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Rapid updates for New Zealand rock lobster (*Jasus edwardsii*) stocks in 2022

New Zealand Fisheries Assessment Report 2023/12

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Pons, M.[1]; Rudd, M.B.[2]; Webber, D.N.[3]; Starr, P.J.[1]; Roberts, J.[4]; Goeden, Z.[1] (2023). Rapid updates for New Zealand rock lobster (*Jasus edwardsii*) stocks in 2022.

***New Zealand Fisheries Assessment Report 2023/12*. 68 p.**

This document describes the operation of stock assessment rapid updates completed in October 2022 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, and only update inputs with new covariates and data (e.g., additional years of catch, length frequencies, sex ratios, and tag-recapture 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 the rapid update stock assessments for five rock lobster stocks: CRA 1, 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 2 was not included because it received a full stock assessment in 2022. The assessment for CRA 6 has not been incorporated into the rapid update system due to time constraints.

For 2022–23, the adjusted vulnerable biomass for all stocks were estimated to be above the reference level (B_R). It was 2% above B_R for CRA 1, 34–45% for CRA 3 (with range representing the two base models), 32% for CRA 4, almost three times B_R for CRA 5, and 1.6 times for CRA 7&8. For all stocks, the probability of the spawning stock biomass (*SSB*) being above the soft and hard limits in 2022–23 was 1.

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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 NZ$300 million in 2019 (Seafood New Zealand 2020) and it is also valuable to customary Māori, recreational fishers, and non-extractive stakeholders. Commercial 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).

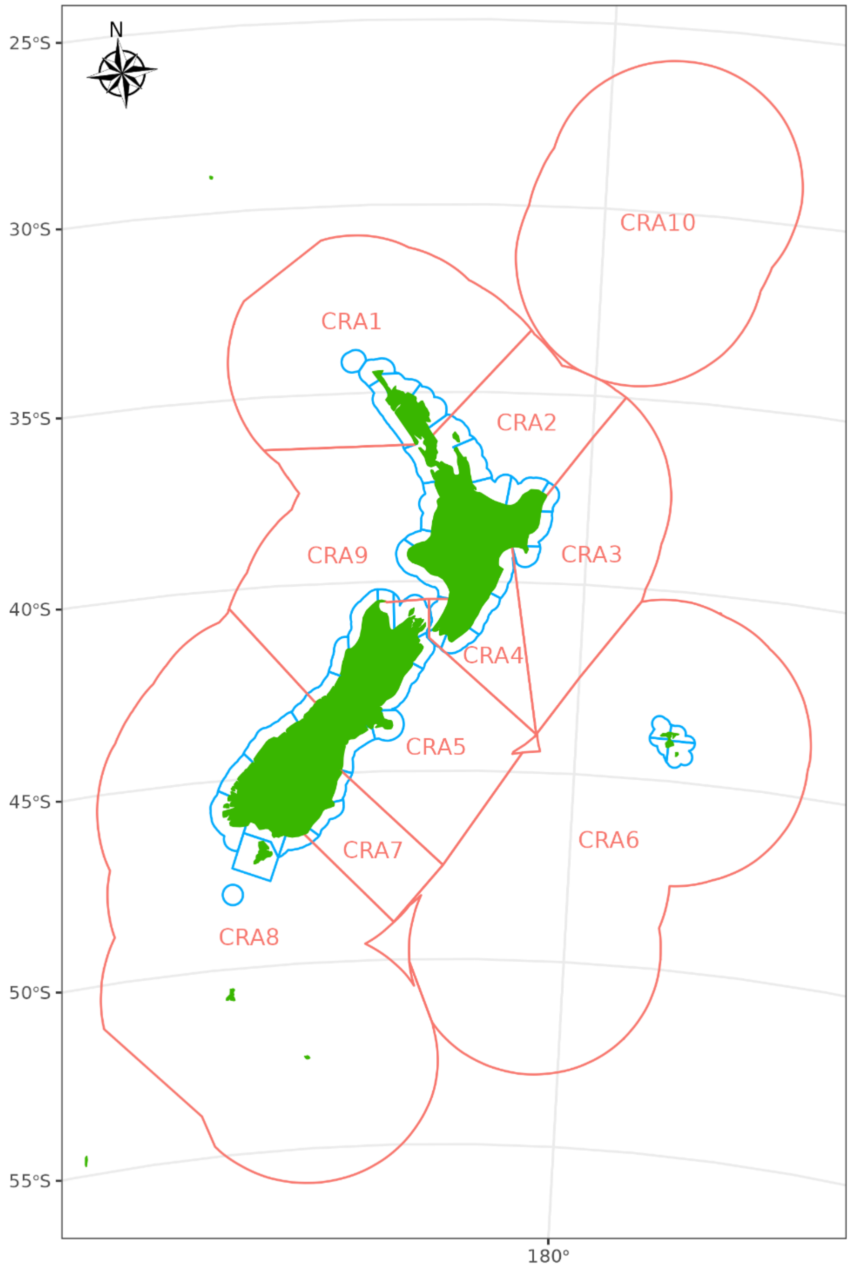


Figure 1: New Zealand red rock lobster (*Jasus edwardsii*) Quota Management Areas (QMAs) in red and statistical areas in blue. CRA 10 is not fished commercially.

Full stock assessments for eight of the nine rock lobster QMAs (i.e., all except CRA 9, which is currently seen as data deficient for stock assessment) are usually 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 many sensitivities to key model assumptions. The last few rock lobster 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 (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, also 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 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 the collection of rock lobster catch and effort data 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 in 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 twice by the RLWG (to the end of 2020–21 and 2021–22) without observing any reason to change the initial conclusion.

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 the estimates of female spawning stock biomass (SSB) 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 is based on the stock status estimates generated by these rapid updates in the years in between full stock assessments. 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 five stocks (CRA 1, 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) and then in 2021 to CRA 1, CRA 2, CRA 3, CRA 4, and CRA 5 (Rudd et al. 2022). Current plans are to continue this system into the future for all rock lobster stocks which are not the subject of a full stock assessment (because CRA 2 was subject to a full stock assessment in 2022, it did not receive rapid update assessment). The first full stock assessment for CRA 7&8 using the lobster stock dynamics (LSD) model was done in 2021 (Webber et al. 2022) and has been integrated into the rapid update system in 2022 for the first time. A stock assessment for CRA 6 was done using the LSD model in 2018 (Rudd et al. 2019) but has not been incorporated into the rapid update system due to time constraints. There is no accepted stock assessment for CRA 9 because of data limitations, so 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 May 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 May 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 May 2021. Calendar years are simply referred to as usual (e.g., 2020).

Rapid updates differ from a full stock assessment 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 catch per unit effort (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, 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 14581), observer catch sampling (replog 14506), and tag-recapture data (replog 14522). The voluntary logbook data extract came directly from FishServe (John Olver, July 2022). Although the CPUE series has been temporarily discontinued, catch and effort data were requested from Fisheries New Zealand (replog 14581) because these data were used to weight the LF data (e.g., see section 5 in 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, these series remained static for the 2022 rapid updates.

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 were assumed to be proportional to the SS abundance as reflected in the SS CPUE. As in 2021 (Rudd et al. 2022), the following steps were taken to scale recreational catch in CRA 1, 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 for sampled lobsters in the survey year. These mean weight estimates either came from direct sampling at recreational landing sites 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 variation for each survey to the SS CPUE in the same year (CRA 1, CRA 3, and CRA 4), b) a power function with two parameters to relate SS CPUE to the survey estimates (CRA 5), or c) constant (CRA 7&8).
3) The function described in step 2 and their estimated parameters were then applied to the SS CPUE for all years, beginning with 1979–80, to estimate the time series of recreational catch (CRA 1, CRA 3, CRA 4, and CRA 5).
4) Recreational catch in 1945–46 was assumed to be 20% of 1979–80 recreational catch and followed a linear trajectory from 1945–46 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, and 2021–22 SS CPUE indices were assumed to be the average of the 2016–17 to 2018–19 SS CPUE indices.

For assessments since 2006, the RLWG had also 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 1945–46.

The handling of illegal catch in these rapid updates reflected the changes in approach adopted by the RLWG over the past six years, evolving 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 commercial CPUE was unavailable for 2019–20, 2020–21, and 2021–22 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.

Table 1: Methods over applicable periods used for setting illegal catches in the five QMAs included in the 2022 rapid update system. This table uses calendar years from 1945 to 1978 and fishing years, designated with the first year of the pair, from 1979–80 to 2021–22.

QMA	Description	Reference
CRA 1	1945–1980: export discrepancy. 1981–82 to 2021–22: 20% of total commercial catch from this period scaled by annual CPUE. Assumed CPUE in 2019–20 to 2021–22 average of 2016–17 to 2018–19.	Starr et al. 2020a
CRA 3	1945–1980: export discrepancy. 1981–82 to 2021–22: 20% of total commercial catch from this period constant across years.	Starr et al. 2020b
CRA 4	1945–1989: 10% of total commercial catch from this period. 1990–91 to 2021–22: 5% of total commercial catch from this period. Scaled by annual CPUE from 1979 to 2018–19. Assumed CPUE in 2019–20 to 2021–22 average of 2016–17 to 2018–19.	Starr et al. 2021a
CRA 5	1945–1989: 10% of total commercial catch from this period. 1990–91 to 2021–22: 5% of total commercial catch from this period. Scaled by annual CPUE from 1979 to 2018–19. Assumed CPUE in 2019–20 to 2021–22 average of 2016–17 to 2018–19.	Starr et al. 2021b
CRA 7&8	1945–1989: 10% of total commercial catch from this period. 1990–91 to 2021–22: 2% of total commercial catch from this period. Scaled by annual CPUE from 1979 to 2018–19. Assumed CPUE in 2019–20 to 2021 average of 2016–17 to 2018–19.	Starr et al. 2022

The catch was split between seasons from 1979–80 onwards for the recreational and customary catch which were assumed to be 90% taken in the SS, with the remainder taken in the AW. Illegal catch was assumed to have the same seasonal split by 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 years contributed by each data source varying by 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.). Tag-recapture growth increment data were extracted from the Fisheries New Zealand tag database and processed up to 2021–22 for each QMA in the 2022 rapid updates (see Roberts et al. in prep. for a description of the updated tag data).

The results of this data updating procedure allowed for additional 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. When additional years were added by the rapid update model, including LF data, more years of recruitment deviates could be estimated. Even though an additional year of data was included in the models, no data re-weighting was done in relation to the previous (2021) year's rapid update (CRA 1, CRA 3, CRA 4, and CRA 5) or full stock assessment (CRA 7&8). All other model specifications remained as they were in the original base case stock assessment. The fixed values and assumptions 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), and all structural assumptions which applied to growth, maturity, selectivity, and vulnerability. All rapid update models were run using the 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.

During the 2022 Fisheries New Zealand Plenary meeting, concerns were raised about the estimates of recruitment in the most recent years. The Plenary noted that the final 2–3 estimated 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 stable. The Plenary suggested that the data may not be sufficiently informative of recent 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 rejected the projection results, and no projections were performed for any stock for the 2022 rapid updates.

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)
mat50	TW at which 50% of immature females become mature
mat95add	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_{2021} is the beginning of season AW adjusted vulnerable biomass for the 2021–22 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)
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}

3. RESULTS

3.1 CRA 1 RAPID UPDATE

CRA 1 is the northernmost 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).

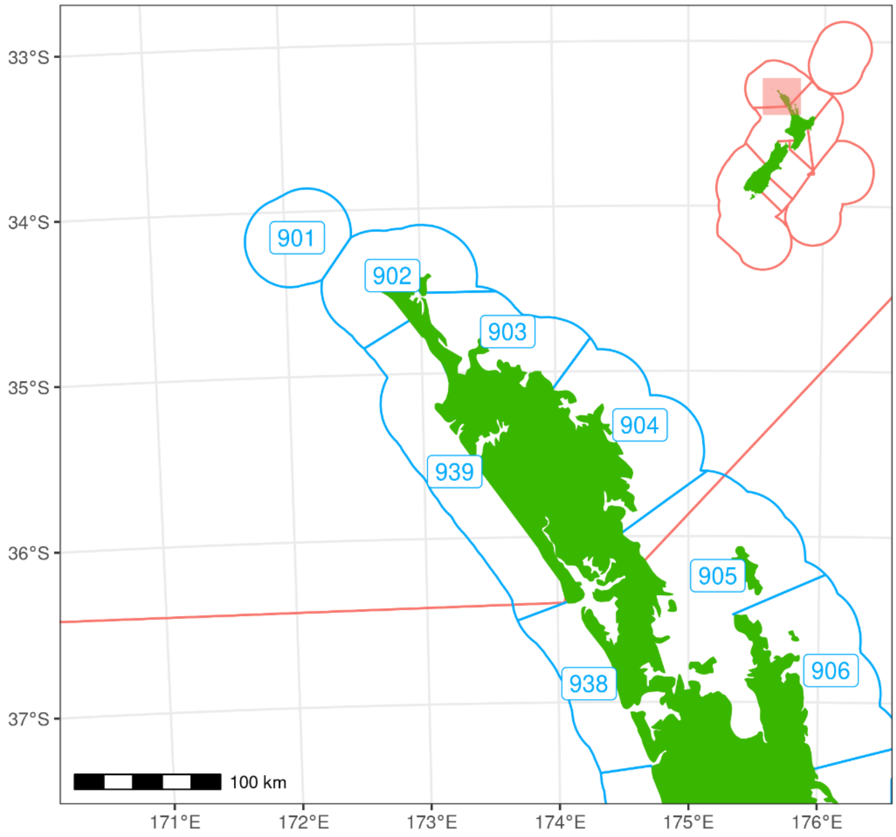


Figure 2: CRA 1 QMA and its statistical areas.

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 2022 rapid update for CRA 1 added three years of data to the 2019 stock assessment including: catch to 2021–22 (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 2021–22, and additional tag recovery data up to 2021–22 (Roberts et al. in prep.). Even though an additional year of data was included in the 2022 rapid update, no data re-weighting was done relative to the 2021 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, and 2022 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

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 36 in Appendix I for MCMC diagnostic plots). The 2022 rapid update fit to the CPUE was good and almost indistinguishable from the fits in the 2019 assessment, and the 2020 and 2021 rapid updates, but the fit to the last full year of the CPUE time series (i.e., 2018–19 SS and 2019–20 AW) was better (Figure 3). The 2022 rapid update fits to the LFs were almost indistinguishable from the equivalent fits of the 2019 stock assessment and the 2020 and 2021 rapid updates (for the years that overlapped) (Figure 4).

The 2022 rapid update suggested that recruitment was higher in 2016–17, lower for 2017–18, almost the same in 2018–19, and lower in 2019–20 (the last year of estimated recruitment) compared with the respective estimates by the 2019 assessment (Figure 5). The 2022 rapid update suggested that the adjusted vulnerable biomass and SSB in 2021–22 were almost indistinguishable to the projections from the 2019 stock assessment and were slightly above the reference level (Figure 6, Figure 7).

The CRA 1 rapid update suggested that, based on mean values, the stock in 2022–23 was at 15% of B_0, 37% of SSB_0, 2% above B_R, and estimated to be below F_{MSY} (Table 5). The probability of the adjusted vulnerable biomass being above B_R in 2022–23 was 55%, and the probability of *SSB* being above the soft and hard limits in 2022–23 was 100%.

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

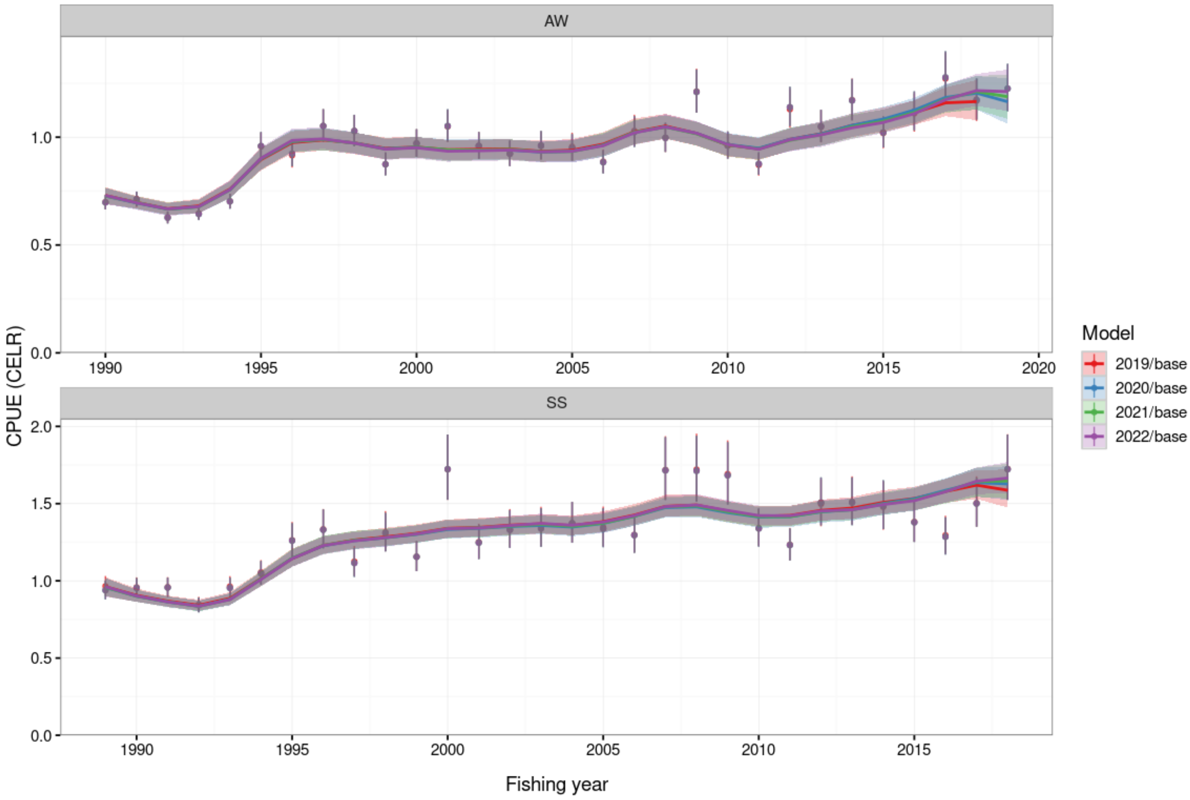


Figure 3: CRA 1 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2019 stock assessment and the 2020, 2021, and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

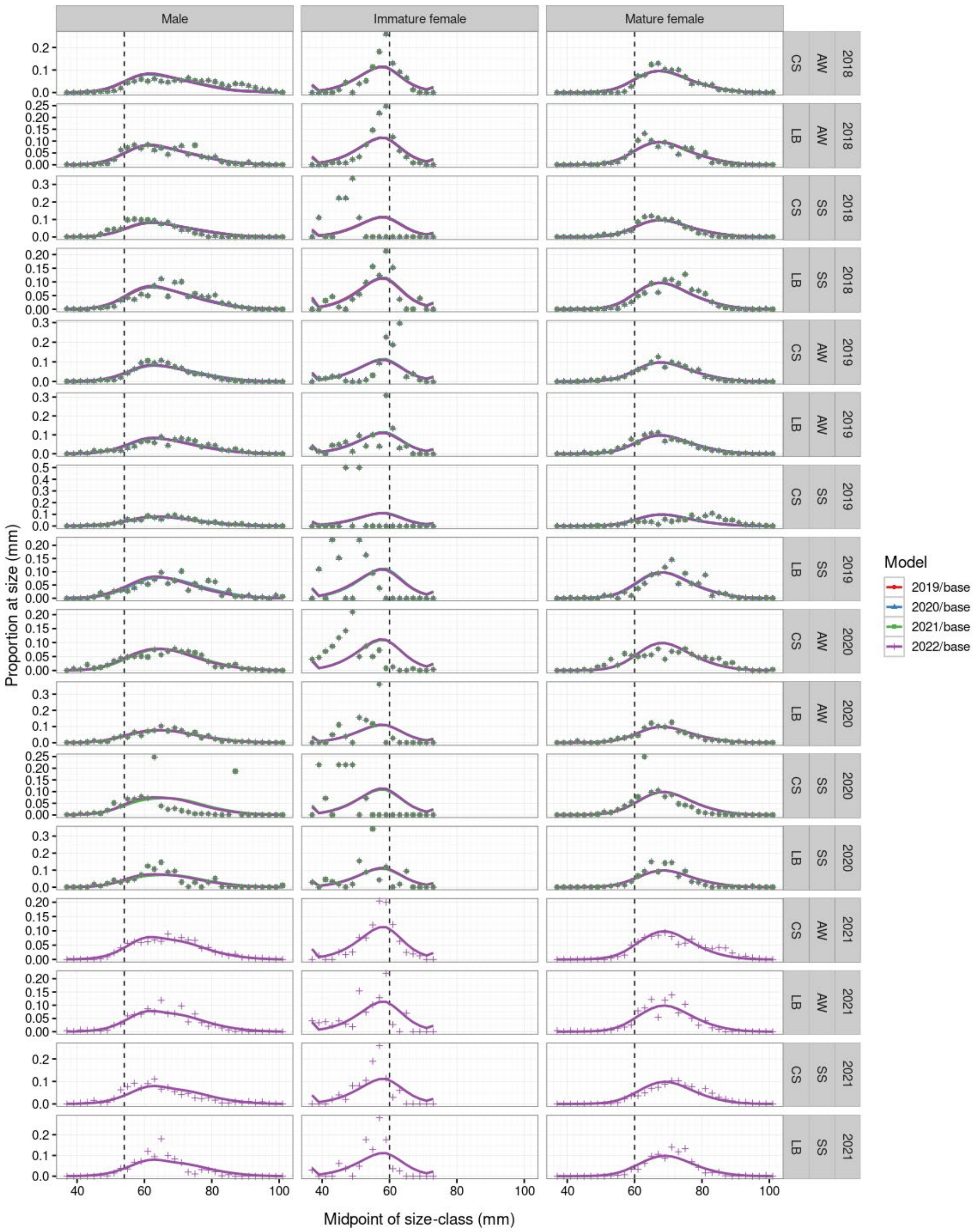


Figure 4: 2018–2021 CRA 1 length frequency observations (points) and median of the posterior distribution (line) by year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2020, 2021, and 2022 rapid updates. Dashed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

