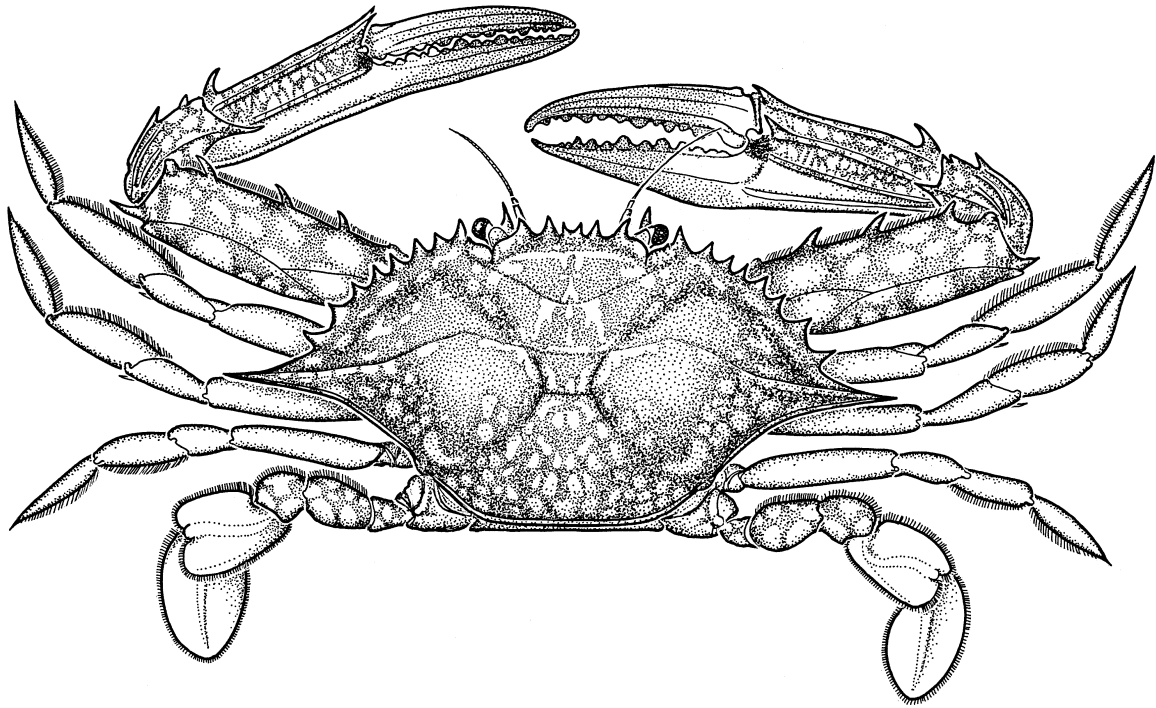




Stock assessment of blue swimmer crab (*Portunus armatus*), Queensland, Australia, with data to June 2024

This publication has been compiled by M. F. O'Neill, R. A. Lovett and A. Garland of Fisheries Queensland, Department of Primary Industries. Print version August 2026.

The Department of Primary Industries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.

Enquiries and feedback regarding this document can be made as follows:

Email: info@dpi.qld.gov.au

Telephone: 13 25 23 (Queensland callers only)
(07) 3404 6999 (outside Queensland)

Monday, Tuesday, Wednesday and Friday: 8 am to 5 pm, Thursday: 9 am to 5 pm

Post: Department of Primary Industries GPO Box 46 BRISBANE QLD 4001 AUSTRALIA

Website: dpi.qld.gov.au

Interpreter statement



The Queensland Government is committed to providing accessible services to Queenslanders from all culturally and linguistically diverse backgrounds. If you need an interpreter to help you understand this document, call **13 25 23** or visit **dpi.qld.gov.au** and search for 'interpreter'.

© State of Queensland, 2026

The Queensland Government supports and encourages the dissemination and exchange of its information. The copyright in this publication is licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) licence.

Under this licence you are free, without having to seek our permission, to use this publication in accordance with the licence terms.



You must keep intact the copyright notice and attribute the State of Queensland as the source of the publication.

Note: Some content in this publication may have different licence terms as indicated.

For more information on this licence, visit creativecommons.org/licenses/by/4.0.

The information contained herein is subject to change without notice. The Queensland Government shall not be liable for technical or other errors or omissions contained herein. The reader/user accepts all risks and responsibility for losses, damages, costs and other consequences resulting directly or indirectly from using this information.

Contents

Executive summary	i
Acknowledgements	x
Glossary	xi
1 Introduction	1
2 Methods	3
2.1 Data sources	3
2.2 Regions	4
2.3 Retained catches	4
2.3.1 Commercial	4
2.3.2 Recreational	6
2.4 Standardised catch rates	7
2.4.1 Commercial pot	7
2.4.2 Recreational pot	9
2.4.3 Survey trawl	10
2.5 Size and discard data	11
2.6 Biological relationships	12
2.6.1 Carapace width	12
2.6.2 Weight	12
2.6.3 Maturity and fecundity	13
2.6.4 Growth	13
2.6.5 Natural mortality	13
2.6.6 Steepness	14
2.7 Population model	15
2.7.1 Description	15
2.7.2 Assumptions	16
2.7.3 Parameters	16
2.7.4 Analyses	18
3 Results	20
3.1 Model inputs	20
3.1.1 Data availability	20
3.1.2 Harvest	21
3.1.3 Catch rates	23
3.1.4 Discards and size	25
3.2 Model outputs	26
3.2.1 Parameters and fits	26
3.2.2 Biomass	30
4 Discussion	37
4.1 Stock status	37
4.2 Key influences	38
4.3 Performance of models	39
4.4 Environment	40
4.5 Stakeholder feedback	41

4.6	Recommendations	41
4.6.1	Monitoring	41
4.6.2	Stock assessment	41
4.6.3	Research	42
4.6.4	Management	42
4.7	Conclusions	43
References		43
A Fishery management		44
B Project team		47
C Stakeholder presentation		49
D Diagnostics for catch rates		52
D.1	Commercial pot offsets and nominal data	52
D.2	Commercial pot fleet 1	55
D.3	Commercial pot fleet 2	58
D.4	Commercial pot fleet 3	61
D.5	Recreational pot fleet 7	65
D.6	Survey beam-trawl fleet 8	66
E Model inputs		69
E.1	Biological data	69
E.2	Recreational harvest	70
F Model outputs		72
F.1	MLE diagnostics	72
F.1.1	Likelihood profile	72
F.2	MCMC diagnostics	73
F.3	Other outputs	75
F.3.1	Stock-recruit curve	75
F.3.2	Fishing mortality	76
F.3.3	Recruitment deviations	76
F.3.4	Sensitivity: parameter estimates and derived quantities	77
F.3.5	Sex ratios	79
G Exploratory analyses		81
H Detailed model outputs		85
H.1	Analysis 1	85
H.2	Analysis 2	98
H.3	Analysis 3	111
H.4	Analysis 4	124
H.5	Analysis 5	137
H.6	Analysis 6	150
H.7	Analysis 7	163
H.8	Analysis 8	176
H.9	Analysis 9	189
H.10	Analysis 10	202
H.11	Analysis 11	215
H.12	Analysis 12	228
H.13	Analysis 13	241

H.14 Analysis 14 252

H.15 Analysis 15 263

H.16 Analysis 16 274

Executive summary

Overview

- Blue swimmer crab numbers along the Queensland east coast are lower than historical levels but are likely above the harvest strategy limit reference point of 20%.
- The estimated legal-sized male crab biomass in 2024 was at about 30% of unfished levels.
- The stock remains below the target reference point, indicating there is potential for further rebuilding.
- Crab abundance and recruitment have likely been affected by a combination of fishing pressure, environmental and natural variation in the population.
- Results from multiple model scenarios were combined using an ensemble approach to provide a more informed assessment of stock status.
- Initial stakeholder feedback indicated that the assessment trends generally matched what fishers were seeing in the fishery.

Introduction

Blue swimmer crabs (*Portunus armatus*) are a key commercial and recreational target species due to their superb eating quality, characterised by a sweet delicate flavour.

Blue swimmer crabs mature from an age of one year, measuring around 9–10 centimetres carapace width. Longevity is around four years, and male crabs generally grow larger to a maximum size of 20 centimetres carapace width compared to females at 17 centimetres.

Commercial fishing for blue swimmer crabs is generally concentrated in south-east Queensland from Hervey Bay to Moreton Bay. Blue swimmer crabs are typically harvested using baited crab pots and by trawlers. The current minimum legal size for male blue swimmer crab is 11.5 centimetres. Female blue swimmer crabs are not legal to harvest.

The blue swimmer crab harvest strategy reference points are designed for assessing exploitable biomass, defined as legal-sized male crab (Queensland Government 2021a). The previous stock assessment estimated exploitable biomass at around 33% of unfished biomass in 2019.

In 2024, the pot-sector total allowable commercial catch (TACC) was 263 tonnes (t). Of the TACC, 49 commercial pot fishing operations harvested 208 t of blue swimmer crab. Landings were commercially valued around \$13 per kilogram for whole crab. The commercial pot sector gross value was \$2.5–2.8 million, which supported 56–85 businesses and employed 47–51 full-time equivalent jobs (BDO EconSearch 2024). In addition, about 47 tonnes were landed by the east coast and Moreton Bay trawl fleets in 2024.

The harvest of blue swimmer crabs by recreational pot fishing was estimated to be around 38 t.

Growth and management differences between sexes require stock assessment models to evaluate both female and male crab dynamics. This report informs on the status of the north-eastern Australia (Queensland east coast) blue swimmer crab biological stock through estimates of exploitable (legal-sized male crab) and spawning biomass (mature female crab).

The assessment results were reviewed by stakeholders through a special meeting held to present the stock assessment findings and discuss fishery trends (Appendix C).

Methods

This was the third stock assessment of blue swimmer crab in Queensland and the first to use the annual age-structured population model stock synthesis (SS). Previous assessments used a monthly time-step length-structured population model.

This stock assessment specified a fishing year as a financial year. The most recent fishing year labelled 2024 referred to the period 1 July 2023 to 30 June 2024.

The assessment period focused on data spanning from 1989 to 2024. The data inputs were: 1) total harvests for all years, including all fishing sectors and discard mortality, 2) standardised catch rates from the Moreton Bay, offshore and Hervey Bay commercial pot fleets, the recreational fishing sector and the Moreton Bay fishery-independent beam trawl survey, and 3) crab size frequencies from commercial pot and trawl fishing.

The stock assessment combined all data inputs into the stock synthesis software. This assessment analysed 12 alternative data scenarios to form an ensemble of Markov chain Monte Carlo (MCMC) simulations, to interpret analyses and results together rather than individually.

The 12 analyses were designed to model key influences and considered:

- Three annual rates of natural mortality, (1, 1.2, 1.4), allowing for a longevity of 4–5 years.
- Two values of steepness, 0.8 and 0.6, allowing for different survival rates of juveniles.
- Two initial average harvests before 1989, based on the mean or three-quarters of mean harvests from 1989 to 1993. The average harvests, together with 1985–1986 length frequencies and discard fractions, allowed the model to estimate the initial equilibrium population dynamics and depletion level in 1989.

The population dynamics in stock synthesis was structured for:

- two sexes, modelling female and male crabs separately
- seasonality, for quarterly recruitment settlements and growth
- eight fleets, identifying fishing sectors including the fishery-independent trawl survey
- change in size limit in 2003
- recruitment variation 1989–2023
- retention of legal male crab only
- discard mortality.

The key assumptions hinged on annual trends in total harvest and catch rates, and that egg production was not limited by the number of mature males.

Compared to previous stock assessments, the SS model allowed for more fleets and modelling of discards, but reduced seasonal dynamics. All stock assessments used maximum likelihood (MLE) and Markov chain Monte Carlo (MCMC) estimation.

Results

Biomass

The stock assessment estimated the exploitable biomass for legal-sized male crab in 2024 between 23% and 38% of unfished biomass, with a median of 30% (Table 1 and Figure 1). The depletion of exploitable biomass reflects the high harvests between 1998 and 2010 followed by a general downturn in catch rates and juvenile recruitment post 2010 (Figure 2).

The decline in recruitment post 2010 also adversely affected the spawning biomass. Despite this, estimated spawning biomass for mature female crab in 2024 remained higher — between 42% and 52%, due to the protection of females (Table 1).

The previous stock assessment estimated the exploitable biomass around 33% and the spawning biomass around 50% in 2019 (Lovett et al. 2020).

The 2024 biomass results were similar to 2019, when fishery management introduced a new harvest strategy and a revised TACC (Table A.1 and Figure A.1).

Table 1: Stock status indicators for blue swimmer crab in Queensland, from the MCMC ensemble.

Indicator	Value
Exploitable biomass ratio (relative to unfished)	
Range (95% credible interval)	23–38
Median	30%
Probability below 20%	0.1%
Probability between 20% and 40%	99.3%
Probability between 40% and 60%	0.6%
Probability above 60%	0%
Spawning biomass ratio (relative to unfished)	
Range (95% credible interval)	42–52
Median	47%
Probability below 20%	0%
Probability between 20% and 40%	0.1%
Probability between 40% and 60%	99.9%
Probability above 60%	0%

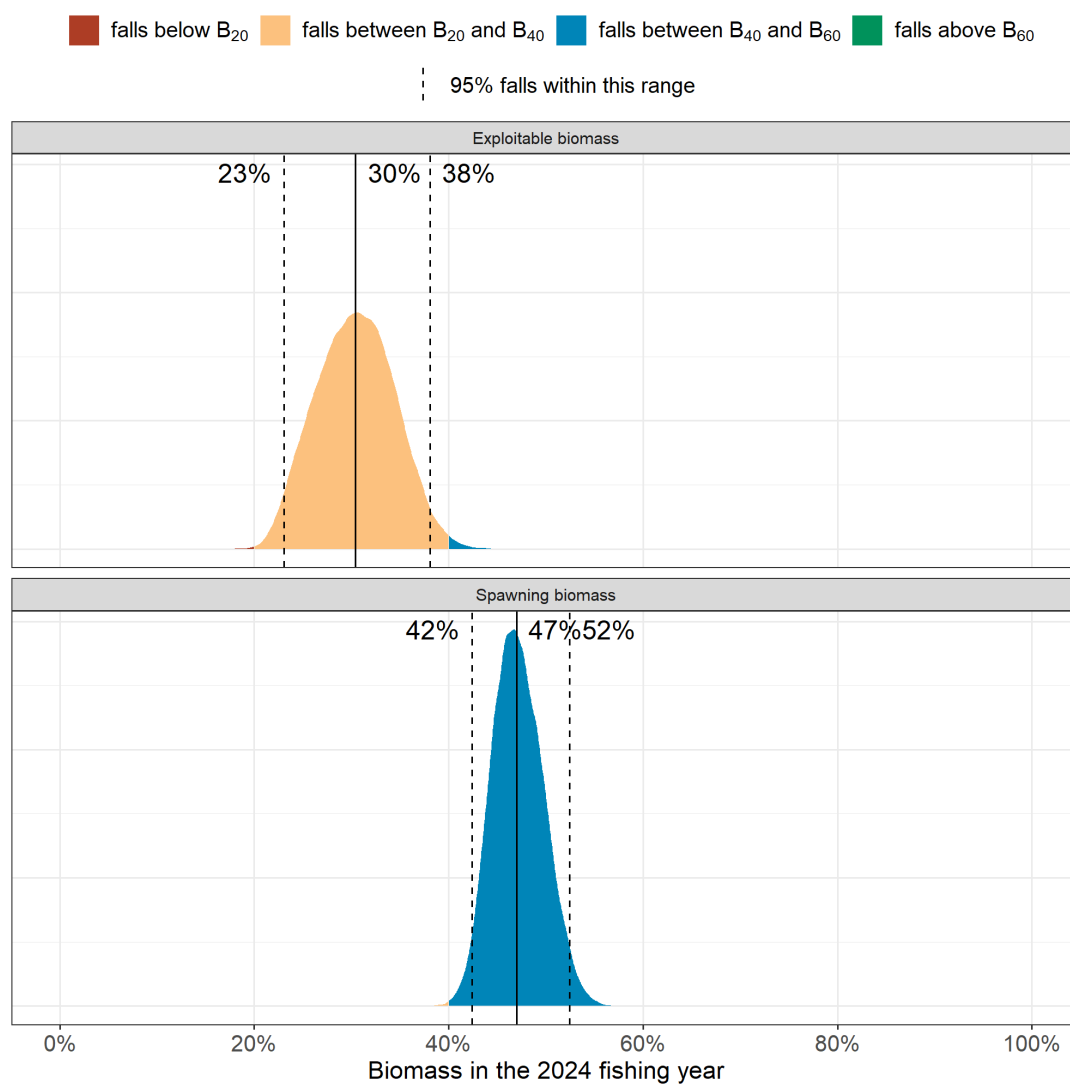


Figure 1: Probability distribution of the biomass ratio in 2024 for the MCMC ensemble with the credible interval and probability of biomass falling into the four categories indicated.

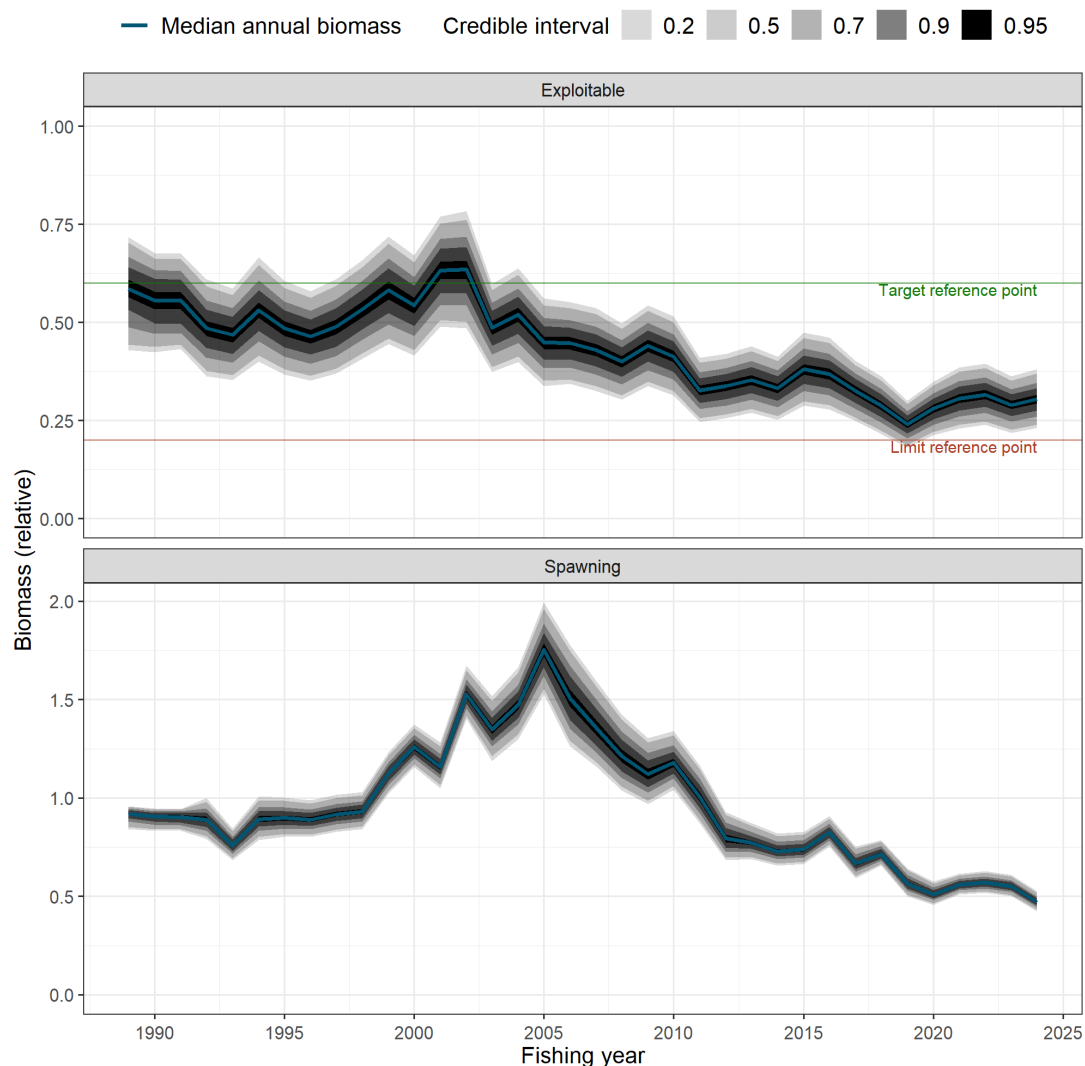


Figure 2: Biomass trajectory relative to unfished levels for blue swimmer crab in Queensland, from the MCMC ensemble. Harvest strategy reference points are shown for exploitable biomass.

Harvest

Over the last three years 2022–2024, the blue swimmer crab harvest averaged 265 t per fishing year by all fishing sectors (Figure 3). During this time, average harvest shares were made up of 184 t from commercial pot fishing (C1 symbol), 21 t from commercial trawling outside Moreton Bay (T1), 22 t from commercial trawling in Moreton Bay (M1/M2) and approximately 38 t from recreational fishing sector. Indigenous and charter sectors had little information on crab fishing, hence these sectors formed part of the recreational data in this assessment. Total annual harvests, from all sectors combined, peaked more than 1500 t in 2004.

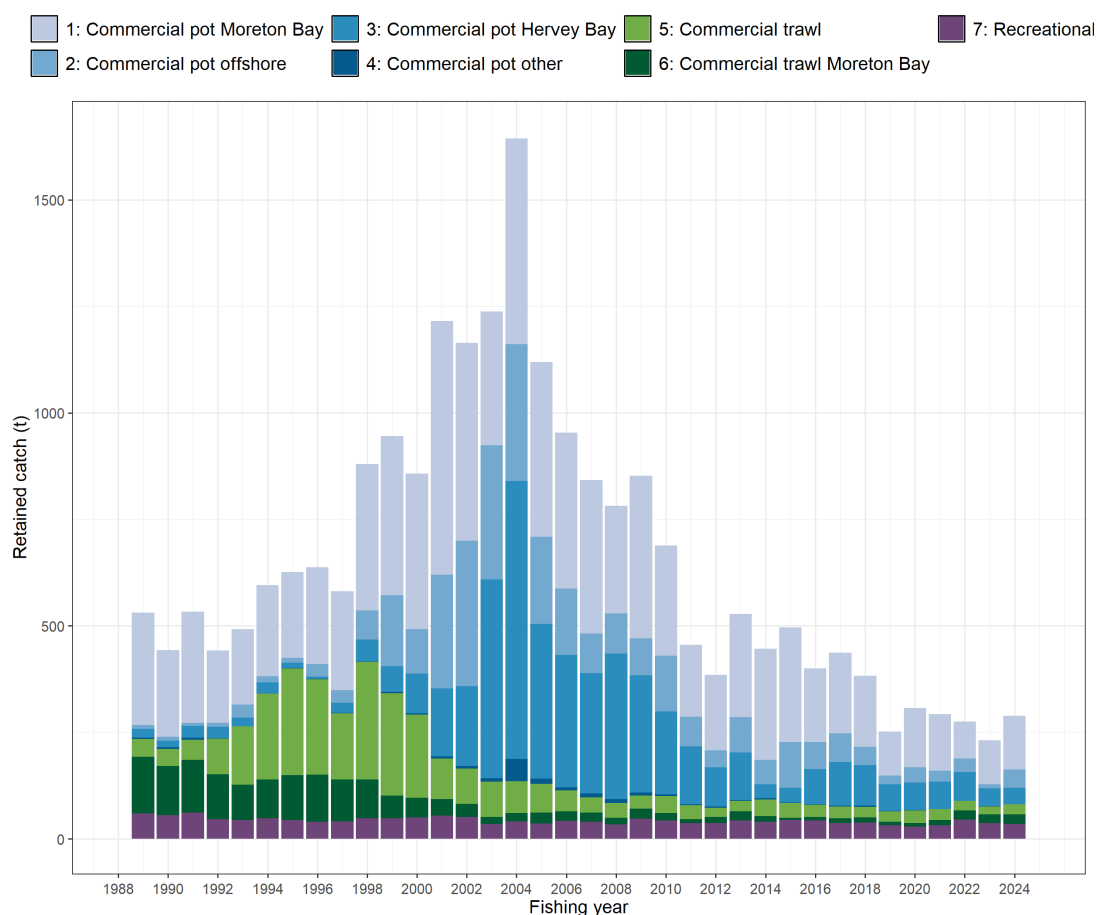


Figure 3: Estimated harvest between 1989 and 2024 for blue swimmer crab on the east coast of Queensland.

Catch rates

Catch rates were standardised using general and generalised linear models. All models considered data between fishing years, seasons, areas, fishing effort, lunar phase and wind strengths. Annual catch rates varied between fleets (Figure 4). In general, the time series of catch rates since 2010 showed a declining trend, with higher catch rates in the commercial pot sectors in 2024.

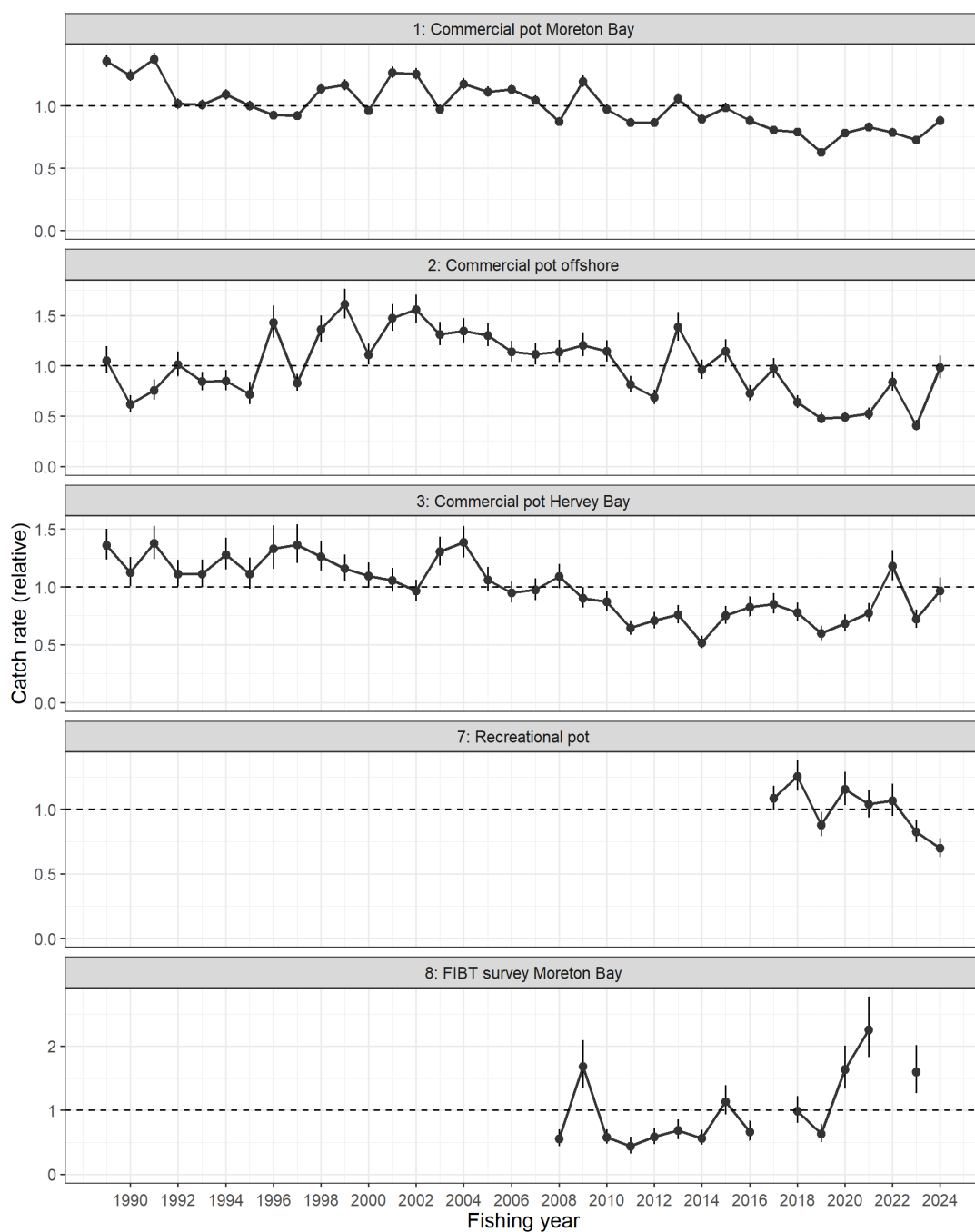


Figure 4: Annual standardised catch rates for blue swimmer crab between the fishing years of 1989 and 2024. The fishery-dependent indices were for legal male crab (available from fleets 1, 2, 3 and 7) and the fishery-independent beam trawl survey (fleet 8) was for all sizes of female and male crab. Catch rates were relative and scaled against their fleet average equal to 1. Error bars represent 95 percent confidence intervals.

Key influences

The key data and parameters that had bearing on results were:

Number of pots fished per day by commercial operators: Many logbook records reported 50 pots per fishing day, corresponding to the legislated limit for licences holding one C1 symbol. However, observer data indicated that some operators used more gear than reported. Observer-derived offsets for effective

pot use had a noticeable influence on standardised catch rates prior to 2014. As no additional observer data were available after 2014, the offset was held constant at the 2014 estimate.

This assumption was considered reasonable because reported effort patterns remained relatively stable and there was no independent evidence of systematic changes in pot use (Figure D.1). If actual pot use increased after 2014, catch rates would be overestimated; if pot use decreased, catch rates would be underestimated. Recent legislative changes allowing licences to hold multiple C1 symbols (50 pots per C1 symbol) may warrant future investigation should additional pot-use information become available.

High commercial harvest: Commercial harvests exceeded 1000 t per year between 2001 and 2005. To explain these removals, the model estimated above-average recruitment of new crab during this period. The magnitude of the reported harvests may also reflect some uncertainty in historical catch reporting, as previously raised by industry representatives (Sumpton et al. 2015).

Exploratory analysis 13 examined the effect of reduced historical catches (Appendix G), which lowered recruitment deviations but had little effect on 2024 biomass ratios. This suggested that uncertainty in early harvests, including the assumed initial depletion in 1989, had limited influence on contemporary stock status.

Natural mortality: The model was sensitive to natural mortality, with higher values associated with shorter longevity and larger population sizes. However, 2024 male biomass ratios varied by less than eight percentage points across the range of natural mortality values examined. This indicates that uncertainty in natural mortality had a limited effect on biomass ratios.

Range of estimates: The MLE and MCMC analyses produced different estimates of male exploitable biomass. Biomass status was based on the MCMC distributions because they better represent the range of plausible stock states supported by the available information. The difference between the MLE and MCMC estimates provides an indication of the variation in plausible male stock states.

Conclusion

Across ensemble analyses, the 2024 exploitable biomass of legal-sized male blue swimmer crab was estimated at approximately 30% of unfished biomass using MCMC results. These results indicated that male biomass was likely above the 20% limit reference point. However, some MLE model outcomes and data limitations suggest that male exploitable biomass may be closer to the limit reference point than indicated by the median estimate. Consequently, a cautious interpretation of male stock status remains appropriate, together with continued improvement of key assessment data.

Key actions remain around improving indices of abundance, reporting and managing levels of actual fishing effort, monitoring of fishery carapace-width compositions, recreational catch, estimating growth and discards. These actions are noted for future work in section 4.6.

Overall, stakeholder feedback indicated that the assessment trends were broadly consistent with fishers' experience, but that some imprecision remains around historical commercial pot effort, recreational harvest and regional differences in fishery performance (Appendix C). Fishers emphasised that recent lower catches likely reflect a mix of biological, environmental, economic and operational factors, and that their ongoing input will be important for interpreting future assessment results.

Variance estimates were within acceptable bounds, with the management uncertainty statistic (discount/buffer factor) exceeding 0.91, consistent with a Tier 1 or 2 assessment category suitable for management discussions (Queensland Government 2021b).

Acknowledgements

The authors proudly acknowledge Aboriginal peoples and Torres Strait Islanders and the Traditional Owners of the country on which we live and work.

This stock assessment was managed by a project advisory team with a wide range of skill sets. In addition to managers, scientists, monitoring and data specialists from within the DPI, the team included two external scientists from New South Wales.

The project team operated under a terms-of-reference designed to ensure a transparent and evidence-based approach. The project team members were Anna Garland, Daniel Johnson (NSW), Geoff Liggins (NSW), James English, Jeffrey Ikin, Jennifer Larkin, Joanne Wortmann, Lauren Jubb, Matthew Campbell, Michael O'Neill, Michelle Winning and Robyn Lovett.

The project team is thanked for contributing their time and knowledge and engaging constructively over the course of the project.

The project team also wishes to acknowledge and thank the many fishers, fish processors and scientists who have contributed to past and current research on blue swimmer crab.

Particularly, special thanks go to Mark McLennan, Matthew Campbell and Wayne Sumpton who contributed many years of research and data on blue swimmer crab, and Jessica Baker for compiling estimates of recreational crab catches.

We also thank Joanne Wortmann for initialising database code, the assessment and managing meeting records, and Alise Fox for analysis support. James English and Alise also developed AI settings for ChatGPT to summarise meeting recordings.

The authors thank Peri Subritzky for coordinating the stakeholder workshop and supporting the preparation of these notes. Stakeholder attendees included Shane Underhill, Ryan Taplin, Anthony Riesenweber and George Bennetts. Our special thanks go to these stakeholders whose valuable insights has meant that this assessment could be considered not only in a scientific context, but also in the context of their extensive on-water experience. We acknowledge these fishing representatives who gave their time to attend the meeting and share their experience. Their local knowledge and observations were valuable for interpreting the assessment trends and improving understanding of recent fishery performance. We also thank DPI executives and the fishery management team for supporting the presentation of the blue swimmer crab stock assessment results and the discussion of key issues affecting the fishery.

Finally, we thank all report reviewers for their in-depth and constructive feedback which greatly added to the robustness of the analyses and the comprehensiveness of the final report.

This assessment was funded by the Department of Primary Industries, Queensland Government.

Glossary

B	Biomass ratio. Measured as legal-sized male crab as per the harvest strategy reference points.
BOM	Bureau of Meteorology, Australian Government.
BSC	Blue swimmer crab. BSCF – abbreviation used in the harvest strategy for blue swimmer crab fishery
Catchability q	The ability to catch crab. It was the average probability of catching a crab with a single unit of standardised fishing effort.
CI	Confidence interval or credible interval if from Markov chain Monte Carlo.
CPUE	Catch per unit effort or catch rate. Index of crab abundance. Catch rates were standardised in a GLM.
CV	Coefficient of variation, a statistical measure of variability that indicates the size of standard deviation relative to the estimate.
DME	Data Mining Environment.
DPI	Department of Primary Industries, Queensland Government.
Ensemble	A group of analyses or scenarios interpreted together as a whole, rather than individually.
FIOT	Fishery Independent Otter Trawl survey.
Fisher–day	Fishing-day or operator–day. A day of commercial fishing by an operator, which corresponds to a single daily logbook record.
Fishing year	A financial year from 1 July to 30 June.
Fleet	A term used to identify a fishing activity or sector, that can have different types or areas of fishing. Typically, a fleet will have its own vulnerability schedule, which describes the ages or sizes of crab caught.
FM	Fisheries Monitoring program by DPI.
FP	Fishing power. Refers to a deviation in actual fishing effort from a standard unit.
FRDC	Fisheries Research and Development Corporation, Australian Government.
Git	Version control system is used to record code and analysis history.
GLM	Generalised linear model.
Harvest rate u	Fraction of vulnerable sized crab harvested each year. This signifies the annual fishing mortality F , where $u = 1 - \exp(-F)$ and $F = -\log(1-u)$.
Hyperstability	When catch rates and age or length frequencies remain similar as abundance declines.
Log	Used to denote the natural logarithm (base e). Also labelled as “ln” in other contexts.
M	Natural mortality per year was defined as the deaths by natural and other causes (such as predation, disease, cannibalism, ageing, pollution, parasitism) not associated with fishing.
MCMC	Markov chain Monte Carlo. A statistical simulation for approximating the final (posterior) distribution of a quantity.
MEY	Maximum economic yield. The harvest and effort level that allows maximum commercial profit for fishers.
MLE	Maximum likelihood estimate. MLE is a method to estimate the parameters that maximise the model fit to the data.
MLS	Minimum legal-size centimetres (cm). Currently 11.5 cm.
MSY	Maximum sustainable yield, tonnes (t). The maximum level that can be routinely fished without long-term depletion and overfishing.

Natural mortality	Natural mortality refers to the annual rate at which crabs in the population die due to natural causes, excluding human-related factors like fishing.
Notch	Current method of measuring carapace width cm. Carapace width is assumed to be notch-to-notch unless otherwise stated. Measurement is the distance between the notch immediately in front of the base of the large horizontal spine on one side, and the same notch on the other side of the crab.
NRIFS	National recreational and indigenous fishing survey, funded by the FRDC in 2000–2001.
Overfished	A biomass ratio below the limit reference point of 20%.
Overfishing	When a fish population is experiencing too much effort, and the removal rate exceeds the target level.
QFB	Queensland fish board, marketing authority until 1981.
Quantile	A set of values which divide a frequency distribution into equal groups.
R	Free programming language for statistical computing and graphics.
RBC	Recommended biological catch (t). The total allowable annual harvest of legal blue swimmer crab by all fishing sectors, minus discards.
Recruitment	Recruitment was the number of new young crab that entered the population in a year and season. They were called the 0+ age group.
Reference point	Fishery health indicators on the level of fishing, harvest or biomass. It is a benchmark for interpreting results and gauging the status of a fishery.
RFish	Recreational fishing surveys conducted by Fisheries Queensland in 1997, 1999, 2002, and 2005.
RROCK	R Repository of Collective Knowledge. R package with functions by Fisheries Queensland that collates all useful stock assessment techniques.
RSE	Relative standard error, like a CV.
RStudio	The computer interface used to run R, Git, SS, and the blue swimmer crab project.
SAFS	Status of Australian fish stocks (www.fish.gov.au).
Sector	A term used to distinguish types of fishing activities or fleets.
SFS	Sustainable Fisheries Strategy 2017–2027, by the Queensland Government.
Spine	Crab spine tip-to-tip measure cm. Fisher's method of measuring carapace width prior to 13 December 2003. Measurements were across the greatest dimension of the carapace.
SRFS	Statewide recreational fishing surveys conducted by Fisheries Queensland in 2010–11, 2013–14, and 2019–20.
SS	Stock Synthesis, software package for fishery stock assessment.
SSAND	Standardised Stock Assessment Numerical Displays. R package with functions by Fisheries Queensland that collates useful stock assessment techniques, particularly for SS outputs.
Steepness	Defines how larvae and juveniles increase their survival rates when the spawning stock size decreases (Hilborn and Walters 1992).
Stock	A distinct population that breeds mostly within itself. It also describes characteristics of a species group with definable attributes which are of interest to fishery managers.
Survival rate	Fraction of crab surviving each year after fishing (F) and natural mortality (M).
t	Tonnes, a metric unit of weight equal to 1000 kilograms (kg).
TACC	Total allowable commercial catch.
Tier	Assessment category for classifying scientific uncertainty. See Table 3 in Queensland Government (2021b).
Vulnerability	Probability of catching a crab and this varies with size. This is a result of crabs being present in the fishing area (fishery) and their susceptibility to the fishing gear. Vulnerability defines the exploitable component of crab biomass.
Zone	A stock assessment region on the Queensland east coast. The zones relate fleets to areas.

1 Introduction

Blue swimmer crabs, *Portunus armatus*, are found from the south coast of Western Australia, north to the Northern Territory, across to Queensland, and down the east coast to the New South Wales–Victoria border (Johnston et al. 2024). Blue swimmer crabs (BSC) are also abundant in warmer waters of South Australia, particularly in the Spencer Gulf and the Gulf of Saint Vincent. In Queensland, blue swimmer crabs generally inhabit bays, estuaries and some offshore areas in water depths up to 60 metres.

Ten fisheries operate for blue swimmer crab within Australia (Johnston et al. 2024). Nationally, commercial landings tally about 900–1200 t of blue swimmer crab per year, with nearly 50% harvested from Western Australia and 25% from Queensland (Johnston et al. 2024). In Queensland, only legal-sized male crabs may be harvested, whereas both legal-sized male and female crabs can be harvested in other jurisdictions.

In 2023, eight of the ten blue swimmer crab fisheries were classified as sustainable under the Status of Australian Fish Stocks classification system (using a 20% biomass reference point), with Cockburn Sound in Western Australia classified as depleted and New South Wales classified as depleting (Johnston et al. 2024).

Blue swimmer crabs on the east coast of Australia are genetically separate from other areas in Australia (Johnston et al. 2024). On the east coast, blue swimmer crabs have been described as having overlapped regional stocks based on genetic microsatellite determination (Chaplin et al. 2001). Larval dispersal modelling by Hewitt et al. (2022) suggested a southward flow, with spawning populations of blue swimmer crab in New South Wales and Queensland weakly connected. This result provided justification for stock assessment and management at a jurisdictional level between New South Wales and Queensland (Johnston et al. 2024).

Several historical studies have described blue swimmer crab biology in Australia (Meagher 1971; Penn 1977; Smith 1982; Potter et al. 1983). In Queensland, the earliest research was conducted by Thomson (1951) who focused primarily on the commercial harvest of the species. In the 1980s, research was conducted on the biology of blue swimmer crabs in Moreton Bay, Hervey Bay and waters off the Sunshine Coast (Potter et al. 1986; Potter et al. 1991; Weng 1992; Sumpton et al. 1994b; Sumpton 1994; Sumpton et al. 1994a; Sumpton et al. 2003).

Tagging studies of blue swimmer crabs did not indicate any clear directional patterns of movement in south-east Queensland (Potter et al. 1991). In Moreton Bay, blue swimmer crabs move into deeper waters as they increase in size (Sumpton 1994; Sumpton et al. 2003). Most crabs were recaptured within two kilometers of their tag release site. Larger males were generally more abundant in deeper water, while females tended to prefer shallower areas, particularly on the top of sand banks (Potter et al. 1986).

Blue swimmer crabs reach maturity at around one year of age (Sumpton et al. 2003). Mating can occur year-round when the female is in the early post-molt (soft shell) phase (Clarke et al. 2004). Females may bear eggs throughout the year, with a higher proportion observed during August–October. In Moreton Bay, peaks in egg-bearing females occurred two or three months earlier than in more southern

populations (Smith 1982; Potter et al. 1983). Sea temperatures are an important cue influencing the reproductive cycle (Clarke et al. 2004).

Female crabs can produce multiple batches of eggs per year, of which can be fertilised from a single mating. Juveniles settle in shallow inshore areas when they reach approximately 1 cm in carapace width. Individual crabs can grow to a maximum whole weight of about 1 kg but are typically harvested at around $\frac{1}{3}$ kg (Sumpton et al. 2003; Clarke et al. 2004). Growth is seasonal, with higher rates during the warmer months of summer and autumn.

In Queensland, blue swimmer crab fishing is concentrated in south-eastern waters and dates to the early 1900s. Limited information about the fishery existed until commercial harvests were initially recorded by the Queensland Fish Board in the 1930s. The Brisbane Metropolitan Fish Market recorded an annual commercial harvest of just over 10 t in 1937. Subsequent records show that by the 1960s, commercial harvests had increased to an annual figure of around 140 t (Thomson 1951; Sumpton et al. 2015). Before 1998, more commercial fishing occurred inshore, primarily in and around Moreton Bay. In 1998 commercial pot fishing expanded further offshore to target blue swimmer crab populations.

Blue swimmer crabs are harvested using regulated and prescribed collapsible trawl-mesh crab pots, wire-mesh traps and hoop/dilly nets, and are taken as permitted by-product by otter trawlers. Commercially, pots can be fished along a trotline in more open bay or offshore waters (excluding some areas).

A total of 390 commercial pot symbols were licensed in 2024 to harvest blue swimmer crabs along the Queensland east coast. Further details on fishery management can be found in Table A.1 (Appendix A).

Blue swimmer crabs are highly regarded for their sweet delicate flavour. No export markets exist, with most crab sold within Queensland. Net financial returns from commercial blue swimmer crab pot fishing have been marginal (BDO EconSearch 2024). Profitable catch rates can be difficult to attain outside of the key fishing months between February and April, due to the high levels of fishing effort (BDO EconSearch 2024; Sumpton et al. 2015).

An assessment of the Queensland blue swimmer crab fishery was first published for 1989–2014 (Sumpton et al. 2015). This assessment was broad in scope and covered population biology, environmental influences, commercial fishery economics as well as population modelling. It primarily focused on blue swimmer crabs in Hervey Bay, Moreton Bay and offshore of Moreton Bay. In 2014, estimates of the Moreton region exploitable biomass (legal-sized male crab) ranged between 20% and 50% and spawning biomass ranged between 38% and 59% of unfished biomasses (Sumpton et al. 2015). Estimates for the Hervey Bay region was less certain, and in 2014 the exploitable biomass ranged between 15% and 64% and spawning biomass between 22% and 68% of unfished biomasses.

In 2020, the stock assessment for blue swimmer crab was updated and run as one continuous stock along the Queensland east coast with inshore and offshore region size selectivity components (Lovett et al. 2020). Model analyses suggested the exploitable biomass fell to around 33% of unfished biomass in 2019. The spawning biomass ratio was estimated to be around 50% in 2019. For the 2020 biomass, the recommended biological catch (RBC) for all fishing sectors was estimated at 343 t (with no uncertainty adjustments).

In 2024, the Department of Primary Industries, Queensland, commissioned an update to the stock assessment for blue swimmer crab. This was to report against the harvest strategy, to determine the status of the Queensland east coast fishery (Queensland Government 2021a). In addition, for blue swimmer

crab, this report tested a seasonal implementation of the stock assessment software called stock synthesis. This enabled new considerations for separating fishing sectors and discards of crab. Even though the assessment suggested the abundance of legal male crabs was low, further work remains to improve data for stock assessment.

2 Methods

2.1 Data sources

The data used in this assessment informed catch rates, carapace-width compositions, discards and total harvests (Table 2.1).

Table 2.1: Overview of the data sources used in the stock assessment.

Data	Years	Source	References
Commercial	1988–2024	Compulsory commercial logbook database (CFISH)	Fisheries Queensland
Commercial	1985–1986 1998–2001 2013–2014	Research on-board observer pot data	Sumpton et al. (2003) and Sumpton et al. (2015)
Commercial	1985–1986 1998–2001	Research on-board observer Moreton Bay trawl data	Sumpton et al. (2003) and Sumpton et al. (2015)
Commercial	2018–2023	Otter trawl surveys (FIOT) of the scallop fishery	Fisheries Queensland
Recreational	1999, 2002, 2005	RFish state-wide catch survey	Higgs (1999), Higgs et al. (2007), and McInnes (2008)
Recreational	2000	National catch survey	Henry and Lyle (2003)
Recreational	2010, 2013, 2019	SRFS state-wide catch surveys	Taylor et al. (2012), Webley et al. (2015), and Teixeira et al. (2021)
Recreational	2017–2024	Boat ramp survey program	Fisheries Queensland
Independent	2008–2016 2018–2023	Fishery-independent beam trawl survey in Moreton Bay	Fisheries Queensland

The data was stratified into eight fleets:

1. Fleet 1. – Commercial inshore pot fishing in Moreton Bay.
2. Fleet 2. – Commercial offshore pot fishing outside Moreton Bay.
3. Fleet 3. – Commercial pot fishing in Hervey Bay and parts of Sandy Straits.
4. Fleet 4. – Commercial pot fishing in other less fished areas / grids, more so north of Hervey Bay.
5. Fleet 5. – Commercial otter trawl T1 fleet outside Moreton Bay.
6. Fleet 6. – Commercial otter trawl M1/M2 fleet in Moreton Bay.
7. Fleet 7. – Recreational pot fishing all east coast areas.
8. Fleet 8. – Fishery-independent beam trawl survey in Moreton Bay.

Year-quarters were defined for seasonality:

1. Quarter 1. – July to September (Q1).
2. Quarter 2. – October to December (Q2).
3. Quarter 3. – January to March (Q3).
4. Quarter 4. – April to June (Q4).

2.2 Regions

Sumpton et al. (2015) and Lovett et al. (2020) spatially stratified blue swimmer crab into three key regions (Figure 2.1). This stock assessment used the same region stratification but extended their meaning and use into the fleet definitions noted above in report section 2.1. From Sumpton et al. (2015), Sunshine Coast offshore waters or Fleet 2, north of Moreton Bay, was stratified to account for more gear being used per operation and larger crabs being caught. Similarly, other fleets were defined based on the fishing region, gear used, and size of crab taken. For recreational fleet 7, the spatial stratification was broad to cover all inshore waters on the Queensland east coast.

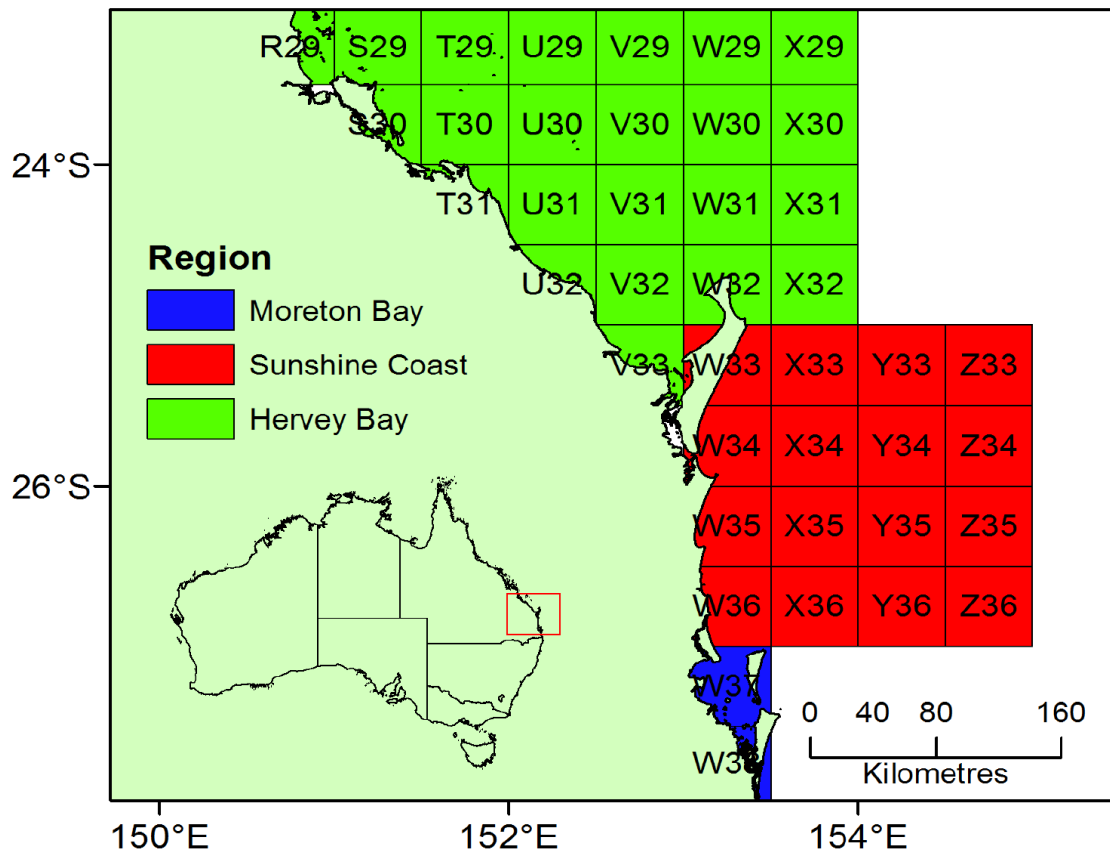


Figure 2.1: Commercial logbook reporting grids for both trawl and pot sectors used in the Sumpton et al. (2015) assessment. (Image by Matthew Campbell, © State of Queensland).

2.3 Retained catches

2.3.1 Commercial

Commercial harvest data were sourced from the Queensland fisheries compulsory logbook records. Data were extracted from the DME database on 29 May 2025, for the time series 1 July 1988 to 30 June 2024. The data contained daily entries where fishing operations recorded their harvest of blue swimmer crabs in kilograms. There were no time gaps in commercial data to estimate (Figure 2.2).

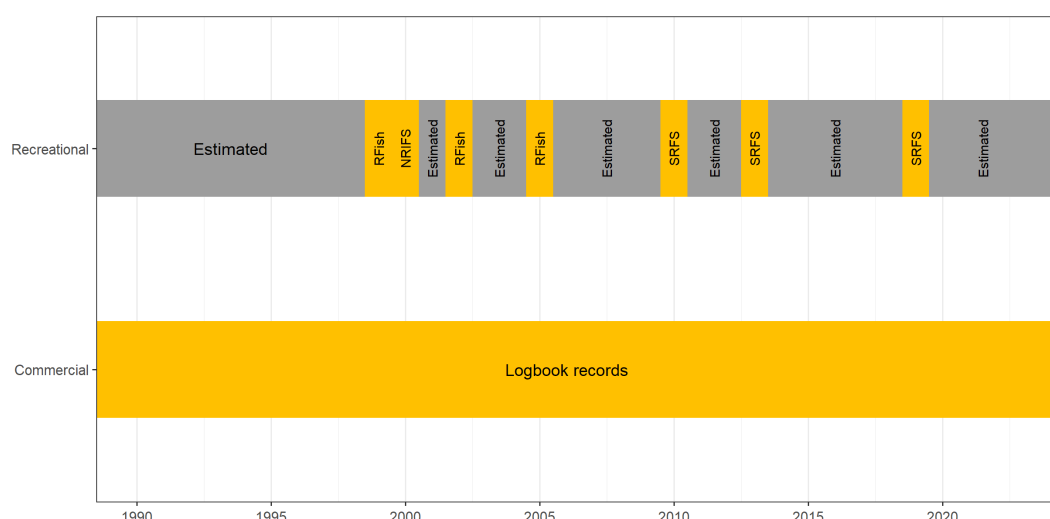


Figure 2.2: Overview of the data for blue swimmer crab retained catch by year, with yellow indicating available data and grey indicating estimated values.

The commercial data were organised for the fishing operation name (anonymous codes called ACN – Authority Chain Number were used), date, fishing logbook 30-minute grid, recorded number of pot lifts, weight of blue swimmer and mud crabs harvested (kg), lunar phase and wind components. Wind, lunar phase, fishing years, fishing months and year-quarter variables were calculated from the fishing dates. Fishing months were factorised from July to June.

Fishing regions were categorised from the logbook grids:

- Moreton Bay: W37, W38, X37, X38,
- Sunshine Coast / offshore: W33, W34, W35, W36, X33, X34, X35, X36, Y33, Y34, Y35, Y36, Z33, Z34, Z35, Z36,
- Hervey Bay: R29, S29, S30, T29, T30, T31, U29, U30, U31, U32, U33, V29, V30, V31, V32, V33, V34, W29, W30, W31, W32, X29, X30, X31, X32, and
- Other: remaining less fished grids.

The wind data were sourced from the Bureau of Meteorology (BOM). Measures of wind speed (km per hour) and direction (degrees from where the wind blew) were averaged into daily readings per weather station. The daily wind data were joined with the harvest data based on date and weather station – grid allocation. For analysis a binary variable 'goodwind' was calculated for wind speeds less than 30 km per hour or about 16 knots (O'Neill et al. 2024). The BOM data was sourced and formatted using the RROCK functions 'get_wind_data' and 'join_wind_data'.

The lunar phase data was a calculated measure of the moon cycle with values ranging between 0 = new moon and 1 = full moon for each catch date. The data were calculated using the lunar R software package, for illumination values with a shift setting of 10.25 hours (Lazaridis 2014). The luminance measure followed a sinusoidal pattern and was advanced 7 days ($\approx$ quarter lunar cycle) into a new variable lunaradv to quantify the cosine (O'Neill et al. 2024). The two variables were modelled together to estimate the variation in catch rate according to the moon phase, contrasting waxing and waning patterns of the moon.

2.3.2 Recreational

Statewide recreational fishing surveys provided estimates of the number of blue swimmer crabs harvested per year on the east coast of Queensland. Seven surveys were used (Table 2.1).

The survey methods used a combination of random phone surveys to sample households to estimate participation rates in fishing, with diary records of crab catches and fishing effort maintained by a sample of households (Department of Agriculture and Fisheries 2020).

Diary records detail participant's fishing activities, including data on fishing location, time spent fishing and the species kept or released.

Survey estimates were statistically weighted to the total Queensland population or regions using benchmarks provided by the Australian Bureau of Statistics (Department of Agriculture and Fisheries 2020).

For a brief about the recreational fishing surveys, read the website: Statewide recreational fishing surveys. The surveys use a stratified sampling approach to ensure representation across the regions, fishing methods, and demographics.

While sufficient records for commercial harvests were available for annual, monthly or quarterly time series, recreational harvests required estimation to fill the missing survey years (Figure 2.2) and to create a monthly time series.

Methods like Lovett et al. (2020) were used to estimate the missing survey years up to 2019 and based on the premise that catch equalled effort times by catch-rate. This assumed fleet 1 catch rates for the annual change in crab abundance (Figure 3.5) and a linear annual increase in recreational effort (Figure E.3). For each survey year, recreational effort (relative) equalled the survey harvest estimate divided by the fleet 1 catch rate. These effort estimates were then modelled for a linear increase by fishing year. The effort for each fishing year was then multiplied by its corresponding catch rate to predict harvest. Known survey results were retained over predicted harvests (Table E.2, Appendix E.2).

Post 2019, a similar estimation process was followed that used data from the boat ramp survey program. This used the 2019 east coast survey harvest and effort estimates for blue swimmer crab. Trends were forecast from 2019 using trailer counts and catch rates from boat ramps. The name of the RROCK function for calculations was 'extend_rec_harvest'. Concepts for this function were published by Filar et al. (2021a) and Mendiolar et al. (2023).

Fractions of unspecified crab harvests were tallied into the known survey estimates. The blue swimmer crab proportion equalled the known species harvest divided by the total crab harvest in each year. This fraction was multiplied by the unspecified crab harvest, to tally in extra blue swimmer crab.

A monthly pattern was generated from blue swimmer crab kept catch rates, collected from boat ramps.

Consideration was given to the standard errors for each of the survey estimates and the number of households with which the estimates were derived. The Australian Bureau of Statistics used the following general advice when interpreting the precision of results by comparing standard errors to their estimates (relative standard error, RSE) (Department of Agriculture and Fisheries 2020):

- Estimates with an RSE of 25% to 50% should be used with caution.
- Estimates with an RSE greater than 50% might be unreliable.
- In addition, estimates with fewer than five households might be considered unreliable.

A constant CV for recreational blue swimmer crab harvest per year was set at the mean RSE of 0.29. Estimates of crab harvest between surveys were similar for the numbers of households 10–69 reporting blue swimmer crab.

2.4 Standardised catch rates

2.4.1 Commercial pot

Standardised catch rates were offset for increased fishing effort. The offset allowed catch rates to be adjusted for increasing numbers of pots per operator-day between fishing years.

An offset is an explanatory variable added or subtracted to the linear model, usually on the log scale for a multiplicative effect (McCullagh and Nelder 1989b). The assumed offset had coefficient = 1, rather than an estimated coefficient.

In fisheries, an offset variable can apply to modelling rates such as catch per unit of effort (Hilborn and Walters 1992). The assumption was that catch per operator-day is directly proportional to the effort (the number of pots fished); this notion was discussed and accepted by the project team. For blue swimmer crab, the offset inferred catch per pot as the catch rate index, rather than catch per day without any measure of effort.

Fishery observer pot-data up to 2014 and data from commercial logbooks 2015–2020 were analysed together in a generalised linear model. This was to develop the annual offset by zone (inshore or offshore), similar to Sumpton et al. (2015) and Lovett et al. (2020).

The idea to extend the time series 2014–2020 with pot numbers from logbooks was to postulate that the trend post 2014 had stabilised and stopped increasing.

The GLM equation for the pot analysis in R was:

$$\text{npots} \sim \exp(\text{zone} + \text{poly}(\text{year}, \text{degree} = 2)) \quad (2.1)$$

where the GLM type and variables were:

- *npots*: number of crab pots used per operator (number)
- *zone*: two zones for inshore fleet 1 and offshore fleet 2 (factor)
- *year*: fishing year 1989 to 2020 (variate; quadratic relationship)
- *GLM family and link function*: Quasi-Poisson and log link

The GLM pot predictions by fishing year and zone were joined into regions against the daily catch rate data (Figure D.1 and Figure D.2, Appendix D), as per Sumpton et al. (2015) and Lovett et al. (2020) and allowed for an:

- Inshore gradual increase between 1989 and 2014 in Moreton Bay (fleet 1 catch rates).
- Offshore faster transition to more fishing gear between 1997 and 2001 (fleet 2) and between 2000 and 2003 for Hervey Bay (fleet 3). Increases were gradual prior to these years and after up until 2014.
- Pot effort was constant post 2014 for no increase.

Annual, quarterly and monthly mean catch rates of blue swimmer crab were standardised using the offsets, in computer software R (R Core Team 2024). Standard errors were calculated for all estimates.

The importance of individual model terms was assessed formally using F statistics by dropping individual terms from the full model.

Given the amount of data and right-skewness in the distribution of catch, standardisations were conducted separately for fleets 1–3 using general linear models.

The general linear models (LM) in the order for monthly, quarterly or annual standardisations by fleet were:

$$\begin{aligned} \logwt &\sim \text{ACN} + \text{grid} + \text{target} + \text{lunar} + \text{lunaradv} + \text{goodwind} + \text{year} : \text{month} + \text{offset}(\log(\text{pots})) \\ &\sim \text{ACN} + \text{grid} + \text{target} + \text{lunar} + \text{lunaradv} + \text{goodwind} + \text{year} : \text{quarter} + \text{offset}(\log(\text{pots})) \quad (2.2) \\ &\sim \text{ACN} + \text{grid} + \text{target} + \text{lunar} + \text{lunaradv} + \text{goodwind} + \text{year} + \text{month} + \text{offset}(\log(\text{pots})) \end{aligned}$$

where the LM type and variables were:

- *logwt*: log-transformed daily harvest per fishing operation of blue swimmer crab (log kg)
- *ACN*: anonymous codes for different fishing operations (factor)
- *grid*: spatial 30 x 30 minute logbook grids fished by the relevant fleet (factor)
- *target*: Effort targeted at blue swimmer crab (binary variate, 1 = TRUE or 0 = FALSE for mud crab)
- *lunar*: luminance measure followed a sinusoidal pattern (variate)
- *lunaradv*: lunar adjusted by a quarter cycle (variate)
- *goodwind*: wind strengths less than 30 km per hour (binary variate, 1 = TRUE and 0 = FALSE)
- *year*: fishing year 1989 to 2024 (factor)
- *month or quarter*: fishing months or fishing year-quarter variables (factor)
- *pots*: annual mean number of pots fished per operation-day by fleet (variate; log-transformed and offset)
- *GLM family and link function*: Normal and identity link

Model development tested general linear, generalised linear and mixed linear models. General linear models were faster in R for the big data and had better diagnostics using a log transformation. DHARMA residuals did not support mixed linear models as the differences and variance between fishing operations was not distributed like a normal random effect (on the log scale).

For blue swimmer crab, a log transformation was used instead of a log-link; see the issue discussion by O'Neill et al. (2024) where a trend-divergence between statistics such as the geometric mean, median and mean might indicate different link-functions or data transformations to be considered. Figure D.3 in Appendix D demonstrated for Moreton Bay that nominal trends were similar, relatively, irrespective of the statistics. This was also the same for other fleets (Figure D.4 and Figure D.5, Appendix D).

Blue swimmer crab harvests were classified as targeted by comparing mud crab catches and pricing data. Lovett et al. (2020) used a mixture model to determine a targeted 'blue swimmer crab fishing day'. This result and application herein classified a target blue swimmer crab day when the value-proportion (p) was greater than 70%:

$$p = \frac{\text{blue}_{\text{kg}}}{\text{blue}_{\text{kg}} + \text{mud}_{\text{kg}} \times \text{value}_{\text{ratio}}} \quad (2.3)$$

where the mud crab value ratio was ≈ 2.7 for the mud crab price of \$33.34 per kg divided by the blue swimmer crab price of \$12.24 per kg (BDO EconSearch 2024).

Catch rate data filters for the standardisations were:

- records that had no blue swimmer crab were omitted.
- only daily records were used; bulk records from more than one day were removed.
- operators who fished in only one year during 1989–2024 were removed.
- operators who had fished less than 30 days during 1989–2024 were removed.

Catch-rate model diagnostics were evaluated for F statistics from the drop1 R procedure, parameter estimates and standard errors, estimates of residual variance, standardised residual plots, DHARMA PIT residuals, and influence plots compared against the nominal catch rates (Hoyle et al. 2024).

The standardisations ensured a continuous time series 1989–2024. Hoyle et al. (2024) advised that splitting catch rates by time should be avoided where possible.

From each LM, standardised catch rates were formed in R by using two steps (O'Neill et al. 2024; VSN International 2022). Prediction of a full interaction table was formed in step A for kg of crab (values on the log scale of the linear predictions were back transformed to kg and bias corrected using half of the model residual variance). Secondly this table was then averaged in step B to form monthly, quarterly or annual catch rates.

Step A used R's PREDICT command, classified by every factor in the LM. In step B, factors that were not specified in prediction of interest were averaged by what was called marginal weights applied to each factor level. That was, by the number of data occurrences, scaled to proportions, for each of the factor levels.

Predictions were set to the middle lunar phase effect, an average fleet profile for operators fishing between 2020–2024, the mean occurrence of good wind days, full targeting of blue swimmer crab, the maximum offset for pot use and the average seasonal and spatial-grid pattern of fishing over years. CVs (log SE) for the monthly, quarterly or annual predictions were taken from the LM table of parameter estimates.

2.4.2 Recreational pot

Blue swimmer crab catch rate data was from the recreational boat ramp surveys conducted by fishery monitoring (FM) 2017–2024, for the Queensland east coast. The data included species catches per boat trip. Catch rates were analysed for kept plus released blue swimmer crab.

The catch rate data contained information on survey date, session (unique identifier for each survey session), siteID (unique identifying number assigned to each boat ramp interview conducted), interview number, boat ramp name, boat trip launch date, launch time, retrieve time, number of fishers, primary target species name, secondary target species name, fishing locations, FM sampling region, fishing method code, species name caught, number kept and number released.

The catch rate data were filtered to include:

- crab potting trips,
- primary or secondary target species specified as blue swimmer crabs or unspecified swimmer crabs,
- zero and nonzero catches, but zero blue swimmer crab catches with nonzero mud crab catches were excluded to remove concern about the target species.

Survey sampling regions were allocated into blue swimmer crab regions as follows:

- Brisbane Offshore → Moreton Bay
- Gold Coast Offshore → Moreton Bay
- Moreton Bay → Moreton Bay
- Sunshine Coast Estuarine → Moreton Bay
- Sunshine Coast Offshore → Moreton Bay
- Fraser Inshore → Hervey Bay
- Hervey Bay → Hervey Bay
- Other regions → Other

Wind, lunar phase, fishing year and fishing month variables were calculated from the launch dates. Trip fishing effort in hours was calculated from the time difference between the survey date and retrieve time, and the launch date and launch time. Any missing hours was imputed to the overall trip mean.

The fleet 7 generalised linear model (GLM) for standardised catch rates was:

$$n \sim \exp(\text{hours} + \text{fishers} + \text{month} + \text{year} * \text{region}) \quad (2.4)$$

where the GLM type and variables were:

- *n*: number of blue swimmer crab (number)
- *hours*: fishing time for the boat trip (variate)
- *fishers*: number of fishers in the boat (variate)
- *month*: fishing months (factor)
- *year*: fishing year (factor)
- *region*: fishing region (factor)
- *GLM family and link function*: Negative binomial and log link

Annual catch rates were standardised and predicted by the R emmeans package, using proportional weights (Lenth 2025).

2.4.3 Survey trawl

The standardised abundance index for blue swimmer crab from the fishery-independent beam trawl survey used data collected from Moreton Bay (Bessell-Browne et al. 2020; Lovett et al. 2020; Fisheries Queensland 2016; Fisheries Queensland 2017). The survey design aims to gather data on the abundance of blue swimmer crabs in Moreton Bay, particularly focusing on pre-recruitment stages of 0+ aged crab. For use in this stock assessment, the index and corresponding size compositions were assumed representative for the entire Queensland east coast.

The survey was conducted in November and December, consisting of 120–179 sampling sites per year in Moreton Bay. Survey dates were weather dependent. No surveys were conducted for the 2017 and 2022 fishing years. The beam trawl was 5 m wide, towing a 3.5 fathom headline net. Trawl swept areas per site were about 0.463 ha.

The generalised linear model (GLM) for survey fleet 8 standardised catch rates was:

$$n \sim \exp(\text{time} + \text{depth} + \text{year} * \text{month} + \text{offset}(\log(\text{sweptarea}))) \quad (2.5)$$

where the GLM type and variables were:

- *n*: number of blue swimmer crab (number, all sizes included)

- *time*: four trawl-start-time groups (factor)
- *depth*: three depth categories (factor)
- *month*: fishing months (factor)
- *year*: fishing year (factor)
- *swept area*: swept area per trawl (variate; log-transformed and offset)
- *GLM family and link function*: Negative binomial and log link

The start time of each trawl shot was grouped into four blocks. The groups covered three-hour blocks following 6 pm, 9 pm, 12 am and 3 am (Bessell-Browne et al. 2020). Depth was categorised into 10 m blocks, with each group representing 0–10, 10–20 and 20–30 metres depth (Bessell-Browne et al. 2020).

Annual catch rates were standardised per hectare and predicted using the R emmeans package, using proportional weights (Lenth 2025).

2.5 Size and discard data

Crab size frequencies were used to inform selectivity schedules and discard fractions by fleet.

Carapace width data were collected before and after the change in minimum legal size in December 2003. These data were tallied in 0.5 cm notch-width size bins ranging 0–23.5 cm. The range of data bins aimed to be inclusive of the observed distribution of carapace widths and the full variance around the growth curve.

The data sources for commercial pot and trawl fishing (fleets 1, 2, 3, 5 and 6), and the beam trawl survey (fleet 8) are listed in Table (2.1). All size measures were by sex. If appropriate, spine tip-to-tip carapace widths were converted to notch measures (Method section 2.6.1).

Most of the commercial measures of crab size were from on-board observer/research sampling of pot and trawl catches or research trawlers operating on commercial grounds (Sumpton et al. 2003; Sumpton et al. 2015). Information describing the fishery-independent beam trawl survey is in report section 2.4.3.

Crab size frequencies for fleet 5 (T1 trawl symbol) were from the fishery-independent otter trawl (FIOT) survey (Fisheries Queensland 2018). The survey primarily monitors the abundance of saucer scallops, with the collection of blue swimmer crab data as a secondary objective. The FIOT survey was undertaken in October. The survey spans ten consecutive nights and followed a random stratified sampling design. Sampling occurred between Noosa and Yeppoon, across water depths ranging from 15 to 70 metres. Survey timing aligned with neap tides. At each survey site, prawn-style otter trawl nets fitted with 43 mm stretched mesh were towed for one nautical mile. Blue swimmer crab data were recorded for notch carapace widths, sex, and abundance counts.

For each size frequency, sample sizes were based on either the number of pots sampled or the number of sites trawled. Size frequencies were tallied by fishing year, quarter, fleet and sex. Size frequencies included discards and retained catches.

Discard fractions were calculated from size frequencies below the minimum legal size. The standard error for fractions was set at 0.2, for relatively broad and simple error assumptions. The fractions were informed by observer and research sampling data and implemented in stock synthesis as fleet-specific discard observations. Discard mortality was important for trawl by-catch and considering total removals. Discard rates and discard mortality primarily affect the model through their contribution to total fishing removals and therefore influence the estimated population scale.

2.6 Biological relationships

2.6.1 Carapace width

The assessment expressed all carapace widths as notch measurements (cm). Some crab measures were converted from spine tip-to-tip measurements (cm).

Mean notch carapace width (cm) at spine carapace width (cm) for each sex was expressed by a quadratic model:

$$\text{notch} \sim -1 + \text{sex} : \text{spine} + \text{sex} : \text{spine}^2 \quad (2.6)$$

where the LM type and variables were:

- *notch*: notch-to-notch carapace width (number, cm)
- *-1*: zero intercept
- *sex*: female or male (factor)
- *spine*: spine tip-to-tip carapace width (linear variate, cm)
- *spine2*: spine * spine (quadratic variate)
- *GLM family and link function*: Normal and identity

The relationships were estimated from paired research data (Table 2.1). For females, the number of crabs analysed equalled $n = 8470$, and for males, $n = 19241$. The analysis used all sized crab, and the quadratic relationship allowed the observed curvature towards a zero intercept.

The R predict function was used to convert spine only measures to a notch measurement. Observation error was then applied using the rnorm function, based on the mean prediction and the model standard deviation. Set.seed was used to control the random number generator. The application of variance reduced granularity in size conversions.

2.6.2 Weight

Mean crab weight (W , kg) at notch carapace width (L , cm) for each sex was expressed in SS by the formula:

$$W = aL^b \quad (2.7)$$

For this, parameters were estimated using a linear model on the log scale:

$$\log(W) \sim -1 + \text{sex} + \text{sex} : \log(\text{notch}) \quad (2.8)$$

where the LM type and variables were:

- *log(W)*: log-transformed individual crab weight (log kg)
- *-1*: zero mean intercept
- *sex*: female and male intercepts (factor)
- *log(notch)*: log-transformed notch carapace width cm (variate)
- *GLM family and link function*: Normal and identity

For females, the number of crabs analysed equalled $n = 4187$, and for males $n = 5413$. For each sex, parameter a was calculated as $a = \exp(\text{sex intercept coefficient})$, while parameter b required no transformation.

2.6.3 Maturity and fecundity

In most species, sexual maturity is attained by age rather than by size (Hancock 1992).

For blue swimmer crab, the age at first maturity was set at one year, based on the growth curve.

Fractions mature (m) were further defined by a size-logistic equation (Methot et al. 2024):

$$m = 1/(1 + \exp(\alpha(\text{notch} - \beta))) \quad (2.9)$$

Parameters were based on Sumpton et al. (2003), where the slope $\alpha = -2.544260118$ and the 50% inflection for maturity $\beta = 8.73522148115377$ cm notch carapace width.

Fecundity, egg production per female crab by size, was assumed proportional to crab weight (Lovett et al. 2020).

2.6.4 Growth

No direct ageing methods or data are available to assess the growth rate of crabs. Several numerical techniques based on length data have been researched, including modal progression analysis and tagging studies (Potter et al. 1986; Sumpton 1994). This assessment used the 3-component modal progression growth model in Sumpton et al. (2015), based on mathematics by Lloyd-Jones et al. (2016). The von Bertalanffy growth parameters by sex are in Table 2.2.

Table 2.2: Growth-curve parameters.

Parameter	Female	Male	Comment
L_{∞}	14.2	18	Mean notch carapace width cm at maximum age
κ	0.8	0.8	Growth rate per year
L_{Amin}	1	1	Minimum length parameter for age 1 month
SD_{young}	0.53	0.73	Standard deviation cm at Amin
SD_{old}	2.0	2.2	Standard deviation cm at maximum age

2.6.5 Natural mortality

Natural mortality rate (M) was defined as the annual instantaneous rate of removal of crab from the population due to causes not associated with fishing.

The assessment assumed one constant rate and was applied equally to female and male crabs.

Three values 1, 1.2, 1.4 were used and considered lifespans of 4.0, 4.5 and 5.5 years. The values were used in previous Queensland assessments and considered ages where growth approached L_{∞} (Figure E.1, Appendix E.1). The growth model identified lower κ to suggest maximum ages ≥ 4.0 years.

The Hamel and Cope (2022) equation calculated M values (The Natural Mortality Tool). The method was based on knowing the maximum age from lightly fished or unfished stocks (Hoyle and Dunn 2024).

2.6.6 Steepness

The assessment compared two steepness values 0.8 and 0.6. Alternative steepness assumptions changed the stock-recruitment relationship and the estimated resilience of the stock to reduced spawning biomass. Higher steepness values implied greater recruitment compensation at low spawning biomass levels, while lower values implied reduced compensation.

Settings were based on profile likelihood plots indicating steepness above 0.5, the protection of female crab limiting reduction in spawning biomass due to fishing, no evidence of sperm limitation and no significant drop in sex ratio for one-year old male abundance (Figure F.3, Figure F.13 and Figure F.14, Appendix F.1.1 and F.3.5) (Sumpton et al. 2003; Sumpton et al. 2015).

The stock assessment used a Beverton-Holt function, with recruitment variation 1990–2023, to specify the spawning stock-recruitment relationship (Haddon 2001). The relationship defined the linkage between annual female-spawning stock size over the whole population and the consequent recruitment of new young crab (called 0+ aged crab) produced by that spawning. The function combines and simplifies the life history stages between birth and age-at-recruitment (Hilborn and Walters 1992).

The Beverton-Holt function contains two parameters: 1) average virgin recruitment for numbers of new 0+ aged fish (labelled R_0), and 2) steepness (labelled h). The steepness parameter defines the behaviour of the stock-recruitment relationship and is sometimes described as the measure of population resilience or productivity when the spawning stock is declining or depleted.

Mathematically, the steepness parameter defines how strong the population responds (through increased survival rate of eggs, larvae and juveniles) when the spawning level is low at 20% of virgin spawning biomass (Haddon 2001). The function can use values between 0.2 and 1.0. For example, values of 0.6 or 0.8 would mean the stock could produce on average 60% or 80% of R_0 , respectively, when the spawning stock had been reduced to 20%; see also the math for recruitment compensation described by Goodyear (1977), Myers et al. (1999) and Begg et al. (2005).

Biologically, steepness defines how decreased competition between individual larvae and juveniles increases their survival rates when the spawning stock size decreases (Hilborn and Walters 1992). The spawning-recruitment relationship incorporates density-dependent survival rates, reflecting population competition for critical resources (Haddon 2001). The relationship infers lower survival of eggs and juveniles when the stock is large, and higher survival when stock level is low. Such behaviour is called recruitment compensation (Goodyear 1977), and is a stochastic process over time.

For fishery management, steepness can influence rebuild times, where higher steepness might indicate fewer years to achieve a target biomass level. Higher values of steepness are also associated with lower biomass ratios for maximum sustainable yield (B_{MSY}/B_0) and higher levels of fishing mortality F_{MSY} (Hillary et al. 2020), which can be difficult to translate into effort control rules when the steepness value is subject to uncertainty. This is a reason to limit fishing mortality below natural mortality, to be more certain of maintaining healthy stock sizes (Hilborn and Walters 2021); and to use biomass proxies for MSY instead (Punt et al. 2014; Sainsbury 2008).

The concepts of spawning and recruitment are not just about how many thousands of eggs are produced per spawner, so that parental abundance is immaterial, or how fast animals grow (Walters and Martell 2004). Steepness is determined by the response of the survival rate of eggs, larvae and juveniles to

changes in parental abundance. Recruitment can compensate for fishing only if survival rates improve when spawning declines (Hilborn and Walters 2021).

Meta-analyses show that the steepness values used in stock assessments can vary between species and stocks, possibly according to the productivity of habitats (Punt et al. 2005; Myers et al. 1999; Thorson 2020). In addition, a range of stock assessment methods can add variability to the range of steepness values seen in analyses. Often, different steepness values need to be tested (O'Neill et al. 2024).

2.7 Population model

2.7.1 Description

Stock synthesis is an age-structured population model that has been applied to a variety of stock assessments globally (Methot and Wetzel 2013).

The software was used to analyse trends in harvest, catch rate, crab size and biological data, to estimate a time series of spawning and exploitable biomass. Uncertainty was quantified through parameter differentiation and MCMC simulations.

The assessment period spanned from 1989 through to 2024, based on available information. Earlier years of size frequency and discard data from 1985 and 1986 and assumed annual average catches supported estimation of the start equilibrium population dynamics for 1989. Sex ratios in the size frequencies were not used (not preserved, as the sexes could not be scaled together to sum to 1.0 Methot et al. 2024).

The age structured model was by sex with quarterly recruitment settlements. Input files detailed the biology and life history characteristics of blue swimmer crabs such as longevity, natural mortality, crab size, reproduction, and functions for recruitment, selectivity and catchability.

Quarterly recruitment settlements were used to model growth and the size frequencies of small crabs (aged less than half a year) sampled by the fishery-independent survey in November and December.

The software was operated through Rstudio using R code to generate the four input text files – starter, data, control and forecast:

- The 'Starter file' specified the data and control file names and other set-up specifications. It defined settings for outputs and jitters of parameters to test maximum likelihood solutions. Fishing mortality outputs were set to be actual rates per year and not fractions of reference points. Depletion reports were set as a fraction of virgin stock.
- The 'Data file' specified the information on which the assessments were based, and the initial sample sizes and CVs for the data. The data were set for 56 years, with four seasons per year, a single area model and eight fleets. The 20 years pre-1989 were used for initial equilibrium harvests. Units of weight were used for commercial harvests and numbers for recreational harvests and the survey.
- The 'Control file' specified the model parameters to be fitted to the data as well as how the data was to be statistically weighted.
- The 'Forecast file' specified management reporting outputs. The file defined the reference points, type and years of forecasting.

Stock synthesis was written in AD Model Builder software (ADMB, Fournier et al. 2011). Key methods were published in peer reviewed journals and reports by NOAA in the USA (Methot and Wetzel 2013; Methot et al. 2024). The SS software version was 3.30.23.1.

The r4ss package allowed for output plotting, statistics and diagnostics (Taylor et al. 2021).

2.7.2 Assumptions

The key assumptions for the assessment included:

- Blue swimmer crabs comprised a single stock along Australia's north east coast (Queensland).
- No immigration or emigration.
- Crabs moved and mixed over time.
- The stock was in an equilibrium fishing state prior to July 1988.
- All legal-sized crab caught were retained.
- The fraction of crab that were female or male at birth was 50%.
- Growth differed by sex. Growth curves were consistent across years with normally distributed error.
- Age at first maturity was set at one year.
- Female reproductive output was based on crab size.
- Female reproductive output was not limited by the number of mature males.
- Crab weight was a function of notch carapace width.
- The instantaneous natural mortality rate per year was constant and did not depend on age or sex.
- Annual recruitment followed a Beverton-Holt function of spawning stock size, with recruitment deviations applied between 1990–2023.
- Selectivity was a function of notch carapace width.
- Finer spatial and demographic patterns were accounted for via fleet and seasonal stratification.
- Discard mortality was low.
- Catch rates inform proportionally on the annual change in selected abundance.

The assumption of proportionality between catch rates and abundance was applied only after standardising catch rates using regression models. This process was intended to reduce variation associated with fishing operations and improve the measurement of abundance trends and fishing efficiency (Hilborn and Walters 1992). Nevertheless, catch rates may still be influenced by other factors. Although standardisation accounted for several sources of variation, these processes may not be fully represented and were therefore considered when specifying variance assumptions and interpreting catch-rate trends.

A single-stock model was adopted as the most parsimonious representation of the population dynamics supported by the available data. Although regional variation in abundance and fishery performance was observed, there was insufficient information to estimate region-specific processes such as recruitment, movement, or productivity with acceptable precision. Consequently, a single-stock model was considered appropriate for assessing stock status at the scale of the managed stock.

2.7.3 Parameters

Parameters were estimated where possible (Table 2.3). No priors were used.

The model commenced 20 years prior to the harvest data available in 1989, assuming deterministic recruitment. Constant harvests by fleets and quarters were used so that the equilibrium dynamics of the spawner-recruitment response was captured pre-1989, rather than lost if the model commenced in 1989

(Methot et al. 2024). The assessment tested two initial constant (warm-up) harvests before 1989, based on the mean or three-quarters of mean harvests by fleet and quarter during the years 1989 to 1993. These constant harvests allowed the model to estimate an initial equilibrium depletion level in 1989.

The alternate stock synthesis method for initial equilibrium conditions, by estimating fishing mortalities by fleet and settlement quarter to match the constant harvests, created too many parameters that were not all estimable. A third model test using a linear increase in pre-1989 harvest showed no significant difference in results compared to using constant warm-up harvests.

Catch rate extra standard deviation (SD) parameters were set as a mean difference between the residual standard error from a Loess (spline) model and GLM standard errors. The Loess models were a simple spline by year. The method followed Sporcic (2022) and O'Neill et al. (2024). The Loess was suggested by Punt (2023). Applying extra-SD was appropriate given uncertainty in potting effort and catch rates. The extra standard deviations, log scale $\approx$ CV, were 0.141, 0.115, 0.177, 0.088 and 0.290 for fleets 1, 2, 3, 7 and 8.

Catchability parameters for each fleet were calculated as simple closed form (float), for analytical solutions (Methot et al. 2024; Haddon 2001). Catch rates were used as relative trends.

Size-based vulnerability (selectivity) schedules were estimated for fleets 1, 2, 5, 6 and 8. Fleet 3 vulnerability mirrored fleet 2. Fleets 4 and 7 vulnerabilities mirrored fleet 1.

Cubic spline vulnerability (pattern 27) was used for fleets 6 and 8, to predict catches of small crab (Methot et al. 2024). The splines used 4 nodes. Three node values were estimated per fleet (Table 2.3). The first node parameter was fixed constant. The slope at the first and last nodes were fixed small to $1e30$. Vulnerability was fixed at zero for size bins below the first node.

Male retention was based on two time blocks, for the change in minimum legal size (MLS) in 2003. Females were protected and had zero retention. Discard mortality rates are in Table 2.3.

In total, the model estimated 16 parameters listed in Table 2.3, plus annual recruitment deviations parameters 1990–2023. The last year 2024 used deterministic recruitment, as crabs generally take one year to enter the fishery (data beyond 2024 would be required to inform the 2024 deviation).

The level of recruitment variability was based on the suggested tuning from the $r4ss$ σ_R information object (Methot et al. 2024).

Settings for the recruitment bias adjustments for all analyses were:

- 1974 for the last year with no bias adjustment.
- 1990 for the first year with full bias adjustment.
- 2023 for the last year with full bias adjustment.
- 2024 for the first recent year with no bias adjustment.
- 0.975 for the maximum bias adjustment.

Lambdas, the emphasis factors used in stock synthesis to re-weight negative log-likelihoods, were not used and set equal to 1.

Francis adjustments were applied to the size composition data (Francis 2011), to calculate effective sample sizes and thus relative weighting against other data inputs like catch rates.

Table 2.3: Key parameters in the population model.

Symbol	Description	Estimated or specified
M	Natural mortality rate per year	Fixed at 1, 1.2, 1.4
$\ln(R_0)$	Natural log of virgin number of recruits	Estimated in phase 1
h	Steepness	Fixed at 0.8, 0.6
η	Simple annual log recruitment deviations.	Estimated in phase 2
σ_R	Standard deviation of log recruitment deviations	Fixed at 0.5
L_{50}	50% logistic vulnerability for fleets 1, 2, and 5	Estimated in phase 3
$L_{95 \text{ width}}$	Difference between 50% and 95% vulnerability. Three parameters for fleets 1, 2, and 5	Estimated in phase 3
S_2-S_4	Spline vulnerability for fleet 6. Nodes positioned at 2.5, 7, 11 and 15 cm.	Estimated in phase 3
S_2-S_4	Spline vulnerability for fleet 8. Nodes positioned at 1.5, 4, 9 and 14 cm.	Estimated in phase 3
SD	Catch rate extra standard deviation by fleet	Fixed from Loess and GLM
ϕ	Quarterly recruitment settlements. Q2 fixed = 0	Estimated in phase 2
D_{pot}	Discard mortality rate for pot fishing	Fixed at 0.01
D_{trawl}	Discard mortality rate for trawling	Fixed at 0.16 (Wassenberg and Hill 1993)

2.7.4 Analyses

Sixteen model runs were used to show the model's sensitivity to parameter values and assumptions (Table 2.4). The ensemble stock assessments 1–12 analysed:

- three natural mortality values of 1, 1.2 and 1.4 per year.
- two steepness values of 0.8 and 0.6.
- two pre-1989 constant harvests – mean and $\frac{3}{4}$ mean, labelled 100% and 75%.

Model tests with $M > 1.4$ made the parameter R_0 and population scale too large, for the two values of steepness.

Analyses 1–12 created an ensemble that accounted for uncertainties in M , h and initial 1989 depletion. The ensemble used median results and considered each analysis equally, to mitigate any skewness. This simple type of model averaging has been used by Australian and Queensland governments (O'Neill et al. 2018; O'Neill et al. 2024; Sumpter et al. 2025), following the concepts by Millar et al. (2015). Klaer (2018) also stated:

- Model structural uncertainty is normally greater than that estimated within any selected model analysis.
- Model averaging and ensemble models are gaining favour to better account for stock assessment uncertainty (e.g., see Millar et al. 2015).

The ensemble confidence intervals incorporated variation across the principal assessment scenarios and key model assumptions. This was a major strength of the assessment because the ensemble was designed to capture the key sources of variation identified during model development. Consequently, the confidence intervals provide a broader representation of stock status than any individual model. However, they do not encompass all potential sources of variation, particularly those associated with regional stock structure and spatial processes that were not explicitly modelled.

Exploratory analyses 13–16 used the middle M and was compared to analysis 2 (Table 2.4). The four analyses considered extra model assumptions and questions (not for the ensemble):

- Reduced commercial harvests in 2001–2005 for possible over reporting (Sumpton et al. 2015).
- Zero discard mortality (D) for checking the influence of trawling.
- Higher L_{∞} growing larger crab for possible underestimation (Sumpton et al. 2015).
- Annual catch rates, rather than quarterly, for fleets 2 and 3. Moreton Bay was used to focus quarterly patterns.

For maximum likelihood results, two standard deviations were used to calculate asymptotic 95% confidence intervals for ensemble results. The standard deviation over analyses, was the square-root of adding the within and between analysis variance components. For MCMC, confidence intervals were based on percentiles and aggregating simulations.

A Markov chain Monte Carlo (MCMC) simulation was performed on all analyses. A total of 500 thousand iterations were run per analysis, with every 100th draw saved to investigate the posterior results.

Convergence of the MCMC was monitored using a factor ($\hat{R}$) (Gelman et al. 2004). Effective sample sizes for each estimated parameter was also calculated, indicating the number of independent draws. Success was determined for values $0.99 < \hat{R} < 1.01$ and independent draws > 400 (Vehtari et al. 2020; Monnahan 2024). MCMC results were used to report biomass estimates.

Table 2.4: Summary of the stock assessment analyses and the ensemble.

Analysis	M	h	Warm-up	Harvest	D	$L_{\infty}^{\text{female}}$	L_{∞}^{male}	Catch rates
1 [†]	1	0.8	100%	logbook	yes	14.2	18	quarterly
2 [†]	1.2	0.8	100%	logbook	yes	14.2	18	quarterly
3 [†]	1.4	0.8	100%	logbook	yes	14.2	18	quarterly
4 [†]	1	0.6	100%	logbook	yes	14.2	18	quarterly
5 [†]	1.2	0.6	100%	logbook	yes	14.2	18	quarterly
6 [†]	1.4	0.6	100%	logbook	yes	14.2	18	quarterly
7 [†]	1	0.8	75%	logbook	yes	14.2	18	quarterly
8 [†]	1.2	0.8	75%	logbook	yes	14.2	18	quarterly
9 [†]	1.4	0.8	75%	logbook	yes	14.2	18	quarterly
10 [†]	1	0.6	75%	logbook	yes	14.2	18	quarterly
11 [†]	1.2	0.6	75%	logbook	yes	14.2	18	quarterly
12 [†]	1.4	0.6	75%	logbook	yes	14.2	18	quarterly
13	1.2	0.8	100%	reduced	yes	14.2	18	quarterly
14	1.2	0.8	100%	logbook	no	14.2	18	quarterly
15	1.2	0.8	100%	logbook	yes	16.4	19.4	quarterly
16	1.2	0.8	100%	logbook	yes	14.2	18	annual

† Analyses 1–12 form the ensemble model; analyses 13–16 were exploratory only)

M natural mortality

h steepness

Warm-up – two pre-1989 equilibrium harvests

D discard mortality

L_{∞} von Bertalanffy growth parameter

3 Results

3.1 Model inputs

3.1.1 Data availability

Figure 3.1 shows the time-series of data for each fleet used in the population model. Pre-1989 harvests, lengths and discards are illustrated, which supported estimation of the population dynamics in 1989.

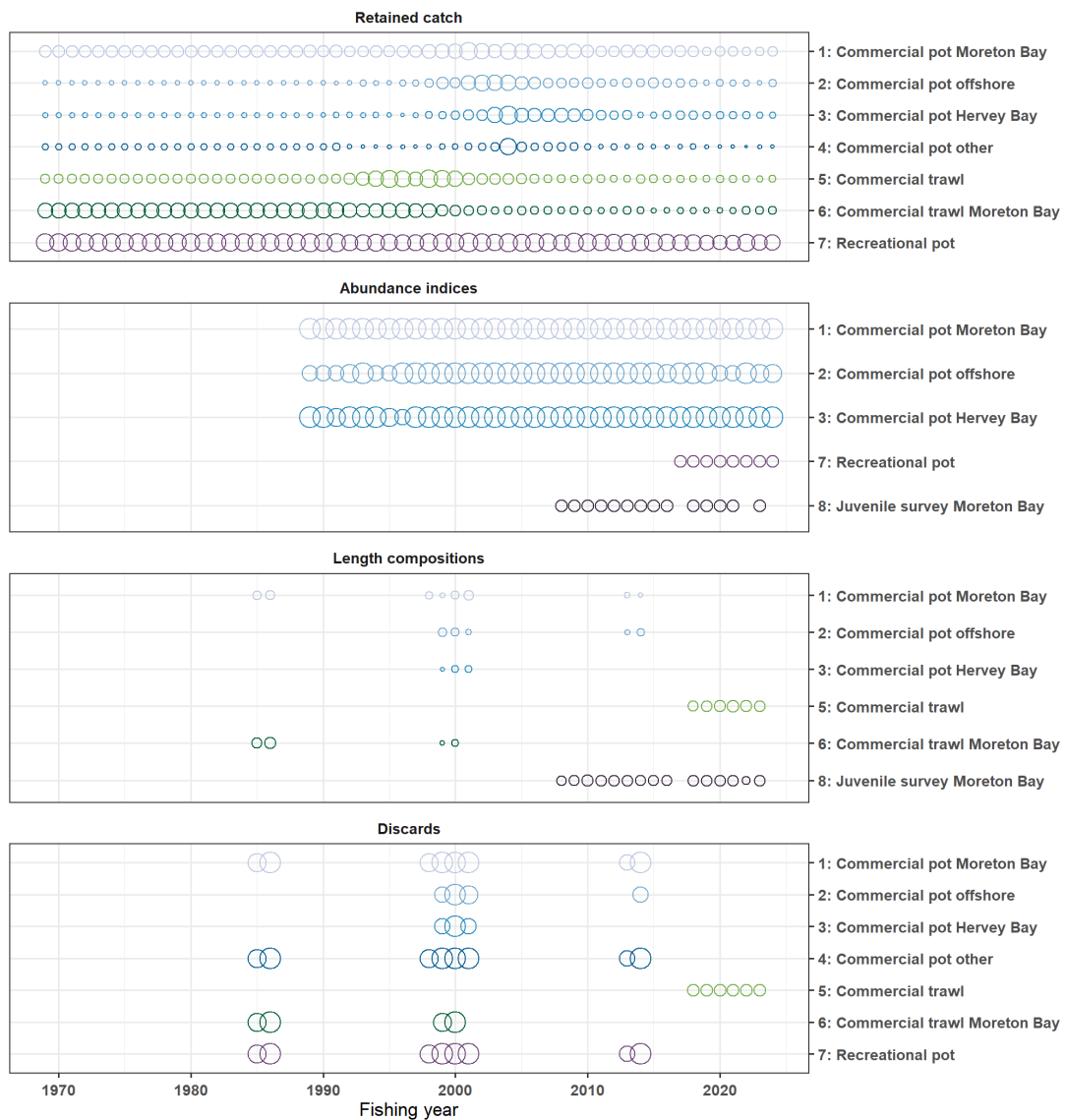


Figure 3.1: Summary of data presence by year for each fleet and category of data type for blue swimmer crab.

3.1.2 Harvest

Total annual harvests are shown in Figure 3.2. Quarterly harvests from 1989 input into the population model are shown in Figure 3.3, with harvests generally higher in the 2nd and 4th quarters for the months leading up to Christmas and in autumn.

Harvests increased from the late 1980s to a peak in the early 2000s, declining again to around 250 t between 2019 and 2024. This 250 t equated to around 800 thousand legal male crab harvested per year. The reductions in harvest since 2019 were associated with new management arrangements (Table A.1), reductions in effort (Figure 3.4) and catch rates (Figure 3.5).

Prior to 1998, most of the pot fishing was conducted around Moreton Bay. In 1998 commercial pot fishers began exploiting populations further offshore and in Hervey Bay, in areas that were previously lightly fished. Fishing in offshore waters and Hervey Bay peaked around 2003–2004, when these harvests contributed significantly to the total harvest. By around 2014, the offshore and Hervey Bay harvests had decreased and returned to levels slightly higher than those pre-expansion.

The 2022–2024 harvest shares show the trawl retained catch was greater than the 10% harvest strategy allocation (Table 3.1, Queensland Government 2021a).

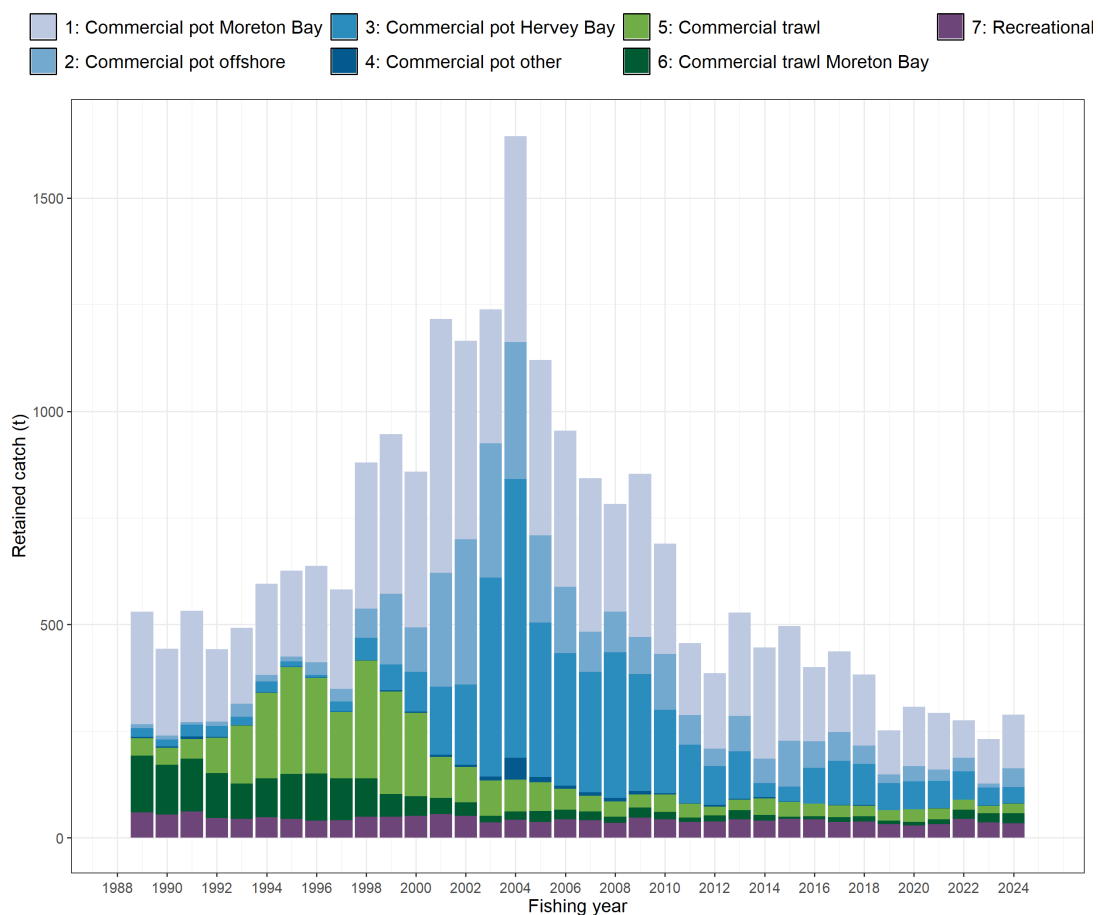


Figure 3.2: Estimated annual retained catch by fleet between 1989 and 2024.

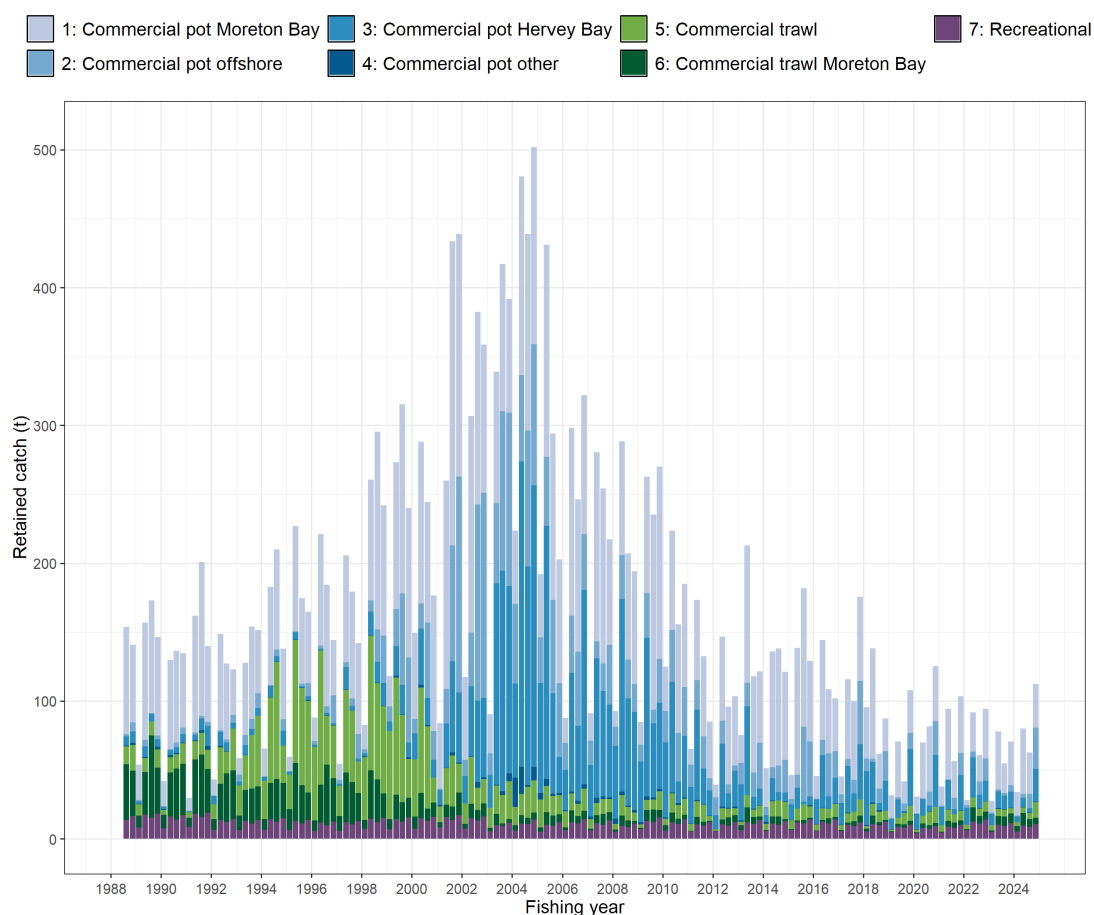


Figure 3.3: Estimated quarterly retained catch by sector between 1989 and 2024

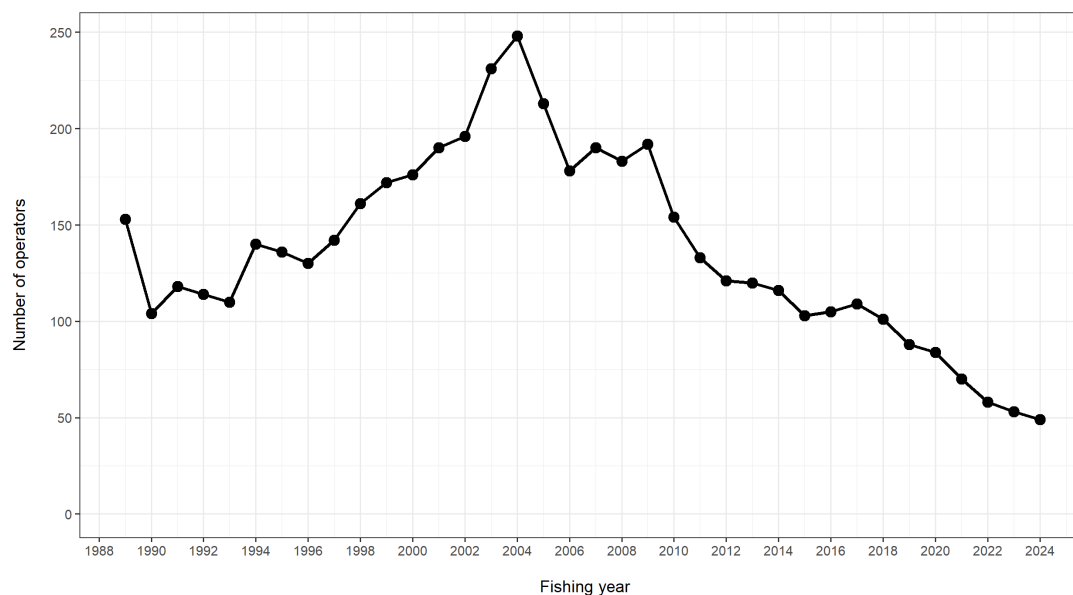


Figure 3.4: Number of commercial C1 pot operators reporting blue swimmer crab harvest between 1989 and 2024.

Table 3.1: Average harvest share per year for blue swimmer crab in Queensland over a three year period 2022–2024.

Sector	Tonnes	Proportion	Sector proportion
Commercial	227	86%	
Pot	184		81%
Trawl	43		19%
Recreational	38	14%	
Pot	38		100%

3.1.3 Catch rates

In general, the time series of catch rates since 2010 showed declining trends (Figure 3.5 and Figure 3.6). Catch rates improved in 2024 across most fleets, with exception of the recreational fishing sector (Figure 3.5).

The following results were generalised from the catch-rate analyses and diagnostics (Appendix D):

- Standardisation primarily accounted for changes in fishing effort, locations fished, between fishing operations (boats) and targeting through time.
- Catch rates experienced temporal and seasonal cycles. Statistical differences were detected between years across fleets, indicating years of improved and reduced catch rates.
- Residuals plots and diagnostics across analyses were satisfactory.
- Significant variance was accounted by classifying targeting of blue swimmer crab or mud crab.
- The inclusion of boat-operation factors and fishing effort (offsets) variables were important in determining annual trends in catch rates.

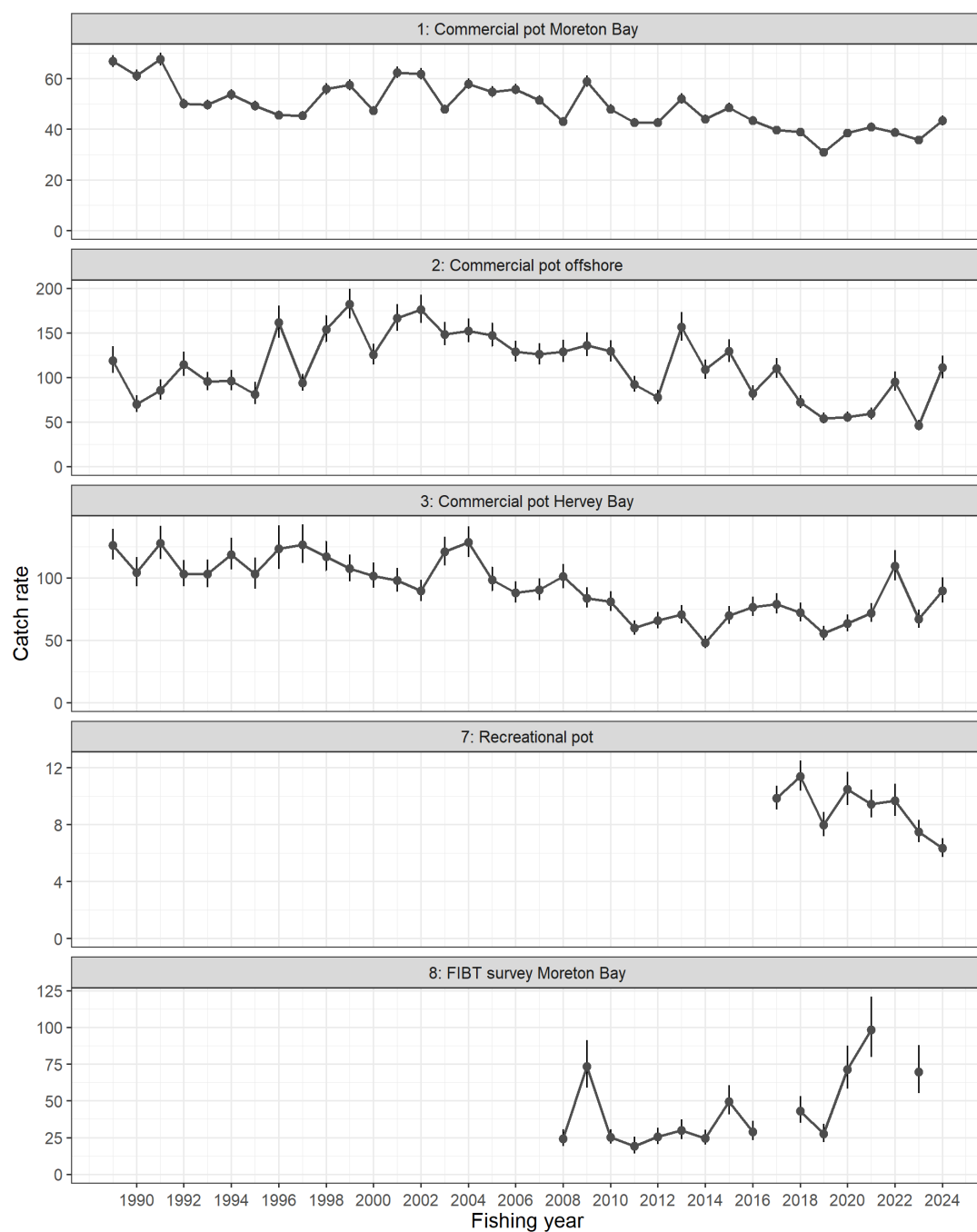


Figure 3.5: Annual standardised catch rates for blue swimmer crab. The standardised units for commercial pot fleets 1 to 3 were kg per operator-day, numbers of crab per boat trip for recreational fleet 7, and numbers of crab per beam trawl for survey fleet 8. 95 percent confidence interval error bars are illustrated.

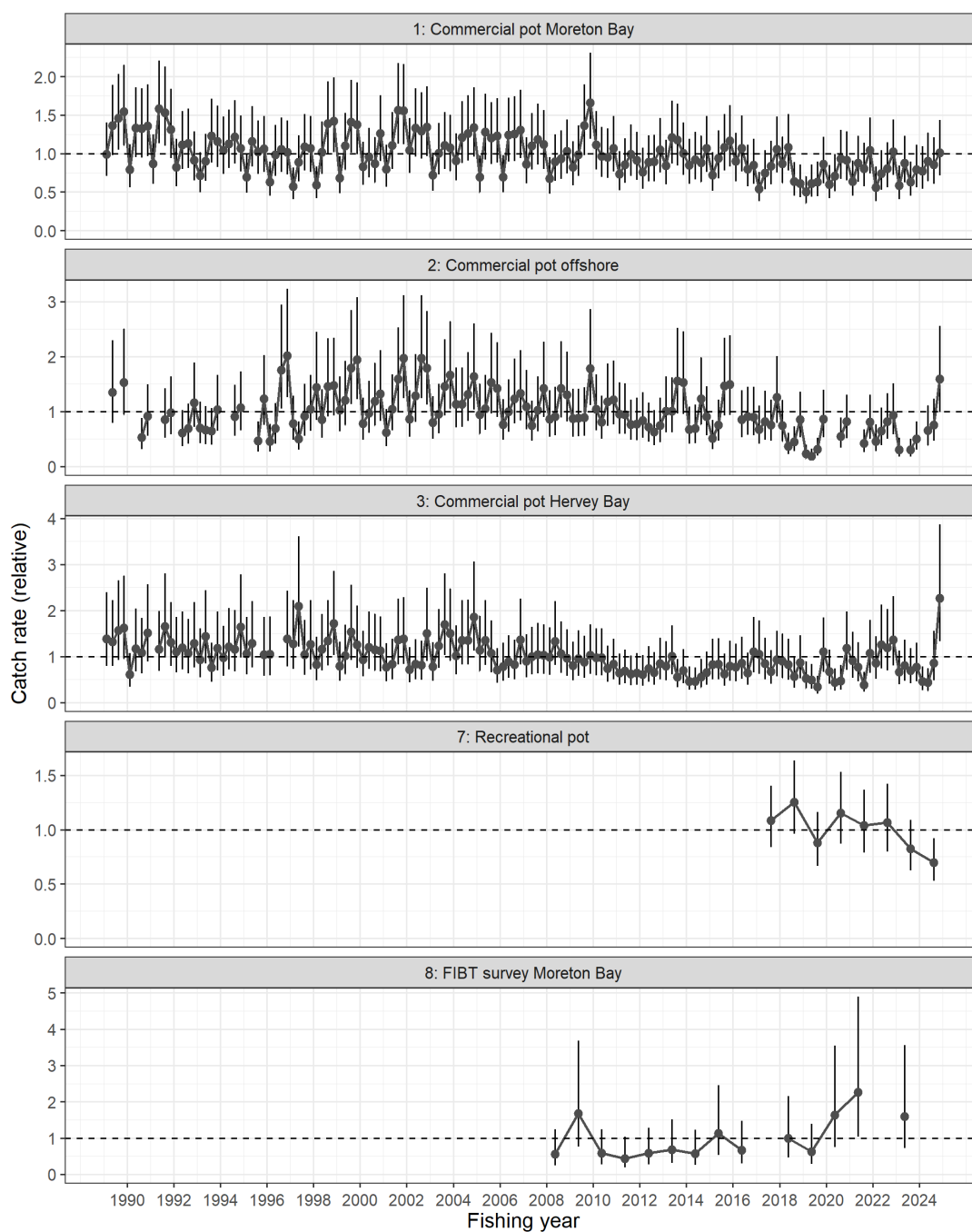


Figure 3.6: Quarterly standardised catch rates for blue swimmer crab, relative to the mean. 95 percent confidence interval error bars are illustrated including extra-SD.

3.1.4 Discards and size

In general, fishers target areas with higher ratios of male crab. Sex ratios from the commercial pot data were 70% – 90% male crab. The male ratios were usually higher in deeper waters.

Discard fractions were higher in Moreton Bay with more females in catches (Figure 3.7). Discards appeared lower in fleets 2 and 3, offshore waters and Hervey Bay. The fractions of female and male crab discarded were less post 2003 with the smaller size limit.

Size frequency plots are in Appendix H. Size distributions by fleet were in general similar at the seasonal level, particularly in the two years of most recent observer data (fleets 1 and 2). In general, harvested crabs were larger offshore and in Hervey Bay, compared to Moreton Bay. Truncation was evident in the male size frequencies, observed by comparing distribution modes to potential maximum sizes (e.g. L_{∞}).

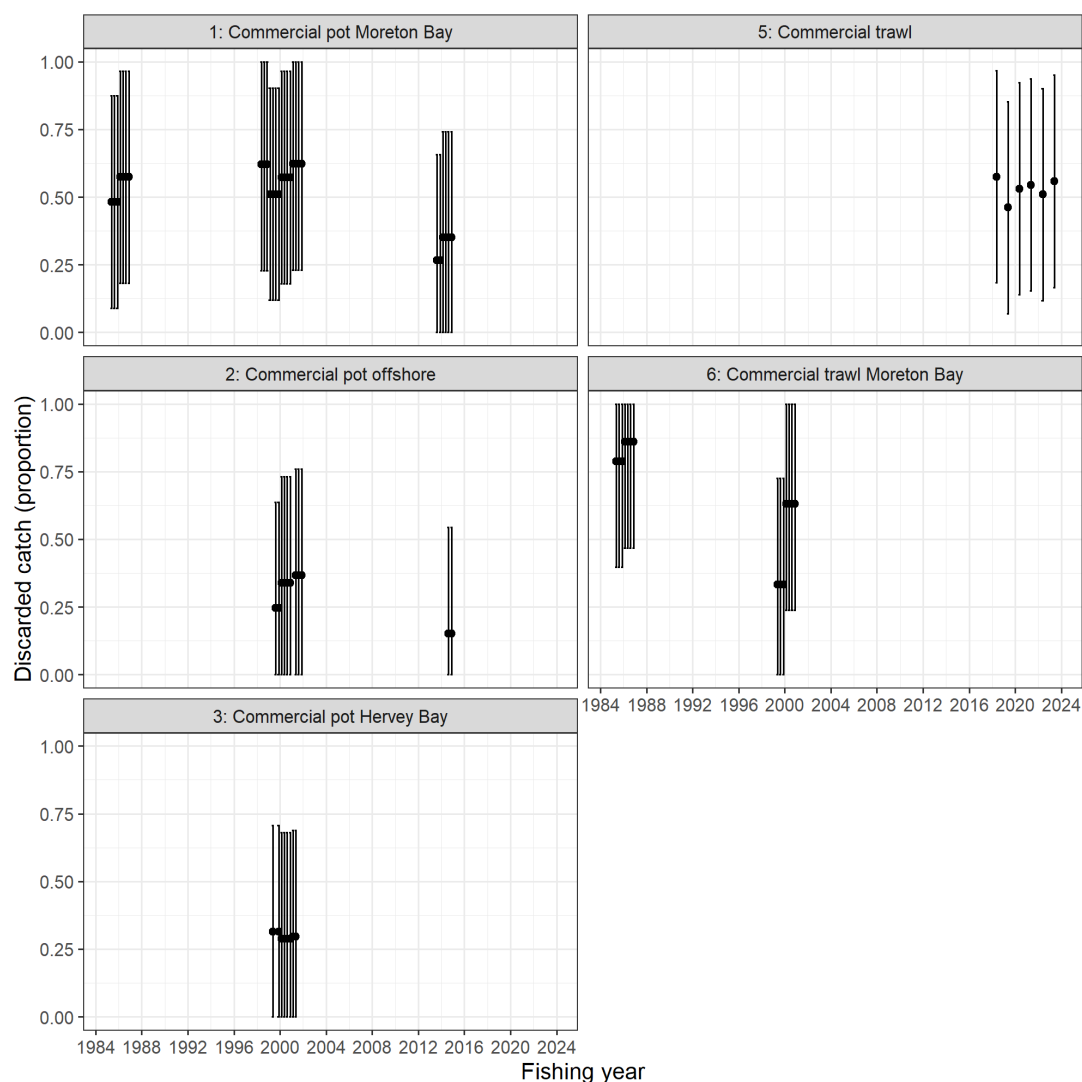


Figure 3.7: Discard proportions of blue swimmer crab input to the model as proportion of catch

3.2 Model outputs

3.2.1 Parameters and fits

Parameter estimates from MCMC across the ensemble (see Table 2.3 and Table 2.4) are listed in Table 3.2.

All analyses resulted in parameter convergence and satisfactory fits to data (Appendix F). Figures F.5 and F.6 (Section F.2) show MCMC diagnostics.

MCMC runs produced higher R_0 estimates than maximum likelihood, by about 7%. Estimates of virgin recruitment (R_0) were negatively correlated with steepness and positively correlated with natural mor-

tality. The R_0 estimates were higher by about 13% compared to the previous assessment that did not include discards (Lovett et al. 2020).

Table 3.2: Summary of MCMC parameter estimates

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Q_{tr_1}	0.32	-0.05	0.72
Recruitment distribution Q_{tr_3}	-1.18	-2.14	-0.49
Recruitment distribution Q_{tr_4}	0.06	-0.22	0.39
$\ln(R_0)$	10.28	9.77	10.83
Commercial pot MBay L_{50}	10.46	10.23	10.68
Commercial pot MBay L_{95}	1.47	1.30	1.65
Commercial pot offshore L_{50}	11.31	10.98	11.62
Commercial pot offshore L_{95}	1.67	1.38	2.00
Commercial trawl L_{50}	10.17	9.59	10.71
Commercial trawl L_{95}	2.58	2.13	3.16
Commercial trawl MBay S_2	-2.51	-2.98	-2.04
Commercial trawl MBay S_3	-0.56	-1.06	-0.06
Commercial trawl MBay S_4	-1.68	-2.49	-0.90
FIBT survey MBay S_2	0.96	0.65	1.27
FIBT survey MBay S_3	-0.45	-0.86	-0.04
FIBT survey MBay S_4	-1.28	-2.10	-0.49

Estimates of crab vulnerability-at-length (selectivity) were consistent between analyses (Table 3.2). The resulting selectivity functions represent the relative proportion of blue swimmer crab at a given length that were vulnerable to fishing by a fleet (ranging from zero to 100%, Figure 3.8). The retention functions were based on the minimum legal sizes (MLS). Discards were assumed to be crab smaller than the MLS.

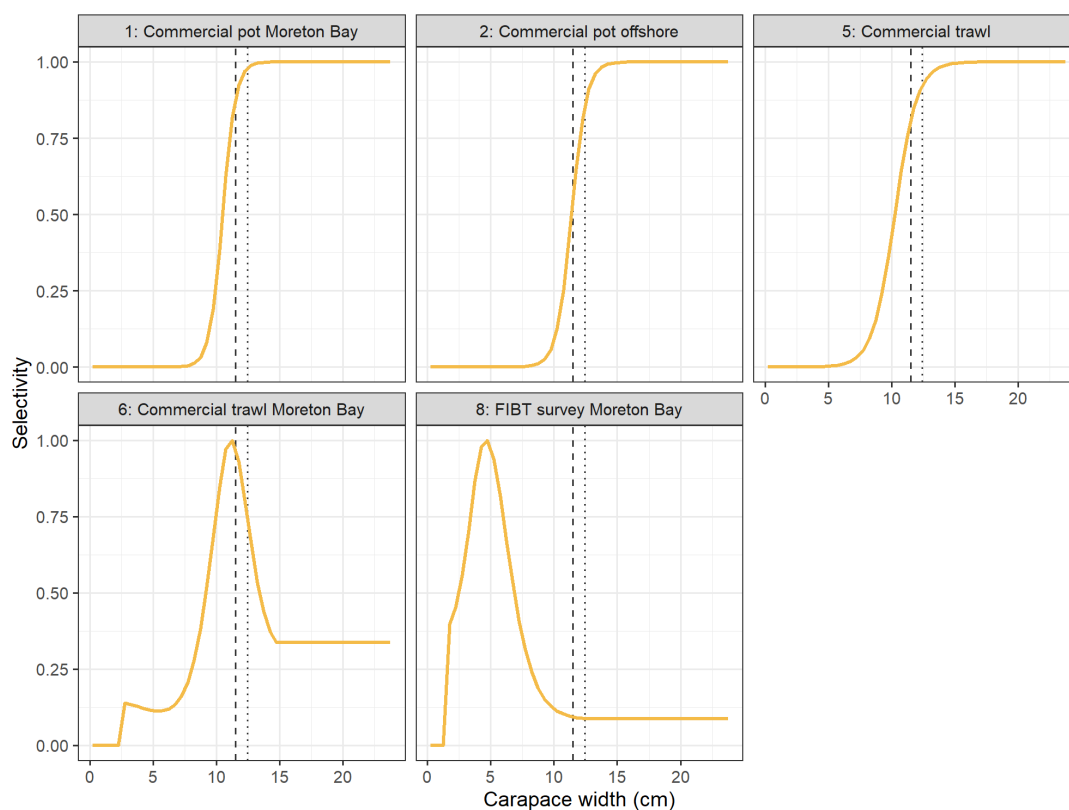


Figure 3.8: Model estimated selectivity for the ensemble MLE model—the dashed line shows the current minimum legal size, the dotted line shows minimum legal size prior to 2003.

Figure 3.9 shows the MCMC and maximum likelihood estimated (MLE) recruitment distribution proportions for each season/quarter. The MCMC recruitment distribution parameters settled more juvenile crab in quarter one, aligning more with August and September spawning (Figure 3.9). However, the MCMC quarterly recruitment parameters did have larger confidence intervals, with MLE estimating more settlement in quarter 2.

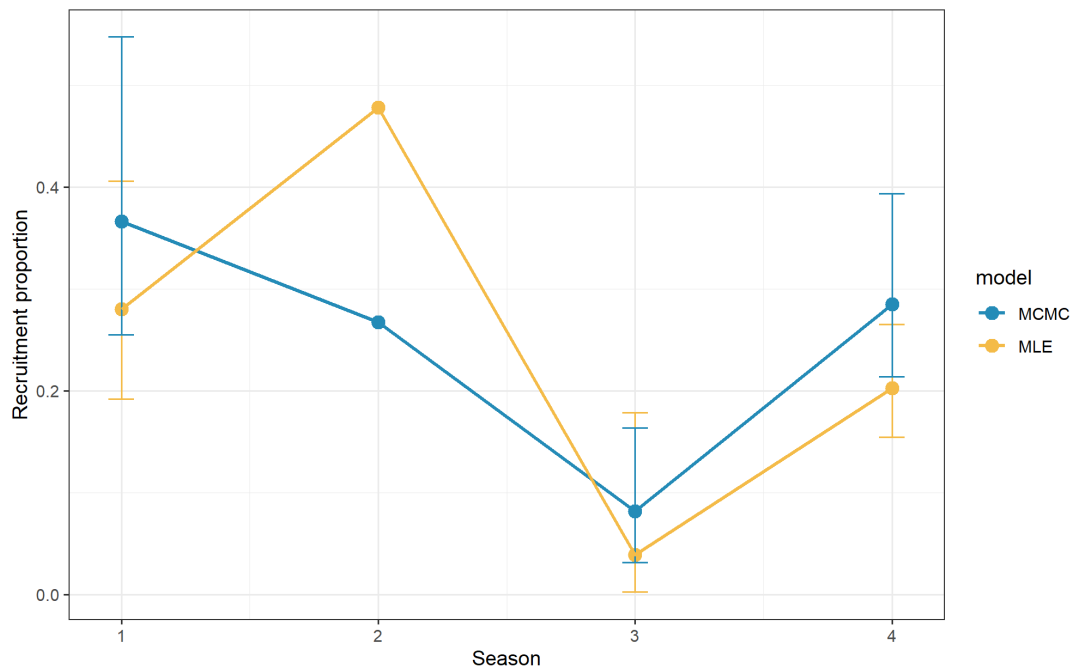


Figure 3.9: Derived recruitment distribution proportions from the MLE and MCMC ensembles—error bars show the 95% confidence intervals.

Plots of model fits to catch rates, size compositions, and discards are provided in Appendix H. For interpretation of diagnostics, the data were characterised by fishing fleets, with no apparent shifts in size selectivity over time, and fishing mortality largely on crab aged $\geq$ one years old.

Model fits to catch rates were lessened by applying extra standard deviations. As a result, model fits to quarterly catch rates were less precise. However, the annual trends were fitted adequately, particularly for Moreton Bay. A lack of fit was noted for recreational fleet 7 in 2024 and 2020–2024 for survey fleet 8.

Overall, size frequencies fits were adequate per fleet (Appendix H). However, an amount of correlation and observation error was suspected in the size input data.

Discards fits were generally above the observed fractions (Appendix H). Again, predictions were flexible by allowing for elevated error and that the observed fishing locations for size frequencies were more for commercial targeting of male crab (non-random).

While all datasets contributed to the assessment, their importance in model estimates varied. Table 3.3 provides a qualitative summary of model fits and the relative information contributed by each dataset, which was generally greater for longer and more complete time series.

Table 3.3: Summary of overall model fits and information provided by the principal datasets.

Fleet and dataset	Model fit	Information provided	Interpretation
Commercial pot-standardised catch-rates for fleets 1, 2 and 3	Good	Strong	Provided a long-term index of fishery trends in male exploitable biomass.
Recreational pot-standardised catch-rate for fleet 7	Moderate	Moderate	Provided supporting information on abundance trends for kept and released crab, although the upturn in 2024 was not indicated like for the commercial pot fishery.
Fishery-independent survey index, called fleet 8	Moderate	Moderate	Provided an independent measure of relative abundance for female and male young crab to support estimation of biomass trends and stock status.
Commercial length compositions for fleets 1, 2, 3, 5 and 6.	Good	Strong	Provided overall information on fleet selectivity and size structures of crab.
Fishery-independent length compositions for fleet 8	Good	Moderate	Provided information on selectivity and size structure for the survey index.
Discard fractions	Moderate	Weak–moderate	Provided information on the proportion of catch released and contributed to estimates of total fishing-related removals.

Note: Model fit described how closely model predictions followed the overall observations. Information provided describes the influence of each dataset on estimates. “Strong” indicates that the dataset materially informed key assessment estimates; “moderate” indicates useful but partly complementary information; and “weak” indicates limited additional influence on assessment outcomes.

3.2.2 Biomass

The estimated biomass ratios from all the ensemble analyses listed in Table 2.4, relative to the unfished state, are shown in Figures 3.10 (Markov chain Monte Carlo results, MCMC) and 3.11 (maximum likelihood estimates, MLE). The MCMC 2024 biomass probability distributions in 2024 are shown in Figure 3.12.

The MCMC ensemble estimated the exploitable biomass for legal-sized male crab in 2024 between 23% and 38% of unfished biomass (Figure 3.10 and Figure 3.12).

The time series of exploitable biomass reflects the high harvests between 1998 and 2010 followed by a general downturn in catch rates and recruitment post 2010. The decline in recruitment post 2010 also adversely affected the spawning biomass (Appendix F.3.3, Figure F.10).

Estimated spawning biomass for mature female crab in 2024 was between 42% and 52%. This percentage was higher than exploitable biomass, due to the protection of females.

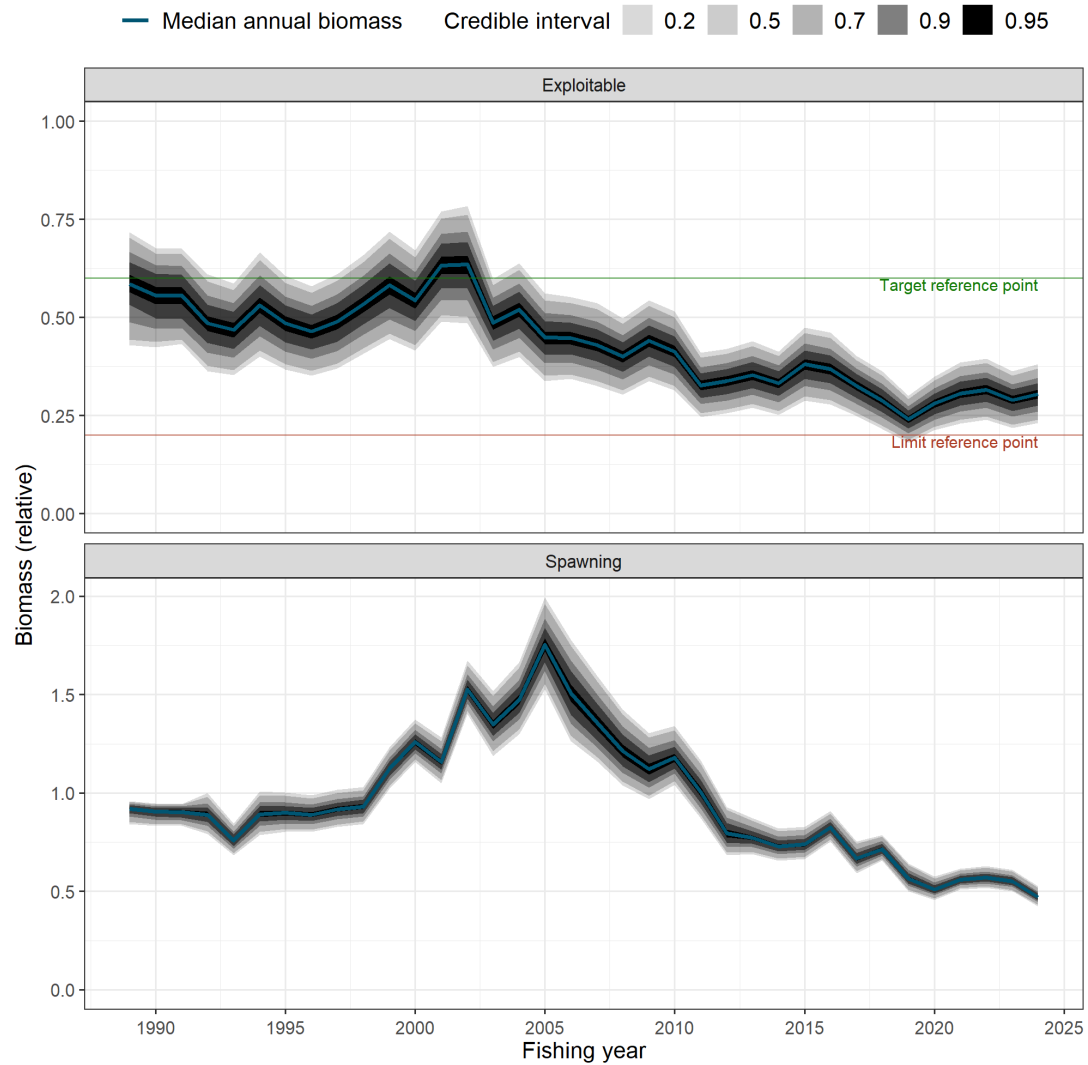


Figure 3.10: Biomass trajectory relative to unfished levels for blue swimmer crab in Queensland, from the MCMC ensemble.

