Fisheries New Zealand
Tini a Tangaroa

Assessment of hoki (*Macruronus novaezelandiae*) in 2023

New Zealand Fisheries Assessment Report 2024/32

V. L. McGregor,
A. D. Langley,
A. Dunn,
M. R. Dunn

ISSN 1179-5352 (online)
ISBN 978-1-991308-04-7 (online)

July 2024



Te Kāwanatanga o Aotearoa
New Zealand Government

Disclaimer

This document is published by Fisheries New Zealand, a business unit of the Ministry for Primary Industries (MPI). The information in this publication is not government policy. While every effort has been made to ensure the information is accurate, the Ministry for Primary Industries does not accept any responsibility or liability for error of fact, omission, interpretation, or opinion that may be present, nor for the consequence of any decisions based on this information. Any view or opinion expressed does not necessarily represent the view of Fisheries New Zealand or the Ministry for Primary Industries.

Requests for further copies should be directed to:

Fisheries Science Editor
Fisheries New Zealand
Ministry for Primary Industries
PO Box 2526
Wellington 6140
NEW ZEALAND

Email: Fisheries-Science.Editor@mpi.govt.nz
Telephone: 0800 00 83 33

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-and-resources/publications
http://fs.fish.govt.nz go to Document library/Research reports

© Crown Copyright - Fisheries New Zealand

Please cite this report as:
McGregor, V.L.; Langley, A.D.; Dunn, A.; Dunn, M.R. (2024). Assessment of hoki (*Macruronus novaezelandiae*) in 2023. *New Zealand Fisheries Assessment Report 2024/32.* 233 p.

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1. INTRODUCTION **2**

2. MODEL STRUCTURE AND ASSUMPTIONS **4**
2.1. Spatial, temporal, and stock structure 4
2.2. Parameters and priors 7
2.3. Conversion to Casal2 10
2.4. Maturity in the model 13

3. MODEL INPUTS **16**
3.1. Fisheries 17
3.2. Composition data 22
3.3. Survey abundance data 27
3.4. Informing recent year classes 28

4. MODEL SENSITIVITIES (MPD) **29**
4.1. Set One 30
4.2. Set Two 38
4.3. Parameter sensitivities 49

5. FINAL MODEL ASSESSMENT RESULTS (MCMC) **54**
5.1. Compare MCMC estimates for different model runs 57

6. PROJECTIONS **60**

7. DISCUSSION **65**

8. FULFILMENT OF BROADER OUTCOMES **66**

9. ACKNOWLEDGEMENTS **66**

10. REFERENCES **66**

Appendices **68**

A. Comparisons of CASAL and Casal2 outputs **68**
A.1. MPD comparisons with updated data for the 2023 assessment 68
A.2. MCMC comparisons with updated data for the 2023 assessment 71

B. Sub-Antarctic length cut-offs used in trawl survey truncated biomass **73**

C. MPD estimates **76**
C.1. Set One 76
C.2. Set Two 77

D. MPD fits **79**
D.1. MPD abundance residuals 79
D.2. MPD age composition residuals 81
D.2.1. Set One 81

D.2.2. Set Two 86
D.3. MPD age composition fits 91
D.3.1. Set One 91
D.3.2. Set Two 107
D.4. Parameter sensitivity age summary fits 123
D.4.1. Natural mortality 123
D.4.2. Maturity and steepness 132

E. MCMCs **141**
E.1. Model 2022A 141
E.1.1. Catchability 141
E.1.2. Selectivity ogives 146
E.1.3. Selectivity parameter traces 152

F. Model input files **160**
F.1. Model 2023A 160
F.1.1. Estimation 160
F.1.2. Estimation fishery 164
F.1.3. Estimation survey 170
F.1.4. Observations fishery 174
F.1.5. Observations survey 208
F.1.6. Population 220

Plain language summary

Integrated stock assessments provide estimates of stock status based on all available data and information. Stock status is the current biomass of the stock as a percentage of the biomass before the stock was fished.

This report presents an integrated stock assessment for hoki, New Zealand's largest finfish fishery. It includes information on movement and biology of hoki and data from commercial fisheries and research surveys.

The base model assumes there are two hoki stocks, an eastern stock that spawns in the Cook Strait and a western stock that spawns off the west coast of South Island. To allow for uncertainty in this assumed stock structure, future work will further develop a simpler model with a single stock.

Results from the assessment estimated current stock status to be at 46–54% of its unfished level for the eastern stock and 35–37% for the western stock. The target range for hoki is 35–50%.

EXECUTIVE SUMMARY

McGregor, V.L.[1]; Langley, A.D.[2]; Dunn, A.[3]; Dunn, M.R.[1] (2024). Assessment of hoki (*Macruronus novaezelandiae*) in 2023.

***New Zealand Fisheries Assessment Report 2024/32*. 233 p.**

This report describes the hoki stock assessment models for 2023. These models were an extension on the 2021 and 2022 assessment models, following further refinement, development, and testing. The model was also converted from CASAL to the new Casal2 model framework.

The base model has western and eastern stocks, with fish residing in four regions based on stock, time of year, age, maturity, and sex. A simplified single-stock multi-region model was developed and taken forward to Markov chain Monte Carlo (MCMC) parameter estimation, but not projections. An alternative to the base model was run with lower female natural mortality and this improved fits to the age composition data and may be considered as the base model in the 2024 assessment.

Current combined (eastern and western) stock status in 2023 was estimated to be 39–44% B_0 across all models. The eastern stock status was estimated to be 46–54% B_0 and the western stock 35–37% B_0. The single-stock model estimated similar total current biomass but with a lower biomass available to the western fisheries. However, this model requires further evaluation and testing before being used for scientific advice.

Models were projected forward five years to 2028 with future catches assumed either at the current TACC of 110 000 tonnes or at 100 000 tonnes, and with two alternative recruitment scenarios: long-term recruitment and recent (last 10 years) recruitment. Median estimates of stock status in 2028 ranged from 39 to 53% B_0 for the combined stock. The eastern and western stocks were generally estimated to have a similar status in 2028 (42–50% B_0 and 37–51% B_0, respectively). Recruitment variability was the major cause of uncertainty when projecting forward, particularly for the western stock. The probability of SSB_{2028} being within the management target zone of 35%–50% B_0 was 0.36–0.41 for the eastern stock, and 0.34–0.54 for the western stock. The probability of being less than 35% B_0 varied more between projections for the western stock (0.09–0.43) compared with the eastern stock (0.13–0.26).

While this assessment was accepted as our current best understanding of the hoki fishery, there remain issues to be further investigated. In the next (2024) assessment, we recommend analysis and improvement of the single-stock multi-area model and consideration of alternative stock hypotheses. Analysis and improvements are also needed on MCMC performance.

[1]National Institute of Water and Atmospheric Research (NIWA), New Zealand
[2]Trophia Ltd., New Zealand
[3]Ocean Environmental Ltd., New Zealand

1. INTRODUCTION

Hoki (*Macruronus novaezelandiae*) is New Zealand's largest finfish fishery and is managed within a single quota management area (HOK 1) (Figure 1) where it is assessed as two separate stocks, western and eastern. The current hypothesis is that juveniles from both stocks mix on Chatham Rise and recruit to their respective stocks as they approach sexual maturity. From 1 October 2021, the Total Allowable Commercial Catch (TACC) for HOK 1 was further reduced from 115 000 t to 110 000 t, but there was an agreement with industry that catches would be limited to 100 000 t with a catch split of 45 000 t from the western stock areas and 55 000 t for the eastern stock areas. In 2022–23 the TACC for HOK 1 remained at 110 000 t (plus any carryover), with voluntary shelving of 10 000 t and an agreed catch split arrangement of 40 000 t from western stock areas and 60 000 t from eastern stock areas (Ballara & O'Driscoll 2023).

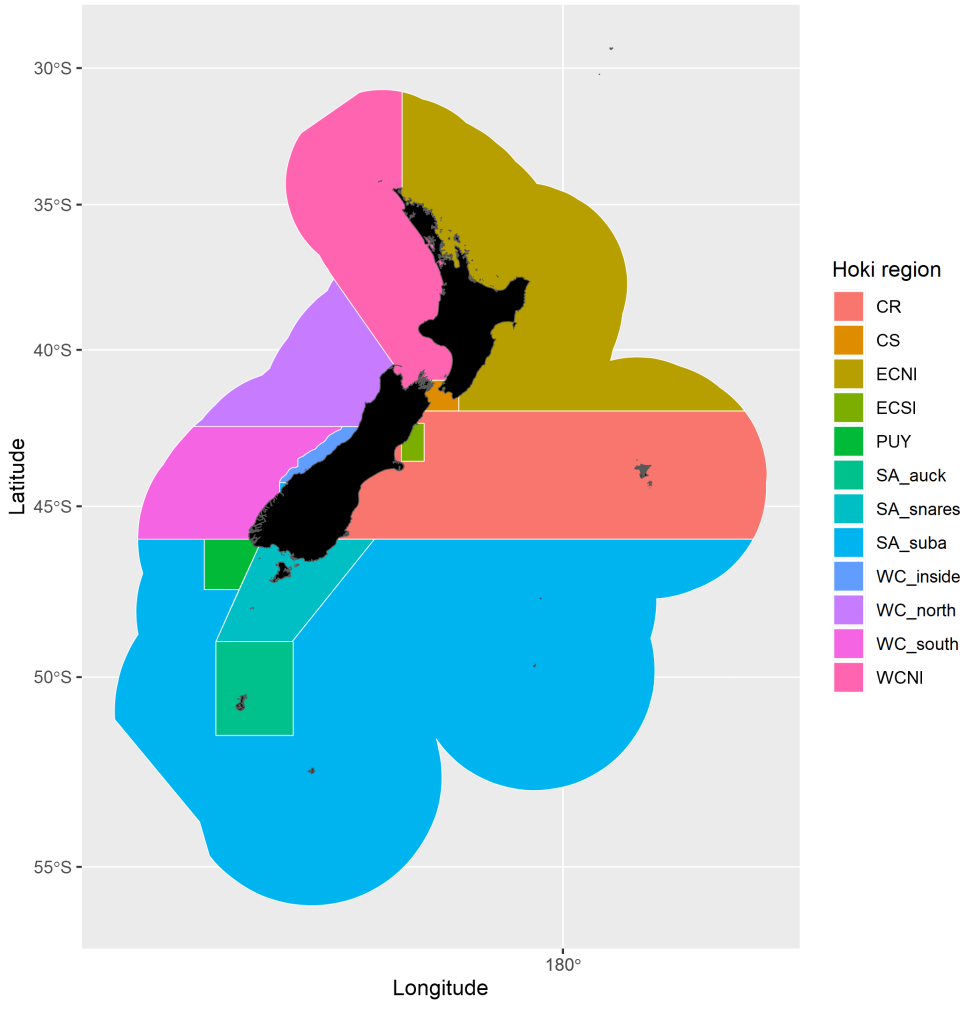


Figure 1: Fisheries management area HOK 1 divided into regions defined for the hoki stock assessment. CR: Chatham Rise, CS: Cook Strait, ECNI: east coast North Island, ECSI: east coast South Island, PUY: Puysegur, SA_auck: Sub-antarctic Auckland Islands, SA_snares: Sub-antarctic Snares, SA_suba: Sub-antarctic 'other', WC_inside: west coast South Island inside 25 nautical mile line, WC_north: west coast South Island north, WC_south: west coast South Island south, WCNI: west coast North Island. Eastern stock spawning fisheries take place in Cook Strait and east coast South Island regions; western stock spawning fisheries take place in Puysegur and west coast South Island regions.

Hoki are widely distributed throughout New Zealand's Exclusive Economic Zone, with most hoki target commercial fishing at depths of 200–800 m. There are four main fisheries: two targeting aggregations on winter spawning grounds (west coast South Island and Cook Strait); and two over wider areas on summer feeding grounds (Chatham Rise and Sub-Antarctic). In addition, there are two smaller spawning fisheries (Puysegur and east coast South Island; Figure 1), the latter of which has seen increasing catches over recent years.

The hoki fishery is monitored with annual stock assessments, and the key inputs to the assessment are surveys and catch-at-age data. There are two biennial trawl surveys that are used in the assessment: the Chatham Rise summer trawl surveys and the sub-Antarctic summer trawl surveys, providing abundance indices and corresponding proportions-at-age. There are also acoustic spawning surveys that have been carried out in the Cook Strait, east coast South Island, and west coast South Island. The commercial catches enter the model along with catch-at-age data. Ballara & O'Driscoll (2023) provide the most recent data collation for the hoki assessment.

Recruitment to the hoki fisheries has shown marked changes over time. In the earlier years of the fishery (1970s) when catches were mostly from west coast South Island and Chatham Rise, the stock assessment models estimate above average recruitment to the western stock up until the mid-1980s. Western stock recruitment is then estimated to have fluctuated from very low to very high and then to a historical low period from 1995 to 2001. The eastern stock is estimated to have had fairly low recruitment up until the mid-1980s, followed by almost yearly fluctuations with the exception of the mid-2000s when it is estimated to have been stable and generally above average. The 2019 year class was estimated to be high in the 2022 assessment for the eastern stock. The western stock 2019 year class was below average, however it is possible it was stronger than this but was not yet evident in the data (McGregor et al. 2023).

This report documents the stock assessment of New Zealand hoki completed in 2023 for the fisheries management area HOK 1. The previous accepted assessment of this stock was completed in 2022 (McGregor et al. 2023). The 2022 assessment estimated current stock status to be 51–55% B_0 for the eastern stock and 28–31% B_0 for the western stock. Projections estimated lower stock status for the western stock in the next five years (out to 2027) than the eastern stock. The difference in projected stock status was partly due to the high recent recruitment (2019 year class) seen in the Chatham Rise trawl survey as 2-year olds, which the model estimated to be eastern stock. Some of this year class could be western stock fish, that were not yet evident in the western stock data.

The work reported here addresses objective two of the Fisheries New Zealand project HOK2022-01: to complete a stock assessment for hoki including estimates of current biomass and yields, the status of the stock in relation to management reference points, and future projections of stock status as required to support management. The project was led by NIWA, with collaboration between NIWA (Vidette McGregor, Matt Dunn), Trophia Ltd. (Adam Langley), and Ocean Environmental Ltd. (Alistair Dunn).

2. MODEL STRUCTURE AND ASSUMPTIONS

This section describes the structure and parameterisation of the base hoki assessment model. Alternative structures or parameterisations developed with the new data for this assessment are described in Model Sensitivities (Section 4).

The stock assessment presented used an integrated age-based model, with Bayesian parameter estimation, implemented using the general-purpose stock assessment program Casal2 (Doonan et al. 2016) v23.04. The models integrate a range of datasets from research surveys and commercial fisheries, including catch, trawl survey abundance indices and age compositions, acoustic survey abundance indices, and catch-at-age data from the commercial fisheries. All analyses of model inputs and outputs were carried out using R-4.2.2 (R Core Team 2022).

Abbreviations used in the 2023 hoki assessment:
CR: Chatham Rise
CS: Cook Strait
SA: Sub-Antarctic
WC: West coast South Island (also abbreviated WCSI)
PUY: Puysegur region (south of South Island)
ECSI: East coast South Island
spwn: spawn
YCS: Year Class Strength
AEX: FV *Amaltal Explorer* commercial fishing vessel
SHI: FV *Shinkai Maru* commercial fishing vessel

Naming conventions used in the 2023 hoki assessment:
Model regions: CR, CS, SA, WC
Fisheries: **fishery_[region]_[subfishery]** e.g., fishery_CR_deep
Fisheries —age: **fishery_[region]_[subfishery]_age** e.g., fishery_CR_deep_age
Surveys —abundance: **survey_[region]_[subsurvey]_abundance** e.g., survey_SA_summer_abundance
Surveys —age: **survey_[region]_[subsurvey]_age** e.g., survey_SA_summer_age
Selectivities: **[type]_[region]_[subsurvey/subfishery]_select** e.g., survey_SA_summer_select
Migrations: **[region from]_to_[region to]** e.g., CR_to_SA

2.1 Spatial, temporal, and stock structure

The base stock structure adopted was two stocks, eastern and western, with mixing of juveniles of both stocks on Chatham Rise, but spatially separate adult stocks. The western stock adults were assumed to spawn off the west coast South Island and otherwise reside in the sub-Antarctic following age-based migration from the Chatham Rise. The eastern stock adults were assumed to spawn in Cook Strait and otherwise reside on Chatham Rise, along with the juveniles of both stocks.

The spatial and temporal structure of the model is defined in Table 1. Alternative models were based on this temporal and spatial structure, but with modified stock and movement hypotheses. Model years matched fishing years for hoki and were 1 October–30 September, labelled by the later year such that 1 October 2021–30 September 2022 was denoted 2022.

The base model annual cycle was split into five time steps. The first time step migrated all mature fish from the spawning grounds back to their 'home' grounds. Hence, for time step two, all fish were either on Chatham Rise or in the sub-Antarctic. In time step two, new recruitment arrived on Chatham Rise (new juveniles of both stocks). In this time step, the summer surveys and fisheries took place for both Chatham Rise and sub-Antarctic. In time step three, western fish migrated from Chatham Rise to sub-Antarctic, and the age-based ogive controlling this was estimated separately for males and females. The sub-Antarctic autumn survey occurred after this migration. In time step four, all adults migrated to the spawning grounds (western fish from sub-Antarctic to west coast South Island, and eastern fish from Chatham Rise to Cook Strait); nothing else took place during this time step. In time step five, spawning fisheries and spawning acoustic surveys occurred for the Cook Strait and west coast South Island. This was followed again by time step one, when fish returned from spawning grounds to their home grounds. Growth and natural mortality were assumed to occur throughout the year by applying proportions within each time step (Table 1).

Table 1: Actions within the model annual cycle by time step 1–5. Each time step relates approximately to a month range, although these are not specified within the model; only the order of the time steps is specified. Fisheries are defined in Section 3.1. CS: Cook Strait; CR: Chatham Rise; ECSI: east coast South Island; PUY Puysegur; WC: west coast South Island; SA: sub-Antarctic. On the Chatham Rise, deep: bottom depth ≥475 m; shallow: bottom depth <475 m. 'All ages' is 1–18 years.

Type	Name	Region	Stock	Maturity stage/Age
Time step 1: October–November				
Migration	CS_to_CR	CS, CR	East	Mature
Migration	WC_to_SA	WC, SA	West	Mature
Time step 2: December–March				
Population	Recruitment	CR	East, West	Age 0
Abundance	survey_CR_summer_abundance	CR	East, West	2–13 years
	survey_SA_summer_abundance	SA	West	4–15 years
Proportion_at_age	survey_CR_summer_age	CR	East, West	2–13 years
	survey_SA_summer_age	SA	West	4–15 years
Catches	fishery_CR_deep	CR	East, West	All ages
	fishery_CR_shallow	CR	East, West	All ages
	fishery_SA_suba	SA	West	All ages
	fishery_SA_snares	SA	West	All ages
	fishery_SA_auck	SA	West	All ages
Catch_at_age	fishery_CR_deep_age	CR	East, West	All ages
	fishery_CR_shallow_age	CR	East, West	All ages
	fishery_SA_suba_age	SA	West	All ages
	fishery_SA_snares	SA	West	All ages
	fishery_SA_auck	SA	West	All ages
Time step 3: April–June				
Migration	CR_to_SA	CR, SA	West	All ages
Abundance	survey_SA_autumn_abundance	SA	West	2–15 years
Proportion_at_age	survey_SA_autumn_age	SA	West	2–15 years
Time step 4: End of June				
Migration	CR_to_CS	CR, SA	East	Mature
Migration	SA_to_WC	CR, SA	West	Mature
Time step 5: July–September				
Population	Ageing	All	East, West	All ages
Abundance	survey_CS_spawning_abundance	CS	East	Mature
	survey_WC_spawning_abundance	WC	West	Mature
Catches	fishery_CS	CS	East	Mature
	fishery_ECSI	CS	East	Mature
	fishery_PUY	WC	West	Mature
	fishery_WC_inside	WC	West	Mature
	fishery_WC_northFrom2000	WC	West	Mature
	fishery_WC_northPre2000	WC	West	Mature
	fishery_WC_south	WC	West	Mature
Catch_at_age	fishery_CS_age	CS	East	Mature
	fishery_WC_inside	WC	West	Mature
	fishery_WC_northFrom2000	WC	West	Mature
	fishery_WC_northPre2000	WC	West	Mature
	fishery_WC_south	WC	West	Mature
Population	Spawning	CS	East	Mature
	Spawning	WC	West	Mature

2.2 Parameters and priors

Biological parameters for length-at-age, length-weight conversion, and stock-recruitment were defined following the previous assessments for hoki (McKenzie 2019, McGregor et al. 2022, McGregor et al. 2023) (Table 2). The values of natural mortality rate for males and females were adopted as given by McGregor et al. (2022) which followed the review work of Langley (2020). M was specified by sex as parameters M_{avg} and M_{diff} such that $M_{male} = M_{avg} + M_{diff}/2$ and $M_{female} = M_{avg} - M_{diff}/2$.

Maturation was defined as given by McGregor et al. (2022) and McGregor et al. (2023) based on the composition data in the spawning fisheries. Maturation defines the age at which fish migrate to the spawning grounds and hence are available to the spawning fisheries (west coast South Island and Cook Strait). The model specified age at maturation is one year younger than the effective age at maturation due to the order of events within the annual cycle. Ageing occurs in the model at the beginning of the spawning fishery time step, which is after migrating to the spawning ground. For four year old fish to be available to the spawning fisheries, they need to migrate there as three year olds, which requires them to be defined as mature within the model at age three.

Table 2: Biological parameter values used in the stock assessment base model. Informed priors for YCS and spawning survey *q*s were taken from the previous hoki assessment model (McGregor et al. 2023).

		Western		Eastern		
Function	**Parameter**	**Male**	**Female**	**Male**	**Female**	**Source**
Growth von Bertalanffy	L_∞	92.6	104.0	89.5	101.8	Horn & Sullivan (1996)
	K	0.261	0.213	0.232	0.161	Horn & Sullivan (1996)
	t_0	-0.50	-0.60	-1.23	-2.18	Horn & Sullivan (1996)
Maturation Logistic	a_{50}	2	3	2	3	Assumed (McGregor et al. 2022)
	a_{50to95}	2	3	2	3	Assumed (McGregor et al. 2022)
					All	
length-weight $w = al^b$ $w(t)$, $l(cm)$	a				4.79e-9	Francis (2003)
	b				2.89	Francis (2003)
Recruitment Beverton-Holt	h				0.75	Assumed (McGregor et al. 2022)
	p_{male}				0.5	Assumed (McGregor et al. 2022)
Natural mortality	M_{avg}				0.275	Assumed (Langley 2020)
	M_{diff}				0.05	Assumed (Langley 2020)

Estimated parameters were in five main categories: model initialisation (B_0), recruitment (YCS), migration, catchability, and selectivity ogives (Table 3). The largest set of estimated parameters were YCSs, then the selectivity ogives. Selectivity ogives were all either logistic capped or double normal capped, depending on whether older fish were generally present within the relevant composition data, and following investigative model runs. The selectivity ogives could, in principle, reflect spatial and temporal dynamics not otherwise modelled through the relatively coarse spatial and temporal structure of the model, as well as attributes of the fishing gear and fisher behaviour.

Initially, selectivity ogive parameters were all estimated with uniform priors. Following inspection of the MCMC diagnostics, some of these ogives were assigned non-uniform priors to help with convergence. The priors in Table 3 are those used for the final MCMC runs on the base model.

Table 3: Estimated parameters in the stock assessment model. E: eastern stock; W: western stock. Years (e.g., 1975–2019) are model years.

Function	Component	Parameters	Prior
Initialisation	Unfished biomass [E]	B_0	uniform-log
Initialisation	Unfished biomass [W]	B_0	uniform-log
Recruitment deviates	YCS.[W]	1975–2019	lognormal ($\mu = 1$, CV$= 0.95$)
Recruitment deviates	YCS.[E]	1975–2019	lognormal ($\mu = 1$, CV$= 0.95$)
Migration logistic-producing (1-8 years)	CR_to_SA.rates_male	a_{50}, a_{50to95}	uniform
Migration logistic-producing (1-8 years)	CR_to_SA.rates_female	a_{50}, a_{50to95}	uniform
Catchability	survey_CS_spawning_q	q	lognormal ($\mu = 0.55$, CV$= 0.90$)
Catchability	survey_WC_spawning_q	q	lognormal ($\mu = 0.39$, CV$= 0.77$)
Catchability	survey_CR_summer_q	q	uniform
Catchability	survey_SA_summer_q	q	uniform
Catchability	survey_SA_autumn_q	q	uniform
Selectivity ogives - surveys (age-based)			
logistic capped	survey_SA_summer_select	$a_{50}, a_{50to95}, a_{max}$	normal
logistic capped	survey_SA_autumn_select	$a_{50}, a_{50to95}, a_{max}$	uniform
logistic capped	survey_SA_AEX_select	$a_{50}, a_{50to95}, a_{max}$	uniform
logistic capped	survey_SA_SHI_select	$a_{50}, a_{50to95}, a_{max}$	uniform
Selectivity ogives - fisheries (age-based)			
logistic capped	fishery_CR_deep_select	$a_{50}, a_{50to95}, a_{max}$	uniform
double normal capped	fishery_CR_shallow_select	a_1, a_L, a_R, a_{max}	uniform
logistic capped	fishery_CS_spwn_select.male	$a_{50}, a_{50to95}, a_{max}$	uniform
logistic capped	fishery_CS_spwn_select.female	$a_{50}, a_{50to95}, a_{max}$	uniform
double normal capped	fishery_PUY_spwn_select.male	a_1, a_L, a_R, a_{max}	uniform
double normal capped	fishery_PUY_spwn_select.female	a_1, a_L, a_R, a_{max}	uniform
logistic capped	fishery_SA_auck_select	$a_{50}, a_{50to95}, a_{max}$	normal
double normal capped	fishery_SA_snares_select	a_1, a_L, a_R, a_{max}	normal
logistic capped	fishery_SA_suba_select	$a_{50}, a_{50to95}, a_{max}$	uniform
logistic capped	fishery_WC_inside_select.male	$a_{50}, a_{50to95}, a_{max}$	uniform
logistic capped	fishery_WC_inside_select.female	$a_{50}, a_{50to95}, a_{max}$	uniform
double normal capped	fishery_WC_north_select.male	a_1, a_L, a_R, a_{max}	normal
double normal capped	fishery_WC_north_select.female	a_1, a_L, a_R, a_{max}	uniform
logistic capped	fishery_WC_south_select.male	$a_{50}, a_{50to95}, a_{max}$	uniform
logistic capped	fishery_WC_south_select.female	$a_{50}, a_{50to95}, a_{max}$	uniform

2.3 Conversion to Casal2

The assessment model was converted to Casal2 (Doonan et al. 2016) as CASAL is no longer supported software. Casal2 provides additional flexibility to the model which may be useful for exploring alternative model structures and assumptions in the future. We first converted Model 2022A from the previous assessment and compared Maximum Posterior Density (MPD) outputs which matched closely (Figures 2–6). We also updated both CASAL and Casal2 versions of Model 2022A with the 2023 assessment data and compared both MPD and MCMC outputs. The models produced very similar results, with only a slight differences mostly in the split of recruitment between western and eastern stocks (the full set of figures with the updated data are in Appendix A).

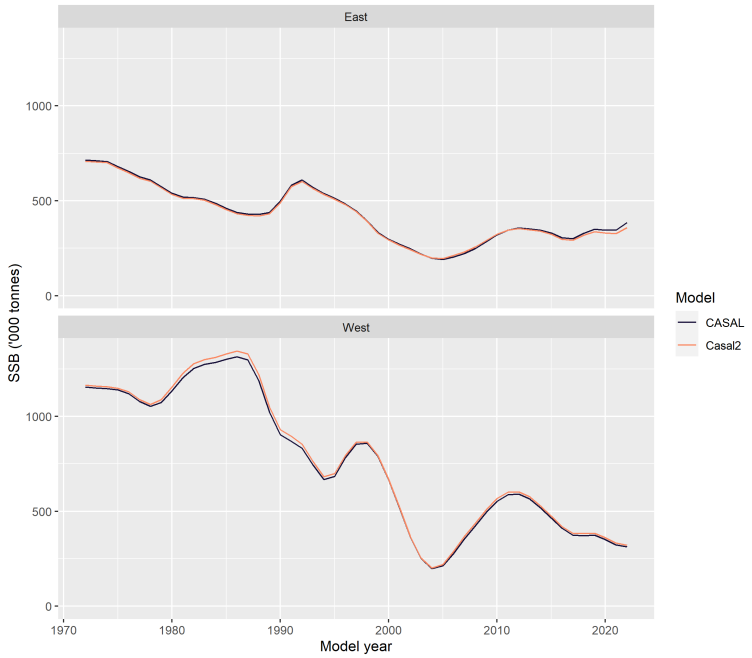


Figure 2: Comparison of *SSB* from CASAL and Casal2 versions of Model 2022A.

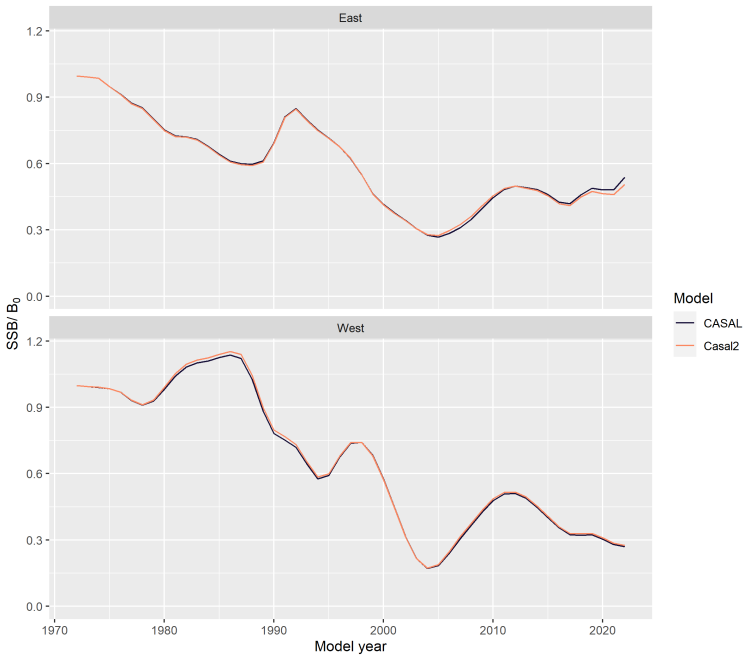


Figure 3: Comparison of SSB/B_0 from CASAL and Casal2 versions of Model 2022A.

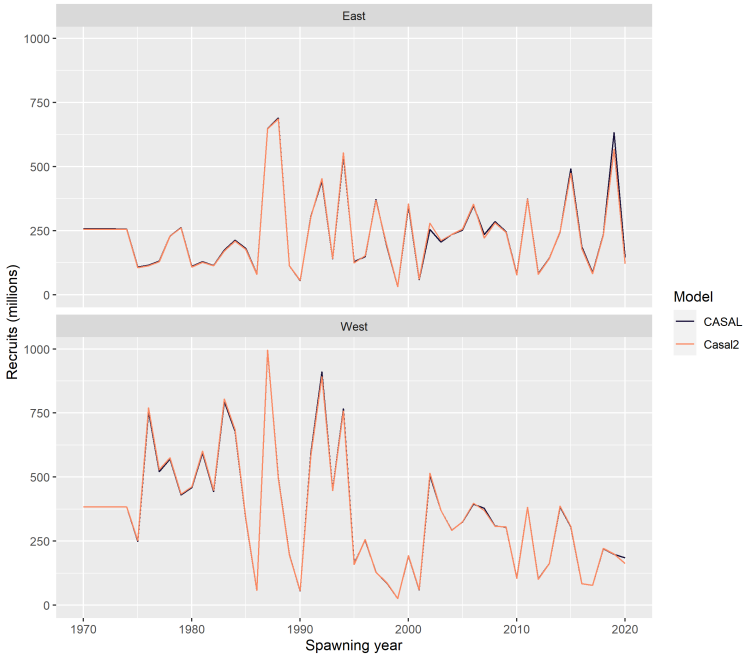


Figure 4: Comparison of year class strengths estimated from CASAL and Casal2 versions of Model 2022A.

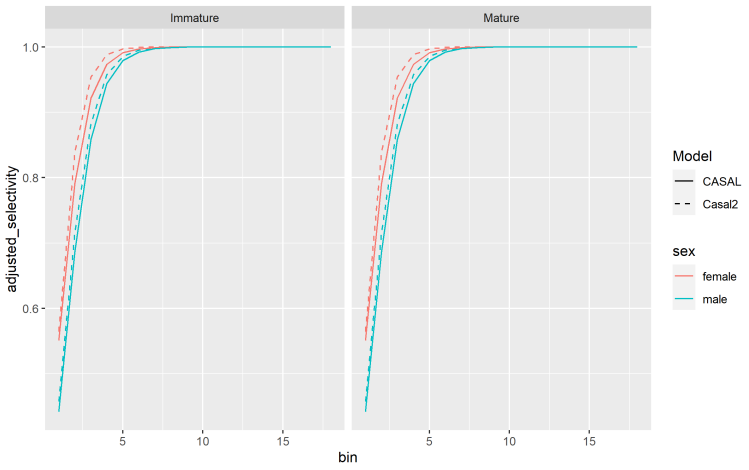


Figure 5: Comparison of Migration from Chatham Rise to sub-Antarctic estimated from CASAL and Casal2 versions of Model 2022A.

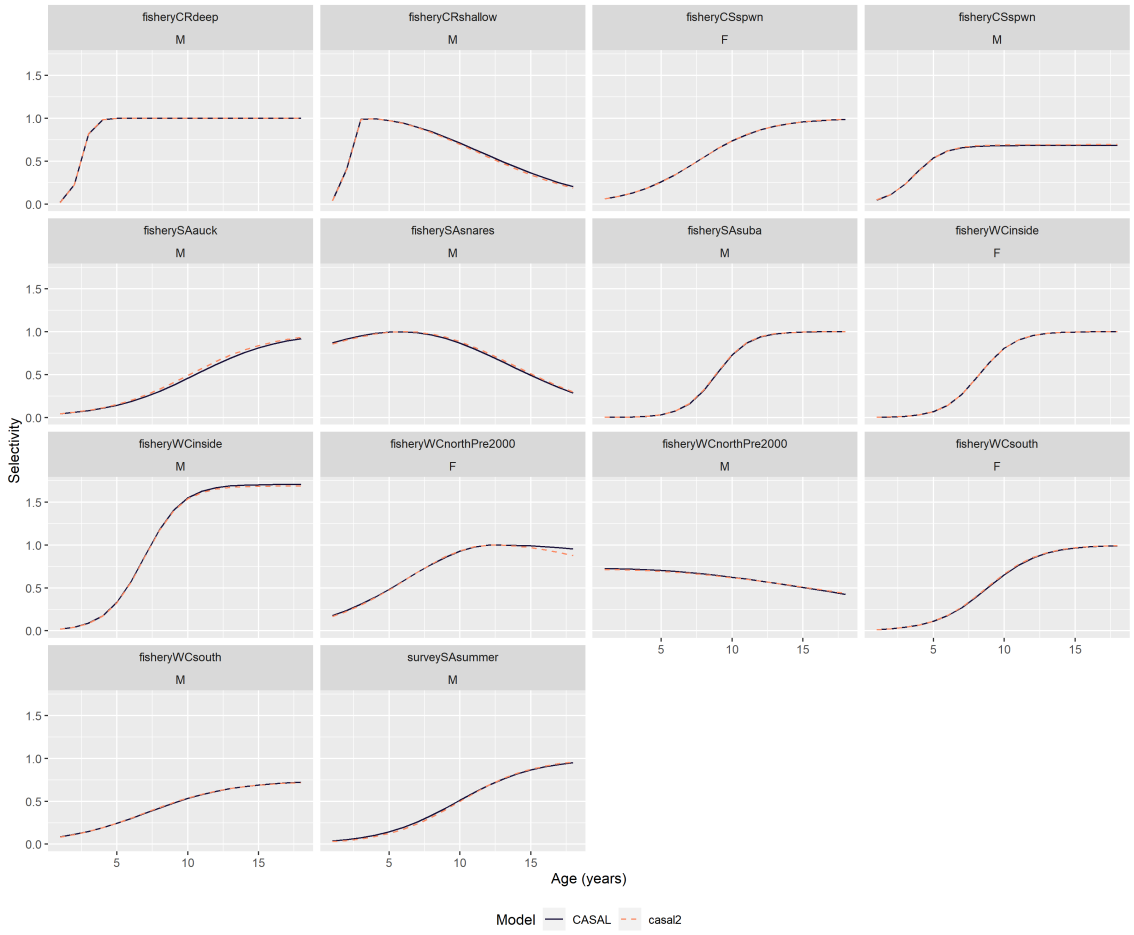


Figure 6: Comparison of selectivity ogives estimated from CASAL and Casal2 versions of Model 2022A.

2.4 Maturity in the model

Defining maturity is optional in the model and maturity was only defined explicitly from 2021. The assessment prior to the 2020 review did not specify maturity explicitly, instead fish that migrated to a spawning ground (Cook Strait for eastern stock or WCSI for western stock) were assumed mature and this biomass was used as *SSB* for the respective stocks. Migration to spawning grounds was defined as proportions migrating, defined separately by sex, age, and stock. These proportions were estimated for fish aged 1 to 8 years and assumed to be 1 for fish over 8 years (McKenzie 2018, 2019).

As migration and selectivity are confounded, we simplified the model in 2021 by assuming all mature fish migrate to the respective spawning grounds. This required maturity to be specified explicitly in the model. Maturity in the 2021 and 2022 models defined *SSB* and movement to the spawning grounds (McGregor et al. 2022, 2023) . In these models, maturity was specified separately for males and females based on inspection of the age-structure on the spawning grounds (McGregor et al. 2022).

Visual inspection of the age composition data from the spawning grounds used in the 2021 and 2022 assessments still suffers the same concern of movement being confounded with selectivity (e.g., do males mature earlier than females, or do young mature males spend more time on the spawning grounds than females, hence increasing their vulnerability to fishing?). We analysed otolith transition zones as a potential independent source of data that may help inform timing of maturity. Data were available from MBIE funded research which produced back-calculated age and growth from hoki (and other) otoliths (hoki aged 4–15 years, sampled 1972–2015, almost all from research vessel surveys) (Morrongiello et al. 2021). We fitted segmented regressions to measured zone width and age, assuming a birthdate 1 August, to estimate the inflection point of growth ('transition zone'). The model estimated the age at which the two linear regressions intersected, then filtered results to omit instances where:

- The segmented regression improved the AIC, compared with a single linear regression, by less than 0.5; or
- A failure to converge or lack of break-point treated as either (a) mature at the first age (age 2), or (b) excluded.

A sample of otolith zone measurements with fitted regression models is shown in Figure 7. Results of the age at growth transition are given in Table 4. For male and females from Chatham Rise and sub-Antarctic, the inflection point was approximately age 4 years, with no apparent difference by sex or area. This age of inflection aligns with the a_{50} parameter assumed for logistic maturation of females in the 2021 and 2022 assessment models, and is one year older than the a_{50} parameter value assumed for males in these assessments.

In the 2023 assessment, we tested setting maturity to be the same for males and females with an effective a_{50} of 4 years. The ogives assumed are in Figure 8. In this model, maturity was used to define *SSB* but did not limit movement of fish to the spawning grounds (i.e., while all mature fish migrated to the spawning grounds, immature fish were also able to migrate). There are young fish on the spawning grounds (e.g., 2-year olds) and this model does not assume they are all mature.

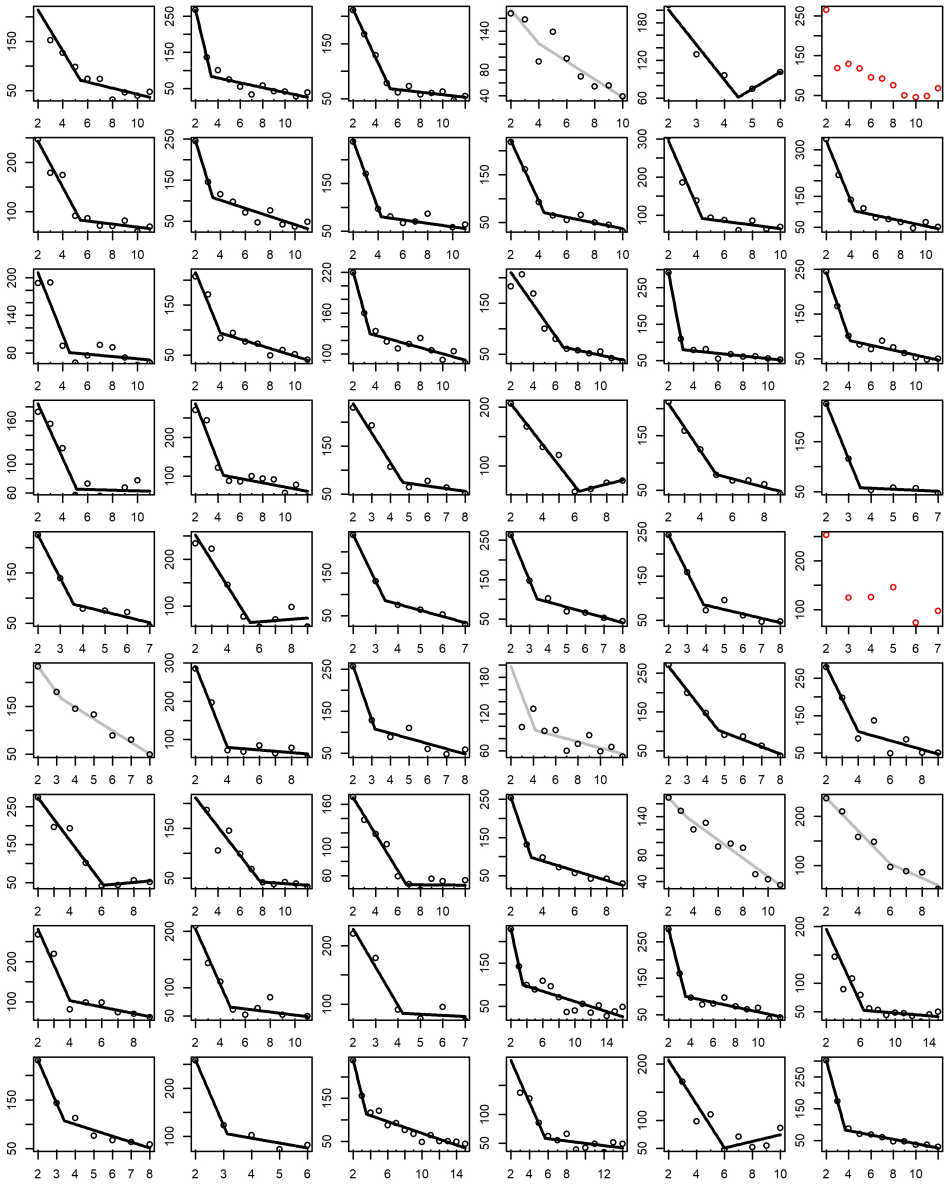


Figure 7: Regression fits (grey and black lines) to otolith zone widths (open circles). Grey lines: segmented regression improved the AIC, compared with a single linear regression, by less than 0.5; Red points: regression model failed to converge or no break-point estimated; Black lines: fits included in the age of transition estimate.

Table 4: Median age at growth transition (inflection) estimated. Non-convergence refers to treatment of data where the model failed to converge or no break-point was estimated.

Area	Male	Female	Non-convergence
Chatham Rise	4.0	4.0	Excluded
sub-Antarctic	4.1	4.0	Excluded
Chatham Rise	3.9	4.0	Assumed age 2 years
sub-Antarctic	4.1	3.8	Assumed age 2 years

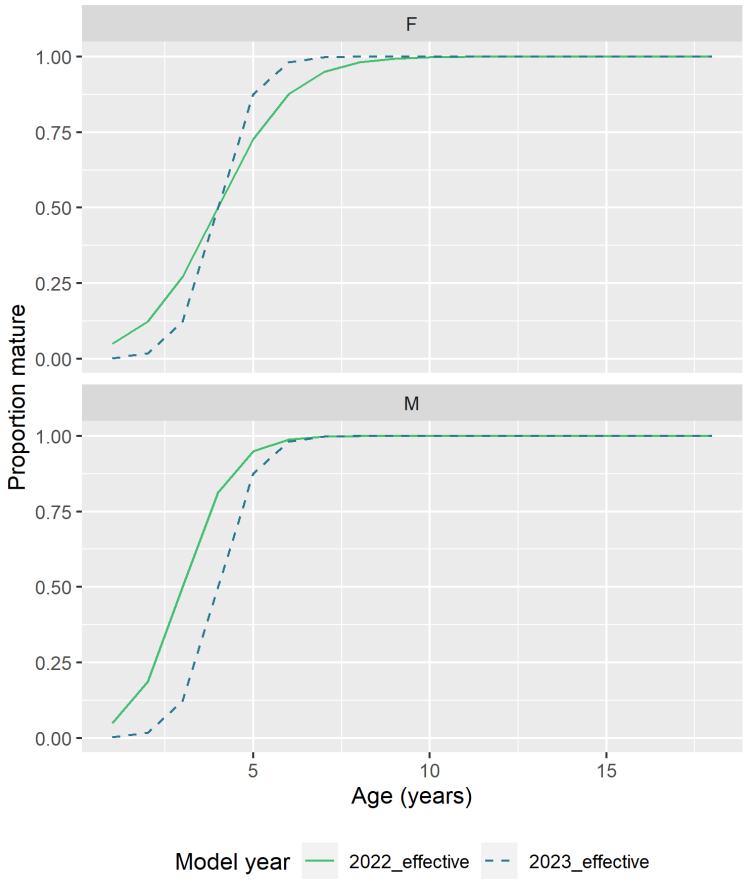


Figure 8: Maturity ogives defined in the base model, which are the same as in the 2022 assessment (green solid lines) and alternatives tested in alternative model in the 2023 assessment (blue dashed lines). Note, these are effectively one year older than the values defined in the model due to the ordering of maturation/movement/ageing/spawning in the model.

3. MODEL INPUTS

Inputs into the model consisted of commercial catches, corresponding catch-at-age, survey biomass indices (acoustic and trawl), and proportion-at-age from the trawl surveys (Table 5). These inputs are described in detail by Ballara & O'Driscoll (2023).

Trawl surveys were assigned process error CVs of 0.10. Effective sample sizes on composition data were then calculated by applying the Francis re-weighting algorithm (Francis 2011). Resulting samples sizes are summarised in Table 6. Datasets survey_CR_SHI_age, survey_SA_SHI_age, and survey_SA_summer_age were given nominal sample sizes and were not re-weighted due to the low number of years in these observations. We reduced these sample sizes from 10 to 5 in the 2023 assessments so they were more in line with the re-weighted sample sizes of the other datasets.

New data in the 2023 assessment:

- Catches (2021–22 fishing year)
- Commercial catch-at-age (2021–22 fishing year)
- Assumed catch (2022–23 fishing year assumed equal to 2021–22)
- SA trawl survey abundance index (Nov-Dec 2022)
- SA trawl survey proportions-at-age (Nov-Dec 2022)

Table 5: Model inputs overview for the hoki stock assessment base model where Years are fishing years which run October–September and are labelled by the latter year (i.e., 2022: October 2021–September 2022). Catches are assumed in the model, meaning they are entered without error, rather than being an observation that the model fits to. (Continued on next page)

Region	Stock	Name	Years
Catches (assumed)			
CS	E	fishery_CS_spwn	1988–2023
CR	E + W	fishery_CR_deep	1972–2023
CR	E + W	fishery_CR_shallow	1972–2023
SA	W	fishery_SA_auck	1983–2023
SA	W	fishery_SA_snares	1983–2023
SA	W	fishery_SA_suba	1983–2023
WC	W	fishery_PUY_spwn	1983–2023
WC	W	fishery_WC_inside	1972–2023
WC	W	fishery_WC_north	1972–2023
WC	W	fishery_WC_south	1972–2023
Catch-at-age (observed)			
CS	E	fishery_CS_spwn_age	1990–2005, 2007–2010, 2014–2022
CR	E + W	fishery_CR_deep	2001–2022
CR	E + W	fishery_CR_shallow	2001–2019, 2021, 2022
SA	W	fishery_SA_auck	2001, 2003, 2004, 2006–2022
SA	W	fishery_SA_snares	2001, 2006–2022
SA	W	fishery_SA_suba	2001–2003, 2009, 2012, 2016, 2018–2022
WC	W	fishery_PUY_spwn	1990–1992, 1994–1997, 2000–2005
WC	W	fishery_WC_inside	2000–2010, 2012–2022
WC	W	fishery_WC_north	1998–2022
WC	W	fishery_WC_south	1988–2022

Survey (observed)			
CS	E	survey_CS_spawning_abundance	1991, 1993–2003, 2005 –2009, 2011, 2013, 2015, 2017, 2019, 2021
WC	W	survey_WC_spawning_abundance	1988–1993, 1997, 2000, 2012, 2013, 2018
CR	E + W	survey_CR_summer_abundance	1992 –2014, 2016, 2018, 2020, 2022
SA	W	survey_SA_summer_abundance	1992–1994, 2001–2010, 2012, 2013, 2015, 2017, 2019, 2021, 2023
SA	W	survey_SA_autumn_abundance	1992, 1996, 1998
Proportion-at-age (observed)			
SA	W	survey_SA_AEX_age	1990, 1991
SA	W	survey_SA_SHI_age	1984
CR	E + W	survey_CR_SHI_age	1983
CR	E + W	survey_CR_summer_age	1992 –2014, 2016, 2018, 2020, 2022
SA	W	survey_SA_summer_age	1992–1994, 2001–2010, 2012, 2013, 2015, 2017, 2019, 2021, 2023
SA	W	survey_SA_autumn_age	1992, 1996, 1998

Table 6: Composition data initial samples sizes and re-weighted sample sizes in model 2023A, which were also applied in model 2023B, with the re-weighted sample sizes from the 2022 assessment base model (McGregor et al. 2023). Values are averages for each dataset. Values for each year within the datasets are in Appendix F. Datasets survey_CR_SHI_age, survey_SA_SHI_age, and survey_SA_summer_age were given a nominal sample size and were not re-weighted due to the low number of years in these observations.

Dataset	Initial	Re-weighted (2022)	Re-weighted (2023)
catch_at[fishery_CR_deep_age]	366.19	18.90	17.43
catch_at[fishery_CR_shallow_age]	66.20	12.84	7.51
catch_at[fishery_CS_spwn_age]	755.64	46.30	40.38
catch_at[fishery_PUY_spwn_age]	390.62	2.25	2.31
catch_at[fishery_SA_auck_age]	109.89	8.59	7.70
catch_at[fishery_SA_snares_age]	176.68	5.98	6.56
catch_at[fishery_SA_suba_age]	118.20	11.95	14.20
catch_at[fishery_WC_inside_age]	542.29	12.53	12.44
catch_at[fishery_WC_northFrom2000_age]	1 188.59	59.62	70.12
catch_at[fishery_WC_northPre2000_age]	963.50	24.31	29.86
catch_at[fishery_WC_south_age]	772.59	36.05	34.44
proportions_at[survey_CR_SHI_age]	10.00	10.00	5.00
proportions_at[survey_CR_summer_age]	1 837.81	63.87	78.33
proportions_at[survey_SA_AEX_age]	10.00	10.00	5.00
proportions_at[survey_SA_autumn_age]	829.33	22.50	26.36
proportions_at[survey_SA_SHI_age]	10.00	10.00	5.00
proportions_at[survey_SA_summer_age]	579.95	11.06	13.60

3.1 Fisheries

Fisheries followed the structure of the 2021 and 2022 assessments (McGregor et al. 2022, 2023), which were defined based on the review work of Langley (2020). The fisheries were defined within four main spatial regions: WC, the spawning ground for the western stock; CS, the spawning ground for the eastern stock; SA, the non-spawning ground for the western stock; CR, the non-spawning ground for the eastern stock and for juveniles of both stocks (Table 7 and Figure 1). Where there are multiple fisheries within one region, selectivity ogives account for differences in the age structure of fish available to each of the fisheries.

Highest catches were from the WC spawning fisheries which peaked in the late 1980s to early 1990s (Figure 9). Catches in the CR and CS fisheries peaked in the mid–late 1990s and then remained fairly steady from the mid–late 2000s (Figures 10 and 11). Sub-Antarctic catches generally declined from 2012 to 2022, mostly attributed to declining catches from the Snares fishery (Figure 12). WC catches declined from 2015 to 2022 which was most apparent in the north fishery (Figure 13) while Chatham Rise catches remained fairly constant (Figure 10).

Table 7: Fishery structure for the 2023 hoki stock assessment. Further details are given by McGregor et al. (2022) which also relates the 2021 structure to that of the 2019 assessment. 'Age-structure' summarises the key differences where there are multiple fisheries in one region, and figures for these were given by McGregor et al. (2023). West coast spawning fisheries are effectively June–September due to few catches outside these months (Ballara and O'Driscoll 2023).

Model area	Fishery	Age-structure	Months	Stock(s)	Spawning status
Cook Strait	CS		June–September	East	Spawning
Chatham Rise	CR_deep	Older	All months	East and West	Non-spawning
Chatham Rise	CR_shallow	Younger	All months	East and West	Non-spawning
sub-Antarctic	SA_auck	Medium	All months	West	Non-spawning
sub-Antarctic	SA_snares	Younger	All months	West	Non-spawning
sub-Antarctic	SA_suba	Older	All months	West	Non-spawning
West coast	PUYS_spwn		June–September	West	Non-spawning
West coast	WC_south	Middle	All months	West	Spawning
West coast	WC_inside	Older	All months	West	Spawning
West coast	WC_north	Younger	All months	West	Spawning

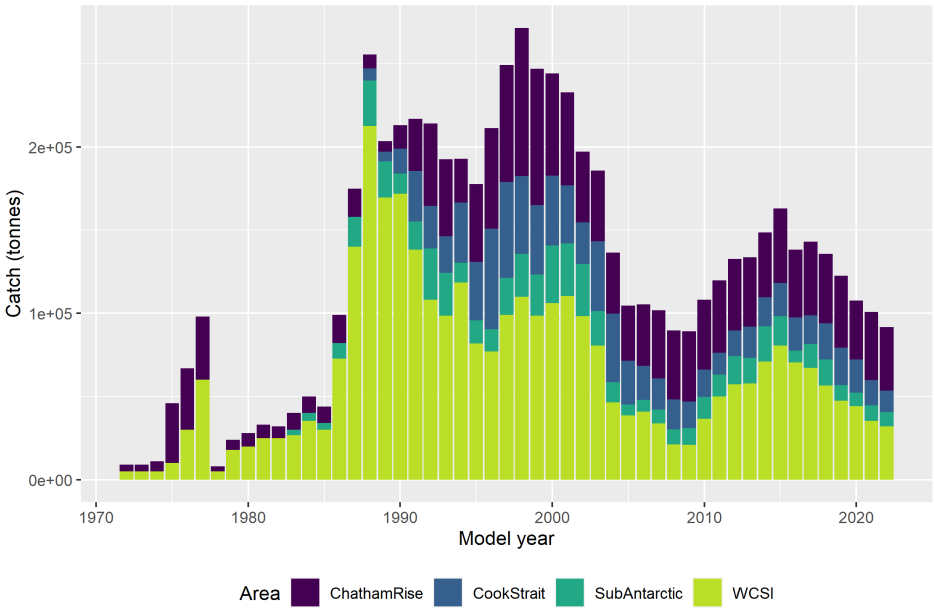


Figure 9: Hoki catch history by model area as defined in the stock assessment model.

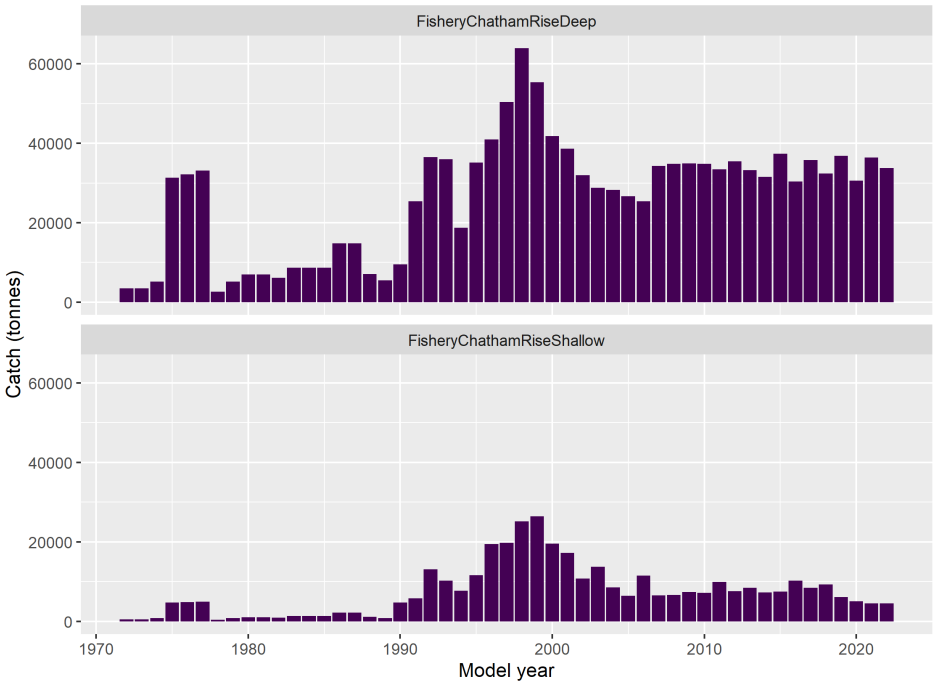


Figure 10: Hoki Chatham Rise catch history by fishery (deep (top) and shallow (bottom)) as defined in the stock assessment model.

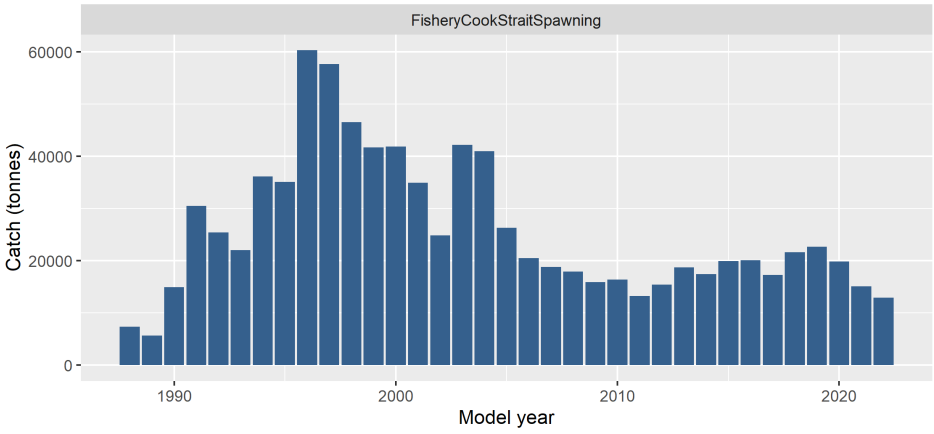


Figure 11: Hoki Cook Strait catch history.

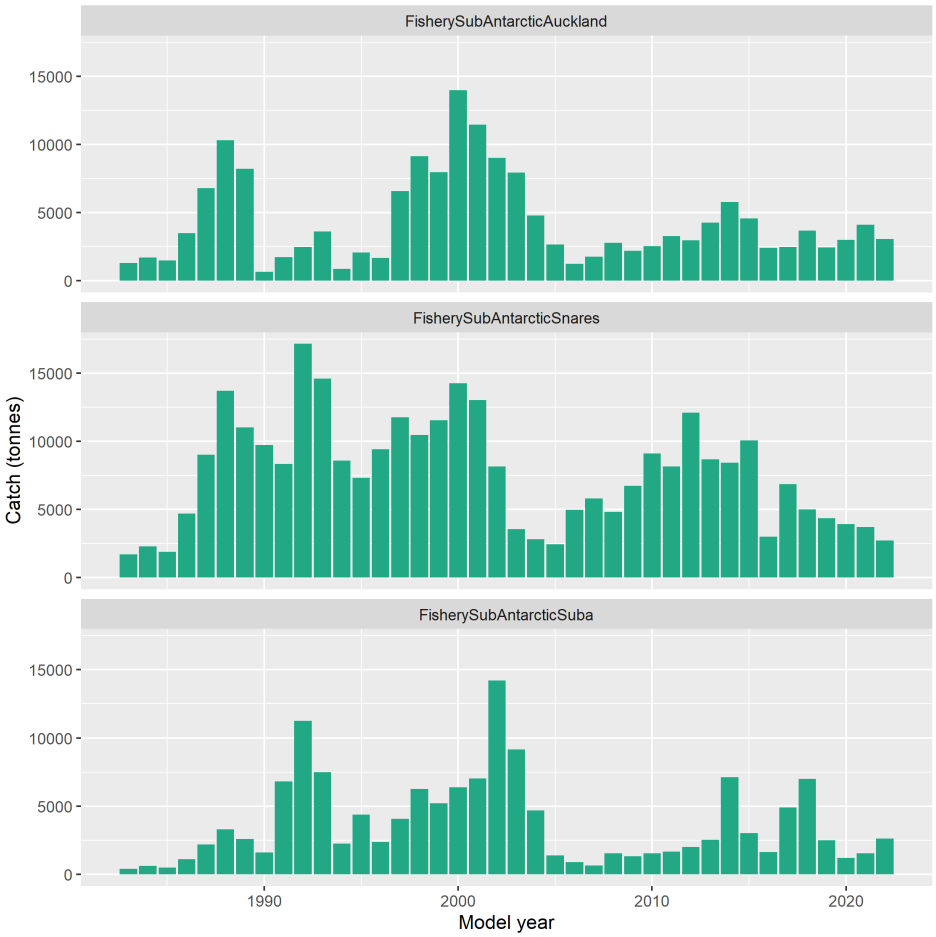


Figure 12: Hoki sub-Antarctic catch history by fishery (Auckland Islands (top), Snares (middle), Suba (bottom)) as defined in the stock assessment model.

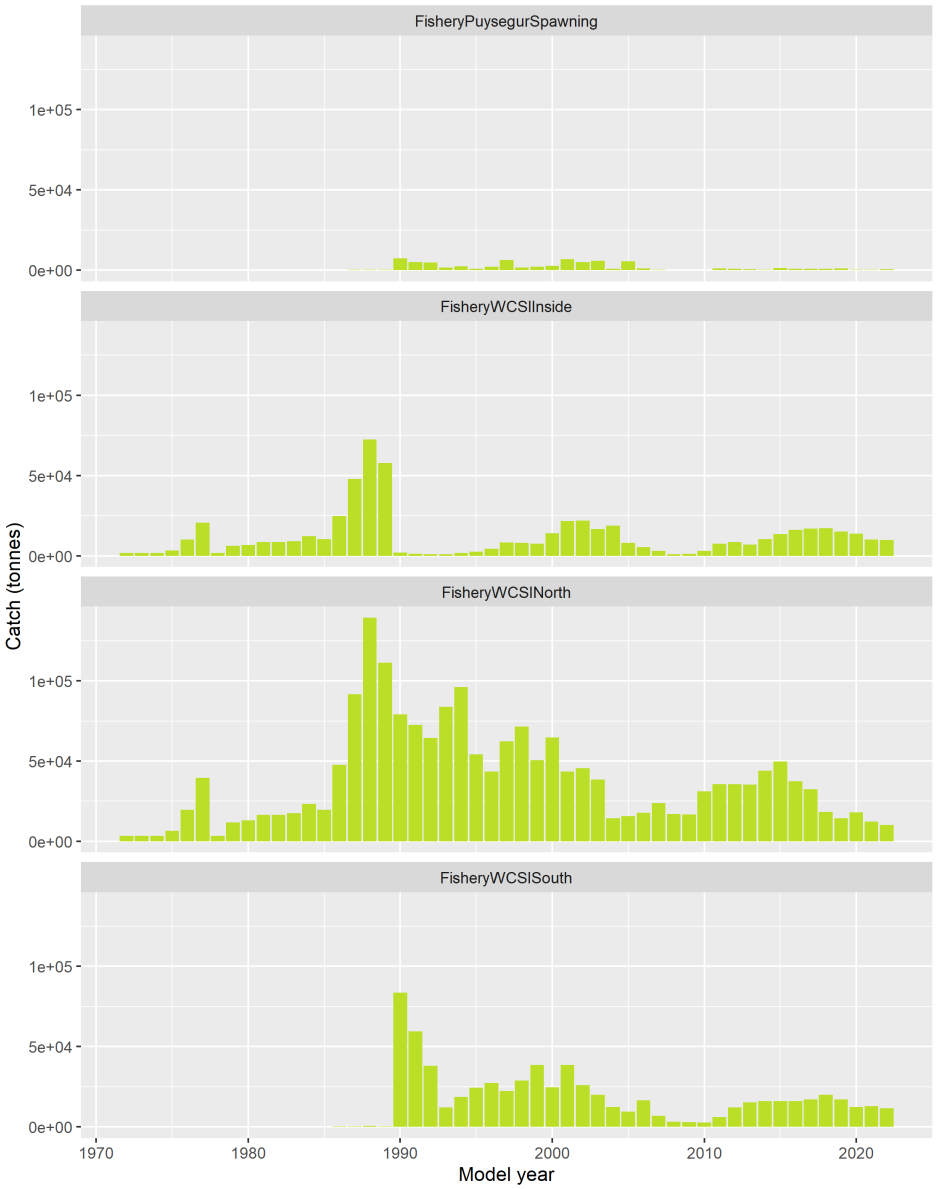


Figure 13: Hoki WCSI catch history by fishery (Puysegur (top), WCSI_inside (second to top), WCSI_north (second to bottom), WCSI_south (bottom)) as defined in the stock assessment model.

3.2 Composition data

Age-structure of new composition data are compared with data from earlier years in Figures 14 to 18. The Chatham Rise deep fishery in 2022 had a higher proportion of 1- and 2-year olds and lower proportions of 3- to 5-year olds than on average in previous years. The Chatham Rise shallow fishery also had a higher proportion of 2-year olds but only amongst females. The Chatham Rise trawl survey was not carried out in 2023, but had a high proportion of 2-year olds in the previous year (January 2022), which aligns with the 2022 non-spawning fisheries (e.g., Chatham Rise). The Cook Strait had a smaller than usual proportion of 4- and 5-year olds and a high proportion of 2-year olds in 2022. The sub-Antarctic fishery had higher proportions of 2- and 3-year olds in the Auckland Islands fishery. The sub-Antarctic trawl survey also had high proportions of 3- and 4-year olds in the 2023 fishing year (November–December 2022), which correspond to the 2- and 3-year olds in the Auckland Islands fishery in the 2022 fishing year.

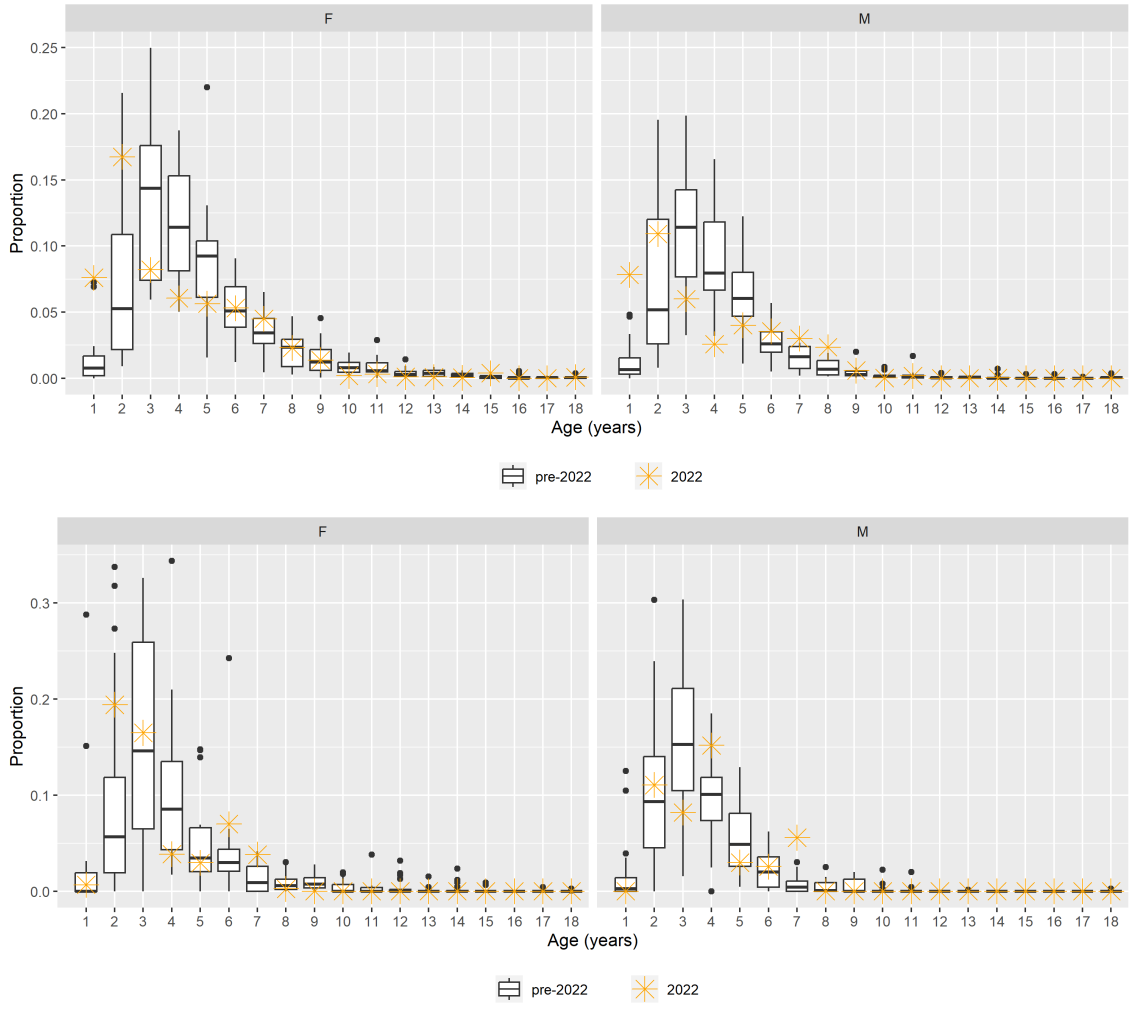


Figure 14: Summary of age composition data for Chatham Rise deep (top) and shallow (bottom) fisheries, separated by sex (female (left), male (right)). Gold asterisks are the new data for the 2023 assessment (i.e., proportions-at-age from the 2022 fishing year); boxplots are proportions-at-age from all earlier fishing years.

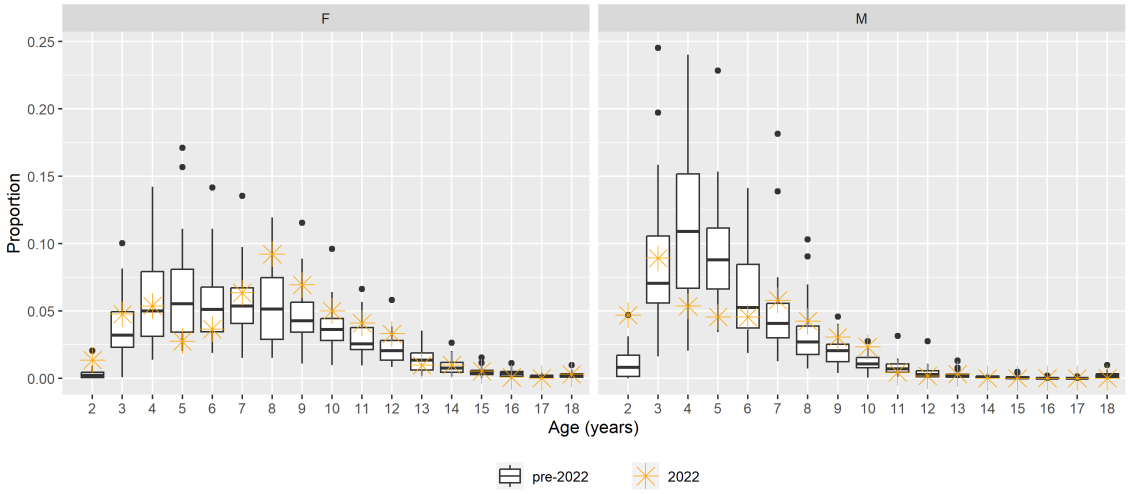


Figure 15: Summary of age composition data for Cook Strait, separated by sex (female (left), male (right)). Gold asterisks are the new data for the 2023 assessment (i.e., proportions-at-age from the 2022 fishing year); boxplots are proportions-at-age from all earlier fishing years.

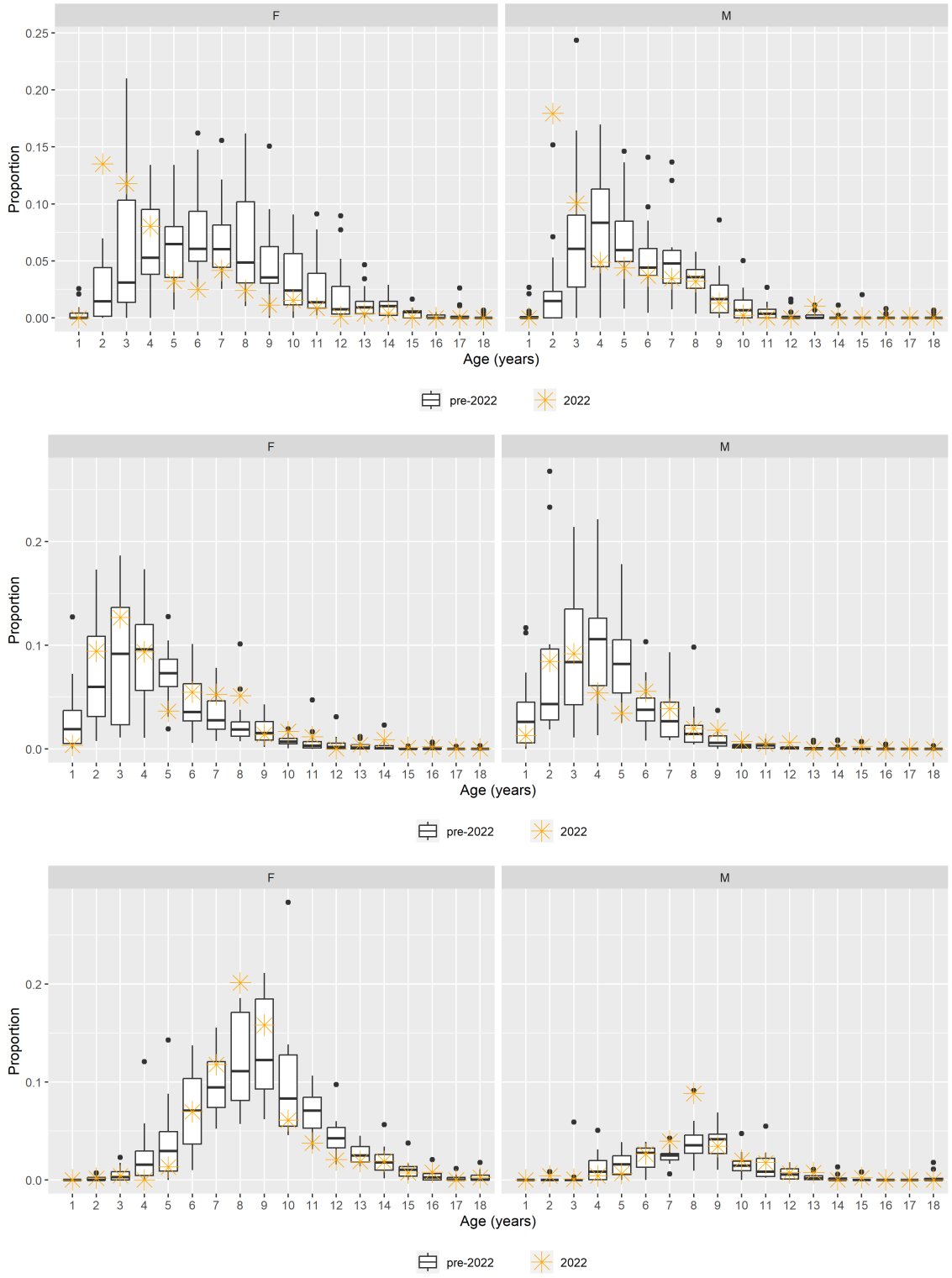


Figure 16: Summary of age composition data for sub-Antarctic Auckland Islands (top), Snares (middle), and Suba (bottom) fisheries, separated by sex (female (left), male (right)). Gold asterisks are the new data for the 2023 assessment (i.e., proportions-at-age from the 2022 fishing year); boxplots are proportions-at-age from all earlier fishing years.

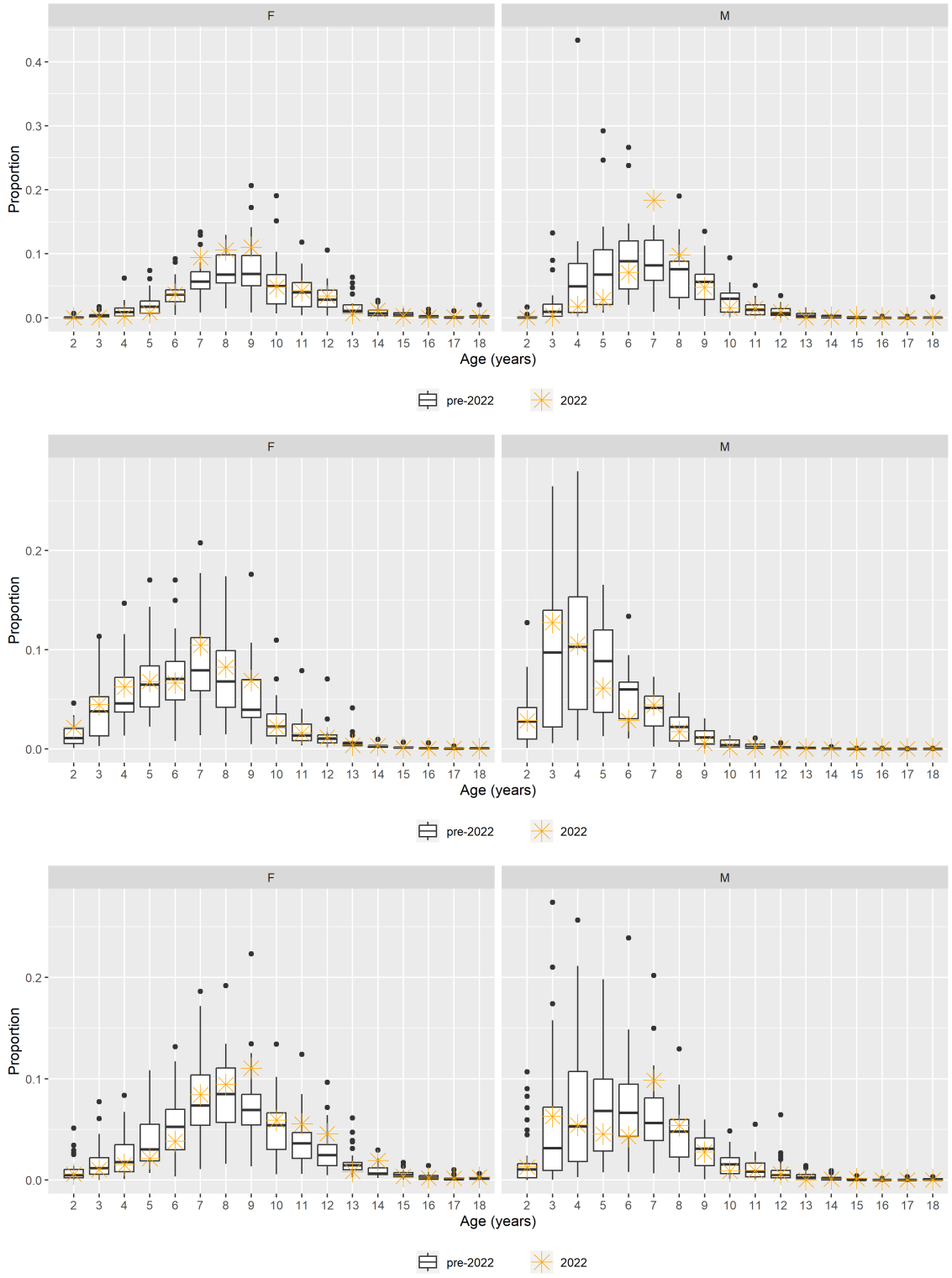


Figure 17: Summary of age composition data for WCSI Inside (top), North (middle), and South (bottom) fisheries, separated by sex (female (left), male (right)). Gold asterisks are the new data for the 2023 assessment (i.e., proportions-at-age from the 2022 fishing year); boxplots are proportions-at-age from all earlier fishing years.

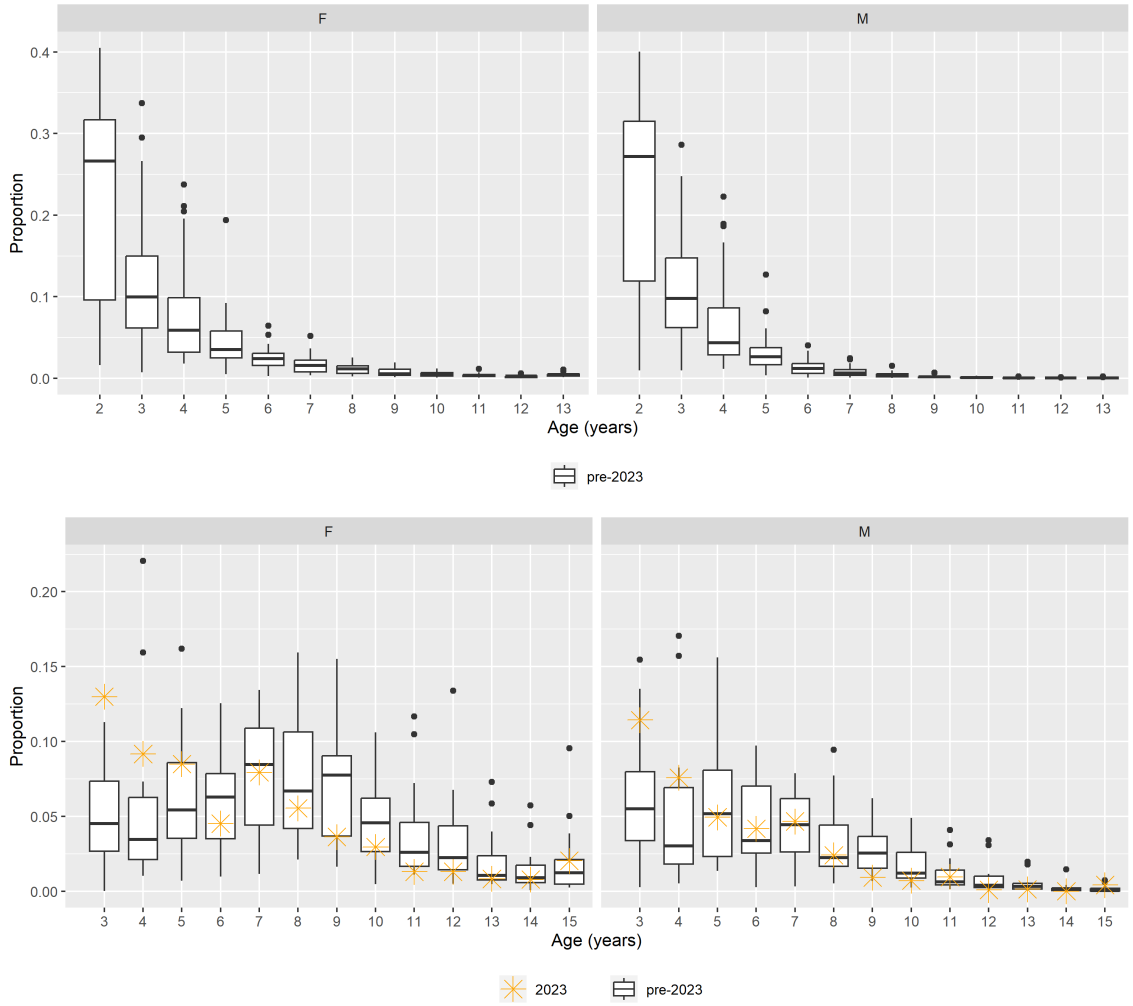


Figure 18: Summary of age composition data for Chatham Rise (top) and sub-Antarctic (bottom) trawl surveys, separated by sex (female (left), male (right)). Gold asterisks are the new data for the 2023 assessment (i.e., proportions-at-age from the 2023 model year); boxplots are proportions-at-age from all earlier fishing years. The Chatham Rise survey did not have new data for this assessment.

3.3 Survey abundance data

Survey abundance indices are available from the Chatham Rise and sub-Antarctic trawl surveys. A new estimate was available for the 2023 fishing year from the sub-Antarctic survey in November–December 2022, and we also updated the whole series for both surveys to consistently match the truncated age composition data in the model. The Chatham Rise age data did not include 1-year olds due to high variability in 1-year olds in the Chatham Rise survey, and, similarly, the sub-Antarctic age data did not include 1- or 2-year olds. Both indices were truncated by removing biomass of 1-year olds or 1- and 2-year olds which were estimated using length cut-offs. For the Chatham Rise, this was the same length cut-off (48 cm) as the 2020 Chatham Rise survey in the 2022 assessment, although the earlier survey truncated biomass values were previously taken from Langley (2020) and were slightly different (Figure 19). The sub-Antarctic abundance index was truncated using length cut-offs given in Appendix B. This index was not truncated to match the age data in any previous years (Figure 19).

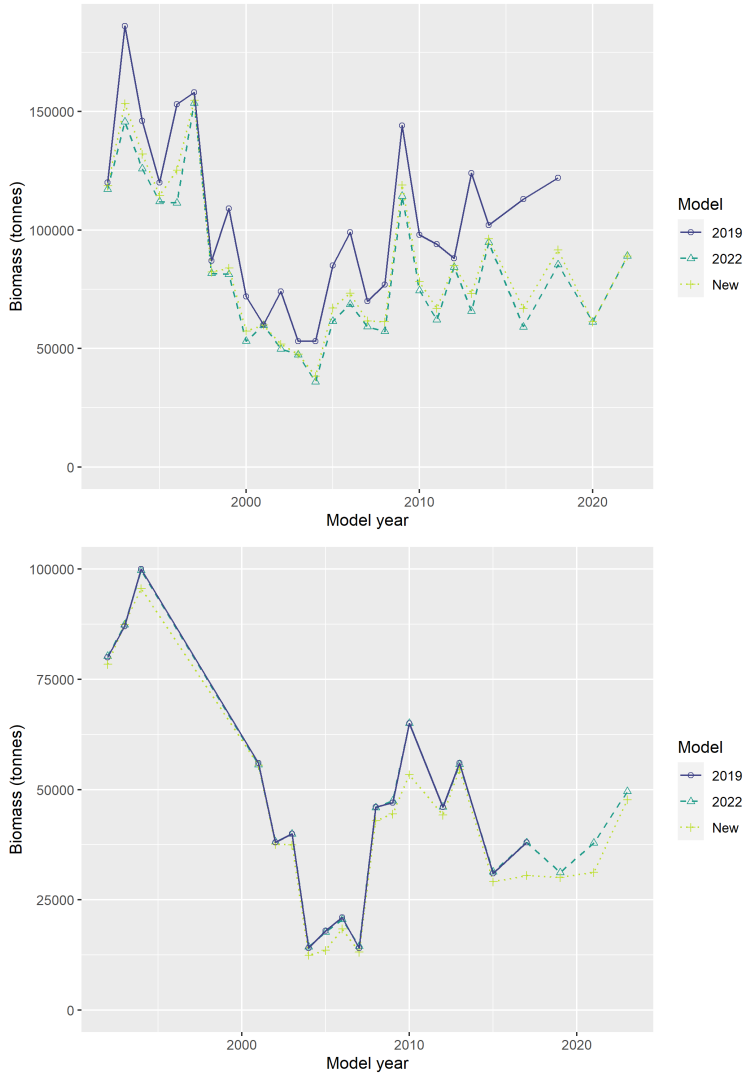


Figure 19: Trawl survey abundance indices for Chatham Rise (top) and sub-Antarctic (bottom). Gold points and error bars are the new data for the 2023 assessment (i.e., the 2023 model year); Error bars are 95% Confidence intervals. The Chatham Rise survey did not have new data for this assessment.

3.4 Informing recent year classes

In the 2022 assessment, year classes were estimated for 1975–2020 but only standardised over 1975–2019 because the most recent estimate was not considered sufficiently informed to contribute to the estimation of virgin recruitment (R_0). An additional recent year class would be estimated with an additional year of data, but this is not possible for the hoki assessment due to the biennial timing of the Chatham Rise survey from which early recruitment signals are most reliable obtained. Hence, the most recent year class we were able to estimate in the 2023 assessment model was still the 2019 year class. We did not estimate the 2020 year class as it is only seen in the data as 2-year olds in the spawning fisheries in time step 5 of the 2022 fishing year, and as 1-year olds in the summer fisheries in time step 2 of the 2022 fishing year.

In the 2023 assessment, the 2020 year class was seen as:

- 2-year olds in spawning fisheries Cook Strait, WCSI, and Puysegur (2022 timestep 5)
- 1-year olds in summer fisheries Sub-Antarctic and Chatham Rise (2022 timestep 2)

In the 2023 assessment, the 2019 year class was seen as:

- 3-year olds in SA summer survey (2023 timestep 2)
- 3-year olds in spawning fisheries Cook Strait, WCSI, and Puysegur (2022 timestep 5)
- 2-year olds in summer fisheries Sub-Antarctic and Chatham Rise (2022 timestep 2)
- 2-year olds in CR summer survey (2022 timestep 2)
- 2-year olds in spawning fisheries Cook Strait, WCSI, and Puysegur (2021 timestep 5)
- 1-year olds in summer fisheries sub-Antarctic and Chatham Rise (2021 timestep 2).

4. MODEL SENSITIVITIES (MPD)

Model sensitivities were carried out in three main groups: 1) structural sensitivities focused on movement to the spawning grounds; 2) structural sensitivities focused on alternative stock structure; 3) parameter sensitivities focused on natural mortality, recruitment steepness, and onset of maturity. Parameter sensitivities were provided on the base model (Update_data) with the modified trawl survey abundance indices to match the age structure (Figure 19). Comparisons showing the effect of modifying these indices are included.

Structural sensitivities are presented here in two sets:

- Set One (see Figures 20–26): 2022A model recoded in Casal2 (PreviousBase_run)
  + updated with new data (Updated_data)
  + maturation separated from migration to spawning grounds (and the latter estimated) (SepMature)
  + WCSI north CPUE included as an index of abundance for the WC north fishery (WCnorthCPUE)

- Set Two (see Figures 27–32): 2022A model in Casal2 with new data (Updated_data)
  + maturation separated from migration to spawning grounds (migration to spawning grounds estimated) (SepMature)
  Single stock version of SepMature (SingleStock)

The SepMature model was defined using maturity ogives estimated in Section 2.4 and estimating the proportion of juvenile fish migrating to the spawning grounds. All mature fish still migrated to the spawning grounds as in the base model structure. Maturity was defined to be the same for males and females, with the proportion of juveniles migrating to spawning grounds estimated separately for males and females. Selectivity ogives on the spawning grounds were still defined separately for males and females as in the base model structure. The key difference between this model and the base model structure was that more younger fish migrated to the western spawning ground (estimation of juvenile spawning migration was close to 1 for western stock and close to 0 for eastern stock). This model also allows us to explore alternative movement scenarios without impacting the defined spawning stock biomass.

The single-stock model was an extension on the SepMature model that only estimated one vector of year class strengths. This model assumed no stock structure, but once a fish migrated from the Chatham Rise to the sub-Antarctic, it did not return to the Chatham Rise. Hence, there became effectively a western and eastern stock structure, but without natal fidelity. The key difference between this model and the base model structure was that the single-stock model does not allow for time-varying differences in recruitment between the stocks.

Recent biomass trajectories were estimated to be either flat or slightly increasing for both stocks for all model options (see Figures 20 and 27). In most model sensitivities, the large 2019 eastern stock recruitment estimated in the 2022 assessment was split more evenly between eastern and western stocks. The increase in western stock recruitment resulted in a higher estimate of biomass and status for the western stock than in the 2022 assessment, and a similar or lower biomass and status for the eastern stock was estimated (Table 8). The SingleStock model estimated a lower stock biomass and status in 2023 for both eastern and western spawning fisheries. Fits to the data were generally good, except for the SA_auck fishery age composition data which had more young fish in the most recent year than typical, and the models were not able to fit to this (see Figures 25 and 32).

Table 8: $SSB_{current}/B_0$ by stock from MPD sensitivities in Set One and Set Two. Ranges are given for parameter sensitivities for the combined stocks (HOK 1). Values were able to be calculated for the SingleStock model at the stock level using mature fish on the relative spawning grounds during the spawning season which matches the defined spawning stock biomass by stock in the two-stock models. Updated_dta_TSedit has the edited trawl survey abundance indices to match the relative age-structure as described in Section 3.3. *TSfull* trawl survey indices were not truncated to match the corresponding age composition data in the model (Section 3.3).

Model	E	W	HOK 1	Parameter sensitivities (HOK 1)
PreviousBase_run	0.53	0.28	0.38	(0.30–0.46)
Updated_data (*TSfull*)	0.56	0.38	0.45	
Updated_data	0.54	0.37	0.44	(0.39–0.48)
SepMature	0.48	0.37	0.41	
WCnorthCPUE	0.49	0.38	0.42	
SingleStock	0.47	0.28	0.36	

4.1 Set One

The main focus of Set One sensitivities was to inform the estimation of recruitment to the western stock. The western spawning fisheries can have quite large proportions of 2-year olds in the age composition data, especially in the north fishery which tends to catch younger fish. The base model structure migrates only mature fish to the spawning grounds, and hence does not have enough 2-year olds to fit to these proportions. If data cannot be fitted by any parameter combinations due to the model specification, they will not provide any information to the model. Hence, any signal from these young fish in the WC_north fishery will not have the power to inform recruitment of fish to the western stock.

The SepMature model separated the specification of maturity and movement to the spawning grounds, allowing for more flexibility in the movement of fish to the spawning grounds without this impacting on the defined mature biomass and hence the spawning stock recruitment relationship. In addition to moving all mature fish to the respective spawning grounds, the model was able to estimate a proportion of juvenile fish to also migrate to the spawning ground in order to explore the potential power the younger fish may have in the spawning fisheries. The estimates of juvenile migration to the spawning grounds were close to one for the western stock and close to zero for the eastern stock. There was little difference in the estimated western stock YCS (Figure 21) despite the difference in underlying population dynamics (Figure 24).

The WCnorthCPUE model was an extension on the SepMature model that included CPUE from the WC_north fishery as an index of abundance to test if this would provide additional information to the model on recruitment to the western stock. This did not seem to impact on the model outputs, with similar biomass and recruitment estimated (Figures 20 and 21), although there were some differences in the selectivity ogives (Figure 26). It was noted, that the error bounds on the index were fairly large and tighter bounds may have given it more influence on the model. The index was fairly noisy, especially from 2016 to 2022, and it would be difficult for this model to do much more than estimate a straight line through this, as was seen the abundance fits (Figure 23).

The models with only mature fish migrating to the spawning grounds estimated declining selectivity ogives for the WC_north fishery males and a shallow left-hand side to the ogive for females allowing for higher selection of younger fish (Figure 26).

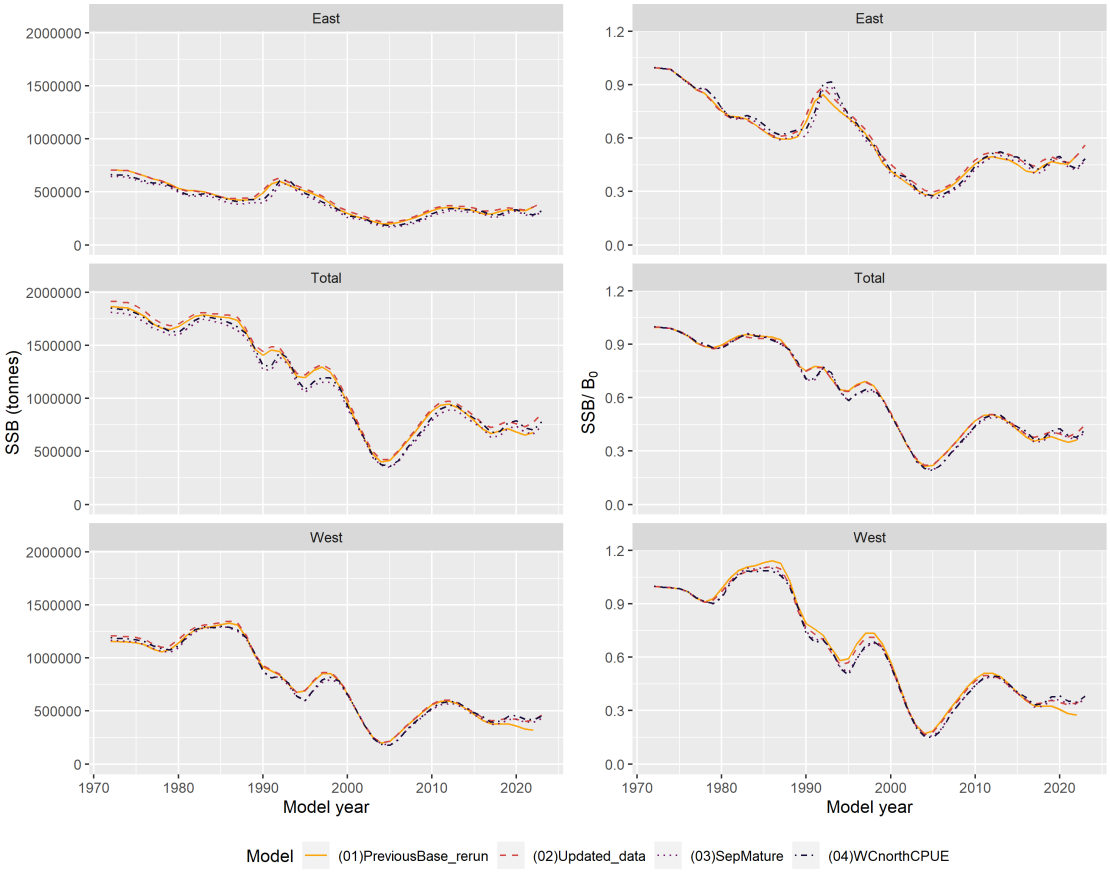


Figure 20: SSB and SSB/B_0 for MPD model sensitivities Set One.

