to be below 0.9 was used in the final version.

3.7. Categorise what to add to REPORT and ADREPORT in the TMB code

34. Similar to the ADMB report, the TMB REPORT includes all penalties, priors, predictions and estimates that need to be accessible outside of the model. The list of variables can be modified at any time with minimum effort. Biomass at age 10+ and TRO will be included in the ADREPORT together with ψ when the latter is estimated.

3.8. Implement "one-step ahead residuals" diagnostics

35. Pearson residuals assume normality and do not account for correlations in the age/length composition data. One-step-ahead (OSA) residuals incorporate an approach for dealing with correlations that result from the assumed distributions of these data (e.g., multinomial, Dirichlet multinomial). However, implementing OSA residuals is not straightforward when the model includes random effects, and some issues with correlations are likely to remain, so the group decided not to proceed with this task right now (it can be revisited in future once higher priority items have been completed).

Agenda Item 4. Discussion of further changes to the OM

36. Dr Webber presented some possible further changes that could be incorporated to the model (**Attachment 6**). The discussion focussed on those changes that are likely to be implemented before the next stock assessment to be conducted in 2026. Issues discussed included alternatives to rewriting the projection code (using the "simulation" option available in the TMB code, or as stand-alone code that would use MCMC samples as input to the projections). Also, the group noted the need to apply or develop the Maximum Sustainable Yield (MSY) calculations as part of the reporting.

37. New diagnostics implemented in a package developed by Dr Cole Monnahan were examined using the sbt TMB code that included all the model changes

implemented during the OMMP meeting. This evaluation indicated that some of the selectivity parameters for the Australian surface fishery had poor mixing properties in MCMC, which could lead to unreliable final estimation of assessment uncertainties from MCMC applications. The existing implementation of the assessment model uses cohort-sliced catch at age for this fishery and estimates very flexible selectivity-at-age functions to achieve almost perfect fits to the surface fishery age composition data.

38. To avoid the problems caused by these selectivity parameters in MCMC, the group agreed to explore using direct removals of the surface catches at age, thus eliminating the need for selectivity function parameter estimation for this fishery. This was considered the "lesser of the two evils", for two reasons. First, while cohort-slicing may be inaccurate, it was already being used to calculate catches at age used in model fitting. Second, ageing inaccuracies arising from cohort slicing would be relatively small (compared, say, to using cohort-slicing for catches of larger lengths) for the young ages (mostly ages 2-4) taken by the Australian surface fishery.

39. The exploration of model diagnostics also indicated some marked differences between the Hessian-based bivariate asymptotic confidence regions and the MCMC outputs, particularly for the M10-B0 bivariate distribution. These issues should be examined in detail.

40. Based on the presentations made by Dr Webber (**Attachment 6**) and the evaluations conducted during the week, the group noted further analyses and changes to be made to future versions. These are outlined and prioritised in the Table 1 below.

Table 1. Summary of modelling issues and further code changes prioritised by the working group.

Issue	Coding status	Evaluation	Priority
Dirichlet-multinomial for age/size composition data	Done	Pending	High
GMRF selectivity	In progress	Pending	High
Treat catch-at-age for the Australian surface fishery as direct removals	Not implemented	Pending	High
Add overdispersion parameters to tag likelihood	Straightforward to add parameters	Pending	High
Add overdispersion to GT, POPs and HSPs using a beta-binomial distribution	Needs coding of beta-binomial distribution	Pending	High
Develop projection model	Implement projections within the "simulate" blocks of the TMB code	Pending	High (2025)
Compute MSY quantities by year using year-specific parameters and catch allocations between fleets	Need to add supplemental optimisation code (linkage between sub-MSY model and main)	Pending	High (2025)
Develop plots showing relationship between the posterior and values of M10 and steepness (and other relevant parameters)	Pending	Pending	High (2025)
Superimpose priors on posterior distributions for comparison	Pending	Pending	High
Combine documentation for C++, R package, and model	Ongoing, github-based website resource (e.g., here)	Pending	High
Estimate recruitment SD and autocorrelation	Need to code auto-regression (AR1) process for Rdevs	Pending	Medium
Use model-estimated Indonesian age composition in POP likelihood	Need to add switch in code to specify this as an option	Pending	Medium
Make M a function of size using Lorenzen + age-based senescence	Not started	Pending – this will mean M varies over time, so needs to be explored.	Low
One-step-ahead (OSA) residuals	OK but not for random effects. Would needs major restructuring to code for random effects-model	Postponed for now	Low

41. The group discussed aspects of model fitting and diagnostics. As part of this, the group evaluated the characteristics of models that failed to achieve a positive definite Hessian (pdH). These were largely resolved by:

   a. Applying the direct-removals option for the smaller-scale fisheries where data to inform year-class strength and selectivity options are unnecessary for yield calculations (i.e., F_{MSY} etc). This reduced the number of parameters and seemed to improve the estimation.

   b. Refining the minimiser settings used by TMB (increasing iterations, applying Newton-steps, and repeating the estimation with ending parameter values a few times).

42. When applying the MCMC approach, the group noted the presence of some divergent transitions. This was explained as being a problem with part of the sampling process and settings could be modified to make improvements. From investigations done during the week, it appeared that model results were insensitive to these issues (but this needs further work).

43. A potential longer-term change to be considered is restructuring the model to be both age and length based. This could include modifying selectivities to be a function of length rather than age.

Agenda Item 5. Review and clean-up of TMB code and model documentation.

44. During the week, the group appreciated Dr Webber's work in providing up to date documentation on different aspects of this project. This included the transformation into TMB of the original ADMB code. Dr. Webber reviewed the "bridging" exercise between these two platforms and the group was satisfied that the TMB version (under same settings) could mimic the earlier ADMB code.

45. The review of the R package within the GitHub account formed the basis of reporting out documentation (i.e., here).

46. Two other aspects of model documentation were developed further during the week. This included creating automated help-files from the C++ code (currently only the R-package "sbt" had documentation on all of the functions). The C++ initial draft-documentation was reviewed by the group (as part of the actual source code of version 3 (here); for those with an account on the repository).

47. The second aspect of the model documentation was related to how the model equations and structure. This had been developed as an MS word file but the group proposed creating a R Markdown file and to generate it as one of the vignettes available (i.e., here). The group reviewed aspects of contributing to these ways of documenting the model and application usage.

Agenda Item 6. Workplan

48. The next steps related to the OM coding project are summarised in Table 1. An extra day (1 September 2024) was added prior to ESC29 for the OMMP group to meet. In addition, the ESC Chair, Dr Kevin Stokes, indicated that he anticipates

that the ESC agenda will allow time to be allocated to continue working on the OM coding project during the meeting.

Adoption of Meeting Report and close of meeting

49. The report was adopted and the meeting closed at 3:35 pm in Seattle time on 28 June 2024.

References

Cheng, M.LH., Thorson, J.T., Ianelli, J.N., and Cunningham, C.J. 2023. Unlocking the triad of age, year, and cohort effects for stock assessment: Demonstration of a computationally efficient and reproducible framework using weight-at-age. Fisheries Research 266 https://doi.org/10.1016/j.fishres.2023.106755

Monnahan, C. (2024) Toward good practices for Bayesian data-rich fisheries stock assessments using a modern statistical workflow. Fisheries research 275, 107024.

Figures

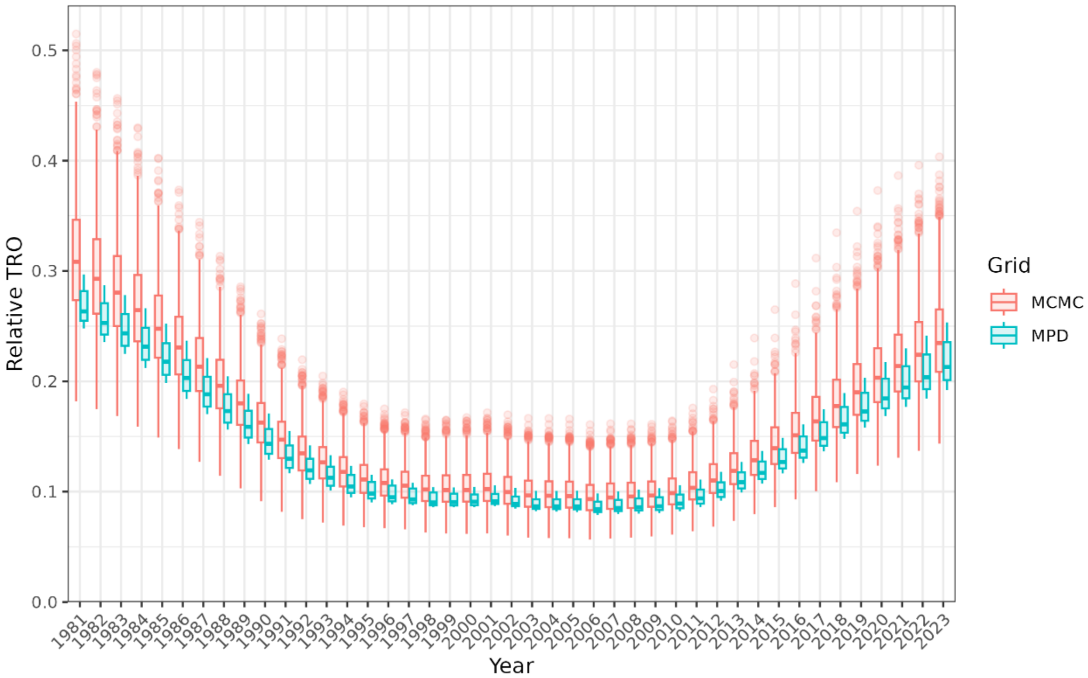


Figure 1. Total reproductive output (TRO) based on the 108 sampled “grid” cell point estimates (MPD) compared preliminary MCMC results.

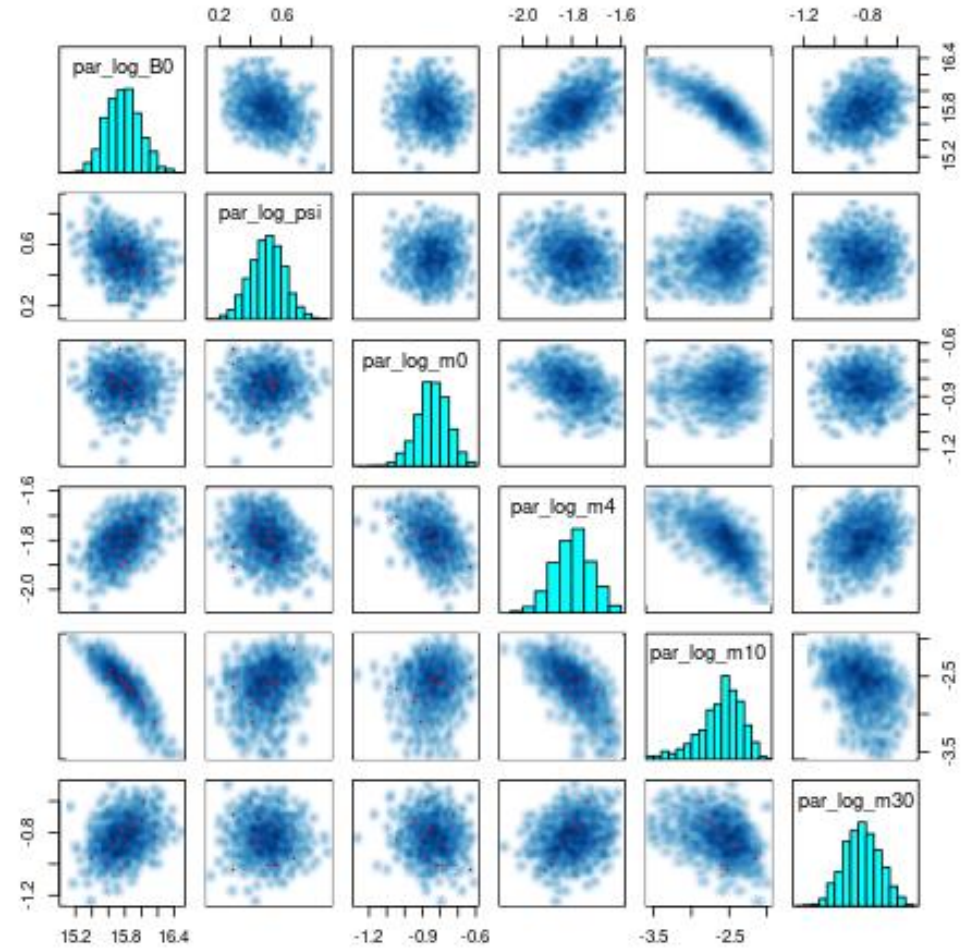


Figure 2. “Pairs” plot of preliminary MCMC runs showing the marginal densities for some parameters (diagonal histograms) and the bivariate distribution of the posterior samples in the off-diagonals. Note parameters are in log-space.