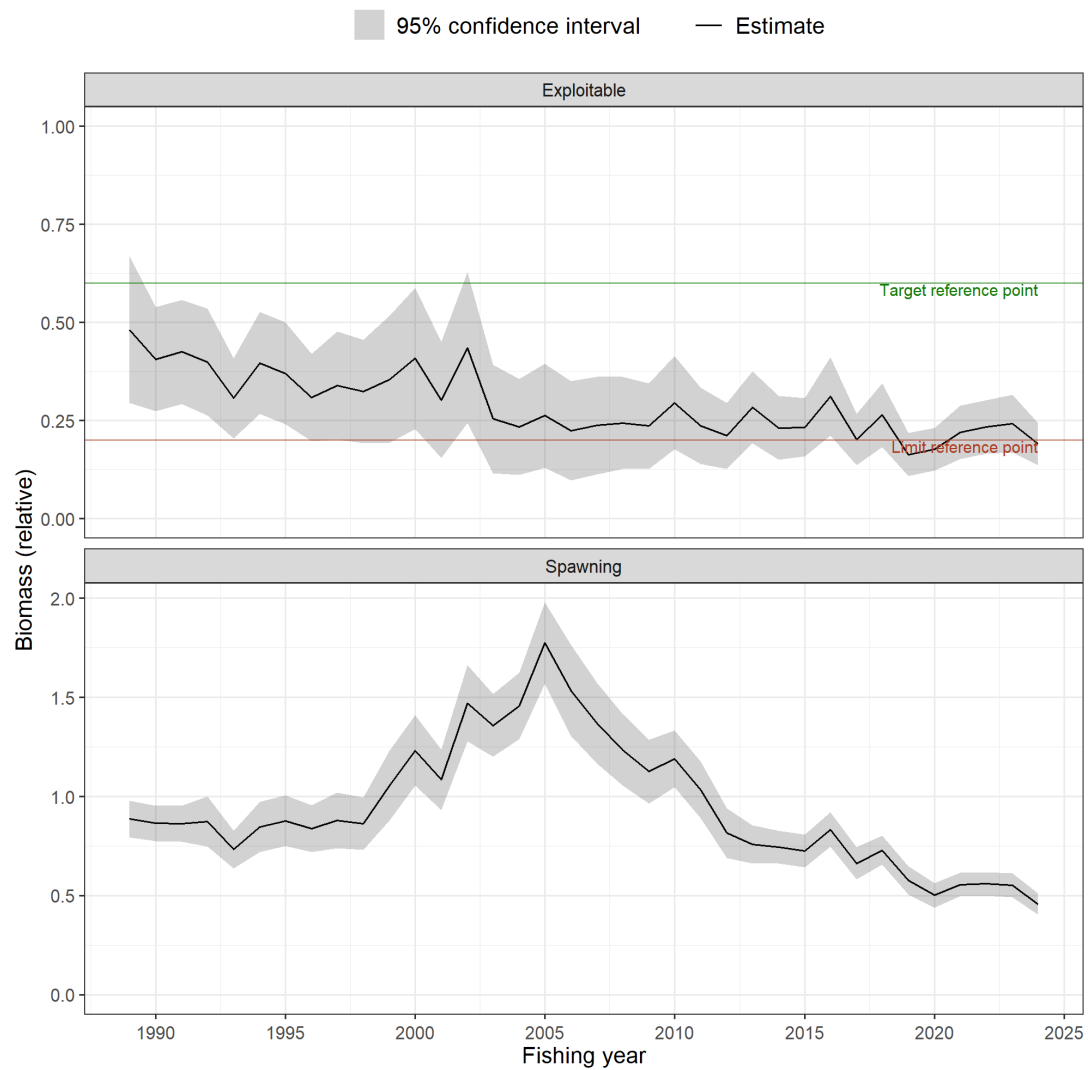


Figure 3.11: Biomass trajectory relative to unfished levels for blue swimmer crab in Queensland, from the MLE ensemble.

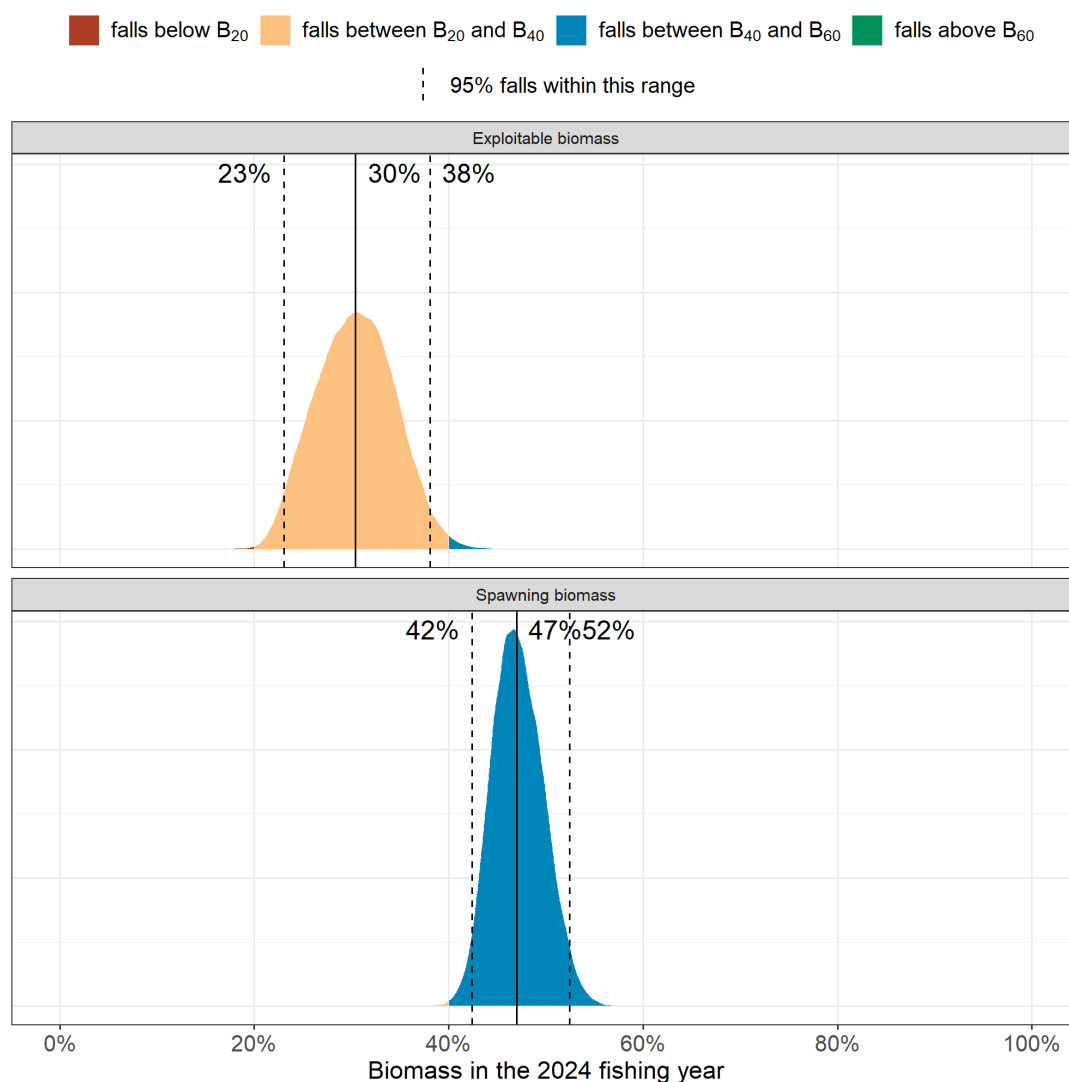


Figure 3.12: Probability distribution of the biomass ratio in 2024 for the MCMC ensemble with the credible interval and probability of biomass falling into the four categories indicated.

MCMC male biomass ratios were higher than MLE (Table 3.4, Figure 3.13 and Table 3.5). The tables and figure present both MLE and MCMC estimates for key stock status metrics. The MLE represents the single best-fitting model solution accompanied by asymptotic standard errors and confidence intervals, whereas the MCMC results are non-asymptotic and describe the range of plausible stock states identified by simulation. Stock status interpretation is therefore based primarily on the MCMC median and credible intervals. The MLE results remain informative because they provide an alternative interpretation of stock status and, in some cases, a lower estimate of male exploitable biomass.

For this assessment, biomass inferences are preferred on MCMC simulations (see report discussion, section 4). MCMC provided a distribution of estimates and together with MLE allowed for better understanding of biomass results. From model profiling, the MLE $\ln(R_0)$ appeared near a likely lower bound (more so for smaller M), where smaller $\ln(R_0)$ values were associated with sharply increasing neagive log-likelihood (Appendix F.1.1, Figure F.1). Therefore, MCMC simulations iterated biomass uncertainty higher than the MLE for male crab.

The likelihood differences between the MLE and MCMC simulations were greater when assuming smaller natural mortality and steepness (Appendix H and Figure F.7). However, these likelihood differences did not influence the variance between MLE and MCMC exploitable biomass ratios (Table 3.5).

Table 3.4: Stock status indicators for blue swimmer crab in Queensland (MCMC and MLE results).

Indicator	MCMC	MLE
Exploitable biomass ratio (relative to unfished)		
Range (95% credible interval)	23–38	14–24
Median	30%	19%
Probability below 20%	0.1%	64.4%
Probability between 20% and 40%	99.3%	35.6%
Probability between 40% and 60%	0.6%	0%
Probability above 60%	0%	0%
Spawning biomass ratio (relative to unfished)		
Range (95% credible interval)	42–52	40–51
Median	47%	46%
Probability below 20%	0%	0%
Probability between 20% and 40%	0.1%	1.7%
Probability between 40% and 60%	99.9%	98.3%
Probability above 60%	0%	0%

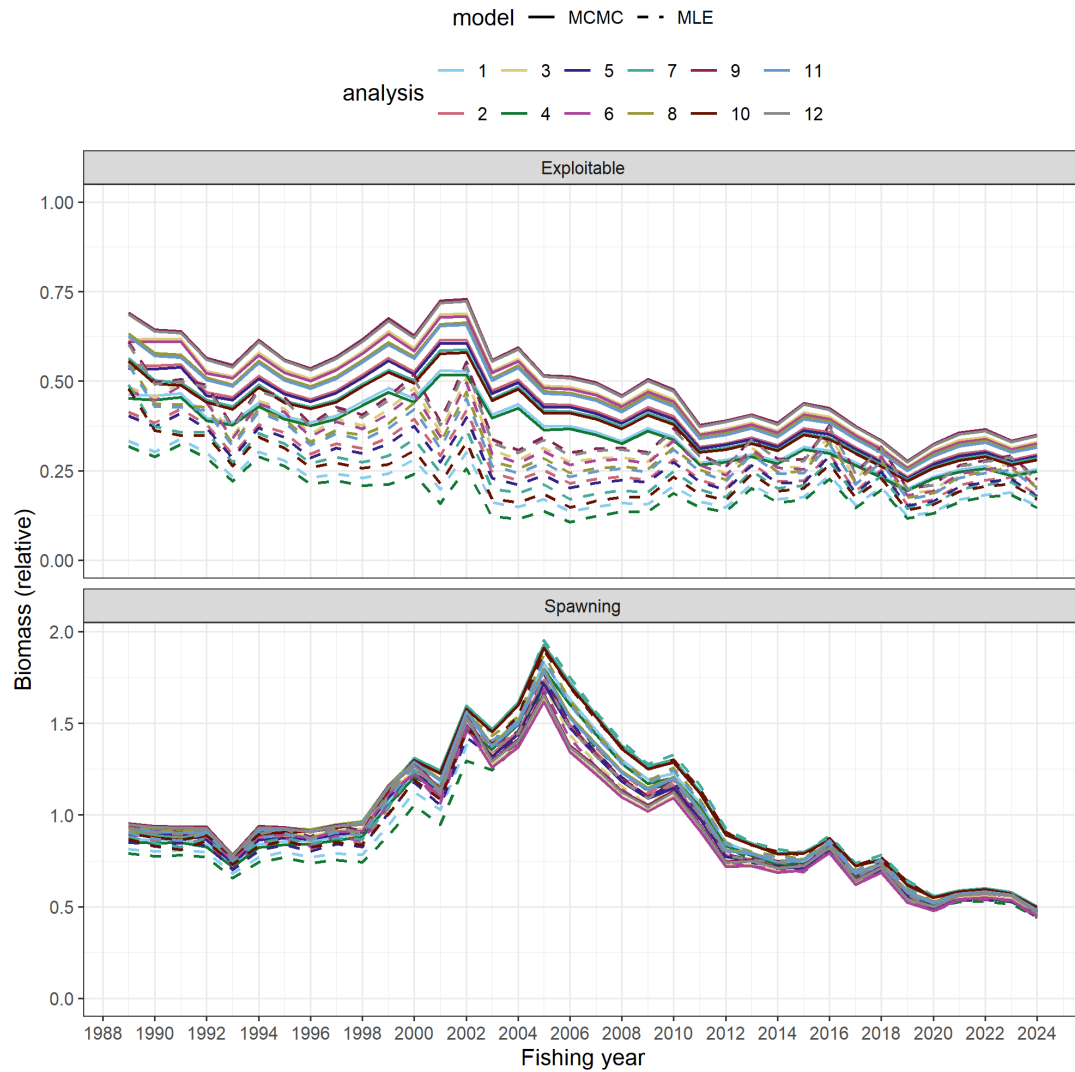


Figure 3.13: Estimated biomass ratios relative to unfished levels for blue swimmer crab from 1989 to 2024 for all ensemble analyses and model types. The upper panel displays exploitable male biomass and the lower panel displays the female spawning biomass. Analyses are shown as MCMC medians (solid lines) and maximum likelihood estimates (dashed lines).

Table 3.5: Final year 2024 biomass for each analysis within the ensemble.

Analysis	Exploitable biomass		Spawning biomass	
	<i>MCMC</i>	<i>MLE</i>	<i>MCMC</i>	<i>MLE</i>
1	25%	15%	47%	47%
2	29%	18%	46%	46%
3	33%	21%	45%	45%
4	25%	15%	46%	46%
5	29%	18%	45%	45%
6	33%	20%	45%	45%
7	28%	17%	50%	50%
8	32%	20%	49%	49%
9	35%	22%	47%	47%
10	28%	17%	50%	50%
11	32%	20%	48%	48%
12	35%	22%	47%	47%

4 Discussion

4.1 Stock status

The status of legal-sized male crab in 2024 was estimated to be between 23% and 38% of unfished biomass (95% credible interval over the MCMC ensemble). The probability that exploitable biomass was below 20% at this time was estimated to be 0.04%.

The decline in recruitment post 2010 also adversely affected the spawning biomass. Despite this, estimated spawning biomass for mature female crab in 2024 remained higher between 42% and 52%, due to the protection of females.

Biomass inferences were based on MCMC simulations. Use of MCMC was inline with workflows for better practices in stock assessment and to improve information used to manage fisheries (Stewart et al. 2013; Monnahan 2024). MCMC is considered useful in models with complex dynamics and also to complement MLE results (Monnahan 2024).

MCMC quantified a higher male exploitable biomass ratio than the MLE, by about 10–13%. In this case, the MLE result signified a lower legal male stock size to have produced the observed harvests, and the MCMC indicated biomass uncertainty was likely higher than MLE. Stewart et al. (2013) noted similar insights and higher MCMC biomass compared to MLE. The result herein was more obvious than Stewart et al. (2013) and might relate to the complex retention and discard dynamics of male crab. For this assessment, the following comments are noted for using MCMC results:

- MLE represented the best fit to the data, a biomass point-estimate towards the lower bound of virgin recruitment R_0 .
- MCMC generated distributions of parameters and the simulations suggested higher male biomass from sampling above the MLE R_0 .
- MCMC sampled more solutions and together with MLE allowed for a better understanding of biomass uncertainty, models and data.
- MCMC was important in forming the ensemble credible intervals.
- MCMC provided a range of hypotheses for biomass and with the ensemble allowed inferences to provide more consistent advice compared to a single estimate or model (Millar et al. 2015).
- MLE male biomass should be considered a plausible lower estimate.

The MCMC results are considered the preferred basis for interpretation because they better reflect the range of plausible stock states. However, the lower MLE estimate provides a plausible alternative view in which male exploitable biomass is near the 20% limit reference point. If the MLE estimate were closer to the true stock status, the risk to the male stock would be greater than implied by the preferred MCMC results. This raises the consideration of a precautionary management approach and continued improvement of the data and assumptions that most strongly influence assessment outcomes. Therefore, the risk is not that the stock spawning biomass is depleted, but that male stock status may be less favourable than indicated by the MCMC estimates, supporting a cautious interpretation of results and future harvest decisions to improve catch rates and profitability.

4.2 Key influences

Several analyses were run to understand which data and parameters were influential in results. The results highlighted future considerations for the ensemble design and add to the findings of past research (Sumpton et al. 2015; Lovett et al. 2020). The key data and parameters influencing results were the pot offsets in commercial catch rates, annual total harvests, variances on data, natural mortality and steepness.

The commercial logbook data had many effort records reported as 50 pots per operation-day. This was the legislated limit for commercial licences with one symbol. Concerns about the accuracy of this data have been noted (Sumpton et al. 2003; Sumpton et al. 2015; Lovett et al. 2020). The observer recorded pot data showed that commercial operations were using more gear than reported in logbooks.

Use of the observer data to create offsets for annual pot increases had a strong effect in catch rate trends before 2014 (Figure D.2). No new observer data were available, and the pot offset post 2014 was set constant at the 2014 level. The resulting trends informed the population model on declining patterns of recruitment.

The project team discussed an adjusted pot offset with a coefficient of 0.88. This coefficient was estimated from commercial logbook data and suggested some correlation among gear. However, a full offset was deemed more rational. Commercial fishers were unlikely to operate their gear too close together (Becker et al. 2024). The use of an offset coefficient of 1 was easier to understand, assuming catch per pot lift was more likely to be the better indicator of abundance. Estimating a pot coefficient was likely difficult and confounded in the logbook data.

Total commercial harvests were reported above 1000 t per year between 2001 and 2005 (Figure G.1). Further review of logbook data is needed to verify harvest amounts for stock assessment. Particularly to identify potential "over reporting of catch", and to assess if consistent across a number of operators, or if excessive harvest was reported by a small subset of fishers. The effect of constraining harvests in high catch years was significant on recruitment deviations. The higher biomass ratios during these years reflected the high harvests. During these years, the model predicted high levels of recruitment to describe the large harvests and higher catch rates. Model inferences indicated the magnitude of harvests may represent over-reporting, as suggested previously by some industry representatives (Sumpton et al. 2015). Assuming smaller harvests lowered spawning biomass ratios (Figure G.3).

Increased standard errors were used on all catch rate indices in stock synthesis to account for various uncertainties in data. This lessened model fits to catch rates compared to previous stock assessments, particularly for within year patterns of seasonality. Even though the fitted annual trends in catch rates were adequate, the seasonal lack-of-fit might have affected the precision of the quarterly parameters for recruitment settlements.

The population model was more sensitive to settings of natural mortality (M) than steepness (h) (Figure F.11). Higher M was associated with higher population sizes and potential yields. Both M and h were not estimable parameters from the available data.

The M values of 1–1.4 per year varied male biomass ratios around $\pm 5\%$ in 2024. M was investigated at higher values up to 1.8 per year and lower values down to 0.8 (Figure F.4). These M values were considered outer limits for longevity, based on using the Hamel and Cope (2022) equation and prior variance range, and the age range suggested by the growth curve.

Higher M above 1.4 was problematic, in underestimating fishing mortality F , particularly with fixed values of higher steepness h . Stock synthesis profiling did not identify a particular M value, noting that M can negatively correlate with h . Future assessments could explore whether M changes with size, such as setting M inversely proportional to crab size (Methot et al. 2024; Hoyle and Dunn 2024).

The central tendency (average or median) of steepness is difficult to identify (O'Neill et al. 2024), particularly for blue swimmer crab with limited data on female spawner abundance. Steepness (h) is a stochastic process relating to the survival of young crabs. A range of fixed h values interacted with fixed values of natural mortality in the final ensemble of results. The 2024 biomass ratios differed little among the steepness scenarios examined, indicating that contemporary stock status and management interpretation were largely insensitive to the steepness values.

4.3 Performance of models

For the ensemble, model fitting compared MLE and MCMC methods across twelve analyses. Individual MLE fits for the quarterly season model took about 20 minutes. Analyses were then MCMC simulated 500,000 iterations, taking about 30 hours of computer time per analysis. This included saving every 100th MCMC iteration and the report file to the server, increasing the run time. The final ensemble was run using parallel computing, taking about 55 hours.

Gradient diagnostics were satisfactory, and Hessians were estimated in all analyses. MCMC trace plots were stable, and convergence illustrated. MLE and MCMC convergence was achieved even after applying extra variance on data inputs. MLE solutions were confirmed using different parameter starting values.

Model development tested monthly and quarterly season dynamics, and a nonseasonal annual model. Monthly was desirable, but MLE run times of around three hours were impractical. The annual model was relatively quick compared to seasonal models. However, the beginning or mid-year dynamics of an annual model did not accommodate for seasonal growth or the timing of the beam trawl survey (fleet 8). The survey in November and December caught small crab aged less than half a year. Annual mid-year predictions over estimated size frequencies of crab aged less than half a year. The intermediate quarterly model provided a balance between model complexity and feasible run times, while capturing the seasonal dynamics of small crabs.

Unfortunately, seasonal von Bertalanffy growth parameter κ was not used (Sumpton et al. 2015; Lovett et al. 2020). Model testing applied seasonal parameters to adjust the base κ value for a season (Methot et al. 2024). However, the seasonal effects appeared nested in growth "morphs". We could not confirm from stock synthesis outputs that crabs can grow from month-to-month or quarter-to-quarter under a seasonal change in κ . Therefore, a constant κ was used to enable size predictions.

Selectivity definitions were required for eight fleets. Male crab retention was defined at the minimum legal-size limit for each time block. This was a knife-edge (steep) logistic function of size. A male offset parameter enabled retention of legal-sized male crabs or no retention of female crab (Methot et al. 2024). Initially, we used the stock synthesis discard option of setting a negative fleet number to simplify the control file. This appeared to run, but unfortunately did not mirror the retention and discard mortality pattern of the lower numbered fleet (Methot et al. 2024); this was checked by comparing outputs for vulnerable biomass, selected biomass and dead biomass. To correct this, full parameter specifications for retention and discard mortality were copied and input for each mirrored fleet.

Recruitment settlement parameters were more difficult to estimate. Consistent solutions were dependent on the specifications of growth parameter κ , selectivity, retention and discard mortality.

Increased standard errors were used on all catch rate indices to account for various uncertainties in data. This appeared to lessen model fits to catch rates, particularly for within year seasonality. Even though the fitted annual trends in catch rates were adequate, the seasonal lack-of-fit might have affected the estimation of the quarterly recruitment settlements. Refitting models with different combinations of catch rates and reduced standard errors made little changes to estimates.

Overall, size frequencies fits were adequate per fleet. However, an amount of correlation and observation error was suspected in the size input data, with some size distributions being more peaked/narrow than expected (Francis 2011). It was not desirable to change the growth model parameters or variances to improve fits. Changing maximum size (L_{∞}) did not help model performance to better predict crab size. Interestingly, the Moreton Bay trawl fleet 6 and survey fleet 8 caught a wider size range of crab. Spline selectivity was used to improve these model predictions.

LM, GLM, LMM, GLMM and GAM catch-rate models were tested. Increased sophistication did not appear to clearly improve catch rate predictions, especially when applying extra error afterwards in stock synthesis. Run times for large datasets were shorter when using LM models.

Further population model development in stock synthesis will assess potential improvements in run times, estimates and performance. Additional testing of data weights, recruitment deviations, standard deviations on catch rates, and use of discard fractions versus discard tonnages might help improve model performance and estimates.

4.4 Environment

In 2010–2024, recruitment deviations were mostly below average (Figure F.10). This result suggested that some years of crab abundance had not responded to reductions in the fishery harvest. Given that similar catch rate declines had occurred in other fisheries (Filar et al. 2021b; O'Neill et al. 2024), it can be hypothesised that environmental conditions may have contributed in-part to this trend.

The hypothesis needs further data and research. Environmental drivers potentially affect the distribution, survival and growth of all life history stages of blue swimmer crab. The potential relationships between measures of abundance of blue swimmer crab and environmental drivers were thus likely to be complex. Consideration of below average recruitment is required in any model forecasts and quota setting.

Blue swimmer crabs in Queensland use a variety of habitats, primarily in estuaries and inshore marine waters. They are commonly found in sandy or sandy-mud bottoms of these areas. Crabs often use seagrass beds, which provide both food and protection.

Seagrass loss and concerns were reported for Tin Can Bay in 2023 (Table A.1). Large floods have occurred in south east Queensland since 2011 (BOM, flood history). This can affect water quality and turbidity, and habitats can be silted following flood events (Saack et al. 2019). Increased sedimentation and nutrient loads have been noted as concerns by commercial fishing in Moreton Bay, along with declines in fish populations (Brewer 2025).

4.5 Stakeholder feedback

Stakeholders generally considered the assessment trends to be consistent with their fishing experience, but highlighted uncertainty associated with historical effort reporting, changes in fishing practices, and the interpretation of catch-rate trends (Appendix C). Participants also noted the potential influence of environmental factors, including habitat change, siltation, flooding, water temperature, and species interactions, on recruitment and abundance. Concerns were raised regarding the accuracy of recreational harvest estimates, historical pot usage, and the effects of market conditions on fishing behaviour and effort patterns. These observations provided valuable context for interpreting assessment results.

4.6 Recommendations

4.6.1 Monitoring

To facilitate stock assessment, annual monitoring of crab-size compositions, sex ratios and catch rates from pot and trawl fishing are fundamental to collect for both female and male crabs. This data can identify change in abundance, recruitment events, selectivity patterns and discard rates. The most recent observer size-data was dated from 2014 for fleets 1 and 2 (> 10 years old) and from 2001 for fleet 3 (> 20 years old).

Such data can be collected by fishery-dependent or independent pot surveys. This requires adequate spatial and temporal sampling to mitigate variance in data and design-control over the locations of sampling effort (Robins et al. 2025). Relative size-frequency distributions and sex ratios can provide key information on measures of fishing mortality (Robins et al. 2025).

Use of electronic reporting systems can enhance the collection of catch and effort information and provide a more cost-effective method of gathering these important data. Further verification of catch and effort data and species targeting would ensure the accuracy of indicators generated from commercial data. Knowing the spatial area fished by commercial operations, from VMS latitude and longitude coordinates, is important for improving the spatial resolution of data for catch rates and density measures.

Hay et al. (2005) noted the important assessment concepts of monitoring the area of habitat and density of crabs per unit of habitat. Reporting on environmental and habitat status data can support management discussions and decision making.

Continuation of annual monitoring of recreational catch rates at boat ramps for indices of annual abundance, and conducting regular statewide surveys of harvest, are critical inputs for serving quantitative stock assessments like in stock synthesis.

Although blue swimmer crab was assessed as a single population unit, regional indicators should be monitored to identify localised changes in stock performance that may not be fully represented in a state-wide assessment. The collection and reporting of regional abundance, recruitment and fishing-pressure indicators would provide early warning of emerging trends and support future assessment refinement.

4.6.2 Stock assessment

Improvements are suggested to optimise time-steps to include seasonal growth in stock synthesis.

Harvest forecasts require new R code to solve reference points for male exploitable biomass. This can be done by iterating forecasts using constant harvests to solve target reference points, and by also considering the number of years to achieve targets.

4.6.3 Research

Annual estimates of discard tonnages and fractions from all sectors are important for the assessment, particularly for trawl by-catch. Time prohibited testing in SS trawl discard estimates from swept area measures versus fractions (Wang et al. 2020). These data are important to confirm population scale in the stock assessment and discard settings for forecasting harvest strategies.

Further size frequency or tagging data is needed by month to refine estimates of blue swimmer crab growth, maximum age and size. The growth and age of large crabs is not known precisely. In the case of the blue swimmer crab, several ageing techniques have been used (Sumpton et al. 2015). The growth curve, based on 3 component mixtures in size frequencies by month (Lloyd-Jones et al. 2016), defined settings of maximum age and natural mortality (M). The population model parameter $\log(R_0)$ was sensitive to M (Figure F.4). Knowing the species lifespan was important to estimate population numbers.

4.6.4 Management

Below, the broader uncertainty (discount factor) with the 2024 stock assessment was calculated following the methods of Ralston et al. (2011).

Three stock assessments have now been conducted for the blue swimmer crab fishery, covering the fishing years 2014, 2019 and 2024. Variance in biomass ratios between models and past assessments was used to quantify the scientific confidence, which is important for informing stock status reporting and quota setting (Queensland Government 2021b). This is relevant given the potential uncertainty around discard tonnages, pot effort, and the annual patterns of recruitment since 2010.

Under the general fishery harvest strategy framework (Queensland Government 2021b, Table 3 - uncertainty tier system), this assessment received an uncertainty category of 0.91. This score was based on a qualitative tier 1-2 assignment process using Ralston et al. (2011).

This score category was confirmed from calculations using assessment data.

For female and male crab respectively, the following standard deviations (log sd) were calculated to represent variation in biomass ratios from the different models and assessments. The potential uncertainty statistics were:

- 0.05 and 0.14 for female and male crab, for the between-analysis sd.
- 0.02 and 0.04, for the within-analysis sd.
- 0.24 and 0.33, for the between-stock-assessment sd, calculated by comparing biomass ratios from this assessment to past results.
- 0.26 and 0.35, were the combined sd, from the three variance components above.
- 0.97 and 0.96, were the calculated uncertainty statistics for the 0.45 P^* buffer in Ralston et al. (2011).
- 0.94 and 0.92, were the calculated uncertainty statistics for the 0.40 P^* buffer in Ralston et al. (2011).

The purpose of reporting the uncertainty statistics, here for management, was to quantify scientific confidence for consideration in stock status reporting and harvest quota. The calculated factors were above 0.91, consistent for a tier 1 or 2 discount factor (Queensland Government 2021b). Consequently, little reduction in management advice would be required to account for assessment uncertainty.

Note that the uncertainty statistic is only one aspect for consideration. It should also be used to support further discussions on the reliability of data inputs, observed trends, and model structures. Accounting for all sources of uncertainty remains complex and can be a substantial task (Klaer 2018).

4.7 Conclusions

This stock assessment was authorised by the Department of Primary Industries to establish the status of north-eastern Australian blue swimmer crabs and to inform management arrangements of the Queensland blue swimmer crab fishery.

Across the MCMC ensemble analyses, the estimated exploitable biomass of legal-sized male blue swimmer crab in fishing year 2024 was approximately 30% of unfished biomass, below the harvest strategy target reference point of 60%, but likely above the 20% limit reference point (Queensland Government 2021a). These biomass results and confidence intervals reflect the quantity and quality of data available.

Although the preferred MCMC results indicated that male biomass was likely above the 20% limit reference point, some MLE results and data limitations suggest that the precise level of biomass remains uncertain. In particular, the more conservative MLE estimates indicate that male exploitable biomass may be closer to the 20% limit reference point than suggested by the preferred MCMC results (Table 3.4). Consequently, a cautious interpretation of male stock status is appropriate, together with ongoing improvement of key assessment data and assumptions.

Key uncertainties and actions remain around improving indices of abundance, reporting and managing levels of actual fishing effort, monitoring of carapace-width compositions and improving estimates of growth and discards.

References

- BDO EconSearch (2024). *Economic and Social Indicators for Queensland's Commercial Fisheries in 2021/22. A report for Fisheries Queensland.*
- Becker, A., D. D. Johnson, H. Pederson, and M. D. Taylor (2024). "Capture Probability of Blue Swimmer Crab (*Portunus armatus*) in Baited Traps and Implications for Trap Survey Design". In: *Fisheries Management and Ecology.*
- Begg G, A., M. F. O'Neill, S. X. Cadrin, and M. A. J. Bergenius (2005). "Stock assessment of the Australian east coast spotted mackerel fishery. CRC Reef Research Centre Technical Report No. 58, CRC Reef Research Centre, Townsville, Australia." In.
- Bessell-Browne, P., A. Prosser, and A. Garland (2020). *Pre-recruit abundance indices from the Fisheries Queensland annual fishery-independent beam trawl survey for eastern king prawn, blue swimmer crab and snapper.* State of Queensland: Fisheries Queensland, the Department of Agriculture and Fisheries.
- Brewer, D. T. (2025). "Fisheries impact statement. In: Sedimentation Impacts in Moreton Bay: a Priority Knowledge Synthesis for The Moreton Bay Foundation. In prep". In.
- Chandrapavan, Arani, Nick Caputi, and Mervi I. Kangas (2019). "The decline and recovery of a crab population from an extreme marine heatwave and a changing climate". In: *Frontiers in Marine Science* 6.
- Chaplin, J., E. S. Yap, E. Sezmis, and I. C. Potter (2001). *Genetic (microsatellite) determination of the stock structure of the blue swimmer crab in Australia. Fisheries Research and Development Corporation, FRDC Project No. 98/118. Murdoch University, Western Australia.*
- Clarke, K., S. Ryan, W. Sumton, S. Gaddes, M. Doohan, C. Bullock, L. Williams, N. Frost, J. Higs, and M Dunning (2004). *Ecological assessment of the Queensland blue swimmer crab pot fishery.* Queensland: Department of Primary Industries and Fisheries.
- Department of Agriculture and Fisheries (2020). *Metadata for the Queensland Statewide Recreational Fishing Surveys.*
- Dowling, N. A., C. M. Dichmont, W. Venables, A. D. M. Smith, D. C. Smith, D. Power, and D. Galeano (2013). "From low- to high-value fisheries: Is it possible to quantify the trade-off between management cost, risk and catch?" In: *Marine Policy* 40.
- Filar, J., S. Helmke, M. Holden, T. Martin, M. Mendiolar, M. F. O'Neill, D. Teixeira, and J. Webley (2021a). *Estimating Queensland's recreational catch between statewide recreational fishery surveys. School of Mathematics and Physics, Centre for Applications in Natural Resource Mathematics, The University of Queensland.*
- Filar, J. A., A. J. Courtney, L. J. Gibson, R. Jemison, S. Leahy, Y. S. Lei, M. Mendiolar, J. Mitchell, B. Robson, C. Steinberg, S. Williams, W.-H. Yang, and N. Ye (2021b). *Modelling environmental changes and effects on wild-caught species in Queensland. Department of Agriculture and Fisheries, Queensland, The University of Queensland and the Australian Institute of Marine Science. FRDC project 2019-013.*
- Fisheries Queensland (2016). *Fishery Monitoring Sampling Protocol Section 1: Eastern king prawn. Department of Agriculture and Fisheries. Brisbane, Australia.*
- (2017). *Fishery Monitoring Sampling Protocol Section 2: Eastern king prawn. Department of Agriculture and Fisheries. Brisbane, Australia.*

- (2018). *Fishery Monitoring Sampling Protocol Section 1: Saucer Scallop*. Department of Agriculture and Fisheries. Brisbane, Australia.
- Fournier, David A., Hans J. Skaug, Johnnoel Ancheta, James Ianelli, Arni Magnusson, Mark N. Maunder, Anders Nielsen, and John Sibert (Oct. 2011). “AD Model Builder: Using automatic differentiation for statistical inference of highly parameterized complex nonlinear models”. In: *Optimization Methods and Software* 27.2, DOI: 10.1080/10556788.2011.597854.
- Francis, R. I. C. Chris (2011). “Data weighting in statistical fisheries stock assessment models”. In: *Canadian Journal of Fisheries and Aquatic Sciences* 68.6, pp. 1124–1138.
- Gelman, A., J.B. Carlin, H.S. Stern, and D.B. Rubin (2004). *Bayesian Data Analysis*. Chapman & Hall/CRC.
- Goodyear, C. P. (1977). “Assessing the impact of power plant mortality on the compensatory reserve of fish populations”. In: *Conference on Assessing the Effects of Power Plant Induced Mortality on Fish populations*. Ed. by Webster van Winkle. New York: Pergamon Press, pp. 186–195.
- Haddon, Malcolm (2001). *Modelling and Quantitative Methods in Fisheries*. Boca Raton, FL: CRC Press.
- Hamel, Owen S. and Jason M. Cope (2022). “Development and considerations for application of a longevity-based prior for the natural mortality rate”. In: *Fisheries Research* 256.
- Hancock, D. A. (1992). “Legal sizes and their use in fisheries management. Keynote address: B. J. Hill, page 9. Australian Society for Fish Biology Workshop, 24 August 1990. Bureau of Rural Resources Proceedings No. 13.” In: p. 135.
- Hay, T., N. A. Gribble, C. de Vries, K. Danaher, M. Dunning, M. Hearnden, P. Caley, C. Wright, I. Brown, S. Bailey, and M. Phelan (2005). *Methods for monitoring the abundance and habitat of the northern Australian mud crab Scylla serrata*. FRDC Project 2000/142. The Northern Territory of Australia, Department of Business Industry and Resource Development, The State of Queensland, Department of Primary Industries and Fisheries and the Fisheries Research and Development Corporation 2005.
- Henry, G. W. and J. M. Lyle (2003). *The National Recreational and Indigenous Fishing Survey / edited by Gary W. Henry and Jeremy M. Lyle*. NSW Fisheries final report series ; no. 48. Cronulla, NSW: NSW Fisheries.
- Hewitt, Daniel E., Hayden T. Schilling, Roshan Hanamseth, Jason D. Everett, Junde Li, Moninya Roughan, Daniel D. Johnson, Iain M. Suthers, and Matthew D. Taylor (2022). “Mesoscale oceanographic features drive divergent patterns in connectivity for co-occurring estuarine portunid crabs”. In: *Fisheries Oceanography* 31.6, pp. 587–600.
- Higgs, J. (1999). *Experimental recreational catch estimates for Queensland residents*. RFISH technical report : results from the 1997 diary round ; no.2. Brisbane: Queensland Fisheries Management Authority.
- Higgs, Jim, Len Olyott, and Kirrily McInnes (2007). *Experimental Results from the Third Statewide Recreational Fishing Information System Diary Program (2002)*. Brisbane: Queensland Department of Primary Industries and Fisheries.
- Hilborn, R. and C. J. Walters (1992). *Quantitative fisheries stock assessment: choice, dynamics and uncertainty*. Chapman and Hall, p. 570.
- Hilborn, Ray and Carl J. Walters (2021). “Steep recruitment relationships result from modest changes in egg to recruit mortality rates”. In: *Fisheries Research* 237, p. 105872.
- Hillary, R., A. Preece, and C. Davies (2020). *Information breakdown for steepness parameter in the CCSBT OM*. CSIRO Oceans & Atmosphere.
- Hoyle, S. D. and A. Dunn (2024). *Review of the 2024 stock assessment for king threadfin (Polydactylus macrochir) in the Gulf of Carpentaria, Queensland*. Hoyle Consulting & Ocean Environmental. 47 p. Report.
- Hoyle, Simon D., Robert A. Campbell, Nicholas D. Ducharme-Barth, Arnaud Grüss, Bradley R. Moore, James T. Thorson, Laura Tremblay-Boyer, Henning Winker, Shijie Zhou, and Mark N. Maunder

- (2024). "Catch per unit effort modelling for stock assessment: A summary of good practices". In: *Fisheries Research* 269.
- Johnston, D., D. Harris, A. Chandrapavan, R. Hanamseth, D. Johnson, and A. Garland (2024). *Blue swimmer crab (2023)*. In Anthony Roelofs, Toby Piddocke, Crispian Ashby, Simon Conron, Klaas Hartmann, Alex Hesp, Patrick Hone, Ian Jacobsen, Marlee Jesson-Kerr, Stephen Mayfield, John Stewart, Michael Usher, James Woodhams and Daniel Wright (eds) 2024, *Status of Australian Fish Stocks Reports 2024*, Fisheries Research and Development Corporation. Canberra.
- Klaer, N. (2018). *Independent review of the stock assessment of Australian east coast snapper*. Prepared for Queensland Department of Agriculture and Fisheries.
- Lazaridis, E. (2014). *Lunar Phase and Distance, Seasons and Other Environmental Factors*. R software library.
- Lenth, R. V. et. al. (2025). *Estimated Marginal Means, aka Least-Squares Means*.
- Lloyd-Jones, L. R., H. D. Nguyen, G. J. McLachlan, W. Sumpton, and Y. G. Wang (2016). "Mixture of time-dependent growth models with an application to blue swimmer crab length-frequency data". In: *Biometrics* 72.4, pp. 1255–1265.
- Lovett, R. A., M. F. O'Neill, and A. Garland (2020). *Stock assessment of Queensland east coast blue swimmer crab (Portunus armatus)*. Fisheries Queensland, Department of Agriculture and Fisheries. 60 p.
- McCullagh, P. and J. A. Nelder (1989a). *Generalized linear models*. 2nd ed. London: Chapman and Hall.
- McCullagh, Peter and John A. Nelder (1989b). *Generalized Linear Models*. 2nd. Springer.
- McInnes, Kirrily (2008). *Experimental Results from the Fourth Queensland Recreational Fishing Diary Program (2005)*. Brisbane: Department of Primary Industries and Fisheries.
- Meagher, T.D. (1971). "Ecology of the crab *Portunus pelagicus* in south Western Australia". Ph.D. University of Western Australia.
- Mendiolar, M., J. A. Filar, M. F. O'Neill, T. Martin, D. Teixeira, J. Webley, and M. Holden (July 2023). "Estimating recreational catch". In: ISBN: 978-0-9872143-0-0, pp. 586–592.
- Methot, R. D. and C. R. Wetzel (2013). "Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management". In: *Fisheries Research* 142, pp. 86–99.
- Methot, R. D., C. R. Wetzel, I. G. Taylor, K. L. Doering, and K. F. Johnson (2024). *Stock synthesis user manual*. NOAA Fisheries. U.S. Department of Commerce.
- Millar, C. P., E. Jardim, F. Scott, G. C. Osio, I. Mosqueira, and N. Alzorriz (2015). "Model averaging to streamline the stock assessment process". In: *ICES Journal of Marine Science* 72.1, pp. 93–98.
- Monnahan, Cole C. (2024). "Toward good practices for Bayesian data-rich fisheries stock assessments using a modern statistical workflow". In: *Fisheries Research* 275, p. 107024.
- Myers, R. A., K. G. Bowen, and N. J. Barrowman (1999). "Maximum reproductive rate of fish at low population sizes". In: *Canadian Journal of Fisheries and Aquatic Sciences* 56.12, pp. 2404–2419.
- O'Neill, M. F., J. Langstreth, S. M. Buckley, and J. Stewart (2018). *Stock assessment of Australian east coast Spanish mackerel. Predictions of stock status and reference points*. Department of Agriculture, Fisheries and Forestry. Queensland Government.
- O'Neill, M. F., J. C. Langstreth, A. G. Trappett, and R. C. Buckworth (2024). *Torres Strait Finfish Fishery: Spanish mackerel stock assessment, with data to June 2023. Year three report*. Torres Strait AFMA Project Number: 2020/0815. Department of Agriculture and Fisheries, Queensland Government. 151 pages.
- Penn, J. W. (1977). *Trawl caught fish and crustaceans from Cockburn Sound / J.W. Penn*. Report (Western Australia. Department of Fisheries and Wildlife) no. 20. Perth, W.A: Dept. of Fisheries and Wildlife.

- Potter, I. C., P. J. Chrystal, and N. R. Loneragan (1983). "The biology of the blue manna crab *Portunus pelagicus* in an Australian estuary". In: *Marine Biology* 78.1, pp. 75–85.
- Potter, M. A., W. D. Sumpton, Fisheries Research Branch, Queensland, and Fishing Industry Research Trust Account (1986). *A study of the sand crab (Portunus pelagicus) and its exploitation in a subtropical multisector fishery : FIRTA project 84/23 final report*. English. Cover title. Brisbane : Queensland Department of Primary Industries.
- Potter, M. A., W. D. Sumpton, and G. S. Smith (1991). "Movement, fishery sector impact, and factors affecting the recapture rate of tagged sand crabs, *Portunus pelagicus* (L.), in Moreton Bay, Queensland". In: *Marine and Freshwater Research* 42.6, pp. 751–760.
- Punt, A. E., A. D. M. Smith, D. C. Smith, G. N. Tuck, and N. L. Klaer (2014). "Selecting relative abundance proxies for B-MSY and B-MEY". In: *Ices Journal of Marine Science* 71.3, pp. 469–483.
- Punt, A. E., D. C. Smith, and T. Koopman (2005). *Using information for data rich species to inform assessments of data poor species through Bayesian stock assessment methods. Final report to Fisheries Research and Development Corporation Project No 2002/094. Primary Industries Research Victoria, Queenscliff*.
- Punt, André E. (2023). "Those who fail to learn from history are condemned to repeat it: A perspective on current stock assessment good practices and the consequences of not following them". In: *Fisheries Research* 261, p. 106642.
- Queensland Government (2021a). *Queensland blue swimmer crab fishery harvest strategy: 2021–2026*. P. 18.
- (2021b). *Queensland harvest strategy policy. FIS/2020/5464. Version 2.01. Effective date 14 June 2021*.
- R Core Team (2024). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. Vienna, Austria.
- Ralston, S., A. E. Punt, O. S. Hamel, J. D. DeVore, and R. J. Conser (2011). "A meta-analytic approach to quantifying scientific uncertainty in stock assessments". In: *Fishery Bulletin* 109.2, pp. 217–231.
- Robins, J. B., N. Flint, N. J. Stratford, R. Pillians, W. Charles, S. Williams, M. Taylor, and S. Seghers (2025). *Knowledge to improve the assessment and management of Giant Mud Crabs (Scylla serrata) in Queensland. Final report to the Fisheries Research and Development Corporation for project number 2019-062. Department of Primary Industries, Queensland. Brisbane. Australia*.
- Saeck, E., J. Udy, P. Maxwell, A. Grinham, D. Moffatt, S. Senthikumar, D. Udy, and T. Weber (2019). "Water quality in Moreton Bay and its major estuaries: Change over two decades (2000-2018)". In: *Moreton Bay Quandamooka & Catchment: Past, present, and future*. Ed. by I. R. Tibbetts, P. C. Rothlisberg, D. T. Neil, T. A. Homburg, D. T. Brewer, and A. H. Arthington. Brisbane: The Moreton Bay Foundation.
- Sainsbury, K. (2008). "Best practice reference points for Australian fisheries". In: *Australian Fisheries Management Authority. Project report R2001/0999. Australian Government*. 42pp. Type: Journal Article.
- Smith, H. (1982). *Blue crabs in South Australia - their status potential and biology*. Vol. 6: 6-9. Adelaide, Australia: Fishing Industry Council.
- Sporcic, M. (2022). *Executive Summary: CPUE standardizations for selected SESSF Species (data to 2021). Technical report prepared for the SESSFRAG data meeting, 23-24 August 2022. Report for the Australian Fisheries Management Authority. CSIRO Oceans and Atmosphere, Hobart. 14 p. Report*.
- Stewart, Ian J., Allan C. Hicks, Ian G. Taylor, James T. Thorson, Chantell Wetzel, and Sven Kupschus (2013). "A comparison of stock assessment uncertainty estimates using maximum likelihood

- and Bayesian methods implemented with the same model framework". In: *Fisheries Research* 142, pp. 37–46.
- Sumpter, L. I., A. B. Campbell, S. D. Hoyle, M. Tanimoto, and A. R. Fox (2025). *Stock assessment of Australian east coast Spanish mackerel (Scomberomorus commerson), with data to June 2024. Fisheries Queensland, Queensland Department of Primary Industries, Australia, and Hoyle Consulting Ltd, New Zealand.*
- Sumpton, D.D., M.A. Potter, and G.S. Smith (1994a). "Parasitism of the commercial sand crab *Portunus pelagicus* L. by the rhizocephalan, *Sacculina granifera*, Boschma, in Moreton Bay, Queensland, Australia". In: *Aust J. Mar. Freshwater Res.* 45:169-175.
- Sumpton, W., M. Campbell, M. O'Neill, M. McLennan, A. Campbell, G. Leigh, Y. Wang, and L. Lloyd-Jones (2015). *Assessment of the blue swimmer crab (Portunus armatus) fishery in Queensland.* Queensland Government.
- Sumpton, W.D. (1994). *Microsporidian infection of the sand crab, Portunus pelagicus (L.) in Moreton Bay.* Australia: Proc.Roy. Soc. Qd 100: 89-100.
- Sumpton, W.D., M. McLennan, M. Campbell, M. Tonks, N. Good, W. Hagedoorn, and G. Skilleter (2003). *Fisheries biology and assessment of the blue swimmer crab (Portunus pelagicus) in Queensland.* Project report (Queensland. Department of Primary Industries) QO03002. Deception Bay [Qld.]: Dept. of Primary Industries.
- Sumpton, W.D., M.A. Potter, and G.S. Smith (1994b). "The biology of the commercial sandcrab, *Portunus pelagicus* L. in a subtropical Australian embayment." In: *Asian Fisheries Sci* 7, pp. 103–113.
- Taylor, I. G., K. L. Doering, K. F. Johnson, C. R. Wetzel, and I. J. Stewart (2021). "Beyond visualizing catch-at-age models: Lessons learned from the r4ss package about software to support stock assessments". In: *Fisheries Research* 239.
- Taylor, Stephen, James Webley, and Kirrily McInnes (2012). *2010 Statewide Recreational Fishing Survey.* Brisbane: Department of Agriculture, Fisheries and Forestry.
- Teixeira, D., R. Janes, and J. Webley (2021). *2019/20 Statewide Recreational Fishing Survey Key Results. Report by Fisheries Queensland, Department of Agriculture and Fisheries. 18 pages.*
- Thomson, J.M. (1951). "Catch Composition of the Sand Crab Fishery in Moreton Bay". In: *Marine and Freshwater Research* 2.2, pp. 237–244.
- Thorson, J. T. (2020). "Predicting recruitment density dependence and intrinsic growth rate for all fishes worldwide using a data-integrated life-history model". In: *Fish and Fisheries* 21.2, pp. 237–251.
- Vehtari, A., A. Gelman, D. Simpson, B. Carpenter, and P. C. Bürkner (2020). "Rank-normalization, folding, and localization: An improved Rhat for assessing convergence of MCMC". In: *Bayesian Analysis.*
- VSN International (2022). *GenStat Statistical Software.*
- Walters, C. J. and S. J. D. Martell (2004). *Fisheries ecology and management.* Princeton University Press, p. 399.
- Wang, Na, Anthony J. Courtney, Matthew J. Campbell, and Wen-Hsi Yang (2020). "Quantifying long-term discards from Queensland's (Australia) east Coast otter trawl fishery". In: *ICES Journal of Marine Science* 77.2, pp. 680–691.
- Wassenberg, T. J. and B. J. Hill (1993). "Selection of the appropriate duration of experiments to measure the survival of animals discarded from trawlers". In: *Fisheries Research* 17.3-4. Export Date: 24 June 2025; Cited By: 56, pp. 343–352.
- Webley, James A. C., Kirrily McInnes, Daniella Teixeira, Ashley Lawson, and Ross Quinn (2015). *State-wide Recreational Fishing Survey 2013–14.* Brisbane: Department of Agriculture and Fisheries.
- Weng, H. T. (1992). "The sand crab (*Portunus pelagicus* (Linnaeus)) populations of two different environments in Queensland". In: *Fisheries Research* 13.4, pp. 407–422.

A Fishery management

Table A.1: Historical events in the Queensland blue swimmer crab (BSC) fishery. The information sources were from the Fisheries Queensland dashboard of fishery timelines, FISHNET, the DME all-seasons summary, stock assessment reports and consultation papers.

Year	Events - changes in management and the fishery
1976	Minimum legal size (MLS) 15 cm carapace width tip-to-tip measure. This converts to a 12.4 cm notch-to-notch measure. No take of females.
1983	Issue of new commercial crab licenses ceased.
1984	Primary/tender commercial boat license system introduced. Majority of commercial operations nominated to have a new C1 crab symbol, increasing latent/potential effort, but enabling fishers' flexibility to access a range of fisheries.
1988	Compulsory commercial logbook reporting began 1 January.
1991	Introduction of new net-crab logbook NC01. Reporting harvest weights.
1993	Moreton Bay Marine Park was created, naming fish habitat areas. These habitat areas prevent developments while still allowing all forms of legal fishing.
1994	Introduction of the Fisheries Act 1994.
1995	Crab gear legislated for pots, collapsible traps, dillies, or inverted dillies. Recreational: No more than four gears used at a time per person. Commercial: No more than fifty gears used at a time per operation.
1996	Introduction of net-crab logbook NC02. Species added and spanner crab removed.
1997	Introduction of the marine park zoning plan for Moreton Bay. The plan had five zones which offered various levels of protection. Introduction of net-crab logbook NC03. Fishing methods now recorded, and the numbers and weights of crab.
1999	Trawl in possession limit of one hundred BSC for Moreton Bay and adjoining waters, and six hundred elsewhere.
2002	Trawl in possession limits reduced to thirty BSC in Moreton Bay and adjoining waters, and five hundred elsewhere.
2003	Investment warning released for commercial fishing in Queensland's east coast waters. Introduction of net-crab logbook NC04. Species of conservation interest added. Minimum legal size changed to 11.5 cm notch-to-notch carapace width. The notch size limit of 11.5 cm was smaller and equated to a 14 cm tip-to-tip measure. The notch measurement allowed MLS checking when carapace tip spines were broken.
2006	Great Sandy Marine Park and zoning plan. The plan had five zones which offered various levels of protection.
2008	Trawl in possession limits increased back to one hundred in Moreton Bay and adjoining waters, and five hundred elsewhere.
2009	The marine park Moreton Bay zoning plan 2008 came into effect on 1 March. Latent effort removal of 319 C1 symbols (40% of C1 symbols) statewide. This included removal of 31 C1 symbols from Moreton Bay.

2010	Inverted dillies prohibited.
2012	C1 applications to use an additional 50 to 100 pots under permit.
2014	Commercial investment and fishing effort warnings released, 6 March. Multiple C1 symbols. Commercial operations with two or more C1 symbols allowed a maximum of one hundred pots to take crab. One C1 symbol allowed fifty pots. MRAG Asia Pacific completed a review of fisheries management in Queensland. The MRAG report made eighty recommendations for public comment in May 2015.
2016	The green paper on fisheries reform represented the Government's vision for the management of wild harvest species as well as a response to the MRAG review. Over 11,800 public responses showed support from all sectors. This feedback fed into the Queensland Sustainable Fisheries Strategy 2017–2017.
2017	Release of the Queensland Sustainable Fisheries Strategy 2017–2027.
2018	Introduction of net–crab logbook NC05.
2019	Recreational in-possession bag limit of 20 blue swimmer crabs per person. Introduction of the Fisheries Declaration 2019. Vessel tracking introduced for net, line, and crab fisheries. The marine park Moreton Bay zoning plan 2019 included minor amendments and no changes to zones.
2020	The World Health Organization (WHO) declared the novel coronavirus (COVID-19) a worldwide pandemic on 11 March.
2021	On 1 September, fishery management introduced: • A harvest strategy with target and limit reference points. • A 242.982 t quota for commercial operations with a C1 symbol, for the 2020–2021 fiscal year. In total, operators caught 77.2% of the quota. • Individual transferable quota units (ITQ) for the whole Queensland coastline including Gulf and east coast waters. • New quota reporting with pre-trip and prior landing notices and catch disposal records (CDR). • New commercial logbook for crabs, version QC01. The Australian Government revoked Wildlife Trade Operation Declarations for the Queensland blue swimmer crab fishery. From the 21/12/2021, commercial fishers could not export BSC without seeking an individual export approval. Release of the commercial fishing app (Qld e-Fisher) at the end of 2021. Moreton Bay trawl harvest strategy 2021–2026, listing BSC as a secondary target species with annual harvests watched against a 21 t per year threshold. The T1 otter trawl harvest strategies 2021–2026 listed BSC as a tier 3 by-product species, with annual harvests to be $\leq$ the 2017–2019 average.
2022	An increased 263 t quota was set for 2021–2022. 63.2% used. The 263 t was based on the harvest strategy catch shares of 85% commercial and 90% for C1 and the recommend biological catch of 343 t (Lovett et al. 2020). No discounts applied for the hockey-stick harvest control rule or uncertainties.
2023	The 263 t quota continued for 2022–2023. Eighty-four per cent used. Seagrass loss and concerns reported for Tin Can Bay. End of COVID-19 pandemic.

2024 No change to the 263 t quota for 2023—2024 and 2024—2025.

As of 1 October, there were seventy-four active ITQ holders, with twenty-seven holding 90% of the quota units. There were 390 C1 symbols, licensed to use a maximum of 50, 100 or 150 pots. The use of 150 pots requires three C1 symbols. Pot use limited to one hundred per operation within Moreton and Hervey Bays.

Discussion papers released for commercial fishing: on a two-for-one C1 licensing policy, up to fifteen crab pots per trotline, intent of the C1 symbol and crab pot escape vent sizes; and for recreational fishing: banning light weight pots, defining rope types, and introducing escape vents.

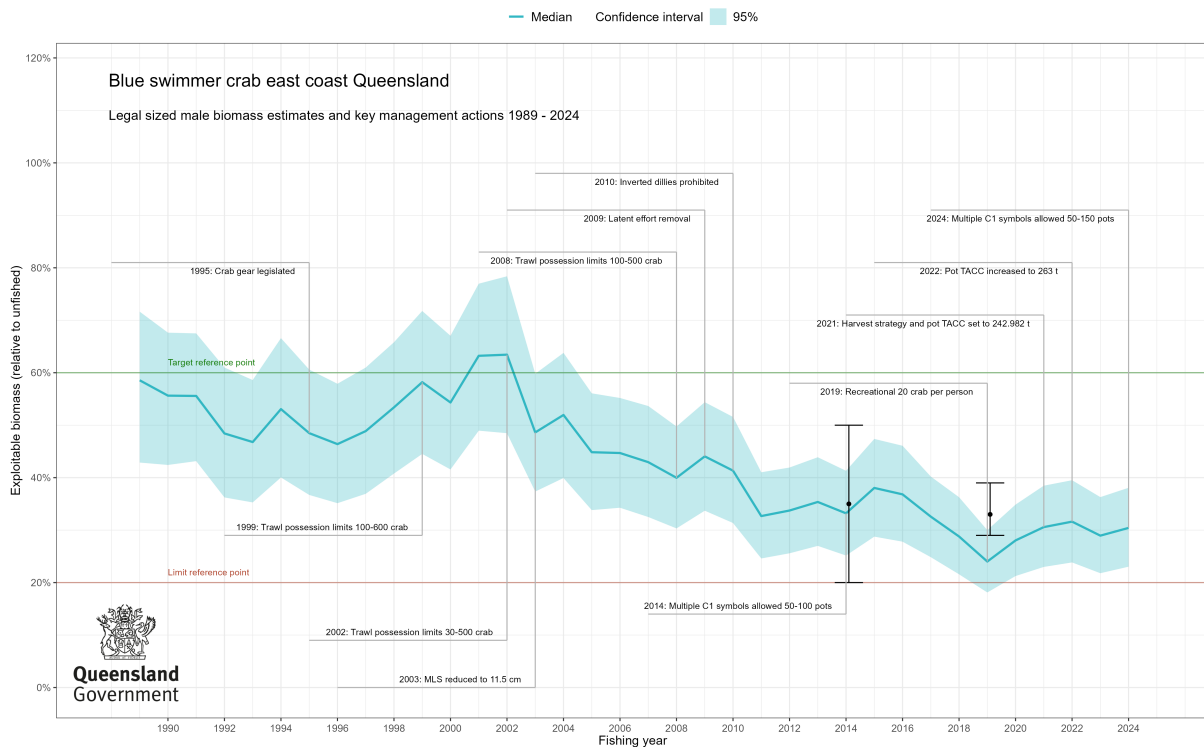


Figure A.1: Blue swimmer crab biomass estimates by fishing year, from the new stock assessment compared with key fishery dates and past assessment results in 2014 and 2019.

B Project team

Key meeting notes and decisions are listed.

Meeting #1, 30 October 2024, 2–3pm, held online through MS Teams.

1. Purpose: Initial meeting to discuss the task and timelines.
2. The spatial coverage for the assessment was discussed, noting that blue swimmer crab generally can have localised dynamics (Potter et al. 1991). The assessment will again aim to assess the Queensland east coast, as done in 2020 for use by fishery management. Regional trends in data will also be reported. The Moreton Bay region has more data. NSW noted there was no need, this time, to form a NSW–Qld combined assessment. In NSW, BSC have localised stock dynamics, particularly with the mid-north coast showing different trends to other areas.
3. An ensemble approach will be adopted. However, if there is a set of data that is better, or we can narrow down the cases that are plausible and sensible then that is an option too.

Meeting #2, 23 January 2025, 1:30–3:30pm, held online through MS Teams.

1. The purpose of the meeting was to provide advice on catch rate data and catch-rate modelling decisions.
2. Three linear models were assessed by region, considering the effects of annual-offsets of effort (annual trends in the number of pot lifts being fished per operator-day, by region).
3. The catch-rate model with partial offset (coefficient = 0.88) was too complex to understand. The model with no pot offset (coefficient = 0) for a catch per day index was dismissed. Pot fishing effort was considered important in catch rates.
4. It was difficult to obtain and confirm a hypothesis for a coefficient less than 1, without accurate and contrasting effort data by fishers – to minimise potential confounding issues of pot use between fishers and changes in time.
5. A catch-rate model using a full offset (coefficient = 1) having the simple concept of catch per pot lift was more likely to be the better indicator of abundance. This was deemed more rational.

Meeting #3, 8 May 2025, 1:30–4pm, held online through MS Teams.

1. Key question for the meeting was to develop a set of population model scenarios to form an ensemble.
2. Noted that many settings had been tested in stock synthesis (SS). For example: annual, quarterly and monthly seasonal time steps; seasonal and nonseasonal growth rates for parameter κ ; trawl discard fractions versus swept area measures; estimating initial model conditions in 1989 using warmup average catches or the initial fishing mortality (F) approach; and settlement assignments.
3. Discussed the components from a quarterly model, including:
 - Estimating recruitment settlements and impacts on R_0 .
 - Warmup catches for pre-1989 appeared a stable approach.
 - Recruitment deviations were systematic suggesting a time shift change to lower levels, or lower steepness.
 - Similarities in catch rates among fleet.

4. For natural mortality WA used a maximum age of 3 years, so M of 1.4, they used the Hoenig equation. Range of 1.2 to 1.6 (in another assessment).
5. Project team discussed and agreed with 1% for a nominal low pot discard mortality.
6. A lot of good fishers have left the fishery. How does this compare with fishing power results? (see Figure D.9)
7. Environmental issues, health of Moreton Bay and habitat change discussed.

Meeting #4, 19 June 2025, 1:30–3:30pm, held online through MS Teams.

Decisions:

The ensemble design was endorsed, with additional sensitivity tests to address uncertainties. MCMC results were preferred for management recommendations.

1. Purpose: Review model scenarios, the ensemble, and diagnostics. Endorsement to finalise results or conduct more work.
2. Key updates:
 - Using three natural mortality values and not four values as larger M greater than 1.4 made R_0 unrealistically large.
 - Focused on larger steepness (0.8 and 0.6, rather than 0.7 and 0.5), given females are protected in Qld, and reviewers comments for high steepness on other stock assessments.
 - Included two warmup catches. And tested a third linear warmup showing no difference.
 - Using all catch rates. Using different/removing catch rates made little difference. Using the survey only CPUE did not work – too few years of data.
 - Using higher L_∞ for growth made the length frequency fits worse.
3. A systematic decline in recruitment deviations since 2010 was observed, potentially linked to environmental factors (e.g., 2010–2011 floods). Similar patterns were noted in other species (e.g., snapper, spanner crab, Spanish mackerel).
4. Historical high catches (2001–2005) were discussed, with concerns about potential over-reporting during investment warning periods. Noted that some high catches could be attributed to increased effort by key operators in Hervey Bay.
5. Recruitment deviations and biomass trends were roughly consistent with previous assessments. Diagnostics (e.g., R-hat, effective sample size) indicated stable MCMC runs.
6. Sensitivity test added for potential over-reported catches (e.g., reducing 2001–2005 catches) to assess impacts on model outputs and recruitment patterns.
7. The ensemble design was endorsed, with additional sensitivity tests to address extra uncertainties (analyses 13–16, Appendix G).
8. Management need to consider trade-off of MLE and MCMC results using a “risk–catch” approach to assess management implications (Dowling et al. 2013).

C Stakeholder presentation

Fisheries Queensland held an online blue swimmer crab stock assessment meeting on 13 July 2026. The meeting ran from 9:30 am to 11:50 am. The purpose was to present the 2024 stock assessment results and discuss the main trends. This included biomass, recruitment, harvest and catch rates. The meeting also covered past management changes and the status of interstate blue swimmer crab fisheries.

Stakeholders were asked to share their views on fishery trends and performance. Their feedback was documented here.

Stakeholder attendees included commercial and recreational fishing representatives Shane Underhill (commercial pot offshore), Ryan Taplin (commercial pot Hervey Bay), Anthony Riesenweber (commercial pot Moreton Bay) and George Bennetts (recreational Moreton Bay). Fisheries Queensland staff included Jeff Ikin, Peri Subritzky, Warren Egling, Michael O'Neill and Robyn Lovett. Meeting apologies were for trawl fishers Scott Hodgetts (Bundaberg), Shane Paulsen (Bundaberg), and Neil Hick (Hervey Bay).

Summary

- Stakeholder representatives generally considered the assessment trends to be reasonable and broadly consistent with their experience in the fishery.
- The meeting identified uncertainty in historical commercial fishing effort, particularly around reported pot numbers during the 2000–2010 peak harvest period. This was an important issue for interpreting nominal catch rates.
- Participants identified recruitment and environmental conditions as key factors likely to influence recent fishery performance.
- Fishers reported regional differences in observed conditions, including habitat change, siltation, gear fouling, three-spot crab abundance and variable juvenile crab observations.
- Stakeholders noted that lower recent catches may reflect both stock conditions and changes in fisher behaviour, market demand and effort shifting to other fisheries.
- There was consistent belief that recreational harvest might be underestimated, supporting the need for improved recreational catch information.

The main themes raised by stakeholder representatives are summarised below, grouped by their relevance to stock assessment interpretation.

Historical commercial catches and pot effort

A recurring theme was concern that nominal catch rates during the peak fishing years may have been inflated because many operators were fishing substantially more pots than were reported in logbooks. Commercial fishers indicated that operators commonly fished hundreds of pots while recording effort against the nominal 50-pot entitlement. Stakeholders therefore considered that nominal catch-rate estimates could overstate abundance during the peak years and may not be directly comparable with more recent data, when compliance, vessel tracking and quota arrangements improved reporting accuracy. They also noted that some older operators may now fish fewer pots than in earlier periods. Stakehold-

ers supported the need to offset and account for unreported pot effort in standardising catch rates and considered this one of the most important uncertainties affecting interpretation of historical trends.

Recruitment and environmental drivers

Stakeholders broadly agreed that recruitment appeared to be a key issue affecting current fishery performance. Participants considered the abundance of mature female crabs, alongside indications of weaker recruitment, to be consistent with what they were observing in the fishery. Some stakeholders noted that recruitment trends over the next few years would be particularly important for confirming whether the recent lower recruitment signals represent a longer-term concern.

Fishers identified several environmental changes that may be affecting recruitment and productivity, including:

- Loss of eelgrass (seagrass) habitat.
- Increased siltation following flood events.
- Increased algal growth and fouling on fishing gear.
- Potential effects of extreme weather.
- Possible temperature-related effects on crab abundance and movement.
- Increased prevalence of parasites in some areas.
- Potential ecological changes indicated by trends in three-spot crab abundance.

Fishers also noted that wind direction can influence short-term catchability, with south-easterly winds considered more favourable than northerly winds.

Stakeholders considered environmental change a plausible explanation for reduced productivity and recruitment, particularly because similar declines have been noted by fishers for other species in these regions despite perceived reduced fishing pressure.

As a follow-up to this discussion, stakeholders asked whether Western Australian blue swimmer crab research could provide insight into cyclone or extreme-weather effects. Research from Shark Bay linked declines in recruitment, abundance and catch rates mainly to an extreme marine heatwave rather than flooding or cyclones alone (Chandrapavan et al. 2019). This suggests that temperature-related events may be important, but local monitoring would be needed to understand how these drivers apply to Queensland stocks.

Regional observations

Stakeholders reported differing regional patterns:

- Moreton Bay fishers reported okay water quality but habitat changes including increased siltation, algal growth on gear and seagrass loss.
- Offshore fishers reported relatively few obvious environmental changes and generally good water quality but noted large numbers of three-spot crabs in recent years.
- Hervey Bay fishers reported increased fouling in inshore areas but fewer apparent changes offshore. They also noted strong year-to-year variability in observations of very small juvenile (jelly) crabs (species unknown).

Across regions, stakeholders considered the modelled trends to be broadly consistent with their observations from Hervey Bay, offshore grounds and Moreton Bay.

Fishery economics and adjacent fisheries

Stakeholders emphasised that reduced catches in recent years are not solely a reflection of stock abundance. Participants noted that market demand and price limitations can discourage targeting blue swimmer crabs, that some operators have shifted effort into mud crab fisheries, and that fewer active crab fishers may reduce the efficiency of locating productive crab aggregations.

Stakeholders also noted that live blue swimmer crab markets are limited, with additional handling, transport and operational costs reducing the appeal of live product despite potentially higher prices. Communication with adjacent trawl fisheries was generally described as positive, and these relationships may help fishers share observations about crab distribution, habitat conditions and broader changes across fishing grounds.

Effort interpretation and data limitations

Several factors may complicate interpretation of catch rates and effort trends. Stakeholders noted that vessel tracking data may not directly estimate pot lifts without further interpretation. For example, lifting, rebaiting and resetting gear while moving could appear to show more pots being worked than were fished. Stakeholder input would be needed if vessel tracking data were used to infer effort.

Spatial closures may also affect interpretation of long-term trends by changing access to historical fishing grounds, particularly in Hervey Bay and the Great Sandy Strait. Fishers noted that some productive areas previously used for blue swimmer crab fishing are now within green or yellow zones, including parts of the Great Sandy Strait and Platypus Bay.

Shark depredation and gear damage were identified as additional factors affecting effective fishing effort, particularly in Hervey Bay. Fishers reported that sharks can damage or destroy crab pots, while turtle damage was also noted as a lesser issue. These losses can increase operating costs and complicate catch-rate interpretation because lower catches may partly reflect damaged or lost gear rather than crab abundance alone.

Stakeholders noted that higher catch rates in some years did not always translate to higher economic value because catches could include recently moulted or “empty” crabs with low meat content.

Fishers also noted that parasite issues and gear fouling appeared more pronounced in inshore areas of Hervey Bay and Moreton Bay, while offshore grounds were generally described as cleaner.

Recreational harvest uncertainty

In addition to commercial data uncertainties, stakeholders raised concerns about the reliability of recreational harvest estimates. Participants believed recreational removals were likely higher than current estimates, which would affect interpretation of total fishing removals and overall assessment uncertainty. They supported improvements to recreational catch monitoring and reporting. At the same time, the recreational representative noted that relatively few recreational fishers consistently achieve catches of blue swimmer crab, which may complicate estimation of overall harvest.

D Diagnostics for catch rates

The nominal pot catch rate data (kg per operation day) for fleets 1–3 showed skewed distributional properties. This was highlighted by using boxplots and comparing measures of the median, geometric mean and arithmetic mean (Figures D.3, D.4) and D.5).

The estimated Box-Cox λ parameter, for normalising and decreasing skewness in residuals and data across regions (fleets 1–3), was 0.17. Small λ is typical for fisheries data. Values less than 0.33 for a cube-root transformation, suggested a log transformation to normalise residuals or a strong variance function with log link (McCullagh and Nelder 1989a; Hoyle et al. 2024). Similarly, Taylor's power coefficients by operator, year or region suggested log transformations with values around 2 (1.8186257, 2.37599, 1.4879626) (Hoyle et al. 2024).

The Box-Cox parameters for fleets 7 and 8 were also low at -0.08 and -0.14. Their Taylor's power coefficients were also around 2. For recreational fleet 7, the coefficients were 1.1404249, 1.9060679, 1.758073 by year, region and month. The survey fleet 8 coefficients were 1.6859461, 2.1476494 by year and depth category.

D.1 Commercial pot offsets and nominal data

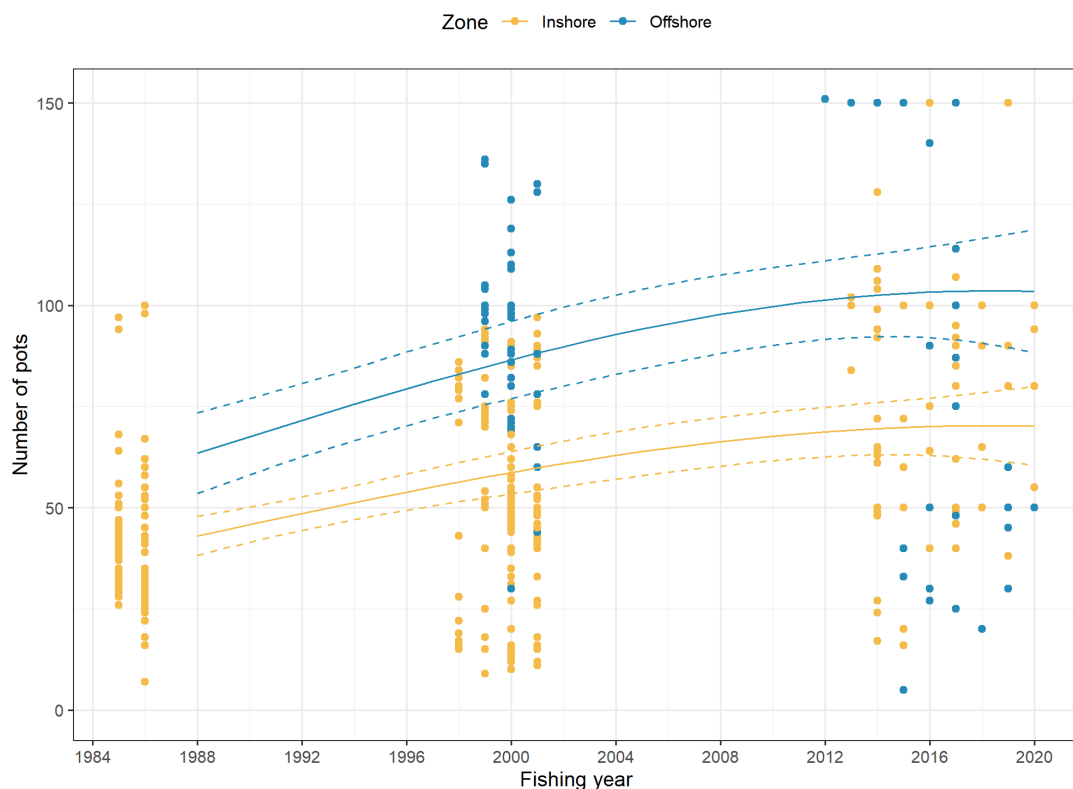


Figure D.1: Commercial pot numbers (points) recorded during observer-based research in the Moreton Bay inshore and Sunshine Coast offshore areas up until 2014, with logbook records shown 2015–2020. The quadratic relationships are shown from 1989 by lines with dashed 95 percent confidence intervals.

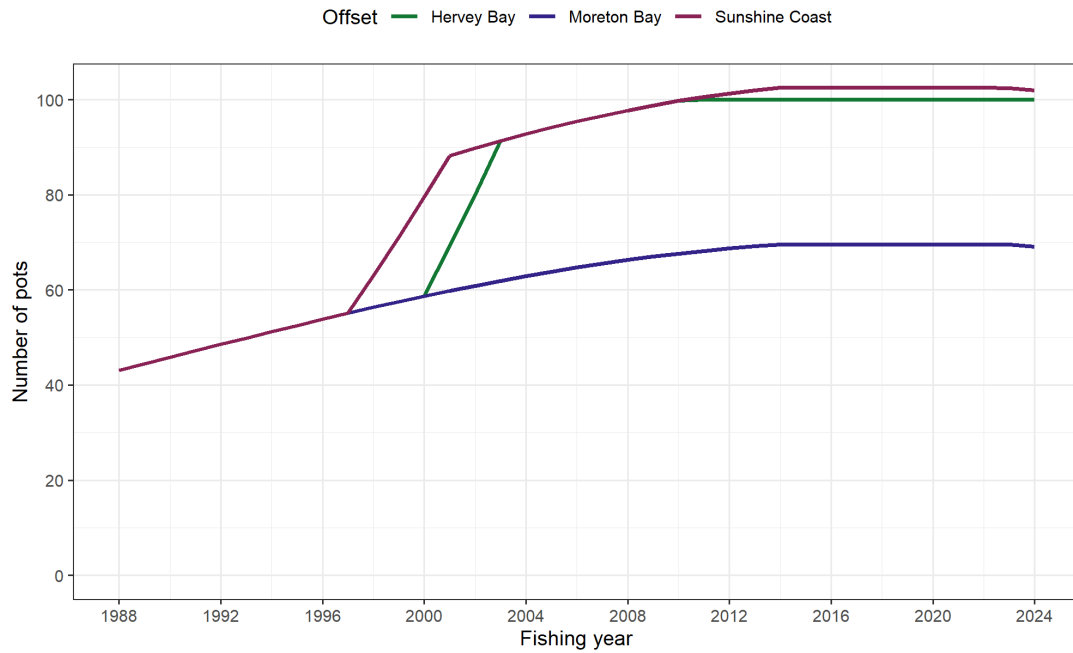


Figure D.2: Offset number of pots per operator-day by Moreton Bay (fleet 1), Offshore (Sunshine Coast, fleet 2) and Hervey Bay (fleet 3).

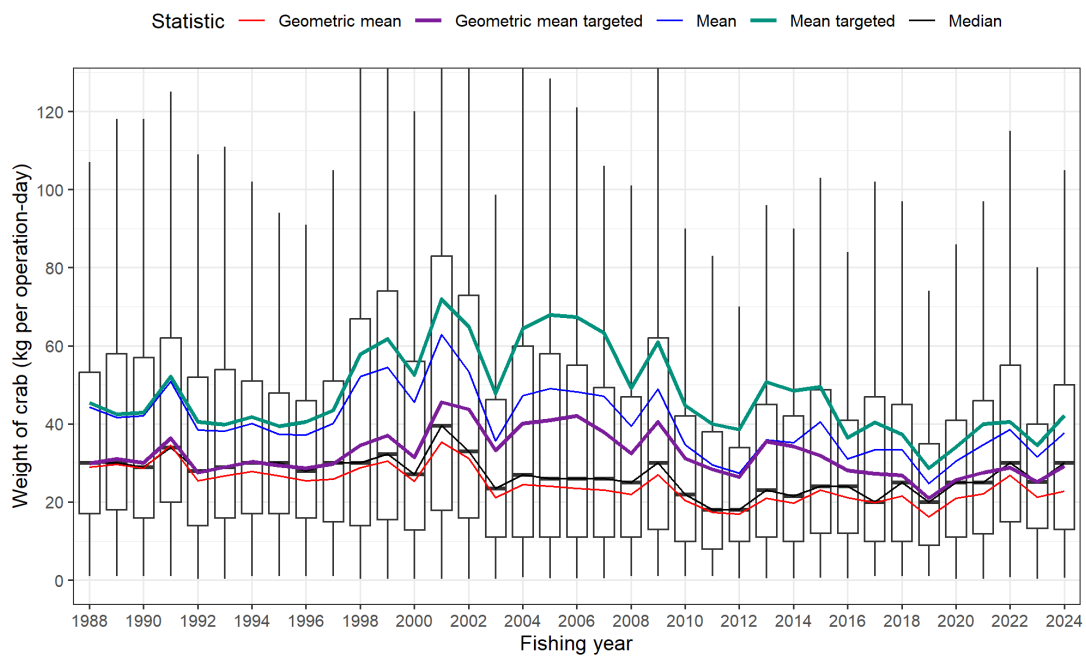


Figure D.3: Boxplot of the annual distribution of nominal daily catch rates by fleet 1 Commercial pot Moreton Bay.

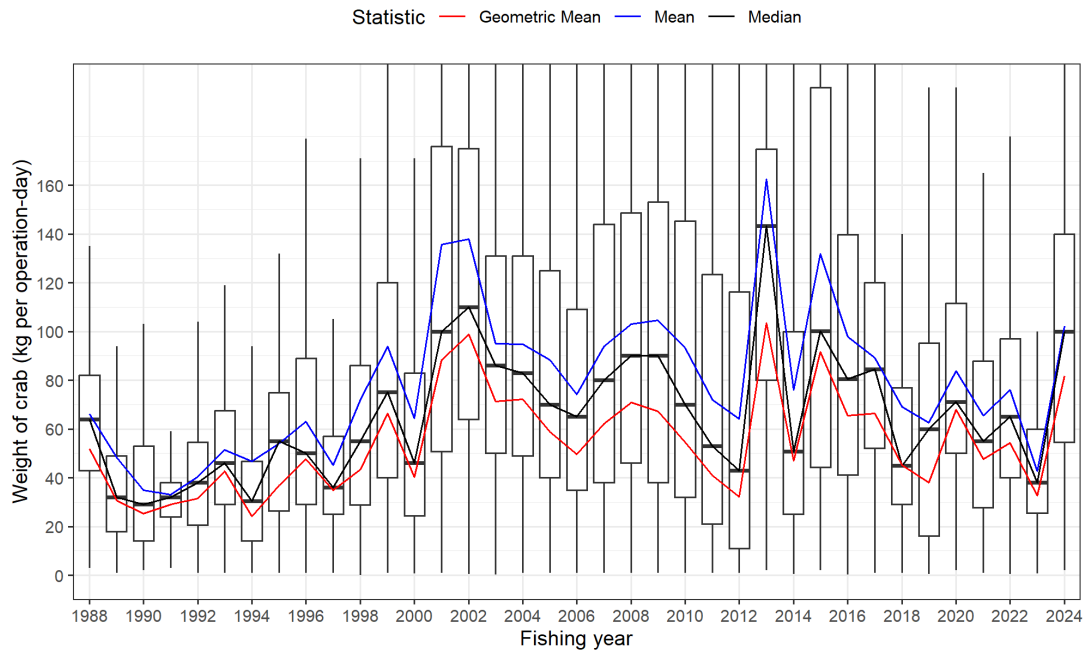


Figure D.4: Boxplot of the annual distribution of nominal daily catch rates by fleet 2 Commercial pot offshore.

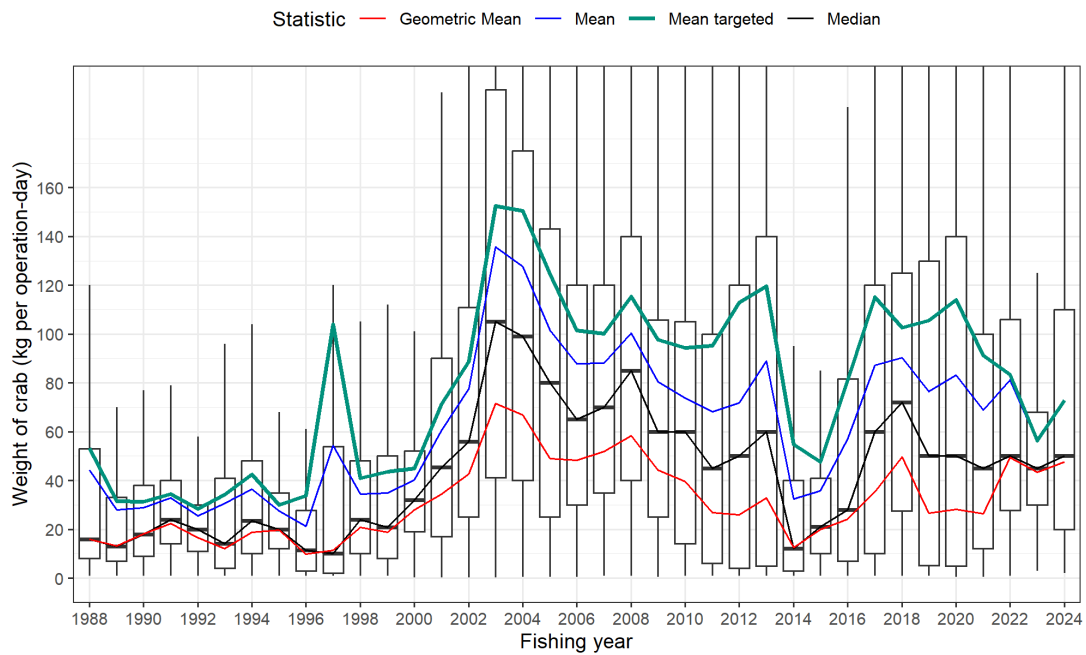


Figure D.5: Boxplot of the annual distribution of nominal daily catch rates by fleet 3 Commercial pot Hervey Bay.

D.2 Commercial pot fleet 1

Table D.1: Analysis of variance table for the Moreton Bay (fleet 1) commercial catch rate analysis. F statistics were derived from the R drop1 procedure. Adjusted R-squared = 0.5842 .

Term	Df	RSS	F value	Pr(>F)
residual	222150	120023.8		
operator	278	199476.1	528.982	0.000
grid	3	120296.0	167.972	0.000
bsc target	1	137281.0	31941.195	0.000
lunar	1	120031.3	13.999	0.000
lunaradv	1	120038.7	27.724	0.000
goodwind	1	120046.6	42.173	0.000
year : quarter	145	129540.3	121.476	0.000

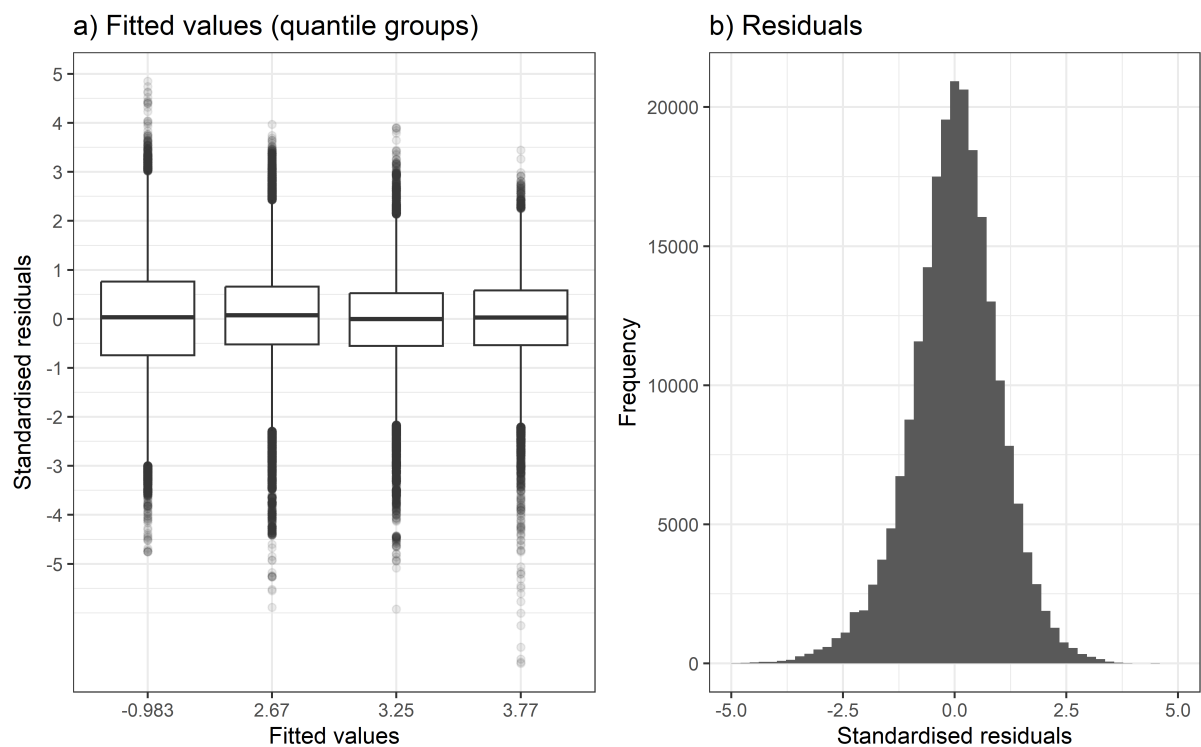


Figure D.6: Fleet 1 catch rate residual plots for a) box plot of fitted values and residuals, and b) histogram of residuals. Fitted values were on the log(kg) and grouped into quantiles. Residuals were standardised by the model residual standard deviation.

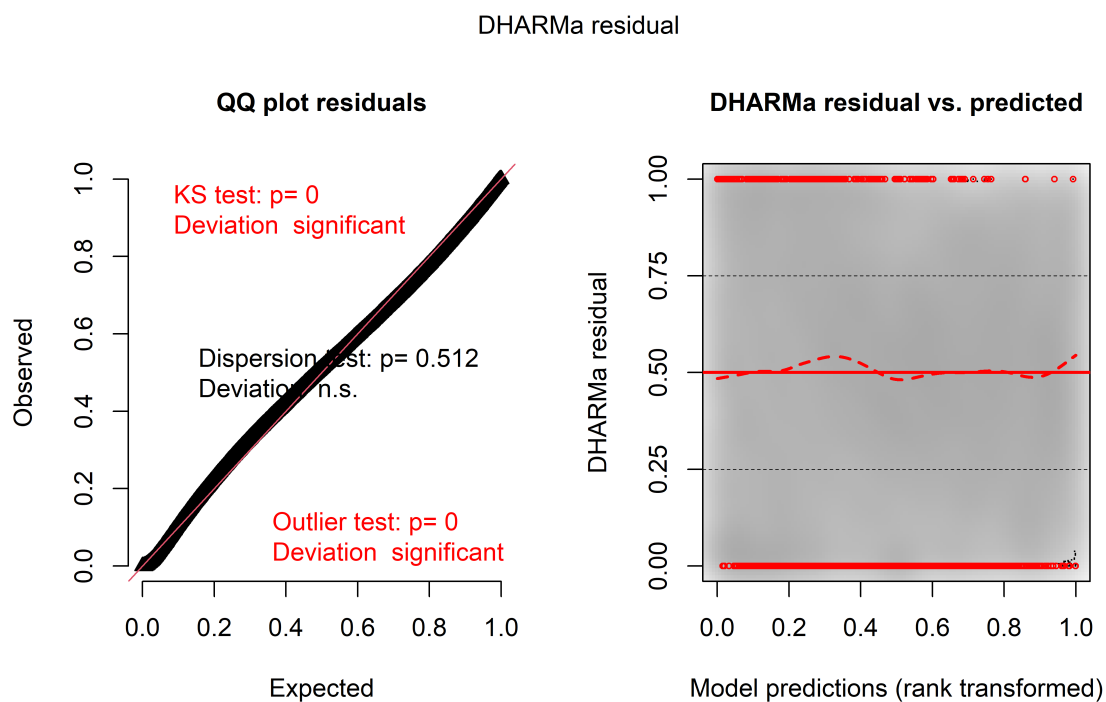


Figure D.7: Plot of fleet 1 DHARMa simulated pit residuals (n=500).

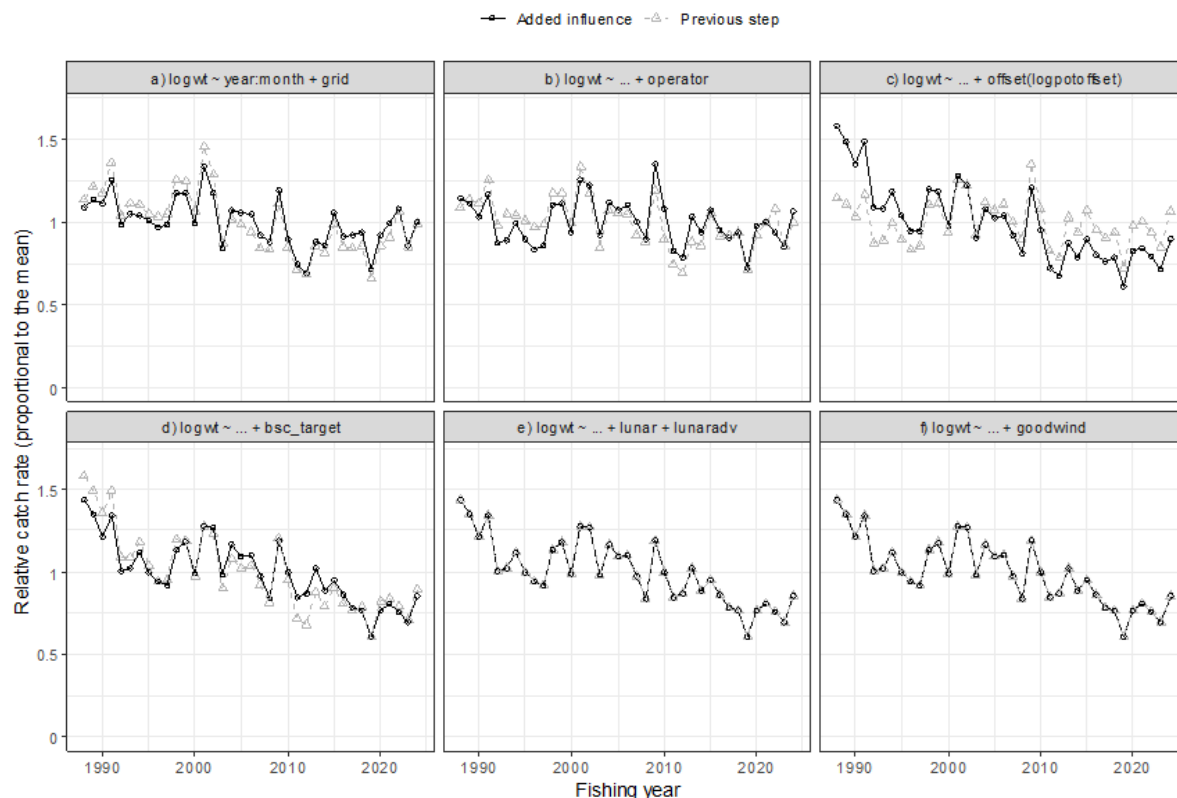


Figure D.8: Influence plot comparing the LM effects on standardised catch rates for fleet 1. Sub-plot: a) compared a year, month and grid model to nominal catch rate; b) compared a year, month, grid and operator model to model a; c) compared adding the log pot offset to model b; d) compared adding targeting to model c; e) compared adding lunar phase to model d; and f) compared the full standardisation model by adding goodwind.

Table D.2: Log parameter estimates for catch rate effects from Moreton Bay (fleet 1) analysis. Grid w37 was the factor reference level, with effect = 0.

Parameter	Estimate	Std. Error	t value
gridW38	-0.102	0.006	-16.3
gridX37	0.337	0.033	10.3
gridX38	0.409	0.041	10.1
bsc target	0.859	0.005	178.7
lunar	0.017	0.004	3.7
lunaradv	-0.023	0.004	-5.3
goodwind	-0.023	0.004	-6.5

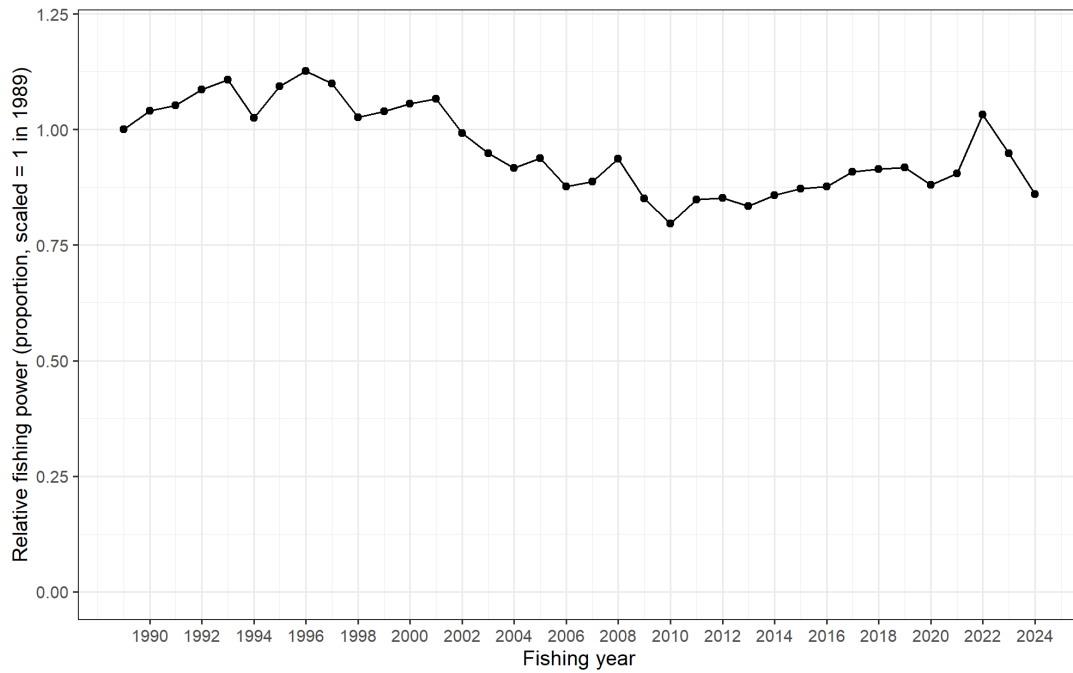


Figure D.9: Fishing-power by year relative to 1989 for fleet 1 in Moreton Bay, as estimated from operator days of fishing effort and their parameter estimate.

D.3 Commercial pot fleet 2

Diagnostics from the commercial catch rate analysis for offshore.

Table D.3: Analysis of variance table for the offshore (fleet 2) commercial catch rate analysis. F statistics were derived from the R drop1 procedure. Adjusted R-squared = 0.5241 .

Term	Df	RSS	F value	Pr(>F)
residual	30329	9904.1		
operator	123	15730.2	145.049	0.000
grid	9	9987.5	28.358	0.000
lunar	1	9907.0	8.715	0.003
lunaradv	1	9905.1	2.876	0.090
goodwind	1	9904.8	2.035	0.154
year : quarter	145	12956.5	64.464	0.000

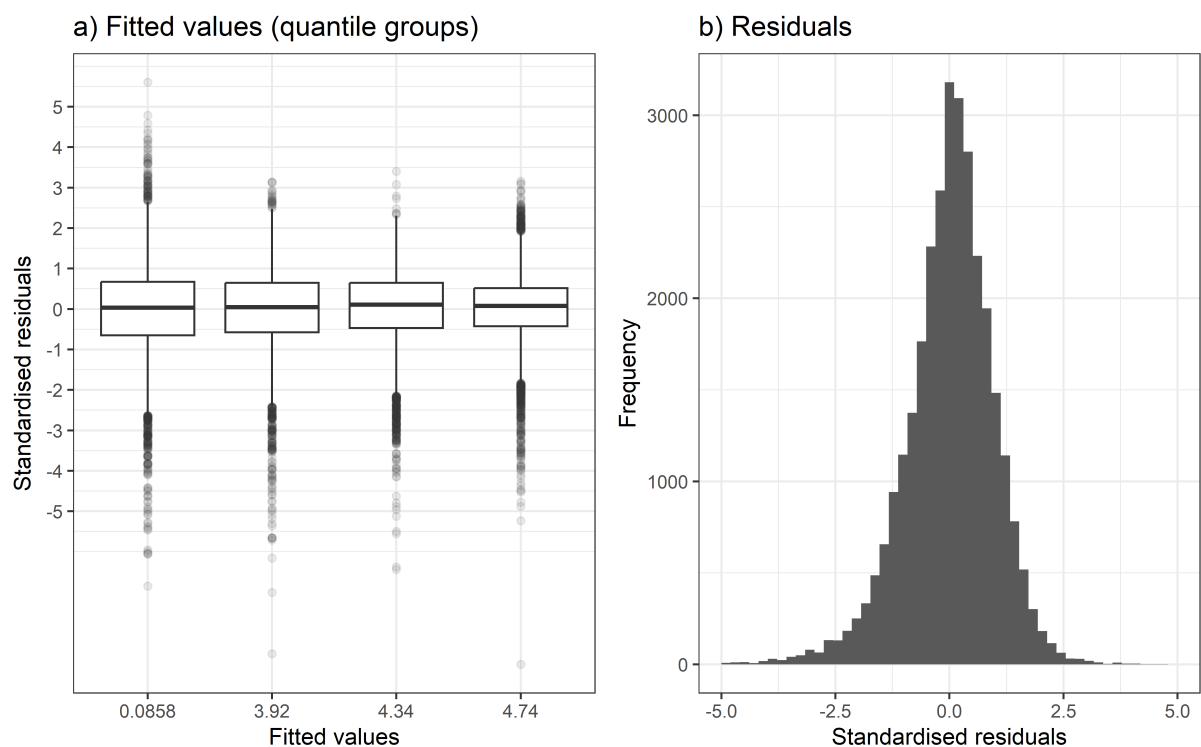


Figure D.10: Fleet 2 catch rate residual plots for a) box plot of fitted values and residuals, and b) histogram of residuals. Fitted values were on the log(kg) and grouped into quantiles. Residuals were standardised by the model residual standard deviation.

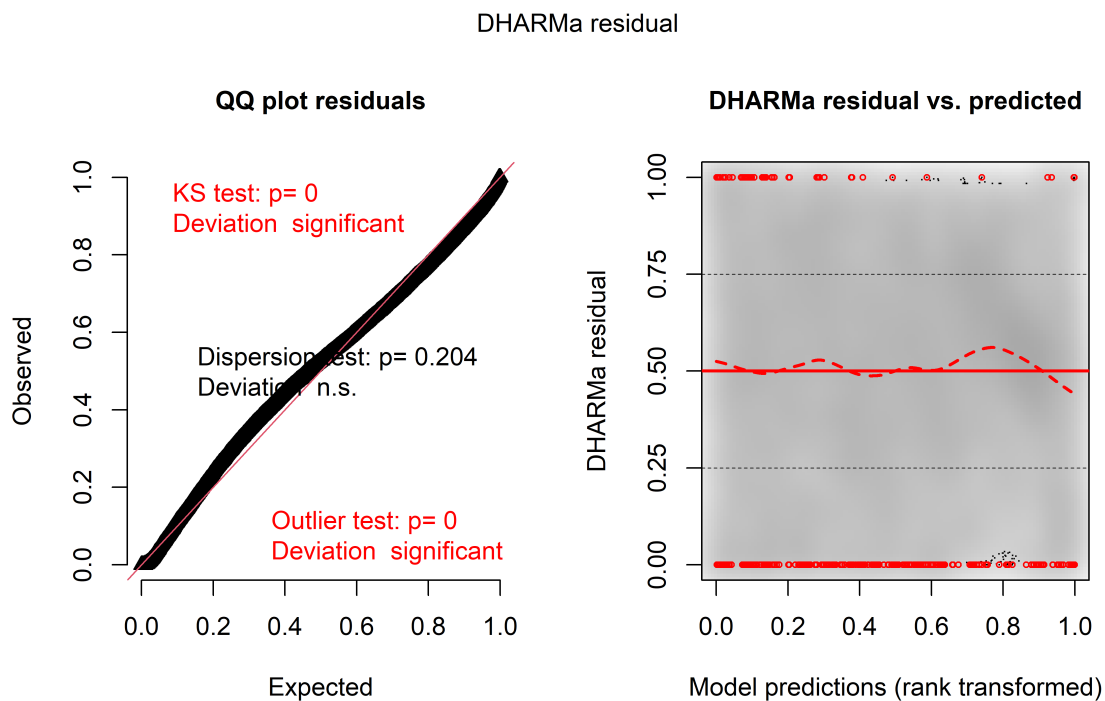


Figure D.11: Plot of fleet 2 DHARMA simulated pit residuals (n=500).

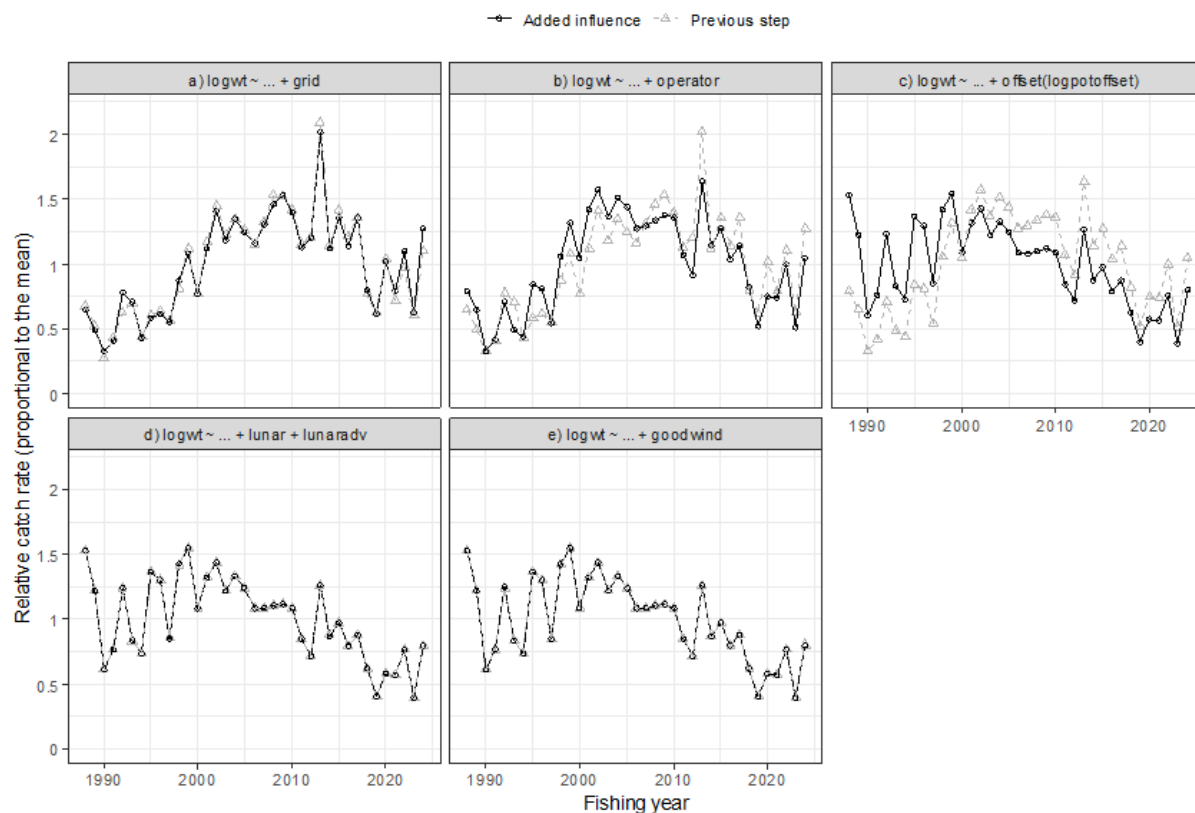


Figure D.12: Influence plot comparing the LM effects on standardised catch rates for fleet 2. Sub-plot: a) compared a year, month and grid model to nominal catch rate; b) compared a year, month, grid and operator model to model a; c) compared adding the log pot offset to model b; d) compared adding lunar phase to model c; and e) compared the full standardisation model by adding good-wind.

Table D.4: Log parameter estimates for catch rate effects from offshore (fleet 2) analysis. Grid w33 was the factor reference level, with effect = 0.

Parameter	Estimate	Std. Error	t value
gridW34	-0.234	0.041	-5.7
gridW35	-0.074	0.045	-1.6
gridW36	0.138	0.034	4.1
gridX33	-0.011	0.093	-0.1
gridX34	-0.074	0.104	-0.7
gridX35	-0.035	0.113	-0.3
gridX36	0.353	0.046	7.6
gridY33	0.987	0.281	3.5
gridY36	0.484	0.214	2.3
lunar	0.027	0.009	3.0
lunaradv	0.016	0.009	1.7
goodwind	-0.028	0.020	-1.4

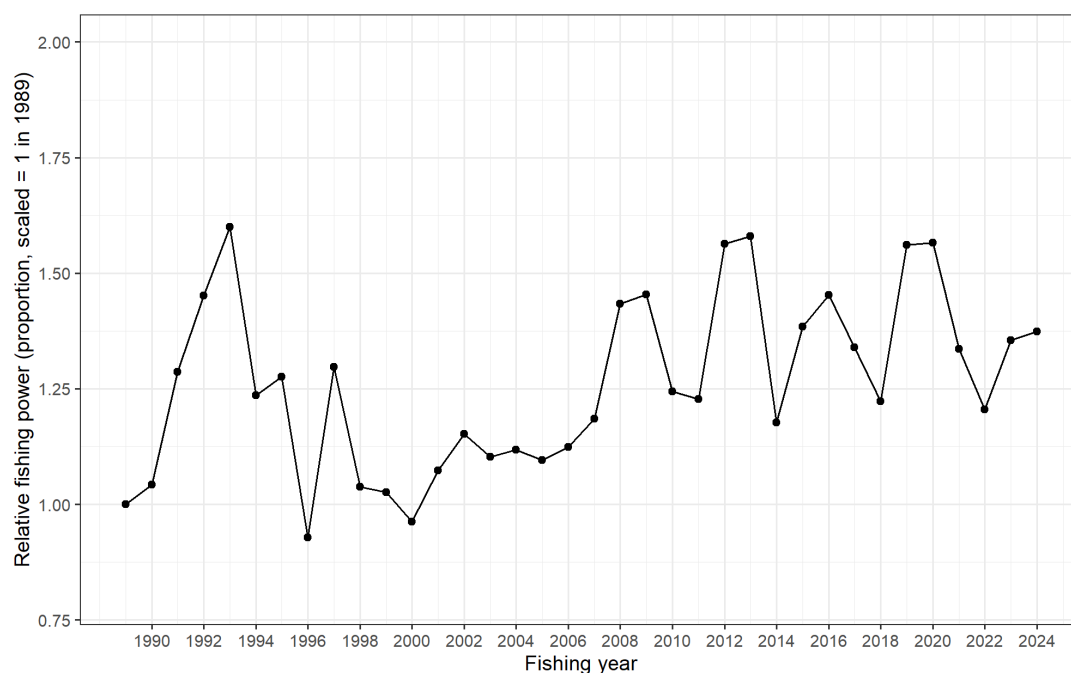


Figure D.13: Relative average fishing-power by year for fleet 2 in offshore waters, as estimated from operator days of fishing effort and their parameter estimate.

D.4 Commercial pot fleet 3

Diagnostics from the commercial catch rate analysis for Hervey Bay.

Table D.5: Analysis of variance table for the Hervey Bay (fleet 3) commercial catch rate analysis. F statistics were derived from the R drop1 procedure. Adjusted R-squared = 0.7771 .

Term	Df	RSS	F value	Pr(>F)
residual	57137	26646.4		
operator	153	40771.1	197.955	0.000
grid	18	28025.3	164.261	0.000
bsc target	1	31038.3	9417.578	0.000
lunar	1	26748.1	218.179	0.000
lunaradv	1	26653.6	15.410	0.000
goodwind	1	26650.4	8.659	0.003
year : quarter	145	30777.6	61.092	0.000

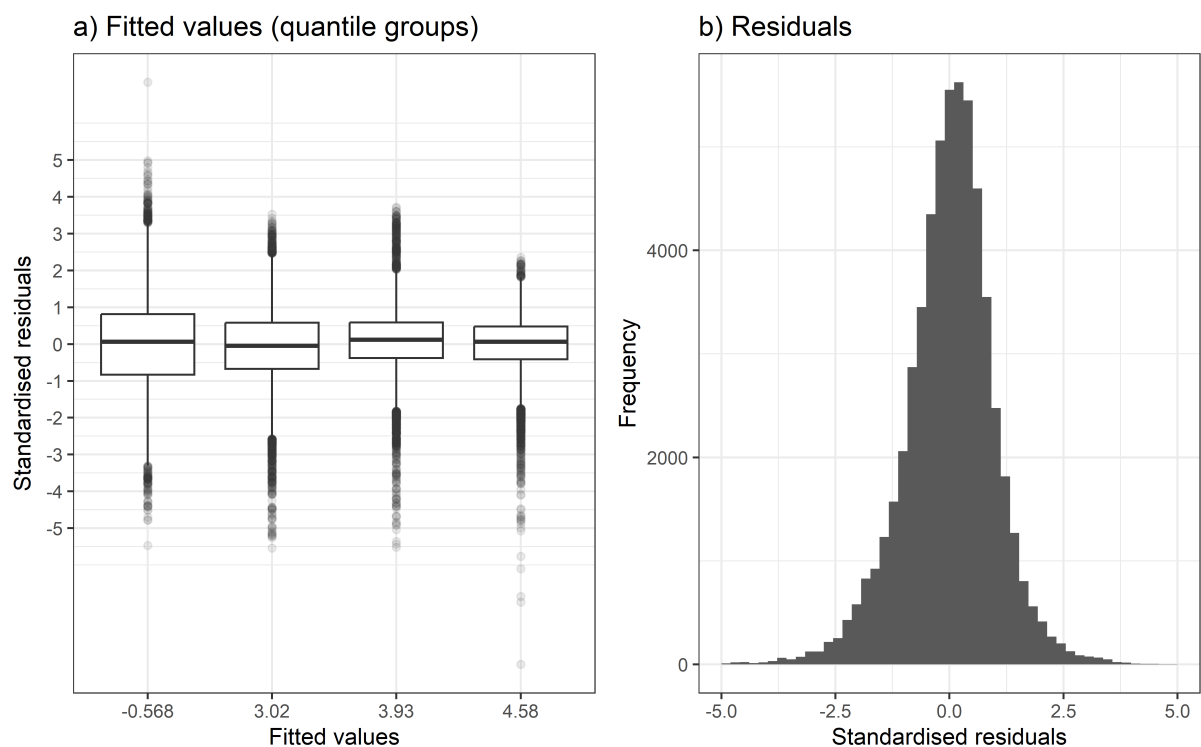


Figure D.14: Fleet 3 catch rate residual plots for a) box plot of fitted values and residuals, and b) histogram of residuals. Fitted values were on the log(kg) and grouped into quantiles. Residuals were standardised by the model residual standard deviation.

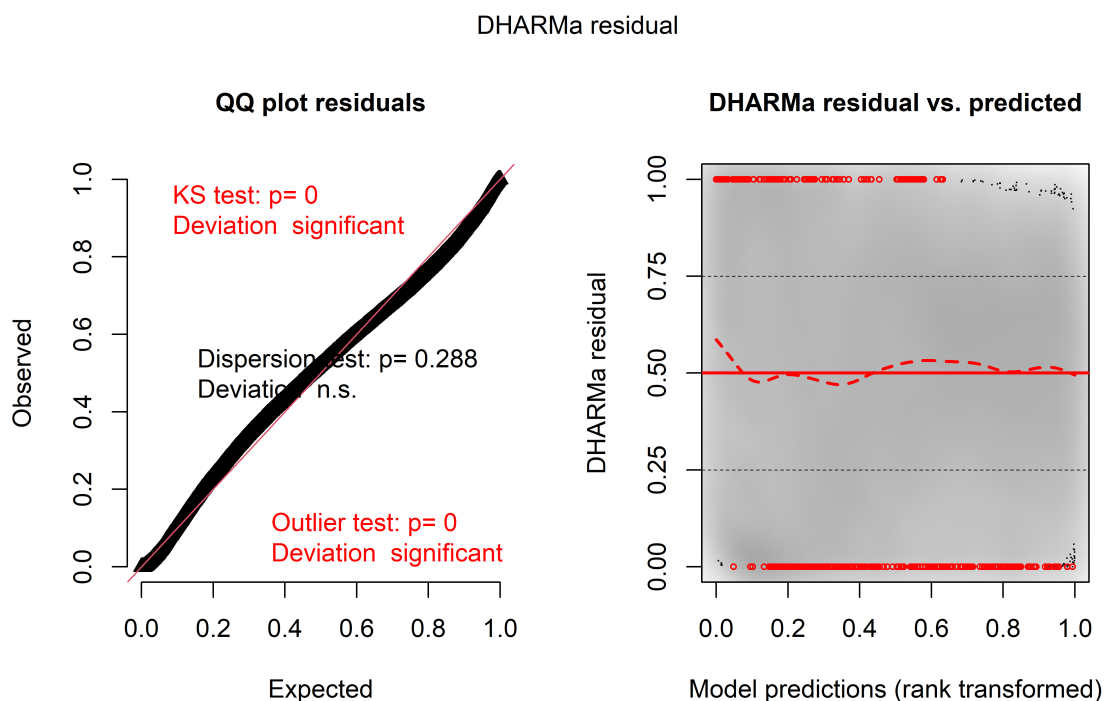


Figure D.15: Plot of fleet 3 DHARMA simulated pit residuals ($n=500$).

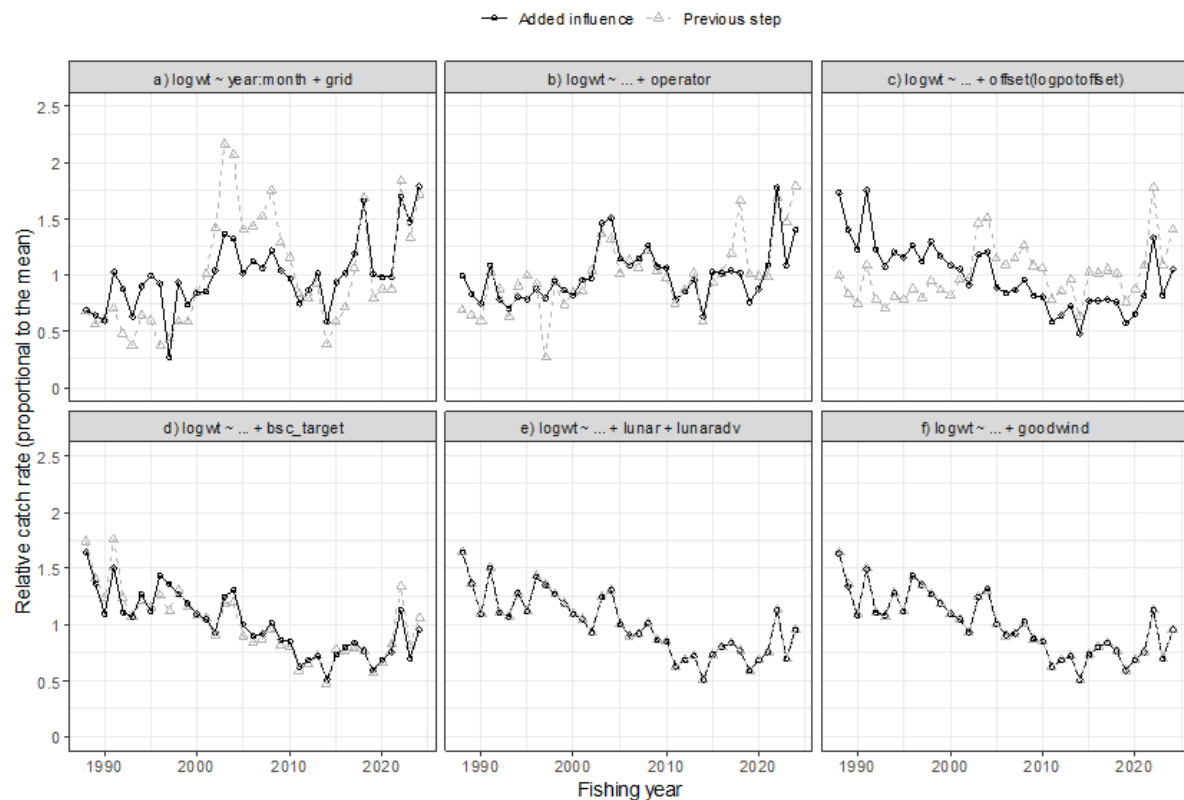


Figure D.16: Influence plot comparing the LM effects on standardised catch rates for fleet 3. Subplot: a) compared a year, month and grid model to nominal catch rate; b) compared a year, month, grid and operator model to model a; c) compared adding the log pot offset to model b; d) compared adding targeting to model c; e) compared adding lunar phase to model d; and f) compared the full standardisation model by adding good-wind.

Table D.6: Log parameter estimates for catch rate effects from Hervey Bay (fleet 3) analysis. R29 was the grid factor reference level, with effect = 0.

Parameter	Estimate	Std. Error	t value
gridS29	0.238	0.219	1.1
gridS30	0.372	0.200	1.9
gridT29	-0.286	0.332	-0.9
gridT30	0.474	0.208	2.3
gridT31	0.658	0.196	3.4
gridU29	-2.699	0.244	-11.1
gridU31	0.943	0.198	4.8
gridU32	0.901	0.193	4.7
gridU33	0.973	0.201	4.8
gridV30	0.899	0.258	3.5
gridV31	1.187	0.197	6.0
gridV32	1.108	0.192	5.8
gridV33	0.670	0.192	3.5
gridV34	0.647	0.192	3.4
gridW30	0.515	0.340	1.5
gridW31	1.412	0.266	5.3
gridW32	1.121	0.192	5.8
gridX32	0.190	0.323	0.6
bsc target	1.396	0.014	97.0
lunar	0.119	0.008	14.8
lunaradv	-0.032	0.008	-3.9
goodwind	-0.049	0.016	-2.9

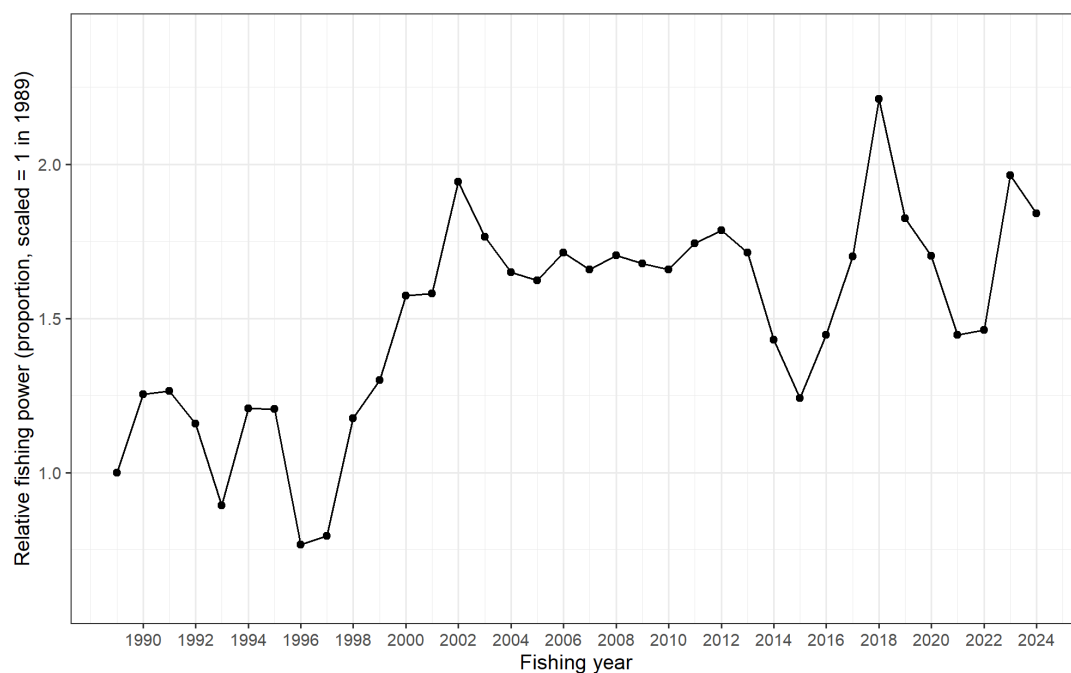


Figure D.17: Relative average fishing-power by year for fleet 3 in offshore waters, as estimated from operator days of fishing effort and their parameter estimate.

D.5 Recreational pot fleet 7

Diagnostics from the recreational catch rate analysis.

Table D.7: Analysis of variance table for the recreational (fleet 7) catch rate analysis. F statistics were derived from the R drop1 procedure. Adjusted R-squared based on mean deviance = 0.1175 .

Term	Df	Deviance	F value	Pr(>F)
residual	4522	5149.3		
Month	11	5205.3	4.476	0.000
Number of fishers	1	5173.1	20.907	0.000
Hours	1	5178.3	25.521	0.000
year : region	14	5201.8	3.292	0.000

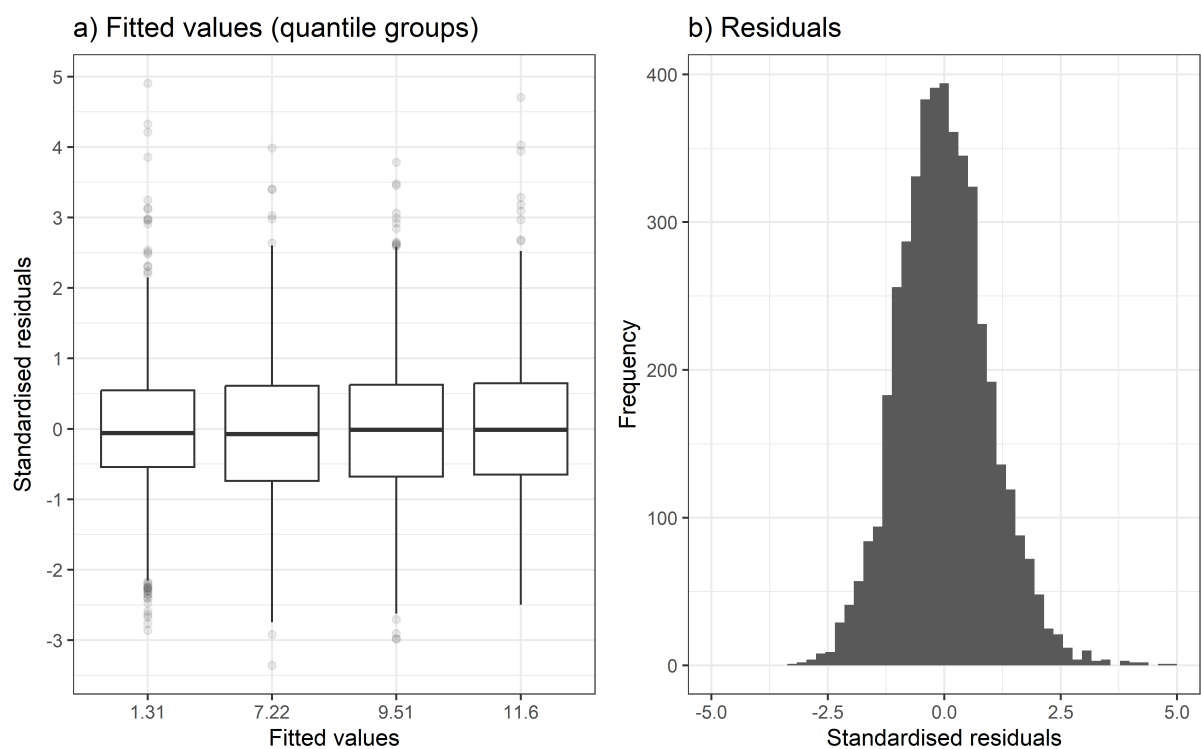


Figure D.18: Fleet 7 catch rate residual plots for a) box plot of fitted values and residuals, and b) histogram of residuals. Fitted values were numbers of crab and grouped into quantiles. Quantile residuals are shown for the generalised linear model.

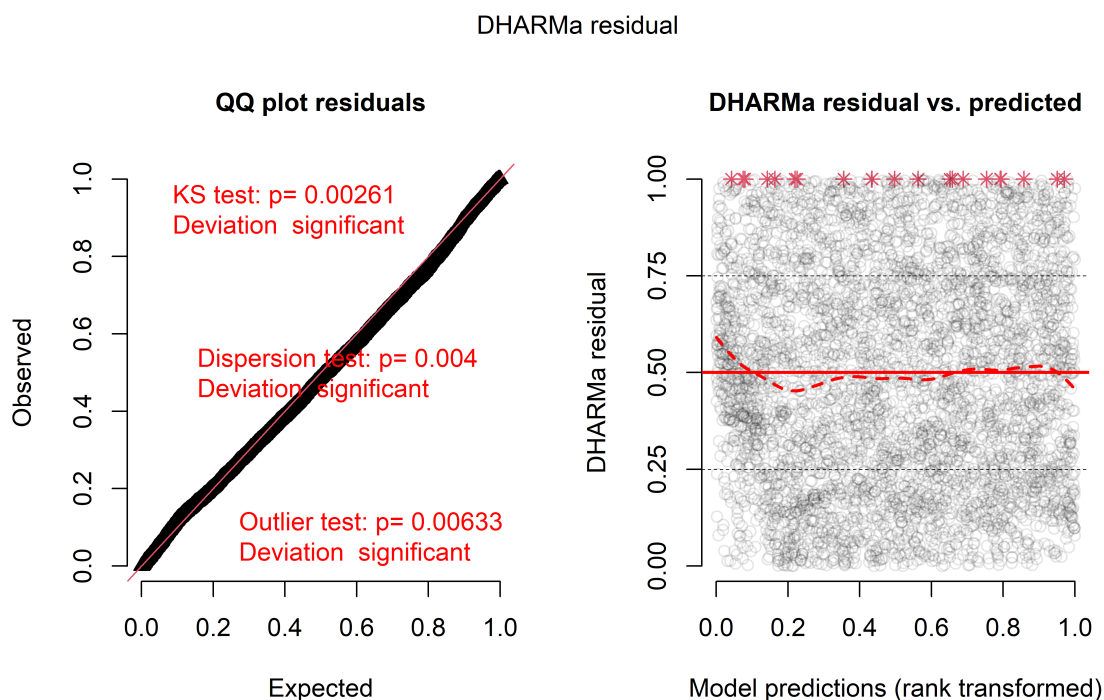


Figure D.19: Plot of fleet 7 DHARMa simulated pit residuals ($n=500$).

Table D.8: Log parameter estimates for catch rate effects from the recreational (fleet 7) analysis. Hervey Bay region was set as the reference level with effect = 0.

Parameter	Estimate	Std. Error	z value
Moreton Bay	0.991	0.164	6.0
Other areas	-0.431	0.239	-1.8
NumberOfFisher	0.101	0.020	5.1
hours	0.006	0.001	5.1

D.6 Survey beam-trawl fleet 8

Diagnostics from the survey catch rate analysis.

Table D.9: Analysis of variance table for the survey (fleet 8) catch rate analysis. F statistics were derived from the R drop1 procedure. Adjusted R-squared based on mean deviance = 0.2460 .

Term	Df	Deviance	F value	Pr(>F)
residual	2153	2514.9		
StartTimeGroup	3	2538.6	6.751	0.000
Depth.cat	2	2792.2	118.670	0.000
year : month	13	2574.1	3.894	0.000

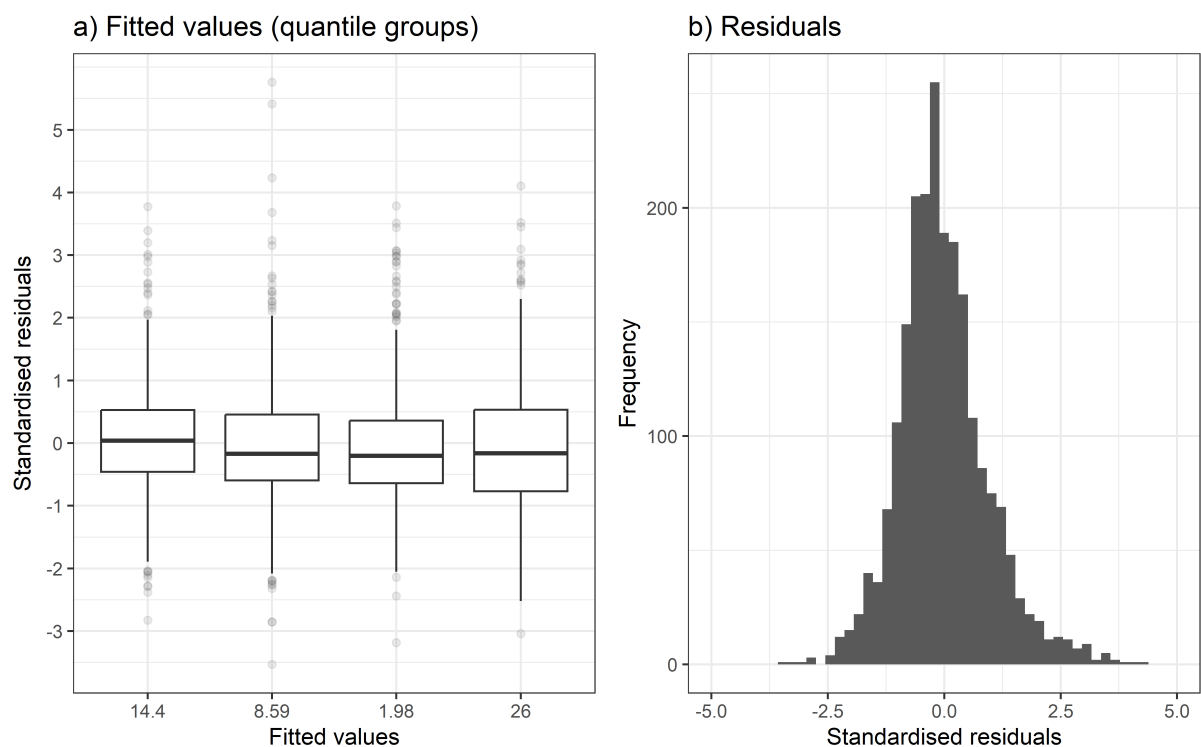


Figure D.20: Survey fleet 8 catch rate residual plots for a) box plot of fitted values and residuals, and b) histogram of residuals. Fitted values were numbers of crab and grouped into quantiles. Quantile residuals are shown for the generalised linear model.

