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Data for the 2020 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 5

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This document describes the data used in the 2020 CRA 5 stock assessment. Data sets described in this report include catch estimates for all sectors of the CRA 5 fisheries, seasonal standardised catch-per-unit-effort (CPUE) indices, length frequency distributions, sex-ratios, tag-recapture data, and puerulus settlement indices.

Catch estimates are provided for the commercial, recreational, customary, and illegal fisheries, collated by year to 1978 and then by six-month season (autumn-winter [AW] and spring-summer [SS]). Recreational catch estimates were available from older telephone/diary surveys and from two recent large-scale multi-species surveys conducted using a population-based survey methodology. The four survey catch estimates were fitted, assuming a lognormal distribution, to the SS standardised commercial CPUE for 1994, 1996, 2011, and 2017. The estimated scaling coefficient was then used to estimate a recreational catch series from 1979 based on the full series of standardised SS commercial CPUE. Recreational catches before 1979 were interpolated from a low value in 1945 to the 1979 value.

An examination of CPUE and length frequency data from statistical areas within CRA 5 indicated that there were different trends in these data within CRA 5. Consequently, the Rock Lobster Working Group (RLWG) agreed, on the basis of an analysis presented in this report, to divide CRA 5 into two regions based on the amalgamation of statistical areas 917, 918, and 919 for region 1 and combining statistical areas 916, 932, and 933 to form region 2. All catches and length frequency data were assigned to respective regions based on the statistical area of origin.

CPUE was standardised for the AW and SS seasons, except for the 2019 SS season, which was dropped because the RLWG had concerns about the comparability of the new electronic data with the previous paper form data. Separate CPUE series were estimated for each CRA 5 region, based on the distribution of catch and effort data by statistical area. The F2 algorithm, which uses a truncated distribution of "vessel correction factors" to adjust estimated catches to final catch, was used to prepare the catch and effort data. The destination codes "X" (discarded at sea) and "F" (section 111 recreational catches) were added to the destination code "L" (landed to a Licensed Fish Receiver [LFR]) to obtain the final catch total for scaling the estimated catches. The CPUE standardisation procedure was updated by the inclusion of a vessel explanatory variable in both the Fisheries Statistics Unit and Catch Effort Landing Return data series, and Bayesian inference was used to better represent the uncertainty in both series.

Length frequency data were available from both observer catch sampling and voluntary logbook programmes. These were collated by data source and by season, and this document describes how the individual records were weighted. These data were assigned to each region based on the statistical area of origin.

Tag-recapture data provided information on sex-specific growth rates, and this document describes this data set. The tagging data were not split by region because it was determined that all of CRA 5 appeared to have similar growth patterns.

1. INTRODUCTION

This work addressed parts of Objectives 3 and 4 of the Fisheries New Zealand contract CRA2019-01. This one-year contract, which began in April 2020, was awarded to New Zealand Rock Lobster Industry Council Ltd. (NZ RLIC Ltd.), who sub-contracted Objectives 3 and 4 to the authors of this report.

Objective 3 - CPUE and decision rules: To update the standardised CPUE analysis from all lobster QMAs and report on the operation of current decision rules.

Objective 4 - Stock assessment: To estimate biomass and sustainable yields for rock lobster stocks.

The National Rock Lobster Management Group (NRLMG) decided that CRA 4 and CRA 5 should be assessed in 2020. Data were compiled for both stocks by a team comprising D'Arcy Webber, Merrill Rudd, Jim Roberts, Maite Pons, and Paul Starr. This document is limited to the data for CRA 5 and describes catches – including commercial, recreational, customary, and illegal catches – catch-per-unit-effort (CPUE), length frequencies, and tag-recapture data. Appendix A documents a formal data request to Fisheries New Zealand for non-commercial catch information and the associated Fisheries New Zealand response is provided in Appendix B.

Decisions on data and modelling choices were discussed and approved by the Rock Lobster Fishery Assessment Working Group (RLFAWG, renamed the Rock Lobster Working Group in 2021[1]).

The CRA 5 (Figure 1) fishery includes all of Tasman and Golden bays as well as the Marlborough Sounds. It then extends down the northern part of the east coast of the South Island, past Kaikoura and the Banks Peninsula as far down as the Waitaki River. The previous stock assessment of CRA 5 was in 2015, with Starr et al. (2016) describing the data and Starr & Webber (2016) documenting the stock assessment and management procedure evaluations. The 2015 stock assessment used the Bayesian multi-stock length-based model (MSLM; Haist et al. 2009). The model was fit to puerulus settlement data, tag-recapture data, standardised CPUE from 1979–2014, historical catch rate data for 1963–1973, and length frequency data from voluntary logbooks and observer catch sampling. The stock assessment model takes into account changes in the minimum legal size (MLS—see table 1 of Webber et al. (in press) for the years when these changes were made) and in selectivity caused by revised escape gap regulations adopted in 1992 for the 1993–94 fishing year.

The CRA 5 Total Allowable Commercial Catch (TACC) was last changed in April 1999 but has been subject to review each year on the basis of the evaluation of a management procedure (MP) that has now been suspended. The current CRA 5 TACC for commercial catch is 350 t. Allowances set by the Minister of Fisheries in 1999 were 40 t for customary catch, 40 t for recreational catch, and 37 t for illegal unreported removals for a total TAC of 467 t. After the 2015 stock assessment, the Minister raised the recreational allowance to 87 t for the 2016–17 fishing year but left the TACC and the other allowances unchanged, increasing the Total Allowable Catch (TAC) from 467 t to 514 t. The fishery is open to recreational fishing all year with MLS of 54 mm tail width (TW) for males and 60 mm TW for females.

[1] 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. The use of RLFAWG is retained in the appendices.

2. CATCH DATA

2.1 CRA 5 Commercial catch 4

The fishing year and calendar year were the same before 1979. From 1979 onwards, the fishing year changed to 1 April to 31 March. Reported annual commercial catches from 1945 to 1978, summarised by **calendar year**, are held in the CRACE database, with sources documented by Bentley et al. (2005). From 1 January 1979 to 31 March 1986, catches were taken from monthly data summarised by **fishing year** from data collected by the Fisheries Statistics Unit (FSU), a version of which is documented and held in CRACE (Bentley et al. 2005). The three months of catch from January to March 1979 were added to the 1978 annual total to ensure that no catch was lost when switching from calendar year to fishing year collation. Year references in this document after 1978 apply to 1 April–31 March fishing years, with the year identified with the first year of the pair (e.g., 1979 refers to the 1979–1980 fishing year).

From 1 April 1986 to 31 March 1988, monthly reported catch totals for all of New Zealand were obtained from Quota Management Returns (QMRs) maintained by the Ministry of Agriculture and Fisheries. Because QMR returns by individual Quota Management Areas (QMAs) were not available for this period, the total catches across New Zealand were divided into QMA catches based on the proportional landings reported on FSU forms. From 1 April 1988 through to 30 September 2001, catches were summarised from the monthly QMRs available for each QMA. The QMRs were replaced by Monthly Harvest Returns (MHRs) on 1 October 2001, but the same information is available from these newer forms.

There is some uncertainty in the quality of the catch estimates in the years before the FSU system began in 1979, but there is confidence in the quality of the catch estimates from the 1980s when the FSU system was operating. Catch estimates generated from the FSU data available to the stock assessment team are consistent with published historical catch estimates from the FSU system.

High levels of commercial catches (up to 900 t/year) were recorded in CRA 5 for a few years in the late 1940s and early 1950s (Figure 2). After that period, commercial catches dropped below 400 t/year and then rose to over 700 t/year by the mid-1980s. Catches dropped when this QMA entered the Quota Management System (QMS) in 1990 to levels below 300 t/year in the mid-1990s. The TACC dropped in each year from an initial value of 465 t in 1990 to 303 t by 1993 (Figure 3). The TACC was raised to 350 t in 1999 and catches immediately rose to that level where they have remained (Figure 3). Annual CPUE peaked in 2009–10 above 2.0 kg/potlift but has since ranged between 1.57 and 1.93 kg/potlift without a discernible trend.

2.2 CRA 5 Recreational catch

Six annual recreational survey catch estimates are available for CRA 5 (Table 1). Estimates from the two Kingett Mitchell National Surveys (Boyd & Reilly 2004, Boyd et al. 2004) were not accepted by the RLWG for the 2015 CRA 5 stock assessment (Starr & Webber 2016) because these survey estimates were considered implausibly high for CRA 5. The earlier 1994 and 1996 surveys, conducted by researchers at the University of Otago, were considered biased in a review of the available recreational surveys (unpublished minutes: Recreational Technical Working Group [Auckland NIWA, 10–11 June 2004]) because the interview questions possibly underestimated fisher participation rates by allowing for an easy exit from the interview ("soft refusal" bias). These two early surveys continue to be used by the RLWG despite this advice because the estimates are plausible and no other recreational information is available for these years. Both the Boyd and the Otago surveys were potentially biased high because recreational logbook participants were not closely supervised and may not have accurately recorded their fishing activity. The much higher harvest estimates in the Boyd surveys were a result of higher claimed participation in saltwater fishing over the previous 12 months in the initial screening survey.

Two large-scale population-based diary/interview surveys (National Panel Survey or NPS) were conducted under contract for the Ministry for Primary Industries (MPI) from 1 October 2011 to 30 September 2012 (Wynne-Jones et al. 2014) and from 1 October 2017 to 30 September 2018 (Wynne-Jones et al. 2019), with the intention of estimating specific Fishery Management Area and QMA annual catches for all major finfish and non-finfish species (Heinemann et al. 2015). This survey was based on a design that resembled the New Zealand national census, making use of the census population strata ("mesh blocks" of dwellings) as the basis for identifying recreational fishers. A door-to-door survey of households in randomly selected strata was used to select participants who would report their catch for an entire year. A structured and carefully designed Computer Assisted Telephone Interview (CATI) method was used to record harvest in detail from those who had fished. The 2011–12 NPS results were considered problematic for CRA 5, even though 44 fishers provided 143 interviews in this survey year. This is because there were no local (Kaikōura) logbooks, while an intensive ramp survey for all of 2012–13, which covered the coast from the Clarence River to Motunau (Kendrick & Hanley 2021), indicated that locals were responsible for an appreciable amount of catch. Furthermore, the CRA 5 estimate from the 2017–18 survey (Wynne-Jones et al. 2019), which had 61 logbook participants who provided 255 interviews, was thought to have been affected by the November 2016 earthquake, which resulted in a value that was potentially biased low at 41 t (Table 1). Both the 2011–12 and 2017–18 surveys provided estimates of the distribution of fishing platforms used to take lobsters in CRA 5, with large and small motorboats accounting for about 80% of the catch in 2011–12 (Table 2; Figure 4). This dropped to 63% in 2017–18 but was offset by a rise to 13% (from 1%) for larger launches. Estimates of shore gathering ranged from 18 to 23% for the two surveys (Table 2; Figure 4). The capture methods were reasonably consistent between surveys, with diving taking 68% and 62% of the catch in 2011–12 and 2017–18, respectively, with the balance taken by potting (Table 2; Figure 4). The NPS results from logbook participants were in terms of number of fish. Mean recreational catch weight for the most important finfish and non-finfish species QMAs was estimated in parallel projects (Hartill & Davey 2015, Davey et al. 2019).

A recreational catch time series was developed by assuming that recreational catch has been proportional to statistical area 917 spring-summer (SS) abundance, as reflected in the geometric mean SS CPUE for that area. This was the abundance series used for the 2015 CRA 5 stock assessment (Starr et al. 2016). The 2015 CRA 5 stock assessment assumed that the 2011–12 NPS estimate was low and replaced it with an estimate of 80 t, but this was considered to be an overestimate (B. Hartill, NIWA, pers. comm.) and the RLWG agreed to use 65 t, assuming that around 22 t were taken by local fishers in 2011–12. The RLWG agreed to omit the 2017–18 NPS estimate, given the concern that it was potentially biased low by an unknown amount due to the impact of the November 2016 earthquake. Consequently, the recreational catch vector was based on three of the six available survey estimates (Table 1) from the 1994 (Otago), 1996 (Otago), and the inflated 2011–12 NPS estimate. The maximum likelihood estimation (MLE) fitting procedure assuming recreational catch was linearly proportional to SS CPUE followed by the 2019 rock lobster stock assessments (CRA 1, CRA 3: see Starr et al. 2020a, 2020b) returned implausibly low catch estimates for the late 1980s to the late 1990s, with these years estimated at less than 10 t/year and some years that were near 5 t. The RLWG agreed to use the power function (Eq. 1) method that was adopted by the 2015 CRA 5 stock assessment, because the resulting trajectory was more plausible because it did not dip so low in the late 1980s and the 1990s (Figure 5). The power function parameters were estimated by minimising the sum of squares between the survey estimates and predicted recreational catch:

Eq. 1

$$\boldsymbol{W_i = \alpha I_i^{\beta}} \quad \textbf{if } \boldsymbol{i \geq 1979}$$

$$\boldsymbol{W_{1945} = 0.2 W_{1979}}$$

$$\boldsymbol{W_i = W_{i-1} + \frac{(W_{1979} - W_{1945})}{(1979 - 1945)}} \quad \textbf{if } \boldsymbol{1945 < i < 1979}$$

where I_i is statistical area 917 SS CPUE from 1979 to 2018, W_i is the recreational survey catch by weight for year i, and α and β are estimated parameters.

The model estimated the parameter $\beta = 0.3659$ when Eq. 1 was fitted to the two Otago survey estimates in Table 1 and the agreed 65 t estimate for 2011–12. The estimated recreational catch trajectory is plotted in Figure 5. The mean of the 2016–2018 statistical area 917 SS CPUE was used for the 2019 estimate because there is no accepted CPUE estimate for 2019 due to the changeover to electronic reporting in the 2019–20 fishing year and the apparent shifts in reporting estimated lobster catches. Recreational catch in 1945 was assumed to be 20% of the 1979 estimated recreational catch, with recreational catch following a linear trajectory from 1945 to 1979.

The estimated recreational catch time series accounted for 2607 t from 1945 to 2019. For assessments since 2006, the RLWG has included recreational landings made by commercial vessels under section 111 of the Fisheries Act. Greenweight landings with destination code "F" were extracted from the CRACE database (Bentley et al. 2005), which showed a maximum annual value of 7215 kg for CRA 5, occurring in 2012–13. The RLWG agreed to add the maximum catch estimate to the estimated recreational catch in each year since 1945, increasing the total 1945 to 2019 recreational catch in the model to 3149 t.

2.3 CRA 5 Customary catch

Fisheries New Zealand were asked to provide estimates of current and historical customary catches, and an appreciation of their uncertainty (see Appendix A and Appendix B). Fisheries New Zealand advised that a constant customary catch of 10 t should be assumed, a value consistent with what was assumed in past CRA 5 stock assessments.

2.4 CRA 5 Illegal catch

Fisheries New Zealand were asked to provide estimates of current and historical illegal catches, and an appreciation of their uncertainty (see Appendix A and Appendix B).

When illegal catches for 2020 were initially discussed in the RLWG, the meeting agreed to reject the Fisheries New Zealand compliance estimates of illegal catch because these had not been adequately documented, as was done for CRA 1 and CRA 3 in the 2019 stock assessments (see Starr et al. 2020a, 2020b). The meeting rejected using the early estimates generated using the 'export-discrepancy' methodology (described by Starr et al. 2020a, 2020b) up to 1980. Instead, the meeting agreed to use 10% of the total commercial catch summed over the period 1945–1989, followed by 5% of the summed commercial catch from 1990 to 2019. The lower percentage was used for the post-1989 illegal catches on the assumption that illegal activity would be lower once rock lobster entered the QMS. These fixed catches were then scaled by the annual standardised CRA 5 CPUE, beginning in 1979. Before 1979, the illegal catches were assumed to be constant.

In the past, MPI Compliance estimates for illegal catch have been provided in two categories ("reported" or "R" and "not reported" or "NR") for some QMAs. The category of "commercial illegal reported" or "reported" or "R" was assumed to represent illegal catch that was eventually reported to the QMS as legitimate commercial catch. Therefore, previous stock assessments subtracted these estimates from the reported commercial catch to avoid double-counting. For the 2020 stock assessment, the RLWG agreed to discontinue this practice, given the lack of confidence in the Fishery Officer estimates of illegal catch, a consensus that this category was unlikely to be large, and that the solution applied was highly speculative.

The illegal catch estimates are shown in Table 3 and Figure 6.

3. CATCH INFORMATION FOR CRA 5 REGIONAL MODEL

The available biological and CPUE data were examined for evidence of differences among the CRA 5 statistical areas (Appendix C). The primary difference was the observed CPUE trends for statistical areas 917 and 933, with the latter declining from the early 2000s while the former was increasing (see Figure C.3, Figure C.4, and Figure C.5). Statistical area 916 CPUE was intermediate but was also declining over the same period as statistical area 933. An analysis of the statistical area length frequency data indicated that rock lobsters in areas 917 and 918 were generally larger than in statistical areas 916 and 933 (Figure C.7 and Figure C.8). In addition, statistical area 916 showed a declining trend in the proportion of mature females while 917 had an increasing trend (statistical area 933 was also declining in this proportion, but less steep than in 916, see Figure C.9). Because of these differences, the RLWG agreed to assess CRA 5 as two spatial regions defined by component statistical areas, with region 1 consisting of statistical areas 917+918+919 and region 2 consisting of statistical areas 916+932+933 (Table C.2).

3.1 Preparation of the regional catch information

The preparation of catch data for the two CRA 5 regions was hampered by inconsistent data availability, depending on the time period (Table 4). Reporting from the modern rock lobster statistical areas was not available until 1979, but the fishery was well-developed by then, with significant catches taken since at least 1945. Historical catches were available by sub-area for 1963–1973, but the sub-area definitions used by Annala & King (1983) (Figure 7) differed from the rock lobster statistical area definitions used from 1979 onward (Figure 1). There were also two periods (1945–1962 and 1974–1978) when sub-area catches were not available (Table 4).

3.1.1 Method used to estimate catches in the two CRA 5 regions beginning in 1979

Beginning with 1 January 1979, data were allocated to each region (Table C.2) on the basis of the declared statistical area. This applied to all data: catch, observer, and logbook catch sampling. Tagging data were not sub-divided because early model exploration indicated that growth appeared to be the same throughout the QMA.

3.1.2 Algorithm used to estimate catches in the two CRA 5 regions before 1979

Only annual estimates of catch for each CRA QMA were available for the periods 1974–1978 and 1945–1962 (Bentley et al. 2005). The Annala & King (A & K) (1983) areas were resolved into regions consistent with the Table C.2 definitions by noting that a) A & K areas 13, 14, and 15 map reasonably closely into rock lobster statistical areas 917, 918, and 919, respectively; and b) A & K area 8 included post-1978 statistical areas 915, 916, 933 and 934 (see Figure 7; note that although A & K area 23 maps into statistical area 932, catches from both of these areas were negligible). Catches were assigned to region 2 (combined 916+933+932) by applying a constant proportion of 0.700 to the A & K area 8 annual catches, where 0.700=0.429 (area 916) + 0.271 (area 933). Catches by region over the period 1974 to 1978 were filled by interpolation. Pre-1963 catches were assigned using the mean regional proportions from 1963 to 1967.

The following algorithm was used to apportion catches to the defined CRA 5 regions, based on distributions available when reporting was more accurate:

1. Starting from the FSU (in place for rock lobster from January 1979 to June 1989) data set, sum reported annual catches for the four statistical areas in Annala & King area 8 from 1979–80 to 1983–84:

$$C_y^{area8} = \sum_{a \in \{915,916,932,933\}} c_y^a$$

where a is one of the four area 8 rock lobster statistical areas in Table 5.

2. Calculate the relative proportions by year of each of the four contributing rock lobster statistical areas in Annala & King area 8 identified in Table 5:

$$P_y^a = \frac{C_y^a}{C_y^{area8}}$$

   where the mean value of P_y^a over the first five FSU years for statistical areas 916(0.429) and 933 (0.271) are then summed to give the mean contribution of Annala & King area 8 to the CRA 5 region 2 (916+932+933). See Table 6 for these calculations.

3. By year, calculate the contribution of the two CRA 5 statistical areas in Annala & King area 8 based on the proportions estimated in step 2:

$$k_y^{916+932+933} = 0.700 K_y^{area8}$$

   where K_y^{area8} is the Annala & King catch in area 8 in years y(y = 1963–1973). <u>Note</u>: only used method codes 8 or 19 in the Annala & King data (these are the potting method).

4. Sum the catches in the Annala & King spatial catch data that are deemed to contribute to the CRA 5 regional catches to get a total CRA 5 catch in each year and divide by the sum of Annala & King catches for each region to get the relative regional proportion in year y:

$$pk_y^R = \sum_{a=1}^{n^R} k_y^a \bigg/ \sum_{a=1}^{N} k_y^a$$

   where R is region 1 (917+918+919) or region 2 (916+932+933) in year y (y=1963–1973) and n^R is the number of Annala & King areas in region R. Note that the CRA 5 allocation in Annala & King area 8 will be decremented by 30% in keeping with the equation in paragraph 3. The denominator will be the sum of the deemed CRA 5 catch in all the Annala & King areas.

5. The total catch held in the term $\sum_{a=1}^{N} k_y^a$ is much greater than the total used in previous stock assessments for CRA 5 (held in CRACE—Bentley et al. 2005—compare columns 4 and 5 in Table 7). Therefore, the catches need to be scaled to match the CRACE catches by using the proportions calculated in step 4 by the historical CRA 5 catch in year y to get the scaled statistical area catch from 1963 to 1973:

$$c_y^R = pk_y^R C_y^{\text{CRA5}}$$

   where C_y^{CRA5} is the catch value used in the combined CRA 5 stock assessment.

6. Values for pk_y^a from 1974 to 1978 were obtained by interpolating between pk_{1973}^a and pk_{1979}^a (Table 8) and then applying the equation in step 5 to the appropriate value of C_y^{CRA5}.

7. Values for pk_y^a before 1963 were obtained by averaging $\sum_{y=1963}^{y=1967} pk_y^a/5$ (see final row in Table 7) and then applying the equation in step 5 to the appropriate value of C_y^{CRA5}.

8. The pk_y^a proportions derived in steps 4, 6, and 7 were used to allocate the CRA 5 non-commercial catches by statistical area and year in the years before 1979. Proportions based on the reported commercial catches by fishing year from the Fisheries Statistics Unit (FSU) and Catch Effort Landing Return (CELR) systems were used to allocate the non-commercial catches to statistical areas from 1979 onward. The commercial catch distributions were based on the F0_LFX algorithm (see appendix D of Starr 2021).

The time series of estimated catches by category of capture are presented by CRA 5 region in Figure 8, in Table 9 [region 1 (917+918+919)] and Table 10 [region 2 (916+932+933)].

The two regions initially show a similar distribution of autumn-winter (AW) commercial catch (Figure 9), being low (between 0.2 and 0.4 during the 1980s) followed by a strong increase to over 0.8 by the end of the 1990s. However, the series diverge after that, with region 1 (917+918+919) retaining a high proportion of AW catches while the proportion of AW drops for region 2 (916+932+933). These seasonal distributions are used to allocate the commercial and illegal catches to the AW and SS seasons for each region. Arbitrary seasonal splits of 0.10 (AW) and 0.90 (SS), consistent with the assumptions used in all rock lobster stock assessments, were used to allocate recreational and customary catches to a season. These seasonal proportions are then used to allocate catches into two categories: SL (size limited: the sum of commercial and recreational catches) and NSL (not size limited: the sum of illegal and customary catches) (Figure 10, Table 9, and Table 10). These are the catch distributions that were used to model the two CRA 5 regions.

4. CATCH RATE INFORMATION

4.1 Seasonal standardised CPUE indices

4.1.1 Introduction and methods

Catch and effort data from the Catch Effort Landing Return (CELR) forms were obtained from Fisheries New Zealand in May 2020 (replog 12983) and processed using standard error checks (Bentley et al. 2005). Data spanned the period from 1 July 1989 to 30 September 2019. Data for the period 1 April 1979 to 30 June 1989 came from the FSU database, a static copy of which is held by the rock lobster stock assessment team.

Preparation of the CELR data used the F2_LFX procedure (see appendix D of Starr 2021). The F2 algorithm scales the monthly estimated catch taken by a vessel in a statistical area using a “vessel correction factor” (*vcf*) which is the ratio of landed catch to estimated catch for one vessel in one year (eq. D.6 in appendix D of Starr 2021). Vessels with a *vcf* less than 0.8 or greater than 1.2 were discarded from the analysis. The F2_LFX procedure scales the estimated catches to the combined “L” (landed to a Licensed Fish Receiver [LFR]), “X” (discarded to sea), and “F” (section 111 recreational catch) destination codes (destination codes are defined in table B.1 in appendix B of Starr 2021). The number of records in each CPUE data set is provided in Table 11 [CRA 5 region 1 (917+918+919) and CRA 5 region 2 (916+932+933)].

The 2019–20 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. There are three different ER reporting “platforms”, each with different user interfaces and slightly different underlying software. Preliminary analyses of the 2019–20 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 in Starr 2021). Therefore, the RLWG agreed to temporarily suspend updating CPUE indices beginning with the 2019–20 spring/summer season (the RLWG concluded that, with the exception of CRA 7, there remained sufficient CELR data in the QMAs that there was comparability with previous indices for the AW 2019–20 data). This meant that the 2020 CRA 4 and CRA 5 stock assessments did not include SS CPUE estimates for 2019–20.

The 2020 CRA 5 stock assessment included four standardised CPUE series calculated from two generalised linear models (GLMs) that used sequential six-month periods as explanatory variables. Two CPUE series (one for each CRA 5 region) were based on the early FSU data and the second two series (again one for each CRA 5 region) used the more recent CELR data. Three explanatory variables were used for all analyses in addition to the sequential [period] variable: [month] of capture, statistical [area] of capture, and an identification code for each fishing [vessel].

All four GLMs included the variable [vessel] as an explanatory variable. The only difference between the FSU and CELR analyses was that all vessels were included in the FSU analyses while the CELR analysis was filtered for vessels with at least five years of data[2]. Bayesian inference was used to estimate parameter uncertainty. This was done using the R package *brms*, which is a wrapper for doing GLMs coded using the Stan language. Stan uses gradient-based Markov chain Monte Carlo (MCMC), specifically the Hamiltonian Monte Carlo (HMC) algorithm, for Bayesian inference. Four thousand samples from the posterior distribution were obtained by combining samples across four chains, with each chain consisting of a warm-up period of 2000 discarded iterations followed by sampling the next 1000 iterations.