List of Attachments

Attachments

1 List of Participants

2 Agenda

3 List of Documents

4 Operating Model Specification and Software Upgrade Project - Introduction and Summary of the Tokyo Workshop (Dr. Darcy Webber)

5 Operating Model Specification and Software Upgrade Project - Details of progress since the Tokyo workshop (Dr. Darcy Webber)

5 Operating Model Specification and Software Upgrade Project - Next Steps (Dr. Darcy Webber)

Attachment 1

List of Participants

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Attachment 2

Agenda

Fourteenth Operating Model and Management Procedure Technical Meeting

1. **Summary progress report on the Operating Model Specification and Software Upgrade project**
    - 1.1. Review of project components and progress
    - 1.2. Matching of ADMB and TMB likelihoods and results
2. **Handling of uncertainty and Bayesian Inference**
    - 2.1. Comparison of uncertainty approximated by sampling the grid versus MCMC
    - 2.2. Evaluation of possible reduced grid structures for applying MCMC
3. **Operating model changes specified at the Tokyo modelling workshop (November 2023)**
    - 3.1. Changes to the tag likelihood
    - 3.2. Treatment of LL3 and LL4 fisheries as removals by age
    - 3.3. Evaluate the Dirichlet-multinomial likelihood for age/length composition data
    - 3.4. Incorporate the age-uncertainty for the adult part of the POP calculations (the possible ages given length)
    - 3.5. Time-varying selectivity for LL1, LL2, Indonesia, and surface fisheries
    - 3.6. Review harvest rate function and determine if a penalty is required to keep it below 0.9 (currently there is no penalty in the *sbt* model)
    - 3.7. Categorise what to add to REPORT and ADREPORT in the TMB code
    - 3.8. Implement "one-step ahead residuals" diagnostics
4. **Discussion of further changes to the OM**
5. **Review and clean-up of TMB code and model documentation**
6. **Workplan**

Attachment 3

List of Documents

The Fourteenth Operating Model and Management Procedure Technical Meeting

(CCSBT-OMMP/2406/)

1. Provisional Agenda
2. List of Participants
3. List of Documents
4. Southern Bluefin Tuna Operating Model Progress (Rev.1) (Webber, D., Eveson, P. and Hillary, R.) (OMMP Agenda item 1)

(CCSBT-OMMP/2406/Info)

1. Report of the Operating Model Specification and Software Upgrade Workshop (November 2023)

(CCSBT-OMMP/2406/Rep)

1. Report of the Thirtieth Annual Meeting of the Commission (October 2023)
2. Report of the Twenty Eighth Meeting of the Scientific Committee (August/September 2023)
3. Report of the Thirteenth Operating Model and Management Procedure Technical Meeting (June 2023)
4. Report of the Twenty Seventh Meeting of the Scientific Committee (August 2022)
5. Report of the Twelfth Operating Model and Management Procedure Technical Meeting (June 2022)
6. Report of the Twenty Sixth Meeting of the Scientific Committee (August 2021)

Operating Model Specification and Software Upgrade Project

Introduction and Summary of the Tokyo Workshop

Darcy Webber

24 June 2024
Seattle

QUANTIFISH
Quantitative Fisheries Science

sbt

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2. Summary of the Tokyo workshop
3. Planning and overview of progress since the Tokyo workshop

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Project specifications

Project specifications

- A (Start year): 2023
- B (Duration): 3 years
- C (General category): OM
- D (Sub category): Asses
- E (Project title): Operating model specification and software upgrade
- ⋮
- I (Impact Scale): High
- J (Impact timing): Med
- K (Priority): to be completed at ESC meetings.
- L (Rank): to be completed at ESC meetings.
- ** (budget source): CCSBT

Project specifications: problem definition

F (Problem): The current operating model (OM) specifications, code, and software present challenges for

1. communicating the population dynamics and statistical assumptions underpinning the SBT model;
2. addressing uncertainty within the OM grid; and
3. revising and implementing alternative hypotheses in stocks assessments and future MP evaluations.

Project specifications: objectives

G (Objectives):

1. Update and revise OM documentation to match the OM code;
2. Develop new OM implementations in ~~either Stan or~~ Template Model Builder (TMB) software;
3. Code modifications to the OM to be decided by the OMMP Working Group to improve estimation efficiency and allow future flexibility in adding/removing complexity and features as needed;
4. Complete validation test comparing estimates from new implementation with current ADMB version.

Project specifications: rationale

H (Rationale): Upgrading to modern software will improve the flexibility, utility, and understanding of the SBT operating and assessment models for all CCSBT participants. Improvements to model structural and statistical procedures will potentially result in better presentation and understanding of historical, current and future SBT stock status, its associated uncertainty, and MP performance.

Project specifications: resources

2023	2024	2025
~~25d Consultant~~	20d Consultant	20d Consultant
~~2d MP Coordinator~~	2d MP Coordinator	2d MP Coordinator
—	1d extra at ESC meeting (VEH, Cat, 3P, 1C, 1Ch, Sec)	—
~~1d extra at Seattle OMMP meeting (Cat, 3P, 1C, 1Ch)~~	—	—
~~3d dedicated inf. OMMP meeting (Tokyo: FreeV, Cat, 3P,1C, 1Ch)~~	5d dedicated OMMP meeting (Seattle: FreeV, Cat, 3P, 1C, 1Ch)	—
~~2*2hr online meetings (3P,1C, 1Ch, Sec)~~	2*2hr online meetings (3P,1C, 1Ch, Sec)	2*2hr online meetings (3P,1C, 1Ch, Sec)

Abbreviations:

Sec	Secretariat Staff
Ch	Independ. ESC Chair
P	Independ. advisory panel
C	Consultant
Cat	Catering only
VEH	venue & equipment hire
FreeV	Free Venue & equip

Project specifications: work plan 2023

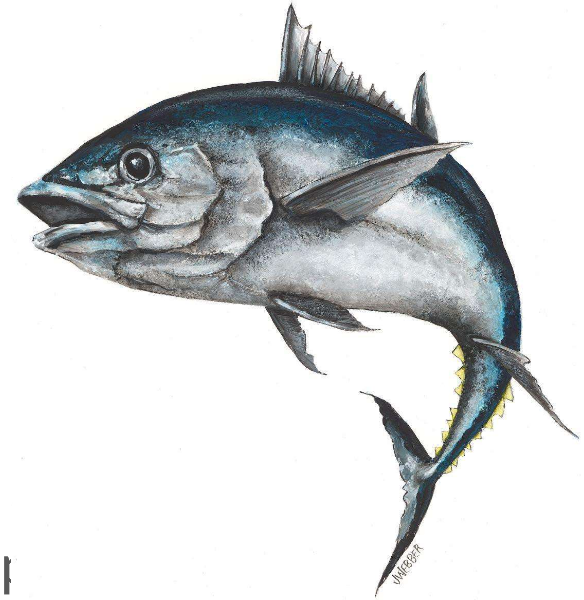
- ✓ Cleaning of old code and documentation.
- ✓ Darcy works on new conditioning code to match old code.
- ✓ One or more informal short (1-2 hour) online meetings.
- ✓ One extra day added to the scheduled in-person OMMP meeting to discuss progress.
- ✓ 3-day in-person meeting in November focused on the transition to the new code:
  - ✓ compare conditioning results obtained with old and new code;
  - ✓ show structure and receive feedback;
  - ✓ discuss projection code (could run old projection code with outputs from new code as an intermediate step);
  - ✓ prioritise work (changes to the code) for 2024
  - ✓ Provide training/tutorial

Project specifications: work plan 2024

- ✓ One or more informal short (1-2 hour) online meetings.
- ❑ 5-day OMMP in person meeting in June to discuss/implement/evaluate changes to the OM (conditioning and projections), and provide training/tutorial
- ❑ One extra day at ESC to discuss progress.

Summary of the Tokyo workshop

Progress prior to the Tokyo meeting



- The operating model (OM) was coded in template model builder (TMB)
- The model was integrated into an R package named *sbt*
- The SBT picture was painted by Joanne Webber (my mum) sp package
- The R package was made available online on GitHub
- The R package is documented with examples on the package website https://quantifish.co.nz/sbt/
- Many of the outstanding issues can be found here: https://github.com/quantifish/sbt/issues
- The new OM mimics the ADMB OM very well (see the website)

Progress at the Tokyo meeting

- Everyone at the workshop successfully installed the *sbt* package and ran the software / fitted a model to data
- The model structured was investigated in detail
- Planning of new features and a timeline was discussed
- A meeting report was published

Commission for the Conservation of Southern Bluefin Tuna

みなみまぐろ保存委員会

Report of the Operating Model Specification and Software Upgrade Workshop

20 – 22 November 2023
Tokyo, Japan

Planning and an overview of progress since the Tokyo workshop

Next steps: prior to June 2024 OMMP

Ideally the following changes would be implemented before the June 2024 meeting so that they can be evaluated by the OMMP working group:

- ✓ Check age likelihood again (small difference in likelihood)
- ✓ Lump the LL3 and LL4 fisheries and cohort slice and treat as removals
- ❑ Specify the LL1, LL2, Australian and, Indonesian selectivity using GMRF (in progress)
- ❑ Review this years sensitivities and robustness tests and make sure all the code to do these is available
- ❑ Can filter out some of the POPs in get_data that result in likelihood values that are not used in the estimation
- ✓ Name the grid runs in run_grid
- ❑ Implement grid sampling in the R code (in progress)
- ✓ Re-code tag likelihoods to remove the H* parameters (harvest rate for mixing periods) and add the output for the PSIS-LOO diagnostic
- ✓ Implement the Dirichlet-multinomial likelihood for composition data
- ❑ Code prior distributions in short-hand (following R format; e.g., dnorm()) (in progress)
- ❑ Incorporate the age-uncertainty for the adult part of the POP calculations (the possible ages given length) (in progress)
- ❑ Update website to improve documentation (e.g., add vignette on “how to run the grid”).
- ❑ Evaluate if other “Stan” R packages (e.g., adnuts) can be used to help evaluate model runs.

Next steps: at the June 2024 OMMP

Other tasks that could be completed at the June 2024 meeting include:

- ❏ Review harvest rate function and determine if a penalty is required to keep it below 0.9 (currently there is no penalty in the *sbt* model)
- ❏ Categorise what we want to add to REPORT and ADREPORT in the TMB code
- ❏ Implement "one-step ahead residuals" diagnostics for judging fits to composition data (in progress)
- ❏ Evaluate how the grid should be modified in light of new MCMC capabilities

Next steps: after the June 2024 OMMP

Tasks that could be done after the June 2024 meeting include:

- Projection model developments: two options were discussed, an interim option that requires the TMB code to output the same variables that the ADMB conditioning code passes to the projection code, so that the old projection code can be run (with inputs in the same format) or a final option where projections are implemented within the "simulate" blocks of the TMB code.
- Add in the supplemental optimization code to compute MSY quantities by year using year-specific parameters and catch allocations between fleets.

Attachment 5

Operating Model Specification and Software Upgrade Project

Details of progress since the Tokyo workshop

Darcy Webber

24 June 2024
Seattle

QUANTIFISH
Quantitative Fisheries Science

sbt

Prior to June 2024 OMMP

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Contents

1. Different model versions
2. Cohort slicing LFs
3. Direct removal of catches
4. Changes to likelihoods
5. Selectivity overhaul
6. Positive definite Hessian issues

Different model versions

Different model versions

- V1:
  - Matches the ADMB model
  - Not pdH
- V2:
  - Updates the tag likelihood (get_tag_like)
  - Adds the Dirichlet-multinomial distribution function and uses this in get_tag_like
  - Adds the student-t distribution function and uses it as prior for sigma_r
  - Adds option to fit to LFs/AFs using old method (which is wrong), multinomial, Dirichlet, or Dirichlet-multinomial
  - Adds cohort slicing of LFs
  - Adds option to specify direct removal of the catch
  - Not pdH
- V3:
  - working on GMRF selectivity - want to retain old selectivity at the same time

Cohort slicing LFs

Cohort slicing LFs

In the ADMB OM, time varying selectivity at age was estimated for the LL3 fishery, time invariant selectivity at age was estimated for the LL4 fishery (figure to right), and the LFs for these two fisheries were fitted to separately (see the next two slides).

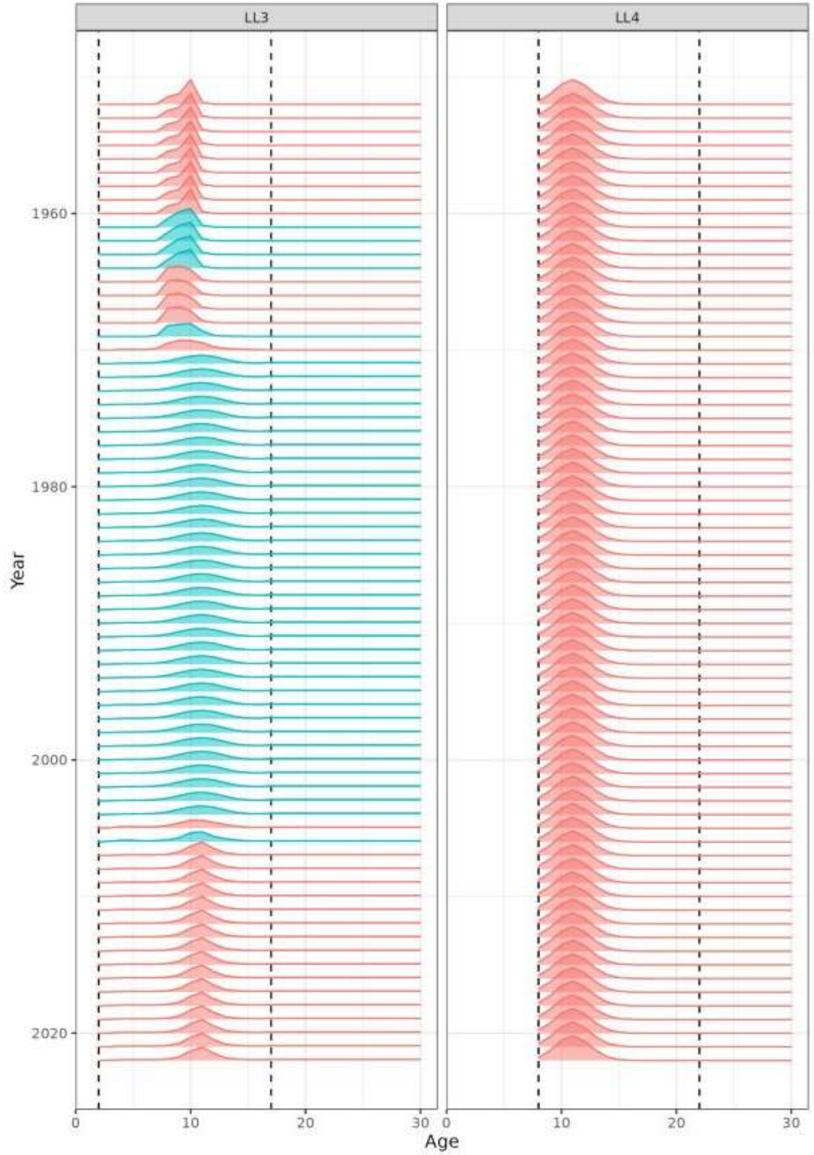


Figure 3: selectivity estimated by the previous OM for LL3 and LL4. The colours represent selectivity periods of that are assumed to be the same (i.e., there are nine periods of different selectivity for LL3 and LL4 selectivity is time invariant).