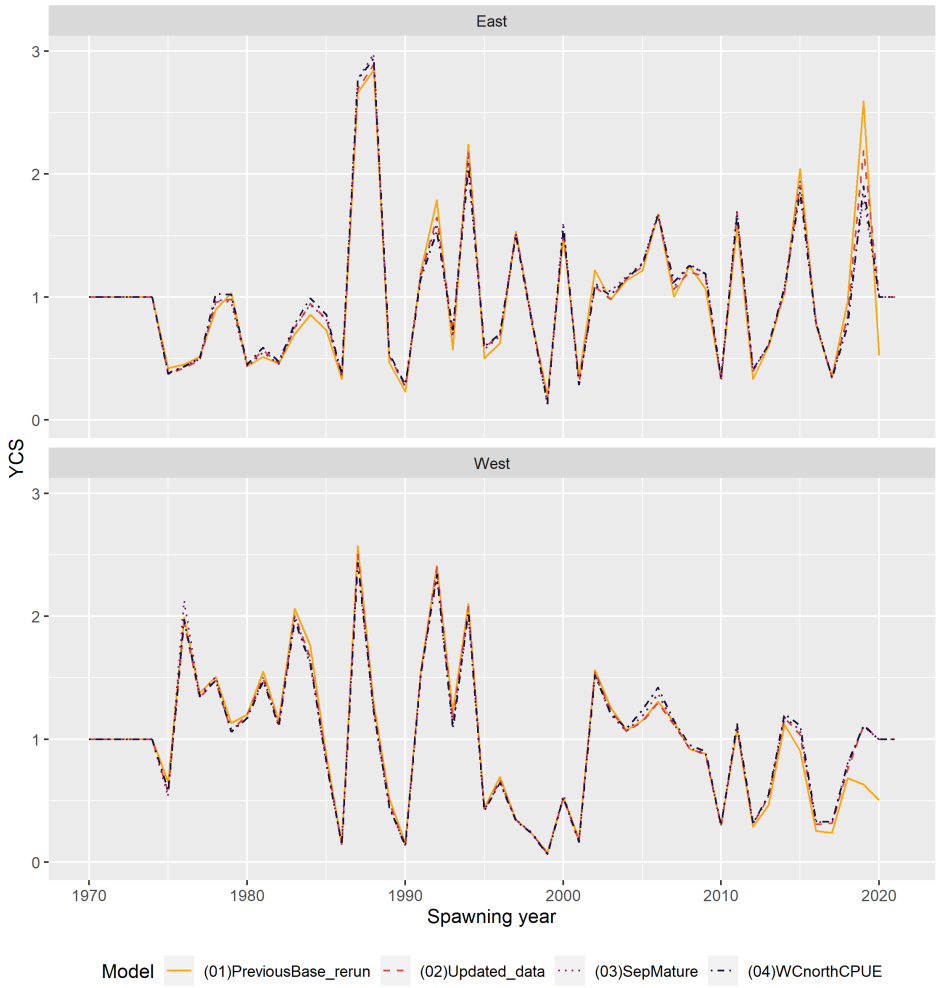


Figure 21: YCS estimates for MPD model sensitivities Set One.

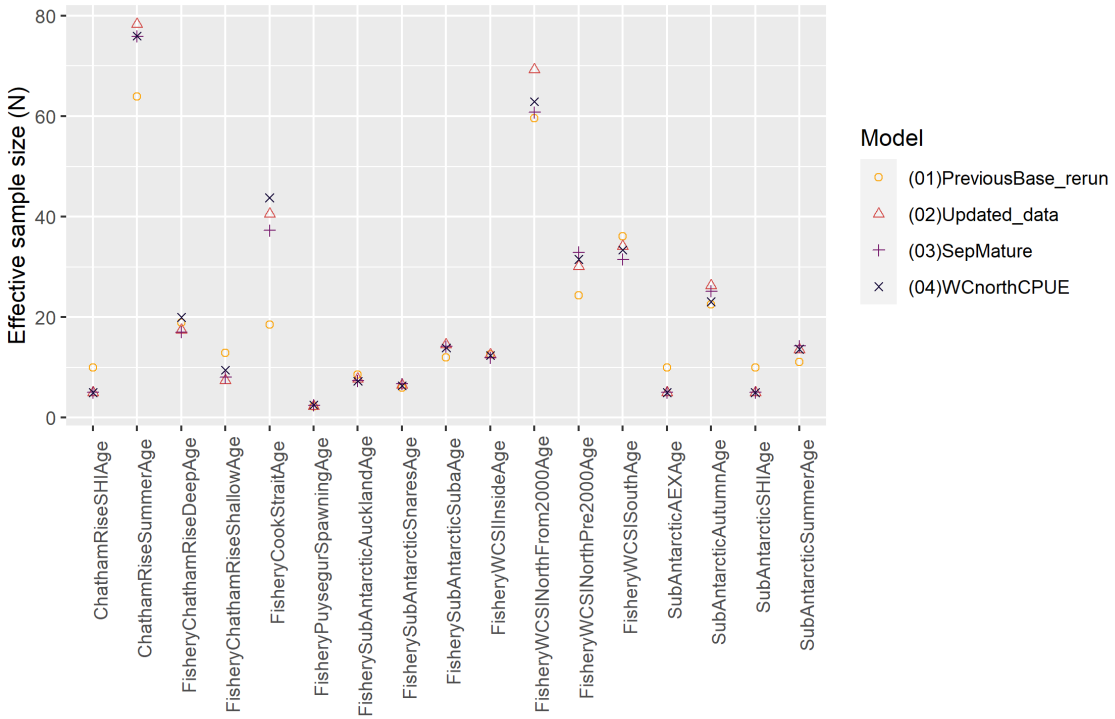


Figure 22: Effective sample sizes for composition datasets following re-weighting of MPD model sensitivities Set One.

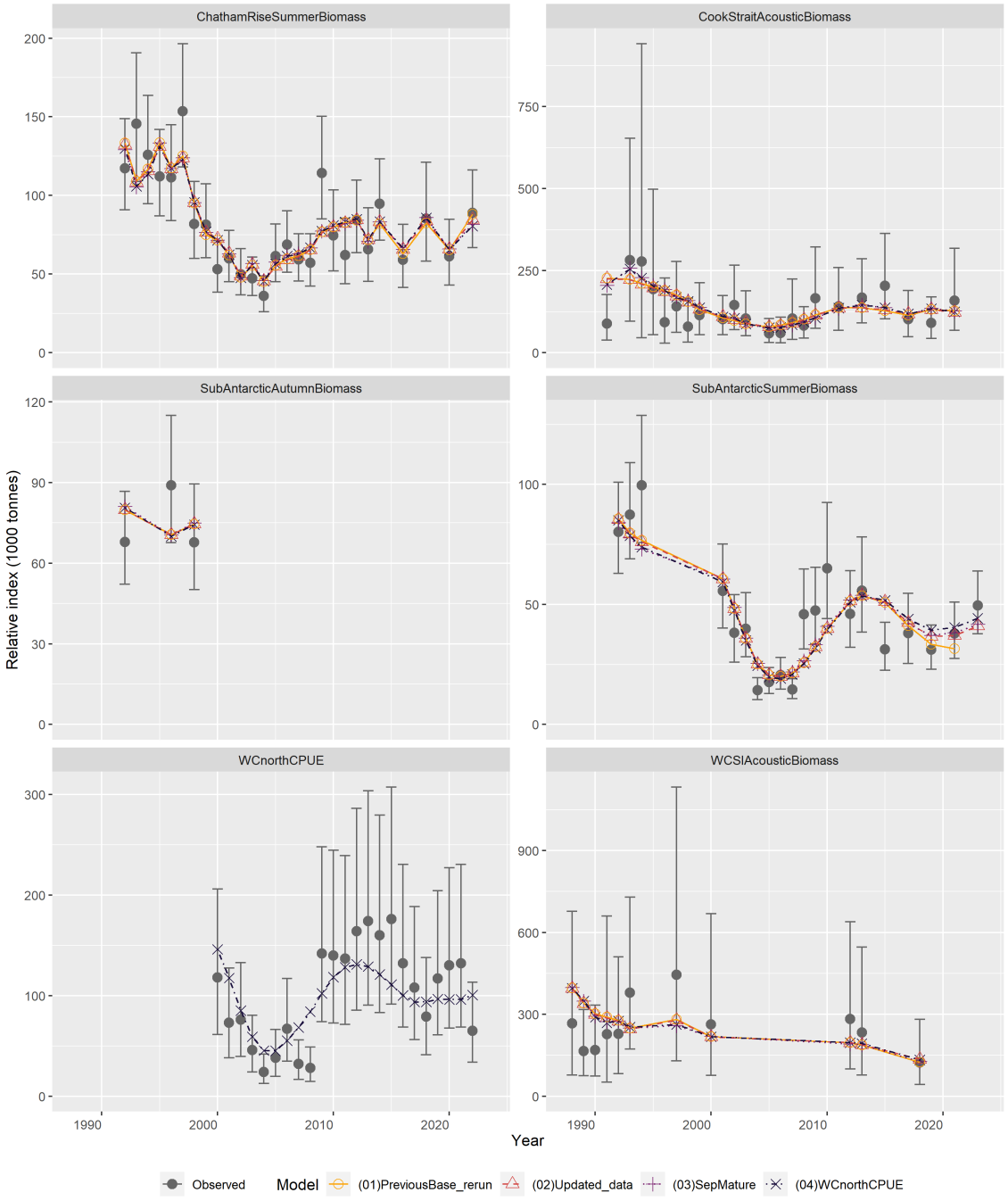


Figure 23: Fits to abundance indices from MPD model sensitivities Set One.

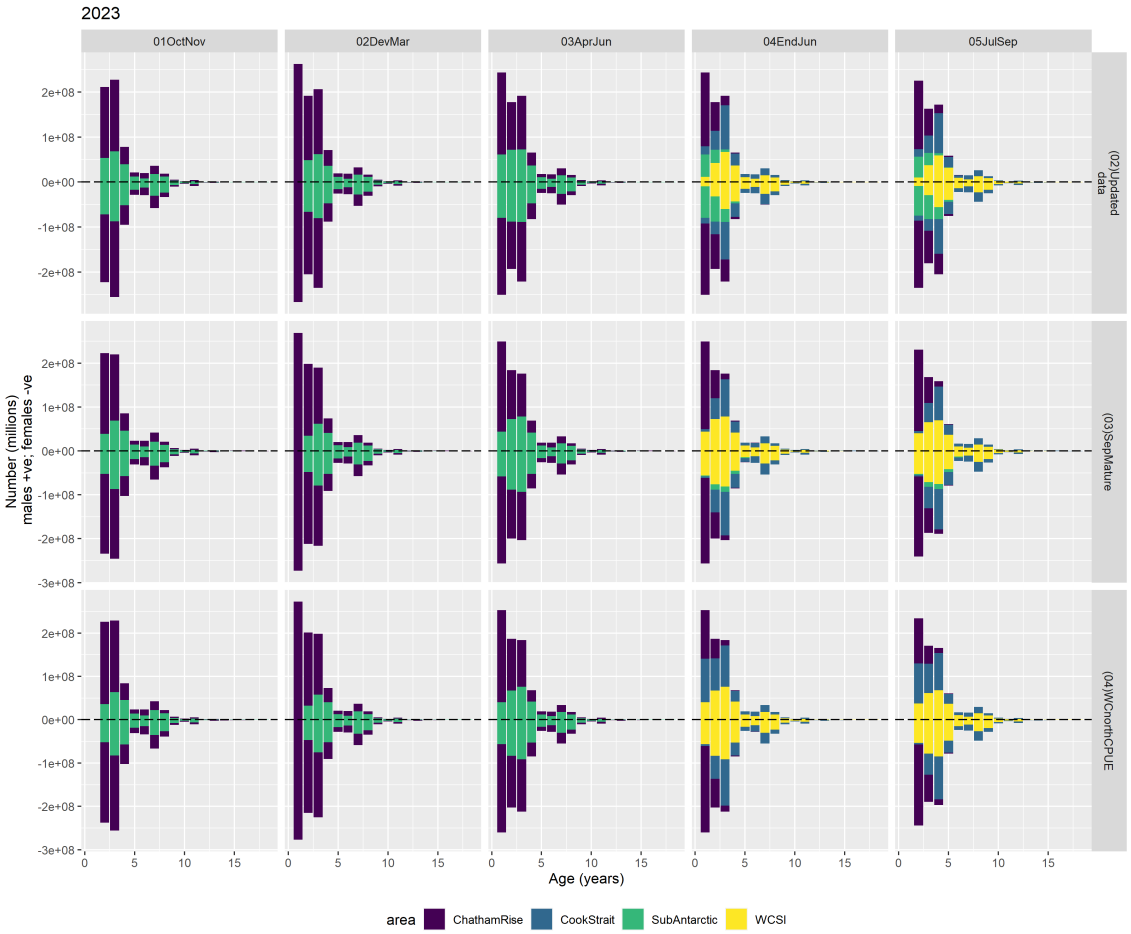


Figure 24: Model population structure in fishing year 2023 at each annual timestep from MPD model sensitivities Set One.

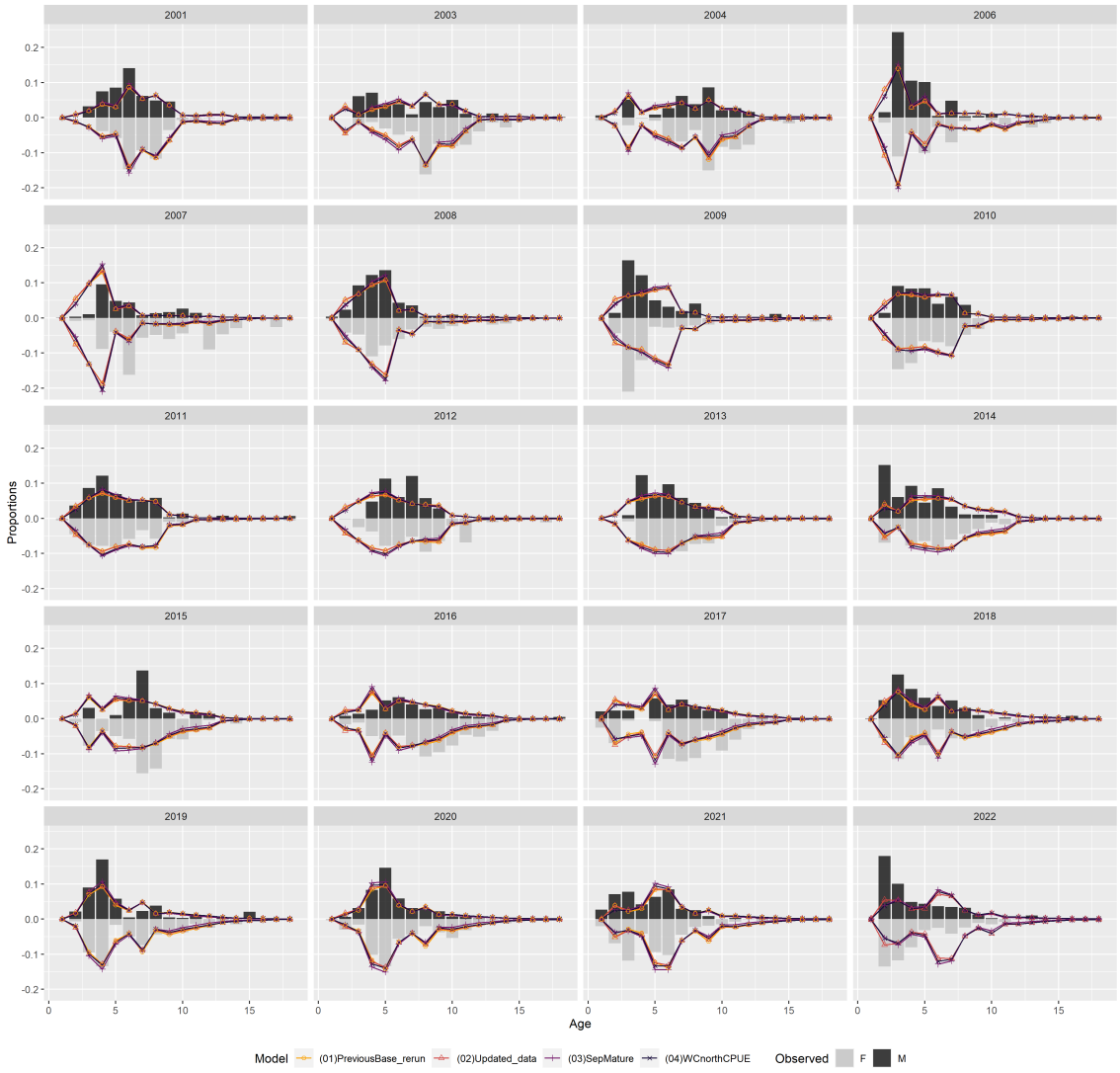


Figure 25: Fits to SA_Auckland age composition data from MPD model sensitivities Set One.

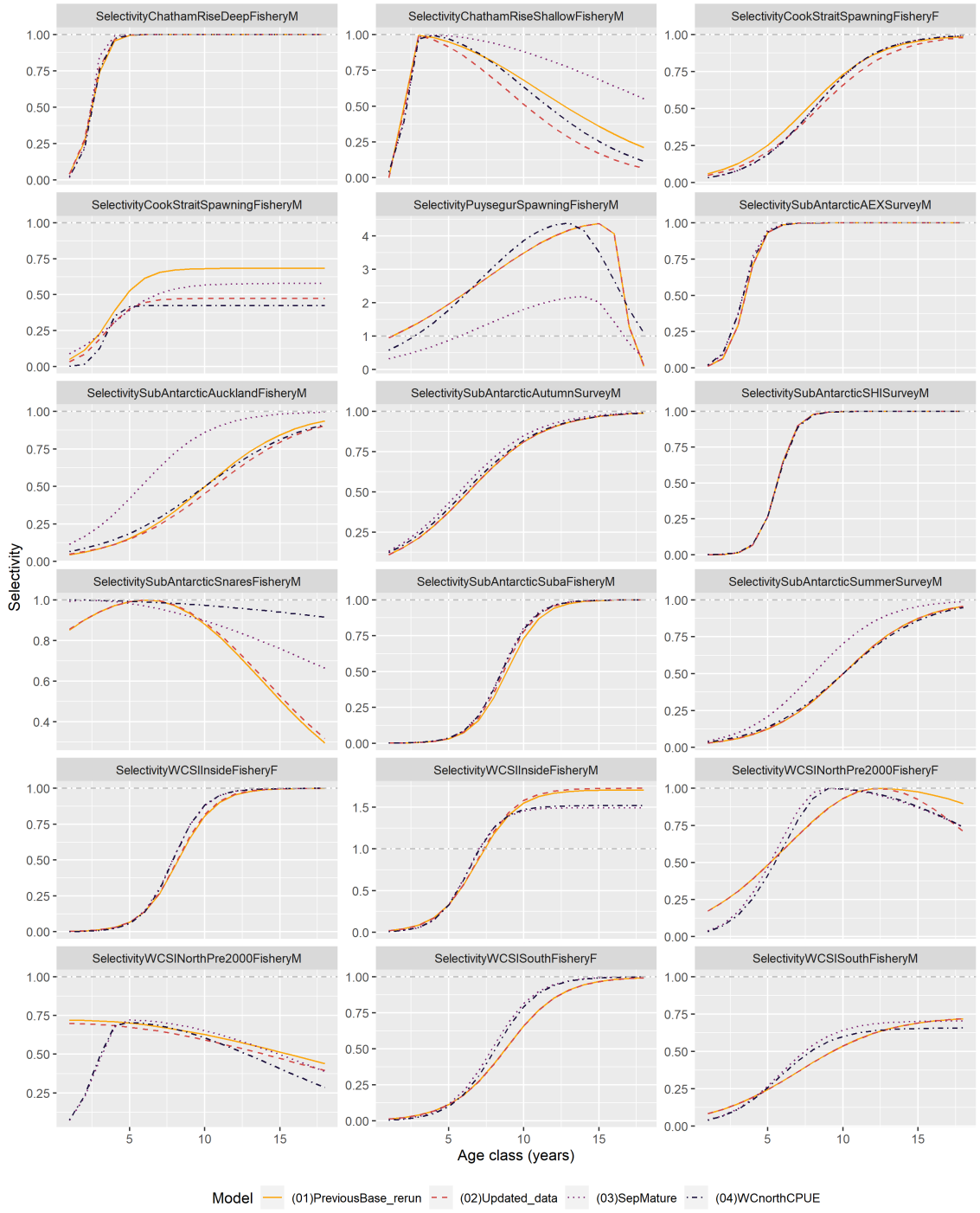


Figure 26: Estimated selectivity ogives from MPD model sensitivities Set One. The same selectivity for WCSINorthPre2000 was used for WCSINorthFrom2000 as these were the same in the 2023 assessment models.

4.2 Set Two

The second set of structural sensitivities compares a newly developed single stock model (SingleStock) which was based on the SepMature model. SingleStock retains the spatial and temporal structure of SepMature but estimates a single vector of year classes for the combined spawning biomass of HOK 1 (i.e., 45 year classes estimated rather than 90 in the two-stock structure). This means there is no time-varying differentiation between eastern and western fish. The migration of fish from Chatham Rise to sub-Antarctic is still estimated, and, once fish migrate to the sub-Antarctic, they do not return to the Chatham Rise (and hence become effectively 'western stock' fish). There is no time-varying component to movement within the model, so there is little flexibility for this model to deal with different east-west dynamics except through catch removals.

The outputs of this model were compared with the SepMature and UpdateData models. SingleStock outputs differed most in the early years of the fishery (pre-1985 and to a lesser extent up until the late 1990s) (Figure 27) due to fewer data particularly for the eastern fisheries (Table 5). This results in a higher eastern biomass and status and lower western biomass and status. Similar fits to the data were obtained except to the Chatham Rise survey biomass (see Figure 30). In the two-stock models, estimation of eastern stock year classes results in very close fits to the Chatham Rise survey biomass due to agreement between the Chatham Rise survey biomass and the eastern stock recruitment signals, which largely come from the Chatham Rise survey (e.g., 2-year olds). The only other eastern stock data in the model are from the Cook Strait fisheries, which do not provide strong information on recruitment as they catch adult fish and do not have clear cohort progression. In the SingleStock model, recruitment to the Chatham Rise needs to agree with all of the datasets, including the SA and WCSI fisheries, the latter of which has strong data signals of cohort progression. Hence, the SingleStock model requires more support in the data for a strong year class to the Chatham Rise and so reduces the fit to the Chatham Rise survey. Similarly, the Chatham Rise survey age structure was down-weighted by the Francis (2011) re-weighting in the SingleStock model (see Figure 29). This model also down-weighted the WCSI north age composition data, which may be in conflict with the Chatham Rise survey.

Vulnerable biomass to the fisheries was more similar between models than SSB, with the largest differences in vulnerable biomass generally pre-dating the respective fisheries (Figures 33–36). This highlighted the influence of selectivity ogives in connecting the underlying population with what the fisheries 'see'. As this is a new model, more analysis is required to provide confidence in how the model handles these dynamics.

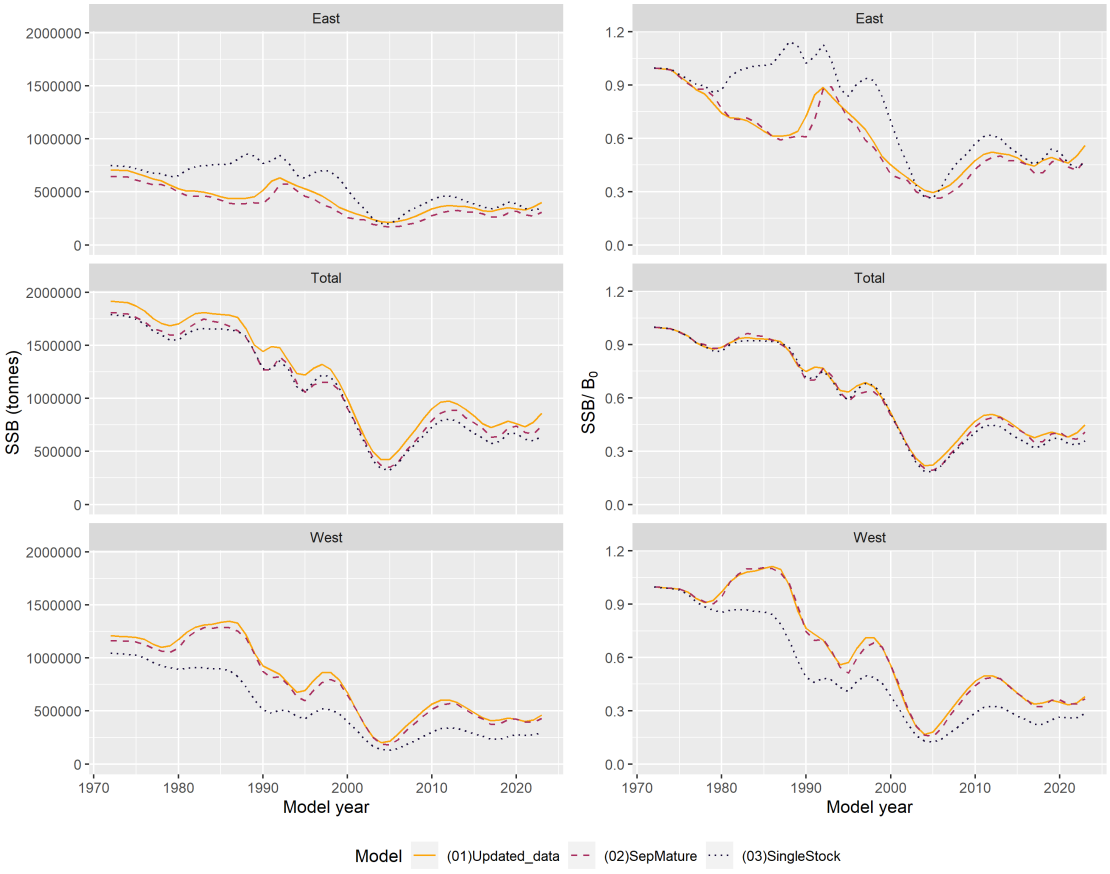


Figure 27: SSB and SSB/B_0 for MPD model sensitivities Set Two.

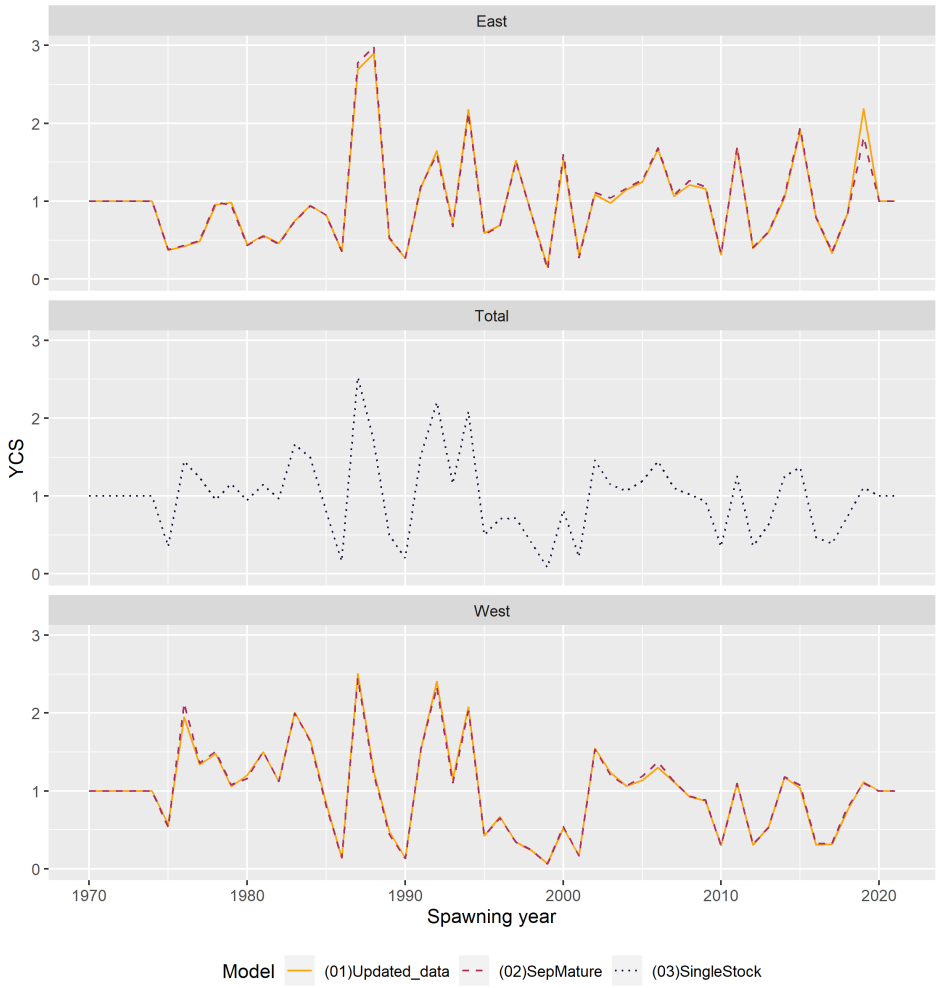


Figure 28: YCS estimates for MPD model sensitivities Set Two.

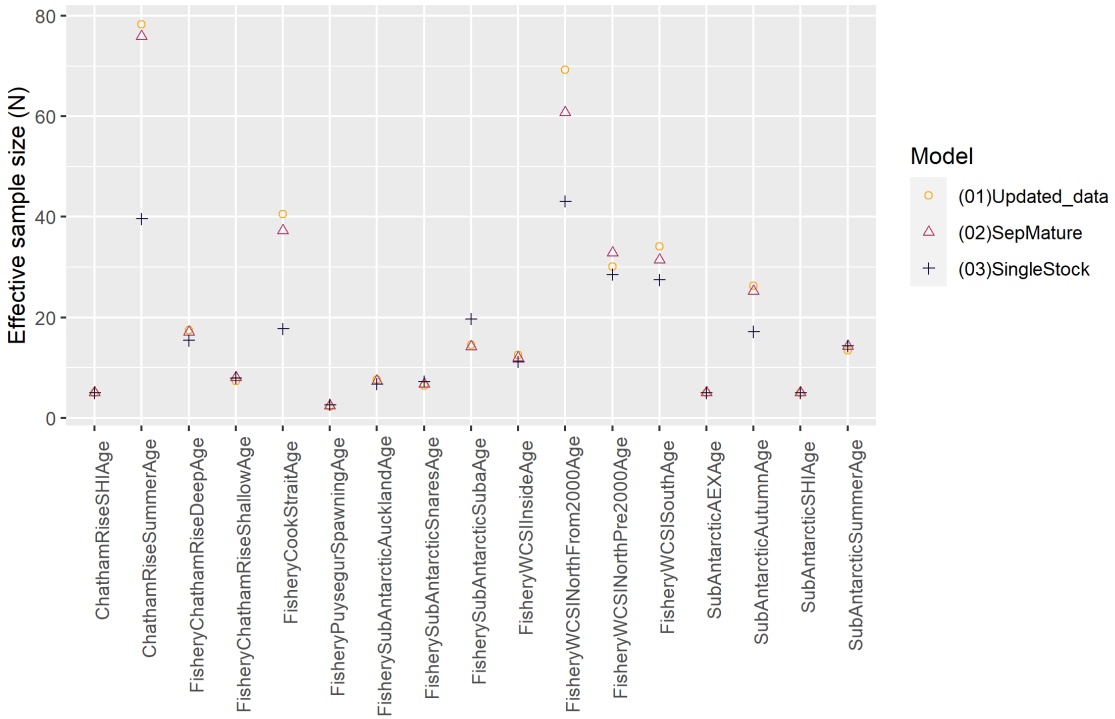


Figure 29: Effective sample sizes for composition datasets following re-weighting of MPD model sensitivities Set Two.

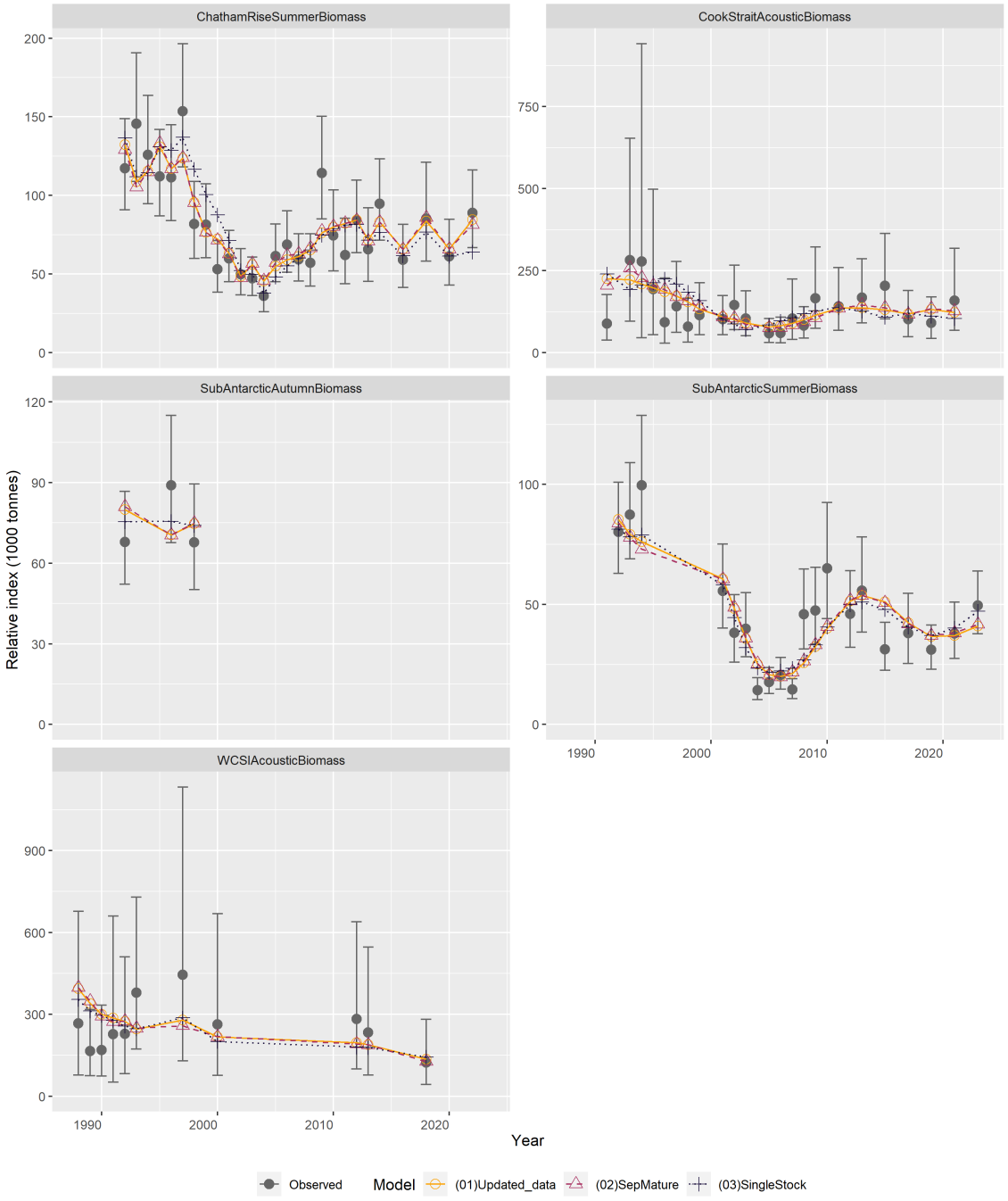


Figure 30: Fits to abundance indices from MPD model sensitivities Set Two.

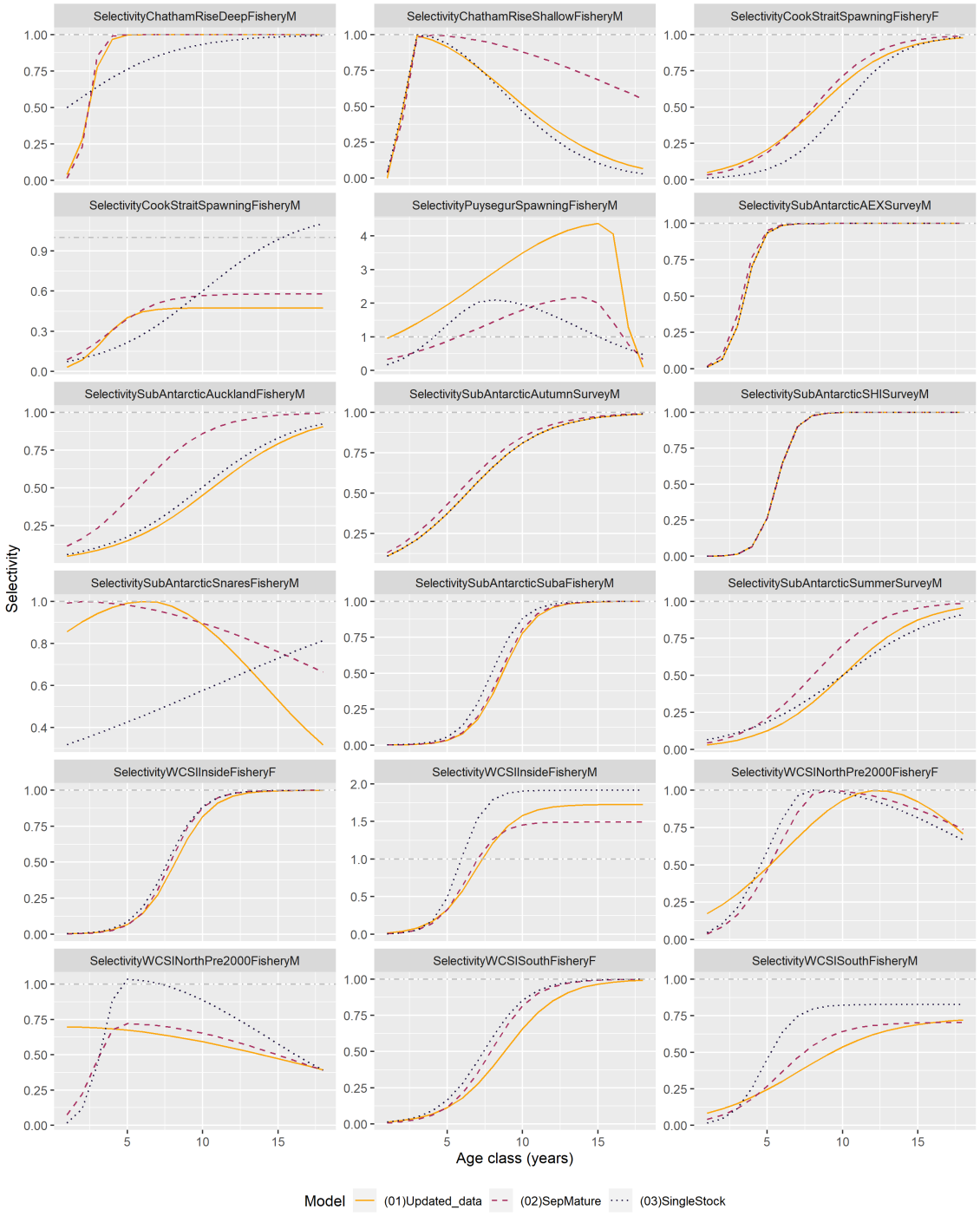


Figure 31: Estimated selectivity ogives from MPD model sensitivities Set Two.

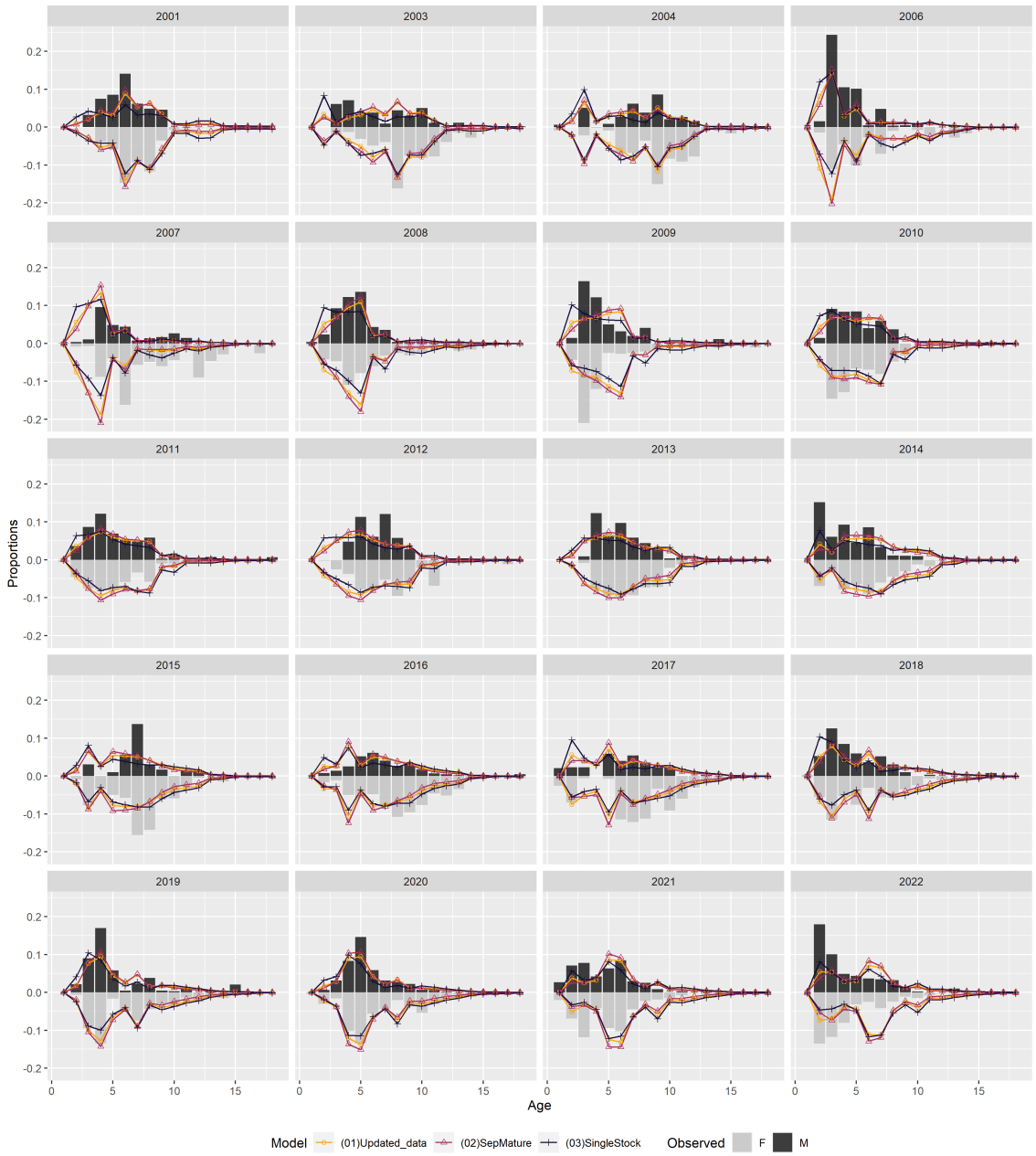


Figure 32: Fits to SA_Auckland age composition data from MPD model sensitivities Set Two.

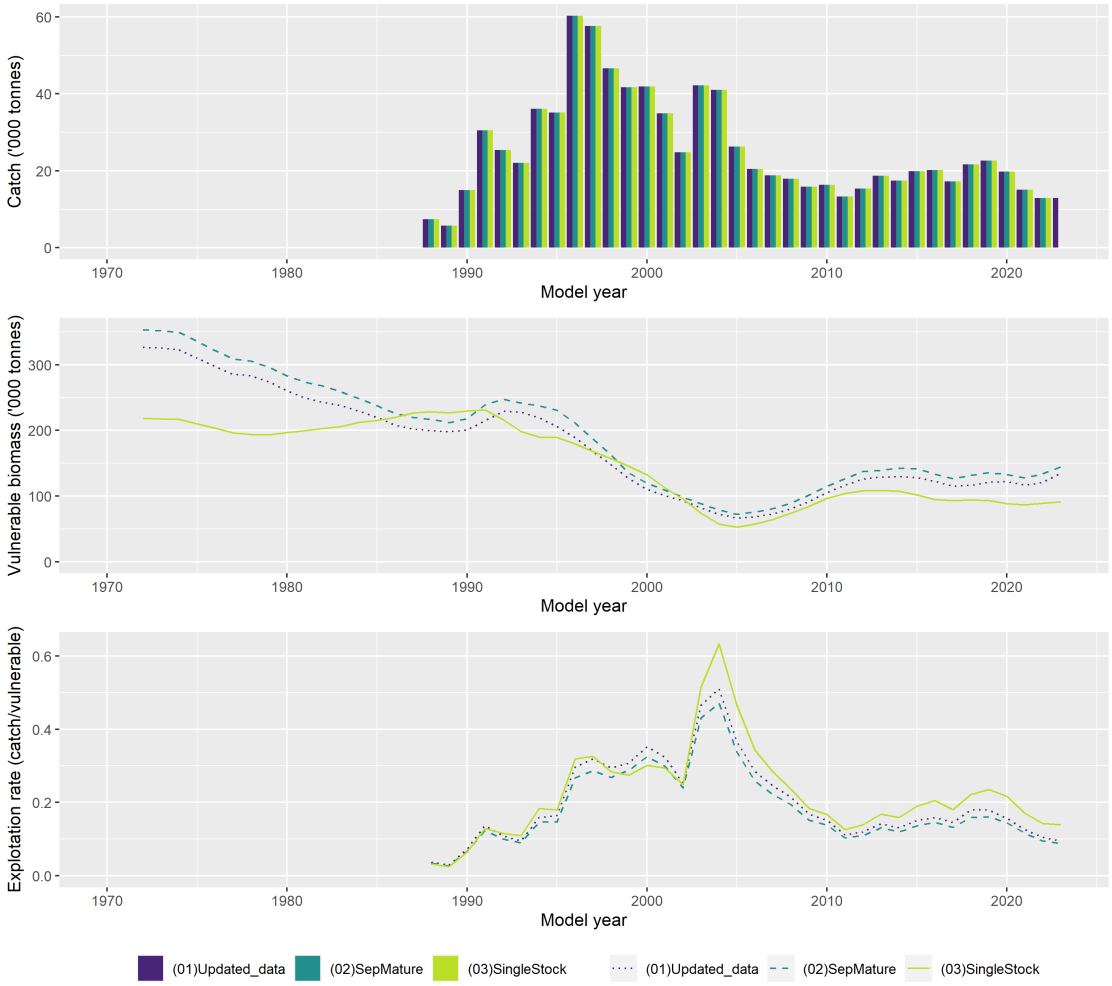


Figure 33: Cook Strait catch history (top), vulnerable biomass to the Cook Strait fishery (middle), and exploitation rate (bottom) for three alternative models (indicated by colour).

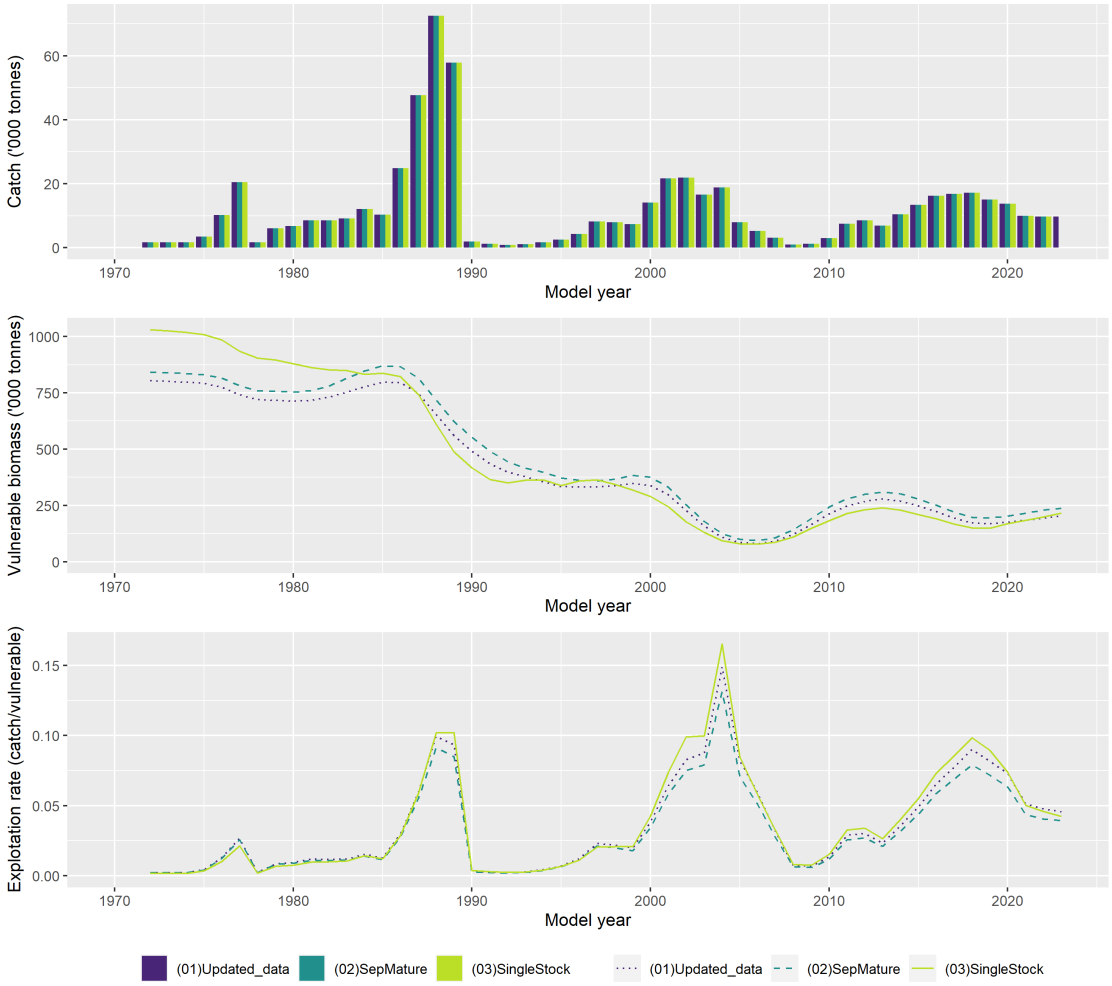


Figure 34: WCSI inside catch history (top), vulnerable biomass to the Cook Strait fishery (middle), and exploitation rate (bottom) for three alternative models (indicated by colour).

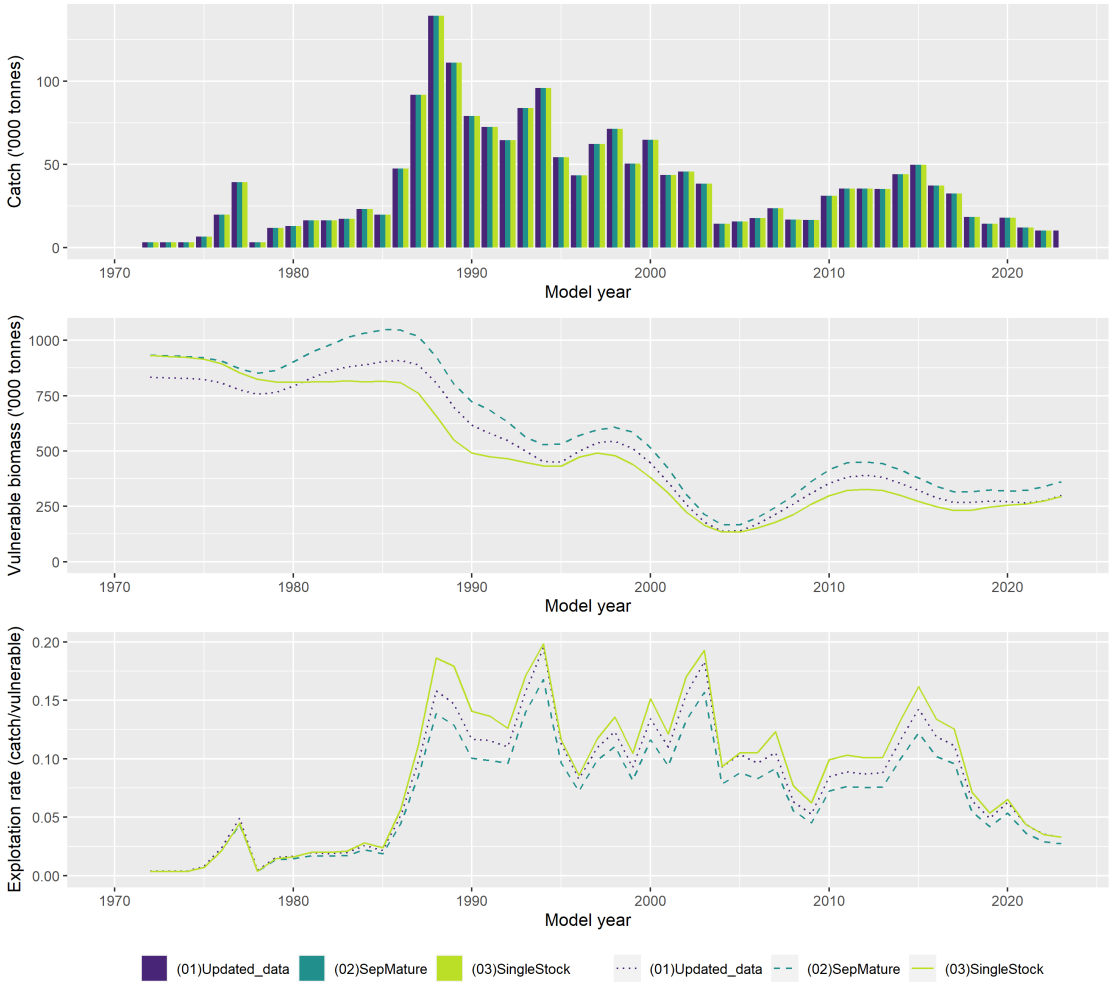


Figure 35: WCSI north catch history (top), vulnerable biomass to the Cook Strait fishery (middle), and exploitation rate (bottom) for three alternative models (indicated by colour).

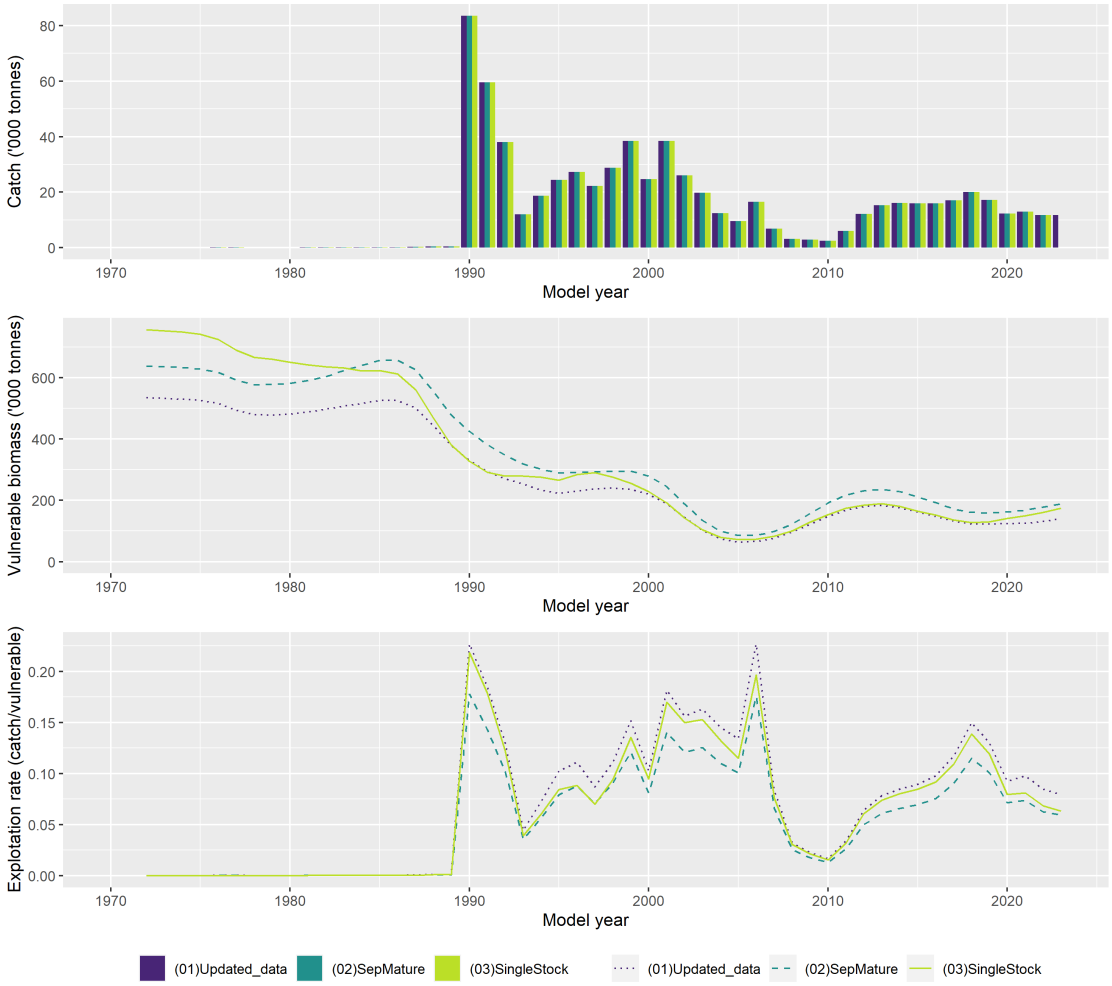


Figure 36: WCSI south catch history (top), vulnerable biomass to the Cook Strait fishery (middle), and exploitation rate (bottom) for three alternative models (indicated by colour).

4.3 Parameter sensitivities

Parameter sensitivities were run on the base model (Update_data) with edited trawl survey indices to match trawl survey age structure in the model (i.e., excluding 1-year olds from the Chatham Rise index and 1- and 2-year olds from the sub-Antarctic index). These sensitivities are summarised in Table 9 with MPD estimates of current status. High and low natural mortality sensitivities gave the largest difference in estimated current status (0.39 and 0.48, respectively) and this was also seen at the stock level (Figures 37 and 38).

The sensitivity with female *M* low was run to improve fits to the declining male:female ratio with age. In the 2022 assessment, model 2022B had *M* high for males while *M* on females remained at the base value. This produced better fits to the data and improved the model's ability to fit the declining ratio of males to females with age, but the *M* used for males in this sensitivity was unrealistically high given the life expectancy of hoki. In the current assessment, the MfemaleLow sensitivity produced the best fits to the data, with little change to the biomass and status trajectories (Figure 37). The largest improvements in fit were to the WCSI fishery age composition data and sub-Antarctic suba fishery age composition data (Figure 39). The improvement can be seen in the declining sex ratio which is better matched under MfemaleLow (e.g., Figure 40).

Steepness sensitivities made almost no difference to the log-likelihood values. Maturity sensitivities gave the largest change in fits with MatureLater producing the worst fits. The difference came from fits to spawning fishery age composition data due to only mature fish migrating to the spawning grounds in the model (Figure 41).

Table 9: Summary of MPD parameter sensitivities on model Update_data. SSB_{2023}/B_0 (rounded to nearest 2 decimal places) by stock and negative log-likelihood values (rounded to nearest whole number). The lowest negative log-likelihood value (and hence the best model) is given in bold. All base model values in italics.

Sensitivity	Value	E	W	HOK 1	Negative log-likelihood
(M base value: male M = 0.30; female M = 0.25)		*0.54*	*0.37*	*0.44*	*5 319*
Mhigh	male M = 0.35; female M = 0.30	0.47	0.34	0.39	5 313
Mlow	male M = 0.25; female M = 0.20	0.60	0.41	0.48	5 328
MfemaleLow	male M = 0.30; female M = 0.225	0.49	0.36	0.41	**5 297**
(Steepness base value: h = 0.75)		*0.54*	*0.37*	*0.44*	*5 319*
hhigh	h = 0.70	0.53	0.37	0.42	5 318
hlow	h = 0.80	0.55	0.38	0.44	5 319
(Maturity base value: male a_{50} = 2; female a_{50} = 3)		*0.54*	*0.37*	*0.44*	*5 319*
MatureEarlier	male a_{50} = 1; female a_{50} = 2	0.59	0.37	0.45	5 310
MatureLater	male a_{50} = 3; female a_{50} = 4	0.48	0.38	0.42	5 342

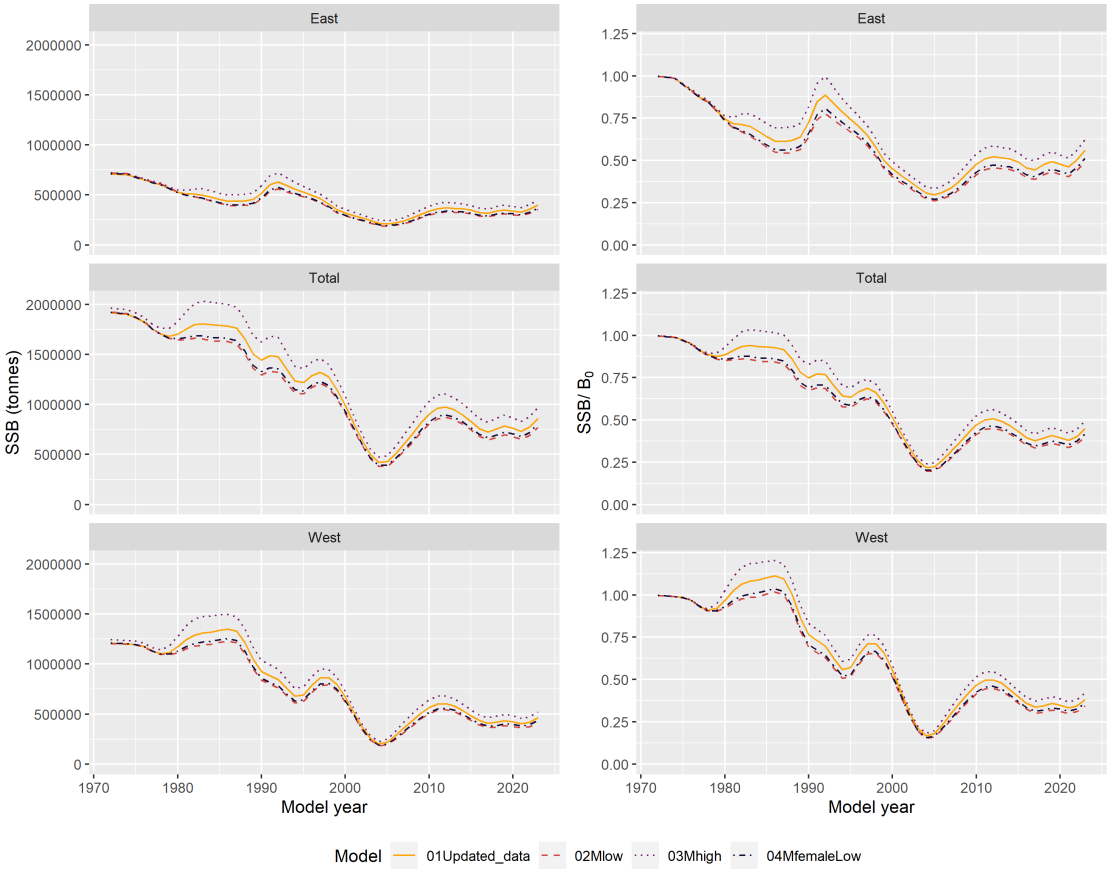


Figure 37: *SSB* and SSB/B_0 for MPD model parameter sensitivities on natural mortality.

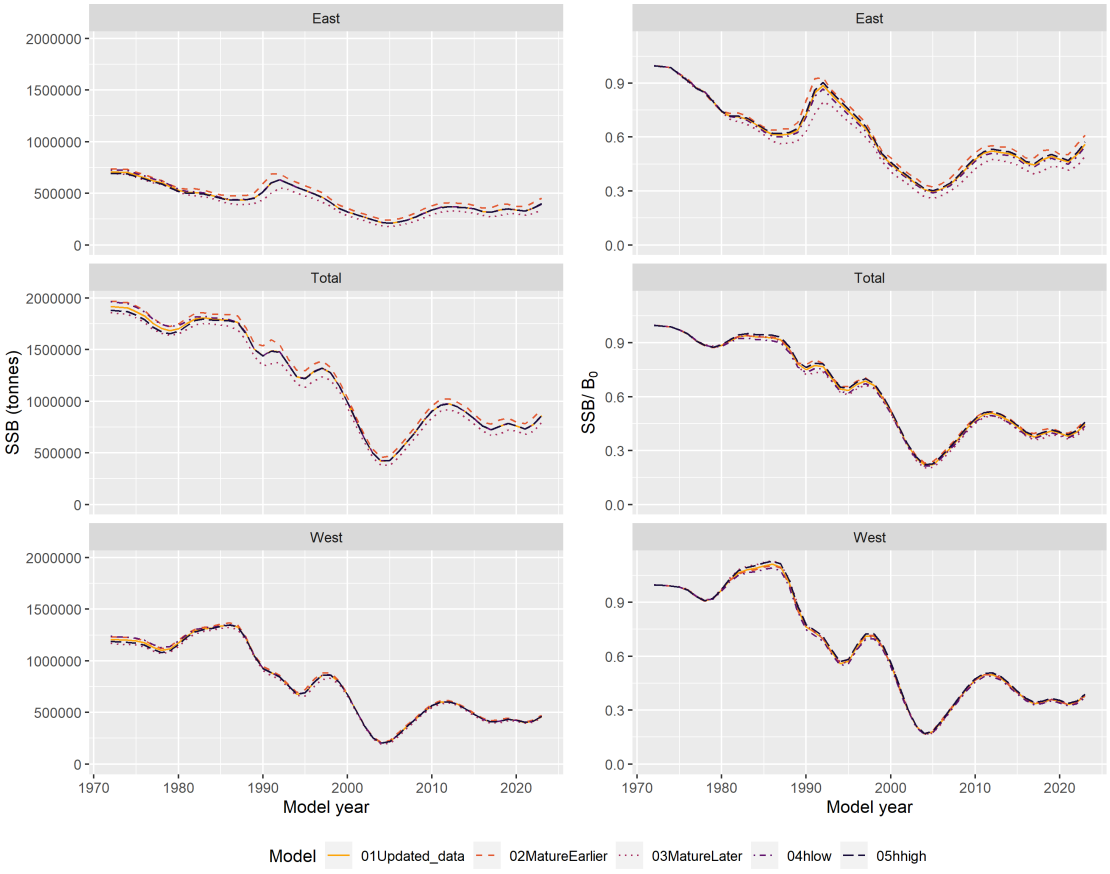


Figure 38: *SSB* and SSB/B_0 for MPD model parameter sensitivities on maturity and recruitment steepness.

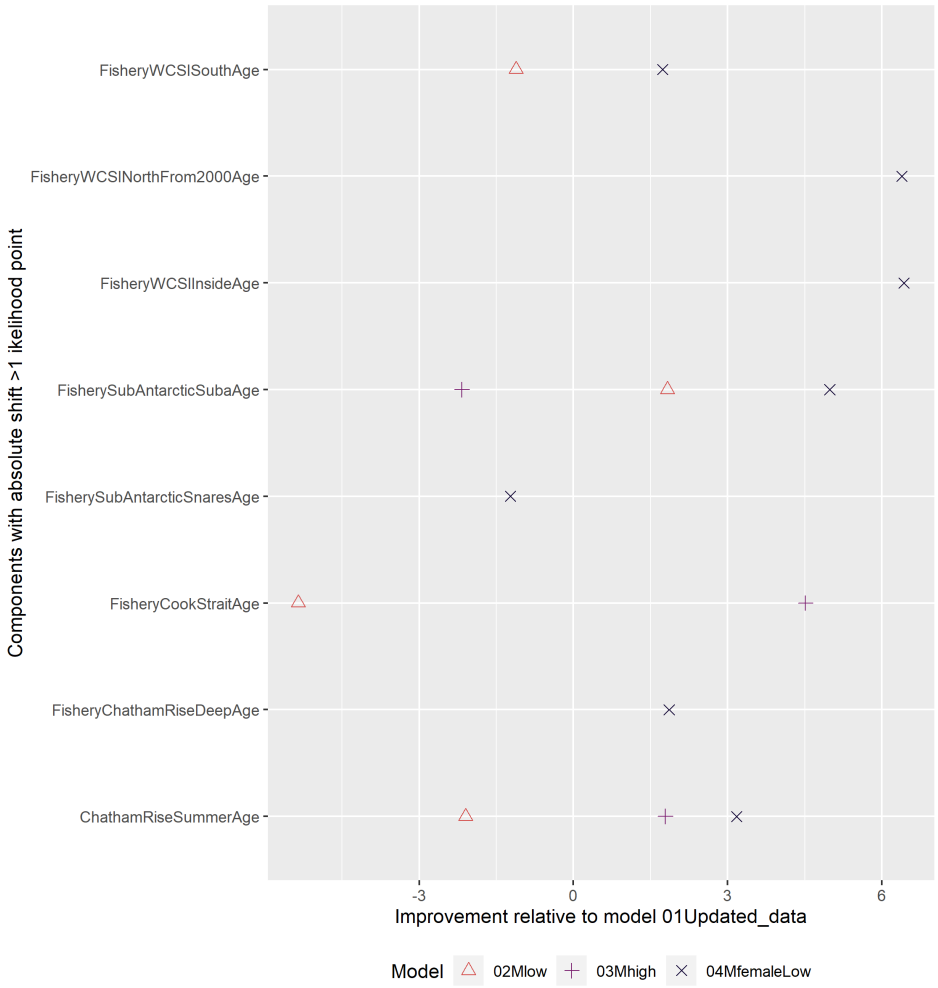


Figure 39: Improvement in likelihood units relative to the base model (Update_data) under natural mortality parameter sensitivities, including only datasets with a movement of more than one likelihood unit for at least one sensitivity.

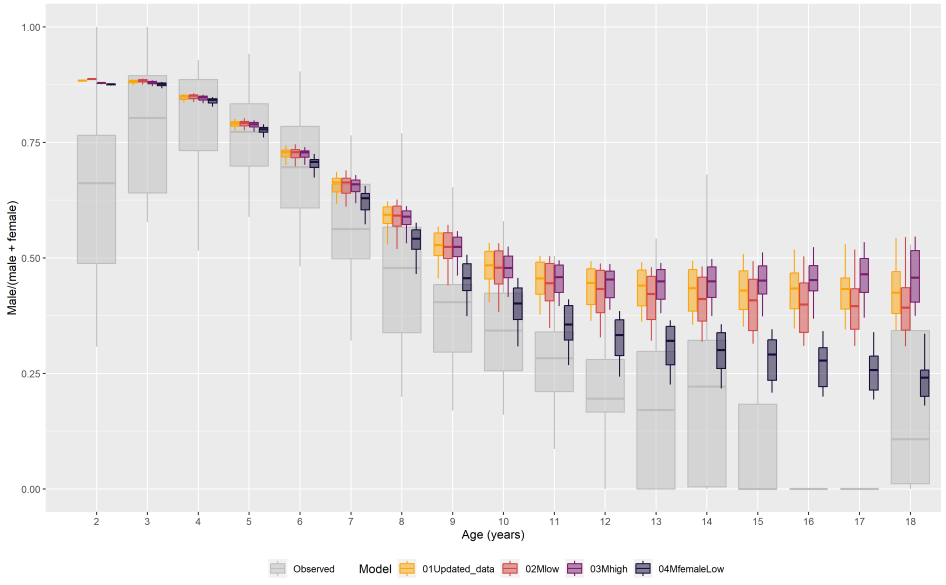


Figure 40: Proportions by sex and age class from non-spawning composition data (grey filled box plots) with model estimates from natural mortality parameter sensitivities.

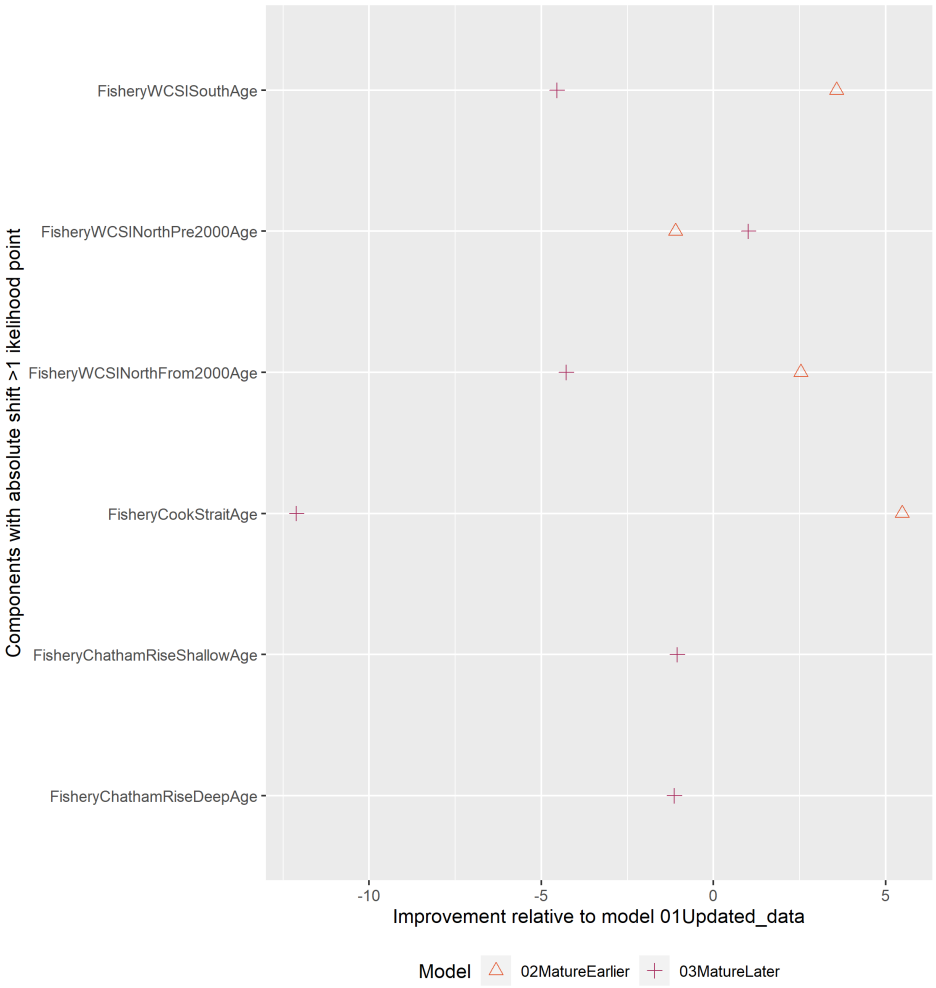


Figure 41: Improvement in likelihood units relative to the base model (Update_data) under maturity and steepness parameter sensitivities, including only datasets with a movement of more than one likelihood unit for at least one sensitivity.

5. FINAL MODEL ASSESSMENT RESULTS (MCMC)

MCMCs were run on four models (Table 10). The base model for this assessment was an updated version of model 2022A in the previous assessment, but with trawl survey abundance indices fixed to match the corresponding age data. All models had some aspects of poor performance in the MCMC convergence, so the focus was given to the base model (2023A) to achieve acceptable chain diagnostics. Results are presented for all four models, but with the qualifier that models 2023B, 2023C, and 2023D had unresolved issues in the chain diagnostics.

MCMC chains for model 2023A showed reasonable mixing, and the resulting distributions of the estimated parameters encompassed the corresponding MPD estimate. The full set of MCMC traces and parameter estimate frequency plots are in Appendix E, and those for B_0 are in Figures 42 and 43. To achieve convergence, informed priors were applied on some selectivity parameters, and for parameters that still did not converge and where there was a high level of correlation with another parameter, one was fixed at its MPD value. Table 11 shows where the selectivity parameters were treated differently than in the 2022 assessment, and full details are in the input files in Appendix E. This process of achieving convergence did not noticeably change the estimates or uncertainty of SSB or stock status (Figure 44).

Table 10: Summary of model definitions that were run with MCMCs.

Model	Short name	Main assumptions
2023A	Base2023 *'Update_data' in MPD sections*	Two spawning stocks, that spawn on the CS and WC. Recruits from both stocks reside on CR as juveniles. Western-spawned fish migrate to SA (estimated ogive; further testing of this parameterisation required). Mature WC-stock fish migrate from SA to WC to spawn and mature CR-stock fish from CR to CS to spawn. After spawning, all mature fish return (WC to SA and CS to CR).
2023B	Base2023_MfemaleLow	Base2023 model with M (female) = 0.225
2023C	SepMature	Two spawning stocks, that spawn on the CS and WC. Recruits from both stocks reside on CR as juveniles. Western-spawned fish migrate to SA (estimated ogive; further testing of this parameterisation required). Estimated WC-stock fish migrate from SA to WC to spawn and estimated CR-stock fish from CR to CS to spawn. After spawning, all mature fish return (WC to SA and CS to CR). This model separates maturity from migration to spawning grounds by estimating logistic producing ogives to determine movement of fish to the spawning grounds. Hence 'maturity' only relates to spawning stock recruitment dynamics, and not movement or availability to the spawning fishing grounds.
2023D	SingleStock	One spawning stock, that spawns on the CS and WC. Recruits from both spawning grounds reside on CR as juveniles. Estimated ogives (logistic producing) determine fish by sex that migrate to SA. These fish effectively become 'western stock' fish as they never return to the CR. Estimated fish migrate from SA to WC to spawn and similarly from CR to CS to spawn. After spawning, all mature fish return (WC to SA and CS to CR). This model has one stock but retains spatial, temporal, and fishery structure of the base model. Maturation is separated from movement to the spawning ground.

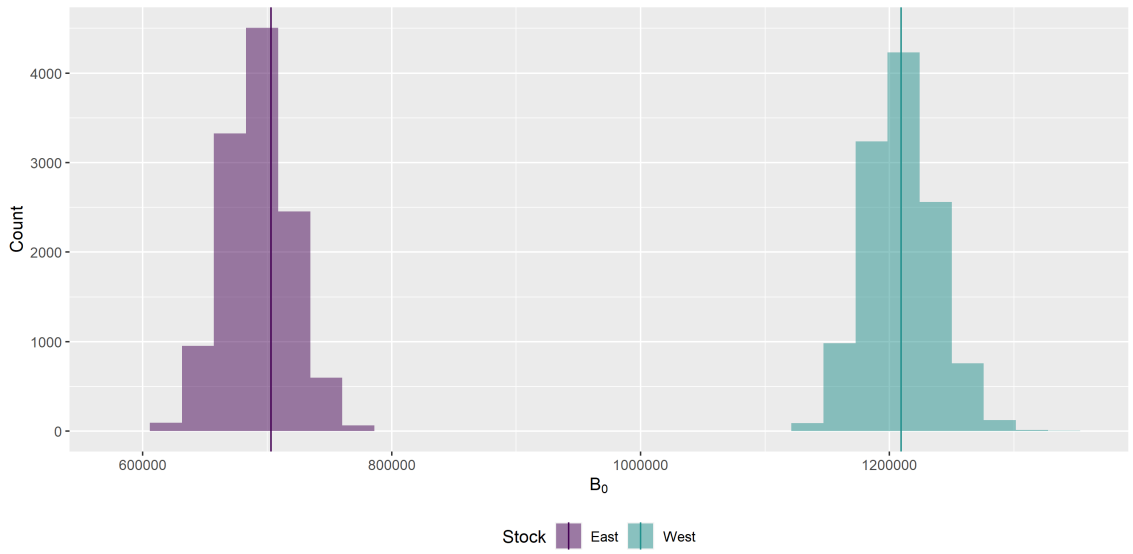


Figure 42: MCMC posterior distribution for eastern stock (purple) and western stock (teal) B_0 with MPD estimate (vertical solid lines) from the base Model 2023A.

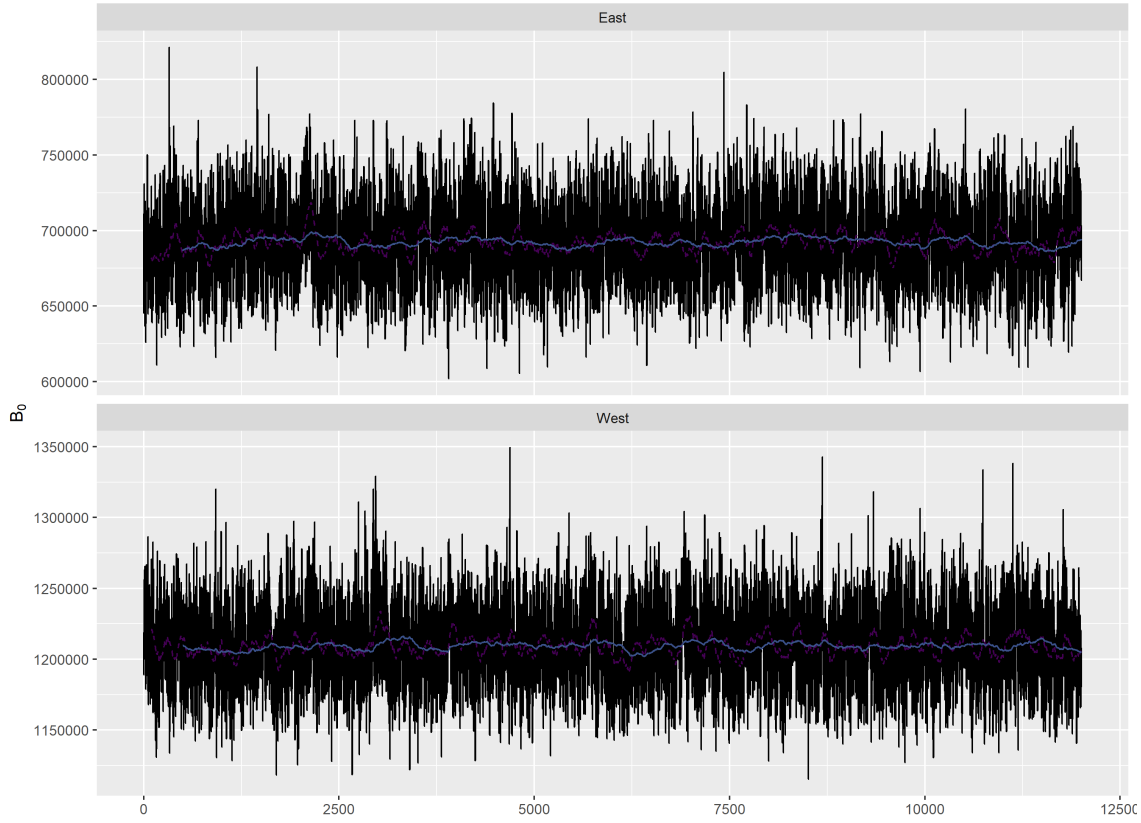


Figure 43: MCMC trace for eastern stock (top) and western stock (bottom) B_0 (left) from the base Model 2023A.

Table 11: Treatment of selectivity parameters for MCMC convergence in the current (2023) assessment and previous (2022) assessment, where they were different.

Fishery/survey	Parameter	2023	2022	Comments
CR shallow	μ	N(4, 52)	uniform	Unlikely influential in the model as it is
	σ_l	Fixed at 2.5	uniform	applied to a small dataset with a low
	σ_r	N(10, 22)	uniform	effective sample size
WC north male	μ	uniform	N(1, 22)	
	σ_l	N(5, 22)	N(3, 52)	2022 MCMC median approximately 5.5
	α	uniform	N(0.725, 102)	
WC north female	σ_l	Fixed at 9	uniform	2022 MCMC median approximately 10, which was thought to be high
	σ_r	Fixed at 50	uniform	2022 MCMC median approximately 50
WC south male	ato95	Fixed at 8.75	uniform	2022 MCMC median approximately 8.75
SA summer trawl survey	a50	Fixed at 9.5	N(7, 52)	Highly correlated (>90%) with the corresponding survey q. Poorly estimated in 2022, with MCMC median approximately 8.75
	ato95	N(7.5, 52)	N(3, 52)	Poorly estimated in 2022, with MCMC median approximately 8

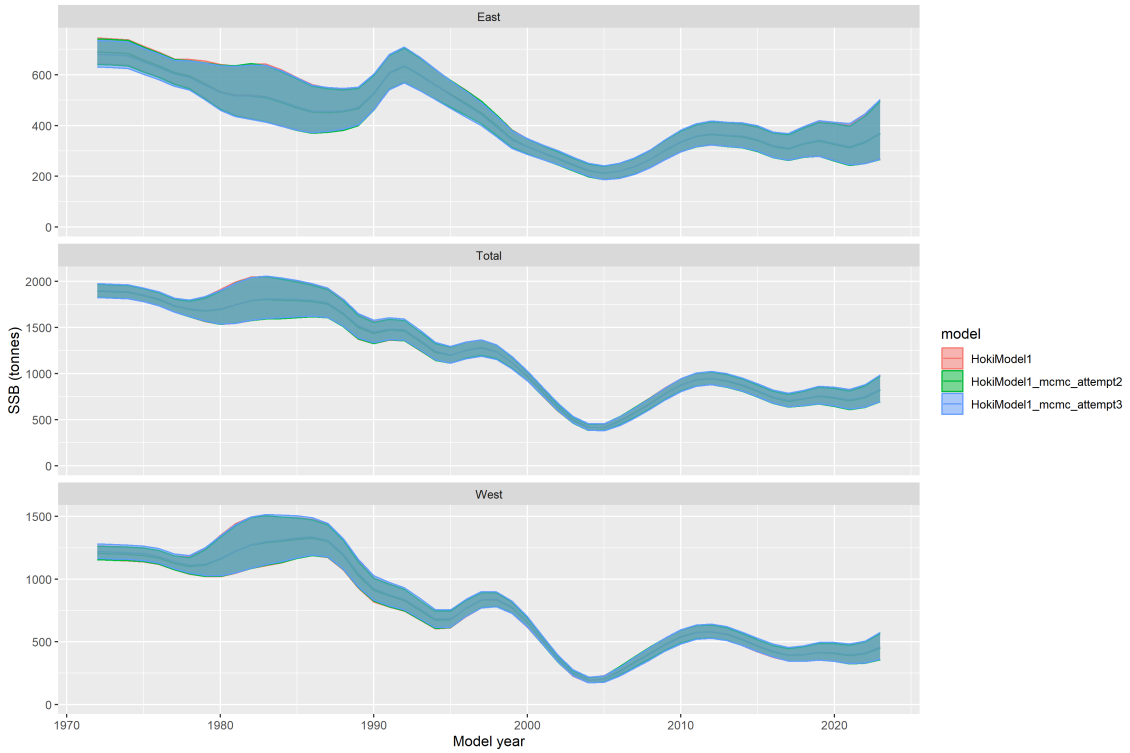


Figure 44: MCMC estimates of *SSB* (median and 95% CIs) from chains with improved levels of convergence. The outputs are overlaid due to very little difference in the model outputs and uncertainty. HokiModel1_mcmc_attempt3 was the final set and was used as the MCMCs for model 2023A.

5.1 Compare MCMC estimates for different model runs

Median estimates of current stock status for both stocks combined from the MCMCs ranged from 39 to 44% B_0 (Table 12). Biomass trajectories were similar between models except the single-stock model (2023D) which was different to the other models, especially prior to the mid-1990s (Figure 45). Model 2023A estimated the highest current stock status and Models 2023C and 2023D the lowest. All models estimated higher eastern stock status (median values 46–54% B_0) than western stock status (median values 35–37% B_0).

The eastern stock is now estimated to be lower than was projected in 2022 (57% B_0), and the western stock is higher than was predicted in 2022 (30% B_0). This is largely due to the 2019 year class that the model estimated to be eastern stock last year, that now has more of a western stock component.

YCS estimates of models 2023A, 2023B, and 2023C were very similar, and corresponding estimates from model 2023D were a combination of the eastern and western stock estimates in the other models (Figure 46).

Table 12: Current stock status (2023) by stock from models 2023A, 2023B, 2023C, and 2023D. Values given are medians from the MCMCs with lower and upper 95% quantiles in brackets.

Model	Stock	B_0 (tonnes)	B_{2023} (tonnes)	B_{2023}/B_0
2023A	All	1 907 597 (1 833 481, 1 983 860)	830 871 (699 108, 988 264)	0.44 (0.38, 0.50)
	East	683 616 (633 117, 738 300)	370 504 (267 188, 502 860)	0.54 (0.41, 0.70)
	West	1 222 890 (1 169 164, 1 284 215)	457 690 (362 809, 576 393)	0.37 (0.31, 0.45)
2023B	All	1 911 079 (1 852 197, 1 975 460)	765 400 (645 589, 907 498)	0.40 (0.35, 0.46)
	East	692 752 (647 000, 741 938)	332 960 (238 910, 452 590)	0.48 (0.36, 0.62)
	West	1 217 855 (1 174 351, 1 268 245)	429 698 (341 389, 537 429)	0.35 (0.29, 0.43)
2023C	All	1 778 514 (1 697 582, 1 863 481)	696 084 (581 886, 833 382)	0.39 (0.34, 0.45)
	East	634 954 (585 849, 686 324)	292 311 (207 693, 402 166)	0.46 (0.35, 0.60)
	West	1 143 220 (1 073 070, 1 220 674)	400 221 (315 368, 507 197)	0.35 (0.29, 0.43)
2023D	All	1 828 240 (1 767 678, 1 894 564)	712 882 (590 622, 859 920)	0.39 (0.33, 0.46)

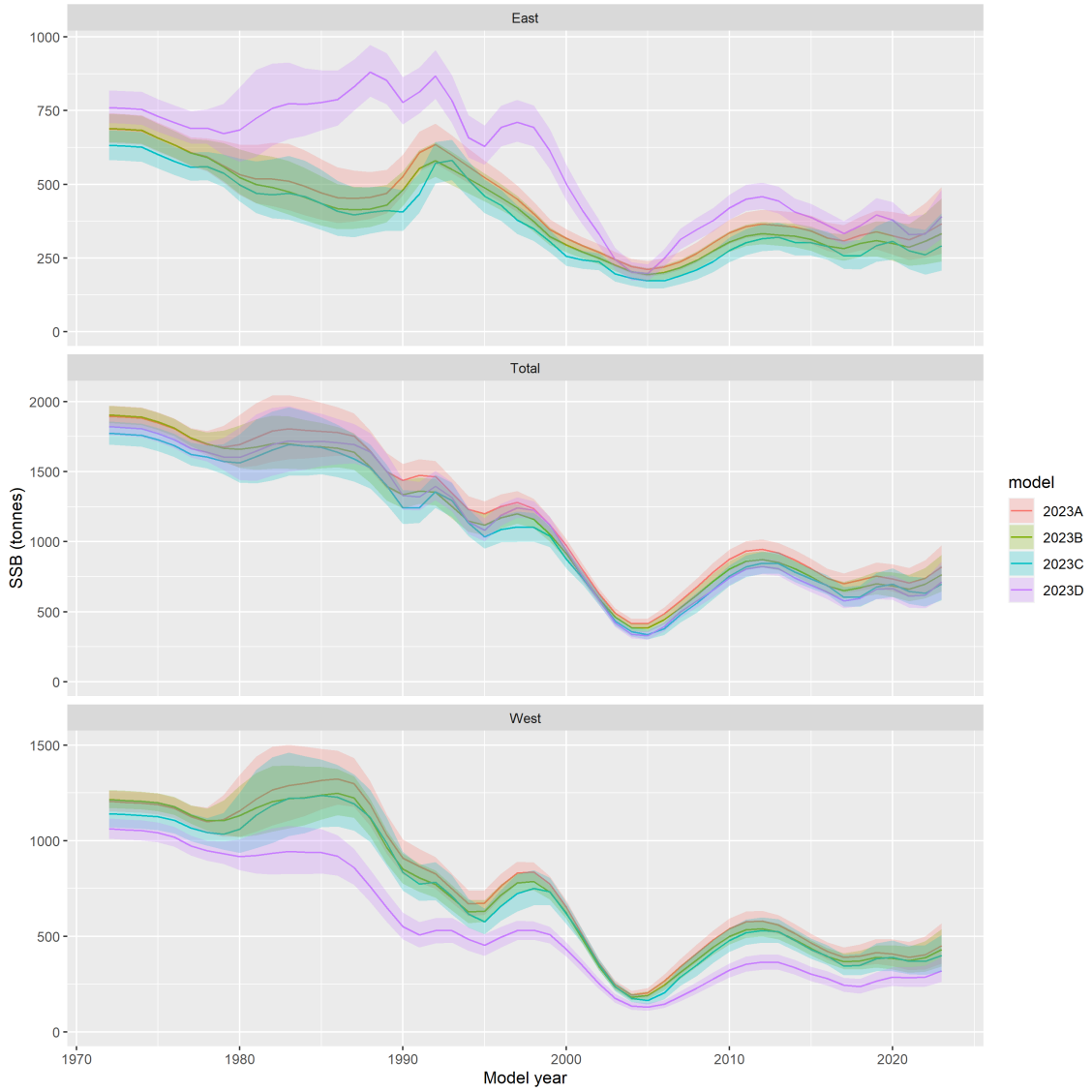


Figure 45: MCMC SSB outputs for models 2023A, 2023B, 2023C, and 2023D, for eastern stock (top), both stocks combined (middle), and western stock (bottom). Shaded areas are 95% credible intervals; solid lines are medians.

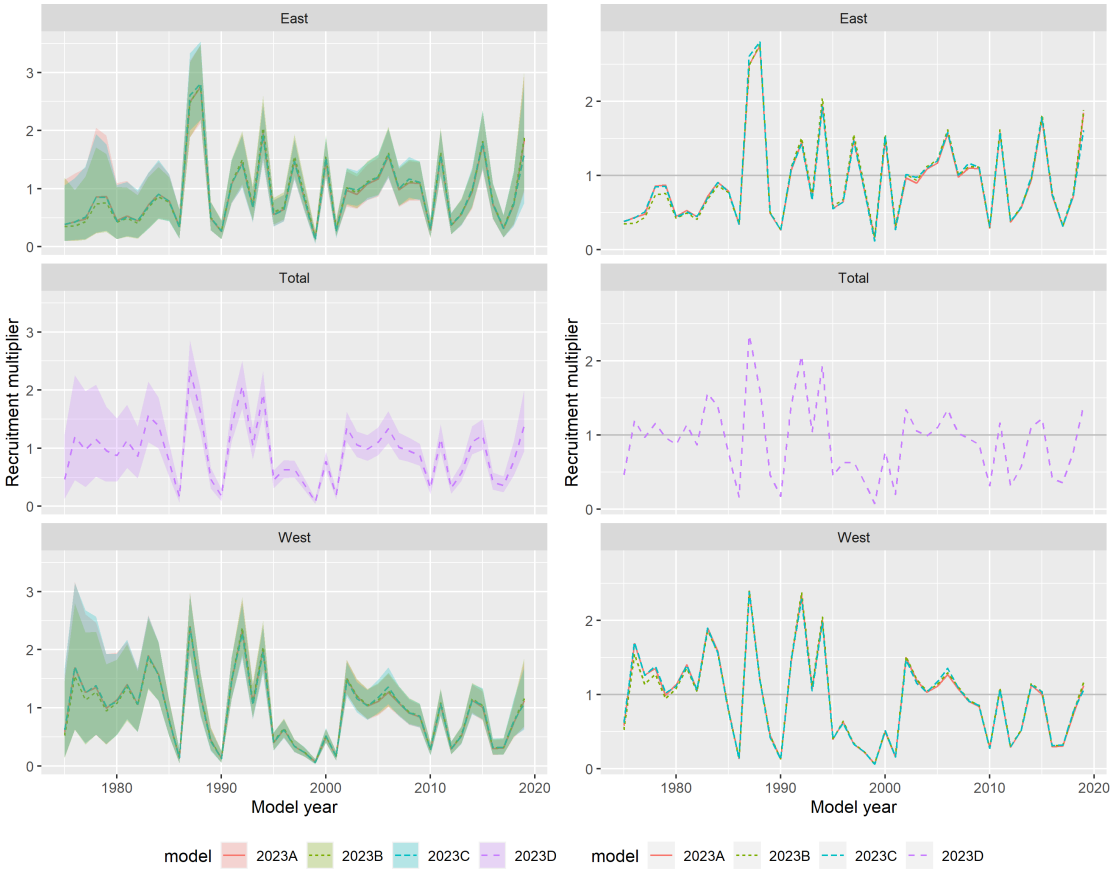


Figure 46: MCMC YCS outputs for models 2023A, 2023B, 2023C, and 2023D, for eastern stock (top), single stock (middle), and western stock (bottom). Shaded areas are 95% credible intervals (left); lines are medians. Horizontal grey line marks the average over the time series, which is 1.

6. PROJECTIONS

MCMC models 2023A and 2023B were projected forward five years (up to and including fishing year 2028) with two alternative recruitment scenarios permuted with two future catch scenarios (Tables 13 and 14).

The western stock projections were most sensitive to the recruitment scenario (Figure 47 and Tables 15–17), which is likely due to the high western stock year classes estimated prior to the mid-1980s. Under recent recruitment, the current TACC has a probability of 0.36 or 0.43 (models 2023A and 2023B respectively) of falling below the target range of 35–50% B_0 by 2028 (Tables 16 and 17).

Under either future catch scenario, the eastern stock is likely to remain within or above the target range for hoki over the next 5 years (Figure 47 and Tables 15–17). Long-term recruitment combined with future catch of 65 000 tonnes is more likely to see the eastern stock increasing to the top of the target range.

Table 13: YCS sampling scenarios applied to projections.

YCS sampling	Year classes sampled	Comments
Recent recruitment	2010–2019	These are the 10 most recent reliably estimated year classes.
Long-term recruitment	1975–2019	The full series of estimated year classes; this includes the high estimated year classes for the western stock in the beginning of the series.

Table 14: Catches assumed for projections. Total catch was assumed to be either at the TACC (110 000 tonnes) or 100 000 tonnes, split into fisheries based on the proportions of catch from each fishery in the 2021 and 2022 fishing years.

Stock	Fishery	Proportion (2021–2022)	Projected catch (TAC)	Projected catch (100 000 t)
East	fishery_CR_deep	0.65	42 543	39 271
East	fishery_CR_shallow	0.08	5 482	5 060
East	fishery_CS_spwn	0.26	16 975	15 669
			65 000	**60 000**
West	fishery_PUY_spwn	0.005	412	366
West	fishery_SA_auck	0.073	3 760	3 342
West	fishery_SA_snares	0.078	3 364	2 990
West	fishery_SA_suba	0.028	2 232	1 984
West	fishery_WC_inside	0.244	10 436	9 277
West	fishery_WC_north	0.31	11 779	10 470
West	fishery_WC_south	0.26	13 018	11 571
			45 000	**40 000**

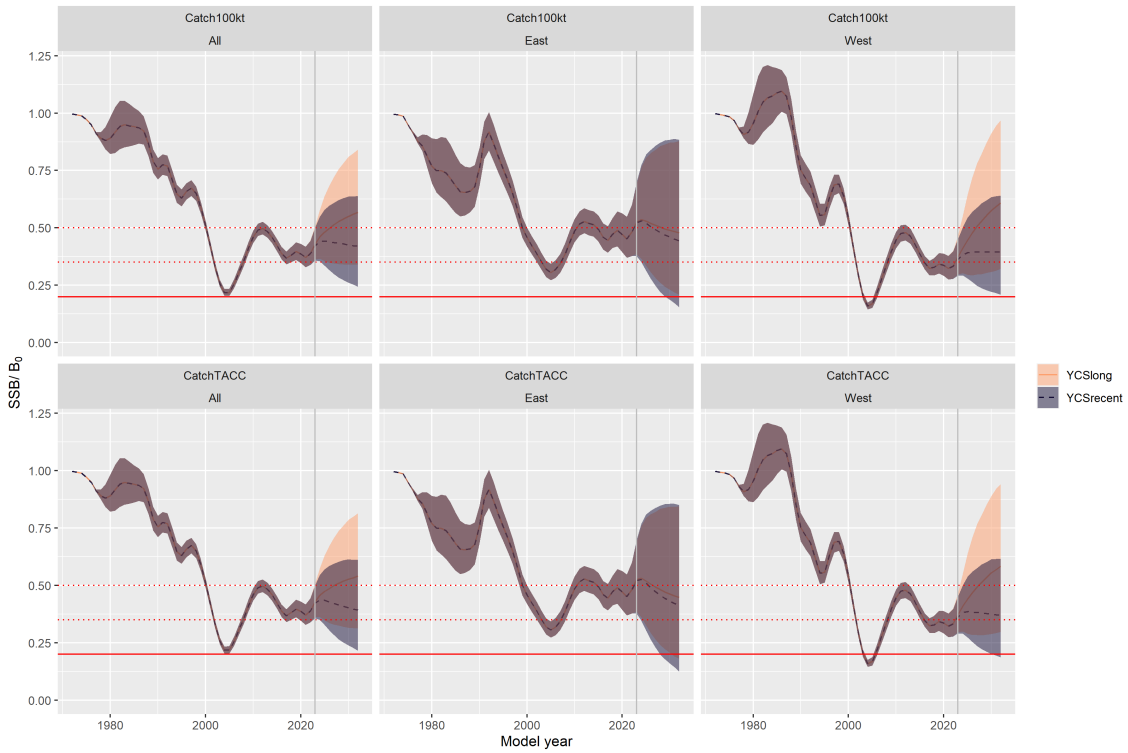


Figure 47: Status median values from MCMCs and Projections with Model 2023A under catch and recruitment scenarios (Tables 13 and 14) with 95% CIs (shaded area) for both stocks combined ('All', left), eastern stock (middle), and western stock (right).

