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Rapid updates for New Zealand rock lobster (*Jasus edwardsii*) stocks in 2023

New Zealand Fisheries Assessment Report 2024/13

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TABLE OF CONTENTS

Plain language summary

The red rock lobster supports the most valuable inshore commercial fishery in New Zealand. This fishery has been managed with catch quotas in nine Quota Management Areas (QMAs), which are usually treated as independent populations or stocks.

To estimate those quotas, each population is fully assessed every five years, requiring a lot of time and effort by a team of at least five researchers working on the review of the previous assessments and data inputs, the addition of new data, data processing, and development of a new assessment.

Every year, instead of a full assessment, a rapid update assessment is done for each of the stocks that were not assessed that year.

A rapid update repeats the previous full assessment model, only updating data inputs, which significantly speeds up the required process to provide advice about stock status in the interim years between full assessments.

This document describes the operation of the stock assessment rapid updates completed in 2023 for six stocks that can be used to guide management decisions of New Zealand red rock lobster QMAs.

For the beginning of the 2023–24 fishing year, all red rock lobster stocks evaluated were estimated to be above sustainable levels.

EXECUTIVE SUMMARY

Pons, M.[1]; Webber, D.N.[2]; Rudd, M.B.[3]; Starr, P.J.[1]; Roberts, J.[4] (2024). Rapid updates for New Zealand rock lobster (*Jasus edwardsii*) stocks in 2023.

***New Zealand Fisheries Assessment Report 2024/13*. 80 p.**

This document describes the operation of stock assessment rapid updates completed in September-October 2023 that can be used to guide management decisions of New Zealand red rock lobster (*Jasus edwardsii*, CRA Quota Management Areas).

Full stock assessments for each rock lobster stock are generally done once every five years. Full stock assessments require significant time and effort, including: a review of the previous stock assessment and data inputs, updates to data processing code, the addition of new data, implementation of new structural changes to the model, review of prior specifications for model parameters, and runs of a range of sensitivities to key model assumptions. For red rock lobsters, the last few stock assessments have required at least five stock assessment scientists working for over five weeks to complete one or two stock assessments, working under the guidance of the Rock Lobster Working Group.

Rapid updates differ from a full stock assessment because they repeat the previous base case stock assessment model(s), with the same model settings and assumptions, only updating inputs with new covariates and data (e.g., additional years of catch, length frequencies, sex ratios, and tag-recapture growth increment data). This significantly speeds up the required process, with the result being that every stock can have a rapid update done each year. Rapid updates do not aim to replace full stock assessments, but complement them by providing inference about stock status in the interim years between full assessments.

This document presents rapid updates for six rock lobster stock assessments: CRA 1, CRA 2, CRA 3, CRA 4, CRA 5, and CRA 7&8. There is no accepted stock assessment for CRA 9, so this stock cannot be included in the rapid update system. CRA 6 was not included because it received a full stock assessment in 2023.

For the beginning of the 2023–24 fishing year, the adjusted vulnerable biomass for all stocks was estimated to be above the reference level (B_R). It was 8% above B_R for CRA 1, 78% above for CRA 2, 54% above for CRA 3, 52% above for CRA 4, and three-times B_R for CRA 5. For CRA 7&8, the reference level was not accepted by the 2023 Plenary meeting, but spawning stock biomass (SSB) indicators showed that the median SSB in 2023–24 was 54% of SSB_0, which is 35% above the default target of 40% SSB_0. For all stocks, the probability of SSB being above the soft and hard limits at the beginning of the 2023–24 fishing year was 1.00.

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1. INTRODUCTION

The red rock lobster (*Jasus edwardsii*) supports the most valuable inshore commercial fishery in New Zealand, with exports worth NZD$300 million in 2019 (Seafood New Zealand 2020) and it is also valuable to customary Māori, recreational fishers, and non-extractive stakeholders. Commercial red rock lobster fisheries have been managed with Individual Transferable Quotas (ITQs) in nine Quota Management Areas (QMAs) since April 1990, which are usually treated as independent stocks for stock assessment (Breen et al. 2016a, Figure 1).

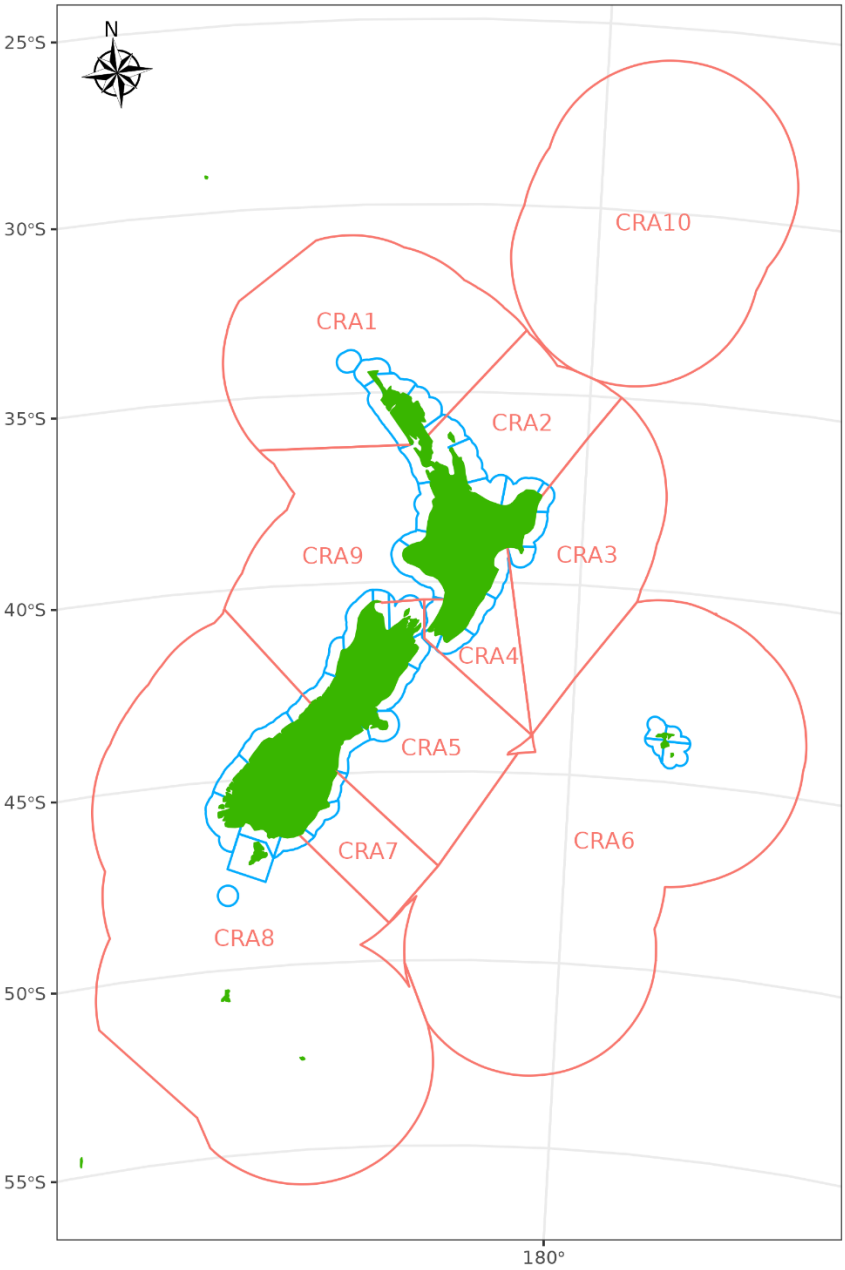

Figure 1: New Zealand red rock lobster (*Jasus edwardsii*) Quota Management Areas (QMAs) in red and statistical areas in blue. CRA 10 is not fished commercially.

Full stock assessments are usually done once every five years for eight of the nine rock lobster QMAs (i.e., all except CRA 9, which is currently seen as data deficient for stock assessment). Full stock assessments require significant time and effort, including: a review of the previous stock assessment and data inputs, updates to data processing code, the addition of new data, implementation of new structural changes to the model, review of prior specifications for model parameters, and runs of many

sensitivities to key model assumptions. The last few red rock lobster stock assessments have required at least five stock assessment scientists working for over five weeks to complete one or two stock assessments, under the guidance of the Rock Lobster Working Group (RLWG).

Up to the 2020–21 fishing year[5], management procedures (MPs) were used to manage New Zealand stocks of red rock lobsters (Bentley et al. 2003, Bentley & Stokes 2009, Breen et al. 2009, 2016a, 2016b, Webber & Starr 2020). MPs, often referred to as harvest control rules, are simulation-tested decision rules or functions (Butterworth & Punt 1999) that specify one or more inputs and return an output value. In the past, New Zealand rock lobster MPs used standardised commercial fishery catch per unit effort (CPUE) as the input and a catch limit as the output. MPs are an important management tool globally (Edwards & Dankel 2016). They are used to manage rock lobsters in South Africa (Johnston & Butterworth 2005, Johnston et al. 2014), South Australia (Punt et al. 2012), and Victoria (Punt et al. 2013).

The 2019–20 fishing year marked the transition of rock lobster catch and effort data collection from the paper-based Catch Effort Landing Return (CELR) system to an electronic reporting (ER) system dependent on a user interface operated from tablets or smart phones. Presently, there are three ER reporting 'platforms', each with different user interfaces and different underlying software. Preliminary analyses of the 2019–20 data indicated that the estimated catches reported using the new ER system differed from the equivalent estimates generated by the previous CELR forms (see appendix B of Starr 2021). Therefore, the RLWG agreed to temporarily suspend updating CPUE indices beginning with the 2019–20 spring/summer (SS) season. The RLWG concluded that, apart from CRA 7, there remained sufficient CELR data for each of the QMAs to ensure comparability with previous indices for the 2019–20 autumn/winter (AW) data. This meant that, after 2019–20 AW, CPUE was no longer available to monitor the abundance of New Zealand rock lobster and was not available for use in MPs. This issue has since been reviewed three times by the RLWG (to the end of 2020–21, 2021–22, and 2022–23) without observing any reason to change the initial conclusion (see table 4 in the introductory Rock Lobster chapter of Fisheries New Zealand 2023). However, for CRA 2 an alternative CPUE series was developed based on voluntary logbook data reported by the CRA 2 fleet since 1993, for use in the 2022 CRA 2 stock assessment (Webber & Starr 2022).

With the loss of MPs, stock status in New Zealand rock lobster stocks is now monitored using current estimates of vulnerable biomass relative to a vulnerable biomass reference level (B_R) and estimates of female spawning stock biomass (SSB) relative to the Harvest Strategy Standard (HSS) default hard (10% SSB_0) and soft (20% SSB_0) limits. While this evaluation is straight-forward for years when a full stock assessment is done, this evaluation can be made based on the stock status estimates generated by these rapid updates in the years between full stock assessments. The reference level (B_R) is estimated for each stock using the procedure developed by Rudd et al. (2021c) and remains unchanged until the next full stock assessment.

This document describes the rapid update framework for New Zealand rock lobster stocks and the application of this system to six stock assessments (CRA 1, CRA2, CRA 3, CRA 4, CRA 5, and CRA 7&8). This framework was first applied in 2020 to CRA 1, CRA 2, and CRA 3 (Webber et al. 2021a), in 2021 to CRA 4 and CRA 5 (Rudd et al. 2022), and in 2022 to CRA 7&8 (Pons et al. 2023). CRA 6 has not been incorporated into the rapid update system due to time constraints in the past and because B_R for this stock was only estimated for the first time as part of a full assessment in 2023 (Rudd et al. in press). Current plans are to continue rapid updates into the future for all rock lobster stocks that are not the subject of a full stock assessment in that year. Because there is no accepted stock assessment for CRA 9 as a result of data limitations, this stock cannot be included in the rapid update system.

[5] Most years in this document refer to the 1 April to 31 March statutory fishing year, for example, 1 April 2020 to 31 March 2021 is designated the 2020–21 fishing year. Two seasons are defined per fishing year: 1 April to 30 September is referred to as autumn/winter (AW) and 1 October to 31 March is referred to as spring/summer (SS). Sometimes specific seasons within a fishing year are referred to, for example, 2020–21 AW refers to 1 April 2020 to 30 September 2020 or 2020–21 SS refers to 1 October 2020 to 31 March 2021. Calendar years are simply referred as usual (e.g., 2020).

Rapid updates differ from full stock assessments because they repeat the previous base case stock assessment model(s) with identical model settings and assumptions, only updating inputs, including additional years of catch, length frequencies (LFs), and tag-recapture data. This significantly speeds up the assessment process, so that every stock not undergoing a full stock assessment can have a rapid update done each year. The rapid update system has been designed to provide fishery advice even in the absence of an updated CPUE series (the main abundance index) and serves to temporarily replace the MPs previously used to manage these stocks (Webber & Starr 2020). Rapid updates could also form the basis for developing new MPs in the future. Rapid updates do not aim to replace full stock assessments but complement them by providing inference about stock status in the interim years between full assessments.

2. METHODS

The additional covariates and data that are used in rapid updates include: commercial and non-commercial catch series, length frequency (LF) data, tag-recapture data, and an updated CPUE index, when available. Data requests are the first step in the operation of rapid updates and were submitted to Fisheries New Zealand for monthly harvest returns (MHRs) (replog 15071), observer catch sampling (replog 15070), and tag-recapture data (replog 15053). The voluntary logbook data extract came directly from FishServe (John Olver, June 2023) and another extract, specifically for CRA 2 CPUE, came directly from Lat37 (Simon Anderson, October 2023). Although the standardisation of CPUE indices based on statutory commercial catch and effort data has been temporarily discontinued[6], commercial catch and effort data were requested from Fisheries New Zealand (replog 15071) because these data were used to rescale the LF data for all QMAs (e.g., see section 5 of Starr et al. 2020a).

CELR CPUE standardisations were done in the *R* package *brms* (Bürkner 2017) for each stock. The terminal CELR CPUE period was in 2019–20 AW for all rapid updates. All CPUE standardisations had been done in 2020, up to the 2019–20 fishing year, during either the 2020 rapid updates (Webber et al. 2021a), the 2021 rapid updates (Rudd et al. 2022), or full stock assessments (Rudd et al. 2021b; Webber et al. 2021b; Webber et al. 2022). Therefore, no revisions were made to the CELR based CPUE indices used for the 2023 rapid updates, except for CRA 2 where a CPUE series was developed using voluntary logbook data reported by the CRA 2 fleet since 1993 (Webber & Starr 2022).

Commercial catches were updated by season (and region where applicable) for each fishing year using the MHR data extract.

Non-commercial catches were updated using the procedures developed for the base case models for each respective stock assessment. Recreational catches in the relevant QMAs were assumed to be proportional to the SS abundance as reflected in the SS CPUE. As in 2021 (Rudd et al. 2022) and in 2022 (Pons et al 2023), the following steps were taken to scale recreational catch in CRA 1, CRA 2, CRA 3, CRA 4, CRA 5, and CRA 7&8:

1) Recent recreational catch estimates for some years were estimated from survey-based estimates of the number of lobsters taken from each stock in each year multiplied by the mean weight of lobsters sampled in the survey year. These mean weight estimates either came from direct sampling of recreational landings or from commercial sampling data, depending on availability.
2) The estimated recreational catch from 1979–80 onwards was assumed to be either:
    a. directly proportional to a scalar quantity, estimated by obtaining the best fit to the survey estimates when minimising a lognormal distribution using the coefficient of

[6] Offset year standardised CPUE, incorporating ERS data, was developed and reviewed by the RLWG for CRA 7 in September 2023 for use in a management procedure.

variation for each survey to the SS CPUE in the same year (CRA 1, CRA 2 prior to 2019, CRA 3, and CRA 4);

b. a power function with two parameters to relate SS CPUE to the survey estimates (CRA 5);

c. constant catch by year or fishing year (CRA 7&8);

d. recent surveys were assumed to represent absolute values (CRA 2 starting in 2019).

3) The function described in step 2 along with the estimated parameters was then applied to the SS CPUE for all years, beginning with 1979–80, to estimate a recreational catch time series for CRA 1, CRA 2 (prior to 2019), CRA 3, CRA 4, and CRA 5.

4) The recreational catch in 1945 was assumed to be 20% of 1979–80 recreational catch and followed a linear trajectory from 1945 to 1979–80.

5) The steps described above duplicated the calculations adopted by the original base case stock assessments (see references in Table 1).

6) Because SS CPUE was unavailable from 2019–20 SS due to the change associated with the shift to electronic reporting, the 2019–20, 2020–21, 2021–22, and 2022–23 SS CPUE indices were assumed, for the purposes of estimating recreational catch in those years, to be the average of the 2016–17 to 2018–19 SS CPUE indices. CRA 2 was an exception where a standardised logbook CPUE was used to 2018–19 and recent survey estimates were considered to be absolute estimates of recreational catch from 2019–20 onwards.

For assessments since 2006, the RLWG has included recreational landings by commercial vessels under section 111 of the Fisheries Act. The maximum annual catch with destination code ‘F’ was included as a constant addition to the recreational catch trajectory for each year since 1945 for all six QMAs.

The illegal catch assumptions in these rapid updates reflect the changes in approach adopted by the RLWG over the past six years, transitioning from using a poorly documented ‘export discrepancy’ procedure for the early years and fisheries compliance estimates from 1990–91 onwards, to using fixed percentages of the commercial catches. The approaches used to set the illegal catches in each rapid update varied by QMA (Table 1). Because the annual commercial CPUE was unavailable after 2018–19 due to the change associated with the shift to electronic reporting, the annual CPUE indices for these fishing years were assumed to be the average of the 2016–17 to 2018–19 annual CPUE indices, except for CRA 2 where a standardised logbook CPUE series was used. This is the same approach as was used for SS CPUE to scale the recreational catch series, except the illegal catch uses annual CPUE.

Table 1: Methods used for setting illegal catches over time for the six stock assessments included in the 2023 rapid update system. This table uses calendar years from 1945 to 1978 and fishing years from 1979–80 to 2022–23.

QMA	Description	Reference
CRA 1	1945–1979–80: export discrepancy. 1981–82 to 2022–23: 20% of total commercial catch from this period scaled by annual CPUE. Assumed CPUE in 2019–20 to 2022–23: average of 2016–17 to 2018–19.	Starr et al. (2020a)
CRA 2	1979–80–1989–90: 20% of total commercial catch from the period. 1990–91 to 2022–23: 10% of total commercial catch from this period scaled by annual CPUE from 1979–80 to 2018–19. Assumed CPUE in 2019–20 to 2022–23: average of 2016–17 to 2018–19.	Roberts et al. (2023)
CRA 3	1945–1979–80: export discrepancy. 1981–82 to 2022–23: 20% of total commercial catch from this period held constant across years.	Starr et al. (2020b)
CRA 4	1945–1989–90: 10% of total commercial catch from this period. 1990–91 to 2022–23: 5% of total commercial catch from this period scaled by annual CPUE from 1979–80 to 2018–19. Assumed CPUE in 2019–20 to 2022–23: average of 2016–17 to 2018–19.	Starr et al. (2021a)
CRA 5	1945–1989–90: 10% of total commercial catch from this period. 1990–91 to 2022–23: 5% of total commercial catch from this period scaled by annual CPUE from 1979–80 to 2018–19. Assumed CPUE in 2019–20 to 2022–23: average of 2016–17 to 2018–19.	Starr et al. (2021b)
CRA 7&8	1945–1989–90: 10% of total commercial catch from this period. 1990–91 to 2022–23: 2% of total commercial catch from this period scaled by annual CPUE from 1979–80 to 2018–19. Assumed CPUE in 2019–20 to 2022–23: average of 2016–17 to 2018–19.	Starr et al. (2022)

The recreational and customary catches were split between seasons from 1979–80 by assuming that 90% was taken in the SS and the remainder taken in the AW. Illegal catch was assumed to have the same seasonal split by fishing year as the commercial catch.

LF data were derived from individual lobster tail-width (TW) measurements and came from both observer catch sampling and the voluntary logbook programme, with the contribution of each data source varying by year for each QMA. Observer catch sampling data were extracted from the Fisheries New Zealand Rock Lobster Catch Sampling (*rlcs*) database (Mackay & George 2018) and the logbook data from FishServe (J. Olver, pers. comm.). A newly-developed procedure to standardise the LF data (Webber 2022) was used for the first time in the CRA 2 stock assessment; however, these data arrived too late for the 2022 LFs to be included in the CRA 2 rapid update.

Tag-recapture growth increment data were extracted from the Fisheries New Zealand tag database and processed up to 2022–23, for each QMA in the 2023 rapid updates (see Roberts et al. 2023).

Adding an additional year of data allowed recruitment deviations to be estimated relative to the last full stock assessment. Recruitment deviations were typically estimated from the first model year through to two years prior to the final model year for all QMAs except for CRA 2 where three years prior to the final model year were estimated (Rudd et al. 2023). This approach was changed for the CRA 2 stock assessment because, during the 2022 Fisheries New Zealand Plenary meeting, concerns were raised about the stability of the recruitment estimates in the most recent years. The 2022 Plenary meeting noted that the final 2–3 estimated annual recruitment deviates tended to be unstable and changed each time a rapid update was done. In contrast, recruitment deviates prior to these years tended to be more stable.

The Plenary meeting suggested that the LF data may not provide sufficient information about recent levels of recruitment, leading to the conclusion that these shifts in recruitment may not be reliable. It was suggested that an investigation of the estimation process for recruitments in the final model years was needed. Consequently, the Plenary meeting rejected the projection results, and no projections were performed for any stock during the 2023 rapid updates except for CRA 2, for which an up-to-date CPUE index was available following its development as part of the 2022 full assessment of this stock. Because of these considerations, and after seeing the 2023 rapid updates results, the 2023 Plenary meeting agreed to accept the projections for CRA 2.

Even though an additional year of data was included in the models, no data re-weighting was done for these rapid updates. All other specifications remained as they were in the original base case stock assessment models. The fixed values and assumptions that were continued from the previous full stock assessment included: the priors and bounds for estimated model parameters; the reference level B_R (Rudd et al. 2021c) (with the exception of CRA 7&8 which was re-examined and determined by the RLWG and the Plenary meeting not to be adequately representative for the multi-area stock), and all structural assumptions which applied to growth, maturity, selectivity, and vulnerability. All rapid update models were run using the lobster stock dynamics (LSD) model coded in Stan (Stan Development Team 2017, Webber et al. 2018, Webber et al. 2023). Lists of parameter and derived quantity definitions are provided in Table 2 and Table 3.

Table 2: Definitions of parameters. CR = historical catch rate; FSU= Fisheries Statistics Unit.

Parameter	Definition
R_0	initial numbers recruiting
M	instantaneous rate of natural mortality
Rdevs	annual recruitment deviations
sigmaR	standard deviation of *Rdevs*
qCR	catchability coefficient (relationship between the vulnerable biomass and CR series)
qFSU	catchability coefficient (relationship between the vulnerable biomass and FSU CPUE series)
qCELR	catchability coefficient (relationship between the vulnerable biomass and CELR CPUE series)
qLB	catchability coefficient (relationship between the vulnerable biomass and logbook CPUE series) (CRA 2 only)
mat50	TW at which 50% of immature females become mature
mat95	difference between *mat50* and the TW at which 95% of immature females become mature
Galpha	annual growth increment at 50 mm TW
Gbeta	annual growth increment at 80 mm TW
Gdiff	the ratio of *Gbeta* to *Galpha*
Gshape	parameter for shape of growth curve: 1 implies von Bertalanffy straight line; >1 implies a concave upwards curve
GCV	coefficient of variation of process error for tag recaptures
Gobs	standard deviation of observation error for tag recaptures
selL	shape of the left-hand limb of the selectivity curve (as if it were a standard deviation)
selM	TW at maximum selectivity
vuln	relative vulnerability by sex and season
qdrift	additive change in catchability coefficient each year
U_0	initial exploitation rate (first year is in equilibrium using this estimate)

Table 3: Definitions of derived quantities including reference points and performance indicators. The 'YEAR' subscript is replaced with the relevant fishing year in the text and tables (e.g., B_{2022} is the beginning of season AW adjusted vulnerable biomass[7] for the 2022–23 fishing year).

Variable	Description
Reference points	
B_0	beginning of season AW adjusted vulnerable biomass (tonnes) before fishing
B_{YEAR}	beginning of season AW adjusted vulnerable biomass (tonnes) for the specified fishing year
B_R	reference level in terms of AW adjusted vulnerable biomass (Rudd et al. 2021c)
SSB_0	mature female spawning stock biomass (tonnes) in the AW season before fishing
SSB_{YEAR}	mature female spawning stock biomass (tonnes) in the AW season at beginning of the specified fishing year
F_{MSY}	fishing mortality rate that would produce the maximum sustainable yield (MSY)
H_{YEAR}	handling mortality (tonnes)
U_{YEAR}	exploitation rate weighted by seasonal vulnerable biomass for the specified fishing year
Performance indicators	
B_{YEAR} / B_0	ratio of B_{YEAR} to B_0
B_{YEAR} / B_R	ratio of B_{YEAR} to B_R
SSB_{YEAR} / SSB_0	ratio of SSB_{YEAR} to SSB_0
F_{YEAR} / F_{MSY}	ratio of F_{YEAR} to F_{MSY}

[7] Adjusted vulnerable biomass is calculated by applying the MLS and selectivity from the final model year to all previous years, including those years where earlier regulations were active.

3. RESULTS

3.1 CRA 1 RAPID UPDATE

CRA 1 is the northernmost red rock lobster stock in New Zealand, extending from Kaipara Harbour on the west coast, to the Three Kings Islands north of the North Island, and to the Waipu River, south of Bream Bay and Whangarei on the east coast (Figure 1, Figure 2).

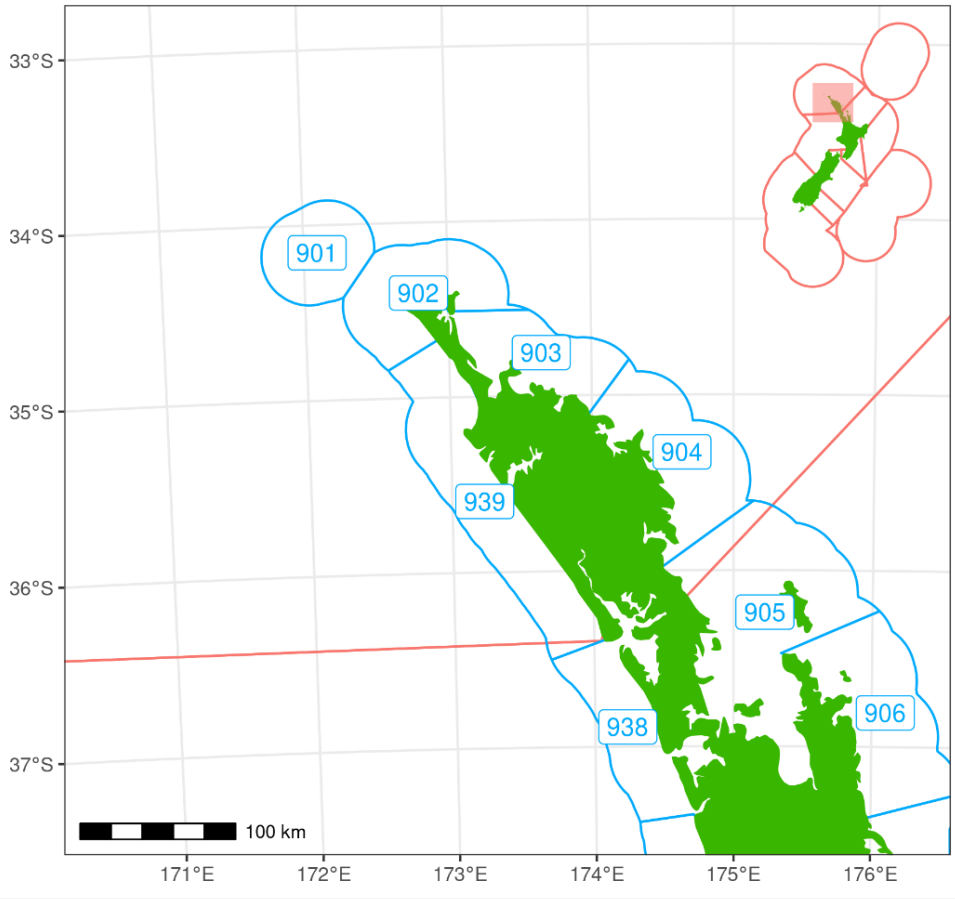

Figure 2: CRA 1 QMA and its statistical areas.

The CRA 1 stock assessment was last done in 2019 as a single-region model (Rudd et al. 2021a). The model was fitted to standardised CPUE indices, LF data, sex ratio data, and tag-recapture data. The model estimated growth by sex (male and female), vulnerability by sex (male, immature female, and mature female) and season (AW and SS), and selectivity by sex (male and female). The 2019 stock assessment estimated increasing fishing mortality from the mid-1940s to the late 1960s, resulting in a decline in adjusted vulnerable biomass. Since the 1990s, the size-limited catch remained relatively stable, with an increase in non-size-limited catches over time (see Starr et al. 2020a). The stock assessment estimated that the spawning stock biomass (SSB) remained well above the soft limit of 20% SSB_0. Although CPUE had been increasing, the projections done in 2019 suggested that continued harvest at recent catch levels would likely lead to a decline in the adjusted vulnerable biomass and SSB.

The 2023 rapid update for CRA 1 added four years of data to the 2019 stock assessment including: catch to 2022–23 (Table 4), a single CPUE index for 2019–20 AW (2019–20 SS and beyond were not included because of the change from paper to electronic forms), logbook and catch sampling LFs up to 2022–23, and additional tag recovery data up to 2022–23. Even though an additional year of data was included in the 2023 rapid update, no data re-weighting was done relative to the 2022 rapid update.

Table 4: Comparison of recent CRA 1 catch (tonnes) for the 2019 stock assessment and the following rapid updates. The table shows the last four fishing years and the five projection years in the 2019 base case model (starting in 2015–16), compared with catch for 2015–16 onwards for the 2020, 2021, 2022, and 2023 rapid updates. Projection years for the 2019 stock assessment are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2019/base												
2015–16	66.14	63.24	129.38	3.54	31.86	35.40	1.00	9.00	10.00	15.74	15.05	30.79
2016–17	60.04	70.57	130.61	2.27	20.43	22.70	1.00	9.00	10.00	14.48	17.02	31.50
2017–18	54.72	69.54	124.26	3.07	27.65	30.72	1.00	9.00	10.00	15.42	19.60	35.02
2018–19	67.98	62.58	130.56	3.15	28.33	31.48	1.00	9.00	10.00	19.62	18.06	37.68
2019–20	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2020–21	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2021–22	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2022–23	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2023–24	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2020/base												
2015–16	66.14	63.24	129.38	3.54	31.86	35.40	1.00	9.00	10.00	15.68	15.00	30.68
2016–17	60.04	70.57	130.61	2.27	20.43	22.70	1.00	9.00	10.00	14.43	16.97	31.40
2017–18	54.72	69.54	124.26	3.07	27.65	30.72	1.00	9.00	10.00	15.37	19.53	34.90
2018–19	67.98	62.58	130.56	3.15	28.33	31.48	1.00	9.00	10.00	19.55	18.00	37.55
2019–20	70.06	56.85	126.91	2.83	16.1	28.30	1.00	9.00	10.00	16.10	13.06	29.16
2021/base												
2015–16	66.14	63.24	129.38	3.51	31.87	35.14	1.00	9.00	10.00	15.55	14.87	30.43
2016–17	60.04	70.57	130.61	2.24	20.43	22.44	1.00	9.00	10.00	14.31	16.83	31.14
2017–18	54.72	69.54	124.26	3.05	27.41	30.45	1.00	9.00	10.00	15.24	19.37	34.61
2018–19	67.98	62.59	130.57	3.12	28.09	31.22	1.00	9.00	10.00	19.39	17.85	37.23
2019–20	70.06	56.85	126.91	2.80	25.23	28.04	1.00	9.00	10.00	18.95	15.38	34.33
2020–21	51.46	58.53	109.99	2.80	25.23	28.04	1.00	9.00	10.00	16.56	18.83	35.39
2022/base												
2015–16	66.14	63.24	129.38	3.54	31.87	35.41	1.00	9.00	10.00	15.38	14.70	30.08
2016–17	60.04	70.57	130.61	2.27	20.43	22.70	1.00	9.00	10.00	14.15	16.64	30.79
2017–18	54.72	69.54	124.26	3.07	27.65	30.72	1.00	9.00	10.00	15.07	19.15	34.23
2018–19	67.98	62.59	130.57	3.15	28.33	31.48	1.00	9.00	10.00	19.17	17.65	36.82
2019–20	70.06	56.85	126.91	2.83	25.47	28.30	1.00	9.00	10.00	18.74	15.21	33.94
2020–21	51.46	58.53	109.99	2.83	25.47	28.30	1.00	9.00	10.00	16.37	18.62	35.00
2021–22	57.84	51.88	109.72	2.83	25.47	28.30	1.00	9.00	10.00	18.58	16.67	35.25
2023/base												
2015–16	66.14	63.24	129.38	3.54	31.87	35.41	1.00	9.00	10.00	15.25	14.58	29.82
2016–17	60.04	70.57	130.61	2.27	20.43	22.70	1.00	9.00	10.00	14.03	16.49	30.52
2017–18	54.72	69.54	124.26	3.07	27.65	30.72	1.00	9.00	10.00	14.94	18.99	33.93
2018–19	67.98	62.59	130.57	3.15	28.33	31.48	1.00	9.00	10.00	19.00	17.49	36.50
2019–20	70.06	56.85	126.91	2.83	25.47	28.30	1.00	9.00	10.00	18.58	15.07	33.65
2020–21	51.46	58.53	109.99	2.83	25.47	28.30	1.00	9.00	10.00	15.74	17.91	33.65
2021–22	57.84	51.88	109.72	2.83	25.47	28.30	1.00	9.00	10.00	17.74	15.91	33.65
2022–23	56.80	48.06	104.85	2.83	25.47	28.30	1.00	9.00	10.00	18.23	15.42	33.65

Markov chain Monte Carlo (MCMC) trace plots for the CRA 1 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure A.1 for MCMC diagnostic plots).

The 2023 rapid update fit to the CPUE was good and almost indistinguishable from the fits of the 2019 assessment, and the 2020, 2021, and 2022 rapid updates. The fit to the last full year of the CPUE time series (i.e., 2018–19 SS and 2019–20 AW) was found to be better than previous fits but almost identical to the 2022 rapid update (Figure 3). The 2023 rapid update fits to the LFs were almost indistinguishable from the equivalent fits of the 2019 stock assessment and the 2020, 2021, and 2022 rapid updates (for the years that overlapped) (Figure 4).

The 2023 rapid update suggested that recruitment was higher in 2016–17, lower for 2017–18, almost the same in 2018–19, lower in 2019–20, and lower in 2020–21 (the last year of estimated recruitment) compared with the respective estimates by the 2019 assessment (Figure 5). Average recruitment has been the same since the 2019 full assessment. The 2023 rapid update suggested that the adjusted vulnerable biomass and SSB in 2022–23 were very similar but slightly above the projections by the 2019 stock assessment. The vulnerable biomass was still decreasing but was not declining as rapidly as was predicted by the 2019 assessment and was above the reference level (Figure 6, Figure 7).

The CRA 1 rapid update suggested that, based on posterior median values, the stock at the beginning of 2023–24 was 16% of B_0, 37% of SSB_0, 7% above B_R, and estimated to be below F_{MSY} (Table 5). The probability of the adjusted vulnerable biomass being above B_R at the beginning of 2023–24 was 0.65, and the probability of SSB being above the soft and hard limits at the beginning of 2023–24 was 1.00.

All parameter estimates were similar to the 2019 stock assessment and previous rapid updates (Table 6).