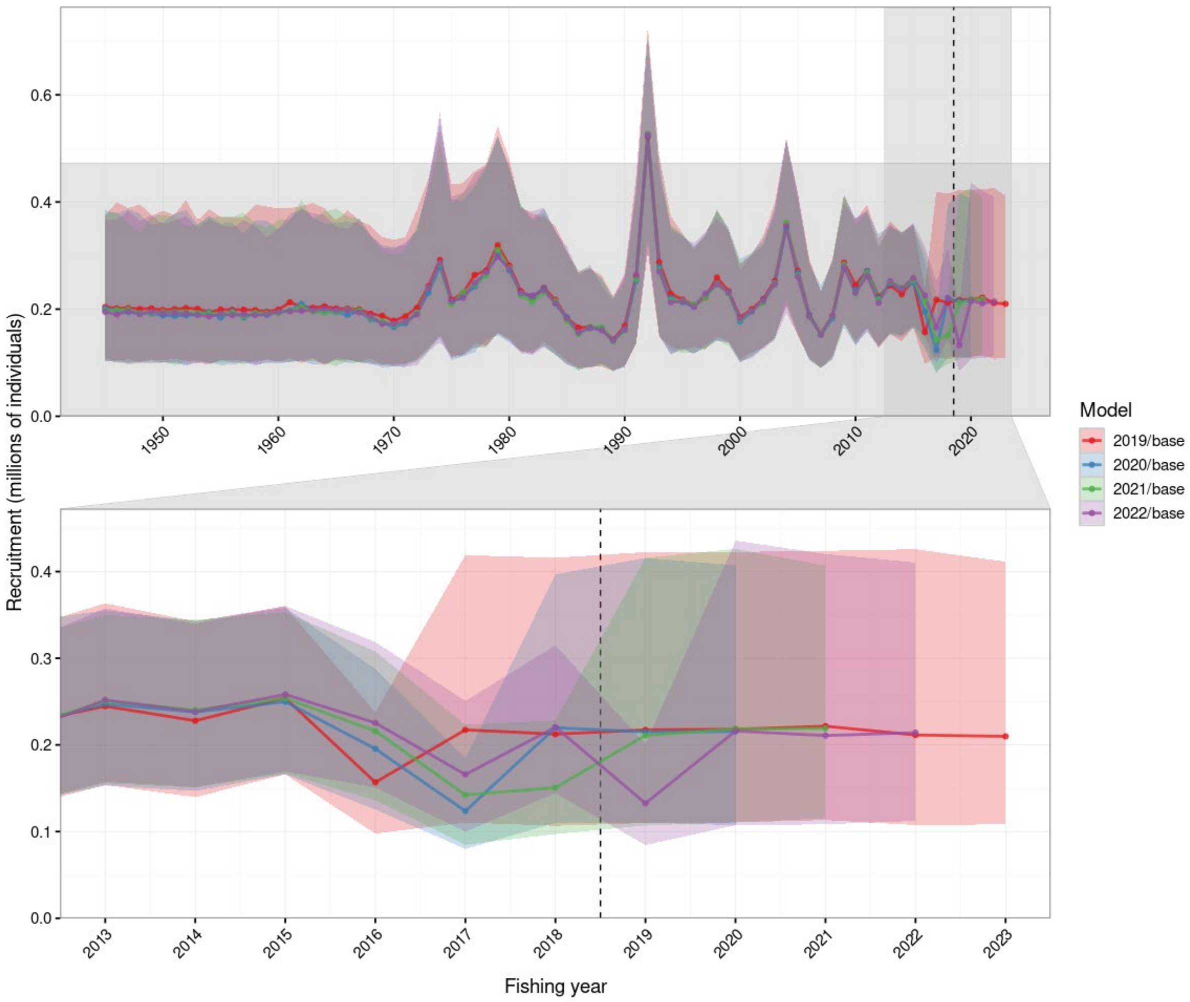


Figure 5: CRA 1 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates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

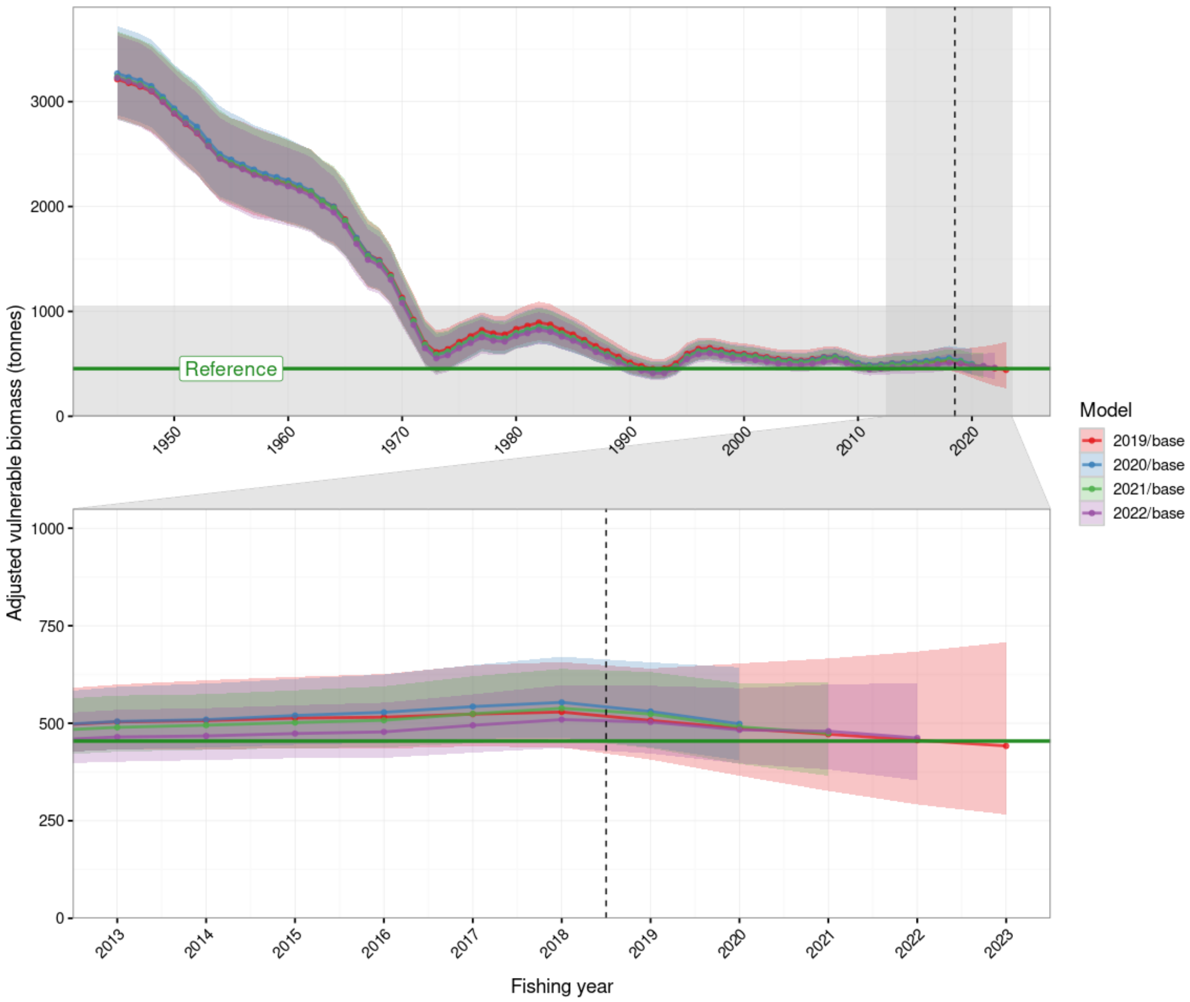


Figure 6: CRA 1 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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).

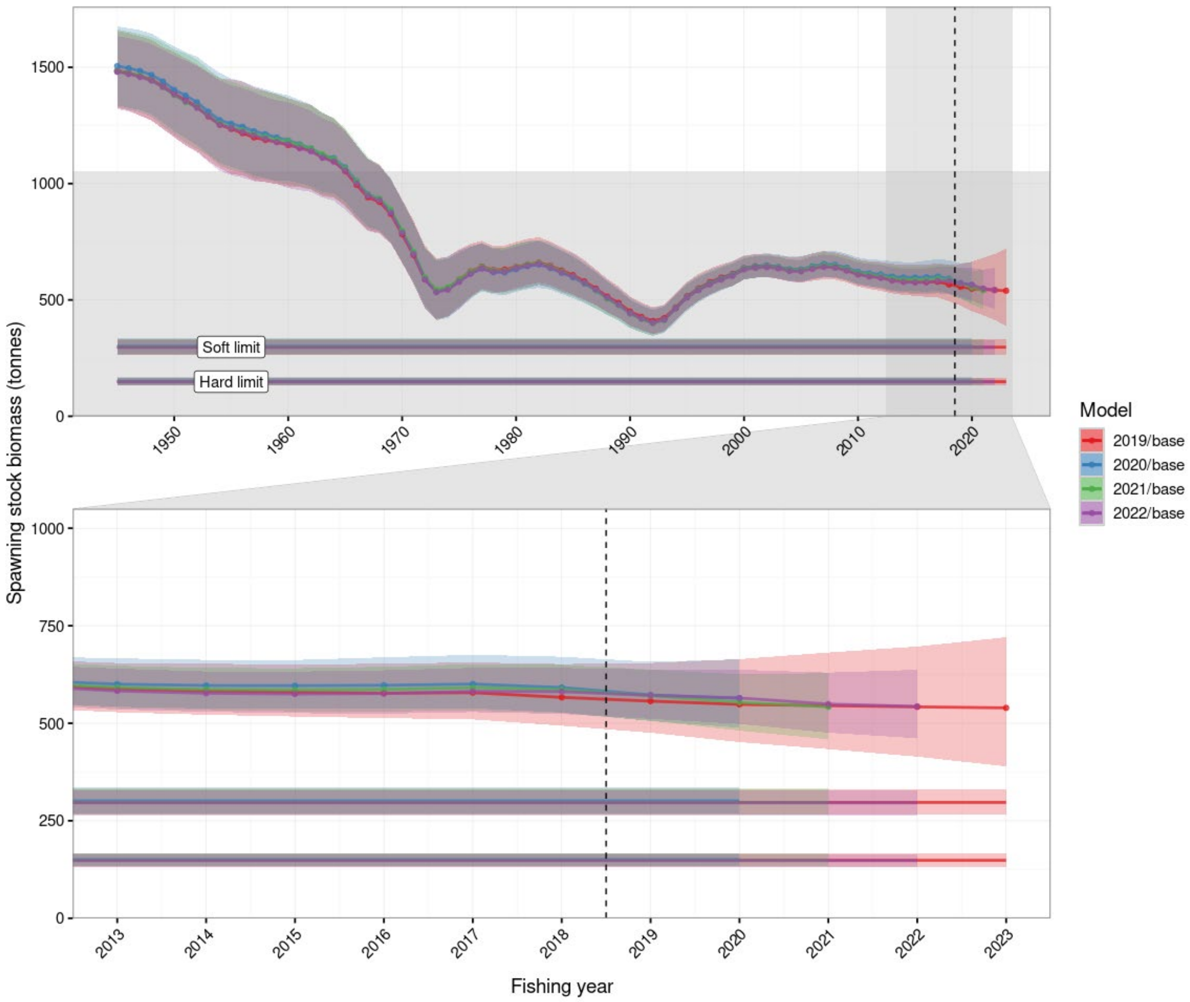


Figure 7: CRA 1 posterior distribution of spawning stock biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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	3 225	2 827	3 226	3 630
B_R	454	–	–	–
B_{2022}	467	354	462	603
B_{2022} / B_0	0.146	0.107	0.144	0.194
B_{2022} / B_R	1.029	0.778	1.017	1.327
$P(B_{2022} > B_R)$	0.545	–	–	–
SSB_0	1 478	1 320	1 480	1 635
SSB_{2022}	544	462	543	637
SSB_{2022} / SSB_0	0.369	0.309	0.368	0.433
P(SSB_{2022} > 20%SSB_0)	1.000	–	–	–
P(SSB_{2022} > 10%SSB_0)	1.000	–	–	–
F_{MSY}	0.675	0.461	0.662	0.935
F_{2022} / F_{MSY}	0.217	0.169	0.213	0.282
H_{2021}	1.911	1.689	1.908	2.154

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, and 2022 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_base			2021_base			2022_base		
	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
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
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
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
mat95add	8.375	12.834	20.055	8.661	13.344	20.552	8.932	13.693	20.885	9.104	13.969	21.357
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

3.2 CRA 3 RAPID UPDATE

The CRA 3 fishery extends from East Cape south to the Wairoa River (Figure 1, Figure 8) and includes East Cape (statistical area 909), Gisborne (910), and the Mahia Peninsula (911).

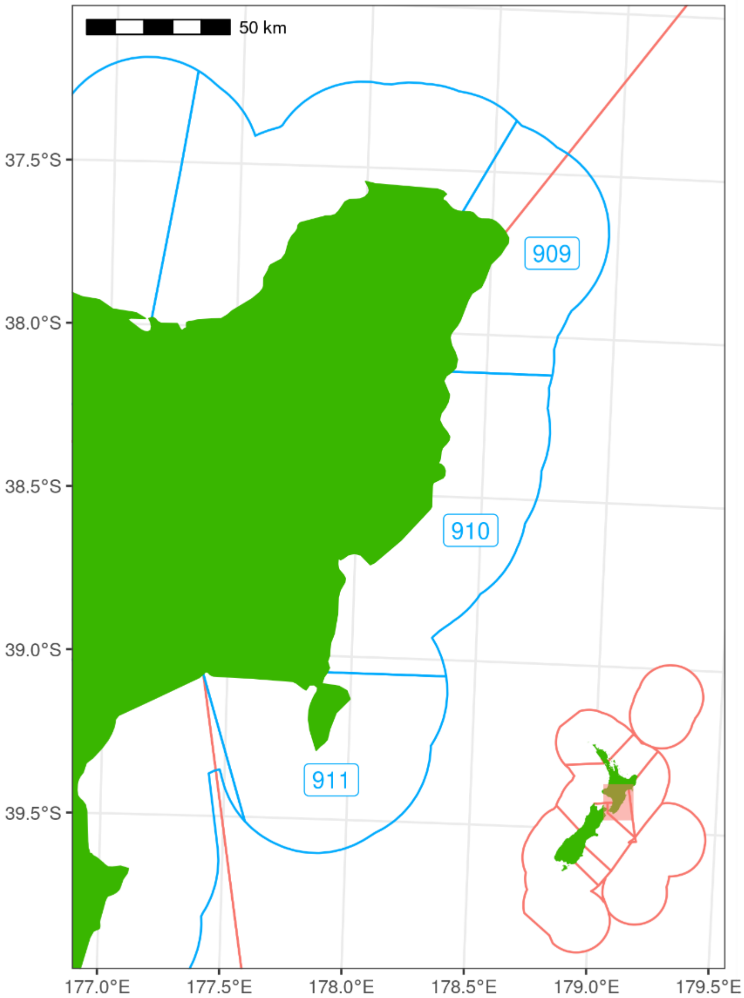


Figure 8: CRA 3 QMA and its statistical areas.

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, prior to 1993 and 1993 and later. The stock assessment portrayed a stock that had declined rapidly between 1960–61 and 1970–71, 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 is due, in part, to the small TW at maturity estimated for CRA 3.

The 2022 rapid update for CRA 3 added three years of additional data to the 2019 stock assessment including: catch up to 2021–22 (Table 7), a single CPUE index 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

2021–22, and additional tag recovery data up to 2021–22 (Roberts et al. in prep.). Even though an additional year of data was included in the 2022 rapid update, no data re-weighting was done relative to last year's rapid update.

Table 7: 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, and 2022 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

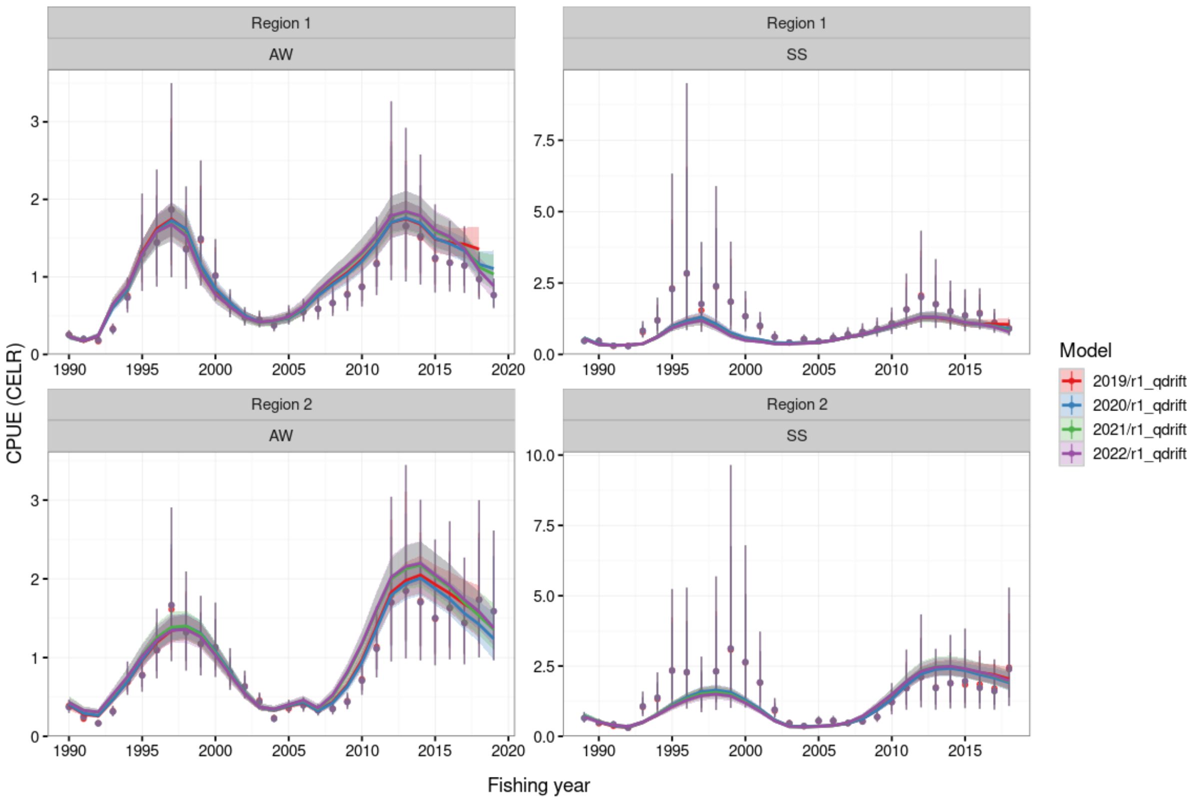
MCMC trace plots for the CRA 3 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure 37 and Figure 38 in Appendix I for MCMC diagnostic plots).

The rapid update fit to the CPUE was generally similar to the fit in the 2019 assessment and acceptably fitted the single new CPUE point (Figure 9). There were some differences in fit to the CPUE series in AW to account for the new CPUE point, but, as in previous rapid updates, it was an acceptable adjustment. The fit to the 2019–20 AW point was better than in the previous 2020 and 2021 rapid updates. The fits to the LFs were similar for the 2018–19 fishing year and reasonable for subsequent fishing years (Figure 10, Figure 11, Figure 12, and Figure 13).

The 2022 rapid update estimated a recruitment pulse in 2018–19 in region 1 and 2019–20 in region 2 by the base case *r1_qdrift* and in 2019–20 in both regions by the base case *r2_qdrift* from the inclusion of the additional years of LF data and the estimation of recruitment deviates up to 2019–20 (Figure 14 and Figure 15). The 2022 rapid update estimated adjusted vulnerable biomass to be lower in 2021–22 than was projected by the 2019 assessment for both model runs and both regions combined (Figure 16). The *SSB* predicted by the 2022 rapid update for 2021–22 was slightly higher than was projected by the 2019 assessment for both model runs and both regions combined (Figure 17).

The 2022 rapid update suggested that, based on mean values, the overall (i.e., region 1 and region 2 combined) stock size in 2022–23 was at 18% of B_0, 83–90% of SSB_0, and 34–45% above the reference level (ranges in percentages represent the range from the two base models). The 2022–23 fishing mortality was above F_{MSY} for region 1 and region 2 (both *r1_qdrift* and *r2_qdrift* models) (Table 8, Table 9). For both base models, the probability of the adjusted vulnerable biomass being above B_R in 2022–23 was around 98%, and the probability of *SSB* being above the soft and hard limits in 2022–23 was 100%.

The parameter estimates for both the *r1_qdrift* and *r2_qdrift* base models were similar to the 2019 stock assessment models and the previous rapid updates (Table 10, Table 11).



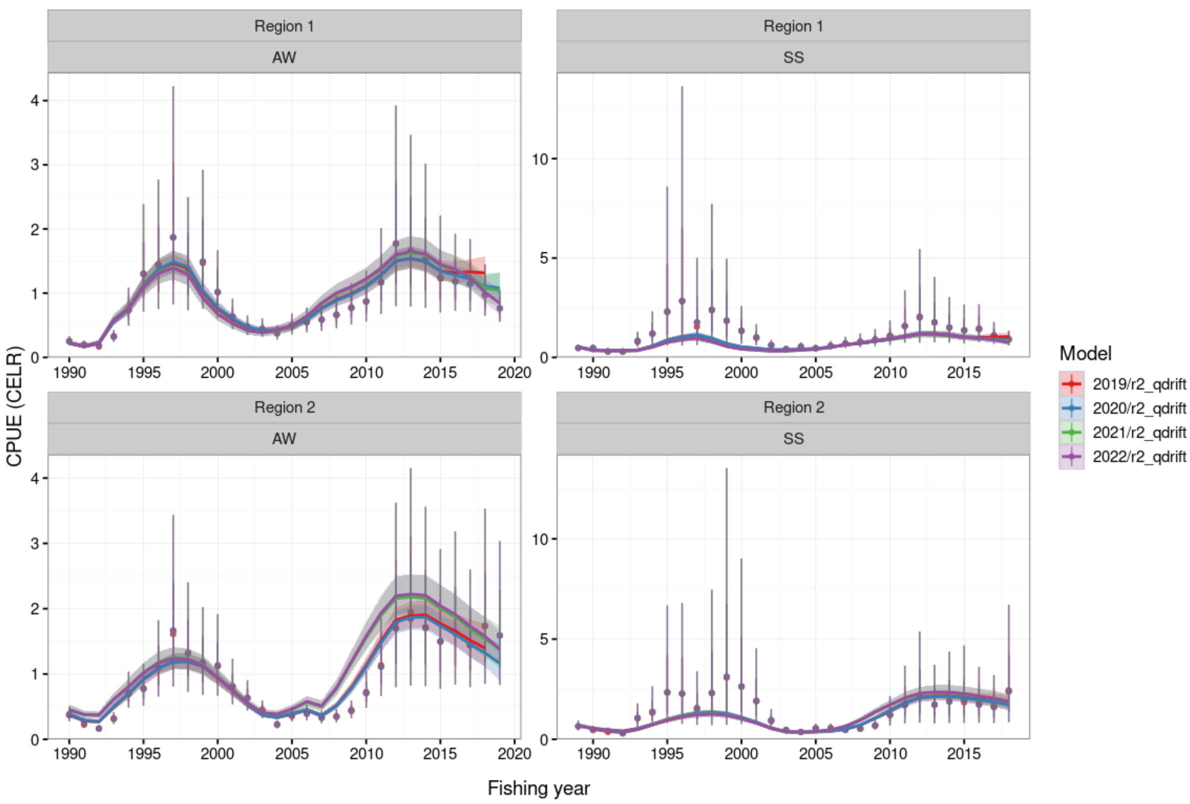


Figure 9: The *r1_qdrift* and *r2_qdrift* model runs are presented top and bottom, respectively. CRA 3 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2019 stock assessment and the 2020, 2021, and 2022 rapid updates.