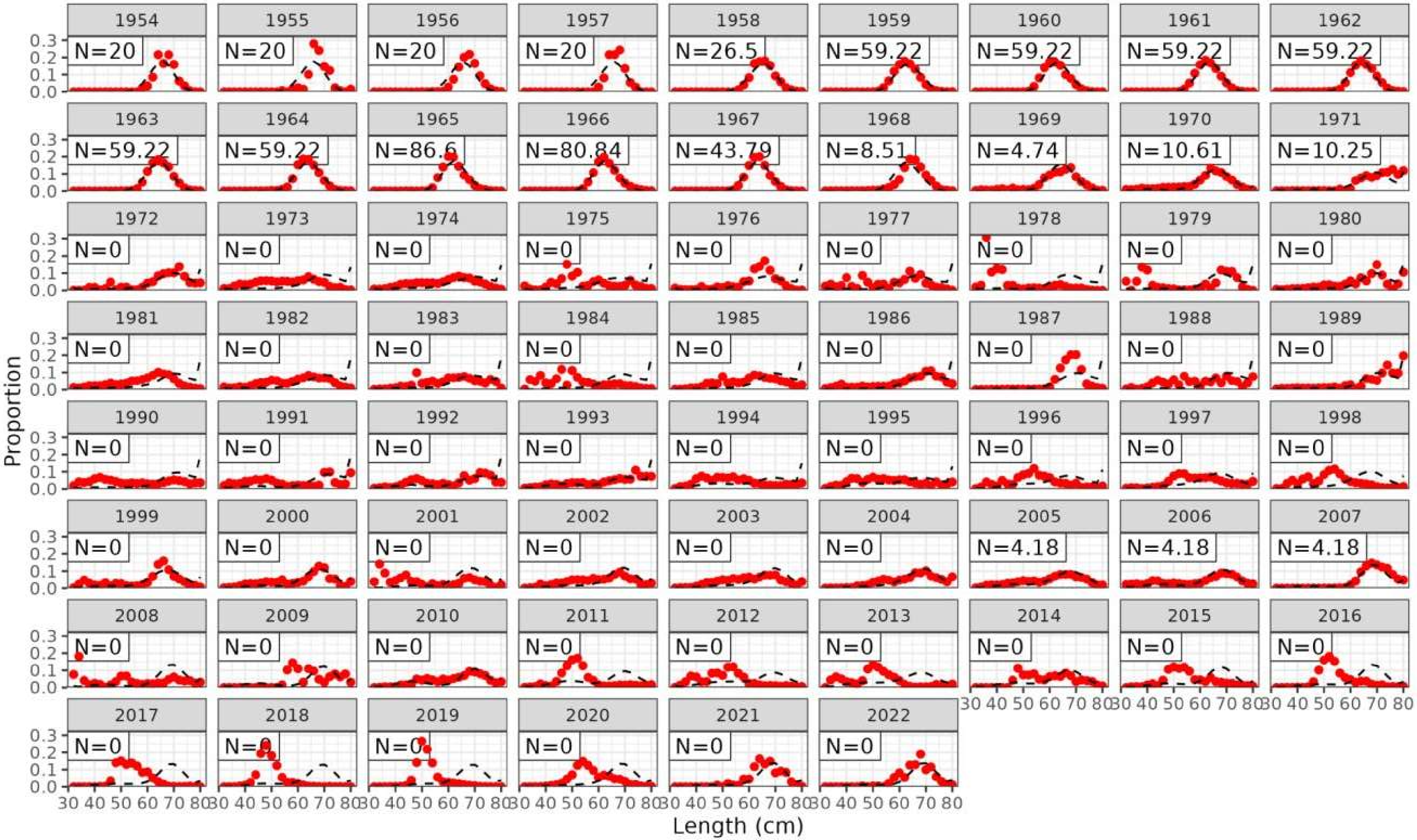


Figure 4: Observed LFs (red) and model fit (black) to the LL3 LFs. The effective sample size (N) is also shown for each year.

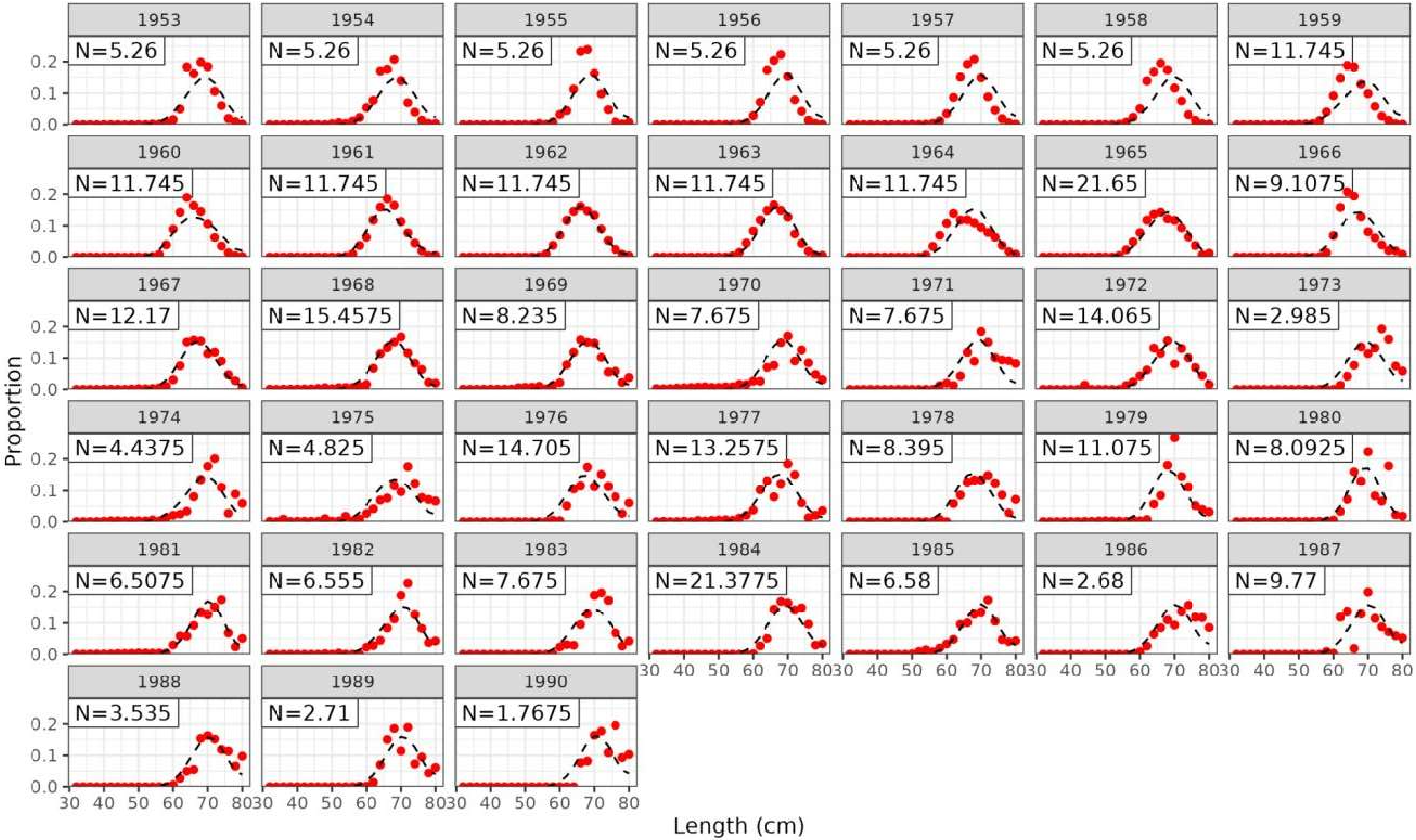


Figure 5: Observed LFs (red) and model fit (black) to the LL4 LFs. The effective sample size (N) is also shown for each year.

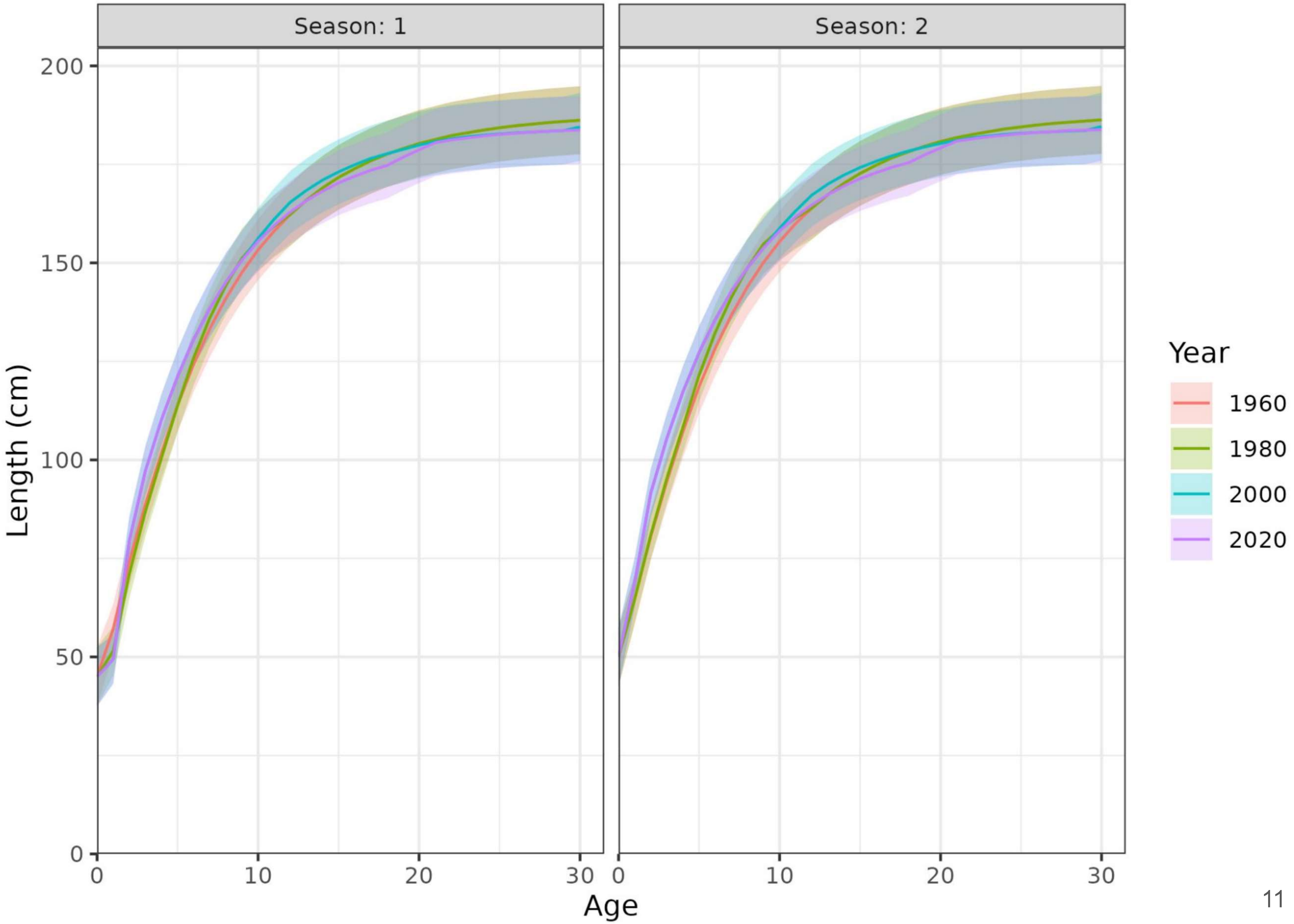
Cohort slicing LFs

Code was written to cohort slice LFs into AFs for the LL3 and LL4 fisheries. This is done outside of the TMB model code (i.e., in R code using the function `get_sliced_afs` which is embedded in the function `get_data`). This code actually slices all four longline fisheries (LL1, LL2, LL3, LL4), but the user can choose to fit to the original LFs or the sliced AFs for each fishery.

In short, the process of cohort slicing for each LF involves taking the mean length at age for each year and season for each LF ($l_{y,s,a}$), finding the midpoints between each length at age (and appending zero and infinity at start and end), then cutting the LFs at these midpoints (Figure 6, Figure 7).