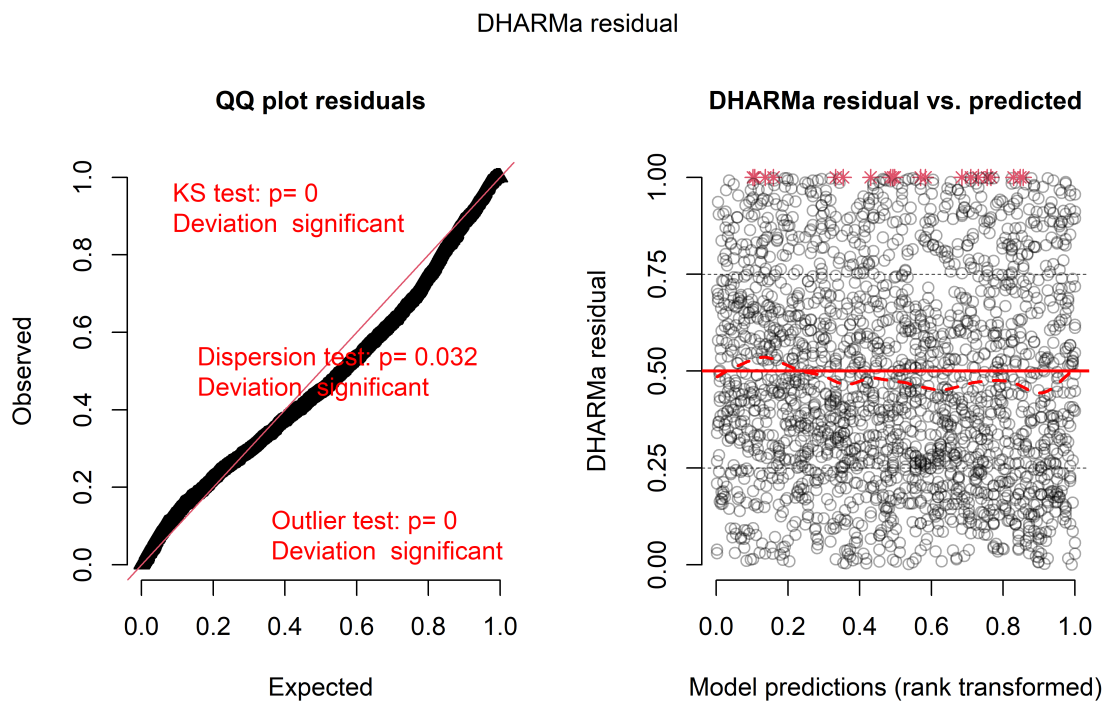


Figure D.21: Plot of survey fleet 8 DHARMA simulated pit residuals (n=500).

Table D.10: Log parameter estimates for catch rate effects from the survey (fleet 8) analysis. Midnight and depth category 0 to 10 m were set as their factor reference levels with effect = 0.

Parameter	Estimate	Std. Error	z value
StartTimeGroup03:00	-0.217	0.096	-2.3
StartTimeGroup17:00	0.240	0.074	3.2
StartTimeGroup21:00	-0.012	0.069	-0.2
Depth.cat20	-0.926	0.062	-14.8
Depth.cat30	-1.263	0.098	-12.8

E Model inputs

E.1 Biological data

The biological relationships are plotted in Figure E.1. These include the von Bertalanffy growth curve and mean weight, spawning output and maturity as a relationship of notch carapace width cm. Parameters including standard deviations were set from Lovett et al. (2020) and Sumpton et al. (2015).

Table E.1 and Figure E.2 show the results for the mean notch carapace width (cm) at spine carapace width (cm) relationship for each sex. The quadratic relationship adjusted R-squared was 0.99, model degrees of freedom was (4, 27707), and model standard deviation was 0.25 cm.

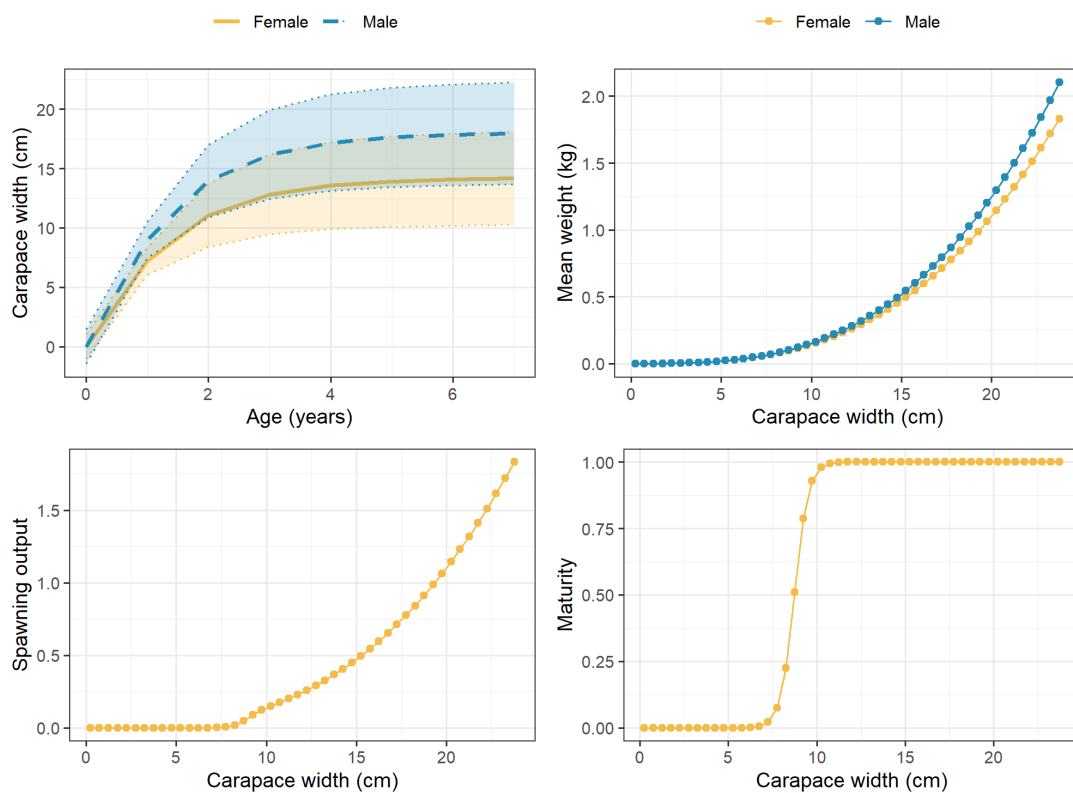


Figure E.1: Biological relationships for Queensland east coast blue swimmer crab – top left: von Bertalanffy growth curve, top right: weight–carapace width relationship, bottom left: relative spawning output, bottom right: maturity proportion.

Table E.1: Parameter estimates and standard errors for the quadratic spine to notch relationship (cm).

Parameter	Estimate	Std. Error	t value
SexFemale:Spine	0.754157043	0.001557424	484.234
SexMale:Spine	0.762219898	0.001199002	635.712
SexFemale:Spine2	0.004519715	0.000107825	41.917
SexMale:Spine2	0.004490902	0.000079725	56.330

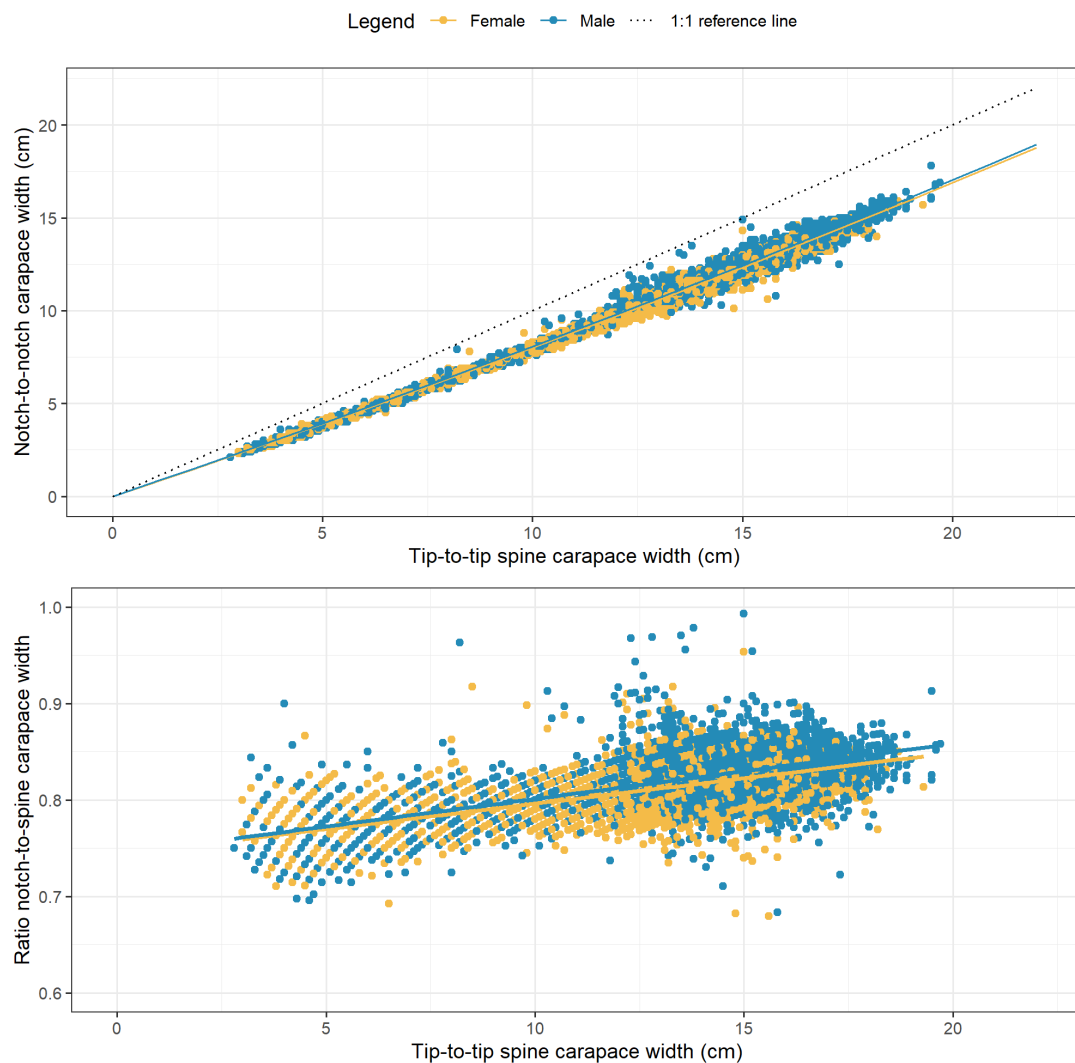


Figure E.2: Carapace width relationship for Queensland east coast blue swimmer crab by sex – top figure: quadratic relationship, and bottom figure: notch to spine ratio.

E.2 Recreational harvest

Table E.2: Statewide survey estimates of numbers of blue swimmer crab harvested by recreational fishing, tallied with lower and upper 95 percent confidence intervals and relative standard error by year.

Year	Estimate	Lower estimate	Upper estimate	RSE
1999	116495	80537	152452	0.15
2002	119991	99988	139993	0.08
2005	107136	76297	137974	0.14
2000	117660	51823	183497	0.28
2010	116295	48473	184116	0.87
2013	111671	58371	164971	0.24
2019	81183	37733	124633	0.27

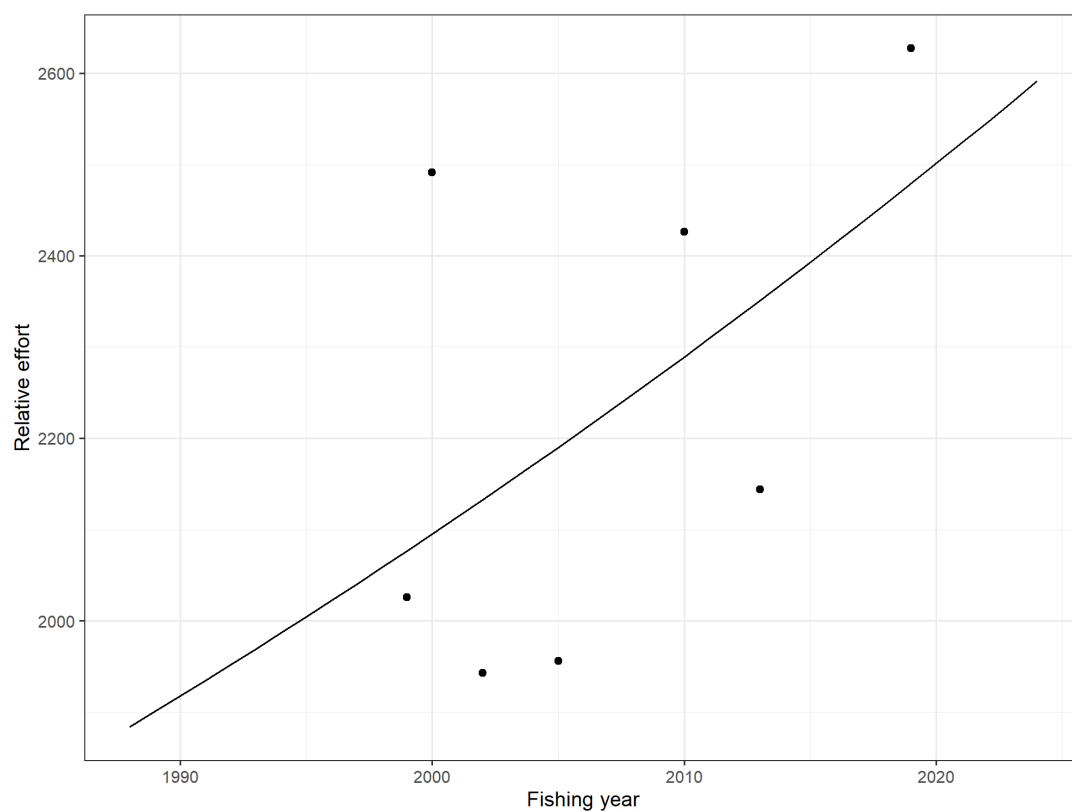


Figure E.3: Estimated recreational fishing effort (relative) by year.

F Model outputs

F.1 MLE diagnostics

F.1.1 Likelihood profile

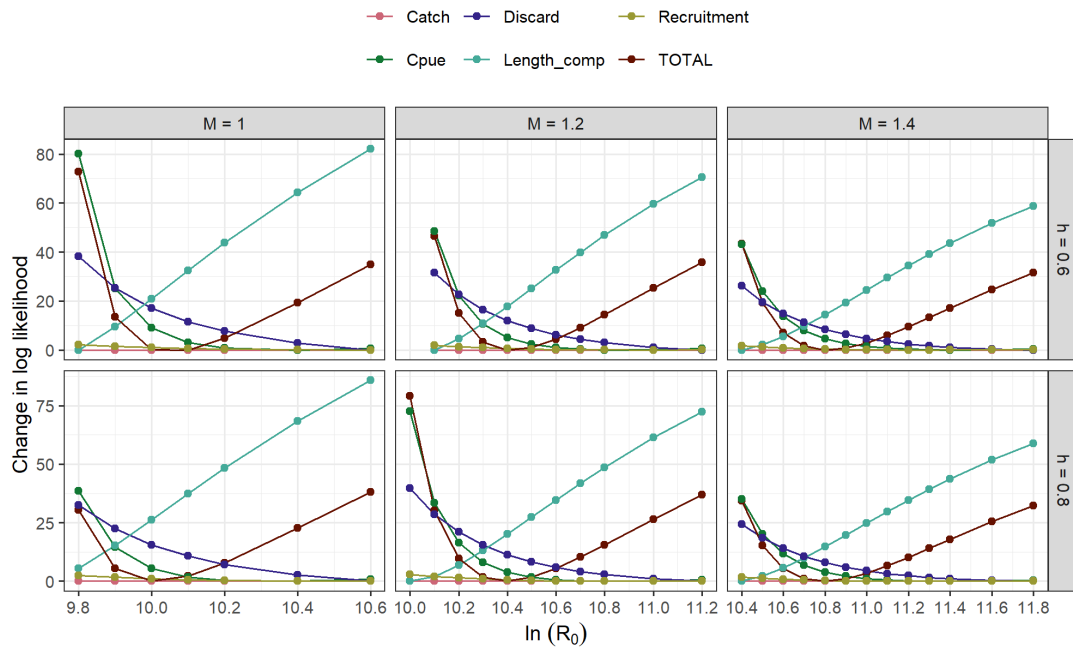


Figure F.1: Likelihood profile for $\ln(R_0)$ for analyses 1–6 natural mortality (M) and steepness (h) values—likelihood change values are relative to the lowest likelihood within each individual plot and are only shown where the change in likelihood is less than 100

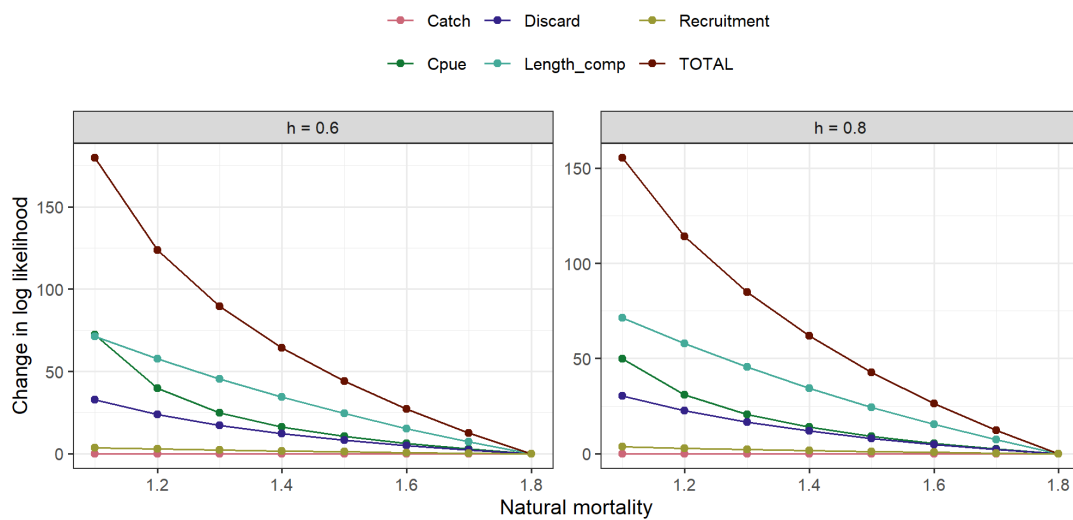


Figure F.2: Likelihood profile for natural mortality over analyses 1–6 steepness (h) values—likelihood change values are relative to the lowest likelihood within each individual plot and are only shown where the change in likelihood is less than 200

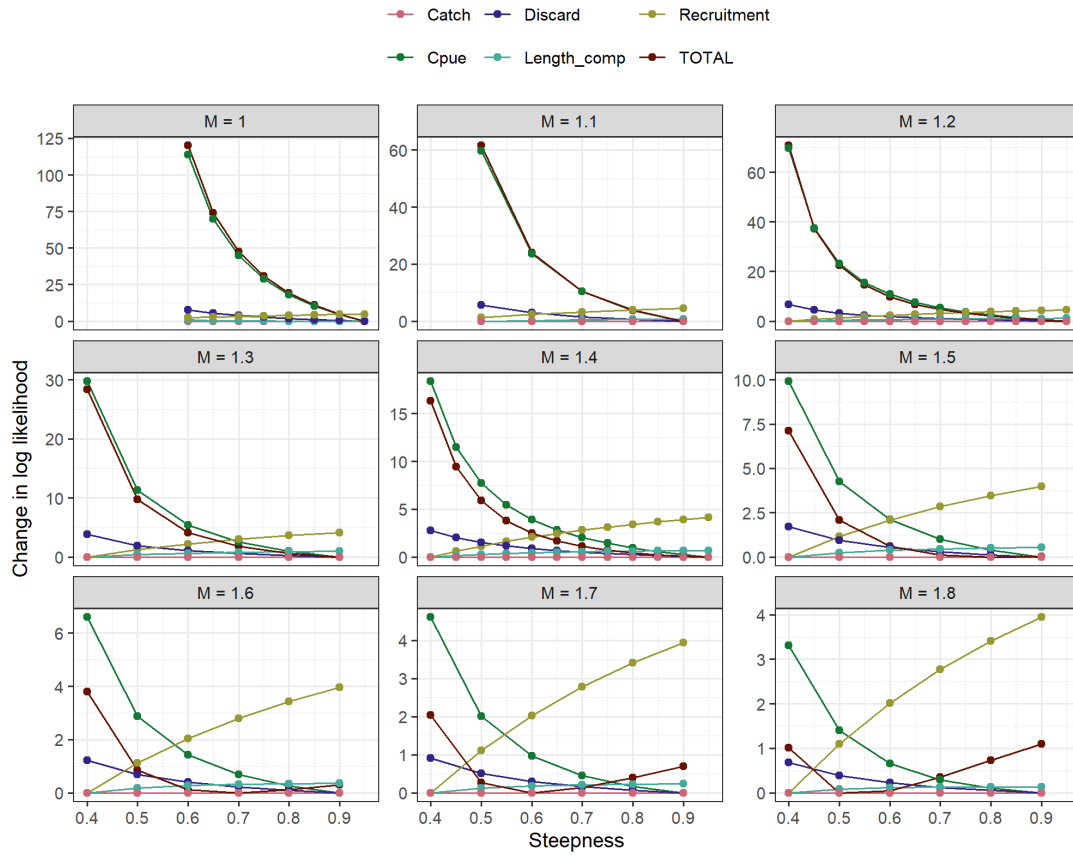


Figure F.3: Likelihood profile for steepness over various values of natural mortality (M)—likelihood change values are relative to the lowest likelihood within each individual plot and are only shown where the change in likelihood is less than 200

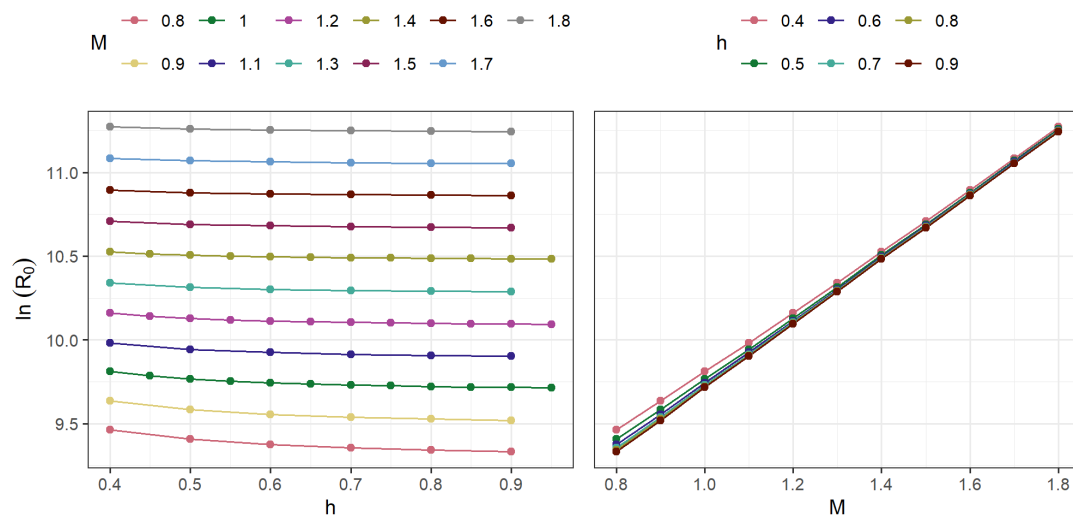


Figure F.4: Estimated values of $\ln(R_0)$ for values of steepness (h) and natural mortality (M)

F.2 MCMC diagnostics

Figures F.5 and F.6 show the potential scale reduction factor ($\hat{R}$) and effective sample sizes from the MCMC model for analyses 1 to 12.

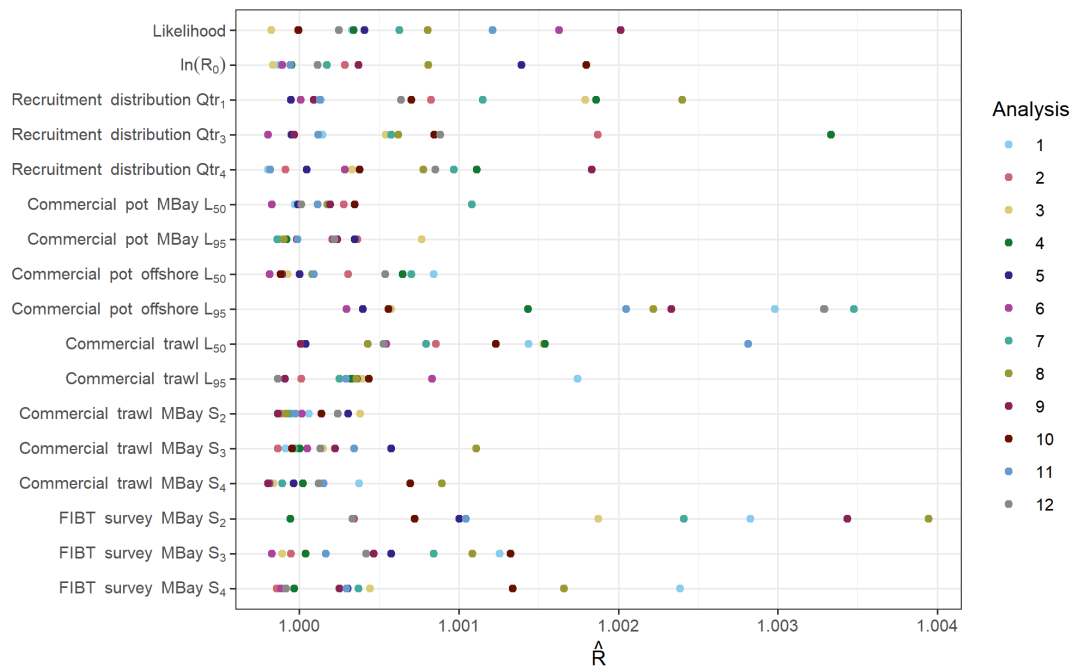


Figure F.5: Potential scale reduction factor, $\hat{R}$ values over each MCMC analysis for blue swimmer crab in the east coast—model is likely converged if $\hat{R} < 1.05$

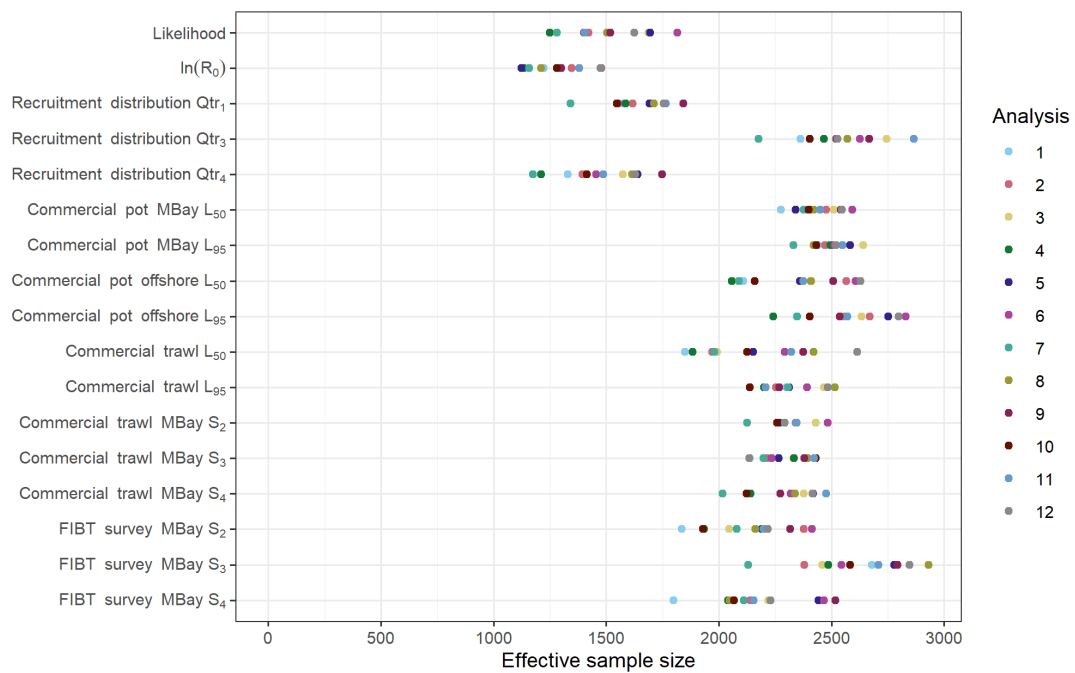


Figure F.6: Potential effective sample size values over each MCMC analysis for blue swimmer crab in the east coast

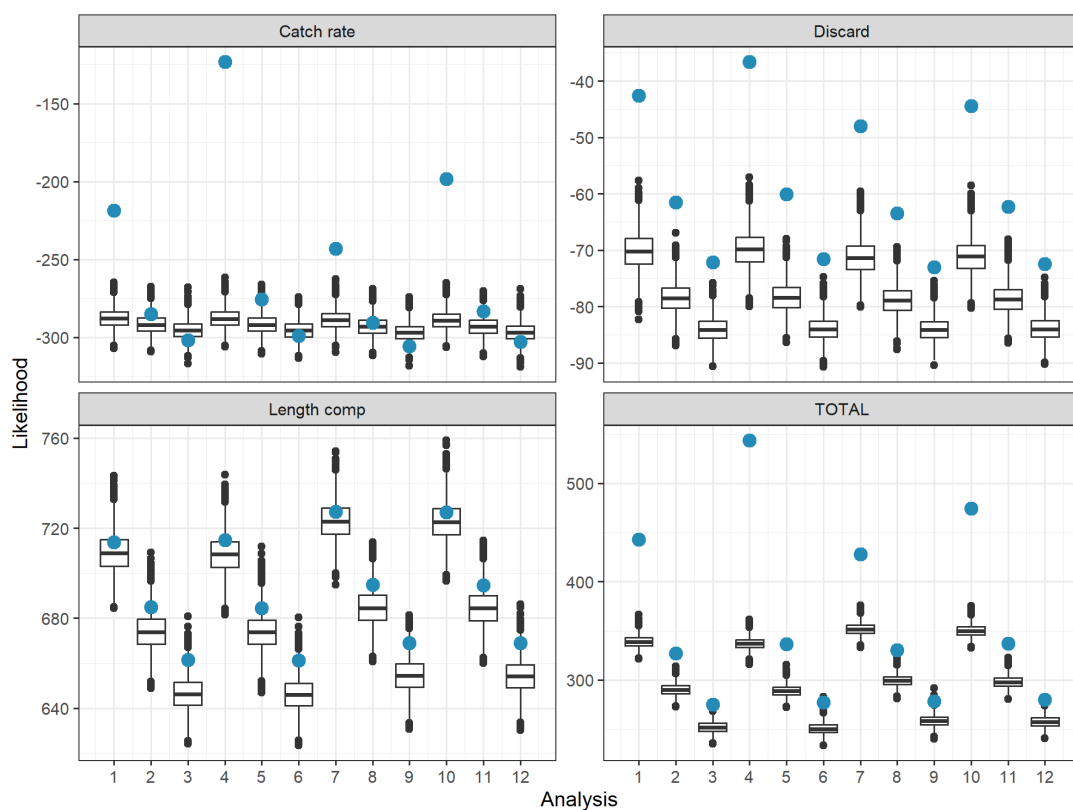


Figure F.7: Likelihood comparisons between MLE (blue dot) and MCMC (box plot) for each analysis in the ensemble

F.3 Other outputs

F.3.1 Stock-recruit curve

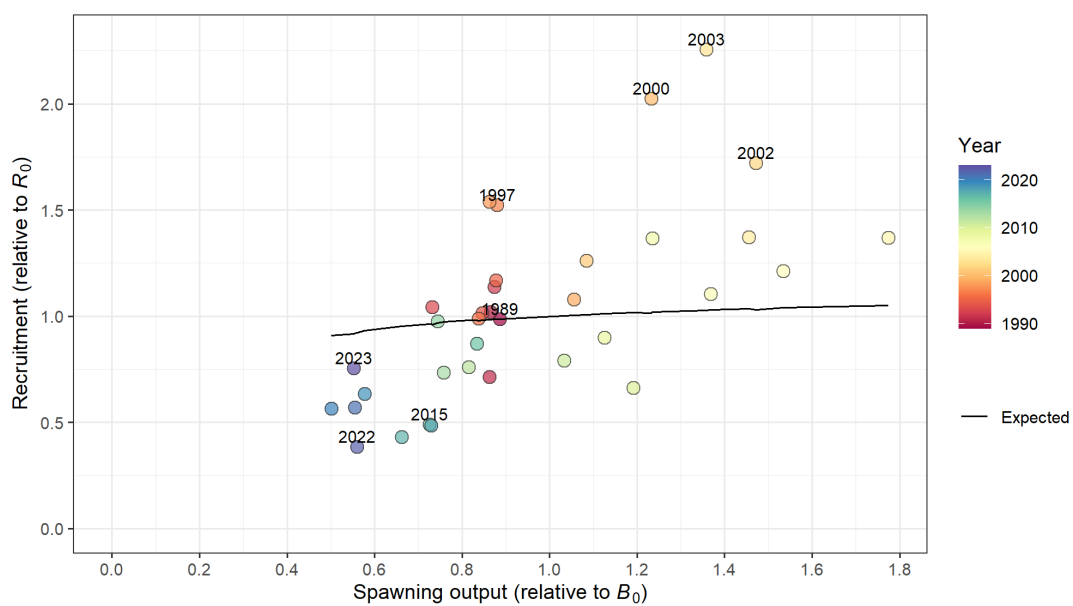


Figure F.8: Stock-recruit curve for blue swimmer crab in the east coast based on the median of all MLE ensemble analyses—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

F.3.2 Fishing mortality

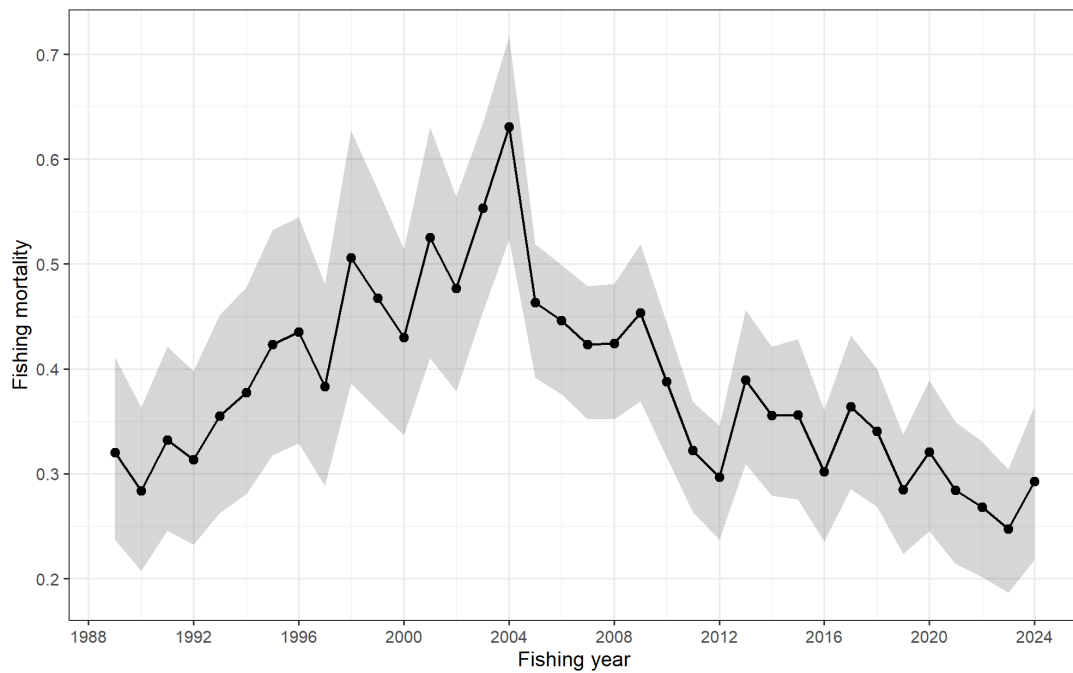


Figure F.9: Time series of fishing mortality from the MCMC ensemble model—error bars represent 95% credible intervals

F.3.3 Recruitment deviations



Figure F.10: Median recruitment deviations from the ensemble model—shaded areas represent 95% confidence/credible intervals

F.3.4 Sensitivity: parameter estimates and derived quantities

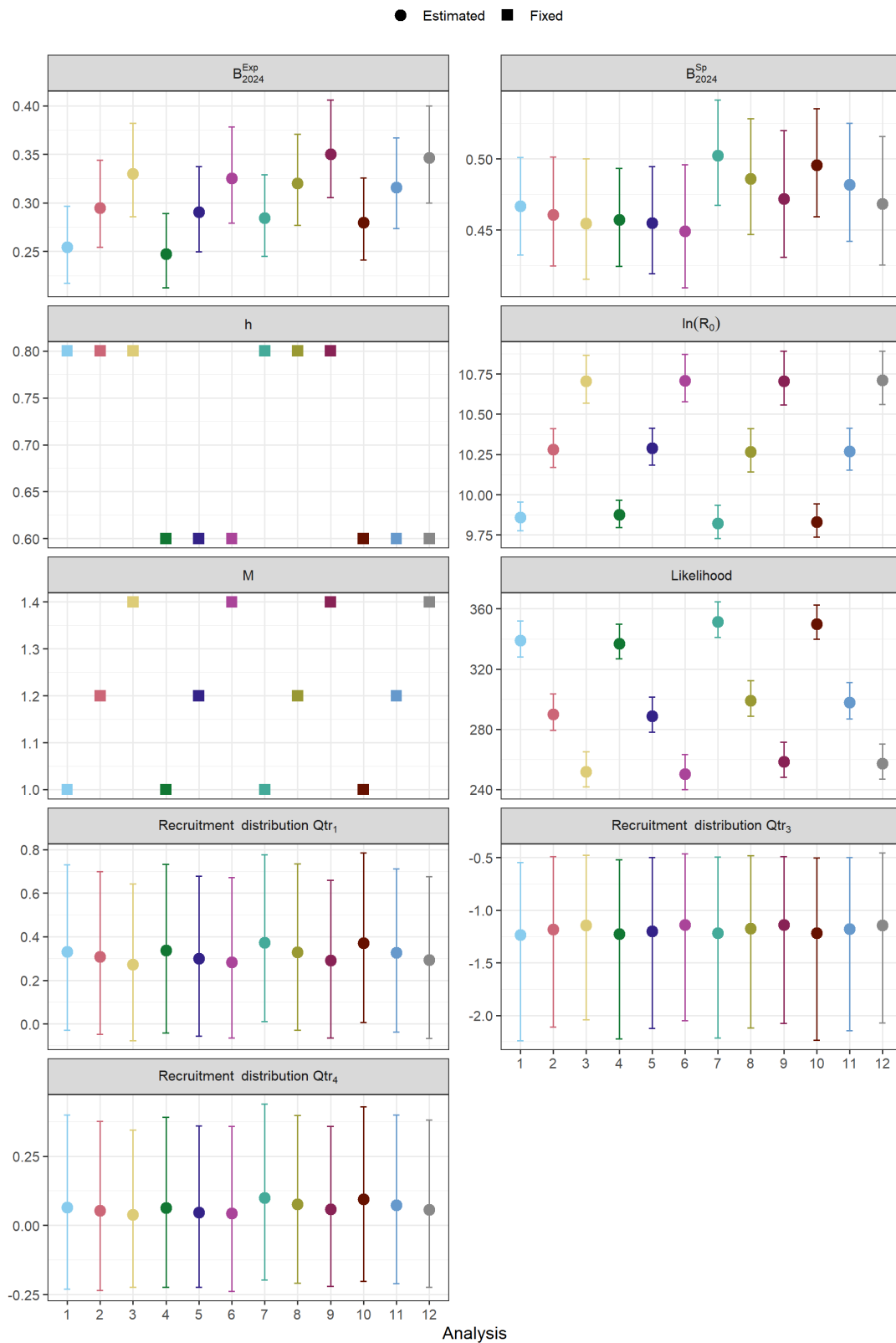


Figure F.11: Comparison of main parameter estimates and derived quantities among the 12 analyses included in the MCMC ensemble model

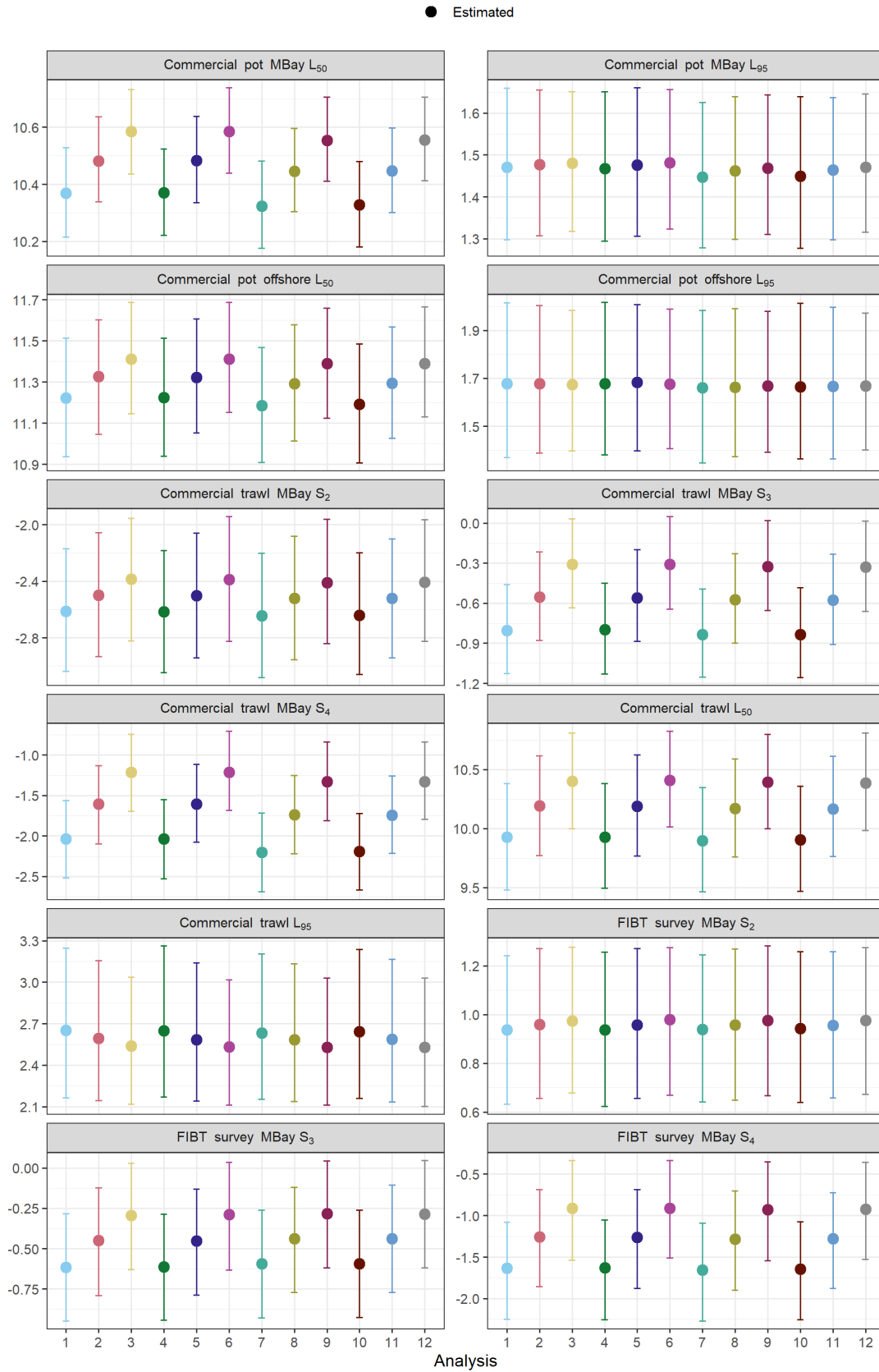


Figure F.12: Comparison of selectivity parameter estimates and derived quantities among the 12 analyses included in the MCMC ensemble model

F.3.5 Sex ratios

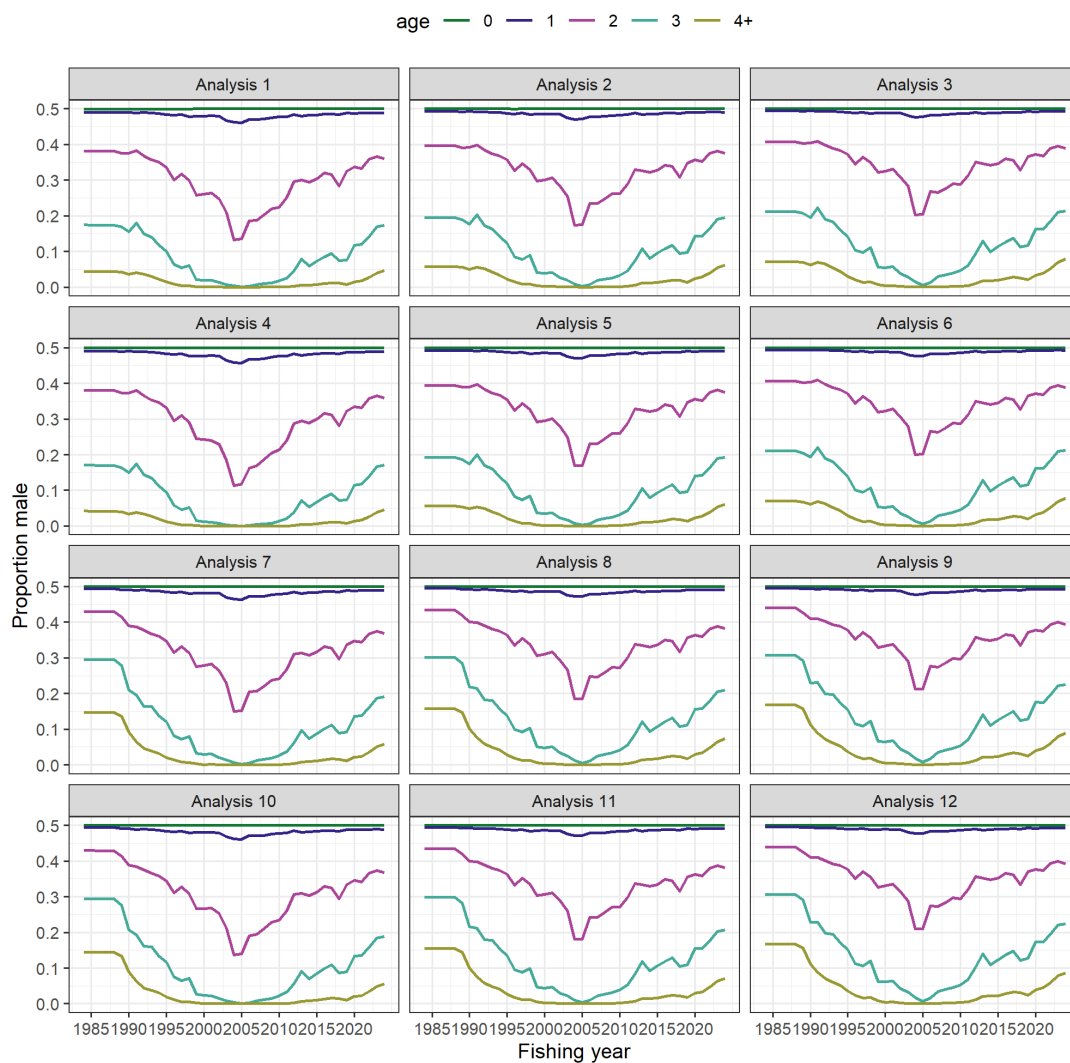


Figure F.13: Proportion of male numbers for each age in the population through time for each MLE ensemble analysis

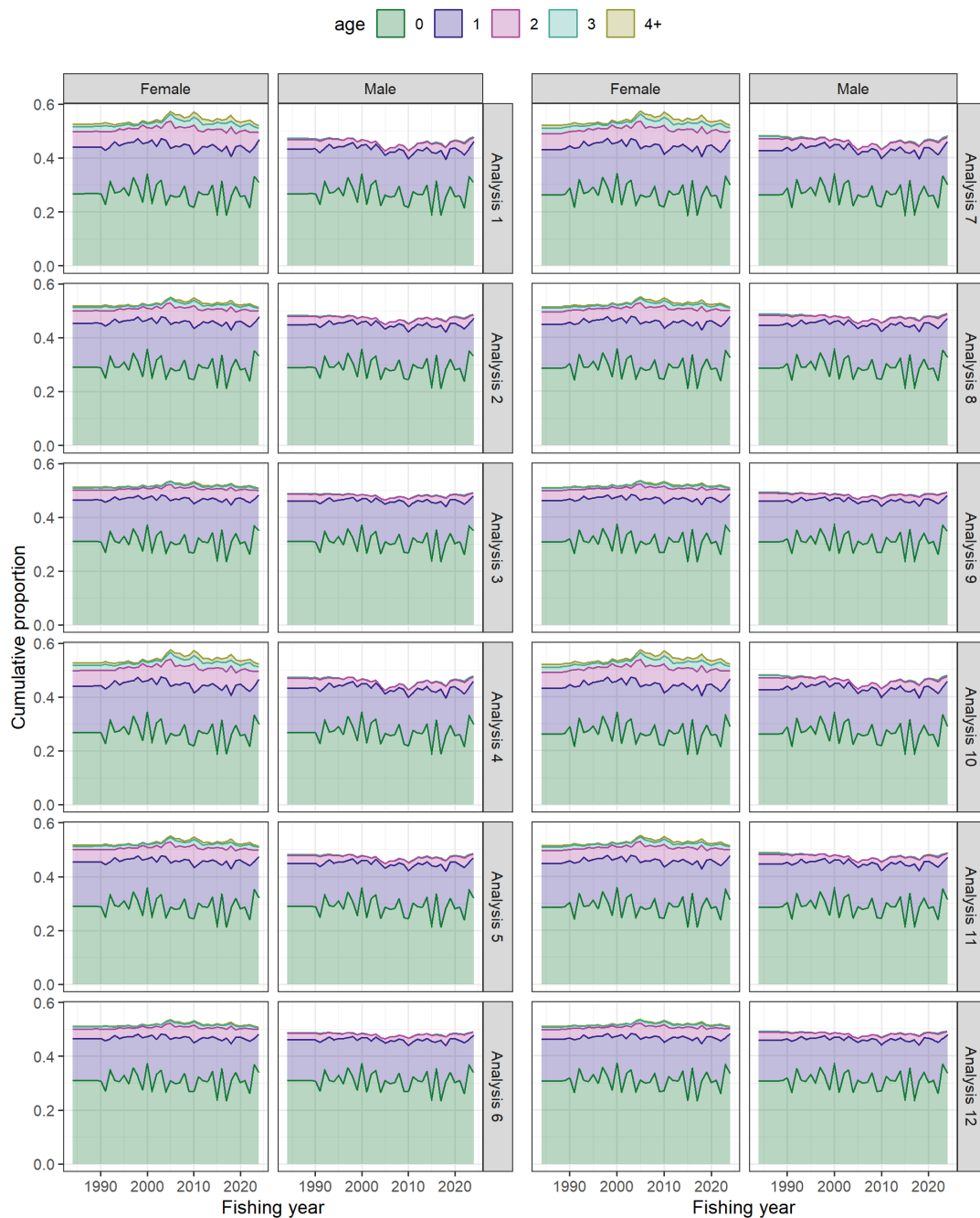


Figure F.14: Proportion of numbers of each age and sex (cumulative by age) in the population through time for each MLE ensemble analysis

G Exploratory analyses

Exploratory analyses 13–16 were based initially on the analysis 2 setup where natural mortality $M = 1.2$. This was the middle M option. Results were compared to analysis 2. The four MLE analyses considered extra model assumptions and questions and were not used in the ensemble. These comprised of:

- Reduced commercial harvests in 2001–2005 for possible over reporting (Sumpton et al. 2015). Figure G.1 displays the harvest input for analysis 13 compared to analysis 2.
- Zero discard mortality (D) for checking the influence of trawling.
- Higher L_{∞} growing larger crab for possible underestimation (Sumpton et al. 2015). Figure G.2 displays the growth input for analysis 13 compared to analysis 2.
- Annual catch rates, rather than quarterly, for fleets 2 and 3 (Figures 3.5, 3.6). For more model focus on quarterly patterns from Moreton Bay.

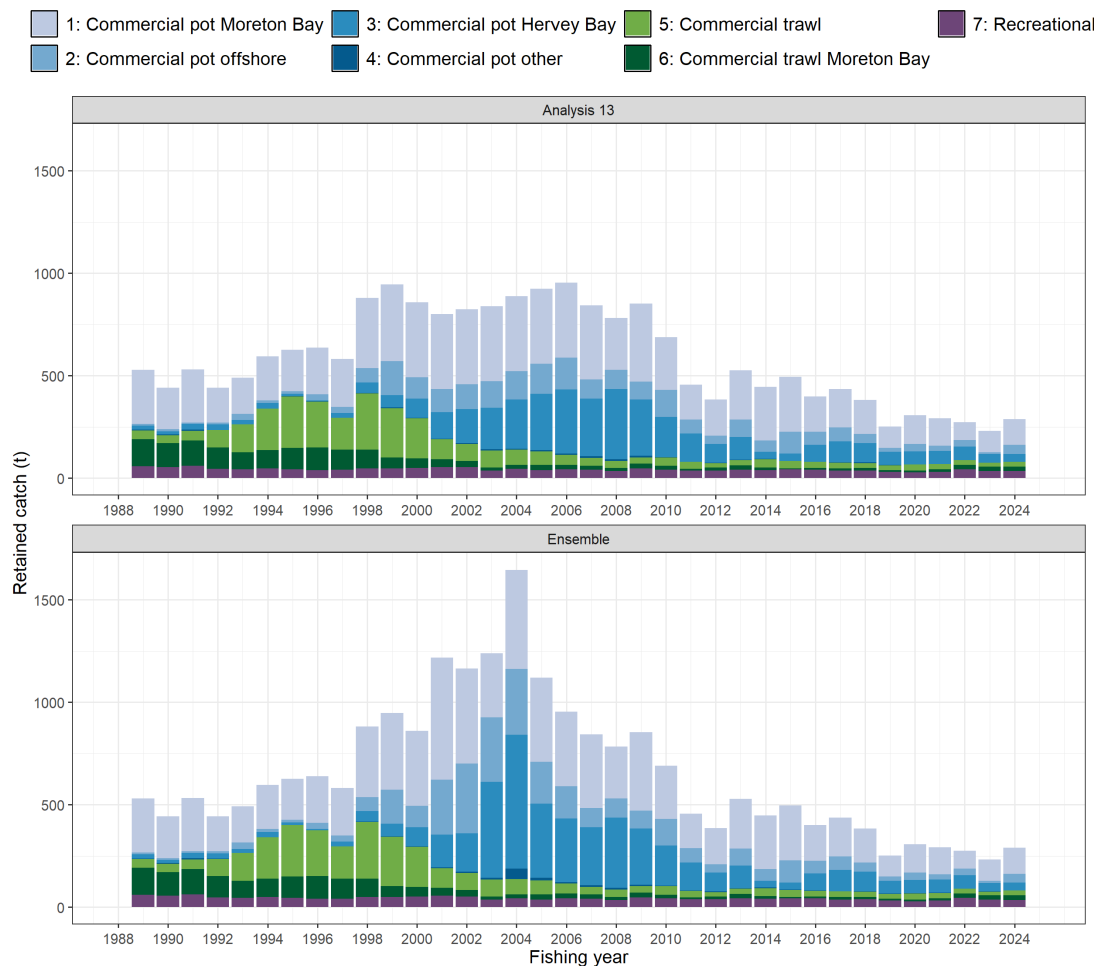


Figure G.1: Annual retained catch by fleet between 1989 and 2024, as input into analysis 13 compared to the ensemble harvests.

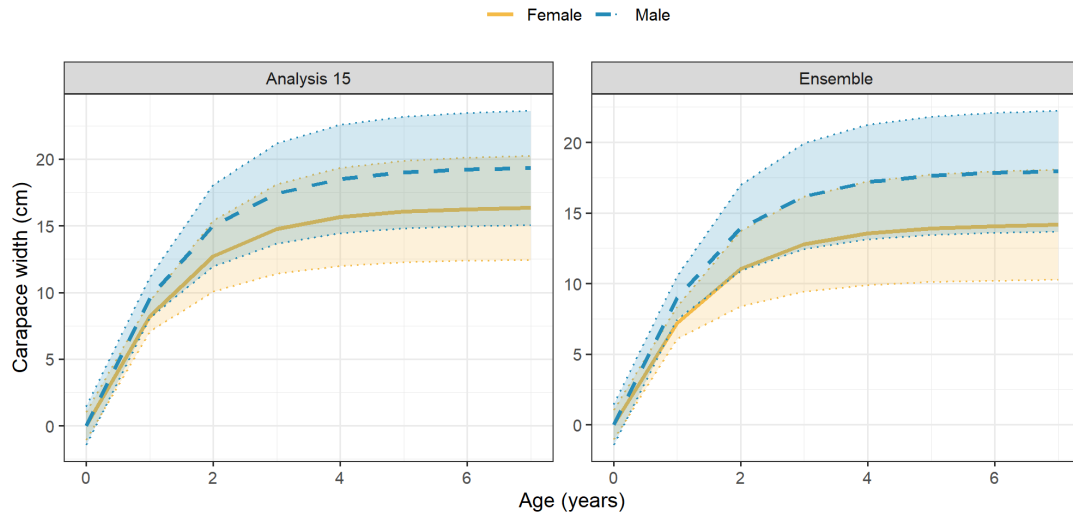


Figure G.2: von Bertalanffy growth curve input to analysis 15 compared to the ensemble.

The findings from the exploratory analyses in Figure G.3 and Figure G.4 were:

- Analysis 13 used smaller harvests. This reduced the recruitment deviations in 2001–2006 and the $\ln(R_0)$ estimate. The resulting spawning biomass ratios 2002–2007 were lower.
- Analysis 14 dissolved trawl discard mortality. This test increased biomass ratios marginally. There was little effect on parameter estimates.
- Analysis 15 increased crab size and had a correlative affect on selectivity parameters and $\ln(R_0)$. Resulting biomass ratios were similar.
- Analysis 16 changed catch rate inputs to have no significant effect on biomass ratios, but did increase the quarter 3 confidence interval on recruitment distribution.
- Overall, the analyses effects on 2024 biomass ratios were small.

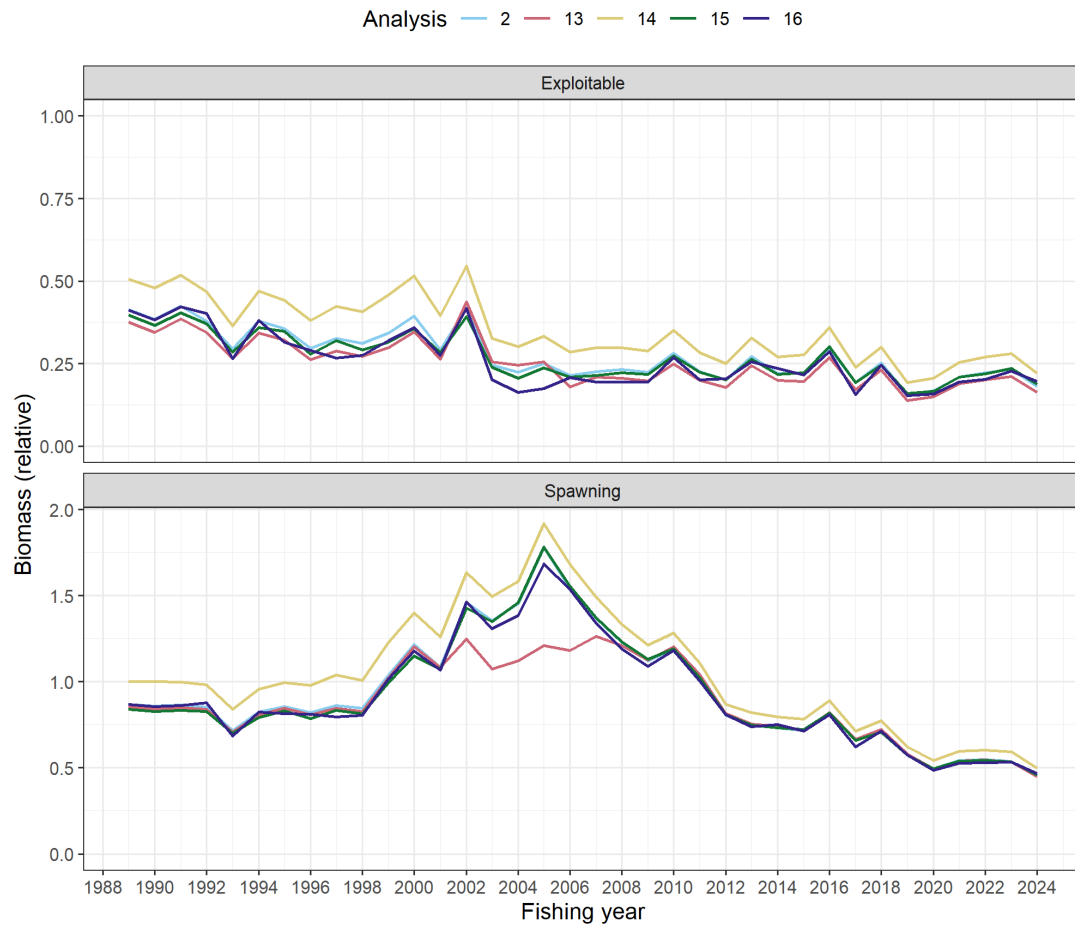


Figure G.3: Estimated biomass trajectory relative to unfished levels for blue swimmer crab in the east coast from 1989 to 2024 for analyses 2, 13–16. The upper panel displays exploitable biomass and the lower panel displays the spawning biomass. Analyses are shown as maximum likelihood estimates.

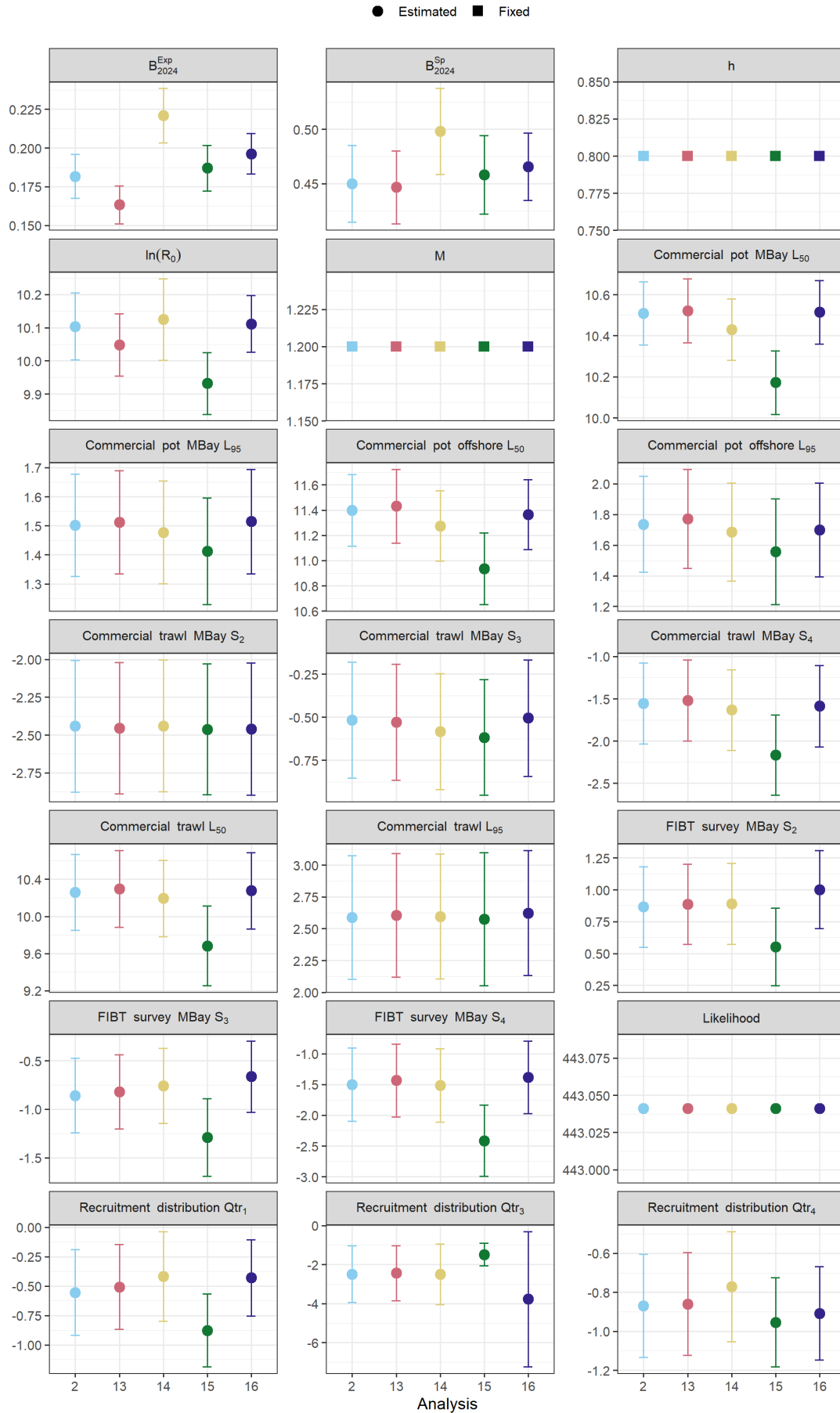


Figure G.4: Comparison of main parameter maximum likelihood estimates for analyses 2, 13–16

H Detailed model outputs

H.1 Analysis 1

Table H.1: Summary of MLE parameter estimates for analysis 1

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.53	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.83	2	-5.00	5.00	0.00	0.95
Recruitment distribution Qtr_4	-0.86	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	9.72	1	5.00	20.00	11.00	0.04
Commercial pot MBay L_{50}	10.40	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.49	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.30	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.73	3	0.10	20.00	1.50	0.17
Commercial trawl L_{50}	10.01	3	0.10	20.00	9.00	0.22
Commercial trawl L_{95}	2.64	3	0.10	20.00	2.20	0.27
Commercial trawl MBay S_2	-2.56	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.75	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.98	3	-9.00	7.00	0.00	0.25
FIBT survey MBay S_2	0.84	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-1.01	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.86	3	-9.00	7.00	-1.00	0.30

Table H.2: Summary of MCMC parameter estimates for analysis 1

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.33	-0.03	0.73
Recruitment distribution Qtr_3	-1.24	-2.24	-0.54
Recruitment distribution Qtr_4	0.06	-0.23	0.40
$\ln(R_0)$	9.86	9.78	9.96
Commercial pot MBay L_{50}	10.37	10.22	10.53
Commercial pot MBay L_{95}	1.47	1.30	1.66
Commercial pot offshore L_{50}	11.22	10.94	11.51
Commercial pot offshore L_{95}	1.68	1.37	2.02
Commercial trawl L_{50}	9.93	9.48	10.38
Commercial trawl L_{95}	2.65	2.17	3.25
Commercial trawl MBay S_2	-2.61	-3.04	-2.17
Commercial trawl MBay S_3	-0.80	-1.13	-0.46
Commercial trawl MBay S_4	-2.03	-2.52	-1.56
FIBT survey MBay S_2	0.94	0.63	1.24
FIBT survey MBay S_3	-0.62	-0.95	-0.28
FIBT survey MBay S_4	-1.64	-2.25	-1.08

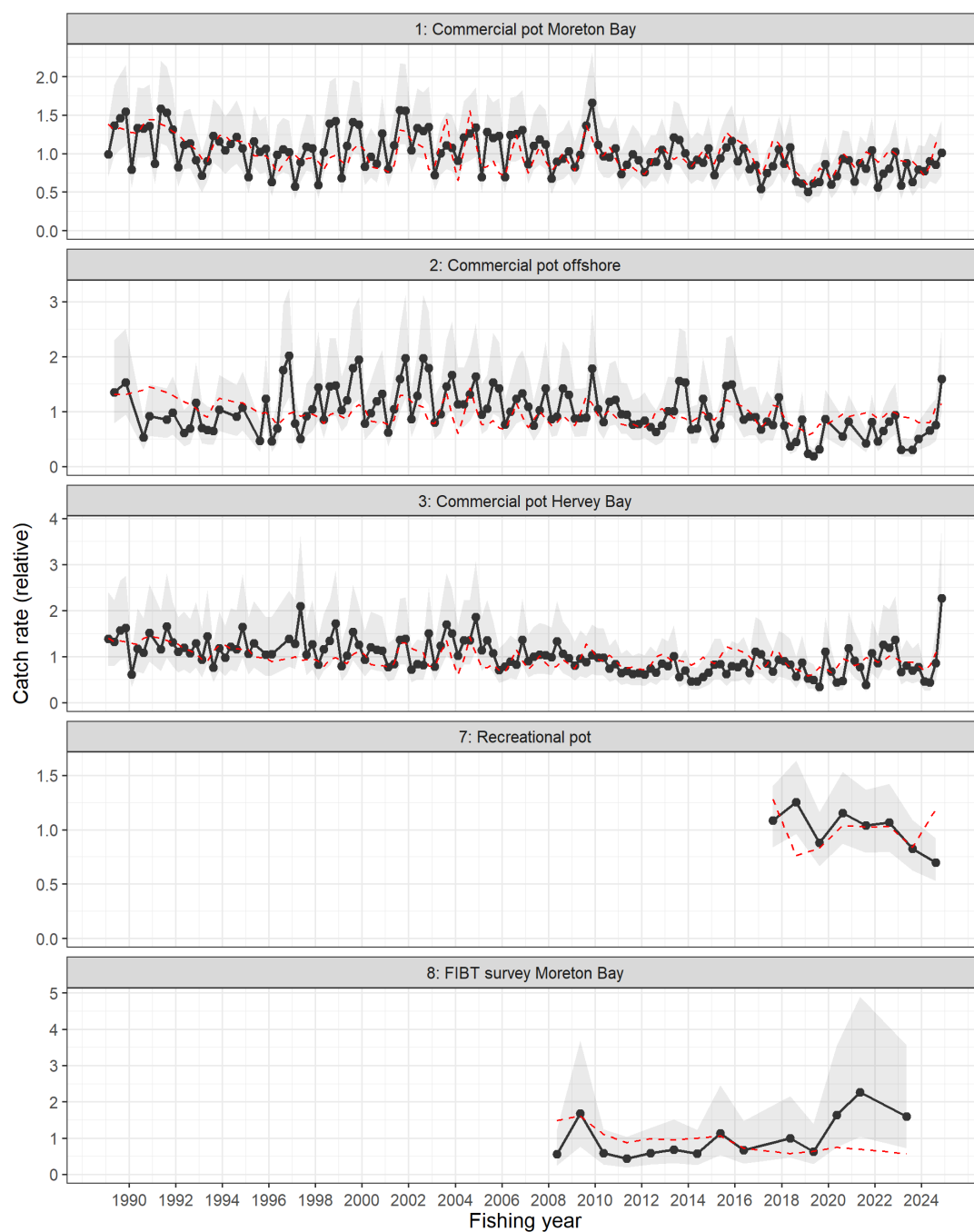


Figure H.1: Analysis 1: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

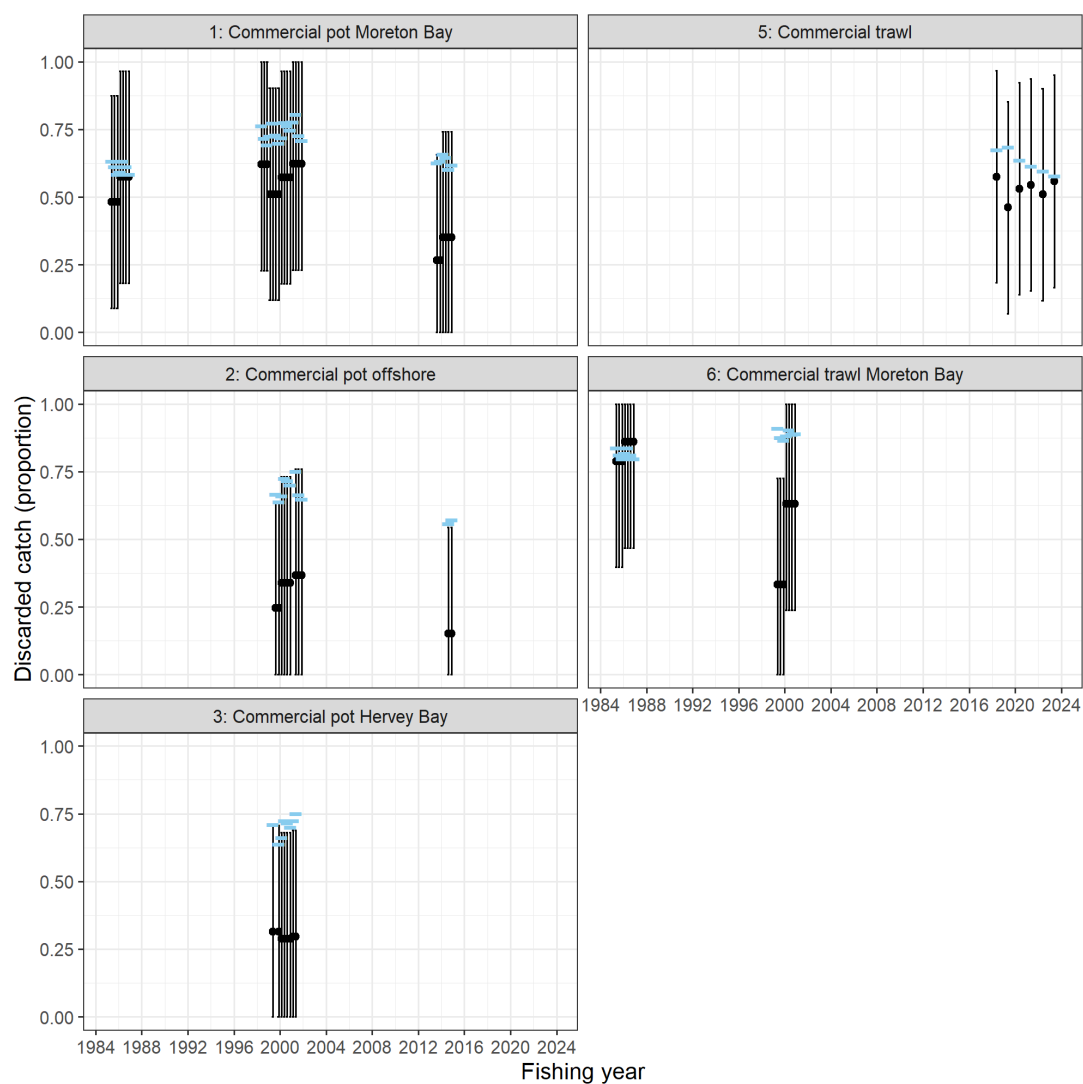


Figure H.2: Analysis 1: Fits to annual discard proportions of blue swimmer crab catch

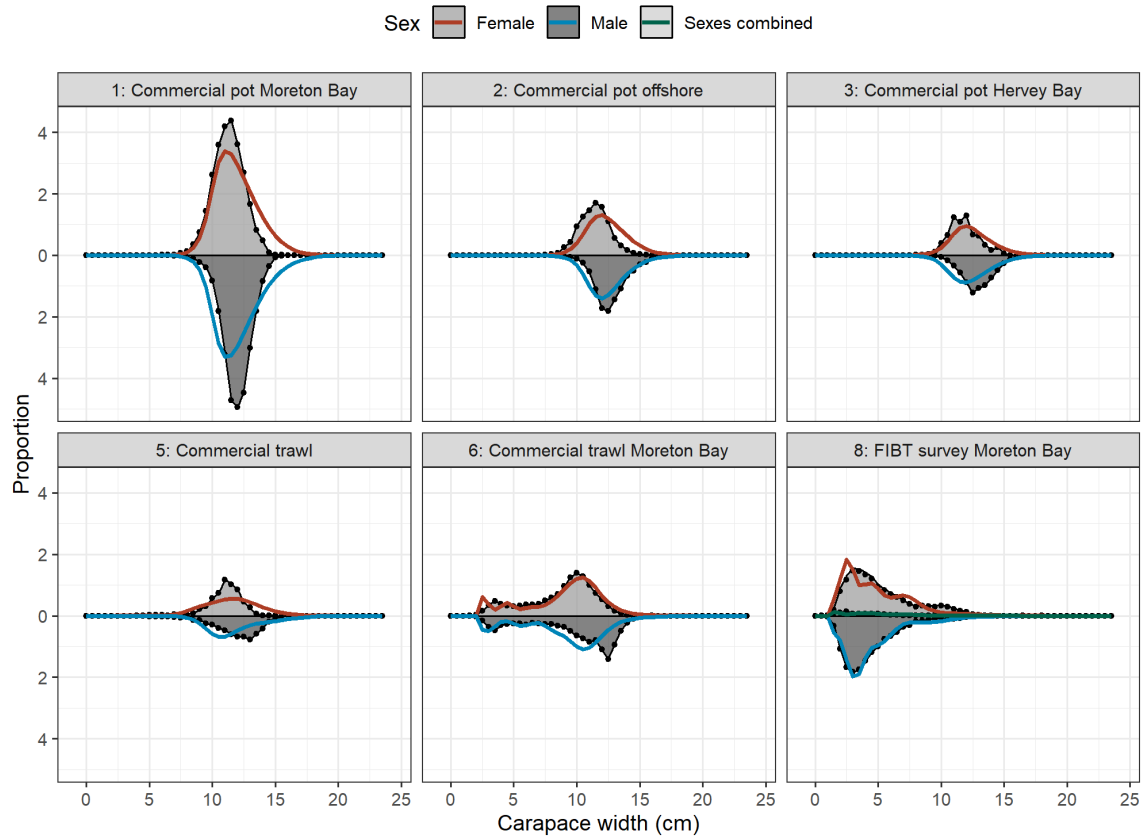


Figure H.3: Analysis 1: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

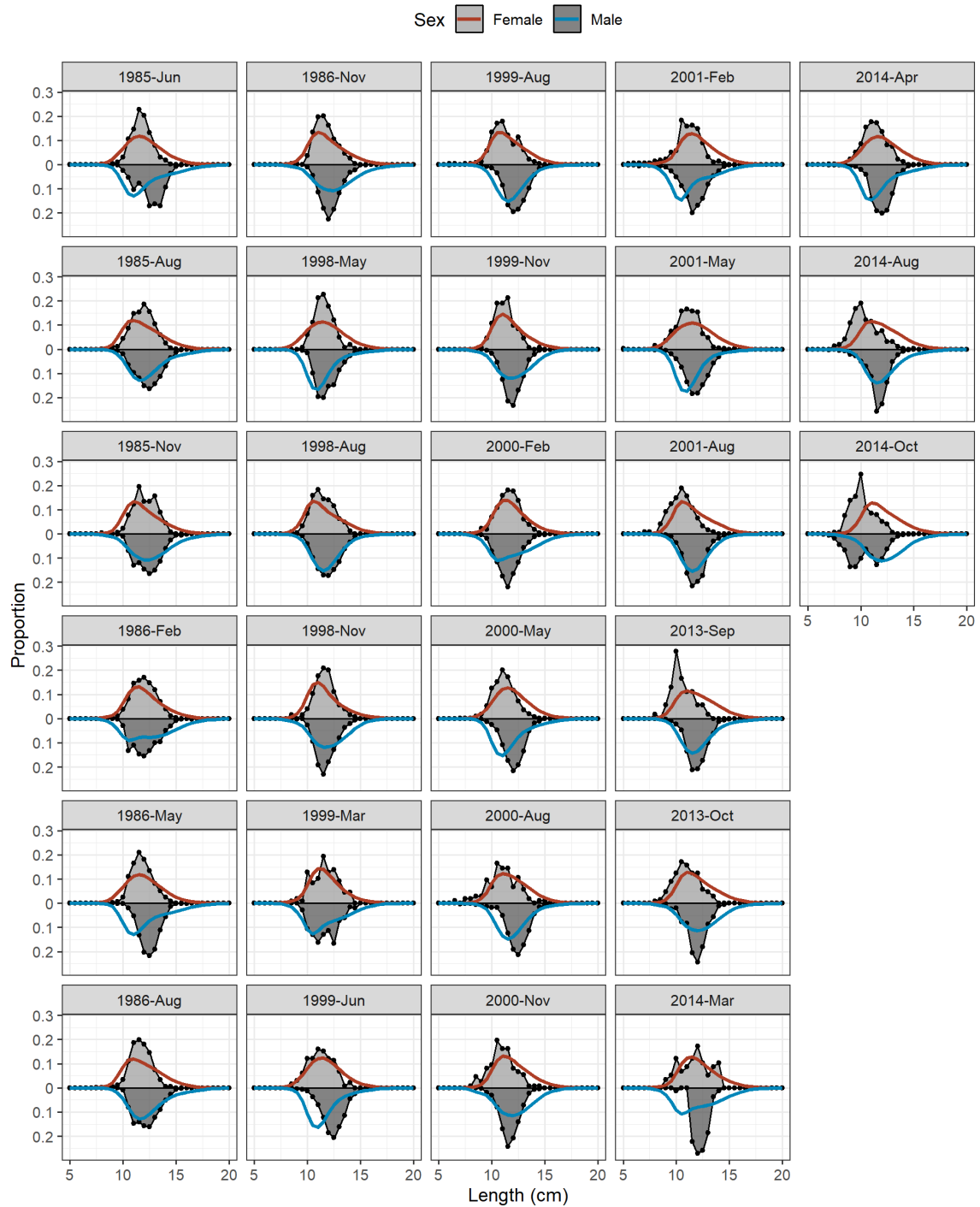


Figure H.4: Analysis 1: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

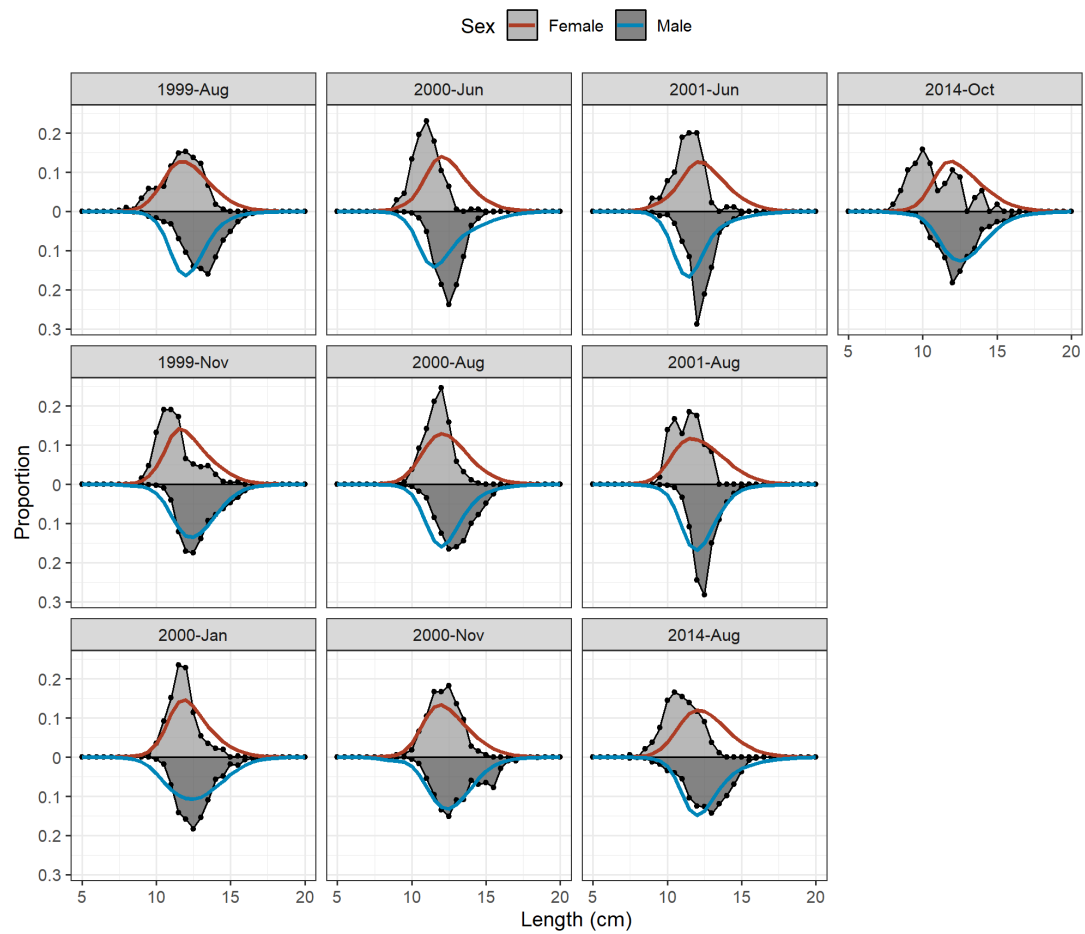


Figure H.5: Analysis 1: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

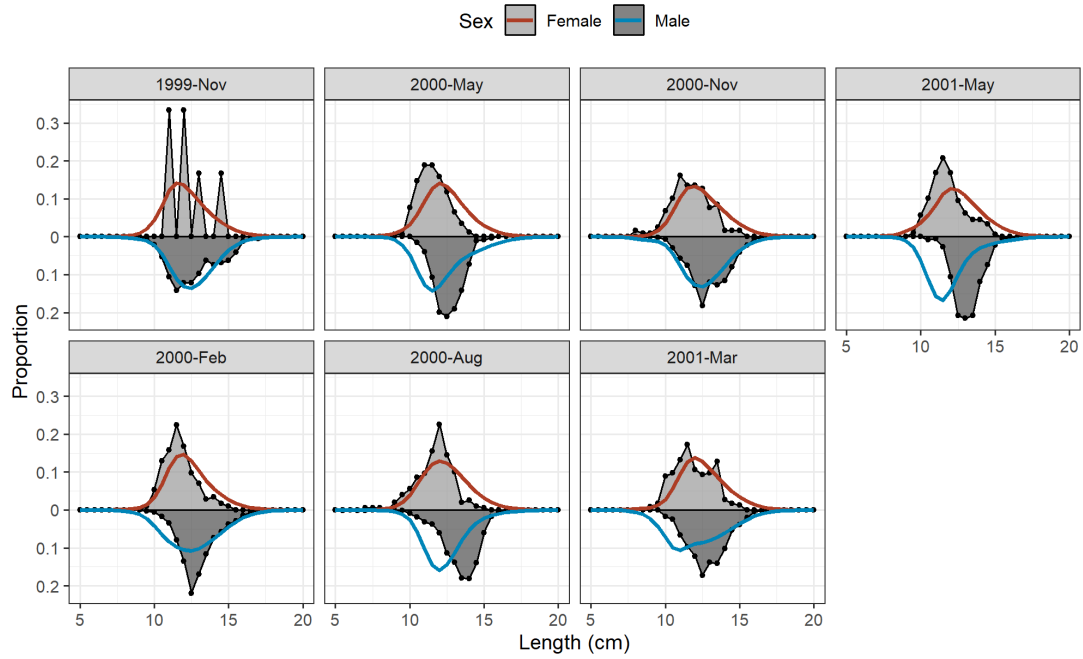


Figure H.6: Analysis 1: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

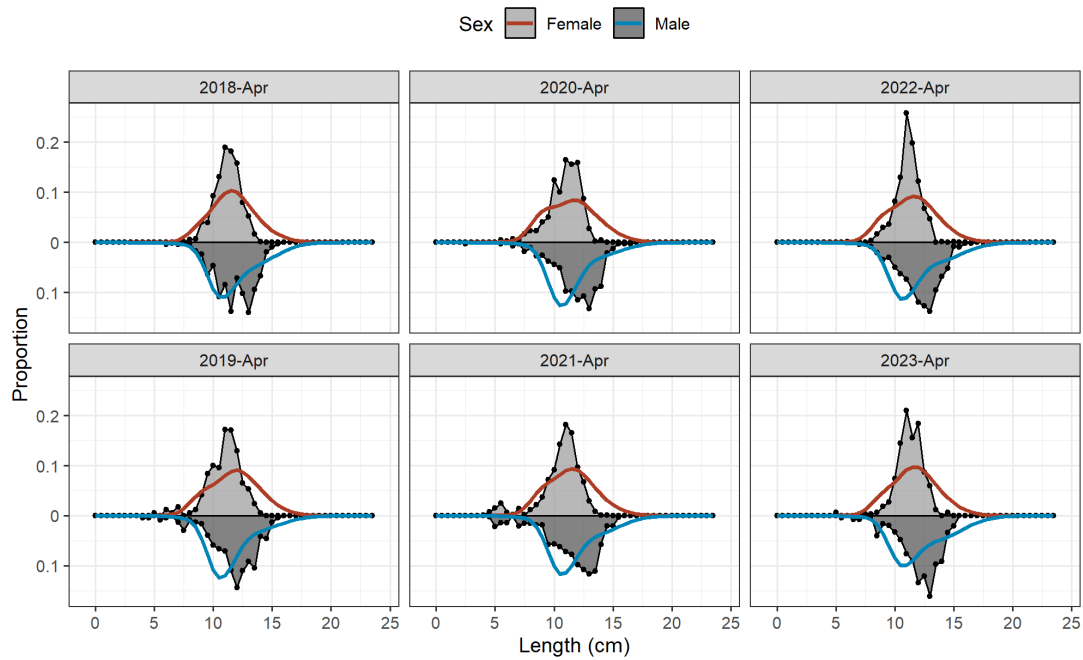


Figure H.7: Analysis 1: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

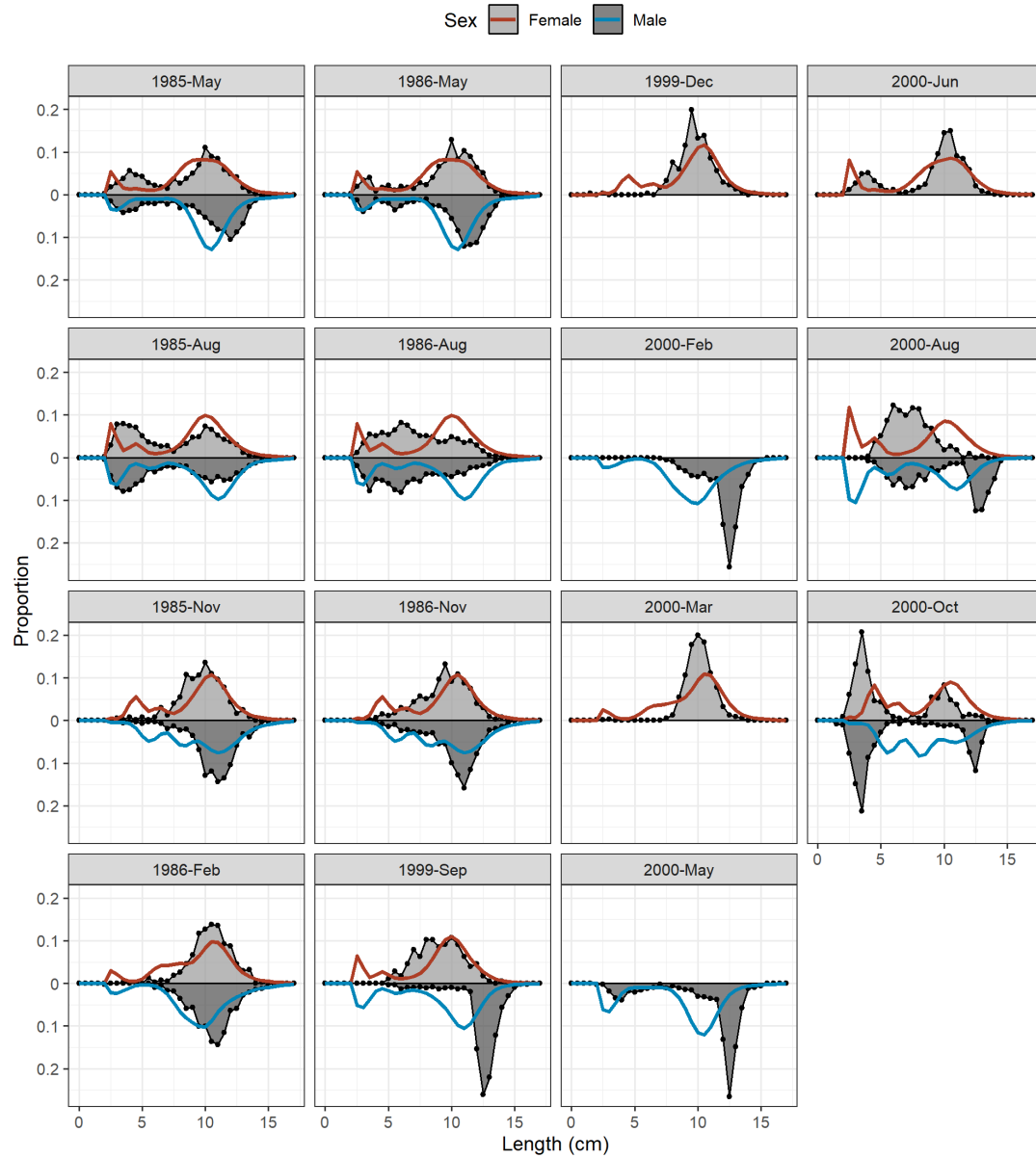


Figure H.8: Analysis 1: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

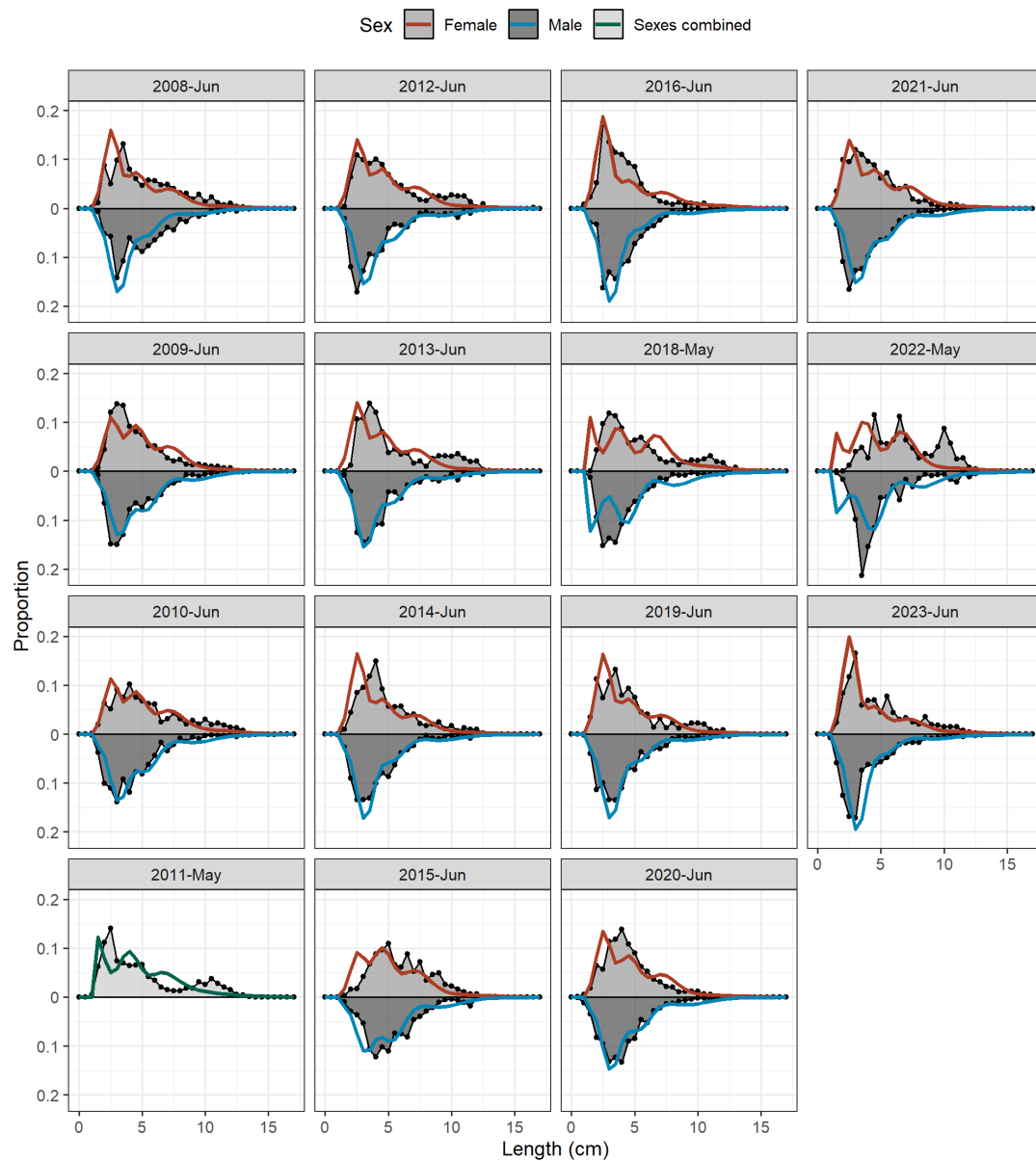


Figure H.9: Analysis 1: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

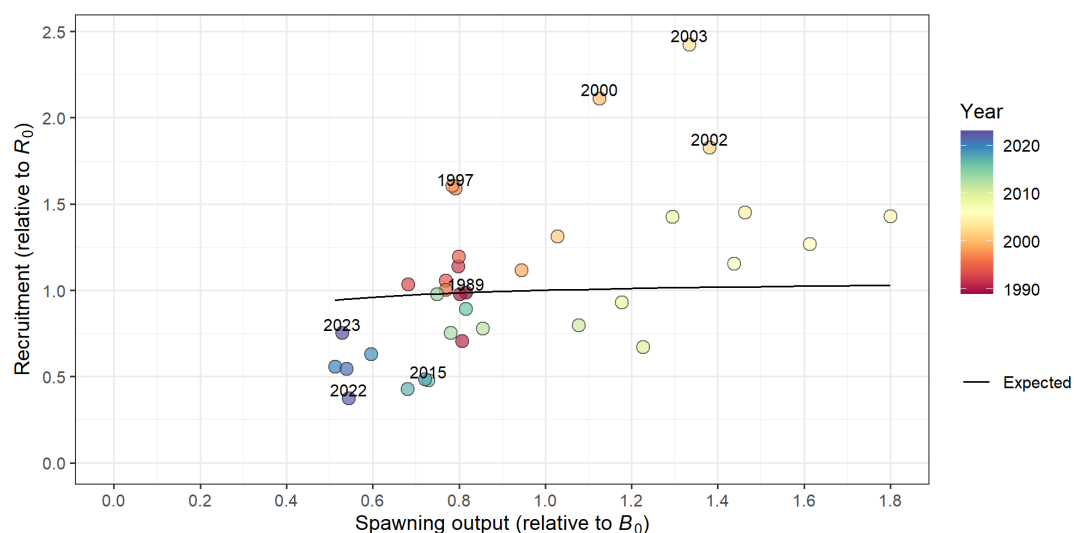


Figure H.10: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 1 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

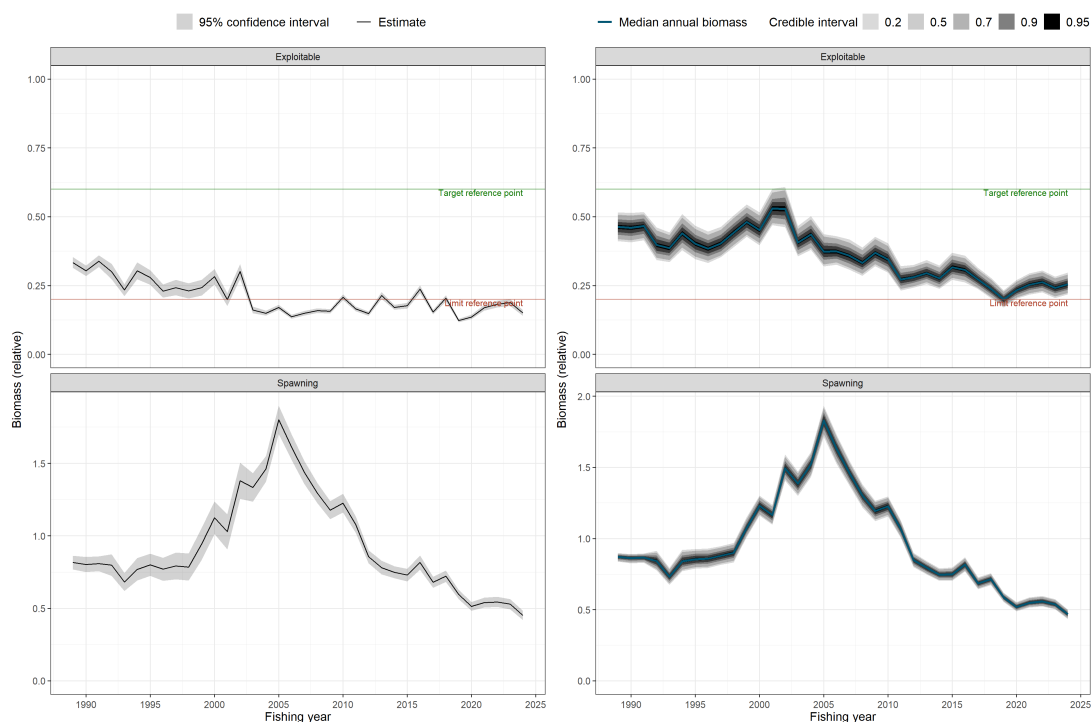


Figure H.11: Analysis 1: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

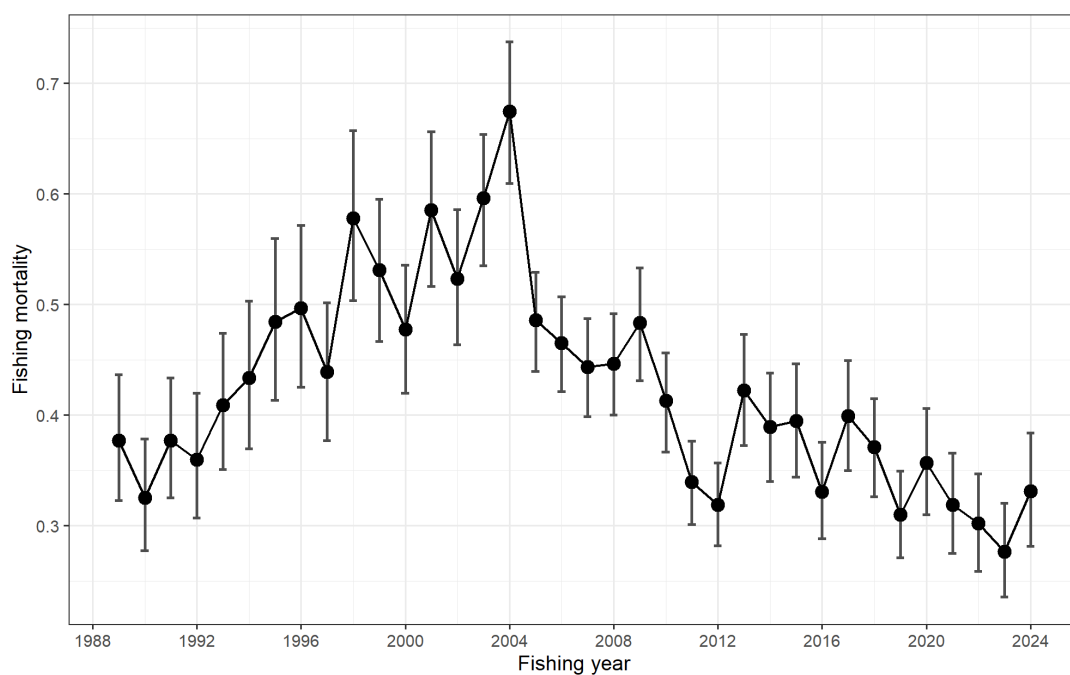


Figure H.12: Analysis 1: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

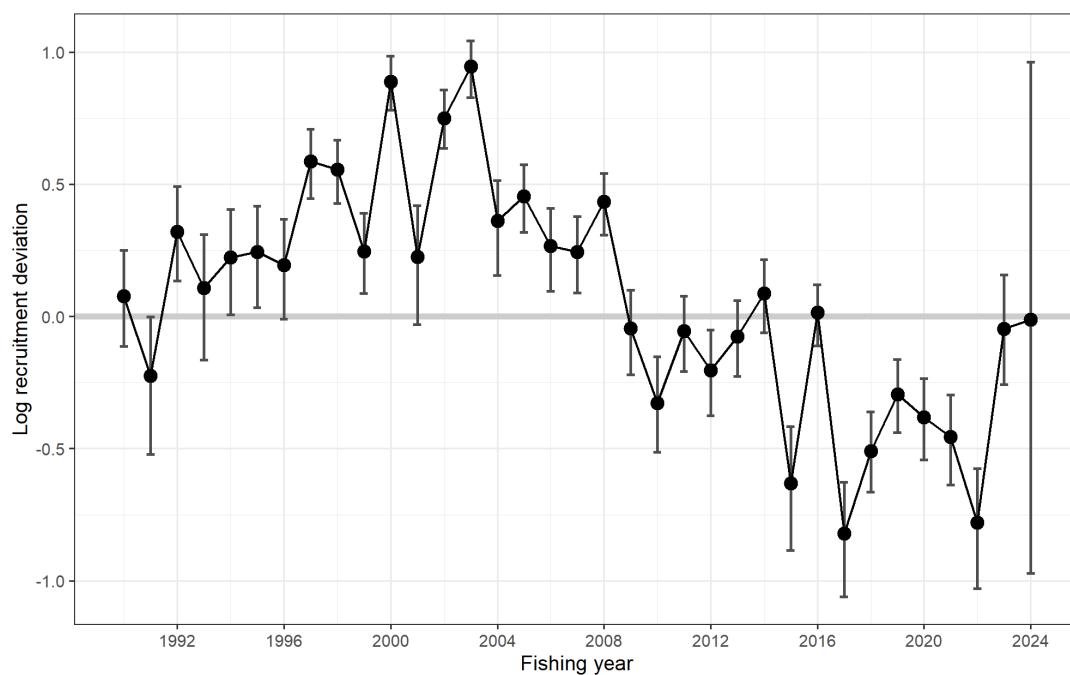


Figure H.13: Analysis 1: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

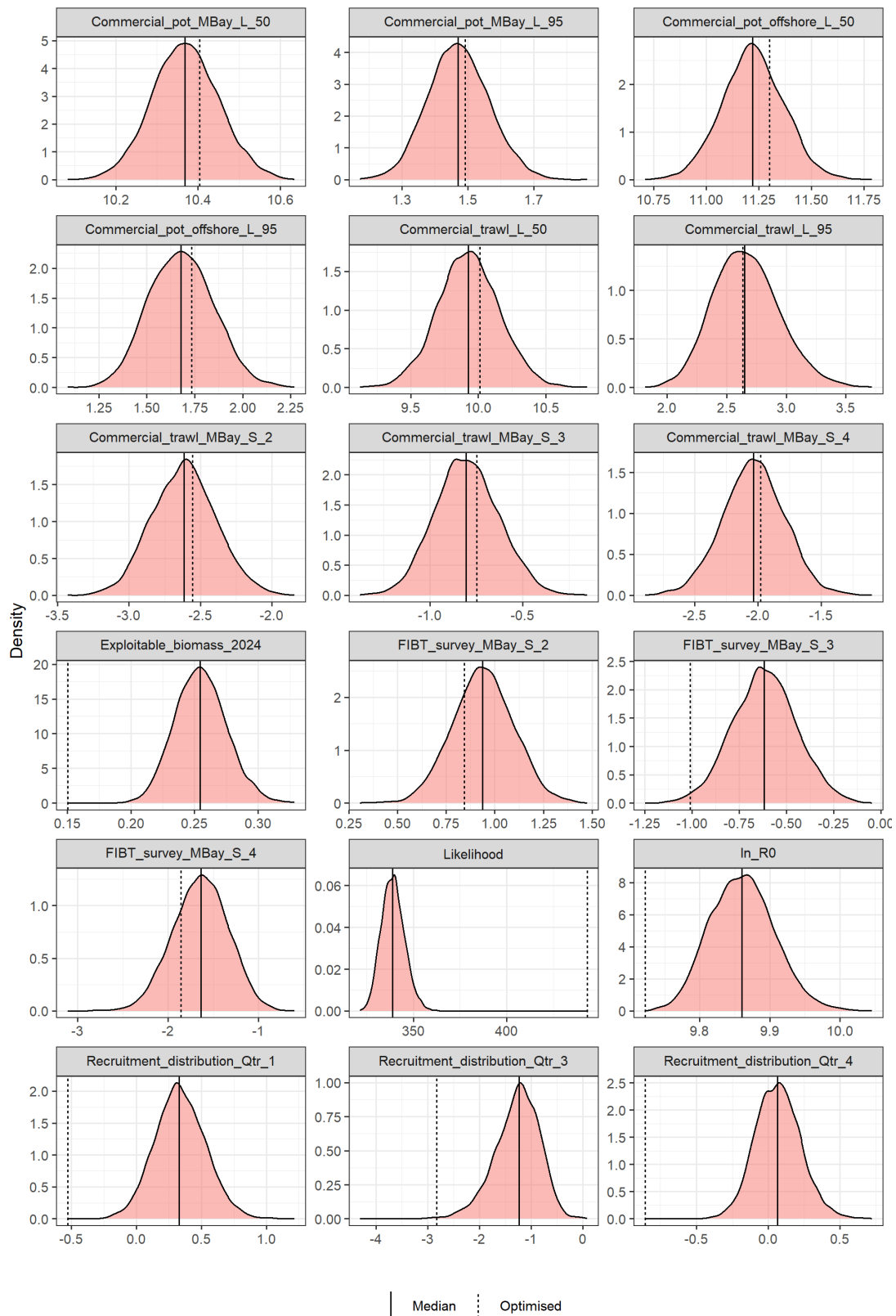


Figure H.14: Analysis 1: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

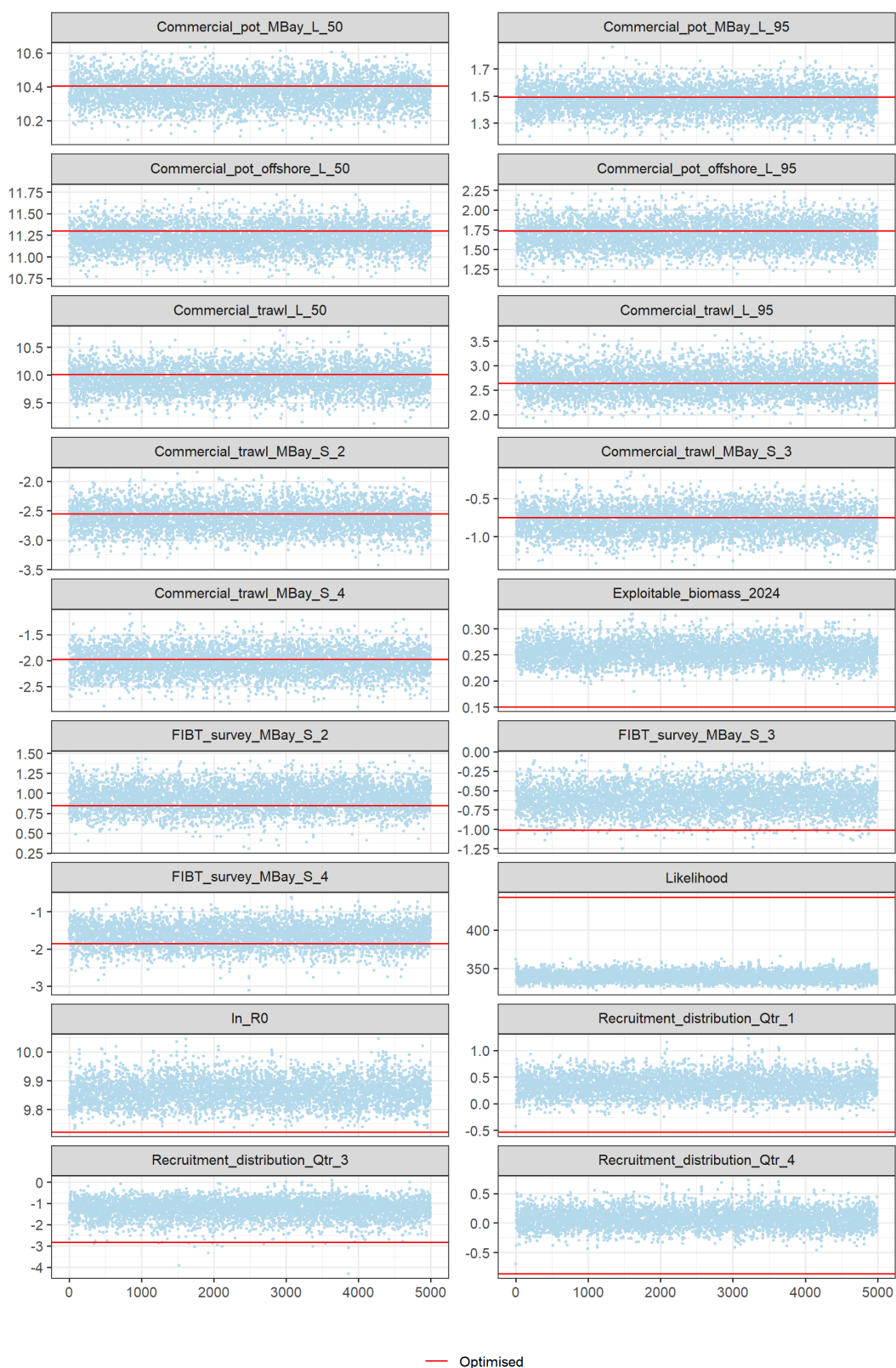


Figure H.15: Analysis 1: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.2 Analysis 2

Table H.3: Summary of MLE parameter estimates for analysis 2

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.55	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.49	2	-5.00	5.00	0.00	0.74
Recruitment distribution Qtr_4	-0.87	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	10.10	1	5.00	20.00	11.00	0.05
Commercial pot MBay L_{50}	10.51	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.50	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.40	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.74	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.26	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.59	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.44	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.52	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.55	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.86	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.86	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.50	3	-9.00	7.00	-1.00	0.30

Table H.4: Summary of MCMC parameter estimates for analysis 2

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.31	-0.05	0.70
Recruitment distribution Qtr_3	-1.18	-2.11	-0.49
Recruitment distribution Qtr_4	0.05	-0.23	0.38
$\ln(R_0)$	10.28	10.17	10.41
Commercial pot MBay L_{50}	10.48	10.34	10.64
Commercial pot MBay L_{95}	1.48	1.31	1.66
Commercial pot offshore L_{50}	11.33	11.05	11.60
Commercial pot offshore L_{95}	1.68	1.39	2.00
Commercial trawl L_{50}	10.19	9.77	10.61
Commercial trawl L_{95}	2.59	2.14	3.16
Commercial trawl MBay S_2	-2.50	-2.93	-2.06
Commercial trawl MBay S_3	-0.55	-0.88	-0.21
Commercial trawl MBay S_4	-1.61	-2.10	-1.13
FIBT survey MBay S_2	0.96	0.66	1.27
FIBT survey MBay S_3	-0.45	-0.79	-0.12
FIBT survey MBay S_4	-1.26	-1.86	-0.69

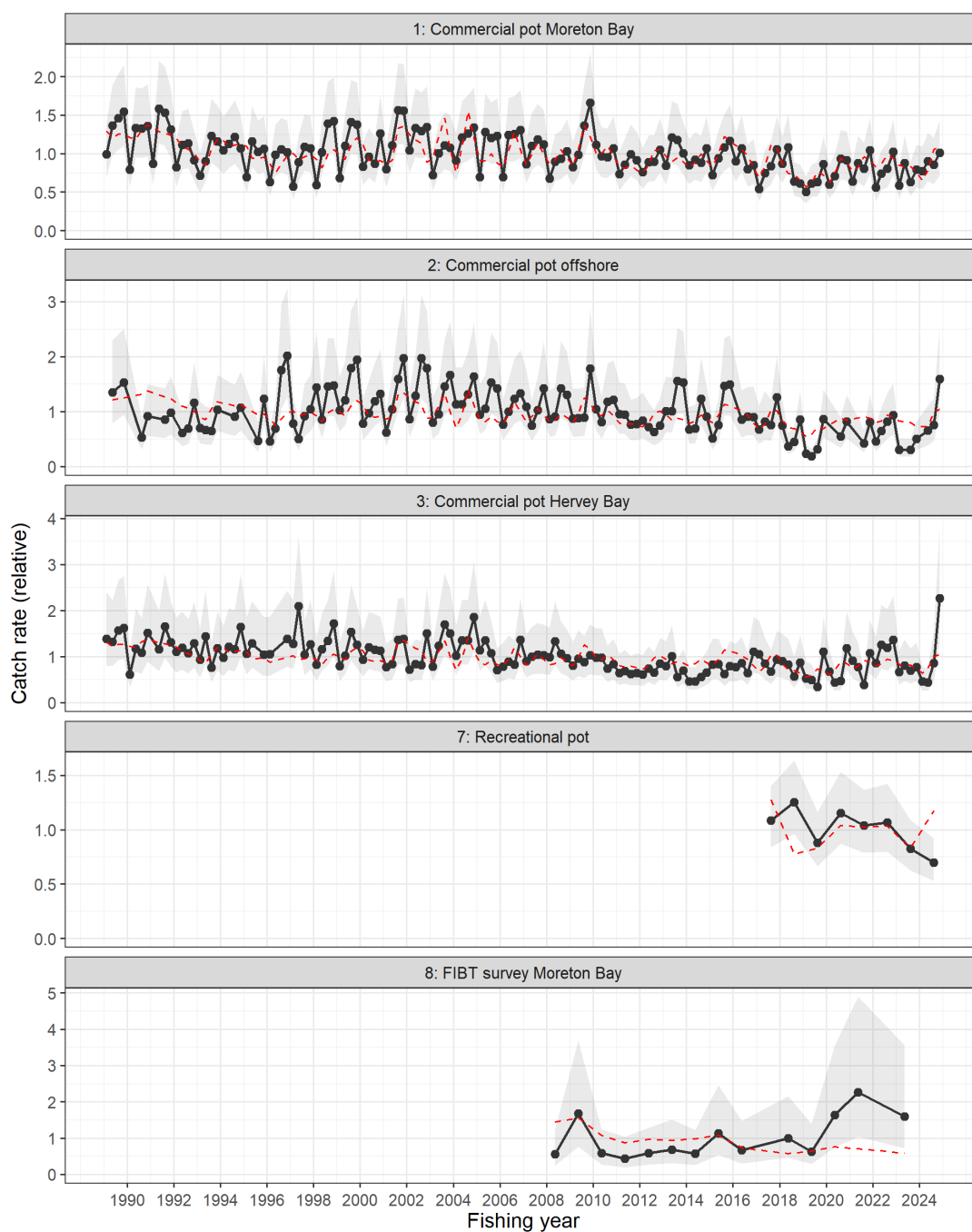


Figure H.16: Analysis 2: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

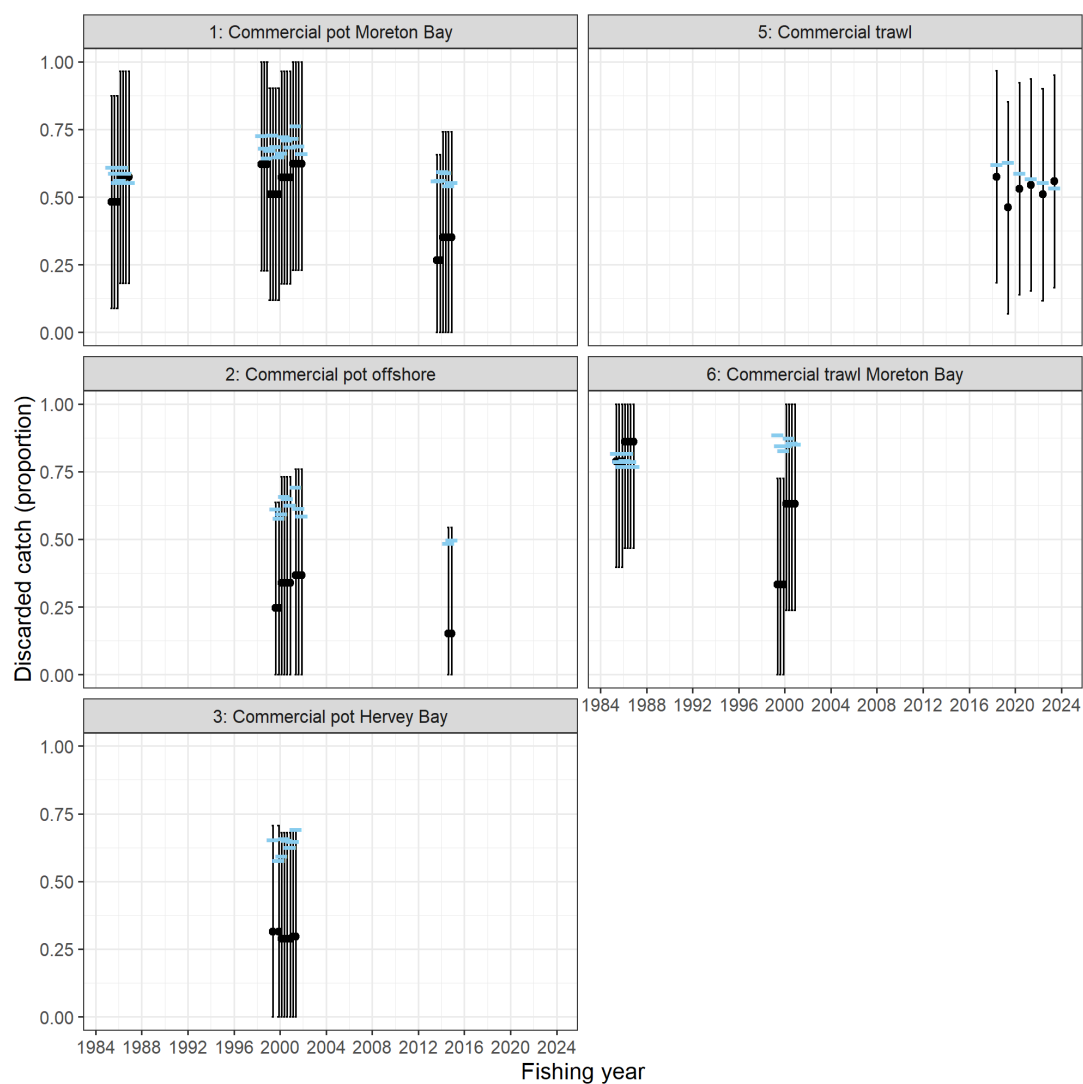


Figure H.17: Analysis 2: Fits to annual discard proportions of blue swimmer crab catch

