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Rapid updates for New Zealand rock lobster (*Jasus edwardsii*) stocks in 2020

New Zealand Fisheries Assessment Report 2021/61

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Webber, D.N.[1]; Rudd, M.B.[2]; Starr, P.J.[3] (2021). Rapid updates for New Zealand rock lobster (*Jasus edwardsii*) stocks in 2020.

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This document describes the operation of rapid updates done in October 2020 that can be used in the future to guide management decisions of New Zealand red rock lobster (*Jasus edwardsii*) Quota Management Areas (QMAs).

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 any new data, implementation of any new structural changes to the model, review of prior specifications for model parameters, and usually runs of many sensitivities to key model assumptions. For rock lobsters, the last few stock assessments have involved five stock assessment scientists over nearly five weeks to complete 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 all the same model settings and assumptions, only updating inputs with new data (e.g., additional years of catch, length frequencies, 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 first rapid updates for three rock lobster QMAs: CRA 1, CRA 2, and CRA 3. Full stock assessments for CRA 4 and CRA 5 were completed in 2020, which implies that these QMAs will be integrated into the rapid update system in 2021, along with CRA 6. The first stock assessments for CRA 7 and CRA 8 using the lobster stock dynamics model are planned for 2021 so these stocks will be integrated into the rapid update system in 2022. There is no accepted stock assessment for CRA 9.

[1] Quantifish Ltd., New Zealand.
[2] Scaleability LLC, Seattle, USA.
[3] Independent contractor.

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 is also valuable to customary Māori and recreational fishers. Commercial rock lobster fisheries have been managed since April 1990 with Individual Transferable Quotas (ITQs) in nine Quota Management Areas (QMAs) which are treated as independent stocks for stock assessment (Breen et al. 2016a, Figure 1).

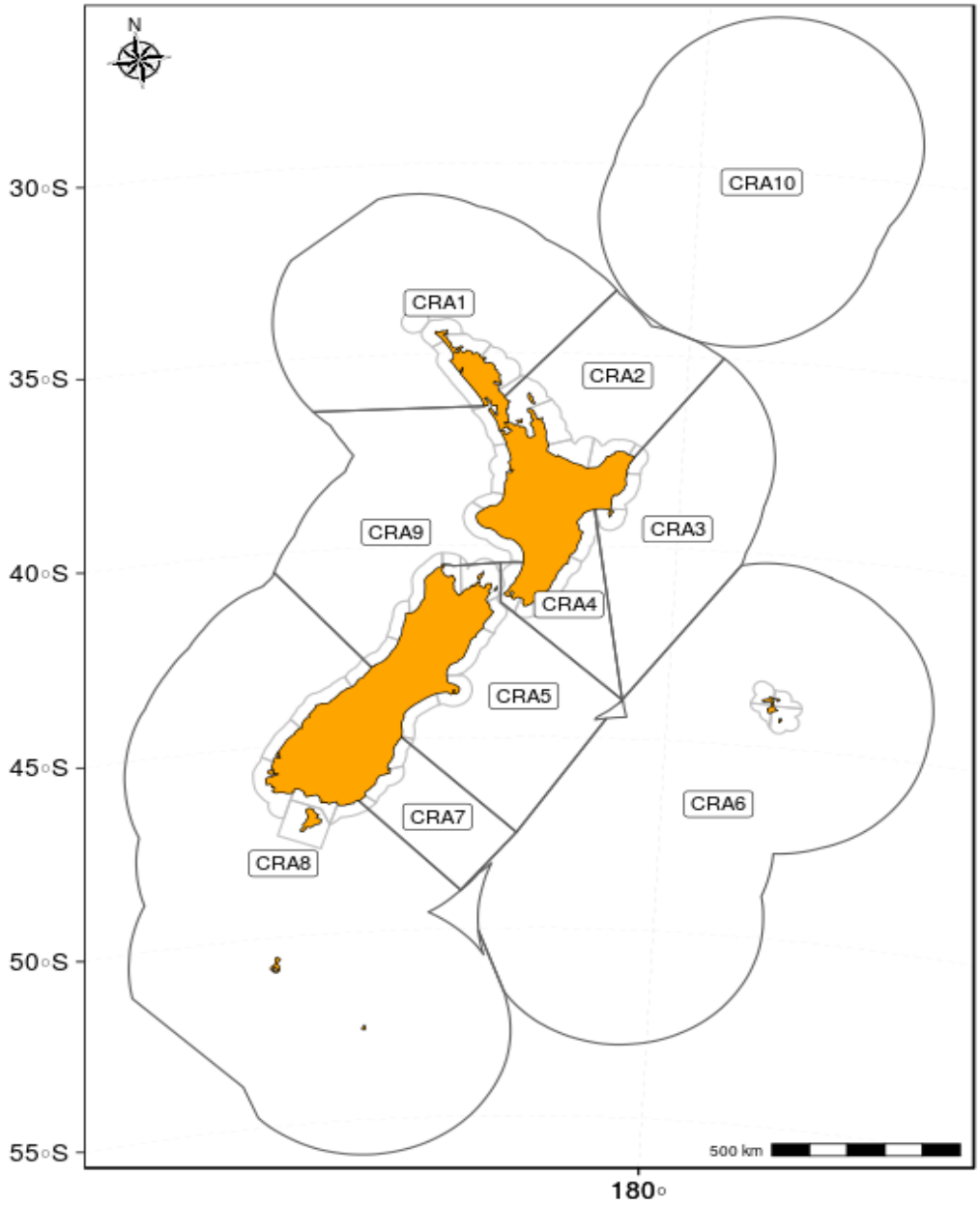

Figure 1: New Zealand red rock lobster (*Jasus edwardsii*) Quota Management Areas (QMAs).

This document describes the new rapid update framework for New Zealand rock lobster stocks and the application of this system to three stocks. A rapid update involves updating all existing data sources required for the stock assessment of a stock with new data for the additional year(s), repeating the base case stock assessment(s) for that stock each year, and producing a short report for all rapid updates. The rapid update system has been designed to provide fishery advice even in the absence of the main abundance index, a catch per unit effort (CPUE) index, and serves to, at least temporarily, replace management procedures (MPs).

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 any new data, implementation of any new structural changes to the model, review of prior specifications for model parameters, and usually runs of many sensitivities to key model assumptions. For rock lobsters, the last few stock assessments have involved five stock assessment scientists over nearly five weeks to complete two stock assessments, working under the guidance of the Rock Lobster Fishery Assessment Working Group (named the Rock Lobster Working Group in 2021[4]).

Rapid updates differ from a full stock assessment because they repeat the previous base case stock assessment models, with all the same model settings and assumptions, only updating inputs with new data (e.g., additional years of catch, length frequencies, 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.

Up to the 2020–21 fishing year[5], MPs were used to manage New Zealand stocks of red rock lobsters (Bentley et al. 2003, Breen et al. 2009, 2016a, 2016b, Bentley & Stokes 2009, Webber & Starr 2018). Management procedures are becoming 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). Management procedures, 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 CPUE as the input and a catch limit as the output. Other controls, such as minimum or maximum change thresholds, may also be used to modify the output.

The 2019 fishing year marked the transition of the collection of rock lobster catch and effort data from a paper-based (CELR) system to an electronic reporting (ER) system dependent on a user interface operated from tablets or smart phones. Presently, there are three different ER reporting 'platforms', each with different user interfaces and slightly different underlying software. Preliminary analyses of the 2019 data indicated that the estimated catches returned using the new ER system differed from the equivalent estimates generated by the previous CELR forms (see appendix B of Starr 2021). Therefore, the Rock Lobster Working Group (RLWG) agreed to temporarily suspend updating CPUE indices beginning with the 2019 spring/summer season; the RLWG concluded that, with the exception of CRA 7, there remained sufficient CELR data for each of the QMAs to ensure comparability with previous indices for the autumn-winter (AW) 2019 data. This meant that, after the 2019 AW season, CPUE was no longer available to monitor the abundance of New Zealand rock lobster and was not available for use in MPs.

This document describes rapid updates of three rock lobster stocks (CRA 1, CRA 2, and CRA 3). Full stock assessments for CRA 4 and CRA 5 were completed in 2020 so no rapid updates were required. A stock assessment for CRA 6 was done in 2018 (Rudd et al. 2019) but was not incorporated into the rapid update system due to time constraints. The stock assessments for CRA 4, CRA 5, and CRA 6 will be integrated into the rapid update system in 2021. The first full stock assessments for CRA 7 and CRA 8 using the lobster stock dynamics (LSD) model are planned for 2021 so again no rapid updates will be required, and these stocks will be integrated into the rapid update system in 2022. There is no accepted stock assessment for CRA 9 so this stock cannot be included in the rapid update system for the time being.

[4] Note that from here on in this report the Rock Lobster Fishery Assessment Working Group is referred to as the Rock Lobster Working Group (RLWG), including for text reporting on past methods and meetings.
[5] Most years in this document refer to the April-March statutory fishing year using the first year in the pair. Thus, the 2020–21 fishing year is designated as 2020.

2. METHODS

Data requests are the first step in the operation of rapid updates. Data requests are submitted to Fisheries New Zealand for monthly harvest returns, observer catch sampling, voluntary logbook, and tag-recapture data. No data requests were submitted for CELR data in 2020 because the CPUE series is temporarily discontinued and the rock lobster stock assessment team already had a CELR data set current up to and including the 2019 fishing year.

Commercial catch is updated to what was actually taken by season each fishing year. Five-year projected catch is updated with revised predictions, given the new catch information and any known future changes due to planned management interventions.

Recreational catch is updated using the procedure from the base model for each stock assessment. Estimated recreational catch is either assumed to be proportional to the spring-summer (SS) abundance as reflected in the SS CPUE (as was done for CRA 1, CRA 2, CRA 3, CRA 4, and CRA 5) or constant over time (CRA 6, CRA 7, and CRA 8). When recreational catch is assumed proportional to the SS abundance, the following steps are taken:

1) Surveyed recreational catch in tonnes is a function of the mean number of lobsters in each survey year multiplied by the mean recruited SS weight for sampled lobsters in the survey year. These samples can come from direct sampling at recreational landing sites or from the commercial sampling data, depending on availability.
2) The estimated recreational catch from 1979 onwards is 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 CVs for each survey, or b) a power function with two parameters to relate SS abundance to the survey estimates. Rapid updates for CRA 1, CRA 2, and CRA 3 all used the scalar approach to estimate recreational catch relative to SS abundance.
3) Recreational catch in 1945 is assumed to be 20% of 1979 recreational catch and follows a linear trajectory from 1945 to 1979.

Because SS CPUE was unavailable for the 2019 fishing season due to the change to electronic reporting, the SS CPUE in 2019 was assumed to be the average of the last three years of the SS CPUE series.

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

In the past, Fisheries New Zealand has provided estimates of current and historical illegal and customary catches. The illegal catch estimates have been rejected by the RLWG and replaced by estimates of illegal catch based on a percentage of the commercial catch. Annual illegal catch is now assumed to be constant at a fixed percentage of total commercial catch over the time period or distributed between years proportional to the annual standardised CPUE series. Beginning with the 2019 fishing year, the CPUE used to estimate illegal catch was the mean of the previous three years’ CPUE because CPUE is not estimated from electronic reporting.

Catch is split between seasons from 1979 onwards, where 90% of recreational and customary catch are assumed to be taken in the SS and the remainder in the AW. Illegal catch is assumed to have the same seasonal split as commercial catch.

Projected recreational, customary, and illegal catches are fixed at the assumed value in the final fishing year. Projected commercial catch is specified by fishing year (and region where applicable) and split by season based on the relationship between the proportion of the catch taken during the AW and the predicted AW CPUE from 1993 to the final model year.

CPUE standardisations, if needing an update, were done in the R package *brms* for each stock. In the future when all stocks have been assessed, these series will remain static.

Length frequency (LF) data come from both observer catch sampling and the voluntary logbook programme, with the years contributed by each data source varying by QMA. The logbook data extract comes from FishServe, including a potlift number and trip number. Season was assigned based on potlift month. Sex codes greater than or equal to '3' were assigned to the mature female category, while '1' was assigned to males and '2' to immature females.

Due to a bug in the data loggers in 2019 which returned invalid dates, 16 049 observations were assigned to the date 1 April 2019 to ensure they were assigned to the 2019 fishing year. However, these samples were not accurately associated with the correct fishing month/season, which is required for the LF data. For now, these observations were removed from the dataset, with 84 observations removed from CRA 1, one observation removed from CRA 2, and no observations removed from CRA 3.

Observer catch sampling data were extracted from the Fisheries New Zealand Rock Lobster Catch Sampling database (*rlcs*, Mackay & George 2018). Information on individual lobster tail-width (TW) measurements were joined by sample number, sample type, and effort number.

Besides the data logger bug in 2019, LF data were removed if there was only a single participant in the logbook programme during a fishing year, or less than 100 TW measurements were taken to characterise the length distribution within a season/sample type stratum. Data were aggregated into 2 mm TW size bins starting at 30 mm TW as the minimum and usually with 90 mm as the maximum accumulator bin (although the maximum bin varied by QMA).

Each LF data record comprised pooled measurements taken from all months in the season and statistical area within the QMA or region. For each month/area stratum, the numbers-at-length were summed for each sex and divided by the total numbers-at-length to calculate proportion-at-length. Proportions-at-length were then adjusted for their 'representativeness' based on the catch in the month/area compared with total catch for the season, then re-normalised to sum to 1 across each sex. A relative weight was assigned to the overall LF dataset, as well as a relative weight for each sex and data record. These weightings combined the representativeness of each month/area cell, the cube root of the number of fish measured, and the cube root of the number of days sampled (Starr et al. 2020a, Starr et al. 2020b).

Tag-recapture data were extracted and processed annually. Key steps in data processing included:

1. removing duplicate records, tags not recaptured, records missing any type of length measurement (TW and carapace length), and records with unreasonable TW, time at liberty, or growth increment;
2. assigning period, stage, statistical area based on latitude and longitude (or the statistical area included in the data extract if the latitude and longitude are missing), and QMA determined by statistical area; and
3. formatting the data for the LSD model input.