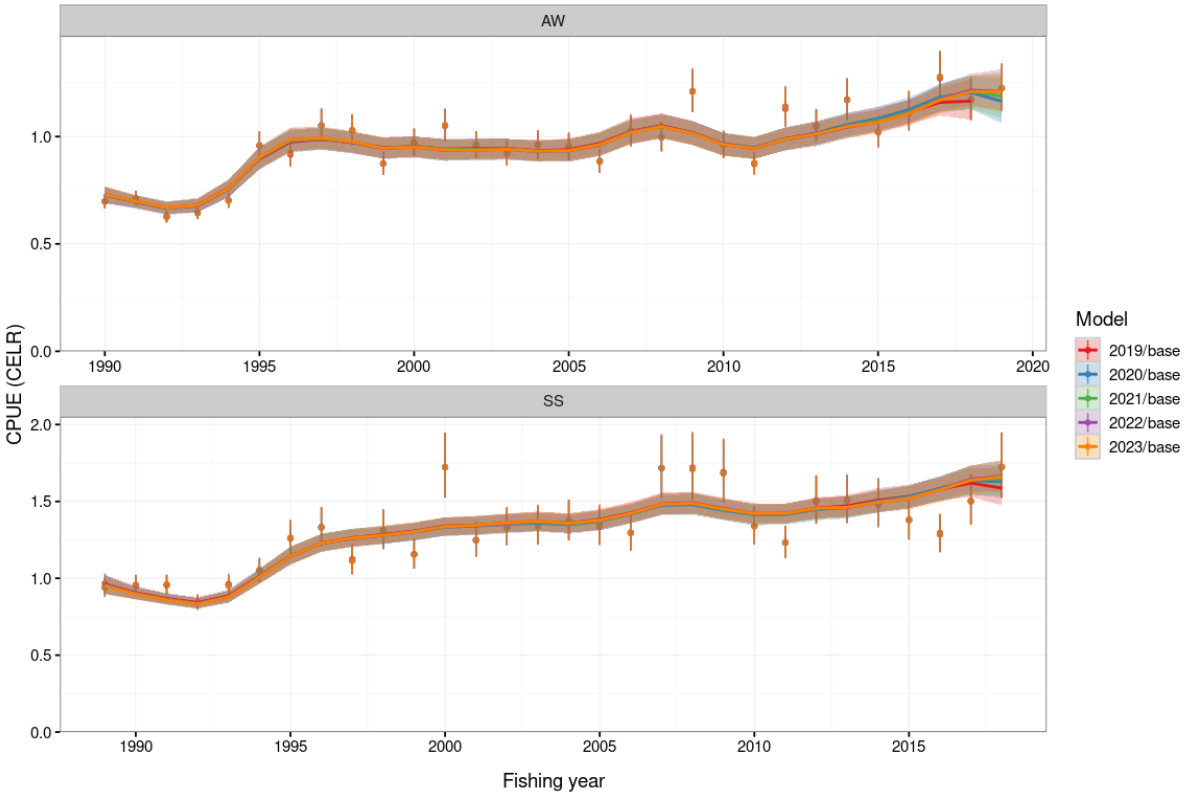

Figure 3: CRA 1 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2019 stock assessment and the 2020, 2021, 2022, and 2023 rapid updates.

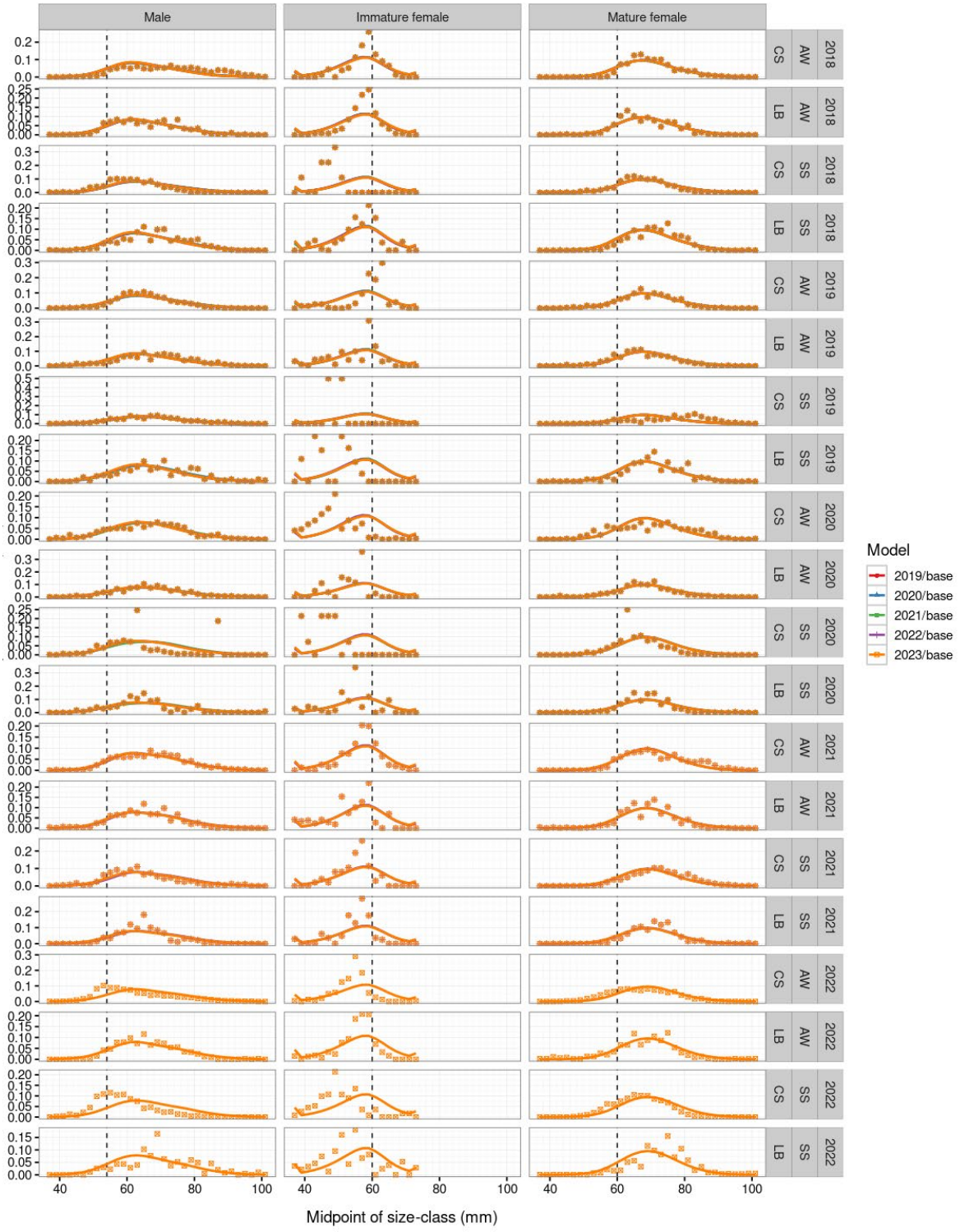

Figure 4: 2018–2022 CRA 1 length frequency observations (points) and median of the posterior distribution (line) by year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2020, 2021, 2022, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size (MLS) for the respective sexes.

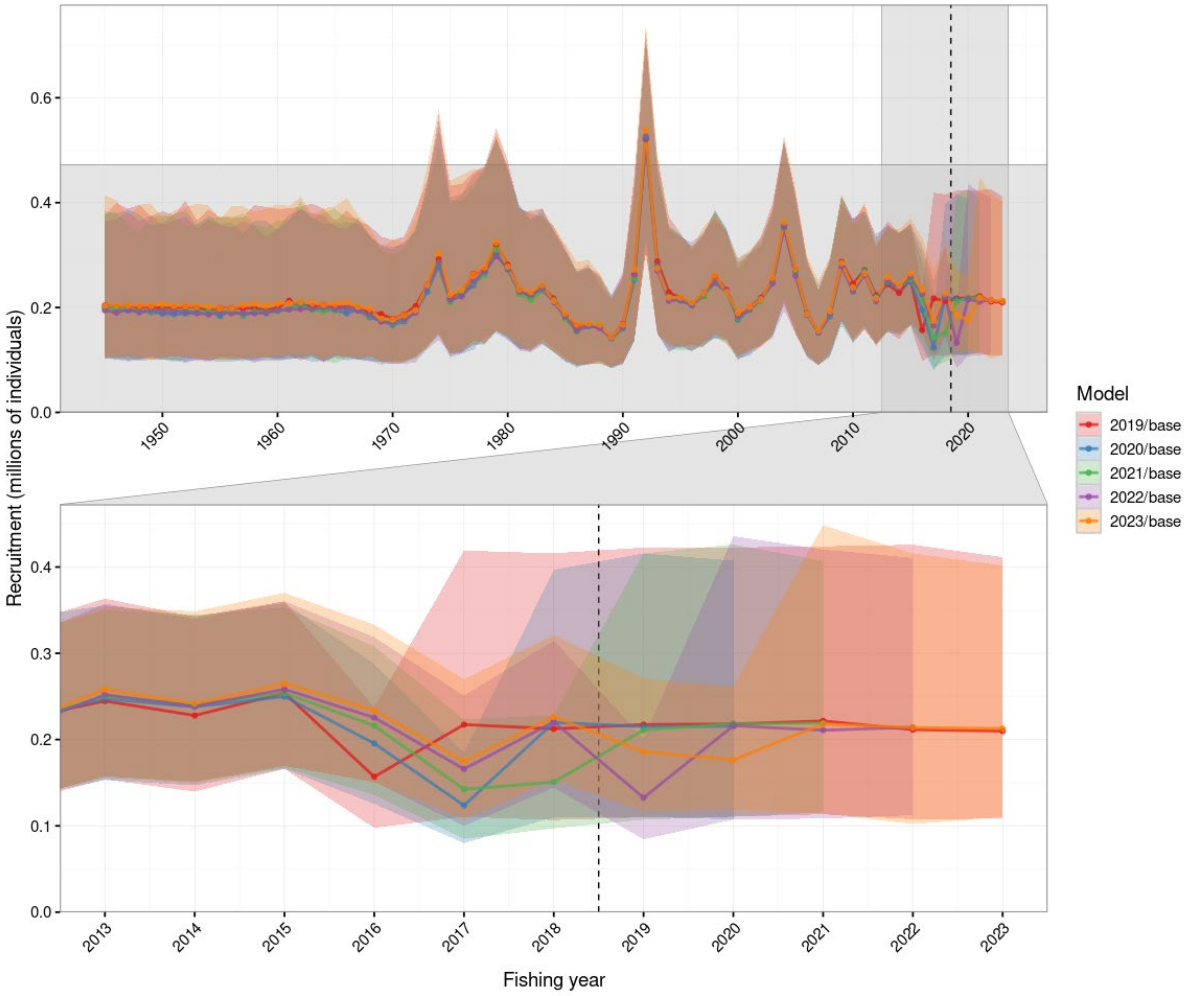

Figure 5: CRA 1 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

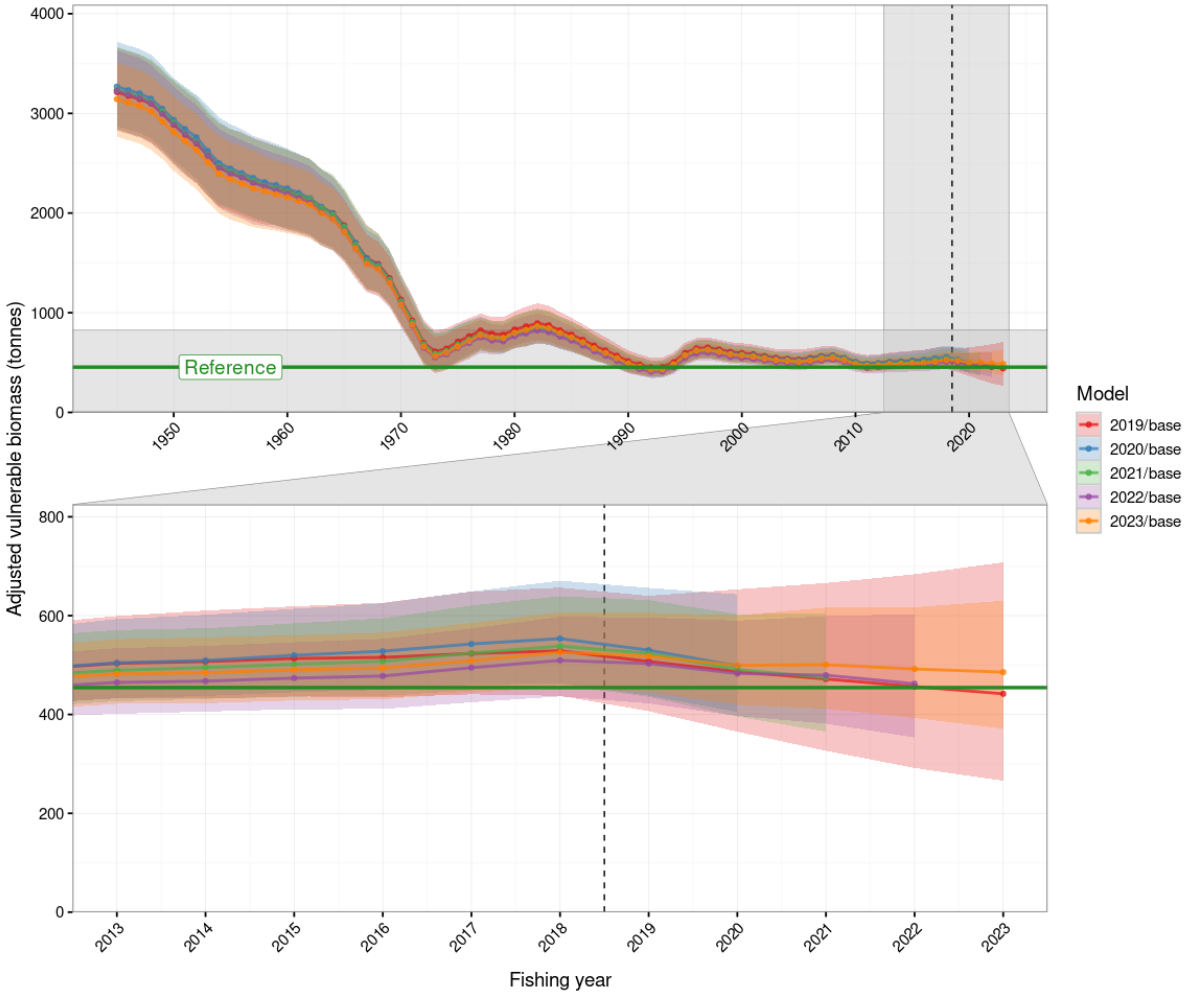

Figure 6: **CRA 1 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. The reference level (B_R) is shown in both panels (horizontal green line) and corresponds to the reference level estimated in the 2019 stock assessment.**

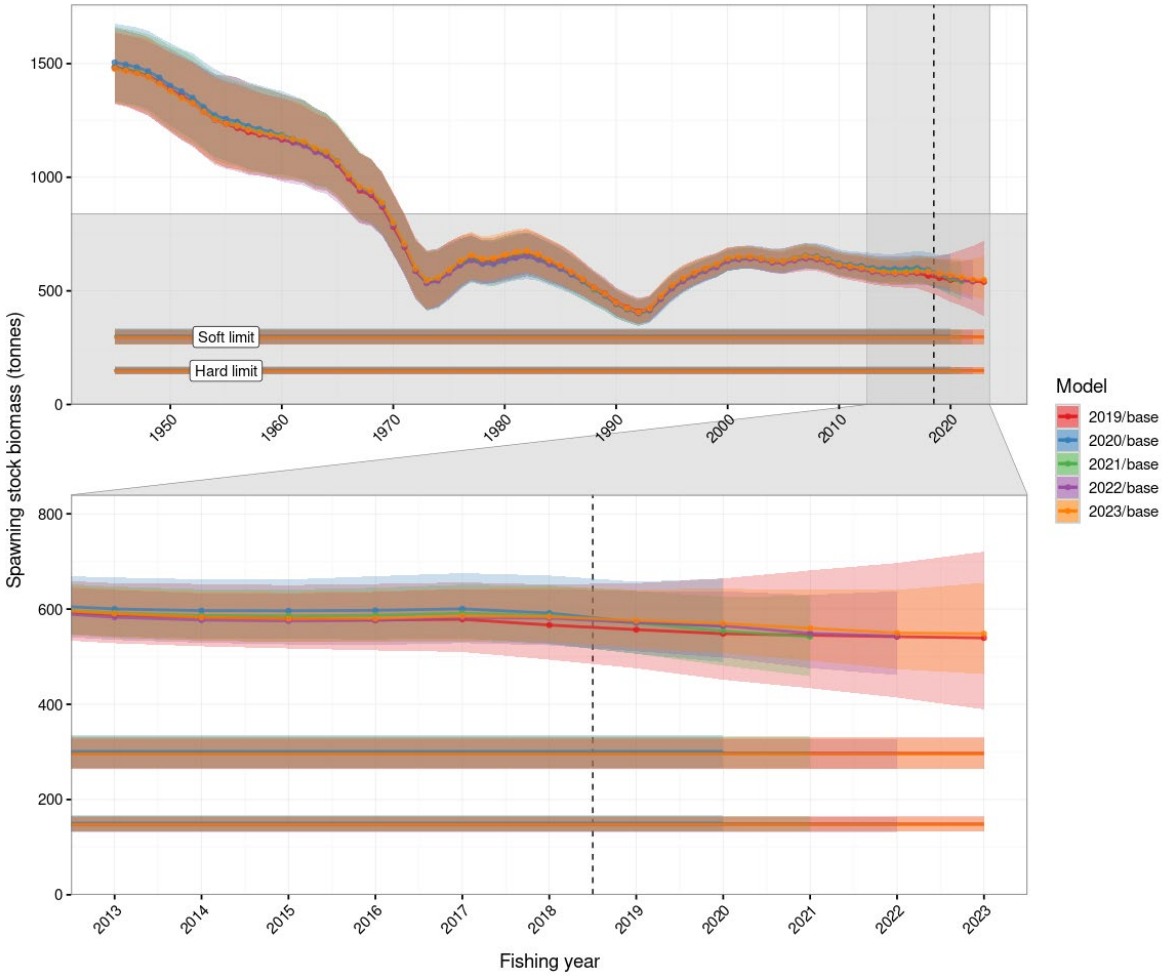

Figure 7: CRA 1 posterior distribution of spawning stock biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. The horizontal lines and shaded regions represent the soft limit (top horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region).

Table 5: CRA 1 rapid update indicators summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
B_0	3 135	2 766	3 143	3 510
B_R	454	–	–	–
B_{2023}	490	371	486	630
B_{2023} / B_0	0.157	0.113	0.155	0.208
B_{2023} / B_R	1.079	0.817	1.069	1.387
$P(B_{2023} > B_R)$	0.649	–	–	–
SSB_0	1 478	1 323	1 477	1 641
SSB_{2023}	552	463	548	655
SSB_{2023} / SSB_0	0.374	0.313	0.371	0.452
P(SSB_{2023} > 20% SSB_0)	1.000	–	–	–
P(SSB_{2023} > 10% SSB_0)	1.000	–	–	–
F_{MSY}	0.562	0.375	0.546	0.794
F_{2023} / F_{MSY}	0.250	0.191	0.245	0.324
H_{2022}	1.863	1.672	1.854	2.084

Table 6: **CRA 1 MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2019 full assessment and the 2020, 2021, 2022, and 2023 rapid updates. Growth increment values in mm TW and R_0 in numbers. M = male, IF = immature female, and MF = mature female.**

	2019 base			2020 rapid update			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
R_0	196 661	229 323	269 993	190 901	223 517	261 838	195 775	222 170	261 099	195 709	222 472	255 252	20 1732	23 2058	26 8591
M	0.093	0.108	0.125	0.090	0.105	0.121	0.092	0.105	0.122	0.093	0.105	0.121	0.097	0.109	0.125
qdrift	0.007	0.017	0.026	0.006	0.014	0.024	0.007	0.016	0.024	0.009	0.017	0.024	0.009	0.017	0.025
mat50	47.188	50.166	52.487	46.753	49.575	51.758	45.769	48.895	51.211	45.945	48.954	51.146	43.582	47.336	49.929
mat95	8.375	12.834	20.055	8.661	13.344	20.552	8.932	13.693	20.885	9.104	13.969	21.357	10.485	15.583	23.023
Galpha [male]	14.890	16.388	17.863	14.922	16.397	17.890	14.933	16.479	17.946	14.950	16.466	18.065	15.385	16.640	17.956
Gbeta [male]	2.418	2.623	2.857	2.433	2.630	2.861	2.436	2.640	2.881	2.437	2.644	2.880	2.372	2.543	2.725
Gshape [male]	2.572	3.056	3.542	2.592	3.040	3.521	2.568	3.076	3.554	2.599	3.093	3.615	2.811	3.220	3.662
GCV [male]	0.388	0.405	0.663	0.389	0.406	0.422	0.385	0.402	0.419	0.384	0.401	0.418	0.376	0.393	0.412
Galpha [female]	16.973	18.431	19.631	17.246	18.593	19.730	17.263	18.614	19.745	17.119	18.345	19.499	17.374	18.610	19.757
Gbeta [female]	1.163	1.236	1.325	1.142	1.218	1.313	1.146	1.218	1.300	1.157	1.232	1.309	1.162	1.238	1.316
Gshape [female]	4.975	5.502	5.958	5.094	5.567	6.044	5.060	5.537	5.976	4.999	5.432	5.856	5.033	5.459	5.864
GCV [female]	0.737	0.771	0.811	0.737	0.775	0.815	0.723	0.762	0.802	0.721	0.758	0.796	0.716	0.752	0.792
Gobs	0.339	0.531	0.663	0.332	0.526	0.674	0.464	0.612	0.753	0.486	0.628	0.761	0.530	0.680	0.826
vuln [M, SS]	0.725	0.757	0.790	0.718	0.750	0.785	0.717	0.748	0.782	0.715	0.747	0.777	0.706	0.738	0.770
vuln [IF, AW]	0.427	0.618	0.902	0.458	0.643	0.886	0.439	0.620	0.863	0.446	0.617	0.877	0.465	0.663	0.901
vuln [IF & MF, SS]	0.521	0.650	0.823	0.517	0.630	0.782	0.530	0.633	0.777	0.513	0.629	0.782	0.535	0.660	0.823
vuln [MF, AW]	0.386	0.480	0.612	0.372	0.457	0.576	0.366	0.442	0.554	0.360	0.436	0.557	0.358	0.440	0.551
selL [male]	8.418	10.115	11.977	8.855	10.356	12.233	9.078	10.680	12.332	9.568	11.071	12.764	9.318	10.773	12.418
selM [male]	59.323	62.118	65.090	60.119	62.530	65.470	60.596	63.141	65.978	61.944	64.341	66.868	61.563	63.864	66.518
selL [female]	12.732	16.228	20.621	12.814	16.137	20.132	13.184	16.022	19.436	14.207	16.953	20.321	13.887	16.864	20.049
selM [female]	64.125	70.540	78.278	64.373	70.201	77.775	65.169	70.439	76.916	67.656	72.811	80.099	67.085	72.783	79.023

3.2 CRA 2 RAPID UPDATE

The CRA 2 fishery extends from Te Arai Point, south of Whangarei, to East Cape at the easternmost end of the Bay of Plenty (Figure 1, Figure 8). This QMA includes the Hauraki Gulf, both sides of the Coromandel Peninsula, and all of the Bay of Plenty up to East Cape.

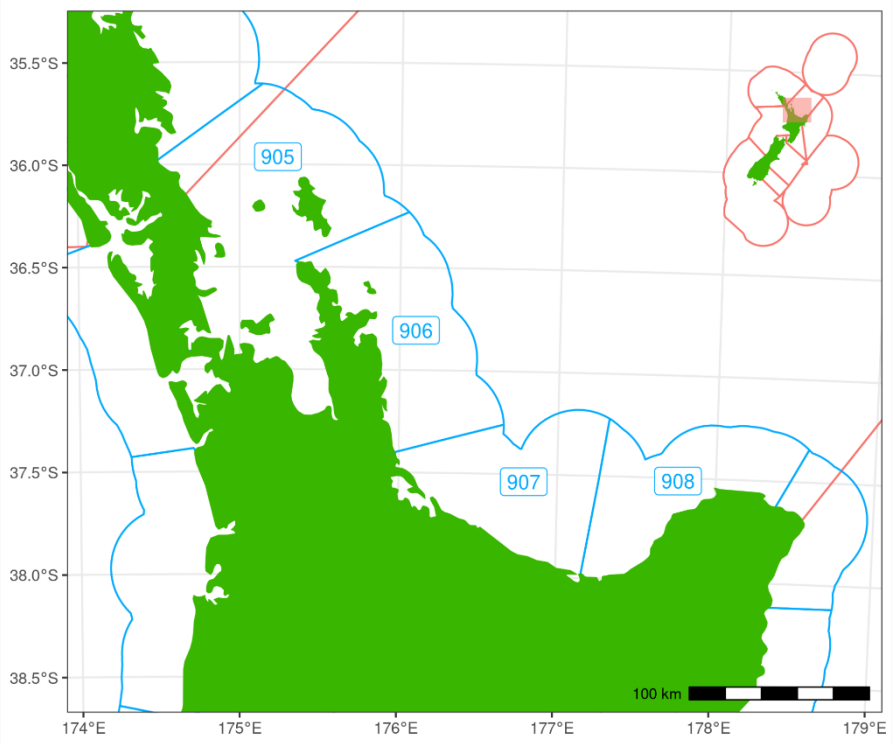

Figure 8: CRA 2 QMA and its statistical areas.

The CRA 2 stock assessment was last done in 2022 (Rudd et al. 2023) as a single-region assessment using the LSD model (Webber et al. 2023). Unlike other CRA stock assessments, this model used a non-equilibrium start to model the stock reconstruction beginning with the 1979–80 fishing year. The model was fitted to standardised CPUE indices, LFs, sex ratio, and tag-recapture data. The model estimated growth by sex (male and female), vulnerability by sex (male, immature female, and mature female) and season (AW and SS), and selectivity by sex (male and female). It estimated three catchability coefficients (FSU, CELR and logbook CPUE) and used a new procedure to standardise the LFs and sex ratio inputs (Webber 2022). The model removed catch from CRA 2 using seasonal exploitation rate (U) instead of instantaneous fishing mortality (F) and recruitment deviates were estimated up to three years before the last assessment year (Webber et al. 2023).

The 2023 rapid update for CRA 2 added one year of data to the stock assessment done in 2022, including: catch to 2022–23 (Table 7), logbook CPUE data to 2022–23, and additional tag recapture data up to 2022–23. There was a minor change made to the inputs used by the 2022 assessment for the illegal and recreational catch. The 2022 assessment scaled the illegal and recreational catch using logbook CPUE expressed as kg/pot instead of numbers/pot which is how this series was estimated and included in the assessment model. This error was fixed for the 2023 rapid update and accounted for the minor differences observed in Table 7 between the 2022 assessment and the 2023 rapid update. The difference was -4 t of ~1800 t for recreational and -8 t of ~1100 tonnes for the illegal catch for the period 1979–80 to 2022–23. The logbook data with the 2022–23 update were received only a week before the Plenary meeting and had a different format than that of previous extracts received from the FishServe database (e.g., different column names, files were linked differently). Consequently, it took a long time to rearrange the format of the data for use in the LSD model. While these efforts allowed the CRA 2 logbook CPUE series to be updated to include the 2022–23 AW and SS indices, there was insufficient

time available to get the logbook length data into an equivalent format. Therefore, the CRA 2 rapid update assessment did not include updated LF data for 2022–23.

The CRA 2 vulnerable biomass decreased to a low point in 1992, increased to a peak in the mid-1990s, and decreased rapidly until 2002. Median estimated vulnerable biomass at the beginning of 2017–18 was about 50% of the reference level and the SSB was close to the soft limit. This triggered management measures designed to reverse the decline and to rebuild the stock. Therefore, there was a decrease in exploitation rate stemming from the 2018 management measures. The 2022 assessment indicated that the stock had rebuilt rapidly and had reached a median of 1.68 times the reference level by the beginning of 2022–23 (Rudd et al. 2023). The SSB responded equivalently, rising to a median of 40% SSB_0.

Because the stock assessment was only one year in the past and included an up-to-date CPUE series, the Plenary meeting agreed to repeat the CRA 2 projections, extending it one more year to 2027–28. Recruitment was also extended an additional year, three years before the model end year as it was done in the 2022 assessment. Projected catches were updated to match the 2023 CRA 2 catches (Table 7). The data set weights used by the 2022 full stock assessment were used for the 2023 rapid update.

Table 7: Comparison of recent CRA 2 catch (tonnes) for the 2022 stock assessment and the following rapid update. The table shows the last five fishing years and the five projection years in the 2022 base case model (starting in 2017–18), compared with catch for 2017–18 onwards for the 2023 rapid update including also the five projection years. All projection years are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2022/base												
2017–18	41.99	100.77	142.75	3.07	27.59	30.65	0.50	4.50	5.00	3.28	7.88	11.17
2018–19	32.52	47.46	79.97	5.14	46.28	51.42	0.50	4.50	5.00	8.38	12.23	20.61
2019–20	45.55	30.46	76.01	3.41	30.73	34.15	0.50	4.50	5.00	15.13	10.12	25.24
2020–21	37.61	46.29	83.90	3.53	31.74	35.27	0.50	4.50	5.00	12.26	15.09	27.35
2021–22	47.49	32.50	79.99	3.31	29.80	33.11	0.50	4.50	5.00	15.77	10.79	26.57
2022–23	47.50	32.50	80.00	3.31	29.80	33.11	0.50	4.50	5.00	15.77	10.79	26.57
2023–24	47.50	32.50	80.00	3.31	29.80	33.11	0.50	4.50	5.00	15.77	10.79	26.57
2024–25	47.50	32.50	80.00	3.31	29.80	33.11	0.50	4.50	5.00	15.77	10.79	26.57
2025–26	47.50	32.50	80.00	3.31	29.80	33.11	0.50	4.50	5.00	15.77	10.79	26.57
2026–27	47.50	32.50	80.00	3.31	29.80	33.11	0.50	4.50	5.00	15.77	10.79	26.57
2023/base												
2017–18	41.99	100.77	142.75	2.92	26.29	29.21	0.50	4.50	5.00	3.39	8.13	11.52
2018–19	32.52	47.46	79.97	4.70	42.30	46.99	0.50	4.50	5.00	8.37	12.21	20.58
2019–20	45.55	30.46	76.01	3.41	30.73	34.15	0.50	4.50	5.00	13.98	9.35	23.33
2020–21	37.61	46.29	83.90	3.53	31.74	35.27	0.50	4.50	5.00	11.64	14.33	25.98
2021–22	47.49	32.50	79.99	3.31	29.80	33.11	0.50	4.50	5.00	13.93	9.53	23.46
2022–23	46.93	33.06	79.99	3.42	30.76	34.17	0.50	4.50	5.00	13.20	9.30	22.50
2023–24	46.93	33.07	80.00	3.42	30.76	34.17	0.50	4.50	5.00	13.20	9.30	22.50
2024–25	46.93	33.07	80.00	3.42	30.76	34.17	0.50	4.50	5.00	13.20	9.30	22.50
2025–26	46.93	33.07	80.00	3.42	30.76	34.17	0.50	4.50	5.00	13.20	9.30	22.50
2026–27	46.93	33.07	80.00	3.42	30.76	34.17	0.50	4.50	5.00	13.20	9.30	22.50
2027–28	46.93	33.07	80.00	3.42	30.76	34.17	0.50	4.50	5.00	13.20	9.30	22.50

MCMC trace plots for the 2023 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure A.2 for MCMC diagnostic plots).

The rapid update fit to the CPUE series was almost indistinguishable from the fit obtained by the 2022 assessment until the final four years, when the model trajectory dropped relative to the 2022 trajectory (Figure 9). The 2023 model estimated a lower biomass for the period 2019–20 to 2022–23 than it did in 2022, so that it could fit the new 2022–23 CPUE index value, which dropped from 2021–22 (Figure 9). The fits to the LF data were almost indistinguishable from the 2022 assessment, as no new

LF data were included in the rapid update (Figure 10). The 2022 assessment estimated a small recruitment pulse in 2018–19 that shifted to 2019–20 in the 2023 rapid update. However, the average recruitment estimated by this rapid update was almost the same as that estimated by the 2022 assessment (Figure 11). Therefore, the adjusted vulnerable biomass and SSB were predicted to be at about the same level at the beginning of 2023–24 as was projected by the 2022 stock assessment (Figure 12, Figure 13).

The CRA 2 rapid update predicted that the posterior median stock size at the beginning of 2023–24 was 21% B_0, 41% SSB_0, and 77% above B_R (Table 8). At the beginning of 2027–28, the posterior median stock size was projected to be 2.6 times B_R, 31% B_0, and 47% SSB_0. Exploitation rates (U) at the beginning of 2023–24 and 2027–28 were about 1/3 of U_R. The probabilities of being greater than B_R at the beginning of 2023–24 and 2027–28 were 1.0. The probabilities of being greater than 20% SSB_0 at the beginning of the same two years were 1.0.

All parameter estimates were similar to the 2022 stock assessment (Table 9).

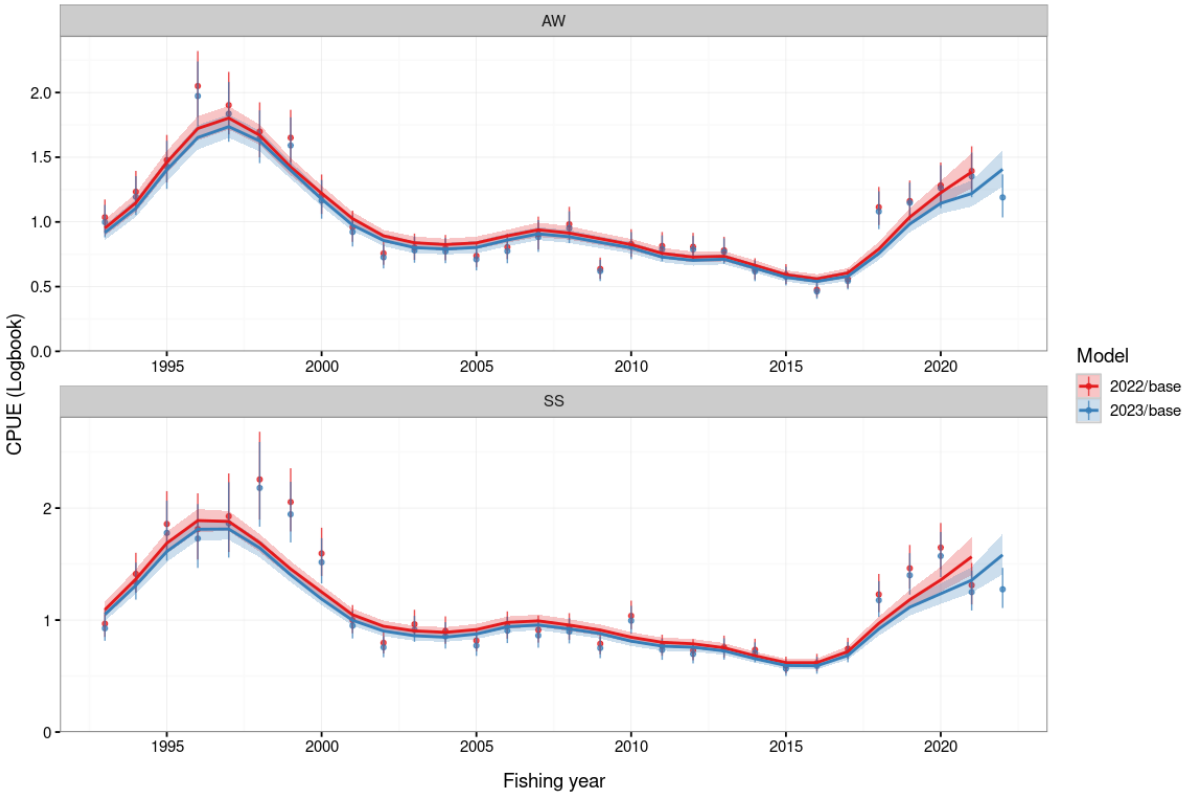

Figure 9: CRA 2 Logbook CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2022 stock assessment and the and the 2023 rapid update.