Both GLMs include population-level effects for period (t), and group-level effects for month (m), vessel (v), and a time period × statistical area interaction term (a):

Eq. 2
$$\log\left(\frac{C_i}{E_i}\right) = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} = \boldsymbol{\beta}_0 + \boldsymbol{T}\boldsymbol{\beta}_t + \boldsymbol{AT}\boldsymbol{\beta}_{a,t} + \boldsymbol{M}\boldsymbol{\beta}_m + \boldsymbol{V}\boldsymbol{\beta}_v + \boldsymbol{\varepsilon}$$

with priors and hyperpriors

$$\begin{gathered}\sigma \sim student(3, 1, 10)\\ \beta_0 \sim N(0, 100)\\ \beta_t \sim N(0, 10)\\ \beta_m \sim N(0, 10)\\ \beta_a \sim N(0, 10)\\ \sigma_{\beta_{a,t}} \sim student(3, 1, 10)\\ \beta_{a,t} \sim N\left(0, \sigma^2_{\beta_{a,t}}\right)\end{gathered}$$

and distribution

$$\varepsilon_i \sim N(0, \sigma^2)$$

where C_i is the catch (tonnes) for record i, E_i is the effort (number of pot lifts) for record i, β_0 is the intercept, β_t are the period coefficients, $\beta_{a,t}$ are the time period × statistical area coefficients, β_m are the month coefficients, and β_v are the vessel coefficients. There are two time periods (t) for each fishing year. The periods are referred to as SS and AW when two (seasonal) time periods are specified. For t = (1, 2, 3, …, n), then t = (AW, SS, AW, …, SS), where SS = October to March.

4.1.2 CRA 5 Regional seasonal standardised series

Trace plots of samples from the posterior distribution for the Bayesian GLM appear well-mixed with no indication of lack of convergence (Figure 11). Vessel coefficients in the CELR analysis (Figure 12) show a wide range of values, but only one vessel has a non-overlapping posterior distribution. The month coefficients in April, September, October, January, and February are below average, suggesting lower catch rates during these months (Figure 13). Vessel coefficients from the FSU analysis show large amounts of inter-vessel variability (Figure 14). Unsurprisingly, the month coefficients estimated by the FSU analysis were very similar to those estimated by the CELR analysis (compare Figure 15 with Figure 13).

[2] Note that the five-year participation requirement was calculated for all of CRA 5, not by region.

There is a gradual declining trend in the resulting standardised FSU series from 1982 SS in both regions (Table 12, Figure 16). The FSU series also begins to show the strong annual variation between the AW and SS seasons that is apparent in the CELR series. Note the wide range of uncertainty in the posterior of the FSU annual indices, probably reflecting the large amount of inter-vessel variability noted in Figure 14.

The standardised CELR series starts from a low level in the early 1990s in both regions and steadily increases until the late 1990s, after which the CPUE in each region begins to diverge, with the CPUE in region 1 remaining relatively high, but declining in region 2 (Table 12, Figure 17). The SS indices are always greater than the AW indices in the same fishing year, but both seasons show the same overall trend.

4.2 Historical catch rate (CR) data

Although catch data from 1963 to 1973 from the Annala & King (1983) data set were allocated to rock lobster statistical areas using the procedure described in section 3.1.2, it would be incorrect to apply the same procedure to the effort (days) data. That is because following this procedure will result in exactly the same CPUE series as was estimated for the entire Annala & King area. The CR series for region 1 (917+918+919) (Table 13) can be used in the CRA 5 model because the catch and days data can be unambiguously assigned to this region (see Table 6). On the other hand, the catch and effort data from Annala & King area 8 will be contaminated with CRA 4 data from the south coast and therefore cannot be used for region 2 (916+932+933).

5. LENGTH FREQUENCY DISTRIBUTIONS (LFS)

CRA 5 length frequency (LF) data were extracted in August/September 2020, comprising both observer and voluntary logbook catch sampling from the 1989–90 to the 2019–20 fishing years. Each data record used for input to the model represented a weighted sum of the length measurements for a season and sampling source for each year of sampling. The protocol of the logbook catch sampling programme requires participating fishers to measure every lobster (up to 25 individuals) in each of 3–5 marked pots each day. This design results in good spatial and temporal representation of the catch if the participating fishers are representative of the wider fishing population. The CRA 5 fishers embraced the logbook programme from the beginning and the sampling quantities in Table 14 (region 1 [917+918+919]) and Table 15 (region 2 [916+932+933]) demonstrate the long-term commitment to the programme. Some observer catch sampling is available from the 1989–90 fishing year to the late 1990s, after which it is only intermittently available. This latter sampling procedure measures and sexes all lobsters from as many pots as is feasible during a day’s fishing for the vessel being observed.

Record fields from both programmes include the following information:

- fishing year
- season (coded 1 for AW, 2 for SS)
- source (coded 1 for logbooks, 2 for observers)
- a relative weight field for the record (w), described below
- the total number of lobsters measured
- 31 fields, representing the relative proportion (see below) of males measured by sex class within the sizes classes {[30, 32), [32, 34), …, [88, 90), [90, ∞)} mm tail width (TW)
- 31 fields for immature female numbers measured
- 31 fields for mature female numbers measured.

Each data record comprised measurements taken from various months within the season and from various statistical areas within the QMA. For each month/area strata, the numbers-at-length were summed for each sex, and the proportion-at-sex was calculated as:

Eq. 3 $$p_{g,m,a,s} = \frac{N_{g,m,a,s}}{\sum_s N_{g,m,a,s}}$$

where g indexes sex, s indexes size group, m indexes month, a indexes statistical area, and $N_{g,m,a,s}$ represents the number-at-length for each sex in the month/area/length bin cell.

Proportions-at-length from the month/area cells were combined to form a record, based on their "representativeness", i.e., using the catch in the month/area cell ($C_{m,a}$) compared with the total catch for the season:

Eq. 4 $$P_{g,s} = \frac{\sum_m \sum_a (C_{m,a} p_{g,m,a,s})}{\sum_m \sum_a \sum_s (C_{m,a} p_{g,m,a,s})}$$

where $P_{g,s}$ was the relative proportion-at-length for each sex in the record. The model re-normalised these to sum to 1 across each sex.

Note that catches based on the F0_LFX algorithm (see appendix D of Starr 2021) were used to calculate the relative weights in Eq. 4. Appendix D documents an analysis which compared the 2019–20 LF distributions across all QMAs generated when using the F0_LFX or the F2_LFX algorithms, given that there was concern that the changes in catch reporting attributed to the transition from CELR to ER may have affected this procedure. Although the analysis presented in Appendix D suggests that there is little sensitivity to the chosen catch algorithm, it is not possible to know if the shift to ER reporting has affected the weighting procedure. The RLWG elected to continue to use the F0_LFX algorithm in Eq. 4 for consistency with past practice and because this algorithm retains all catch data.

As well as the relative weight assigned to the overall LF dataset, a relative weight for each sex (w_s) was assigned to each data record within the dataset, which combined the representativeness of each month/area cell, the cube root of the number of fish measured ($N_{m,a,s}$), and the cube root of the number of days sampled ($D_{m,a}$):

Eq. 5 $$w_s = \sum_m \sum_a \frac{C_{m,a} \sqrt[3]{N_{m,a,s}} \sqrt[3]{D_{m,a}}}{\sum_m \sum_a C_{m,a}}$$

This approach of applying the relative weight by sex represented a change from earlier rock lobster stock assessments which used a single weight for the total record, after applying a truncation rule to the weights so that single records did not have exceptional influence (see Starr et al. 2016, for instance). This former rule truncated weights to a maximum value of 10, while raising weights less than 1.0 to 1.0. Because of the change to using weights by sex category, the stock assessment team decided to use the length frequency records without applying the truncation rule. Applying relative weights by sex in this way is more practical if there are few (or no) immature female individuals measured but there are male and mature female records. Using the previous methodology, these records would have received the same weight (across all three sex categories) and the size class with few or no measured individuals would have been inappropriately up-weighted, given the small amount of data.

The region 1 (917+918+919) LF data comprised 70 records for 1989–2019, with 52 being logbook samples and the remaining 18 being observer catch sampling (with separate records for each season). The logbook records ranged from 115 to 11 590 lobsters measured across both seasons while the observer samples ranged from 544 to 6402 lobsters measured, across both seasons (Table 16). None of the logbook or observer samples were dropped. The logbook sampling relative weights by sex (Eq. 5) ranged from 1.8 to 71.1 for the accepted samples while the observer catch sampling record weights ranged from 0.87 to 8.3 (Table 17). All low weights corresponded to samples with few observed immature females or to mature females in the AW, giving an appropriate low weight to these poorly represented sex categories.

The region 2 (916+932+933) LF data comprised 58 records for 1994–2019, with 50 being logbook samples and the remaining 8 being observer samples (with separate records for each season). Two logbook samples were dropped because there was only one vessel involved. The logbook records ranged from 145 to 23 834 lobsters measured across both seasons while the observer samples ranged from 719 to 11 196 lobsters measured, across both seasons (Table 18). The logbook sampling relative weights by sex (Eq. 5) ranged from 0.31 to 73.9 for the accepted samples while the observer catch sampling record weights ranged from 0.68 to 9.1 (Table 19). Again, all the very low weights corresponded to samples with few observed immature or mature females in the AW, giving an appropriate low weight to these poorly represented sex categories.

Sex proportions were calculated from normalised data records for both CRA 5 regions. The sex ratios of males and mature females showed little systematic pattern over time in region 1 (917+918+919) AW but there may be an increasing trend in the mature females in the SS (Figure 19). The region 2 (916+932+933) sex ratios for males appear to be trending upwards in both seasons, with the mature females showing the reverse downward trend (Figure 20).

Mean tail width, also calculated from the data records, shows a rising trend in region 1 (917+918+919) AW for both males and mature females, and for the mature females in the SS (Figure 21). There seems to be no corresponding trend among males or mature females in region 2 (916+932+933) (Figure 22).

Although the model contains size bins in the range 30–90+ mm TW, few fish as small as 30 mm were measured and very few large fish were measured, especially for immature females, leading to many cells with zero observations in both CRA 5 regions (region 1 (917+918+919): Figure 23 [top panel]; region 916+932+933: Figure 23 [bottom panel]). For sex/size bins with few observations, the model would be comparing many zero observations with zero or very small predictions, resulting in a large number of very small residuals that would distort the diagnostics and waste computing time. Bins at both ends of the range for each sex were therefore combined into accumulator "plus" and "minus" bins. Table 24 shows the number of year, season, and sampling category records for each 2-mm TW bin by sex category. This table also shows the number of these records where the year, season, and sampling category proportion within a sex category is less than 0.001 (an arbitrary threshold) and the calculated proportion of records greater than 0.001 in the bin. This information is useful to select appropriate accumulator bins for each sex category. Past experience has shown that model results were not very sensitive to the chosen threshold value.

The observed distributions of the LF data are shown for each data record included in the stock assessment, where a "data record" represents the normalised frequency by sex class in a sequential six-month season by data source (logbook or observer catch sampling) (Figure E.1 to Figure E.13). Figure 24, which plots the weighted LFs in a single plot for CRA 5 region 1, shows the progression of increasing size distribution over the period of sampling for males and mature females. The same plot for CRA 5 region 2 is given in Figure 25.

6. TAG DATA

This section describes tag-recapture data that were used to inform growth in the stock assessment of rock lobster stocks (Haist et al. 2009). These data are also useful for informing decisions about stock structure and movement. Tag data for all CRA areas were extracted in August 2020.

6.1 Data processing

Before the tag data were summarised to inform growth in stock assessments, they were pre-processed (i.e., obvious errors were corrected and records that cannot be used were removed). As part of this procedure, every release-recapture event was linked to form a single record. Processing, linking, and formatting were done using purpose-built software written in the R statistical computing language.

The tag processing software implemented the following rules:

1. remove duplicate records
2. remove records with no date
3. remove records that are missing both tail width and carapace length
4. remove releases with no corresponding recapture
5. iteratively match captures with recaptures
6. if sex is missing at capture but not recapture, then infer sex and vice versa
7. remove matched records that change sex
8. remove matched records that do not have a sex code of 1 or 2
9. if statistical area is not 901 to 943 then set to NA
10. if the option [qma_method] = "area", then determine the quota management area (i.e., CRA 1, ..., CRA 9) from the statistical area, unless the statistical area is NA, then set the QMA using the project ID (this option was used). Otherwise, determine the quota management area from the project ID, unless the project ID is NA then set the QMA using the statistical area
11. if the calendar year > 1992 and the source = 2 (catch sampling) then add 0.5 to the tail width measurement (this step is required because of the measurement instructions provided to the observers doing the catch sampling)
12. if there is no recorded tail width, then calculate this from the carapace length using the relationships given by Breen et al. (1988)
13. remove records where tail width is less than 20 mm
14. remove records where tail width is greater than 150 mm
15. calculate the time at liberty in days
16. remove those records that are at liberty for less than 1 day
17. remove those records that are at liberty for greater than 10 years
18. calculate the growth increment as the difference in tail widths
19. remove records with a growth increment less than -40 mm or greater than 40 mm

Data were then rearranged into the format used by the model:

- sex (1 for males and 2 for females)
- year of release, extracted from release date
- year of recovery, extracted from recovery date
- days at liberty, obtained by subtracting release from recovery dates
- TW at release
- TW at recovery
- number of re-releases
- statistical areas of release and recovery

6.2 Tag data summaries: all QMAs

6.2.1 Comparison with previous extract

A comparison was done to ensure that new data extracts were not missing records that were available in previous years and to see how many new data records are available (Table 26 and Table 27). This comparison showed small decreases in the overall number of recoveries for a number of tagging programmes (Table 26) and only a small increase of 15 recoveries in 2019 (Table 27). The reasons for the differences with the numbers available in 2019 will be investigated before the next stock assessment.

6.2.2 Summaries of all data (paired tag release and recovery records)

Recovery rates (tags turned in relative to number released) vary by QMA, with the highest rate occurring in CRA 8 (0.460) and the lowest rate in CRA 9 (0.020) (Table 28). There was a total of 34 695 complete release/recovery records (i.e., not missing a key piece of information such as sex, QMA, initial size, recapture size, or time at liberty) available in the New Zealand rock lobster tagging data set (Table 29). The CRA QMA with most recovered tags was CRA 8, and the fewest recaptured tags came from CRA 6 and CRA 9, both of which had fewer than 200 recoveries (Table 29).

Tagged lobsters are generally recaptured in the QMA or statistical area of release but, for a number of recaptures, it appears that individuals moved much greater distances (Table 30). However, it seems more likely that many of these large-scale movements (e.g., from CRA 8 to CRA 3 and from CRA 3 to CRA 8 – see Table 30) may be due to data errors, which will be investigated in the future.

6.2.3 Summary for QMAs: growth patterns

The observed growth increment (mm) by tail width (mm) at release was generally greater in smaller individuals, but this relationship is highly variable (Figure 26, Figure 27). Growth rates differed by QMA, with CRA 3 and CRA 4 showing fewer large individuals compared with most of the other QMAs (Figure 27). The relationship between observed growth increment (mm) and time at liberty (years) appears to be less variable than for tail width, but it is still highly variable (Figure 28, Figure 29). This observation holds true for all the QMAs with an adequate amount of data (Figure 29).

6.3 CRA 5: tag data summaries

Tagging data were not sub-divided into the component CRA 5 regions because early model exploration indicated that growth appeared to be the same throughout this QMA.

The total number of CRA 5 tag recoveries consisted of just over 7400 events, with 1447 recoveries occurring from releases before 1996 and the remainder occurring from releases beginning in 1996 (Table 31, Table 32). It is interesting to note that the 227 recoveries in statistical area 918 were from releases made in the 1970s and early 1980s. Apart from those early tag recoveries in statistical area 918, the remainder of the tagging occurred in statistical areas 916, 917, and 933, with a total of 2000 to 3000 tag recoveries in these three principal statistical areas. Females were not well represented in the recovery data set, with 70% of the recoveries being male. Releases were reasonably well distributed across the entire year with every month showing several hundred release/recovery pairs, except for March when there is little fishing (Table 33). Most recaptures were made in the statistical area of release, with little evidence of large-scale movement, although there are a few recoveries off the south coast of the North Island, just across Cook Strait (statistical areas of 915 and 934; Table 34).

The distributions of sizes at release and recapture by sex are shown in Figure 30, with most of the tagged males just below 54 mm TW whereas the females show a broader distribution of tagged individuals, with a mode near the 60 mm TW MLS. The recapture polygon for males in this plot shows a greater shift to the right of the release polygon for larger individuals compared to the female recapture polygon, indicating males in this data set tended to have larger growth increments. Females, however, show larger growth increments at smaller sizes.

6.3.1 CRA 5: times at liberty

Times at liberty varied from 1 day to 2523 days (6.9 years) for males and from 1 day to 3532 days (9.7 years) for females (Table 35). The medians were 224 days for males and 289 days for females (Table 35). The number of times an individual was re-released is also monitored with a few males re-released seven to thirteen times and four to six times for females (Table 36). Thirty percent of the male recoveries came from re-releases while the equivalent percentage for females was 19%.

6.3.2 CRA 5: growth increments

Growth increments ranged from -30 to 34.5 mm (males) and -30 to 31.3 mm (females) (Table 37). As with the overall QMA summaries, the observed growth increment (mm) in CRA 5 by TW at release was generally greater in smaller individuals, even when viewed by statistical area (Figure 31, Figure 32). Similarly, the relationship between observed growth increment (mm) and time at liberty (years) is somewhat tighter, even when viewed by statistical area (Figure 33; Figure 34).

7. PUERULUS SETTLEMENT DATA

The puerulus settlement programme, conducted by NIWA, is described in annual reports (e.g., Forman et al. 2021). For CRA 5, the only site available is Kaikōura (Figure 35, Table 38). Each site has at least one group of three collectors that are checked monthly when possible, and the monthly catches of the puerulus from each collector are used to calculate a standardised settlement index using fishing year, month, and collector group as explanatory variables while assuming a negative binomial likelihood (Forman et al. 2021). Although the previous CRA 5 stock assessment (Starr & Webber 2016) incorporated this settlement series into the base case stock assessment, these data were only used in a sensitivity run for this assessment. This was because the puerulus series did not match well the model estimates of peak recruitment, particularly in model region 1 where the settlement traps are located, leading to the conclusion that the CRA 5 puerulus series was not a consistent representation of settlement to this QMA.

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TABLES

Table 1: Information used to estimate recreational catch for CRA 5.

Category	Numbers	Mean weight	Weight (kg)	Assumed CV
1994 (Bradford 1997)	67 000	0.563[1]	37 721	1.5*(0.17+0.23)/2
1996 (Bradford 1998)	41 000	0.563[1]	23 083	1.5*(0.17+0.23)/2
2000 (Boyd & Reilly 2004)	151 000	0.565[2]	85 315	not used
2001 (Boyd et al. 2004)	162 000	0.565[2]	91 530	not used
2011 (NPS)	49 274[3]	0.88[3]	43 470	0.24
2017 (NPS)	51 464[4]	0.80[4]	40 960	0.21
Section 111 reported landings				
Maximum reported landings (kg) (in 2012)			7 215	

[1] SS mean weight (kg) calculated from commercial sampling data from 1994 to 1996 assuming recreational minimum legal sizes
[2] SS mean weight (kg) calculated from commercial sampling data from 2000 and 2001 assuming recreational minimum legal sizes
[3] estimate provided in Wynne-Jones et al. (2014), Table 60
[4] estimate provided in Wynne-Jones et al. (2019), Table 57

Table 2: Fishing platform and capture method categories for CRA 5 during 2011–12 and 2017–18 estimated by the national recreational panel surveys (Wynne-Jones et al. 2014, 2019). The final line shows the 2011–12 and 2017–18 CRA 5 total catch estimates. CV=standard error of the estimate, which does not include error associated with the estimate of mean weight.

Category	Numbers	CV	Catch (t)[1,2]	CV	% of total catch weight
Survey year: 2011–12					
Fishing platform					
Trailer motor boat	39 469	0.42	34.03	0.43	80
Larger motor boat or launch	663	0.54	0.60	0.51	1.3
Trailer yacht	0	0.00			0
Larger yacht or keeler	0	0.00			0
Kayak canoe or rowboat	0	0.00			0
Off land including beach rocks or jetty	9 142	0.42	8.83	0.43	19
Something else	0	0.00			
Capture method					
Rod or line (not longline)	0	0.00			0
Longline including set line kontiki or kite	0	0.00			0
Net (not including landing net used if caught by line)	0	0.00			0
Pot (e.g., for crayfish)	17 628	0.60	12.51	0.59	29
Dredge grapple or rake	0	0.00			0
Hand gather or floundering from shore	1 595	0.62	1.50	0.62	3.5
Hand gather by diving	30 050	0.28	29.46	0.28	68
Spearfishing	0	0.00			0
Some other method	0	0.00			0
Total (2011–12)	49 273	0.24	43.47	0.24	100
Survey year: 2017–18					
Fishing platform					
Trailer motor boat	32 212	0.22	25.82	0.21	63
Larger motor boat or launch	8 058	0.43	5.33	0.43	13
Trailer yacht	0	0			0
Larger yacht or keeler	0	0			0
Kayak canoe or rowboat	982	0.88	0.58	0.88	1.4
Off land including beach rocks or jetty	10 213	0.51	9.22	0.52	23
Something else	0	0			
Capture method					
Rod or line (not longline)	0	0.00			0
Longline including set line kontiki or kite	0	0.00			0
Net (not including landing net used if caught by line)	0	0.00			0
Pot (e.g., for crayfish)	25 576	0.31	15.73	0.32	38.4
Dredge grapple or rake	0	0.00			0
Hand gather or floundering from shore	0	0.00			0
Hand gather by diving	25 889	0.28	25.23	0.28	61.6
Spearfishing	0	0.00			0
Some other method	0	0.00			0
Total (2017–18)	51 465	0.33	40.96	0.21	100

[1] mean weight estimate (Hartill & Davey 2015)
[2] mean weight estimate (Davey et al. 2019)

Table 3: Estimated CRA 5 catches (commercial, recreational including section 111, customary, and illegal) by season in tonnes. Note that the model does not use two seasons until 1979; annual estimates are provided in the AW column before 1979.

Calendar	Comm-ercial	Recrea-tional	Illegal	Cus-tomary	Fishing	Commercial		Recreational			Illegal	Customary	
Year	Annual	Annual	Annual	Annual	Year	AW	SS	AW	SS	AW	SS	AW	SS
1945	135.7	14.2	50.7	10.0	1979	129.4	271.0	4.2	37.8	9.2	19.3	1.0	9.0
1946	200.6	15.0	50.7	10.0	1980	136.2	366.9	4.6	41.4	9.4	25.3	1.0	9.0
1947	250.2	15.8	50.7	10.0	1981	96.2	378.0	4.5	40.8	6.3	24.7	1.0	9.0
1948	530.3	16.6	50.7	10.0	1982	145.5	478.1	4.6	41.8	8.0	26.2	1.0	9.0
1949	686.8	17.4	50.7	10.0	1983	156.8	440.5	4.3	39.1	8.0	22.6	1.0	9.0
1950	898.7	18.3	50.7	10.0	1984	194.2	525.9	4.3	38.9	8.4	22.6	1.0	9.0
1951	577.9	19.1	50.7	10.0	1985	146.6	576.6	4.2	37.5	5.2	20.3	1.0	9.0
1952	576.1	19.9	50.7	10.0	1986	146.2	478.7	4.0	35.9	5.2	17.1	1.0	9.0
1953	378.4	20.7	50.7	10.0	1987	116.6	378.9	3.7	33.5	4.4	14.3	1.0	9.0
1954	336.7	21.5	50.7	10.0	1988	67.6	283.2	3.5	31.9	3.1	13.2	1.0	9.0
1955	353.9	22.3	50.7	10.0	1989	64.5	246.9	3.6	32.3	3.4	13.2	1.0	9.0
1956	348.1	23.2	50.7	10.0	1990	56.2	252.2	3.6	32.2	0.8	3.8	1.0	9.0
1957	256.1	24.0	50.7	10.0	1991	52.1	235.1	3.4	30.5	0.7	3.2	1.0	9.0
1958	334.0	24.8	50.7	10.0	1992	48.0	210.6	3.3	30.1	0.7	3.0	1.0	9.0
1959	427.0	25.6	50.7	10.0	1993	97.1	213.7	3.5	31.6	1.3	2.9	1.0	9.0
1960	388.8	26.4	50.7	10.0	1994	95.8	197.8	3.6	32.4	1.5	3.1	1.0	9.0
1961	362.9	27.3	50.7	10.0	1995	104.0	193.3	3.7	32.9	1.8	3.4	1.0	9.0
1962	433.0	28.1	50.7	10.0	1996	182.4	117.5	4.0	35.7	4.1	2.7	1.0	9.0
1963	373.1	28.9	50.7	10.0	1997	218.1	81.0	4.6	41.6	6.9	2.6	1.0	9.0
1964	458.7	29.7	50.7	10.0	1998	232.9	64.7	5.2	46.6	8.7	2.4	1.0	9.0
1965	469.4	30.5	50.7	10.0	1999	281.4	67.4	4.9	44.0	9.8	2.4	1.0	9.0
1966	599.8	31.3	50.7	10.0	2000	292.5	54.1	5.4	48.5	13.2	2.4	1.0	9.0
1967	480.5	32.2	50.7	10.0	2001	319.1	28.9	5.5	49.8	16.7	1.5	1.0	9.0
1968	392.8	33.0	50.7	10.0	2002	296.1	51.5	5.7	51.6	17.5	3.0	1.0	9.0
1969	436.8	33.8	50.7	10.0	2003	275.4	73.2	6.2	55.8	18.2	4.8	1.0	9.0
1970	391.6	34.6	50.7	10.0	2004	235.3	108.8	5.7	51.0	12.1	5.6	1.0	9.0
1971	395.0	35.4	50.7	10.0	2005	238.6	109.9	6.4	57.3	12.2	5.6	1.0	9.0
1972	414.9	36.2	50.7	10.0	2006	213.8	135.0	6.3	56.6	11.2	7.1	1.0	9.0
1973	374.0	37.1	50.7	10.0	2007	215.3	133.4	6.5	58.6	11.6	7.2	1.0	9.0
1974	313.2	37.9	50.7	10.0	2008	236.4	112.1	6.9	61.8	14.7	7.0	1.0	9.0
1975	414.2	38.7	50.7	10.0	2009	245.8	102.5	7.6	68.7	19.4	8.1	1.0	9.0
1976	379.2	39.5	50.7	10.0	2010	255.7	92.8	7.4	66.5	19.6	7.1	1.0	9.0
1977	372.2	40.3	50.7	10.0	2011	244.6	103.9	7.2	64.4	17.4	7.4	1.0	9.0
1978[1]	444.5	41.2	50.7	10.0	2012	244.5	105.5	7.8	70.0	16.2	7.0	1.0	9.0
					2013	244.5	105.5	6.9	62.5	15.0	6.5	1.0	9.0
					2014	229.3	119.8	7.3	65.4	15.4	8.1	1.0	9.0
					2015	225.6	124.6	6.9	62.2	13.2	7.3	1.0	9.0
					2016	233.3	116.7	7.9	71.4	15.1	7.6	1.0	9.0
					2017	204.4	145.5	7.3	66.1	14.7	10.5	1.0	9.0
					2018	216.7	133.2	7.1	63.8	13.9	8.5	1.0	9.0
					2019	204.2	131.9	7.5	67.2	14.3	9.2	1.0	9.0

[1] includes January-March 1979 catches

Table 4: Data availability by time period for CRA 5 multi-area stock assessment. FSU: Fisheries Statistics Unit; QMR: Quota Management Reports; MHR: Monthly Harvest Returns; CELR: Catch Effort Landing Returns. See Bentley et al. (2005) for more information on the historical data sources by year.