The results of this data updating procedure allow for an additional recruitment deviation to be estimated. Otherwise, all model specifications remain as they were in the original base case stock assessment. These static specifications include the priors and bounds for estimated model parameters, the reference level B_R (Rudd et al. in press), and all structural assumptions to do with growth, maturity, selectivity, and vulnerability. All rapid update models are run using the lobster stock dynamics (LSD) model (Stan Development Team 2017, Webber et al. 2018a). A list of parameter and derived quantity definitions is provided in Table 1 and Table 2.

Table 1: Definitions of parameters discussed in the text.

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	size where 50% of immature females become mature
Mat95add	difference between *Mat50* and the size 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	standard deviation of growth-at-size divided by growth-at-size
Gobs	standard deviation of observation error for tag recaptures
SelLH	shape of the left-hand limb of the selectivity curve (as if it were a standard deviation)
SelM	size 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)
Gdd	density-dependent growth parameter

Table 2: Definitions of derived quantities discussed in the text including reference points and performance indicators.

Variable	Description
Reference points	
B_0	beginning of season AW adjusted vulnerable biomass before fishing
B_{YEAR}	beginning of season AW adjusted vulnerable biomass for the specified fishing year
B_R	reference level in terms of AW adjusted vulnerable biomass (Rudd & Webber in prep.)
SSB_0	female AW spawning stock biomass before fishing
SSB_{YEAR}	female spawning stock biomass at beginning of the specified fishing year AW season
Performance indicators	
B_{YEAR} / B_0	ratio of B_{YEAR} to B_0
B_{YEAR} / B_R	ratio of B_{YEAR} to B_R
B_{YEAR1} / B_{YEAR2}	ratio of B_{YEAR1} to B_{YEAR2}
SSB_{YEAR} / SSB_0	ratio of SSB_{YEAR} to SSB_0
SSB_{YEAR} / SSB_{YEAR}	ratio of SSB_{YEAR1} to SSB_{YEAR2}

3. CRA 1 RAPID UPDATE

CRA 1 is the northernmost rock lobster stock in New Zealand (Figure 1, Figure 2) and it extends from Kaipara Harbour on the west coast to the Waipu River, south of Bream Bay and Whangarei on the east coast. This QMA includes the Three Kings Islands, designated by a separate statistical area (901).

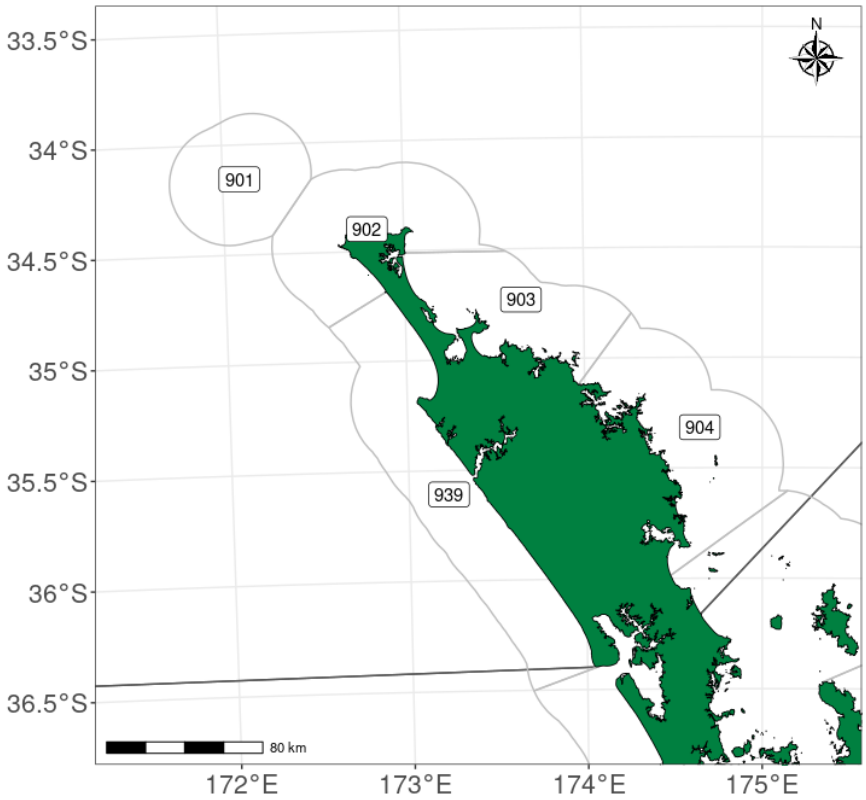

Figure 2: CRA 1 QMA and its statistical areas.

The CRA 1 stock assessment was last done in 2019, with the assumption CRA 1 was a single region (Rudd et al. 2021). at the same time that the CRA 3 stock assessment was completed. The model was fit to standardised CPUE indices, length frequency data, sex-ratio data, and tag-recapture data. The stock assessment estimated increasing fishing mortality from 1945 to the late 1960s, resulting in a decline in biomass. Since the 1990s, size-limited catch remained relatively stable, with an increase in non-size-limited catches over time. The stock assessment estimated that the spawning stock biomass remained above the soft limit of 20% SSB_0. Although CPUE had been increasing, the 2019 projections predicted that continued harvest at existing catch levels would likely lead to a decline in the vulnerable and spawning stock biomass.

The rapid update for CRA 1 added a single year of additional data including: a single CPUE index for the AW 2019 fishing year (the SS 2019 was not included because of the change from paper to electronic forms), logbook and catch sampling LFs for both AW and SS 2019, and additional tags. The commercial catch that was actually taken was included up to 2019, and the projected catch from 2020 to 2024 was updated to reflect management changes (Table 3).

Markov chain Monte Carlo (MCMC) trace plots for the rapid update suggested that mixing was adequate with no signs of non-convergence (see Appendix I for MCMC diagnostic plots). The rapid update fit to the CPUE was almost indistinguishable to the fit in the 2019 assessment. The fit to the new CPUE point was reasonably good, suggesting that CPUE was about the same as last year (Figure 3). The same pattern was observed for the fits to the LFs, with fits that were almost indistinguishable during the 2016, 2017, and 2018 fishing years and reasonable fits to the 2019 LFs (Figure 4). The rapid update suggested that recruitment was higher in 2016 and lower in 2017 when compared with the 2019

assessment (Figure 5). Projected recruitment for the next five years was assumed to be about the same as the original base assessment. The rapid update suggested that the adjusted vulnerable biomass was lower than projected in 2020 but remained roughly the same for the next five years (Figure 6). The spawning stock biomass was projected to increase over the next five years, but not as quickly as was projected in 2019 (Figure 7).

The rapid update suggested that the stock was at 15% of B_0, 38% of SSB_0, and above the interim reference level in 2020 (Table 4). At the assumed projected levels of catch and recruitment, the stock was projected to increase and therefore remain above the interim reference level.

The CRA 1 rapid update was accepted by the RLWG.

Table 3: CRA 1 commercial catch (tonnes) for the last four fishing years and the five projection years in the 2019 base case model compared with the last five fishing years and the five projection years in the 2020 rapid update. All projection years are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2019/base												
2015	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	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	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	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	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2020	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2021	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2022	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2023	–	–	130.56	–	–	31.48	–	–	10.00	–	–	37.68
2020/base												
2015	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	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	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	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	70.06	56.85	126.91	2.83	16.1	28.30	1.00	9.00	10.00	16.10	13.06	29.16
2020	–	–	110.00	–	–	28.30	–	–	10.00	–	–	29.16
2021	–	–	110.00	–	–	28.30	–	–	10.00	–	–	29.16
2022	–	–	110.00	–	–	28.30	–	–	10.00	–	–	29.16
2023	–	–	110.00	–	–	28.30	–	–	10.00	–	–	29.16
2024	–	–	110.00	–	–	28.30	–	–	10.00	–	–	29.16

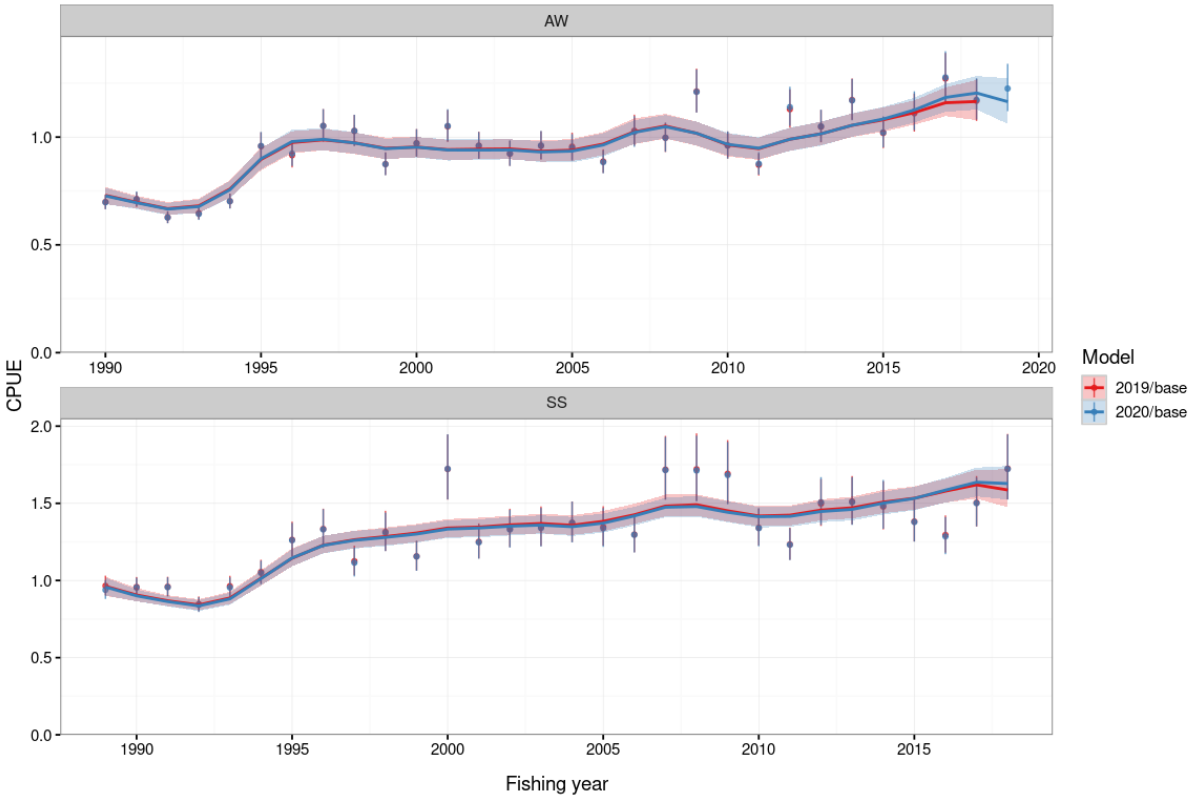

Figure 3: CRA 1 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season for the 2019 stock assessment and the 2020 rapid update.

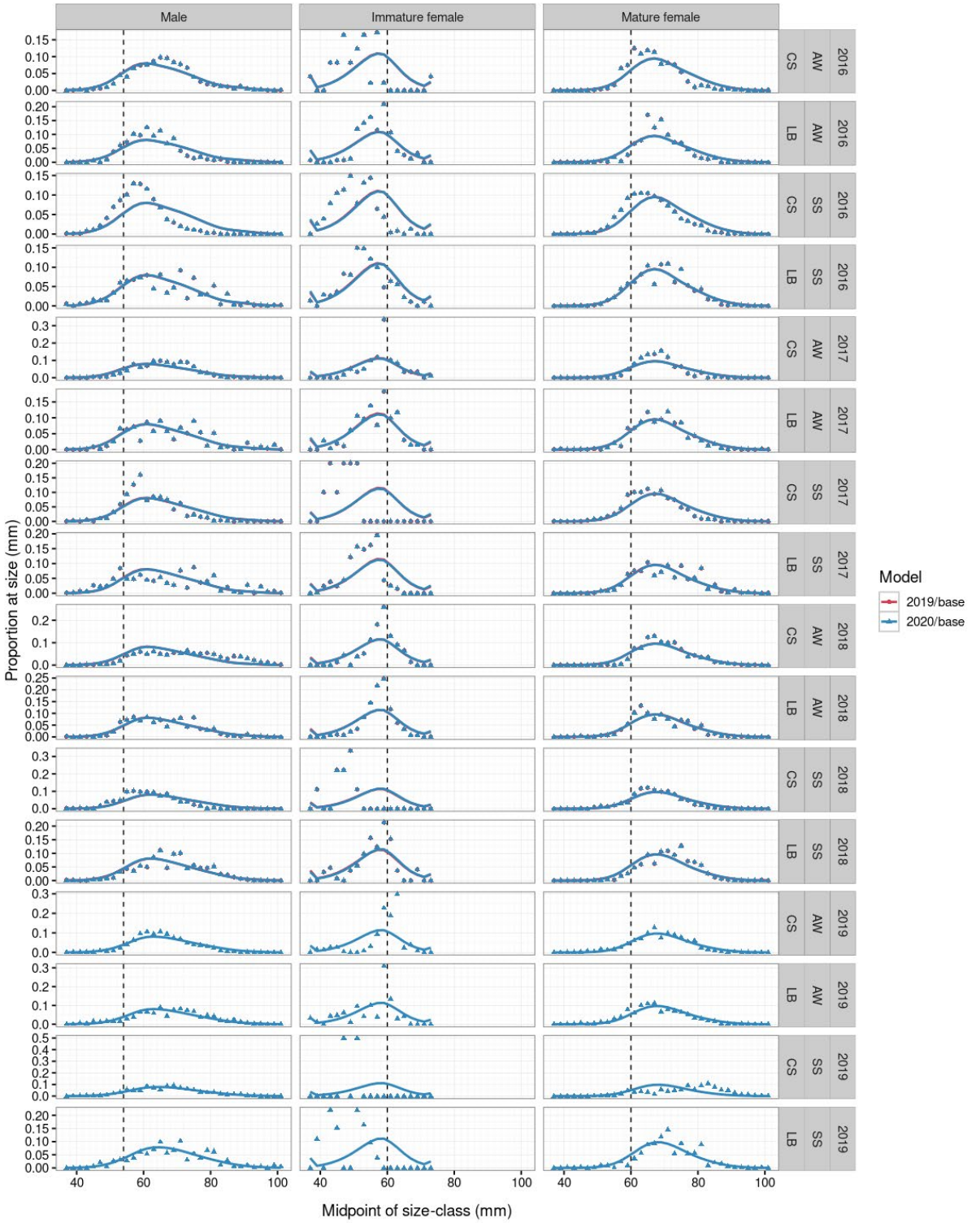

Figure 4: CRA 1 length frequency observations (points) and median of the posterior distribution (line) by year, season, and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2020 rapid update.