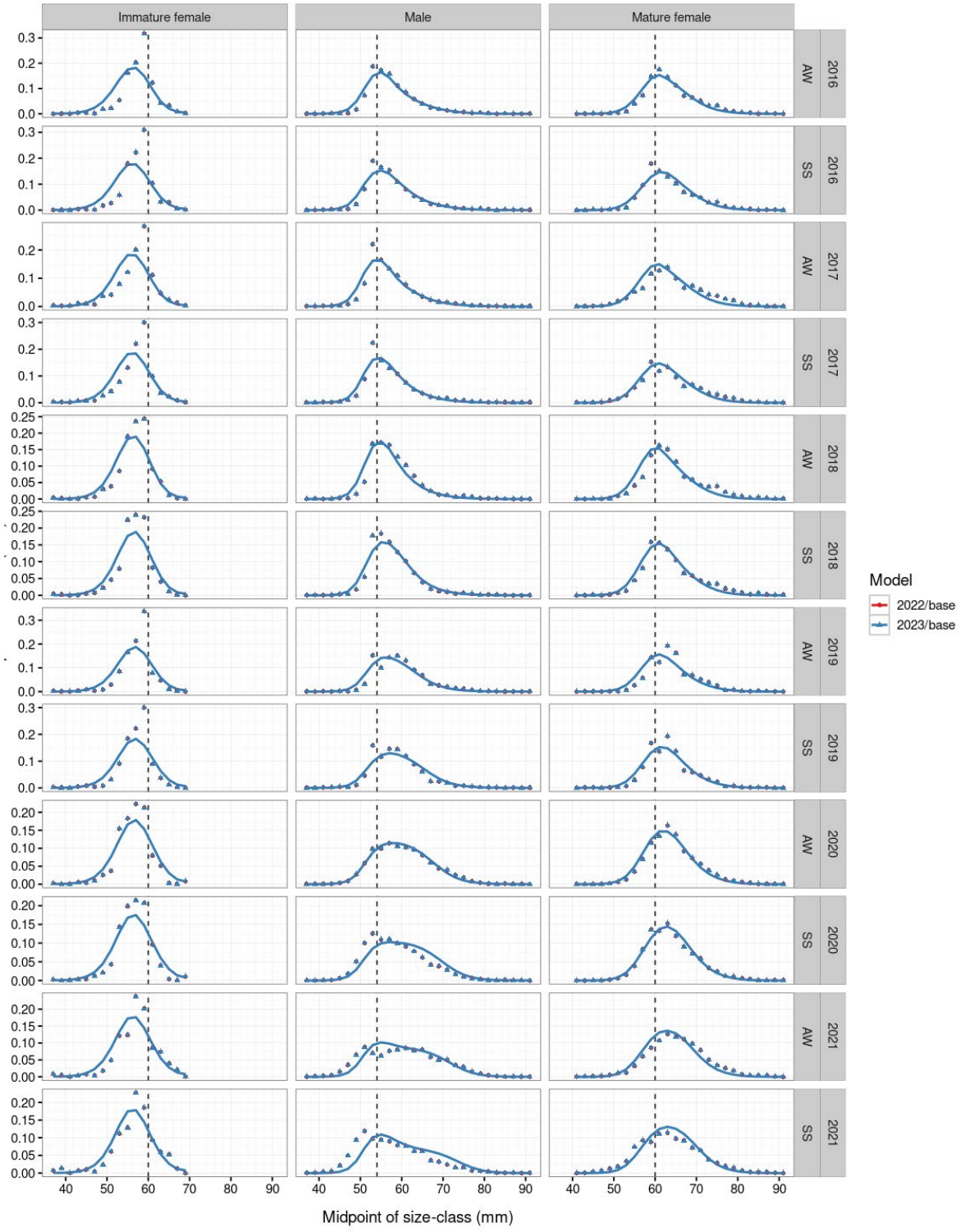

Figure 10: 2016–2021 CRA 2 length frequency observations (points) and median of the posterior distribution (line) by year, and season (AW = autumn/winter, SS = spring/summer) for the 2022 stock assessment and the 2023 rapid update. Dashed vertical lines represent the minimum legal size (MLS) for the respective sexes.

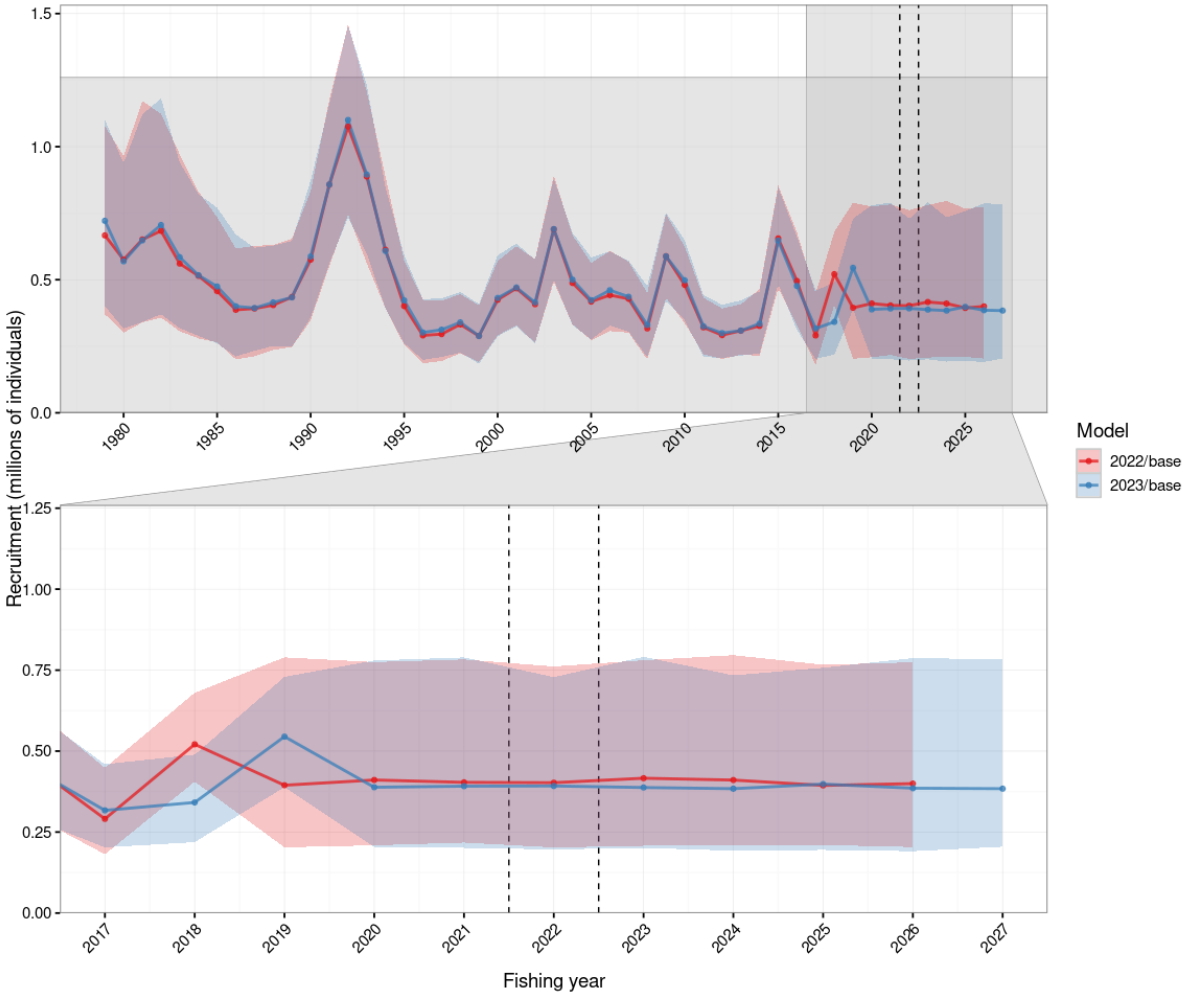

Figure 11: CRA 2 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2022 stock assessment and the 2023 rapid update (showing the five projected years). The vertical dashed lines indicate the transition between the final model year and the five projected years for the 2019 stock assessment and the 2023 rapid update. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

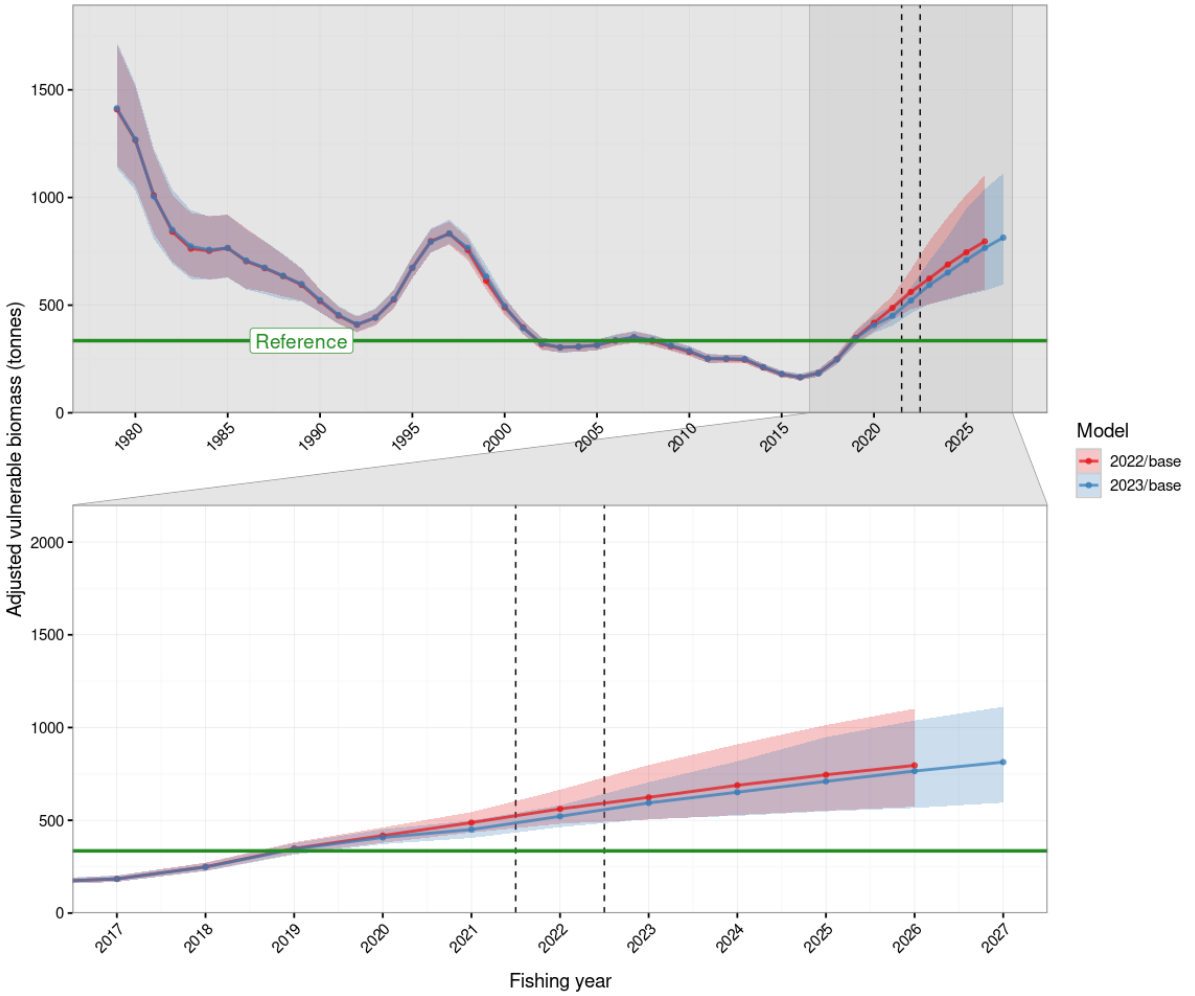

Figure 12: CRA 2 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2022 stock assessment and the 2023 rapid update (showing the five projected years). The vertical dashed lines indicate the transition between the final model year and the five projected years for the 2022 stock assessment and the 2023 rapid update. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. The reference level (B_R) is shown in both panels (horizontal green line) and corresponds to the reference level estimated by the 2022 stock assessment.

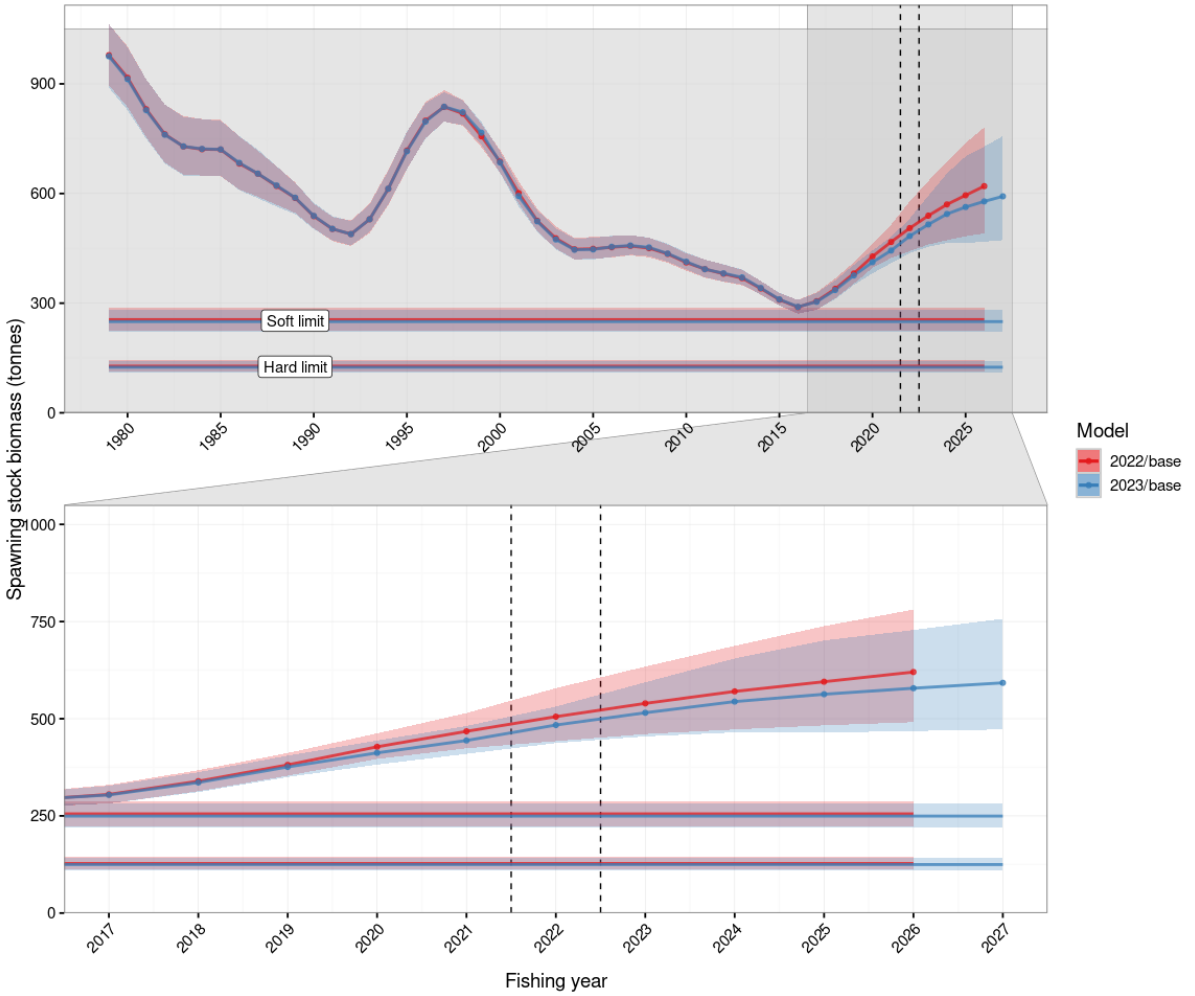

Figure 13: CRA 2 posterior distribution of spawning stock biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2022 stock assessment and the 2023 rapid update (showing the five projected years). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment and the 2023 rapid update. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. The horizontal lines and shaded regions represent the soft limit (top horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region).

Table 8: CRA 2 rapid update indicators summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
Vulnerable biomass				
B_0	2 775	2 407	2 768	3 195
B_{0now}	2 107	1 881	2 102	2 358
B_{MIN}	1656	152	165	181
B_R	335	335	335	335
B_{2023}	597	506	594	705
B_{2027}	874	615	857	1 184
B_R / B_0	0.122	0.105	0.121	0.139
B_R / B_{0now}	0.160	0.142	0.159	0.178
B_{2023} / B_0	0.217	0.175	0.213	0.269
B_{2027} / B_0	0.317	0.217	0.310	0.431
B_{2023} / B_{0now}	0.284	0.238	0.282	0.338
B_{2027} / B_{0now}	0.415	0.295	0.409	0.562
B_{2027} / B_{2023}	1.462	1.095	1.431	1.921
B_{2023} / B_R	1.782	1.511	1.772	2.105
B_{2027} / B_R	2.607	1.835	2.557	3.534
Exploitation				
U_R	–	0.296	0.296	0.296
U_{2023}	0.099	0.083	0.099	0.117
U_{2027}	0.075	0.054	0.074	0.100
U_{2023} / U_R	0.336	0.279	0.336	0.394
U_{2027} / U_R	0.254	0.183	0.250	0.337
Spawning stock biomass				
SSB_0	1 254	1 103	1 248	1 414
SSB_{0now}	952	869	948	1041
SSB_{2023}	519	454	515	594
SSB_{2027}	601	471	592	757
SSB_{2023} / SSB_0	0.416	0.350	0.412	0.497
SSB_{2027} / SSB_0	0.481	0.368	0.473	0.616
SSB_{2023} / SSB_{0now}	0.546	0.479	0.544	0.624
SSB_{2027} / SSB_{0now}	0.632	0.495	0.625	0.795
SSB_{2027} / SSB_{2023}	1.155	0.967	1.143	1.382
Handling mortality				
H_{2022}	2.185	1.960	2.166	2.472
H_{2027}	1.217	0.992	1.201	1.487
Probabilities				
P($B_{2023} > B_{MIN}$)	1.000	–	–	–
P($B_{2023} > B_R$)	1.000	–	–	–
P($B_{2027} > B_R$)	1.000	–	–	–
P($B_{2027} > B_{2023}$)	0.990	–	–	–
P($SSB_{2023} > 20\% SSB_0$)	1.000	–	–	–
P($SSB_{2023} > 10\% SSB_0$)	1.000	–	–	–
P($SSB_{2027} > 20\% SSB_0$)	1.000	–	–	–
P($SSB_{2027} > 10\% SSB_0$)	1.000	–	–	–
P($SSB_{2023} > 20\% SSB_{0now}$)	1.000	–	–	–
P($SSB_{2023} > 10\% SSB_{0now}$)	1.000	–	–	–
P($SSB_{2027} > 20\% SSB_{0now}$)	1.000	–	–	–
P($SSB_{2027} > 10\% SSB_{0now}$)	1.000	–	–	–
P($SSB_{2027} > SSB_{2023}$)	0.914	–	–	–

Table 9: CRA 2 MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2022 full assessment and the 2023 rapid update. Growth increment values in mm TW and R_0 in numbers. M = male, F = female, IF = immature female, and MF = mature female.

	2022 base			2023 rapid update		
	5%	50%	95%	5%	50%	95%
R_0	460 917	535 990	624 415	467 500	541 700	626 900
M	0.162	0.181	0.200	0.166	0.184	0.203
U_0	0.035	0.065	0.100	0.034	0.062	0.099
qCR	0.001	0.001	0.001	0.001	0.001	0.001
qFSU	0.002	0.002	0.003	0.002	0.002	0.003
qCELR	0.000	0.000	0.000	0.000	0.000	0.000
qLB	0.001	0.001	0.001	0.001	0.001	0.001
mat50	49.610	50.600	51.460	49.590	50.550	51.400
mat95	9.131	11.420	14.200	9.090	11.350	13.960
Galpha [M]	6.671	6.854	7.023	6.669	6.833	7.000
Galpha [F]	4.739	4.902	5.064	4.756	4.932	5.101
Gbeta [M]	2.472	2.723	2.985	2.502	2.777	3.075
Gbeta [F]	1.114	1.183	1.267	1.123	1.188	1.269
Gshape [M]	1.810	2.338	2.926	1.830	2.394	3.006
Gshape [F]	3.886	4.174	4.445	3.902	4.171	4.431
IGCV [M]	0.417	0.439	0.463	0.415	0.437	0.458
GCV [F]	0.713	0.748	0.791	0.705	0.744	0.785
Gobs	0.899	0.999	1.099	0.934	1.034	1.144
vuln SS [M]	0.867	0.903	0.943	0.866	0.904	0.942
vuln AW [IF]	0.533	0.642	0.776	0.535	0.646	0.781
vuln SS [IF+MF]	0.693	0.755	0.817	0.689	0.753	0.818
vuln AW [MF]	0.530	0.582	0.637	0.531	0.588	0.644
selL [M]	4.490	4.861	5.239	4.464	4.849	5.234
selL [F]	7.117	7.602	8.072	7.106	7.556	8.043
selM [M]	50.490	50.820	51.100	50.490	50.800	51.100
selM [F]	55.020	55.510	55.980	55.010	55.480	55.950

3.3 CRA 3 RAPID UPDATE

The CRA 3 fishery extends from East Cape south to the Wairoa River (Figure 1, Figure 14) and includes East Cape (statistical area 909), Gisborne (910), and the Mahia Peninsula (911).

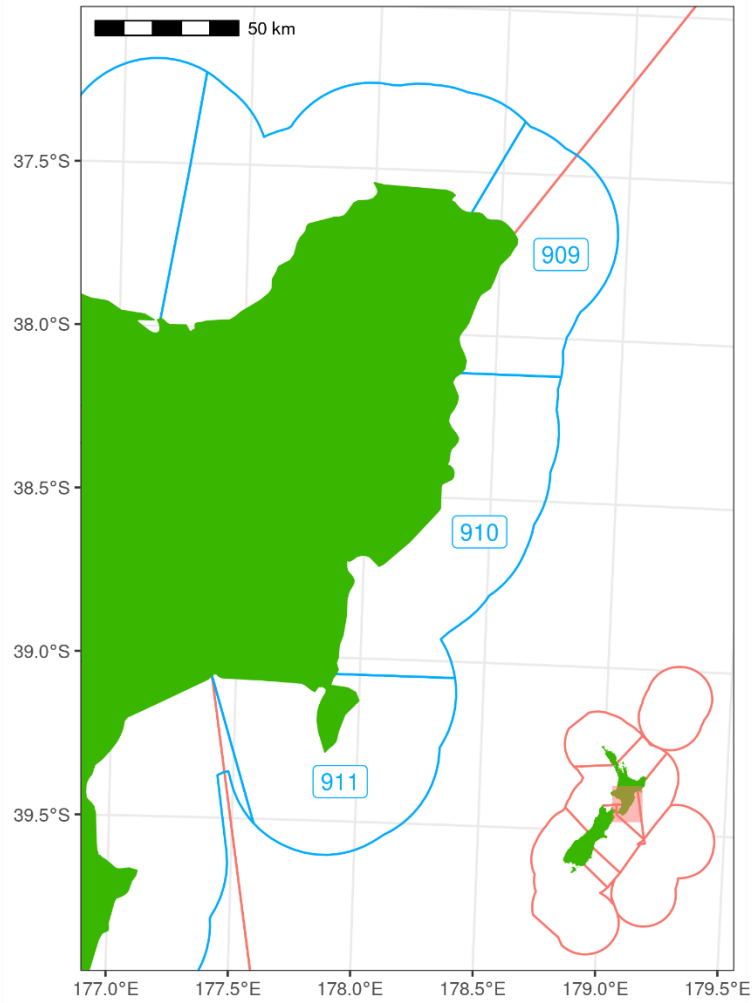

Figure 14: CRA 3 QMA and its statistical areas.

The CRA 3 stock assessment was last done in 2019 as a two-region model: region 1 included statistical areas 909 and 910 and region 2 consisted of statistical area 911 (Webber et al. 2020). The RLWG selected two base case models that tested alternative growth assumptions, based on the choice of tagging data used to estimate growth; these were designated *r1_qdrift* (using tag days at liberty > 365) and *r2_qdrift* (using all tag data). Each model was fitted to standardised CPUE indices, LF data, sex ratio data, and tag-recapture growth increment data. Each model estimated growth by region, vulnerability parameters by sex (male and female), season (AW and SS), and region, and selectivity by sex (male and female) and region. Female selectivity was separated into two epochs: one prior to 1993–94, and the other from 1993–94 and later. The stock assessment portrayed a stock that had declined rapidly between 1960 and 1970, followed by a levelling off until about 1980–81. After 1980–81, the stock size oscillated over roughly a 10-year cycle, with the stock increasing slightly after 1980–81 and then steadily declining until 1992–93. From there it increased strongly up to 1998–99, declined to a trough in 2004–05, increased again to 2013–14, and has since declined. However, at no point did the SSB fall below the soft limit (the default of 20% SSB_0). This was due, in part, to the small TW at maturity estimated for CRA 3 which meant that most females are mature.

The 2023 rapid update for CRA 3 added four years of additional data to the 2019 stock assessment including: catch up to 2022–23 (Table 10), a single CPUE data point for 2019–20 AW (2019–20 SS is

not included because of the change from paper to electronic forms), logbook and catch sampling LFs up to 2022–23, and additional tag recapture data up to 2022–23. Even though an additional year of data was included in the 2023 rapid update, no data re-weighting was done relative to last year's rapid update.

Table 10: Comparison of recent CRA 3 catch (tonnes) for the 2019 stock assessment and the following rapid updates. The table shows the last four fishing years and the five projection years in the 2019 base case models (both *r1_qdrift* and *r2_qdrift*, starting in 2015–16), compared with catch for 2015–16 onwards for the 2020, 2021, 2022, and 2023 rapid updates. All projection years for the 2019 stock assessment are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2019/base												
2015–16	193.90	66.95	260.85	1.29	11.66	12.95	2.00	18.00	20.00	45.28	15.63	60.91
2016–17	181.95	78.90	260.85	1.31	11.79	13.10	2.00	18.00	20.00	42.48	18.42	60.90
2017–18	167.21	70.52	237.73	1.16	10.43	11.59	2.00	18.00	20.00	42.84	18.07	60.91
2018–19	168.92	71.04	239.96	1.08	9.64	10.72	2.00	18.00	20.00	42.87	18.03	60.90
2019–20	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2020–21	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2021–22	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2022–23	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2023–24	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2020/base												
2015–16	193.90	66.95	260.85	1.29	11.66	12.95	2.00	18.00	20.00	44.77	15.46	60.23
2016–17	181.95	78.90	260.85	1.31	11.79	13.10	2.00	18.00	20.00	42.01	18.22	60.23
2017–18	167.28	70.45	237.73	1.16	10.42	11.58	2.00	18.00	20.00	42.37	17.84	60.21
2018–19	166.91	71.16	238.07	1.08	9.64	10.72	2.00	18.00	20.00	42.22	18.00	60.22
2019–20	135.53	53.12	188.65	1.18	10.61	11.79	2.00	18.00	20.00	43.26	16.96	60.22
2021/base												
2015–16	231.54	66.95	260.85	1.34	12.02	13.36	2.00	18.00	20.00	45.56	15.73	61.29
2016–17	181.95	78.91	260.86	1.35	12.15	13.50	2.00	18.00	20.00	42.75	18.54	61.29
2017–18	167.34	70.39	237.73	1.20	10.79	11.99	2.00	18.00	20.00	43.14	18.15	61.29
2018–19	166.33	71.74	238.08	1.11	10.00	11.11	2.00	18.00	20.00	42.82	18.47	61.29
2019–20	122.93	66.06	188.99	1.22	10.98	12.20	2.00	18.00	20.00	39.87	21.42	61.29
2020–21	105.44	109.94	215.39	1.22	10.98	12.20	2.00	18.00	20.00	30.00	31.28	61.29
2022/base												
2015–16	193.89	66.95	260.85	1.30	11.66	12.96	2.00	18.00	20.00	45.05	15.56	60.60
2016–17	181.95	78.91	260.86	1.31	11.78	13.09	2.00	18.00	20.00	42.27	18.33	60.60
2017–18	167.35	70.39	237.73	1.16	10.43	11.59	2.00	18.00	20.00	42.66	17.94	60.60
2018–19	166.35	71.72	238.08	1.07	9.64	10.71	2.00	18.00	20.00	42.35	18.26	60.60
2019–20	134.41	54.58	188.99	1.18	10.62	11.80	2.00	18.00	20.00	43.10	17.50	60.60
2020–21	104.30	111.09	215.39	1.18	10.62	11.80	2.00	18.00	20.00	29.35	31.26	60.60
2021–22	103.33	66.69	170.02	1.18	10.62	11.80	2.00	18.00	20.00	36.83	23.77	60.60
2023/base												
2015–16	193.89	66.95	260.85	1.30	11.66	12.96	2.00	18.00	20.00	44.52	15.37	59.90
2016–17	181.99	78.86	260.86	1.31	11.78	13.09	2.00	18.00	20.00	41.79	18.11	59.90
2017–18	167.35	70.39	237.73	1.16	10.43	11.59	2.00	18.00	20.00	42.16	17.73	59.90
2018–19	166.35	71.72	238.08	1.07	9.64	10.71	2.00	18.00	20.00	41.85	18.04	59.90
2019–20	134.41	54.58	188.99	1.18	10.62	11.80	2.00	18.00	20.00	42.60	17.30	59.90
2020–21	104.30	111.09	215.39	1.18	10.62	11.80	2.00	18.00	20.00	29.00	30.89	59.90
2021–22	103.24	66.79	170.02	1.18	10.62	11.80	2.00	18.00	20.00	36.37	23.53	59.90
2022–23	83.15	74.51	157.66	1.18	10.62	11.80	2.00	18.00	20.00	31.59	28.31	59.90

MCMC trace plots for the CRA 3 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure A.3 and Figure A.4 for MCMC diagnostic plots).

The rapid update fit to the CPUE for both base models (*r1_qdrift* and *r2_qdrift*) was generally similar to the equivalent fits in the 2019 assessment, with both fitting the single new CPUE point better than the 2020, 2021, and 2022 rapid updates (Figure 15). The *r2_qdrift* model fitted the region 2 AW CPUE by increasing the biomass to reach the final CPUE point, but consequently degraded the fits to the CPUE earlier in the time series. This behaviour was also seen in the previous three rapid updates, but this was considered an acceptable adjustment. The fits to the LFs were similar for the 2018–19 fishing year and reasonable for subsequent fishing years (Figure 16, Figure 17, Figure 18, and Figure 19). There were some minor differences in predicted immature female LFs in 2017–18 and 2018–19 for both base models compared with the last full assessment and previous rapid updates.

The 2023 rapid update estimated slightly lower average recruitment than that estimated by the 2019 full assessment in region 1 starting in 2014–15 and up to 2017–18. The 2021 rapid update estimated a small peak in recruitment in both regions in 2017–18 and 2018–19 for both *r1_qdrift* and *r2_qdrift*. This peak became more pronounced for the 2022 rapid update and shifted to 2018–19 and 2019–20, also for both *r1_qdrift* and *r2_qdrift* (Figure 20 and Figure 21). For the 2023 rapid update, this peak was higher in 2019–20 for region 1 but shifted to 2020–21 for region 2, again for both model runs (Figure 20, Figure 21). The 2022 Plenary meeting raised concerns about this pattern of shifting peaks in the estimated recruitment, questioning whether the increase in the final estimated year was supported by the data, or was potentially an artefact of the model configuration. The 2023 rapid update estimated the average recruitment in region 1 to be slightly lower than that projected by the 2019 full assessment for both *r1_qdrift* and *r2_qdrift* (Figure 20, Figure 21). In region 2, the estimated average recruitment by the 2023 rapid update was slightly higher than that projected by the 2019 full assessment; again this was true for both *r1_qdrift* and *r2_qdrift* (Figure 20 and Figure 21).

While the 2019 full stock assessment predicted a declining trend in adjusted vulnerable biomass for CRA 3 which extended into the projections, the 2021, 2022, and 2023 rapid updates all predicted trends that initially dropped below the 2019 predicted trend but then increased above the 2019 trend in the final year for both model runs (Figure 22). Each successive rapid update, beginning with 2021, dipped lower than the previous rapid update but then moved to be higher than the 2019 projection in the final rapid update year, with the 2023 rapid update extending well above the 2019 projected biomass at the beginning of 2023. The SSB predicted by the 2023 rapid update for 2023–24 was estimated to be slightly higher than was projected by the 2019 assessment for both model runs and both regions combined (Figure 23).

The 2023 rapid update suggested that, based on posterior median values, the overall (i.e., region 1 and region 2 combined) stock size at the beginning of 2023–24 was 19% (*r1_qdrift*) and 18% (*r2_qdrift*) of B_0, 95% (*r1_qdrift*) and 81% (*r2_qdrift*) of SSB_0, and 51% (*r1_qdrift*) and 50% (*r2_qdrift*) above the reference level. The 2023–24 fishing mortality was above F_{MSY} for region 1 and region 2 for *r1_qdrift*. For *r2_qdrift,* fishing mortality exceeded F_{MSY} in region 1 but was below F_{MSY} in region 2 (Table 11, Table 12). For both base models, the probability of the combined adjusted vulnerable biomass being above B_R at the beginning of 2023–24 was 0.99, and the probability of SSB being above the soft and hard limits at the beginning of 2023–24 was 1.00.

The parameter estimates for the 2023 rapid update for both the *r1_qdrift* and *r2_qdrift* models were similar to the 2019 stock assessment models and the previous rapid updates (Table 13, Table 14).

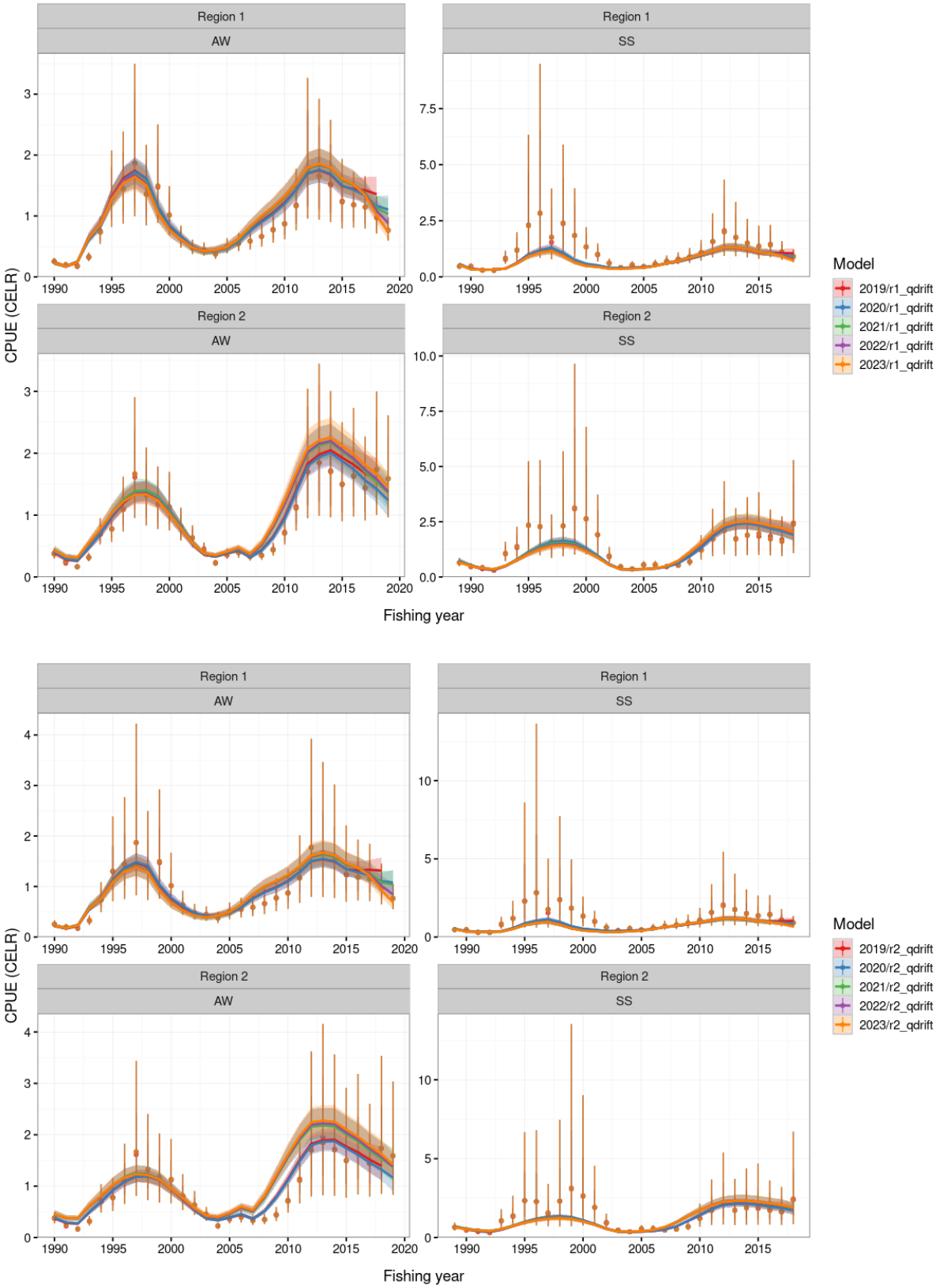

Figure 15: The *r1_qdrift* and *r2_qdrift* model runs are presented top and bottom, respectively. CRA 3 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2019 stock assessment and the 2020, 2021, 2022, and 2023 rapid updates.