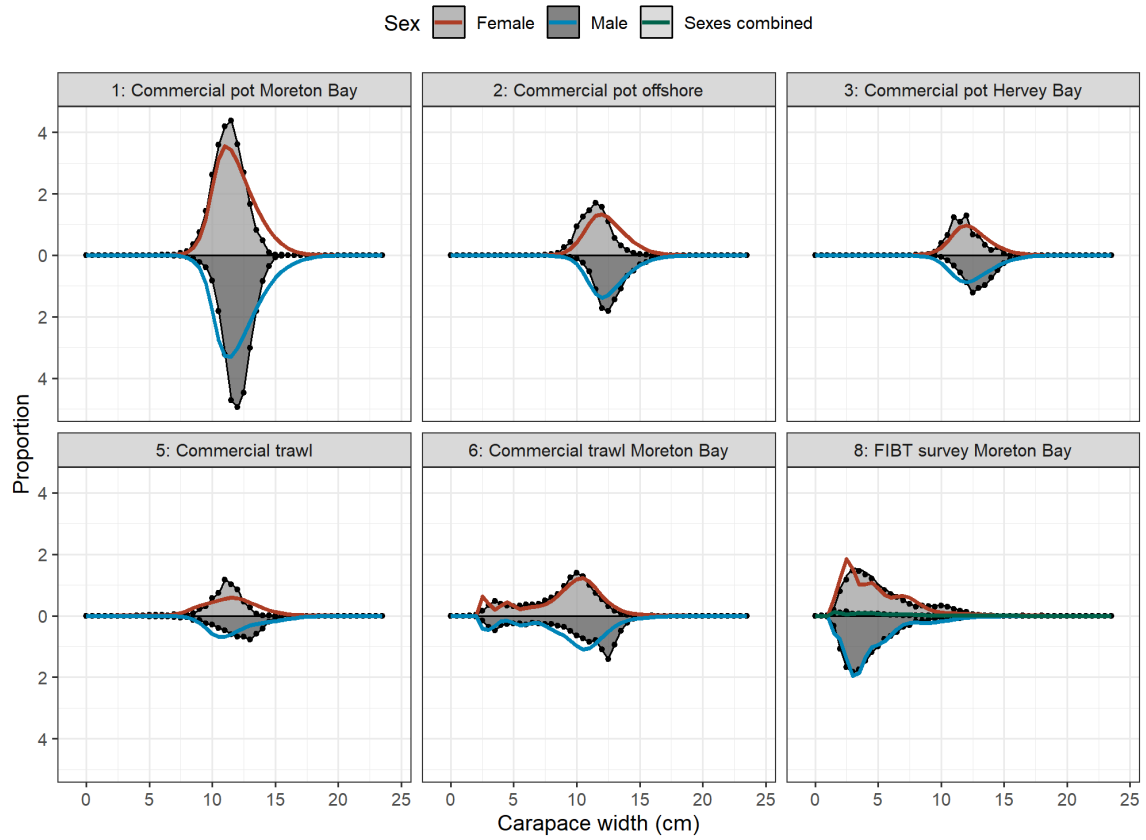


Figure H.18: Analysis 2: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

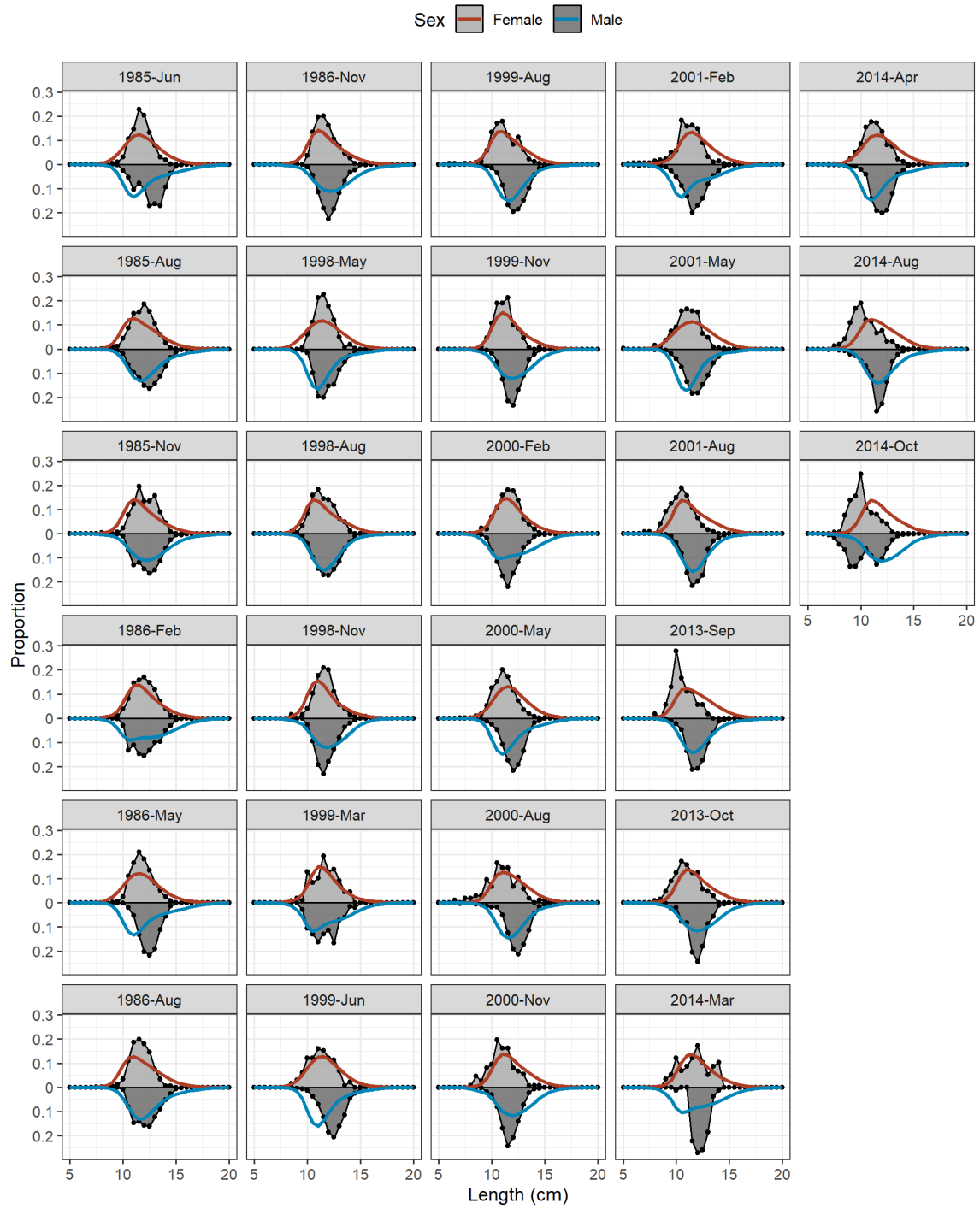


Figure H.19: Analysis 2: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

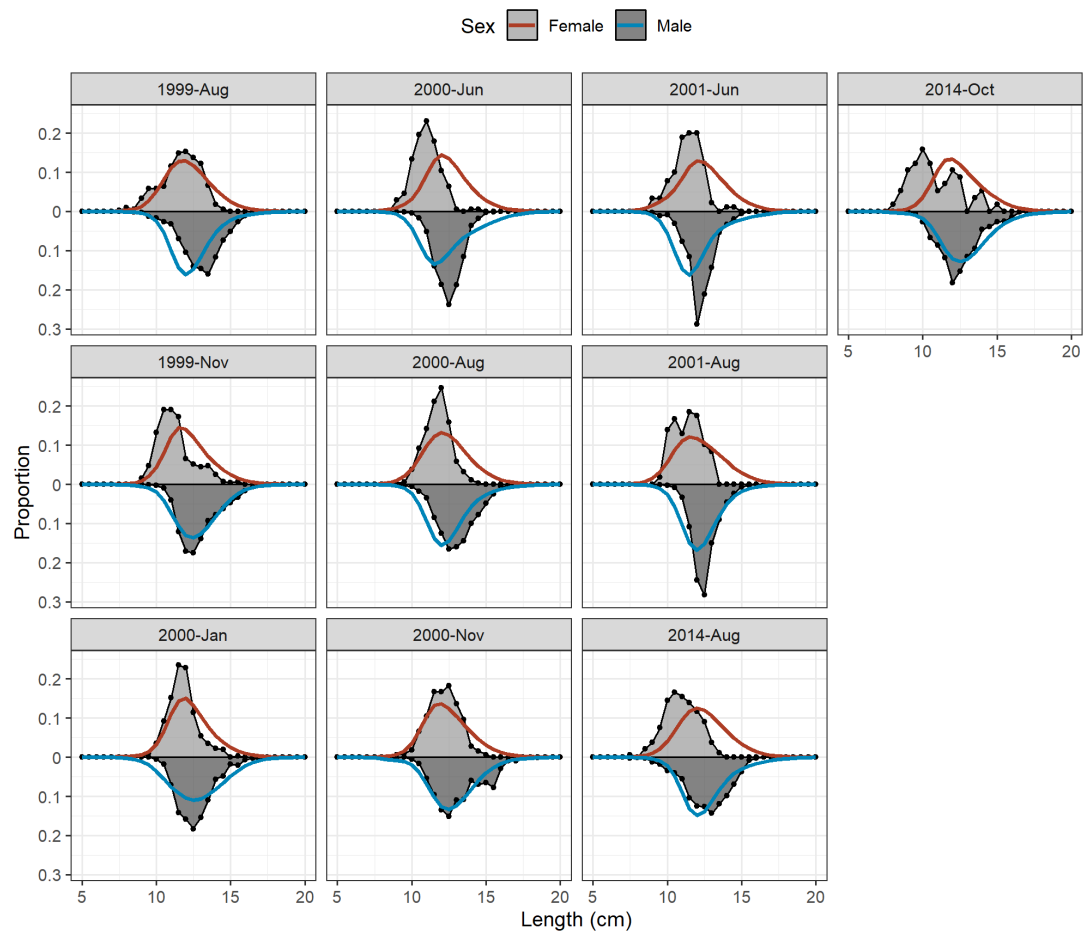


Figure H.20: Analysis 2: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

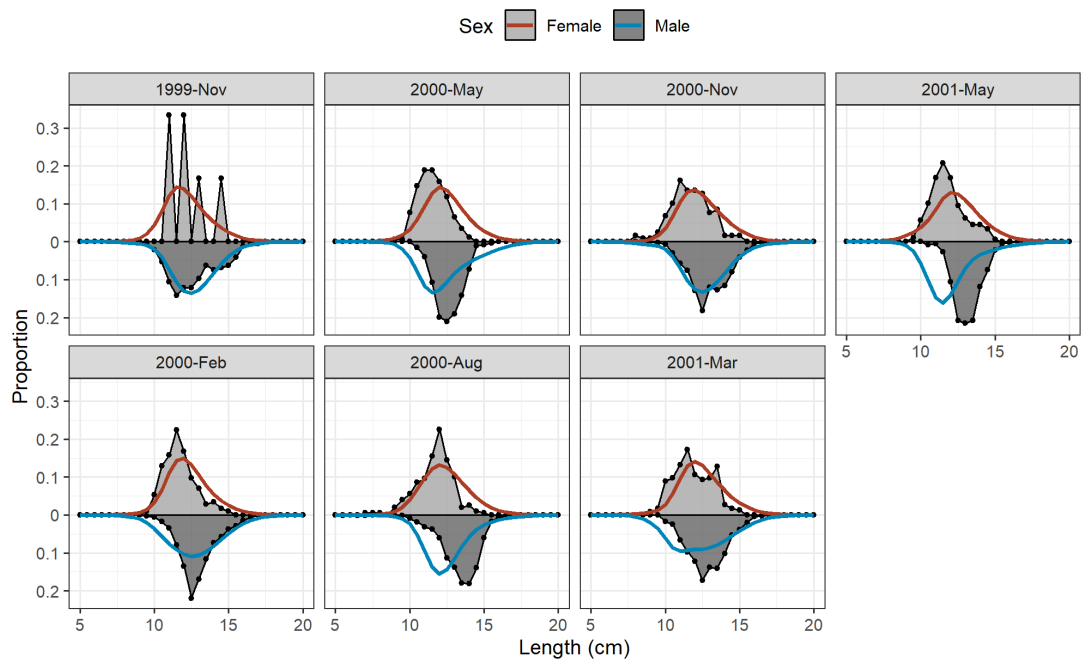


Figure H.21: Analysis 2: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

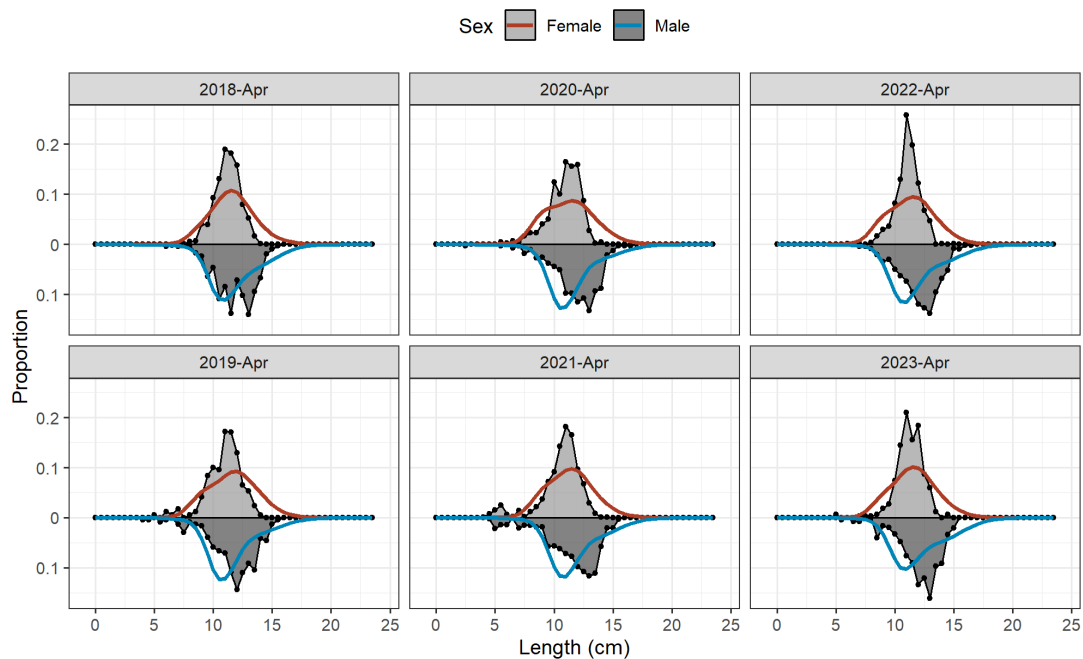


Figure H.22: Analysis 2: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

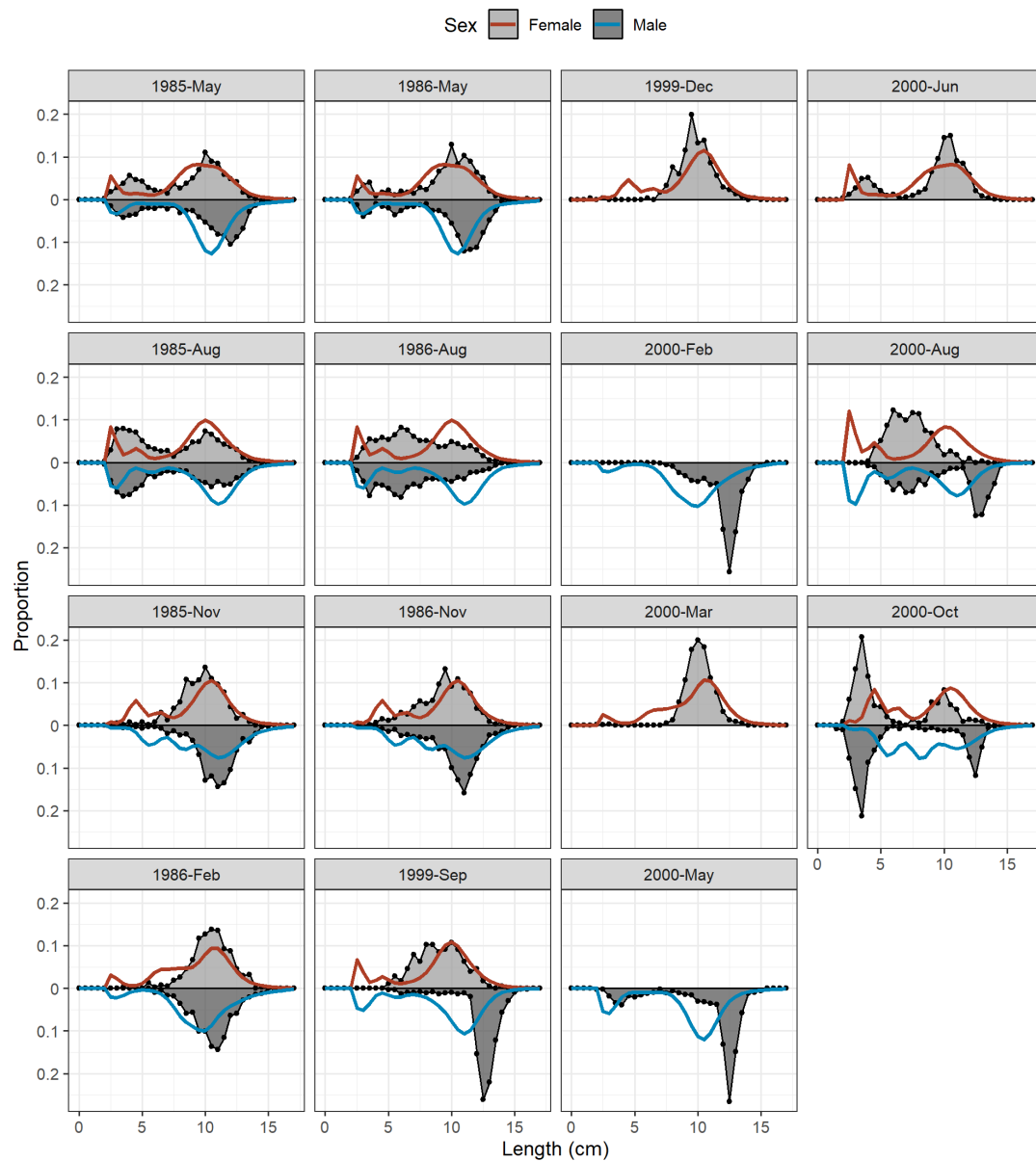


Figure H.23: Analysis 2: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

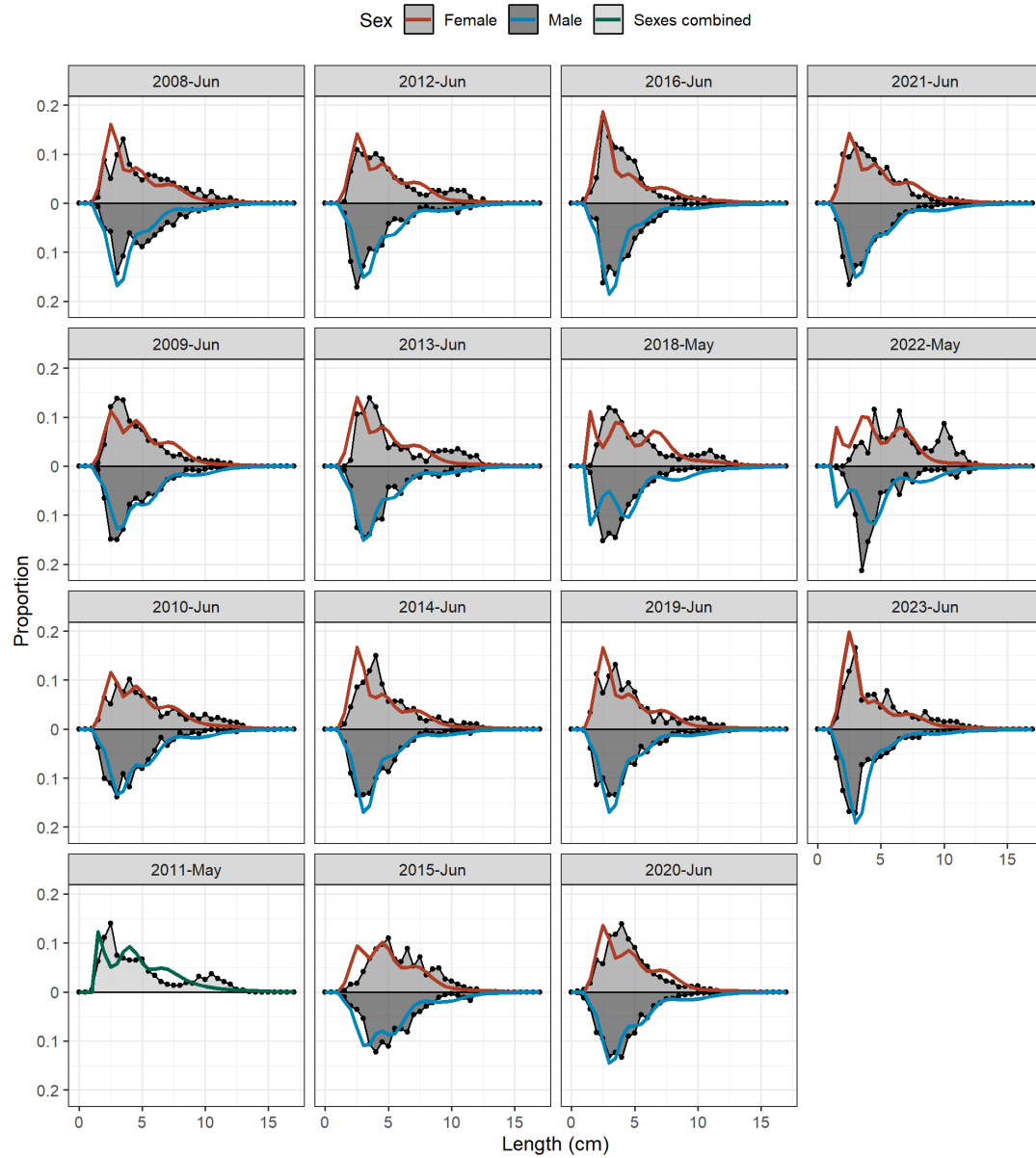


Figure H.24: Analysis 2: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

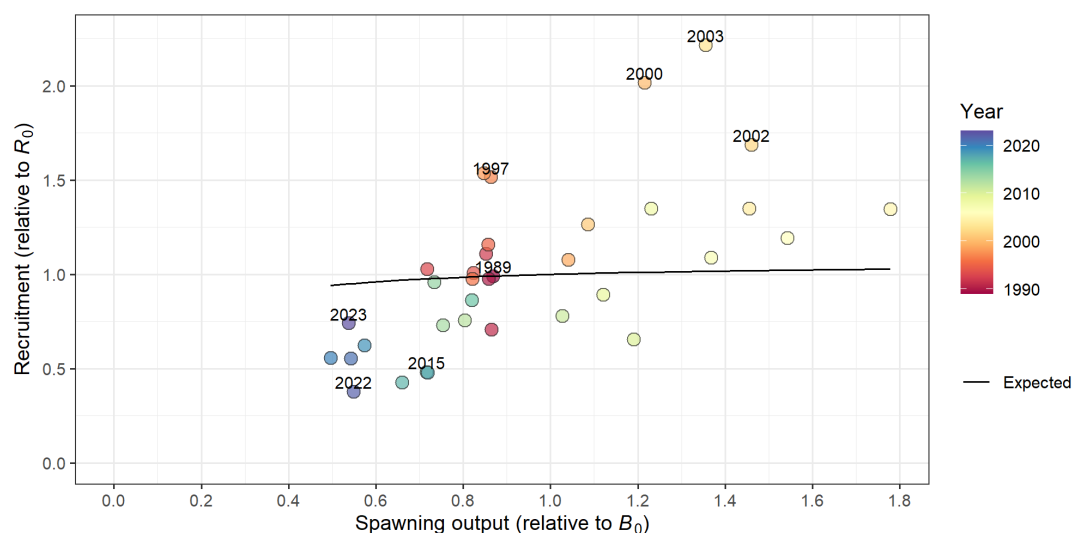


Figure H.25: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 2 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

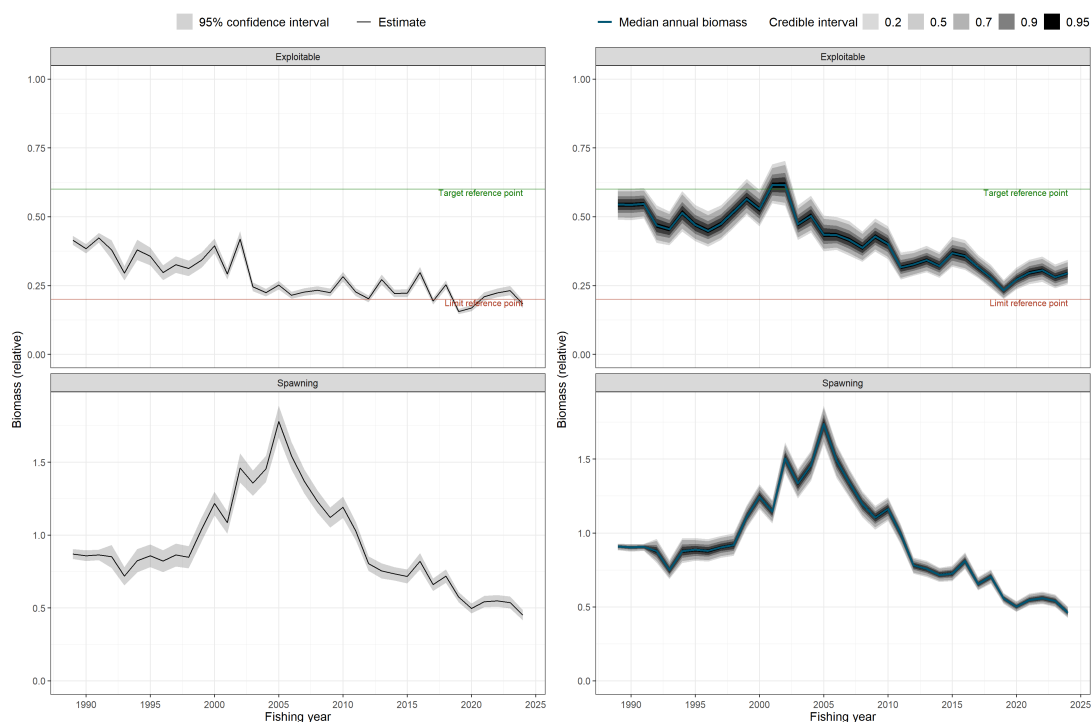


Figure H.26: Analysis 2: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

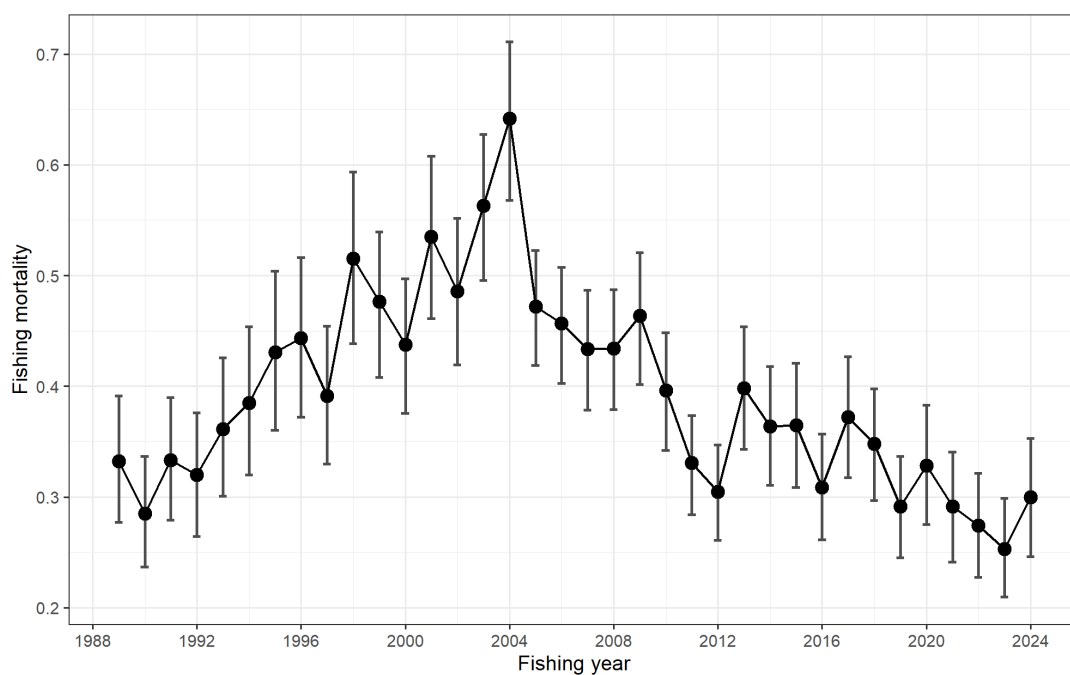


Figure H.27: Analysis 2: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

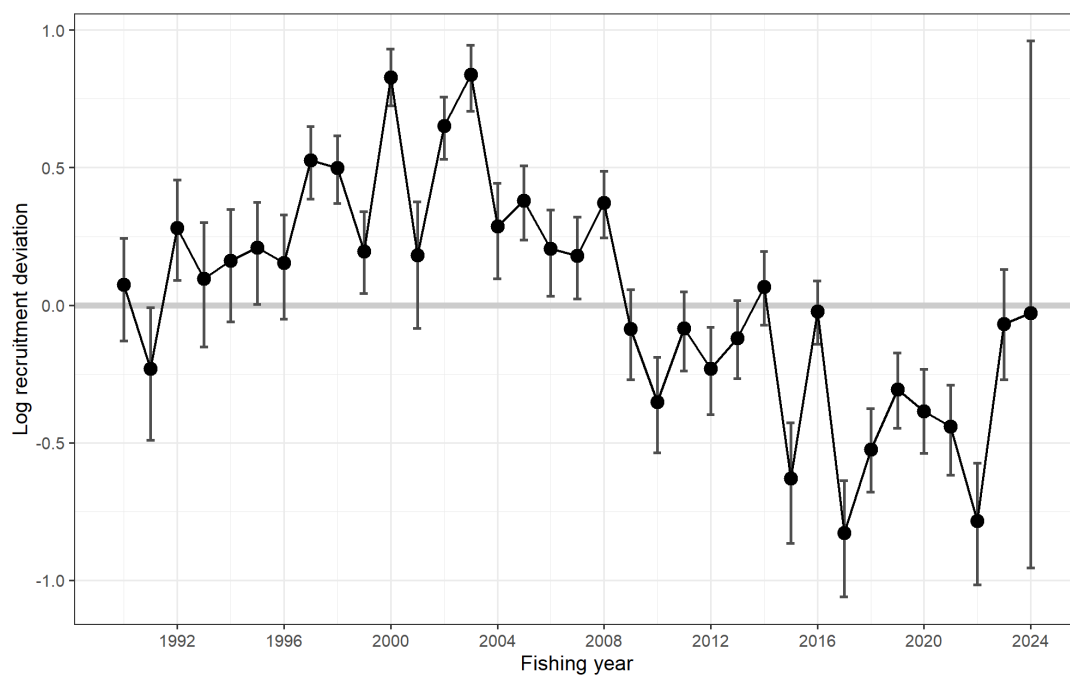


Figure H.28: Analysis 2: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

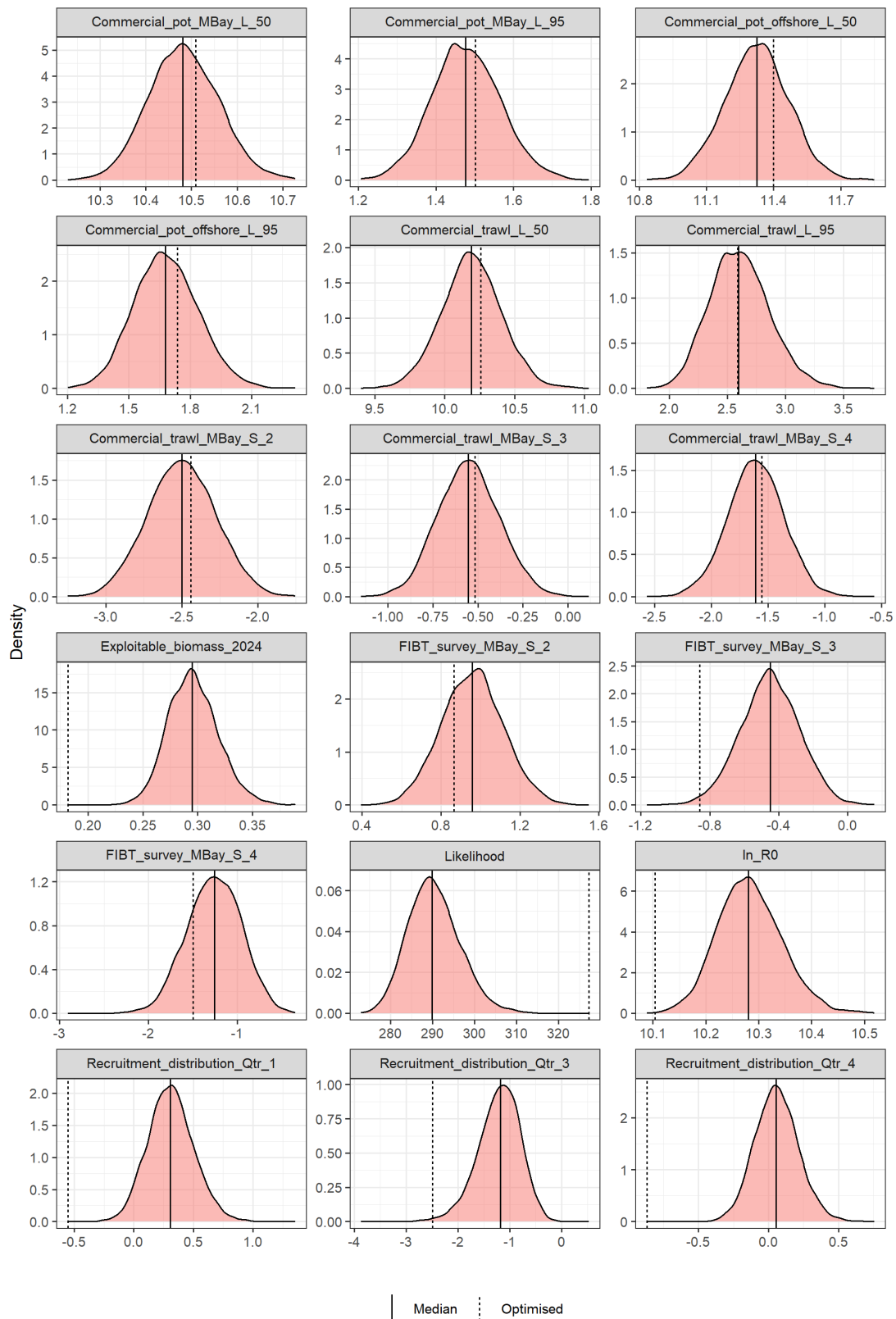


Figure H.29: Analysis 2: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

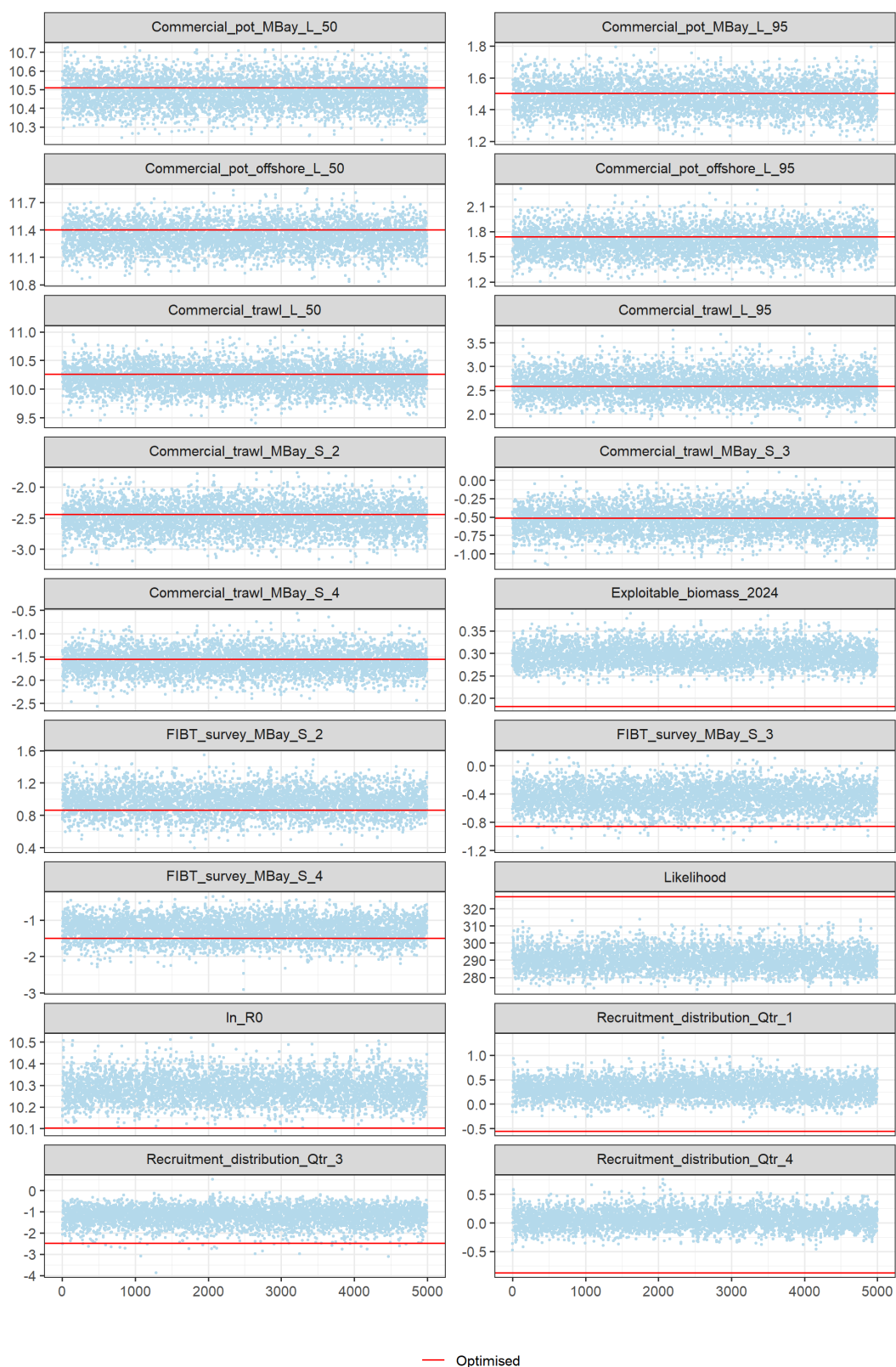


Figure H.30: Analysis 2: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.3 Analysis 3

Table H.5: Summary of MLE parameter estimates for analysis 3

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.58	2	-5.00	5.00	0.00	0.18
Recruitment distribution Qtr_3	-2.21	2	-5.00	5.00	0.00	0.60
Recruitment distribution Qtr_4	-0.88	2	-5.00	5.00	-1.15	0.13
$\ln(R_0)$	10.49	1	5.00	20.00	11.00	0.07
Commercial pot MBay L_{50}	10.61	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.51	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.49	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.73	3	0.10	20.00	1.50	0.15
Commercial trawl L_{50}	10.46	3	0.10	20.00	9.00	0.20
Commercial trawl L_{95}	2.54	3	0.10	20.00	2.20	0.23
Commercial trawl MBay S_2	-2.33	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.28	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.16	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.88	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.71	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.17	3	-9.00	7.00	-1.00	0.30

Table H.6: Summary of MCMC parameter estimates for analysis 3

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.27	-0.08	0.64
Recruitment distribution Qtr_3	-1.14	-2.04	-0.48
Recruitment distribution Qtr_4	0.04	-0.22	0.35
$\ln(R_0)$	10.71	10.57	10.87
Commercial pot MBay L_{50}	10.59	10.44	10.73
Commercial pot MBay L_{95}	1.48	1.32	1.65
Commercial pot offshore L_{50}	11.41	11.15	11.69
Commercial pot offshore L_{95}	1.67	1.40	1.98
Commercial trawl L_{50}	10.40	10.00	10.81
Commercial trawl L_{95}	2.54	2.12	3.04
Commercial trawl MBay S_2	-2.38	-2.82	-1.95
Commercial trawl MBay S_3	-0.31	-0.63	0.03
Commercial trawl MBay S_4	-1.21	-1.70	-0.74
FIBT survey MBay S_2	0.97	0.68	1.28
FIBT survey MBay S_3	-0.30	-0.63	0.03
FIBT survey MBay S_4	-0.92	-1.54	-0.34

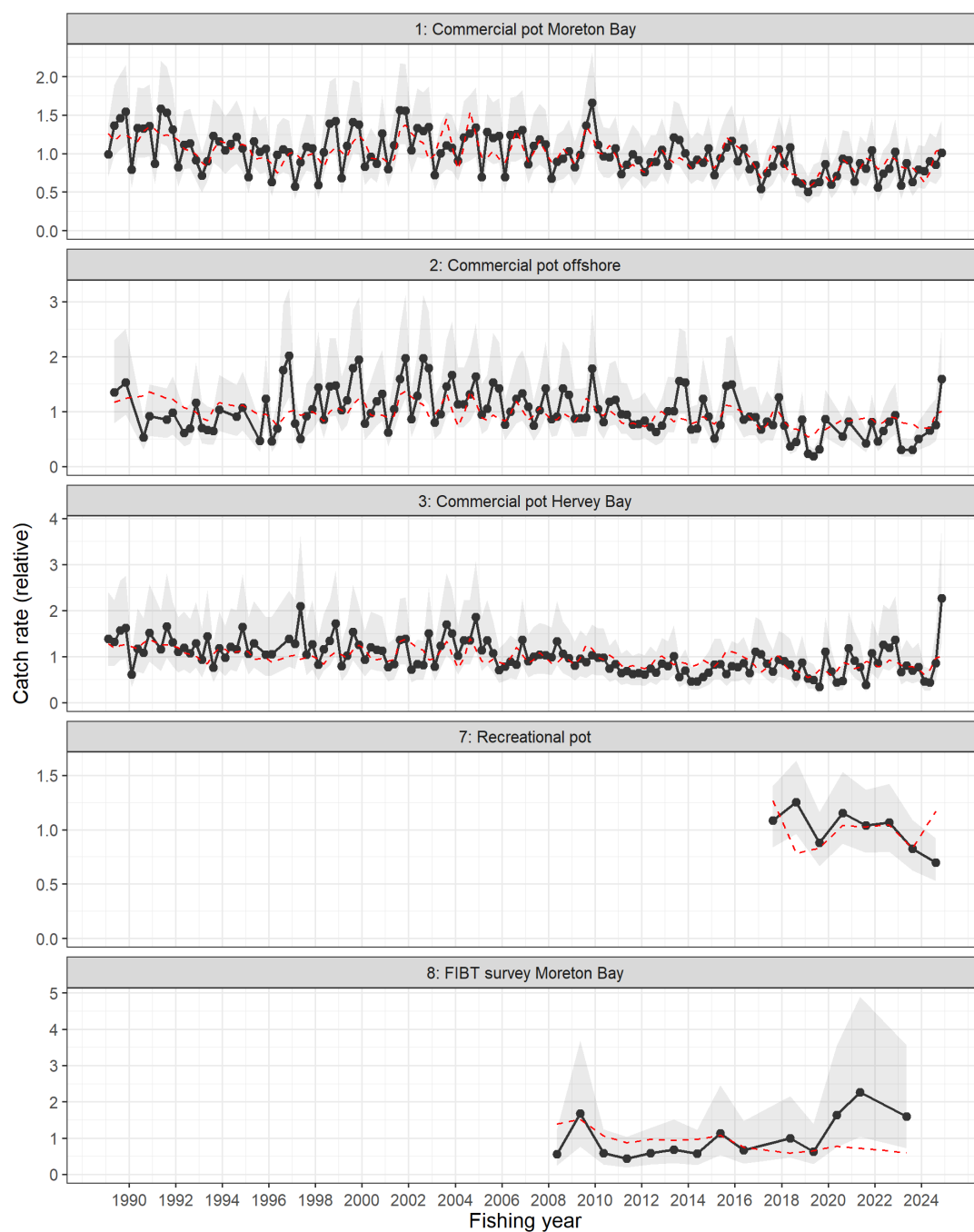


Figure H.31: Analysis 3: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

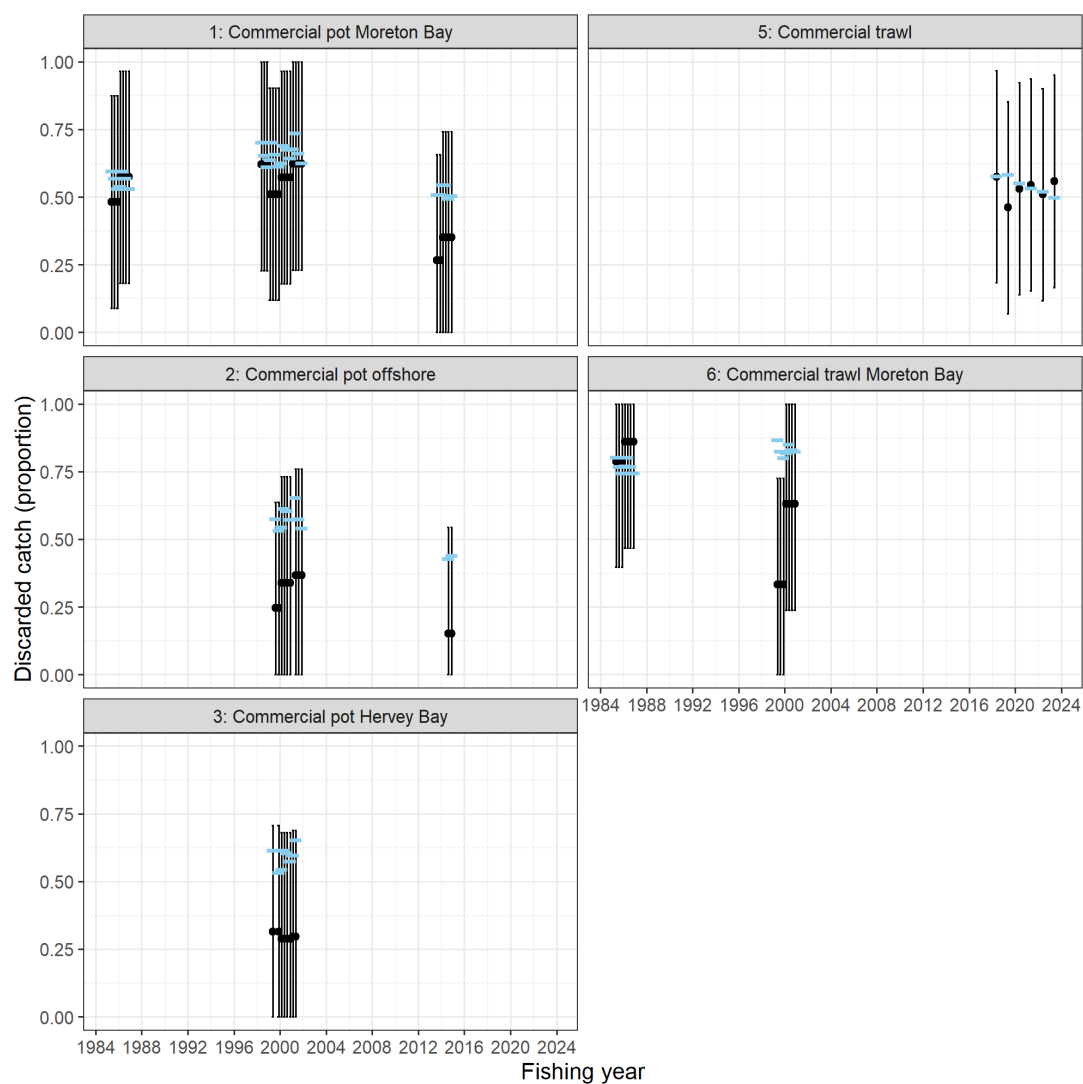


Figure H.32: Analysis 3: Fits to annual discard proportions of blue swimmer crab catch

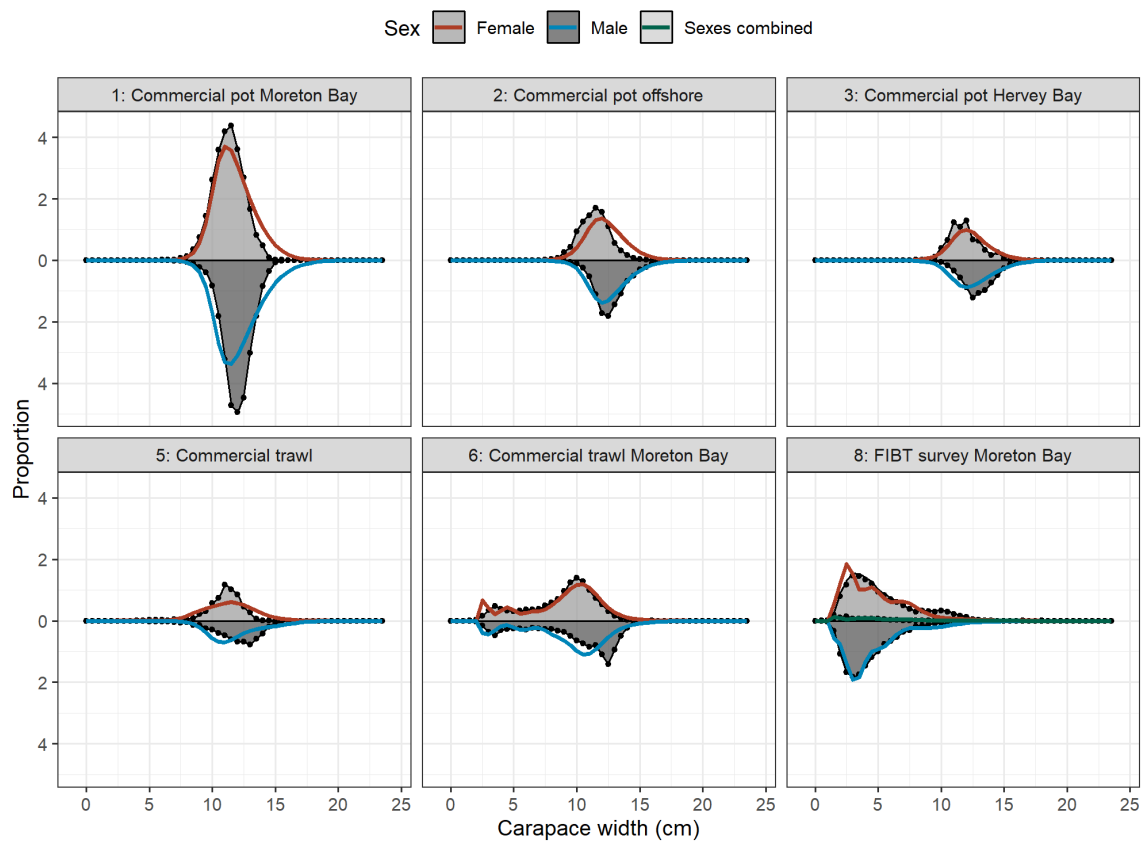


Figure H.33: Analysis 3: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

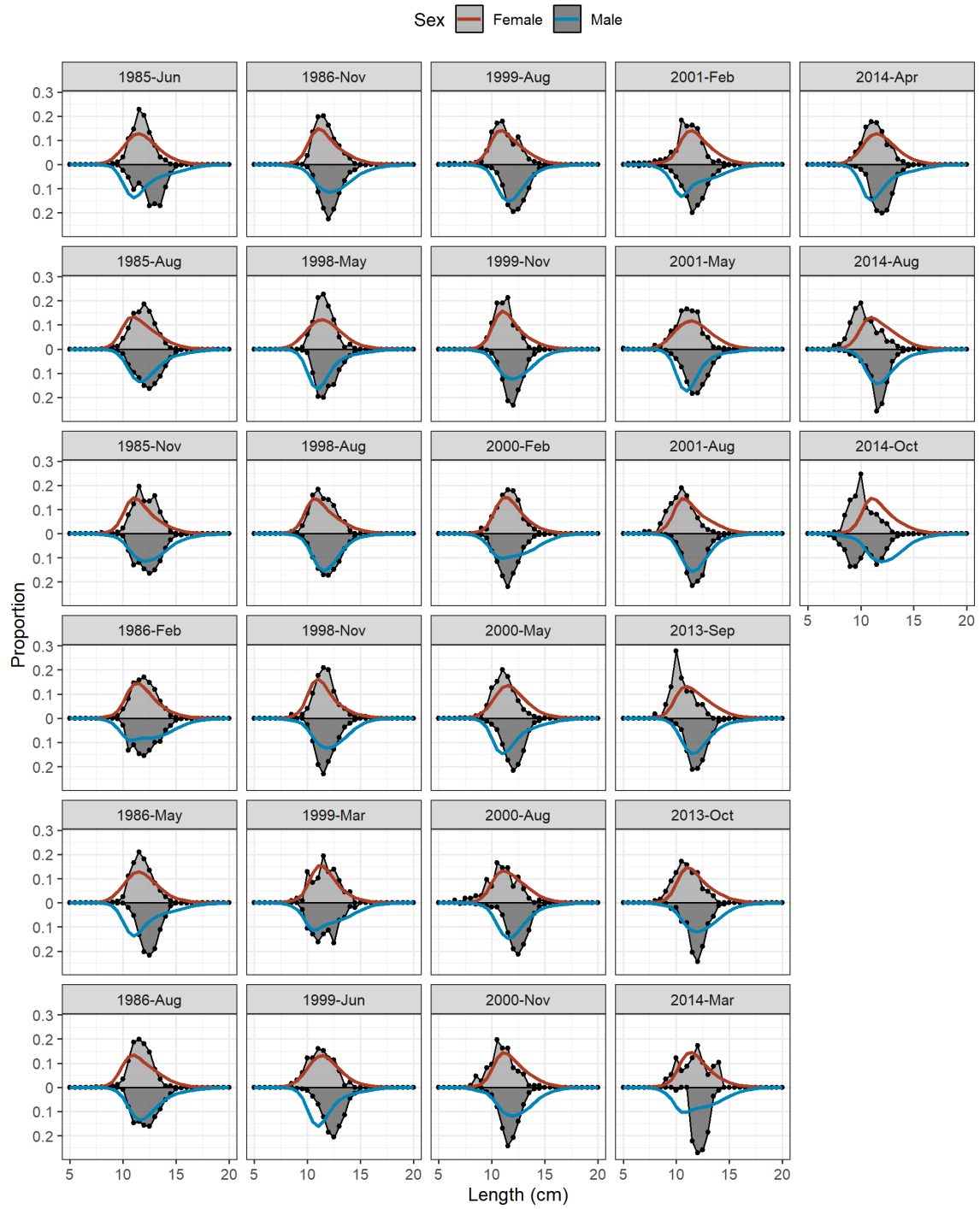


Figure H.34: Analysis 3: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

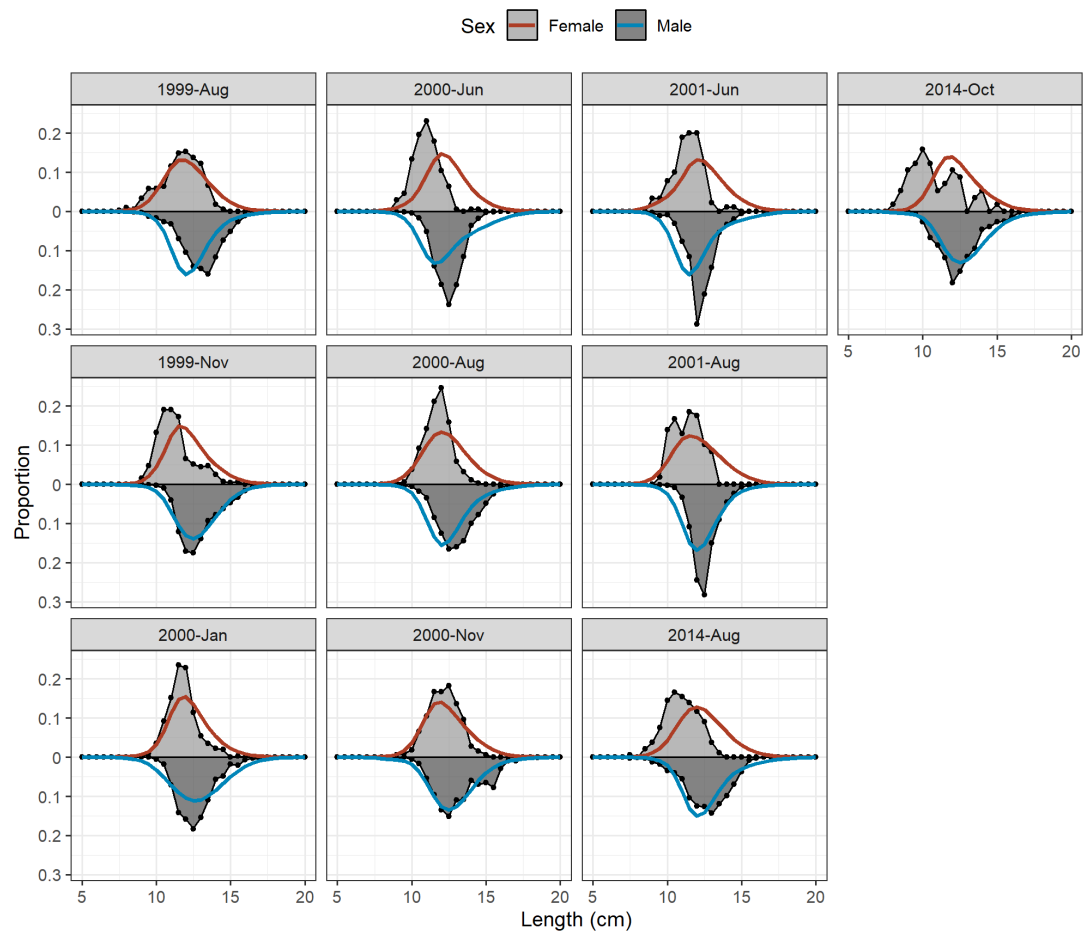


Figure H.35: Analysis 3: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

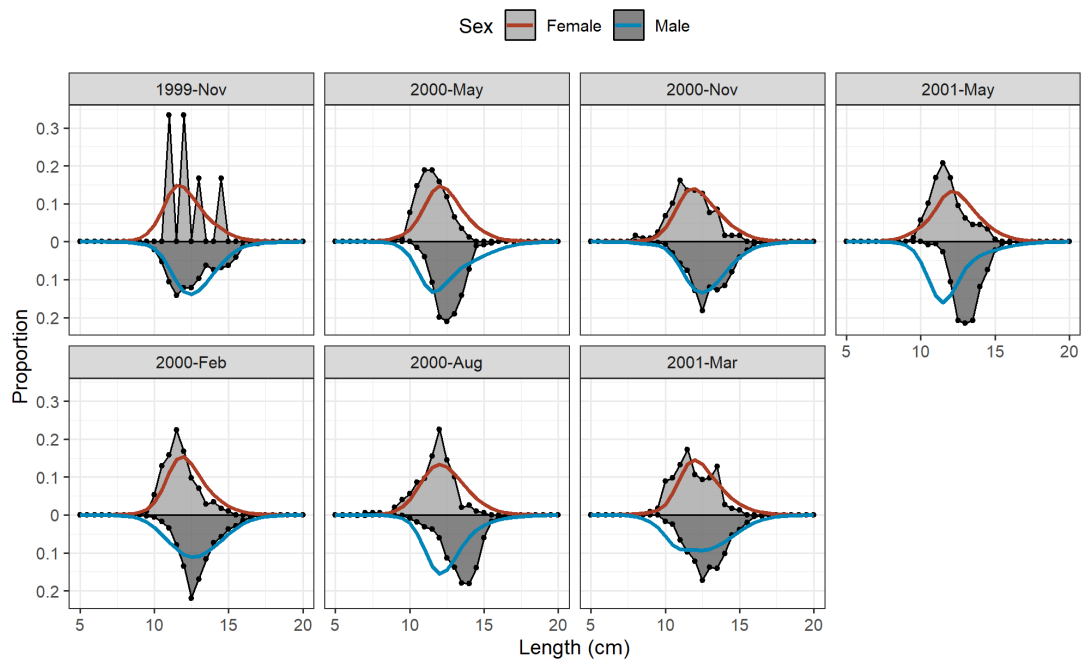


Figure H.36: Analysis 3: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

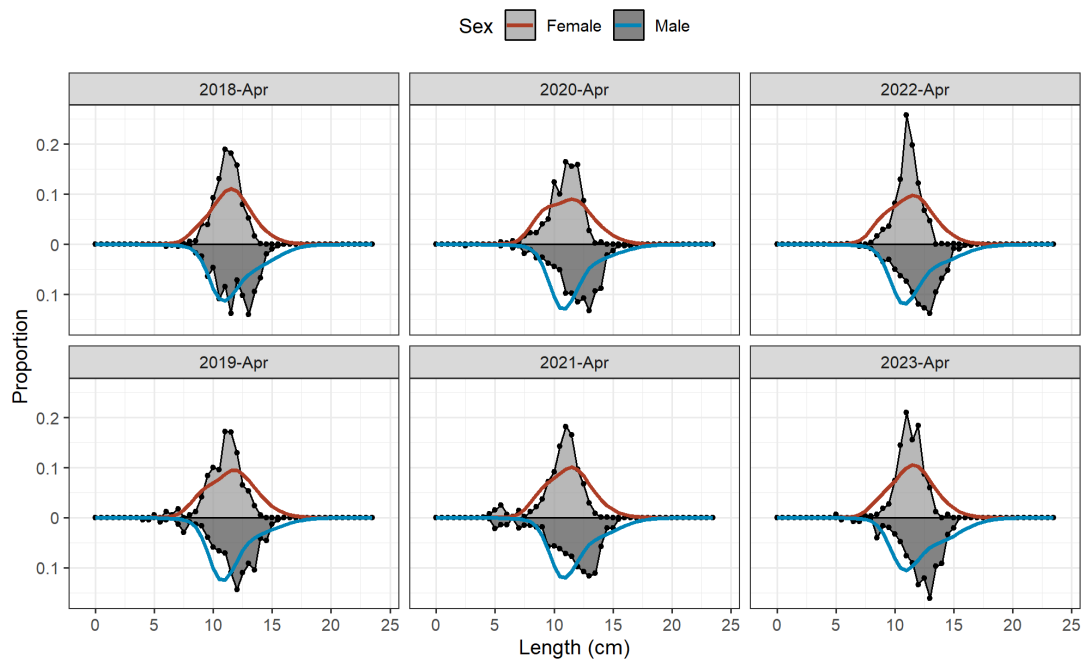


Figure H.37: Analysis 3: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

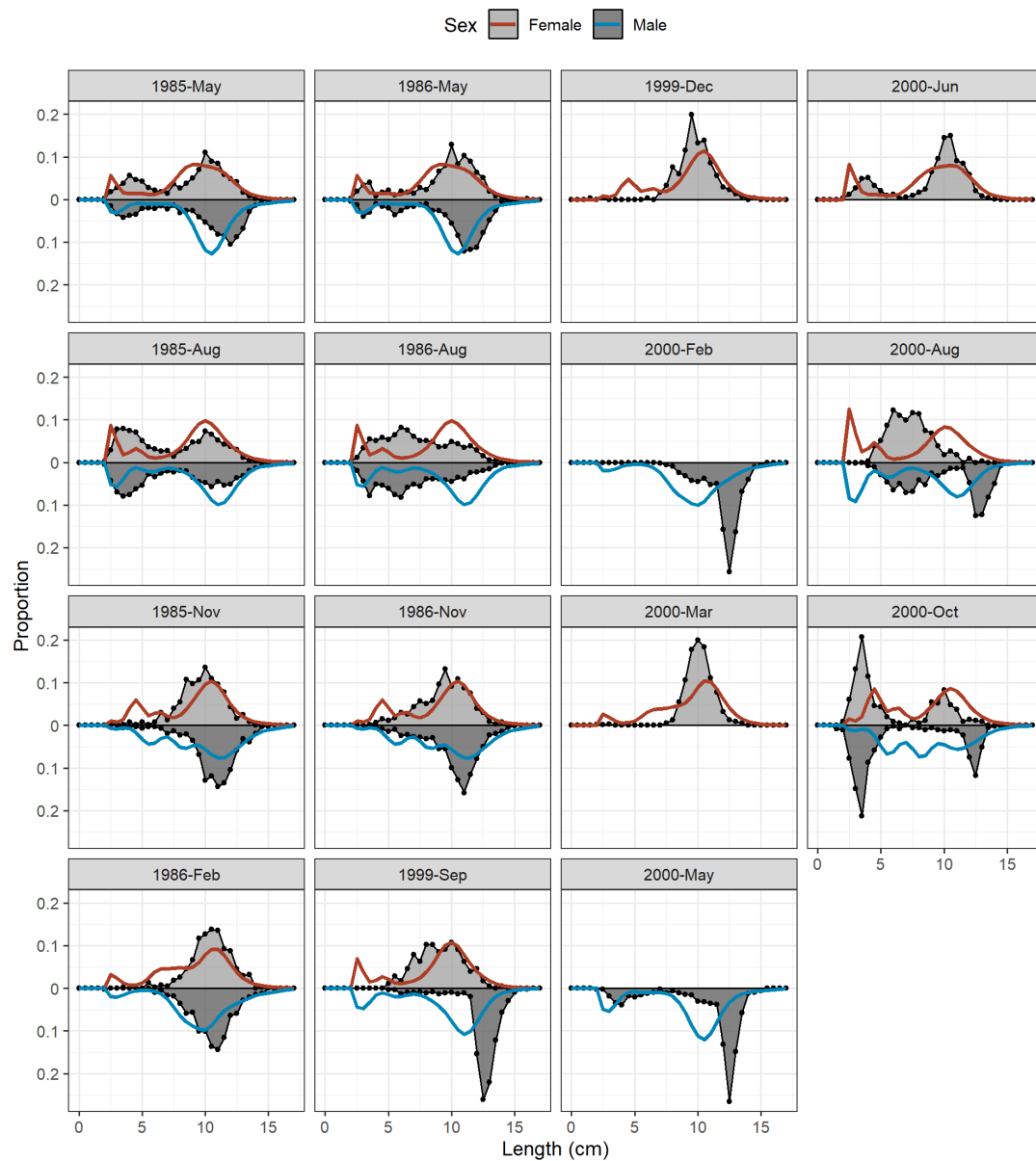


Figure H.38: Analysis 3: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

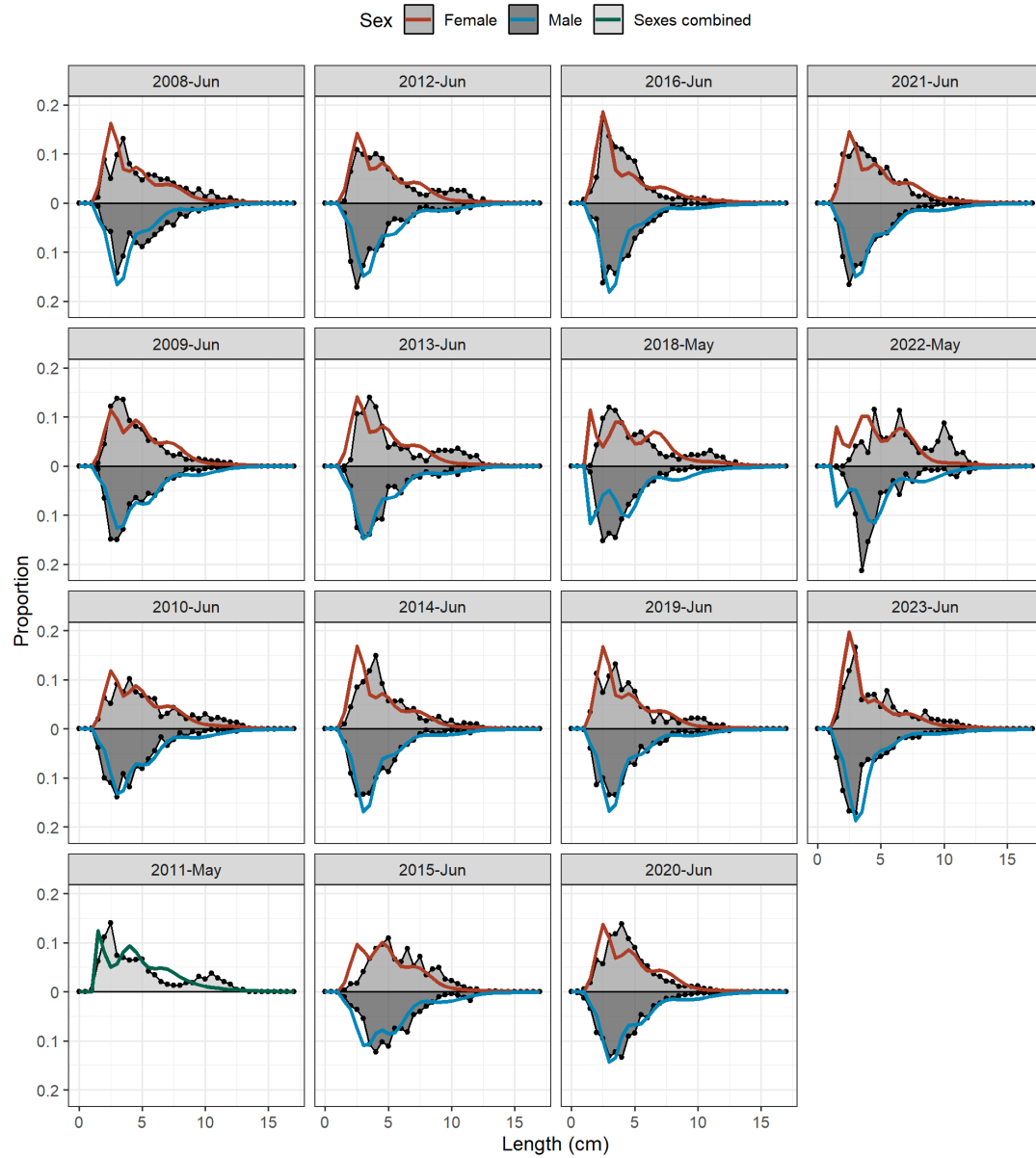


Figure H.39: Analysis 3: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

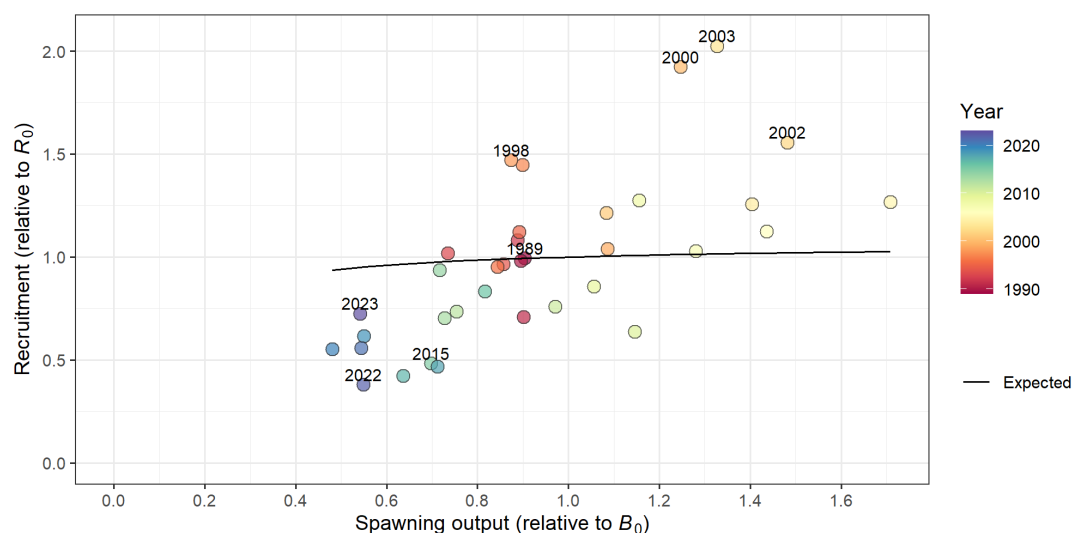


Figure H.40: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 3 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

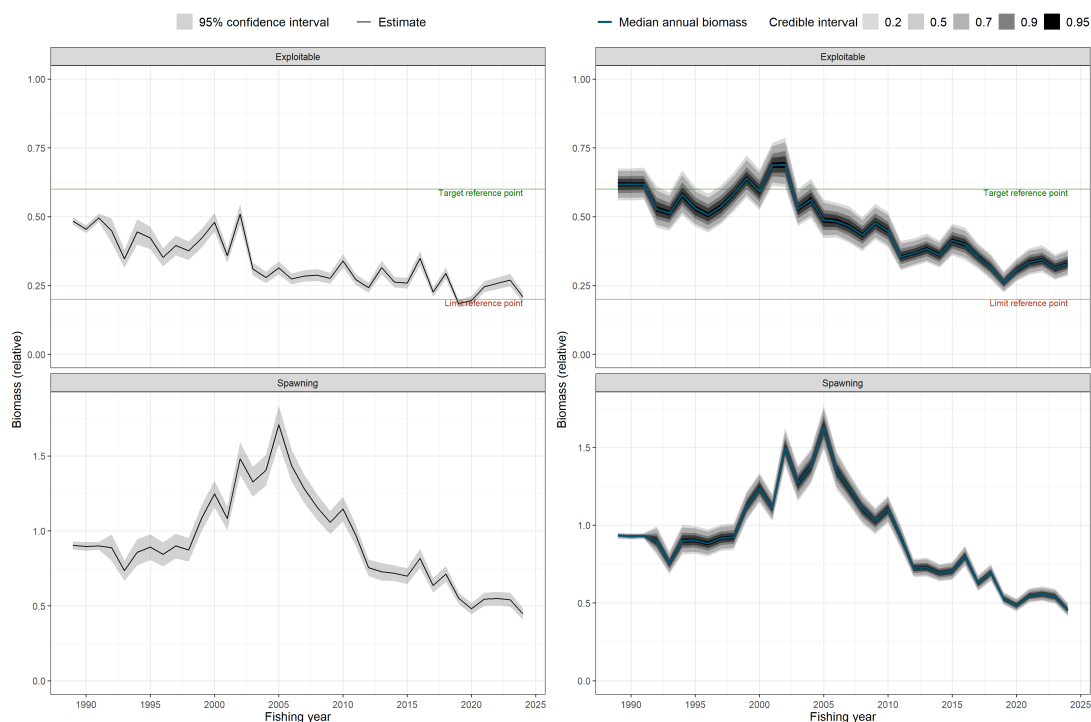


Figure H.41: Analysis 3: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

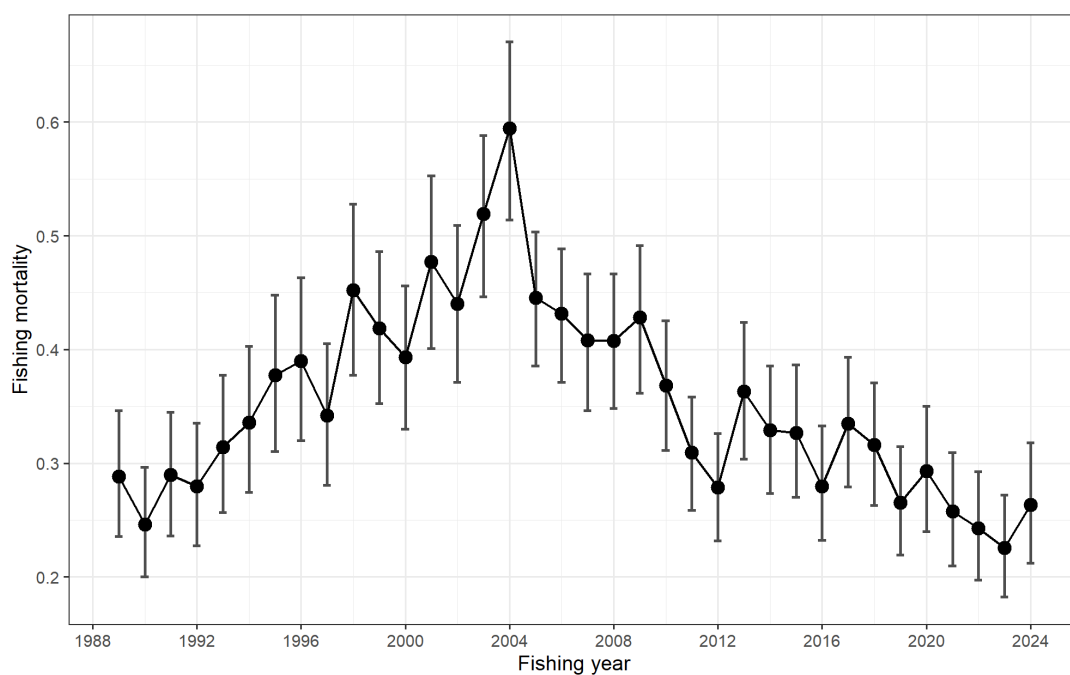


Figure H.42: Analysis 3: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

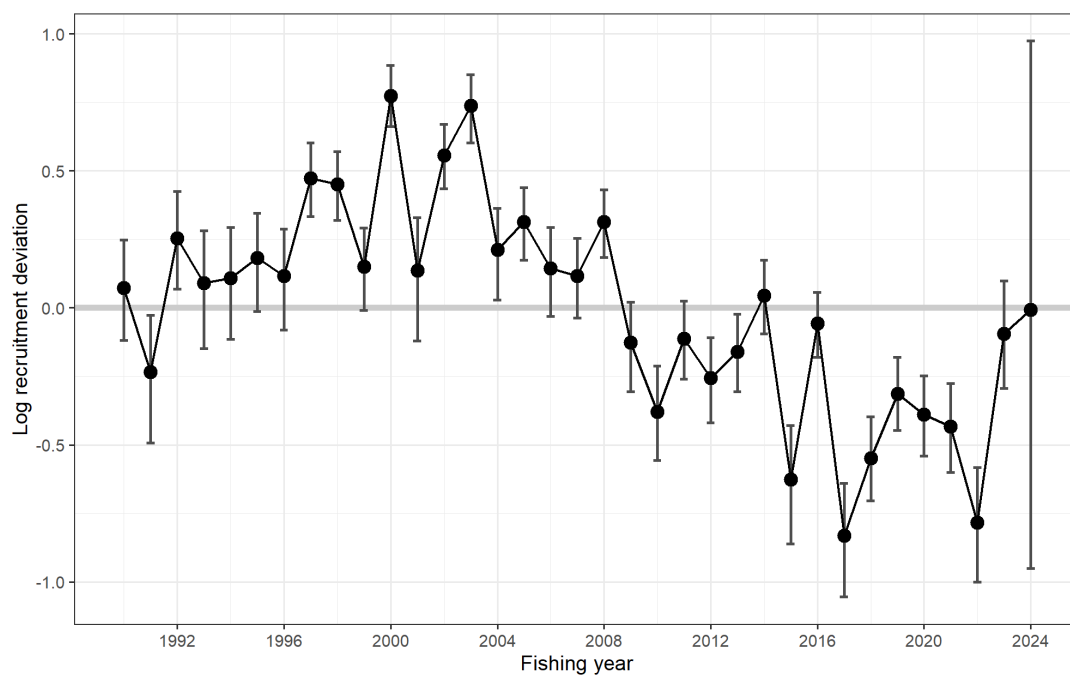


Figure H.43: Analysis 3: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

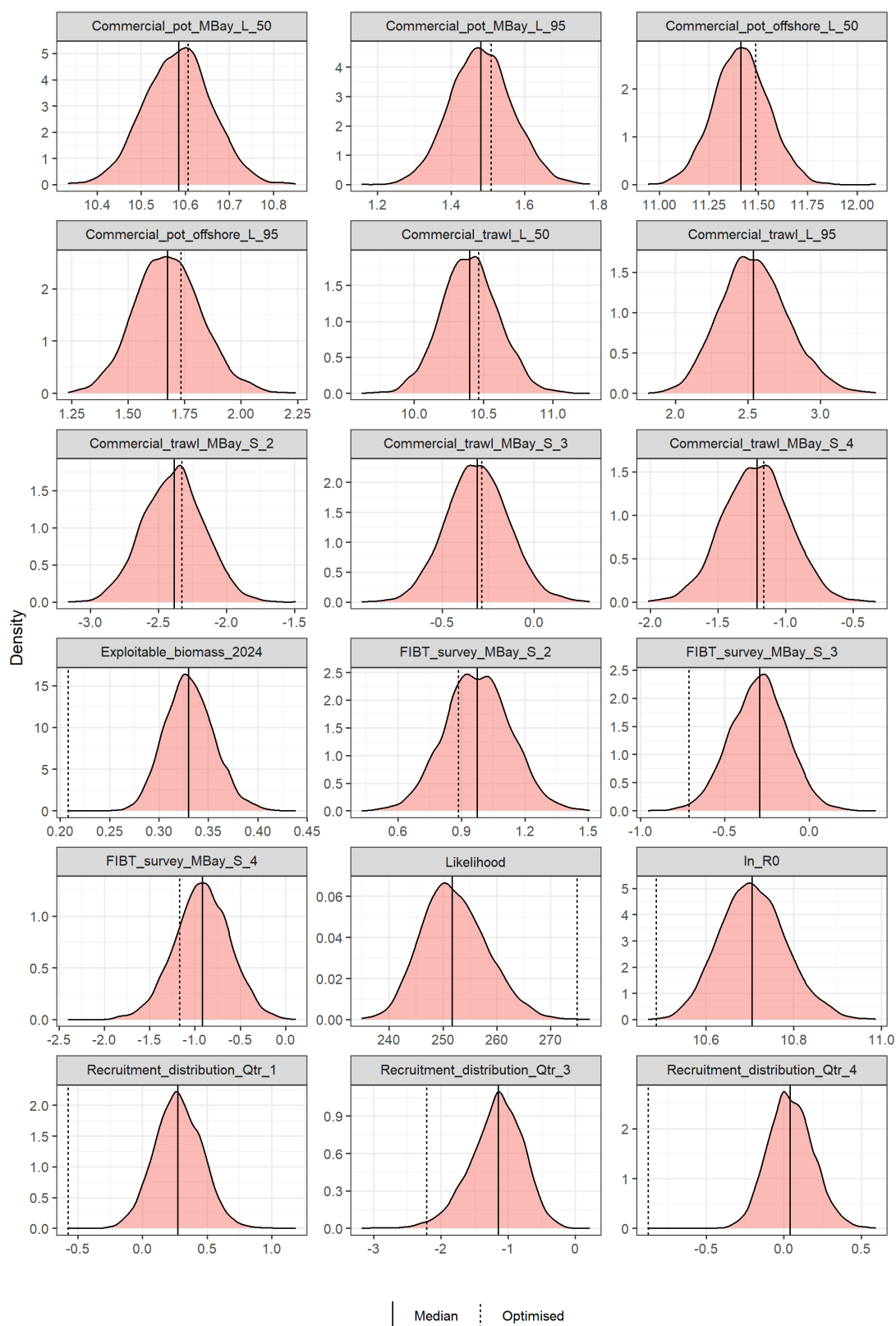


Figure H.44: Analysis 3: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

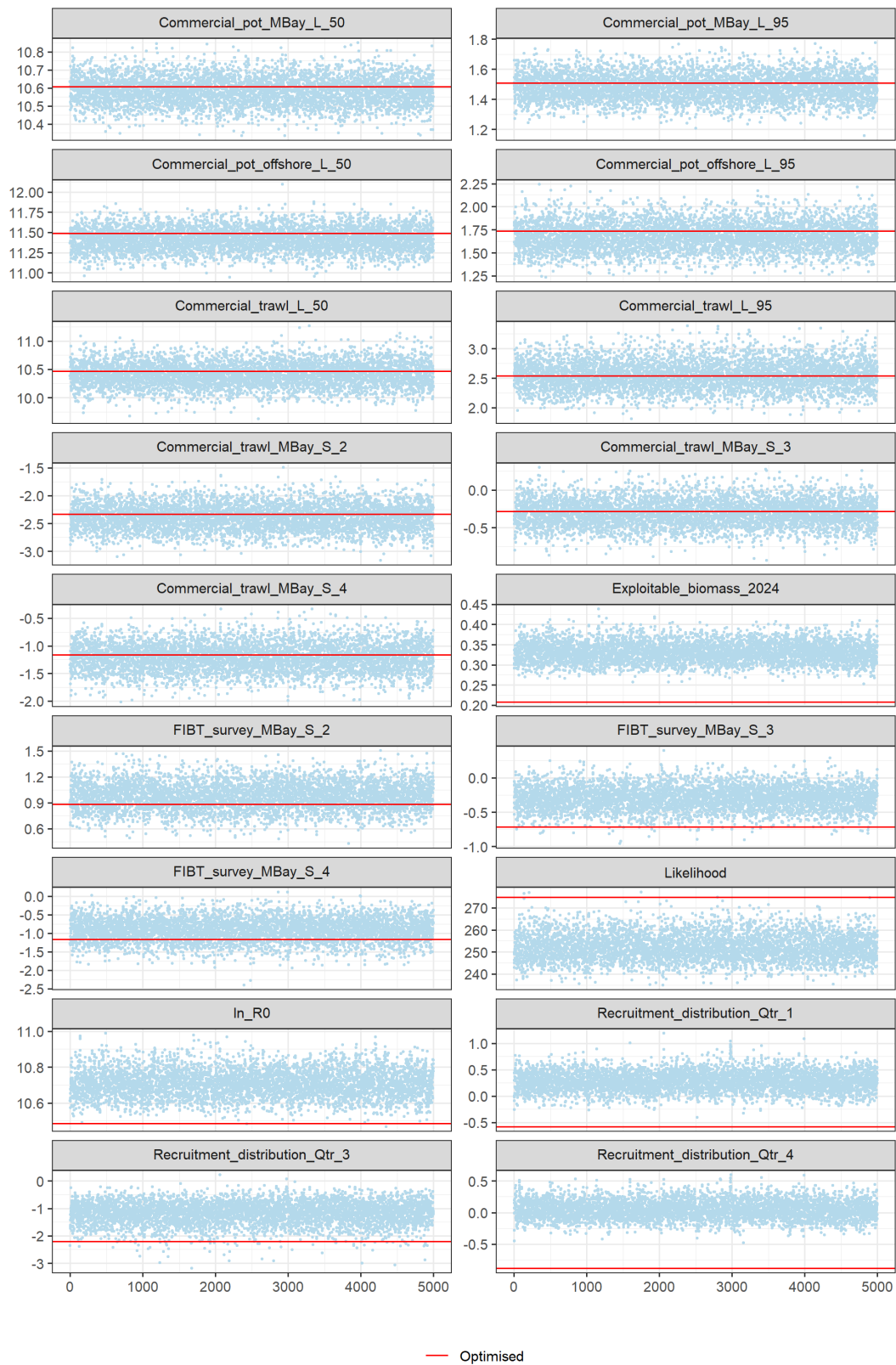


Figure H.45: Analysis 3: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.4 Analysis 4

Table H.7: Summary of MLE parameter estimates for analysis 4

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.53	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.83	2	-5.00	5.00	0.00	0.94
Recruitment distribution Qtr_4	-0.86	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	9.74	1	5.00	20.00	11.00	0.04
Commercial pot MBay L_{50}	10.40	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.49	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.30	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.73	3	0.10	20.00	1.50	0.17
Commercial trawl L_{50}	10.01	3	0.10	20.00	9.00	0.22
Commercial trawl L_{95}	2.64	3	0.10	20.00	2.20	0.26
Commercial trawl MBay S_2	-2.56	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.75	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.98	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.84	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-1.01	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.86	3	-9.00	7.00	-1.00	0.30

Table H.8: Summary of MCMC parameter estimates for analysis 4

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.34	-0.04	0.73
Recruitment distribution Qtr_3	-1.22	-2.22	-0.52
Recruitment distribution Qtr_4	0.06	-0.22	0.39
$\ln(R_0)$	9.87	9.80	9.97
Commercial pot MBay L_{50}	10.37	10.22	10.52
Commercial pot MBay L_{95}	1.47	1.29	1.65
Commercial pot offshore L_{50}	11.22	10.94	11.51
Commercial pot offshore L_{95}	1.68	1.38	2.02
Commercial trawl L_{50}	9.93	9.49	10.38
Commercial trawl L_{95}	2.65	2.17	3.26
Commercial trawl MBay S_2	-2.62	-3.05	-2.18
Commercial trawl MBay S_3	-0.80	-1.13	-0.45
Commercial trawl MBay S_4	-2.03	-2.53	-1.55
FIBT survey MBay S_2	0.94	0.62	1.26
FIBT survey MBay S_3	-0.61	-0.94	-0.29
FIBT survey MBay S_4	-1.63	-2.25	-1.05

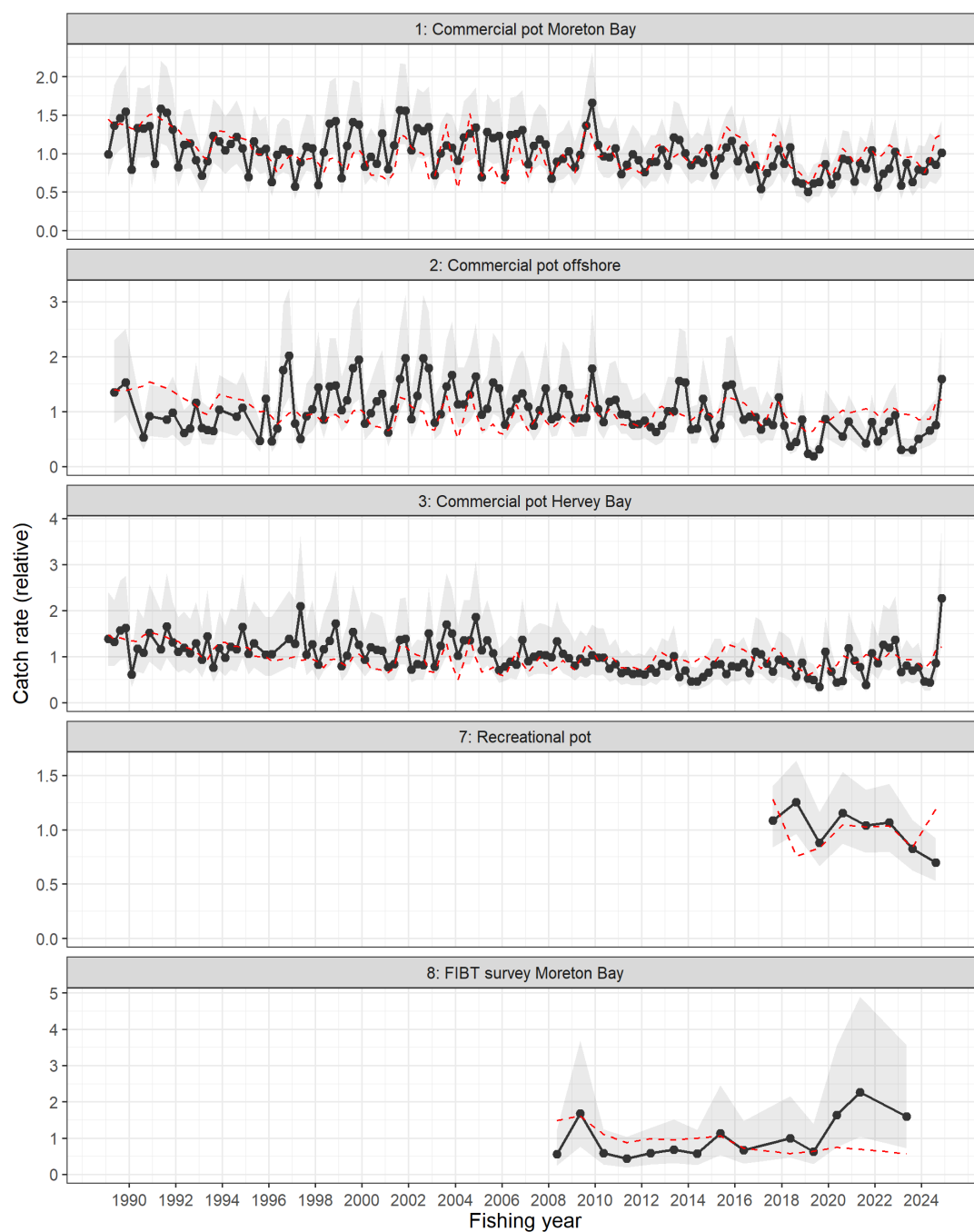


Figure H.46: Analysis 4: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

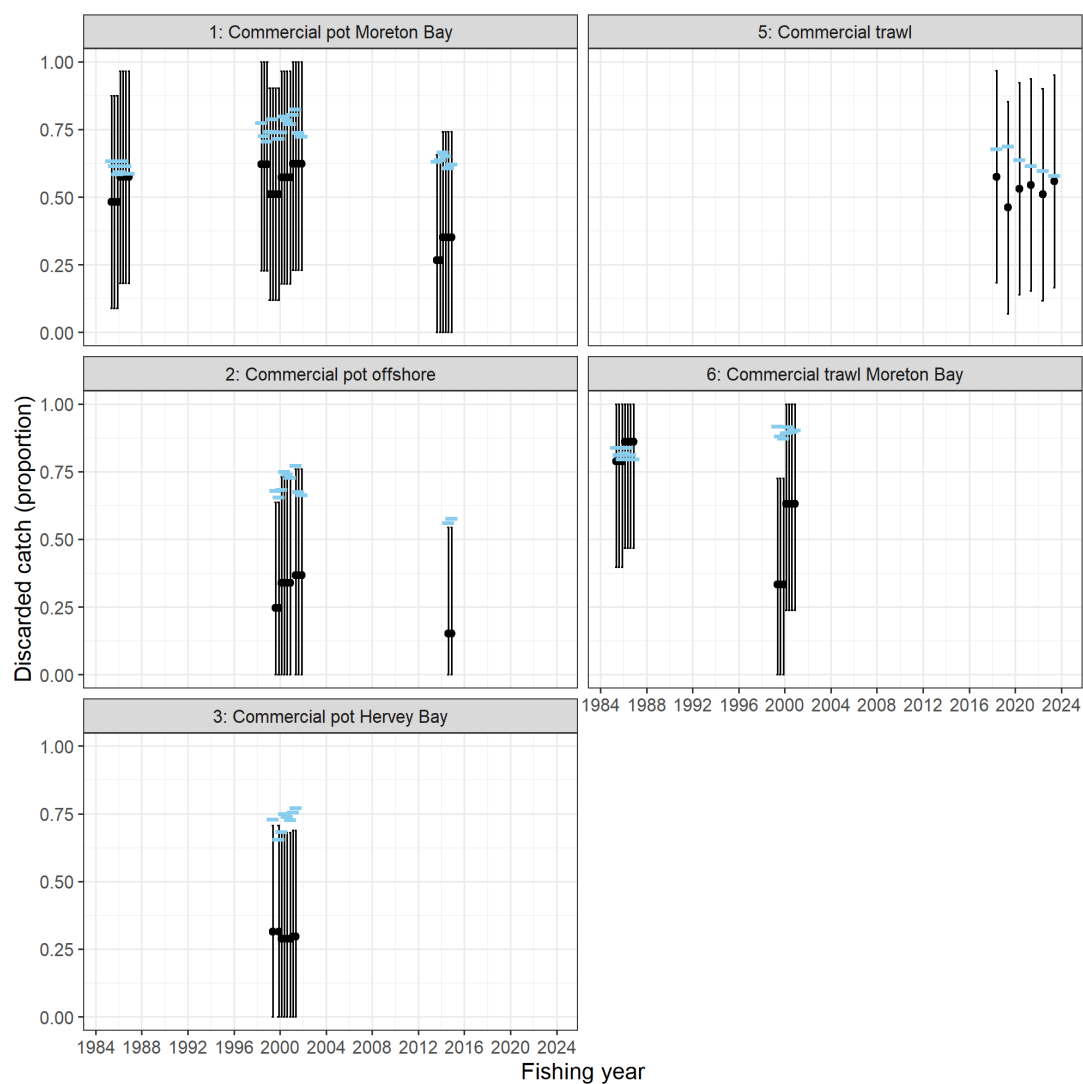


Figure H.47: Analysis 4: Fits to annual discard proportions of blue swimmer crab catch

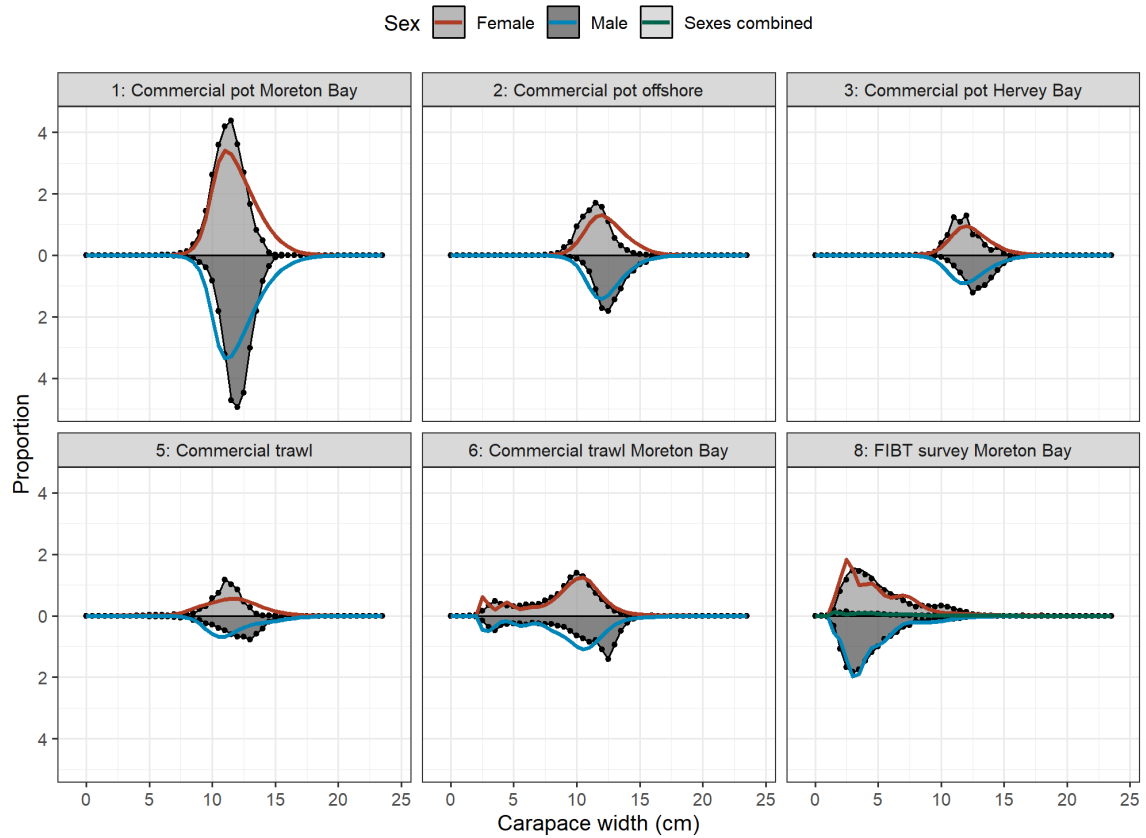


Figure H.48: Analysis 4: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

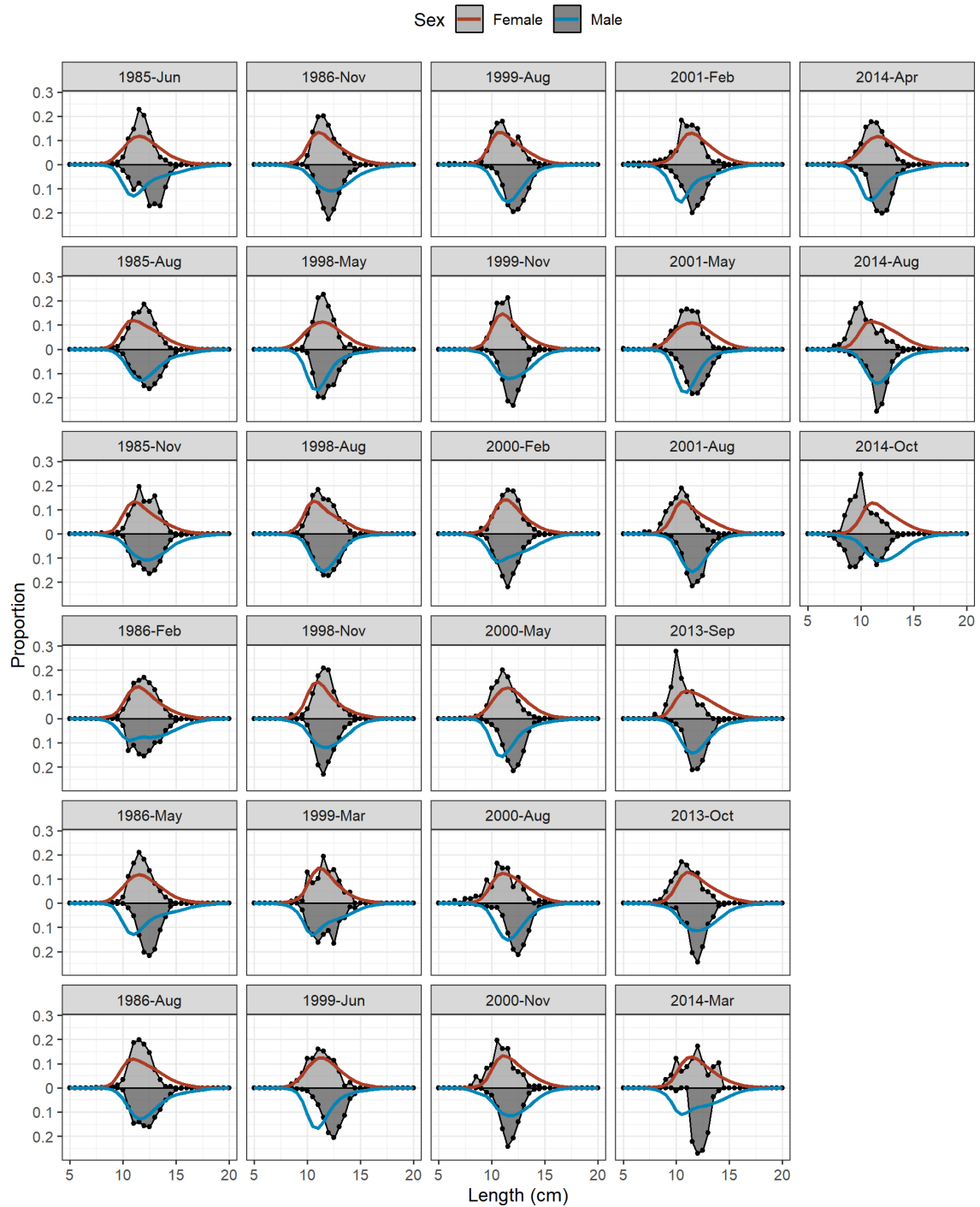


Figure H.49: Analysis 4: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

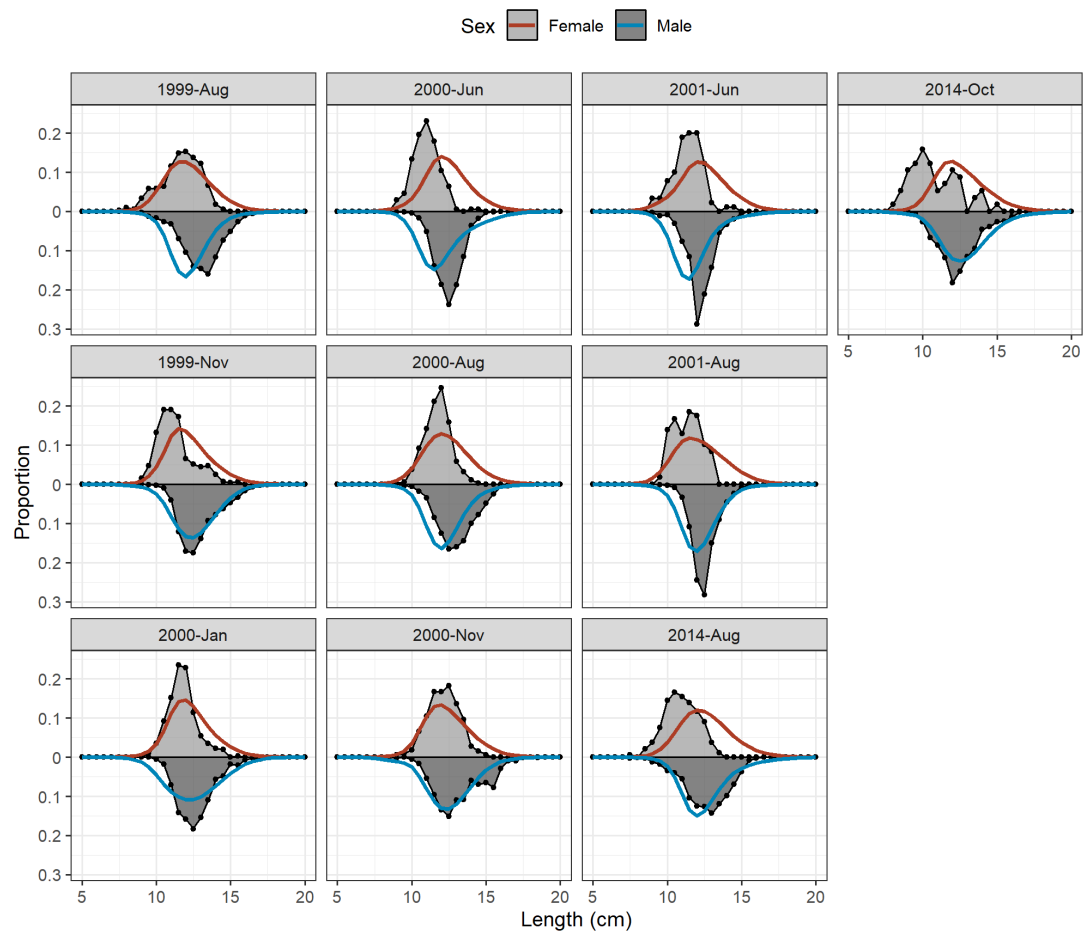


Figure H.50: Analysis 4: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

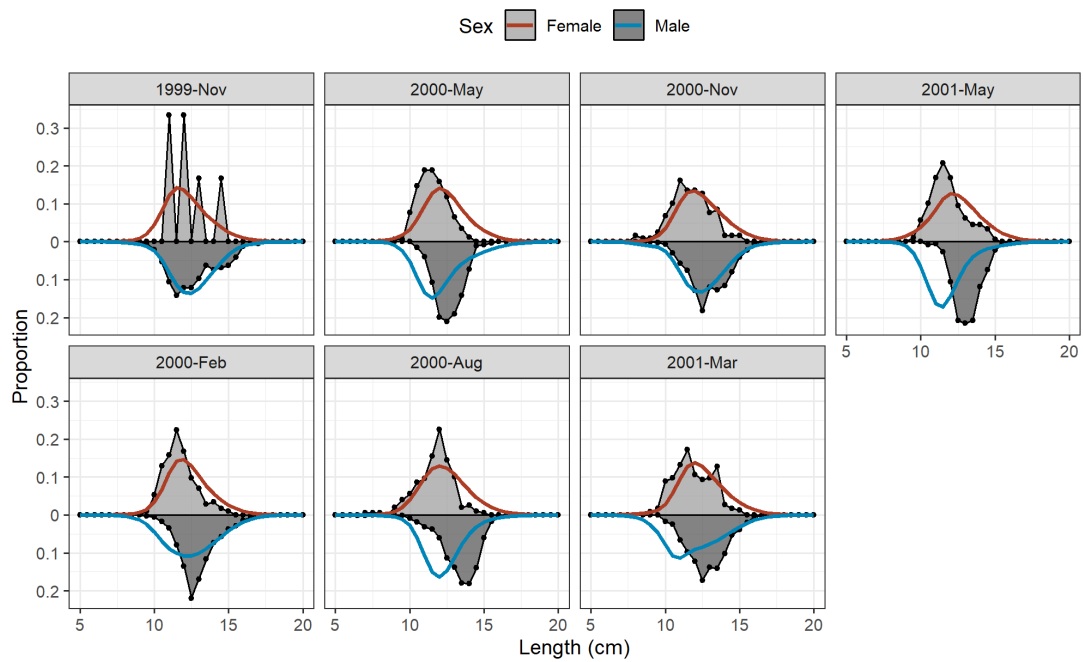


Figure H.51: Analysis 4: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

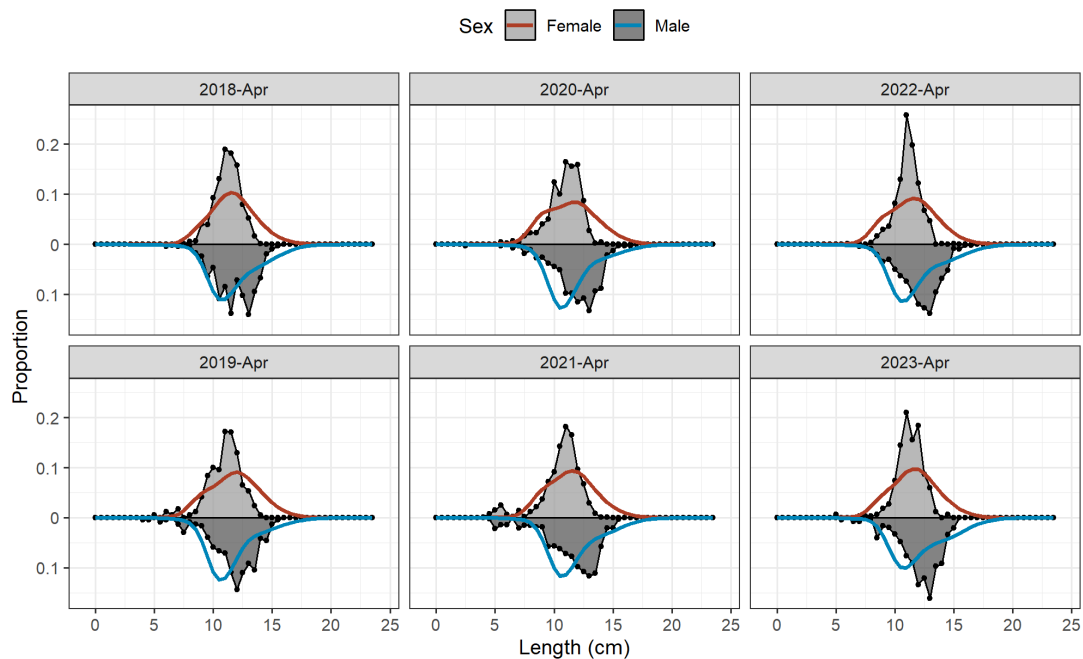


Figure H.52: Analysis 4: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

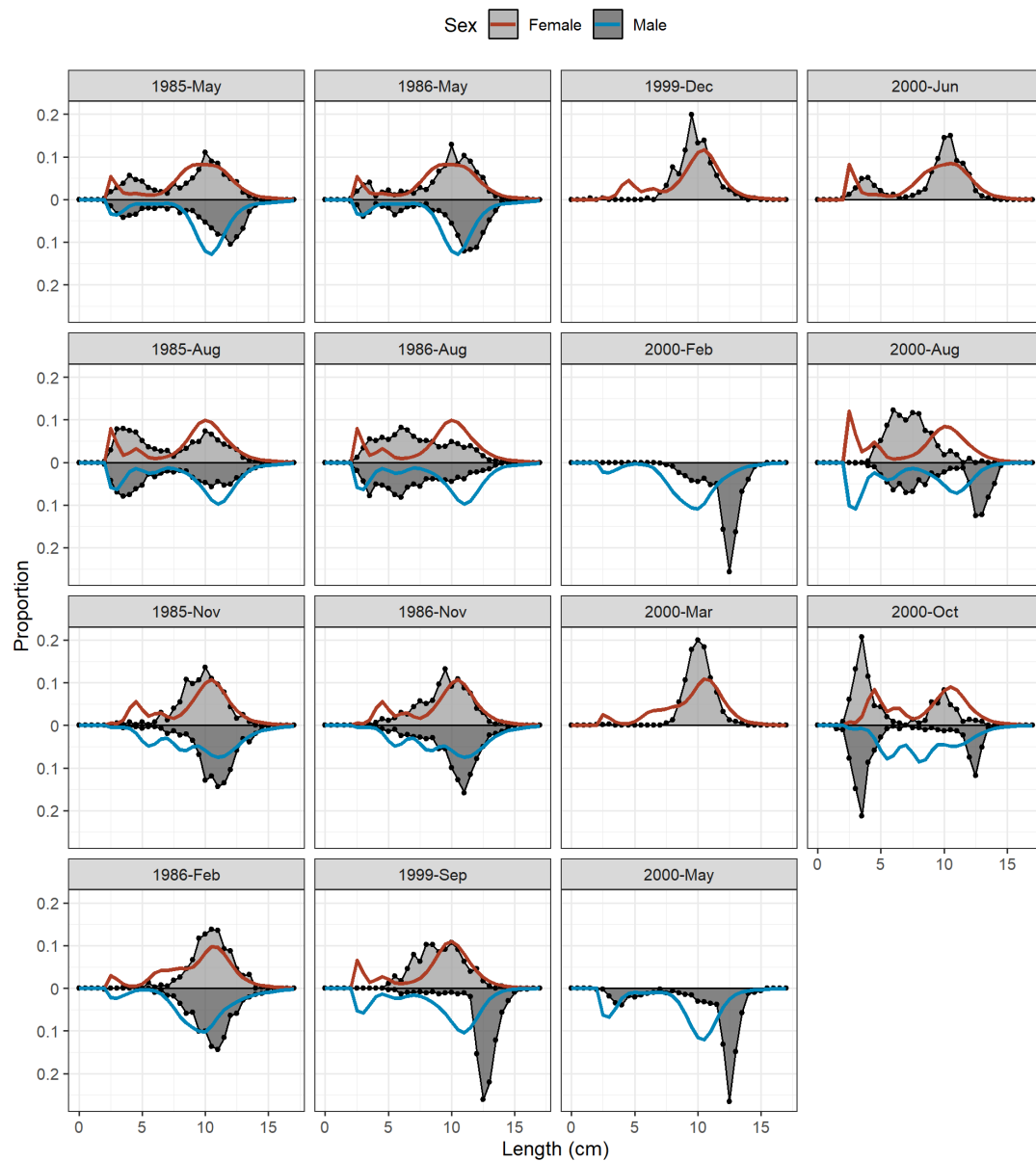


Figure H.53: Analysis 4: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

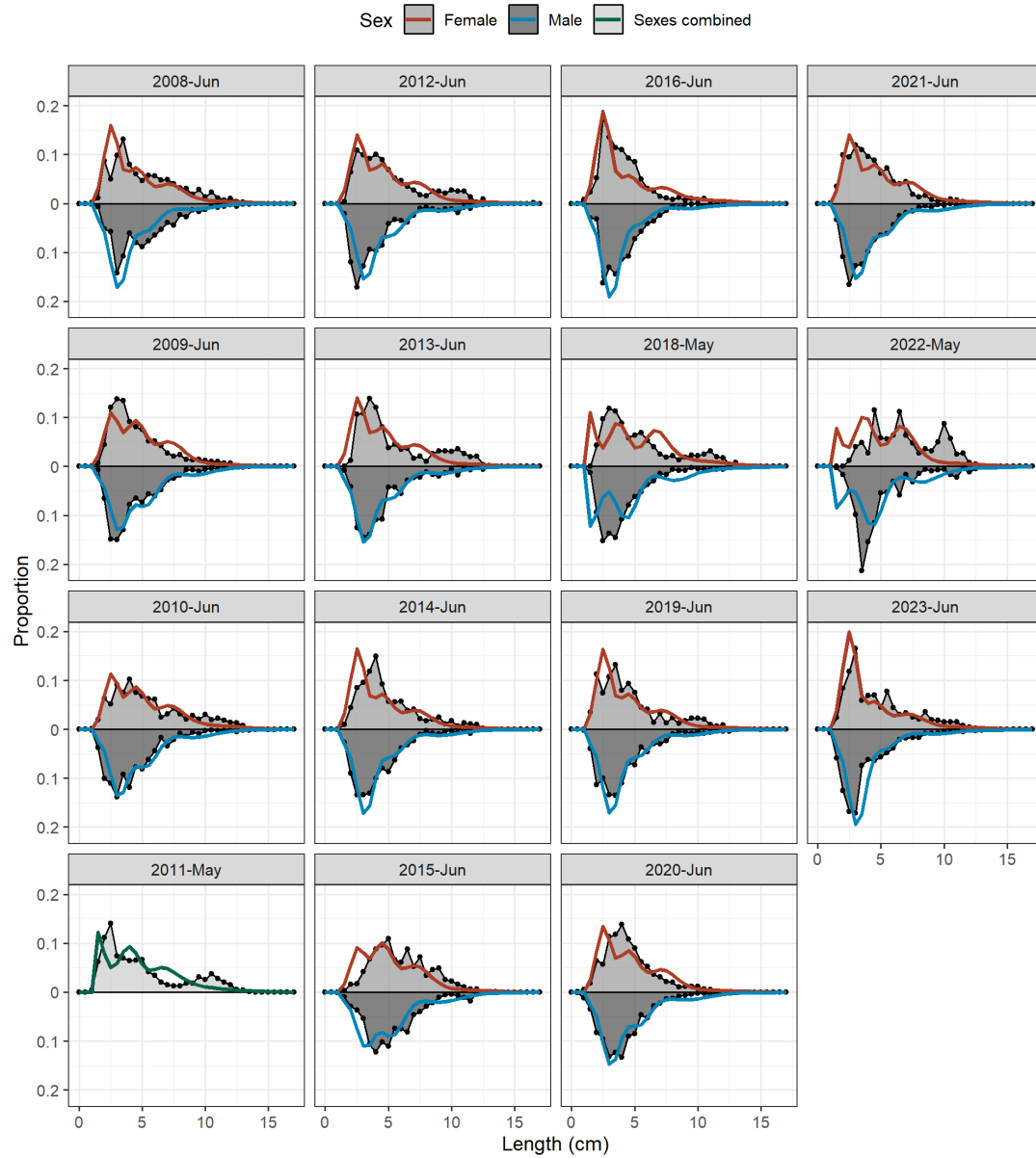


Figure H.54: Analysis 4: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

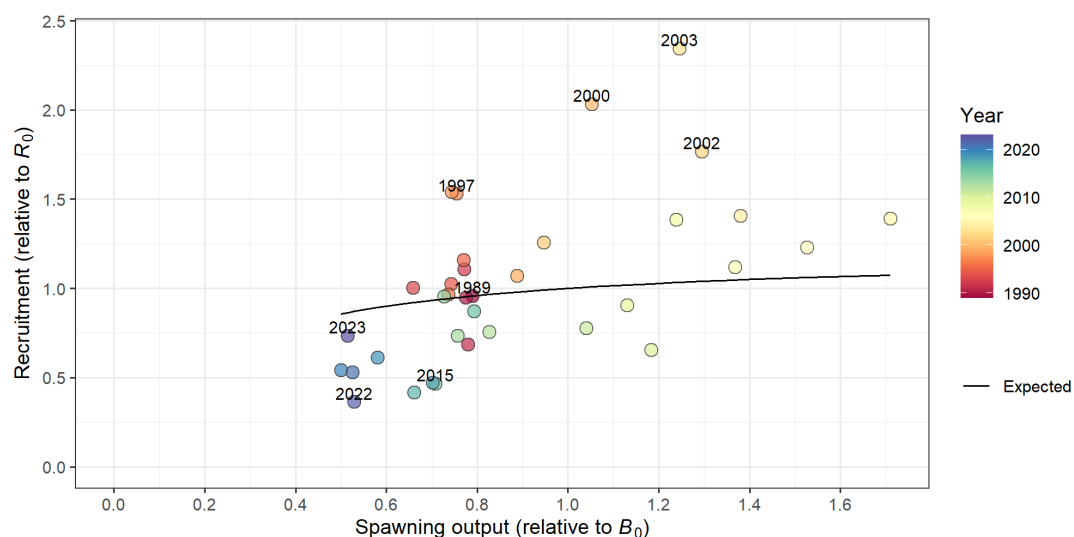


Figure H.55: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 4 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

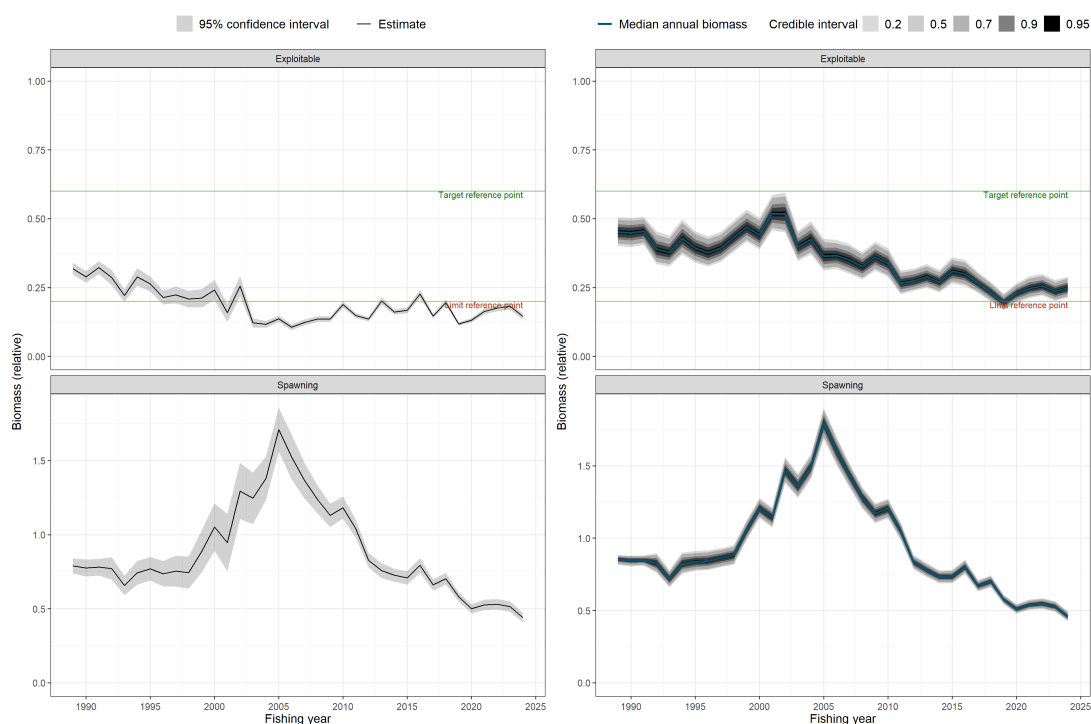


Figure H.56: Analysis 4: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

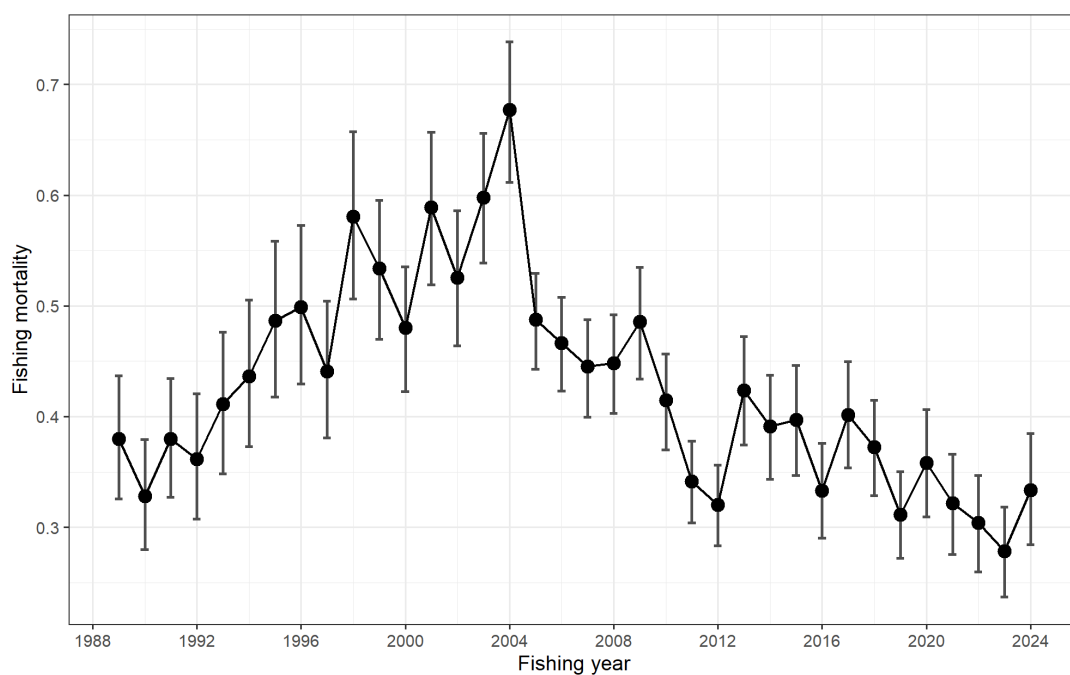


Figure H.57: Analysis 4: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

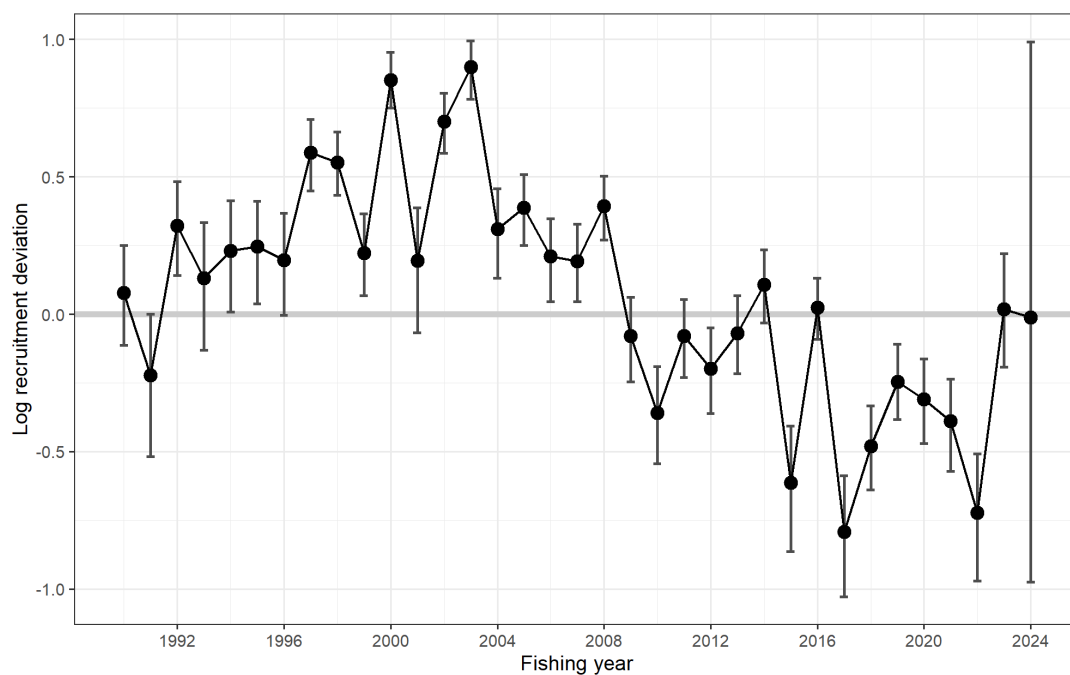


Figure H.58: Analysis 4: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

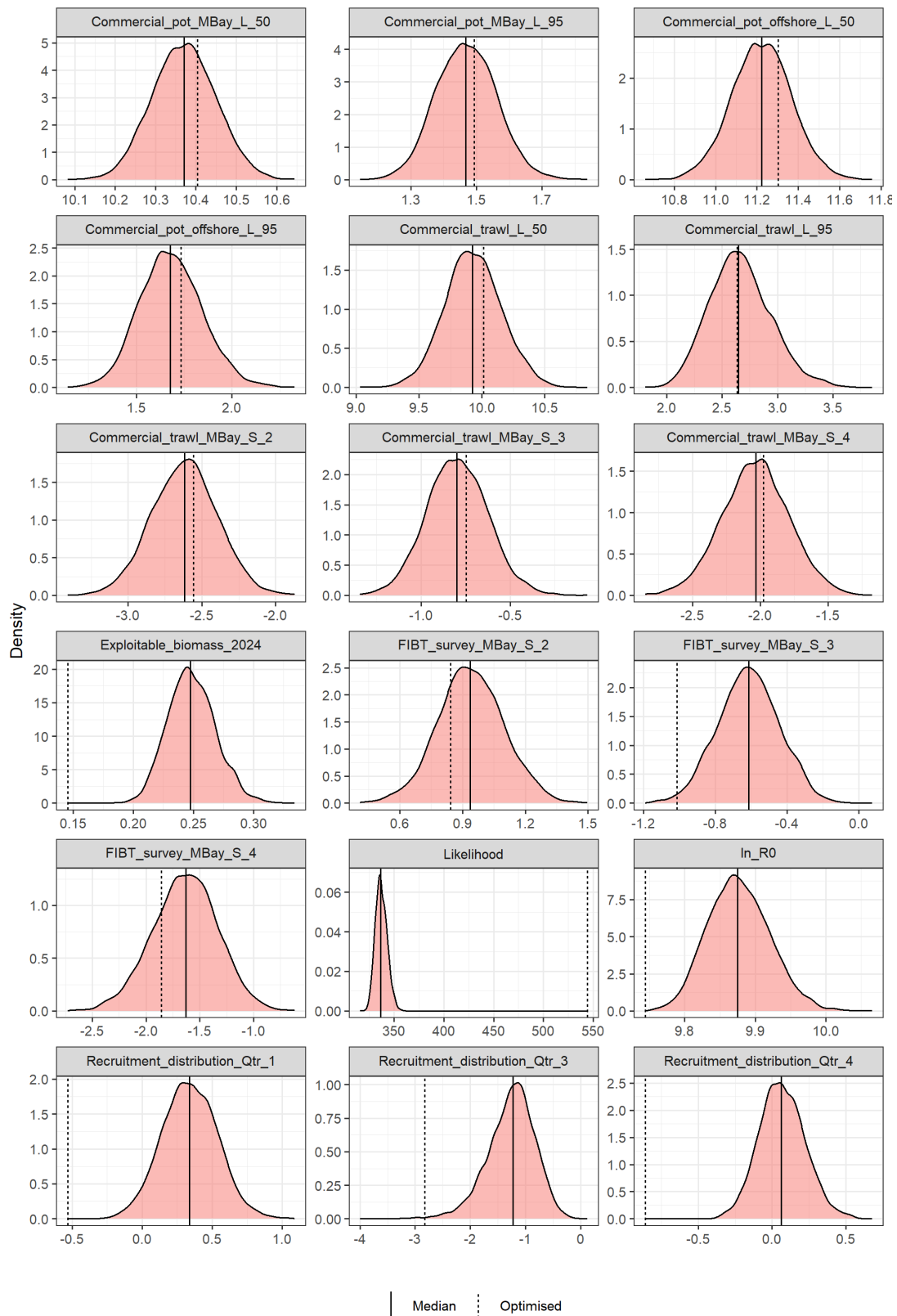


Figure H.59: Analysis 4: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

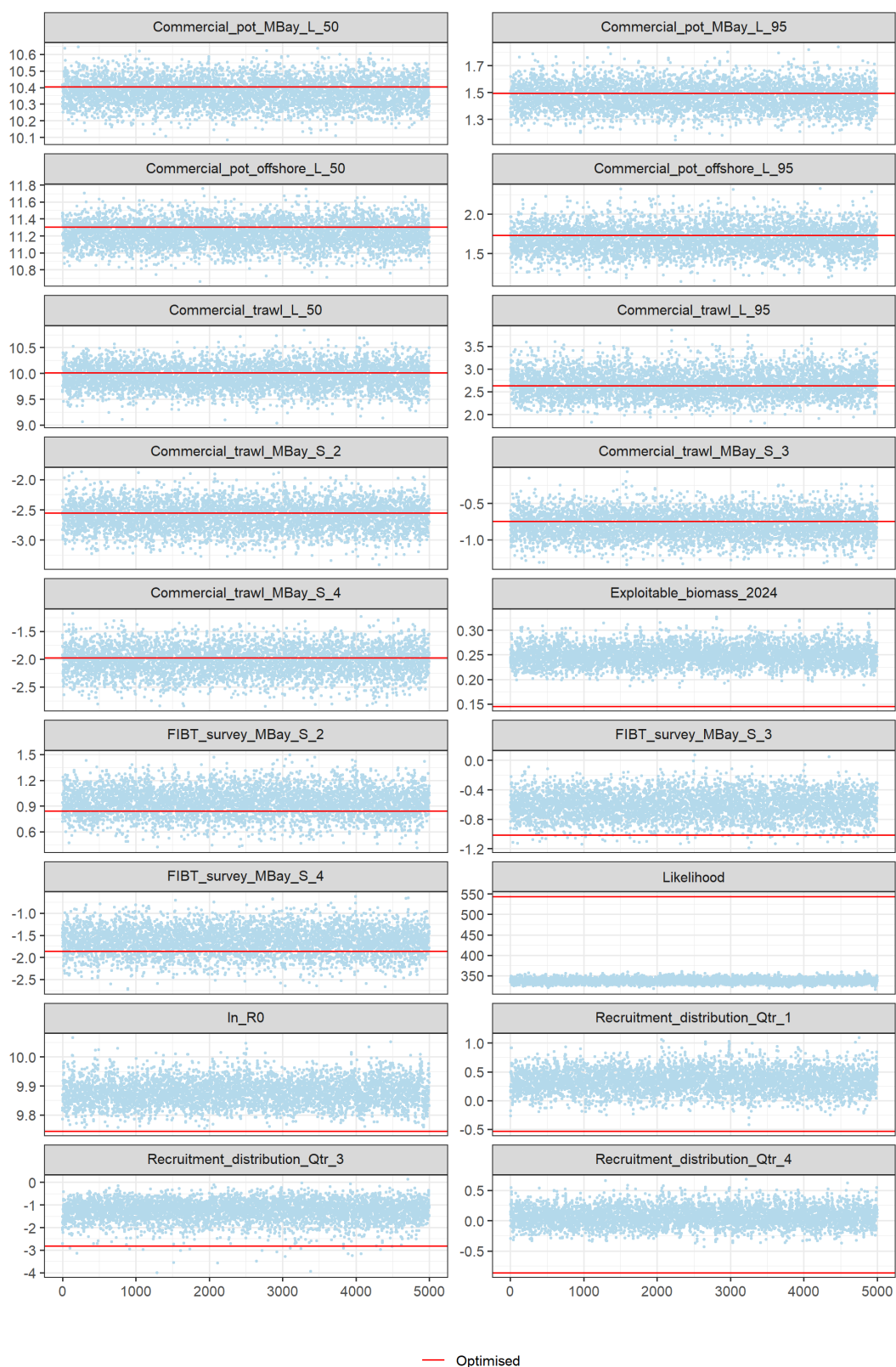


Figure H.60: Analysis 4: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.5 Analysis 5

Table H.9: Summary of MLE parameter estimates for analysis 5

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.56	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.49	2	-5.00	5.00	0.00	0.74
Recruitment distribution Qtr_4	-0.87	2	-5.00	5.00	-1.15	0.13
$\ln(R_0)$	10.12	1	5.00	20.00	11.00	0.05
Commercial pot MBay L_{50}	10.51	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.50	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.40	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.74	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.26	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.59	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.44	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.52	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.55	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.86	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.86	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.50	3	-9.00	7.00	-1.00	0.30

Table H.10: Summary of MCMC parameter estimates for analysis 5

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.30	-0.06	0.68
Recruitment distribution Qtr_3	-1.20	-2.12	-0.50
Recruitment distribution Qtr_4	0.05	-0.22	0.36
$\ln(R_0)$	10.29	10.18	10.41
Commercial pot MBay L_{50}	10.48	10.34	10.64
Commercial pot MBay L_{95}	1.48	1.31	1.66
Commercial pot offshore L_{50}	11.32	11.05	11.61
Commercial pot offshore L_{95}	1.68	1.40	2.01
Commercial trawl L_{50}	10.19	9.77	10.62
Commercial trawl L_{95}	2.58	2.14	3.14
Commercial trawl MBay S_2	-2.50	-2.94	-2.06
Commercial trawl MBay S_3	-0.56	-0.89	-0.20
Commercial trawl MBay S_4	-1.61	-2.07	-1.12
FIBT survey MBay S_2	0.96	0.66	1.27
FIBT survey MBay S_3	-0.45	-0.79	-0.13
FIBT survey MBay S_4	-1.26	-1.88	-0.69

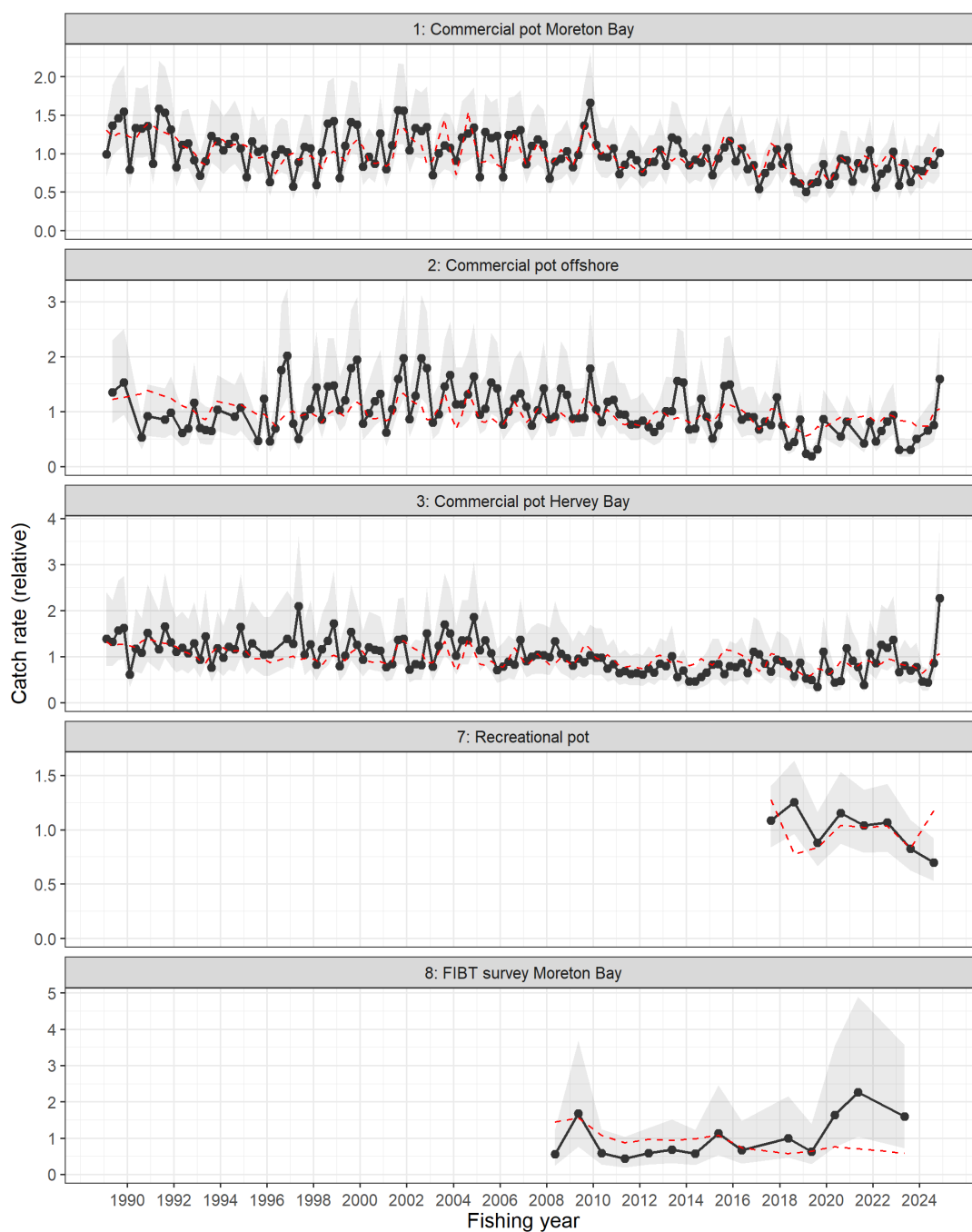


Figure H.61: Analysis 5: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

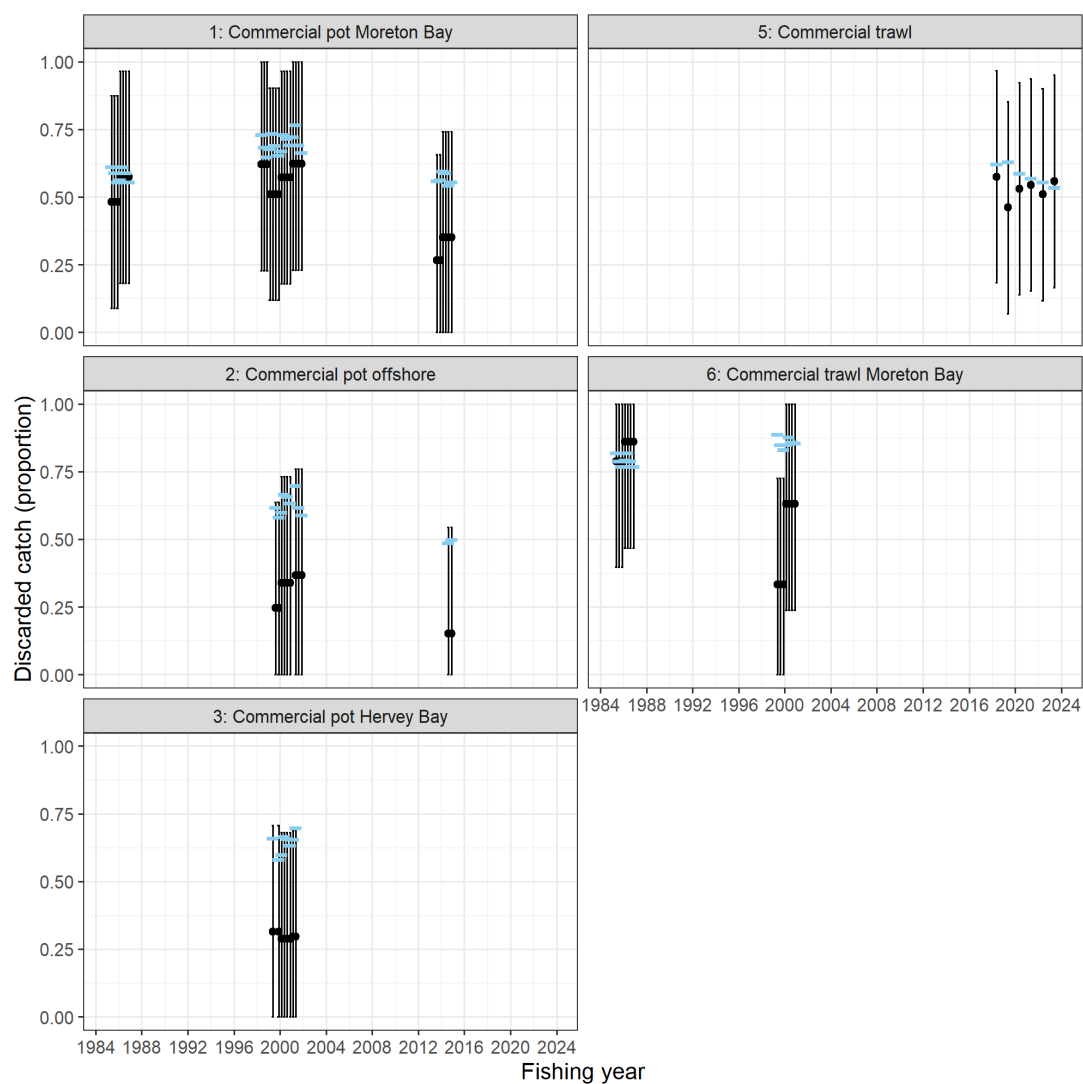


Figure H.62: Analysis 5: Fits to annual discard proportions of blue swimmer crab catch