Table 15: Projected $SSB(\%\ B_0)$ from Models 2023A and 2023B under alternative YCS sampling ('Long-term': 1975–2020; 'Recent': 2010–2019) and future catches set at either the current TACC of 110 000 tonnes with 65 000 tonnes from the eastern stock and 45 000 tonnes from the western stock or 100 000 tonnes with 60 000 tonnes from the eastern stock and 40 000 tonnes from the western stock.

Model	Recruitment	Catch	Stock	2023	2024	2022	2026	2027	2028
2023A	Long-term	110 kt	All	43	46	47	49	50	51
		65 kt	East	53	53	52	51	49	48
		45 kt	West	37	41	44	47	49	51
	Recent	110 kt	All	42	44	44	43	42	41
		65 kt	East	52	53	51	49	47	46
		45 kt	West	36	38	39	38	38	38
	Long-term	100 kt	All	43	46	48	50	51	53
		60 kt	East	53	54	53	52	51	50
		40 kt	West	37	41	45	48	51	53
	Recent	100 kt	All	42	44	44	44	44	43
		60 kt	East	52	53	52	51	49	48
		40 kt	West	36	38	39	39	39	40
2023B	Long-term	110 kt	All	40	42	44	45	46	47
		65 kt	East	48	48	47	46	45	43
		45 kt	West	35	39	41	44	46	48
	Recent	110 kt	All	39	41	41	40	40	39
		65 kt	East	48	48	46	45	44	42
		45 kt	West	34	36	37	37	37	37
	Long-term	100 kt	All	40	43	45	46	48	49
		60 kt	East	48	49	48	47	46	46
		40 kt	West	35	39	42	45	48	50
	Recent	100 kt	All	39	41	42	42	41	41
		60 kt	East	48	48	47	46	45	44
		40 kt	West	34	37	37	38	38	38

Table 16: Projected probabilities (to 2 significant figures) of given status levels from Model 2023A under scenarios defined in Tables 13 and 14. Target status for hoki is 35–50% B_0.

	2023	2024	2025	2026	2027	2028	YCS	Catch	Stock
below 20%	0.00	0.00	0.00	0.00	0.00	0.01	long	TACC	East
below target	0.01	0.02	0.05	0.09	0.13	0.17	long	TACC	East
within target	0.37	0.35	0.38	0.39	0.39	0.38	long	TACC	East
above target	0.63	0.63	0.57	0.52	0.48	0.45	long	TACC	East
below target	0.30	0.16	0.13	0.12	0.10	0.09	long	TACC	West
within target	0.70	0.74	0.61	0.49	0.42	0.37	long	TACC	West
above target	0.00	0.1	0.26	0.39	0.48	0.54	long	TACC	West
below target	0.01	0.01	0.03	0.04	0.05	0.05	long	TACC	All
within target	0.96	0.76	0.62	0.52	0.46	0.42	long	TACC	All
above target	0.03	0.22	0.36	0.44	0.5	0.53	long	TACC	All
below 20%	0.00	0.00	0.00	0.00	0.01	0.03	recent	TACC	East
below target	0.01	0.03	0.07	0.13	0.19	0.24	recent	TACC	East
within target	0.39	0.38	0.39	0.39	0.38	0.36	recent	TACC	East
above target	0.60	0.60	0.53	0.47	0.43	0.40	recent	TACC	East
below target	0.38	0.28	0.30	0.33	0.35	0.37	recent	TACC	West
within target	0.62	0.70	0.64	0.58	0.54	0.51	recent	TACC	West
above target	0.00	0.03	0.07	0.09	0.11	0.12	recent	TACC	West
below target	0.01	0.02	0.06	0.12	0.17	0.21	recent	TACC	All
within target	0.96	0.86	0.78	0.71	0.66	0.62	recent	TACC	All
above target	0.02	0.12	0.16	0.17	0.17	0.17	recent	TACC	All
below target	0.01	0.01	0.04	0.07	0.10	0.13	long	100 000 t	East
within target	0.37	0.34	0.36	0.37	0.36	0.36	long	100 000 t	East
above target	0.63	0.65	0.61	0.56	0.53	0.51	long	100 000 t	East
below target	0.30	0.15	0.12	0.1	0.08	0.07	long	100 000 t	West
within target	0.70	0.74	0.60	0.48	0.39	0.34	long	100 000 t	West
above target	0.00	0.11	0.28	0.42	0.52	0.59	long	100 000 t	West
below target	0.01	0.01	0.02	0.03	0.03	0.03	long	100 000 t	All
within target	0.96	0.75	0.58	0.48	0.41	0.36	long	100 000 t	All
above target	0.03	0.24	0.40	0.49	0.56	0.61	long	100 000 t	All
below 20%	0.00	0.00	0.00	0.00	0.01	0.01	recent	100 000 t	East
below target	0.01	0.02	0.06	0.11	0.15	0.19	recent	100 000 t	East
within target	0.39	0.36	0.38	0.38	0.37	0.36	recent	100 000 t	East
above target	0.60	0.61	0.56	0.51	0.48	0.45	recent	100 000 t	East
below target	0.38	0.26	0.26	0.28	0.3	0.31	recent	100 000 t	West
within target	0.62	0.71	0.66	0.61	0.57	0.54	recent	100 000 t	West
above target	0.00	0.03	0.08	0.11	0.13	0.15	recent	100 000 t	West
below target	0.01	0.02	0.05	0.08	0.12	0.15	recent	100 000 t	All
within target	0.96	0.85	0.76	0.7	0.66	0.63	recent	100 000 t	All
above target	0.02	0.13	0.19	0.21	0.22	0.22	recent	100 000 t	All

Table 17: Projected probabilities (to 2 significant figures) of given status levels from Model 2023B under scenarios defined in Tables 13 and 14. Target status for hoki is 35–50% B_0.

	2023	2024	2025	2026	2027	2028	YCS	Catch	Stock
below 20%	0.00	0.00	0.00	0.00	0.01	0.02	long	TACC	East
below target	0.03	0.05	0.11	0.17	0.22	0.26	long	TACC	East
within target	0.60	0.51	0.48	0.46	0.43	0.40	long	TACC	East

above target	0.38	0.43	0.40	0.37	0.35	0.33	long	TACC	East
below target	0.48	0.26	0.20	0.17	0.14	0.13	long	TACC	West
within target	0.52	0.71	0.65	0.57	0.49	0.43	long	TACC	West
above target	0.00	0.04	0.15	0.27	0.36	0.44	long	TACC	West
below target	0.06	0.05	0.06	0.08	0.09	0.09	long	TACC	All
within target	0.94	0.88	0.75	0.65	0.58	0.52	long	TACC	All
above target	0.00	0.07	0.18	0.27	0.33	0.39	long	TACC	All
below 20%	0.00	0.00	0.00	0.01	0.02	0.04	recent	TACC	East
below target	0.03	0.07	0.14	0.21	0.27	0.31	recent	TACC	East
within target	0.59	0.52	0.47	0.43	0.39	0.37	recent	TACC	East
above target	0.37	0.41	0.39	0.37	0.34	0.32	recent	TACC	East
below 20%	0.00	0.00	0.00	0.00	0.01	0.01	recent	TACC	West
below target	0.56	0.4	0.39	0.40	0.42	0.43	recent	TACC	West
within target	0.44	0.59	0.58	0.55	0.51	0.48	recent	TACC	West
above target	0.00	0.01	0.03	0.06	0.07	0.09	recent	TACC	West
below target	0.09	0.09	0.15	0.21	0.26	0.30	recent	TACC	All
within target	0.91	0.87	0.78	0.7	0.64	0.59	recent	TACC	All
above target	0.00	0.04	0.08	0.10	0.11	0.11	recent	TACC	All
below 20%	0.00	0.00	0.00	0.00	0.01	0.01	long	100 000 t	East
below target	0.03	0.05	0.09	0.13	0.17	0.21	long	100 000 t	East
within target	0.60	0.50	0.47	0.45	0.43	0.41	long	100 000 t	East
above target	0.38	0.45	0.44	0.41	0.40	0.39	long	100 000 t	East
below target	0.48	0.24	0.17	0.14	0.12	0.1	long	100 000 t	West
within target	0.52	0.72	0.66	0.56	0.47	0.41	long	100 000 t	West
above target	0.00	0.04	0.17	0.30	0.41	0.49	long	100 000 t	West
below target	0.06	0.04	0.05	0.06	0.06	0.06	long	100 000 t	All
within target	0.94	0.89	0.74	0.63	0.54	0.48	long	100 000 t	All
above target	0.00	0.08	0.22	0.31	0.40	0.46	long	100 000 t	All
below 20%	0.00	0.00	0.00	0.00	0.01	0.02	recent	100 000 t	East
below target	0.03	0.06	0.11	0.17	0.22	0.26	recent	100 000 t	East
within target	0.59	0.51	0.46	0.42	0.39	0.37	recent	100 000 t	East
above target	0.37	0.43	0.42	0.40	0.38	0.37	recent	100 000 t	East
below 20%	0.00	0.00	0.00	0.00	0.00	0.01	recent	100 000 t	West
below target	0.56	0.38	0.34	0.34	0.35	0.36	recent	100 000 t	West
within target	0.44	0.61	0.62	0.59	0.55	0.53	recent	100 000 t	West
above target	0.00	0.01	0.04	0.07	0.10	0.12	recent	100 000 t	West
below target	0.09	0.08	0.11	0.16	0.19	0.22	recent	100 000 t	All
within target	0.91	0.88	0.79	0.72	0.66	0.62	recent	100 000 t	All
above target	0.00	0.04	0.10	0.12	0.15	0.16	recent	100 000 t	All

7. DISCUSSION

The stock assessment model and sensitivities presented here provided the best available representation of current knowledge and data for the hoki stock and fishery in 2023, as presented to and reviewed by the Fisheries New Zealand Deepwater Working Group. The two models used to project stock status to fishing year 2028 estimated that, with current catches, the combined stocks status was likely to be within the management target level of 35 to 50% B_0 in 2028. The western stock projections were most sensitive to recruitment scenario, due to high early (pre-1985) recruitment to the western stock which when included in projections result in higher future biomass levels.

The single-stock model developed in this assessment reflects our uncertainty in hoki stock structure. This model presented similar fits to the data, but with a different estimation of biomass in the early (pre-1990s) part of the fishery. Given these fisheries are managed relative to the beginning of the fishery (e.g., the virgin state of the stock), considering our uncertainty in the virgin state is important. There was an increase in conflict between some of the WCSI and Chatham Rise age composition data, some of which is expected due to the model being a lot more constrained with only one recruitment pattern. The single-stock multi-area model needs more thorough analyses and refinement to bring it up to the standard of the base model. This is a time-consuming task because of the complexity of the hoki model and the large number of data inputs. We need to analyse the model patterns in residuals, specification of selectivity and movement ogives, and highly correlated parameters, and make improvements as appropriate.

We are unlikely to further test the inclusion of the WC_north fishery CPUE unless it has a clearer biomass signal, in particular over the more recent years (e.g., post-2010). This index is not considered to track abundance, but it was considered here as a potential signal for western stock recruitment. The *Tangaroa* WCSI trawl survey has not yet been included in the hoki assessment models. This index consists of estimates for hoki in six years (2000, 2012, 2013, 2016, 2018, and 2021) and the survey was carried out in winter which is when hoki are spawning off WCSI, although it only monitors a portion of the hoki population (on the bottom and north of the Hokitika Canyon). We intend to evaluate this index in the model framework in the 2024 assessment.

The Puysegur spawning fishery was included as a potential emerging fishery, but it has not 'emerged' and has low catches (approximately 200–500 tonnes per year in 2020–2022) and insufficient observations to create age frequencies. This means the catches are not influential in the model and we are unable to estimate an appropriate selectivity ogive for the fishery. We could consider re-absorbing the Puysegur fishery within the WCSI spawning fishery. The ECSI spawning fishery has also been flagged as an emerging fishery and has had catches over 3000 tonnes every year since 2017 (Ballara & O'Driscoll 2023). There are also acoustic survey estimates from Pegasus Canyon and Conway Trough that align with the ECSI spawning fishery. This may be an important fishery to help understand the dynamics between the Chatham Rise and the Cook Strait spawning fishery.

The hoki assessment model has had challenges with MCMC convergence in 2021, 2022, and the current (2023) assessments. These were largely addressed in the base model by providing informed priors or tighter bounds on selectivity parameters where there were high correlations with other parameters in the model. These adjustments did not changed the MCMC estimates but helped with MCMC performance. We need to better understand the convergence issues of the MCMCs and test alternative solutions such as transforming correlated parameters.

Other key issues that we plan to explore further in the 2024 assessment include understanding the ECSI spawning dynamics and including this spawning fishery in the model; refining movement from the

Chatham Rise to the Stewart-Snares shelf; and understanding why younger sub-Antarctic fish are not captured in the sub-Antarctic trawl surveys.

8. FULFILMENT OF BROADER OUTCOMES

This project delivered against two aspects of broader outcomes.

Supporting women in science
The lead researcher of the project was a woman.

Building capacity and capability in the research sector
The team working on the project brought together a diverse range of skill sets and experience levels.

9. ACKNOWLEDGEMENTS

We thank Sira Ballara, Richard O'Driscoll, and Dan MacGibbon for providing data, and to members of the Deepwater Working Group for suggestions during the assessment process. This work was funded under Fisheries New Zealand project HOK202201. Thank you to Samik Datta for reviewing the manuscript.

10. REFERENCES

Ballara, S. L.; O'Driscoll, R. L. (2023). Catches, size, and age structure of the 2021–22 hoki fishery and a summary of input data used for the 2023 stock assessment. *New Zealand Fisheries Assessment Report 2024/16*. 184 p.

Doonan, I.; Large, K.; Dunn, A.; Rasmussen, S.; Marsh, C.; Mormede, S. (2016). Casal2: New Zealand's integrated population modelling tool. *Fisheries Research 183*: 498–505.

Francis, R. I. C. C. (2003). Analyses supporting the 2002 stock assessment of hoki. *Fisheries Assessment Report 2003/5*. 34 p.

Francis, R. I. C. C. (2011). Data weighting in statistical fisheries stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences 68(6):* 1124–1138.

Horn, P. L.; Sullivan, K. J. (1996). Validated aging methodology using otoliths, and growth parameters for hoki (*Macruronus novaezelandiae*) in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 30(2):* 161–174.

Langley, A. (2020). A review of the 2019 hoki stock assessment. *New Zealand Fisheries Assessment Report 2020/28*. 52 p.

McGregor, V. L.; Dunn, M. R.; Langley, A. D.; Dunn, A. (2022). Assessment of hoki (*Macruronus novaezelandiae*) in 2021. *New Zealand Fisheries Assessment Report 2022/43*. 247 p.

McGregor, V. L.; Dunn, M. R.; Langley, A. D.; Dunn, A. (2023). Assessment of hoki (*Macruronus novaezelandiae*) in 2022. *New Zealand Fisheries Assessment Report 2023/40*. 232 p.

McKenzie, A. (2018). Assessment of hoki (*Macruronus novaezelandiae*) in 2017. *New Zealand Fisheries Assessment Report 2018/40*. 101 p.

McKenzie, A. (2019). Assessment of hoki (*Macruronus novaezelandiae*) in 2019. *New Zealand Fisheries Assessment Report 2019/68*. 99 p.

Morrongiello, J. R.; Horn, P. L.; Ó Maolagáin, C.; Sutton, P. J. (2021). Synergistic effects of harvest and climate drive synchronous somatic growth within key new zealand fisheries. *Global Change Biology 27(7)*: 1470–1484.

R Core Team (2022). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Appendices

Appendix A Comparisons of CASAL and Casal2 outputs

A.1 MPD comparisons with updated data for the 2023 assessment

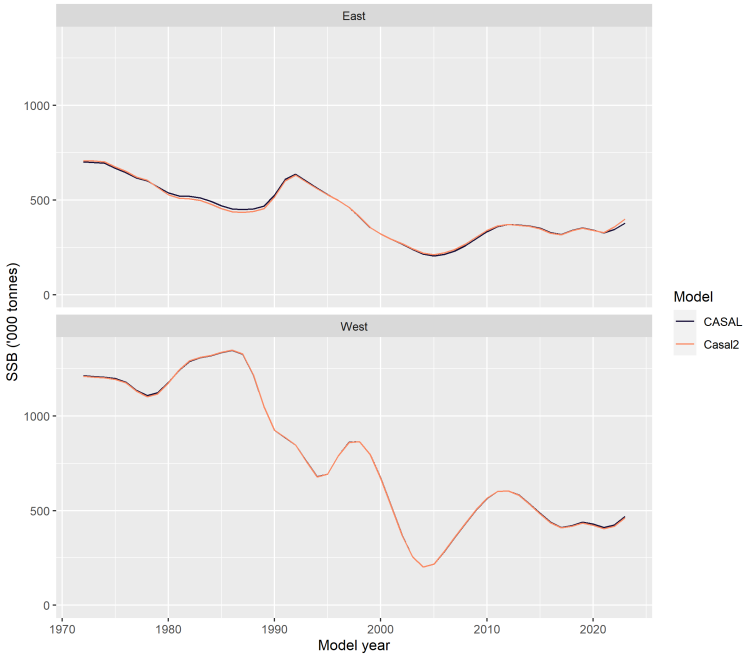


Figure 48: Comparison of SSB from CASAL and Casal2 versions of Model 2023A.

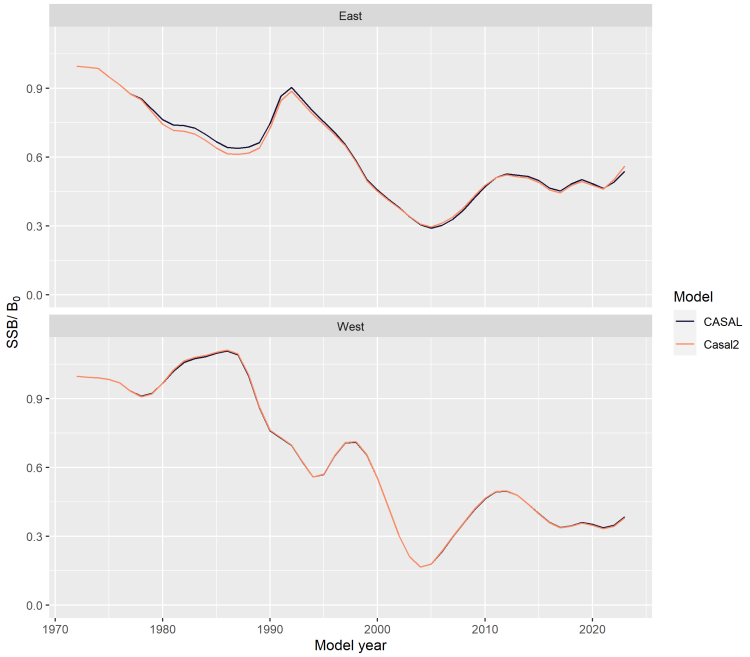


Figure 49: Comparison of SSB/B_0 from CASAL and Casal2 versions of Model 2023A.

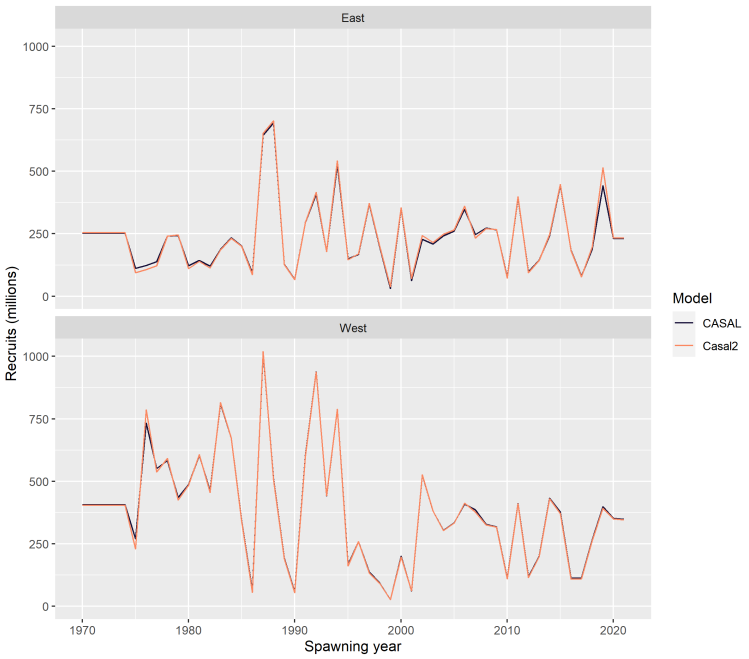


Figure 50: Comparison of year class strengths estimated from CASAL and Casal2 versions of Model 2023A.

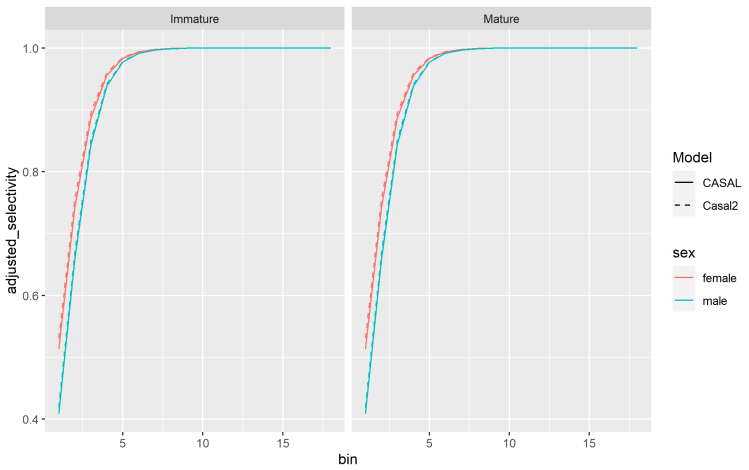


Figure 51: Comparison of Migration from Chatham Rise to sub-Antarctic estimated from CASAL and Casal2 versions of Model 2023A.

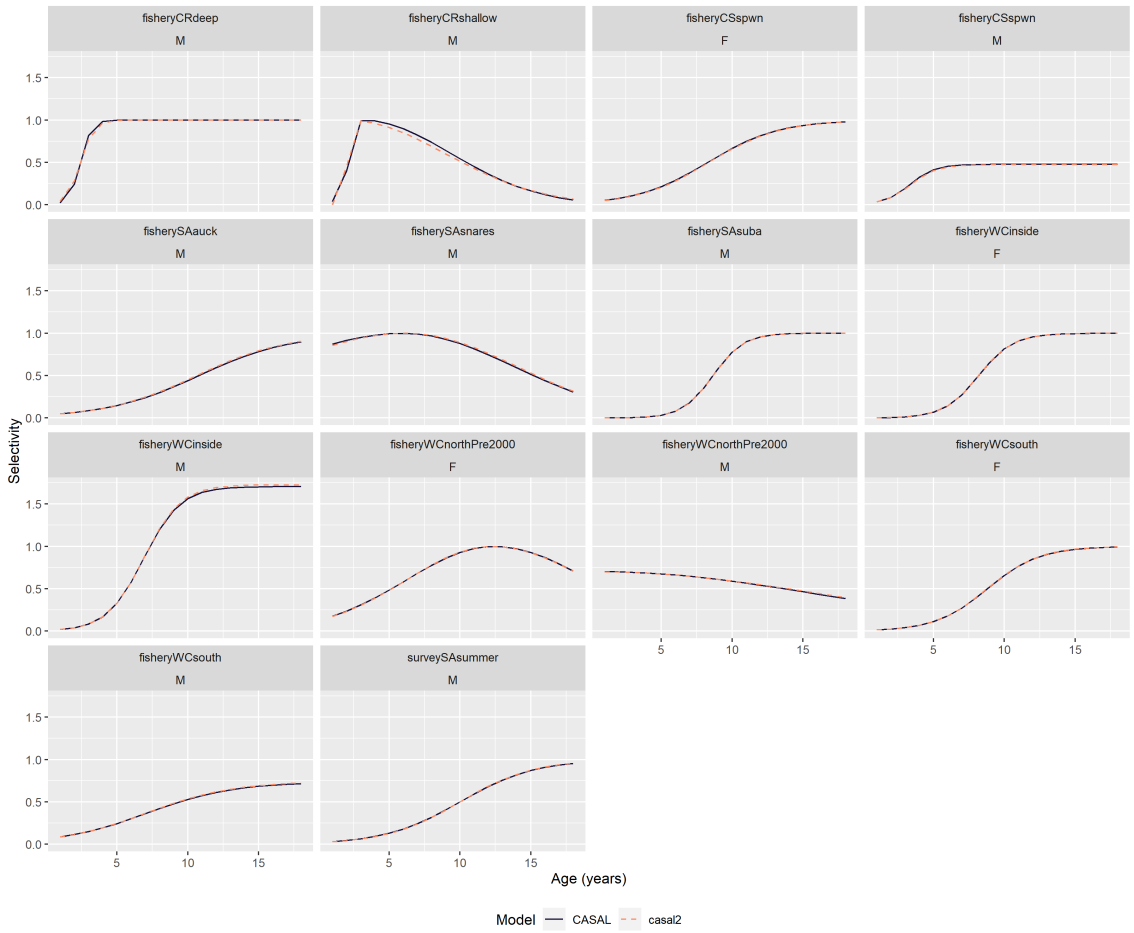


Figure 52: Comparison of selectivity ogives estimated from CASAL and Casal2 versions of Model 2023A.

A.2 MCMC comparisons with updated data for the 2023 assessment

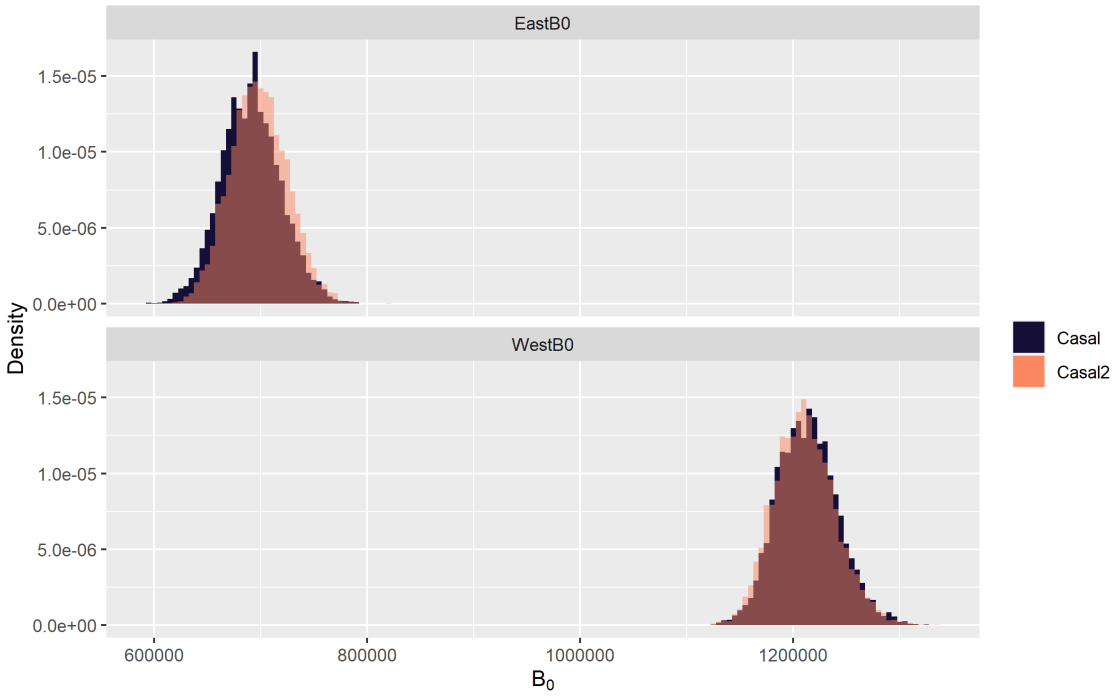


Figure 53: MCMC posterior distribution for eastern stock (top) and western stock (bottom) B_0 from the CASAL Model (black bars) and Casal2 model (orange bars).

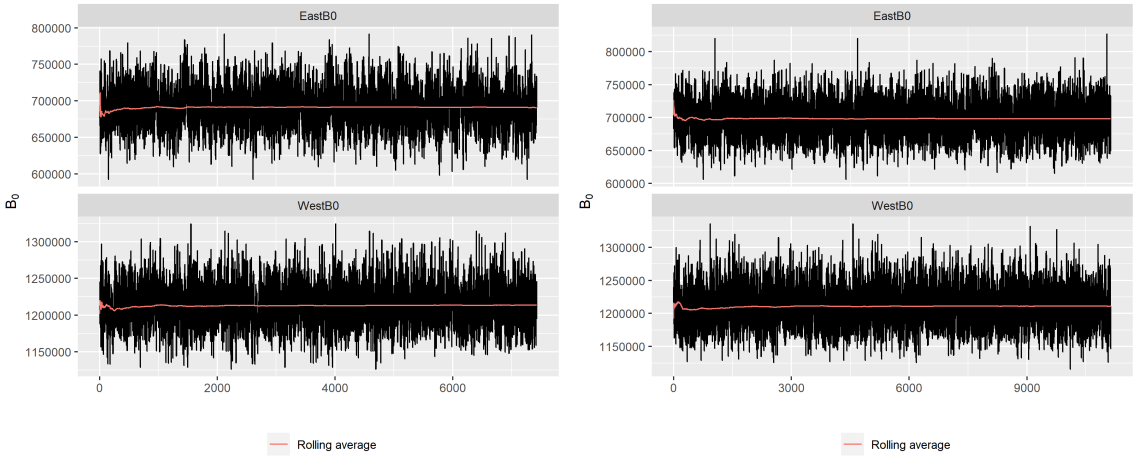


Figure 54: MCMC trace for eastern stock (top) and western stock (bottom) B_0 from the CASAL model (left) and Casal2 model (right).

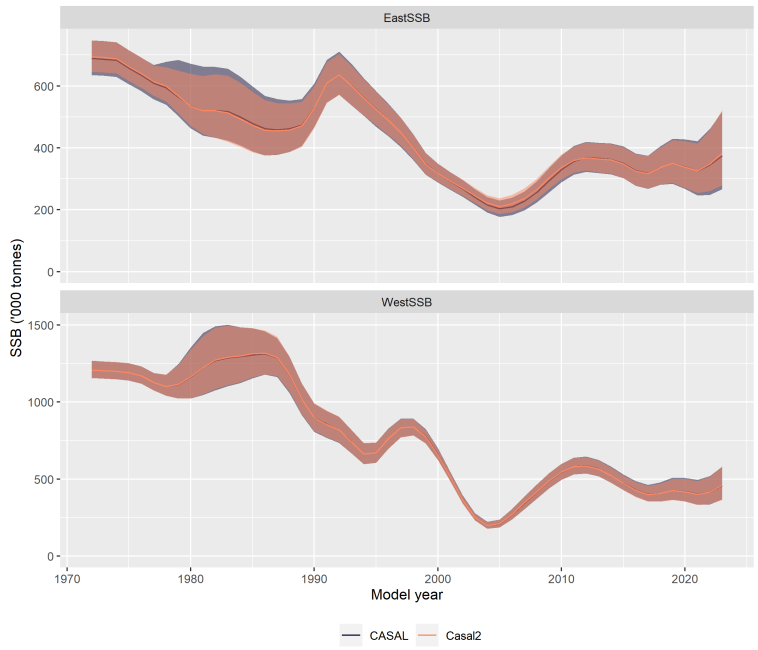


Figure 55: MCMC estimates of SSB (median and 95% CIs) from CASAL model (grey) and Casal2 model (orange).

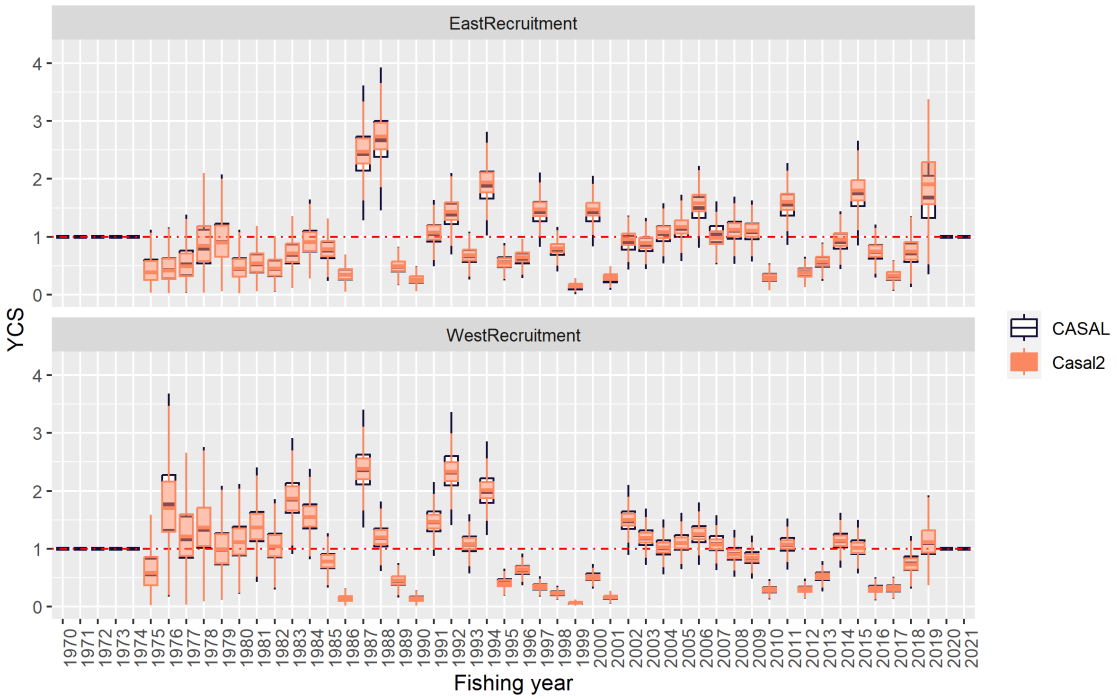


Figure 56: MCMC YCS outputs for CASAL (white boxes) and Casal2 (orange boxes) models, for eastern stock (top) and western stock (bottom). Shaded areas are 95% credible intervals; solid lines are medians.

Appendix B Sub-Antarctic length cut-offs used in trawl survey truncated biomass

```
Sub-Antarctic trawl surveys
#-------------------------------------------------
@sub_populations HOK #tan9105        from FAR: calculated biomass >55, >65, all sira
from lfs in FAR:  <46, <62
sexes male  female  all  all all
Lmin     0       0    0   46  62
Lmax   200     200   46   62 200
labels male female   1+   2+ 3++

#-------------------------------------------------
@sub_populations HOK #tan9211         from FAR: calculated biomass >55, >65, all; sira
from lfs in FAR:  <43, <60
sexes male  female  all  all all
Lmin     0       0    0   43  60
Lmax   200     200   43   60 200
labels male female   1+   2+ 3++

#-------------------------------------------------
@sub_populations HOK     #tan9310        from FAR: calculated biomass >55, >65, all;
sira from lfs in FAR:  <43, <59
sexes male  female  all  all all
Lmin     0       0    0   43  59
Lmax   200     200   43   59 200
labels male female   1+   2+ 3++

#-------------------------------------------------
@sub_populations HOK #tan0012         sira  from lfs in FAR: <43, <58
sexes male  female  all  all all
Lmin     0       0    0   43  58
Lmax   200     200   43   58 200
labels male female   1+   2+ 3++

#-------------------------------------------------
@sub_populations HOK #tan0118         in FAR no info  sirafrom lfs in FAR: <43, <60
sexes male  female  all  all all
Lmin     0       0    0   43  60
Lmax   200     200   43   60 200
labels male female   1+   2+ 3++

# -------------------------------------------------
@sub_populations HOK #tan0219         from FAR: small (47-57 cm) 2 yo hoki
sexes male  female  all  all all
Lmin     0       0    0   47  58
Lmax   200     200   47   58 200
labels male female   1+   2+ 3++

# -------------------------------------------------
@sub_populations HOK #tan0317        from FAR: 1+ 30-43 cm, sira from lfs 2+ to 60
sexes male  female  all  all all
Lmin     0       0    0   44  60
Lmax   200     200   44   60 200
labels male female   1+   2+ 3++

## -------------------------------------------------
@sub_populations HOK #tan0414        from FAR: 1+  30-40 cm, 2+ 42-55 cm
sexes male  female  all  all all
Lmin     0       0    0   42  56
Lmax   200     200   42   56 200
labels male female   1+   2+ 3++

## -------------------------------------------------
@sub_populations HOK #tan0515          from FAR: 1+ < 45 cm) and 2+ (46-60 cm) hoki
sexes male  female  all  all all
Lmin     0       0    0    46  61
Lmax   200     200   46    61 200
labels male female   1+   2+ 3++

## -------------------------------------------------
@sub_populations HOK #tan0617          from FAR: 1 + (< 45 cm) and 2+ (46-59 cm) hoki
```

```
sexes male  female  all  all all
Lmin     0       0    0   46  60
Lmax   200     200   46   60 200
labels male female   1+   2+ 3++

## ------------------------------------------------
@sub_populations HOK #tan0617          from FAR: 1 + (< 45 cm) and 2+ (46-59 cm) hoki
sexes male  female  all  all all
Lmin     0       0    0   46  60
Lmax   200     200   46   60 200
labels male female   1+   2+ 3++

## ------------------------------------------------
@sub_populations HOK #tan0813         from FAR: 1+ (less than 46 cm) and 2+ (46-57 cm) hoki
sexes male  female  all  all all
Lmin     0       0    0   46  58
Lmax   200     200   46   58 200
labels male female   1+   2+ 3++

## ------------------------------------------------
@sub_populations HOK #tan0911         from FAR: 1+ (less than 45 cm) and 2+ (45-57 cm) hoki
sexes male  female  all  all all
Lmin     0       0    0   46  58
Lmax   200     200   46   58 200
labels male female   1+   2+ 3++

## ------------------------------------------------
@sub_populations HOK #tan1117          FAR says:  1+ (less than 45 cm) and 2+ (45-57 cm) hoki
sexes male  female  all  all all
Lmin     0       0    0   46  58
Lmax   200     200   46   58 200
labels male female   1+   2+ 3++

## ------------------------------------------------
@sub_populations HOK #tan1215        FAR says in words: 1+ (less than 49 cm) and 2+ (49-55 cm) hoki
sexes  male  female  all all all
Lmin      0       0    0  49  56
Lmax    200     200   49  56 200
labels male  female  1+   2+ 3++

## ------------------------------------------------
@sub_populations HOK #tan1412       draft FAR: to ages 1+ (less than 48 cm) and 2+ (50-60 cm) hoki
sexes  male female  all all all
Lmin      0      0    0  49  60
Lmax    200    200   49  60 200
labels male female   1+  2+ 3++

# ------------------------------------------------
# tan1614
@sub_populations HOK # sb chose from 2016 lf
sexes male  female  all  all all
Lmin     0       0    0   43  62
Lmax   200     200   43   62 200
labels male female   1+   2+ 3++

#------------------------------------------------
# tan1811
#There are lots of 3+ fish, with an overlap in lengths between 2+ and 3+ (as is almost always the case).
@sub_populations HOK
sexes male  female  all  all all
Lmin     0       0    0   47  58
Lmax   200     200   47   58 200
labels male female   1+   2+ 3++
```

```
130
131  #-------------------------------------------------
132  # tan2014
133  #Lmin <= length < Lmax
134  #For now 1+ 0-43; 2+ 44-60; 3++ 61 cm and bigger
135
136  @sub_populations HOK
137  sexes male  female  all  all all
138  Lmin     0       0    0   44  61
139  Lmax   200     200   44   61 200
140  labels male female   1+   2+ 3++
141
142  #-------------------------------------------------
143  # tan2215
144  # difficult to figure out cutoff between 2 and 3 chose 58
145  @sub_populations HOK
146  sexes male  female  all  all all
147  Lmin     0       0    0   44  58
148  Lmax   200     200   44   58 200
149  labels male female   1+   2+ 3++
150
151  #-------------------------------------------------
152
153
```

Appendix C MPD estimates

C.1 Set One

Table 18: MPD estimates for catchability parameters (q) from models in Set One.

description	parameter	(04)WCnorthCPUE	(02)Updated_data	(03)SepMature	(01)PreviousBase_rerun
CookStraitAcousticQ	q	0.42	0.37	0.45	0.40
WCSIAcousticQ	q	0.33	0.32	0.34	0.33
ChathamRiseSummerQ	q	0.13	0.15	0.14	0.16
SubAntarcticSummerQ	q	0.37	0.42	0.25	0.43
SubAntarcticAutumnQ	q	0.16	0.18	0.15	0.18
WCnorthQ	q	0.30			

Table 19: MPD estimates for ogive parameters (selectivity and movement) from models in Set One.

description	parameter	(04)WCnorthCPUE	(02)Updated_data	(03)SepMature	(01)PreviousBase_rerun
SelectivityWestHomeMigrationM	a50	1.72	1.32	1.59	1.17
SelectivityWestHomeMigrationM	ato95	2.08	2.84	1.93	2.92
SelectivityWestHomeMigrationF	a50	1.43	0.88	1.34	0.74
SelectivityWestHomeMigrationF	ato95	2.21	2.91	1.95	2.65
SelectivityWestSpawningM	a50	-7.38		-7.94	
SelectivityWestSpawningM	ato95	1.24		1.20	
SelectivityWestSpawningF	a50	-0.08		-0.64	
SelectivityWestSpawningF	ato95	0.20		1.44	
SelectivityEastSpawningM	a50	-4.02		1.78	
SelectivityEastSpawningM	ato95	0.84		0.85	
SelectivityEastSpawningF	a50	1.82		1.82	
SelectivityEastSpawningF	ato95	0.74		0.75	
SelectivitySubAntarcticSummerSurveyM	a50	10.00	10.00	8.03	10.00
SelectivitySubAntarcticSummerSurveyM	ato95	8.07	7.60	6.70	7.53
SelectivitySubAntarcticAutumnSurveyM	a50	6.07		5.70	
SelectivitySubAntarcticAutumnSurveyM	ato95	7.59		7.34	
SelectivitySubAntarcticAEXSurveyM	a50	3.34		3.30	
SelectivitySubAntarcticAEXSurveyM	ato95	1.79		1.68	
SelectivitySubAntarcticSHISurveyM	a50	5.64		5.64	
SelectivitySubAntarcticSHISurveyM	ato95	1.91		1.82	
SelectivityChathamRiseDeepFisheryM	a50	2.53	2.43	2.41	2.50
SelectivityChathamRiseDeepFisheryM	ato95	1.21	1.34	1.00	1.42
SelectivityChathamRiseShallowFisheryM	mu	3.21	2.11	3.17	2.10
SelectivityChathamRiseShallowFisheryM	sigma_l	1.03	0.10	1.00	0.10
SelectivityChathamRiseShallowFisheryM	sigma_r	8.38	8.05	16.03	10.60
SelectivityCookStraitSpawningFisheryM	a50	3.36	3.39	3.78	3.72
SelectivityCookStraitSpawningFisheryM	ato95	1.20	2.72	4.77	3.10
SelectivityCookStraitSpawningFisheryM	alpha	0.42	0.47	0.58	0.68
SelectivityCookStraitSpawningFisheryF	a50	8.03	8.34	8.06	7.59
SelectivityCookStraitSpawningFisheryF	ato95	6.18	7.35	6.16	7.07
SelectivityPuysegurSpawningFisheryM	mu	13.03		14.22	
SelectivityPuysegurSpawningFisheryM	sigma_l	7.05		8.01	
SelectivityPuysegurSpawningFisheryM	sigma_r	3.50		2.29	
SelectivitySubAntarcticAucklandFisheryM	a50	10.00	10.63	5.76	10.03
SelectivitySubAntarcticAucklandFisheryM	ato95	10.00	9.53	6.84	8.69
SelectivitySubAntarcticSnaresFisheryM	mu	0.10	6.28	1.52	6.20
SelectivitySubAntarcticSnaresFisheryM	sigma_l	6.96	11.16	4.84	10.78
SelectivitySubAntarcticSnaresFisheryM	sigma_r	50.00	9.10	21.44	8.88
SelectivitySubAntarcticSubaFisheryM	a50	8.54	8.65	8.49	8.86
SelectivitySubAntarcticSubaFisheryM	ato95	3.16	3.15	3.11	3.33
SelectivityWCSIInsideFisheryM	a50	6.36	6.89	6.28	6.92
SelectivityWCSIInsideFisheryM	ato95	3.10	3.83	2.98	3.94
SelectivityWCSIInsideFisheryM	alpha	1.52	1.73	1.49	1.71
SelectivityWCSIInsideFisheryF	a50	7.89	8.18	7.87	8.24
SelectivityWCSIInsideFisheryF	ato95	3.06	3.57	3.14	3.65
SelectivityWCSINorthPre2000FisheryM	mu	4.41	0.75	4.61	1.03
SelectivityWCSINorthPre2000FisheryM	sigma_l	1.91	3.00	2.00	3.00
SelectivityWCSINorthPre2000FisheryM	sigma_r	11.88	19.00	14.20	20.07
SelectivityWCSINorthPre2000FisheryM	alpha	0.71	0.70	0.72	0.72

SelectivityWCSINorthPre2000FisheryF	mu	9.17	12.26	8.71	12.23
SelectivityWCSINorthPre2000FisheryF	sigma_l	3.70	7.07	3.54	7.06
SelectivityWCSINorthPre2000FisheryF	sigma_r	13.39	8.16	14.06	14.64
SelectivityWCSISouthFisheryM	a50	5.78	7.10	5.86	7.06
SelectivityWCSISouthFisheryM	ato95	5.22	8.77	5.18	8.73
SelectivityWCSISouthFisheryM	alpha	0.66	0.74	0.71	0.74
SelectivityWCSISouthFisheryF	a50	8.10	8.79	7.88	8.78
SelectivityWCSISouthFisheryF	ato95	4.15	5.41	4.19	5.41
SelectivityPuysegurSpawningFisheryM	alpha			2.18	

C.2 Set Two

Table 20: MPD estimates for catchability parameters (q) from models in Set Two.

description	parameter	(01)Updated_data	(02)SepMature	(03)SingleStock
CookStraitAcousticQ	q	0.37	0.45	0.20
WCSIAcousticQ	q	0.32	0.34	0.44
ChathamRiseSummerQ	q	0.15	0.14	0.11
SubAntarcticSummerQ	q	0.42	0.25	0.51
SubAntarcticAutumnQ	q	0.18	0.15	0.23

Table 21: MPD estimates for ogive parameters (selectivity and movement) from models in Set Two.

description	parameter	(01)Updated_data	(02)SepMature	(03)SingleStock
SelectivityWestHomeMigrationM	a50	1.32	1.59	-9.99
SelectivityWestHomeMigrationM	ato95	2.84	1.93	30.00
SelectivityWestHomeMigrationF	a50	0.88	1.34	-10.00
SelectivityWestHomeMigrationF	ato95	2.91	1.95	3.84
SelectivitySubAntarcticSummerSurveyM	a50	10.00	8.03	10.00
SelectivitySubAntarcticSummerSurveyM	ato95	7.60	6.70	9.99
SelectivityChathamRiseDeepFisheryM	a50	2.43	2.41	1.01
SelectivityChathamRiseDeepFisheryM	ato95	1.34	1.00	10.00
SelectivityChathamRiseShallowFisheryM	mu	2.11	3.17	2.98
SelectivityChathamRiseShallowFisheryM	sigma_l	0.10	1.00	0.94
SelectivityChathamRiseShallowFisheryM	sigma_r	8.05	16.03	6.67
SelectivityCookStraitSpawningFisheryM	a50	3.39	3.78	9.99
SelectivityCookStraitSpawningFisheryM	ato95	2.72	4.77	9.72
SelectivityCookStraitSpawningFisheryM	alpha	0.47	0.58	1.20
SelectivityCookStraitSpawningFisheryF	a50	8.34	8.06	9.99
SelectivityCookStraitSpawningFisheryF	ato95	7.35	6.16	5.76
SelectivitySubAntarcticAucklandFisheryM	a50	10.63	5.76	9.91
SelectivitySubAntarcticAucklandFisheryM	ato95	9.53	6.84	9.40
SelectivitySubAntarcticSnaresFisheryM	mu	6.28	1.52	30.53
SelectivitySubAntarcticSnaresFisheryM	sigma_l	11.16	4.84	22.99
SelectivitySubAntarcticSnaresFisheryM	sigma_r	9.10	21.44	49.90
SelectivitySubAntarcticSubaFisheryM	a50	8.65	8.49	7.93
SelectivitySubAntarcticSubaFisheryM	ato95	3.15	3.11	3.04
SelectivityWCSIInsideFisheryM	a50	6.89	6.28	5.86
SelectivityWCSIInsideFisheryM	ato95	3.83	2.98	2.38
SelectivityWCSIInsideFisheryM	alpha	1.73	1.49	1.92
SelectivityWCSIInsideFisheryF	a50	8.18	7.87	7.67
SelectivityWCSIInsideFisheryF	ato95	3.57	3.14	3.33
SelectivityWCSINorthPre2000FisheryM	mu	0.75	4.61	4.73
SelectivityWCSINorthPre2000FisheryM	sigma_l	3.00	2.00	1.54
SelectivityWCSINorthPre2000FisheryM	sigma_r	19.00	14.20	11.19
SelectivityWCSINorthPre2000FisheryM	alpha	0.70	0.72	1.04
SelectivityWCSINorthPre2000FisheryF	mu	12.26	8.71	7.78
SelectivityWCSINorthPre2000FisheryF	sigma_l	7.07	3.54	3.20
SelectivityWCSINorthPre2000FisheryF	sigma_r	8.16	14.06	13.34

SelectivityWCSISouthFisheryM	a50	7.10	5.86	4.80
SelectivityWCSISouthFisheryM	ato95	8.77	5.18	2.93
SelectivityWCSISouthFisheryM	alpha	0.74	0.71	0.83
SelectivityWCSISouthFisheryF	a50	8.79	7.88	7.39
SelectivityWCSISouthFisheryF	ato95	5.41	4.19	4.34
SelectivityWestSpawningM	a50		-7.94	-2.74
SelectivityWestSpawningM	ato95		1.20	0.10
SelectivityWestSpawningF	a50		-0.64	-5.95
SelectivityWestSpawningF	ato95		1.44	0.29
SelectivityEastSpawningM	a50		1.78	1.88
SelectivityEastSpawningM	ato95		0.85	0.73
SelectivityEastSpawningF	a50		1.82	-9.55
SelectivityEastSpawningF	ato95		0.75	0.12
SelectivitySubAntarcticAutumnSurveyM	a50		5.70	
SelectivitySubAntarcticAutumnSurveyM	ato95		7.34	
SelectivitySubAntarcticAEXSurveyM	a50		3.30	
SelectivitySubAntarcticAEXSurveyM	ato95		1.68	
SelectivitySubAntarcticSHISurveyM	a50		5.64	
SelectivitySubAntarcticSHISurveyM	ato95		1.82	
SelectivityPuysegurSpawningFisheryM	mu		14.22	7.85
SelectivityPuysegurSpawningFisheryM	sigma_l		8.01	3.59
SelectivityPuysegurSpawningFisheryM	sigma_r		2.29	6.97
SelectivityPuysegurSpawningFisheryM	alpha		2.18	2.10
SelectivityWestHomeMigrationM	alpha			0.37
SelectivityWestHomeMigrationF	alpha			0.15

Appendix D MPD fits

D.1 MPD abundance residuals

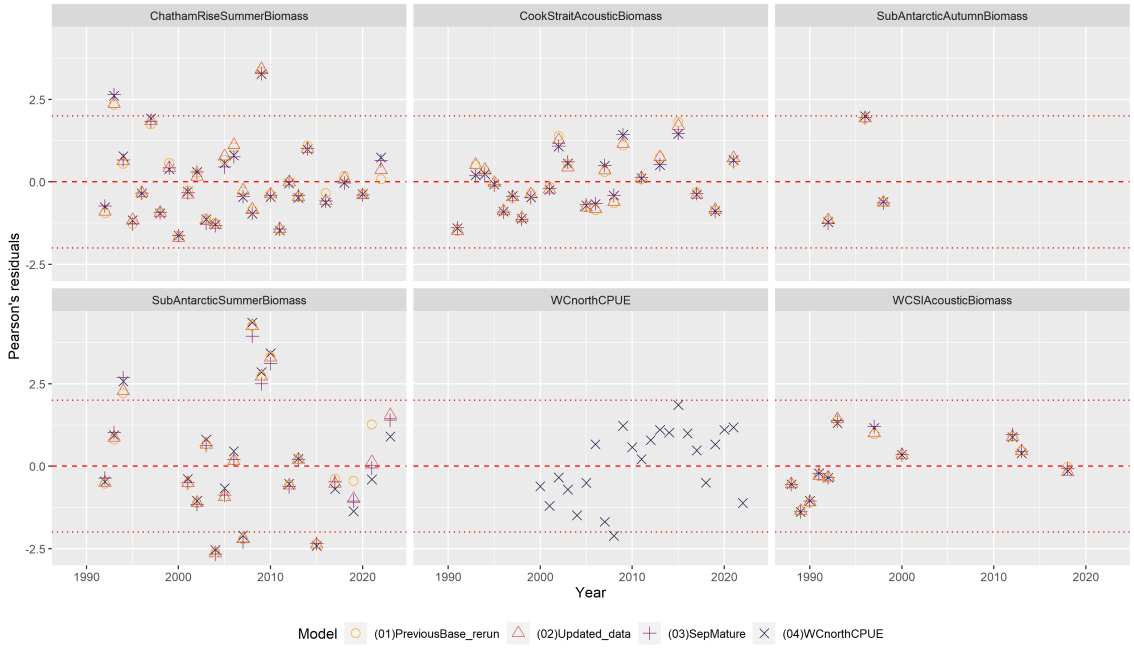


Figure 57: Residuals for abundance observations from MPD models in Set One.



Figure 58: Residuals for abundance observations from MPD models in Set Two.

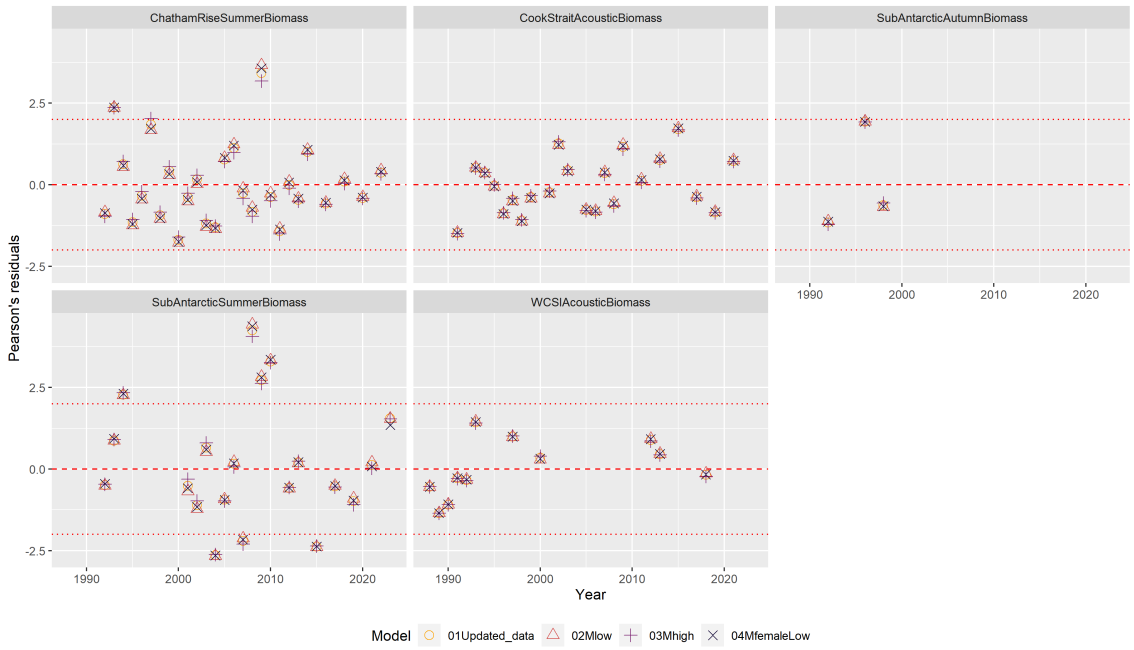


Figure 59: Residuals for abundance observations from MPD models in natural mortality sensitivities.



Figure 60: Residuals for abundance observations from MPD models in maturity and steepness sensitivities.

D.2 MPD age composition residuals

D.2.1 Set One

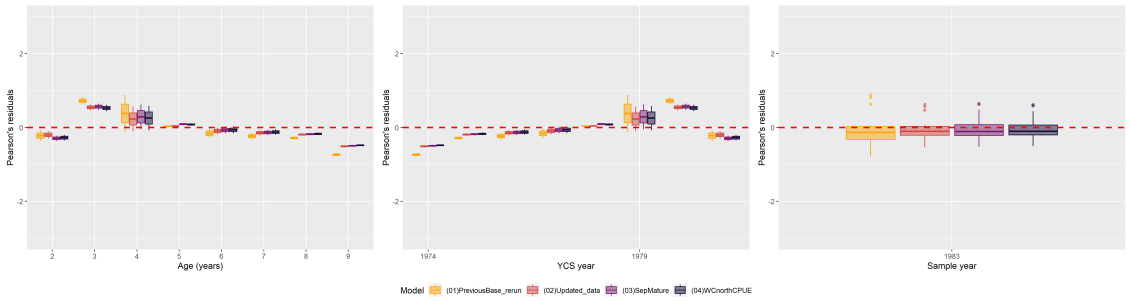


Figure 61: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for ChathamRiseSHIAge.

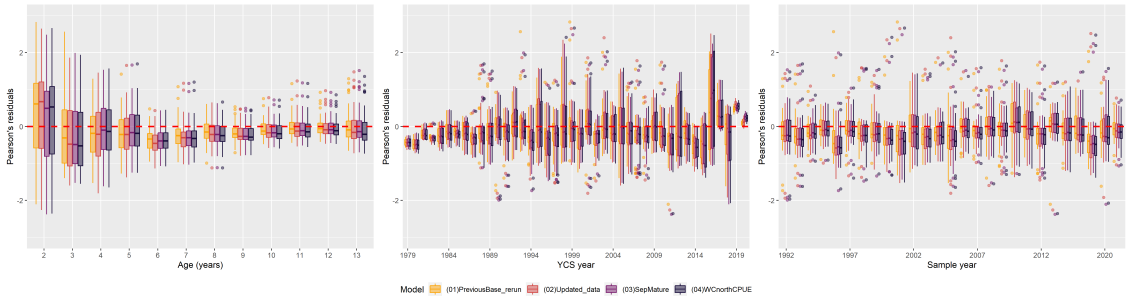


Figure 62: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for ChathamRiseSummerAge.

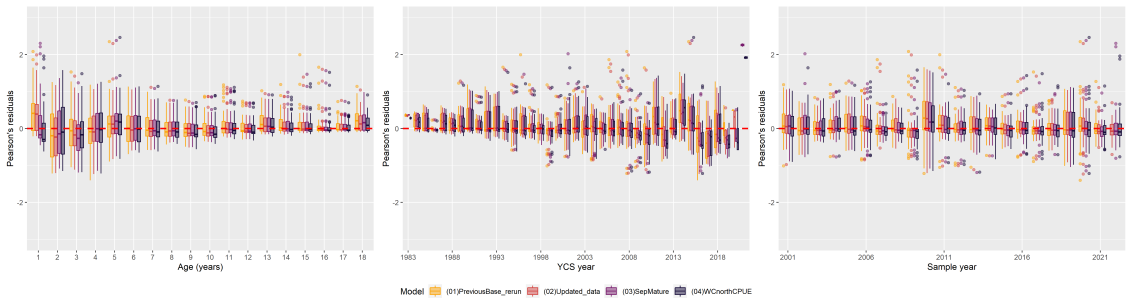


Figure 63: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryChathamRiseDeepAge.

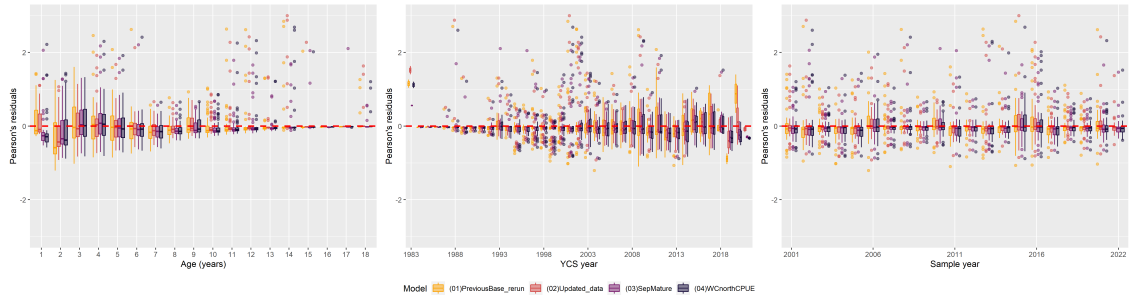


Figure 64: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryChathamRiseShallowAge.

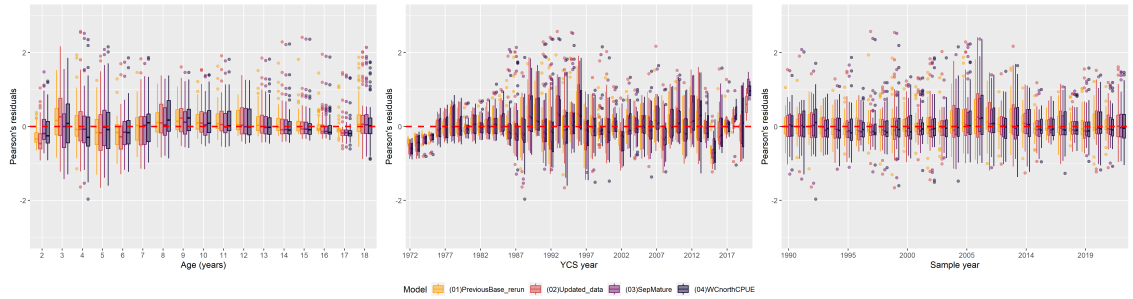


Figure 65: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryCookStraitAge.

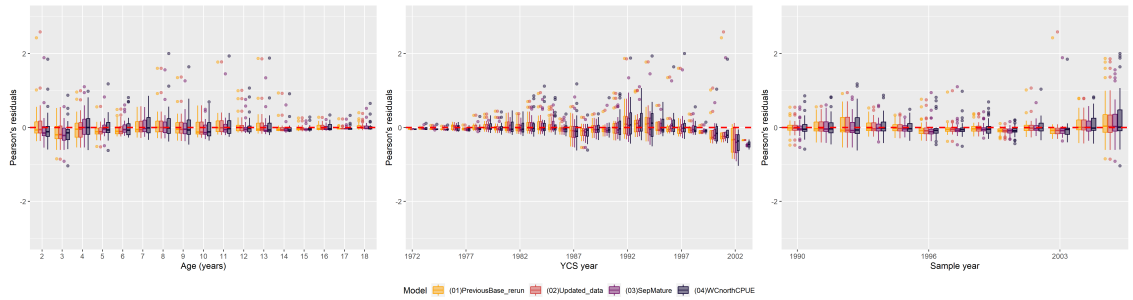


Figure 66: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryPuysegurSpawningAge.

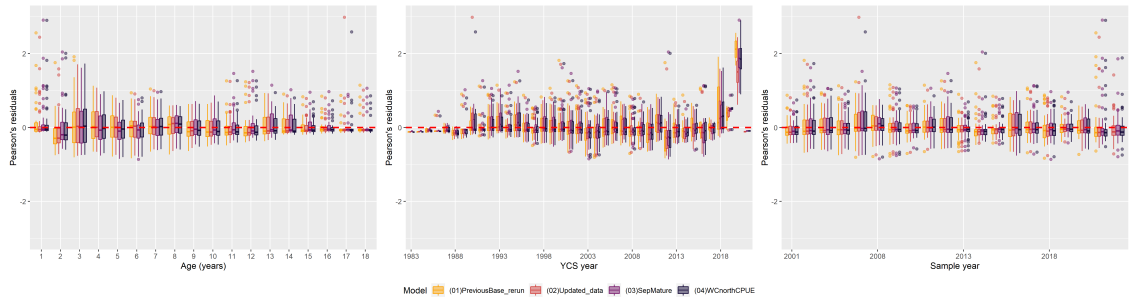


Figure 67: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisherySubAntarcticAucklandAge.

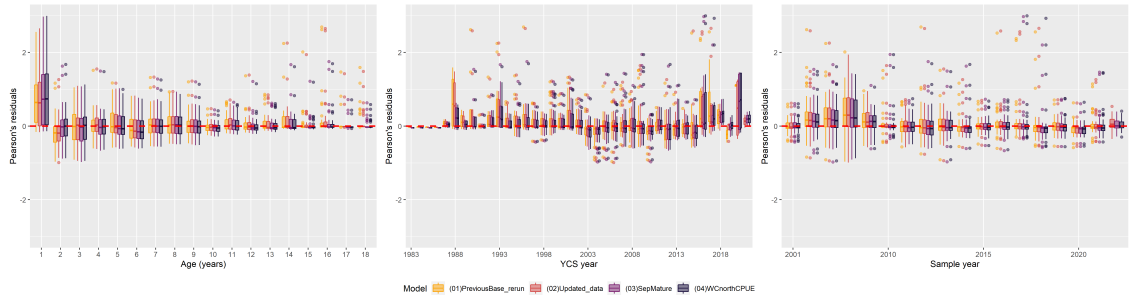


Figure 68: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisherySubAntarcticSnaresAge.

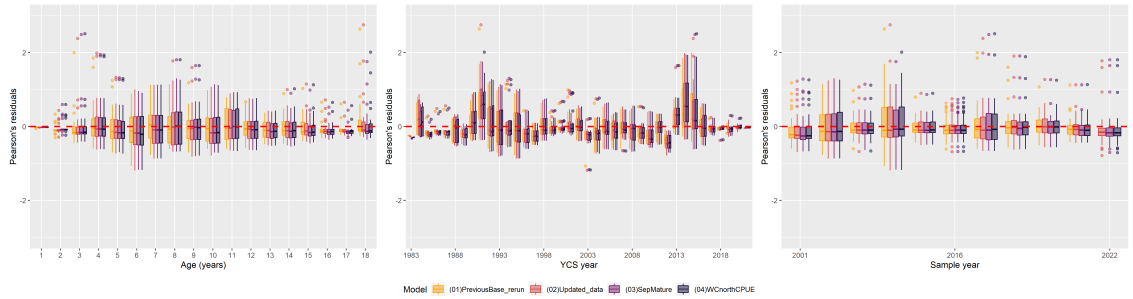


Figure 69: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisherySubAntarcticSubaAge.

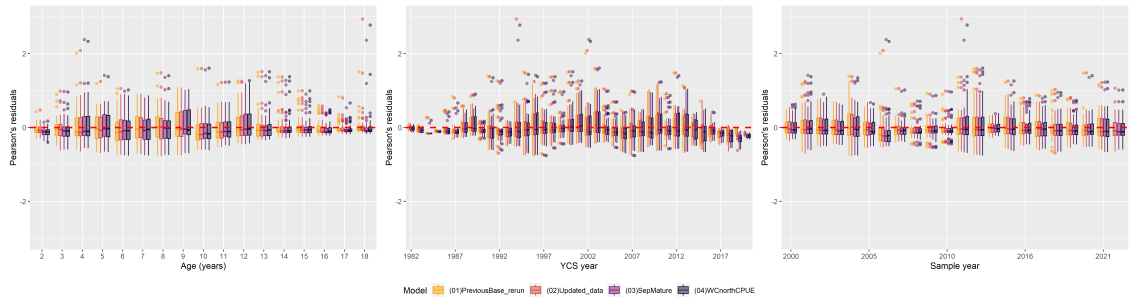


Figure 70: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryWCSIInsideAge.

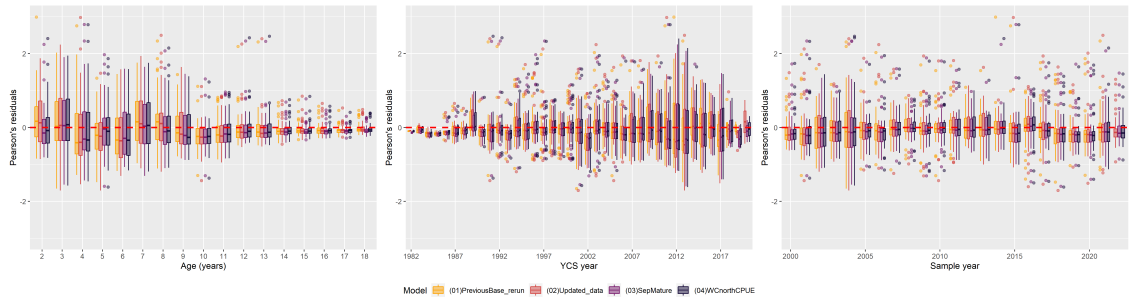


Figure 71: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryWCSINorthFrom2000Age.

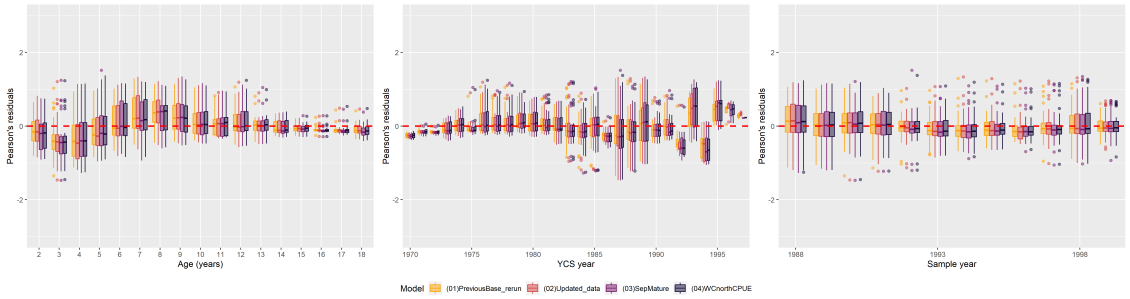


Figure 72: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryWCSINorthPre2000Age.

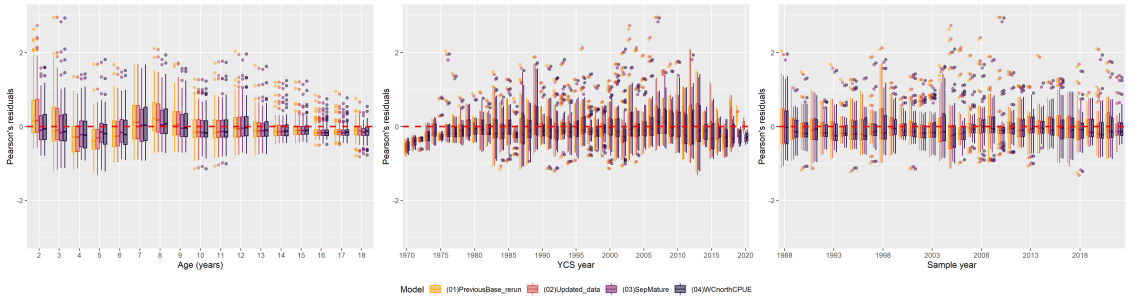


Figure 73: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for FisheryWCSISouthAge.

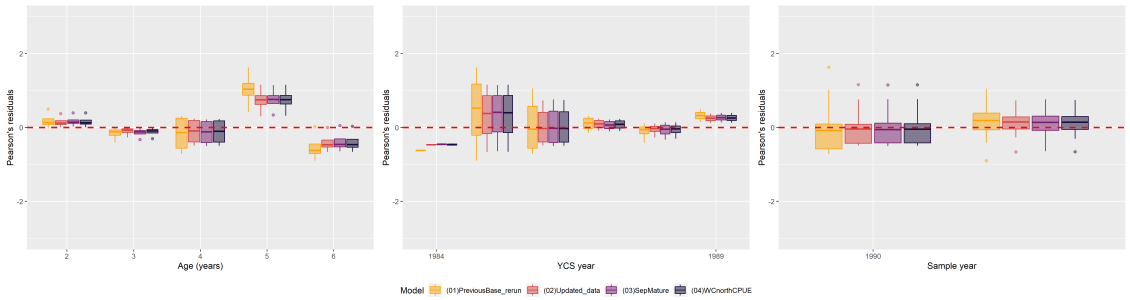


Figure 74: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for SubAntarcticAEXAge.

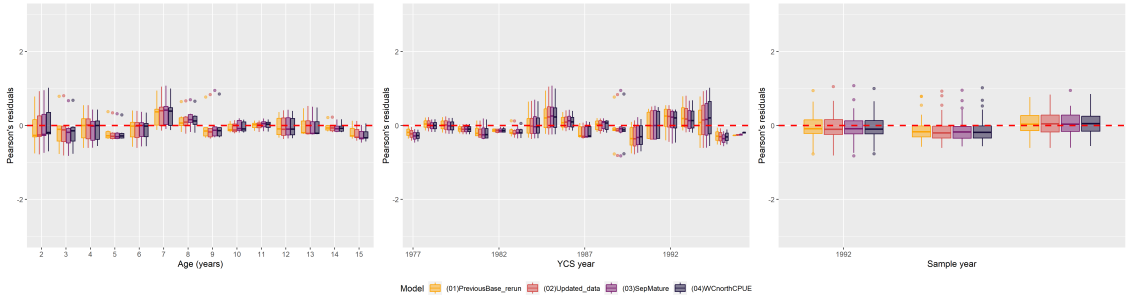


Figure 75: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for SubAntarcticAutumnAge.

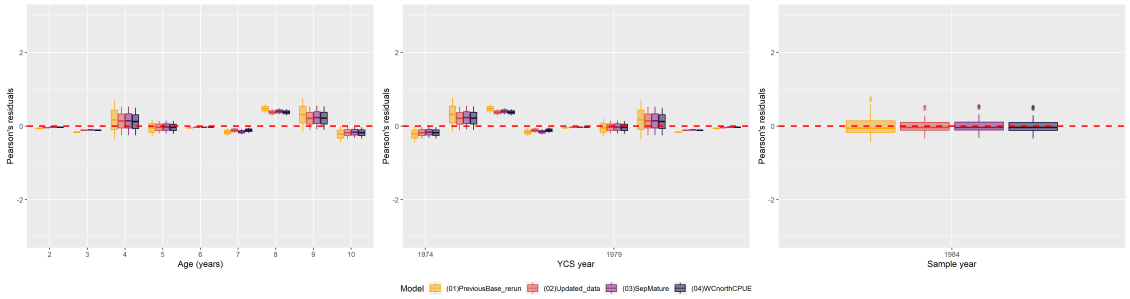


Figure 76: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for SubAntarcticSHIAge.

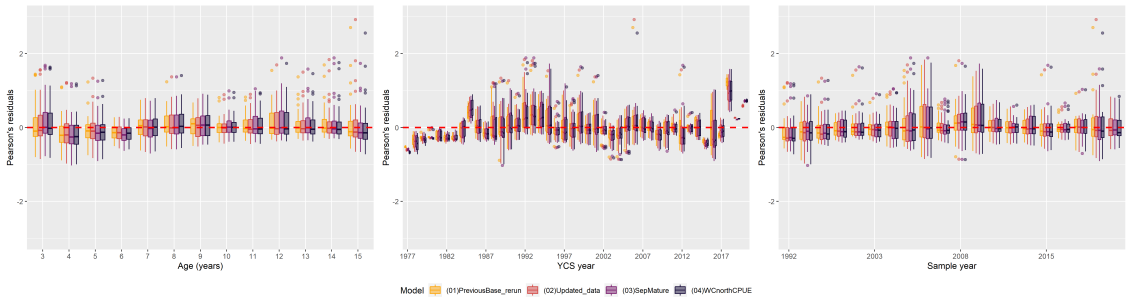


Figure 77: Residuals by year (left), age(middle), and year class (right) from MPD models in Set One for SubAntarcticSummerAge.

D.2.2 Set Two

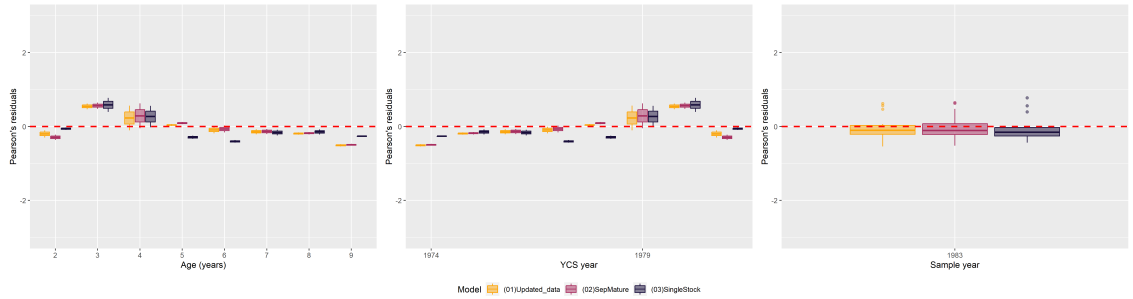


Figure 78: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for ChathamRiseSHIAge.

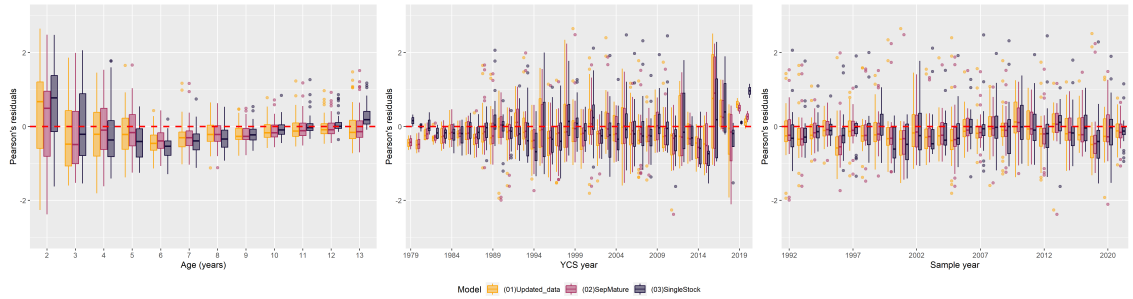


Figure 79: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for ChathamRiseSummerAge.



Figure 80: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryChathamRiseDeepAge.

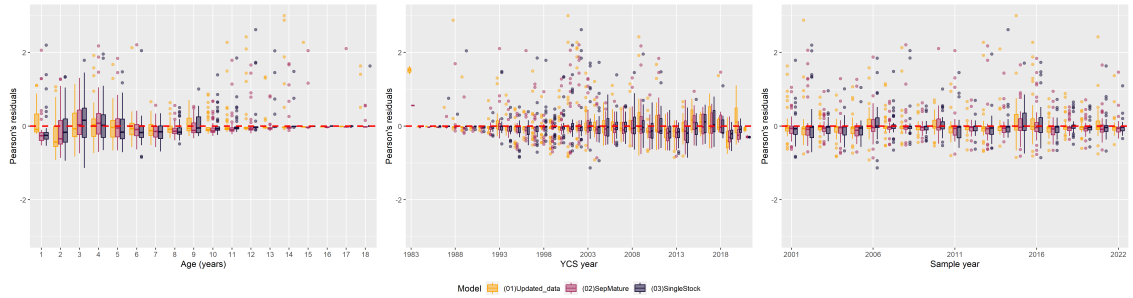


Figure 81: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryChathamRiseShallowAge.

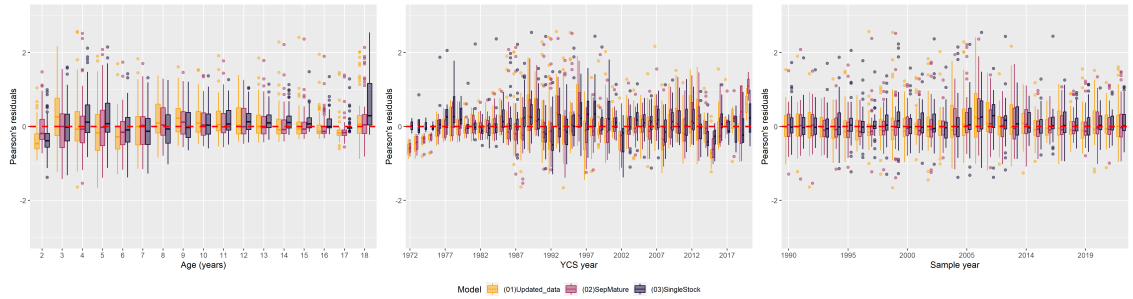


Figure 82: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryCookStraitAge.

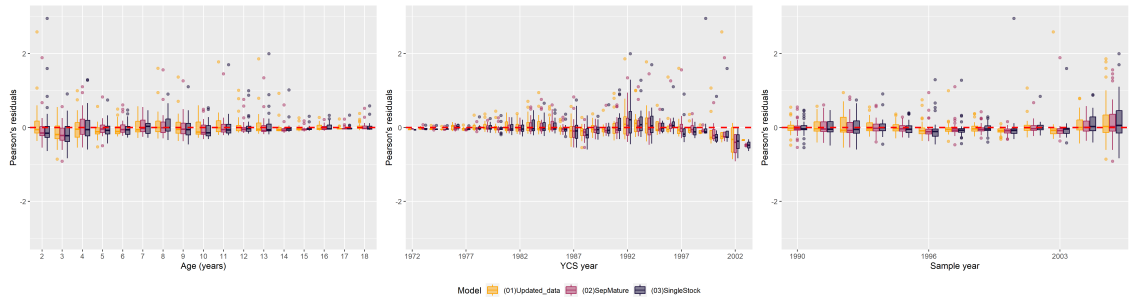


Figure 83: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryPuysegurSpawningAge.

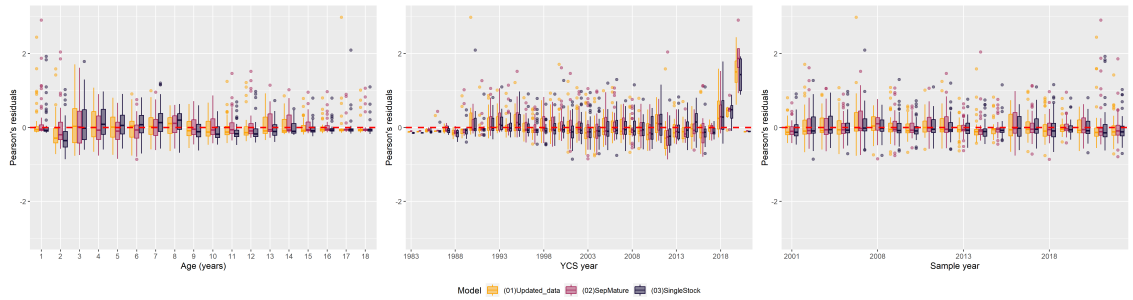


Figure 84: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisherySubAntarcticAucklandAge.

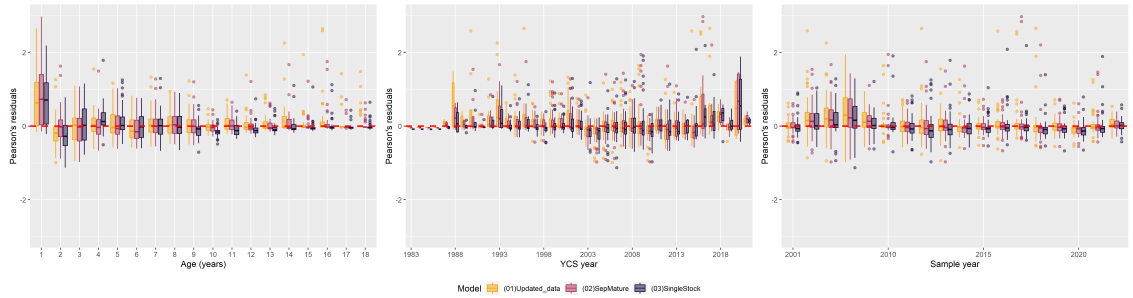


Figure 85: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisherySubAntarcticSnaresAge.

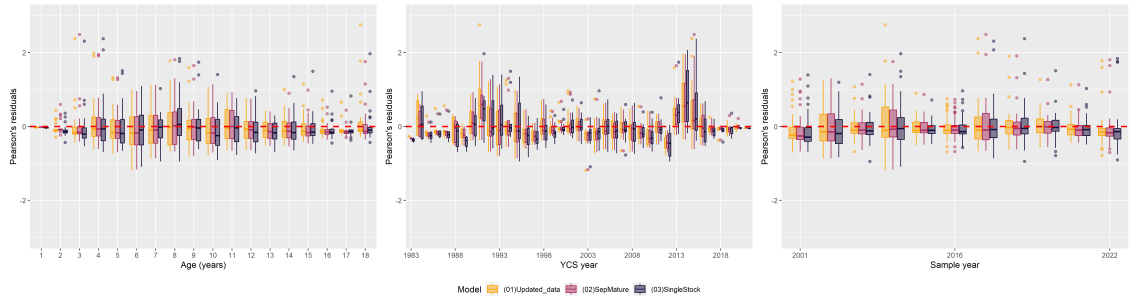


Figure 86: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisherySubAntarcticSubaAge.

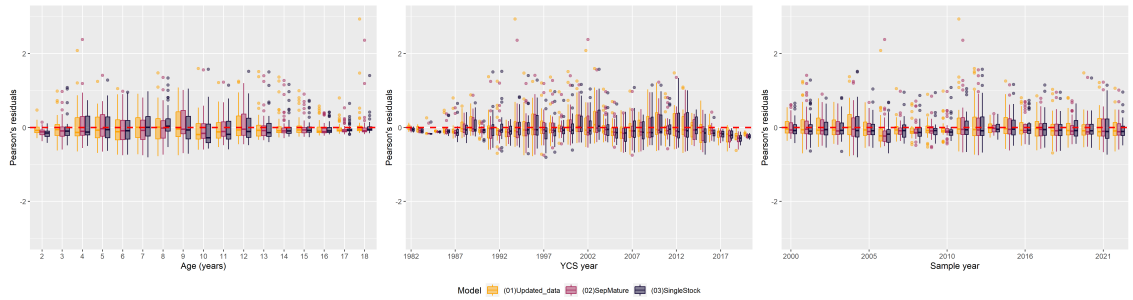


Figure 87: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryWCSIInsideAge.

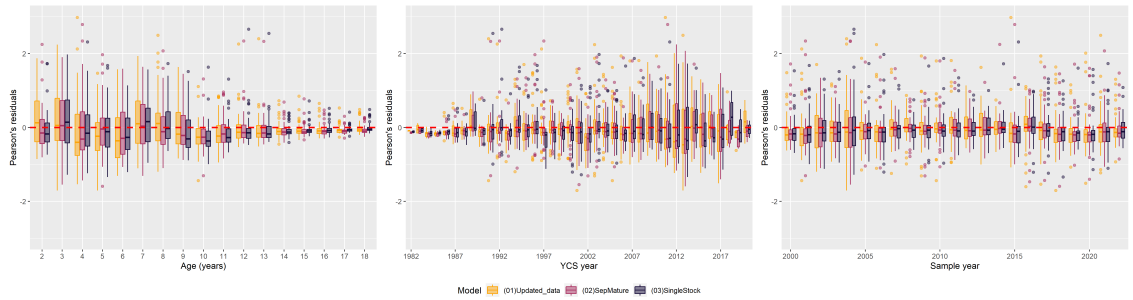


Figure 88: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryWCSINorthFrom2000Age.

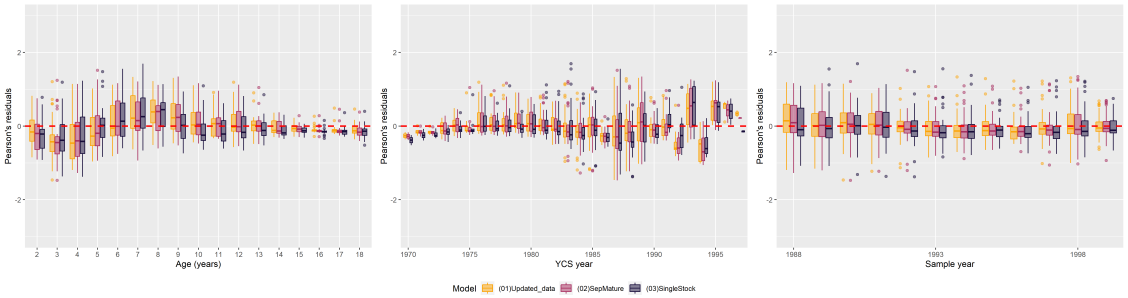


Figure 89: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryWCSINorthPre2000Age.

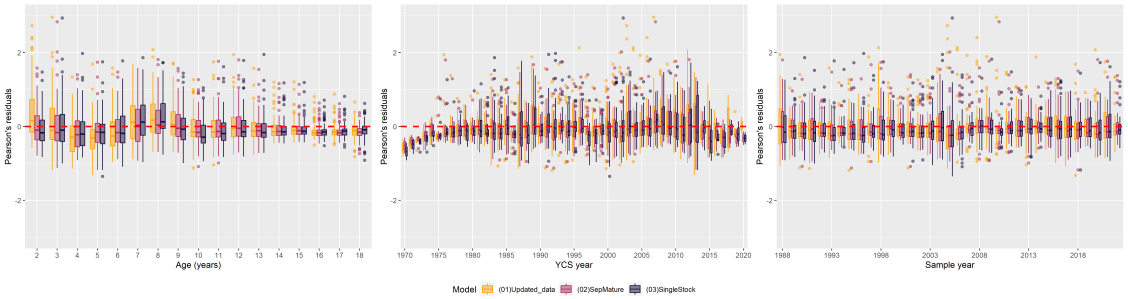


Figure 90: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for FisheryWCSISouthAge.

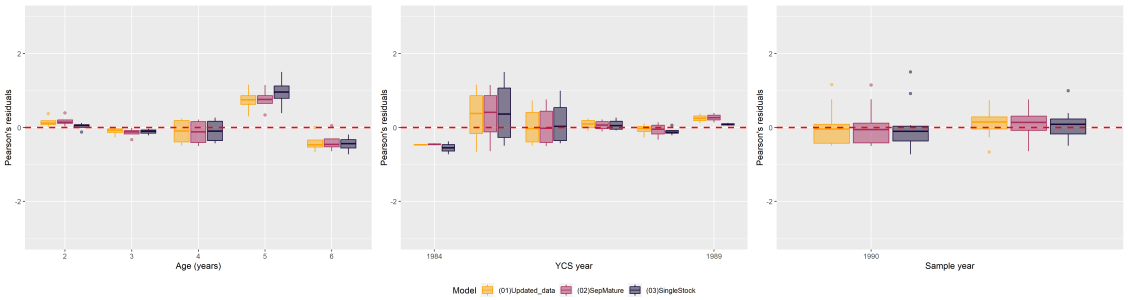


Figure 91: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for SubAntarcticAEXAge.

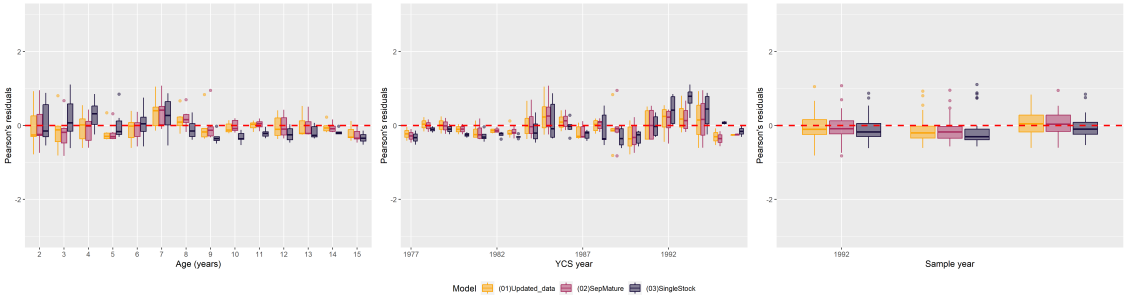


Figure 92: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for SubAntarcticAutumnAge.

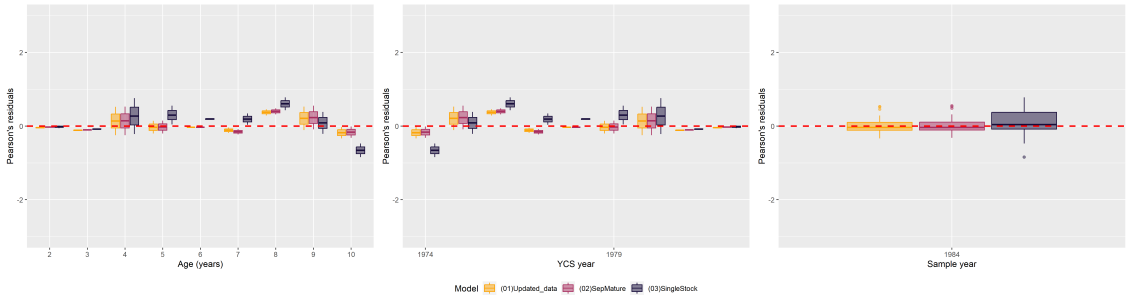


Figure 93: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for SubAntarcticSHIAge.

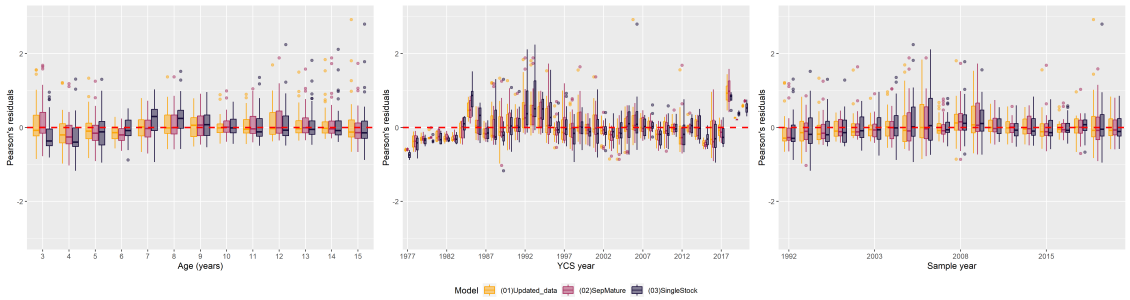


Figure 94: Residuals by year (left), age(middle), and year class (right) from MPD models in Set Two for SubAntarcticSummerAge.

D.3 MPD age composition fits

D.3.1 Set One

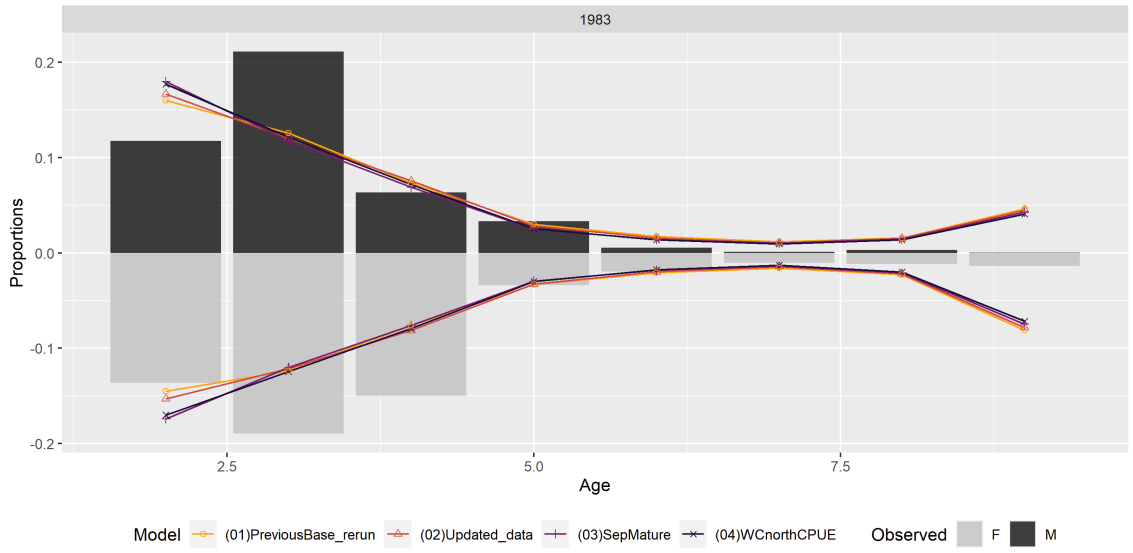


Figure 95: MPD fits to age composition data from models in Set One for ChathamRiseSHIAge.

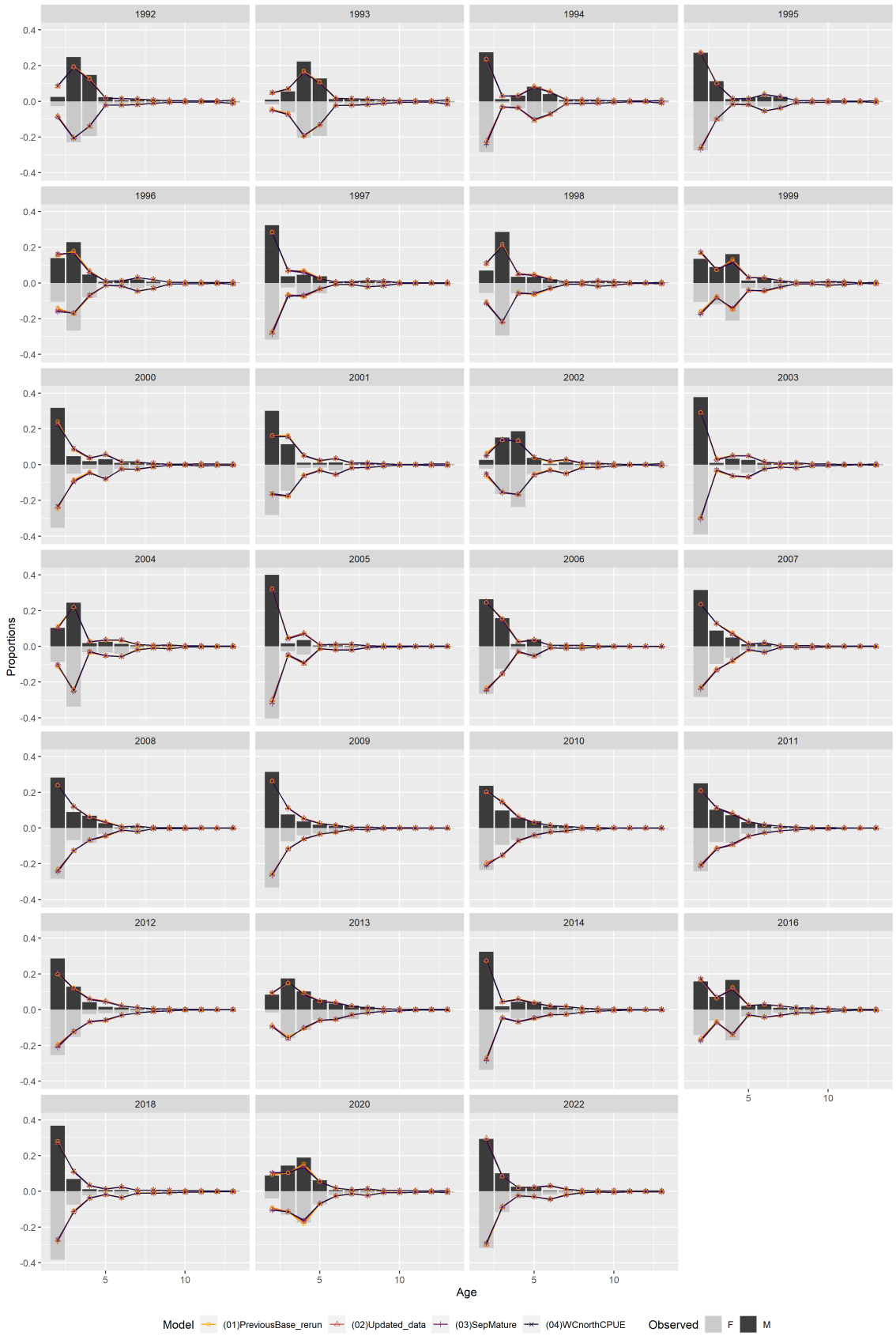


Figure 96: MPD fits to age composition data from models in Set One for ChathamRiseSummerAge.