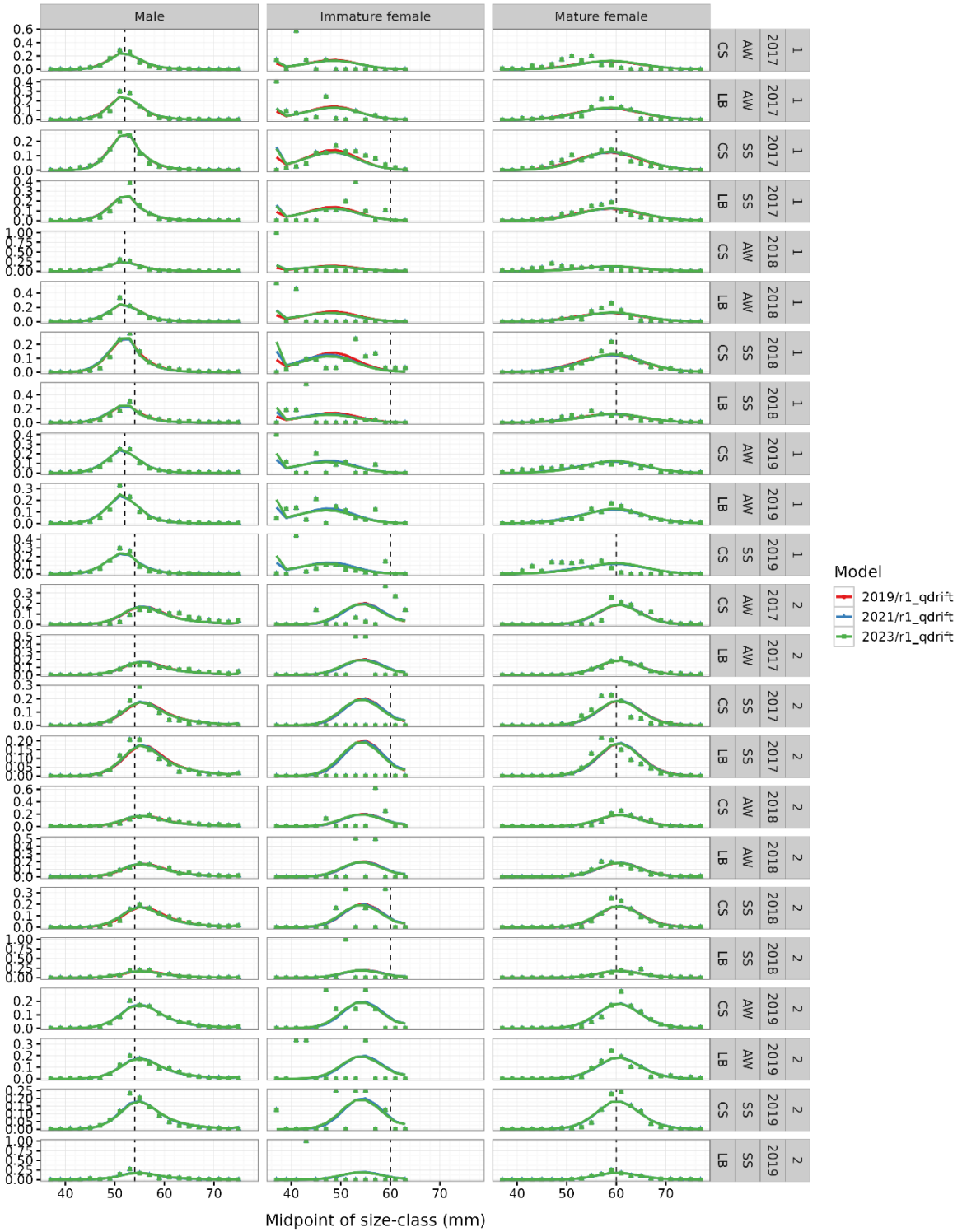

Figure 16: 2017–2019 *r1_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2021, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size (MLS) for the respective sexes. The MLS for females in the AW has not been plotted because the model assumes that females are not landed during the AW in CRA 3.

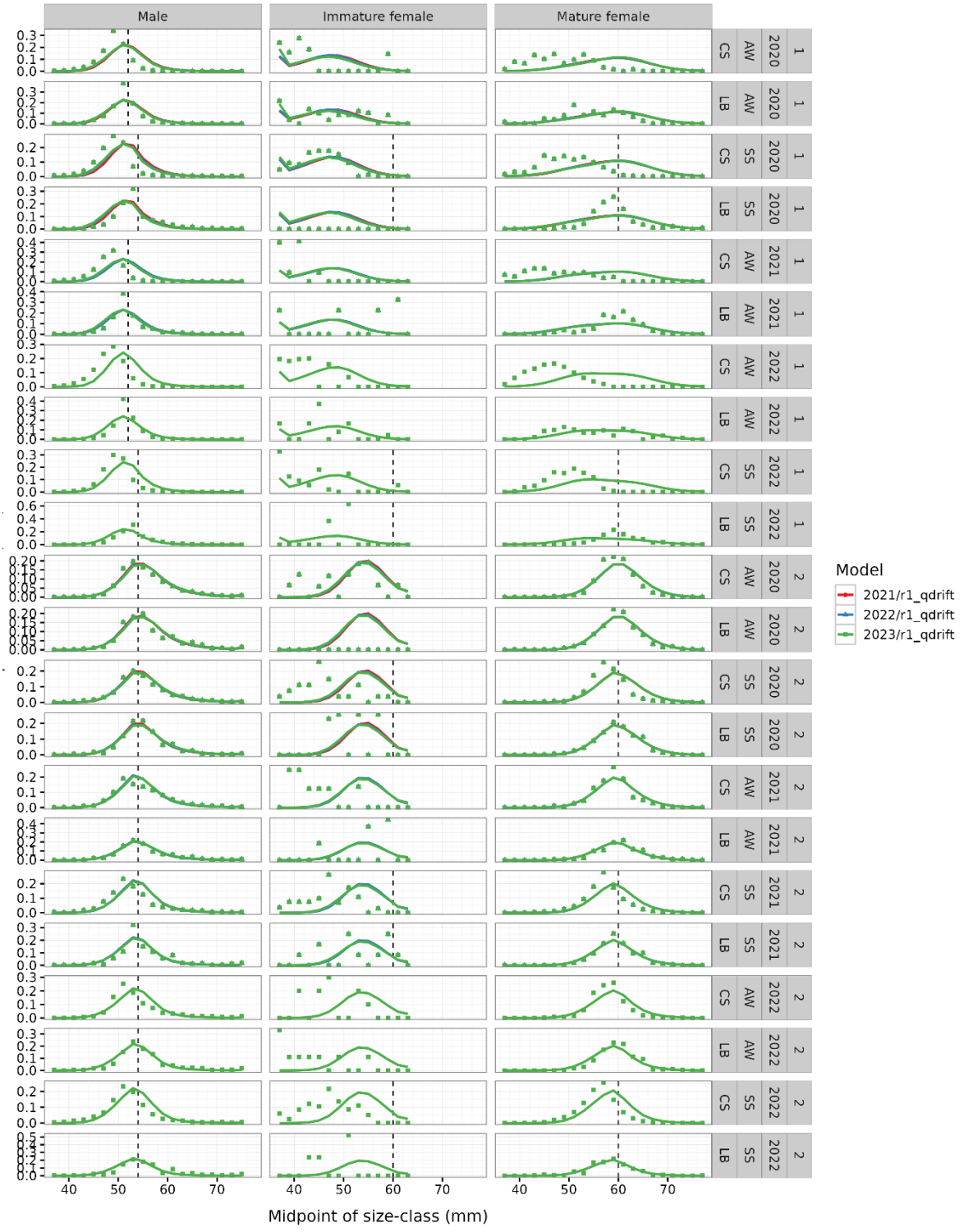

Figure 17: 2020–2022 (years not included in the 2019 assessment and 2020 rapid update) *r1_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2021, 2022, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes. The MLS for females in the AW has not been plotted because the model assumes that females are not landed during the AW in CRA 3.

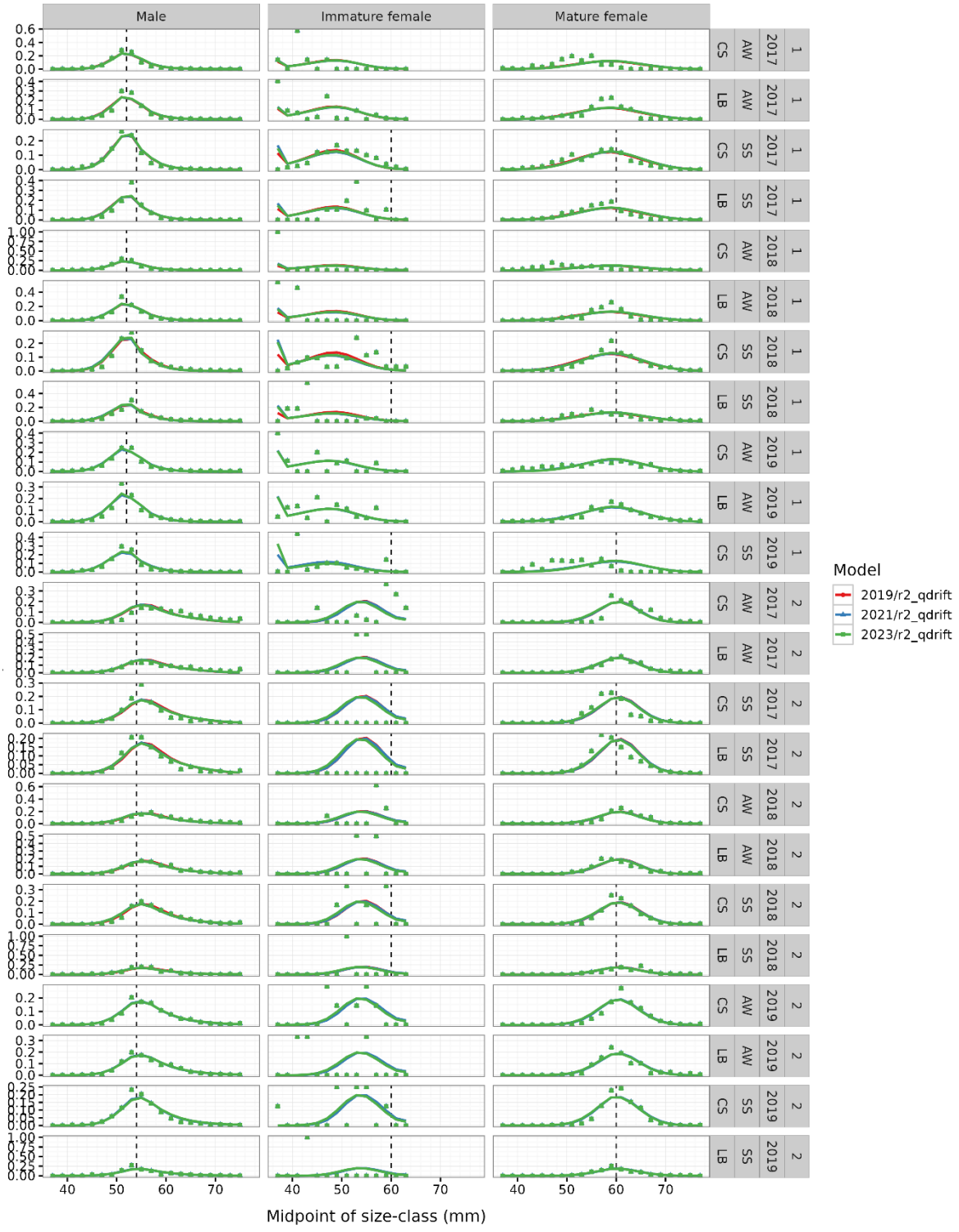

Figure 18: 2017–2019 *r2_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2021, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes. The MLS for females in the AW has not been plotted because the model assumes that females are not landed during the AW in CRA 3.

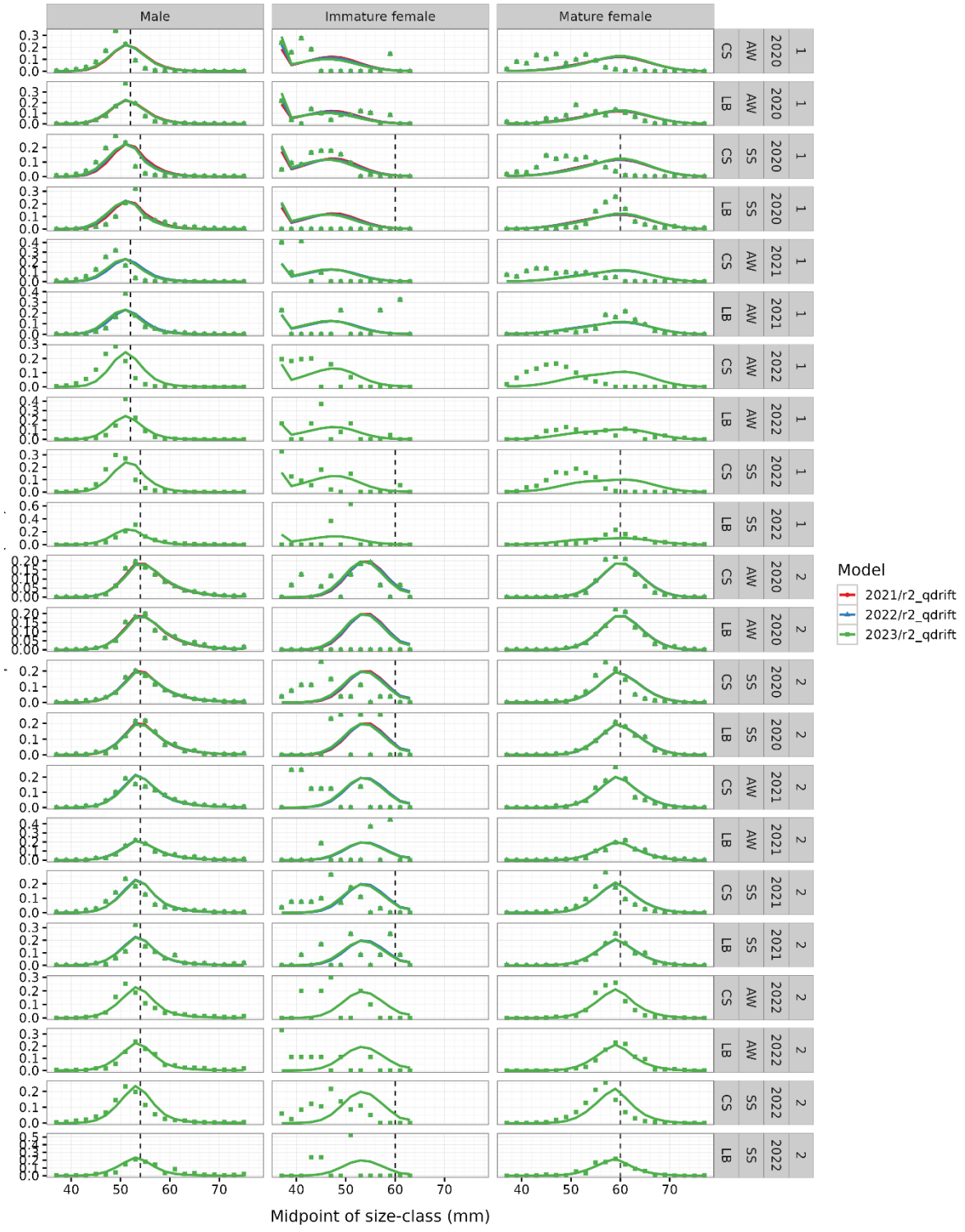

Figure 19: 2020–2022 (years not included in the 2019 assessment and 2020 rapid update) *r2_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2021, 2022, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes. The MLS for females in the AW has not been plotted because the model assumes that females are not landed during the AW in CRA 3.

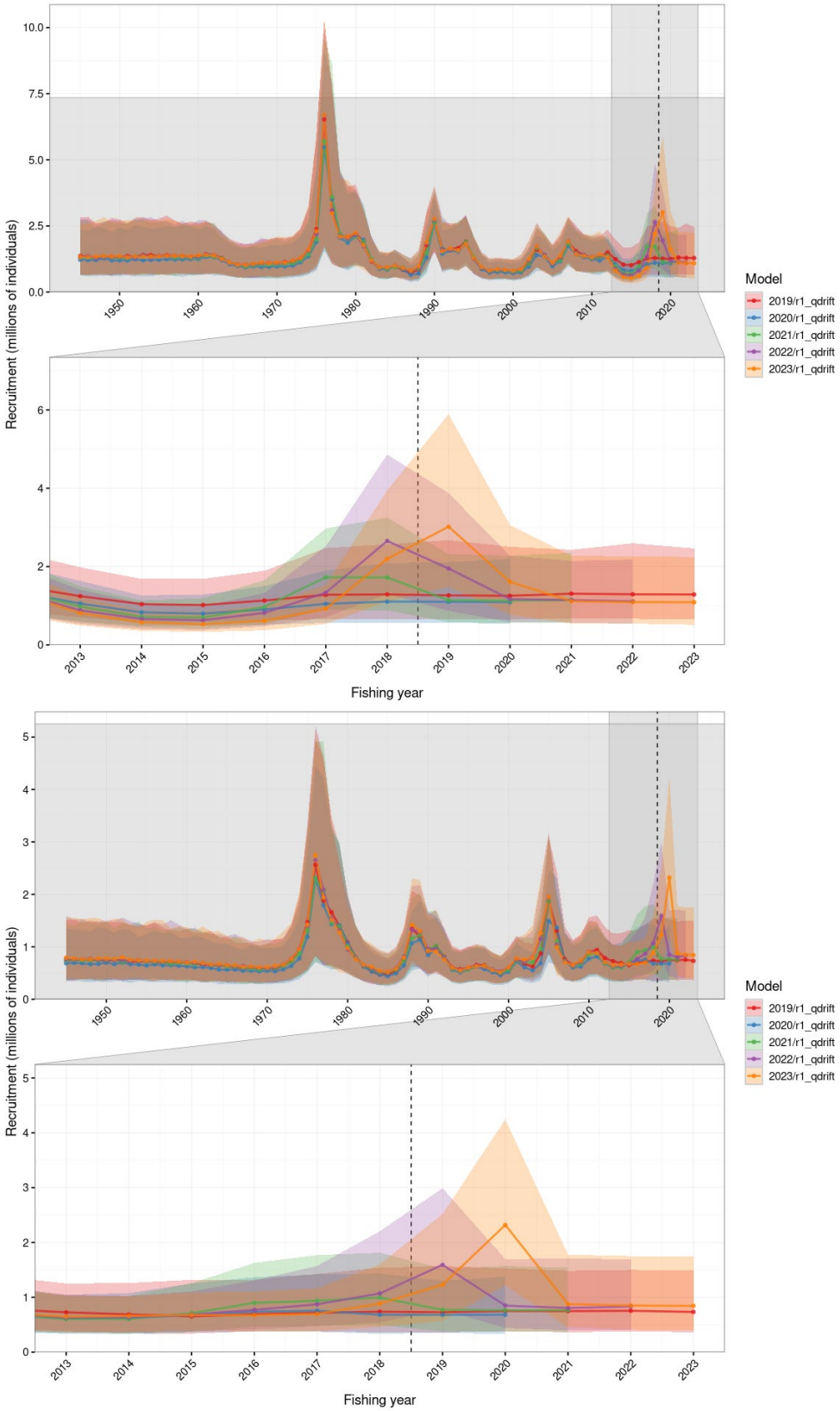

Figure 20: Region 1 (upper panels) and region 2 (lower panels). CRA 3 base case *r1_qdrift* posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

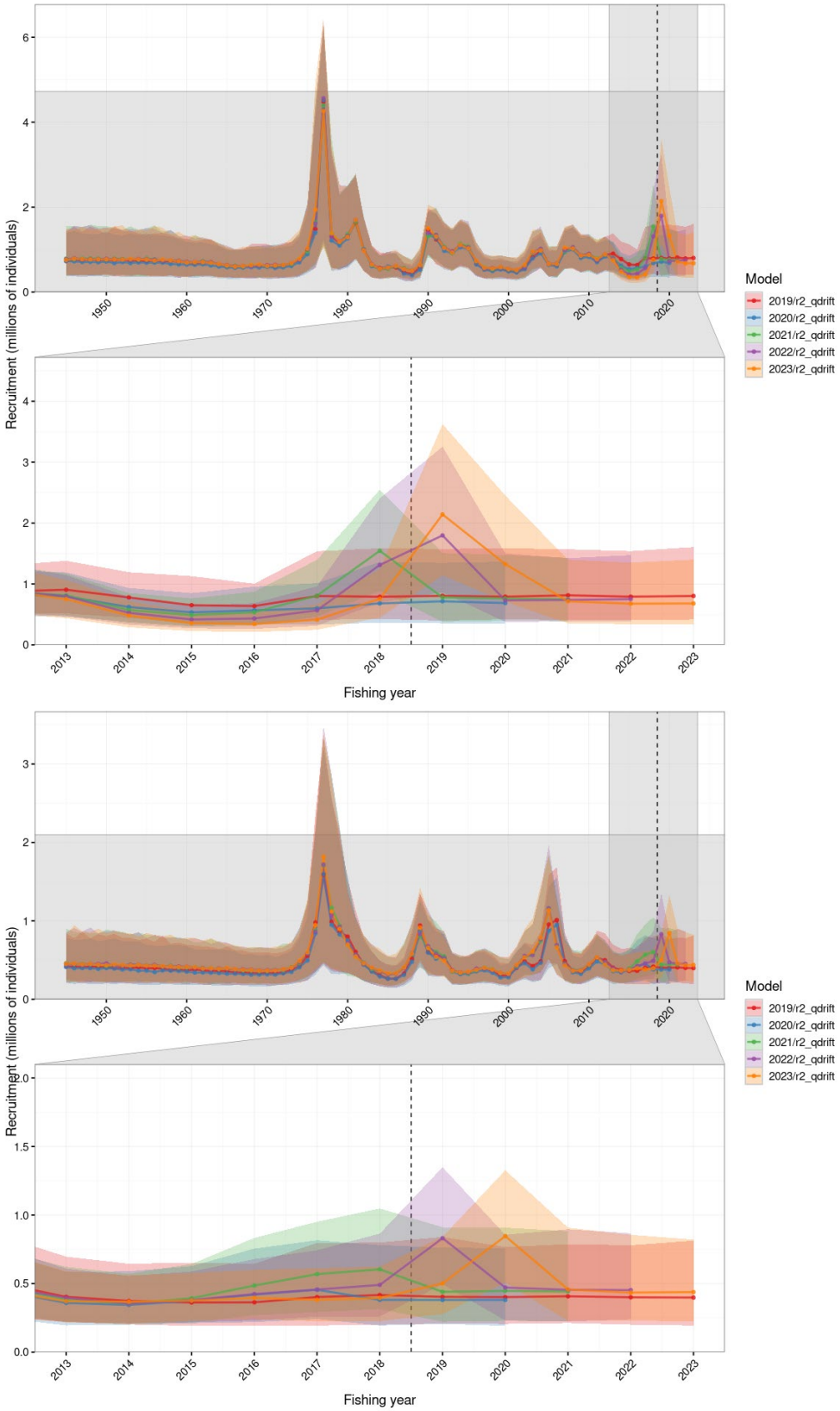

Figure 21: Region 1 (upper panels) and region 2 (lower panels). CRA 3 base case *r2_qdrift* posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

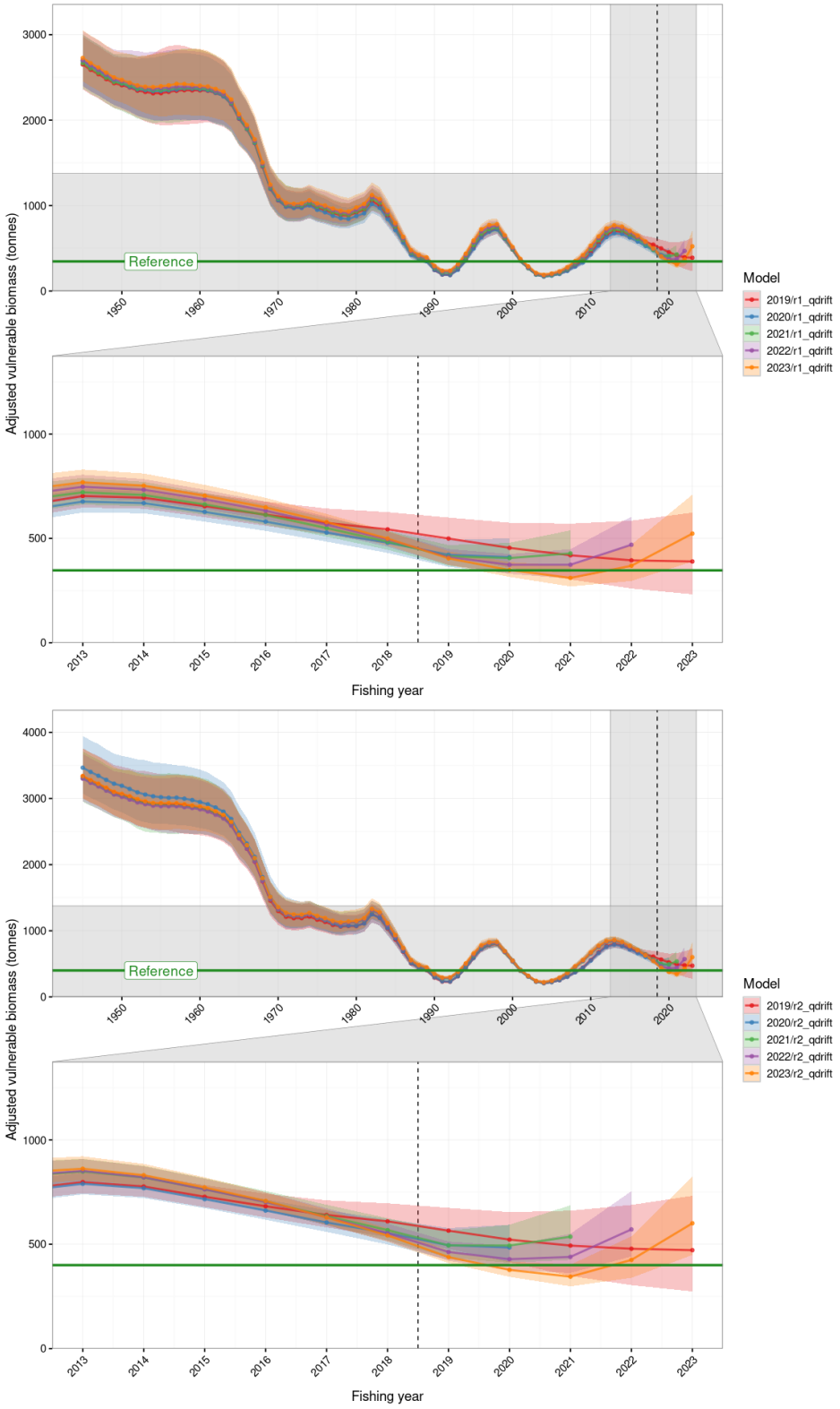

Figure 22: CRA 3 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. The *r1_qdrift* and *r2_qdrift* model runs are presented in the top and bottom panels, respectively. The reference level (B_R) is shown in all panels (horizontal green line).

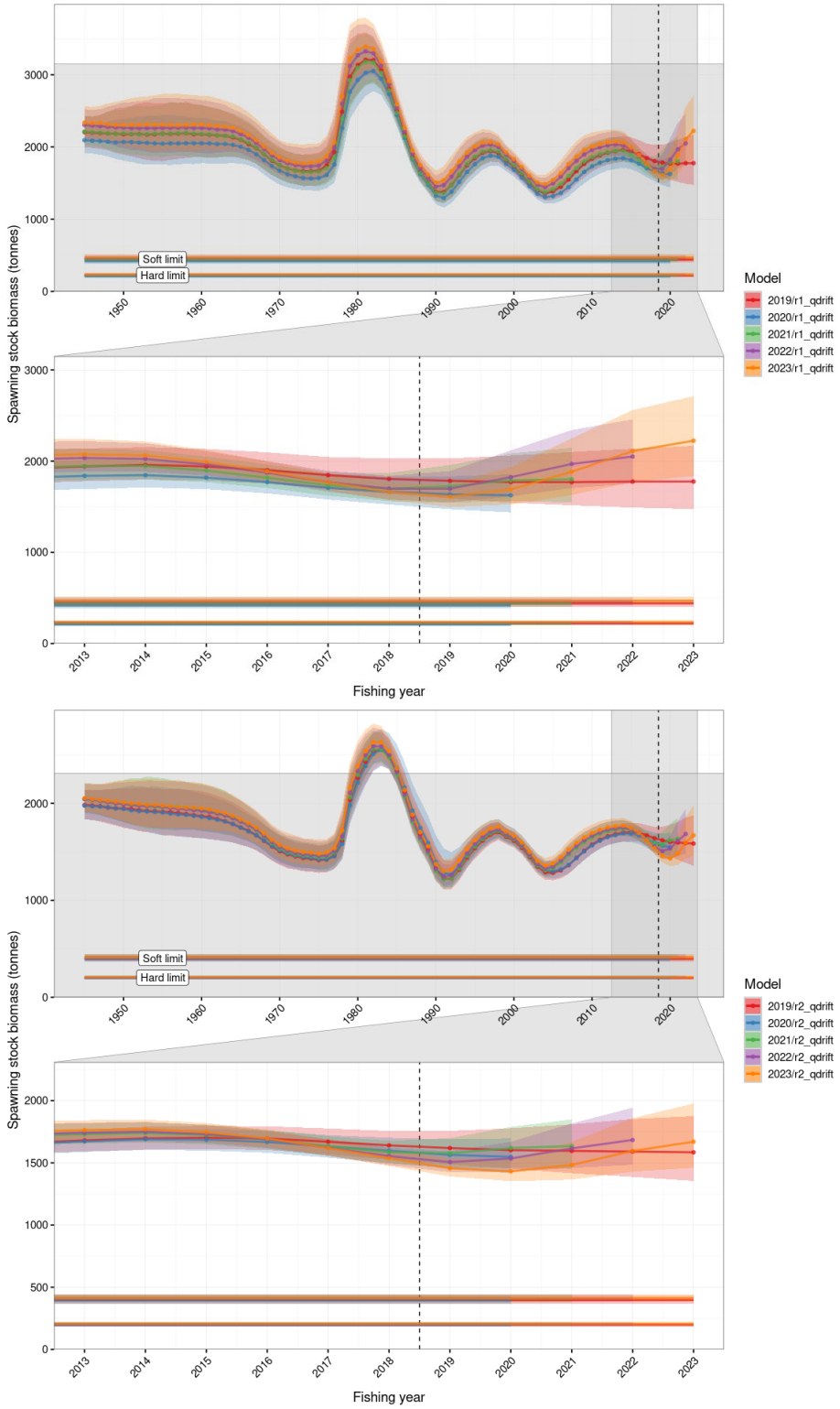

Figure 23: CRA 3 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2019 stock assessment. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. The horizontal lines and shaded regions represent the soft limit (top horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region). The *r1_qdrift* and *r2_qdrift* model runs are presented top and bottom, respectively.