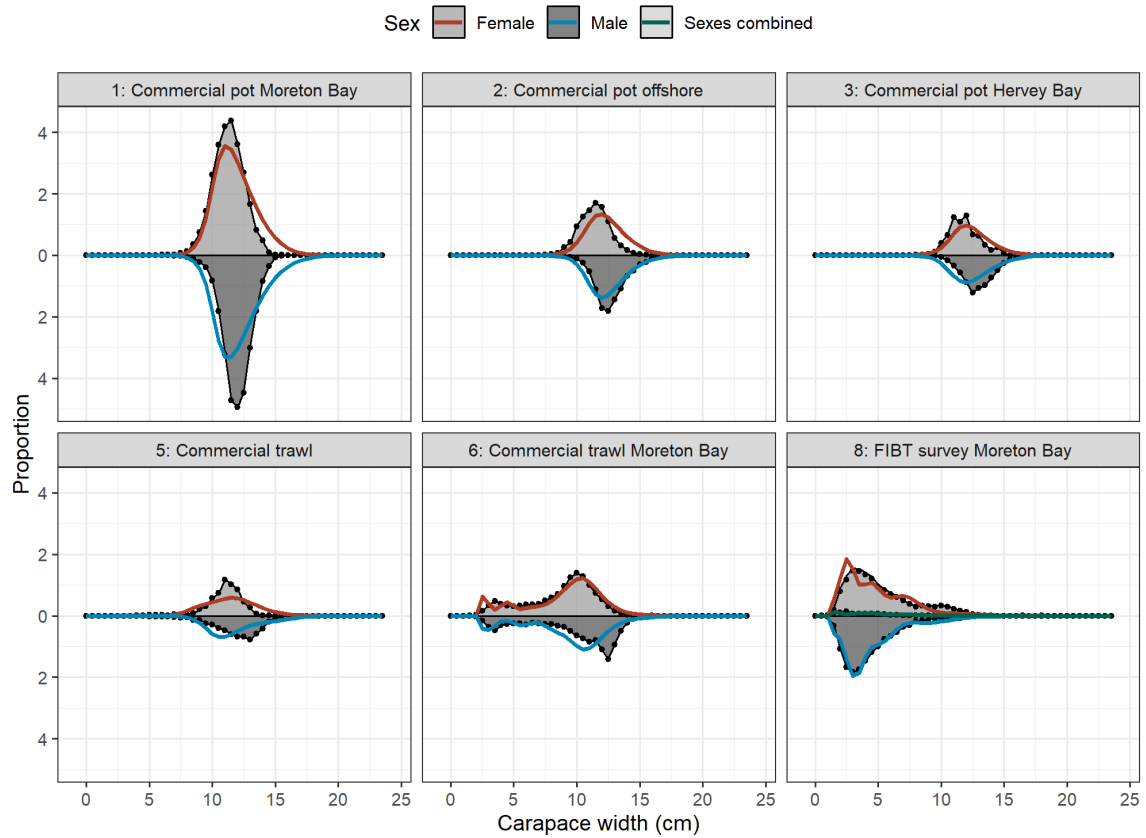


Figure H.63: Analysis 5: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

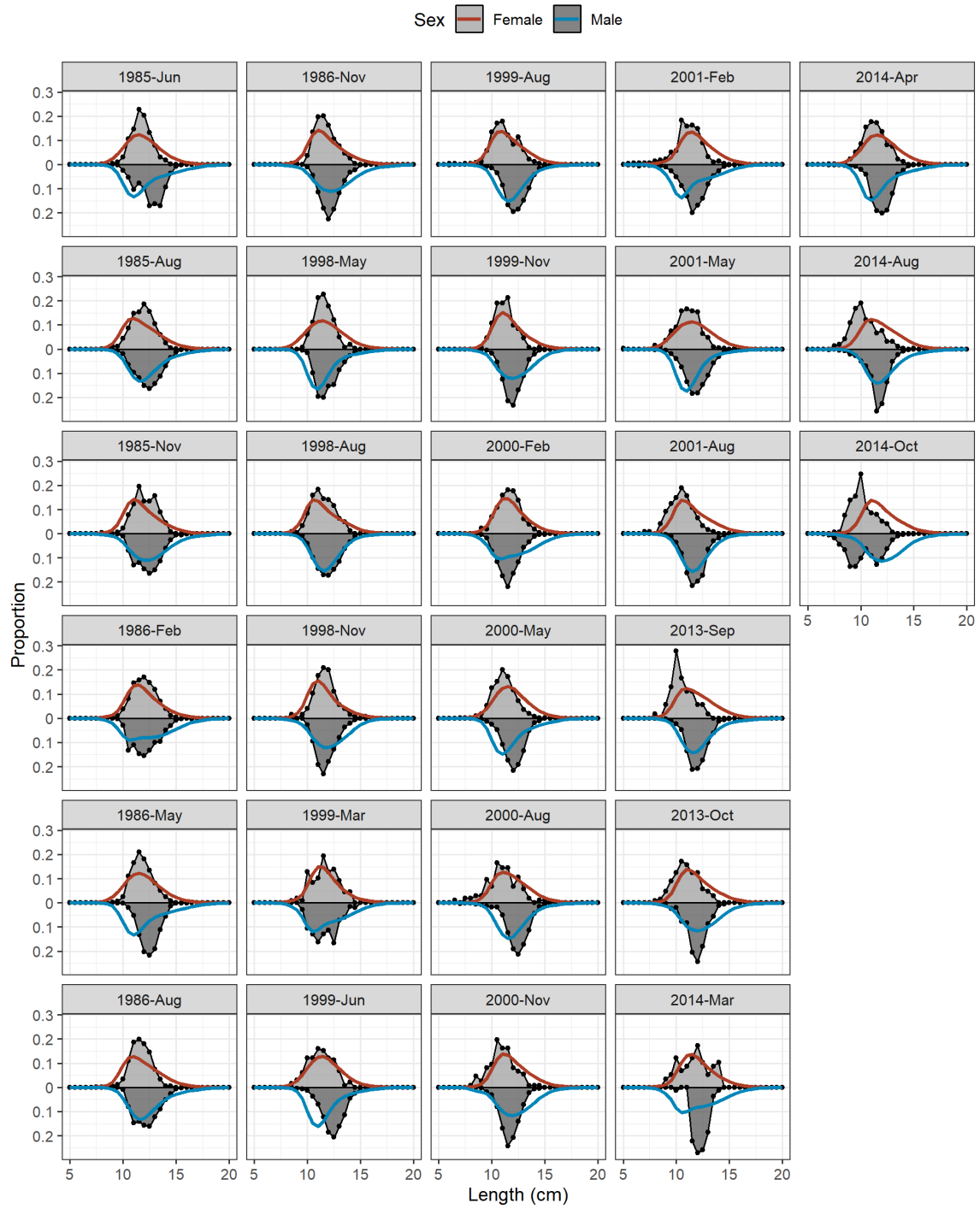


Figure H.64: Analysis 5: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

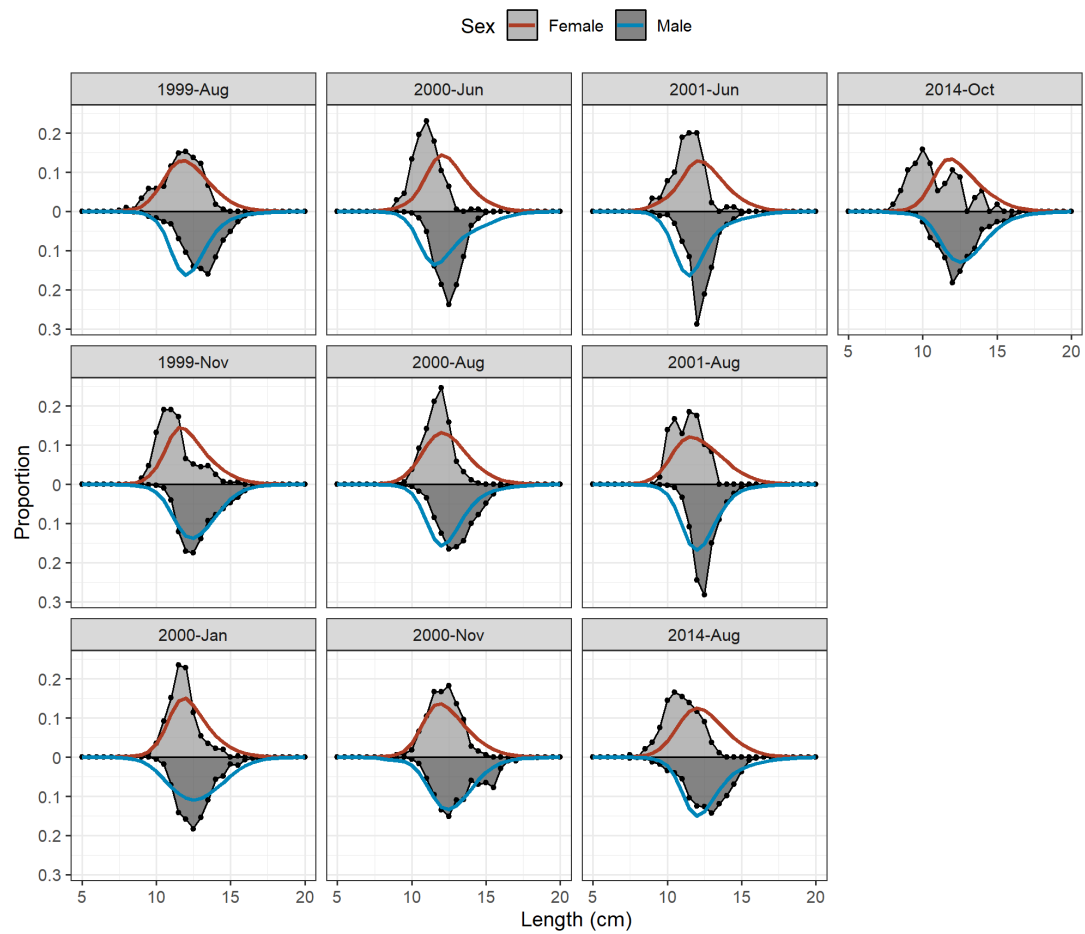


Figure H.65: Analysis 5: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

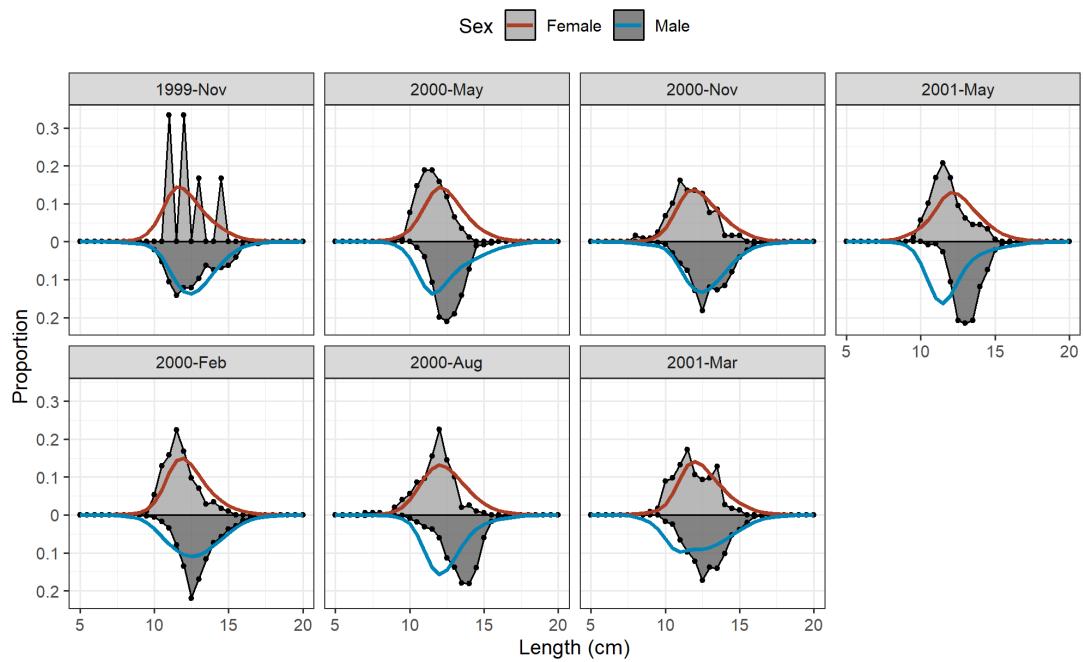


Figure H.66: Analysis 5: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

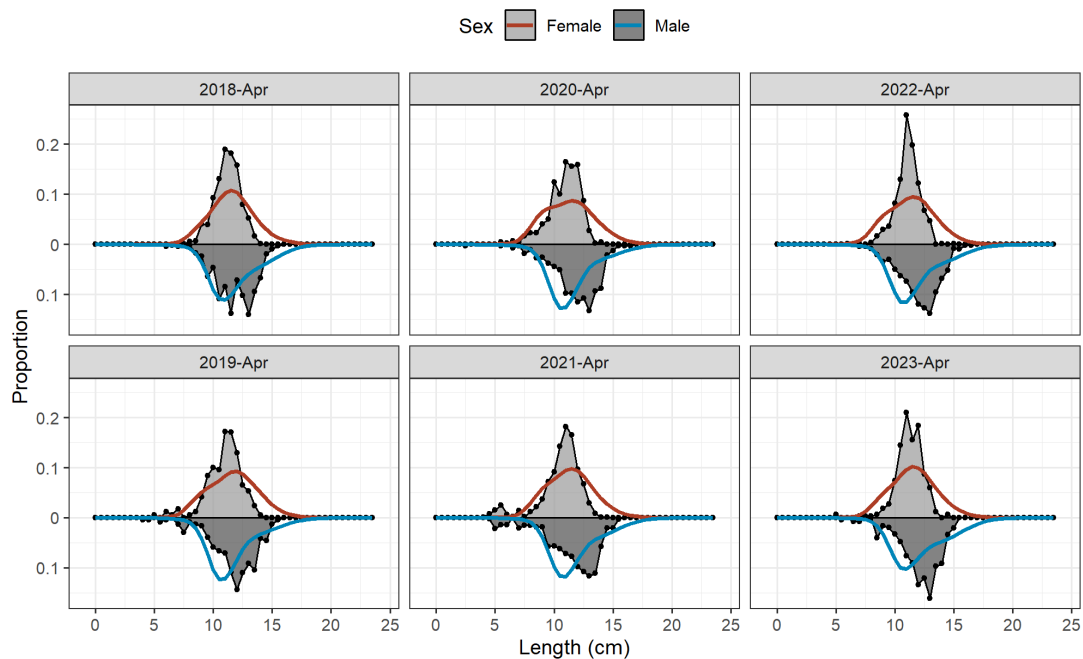


Figure H.67: Analysis 5: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

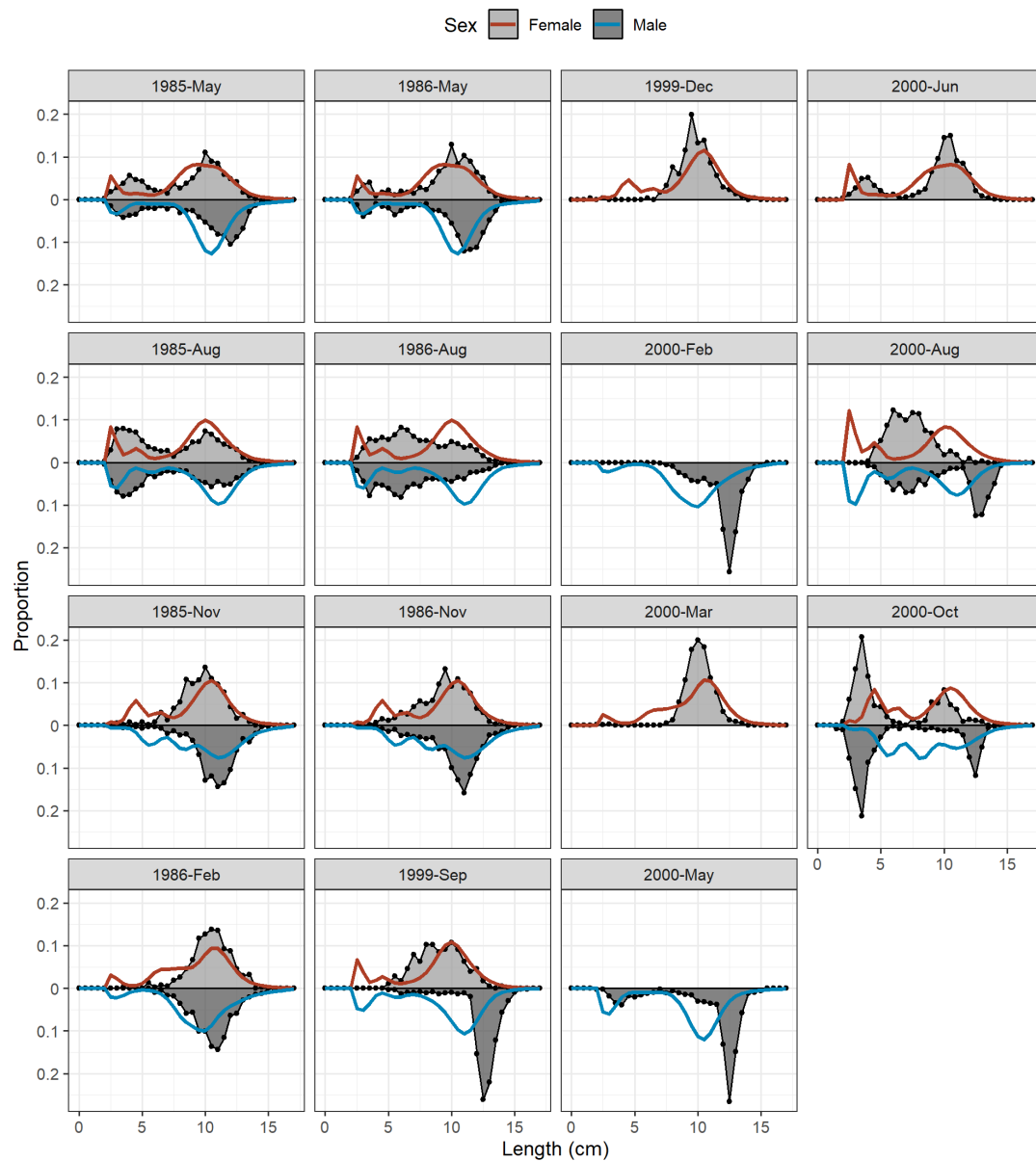


Figure H.68: Analysis 5: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

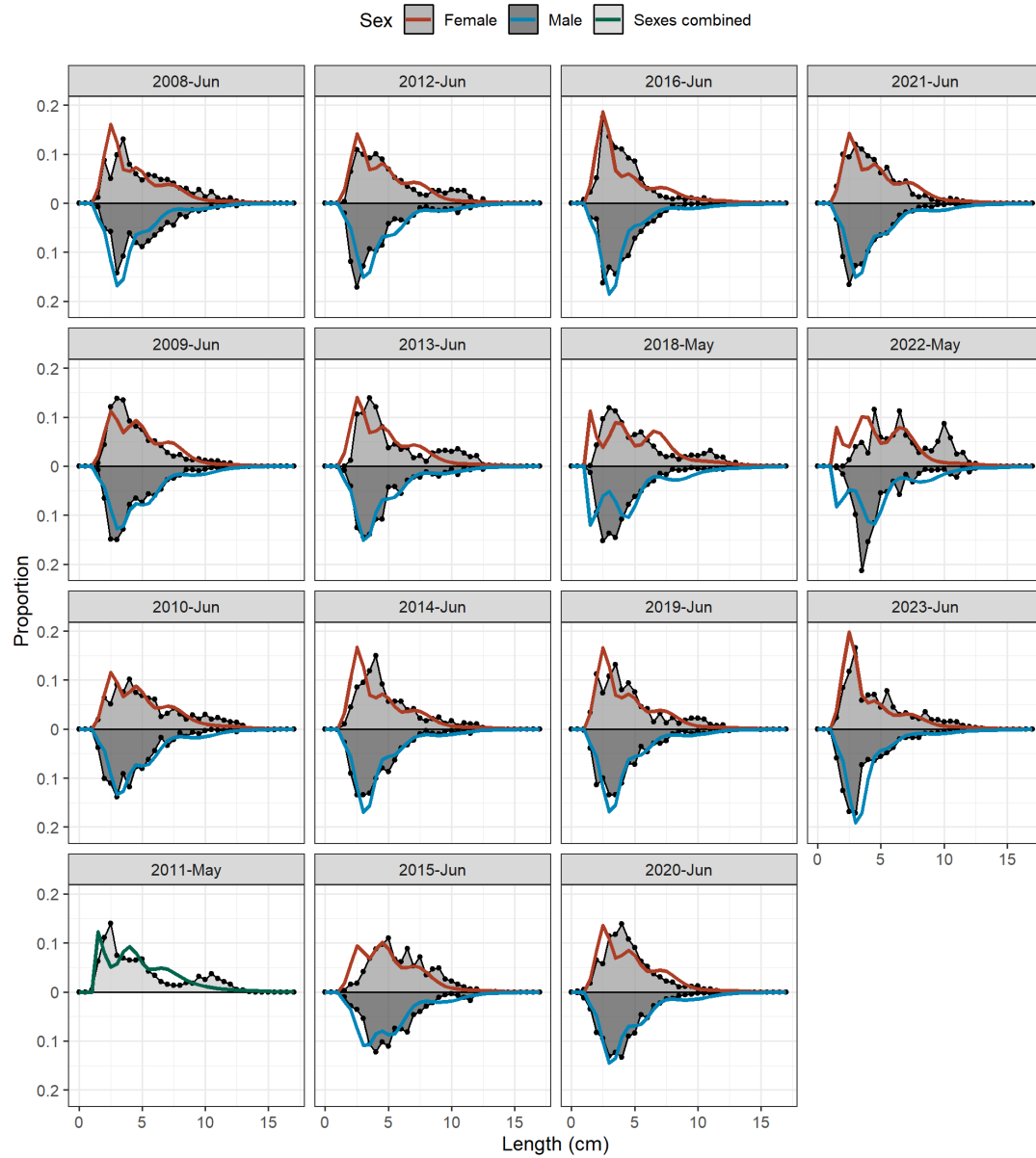


Figure H.69: Analysis 5: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

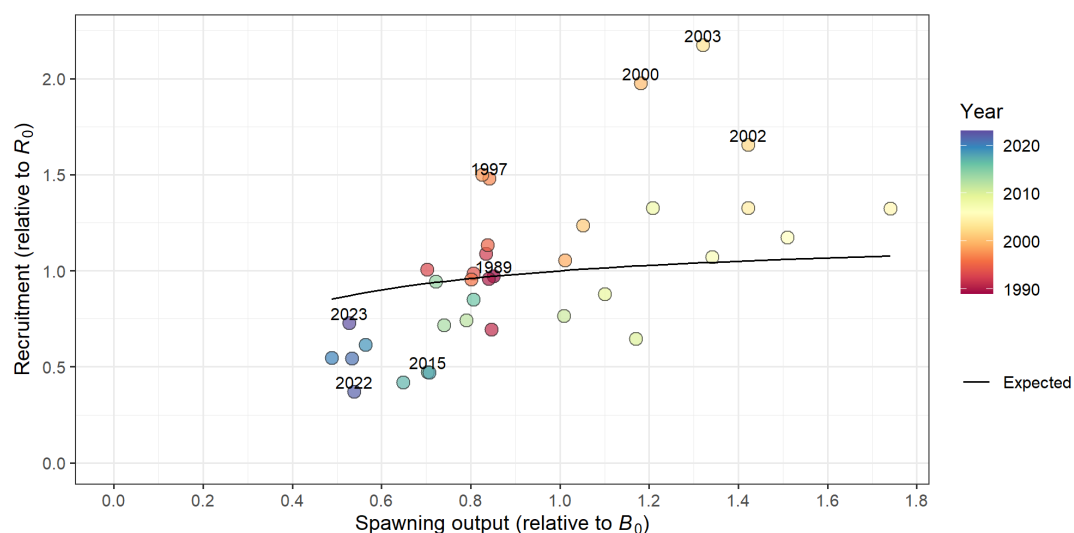


Figure H.70: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 5 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

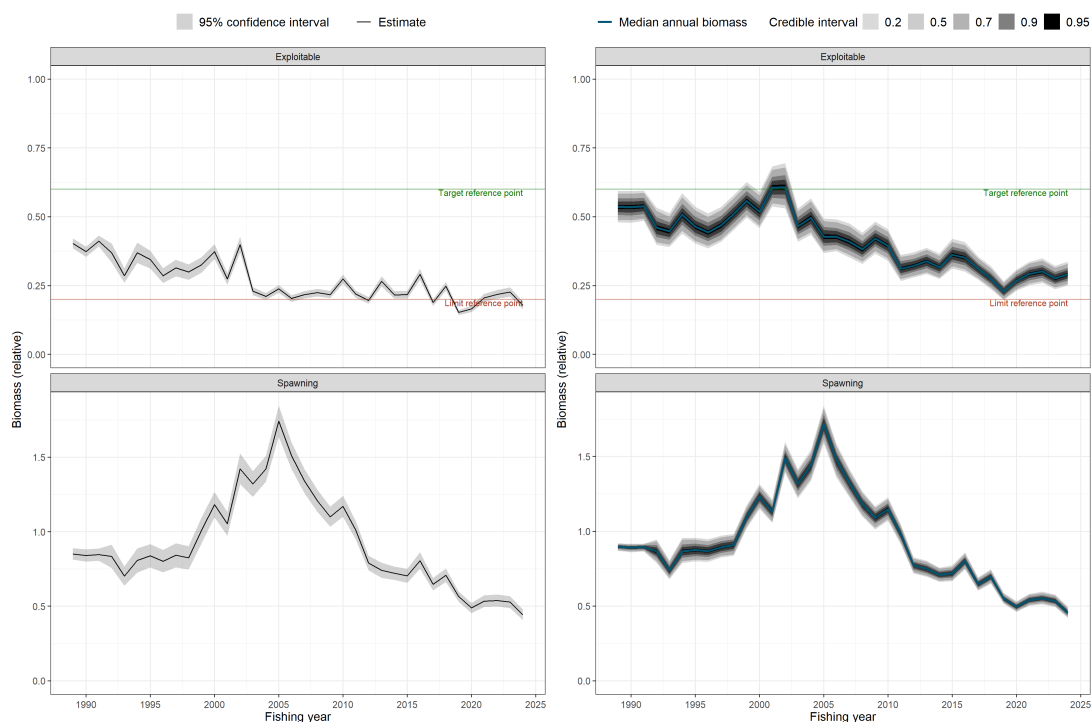


Figure H.71: Analysis 5: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

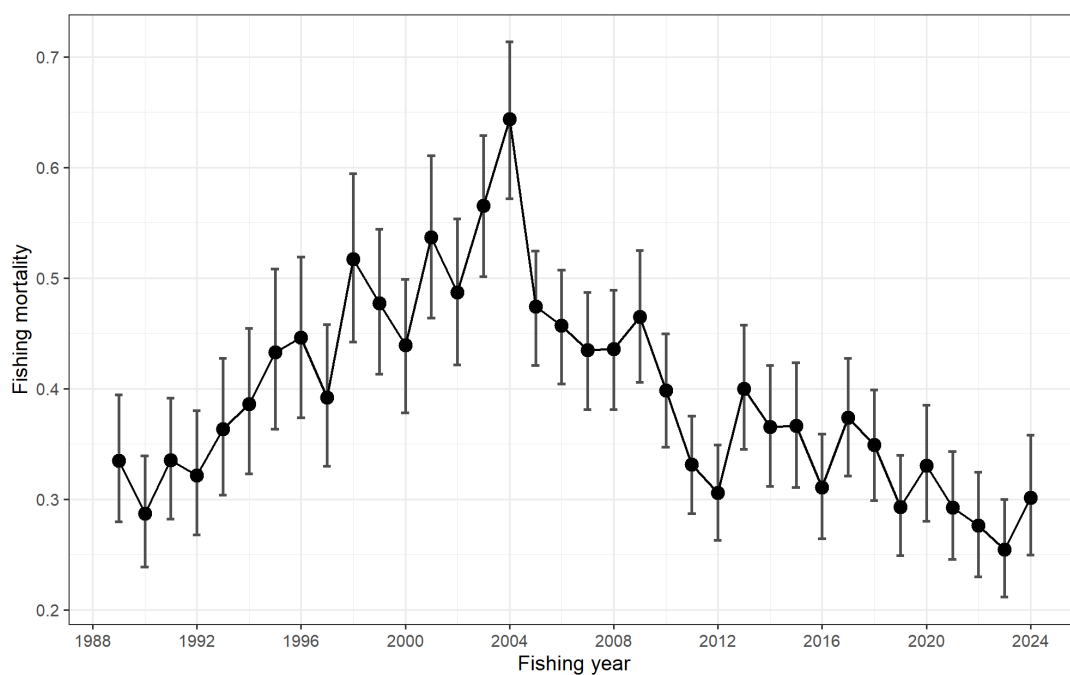


Figure H.72: Analysis 5: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

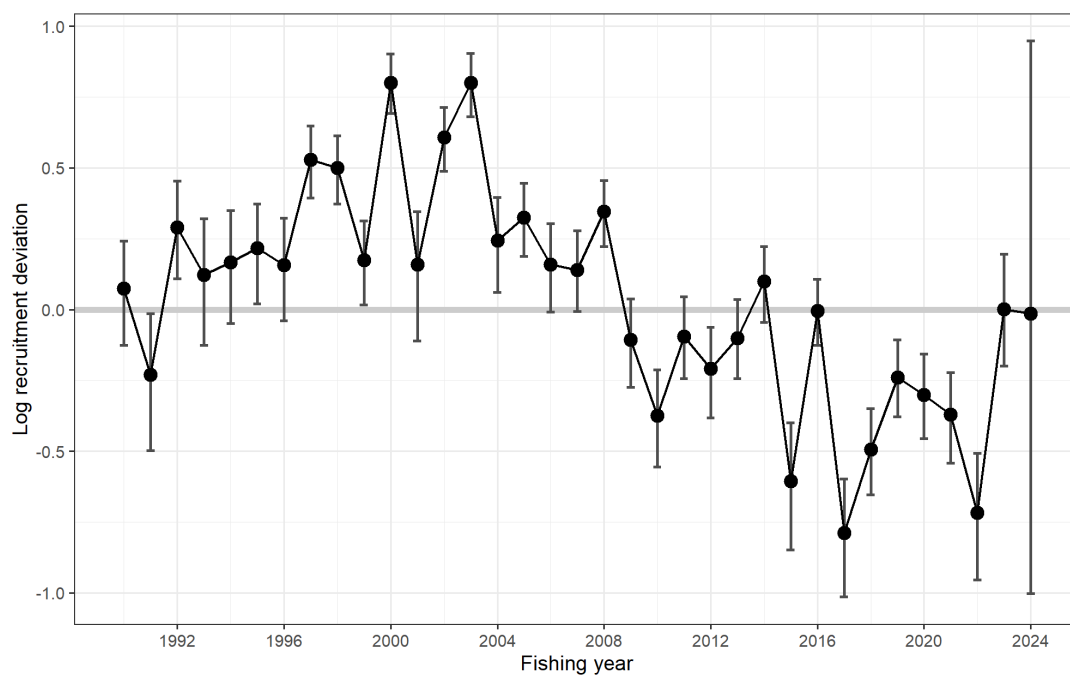


Figure H.73: Analysis 5: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

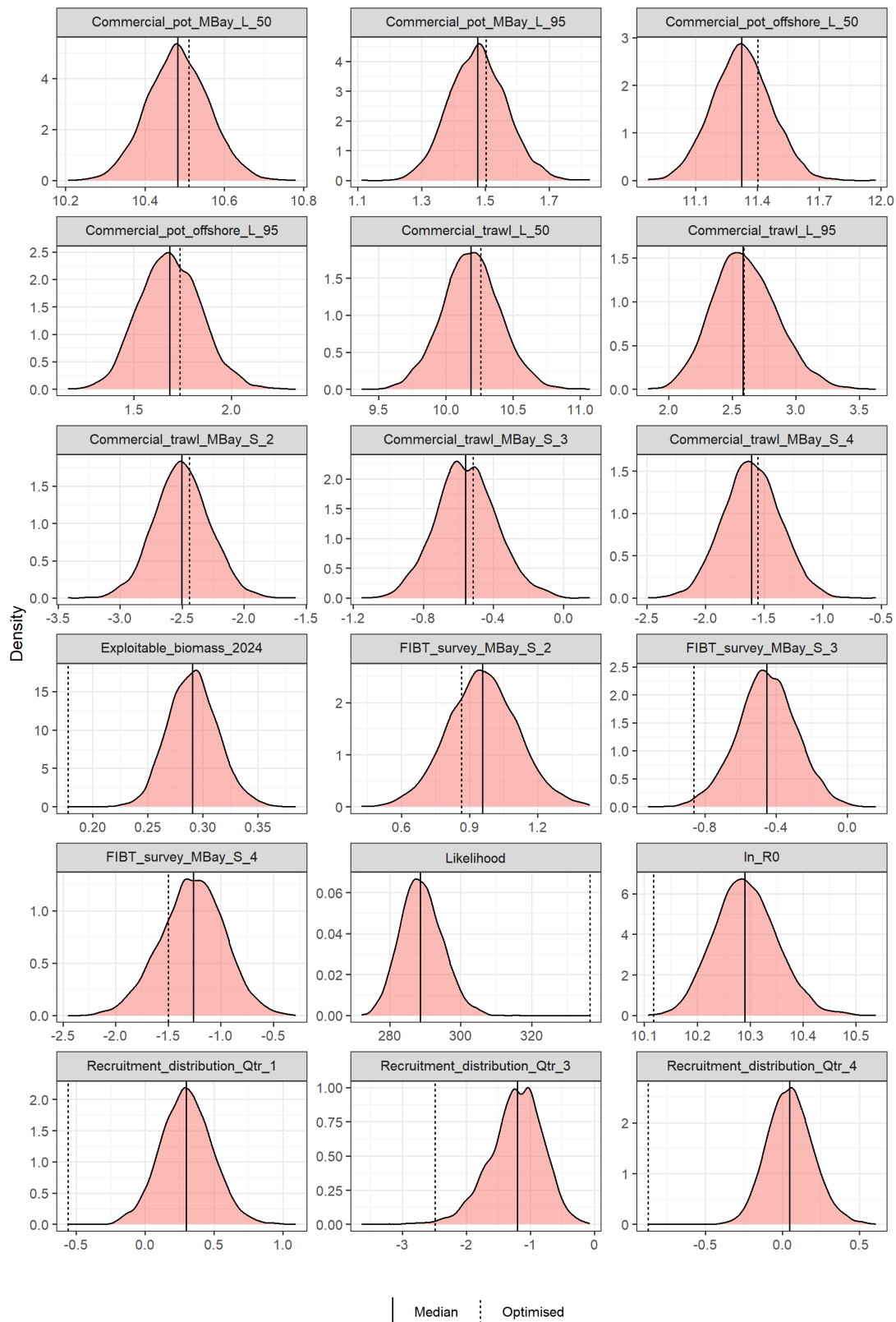


Figure H.74: Analysis 5: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

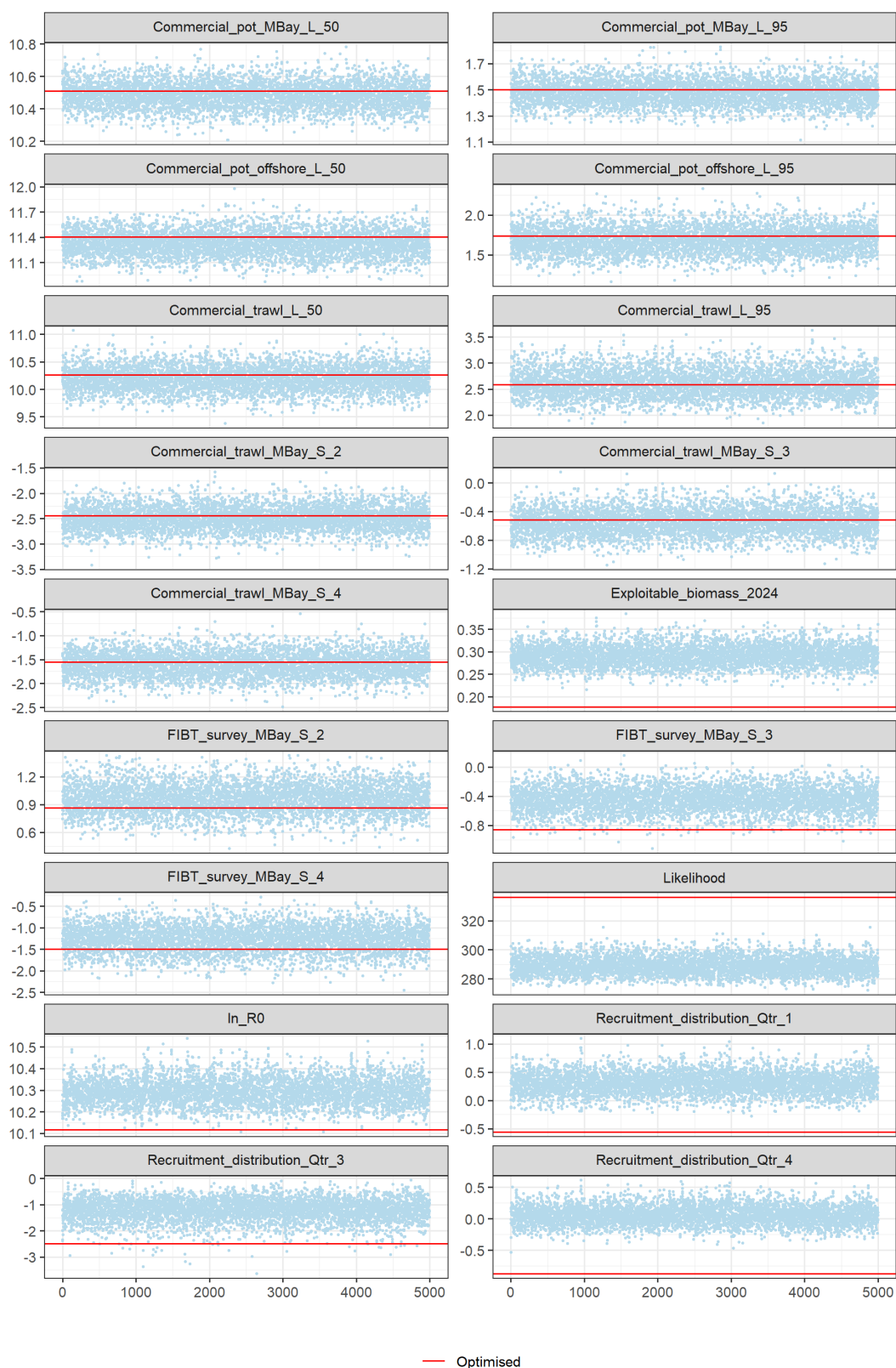


Figure H.75: Analysis 5: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.6 Analysis 6

Table H.11: Summary of MLE parameter estimates for analysis 6

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.58	2	-5.00	5.00	0.00	0.18
Recruitment distribution Qtr_3	-2.21	2	-5.00	5.00	0.00	0.60
Recruitment distribution Qtr_4	-0.88	2	-5.00	5.00	-1.15	0.13
$\ln(R_0)$	10.50	1	5.00	20.00	11.00	0.06
Commercial pot MBay L_{50}	10.61	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.51	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.49	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.73	3	0.10	20.00	1.50	0.15
Commercial trawl L_{50}	10.47	3	0.10	20.00	9.00	0.20
Commercial trawl L_{95}	2.54	3	0.10	20.00	2.20	0.23
Commercial trawl MBay S_2	-2.33	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.28	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.16	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.88	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.72	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.17	3	-9.00	7.00	-1.00	0.30

Table H.12: Summary of MCMC parameter estimates for analysis 6

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.28	-0.06	0.67
Recruitment distribution Qtr_3	-1.14	-2.05	-0.46
Recruitment distribution Qtr_4	0.04	-0.24	0.36
$\ln(R_0)$	10.71	10.58	10.87
Commercial pot MBay L_{50}	10.58	10.44	10.74
Commercial pot MBay L_{95}	1.48	1.32	1.66
Commercial pot offshore L_{50}	11.41	11.15	11.69
Commercial pot offshore L_{95}	1.68	1.41	1.99
Commercial trawl L_{50}	10.41	10.01	10.82
Commercial trawl L_{95}	2.53	2.11	3.02
Commercial trawl MBay S_2	-2.39	-2.82	-1.94
Commercial trawl MBay S_3	-0.31	-0.65	0.05
Commercial trawl MBay S_4	-1.22	-1.68	-0.71
FIBT survey MBay S_2	0.98	0.67	1.27
FIBT survey MBay S_3	-0.29	-0.63	0.04
FIBT survey MBay S_4	-0.91	-1.51	-0.34

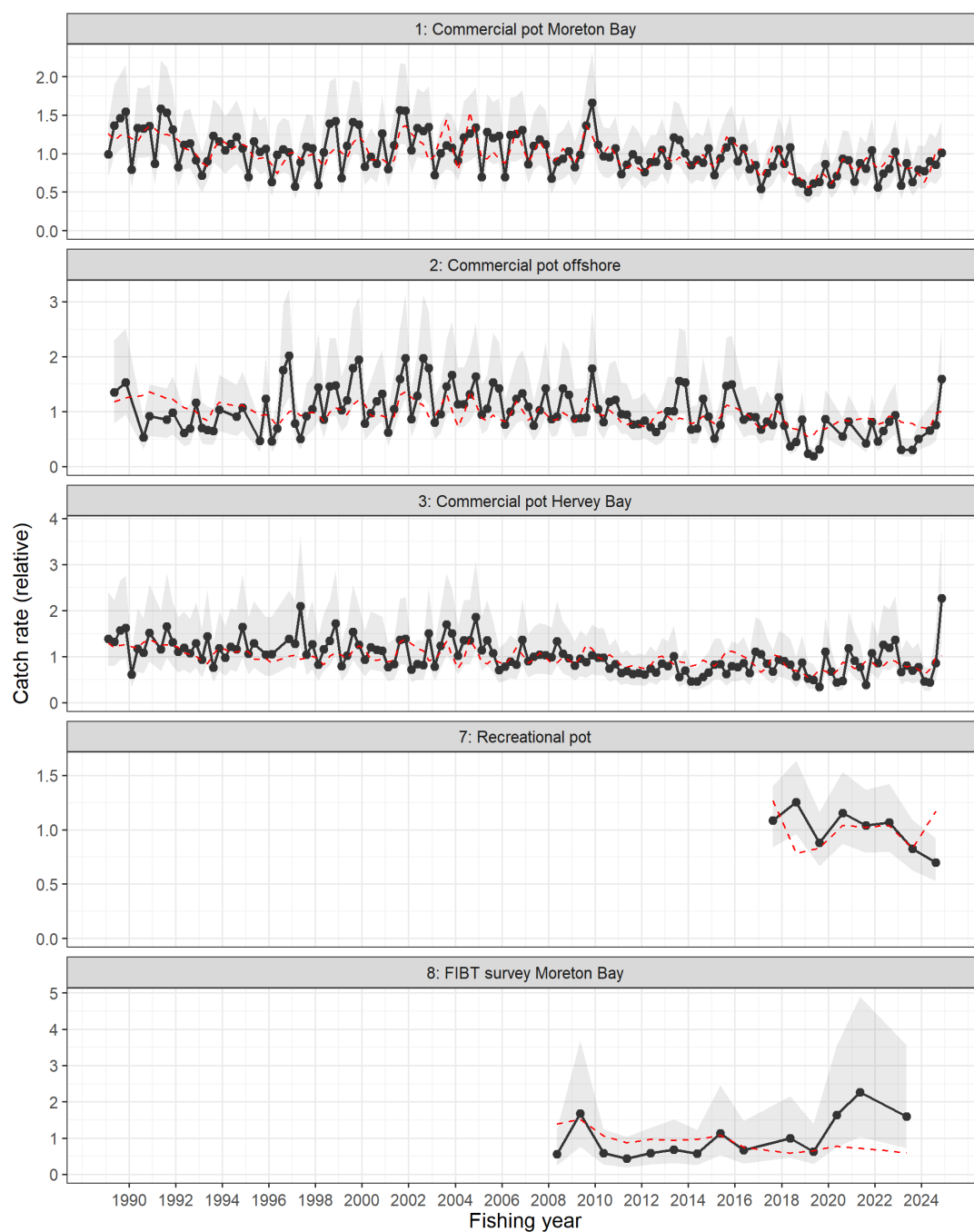


Figure H.76: Analysis 6: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

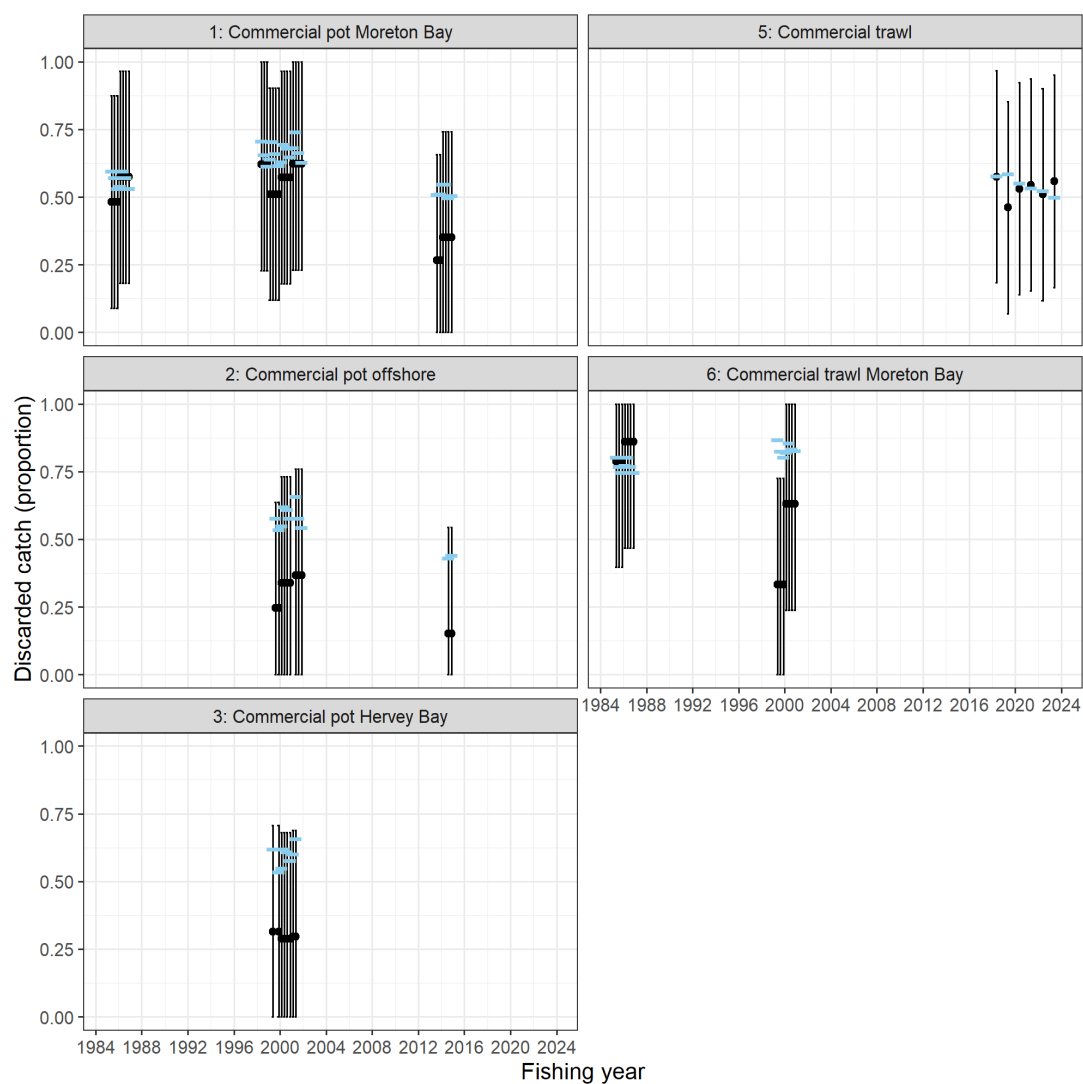


Figure H.77: Analysis 6: Fits to annual discard proportions of blue swimmer crab catch

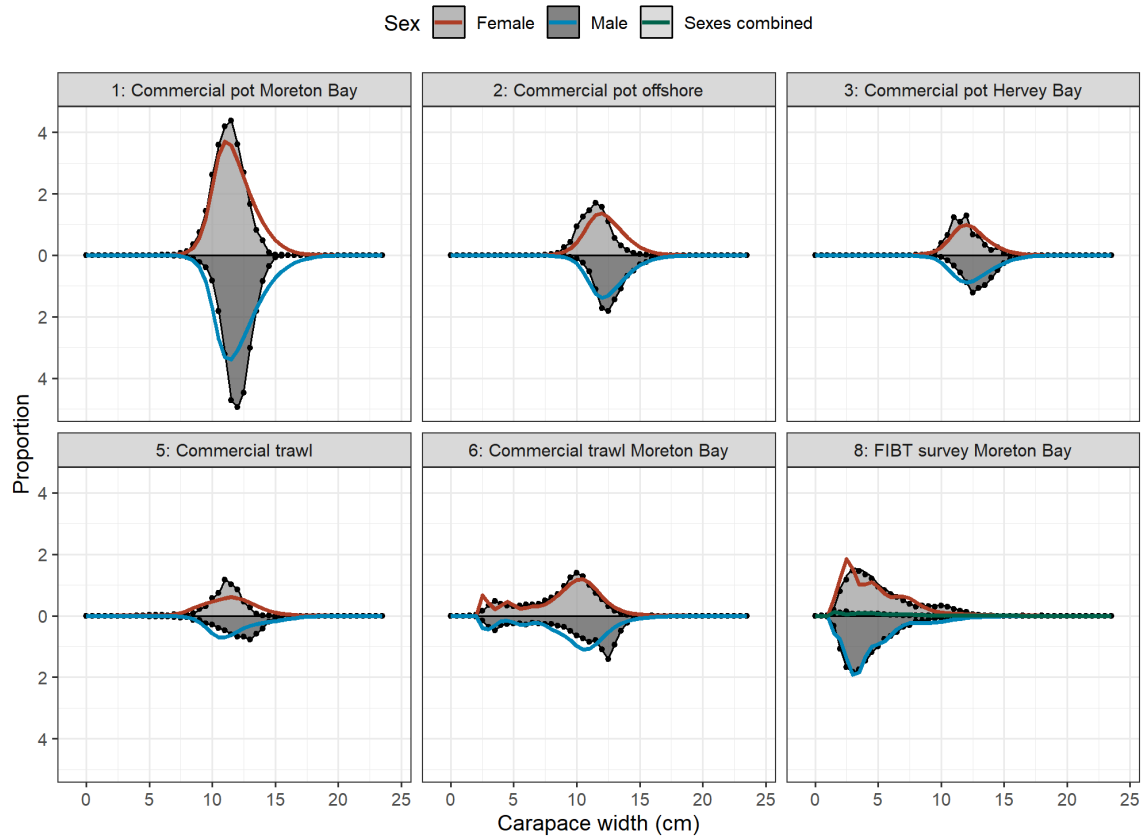


Figure H.78: Analysis 6: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

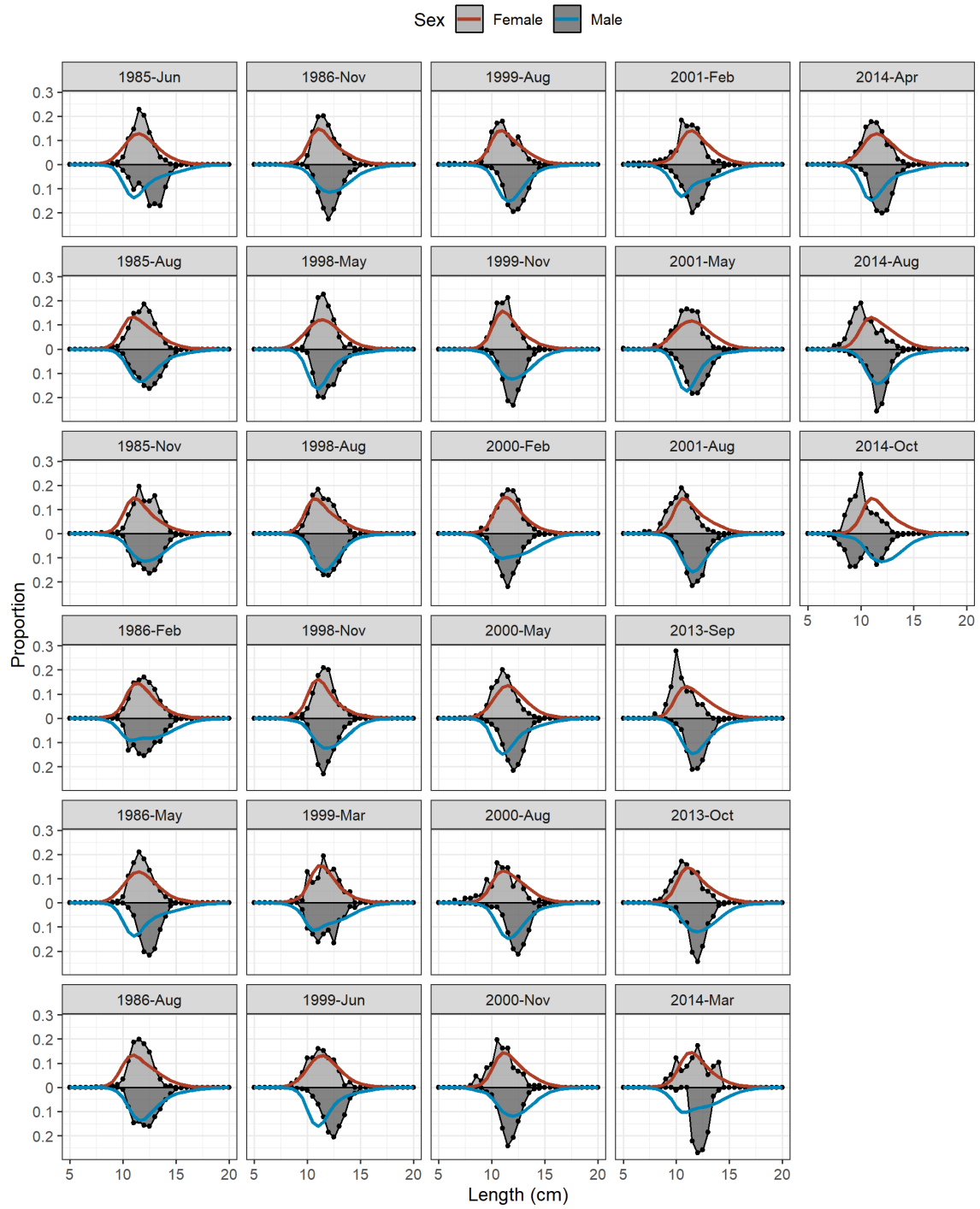


Figure H.79: Analysis 6: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

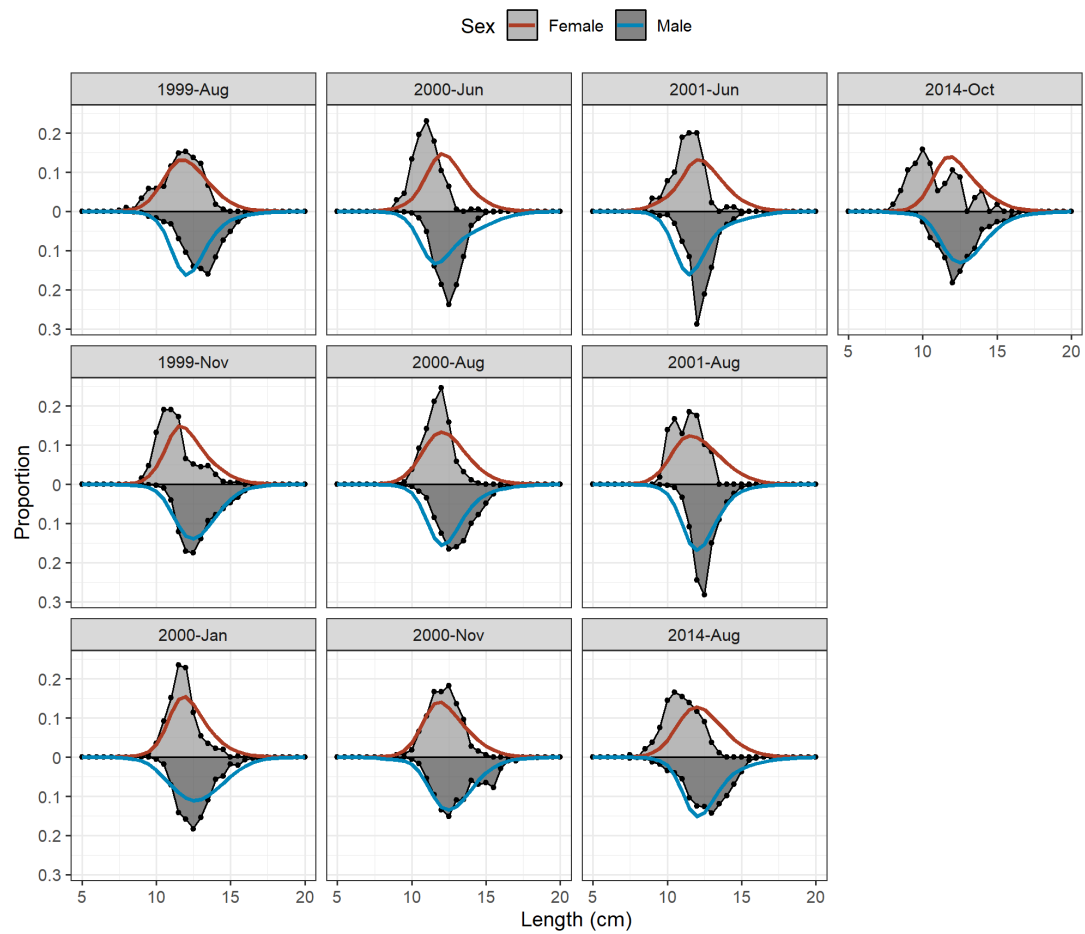


Figure H.80: Analysis 6: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

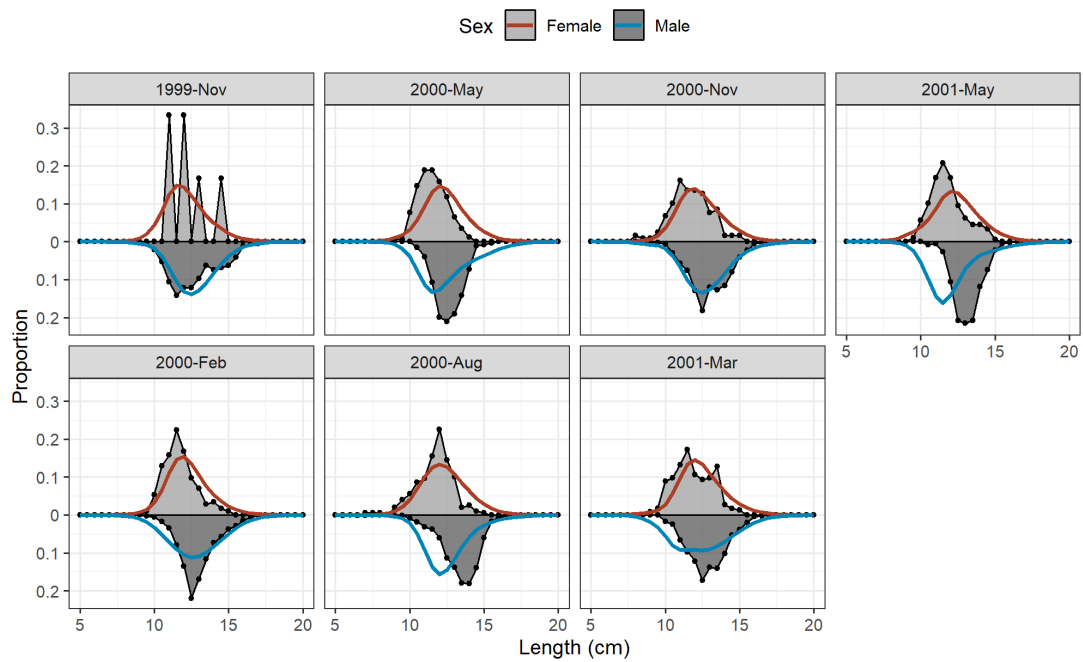


Figure H.81: Analysis 6: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

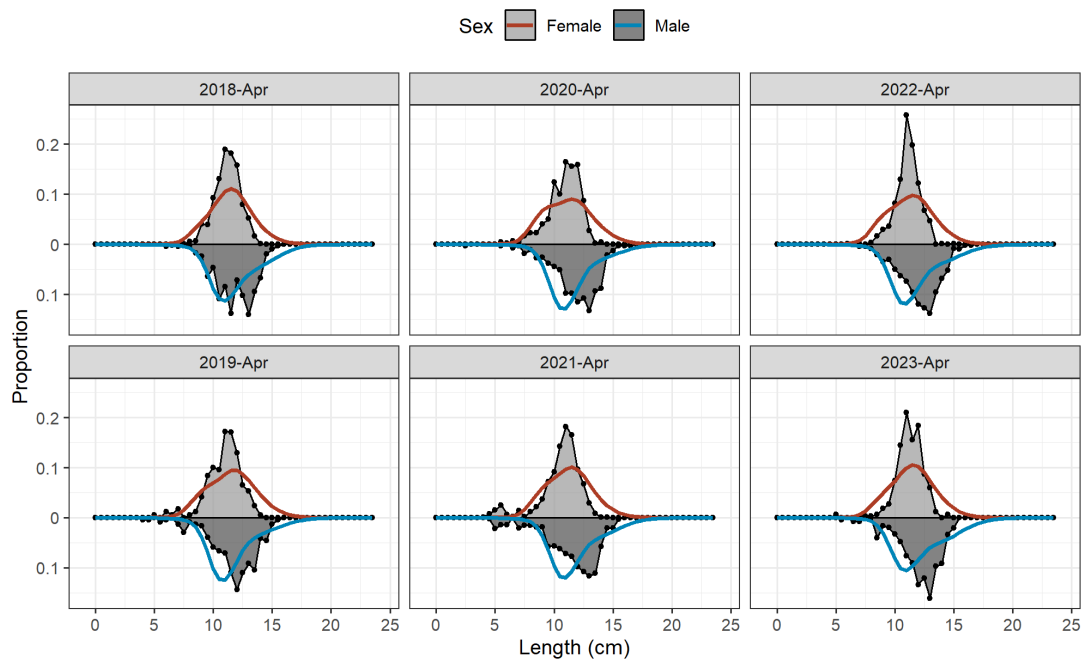


Figure H.82: Analysis 6: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

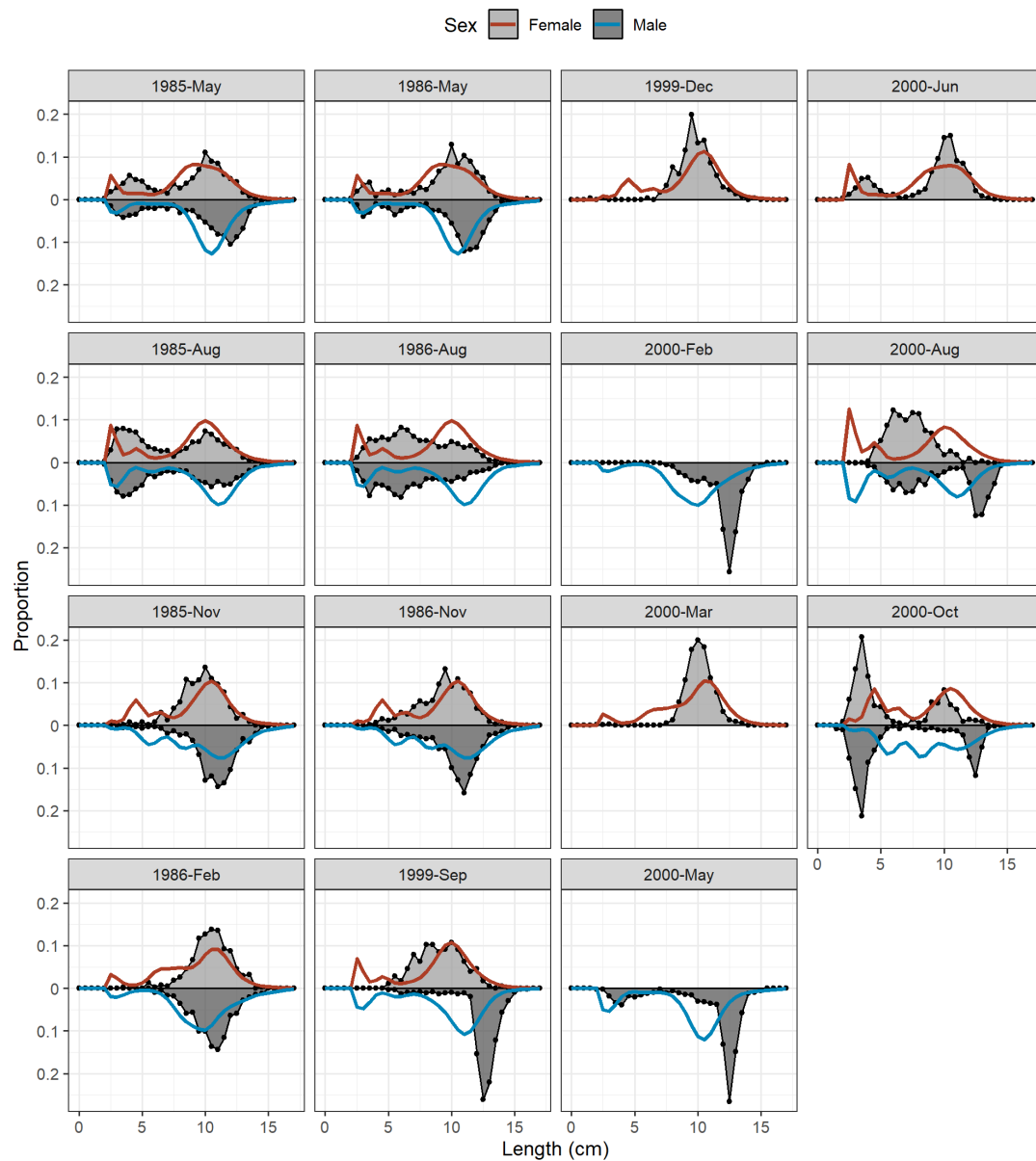


Figure H.83: Analysis 6: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

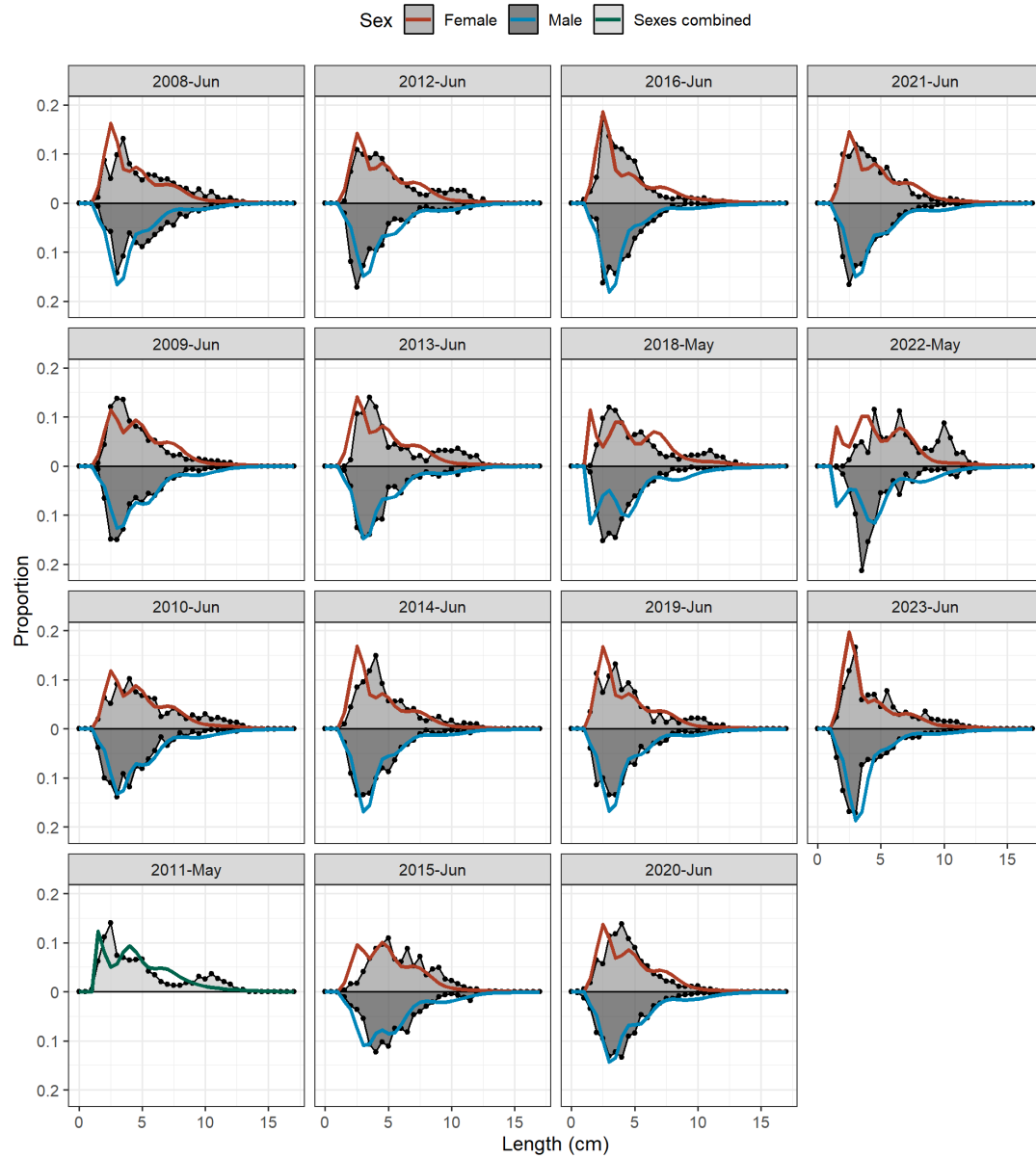


Figure H.84: Analysis 6: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

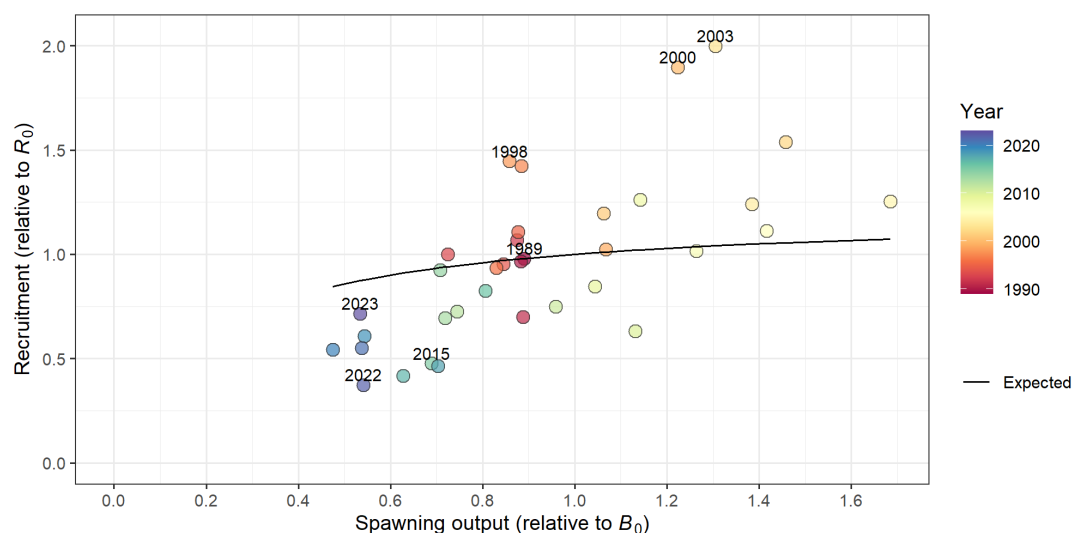


Figure H.85: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 6 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

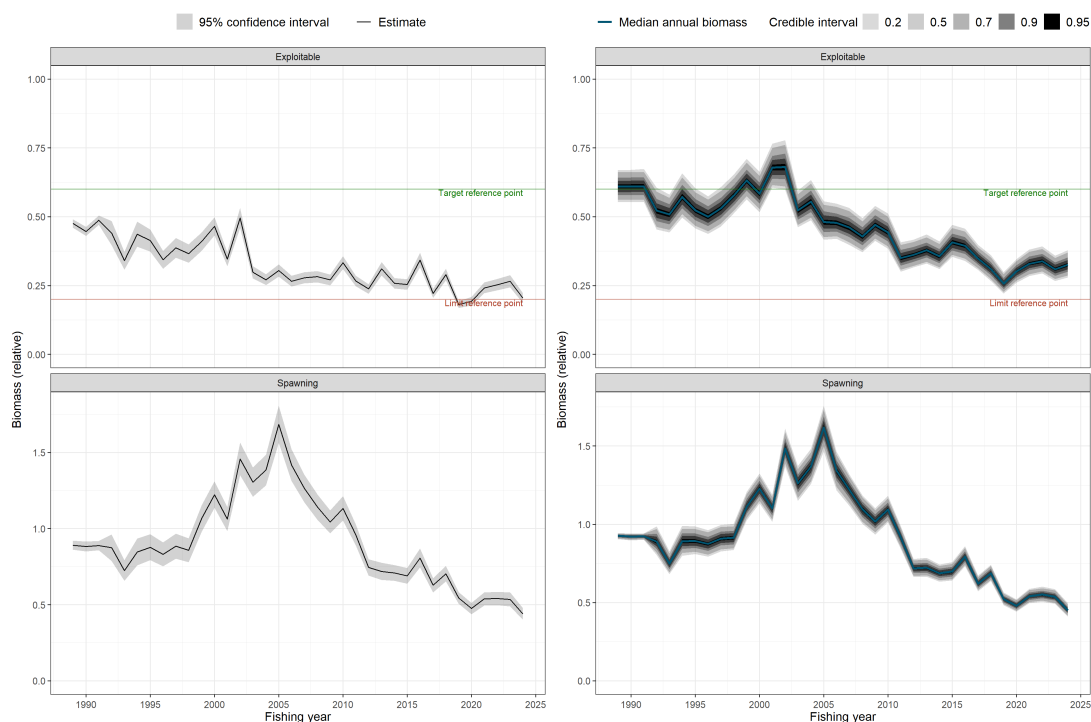


Figure H.86: Analysis 6: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

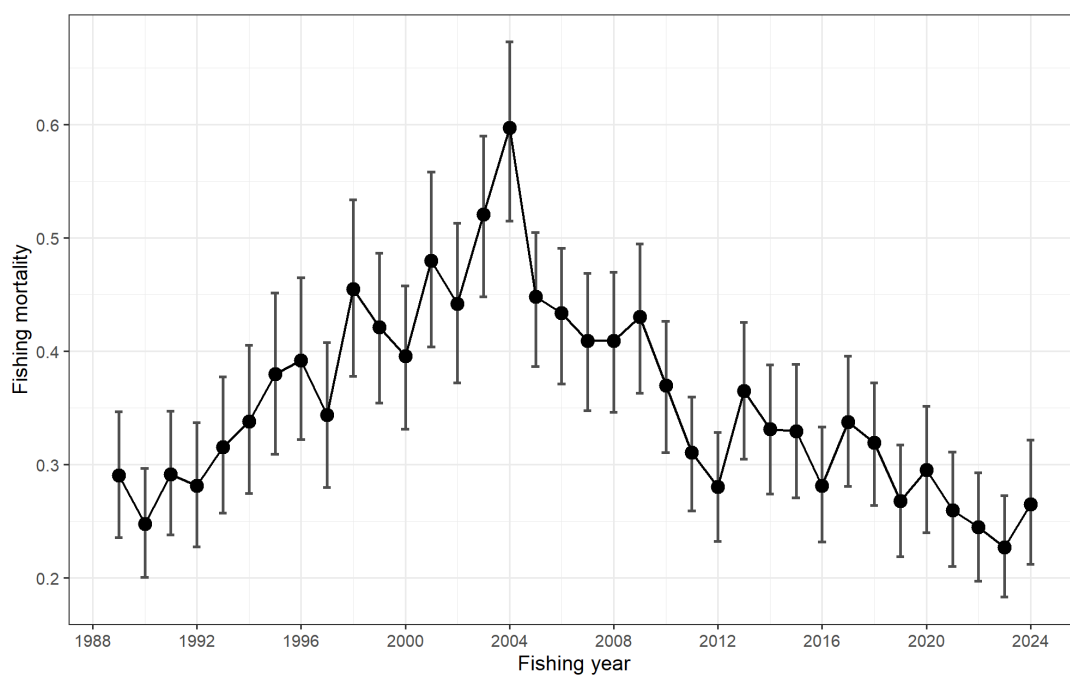


Figure H.87: Analysis 6: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

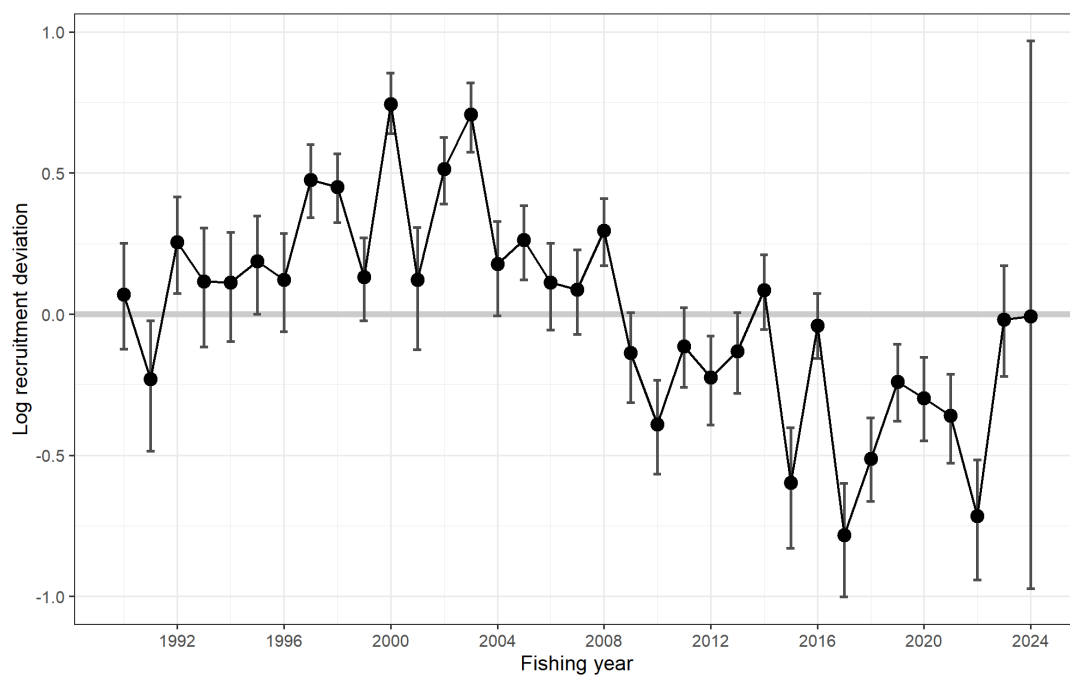


Figure H.88: Analysis 6: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

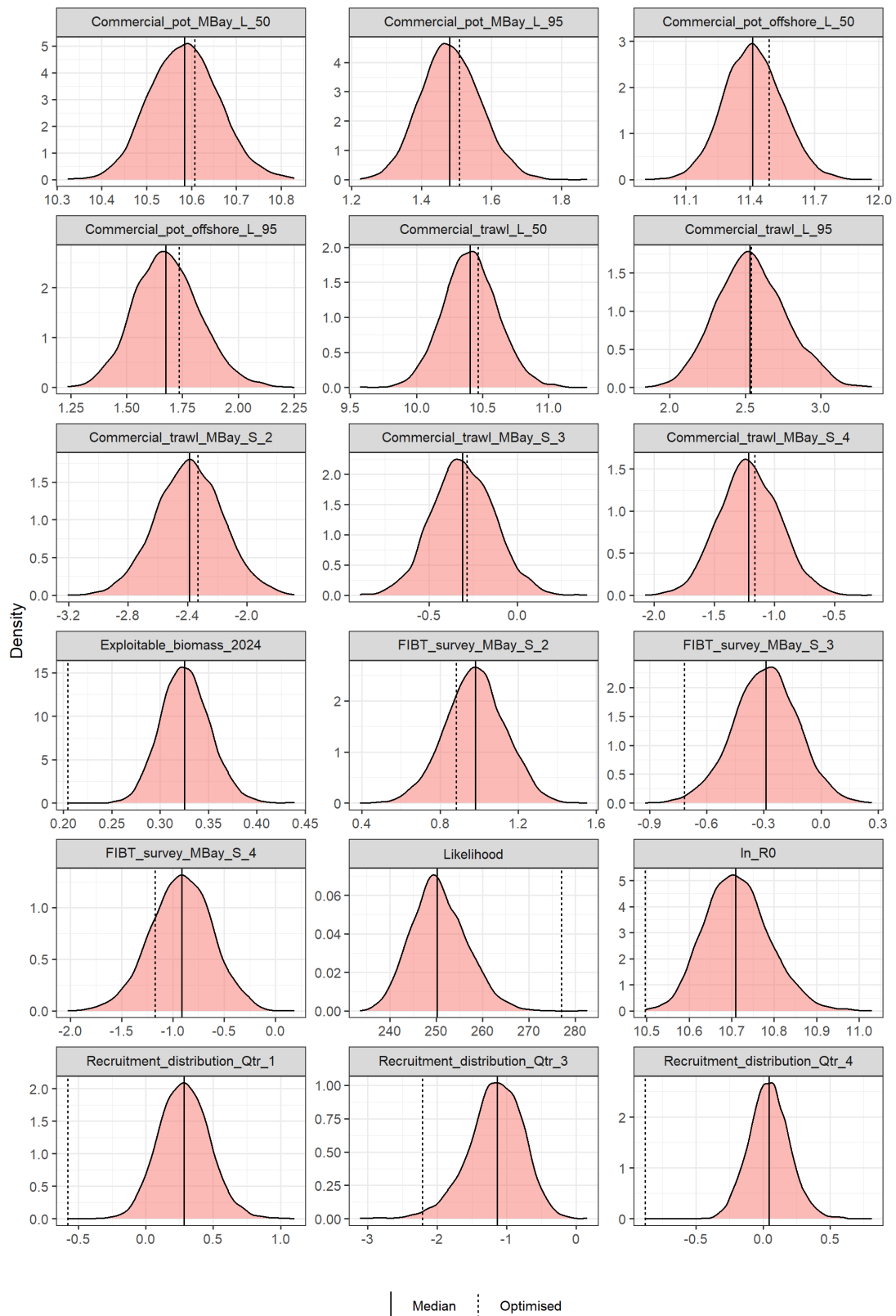


Figure H.89: Analysis 6: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

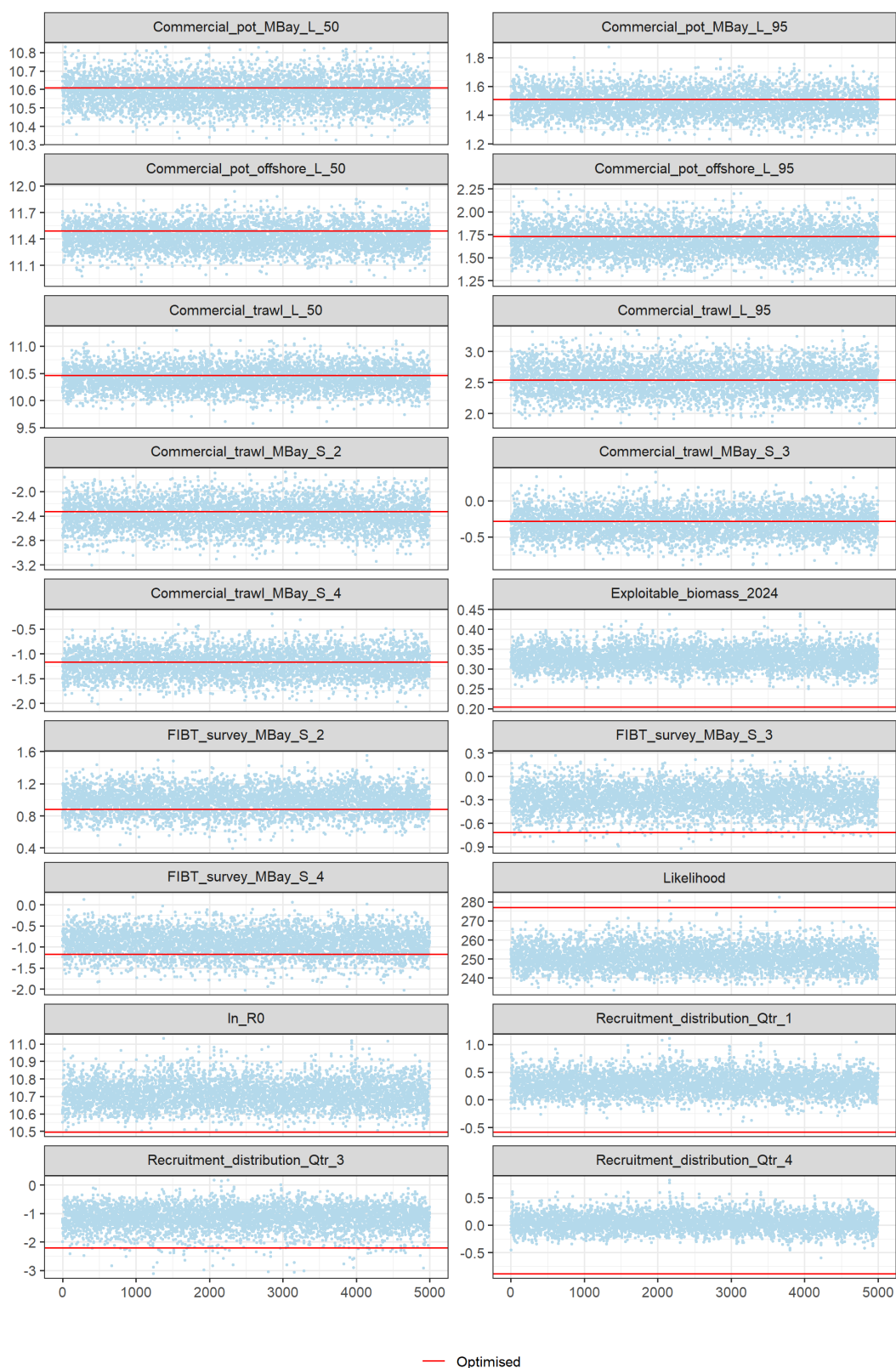


Figure H.90: Analysis 6: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.7 Analysis 7

Table H.13: Summary of MLE parameter estimates for analysis 7

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.47	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.87	2	-5.00	5.00	0.00	1.01
Recruitment distribution Qtr_4	-0.83	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	9.67	1	5.00	20.00	11.00	0.05
Commercial pot MBay L_{50}	10.35	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.47	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.26	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.71	3	0.10	20.00	1.50	0.17
Commercial trawl L_{50}	9.98	3	0.10	20.00	9.00	0.22
Commercial trawl L_{95}	2.63	3	0.10	20.00	2.20	0.27
Commercial trawl MBay S_2	-2.58	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.78	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-2.16	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.87	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.96	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.85	3	-9.00	7.00	-1.00	0.30

Table H.14: Summary of MCMC parameter estimates for analysis 7

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.37	0.01	0.78
Recruitment distribution Qtr_3	-1.22	-2.22	-0.49
Recruitment distribution Qtr_4	0.10	-0.20	0.44
$\ln(R_0)$	9.82	9.73	9.94
Commercial pot MBay L_{50}	10.32	10.18	10.48
Commercial pot MBay L_{95}	1.45	1.28	1.63
Commercial pot offshore L_{50}	11.19	10.91	11.47
Commercial pot offshore L_{95}	1.66	1.35	1.98
Commercial trawl L_{50}	9.90	9.46	10.35
Commercial trawl L_{95}	2.63	2.15	3.21
Commercial trawl MBay S_2	-2.64	-3.08	-2.20
Commercial trawl MBay S_3	-0.83	-1.15	-0.49
Commercial trawl MBay S_4	-2.20	-2.69	-1.72
FIBT survey MBay S_2	0.94	0.64	1.25
FIBT survey MBay S_3	-0.59	-0.93	-0.26
FIBT survey MBay S_4	-1.66	-2.27	-1.09

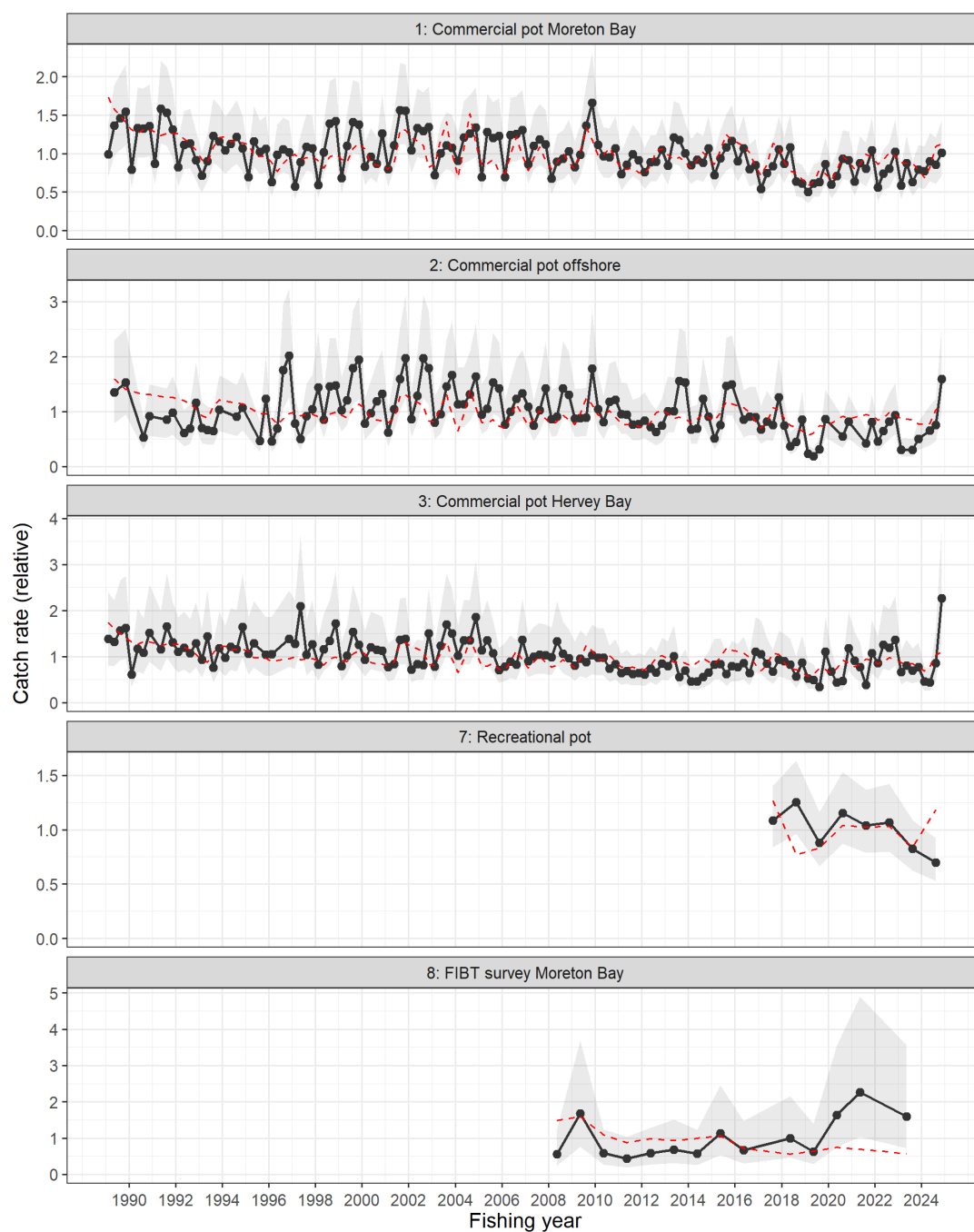


Figure H.91: Analysis 7: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

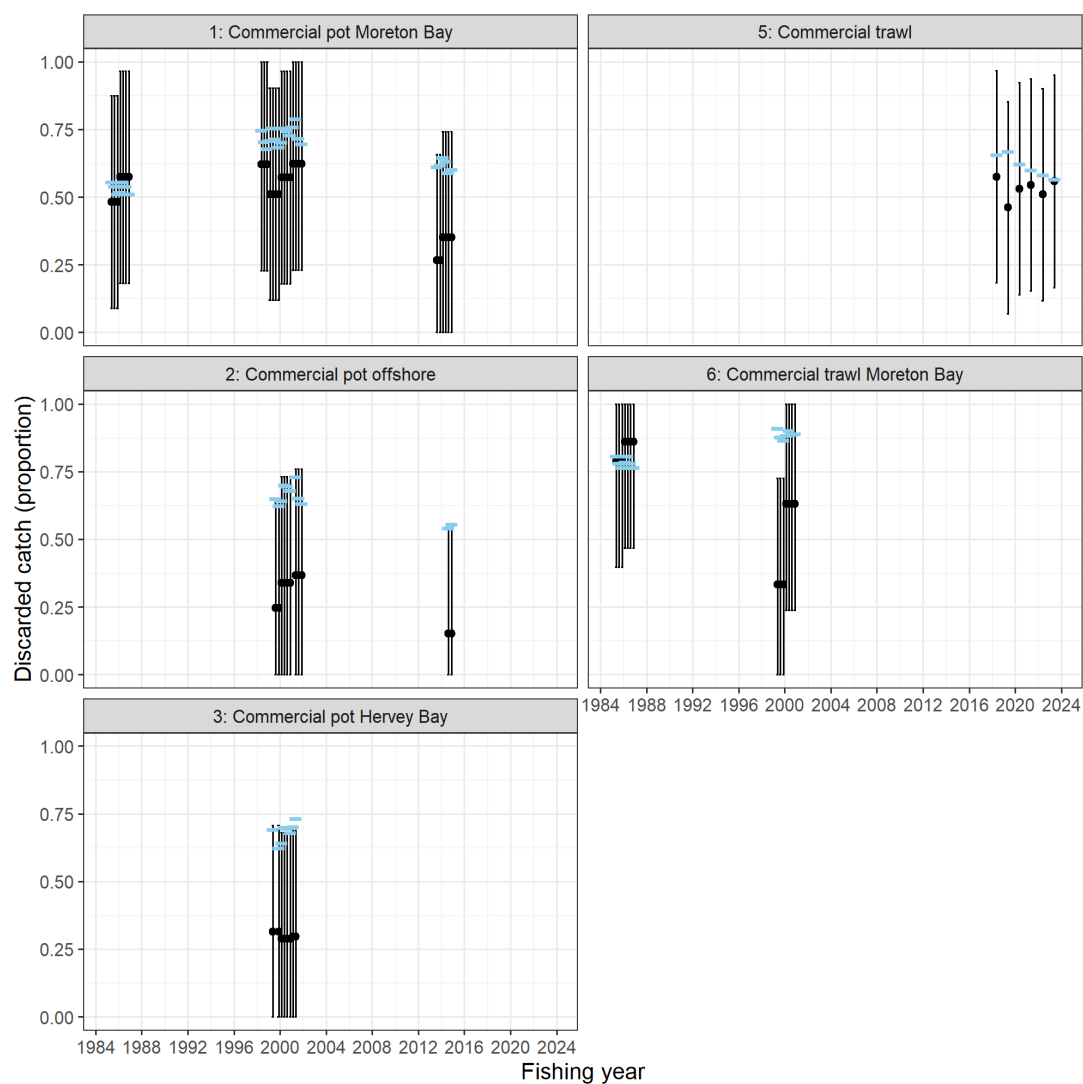


Figure H.92: Analysis 7: Fits to annual discard proportions of blue swimmer crab catch

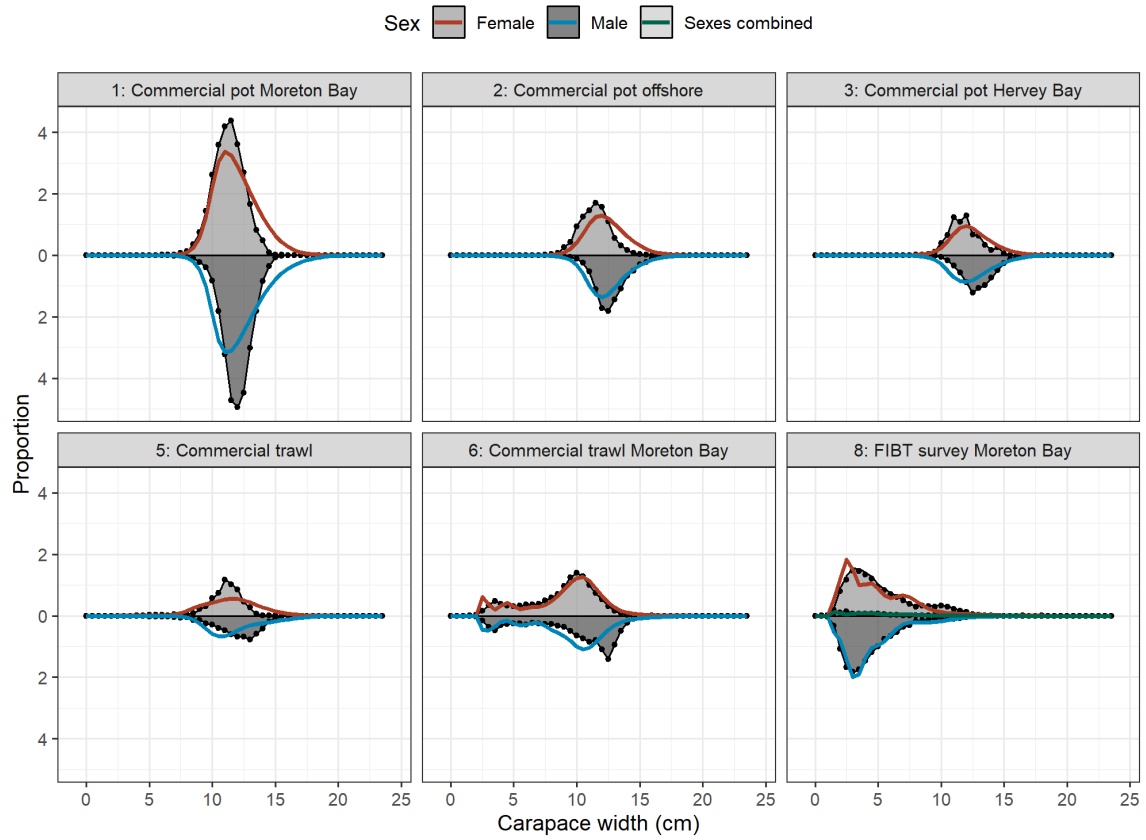


Figure H.93: Analysis 7: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

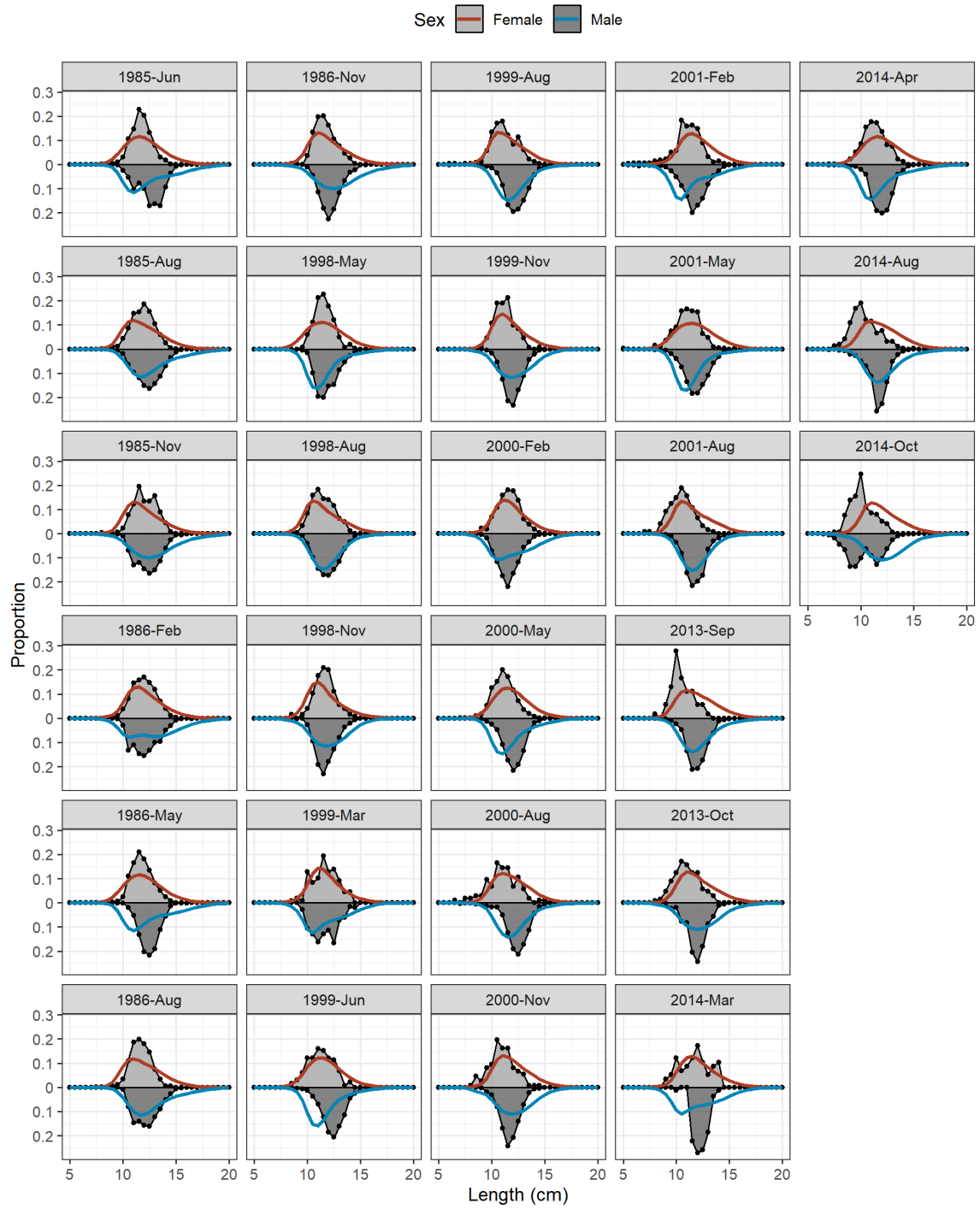


Figure H.94: Analysis 7: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

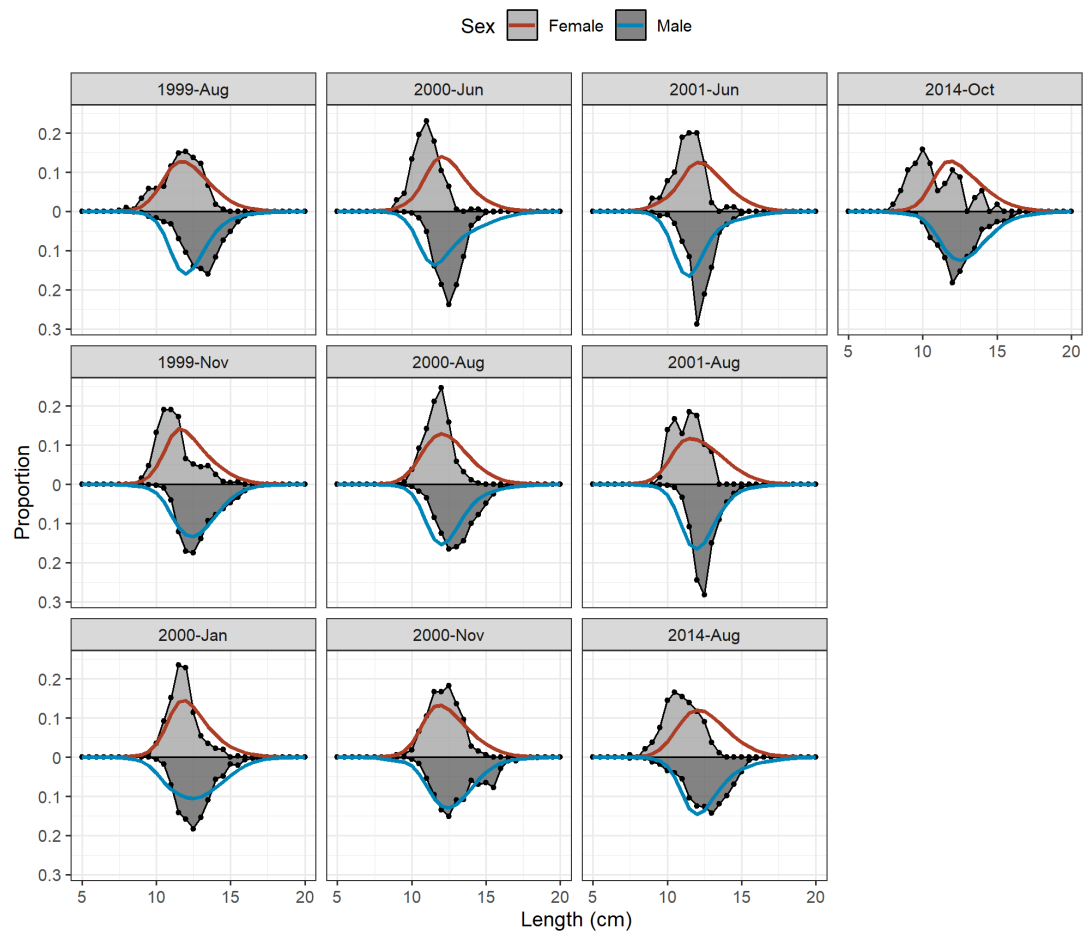


Figure H.95: Analysis 7: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

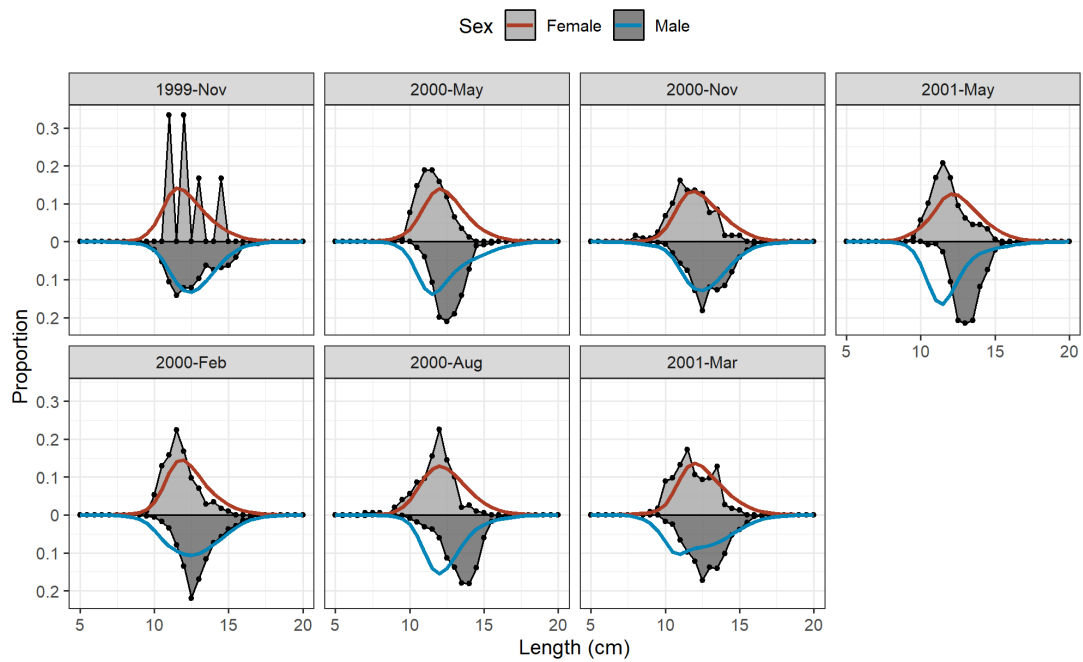


Figure H.96: Analysis 7: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

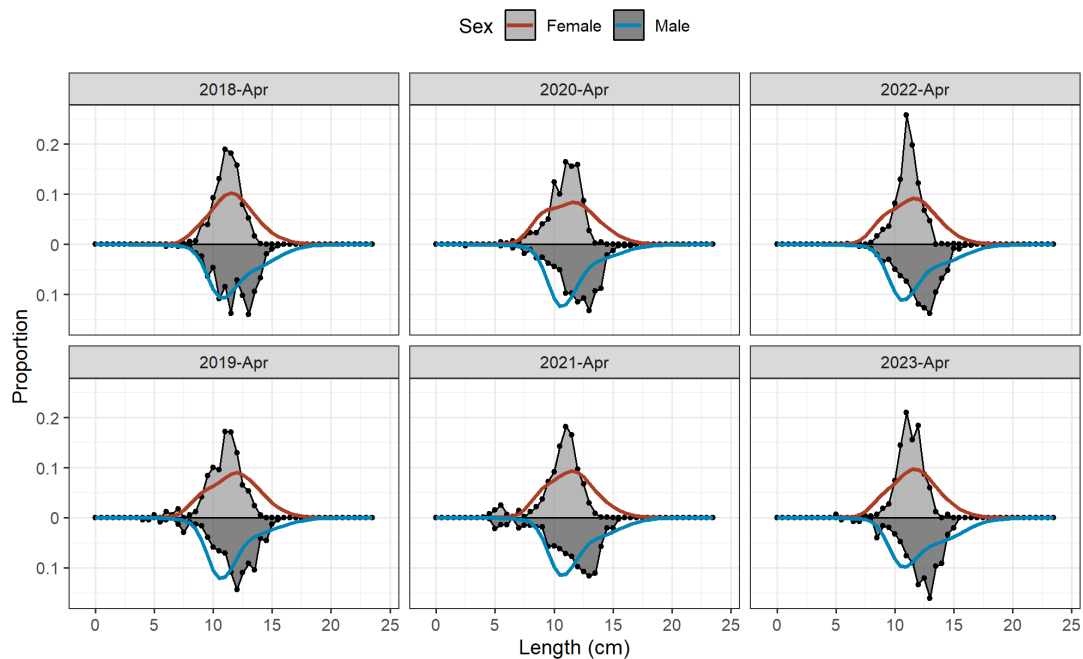


Figure H.97: Analysis 7: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

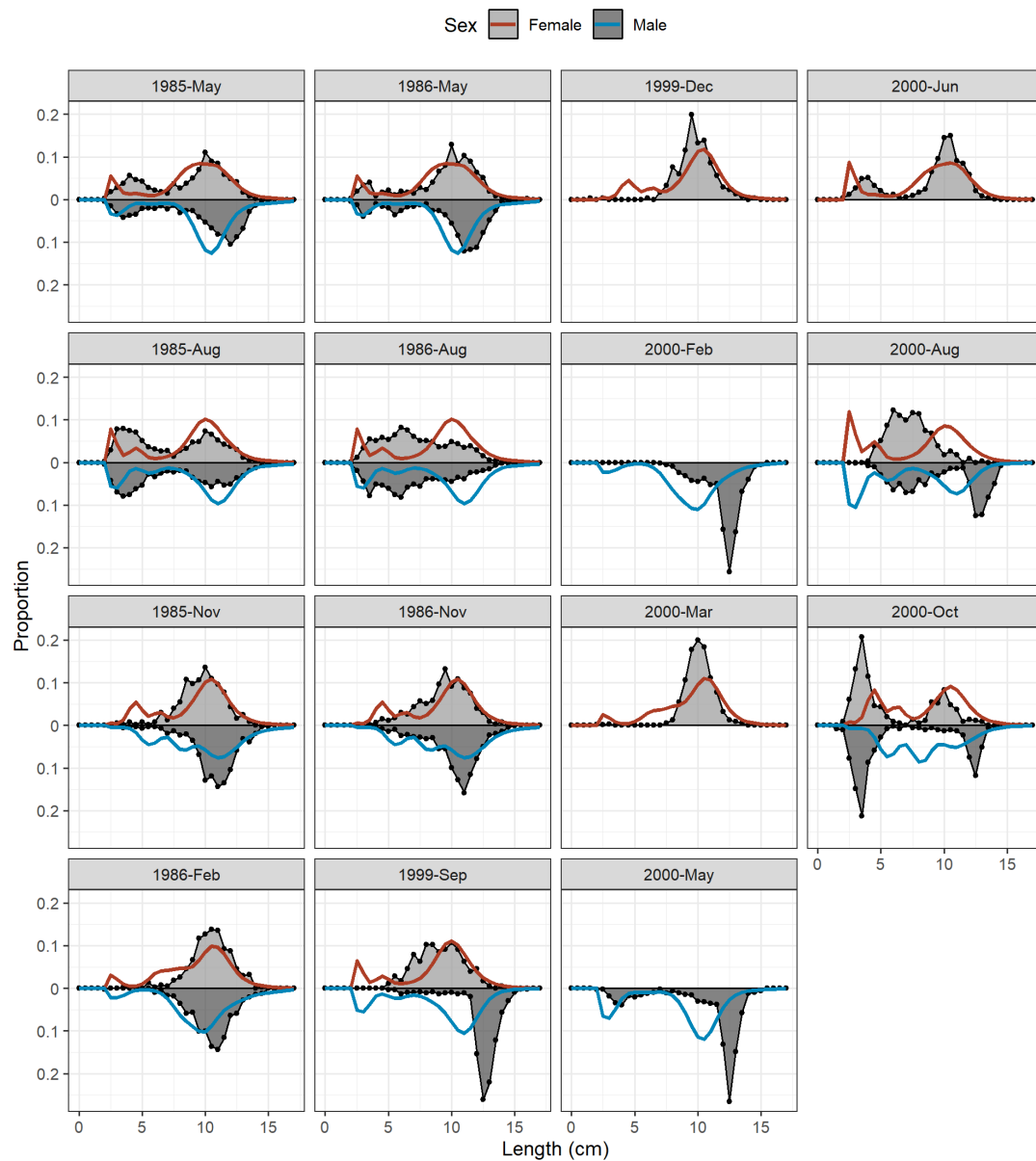


Figure H.98: Analysis 7: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

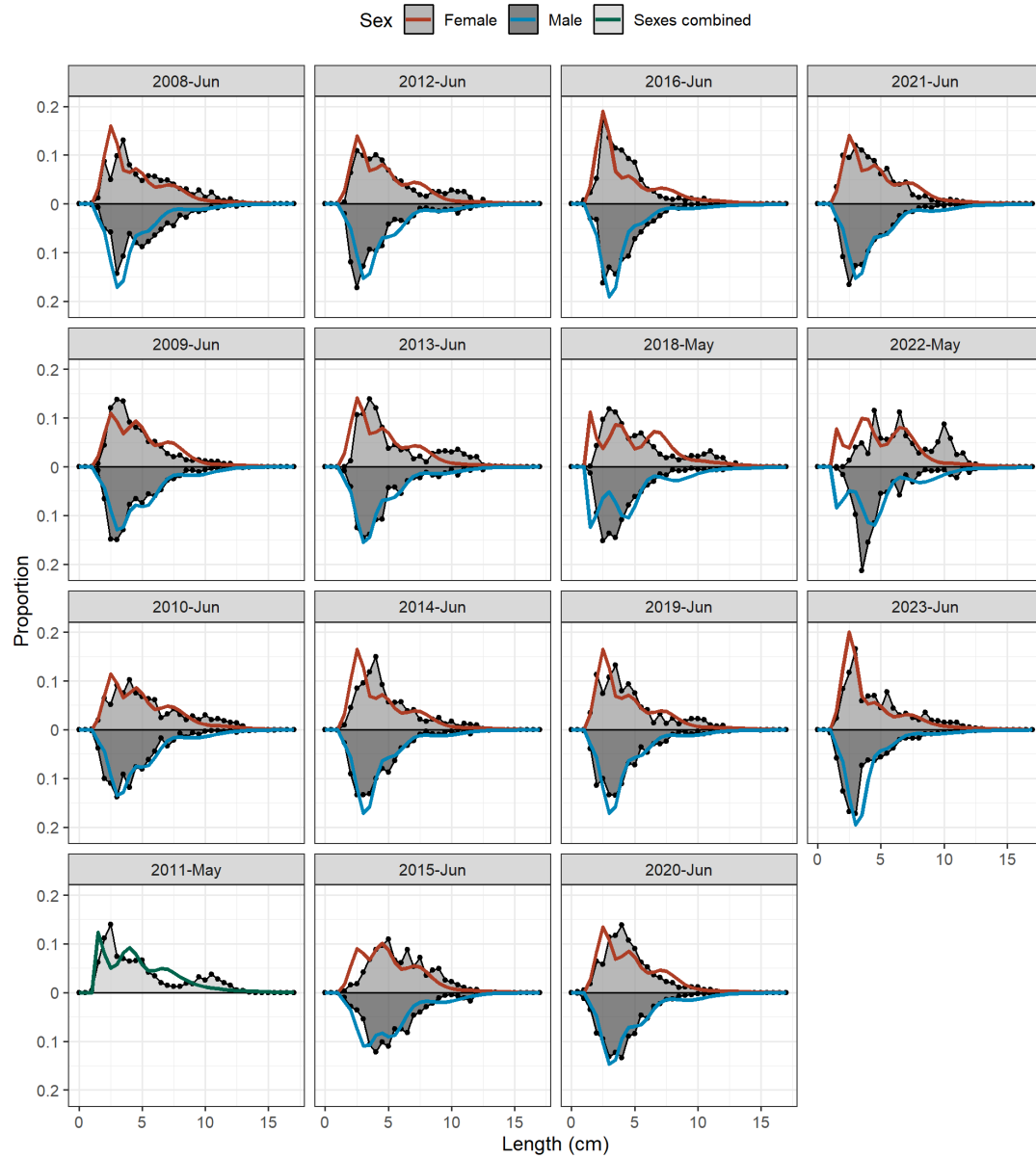


Figure H.99: Analysis 7: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

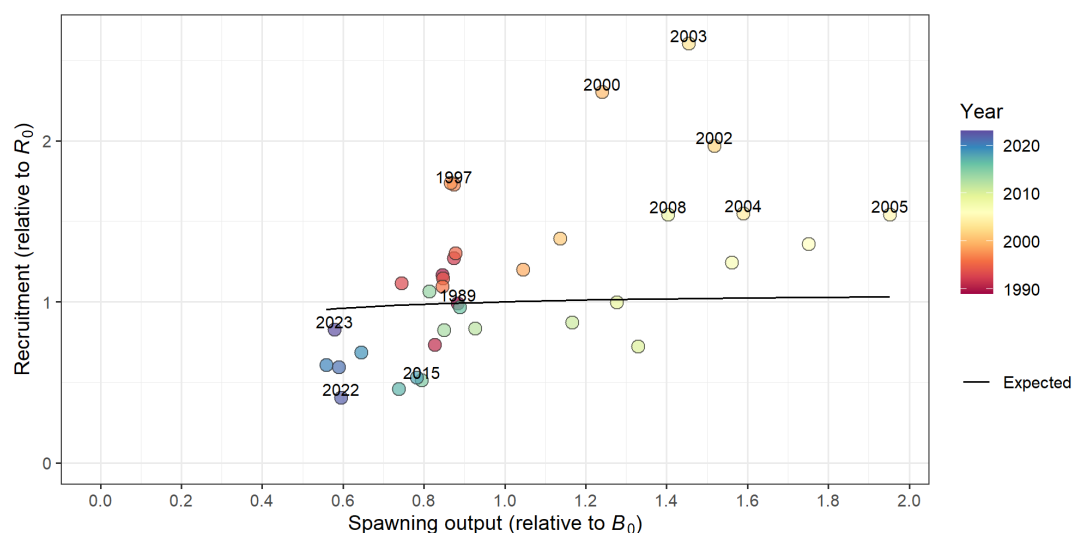


Figure H.100: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 7 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

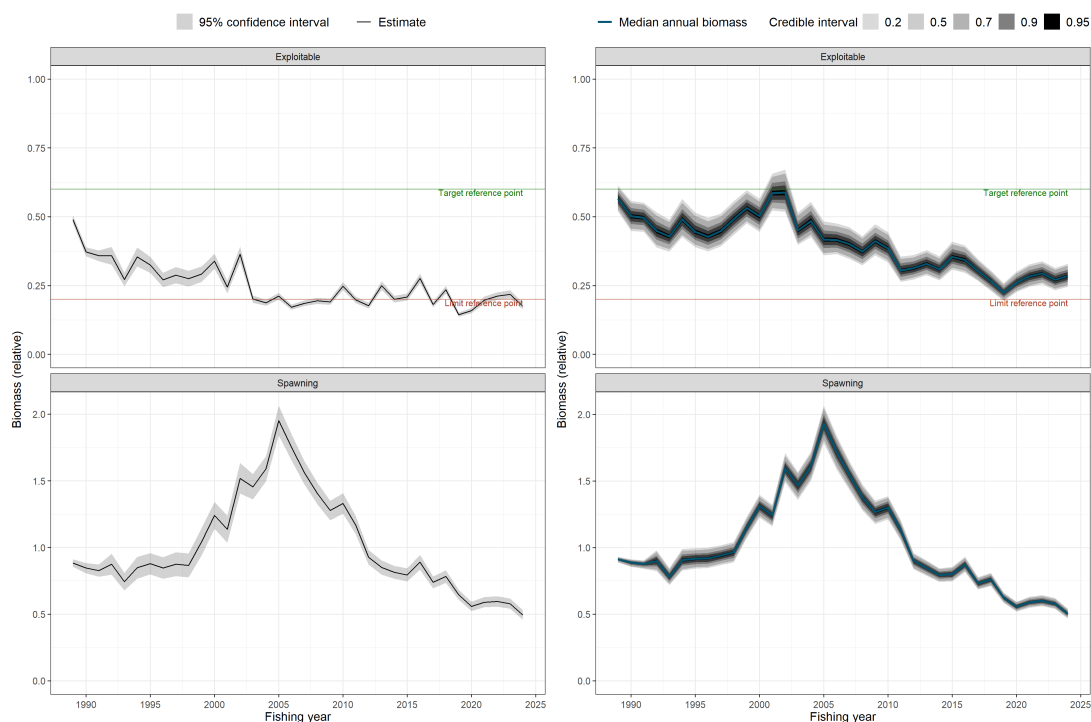


Figure H.101: Analysis 7: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

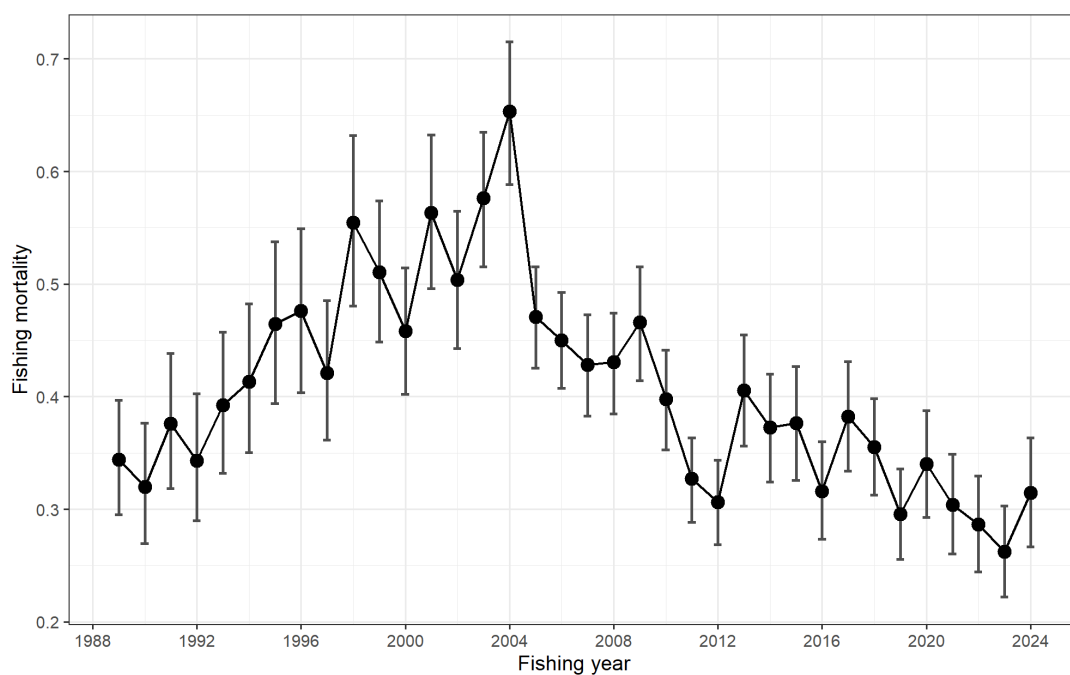


Figure H.102: Analysis 7: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

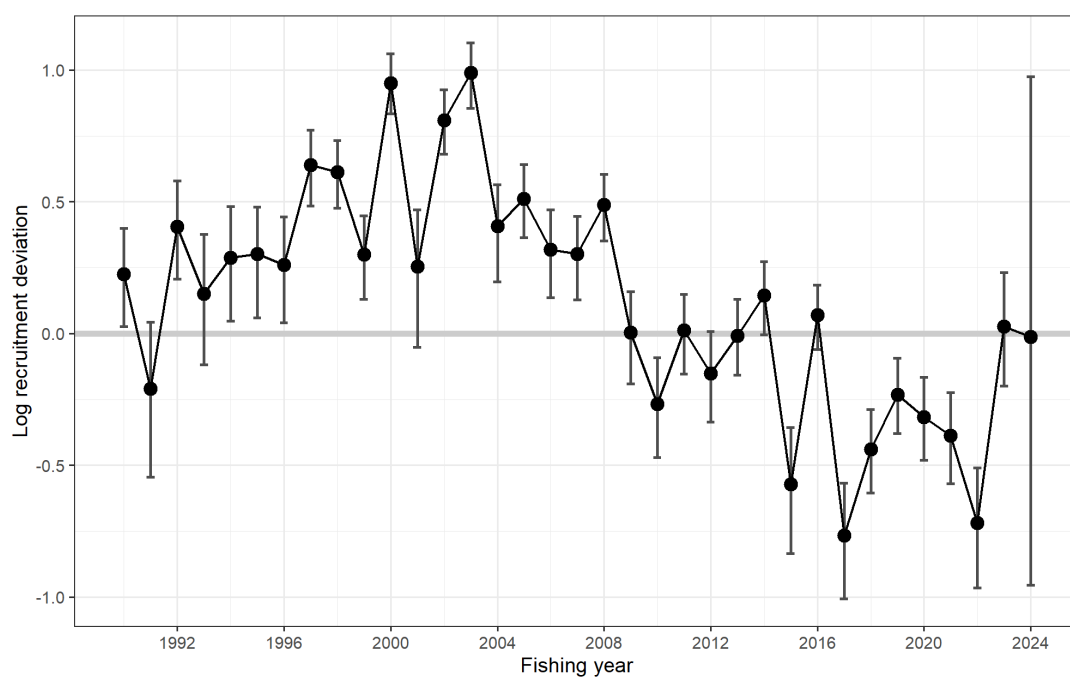


Figure H.103: Analysis 7: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

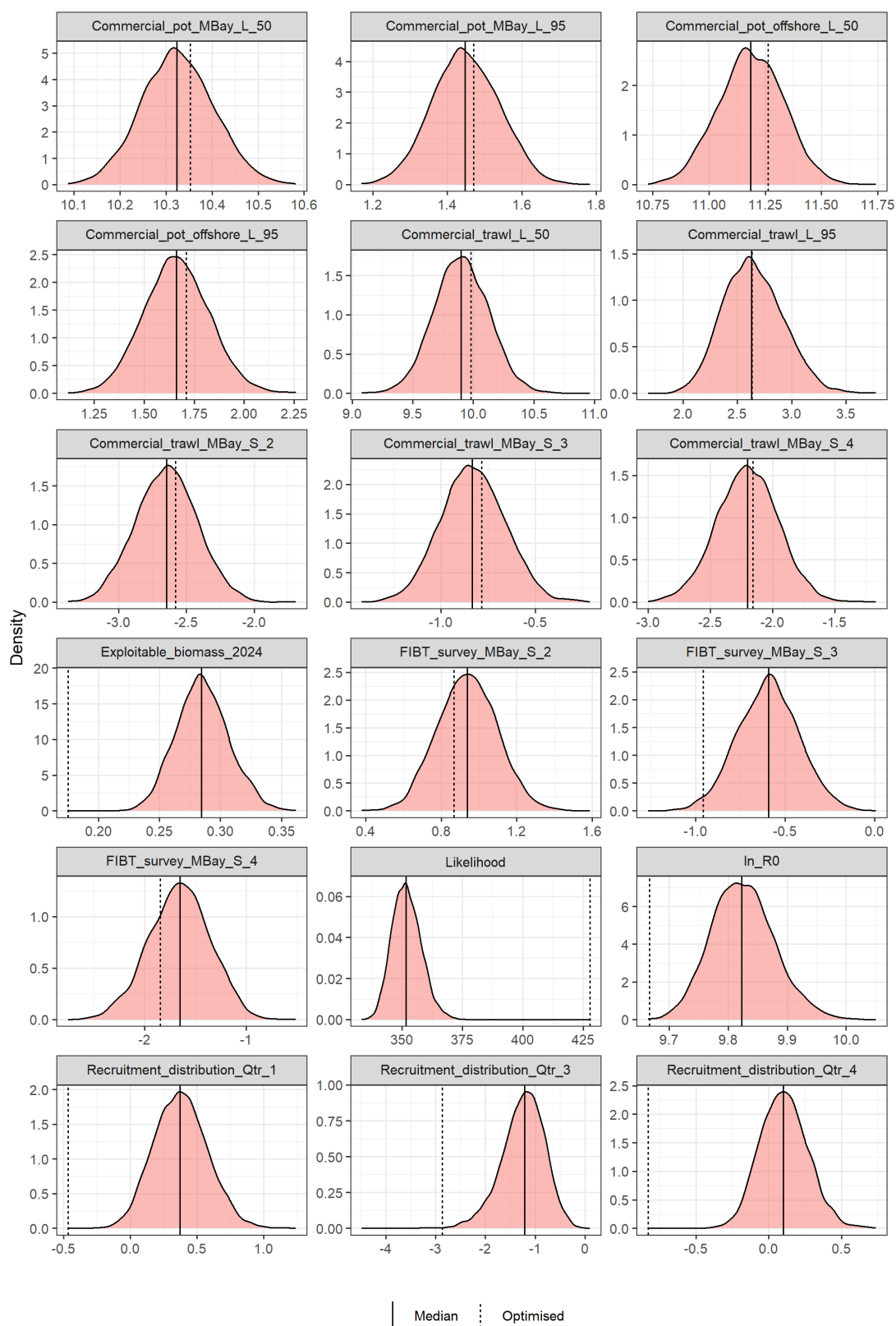


Figure H.104: Analysis 7: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

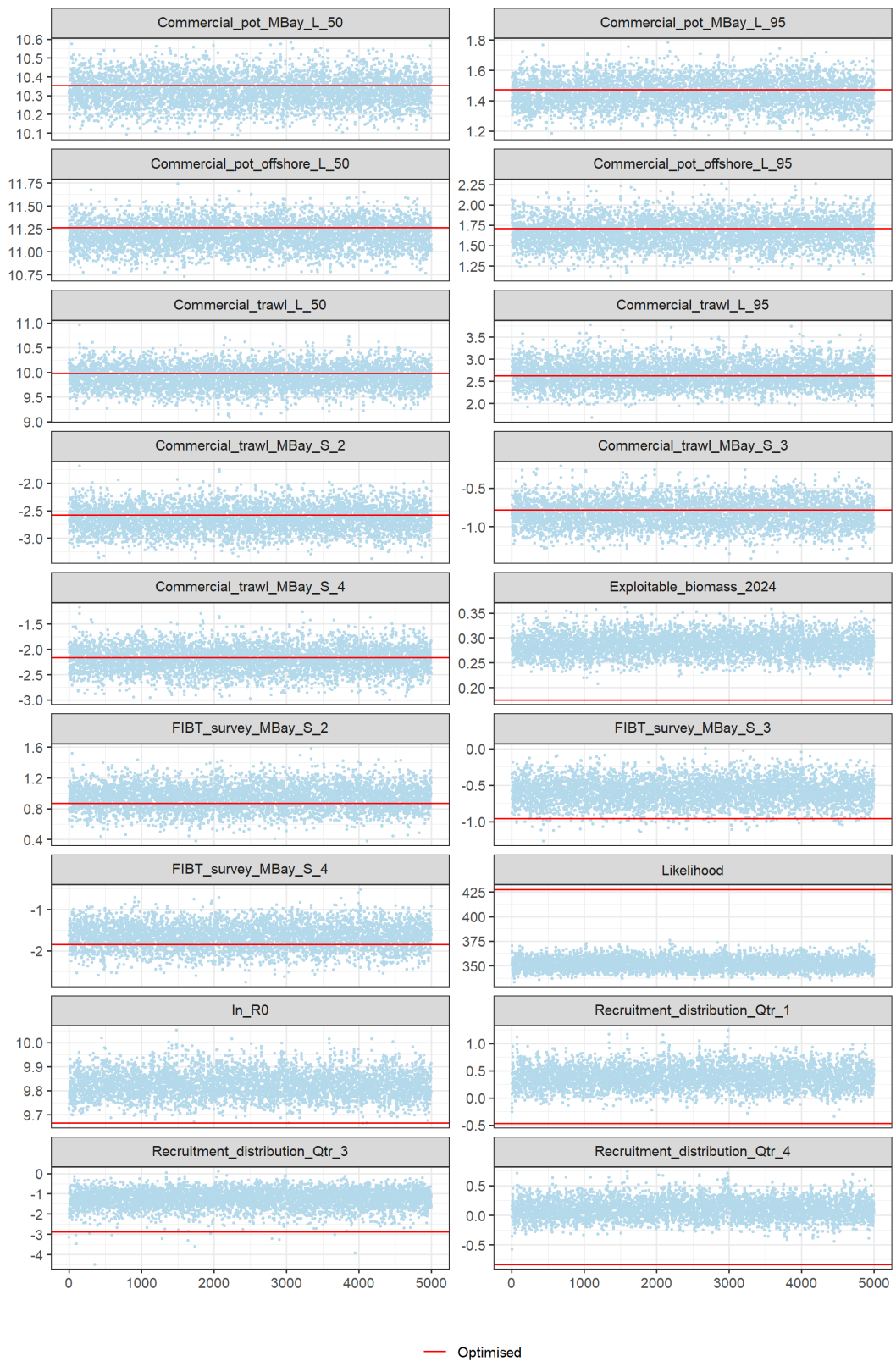


Figure H.105: Analysis 7: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.8 Analysis 8

Table H.15: Summary of MLE parameter estimates for analysis 8

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.52	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.54	2	-5.00	5.00	0.00	0.78
Recruitment distribution Qtr_4	-0.85	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	10.07	1	5.00	20.00	11.00	0.06
Commercial pot MBay L_{50}	10.47	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.48	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.37	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.72	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.24	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.59	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.46	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.54	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.71	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.88	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.82	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.50	3	-9.00	7.00	-1.00	0.30