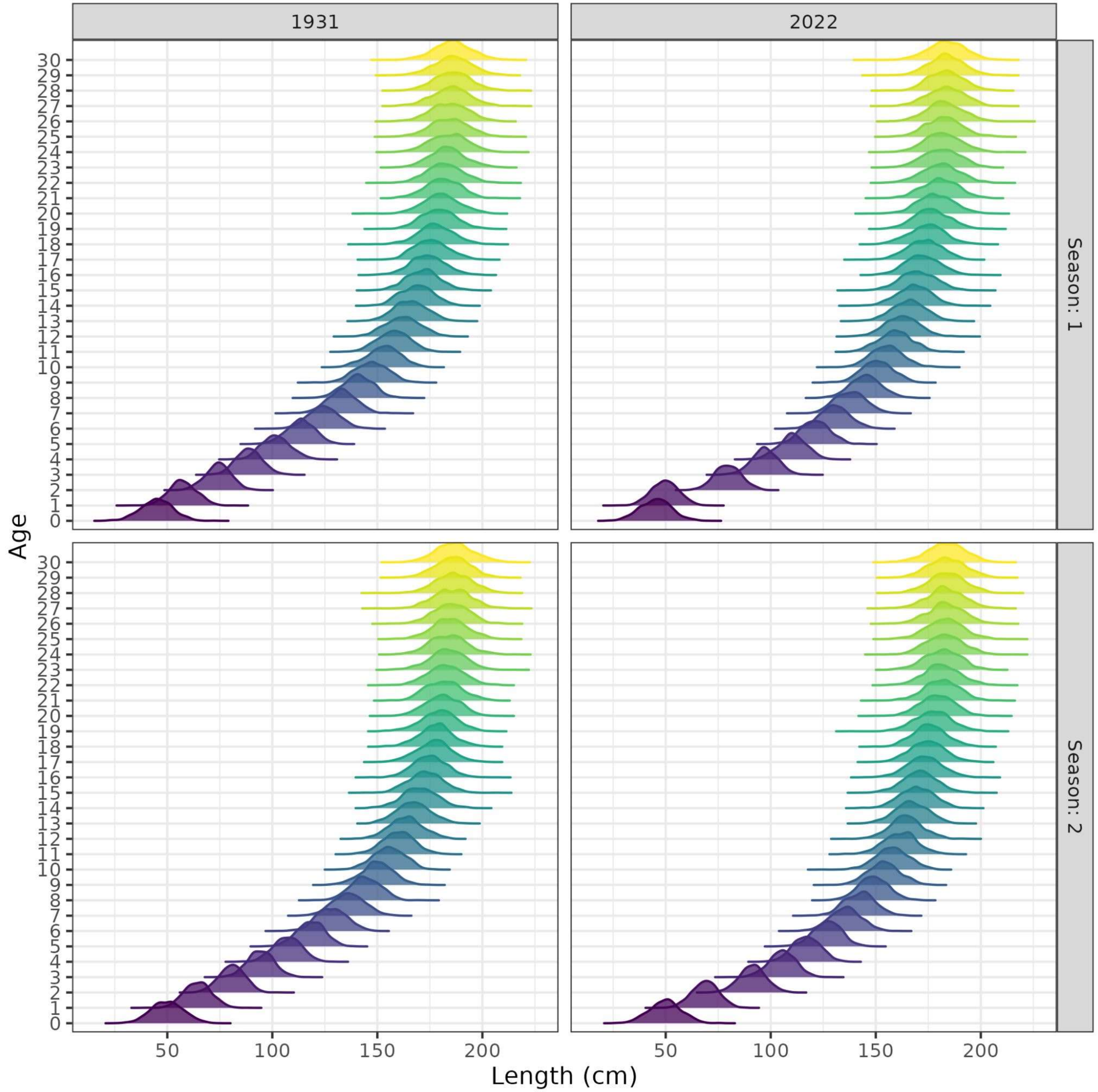
Cohort slicing LFs

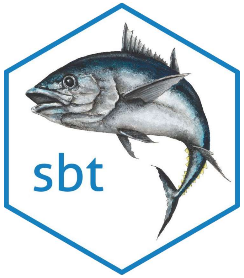
Note that this is just a subset of years for each fishery.



Cohort slicing LFs

Note that this is just a subset of years for each fishery.





Cohort slicing LFs

Note that this is just a subset of years for each fishery.

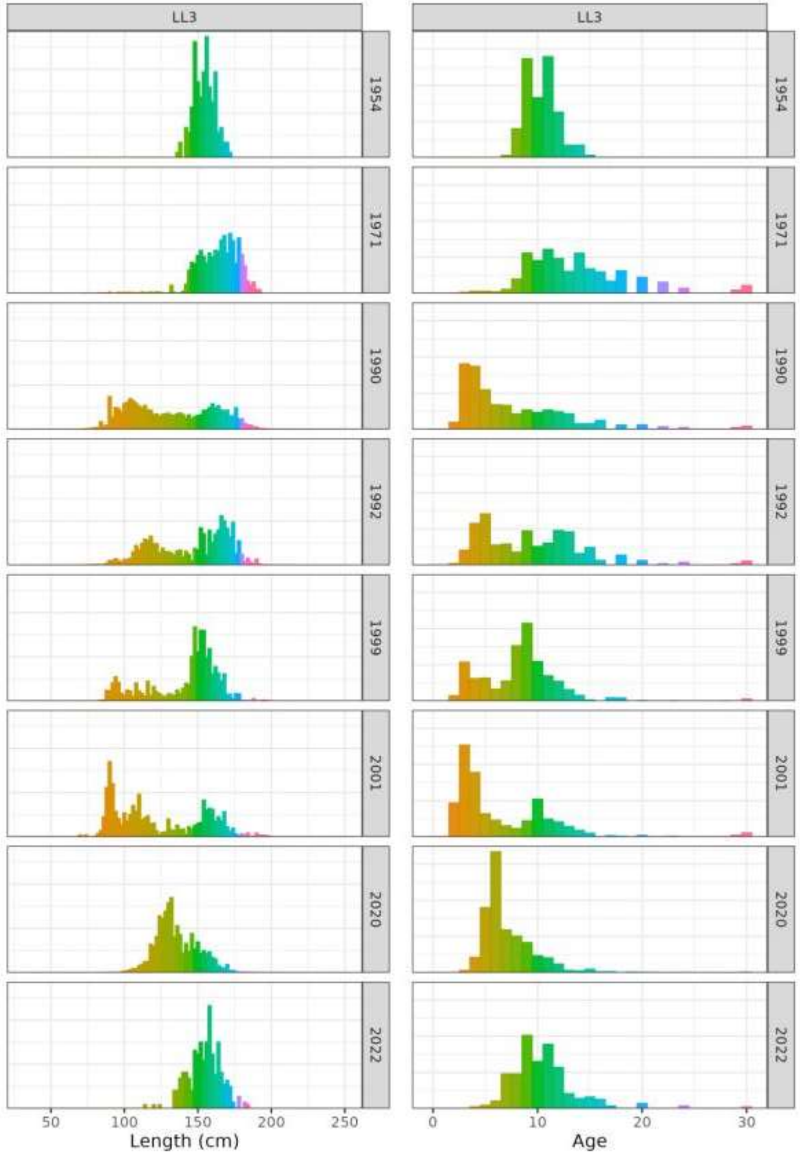


Figure 6: original LFs for a subset of years (left) and sliced LFs for those same years (right) for the LL3 fishery. Each colour represents an age.

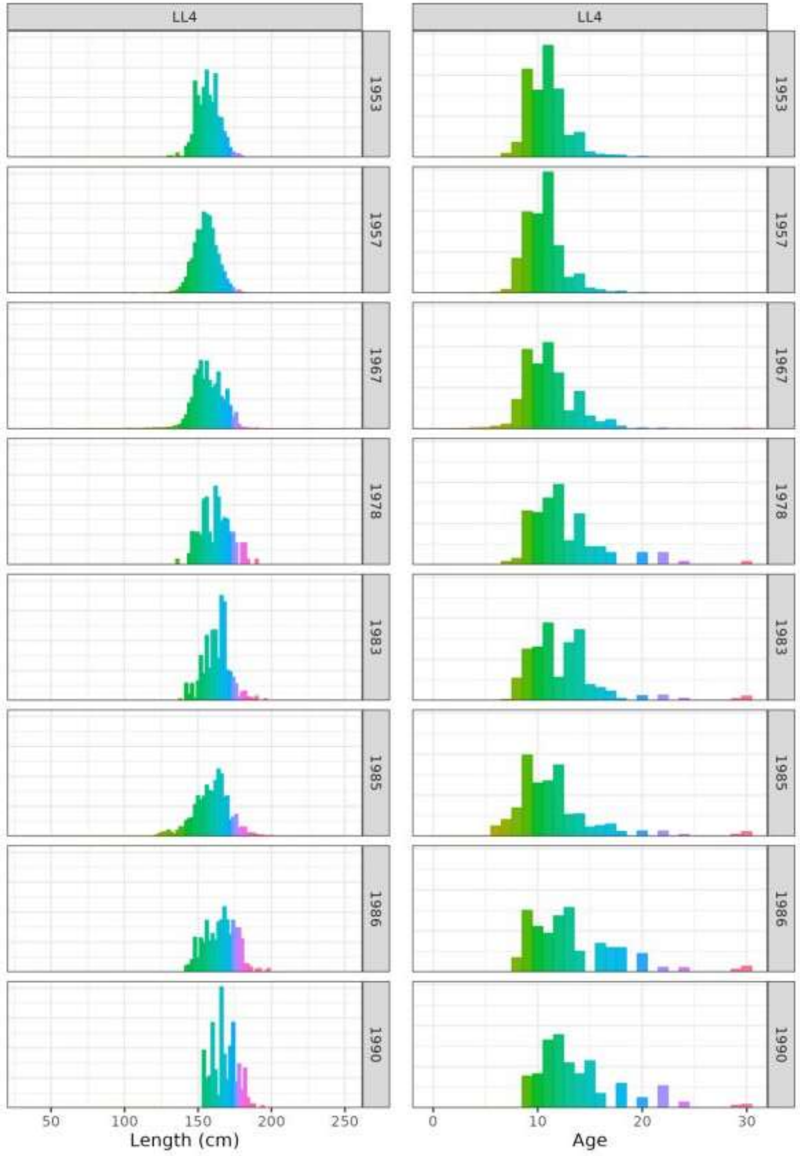


Figure 7: original LFs for a subset of years (left) and sliced LFs for those same years (right) for the LL4 fishery. Each colour represents an age.

Direct removal of catches

Direct removal of catches

- Typically, the catch for each year (y), season (s), and fishery (f, see next slide for other variable definitions) is removed by estimating selectivity ogives and using the process outlined in Table 2 on slide 18.
- The *sbt* code has been re-structured so that direct removals can optionally be specified for any fishery (all seasons and all years for the selected fishery).
- When specifying direct removals, the catch is removed from the model using the observed catch (tonnes) for each fishery ($C_{y,s,f}$) which is split proportionally by the AF or the sliced AF ($A_{y,s,f,a}$) for each fishery.

Direct removal of catches

Variable	Class	Description
a	Dimension	Age
y		Year
s		Season
f		Fishery
$N_{y,s,a}$	Derived quantity	Numbers at age in the population
$w_{y,f,a}$		Weight (tonnes) at age for each fishery
$S_{y,f,a}$		Selectivity at age for each fishery
M_a		Natural mortality at age
$H_{y,s,f,a}$		Harvest rate at age for each fishery
$C^N_{y,s,f,a}$		Catch (numbers) at age for each fishery
$C_{y,s,f}$	Covariate	Catch (tonnes) for each fishery
$A_{y,s,f,a}$		Proportion at age derived from an LF (i.e., cohort sliced LF) for each fishery

Direct removal of catches

<table>
<tr><th>Standard removals</th><th>Direct removals</th></tr>
<tr><td></td><td></td></tr>
<tr><td>$$U_{y,s,f,a} = \frac{C_{y,s,f}}{\sum_a N_{y,s,a} S_{y,f,a} w_{y,f,a}}$$</td><td>Define the catch biomass (tonnes) as $$C_{y,s,f} = X_{y,s,f} \sum_a A_{y,s,f,a} w_{y,f,a}$$ where $X_{y,s,f}$ is the catch in numbers obtained by dividing the catch in biomass by the average weight: $$X_{y,s,f} = \frac{C_{y,s,f}}{\sum_a A_{y,s,f,a} w_{y,f,a}}$$ The catch at age in numbers can be calculated as $$C^N_{y,s,f,a} = X_{y,s,f} A_{y,s,f,a}$$</td></tr>
<tr><td>$$H_{y,s,f,a} = U_{y,s,f,a} S_{y,f,a} \frac{C_{y,s,f} S_{y,f,a}}{\sum_a N_{y,s,a} S_{y,f,a} w_{y,f,a}}$$</td><td>$$H_{y,s,f,a} = \frac{C^N_{y,s,f,a}}{N_{y,s,a}} = \frac{X_{y,s,f} A_{y,s,f,a}}{N_{y,s,a}} = \frac{C_{y,s,f} A_{y,s,f,a}}{N_{y,s,a} \sum_a A_{y,s,f,a} w_{y,f,a}}$$</td></tr>
<tr><td colspan="2">The catch from all fisheries is removed from the population using $$N_{y,s+1,a} = N_{y,s,a} \left(1 - \sum_f H_{y,s,f,a}\right) e^{-0.5 M_a}$$</td></tr>
<tr><td colspan="2">The catch for deriving LFs and AFs is calculated as $$C^N_{y,s,f,a} = H_{y,s,f,a} N_{y,s,a}$$ And the catch biomass is $$C'_{y,s,f} = H_{y,s,f,a} N_{y,s,a} w_{y,f,a}$$</td></tr>
</table>

Model input

```
Data <- list(last_yr = 2022, age_increase_M = 25,
             length_m50 = 150, length_m95 = 180,
             catch_UR_on = 0, catch_surf_case = 1, catch_LL1_case = 1,
             scenarios_surf = scenarios_surface, scenarios_LL1 = scenarios_LL1,
             sel_min_age_f = c(2, 2, 2, 8, 6, 0),
             sel_max_age_f = c(17, 9, 17, 22, 25, 7),
             sel_end_f = c(1, 0, 1, 1, 1, 0),
             sel_change_sd_fy = t(as.matrix(sel_change_sd[,-1])),
             sel_smooth_sd_f = lr$sel.smooth.sd,
             removal_switch = c(0, 0, 0, 0, 0, 0), # 0=standard removals, 1=direct removals
             pop_switch = 1,
             hsp_switch = 1, hsp_false_negative = 0.7467647,
             gt_switch = 1,
             cpue_switch = 1, cpue_a1 = 5, cpue_a2 = 17,
             aerial_switch = 4, aerial_tau = 0.3,
             troll_switch = 1,
             af_switch = 3, # 0=multinomial, 1=Dirichlet, 2=Dirichlet-multinomial, 3=old
             lf_switch = 3, lf_minbin = c(1, 1, 1, 11),
             tag_switch = 1, tag_var_factor = 1.82)
```

Direct removal of catches

An example of direct removal of the catch is provided below. In this example:

- the LL3 catch is all removed because there is an LF associated with the catch in every year, but
- the LL4 catch is not all removed because in some years there is catch but no LF (see figure to right).