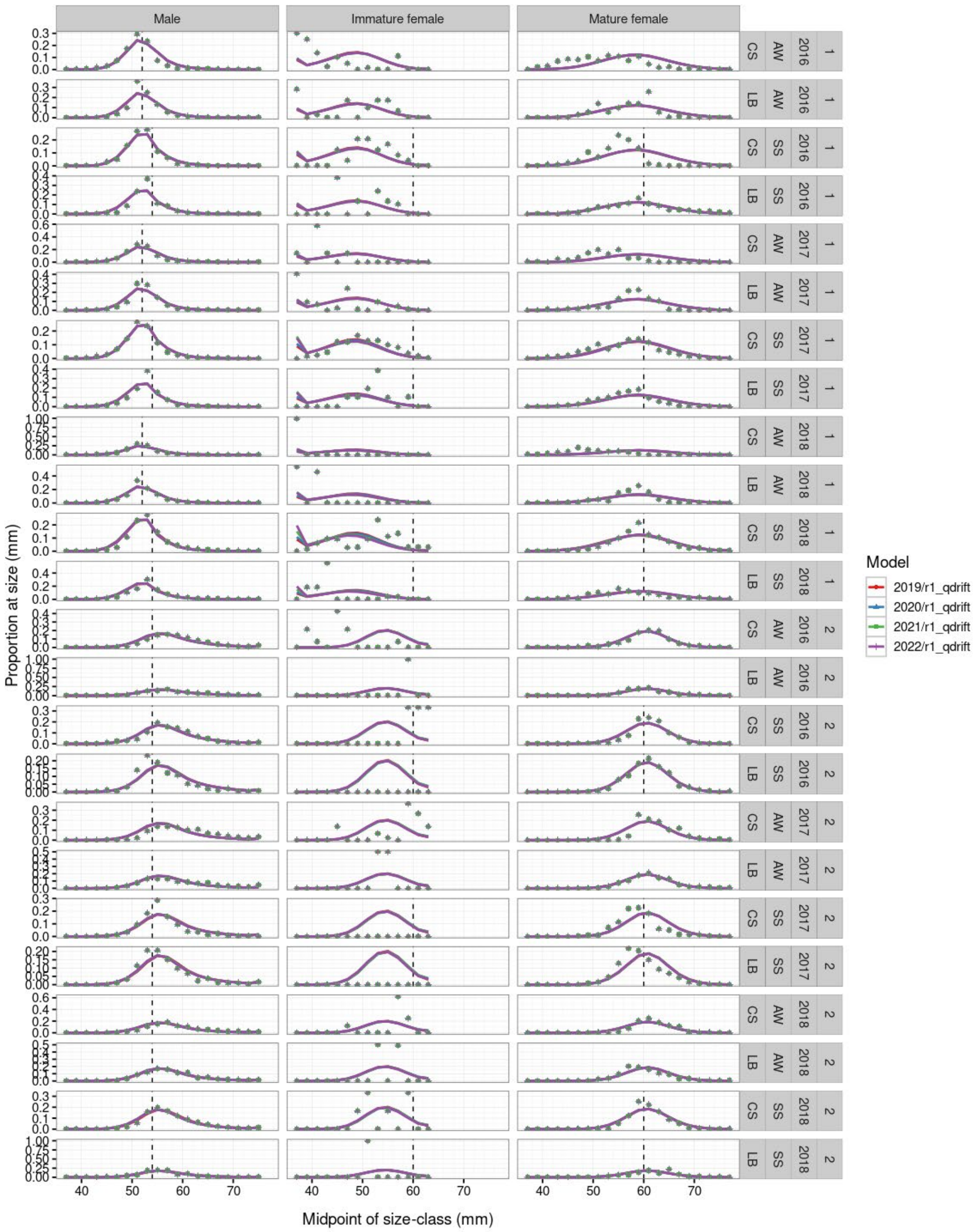


Figure 10: 2016–2018 *r1_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2020, 2021, and 2022 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.

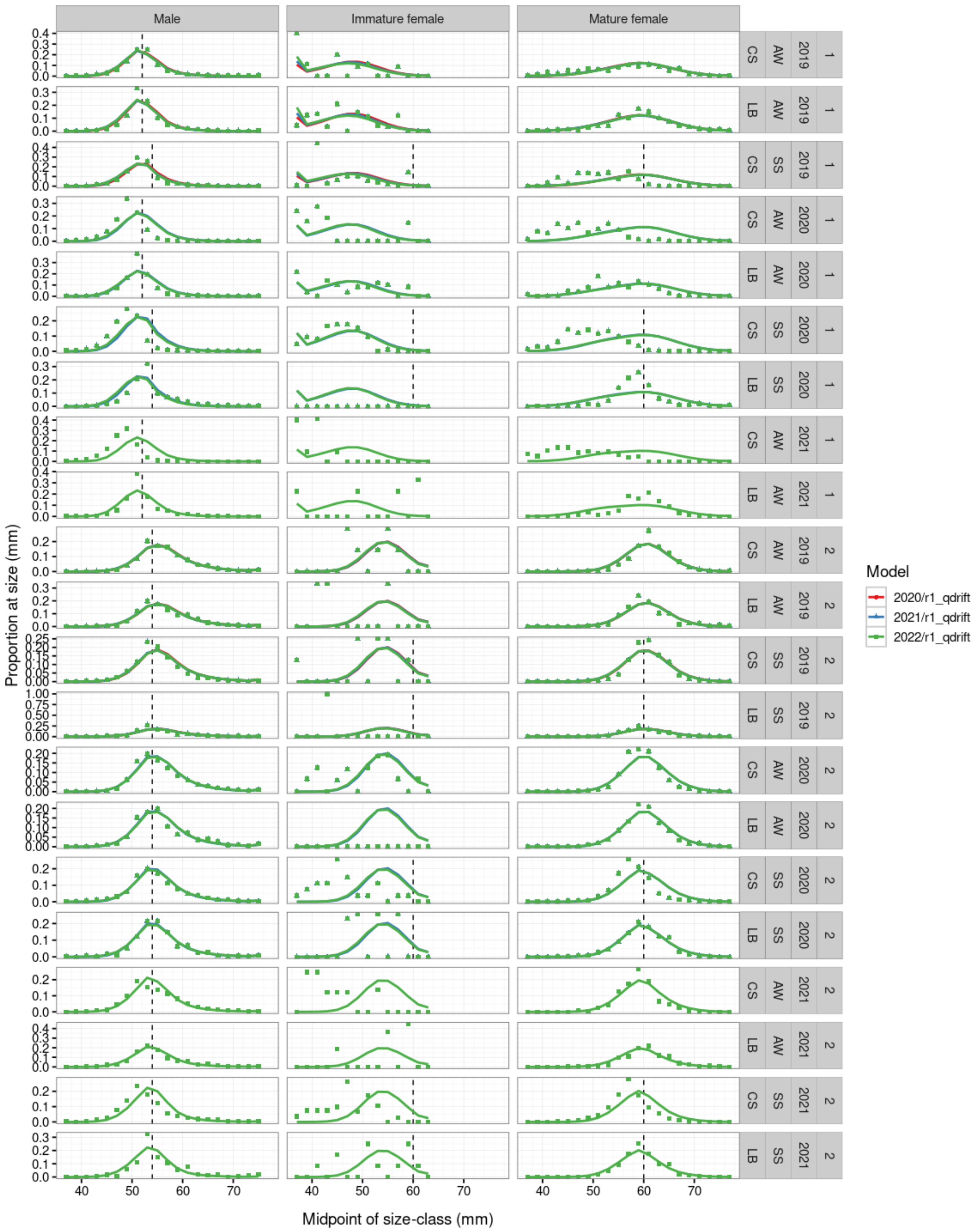


Figure 11: 2019–2021 (years not included in the 2019 assessment) *r1_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2020, 2021, and 2022 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.

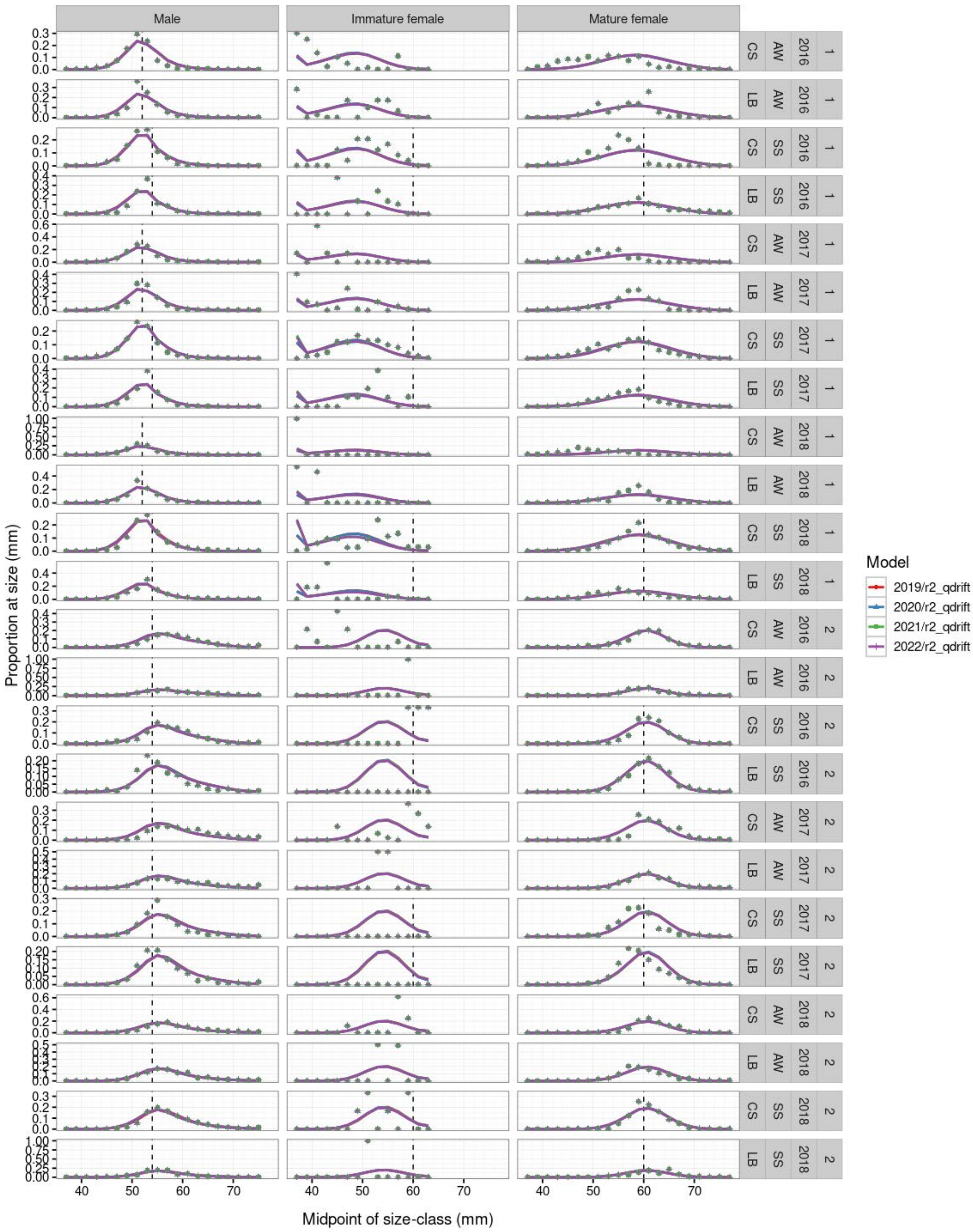


Figure 12: 2016–2018 *r2_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2020, 2021, and 2022 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.

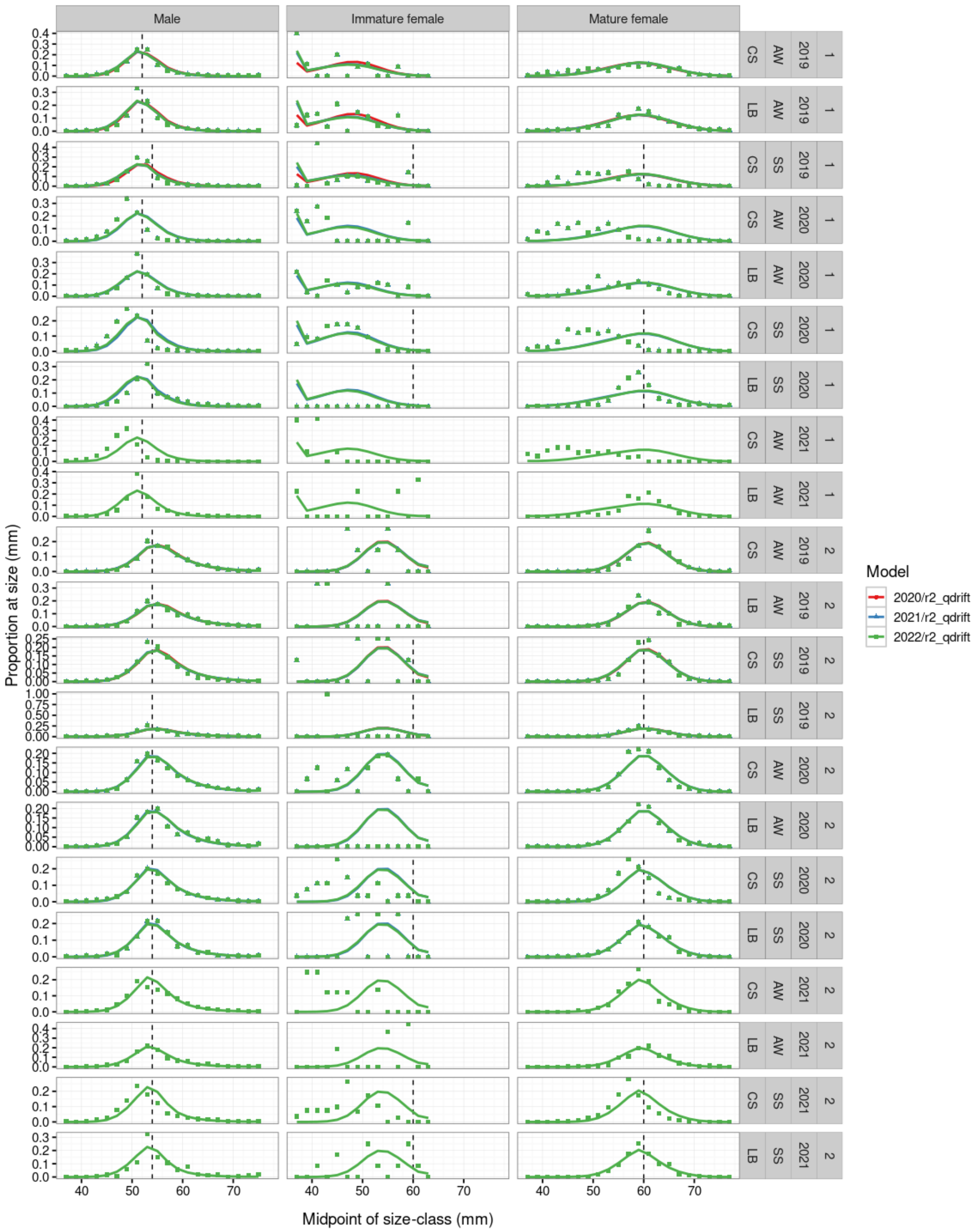


Figure 13: 2019–2021 (years not included in the 2019 assessment) *r2_qdrift* CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2020, 2021, and 2022 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.

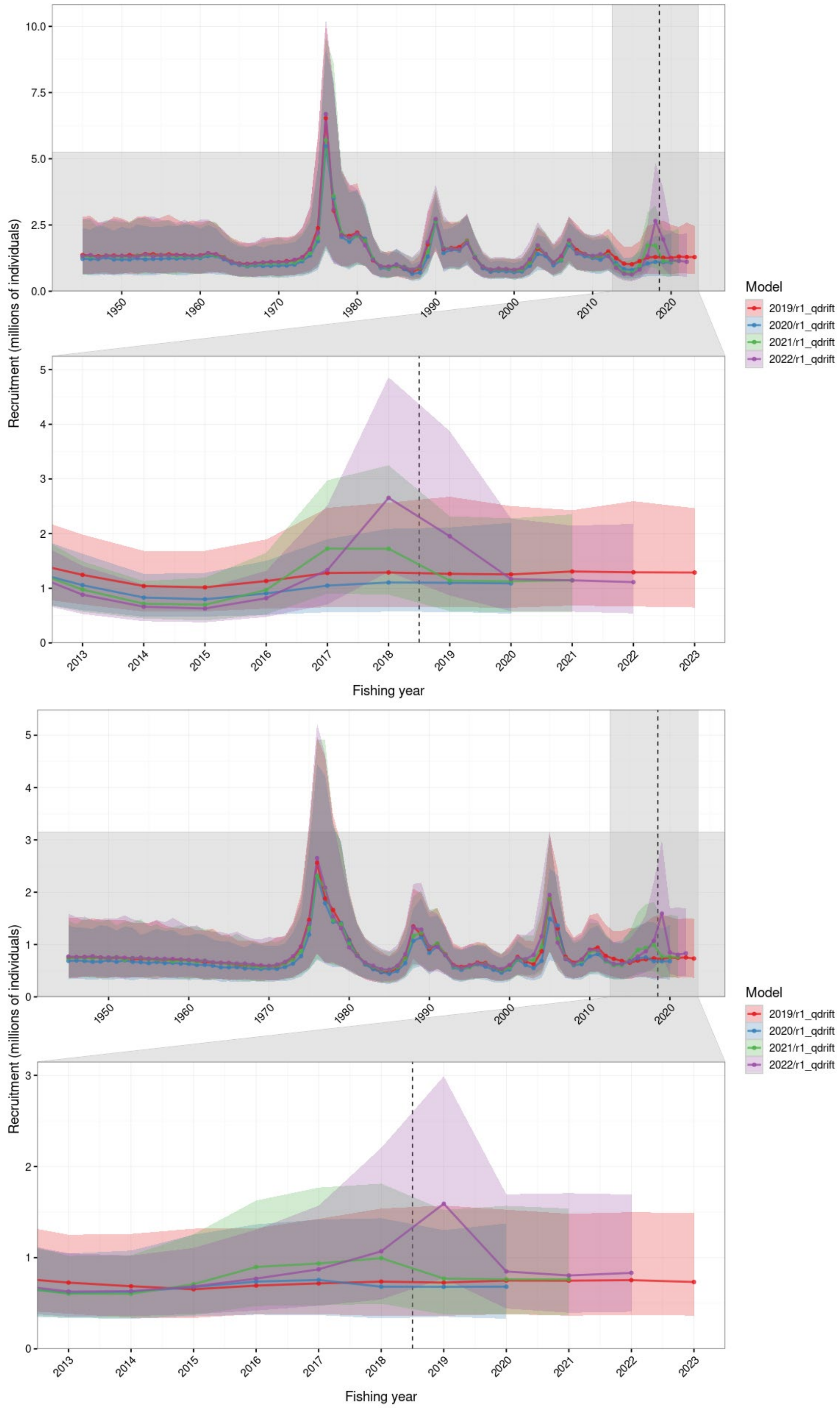


Figure 14: Region 1 (upper panels) and region 2 (lower panels). CRA 3 base case *r1_qdrift* posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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.

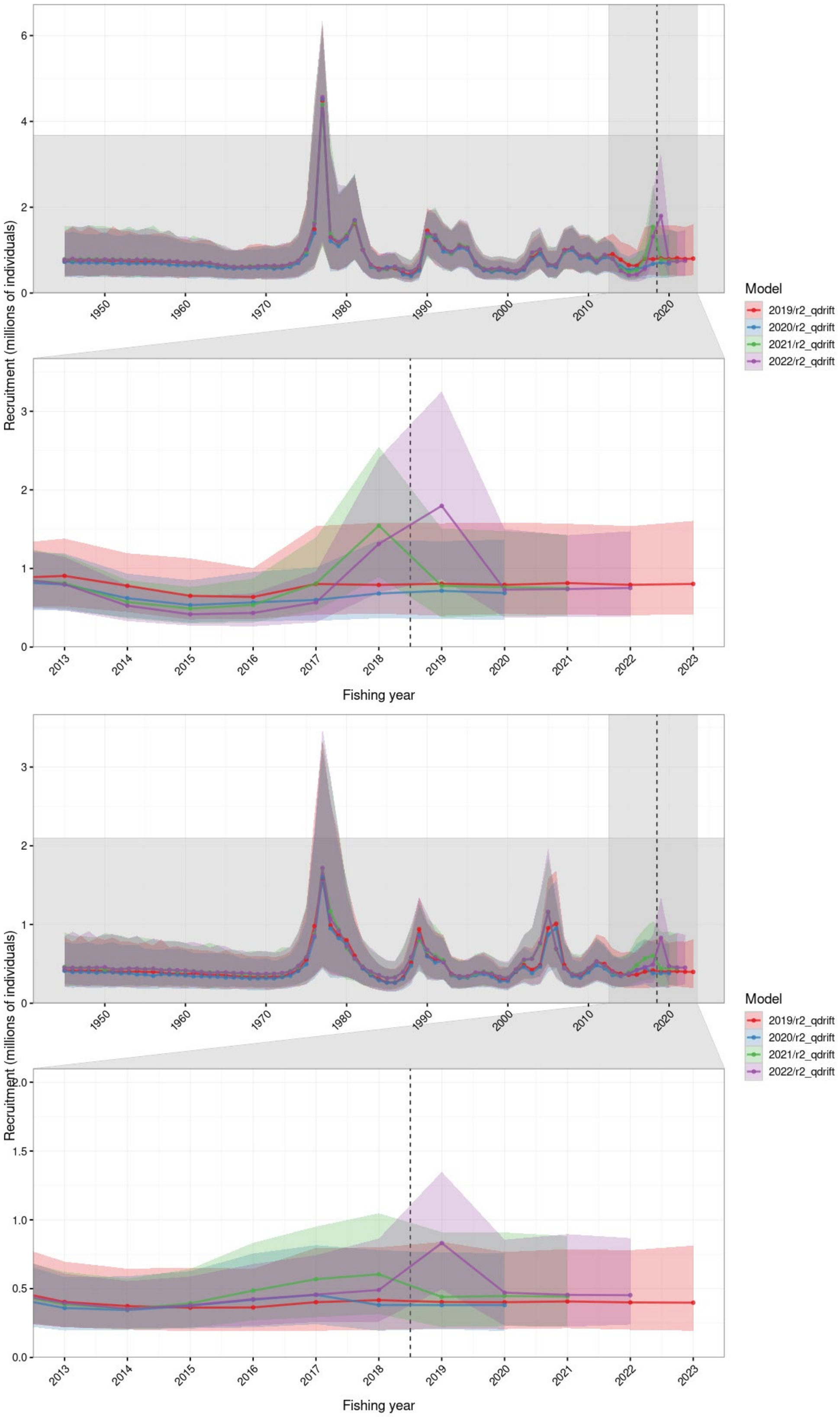
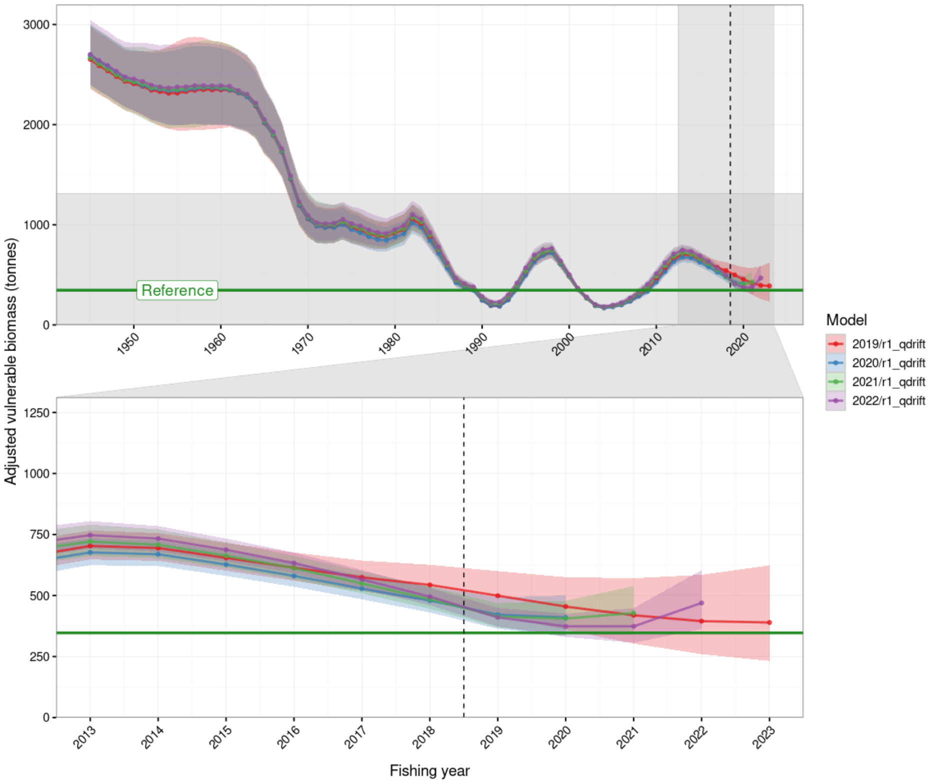


Figure 15: Region 1 (upper panels) and region 2 (lower panels). CRA 3 base case *r2_qdrift* posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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.