Table H.16: Summary of MCMC parameter estimates for analysis 8

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.33	-0.03	0.73
Recruitment distribution Qtr_3	-1.17	-2.12	-0.48
Recruitment distribution Qtr_4	0.08	-0.21	0.40
$\ln(R_0)$	10.27	10.14	10.41
Commercial pot MBay L_{50}	10.45	10.30	10.60
Commercial pot MBay L_{95}	1.46	1.30	1.64
Commercial pot offshore L_{50}	11.29	11.01	11.58
Commercial pot offshore L_{95}	1.66	1.37	1.99
Commercial trawl L_{50}	10.17	9.76	10.59
Commercial trawl L_{95}	2.58	2.14	3.13
Commercial trawl MBay S_2	-2.52	-2.95	-2.08
Commercial trawl MBay S_3	-0.57	-0.90	-0.23
Commercial trawl MBay S_4	-1.74	-2.22	-1.25
FIBT survey MBay S_2	0.96	0.65	1.27
FIBT survey MBay S_3	-0.44	-0.77	-0.12
FIBT survey MBay S_4	-1.28	-1.90	-0.71

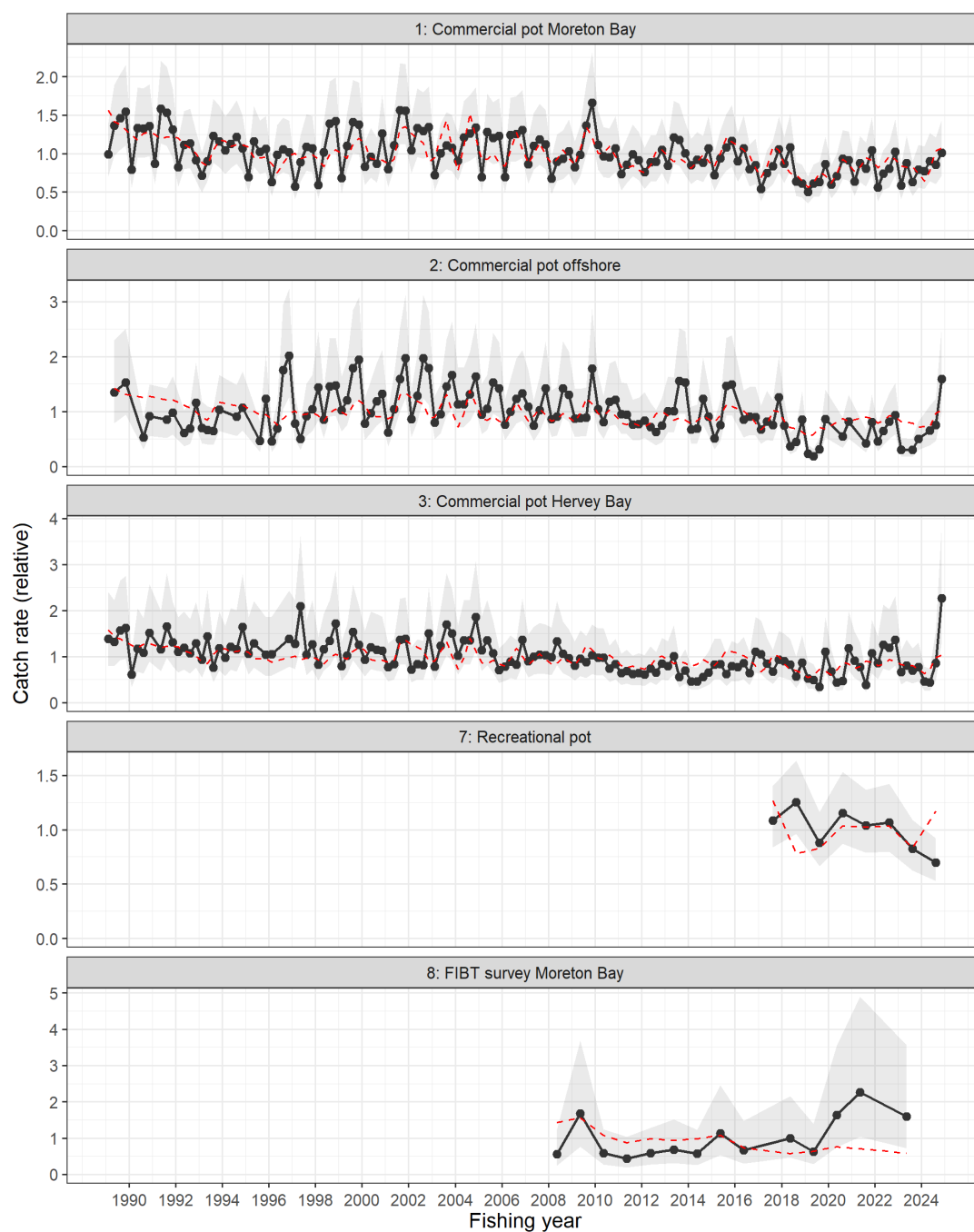


Figure H.106: Analysis 8: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

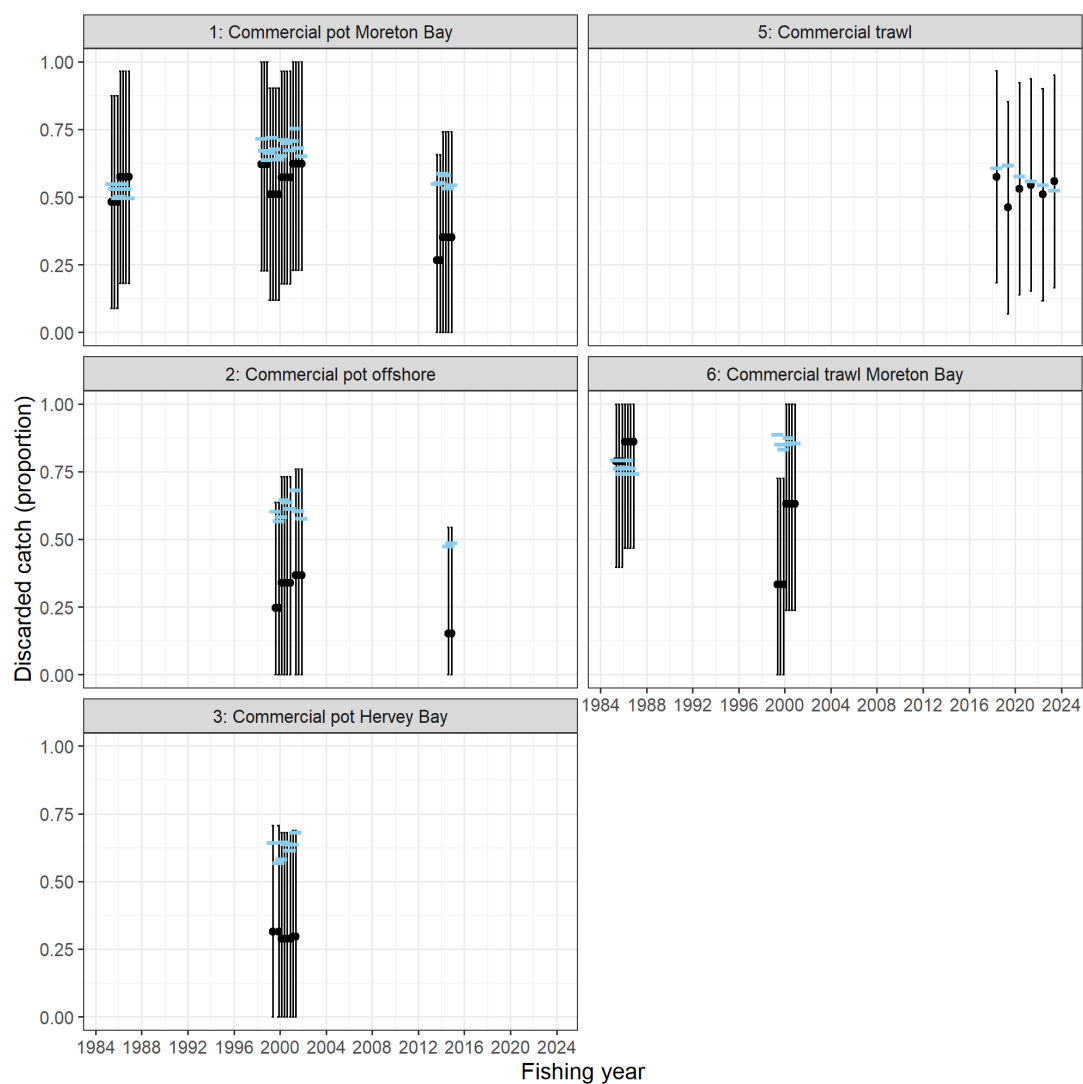


Figure H.107: Analysis 8: Fits to annual discard proportions of blue swimmer crab catch

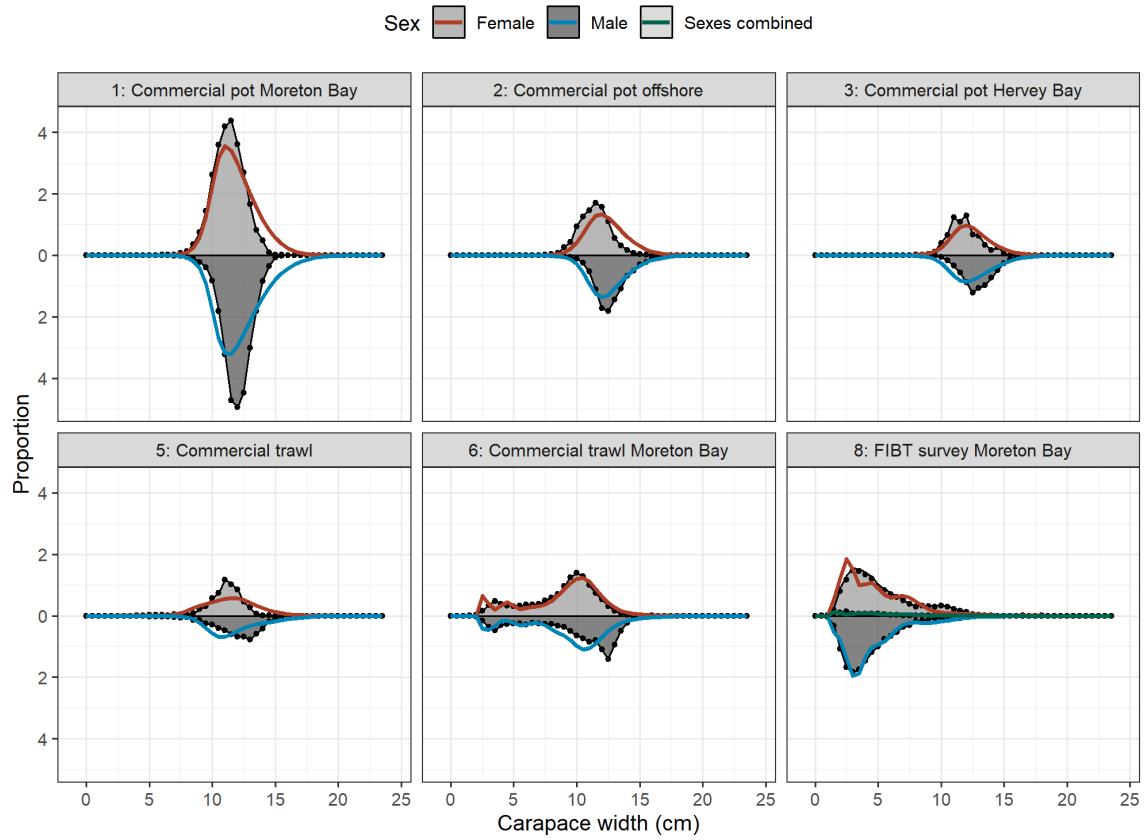


Figure H.108: Analysis 8: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

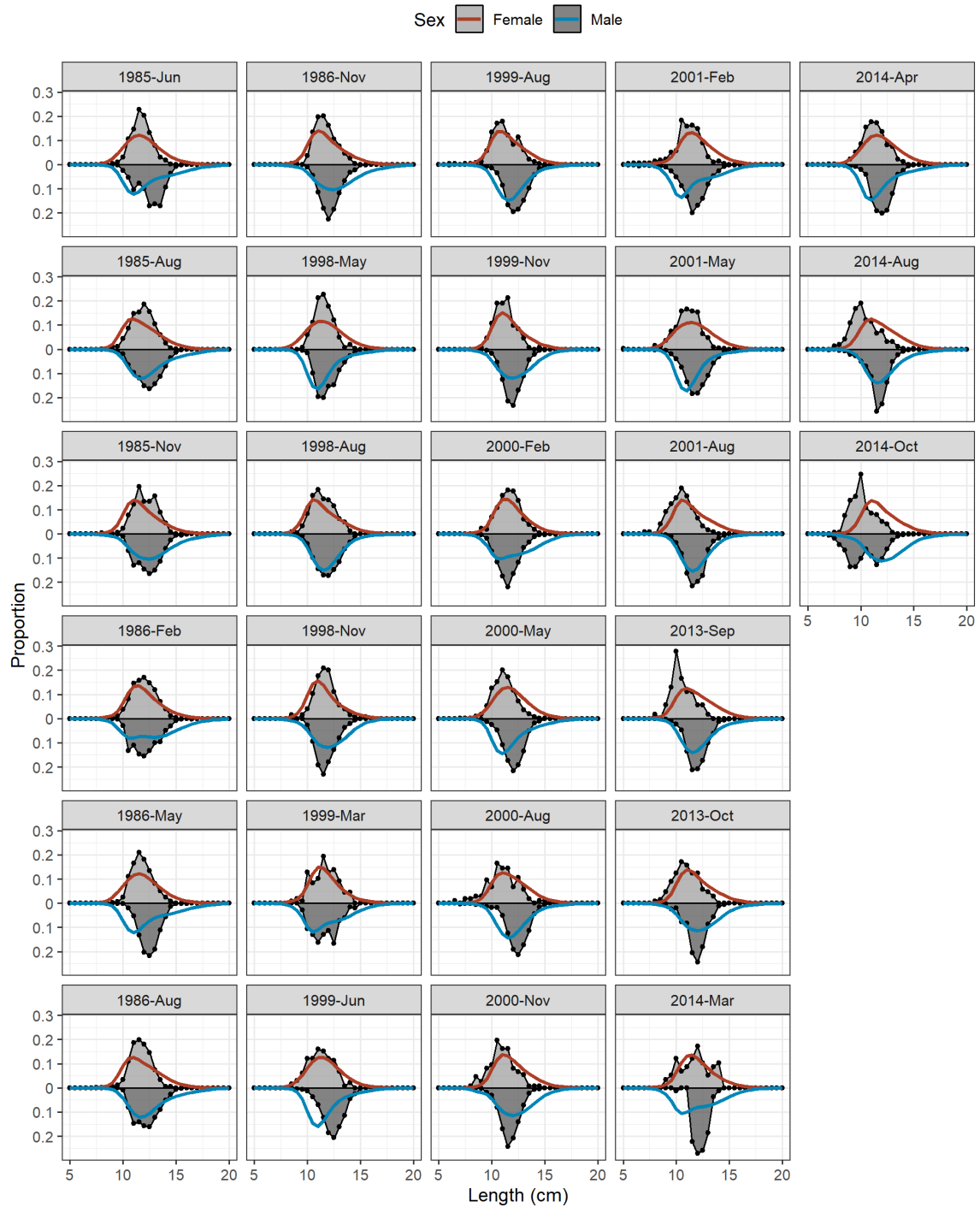


Figure H.109: Analysis 8: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

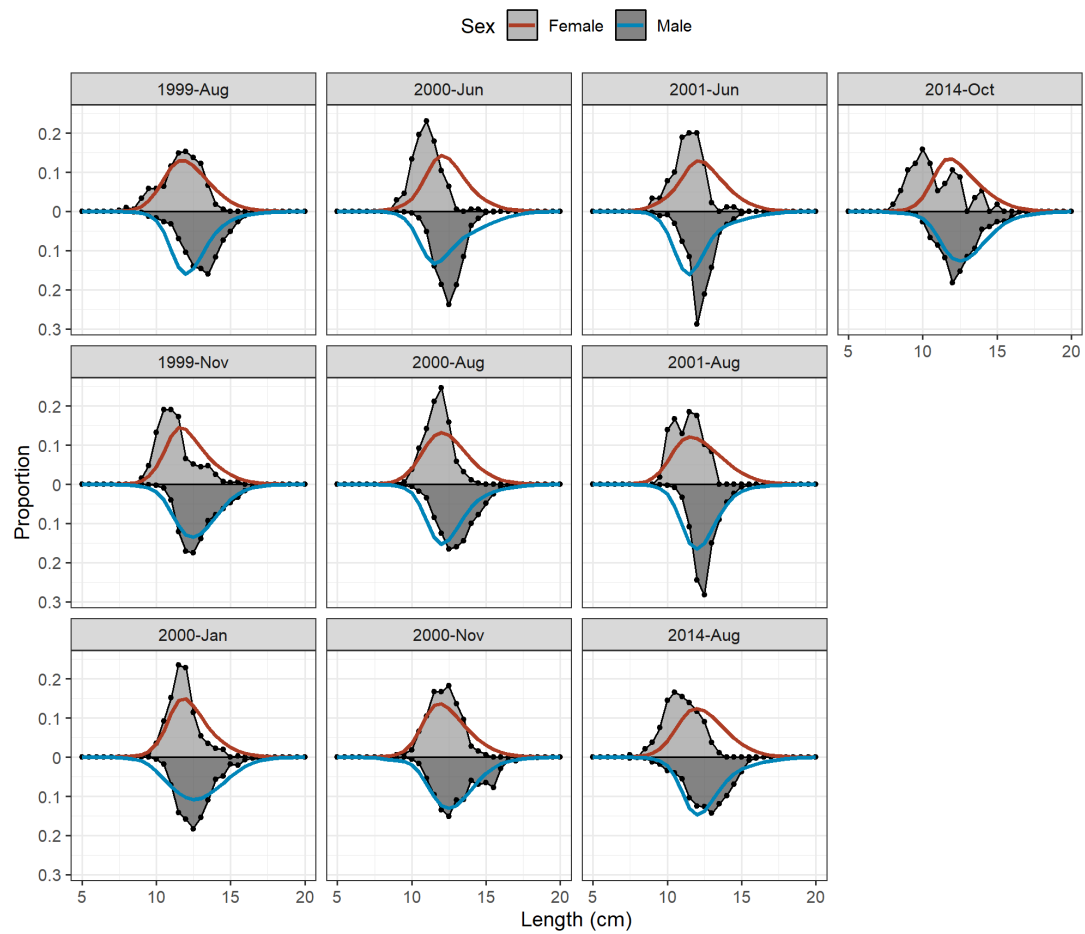


Figure H.110: Analysis 8: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

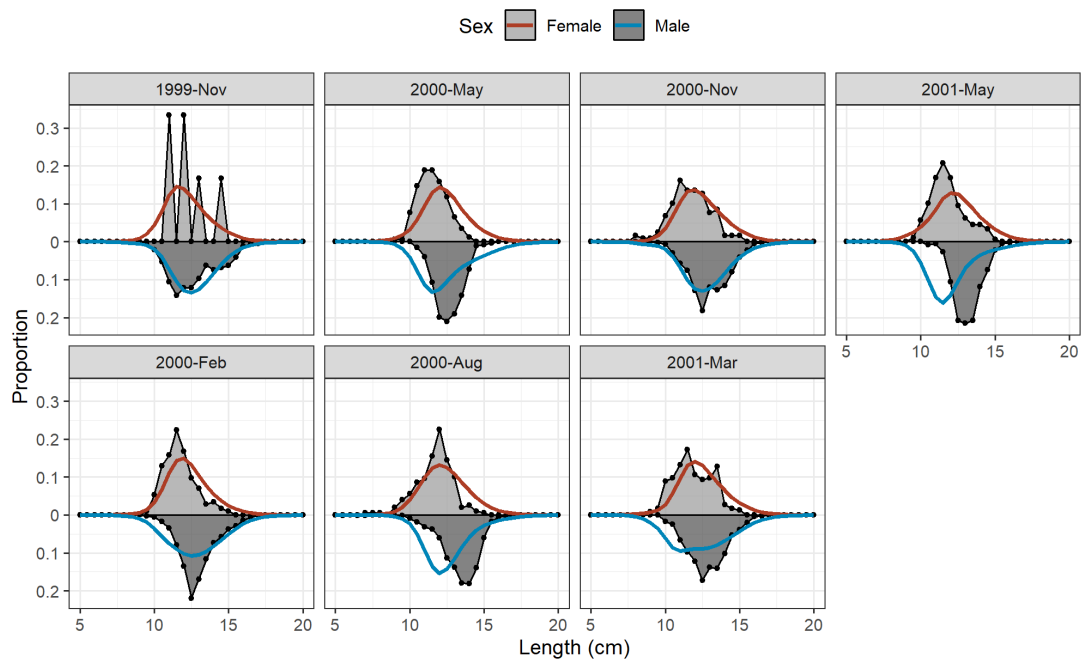


Figure H.111: Analysis 8: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

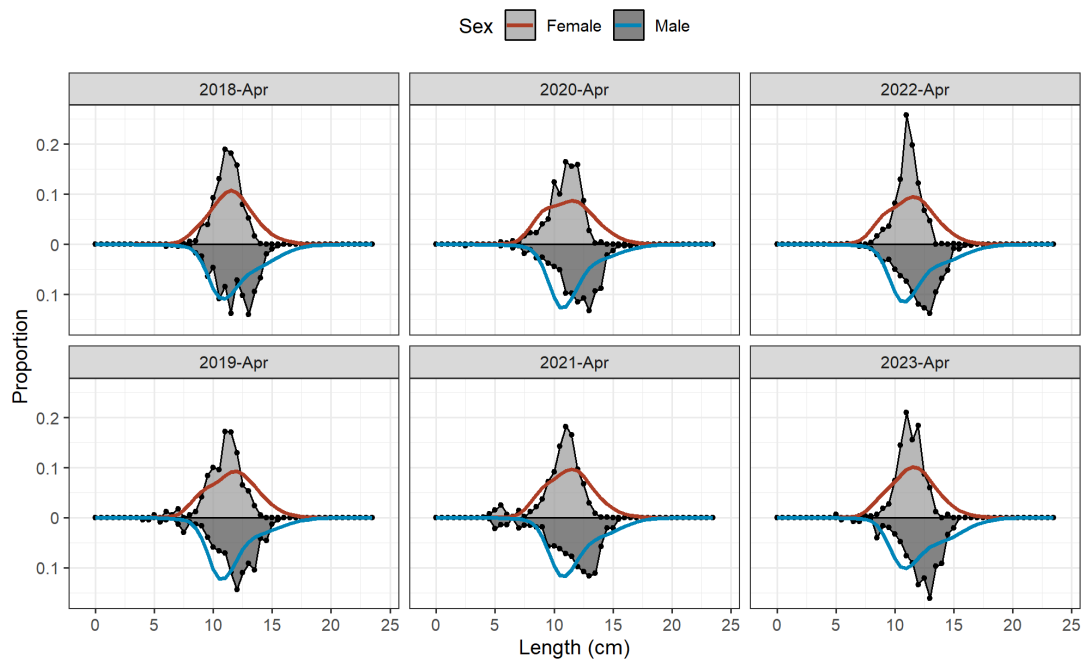


Figure H.112: Analysis 8: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

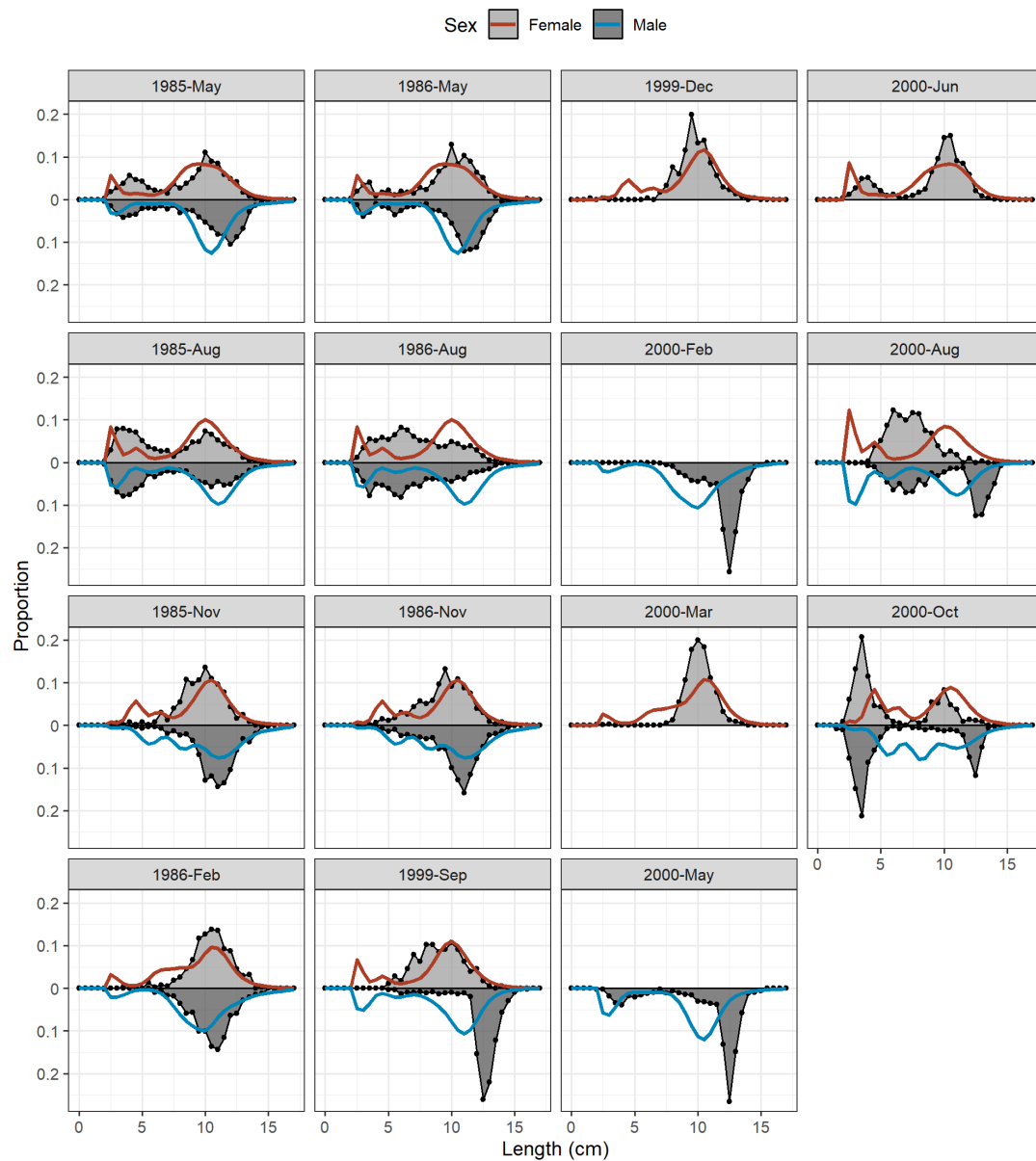


Figure H.113: Analysis 8: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

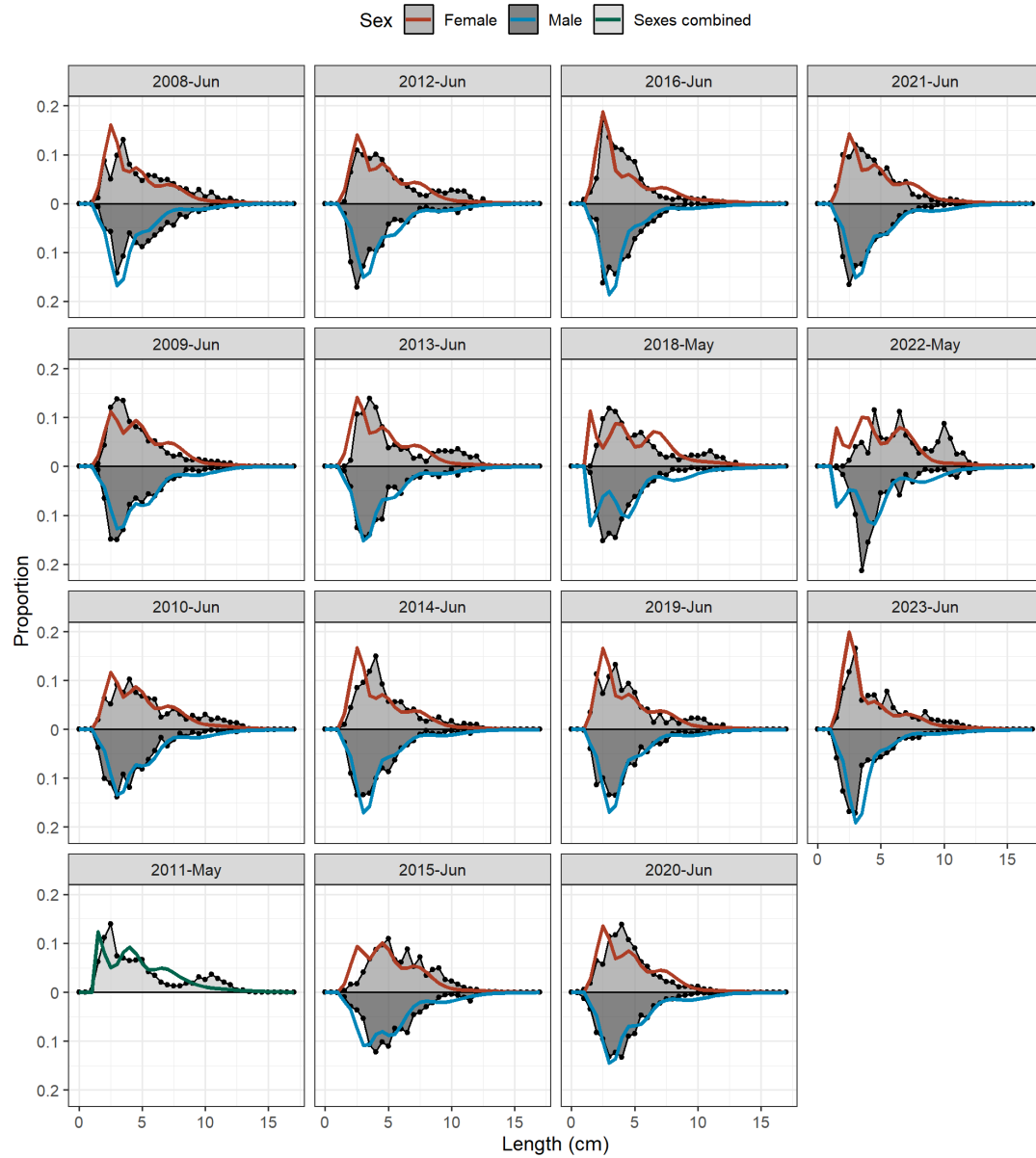


Figure H.114: Analysis 8: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

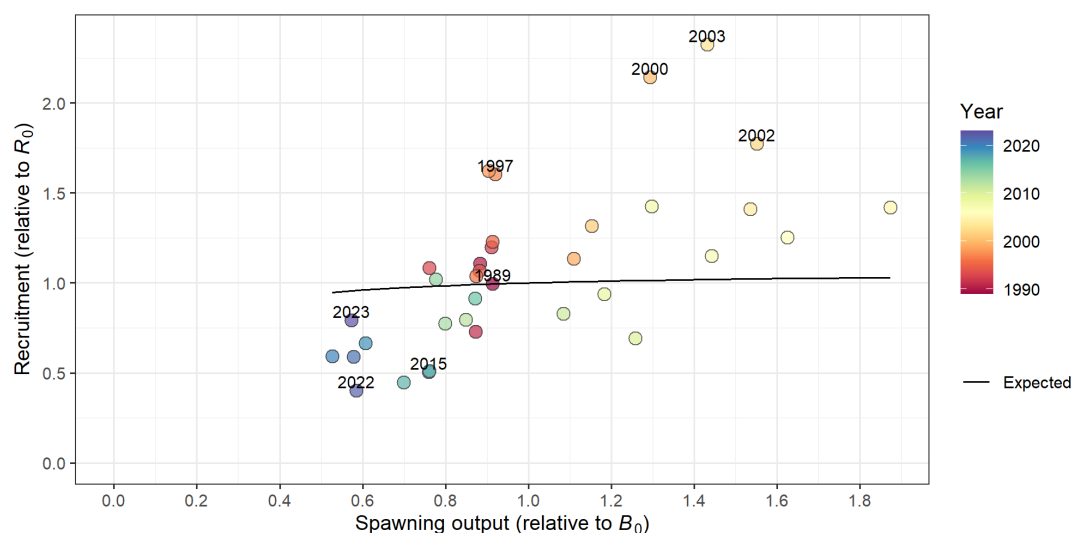


Figure H.115: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 8 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

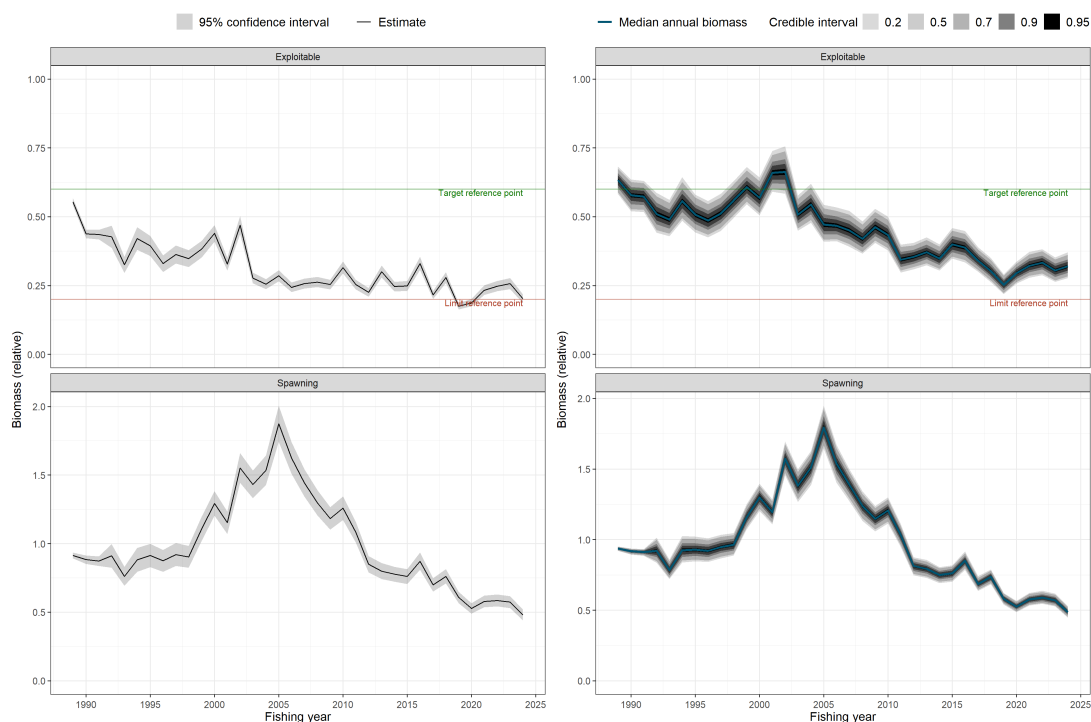


Figure H.116: Analysis 8: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

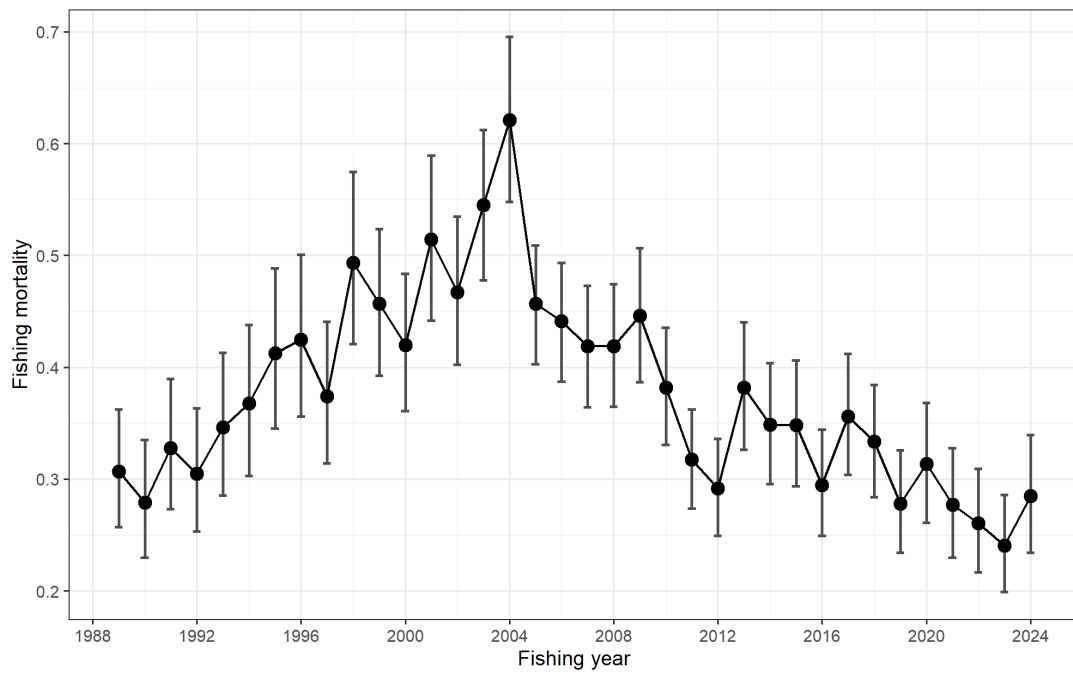


Figure H.117: Analysis 8: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

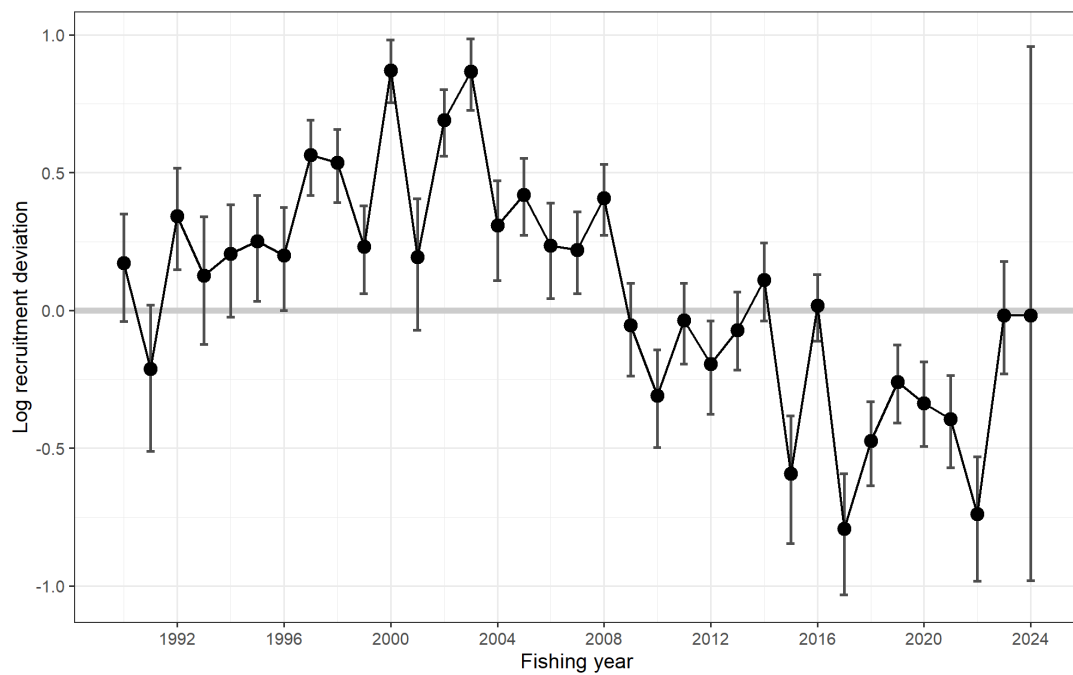


Figure H.118: Analysis 8: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

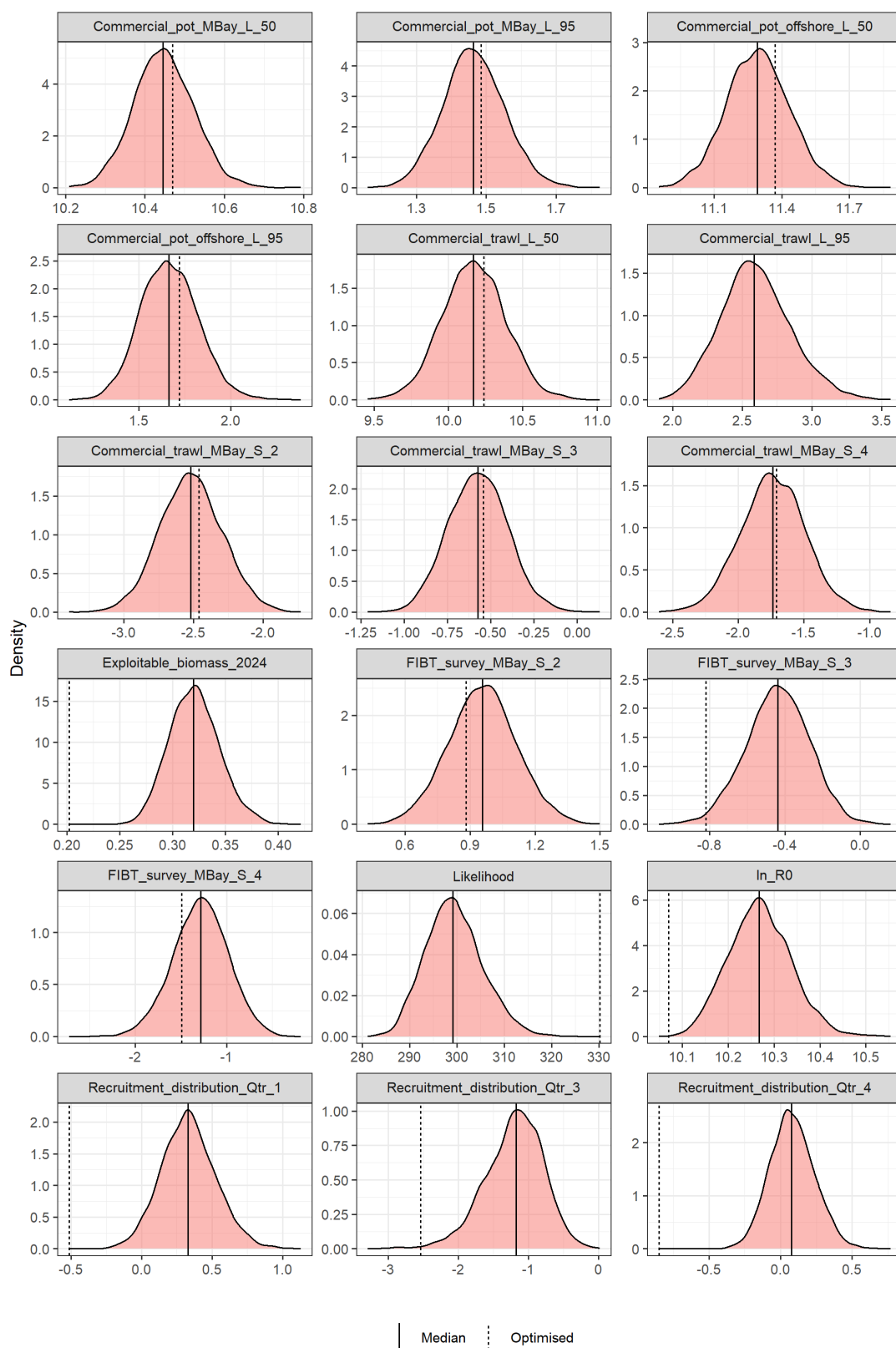


Figure H.119: Analysis 8: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

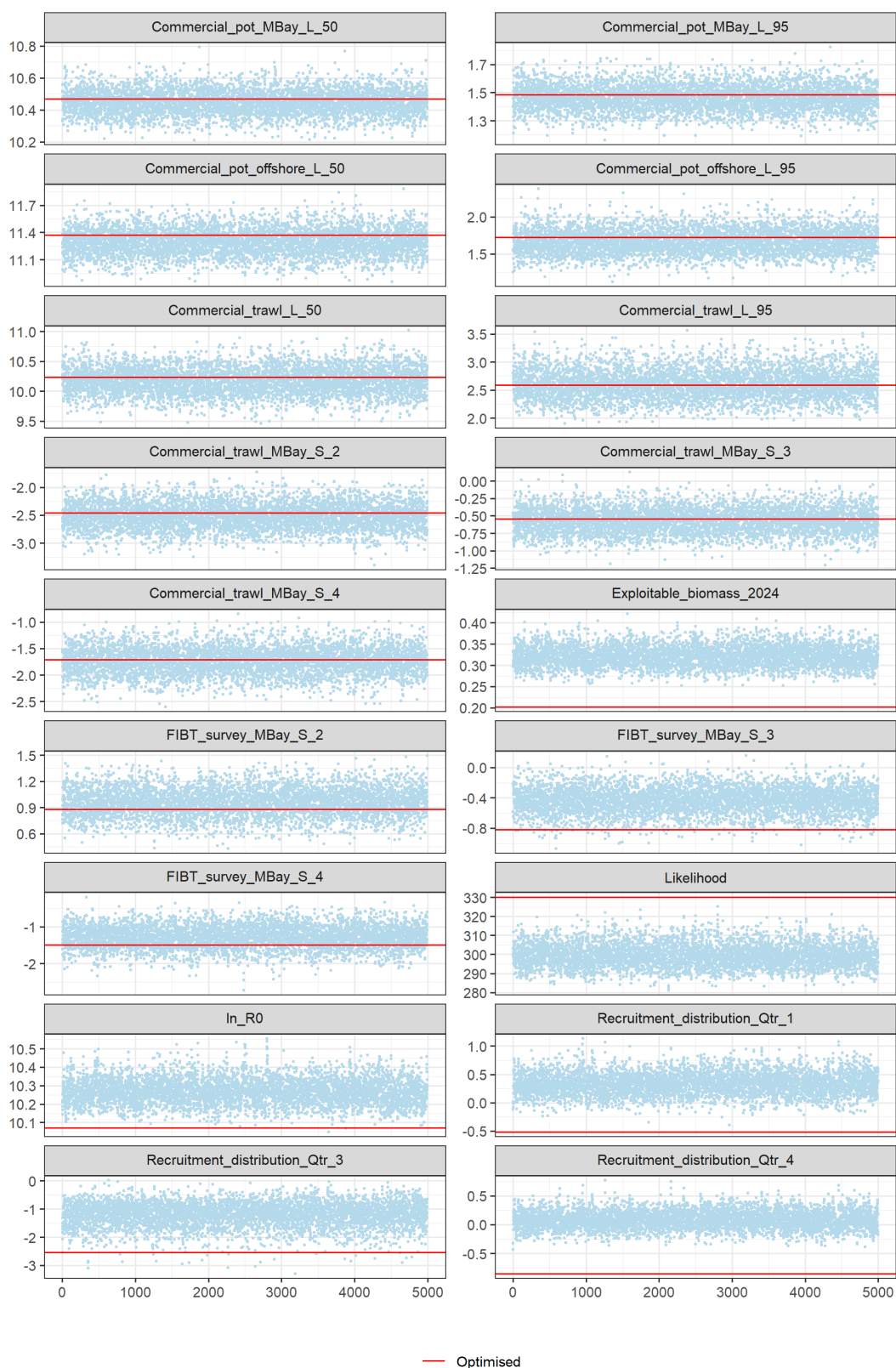


Figure H.120: Analysis 8: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.9 Analysis 9

Table H.17: Summary of MLE parameter estimates for analysis 9

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.55	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.25	2	-5.00	5.00	0.00	0.62
Recruitment distribution Qtr_4	-0.87	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	10.47	1	5.00	20.00	11.00	0.07
Commercial pot MBay L_{50}	10.57	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.49	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.46	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.72	3	0.10	20.00	1.50	0.15
Commercial trawl L_{50}	10.45	3	0.10	20.00	9.00	0.20
Commercial trawl L_{95}	2.54	3	0.10	20.00	2.20	0.23
Commercial trawl MBay S_2	-2.35	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.30	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.30	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.90	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.69	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.17	3	-9.00	7.00	-1.00	0.30

Table H.18: Summary of MCMC parameter estimates for analysis 9

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.29	-0.06	0.66
Recruitment distribution Qtr_3	-1.14	-2.07	-0.49
Recruitment distribution Qtr_4	0.06	-0.22	0.36
$\ln(R_0)$	10.71	10.56	10.89
Commercial pot MBay L_{50}	10.55	10.41	10.71
Commercial pot MBay L_{95}	1.47	1.31	1.64
Commercial pot offshore L_{50}	11.39	11.12	11.66
Commercial pot offshore L_{95}	1.67	1.39	1.98
Commercial trawl L_{50}	10.39	10.00	10.80
Commercial trawl L_{95}	2.53	2.11	3.03
Commercial trawl MBay S_2	-2.41	-2.84	-1.96
Commercial trawl MBay S_3	-0.32	-0.65	0.02
Commercial trawl MBay S_4	-1.33	-1.81	-0.84
FIBT survey MBay S_2	0.98	0.67	1.28
FIBT survey MBay S_3	-0.28	-0.62	0.04
FIBT survey MBay S_4	-0.93	-1.54	-0.35

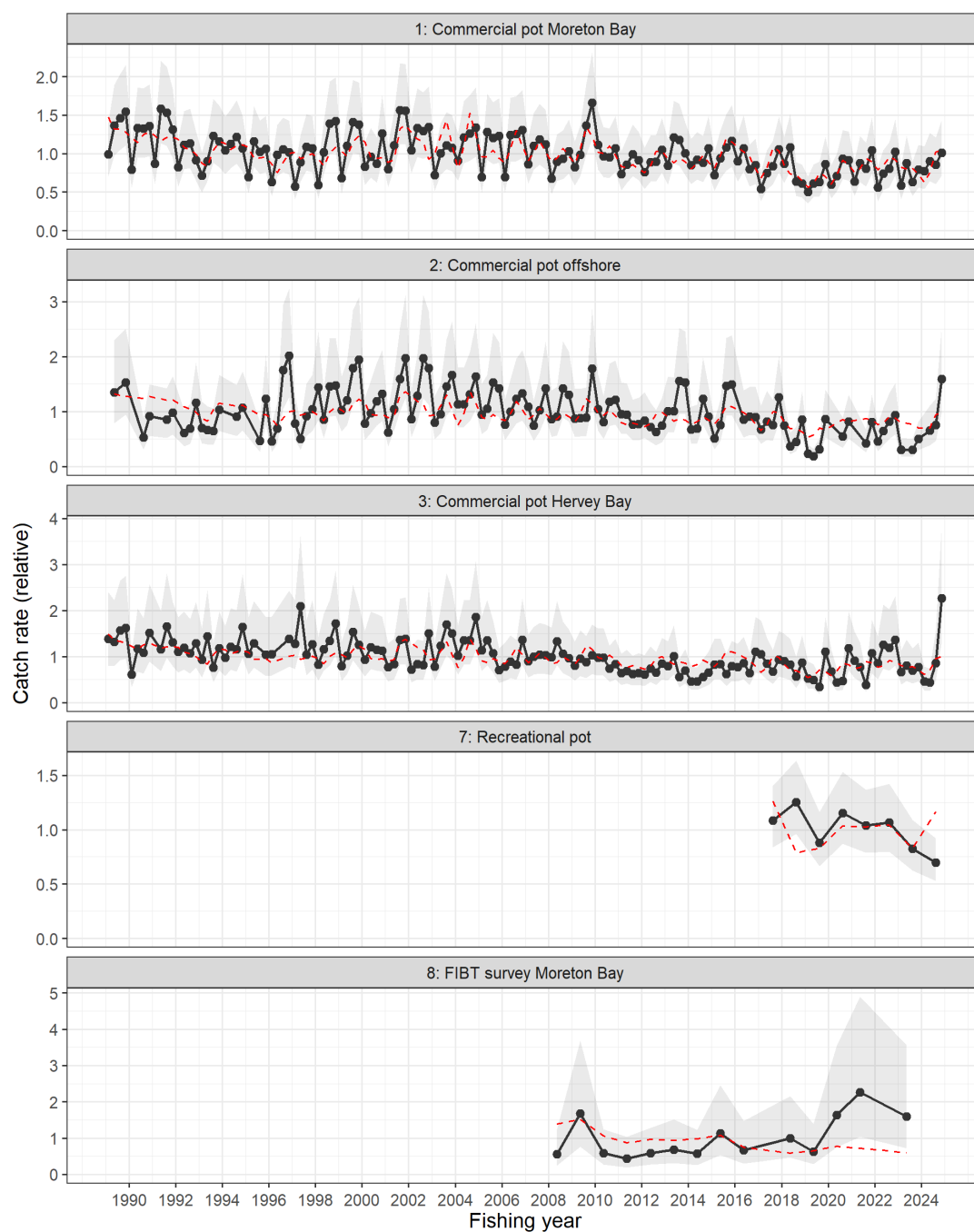


Figure H.121: Analysis 9: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

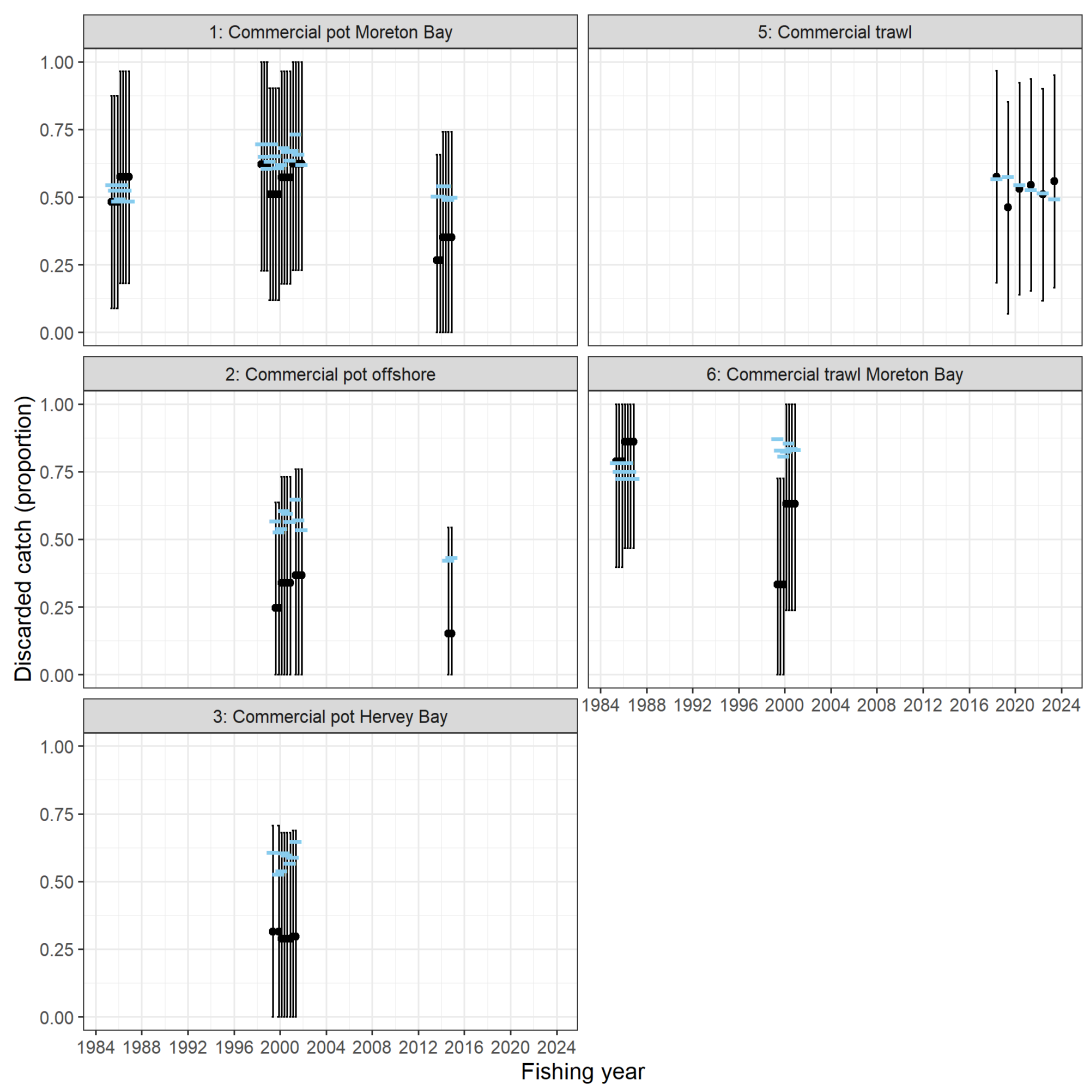


Figure H.122: Analysis 9: Fits to annual discard proportions of blue swimmer crab catch

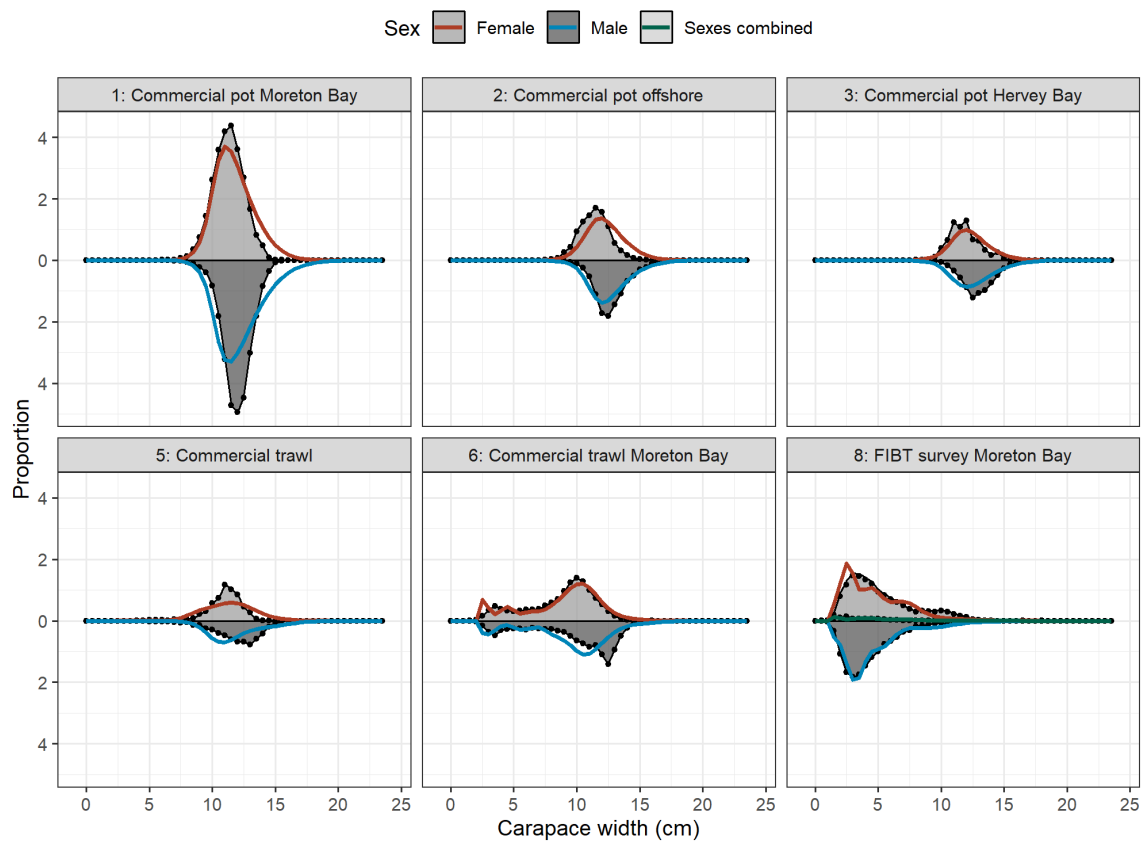


Figure H.123: Analysis 9: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

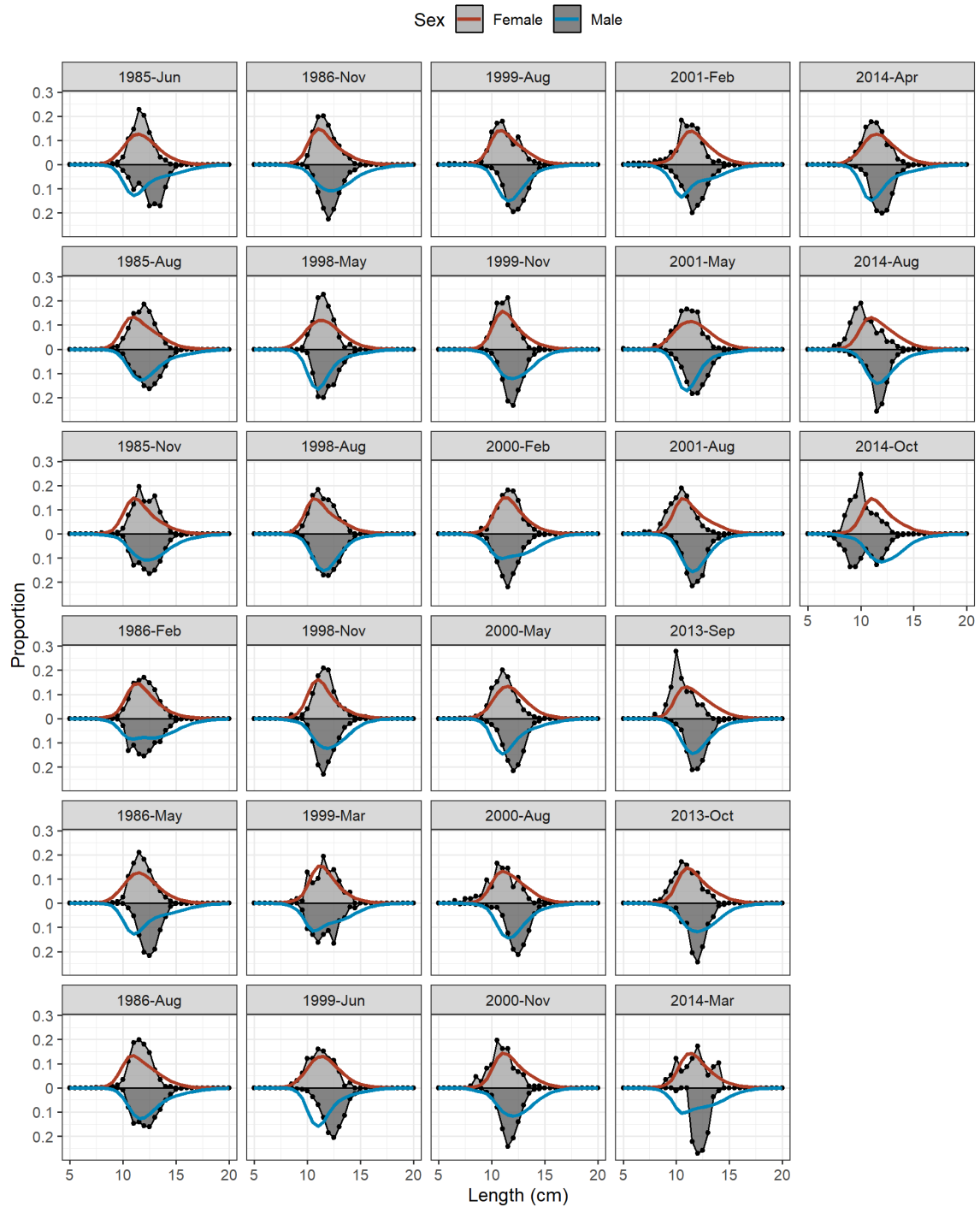


Figure H.124: Analysis 9: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

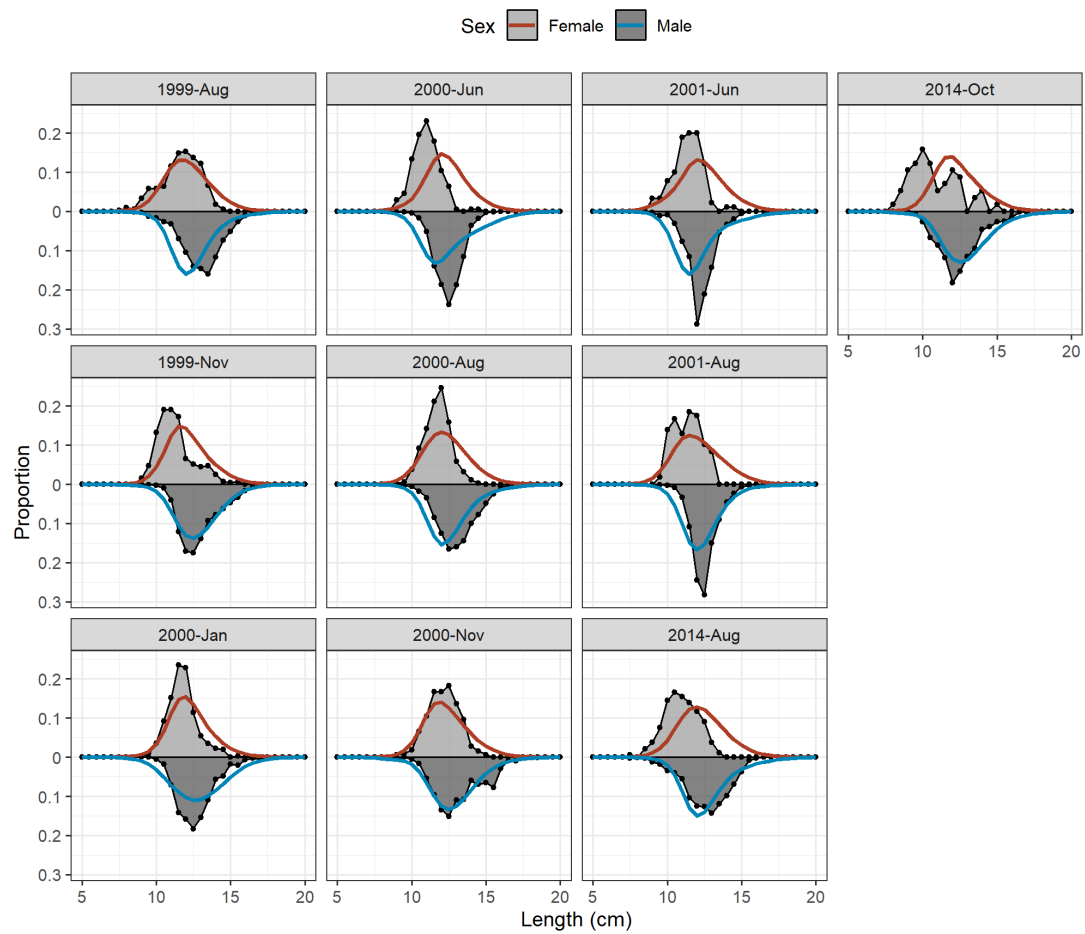


Figure H.125: Analysis 9: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

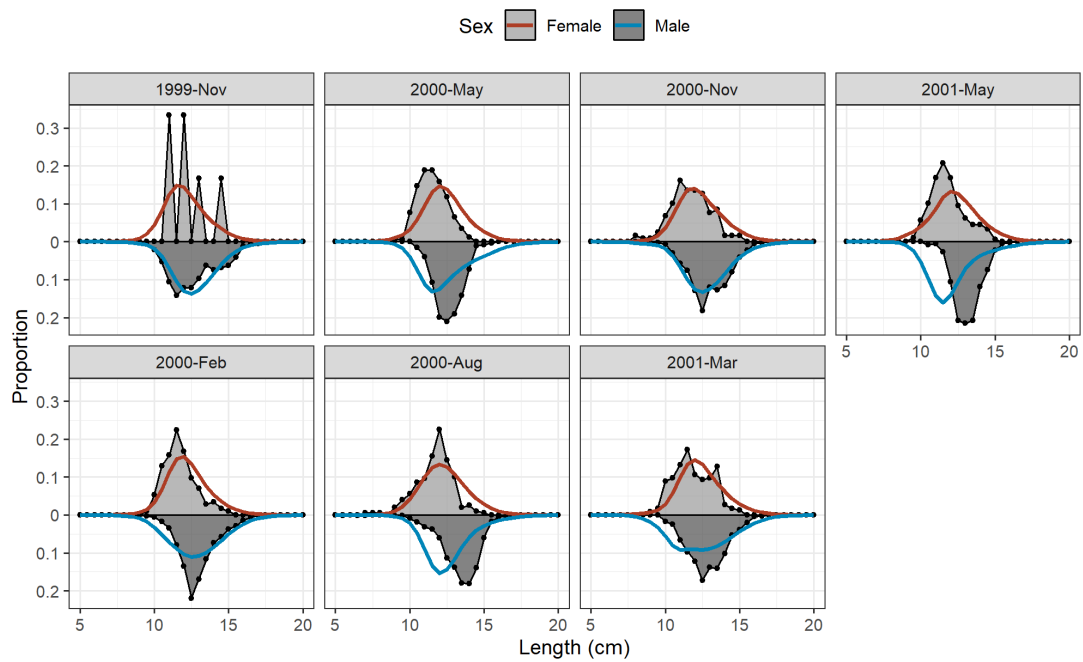


Figure H.126: Analysis 9: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

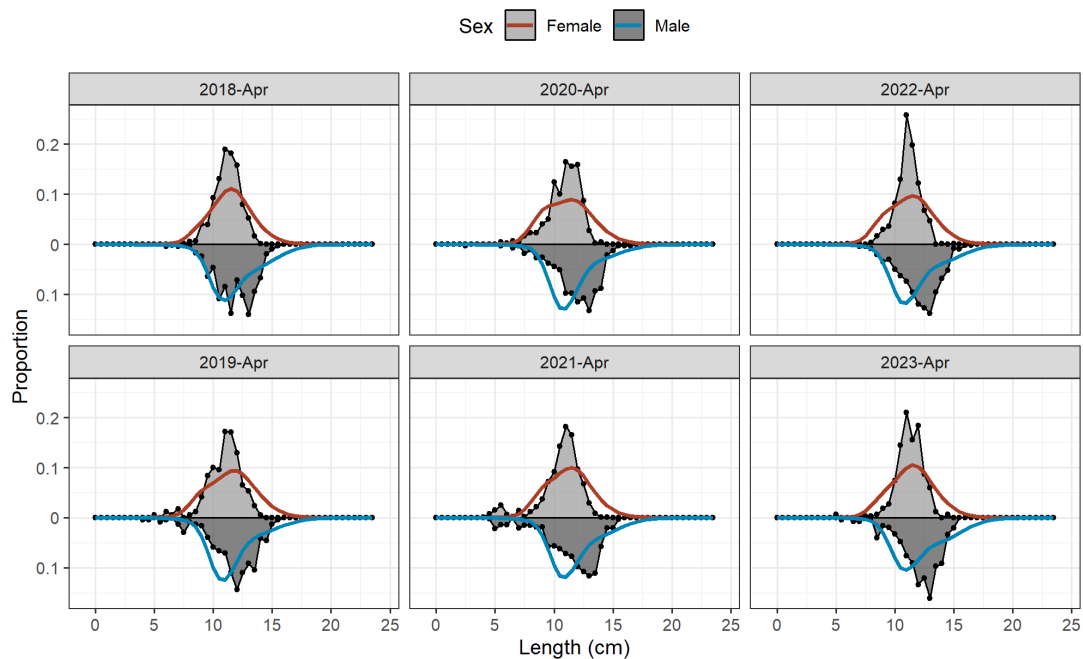


Figure H.127: Analysis 9: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

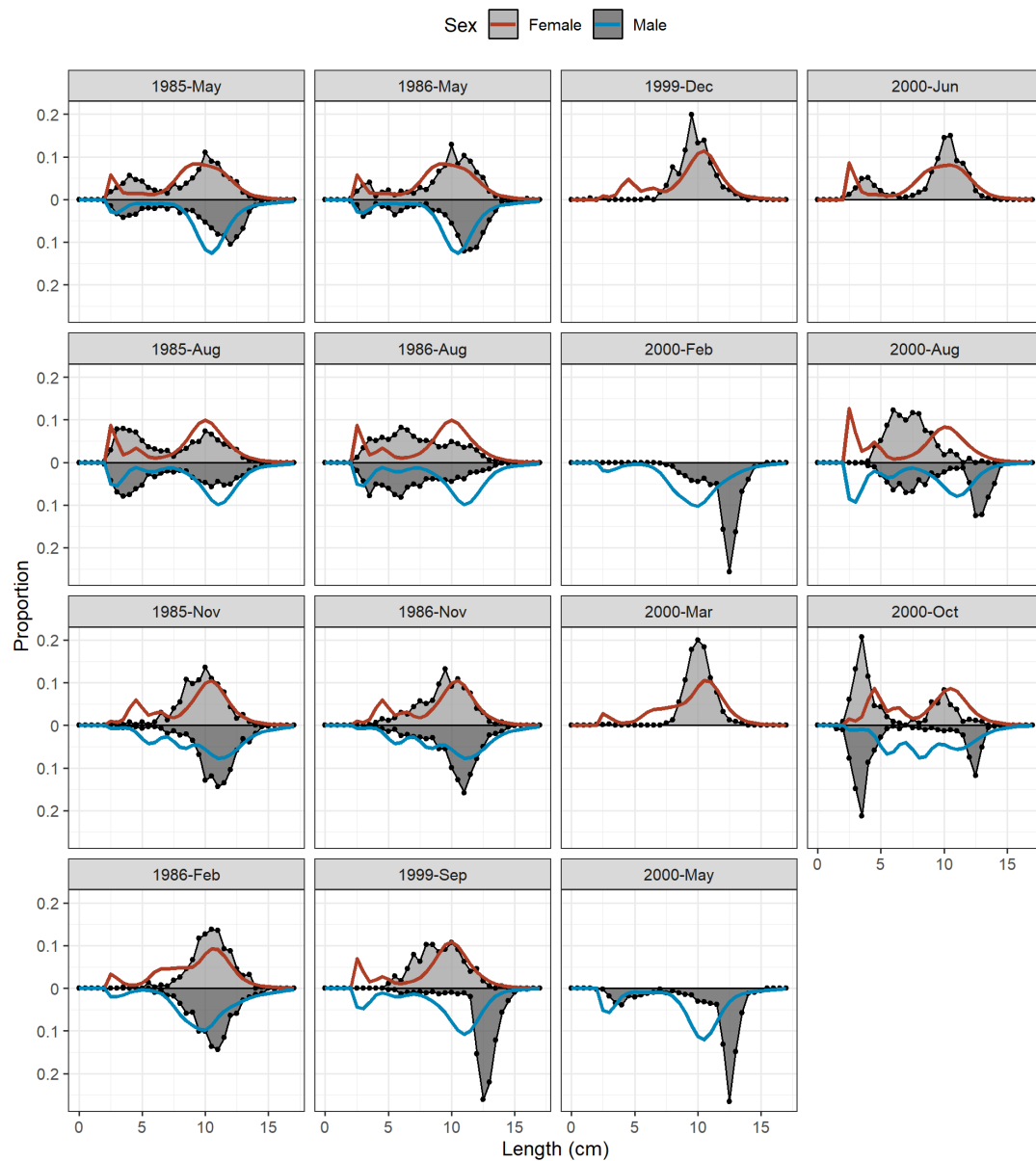


Figure H.128: Analysis 9: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

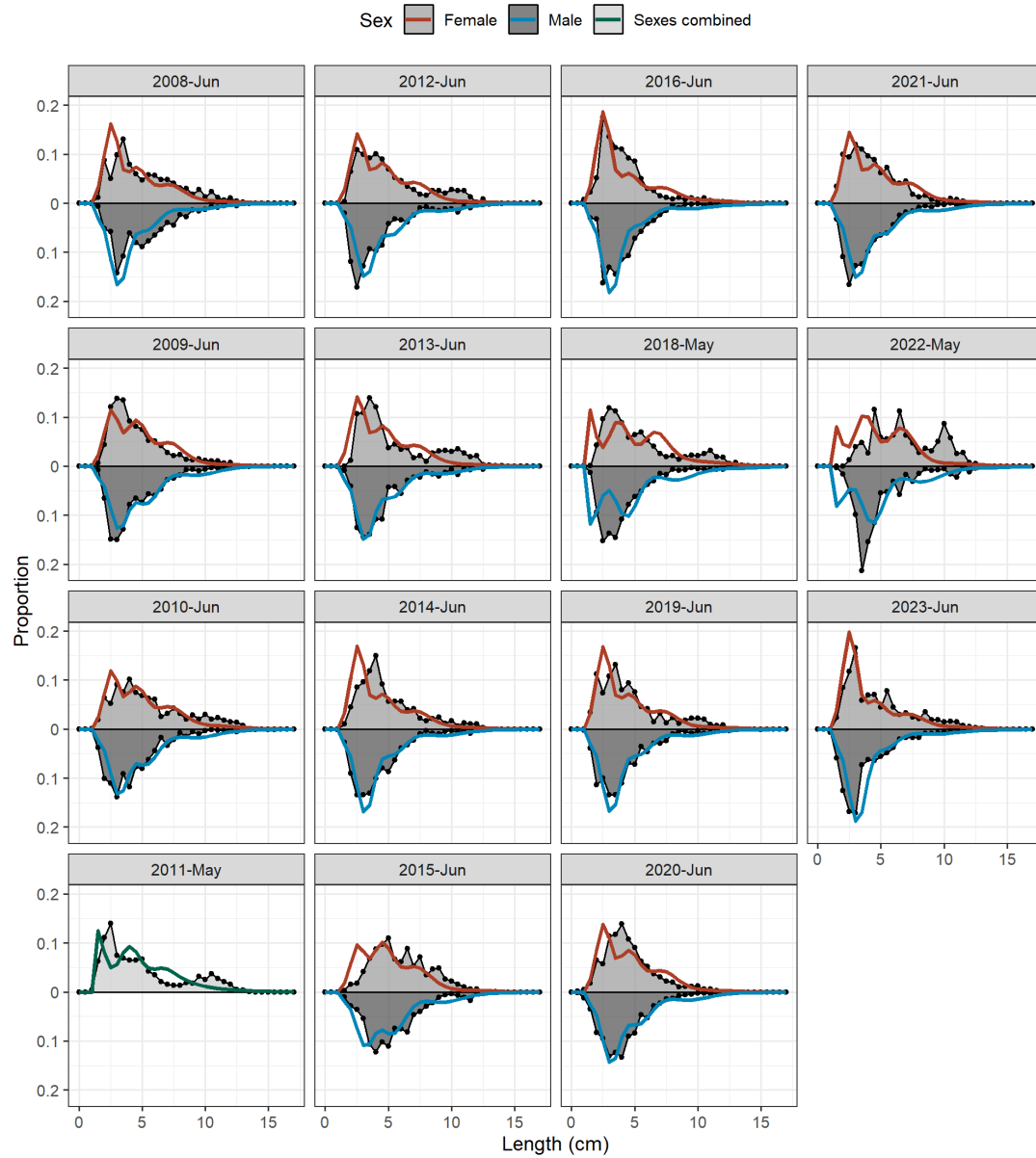


Figure H.129: Analysis 9: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

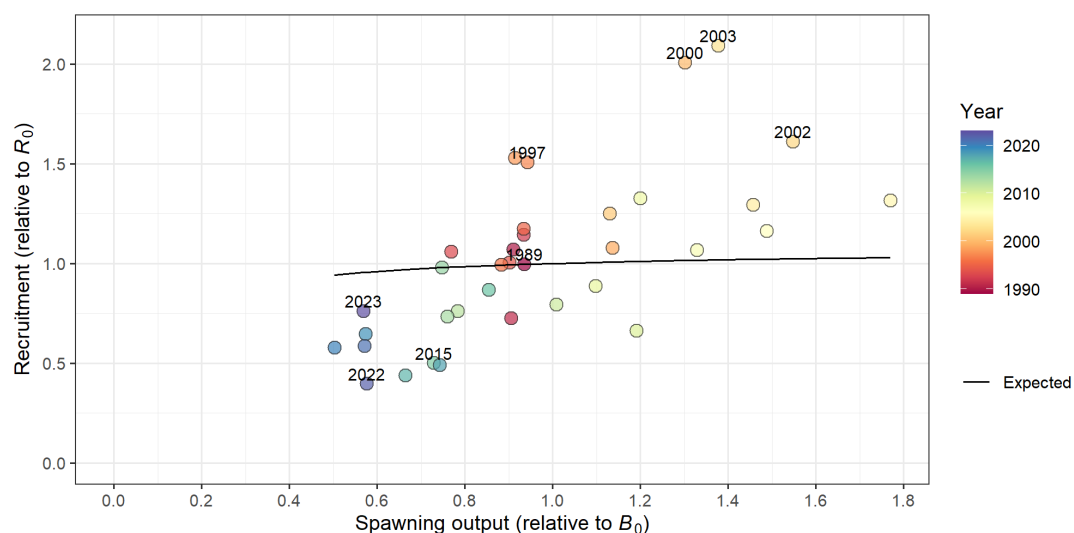


Figure H.130: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 9 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

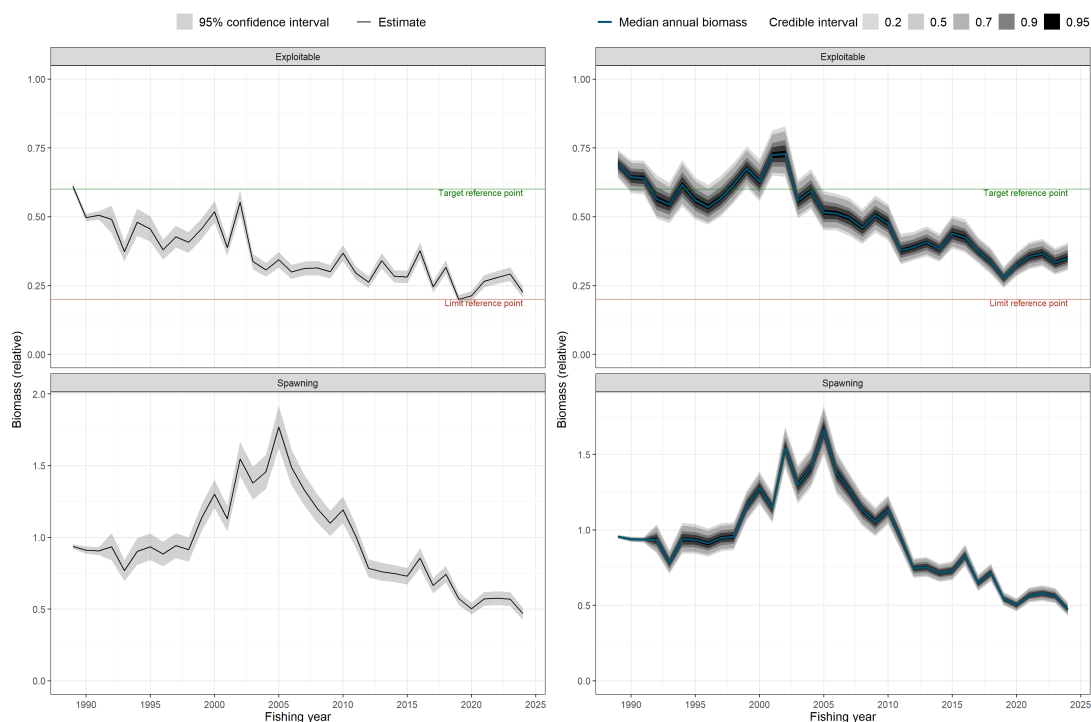


Figure H.131: Analysis 9: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

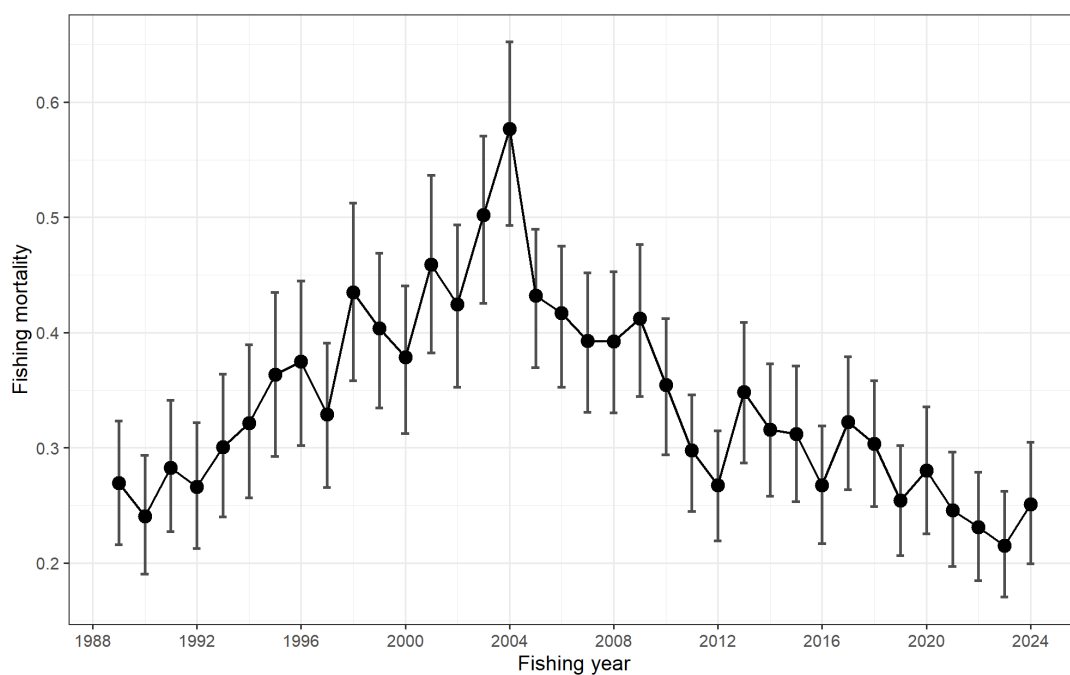


Figure H.132: Analysis 9: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

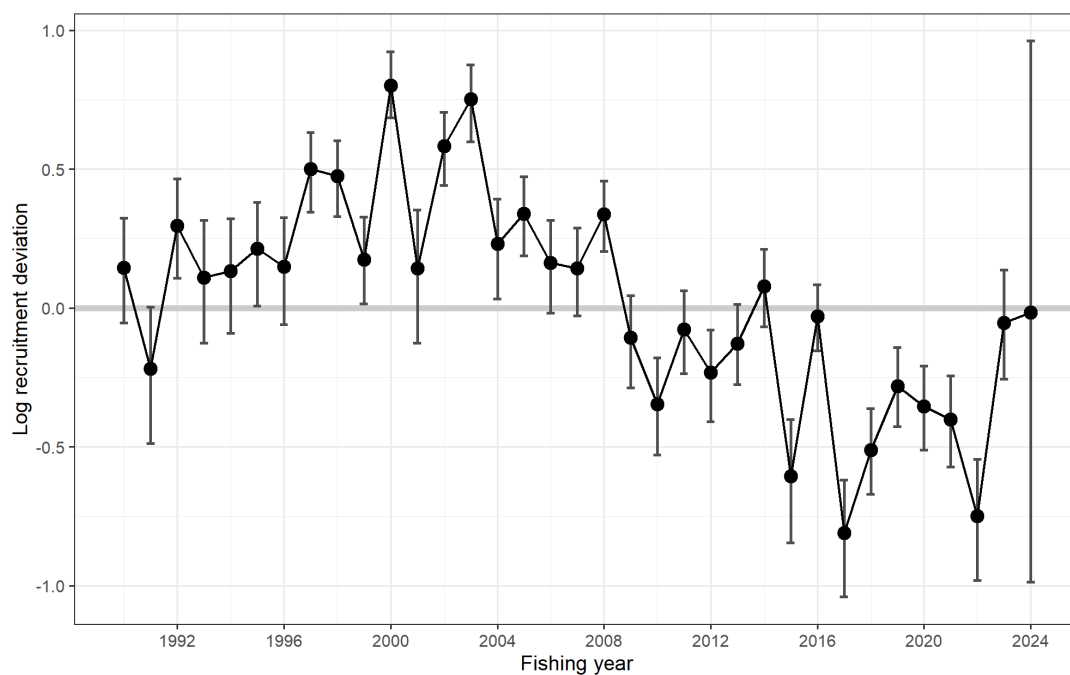


Figure H.133: Analysis 9: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

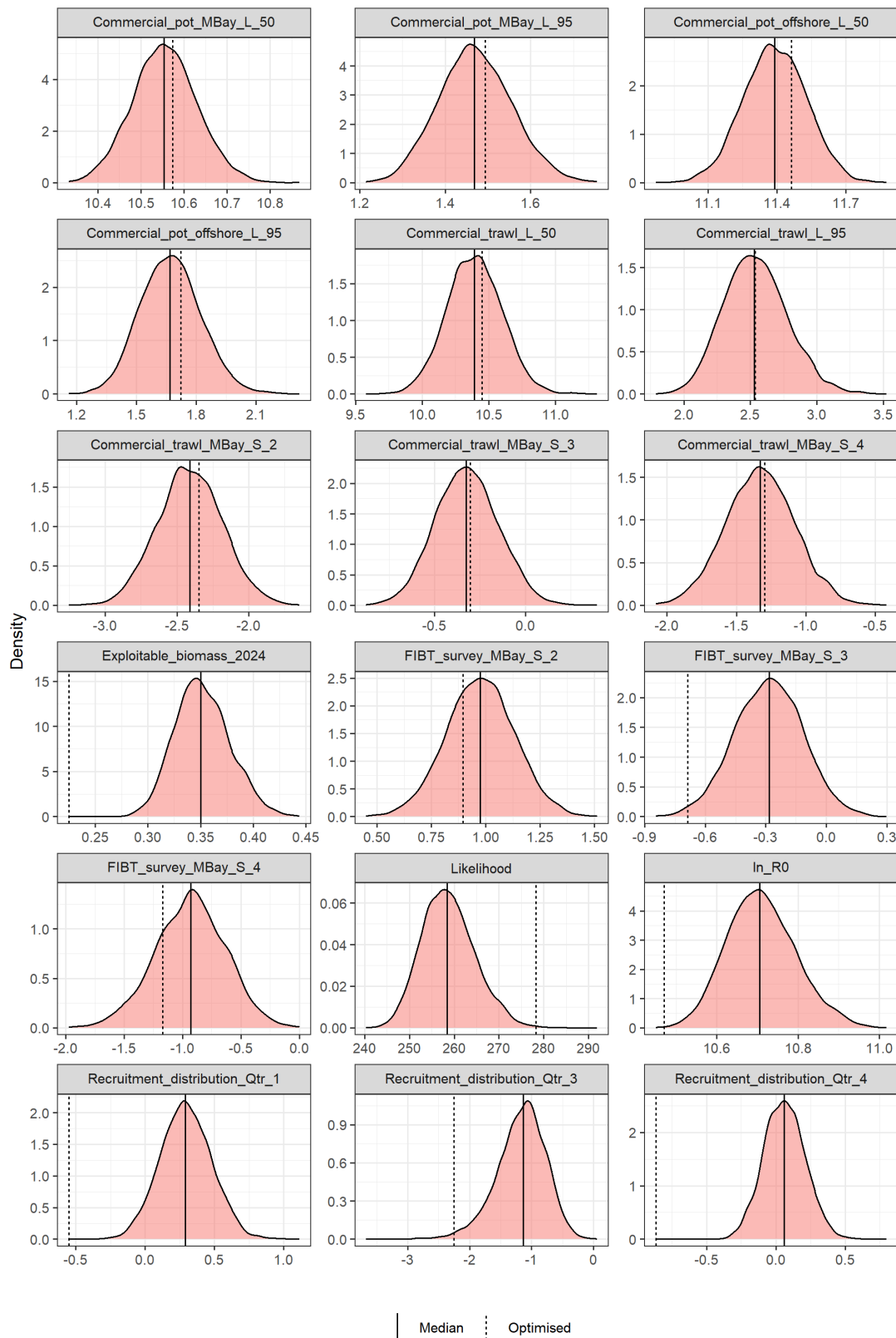


Figure H.134: Analysis 9: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

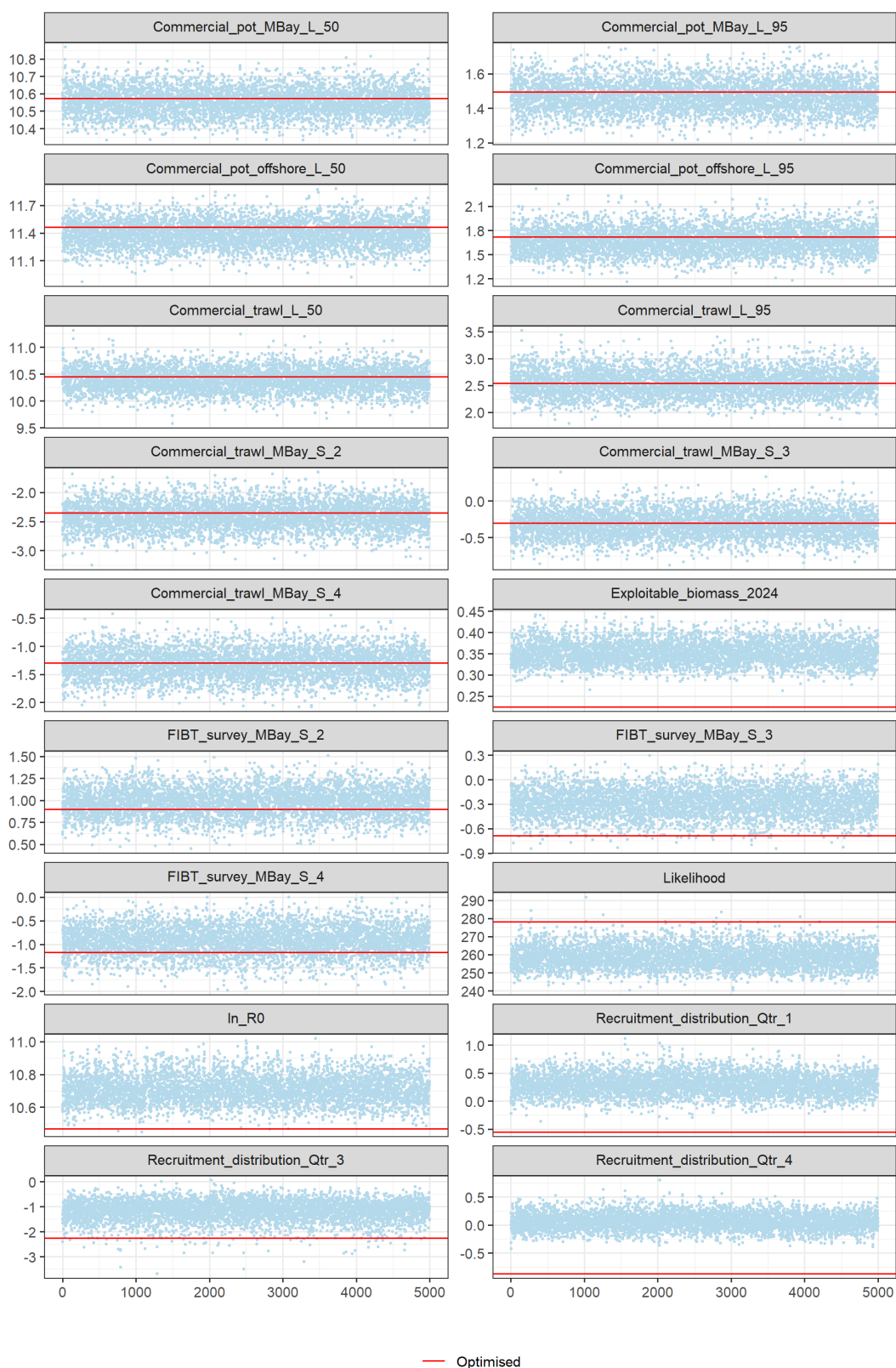


Figure H.135: Analysis 9: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.10 Analysis 10

Table H.19: Summary of MLE parameter estimates for analysis 10

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.47	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.87	2	-5.00	5.00	0.00	1.00
Recruitment distribution Qtr_4	-0.83	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	9.68	1	5.00	20.00	11.00	0.05
Commercial pot MBay L_{50}	10.35	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.47	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.27	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.71	3	0.10	20.00	1.50	0.17
Commercial trawl L_{50}	9.99	3	0.10	20.00	9.00	0.22
Commercial trawl L_{95}	2.63	3	0.10	20.00	2.20	0.27
Commercial trawl MBay S_2	-2.58	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.78	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-2.16	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.87	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.96	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.85	3	-9.00	7.00	-1.00	0.30

Table H.20: Summary of MCMC parameter estimates for analysis 10

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.37	0.01	0.78
Recruitment distribution Qtr_3	-1.22	-2.24	-0.50
Recruitment distribution Qtr_4	0.09	-0.20	0.43
$\ln(R_0)$	9.83	9.74	9.94
Commercial pot MBay L_{50}	10.33	10.18	10.48
Commercial pot MBay L_{95}	1.45	1.28	1.64
Commercial pot offshore L_{50}	11.19	10.91	11.48
Commercial pot offshore L_{95}	1.66	1.36	2.01
Commercial trawl L_{50}	9.90	9.47	10.36
Commercial trawl L_{95}	2.64	2.16	3.24
Commercial trawl MBay S_2	-2.64	-3.06	-2.20
Commercial trawl MBay S_3	-0.83	-1.16	-0.48
Commercial trawl MBay S_4	-2.19	-2.66	-1.72
FIBT survey MBay S_2	0.94	0.64	1.26
FIBT survey MBay S_3	-0.59	-0.93	-0.26
FIBT survey MBay S_4	-1.64	-2.25	-1.07

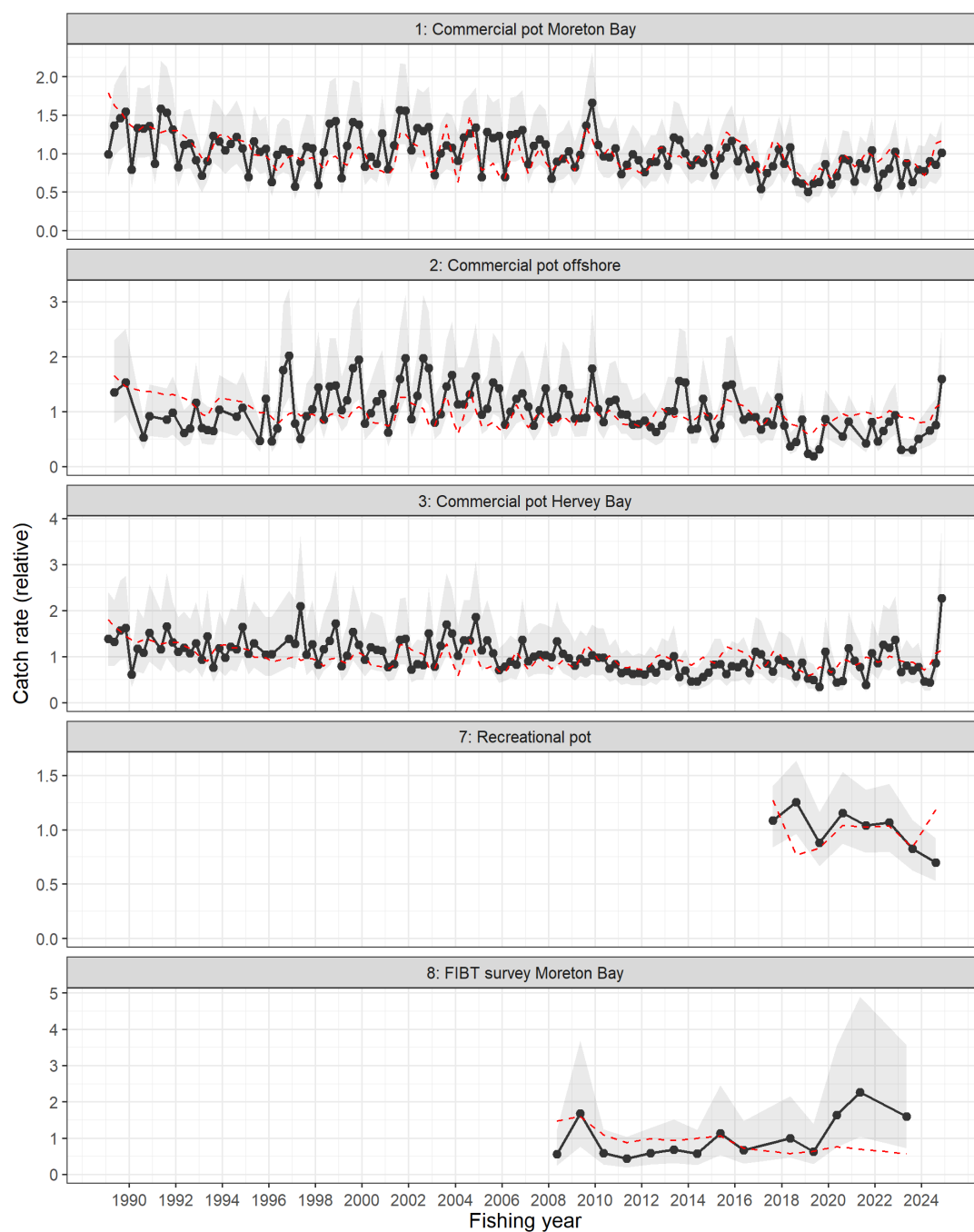


Figure H.136: Analysis 10: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

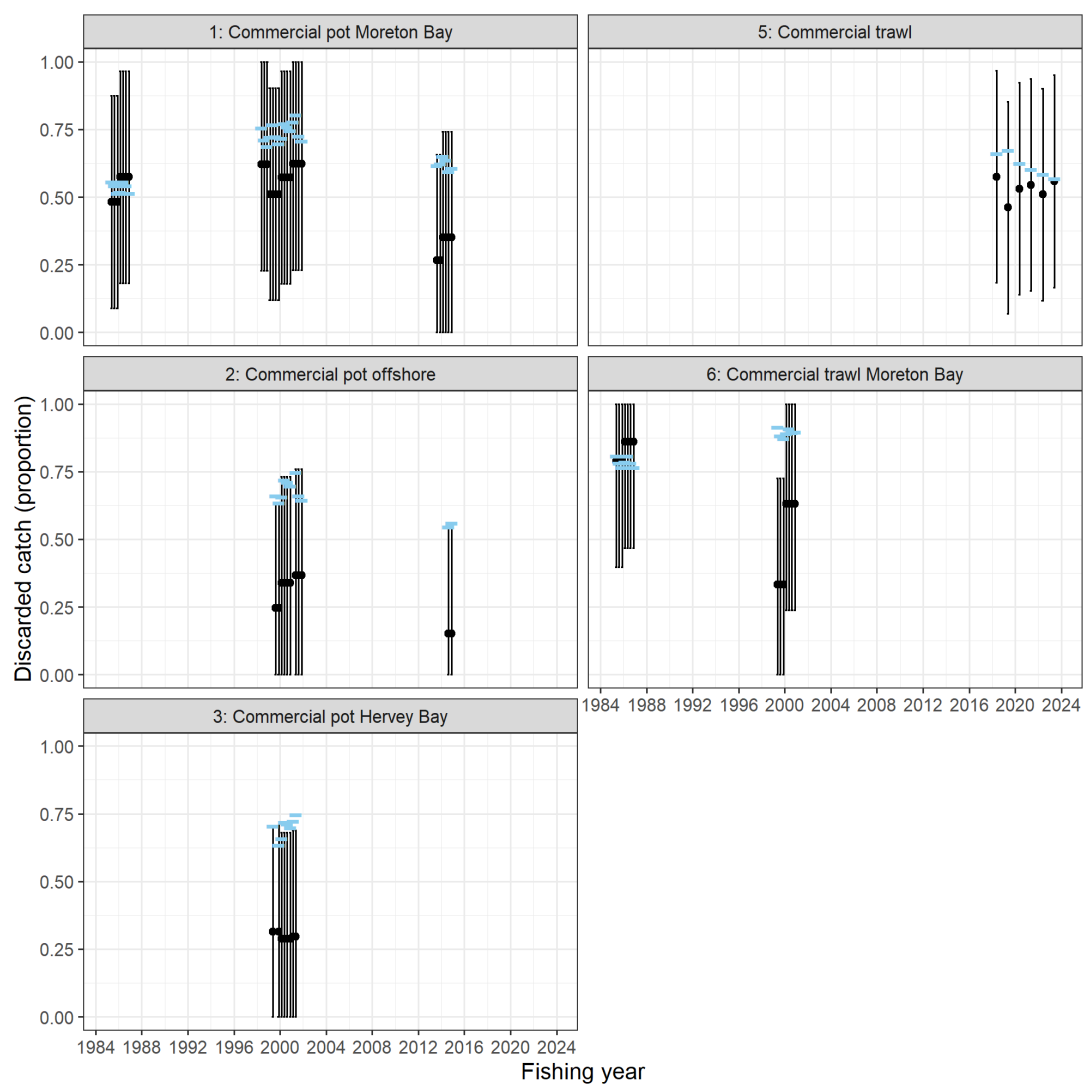


Figure H.137: Analysis 10: Fits to annual discard proportions of blue swimmer crab catch

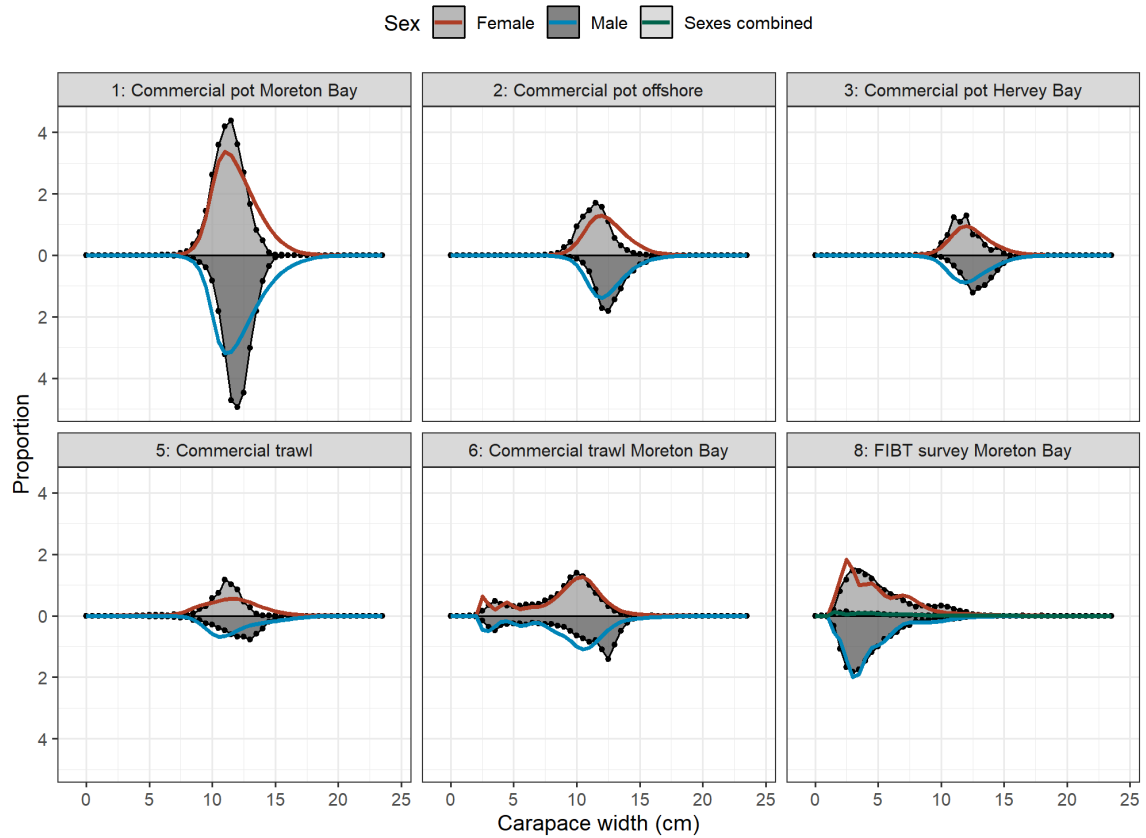


Figure H.138: Analysis 10: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

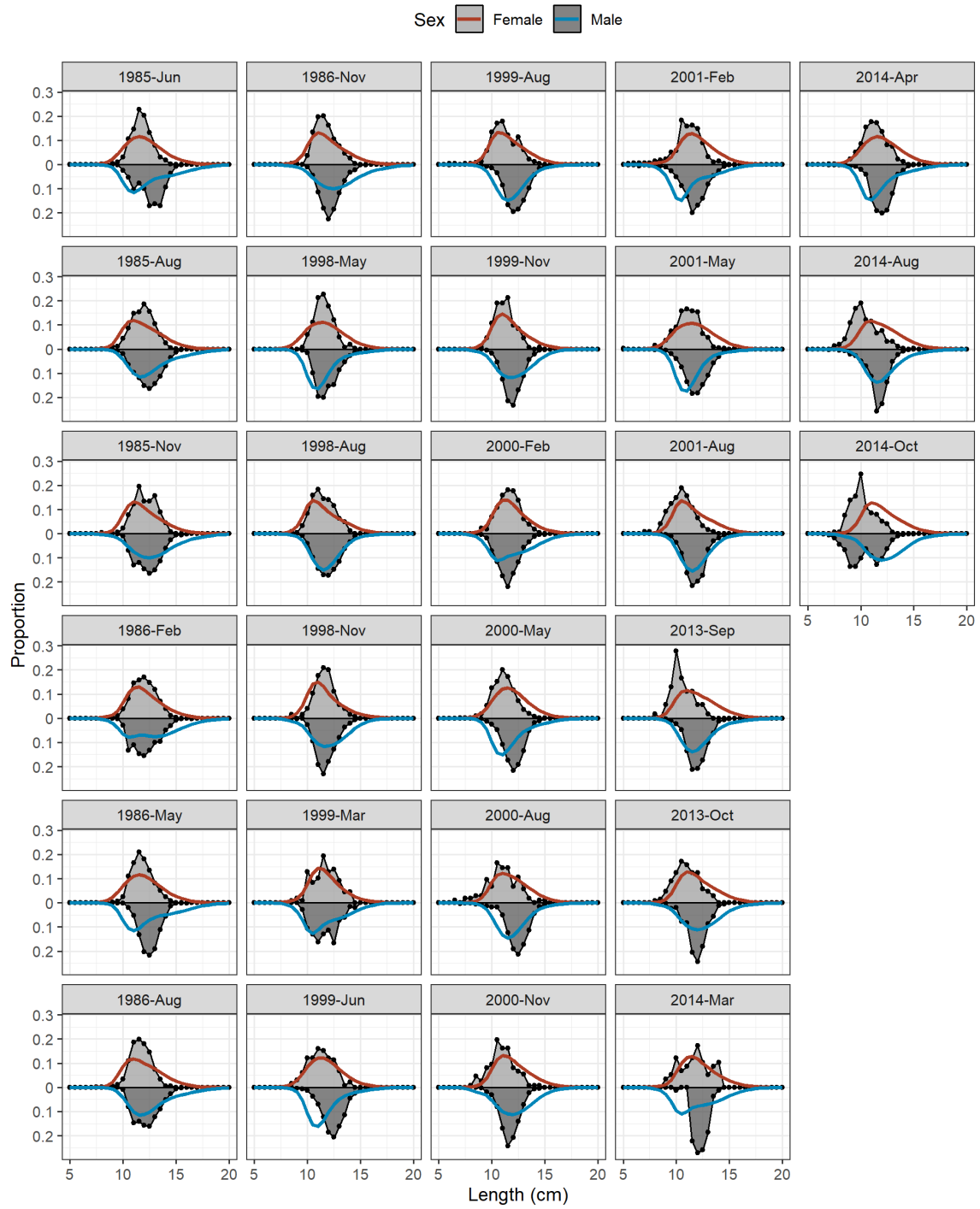


Figure H.139: Analysis 10: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

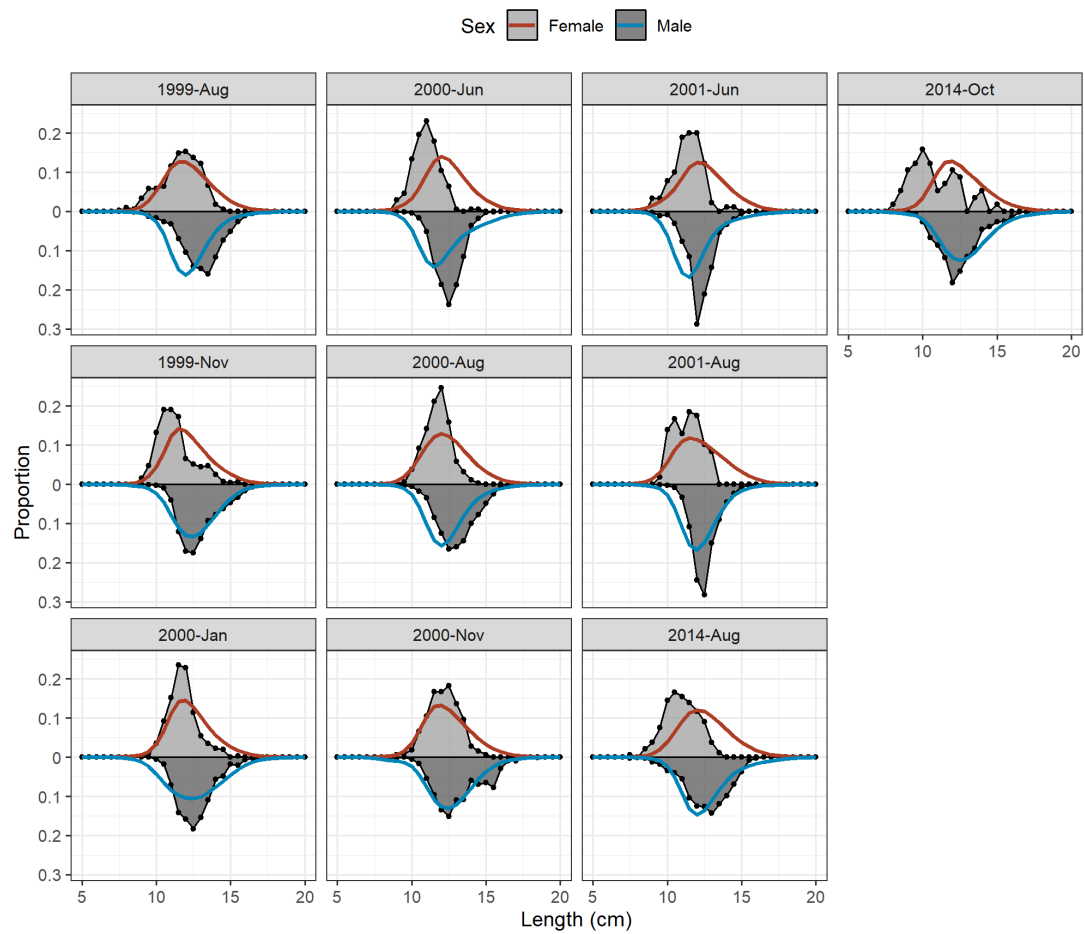


Figure H.140: Analysis 10: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

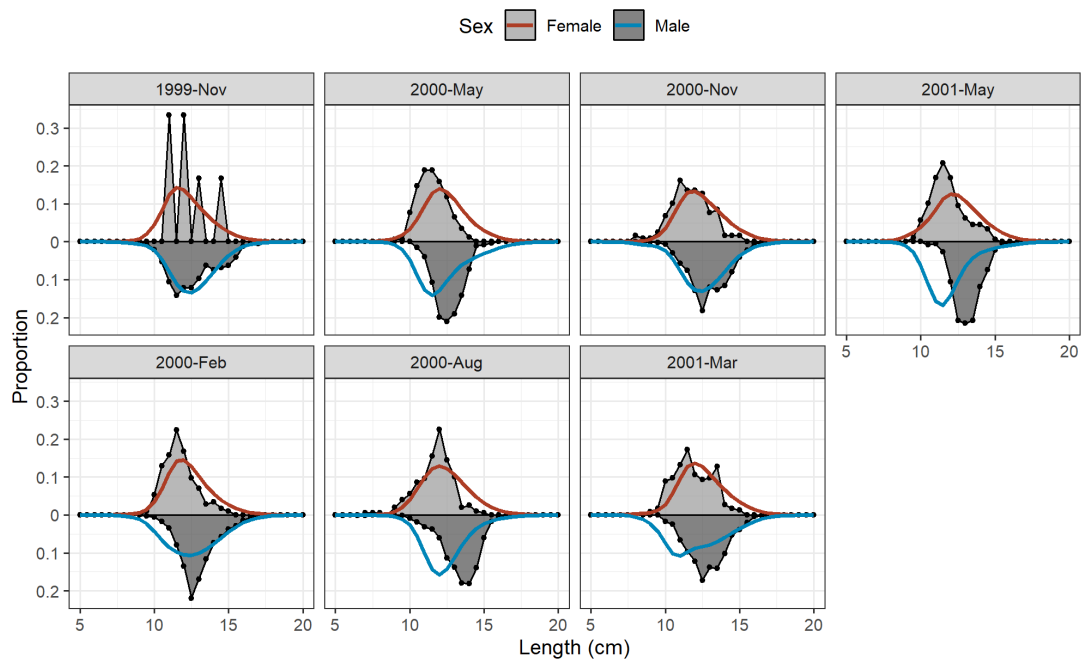


Figure H.141: Analysis 10: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

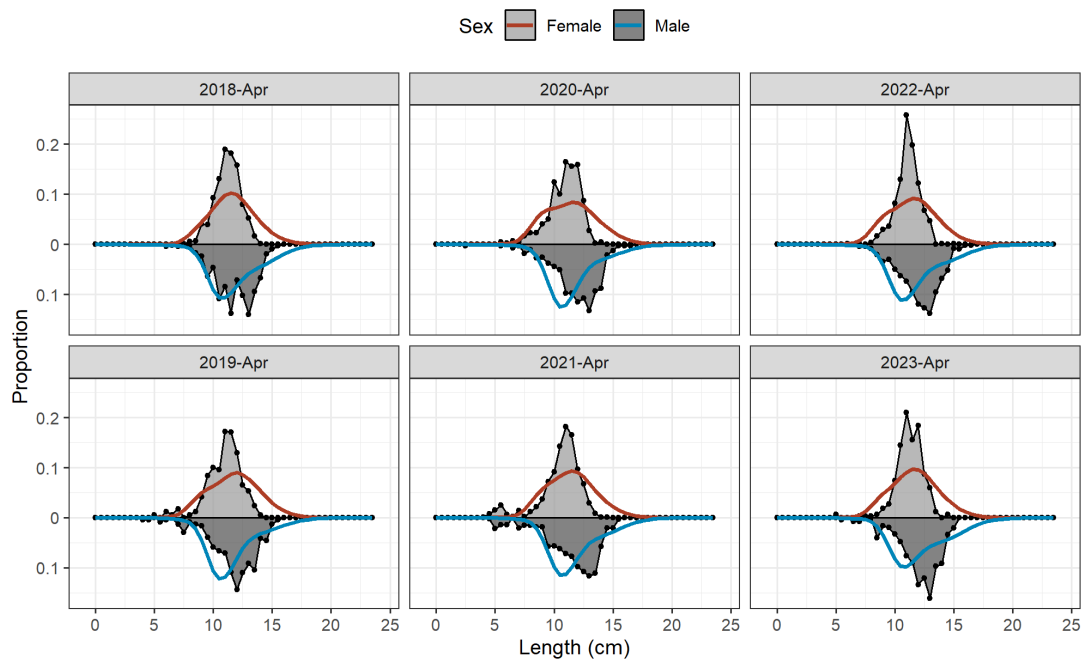


Figure H.142: Analysis 10: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

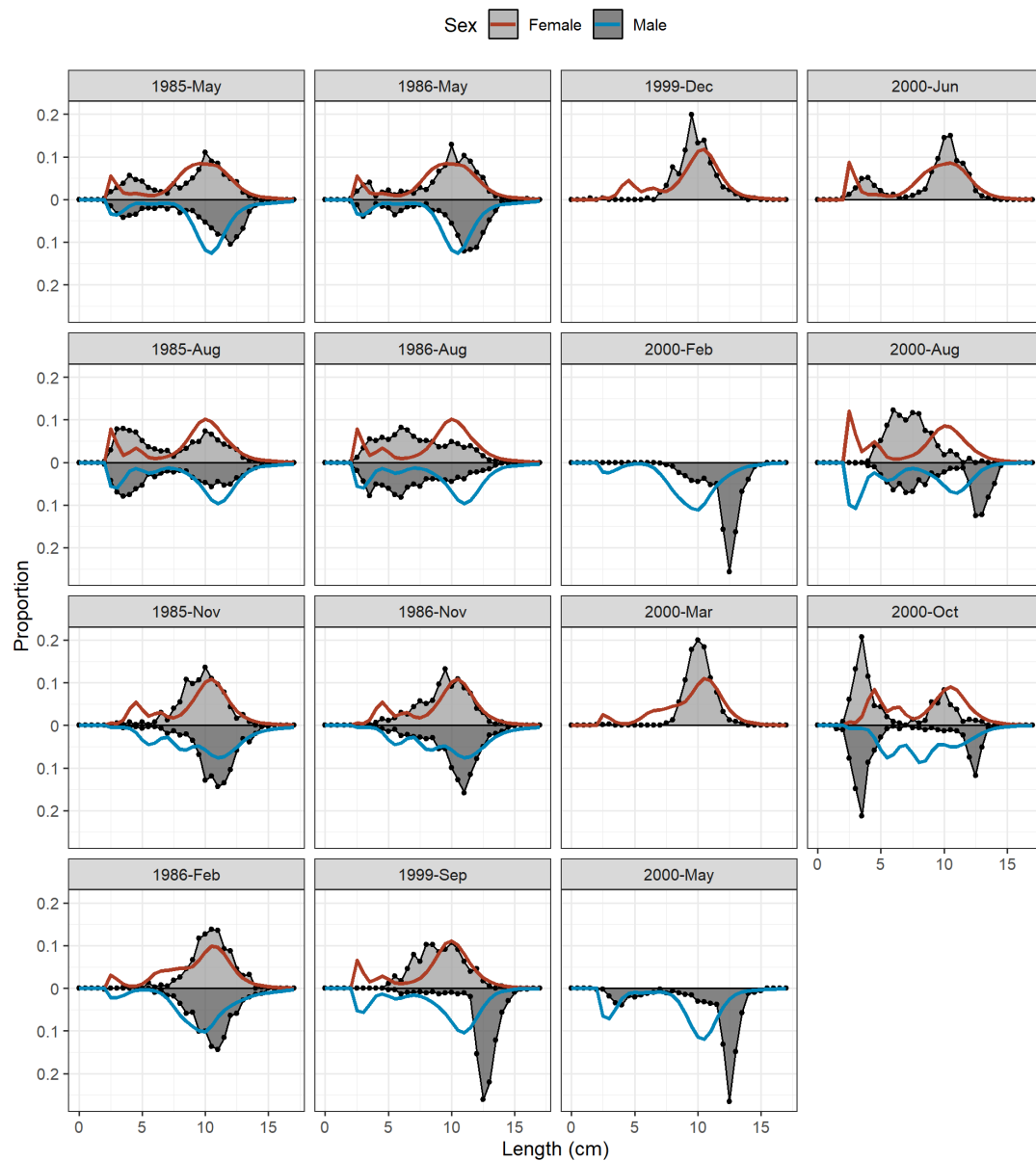


Figure H.143: Analysis 10: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

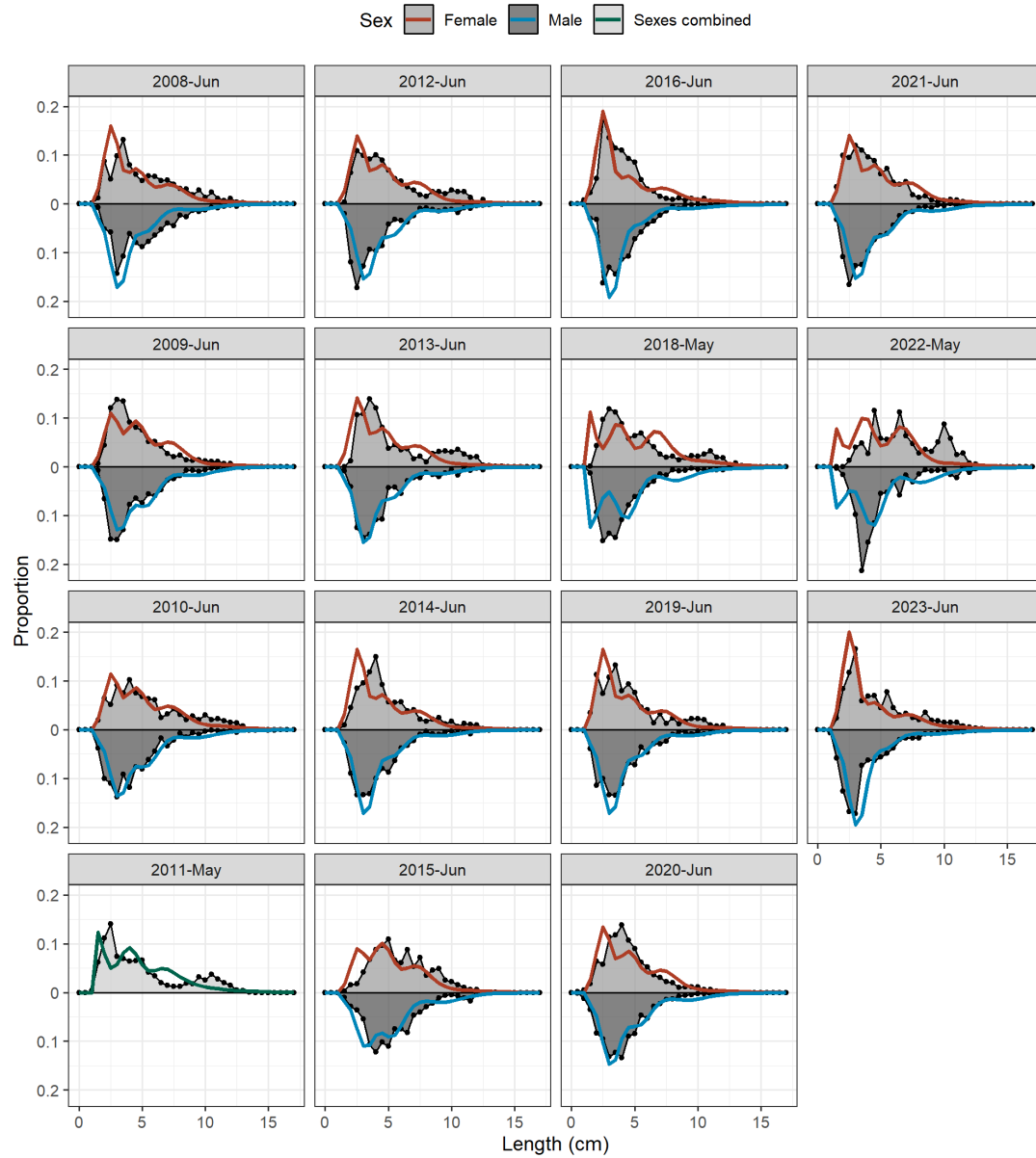


Figure H.144: Analysis 10: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

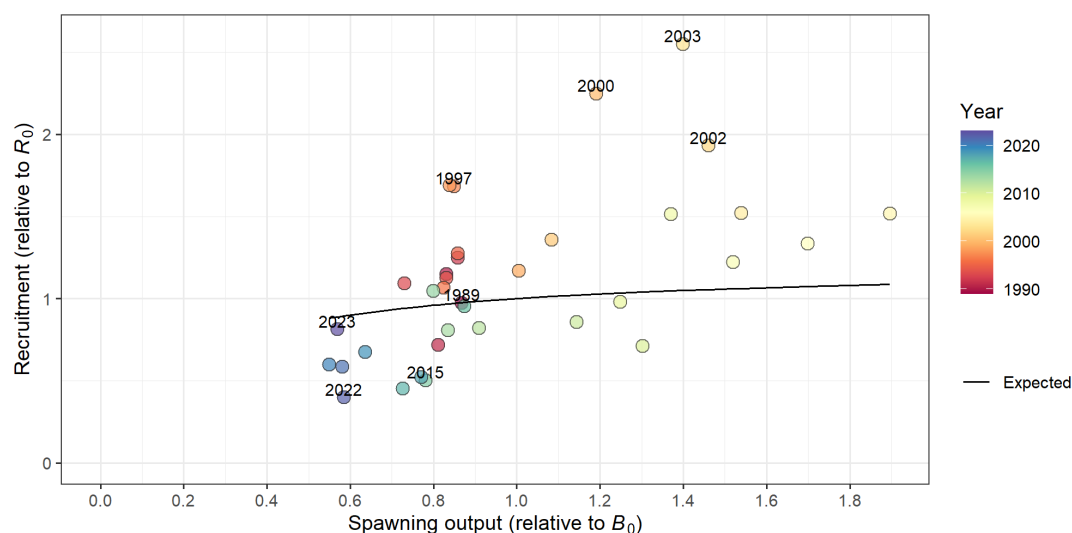


Figure H.145: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 10 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