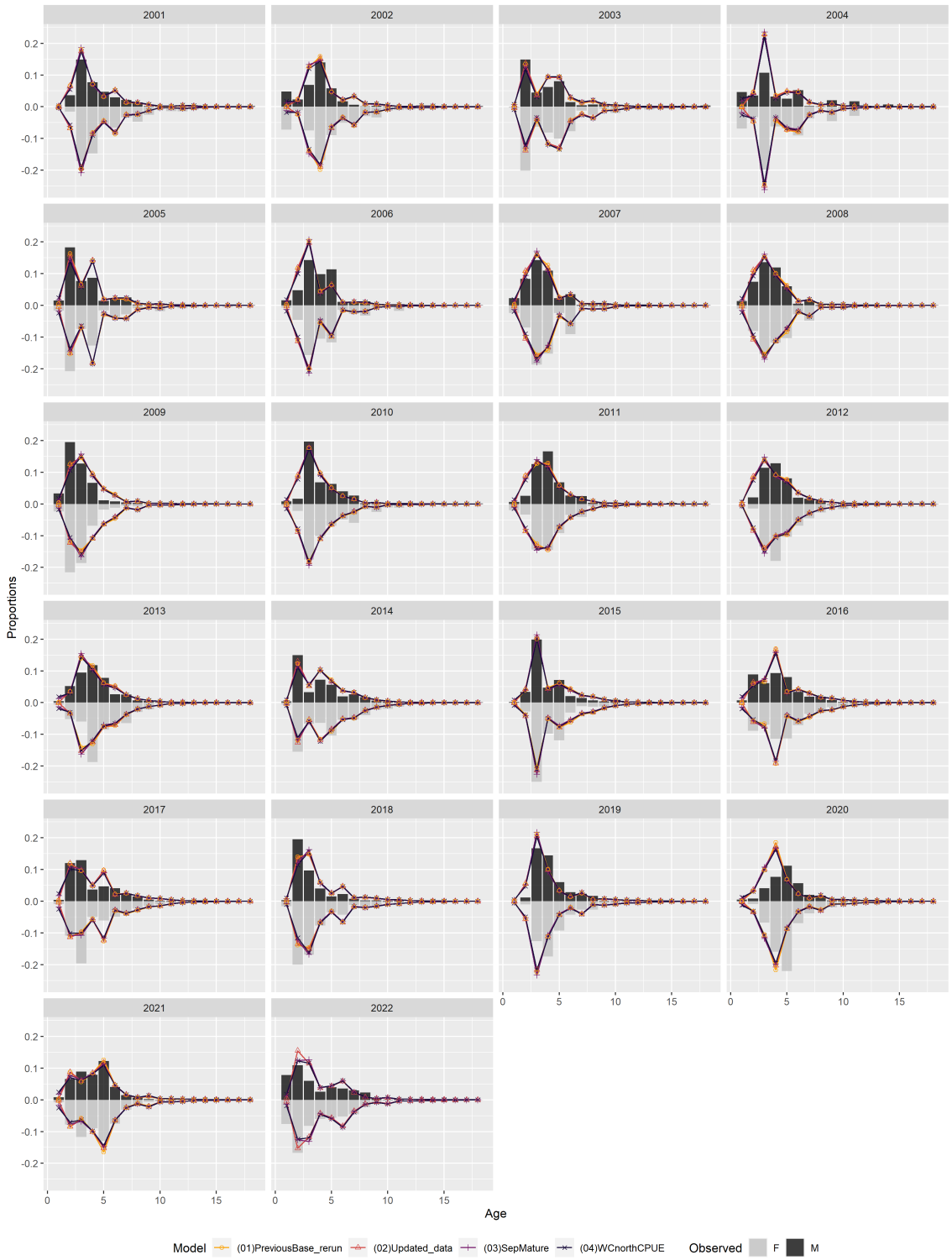


Figure 97: MPD fits to age composition data from models in Set One for FisheryChathamRiseDeepAge.

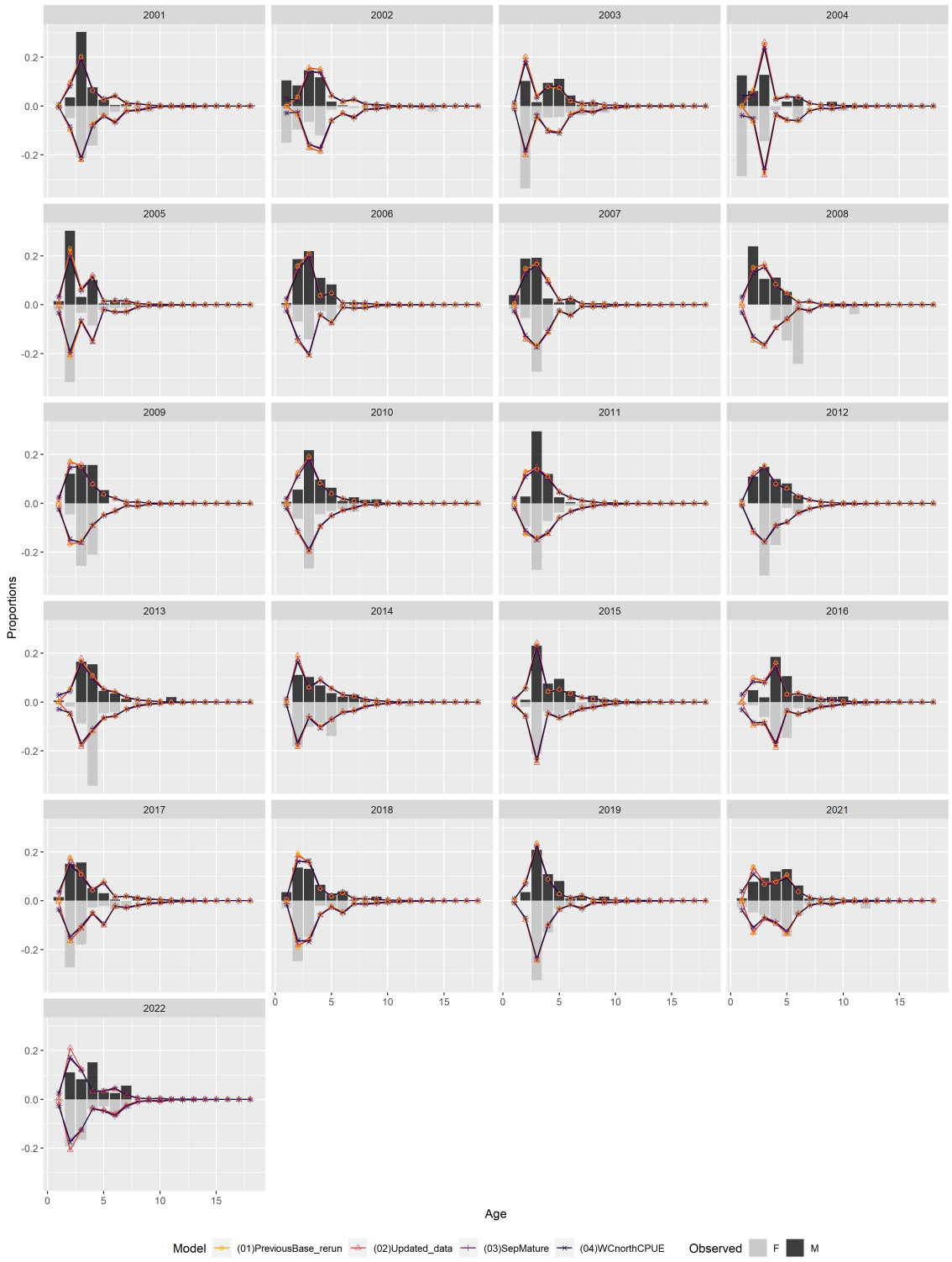


Figure 98: MPD fits to age composition data from models in Set One for FisheryChathamRiseShallowAge.



Figure 99: MPD fits to age composition data from models in Set One for FisheryCookStraitAge.

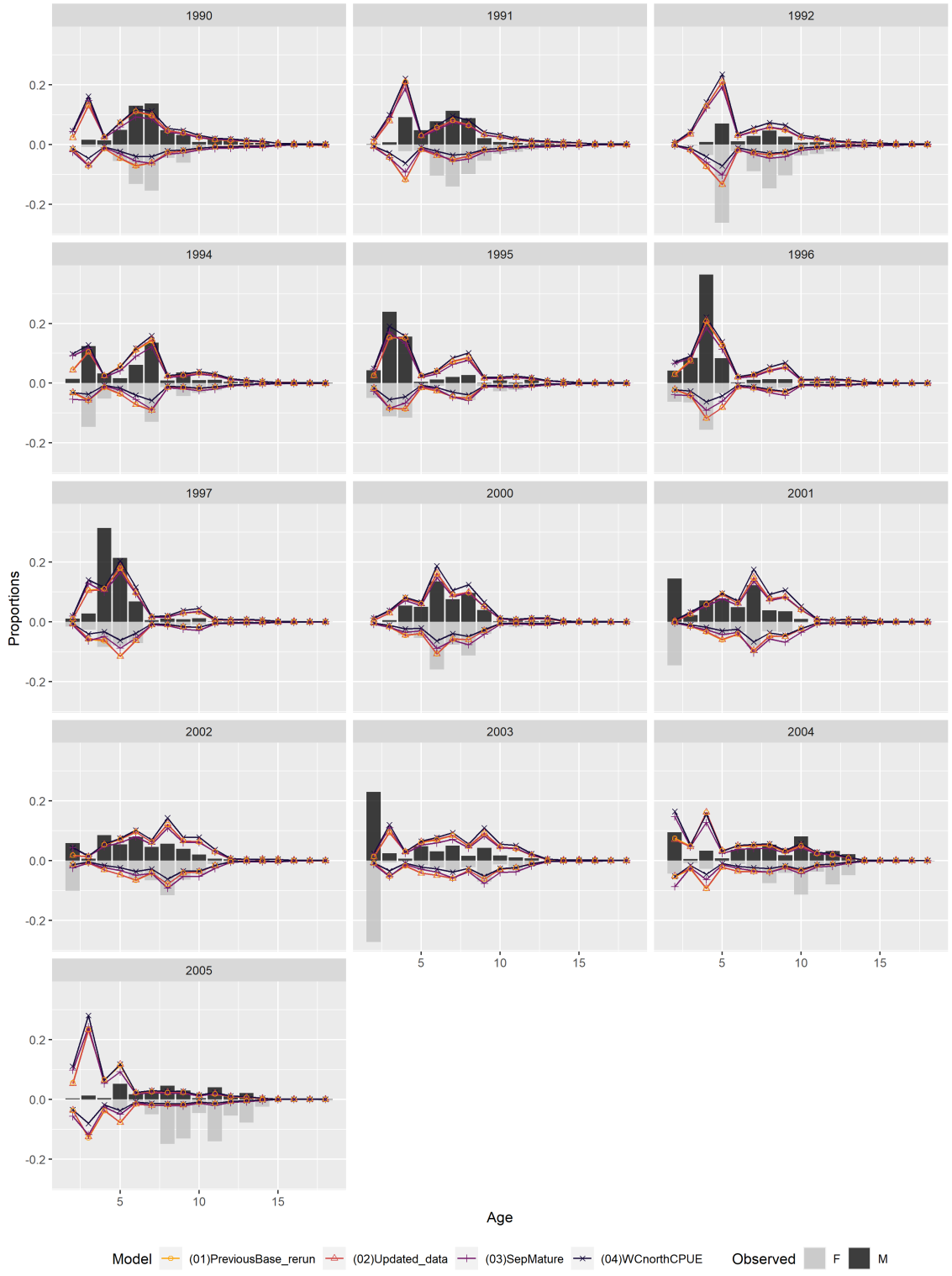


Figure 100: MPD fits to age composition data from models in Set One for FisheryPuysegurSpawningAge.

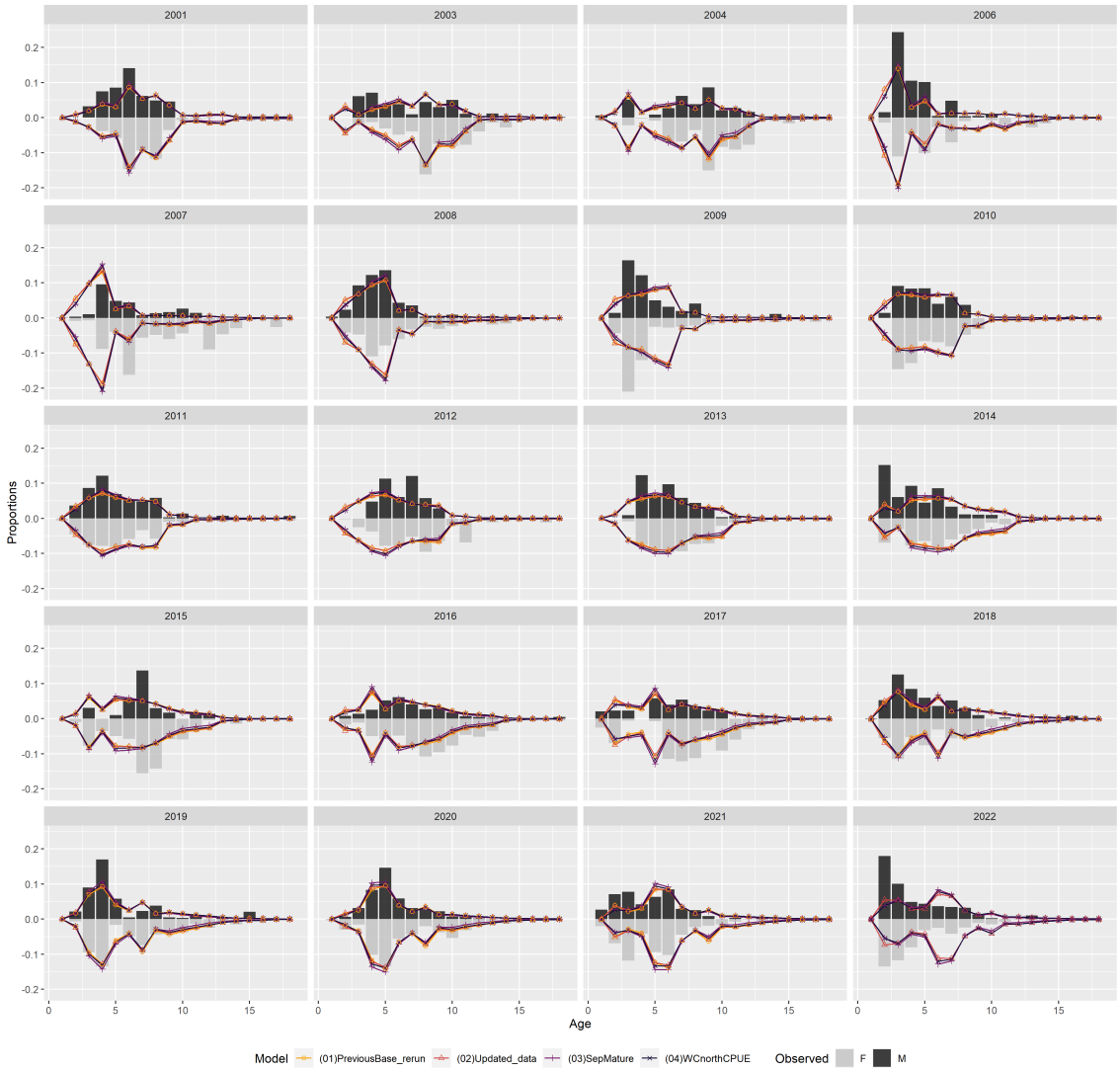


Figure 101: MPD fits to age composition data from models in Set One for FisherySubAntarcticAucklandAge.

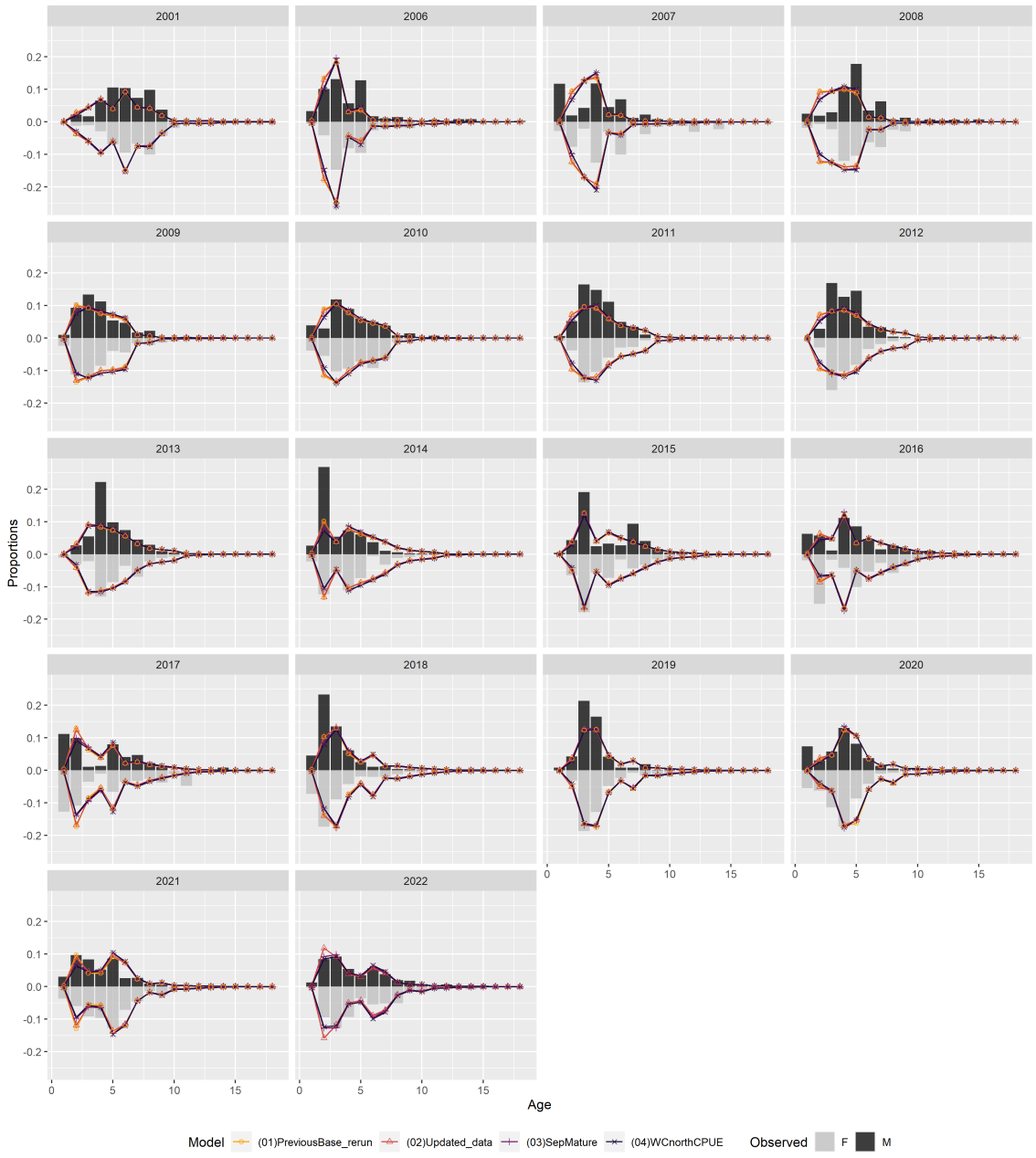


Figure 102: MPD fits to age composition data from models in Set One for FisherySubAntarcticSnaresAge.

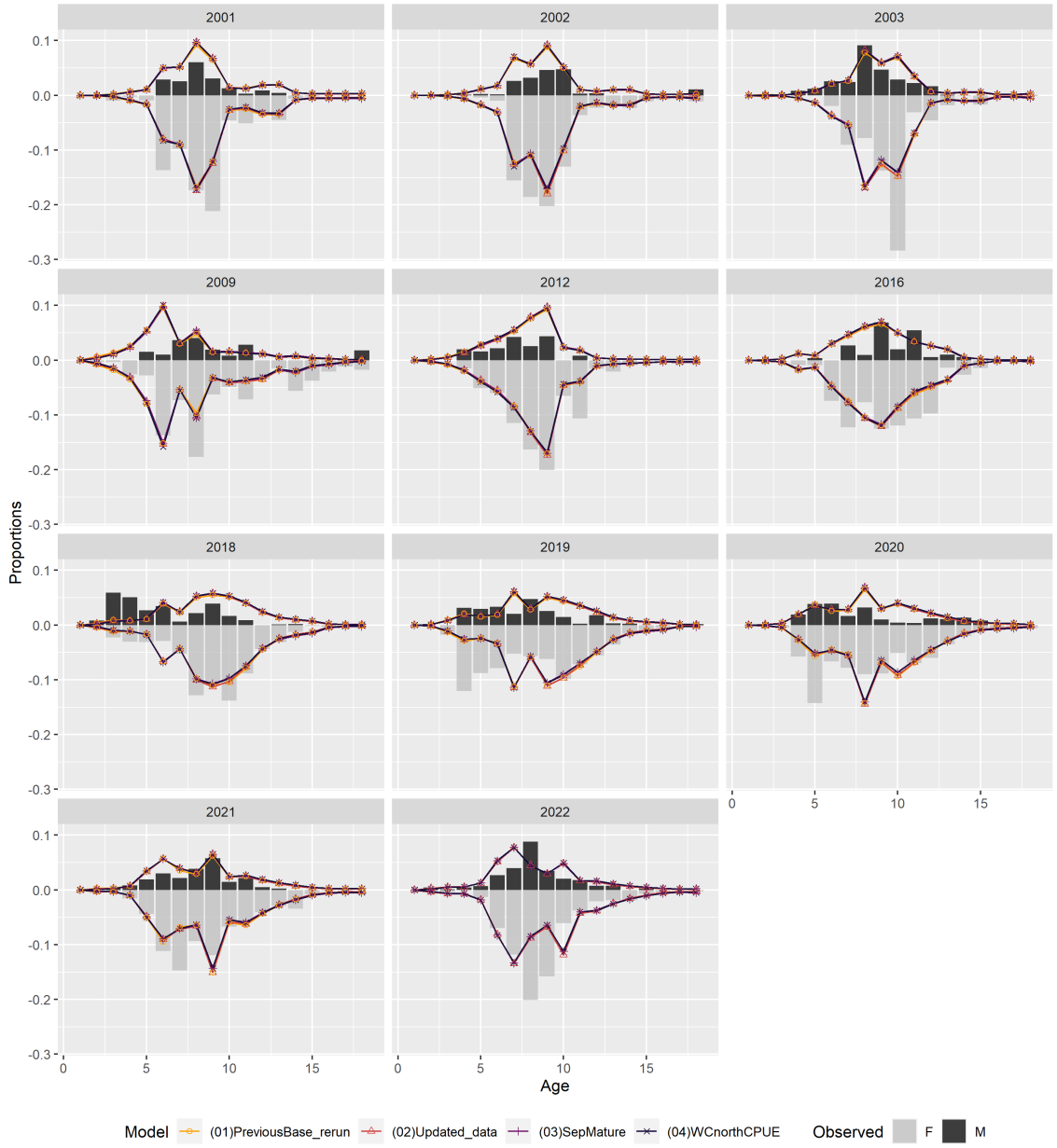


Figure 103: MPD fits to age composition data from models in Set One for FisherySubAntarcticSubaAge.

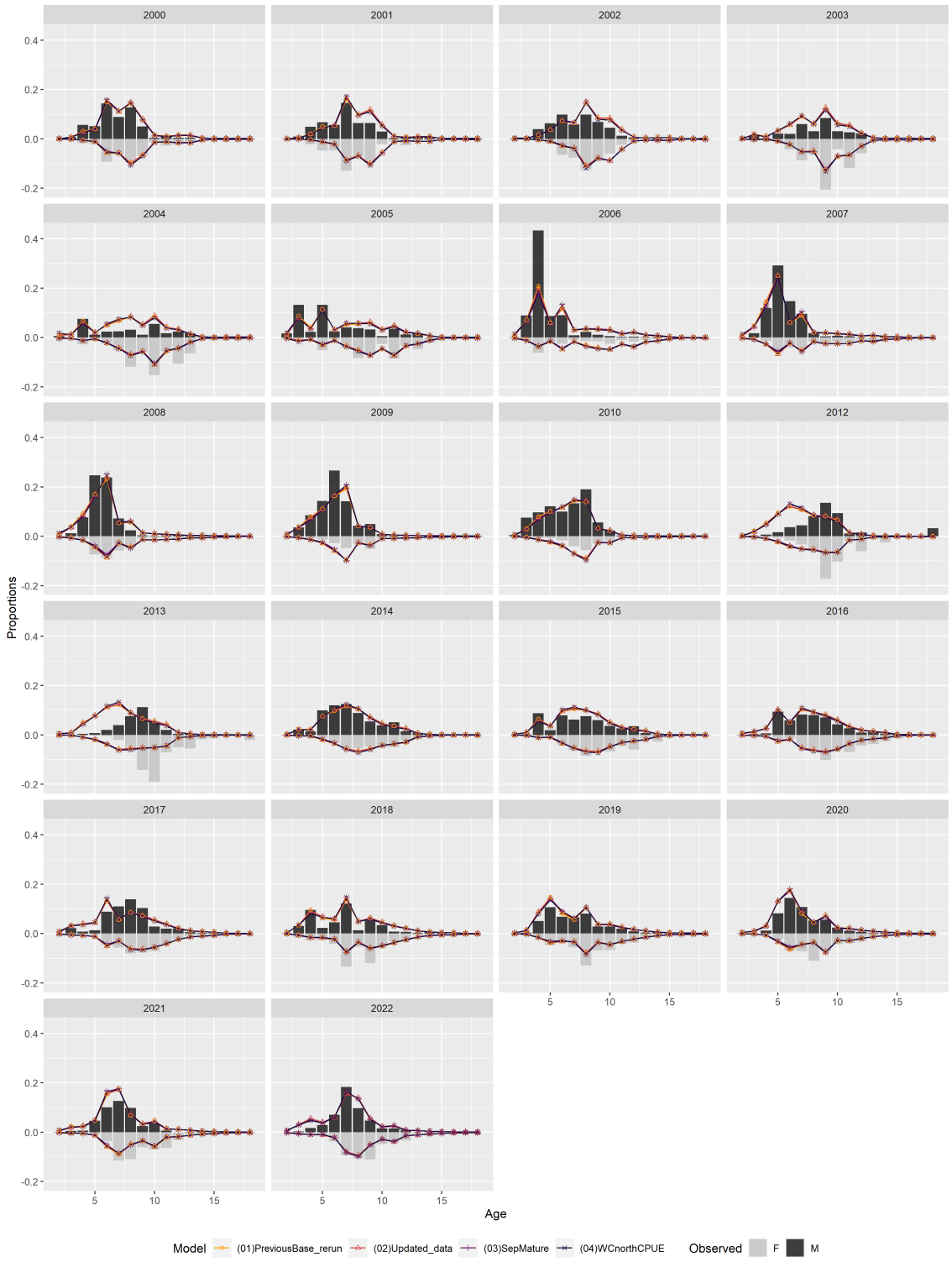


Figure 104: MPD fits to age composition data from models in Set One for FisheryWCSIInsideAge.

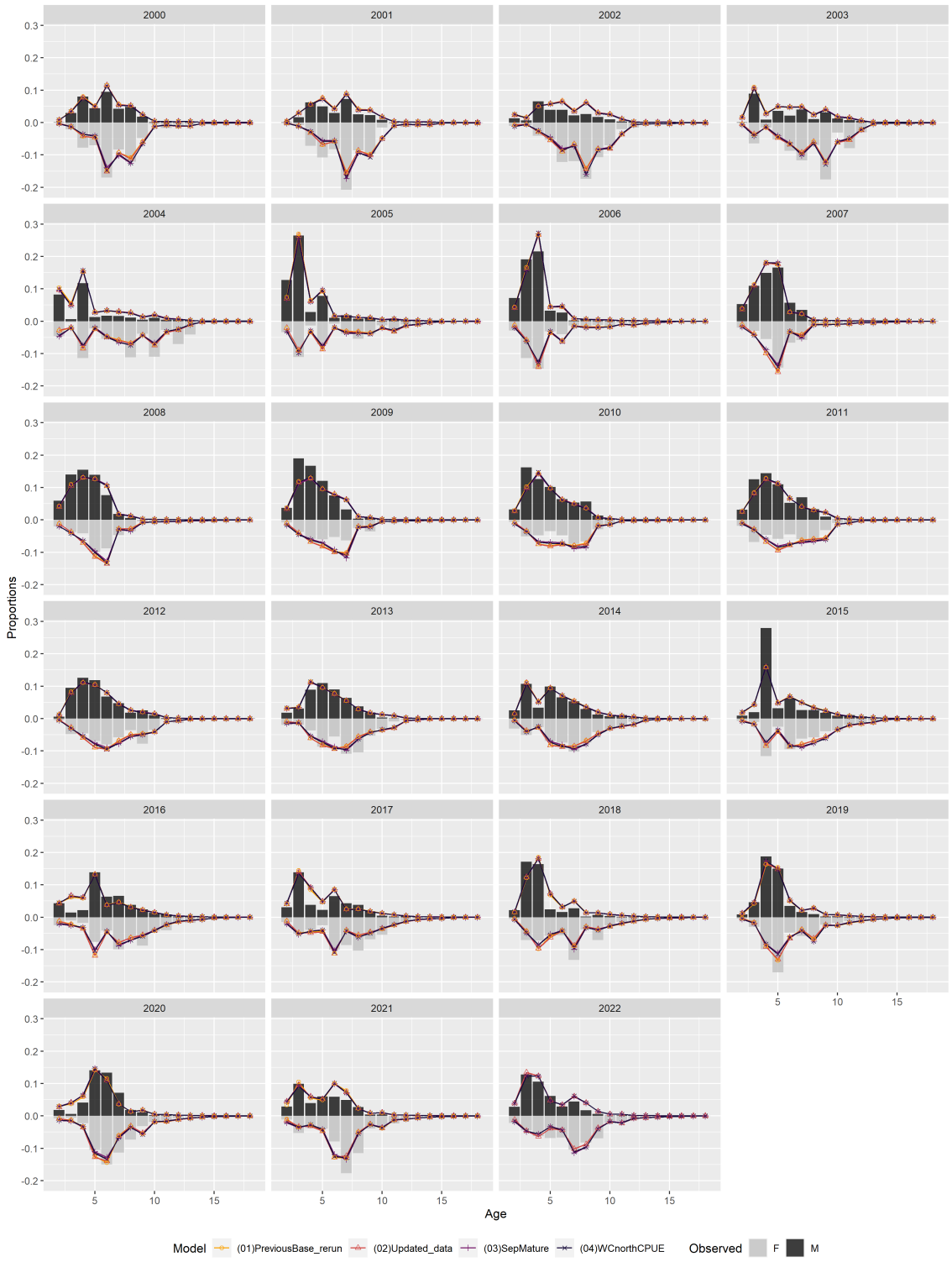


Figure 105: MPD fits to age composition data from models in Set One for FisheryWCSINorthFrom2000Age.

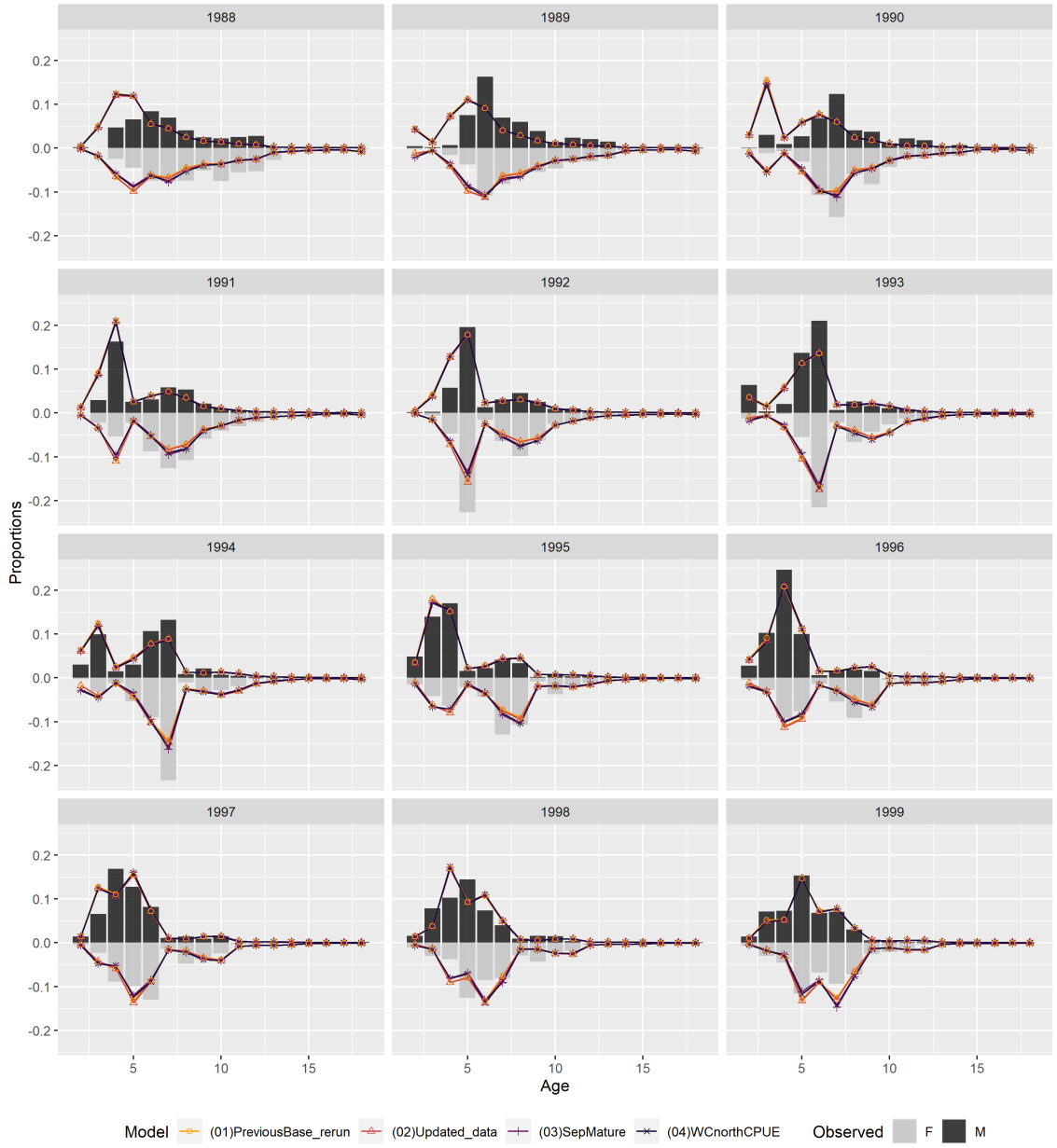


Figure 106: MPD fits to age composition data from models in Set One for FisheryWCSINorthPre2000Age.

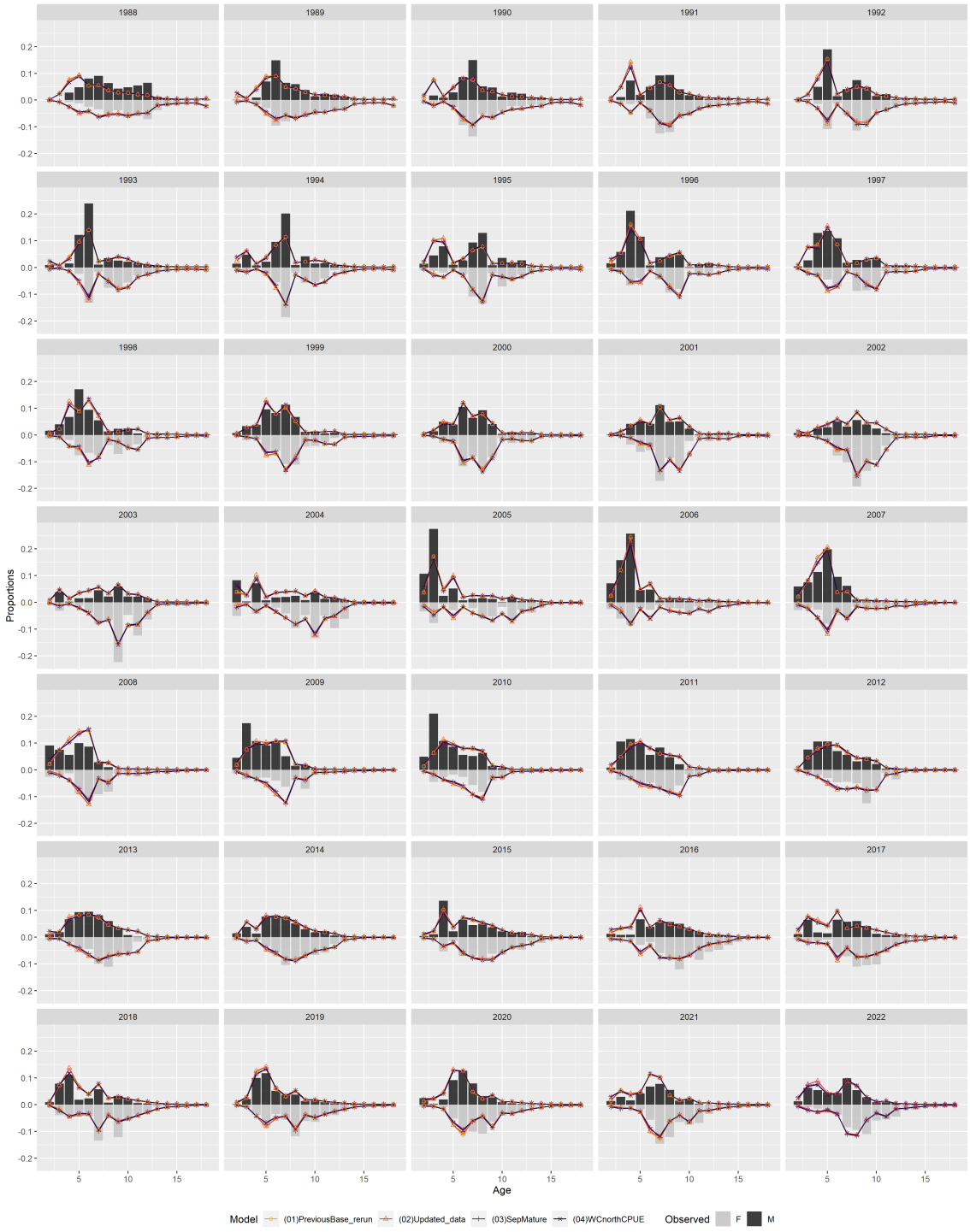


Figure 107: MPD fits to age composition data from models in Set One for FisheryWCSISouthAge.

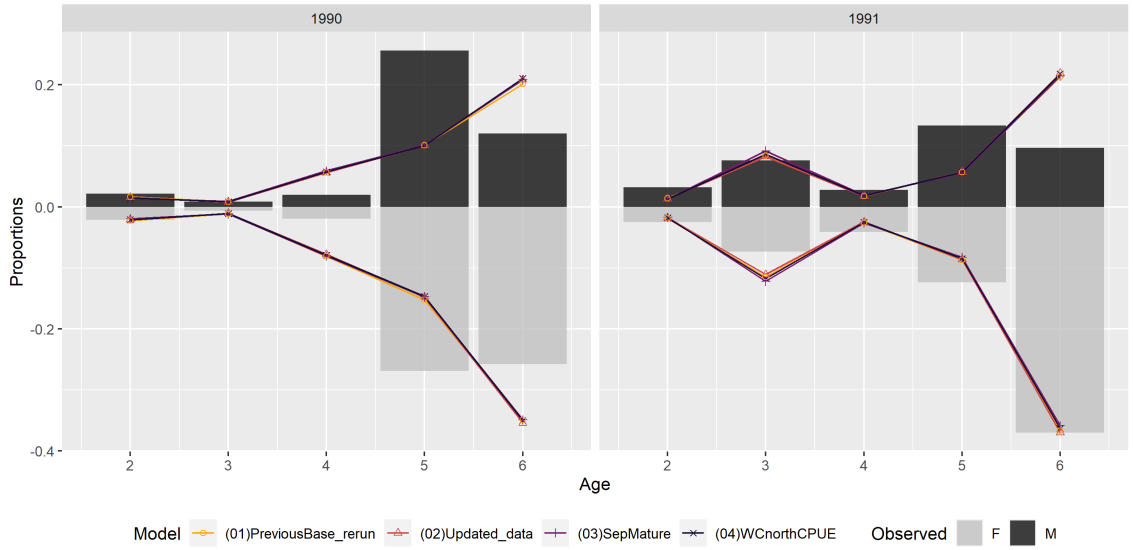


Figure 108: MPD fits to age composition data from models in Set One for SubAntarcticAEXAge.

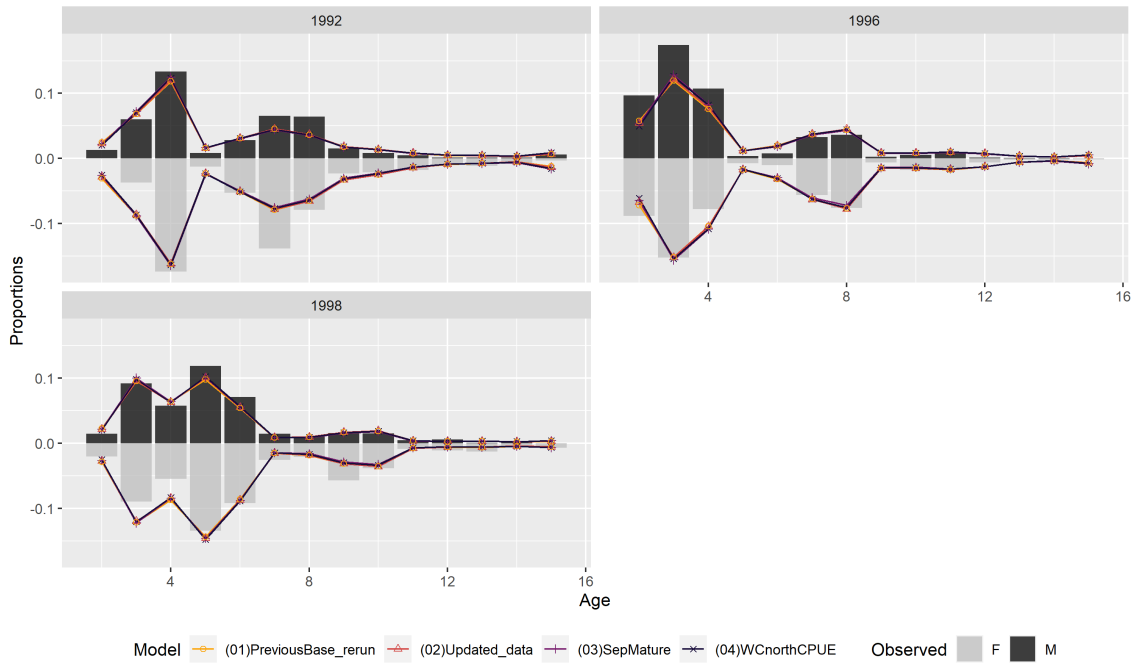


Figure 109: MPD fits to age composition data from models in Set One for SubAntarcticAutumnAge.

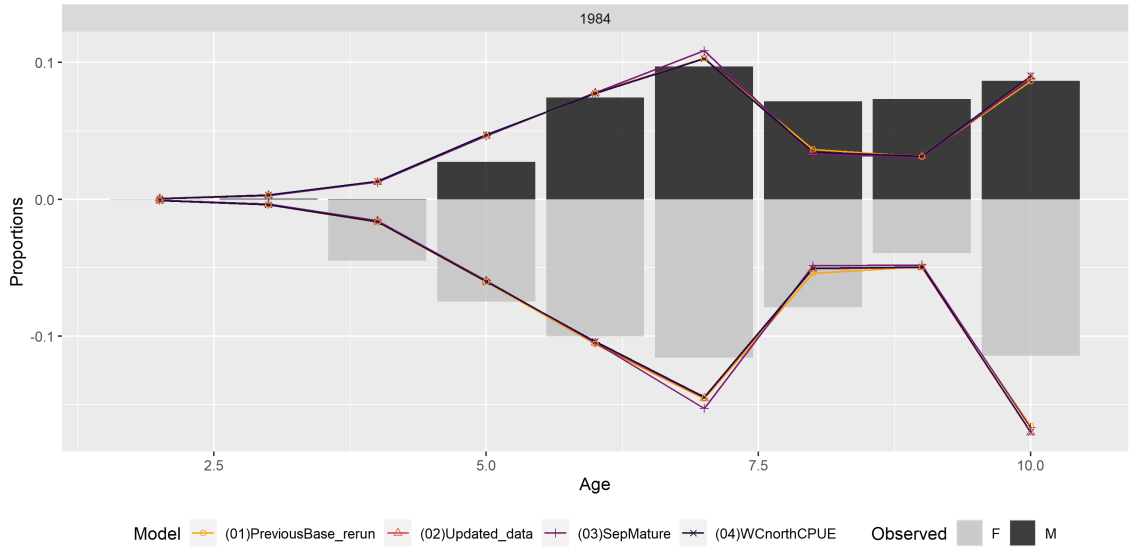


Figure 110: MPD fits to age composition data from models in Set One for SubAntarcticSHIAge.

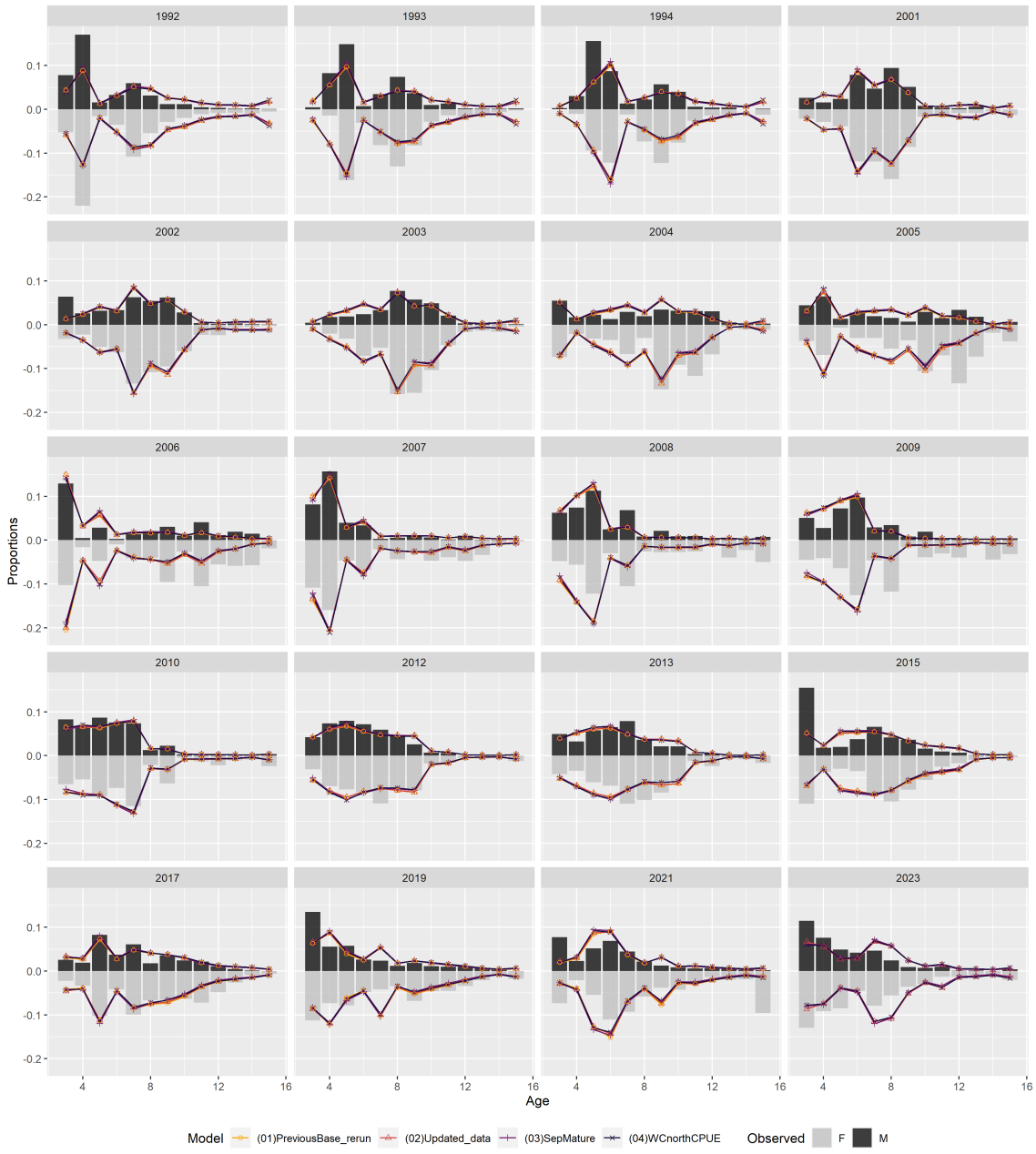


Figure 111: MPD fits to age composition data from models in Set One for SubAntarcticSummerAge.

D.3.2 Set Two

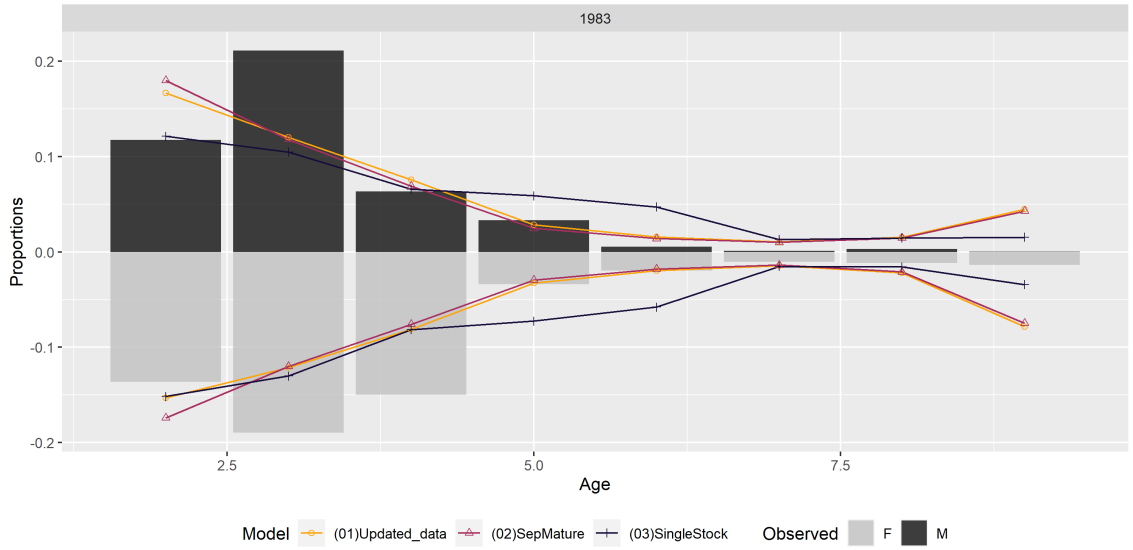


Figure 112: MPD fits to age composition data from models in Set Two for ChathamRiseSHIAge.

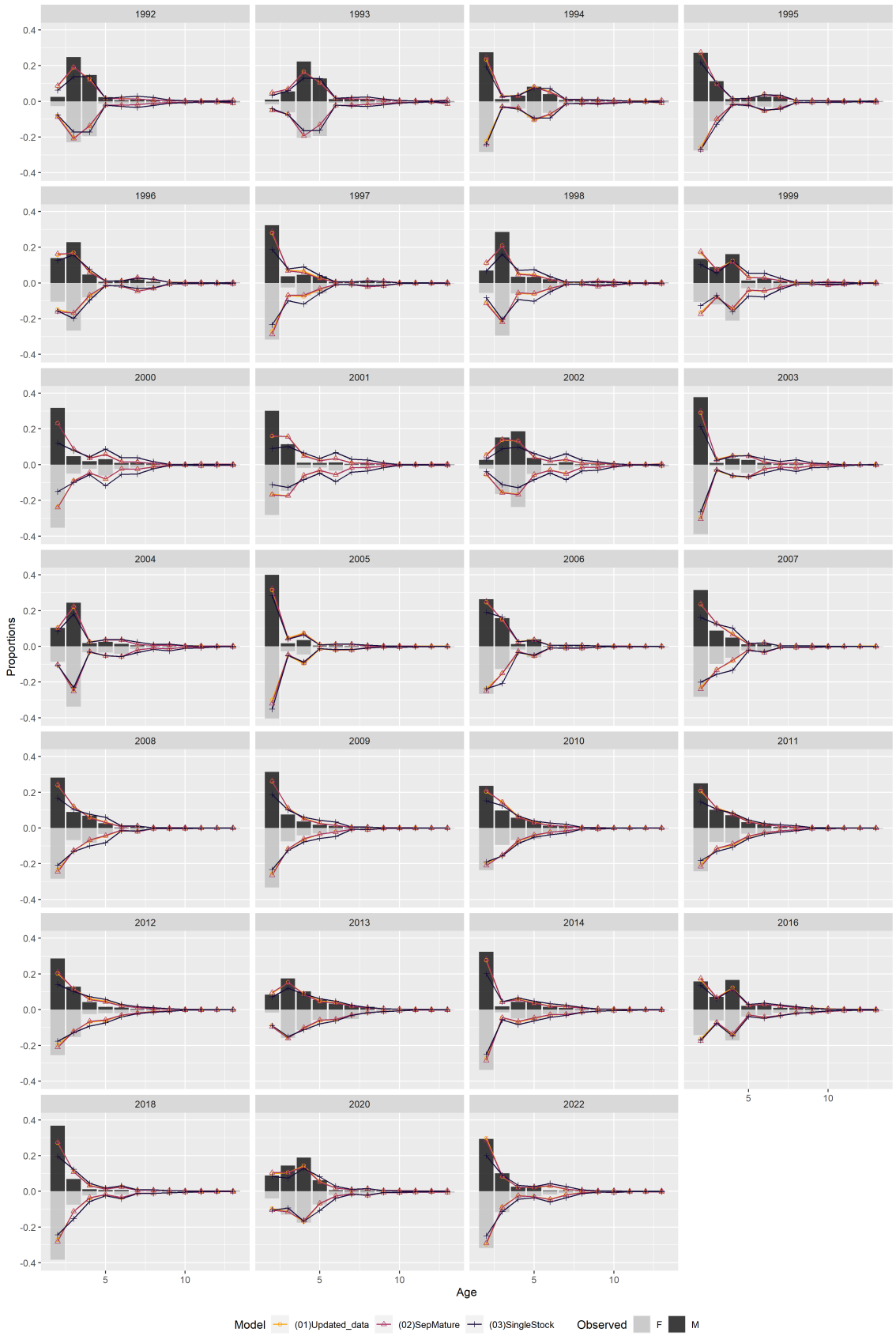


Figure 113: MPD fits to age composition data from models in Set Two for ChathamRiseSummerAge.

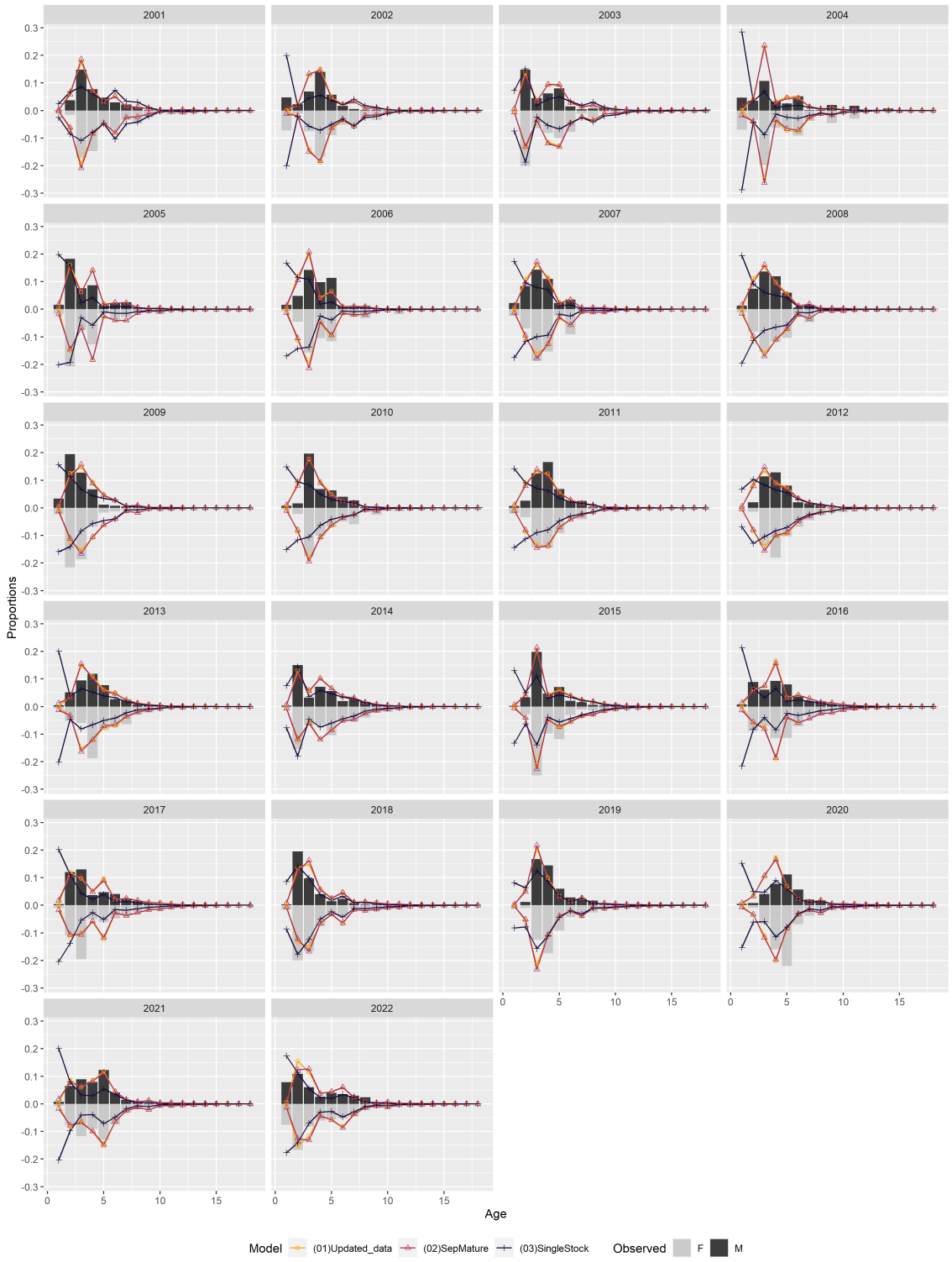


Figure 114: MPD fits to age composition data from models in Set Two for FisheryChathamRiseDeepAge.

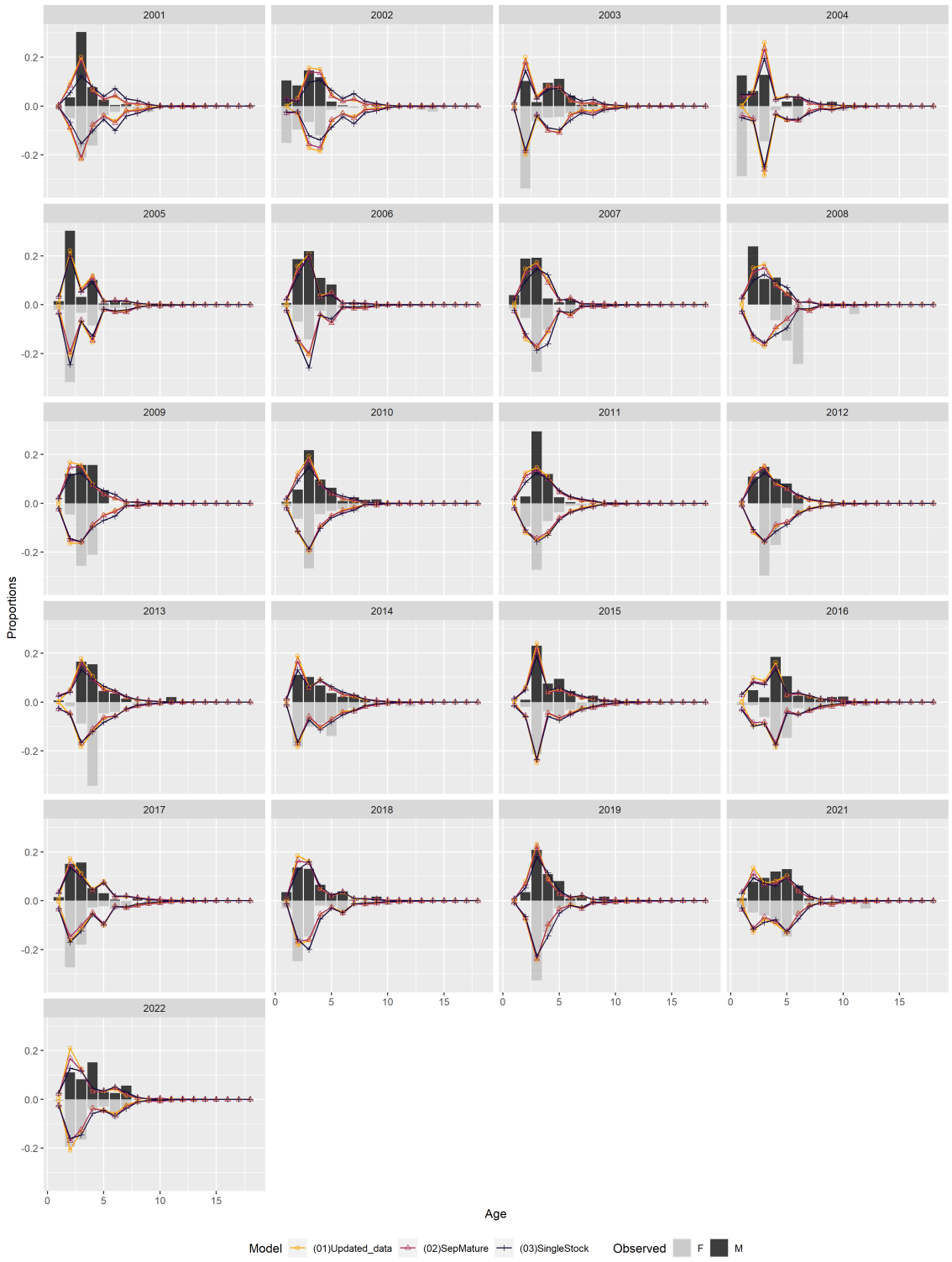


Figure 115: MPD fits to age composition data from models in Set Two for FisheryChathamRiseShallowAge.



Figure 116: MPD fits to age composition data from models in Set Two for FisheryCookStraitAge.

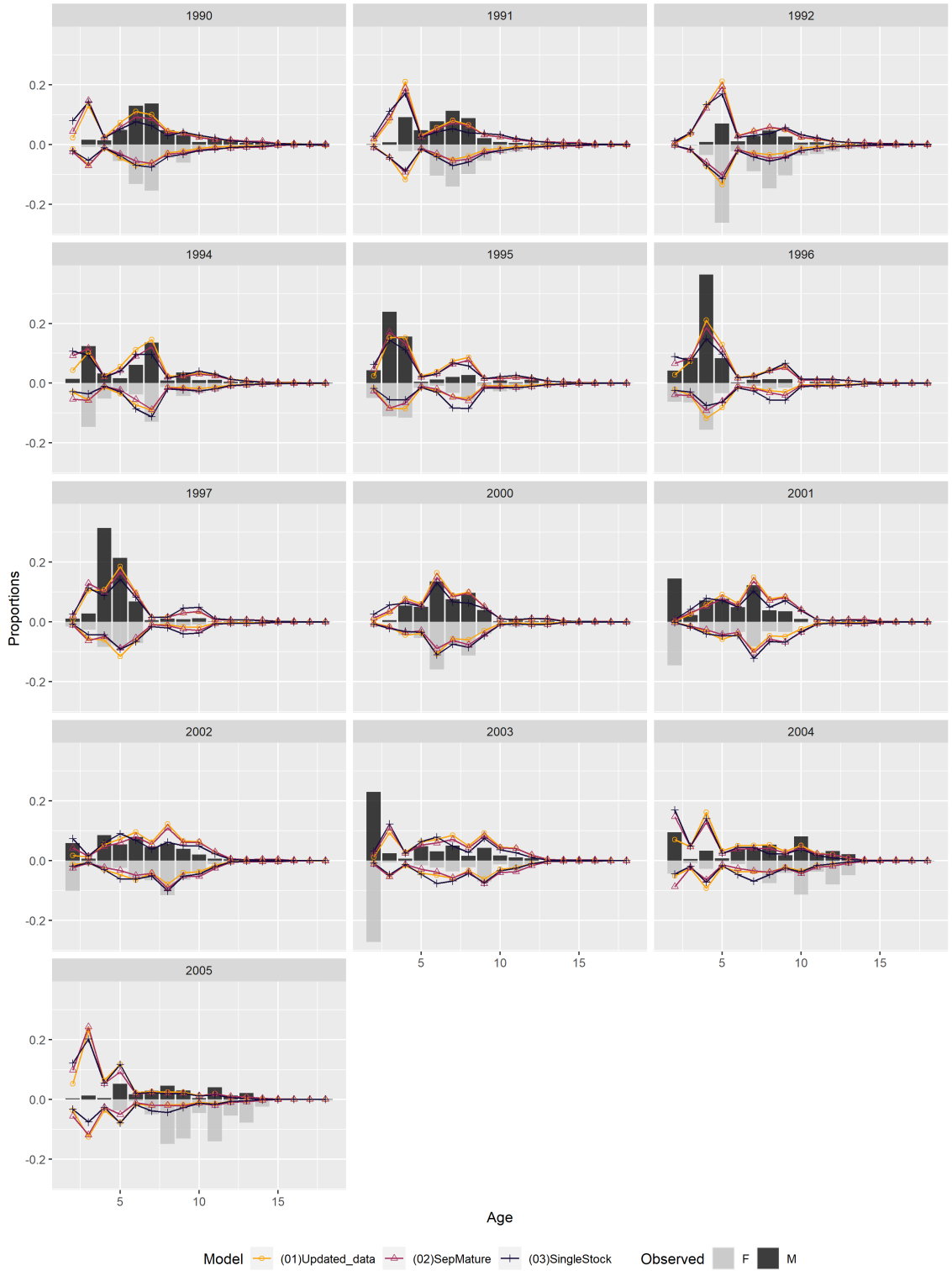


Figure 117: MPD fits to age composition data from models in Set Two for FisheryPuysegurSpawningAge.

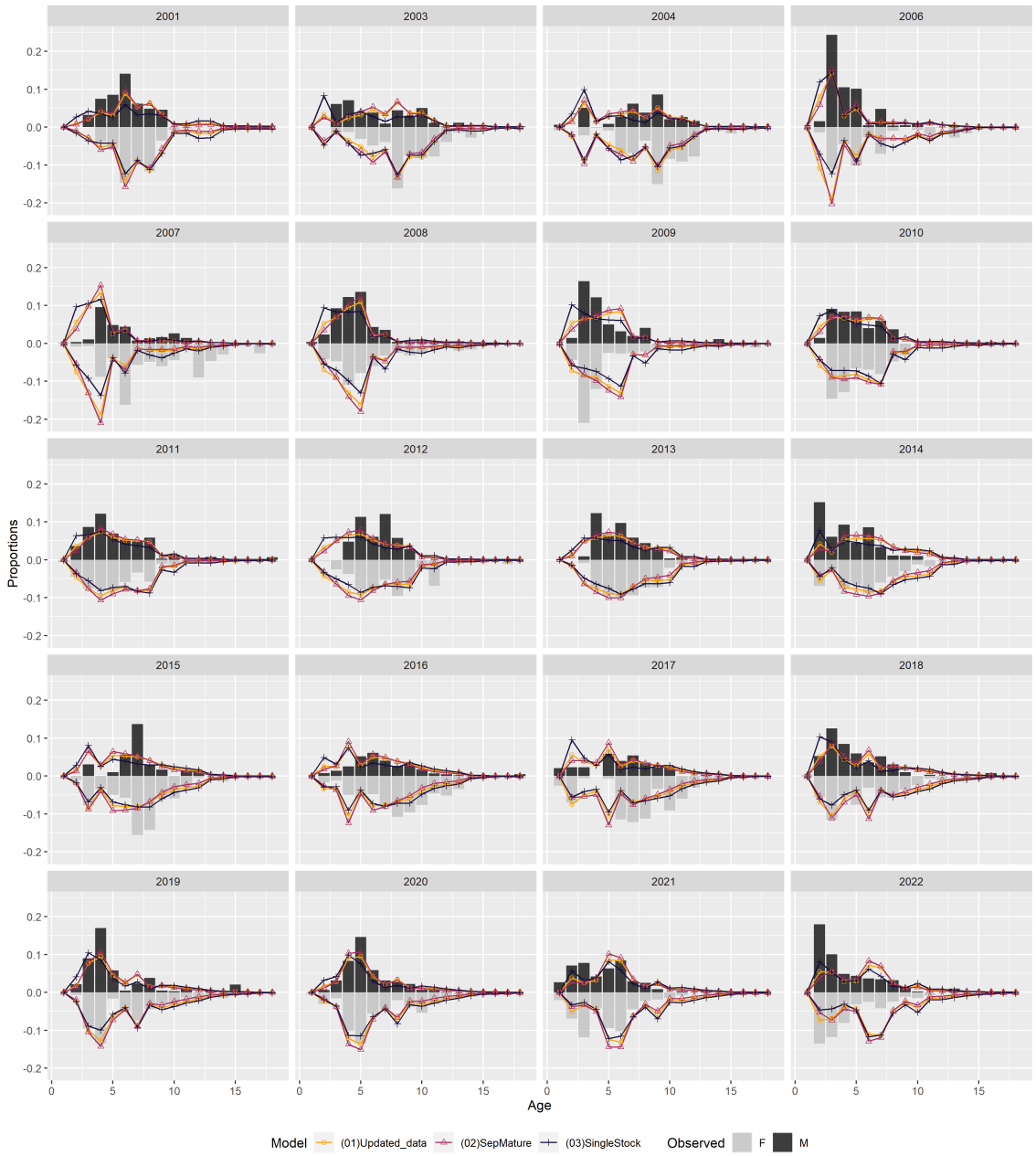


Figure 118: MPD fits to age composition data from models in Set Two for FisherySubAntarcticAucklandAge.

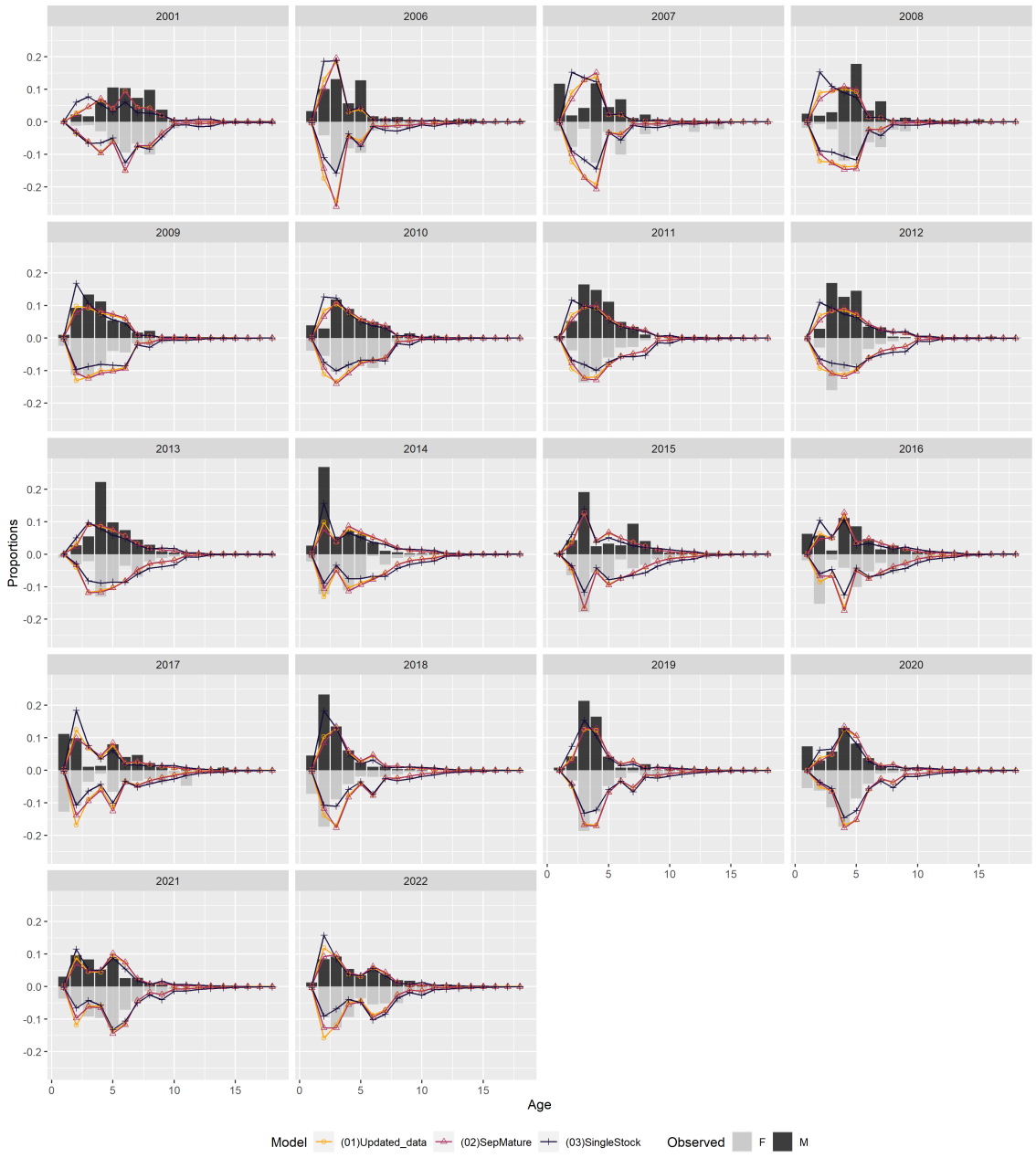


Figure 119: MPD fits to age composition data from models in Set Two for FisherySubAntarcticSnaresAge.

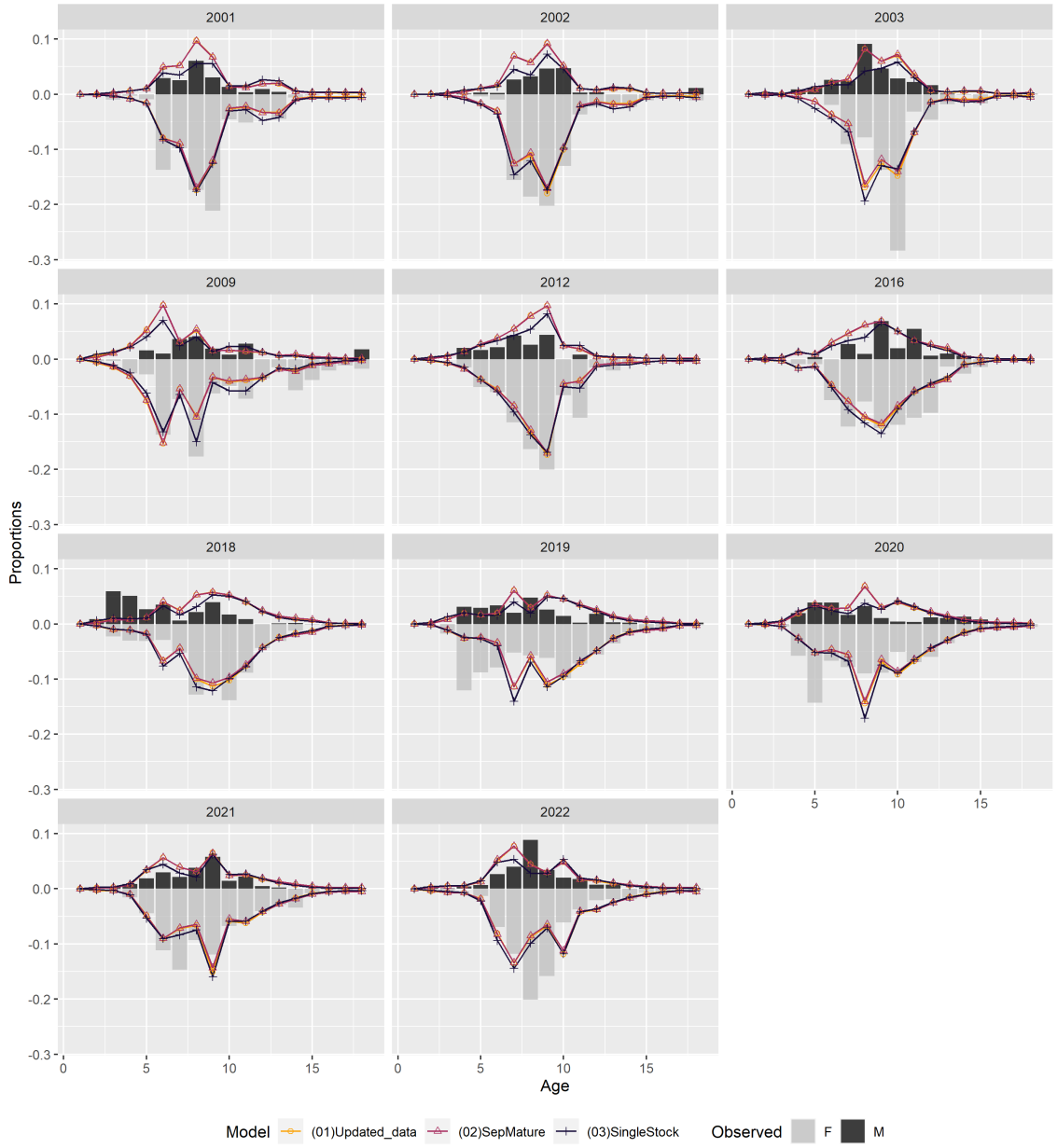


Figure 120: MPD fits to age composition data from models in Set Two for FisherySubAntarcticSubaAge.

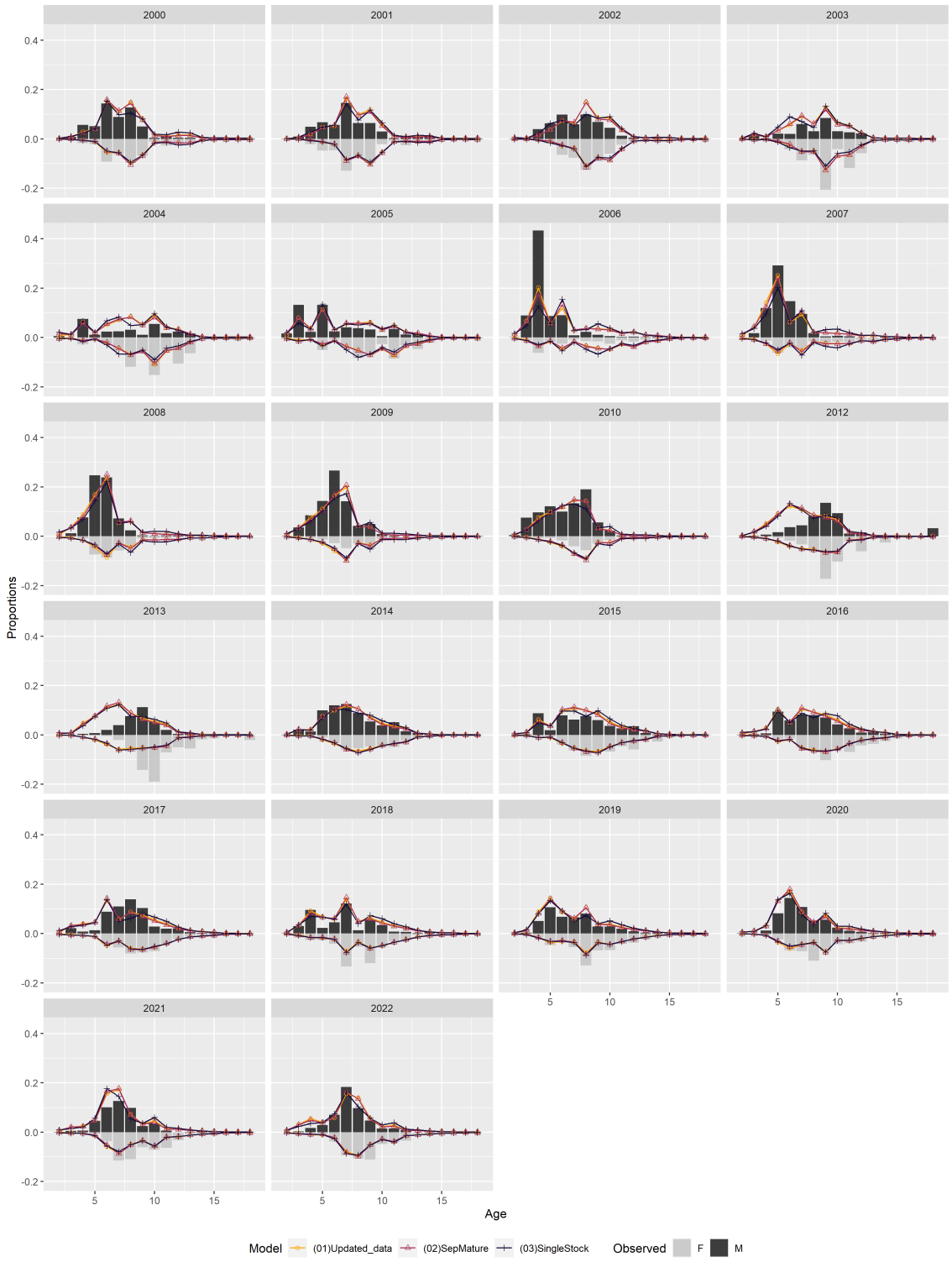


Figure 121: MPD fits to age composition data from models in Set Two for FisheryWCSIInsideAge.

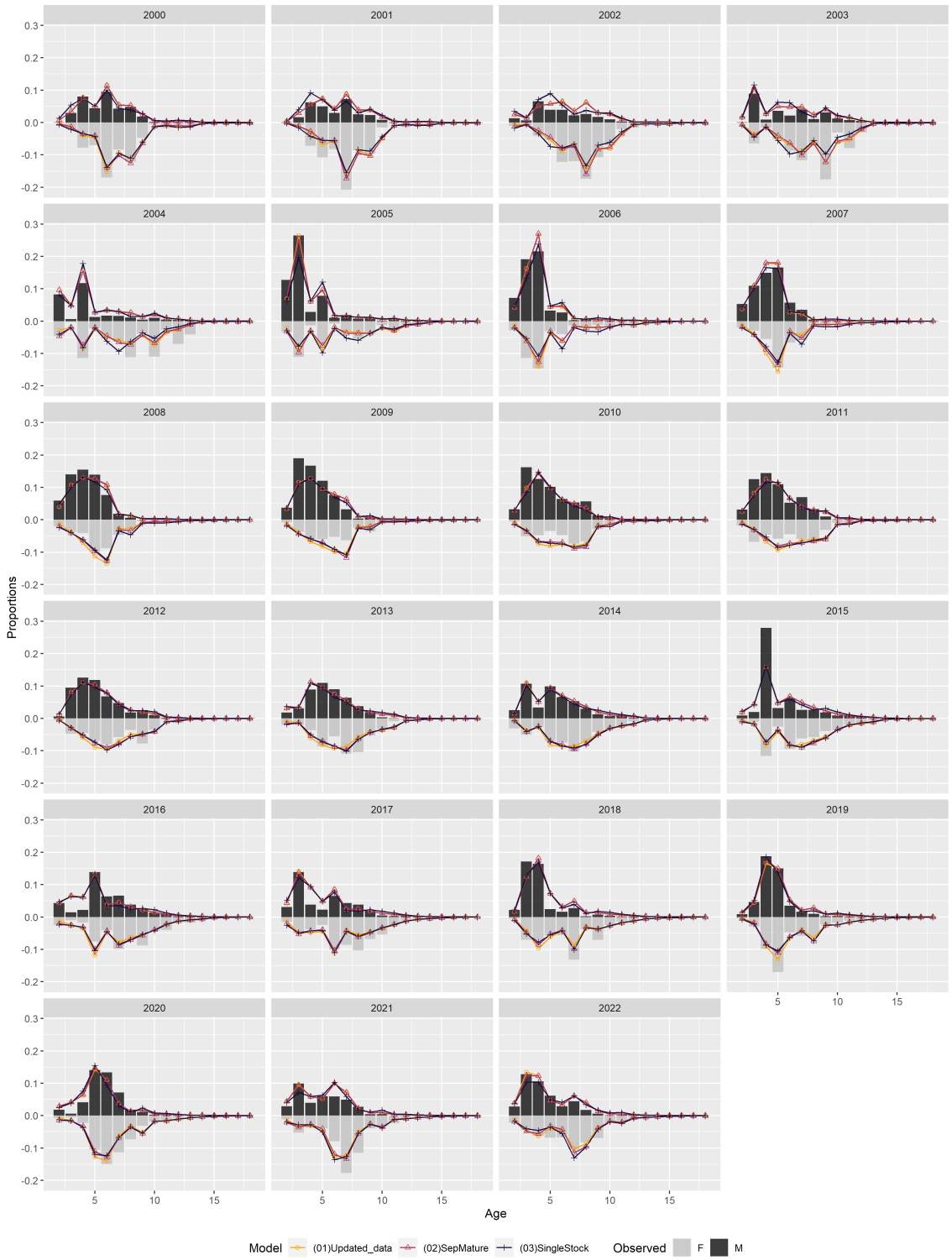


Figure 122: MPD fits to age composition data from models in Set Two for FisheryWCSINorthFrom2000Age.

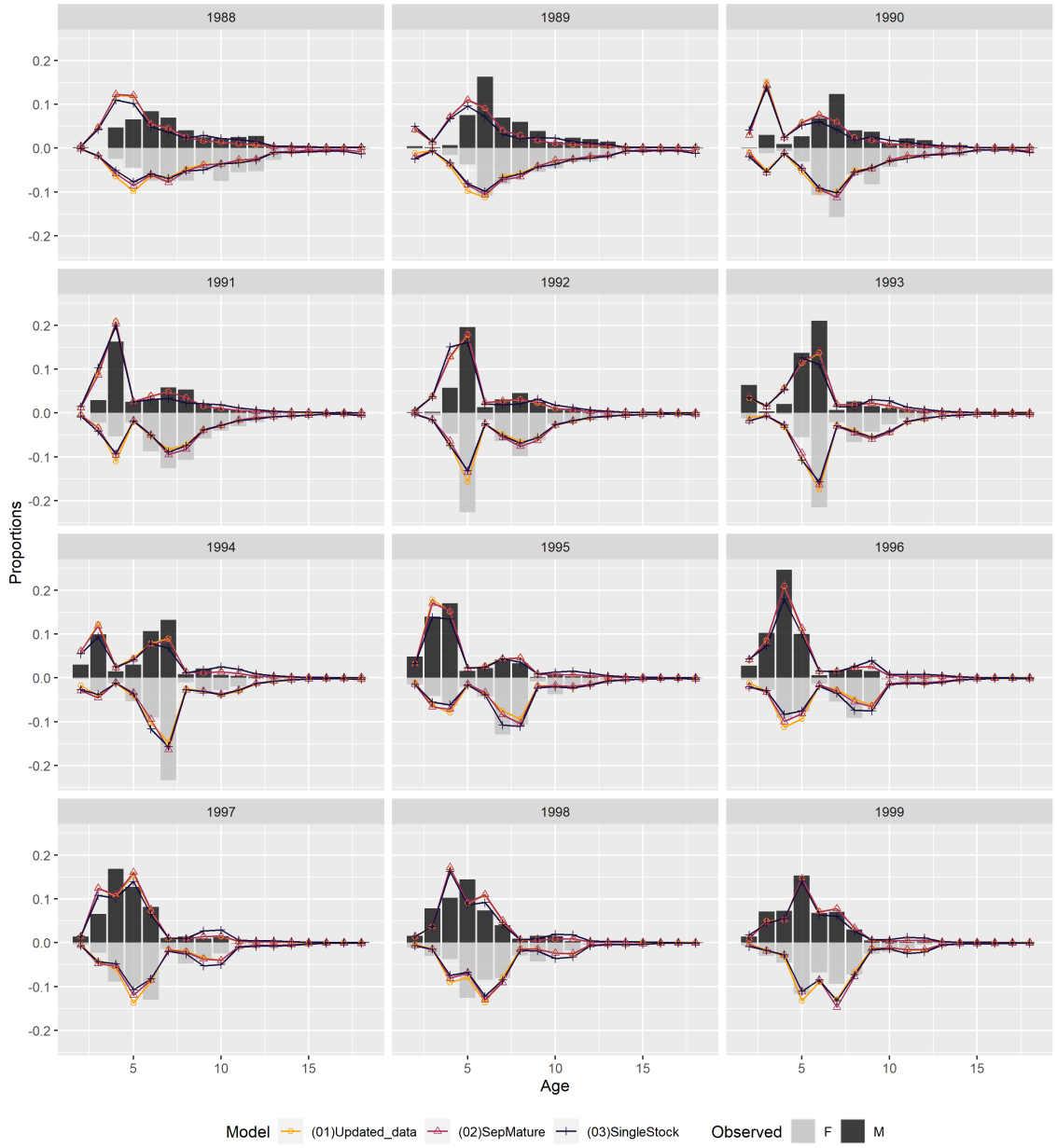


Figure 123: MPD fits to age composition data from models in Set Two for FisheryWCSINorthPre2000Age.



Figure 124: MPD fits to age composition data from models in Set Two for FisheryWCSISouthAge.

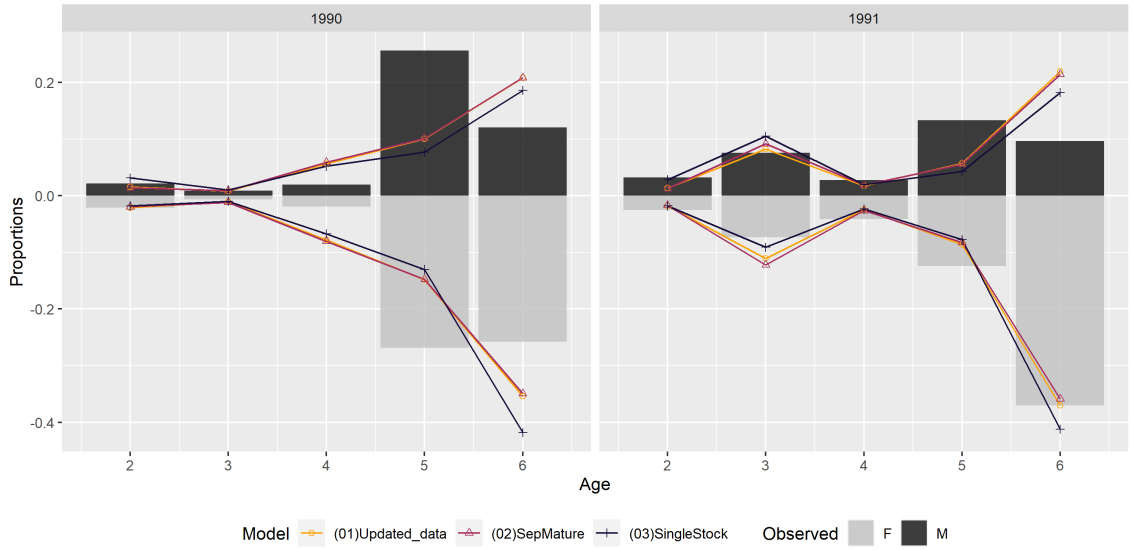


Figure 125: MPD fits to age composition data from models in Set Two for SubAntarcticAEXAge.

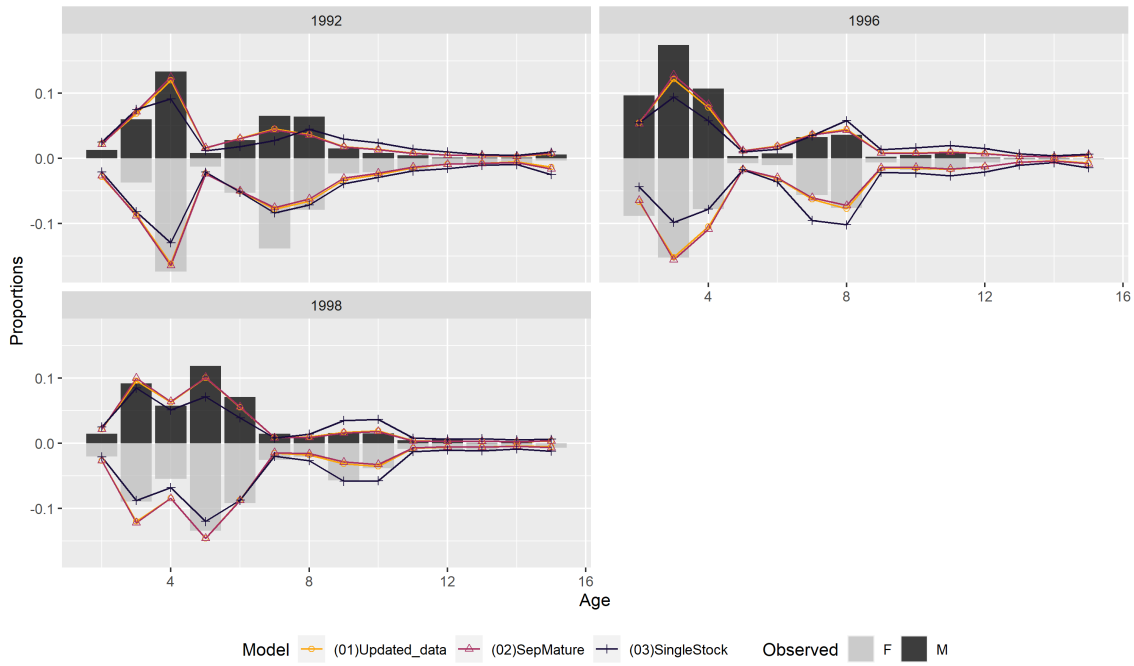


Figure 126: MPD fits to age composition data from models in Set Two for SubAntarcticAutumnAge.

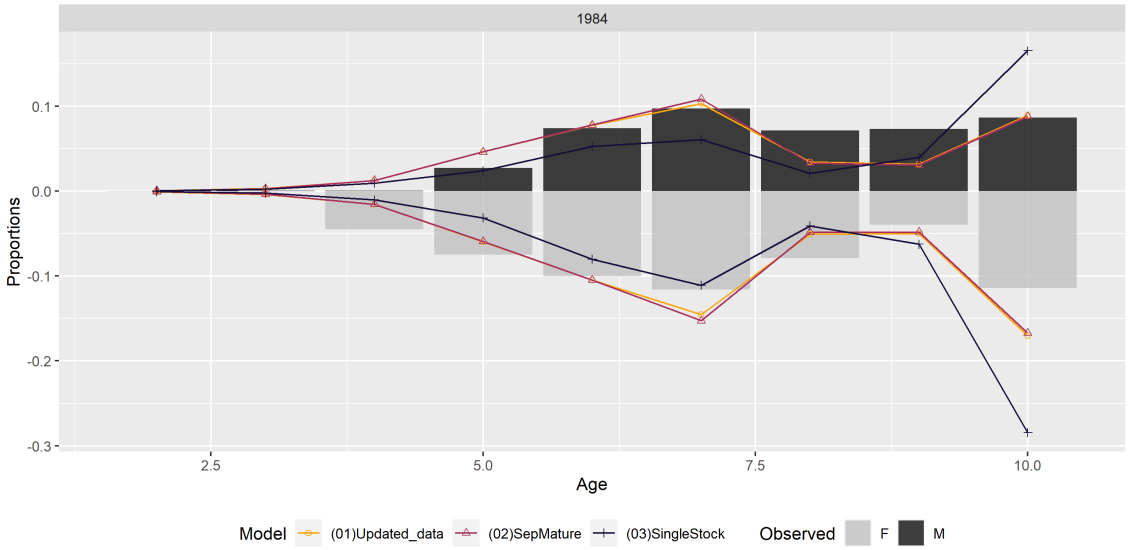


Figure 127: MPD fits to age composition data from models in Set Two for SubAntarcticSHIAge.

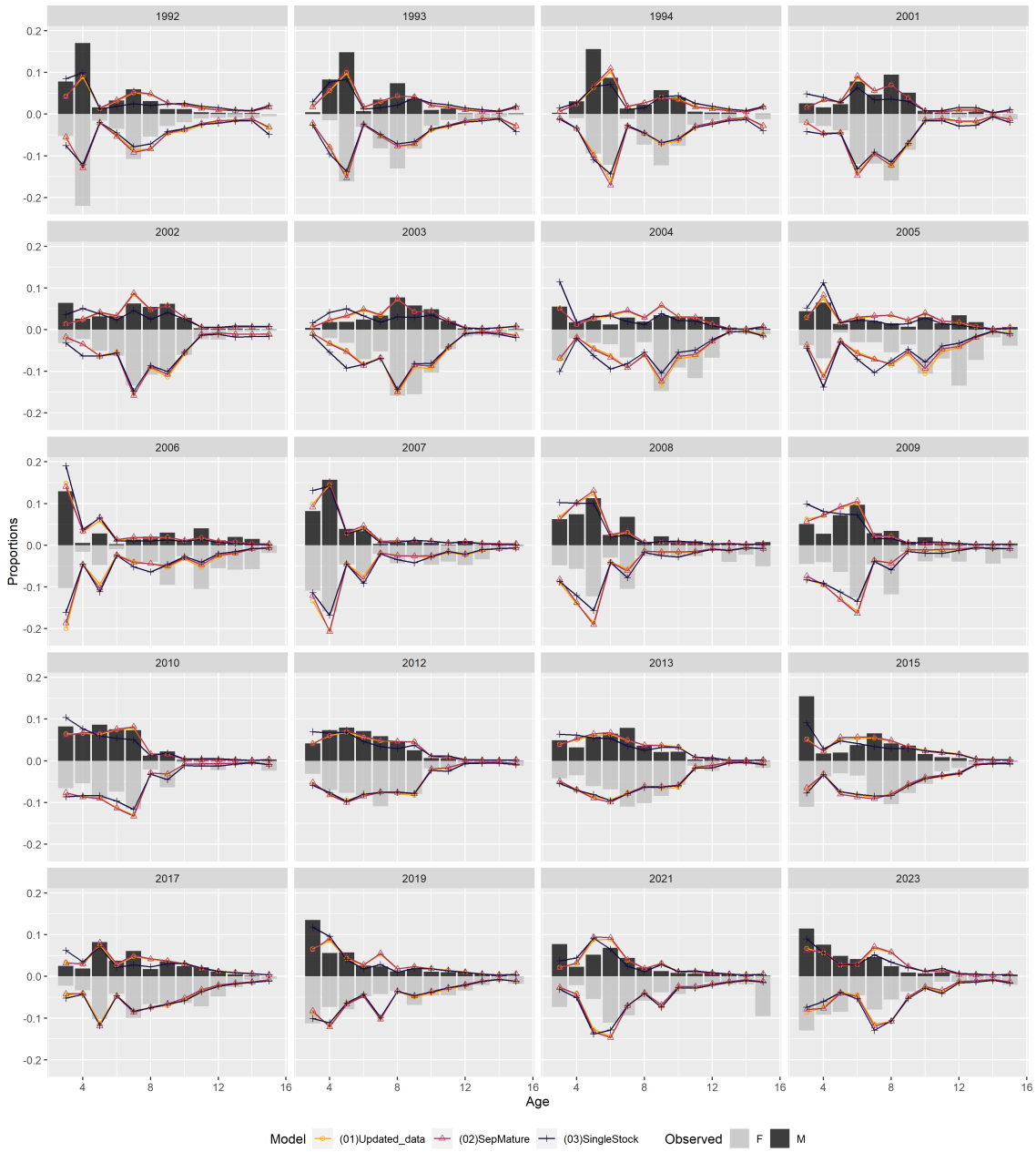


Figure 128: MPD fits to age composition data from models in Set Two for SubAntarcticSummerAge.