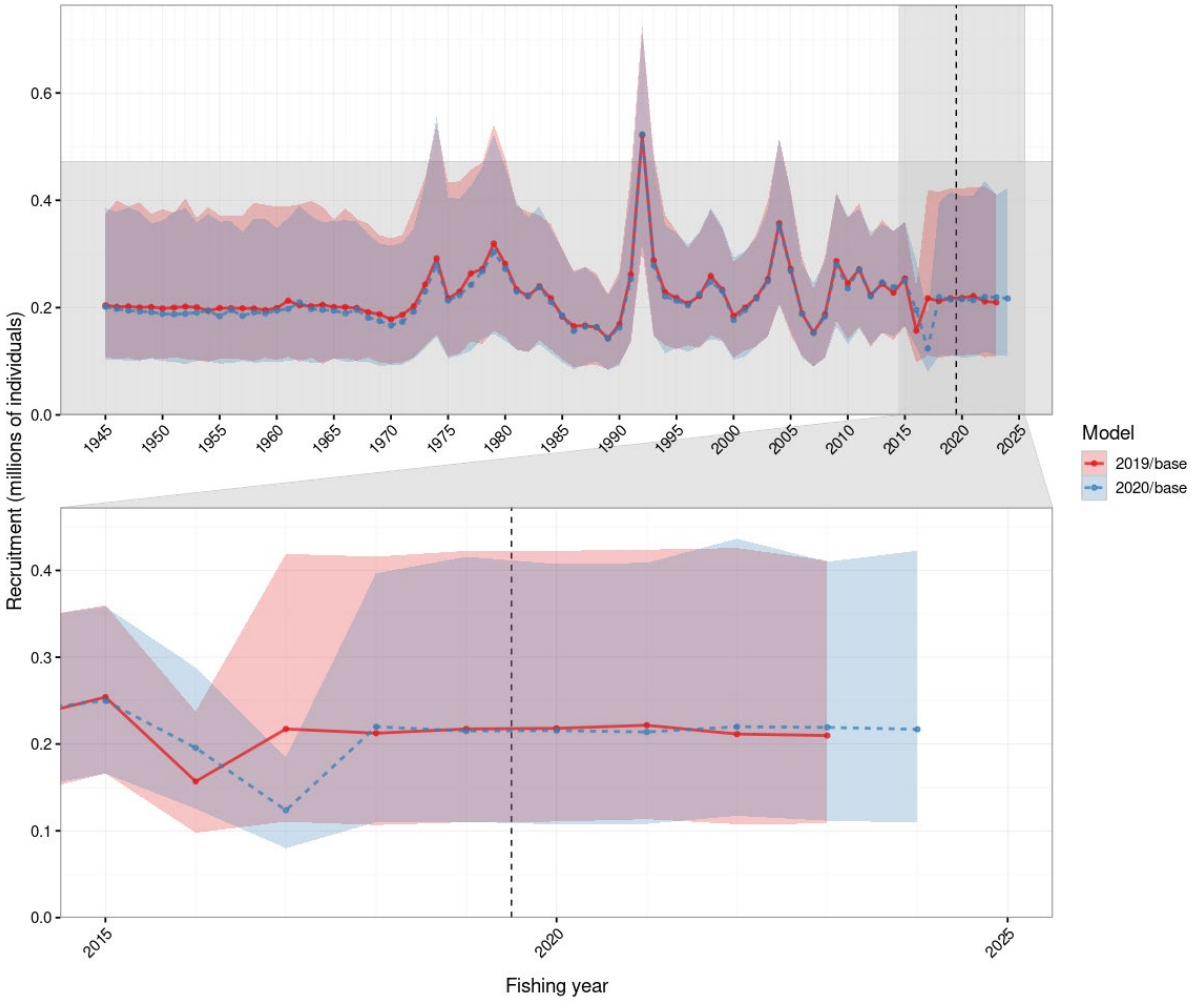

Figure 5: CRA 1 posterior distribution of recruitment showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment and the 2020 rapid update. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

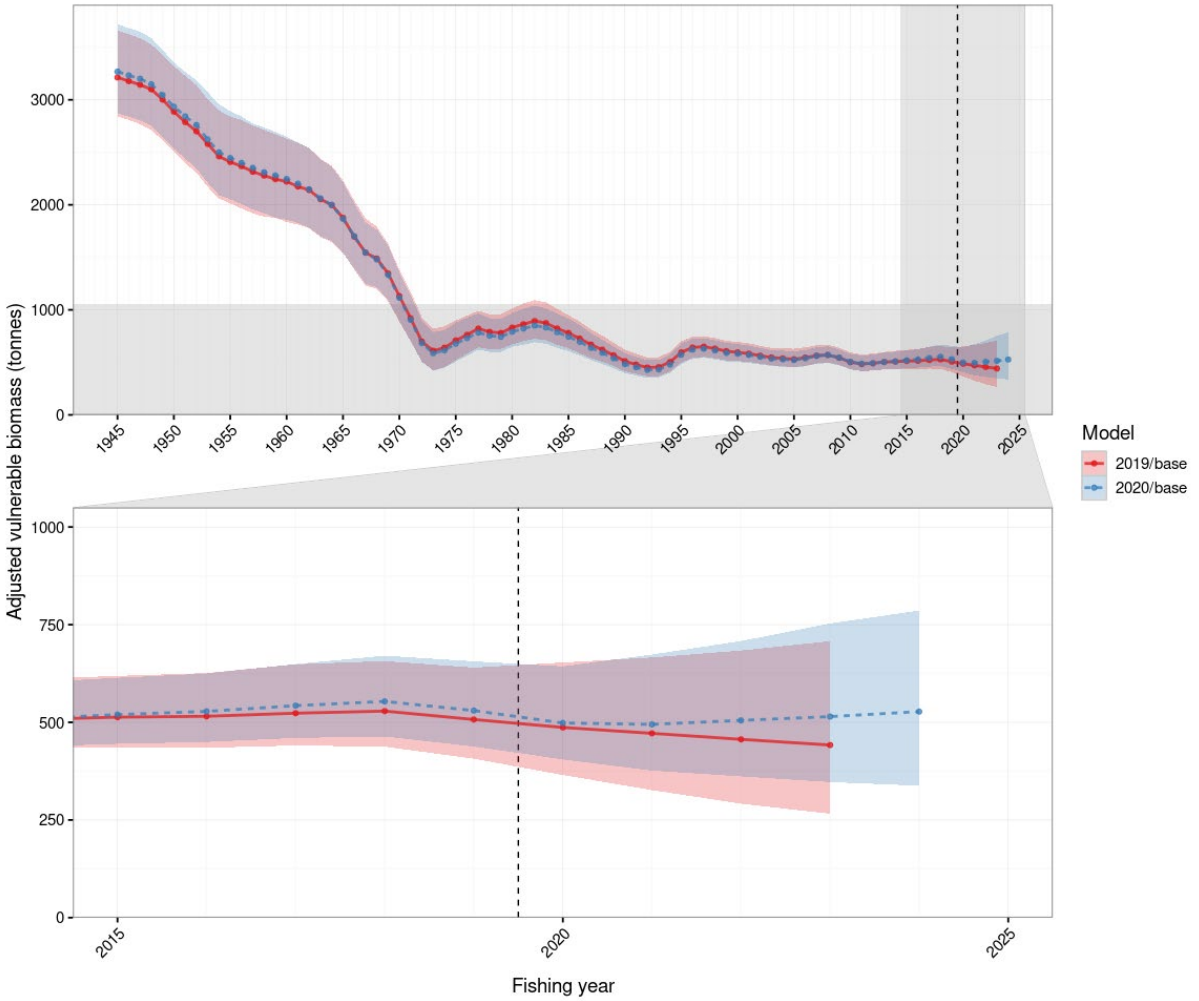

Figure 6: CRA 1 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment and the 2020 rapid update. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years.

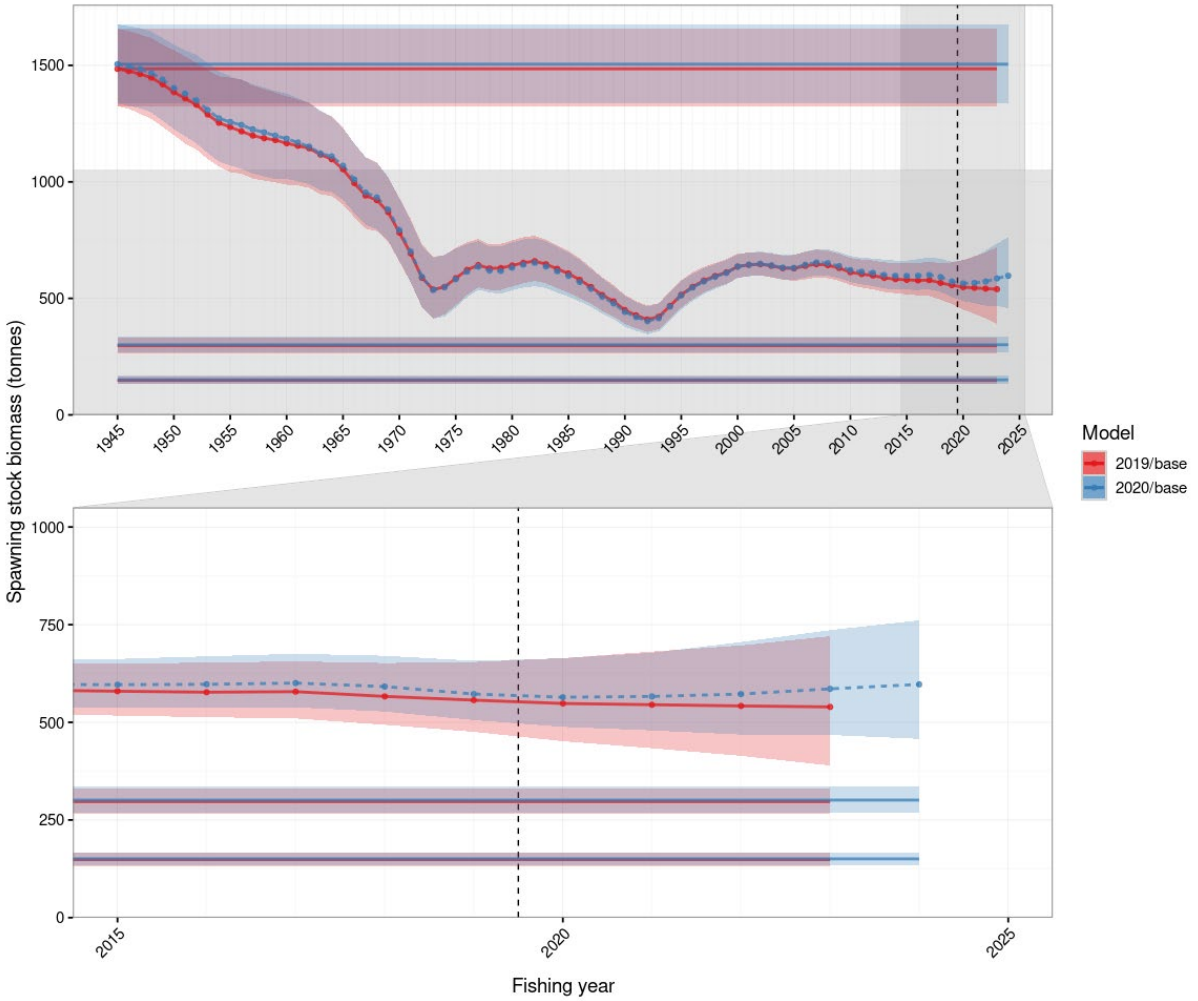

Figure 7: **CRA 1 posterior distribution of spawning stock biomass (tonnes) showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment and the 2020 rapid update. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. From top to bottom, the horizontal lines and shaded regions represent SSB_0 (uppermost horizontal line and shaded region), the soft limit (middle horizontal line and shaded region), and the hard limit (lower horizontal line and shaded region).**

Table 4: **CRA 1 rapid update indicators.**

Indicator	Mean	5%	Median	95%
B_0	3 279	2 873	3 268	3 718
B_R	454	–	–	–
B_{2020}	506	405	498	643
B_{2024}	560	340	545	823
B_{2020} / B_0	0.155	0.118	0.152	0.203
B_{2020} / B_R	1.114	0.891	1.097	1.415
B_{2024} / B_0	0.172	0.103	0.168	0.256
B_{2024} / B_R	1.233	0.748	1.199	1.812
B_{2024} / B_{2020}	1.101	0.754	1.080	1.495
SSB_0	1 506	1 337	1 505	1 676
SSB_{2020}	569	488	564	664
SSB_{2024}	603	458	597	761
SSB_{2020} / SSB_0	0.379	0.322	0.377	0.444
SSB_{2024} / SSB_0	0.401	0.305	0.398	0.510
SSB_{2024} / SSB_{2020}	1.057	0.883	1.048	1.253

4. CRA 2 RAPID UPDATE

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

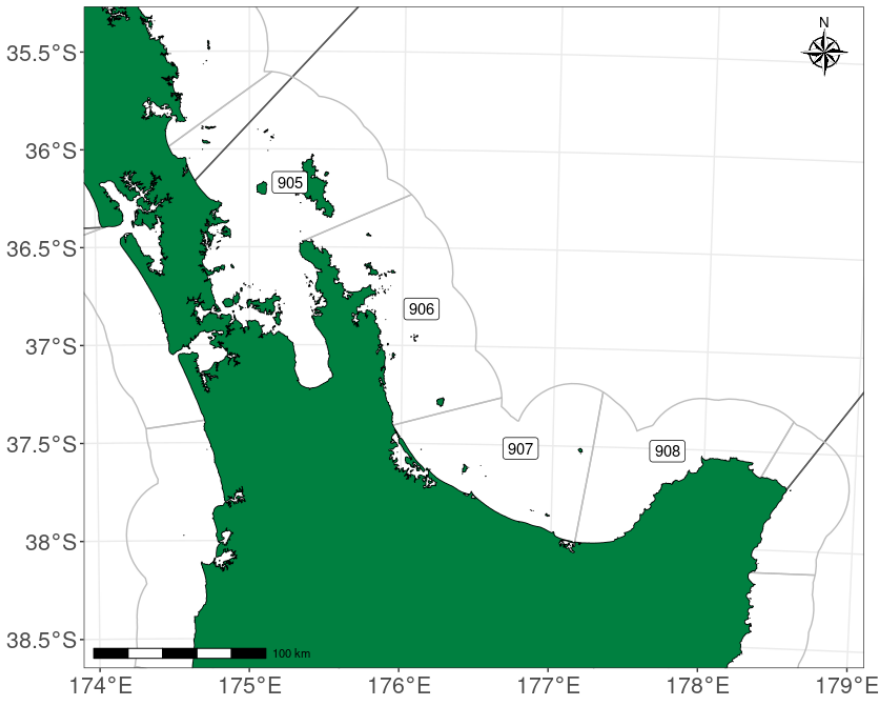

Figure 8: CRA 2 QMA and its statistical areas.