Thus, as it is currently coded, when no AF or LF is available for a fishery in a year then the catch collapses to zero even if there is catch in that year/season/fishery. This can be amended by combining the LL3 and LL4 fisheries (this code change will be done in future updates to the TMB code).

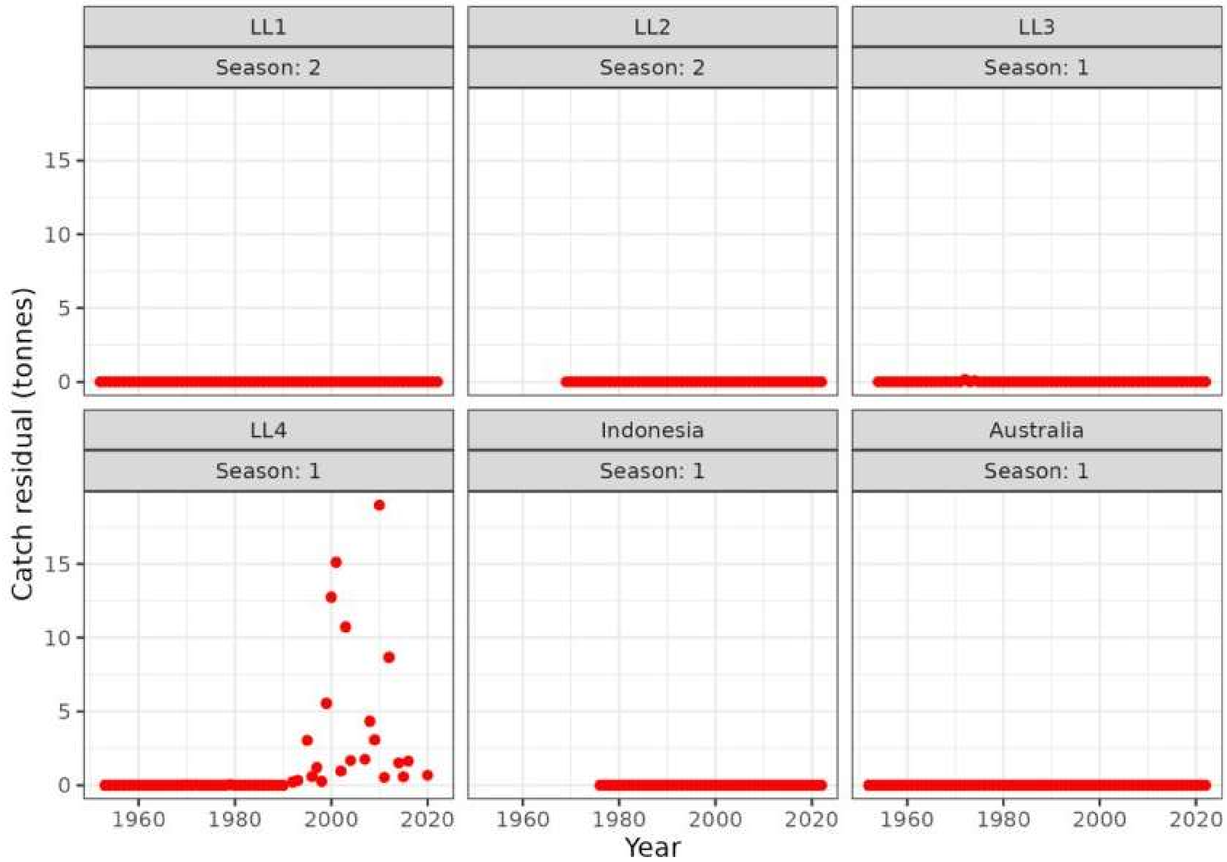


Figure 8: Catch residuals (input catch minus output catch, tonnes).

Direct removal of catches

Further to the example above, the predicted LFs for the LL3 and LL4 fisheries can be derived.

Note that the model predicted LFs do not match the observed LFs exactly because the catches are modified by the age-length-key (to convert from catch at age to catch at length) which distorts the predictions a little (Figure 9, Figure 10).

```
obs = lf_obs.row(i);
catch_a = catch_pred_fya(f, y);
pred = (alk_la * catch_a) / sum(catch_a);
```

However, when a fishery with AFs is specified to use as direct removals then the predicted AFs match the observed AFs exactly (Figure 11).

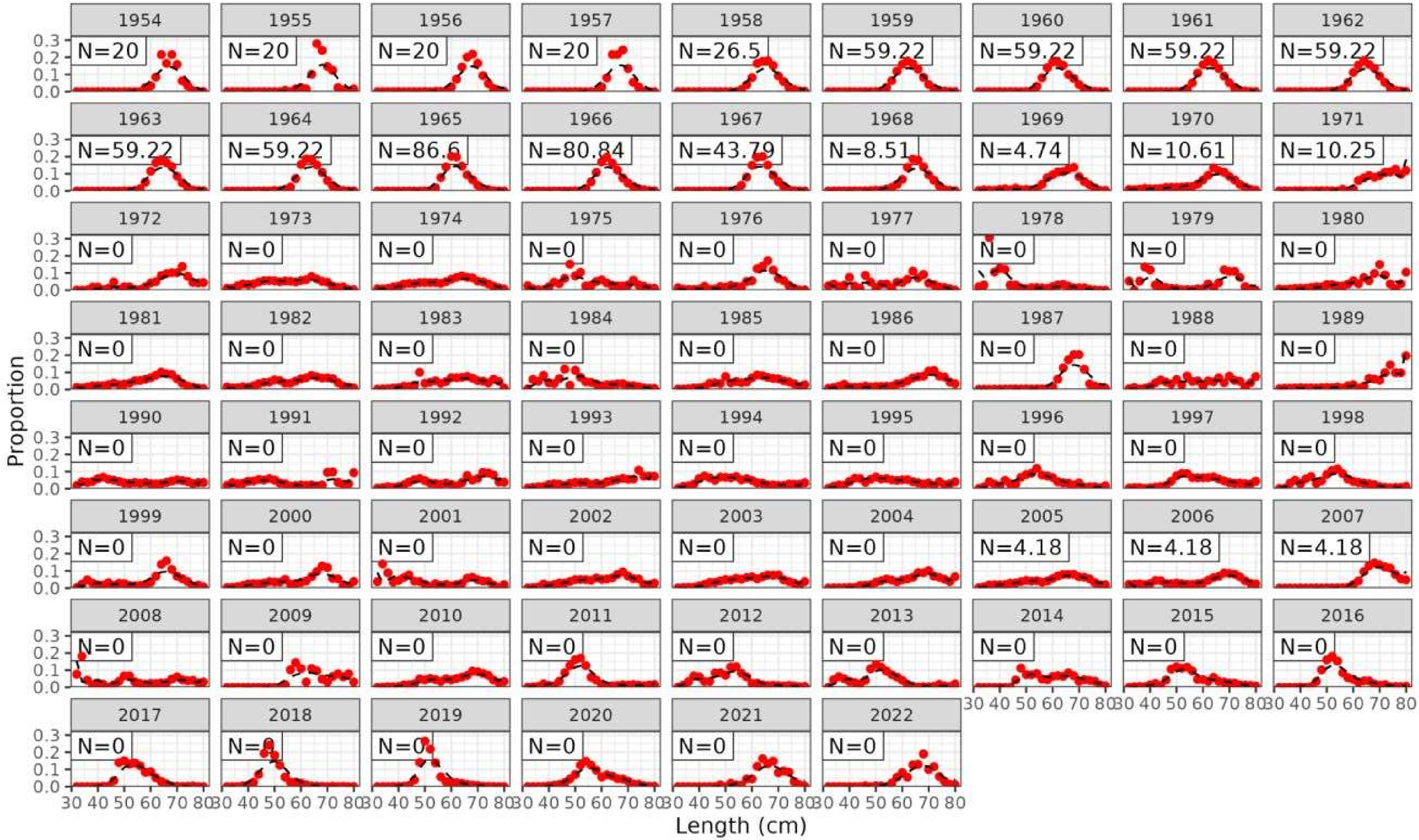


Figure 9: Observed LFs (red) and model fit (black) to the LL3 when treating as direct removals.

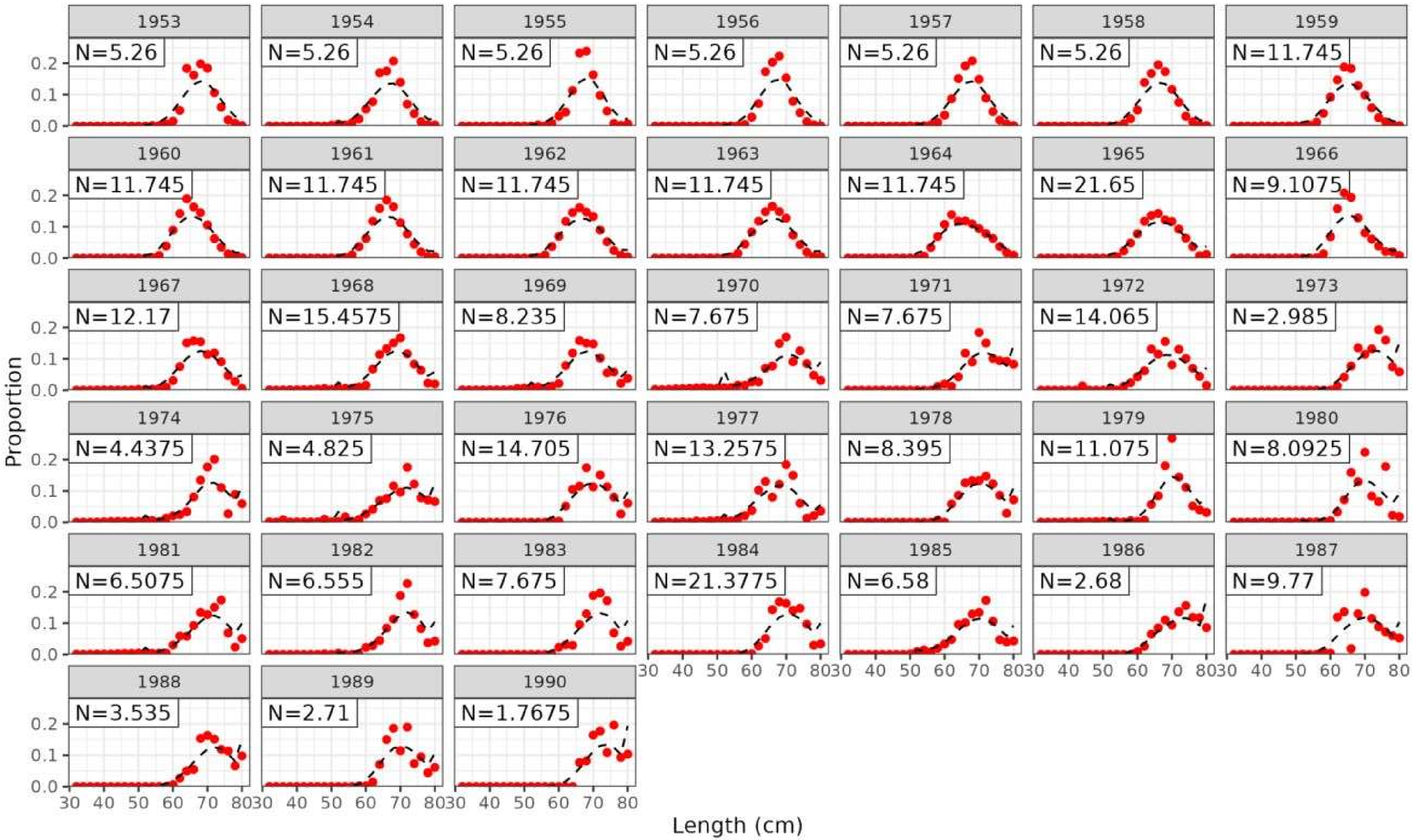


Figure *10*: Observed LFs (red) and model fit (black) to the LL4 when treated as direct removals.