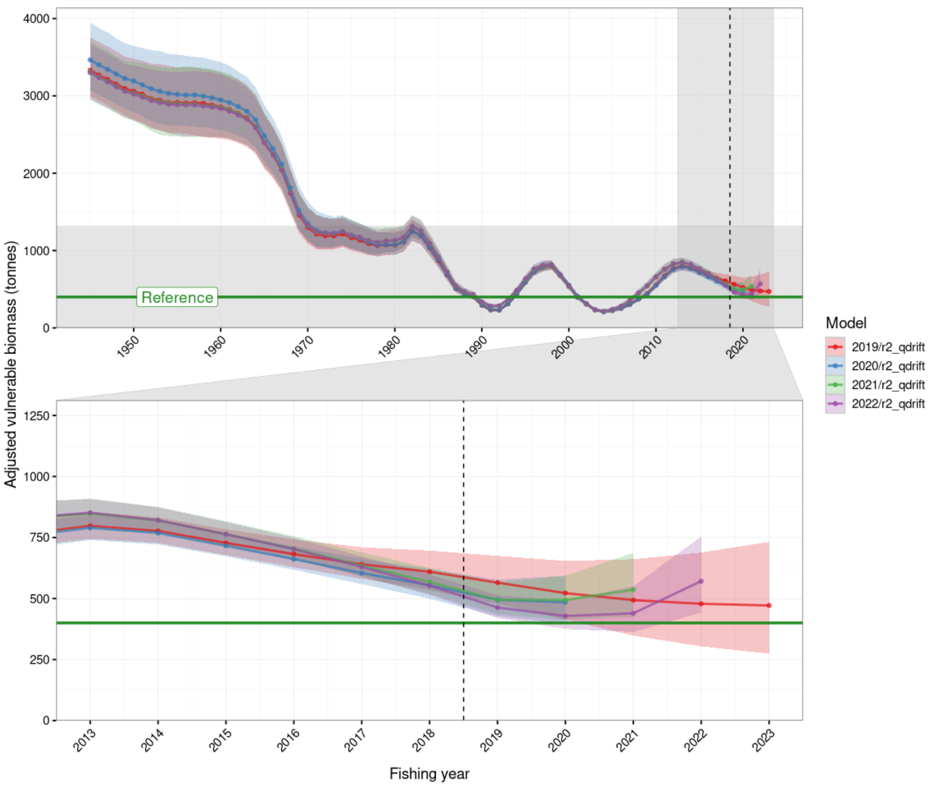


Figure 16: CRA 3 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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).

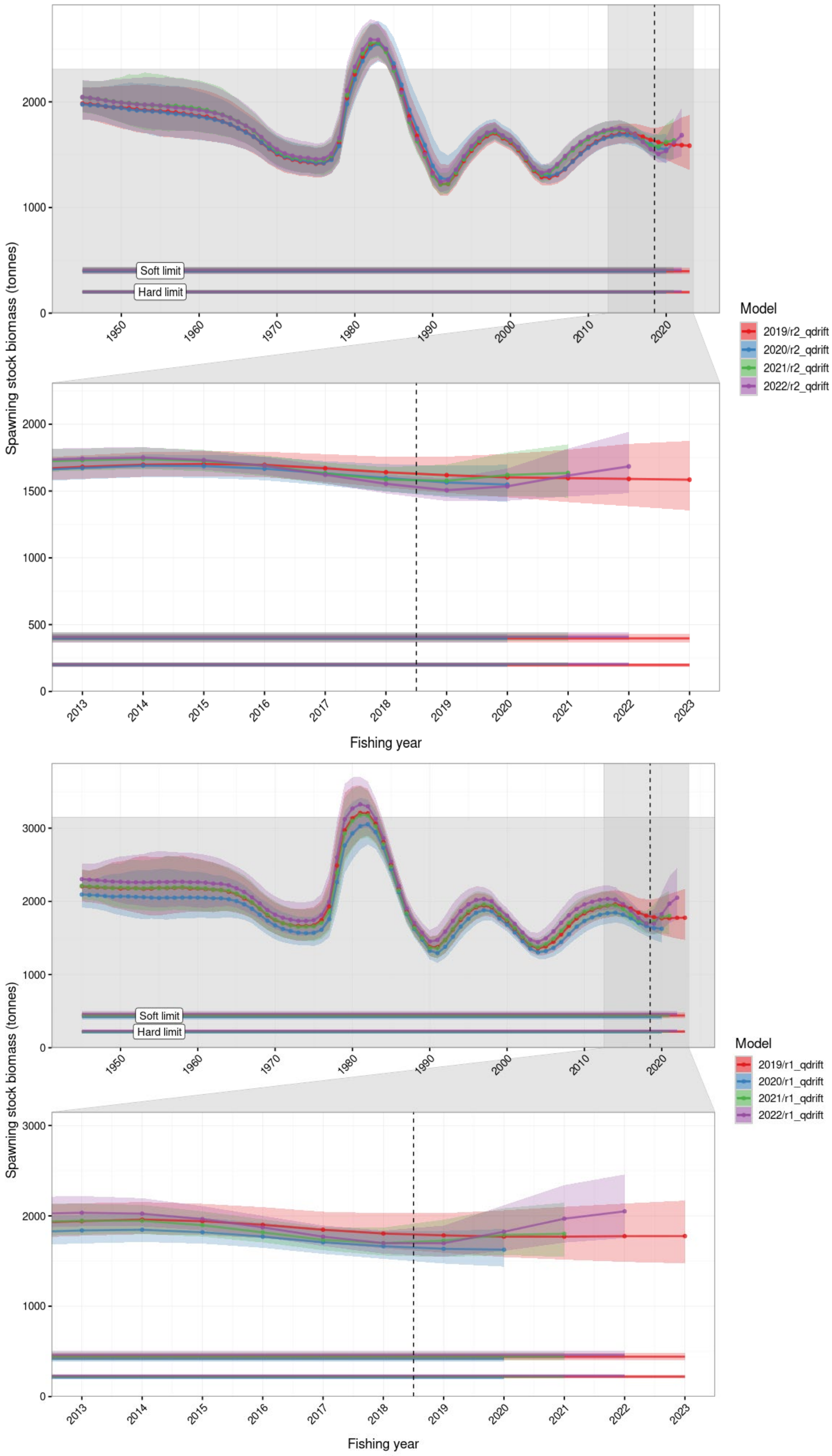


Figure 17: CRA 3 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2019 stock assessment (showing the five projected years) and the 2020, 2021, and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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 8: 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	2 714	2 396	2 701	3 046
B_R	347	–	–	–
B_{2022}	474	363	470	604
B_{2022} / B_0	0.176	0.131	0.174	0.228
B_{2022} / B_R	1.368	1.046	1.354	1.742
P($B_{2022} > B_R$)	0.972	–	–	–
SSB_0	2 311	2 104	2 304	2 521
SSB_{2022}	2 068	1 753	2 050	2 458
SSB_{2022} / SSB_0	0.895	0.763	0.890	1.043
P($SSB_{2022} > 20\% SSB_0$)	1.000	–	–	–
P($SSB_{2022} > 10\% SSB_0$)	1.000	–	–	–
F_{MSY} [region 1]	0.114	0.082	0.111	0.155
F_{MSY} [region 2]	0.349	0.256	0.342	0.457
F_{2022} / F_{MSY} [region 1]	2.013	1.807	2.008	2.228
F_{2022} / F_{MSY} [region 2]	1.798	1.542	1.792	2.070
H_{2021} [region 1]	3.924	3.300	3.903	4.646
H_{2021} [region 2]	6.157	5.402	6.148	6.941

Table 9: 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	3 307	2 958	3 300	3 670
B_R	400	–	–	–
B_{2022}	578	442	571	754
B_{2022} / B_0	0.176	0.130	0.173	0.235
B_{2022} / B_R	1.445	1.104	1.428	1.886
P($B_{2022} > B_R$)	0.985	–	–	–
SSB_0	2 047	1 904	2 045	2 208
SSB_{2022}	1 690	1 484	1 684	1 943
SSB_{2022} / SSB_0	0.826	0.727	0.823	0.942
P($SSB_{2022} > 20\% SSB_0$)	1.000	–	–	–
P($SSB_{2022} > 10\% SSB_0$)	1.000	–	–	–
F_{MSY} [region 1]	0.126	0.084	0.123	0.175
F_{MSY} [region 2]	0.463	0.342	0.455	0.610
F_{2022} / F_{MSY} [region 1]	1.476	1.328	1.474	1.628
F_{2022} / F_{MSY} [region 2]	1.086	0.942	1.079	1.240
H_{2021} [region 1]	3.909	3.236	3.874	4.691
H_{2021} [region 2]	6.143	5.378	6.112	6.997

Table 10: 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, and 2022 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.

	2019_base			2020_base			2021_base			2022_base		
	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
R_0 [911]	671900	818049	1014742	619297	749515	922554	653078	810650	1014608	695809	847729	1059602
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Table 11: 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, and 2022 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.

	2019_base			2020_base			2021_base			2022_base		
	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
R_0 [911]	388754	464490	547652	370826	440977	516670	421069	501959	591384	428061	497037	586186
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

3.3 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 18).

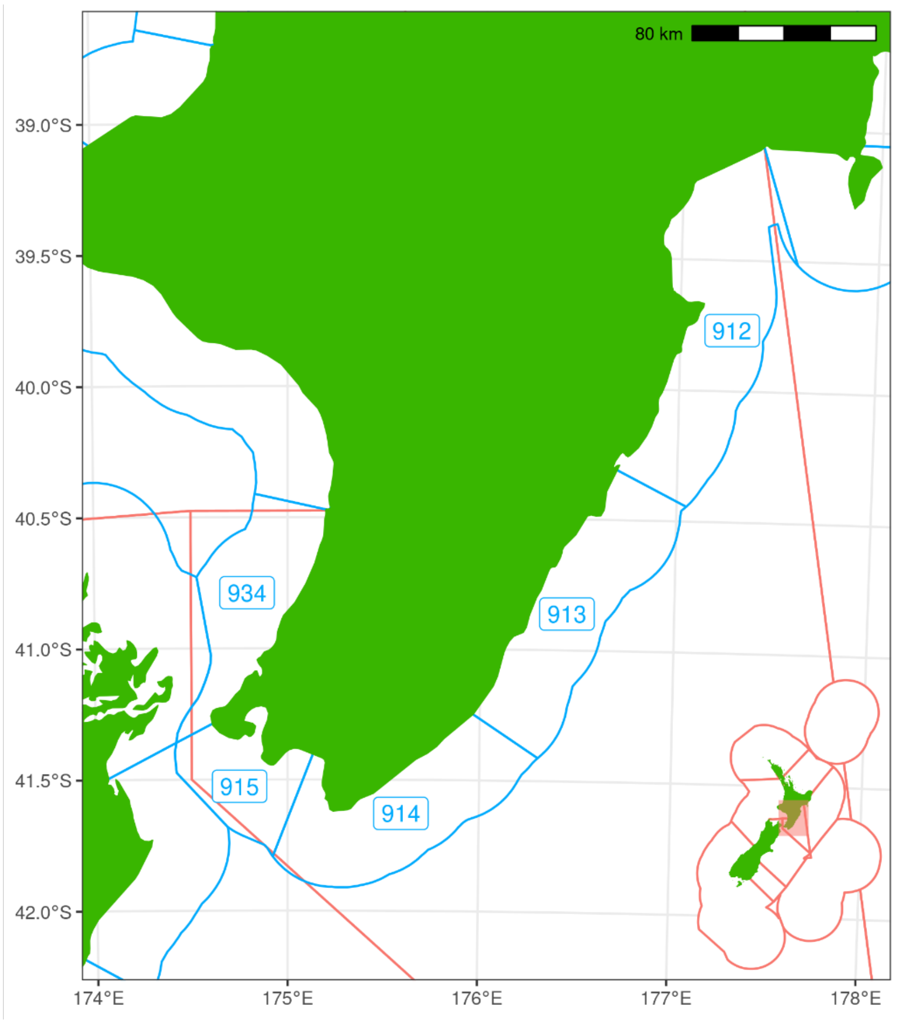


Figure 18: CRA 4 QMA and its statistical areas.

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 2022 rapid update for CRA 4 added two years of data, including: catch up to 2021–22 (Table 12), LFs for 2020–21 and 2021–22, and additional tag recovery data up to 2021–22 (Roberts et al. in prep.). Even though an additional year of data was included in the 2022 rapid update, no data re-weighting was done relative to the 2021 rapid update.

Table 12: 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 and 2022 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

MCMC trace plots for the 2022 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure 39 in Appendix I for MCMC diagnostic plots).

Model fits for the 2022 rapid update were almost indistinguishable from the 2020 stock assessment and the 2021 rapid update. 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 19). The fits to the LFs were almost indistinguishable from those obtained in the 2020 full assessment and 2021 rapid update for 2019–20 and 2020–21, and the fits to the 2021–22 LFs were good except for the immature females (Figure 20).

The rapid update in 2021 suggested that there had been a pulse of recruitment in 2018–19 that had not been estimated by the 2020 assessment because the 2018–19 recruitment deviate was not estimated by the earlier assessment (Figure 21). This recruitment pulse shifted to 2019–20 for the 2022 rapid update with the addition of one more year of data. The 2022 rapid update predicted that the adjusted vulnerable biomass in 2021–22 was slightly higher than was projected by the 2020 and above the reference level (Figure 22). *SSB* was also estimated to be higher in 2021–22 than was projected by the 2020 stock assessment and above the soft and hard limits (Figure 23).

The rapid update suggested that, based on mean values, CRA 4 in 2022–23 was at 15% of B_0, 57% of SSB_0, 32% above B_R, and fishing mortality was above F_{MSY} (Table 13). The probability of the adjusted vulnerable biomass being above B_R in 2022–23 was about 85%, and the probability of SSB being above the soft and hard limits in 2022–23 was 100%.

All parameter estimates were similar to the 2020 stock assessment and the previous rapid updates (Table 14).

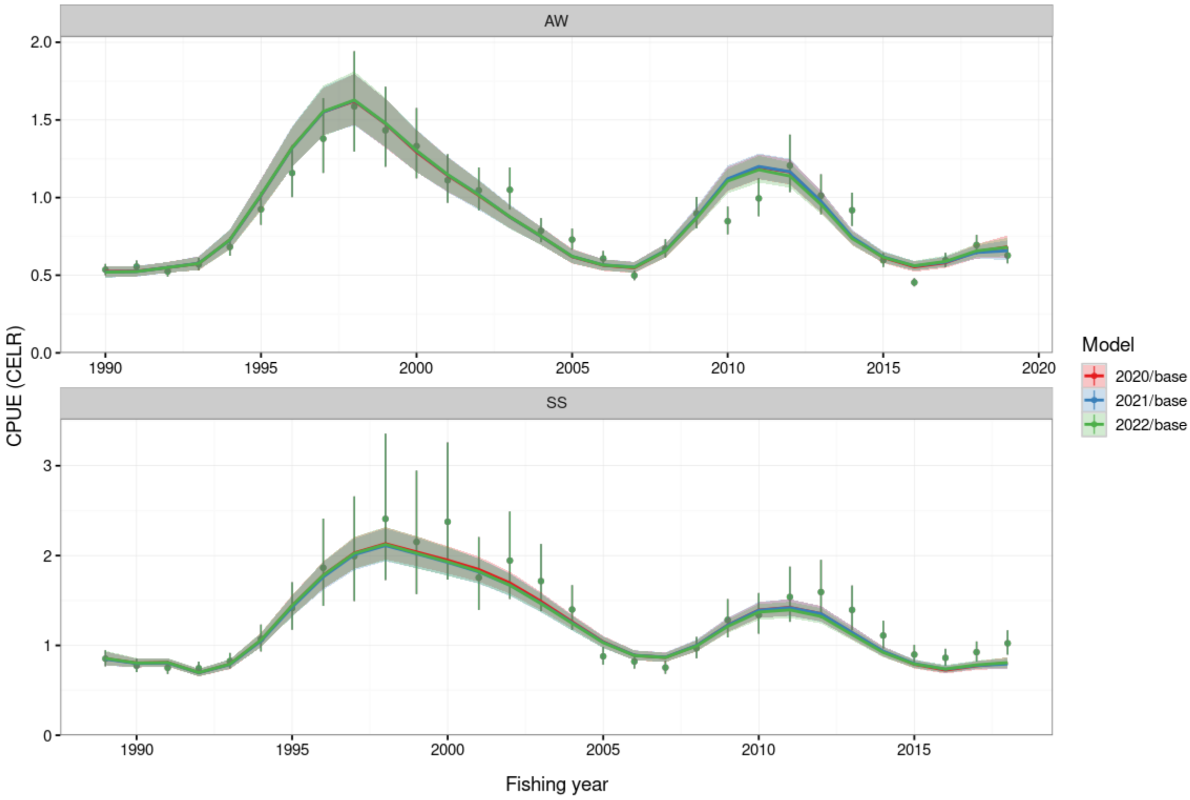


Figure 19: CRA 4 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2020 stock assessment and the 2021 and 2022 rapid updates.

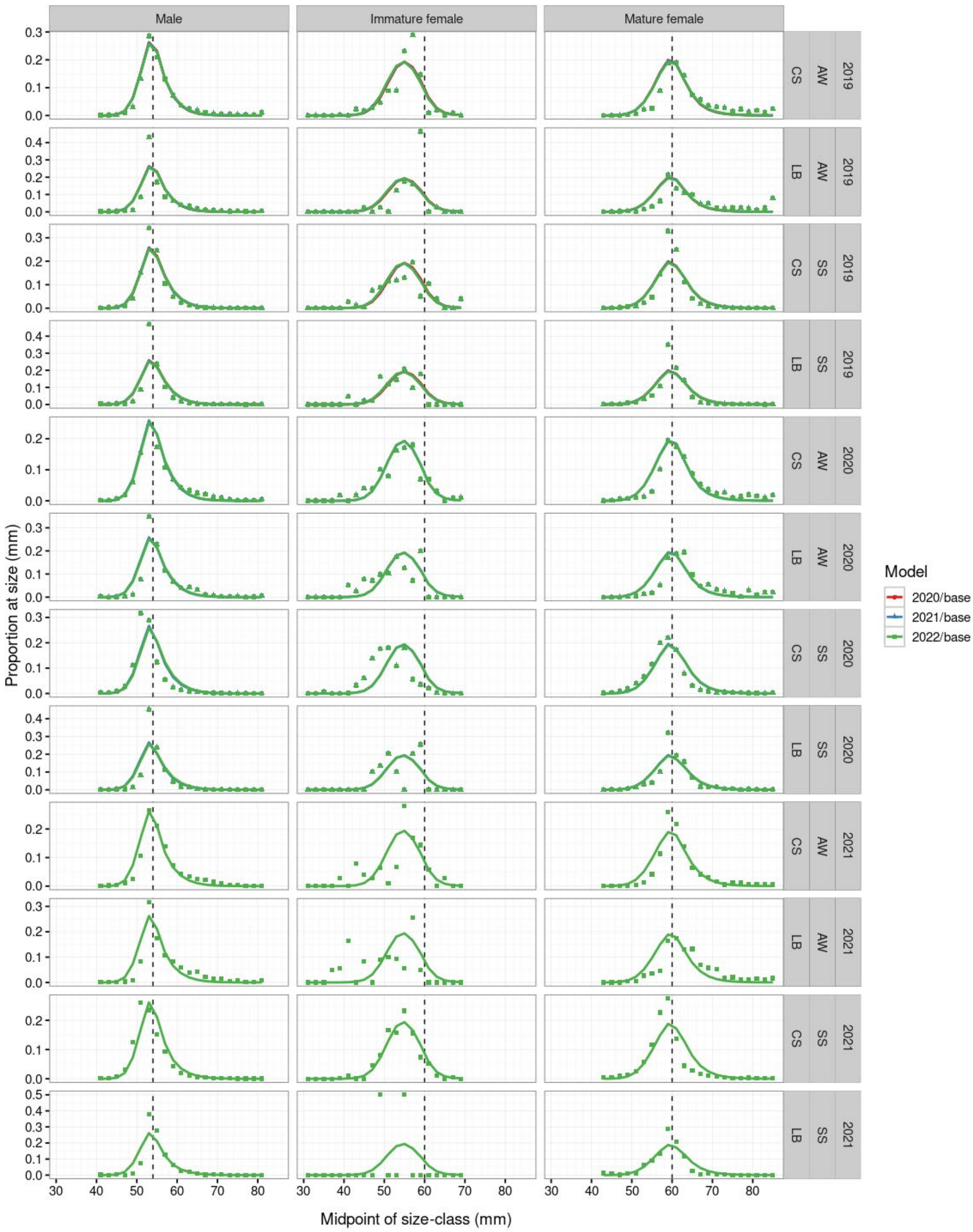


Figure 20: 2019–2021 CRA 4 length frequency observations (points) and median of the posterior distribution (line) by year (from 2019 to 2021), season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2020 stock assessment and the 2021 and 2022 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes.