D.4 Parameter sensitivity age summary fits

D.4.1 Natural mortality

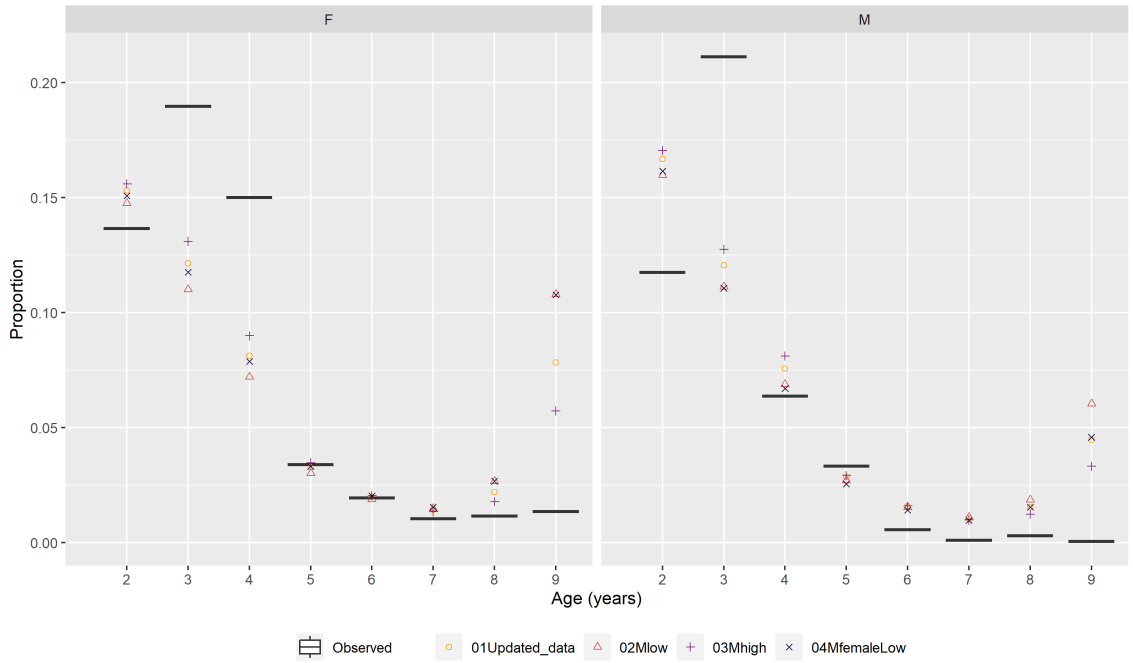


Figure 129: Summary of MPD fits to age composition data from models in natural mortality sensitivities for ChathamRiseSHIAge.

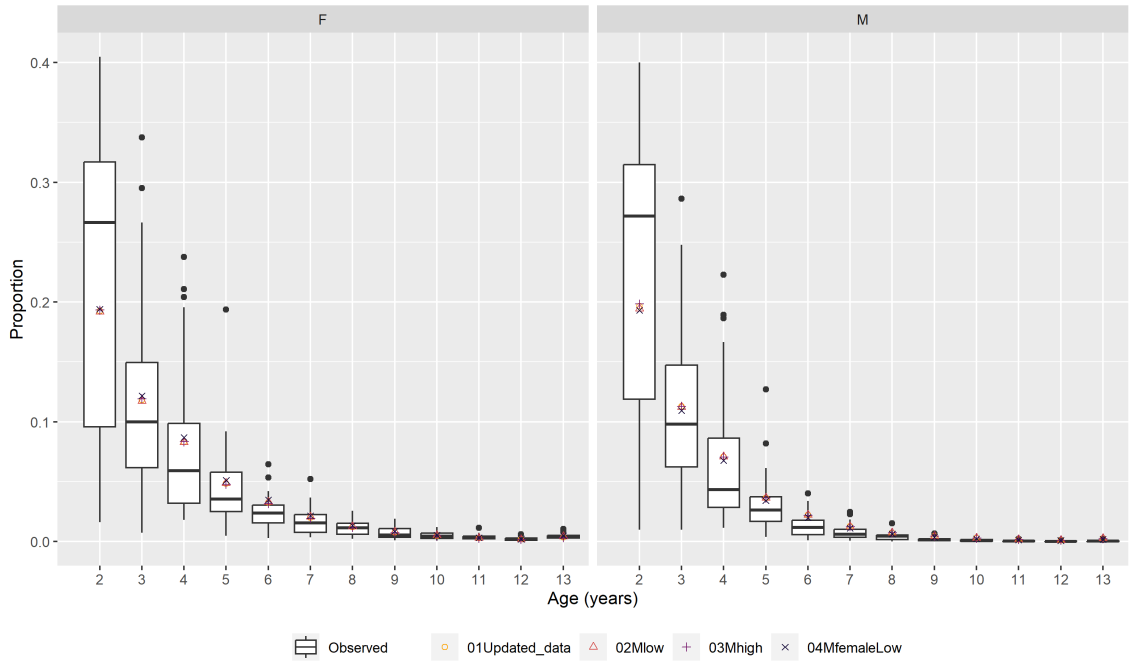


Figure 130: Summary of MPD fits to age composition data from models in natural mortality sensitivities for ChathamRiseSummerAge.

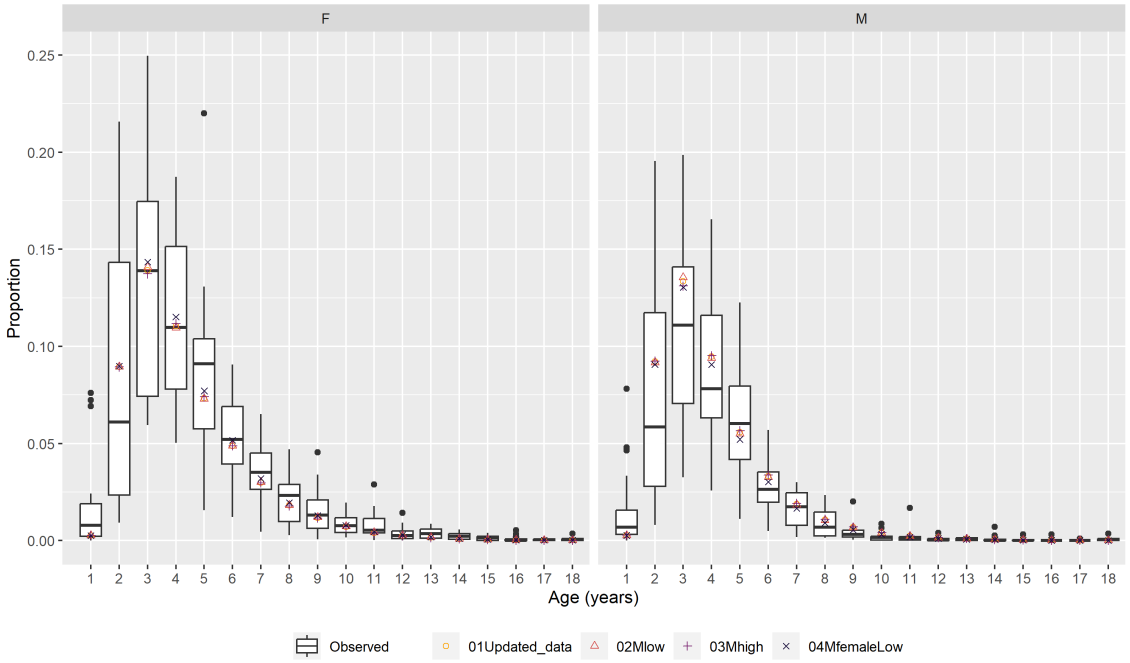


Figure 131: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryChathamRiseDeepAge.

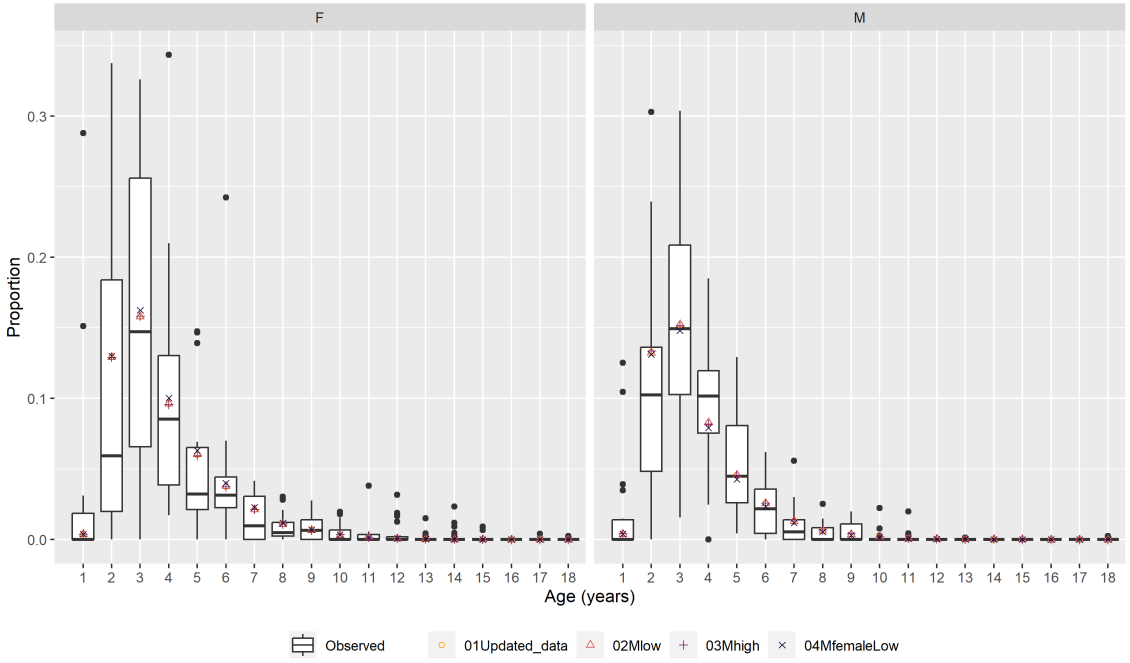


Figure 132: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryChathamRiseShallowAge.

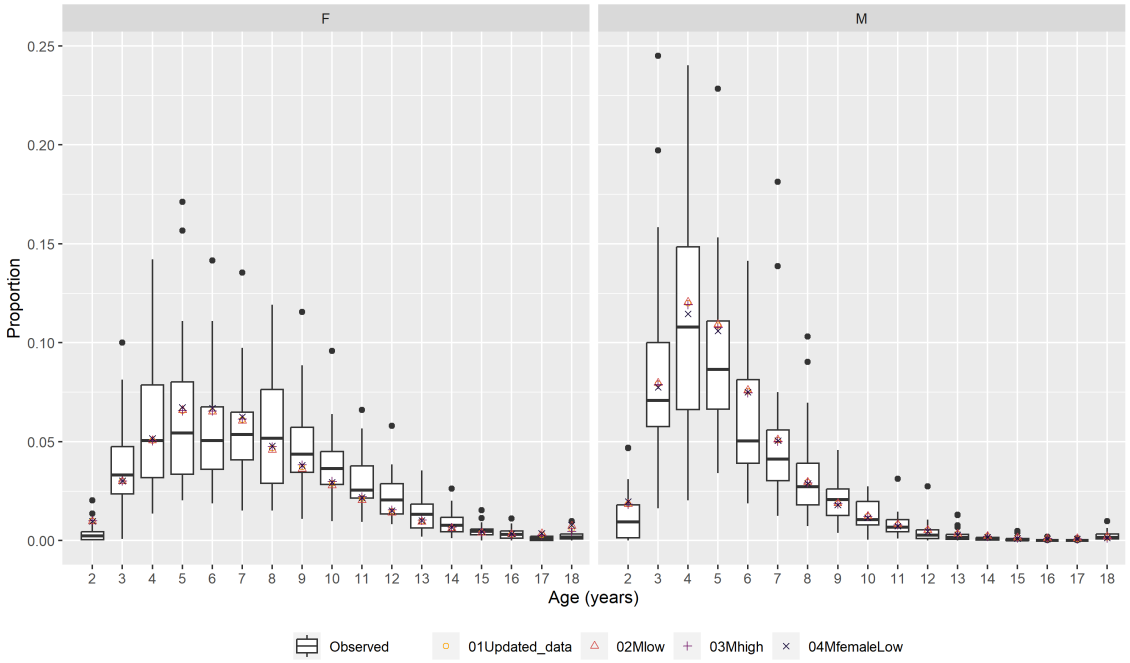


Figure 133: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryCookStraitAge.

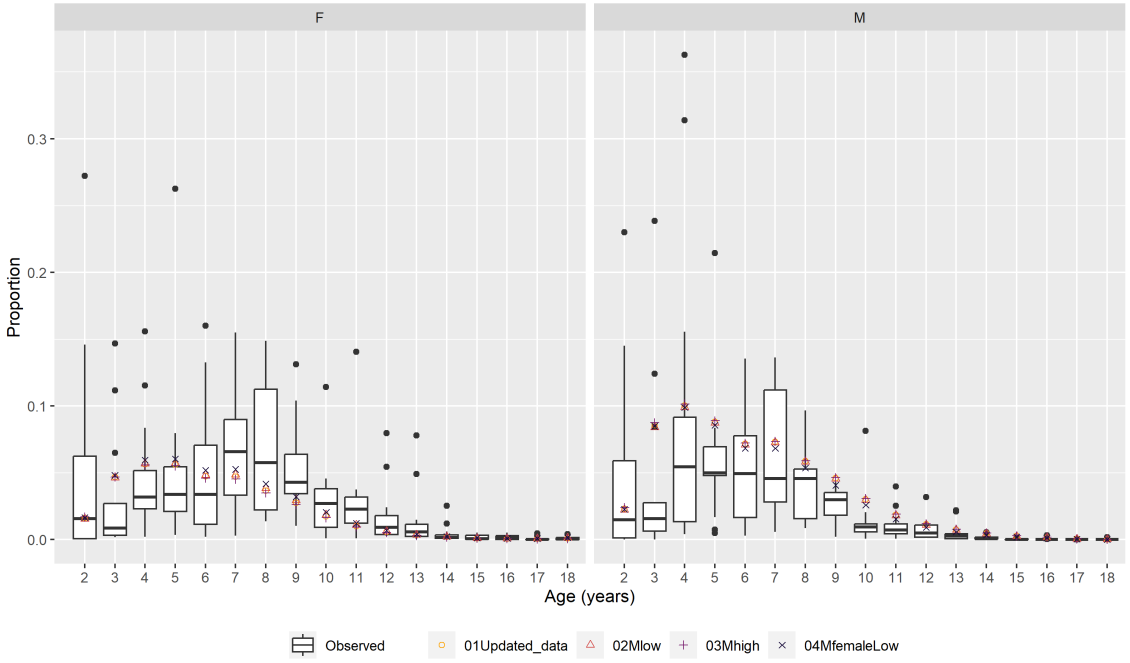


Figure 134: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryPuysegurSpawningAge.

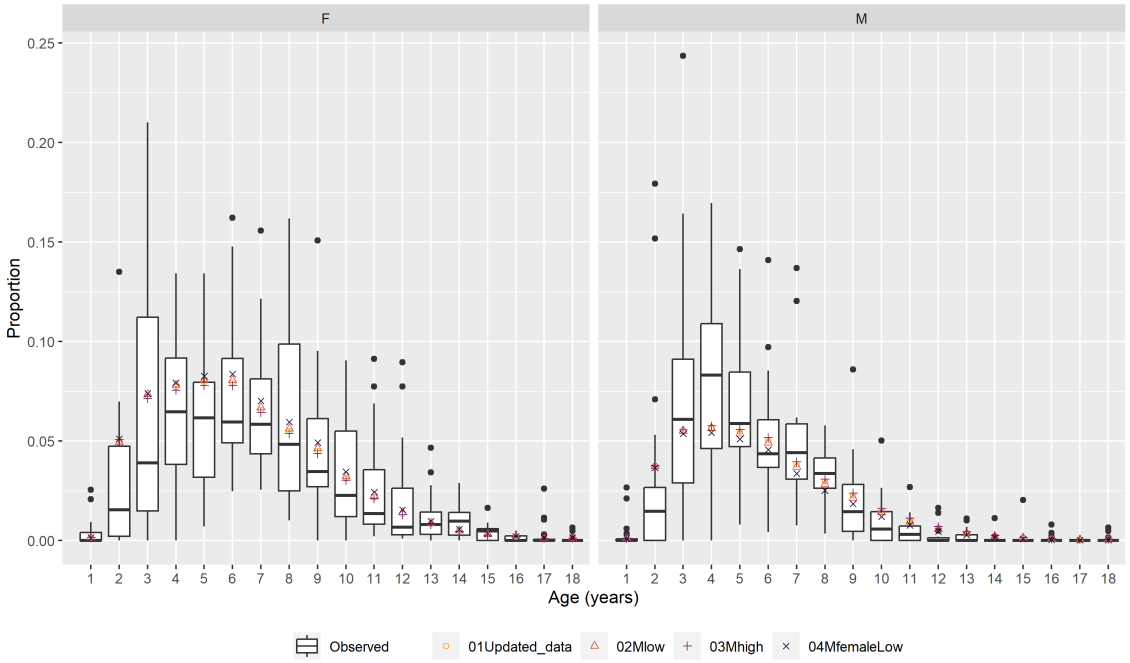


Figure 135: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisherySubAntarcticAucklandAge.

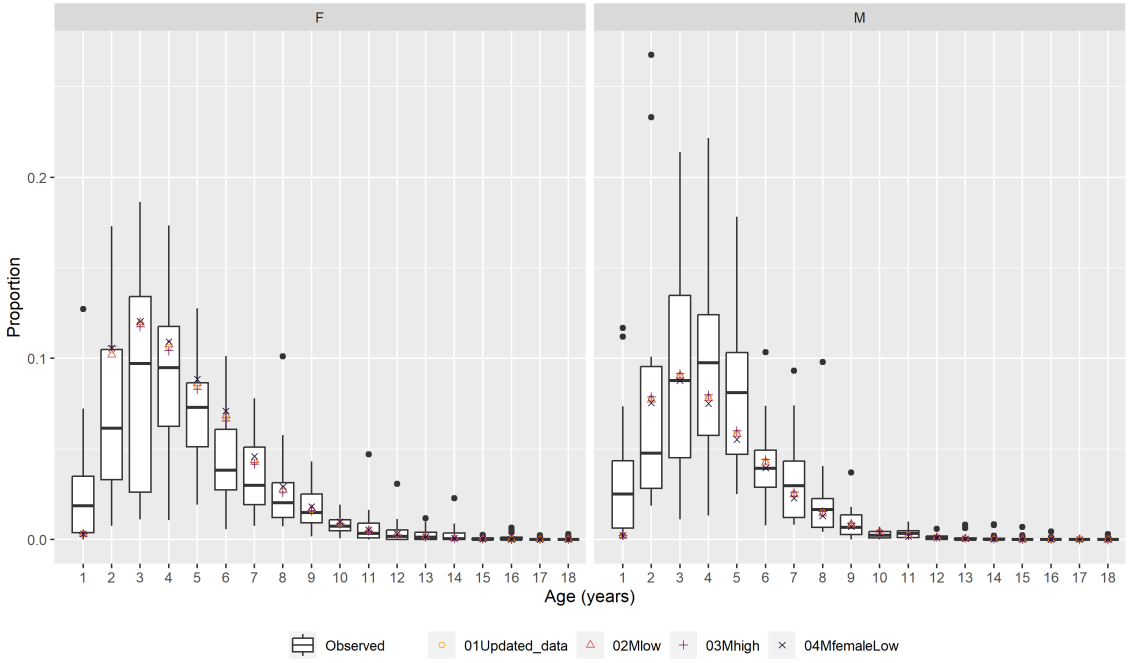


Figure 136: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisherySubAntarcticSnaresAge.

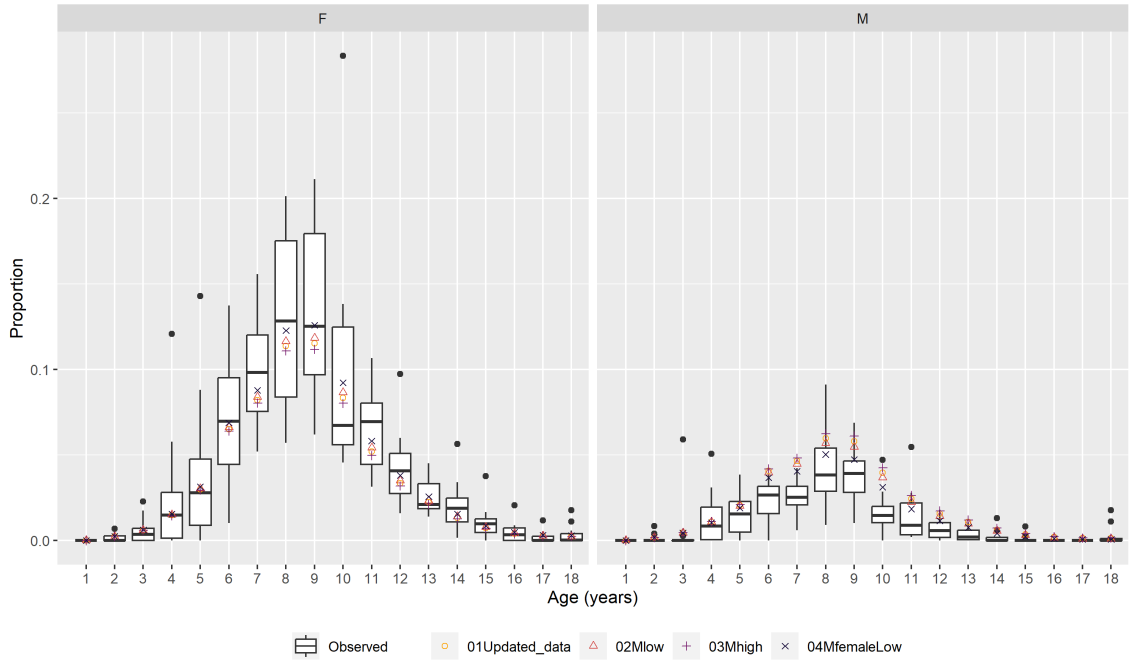


Figure 137: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisherySubAntarcticSubaAge.

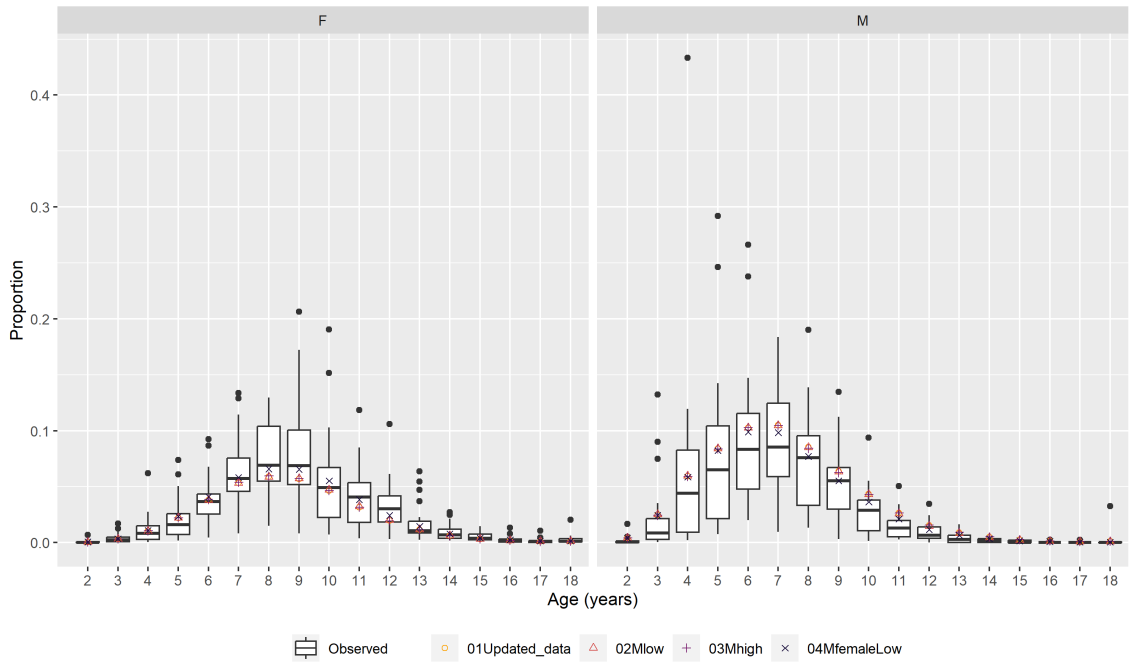


Figure 138: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryWCSIInsideAge.

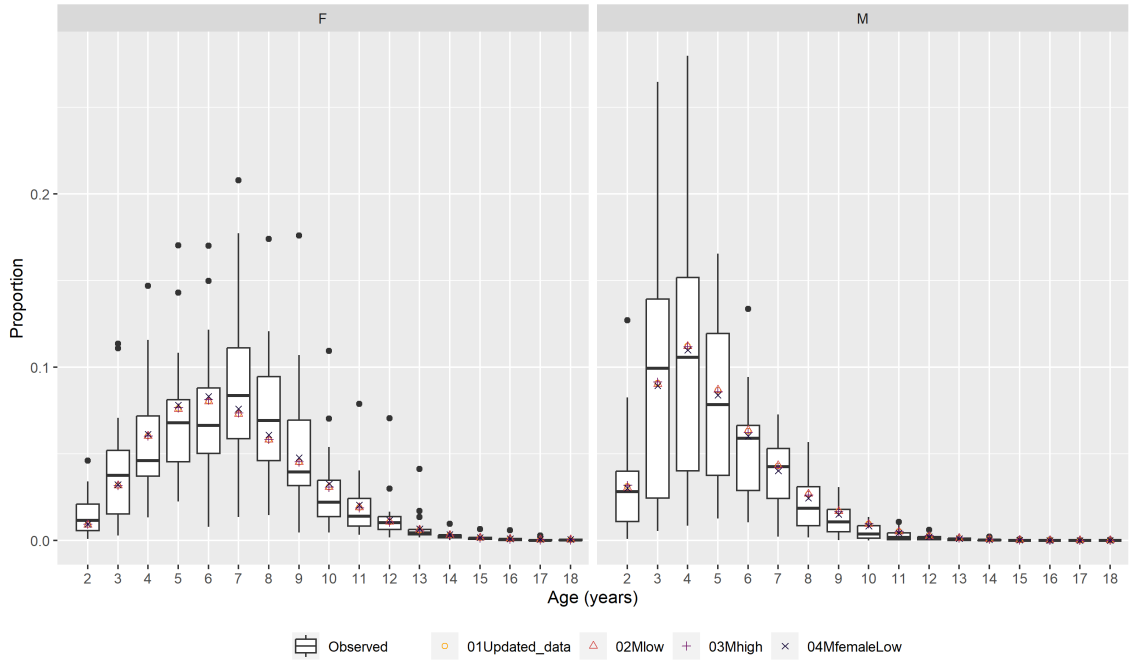


Figure 139: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryWCSINorthFrom2000Age.

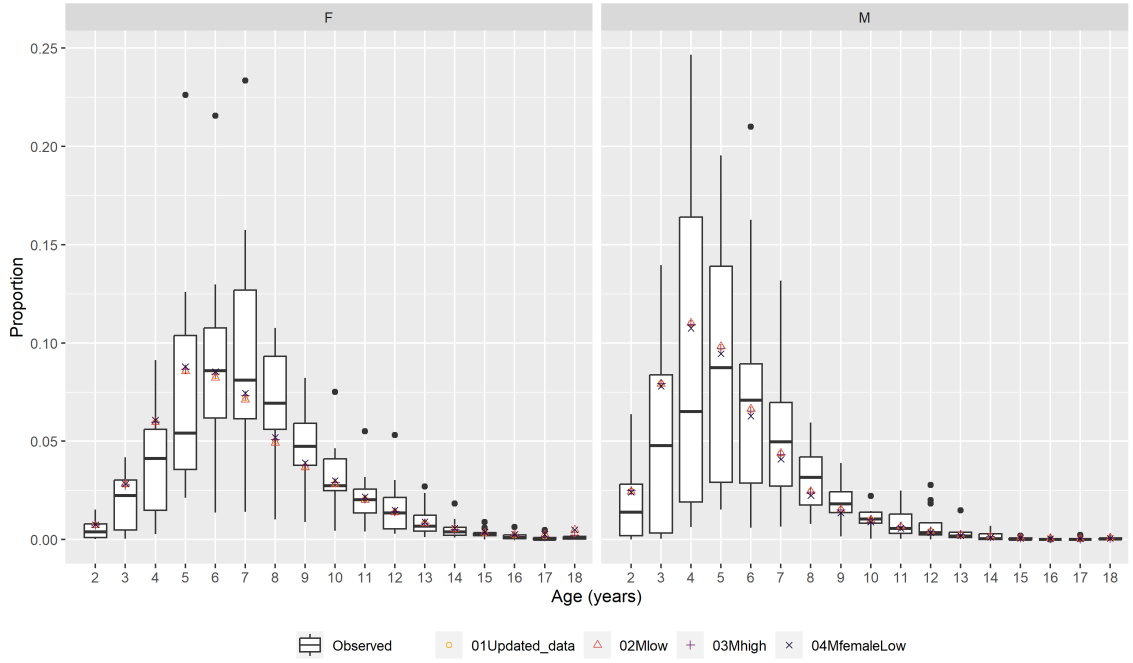


Figure 140: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryWCSINorthPre2000Age.

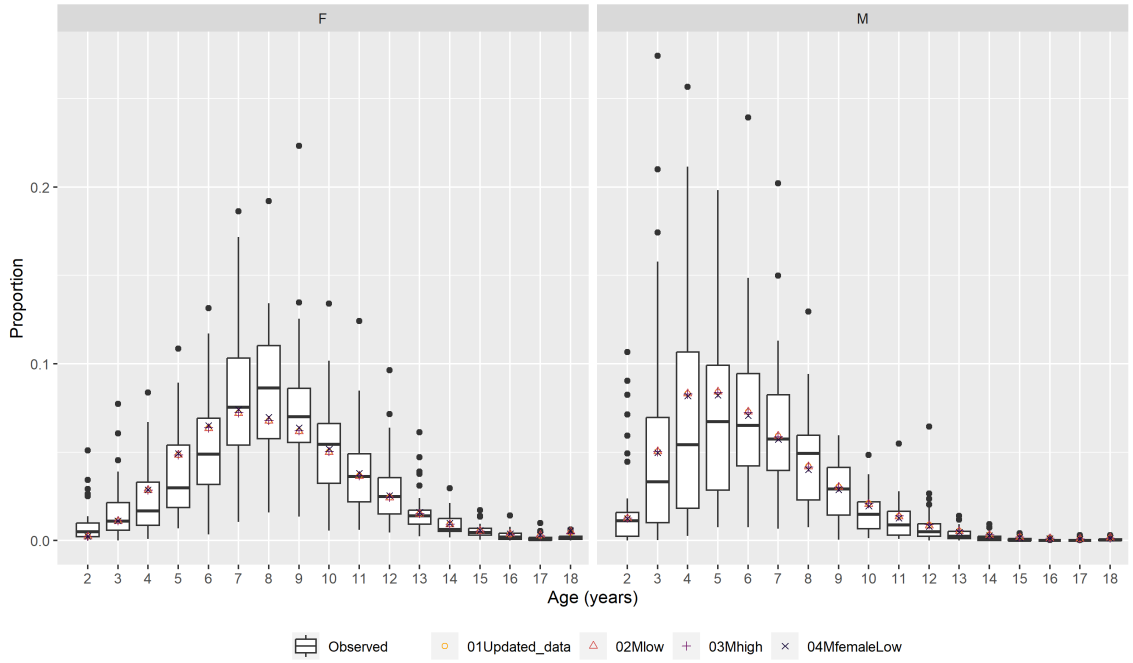


Figure 141: Summary of MPD fits to age composition data from models in natural mortality sensitivities for FisheryWCSISouthAge.

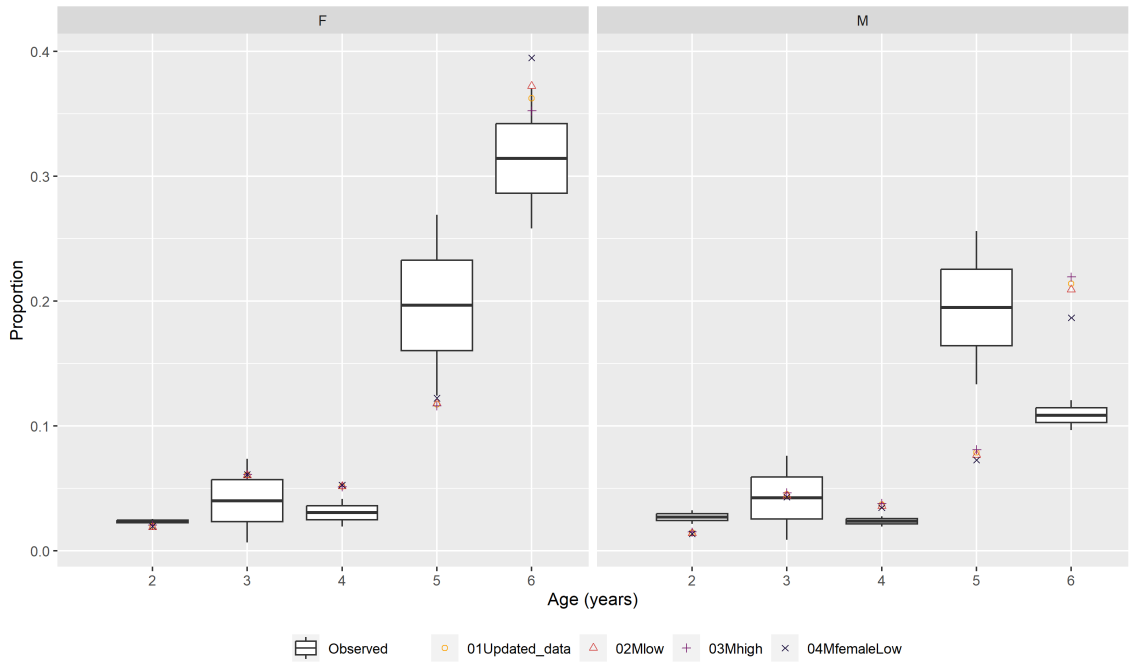


Figure 142: Summary of MPD fits to age composition data from models in natural mortality sensitivities for SubAntarcticAEXAge.

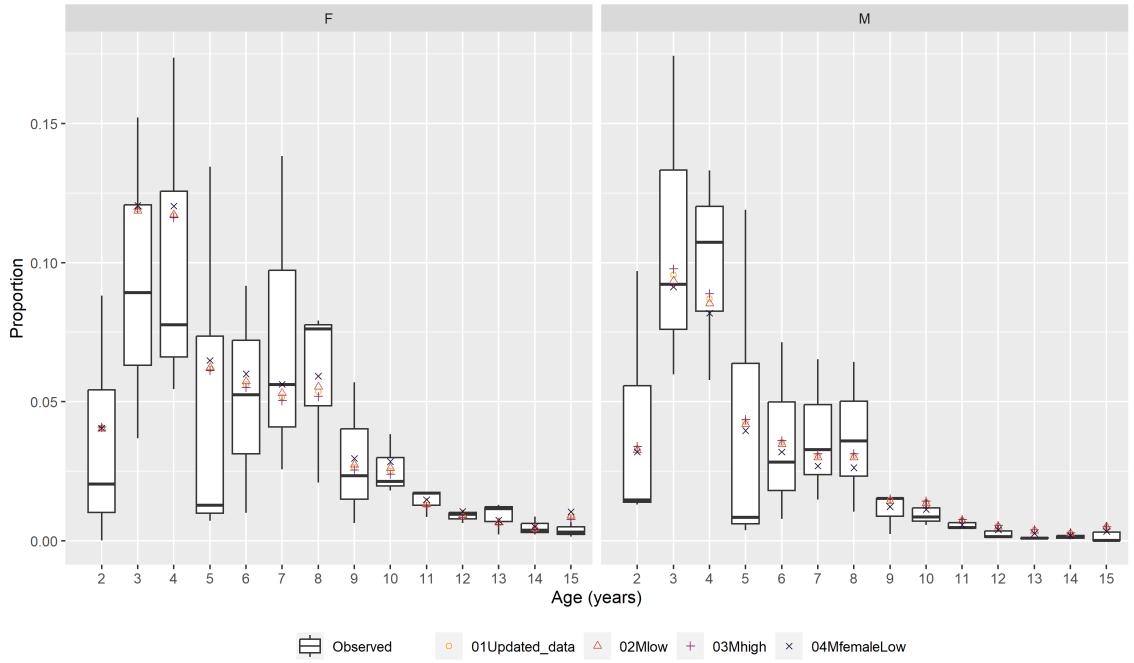


Figure 143: Summary of MPD fits to age composition data from models in natural mortality sensitivities for SubAntarcticAutumnAge.

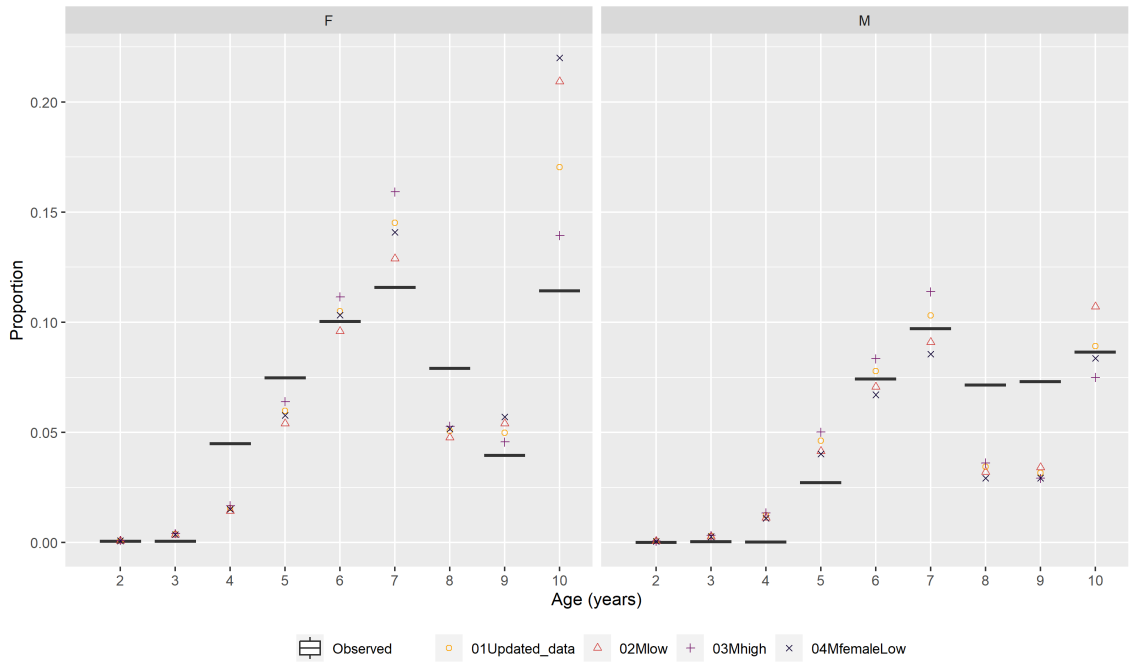


Figure 144: Summary of MPD fits to age composition data from models in natural mortality sensitivities for SubAntarcticSHIAge.

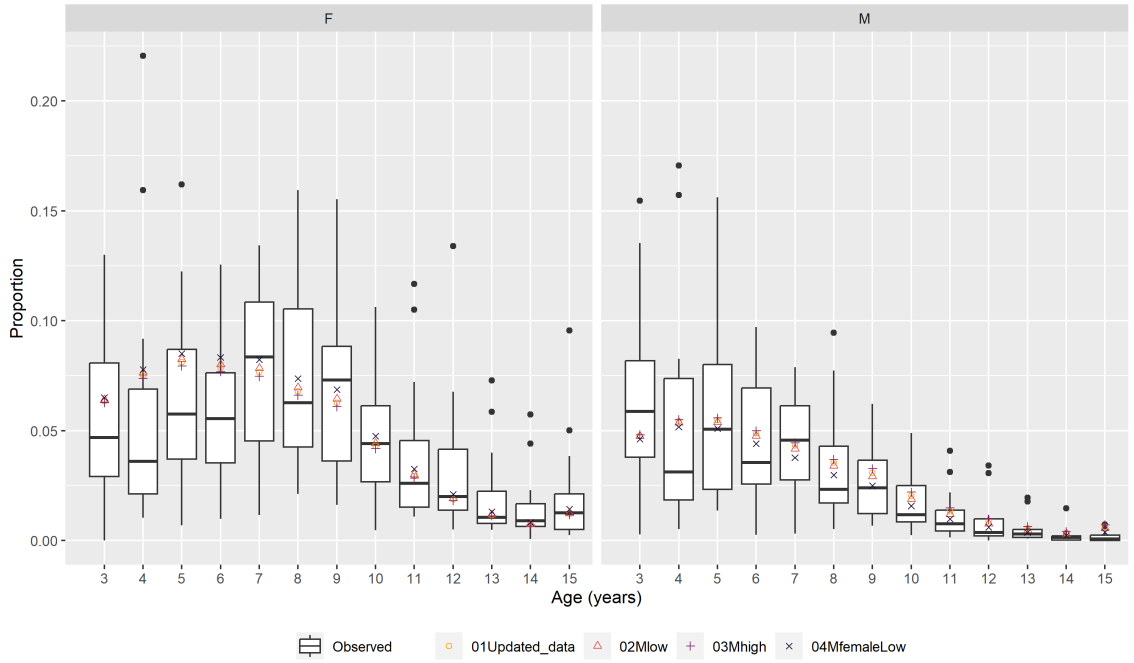


Figure 145: Summary of MPD fits to age composition data from models in natural mortality sensitivities for SubAntarcticSummerAge.

D.4.2 Maturity and steepness

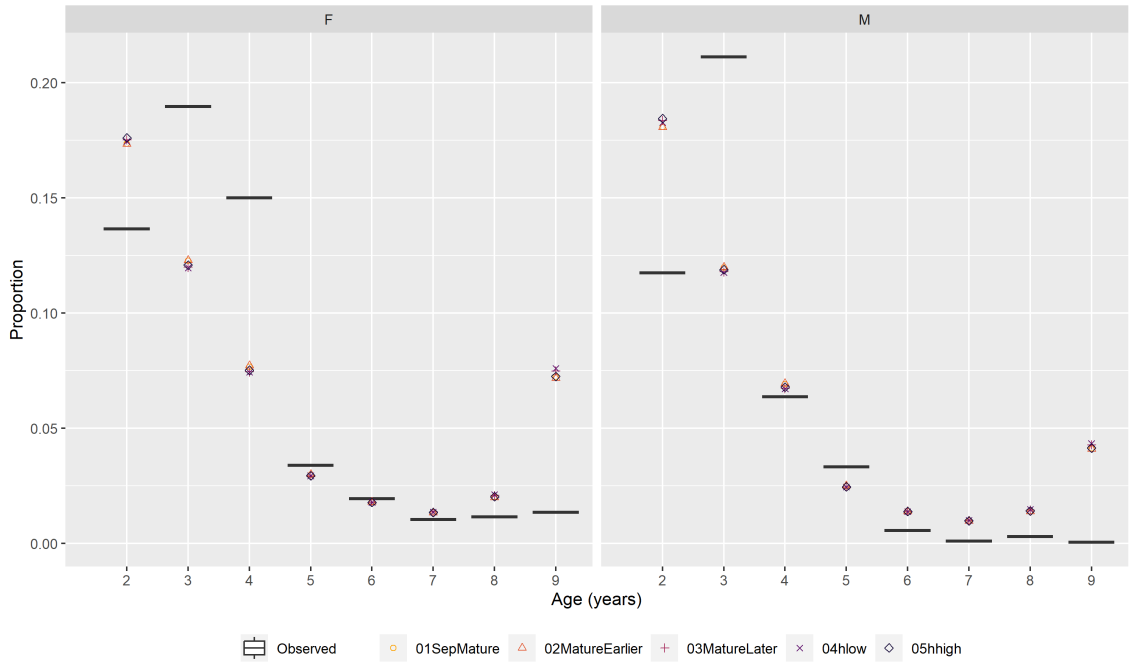


Figure 146: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for ChathamRiseSHIAge.

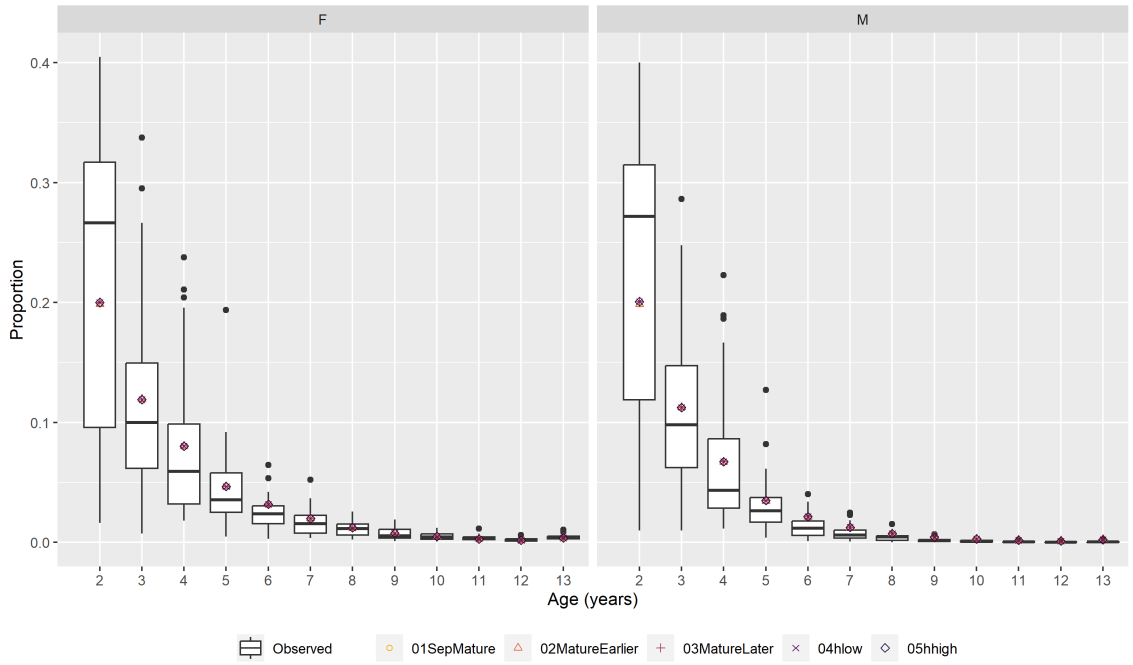


Figure 147: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for ChathamRiseSummerAge.

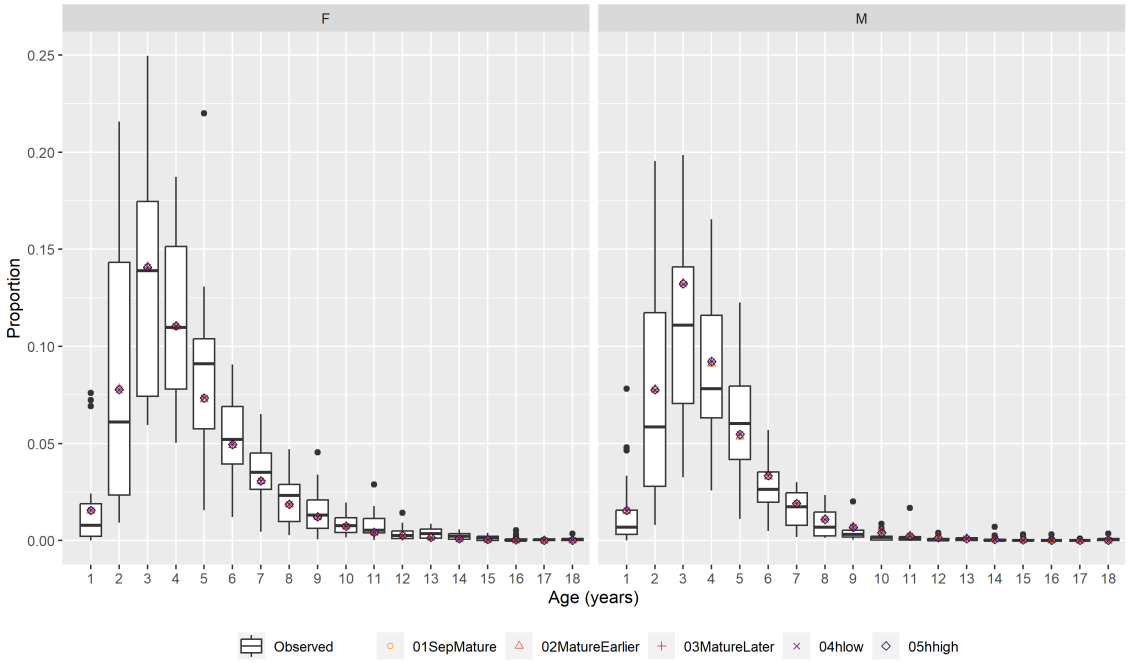


Figure 148: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryChathamRiseDeepAge.

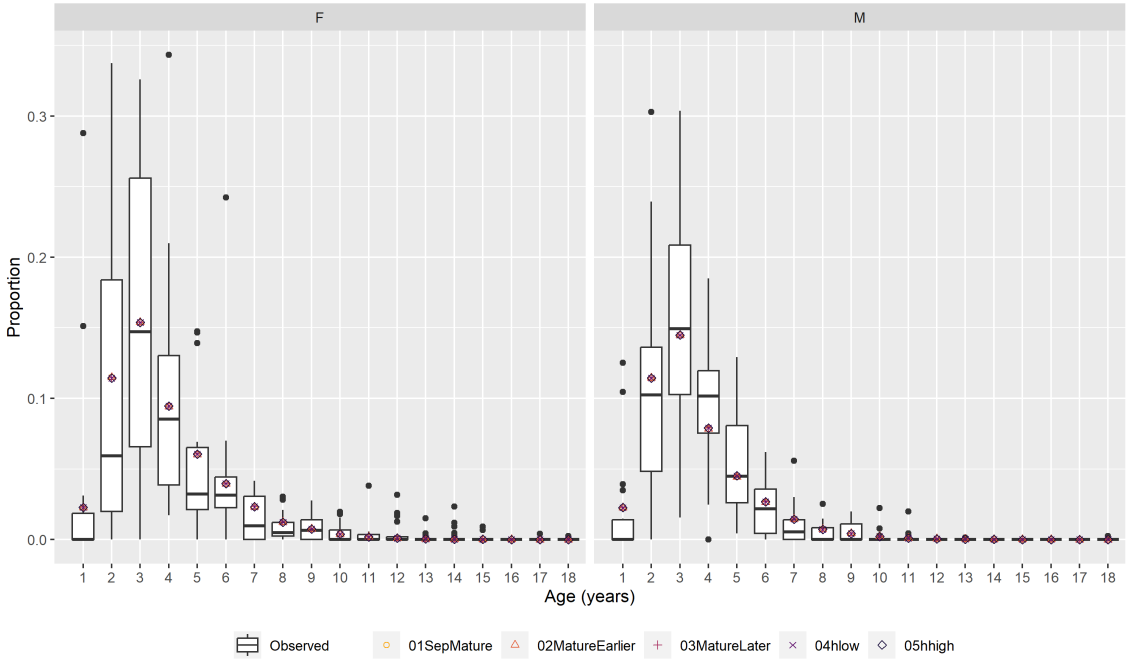


Figure 149: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryChathamRiseShallowAge.

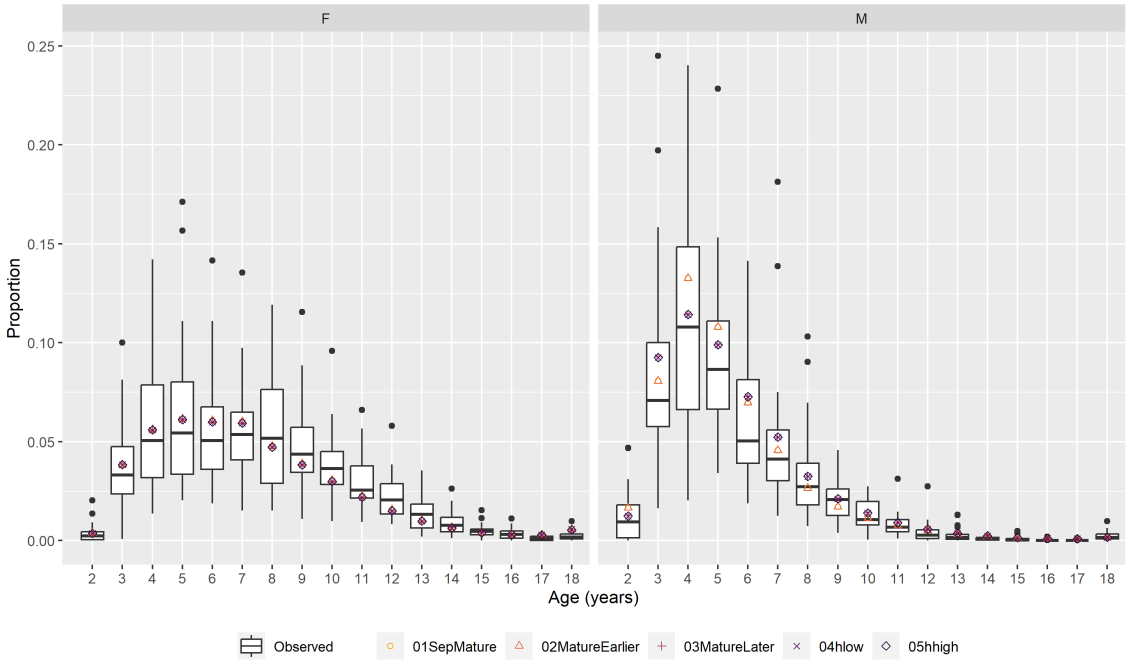


Figure 150: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryCookStraitAge.

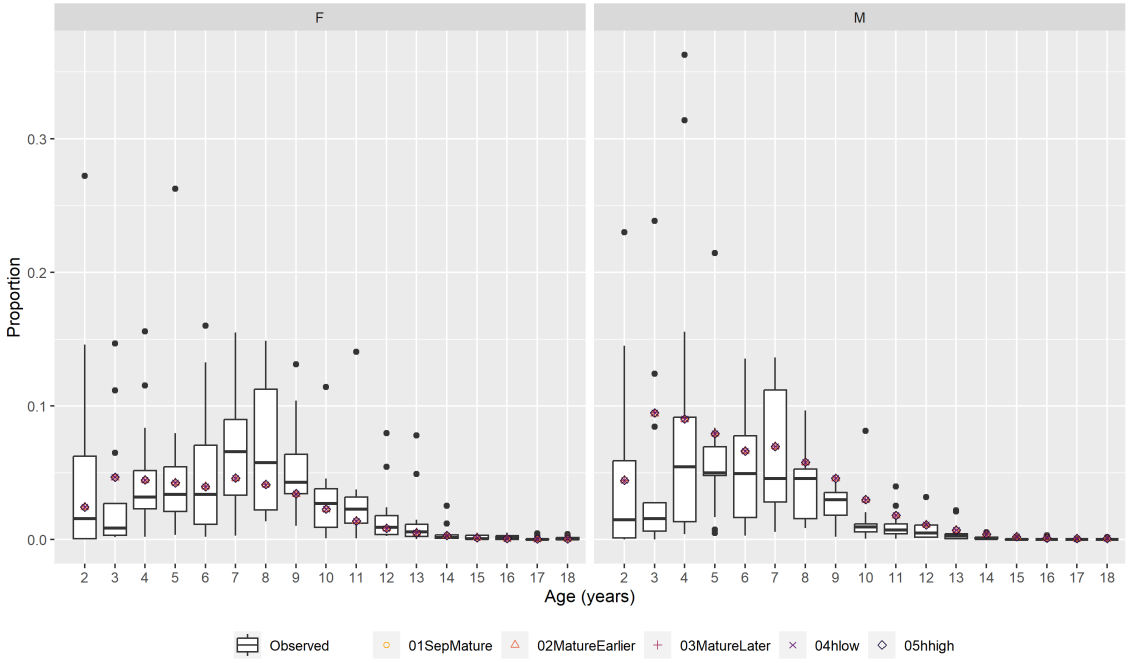


Figure 151: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryPuysegurSpawningAge.

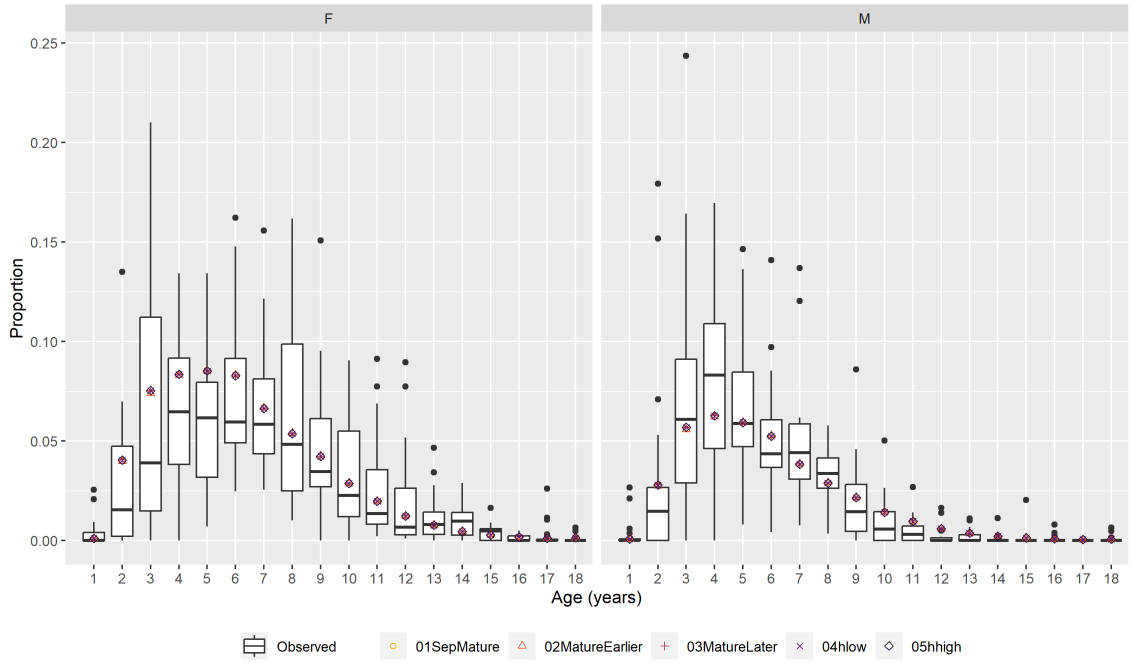


Figure 152: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisherySubAntarcticAucklandAge.

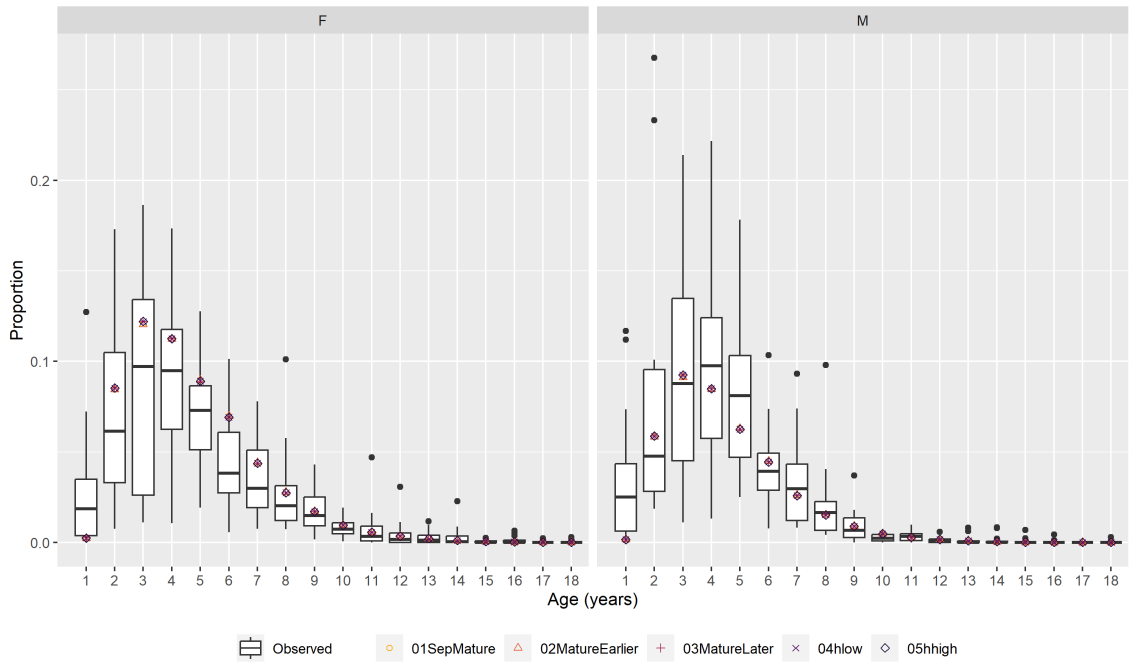


Figure 153: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisherySubAntarcticSnaresAge.

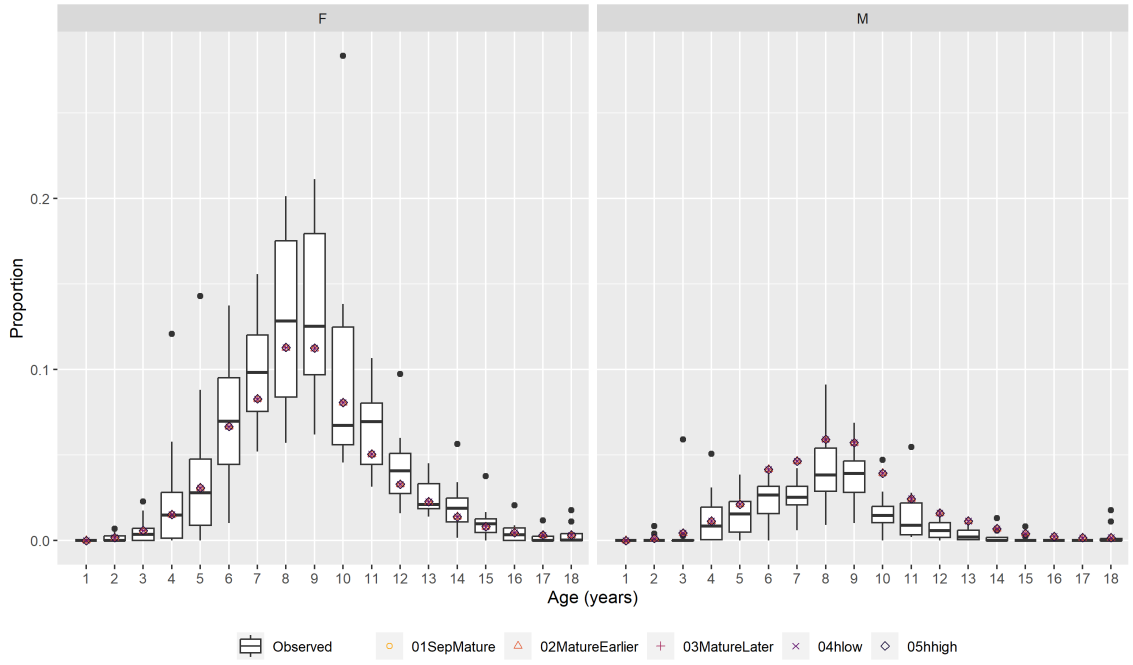


Figure 154: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisherySubAntarcticSubaAge.

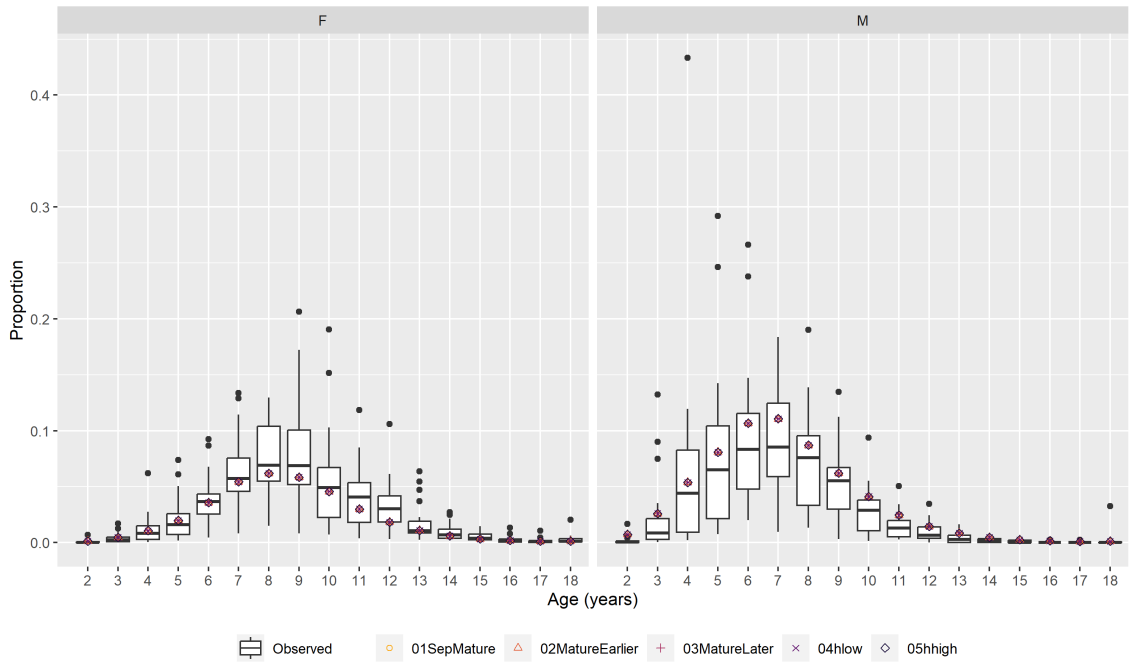


Figure 155: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryWCSIInsideAge.

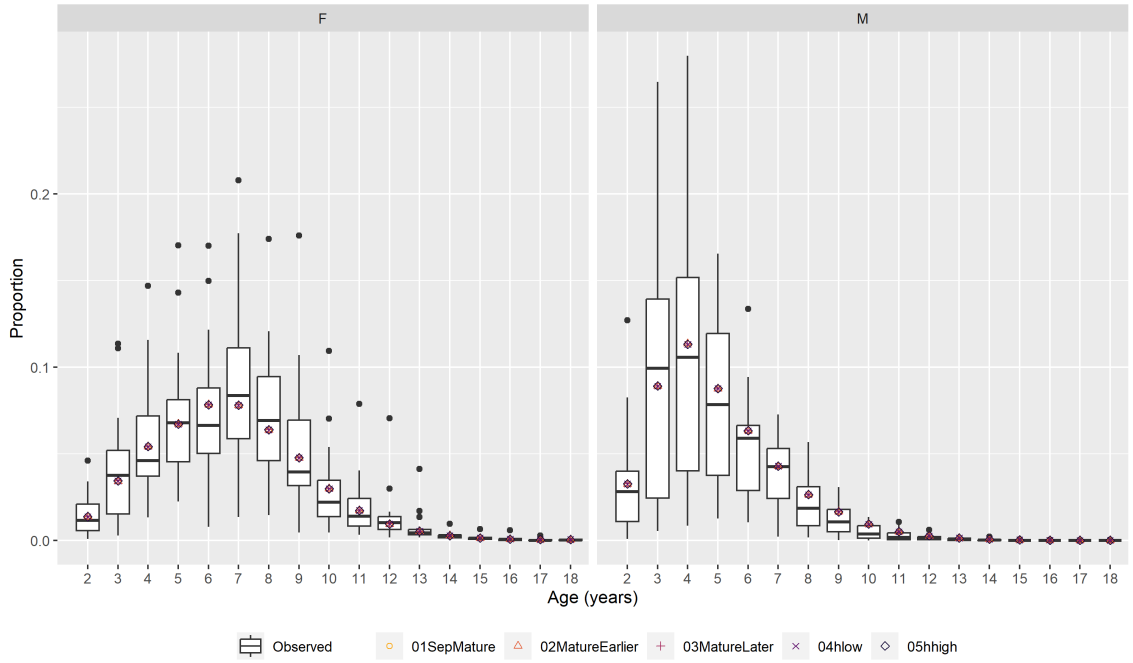


Figure 156: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryWCSINorthFrom2000Age.

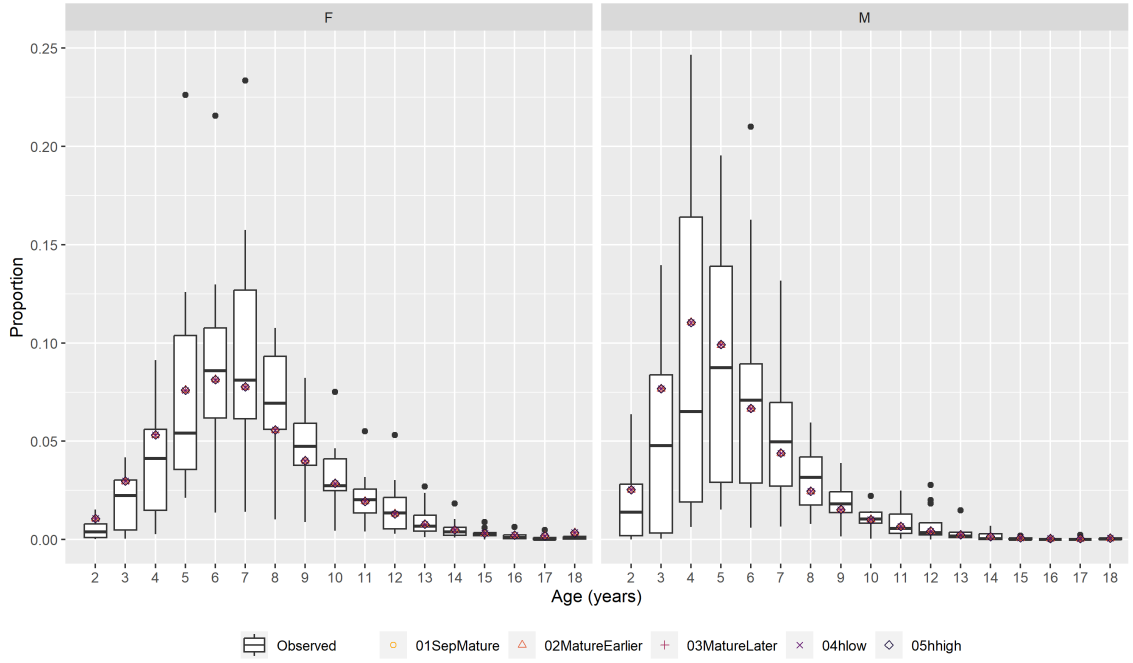


Figure 157: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryWCSINorthPre2000Age.

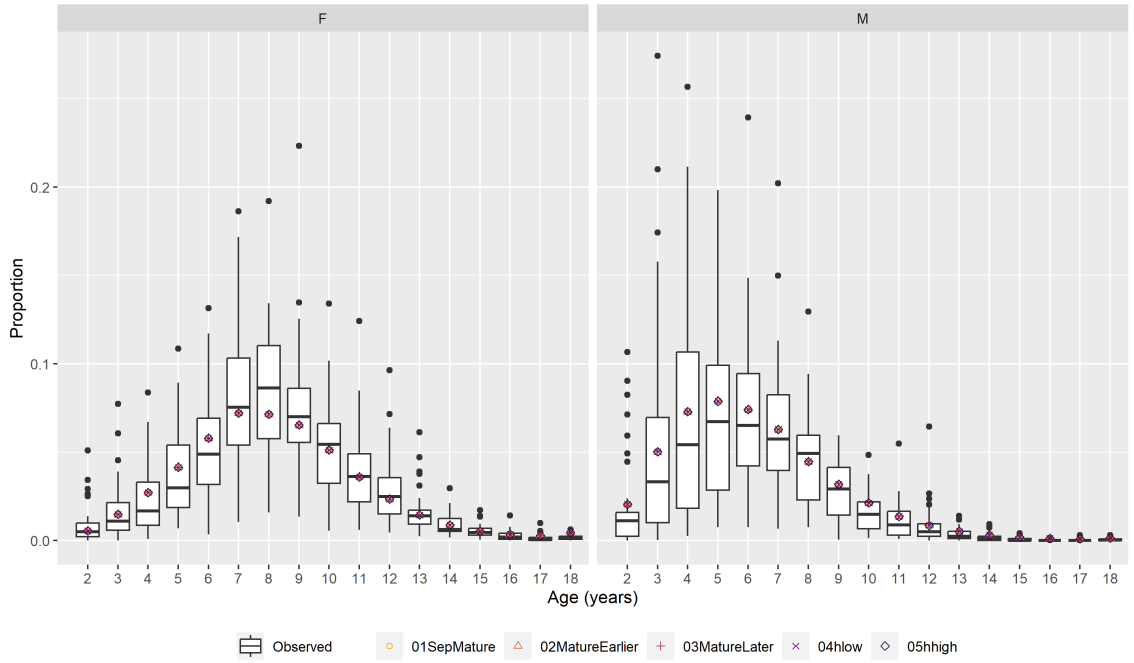


Figure 158: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for FisheryWCSISouthAge.

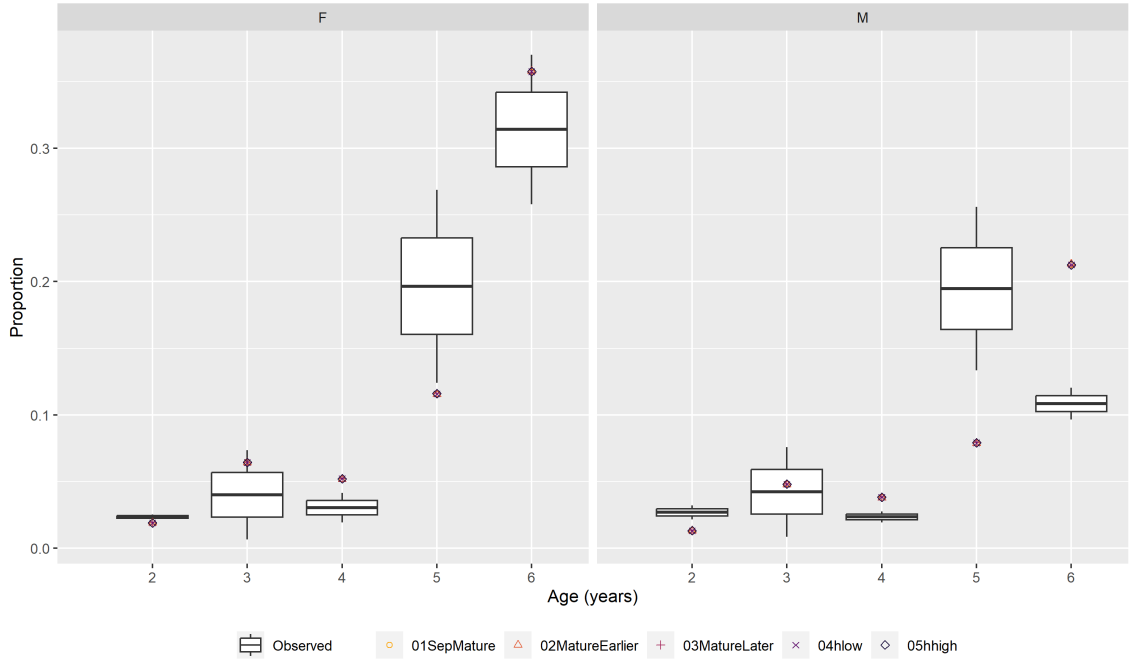


Figure 159: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for SubAntarcticAEXAge.

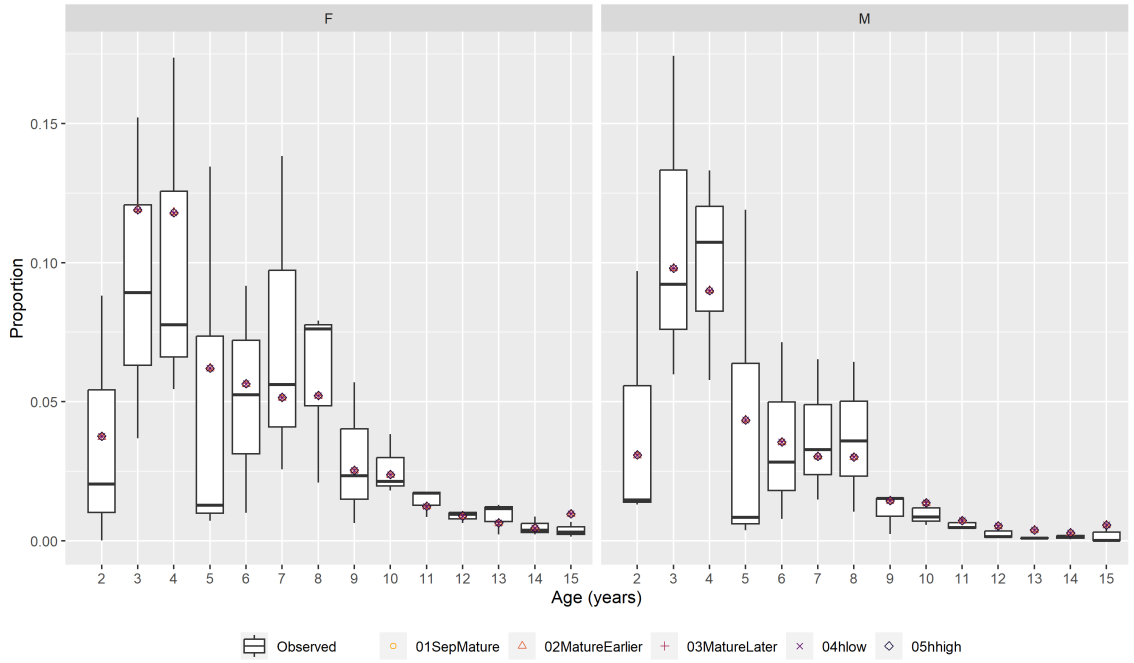


Figure 160: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for SubAntarcticAutumnAge.

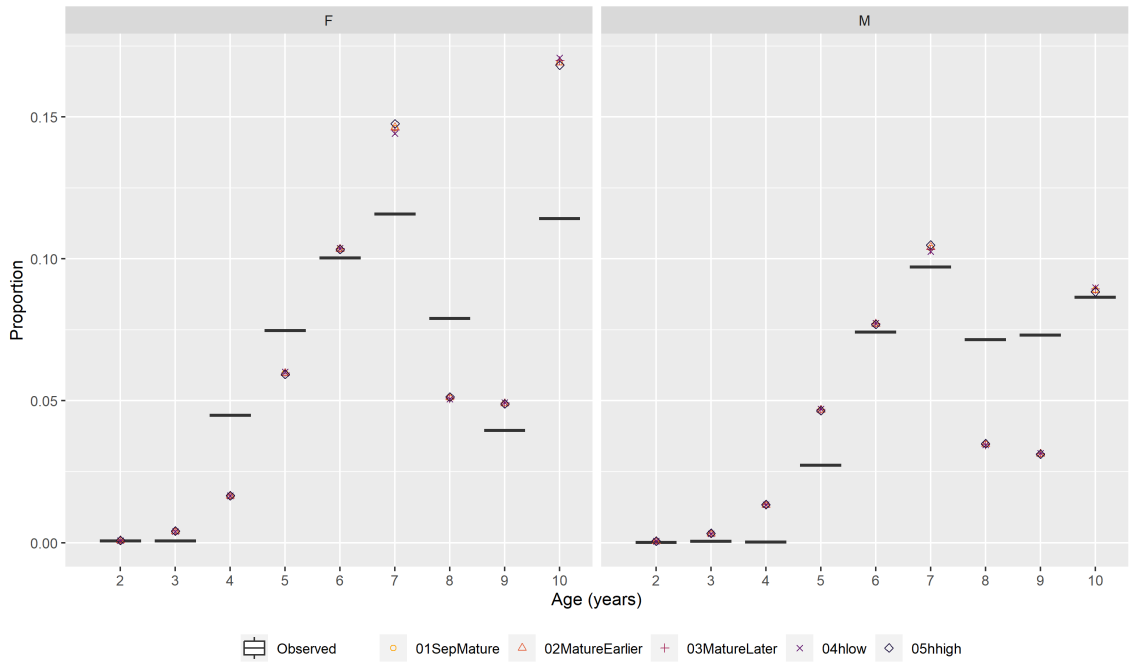


Figure 161: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for SubAntarcticSHIAge.

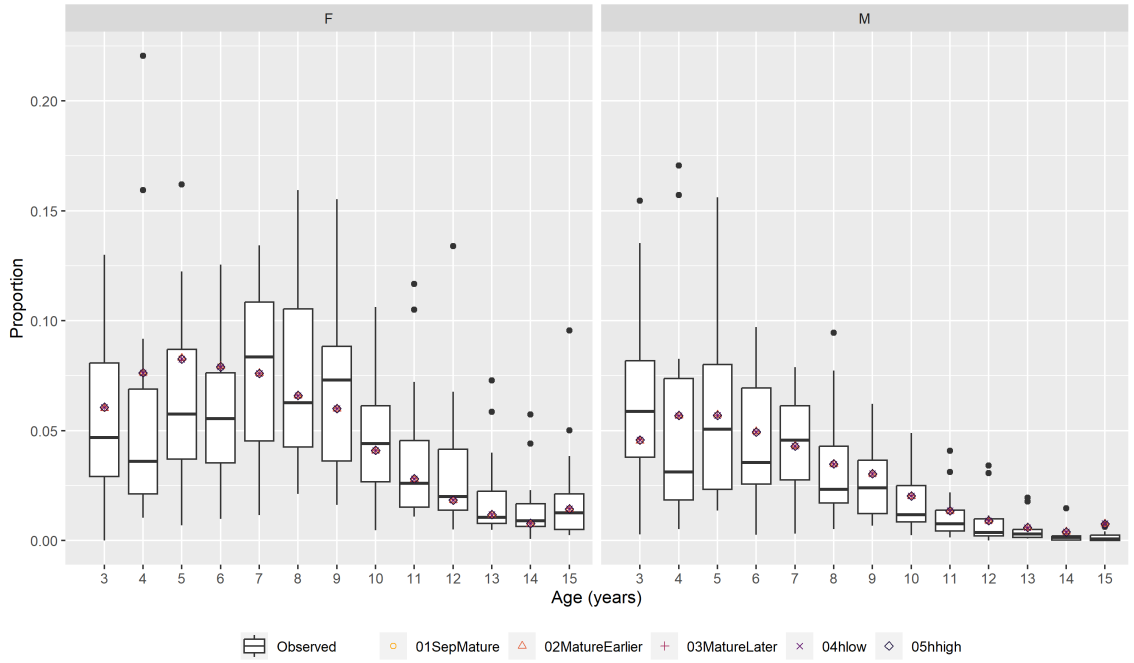


Figure 162: Summary of MPD fits to age composition data from models in maturity and steepness sensitivities for SubAntarcticSummerAge.

Appendix E MCMCs

E.1 Model 2022A

E.1.1 Catchability

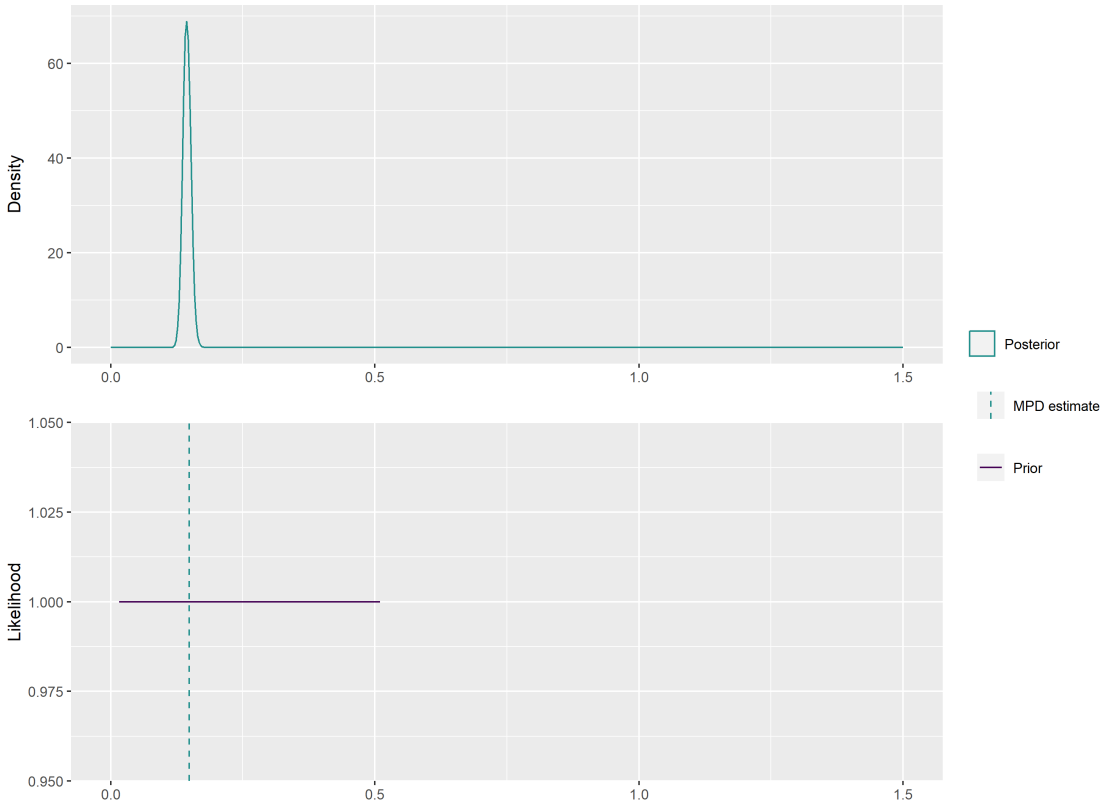


Figure 163: MCMC posterior (top) and prior (bottom) distributions for ChathamRiseSummer from model 2023A.

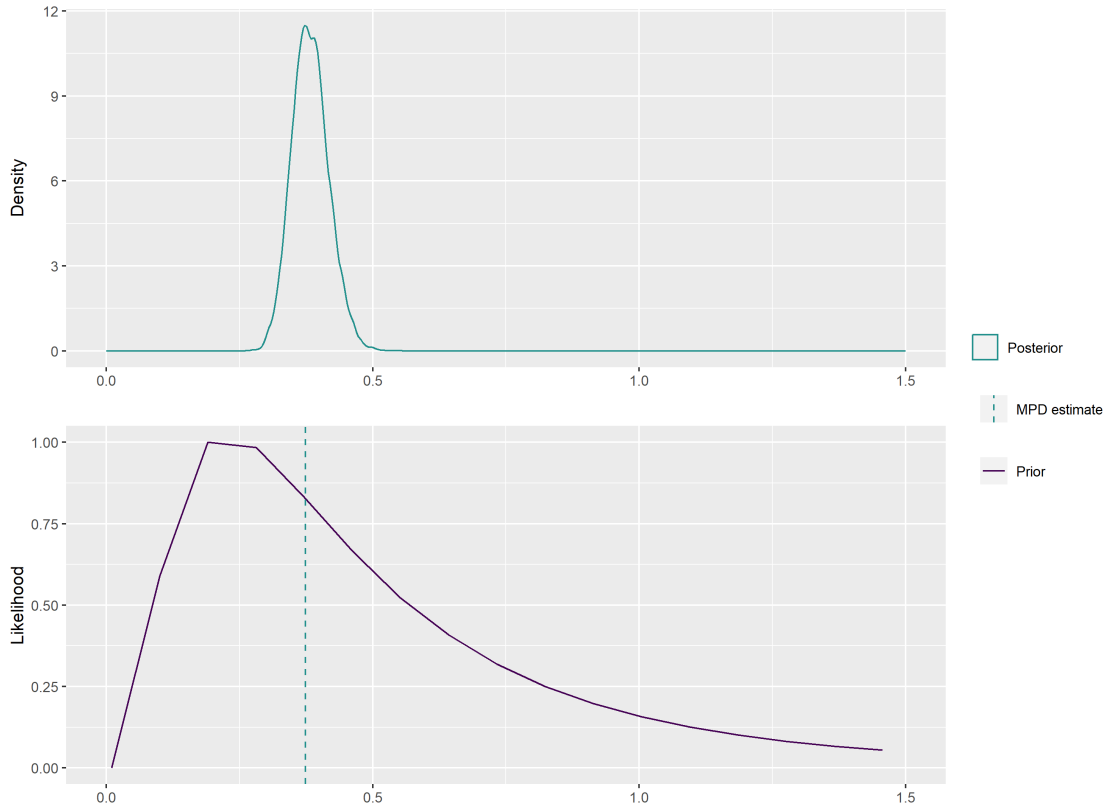


Figure 164: MCMC posterior (top) and prior (bottom) distributions for CookStraitAcoustic from model 2023A.

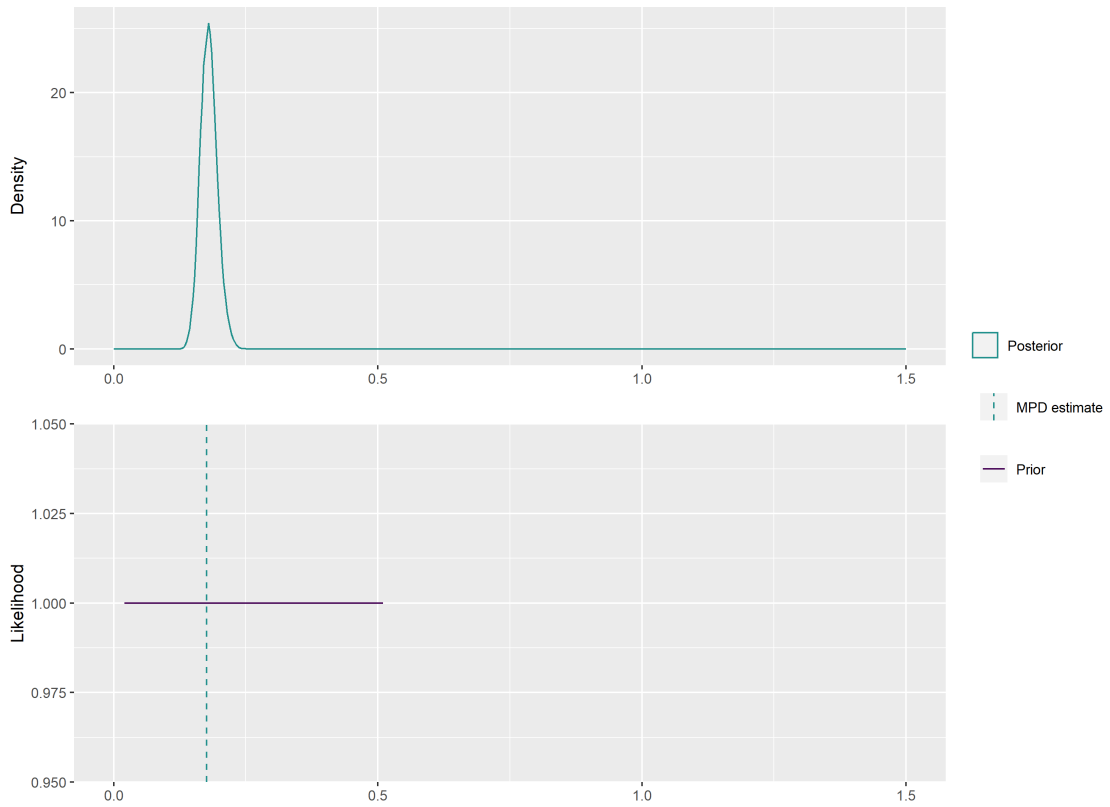


Figure 165: MCMC posterior (top) and prior (bottom) distributions for SubAntarcticAutumn from model 2023A.

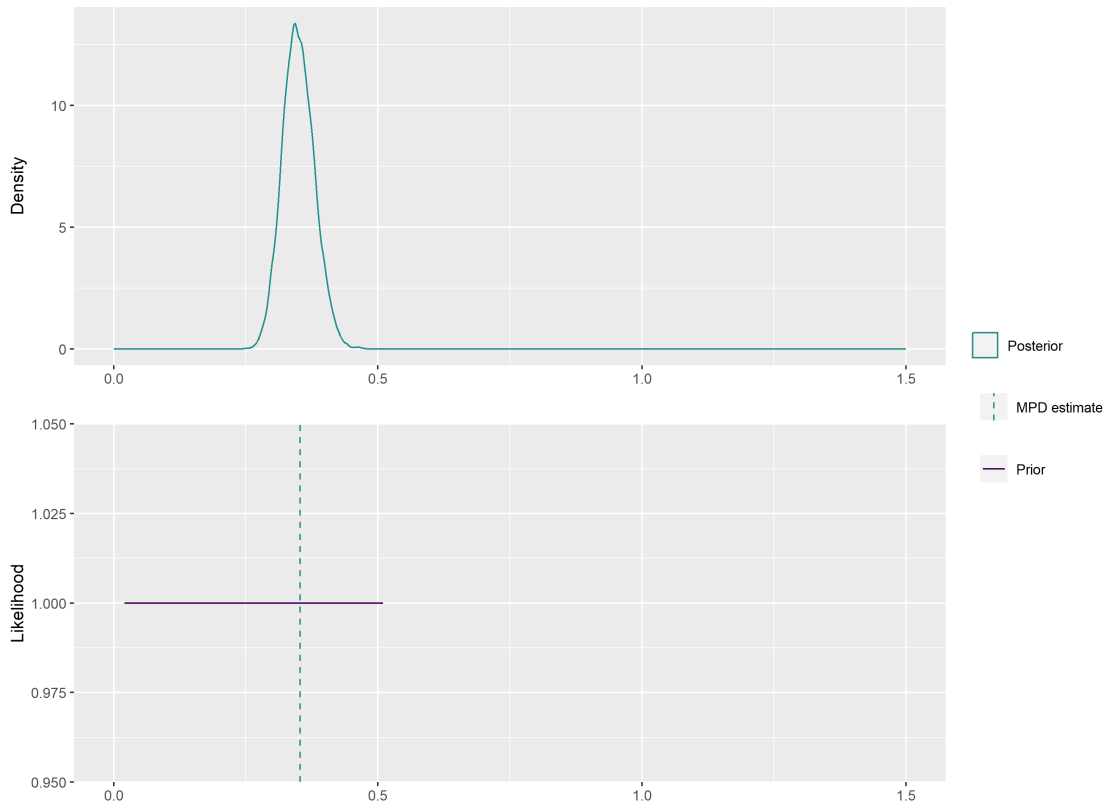


Figure 166: MCMC posterior (top) and prior (bottom) distributions for SubAntarcticSummer from model 2023A.

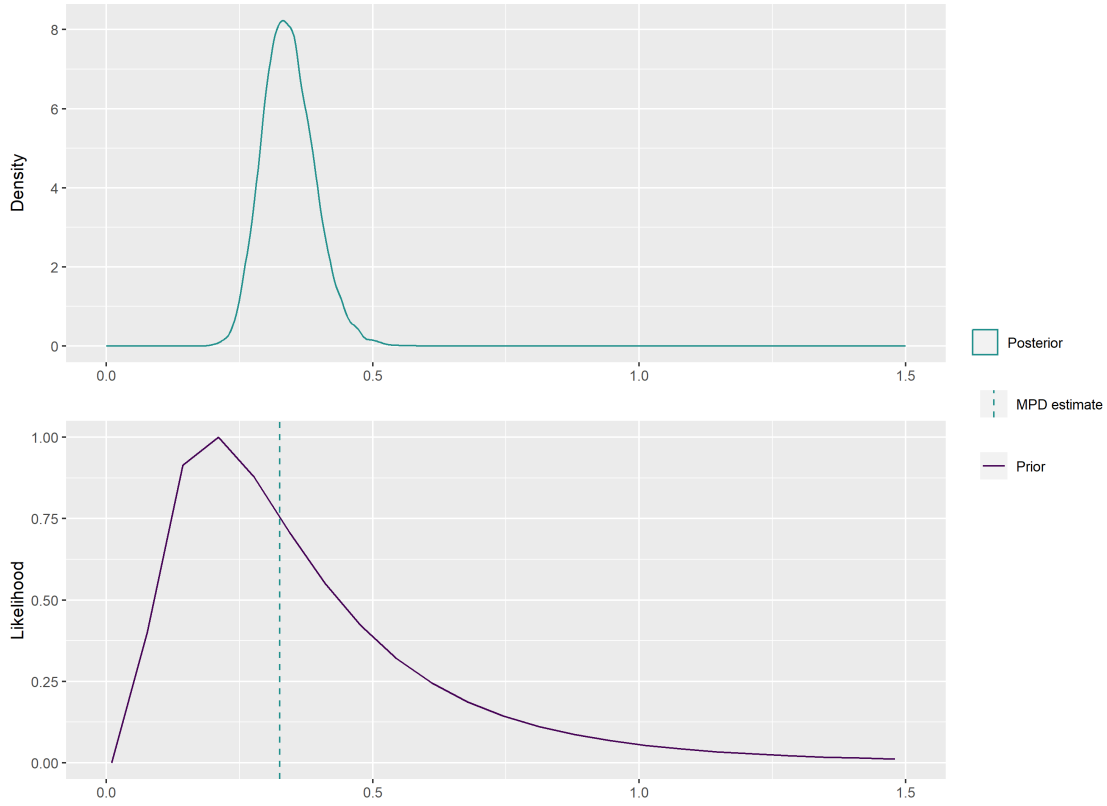


Figure 167: MCMC posterior (top) and prior (bottom) distributions for WCSIAcoustic from model 2023A.

E.1.2 Selectivity ogives

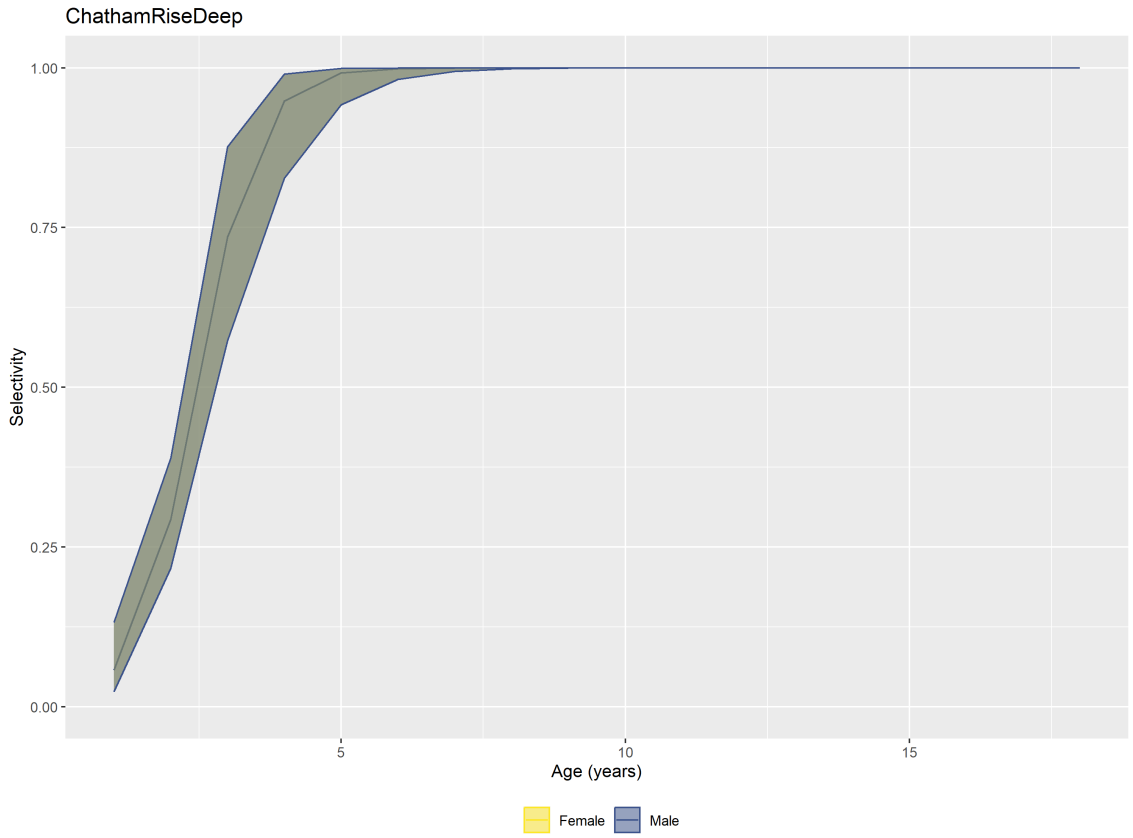


Figure 168: MCMC estimated selectivity ogive for ChathamRiseDeep from model 2023A.