Table 11: CRA 3 *r1_qdrift* rapid update indicators for region 1 and region 2 combined (except for *F* and *H* where values by region are presented), summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
B_0	2 731	2 455	2 727	3 052
B_R	347	–	–	–
B_{2023}	532	389	523	709
B_{2023} / B_0	0.196	0.143	0.190	0.264
B_{2023} / B_R	1.535	1.120	1.508	2.046
P($B_{2023} > B_R$)	0.993	–	–	–
SSB_0	2 347	2 135	2 337	2 564
SSB_{2023}	2 249	1 837	2 224	2 712
SSB_{2023} / SSB_0	0.958	0.810	0.951	1.135
$P(SSB_{2023} > 20\% SSB_0)$	1.000	–	–	–
$P(SSB_{2023} > 10\% SSB_0)$	1.000	–	–	–
F_{MSY} [region 1]	0.120	0.081	0.119	0.166
F_{MSY} [region 2]	0.345	0.245	0.338	0.467
F_{2023} / F_{MSY} [region 1]	1.846	1.660	1.843	2.034
F_{2023} / F_{MSY} [region 2]	1.303	1.128	1.299	1.495
H_{2022} [region 1]	5.052	4.314	5.026	5.872
H_{2022} [region 2]	6.039	5.288	6.032	6.875

Table 12: CRA 3 *r2_qdrift* rapid update indicators for region 1 and region 2 combined (except for *F* and *H* where values by region are presented) summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
B_0	3 351	3 005	3 340	3 755
B_R	400	–	–	–
B_{2023}	615	449	600	824
B_{2023} / B_0	0.184	0.131	0.180	0.248
B_{2023} / B_R	1.537	1.122	1.501	2.061
P($B_{2023} > B_R$)	0.990	–	–	–
SSB_0	2 056	1 920	2 053	2 210
SSB_{2023}	1 687	1 460	1 670	1 977
SSB_{2023} / SSB_0	0.821	0.716	0.814	0.952
$P(SSB_{2023} > 20\% SSB_0)$	1.000	–	–	–
$P(SSB_{2023} > 10\% SSB_0)$	1.000	–	–	–
F_{MSY} [region 1]	0.136	0.092	0.132	0.195
F_{MSY} [region 2]	0.524	0.382	0.513	0.704
F_{2023} / F_{MSY} [region 1]	1.330	1.189	1.329	1.466
F_{2023} / F_{MSY} [region 2]	0.784	0.679	0.784	0.893
H_{2022} [region 1]	4.886	4.276	4.872	5.522
H_{2022} [region 2]	6.194	5.441	6.149	7.063

Table 13: CRA 3 *r1_qdrift* MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2019 full assessment and the 2020, 2021, 2022, and 2023 rapid updates. These values are by region (regional values denoted by [909+910] and [911]), by sex (M = male, F = female), season (SS and AW), and epoch (< 1993 and ≥ 1993) where appropriate. Growth increment values in mm TW and R_0 in numbers. (Continued next page)

	2019 base			2020 rapid update			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters															
R_0 [909+910]	1175763	1432540	1729369	1083815	1292335	1580078	1134131	1387935	1702889	1168792	1419625	1757230	1171035	1413725	1735247
R_0 [911]	671900	818049	1014742	619297	749515	922554	653078	810650	1014608	695809	847729	1059602	686497	853322	1052298
M	0.213	0.235	0.261	0.210	0.231	0.255	0.211	0.235	0.260	0.207	0.232	0.258	0.209	0.231	0.254
q_drift	0.005	0.012	0.020	0.006	0.013	0.020	0.009	0.017	0.025	0.011	0.019	0.026	0.013	0.021	0.029
mat50	35.347	40.341	43.507	34.768	39.843	43.153	35.437	39.893	42.971	35.034	39.975	43.016	34.364	39.281	42.164
mat95	10.306	21.698	34.952	8.894	19.810	32.498	9.486	19.384	32.154	9.731	19.475	33.034	8.385	17.473	29.385
Galpha [909+910]	6.727	7.325	7.871	7.049	7.625	8.218	6.975	7.510	8.056	6.788	7.296	7.850	6.795	7.339	7.823
Galpha [911]	7.097	7.582	8.070	7.194	7.703	8.210	7.363	7.823	8.285	7.160	7.717	8.245	7.231	7.693	8.158
Gbeta [909+910]	2.411	2.613	2.834	2.419	2.645	2.892	2.313	2.517	2.733	2.290	2.486	2.685	2.283	2.469	2.673
Gbeta [911]	0.649	0.747	0.870	0.609	0.706	0.814	0.580	0.670	0.769	0.565	0.650	0.753	0.541	0.612	0.695
GCV [909+910]	0.754	0.797	0.844	0.745	0.795	0.849	0.764	0.813	0.863	0.761	0.802	0.848	0.741	0.785	0.832
GCV [911]	1.138	1.259	1.402	1.160	1.278	1.416	1.149	1.263	1.405	1.150	1.282	1.437	1.188	1.309	1.448
Gobs	0.029	0.249	0.657	0.020	0.267	0.667	0.028	0.292	0.725	0.016	0.271	0.647	0.022	0.274	0.645
vuln1 (M, SS [909+910])	0.893	0.942	0.978	0.911	0.951	0.982	0.861	0.917	0.962	0.850	0.917	0.968	0.859	0.920	0.968
vuln2 (F, AW [909+910])	0.059	0.089	0.143	0.052	0.081	0.123	0.062	0.092	0.136	0.060	0.090	0.133	0.053	0.083	0.124
vuln3 (F, SS [909+910])	0.210	0.310	0.470	0.195	0.288	0.430	0.220	0.310	0.451	0.212	0.308	0.445	0.196	0.294	0.418
vuln4 (M, SS [911])	0.861	0.914	0.960	0.874	0.926	0.966	0.801	0.858	0.918	0.788	0.841	0.896	0.763	0.826	0.883
vuln5 (F, AW [911])	0.331	0.416	0.506	0.310	0.384	0.470	0.320	0.380	0.442	0.302	0.357	0.418	0.311	0.363	0.421
vuln6 (F, SS [911])	0.793	0.896	0.965	0.783	0.887	0.965	0.787	0.894	0.963	0.808	0.906	0.964	0.840	0.926	0.978
selL (M [909+910])	4.473	4.637	4.800	4.493	4.656	4.841	4.466	4.645	4.830	4.491	4.663	4.842	4.489	4.667	4.860
selL (F [909+910], ≥1993)	13.550	15.778	18.446	13.898	16.150	18.748	14.998	17.278	19.478	14.707	17.224	19.738	14.669	17.240	19.519

	2019 base			2020 rapid update			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
selL (M [911])	5.330	5.667	6.045	5.289	5.612	5.964	5.188	5.476	5.812	5.254	5.544	5.873	5.358	5.624	5.971
selL (F [911])	5.950	6.341	6.769	5.959	6.378	6.816	5.981	6.363	6.811	6.064	6.435	6.883	6.311	6.654	7.086
selL (F [909+910], <1993)	5.207	6.825	9.018	5.250	6.749	8.954	5.311	6.884	9.139	5.240	6.749	8.857	5.159	6.675	8.671
selM (M [909+910])	54.250	54.608	54.976	54.221	54.556	54.926	54.127	54.482	54.877	54.108	54.449	54.793	54.028	54.372	54.731
selM (F [909+910], ≥1993)	73.960	79.858	87.563	74.124	79.982	86.677	77.053	83.142	88.675	76.283	82.664	88.893	75.429	82.226	88.252
selM (M [911])	58.891	59.640	60.443	58.683	59.405	60.108	58.401	59.003	59.712	58.447	59.016	59.738	58.413	58.944	59.671
selM (F [911])	64.989	65.841	66.876	64.853	65.784	66.842	64.756	65.584	66.588	64.748	65.602	66.585	64.985	65.780	66.672
selM (F [909+910], <1993)	56.636	59.766	64.436	56.241	59.292	63.400	56.734	59.811	64.120	56.779	59.492	63.531	56.321	59.173	62.939

Table 14: CRA 3 *r2_qdrift* MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2019 full assessment and the 2020, 2021, 2022, and 2023 rapid updates. These values are by region (regional values denoted by [909+910] and [911]), by sex (M = male, F = female), season (SS and AW), and epoch (< 1993 and ≥ 1993) where appropriate. Growth increment values in mm TW and R_0 in numbers. (Continued next page)

	2019 base			2020 rapid update			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters															
R_0 [909+910]	716482	831780	956128	677314	785536	909505	739149	853282	983696	740040	855100	986000	735328	848546	972736
R_0 [911]	388754	464490	547652	370826	440977	516670	421069	501959	591384	428061	497037	586186	425511	497321	583681
M	0.158	0.175	0.194	0.148	0.168	0.186	0.161	0.179	0.198	0.161	0.179	0.197	0.158	0.176	0.194
q_drift	0.009	0.016	0.023	0.010	0.016	0.022	0.011	0.020	0.028	0.013	0.022	0.031	0.014	0.024	0.033
mat50	36.319	41.111	45.044	37.370	41.891	45.227	36.334	40.865	43.843	35.888	40.588	43.914	35.606	40.515	43.734
mat95	11.400	24.161	36.933	12.953	24.446	37.026	11.201	21.241	33.599	10.196	21.095	33.257	10.502	21.034	33.849
Galpha [909+910]	9.850	10.108	10.343	9.923	10.176	10.442	9.867	10.129	10.382	9.848	10.081	10.299	9.769	10.007	10.242
Galpha [911]	7.135	7.621	8.076	7.001	7.477	7.961	7.325	7.775	8.234	7.326	7.758	8.185	7.162	7.628	8.079
Gbeta [909+910]	1.224	1.321	1.423	1.199	1.292	1.391	1.131	1.222	1.324	1.150	1.241	1.336	1.171	1.256	1.349
Gbeta [911]	0.425	0.491	0.566	0.409	0.475	0.544	0.392	0.456	0.516	0.387	0.445	0.508	0.374	0.437	0.496
GCV [909+910]	0.702	0.721	0.744	0.698	0.721	0.744	0.710	0.733	0.756	0.709	0.728	0.751	0.698	0.719	0.741
GCV [911]	1.224	1.328	1.450	1.236	1.355	1.491	1.220	1.335	1.465	1.230	1.342	1.473	1.258	1.357	1.487
Gobs	0.001	0.009	0.027	0.001	0.010	0.028	0.001	0.009	0.027	0.001	0.008	0.023	0.001	0.008	0.021
vuln1 (M, SS [909+910])	0.909	0.954	0.984	0.922	0.962	0.986	0.835	0.896	0.954	0.838	0.899	0.956	0.848	0.909	0.963
vuln2 (F, AW [909+910])	0.048	0.087	0.128	0.038	0.076	0.116	0.070	0.099	0.136	0.065	0.095	0.133	0.060	0.089	0.126
vuln3 (F, SS [909+910])	0.179	0.310	0.436	0.141	0.275	0.411	0.243	0.332	0.441	0.227	0.321	0.442	0.223	0.308	0.421
vuln4 (M, SS [911])	0.846	0.902	0.950	0.858	0.916	0.963	0.760	0.816	0.884	0.746	0.805	0.871	0.725	0.791	0.858
vuln5 (F, AW [911])	0.367	0.445	0.539	0.340	0.416	0.510	0.352	0.416	0.489	0.334	0.391	0.450	0.336	0.392	0.455
vuln6 (F, SS [911])	0.832	0.919	0.973	0.829	0.919	0.975	0.833	0.919	0.967	0.848	0.927	0.975	0.870	0.941	0.981
selL (M [909+910])	4.665	4.836	5.037	4.655	4.839	5.037	4.666	4.847	5.058	4.695	4.881	5.081	4.723	4.911	5.108
selL (F [909+910], ≥1993)	14.728	18.038	20.914	13.480	17.796	20.793	17.377	19.717	21.618	17.354	19.889	21.735	17.369	19.858	21.859
selL (M [911])	5.527	5.969	6.503	5.485	5.870	6.315	5.151	5.564	5.958	5.308	5.665	6.040	5.478	5.820	6.175
selL (F [911])	6.049	6.497	6.944	6.066	6.494	6.944	5.991	6.426	6.892	6.140	6.546	6.971	6.360	6.780	7.216

	2019 base			2020 rapid update			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
selL (F [909+910], <1993)	5.281	7.166	9.769	5.185	7.098	9.457	5.368	7.141	9.598	5.257	7.172	9.407	5.268	7.096	9.429
selM (M [909+910])	53.457	53.775	54.123	53.396	53.710	54.057	53.430	53.749	54.105	53.432	53.747	54.071	53.399	53.732	54.060
selM (F [909+910], ≥1993)	72.788	81.790	88.598	69.155	80.609	87.669	80.651	86.129	89.519	79.781	86.247	89.640	79.576	85.978	89.560
selM (M [911])	58.035	58.909	59.950	57.913	58.646	59.518	57.139	57.893	58.667	57.239	57.948	58.645	57.347	57.979	58.646
selM (F [911])	64.472	65.413	66.297	64.402	65.310	66.263	63.987	64.831	65.769	63.975	64.907	65.742	64.204	65.049	65.943
selM (F [909+910], <1993)	54.975	58.479	62.925	54.458	58.066	61.969	55.435	58.732	62.444	55.353	58.675	62.268	55.172	58.396	62.080

3.4 CRA 4 RAPID UPDATE

The CRA 4 fishery extends from the Wairoa River in northern Hawke Bay, southwards through Hawke Bay, the Wairarapa and the Wellington coasts, then passing north to the Manawatu River on the Kapiti coast (Figure 1, Figure 24).

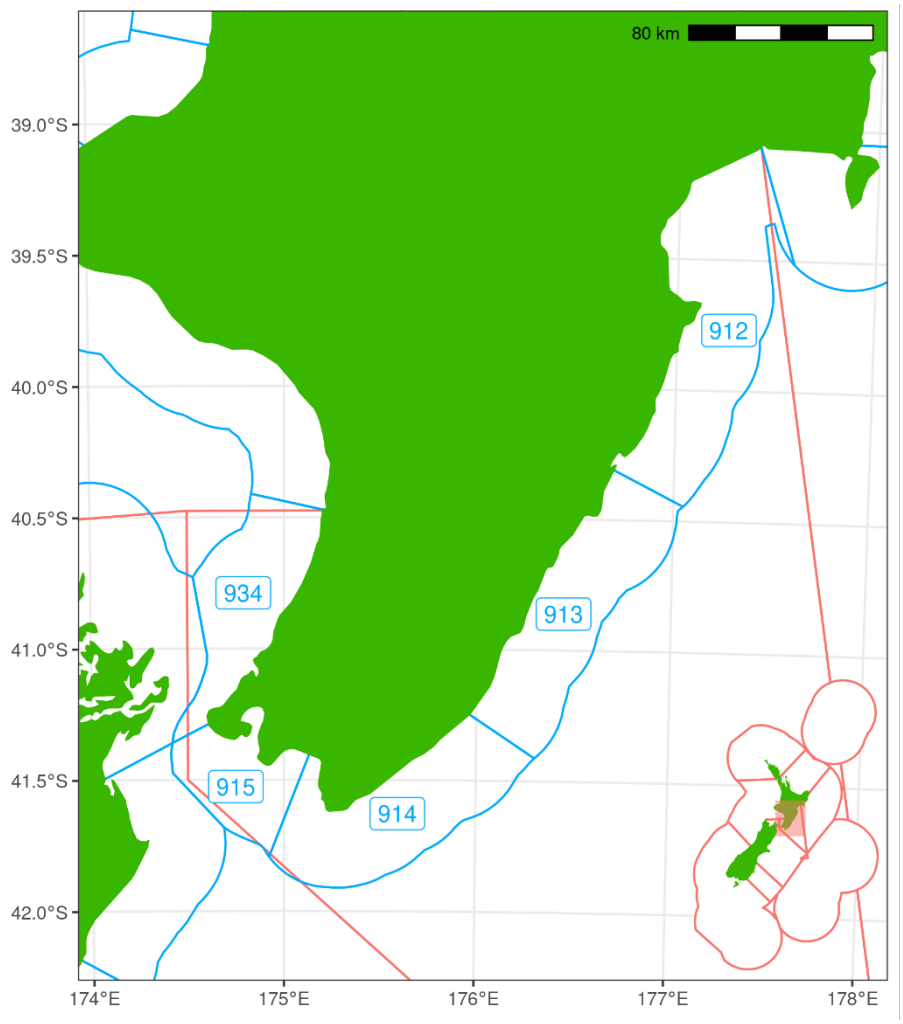

Figure 24: CRA 4 QMA and its statistical areas.

The CRA 4 stock assessment was last done in 2020 as a single region model (Rudd et al. 2021b). The model was fitted to standardised CPUE indices, LF data, sex ratio data, and tag-recapture growth increment data. The model estimated growth by sex (male and female), vulnerability by sex (male, immature female, and mature female) and season (AW and SS), and selectivity by sex (male and female) and epoch (< 1993 and ≥ 1993). The stock assessment indicated a stock with high estimates of SSB relative to the unfished stock level (SSB_0), attributable to the relatively small estimated TW at maturity, which was below the MLS. Adjusted vulnerable biomass decreased strongly in the first decade of the fishery and has since undergone at least two cycles from low to high then low, while the overall stock size gradually decreased in size. Adjusted vulnerable biomass peaked in the mid-1960s, again in the early 1980s, peaked strongly in the late 1990s and finally just after 2010–11.

The 2023 rapid update for CRA 4 added three years of data, including: catch up to 2022–23 (Table 15), LFs for 2020–21, 2021–22, and 2022–23, and additional tag recapture data up to 2022–23. Even though an additional year of data was included in the 2023 rapid update, no data re-weighting was done relative to the 2021 and 2022 rapid updates.

Table 15: Comparison of recent CRA 4 catch (tonnes) for the 2020 stock assessment and the following rapid updates. The table shows the last five fishing years and the five projection years in the 2020 base case model (starting in 2015–16), compared with catch for 2015–16 onwards for the 2021, 2022, and 2023 rapid updates. All projection years for the 2020 stock assessment are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2020/base												
2015–16	108.82	329.33	438.15	3.66	32.93	36.59	2.00	18.00	20.00	4.39	13.28	17.67
2016–17	79.09	303.78	382.87	3.52	31.68	35.20	2.00	18.00	20.00	3.17	12.17	15.34
2017–18	63.50	225.49	288.99	4.11	36.97	41.08	2.00	18.00	20.00	4.27	15.18	19.45
2018–19	90.27	228.10	318.37	4.24	38.16	42.40	2.00	18.00	20.00	6.02	15.22	21.24
2019–20	82.44	197.84	280.28	3.96	35.60	39.56	2.00	18.00	20.00	5.49	13.18	18.68
2020–21	–	–	350.60	–	–	39.56	–	–	20.00	–	–	18.68
2021–22	–	–	350.80	–	–	39.56	–	–	20.00	–	–	18.68
2022–23	–	–	350.80	–	–	39.56	–	–	20.00	–	–	18.68
2023–24	–	–	350.80	–	–	39.56	–	–	20.00	–	–	18.68
2021/base												
2015–16	108.82	329.33	438.15	3.66	32.93	36.59	2.00	18.00	20.00	4.39	13.28	17.67
2016–17	79.09	303.78	382.87	3.52	31.67	35.19	2.00	18.00	20.00	3.17	12.17	15.34
2017–18	63.50	225.49	288.99	4.11	37.01	41.12	2.00	18.00	20.00	4.27	15.18	19.45
2018–19	90.27	228.10	318.37	4.25	38.22	42.46	2.00	18.00	20.00	6.02	15.22	21.24
2019–20	82.44	197.85	280.28	3.96	35.63	39.59	2.00	18.00	20.00	5.49	13.18	18.68
2020–21	117.90	232.64	350.53	3.96	35.63	39.59	2.00	18.00	20.00	6.28	12.40	18.68
2022/base												
2015–16	108.82	329.33	438.15	3.69	33.21	36.90	2.00	18.00	20.00	4.36	13.20	17.56
2016–17	79.09	303.78	382.87	3.55	31.94	35.49	2.00	18.00	20.00	3.15	12.09	15.24
2017–18	63.50	225.49	288.99	4.14	37.29	41.43	2.00	18.00	20.00	4.25	15.08	19.33
2018–19	90.27	228.10	318.37	4.28	38.49	42.77	2.00	18.00	20.00	5.98	15.12	21.10
2019–20	82.44	197.85	280.28	3.99	35.91	39.90	2.00	18.00	20.00	5.46	13.10	18.56
2020–21	117.90	232.64	350.53	3.99	35.91	39.90	2.00	18.00	20.00	6.24	12.32	18.56
2021–22	113.05	166.60	279.65	3.99	35.91	39.90	2.00	18.00	20.00	7.50	11.06	18.56
2023/base												
2015–16	108.82	329.33	438.15	3.69	33.21	36.90	2.00	18.00	20.00	4.33	13.12	17.45
2016–17	79.09	303.78	382.87	3.55	31.94	35.49	2.00	18.00	20.00	3.13	12.02	15.14
2017–18	63.50	225.49	288.99	4.14	37.29	41.43	2.00	18.00	20.00	4.22	14.99	19.21
2018–19	90.27	228.10	318.37	4.28	38.49	42.77	2.00	18.00	20.00	5.95	15.03	20.97
2019–20	82.44	197.85	280.28	3.99	35.91	39.90	2.00	18.00	20.00	5.42	13.02	18.44
2020–21	117.90	232.64	350.53	3.99	35.91	39.90	2.00	18.00	20.00	6.20	12.24	18.44
2021–22	113.05	166.60	279.65	3.99	35.91	39.90	2.00	18.00	20.00	7.46	10.99	18.44
2022–23	140.37	138.82	279.19	3.99	35.91	39.90	2.00	18.00	20.00	9.27	9.17	18.44

MCMC trace plots for the 2023 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure A.5 for MCMC diagnostic plots).

Model fits for the 2023 rapid update were almost indistinguishable from the 2020 stock assessment and the 2021 and 2022 rapid updates. There were negligible changes to the CPUE fits because no further points in the CPUE series were added compared with the 2020 stock assessment due to the shift to electronic reporting (Figure 25). The fits to the LFs were almost indistinguishable from those obtained in the 2020 full assessment and 2021, 2022, and 2023 rapid updates for the years that overlapped (Figure 26).

The rapid update in 2023 suggested that there had been an increase in the estimated average recruitment since the last assessment in 2020 (Figure 27) and that average recruitment increased every time new data were added to the model. These increases in average recruitment occurred because good recruitments were estimated for 2018–19 and 2019–20 by the 2021 and 2022 rapid updates. However, unlike the CRA 3 rapid update, the higher 2018–19 and 2019–20 recruitments have persisted in

successive rapid updates, indicating that the supporting data were consistent with good recruitment in these years. The 2023 rapid update predicted that the adjusted vulnerable biomass in 2022–23 was higher than was projected by the 2020 assessment and above the reference level (Figure 28). The 2020 assessment and 2021 rapid update predicted that vulnerable biomass would be decreasing up to 2023–24, but the 2022 and 2023 rapid updates predicted an increasing vulnerable biomass during this period, likely due to the predicted increase in the average recruitment. The 2023 rapid update predicted that SSB would be higher in 2022–23 than was projected by the 2020 stock assessment and was above the soft and hard limits (Figure 29).

The rapid update suggested that, based on posterior median values, CRA 4 at the beginning of 2023–24 was 17% of B_0, 62% of SSB_0, 51% above B_R, and fishing mortality was above F_{MSY} (Table 16). The probability of the adjusted vulnerable biomass being above B_R at the beginning of 2023–24 was 0.93, and the probability of SSB being above the soft and hard limits was 1.0.

All parameter estimates were very similar to the 2020 stock assessment and the previous rapid updates (Table 17).

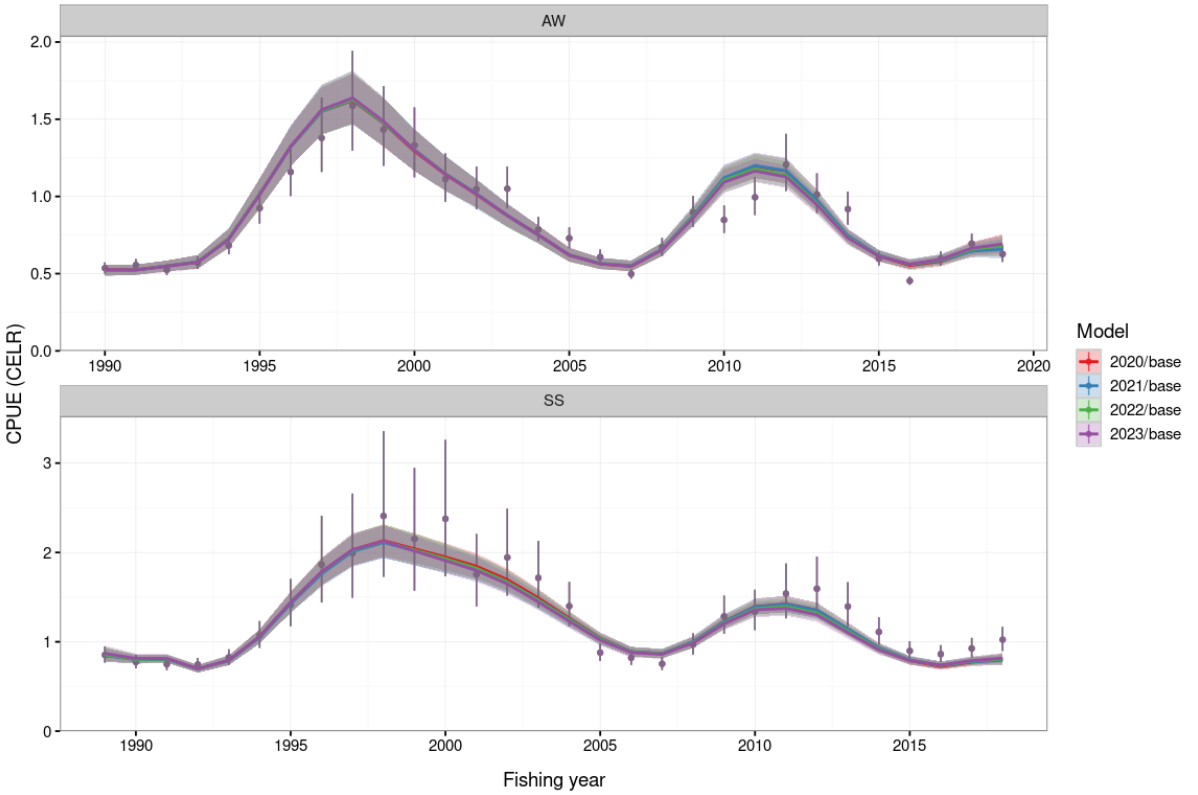

Figure 25: CRA 4 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2020 stock assessment and the 2021, 2022, and 2023 rapid updates.

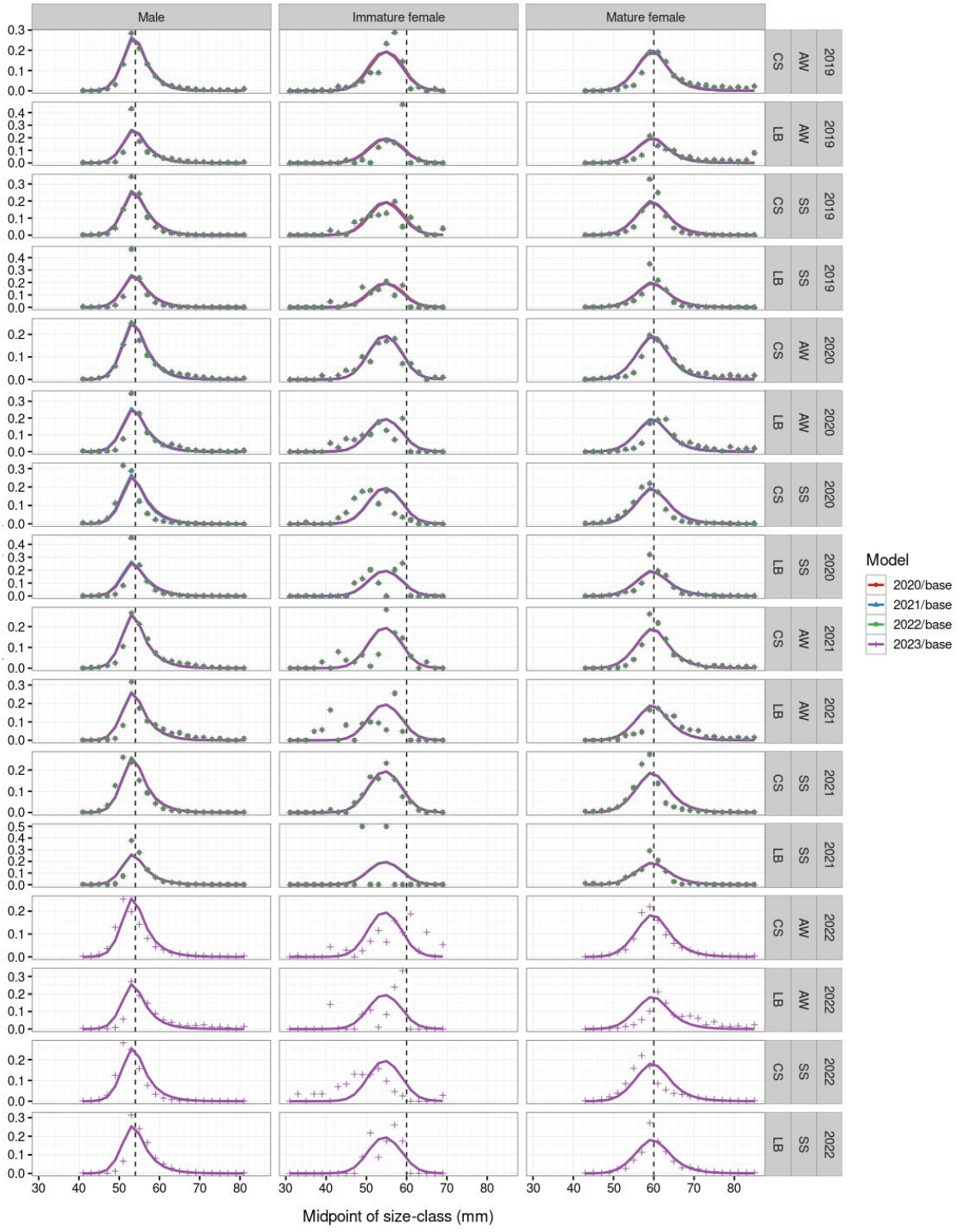

Figure 26: 2019–2022 CRA 4 length frequency observations (points) and median of the posterior distribution (line) by year (from 2019 to 2022), season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2020 stock assessment and the 2021, 2022, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes.

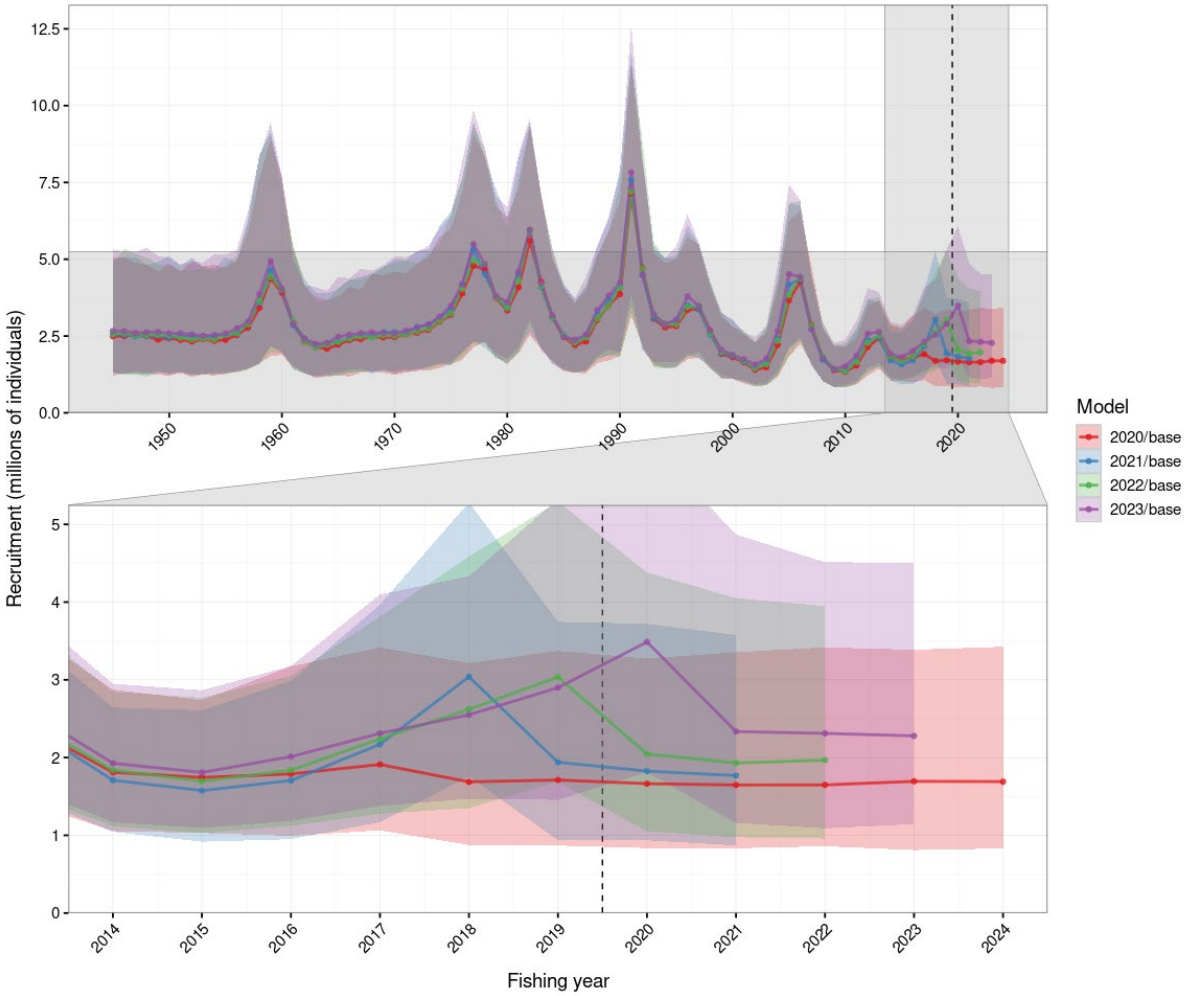

Figure 27: CRA 4 posterior distribution of recruitment showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2020 stock assessment. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

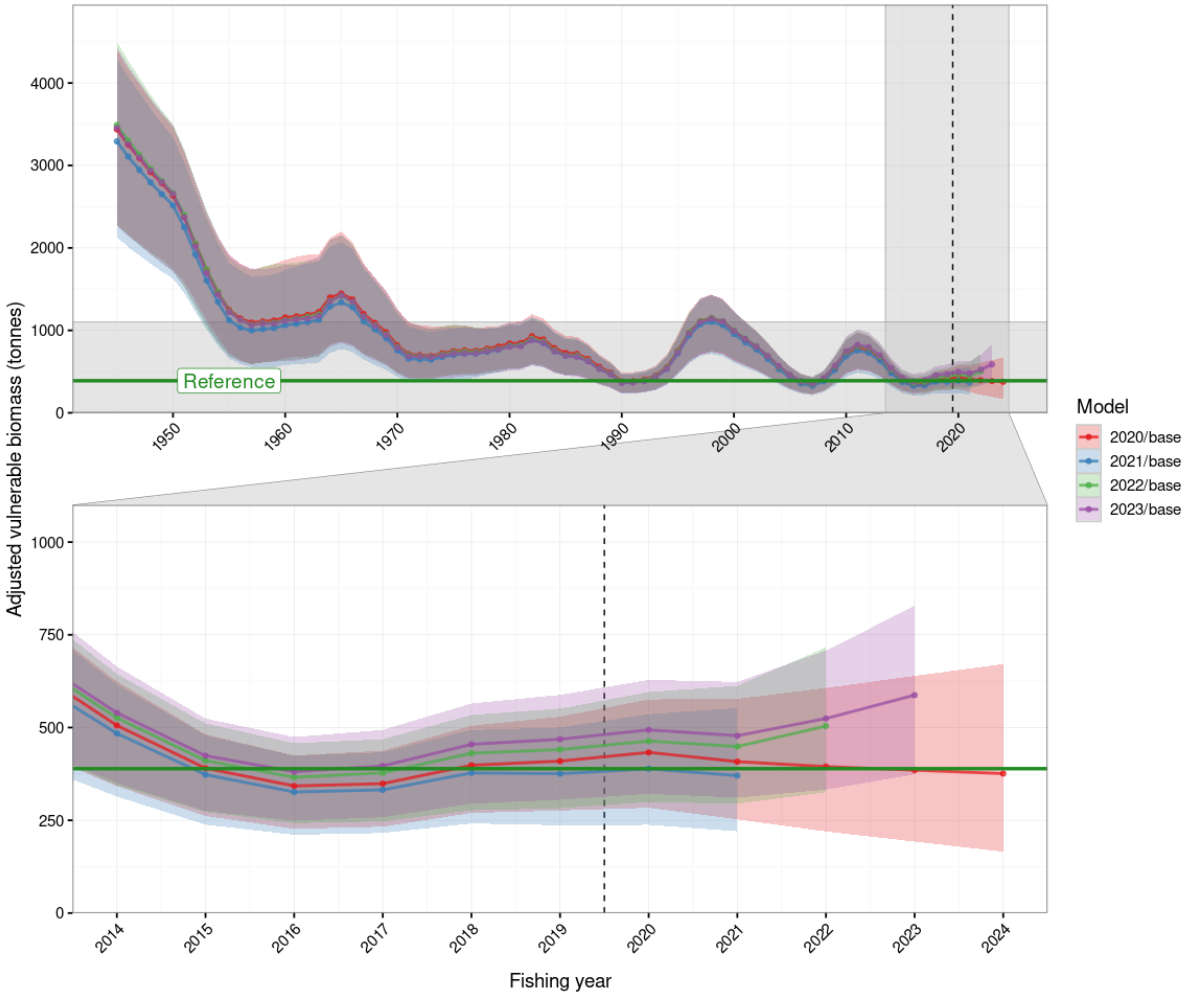

Figure 28: CRA 4 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2020 stock assessment. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. The reference level (B_R) is shown in both panels (horizontal green line).