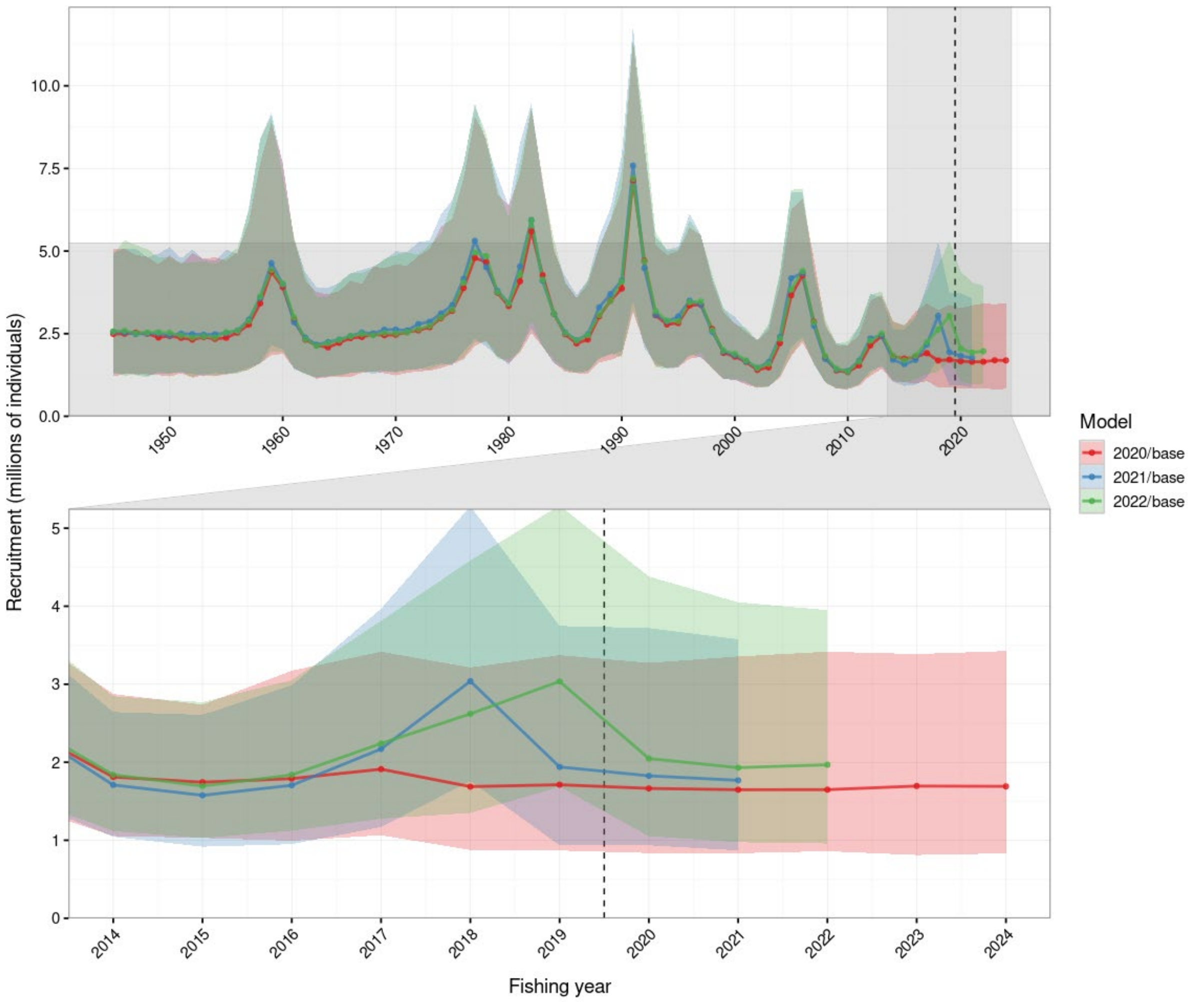


Figure 21: CRA 4 posterior distribution of recruitment showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021 and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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.

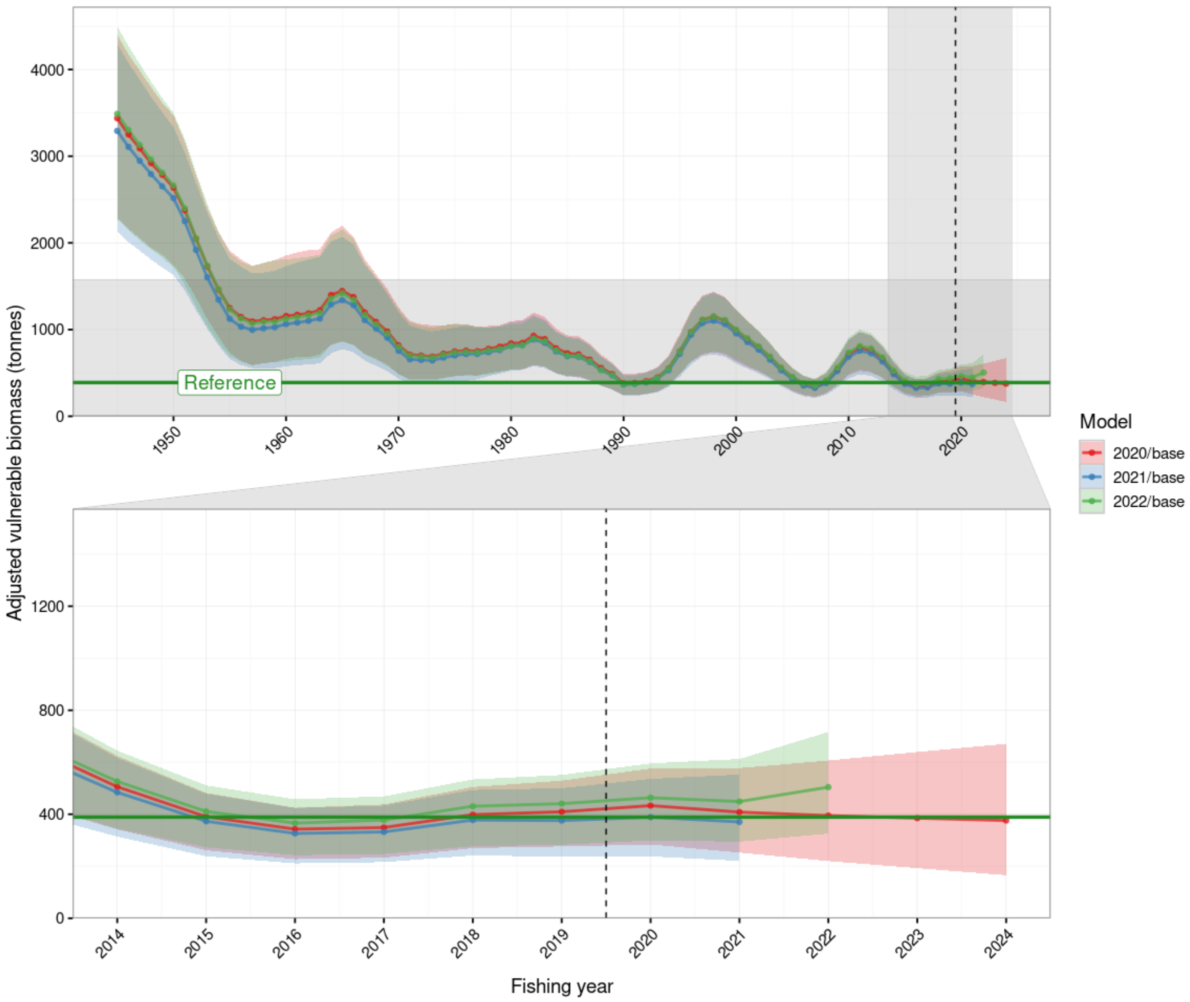


Figure 22: CRA 4 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021 and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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).

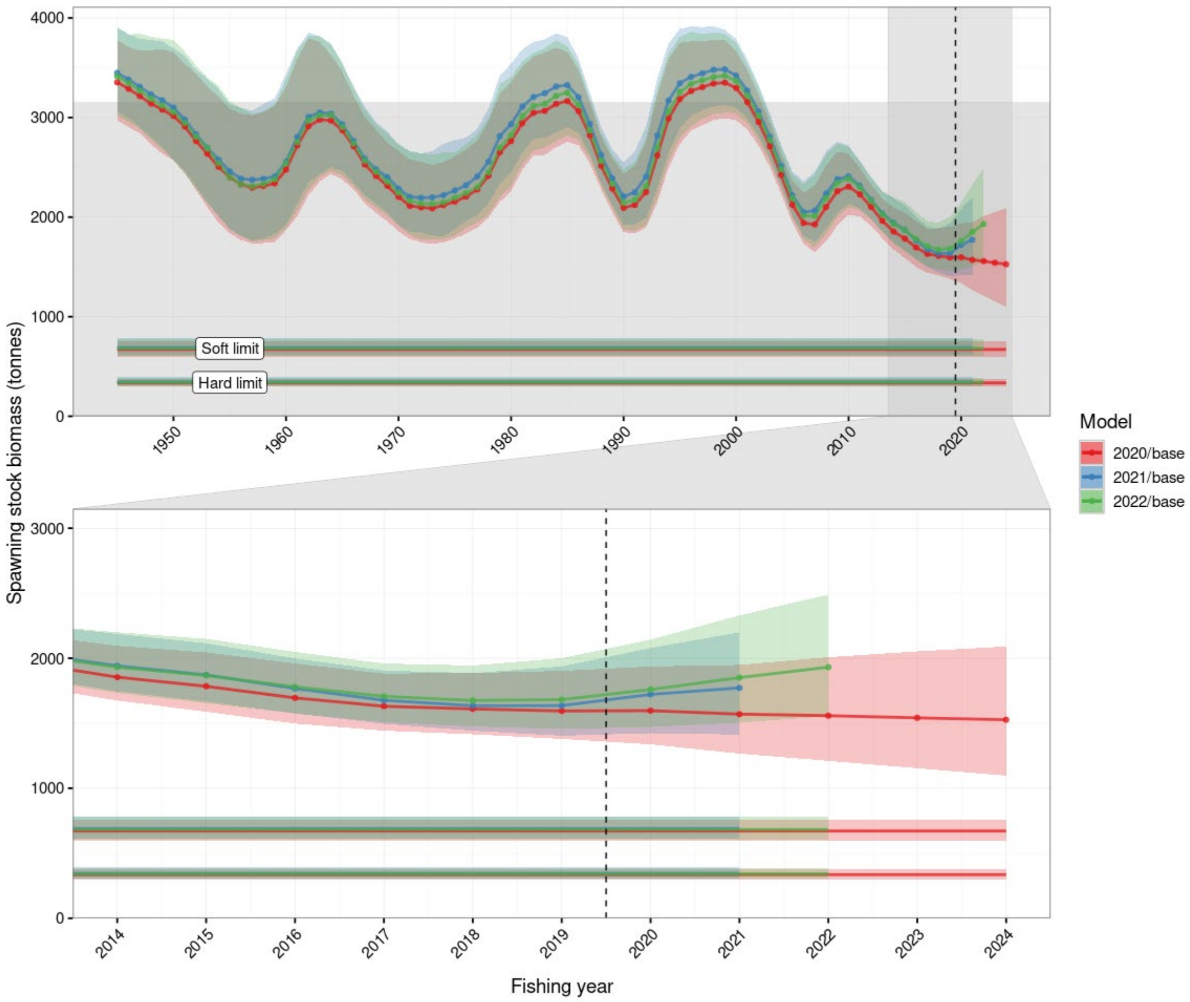


Figure 23: CRA 4 posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021 and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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 13: CRA 4 rapid update indicators summarising the mean, median, and 90% credible intervals.

Indicator	Mean	5%	50%	95%
B_0	3 443	2 273	3 489	4 499
B_R	389	–	–	–
B_{2022}	512	326	504	716
B_{2022} / B_0	0.150	0.109	0.148	0.200
B_{2022} / B_R	1.315	0.837	1.296	1.841
$P(B_{2022} > B_R)$	0.847	–	–	–
SSB_0	3 429	3 021	3 414	3 899
SSB_{2022}	1 956	1 554	1 932	2 490
SSB_{2022} / SSB_0	0.570	0.462	0.565	0.693
$P(SSB_{2022} > 20\%SSB_0)$	1.000	–	–	–
$P(SSB_{2022} > 10\%SSB_0)$	1.000	–	–	–
F_{MSY}	0.257	0.195	0.254	0.328
F_{2022} / F_{MSY}	1.278	0.964	1.213	1.802
H_{2021}	15.900	14.150	15.810	17.790

Table 14: 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 and 2022 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_base			2022_base		
	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters									
R_0	2258915	2831890	3577511	2380302	2918420	3683576	2368937	2874335	3694149
M	0.199	0.223	0.251	0.200	0.223	0.250	0.201	0.224	0.252
qdrift	-0.006	0.002	0.010	-0.005	0.003	0.010	-0.009	-0.002	0.005
mat50	37.906	41.727	43.789	37.714	41.626	43.674	37.931	41.608	43.475
Galpha [male]	2.567	2.658	2.759	2.540	2.631	2.722	2.552	2.646	2.755
Gbeta [male]	2.138	2.352	2.554	2.198	2.385	2.567	2.208	2.422	2.590
Gshape [male]	5.612	6.382	7.111	5.539	6.241	6.976	5.625	6.438	7.204
GCV [male]	0.683	0.716	0.751	0.688	0.723	0.757	0.689	0.722	0.757
Galpha [female]	1.870	2.042	2.214	1.850	2.023	2.204	1.879	2.055	2.232
Gbeta [female]	1.083	1.237	1.393	1.102	1.244	1.402	1.127	1.263	1.415
Gshape [female]	4.999	5.467	5.985	4.968	5.494	5.944	4.950	5.445	5.939
GCV [female]	1.159	1.269	1.409	1.158	1.270	1.394	1.139	1.255	1.385
Gobs	0.446	0.494	0.546	0.448	0.494	0.549	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
vuln [M, SS]	0.444	0.674	0.811	0.422	0.644	0.802	0.448	0.675	0.820
vuln [IF & MF, SS]	0.379	0.545	0.694	0.325	0.495	0.637	0.351	0.516	0.663
vuln [MF, AW]	0.240	0.343	0.452	0.211	0.323	0.421	0.234	0.342	0.441
selL [male < 1993]	4.763	5.687	6.925	4.725	5.645	6.882	4.821	5.755	6.952
selM [male < 1993]	52.720	54.229	56.071	52.814	54.276	56.055	52.875	54.426	56.279
selL [female < 1993]	6.585	8.448	11.152	6.404	8.185	10.389	6.433	8.165	10.710
selM [female < 1993]	58.453	61.760	66.424	58.128	61.275	65.177	58.255	61.299	65.916
selL [male ≥ 1993]	3.767	3.981	4.232	3.742	3.931	4.148	3.737	3.920	4.149
selM [male ≥ 1993]	55.204	55.532	55.916	55.128	55.502	55.868	55.119	55.433	55.791
selL [female ≥ 1993]	5.848	6.234	6.647	5.834	6.181	6.583	5.832	6.193	6.573
selM [female ≥ 1993]	63.769	64.543	65.340	63.658	64.428	65.242	63.563	64.352	65.142

3.4 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 24).

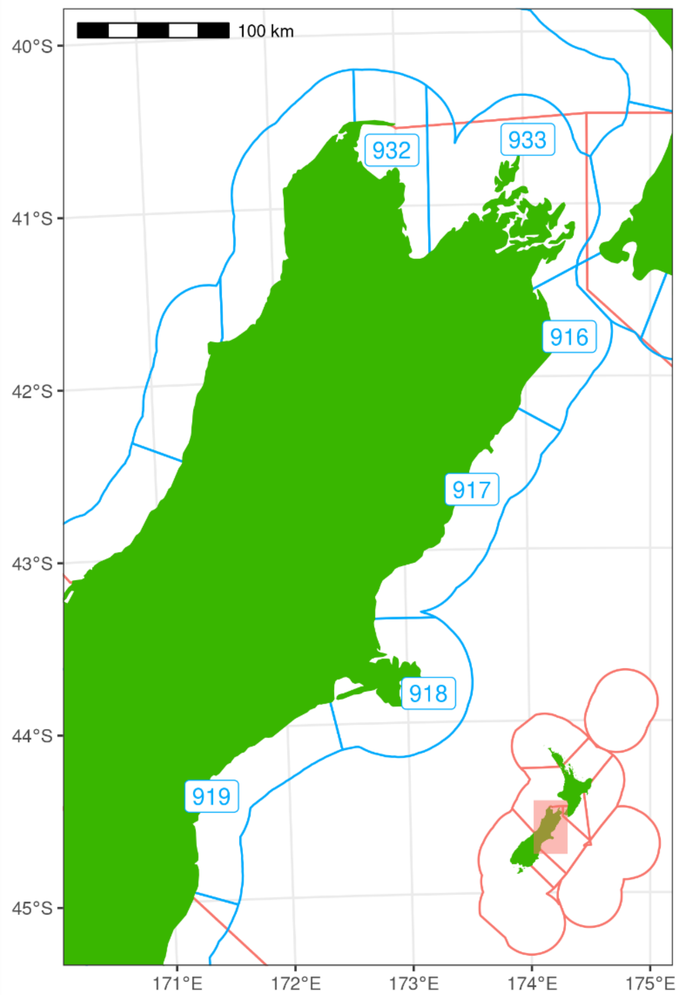


Figure 24: CRA 5 QMA and its statistical areas.

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), 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 differ between the two regions, with region 1 (917, 918, and 919) 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 (916, 932, and 933) 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 2022 rapid update for CRA 5 added two years of data, including: catch up to 2021–22 (Table 15), LF data for 2020–21 and 2021–22, and tag recovery data up to 2021–22 (Roberts et al. in prep.). Even though an additional year of data was included in the 2022 rapid update, no data re-weighting was done relative to the 2021 rapid update, which also did not re-weight the datasets relative to the last full stock assessment in 2020 (Rudd et al. 2022).

Table 15: 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 and 2022 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

MCMC trace plots for the 2022 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure 40 in Appendix I for MCMC diagnostic plots).

The 2022 rapid update fit to the CPUE was very similar to the fit by the 2020 assessment and the 2021 rapid update with only minor differences (Figure 25). The fits to the LFs were very similar to the 2020 stock assessment and 2021 rapid update and were acceptable for 2021–22 in both regions (Figure 26).

The 2022 rapid update estimated approximately the same series of recruitment, adjusted vulnerable biomass, and *SSB* as were estimated by the 2020 stock assessment and 2021 rapid update. This was not surprising given that there were only two additional years of LF data and no change to the CPUE data (Figure 27, Figure 28, Figure 29). A small recruitment pulse in 2018–19, estimated for region 1 by the 2021 rapid update, disappeared from the 2022 rapid update (Figure 27). The region 2 recruitment for 2017–18 was estimated to be above average by the 2020 assessment. The adjusted vulnerable biomass in 2021–22 estimated by the 2022 rapid update was slightly greater than was projected by the 2020 stock assessment and in both cases above the reference level (Figure 28). The 2021–22 *SSB* estimated by the 2022 rapid update was similar to the projected *SSB* by the 2020 stock assessment and above the soft limit (Figure 29).

The 2022 rapid update estimated that, based on mean values, the overall stock (i.e., region 1 and region 2 combined) at the beginning of 2022–23 was at 40% of B_0, 69% of SSB_0, almost three times B_R, and was estimated to be close to F_{MSY} in both regions (Table 16). The probability of the adjusted vulnerable biomass being above B_R in 2022–23 and the probability of *SSB* being above the soft and hard limits in 2022–23 were all 100%.

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

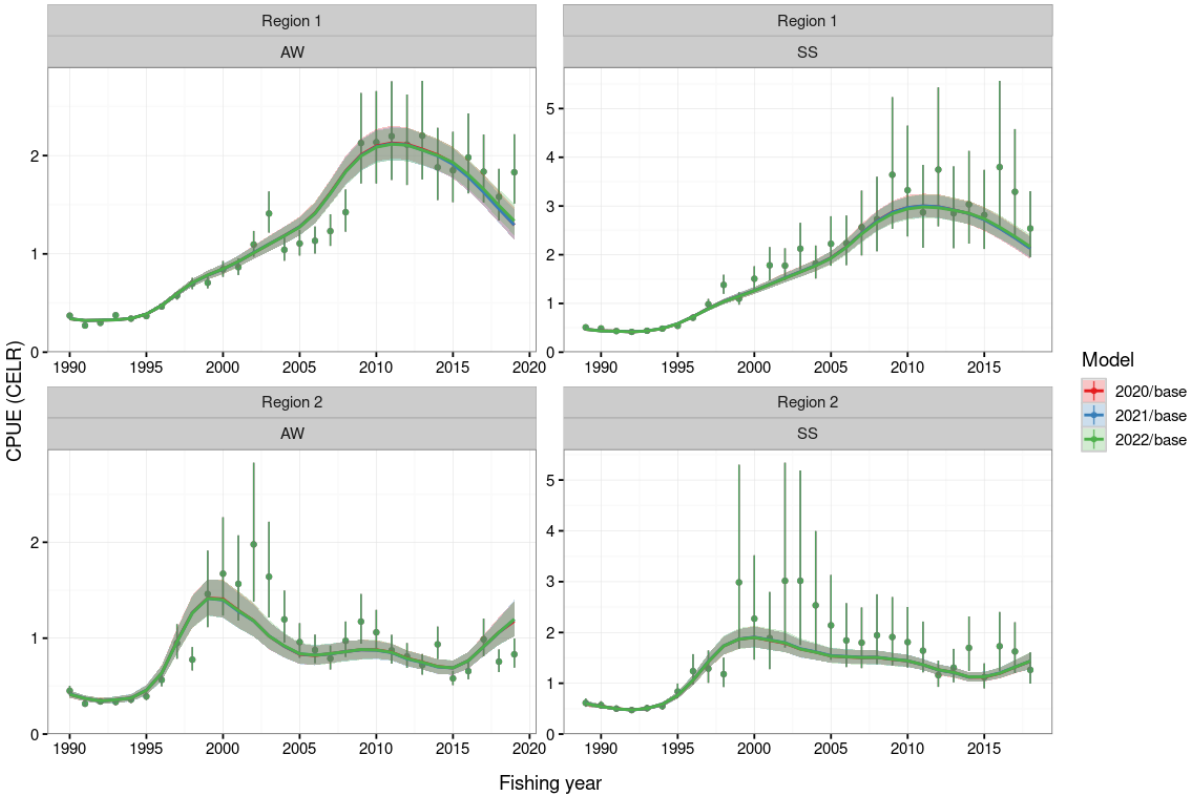


Figure 25: CRA 5 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2020 stock assessment and the 2021 and 2022 rapid updates.