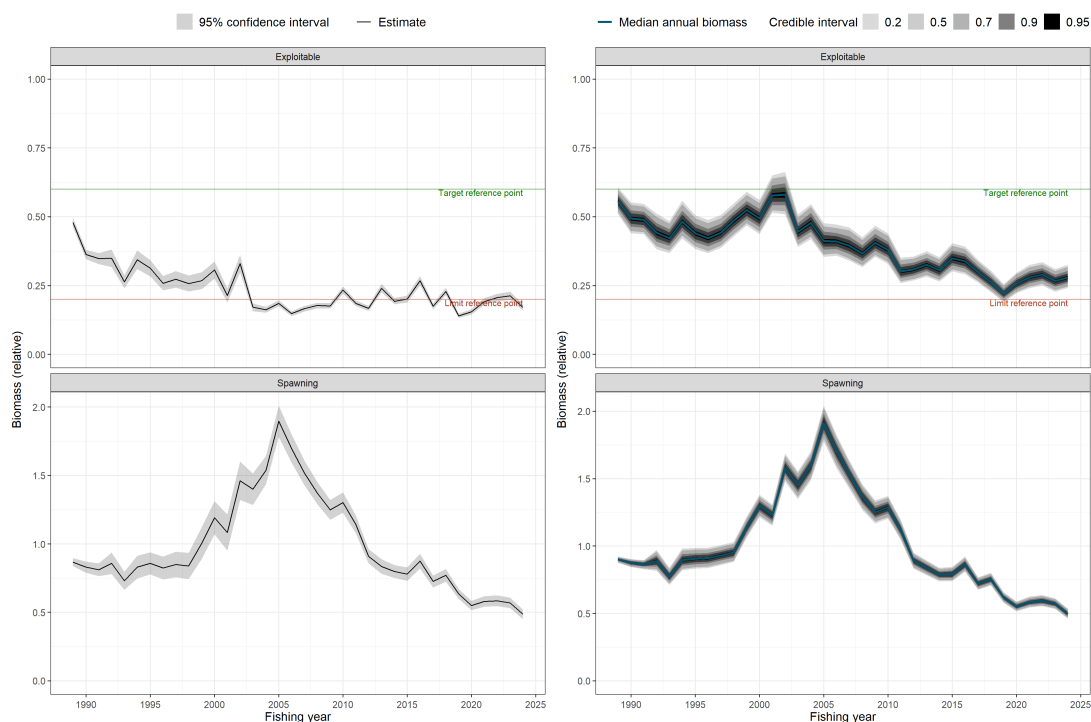


Figure H.146: Analysis 10: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

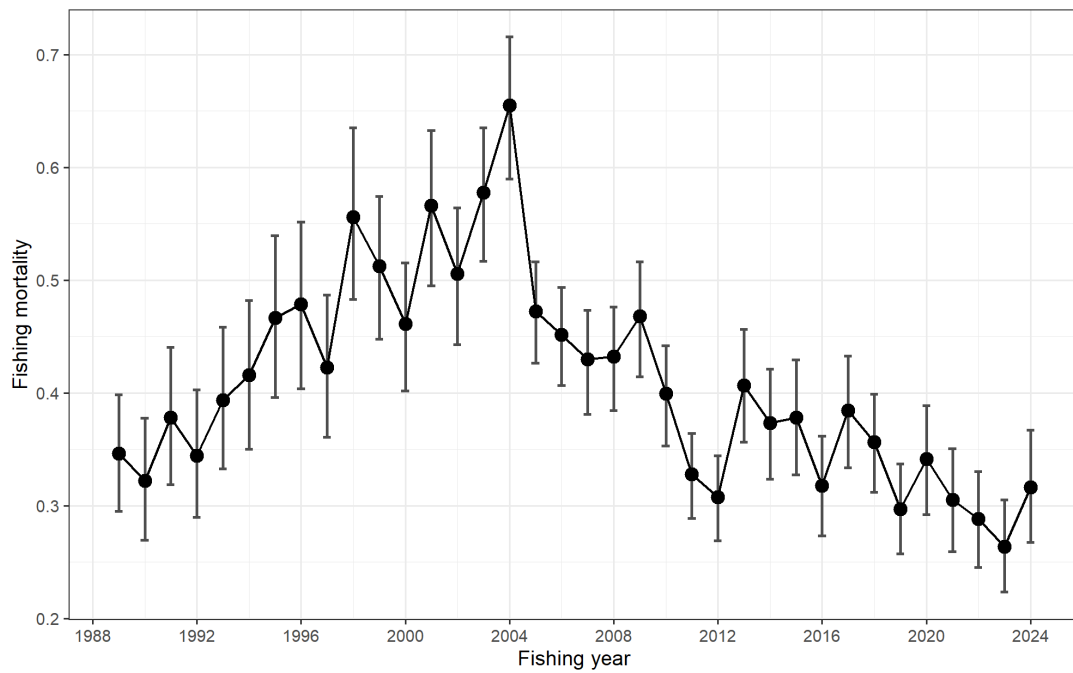


Figure H.147: Analysis 10: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

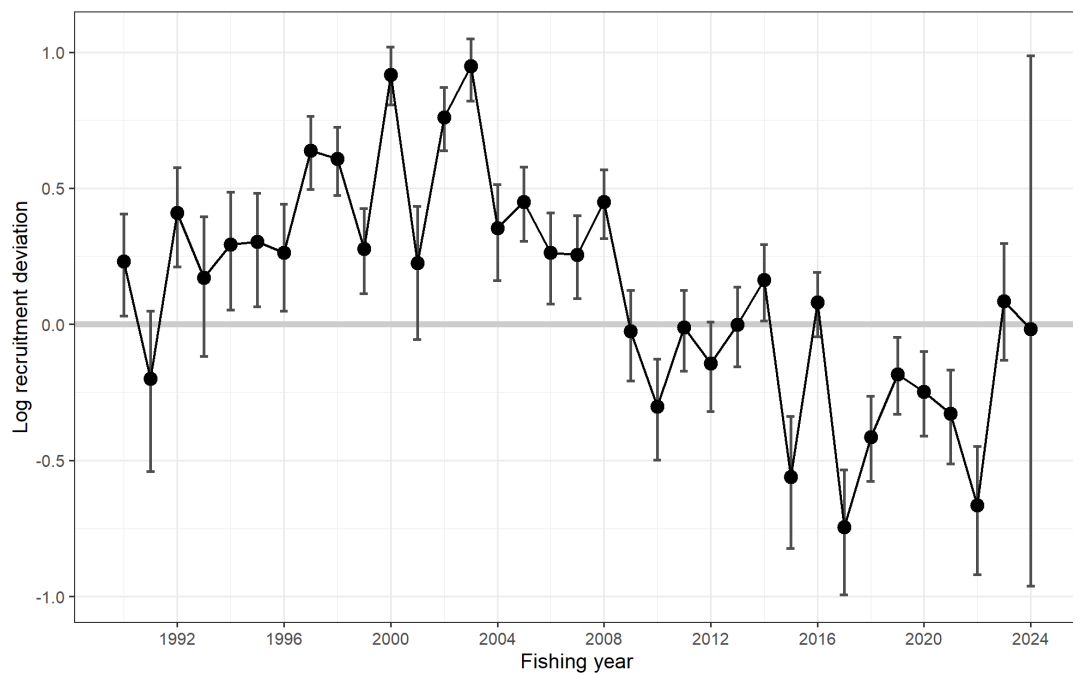


Figure H.148: Analysis 10: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

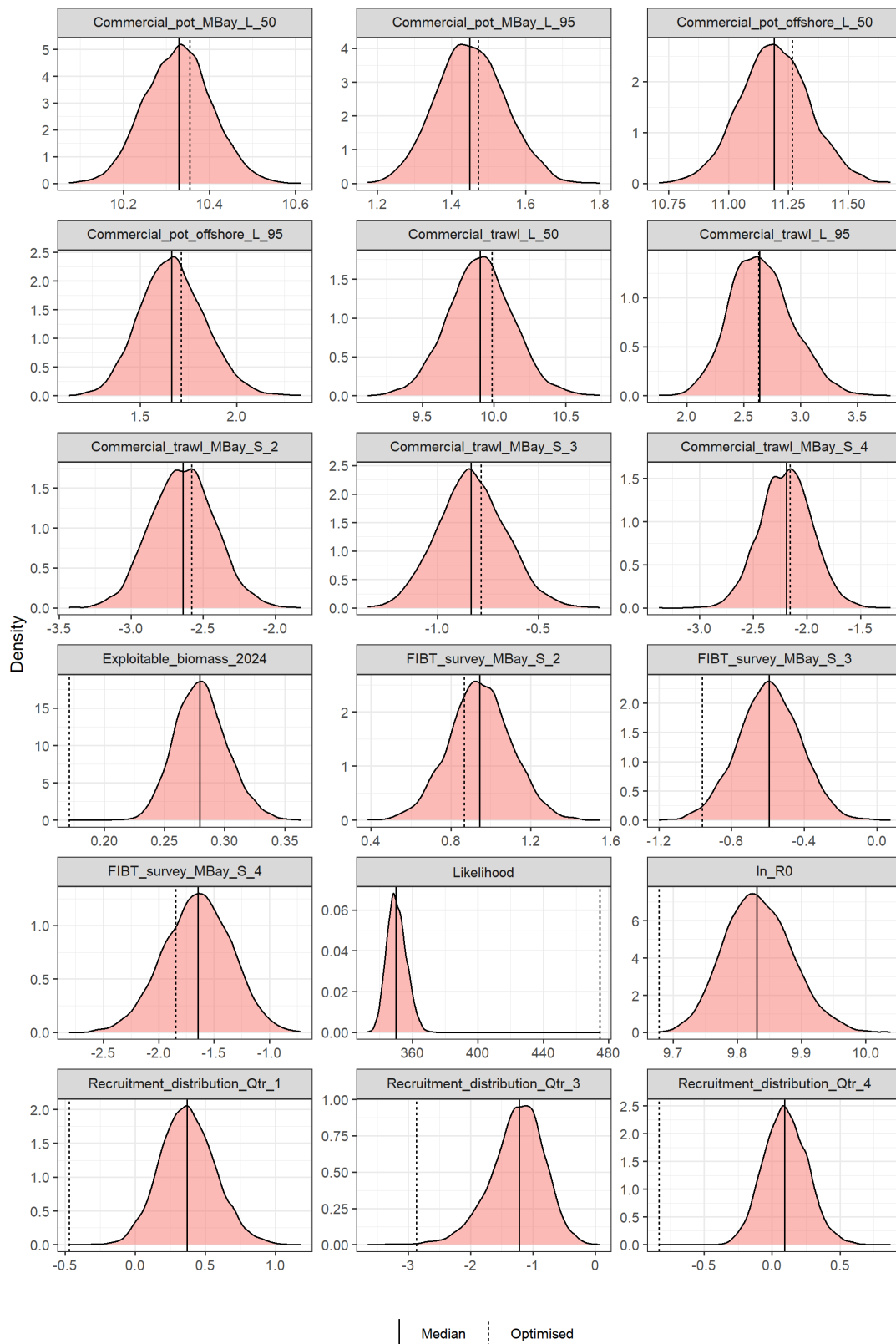


Figure H.149: Analysis 10: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

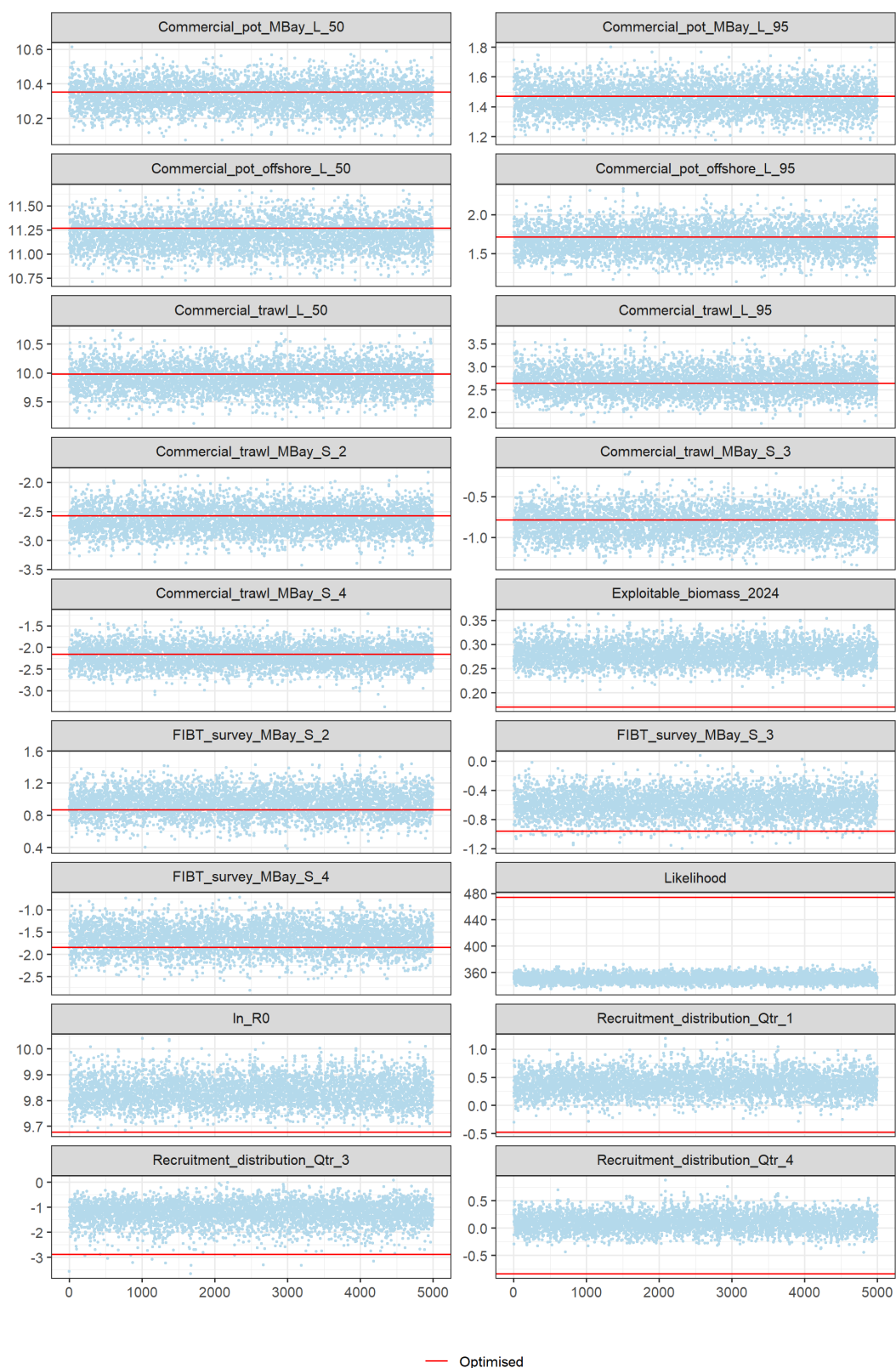


Figure H.150: Analysis 10: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.11 Analysis 11

Table H.21: Summary of MLE parameter estimates for analysis 11

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.52	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.54	2	-5.00	5.00	0.00	0.78
Recruitment distribution Qtr_4	-0.85	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	10.08	1	5.00	20.00	11.00	0.06
Commercial pot MBay L_{50}	10.47	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.49	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.37	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.72	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.24	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.59	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.46	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.54	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.71	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.88	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.82	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.50	3	-9.00	7.00	-1.00	0.30

Table H.22: Summary of MCMC parameter estimates for analysis 11

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.33	-0.04	0.71
Recruitment distribution Qtr_3	-1.18	-2.14	-0.50
Recruitment distribution Qtr_4	0.07	-0.21	0.40
$\ln(R_0)$	10.27	10.15	10.41
Commercial pot MBay L_{50}	10.45	10.30	10.60
Commercial pot MBay L_{95}	1.46	1.30	1.64
Commercial pot offshore L_{50}	11.29	11.03	11.57
Commercial pot offshore L_{95}	1.67	1.36	2.00
Commercial trawl L_{50}	10.17	9.76	10.61
Commercial trawl L_{95}	2.59	2.13	3.17
Commercial trawl MBay S_2	-2.52	-2.94	-2.10
Commercial trawl MBay S_3	-0.58	-0.91	-0.23
Commercial trawl MBay S_4	-1.74	-2.21	-1.26
FIBT survey MBay S_2	0.96	0.66	1.26
FIBT survey MBay S_3	-0.44	-0.77	-0.11
FIBT survey MBay S_4	-1.28	-1.88	-0.72

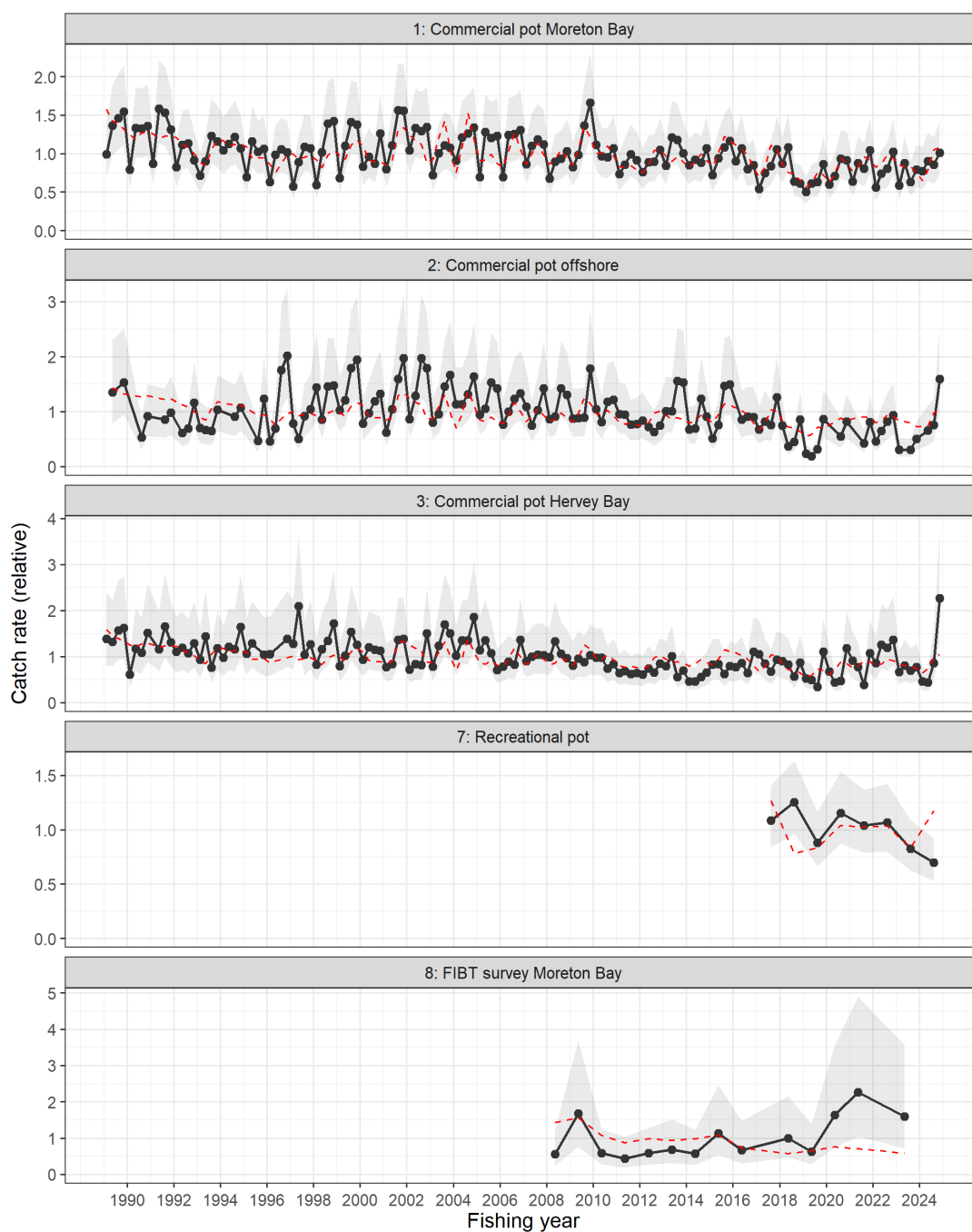


Figure H.151: Analysis 11: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

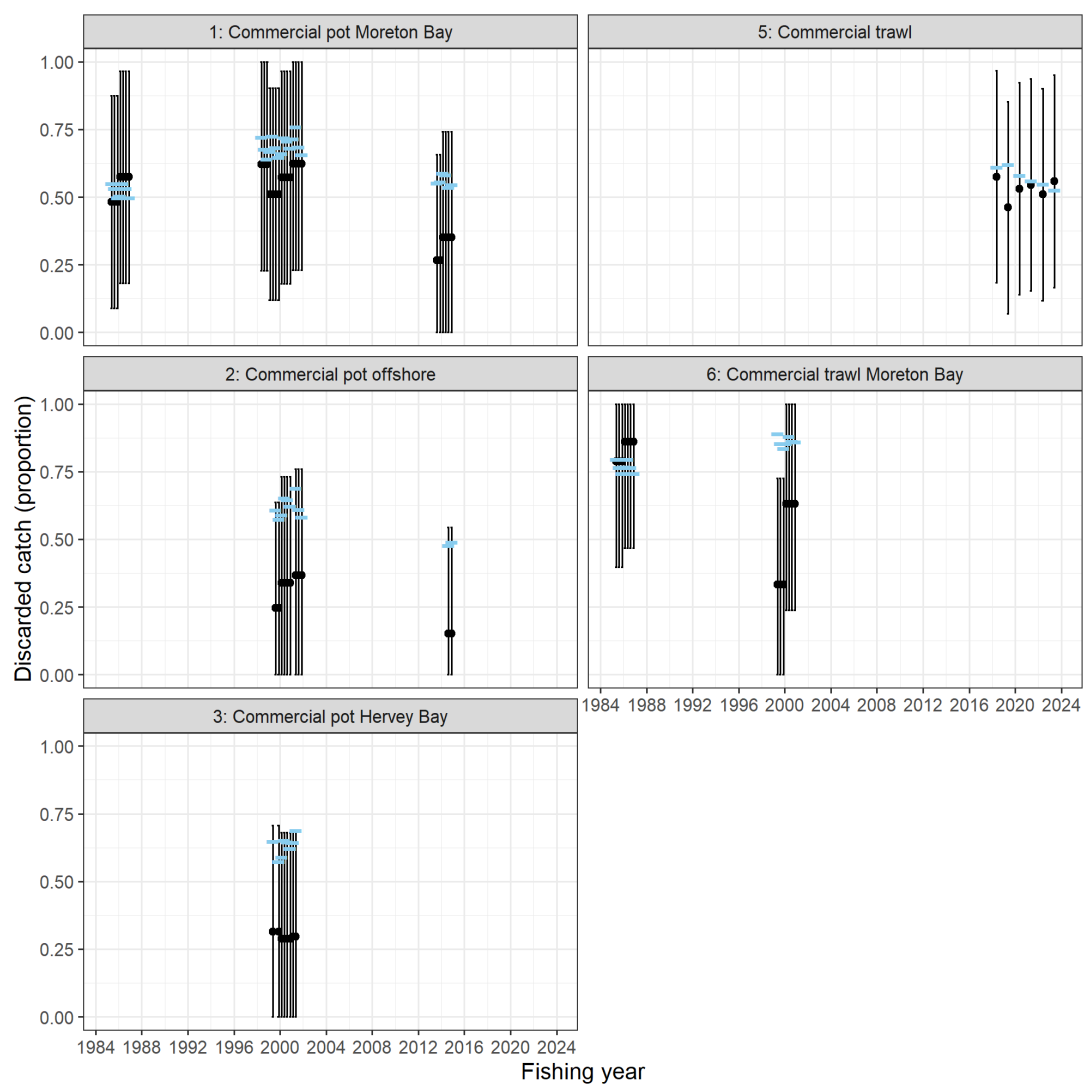


Figure H.152: Analysis 11: Fits to annual discard proportions of blue swimmer crab catch

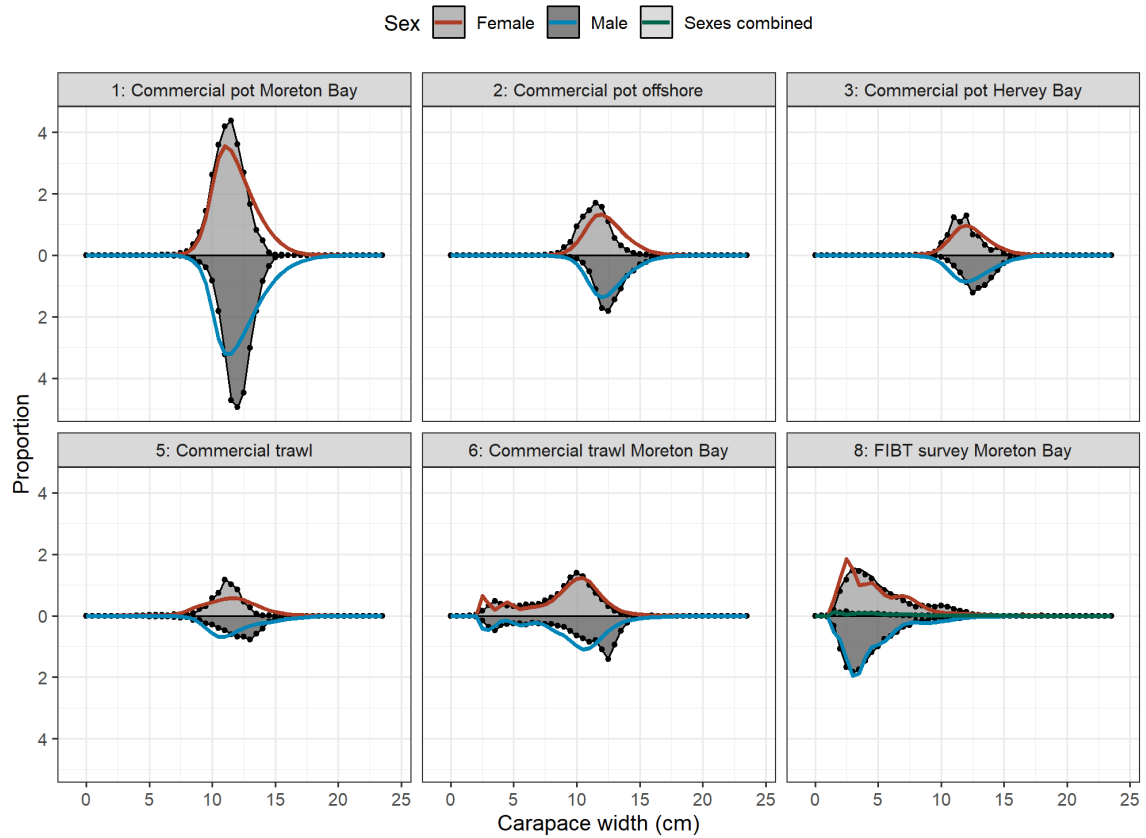


Figure H.153: Analysis 11: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

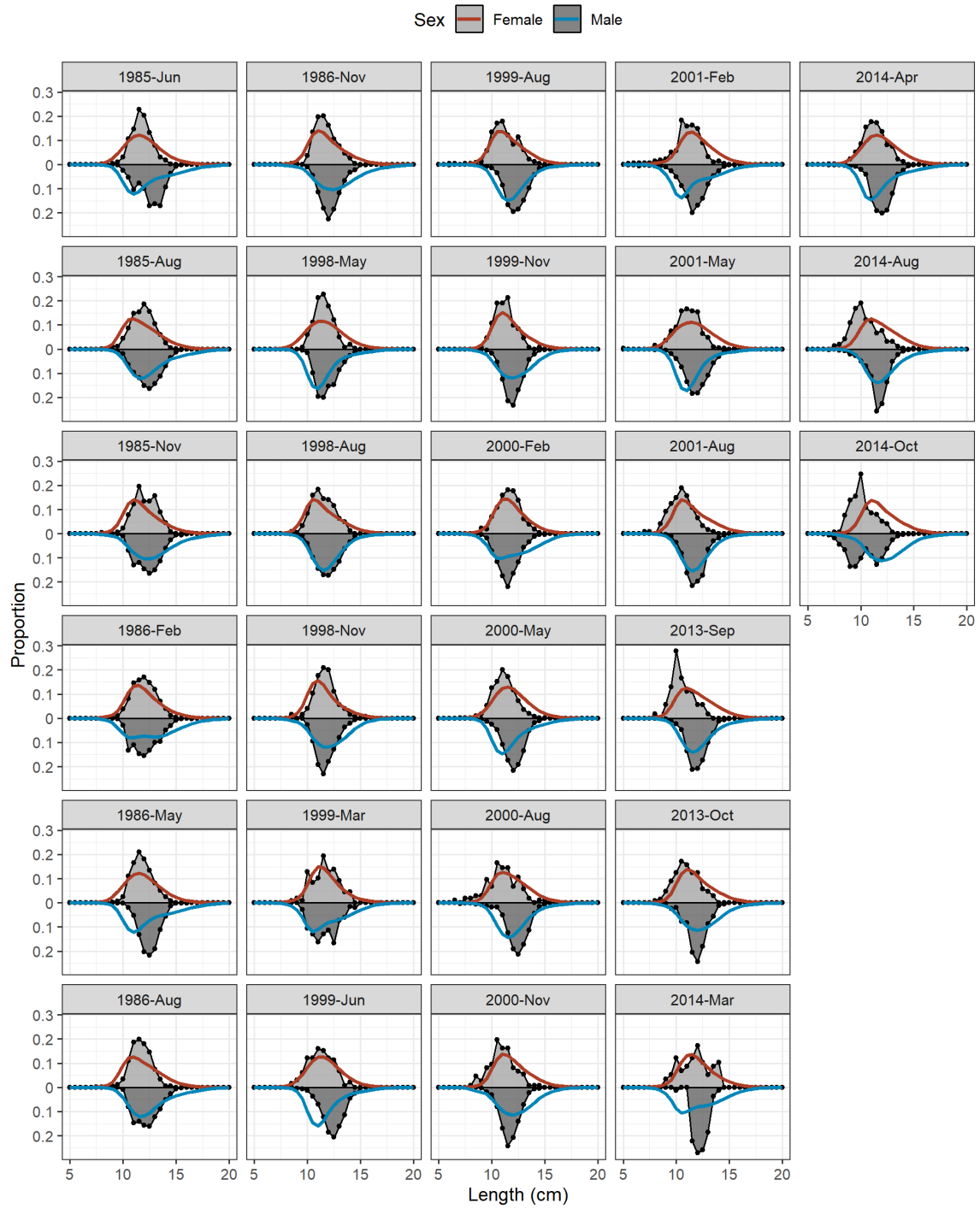


Figure H.154: Analysis 11: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

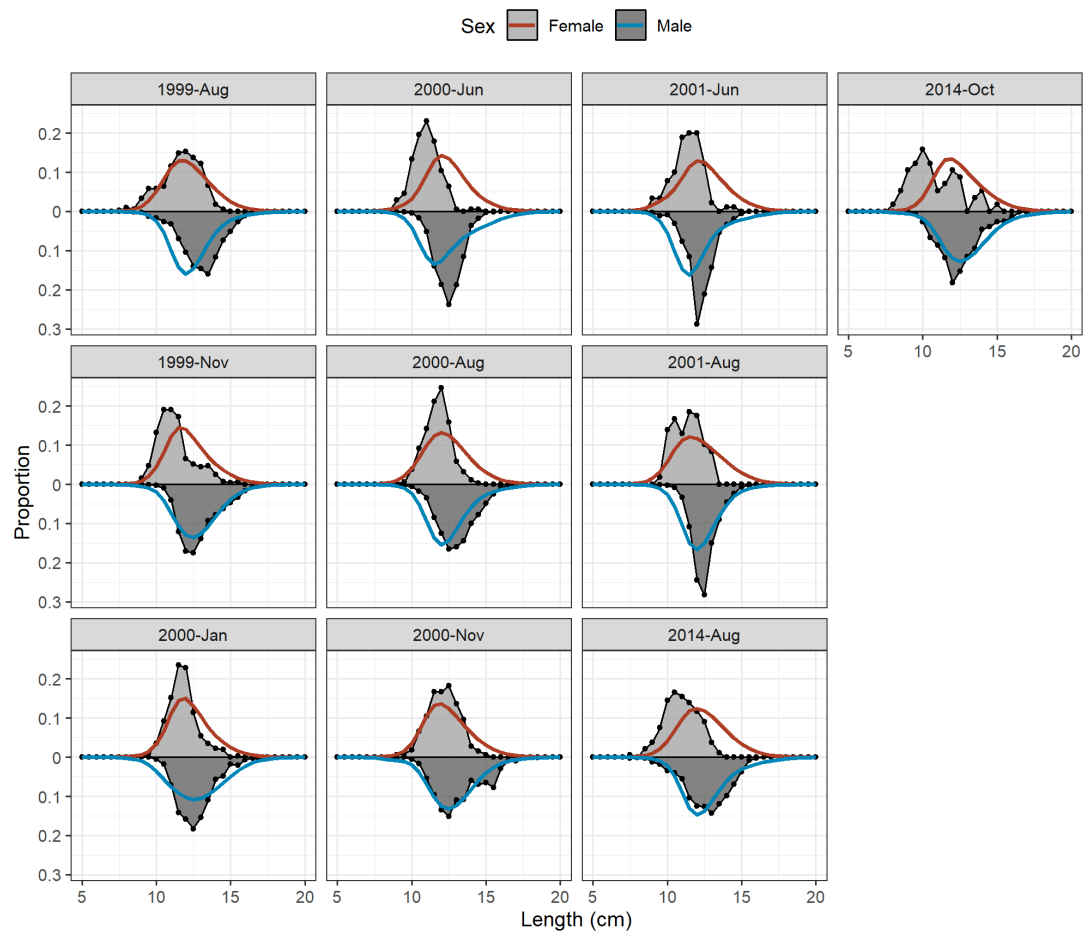


Figure H.155: Analysis 11: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

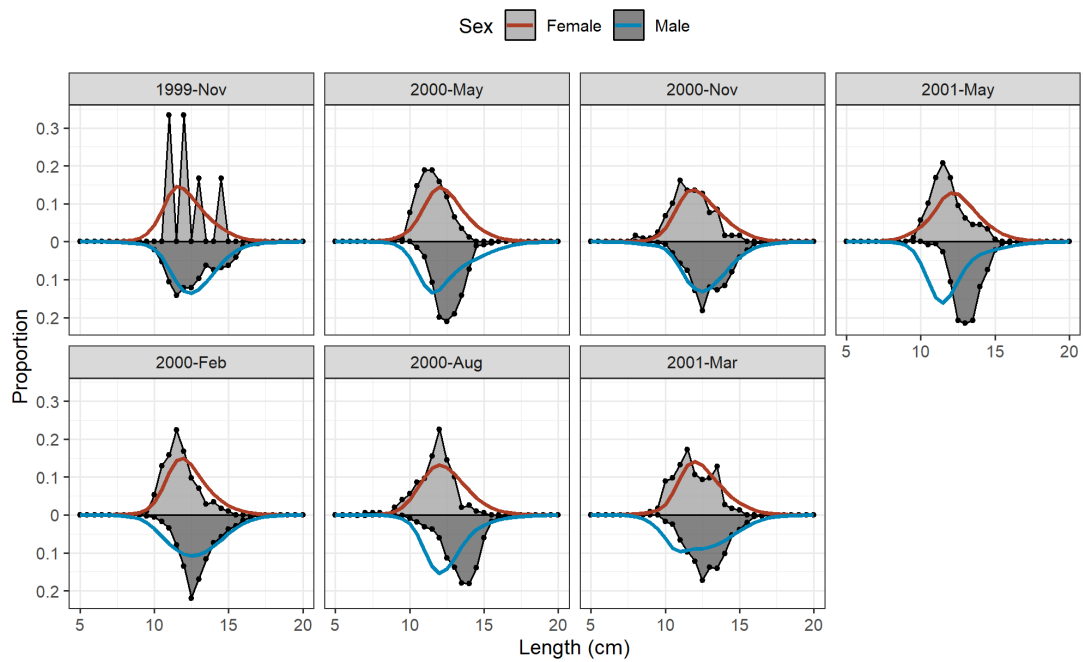


Figure H.156: Analysis 11: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

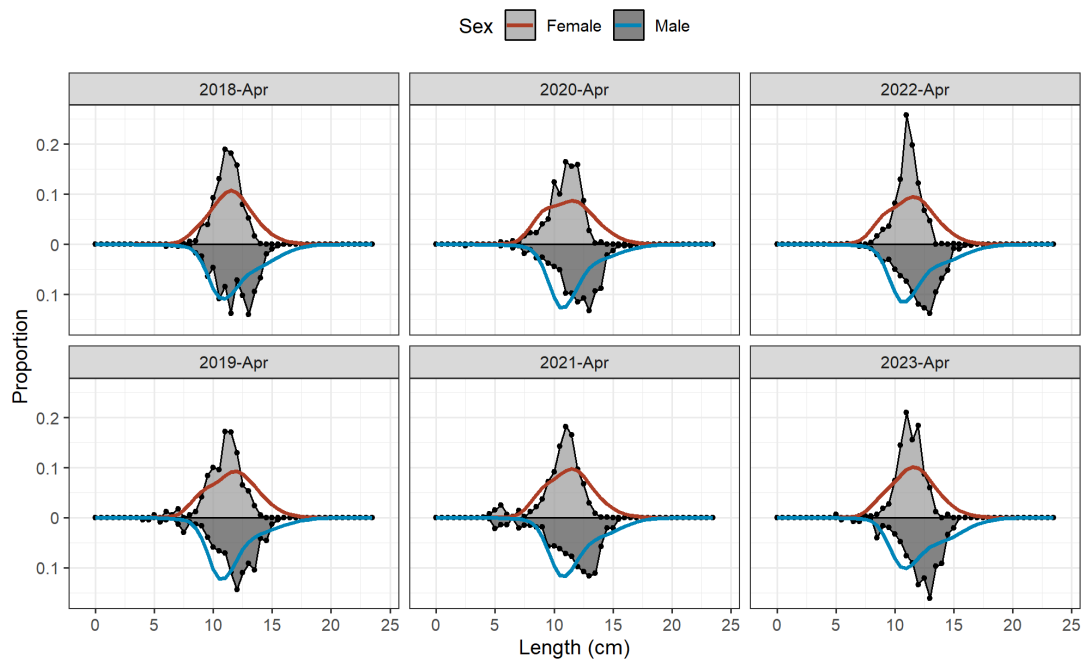


Figure H.157: Analysis 11: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

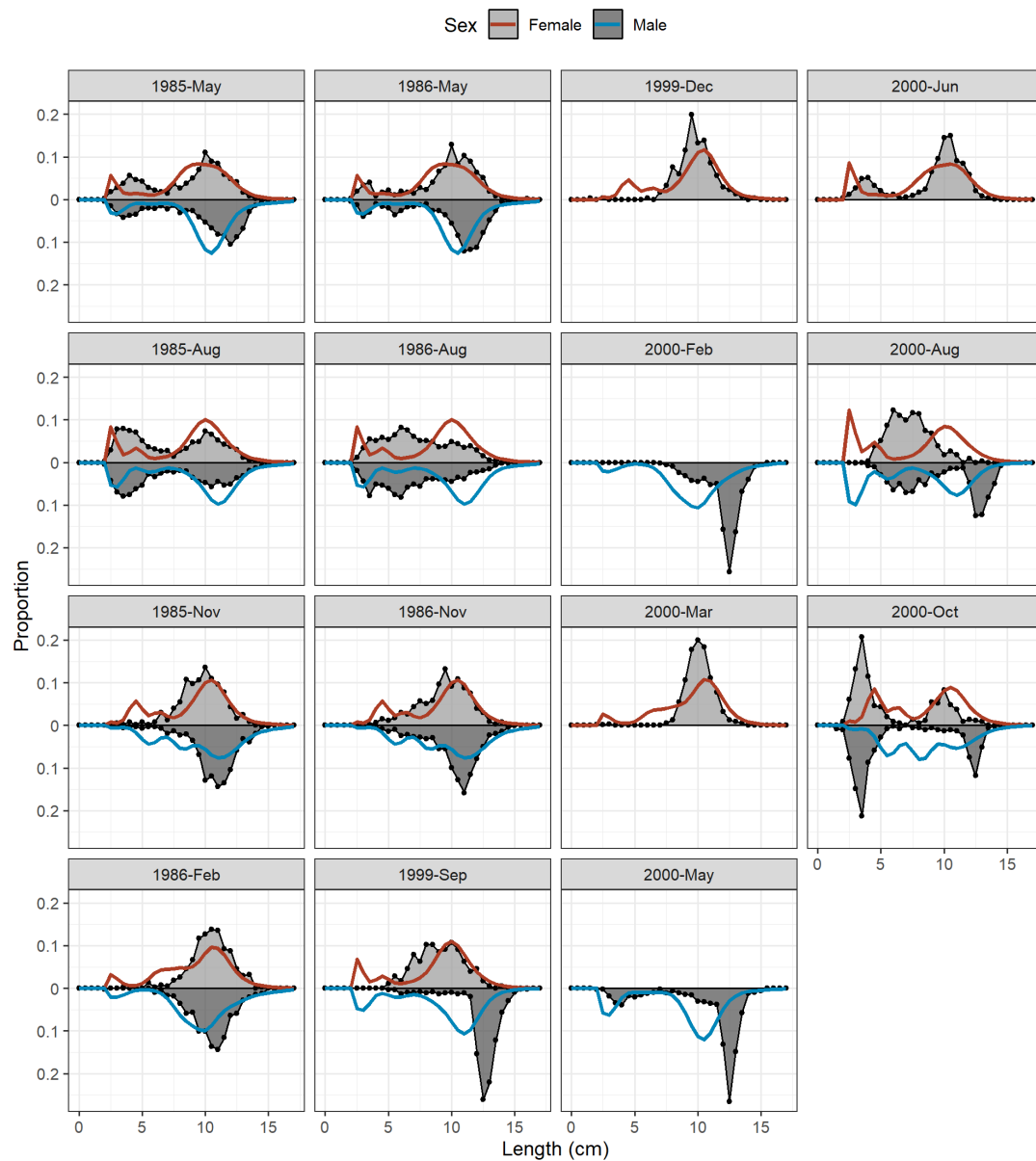


Figure H.158: Analysis 11: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

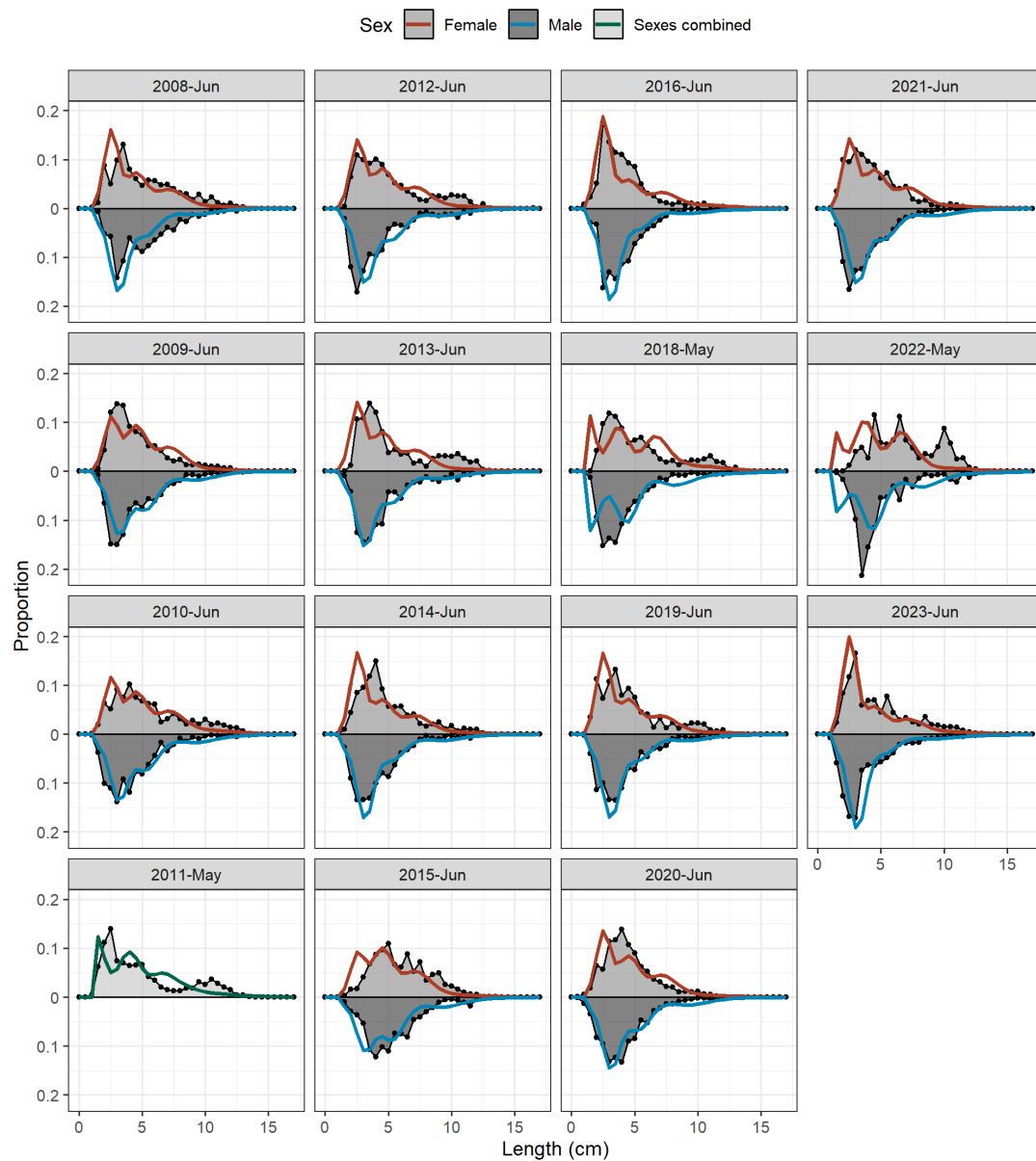


Figure H.159: Analysis 11: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

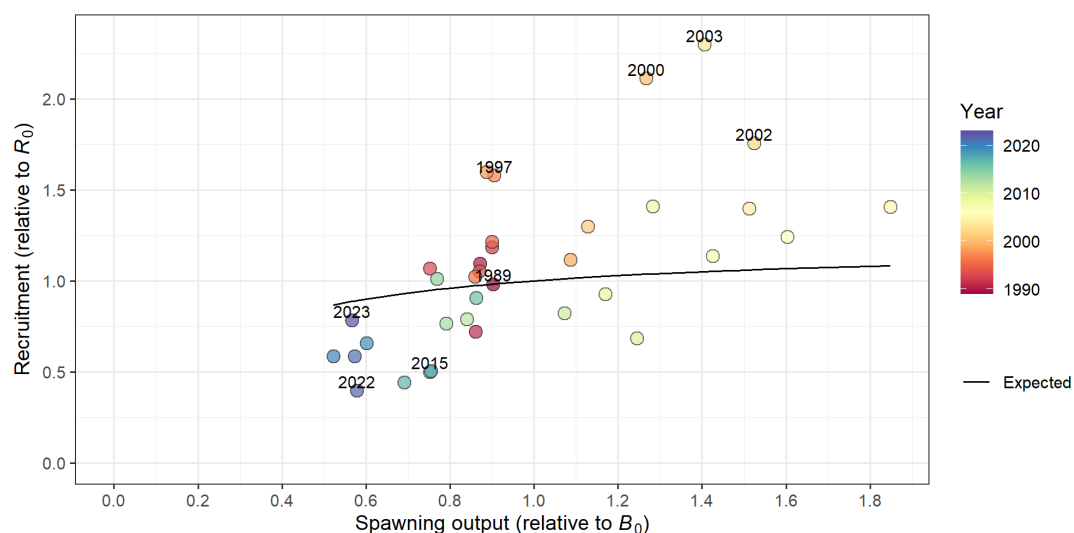


Figure H.160: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 11 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

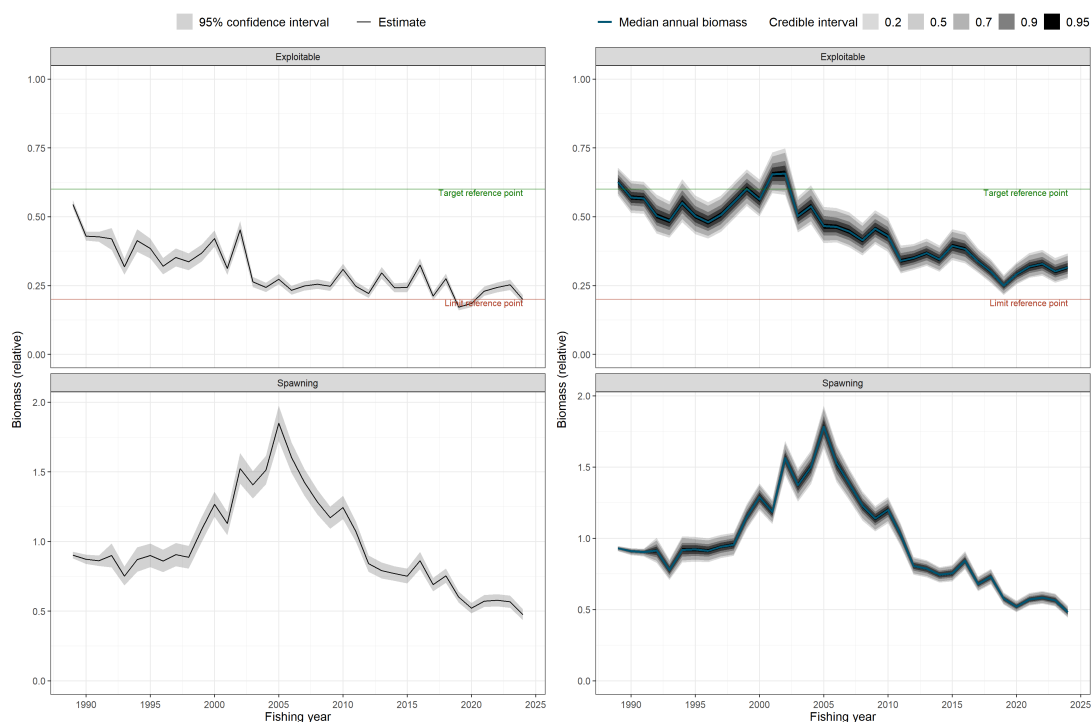


Figure H.161: Analysis 11: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

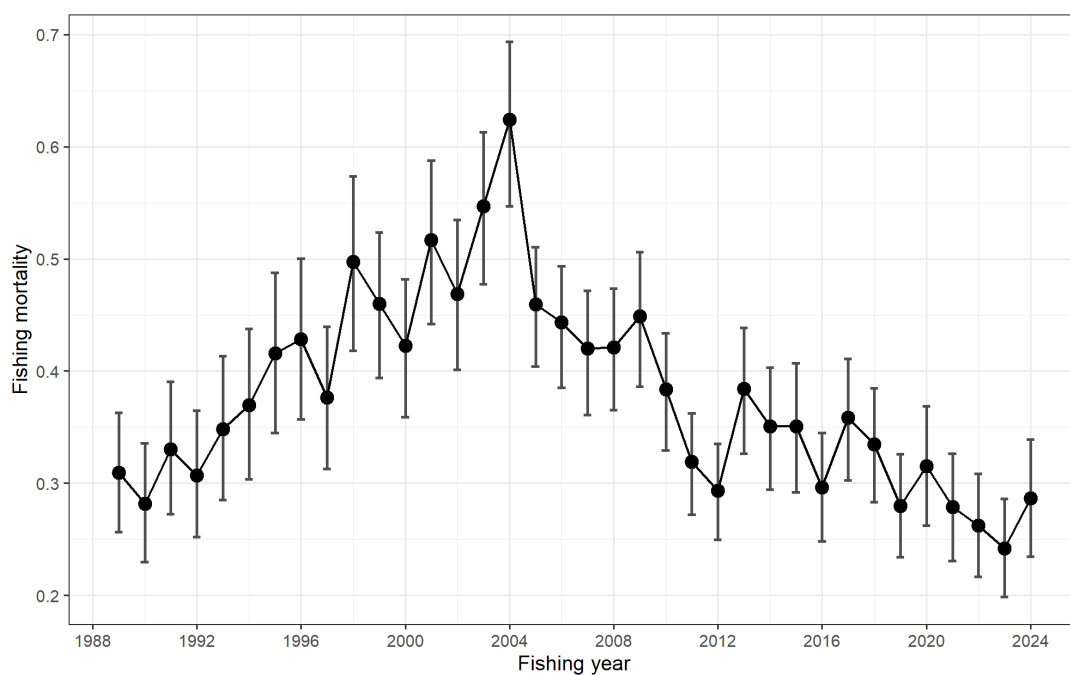


Figure H.162: Analysis 11: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

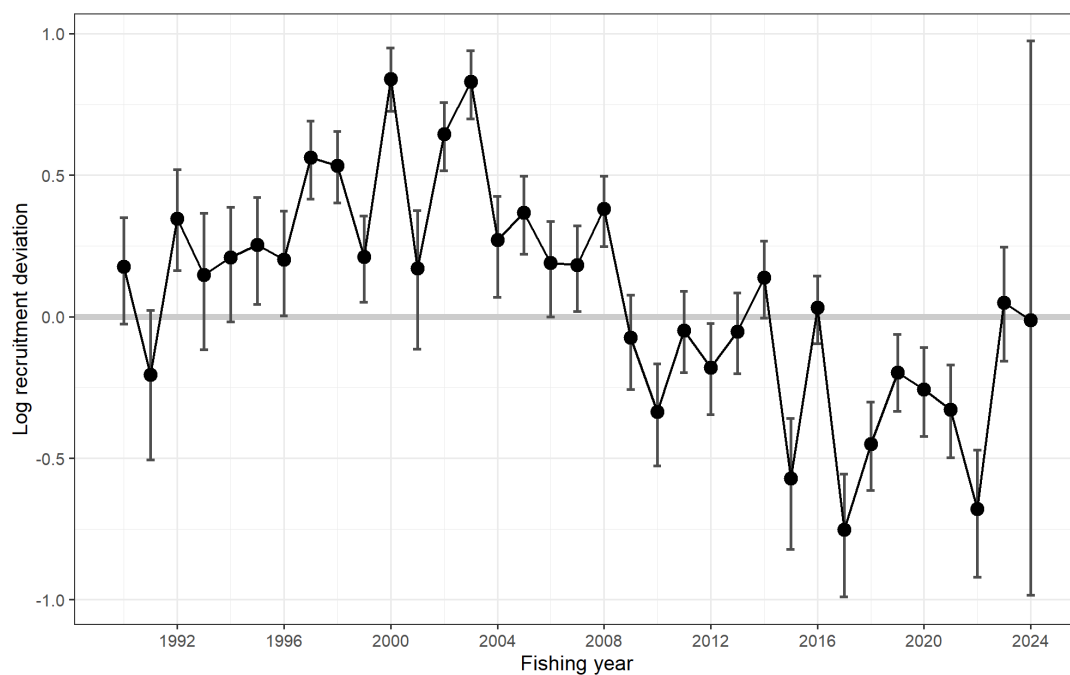


Figure H.163: Analysis 11: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

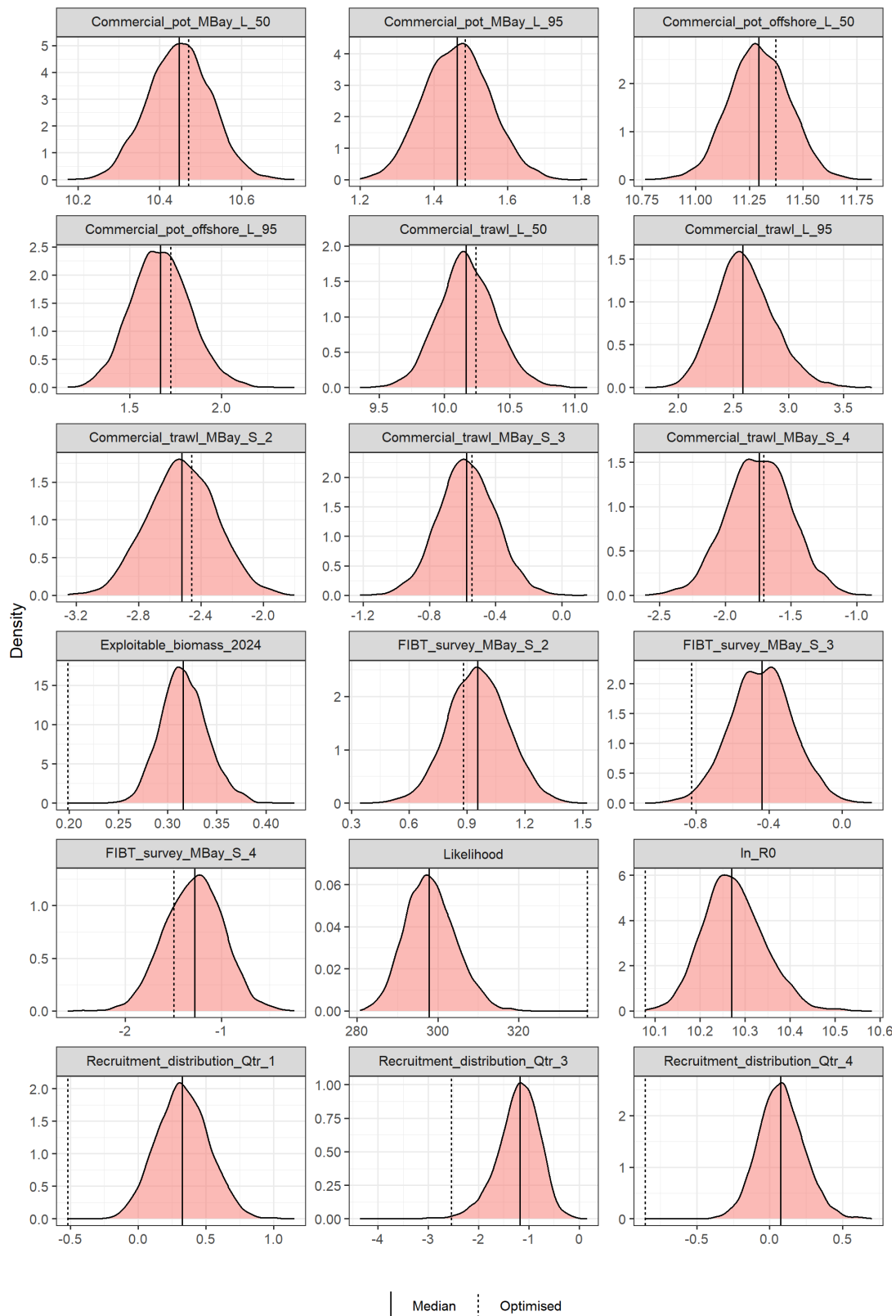


Figure H.164: Analysis 11: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

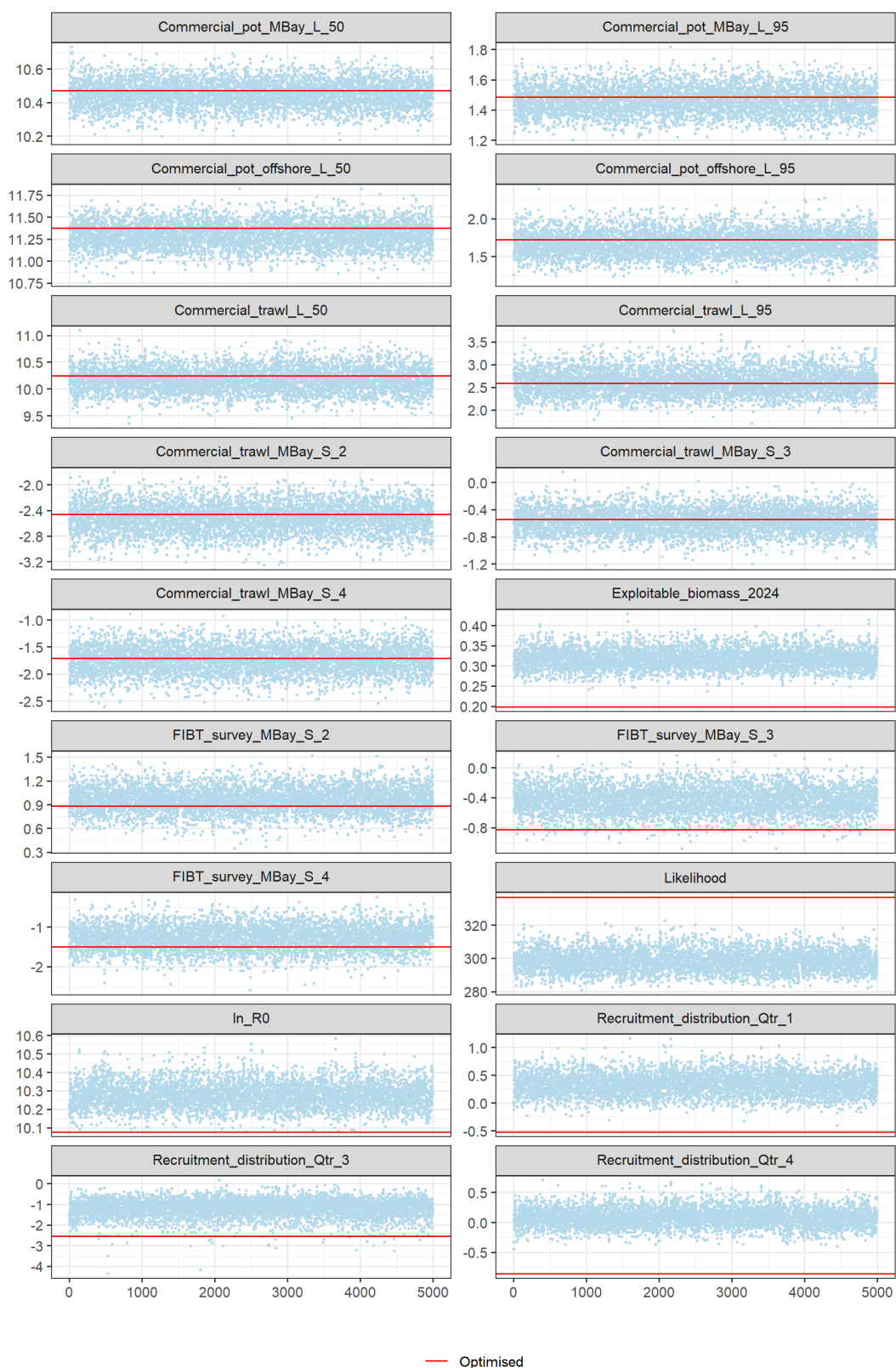


Figure H.165: Analysis 11: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.12 Analysis 12

Table H.23: Summary of MLE parameter estimates for analysis 12

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.55	2	-5.00	5.00	0.00	0.18
Recruitment distribution Qtr_3	-2.25	2	-5.00	5.00	0.00	0.62
Recruitment distribution Qtr_4	-0.87	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	10.47	1	5.00	20.00	11.00	0.07
Commercial pot MBay L_{50}	10.57	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.49	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.47	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.72	3	0.10	20.00	1.50	0.15
Commercial trawl L_{50}	10.45	3	0.10	20.00	9.00	0.20
Commercial trawl L_{95}	2.54	3	0.10	20.00	2.20	0.23
Commercial trawl MBay S_2	-2.35	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.30	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.30	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.90	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.69	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.17	3	-9.00	7.00	-1.00	0.30

Table H.24: Summary of MCMC parameter estimates for analysis 12

Parameter	MCMC median	MCMC 2.5%	MCMC 97.5%
Recruitment distribution Qtr_1	0.29	-0.07	0.68
Recruitment distribution Qtr_3	-1.14	-2.07	-0.46
Recruitment distribution Qtr_4	0.06	-0.22	0.38
$\ln(R_0)$	10.71	10.56	10.89
Commercial pot MBay L_{50}	10.56	10.41	10.71
Commercial pot MBay L_{95}	1.47	1.32	1.65
Commercial pot offshore L_{50}	11.39	11.13	11.67
Commercial pot offshore L_{95}	1.67	1.40	1.97
Commercial trawl L_{50}	10.39	9.98	10.81
Commercial trawl L_{95}	2.53	2.10	3.03
Commercial trawl MBay S_2	-2.41	-2.83	-1.96
Commercial trawl MBay S_3	-0.33	-0.66	0.02
Commercial trawl MBay S_4	-1.33	-1.80	-0.84
FIBT survey MBay S_2	0.98	0.67	1.27
FIBT survey MBay S_3	-0.29	-0.62	0.05
FIBT survey MBay S_4	-0.93	-1.52	-0.36

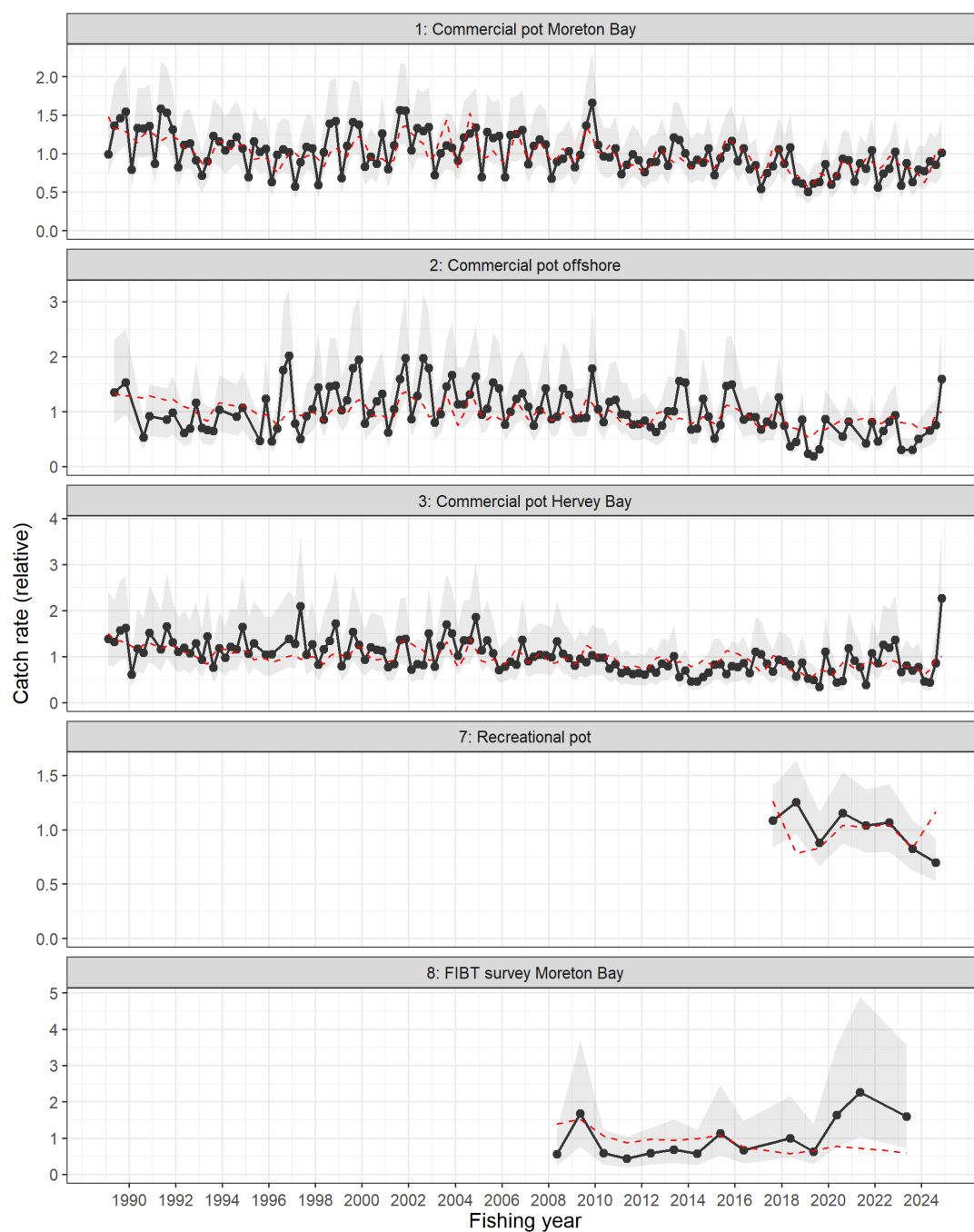


Figure H.166: Analysis 12: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

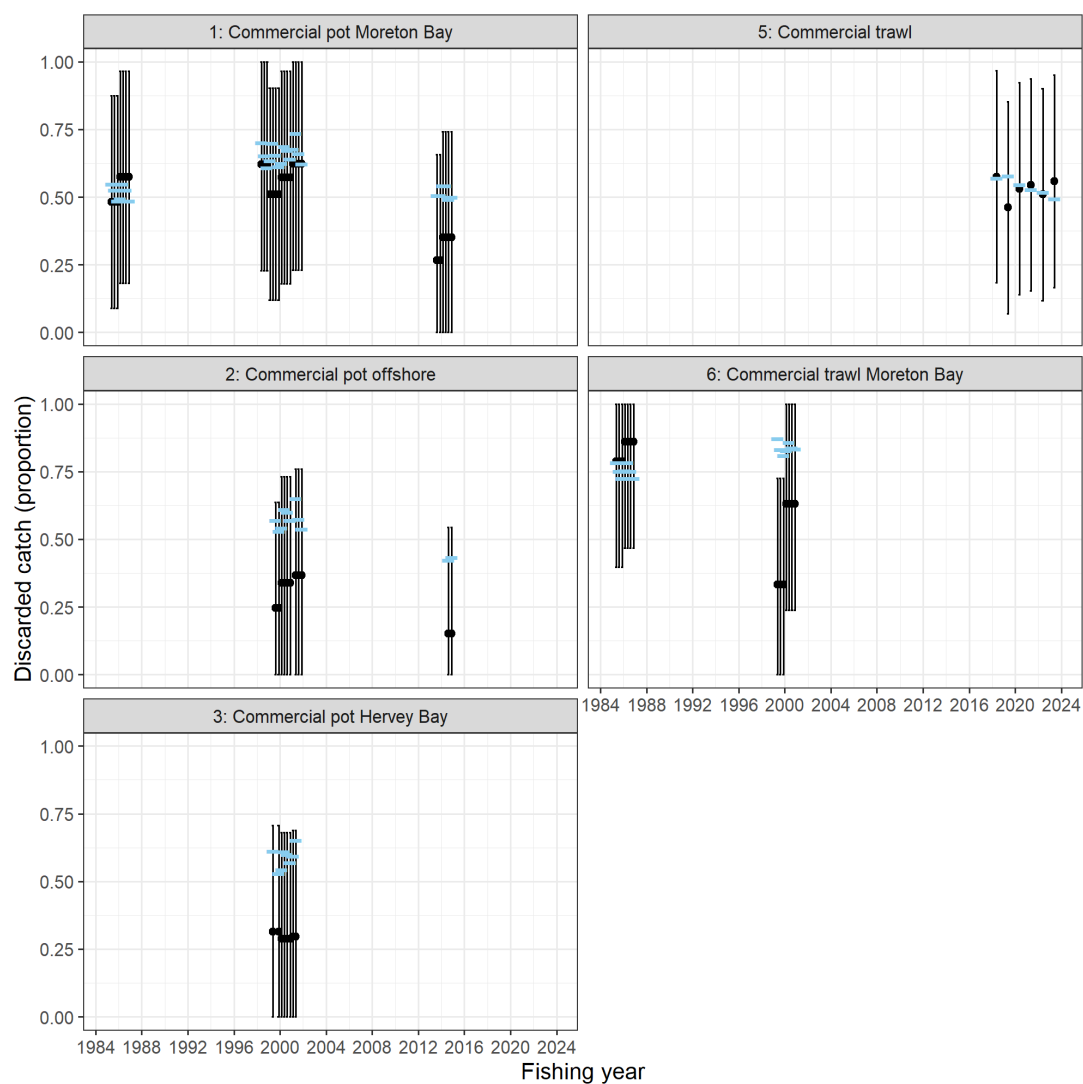


Figure H.167: Analysis 12: Fits to annual discard proportions of blue swimmer crab catch

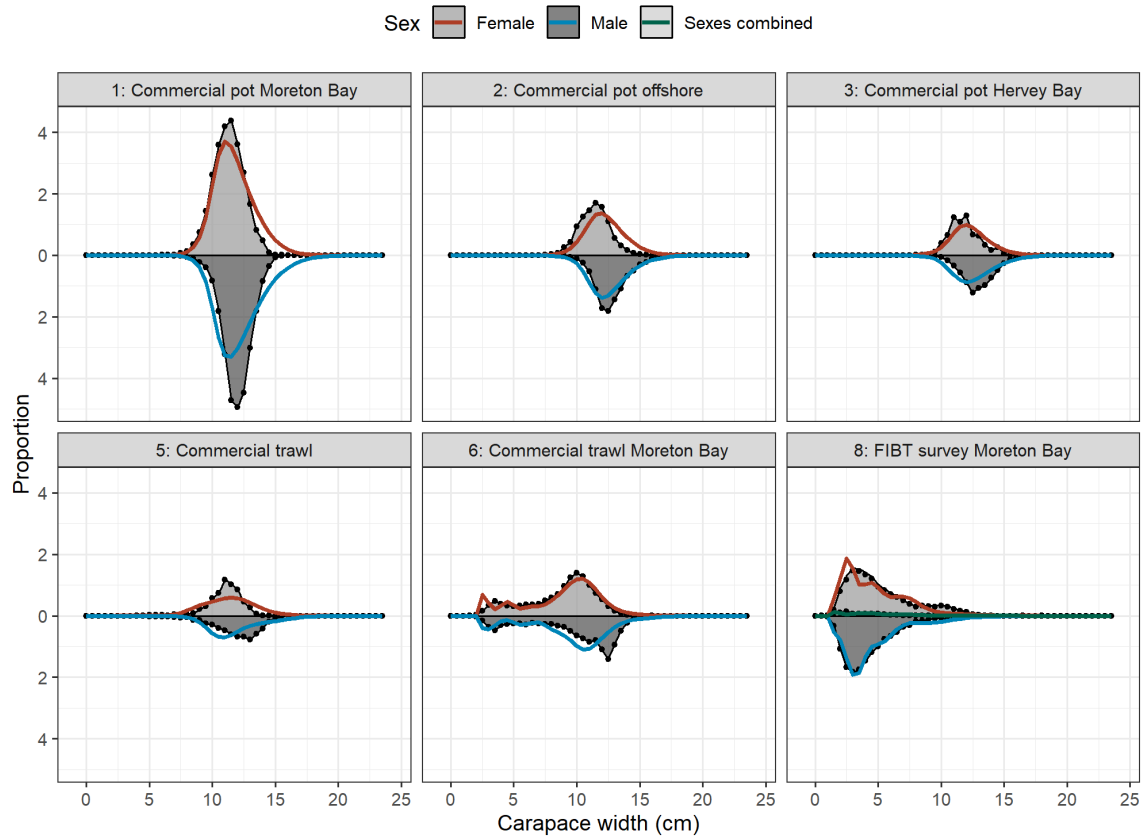


Figure H.168: Analysis 12: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

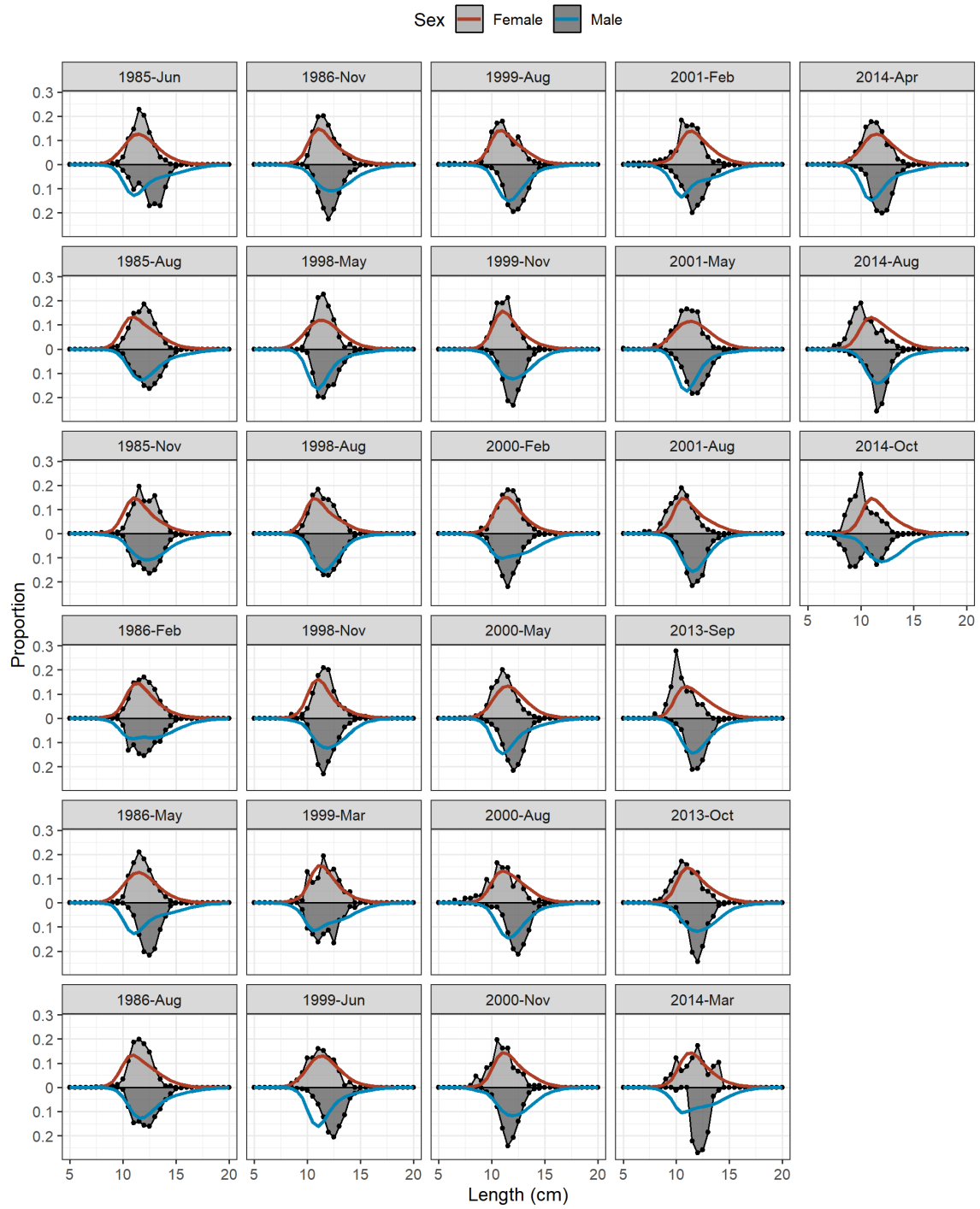


Figure H.169: Analysis 12: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

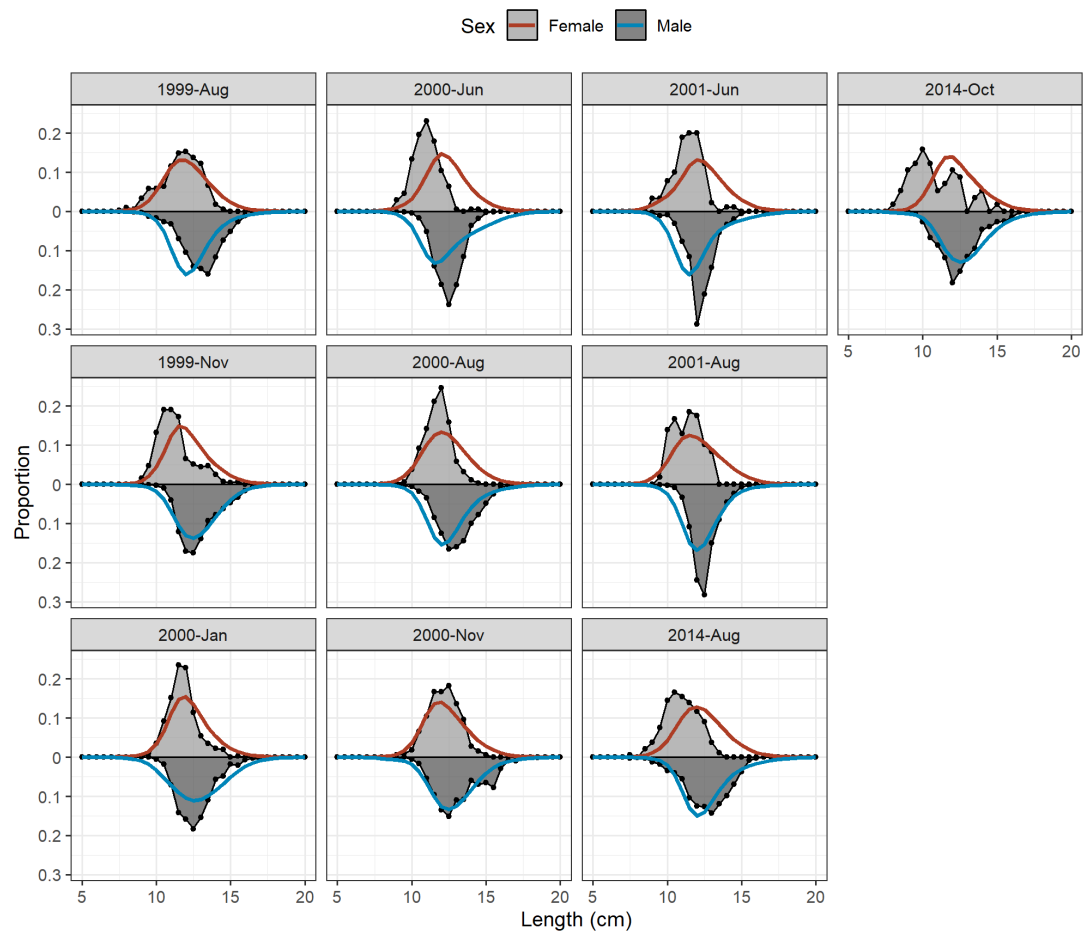


Figure H.170: Analysis 12: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

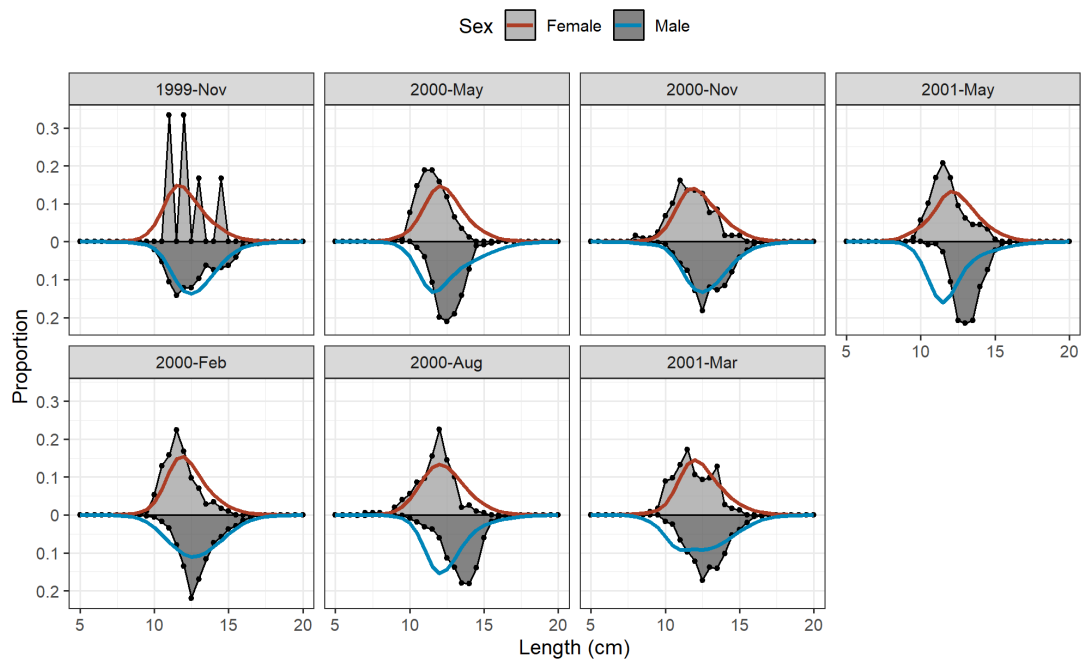


Figure H.171: Analysis 12: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

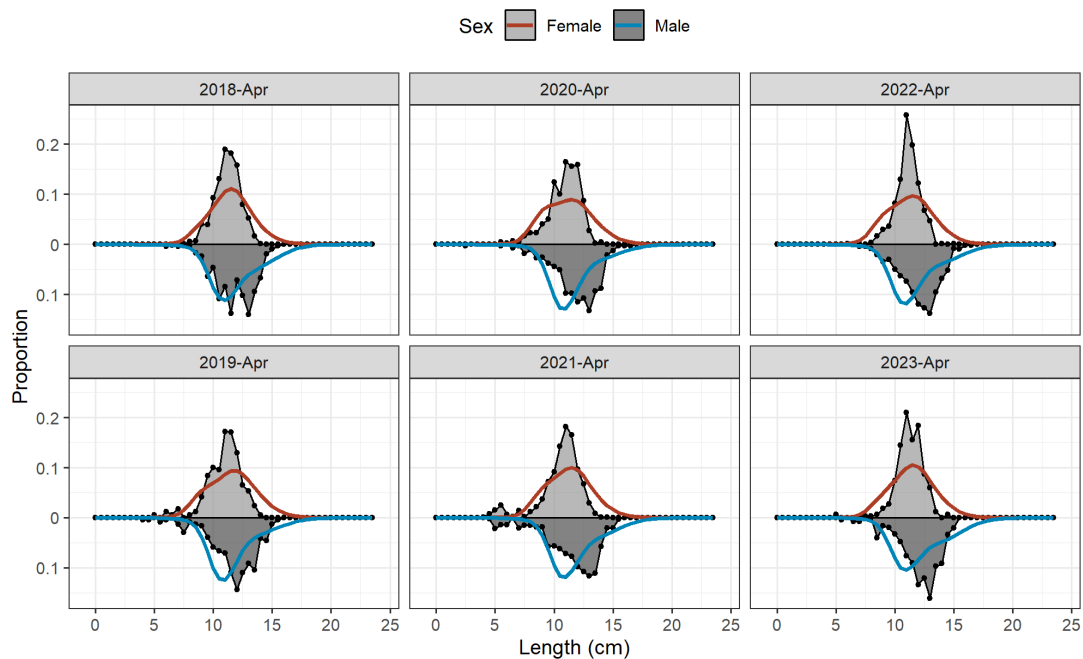


Figure H.172: Analysis 12: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

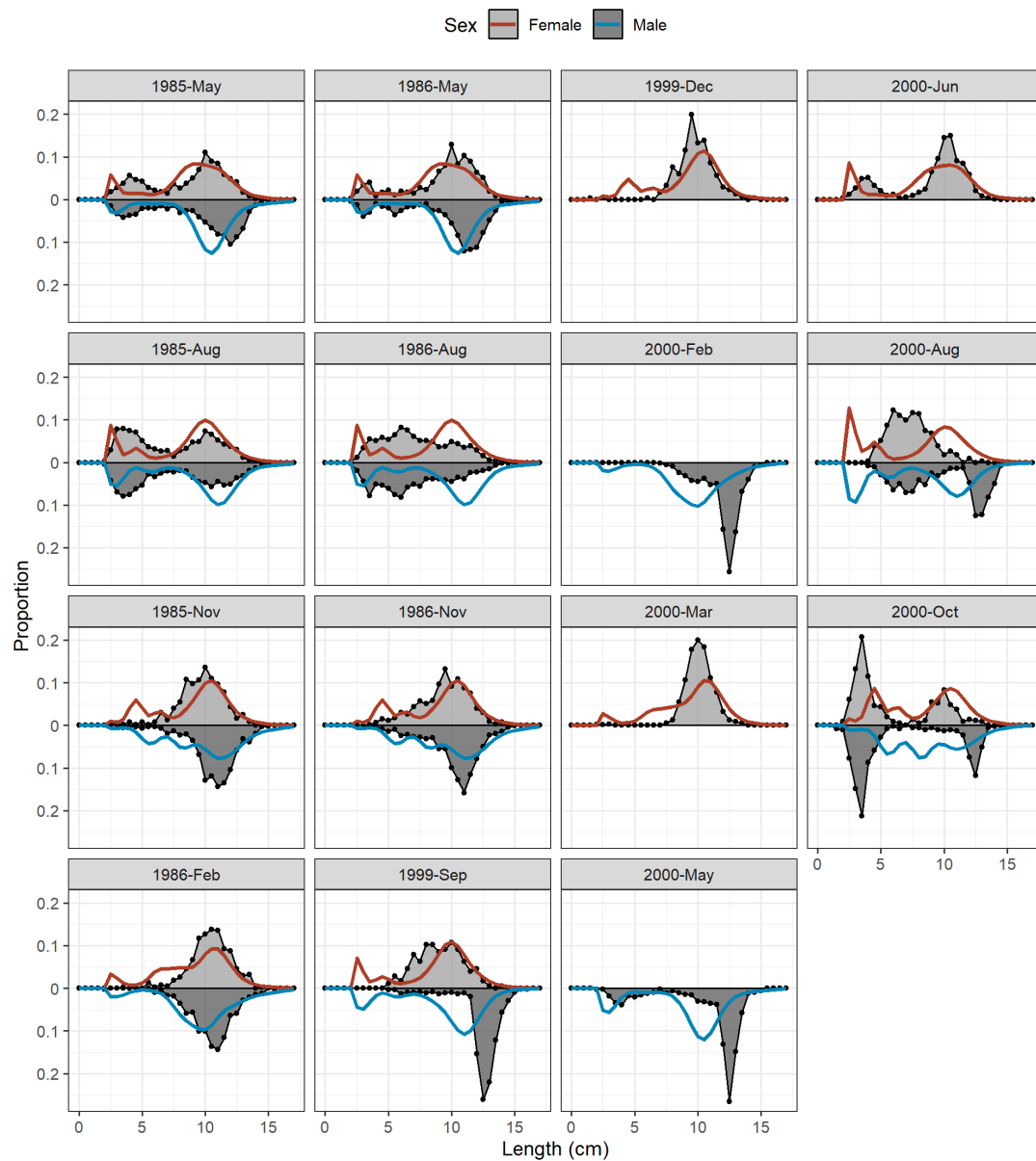


Figure H.173: Analysis 12: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

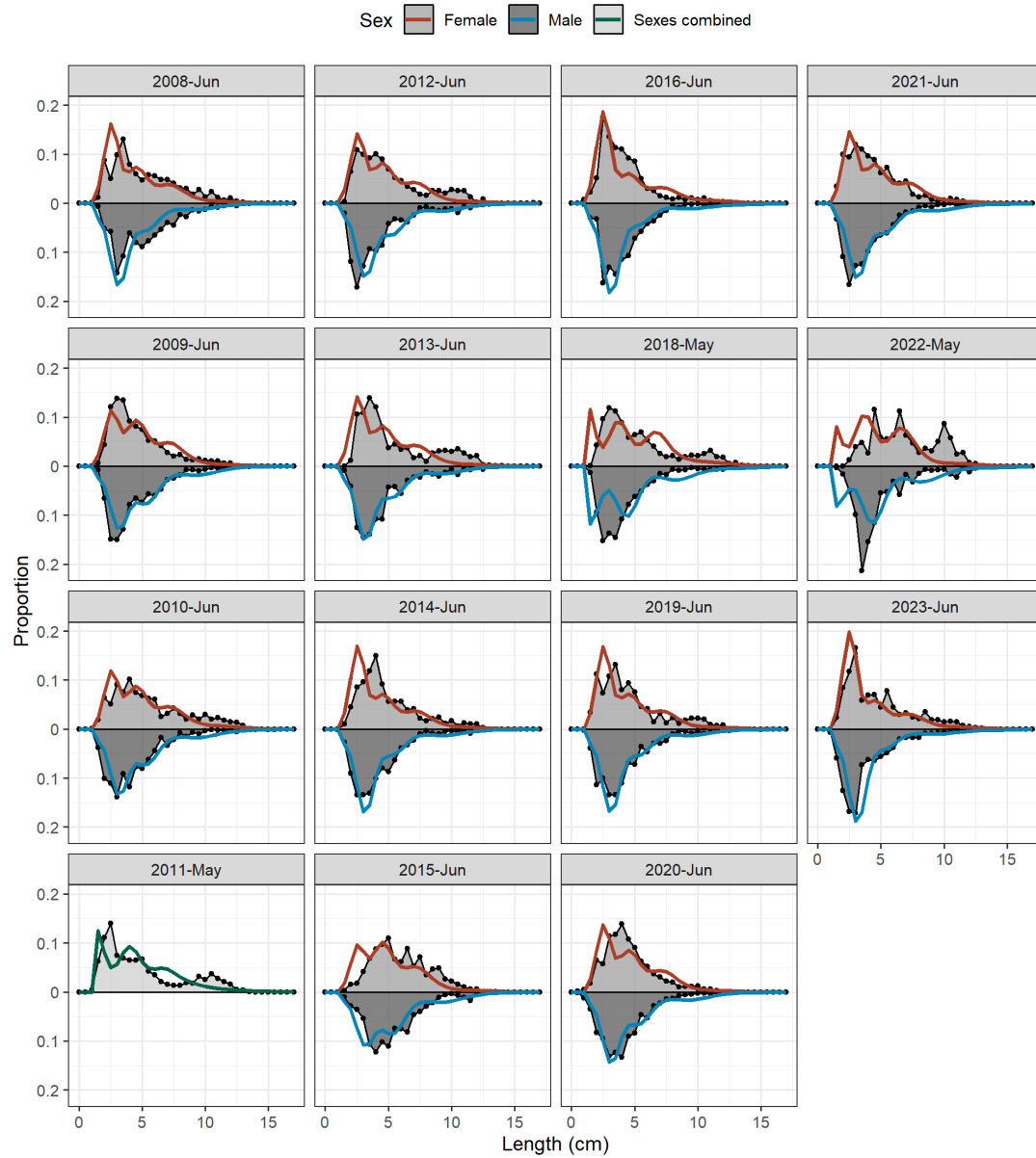


Figure H.174: Analysis 12: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

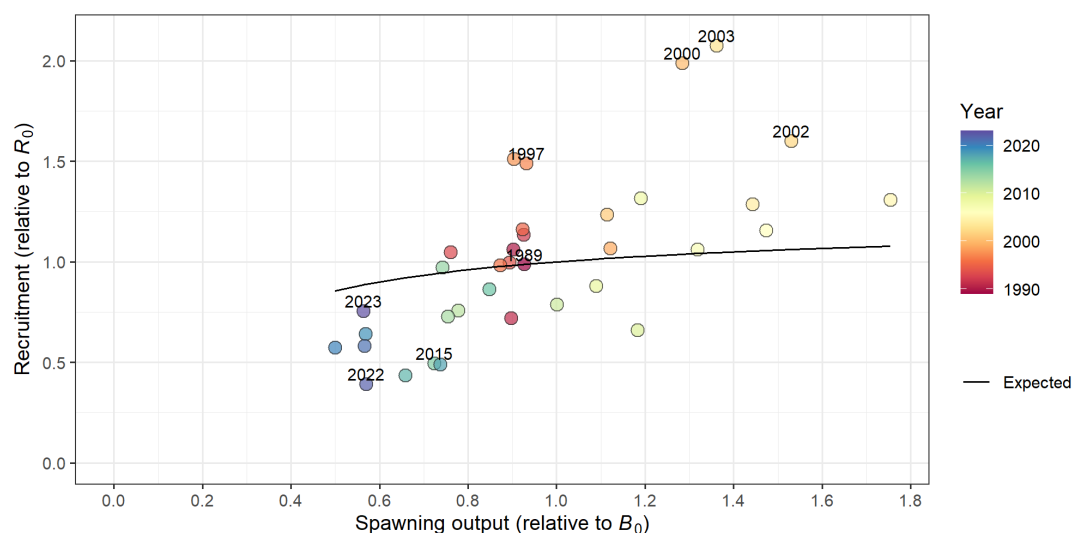


Figure H.175: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 12 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

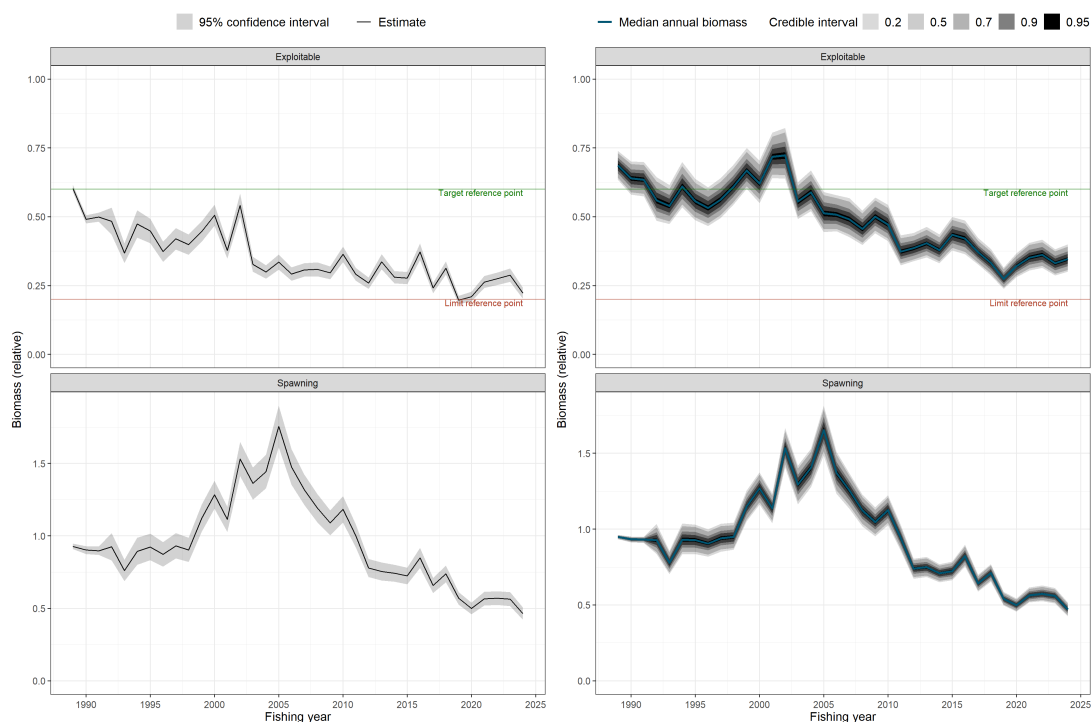


Figure H.176: Analysis 12: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

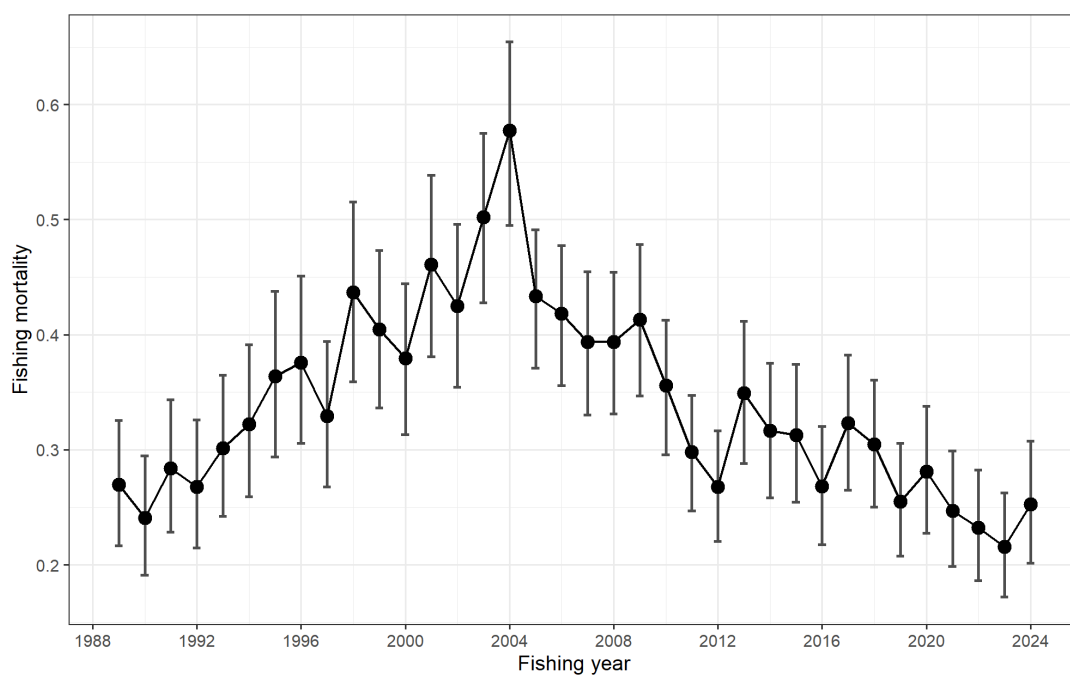


Figure H.177: Analysis 12: Time series of fishing mortality from the MCMC model—error bars represent 95% credible intervals

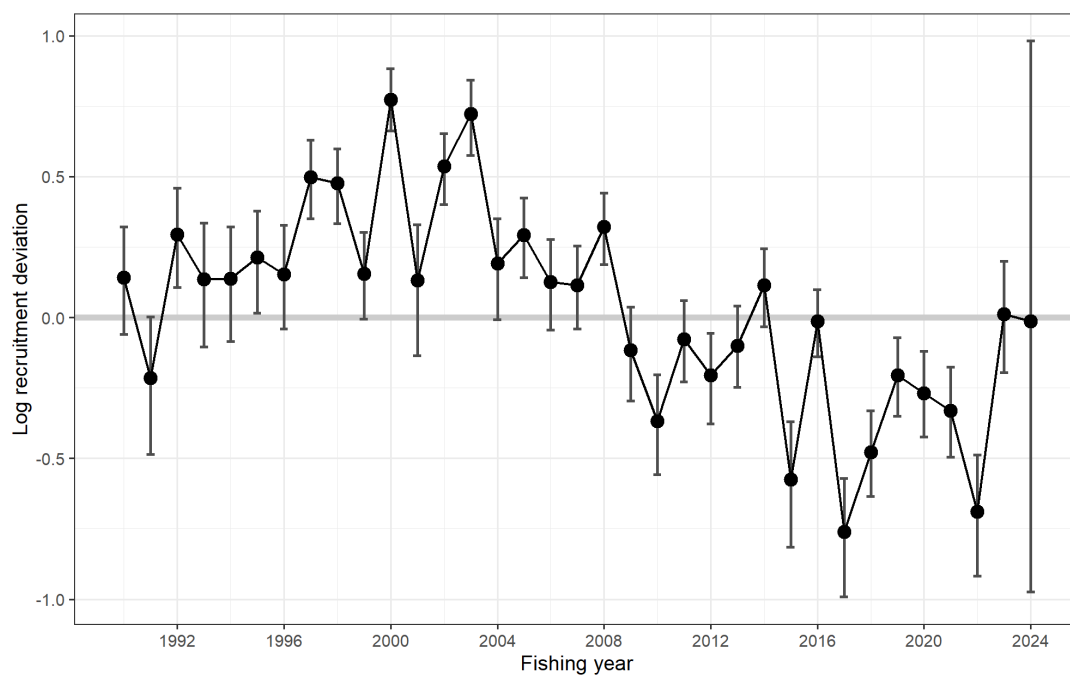


Figure H.178: Analysis 12: Median recruitment deviations from the MCMC model—error bars represent 95% credible intervals

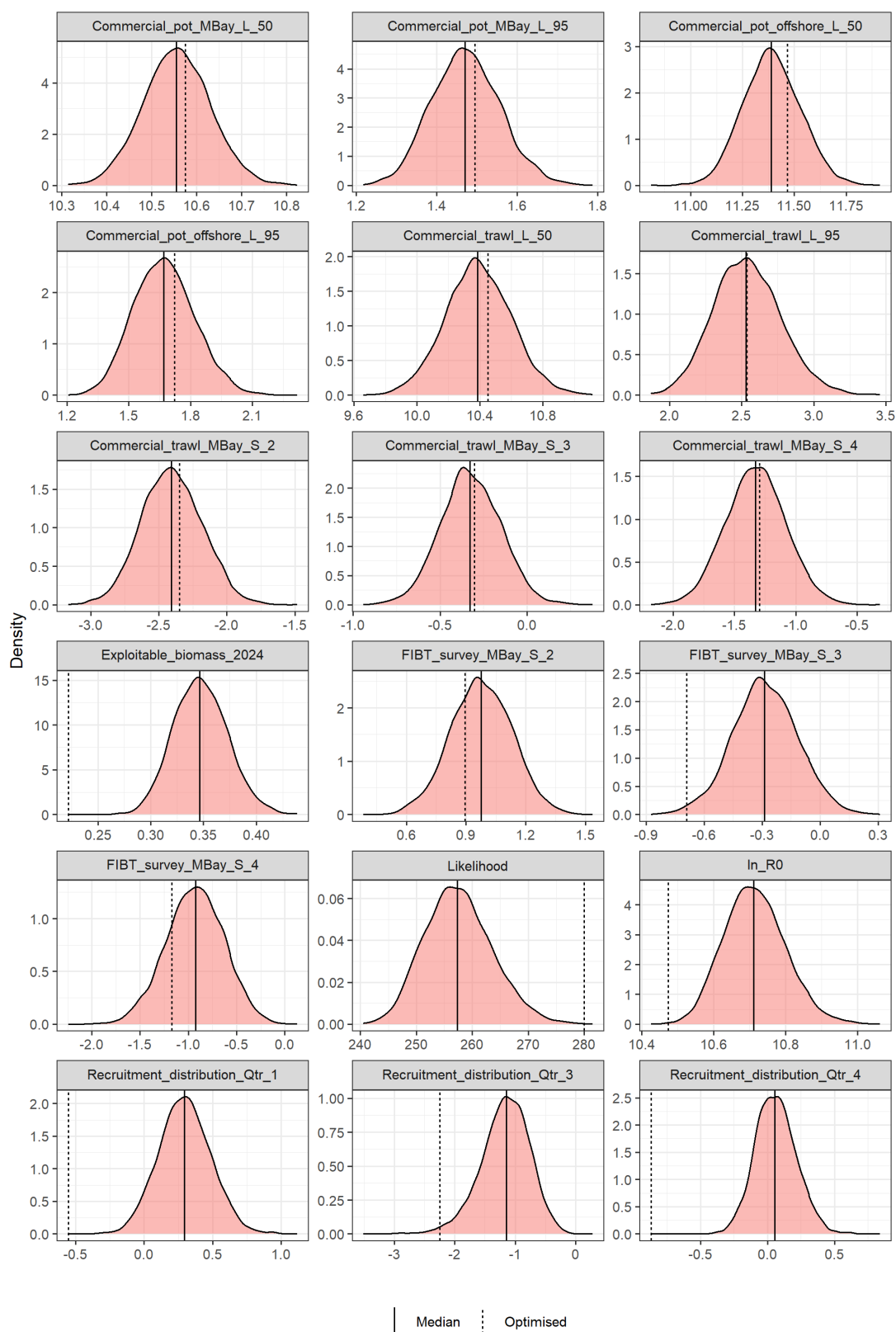


Figure H.179: Analysis 12: Posterior density of MCMC iterations. "Median" line shows median parameter value for MCMC iterations "Optimised" shows the parameter value found from maximum likelihood estimates.

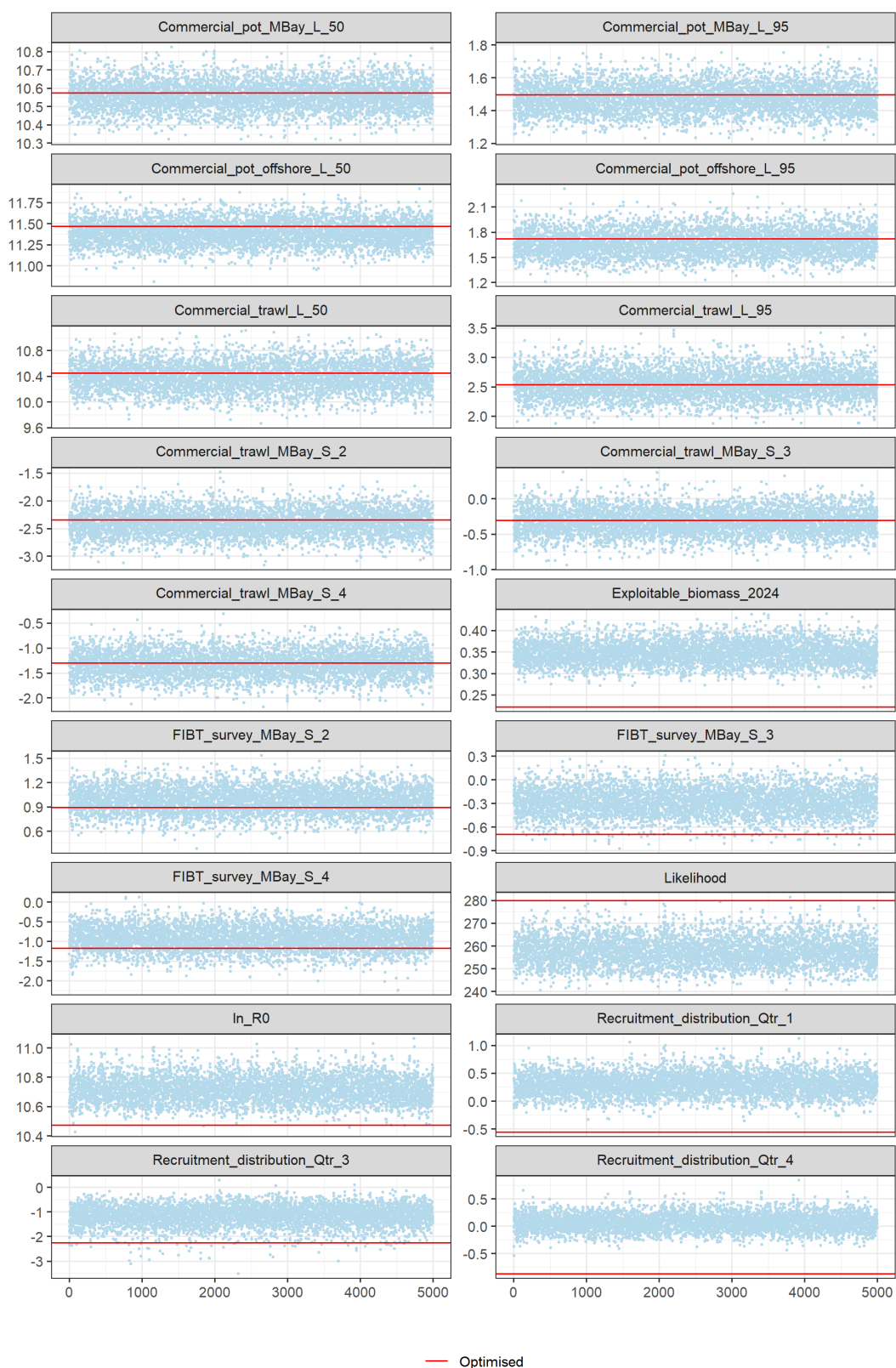


Figure H.180: Analysis 12: Trace plot of MCMC iterations—“Optimised” shows the parameter value found from maximum likelihood estimates

H.13 Analysis 13

Table H.25: Summary of MLE parameter estimates for analysis 13

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.51	2	-5.00	5.00	0.00	0.18
Recruitment distribution Qtr_3	-2.44	2	-5.00	5.00	0.00	0.72
Recruitment distribution Qtr_4	-0.86	2	-5.00	5.00	-1.15	0.13
$\ln(R_0)$	10.05	1	5.00	20.00	11.00	0.05
Commercial pot MBay L_{50}	10.52	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.51	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.43	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.77	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.30	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.60	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.45	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.53	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.52	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.89	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.82	3	-9.00	7.00	0.00	0.19
FIBT survey MBay S_4	-1.43	3	-9.00	7.00	-1.00	0.30

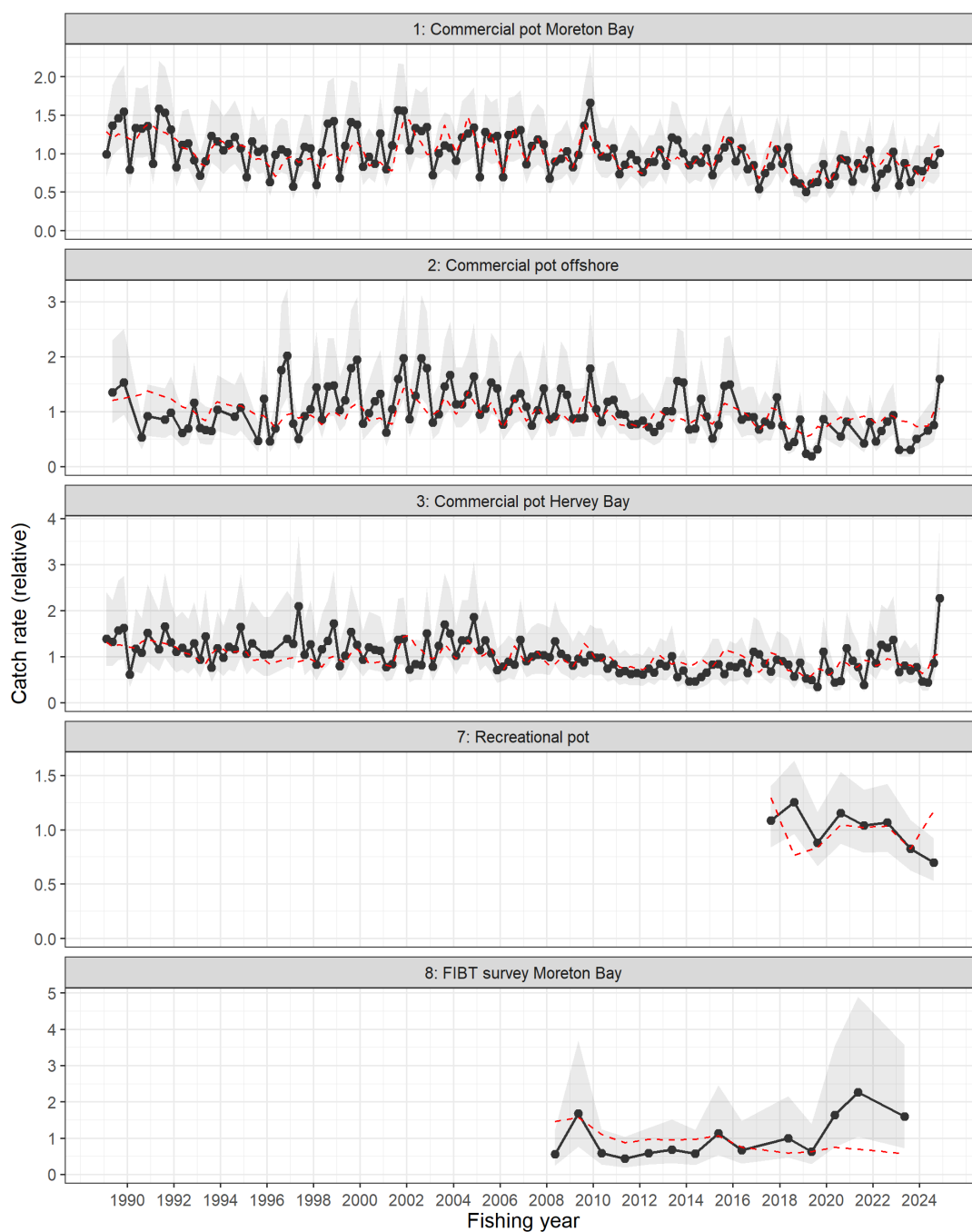


Figure H.181: Analysis 13: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

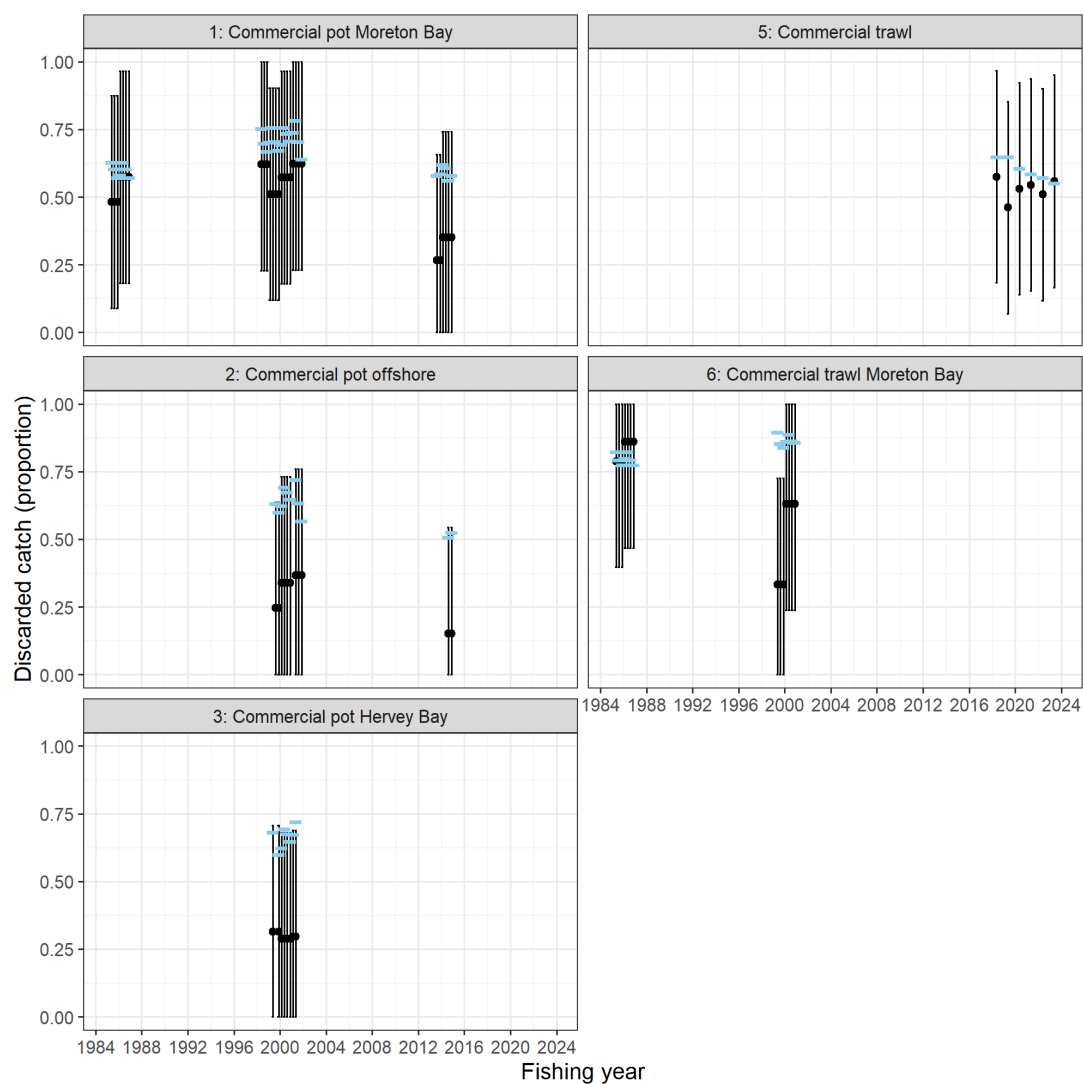


Figure H.182: Analysis 13: Fits to annual discard proportions of blue swimmer crab catch

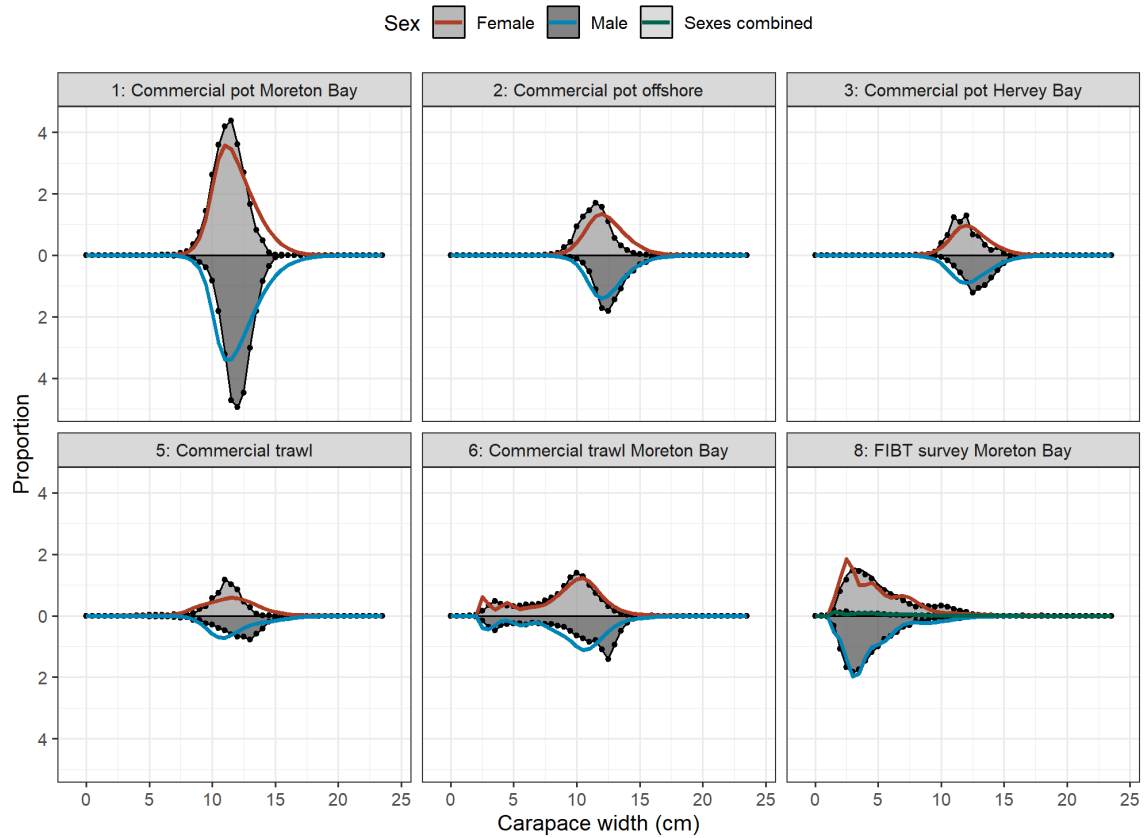


Figure H.183: Analysis 13: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

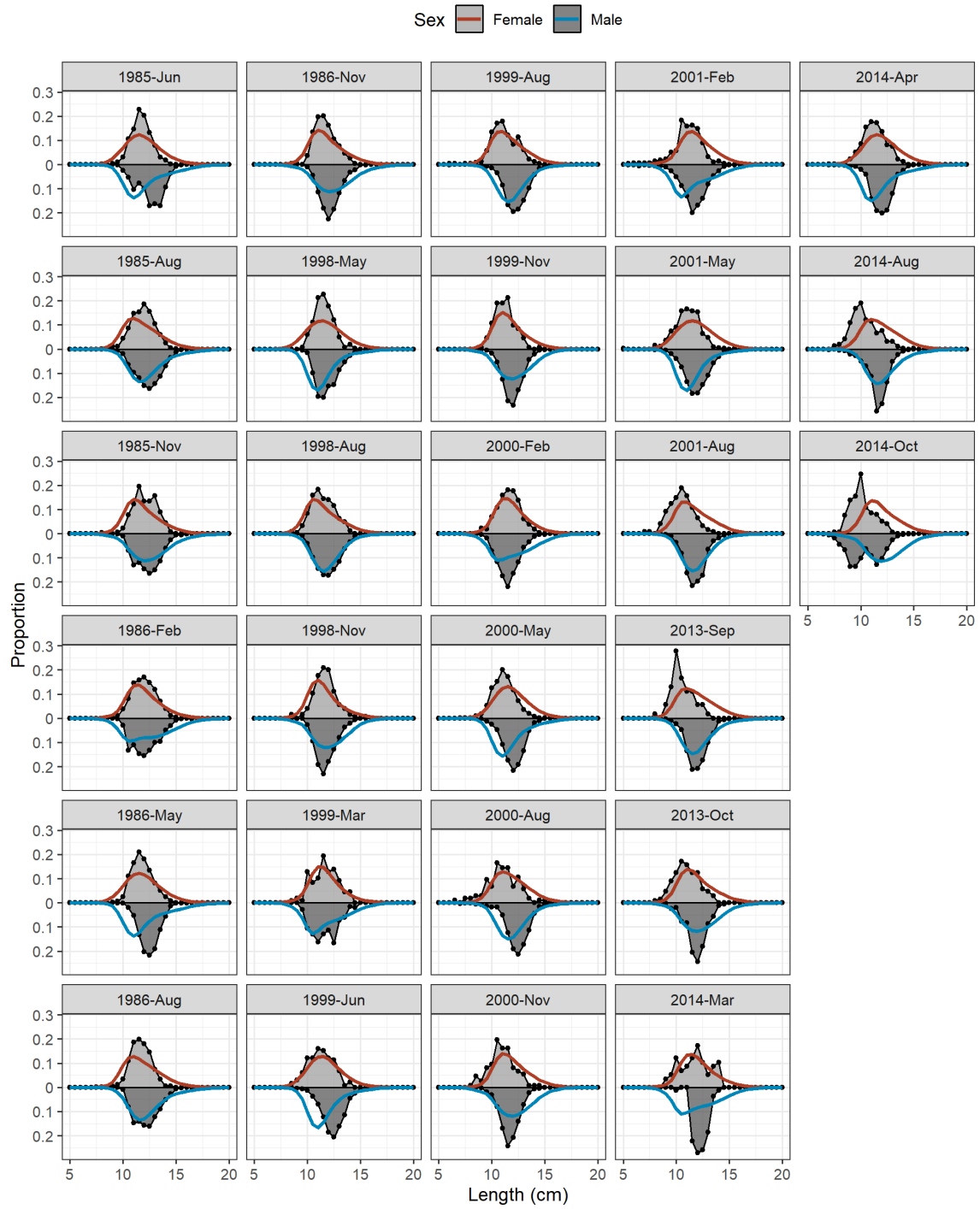


Figure H.184: Analysis 13: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

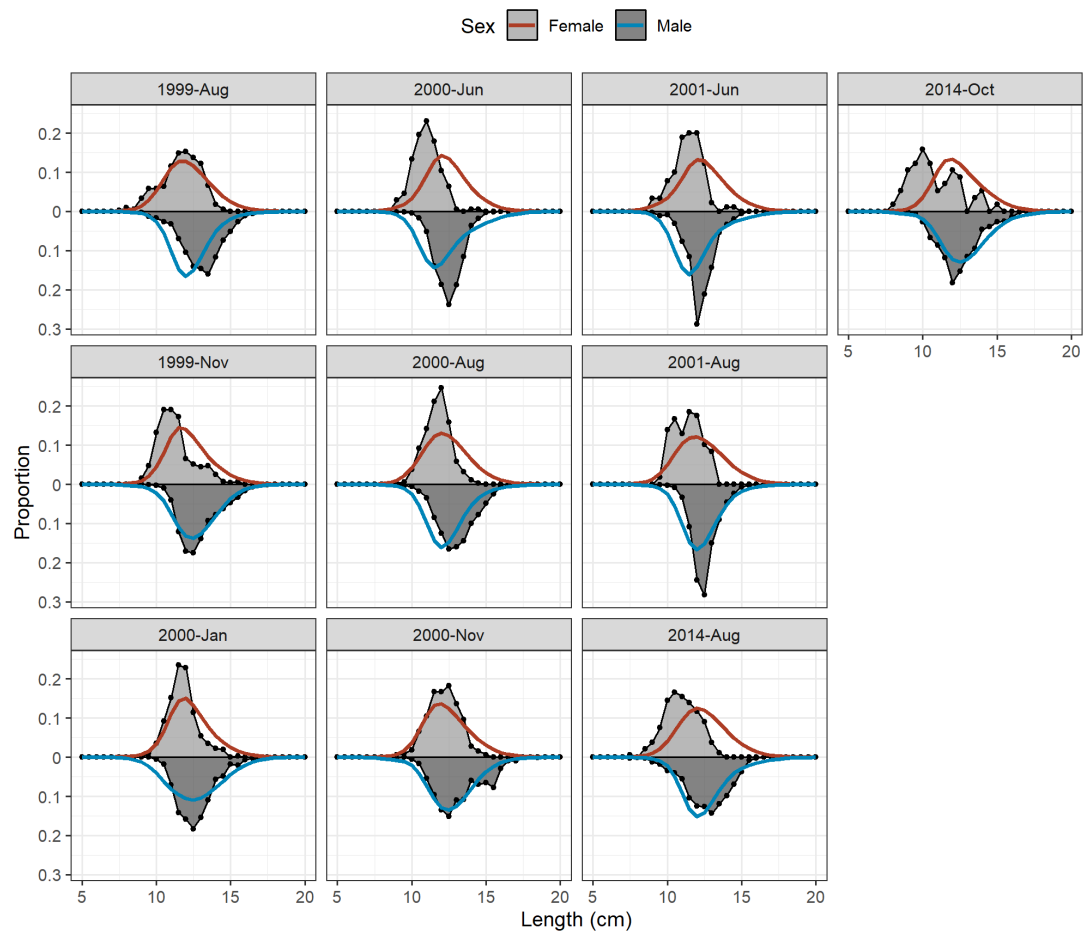


Figure H.185: Analysis 13: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

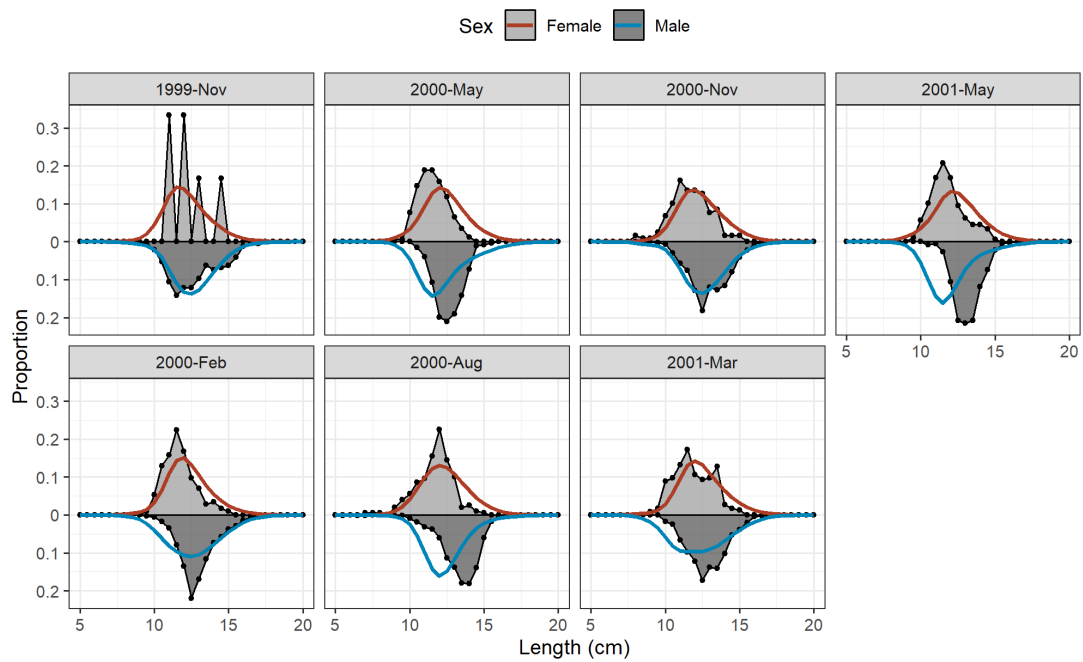


Figure H.186: Analysis 13: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

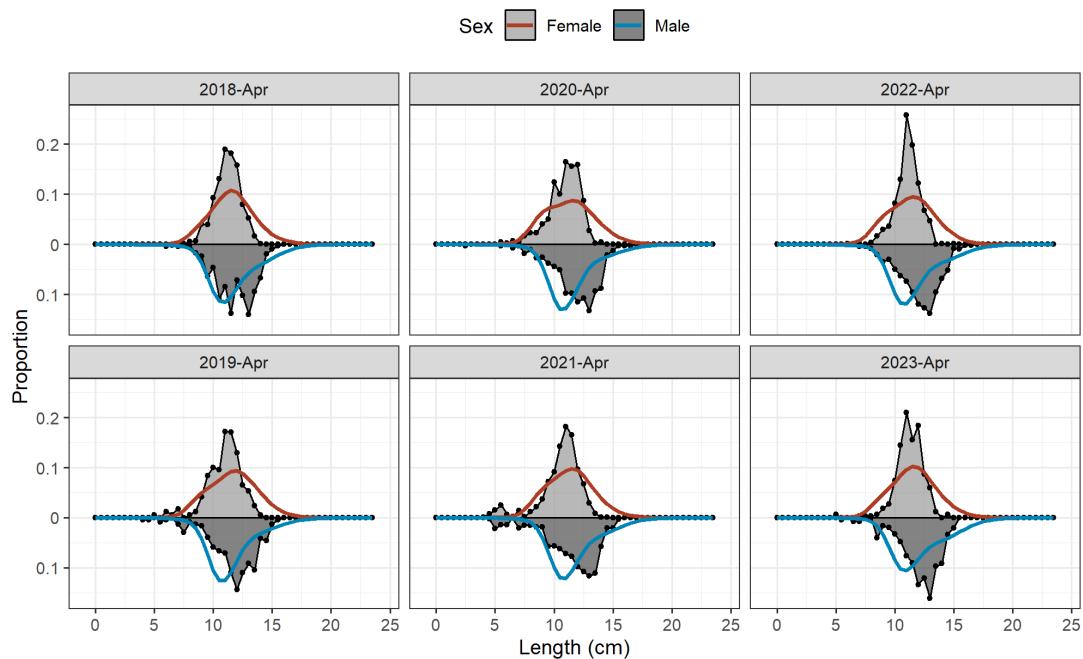


Figure H.187: Analysis 13: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

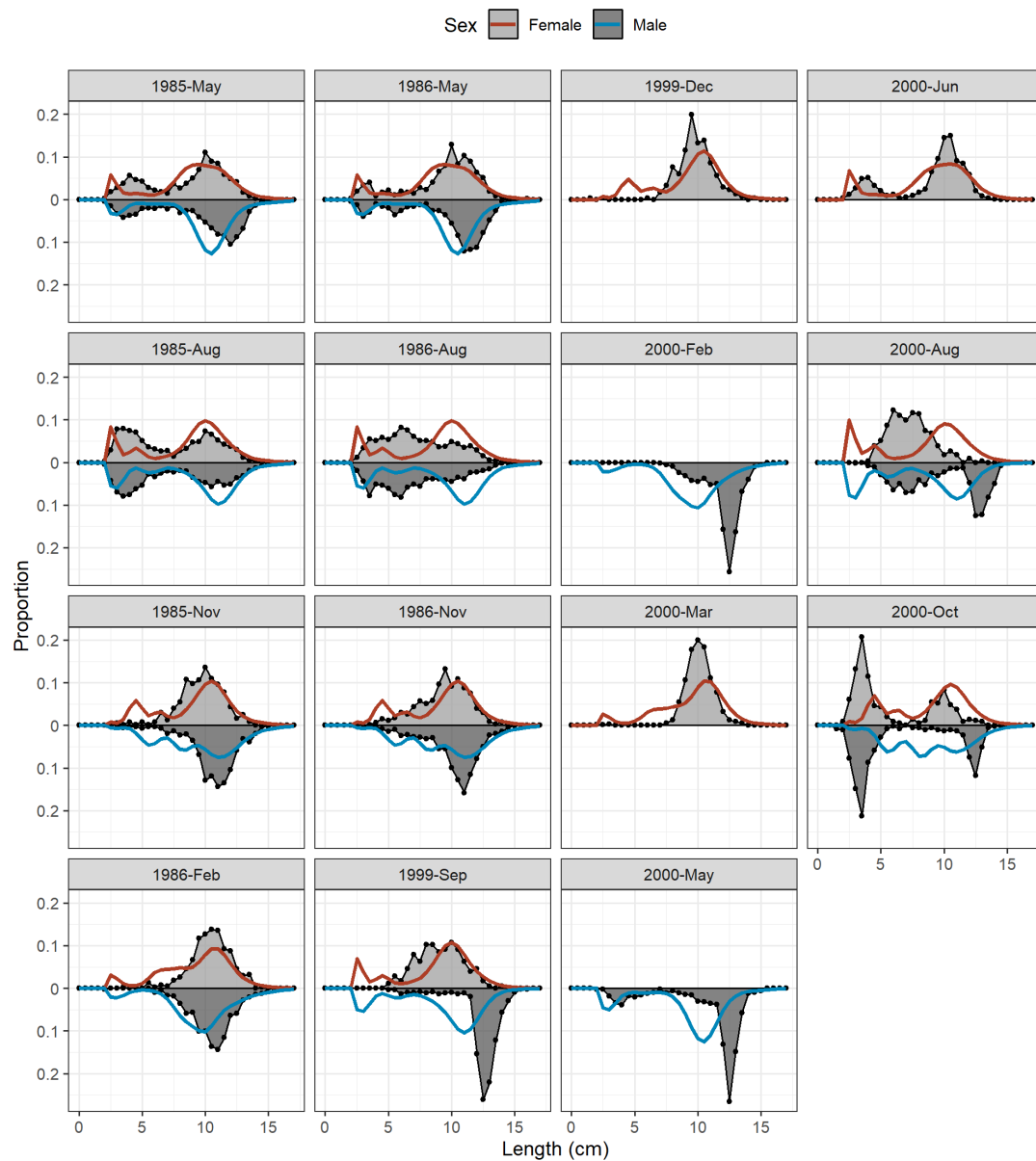


Figure H.188: Analysis 13: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

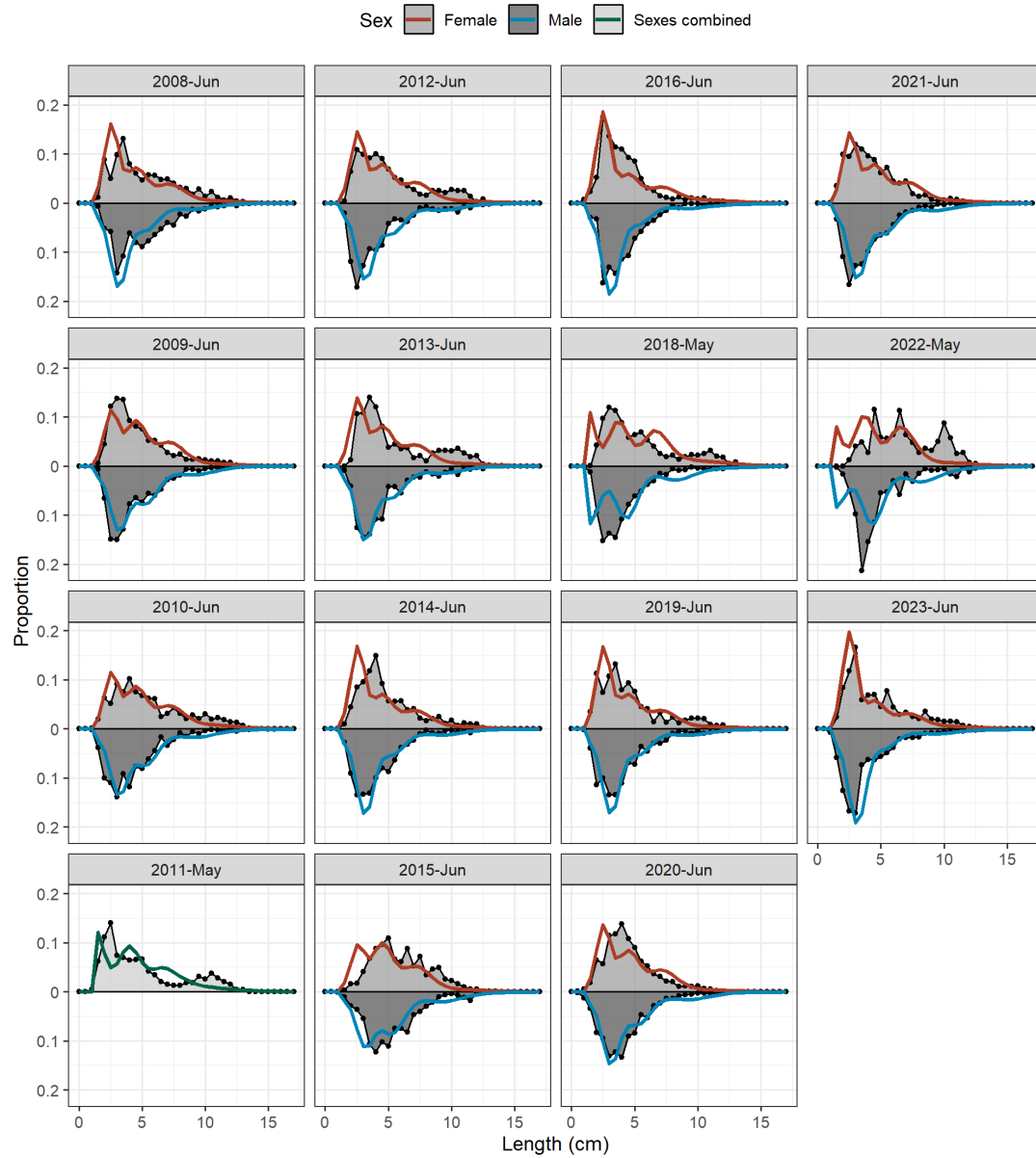


Figure H.189: Analysis 13: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

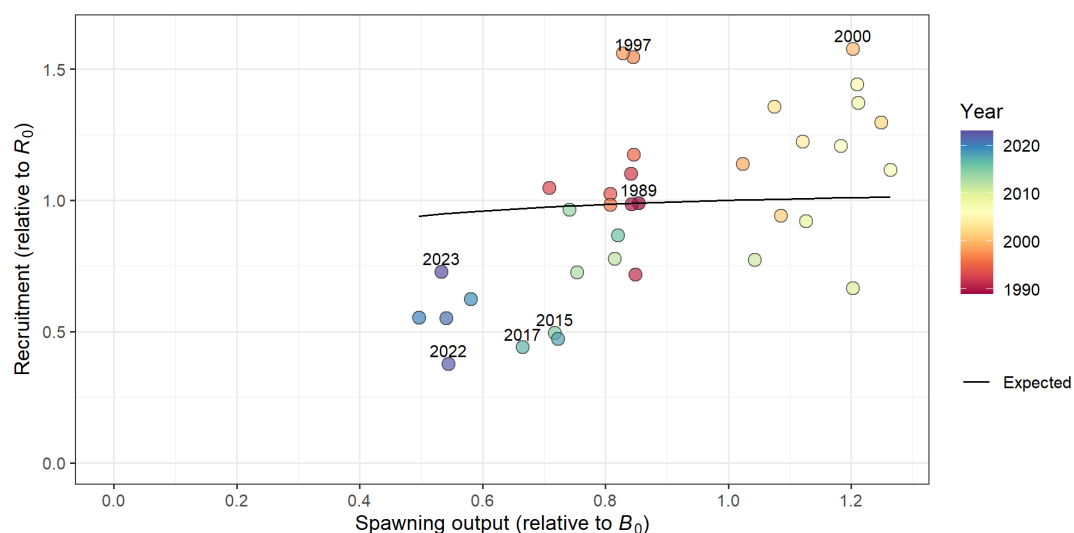


Figure H.190: Analysis 13: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 1 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