The CRA 2 stock assessment was last done in 2017 (Webber et al. 2018b) as a single-region assessment. The model was fitted to standardised CPUE indices, size frequency, sex ratio, and tag-recapture observations. The stock assessment showed a stock with low estimates of spawning stock (mature female) biomass (*SSB*) relative to the unfished stock level (SSB_0) in spite of the small size at maturity. Depletion of the stocks vulnerable biomass was recognised by all stakeholders even before the stock assessment. Because the stock was estimated to be below the soft limit, a rebuilding plan was required at the time. The chosen rebuilding plan used a fixed catch rather than an MP.

The rapid update for CRA 2 added three years of additional data, including: CPUE from AW 2017 to AW 2019 (the SS 2019 was not included because of the change from paper to electronic forms), logbook and catch sampling LFs for both AW and SS up to 2019, any additional tags, and an additional recreational catch survey in 2017 (Wynne-Jones et al. 2019). The additional recreational catch survey required re-calculation of the scalar value relating estimated recreational catch with SS abundance from 1979 onwards, which estimated slightly lower recreational catch over the time series than was assumed in the 2017 assessment (Table 5). Actual commercial catch was included up to 2019, and the projected catch from 2020 to 2024 was updated to reflect management changes (Table 5). In 2020 the commercial catch was set to be slightly higher than the 80 tonne TACC to include catch carried over from 2019 due to COVID-19 disruptions (Table 5).

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

The CPUE update resulted in some minor differences compared to the CPUE series used in the 2017 stock assessment, particularly during the SS season (Figure 9). These differences were most notable from SS 1989 to 2000, but the updated series was consistently higher than the 2017 series in all years. The rapid updates fit to the overall CPUE was similar to the fit in the 2017 assessment and the fit to the

new CPUE points was good (Figure 9). The fits to the LFs were almost indistinguishable during the 2016 fishing year and the fits to the 2017, 2018, and 2019 LFs were excellent (Figure 10).

The rapid update suggested that there had been a substantial pulse of recruitment in 2015 that had not been estimated by the 2017 assessment (Figure 11). Recruitment was also slightly higher from 2015 onwards in all but one year, including the projection years. The rapid update suggested that the adjusted vulnerable biomass was higher in all years compared with the 2017 assessment, and that vulnerable biomass had increased rapidly since the 2017 assessment (Figure 12). At current catch levels, the vulnerable and spawning stock biomass were projected to increase over the next five years (Figure 13). The rapid update suggested that the stock was at 14% of B_0, 31% of SSB_0, and above the interim reference level in 2020 (Table 6).

Table 5: CRA 2 commercial catch (tonnes) for the last two fishing years and the five projection years in the 2017 base case model compared with the last five fishing years and the five projection years in the 2020 rapid update. All projection years are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2017/base												
2015	51.40	123.31	174.71	7.19	27.07	34.26	0.50	4.50	5.00	12.47	29.92	42.40
2016	38.16	104.14	142.30	7.20	27.10	34.30	0.50	4.50	5.00	10.73	29.27	40.00
2017	–	–	142.30	–	–	34.30	–	–	5.00	–	–	40.00
2018	–	–	142.30	–	–	34.30	–	–	5.00	–	–	40.00
2019	–	–	142.30	–	–	34.30	–	–	5.00	–	–	40.00
2020	–	–	142.30	–	–	34.30	–	–	5.00	–	–	40.00
2021	–	–	142.30	–	–	34.30	–	–	5.00	–	–	40.00
2020/base												
2015	51.40	123.31	174.71	2.73	24.55	27.28	0.50	4.50	5.00	12.47	29.93	42.40
2016	38.16	104.37	142.53	2.73	24.60	27.34	0.50	4.50	5.00	10.71	29.29	40.00
2017	41.99	100.77	142.75	2.56	23.01	25.57	0.50	4.50	5.00	11.77	28.23	40.00
2018	32.52	47.46	79.97	4.22	37.95	42.16	0.50	4.50	5.00	16.26	23.74	40.00
2019	45.55	30.46	76.01	3.17	28.52	31.69	0.50	4.50	5.00	23.97	16.03	40.00
2020	–	–	83.97	–	–	31.69	–	–	5.00	–	–	40.00
2021	–	–	80.00	–	–	31.69	–	–	5.00	–	–	40.00
2022	–	–	80.00	–	–	31.69	–	–	5.00	–	–	40.00
2023	–	–	80.00	–	–	31.69	–	–	5.00	–	–	40.00
2024	–	–	80.00	–	–	31.69	–	–	5.00	–	–	40.00

The CRA 2 rapid update was not accepted by the RLWG which wanted to see more diagnostic plots of model fits to the CRA 2 data. This was not possible in the timeframe available in 2020. Further diagnostic plots were presented to the RLWG in June 2021, where the CRA 2 rapid update was accepted.

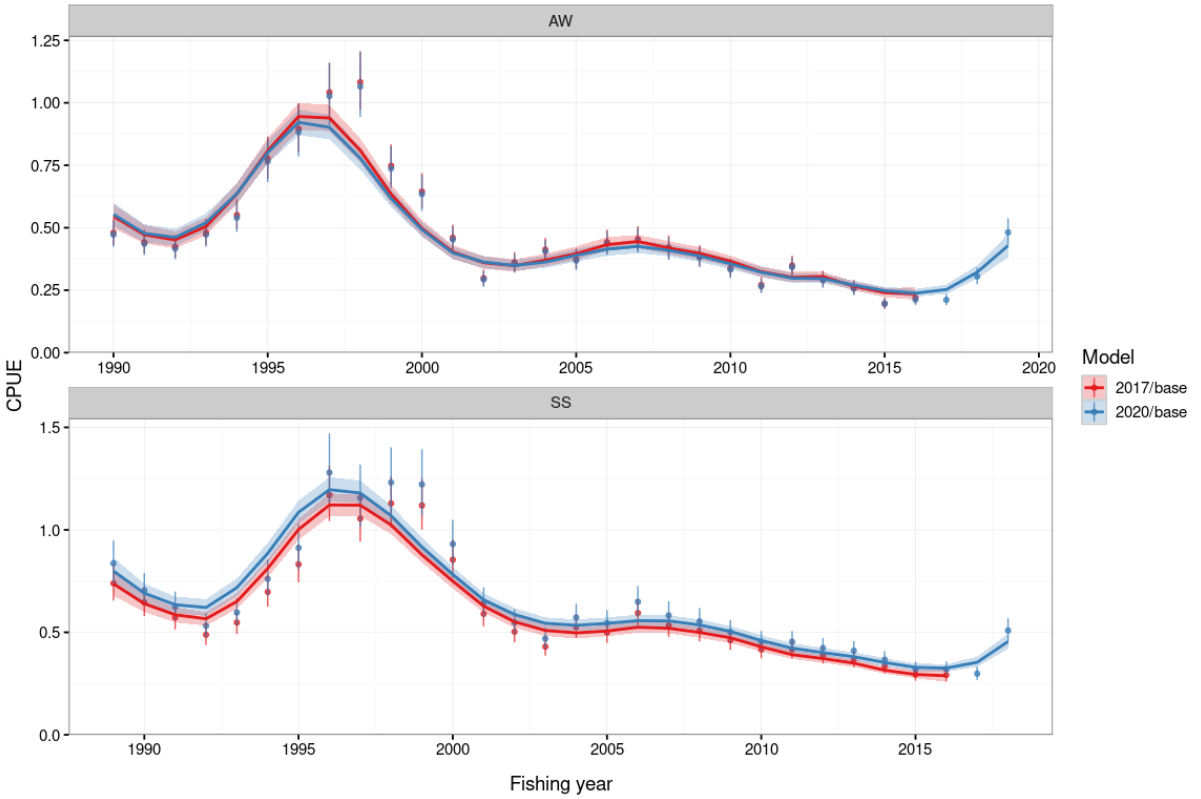

Figure 9: CRA 2 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by season for the 2017 stock assessment and the 2020 rapid update.

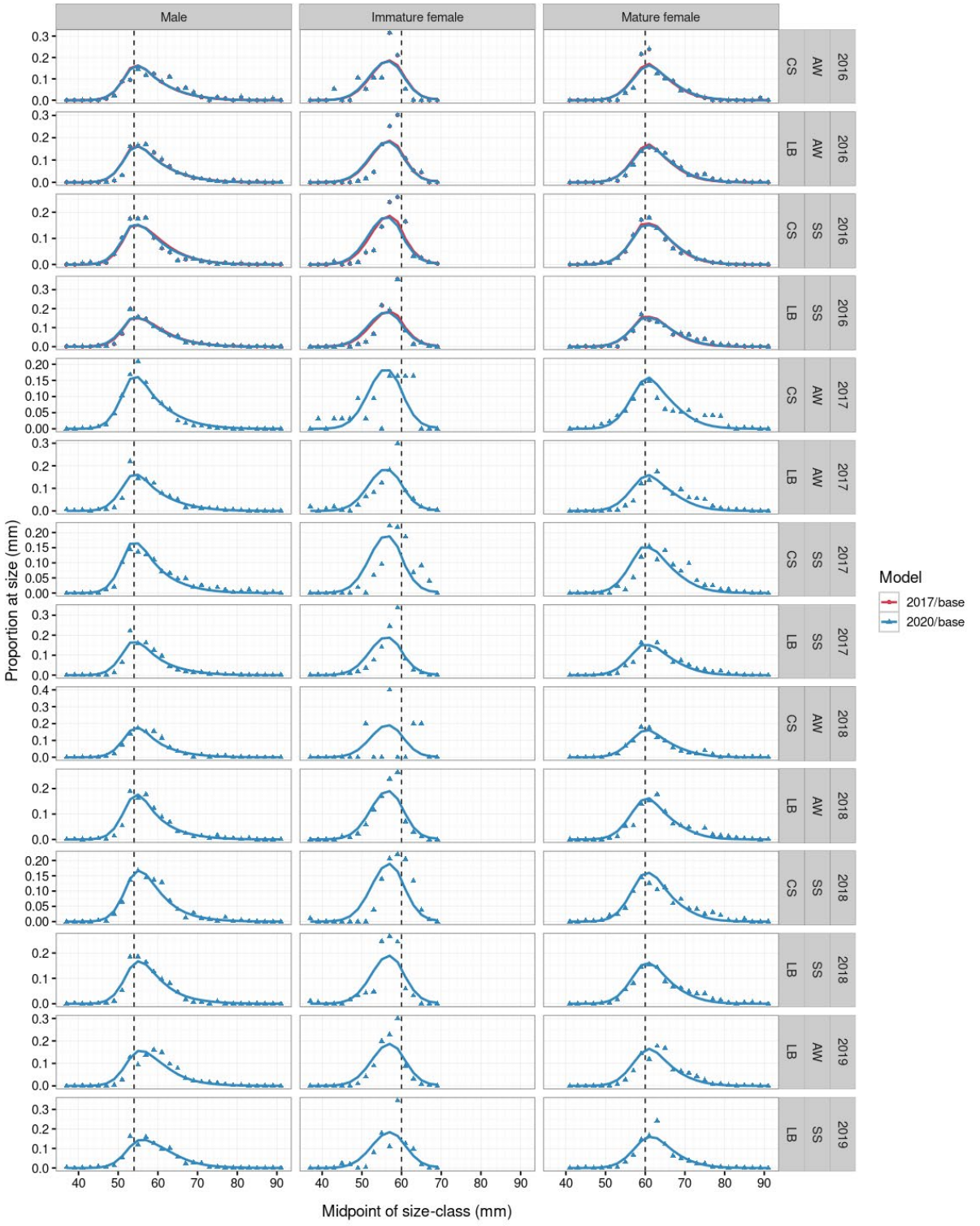

Figure 10: CRA 2 length frequency observations (points) and median of the posterior distribution (line) by year, season, and data source (CS = catch sampling, LB = logbook) for the 2017 stock assessment and the 2020 rapid update.