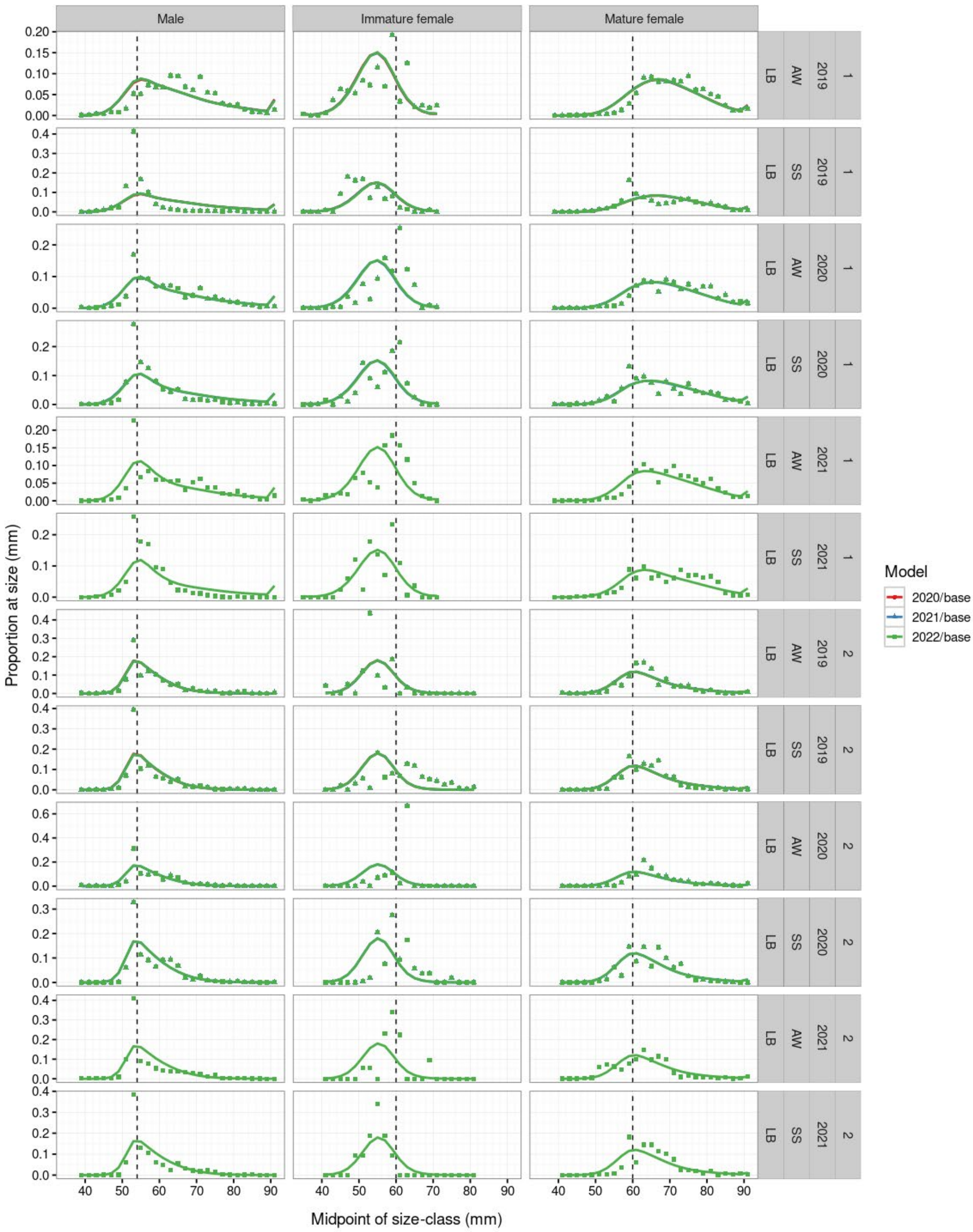


Figure 26: 2019–2021 CRA 5 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year (from 2019 to 2021), season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2020 stock assessment and the 2021 and 2022 rapid updates. Dashed vertical lines represent the minimum legal size for the respective sexes.

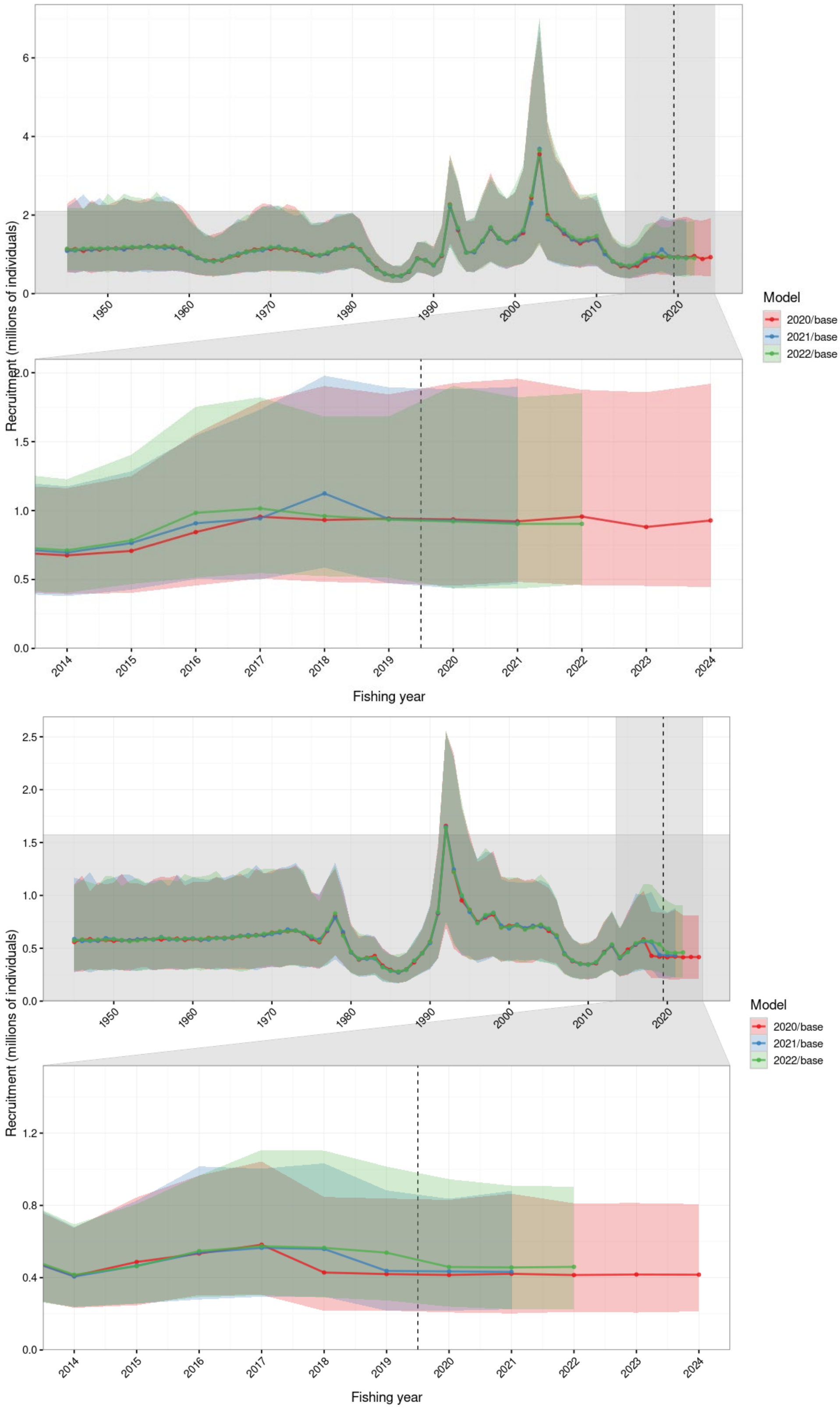


Figure 27: Region 1 (upper panels) and region 2 (lower panels). CRA 5 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021 and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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.

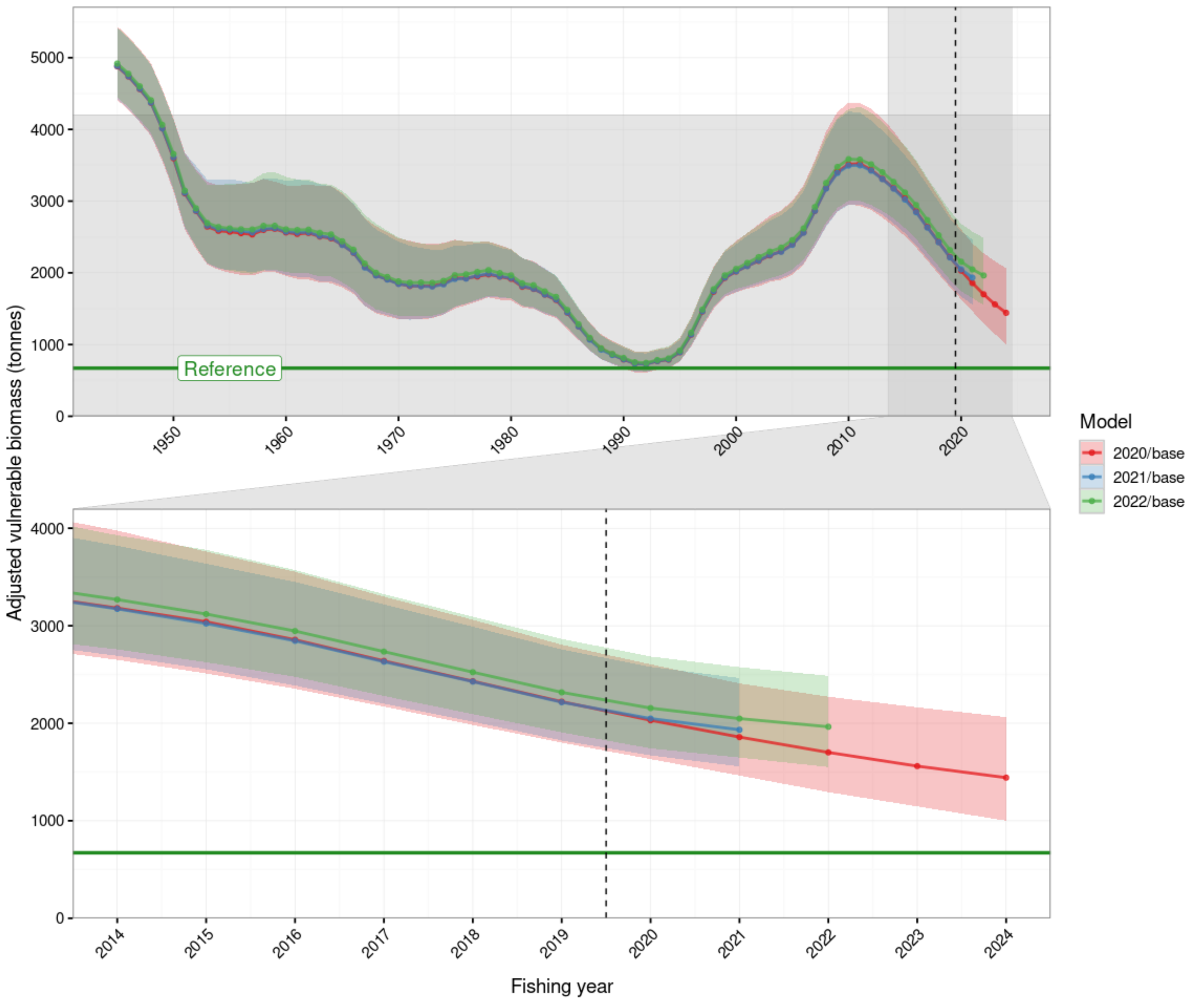


Figure 28: CRA 5 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021 and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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).

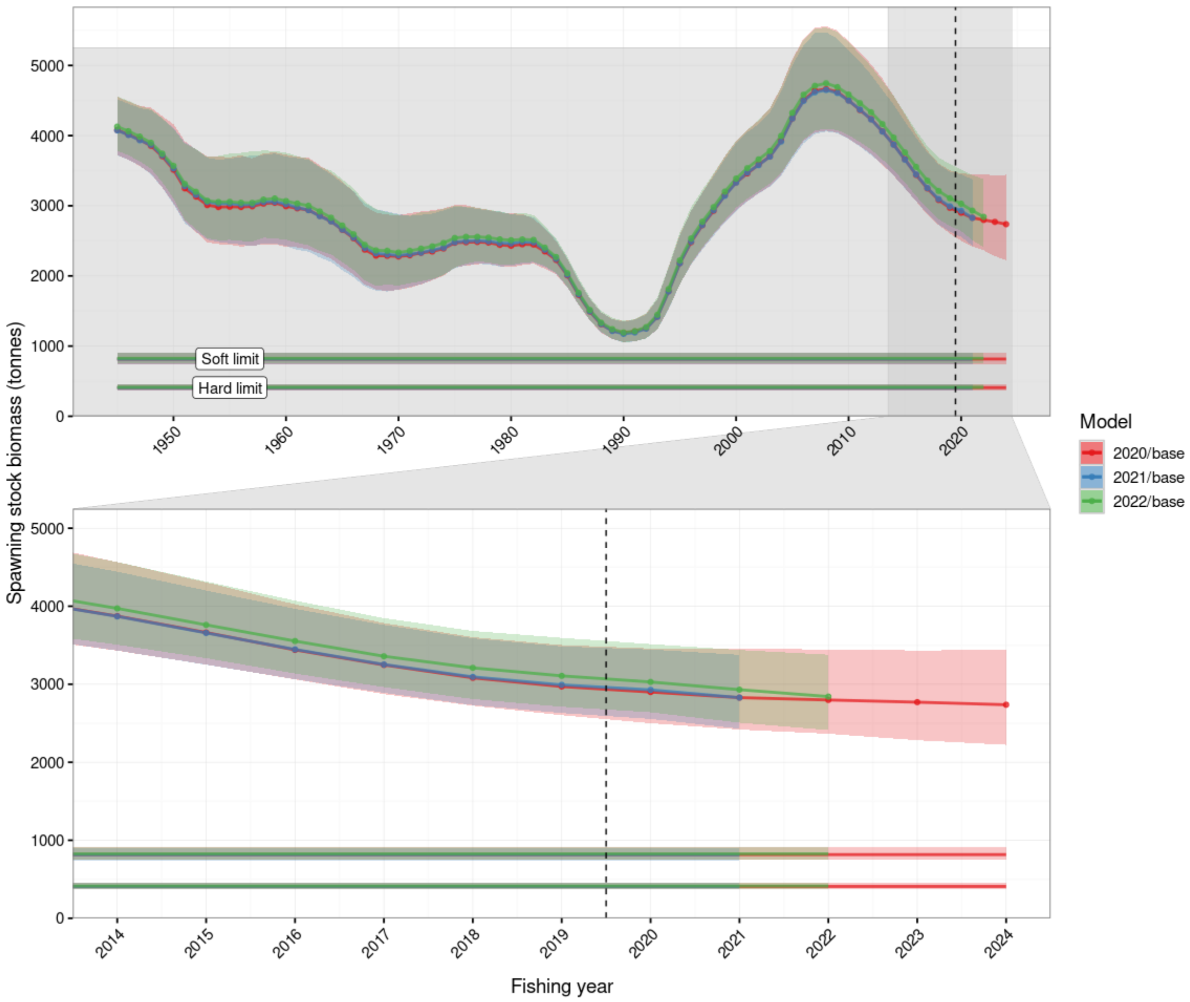


Figure 29: CRA 5 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2020 stock assessment (showing the five projected years) and the 2021 and 2022 rapid updates (showing one projected year). The vertical dashed line indicates final model year 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 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	4 933	4 450	4 918	5 423
B_R	671	–	–	–
B_{2022}	1 986	1 551	1 964	2 486
B_{2022} / B_0	0.403	0.324	0.400	0.488
B_{2022} / B_R	2.959	2.311	2.926	3.704
P($B_{2022} > B_R$)	1.000	–	–	–
SSB_0	4 141	3 786	4 127	4 558
SSB_{2022}	2 860	2 412	2 842	3 379
SSB_{2022} / SSB_0	0.690	0.606	0.688	0.785
P($SSB_{2022} > 20\% SSB_0$)	1.000	–	–	–
P($SSB_{2022} > 10\% SSB_0$)	1.000	–	–	–
F_{MSY} [region 1]	0.118	0.084	0.115	0.159
F_{MSY} [region 2]	0.066	0.066	0.066	0.069
F_{2022} / F_{MSY} [region 1]	1.015	0.849	1.007	1.208
F_{2022} / F_{MSY} [region 2]	1.072	0.843	1.065	1.327
H_{2021} [region 1]	11.110	9.915	11.080	12.430
H_{2021} [region 2]	1.793	1.486	1.779	2.143

Table 17: 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 and 2022 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_base			2022_base		
	5%	50%	95%	5%	50%	95%	5%	50%	95%
Parameters									
R_0[1]	956976	1162150	1483363	944403	1164910	1466379	953979	1178995	1513520
R_0[2]	534223	615921	704749	532448	610511	718960	529898	612705	724961
M	0.168	0.183	0.201	0.167	0.183	0.201	0.167	0.182	0.202
mat50	43.325	46.013	48.360	43.037	46.063	48.157	43.224	46.130	48.230
mat95add	5.959	11.394	18.196	6.412	12.007	18.719	6.645	12.159	18.228
Galpha [male]	3.235	3.297	3.364	3.232	3.297	3.365	3.222	3.294	3.362
Gbeta [male]	2.385	2.599	2.799	2.372	2.569	2.774	2.332	2.536	2.744
Gshape [male]	4.375	4.900	5.469	4.361	4.903	5.456	4.320	4.847	5.396
GCV [male]	0.559	0.569	0.581	0.559	0.570	0.580	0.559	0.570	0.580
Galpha [female]	3.628	3.770	3.906	3.607	3.750	3.901	3.628	3.760	3.900
Gbeta [female]	1.389	1.471	1.556	1.378	1.457	1.538	1.360	1.439	1.523
Gshape [female]	5.204	5.579	5.932	5.308	5.659	5.988	5.300	5.622	5.972
GCV [female]	0.779	0.797	0.816	0.777	0.797	0.817	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
vuln (M, SS) [1]	0.641	0.679	0.717	0.653	0.687	0.722	0.649	0.684	0.721
vuln (IF, AW) [1]	0.371	0.593	0.863	0.444	0.662	0.907	0.448	0.670	0.928
vuln (IF & MF, SS) [1]	0.914	0.976	0.998	0.911	0.974	0.998	0.918	0.979	0.998
vuln (MF, AW) [1]	0.901	0.965	0.996	0.895	0.964	0.997	0.889	0.960	0.995
vuln (M, SS) [2]	0.655	0.696	0.736	0.660	0.701	0.744	0.657	0.701	0.747
vuln (IF, AW) [2]	0.070	0.124	0.205	0.071	0.124	0.205	0.069	0.116	0.200
vuln (IF & MF, SS) [2]	0.291	0.341	0.403	0.295	0.349	0.407	0.290	0.343	0.407
vuln (MF, AW) [2]	0.258	0.296	0.341	0.260	0.302	0.342	0.258	0.297	0.344
selL male [1]	5.024	5.897	6.954	4.973	5.808	6.751	4.896	5.679	6.599
selM male [1]	8.964	10.583	12.560	9.143	10.577	12.541	9.146	10.713	12.697
selL female [1]	3.126	3.549	4.015	3.167	3.541	4.007	3.131	3.538	3.971
selM female [1]	6.018	7.088	8.226	6.174	7.103	8.384	6.048	7.117	8.470
selL male [2]	55.512	56.939	58.605	55.486	56.869	58.417	55.418	56.742	58.128
selM male [2]	66.082	68.558	71.525	66.586	68.725	71.710	66.607	69.139	72.373
selL female [2]	53.950	54.570	55.330	53.928	54.554	55.239	53.915	54.552	55.242
selM female [2]	60.222	61.740	63.278	60.546	61.804	63.361	60.313	61.735	63.406

3.5 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 30).

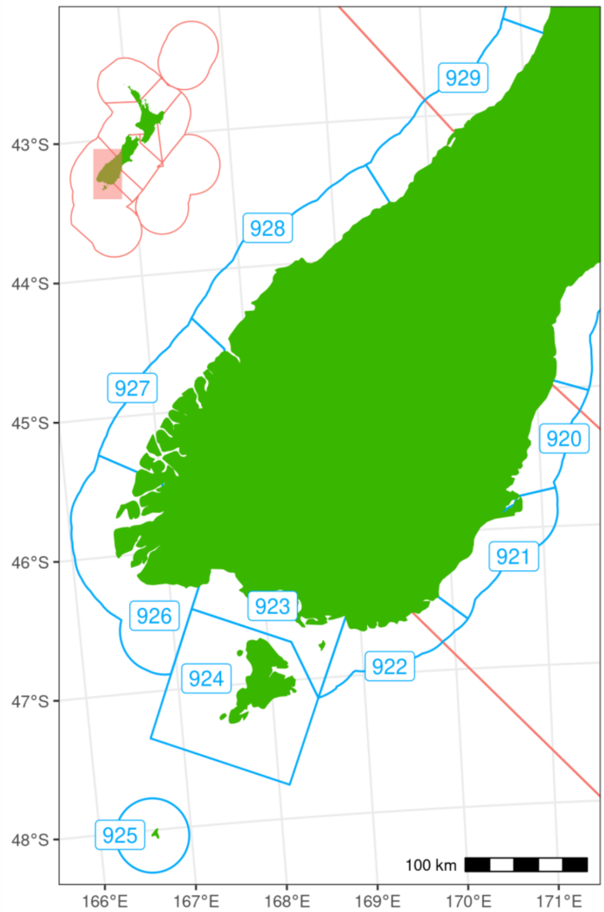


Figure 30: The CRA 7 and CRA 8 Quota Management Area (QMA) boundaries (solid red lines) and statistical area boundaries (solid blue lines).

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 Island statistical areas (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 growth 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, 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 2022 rapid update for CRA 7&8 added one year of data, including: updated catch to 2021–22 (Table 18), LF data for 2021–22 for both regions, and additional tag recovery data up to 2021–22 (Roberts et al. in prep.). 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 2021 full stock assessment. Even though an additional year of data was included in the 2022 rapid update, no data re-weighting was done relative to the last full stock assessment in 2021.

Table 18: 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 rapid update. 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

MCMC trace plots for the 2022 rapid update suggested that mixing was adequate with no signs of non-convergence (see Figure 41 in Appendix I for MCMC diagnostic plots).

The 2022 rapid update fit to the CPUE was very similar to the fit in the 2021 assessment with only minor differences in the last 2 to 3 years for region 1 (Figure 31). The fits to the LFs were very similar to the 2021 stock assessment for the years that overlapped and fitted very well for 2021–22 in both regions (Figure 32).

The 2022 rapid update estimated a small recruitment pulse in 2017–18 for region 1 that was not present in the 2021 stock assessment (Figure 33). For region 2, the recruitment peak observed by the 2021 stock assessment for 2015–16 was estimated to be higher by the 2022 rapid update (Figure 33). Therefore, the 2022 rapid update estimated that the adjusted vulnerable biomass was slightly higher for 2022–23 than was projected by the 2021 stock assessment (Figure 34). Both models estimated almost the same *SSB* for 2022–23 (Figure 35).

The 2022 rapid update estimated that, based on mean values, the overall (i.e., region 1 and region 2 combined) stock at the beginning of 2022–23 was at 24% of B_0, 51% of SSB_0, 1.6 times B_R, and fishing mortality to be below F_{MSY} for region 1 and slightly above F_{MSY} for region 2 (Table 19). The probability of the adjusted vulnerable biomass being above B_R in 2022–23 and the probability of SSB being above the soft and hard limits in 2022–23 were all 100%.

All parameter estimates were similar to the 2021 stock assessment (Table 20).