Period	CRA 5 (QMA) data availability	CRA 5 (sub-area) data availability
1945–1962	estimates based on port of landing	not available
1963–1973	Annala & King (1983)	Annala & King (1983) area definitions
1974–1978	estimates based on Annala & Esterman (1986)	not available
1979–1985	FSU estimates	FSU statistical area definitions
1986–1988	QMR estimates	FSU statistical area definitions
1989–2000	QMR estimates	CELR (=FSU) statistical area definitions
2001–2019	MHR estimates	CELR (=FSU) statistical area definitions

Table 5: Mapping of Annala & King (1983) statistical areas into the NZ rock lobster statistical areas. CRA 5 statistical areas are marked with *.

Rock lobster statistical area	Annala & King statistical area Area 8	Area 13	Area 14	Area 15	Area 23
915	x				
916*	x				
917*		x			
918*			x		
919*				x	
932*					x
933*	x				
934	x				

Table 6: Percent distribution between adjacent rock lobster statistical areas in the Annala & King (1983) area groupings identified in Table 5.

Fishing				area 8	area 13	area 14	area 15	area 23
Year	915	916	933	934	917	918	919	932
1979	0.254	0.535	0.209	0.002	1	1	1	1
1980	0.255	0.507	0.234	0.003	1	1	1	1
1981	0.291	0.417	0.292	0.000	1	1	1	1
1982	0.346	0.342	0.310	0.002	1	1	1	1
1983	0.343	0.342	0.311	0.004	1	1	1	1
Mean	0.298	0.429	0.271	0.002	1	1	1	1

Table 7: Proportions by CRA 5 Region as calculated in step 4 (see section 3.1.2). The final two columns are the sums of annual catch defined in steps 4 and 5 (see section 3.1.2).

Calendar year	Region 1: 917+918+919	Region 2: 916+932+933	$\sum_{a=1}^{4} k_y^a$	C_y^{CRA5}
1963	0.506	0.494	903.5	375.9
1964	0.531	0.469	1 174.7	461.5
1965	0.539	0.461	1 287.3	472.3
1966	0.534	0.466	1 574.3	602.7
1967	0.538	0.462	1 180.6	483.4
1968	0.478	0.522	988.6	395.6
1969	0.442	0.558	1 081.6	439.7
1970	0.489	0.511	946.6	394.5
1971	0.530	0.470	951.3	397.8
1972	0.569	0.431	1 016.4	417.7
1973	0.649	0.351	886.8	376.8
Mean	0.528	0.472	–	–

Table 8: Interpolated proportions by CRA 5 Region as described in step 6 (see section 3.1.2).

Calendar year	Region 1: 917+918+919	Region 2: 916+932+933
1973	0.649	0.351
1974	0.644	0.356
1975	0.639	0.361
1976	0.634	0.366
1977	0.629	0.371
1978	0.623	0.377
1979	0.618	0.382

Table 9: Estimated catches (t) (commercial, recreational including section 111, illegal, and customary) for CRA 5 region 1 (917+918+919), provided annually before 1979 (January–March 1979 added to 1978) and seasonally (AW and SS) from 1979 to 2019.

Calendar Year	Commercial Annual	Recreational Annual	Illegal Annual	Customary Annual	Fishing Year	Commercial		Recreational		Illegal		Customary	
						AW	SS	AW	SS	AW	SS	AW	SS
1945	73.4	7.5	26.8	5.3	1979	83.5	164.1	2.6	23.4	5.9	11.7	0.6	5.6
1946	107.7	7.9	26.8	5.3	1980	77.5	208.5	2.6	23.5	5.4	14.4	0.6	5.1
1947	134.0	8.4	26.8	5.3	1981	54.0	227.5	2.7	24.2	3.5	14.9	0.6	5.3
1948	282.3	8.8	26.8	5.3	1982	87.7	298.7	2.9	25.9	4.8	16.4	0.6	5.6
1949	365.1	9.2	26.8	5.3	1983	105.0	273.9	2.8	24.8	5.4	14.0	0.6	5.7
1950	477.3	9.7	26.8	5.3	1984	131.4	349.9	2.9	26.0	5.7	15.1	0.7	6.0
1951	307.5	10.1	26.8	5.3	1985	95.7	407.1	2.9	26.1	3.4	14.3	0.7	6.3
1952	306.5	10.5	26.8	5.3	1986	114.3	351.2	3.0	26.7	4.1	12.6	0.7	6.7
1953	201.8	11.0	26.8	5.3	1987	75.4	259.1	2.5	22.6	2.9	9.8	0.7	6.1
1954	179.8	11.4	26.8	5.3	1988	53.6	192.1	2.5	22.3	2.5	8.9	0.7	6.3
1955	188.9	11.8	26.8	5.3	1989	32.9	170.2	2.3	21.1	1.8	9.1	0.7	5.9
1956	185.8	12.3	26.8	5.3	1990	27.2	164.7	2.2	20.1	0.4	2.5	0.6	5.6
1957	137.1	12.7	26.8	5.3	1991	21.4	141.2	1.9	17.3	0.3	1.9	0.6	5.1
1958	178.3	13.1	26.8	5.3	1992	28.5	140.0	2.2	19.6	0.4	2.0	0.7	5.9
1959	227.6	13.6	26.8	5.3	1993	69.9	123.1	2.2	19.6	1.0	1.7	0.6	5.6
1960	207.3	14.0	26.8	5.3	1994	50.0	109.9	2.0	17.6	0.8	1.7	0.5	4.9
1961	193.7	14.4	26.8	5.3	1995	43.1	94.9	1.7	15.3	0.8	1.7	0.5	4.2
1962	230.7	14.9	26.8	5.3	1996	71.5	74.9	1.9	17.4	1.6	1.7	0.5	4.4
1963	190.1	14.6	25.6	5.1	1997	93.7	45.3	2.2	19.3	3.0	1.4	0.5	4.2
1964	245.2	15.8	26.9	5.3	1998	93.4	52.1	2.5	22.8	3.5	2.0	0.5	4.4
1965	254.4	16.4	27.3	5.4	1999	101.9	54.3	2.2	19.7	3.6	1.9	0.5	4.0
1966	321.8	16.7	27.1	5.3	2000	106.3	42.1	2.3	20.8	4.8	1.9	0.4	3.9
1967	259.9	17.3	27.2	5.4	2001	108.8	24.3	2.1	19.1	5.7	1.3	0.4	3.4
1968	189.2	15.8	24.2	4.8	2002	105.1	23.5	2.1	19.1	6.2	1.4	0.4	3.3
1969	194.2	14.9	22.4	4.4	2003	110.3	21.9	2.4	21.2	7.3	1.4	0.4	3.4
1970	192.8	16.9	24.8	4.9	2004	96.1	48.5	2.4	21.4	4.9	2.5	0.4	3.8
1971	210.8	18.8	26.9	5.3	2005	99.8	51.2	2.8	24.8	5.1	2.6	0.4	3.9
1972	237.6	20.6	28.8	5.7	2006	105.6	59.1	3.0	26.7	5.5	3.1	0.5	4.3
1973	244.7	24.1	32.9	6.5	2007	112.4	53.9	3.1	28.0	6.1	2.9	0.5	4.3
1974	203.5	24.4	32.6	6.4	2008	138.5	46.4	3.6	32.8	8.6	2.9	0.5	4.8
1975	266.4	24.7	32.4	6.4	2009	142.8	27.0	3.7	33.5	11.3	2.1	0.5	4.4
1976	242.1	25.1	32.1	6.3	2010	169.5	23.7	4.1	36.9	13.0	1.8	0.6	5.0
1977	235.7	25.4	31.9	6.3	2011	164.5	36.4	4.1	37.1	11.7	2.6	0.6	5.2
1978[1]	278.9	25.7	31.6	6.2	2012	166.8	47.8	4.8	43.0	11.1	3.2	0.6	5.5
					2013	202.9	38.2	4.8	43.0	12.4	2.3	0.7	6.2
					2014	174.9	57.6	4.8	43.5	11.8	3.9	0.7	6.0
					2015	197.7	67.3	5.2	47.0	11.6	3.9	0.8	6.8
					2016	211.1	72.6	6.4	57.9	13.7	4.7	0.8	7.3
					2017	184.7	101.2	6.0	54.0	13.3	7.3	0.8	7.4
					2018	190.7	91.7	5.7	51.5	12.2	5.9	0.8	7.3
					2019	206.6	64.6	6.0	54.2	14.4	4.5	0.8	7.3

[1] includes January-March 1979 catches

Table 10: Estimated catches (t) (commercial, recreational including section 111, illegal, and customary) for the CRA 5 region 2 (916+932+933), provided annually before 1979 (January–March 1979 added to 1978) and seasonally (AW and SS) from 1979 to 2019.

Calendar Year	Comm-ercial Annual	Recrea-tional Annual	Illegal Annual	Cus-tomary Annual	Fishing Year	Commercial AW	Commercial SS	Recreational AW	Recreational SS	Illegal AW	Illegal SS	Customary AW	Customary SS
1945	65.2	6.7	23.9	4.7	1979	45.9	106.9	1.6	14.4	3.3	7.6	0.4	3.4
1946	95.7	7.1	23.9	4.7	1980	58.7	158.4	2.0	17.9	4.1	10.9	0.4	3.9
1947	119.1	7.4	23.9	4.7	1981	42.3	150.6	1.8	16.6	2.8	9.8	0.4	3.7
1948	250.9	7.8	23.9	4.7	1982	57.7	179.5	1.8	15.9	3.2	9.8	0.4	3.4
1949	324.5	8.2	23.9	4.7	1983	51.9	166.6	1.6	14.3	2.7	8.5	0.4	3.3
1950	424.2	8.6	23.9	4.7	1984	62.8	176.0	1.4	12.9	2.7	7.6	0.3	3.0
1951	273.3	9.0	23.9	4.7	1985	50.9	169.4	1.3	11.4	1.8	6.0	0.3	2.7
1952	272.5	9.4	23.9	4.7	1986	31.9	127.5	1.0	9.2	1.1	4.6	0.3	2.3
1953	179.4	9.8	23.9	4.7	1987	41.7	119.2	1.2	10.9	1.6	4.5	0.3	2.9
1954	159.8	10.1	23.9	4.7	1988	25.8	79.3	1.1	9.6	1.2	3.7	0.3	2.7
1955	167.9	10.5	23.9	4.7	1989	17.6	90.7	1.3	11.2	0.9	4.8	0.4	3.1
1956	165.2	10.9	23.9	4.7	1990	25.5	91.0	1.4	12.2	0.4	1.4	0.4	3.4
1957	121.9	11.3	23.9	4.7	1991	25.0	99.7	1.5	13.3	0.3	1.3	0.4	3.9
1958	158.5	11.7	23.9	4.7	1992	19.3	70.7	1.2	10.5	0.3	1.0	0.4	3.1
1959	202.3	12.1	23.9	4.7	1993	44.2	73.6	1.3	12.0	0.6	1.0	0.4	3.4
1960	184.3	12.4	23.9	4.7	1994	56.9	76.9	1.6	14.8	0.9	1.2	0.5	4.1
1961	172.1	12.8	23.9	4.7	1995	76.5	82.8	2.0	17.6	1.3	1.5	0.5	4.8
1962	205.1	13.2	23.9	4.7	1996	114.9	38.6	2.0	18.3	2.6	0.9	0.5	4.6
1963	185.8	14.3	25.1	4.9	1997	128.5	31.6	2.5	22.3	4.1	1.0	0.5	4.8
1964	216.4	13.9	23.8	4.7	1998	137.5	14.6	2.7	23.8	5.2	0.6	0.5	4.6
1965	217.9	14.1	23.4	4.6	1999	177.9	14.7	2.7	24.3	6.2	0.5	0.6	5.0
1966	280.9	14.6	23.6	4.7	2000	181.0	17.2	3.1	27.7	8.2	0.8	0.6	5.2
1967	223.5	14.9	23.4	4.6	2001	191.8	23.2	3.4	30.8	10.0	1.2	0.6	5.6
1968	206.4	17.2	26.4	5.2	2002	164.2	54.8	3.6	32.5	9.7	3.2	0.6	5.7
1969	245.4	18.9	28.3	5.6	2003	169.6	46.8	3.9	34.7	11.2	3.1	0.6	5.6
1970	201.6	17.7	25.9	5.1	2004	141.4	58.1	3.3	29.6	7.3	3.0	0.6	5.2
1971	187.0	16.7	23.8	4.7	2005	139.9	57.7	3.6	32.5	7.1	3.0	0.6	5.1
1972	180.2	15.6	21.9	4.3	2006	107.3	76.8	3.3	29.9	5.6	4.0	0.5	4.8
1973	132.2	13.0	17.8	3.5	2007	98.8	83.7	3.4	30.7	5.3	4.5	0.5	4.7
1974	112.5	13.5	18.0	3.6	2008	93.4	70.2	3.2	29.0	5.8	4.4	0.5	4.2
1975	150.6	14.0	18.3	3.6	2009	100.6	78.1	3.9	35.2	7.9	6.2	0.5	4.6
1976	139.9	14.5	18.6	3.7	2010	80.8	74.6	3.3	29.7	6.2	5.7	0.5	4.0
1977	139.3	15.0	18.8	3.7	2011	81.9	65.8	3.0	27.3	5.8	4.7	0.4	3.8
1978[1]	168.4	15.5	19.1	3.8	2012	74.3	61.0	3.0	27.1	4.9	4.0	0.4	3.5
					2013	46.8	62.2	2.2	19.5	2.9	3.8	0.3	2.8
					2014	58.0	58.7	2.4	21.8	3.9	3.9	0.3	3.0
					2015	32.9	52.3	1.7	15.1	1.9	3.1	0.2	2.2
					2016	30.5	35.8	1.5	13.5	2.0	2.3	0.2	1.7
					2017	27.0	37.1	1.3	12.1	2.0	2.7	0.2	1.7
					2018	32.3	35.2	1.4	12.3	2.1	2.3	0.2	1.7
					2019	43.7	21.3	1.4	13.0	3.1	1.5	0.2	1.7

[1] includes January-March 1979 catches

Table 11: Number of vessel/statistical area/month records in the dataset used to calculate the CRA 5 seasonal CPUE time series for both the FSU and CELR data sets. Data are provided by fishing year (designated by the first year of the pair), season, and CRA 5 region.

Fishing	Autumn-Winter								Spring-Summer							
	Region 1				Region `2				Region 1				Region `2			
year	917	918	919	Total	916	932	933	Total	917	918	919	Total	916	932	933	Total
FSU data																
1979	211	65	13	289	50	7	35	92	373	43	7	423	88	5	57	150
1980	205	50	4	259	43	4	26	73	273	43	–	316	67	1	53	121
1981	149	32	2	183	48	2	36	86	296	51	–	347	63	8	48	119
1982	206	32	9	247	45	5	49	99	299	50	9	358	60	4	67	131
1983	207	33	12	252	39	–	55	94	300	59	–	359	56	–	69	125
1984	201	30	14	245	37	4	60	101	285	49	4	338	58	6	66	130
1985	185	29	11	225	40	5	57	102	308	51	8	367	56	7	64	127
1986	194	30	14	238	35	6	44	85	272	49	5	326	50	10	55	115
1987	185	25	11	221	46	7	40	93	288	43	5	336	45	6	51	102
1988	165	21	10	196	28	3	30	61	250	38	6	294	32	5	42	79
1989	88	8	3	99	11	–	8	19	–	–	–	–	–	–	–	–
Total	1 996	355	103	2 454	422	43	440	905	2 944	476	44	3 464	575	52	572	1 199
CELR data																
1989	–	–	–	–	–	–	–	–	86	33	–	119	20	–	10	30
1990	50	16	–	66	30	–	20	50	130	29	–	159	25	2	32	59
1991	51	22	–	73	15	1	36	52	90	43	–	133	21	2	38	61
1992	54	27	–	81	12	–	19	31	98	36	–	134	12	–	28	40
1993	67	25	–	92	10	1	39	50	91	44	–	135	9	1	26	36
1994	64	35	–	99	4	2	35	41	87	31	–	118	4	1	16	21
1995	57	11	–	68	7	–	29	36	83	19	1	103	4	1	15	20
1996	84	19	1	104	10	–	34	44	65	20	1	86	4	–	10	14
1997	73	19	1	93	4	–	35	39	49	24	–	73	5	–	7	12
1998	69	15	–	84	12	–	22	34	47	18	–	65	4	–	4	8
1999	74	21	–	95	11	1	26	38	55	19	1	75	7	–	2	9
2000	57	12	–	69	16	–	18	34	28	7	–	35	3	–	4	7
2001	47	4	–	51	22	–	21	43	19	2	–	21	2	–	2	4
2002	46	6	–	52	14	–	13	27	33	1	–	34	6	–	3	9
2003	38	5	–	43	20	–	16	36	12	1	–	13	10	–	8	18
2004	47	4	–	51	17	–	18	35	42	3	–	45	10	1	12	23
2005	57	5	–	62	18	–	27	45	48	8	–	56	14	–	21	35
2006	75	5	–	80	32	–	25	57	52	6	–	58	21	–	14	35
2007	72	5	–	77	29	–	20	49	57	9	–	66	20	–	20	40
2008	69	9	1	79	21	–	23	44	56	7	–	63	17	–	13	30
2009	59	–	–	59	20	–	25	45	48	–	1	49	17	–	19	36
2010	60	–	–	60	21	–	25	46	52	3	1	56	15	–	22	37
2011	50	–	–	50	20	–	23	43	39	–	–	39	14	–	24	38
2012	41	–	–	41	20	–	27	47	32	–	–	32	15	–	19	34
2013	53	1	–	54	13	–	28	41	40	2	–	42	8	–	23	31
2014	50	3	–	53	17	–	23	40	41	–	–	41	10	–	19	29
2015	46	2	–	48	15	–	25	40	41	2	–	43	7	–	21	28
2016	44	4	–	48	10	–	17	27	42	–	–	42	4	–	17	21
2017	45	5	–	50	6	–	14	20	42	–	–	42	8	–	10	18
2018	34	7	–	41	9	–	8	17	30	–	–	30	9	–	6	15
2019	17	4	–	21	3	–	3	6	–	–	–	–	–	–	–	–
Total	1 650	291	3	1 944	458	5	694	1 157	1 635	367	5	2 007	325	8	465	798

Table 12: Seasonal standardised CPUE Bayesian GLM index series used in the CRA 5 regional stock assessment, showing median estimated standardised indices and standard error derived from separate analyses using the FSU (1979–80 AW to 1989–90 AW) data and the CELR (1989–90 SS to 2019–20 AW) data.

	Region 1 (917+918+919)				Region 2 (916+932+933)			
	Autumn-Winter		Spring-Summer		Autumn-Winter		Spring-Summer	
Fishing year	Standardised Index	Standard Error	Standardised Index	Standard Error	Standardised Index	Standard Error	Standardised Index	Standard Error
FSU data	0.787	0.807	0.863	0.881	0.721	0.732	0.855	0.857
1979–80	0.794	0.813	0.833	0.843	0.874	0.876	0.949	0.965
1980–81	0.630	0.639	0.822	0.836	0.585	0.598	0.723	0.724
1981–82	0.699	0.710	0.778	0.787	0.651	0.650	0.833	0.850
1982–83	0.641	0.647	0.665	0.677	0.606	0.618	0.737	0.753
1983–84	0.663	0.674	0.659	0.667	0.622	0.626	0.669	0.675
1984–85	0.580	0.577	0.562	0.567	0.515	0.521	0.597	0.608
1985–86	0.489	0.499	0.557	0.561	0.359	0.363	0.469	0.472
1986–87	0.490	0.500	0.474	0.482	0.364	0.367	0.477	0.481
1987–88	0.396	0.405	0.432	0.441	0.319	0.325	0.384	0.391
1988–89	0.303	0.309	–	–	0.330	0.340	–	–
1989–90	0.787	0.807	0.863	0.881	0.721	0.732	0.855	0.857
CELR data								
1989–90	–	–	0.515	0.303	–	–	0.621	0.376
1990–91	0.376	0.220	0.493	0.289	0.457	0.274	0.578	0.355
1991–92	0.274	0.160	0.438	0.258	0.320	0.190	0.508	0.307
1992–93	0.302	0.178	0.422	0.251	0.344	0.209	0.479	0.295
1993–94	0.380	0.222	0.445	0.261	0.339	0.209	0.516	0.311
1994–95	0.345	0.200	0.489	0.289	0.363	0.220	0.556	0.344
1995–96	0.372	0.219	0.547	0.320	0.398	0.243	0.847	0.528
1996–97	0.470	0.275	0.717	0.424	0.572	0.345	1.258	0.817
1997–98	0.582	0.340	0.996	0.587	0.959	0.591	1.307	0.828
1998–99	0.705	0.410	1.402	0.835	0.786	0.475	1.194	0.778
1999–00	0.715	0.418	1.110	0.658	1.479	0.894	3.052	2.219
2000–01	0.854	0.497	1.526	0.907	1.692	1.001	2.309	1.542
2001–02	0.876	0.518	1.808	1.096	1.588	0.953	1.927	1.356
2002–03	1.109	0.656	1.800	1.069	2.005	1.233	3.045	1.912
2003–04	1.428	0.833	2.154	1.346	1.656	0.972	3.058	1.907
2004–05	1.056	0.628	1.847	1.103	1.211	0.735	2.567	1.561
2005–06	1.120	0.661	2.255	1.331	0.971	0.586	2.172	1.316
2006–07	1.146	0.664	2.272	1.359	0.887	0.523	1.867	1.128
2007–08	1.249	0.735	2.600	1.520	0.800	0.481	1.821	1.105
2008–09	1.440	0.846	2.763	1.636	0.984	0.593	1.975	1.210
2009–10	2.157	1.271	3.691	2.195	1.187	0.701	1.936	1.185
2010–11	2.162	1.283	3.369	1.991	1.075	0.645	1.835	1.134
2011–12	2.225	1.310	2.906	1.732	0.883	0.531	1.661	1.000
2012–13	2.135	1.259	3.805	2.288	0.821	0.489	1.173	0.704
2013–14	2.230	1.308	2.883	1.664	0.728	0.438	1.322	0.804
2014–15	1.906	1.139	3.074	1.839	0.946	0.565	1.718	1.047
2015–16	1.873	1.102	2.855	1.705	0.586	0.348	1.131	0.710
2016–17	2.004	1.169	3.852	2.313	0.665	0.401	1.762	1.158
2017–18	1.863	1.106	3.339	2.000	1.000	0.625	1.647	1.016
2018–19	1.597	0.928	2.568	1.512	0.767	0.489	1.281	0.814
2019–20	1.852	1.102	–	–	0.843	0.574	–	–

Table 13: Catch rate (kg/day) from the potlift and days fishing data in Annala & King (1983) calculated for region 1 (917+918+919) using the combined data for Annala & King areas 13, 14, and 15. These three Annala & King areas are unambiguously in region 1 (917+918+919) (see Figure 7), allowing the catch and number days to be summed (see Table 5). The equivalent data for region 2 (916+932+933) were contaminated with CRA 4 catches and could not be used.

Calendar year	Region 1 917+918+919	Region 2 916+932+933
1963	89.2	NA
1964	96.7	NA
1965	106.5	NA
1966	107.7	NA
1967	82.3	NA
1968	61.2	NA
1969	65.5	NA
1970	72.6	NA
1971	70.8	NA
1972	69.4	NA
1973	68.9	NA

Table 14: Sampling intensity by fishing year and season in CRA 5 region 1 (917+918+919) by the logbook and observer catch sampling programme from 1989. "Lobsters" are the number of individuals measured. '–': no data.