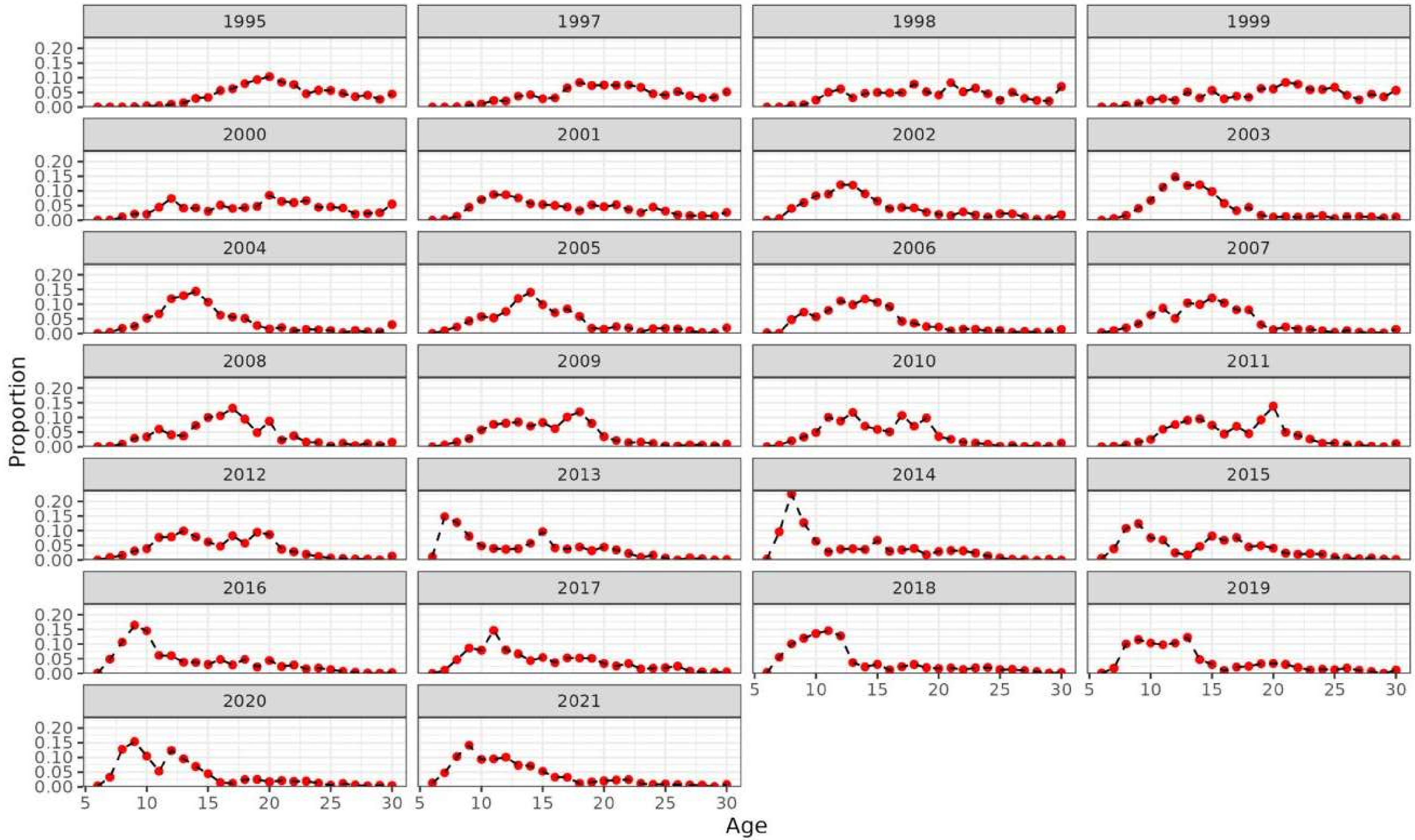


Figure 11: Observed AFs (red) and model fit (black) to the Indonesian fishery when treated as direct removals.

Changes to likelihoods

Changes to likelihoods

Both the tag and POP likelihoods have been updated - see paper for further details.

R format likelihoods/priors

Code prior distributions in short-hand (following R format; e.g., dnorm()) to improve readability of the code:

- ddm - Dirichlet-multinomial density, I coded this in TMB, used in get_tag_like and an option for fitting to AFs/LFs
- ddirichlet - Dirichlet density, I coded this in TMB, also a version in OSA_multivariate_dists-main/distr.hpp (not yet used), an option for fitting to AFs/LFs
- dmultinom - this is available in TMB, an option for fitting to AFs/LFs
- dlnorm - this is not available in TMB and had to be coded, used in get_cpue_like
- dstudent = I coded a different version of this in TMB, used as prior for sigma_r

Model input

```
Data <- list(last_yr = 2022, age_increase_M = 25,
             length_m50 = 150, length_m95 = 180,
             catch_UR_on = 0, catch_surf_case = 1, catch_LL1_case = 1,
             scenarios_surf = scenarios_surface, scenarios_LL1 = scenarios_LL1,
             sel_min_age_f = c(2, 2, 2, 8, 6, 0),
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             af_switch = 3, # 0=multinomial, 1=Dirichlet, 2=Dirichlet-multinomial, 3=old
             lf_switch = 3, lf_minbin = c(1, 1, 1, 11),
             tag_switch = 1, tag_var_factor = 1.82)
```

Age/length composition likelihoods

Will change the get_age_like TMB code:

```
// multinomial
obs += Type(1e-6);
pred += Type(1e-6);
lp(i) -= af_n(i) * (obs * log(pred)).sum();
lp(i) += af_n(i) * (obs * log(obs)).sum();
```

to:

Age/length composition likelihoods

```
if (af_switch == 0) {
   obs *= af_n(i);
   lp(i) -= dmultinom(obs, pred, true);
 }
 if (af_switch == 1) {
   obs += Type(1e-6);
   obs /= sum(obs);
   pred *= af_n(i) * exp(par_log_af_alpha(f - 4));
   lp(i) -= ddirichlet(obs, pred, true);
 }
 if (af_switch == 2) {
   obs *= af_n(i);
   pred *= exp(par_log_af_alpha(f - 4));
   lp(i) -= ddm(obs, pred, true);
 }
 if (af_switch == 3) {
   obs += Type(1e-6);
   pred += Type(1e-6);
   lp(i) -= af_n(i) * (obs * log(pred)).sum();
   lp(i) += af_n(i) * (obs * log(obs)).sum();
 }
```

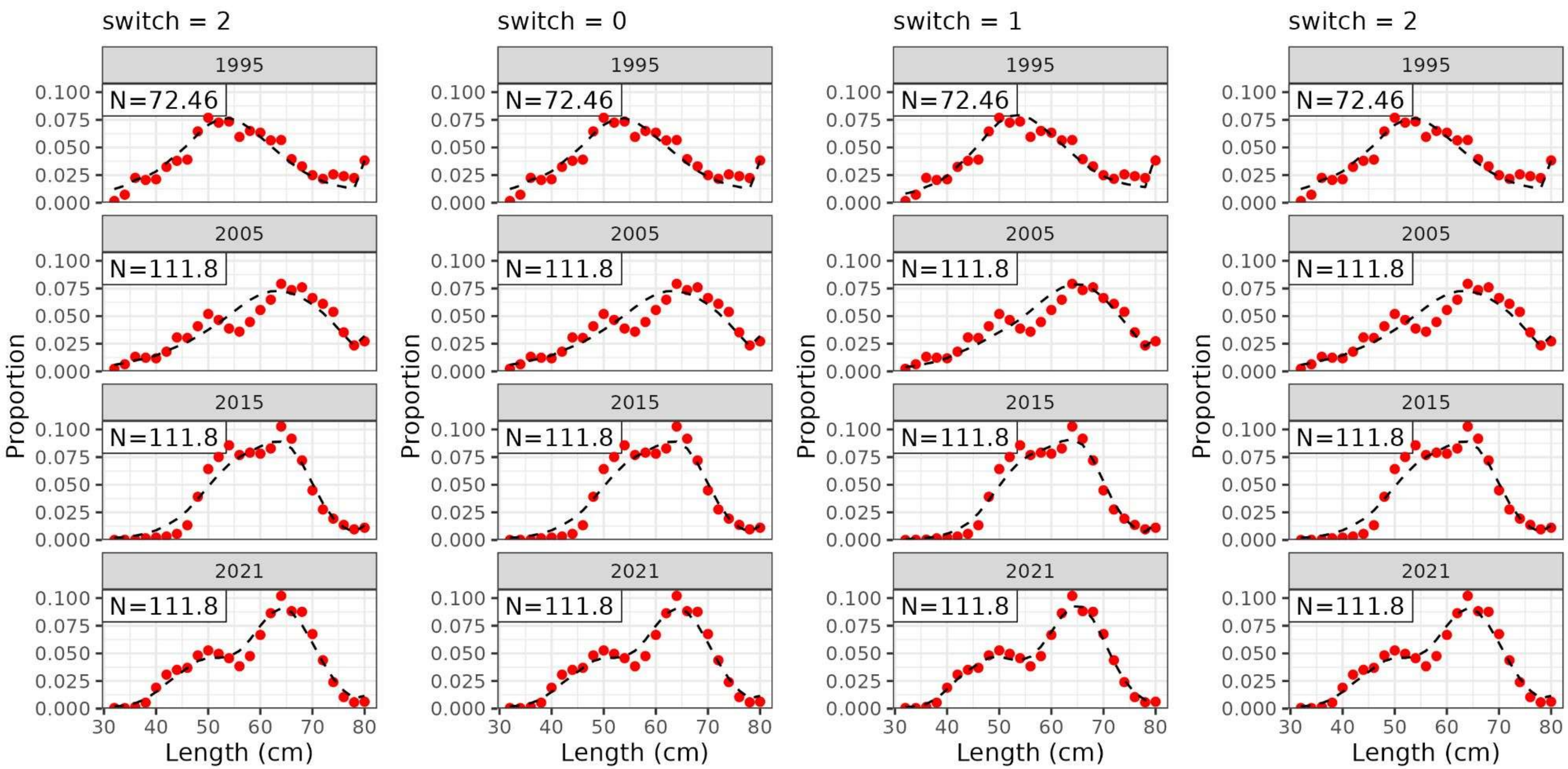
Age/length composition likelihoods

alpha0 is an estimated (or fixed) scaling parameter and:

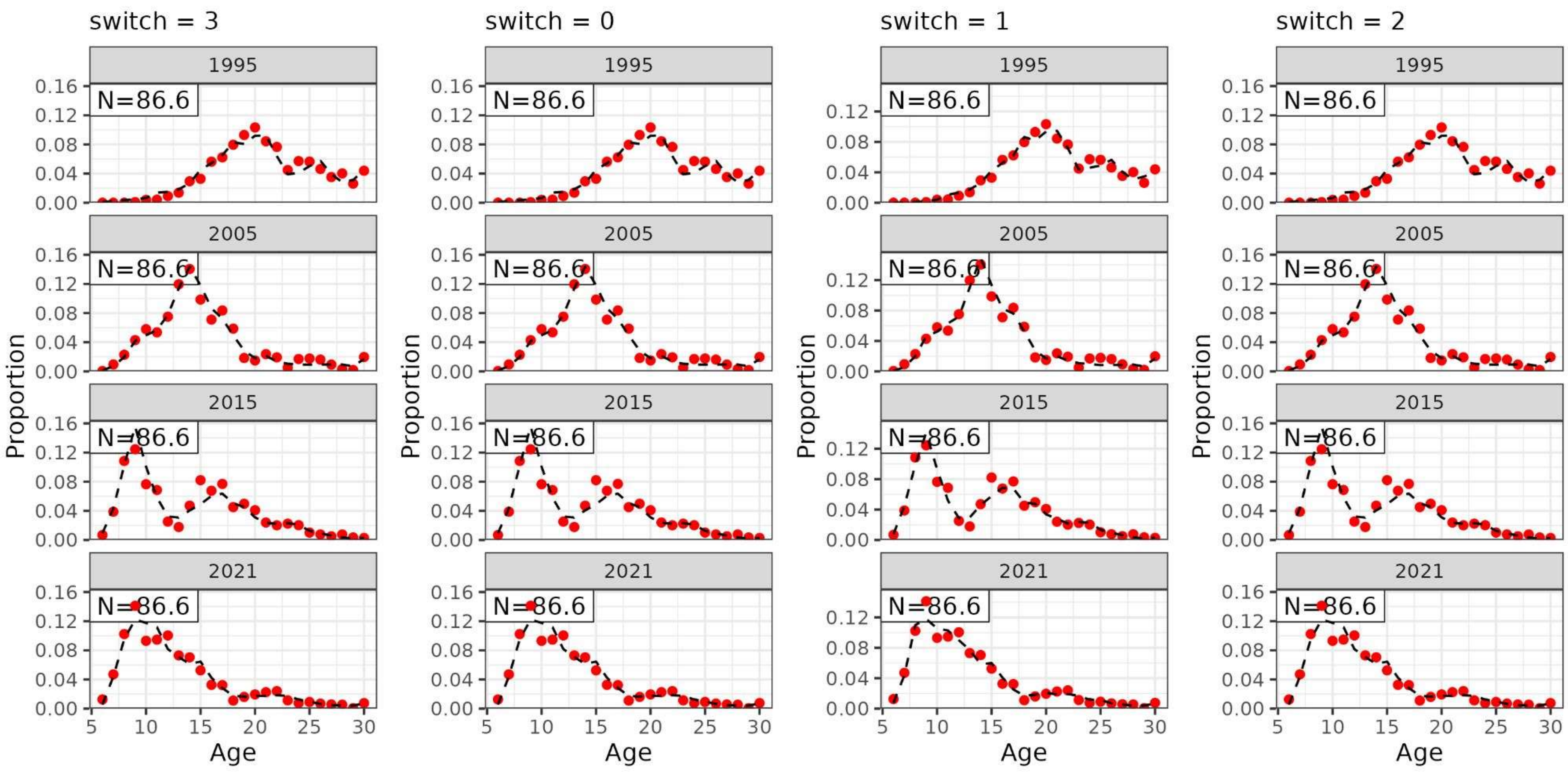
```
template <class Type>
Type ddm(vector<Type> x, vector<Type> alpha, int give_log) {
  Type sum_alpha = alpha.sum();
  Type logres = lgamma(sum_alpha) - lgamma(x.sum() + sum_alpha) +
    lgamma(x.sum() + Type(1.0)) - lgamma(vector<Type>(x + Type(1.0))).sum() + // constant, may
omit
    lgamma(vector<Type>(x + alpha)).sum() - lgamma(alpha).sum();
  if (give_log) return logres;
  else return exp(logres);
}
```

The ddm function is used in the new tag recapture likelihood also.