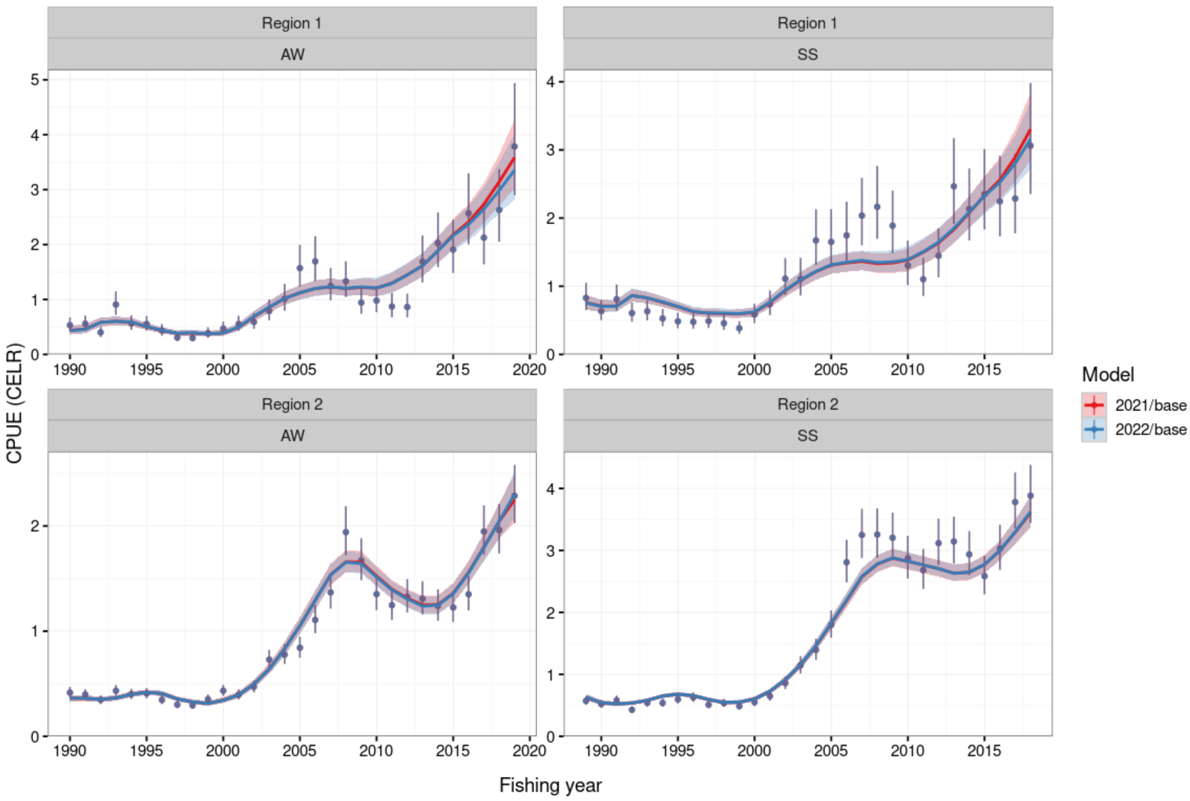


Figure 31: CRA 7&8 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season (AW = autumn/winter, SS = spring/summer) and fishing year (labelled using the first year in the pair) for the 2021 stock assessment and the 2022 rapid update.

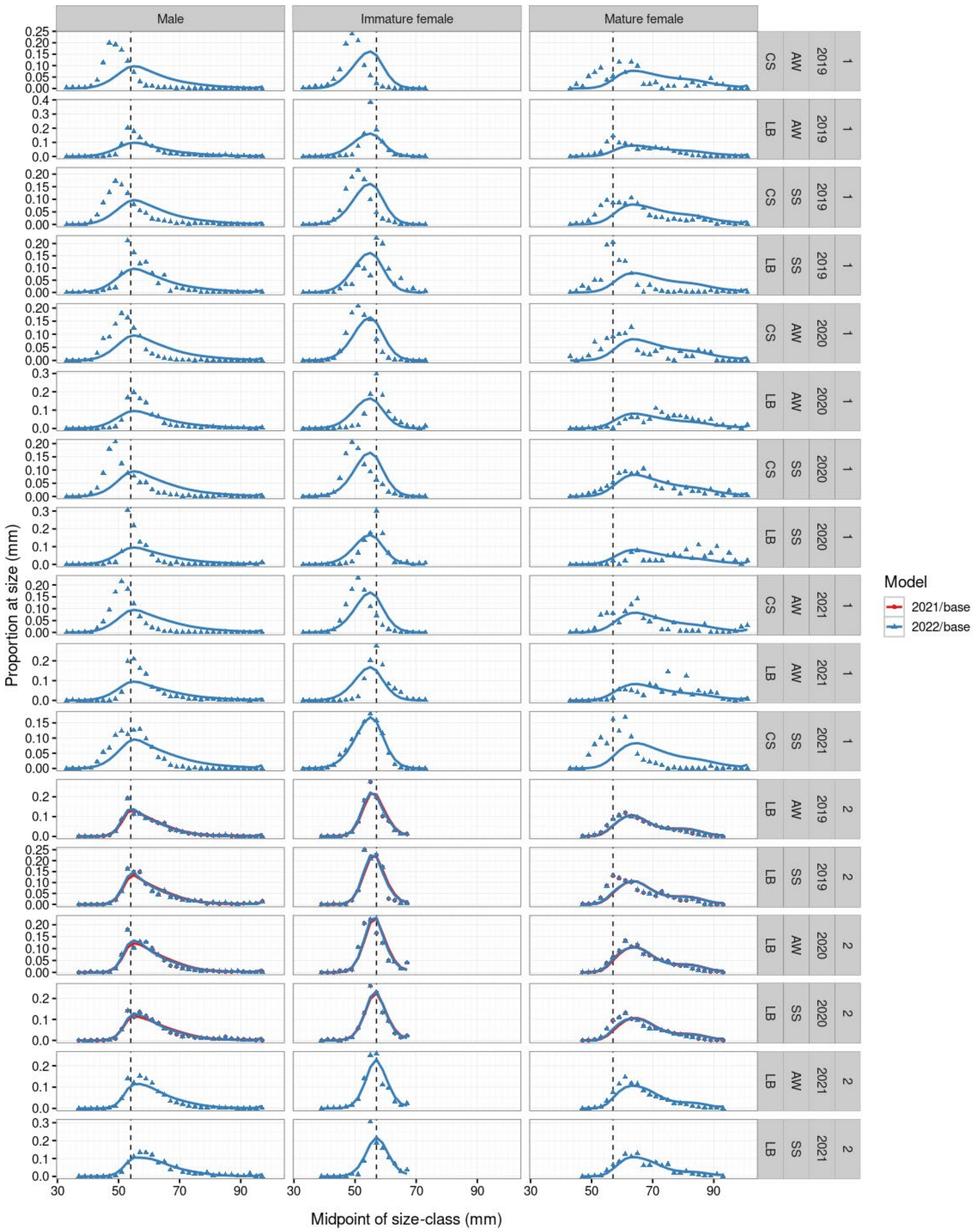


Figure 32: 2019–2021 CRA 7&8 length frequency observations (points) and median of the posterior distribution (line) by region (1 = region 1, 2 = region 2), year, season (AW = autumn/winter, SS = spring/summer), and data source (CS = catch sampling, LB = logbook) for the 2021 stock assessment and the 2022 rapid update. Dashed vertical lines represent the minimum legal size for the respective sexes.

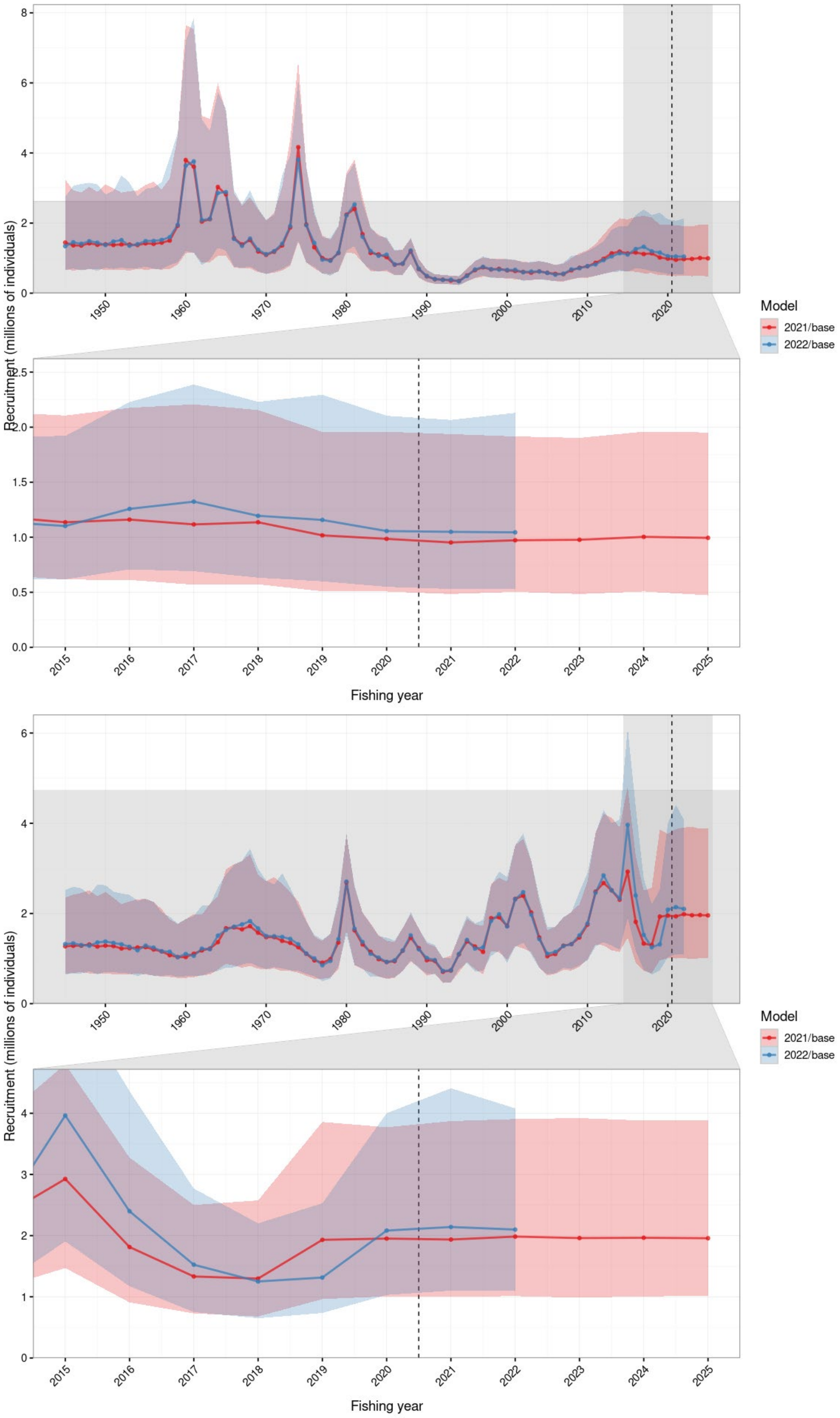


Figure 33: Region 1 (upper panels) and region 2 (lower panels). CRA 7&8 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2021 stock assessment (showing the five projected years) and the 2022 rapid update (showing one projected year). The vertical dashed line indicates final model year 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.

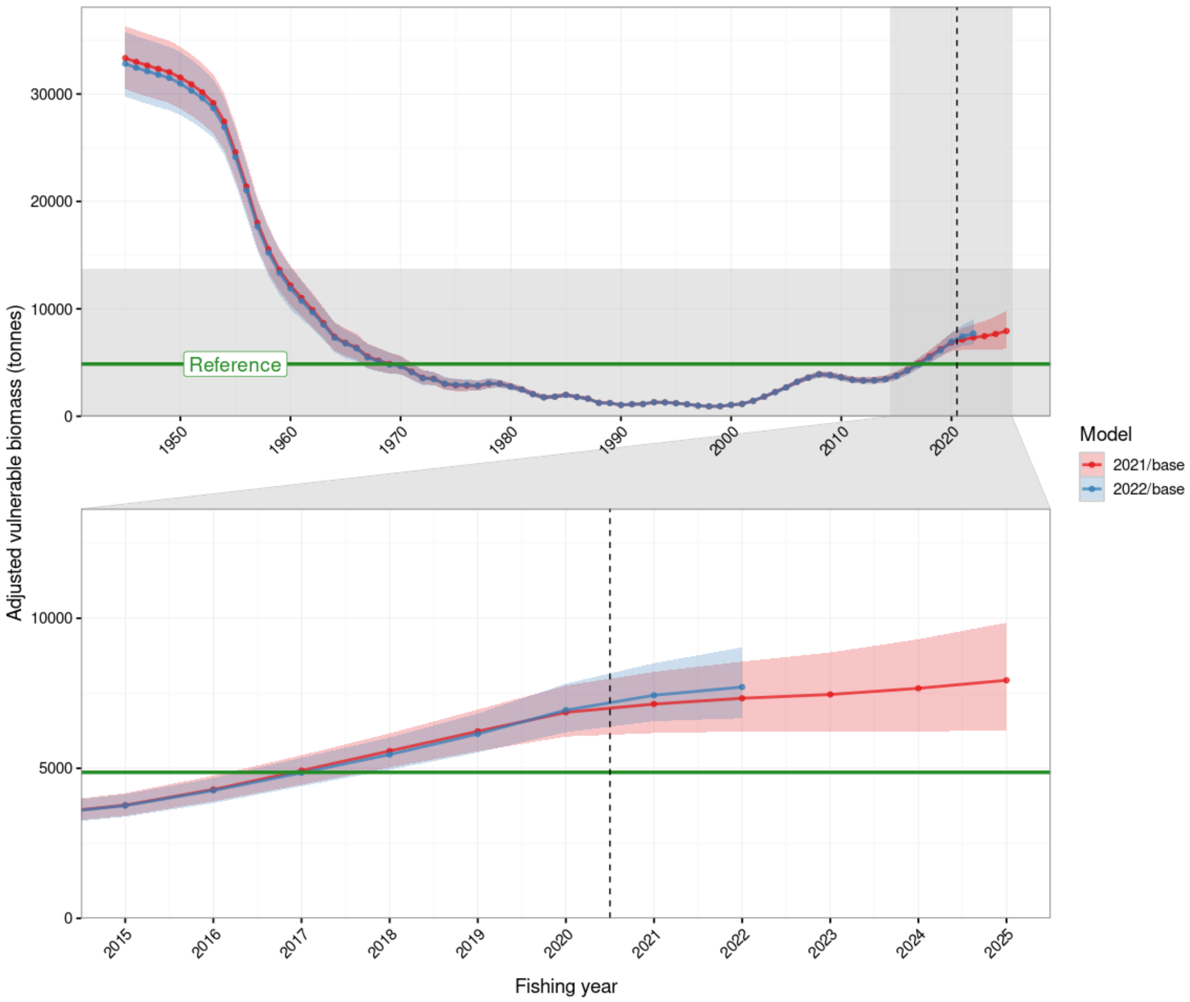


Figure 34: CRA 7&8 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2021 stock assessment (showing the five projected years) and the 2022 rapid update (showing one projected year). The vertical dashed line indicates final model year 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. The reference level (B_R) is shown in both panels (horizontal green line).

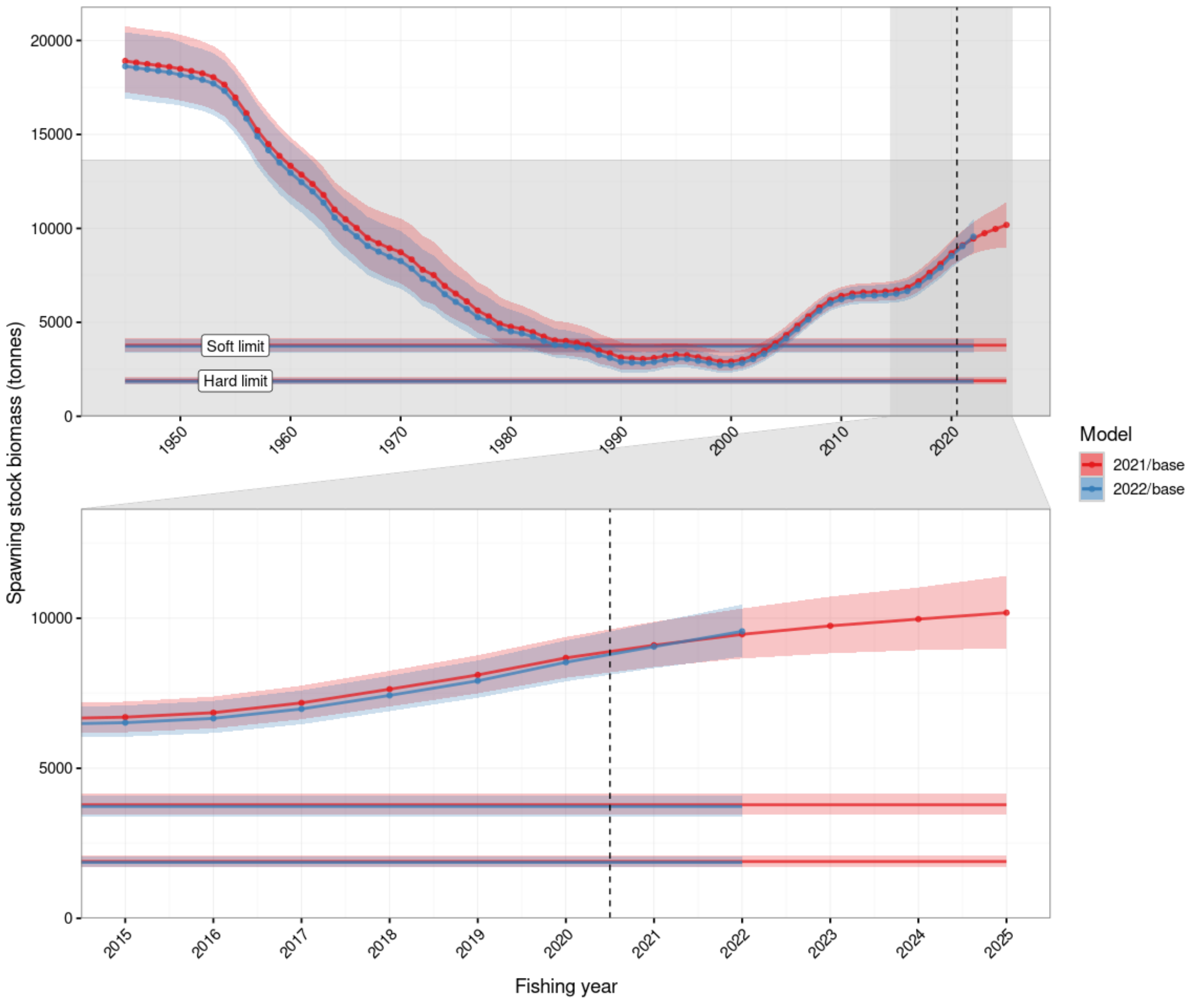


Figure 35: CRA 7&8 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2021 stock assessment (showing the five projected years) and the 2022 rapid update (showing one projected year). The vertical dashed line indicates final model year 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 the soft limit (top horizontal line and shaded region) and the hard limit (lower horizontal line and shaded region).

Table 19: 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	32 813	29 767	32 813	35 753
B_R	4 863	–	–	–
B_{2022}	7 764	6 667	7 706	9 031
B_{2022} / B_0	0.237	0.198	0.235	0.286
B_{2022} / B_R	1.597	1.371	1.585	1.857
P($B_{2022} > B_R$)	1.000	–	–	–
SSB_0	18 653	16 925	18 630	20 439
SSB_{2022}	5 882	5 288	5 882	6 502
SSB_{2022} / SSB_0	0.514	0.472	0.513	0.560
P(SSB_{2022} > 20%SSB_0)	1.000	–	–	–
P(SSB_{2022} > 10%SSB_0)	1.000	–	–	–
F_{MSY} [region 1]	0.119	0.088	0.118	0.154
F_{MSY} [region 2]	0.331	0.260	0.330	0.408
F_{2022} / F_{MSY} [region 1]	1.117	0.976	1.109	1.276
F_{2022} / F_{MSY} [region 2]	0.626	0.521	0.619	0.753
H_{2021} [region 1]	16.630	14.380	16.520	19.160
H_{2021} [region 2]	76.000	69.960	75.930	82.500

Table 20: 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 rapid update. 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_base		
	5%	50%	95%	5%	50%	95%
Parameters						
R_0[1]	1091411	1218670	1372672	1101081	1239970	1420268
R_0[2]	1280379	1444830	1615812	1294541	1484645	1666654
M	0.085	0.093	0.102	0.086	0.095	0.106
mat50	59.319	59.937	60.662	59.350	60.026	60.735
mat95add	8.520	9.527	10.806	8.533	9.475	10.840
Galpha [male]	4.358	4.423	4.496	4.351	4.421	4.493
Gbeta [male]	2.584	2.798	3.025	2.579	2.798	3.035
Gshape [male]	1.475	1.913	3.760	1.497	1.915	2.371
GCV [male]	0.411	0.427	0.444	0.413	0.429	0.445
Galpha [female]	3.788	3.846	3.909	3.784	3.849	3.915
Gbeta [female]	1.553	1.602	1.656	1.559	1.608	1.663
Gshape [female]	3.279	3.507	3.760	3.292	3.531	3.818
GCV [female]	0.357	0.376	0.395	0.357	0.375	0.395
Gobs	1.293	1.316	1.340	1.291	1.315	1.340
vuln (M, SS & IF, AW) [1]	0.785	0.861	0.934	0.779	0.860	0.931
vuln (IF, SS) [1]	0.692	0.833	0.959	0.680	0.829	0.972
vuln (MF, AW) [1]	0.033	0.043	0.056	0.038	0.048	0.062
vuln (MF, SS) [1]	0.055	0.075	0.099	0.063	0.083	0.107
vuln (M, SS) [2]	0.747	0.787	0.836	0.744	0.789	0.840
vuln (IF, AW) [2]	0.466	0.543	0.628	0.454	0.518	0.605
vuln (IF, SS) [2]	0.357	0.421	0.496	0.342	0.407	0.480
vuln (MF, AW) [2]	0.716	0.800	0.899	0.711	0.804	0.910
vuln (MF, SS) [2]	0.646	0.714	0.796	0.650	0.724	0.811
selL male [1]	7.022	7.893	8.922	6.904	7.684	8.562
selL female [1]	7.396	8.243	9.150	7.297	8.164	9.213
selL male [2]	3.764	4.062	4.418	3.740	4.057	4.426
selL female [2]	4.389	4.807	5.272	4.411	4.795	5.233
selM male [1]	56.439	57.901	59.555	56.193	57.543	58.807
selM female [1]	57.192	58.465	59.744	57.011	58.265	59.769
selM male [2]	54.688	55.172	55.727	54.685	55.196	55.811
selM female [2]	56.816	57.525	58.292	56.835	57.488	58.210

4. DISCUSSION

Fisheries New Zealand implemented an electronic catch and effort reporting system for the rock lobster potting fishery in April to 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 and 2021–22 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.

The rapid update system provides 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, CRA 7, and CRA 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 will not be available for the next few years, although an alternative CPUE series for CRA 2, based on catch and effort from logbook data, has been developed (Webber & Starr 2022). This information will be included in future CRA 2 rapid updates but logbook CPUE indices have yet to be developed for any of the other CRA QMAs. Sufficient logbook data for developing CPUE are potentially available for CRA 5 and CRA 8 (Webber & Starr 2022) but 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 return data) will be available to inform future rapid update assessments.

The rapid update system was designed to replace MPs in the short term to help bridge the gap in knowledge while there is no reliable 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 a CELR CPUE series, simulation studies or retrospective analysis of rock lobster stock assessments are needed. 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 to 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 could have impacts.

All projections based on the rapid update recruitment estimates have been omitted from this document because they were rejected by the Plenary for reasons given in the Introduction to this report.

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.

5. ACKNOWLEDGEMENTS

Thank you to all who have worked with us on rock lobster stock assessments including members of the RLWG. Thanks also to Martin Cryer and Leyla Knittweis (both Fisheries New Zealand). Also, thank you to the New Zealand Rock Lobster Industry Council, members of the National Rock Lobster Management Group, and many individual fishers and quota owners in the commercial rock lobster fishery. This research project was awarded to Quantifish Limited by Fisheries New Zealand (project code CRA2022-01).