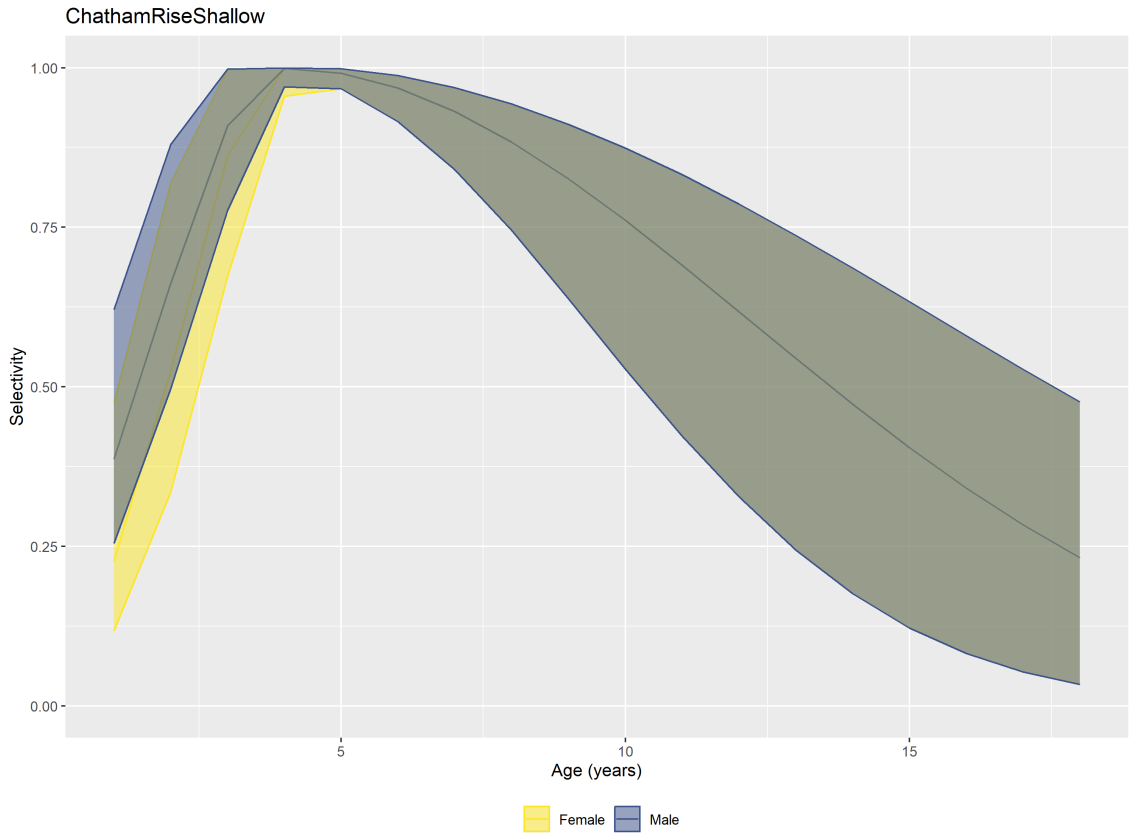


Figure 169: MCMC estimated selectivity ogive for ChathamRiseShallow from model 2023A.

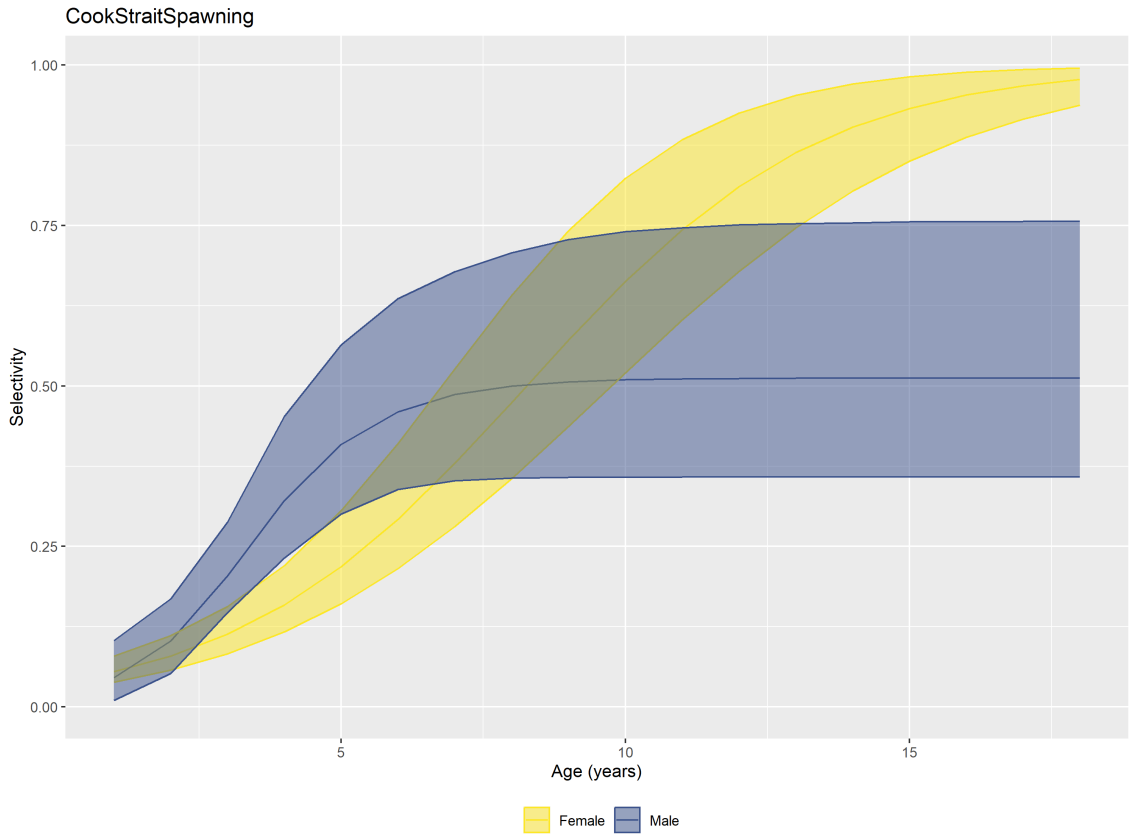


Figure 170: MCMC estimated selectivity ogive for CookStraitSpawning from model 2023A.

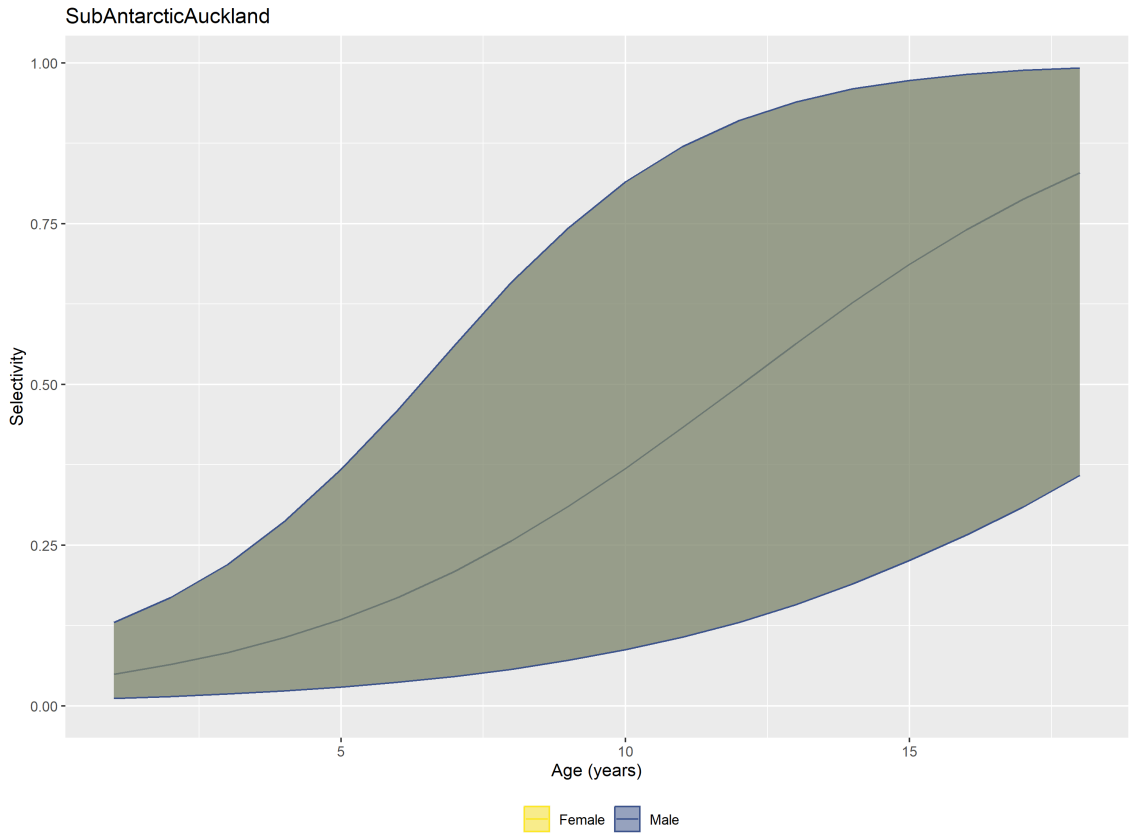


Figure 171: MCMC estimated selectivity ogive for SubAntarcticAuckland from model 2023A.

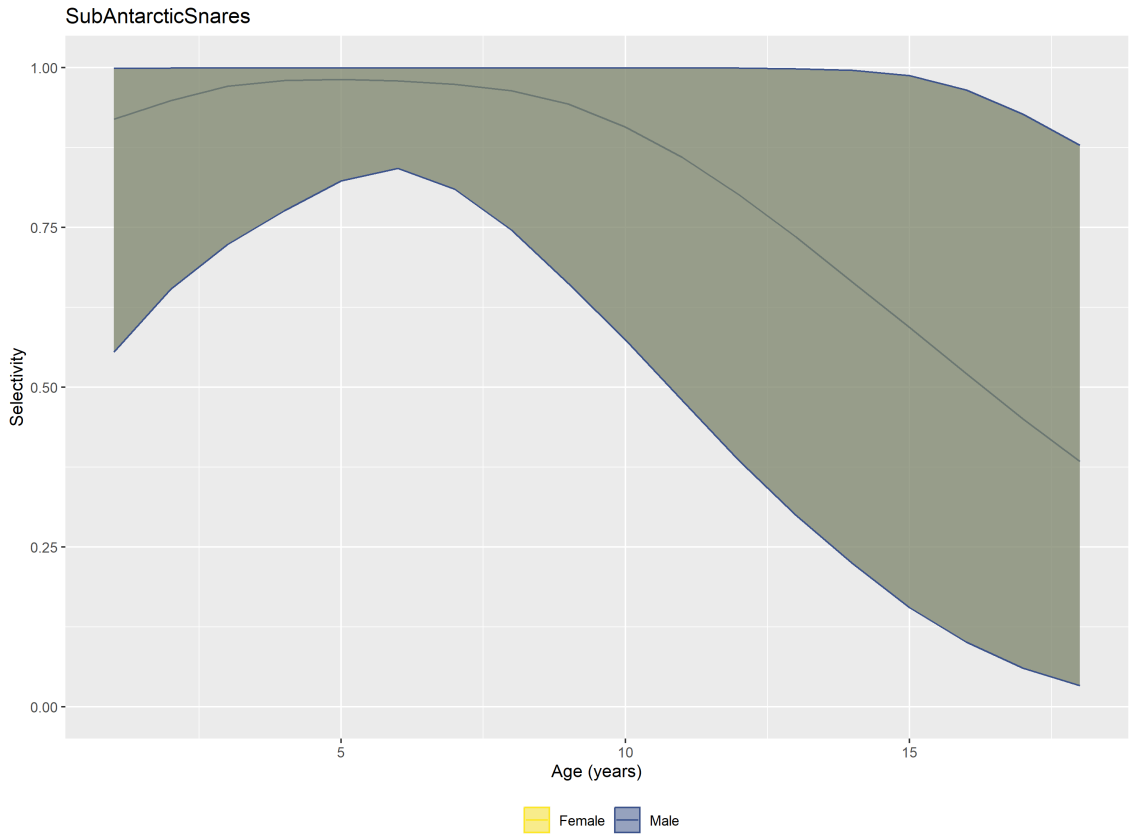


Figure 172: MCMC estimated selectivity ogive for SubAntarcticSnares from model 2023A.

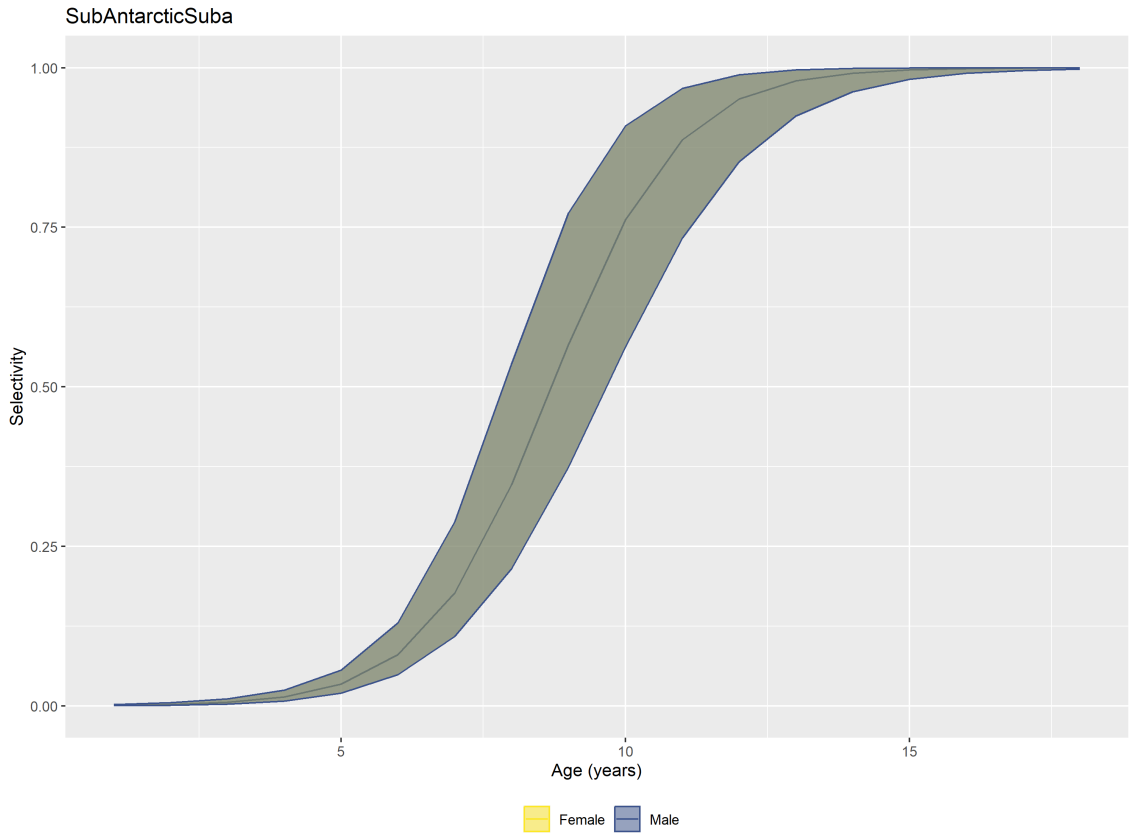


Figure 173: MCMC estimated selectivity ogive for SubAntarcticSuba from model 2023A.

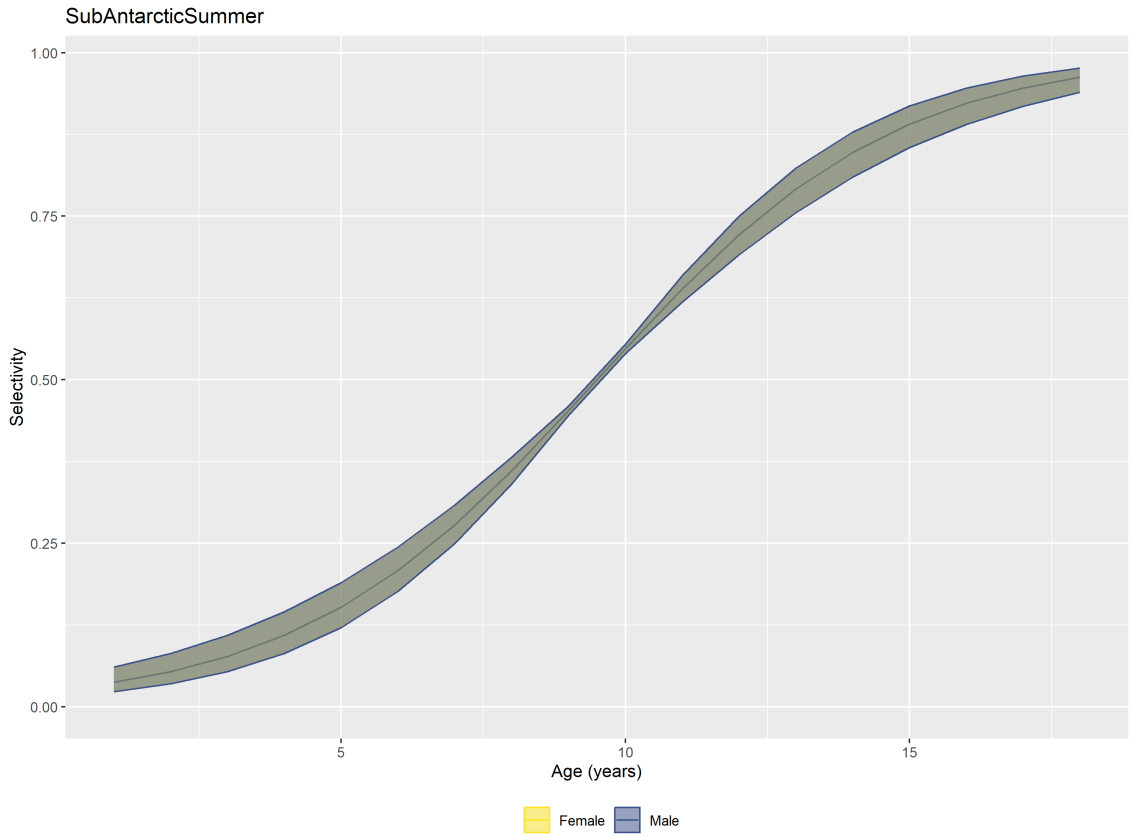


Figure 174: MCMC estimated selectivity ogive for SubAntarcticSummer from model 2023A.

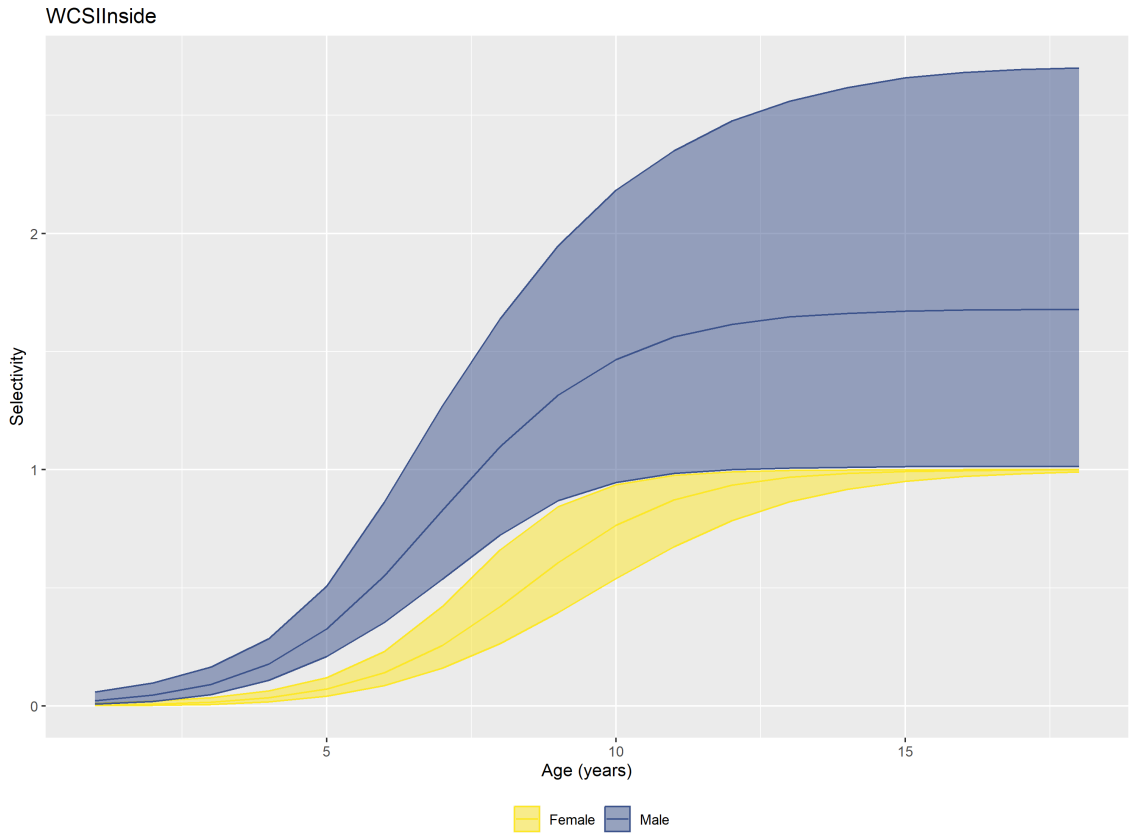


Figure 175: MCMC estimated selectivity ogive for WCSIInside from model 2023A.

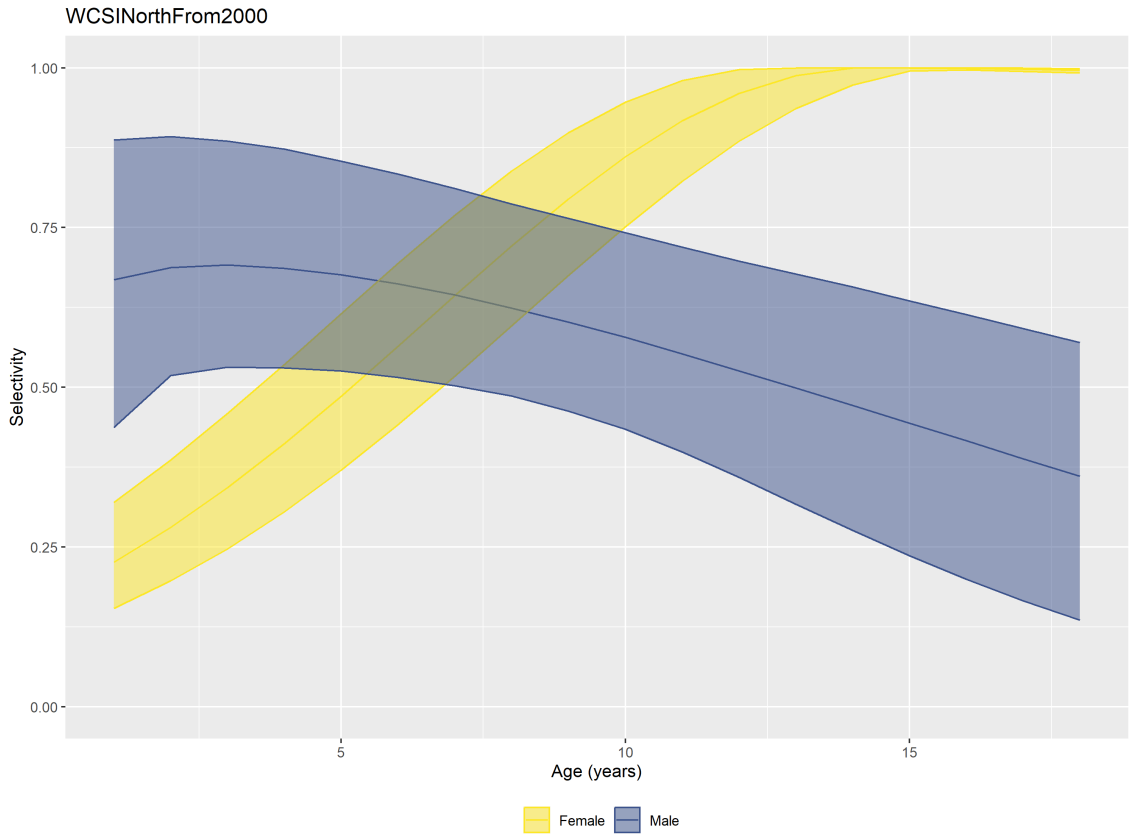


Figure 176: MCMC estimated selectivity ogive for WCSINorthFrom2000 from model 2023A.

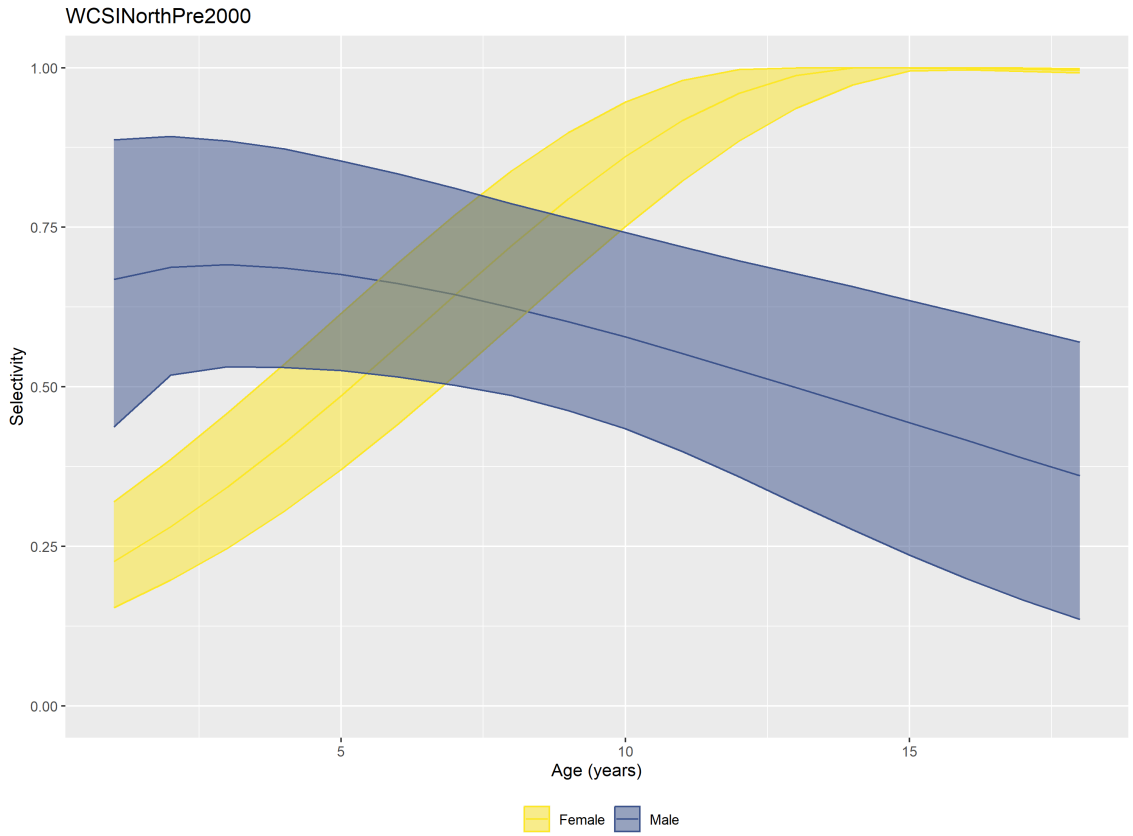


Figure 177: MCMC estimated selectivity ogive for WCSINorthPre2000 from model 2023A.

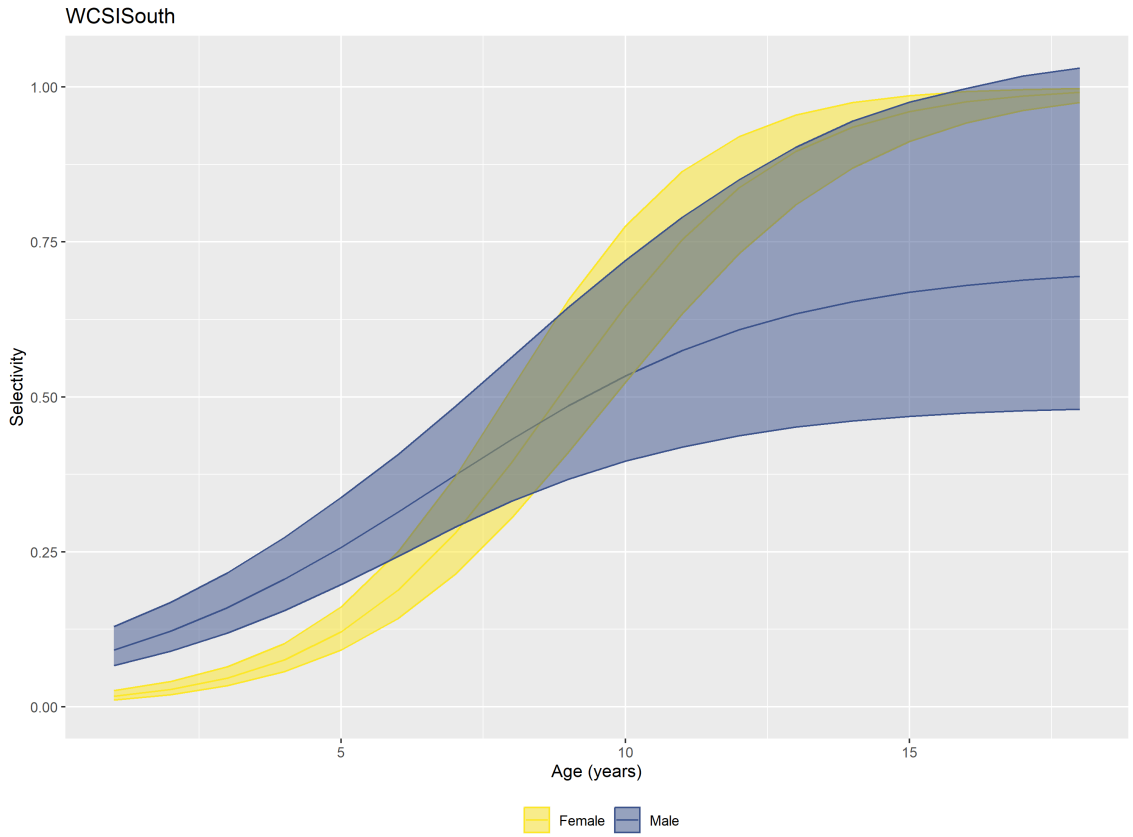


Figure 178: MCMC estimated selectivity ogive for WCSISouth from model 2023A.

E.1.3 Selectivity parameter traces

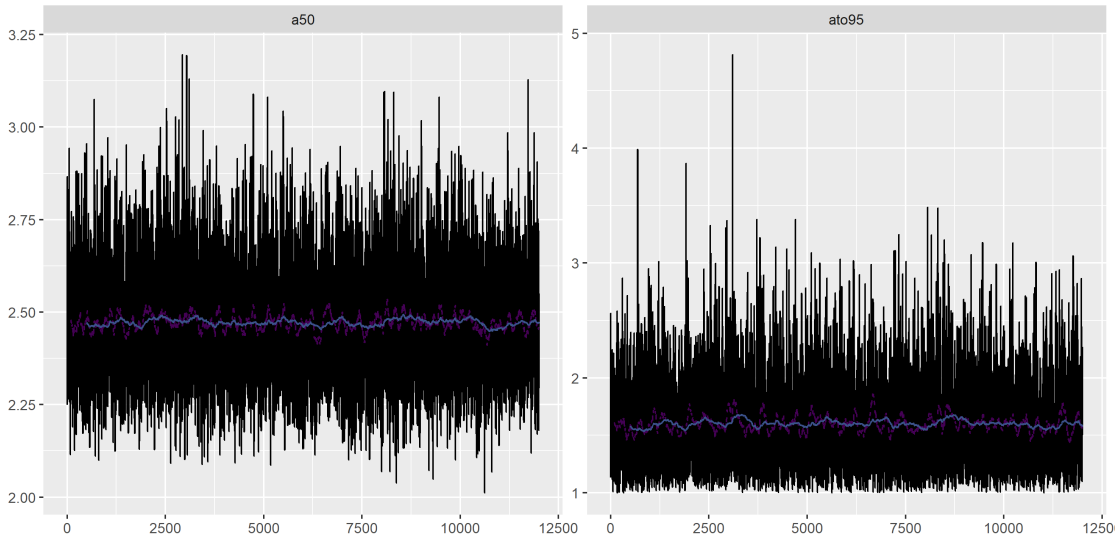


Figure 179: MCMC parameter traces for ChathamRiseDeepFisheryM selectivity ogive from model 2023A.

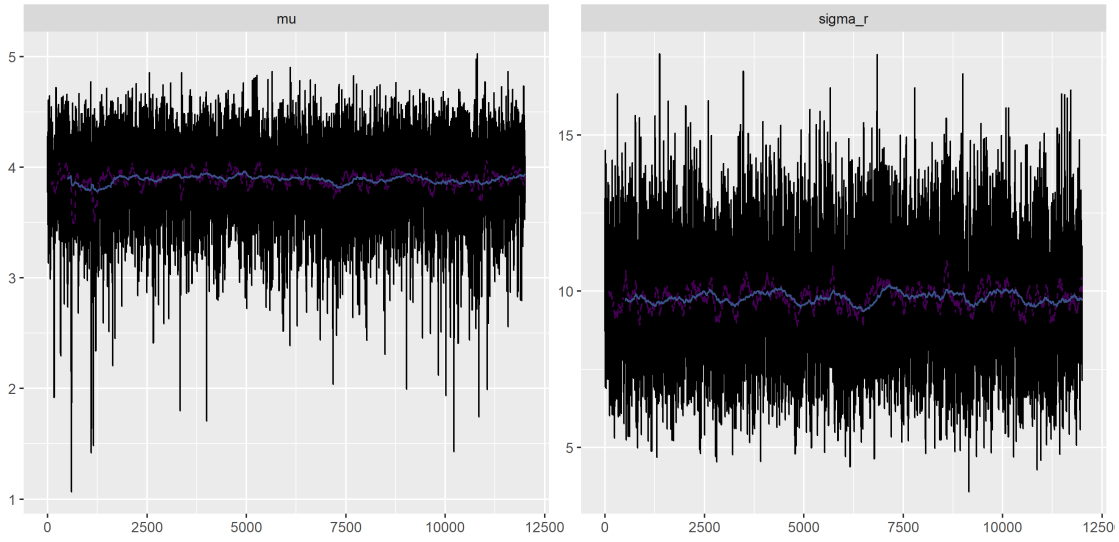


Figure 180: MCMC parameter traces for ChathamRiseShallowFisheryM selectivity ogive from model 2023A.

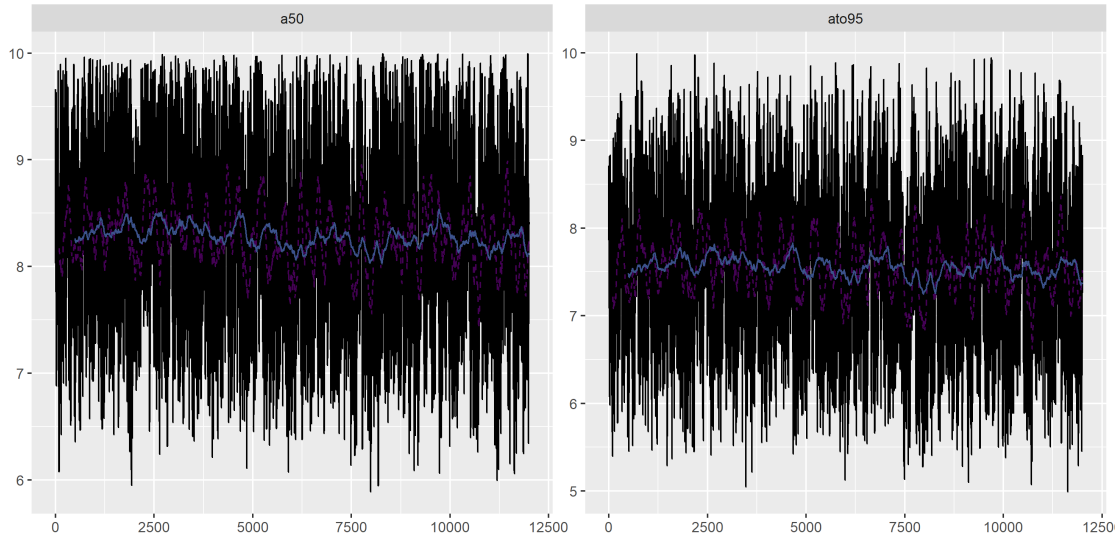


Figure 181: MCMC parameter traces for CookStraitSpawningFisheryF selectivity ogive from model 2023A.

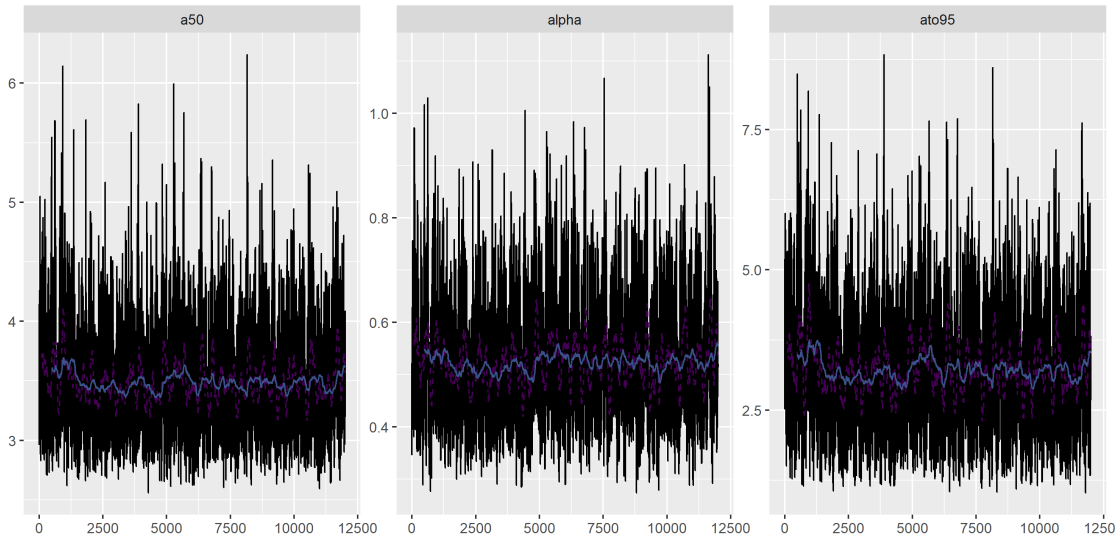


Figure 182: MCMC parameter traces for CookStraitSpawningFisheryM selectivity ogive from model 2023A.

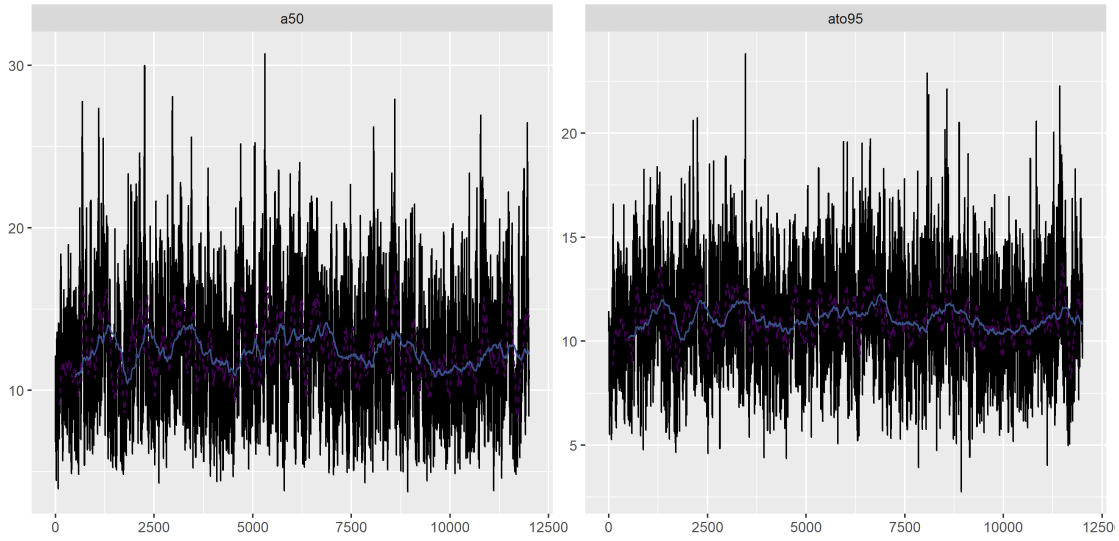


Figure 183: MCMC parameter traces for SubAntarcticAucklandFisheryM selectivity ogive from model 2023A.

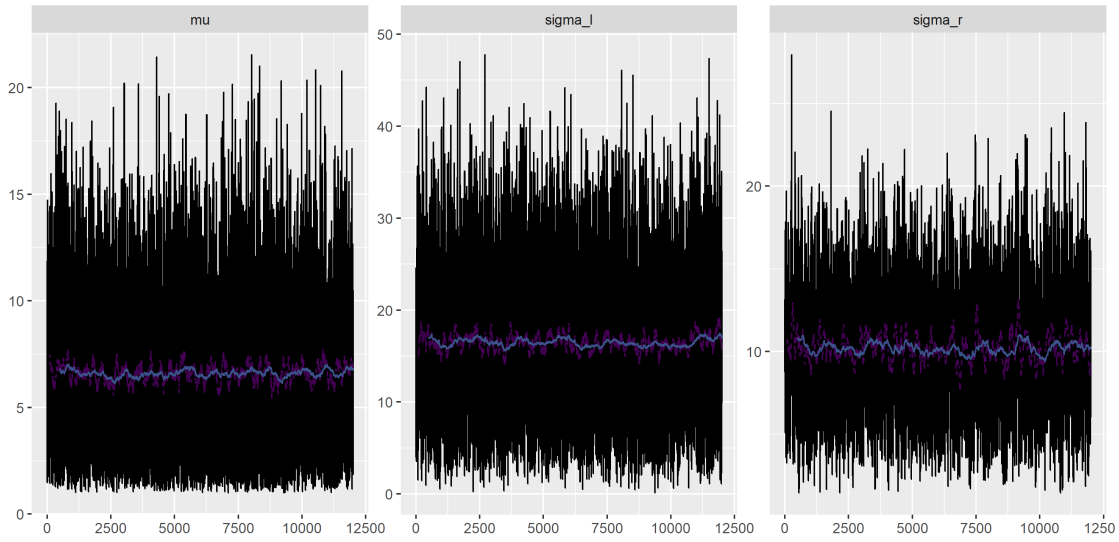


Figure 184: MCMC parameter traces for SubAntarcticSnaresFisheryM selectivity ogive from model 2023A.

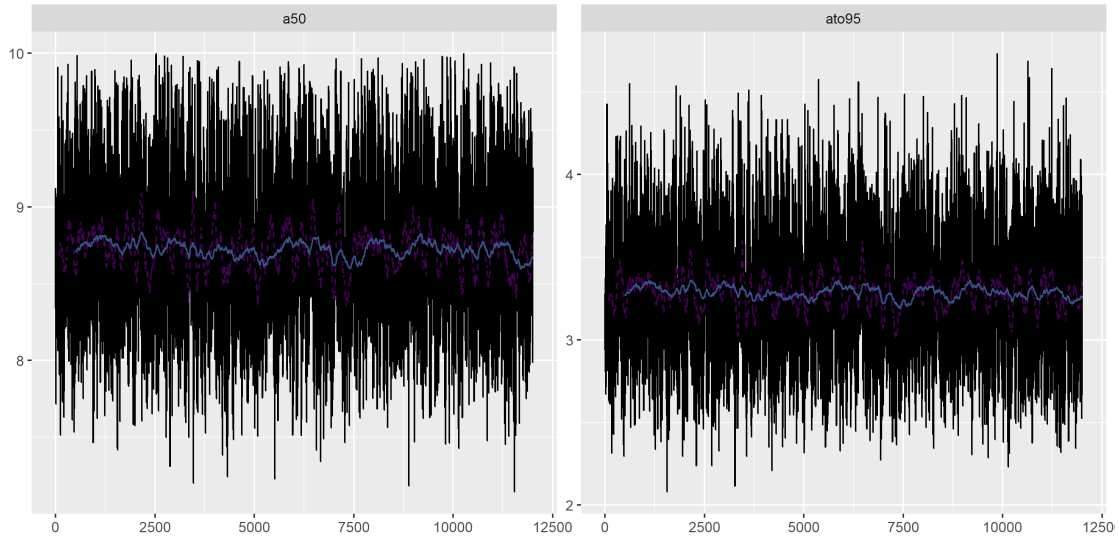


Figure 185: MCMC parameter traces for SubAntarcticSubaFisheryM selectivity ogive from model 2023A.

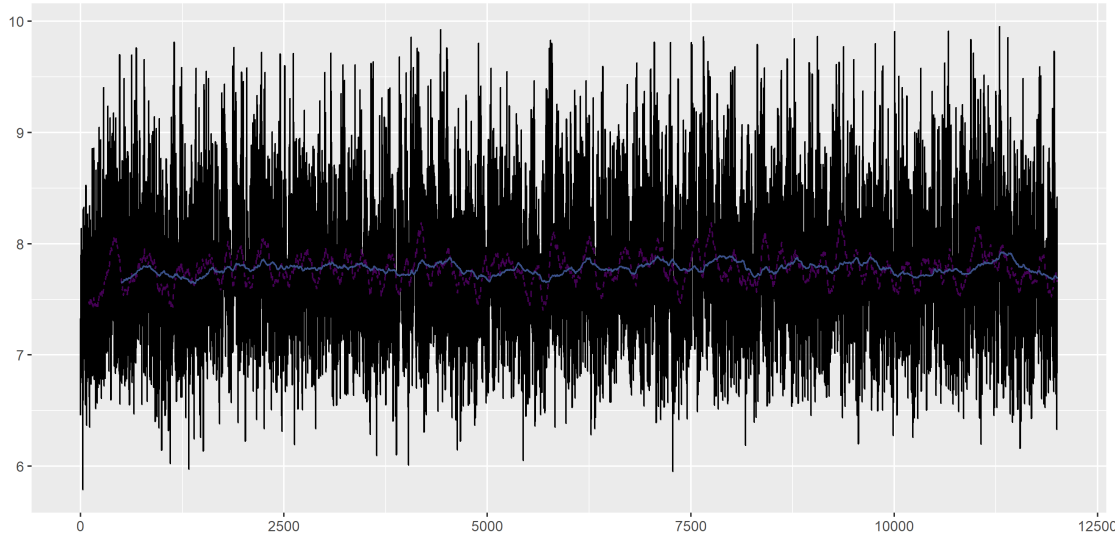


Figure 186: MCMC parameter traces for SubAntarcticSummerSurveyM selectivity ogive from model 2023A.

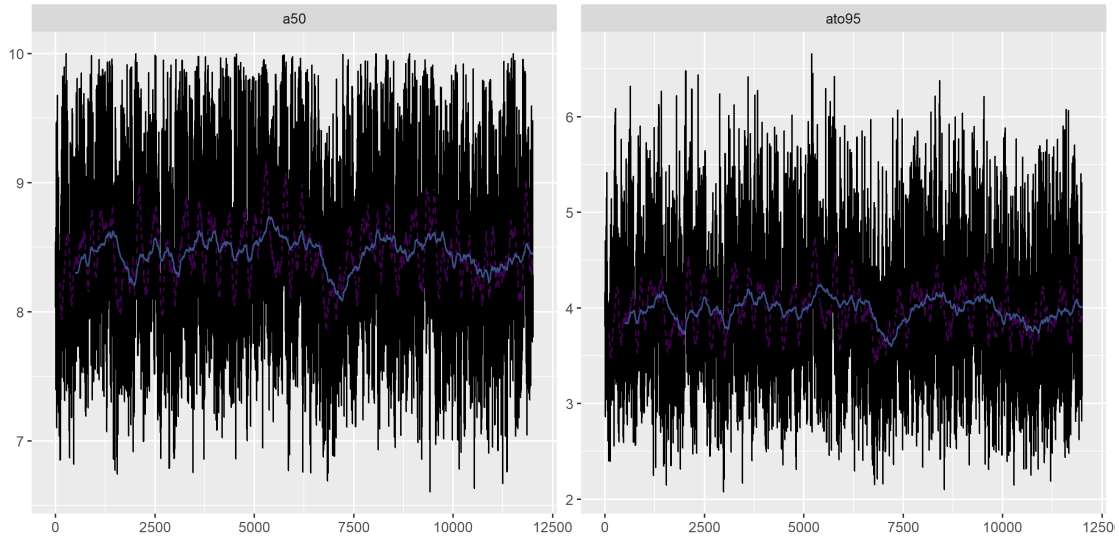


Figure 187: MCMC parameter traces for WCSIInsideFisheryF selectivity ogive from model 2023A.

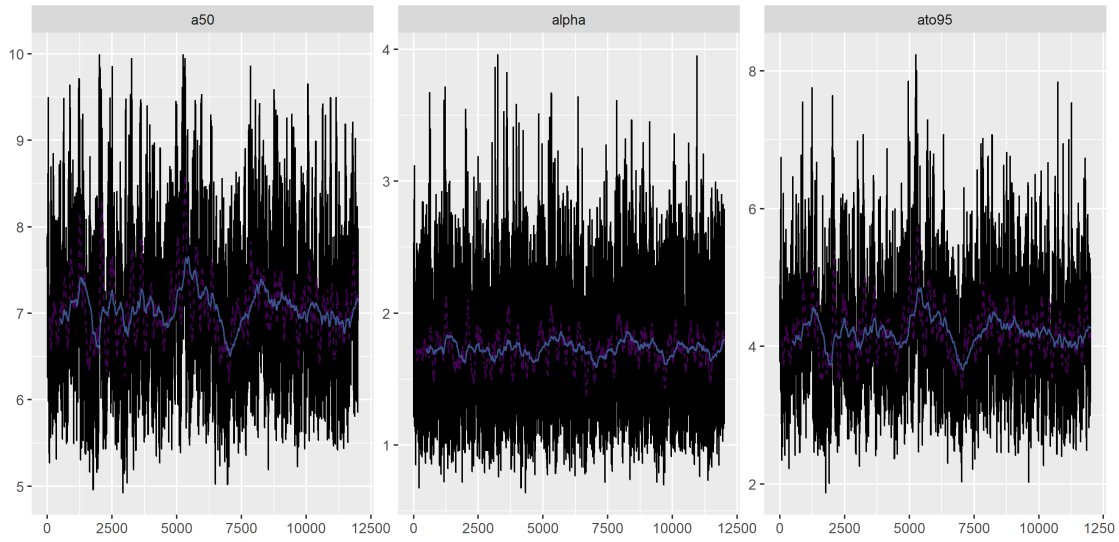


Figure 188: MCMC parameter traces for WCSIInsideFisheryM selectivity ogive from model 2023A.

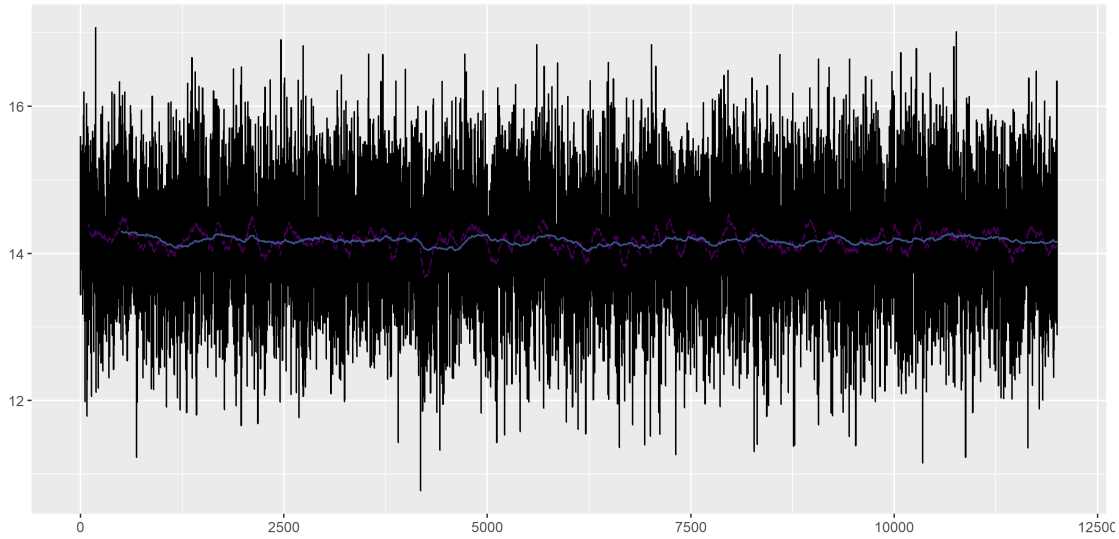


Figure 189: MCMC parameter traces for WCSINorthPre2000FisheryF selectivity ogive from model 2023A.

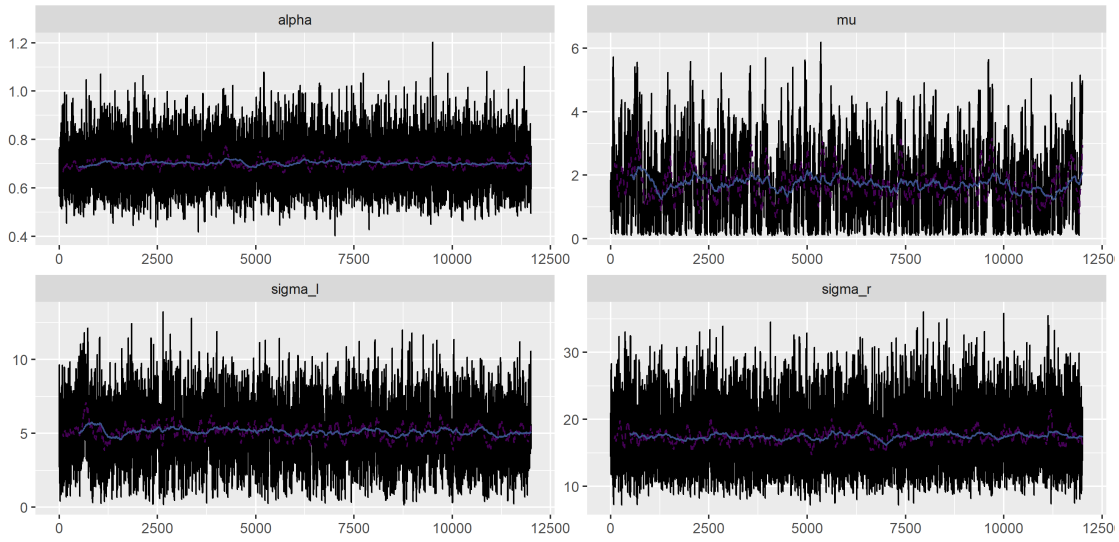


Figure 190: MCMC parameter traces for WCSINorthPre2000FisheryM selectivity ogive from model 2023A.

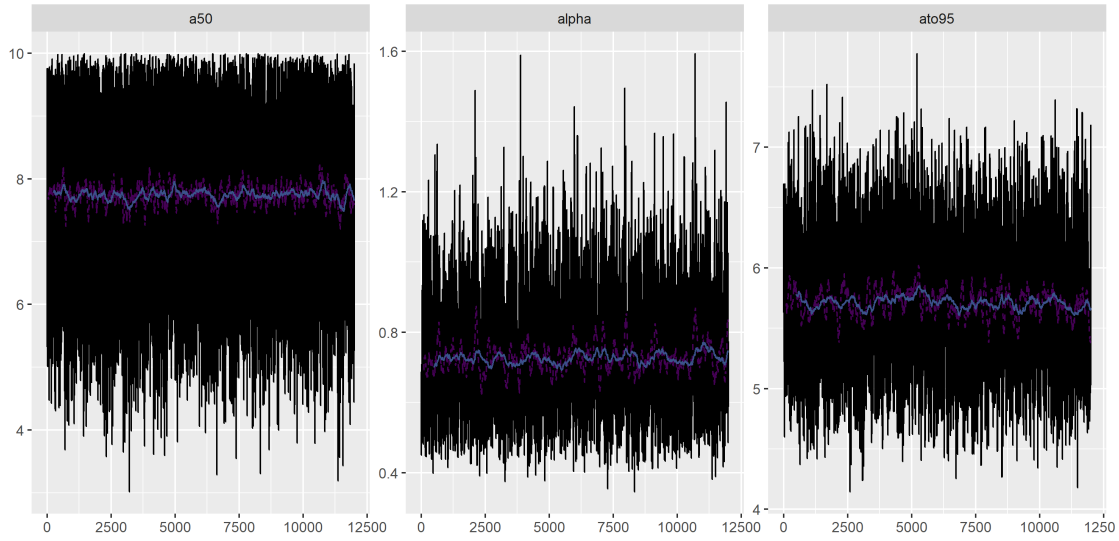


Figure 191: MCMC parameter traces for WCSISouth selectivity ogive from model 2023A.

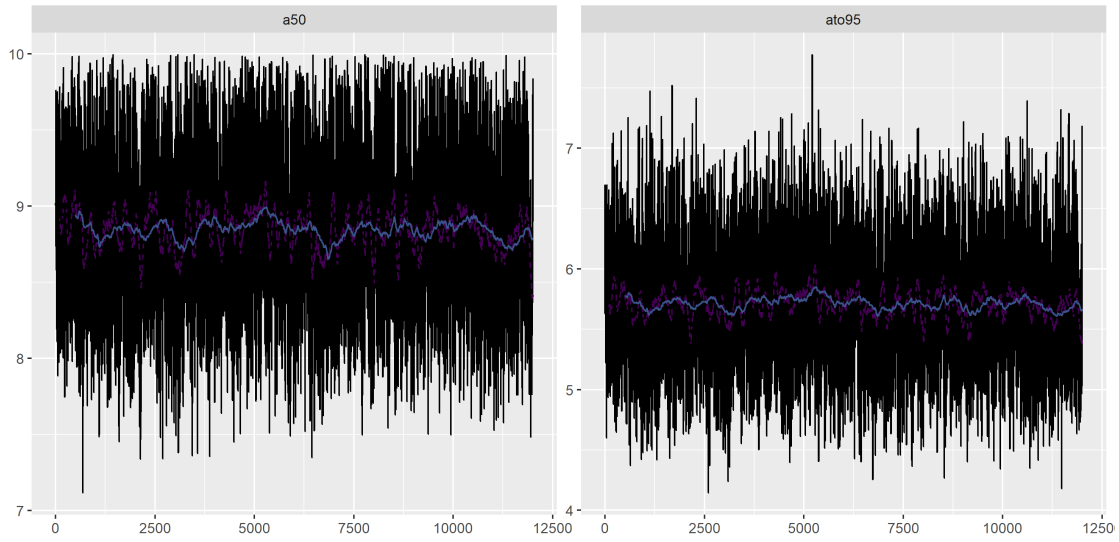


Figure 192: MCMC parameter traces for WCSISouthFisheryF selectivity ogive from model 2023A.

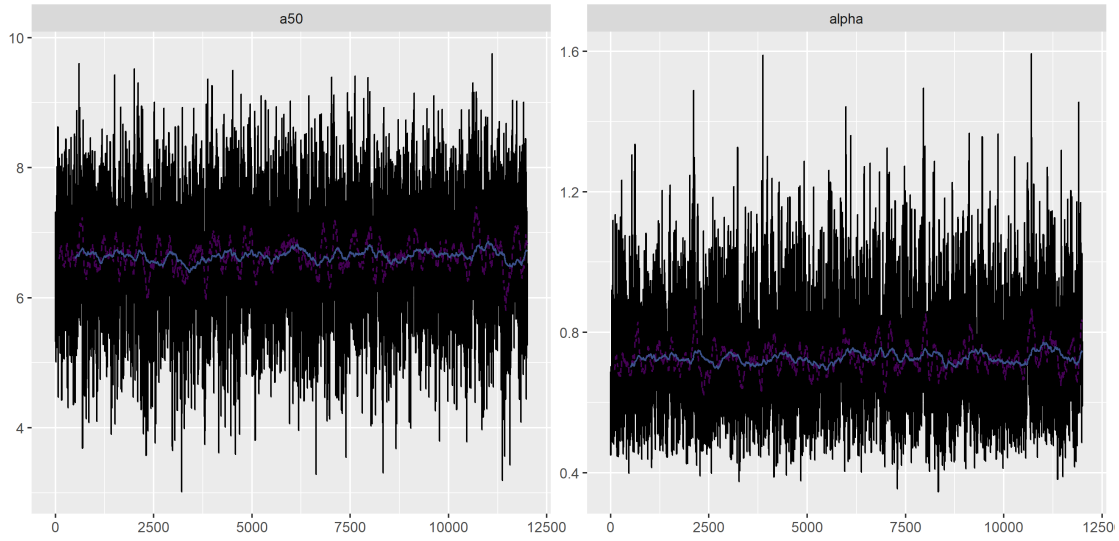


Figure 193: MCMC parameter traces for WCSISouthFisheryM selectivity ogive from model 2023A.

Appendix F Model input files

F.1 Model 2023A

F.1.1 Estimation

```
@minimiser adolc
type adolc
tolerance 1e-6
iterations 2500
covariance TRUE
active TRUE


@mcmc MCMC
type random_walk
start 1
length 5000000 # 8000000
keep 1000
step_size 0.3
adapt_stepsize_at 20000 40000 60000 80000 100000 200000 300000 400000 500000
proposal_distribution t
df 4
adapt_stepsize_method ratio
burn_in 1000000
max_correlation 0.8


@penalty PenaltyCatchMustBetaken
type process
log_scale TRUE
multiplier 10000


@estimate estimate_1
parameter process[EastRecruitment].b0
estimation_phase 1
type uniform_log
lower_bound 1.0e+5
upper_bound 1.5e+6


@estimate estimate_2
parameter process[WestRecruitment].b0
estimation_phase 1
type uniform_log
lower_bound 1.0e+5
upper_bound 1.5e+6


@estimate estimate_3
parameter process[EastRecruitment].recruitment_multipliers
estimation_phase 1
type lognormal
mu 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
cv 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
lower_bound 1 1 1 1 1 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 1 1
upper_bound 1 1 1 1 1 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1 1


@estimate estimate_4
parameter process[WestRecruitment].recruitment_multipliers
estimation_phase 1
type lognormal
mu 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
```

```
 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
cv 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
lower_bound 1 1 1 1 1 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 1 1
upper_bound 1 1 1 1 1 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1 1


@additional_prior PenaltyEastYCSAverageOne
type vector_average
parameter process[EastRecruitment].recruitment_multipliers
k 1
multiplier 100


@additional_prior PenaltyWestYCSAverageOne
type vector_average
parameter process[WestRecruitment].recruitment_multipliers
k 1
multiplier 100


@estimate estimate_5
parameter selectivity[SelectivityWestHomeMigrationM].a50
type uniform
lower_bound -10
upper_bound 30


@estimate estimate_6
parameter selectivity[SelectivityWestHomeMigrationM].ato95
type uniform
lower_bound 0.1
upper_bound 30


@estimate estimate_7
parameter selectivity[SelectivityWestHomeMigrationF].a50
type uniform
lower_bound -10
upper_bound 30


@estimate estimate_8
parameter selectivity[SelectivityWestHomeMigrationF].ato95
type uniform
lower_bound 0.1
upper_bound 30


@ageing_error AgeingError
type data
table data
#  1     2     3     4     5     6     7     8     9    10    11    12    13    14
15    16    17    18
0.98  0.02  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
  0.00  0.00  0.00
0.03  0.94  0.03  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
  0.00  0.00  0.00
0.00  0.05  0.90  0.05  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
  0.00  0.00  0.00
0.00  0.00  0.06  0.88  0.06  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
  0.00  0.00  0.00
0.00  0.00  0.00  0.07  0.86  0.07  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
```

```
      0.00  0.00  0.00
116   0.00  0.00  0.00  0.00  0.08  0.84  0.08  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00
117   0.00  0.00  0.00  0.00  0.00  0.09  0.82  0.09  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00
118   0.00  0.00  0.00  0.00  0.00  0.01  0.11  0.76  0.11  0.01  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00
119   0.00  0.00  0.00  0.00  0.00  0.00  0.01  0.11  0.76  0.11  0.01  0.00  0.00  0.00  0.00
      0.00  0.00  0.00
120   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.01  0.12  0.74  0.12  0.01  0.00  0.00  0.00
      0.00  0.00  0.00
121   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.01  0.13  0.72  0.13  0.01  0.00  0.00
      0.00  0.00  0.00
122   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.01  0.14  0.70  0.14  0.01  0.00
      0.00  0.00  0.00
123   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.01  0.15  0.68  0.15  0.01
      0.00  0.00  0.00
124   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.02  0.15  0.66  0.15
      0.02  0.00  0.00
125   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.02  0.16  0.64
      0.16  0.02  0.00
126   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.02  0.16
      0.63  0.17  0.02
127   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.02
      0.17  0.63  0.18
128   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.02  0.17  0.81
129   end_table
130
```

F.1.2 Estimation fishery

```
# ESTIMATION: Estimation of selectivities etc. for fisheries

# Fishery
@estimate
parameter selectivity[SelectivityChathamRiseDeepFisheryM].a50
same selectivity[SelectivityChathamRiseDeepFisheryF].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityChathamRiseDeepFisheryM].ato95
same selectivity[SelectivityChathamRiseDeepFisheryF].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityChathamRiseShallowFisheryM].mu
same selectivity[SelectivityChathamRiseShallowFisheryF].mu
type normal_by_stdev
mu 4
sigma 5
lower_bound 1
upper_bound 10
/*
@estimate
parameter selectivity[SelectivityChathamRiseShallowFisheryM].sigma_l
same selectivity[SelectivityChathamRiseShallowFisheryF].sigma_l
type normal_by_stdev
mu 2.5
sigma 5
lower_bound 1
upper_bound 10
*/
@estimate
parameter selectivity[SelectivityChathamRiseShallowFisheryM].sigma_r
same selectivity[SelectivityChathamRiseShallowFisheryF].sigma_r
type normal_by_stdev
mu 10
sigma 2
lower_bound 1
upper_bound 50

@estimate
parameter selectivity[SelectivityCookStraitSpawningFisheryM].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityCookStraitSpawningFisheryM].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityCookStraitSpawningFisheryM].alpha
type uniform
lower_bound 0.1
upper_bound 10

@estimate
parameter selectivity[SelectivityCookStraitSpawningFisheryF].a50
type uniform
lower_bound 1
upper_bound 10
```

```
68
69  @estimate
70  parameter selectivity[SelectivityCookStraitSpawningFisheryF].ato95
71  type uniform
72  lower_bound 1
73  upper_bound 10
74  /*
75  @estimate
76  parameter selectivity[SelectivityPuysegurSpawningFisheryM].mu
77  same selectivity[SelectivityPuysegurSpawningFisheryF].mu
78  type uniform
79  lower_bound 0.1
80  upper_bound 50
81
82  @estimate
83  parameter selectivity[SelectivityPuysegurSpawningFisheryM].sigma_l
84  same selectivity[SelectivityPuysegurSpawningFisheryF].sigma_l
85  type uniform
86  lower_bound 1
87  upper_bound 50
88
89  @estimate
90  parameter selectivity[SelectivityPuysegurSpawningFisheryM].sigma_r
91  same selectivity[SelectivityPuysegurSpawningFisheryF].sigma_r
92  type uniform
93  lower_bound 1
94  upper_bound 200
95  */
96  @estimate
97  parameter selectivity[SelectivitySubAntarcticAucklandFisheryM].a50
98  same selectivity[SelectivitySubAntarcticAucklandFisheryF].a50
99  type normal_by_stdev
100 mu 10
101 sigma 5
102 lower_bound 1
103 upper_bound 50
104
105 @estimate
106 parameter selectivity[SelectivitySubAntarcticAucklandFisheryM].ato95
107 same selectivity[SelectivitySubAntarcticAucklandFisheryF].ato95
108 type normal_by_stdev
109 mu 7
110 sigma 10
111 lower_bound 1
112 upper_bound 50
113
114 @estimate
115 parameter selectivity[SelectivitySubAntarcticSnaresFisheryM].mu
116 same selectivity[SelectivitySubAntarcticSnaresFisheryF].mu
117 type normal_by_stdev
118 mu 3
119 sigma 5
120 lower_bound 1
121 upper_bound 50
122
123 @estimate
124 parameter selectivity[SelectivitySubAntarcticSnaresFisheryM].sigma_l
125 same selectivity[SelectivitySubAntarcticSnaresFisheryF].sigma_l
126 type normal_by_stdev
127 mu 10
128 sigma 10
129 lower_bound 0.1
130 upper_bound 100
131
132 @estimate
133 parameter selectivity[SelectivitySubAntarcticSnaresFisheryM].sigma_r
134 same selectivity[SelectivitySubAntarcticSnaresFisheryF].sigma_r
```

```
type normal_by_stdev
mu 5
sigma 5
lower_bound 1
upper_bound 100

@estimate
parameter selectivity[SelectivitySubAntarcticSubaFisheryM].a50
same selectivity[SelectivitySubAntarcticSubaFisheryF].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivitySubAntarcticSubaFisheryM].ato95
same selectivity[SelectivitySubAntarcticSubaFisheryF].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSIInsideFisheryM].a50
type uniform
lower_bound 0.1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSIInsideFisheryM].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSIInsideFisheryM].alpha
type normal_by_stdev
# type uniform
mu 1.0
sigma 1.0
lower_bound 0.5
upper_bound 5

@estimate
parameter selectivity[SelectivityWCSIInsideFisheryF].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSIInsideFisheryF].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryM].mu
same selectivity[SelectivityWCSINorthFrom2000FisheryM].mu
# type normal_by_stdev
# mu 1.5
# sigma 2
type uniform
lower_bound 0.1
upper_bound 50

@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryM].sigma_l
same selectivity[SelectivityWCSINorthFrom2000FisheryM].sigma_l
type normal_by_stdev
```

```
mu 5
sigma 2
lower_bound 0.1
upper_bound 50

@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryM].sigma_r
same selectivity[SelectivityWCSINorthFrom2000FisheryM].sigma_r
type normal_by_stdev
mu 20
sigma 5
lower_bound 1
upper_bound 100

@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryM].alpha
same selectivity[SelectivityWCSINorthFrom2000FisheryM].alpha
type uniform
lower_bound 0.1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryF].mu
same selectivity[SelectivityWCSINorthFrom2000FisheryF].mu
type uniform
lower_bound 1
upper_bound 50
/*
@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryF].sigma_l
same selectivity[SelectivityWCSINorthFrom2000FisheryF].sigma_l
type uniform
lower_bound 0.1
upper_bound 50

@estimate
parameter selectivity[SelectivityWCSINorthPre2000FisheryF].sigma_r
same selectivity[SelectivityWCSINorthFrom2000FisheryF].sigma_r
type uniform
lower_bound 1
upper_bound 100
*/
@estimate
parameter selectivity[SelectivityWCSISouthFisheryM].a50
type uniform
lower_bound 1
upper_bound 10
/*
@estimate
parameter selectivity[SelectivityWCSISouthFisheryM].ato95
type uniform
lower_bound 1
upper_bound 10
*/
@estimate
parameter selectivity[SelectivityWCSISouthFisheryM].alpha
type uniform
lower_bound 0.1
upper_bound 10

@estimate
parameter selectivity[SelectivityWCSISouthFisheryF].a50
type uniform
lower_bound 0.1
upper_bound 10

@estimate
```

```
parameter selectivity[SelectivityWCSISouthFisheryF].ato95
type uniform
lower_bound 0.1
upper_bound 10

```

F.1.3 Estimation survey

```
# ESTIMATION: Estimation of catchability constants and selectivities etc. for surveys

## Define Catchabilities
@catchability CookStraitAcousticQ
type free
q 1.22472

@catchability WCSIAcousticQ
type free
q 0.938112

@catchability ChathamRiseSummerQ
type free
q 0.0804276

@catchability SubAntarcticSummerQ
type free
q 0.109987

@catchability SubAntarcticAutumnQ
type free
q 0.0878128

# Estimate catchabilities
@estimate CookStraitAcousticQ
parameter catchability[CookStraitAcousticQ].q
type lognormal
mu 0.55
cv 0.90
lower_bound 0.01
upper_bound 4.53

@estimate WCSIAcousticQ
parameter catchability[WCSIAcousticQ].q
type lognormal
mu 0.39
cv 0.77
lower_bound 0.01
upper_bound 3.35

@estimate ChathamRiseSummerQ
parameter catchability[ChathamRiseSummerQ].q
type uniform
lower_bound 0.016
upper_bound 0.51

@estimate SubAntarcticSummerQ
parameter catchability[SubAntarcticSummerQ].q
type uniform
lower_bound 0.020
upper_bound 0.51

@estimate SubAntarcticAutumnQ
parameter catchability[SubAntarcticAutumnQ].q
type uniform
lower_bound 0.020
upper_bound 0.51
/*
# Process error
@estimate
parameter observation[CookStraitAcousticBiomass].process_error
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
```

```
parameter observation[WCSIAcousticBiomass].process_error
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
parameter observation[ChathamRiseSummerBiomass].process_error
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
parameter observation[SubAntarcticSummerBiomass].process_error
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
parameter observation[SubAntarcticAutumnBiomass].error_value_multiplier
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
parameter observation[SubAntarcticAEXAge].error_value_multiplier
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
parameter observation[SubAntarcticSHIAge].error_value_multiplier
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True

@estimate
parameter observation[ChathamRiseSHIAge].error_value_multiplier
lower_bound 0
upper_bound 10
type uniform
mcmc_fixed True
*/

# Parameters
# Surveys
/*
@estimate
parameter selectivity[SelectivityChathamRiseSummerSurveyM].e
same selectivity[SelectivityChathamRiseSummerSurveyF].2
type uniform
lower_bound 0
upper_bound 18
*/
/*
@estimate
parameter selectivity[SelectivitySubAntarcticSummerSurveyM].a50
same selectivity[SelectivitySubAntarcticSummerSurveyF].a50
type normal_by_stdev
mu 8
sigma 2
lower_bound 1
```

```
upper_bound 10
*/
@estimate
parameter selectivity[SelectivitySubAntarcticSummerSurveyM].ato95
same selectivity[SelectivitySubAntarcticSummerSurveyF].ato95
type normal_by_stdev
mu 7.5
sigma 5
lower_bound 1
upper_bound 10
/*
@estimate
parameter selectivity[SelectivitySubAntarcticAutumnSurveyM].a50
same selectivity[SelectivitySubAntarcticAutumnSurveyF].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivitySubAntarcticAutumnSurveyM].ato95
same selectivity[SelectivitySubAntarcticAutumnSurveyF].ato95
type uniform
lower_bound 1
upper_bound 50

@estimate
parameter selectivity[SelectivitySubAntarcticAEXSurveyM].a50
same selectivity[SelectivitySubAntarcticAEXSurveyF].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivitySubAntarcticAEXSurveyM].ato95
same selectivity[SelectivitySubAntarcticAEXSurveyF].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivitySubAntarcticSHISurveyM].a50
same selectivity[SelectivitySubAntarcticSHISurveyF].a50
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivitySubAntarcticSHISurveyM].ato95
same selectivity[SelectivitySubAntarcticSHISurveyF].ato95
type uniform
lower_bound 1
upper_bound 10

@estimate
parameter selectivity[SelectivityChathamRiseSHISurveyM].e
same selectivity[SelectivityChathamRiseSHISurveyF].e
type uniform
lower_bound 0
upper_bound 10
*/

```

F.1.4 Observations fishery

```
@observation FisheryPuysegurSpawningAge
type process_removals_by_age
mortality_process Mortality
method_of_removal FisheryPuysegurSpawning
categories West.WCSI.Mature.M West.WCSI.Mature.F
time_step JulSep
min_age 2
max_age 18
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1990 1991 1992 1994 1995 1996 1997 2000 2001 2002 2003 2004 2005
table obs
1990 0 0.015545498944123 0.0133839525613909 0.0485008300472377 0.129358035095686
0.136389166556878 0.0476689398265429 0.0315776050871023 0.00781333008518296
0.0162587693860126 0.0140857987724539 0.00497500453002343 0.00538784918932775 0 0 0 0 0
0.00866209013475272 0.0078625030535018 0.0558669439942776 0.132660327251013
0.155032784774396 0.0449858096996659 0.0608509236766402 0.0216063199149524
0.0132710850299573 0.00990418042159528 0.00583613551302828 0.00595939619266464
0.00034042396779754 0.00293802774618644 0.00284707432209225 0.000431194225517465
1991 0.00112961234094251 0.00703507088583329 0.0915788141500997 0.0478769821559553
0.0777107001518195 0.112012081024287 0.0884566069928297 0.0204988772631444
0.00800419922001586 0.00442641642825969 0.00152591175859004 0.00288342502699206
0.000890426245605979 0 0 0 0 0.00282402923649605 0.00339593711269749 0.0230575919443137
0.0209037892158412 0.104357751093943 0.140591813916967 0.0988641914814027
0.054510728298812 0.0311348377420857 0.0245445420809319 0.0178940394674444
0.0081764079086366 0.00183863242147356 0.00360135172913511 0.000275232705445487 0 0
1992 0 0 0.00836318560584888 0.0694622735882546 0.0100130019885113 0.0280295402583013
0.0460509247536943 0.0259590425078425 0.00569865936609467 0.00721407870743337
0.00171753628791696 0.00174732060369492 0.00062064561459902 0.000261109403974237 0 0 0 0
0.00332822584986422 0.0353424876237349 0.262746346575975 0.0226327537342952
0.0897859510521387 0.147711372786792 0.104080786008164 0.0381577982876691
0.0321181251195274 0.024026978552638 0.0148713131097122 0.0119230440724487
0.00312261651021824 0.00364127222888304 0.00137360980177301 0
1994 0.0147776478458169 0.124167724738133 0.0327762583908389 0.01671433141573
0.0609908707830035 0.135123543260567 0.00869906547624309 0.0351864580997922
0.0101608270715 93 0.0115932653284209 0.00488916014241831 0.00439429465500936
0.00189870893586453 0.00160753592497424 0 0 0 0.00168446415546005 0.000725507887821542
0.14669555599853 0.0515359894263866 0.0286578945299959 0.0379322427005533
0.129352264014727 0.0137733121181559 0.0428970902955464 0.0326710085507868
0.0240529465205539 0.00340899746914887 0.0114440077140187 0.00349177670739877
0.00519241650883696 0.000716241894981138 2.90444480740677e-05 0.00275954699061868
1995 0.0432073627226489 0.238639569509422 0.155671320515129 0.00479507904801683
0.012316602959629 0.0203371035331977 0.0265144215064283 0.00195740753959178
0.00944509355699031 0.00260296048567935 0.0109113351175789 0.000464974995358313 0 0 0 0 0
0.0498800669632526 0.111695638547393 0.115462793925133 0.0155244756442875
0.00872861457053678 0.0325481110984488 0.0575168866335556 0.0101967584103607
0.0269333890596167 0.0228622721362377 0.00913053719786105 0.00720851709119786
0.0028118332653006 0 0.00211889970858846 0.000128498332456983 0.000389475926101 97
1996 0.0414559023173921 0.0845067725269534 0.36288354844603 0.0837663384343736
0.00296759921749097 0.0112927593344368 0.0133247144369769 0.0128535652655234
0.00056748211726873 0.00457250701804559 0.00527935093251775 0.000796282373166013
0.000796282373166013 0 0.000235748606632219 0 0.000664710138577695 0.0622972053075398
0.0649480326134899 0.15582816335523 0.0337550629155389 0.00215558038244599
0.00871384823934328 0.0196934901012538 0.0155933131108059 0.000974276755961779
0.00423500175862627 0.00383050673731672 0.000362427539093351 0.000564536247359248
0.000899021001062468 0.000185970340962433 0 0
1997 0.0105401453972059 0.0276449723815581 0.313884783189669 0.214328204653949
0.0686609869020054 0.005632292727447 0.010858590174777 0.00869695291970437
0.0118029435163434 0.0010409575107025 0.00148161092448802 0.00123013472672818
0.000816138670288028 0.000562047101036183 0 0 0 0.015694889928948 0.0269138739330662
0.0835362443891954 0.0796973350930943 0.0706291540833722 0.00281385617867933
0.0152009416289136 0.0126038638574418 0.00925216515680352 0.00105046723145736
0.00272171935751248 0.00152680985789233 4.96504186200491e-05 0.000616111330832279 0 0
```

```
    0.000512156758268649
24  2000 0 0.00518979419600013 0.0544529438772439 0.0499595466883848 0.135594979771336
    0.0756670669552241 0.0966063486474831 0.0400568411090464 0.0023100786777926
    0.0105289329367907 0.00196593577395481 0.00351435856903489 0 0 0 0 0 0 0.001899011899771
    0.0450306908157633 0.0543307511191625 0.159968330819391 0.076032492039768
    0.112436196621513 0.0400518655489909 0.0040198962021725 0.0165639244828412
    0.00647751837567296 0.00416582652801863 0.00111482994633852 0.000146895636325639 0
    0.000370575566632554 0.00154436719534735
25  2001 0.145214448479474 0.0224649171219831 0.0714846327538816 0.0772702217463549
    0.0493310873444339 0.12243691199502 0.0384318611315716 0.034801742436155
    0.0102934054242692 0.000524059113823744 0.00150367102444889 0.00261468114440882
    0.0031274246639208 0 0 0 0 0.145976375006525 0.00313575401918569 0.0317597854840902
    0.0465265105576922 0.0336660616997923 0.0825030722872113 0.032222418140585
    0.0342374318468224 0.00333108690517254 0.00122295717149801 0.00389238357091833
    0.000620550809503609 0.000246056500155854 0.00022814829405456 0.00011730677848007 0
    0.000815036548566775
26  2002 0.0589875022715996 0.00630270759929692 0.0845977220257449 0.0545596567136593
    0.0791045356650227 0.0457375418958856 0.0563342341833632 0.0396225874094479
    0.0205805186587333 0.00624112321695007 0.00377608407648742 0 0.000569533426755168 0 0
    9.63896580476672e-05 0 0.101386728212352 0.0116640089080834 0.0278190580322243
    0.0246398032899724 0.0593702752212444 0.0657035118844607 0.115929078274462
    0.0639360687872498 0.0445856653143785 0.0121676943456086 0.00581774043589232
    0.00524738453951167 0.00162010128861483 0.00158868988180762 0.00153142582838666
    0.000126874604822649 0.000355754349929166
27  2003 0.230165073613882 0.0244463508574061 0.00653579530692045 0.0480793231447026
    0.030913784042327 0.0503577708865231 0.0155880820048872 0.0428788061082397
    0.0167138938082314 0.0105154317118918 0.00761717533771234 0 0 0 0.000592882932204154 0 0 0
    0.272291010630074 0.00673060999190478 0.003129836396597 0.0160407522863088
    0.023815403247106 0.0358504264081279 0.0222098353283288 0.0707993723118828
    0.0126739660075971 0.0318474887375539 0.0124909277721829 0.00238100686161041
    0.0015604517030021 0.00066417162507757 0.00310496493771835 0 0
28  2004 0.0950788799190585 0.00509296769334693 0.0325908517662229 0.00735655519614763
    0.0366279787271118 0.0428027820476027 0.0526889686887587 0.0181223225974766
    0.0813362282303827 0.025330566240175 0.0319305606036067 0.0217653586198888
    0.00179372587430234 0 0.00317109063482085 0 0 0.0438382279879373 0.0085357544669153
    0.0272897686334557 0.00361422805295061 0.011403710247672 0.0332267108534728
    0.0761357385678334 0.04121737998863 0.114279209236346 0.0373929266901774
    0.0795729252388392 0.0490374413480421 0.000862962781405805 0.00449487673965884
    0.00527769293694748 0.00459794467379976 0.00353366471701484
29  2005 0.00266233296900452 0.0120945454097317 0.00413911787350102 0.0517483827947312
    0.0165310620154484 0.0288133994176845 0.045722968153509 0.0297484374190731
    0.00356204417610422 0.0398206206557619 0.0126118570794063 0.0210945260913669
    0.000682167267395646 0 0 0 0.00067580553001516 0.00069489490559731 3 0.00333219726914929
    0.00198241812302434 0.0371018772287939 0.00633310956227416 0.0503269674880247
    0.1489025628309 0.131158182601514 0.0457010559651364 0.140446656415721 0.0544912658508432
     0.0780143019183969 0.0252983438332532 0.000709546053399624 0.00149362185866318 0
    0.00410573124257554
30  end_table
31
32  table error_values
33  1990 1.99620363605166
34  1991 1.93696910679197
35  1992 2.30422318820207
36  1994 2.0080505419036
37  1995 1.88958148338422
38  1996 4.04571834843705
39  1997 2.23906520601641
40  2000 2.80179323398349
41  2001 3.18089422124553
42  2002 1.75926551901289
43  2003 1.69410753682723
44  2004 1.51048049612218
45  2005 2.71294144009395
46  end_table
47
48
49
```

```
50
51  @observation FisheryChathamRiseShallowAge
52  type process_removals_by_age
53  mortality_process Mortality
54  method_of_removal FisheryChathamRiseShallow
55  categories East.ChathamRise.Immature.M + East.ChathamRise.Mature.M +
    West.ChathamRise.Immature.M + West.ChathamRise.Mature.M East.ChathamRise.Immature.F +
    East.ChathamRise.Mature.F + West.ChathamRise.Immature.F + West.ChathamRise.Mature.F
56  time_step OctNov
57  min_age 1
58  max_age 18
59  plus_group TRUE
60  ageing_error AgeingError
61  likelihood multinomial
62  process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
63  error_value_multiplier 1.0
64  likelihood_multiplier 1.0
65  years 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
    2017 2018 2019 2021 2022
66  table obs
67  2001 0 0.0354546163332504 0.303530166479716 0.0766638695528872 0.0260685629785803
    0.00398368625600617 0.00718867684513498 0 0 0 0 0 0 0 0 0 0.00249713138749524 0
    0.0501051929265194 0.211554903092074 0.161404801275076 0.0368034250089787
    0.0245917210276539 0.006958693484935 0.0208711928623319 0.0245254638560276 0 0 0
    0.00280363385834211 0.00249713138749524 0 0 0 0.00249713138749524
68  2002 0.104699453534913 0.0841648936704576 0.145999589681699 0.118219123956505
    0.0178028952370521 0.00297423863695749 0 0 0.00328778490183521 0 0 0 0 0 0 0 0 0
    0.151171267207346 0.0965959754262184 0.065759167249509 0.121252215531035
    0.0150372155312236 0.00585984962212384 0.00793690050644983 0.00432337756098821
    0.0163104360541075 0 0 0 0.0151109146026075 0.0234947010889726 0 0 0 0
69  2003 0 0.102385567451047 0.015562148681852 0.094847401914755 0.110785203503404
    0.0424519491111892 0.00534652220113951 0.0147652945126304 0 0 0 0 0 0 0 0 0 0 0
    0.337373190389554 0.0622511184932708 0.0473370810351484 0.0452241534987426
    0.0281853023910231 0.0379599660219251 0.0129247450189824 0.0277046215353909
    0.0148957342399454 0 0 0 0 0 0 0 0
70  2004 0.125259642533358 0.0613219511981279 0.127923188632221 0 0.0180055006913517
    0.036412353568239 0 0 0.0170961222315372 0 0.00293804631243362 0 0 0 0 0 0 0 0
    0.287760640916728 0.0593951656620727 0.144237400543532 0.0172120999703795
    0.00629119174670744 0.0649103856381111 0 0.00267150481729857 0.00612467427667198
    0.0197686264439317 0 0.00267150481729857 0 0 0 0 0 0
71  2005 0.0138947319894411 0.302913780246669 0.0321257333768016 0.101596845644521
    0.00444679790647601 0.0180254311612364 0.00754126272238656 0.00307933129629477 0 0 0 0 0
    0 0 0 0 0 0.0212917642809477 0.317578234985347 0.0330358445494066 0.0852081843844537
    0.0213279874758514 0.0147544875202957 0.0131480526995362 0.00316025253093841 0
    0.00687127722939749 0 0 0 0 0 0 0 0
72  2006 0.00639436613733321 0.18637860020492 0.219237103371443 0.109562332810131
    0.0822244490201724 0 0.00955102579418946 0.00416138747247252 0 0 0 0 0 0 0 0 0 0
    0.0128124974997893 0.0691185328420931 0.141799999751917 0.0261289795024692
    0.0691758292046056 0.0151549742366943 0.0133075662039685 0.0106039400258708
    0.00832866122307748 0.00457788636122819 0.00525685962252955 0.00184032186607319
    0.00438468684902238 0 0 0 0 0
73  2007 0.0391224724311877 0.188699067266086 0.191770239171381 0.0247196993210489
    0.00871749206567292 0.0227464400904889 0 0.00371145273386731 0 0 0 0 0 0 0 0 0 0
    0.018509723194552 0.0537877623864863 0.27547939228955 0.102755561303385 0
    0.0391631661377856 0 0.0122692849445424 0.0139226750050616 0 0 0 0 0.00462557165890492 0
    0 0 0
74  2008 0 0.239257262201685 0.105221679770449 0.110774179757625 0.0526108398852245 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0.0640220744559914 0.147503525847978 0.242367844300728 0 0 0 0
    0.0382425937803185 0 0 0 0 0 0 0
75  2009 0 0.121033335127011 0.156741187910361 0.156741187910361 0.0544175942314582 0 0 0 0 0
    0 0 0 0 0 0 0 0 0 0 0.0453473450666041 0.255837611222933 0.209881722388172 0 0 0 0 0 0 0 0
    0 0 0 0 0 0
76  2010 0.00698100087447613 0.056660249219107 0.217890721626029 0.0980426287871297
    0.0635539661273726 0.010076552735411 0.025300316977834 0.013921386761408
    0.0161741511241211 0.00275739902828232 0 0 0 0 0 0 0 0 0 0.0115093530132095
    0.0630293881112799 0.267299425465832 0.0446676370961202 0.0318631661263786
    0.0229228440986718 0.0343124670530605 0.00244274930296O1 0.00651867288713830 0 0 0 0 0 0 0
```

```
 0.00407592358417819 0
77  2011 0 0.0285917368492783 0.295362001375306 0.1203091219883 0.0248999904874632
    0.00570900768428397 0 0 0 0 0 0 0 0 0 0 0 0 0 0.0958548915728862 0.271676383150468
    0.072920942851894 0.0369861618899703 0.00936989978719414 0.00975027477791955
    0.0116107212923911 0.00499040098782718 0 0.00519178701858852 0 0 0 0.0067766782862293 0 0
     0
78  2012 0 0.109094196113803 0.149201572630631 0.0994717859748155 0.0807111961811361
    0.0340790151342469 0 0 0 0 0 0 0 0 0 0 0 0 0 0.295824400182982 0.17018848588862
    0.0180045364620121 0.0434248114317538 0 0 0 0 0 0 0 0 0 0 0 0
79  2013 0.00570302166298869 0 0.165096339233076 0.154541412343959 0.0449283852622419
    0.0357314647191126 0.0140440194678146 0 0 0 0.0199237279674279 0 0 0 0 0 0 0 0
    0.017466321803475 0.0879051549764596 0.343333440125845 0.0454584640718276
    0.0410517565449272 0 0 0.0194186334800581 0.00539785834078744 0 0 0 0 0 0 0 0 0
80  2014 0 0.110796365999903 0.102668008957596 0.0676092190150807 0.0362181167645026
    0.0217321713829919 0.0301812334129941 0.00973083281497126 0 0 0 0 0 0 0 0 0 0
    0.183916925735685 0.101761607791086 0.0856235147388723 0.139079693118182
    0.0506230433478215 0.0242813220891682 0.00495630146027226 0.00455011379968397
    0.00741862191459053 0 0.0188529076565981 0 0 0 0 0 0
81  2015 0 0.00922699492575942 0.230825426948479 0.0753437042734111 0.0949027065635086
    0.0452437483804001 0 0.0251732172432664 0.0110580488548273 0.00775582849241511 0 0 0 0 0
    0 0 0 0 0.0198504683431099 0.213548895583108 0.038791678711807 0.0651582645632488
    0.0315285523298253 0.0406934108761481 0.0304084407605101 0.0147190073568707
    0.0155392906521851 0.00569205289719161 0.0127722052230951 0 0.0117680570208333 0 0 0 0
82  2016 0 0.0482066239562728 0.0190431751223616 0.184851011422726 0.106278124470617
    0.0253944198950544 0.0247294479325465 0.0106690450215422 0.0198116176834401
    0.0223562333841859 0.00438370563052096 0 0 0 0 0 0 0 0.0136229412145843
    0.0130950724387997 0.0611128116556686 0.148708210031629 0.146558705048151
    0.0253188105633088 0.0416593289358222 0.0282734607280306 0.0131289896516698
    0.00281329463456466 0.00511921842211283 0.0166756694252021 0 0.00909504136559454
    0.00909504136559454 0 0 0
83  2017 0.0148244406693199 0.150578410740195 0.155955520754185 0.0507970128027308
    0.0309138712508268 0.00430099979814877 0 0.00848543504383143 0 0 0 0 0 0 0 0 0 0 0 0
    0.272900868355853 0.179894596686248 0.0278486741235871 0.0229206962865683
    0.0350220509610268 0.0305716640511563 0 0.0149857584763219 0 0 0 0 0 0 0 0 0 0
84  2018 0.0348748395298024 0.136316527605053 0.129841336421824 0.0656750805736937
    0.0297062980483228 0.0379854078408467 0.00304977035981174 0 0.0162902201009416 0 0 0 0 0
    0 0 0 0 0.0312002032783462 0.24805895908201 0.147303560883911 0.0198450632116508
    0.0248920306918151 0.0443829687385369 0 0.00876330642767421 0 0.0181384973781477
    0.00367592982761166 0 0 0 0 0 0 0
85  2019 0 0.0347461515177616 0.208666389002659 0.108249656539488 0.0799811171632861
    0.00938941536465216 0.0177561713270063 0 0.0166266459796 0 0 0 0 0 0 0 0 0 0 0 0
    0.325992154900624 0.130330891829169 0.032173769975097 0.0226943207599776 0 0
    0.0133933156406707 0 0 0 0 0 0 0 0 0
86  2021 0.0101615729898384 0.0769546159230454 0.0931401439068598 0.119643086880357
    0.129134947870865 0.0620932389379068 0.00940551599059448 0.00153592799846407 0 0 0 0 0
    0.00153592799846407 0 0 0 0 0 0 0.0264289479735711 0.0489944989510055 0.0603658559396341
    0.0880600359119399 0.147370677852629 0.0591156149408844 0.0160999769839
    0.00635298699364701 0.00951237199048763 0.00147722399852278 0 0 0.0318064599681935 0 0 0 0
    0 0.00081036999918963
87  2022 0 0.110585385113439 0.0818768493950281 0.151724549868403 0.0298686693445171
    0.0257520149965164 0.055800113530132 0 0 0 0 0 0 0 0 0 0 0 0 0.00668043905033892
    0.193976664324581 0.164828129429175 0.0385704494596255 0.0297381218752083
    0.0699300089585676 0.0381520865464443 0.00251651810802371 0 0 0 0 0 0 0 0 0 0
88  end_table
89
90  table error_values
91  2001 9.65687261044822
92  2002 7.15744675833221
93  2003 5.22607223624257
94  2004 7.15744675833221
95  2005 15.1101653787013
96  2006 16.7007091027752
97  2007 4.43080037420565
98  2008 1.24971292605801
99  2009 1.93137452208964
100 2010 6.93022622632166
101 2011 7.49827755634803
```

```
2012 3.06747718214238
2013 7.72549808835858
2014 7.27105702433748
2015 15.3373859107119
2016 8.29354941838494
2017 6.47578516230057
2018 5.11246197023729
2019 4.31719010820038
2021 9.77048287645349
2022 4.20357984219511
end_table



@observation FisheryChathamRiseDeepAge
type process_removals_by_age
mortality_process Mortality
method_of_removal FisheryChathamRiseDeep
categories East.ChathamRise.Immature.M + East.ChathamRise.Mature.M +
West.ChathamRise.Immature.M + West.ChathamRise.Mature.M East.ChathamRise.Immature.F +
East.ChathamRise.Mature.F + West.ChathamRise.Immature.F + West.ChathamRise.Mature.F
time_step OctNov
min_age 1
max_age 18
plus_group TRUE
sum_to_one TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
2017 2018 2019 2020 2021 2022
table obs
2001 0.000754896625947443 0.0366444930358286 0.148738688050782 0.0771286787540796
0.0469143675262126 0.0299053817854768 0.0212967116809056 0.0134411207145523
0.00184956777713068 0.0025742707604128 0.000908600485040365 0.0020728460924249
0.00097592694800373 0 0 0 0 0.00188170508134664 0.000820675207824281 0.0155878960201522
0.17141431269709 0.147128227748533 0.0558395658484922 0.0661388264339352
0.0336125166637748 0.0469794326037012 0.0252969777134306 0.00719580620373303
0.0136128682973662 0.0142917899656121 0.00856359397145125 0.00433459298633612
0.00142305492185255 0.000200159386577138 0.000590742930646992 0.00188170508134664
2002 0.0480663636170083 0.0231705507307879 0.0685734443306294 0.139967510679053
0.0576140631241263 0.0169443486466107 0.00588722222160583 0.00146492255863357
0.00293350160543746 0.000846193065376369 0 0.000229589662002795 0.000665370089678791 0 0
0 0 0.00237135365828253 0.072269961798939 0.0115517975871003 0.0750363129248782
0.168090863542033 0.089738215938097 0.0508804336906258 0.0522516368112074
0.029503257384091 0.0338625445238919 0.0130492392140873 0.0102327476283106
0.00895322703151085 0.00582891466932301 0.00580635194939214 0.0010644246318725
0.000386568611336223 0.000387714415787732 0.00237135365828253
2003 0 0.14855802106511 0.0447380756634628 0.0619943449031239 0.0800516499882087
0.0147576337095688 0.0045708600088338 0.00699222135721085 0.00827850648837004
0.00215558684329943 0 0.000119148587175573 0 0.000225291571576022 0.00309950535404761
0.00314658534087701 0 0.00353066180200179 0.00278972805641627 0.201120145448029
0.0633498452069288 0.081335792161846 0.100529462968556 0.0773705675204676
0.0122757500557484 0.0252486328000416 0.00591652030029908 0.0194778652944764
0.00810961605086968 0.00273518117821726 0.00859891706520713 0.00285997768059283
0.00253325151253819 0 0 0.00353066180200179
2004 0.0464887728904547 0.0353457971267965 0.107548085706035 0.0320908888909042
0.0254929955328756 0.0517009927157964 0.00184972133541245 0.00144483116694414
0.0201042625537132 0 0.0167780437964627 0 0.00224709893393296 0.00706799182851016
0.00100585244887381 0 0 0 0.0692393027315869 0.0333419063246116 0.198156558670049
0.0622131874291576 0.0685685286948638 0.0907158271131524 0.037456660949574
0.00287875671944005 0.0454973364840489 0.00715823369639644 0.0289339894347691
0.00104833095561649 0 0.00373573135144408 0 0 0 0.00189031451857772 0
2005 0.0152514569008844 0.182467461018456 0.0764861176818267 0.0869508861748385
```