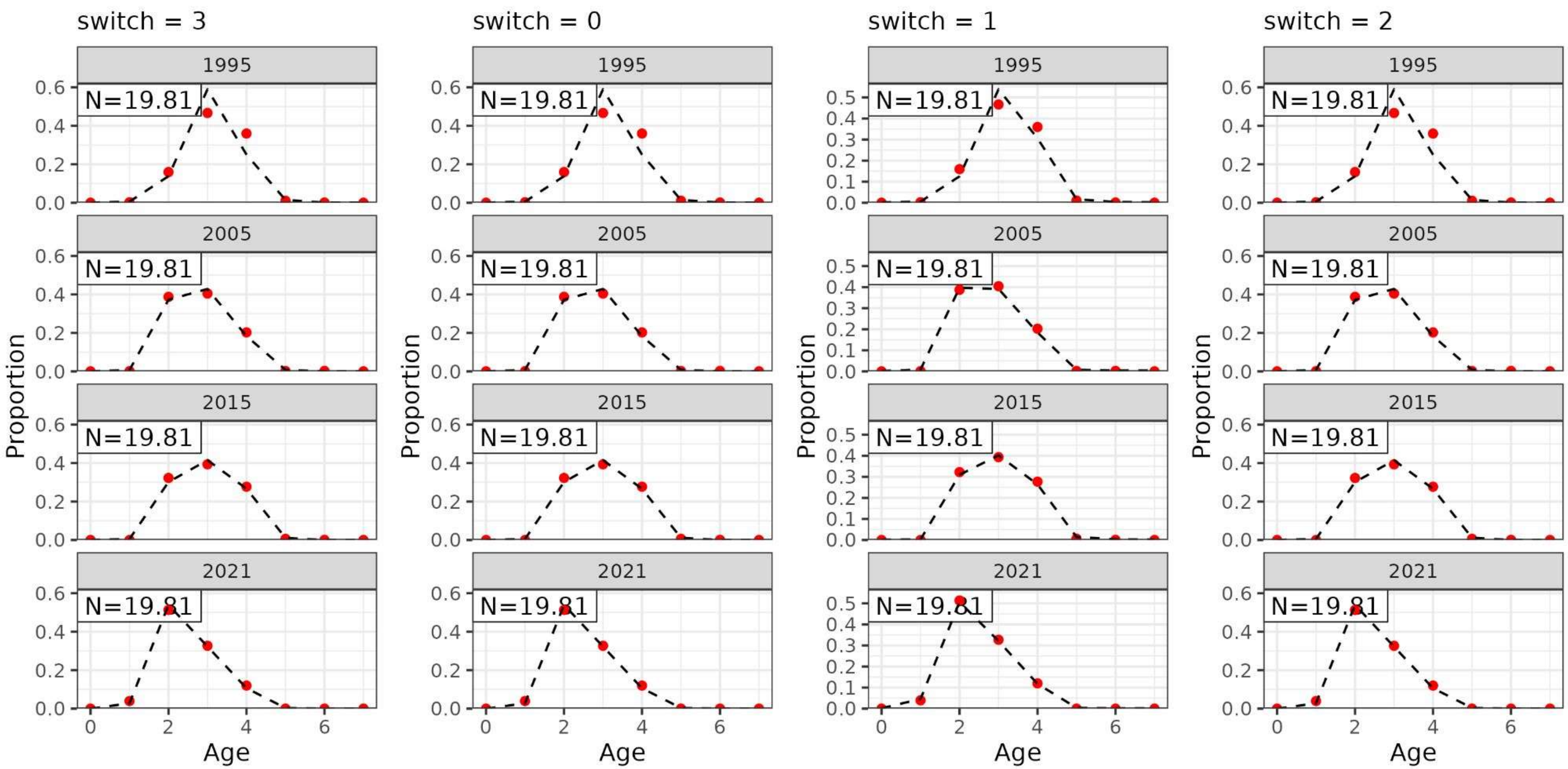
Length composition likelihoods - LL1



Age composition likelihoods - Indo



Age composition likelihoods - Aussie



Selectivity overhaul

Fisheries Research 266 (2023) 106755

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Short Communication

Unlocking the triad of age, year, and cohort effects for stock assessment: Demonstration of a computationally efficient and reproducible framework using weight-at-age

Matthew LH. Cheng[a,*], James T. Thorson[b], James N. Ianelli[c], Curry J. Cunningham[a]

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Assuming time invariant selectivity (for catches at least) is wrong! I have implemented this in the SBT model.

The fisheries

Fishery	Type	Min age	Max age	N ages	First year	Last year	N years	Notes
LL1	LF	2	17	16	1952	2022	71	GMRF
LL2	LF	2	9	8	1997	2022	26	GMRF
LL3	LF	2	17	16	1954	2022	69	To be combined, cohort sliced, and treated as direct removals
LL4	LF	8	22	15	1953	1990	38	
Indo	AF	6	25	20	1995	2021	27	GMRF with cohort effect
Aussie	AF	0	7	8	1964	2022	59	GMRF with cohort effect

Selectivity inputs

Retain

- DATA_IVECTOR(sel_min_age_f);
- DATA_IVECTOR(sel_max_age_f);
- DATA_IVECTOR(sel_end_f);
- DATA_IMATRIX(sel_change_year_fy)

Drop

- DATA_MATRIX(sel_change_sd_fy);
- DATA_VECTOR(sel_smooth_sd_f);
- PARAMETER_VECTOR(par_sels_init_i);
- PARAMETER_VECTOR(par_sels_change_i);

Add

- DATA_MATRIX(Index_ay);
- DATA_INTEGER(sel_switch); // Variance parameterization of Precision Matrix 0=Conditional, 1=Marginal
- PARAMETER_VECTOR(par_rho_a); // Correlation by age
- PARAMETER_VECTOR(par_rho_y); // Correlation by year
- PARAMETER_VECTOR(par_rho_c); // Correlation by cohort
- PARAMETER_VECTOR(par_log_sigma2); // Variance of the GMRF process
- PARAMETER_MATRIX(par_log_sel_ay); // Random effects selectivity array

Positive definite Hessian (pdH) issues

pdH issues

I have not managed to get pdH for any of the model versions.

It seems like B0 and many of the recruitment deviates are the culprits.

There are also divergent transitions when running the MCMC.

```
ce <- TMBhelper::check_estimability(obj = obj)
> ce[[4]] %>% filter(Param_check != "OK")
          Param          MLE Param_chec
1  par_log_B0 16.188096890         Ba
2  par_rdev_y  0.241066963         Ba
3  par_rdev_y  0.010828190         Ba
4  par_rdev_y -0.099010364         Ba
5  par_rdev_y -0.721471259         Ba
6  par_rdev_y -0.894094926         Ba
7  par_rdev_y -1.247567051         Ba
8  par_rdev_y -0.906158525         Ba
9  par_rdev_y  0.047462311         Ba
10 par_rdev_y  0.509574893         Ba
11 par_rdev_y  0.367630732         Ba
12 par_rdev_y  0.017139926         Ba
13 par_rdev_y  0.014245081         Ba
14 par_rdev_y  0.125911155         Ba
15 par_rdev_y  0.492768309         Ba
16 par_rdev_y  0.515632636         Ba
17 par_rdev_y  0.186693565         Ba
18 par_rdev_y  0.655020127         Ba
19 par_rdev_y -0.005032565         Ba
20 par_rdev_y -0.055016461         Ba
21 par_rdev_y  0.149471082         Ba
22 par_rdev_y -0.379260918         Ba
23 par_rdev_y -0.642502473         Ba
24 par_rdev_y  0.290348950         Ba
25 par_rdev_y -0.020684511         Ba
26 par_rdev_y  0.105792142         Ba
27 par_rdev_y  0.390174332         Ba
28 par_rdev_y  0.402433542         Ba
29 par_rdev_y -0.105798458         Ba
```

Operating Model Specification and Software Upgrade Project

Next steps

Darcy Webber

26 June 2024
Seattle

QUANTIFISH
Quantitative Fisheries Science

sbt

Next steps: prior to June 2024 OMMP

Ideally the following changes would be implemented before the June 2024 meeting so that they can be evaluated by the OMMP working group:

- ✓ Check age likelihood again (small difference in likelihood)
- ✓ Lump the LL3 and LL4 fisheries and cohort slice and treat as removals
- ❏ Specify the LL1, LL2, Australian and, Indonesian selectivity using GMRF
- ❏ Review this years sensitivities and robustness tests and make sure all the code to do these is available
- ❏ Can filter out some of the POPs in get_data that result in likelihood values that are not used in the estimation
- ✓ Name the grid runs in run_grid
- ❏ Implement grid sampling in the R code
- ✓ Re-code tag likelihoods to remove the H* parameters (harvest rate for mixing periods) and add the output for the PSIS-LOO diagnostic
- ✓ Implement the Dirichlet-multinomial likelihood for composition data
- ❏ Code prior distributions in short-hand (following R format; e.g., dnorm())
- ❏ Incorporate the age-uncertainty for the adult part of the POP calculations (the possible ages given length)
- ❏ Update website to improve documentation (e.g., add vignette on “how to run the grid”).
- ❏ Evaluate if other “Stan” R packages (e.g., adnuts) can be used to help evaluate model runs.

Next steps: at the June 2024 OMMP

Other tasks that could be completed at the June 2024 meeting include:

- ❑ Review harvest rate function and determine if a penalty is required to keep it below 0.9 (currently there is no penalty in the *sbt* model)
- ❑ Categorise what we want to add to REPORT and ADREPORT in the TMB code
- ❑ Implement “one-step ahead residuals” diagnostics for judging fits to composition data
- ❑ Evaluate how the grid should be modified in light of new MCMC capabilities

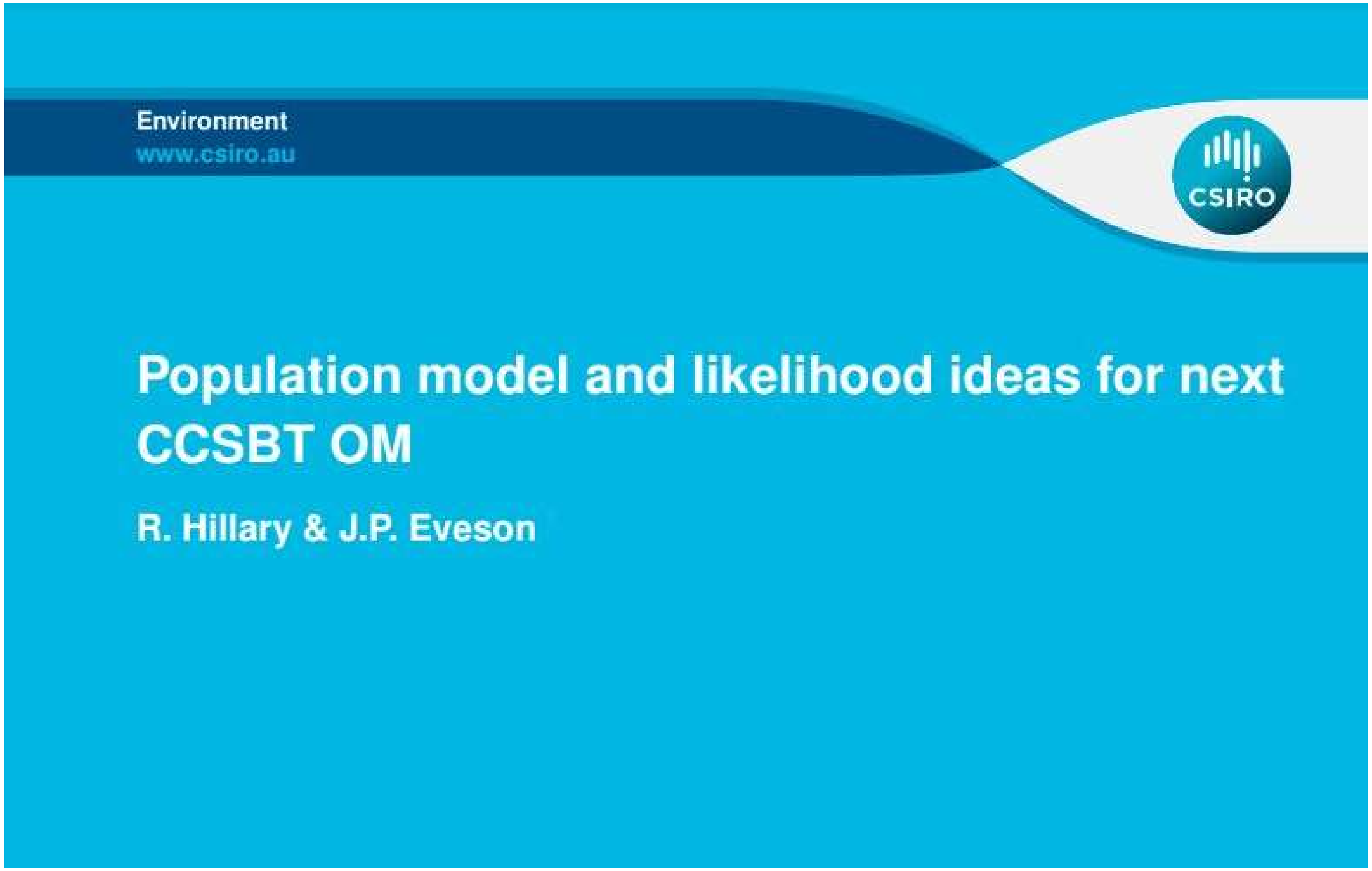
Next steps: after the June 2024 OMMP

Tasks that could be done after the June 2024 meeting include:

- Projection model developments: two options were discussed, an interim option that requires the TMB code to output the same variables that the ADMB conditioning code passes to the projection code, so that the old projection code can be run (with inputs in the same format) or a final option where projections are implemented within the "simulate" blocks of the TMB code.
- Add in the supplemental optimization code to compute MSY quantities by year using year-specific parameters and catch allocations between fleets.