Fishing				Logbooks				Observer catch sampling
Year	N vessels	Days	Potlifts	Lobsters	Vessels	Days	Potlifts	Lobsters
Season=AW								
1995	4	66	295	2 014	–	–	–	–
1996	6	172	854	5 976	–	–	–	–
1997	5	147	784	5 275	2	3	206	1 336
1998	4	121	407	3 069	2	3	419	1 086
1999	5	180	729	3 126	3	7	1 066	2 248
2000	11	395	1 351	6 885	2	3	206	1 336
2001	12	408	2 065	9 610	–	–	–	–
2002	11	382	1 967	9 015	–	–	–	–
2003	6	330	1 118	5 920	–	–	–	–
2004	7	230	1 133	6 043	–	–	–	–
2005	6	250	1 137	5 298	–	–	–	–
2006	7	214	1 329	8 514	–	–	–	–
2007	8	283	1 277	7 731	–	–	–	–
2008	6	207	868	4 576	–	–	–	–
2009	9	264	1 361	10 971	2	2	288	1 207
2010	6	109	1 387	13 721	3	3	405	1 750
2011	7	176	1 042	11 196	–	–	–	–
2012	8	219	1 195	12 001	–	–	–	–
2013	5	137	1 145	8 419	–	–	–	–
2014	5	185	977	8 726	–	–	–	–
2015	6	182	770	5 842	–	–	–	–
2016	8	189	987	7 883	–	–	–	–
2017	7	163	857	7 610	–	–	–	–
2018	9	105	1 000	7 081	1	2	377	1 166
2019	9	156	1 135	7 250	–	–	–	–
Total	177	5 270	27 170	183 752	13	20	2 761	8 793
Season=SS								
1989	–	–	–	–	4	10	1 006	3 340
1990	–	–	–	–	4	11	1 284	5 345
1991	–	–	–	–	4	10	1 080	4 984
1992	–	–	–	–	2	12	1 850	3 051
1993	–	–	–	–	4	12	1 652	6 512
1994	11	91	2 589	10 846	4	12	1 510	5 049
1995	5	101	862	4 408	3	12	1 576	4 979
1996	4	21	696	4 296	3	9	873	5 737
1997	–	–	–	–	2	7	360	3 278
1998	–	–	–	–	1	1	42	544
1999	3	5	242	1 434	–	–	–	–
2000	5	20	379	2 907	1	1	114	743
2002	3	44	298	2 986	–	–	–	–
2003	2	22	129	1 110	–	–	–	–
2004	4	105	265	2 039	–	–	–	–
2005	3	120	244	2 432	–	–	–	–
2006	3	113	368	2 982	–	–	–	–
2007	5	113	468	4 986	–	–	–	–
2008	5	105	365	3 864	3	4	303	1 140
2009	5	142	282	5 096	–	–	–	–
2010	4	108	169	2 583	–	–	–	–
2011	5	139	178	3 213	–	–	–	–
2012	5	52	225	2 850	–	–	–	–
2013	3	251	177	1 088	–	–	–	–
2014	6	205	445	4 197	–	–	–	–
2015	3	177	222	2 874	–	–	–	–
2016	6	286	247	2 893	–	–	–	–
2017	4	182	271	3 578	–	–	–	–
2018	5	77	303	4 220	–	–	–	–
2019	7	75	459	6 612	–	–	–	–
Total	106	2 554	9 883	83 494	35	101	11 650	44 702

Table 15: Sampling intensity by fishing year and season in CRA 5 region 2 (916+932+933) by the logbook and observer catch sampling programme from 1994. "Lobsters" are the number of individuals measured. Samples marked in grey were dropped from the stock assessment because there was only one vessel; '–': no data.

Fishing				Logbooks				Observer catch sampling
year	N vessels[1]	Days	Potlifts	Lobsters	Vessels	Days	Potlifts	Lobsters
Season=AW								
1994	1	53	46	234	–	–	–	–
1995	1	94	243	731	–	–	–	–
1996	4	222	627	2 180	–	–	–	–
1997	6	254	705	4 000	–	–	–	–
1998	6	158	613	5 011	–	–	–	–
1999	7	305	1 119	8 020	8	14	1 603	11 307
2000	12	411	2 013	15 766	5	9	981	8 202
2001	13	637	2 062	19 399	–	–	–	–
2002	13	725	2 454	23 177	–	–	–	–
2003	14	568	2 505	23 840	–	–	–	–
2004	13	474	1 646	16 774	–	–	–	–
2005	11	570	1 972	19 529	–	–	–	–
2006	11	613	1 786	14 928	–	–	–	–
2007	11	531	1 935	14 580	–	–	–	–
2008	10	365	1 380	10 821	–	–	–	–
2009	10	454	1 651	12 357	2	2	263	723
2010	11	497	1 265	11 000	2	3	322	1 705
2011	9	330	1 169	9 726	–	–	–	–
2012	11	354	1 180	8 296	–	–	–	–
2013	7	268	608	2 422	–	–	–	–
2014	10	292	1 047	4 944	–	–	–	–
2015	11	247	906	4 058	–	–	–	–
2016	10	264	790	3 023	–	–	–	–
2017	9	302	738	3 505	–	–	–	–
2018	9	298	686	3 391	–	–	–	–
2019	9	374	922	2 689	–	–	–	–
Total	239	9 660	32 068	244 401	17	28	3 169	21 937
Season=SS								
1994	3	843	835	5 177	–	–	–	–
1995	2	262	484	2 394	–	–	–	–
1996	3	206	162	1 635	–	–	–	–
1998	1	10	8	177	2	4	424	2 611
1999	1	38	20	145	–	–	–	–
2000	3	72	74	472	1	2	34	1 067
2002	5	77	177	916	–	–	–	–
2003	5	48	90	591	–	–	–	–
2004	9	125	458	3 669	–	–	–	–
2005	8	126	616	5 504	–	–	–	–
2006	10	187	766	7 814	–	–	–	–
2007	11	198	705	7 420	–	–	–	–
2008	6	128	531	4 497	2	2	232	944
2009	11	145	788	6 924	–	–	–	–
2010	10	82	569	4 678	–	–	–	–
2011	9	91	685	5 933	–	–	–	–
2012	6	87	377	4 574	–	–	–	–
2013	9	50	1 083	4 275	–	–	–	–
2014	10	125	1 045	5 162	–	–	–	–
2015	11	191	1 093	4 976	–	–	–	–
2016	8	95	1 183	3 013	–	–	–	–
2017	8	83	715	1 900	–	–	–	–
2018	9	221	751	4 199	–	–	–	–
2019	9	221	578	3 124	–	–	–	–
Total	167	3 711	13 793	89 169	5	8	690	4 622

Table 16: Number of lobsters measured by the logbook and observer catch sampling programmes by fishing year, sex, and season for CRA 5 region 1 (917+918+919). '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1994	240	80	429	749	–	–	–	–
1995	757	99	1 158	2 014	–	–	–	–
1996	3 058	504	2 413	5 975	–	–	–	–
1997	2 304	138	2 833	5 275	788	7	532	1 327
1998	891	22	2 156	3 069	384	33	667	1 084
1999	1 058	162	1 906	3 126	1 057	72	1 118	2 247
2000	2 974	305	3 605	6 884	–	–	–	–
2001	4 607	345	4 654	9 606	–	–	–	–
2002	3 849	116	5 050	9 015	–	–	–	–
2003	2 793	18	3 108	5 919	–	–	–	–
2004	2 313	25	3 698	6 036	–	–	–	–
2005	2 152	80	3 040	5 272	–	–	–	–
2006	4 220	87	4 203	8 510	–	–	–	–
2007	3 532	136	4 062	7 730	–	–	–	–
2008	2 361	156	1 970	4 487	–	–	–	–
2009	4 964	63	4 680	9 707	738	4	463	1 205
2010	4 892	59	6 639	11 590	992	15	737	1 744
2011	5 201	20	4 843	10 064	–	–	–	–
2012	4 497	118	6 315	10 930	–	–	–	–
2013	3 228	28	4 186	7 442	–	–	–	–
2014	2 949	57	5 035	8 041	–	–	–	–
2015	2 669	18	3 046	5 733	–	–	–	–
2016	3 409	175	4 283	7 867	–	–	–	–
2017	2 250	22	5 328	7 600	–	–	–	–
2018	2 880	76	4 105	7 061	450	3	712	1 165
2019	2 795	135	4 315	7 245	–	–	–	–
Total	76 843	3 044	97 060	176 947	4 409	134	4 229	8 772
Season=SS								
1989	–	–	–	–	1 274	291	1 746	3 311
1990	–	–	–	–	2 393	958	1 957	5 308
1991	–	–	–	–	2 346	883	1 734	4 963
1992	–	–	–	–	1 524	142	1 351	3 017
1993	–	–	–	–	2 594	426	3 382	6 402
1994	4 366	708	5 768	10 842	2 208	259	2 520	4 987
1995	2 415	260	1 732	4 407	2 327	324	2 282	4 933
1996	2 416	188	1 692	4 296	2 731	232	2 698	5 661
1997	919	56	779	1 754	1 843	26	1 409	3 278
1998	26	9	80	115	170	6	368	544
1999	375	18	1 041	1 434	–	–	–	–
2000	1 030	64	1 813	2 907	304	45	392	741
2001	349	50	806	1 205	–	–	–	–
2002	916	42	2 027	2 985	–	–	–	–
2003	294	5	811	1 110	–	–	–	–
2004	507	203	1 328	2 038	–	–	–	–
2005	556	23	1 853	2 432	–	–	–	–
2006	1 010	36	1 936	2 982	–	–	–	–
2007	2 294	126	2 564	4 984	–	–	–	–
2008	1 139	75	1 552	2 766	335	65	739	1 139
2009	2 227	6	2 109	4 342	–	–	–	–
2010	852	2	1 190	2 044	–	–	–	–
2011	1 166	15	1 508	2 689	–	–	–	–
2012	521	57	1 919	2 497	–	–	–	–
2013	158	6	342	506	–	–	–	–
2014	503	41	1 468	2 012	–	–	–	–
2015	868	11	1 995	2 874	–	–	–	–
2016	830	20	2 038	2 888	–	–	–	–
2017	858	59	2 661	3 578	–	–	–	–
2018	686	37	3 492	4 215	–	–	–	–
2019	1 538	110	4 957	6 605	–	–	–	–
Total	28 819	2 227	49 461	80 507	20 049	3 657	20 578	44 284

Table 17: Sample weights calculated for each LF sampling record described for CRA 5 region 1 (917+918+919) in Table 16. '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1994	0.608	0.279	1.041	1.928	–	–	–	–
1995	2.814	0.340	4.026	7.181	–	–	–	–
1996	6.112	0.721	5.504	12.338	–	–	–	–
1997	6.725	0.274	8.303	15.302	0.514	0.005	0.347	0.866
1998	2.718	0.053	5.349	8.120	0.350	0.030	0.609	0.989
1999	3.307	0.438	5.546	9.291	1.196	0.080	1.418	2.694
2000	6.911	0.621	8.699	16.232	–	–	–	–
2001	10.280	0.657	12.432	23.369	–	–	–	–
2002	10.803	0.420	11.852	23.074	–	–	–	–
2003	10.084	0.053	9.337	19.475	–	–	–	–
2004	8.062	0.075	10.638	18.775	–	–	–	–
2005	7.972	0.192	10.071	18.234	–	–	–	–
2006	13.032	0.236	12.512	25.780	–	–	–	–
2007	15.890	0.290	14.688	30.867	–	–	–	–
2008	12.252	0.258	9.136	21.646	–	–	–	–
2009	19.457	0.131	17.008	36.596	0.882	0.005	0.553	1.440
2010	19.031	0.144	22.063	41.237	1.774	0.013	1.392	3.180
2011	41.281	0.045	19.489	60.814	–	–	–	–
2012	16.194	0.659	24.092	40.945	–	–	–	–
2013	21.845	0.160	22.448	44.453	–	–	–	–
2014	15.658	0.684	21.703	38.045	–	–	–	–
2015	36.957	0.669	33.441	71.067	–	–	–	–
2016	31.420	1.163	31.604	64.187	–	–	–	–
2017	14.730	0.192	29.047	43.968	–	–	–	–
2018	26.995	0.574	36.011	63.580	1.990	0.013	3.149	5.152
2019	28.689	0.643	31.583	60.916	–	–	–	–
Total	389.828	9.971	417.623	817.422	6.707	0.146	7.468	14.321
Season=SS								
1989	–	–	–	–	2.410	0.656	2.921	5.986
1990	–	–	–	–	3.621	1.461	3.186	8.268
1991	–	–	–	–	2.847	1.011	2.169	6.026
1992	–	–	–	–	3.298	0.280	2.905	6.483
1993	–	–	–	–	3.229	0.577	3.737	7.543
1994	14.802	2.455	20.371	37.628	3.195	0.358	3.700	7.253
1995	7.747	0.801	6.072	14.621	2.843	0.370	2.466	5.678
1996	10.941	0.897	8.556	20.394	3.998	0.340	3.791	8.129
1997	2.911	0.319	3.600	6.830	2.058	0.028	1.619	3.704
1998	0.428	0.156	1.224	1.808	0.468	0.017	1.013	1.497
1999	3.917	0.137	16.217	20.271	–	–	–	–
2000	11.791	0.392	21.524	33.707	0.448	0.066	0.578	1.092
2001	3.571	0.877	7.295	11.743	–	–	–	–
2002	1.197	0.054	2.696	3.948	–	–	–	–
2003	1.009	0.017	2.869	3.894	–	–	–	–
2004	2.403	1.091	6.379	9.872	–	–	–	–
2005	2.424	0.104	8.404	10.932	–	–	–	–
2006	3.373	0.135	7.644	11.152	–	–	–	–
2007	5.014	0.249	6.059	11.322	–	–	–	–
2008	4.022	0.270	5.467	9.759	0.390	0.079	0.883	1.352
2009	3.834	0.009	3.139	6.982	–	–	–	–
2010	2.067	0.004	3.029	5.100	–	–	–	–
2011	3.271	0.042	3.992	7.305	–	–	–	–
2012	0.941	0.046	6.098	7.085	–	–	–	–
2013	0.883	0.002	2.045	2.930	–	–	–	–
2014	1.935	0.085	6.086	8.107	–	–	–	–
2015	3.071	0.039	6.918	10.028	–	–	–	–
2016	3.703	0.058	10.666	14.428	–	–	–	–
2017	7.555	0.810	15.215	23.580	–	–	–	–
2018	2.762	0.149	17.336	20.247	–	–	–	–
2019	7.656	0.568	22.820	31.044	–	–	–	–
Total	113.228	9.765	221.720	344.713	28.804	5.242	28.966	63.012

Table 18: Number of lobsters measured by the observer and logbook catch sampling programmes by fishing year, sex, and season for CRA 5 region 2 (916+932+933). '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1994	132	4	98	234	–	–	–	–
1995	320	43	368	731	–	–	–	–
1996	1 204	296	680	2 180	–	–	–	–
1997	2 070	17	1 913	4 000	–	–	–	–
1998	2 595	10	2 406	5 011	–	–	–	–
1999	4 797	5	3 217	8 019	7 337	61	3 798	11 196
2000	9 241	42	6 479	15 762	4 069	56	4 011	8 136
2001	11 674	185	7 537	19 396	–	–	–	–
2002	15 194	105	7 877	23 176	–	–	–	–
2003	15 493	115	8 226	23 834	–	–	–	–
2004	10 883	53	5 833	16 769	–	–	–	–
2005	12 811	88	6 628	19 527	–	–	–	–
2006	9 699	331	4 890	14 920	–	–	–	–
2007	9 161	349	5 068	14 578	–	–	–	–
2008	7 366	118	3 335	10 819	–	–	–	–
2009	9 046	45	3 255	12 346	477	1	241	719
2010	8 424	20	2 553	10 997	1 284	5	402	1 691
2011	7 283	11	2 431	9 725	–	–	–	–
2012	5 133	216	2 794	8 143	–	–	–	–
2013	1 454	9	954	2 417	–	–	–	–
2014	3 070	342	1 479	4 891	–	–	–	–
2015	2 810	28	1 202	4 040	–	–	–	–
2016	1 576	34	1 398	3 008	–	–	–	–
2017	2 411	29	1 058	3 498	–	–	–	–
2018	2 244	9	1 129	3 382	–	–	–	–
2019	1 769	23	894	2 686	–	–	–	–
Total	157 860	2 527	83 702	244 089	13 167	123	8 452	21 742
Season=SS								
1994	2 623	549	2 005	5 177	–	–	–	–
1995	1 393	129	872	2 394	–	–	–	–
1996	1 024	37	574	1 635	–	–	–	–
1998	74	–	103	177	1 149	24	1 438	2 611
1999	13	–	132	145	–	–	–	–
2000	52	3	417	472	724	2	323	1 049
2002	135	–	781	916	–	–	–	–
2003	146	2	443	591	–	–	–	–
2004	1 069	27	2 573	3 669	–	–	–	–
2005	2 354	48	3 102	5 504	–	–	–	–
2006	3 850	323	3 641	7 814	–	–	–	–
2007	3 047	851	3 522	7 420	–	–	–	–
2008	1 877	20	2 600	4 497	251	16	674	941
2009	3 607	241	3 073	6 921	–	–	–	–
2010	2 549	33	2 093	4 675	–	–	–	–
2011	3 425	69	2 438	5 932	–	–	–	–
2012	2 815	35	1 654	4 504	–	–	–	–
2013	1 936	53	2 282	4 271	–	–	–	–
2014	2 124	903	2 092	5 119	–	–	–	–
2015	2 857	375	1 732	4 964	–	–	–	–
2016	1 306	52	1 645	3 003	–	–	–	–
2017	902	155	834	1 891	–	–	–	–
2018	3 129	476	587	4 192	–	–	–	–
2019	2 169	381	566	3 116	–	–	–	–
Total	44 476	4 762	39 761	88 999	2 124	42	2 435	4 601

Table 19: Sample weight calculated for each LF sampling record described for CRA 5 region 2 (916+932+933) in Table 18. '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1994	0.176	0.005	0.131	0.312	–	–	–	–
1995	1.788	0.227	2.025	4.041	–	–	–	–
1996	3.720	0.841	2.162	6.723	–	–	–	–
1997	9.261	0.102	7.367	16.731	–	–	–	–
1998	9.496	0.040	9.842	19.378	–	–	–	–
1999	15.191	0.022	10.910	26.123	4.088	0.044	2.923	7.055
2000	26.309	0.147	26.633	53.090	3.396	0.061	5.645	9.102
2001	29.010	0.490	20.307	49.807	–	–	–	–
2002	40.311	0.255	24.249	64.815	–	–	–	–
2003	39.640	0.359	31.102	71.101	–	–	–	–
2004	32.066	0.461	24.804	57.331	–	–	–	–
2005	41.567	0.421	31.864	73.852	–	–	–	–
2006	34.498	0.730	24.294	59.523	–	–	–	–
2007	32.994	0.727	19.141	52.862	–	–	–	–
2008	22.410	0.234	13.402	36.046	–	–	–	–
2009	23.413	0.115	10.620	34.148	0.767	0.002	0.396	1.165
2010	21.549	0.078	8.834	30.461	0.707	0.004	0.378	1.089
2011	24.251	0.021	11.532	35.804	–	–	–	–
2012	13.687	0.478	8.035	22.200	–	–	–	–
2013	3.120	0.118	2.126	5.365	–	–	–	–
2014	9.566	0.257	5.112	14.935	–	–	–	–
2015	5.838	0.054	3.247	9.139	–	–	–	–
2016	3.403	0.031	2.642	6.077	–	–	–	–
2017	3.468	0.050	1.558	5.076	–	–	–	–
2018	6.007	0.025	2.440	8.471	–	–	–	–
2019	7.001	0.065	2.724	9.791	–	–	–	–
Total	459.740	6.355	307.105	773.199	8.958	0.111	9.341	18.410
Season=SS								
1994	9.246	2.186	8.901	20.333	–	–	–	–
1995	5.522	0.587	4.607	10.716	–	–	–	–
1996	2.151	0.081	1.672	3.904	–	–	–	–
1998	0.425	–	0.591	1.016	1.971	0.042	3.127	5.139
1999	0.055	–	0.554	0.609	–	–	–	–
2000	0.222	0.025	2.925	3.172	0.467	0.001	0.208	0.676
2002	0.590	–	3.035	3.625	–	–	–	–
2003	5.115	0.025	6.546	11.686	–	–	–	–
2004	9.949	0.129	13.616	23.693	–	–	–	–
2005	10.718	0.162	13.792	24.672	–	–	–	–
2006	16.459	0.652	16.844	33.955	–	–	–	–
2007	15.888	2.683	17.496	36.067	–	–	–	–
2008	8.212	0.093	11.241	19.547	0.478	0.030	1.284	1.793
2009	24.307	0.897	20.189	45.393	–	–	–	–
2010	19.158	0.415	17.734	37.307	–	–	–	–
2011	17.812	0.493	17.272	35.577	–	–	–	–
2012	8.868	0.119	6.540	15.527	–	–	–	–
2013	15.199	0.499	17.905	33.603	–	–	–	–
2014	14.563	4.424	14.547	33.534	–	–	–	–
2015	11.640	1.026	13.054	25.720	–	–	–	–
2016	11.169	0.280	7.690	19.139	–	–	–	–
2017	5.956	0.433	3.659	10.048	–	–	–	–
2018	7.345	0.750	2.835	10.930	–	–	–	–
2019	4.763	0.449	3.651	8.862	–	–	–	–
Total	225.330	16.409	226.896	468.635	2.916	0.073	4.619	7.608

Table 20: CRA 5 region 1 (917+918+919) statistics for the proportion-at-sex for each season, summarised across all records for a season using the weights in Table 17.

	Autumn-Winter			Spring-Summer		
Statistic	Male	Immature female	Mature female	Male	Immature female	Mature female
Maximum	0.679	0.145	0.661	0.549	0.177	0.861
Minimum	0.315	0.001	0.320	0.133	0.001	0.360
Mean	0.477	0.012	0.511	0.348	0.037	0.615

Table 21: CRA 5 region 2 (916+932+933) statistics for the proportion-at-sex for each season, summarised across all records for a season using the weights in Table 19.

	Autumn-Winter			Spring-Summer		
Statistic	Male	Immature female	Mature female	Male	Immature female	Mature female
Maximum	0.715	0.125	0.519	0.672	0.132	0.910
Minimum	0.443	0.001	0.278	0.090	0.002	0.259
Mean	0.592	0.008	0.400	0.479	0.035	0.486

Table 22: CRA 5, region 1 (917+918+919) statistics for mean tail width (mm) by sex for each season, summarised across all records for a season using the weights in Table 17.

	Autumn-Winter			Spring-Summer		
Statistic	Male	Immature female	Mature female	Male	Immature female	Mature female
Maximum mean TW	66.6	59.5	71.8	63.1	60.7	71.6
Minimum mean TW	51.8	47.4	59.1	48.2	45.1	54.8
Mean TW	61.8	55.1	68.1	54.4	51.1	64.1

Table 23: CRA 5, region 2 (916+932+933) statistics for mean tail width (mm) by sex for each season, summarised across all records for a season using the weights in Table 19.

	Autumn-Winter			Spring-Summer		
Statistic	Male	Immature female	Mature female	Male	Immature female	Mature female
Maximum mean TW	58.5	61.3	66.0	63.7	65.0	70.8
Minimum mean TW	51.1	45.5	57.5	52.6	46.0	59.0
Mean TW	55.1	55.8	62.3	54.0	59.0	61.2

Table 24: Number of year, season, and sampling category records for CRA 5, region 1 (917+918+919) by 2-mm tail width bin for each sex category. Also shown are the number of these records where the year, season, sampling category proportion within a sex category is less than 0.001 and the calculated proportion of records greater than 0.001. Bold grey cells indicate accumulator bins.

	Males			Immature females			Mature females		
Bin	N records	N records<0.001	Prop >0.001	N records	N records<0.001	Prop >0.001	N records	N records<0.001	Prop >0.001
[30,32)	6	5	0.17	1	1	0.00	1	1	0.00
[32,34)	13	11	0.15	5	5	0.00	5	4	0.20
[34,36)	12	10	0.17	**10**	**9**	**0.10**	3	3	0.00
[36,38)	18	14	0.22	14	8	0.43	3	3	0.00
[38,40)	**28**	**20**	**0.29**	18	12	0.33	**11**	**10**	**0.09**
[40,42)	53	25	0.53	36	24	0.33	23	18	0.22
[42,44)	63	21	0.67	46	27	0.41	37	28	0.24
[44,46)	69	12	0.83	51	25	0.51	54	33	0.39
[46,48)	68	4	0.94	60	26	0.57	62	25	0.60
[48,50)	68	1	0.99	57	26	0.54	66	14	0.79
[50,52)	70	0	1.00	60	27	0.55	68	3	0.96
[52,54)	69	0	1.00	59	24	0.59	70	1	0.99
[54,56)	70	0	1.00	60	21	0.65	69	0	1.00
[56,58)	70	0	1.00	63	19	0.70	70	0	1.00
[58,60)	70	0	1.00	60	22	0.63	70	0	1.00
[60,62)	70	0	1.00	54	24	0.56	70	0	1.00
[62,64)	70	0	1.00	47	27	0.43	70	0	1.00
[64,66)	69	2	0.97	35	31	0.11	70	0	1.00
[66,68)	67	6	0.91	17	14	0.18	70	0	1.00
[68,70)	67	8	0.88	10	8	0.20	70	0	1.00
[70,72)	64	13	0.80	**5**	**3**	**0.40**	70	0	1.00
[72,74)	61	13	0.79	3	3	0.00	70	0	1.00
[74,76)	55	20	0.64	2	2	0.00	70	2	0.97
[76,78)	55	20	0.64	1	1	0.00	69	2	0.97
[78,80)	50	12	0.76	4	4	0.00	68	5	0.93
[80,82)	45	14	0.69	3	3	0.00	67	12	0.82
[82,84)	38	14	0.63	1	1	0.00	62	7	0.89
[84,86)	36	14	0.61	1	1	0.00	59	11	0.81
[86,88)	38	17	0.55	1	1	0.00	53	9	0.83
[88,90)	28	16	0.43	–	–	–	53	14	0.74
[90, ∞)	**36**	**18**	**0.50**	2	2	0.00	**56**	**12**	**0.79**

Table 25: Number of year, season, and sampling category records for CRA 5, region 2 (916+932+933) by 2-mm tail width bin for each sex category. Also shown are the number of these records where the year, season, sampling category proportion within a sex category is less than 0.001 and the calculated proportion of records greater than 0.001. Bold grey cells indicate accumulator bins.

	Males			Immature females			Mature females		
Bin	N records	N records<0.001	Prop >0.001	N records	N records<0.001	Prop >0.001	N records	N records<0.001	Prop >0.001
[30,32)	13	12	0.08	6	5	0.17	1	1	0.00
[32,34)	8	8	0.00	2	2	0.00	6	6	0.00
[34,36)	20	18	0.10	5	5	0.00	4	4	0.00
[36,38)	14	13	0.07	8	8	0.00	1	1	0.00
[38,40)	**30**	**25**	**0.17**	12	12	0.00	14	14	0.00
[40,42)	39	29	0.26	**21**	**17**	**0.19**	**20**	**18**	**0.10**
[42,44)	43	23	0.47	29	25	0.14	20	18	0.10
[44,46)	49	12	0.76	35	27	0.23	28	22	0.21
[46,48)	53	6	0.89	29	22	0.24	31	21	0.32
[48,50)	54	0	1.00	38	27	0.29	48	20	0.58
[50,52)	56	0	1.00	42	27	0.36	54	7	0.87
[52,54)	56	0	1.00	45	25	0.44	56	0	1.00
[54,56)	57	0	1.00	49	22	0.55	55	0	1.00
[56,58)	56	0	1.00	48	16	0.67	57	1	0.98
[58,60)	56	0	1.00	48	16	0.67	57	0	1.00
[60,62)	57	0	1.00	38	22	0.42	57	0	1.00
[62,64)	56	0	1.00	35	20	0.43	57	0	1.00
[64,66)	56	0	1.00	26	11	0.58	57	0	1.00
[66,68)	56	5	0.91	20	10	0.50	56	0	1.00
[68,70)	53	3	0.94	19	11	0.42	57	1	0.98
[70,72)	53	5	0.91	17	12	0.29	57	1	0.98
[72,74)	50	16	0.68	13	10	0.23	55	2	0.96
[74,76)	49	23	0.53	11	7	0.36	52	1	0.98
[76,78)	39	27	0.31	7	6	0.14	53	7	0.87
[78,80)	43	31	0.28	7	6	0.14	51	9	0.82
[**80,82)**	37	23	0.38	**5**	**4**	**0.20**	52	11	0.79
[82,84)	32	22	0.31	1	1	0.00	46	16	0.65
[84,86)	30	23	0.23	4	4	0.00	50	24	0.52
[86,88)	20	18	0.10	2	2	0.00	49	31	0.37
[88,90)	19	18	0.05	4	4	0.00	40	26	0.35
[90, ∞)	**28**	**20**	**0.29**	5	5	0.00	**48**	**22**	**0.54**

Table 26: Comparison of the number of records by Project ID in the new tag data extract with the number of records in the extract made for the 2019 CRA 1/CRA 3 stock assessments (Starr et al. 2020a, 2020b).