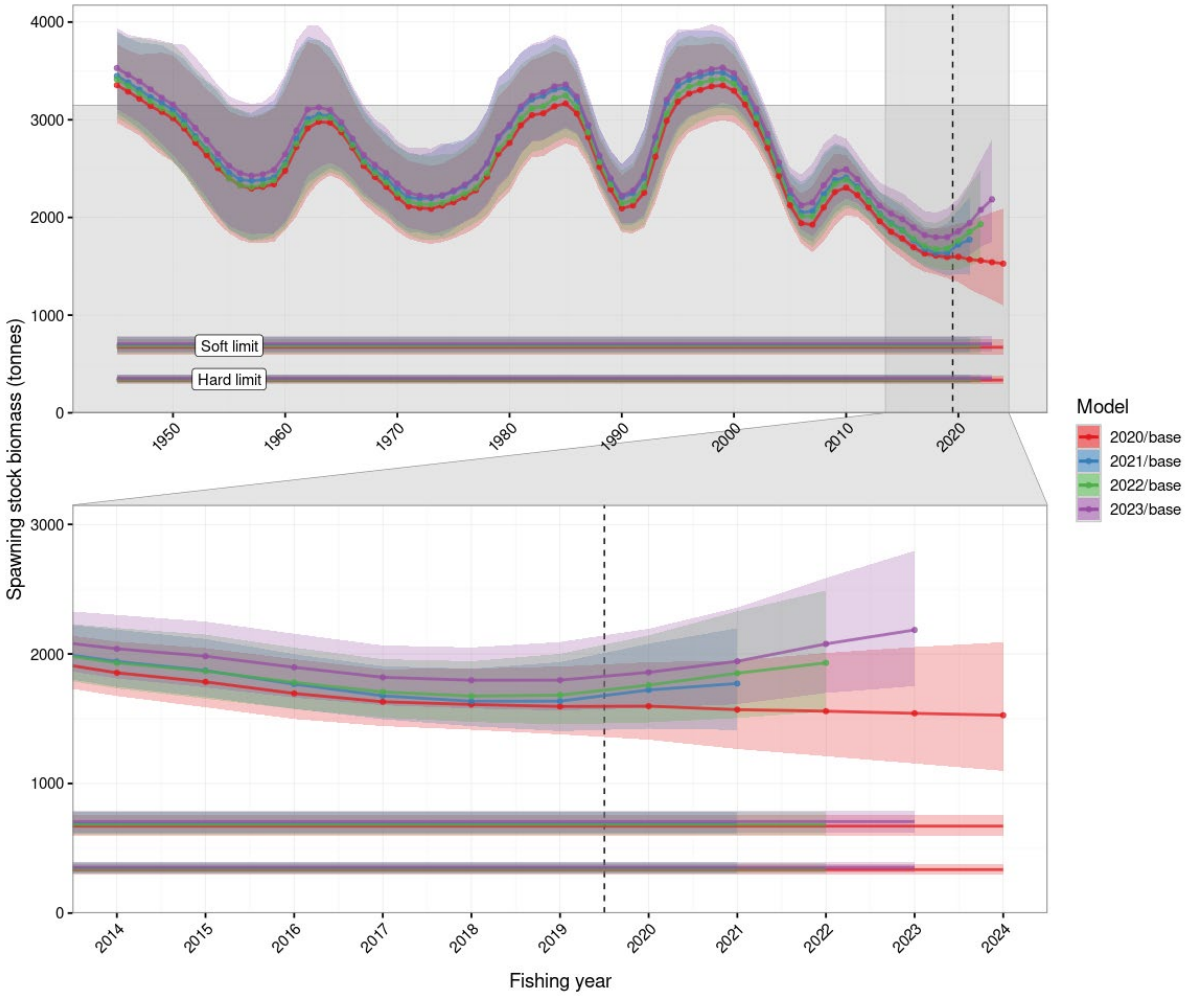

Figure 29: CRA 4 posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2020 stock assessment. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. The horizontal lines and shaded regions represent the soft limit (top horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region).

Table 16: CRA 4 rapid update indicators summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
B_0	3 416	2276	3 455	4434
B_R	389	–	–	–
B_{2023}	592	374	587	828
B_{2023} / B_0	0.175	0.127	0.171	0.230
B_{2023} / B_R	1.521	0.960	1.510	2.128
P($B_{2023} > B_R$)	0.934	–	–	–
SSB_0	3 526	3 109	3 529	3 937
SSB_{2023}	2212	1752	2185	2796
SSB_{2023} / SSB_0	0.627	0.512	0.620	0.770
P($SSB_{2023} > 20\%\ SSB_0$)	1.000	–	–	–
P($SSB_{2023} > 10\%\ SSB_0$)	1.000	–	–	–
F_{MSY}	0.220	0.170	0.219	0.283
F_{2023} / F_{MSY}	1.604	1.213	1.515	2.258
H_{2022}	15.761	13.971	15.732	17.627

Table 17: CRA 4 MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2020 full assessment and the 2021, 2022, and 2023 rapid updates. These values are by sex (M = male, F = female), season (SS and AW) and epoch (< 1993 and ≥ 1993) where appropriate. Growth increment values in mm TW and R_0 in numbers. M = male, IF = immature female, and MF = mature female.

	2020 base			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters												
R_0	2258915	2831890	3577511	2380302	2918420	3683576	2368937	2874335	3694149	2413457	3042815	3854219
M	0.199	0.223	0.251	0.200	0.223	0.250	0.201	0.224	0.252	0.201	0.225	0.253
qdrift	-0.006	0.002	0.010	-0.005	0.003	0.010	-0.009	-0.002	0.005	-0.012	-0.005	0.002
mat50	37.906	41.727	43.789	37.714	41.626	43.674	37.931	41.608	43.475	38.299	41.675	43.436
Galpha [male]	2.567	2.658	2.759	2.540	2.631	2.722	2.552	2.646	2.755	2.539	2.630	2.723
Gbeta [male]	2.138	2.352	2.554	2.198	2.385	2.567	2.208	2.422	2.590	2.261	2.457	2.606
Gshape [male]	5.612	6.382	7.111	5.539	6.241	6.976	5.625	6.438	7.204	5.517	6.231	6.984
GCV [male]	0.683	0.716	0.751	0.688	0.723	0.757	0.689	0.722	0.757	0.691	0.723	0.759
Galpha [female]	1.870	2.042	2.214	1.850	2.023	2.204	1.879	2.055	2.232	1.864	2.031	2.215
Gbeta [female]	1.083	1.237	1.393	1.102	1.244	1.402	1.127	1.263	1.415	1.126	1.280	1.435
Gshape [female]	4.999	5.467	5.985	4.968	5.494	5.944	4.950	5.445	5.939	4.951	5.457	5.937
GCV [female]	1.159	1.269	1.409	1.158	1.270	1.394	1.139	1.255	1.385	1.141	1.256	1.381
Gobs	0.446	0.494	0.546	0.448	0.494	0.549	0.442	0.485	0.536	0.442	0.485	0.536
vuln [M, AW]	0.542	0.823	0.979	0.507	0.781	0.979	0.541	0.815	0.982	0.531	0.814	0.979
vuln [M, SS]	0.444	0.674	0.811	0.422	0.644	0.802	0.448	0.675	0.820	0.440	0.674	0.814
vuln [IF & MF, SS]	0.379	0.545	0.694	0.325	0.495	0.637	0.351	0.516	0.663	0.329	0.485	0.629
vuln [MF, AW]	0.240	0.343	0.452	0.211	0.323	0.421	0.234	0.342	0.441	0.227	0.339	0.438
selL [male < 1993]	4.763	5.687	6.925	4.725	5.645	6.882	4.821	5.755	6.952	4.554	5.611	6.907
selM [male < 1993]	52.720	54.229	56.071	52.814	54.276	56.055	52.875	54.426	56.279	52.742	54.445	56.239
selL [female < 1993]	6.585	8.448	11.152	6.404	8.185	10.389	6.433	8.165	10.710	6.312	7.968	10.287
selM [female < 1993]	58.453	61.760	66.424	58.128	61.275	65.177	58.255	61.299	65.916	58.000	61.038	65.354
selL [male ≥ 1993]	3.767	3.981	4.232	3.742	3.931	4.148	3.737	3.920	4.149	3.702	3.912	4.131
selM [male ≥ 1993]	55.204	55.532	55.916	55.128	55.502	55.868	55.119	55.433	55.791	55.071	55.402	55.766
selL [female ≥ 1993]	5.848	6.234	6.647	5.834	6.181	6.583	5.832	6.193	6.573	5.785	6.140	6.551
selM [female ≥ 1993]	63.769	64.543	65.340	63.658	64.428	65.242	63.563	64.352	65.142	63.491	64.193	65.018

3.5 CRA 5 RAPID UPDATE

The CRA 5 fishery includes all of Tasman Bay and Golden Bay as well as the Marlborough Sounds, then extends down the northern part of the east coast of the South Island, past Kaikōura and the Banks Peninsula as far down as the Waitaki River (Figure 1, Figure 30).

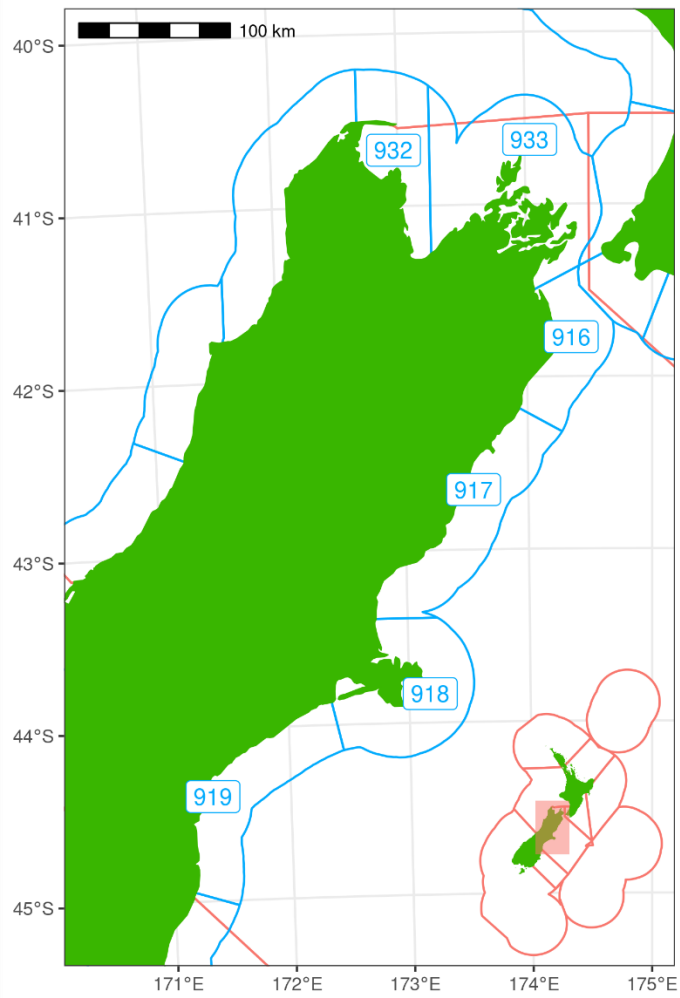

Figure 30: CRA 5 QMA and its statistical areas.

The CRA 5 stock assessment was last done in 2020 as a two-region model: region 1 included statistical areas 917, 918, and 919 and region 2 consisted of statistical areas 916, 932, and 933 (Webber et al. 2021b). The model was fitted to standardised CPUE indices, LF data, sex ratio data, and tag-recapture growth increment data. The model estimated growth by sex (male and female; growth was assumed to be the same for each region), vulnerability by sex (male, immature female, and mature female), season (AW and SS), and region, and selectivity by sex (male and female) and region. The stock assessment results differed between the two regions, with region 1 declining steadily from the beginning of the reconstruction to the early 1990s, followed by a strong recovery to biomass levels near the size of the initial biomass, peaking around 2010–11. Region 1 has since declined to about half of the peak. Region 2 declined strongly to the mid-1950s, followed by a period of relative stability. Biomass then peaked near 2000–01, followed by a decline to the mid-2010s and now appears to be rising again.

The 2023 rapid update for CRA 5 added three years of data, including: catch up to 2022–23 (Table 18), LF data for 2020–21, 2021–22, and 2022–23, and tag recapture data up to 2022–23. Even though an additional year of data was included in the 2023 rapid update, no data re-weighting was done relative to the 2021 and 2022 rapid updates, which also did not re-weight the data sets relative to the last full stock assessment in 2020 (Rudd et al. 2022).

Table 18: Comparison of recent combined CRA 5 catch (tonnes) for the 2020 stock assessment and the following rapid updates. The table shows the last five fishing years and the five projection years in the 2020 base case model (starting in 2015–16), compared with catch for 2015–16 onwards for the 2021, 2022, and 2023 rapid updates. All projection years for the 2020 stock assessment are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2020/base												
2015–16	230.51	119.64	350.15	6.91	62.17	69.08	1.00	9.00	10.00	13.49	7.00	20.49
2016–17	241.54	108.42	349.96	7.93	71.39	79.32	1.00	9.00	10.00	15.67	7.03	22.70
2017–18	211.70	138.27	349.96	7.34	66.07	73.41	1.00	9.00	10.00	15.26	9.97	25.23
2018–19	223.01	126.91	349.92	7.09	63.75	70.84	1.00	9.00	10.00	14.31	8.14	22.45
2019–20	250.34	85.84	336.18	7.46	67.22	74.68	1.00	9.00	10.00	17.47	5.99	23.46
2020–21	293.45	70.36	363.80	7.46	67.22	74.68	1.00	9.00	10.00	17.47	5.99	23.46
2021–22	282.31	67.69	350.00	7.46	67.22	74.68	1.00	9.00	10.00	17.47	5.99	23.46
2022–23	282.31	67.69	350.00	7.46	67.22	74.68	1.00	9.00	10.00	17.47	5.99	23.46
2023–24	282.31	67.69	350.00	7.46	67.22	74.68	1.00	9.00	10.00	17.47	5.99	23.46
2024–25	282.31	67.69	350.00	7.46	67.22	74.68	1.00	9.00	10.00	17.47	5.99	23.46
2021/base												
2015–16	230.50	119.64	350.15	6.85	61.68	68.53	1.00	9.00	10.00	13.35	6.93	20.29
2016–17	241.54	108.42	349.96	7.88	70.90	78.78	1.00	9.00	10.00	15.51	6.96	22.47
2017–18	211.70	138.27	349.97	7.29	65.58	72.87	1.00	9.00	10.00	15.11	9.87	24.98
2018–19	222.98	126.94	349.92	7.03	63.27	70.30	1.00	9.00	10.00	14.16	8.06	22.23
2019–20	223.69	112.48	336.17	7.41	66.73	74.14	1.00	9.00	10.00	15.45	7.77	23.22
2022/base												
2015–16	230.50	119.64	350.15	6.91	62.17	69.07	1.00	9.00	10.00	13.21	6.86	20.07
2016–17	241.54	108.42	349.96	7.93	71.39	79.32	1.00	9.00	10.00	15.35	6.89	22.23
2017–18	211.70	138.27	349.97	7.34	66.07	73.41	1.00	9.00	10.00	14.95	9.76	24.71
2018–19	222.98	126.94	349.92	7.08	63.75	70.84	1.00	9.00	10.00	14.01	7.98	21.99
2019–20	222.70	113.47	336.17	7.47	67.22	74.69	1.00	9.00	10.00	15.22	7.76	22.98
2020–21	168.88	194.80	363.69	7.47	67.22	74.69	1.00	9.00	10.00	10.67	12.31	22.98
2021–22	189.08	160.90	349.98	7.47	67.22	74.69	1.00	9.00	10.00	12.41	10.56	22.98
2023/base												
2015–16	230.50	119.64	350.15	6.91	62.17	69.07	1.00	9.00	10.00	13.08	6.79	19.87
2016–17	241.49	108.47	349.96	7.93	71.39	79.32	1.00	9.00	10.00	15.19	6.82	22.02
2017–18	211.70	138.27	349.97	7.34	66.07	73.41	1.00	9.00	10.00	14.80	9.67	24.47
2018–19	222.88	127.04	349.92	7.08	63.75	70.84	1.00	9.00	10.00	13.87	7.91	21.77
2019–20	223.85	112.32	336.17	7.47	67.22	74.69	1.00	9.00	10.00	15.15	7.60	22.75
2020–21	168.88	194.80	363.69	7.47	67.22	74.69	1.00	9.00	10.00	10.57	12.19	22.75
2021–22	189.00	160.99	349.98	7.47	67.22	74.69	1.00	9.00	10.00	12.29	10.47	22.75
2022–23	187.96	161.99	349.95	7.47	67.22	74.69	1.00	9.00	10.00	12.22	10.53	22.75

MCMC trace plots for the 2023 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure A.6 for MCMC diagnostic plots).

The 2023 rapid update fit to the CPUE was very similar to the fit by the 2020 assessment and the 2021 and 2022 rapid updates with only minor differences in the last five years of AW in region 1 (Figure 31). The fits to the LFs were very similar to the 2020 stock assessment and 2021 and 2022 rapid updates for the years that overlapped and were acceptable for 2022–23 in both regions (Figure 32).

The 2023 rapid update estimated approximately the same series of recruitment, adjusted vulnerable biomass, and SSB as were estimated by the 2020 stock assessment and 2021 and 2022 rapid updates. This was not surprising given that there were only three additional years of LF data and no change to the CPUE data (Figure 33, Figure 34, Figure 35). A small recruitment pulse estimated for region 1 in 2018–19 by the 2021 rapid update disappeared from the 2022 and 2023 rapid updates (Figure 33). There was little change in the average region 1 recruitment estimated by the 2020 assessment and the three

rapid updates. The region 2 recruitment in 2017–18 was estimated to be above average by the 2020 assessment and this recruitment continued to be estimated at a similar level by the 2021, 2022, and 2023 rapid updates. The region 2 average recruitment was estimated in 2023 to be higher than that estimated by the 2020 assessment and the 2021 and 2022 rapid updates. The combined adjusted vulnerable biomass in 2022–23 was estimated by the 2023 rapid update to be higher than was projected by the 2020 stock assessment and that was observed by the 2021 and 2022 rapid updates. In all cases, the adjusted vulnerable biomass levels were estimated to be above the reference level (Figure 34). The combined region SSB estimated by the 2023 rapid update was similar to the SSB projected for 2022–23 by the 2020 stock assessment and was above the soft and hard limits (Figure 35).

The 2023 rapid update estimated that, based on posterior median values, the overall stock (i.e., region 1 and region 2 combined) at the beginning of 2023–24 was 41% of B_0, 68% of SSB_0, three times B_R, and was estimated to be close to F_{MSY} in region 1 and below F_{MSY} in region 2 (Table 19). The probability of the combined adjusted vulnerable biomass being above B_R in 2023 and the probability of the combined SSB being above the soft and hard limits in 2023 were 1.0.

All parameter estimates were similar to the 2020 stock assessment and the previous rapid updates (Table 20).

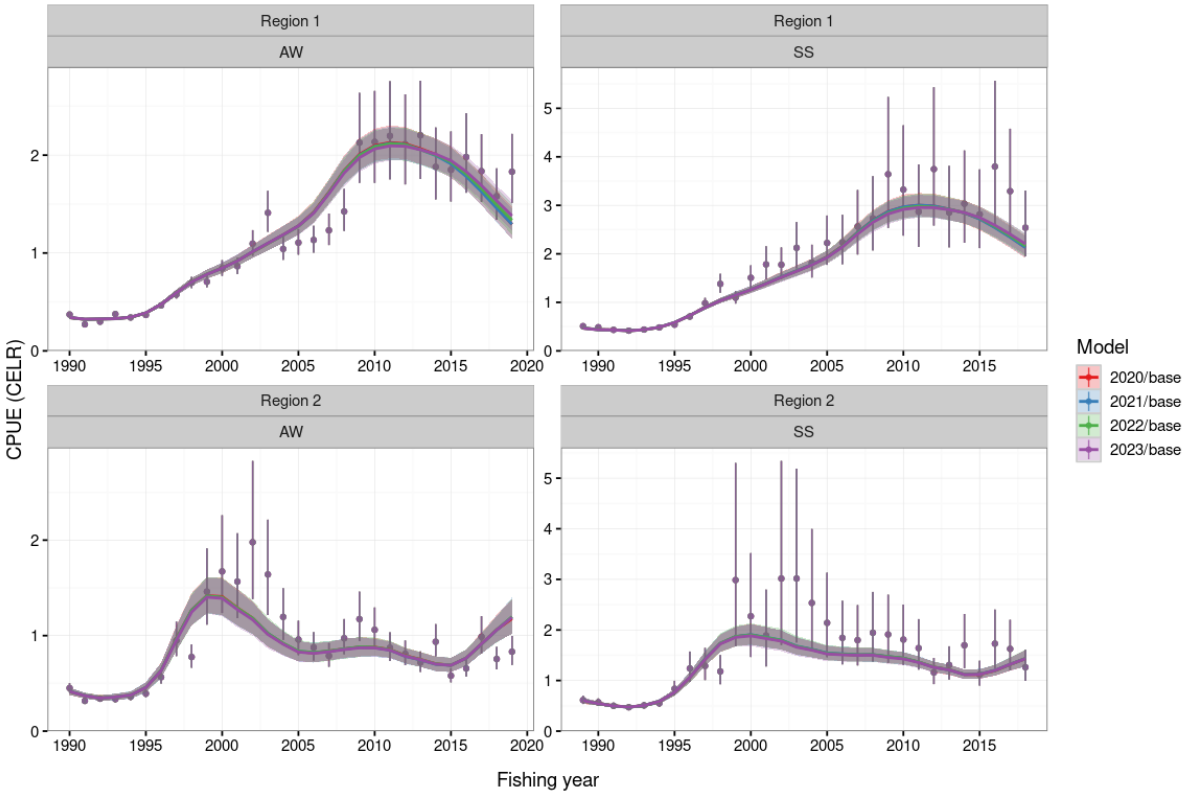

Figure 31: CRA 5 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2020 stock assessment and the 2021, 2022, and 2023 rapid updates.

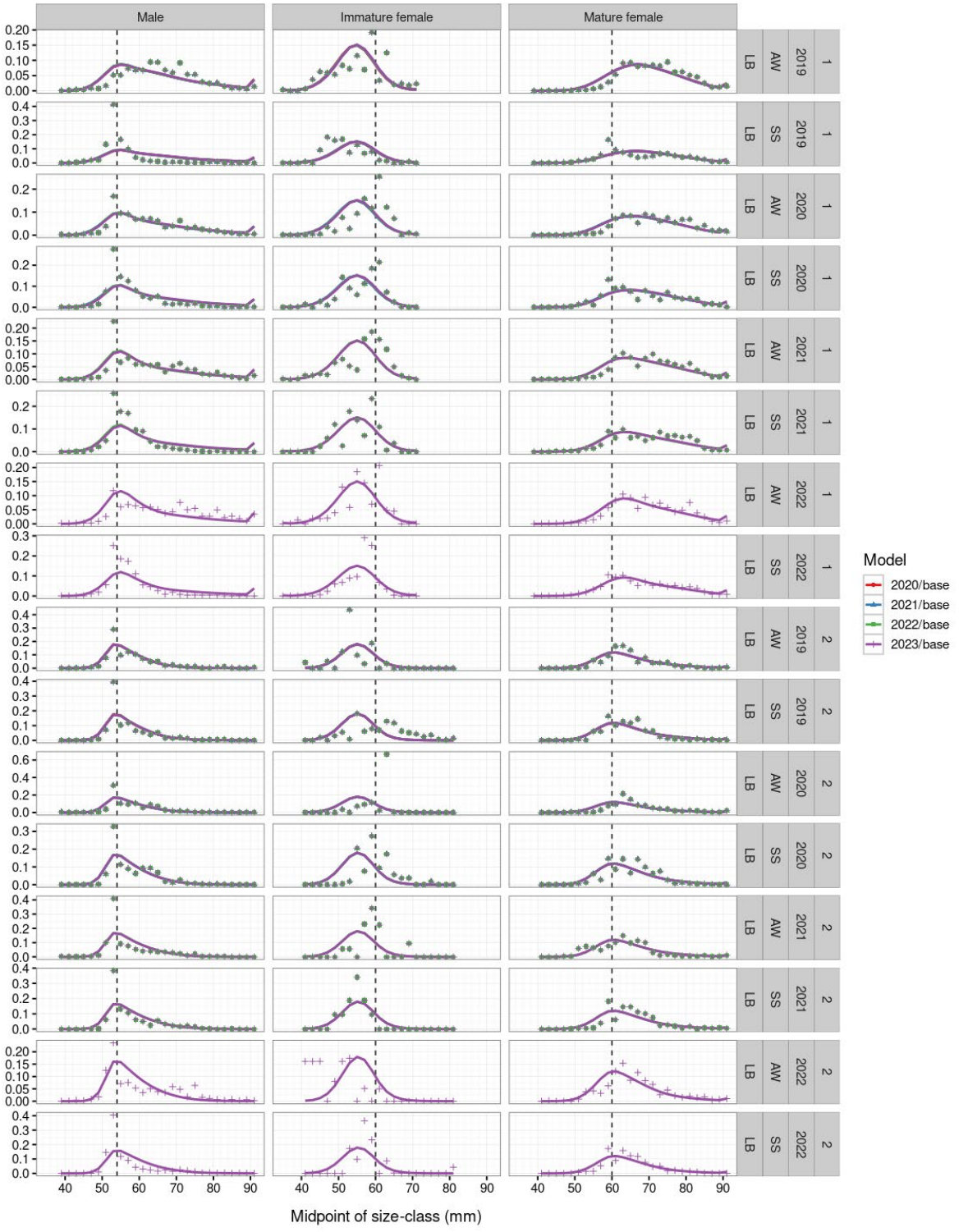

Figure 32: 2019–2022 CRA 5 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year (from 2019 to 2022), season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2020 stock assessment and the 2021, 2022, and 2023 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes.

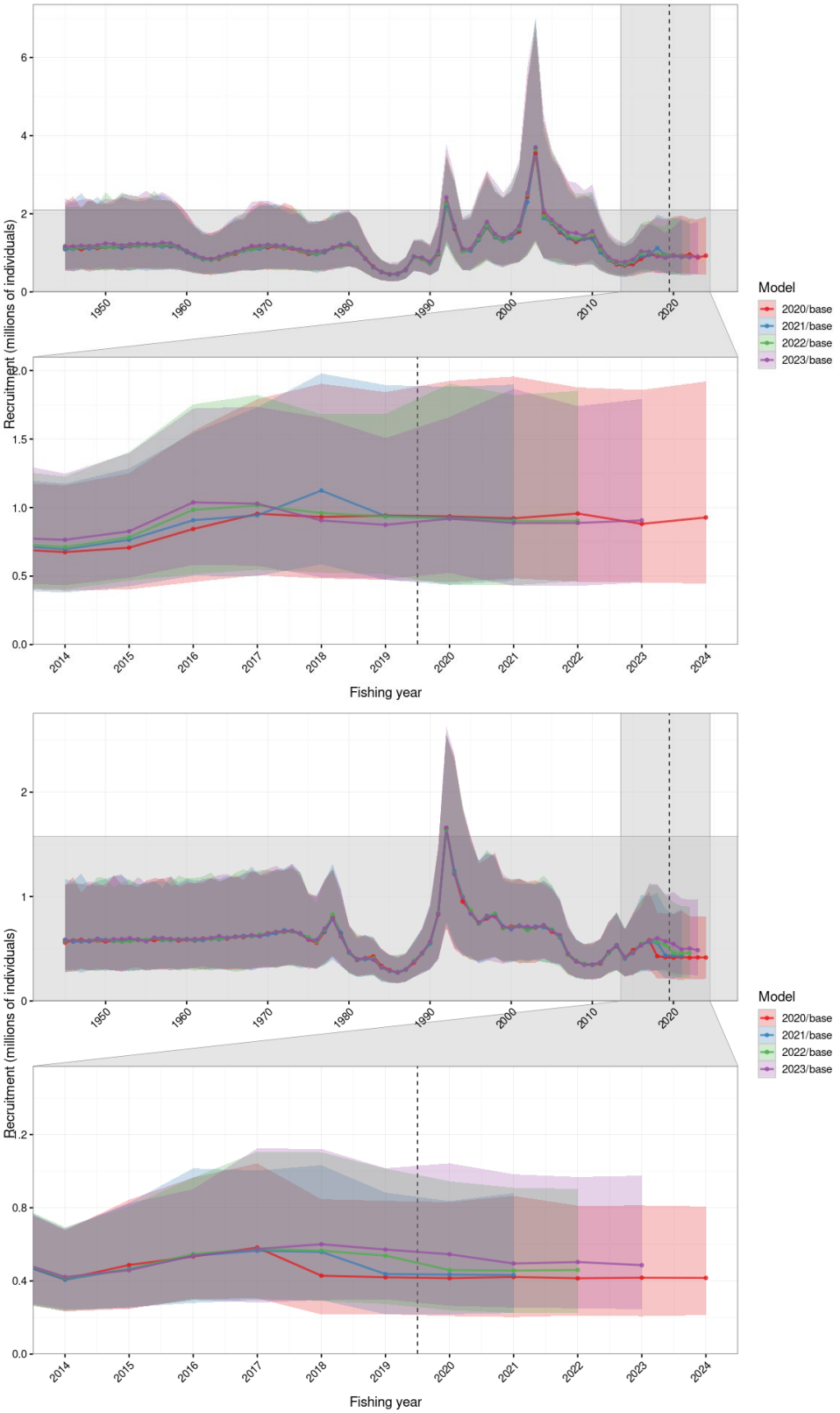

Figure 33: Region 1 (upper panels) and region 2 (lower panels). CRA 5 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2020 stock assessment. The top panel shows the recruitment for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years.

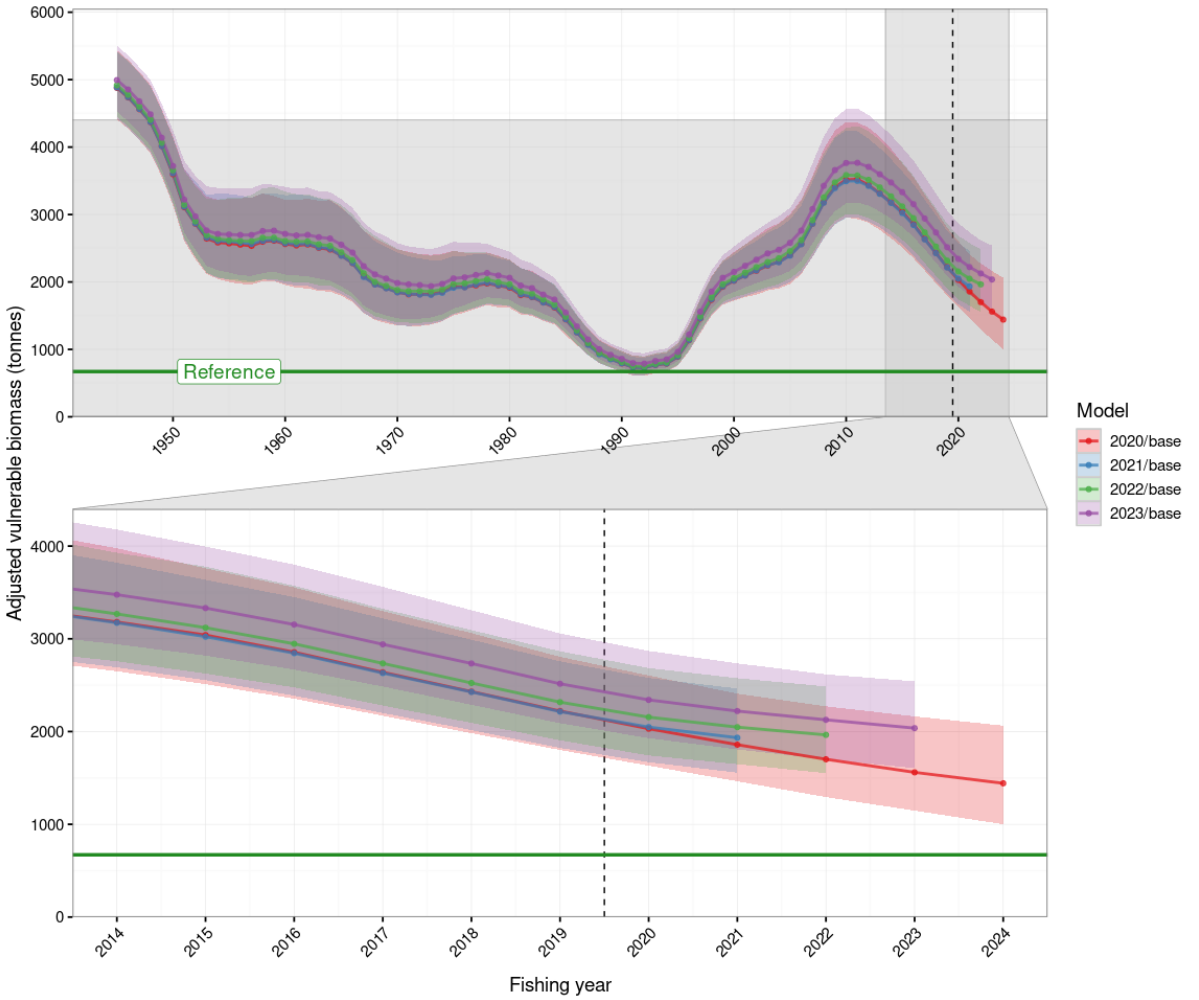

Figure 34: CRA 5 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2020 stock assessment. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. The reference level (B_R) is shown in both panels (horizontal green line).

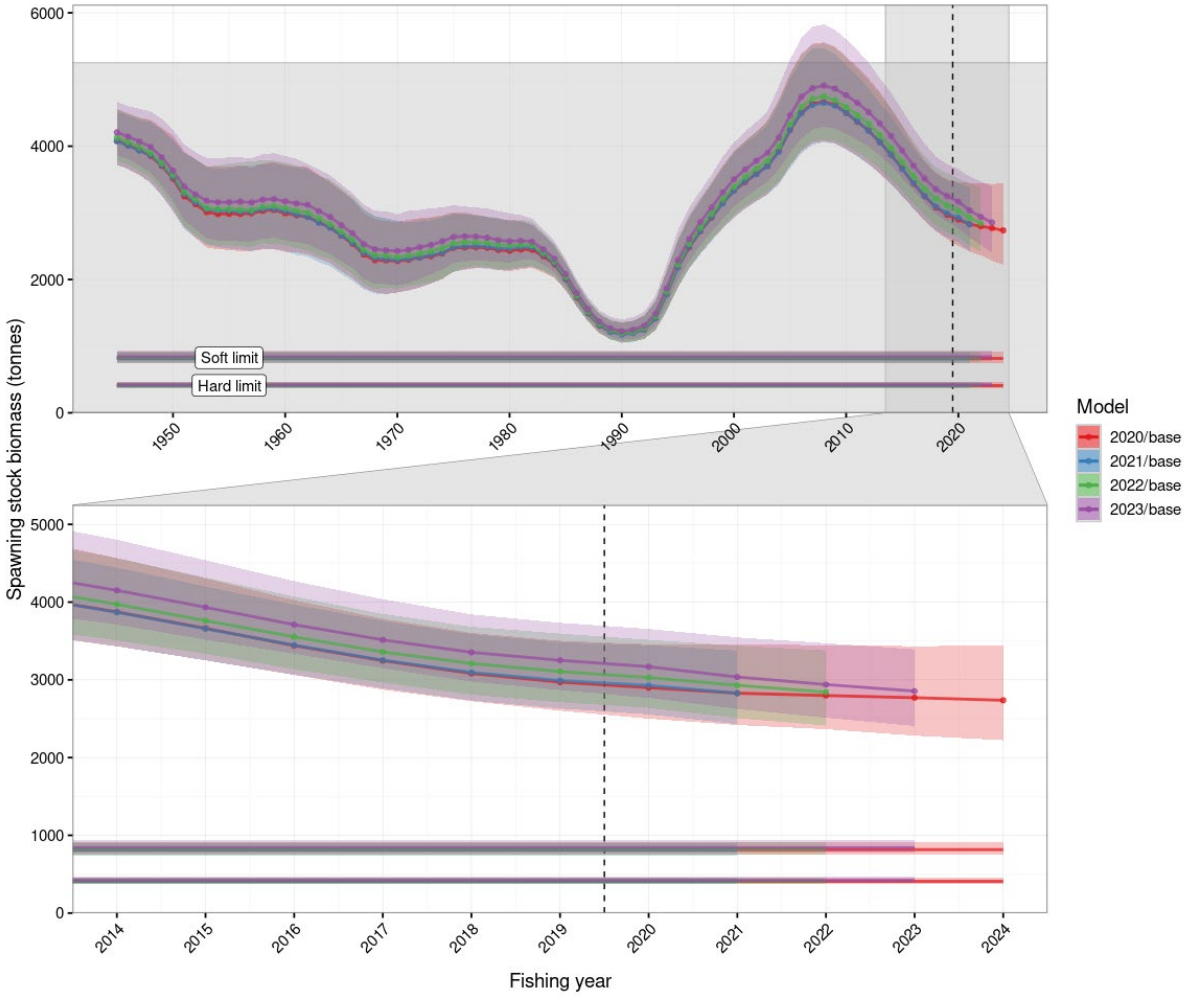

Figure 35: CRA 5 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021, 2022, and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2020 stock assessment. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. The horizontal lines and shaded regions represent the soft limit (top horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region).