0.014313398762006 0.022907103309392 0.0249809058269471 0.00275195756340318
0.0010166885584436 0.00222054712159871 0.00110054865561348 0.000201033462990489 0 0 0 0 0
0.00120156332038642 0.0167198478590649 0.207784051181444 0.0741408507043788
0.126950754636959 0.015727433953143 0.038423738192259 0.0286123124149945
0.00875518322854885 0.00189830335840883 0.0183663805405564 0.00274411977003752
0.00925138450545838 0.00684605545554445 0.00355409806465008 0.000320417264373658
0.00540494417009904 0.0014488930229062 0.00120156332038642
139 2006 0.0156860795888675 0.0479626791149141 0.142373214310268 0.0981428640889389
0.113911132695744 0.0109303785023672 0.00879011336124506 0.0122858582922735
0.000571044511386675 0 0.00150495076888885 0 0 0 0 0 0 0.000730700115448837
0.00784165780408319 0.0457997956832508 0.156794656115915 0.105407431629633
0.11673823143244 0.0139223779971374 0.0267485919900301 0.0323764557737118
0.00778591015278379 0.00385203063183547 0.0177082663158843 0.00211830433544555
0.0048945256811443 0.00337534976225467 0 0 0.00101669922866034 0.000730700115448837
140 2007 0.0222067125245923 0.0836918224543534 0.143112793960037 0.109634138404844
0.0223929834519021 0.0350253224821653 0.00211921741040086 0.00224327293636506
0.0032607120675841 0 0 0.0003735364018023 0 0 0 0 0 0.000962615068801253
0.0241351642684476 0.0697489532825782 0.186881670023416 0.152949739775833
0.0241084881775721 0.0904984886472938 0.00451231013853944 0.00583304186918309
0.00742662233159099 0.00177450513520554 0.000318800509600115 0.00418195436237255 0
0.000303784756903955 0.00134073448981468 0 0 0.000962615068801253
141 2008 0.0132457864806928 0.0741968946867452 0.136212978950668 0.119610226802611
0.0602297317913179 0.0050102313584874 0.0153074699024889 0.00152145018641097
0.00158605244043575 0 0.000486460002964217 0 0 0.000620824904183759 0 0 0 0
0.000827477586131868 0.010765670081599 0.0811642907601311 0.153757086564053
0.117753742576633 0.103338519892304 0.0286026456924692 0.0484087364763648
0.00595752456689649 0.00508801624375626 0.00888252410352598 0.00277740401558475
9.0047610711998e-05 0.00262849088957028 0.000693745832407089 0 0 0.000408492014722735
0.000827477586131868
142 2009 0.0333222146872613 0.194780585914773 0.127610043971436 0.0667008720259503
0.0111973394031045 0.00798574856780342 0.0044379703526568 0.00290918254565354
0.000755054765672628 0.000642162785318959 0.00100526181960126 0.000354397299182211 0 0 0
0 0 0 0.0234116748544081 0.215614772287804 0.186338715870707 0.0682211916703573
0.0177454919204067 0.0121677466743982 0.00537960161609343 0.00755517124510 83
0.000599445076812743 0.00403285177936698 0.00491619343128298 0.000422927990253014
0.00123305804324487 0.000660323401342608 0 0 0 0
143 2010 0.00788267321966815 0.0166113702800437 0.196896660159694 0.0679870518889976
0.0629775281742455 0.03985581708059 0.0268254025920446 0.00238535165812272
0.00386344394385619 0 0.00210100680315949 0.00184071850715727 0.00133188012340561 0 0 0 0
0.00145977539374728 0.00545874722497902 0.0218035114035116 0.175762701143331
0.101492148444606 0.0688417068700378 0.0497474210489093 0.0598391904756889
0.016780916933179 0.025238703812929 0.0107887634197794 0.0122777636586664
0.00252421638774 99 0.00547369481319808 0.00201615811536943 0.00394083750292478
0.00330132117850534 0.00123374234815532 0.00145977539374728
144 2011 0.00653102505347002 0.0259605579876231 0.125926217898998 0.165480516860454
0.0682962998492094 0.0261080251990095 0.0248809912136361 0.00409650028859243
0.0046752271518415 0.00185728602441888 0 0 0.00250151023657191 0 0.00307720522863939 0 0
0.000459659898206544 0.0198197626446262 0.033186579752639 0.143515723264927
0.144770976132254 0.092379195514066 0.0343388211576804 0.041511821133274
0.00702096380561388 0.0121889059085007 0.00167734439502959 0.00351152196628852
0.000959639681117761 0.00248356197531466 0 0.00168604620173241 0 0.000638453678058904
0.000459659898206544
145 2012 0 0.0203805756637215 0.114150145568748 0.128434617460382 0.0808296789129046
0.0201496858294719 0.0161462747680683 0.010041142176706 0.000508205502107174
0.00271484424134768 0.000215036568803477 0 0.000611775901047595 0 0 0 0
0.000477814614854924 0 0.0145439499473671 0.134472591734586 0.179973686292392
0.103866982982174 0.0685694337495184 0.0451429348569259 0.0273315614103238
0.00594446642685831 0.0157161459978042 0.0037019993692939 0.00388316532690451
0.00123829478387999 0.000477175298954095 0 0 0 0.000477814614854924
146 2013 0.00456765741841345 0.0516881464428582 0.0943201602552125 0.118131176306331
0.0776969369890102 0.0265237654577581 0.0249794109604905 0.00737089550979656
0.00528132500015216 0.0017768429111091 0 0 0 0 0 0 0 0.00651725443649537
0.0524597949201663 0.0593924524156356 0.187301017267825 0.0855742321861503
0.0667383408652613 0.0650349411893187 0.0293696765626162 0.0215559717912082
0.00203060171902808 0.00508480827430626 0.00147624788393452 0.00333411219820127
0.000411367333919957 0 0.000508665573740045 0.000874198131061622 0
147 2014 0.00354149186616066 0.14989269400907 0.0326672681794556 0.0720096415823204

0.05606942712984 0.0197183411184355 0.0263208541974652 0.0169756059096681
0.00586111399990569 0.00245465058551852 0.00228022253317425 0.000985364382724812
0.00136253404923931 0 0 0.000411260566715905 0 0.00100722431062735 0.00539346551625785
0.154613568722732 0.066708272623089 0.0640481720406653 0.103830696452162
0.0538100315663545 0.0530580893659526 0.0398973653659739 0.0224128532516709
0.0193681174177104 0.0129221850143325 0.00507217649482494 0.004393919522988
0.000996737202838828 0.000355115594113409 0.000554315117385959 0 0.00100722431062735
148 2015 0.00217132934034051 0.0335642798110072 0.198523978870301 0.0468358851695952
0.0708755411654654 0.0203770743053682 0.0148869335311259 0.00682174680677222
0.0039142767008O2 0.00865481021279107 0.00172535336714113 0.00185269247991361
0.00263659485155911 0.00177771602880675 0 0 0 0 0.00187980835128138 0.0283786125518011
0.249589360267698 0.0978310966985838 0.118689274373432 0.0315361278075976
0.0112809886686594 0.01331951838353 0.0122632469205138 0.00745280753343215
0.00560430960304066 0.00415975889981303 0 0.0015781286431773 0.000457825482962104
0.000960954699779969 0.000399968473708706 0
149 2016 0.00722120946883917 0.0887280004759652 0.0611145556949102 0.0926853054021413
0.0802987132698022 0.033876341827654 0.018581056431134 0.0190531668703043
0.00761259727779727 0.0017896411657291 0.00421679691016636 0.00117495937834399
0.000870527591710169 0 0 0 0 0.000567300165362425 0 0.0891664909920039 0.0695394223067415
0.114095489309724 0.113288932766951 0.0711295455027105 0.0359524982872239
0.0311544462154804 0.0142441888411988 0.0120057155214889 0.0117046342331579
0.00637670874982992 0.00732144918507342 0.00319630620934133 0.00246669978385203 0 0
0.000567300165362425
150 2017 0.00396594760637852 0.120124219570853 0.12943823972388 0.036556599550098
0.0467820818075499 0.0408088731114183 0.0240065173447253 0.0151804146249338
0.00536032132552783 0.00156460163410323 0.00157209778813647 0.00260758879925599 0
0.00118518311405585 0 0 0 0 0.00924251819O2494 0.10872736279341 0.195752843248219
0.0503234145373469 0.0611849268201604 0.0489519706795941 0.0341355573998736
0.0233857959974175 0.015335594281322 0.00998424156092933 0.00503663055920362
0.00334721176089196 0.000746860575598638 0.00217667592303964 0.00170737045835425 0
0.000808339213473805 0
151 2018 0.00311690734267393 0.195382752231967 0.0971229524891603 0.0397870805421062
0.0148143880907331 0.0222402974408329 0.00747238466300482 0.00212080156122499
0.00262771340388765 0.00165611198071141 0.00236286910319317 0.000304375310607681
0.00216217408356364 0.000599710770580172 0.00113065742304518 0 0 0 0.0157749461517529
0.200450271977529 0.168106853369707 0.0768133582479467 0.0350047530669503
0.0423006893634586 0.0113121841003845 0.0159605503211747 0.014700352091908
0.00473770698059242 0.00874819947164616 0.00126773823274959 0.00369978828570997
0.00206666349681708 0.00236981277343171 0.00252311516215873 0.00126184046879006 0
152 2019 0 0.0120187984972711 0.16691087633855 0.144482498909316 0.0600927544614345
0.0282533995839058 0.0234791135493258 0.0165549856496282 0.002057735584180S1
0.00126756359970151 0.00063413023592863 0.00397890155819486 0.00107596773622156 0
0.00063834602046018 0.000967106532222024 0.00100124084163824 0 0 0.0101087925551684
0.125541510392591 0.174107465396386 0.092311633347074 0.0426043138274484
0.026273192330596 0.0267340265454432 0.00758965428279945 0.0078789715184345
0.00613733607325248 0.00254219291054382 0.00580598842083556 0.00496703740597156
0.00398446589547649 0 0 0
153 2020 0.00461174232844033 0.00804107551307792 0.0407741266158345 0.0766971874915978
0.111684634292467 0.0568430342283293 0.020071133598483 0.0178402733508353
0.0027149529443299 0.00652811639851083 0.0037847931848878 0 0.00147696904521681
0.000806091144735477 0.000923992138096532 0.000383095676095342 0 0 0.000826985740871245
0.00913357480846061 0.0672377524709311 0.159634602087127 0.21997756070584
0.0692222323387275 0.038236180503198 0.0277136512402457 0.0189477077792137
0.00983719806976731 0.00506758367985607 0.00617443971952698 0.00783399043827403
0.00363859379438 0.00133864514545102 0.00112863069503361 0.000869452832158097 0
154 2021 0.007693108 0.065392376 0.088762857 0.079384141 0.122508465 0.040824487 0.014439459
0.00627625 0.001874982 0.000391541 0.000689872 0.000196194 0.001378469 0.002579188 0 0 0
0 0.007772387 0.077814752 0.117148941 0.089780732 0.130664178 0.07537277 0.031287385
0.01424364 0.005928038 0.004506191 0.004791755 0.00051102 0.002019857 0.002376701
0.00192285 0.001467414 0 0
155 2022 0.078217996739588 0.109152020027841 0.0599571013027965 0.0257703313504433
0.0400837447301447 0.0355238271619387 0.0300496727212457 0.0234808577596104
0.00589808058946488 0.000186186304502039 0.00186105729384587 0 0 0.000409118126779453 0 0
0 0 0.0760289348768243 0.167370959272088 0.0820375435520683 0.0605508160474896
0.0563805432932826 0.0531302601391923 0.0449281571194073 0.022996713427924
0.013798942847631 0.00180846717898274 0.00321872593192117 0.00105329185142G3
0.000939645591264528 0.000452259154659359 0.00391089091250416 0 0 0.0008038546951341

```
end_table

table error_values
2001 22.3138535902489
2002 14.3821625924302
2003 9.60403548531054
2004 6.64159667889634
2005 14.1432562370742
2006 14.8599753031422
2007 21.119321813469
2008 21.6449157952521
2009 17.1056950434884
2010 21.7404783373945
2011 21.1671030845401
2012 15.9589445377797
2013 18.6346957177667
2014 19.3991960549059
2015 15.8633819956373
2016 13.2354120867215
2017 19.2558522416923
2018 16.2456321642069
2019 17.2968201277732
2020 23.317260282744
2021 23.5083853670288
2022 16.6756636038477
end_table




@observation FisheryCookStraitAge
type process_removals_by_age
mortality_process Mortality
method_of_removal FisheryCookStraitSpawning
categories East.CookStrait.Mature.M East.CookStrait.Mature.F
time_step JulSep
min_age 2
max_age 18
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
2007 2008 2009 2010 2014 2015 2016 2017 2018 2019 2020 2021 2022
table obs
1990 0 0.0575430423396771 0.107962201295204 0.0801035114686455 0.0813700856376859
0.0456131041482222 0.0180313105087812 0.0302328237150323 0.00894251291256549
0.0312903503983964 0.0274261981556816 0.0128505060086973 0.00121206594194969 0 0 0
0.000872126627642366 0 0.0209189049884359 0.0402166995617402 0.0559641208618143
0.0574643560671419 0.0473111187687714 0.0285755012956054 0.0414702836628862
0.02836375568022 0.0660965540283279 0.0580090328677201 0.0204718914728734
0.0165255538988728 0.00497505083509141 0.00849526912990357 0.000819941094772586
0.000872126627642366
1991 0.000109104027605633 0.0512376672879414 0.193867647913696 0.110880381089671
0.0412603817499686 0.04507359697316 0.0379458470053655 0.0146840036448079
0.0106157548661161 0.00824853813755877 0.0105634721600406 0.0131135553352755 0
0.00484203333505685 0 0 0.00247502509413526 0 0.030976762880994 0.0786966815973033
0.0343849647053244 0.0359847992205004 0.0533765482734443 0.0574086489256431
0.0229172888438186 0.0339569606911676 0.0154796895318781 0.0385562257898929
0.0354288424615332 0.00386765286422232 0.00904661825612182 0.00330424583757611
0.00143355718488999 0.000263504315291223
1992 0.000748126877626838 0.0162287660622086 0.0958767826241383 0.153207918954192
0.0238795922682318 0.0403474076205261 0.0494750433409967 0.0207000216892798
0.0132047510891199 0.0110123275680594 0.00495746521101529 0.00683503410933197
0.00273198468921046 0.00404048233835842 0.00121348207385987 0 0.000436957446258283
```

0.000170034382975482 0.000799406626304825 0.0710236129530257 0.17112528695202
0.0254551316591635 0.0408830854265965 0.0659650918788689 0.0385089069009862
0.0317508632299088 0.0236480409962655 0.0235221583744576 0.0261195582847998
0.0263176914822807 0.00610541659941458 0.00129971432047141 0.000835950087915802
0.00157390588213128
205 1993 0.000433607074526961 0.0214262908411431 0.0661938355307592 0.228367930624608
0.100457559000301 0.0146776654668856 0.0207287533586289 0.0259942842249709
0.0102524187619377 0.005954174938589 0.0014908406166054 0.00323329091054087
0.0019048159513242 0.00166765510323385 0.00191489798547133 0 0.000373316619709714
9.10938006624534e-05 0.00485768156297978 0.0386882087502969 0.156606296445626
0.0874298286610163 0.0151108745104098 0.0495444636352577 0.0407920541796495
0.0193686006007229 0.0141419600979122 0.0155945362623341 0.0136396589491224
0.0119550720324089 0.0113378310759669 0.0112294499684865 0.00273465043161446
0.00180640202629696
206 1994 0.00103368176909198 0.0195903068511307 0.0441915970374872 0.051800088823781
0.141309162234337 0.138686584608778 0.0101600492865492 0.0238041509954121
0.010553308491702 0.00712021016841731 0.000791104777930137 0.00772520103870487 0
0.00049773933130785 0.000259631154270162 0.00123965865605404 0.0043267346890471
0.00102738731348625 0.0210632379606884 0.0317911686148241 0.0420135070076108
0.141509573141173 0.135369203457607 0.0166835863853804 0.0436201320692559
0.0333628606946369 0.0255082385954684 0.0127363286441355 0.00351793632821168
0.0060856307180505 0.00926258352645963 0.00651042988355031 0.00252225105641368
0.0043267346890471
207 1995 0.00143896326227352 0.0411774327641771 0.087259068634786 0.0666024342366249
0.0546414309139771 0.181362092357551 0.103102829356749 0.0103712897898799
0.0126112531057207 0.0108975367200108 0.00812055073403518 0.00167396391455416
0.00138765718145636 0.000990312089708159 0 0 0.0041918787452722 0.000475814323063204
0.0118881674900255 0.031847031077211 0.0276827007958983 0.0302967556809328
0.0890954899754619 0.0954159402324935 0.0162929956589079 0.0428830126622405
0.0214090110796741 0.0116435238613763 0.01329096922878 0.0066389654292996
0.00411256501114469 0.00491748628103008 0.00208899866041285 0.0041918787452722
208 1996 0.00663555869388881 0.0701336908658843 0.112842907166214 0.0663381753892677
0.0207786646851091 0.0506702978295191 0.0902591726486579 0.0456718744305579
0.00303349587892612 0.00582695314000793 0.00146154935875953 0.00040719155687438
0.00180853002788769 0 0 0 0.00330840161417224 0.00230297110658638 0.0236044638401302
0.0541969467488243 0.0406749199619308 0.018747562652643 0.0403450608309405
0.119223381879195 0.115510266710804 0.0138472313992632 0.0363579451138496
0.0209865263186018 0.0176332300670465 0.00303323144240702 0.00496050073211067
0.0031503601114679 0.00294050793934252 0.00330840161417224
209 1997 0.000546356721557127 0.0590182443456243 0.109954616357029 0.105128782972584
0.0947812860019832 0.0213897156878911 0.018885787849622 0.0402544634792483
0.0215739911884077 0.00439850772070263 0.00369960786789154 0.00124932090944656
0.00160255453569043 0.000116101724334573 0 0 0.00115887726419891 0.00158735147371118
0.0363680403077413 0.107698174127372 0.0664051776846383 0.068213320829614
0.0180926823223998 0.0221478089892039 0.0700881110517246 0.0639172644751236
0.0144021105841766 0.0209632173021633 0.0105560956366302 0.00861879851982508
0.00159901408917791 0.00360375738925521 0.000821983326833025 0.00115887726419891
210 1998 0.00133178841271114 0.0610560574436747 0.192797283563316 0.0927102630235652
0.0280027799141509 0.0228140853859598 0.00729257911733599 0.0127647775497695
0.0273729280525071 0.0106646148607319 0.000897938813939905 0.00288936908469253
0.000473292862585073 0 0 0 0.0015668788464544 0.000434466079575229 0.0255916297846546
0.105323503837893 0.0801796626939748 0.039194996308402 0.0536952133519767
0.0200553600912749 0.0345563966433317 0.0959434574262092 0.0392622823112473
0.00936313428829382 0.0218598832459499 0.00316617471950594 0.00461605866095308
0.00195911105910972 0.000597153719800004 0.0015668788464544
211 1999 0.0144591696042391 0.0895466939927974 0.171836877017276 0.0894354350435334
0.05900105269709 0.0289804769847618 0.0162483919782079 0.00613100256368241
0.0103883026701592 0.0145708338197801 0.00537255168720304 0.00470998559071554
0.000771516325435311 0.000247650513407195 0.000247650513407195 0 0.00242636888736569
0.00382120077427443 0.045679135824173 0.080880478399454 0.0772223915775636
0.0505621632462387 0.0401049920214595 0.0308500962506645 0.0195696872596622
0.0368716769195626 0.0374582048354302 0.0334479820691515 0.00629180626932368
0.00442997406900293 0.00876532647607121 0.00472606496910235 0.00251849026243896
0.00242636888736569
212 2000 0.00945318117247331 0.158396791665931 0.0790752580170599 0.0584813010199119
0.131034200635666 0.0717834967995778 0.0534667256686968 0.0201663954817798
0.0129036503515015 0.0142704753827886 0.00587455793989155 0.00237072514436986

0.00101786798473769 0 0 0 0.00353394215891316 0.00163947159890701 0.0667462929193024
0.038251559185932 0.0202421707627213 0.0653116787956392 0.0435983591856311
0.0275672873492362 0.0212348516138908 0.0123967551849255 0.0331994702359627
0.0199723374663099 0.0123755999425202 0.00274856199164672 0.00368355785074627
0.00399277594928634 0.00167675838513092 0.00353394215891316
213 2001 0 0.0760017898261001 0.134631306090632 0.0819956851781832 0.0440295889699482
0.0545697521409479 0.0342849626207727 0.0194683833654715 0.0067275362559518
0.0011096703674955 0.00265465232835132 0.00069749291918766 0 0 0 0 0.000881478178563678
0.0074405141042817 0.0626492682354429 0.0846593473051787 0.0519898654586139
0.0488954552712078 0.0795596953081921 0.0764280930336747 0.0393057601592477
0.026906396710211 0.0198901357558228 0.0205864503510228 0.0125181791973165
0.00692506517689328 0.0031573982449808 0 0.00115459926774398 0.000881478178563678
214 2002 0.0201763267215385 0.0169470642333762 0.064483850989096 0.0915926975599983
0.110349887528888 0.0386419849476903 0.0384216371213455 0.0199526693656387
0.00937971090626321 0.00729227859890561 0.00036595438146444 0.00121292204780961
0.00105638993833964 0 0.000592051754233418 0 0.00244118518833176 0.00501604166644746
0.00465255987317429 0.0451097842539492 0.0772025090187902 0.111033242363566
0.0973514616683143 0.0792579492071163 0.0536629709549951 0.0362198936348356
0.0209662634190182 0.0148214470073533 0.0140053385444881 0.0117291554255186
0.00266907539996108 0.000496333135426676 0.000458177955794624 0.00244118518833176
215 2003 0.0164340720232147 0.24504447072379 0.0203343139838692 0.0663721469383336
0.0665549097356586 0.0558345906771536 0.0209240914016882 0.0348226200240169
0.00890334418441872 0.00352974205252309 0.00171222699706618 0.000695246110107501
0.000537477883271568 0 0 0 0.000735310708642884 0.00432937477185509 0.100122014929361
0.0160352736645872 0.0329176781620176 0.073222434625513 0.0558639574481312
0.0415691111727047 0.0449422118098498 0.0337621407741415 0.0236231188020338
0.00826142550175331 0.00425995802508618 0.00716626798414311 0.00569304715905165
0.00399069653538886 0.00107141448198454 0.000735310708642884
216 2004 0.00970334602222724 0.0641486102551674 0.176155926326575 0.0341901697346258
0.0449677856836115 0.0302806032356136 0.0155347211738803 0.00655183985398862
0.00709985353206828 0.00300082039385839 0.00269570718245165 0.00099417523228048
0.000389937555160958 0 5.540024237736 38e-05 0 0.00141420423598 79 0.00356768576053799
0.0266962555193761 0.142159580104466 0.0613336104214394 0.0686543549977078
0.0606725039905927 0.0741684274248093 0.0331797027157788 0.0436997886968578
0.0254462473621865 0.0286538584844621 0.0184167433442482 0.00231390205197871
0.00537502960158271 0.00603635152995291 0.00102865309816054 0.00141420423598 79
217 2005 0.0168294820469718 0.100160200838583 0.0737273337184441 0.136498546839287
0.0188270211858285 0.0357566909409139 0.0391041214600247 0.0213556544469852
0.00733832080295923 0.00787907060904532 0.00335044799063 79 0.00149313742787 18 0
0.000985215145854939 0 0 0.00974479317561345 0.00370654339589789 0.0330889118368293
0.0266189565363311 0.111010290120399 0.024531910705695 0.0630360066582372
0.0891619020442348 0.0374174100260109 0.0103329772739441 0.0544515905433446
0.0149574926838864 0.0202219945586288 0.0202096455479631 0.00397146974255806
0.00185102125620394 0.00263704726520129 0.00974479317561345
218 2007 0.01804815985489 0.155804638133776 0.124672222290085 0.0832293506217359
0.0504154904605803 0.0466457358238671 0.009046824260256 56 0.0194411240245688
0.0200382146563925 0.00682148926644257 0 0.00479348025998918 0.00179362192963311
0.000370990180372003 0 0 0.00643443197682412 0.00487757791107403 0.0331141968335334
0.0495283897241607 0.0497394801973276 0.0276657489825976 0.0505545948000558
0.0152184278525936 0.0492674372666165 0.0449668094001474 0.0425669657899235
0.0131395766130 53 0.0285561197774586 0.00893161748736892 0.0153404412675035
0.00860456935798888 0.00393784102235958 0.00643443197682412
219 2008 0.0125868522949294 0.140460954747585 0.161487868287244 0.135150884390704
0.0391083528158102 0.0219841111349732 0.0181853516559672 0.00523700758380346
0.00416609809742996 0.00439270317506101 0.0024940159597842 0.000614070914985485
0.00325377812607182 0.00126716087503863 0 0 0.00322034769282121 0.00205534441163556
0.0618901814331896 0.074419306258457 0.0867820345318285 0.0398654123769608
0.0314948808579854 0.0482293693174243 0.0109864302753609 0.0205793316109473
0.0227125717931209 0.0141357663579607 0.00301716372583222 0.0139160248996733
0.00585007639275822 0.00502631882567658 0.00220988 14861577 0.00322034769282121
220 2009 0.0301478901104697 0.1971726886756 0.148464856940802 0.0806011317459 47
0.0494221104352284 0.0124572899622185 0.00955372739018868 0.00670755241747936
0.000475074572525927 0.00196812435804708 0.000355022737442054 0.000629423817879795 0 0
0.000249662941586587 0 0.00104483941053986 0.000398399857019574 0.0620414778588854
0.0857967439903751 0.103557297718481 0.0675283499717917 0.030613271715473
0.0289911717657976 0.031239823973559 0.00978883925474322 0.014042855998323
0.0119251358726981 0.00534744451530677 0.00320558207042359 0.00234081677946324

0.00172683195513069 0.00116172177603352 0.00104483941053986
221 2010 0.0032833135549644 0.0986843393086439 0.126403665654319 0.0864254782292579
0.0462744699070877 0.0379627497188819 0.0268118306444108 0.00380373405092856
0.00306025069215364 0.00144964782869238 0.000901273015007644 0.00152925373145269
0.000183129913202752 0.000142218061276535 0 0 0.00386469852106279 0.00049365495721882
0.0813990669905019 0.0691492008487374 0.075523201909855 0.0665009944190946
0.0918566835883395 0.061610965417555 0.0353721638290543 0.0302112858691384
0.00936578497577026 0.0127421083471577 0.00198309164109797 0.00940854186278582
0.00267463365974698 0.00286233230584927 0.00420153802563597 0.00386469852106279
222 2014 0.00219113196026852 0.0914692866324551 0.0441977453794144 0.132134997566533
0.0634828019811292 0.0750284716424936 0.0695827852840686 0.032004054465264
0.0236592648028781 0.0116797152268002 0.00281317867030589 0.00172485955477011
0.00319420489530911 0 0.000493695044507 54 0 0.00293427161654493 0.000832691825778021
0.0459703684013972 0.0136486592486167 0.0831540771630786 0.0246874386810341
0.0613951578371213 0.0432871718727633 0.0571841832776576 0.0386326786218393
0.0376731762405317 0.0134709391729154 0.00569563981006368 0.0109721068190723 0
0.00387097468884401 0 0.00293427161654493
223 2015 0.00203222255771214 0.0417228322633193 0.240160034848344 0.0467097093879541
0.0576404808878452 0.0333902112350453 0.0282427625308642 0.0230675362371648
0.0200079796261597 0.00675429704161066 0.003012117982727 44 0 0.00107561726578635
0.00183435011605434 0 0 0.000385709073482174 0.00356117487914065 0.0252247200585316
0.126817721761523 0.0335389531244173 0.0516215755852466 0.0314134501667667
0.0534980846448887 0.0675507108306651 0.0440339949473114 0.023140433637285
0.024367548369004 0.00398618260774067 0.00120453967074682 0.00294244185160642
0.000676897737573683 0 0.000385709073482174
224 2016 0.0257847951336817 0.0695578036673003 0.0669953966101364 0.152615258513009
0.0287869133383448 0.0412514744068725 0.0272027411741896 0.0249460250859658
0.0200034986897413 0.00909185381221539 0.00445332877967476 0.000760187886518215 0
0.000341465774110277 0 0 0.00135558408977004 0.00917768575923193 0.0300246647023627
0.0228712329334892 0.0895414305303239 0.0398293526276598 0.0585066336014367
0.060494142125646 0.0676239539026722 0.0620442359862351 0.0355663440874035
0.0277696261507861 0.0128574442891243 0.00778980434776293 0.00140153790456553 0 0
0.00135558408977004
225 2017 0.0125636381395203 0.0707825833316983 0.0381345485666661 0.0590403571960444
0.074797363798035 0.0342266651320265 0.0490664398758914 0.0178684331983242
0.0198440359694322 0.0132001565959815 0.00746337550578262 0.00216812397164192
0.000671766192733002 0 0 0 0.00176462757106884 0.00371852987207905 0.0354733050618379
0.0240922469879567 0.0329658257752818 0.0778805409808708 0.0506442938610295
0.0960882458837554 0.0885964667463719 0.0607459678017053 0.0566475626484199
0.0359128231916717 0.0163352964192363 0.0133972094776884 0.00310065652450302
0.00104428615167707 0 0.00176462757106884
226 2018 0.0311266918109382 0.141978848247529 0.128925005975194 0.0436887292573241
0.0314075386246414 0.0552893669276487 0.00983166384137077 0.0212607475909792
0.0105729336815796 0.00741054362825487 0.00614681589083157 0.000911958082107855
0.00158935741045869 0.00141335824786285 0 0 0.0020632996010756 0.00692567428426669
0.0595448781443107 0.0505892900608 98 0.0314917984483206 0.0291384587506606
0.0952780077641113 0.0289764360919285 0.0680186123106745 0.0403924881714475
0.0451592424099656 0.0204084962186974 0.0192232901987734 0.00646340430876064
0.00270976441831291 0 0 0.0020632996010756
227 2019 0.0029710442497557 0.121798226550849 0.166717119679679 0.0954387186905411
0.0309416994202788 0.027396901135035 0.0253989002640037 0.00940665576632 65
0.00786389126948516 0.00101635622451106 0.00557543004905011 0.000548419530905271
0.00157953513923575 0.000610202909325226 0 0 0.000867349402652636 0.000535819684675284
0.0265221256193172 0.0596996446697106 0.0487832253967492 0.0379992425008567
0.0435380125555198 0.0903752033388 1 0.0521201484759165 0.0575287218149646
0.0253341993477568 0.0289404261757389 0.0159453018990753 0.00657855179290413
0.00580641535968338 0.00129516168435676 0 0.000867349402652636
228 2020 0.0226368877633196 0.0647488671306663 0.0772323928518475 0.113607793789437
0.0933425230142566 0.0651060612297926 0.0299811011756792 0.0217229198791801
0.00952697973013729 0.00550337486650134 0.00082722755697191 0.00243078905020357
0.00138431703741132 0.000352760476264304 0 0.000196790271461608 0 0.00446637371649419
0.0151362967972202 0.0292809016815366 0.0543524510873403 0.0588894378162693
0.0741295039778096 0.0511875201928191 0.0510472023709205 0.0526464783681763
0.0235930495909873 0.0327684427504333 0.0168772209809713 0.0135988045241898
0.00561875830449085 0.00715501834698686 0.000651753670224568 0
229 2021 0.0467277264355112 0.0866279671484263 0.0519009895608296 0.103268745741678
0.104614304624429 0.0652606593970426 0.0342154083145557 0.0292459915180938

```
0.0140821392364965 0.00442620307024214 0.00101890310036184 0 0.00340521523335766
0.00130238900329034 0 0 0.000334036805242191 0.0203230737828182 0.033795353697045
0.0289533433300936 0.0319555842714377 0.0551907341409956 0.0648871748906501
0.0517464235005709 0.0559671520363433 0.0363823692206713 0.0274411757350317
0.0232439479854649 0.00813283426007657 0.0108129345888926 0.00292506346749439
0.00169023708043322 0 0.000121918822423433
2022 0.0468863633766067 0.0891422267285158 0.0534841993575854 0.0455338692869321
0.0454209827365816 0.0578925137852433 0.0424423597123797 0.0304320659870629
0.0232706845797774 0.00442211398796607 0.00170850086636824 0.00314229028949547 0 0 0 0
6.36964227035332e-05 0.0135431597197923 0.0475579350324758 0.0536630431872547
0.0275146944653539 0.0364866886232309 0.0634485272424036 0.0921267224232805
0.0692739716013557 0.0500410015550352 0.0409499720808518 0.0330214639649479
0.00968483773389278 0.00986346798033341 0.00525887577491338 0.000805740125325846 0
0.00291803137233403
end_table

table error_values
1990 23.6915720183146
1991 29.8977924786931
1992 39.0182381987277
1993 42.202299130574
1994 43.1197404160213
1995 42.0943648616979
1996 38.9103039298515
1997 36.2119472079478
1998 37.1833556278331
1999 47.9228153810099
2000 39.7737780808607
2001 40.5832850974318
2002 44.0911488359066
2003 37.6690598377758
2004 53.5353973625696
2005 48.3545524565145
2007 40.5832850974318
2008 55.7480498745307
2009 40.691219366308
2010 51.2687777161705
2014 43.3356089537736
2015 39.8277452152988
2016 36.6976514178905
2017 42.5261019372025
2018 45.11652439023
2019 40.745186500746
2020 33.0818534105395
2021 27.9549756389224
2022 34.2691303681771
end_table




@observation FisherySubAntarcticAucklandAge
type process_removals_by_age
mortality_process Mortality
method_of_removal FisherySubAntarcticAuckland
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
time_step OctNov
min_age 1
max_age 18
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 2001 2003 2004 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
```

```
     2019 2020 2021 2022
283  table obs
284  2001 0 0 0.0321748372126268 0.0743196165038776 0.0851044096300212 0.140815685125722
     0.0619149332719593 0.0489971588825482 0.0457702149724092 0 0 0 0 0 0 0 0 0 0 0
     0.0384547455603152 0.0581414121094158 0.147700564365351 0.0934912868844586
     0.116703254579946 0.035709289582418 0.00648812971100191 0.00311554429502226
     0.00145592645628311 0.000657745518704647 0 0.00898524533791882 0 0 0
285  2003 0 0 0.0611811381109768 0.0710992976593973 0.0342117768397675 0.0376836208291692
     0.00947621005950677 0.0443638644943132 0.0294147214510748 0.0502331389509747
     0.0105666191464536 0.00189853682006165 0.0111106429077531 0 0 0 0 0.00152766730045629 0 0
      0.0210179814552238 0.0127990979648181 0.0313202636471893 0.0494318127201475
     0.039169271497487 0.161797392319156 0.0754744420665771 0.0814831260432676
     0.077475613542726 0.039428691011842 0.014359415279084 0.0281529334467037
     0.00138263017642434 0.00241242695899285 0 0.00152766730045629
286  2004 0.00593248026552582 0 0.0509631166376121 0 0.00802526466265792 0.026858215360813
     0.0618105627113855 0.0379231855864514 0.0859863370158557 0.0205456877817369
     0.0268762354462384 0.0163402961577007 0 0 0 0 0 0 0.00944924409475192 0 0.021995561483334
      0.00190437657649487 0.00913132967891058 0.0696306027028154 0.0681674302177341
     0.0357743372333533 0.150719339239999 0.0833671413344568 0.0912937720124978
     0.0773469297062812 0.00691650922255125 0.0101609930031198 0.0163184144081362
     0.00380416265611241 0.00275847480347355 0
287  2006 0 0.0155894279936069 0.243531817276182 0.104982528126209 0.101319788677558
     0.00432377838385591 0.0477761425774807 0.0035565596238414 0.00465283724165753
     0.0108941711994826 0 0 0.00445481410180489 0 0 0 0 0 0 0.014403664400835
     0.110980951953641 0.0458734674518365 0.100813816901863 0.0269658470867917
     0.0706795238026919 0.010170642331214 0 0.00732811393753174 0.0199092440596052
     0.00177279179215563 0.0277510909024327 0.0164985006126296 0.005770479565093 0 0 0
288  2007 0.000673168900919925 0.00376954466607049 0.0102608857258889 0.0956983465965174
     0.0482265571884021 0.0440109246903182 0.00756721513729569 0.0135191349609741
     0.0163387018224114 0.0264415101720059 0.0141306342610559 0 0 0 0 0 0 0 0
     0.00828308577219839 0.00677895907995483 0.0881492181065704 0.0396937969485891
     0.162099042621227 0.0567231710179307 0.0486515843804933 0.0600748130895725
     0.0438809060795672 0.0136814924989536 0.0895115770372105 0.046689432369799
     0.0289914839254729 0 0 0.0261548093595571 0
289  2008 0.00362560707085857 0.0233733129573971 0.0923875542808386 0.122184020762168
     0.136317985315144 0.0429685036571289 0.0354708743653272 0.00369017287219958
     0.00441168713551128 0.00871541826390216 0.00378855219383538 0.000787780023563164
     0.00498917039348445 0.00210682009309776 0 0.00216282827917847 0 0 0.0042576085128827
     0.0423141816623376 0.0472667446183784 0.10962638139833 0.0787924459188312
     0.06040569293608 0.0328335524582247 0.0253404969278584 0.0314583627247953
     0.0239032244493556 0.0123530429331247 0.00275771080203359 0.0194495969556868
     0.0158106594373446 0.00470209024855243 0.00174792035254937 0 0
290  2009 0 0.0146587832337828 0.164360354715183 0.121117767292833 0.050339470519265
     0.0320492765710648 0.0196645612168735 0.0407607946729024 0 0.00472382289338603 0 0 0
     0.0112108283340387 0 0 0 0 0 0.0432555539388486 0.210120209879827 0.120191120653233
     0.0249158794020333 0.0276156371793587 0.0254587502435099 0.0210642496376381
     0.0188730621350457 0.00386217226517683 0.00952518890111803 0.00752543987090871
     0.00640040490140713 0.0117457575493226 0 0 0.0105609139932428 0
291  2010 0 0.0146382253233704 0.0907571657888231 0.0835447397113586 0.0844225548361656
     0.0401117386453205 0.0601248267673 9 0.0372808379680462 0 0 0 0 0 0 0 0.00393577294591659
     0 0 0 0 0.146152562904077 0.128847068121245 0.066112480955318 0.0691603603590574
     0.0809559281995198 0.0479996755557136 0.0318469184669719 0 0.00211014755500182
     0.0047687290724777 0 0 0.00488563348339272 0.00234463334083402 0 0
292  2011 0 0.0364912756346332 0.0863781727143655 0.121419839323489 0.0686039290230407
     0.0530028251317692 0.0486774623222922 0.0579102864114135 0.00289381851363816
     0.0132525900005941 0 0.00157211917226797 0.00693773449507587 0 0 0 0 0.00650239475624984
     0.00630694234911834 0.044792984103581 0.0757900745449867 0.0788322134289702
     0.0814089251511587 0.0586811691128361 0.0336208559499987 0.0579479124264195
     0.00991645728013406 0.0104439705868658 0.00638360042234509 0.00782586802161011
     0.00913955223020304 0.00057029538857487 0.00589813924705123 0.00229619750043752 0
     0.00650239475624984
293  2012 0 0 0 0.0478250805291497 0.113286602912973 0.0603223724347647 0.120449788649068
     0.0576325188988803 0.0278283984317872 0 0 0 0 0 0 0 0 0 0.00291366359246449
     0.0252831593633486 0.0378768019401365 0.078347231814070 1 0.0781051720329975
     0.0525298020008696 0.09559291546364 0.0650459145311172 0.0217015357378242
     0.06893881558069 0.00603635971360784 0.0106080903241538 0.00719737657815238
     0.00636925188254754 0.00468835827951809 0.0114207893082391 0
```

```
294  2013 0 0 0.0090000524084152 0.122694998149395 0.065090493573817 0.097251544032167
     0.058187390947664 0.0440470623599772 0.0305361992455793 0.00311546175702536
     0.00658699467121495 0 0 0 0 0 0 0 0 0 0.0083758279872109 0.076657052157415
     0.0938206714038816 0.0976976302829529 0.0941734557830503 0.0732344128666412
     0.0716032993458561 0.0215697902323242 0.0124514819936957 0.00392903149201269
     0.00997714930970449 0 0 0 0 0
295  2014 0 0.151693510820313 0.0604394721728782 0.0921548531741536 0.044270855420951
     0.0853508848038672 0.0332983920318284 0.0109955204844309 0.0100131502708631
     0.00982661033974991 0 0 0 0 0 0 0 0 0 0.0694945218121963 0.030904127074081
     0.077884644710707 0.0646171838606241 0.0893869348006602 0.0601190456145178
     0.0444390914779826 0.0306996578367505 0.0125329091281401 0.0170760902861316
     0.00289387939486596 0.0019086644843076 0 0 0 0 0
296  2015 0 0 0.0309696431759106 0 0.00999604613098642 0.0566891386574732 0.13682016777865
     0.0300515020976945 0.0169765098757192 0 0.0139105751922061 0.0139105751922061 0 0 0 0 0 0
      0 0.00936612215005228 0.0771427394959643 0.0355079702574281 0.0496633346022385
     0.0577630149287333 0.155763505090359 0.142187046013432 0.0580912585781281
     0.0589661205638218 0.0277560578329019 0.0045395596787269 0 0.0139291127073675 0 0 0 0
297  2016 0 0.00780615359600456 0.0142113631645836 0.0253094961083933 0.0519327921053861
     0.0614207593548353 0.0405559296020903 0.0267439326046673 0.0310430070025875
     0.0180579626311094 0.00678974432079074 0.00492162136239294 0.00147579187163918 0 0 0 0
     0.00474852944387793 0 0.0163221831298834 0.0109180198908275 0.0498004554019085
     0.0586095415283924 0.0481759510401449 0.082196366397268 0.10800934645165
     0.0953038086218398 0.0764171372247862 0.0460242868606106 0.0517398269614097
     0.0343098028574522 0.00915881836937996 0.005084938578431 0.00507360846846877
     0.00309029560531073 0.00474852944387793
298  2017 0.0211215215952568 0.0228241876615645 0.0232575852364017 0 0.0577040970650609
     0.0400177424766893 0.0543766960511833 0.0355556356811806 0.0233023495800011
     0.0235010064239638 0 0 0.00218961313991126 0 0 0 0 0 0.0255345125554363
     0.0698556039035966 0.00584359854287724 0 0.00706196231113108 0.114258028282634
     0.121515393260723 0.112558910289226 0.0339184050694876 0.0905679466646666
     0.0599514276013613 0.0299383645413607 0.0145032936550555 0.0106421184112309 0 0 0 0
299  2018 0.00119154857886564 0.0530980729187054 0.125519734440472 0.0849138448019299
     0.0593675378045913 0.0363346412350758 0.0519485032169522 0.0304679889391722
     0.0100377303209622 0 0 0.00343411766195629 0 0 0 0.00136875702381438 0 0.00805607534946701 0
     0 0.00167845870180805 0.0551257263561067 0.115593788516974 0.0526466172354568
     0.0757186874459612 0.0308767170375359 0.0562303347871641 0.0574643397585111
     0.0354412244613405 0.0238148816184902 0.00687680374819581 0.0113713174693868 0
     0.00349965145795888 0.00673481247617408 0.00118808663697205 0 0
300  2019 0 0.021632946070798 0.0895197287108126 0.169681919723005 0.0581356727012357
     0.00438973053618551 0.0230550169839076 0.0379926825986625 0.00434760608481614
     0.0030405004061895 0.00837631170961317 0 0.00252028781656766 0 0.0204543869239261 0 0 0 0
      0.00639997330447615 0.095255991335264 0.134184196512424 0.016308735712207
     0.0498577324728667 0.0745301078449279 0.0438128249183784 0.0298142756152515
     0.0376891495192292 0.0133326591251719 0.0251613615677955 0.0100825076306633
     0.0147815396048227 0.00564215457080258 0 0 0
301  2020 0 0.00605609959453631 0.0311773002761666 0.0826027187911024 0.146348076110428
     0.0588216126106736 0.0314851453468425 0.0271433772037021 0.0220725367903194
     0.00666944662651631 0.00606128935535115 0.00135672022598 24 0 0 0 0 0 0
     0.00401945178934543 0.0304720225200984 0.0162125488178956 0.102061827760025
     0.134148811643593 0.0559250915561757 0.0443200340592246 0.020190609848482
     0.037604814560944 0.0536999065830528 0.0320849581787312 0.0190767182639885
     0.00604800056162177 0.012060113958838 0.00843925619095037 0.00384151077541266 0 0
302  2021 0.026684045026684 0.0709975050709975 0.0772838060772838 0.0418557820418558
     0.0631417220631417 0.0846713540846714 0.0291135180291135 0.0248404460248404
     0.00837074700837075 0 0.00277397300277397 0 0.00223120900223121 0 0 0 0 0
     0.0207853610207854 0.0687886910687887 0.118681590118682 0.0416079500416079
     0.0939045770939046 0.102541303102541 0.0445802680445803 0.022331972022332
     0.0186191980186192 0.0149368810149369 0.00765023100765023 0.00171184000171184
     0.00528957300528957 0.00448207900448208 0.00212437800212438 0 0 0
303  2022 0 0.179314028767317 0.100601576928 17 0.0486903231824394 0.0437607146320906
     0.0367942429765712 0.0343894985699995 0.031918333936618 0.0127114411807176
     0.0022856429023406 0 0 0.0102096251229587 0 0 0 0 0 0 0.135086812822899 0.117764392955511
      0.0803572323317164 0.032043813619447 0.0248357013931714 0.041586340994778
     0.0239412842802145 0.0112332805014381 0.0152150165747976 0.0084653099573589
     0.00105042465817331 0.0036043155518479 0.00384004694833504 0.000300599211089992 0 0 0
304  end_table
305
```

```
table error_values
2001 6.38782519834314
2003 9.26585633166258
2004 6.66860872354504
2006 5.61567050403793
2007 4.28194875932892
2008 10.950557482874
2009 5.61567050403793
2010 7.23017577394883
2011 11.4419286519773
2012 6.31762931704267
2013 8.00233046825405
2014 8.21291811215547
2015 4.35214464062939
2016 11.5823204145782
2017 4.0713611154275
2018 11.5823204145782
2019 3.93096935282655
2020 10.1784027885687
2021 10.8803616015735
2022 6.80900048614599
end_table



@observation FisherySubAntarcticSnaresAge
type process_removals_by_age
mortality_process Mortality
method_of_removal FisherySubAntarcticSnares
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
time_step OctNov
min_age 1
max_age 18
plus_group TRUE
sum_to_one TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 2001 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
2021 2022
table obs
2001 0 0.0223227334411969 0.016565444471791 0.0653645386622344 0.10509345553421
0.103408746897569 0.0738989261045797 0.0980619237686868 0.0371216780665615
0.0042609719562791 0 0 0 0 0 0 0 0 0.0120714074913477 0.0110575621182393
0.0291807377793033 0.0693532732653848 0.0946508036811155 0.0675130937317046
0.10120010611273 0.0429954820375339 0.0193282843414114 0.00695577042286762
0.0114437789844509 0.00437338006929197 0.00377790106151102 0 0 0 0
2006 0.0331440523261772 0.100995519701372 0.130813600602594 0.0563184793360147
0.12762720294536 0.0164957313341637 0.0103228483396759 0.0144057661742135
0.00372689459243685 0 0.00658752936117645 0.000644473110169565 0.00814775701200921
0.00797844459619907 0 0 0 0 0.00305548933531772 0.00517319156021171 0.0415001205439769
0.147642360248129 0.0810221810995929 0.0958827122823042 0.0268215680056086
0.0201185011421599 0.0187357680723441 0.0196722151022837 0.00497200078233059 0
0.00172726428494465 0.00629882708653218 0.000624423491457007 0 0 0.00648958819592695 0
0.00305548933531772
2007 0.1167010116345 19 0.019425418823528 0.0425939138002495 0.117844972743736
0.0447793358764472 0.0694097928552836 0.0112067663077004 0.0221009212386177
0.00774731064442687 0.00475617806740062 0.00342422572938123 0.00171131880875454 0 0 0 0 0
0.00068756211595472 0.0286589920659568 0.0774095802659363 0.0213175084085342
0.12537224957667 0.0307898455824989 0.101290810718548 0.0141301564046515
0.0377216188933731 0.0152373773629767 0.00962337599006892 0.0129592644516376
0.0308044780848835 0.00363593986534021 0.0229142397053223 0.0026252205051211 0
0.00243305135652675 0.00068756211595472
```

```
352 2008 0.0244344123960328 0.0185580141790771 0.0293632738993103 0.105887215548584
0.178208348645713 0.0345755156831365 0.0627373905571953 0.00642078063932933
0.0125979421205554 0.000774650466469176 0.00681037550391577 0.00329827041789497
0.00625040322077371 0 0.006853783533433102 0 0 0 0.0182551707609801 0.00748692691680875
0.0232187168291441 0.119954099399047 0.104417288459907 0.0628188975471037
0.0780092988431405 0.0249818214221209 0.0294984828294766 0.00491196620329087
0.00983303565180053 0.0066791927310268 0.00996131225197299 0.000535091648650159
0.00213772869305002 0.0005305930001617 0 0
353 2009 0.00973194478563776 0.0930383115066019 0.133720764334122 0.111824766537569
0.0537738220739608 0.0465536536527126 0.0168869696823793 0.0219801550543572
0.000935634539163758 0.00237934462594779 0.00319787394324005 0.00212999027602487
0.0013874148973087 0.00211744667946487 0 0 0 0 0.0241783489944865 0.112454022690011
0.11635583839349 0.085526193695545 0.0397272159558626 0.044307733781767
0.0172160936785397 0.0217115169821646 0.0143983487343245 0.00975342996211924
0.00385000374209877 0.000956835006022137 0.0011030127290714 0.00286102819281213 0
0.00391911405011889 0.00202317082307554 0
354 2010 0.0390744683470288 0.0291350834241371 0.118176173700948 0.0893897990018895
0.0601404321192655 0.0494453237085567 0.0376446010028206 0.00744594833064886
0.0138795780569102 0.00160832941469905 0.00664591043683066 0 0 0 0 0 0 0
0.0395374143630427 0.0552599772108588 0.102692663083684 0.0936578988971422
0.072921470986809 0.0921849793648797 0.0627763117427212 0.0123272158649379
0.0114162339812637 0.00113720654927323 0.00188439560568635 0.00161858480596577 0 0 0 0 0
0
355 2011 0.00572740062679888 0.0519393150593089 0.164473104417588 0.147242225072095
0.1116997368927 0.0489355926662504 0.0340377671861279 0.0103170696602055 0
0.00254477171536866 0 0 0.000845628567834946 0 0 0 0 0 0.00700266740877524
0.0384896753108001 0.136591754875191 0.10424371992858 0.059966557484465
0.0292965021451347 0.0276808320862647 0.00761250207675416 0.00175191688983899
0.00307559252518045 0.000259537733405441 0.00275272641411108 0.00101779247803277 0 0
0.000660025016070059 0.00183558576311807 0
356 2012 0 0.0279572625566829 0.168681557897899 0.126079031704612 0.145079884268314
0.0346420325776569 0.0328753205117499 0.00430253613786149 0.00283478941741329 0
0.002492936864571 0 0 0.000840529144358841 0 0.00439366936771991 0 0.000938842413095674
0.000311458491832094 0.029719316374129 0.160436473118064 0.103294363344918
0.0822926904716269 0.0342170298611186 0.0189531255934915 0.00976113559517634
0.00345918947876019 0.000693779338872265 0.00285005847698957 0 0.000693779338872265
0.000339856376705595 0 0.000920508807694703 0 0.000938842413095674
357 2013 0 0.0271280669600379 0.054851043223994 0.221555004660108 0.0979967847633041
0.0737457486128097 0.0449675185458534 0.0290779907586357 0.00909493953662956
0.00462065995043877 0.00265979122173038 0 0 0 0 0.00133794907083777 0 0
0.0105931576271904 0.0308640773523538 0.0213963536447363 0.130141142464936
0.0861137539357331 0.0354968007672903 0.0693603310824771 0.0228842148143309
0.0114816584074988 0.00709418876898902 0.00246596115193746 0.00182026564949591
0.00134016029260535 0 0 0.001912436736046 0 0 0
358 2014 0.0259908375678378 0.267595924123801 0.0532083443238229 0.0727478367681787
0.0604040565158578 0.0367648287722863 0.0104139282381312 0.00590839627135294
0.00255314775470679 0.00153772863417047 0.00305103050672826 0.00151330187255779 0 0 0 0 0
 0 0 0.0224098925836224 0.123579540365148 0.0578435002173079 0.110919237574827
0.0735854123284123 0.00566190850804775 0.032144517227206 0.0120186048684718
0.00861658343797608 0.0047172531256873 0.00391270334829621 0 0 0.00290148506556562 0 0 0
0
359 2015 0.00362066698701131 0.0432573575436412 0.190772481286338 0.0244188444801133
0.0324758273486665 0.0269894835578804 0.0931920424696694 0.0406622778635714
0.0151520814142835 0.0048877203200255 0.00375604604569737 0.00170644831762536 0 0 0 0 0 0
 0 0.0650158252105738 0.178477900988557 0.0563441964888576 0.0729591121481468
0.016240908945953 0.0435258956151844 0.0332450430526679 0.0157316829853165
0.0191262867112801 0.00594155287842863 0 0.011769947767947 0 0.000730369251544797 0 0 0
360 2016 0.0622834302059917 0.0573982123389666 0.0111216905452732 0.110794632335694
0.085150816332496 0.0463733896204645 0.0144362256732169 0.0263244125081569
0.0163926343760368 0.00680153648566597 0.00986907091353866 0 0 0 0 0 0 0
0.0189704295866707 0.152477451845709 0.0169436483079845 0.0422278781456416
0.101130310013774 0.0535784361738748 0.0266626599824431 0.0577289413381409
0.0368612201255039 0.0153928984952866 0.0164112964890799 0.00511636830958497
0.00164973657538404 0.00711788673744291 0.000784786537978353 0 0 0
361 2017 0.111926957053815 0.0985483636456818 0.0110826236811751 0.013208015935001
0.0803127326567505 0.0411654611773192 0.047610471622658 0.0227123824049031
0.0101290607018415 5.5729146621606e-05 0.00495308079143781 0 0 0.00851591377888779 0 0 0
```

```
0 0.127219121488011 0.108390598269567 0.034917369575815 0.0107136462028339
0.066286120296744 0.0349159945117246 0.0321645642864055 0.0258716669214973
0.0379028592797237 0.0112032518911425 0.0471223046011346 0.00763101709583099 0
8.13397892021077e-05 0 0.00535935319427532 0 0
2018 0.0450052013059172 0.233111050087659 0.135049054461151 0.0610023870596189
0.0251240952480747 0.0107693112857283 0.0116517089838073 0.00421594445874403
0.00346621253243694 0.00220742384309821 0 0.00220742384309821 0.00161905687136609 0 0 0 0
 0 0.0722452302890591 0.173057700967164 0.0889836090275413 0.0423905660687848
0.0192148406641791 0.0199112731949495 0.0200837931255385 0.0122364999010951
0.00522684797833115 0.0065406004949779 0 0 0.00393695628283925 0 0.000743212024840842 0 0
 0
2019 0.00801907487397924 0.0428739039676572 0.213922619368853 0.164608866212606
0.0415411938857701 0.00783713822396461 0.0081926095041886 0.0185311612262156
0.00116778740673629 0.00263909200511793 0.00343055501660298 0 0.00103750883169558 0 0 0 0
 0 0.00140852603511685 0.0311529103863966 0.186400917245512 0.127703555577707
0.0483128524124668 0.0236489266346757 0.00753189151650565 0.0155764794082183
0.0212057807813383 0.0100275236353371 0.00139066661566607 0.00539649198612831 0
0.00413042751980201 0.000916945202697853 0.00139459451904391 0 0
2020 0.0736036636787535 0.030140228572048 0.058102342307136 0.130158636805574
0.081957738202683 0.0375647083486516 0.0135443258400999 0.00543926262384401
0.00299058599149476 0.00358086159815027 0.000174291565183476 0.000964663502940052
0.000455877429633901 0.00208393260962536 0 0 0 0 0.0545846797566732 0.0629655450909104
0.114219336298091 0.173313898276523 0.0865552464413123 0.0410591662105676
0.00996731082471622 0.00727637291765711 0.00416300546760532 0.00225277782836416
0.000755422255626183 0.00202786169241218 0 9.82578637229323e-05 0 0 0 0
2021 0.0298854030298854 0.0962509340962509 0.083690961083691 0.0525048040525048
0.0862009190862009 0.026058043026058 0.0267168530267168 0.00859721200859721
0.00565564300565564 0 0.000613135000613135 0.00336871900336872 0 0 0 0 0 0
0.0371423410371423 0.0598820600598821 0.0915841950915842 0.0959734700959735
0.127602159127602 0.0715127430715127 0.0463347250463347 0.0138637750138638
0.026334017026334 0.00767768800767769 0 0 0 0.000389459000389459 0 0 0
0.00216074100216074
2022 0.0128355489003644 0.0843382234493999 0.0917534426626688 0.0540582015195659
0.034433606549854 0.0555887681073839 0.038431528651071 0.0196303308954726
0.0180305937681797 0.00692567728499497 0.00482011706717065 0.00594088312875235 0 0
0.00245814448746665 0 0 0 0.00340305706209972 0.0942305641366442 0.126635495127784
0.0935275473238722 0.0363672330918071 0.0546023637591383 0.0524693836569175
0.05116457405644 0.0138650366587494 0.0167889177139855 0.0117030598770811 0
0.00400720485578391 0.00882880554918691 0.00115931076487511 0.00200237989329043 0 0
end_table

table error_values
2001 3.55079985140171
2006 6.05504816765344
2007 5.75603344332488
2008 8.1481512379534
2009 8.55929648390517
2010 5.04587347304453
2011 8.93306488931588
2012 12.2969805380122
2013 9.97961642446586
2014 4.93374295142132
2015 5.53177240007845
2016 3.58817669194278
2017 2.1678567513821
2018 6.27930921089987
2019 7.2511070649677
2020 8.91437646904534
2021 5.27013451629096
2022 3.99932193789456
end_table



@observation FisherySubAntarcticSubaAge
type process_removals_by_age
```

```
mortality_process Mortality
method_of_removal FisherySubAntarcticSuba
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
time_step OctNov
min_age 1
max_age 18
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 2001 2002 2003 2009 2012 2016 2018 2019 2020 2021 2022
table obs
2001 0 0 0 0 0 0.0289443755206763 0.0253366278286273 0.0604264273985194
0.0304581176334731 0.0129669861610063 0.00327750134822454 0.00907401065256747
0.00438767970090058 0 0 0 0 0 0 0 0 0.00981854487120288 0.00295356759831625
0.00891852796981396 0.13703578537959 0.0983592727620407 0.173690117326364
0.211352656907276 0.0456823092804103 0.0513523605012954 0.0320745438462007
0.0451896907728797 0.0057782560475823 0.00229480403160533 0 0 0.000627836461427025 0
2002 0 0 0 0 0.000889987599974442 0.00263252462833764 0.00205976822994172
0.0264261735755108 0.0323318564834706 0.0462643731451075 0.0472172009160622
0.00321745866754032 0.00387083700052656 0 0 0 0 0 0.0110737442567888 0 0 0 0
0.00424171637827789 0.010140974026783 0.155653422845236 0.185625595991231
0.202244579356653 0.13028850150398 0.0365476999037275 0.0229015252240327
0.019114056705266 0.0227498921528724 0.010954875106317 0.00706823366163551
0.00541125838393796 0.0110737442567888
2003 0 0 0 0 0.00841040107843039 0.0122044375143711 0.0258796196018192 0.0245980525088264
0.0912520179741985 0.0466378405758781 0.0285532599407024 0.022210115713125
0.0165214178000545 0.00099611072914256 0 0 0 0 0 0.0001818781793243 0 0 0 0 0
0.0192249091310 7 0.0902713647047295 0.0783057690969038 0.137220121911258
0.283355067301216 0.0313694014751707 0.0460335979891469 0.0182194155022914
0.00161933357738658 0.0167539895156304 0 0 0 0.0001818781793243
2009 0 0 0 0 0 0.0154514632627692 0.0101003408410564 0.0361993367745785 0.0402680236515666
0.019047386870056 0.00794530472447511 0.0279615812186502 0 0 0 0 0 0 0 0.0178176869128075 0
0.00352196941248151 0.00352196941248151 0.0256454669301475 0.0278584679542442
0.137454985111737 0.0726801027812939 0.176674096531209 0.0624692652669474
0.0488960197847211 0.0719664458570387 0.0349941563654659 0.0152187537159132
0.0564114125718898 0.0377161155278075 0.0206511439711275 0.0117108176367275
0.0178176869128075
2012 0 0 0 0 0.0199382878516091 0.0161042934941641 0.021658849974296 0.0423209034172595
0.0257420094869669 0.0438910173751834 0 0 0.00789388654468627 0 0 0 0 0 0 0 0 0 0
0.0148457067634275 0.0509056790846092 0.0599940590913168 0.114909788425949
0.163360235603495 0.200557608517851 0.0652850142714576 0.106544538782342
0.0158972338499693 0.0209873346509971 0.00916355281442052 0 0 0 0 0
2016 0 0 0 0 0 0.00337175791262848 0 0.0271791101845902 0.00922606861078285
0.0689234800807944 0.0197863913182335 0.0547305454491288 0.005803067394066 45
0.00981261877845251 0.00580306739406645 0 0 0 0 0 0 0 0.00907128463158536
0.00907128463158536 0.0743532848128613 0.122534290336698 0.0771418355959409
0.125232543579135 0.119183818778621 0.106174687429167 0.0973506965310217
0.0139194004830746 0.0268060719478737 0.0145246941196927 0 0 0
2018 0 0 0.00836963758493185 0.0591313558803296 0.0506959163584159 0.0265500056493065
0.0348191532008273 0.00594386876034987 0.0214558470540501 0.0391966386115198
0.0168304171503957 0.00896236753688 11 0 0.00124451064806 58 0.00157830184800706 0 0 0 0 0
0.00694854168518778 0.0229069608669943 0.0306475309232567 0.0312069709291958
0.0289280856499866 0.0520866343190005 0.128394902651388 0.105171611891272
0.138203419813098 0.0885735364518496 0.0438757077033875 0.0311285341902317
0.012579934132093 0.00127322277011973 0.00329638573985772 0 0
2019 0 0 0 0 0.0310488083979419 0.0293851846052136 0.0333151238674022 0.0202107299053639
0.0475340991080368 0.025702304931218 0.0145919847062253 0.00212131985808196
0.0179971472443492 0.00301104540361692 0.00212131985808196 0 0 0 0.00198132023532185 0 0
0.0175783875368135 0.120798813467187 0.0879893388989703 0.0787725158145073
0.0522968521622637 0.0570719535576661 0.0619982083222328 0.0986676192068401
0.071771591242886 0.0558926146932447 0.0355664751556184 0.0155885084996652
0.0098871336841328 0.00511827940179679 0 0 0.00198132023532185
2020 0 0 0 0 0.0192844100901342 0.0386139752100589 0.0388461932950851 0.0164210735863098
```

```
0.0320989845119347 0.0102926129009693 0.00447936727811123 0.00360849072834931
0.0120642521230799 0.0107167991569311 0.0132075548490179 0.00820164971646616 0 0 0 0 0
0.004507790224343 0.0576823749521576 0.14289039020121 0.0668445313177143
0.0784371407407662 0.0896141483209824 0.0885551181911495 0.0511401359649503
0.0694660062221058 0.0599208839002117 0.0351415043725764 0.0200839137401029
0.0105654166625779 0.00887741310943004 0.00272244262443981 0.00571542600883452
418 2021 0 0 0.002765465 0.008383222 0.0190188 0.029892646 0.021495637 0.038325701
0.057805198 0.014411159 0.021814048 0.004771111 0.002110206 0 0 0 0 0 0 0.005285797
0.002148494 0.015883664 0.044171844 0.111705837 0.147027651 0.093347155 0.119262877
0.067340807 0.057551152 0.040837069 0.028900457 0.034106434 0.007912808 0.001576267
0.002148494 0
419 2022 0 0.00408669024185586 0.00079005617423702 0.00408669024185586 0.00659339854865368
0.0265079926480578 0.0397113087011841 0.0883322506143733 0.0343052526058991
0.0201703550357347 0.0176872263371335 0.007266555300935 0.00754173682973498 0
0.0022172386553316 0 0 0 0 0.0017504094377645 0.00423891500188942 0 0.0132187421594387
0.0696814175654799 0.117825987646489 0.20129916275626 0.158174750322109
0.0609503367933374 0.0376505170045511 0.0205588004590611 0.0188512550451144
0.0189667335608318 0.00720550745898828 0.0078129433968122 0 0.00251776945688716
420 end_table
421
422 table error_values
423 2001 21.7895477170223
424 2002 26.5522903874097
425 2003 7.85852540613919
426 2009 15.9551879457978
427 2012 6.54877117178266
428 2016 9.88269104105384
429 2018 17.1458736133946
430 2019 10.3589653080926
431 2020 9.76362247429415
432 2021 14.8835708449606
433 2022 19.4081763818286
434 end_table
435
436
437
438
439 @observation FisheryWCSIInsideAge
440 type process_removals_by_age
441 mortality_process Mortality
442 method_of_removal FisheryWCSIInside
443 categories West.WCSI.Mature.M West.WCSI.Mature.F
444 time_step JulSep
445 min_age 2
446 max_age 18
447 plus_group TRUE
448 sum_to_one TRUE
449 ageing_error AgeingError
450 likelihood multinomial
451 process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
452 error_value_multiplier 1.0
453 likelihood_multiplier 1.0
454 years 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2012 2013 2014 2015 2016
    2017 2018 2019 2020 2021 2022
455 table obs
456 2000 0 0.00755724191444786 0.0567546040824195 0.051305691338222 0.143353773999976
0.0886409394501263 0.126988366889271 0.0496615484028632 0.00427842456429371
0.0136606597342939 0.00402659188846356 0.00363814395914609 0 0 0 0 0.000408690293354426
0.000770386990167564 0.00406378767603352 0.0174480068343237 0.022128681836045
0.09244438816176 0.0627731187313063 0.0982429026620924 0.0682733275110016
0.0124814759742807 0.0266336331634424 0.023216958334071 0.0126841815801732
0.00176800072777865 0.00133240540254381 0 0.00195084058092682 0.00351322731717556
457 2001 0.000307303231301643 0.00955025309954515 0.0490855451130966 0.0675479360513076
0.0567576475066867 0.14506114027514 0.0643753987943542 0.0637849655412057
0.029496576308503 0.00306904130296079 0.00532585186508236 0.00739592199909979
0.00570993717800362 0 0 0 0.000951397057045085 0.000162215137511808 0.00284909280911484
0.0214553032132751 0.0472161192048785 0.0460550464729838 0.128914642521163
```

0.0709047412181832 0.0973570718217717 0.0216537883866795 0.00747879167716171
0.026080281922588 0.00898882451765475 0.00662635781340004 0.00233212526041965
0.000593048875276578 1.60651215813852e-05 0.0028975687030234
458 2002 0.000317947151788932 0.00249255534273929 0.0392981864177695 0.0627117016380136
0.0985335538437537 0.0585531944675744 0.0985269910648254 0.0679539097215213
0.0443460742451033 0.0122808699151154 0.00510907678342734 3.9250876677698e-05
0.00153771874410183 0.000184857409610415 0 0.000445335599112073 0.000151781812506173
0.000132477605516543 0.000872236337613173 0.00787944333028771 0.0188875272486036
0.0642610835511024 0.0765616148465258 0.125335508313673 0.0911266732773908
0.0604057322889632 0.0238534842340884 0.0112285575729744 0.00886232701990894
0.00327390342588101 0.00359937592745935 0.00631006982004933 0.000199179161127537
0.00472780100519422
459 2003 0 0.0134059785235038 0.00220065148357062 0.0209266833853067 0.0204524077802887
0.0597055991441217 0.0311365684762608 0.0845674111914968 0.0312158893834293
0.0268302992505345 0.0224842303241291 0 4.66199273517368e-05 0.00236500915106939 0 0
6.04236359117389e-05 0 0.0075138635079848 0.00206496911436055 0.0123214894978631
0.043519357426246 0.0869641609975909 0.0643048807497291 0.206494174510398
0.0425623246276472 0.118349952963868 0.0577583946590023 0.0103211156703107
0.0113757309123223 0.00706148714952327 0.0131659511036957 0.000348238738018599
0.000476136714464836
460 2004 0.00525751086280398 0.000800599634784624 0.0755596689278688 0.0106782206018013
0.0235944743985703 0.0247560201105071 0.0317307157141159 0.0115007082311577
0.0553777773496445 0.0172534903878011 0.0244963170915801 0.0160273051085616
0.00171280840855684 0 0.00240216940426199 0.00067494633261331 5.67498192593781e-05
0.00161075151720029 0 0.0276003431551149 0.00724683570278475 0.0254058943660049
0.0523700210955682 0.118490398947714 0.0563520100247015 0.151566379244871
0.0549042753004064 0.105807580676386 0.0635818787316941 0.00208455281636423
0.00766909476473117 0.00800033434925042 0.0105868733744554 0.0048432935488632
461 2005 0.0167867880774896 0.132412871050213 0.0229150883425623 0.132220382046481
0.0246808346342245 0.0406440196754409 0.0379752468138142 0.033123660103029
0.00554140509431576 0.0343975483142207 0.0119822352223422 0.0162000412458695
0.000877584683113399 0 0 0 0 0.00687868241342491 0.0105896860508764 0.00308466405527001
0.0505461572765561 0.00773005936577106 0.0409776516430548 0.0826798123291895
0.0687936408350515 0.0258475322951463 0.0848651789914015 0.0327403931702606
0.0470090623035035 0.0215451350163678 0.00207035208490778 0.0026100305634163 0
0.00227425630268586
462 2006 0.00133478701561324 0.089932877295898 0.433294670686577 0.0875541714571898
0.0906140119378231 0.00950378788650322 0.023235060005131 0.010759812666997
0.0060035197367831 0.00267184192637081 0.00363442053166211 0.000967491364746032
0.0021559717828851 0 0 0 0.000734262973751059 0 0.0125603876483377 0.0619710495584642
0.0174377120014549 0.0254918649597949 0.00832043303299328 0.0148891997938708
0.0161512439207262 0.0248845858736824 0.0117600577881571 0.0169409760832217
0.00920361098764189 0.00617140477894148 0.00572271418894005 0 0 0.00609807211584311
463 2007 0.000743561485473409 0.0173989826952978 0.119395411825983 0.291874956249691
0.147237636391036 0.096035075941481 0.0179797519772454 0.00452805432099728
0.00694203540103477 0.00492158264103162 0 0 0 0.00306981557056856 0 0 0
0.000654115557110236 0.000714493093517361 0.00247237877348668 0.0135285278411119
0.0608516243836415 0.0403294777912498 0.0450473975171511 0.0158746570938855
0.020172711984126 0.0166141514601042 0.0172898150754543 0.00971352393736803
0.0200210928478358 0.0118200308017522 0.0108676956437454 0.00258530656018815
0.00131613513843239 0
464 2008 0.000586496013367325 0.0117914692161927 0.0766297148773301 0.246378392589801
0.237697184982311 0.0723814842454391 0.0236653021890213 0.00304926984400396
0.00135079346803472 0.00376972884593671 0.00315873662952066 0.0027603897630467
0.00443466842747 0 0 0 0 0 0.00299751141660368 0.00986003016833768 0.0738207306968627
0.0866469306735166 0.0580246397177655 0.0463040522848868 0.00815458899052 68
0.00707078622623276 0.00722737487106659 0.00401761609319749 0.00232950732225537
0.00208213746027426 0.000881803611452729 0.00159764594473617 0.00133101343080447 0
465 2009 0.00160752587024956 0.0352958267279041 0.0846164976276913 0.142622005004642
0.2661088203786 0.141698149296262 0.0413716663296907 0.0492751117086274
0.00899029477878808 0.00271843303231751 0 0 0 0 0 0 0.000778411323245299 0
0.00244581498759065 0.0100256568035697 0.0142451436411508 0.0283343980017064
0.0482071446723411 0.0302568233553634 0.0502986016825629 0.0118246410578741
0.0121550981032885 0.00315787142691261 0.00637562064792101 0.0031192441333406
0.00309338282310908 0.000342595707706281 0.000342595707706281 0.000692625169839331
466 2010 0.00417365681058432 0.0746748966372678 0.0961518856407994 0.121433007770588
0.100244972986313 0.132536109542217 0.190225385784323 0.0558953822841347

0.0223108037070638 0.0031972086528481 0.00127262192486747 0 0 0 0 0 0 0
0.00561938706716269 0.00873710028473506 0.00751874845364119 0.0169276515035906
0.0405983205183583 0.0569183985358826 0.0296736685100426 0.0161673073302258
0.00386902864848697 0.00390877923786225 0.00366052902480518 0.00257096313007341
0.000582847826875311 0.000565669093625566 0.000179138980294057 0.000386530113331509
467 2012 0 0.00244019970207206 0.00688661639252704 0.0159140097738829 0.0360970892096647
0.0437961569738639 0.0818126504483846 0.134767647397036 0.0938740868626217
0.0103371417787052 0.0153400995014194 0 0 0 0 0 0.0325484915025512 0 0
0.000989073054508188 0.00654916882480499 0.0184229583012611 0.033028793120049
0.0625708075168726 0.172298058806629 0.102996807410342 0.0198528602171393
0.0614722212075907 0.00954718449372882 0.0252321384585886 0.0021013572387345
0.00660054562011551 0.00364015865531572 0.00088367753159138
468 2013 0 0.000738648783206318 0.00430249062329248 0.00763323572202136 0.0200391176655984
0.0392965670867702 0.075766886869541 0.112444584398002 0.0529380575482918
0.0200261152844558 0.00382679733136766 0.00448260468889189 0 0 0 0 0 0
8.81783103684907e-05 0.000331813661211448 0.00174024533427201 0.00444208375472807
0.0204055322579171 0.0675716756453573 0.141640313288415 0.190499152761833
0.0711497594758367 0.0508729071538966 0.054579354260046 0.0180830065447236
0.013813263231229 0.0022008933999029 0.000722688331390912 0.0203640265874327
469 2014 0.00115906345504756 0.0214870190027467 0.0136797547320368 0.0989352484097286
0.120207721899223 0.125488574619494 0.0883618176594989 0.0542153302277598
0.0385521121535016 0.0506131897267549 0.0145117686960989 0.008553648445611
0.0026979495126859 0.000706765164651362 0 0 0 0.000951514411962529 0.00252889672613996
0.0012969409292006 0.0121604071700069 0.0315505868289814 0.061625252144627
0.0543387501738356 0.0477291783540673 0.0497167492418836 0.0497558243894985
0.0225795081404778 0.0158136873511104 0.00568331844449454 0.00315265923469711
0.000640845326098995 0 0.00130591742807942
470 2015 0.00019954927930305 0.0015008192789502 0.0881011001726225 0.0184935618068661
0.0787592103500972 0.0616853744307325 0.0759852653835759 0.0595840125584025
0.0364300792798289 0.0269604113113136 0.0345506593905914 0.00693411323794862
0.00228399915813474 0.00208105217516053 0 0 0.000414268846348669 0.000401562659016262
0.00103385541575561 0.0114447332160957 0.00544611034212557 0.0385039840333027
0.0625440950577086 0.0854525503680299 0.0683394204648574 0.0673856804528722
0.0466454207643911 0.0596767652771336 0.0163788953228183 0.0270283225308166
0.0113311856325989 0.00353172930650962 9.7801828826245e-05 0.000794410667265152
471 2016 0.00054292219702950 8 0.00321333263165603 0.0061075588807005 0.0937161697242395
0.058850365678585 0.0820503491661656 0.0795840998604707 0.0700909247849602
0.0423832986513012 0.0262894083492493 0.00949888229641377 0.0110133562134772
0.00463040111558631 0.00258021252203015 0 0 0 0.000895474870880178 0.00152337687755767
0.00251988628473859 0.0174433794109353 0.0141066433329863 0.0512814047132123
0.0667427273808412 0.101670133678763 0.0584602953767363 0.0684321889484049
0.0431871475372142 0.0370559373958213 0.0249527972346021 0.0147453768947883
0.00311631494488089 0.00163969191494014 0.00167594113083242
472 2017 0.00040022537266826 8 0.0213499084020059 0.00829700296910438 0.0130552521682495
0.0881447604560629 0.109629998857118 0.138603375664629 0.103371327412977
0.0280966159191624 0.0192145370392066 0.02068680563293 0.00535400197876534
0.00229173949157494 0.00225942555552952 0.00125101436828467 0.00232451727546298
0.000565291843976888 0.000899628108796707 0.00505724695306959 0.00389148973103042
0.0029409949679682 0.0432866488810508 0.0566657266176455 0.0814086054773257
0.0764264181908691 0.0712160046155251 0.0415998482691541 0.0228911731668327
0.0121041261895665 0.00658554430153362 0.0032647021833844 0.00322419200814077
0.00264445871586833 0.000997391214530584
473 2018 0.00101402585242452 0.0300138085536167 0.096257121919897 0.0229911496502856
0.044928863275687 0.121160308845466 0.0132853453891769 0.0567592765142111
0.0336209520776674 0.00820338720021613 0.00676656445856601 0.00283535863000784
0.00626720208789595 0.00263897870415753 0 0 0.000185503940272283 0.000340665337806726
0.0171243920452139 0.0261965279689764 0.0263376702023004 0.041057404866605
0.133825614954851 0.0533318793321902 0.120078731090396 0.0538541275683641
0.0320685884395314 0.0283971630936336 0.00579211680646828 0.00765434968193406
0.00520242241945399 0.00138141702125678 0.000429082071470294 0
474 2019 0.000204075867997696 0.00375867558620096 0.0507891302345024 0.106173528333981
0.0674135812308006 0.0658269996188175 0.0807458516839532 0.0287613814552463
0.028085199920126 0.0191817885823187 0.009289513090328 0.00372839309580717
0.00498068977507415 0.00187610341070773 0 0 6.66142956256369e-05 0.000193693519757807
0.00274543459164799 0.015401160499481 0.0466015985037392 0.0270992578056374
0.0554690064130318 0.12976925156639 0.0684417543869375 0.0667216273514799
0.0421945405238874 0.0376212572235871 0.0229062501365698 0.00563973799842777

```
    0.00427382810587893 0.00140785745273427 0.00198169320068339 0.000650524538642225
475 2020 0.00153647464808406 0.000567101291109588 0.0126656992469482 0.0820806947772672
    0.143953231382845 0.107551945281869 0.0526658849157713 0.0564440033258565
    0.0239840888275673 0.0105876655151287 0.00661401427172181 0.00299613575912331
    0.00293290895451861 0 0 0 0.000255270559371665 0.000784663180874227 0.000378971421539543
    0.00375000187445931 0.0241673985577704 0.0677936275228553 0.0717788575793067
    0.109827968645424 0.0718449291723921 0.044079062933528 0.039701869452396
    0.0332167825805635 0.0107055196218775 0.00732358438245221 0.00641093120834591
    0.00210933490123989 0.000625495212148062 0.000665882995645305
476 2021 0.000675498843566984 0.00487774208500371 0.00651639165610488 0.0459782491757921
    0.100430392779213 0.126810750399347 0.0990279265601737 0.0242017793137638
    0.035510411610877 0.00601111113746234 0 0.00125731806924868 0.00369378265371643
    0.00210229249148713 0 0 4.60661978989963e-05 0.000708165739760164 0.00320185762868971
    0.00273484945048197 0.00709610411091353 0.0361236372545264 0.114388669783059
    0.109828406917473 0.0616304675341342 0.0705815236604636 0.0634577587232765
    0.0321919647245152 0.00833037115972135 0.0119242693769888 0.0119738860214536 0
    0.00458306298514709 0.00410529195574007
477 2022 0.000276110185848133 0.00326823540892652 0.017463400855741 0.0284098850601561
    0.0707281143523045 0.183595025093 0.0980277222806597 0.0473533561229953
    0.0153535361490113 0.0148696781320142 0.00926071940513865 0 0.00088665943153581
    0.00153500516150709 0 0 0.000278954241032334 0.000124679178064262 0.000508235338659207
    0.00295137965333224 0.00798887893281939 0.0370873569137251 0.0940944928129356
    0.105877788255017 0.110252214911975 0.0483255452111967 0.0422250468410843
    0.0340536438192565 0.00652789128570432 0.0118568701817707 0.00284111021757345
    0.00118591540754704 0.00155961313789813 0.00123293602156999
478 end_table
479
480 table error_values
481 2000 9.86890809917711
482 2001 16.646626886547
483 2002 13.280665191468
484 2003 7.89970601906288
485 2004 16.3489568046693
486 2005 12.6853250277126
487 2006 13.1203813012262
488 2007 8.63243237445422
489 2008 9.63993111311731
490 2009 10.6932252489924
491 2010 11.2656677141418
492 2012 6.09078782919051
493 2013 6.50294640409814
494 2014 12.9829951095903
495 2015 15.8910028325497
496 2016 14.2652662315251
497 2017 14.2652662315251
498 2018 14.7461179022507
499 2019 17.5396371321802
500 2020 13.0745859040142
501 2021 15.3185603674002
502 2022 14.9292994910985
503 end_table
504
505
506
507
508 @observation FisheryWCSINorthFrom2000Age
509 type process_removals_by_age
510 mortality_process Mortality
511 method_of_removal FisheryWCSINorthFrom2000
512 categories West.WCSI.Mature.M West.WCSI.Mature.F
513 time_step JulSep
514 min_age 2
515 max_age 18
516 plus_group TRUE
517 ageing_error AgeingError
518 likelihood multinomial
519 process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
2016 2017 2018 2019 2020 2021 2022
table obs
2000 0.000905772623051441 0.0296468014693398 0.0800991198162395 0.0444151098311802
0.0944333884840262 0.0425824895957116 0.048391948110442 0.0176091572408323
0.00128473711307501 0.00467253462477352 0.00100450589471843 0.00167465990620769 0 0 0 0
0.000165027882829699 0.00100086633969325 0.0209871883558733 0.0779394182808058
0.0698870540804444 0.170187865020156 0.0836978359136914 0.12076898971521
0.0483026433903323 0.00474261351587472 0.0175661260072149 0.00966385905642973
0.0061574230665965 0.000389780142302526 0.000193341883304803 0 0.00113118282779096
0.000498559811852598
2001 0.000875098590619905 0.0165307772895166 0.0619683712844784 0.0498021073564423
0.0290706602084613 0.0726767512563294 0.0253577439229329 0.0227615448827027
0.00796827901467424 0.000492350135291285 0.00133501236096206 0.00214084421479889
0.0020394995639082 0 0 0 6.47027279855358e-05 0.00255358390118289 0.00823145463529921
0.0720208487915109 0.108281024805791 0.0824530147194427 0.207860228981956
0.0856704296852889 0.0963610437338472 0.0155518737224519 0.00430126794776385
0.0134992547130615 0.00429158109409394 0.00286825816506093 0.00129011123874774
0.000170127786487968 1.93122172862766e-05 0.00149284105162321
2002 0.0130304092289822 0.00660461854237904 0.0650566748132486 0.0393553962760877
0.0393029234621058 0.0219479632076705 0.0265269089177849 0.0172707141094869
0.00951163963886434 0.00294117708246156 0.00248911359887887 1.19427756822944e-05
0.000391286433012917 6.02425910523538e-05 0 5.71611158562581e-05 6.83610119656035e-05
0.0102209275691126 0.00786851300665874 0.0404923548809189 0.0528419806872483
0.121622541841152 0.119159937051158 0.174022985024241 0.107040602380365 0.0704186757438924
0.0201610616015293 0.0151817336853532 0.00816248834561695 0.00227788447009437
0.00239499700192539 0.00229054790409369 0.000147534197437239 0.00106870180289329
2003 0.00102773206229834 0.0888319426468372 0.00864833878598264 0.0358899161005719
0.0216228649354184 0.0402983087457205 0.0107919175864026 0.0307973321956091
0.0123394588971659 0.00716743794077544 0.00460607951509954 0 0 0.000451702525747002 0 0
2.60526399850384e-06 0.00126198750885948 0.0645504174413934 0.0155609945584552
0.0521665447450555 0.0876622195236297 0.116633953494223 0.0692920923600394
0.175986723423558 0.031214281615342 0.07886932482486 0.030024022545887
0.00360679143610235 0.00298842449271104 0.0015971774980111 0.00599097873201454
0.000102434183678149 1.59944145529458e-05
2004 0.0825835071785007 0.00586228966234913 0.117205875743215 0.0127073962739854
0.0168649309300438 0.0159883048108318 0.0111995657378576 0.00445411338227524
0.0100071441681721 0.00439901986650923 0.00344016384152395 0.00260100930326447
0.000174353151366309 0 0.000489172621098212 0 7.84041481166048e-06 0.0461820017159392
0.00284733424913909 0.113882421394063 0.0224956493487185 0.0541337955801041
0.0632275216520541 0.111555871120008 0.038901709742713 0.109505397462821
0.0269627924538642 0.070491613864851 0.0412340247083562 0.000775154519708244
0.00246282497768953 0.00284261718982634 0.00280975953340295 0.00170482340093674
2005 0.127257524177513 0.264735558947997 0.0280390027490541 0.0785260977049843
0.0106072751132167 0.0182979729690791 0.00764986191212742 0.00891165201397247
0.00122008553735035 0.00702767173338086 0.00108369269562044 0.00168780766601151
3.79838525956371e-05 0 0 0 0 0.0340319518973501 0.110977145462193 0.0134609635096956
0.0715849671604068 0.00801677091039442 0.0387791883244093 0.054537581238977
0.0396713293243179 0.0126222469937229 0.0304703067133212 0.0102613135147596
0.0135778863247756 0.0050562292388332 0.000298935475539156 0.000615582200156773 0
0.000955414638244565
2006 0.0719693774918056 0.191154567020578 0.215250284341502 0.0322323029224791
0.0265767243308503 0.00229837521564045 0.00513639661881748 0.00207294544770927
0.00104877679707306 0.00035176431943981 0.000403561415252713 0.000232638439750572
0.000460507813456771 0 0 0 5.97580380009799e-05 0.0285540037198223 0.113539922431293
0.146985316396006 0.0309603437944953 0.0407081782790736 0.0136356890270984
0.0182994635844739 0.0116293417704697 0.0198703669889945 0.00551334676271866
0.0102688426464387 0.00477852215321345 0.00305036026058051 0.00229445860550449 0
7.43464587018279e-05 0.000589516908760571
2007 0.0530753524130475 0.108954310173354 0.149053487649355 0.165512351817414
0.0566947510702187 0.0350938258041884 0.00445729657369281 0.000655488353700998
0.00109122951179871 0.000545975847187314 0 0 0.000635610608968279 0 0 0
0.000393134502403933 0.0201103287897438 0.0296396120014697 0.0550859542045766
0.14318064338941 0.0663943095902751 0.0582833453412368 0.0146984343569029
0.0102014648288961 0.00655477613549869 0.00603913989257259 0.00294722762143052
```

0.00487205052415544 0.00255822516731815 0.0025072724089612 0.00053577534897202
0.000172973572899998 5.56525003510694e-05
532 2008 0.0594598683303645 0.140074887473169 0.154489623541628 0.139452507037111
0.0766647911866934 0.0180518307333941 0.00630585613852282 0.000333624022427956
0.000143239486451894 0.000517819250801329 0.00104085354469164 0.000835539379307505
0.00223350217708876 0 0 0 0 0.0205329675675192 0.0377303768959185 0.0414048014799617
0.0990779349421714 0.088426796719579 0.0475424372104896 0.0345794137233283
0.00468440797305935 0.0060451733517072 0.00812137545688222 0.00548790729986323
0.00264462855187643 0.00177021757729517 0.000687942202538695 0.00117213140115002
0.000487545345008151 0
533 2009 0.0368525473836653 0.189669156675094 0.167274543314942 0.120535069669471
0.0751401433957978 0.0322818616675273 0.00374414611192851 0.00619197852599655
0.00178441498097861 0.000383108693623104 0 0 0 0 0 0 0.000162500314765463
0.00766870946068657 0.0375412636828371 0.0589057343563804 0.0598958924691579
0.0526072017861516 0.0635129446290421 0.025322836612495 0.035586569086184
0.00707005761252995 0.00847816056735862 0.00174640715002992 0.0044758515480555
0.0010297403089757 0.00170030657962369 0.000157436524942704 0.000157436524942704
0.000123980366829026
534 2010 0.0321603528063594 0.162139976473751 0.125864253147009 0.102003788137761
0.0641061986072129 0.0530313944443572 0.0567618877952552 0.0132774699508904
0.00405213345971504 0.000547151494073891 0.000197872498011184 0 0 0 0 0
4.89597114752773e-05 0.00657700796931529 0.0513034397477819 0.0476624072744345
0.0346140611228223 0.048158395682633 0.0745322746392303 0.0664195056669096
0.0289499255981849 0.0149727164914144 0.00344357351188054 0.00344028158868096
0.00178306791798333 0.00197647982129004 0.00106243482820215 0.000238745416209098
8.15093451845509e-05 0.000592734851971798
535 2011 0.0311184785461608 0.125500992509606 0.143918860985831 0.109535252988827
0.0525545524054093 0.0698406931689316 0.032931089199618 0.0103602292870766
0.00143255370722343 0.00222946734558708 0.000791200895727512 0.00108367670880569 0 0 0 0
0 0.0181783057711708 0.0681159990270873 0.046209123433971 0.0584361130360287
0.0449538693682009 0.0592184318803691 0.0640880556926653 0.0315370665543727
0.00960167213012428 0.00885003529029536 0.0022923064543787 0.00360338990112178
0.00107557532234167 0.000633366987471864 0.00177986690198111 4.67642673720578e-05
8.30102322956583e-05
536 2012 0.00604029879393341 0.095168402545575 0.12614609087249 0.118331197018493
0.0679463852716308 0.0470343438834346 0.0182104949702667 0.025060132734652
0.0107058734361209 0.00172815875512795 0.00222127553666595 0 0 0 0 0 0.000526186668810998
0.00489770268654332 0.0485355021117304 0.0454638780872262 0.0694557399088502
0.0797752887093743 0.0579219002325875 0.0355990314454199 0.0776111444432921
0.0355931753500739 0.00374936586943522 0.0140688795048155 0.00276843308547672
0.00379650511094247 0.00025842864145603 0.000695063974962509 0.000374567755868032
0.000316552594743778
537 2013 0.0177079689586838 0.0310563774102307 0.0886456676367776 0.109161000486463
0.0899772461483012 0.0635876152384841 0.0377147101477927 0.0184234460266576
0.00299394599847769 0.000579532744387463 0.000112335505713617 0.000884066403398821 0 0 0
0 0 0.0193181563645947 0.0195394672524145 0.0368766546368267 0.0863110174062122
0.0559850135702641 0.108788653689 0.104625715643802 0.0528266207631459 0.0318318219093571
0.00884486325061397 0.00440344469684725 0.00442012776683065 0.00285257278891419
0.000677582410097306 4.31163758307183e-05 0.00016207959092984 0.00164917917895109
538 2014 0.0256444852953696 0.107162619389958 0.0334812476551981 0.0985545804256533
0.0649566421925477 0.053247184461564 0.0291095019196379 0.0119050127226164
0.00707207808800113 0.0103361363955075 0.00224019510727013 0.00230860074770063
0.000447380044924927 0.000117828559193168 0 0 1.42077573274792e-05 0.0307241141189802
0.0508645751362451 0.0270639856931966 0.0696747511136807 0.0748097408334174
0.101838290572419 0.074286823991223 0.0414904873495131 0.0335236167587716
0.0260073854735128 0.0102546914664076 0.00792150666444988 0.00229902033164765
0.00116399471639975 4.39069508157842e-05 0 0.00143540806684954
539 2015 0.00901467950000734 0.0193470304863237 0.279792978345655 0.032078939565811
0.0608954354381938 0.0264896893496954 0.0263403309977757 0.0178197865587702
0.00903495403665385 0.0107274071813109 0.00609344611260995 0.000823266205426058
0.00022156948264082 0.000273814027503934 0 0 1.94214297322426e-05 0.00724383123987504
0.0110445937192026 0.115823648798214 0.025219495829422 0.0944732960594378
0.062391109693556 0.0582944151068436 0.0393896685368552 0.0371740869031693
0.019769753146623 0.0154448931042985 0.00678424631531825 0.00520520894919185
0.00208062955257505 0.000650665337097553 1.04825338695367e-05 2.72264563401104e-05
540 2016 0.0431122151896199 0.0140249025478008 0.0220701259394622 0.138621886529979
0.0635940992039113 0.0656011817384629 0.0379494336420408 0.0243789252530232

```
      0.0137011443679274 0.00838898514700612 0.00187066439993128 0.00222310266114264
      0.000794732678337012 0.000653015052390717 0 0 0 0.0249108295854195 0.00998659812391193
      0.0173929415760069 0.0761678512370742 0.0413658573205605 0.0995026961184618
      0.0695363321936088 0.08782668143365 0.0432686332183731 0.0404107565372327
      0.0166569491532554 0.0171033224934671 0.00970536063111896 0.00655667211375649
      0.00134082325325955 0.000709081838131479 0.000574198821676265
541   2017 0.0308976517007144 0.138850598949293 0.0382179548596382 0.0227001855300226
      0.0650289843346643 0.0426972778263156 0.0377978895484994 0.0182881649059842
      0.00480519675044983 0.00251065568553985 0.00305370010221479 0.00120819137673979
      0.000233341383013255 0.000241821863171493 8.93351302116742e-05 0.000301849954321263 0
      0.0150691377171546 0.0506104945470621 0.0384320483051604 0.0247251938543497
      0.100236969603714 0.0865018366913829 0.103517576070375 0.0682592728059865
      0.053974123457283 0.0253685922686459 0.0135817763634705 0.00561165731192109
      0.00343201065211633 0.00103612883876472 0.00158677042720637 0.00081226727972131
      0.000321343904892894
542   2018 0.0220387639664743 0.171058394719587 0.164115585778442 0.0244652514485504
      0.0157508689916217 0.0270737698544785 0.00185971159732358 0.00730442908379787
      0.00370109006537977 0.000972947343756246 0.00110354416861256 0.000305801182236306
      0.000664381953165199 0.000338581128034729 0 0 0 0.00484214373510791 0.070878469609159
      0.0718936567490344 0.0571955443130083 0.0557065450844797 0.131896868216213
      0.0378736502462879 0.0702861560488786 0.0249320579666046 0.0140029240205762
      0.0120091671800528 0.00292062763441788 0.00280910362530334 0.00148608930193827
      0.000424012696765672 8.98622907124525e-05 0
543   2019 0.0085110709576229 0.0463168778679315 0.187562742486076 0.150448193161137
      0.034489004485785 0.0157593308710163 0.00931846481584404 0.00235171998008153
      0.00322609369983392 0.00131798271620963 0.000635140344291726 0.000458042106912492
      0.000430097727993428 0.000158500580501214 0 0 0 0.0041501510999205 0.0293514270382056
      0.0993919094348682 0.170333903208612 0.0480929395998845 0.0580481924756866
      0.060673435892722 0.0233711295873009 0.0177916927976063 0.011546935664085
      0.0087634175134424 0.00498212623953804 0.000983647586397531 0.000892756953898365
      0.000232156546521538 0.000341070112674312 6.9846447399797e-05
544   2020 0.0178836696424232 0.00562082621693875 0.0410507837551381 0.141145513233159
      0.133739645223085 0.071015406011253 0.0185431604600004 0.01085112956929
      0.00294152700586983 0.00193931221285783 0.000810047418058334 0.000181581128849028
      0.000270658140718746 0 0 0 2.95957098752147e-05 0.0075674464720536 0.00561494778520235
      0.0226621138986416 0.105230665863562 0.149831171749422 0.113416332158728
      0.0734919405128718 0.0317403339595362 0.0189827676751672 0.0130262895007099
      0.00726741676538061 0.00182917042458537 0.0014053602076646 0.00120754250503545
      0.000410579389359932 0.000277347609116157 1.57177954471496e-05
545   2021 0.0291437436880388 0.0993339606346781 0.0394200444024822 0.0600802306656192
      0.0589709346031233 0.0494200240589699 0.0271640521696897 0.00432569777414855
      0.00464869516682472 0.000403825235760188 0 4.72746733175821e-05 0.00032905186838176
      4.32782454203339e-05 0 0 0 0.0116384534832564 0.0529593970970628 0.0375731342898813
      0.0389329446519487 0.0789725941455777 0.177458928181474 0.114769073937621
      0.038791220157624 0.0339514914719268 0.0231591610395716 0.00948480656987438
      0.00273805192258413 0.00323409002237842 0.00173809424111813 0 0.000667691372264419
      0.000600054229382025
546   2022 0.0283192017166978 0.127320596355499 0.105733488086526 0.06120424396437
      0.0285442555002728 0.0442267385746039 0.0172646393407805 0.00572319231926155
      0.00122994788908683 0.00149935513350412 0.000870562096986795 0 8.42035242614165e-05
      0.000107726603719534 0 0 1.07654549360765e-05 0.0216847099009454 0.04449855563702
      0.0624873693045683 0.068052282215734 0.0664248571312179 0.104342063710758
      0.0824908175059374 0.0689062904909636 0.0221596522037512 0.015910469737176
      0.0117405852540568 0.00377508263934422 0.00320023563376525 0.00106438565533954
      0.000347571545941879 0.000509172126240998 0.000266982748678707
547   end_table
548
549   table error_values
550   2000 66.4144722821096
551   2001 83.28163984582
552   2002 64.7746087689711
553   2003 53.1784310689202
554   2004 68.8157009977767
555   2005 67.1172709305976
556   2006 88.3183634933169
557   2007 71.2169297134438
558   2008 51.655700663863
```

```
2009 69.7527658624273
2010 70.9826634972812
2011 59.2107861351083
2012 65.5945405255404
2013 60.3235506618809
2014 66.1216395119063
2015 80.9389776841936
2016 57.3366564058072
2017 68.3471685654514
2018 83.9258719402673
2019 92.6522884923258
2020 70.4555645109152
2021 71.0412300513218
2022 62.197680391182
end_table



@observation FisheryWCSINorthPre2000Age
type process_removals_by_age
mortality_process Mortality
method_of_removal FisheryWCSINorthPre2000
categories West.WCSI.Mature.M West.WCSI.Mature.F
time_step JulSep
min_age 2
max_age 18
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
table obs
1988 0.00199557051280374 0.000457169904042932 0.047265072403215 0.0654582388841686
0.0836769917685558 0.0696099899710184 0.0405040105614651 0.024117115256502
0.0222521612682205 0.0248426035926381 0.0277182973955408 0.00389501724710157
0.00289917139752833 0.00192887351188932 0 0 0.000340140401594058 0.000458714635547827
0.000805000887313264 0.0243524955074439 0.0446883404648453 0.0741990618772268
0.0763593089927171 0.0747264607464062 0.051162246731984 0.0752026939602534
0.0551564137507304 0.0531399401958092 0.0270971803453551 0.0105376720220222
0.00889410720089616 0.00231077708850978 0.00212646594718109 0.00182269556947395
1989 0.00419780092350573 0.0016235597322357 0.00647491138515025 0.0747232263812649
0.162698389697082 0.0693556988594144 0.0594411080101502 0.0389153432547144
0.0137277419492426 0.0235774517569791 0.0200874977592752 0.0149294372860703
0.00310476866647989 0.00113117647026819 0 0 0.00143886634065901 0.00180858085452283
0.0007463424320932 0.0160973228089535 0.0372471725182899 0.108411183407364
0.0815210906771799 0.058558136144298 0.0547050008266311 0.0464456096463598
0.0317714992170727 0.0302190559779861 0.023736062710676 0.00456594532880257
0.00559660914641405 0 0.000961540484109839 0.00218186934675502
1990 0.000725195879618012 0.029691204396691 0.009476546288219840.0268422740791528
0.0681667914736177 0.123594520445006 0.0408413293747938 0.0370543840308002
0.0110473373775803 0.0223987326500011 0.0182794121095078 0.00421618310577436
0.00693710704125864 0 0 0 0.00105492719603372 0.00111118462772139 0.0121182706729801
0.00700304521147295 0.0311815373982045 0.107374779208964 0.157439371462879
0.0601320013805062 0.0822498069487148 0.043055943566032 0.0239034832156295
0.023427715285014 0.0171799189367756 0.018395678348324 0.00212126735027587
0.00643843962087309 0.0049117947073137 0.00162981661026366
1991 0.000155994205258051 0.0292094784740097 0.162624139794713 0.0255816879399775
0.0310264287486643 0.0580075234428401 0.0534844936866986 0.0209207383770443
0.0098280867479621 0.00694012844109894 0.00253616092990891 0.00345044242016108
0.0028698555752287 0 0 0.00234527431988624 0 0.000343343494931822 0.0219938949717931
0.0537241094528965 0.0224580510958759 0.0871606816344376 0.12621667379735
0.107668692480766 0.058229348574821 0.0404088535777233 0.030652671436095
0.0208631147688956 0.0108071588402121 0.00321495832199286 0.00609116766425852
0.000890878293329406 0.000295968491169 0
```

```
598   1992 0.00158009428196205 0.00262826855930524 0.0574178322152847 0.195453177699003
      0.0130161040881832 0.0305941329971091 0.0452390015978017 0.024842008277093
      0.00898347337072026 0.00969402479774113 0.00179237311196119 0.00183351192635595
      0.000521680598967966 0.00102758279601896 0 0 1.78418728992323e-05 0.00042710998091459
      0.00612274838996998 0.0474215790499826 0.226268577604697 0.0157142768084267
      0.0638049237927423 0.0986504214098434 0.0634563429779525 0.0249989399130522
      0.0210289433808147 0.0169184905591024 0.00772806604087234 0.00689012505777408
      0.00210860038490121 0.0023546556181762 0.00125494078397952 0.000210150056391622
599   1993 0.0637444310127186 0.00365689271571778 0.0206755357994231 0.137110331989033
      0.210065351476267 0.00667958115953551 0.025997307756485 0.0155370485468074
      0.0111197828783931 0.00846237207675792 0.00445959862286009 0.00376565749922829 0 0 0 0
      2.38975168873441e-05 0.0125707314040657 0.000501925119810279 0.00274363689846494
      0.0549076263738595 0.215590898795567 0.021372395773959 0.0668009283227608
      0.0428974737237054 0.0265451685286254 0.0122888143575733 0.0156608082934137
      0.00459944022948666 0.00599831152477665 0.00262022200206006 0.00277702783032789
      0.000126727599018051 0.000700074172411608
600   1994 0.0300955741606423 0.0992888221135287 0.0143391760165329 0.0298381618000043
      0.106725772768416 0.131750855370213 0.00794901683526044 0.0211170019968775
      0.00703774839693588 0.00449125852438955 0.00269242928953874 0.00159597706959168
      0.000414083762065527 0.000647071662977155 0 0 0.000129960760843709 0.00319669698006856
      0.031545700707017 0.0115451812631008 0.0532448404468712 0.090889892253549
      0.233403135818257 0.0101821457085748 0.0364242339134725 0.028063959720586
      0.0200075202761899 0.00294327037171762 0.0095736196395259 0.00558510239811816
      0.00270749514383148 0.000827707245286696 9.3922239856056e-05 0.00165266534616017
601   1995 0.0488223703502406 0.139623087600161 0.170168452388128 0.0153194161688507
      0.0215720719603992 0.0414623215148915 0.033013508605481 0.00158432156087315
      0.00877971406200844 0.00313264207942944 0.0048482110633682 0.000600005290145693 0 0 0
      0.000306172665546698 0.000250642832044032 0.0153383874823003 0.041848072724239
      0.0631381245549411 0.0212880255955576 0.0429731107334522 0.129128169346691
      0.107396112734216 0.00889720530101781 0.0372536508280412 0.0207141452928997
      0.0114123678290615 0.00539512431590063 0.00254809323366725 2.73309072385524e-05
      0.00130125265280072 0.000124913596738455 0.00173297472966844
602   1996 0.0274668051740073 0.102636429578232 0.246596788148533 0.100315064888212
      0.00609502943658142 0.0171734734566645 0.018805009162318 0.0154324101297819
      0.000460961792070693 0.00416779033657525 0.00528416127682874 0.000535617576448384
      0.000535617576448384 0 0.00012919271812223 0 2.22055919155291e-08 0.00483060388094651
      0.0268358651272212 0.0912768954885295 0.07610069844530 92 0.0136534605569453
      0.0542673152005741 0.0915108442552286 0.0615042753824191 0.00445642475604895
      0.0138323409165881 0.0110476203210736 0.00122295076915585 0.00188088989392282
      0.00149916992531805 0.000446271624303207 0 0
603   1997 0.0140913319151253 0.0657316838916202 0.168084625387606 0.127586303748109
      0.0810682137051068 0.0103339775204529 0.0139890010656583 0.00927093803565219
      0.0145483957086172 0.000524454982690509 0.00148239064529625 0.00109143003594965
      0.000306262196319054 0.000197731713854406 0 0 0.00190323717211439 0.00477739547110885
      0.0227948018792789 0.0889904444795213 0.0997440021346149 0.12978880604999
      0.0141690940223267 0.048193264073098 0.038212255396667 0.0249438337228466
      0.00404147481154808 0.00551644918206219 0.00334918565449276 0.00105308879450317
      0.00280905970577784 0.000179405830337951 5.68830498246288e-05 0.00117057801782993
604   1998 0.0155377333973147 0.0786225202664414 0.102730762860741 0.144396783042026
      0.0736759708375126 0.0393633223263129 0.00934652816988432 0.015152859845201
      0.0143957013055141 0.00311208683040801 0 0.000620873172332449 1.57619173938943e-05 0 0 0
      0.000879441879110403 0.0114335775765749 0.030334146884986 0.0372319506389865
      0.125870426853308 0.0847746091699591 0.0807514470897427 0.0297697413500284
      0.0435427233154617 0.0249912445780561 0.0180812361978856 0.00494209353060524
      0.00593780815362288 0.00127215775225406 0.00178519976067057 0.000403068142036027 0
      0.00102822315562919
605   1999 0.0137703635806216 0.0712994292466759 0.0727762912054492 0.153315102765341
      0.0680420586974322 0.0704359260357956 0.0300625174257002 0.00494465975059978
      0.00504274777486483 0.00201791105854941 0.0026518197419234 0.00108922915880678
      0.000156353460340 22 0.000395516884180577 0 0 0.000612323301615571 0.00680763699874141
      0.0302240990585962 0.0453284936048828 0.116048622028362 0.0680860469326476
      0.093534259425974 0.0717887060325796 0.0256212330996627 0.021527956315402
      0.0127087091444309 0.00474385288174239 0.00113428769478336 0.00224348311052476
      0.00206593490675503 0.0012378486773243 0.000133465861448303 0.000153114138246972
606   end_table
607
608   table error_values
```

```
1988 28.247562608628
1989 20.7482097036825
1990 18.5296511359695
1991 33.247131211925
1992 29.4349601519111
1993 25.4040579655029
1994 30.5286157838823
1995 40.2465272565408
1996 38.246699815222
1997 32.7784216553659
1998 29.0287452028932
1999 34.840743704226
end_table




@observation FisheryWCSISouthAge
type process_removals_by_age
mortality_process Mortality
method_of_removal FisheryWCSISouth
categories West.WCSI.Mature.M West.WCSI.Mature.F
time_step JulSep
min_age 2
max_age 18
plus_group TRUE
sum_to_one TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
table obs
1988 0.000906491227018376 0.000344941421324844 0.0277316856947895 0.0477720850706582 0.0804192366486701 0.0902053034076703 0.0634000988865168 0.0428817226977391 0.0483249340384552 0.0548773564972541 0.0643839072952518 0.0118492013897162 0.0073027295705304 8 0.00413804737551901 0 0 0.00170127189492969 0.00042173996098688 3.94575465947559e-05 0.00753371915815528 0.0117135579695147 0.024939562610509 0.0347564700488258 0.0562199725931015 0.0380596309072705 0.0661970774483178 0.0596057469565297 0.0716338156422481 0.0377303463016836 0.0205240343266208 0.0140640845112903 0.00496770425187634 0.00277328279421717 0.00258078385621395
1989 0.00130273913290529 0.00134139667452101 0.00941106086674624 0.0692996105578248 0.14848365698861 0.0643526146895356 0.0593016262087833 0.0377418100039768 0.0134168210168568 0.0234828817268064 0.020299405523996 0.0140266381363187 0.00317375185788 06 0.00127209931963064 0 0 0.00178214180584071 0.00223321979694827 0.000662696465984155 0.0163196707813312 0.0302158488820623 0.0956304012841717 0.0796156023931093 0.0624853581067621 0.0633792644510649 0.0554004295254652 0.039864914379353 0.0384102031204559 0.0310097744512722 0.00521016764265215 0.00705525208470302 0 0.00155680895212808 0.00226213317230326
1990 0.000394963181963349 0.0174412526065814 0.00854435568933991 0.0285162631092423 0.0865347229980447 0.149737189795359 0.0511170331191915 0.0467784639633421 0.0132319779965905 0.0278063948661157 0.023603669440991 0.00547899295950139 0.00918735417019835 0 0 0 0.000714360024489701 0.000696020392 20915 0.00684420367902558 0.00549333245135516 0.0262839028712907 0.0932083198262733 0.135892281490417 0.0528266839472506 0.0719149511352585 0.0392428880369876 0.0233506347643355 0.0231579010930499 0.0168599458090682 0.0201585210018514 0.00265675656507619 0.00606386356876963 0.00497196883140786 0.00129083061542303
1991 7.08606244618418e-05 0.0115159645483806 0.0727602784147163 0.0199759068982784 0.0493558268240728 0.0918849237651472 0.0941685703086226 0.0400303191129789 0.0177799271952547 0.0134905901237774 0.00465276952014957 0.00690875472634698 0.00553910720589649 0 0 0.00307203699582975 0 8.65885406001191e-05 0.00831422215079321 0.0148709871571699 0.00912381766433635 0.0684418008451615 0.124370582306287 0.119394619693166 0.0699446639569729 0.054355467601147 0.0387441234364568 0.028623587724057 0.0167312347079759 0.00531480795771355 0.00844753336922 37
```