Project_ID	Previous	Current	Difference
CRA_Akaroa	227	227	0
CRA_CCampb	44	44	0
CRA_Gis70s	2 244	2 240	-4
CRA_Gisb	48	48	0
CRA_ReefPt	573	573	0
CRA_StewIs	1 622	1 614	-8
CRA01Gisb	1 179	1 179	0
CRA1_TAG	1 592	1 591	-1
CRA2_EBOP	5	5	0
CRA2_TAG	4 364	4 357	-7
CRA2_WBOP	268	268	0
CRA3_TAG	2 070	2 057	-13
CRA4_TAG	3 128	3 115	-13
CRA4_Wair	10	10	0
CRA5_Kaik	1 176	1 176	0
CRA5_TAG	5 946	5 903	-43
CRA6_TAG	183	181	-2
CRA7_TAG	632	646	14
CRA7rs	199	199	0
CRA8_Fiord	1 714	1 714	0
CRA8_TAG	7 295	7 189	-106
CRA8rs	236	233	-3
CRA9_TAG	126	126	0

Table 27: Comparison of the number of records by recapture year in the new tag data extract with the number of records in the extract for the 2018 CRA 1 stock assessment (Starr et al. 2020a, 2020b).

Year	Previous	Current	Difference	Year	Previous	Current	Difference
1966	53	53	0	1997	2 579	2 558	- 21
1967	29	28	- 1	1998	2 950	2 944	- 6
1968	7	7	0	1999	2 494	2 486	- 8
1969	2	2	0	2000	1 593	1 587	- 6
1971	1	1	0	2001	1 378	1 377	- 1
1975	115	115	0	2002	1 576	1 571	- 5
1976	1 275	1 268	- 7	2003	1 122	1 121	- 1
1977	2 096	2 091	- 5	2004	2 083	2 079	- 4
1978	886	886	0	2005	2 410	2 386	- 24
1979	1 081	1 081	0	2006	978	978	0
1980	1 112	1 112	0	2007	489	488	- 1
1981	593	593	0	2008	367	366	- 1
1982	332	332	0	2009	306	304	- 2
1983	273	273	0	2010	237	237	0
1984	1 071	1 071	0	2011	550	548	- 2
1985	395	394	- 1	2012	333	333	0
1986	76	76	0	2013	485	484	- 1
1987	18	18	0	2014	768	764	- 4
1988	4	4	0	2015	856	855	- 1
1989	2	2	0	2016	516	514	- 2
1991	1	1	0	2017	375	372	- 3
1992	1	1	0	2018	306	306	0
1994	40	39	- 1	2019	79	94	15
1995	73	72	- 1				
1996	515	423	- 92				

Table 28: Number of tags released, including tags that were never recaptured, compared with the number and proportion recaptured by QMA.

QMA	Number released	Number recaptured	Proportion recaptured
CRA 1	16 892	2 163	0.128
CRA 2	24 358	4 522	0.186
CRA 3	36 255	5 633	0.155
CRA 4	39 594	3 121	0.079
CRA 5	35 439	7 354	0.208
CRA 6	4 724	181	0.038
CRA 7	10 578	838	0.079
CRA 8	23 389	10 757	0.460
CRA 9	6 452	126	0.020

Table 29: Number of complete tagging release/recovery records by sex and QMA. Note that the row totals are not always consistent with other tables because some records could not be assigned to a sex category.

QMA	Male	Female	Total
CRA 1	947	1 216	2 163
CRA 2	2 358	2 164	4 522
CRA 3	4 269	1 364	5 633
CRA 4	2 411	710	3 121
CRA 5	5 163	2 191	7 354
CRA 6	21	160	181
CRA 7	391	447	838
CRA 8	5 879	4 878	10 757
CRA 9	32	94	126
Total	21 471	13 224	34 695

Table 30: Number of tags released by QMA (rows) and recaptured by QMA (columns). Note that the row totals are not always the same as in previous tables because some records could not be assigned to a QMA.

Release	Recovery QMA								
QMA	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9
CRA 1	1 841	9	30	–	–	–	–	–	–
CRA 2	–	3 759	2	–	–	–	–	–	–
CRA 3	–	16	5 136	–	3	–	–	52	–
CRA 4	–	–	–	2 580	32	–	–	–	–
CRA 5	–	–	–	3	5 854	–	6	–	–
CRA 6	–	–	–	–	–	177	–	–	–
CRA 7	–	–	6	–	–	–	815	17	–
CRA 8	–	1	121	–	–	–	–	8 474	3
CRA 9	–	–	–	–	–	–	–	–	73

Table 31: Number of tag recaptures by calendar year of release and sex for each CRA 5 statistical area and for all of CRA 5. Tags are classified to statistical area on the basis of release statistical area. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

	Release statistical area																	
Release	Unknown			916			917			918			933			CRA 5		
year	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1974	–	–	–	–	–	–	–	–	–	2	–	2	–	–	–	2	–	2
1975	–	–	–	–	–	–	–	–	–	29	15	44	–	–	–	29	15	44
1976	–	–	–	–	–	–	–	–	–	39	74	113	–	–	–	39	74	113
1977	–	–	–	–	–	–	–	–	–	2	8	10	–	–	–	2	8	10
1979	–	–	–	–	–	–	–	–	–	3	11	14	–	–	–	3	11	14
1980	–	–	–	–	–	–	–	–	–	6	10	16	–	–	–	6	10	16
1981	–	–	–	–	–	–	–	–	–	7	21	28	–	–	–	7	21	28
1982	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	1	–	1
1983	52	–	52	25	16	41	791	192	983	–	–	–	–	–	–	868	208	1 076
1984	108	8	116	–	1	1	9	1	10	–	–	–	–	–	–	117	10	127
1985	9	3	12	2	–	2	–	–	–	–	–	–	–	–	–	11	3	14
1986	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2
1996	–	–	–	252	78	330	–	–	–	–	–	–	245	151	396	497	229	726
1997	–	–	–	72	4	76	176	194	370	–	–	–	199	80	279	447	278	725
1998	–	–	–	12	2	14	51	32	83	–	–	–	39	7	46	102	41	143
1999	–	–	–	3	4	7	71	257	328	–	–	–	44	73	117	118	334	452
2000	–	–	–	304	31	335	44	79	123	–	–	–	117	30	147	465	140	605
2001	–	–	–	372	45	417	150	99	249	–	–	–	166	97	263	688	241	929
2002	–	–	–	147	6	153	60	22	82	–	–	–	70	14	84	277	42	319
2003	–	–	–	71	10	81	30	13	43	–	–	–	14	12	26	115	35	150
2004	–	–	–	406	11	417	53	147	200	–	–	–	226	104	330	685	262	947
2005	–	–	–	237	–	237	18	52	70	–	–	–	63	6	69	318	58	376
2006	–	–	–	49	–	49	4	13	17	–	–	–	14	3	17	67	16	83
2007	–	–	–	5	–	5	–	6	6	–	–	–	–	1	1	5	7	12
2008	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	1	1
2012	–	–	–	17	–	17	53	64	117	–	–	–	18	12	30	88	76	164
2013	–	–	–	2	–	2	8	13	21	–	–	–	8	3	11	18	16	34
2014	–	–	–	–	–	–	5	3	8	–	–	–	10	5	15	15	8	23
2015	–	–	–	–	–	–	3	–	3	–	–	–	5	9	14	8	9	17
2016	1	1	2	31	1	32	42	36	78	–	–	–	11	4	15	85	42	127
2017	–	–	–	2	–	2	26	22	48	–	–	–	–	–	–	28	22	50
2018	–	–	–	33	–	33	5	14	19	–	–	–	25	1	26	63	15	78
Total	172	12	184	2 042	209	2 251	1 600	1 260	2 860	88	139	227	1 274	612	1 886	5 176	2 232	7 408

Table 32: Number of tag recaptures by calendar year of recovery and sex for each CRA 5 statistical area and for all of CRA 5. Tags are classified to statistical area on the basis of release statistical area. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

Recovery	Release statistical area																	
	Unknown			916			917			918			933			CRA 5		
year	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1975	–	–	–	–	–	–	–	–	–	1	1	2	–	–	–	1	1	2
1976	–	–	–	–	–	–	–	–	–	41	65	106	–	–	–	41	65	106
1977	–	–	–	–	–	–	–	–	–	27	28	55	–	–	–	27	28	55
1978	–	–	–	–	–	–	–	–	–	3	2	5	–	–	–	3	2	5
1979	–	–	–	–	–	–	–	–	–	1	3	4	–	–	–	1	3	4
1980	–	–	–	–	–	–	–	–	–	6	15	21	–	–	–	6	15	21
1981	–	–	–	–	–	–	–	–	–	6	25	31	–	–	–	6	25	31
1982	–	–	–	–	–	–	–	–	–	3	–	3	–	–	–	3	–	3
1983	20	–	20	15	5	20	293	62	355	–	–	–	–	–	–	328	67	395
1984	127	7	134	8	9	17	446	91	537	–	–	–	–	–	–	581	107	688
1985	18	4	22	2	3	5	51	27	78	–	–	–	–	–	–	71	34	105
1986	6	–	6	1	–	1	10	11	21	–	–	–	–	–	–	17	11	28
1987	–	–	–	1	–	1	1	2	3	–	–	–	–	–	–	2	2	4
1996	–	–	–	19	1	20	–	–	–	–	–	–	35	3	38	54	4	58
1997	–	–	–	238	41	279	18	38	56	–	–	–	208	131	339	464	210	674
1998	–	–	–	53	24	77	165	109	274	–	–	–	164	60	224	382	193	575
1999	–	–	–	17	10	27	36	49	85	–	–	–	61	19	80	114	78	192
2000	–	–	–	6	1	7	88	207	295	–	–	–	71	92	163	165	300	465
2001	–	–	–	269	22	291	26	94	120	–	–	–	66	22	88	361	138	499
2002	–	–	–	397	47	444	146	106	252	–	–	–	231	61	292	774	214	988
2003	–	–	–	199	30	229	81	48	129	–	–	–	46	39	85	326	117	443
2004	–	–	–	70	4	74	31	25	56	–	–	–	25	63	88	126	92	218
2005	–	–	–	509	11	520	43	128	171	–	–	–	235	59	294	787	198	985
2006	–	–	–	128	–	128	17	58	75	–	–	–	49	18	67	194	76	270
2007	–	–	–	20	–	20	6	32	38	–	–	–	6	11	17	32	43	75
2008	–	–	–	4	–	4	–	16	16	–	–	–	–	–	–	4	16	20
2009	–	–	–	1	–	1	–	2	2	–	–	–	–	–	–	1	2	3
2010	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	2	2
2011	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	1	1
2012	–	–	–	6	–	6	8	3	11	–	–	–	5	5	10	19	8	27
2013	–	–	–	10	–	10	33	51	84	–	–	–	10	4	14	53	55	108
2014	–	–	–	2	–	2	12	10	22	–	–	–	12	4	16	26	14	40
2015	–	–	–	–	–	–	8	9	17	–	–	–	11	8	19	19	17	36
2016	1	1	2	24	–	24	17	5	22	–	–	–	11	10	21	53	16	69
2017	–	–	–	7	–	7	50	53	103	–	–	–	3	2	5	60	55	115
2018	–	–	–	36	1	37	14	21	35	–	–	–	25	1	26	75	23	98
Total	172	12	184	2 042	209	2 251	1 600	1 260	2 860	88	139	227	1 274	612	1 886	5 176	2 232	7 408

Table 33: Number of tag releases by sex and release month for CRA 5 by release statistical area and for all of CRA 5.

Release month	Release statistical area					
	Unknown	916	917	918	933	CRA 5
Males						
Jan	11	512	2	9	276	810
Feb	7	–	347	14	14	382
Mar	33	13	1	2	1	50
Apr	2	93	20	–	30	145
May	47	474	262	–	101	884
Jun	20	523	121	–	276	940
Jul	–	79	38	21	42	180
Aug	1	32	108	9	34	184
Sep	2	79	179	10	335	605
Oct	7	202	383	17	119	728
Nov	18	1	94	6	33	152
Dec	24	34	45	–	13	116
CRA 5	172	2 042	1 600	88	1 274	5 176
Females						
Jan	–	98	1	6	155	260
Feb	–	1	13	6	19	39
Mar	–	–	–	–	–	–
Apr	2	6	44	–	9	61
May	1	26	207	–	15	249
Jun	–	18	216	–	31	265
Jul	–	28	16	15	13	72
Aug	1	3	168	28	10	210
Sep	–	24	143	31	191	389
Oct	1	4	372	46	96	519
Nov	3	–	26	7	70	106
Dec	4	1	54	–	3	62
CRA 5	12	209	1 260	139	612	2 232

Table 34: Number of tag recaptures by release and recovery statistical areas for CRA 5 releases. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

Release statistical area	Recovery statistical area										
	Unknown	915	916	917	918	919	920	921	933	934	Total
Unknown	183	–	–	–	–	–	–	–	1	–	184
916	3	1	2 082	2	–	–	–	–	163	–	2 251
917	998	–	–	1 861	–	–	–	–	1	–	2 860
918	–	–	–	–	220	1	5	1	–	–	227
933	1	11	278	3	–	–	–	–	1 590	3	1 886
CRA 5	1 185	12	2 360	1 866	220	1	5	1	1 755	3	7 408

Table 35: Days-at-liberty statistics for recaptures of CRA 5 releases. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

Release statistical area	Sex	N	Min(days)	p5%(days)	Median(days)	p95%(days)	Max(days)
Unknown	Males	172	1	4	56	320	659
	Females	12	13	13	74	313	313
916	Males	2 042	1	3	215	723	1 966
	Females	209	1	9	362	1 215	2 394
917	Males	1 600	1	9	228	724	2 523
	Females	1 260	1	20	333	1 380	3 371
918	Males	88	2	9	295	559	909
	Females	139	7	13	102	498	773
933	Males	1 274	1	4	241	708	2 182
	Females	612	1	11	268	1 137	3 532
CRA 5	Males	5 176	1	4	224	716	2 523
	Females	2 232	1	15	289	1 294	3 532

Table 36: Number of tag re-releases by sex for CRA 5 by release statistical area and for all of CRA 5. Re-release event code = 0 means the first release-recapture event.

	Release statistical area									
Re-	916		917		918		933		CRA 5	
release event	N	Cum Prop	N	Cum Prop	N	Cum Prop	N	Cum Prop	N	Cum Prop
Males										
0	1 307	0.64	1 318	0.83	78	0.89	937	0.74	3 640	0.70
1	457	0.86	161	0.93	6	0.95	232	0.92	963	0.89
2	176	0.95	64	0.97	3	0.99	69	0.97	346	0.96
3	66	0.98	27	0.98	1	1.00	27	0.99	132	0.98
4	21	0.99	13	0.99	–	1.00	6	1.00	46	0.99
5	8	1.00	6	1.00	–	1.00	1	1.00	20	1.00
6	4	1.00	4	1.00	–	1.00	1	1.00	12	1.00
7	2	1.00	1	1.00	–	1.00	1	1.00	6	1.00
8	1	1.00	1	1.00	–	1.00	–	1.00	3	1.00
9	–	1.00	1	1.00	–	1.00	–	1.00	2	1.00
10	–	1.00	1	1.00	–	1.00	–	1.00	2	1.00
11	–	1.00	1	1.00	–	1.00	–	1.00	2	1.00
12	–	1.00	1	1.00	–	1.00	–	1.00	1	1.00
13	–	1.00	1	1.00	–	1.00	–	1.00	1	1.00
Females										
0	177	0.85	976	0.77	131	0.94	527	0.86	1 811	0.81
1	26	0.97	189	0.92	7	0.99	69	0.97	300	0.95
2	5	1.00	66	0.98	1	1.00	11	0.99	86	0.98
3	1	1.00	22	0.99	–	1.00	4	1.00	27	1.00
4	–	1.00	5	1.00	–	1.00	1	1.00	6	1.00
5	–	1.00	1	1.00	–	1.00	–	1.00	1	1.00
6	–	1.00	1	1.00	–	1.00	–	1.00	1	1.00

Table 37: Statistics for tail width growth increments (mm) for recaptures of CRA 5 releases. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture. Columns "Min", "p5%, "Median", "p95%", and "Max" are in terms of increment.

Release statistical area	Sex	N	Min	p5%	Median	p95%	Max
Unknown	Males	172	-3.0	-0.2	0.1	4.7	8.4
	Females	12	-0.8	-0.8	0.0	5.5	5.5
916	Males	2 042	-6.8	-1.0	1.0	5.4	21.1
	Females	209	-30.0	-2.2	0.7	5.1	31.0
917	Males	1 600	-30.0	-0.1	3.0	10.5	34.5
	Females	1 260	-14.2	-0.6	2.2	10.4	30.2
918	Males	88	-2.5	-0.5	2.3	7.4	11.2
	Females	139	-5.1	-2.0	0.3	8.5	16.2
933	Males	1 274	-10.0	-1.0	1.9	8.6	20.0
	Females	612	-14.7	-1.3	1.5	8.4	31.3
CRA 5	Males	5 176	-30.0	-1.0	1.5	8.3	34.5
	Females	2 232	-30.0	-1.0	1.7	9.5	31.3

Table 38: Puerulus index series with lower and upper 95% confidence bounds for the Kaikoura standardised series (Forman et al. 2021).

Fishing year	Index	lower 2.5%	upper 97.5%	Fishing year	Index	lower 2.5%	upper 97.5%
1981	0.576	0.325	1.019	2001	0.557	0.373	0.832
1982	0.757	0.460	1.247	2002	3.331	2.536	4.377
1983	0.166	0.069	0.400	2003	3.486	2.680	4.536
1984	0.396	0.229	0.684	2004	1.074	0.776	1.487
1985	0.254	0.122	0.527	2005	2.355	1.786	3.106
1986	0.092	0.033	0.260	2006	1.155	0.842	1.583
1987	1.102	0.747	1.625	2007	1.702	1.308	2.214
1988	0.413	0.255	0.670	2008	1.660	1.277	2.157
1989	0.846	0.599	1.197	2009	0.517	0.373	0.717
1990	1.621	1.205	2.180	2010	1.312	1.003	1.716
1991	6.996	5.431	9.011	2011	0.560	0.402	0.782
1992	5.527	4.252	7.184	2012	1.153	0.862	1.543
1993	2.166	1.621	2.893	2013	0.767	0.534	1.101
1994	1.110	0.797	1.545	2014	1.342	1.030	1.750
1995	0.622	0.422	0.917	2015	0.856	0.630	1.162
1996	0.661	0.408	1.070	2016	2.778	2.172	3.552
1997	2.101	1.384	3.190	2017	0.935	0.714	1.225
1998	2.078	1.411	3.060	2018	0.379	0.272	0.527
1999	1.346	0.918	1.974	2019	0.384	0.275	0.537
2000	1.366	0.995	1.877				

FIGURES

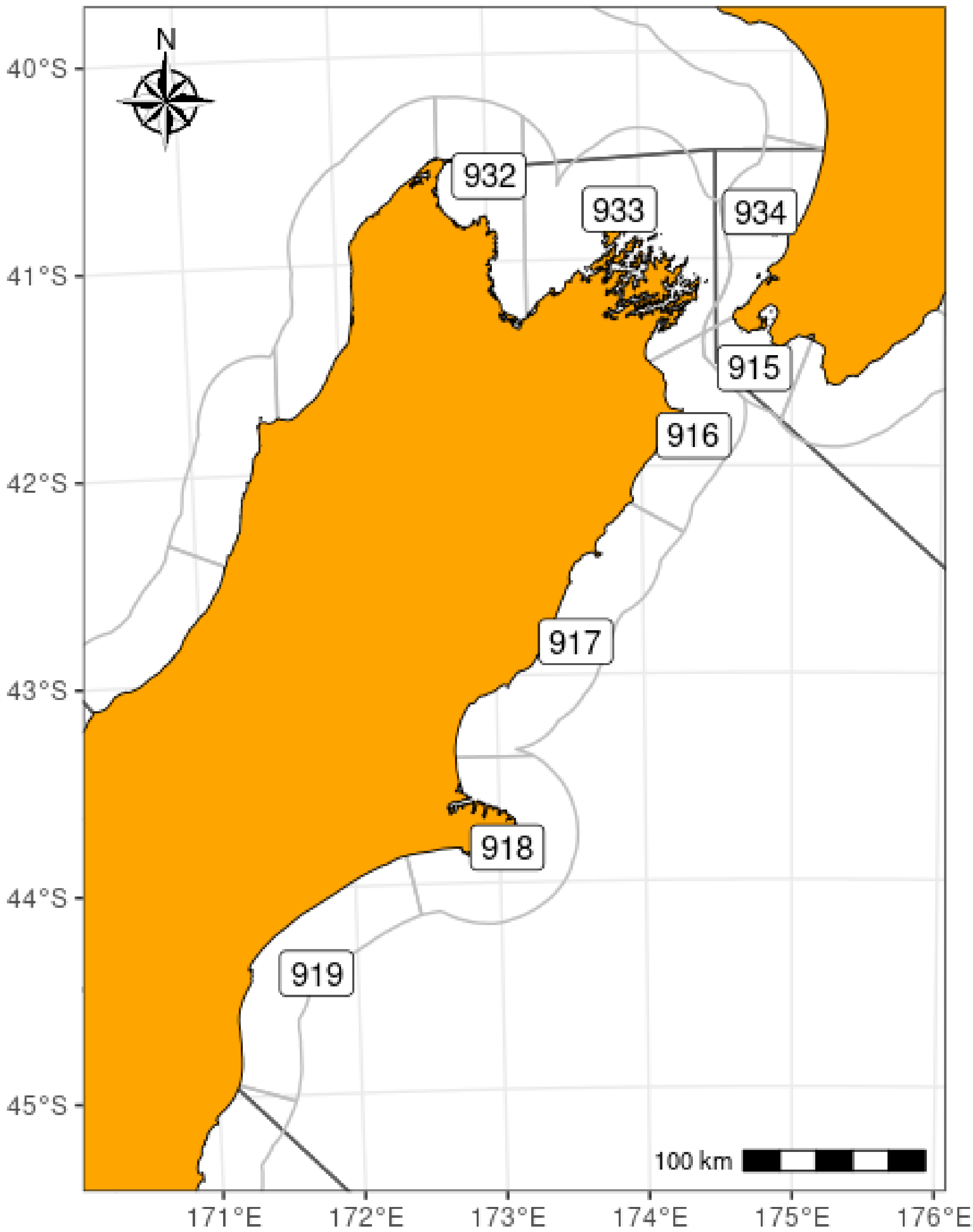

Figure 1: The CRA 5 Quota Management Area (QMA) on the east coast of the South Island and Cook Strait, along with its six statistical areas (916–919, 932, 933). The QMA boundaries are shown with heavy black lines and the statistical area boundaries have thinner grey lines.

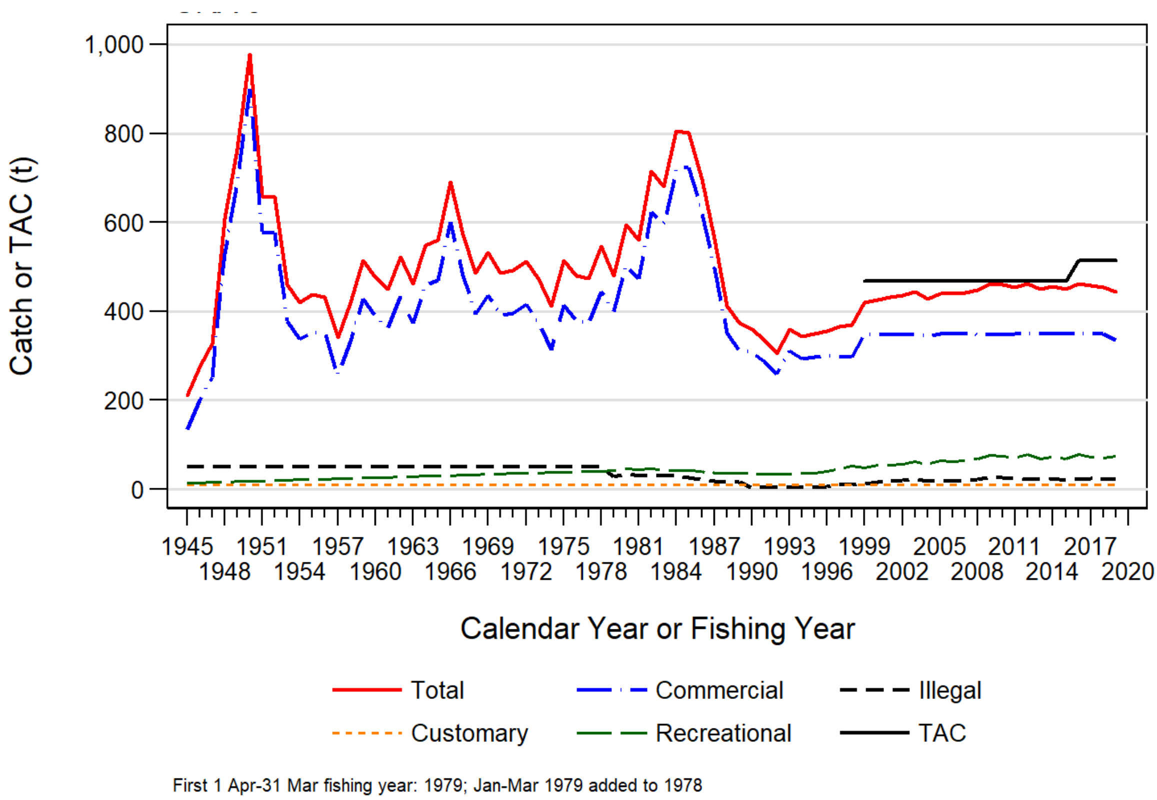

Figure 2: CRA 5 catches by fishery source from 1945 to 2019.