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7. APPENDIX I: MCMC DIAGNOSTICS

This appendix presents the MCMC trace plots for the CRA 1 (Figure 36), CRA 3 (Figure 37, Figure 38), CRA 4 (Figure 39), CRA 5 (Figure 40), and CRA 7&8 (Figure 41) rapid updates.

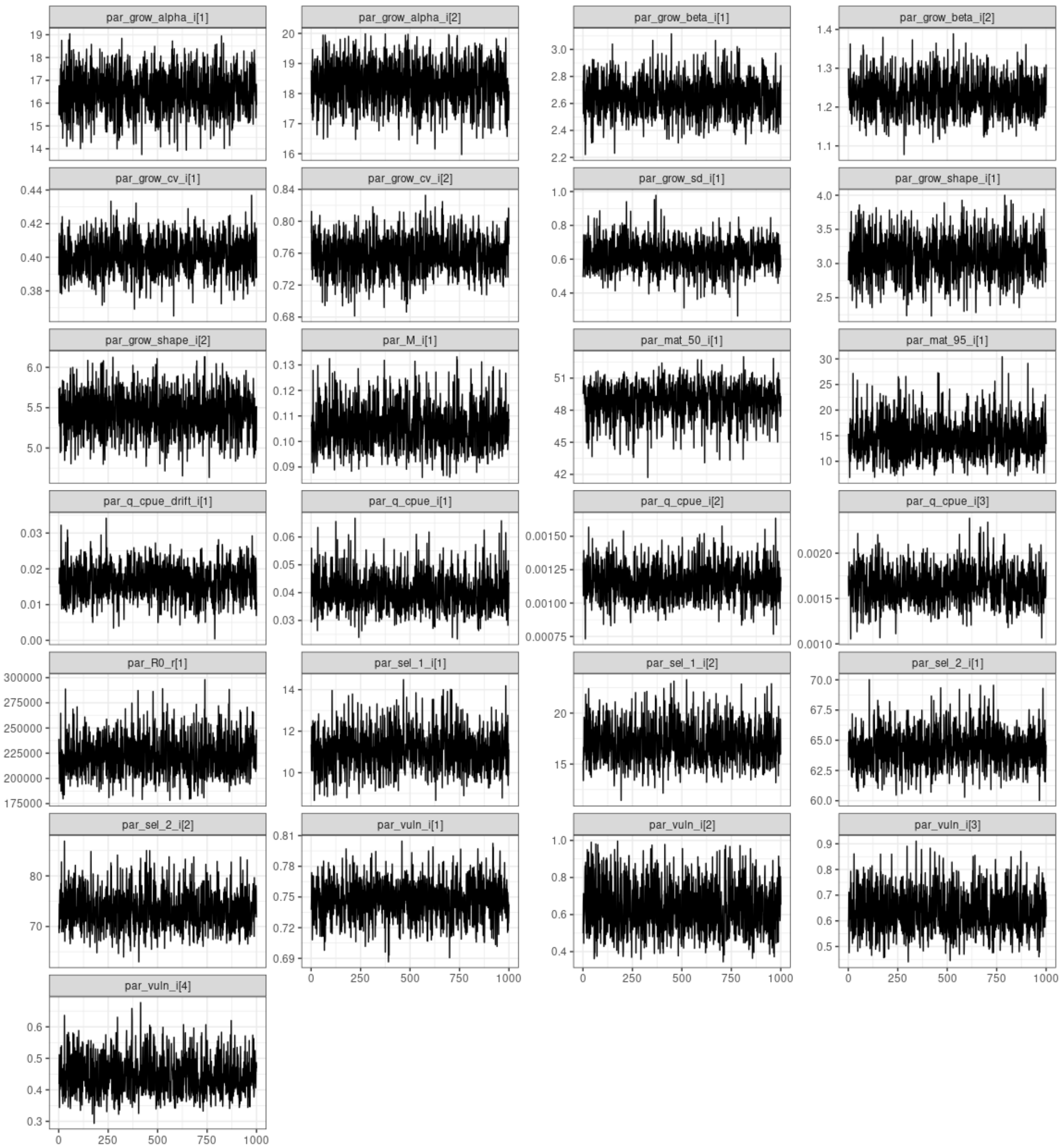

Figure 36: MCMC trace plots for model parameters in the CRA 1 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

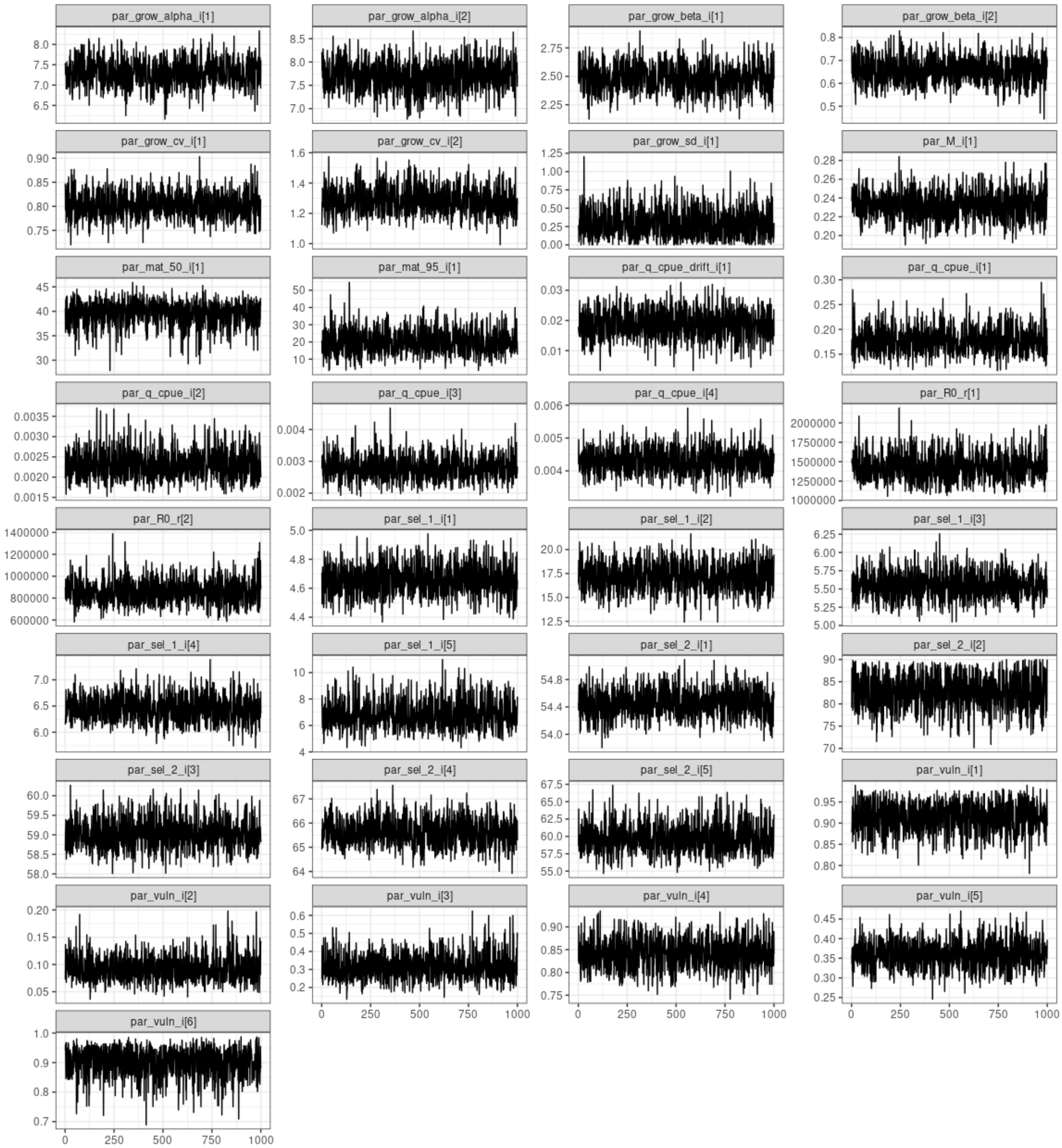

Figure 37: MCMC trace plots for model parameters in the *r1_qdrift* CRA 3 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

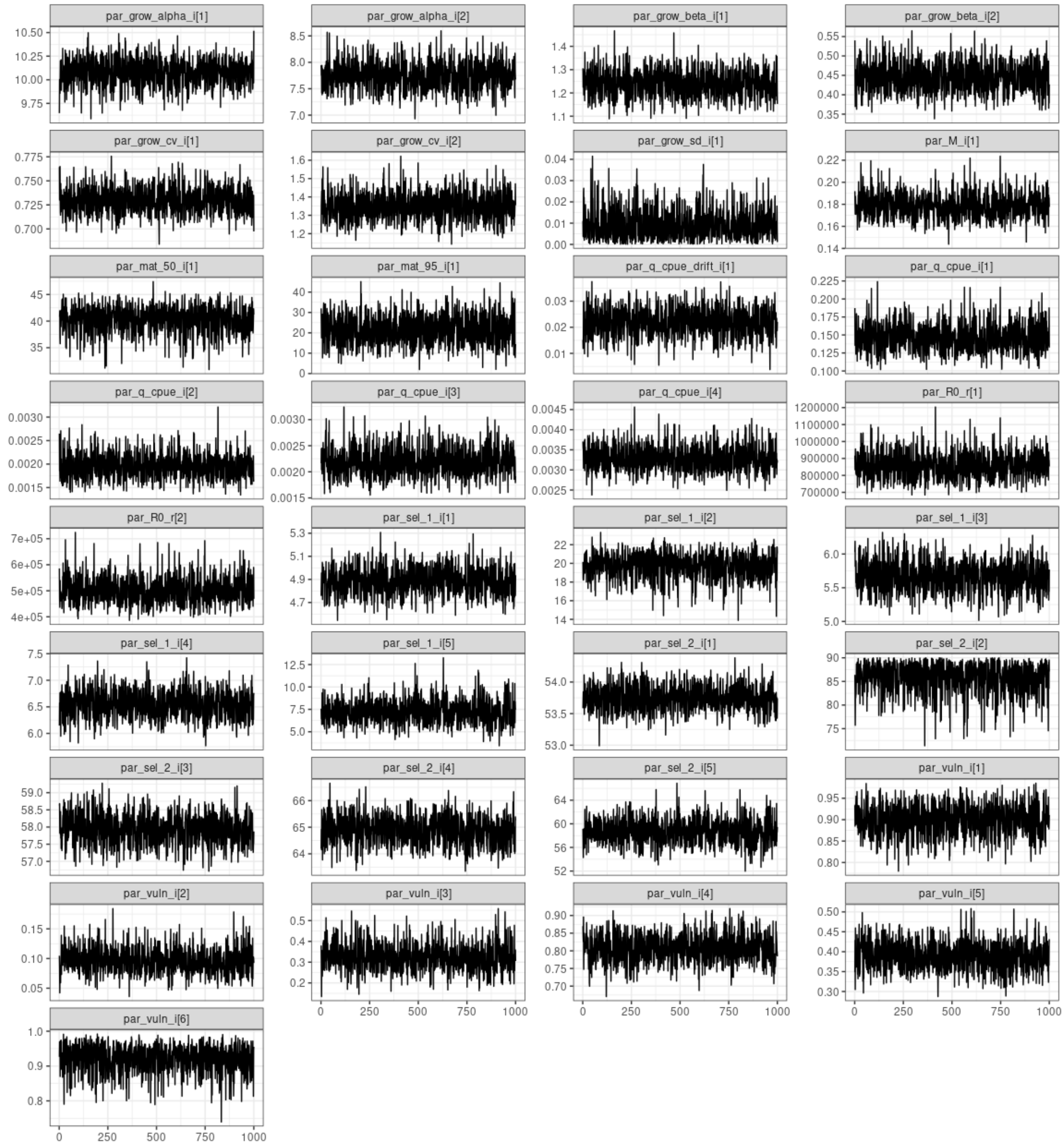

Figure 38: MCMC trace plots for model parameters in the *r2_qdrift* CRA 3 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

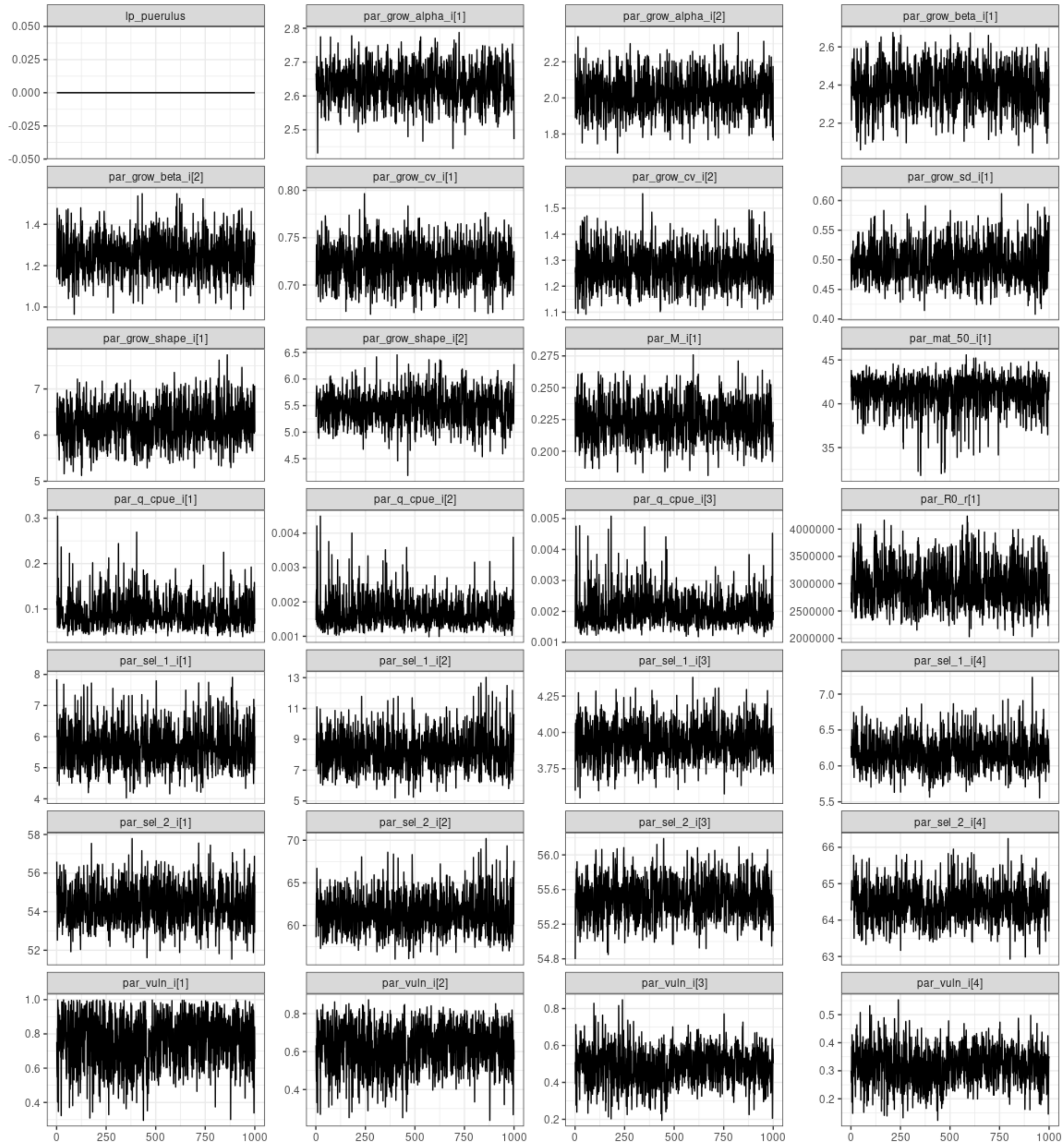

Figure 39: MCMC trace plots for model parameters in the CRA 4 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

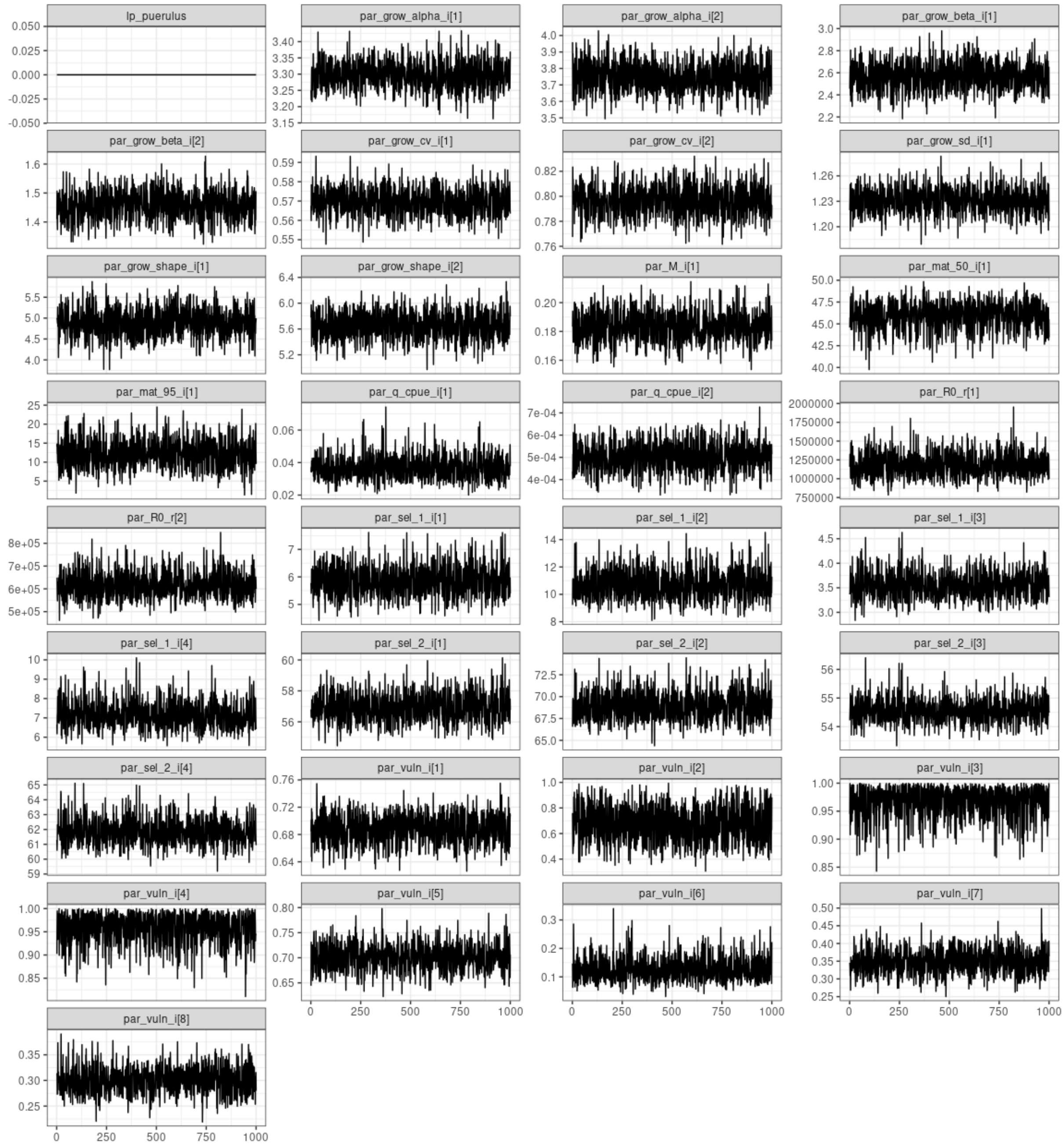

Figure 40: MCMC trace plots for model parameters in the CRA 5 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

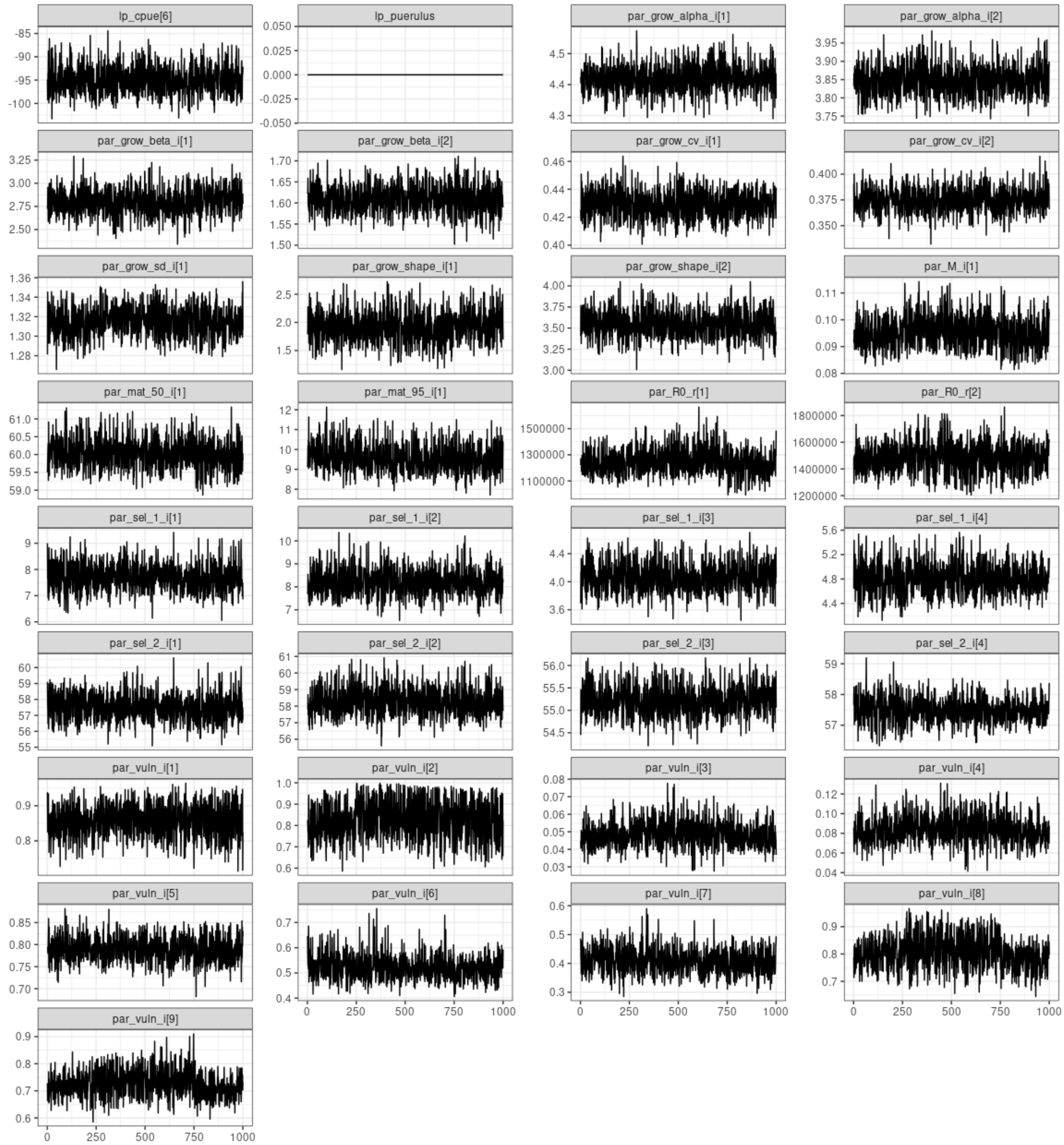

Figure 41: MCMC trace plots for model parameters in the CRA 7&8 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).