Table 19: CRA 5 rapid update indicators for region 1 and region 2 combined (except for *F* and *H* where values by region are presented) summarising the mean, median, and 95% credible interval.

Indicator	Mean	5%	50%	95%
B_0	4 997	4 526	4 993	5 502
B_R	671	–	–	–
B_{2023}	2 053	1 606	2 037	2 541
B_{2023} / B_0	0.411	0.331	0.409	0.496
B_{2023} / B_R	3.059	2.392	3.035	3.786
P($B_{2023} > B_R$)	1.000	–	–	–
SSB_0	4 227	3 865	4 208	4 665
SSB_{2023}	2872	2406	2855	3393
SSB_{2023} / SSB_0	0.679	0.593	0.675	0.775
P($SSB_{2023} > 20\%\ SSB_0$)	1.000	–	–	–
P($SSB_{2023} > 10\%\ SSB_0$)	1.000	–	–	–
F_{MSY} [region 1]	0.123	0.088	0.121	0.160
F_{MSY} [region 2]	0.066	0.066	0.066	0.066
F_{2022} / F_{MSY} [region 1]	0.992	0.848	0.987	1.158
F_{2022} / F_{MSY} [region 2]	0.771	0.590	0.757	0.996
H_{2021} [region 1]	11.157	9.995	11.128	12.406
H_{2021} [region 2]	1.323	1.102	1.314	1.577

Table 20: CRA 5 MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2020 full assessment and the 2021, 2022, and 2023 rapid updates. These values are by region where appropriate (regional values denoted by [1] and [2], where [1] = statistical areas 917, 918, and 919 and [2] = statistical areas 916, 932, and 933), by sex and season (SS and AW). Growth increment values in mm TW and R_0 in numbers. M = male, IF = immature female, and MF = mature female.

	2020 base			2021 rapid update			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters												
R_0[1]	956 976	1 162 150	1 483 363	944 403	1 164 910	1 466 379	953 979	1 178 995	1 513 520	997 374	1 207 485	1 528 086
R_0[2]	534 223	615 921	704 749	532 448	610 511	718 960	529 898	612 705	724 961	538 195	616 764	723 142
M	0.168	0.183	0.201	0.167	0.183	0.201	0.167	0.182	0.202	0.168	0.183	0.201
mat50	43.325	46.013	48.360	43.037	46.063	48.157	43.224	46.130	48.230	43.425	46.052	48.120
mat95add	5.959	11.394	18.196	6.412	12.007	18.719	6.645	12.159	18.228	7.061	12.078	18.474
Galpha [male]	3.235	3.297	3.364	3.232	3.297	3.365	3.222	3.294	3.362	3.224	3.295	3.366
Gbeta [male]	2.385	2.599	2.799	2.372	2.569	2.774	2.332	2.536	2.744	2.300	2.505	2.691
Gshape [male]	4.375	4.900	5.469	4.361	4.903	5.456	4.320	4.847	5.396	4.285	4.799	5.310
GCV [male]	0.559	0.569	0.581	0.559	0.570	0.580	0.559	0.570	0.580	0.558	0.569	0.581
Galpha [female]	3.628	3.770	3.906	3.607	3.750	3.901	3.628	3.760	3.900	3.650	3.785	3.915
Gbeta [female]	1.389	1.471	1.556	1.378	1.457	1.538	1.360	1.439	1.523	1.341	1.421	1.501
Gshape [female]	5.204	5.579	5.932	5.308	5.659	5.988	5.300	5.622	5.972	5.295	5.625	5.964
GCV [female]	0.779	0.797	0.816	0.777	0.797	0.817	0.779	0.798	0.818	0.779	0.798	0.818
Gobs	1.211	1.237	1.263	1.207	1.231	1.254	1.210	1.233	1.258	1.211	1.234	1.258
vuln (M, SS) [1]	0.641	0.679	0.717	0.653	0.687	0.722	0.649	0.684	0.721	0.643	0.678	0.717
vuln (IF, AW) [1]	0.371	0.593	0.863	0.444	0.662	0.907	0.448	0.670	0.928	0.446	0.651	0.886
vuln (IF & MF, SS) [1]	0.914	0.976	0.998	0.911	0.974	0.998	0.918	0.979	0.998	0.927	0.981	0.998
vuln (MF, AW) [1]	0.901	0.965	0.996	0.895	0.964	0.997	0.889	0.960	0.995	0.866	0.946	0.995
vuln (M, SS) [2]	0.655	0.696	0.736	0.660	0.701	0.744	0.657	0.701	0.747	0.658	0.703	0.748
vuln (IF, AW) [2]	0.070	0.124	0.205	0.071	0.124	0.205	0.069	0.116	0.200	0.068	0.119	0.191
vuln (IF & MF, SS) [2]	0.291	0.341	0.403	0.295	0.349	0.407	0.290	0.343	0.407	0.294	0.341	0.404
vuln (MF, AW) [2]	0.258	0.296	0.341	0.260	0.302	0.342	0.258	0.297	0.344	0.261	0.298	0.344
selL male [1]	5.024	5.897	6.954	4.973	5.808	6.751	4.896	5.679	6.599	4.883	5.611	6.511
selM male [1]	8.964	10.583	12.560	9.143	10.577	12.541	9.146	10.713	12.697	9.198	10.617	12.500
selL female [1]	3.126	3.549	4.015	3.167	3.541	4.007	3.131	3.538	3.971	3.129	3.500	3.891
selM female [1]	6.018	7.088	8.226	6.174	7.103	8.384	6.048	7.117	8.470	6.091	7.100	8.225
selL male [2]	55.512	56.939	58.605	55.486	56.869	58.417	55.418	56.742	58.128	55.479	56.612	58.173
selM male [2]	66.082	68.558	71.525	66.586	68.725	71.710	66.607	69.139	72.373	66.569	68.871	71.764
selL female [2]	53.950	54.570	55.330	53.928	54.554	55.239	53.915	54.552	55.242	53.907	54.487	55.130
selM female [2]	60.222	61.740	63.278	60.546	61.804	63.361	60.313	61.735	63.406	60.377	61.707	63.227

3.6 CRA 7&8 RAPID UPDATE

The CRA 7 QMA extends from the Waitaki River south along the Otago coastline to Long Point. The CRA 8 QMA extends from Long Point south to Stewart Island and the Snares Islands, the islands and coastline of Foveaux Strait, then north along the Fiordland coastline to Bruce Bay (Figure 1, Figure 36).

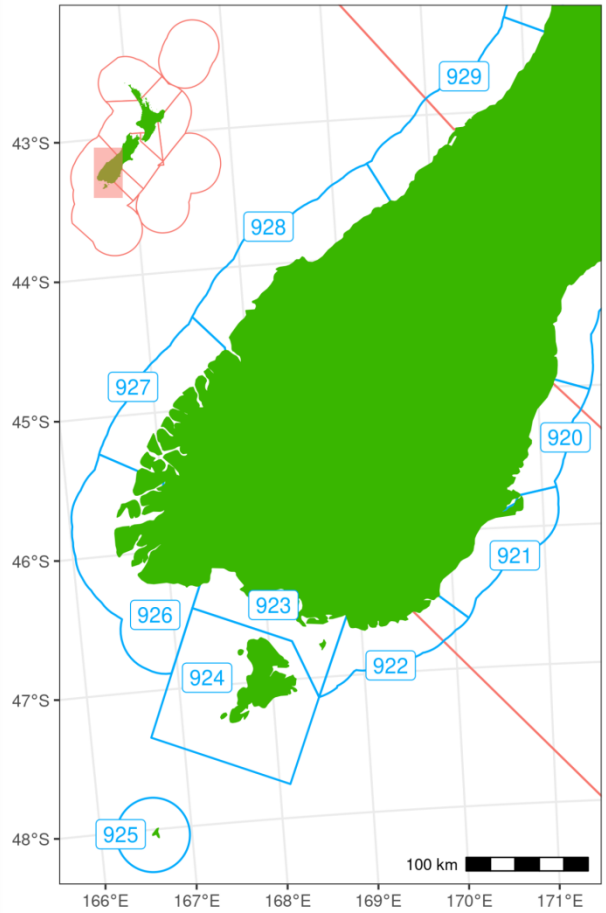

Figure 36: The CRA 7 and CRA 8 Quota Management Area (QMA) boundaries (solid red lines) and statistical area boundaries (solid blue lines).

The combined CRA 7 and CRA 8 (CRA 7&8) stock assessment was done in 2021 as a two-region model: region 1 included CRA 7 along with the four CRA 8 Southland, Stewart Island, and Snares Islands statistical areas (920, 921, 922, 923, 924, and 925); and region 2 which comprised the three Fiordland statistical areas (926, 927, and 928) (Starr et al. 2022). The model was fitted to standardised CPUE indices, LF data, sex ratio data, and tag-recapture growth increment data. The model assumed no movement between the two regions, estimated the same growth in both regions by sex (male and female), vulnerability by region, sex (male, immature female, and mature female), and season (AW and SS), and selectivity by sex (male and female) and region. Recruitment to the Fiordland region was estimated by the base case assessment to be above average in most years since 2010–11, and slightly below average in region 1 for the same period. The SSB and adjusted vulnerable biomass decreased steadily until 1990–91, followed by a period of stability at low levels (with the adjusted vulnerable biomass well below B_R and the SSB below the soft limit) up to about 2000–01. Since then, stock size has increased, with the SSB in both regions estimated to be above the soft limit by the 2021 stock assessment (Webber et al. 2022).

The 2023 rapid update for CRA 7&8 added two years of data, including: updated catch to 2022–23 (Table 21), LF data for 2021–22 and 2022–23 for both regions, and additional tag recovery data up to 2022–23. In comparison with the assessment in 2021, it also included LF data for 2019–20 and 2020–

21 for region 1 (statistical areas 920, 921, 922, 923, 924, and 925) because the LF data from these fishing years in this region had been inadvertently left out of the data used in the full stock assessment. Even though additional years of data were included in the 2023 rapid update, no data re-weighting was done relative to the last full stock assessment in 2021.

Table 21: Comparison of recent combined CRA 7&8 catch (tonnes) for the 2021 stock assessment and the following rapid updates. The table shows the last five fishing years and the five projection years in the 2021 base case model (starting in 2016–17), compared with catch for 2016–17 onwards for the 2022 and 2023 rapid updates. All projection years for the 2021 stock assessment are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2021/base												
2016–17	577.87	481.66	1 059.53	4.33	38.97	43.30	1.60	14.40	16.00	16.93	14.11	31.04
2017–18	661.61	412.97	1 074.58	4.33	38.98	43.31	1.60	14.40	16.00	22.34	13.94	36.28
2018–19	658.20	509.35	1 167.55	4.34	38.98	43.32	1.60	14.40	16.00	22.39	17.32	39.71
2019–20	744.31	367.71	1 112.02	4.33	38.98	43.31	1.60	14.40	16.00	23.88	11.80	35.68
2020–21	806.84	602.84	1 409.68	4.33	38.98	43.31	1.60	14.40	16.00	20.42	15.26	35.68
2021–22	742.86	555.03	1 297.89	4.33	38.98	43.31	1.60	14.40	16.00	20.42	15.26	35.68
2022–23	742.86	555.03	1 297.89	4.33	38.98	43.31	1.60	14.40	16.00	20.42	15.26	35.68
2023–24	742.86	555.03	1 297.89	4.33	38.98	43.31	1.60	14.40	16.00	20.42	15.26	35.68
2024–25	742.86	555.03	1 297.89	4.33	38.98	43.31	1.60	14.40	16.00	20.42	15.26	35.68
2025–26	742.86	555.03	1 297.89	4.33	38.98	43.31	1.60	14.40	16.00	20.42	15.26	35.68
2022/base												
2016–17	569.44	490.10	1 059.53	4.31	38.82	43.13	1.60	14.40	16.00	16.59	14.28	30.86
2017–18	645.16	429.43	1 074.59	4.31	38.82	43.13	1.60	14.40	16.00	21.67	14.43	36.10
2018–19	646.76	520.79	1 167.56	4.31	38.82	43.13	1.60	14.40	16.00	21.88	17.62	39.50
2019–20	735.11	376.90	1 112.02	4.31	38.82	43.13	1.60	14.40	16.00	22.04	11.30	33.33
2020–21	779.11	630.57	1 409.68	4.31	38.82	43.13	1.60	14.40	16.00	18.42	14.91	33.33
2021–22	858.25	439.09	1 297.34	4.31	38.82	43.13	1.60	14.40	16.00	22.05	11.28	33.33
2023/base												
2016–17	569.34	490.19	1059.53	4.31	38.82	43.13	1.60	14.40	16.00	17.94	15.45	33.39
2017–18	644.95	429.63	1074.59	4.31	38.82	43.13	1.60	14.40	16.00	19.71	13.13	32.83
2018–19	646.92	520.64	1167.56	4.31	38.82	43.13	1.60	14.40	16.00	23.82	19.17	42.99
2019–20	736.55	375.47	1112.02	4.31	38.82	43.13	1.60	14.40	16.00	22.88	11.67	34.55
2020–21	777.74	631.95	1409.68	4.31	38.82	43.13	1.60	14.40	16.00	19.06	15.49	34.55
2021–22	858.53	439.28	1297.82	4.31	38.82	43.13	1.60	14.40	16.00	22.86	11.69	34.55
2022–23	836.57	526.74	1363.31	4.31	38.82	43.13	1.60	14.40	16.00	21.20	13.35	34.55

MCMC trace plots for the 2023 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure A.7 for MCMC diagnostic plots).

The 2023 rapid update fit to the CPUE was very similar to the fit in the 2021 assessment with only minor differences in the last two to three years for region 1 where the estimated CPUE was slightly lower than that estimated in 2021 (Figure 37). The fits to the LFs were very similar to the 2021 stock assessment, to that of the 2022 rapid update for the years that overlapped and with a reasonable fit to the 2022–23 LFs (Figure 38).

The 2023 rapid update region 1 average estimated recruitment was similar to that estimated by the 2021 assessment and the 2022 rapid update (Figure 39). For region 2, a recruitment peak was estimated by the 2023 rapid update in 2016–17 which was not present in the 2021 assessment nor in the 2022 rapid update but which could be a shift forward of the above average recruitment estimated for 2015–16 by the two earlier assessments (Figure 39). Supporting that hypothesis is the observation that the average recruitment by all three assessments were nearly the same. The combined adjusted vulnerable biomass and combined SSB estimated by the 2023 rapid update were greater at the beginning of 2023–24 than was projected by the 2021 stock assessment (Figure 40, Figure 41). Similarly, the beginning year 2022–

23 combined adjusted vulnerable biomass and combined SSB were estimated by the 2023 rapid update to be higher than that estimated by the 2021 stock assessment and the 2022 rapid update. This relative increase in biomass will have been caused by growth because there is little difference in the recruitment estimates made by the three assessments.

The vulnerable biomass reference levels estimated during the 2021 full assessment were rejected by the RLWG in 2023 because attempts to derive a separate B_R for region 1 and region 2 were unsuccessful. Therefore, stock status indicators for CRA 7&8 using the default Fisheries New Zealand Harvest Strategy Standards of 40% SSB_0 target biomass, 20% SSB_0 soft limit, and 10% SSB_0 hard limit were adopted by the Plenary meeting as interim reference points to be used until the next full stock assessment. The 2023 rapid update estimated that, based on the posterior median values, the overall (i.e., region 1 and region 2 combined) stock at the beginning of 2023–24 was 25% of B_0 and 54% of SSB_0. Fishing mortality was estimated to be below F_{MSY} for both regions at the beginning of 2023–24 (Table 22). The probability of SSB being above 40% SSB_0 and above the soft and hard limits in 2023–24 was 1.0.

All parameter estimates were similar to the 2021 stock assessment and 2022 rapid update (Table 23).

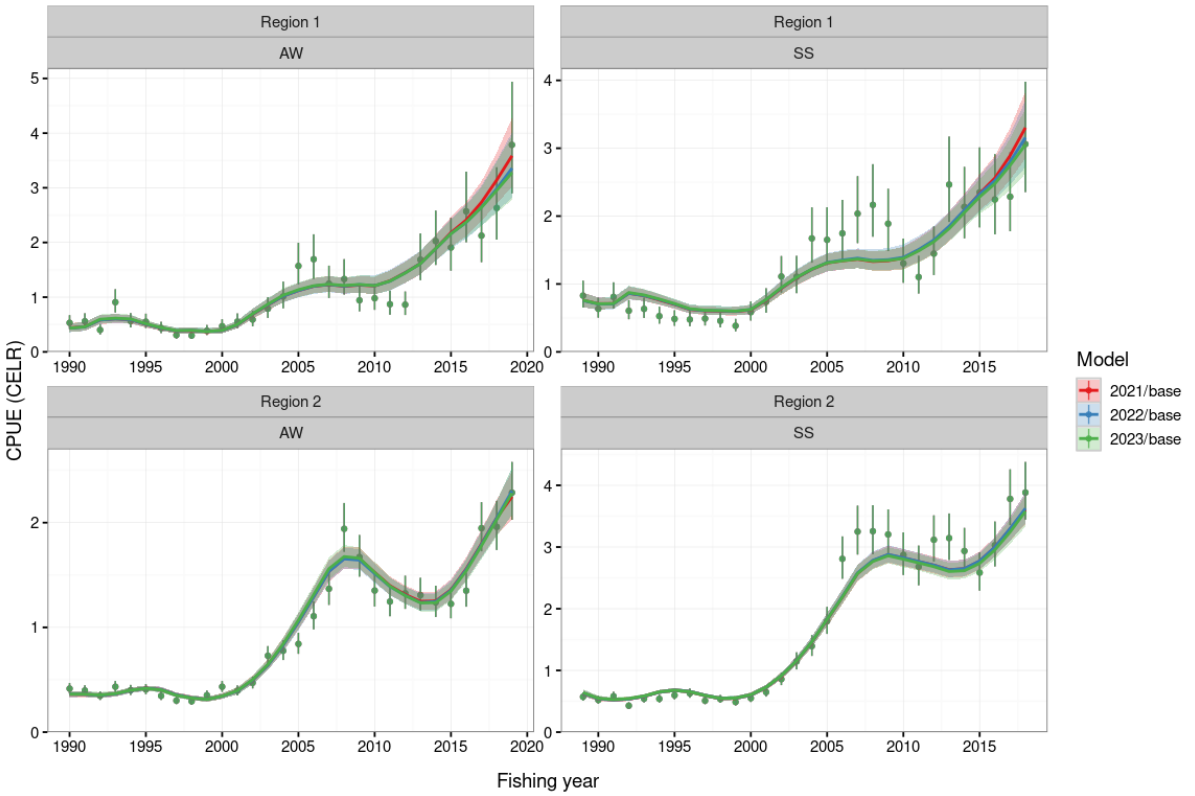

Figure 37: CRA 7&8 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2021 stock assessment and the 2022 and 2023 rapid updates.

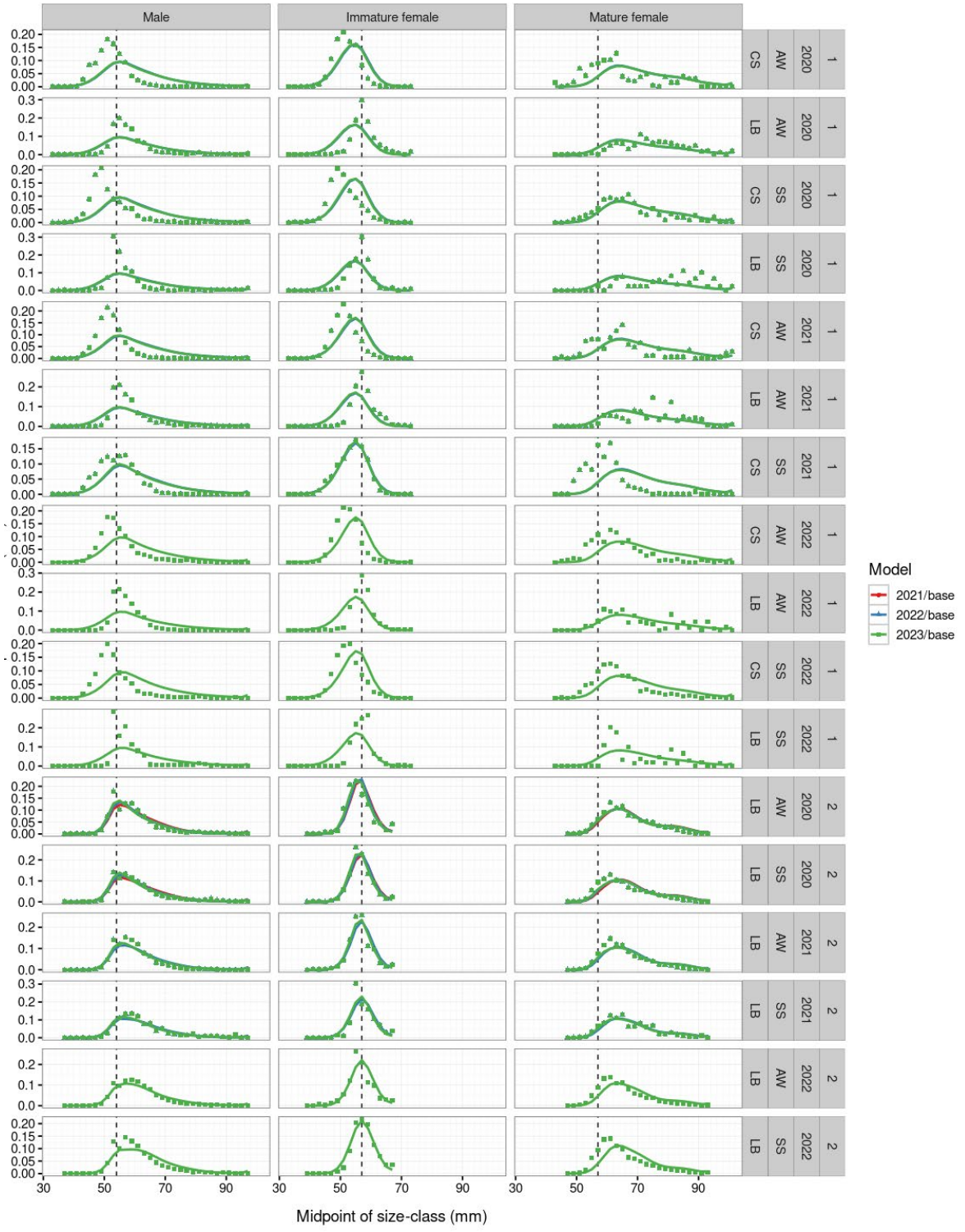

Figure 38: 2020–2022 CRA 7&8 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2021 stock assessment and the 2022 and 2023 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes.

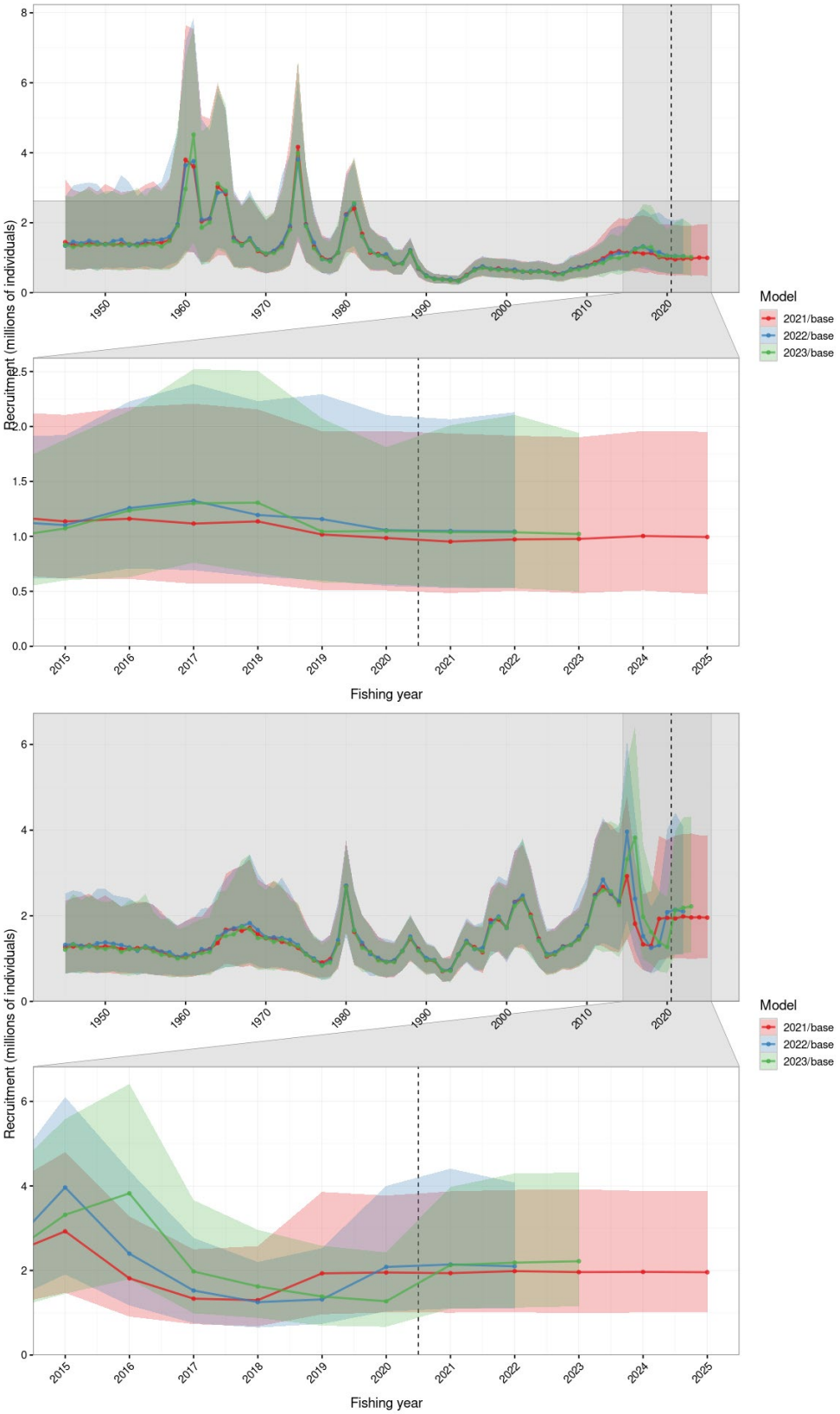

Figure 39: Region 1 (upper panels) and region 2 (lower panels). CRA 7&8 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2021 stock assessment (showing the five projected years) and the 2022 and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2021 stock assessment. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

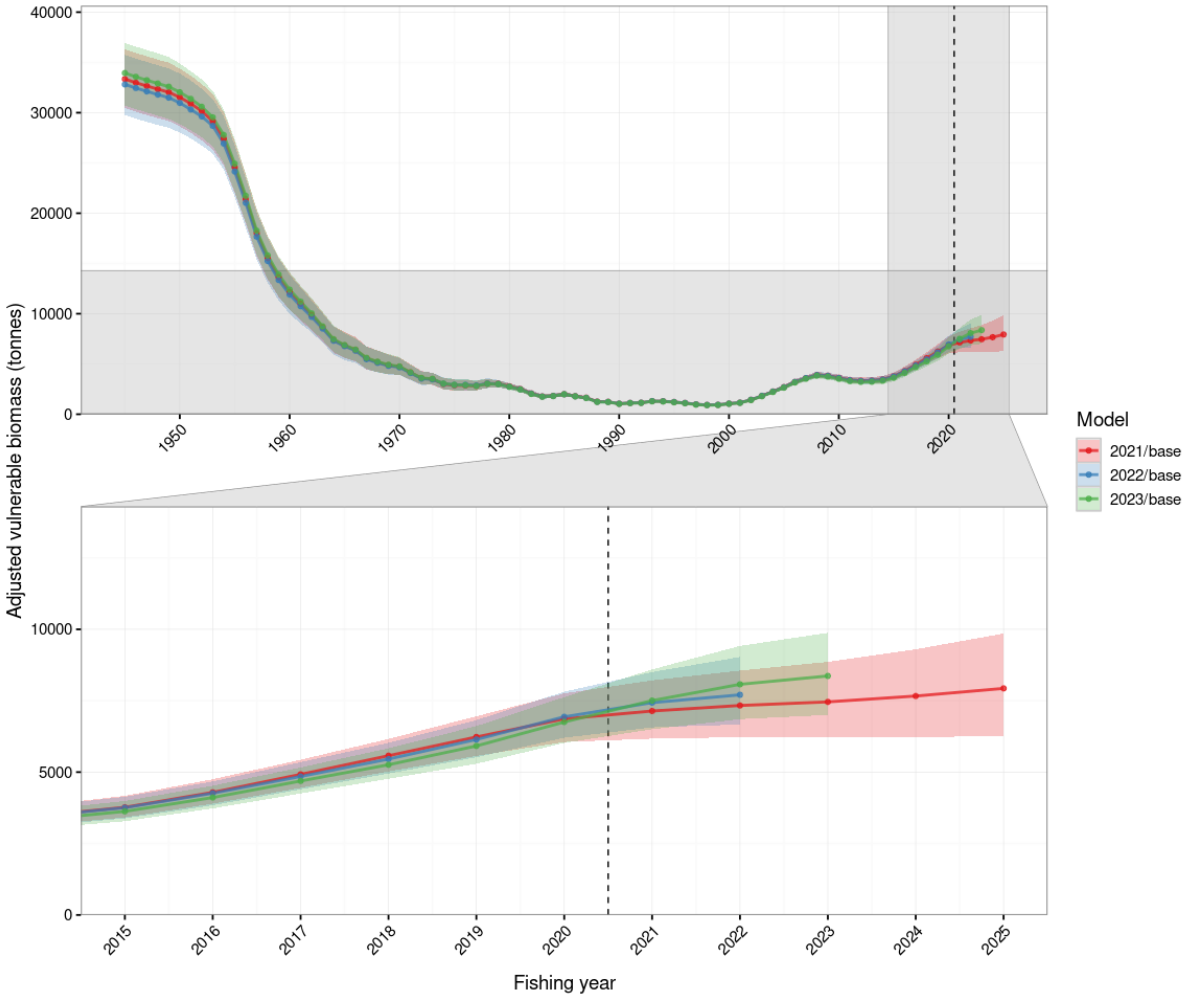

Figure 40: CRA 7&8 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2021 stock assessment (showing the five projected years) and the 2022 and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2021 stock assessment. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. Note: there is no reference level because it was rejected by the 2023 Plenary meeting.

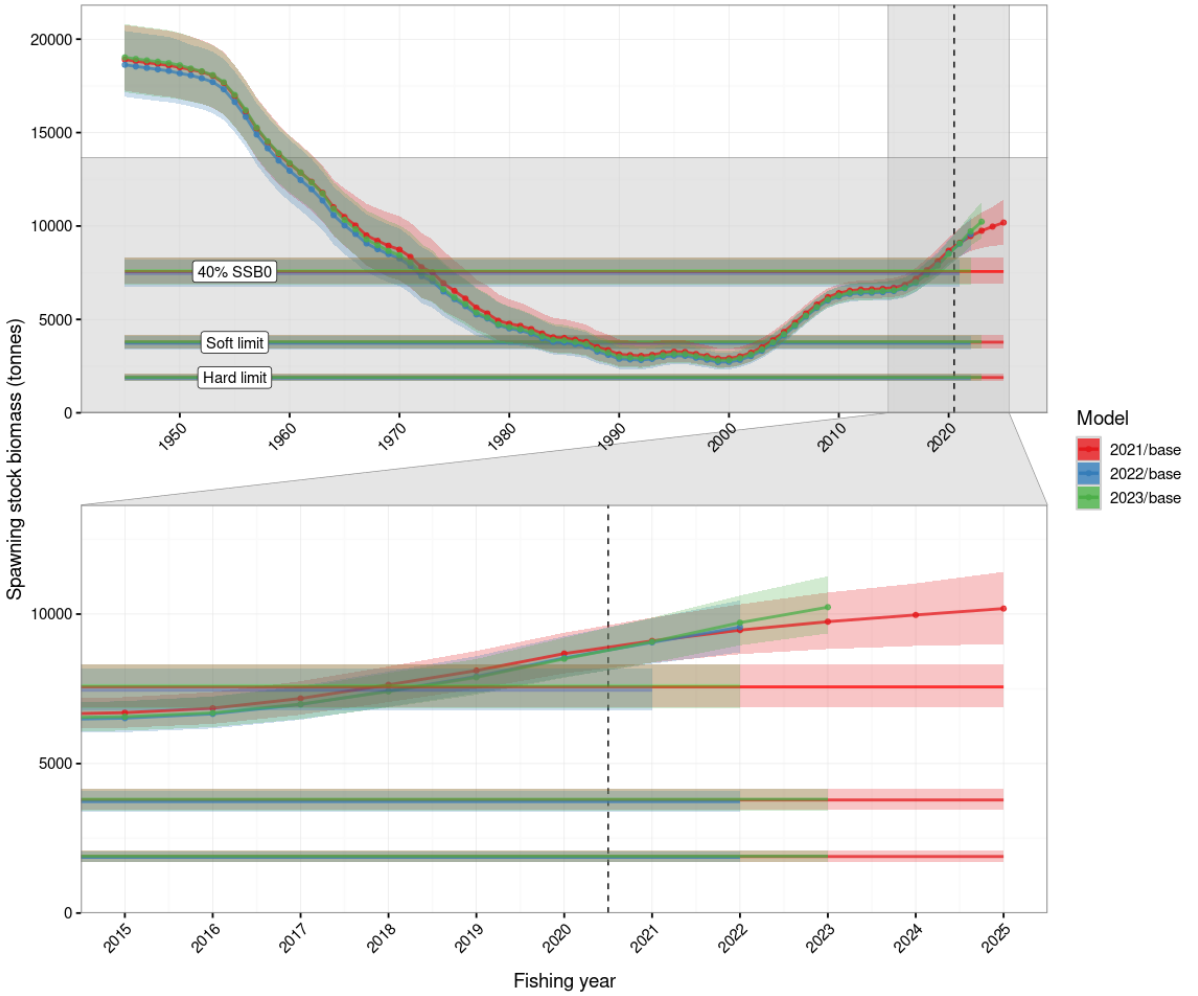

Figure 41: CRA 7&8 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2021 stock assessment (showing the five projected years) and the 2022 and 2023 rapid updates (showing one projected year). The vertical dashed line indicates the transition between the final model year and the five projected years for the 2021 stock assessment. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. The horizontal lines and shaded regions represent 40% of SSB_0 (top horizontal line and shaded region), the soft limit (middle horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region).