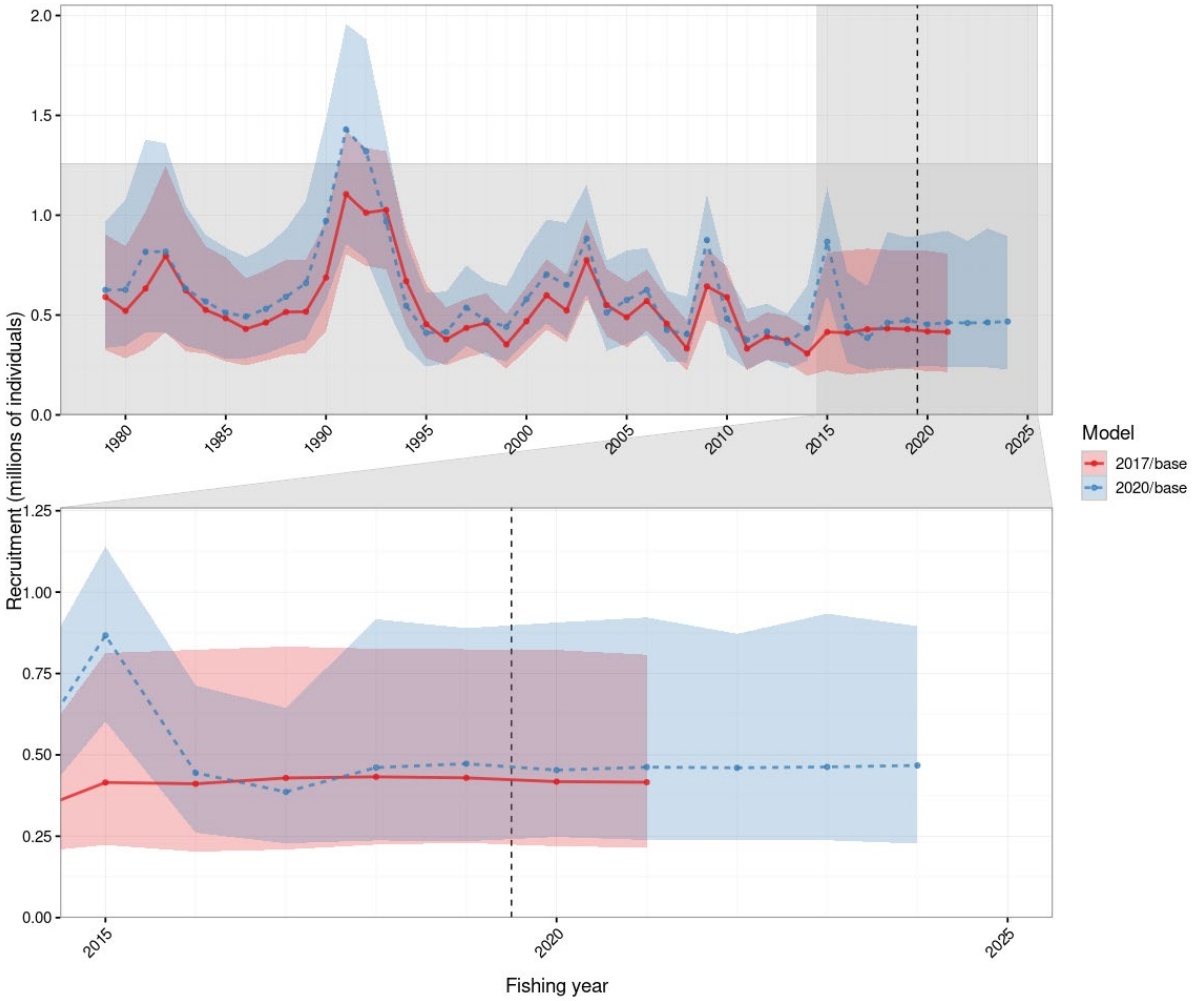

Figure 11: CRA 2 posterior distribution of recruitment showing the median (line) and 90% credible interval (shaded region) for the 2017 stock assessment and the 2020 rapid update. The top panel shows the recruitment for all model years, and the lower panel shows recruitment for the last ten years.

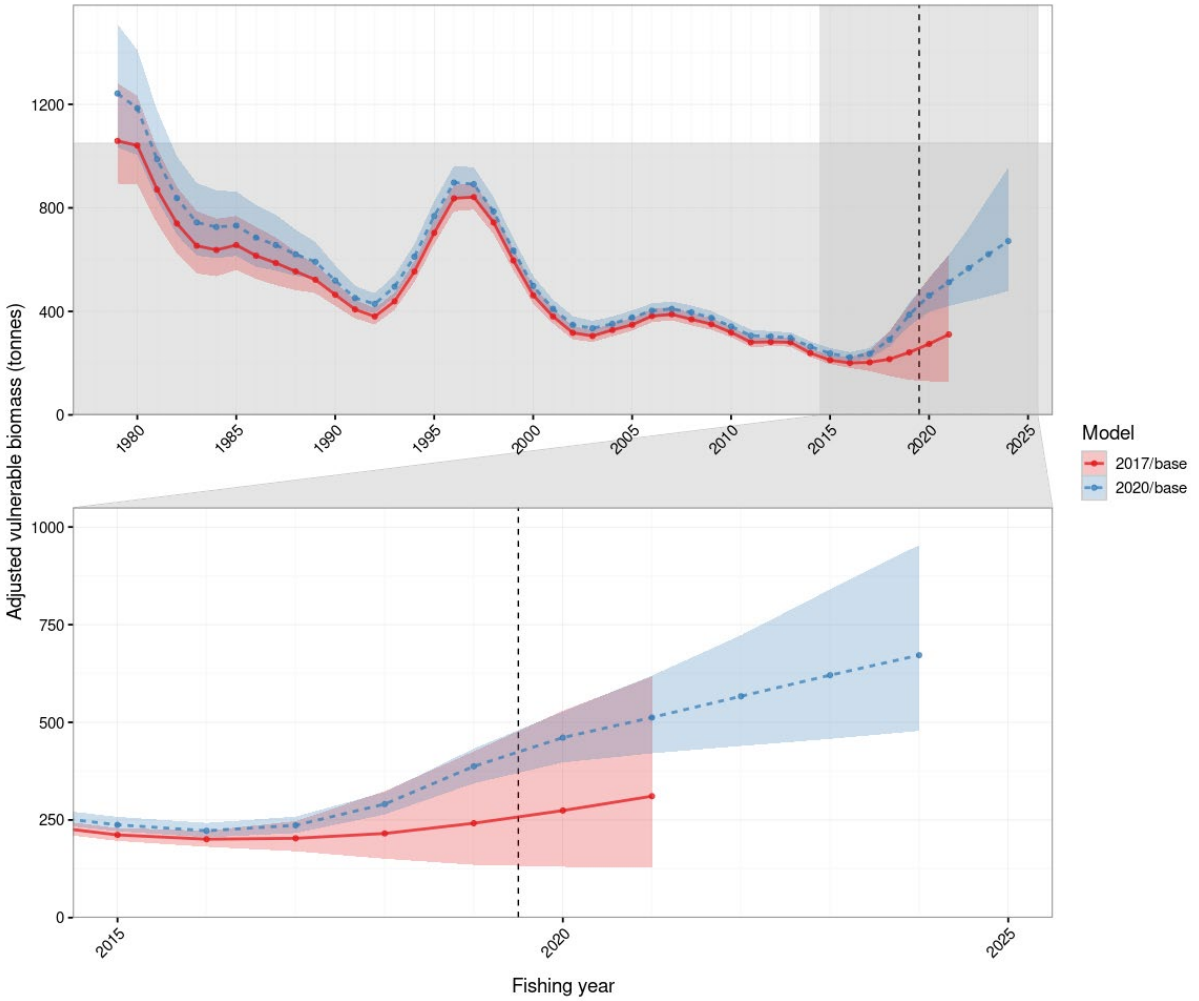

Figure 12: CRA 2 posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2017 stock assessment and the 2020 rapid update. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years.

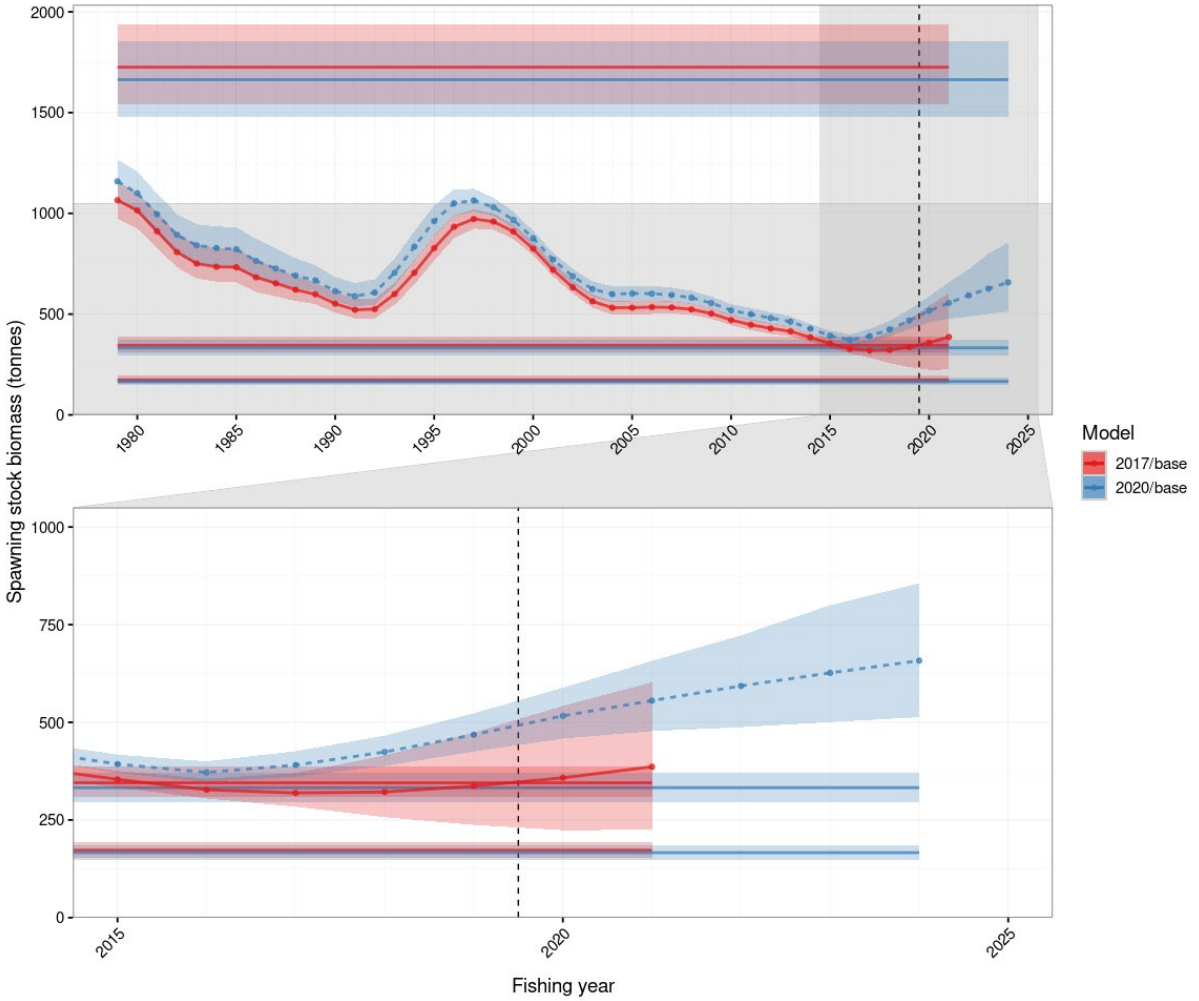

Figure 13: CRA 2 posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2017 stock assessment and the 2020 rapid update. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. From top to bottom, the horizontal lines and shaded regions represent SSB_0 (uppermost horizontal line and shaded region), the soft limit (middle horizontal line and shaded region), and the hard limit (lower horizontal line and shaded region).

Table 6: CRA 2 rapid update indicators.

Indicator	Mean	5%	Median	95%
B_0	3 269	2 859	3 269	3 735
B_R	438	–	–	–
B_{2020}	461	397	461	527
B_{2024}	736	500	717	1046
B_{2020} / B_0	0.142	0.116	0.141	0.172
B_{2020} / B_R	1.054	0.907	1.052	1.204
B_{2024} / B_0	0.226	0.151	0.220	0.321
B_{2024} / B_R	1.681	1.141	1.637	2.389
B_{2024} / B_{2020}	1.595	1.122	1.561	2.182
SSB_0	1 660	1 481	1664	1 855
SSB_{2020}	518	458	516	588
SSB_{2024}	668	513	658	856
SSB_{2020} / SSB_0	0.313	0.266	0.312	0.368
SSB_{2024} / SSB_0	0.404	0.304	0.398	0.521
SSB_{2024} / SSB_{2020}	1.287	1.049	1.272	1.554

5. CRA 3 RAPID UPDATE

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

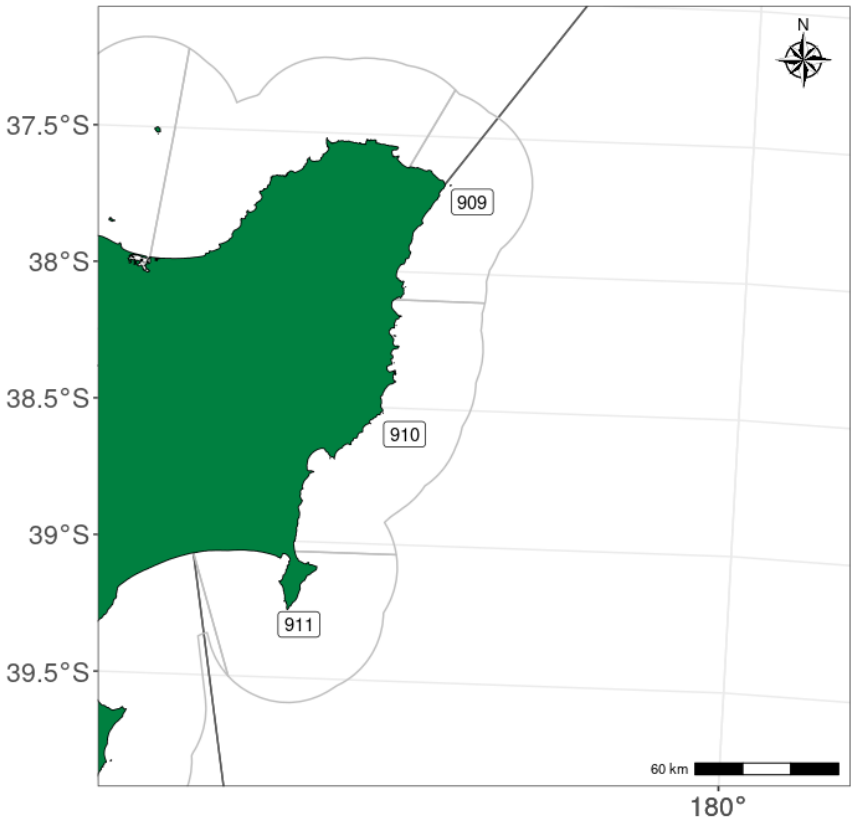

Figure 14: CRA 3 QMA and its statistical areas.

The CRA 3 stock assessment was last done in 2019 (Webber et al. 2020) alongside the CRA 1 stock assessment. This assessment was more complex because there were two regions assumed by the assessment model and the RLWG selected two base case models. Region 1 included statistical areas 909+910 and region 2 consisted of area 911. Two base case models tested two alternative growth assumptions and were designated *r1_qdrift* and *r2_qdrift*. Each model was fitted to standardised CPUE indices, size frequency, sex ratio, and tag-recapture observations. The stock assessment portrayed a stock that had declined rapidly between 1960 and 1970, followed by a levelling off until about 1980. After 1980, the stock size oscillated over roughly a 10-year cycle, with the stock increasing slightly after 1980 and then steadily declining until 1992. From there it increased strongly up to 1998, declined to a trough in 2004, increased again to 2013, and has since declined. However, at no point did the spawning stock biomass fall below the soft limit (the default of 20% SSB_0). This is due, in part, to the small size at maturity in CRA 3.