Next steps

Next steps: ideas for next OM



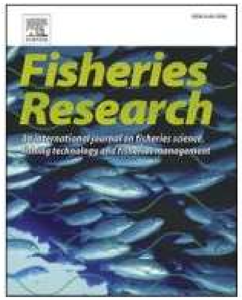
OSA residuals

Fisheries Research 257 (2023) 106487

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres



Model validation for compositional data in stock assessment models: Calculating residuals with correct properties

Vanessa Trijoulet [a,*], Christoffer Moesgaard Albertsen [a], Kasper Kristensen [a], Christopher M. Legault [b], Timothy J. Miller [b], Anders Nielsen [a]

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Pearson residuals for multinomial distributions (e.g., LFs and age comps) are wrong!

NOAA FISHERIES

One step ahead (OSA) residuals

Cole Monnahan
2023 September Plan Team
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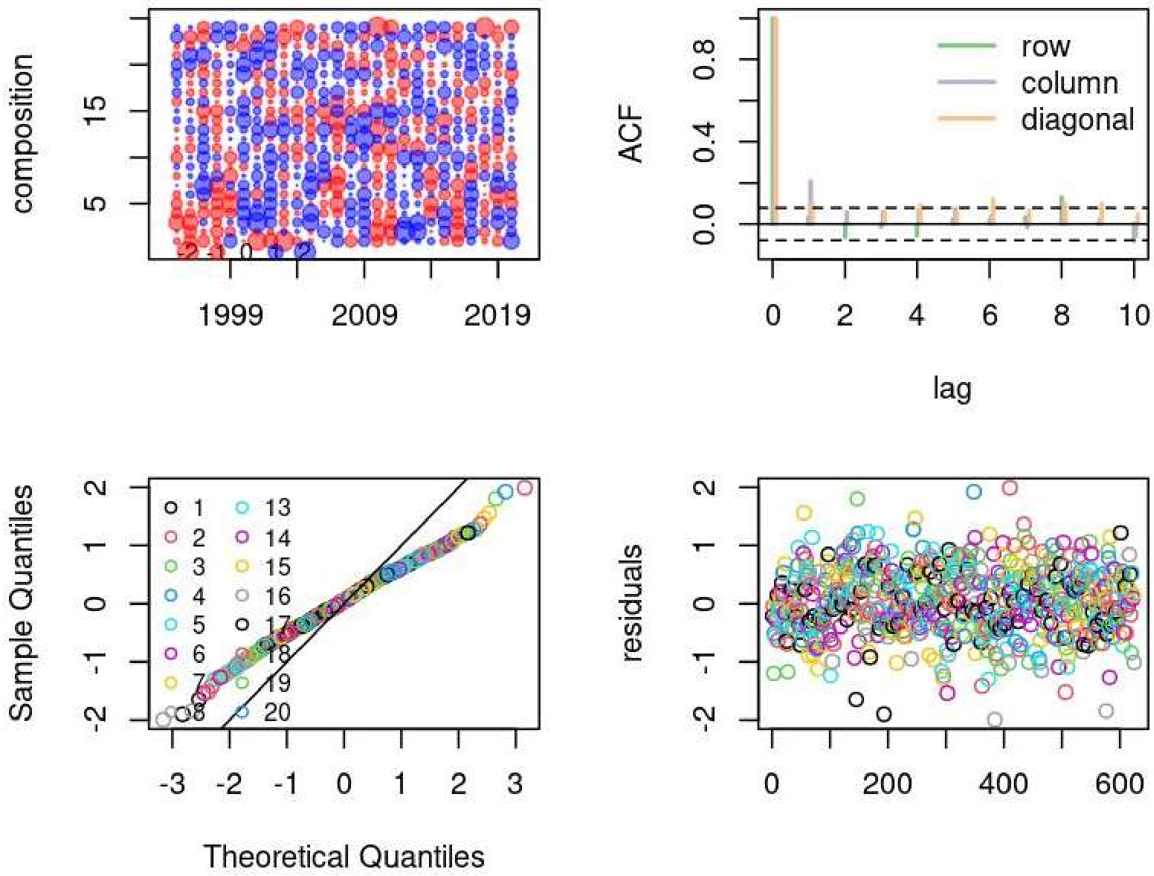
https://meetings.npfmc.org/CommentReview/DownloadFile?p=647c6817-09f4-4fcf-8f92-2014bda48db3.pdf&fileName=One%20step%20ahead%20residuals%20PRESENTATION.pdf

OSA residuals - age compositions



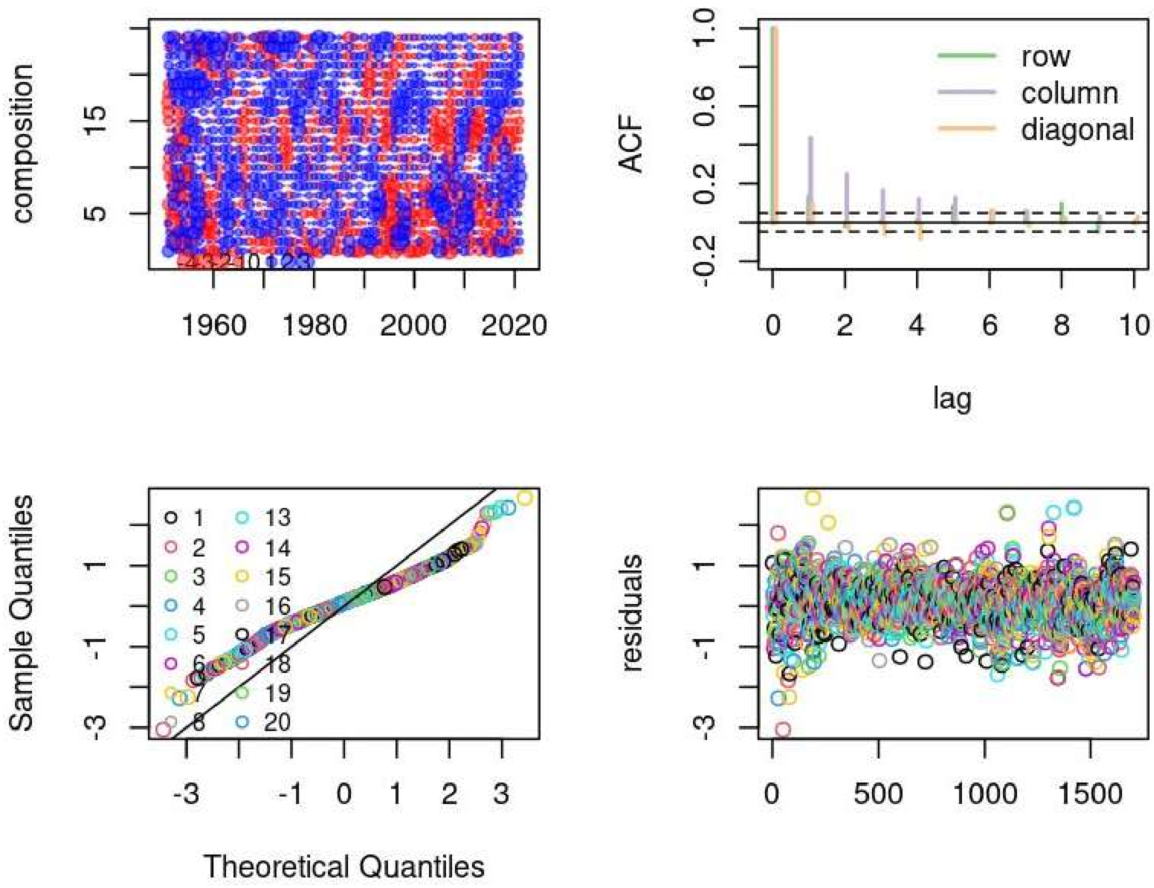

```
library(compResidual)

# Age comps ----

X <- t(Data$af_obs * Data$af_n)
P <- t(obj1$report()$af_pred)

X5 <- X[7:31, Data$af_fishery == 5]
P5 <- P[7:31, Data$af_fishery == 5]
res5 <- resMulti(obs = X5, pred = P5)
colnames(res5) <-
c(Data$first_yr:Data$last_yr)[Data$af_year[
Data$af_fishery == 5]]
plot(res5)
```

OSA residuals - length compositions




```
# Length comps ----

X <- t(Data$lf_obs * Data$lf_n)
P <- t(obj1$report()$lf_pred)

i <- 1
Xi <- X[,Data$lf_fishery == i]
Pi <- P[,Data$lf_fishery == i]
resi <- resMulti(obs = Xi, pred = Pi)
colnames(resi) <-
c(Data$first_yr:Data$last_yr)[Data$lf_year[Data$lf_fishery == i]]
plot(resi)
```

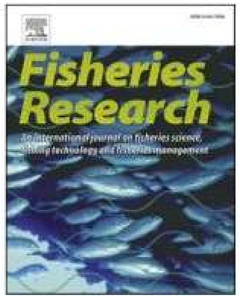
Length based M

Fisheries Research 255 (2022) 106454

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres



Size- and age-dependent natural mortality in fish populations: Biology, models, implications, and a generalized length-inverse mortality paradigm

Kai Lorenzen

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Natural mortality is likely to be a length-based process.

Fisheries Research 252 (2022) 106327

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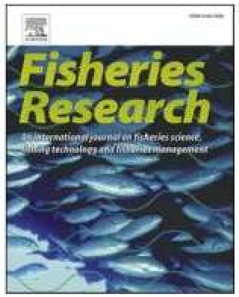

Check for updates

Natural mortality and body size in fish populations

Kai Lorenzen *, Edward V. Camp, Taryn M. Garlock

School of Forest, Fisheries, and Geomatics Sciences, University of Florida, Gainesville, FL 32653, USA

Natural mortality is likely to be a length-based process.

Other stuff

Fisheries Research 275 (2024) 107024

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Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Toward good practices for Bayesian data-rich fisheries stock assessments using a modern statistical workflow

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We are doing this reasonably well, but can always do better! I am meeting with Cole later this month to discuss.

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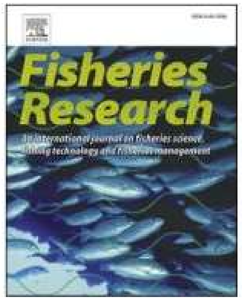

Towards best practice for specifying selectivity in age-structured integrated stock assessments

Kristin M. Privitera-Johnson [a,*], Richard D. Methot [b], André E. Punt [a]

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Fisheries Research 229 (2020) 105594

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journal homepage: www.elsevier.com/locate/fishres

The need for spatio-temporal modeling to determine catch-per-unit effort based indices of abundance and associated composition data for inclusion in stock assessment models

Mark N. Maunder[a,b,*], James T. Thorson[c], Haikun Xu[a], Ricardo Oliveros-Ramos[a], Simon D. Hoyle[d], Laura Tremblay-Boyer[e], Hui Hua Lee[f], Mikihiko Kai[g], Shui-Kai Chang[h], Toshihide Kitakado[i], Christoffer M. Albertsen[j], Carolina V. Minte-Vera[a], Cleridy E. Lennert-Cody[a], Alexandre M. Aires-da-Silva[a], Kevin R. Piner[f]

Assuming LFs are the same for catch and CPUE may be wrong!

Other new features to consider

- GMRF selectivity by age and year, treat selectivity parameters as random effects - almost done
- One step ahead (OSA) residuals - almost done
- Length based M
- Self-weighting likelihoods (i.e., estimate data set weights as parameters). This is set up for the AFs/LFs but would need to be set up for the other data sources too:
  - ✓ CPUE (cpue_sigma), aerial survey (aerial_tau), troll index (troll tau)
  - POPs
  - HSPs
  - GT
  - tags
- Treat recruitment deviates as random-effects and estimate sigma_r
- Length dimension? Spatial structure?