Table 22: CRA 7&8 rapid update indicators for region 1 and region 2 combined (except for *F* and *H* where values by region are presented) summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
B_0	33 838	30 724	33 942	36 946
B_R	4 863	–	–	–
B_{2023}	8 392	7 003	8 367	9 877
B_{2023} / B_0	0.249	0.202	0.248	0.297
B_{2023} / B_R	1.726	1.440	1.720	2.031
P($B_{2023} > B_R$)	1.000	–	–	–
SSB_0	19 004	17 161	19 026	20 805
SSB_{2023}	10 267	9 353	10 232	11 266
SSB_{2023} / SSB_0	0.541	0.490	0.540	0.595
P($SSB_{2023} > 40\%\ SSB_0$)	1.000	–	–	–
P($SSB_{2023} > 20\%\ SSB_0$)	1.000	–	–	–
P($SSB_{2023} > 10\%\ SSB_0$)	1.000	–	–	–
F_{MSY} [region 1]	0.128	0.094	0.124	0.169
F_{MSY} [region 2]	0.338	0.267	0.336	0.418
F_{2023} / F_{MSY} [region 1]	0.990	0.847	0.990	1.129
F_{2023} / F_{MSY} [region 2]	0.535	0.455	0.529	0.628
H_{2022} [region 1]	17.725	15.275	17.602	20.813
H_{2022} [region 2]	72.215	66.222	71.974	78.919

Table 23: CRA 7&8 MCMC outputs, reporting the 5%, 50% (median), and 95% quantiles of the posterior distribution of parameter estimates for the 2021 full assessment and the 2022 and 2023 rapid updates. These values are by region where appropriate (regional values denoted by [1] and [2], where [1] = statistical areas 920 to 925 and [2] = statistical areas 926, 927, and 928), by sex and season (SS and AW). Growth increment values in mm TW and R_0 in numbers. M = male, IF = immature female, and MF = mature female.

	2021 base			2022 rapid update			2023 rapid update		
	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters									
R_0[1]	1091411	1218670	1372672	1101081	1239970	1420268	1078907	1191400	1328912
R_0[2]	1280379	1444830	1615812	1294541	1484645	1666654	1282328	1438755	1593110
M	0.085	0.093	0.102	0.086	0.095	0.106	0.084	0.092	0.100
mat50	59.319	59.937	60.662	59.350	60.026	60.735	59.410	60.035	60.722
mat95	8.520	9.527	10.806	8.533	9.475	10.840	8.673	9.592	10.728
Galpha [male]	4.358	4.423	4.496	4.351	4.421	4.493	4.403	4.473	4.550
Gbeta [male]	2.584	2.798	3.025	2.579	2.798	3.035	2.528	2.733	2.930
Gshape [male]	1.475	1.913	3.760	1.497	1.915	2.371	1.517	1.927	2.293
GCV [male]	0.411	0.427	0.444	0.413	0.429	0.445	0.409	0.425	0.441
Galpha [female]	3.788	3.846	3.909	3.784	3.849	3.915	3.709	3.779	3.839
Gbeta [female]	1.553	1.602	1.656	1.559	1.608	1.663	1.532	1.579	1.631
Gshape [female]	3.279	3.507	3.760	3.292	3.531	3.818	3.380	3.683	3.945
GCV [female]	0.357	0.376	0.395	0.357	0.375	0.395	0.361	0.379	0.399
Gobs	1.293	1.316	1.340	1.291	1.315	1.340	1.288	1.311	1.332
vuln (M, SS & IF, AW) [1]	0.785	0.861	0.934	0.779	0.860	0.931	0.763	0.844	0.916
vuln (IF, SS) [1]	0.692	0.833	0.959	0.680	0.829	0.972	0.667	0.802	0.935
vuln (MF, AW) [1]	0.033	0.043	0.056	0.038	0.048	0.062	0.035	0.045	0.057
vuln (MF, SS) [1]	0.055	0.075	0.099	0.063	0.083	0.107	0.060	0.079	0.100
vuln (M, SS) [2]	0.747	0.787	0.836	0.744	0.789	0.840	0.742	0.787	0.836
vuln (IF, AW) [2]	0.466	0.543	0.628	0.454	0.518	0.605	0.432	0.493	0.568
vuln (IF, SS) [2]	0.357	0.421	0.496	0.342	0.407	0.480	0.329	0.386	0.456
vuln (MF, AW) [2]	0.716	0.800	0.899	0.711	0.804	0.910	0.689	0.771	0.866
vuln (MF, SS) [2]	0.646	0.714	0.796	0.650	0.724	0.811	0.622	0.690	0.782
selL male [1]	7.022	7.893	8.922	6.904	7.684	8.562	6.869	7.711	8.656
selL female [1]	7.396	8.243	9.150	7.297	8.164	9.213	7.342	8.168	9.266
selL male [2]	3.764	4.062	4.418	3.740	4.057	4.426	3.735	4.094	4.397
selL female [2]	4.389	4.807	5.272	4.411	4.795	5.233	4.423	4.815	5.259
selM male [1]	56.439	57.901	59.555	56.193	57.543	58.807	56.110	57.510	58.936
selM female [1]	57.192	58.465	59.744	57.011	58.265	59.769	57.028	58.329	59.810
selM male [2]	54.688	55.172	55.727	54.685	55.196	55.811	54.723	55.300	55.820
selM female [2]	56.816	57.525	58.292	56.835	57.488	58.210	56.880	57.490	58.173

4. DISCUSSION

Fisheries New Zealand implemented an electronic catch and effort reporting system for the rock lobster potting fishery between April and September 2019. Preliminary evaluations of the lobster catch and effort data collected using the new system found substantial changes in the nature of the data, indicating that comparability with the previous paper-based data collection system has likely been lost (see appendix B of Starr 2021). Subsequent evaluations at the end of the 2020–21, 2021–22, and 2022–23 fishing years have confirmed this conclusion. Consequently, it is likely that these changes to the collection of the catch and effort data will require the development of new evaluation procedures that accommodate changes in reporting fidelity.

Rapid updates provide an annual update of stock status for the rock lobster stocks which have already been formally assessed, for CRA 1, CRA 2, CRA 3, CRA 4, CRA 5, and CRA 7&8. This provides a framework for managing these stocks that will be responsive to annual changes, much as the previous MPs were. However, CPUE based on commercial catch and effort data may not be available for the next few years for most stocks, except for CRA 2 where an alternative CPUE series based on catch and effort from logbook data has been developed (Webber & Starr 2022). This information was included in this year's CRA 2 rapid update. Sufficient logbook data for developing CPUE are potentially available for CRA 5 and CRA 8 (Webber & Starr 2022), but they need to be evaluated in the context of a full stock assessment. In the meantime, the standard data sources (i.e., catch, LF, sex ratio, and tag recapture data) will be available to inform future rapid update assessments.

The rapid update system was designed to replace MPs in the short term and to help bridge the gap in knowledge while there is no reliable recent CPUE series. However, the system is likely to be useful even after the situation with CPUE has been resolved. For example, the previous MPs used offset-year CPUE as the only input to determine the Total Allowable Commercial Catch (TACC) for the next year. Instead, the rapid update system, based on the agreed-upon base case model for each QMA and incorporating all the available data, could become the input to a more broadly defined MP that could determine the Total Allowable Catch or TACC for the following year. In this way, all data types (e.g., LFs, tags, and CPUE when available) will drive the new system, which could result in more stable MPs.

To confirm that the rapid update framework can indeed predict stock status in the absence of an ERS CPUE series for more recent years, simulation studies or retrospective analysis of rock lobster stock assessments can be used. Simulation studies require a simulation model be developed, which can be a large task. Retrospective analyses, on the other hand, do not require a large amount of additional work and it has been already done for CRA 2 and CRA 4, showing no systematic biases when missing 3–5 years of CPUE data (Pons et al. 2022). However, rapid updates in 2023 will be reaching the point where the effect of missing three or more years of CPUE data may have an appreciable impact on the reliability of stock status estimates.

Except for CRA 2, all projections based on the rapid update recruitment estimates have been omitted from this document because they were rejected by the 2022 Plenary meeting for reasons given in the Introduction to this report.

5. POTENTIAL RESEARCH

Future research considerations for rapid assessment updates include:

- Construct performance criteria to identify changes in parameter estimates and model fits between the full assessment and the rapid update.
- Develop better diagnostics for specific model outcomes (e.g., interpreting productivity changes), particularly when CPUE is unavailable.
- Develop diagnostic procedures such as likelihood profiles to improve the understanding of contributions by model components.

- Explore how recent recruitment is informed in rapid updates (e.g., using likelihood profiles) and determine the range of years for which recruitment should be estimated in rock lobster stock assessment models.

6. FULFILLMENT OF BROADER OUTCOMES

Whakapapa links all people back to the land, sea, and sky, and our obligations to respect the physical world. This research aims to ensure the long-term sustainability of red rock lobster stocks, for the good of the wider community (including stakeholders and the public) and the marine ecosystems that lobsters inhabit. This project supports both Māori and regional businesses, and our research is inextricably linked to the moana from the work it carries out and the tangata whenua it supports.

To support the wider fisheries science community and enable more value to be extracted from the limited resources (time and money) available for fisheries research, we make as much code as possible open source (i.e., publicly available). Furthermore, this project has built capacity and capability in fisheries science and stock assessment by employing researchers with a range of experience so that those with a long history of working in fisheries science can pass on their knowledge. This approach has meant that rock lobster stock assessments have consisted of a team with some members that have been involved for many years and some newer team members. This approach further mitigates risk associated with team members not being able to participate any longer.

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APPENDIX A. MCMC DIAGNOSTICS

This appendix presents the MCMC trace plots for the CRA 1 (Figure A.1), CRA 2 (Figure A.2), CRA 3 (***r1_qdrift*:** Figure A.3, ***r2_qdrift*:** Figure A.4), CRA 4 (Figure A.5), CRA 5 (Figure A.6), and CRA 7&8 (Figure A.7) rapid updates.

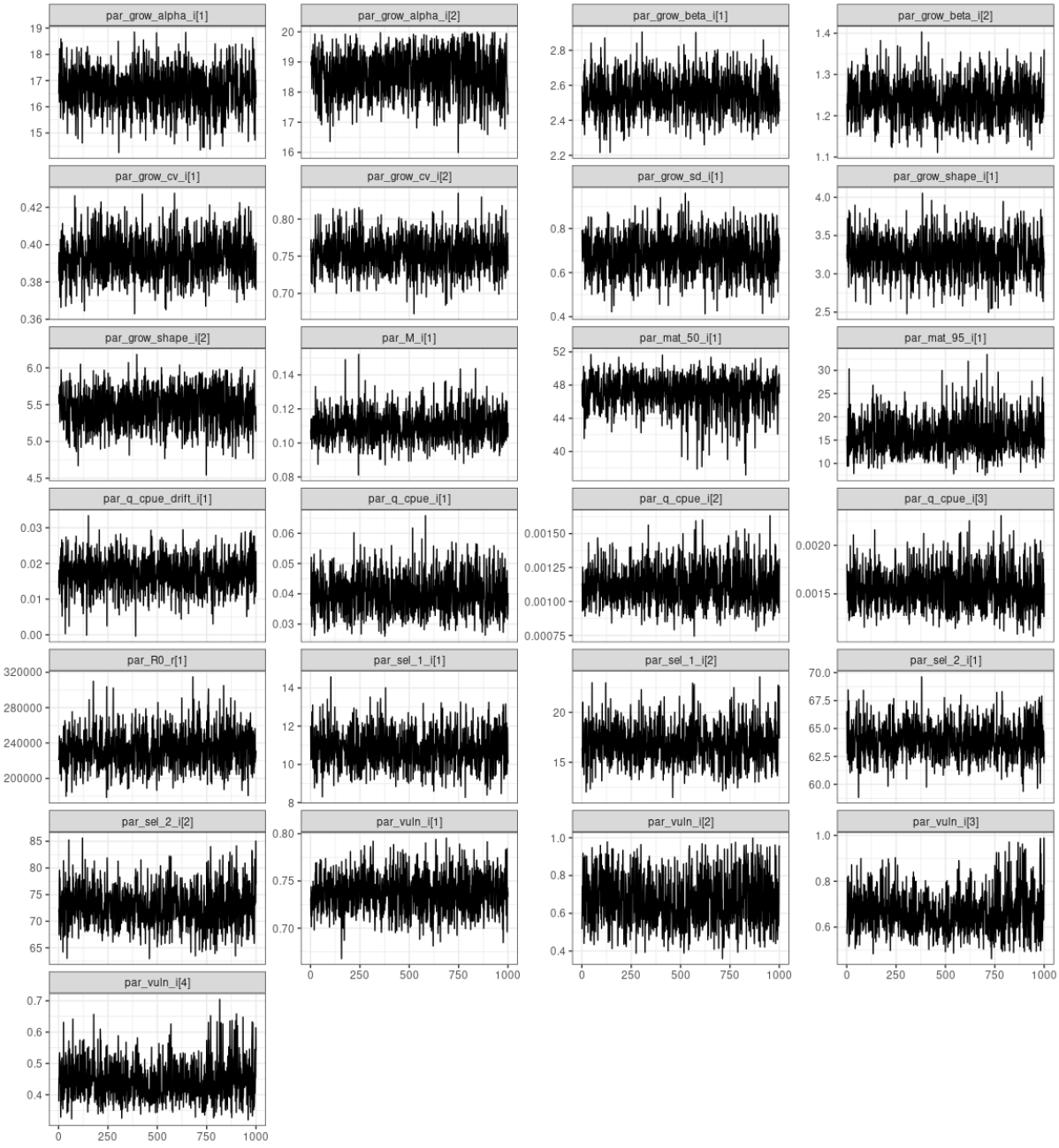

Figure A.1: MCMC trace plots for model parameters in the CRA 1 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

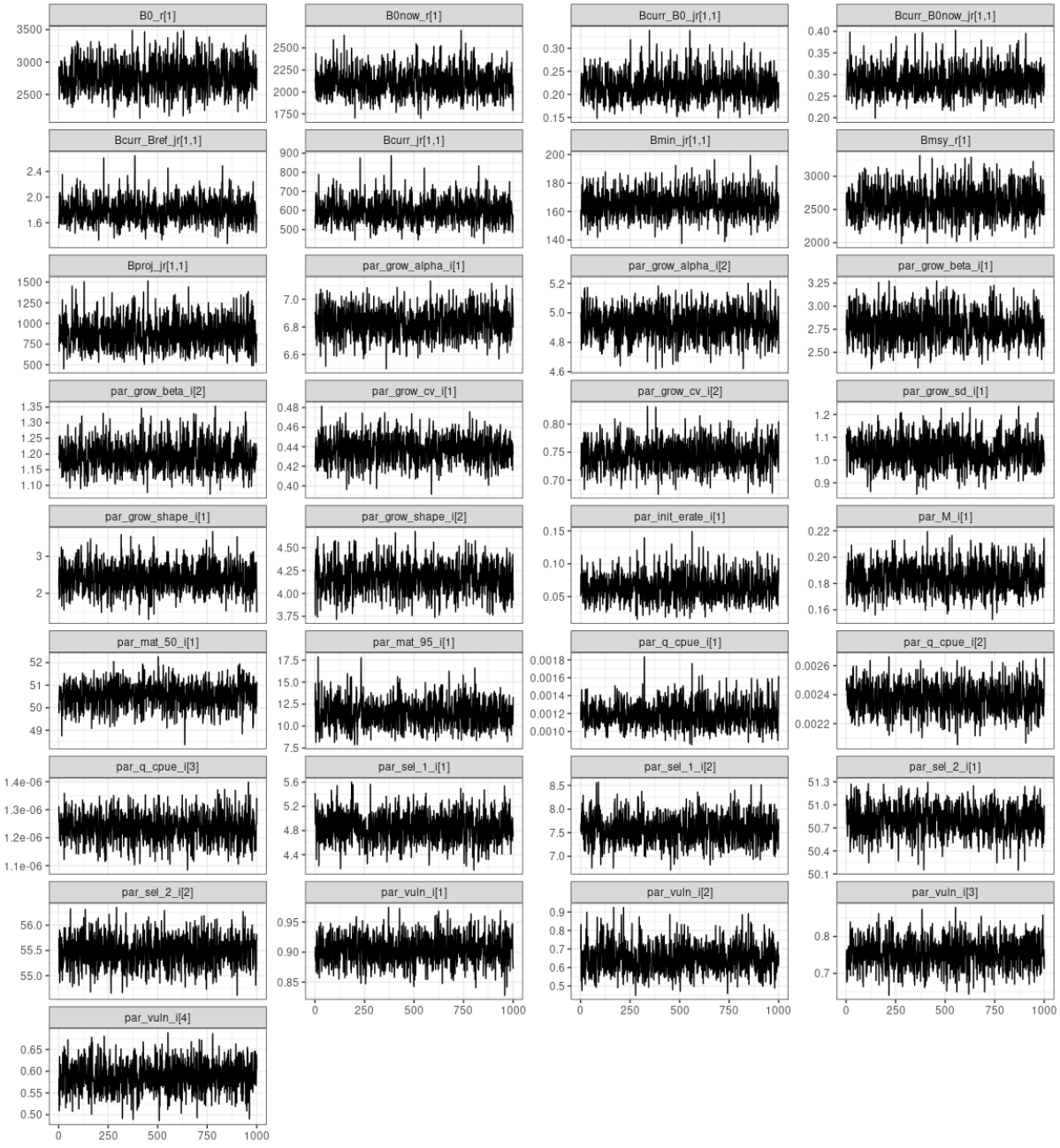

Figure A.2: MCMC trace plots for model parameters in the CRA 2 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

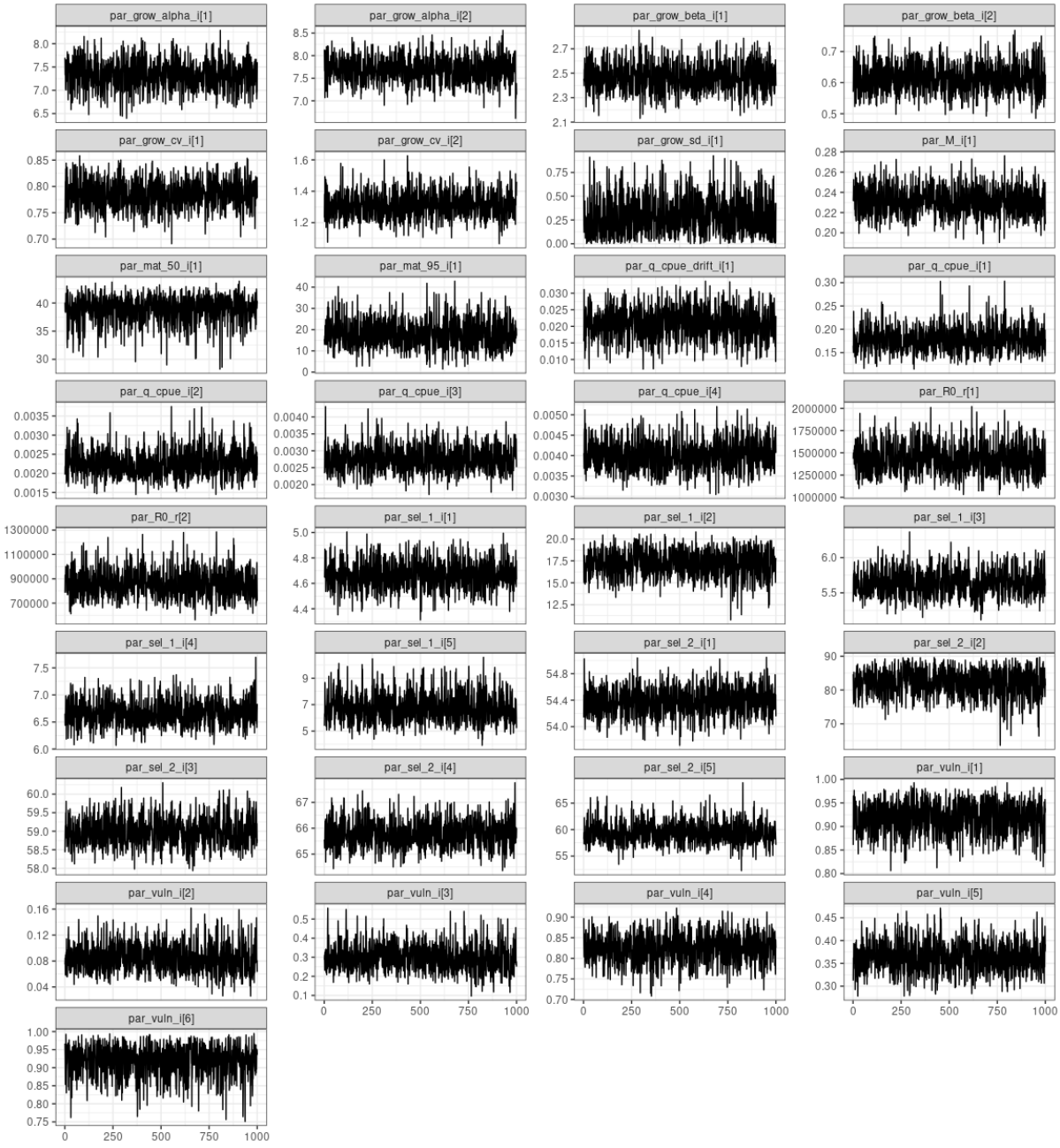

Figure A.3: MCMC trace plots for model parameters in the *r1_qdrift* CRA 3 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

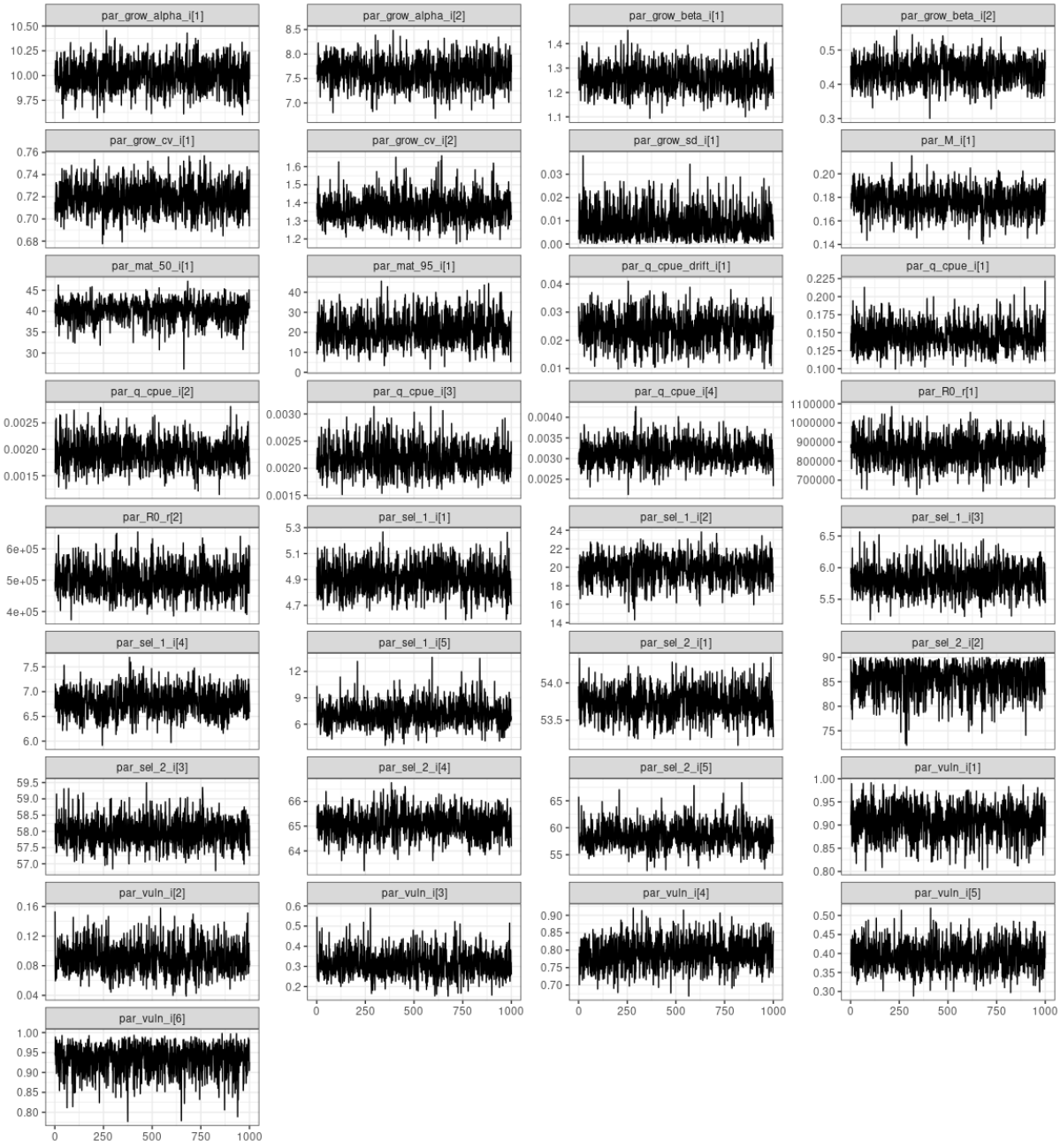

Figure A.4: MCMC trace plots for model parameters in the *r2_qdrift* CRA 3 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

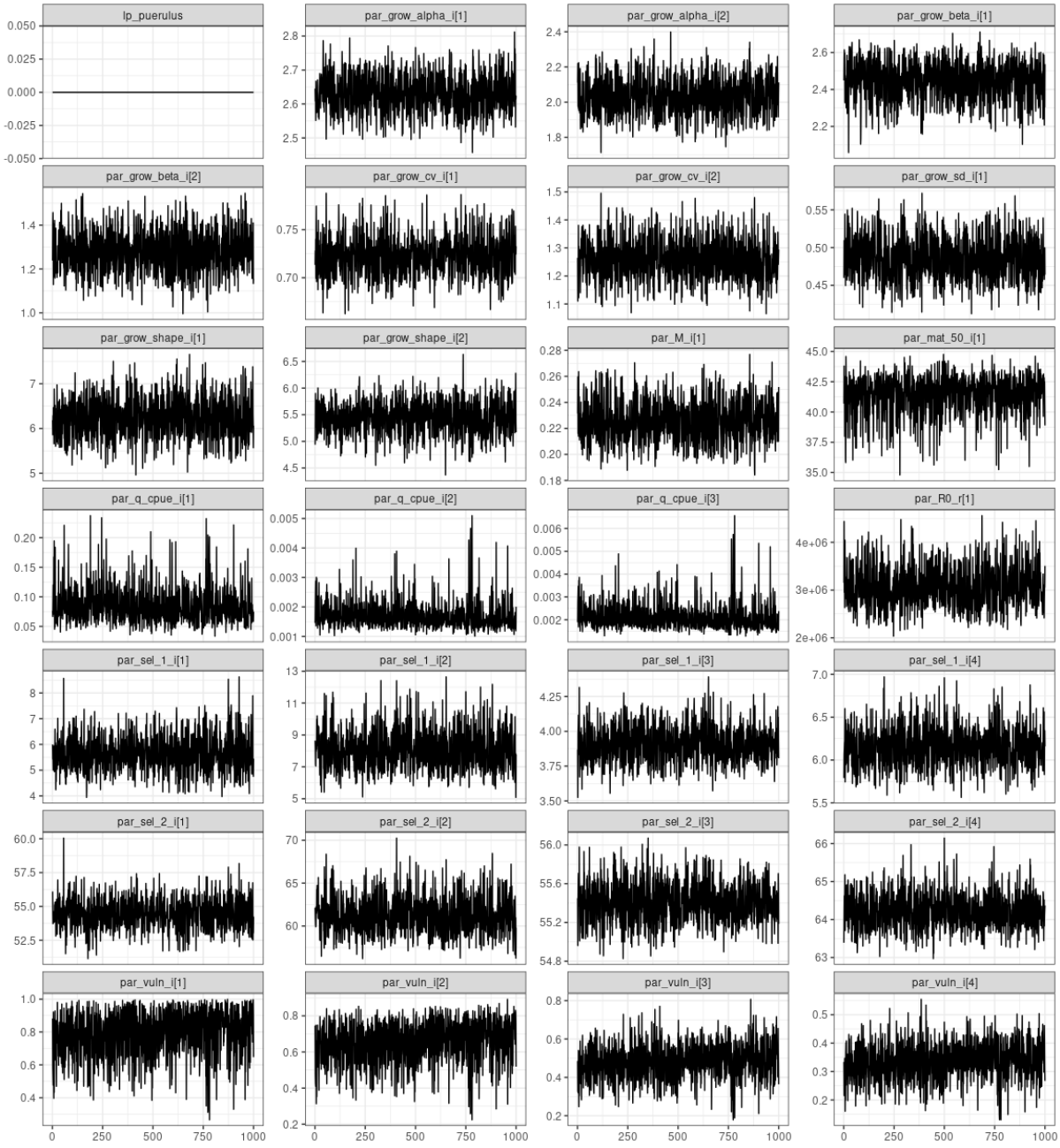

Figure A.5: MCMC trace plots for model parameters in the CRA 4 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

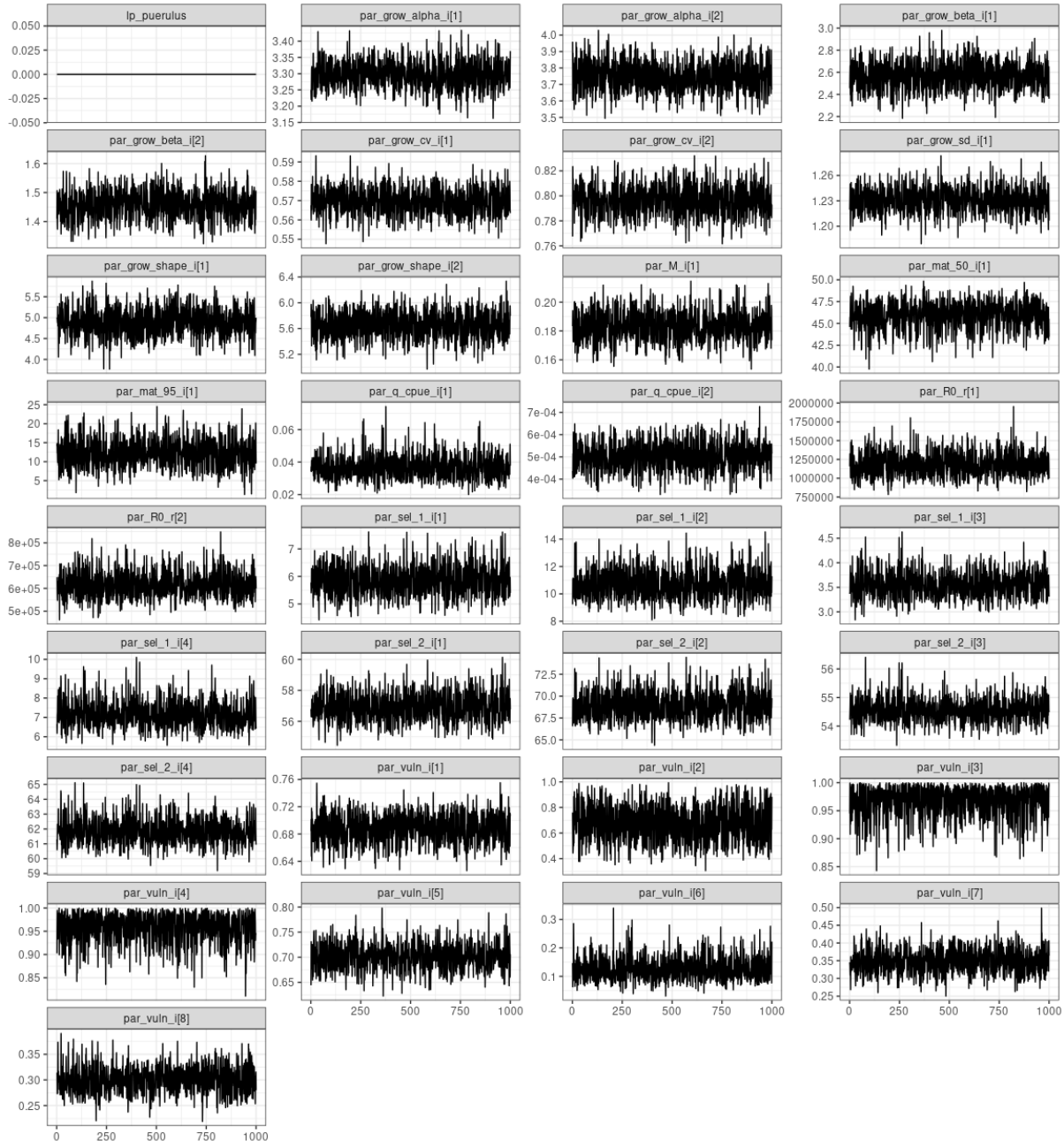

Figure A.6: MCMC trace plots for model parameters in the CRA 5 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

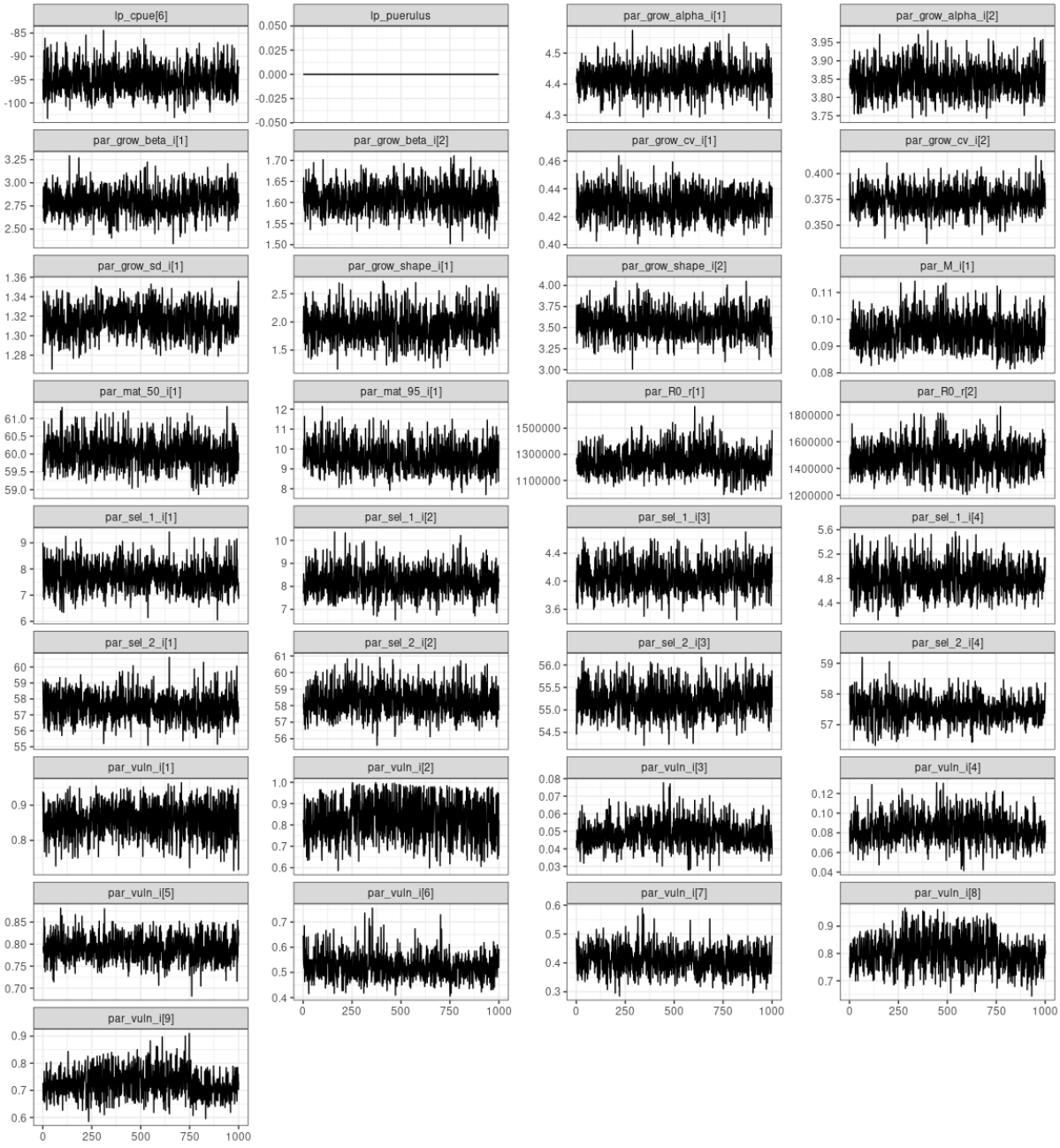

Figure A.7: MCMC trace plots for model parameters in the CRA 7&8 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).