The rapid update for CRA 3 added a single year of additional data including: a single CPUE index for the AW 2019 fishing year (the SS 2019 is not included because of the change from paper to electronic forms), logbook and catch sampling LFs for both AW and SS 2019, and additional tag-recapture data. An additional year of commercial catch was included up to 2019, and the projected catch from 2020 to 2024 was updated to reflect management changes (Table 7). In 2020 the commercial catch was set to be slightly higher than the 222.9 tonne TACC to include catch carried over from 2019 due to COVID-19 disruptions (Table 7).

MCMC trace plots for the rapid update suggested that mixing was adequate with no signs of non-convergence (see Appendix I for MCMC diagnostic plots). The rapid updates fit to the CPUE was very

similar to the fit in the 2019 assessment and acceptably fitted the new CPUE point (Figure 15). The fits to the LFs were very similar during the 2018 fishing year and reasonable during 2019 (Figure 16).

The rapid update suggested that recruitment had been lower in the last few years in region 1 in both model runs and about the same in region 2, when compared with the 2019 assessment (Figure 17). Recruitment for the next five years was projected to be lower in region 1 and about the same in region 2 in both model runs. The rapid update estimated adjusted vulnerable biomass to be lower than was projected in 2020 in both model runs (Figure 18). The adjusted vulnerable biomass was predicted to decline for the next four years, before levelling out or increasing slightly (Figure 18). The difference in *SSB* between the 2019 and 2020 *SSB* in the two (*r1_qdrift* and *r2_qdrift*) model runs was minimal (Figure 19). In both model runs, the *SSB* was projected to decrease slightly over the next five years (Figure 19). The rapid update suggested that overall (i.e., region 1 and region 2 combined) the 2020 stock was at 14–15% of B_0, 77–78% of SSB_0, and above the interim reference level (Table 8, Table 9).

The CRA 3 rapid update was accepted by the RLWG.

Table 7: CRA 3 *r1_qdrift* and *r2_qdrift* commercial catch (tonnes) for the last four fishing years and the five projection years in the 2019 base case model compared with the last five fishing years and the five projection years in the 2020 rapid update. All projection years are highlighted in grey.

	Commercial			Recreational			Customary			Illegal		
Fishing year	AW	SS	Total	AW	SS	Total	AW	SS	Total	AW	SS	Total
2019/base												
2015	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	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	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	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	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2020	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2021	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2022	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2023	–	–	239.96	–	–	10.72	–	–	20.00	–	–	60.90
2020/base												
2015	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	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	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	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	135.53	53.12	188.65	1.18	10.61	11.79	2.00	18.00	20.00	43.26	16.96	60.22
2020	–	–	244.24	–	–	11.79	–	–	20.00	–	–	60.22
2021	–	–	222.90	–	–	11.79	–	–	20.00	–	–	60.22
2022	–	–	222.90	–	–	11.79	–	–	20.00	–	–	60.22
2023	–	–	222.90	–	–	11.79	–	–	20.00	–	–	60.22
2024	–	–	222.90	–	–	11.79	–	–	20.00	–	–	60.22

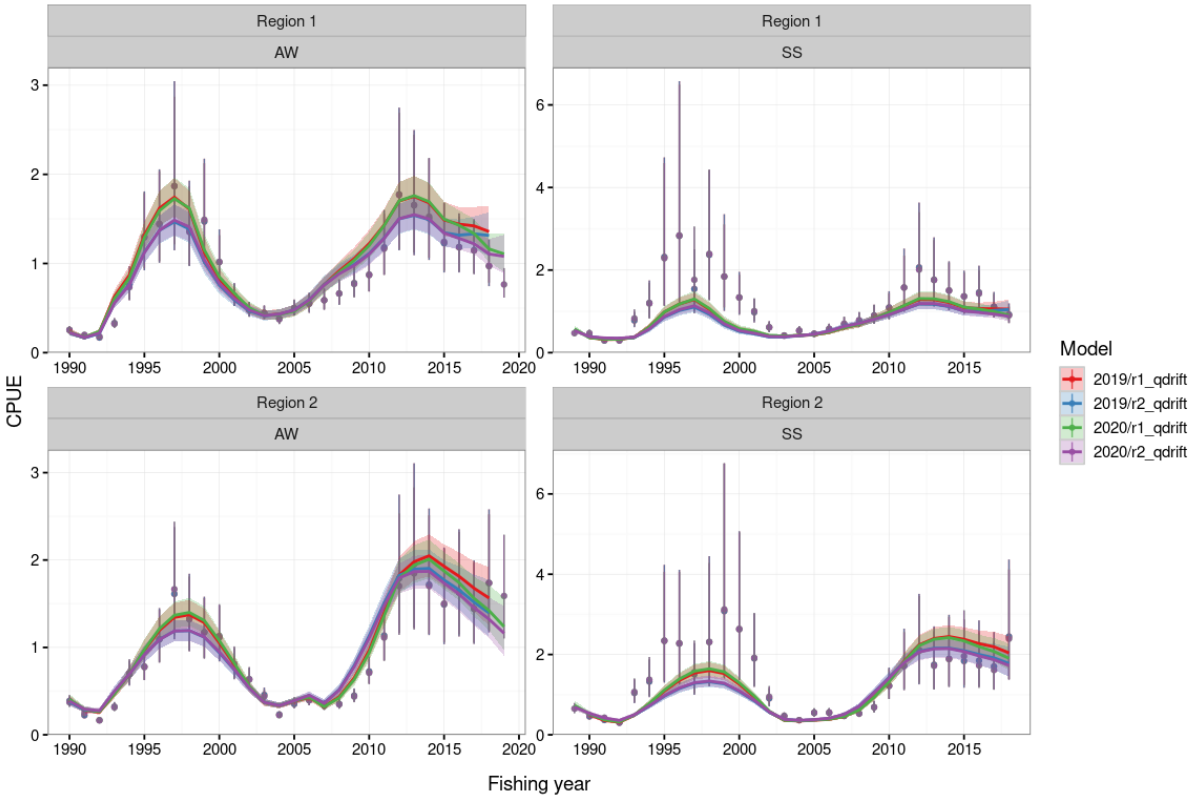

Figure 15: CRA 3 CPUE observations (points) and posterior distribution showing the median (line) and 90% credible interval (shaded region) by region and season for the 2019 stock assessment and the 2020 rapid update.

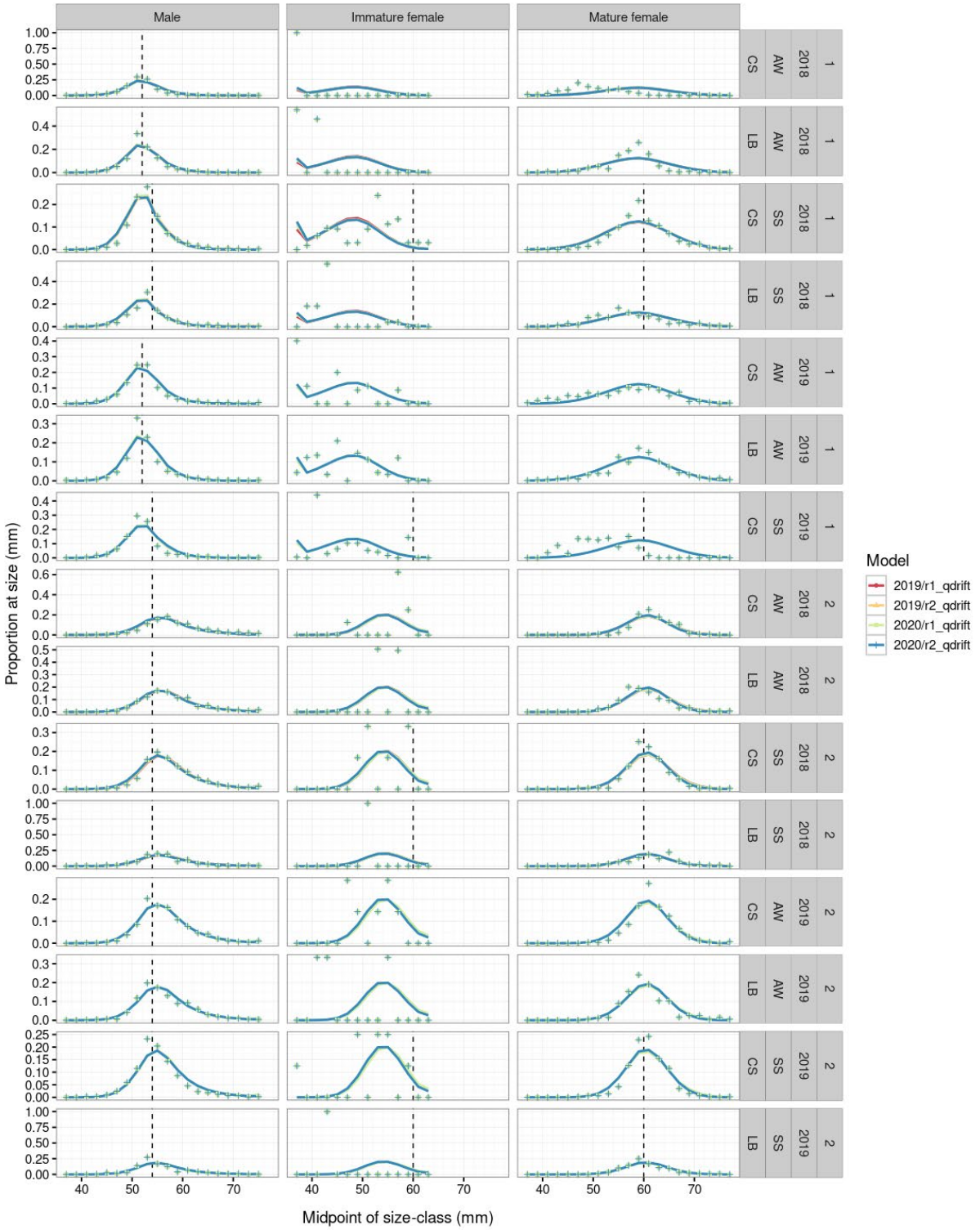

Figure 16: CRA 3 length frequency observations (points) and median of the posterior distribution (line) by region, year, season, and data source (CS = catch sampling, LB = logbook) for the 2019 stock assessment and the 2020 rapid update.

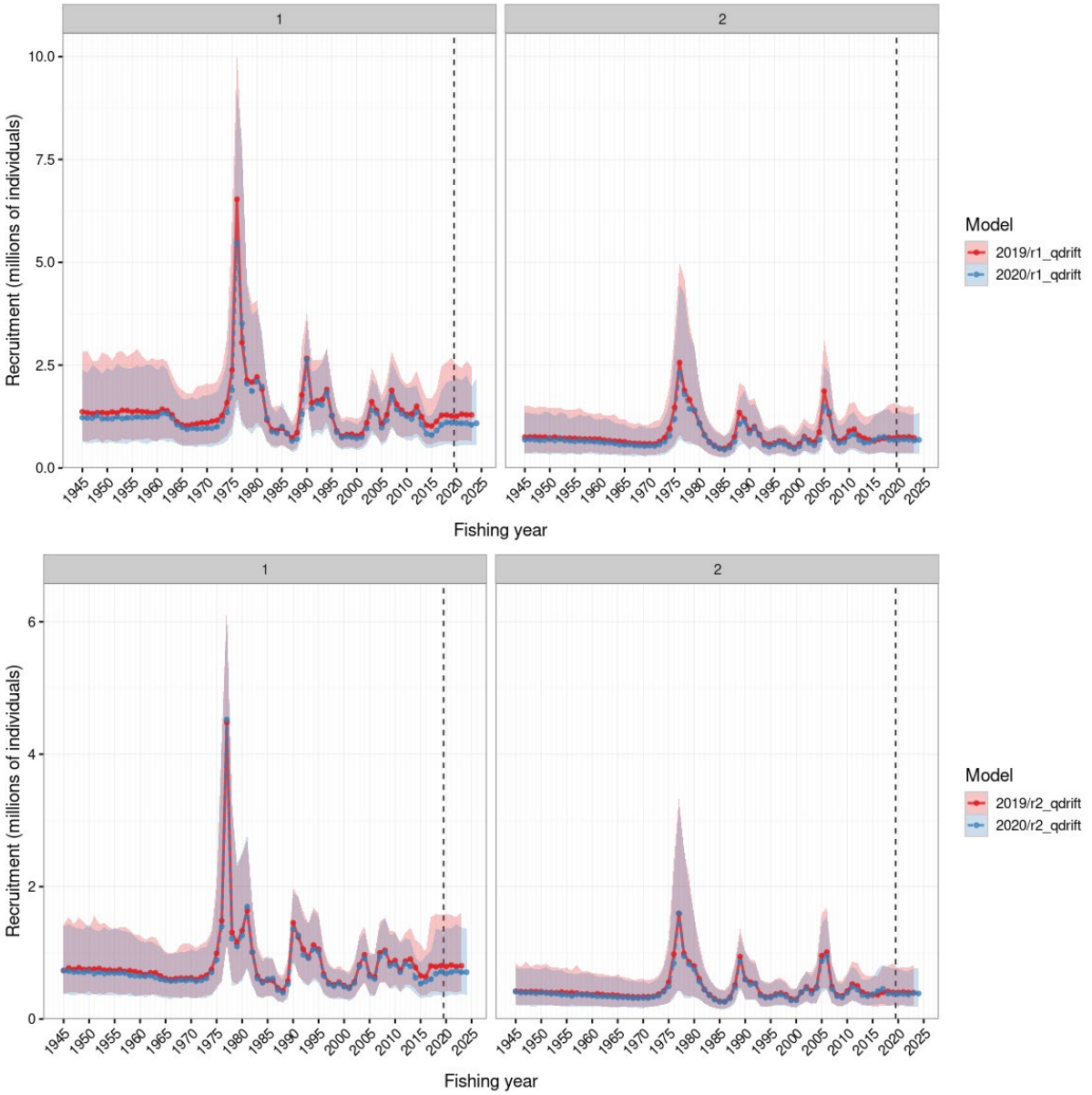

Figure 17: CRA 3 posterior distribution of recruitment by region showing the median (line and points) and 90% credible interval (shaded region) for the 2019 stock assessment and the 2020 rapid update. The *r1_qdrift* and *r2_qdrift* model runs are presented top and bottom, respectively.