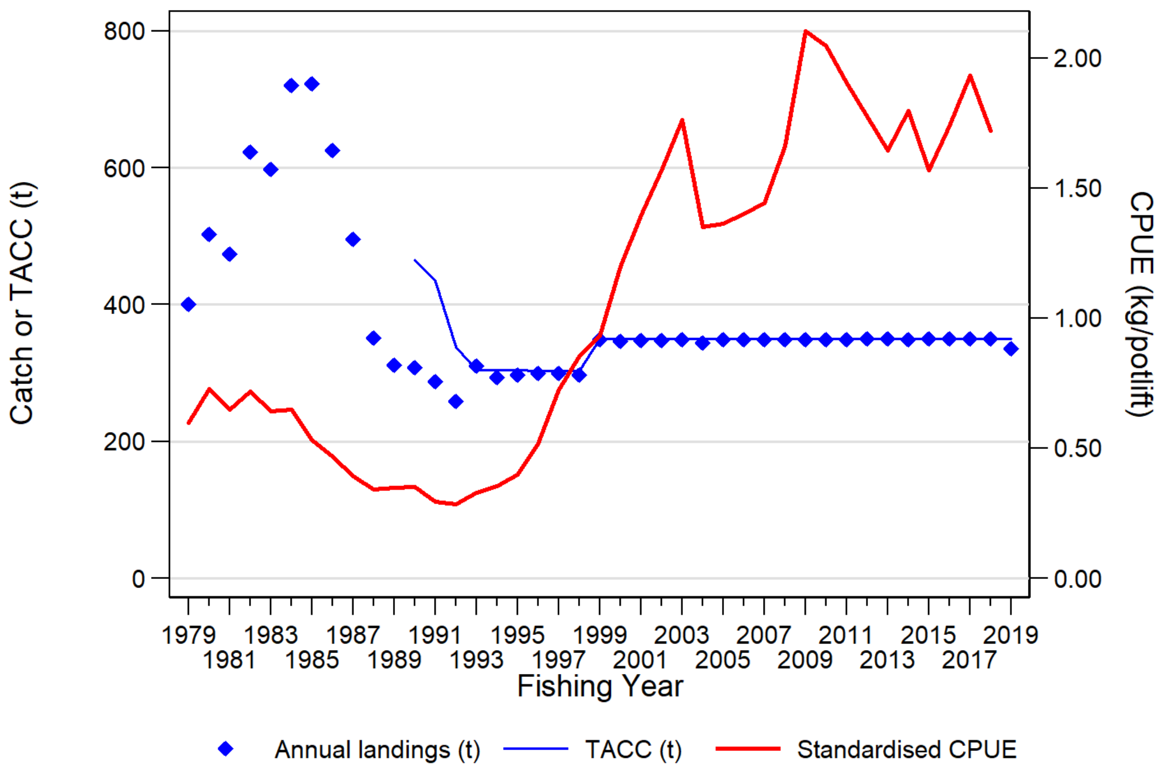

Figure 3: CRA 5 commercial catch, TACC, and standardised CPUE from 1979 to 2019.

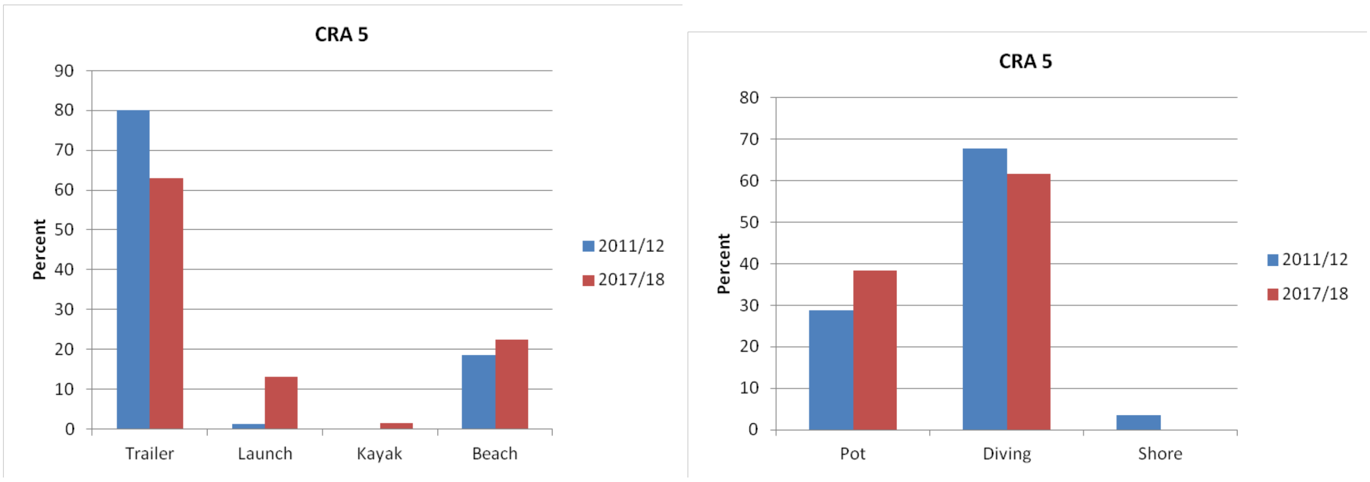

Figure 4: CRA 5 recreational catch information: distribution of fishing platform by survey year [left panel]; distribution of fishing method by survey year [right panel] (2011/12 data from Wynne-Jones et al. 2014; 2017/18 data from Wynne-Jones et al. 2019).

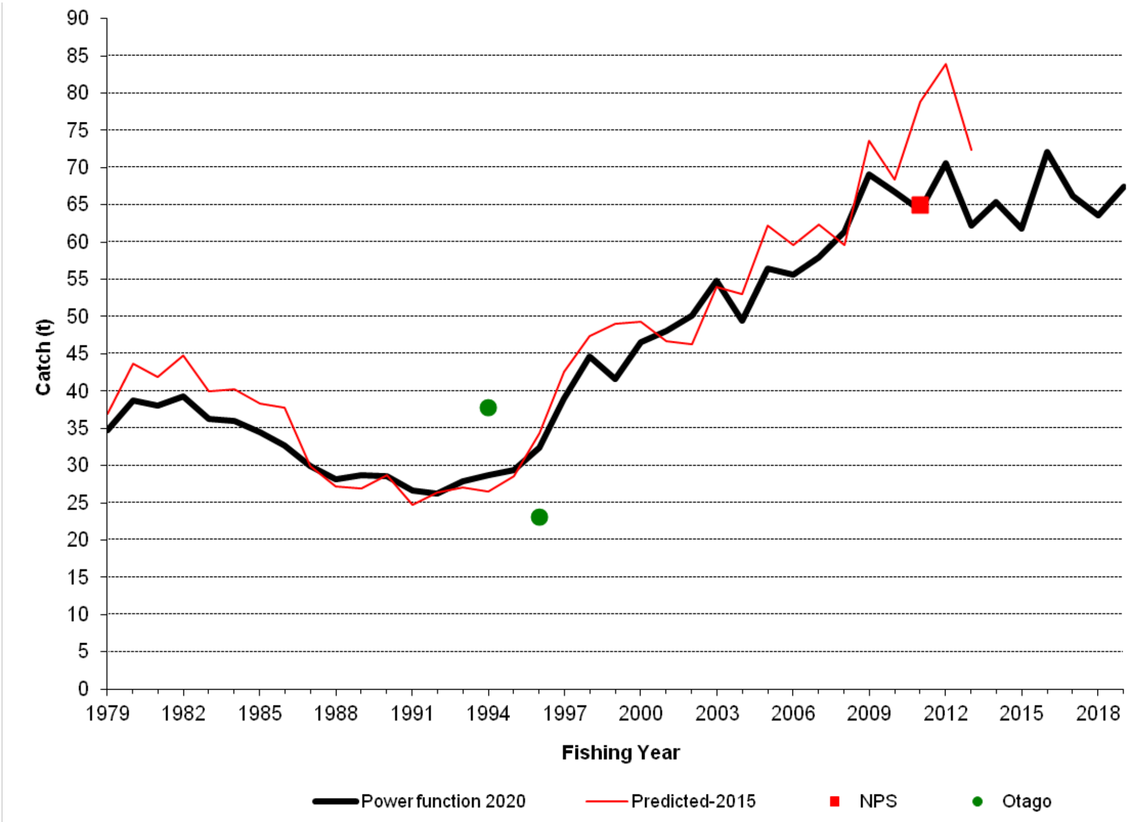

Figure 5: CRA 5 recreational catch trajectory (tonnes) (power function: Eq. 1) based on the statistical area 917 SS geometric mean CPUE series fitted to the two Otago recreational catch surveys (Table 1) and an inflated 2011–12 NPS survey estimate of 65 t. Also shown is the equivalent recreational catch series used in the 2015 CRA 5 stock assessment.

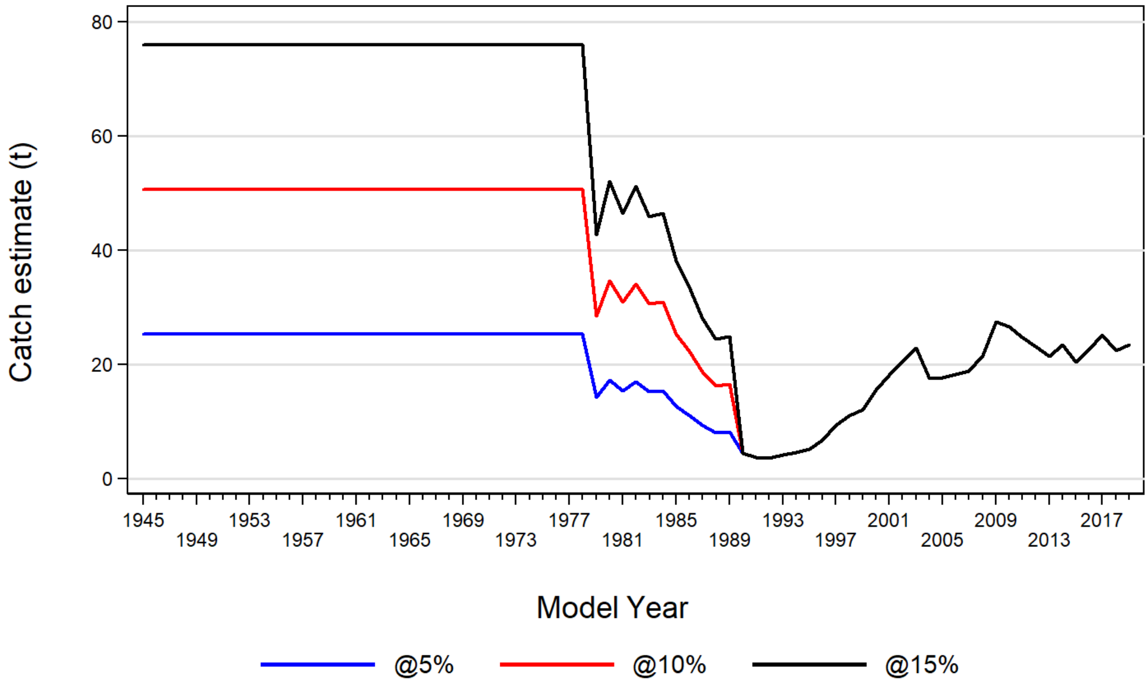

Figure 6: Illegal catch trajectory options considered for the 2020 stock assessment. Option 10% selected by RLWG for base run.

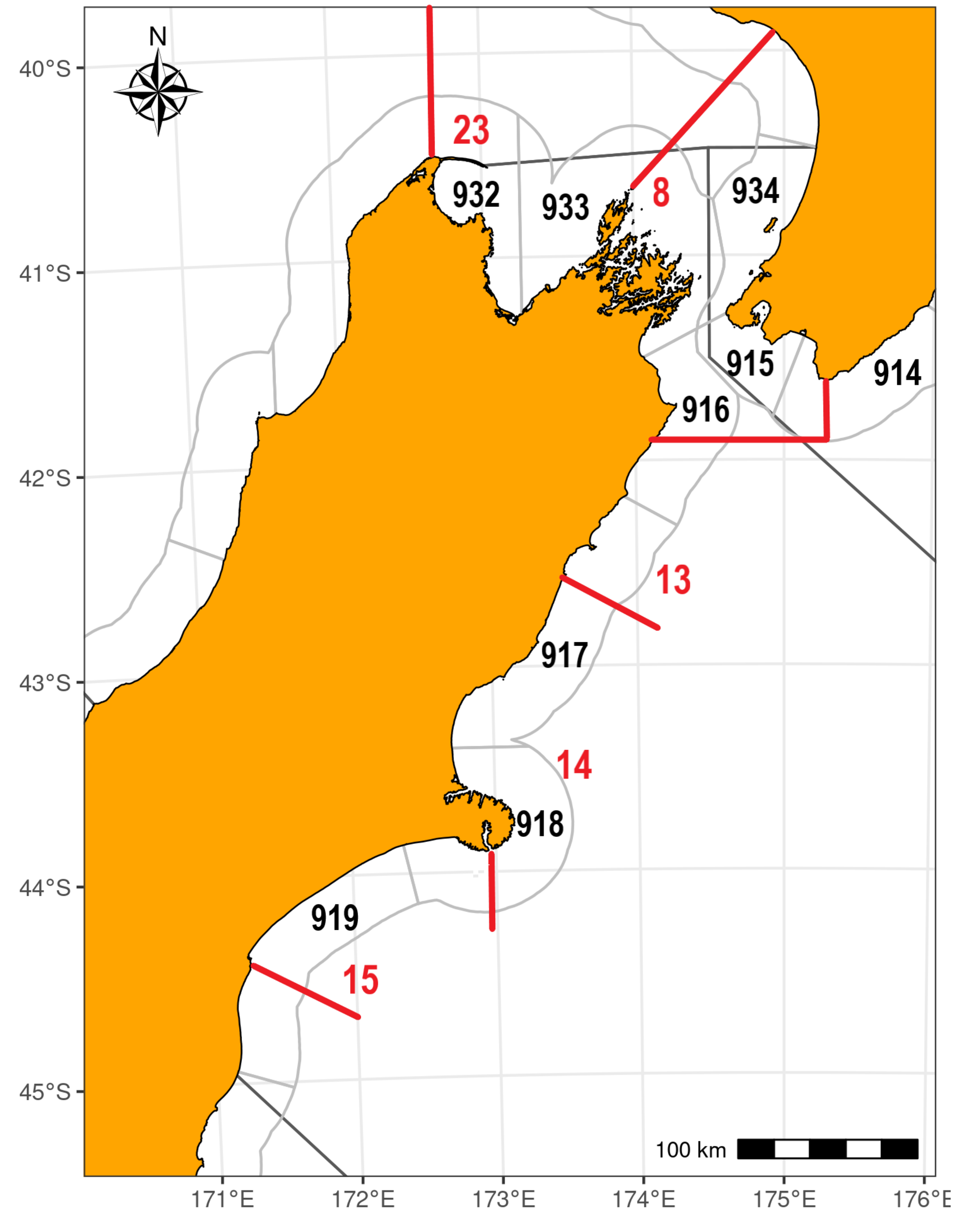

Figure 7: CRA 5, showing the location of the post-1978 rock lobster statistical areas and the boundaries of the Annala & King (1983) reporting areas. The QMA boundaries are shown with heavy black lines while the statistical area boundaries have thinner grey lines. The approximate location of the Annala & King (1983) reporting areas are labelled in red with red boundary lines.

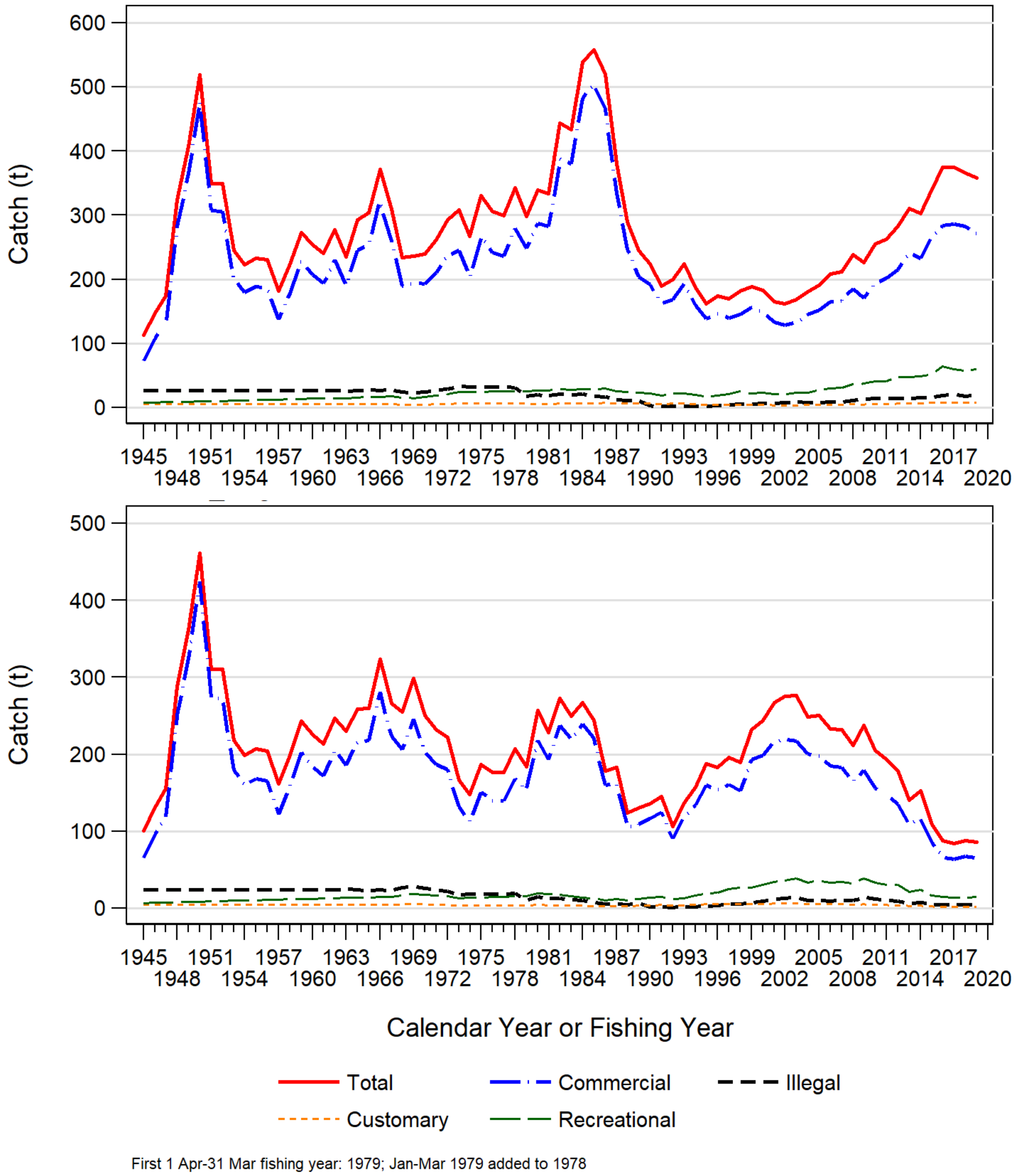

Figure 8: Commercial, recreational, illegal, and customary catch trajectories for CRA 5 region 1 [top panel] and region 2 [bottom panel] defined by rock lobster statistical areas (Table C.2).

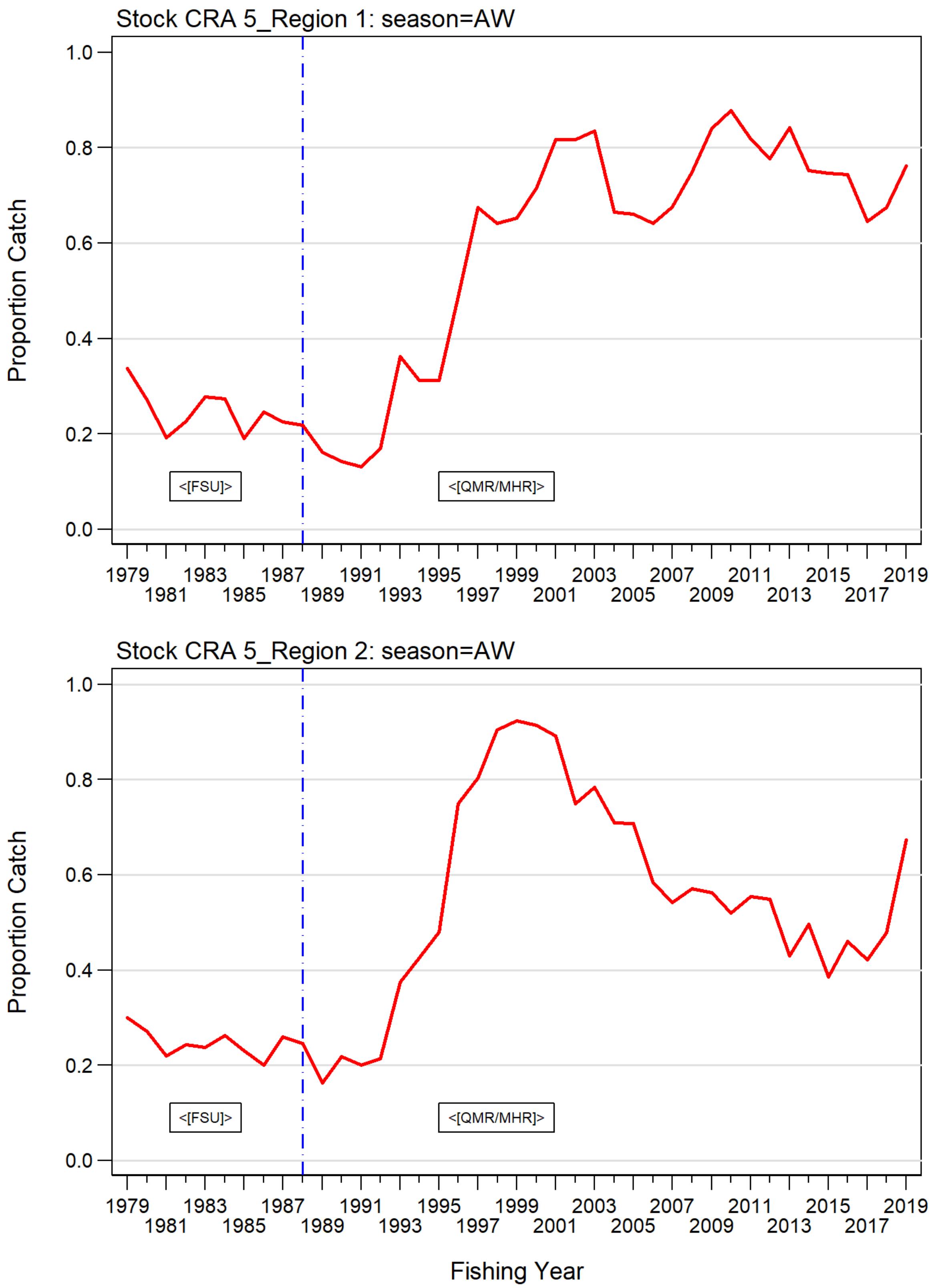

Figure 9: Seasonal proportion of the commercial AW catch by fishing year for CRA 5 region 1 [top panel] and region 2 [bottom panel] defined by rock lobster statistical areas (Table C.2). These proportions have been derived from reported landings by month from the FSU or QMR/MHR catch reporting systems using the F0_LFX algorithm (appendix D of Starr 2021).

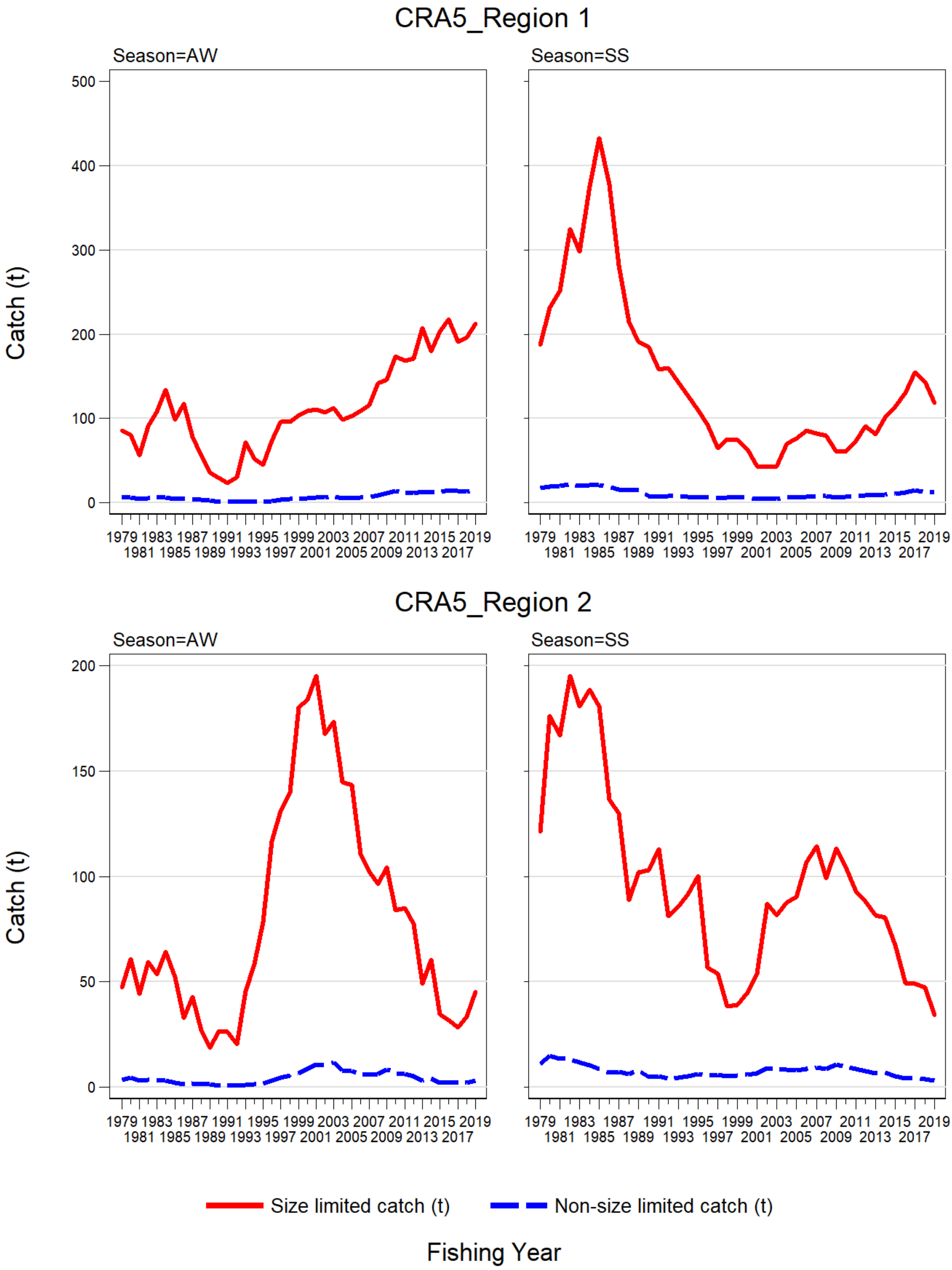

Figure 10: The seasonal SL (size-limited) and NSL (non-size-limited) catches (t) for the two CRA 5 regions, defined by rock lobster statistical areas (Table C.2), plotted by calendar year from 1945 to 1978 (January–March 1979 added to 1978) and by 1 April–31 March fishing year from 1979 onwards.