0.00100179175635262 0.00102833486867262 0
647 1992 0.00289104886100342 0.0040751079832259 0.0493512570055858 0.190066182739038
0.0144389007682675 0.0409757732102874 0.0747397214372454 0.0485087678010545
0.0155607904301699 0.0224376946042047 0.00264866669017592 0.00348963528960056
0.00144593152343044 0.0027047930009515 0 0 0.000504617142742592 0.0023686050207344
0.00248369793170421 0.0147072588014068 0.108462591864327 0.0119665845429554
0.0539260084286045 0.11410631634817 0.087002196098536 0.0368414365165577
0.0361938459627255 0.0206072582157683 0.01447206365874 0.0127210530870755
0.00361685605373271 0.0042051105870909 0.00177921391497057 0.000701014479916466
648 1993 0.00944055122370427 0.00158273822765325 0.0147566610871088 0.12159286898415
0.239248840248267 0.0110738864748092 0.03543758398238 0.0262544771126871
0.0220260655706936 0.0167590185509882 0.00885235626006826 0.00839004833173398 0 0 0 0 0
0.00502141528781828 0.000358889882760442 0.000900826236018064 0.0233955275240621
0.13147124869662 0.0161652319798291 0.0760961488490193 0.0737953779690728
0.057059251290693 0.029332196238264 0.0328208240556845 0.0140068223034798
0.0119751707168706 0.00448519136576392 0.0055775329693016 0.000198060920145297
0.00192518766035453
649 1994 0.0138349522929899 0.0484791258583161 0.00718868521693665 0.0217536323951632
0.0958785227669234 0.202051571986037 0.00960947079453283 0.0413352758692321
0.0148640674118214 0.0162379094809859 0.00951680514668404 0.00456735034719581
0.0018376619434825 0.00290814342653812 0 0 0.000271723869091413 0.00235896719429012
0.0103866427923884 0.00192611276602305 0.0267472322424962 0.056233519482319
0.186290231800472 0.0188538458194325 0.057814715262144 0.0538459892356765
0.0405520860689792 0.0101611704383438 0.0212353157183348 0.00727850694497225
0.00682134872590814 0.00338251738226386 0.00045496760662824 0.00532193171339715
650 1995 0.0140983405120716 0.0449300010880883 0.0792599876706288 0.00973706344016319
0.0257084296394425 0.0935514747626376 0.129465456043959 0.00852280506545115
0.0355122550235562 0.0160131088290024 0.026519675844294 0.0037139982932502 0 0 0
0.00171007220844185 0.00125088534186622 0.00940004396326788 0.0126657232128638
0.0183867654972012 0.00682283788720923 0.0232622473855829 0.108666232629237
0.13430263755726 0.0209316077778439 0.070840488276437 0.0483668178719415
0.0256893411642012 0.0146881694456693 0.00846578074824492 0.000396853856469317
0.00539151295836007 0.000392397654399895 0.00133698835093382
651 1996 0.0156991365448825 0.0586811011581149 0.211527350465961 0.115108397860165
0.00762784904467309 0.0382154799147988 0.0427984969193347 0.0470246638352129
0.00168864745748724 0.0121908434816542 0.016717265290445 0.00123905838198361
0.00123905838198361 4.69709388534523e-05 0.00144354191827546 0 3.61884263185173e-05
0.00622194760979091 0.0226279099434948 0.0670322983671103 0.039903519429324
0.00755824014052215 0.045026847436382 0.094375089047612 0.0807604165937283
0.00553744394972822 0.0240848373419875 0.0195128305460959 0.00436972903034672
0.00541932955924716 0.0047289255754367 0.00150288585241305 0 5.36995566368593e-05
652 1997 0.00443534015963807 0.0264678266207608 0.1289438359515 0.136833369903809
0.109008158035333 0.0174944111200106 0.0280109031047911 0.0274679240354791
0.0339997500826347 0.00185379258913009 0.00638415122785984 0.00422824522776731
0.00139651705163825 0.000136780430016158 0 0 0.00210577526287087 0.00253173121745747
0.0110176293789523 0.0366232220609595 0.044608279913803 0.0716398988889663
0.0127164892367018 0.0873108351852498 0.0849953077673583 0.0672876546776045
0.0125091649096822 0.0168490067407042 0.0118672149956821 0.002443956360261
0.00502958265172607 0.000656628947177223 0.000221083523255782 0.00292553274122023
653 1998 0.015892664186885 0.0397147904045768 0.0674548255456478 0.170953212484075
0.0937010905339965 0.0546273513558133 0.0130026250358419 0.0227945241356058
0.0234943590255422 0.00547703676603619 0 0.00123371186320389 4.41856219048291e-05 0 0 0
0.00174238189560959 0.0137746799668114 0.01879331837172 0.0182798711837263
0.0761437895077592 0.0668087975113548 0.0752923036296449 0.0378303190819095
0.0713071999919899 0.0445071719909205 0.0343401429284464 0.00906025312742087
0.0126609898156736 0.00346800470849973 0.00463698572310469 0.00114417393605427 0
0.00181923967022544
654 1999 0.00734506533881667 0.0331334736994098 0.0384066156261058 0.0959685307854303
0.082451926631986 0.112943234456462 0.0670052935540934 0.0114196916688164
0.0133297131130945 0.00534548497063177 0.00923720379916071 0.00220038473351613
0.000420319738956338 0.00145514329105117 0 0 0.00296337643311888 0.00410779675162947
0.0193930743837817 0.0168291375090764 0.0564929986042416 0.0578902148899228
0.10879934816118 0.111099110565294 0.0435849893190149 0.041599771204681 0.026668916192123
0.011396731234303 0.00242746813701539 0.00621887673739116 0.00429888907220416
0.00416651621404 77 0.000726736898076431 0.000673966285367275
655 2000 0.000344866512218234 0.0137455744699967 0.0500783023835485 0.0386175835339154
0.104692967591588 0.0635130449690092 0.0919641292602922 0.0405311206508534

0.00369608449902621 0.0105890083898949 0.00341661174754647 0.00411055694224005 0 0 0 0
0.000243972259347498 0.000631729176958394 0.00949520997582955 0.0293349100330986
0.0337491177300966 0.117182875127625 0.0803934603567417 0.133613763617451
0.0822877609228227 0.0116759709699416 0.0302204140729075 0.0235046203364901
0.0155772086008297 0.00174118051210741 0.000742199729557499 0 0.00229339749283815
0.00201235813522813
656 2001 0.000946212942512234 0.00437152140463027 0.0409925181797516 0.0485545597848545
0.0414182030334383 0.111524718560114 0.0492466759804263 0.0503803889918883
0.0233041888112886 0.00197913531671243 0.00362558152202624 0.00629721982697584
0.00570251773606038 0 0 0 4.48800364385097e-05 0.00212306449362909 0.00533315259082358
0.0363362443849856 0.0633097673842905 0.0572502195628331 0.171725201966429
0.0863057391585774 0.115660128146949 0.0229928969585563 0.00782874072652556
0.0238614222223392 0.00691170645569729 0.0053823268626573 0.0028047930746432
0.000478429984248487 6.34577067457388e-05 0.00324438619295251
657 2002 0.00681025895089816 0.00189049720271405 0.0254984361526605 0.0285848223757572
0.049714848892499 0.0317069254955394 0.0557779341288603 0.0391528593835107
0.0237256518351321 0.00660893437669562 0.00337200842758166 1.59465089737327e-05
0.00101326853656894 0.000225083824156073 0 0.000344282373599654 0.000122232457908947
0.00553845720075202 0.00210597053461109 0.0097793874157152 0.0187820024261889
0.0769732632293666 0.102350346294319 0.191952956925659 0.134551596500785
0.0949045074953619 0.0401264823029222 0.0130951421576985 0.0152636869528169
0.0057514444019243 0.00624391690888839 0.00524858768696076 0.000296216095952007
0.00247204454702185
658 2003 0.00038893060049176 0.0374820159062347 0.00270914307980197 0.0149595666675445
0.0160356260758521 0.0447794673565626 0.021902338123302 0.0595724498127031
0.021958075449604 0.0213054868203266 0.0154034231427138 0 2.30545183930611e-05
0.00174838651731527 0 0 8.71840481144353e-05 0.000527173432252637 0.031528634126214
0.00486770272615602 0.0127848860381833 0.0368824687686344 0.0798597258379406
0.0655645478838172 0.223246017734972 0.0475389128736233 0.124179637129314
0.0639288796686663 0.0129492617181354 0.0130492550325735 0.00951384998544709
0.0140938482701615 0.000600393165059769 0.000529657489888932
659 2004 0.0824709051299077 0.00337259841839483 0.0711985467416373 0.00746688143031204
0.0182972414480597 0.0197673168226771 0.024192497416057 0.00828474967509844
0.0375724638272358 0.0122588773975268 0.0154108219491786 0.00922459313129456
0.00081173339687526 0 0.00160756814250819 0.000730339333323993 1.54584479059086e-05
0.0510335832011985 0.00224945615949876 0.0422439265211782 0.00786312198617916
0.0201514214547606 0.0418182374509466 0.0968679699050806 0.0483320584365481
0.133991359443145 0.0497546214051193 0.0963184032606107 0.0612121576265859
0.00214058127494188 0.00929029697910554 0.00780671685054181 0.00995930961016164
0.00628418572640433
660 2005 0.106646777421555 0.274158367271934 0.0244616193156076 0.0522256415086957
0.00791474228138926 0.0138787788076988 0.0159811861726617 0.0128136438883053
0.00192161515547186 0.0149729294585398 0.00502579593982595 0.007623162471867
0.000437408588135886 0 0 0 0.000293212511326545 0.0342520192202002 0.0772558441884391
0.00621752283994329 0.0292893040247753 0.00339714421507029 0.0219395327187855
0.0589302479611586 0.0533300318202351 0.0176763409806091 0.068861408645819
0.0275490800240771 0.0389929576474387 0.0186723970641407 0.00162833641461885
0.00191813090647155 0 0.00173482053520299
661 2006 0.0713613307381719 0.157719857075466 0.256665041478604 0.0462606779261902
0.0479875251430113 0.0065957431173391 0.0125112616922681 0.00907734233380117
0.00513630985188052 0.00264712701963265 0.00560651153066676 0.00172142752230502
0.00218781723007824 0 0 0 0.000172806309100853 0.0250628648422429 0.0605308378266872
0.083669674593826 0.02107277739123 0.0279220165809356 0.0105871004644839
0.020366368184061 0.0225971762297436 0.0370287704395889 0.0157378265668203
0.0216884723405034 0.013150425752499 0.00612238610047082 0.00561388286303688 0
0.000175082078621806 0.00302355877673312
662 2007 0.0592713355770696 0.0742331501184876 0.113863233965427 0.198292524091642
0.0949399138494696 0.0614767922410983 0.0100282303758569 0.00329014800722005
0.00554815075497121 0.00133077759485432 0 0 0.00128232612430438 0 0 0 0.00119131245661847
0.0291883062526109 0.0201339621959307 0.0277094430520013 0.0798154778255342
0.0486258270195688 0.0541263386926673 0.0159351345843049 0.0181188701966482
0.0170346601883033 0.0160204506413211 0.0114329309843737 0.0157677041092956
0.00859784042565456 0.00944617893541021 0.00196141989693767 0.000983349667173616
0.000354210175243977
663 2008 0.0902587246636358 0.0751940562306301 0.0552816740519941 0.100127841480447
0.0867145105857079 0.0282774091347143 0.00979295422498292 0.000472745564842759
0.00126858333320983 0.000836864852776222 0.00175145781828l3 0.00243149922401303

0.00215113008587383 0 0 0 0.000122580286539169 0.0263871313597486 0.0228721768674582
0.0130416605776601 0.0893214994843069 0.115471104794571 0.0920408353811564
0.0818513503671887 0.0134832627133813 0.0194198223375911 0.0251210267679652
0.017670326638839 0.00792134267755882 0.0100095075127991 0.00335813626364891
0.00276662506486214 0.00361775181304541 0.000964407840571192
664 2009 0.044637967413196 0.174152061371326 0.107555909268856 0.0905542538544059
0.107301126878164 0.0506534699073225 0.0146224933876397 0.0155690527799065
0.0042384692416845 1 0.000923058422936651 0 0 0 0 0 0 0.00111994717846026
0.0135181175297772 0.0360505692315313 0.0298727043512647 0.0297772297349445
0.0402366832502946 0.0639412470830001 0.0396235650729808 0.0713683864672595
0.0182437819212072 0.0181957154966276 0.00462058883205963 0.0109232865417549
0.00415132538473298 0.00551594490887343 0.000834238129223285 0.000834238129223285
0.000964568231346464
665 2010 0.04920361113527 0.210041218207535 0.107725828025785 0.0859701935576419
0.0552836726736495 0.0512937479392709 0.0628069023338276 0.0140080061819009
0.00585269875975881 0.0014149589776487 0.000455848076552637 0 0 0 0 0 0
0.00289951415259485 0.0453733413870976 0.0277301148802633 0.0186310610400979
0.0273295041081517 0.0572674683122738 0.0829990837202264 0.0414742004020162
0.0277349265125193 0.00595906331095443 0.00581472603618296 0.00420788056731284
0.00408568966311956 0.0024038458727666 0.000584511006149839 0.000200837413437684
0.00124754574599441
666 2011 0.00826677820278546 0.106021692110062 0.1147039665692 0.0979232301704494
0.0559283687599128 0.0831254756986491 0.0462296834651146 0.0208399236185989
0.00177050665450641 0.00318918862520402 0.00121591944935285 0.00135455604817160 0 0 0 0
0.000764521382492314 0.0042351784608508 0.0374591426799464 0.036305270569971
0.0560474955161166 0.0488237987649652 0.0692906411943375 0.0888581019164958
0.0587314115934309 0.0159546084235698 0.0204466578634318 0.0047083798855019
0.0086081446750461 0.00252545676014482 0.00220664454744041 0.00322926392595957
0.000164681463321992 0.00107131100497006
667 2012 0.00203854131613354 0.0754738006913902 0.105841076730699 0.105744335425141
0.0699937215159111 0.055203143436414 0.0317120083956095 0.0469150871393118
0.0218295886215224 0.00366196009532258 0.00391155046962881 0 0 0 0 0 0 0.00125603219182051
0.00191672374894741 0.0169292128744051 0.0193827623241896 0.0309543953085573
0.0466257110607415 0.0449928469575834 0.0510684454249542 0.125440365310214
0.0662352019065645 0.0115684484981714 0.0359949683738991 0.00552371697967946
0.0120190971756588 0.00160216327412999 0.00337020975662066 0.00181207764596035
0.000982807350818443
668 2013 0.0112406769933361 0.0184029789986763 0.0671520369512227 0.0934636866463799
0.0952480337519102 0.0817332365529499 0.0599030763293032 0.0352044595789589
0.00769433366324595 0.00212444112030912 0.000277891102485203 0.00169592796219842 0 0 0 0
1.16942516283784e-05 0.0106110970090184 0.00755445815633965 0.0185443937833415
0.0563607225799993 0.0443087917828606 0.100075747136792 0.110919120094787
0.0743073808531812 0.0552834233685014 0.0166917706581109 0.00936044152042194
0.0100445812699755 0.00498585080739745 0.00208241445983849 0.000261039501317356
0.000320189887386676 0.00413610322812646
669 2014 0.0142079588680609 0.0388632891111473 0.0134610778594914 0.0770332432231176
0.0808993635269978 0.0764553448259418 0.0520229044981681 0.0291790425946153
0.017602893494313 0.0223567156501144 0.00615684643297144 0.00478765060643358
0.00156763894576677 0.000489933382642714 0 0 0 0.0119743484823216 0.0146579373972034
0.00775940371452016 0.0333320103471967 0.0564846638407578 0.104024991949913
0.0903587972251227 0.0679259384534702 0.0665344515948673 0.0579033426136574
0.0248407211474279 0.0183011521816885 0.00570007772729602 0.00382716051072047
0.000269138015332538 0 0.00102196177872166
670 2015 0.00420525861814405 0.0113931899252237 0.136056978478423 0.0220548413650195
0.0651759911489967 0.0450193477343709 0.0504141049392679 0.0372311681027034
0.0217713413784361 0.0170066134064649 0.0190758684321033 0.00314694323627534
0.00111716760903145 0.00121100593438106 0 0 0 0.000233946027190946 0.00396931262958606
0.00627440438769857 0.0530645770297461 0.0137345087006232 0.0700838917434782
0.0693027831977613 0.0824692913695022 0.0624230345517099 0.0649892069479932
0.0423837241207241 0.0474455895386752 0.0149408580257028 0.0213331508779734
0.00845277058914915 0.00337433389843341 0.000190462105806177 0.000454333949404239
671 2016 0.0129146863990611 0.00880153291156912 0.00907879027922791 0.0671757998001839
0.0392092917206921 0.0548906875923173 0.0572127854435825 0.0500043660903089
0.0296494312484404 0.0197179234108912 0.00590775957797361 0.00704227955652562
0.0031472702709361 0.00187392268889131 0 0 5.71658469464343e-05 0.00675175869683802
0.00357874795972387 0.00688962441906379 0.0291211425003213 0.0185184640143369
0.0598752322215305 0.0770985551725443 0.119964504618224 0.0698474557733373

```
      0.0847074770204438 0.0544248740140022 0.0470427022608103 0.0295578994122807
      0.0170822103887561 0.00334445723935561 0.00343895847496408 0.00207224297591931
672   2017 0.0111981457808999 0.0651166595729258 0.0179913386728549 0.0147864542102582
      0.0650152757294911 0.0574640825987312 0.0602958773362226 0.0415172683265365
      0.0126921075569885 0.00754834643252247 0.00845153722979962 0.00188338897642204
      0.00131801457265208 0.000906025191514337 0.000242033107272757 0.00111165859189433
      0.000498257201004506 0.00909870974571269 0.019728434204965 0.0143363772371038
      0.00866829903912425 0.0599274765537545 0.0713994176592748 0.109460531467398
      0.104577577111748 0.101746313689 0.0583140686618783 0.0337938930164137
      0.0175229880222527 0.00932673083380268 0.0038852095478845 0.00480022225230165
      0.00400118817269521 0.00137609169087732
673   2018 0.00907949585503297 0.0781211180649679 0.111232711908741 0.0179003290352703
      0.0234620521961106 0.0574885282866355 0.0074919899060329 0.0321564106733701
      0.0203886986124435 0.00529707722765288 0.00393993216276947 0.00151108531573351
      0.00385001929994944 0.00178813536621997 0 0 9.78322543407763e-05 0.0025301210151609
      0.0390126413230524 0.0457866066998732 0.0344620199740354 0.0429237398700861
      0.13425758488194 0.0520918339743826 0.121532346721144 0.060266024057709
      0.0369915892320248 0.0314935102190117 0.00671773869362919 0.00918556007269116
      0.00683828449852769 0.00143330658066056 0.000408130883940402 0.000263545136860082
674   2019 0.0017204803846089 0.0203569301874541 0.0997748860761569 0.117622008215334
      0.0516136206060821 0.036806312438007 0.0376619414338816 0.0129505546993818
      0.0142644547465421 0.00879451090591982 0.00457307308657259 0.00242088584960839
      0.00285875023260666 0.000892805898146081 0 0 0.000174413934956312 0.00132114613941726
      0.0119169319765262 0.0381937578499118 0.0808044445610246 0.0354664681674049
      0.0569626506889302 0.118251810624512 0.0612338132201081 0.0640397471023175
      0.0420898321208333 0.0393831355112042 0.024068935589521 0.00590638495763153
      0.00388818554626426 0.00148755291586059 0.00178294240016796 0.000716631933106333
675   2020 0.0237988543363961 0.0020999810597395 0.0186497847828718 0.0919776860432853
      0.126308860448271 0.0789225142476765 0.0312980139939515 0.0263618141444215
      0.00904145066594458 0.00466779401128 49 0.00213604461636989 0.00113005668303 05
      0.00105188635602546 0 0 0 5.90963443337 13e-05 0.00873687126457779 0.00269960358546529
      0.00930199746901065 0.0520555974407255 0.107551472173013 0.10066448435313
      0.108475985298641 0.0645895641950552 0.0422486501753488 0.0360160095389857
      0.026555761303252 0.0100158767368636 0.00594028624209073 0.00456068197647103
      0.00226231635319898 0.000474142264171948 0.000346861896396418
676   2021 0.0135586153851526 0.0294087879814158 0.015434976726646 0.0412614855193011
      0.0674923934643424 0.0776046251208111 0.0552331958702308 0.0146712163653221
      0.0208516050240588 0.00312775784719361 0 0.000996846730342754 0.00259485000094453
      0.00104363347900428 0 0 1.35039319847138e-05 0.00760325427375049 0.00956529976574046
      0.00687685289163043 0.0171127763574275 0.0570140391365075 0.146469553089394
      0.120755127078311 0.0649677966358978 0.075426041895266 0.0687121785261008
      0.0350191479560945 0.00997920119808205 0.0135272026358717 0.0134461629730717 0
      0.0054909590934299 0.00474091304667275
677   2022 0.012681573896399 0.0626291478785896 0.0542197835010659 0.0453285075301676
      0.0428885188096602 0.0985291038727767 0.0537219402740224 0.0275252386109701
      0.00869764759770387 0.00925151170398736 0.00585717780169676 0 0.000924363206561632
      0.00135568153788193 0 0 6.76110695637874e-05 0.00576445140108076 0.0101611351412891
      0.0150091956566776 0.0211354535152938 0.0381400399477503 0.0841382890973075
      0.0944318789108427 0.110373455623196 0.0589831370909614 0.0552811477003205
      0.0455955469461139 0.00820166289865427 0.0191693585390466 0.00356245019829933
      0.00194232272841705 0.00171408638512587 0.00271858092857629
678   end_table
679
680   table error_values
681   1988 34.9882190902703
682   1989 26.4955034577394
683   1990 26.0974074124646
684   1991 32.5554099247016
685   1992 29.9014362895357
686   1993 32.0688480915878
687   1994 19.8163364759053
688   1995 39.6326729518106
689   1996 44.5867570707869
690   1997 26.760900821256
691   1998 31.0072586375215
692   1999 34.3247256814788
693   2000 34.23625989364
```

```
694   2001 36.492137483531
695   2002 38.7922479673414
696   2003 31.980382303749
697   2004 37.7748914071945
698   2005 50.4254990681519
699   2006 45.2944833734978
700   2007 22.6030087928295
701   2008 25.3896811097537
702   2009 25.3454482158342
703   2010 22.6030087928295
704   2011 29.6360389260191
705   2012 29.3706415625025
706   2013 38.3499190281471
707   2014 38.4826177099054
708   2015 45.6041136309338
709   2016 36.8902335288058
710   2017 32.2457796672655
711   2018 43.1713044653651
712   2019 47.8157583269054
713   2020 36.8460006348864
714   2021 34.3247256814788
715   2022 32.8650401821376
716   end_table
717
718
719
720
721
```

F.1.5 Observations survey

```
@observation CookStraitAcousticBiomass
type biomass
time_step JulSep
time_step_proportion 0.5
categories East.CookStrait.Mature.M + East.CookStrait.Mature.F
selectivities SelectivityOne SelectivityOne
catchability CookStraitAcousticQ
likelihood lognormal
process_error 0.0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1991 1993 1994 1995 1996 1997 1998 1999 2001 2002 2003 2005 2006 2007 2008 2009
2011 2013 2015 2017 2019 2021
table obs
1991 88247.565 0.41
1993 282537.285 0.52
1994 277977.2016 0.91
1995 193889.0408 0.61
1996 92408.95769 0.57
1997 140626.4634 0.40
1998 79550.3042 0.44
1999 114409.8282 0.36
2001 102034.0909 0.30
2002 145075.0048 0.35
2003 104148.7844 0.34
2005 59139.10151 0.32
2006 59669.34895 0.34
2007 104427.6999 0.46
2008 82252.28529 0.30
2009 165538.3474 0.39
2011 140964.7624 0.35
2013 167829.5328 0.30
2015 203533.5384 0.33
2017 101733.8644 0.36
2019 91116.11374 0.36
2021 158893.5 0.41
end_table



@observation WCSIAcousticBiomass
type biomass
time_step JulSep
time_step_proportion 0.5
catchability WCSIAcousticQ
categories West.WCSI.Mature.M + West.WCSI.Mature.F
selectivities SelectivityOne SelectivityOne
likelihood lognormal
process_error 0.0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1988 1989 1990 1991 1992 1993 1997 2000 2012 2013 2018
table obs
1988 266265.4393 0.60
1989 165189.2979 0.38
1990 169048.7622 0.40
1991 227139.9065 0.73
1992 228885.0556 0.49
1993 379902.3464 0.38
1997 445491.0422 0.60
2000 262870.8502 0.60
2012 283102.407 0.50
2013 233385.3339 0.53
2018 123206.777 0.51
end_table

```

```
67
68
69
70  @observation ChathamRiseSummerBiomass
71  type biomass
72  time_step DecMar
73  time_step_proportion 0.6
74  categories East.ChathamRise.Immature.M + East.ChathamRise.Mature.M +
    West.ChathamRise.Immature.M + West.ChathamRise.Mature.M + East.ChathamRise.Immature.F +
    East.ChathamRise.Mature.F + West.ChathamRise.Immature.F + West.ChathamRise.Mature.F
75  selectivities SelectivityChathamRiseSummerSurveyM SelectivityChathamRiseSummerSurveyM
    SelectivityChathamRiseSummerSurveyM SelectivityChathamRiseSummerSurveyM
    SelectivityChathamRiseSummerSurveyF SelectivityChathamRiseSummerSurveyF
    SelectivityChathamRiseSummerSurveyF SelectivityChathamRiseSummerSurveyF
76  catchability ChathamRiseSummerQ
77  likelihood lognormal
78  process_error 0.10
79  error_value_multiplier 1.0
80  likelihood_multiplier 1.0
81  years 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
    2008 2009 2010 2011 2012 2013 2014 2016 2018 2020 2022
82  table obs
83  1992 118621 0.077
84  1993 153271 0.103
85  1994 131993 0.098
86  1995 114572 0.076
87  1996 125249 0.098
88  1997 154790 0.084
89  1999 82236 0.109
90  1998 83874 0.116
91  2000 57324 0.123
92  2001 59968 0.097
93  2002 51808 0.114
94  2003 47615 0.087
95  2004 38271 0.127
96  2005 67052 0.115
97  2006 73331 0.106
98  2007 61636 0.084
99  2008 61234 0.110
100 2009 118916 0.106
101 2010 78233 0.146
102 2011 66955 0.140
103 2012 84330.4 0.098
104 2013 65681.3 0.153
105 2014 94778.8 0.098
106 2016 59100.3 0.142
107 2018 85348.0 0.160
108 2020 61200.0 0.144
109 2022 88999.0 0.101
110 end_table
111
112
113
114
115 @observation SubAntarcticSummerBiomass
116 type biomass
117 time_step DecMar
118 time_step_proportion 0.5
119 categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M +
    West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
120 selectivities SelectivitySubAntarcticSummerSurveyM SelectivitySubAntarcticSummerSurveyM
    SelectivitySubAntarcticSummerSurveyF SelectivitySubAntarcticSummerSurveyF
121 catchability SubAntarcticSummerQ
122 likelihood lognormal
123 process_error 0.10
124 error_value_multiplier 1.0
125 likelihood_multiplier 1.0
```

```
years 1992 1993 1994 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2012 2013 2015
2017 2019 2021 2023
table obs
1992 78434 0.068
1993 87421 0.061
1994 95608 0.092
2001 55523 0.126
2002 37582 0.160
2003 37425 0.140
2004 12429 0.129
2005 13538 0.120
2006 18393 0.130
2007 13112 0.106
2008 42895 0.157
2009 44439 0.140
2010 53366 0.162
2012 44221 0.147
2013 54533 0.152
2015 29072 0.129
2017 30506 0.17
2019 30076 0.113
2021 31220 0.123
2023 47698 0.09
end_table



@observation SubAntarcticAutumnBiomass
type biomass
time_step AprJun
time_step_proportion 0.1
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M +
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
selectivities SelectivitySubAntarcticAutumnSurveyM SelectivitySubAntarcticAutumnSurveyM
SelectivitySubAntarcticAutumnSurveyF SelectivitySubAntarcticAutumnSurveyF
catchability SubAntarcticAutumnQ
likelihood lognormal
process_error 0.10
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1992 1996 1998
table obs
1992 67832 0.083
1996 89029 0.092
1998 67709 0.110
end_table



@observation SubAntarcticAEXAge
type proportions_at_age
time_step DecMar
time_step_proportion 0.6
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
selectivities SelectivitySubAntarcticAEXSurveyM SelectivitySubAntarcticAEXSurveyF
min_age 2
max_age 6
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0.0 0.0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1990 1991
```

```
table obs
1990 0.021505376 0.008602151 0.019354839 0.255913978 0.120430108 0.021505376 0.006451613
0.019354839 0.268817204 0.258064516
1991 0.03218391 0.07586207 0.02758621 0.13333333 0.09655172 0.02528736 0.07356322
0.04137931 0.12413793 0.37011494
end_table

table error_values
1990 5
1991 5
end_table




@observation SubAntarcticSHIAge
type proportions_at_age
time_step DecMar
time_step_proportion 0.6
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
selectivities SelectivitySubAntarcticSHISurveyM SelectivitySubAntarcticSHISurveyF
min_age 2
max_age 10
plus_group TRUE
sum_to_one TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0.0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1984
table obs
1984 2.668759e-05 4.430140e-04 2.668759e-04 2.722134e-02 7.419150e-02 9.714283e-02
7.152274e-02 7.312400e-02 0.08646779 5.604394e-04 5.871270e-04 4.483515e-02 7.472525e-02
1.003453e-01 1.158241e-01 7.899527e-02 3.949763e-02 1.142229e-01
end_table

table error_values
1984 5
end_table




@observation ChathamRiseSHIAge
type proportions_at_age
time_step DecMar
time_step_proportion 0.6
categories East.ChathamRise.Immature.M + East.ChathamRise.Mature.M +
West.ChathamRise.Immature.M + West.ChathamRise.Mature.M East.ChathamRise.Immature.F +
East.ChathamRise.Mature.F + West.ChathamRise.Immature.F + West.ChathamRise.Mature.F
selectivities SelectivityChathamRiseSHISurveyM SelectivityChathamRiseSHISurveyF
min_age 2
max_age 9
plus_group TRUE
sum_to_one TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0.0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1983
table obs
1983 0.1173777529 0.2111396632 0.0635991012 0.0332024719 0.0056116854 0.0009118989
0.0030396629 0.0004419202 0.1365510114 0.1896282025 0.1498787642 0.0339039326
0.0194070787 0.0102880899 0.0114571910 0.0135615730
```

```
end_table

table error_values
1983 5
end_table



@observation ChathamRiseSummerAge
type proportions_at_age
time_step DecMar
time_step_proportion 0.6
categories East.ChathamRise.Immature.M + East.ChathamRise.Mature.M +
West.ChathamRise.Immature.M + West.ChathamRise.Mature.M East.ChathamRise.Immature.F +
East.ChathamRise.Mature.F + West.ChathamRise.Immature.F + West.ChathamRise.Mature.F
selectivities SelectivityChathamRiseSummerSurveyM SelectivityChathamRiseSummerSurveyF
ageing_error AgeingError
min_age 2
max_age 13
plus_group TRUE
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
2008 2009 2010 2011 2012 2013 2014 2016 2018 2020 2022
table obs
1992 0.024381653310976 0.247836745453897 0.147479453268408 0.0231586271423216
0.00515356433258101 0.0085989975939229 0.00494072320605722 0.00131918281972357
0.000639603791381123 0.0001717854777527 0.000150177241557392 0.000555331670219421
0.027292282726484 0.229115369614282 0.195528607684105 0.0125025254626053
0.0149280499755287 0.01708671277144 0.0159403958412789 0.0053912549307294
0.00268266252364751 0.00376847639246175 0.00282203564710725 0.00855578112153228
1993 0.00977431855392742 0.0552746764519553 0.222676336769703 0.127057913660186
0.0119052516393375 0.0122322963889323 0.00956451626173453 0.0019787235793093 8
0.000411377043515464 0.000388751306122113 0.000246826226109278 0.000989361789654 69
0.0176151650033322 0.0621652419308393 0.204308351776737 0.193873773067968
0.00872530709296298 0.0159161778136133 0.0157022617509852 0.0115596949227845
0.0055494763170236 0.00188822062973598 0.00282616028895124 0.00736981973457953
1994 0.27407478654611 6 0.0121635419287057 0.0309741191790349 0.0818775063259296
0.0402654670829696 0.0061957116855828 0.00468784681631868 0.00299057399488007
0.00276417230204649 0.000147974962636322 0.000147974962636322 0.00219446869589665
0.284017224285651 0.00896876248538747 0.0408233326921085 0.092061143254561 3
0.0645333609553264 0.00720786043001524 0.0150031814616967 0.00725817191731159
0.00678909128575445 0.00422172568401426 0.00281004454046375 0.00782195652495598
1995 0.271844905259413 0.11236772136988 0.0121328531797355 0.0189649452615283
0.0260614744048964 0.0247056334710009 0.0013486290140344 0.00243402295313694
0.00178134420570319 0.000802927077874311 0.000120198664352442 0.000182701969815711
0.275954497593623 0.111784757847771 0.0229459250248811 0.0282166364567357
0.0296638283755391 0.0366125131617537 0.00235348984802081 0.00682968810850574
0.00446658236733673 0.00392208241782017 0.000983225074402973 0.00351941689223949
1996 0.138868675560531 0.228574390231261 0.0470317504742358 0.00661960589192607
0.0154865192648568 0.0185361403945227 0.00622985145795109 0.000207316188284562
0.000406339729037742 0.000263291559121394 0.000398047081506359 0.000294388987364078
0.105700158596884 0.266415814078842 0.0814939204527785 0.0077308206611313 2
0.0159861512786226 0.0276767111359891 0.0189839433612174 0.0012190191871132 3
0.0059665598988297 0.0029853531112977 0.000514144146945714 0.00241108726974946
1997 0.323579027795961 0.0373005874260352 0.0449519349431568 0.0370162105547817
0.00521321826622397 0.00900777153698724 0.00944882396749733 0.00352305384273637
0.000737233624721257 0.000665334566706229 0.000480757880458695 0.000178137964634248
0.316832320665506 0.025821419909815 0.071872230008306 0.0569580045113976
0.00451139761037579 0.0105584303255203 0.0169316916024046 0.0145858506946307
0.00184040126113094 0.00229111177406097 0.00265811890601827 0.00303693036093327
1998 0.0686836310106784 0.286179817297933 0.034265838037407 0.0337268728742632
0.0200901045283758 0.00203833300686765 0.00470822871592144 0.00676793038564501
0.00322548094330775 0.000585263932664969 0.00011871479364401 0.000438057588546397
```

0.0565770963548623 0.295108356927899 0.059020246808056 0.0515792035424494
0.0309382623715654 0.00812127903318672 0.00917546640074553 0.0112707825085623
0.00803936582557235 0.00283728356809184 0.00266514711730802 0.00383923642644728
279 1999 0.134272437689558 0.0890052356020942 0.161767820532371 0.0130678256154798
0.0240367508768363 0.00919407309510497 0.00241871261797048 0.000766702248428472
0.00181509344448398 0.00171978515393348 0.000285924871651502 0.000211796201223335
0.106988851047968 0.120050322777411 0.210929954760331 0.0291007980480862
0.031866856436063 0.028708975075823 0.00588369846998424 0.00197605855741371
0.011953777597045 0.00735356410647419 0.00175790847015368 0.00486707670411224
280 2000 0.317897972359182 0.0468374173717799 0.0196231905586249 0.029886134456182
0.00927454755633764 0.0114094074763899 0.00479534101578197 0.000834137952705521
0.000373267211712973 0.00138832549662631 0.000234244219595386 0.000190442454955598
0.352847971692633 0.0504082134021973 0.0243556855642715 0.0615357660452529
0.0244052006025599 0.0167932156779847 0.00686735492569888 0.00343177303829988
0.00374028981532795 0.00720062922187117 0.00314230050676737 0.00252717137726079
281 2001 0.30166848404296 0.114297838223249 0.0113132949321213 0.00888967318848045
0.0128892610911806 0.00367011407138872 0.00531442309948172 0.00187687879137166
0.000319273403097462 0.000925178839007662 0.000497780896842049 0.000600805221803211
0.28249575917197 0.146364924399526 0.0181067801226295 0.0172009820972284
0.0342285569148193 0.00427499946447752 0.0175804380267884 0.00571734001393379
0.00234915861767877 0.00247462388471068 0.00233997823228693 0.00460345325296756
282 2002 0.0264884298104129 0.151151045145734 0.18640197244443 0.0369941945399349
0.00326930491970652 0.0134600867832103 0.00222931838793941 0.00188446645704014
0.000605527406224713 0.00240581740769101 0.000271536953463997 0.000426313016938475
0.0222823224012556 0.165078175488902 0.237507942455889 0.052447362561571
0.00640827210175033 0.0310149508246577 0.0118878878226538 0.0191813703926967
0.0103021120144424 0.00179214389286238 0.00610686608340529 0.0104025806872057
283 2003 0.377630038871384 0.0098422547941797 0.0337833205962479 0.0267986584167591
0.0091186529326187 0.00369671687871163 0.00430733529171311 0.000147259326212414
0.000798501001617314 0.000126947695010702 0.000126947695010702 0.000525563457344305
0.389665949835349 0.00749118348258151 0.0297590786644087 0.0469084427834044
0.0239321794634175 0.00351899010569665 0.0134336050860325 0.00345678573514141
0.00453711061968248 0.00455234434308376 0.000982575159382831 0.00485955776500966
284 2004 0.1035972112283 0.243411372350465 0.0180157694437908 0.0247690087880063
0.0144477961049426 0.0057001999110978 0.000893776132849363 0.00182320822844538
0.000330411921452291 0.0012360733752172 0.000931809159779123 0.000415986232044251
0.0859047225134126 0.337433769049198 0.0341607893754739 0.03537309210886
0.0421096920037938 0.015731410763822 0.00602110357581765 0.0119257310066629
0.00333264398472023 0.00564552743488627 0.00246739262206819 0.004321502684894
285 2005 0.400116080021747 0.0170777221867125 0.0353052243356623 0.00375239690551233
0.00582604159779007 0.00279179799137481 0.00140875596012137 0.000440810209164444
0.00200935987010792 0.000551012761455555 0.000503258322129407 0.000183670920485185
0.404759280891612 0.0281769559116322 0.0459122199936817 0.00716867602653677
0.0123555428210384 0.0133602227560924 0.00313342590347726 0.00106161792040437
0.00729540896167155 0.00102304702710248 0.00200201303328852 0.00378545767119966
286 2006 0.264060127316911 0.158064220711041 0.0122248086945225 0.0391023497615736
0.000926444561344473 0.00373133533672533 0.00614009119622096 0.00102228365389735
0.000212975761228615 0.000238532852576048 0.000212975761228615 0.000212975761228615
0.266332578689219 0.126884569267172 0.0182115573426588 0.0620504880339569
0.00289860011032144 0.0100950510822363 0.0110470527349282 0.00680031605602966
0.000888108924323323 0.00278572295687028 0.000711339042503573 0.00514549439128333
287 2007 0.31552319480352 0.0877594869179315 0.0483403389671527 0.0116780105172444
0.0119125087204019 0.000690304085544944 0.00174114915844457 0.00122525311149803
0.000407440627986188 0.000146561376973449 0.000146561376973449 0.000146561376973449
0.283251845207736 0.0997584668507478 0.0648607373795998 0.0228269344636147
0.0284373039741583 0.00366550003810596 0.00597237611166804 0.00397914138482914
0.00278173493495606 0.000681510402926538 0.00136741764716228 0.00269966056385093
288 2008 0.282401714971055 0.0893711458008707 0.0678527920219849 0.0264385075218857
0.00255923544021683 0.00863718351890151 0.00108035621535352 0.00201339112861339
0.000630837370503631 0.000188873464222644 0.000188873464222644 0.00049862594554778
0.283748382770963 0.0686063971442332 0.0831534313586613 0.033047190035036
0.00619504962650272 0.0218998781766156 0.00416277115146707 0.00586829853339755
0.0051146934111492 0.00155820607983681 0.000309752481325136 0.00447441236743444
289 2009 0.314126366699858 0.0747366338511546 0.0360692673818388 0.0182570008878337
0.0118263377594216 0.00239698757850298 0.00454708216631431 0.000163505291848771
0.000825701723836292 0.000420208600051341 0.000344996165800906 0.000197841403137013
0.333022673278821 0.0757928780364976 0.0412066036517272 0.0308779743656403

```
     0.0237540487997894 0.00530574672049261 0.0144178966352246 0.00208305741815334
     0.00219260596369201 0.00404839102617556 0.00101536786238087 0.00237082673180717
290  2010 0.236375906549716 0.097963764329031 0.0575041074362454 0.037527116598554
     0.0120459732086126 0.0105571450592336 0.00018798335219433 0.00149822731698881
     0.00018798335219433 0.00018798335219433 0.00123129095687286 0.000268816193637891
     0.235263045104726 0.0946740556656302 0.0687661900662077 0.0592843097815257
     0.0257875562540181 0.029438192953632 0.00365627620017971 0.0107037720739451
     0.00193810836112354 0.00635759697121223 0.00358108285930198 0.00501351600302277
291  2011 0.249820422212688 0.101371058327829 0.0707801630421682 0.0328494776576307
     0.019599288438083 0.00527163249466088 0.00593209308155483 0.000241044009815312
     0.00226340325216578 0.000241044009815312 0.000296484132072834 0.000241044009815312
     0.243010928935405 0.0784550043146878 0.0824635661979164 0.0316032801268856
     0.0323842627186872 0.00738558846074116 0.0136213969946633 0.00242008185854573
     0.00937179110161933 0.00251408902237371 0.00292627427915789 0.00493658132101759
292  2012 0.286758347299707 0.128040214409799 0.0418564836224455 0.0153963552957974
     0.0109828719237081 0.00394228908589402 0.00278234213078211 0.00102328967953322
     0.000244889837837011 0.000109325820462951 0.00010932582046295 0.000109325820462951
     0.254500670713909 0.152864828462321 0.0251711769033899 0.0213283743141171
     0.0209872777542727 0.0139128039121152 0.0090576442253555 0.00477207206320782
     0.00195911870269608 0.00207719058879607 0.00049305945028791 0.00152072216263965
293  2013 0.0834959887693975 0.17397737859862 0.101931208343697 0.0540451669203108
     0.0338477882373772 0.0229375782537762 0.015218646847295 0.00230176763950778
     0.00224696364809092 0.000421569164745014 0.00042156916474501 0.000421569164745014
     0.0162810011424524 0.159218242140897 0.114026027680231 0.0587035061907432
     0.0534212445564882 0.052080654612599 0.0256440522914392 0.0132204090064036
     0.00930824715756991 0.00136588409377384 0.0030184352195743 0.00244510115552108
294  2014 0.32351089358977 0.017761222490193 0.0435119969202688 0.0430107011065685
     0.0159383286221921 0.0101386478684734 0.00355224449803859 0.00386045747440453
     0.000404154758892304 0.000149909035197442 0.000119927228157954 0.000177492297673772
     0.337890168245908 0.0145243866022098 0.0502986787617274 0.0545644902673058
     0.0254869345281283 0.022843738419527 0.0115154124477267 0.00460520556126542
     0.00638372635484788 0.00521443588030783 0.00029382170898698 7 0.0042430253322284
295  2016 0.157522982998648 0.071043304697863 0.16655717400128 0.0210560672187329
     0.0248764546135467 0.00986270875090488 0.00853205903398178 0.00629757177348827
     0.00162356003196907 0.000418443307208523 0.000665324858461551 0.000502131968650227
     0.141458944434913 0.0611596737815977 0.172457224632921 0.0390909737594202
     0.0297806101740306 0.0177043363279926 0.0182232060289312 0.0172105732254865
     0.00969951586109356 0.0113816579560718 0.00605487465530733 0.00682062590749892
296  2018 0.367896211703737 0.0691218484603329 0.0119593382499502 0.00765632144825241
     0.00766218386896317 0.000721077747423466 0.0010669605693583 0.00171573512801573
     0.000295075175774914 0.000216909566298116 0.000195414023691996 0.00125064975162878
     0.38260697940727 0.0754649876693751 0.0227950458636714 0.00477201045855855
     0.019091950114708 0.00434796202714692 0.00493029581774906 0.00476028561713703
     0.00234301414406703 0.00337089190868693 0.00277878741690019 0.00298006386130294
297  2020 0.0880159387977129 0.143517767641523 0.189199632019564 0.0613185316169338
     0.0056551715785139 0.00457790200598837 0.00486620951714943 0.00260069172739116
     0.002460224095241 0.000967475753206664 0.000216296457003477 0.000894016579130012
     0.0400664502736683 0.130775628826328 0.175839409293454 0.0741000329644753
     0.0207364190048099 0.0182547364053135 0.0119277688316147 0.00467202980072817
     0.00513476993850493 0.00313254667948735 0.00334713172204102 0.00772321847021665
298  2022 0.293405910512488 0.100374356324597 0.0261706783779032 0.0227971433288859
     0.00434415774903165 0.00329358491332256 0.00148184938222657 0.00014086452479563
     0.000140063019675882 0 0 8.85663157321028e-05 0.316997345415043 0.116841212217717
     0.0368403813240758 0.0275319012396078 0.0182769884139763 0.0108296700096555
     0.00749848114779808 0.00407986143579 49 0.00411713142386316 0.00225877501163518
     0.00128033763670338 0.00121074027547197
299  end_table
300
301  table error_values
302  1992 81.8563753465987
303  1993 82.4526236581764
304  1994 55.5362713069536
305  1995 76.8734430284135
306  1996 140.757190697455
307  1997 59.1137611764199
308  1998 68.8240908221142
309  1999 58.1342103788279
```

```
2000 74.4458606169899
2001 68.8240908221142
2002 58.0490320486025
2003 54.5567205093616
2004 73.040418168271
2005 109.709689330301
2006 93.09991493635
2007 69.5055174639173
2008 82.4526236581764
2009 100.510429665959
2010 68.7389124918888
2011 86.4560051787697
2012 68.3130208407619
2013 79.5991495956259
2014 67.6315941989588
2016 85.0079735649381
2018 99.9567705194939
2020 102.171407105354
2022 47.6998649262178
end_table



@observation SubAntarcticSummerAge
type proportions_at_age
time_step DecMar
time_step_proportion 0.5
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
selectivities SelectivitySubAntarcticSummerSurveyM SelectivitySubAntarcticSummerSurveyF
min_age 3
max_age 15
plus_group TRUE
ageing_error AgeingError
likelihood multinomial
process_errors 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1992 1993 1994 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2012 2013 2015
2017 2019 2021 2023
table obs
1992 0.0778071714180383 0.170477149258024 0.0157621707901038 0.0327508396093032
0.0594988271802496 0.0311749263696063 0.0116957879768758 0.0119955760995945
0.00439047808103192 0.00295736931871123 0.00136120012477668 0.00195166119080704
0.000426387836704599 0.0527434664419606 0.220470869912211 0.0157338124541709
0.0357092217257263 0.10816375723644 0.0541877159791121 0.0288110565100611
0.019780952110873 0.0109716376128763 0.00871411151307927 0.00799097394679166
0.00917999846054748 0.0052928808423236
1993 0.00430883752611301 0.0826139267386124 0.148569244975304 0.00709017137030359
0.0349785166287071 0.0738208979126819 0.0367634761402303 0.00990191338334463
0.0132863425764031 0.00172211596256552 0.00100245596643749 0.00111395258555592
0.0016025104984203 0.001668394864263 0.0147023496392071 0.16195796172017
0.0308825362845475 0.0821334776707748 0.130701404958761 0.0828328655543358
0.0279998418777522 0.0140171522344429 0.0165217717420941 0.0104786549858754
0.00688947745589042 0.00243974874743684
1994 0.00278700946431374 0.0302584759304241 0.156175292506129 0.0870612972693405
0.0129616266739843 0.0224801448160834 0.0571777350918143 0.0401790100244259
0.00583826536892304 0.00385867558329014 0.00366105538221441 0.000112925829186132
0.000945189190287927 0.000112925829186132 0.0103485229866172 0.0945945793343474
0.121992644011487 0.0116629796383437 0.0734548641107034 0.122868948445971
0.0763627042122463 0.0259582603550162 0.0145640441901355 0.0116618503800519
0.000699010882662159 0.0122219624928151
2001 0.0260063628426049 0.0158278218805512 0.0234953483003984 0.0782880541142702
0.0469284732188557 0.0945012595216828 0.0512018145141056 0.00807599281420299
0.00397326401782399 0.00282413865778144 0.00563723768328299 0.000100360293453498
0.000114410734536988 0.0215573910338114 0.0290292148814243 0.0387270300378358
```

0.119515059062033 0.119213978181672 0.159308919019279 0.085999739063237
0.0168866229764856 0.0177968908381088 0.00884374905912225 0.00839915295912325
0.00460352666071196 0.0131441876336046
354 2002 0.0639218329388168 0.0259995208958436 0.0319802024418071 0.0330114944395496
0.0629209924764407 0.0544686613099032 0.062120117096304 0.027999171718238
0.00378715594840292 0.00187479952739217 0.00314158339863496 0.00137945455209852
0.000464893439927241 0.0325222397713293 0.022540226478219 0.0506134969325153
0.0629382483464816 0.13432984291068 0.1080004303817 0.0950707084651208 0.0606097209421299
0.0232294462286788 0.0239450573097896 0.00570357257412919 0.00483976402090193
0.00258736545496624
355 2003 0.00448362288168643 0.0176627961999054 0.0189380742651226 0.0241509846030648
0.0334692243293415 0.0773343698488386 0.0576891077473467 0.0488713594126181
0.0205500465391995 0.00282355143491532 0.00234645964089418 0.000129997764038459
0.00115438014466151 0.00137017643296535 0.0203823494235899 0.0313606605966377
0.0708227818481522 0.0523760991310949 0.158137080042223 0.155190030731471
0.103453520599446 0.0470006915881047 0.0162783200128958 0.0134495686674189
0.0161561221146996 0.00441862399966721
356 2004 0.0550670088280036 0.0169385938294405 0.0228929245349372 0.0126913856127454
0.0292351006086962 0.0192747090657348 0.0344870895721845 0.0317159042725287
0.0312557146904974 0.0306558605846618 0.00482294758460756 0.00147401335554569
0.00222558935414703 0.0733459801736663 0.0211858020461355 0.0319530325287719
0.0348096241919051 0.0668440439611672 0.030475000050239 0.147383249501126
0.0910954320657689 0.116627915622532 0.0676197346976916 0.00485309100701136
0.0100327357567305 0.0110375165035238
357 2005 0.0443768817253204 0.0646199255951027 0.0135825321314547 0.0270809266957131
0.019503997671436 0.0152971193116183 0.0068151429429047 0.0295436560274334
0.0151015563175943 0.0341621262700225 0.0178348902573245 0.00284930734316303
0.0062170840193198 0.0368909122331475 0.0687222004930007 0.00689700652179845
0.030528292962461 0.0303440999099501 0.0543483204322397 0.03563567069011
0.106129308070839 0.0693748351358481 0.133987938766043 0.0729108869463976
0.0187467595666688 0.0384986219630886
358 2006 0.129113898149889 0.00518957021713581 0.0281832795577228 0.00264210253045899
0.0133921092444175 0.0204321743122669 0.0304852081902621 0.00983051411018309
0.0407850599716351 0.0114546526453636 0.0195612779796228 0.0147093239619261
0.000127884924029961 0.102767046101236 0.0162720777335722 0.0474823934430842
0.00984202375334579 0.0412313783564997 0.0403195588481661 0.0952141624880268
0.0262726787927152 0.104947484055947 0.0551286330508355 0.0586198914768535
0.0573819654122434 0.0186136506925608
359 2007 0.0815597829144436 0.157079333588215 0.0394538188022177 0.0339003872591399
0.00315157527098381 0.0052606622556094 0.00855919622775384 0.00632037226475988
0.00135821987088 3 0.0102871090812441 0.000902418274314489 0.00119059510237166
0.000328360847905781 0.108757475662835 0.15935145288194 0.0462598436497193
0.0677961820588684 0.020631623905129 0.0433872602879702 0.0230908859198639
0.0471599656943282 0.0391139768057837 0.0477983175524947 0.0336122104310827
0.010482288606223 0.00320668478391904
360 2008 0.0623410867313306 0.074265180451974 0.112816649402015 0.0247898957000682
0.0683071530781227 0.00816070595963517 0.0214858778213924 0.0089990559948918
0.00939066881958018 0.00230259153519118 0.00327415883632421 0.00182599528227131
0.00730512955379106 0.0484313666943054 0.056310708601012 0.122391066174528
0.029507624391622 0.105119907023536 0.0261151778105972 0.0279825163822784
0.0269167782552673 0.0260428270541298 0.012864653554719 0.0399215396240976
0.022929447676622 0.0502022375906968
361 2009 0.0506951116328875 0.0274983547992855 0.0720930392532279 0.0971287521467863
0.0288775718442528 0.0341513859812848 0.00805173840964695 0.0190189788520053
0.00488859640876187 0.00330874513032053 0.00148469332770793 0.00339587771171497
0.00405510447884398 0.045192001229028 0.0406565210711804 0.0641204080556364
0.125483528502672 0.0462593753511099 0.117577393222461 0.0162777419820828
0.0387762916831951 0.0306935982775264 0.0393632901262735 0.00498031491549286
0.044082207297583 0.0318893783090317
362 2010 0.0826257917248257 0.0647924650053745 0.0863491198073117 0.0754517425278948
0.0735176133432484 0.0123898141614144 0.0223882785905185 0.00250694888964421
0.00236719468450919 0.00186684012291469 0.00273642184375 48 0.000172536055722245
0.00335582628379766 0.0656137366306124 0.0541918497417998 0.0928985884825281
0.0739282491558673 0.114934893519373 0.0212046812482639 0.0635036206691293
0.00469815679731672 0.0128746404779939 0.0223675742638318 0.0106817072097642
0.00875447946734669 0.023827229295242
363 2012 0.0418425225241884 0.0734260804445205 0.079298086657452 0.0715434789643265

```
      0.0588575879587469 0.0468015421383764 0.025457302274839 0.00690171641480564
      0.00581191089250796 0.000115567923891588 0.00163644180230489 0.00168729168881719
      0.000115567923891588 0.0313246857708149 0.0696516320502212 0.0770075304059208
      0.0829893261465494 0.109359615020132 0.0751110607748598 0.0794148102605826
      0.0183752998987625 0.0156698548004604 0.00508845568894662 0.0072553542619139
      0.0030348136813931 0.0122224636307744
364   2013 0.0493004203068698 0.0321527131901139 0.0579637224856552 0.0650169494971056
      0.0788723375059082 0.0362460040353525 0.0208801540955779 0.0214503890506757
      0.0033278952637972 0.00451715533057872 0.00100426405639329 0.000101646159553977
      0.000399469407047128 0.0425257037725972 0.0346430440991863 0.0607793211053003
      0.0686843429338131 0.10989982770976 0.101305644919471 0.0844161190479821
      0.0582544305019796 0.0121924568384995 0.0239153084198596 0.00651653528900544
      0.00863382479251478 0.0170003201854026
365   2015 0.154610264278513 0.0176271044378581 0.0196736273279489 0.0373542812839778
      0.0655411178811154 0.0414973842224494 0.0365009813531265 0.0160741684109064
      0.00903007853153252 0.0063875262218021 0.000901028849220854 0.000752021494310946
      0.000116411996023366 0.110183954236116 0.0373286706448526 0.0298259175011467
      0.0354928534675641 0.0847118453862434 0.104486751150733 0.0776048930290169
      0.0556193234600439 0.0253417274143266 0.0175025436021131 0.0096831498292236
      0.0024725907955363 0.00367978319429861
366   2017 0.0253058373805109 0.0186907525513374 0.0824605182707077 0.0372025510888855
      0.0608418792159826 0.0177972252185973 0.0359150763785673 0.0240494310753645
      0.0218274187374794 0.0114766688704522 0.00478577713265961 0.00163295537582828
      0.000124273620687084 0.0222897166064354 0.0337067341389578 0.102510824232362
      0.0417845194836183 0.0996251907600078 0.0668492660399962 0.0653430697572688
      0.0635435877297198 0.0722091873002302 0.048541276240375 0.0261123731787701
      0.00902972127912352 0.00634416833607564
367   2019 0.135209046786075 0.0557390254588146 0.0574871966810455 0.0260072604807257
      0.0237374229685276 0.0120293889863071 0.0181137103970127 0.0114755871959312
      0.00961601290561697 0.0097970428912524 0.00590864734180497 0.00411977115238976
      0.000107118334695522 0.112865233351936 0.0732785815818593 0.0786805592005545
      0.0478947498090616 0.0421060750021156 0.0347020557079611 0.0684486158704382
      0.0457363153649468 0.0450582563063242 0.0340732710832984 0.0211858642360802
      0.00883512024568661 0.0177880706595383
368   2021 0.0774445968243599 0.0230643414185423 0.0518655865038897 0.0686790422642108
      0.0445190065256499 0.0215555400773855 0.0123802409951076 0.00859742960968592
      0.00618507674903989 0.00682635334580666 0.00582240721304073 0.00236960108752825
      0.00172880484776286 0.0734518694293599 0.0212658848055875 0.0541664965402287
      0.110944213739651 0.0932358528858648 0.0585862613094052 0.0382777280074551
      0.0423996714358111 0.0284784451804581 0.0139894369495409 0.0198373030836518
      0.0187584212586795 0.0955703879122964
369   2023 0.114350602924598 0.0758388255689737 0.0494588195171588 0.0418174280009563
      0.0466853496483427 0.02412116335275 0.00923514755896201 0.00711339016986876
      0.00958621969425518 0.000944551221145911 0.00140150225438464 0 0.00422066722652456
      0.129906442062231 0.0916969768231092 0.0849859264654336 0.0451963579888136
      0.0793751807603554 0.0554443207952285 0.0363264926277638 0.0296254729025251
      0.0130598834329059 0.0130612765763 0.00830647817250793 0.00784757673851757
      0.0203939475163875
370   end_table
371
372   table error_values
373   1992 17.6830238196773
374   1993 17.0514872546889
375   1994 12.256487409406
376   2001 15.7884141247119
377   2002 13.3324385942012
378   2003 12.2798776525537
379   2004 17.6362433333819
380   2005 14.3849995358486
381   2006 12.256487409406
382   2007 11.2740971972017
383   2008 12.6073410566218
384   2009 13.1219264058717
385   2010 12.7009020292127
386   2012 18.384731114109
387   2013 11.6717313307129
388   2015 11.3910484129403
```

```
2017 7.78895096819121
2019 11.7185118170084
2021 14.4083897789963
2023 11.6951215738607
end_table



@observation SubAntarcticAutumnAge
type proportions_at_age
time_step AprJun
time_step_proportion 0.1
categories West.SubAntarctic.Immature.M + West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F + West.SubAntarctic.Mature.F
selectivities SelectivitySubAntarcticAutumnSurveyM SelectivitySubAntarcticAutumnSurveyF
min_age 2
max_age 15
plus_group TRUE
ageing_error AgeingError
sum_to_one TRUE
likelihood multinomial
process_errors 0 0 0
error_value_multiplier 1.0
likelihood_multiplier 1.0
years 1992 1996 1998
table obs
1992 0.013118 0.059901 0.13316 0.008441 0.028278 0.065237 0.064278 0.015269 0.008562
0.004832 0.001474 0.001256 0.001256 0.006192 1e-04 0.036813 0.17361 0.012739 0.052545
0.13831 0.079153 0.023387 0.021406 0.017684 0.009491 0.011604 0.008741 0.003163
1996 0.096951 0.174331 0.107319 0.003837 0.0079 0.032796 0.035954 0.00251 0.005663
0.008163 0.001266 0.00096 0.000569 0.00011 0.088084 0.15215 0.077643 0.007186 0.010082
0.05615 0.07618 0.006404 0.018146 0.017132 0.006386 0.002375 0.00231 0.001443
1998 0.014676 0.092163 0.057829 0.118981 0.071411 0.014817 0.01053 0.015554 0.015091
0.004496 0.005704 0.00091 0.002671 1e-04 0.020344 0.089263 0.054525 0.134439 0.091695
0.025744 0.020915 0.057038 0.038373 0.00852 0.010801 0.012873 0.003755 0.006783
end_table

table error_values
1992 21.3919227454797
1996 25.132586832121
1998 32.3801234999884
end_table
```

F.1.6 Population

```
@model
min_age 1
max_age 18
age_plus TRUE
start_year 1972
final_year 2023
projection_final_year 2032
type age
base_weight_units tonnes
initialisation_phases phase1
time_steps OctNov DecMar AprJun EndJun JulSep
length_bins 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
length_plus FALSE
threads 1


@initialisation_phase phase1
type derived


@categories
format stock.area.maturity.sex
names East.ChathamRise.Immature.M East.ChathamRise.Mature.M East.ChathamRise.Immature.F
East.ChathamRise.Mature.F East.CookStrait.Mature.M East.CookStrait.Mature.F
West.ChathamRise.Immature.M West.ChathamRise.Mature.M West.ChathamRise.Immature.F
West.ChathamRise.Mature.F West.SubAntarctic.Immature.M West.SubAntarctic.Mature.M
West.SubAntarctic.Immature.F West.SubAntarctic.Mature.F West.WCSI.Mature.M
West.WCSI.Mature.F
age_lengths AgeLengthEastM AgeLengthEastM AgeLengthEastF AgeLengthEastF AgeLengthEastM
AgeLengthEastF AgeLengthWestM AgeLengthWestM AgeLengthWestF AgeLengthWestF AgeLengthWestM
 AgeLengthWestM AgeLengthWestF AgeLengthWestF AgeLengthWestM AgeLengthWestF


@time_step OctNov
processes WestReturnMigration EastReturnMigration Mortality


@time_step DecMar
processes WestRecruitment EastRecruitment Mortality


@time_step AprJun
processes EastMaturation WestMaturation WestHomeMigration Mortality


@time_step EndJun
processes EastSpawningMigration WestSpawningMigration


@time_step JulSep
processes Ageing Mortality


@process None
type null_process


@process Ageing
type ageing
categories *


@process EastMaturation
type transition_category
from East.ChathamRise.Immature.M East.ChathamRise.Immature.F
to East.ChathamRise.Mature.M East.ChathamRise.Mature.F
selectivities SelectivityEastMaturationM SelectivityEastMaturationF
```

```
61  proportions 1.0 1.0
62
63
64  @process WestMaturation
65  type transition_category
66  from West.ChathamRise.Immature.M West.ChathamRise.Immature.F West.SubAntarctic.Immature.M
     West.SubAntarctic.Immature.F
67  to West.ChathamRise.Mature.M West.ChathamRise.Mature.F West.SubAntarctic.Mature.M
    West.SubAntarctic.Mature.F
68  selectivities SelectivityWestMaturationM SelectivityWestMaturationF
    SelectivityWestMaturationM SelectivityWestMaturationF
69  proportions 1.0 1.0 1.0 1.0
70
71
72  @process WestHomeMigration
73  type transition_category
74  from West.ChathamRise.Immature.M West.ChathamRise.Mature.M West.ChathamRise.Immature.F
    West.ChathamRise.Mature.F
75  to West.SubAntarctic.Immature.M West.SubAntarctic.Mature.M West.SubAntarctic.Immature.F
    West.SubAntarctic.Mature.F
76  selectivities SelectivityWestHomeMigrationM SelectivityWestHomeMigrationM
    SelectivityWestHomeMigrationF SelectivityWestHomeMigrationF
77  proportions 1.0 1.0 1.0 1.0
78
79
80  @process WestSpawningMigration
81  type transition_category
82  from West.SubAntarctic.Mature.M West.SubAntarctic.Mature.F
83  to West.WCSI.Mature.M West.WCSI.Mature.F
84  selectivities SelectivityOne SelectivityOne
85  proportions 1.0 1.0
86
87
88  @process WestReturnMigration
89  type transition_category
90  from West.WCSI.Mature.M West.WCSI.Mature.F
91  to West.SubAntarctic.Mature.M West.SubAntarctic.Mature.F
92  selectivities SelectivityOne SelectivityOne
93  proportions 1.0 1.0
94
95
96  @process EastSpawningMigration
97  type transition_category
98  from East.ChathamRise.Mature.M East.ChathamRise.Mature.F
99  to East.CookStrait.Mature.M East.CookStrait.Mature.F
100 selectivities SelectivityOne SelectivityOne
101 proportions 1.0 1.0
102
103
104 @process EastReturnMigration
105 type transition_category
106 from East.CookStrait.Mature.M East.CookStrait.Mature.F
107 to East.ChathamRise.Mature.M East.ChathamRise.Mature.F
108 selectivities SelectivityOne SelectivityOne
109 proportions 1.0 1.0
110
111
112 @derived_quantity EastSSB
113 type biomass
114 time_step JulSep
115 categories East.CookStrait.Mature.M East.CookStrait.Mature.F
116 selectivities SelectivityOne SelectivityOne
117 time_step_proportion 0.5
118 time_step_proportion_method weighted_sum
119
120
121 @derived_quantity WestSSB
```

```
type biomass
time_step JulSep
categories West.WCSI.Mature.M West.WCSI.Mature.F
selectivities SelectivityOne SelectivityOne
time_step_proportion 0.5
time_step_proportion_method weighted_sum


@derived_quantity TotalSSB
type biomass
time_step JulSep
categories West.WCSI.Mature.M West.WCSI.Mature.F East.CookStrait.Mature.M
East.CookStrait.Mature.F
selectivities SelectivityOne SelectivityOne SelectivityOne SelectivityOne
time_step_proportion 0.5
time_step_proportion_method weighted_sum


@derived_quantity WestRecruitApprox
type abundance
time_step JulSep
categories West.WCSI.Mature.M West.WCSI.Mature.F
selectivities Select2yrs Select2yrs
time_step_proportion 0.5
time_step_proportion_method weighted_sum


@derived_quantity EastRecruitApprox
type abundance
time_step JulSep
categories East.CookStrait.Mature.M East.CookStrait.Mature.F
selectivities Select2yrs Select2yrs
time_step_proportion 0.5
time_step_proportion_method weighted_sum



@derived_quantity VulnerableBiomass_CookStraitFishery
type biomass
time_step JulSep
categories East.CookStrait.Mature.M East.CookStrait.Mature.F
selectivities SelectivityCookStraitSpawningFisheryM SelectivityCookStraitSpawningFisheryF
time_step_proportion 0.5
time_step_proportion_method weighted_sum


@derived_quantity VulnerableBiomass_WCSINorthFishery
type biomass
time_step JulSep
categories West.WCSI.Mature.M West.WCSI.Mature.F
selectivities SelectivityWCSINorthFrom2000FisheryM SelectivityWCSINorthFrom2000FisheryF
time_step_proportion 0.5
time_step_proportion_method weighted_sum


@derived_quantity VulnerableBiomass_WCSISouthFishery
type biomass
time_step JulSep
categories West.WCSI.Mature.M West.WCSI.Mature.F
selectivities SelectivityWCSISouthFisheryM SelectivityWCSISouthFisheryF
time_step_proportion 0.5
time_step_proportion_method weighted_sum


@derived_quantity VulnerableBiomass_WCSIInsideFishery
type biomass
```

```
time_step JulSep
categories West.WCSI.Mature.M West.WCSI.Mature.F
selectivities SelectivityWCSIInsideFisheryM SelectivityWCSIInsideFisheryF
time_step_proportion 0.5
time_step_proportion_method weighted_sum



@process EastRecruitment
type recruitment_beverton_holt
b0 731400
standardise_years 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
recruitment_multipliers 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
steepness 0.75
ssb EastSSB
categories East.ChathamRise.Immature.M East.ChathamRise.Immature.F
East.ChathamRise.Mature.M East.ChathamRise.Mature.F East.CookStrait.Mature.M
East.CookStrait.Mature.F
proportions 0.5 0.5 0.0 0.0 0.0 0.0


@process WestRecruitment
type recruitment_beverton_holt
b0 1169000
standardise_years 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
recruitment_multipliers 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
steepness 0.75
ssb WestSSB
categories West.ChathamRise.Immature.M West.ChathamRise.Immature.F
West.ChathamRise.Mature.M West.ChathamRise.Mature.F West.SubAntarctic.Immature.M
West.SubAntarctic.Mature.M West.SubAntarctic.Immature.F West.SubAntarctic.Mature.F
West.WCSI.Mature.M West.WCSI.Mature.F
proportions 0.5 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0


@process Mortality
type mortality_instantaneous
m 0.30 0.30 0.25 0.25 0.30 0.25 0.30 0.30 0.25 0.25 0.30 0.30 0.25 0.25 0.30 0.25
time_step_proportions 0.17 0.33 0.25 0.25
relative_m_by_age SelectivityOne SelectivityOne SelectivityOne SelectivityOne
SelectivityOne SelectivityOne SelectivityOne SelectivityOne SelectivityOne SelectivityOne
 SelectivityOne SelectivityOne SelectivityOne SelectivityOne SelectivityOne
SelectivityOne
categories *
table catches
year FisheryChathamRiseDeep FisheryChathamRiseShallow FisheryCookStraitSpawning
FisheryPuysegurSpawning FisherySubAntarcticAuckland FisherySubAntarcticSnares
FisherySubAntarcticSuba FisheryWCSIInside FisheryWCSINorthFrom2000
FisheryWCSINorthPre2000 FisheryWCSISouth
1972 3500 500 0 0 0 0 0 1700 0 3300 10
1973 3500 500 0 0 0 0 0 1700 0 3300 10
1974 5200 800 0 0 0 0 0 1700 0 3300 10
1975 31300 4700 0 0 0 0 0 3400 0 6600 10
1976 32200 4800 0 0 0 0 0 10200 0 19700 100
1977 33100 4900 0 0 0 0 0 20500 0 39400 100
1978 2600 400 0 0 0 0 0 1700 0 3300 10
1979 5200 800 0 0 0 0 0 6100 0 11800 10
1980 7000 1000 0 0 0 0 0 6800 0 13100 10
1981 7000 1000 0 0 0 0 0 8500 0 16400 100
1982 6100 900 0 0 0 0 0 8500 0 16400 100
```

```
1983 8700 1300 0 10 1300 1700 400 9100 0 17400 100
1984 8700 1300 0 10 1700 2300 600 12100 0 23200 100
1985 8700 1300 0 10 1500 1900 500 10300 0 19700 100
1986 14800 2200 0 100 3500 4700 1100 24800 0 47600 200
1987 14800 2200 0 200 6800 9000 2200 47700 0 91700 300
1988 7100 1100 7400 300 10300 13700 3300 72500 0 139300 500
1989 5500 800 5700 200 8200 11000 2600 57800 0 111200 400
1990 9472.1 4726.7 14967.3 7412 660.4 9724.7 1595.6 1878.2 0 79067.4 83548.3
1991 25403.2 5779.1 30502.1 4921.2 1747.7 8339.2 6804.1 1204.6 0 72509.7 59538
1992 36533 13077.8 25435.8 4756.2 2495.5 17136.3 11251.7 907.5 0 64469.7 38070
1993 36037.2 10243.3 22030.6 1682.3 3635.1 14590.3 7496.4 1042.6 0 83797.3 12068.4
1994 18703.3 7680.4 36122.3 2348.9 864.8 8584.7 2246 1666 0 95963.2 18647.2
1995 35136.6 11617.6 35133.2 799.1 2088.9 7316.7 4376.9 2510.8 0 54213.4 24402.5
1996 40982.9 19436.8 60309.1 2213.9 1665.9 9424.5 2379.2 4277.5 0 43324.4 27225.6
1997 50371.5 19800.3 57632 6355.2 6573.2 11758 4073.6 8160.1 0 62244.8 22243.9
1998 63956.7 25158.9 46579 1758 9149.3 10455.2 6263.3 7945.8 0 71412 28794
1999 55387.9 26401.2 41711.9 2240.2 7982.7 11536.5 5211.4 7363.4 0 50554 38445.7
2000 41838 19587.2 41874.7 2641.3 13984.7 14249.2 6376.9 14136.6 64726.5 0 24653.6
2001 38599.1 17225.5 34925.5 6854.2 11442.5 13004 7039.4 21610.9 43551 0 38473.9
2002 31962.5 10721.2 24828 4912.1 9018.1 8139.9 14208.7 21844.2 45635.3 0 25993.5
2003 28787.9 13669.2 42164.5 5726.5 7925.7 3563.9 9152.4 16531.8 38514.3 0 19817.4
2004 28318.3 8478.9 41019.2 736.1 4777.6 2801.9 4687.1 18801.6 14459.9 0 12419.7
2005 26688.8 6438.1 26276.4 5446.4 2654.3 2452.3 1399.3 7910.3 15795.2 0 9574.5
2006 25376.7 11505.8 20504.8 1220.7 1232.4 4982 883.2 5276 17790.8 0 16552.4
2007 34254.9 6544.6 18802.6 250.4 1779.7 5794.5 653.2 3108.8 23685.9 0 6864.1
2008 34790.9 6655.2 17932.1 133 2800.7 4825.2 1525.3 918.8 16952.2 0 3212.5
2009 34969.9 7342.6 15894.1 119.9 2200.6 6717.5 1325.6 1151.4 16717.2 0 2861.4
2010 34849.3 7098.2 16377.6 106 2527.2 9101.5 1549.6 2954.1 31066.7 0 2522.4
2011 33479.7 9853.5 13271.7 1098.3 3272.1 8132.5 1656.6 7528.1 35454.6 0 5958.7
2012 35519.2 7573.8 15406.7 894.1 2973.3 12107 1988.4 8578.9 35584.8 0 12138.3
2013 33279.5 8459.2 18730 459.6 4256.7 8681.2 2518 6876.7 35189.2 0 15222.3
2014 31597.3 7289.7 17457.2 400.1 5784.2 8428.3 7114.8 10368.5 44035.3 0 16111.7
2015 37373 7439.9 19922.7 1295.7 4574.6 10057.7 3015.8 13427.6 49850.3 0 16016.7
2016 30354.4 10272.3 20139.3 928.3 2406.2 2992.2 1643.9 16185.8 37392.3 0 15905.7
2017 35743.4 8412.6 17245.5 925.6 2489.5 6852.9 4914.4 16787.9 32552.5 0 17037.8
2018 32445.2 9247 21629.9 946.5 3692.5 5012.3 7007.6 17156.7 18405.3 0 20045.4
2019 36891.3 6127.5 22645.7 1026.5 2440.5 4367.2 2494.4 14990.4 14342.1 0 17134.3
2020 30597.8 5001.1 19822.3 256.6 3013.2 3906.3 1211.2 13727.6 17950.1 0 12251.1
2021 36431.1 4547.5 15107.7 238.9 4104.5 3702 1538.5 9985.1 12182.7 0 12980.8
2022 33735.5 4480.6 12939 526 3052.5 2703.7 2624.8 9748.1 10175.3 0 11682.9
2023 35998  4638    14363   321 2924    2616    1736    8117    9161    0   10125
end_table


table method
method category selectivity u_max time_step penalty
FisheryChathamRiseDeep East.ChathamRise.Immature.M SelectivityChathamRiseDeepFisheryM
0.95 OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep East.ChathamRise.Immature.F SelectivityChathamRiseDeepFisheryF
0.95 OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep East.ChathamRise.Mature.M SelectivityChathamRiseDeepFisheryM 0.95
OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep East.ChathamRise.Mature.F SelectivityChathamRiseDeepFisheryF 0.95
OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep West.ChathamRise.Immature.M SelectivityChathamRiseDeepFisheryM
0.95 OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep West.ChathamRise.Immature.F SelectivityChathamRiseDeepFisheryF
0.95 OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep West.ChathamRise.Mature.M SelectivityChathamRiseDeepFisheryM 0.95
OctNov PenaltyCatchMustBetaken
FisheryChathamRiseDeep West.ChathamRise.Mature.F SelectivityChathamRiseDeepFisheryF 0.95
OctNov PenaltyCatchMustBetaken
FisheryChathamRiseShallow East.ChathamRise.Immature.M
SelectivityChathamRiseShallowFisheryM 0.95 OctNov PenaltyCatchMustBetaken
FisheryChathamRiseShallow East.ChathamRise.Immature.F
SelectivityChathamRiseShallowFisheryF 0.95 OctNov PenaltyCatchMustBetaken
FisheryChathamRiseShallow East.ChathamRise.Mature.M SelectivityChathamRiseShallowFisheryM
```

```
 0.95 OctNov PenaltyCatchMustBetaken
294 FisheryChathamRiseShallow East.ChathamRise.Mature.F SelectivityChathamRiseShallowFisheryF
 0.95 OctNov PenaltyCatchMustBetaken
295 FisheryChathamRiseShallow West.ChathamRise.Immature.M
SelectivityChathamRiseShallowFisheryM 0.95 OctNov PenaltyCatchMustBetaken
296 FisheryChathamRiseShallow West.ChathamRise.Immature.F
SelectivityChathamRiseShallowFisheryF 0.95 OctNov PenaltyCatchMustBetaken
297 FisheryChathamRiseShallow West.ChathamRise.Mature.M SelectivityChathamRiseShallowFisheryM
 0.95 OctNov PenaltyCatchMustBetaken
298 FisheryChathamRiseShallow West.ChathamRise.Mature.F SelectivityChathamRiseShallowFisheryF
 0.95 OctNov PenaltyCatchMustBetaken
299 FisheryCookStraitSpawning East.CookStrait.Mature.M SelectivityCookStraitSpawningFisheryM
0.95 JulSep PenaltyCatchMustBetaken
300 FisheryCookStraitSpawning East.CookStrait.Mature.F SelectivityCookStraitSpawningFisheryF
0.95 JulSep PenaltyCatchMustBetaken
301 FisheryPuysegurSpawning West.WCSI.Mature.M SelectivityPuysegurSpawningFisheryM 0.95
JulSep PenaltyCatchMustBetaken
302 FisheryPuysegurSpawning West.WCSI.Mature.F SelectivityPuysegurSpawningFisheryF 0.95
JulSep PenaltyCatchMustBetaken
303 FisherySubAntarcticAuckland West.SubAntarctic.Immature.M
SelectivitySubAntarcticAucklandFisheryM 0.95 OctNov PenaltyCatchMustBetaken
304 FisherySubAntarcticAuckland West.SubAntarctic.Immature.F
SelectivitySubAntarcticAucklandFisheryF 0.95 OctNov PenaltyCatchMustBetaken
305 FisherySubAntarcticAuckland West.SubAntarctic.Mature.M
SelectivitySubAntarcticAucklandFisheryM 0.95 OctNov PenaltyCatchMustBetaken
306 FisherySubAntarcticAuckland West.SubAntarctic.Mature.F
SelectivitySubAntarcticAucklandFisheryF 0.95 OctNov PenaltyCatchMustBetaken
307 FisherySubAntarcticSnares West.SubAntarctic.Immature.M
SelectivitySubAntarcticSnaresFisheryM 0.95 OctNov PenaltyCatchMustBetaken
308 FisherySubAntarcticSnares West.SubAntarctic.Immature.F
SelectivitySubAntarcticSnaresFisheryF 0.95 OctNov PenaltyCatchMustBetaken
309 FisherySubAntarcticSnares West.SubAntarctic.Mature.M
SelectivitySubAntarcticSnaresFisheryM 0.95 OctNov PenaltyCatchMustBetaken
310 FisherySubAntarcticSnares West.SubAntarctic.Mature.F
SelectivitySubAntarcticSnaresFisheryF 0.95 OctNov PenaltyCatchMustBetaken
311 FisherySubAntarcticSuba West.SubAntarctic.Immature.M SelectivitySubAntarcticSubaFisheryM
0.95 OctNov PenaltyCatchMustBetaken
312 FisherySubAntarcticSuba West.SubAntarctic.Immature.F SelectivitySubAntarcticSubaFisheryF
0.95 OctNov PenaltyCatchMustBetaken
313 FisherySubAntarcticSuba West.SubAntarctic.Mature.M SelectivitySubAntarcticSubaFisheryM
0.95 OctNov PenaltyCatchMustBetaken
314 FisherySubAntarcticSuba West.SubAntarctic.Mature.F SelectivitySubAntarcticSubaFisheryF
0.95 OctNov PenaltyCatchMustBetaken
315 FisheryWCSIInside West.WCSI.Mature.M SelectivityWCSIInsideFisheryM 0.95 JulSep
PenaltyCatchMustBetaken
316 FisheryWCSIInside West.WCSI.Mature.F SelectivityWCSIInsideFisheryF 0.95 JulSep
PenaltyCatchMustBetaken
317 FisheryWCSINorthFrom2000 West.WCSI.Mature.M SelectivityWCSINorthFrom2000FisheryM 0.95
JulSep PenaltyCatchMustBetaken
318 FisheryWCSINorthFrom2000 West.WCSI.Mature.F SelectivityWCSINorthFrom2000FisheryF 0.95
JulSep PenaltyCatchMustBetaken
319 FisheryWCSINorthPre2000 West.WCSI.Mature.M SelectivityWCSINorthPre2000FisheryM 0.95
JulSep PenaltyCatchMustBetaken
320 FisheryWCSINorthPre2000 West.WCSI.Mature.F SelectivityWCSINorthPre2000FisheryF 0.95
JulSep PenaltyCatchMustBetaken
321 FisheryWCSISouth West.WCSI.Mature.M SelectivityWCSISouthFisheryM 0.95 JulSep
PenaltyCatchMustBetaken
322 FisheryWCSISouth West.WCSI.Mature.F SelectivityWCSISouthFisheryF 0.95 JulSep
PenaltyCatchMustBetaken
323 end_table
324
325
326
327
328
329 @selectivity SelectivityOne
330 type constant
```

```
331   c 1.0
332
333
334   @selectivity Select2yrs
335   type all_values
336   v 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
337
338
339   @selectivity SelectivityEastMaturationM
340   type logistic
341   a50 2.0
342   ato95 2.0
343   alpha 1.0
344
345
346   @selectivity SelectivityEastMaturationF
347   type logistic
348   a50 3.0
349   ato95 3.0
350   alpha 1.0
351
352
353   @selectivity SelectivityWestMaturationM
354   type logistic
355   a50 2.0
356   ato95 2.0
357   alpha 1.0
358
359
360   @selectivity SelectivityWestMaturationF
361   type logistic
362   a50 3.0
363   ato95 3.0
364   alpha 1.0
365
366
367   @selectivity SelectivityWestHomeMigrationM
368   type logistic_producing
369   l 1
370   h 8
371   a50 3.0
372   ato95 2.0
373   alpha 1.0
374
375
376   @selectivity SelectivityWestHomeMigrationF
377   type logistic_producing
378   l 1
379   h 8
380   a50 3.0
381   ato95 2.0
382   alpha 1.0
383
384
385   @selectivity SelectivityChathamRiseSummerSurveyM
386   type knife_edge
387   e 2.0
388   alpha 1.0
389
390
391   @selectivity SelectivityChathamRiseSummerSurveyF
392   type knife_edge
393   e 2.0
394   alpha 1.0
395
396
397   @selectivity SelectivitySubAntarcticSummerSurveyM
```

```
398   type logistic
399   a50 9.5
400   ato95 3.0
401   alpha 1.0
402
403
404   @selectivity SelectivitySubAntarcticSummerSurveyF
405   type logistic
406   a50 9.5
407   ato95 3.0
408   alpha 1.0
409
410
411   @selectivity SelectivitySubAntarcticAutumnSurveyM
412   type logistic
413   a50 6.304
414   ato95 7.466
415   alpha 1.0
416
417
418   @selectivity SelectivitySubAntarcticAutumnSurveyF
419   type logistic
420   a50 6.304
421   ato95 7.466
422   alpha 1.0
423
424
425   @selectivity SelectivitySubAntarcticAEXSurveyM
426   type logistic
427   a50 3.5
428   ato95 1.663
429   alpha 1.0
430
431
432   @selectivity SelectivitySubAntarcticAEXSurveyF
433   type logistic
434   a50 3.5
435   ato95 1.663
436   alpha 1.0
437
438
439   @selectivity SelectivitySubAntarcticSHISurveyM
440   type logistic
441   a50 5.624
442   ato95 1.827
443   alpha 1.0
444
445
446   @selectivity SelectivitySubAntarcticSHISurveyF
447   type logistic
448   a50 5.624
449   ato95 1.827
450   alpha 1.0
451
452
453   @selectivity SelectivityChathamRiseSHISurveyM
454   type knife_edge
455   e 2
456   alpha 1.0
457
458
459   @selectivity SelectivityChathamRiseSHISurveyF
460   type knife_edge
461   e 2
462   alpha 1.0
463
464
```

```
@selectivity SelectivityChathamRiseDeepFisheryM
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityChathamRiseDeepFisheryF
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityChathamRiseShallowFisheryM
type double_normal
mu 4
sigma_l 2.5
sigma_r 20
alpha 1


@selectivity SelectivityChathamRiseShallowFisheryF
type double_normal
mu 4
sigma_l 2.5
sigma_r 20
alpha 1


@selectivity SelectivityCookStraitSpawningFisheryM
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityCookStraitSpawningFisheryF
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityPuysegurSpawningFisheryM
type double_normal
mu 15.67
sigma_l 9.894
sigma_r 1
alpha 4.384


@selectivity SelectivityPuysegurSpawningFisheryF
type double_normal
mu 0.1
sigma_l 2.553
sigma_r 182.1
alpha 1


@selectivity SelectivitySubAntarcticAucklandFisheryM
type logistic
a50 7
ato95 3
alpha 1


```

```
@selectivity SelectivitySubAntarcticAucklandFisheryF
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivitySubAntarcticSnaresFisheryM
type double_normal
mu 4
sigma_l 2
sigma_r 20
alpha 1


@selectivity SelectivitySubAntarcticSnaresFisheryF
type double_normal
mu 4
sigma_l 2
sigma_r 20
alpha 1


@selectivity SelectivitySubAntarcticSubaFisheryM
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivitySubAntarcticSubaFisheryF
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityWCSIInsideFisheryM
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityWCSIInsideFisheryF
type logistic
a50 7
ato95 3
alpha 1


@selectivity SelectivityWCSINorthFrom2000FisheryM
type double_normal
mu 4
sigma_l 2
sigma_r 20
alpha 1


@selectivity SelectivityWCSINorthFrom2000FisheryF
type double_normal
mu 4
sigma_l 9
sigma_r 50
alpha 1


```

```
@selectivity SelectivityWCSINorthPre2000FisheryM
type double_normal
mu 4
sigma_l 2
sigma_r 20
alpha 1


@selectivity SelectivityWCSINorthPre2000FisheryF
type double_normal
mu 4
sigma_l 9
sigma_r 50
alpha 1


@selectivity SelectivityWCSISouthFisheryM
type logistic
a50 7
ato95 8.75
alpha 1


@selectivity SelectivityWCSISouthFisheryF
type logistic
a50 7
ato95 3
alpha 1


@time_varying ChathamRiseSummerSurveyShiftM
type exogenous
parameter selectivity[SelectivityChathamRiseSummerSurveyM].e
years 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
exogenous_variable -0.846349 -0.571551 -0.577387 0 0 0 0 0 0 -0.0386661 -0.0163429
0.0559784 0.723787 0.522114 0.679399 0.0981645 -0.180663 0.0214547 -0.273193 0 -0.115074
0.032279 0 0.507732 0 -0.053837
a 0.0


@time_varying ChathamRiseSummerSurveyShiftF
type exogenous
parameter selectivity[SelectivityChathamRiseSummerSurveyF].e
years 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
exogenous_variable -0.846349 -0.571551 -0.577387 0 0 0 0 0 0 -0.0386661 -0.0163429
0.0559784 0.723787 0.522114 0.679399 0.0981645 -0.180663 0.0214547 -0.273193 0 -0.115074
0.032279 0 0.507732 0 -0.053837
a 0.0


@selectivity SelectivityChathamRiseDeepFishery
type double_normal
mu 14
sigma_l 10.7575
sigma_r 44
alpha 1.0
length_based FALSE


@age_length AgeLengthEastM
type von_bertalanffy
length_weight LengthWeightEastM
k 0.232
t0 -1.23
Linf 89.5
```

```
  cv_first 0.05
  cv_last 0.05
  time_step_proportions 0.25 0.60 0.90 0.90 0.0
  by_length TRUE
  distribution normal
  compatibility_option casal


  @age_length AgeLengthEastF
  type von_bertalanffy
  length_weight LengthWeightEastF
  k 0.161
  t0 -2.18
  Linf 101.8
  cv_first 0.05
  cv_last 0.05
  time_step_proportions 0.25 0.60 0.90 0.90 0.0
  by_length TRUE
  distribution normal
  compatibility_option casal


  @age_length AgeLengthWestM
  type von_bertalanffy
  length_weight LengthWeightWestM
  k 0.261
  t0 -0.50
  Linf 92.6
  cv_first 0.05
  cv_last 0.05
  time_step_proportions 0.25 0.60 0.90 0.90 0.0
  by_length TRUE
  distribution normal
  compatibility_option casal


  @age_length AgeLengthWestF
  type von_bertalanffy
  length_weight LengthWeightWestF
  k 0.213
  t0 -0.60
  Linf 104.0
  cv_first 0.05
  cv_last 0.05
  time_step_proportions 0.25 0.60 0.90 0.90 0.0
  by_length TRUE
  distribution normal
  compatibility_option casal


  @length_weight LengthWeightEastM
  type basic
  units tonnes
  a 4.79e-09
  b 2.89


  @length_weight LengthWeightEastF
  type basic
  units tonnes
  a 4.79e-09
  b 2.89


  @length_weight LengthWeightWestM
  type basic
  units tonnes
```

```
  a 4.79e-09
  b 2.89


  @length_weight LengthWeightWestF
  type basic
  units tonnes
  a 4.79e-09
  b 2.89
```