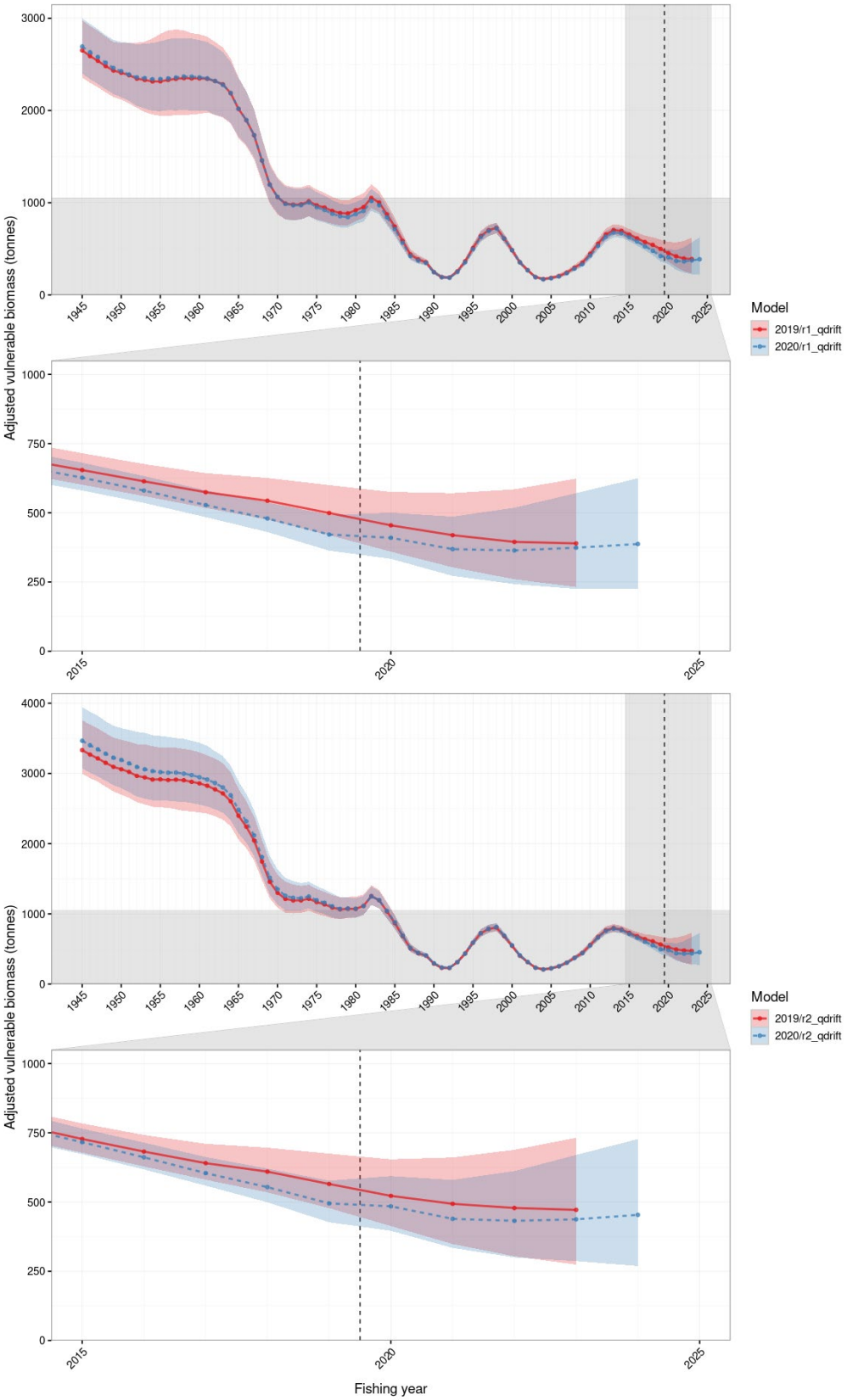

Figure 18: CRA 3 (summed region 1 and region 2) posterior distribution of adjusted vulnerable biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2019 stock assessment and the 2020 rapid update. The top panel shows the adjusted vulnerable biomass for all model years, and the lower panel shows adjusted vulnerable biomass for the last ten years. The *r1_qdrift* and *r2_qdrift* model runs are presented top and bottom, respectively.

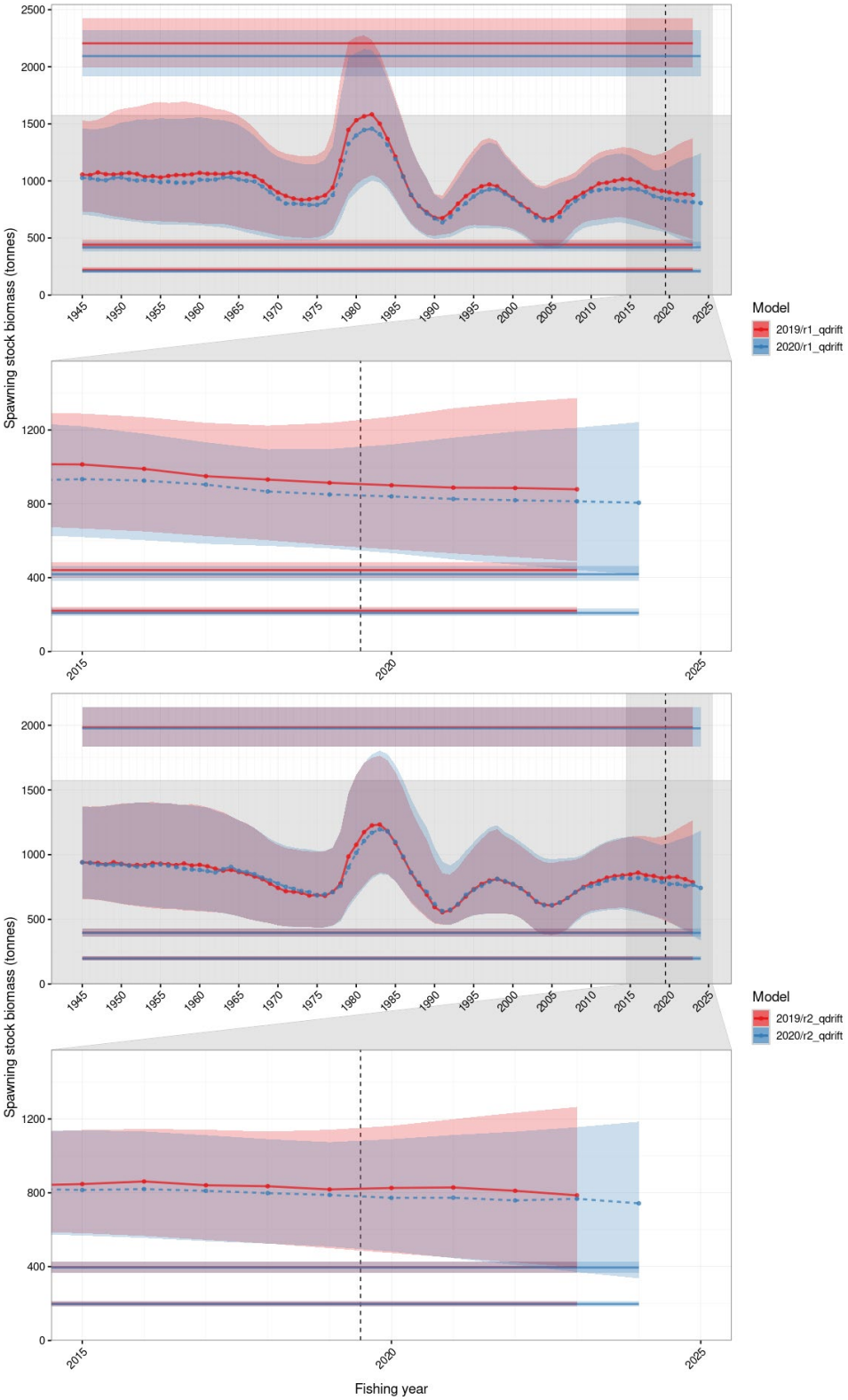

Figure 19: CRA 3 (summed region 1 and region 2) posterior distribution of spawning stock biomass (tonnes) showing the median (line) and 90% credible interval (shaded region) for the 2019 stock assessment and the 2020 rapid update. The top panel shows the spawning stock biomass for all model years, and the lower panel shows spawning stock biomass for the last ten years. From top to bottom, the horizontal lines and shaded regions represent SSB_0 (uppermost horizontal line and shaded region), the soft limit (middle 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.

Indicator	Mean	5%	Median	95%
B_0	2 696	2 400	2 694	3 000
B_R	347	–	–	–
B_{2020}	413	334	410	500
B_{2024}	423	223	412	667
B_{2020} / B_0	0.154	0.122	0.153	0.194
B_{2020} / B_R	1.192	0.962	1.181	1.442
B_{2024} / B_0	0.158	0.082	0.152	0.255
B_{2024} / B_R	1.220	0.642	1.188	1.924
B_{2024} / B_{2020}	1.017	0.581	0.999	1.513
SSB_0	2 104	1 916	2 094	2 321
SSB_{2020}	1 634	1 438	1 625	1 855
SSB_{2024}	1 606	1 307	1 595	1 928
SSB_{2020} / SSB_0	0.777	0.696	0.774	0.867
SSB_{2024} / SSB_0	0.764	0.630	0.758	0.914
SSB_{2024} / SSB_{2020}	0.981	0.864	0.974	1.107

Table 9: CRA 3 *r2_qdrift* rapid update indicators for region 1 and region 2 combined.

Indicator	Mean	5%	Median	95%
B_0	3 481	3 074	3 465	3 943
B_R	400	–	–	–
B_{2020}	488	396	484	594
B_{2024}	496	267	479	778
B_{2020} / B_0	0.141	0.109	0.139	0.178
B_{2020} / B_R	1.220	0.991	1.211	1.484
B_{2024} / B_0	0.143	0.076	0.138	0.228
B_{2024} / B_R	1.241	0.668	1.198	1.945
B_{2024} / B_{2020}	1.012	0.601	0.987	1.497
SSB_0	1 983	1 835	1 976	2 141
SSB_{2020}	1 549	1 416	1 548	1 696
SSB_{2024}	1 485	1 262	1 476	1 739
SSB_{2020} / SSB_0	0.782	0.711	0.781	0.855
SSB_{2024} / SSB_0	0.749	0.635	0.745	0.874
SSB_{2024} / SSB_{2020}	0.957	0.860	0.954	1.062

7. SUMMARY

Fisheries New Zealand has implemented electronic reporting of catch for rock lobster (from April 2019). It is not yet known how this change in the catch and effort data collection procedure will affect CPUE, but experience suggests that the new data will not necessarily be comparable with the previous paper-based data collection system. Preliminary evaluations of the lobster catch and effort data collected under the new system have pointed to substantial changes in the nature of the data, indicating that comparability has likely been lost (see appendix B of Starr 2021). Consequently, it is also likely that these changes to the collection of catch and effort data will require the development of new evaluation procedures that accommodate these changes.

The rapid update system will allow an annual update of stock status for most rock lobster stocks (CRA 1–8) which should provide a framework for managing these stocks that will be responsive to annual changes, much as the previous MPs were. Although CPUE based on commercial catch and effort data will not be available for the next few years, we may be able to develop alternative CPUE series for some stocks (e.g., logbook CPUE for CRA 2) and other data sources (i.e., catch and LFs) which should also inform stock status.

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 may be useful beyond this scope. For example, previous MPs used offset-year CPUE as the only input to determine TACC for the next year. Instead, the rapid update system, based on the agreed-upon base case model for each QMA, could become the input to a more broadly defined MP that could determine the TAC 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.

It is important to confirm that the rapid update framework can indeed predict stock status in the absence of a CELR CPUE series. To do so will require either (a) a simulation study or (b) a retrospective analysis of rock lobster stock assessments. A simulation study would require a simulation model be developed, likely to be a rather large task. A retrospective analysis, however, does not require such a large amount of additional work. A retrospective analysis study was presented to the RLWG in 2021, and this indicated no systematic biases in the stock assessments in the CRA 2 and CRA 4 examples tested (Pons et al. in prep.). These results suggest that the rapid update system should be adequate for predicting stock status in the absence of a CELR CPUE series for the next few years.

8. ACKNOWLEDGEMENTS

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10. APPENDIX I: MCMC DIAGNOSTICS

This appendix presents the MCMC trace plots for the CRA 1 (Figure 20), CRA 2 (Figure 21), and CRA 3 (Figure 22, Figure 23) rapid updates.