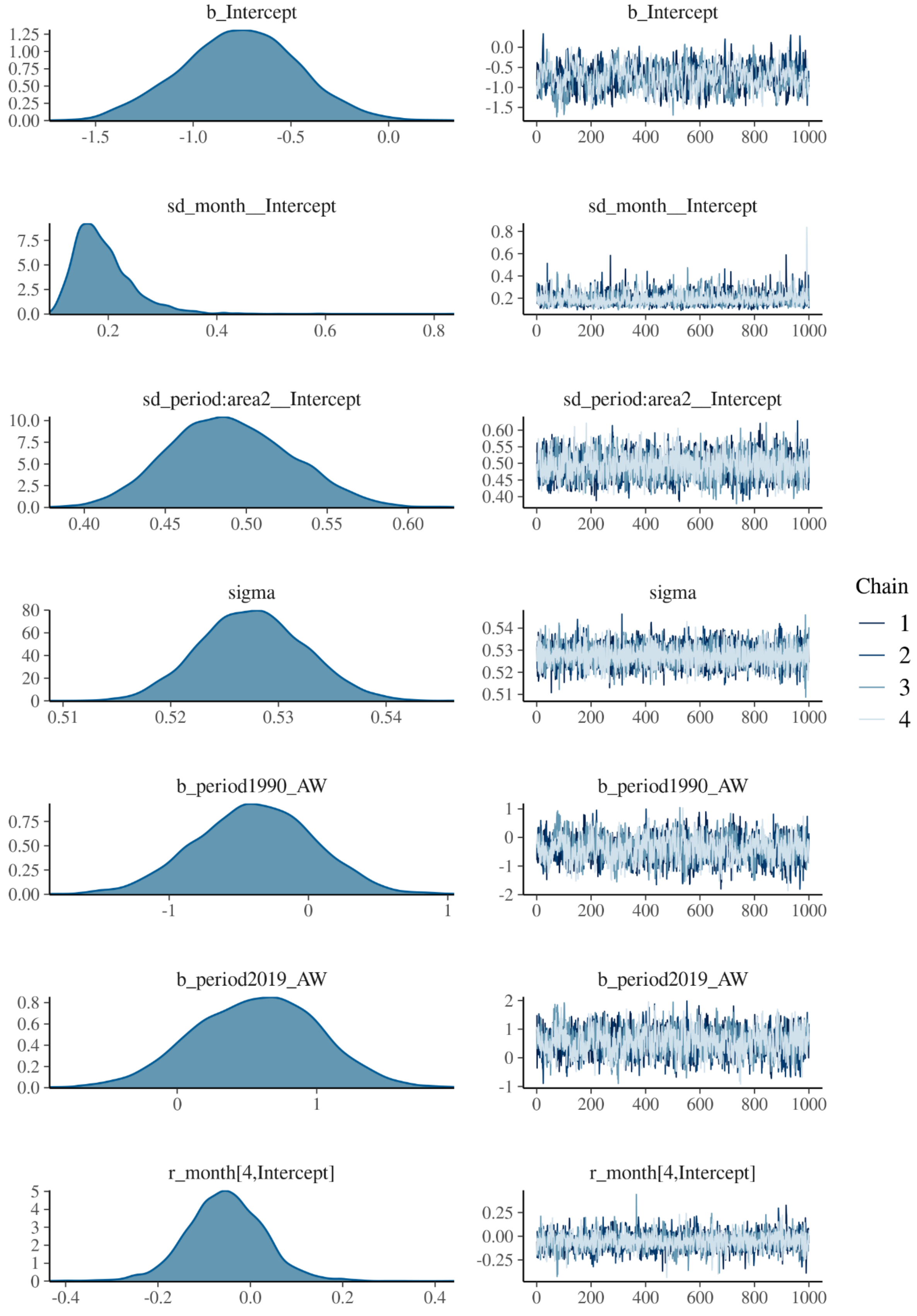

Figure 11: CRA 5: density and trace plots of the MCMC posterior samples for a subset of model parameters from the CPUE analysis based on the CELR data.

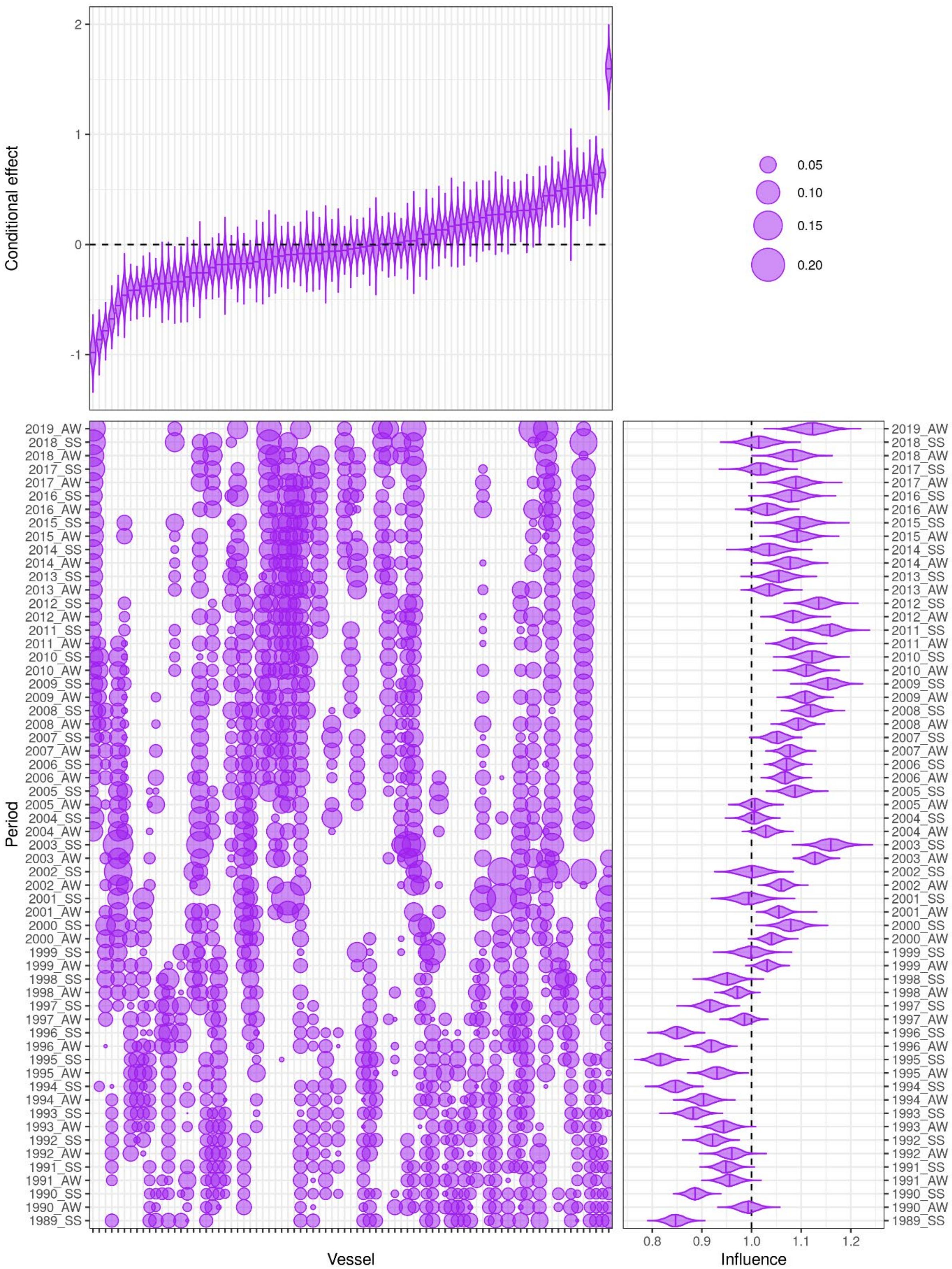

Figure 12: [top panel]: CDI plot (Bentley et al. 2012) showing MCMC posterior distribution of coefficients for vessels with at least five years of data in the CRA 5 fishery from the CELR seasonal CPUE standardisation. Vessel coefficients were estimated as group-level effects; [bottom left panel]: relative distribution of records by fishing year/season, with each row summing to one; [bottom right panel]: MCMC posterior distribution of influence (product of coefficients weighted by the data distribution) for core vessels in each fishing year/season.

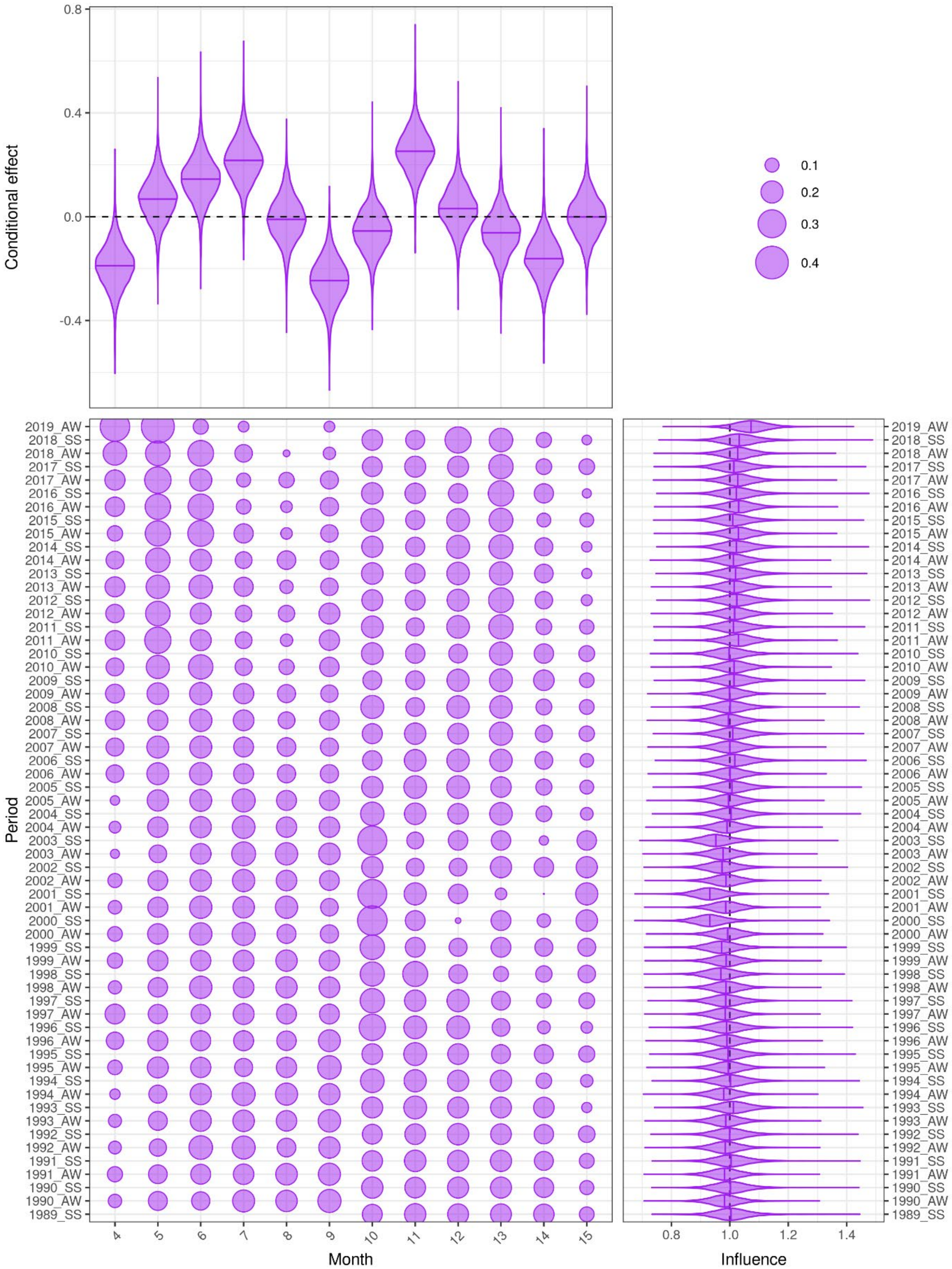

Figure 13: [top panel]: CDI plot (Bentley et al. 2012) showing MCMC posterior distribution of coefficients for in the CRA 5 fishery from the CELR seasonal CPUE standardisation. Month coefficients (4=April to 15=March) were estimated as group-level effects; [bottom left panel]: relative distribution of records by fishing year/season, with each row summing to one; [bottom right panel]: MCMC posterior distribution of influence (product of coefficients weighted by the data distribution) for the month variable for each fishing year/season.

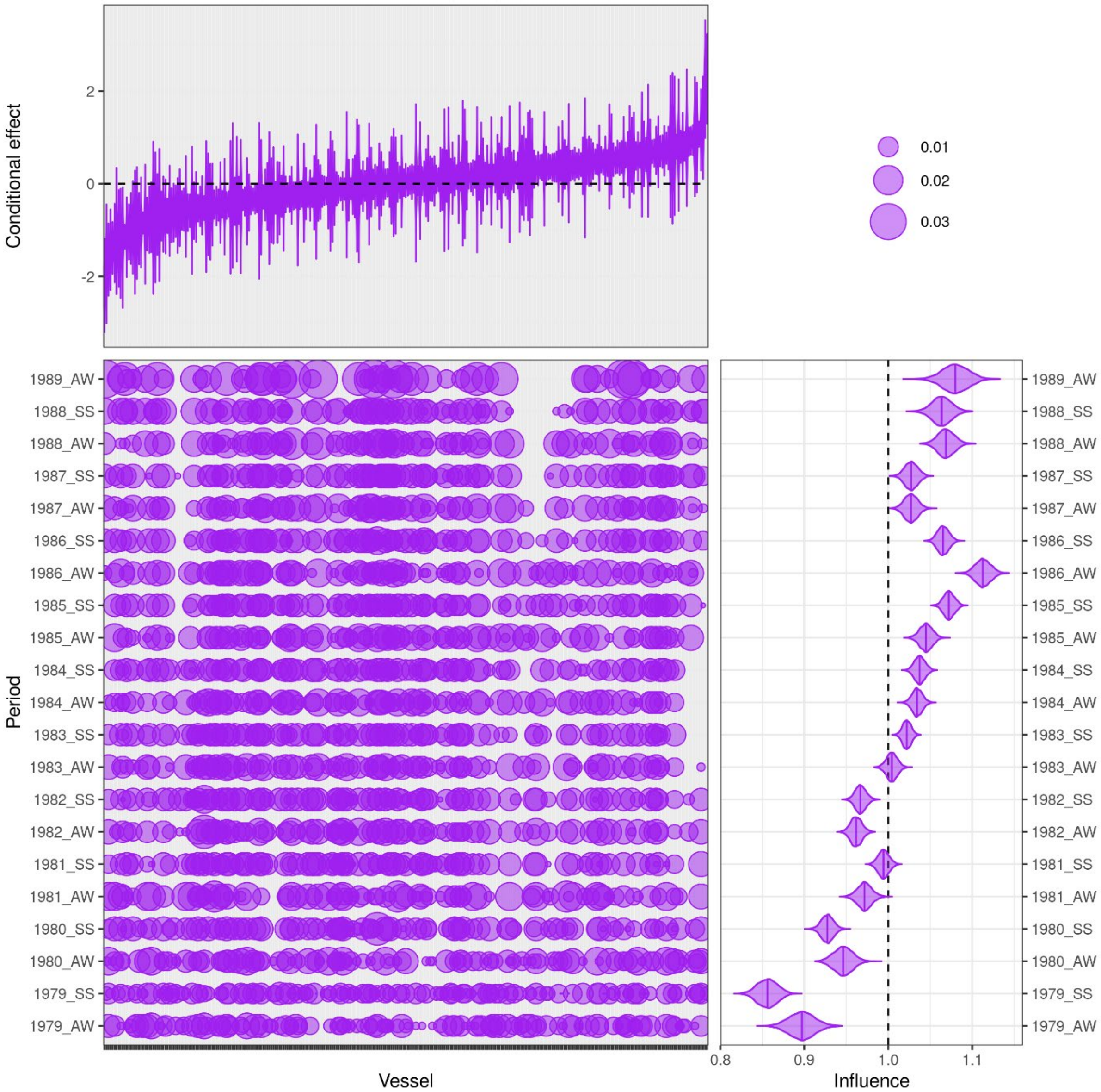

Figure 14: [top panel]: CDI plot (Bentley et al. 2012) showing MCMC posterior distribution of coefficients for vessels in the CRA 5 fishery from the FSU seasonal CPUE standardisation. Vessel coefficients were estimated as group-level effects; [bottom left panel]: relative distribution of records by fishing year/season, with each row summing to one; [bottom right panel]: MCMC posterior distribution of influence (product of coefficients weighted by the data distribution) for vessels in each fishing year/season.

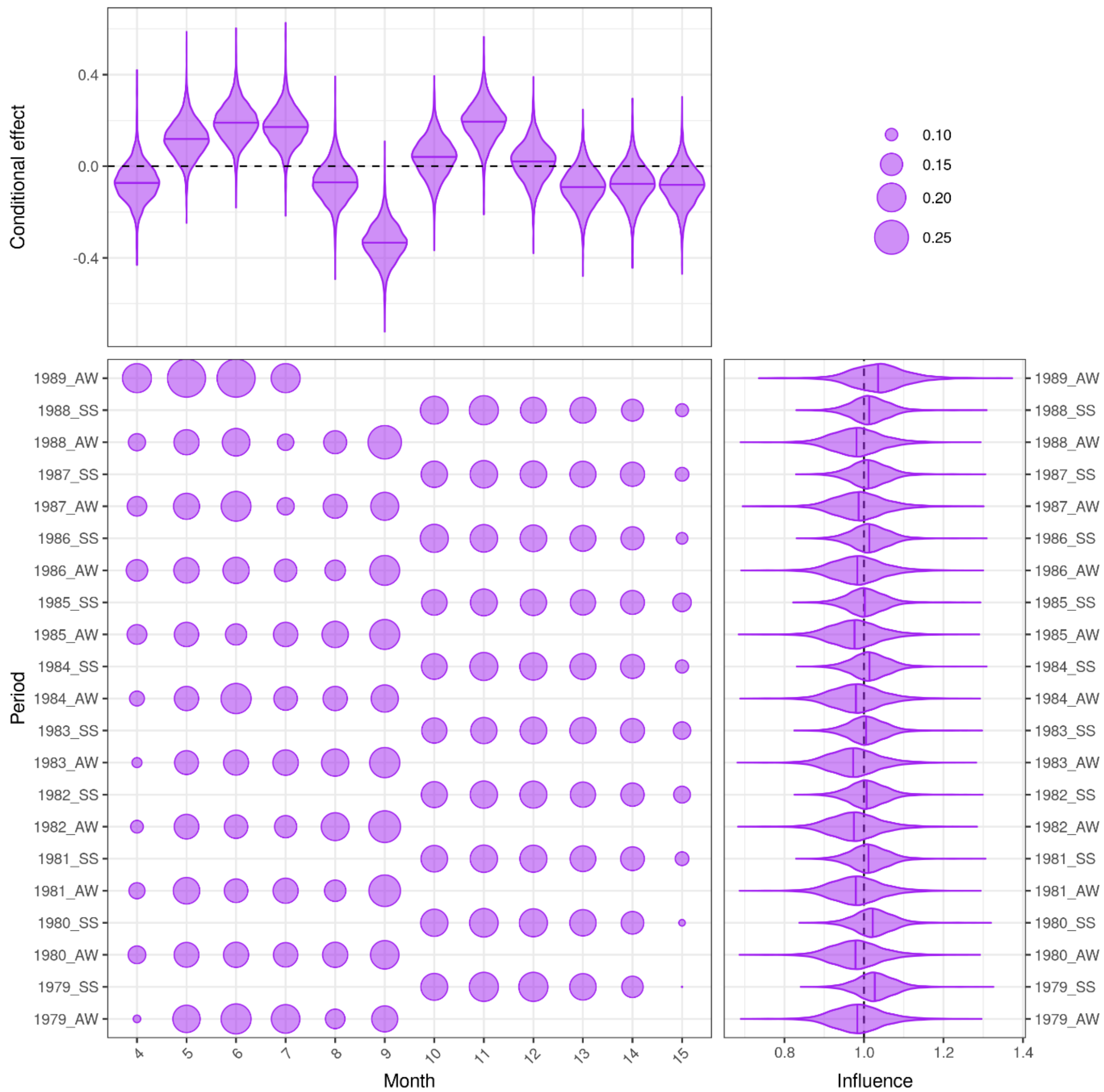

Figure 15: [top panel]: CDI plot (Bentley et al. 2012) showing MCMC posterior distribution of coefficients for in the CRA 5 fishery from the FSU seasonal CPUE standardisation. Month coefficients (4=April to 15=March) were estimated as group-level effects; [bottom left panel]: relative distribution of records by fishing year/season, with each row summing to one; [bottom right panel]: MCMC posterior distribution of influence (product of coefficients weighted by the data distribution) for the month variable for each fishing year/season.

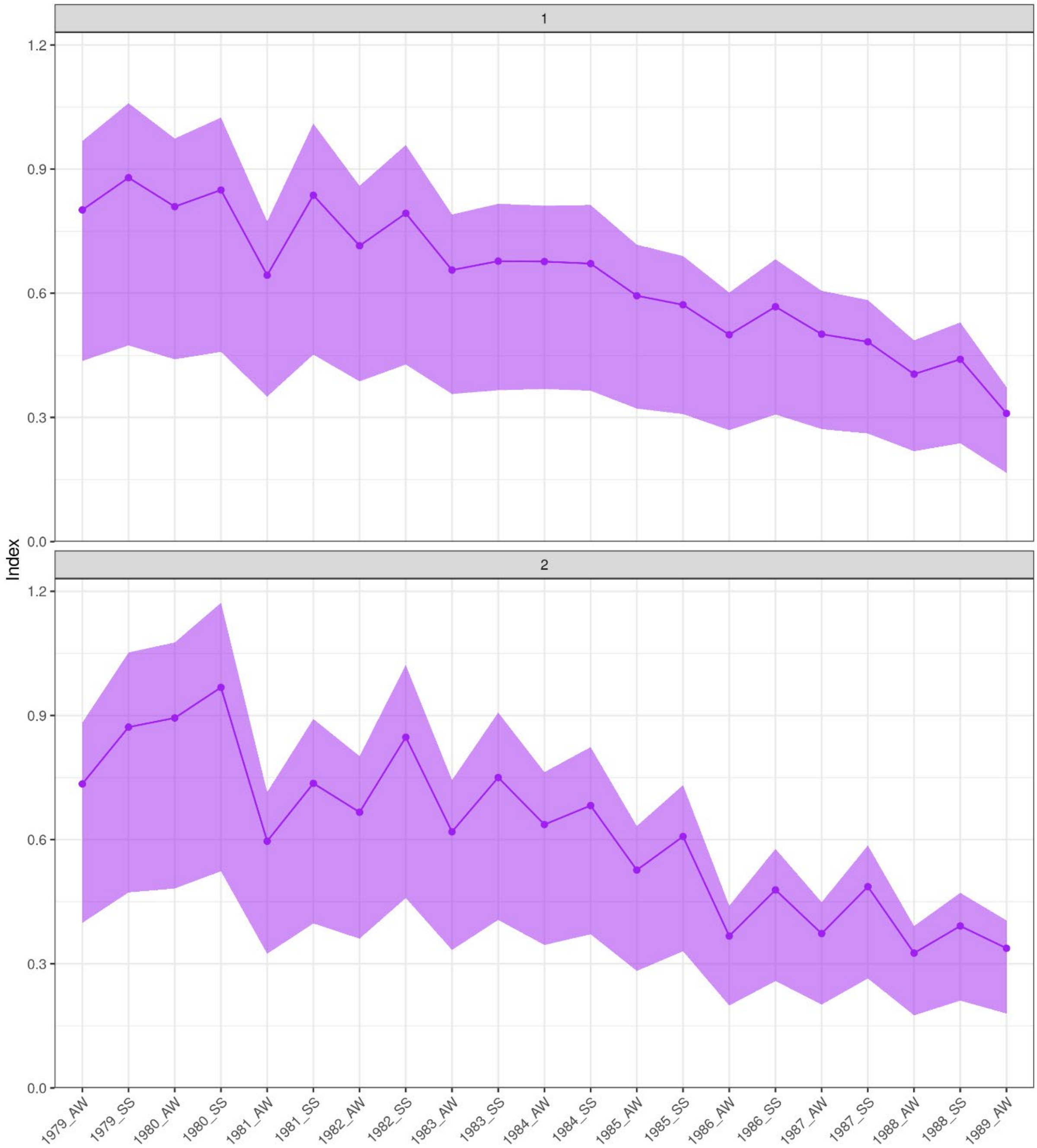

Figure 16: CRA 5: region 1 (917+918+919) and region 2 (916+932+933) standardised FSU CPUE indices (kg/potlift) by season and fishing year. Plot shows the posterior median (points connected by lines) and the 50% credible interval (shaded region).