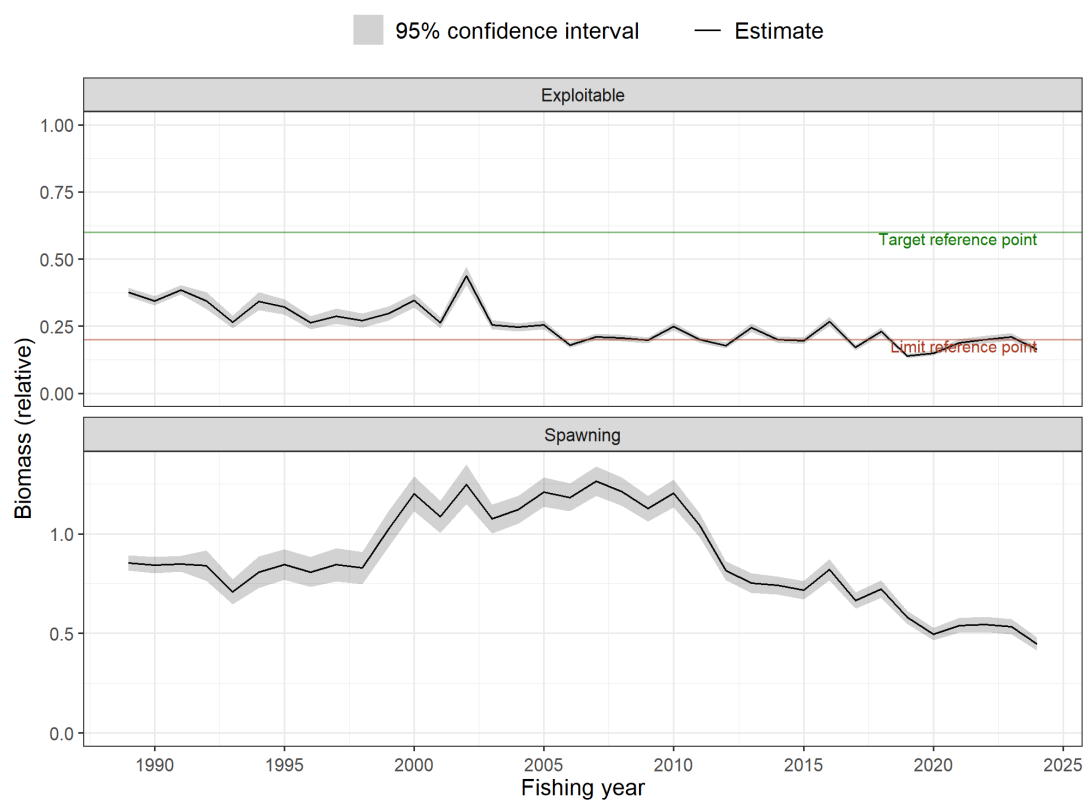


Figure H.191: Analysis 13: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

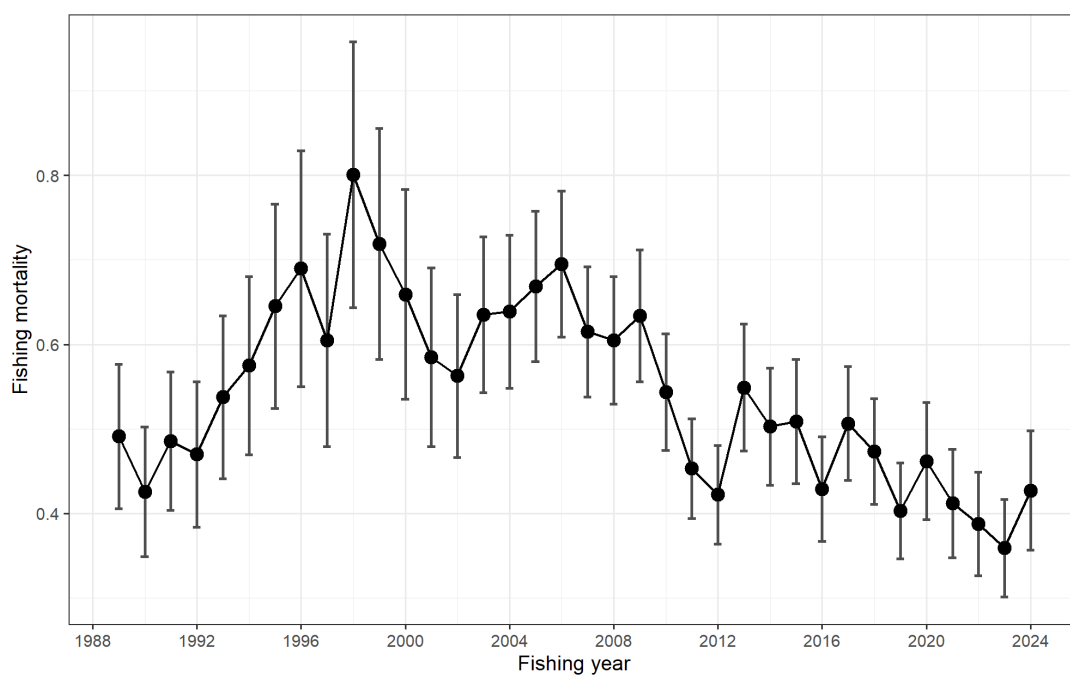


Figure H.192: Analysis 13: Time series of fishing mortality from the MCMC model—error bars represent 95% confidence intervals

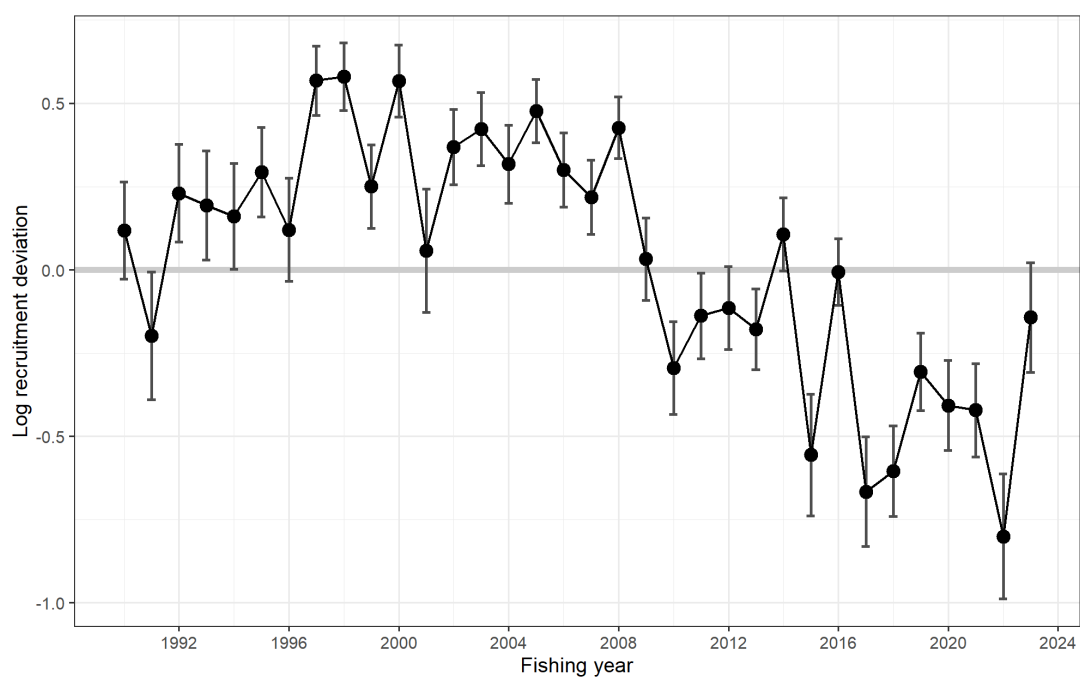


Figure H.193: Analysis 13: Recruitment deviations from the MLE model—error bars represent 95% confidence intervals

H.14 Analysis 14

Table H.26: Summary of MLE parameter estimates for analysis 14

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.42	2	-5.00	5.00	0.00	0.19
Recruitment distribution Qtr_3	-2.49	2	-5.00	5.00	0.00	0.79
Recruitment distribution Qtr_4	-0.77	2	-5.00	5.00	-1.15	0.14
$\ln(R_0)$	10.12	1	5.00	20.00	11.00	0.06
Commercial pot MBay L_{50}	10.43	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.48	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.28	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.69	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.19	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.60	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.44	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.58	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.63	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.89	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.76	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-1.52	3	-9.00	7.00	-1.00	0.30

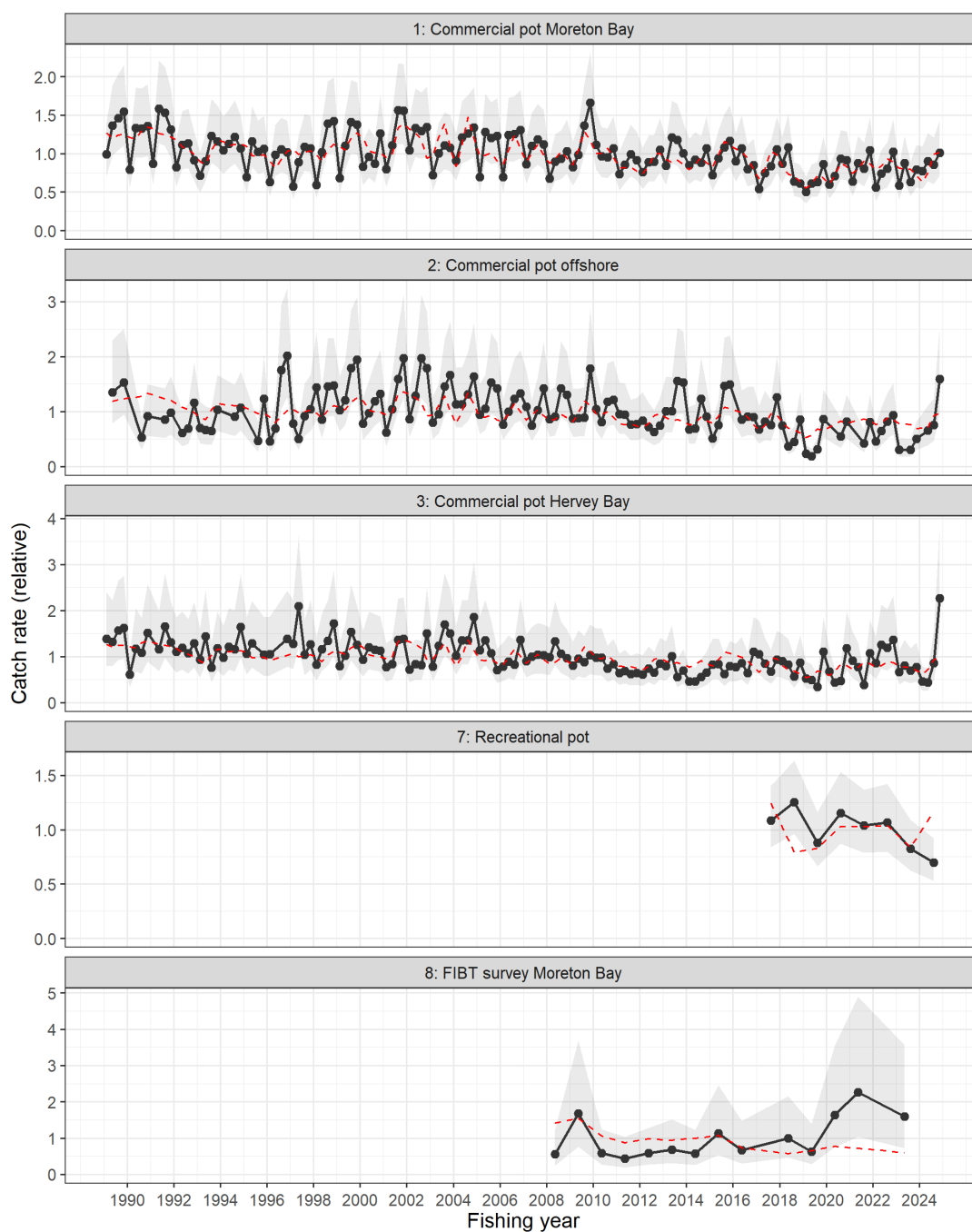


Figure H.194: Analysis 14: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

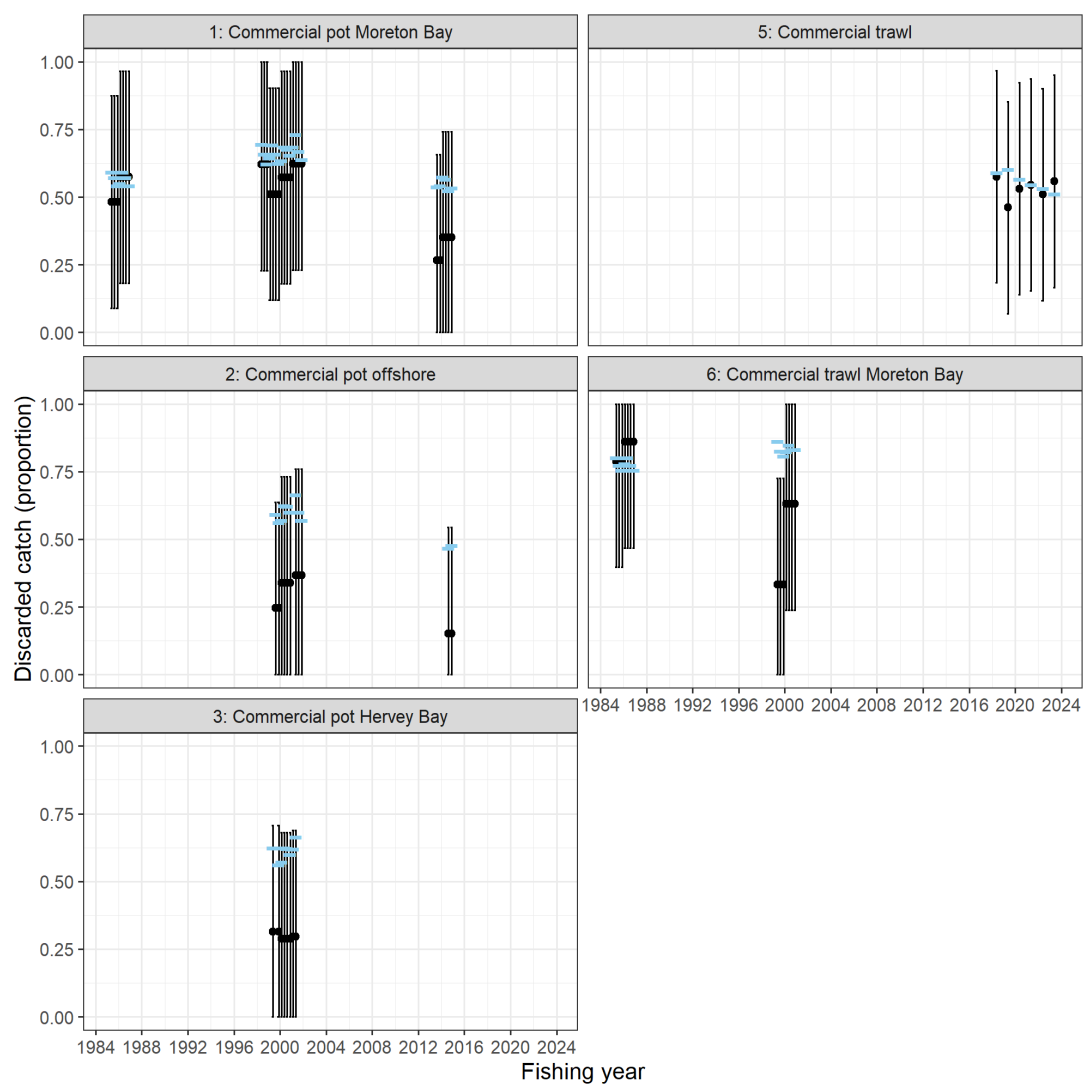


Figure H.195: Analysis 14: Fits to annual discard proportions of blue swimmer crab catch

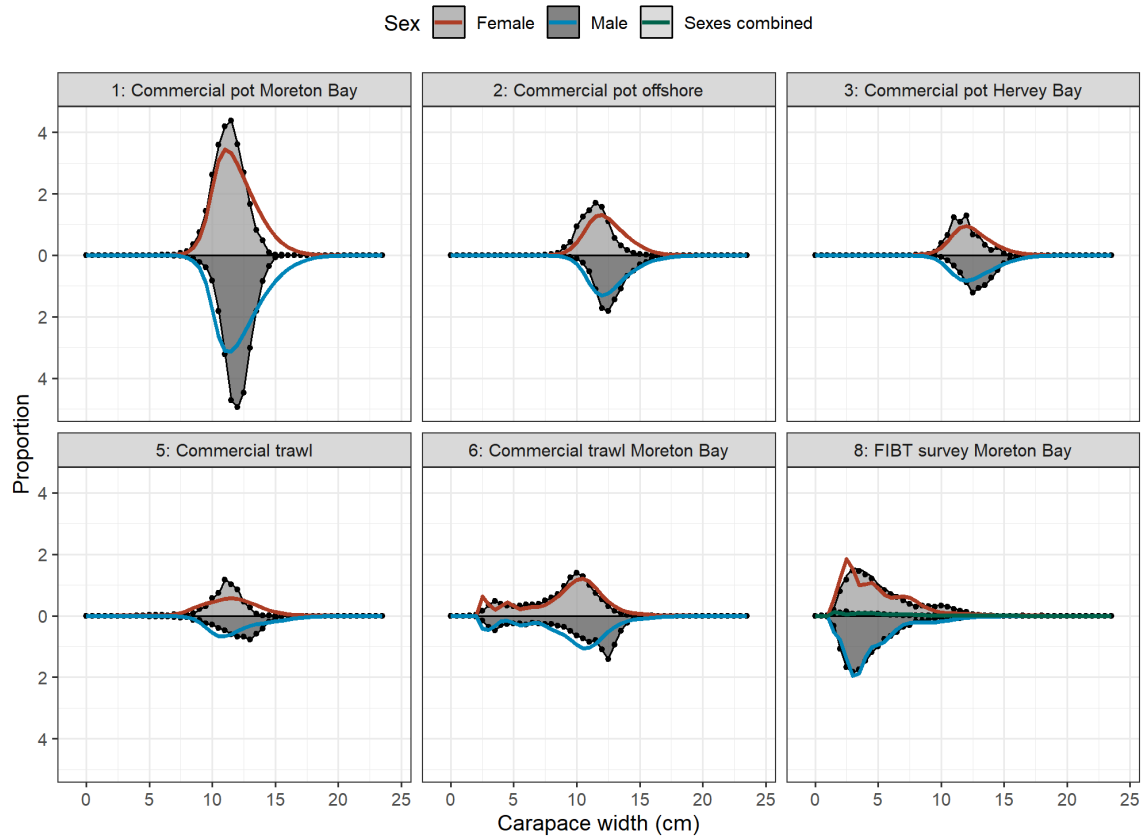


Figure H.196: Analysis 14: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

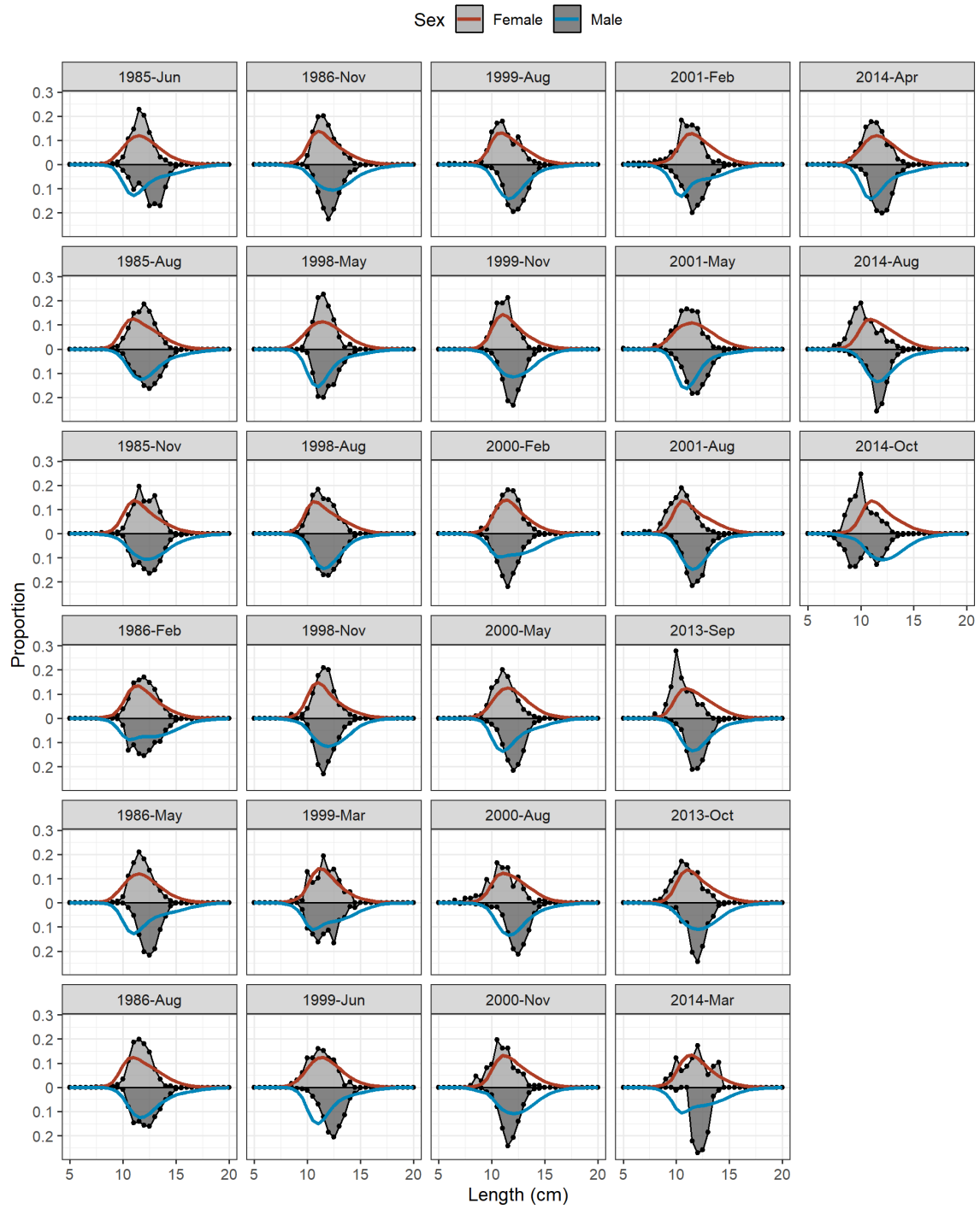


Figure H.197: Analysis 14: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

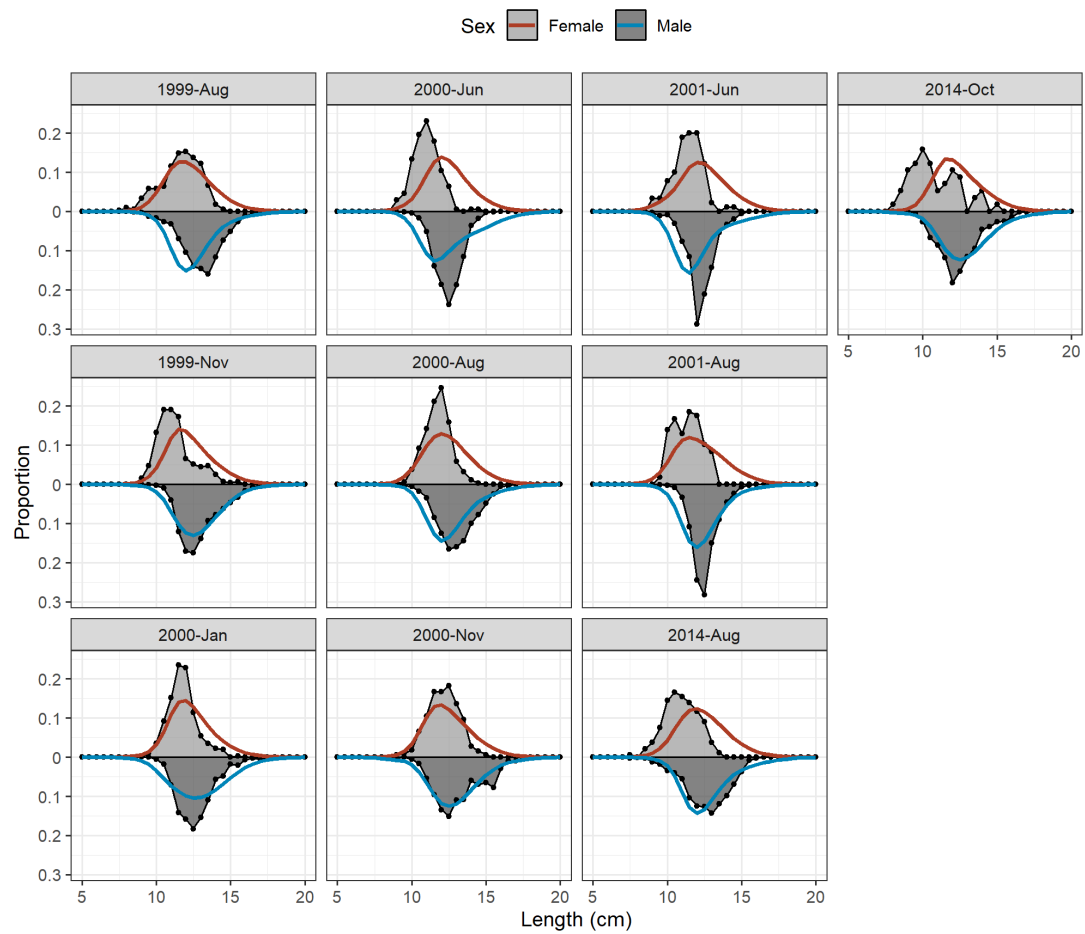


Figure H.198: Analysis 14: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

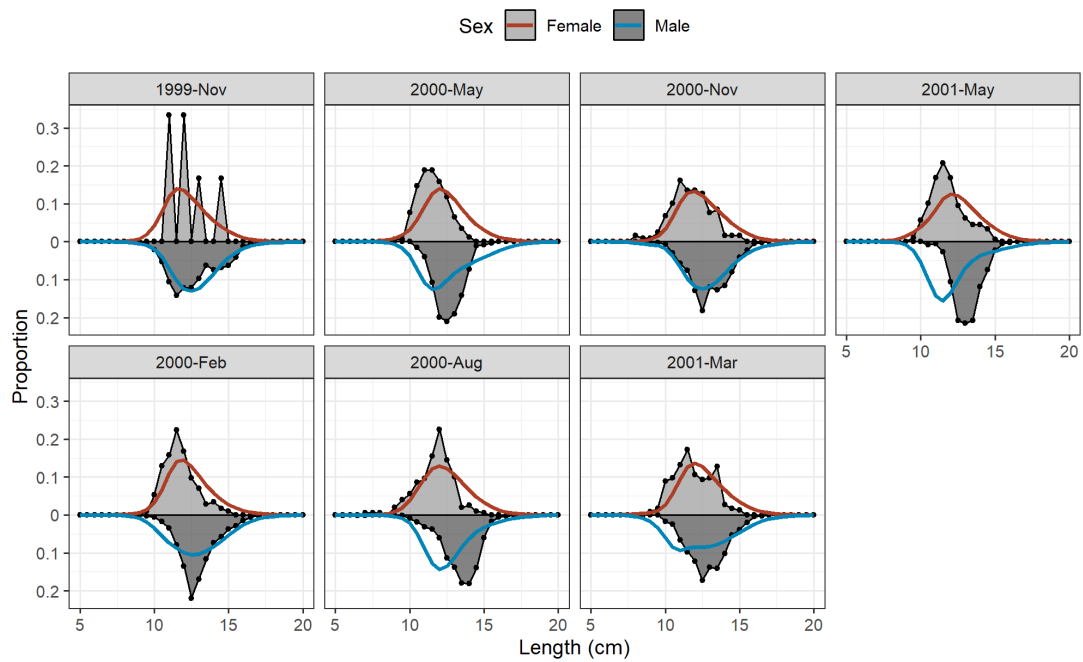


Figure H.199: Analysis 14: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

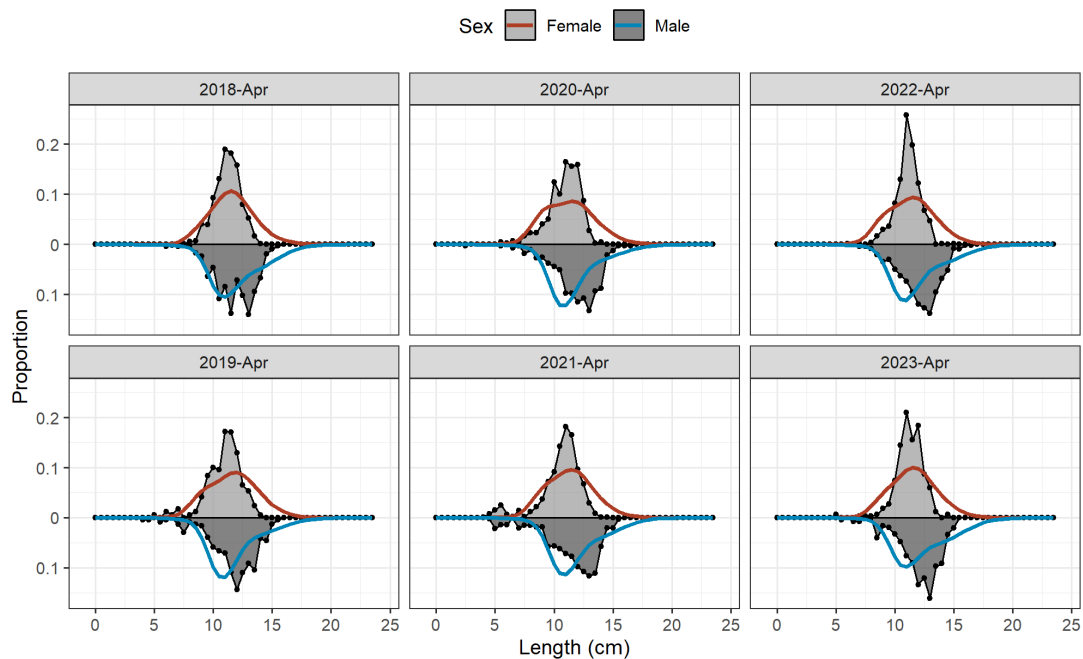


Figure H.200: Analysis 14: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

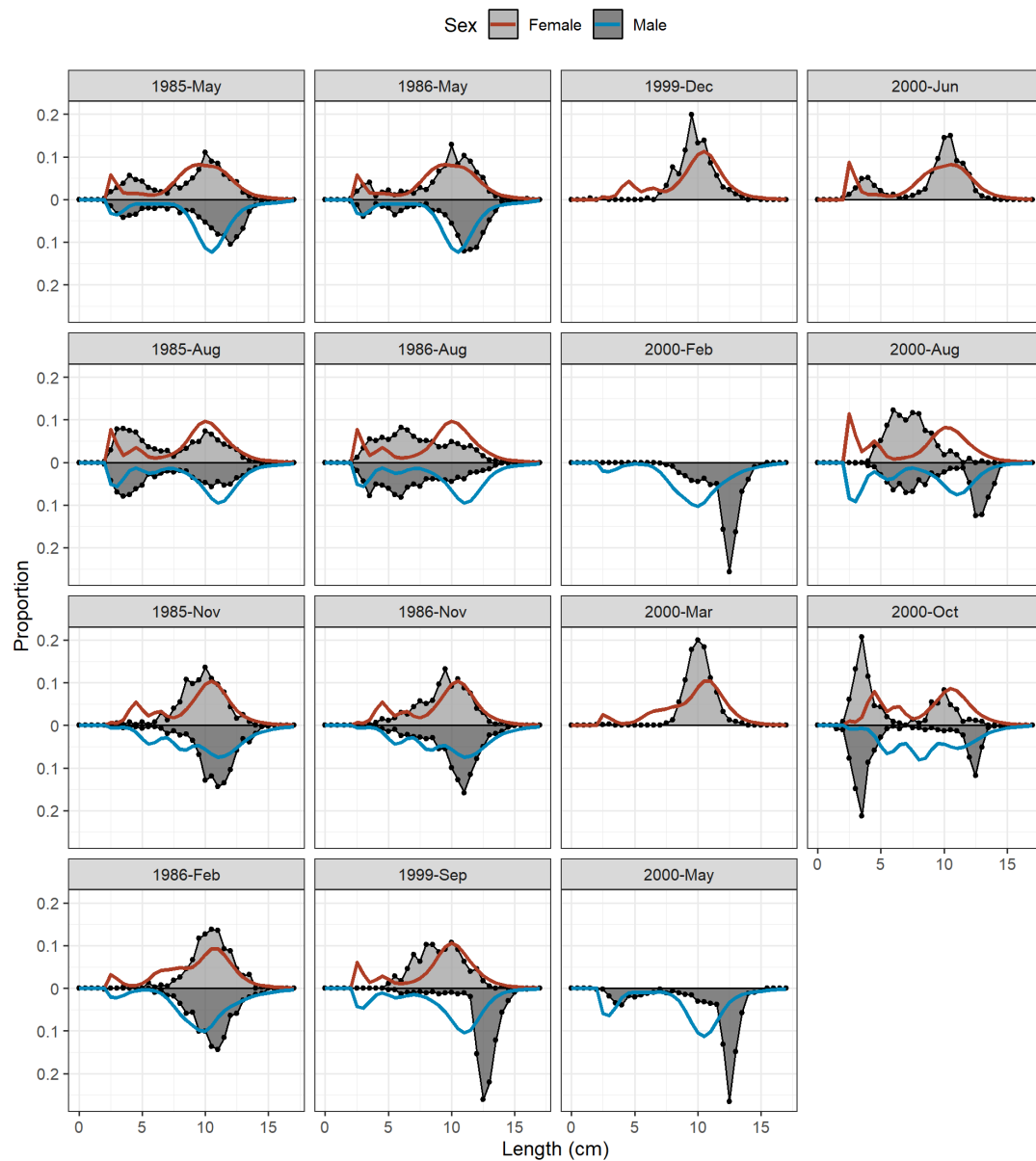


Figure H.201: Analysis 14: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

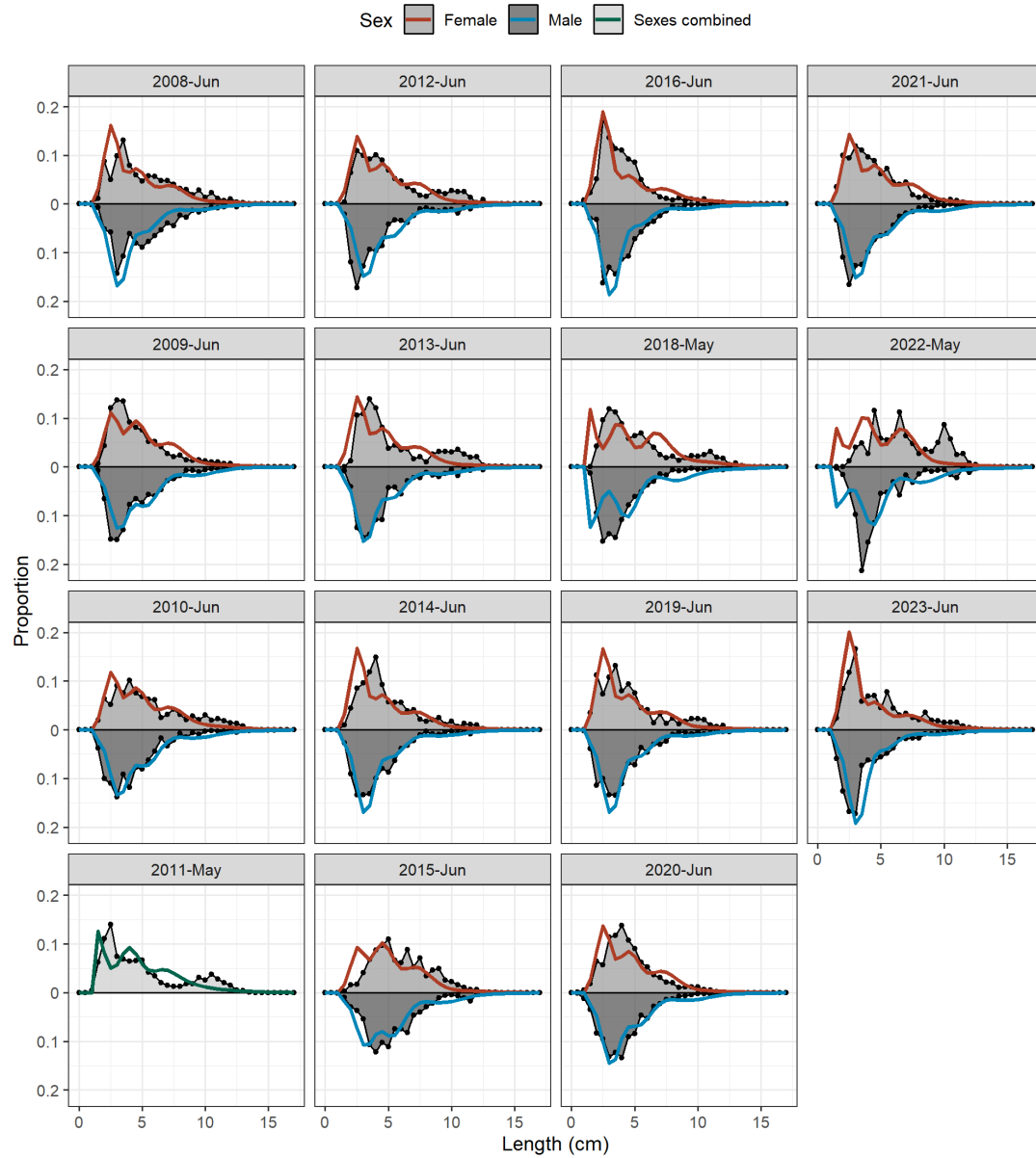


Figure H.202: Analysis 14: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

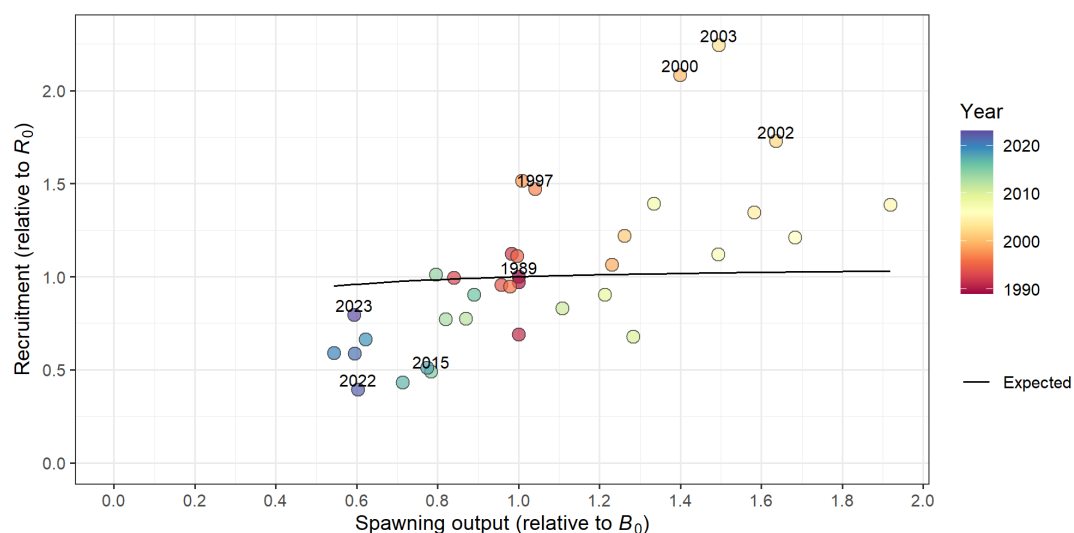


Figure H.203: Analysis 14: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 1 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

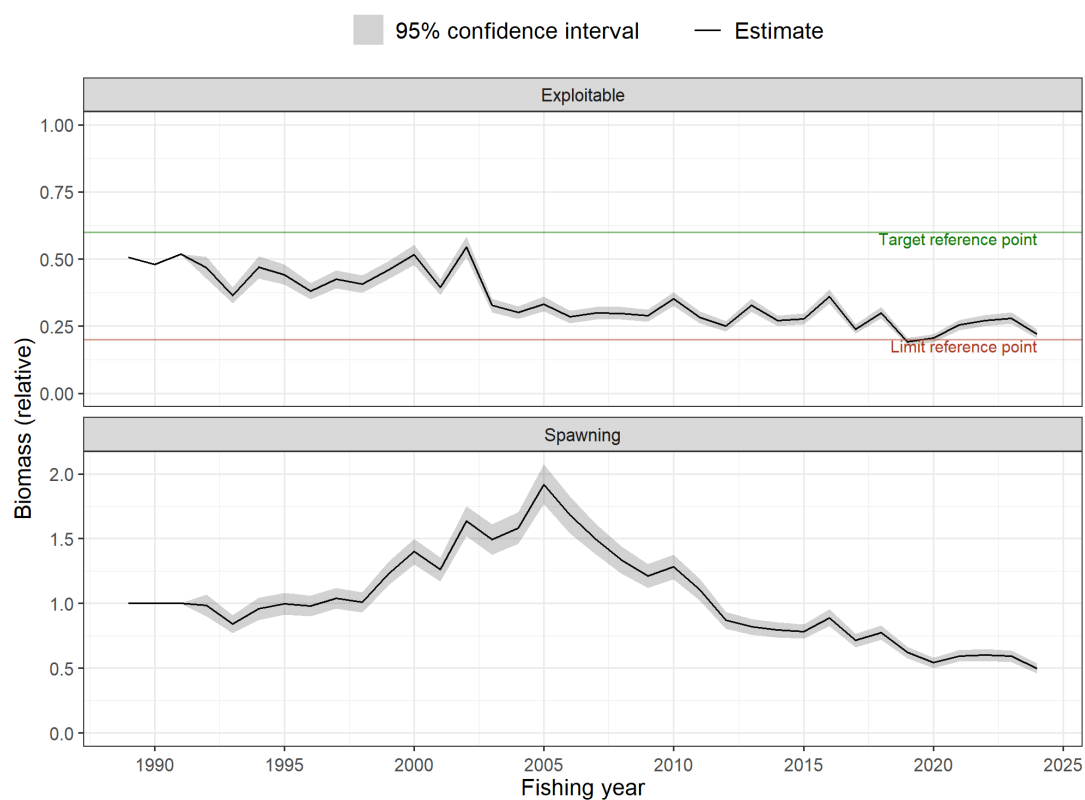


Figure H.204: Analysis 14: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

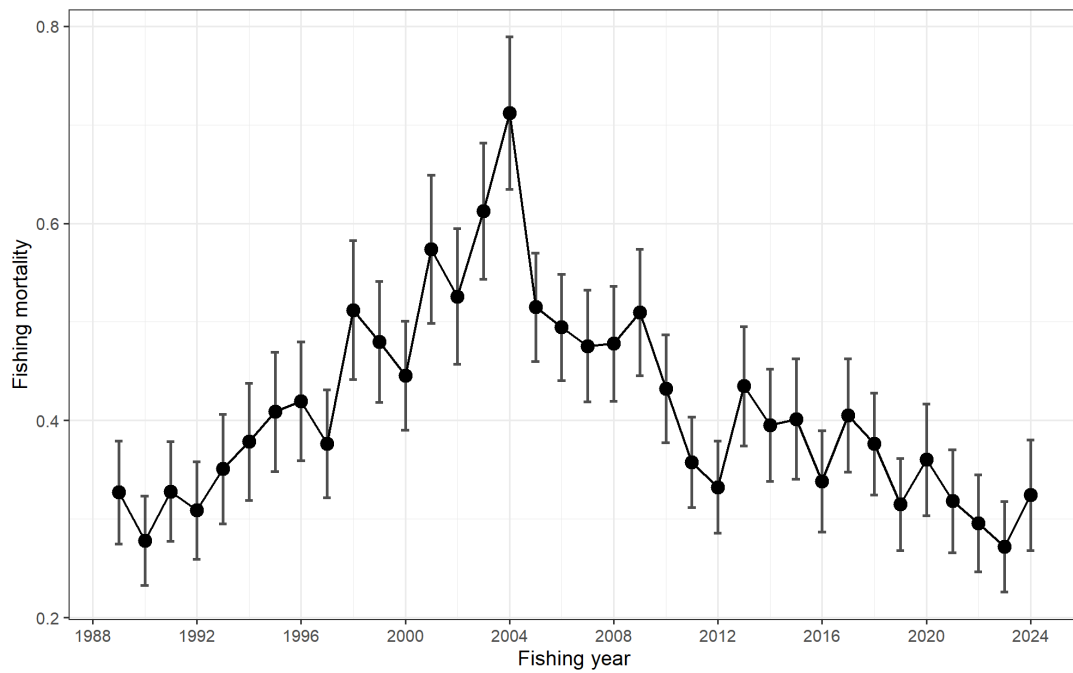


Figure H.205: Analysis 14: Time series of fishing mortality from the MCMC model—error bars represent 95% confidence intervals

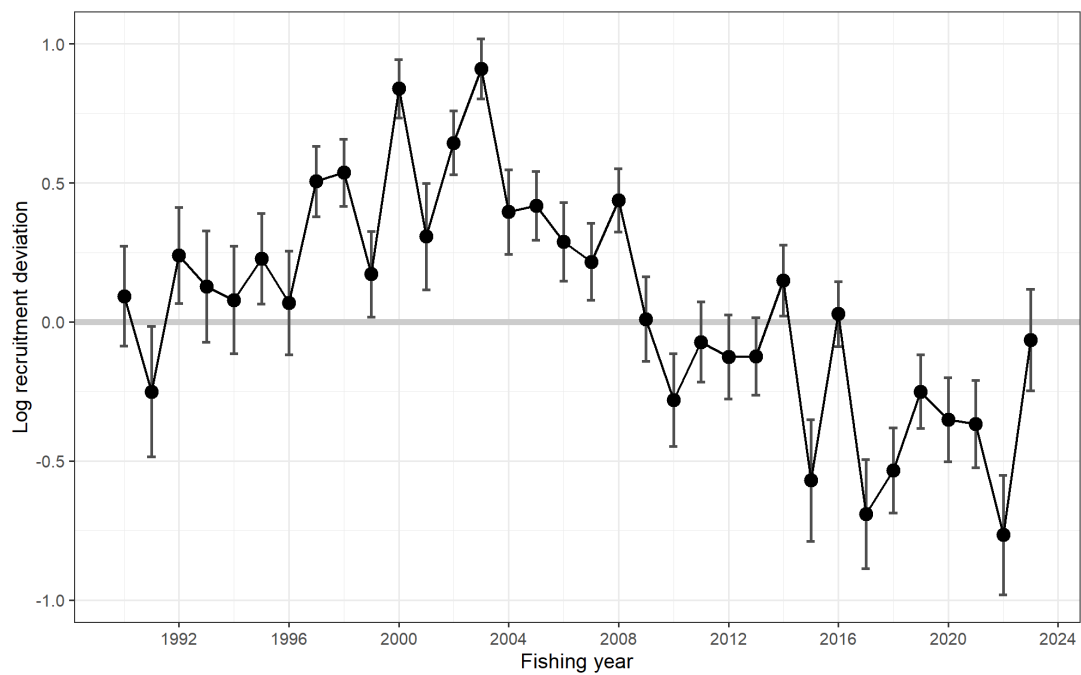


Figure H.206: Analysis 14: Recruitment deviations from the MLE model—error bars represent 95% confidence intervals

H.15 Analysis 15

Table H.27: Summary of MLE parameter estimates for analysis 15

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.88	2	-5.00	5.00	0.00	0.16
Recruitment distribution Qtr_3	-1.49	2	-5.00	5.00	0.00	0.30
Recruitment distribution Qtr_4	-0.95	2	-5.00	5.00	-1.15	0.12
$\ln(R_0)$	9.93	1	5.00	20.00	11.00	0.05
Commercial pot MBay L_{50}	10.17	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.41	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	10.93	3	0.10	20.00	11.20	0.15
Commercial pot offshore L_{95}	1.56	3	0.10	20.00	1.50	0.18
Commercial trawl L_{50}	9.68	3	0.10	20.00	9.00	0.22
Commercial trawl L_{95}	2.57	3	0.10	20.00	2.20	0.27
Commercial trawl MBay S_2	-2.46	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.62	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-2.16	3	-9.00	7.00	0.00	0.24
FIBT survey MBay S_2	0.55	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-1.29	3	-9.00	7.00	0.00	0.20
FIBT survey MBay S_4	-2.41	3	-9.00	7.00	-1.00	0.30

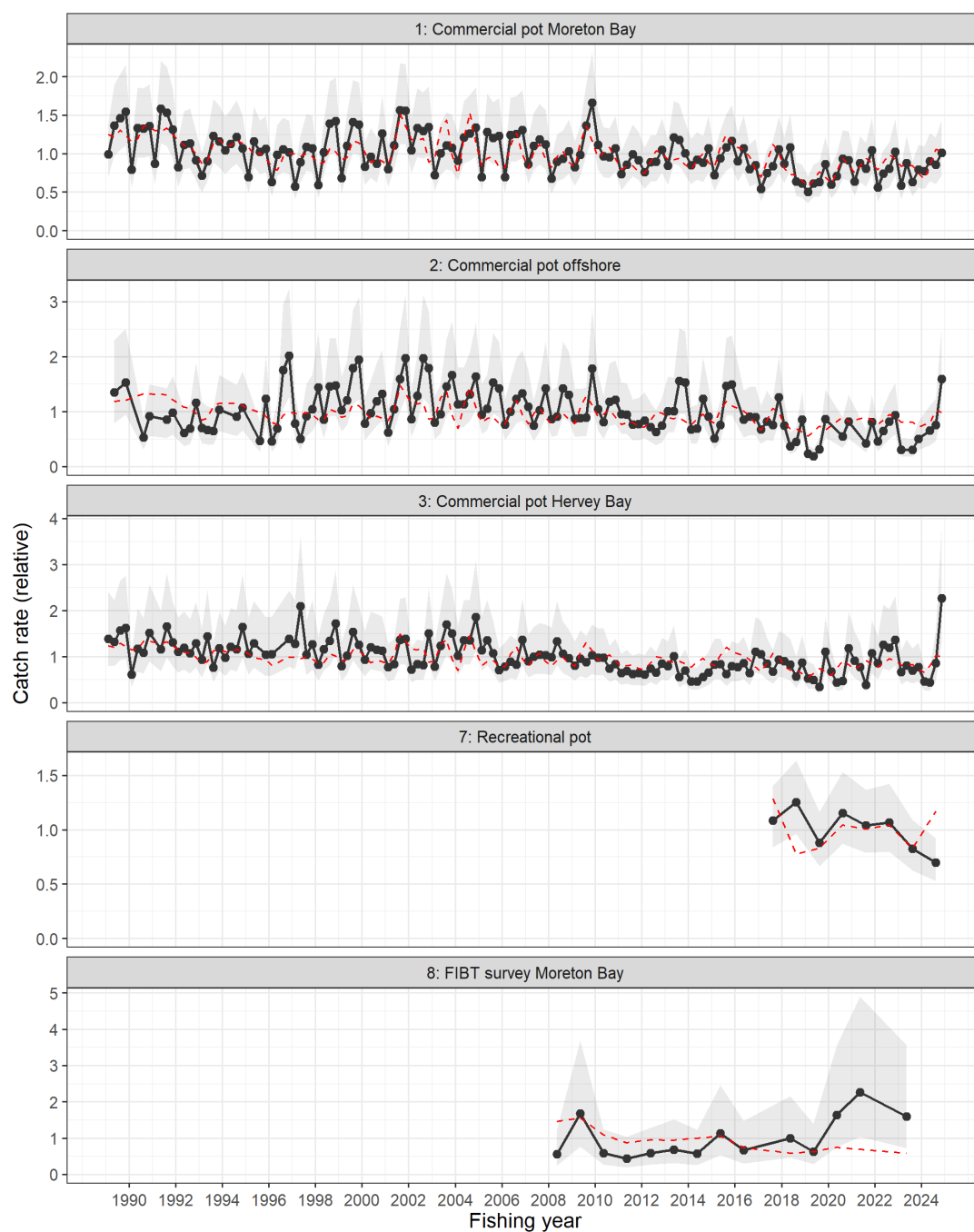


Figure H.207: Analysis 15: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

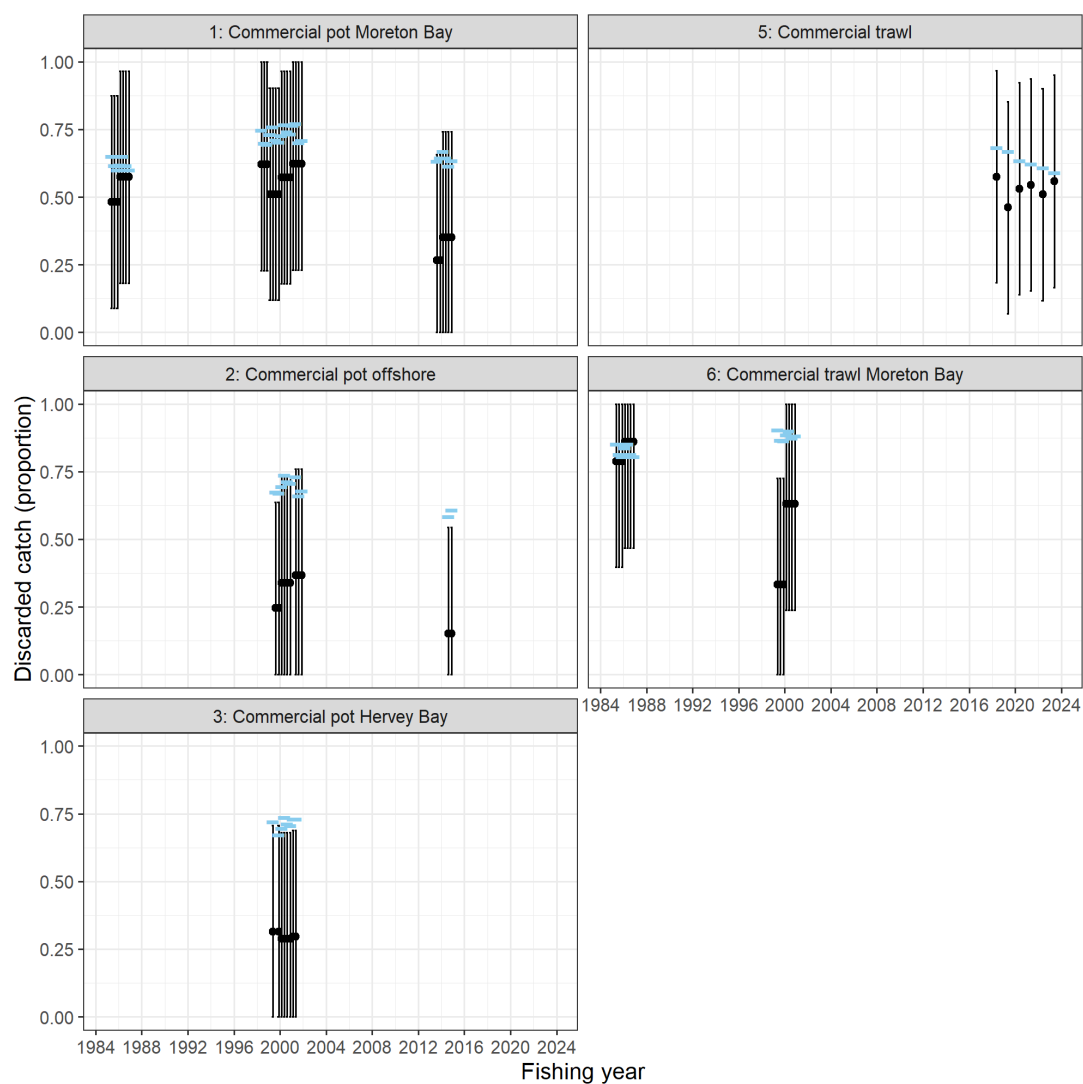


Figure H.208: Analysis 15: Fits to annual discard proportions of blue swimmer crab catch

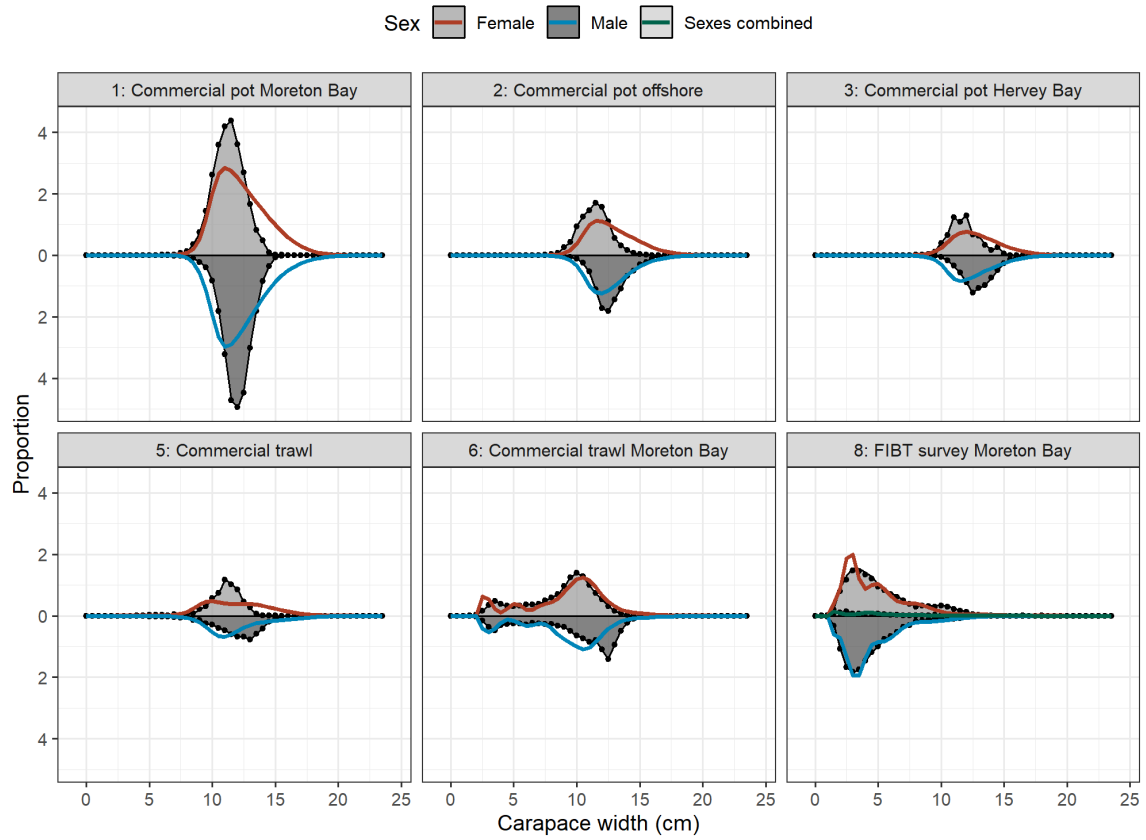


Figure H.209: Analysis 15: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

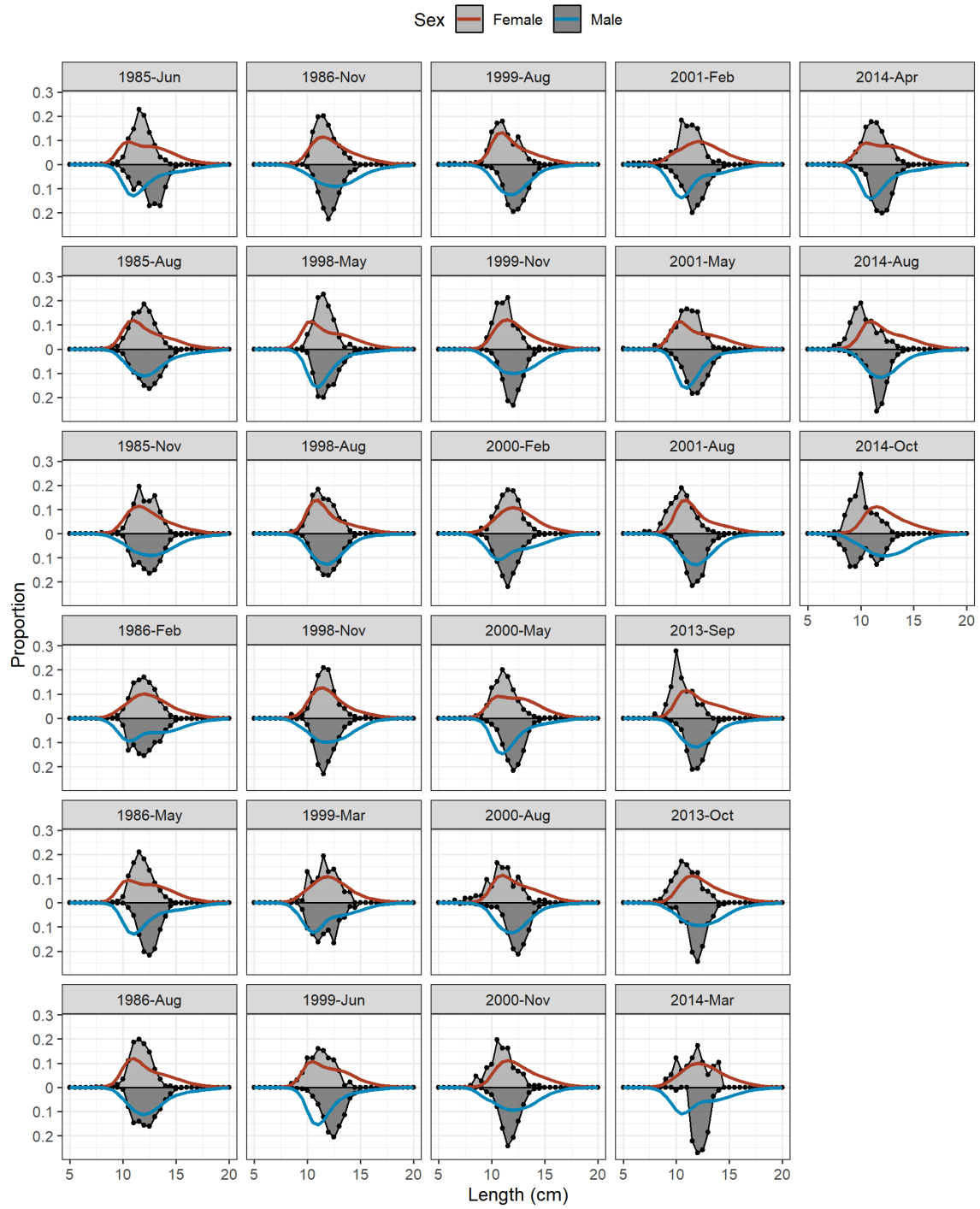


Figure H.210: Analysis 15: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

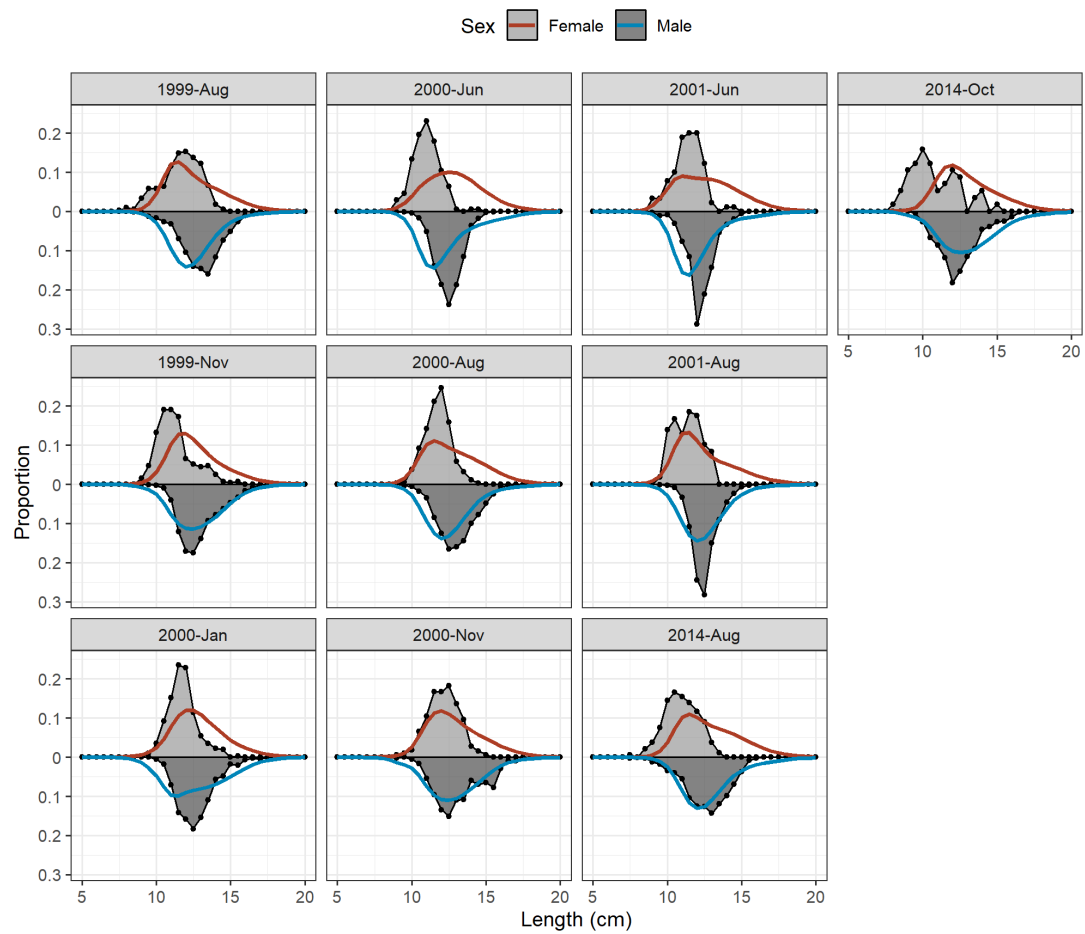


Figure H.211: Analysis 15: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

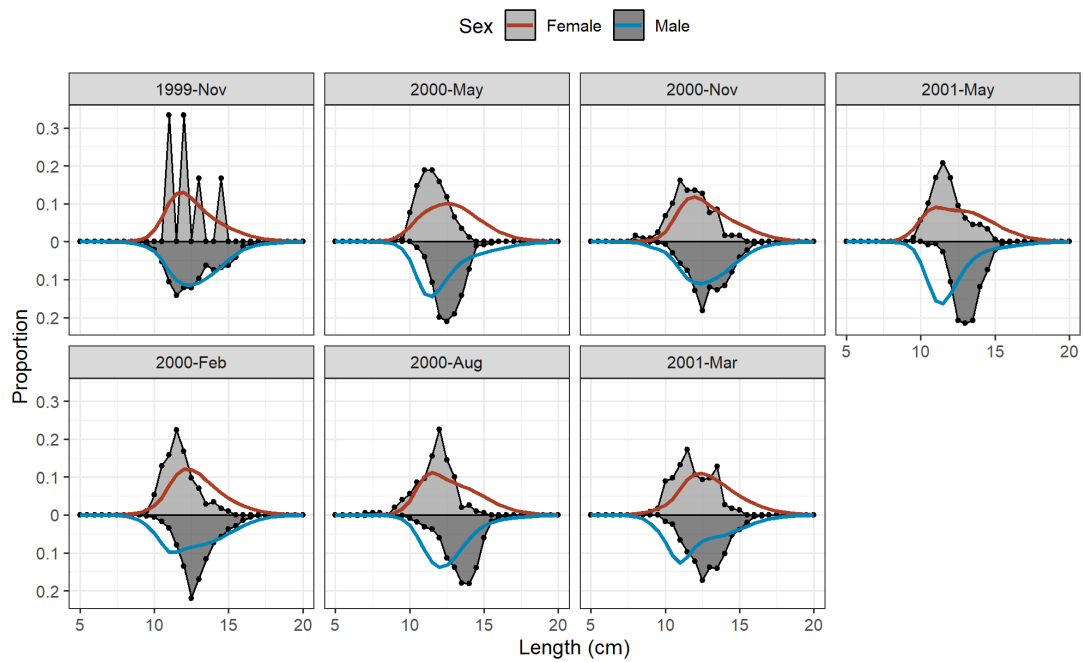


Figure H.212: Analysis 15: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

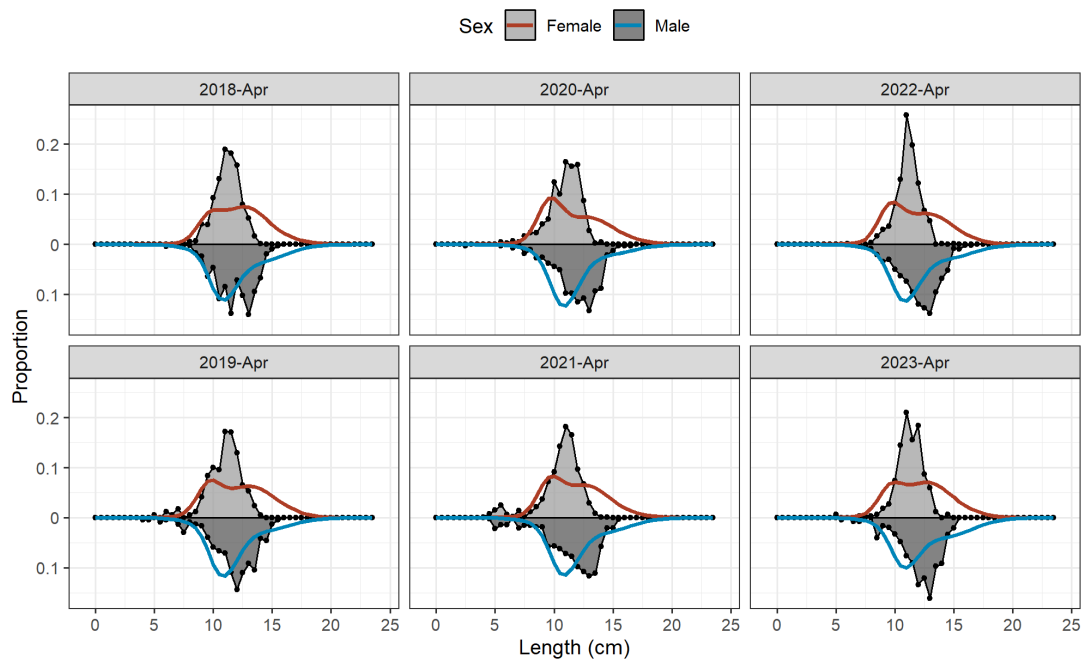


Figure H.213: Analysis 15: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

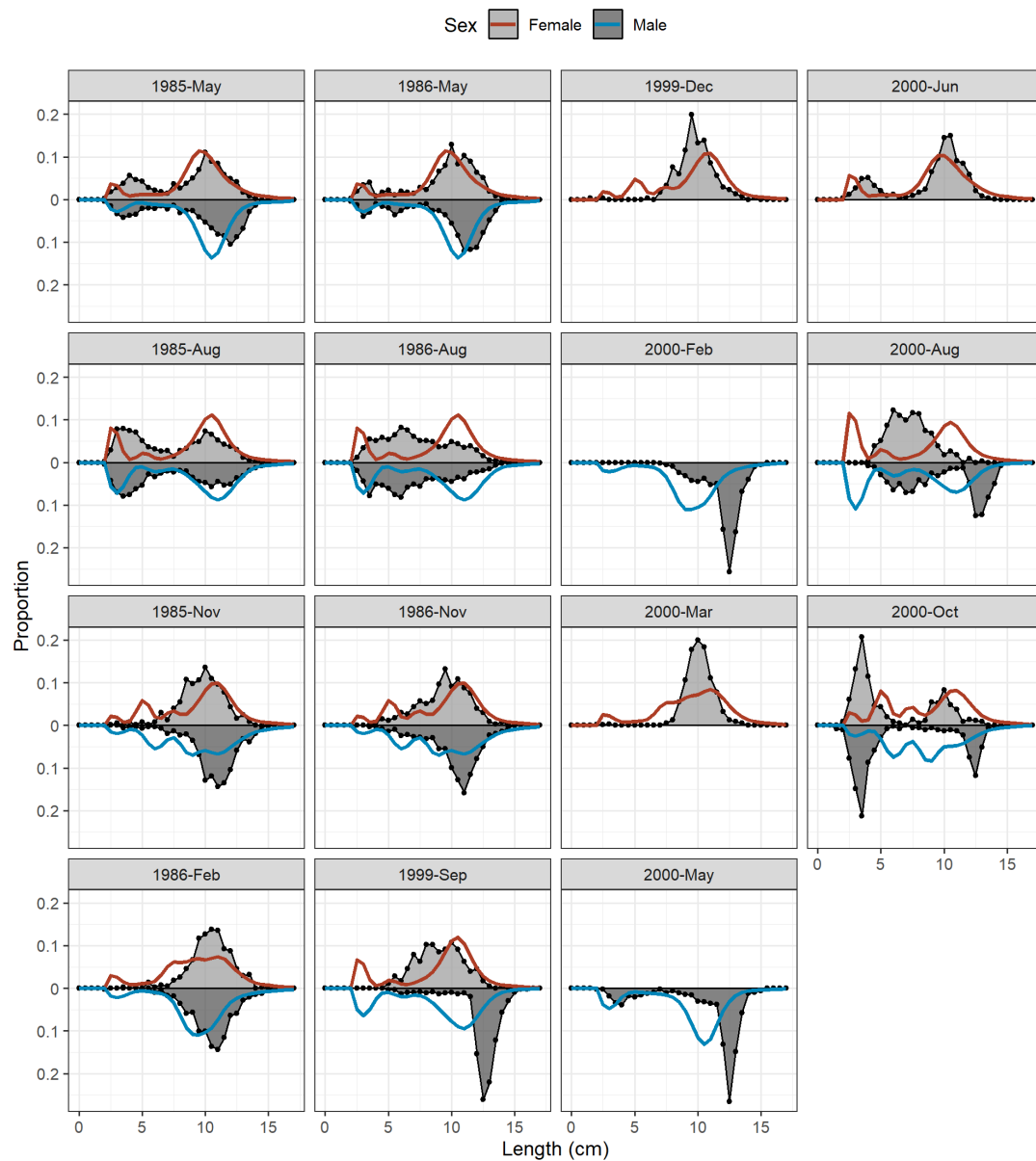


Figure H.214: Analysis 15: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

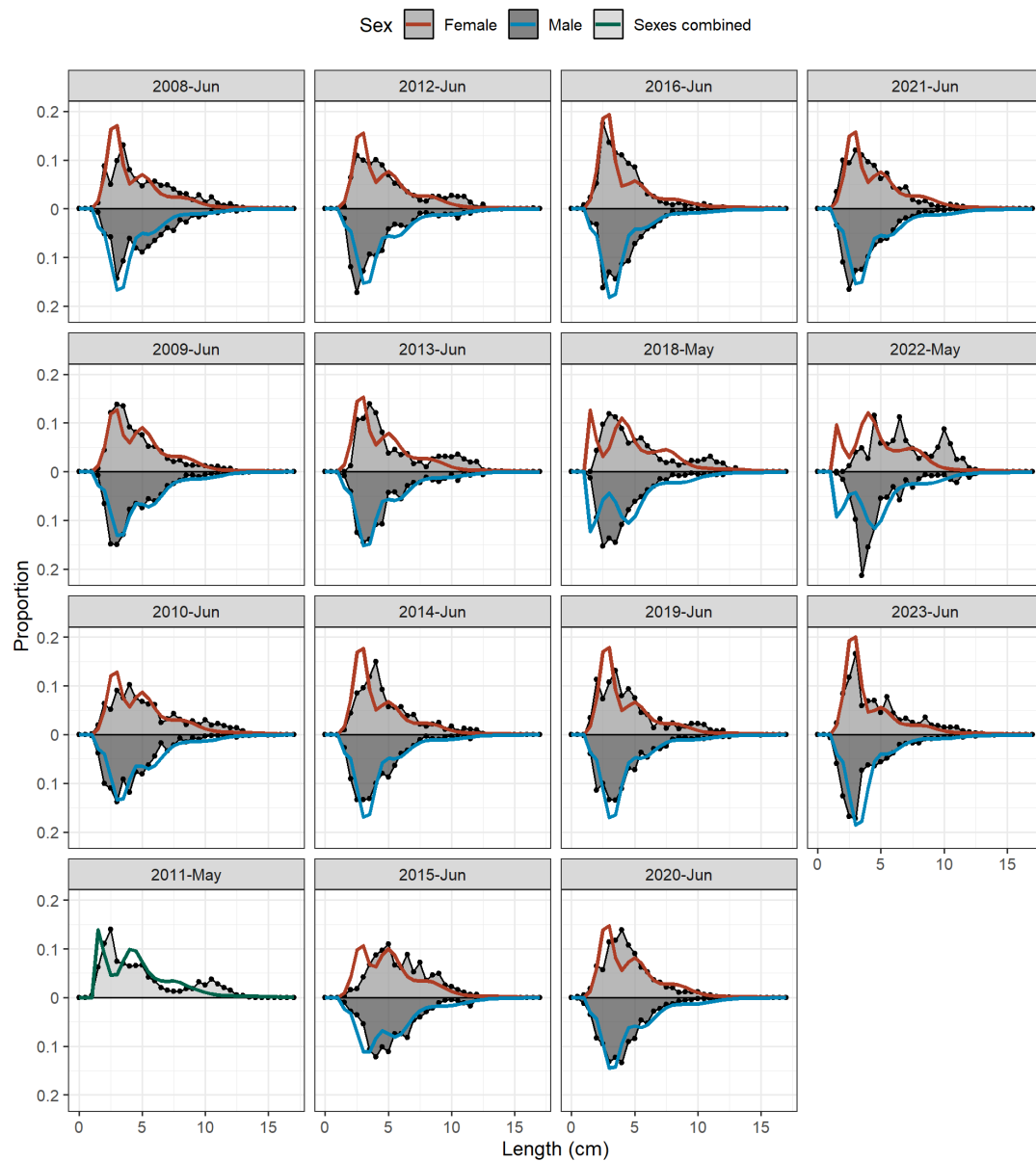


Figure H.215: Analysis 15: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

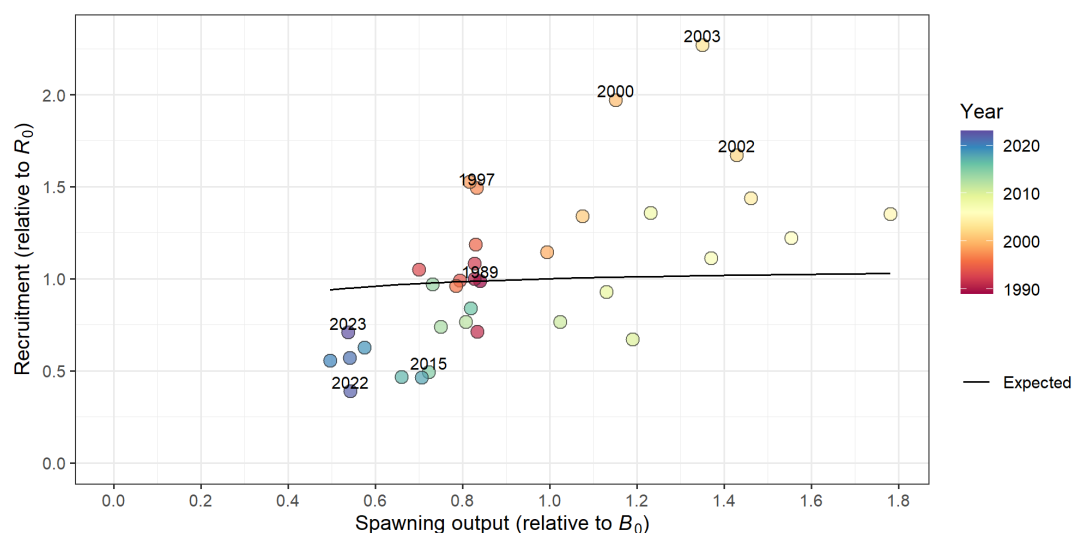


Figure H.216: Analysis 15: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 1 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

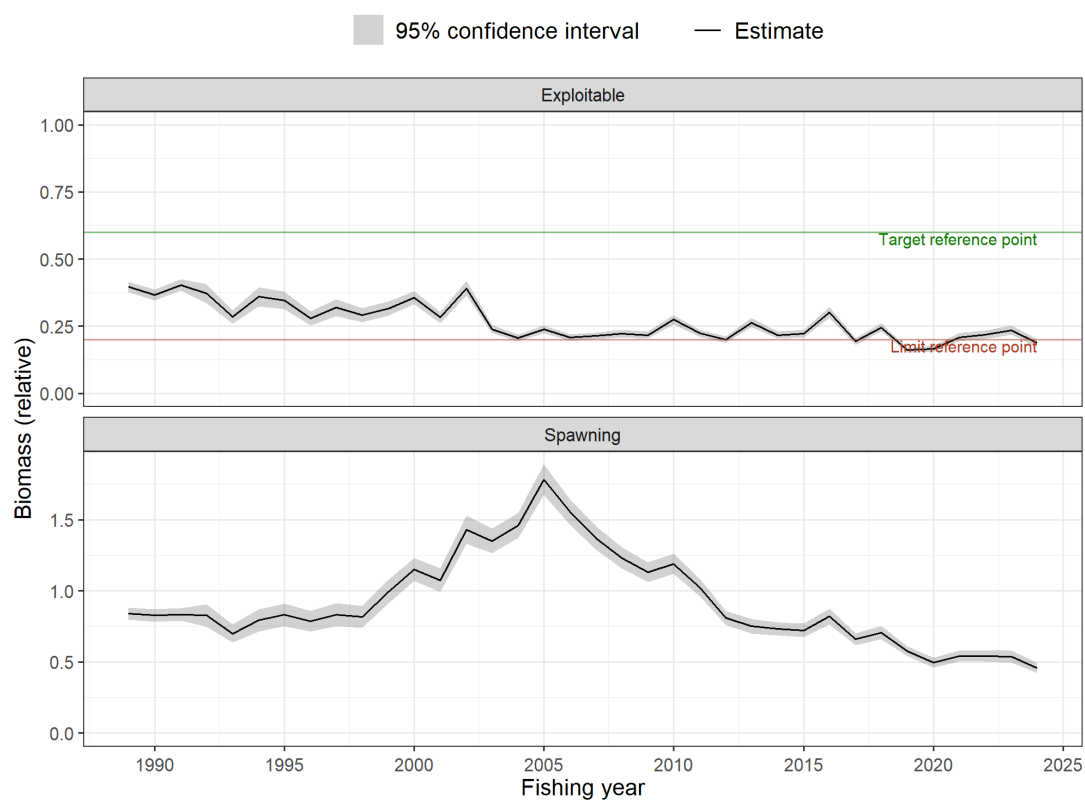


Figure H.217: Analysis 15: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

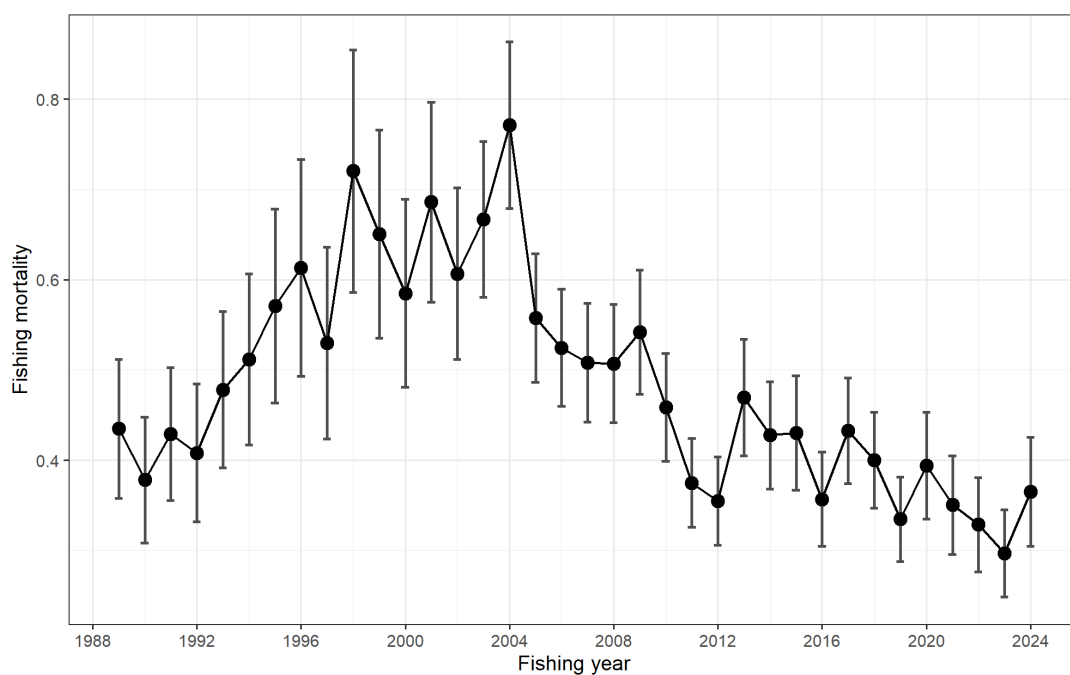


Figure H.218: Analysis 15: Time series of fishing mortality from the MCMC model—error bars represent 95% confidence intervals

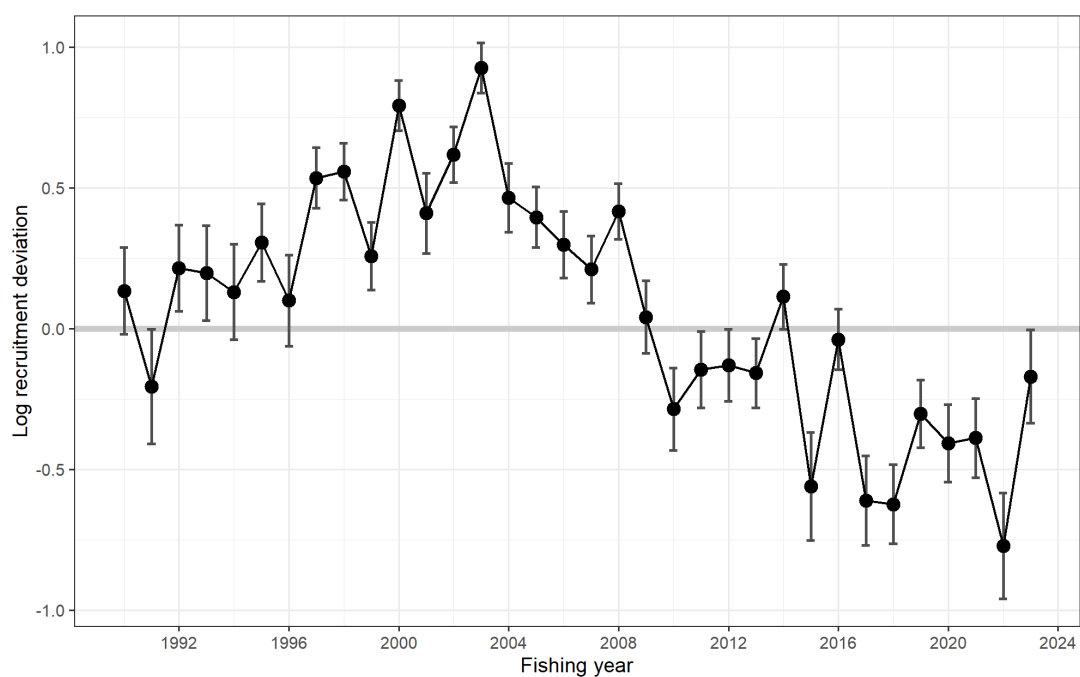


Figure H.219: Analysis 15: Recruitment deviations from the MLE model—error bars represent 95% confidence intervals

H.16 Analysis 16

Table H.28: Summary of MLE parameter estimates for analysis 16

Parameter	Estimate	Phase	Min	Max	Init	σ
Recruitment distribution Qtr_1	-0.43	2	-5.00	5.00	0.00	0.17
Recruitment distribution Qtr_3	-3.77	2	-5.00	5.00	0.00	1.77
Recruitment distribution Qtr_4	-0.91	2	-5.00	5.00	-1.15	0.12
$\ln(R_0)$	10.11	1	5.00	20.00	11.00	0.04
Commercial pot MBay L_{50}	10.51	3	0.10	20.00	10.00	0.08
Commercial pot MBay L_{95}	1.51	3	0.10	20.00	1.50	0.09
Commercial pot offshore L_{50}	11.36	3	0.10	20.00	11.20	0.14
Commercial pot offshore L_{95}	1.70	3	0.10	20.00	1.50	0.16
Commercial trawl L_{50}	10.28	3	0.10	20.00	9.00	0.21
Commercial trawl L_{95}	2.62	3	0.10	20.00	2.20	0.25
Commercial trawl MBay S_2	-2.46	3	-9.00	7.00	-1.40	0.22
Commercial trawl MBay S_3	-0.50	3	-9.00	7.00	0.00	0.17
Commercial trawl MBay S_4	-1.59	3	-9.00	7.00	0.00	0.25
FIBT survey MBay S_2	1.00	3	-9.00	7.00	1.00	0.16
FIBT survey MBay S_3	-0.66	3	-9.00	7.00	0.00	0.19
FIBT survey MBay S_4	-1.38	3	-9.00	7.00	-1.00	0.30

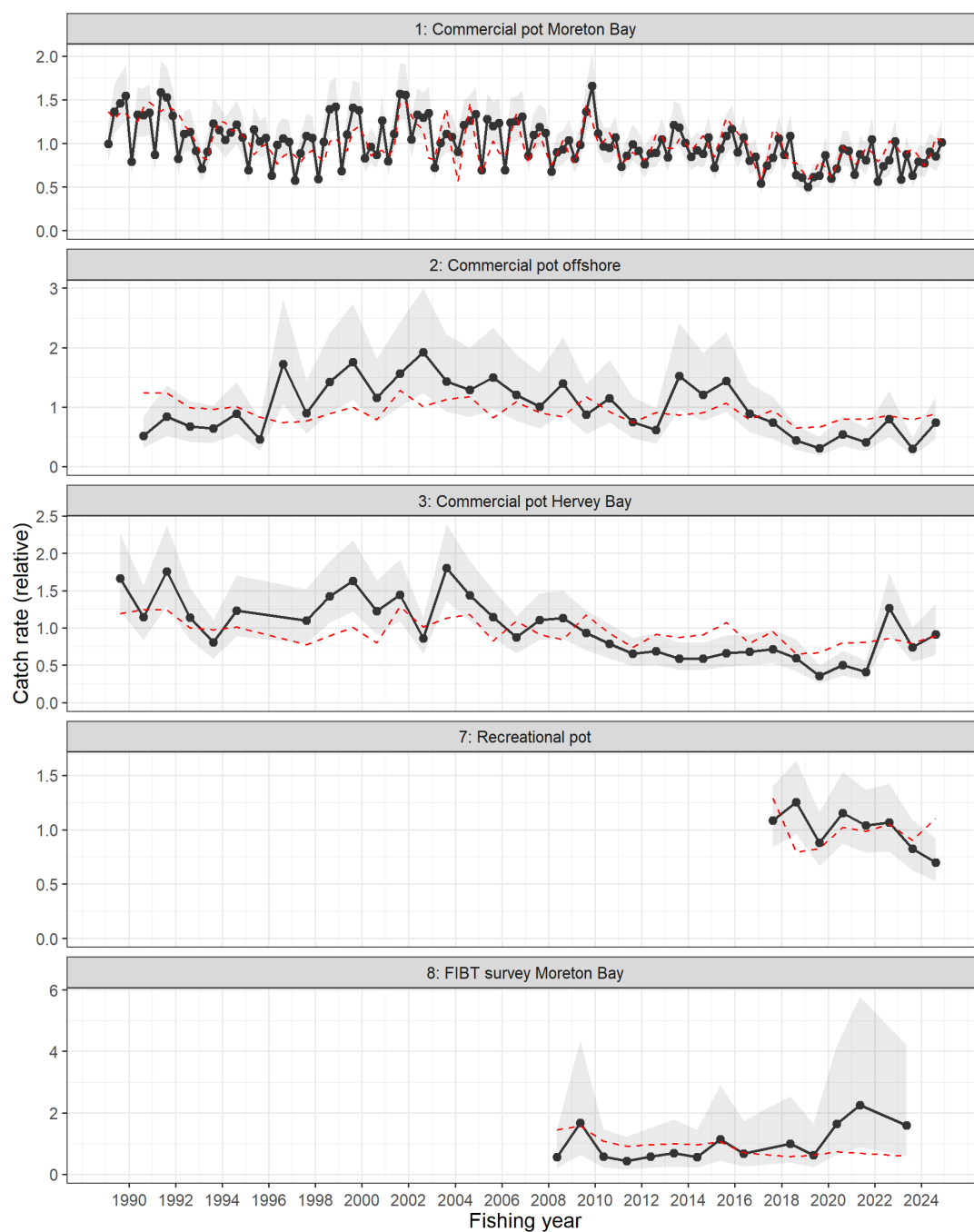


Figure H.220: Analysis 16: Model predictions (dashed line) to standardised catch rates for blue swimmer crab in the east coast, based on maximum likelihood estimation—grey line and error bars represent the model input and associated uncertainty

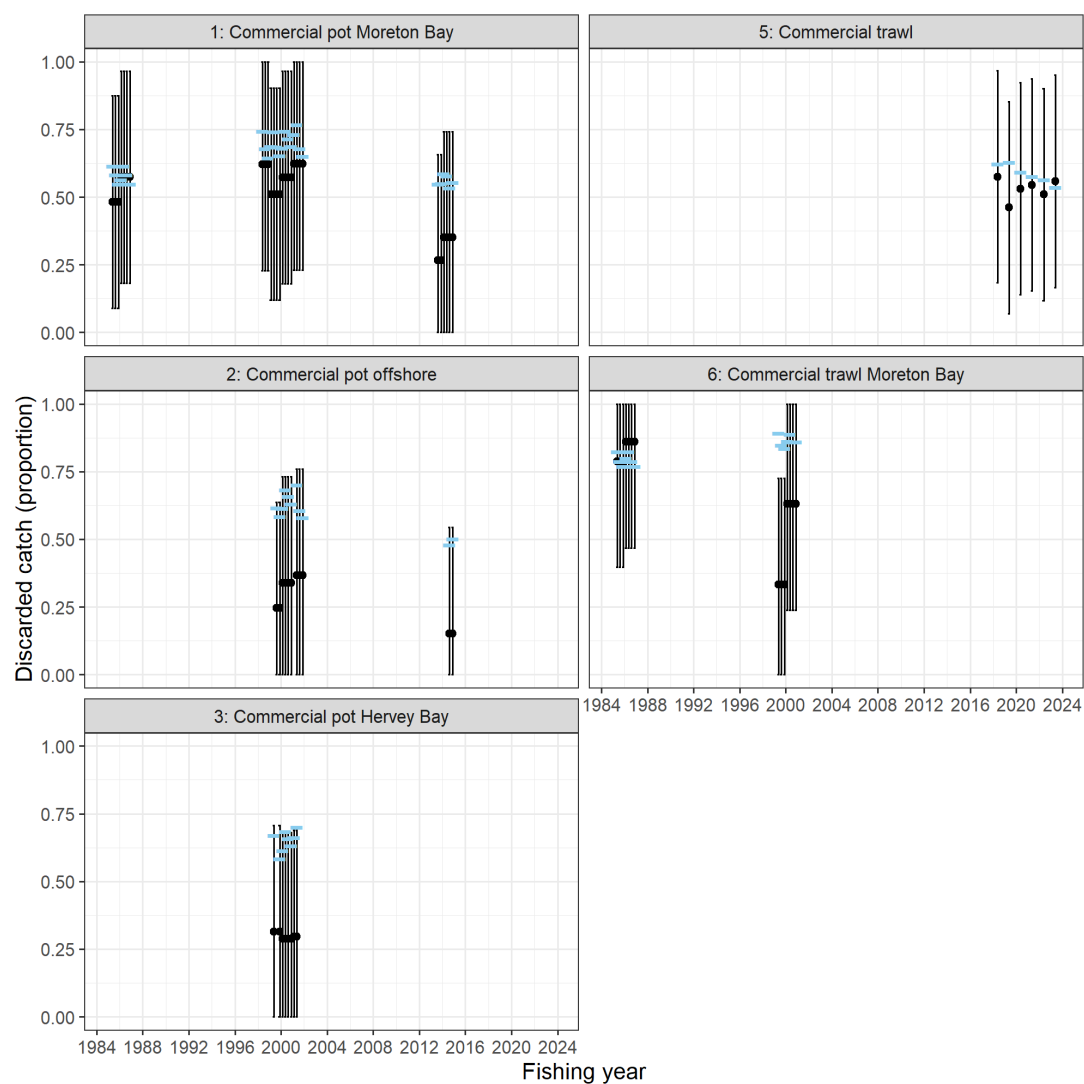


Figure H.221: Analysis 16: Fits to annual discard proportions of blue swimmer crab catch

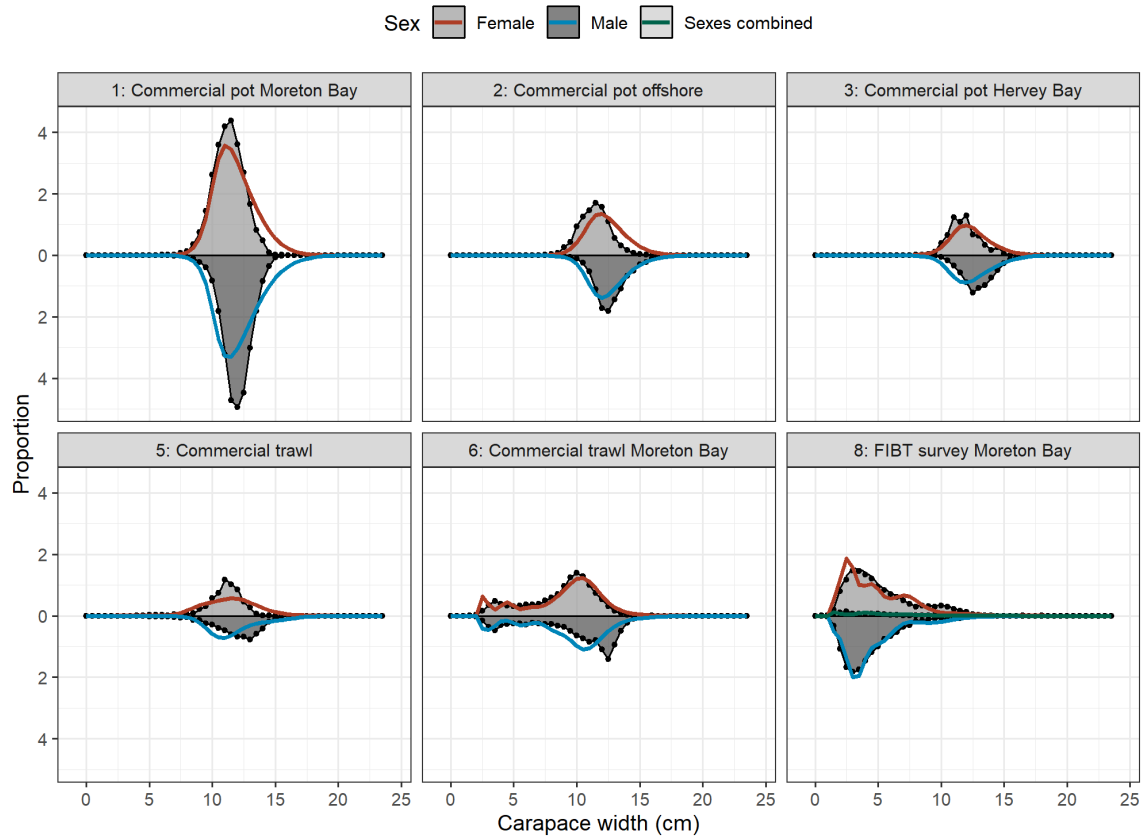


Figure H.222: Analysis 16: Aggregated fits to length structures based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

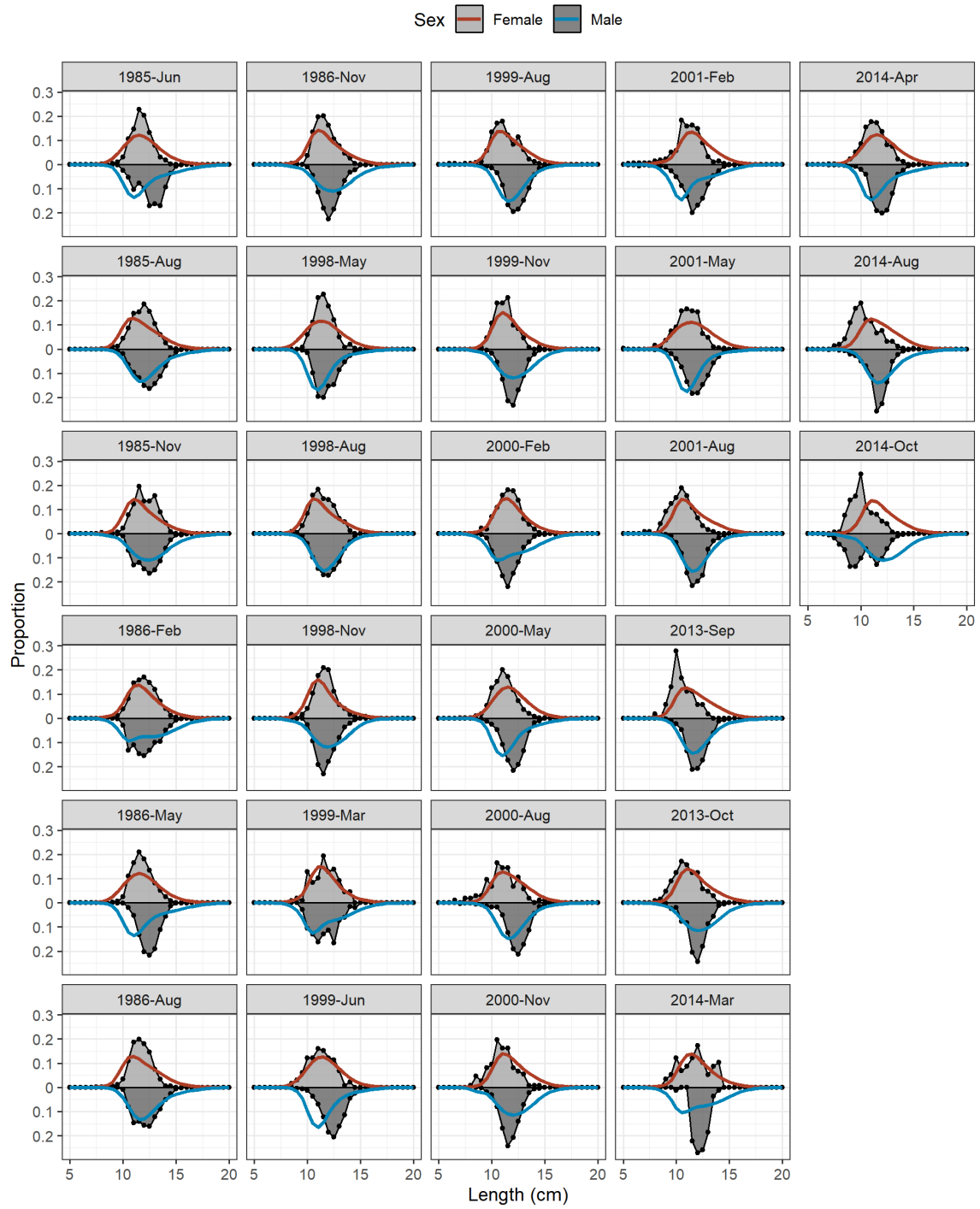


Figure H.223: Analysis 16: Fits to length structures for commercial pot Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

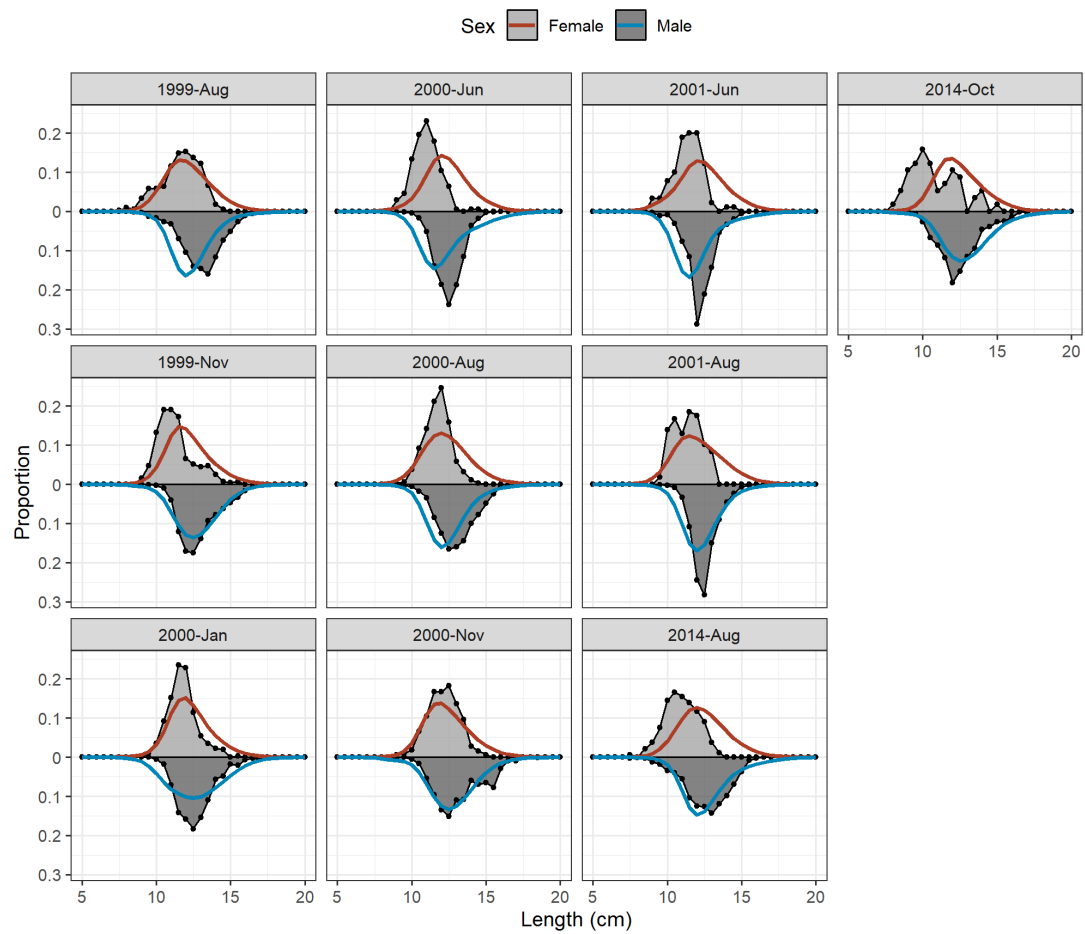


Figure H.224: Analysis 16: Fits to length structures for commercial offshore pot fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

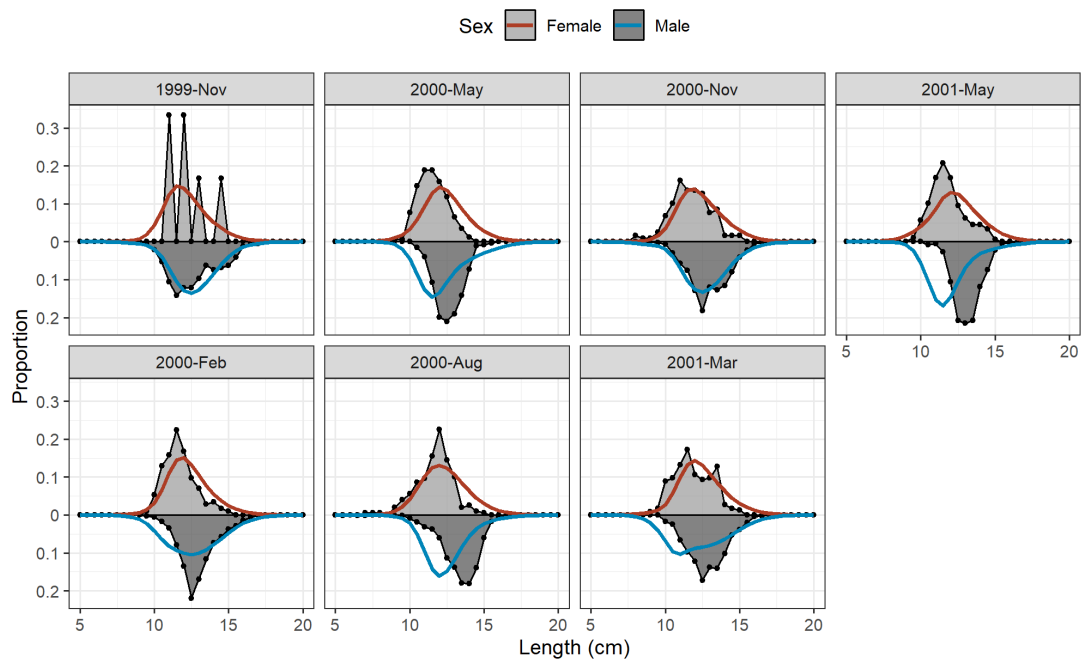


Figure H.225: Analysis 16: Fits to length structures for commercial pot Hervey Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

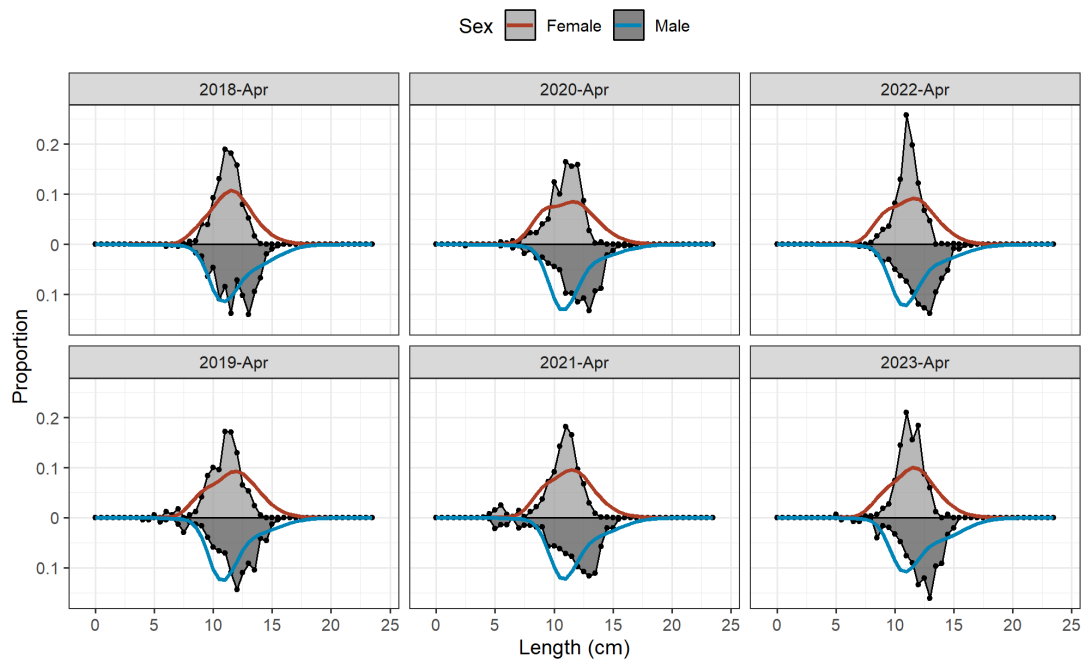


Figure H.226: Analysis 16: Fits to length structures for commercial trawl fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

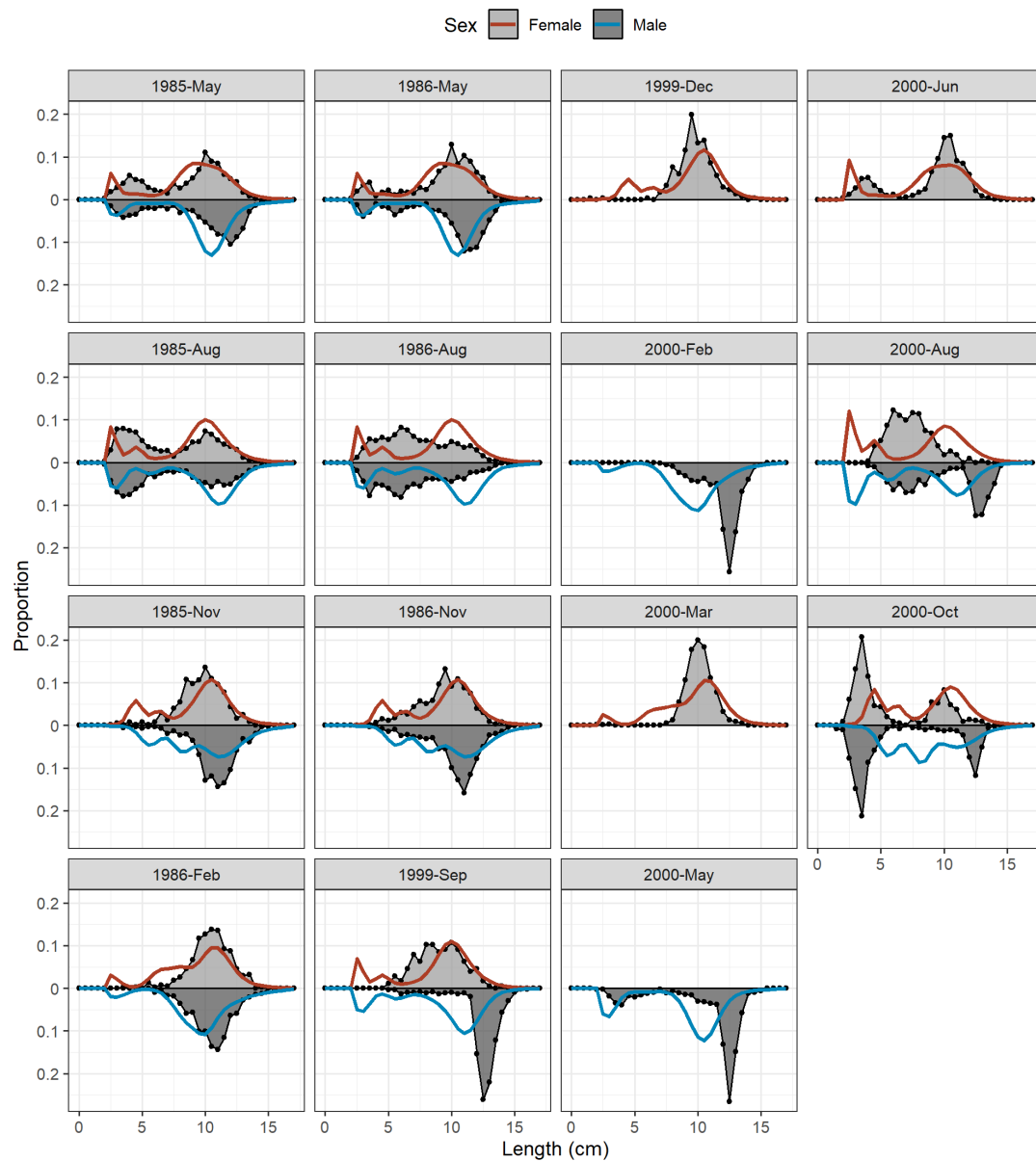


Figure H.227: Analysis 16: Fits to length structures for commercial trawl Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

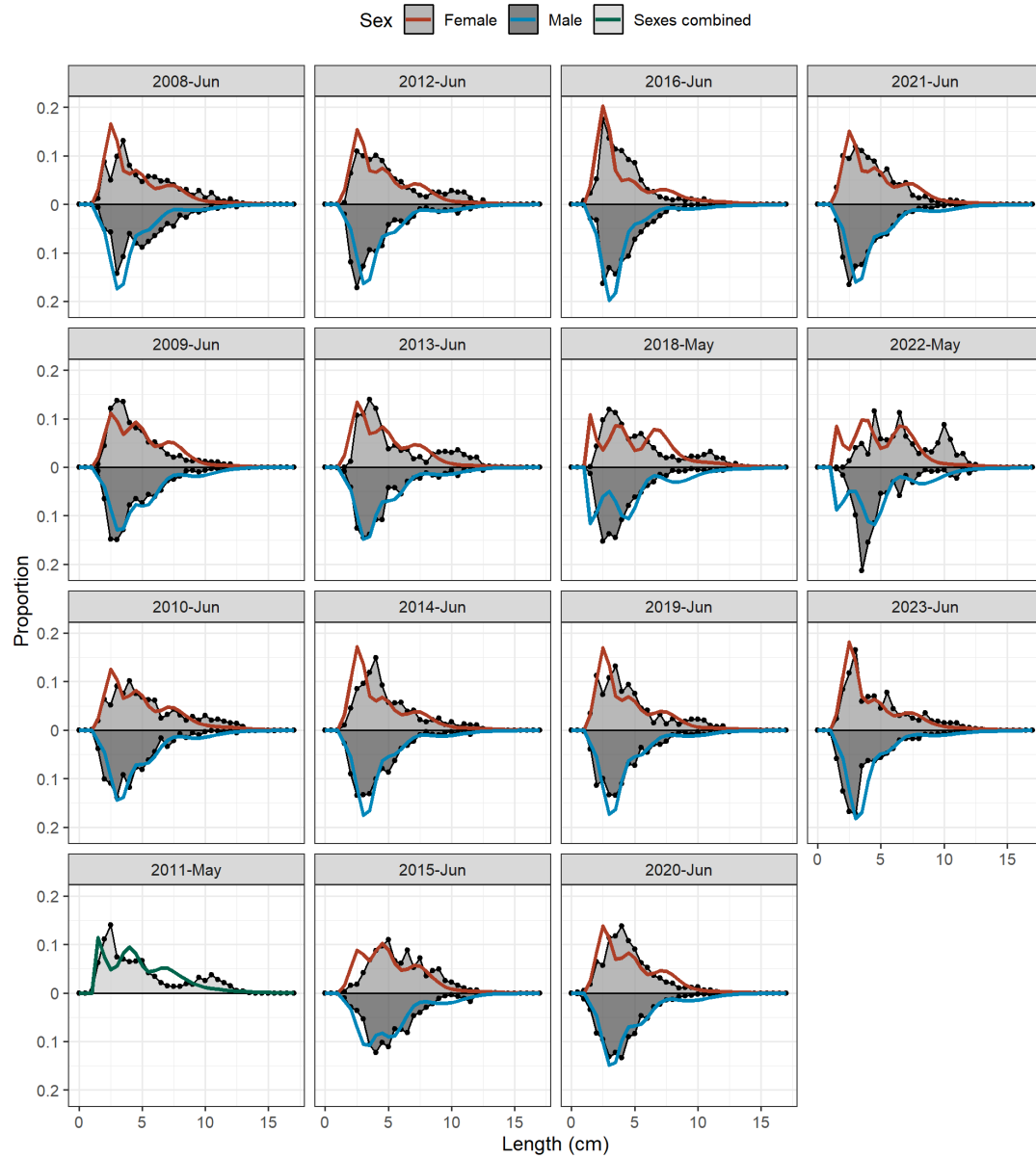


Figure H.228: Analysis 16: Fits to length structures for juvenile survey Moreton Bay fleet, based on maximum likelihood estimation—grey area and black line and points represent input data and coloured lines represent model fits

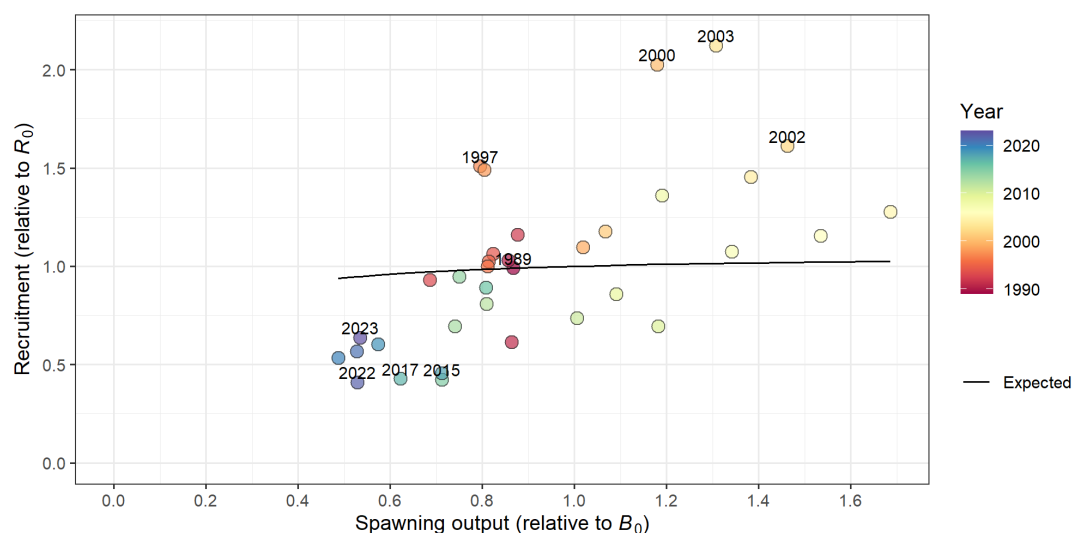


Figure H.229: Analysis 16: Stock-recruit curve for blue swimmer crab in the east coast for the analysis 1 MLE model—point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years

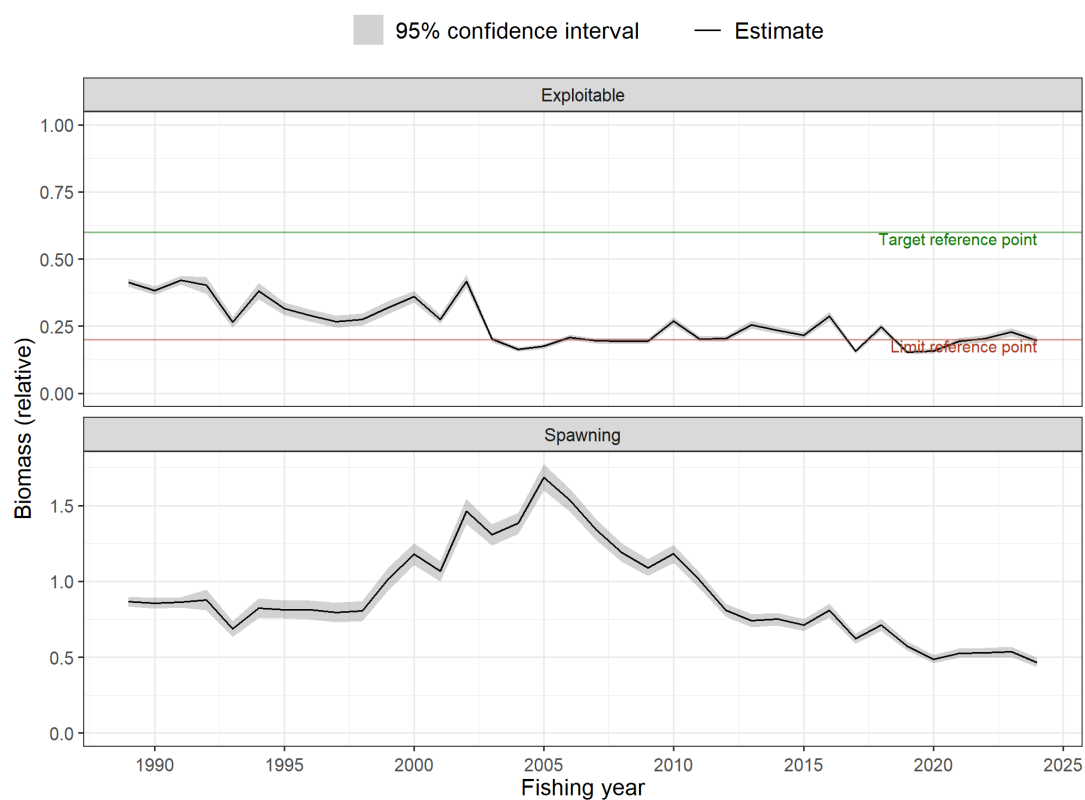


Figure H.230: Analysis 16: Predicted exploitable biomass trajectory relative to unfished for blue swimmer crab in the east coast

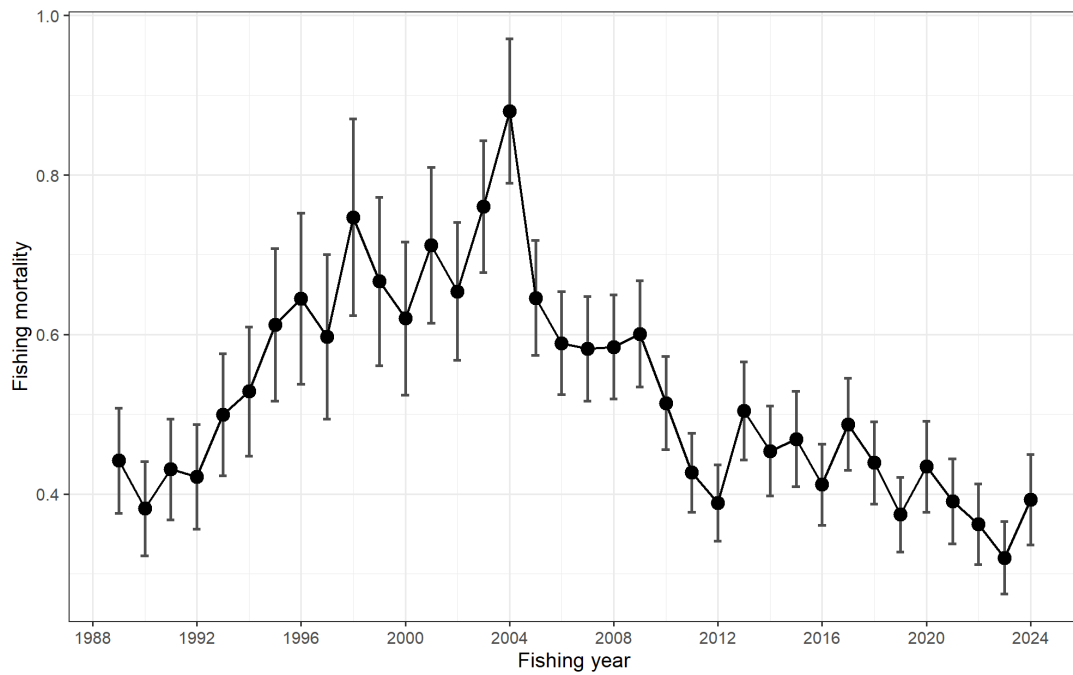


Figure H.231: Analysis 16: Time series of fishing mortality from the MCMC model—error bars represent 95% confidence intervals

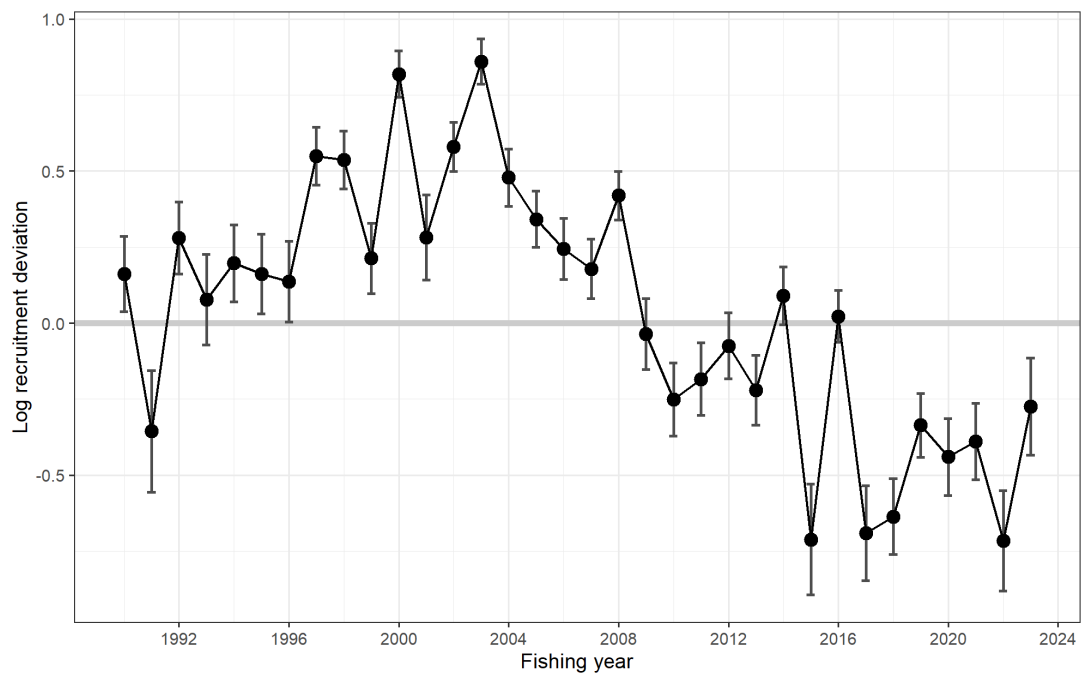


Figure H.232: Analysis 16: Recruitment deviations from the MLE model—error bars represent 95% confidence intervals