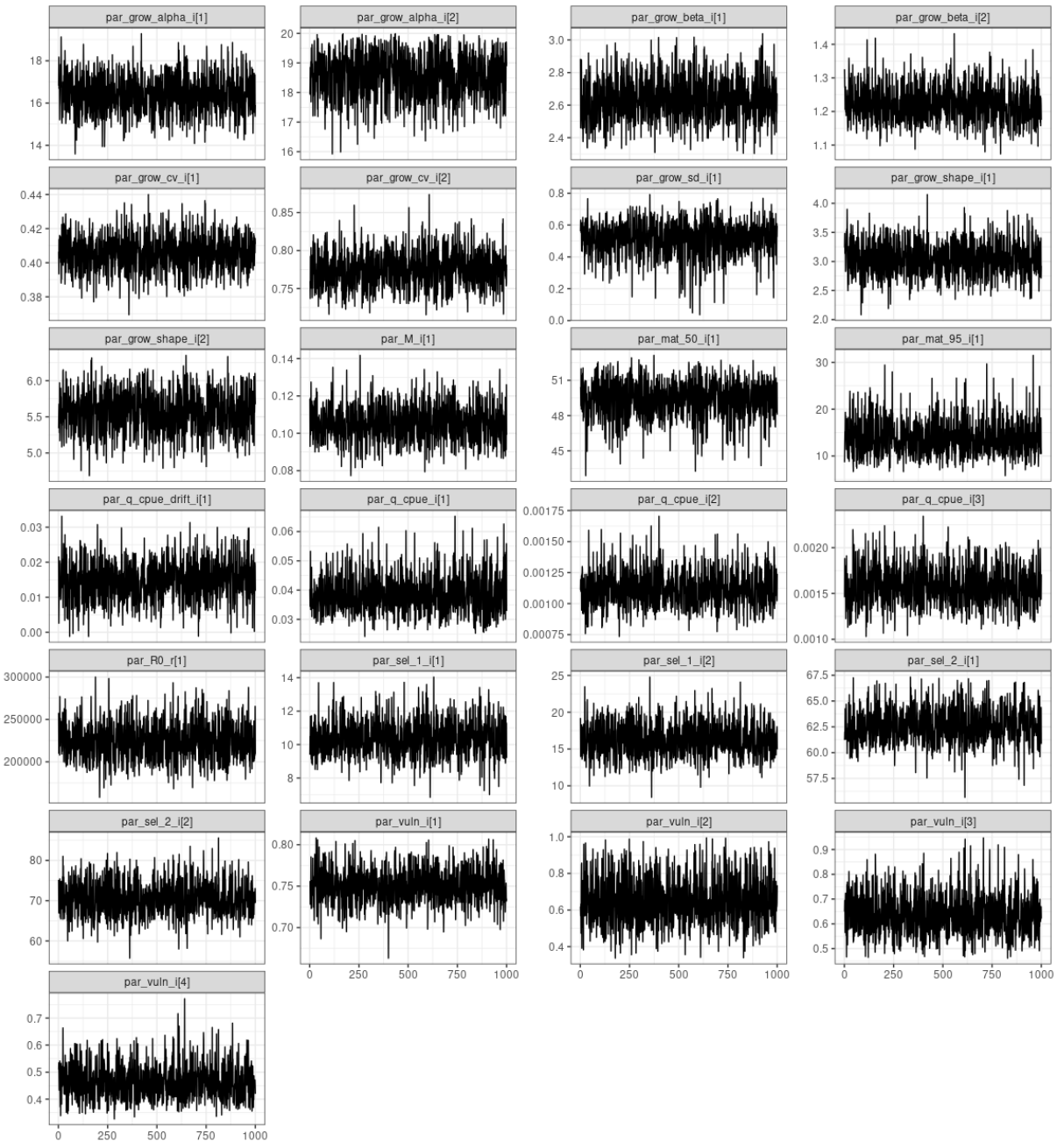

Figure 20: MCMC trace plots for model parameters in the CRA 1 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

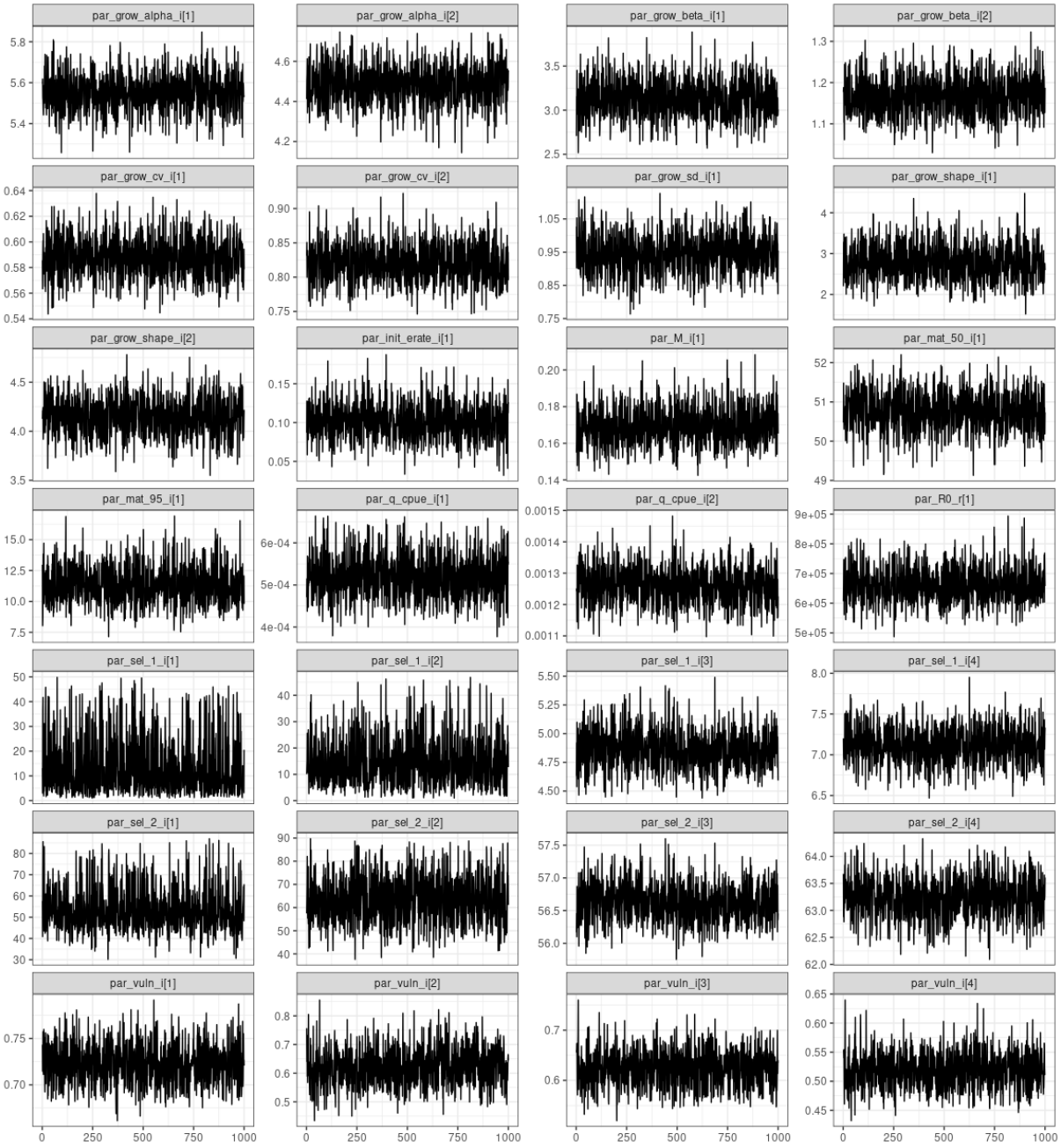

Figure 21: MCMC trace plots for model parameters in the CRA 2 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

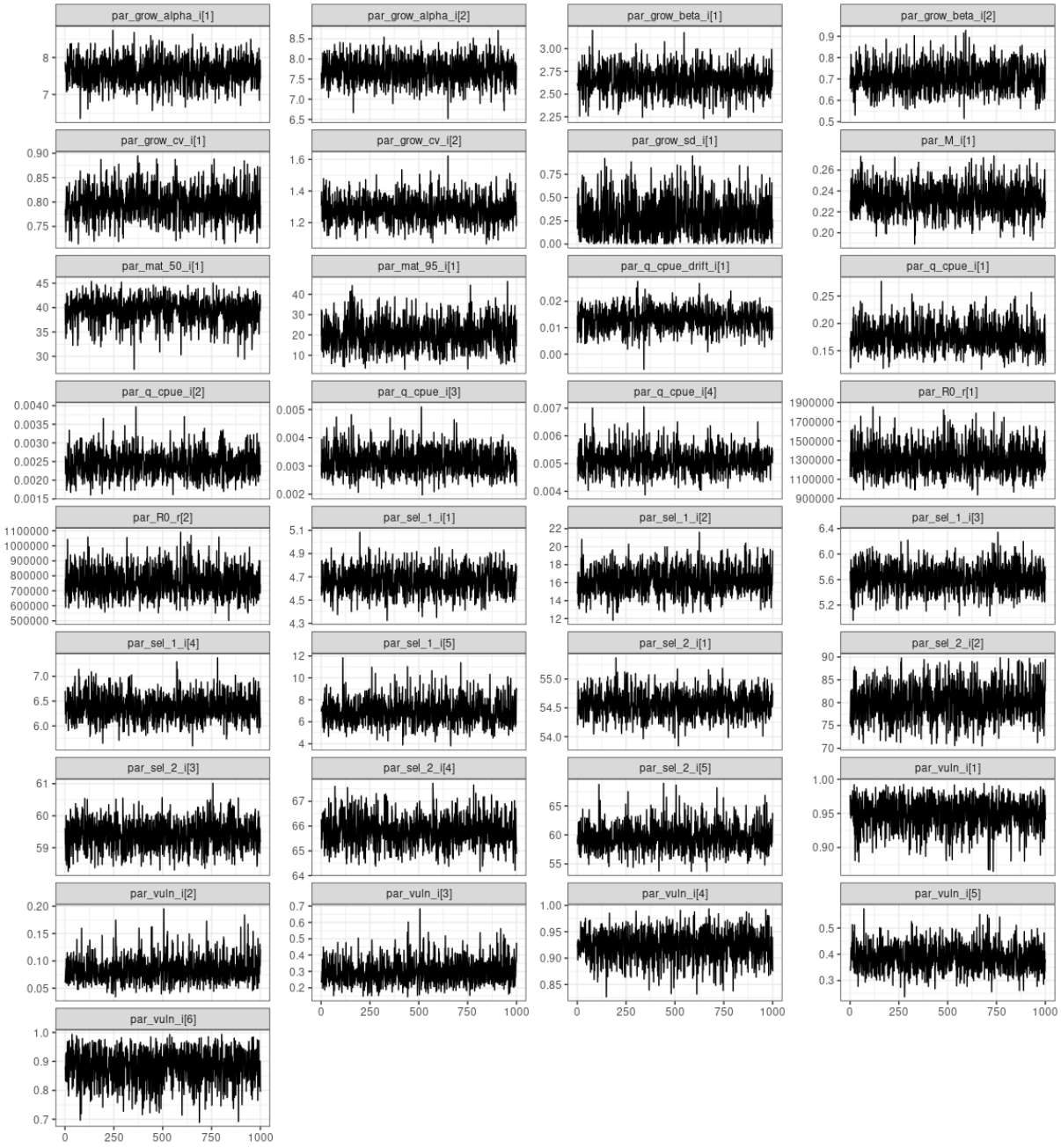

Figure 22: MCMC trace plots for model parameters in the *r1_qdrift* CRA 3 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).

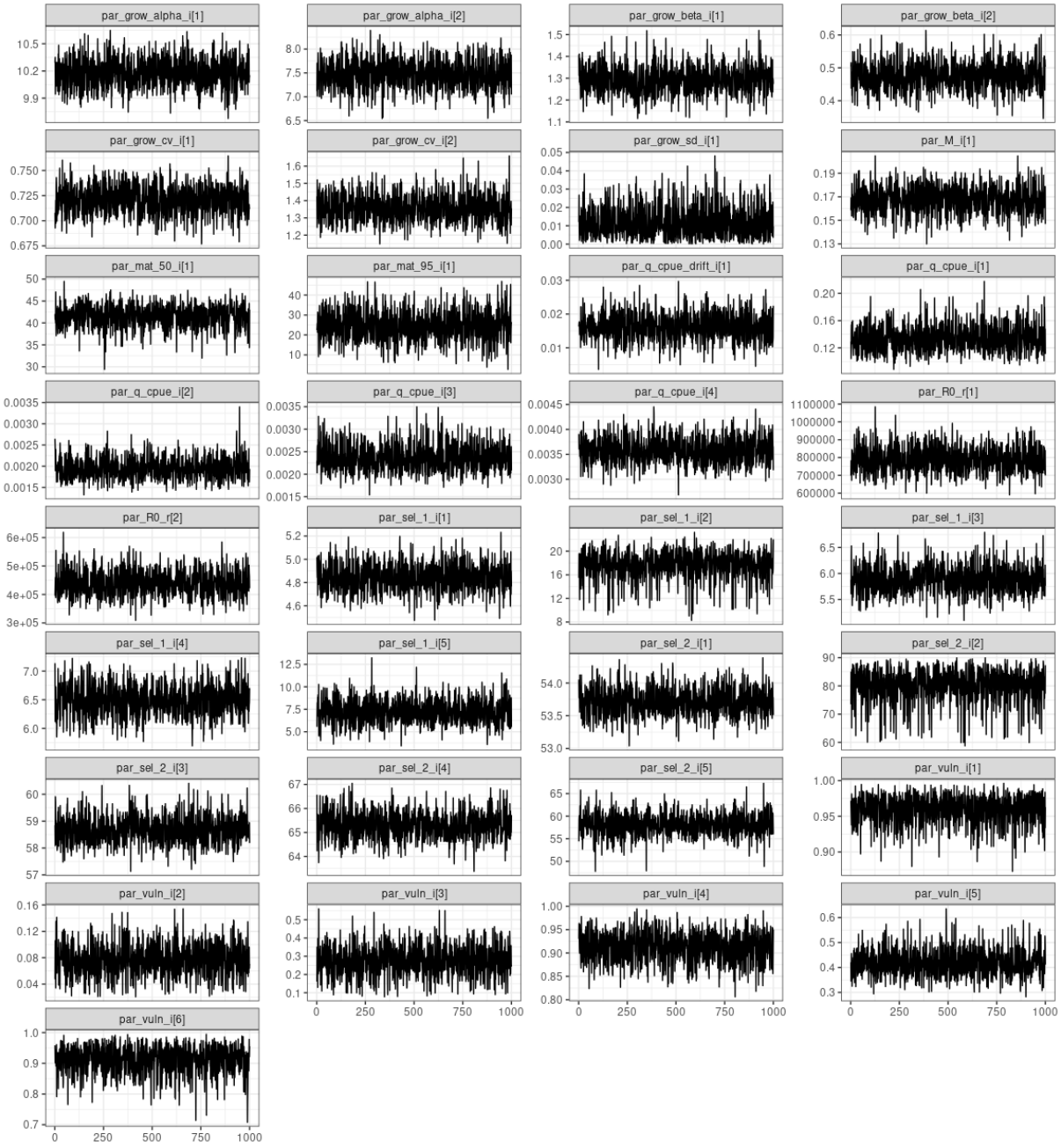

Figure 23: MCMC trace plots for model parameters in the *r2_qdrift* CRA 3 rapid update (MCMC iteration on the x-axis and parameter value on y-axis).