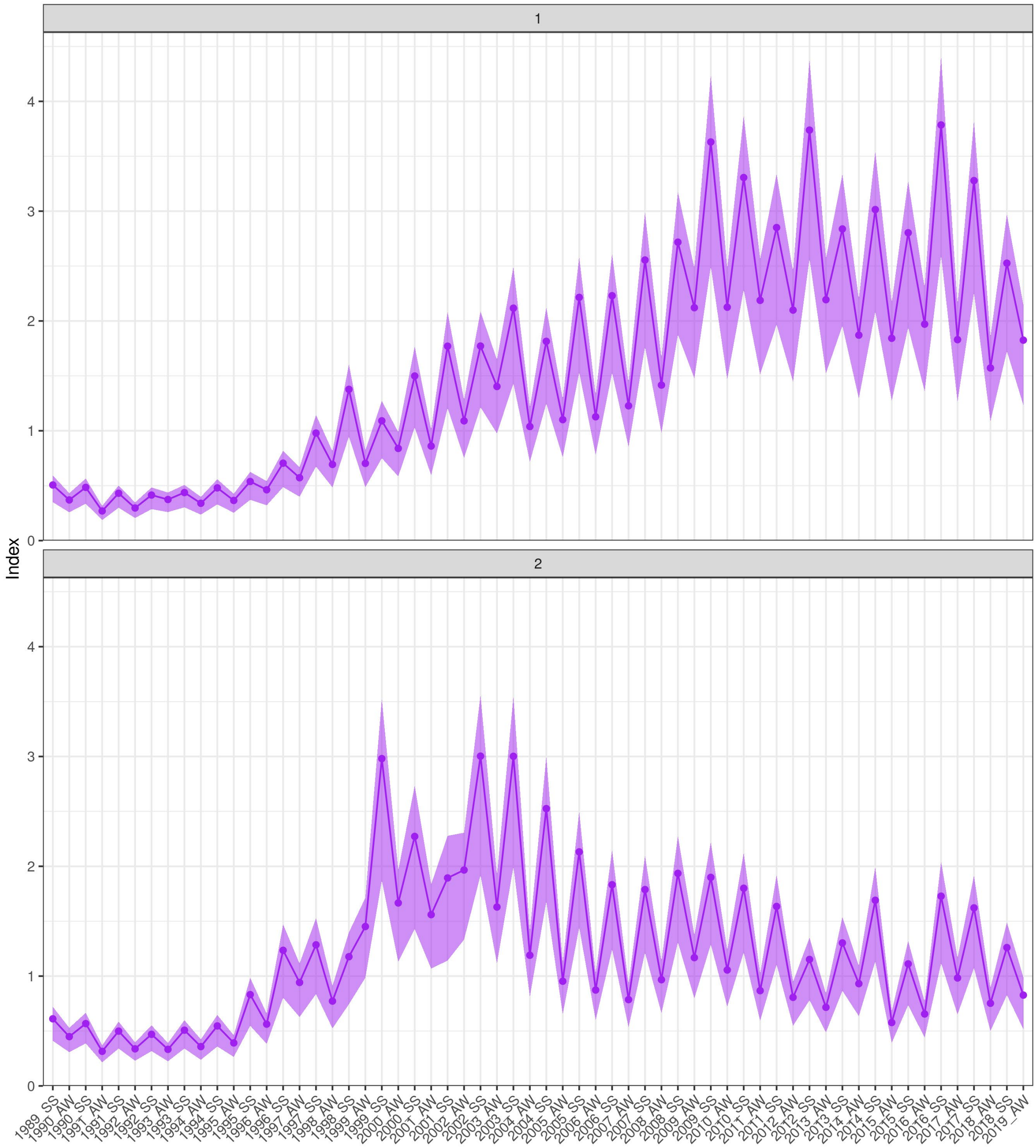

Figure 17: CRA 5: region 1 (917+918+919) and region 2 (916+932+933) standardised CELR CPUE indices (kg/potlift) by season and fishing year which included a vessel variable filtered for vessels with at least five years of data using the F2 algorithm scaled to "LFX" landings from SS 1989–90 to AW 2019–20. Plot shows the posterior median (points connected by lines) and the 50% credible interval (shaded region).

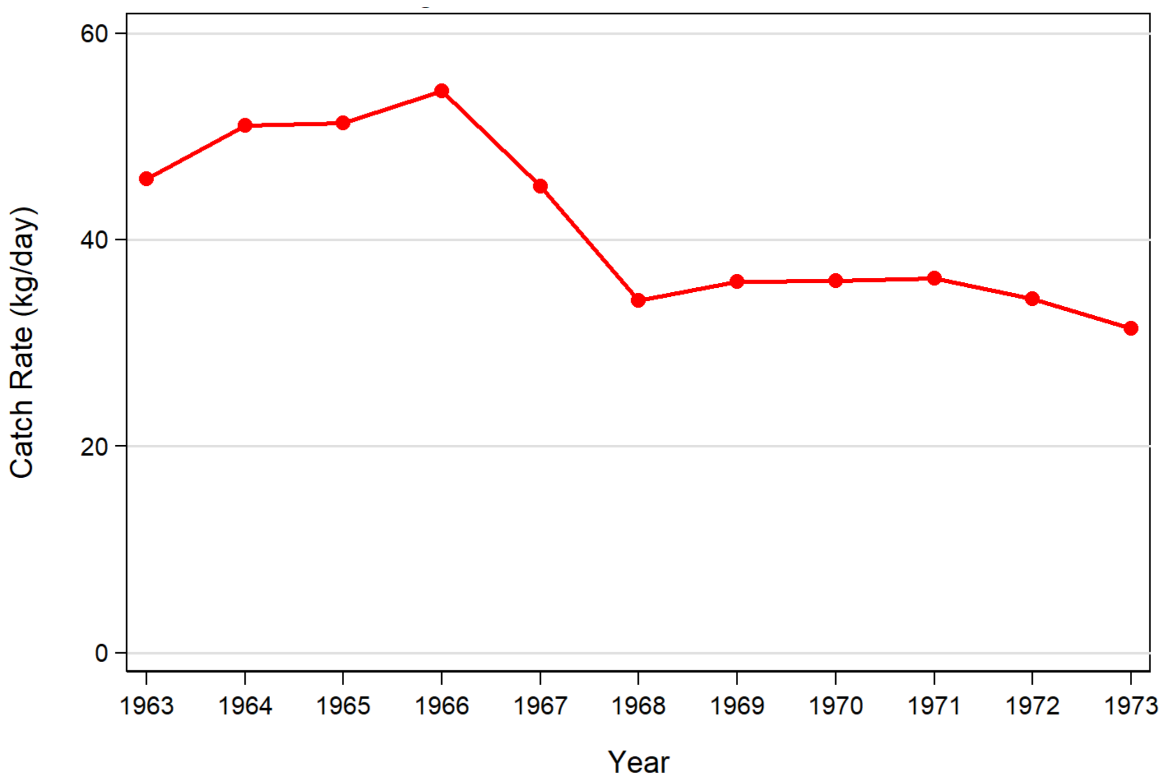

Figure 18: Catch rate (kg/day) by year for region 1 (917+918+919) from Annala & King (1983).

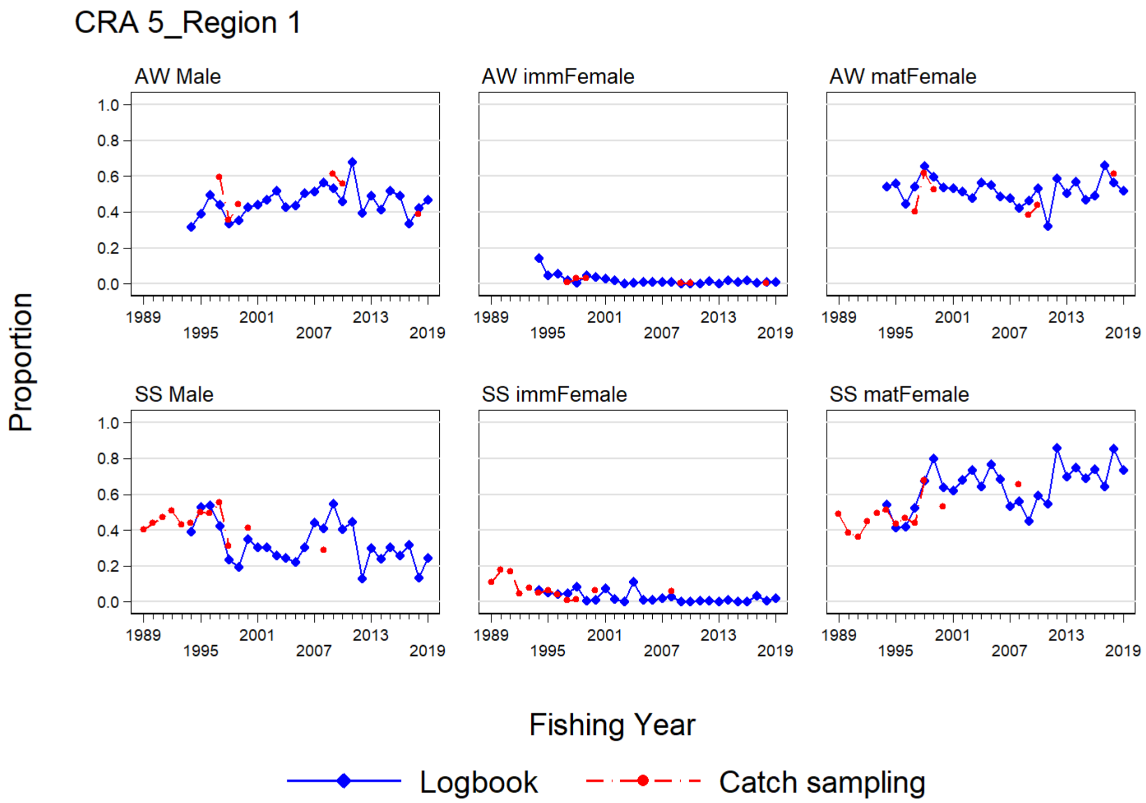

Figure 19: Proportion-at-sex by year, season, sex category, and sampling source for CRA 5 region 1 (917+918+919).

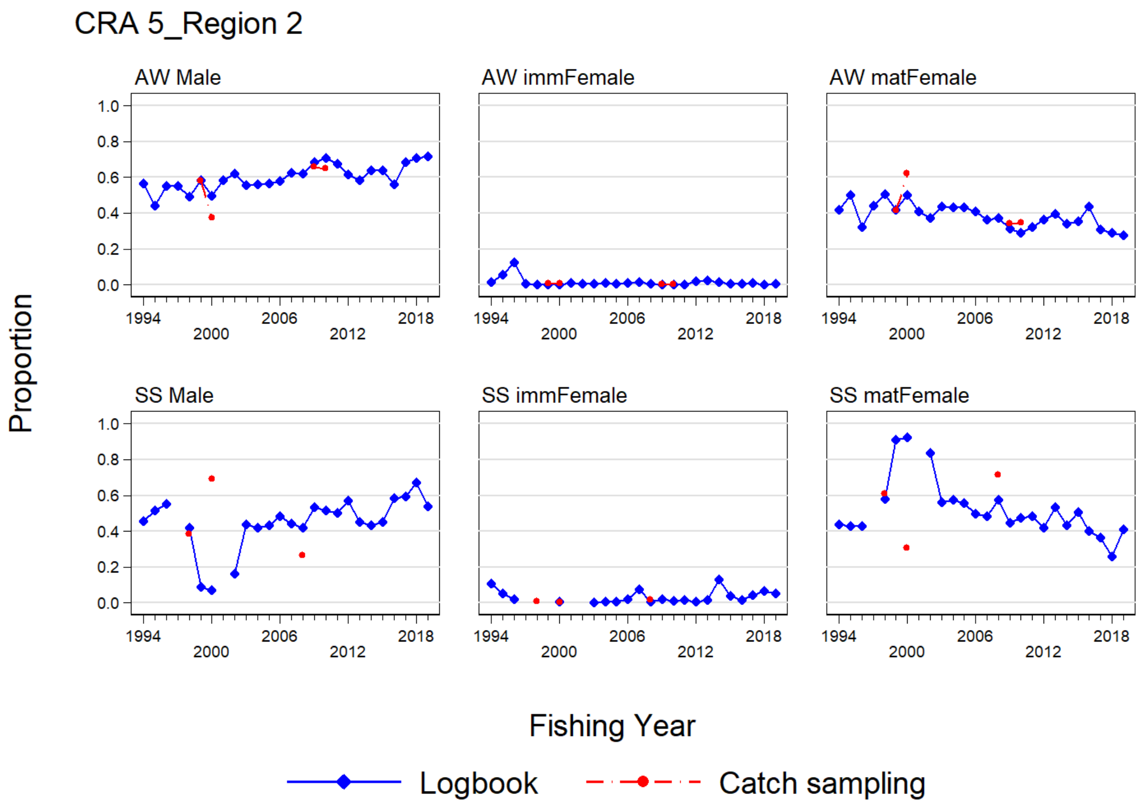

Figure 20: Proportion-at-sex by year, season, sex category, and sampling source for CRA 5 region 2 (916+932+933).

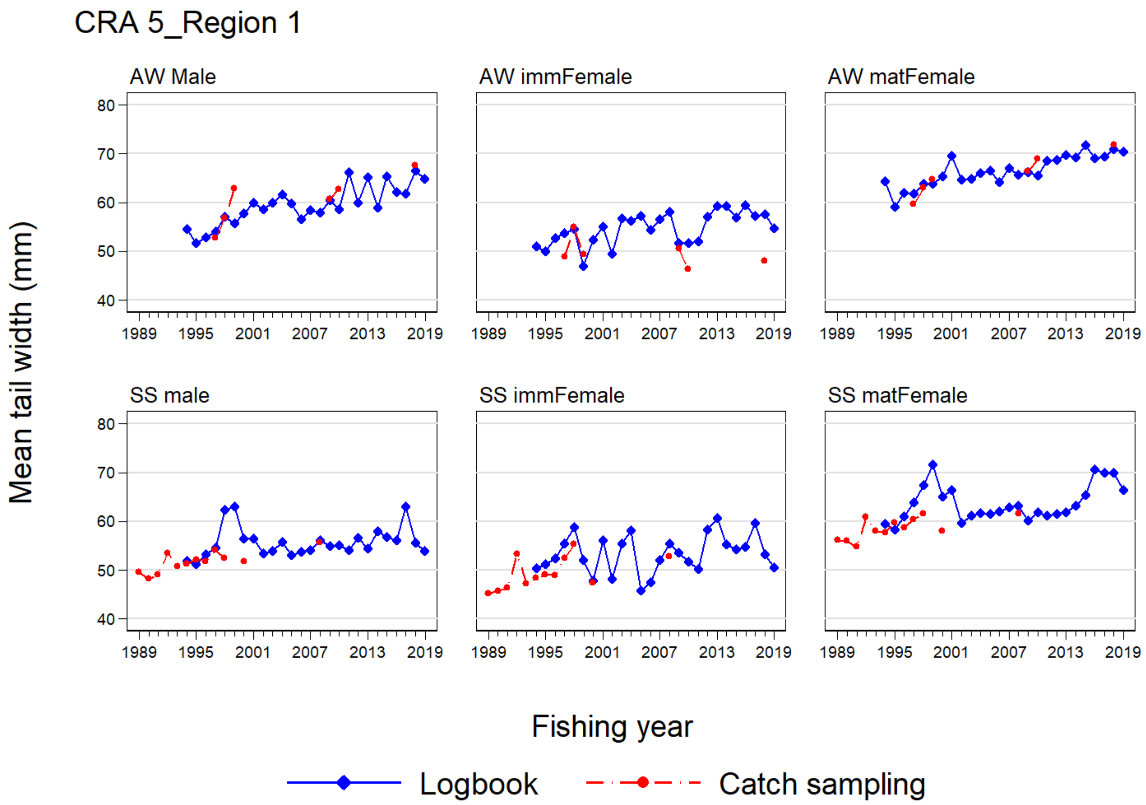

Figure 21: Mean length by year, season, sex category, and sampling source for CRA 5 region 1 (917+918+919).

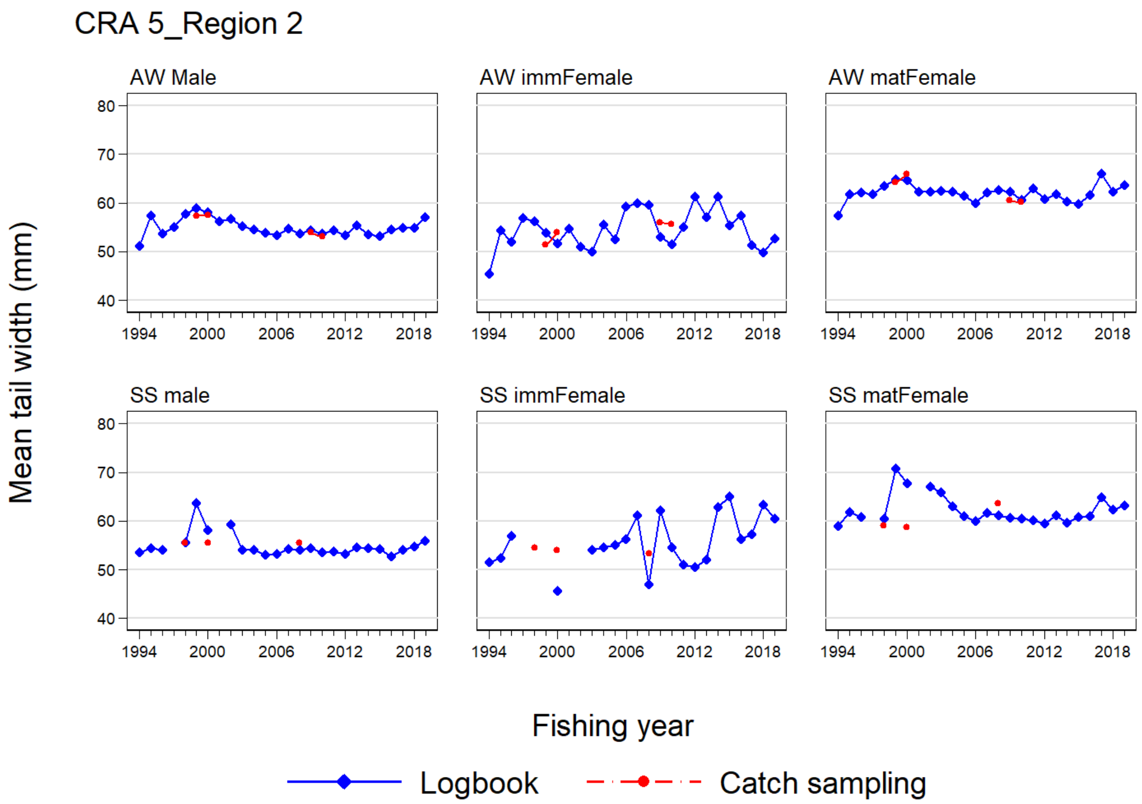

Figure 22: Mean length by year, season, sex category, and sampling source for CRA 5 region 2 (916+932+933).

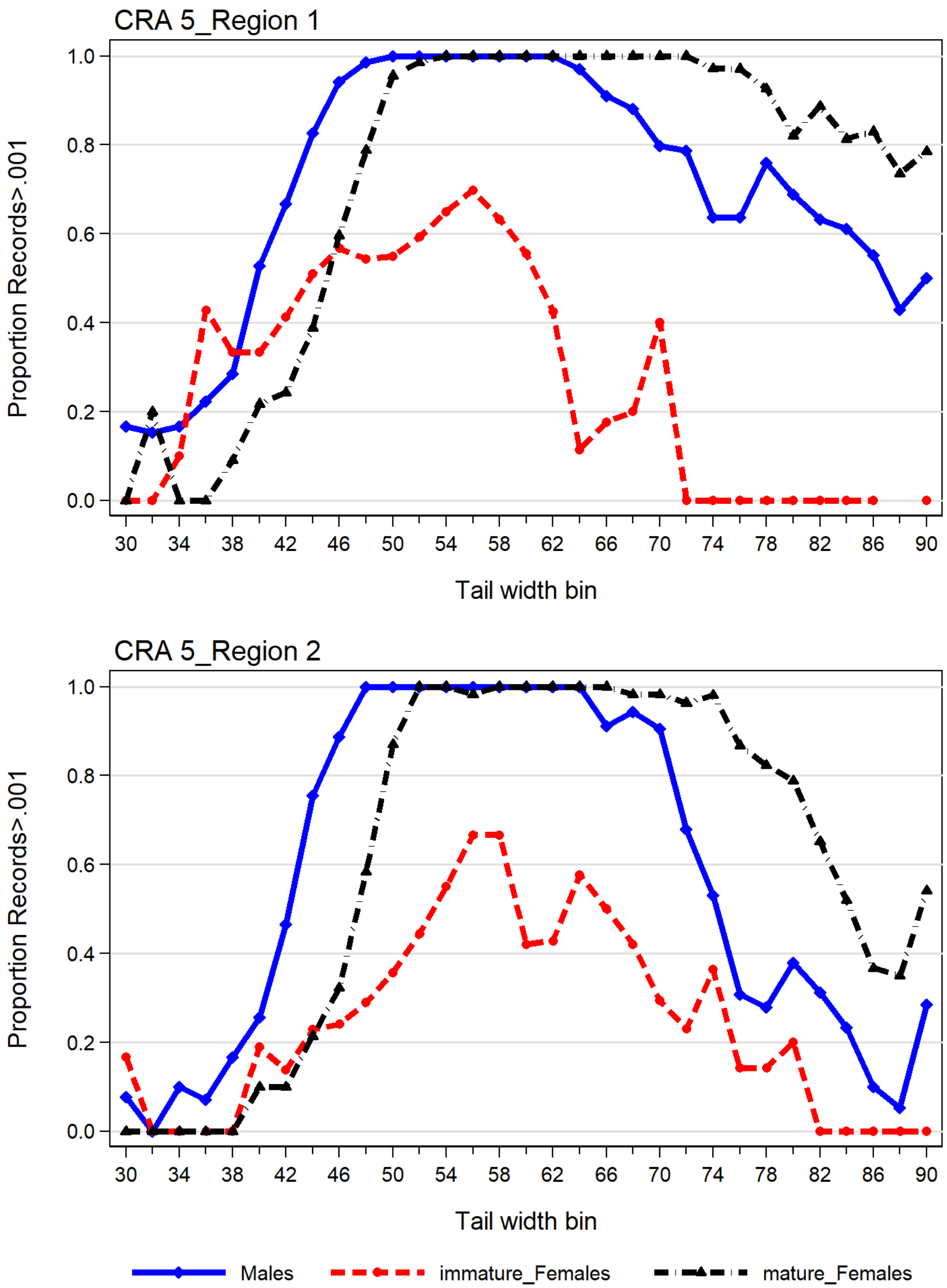

Figure 23: CRA 5: The proportion of size bins in region 1 [top panel] and region 2 [bottom panel] that contain a proportion of 0.001 or higher when the data are normalised by sex. Length bins with little or no data will have a low proportion on this figure.

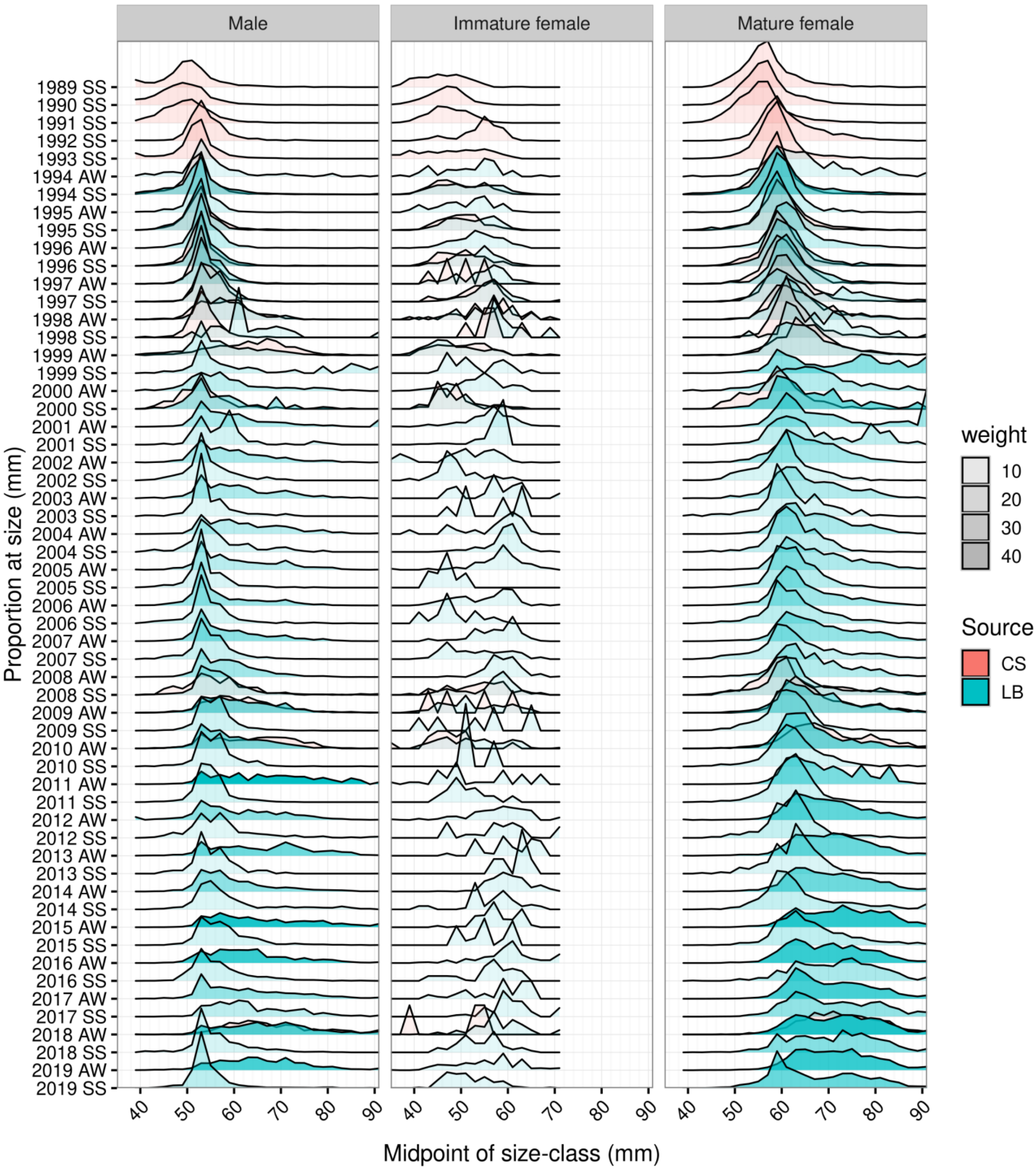

Figure 24: All observed CRA 5 region 1 (917+918+919) length frequency distributions, by sex category, fishing year, and sample source.

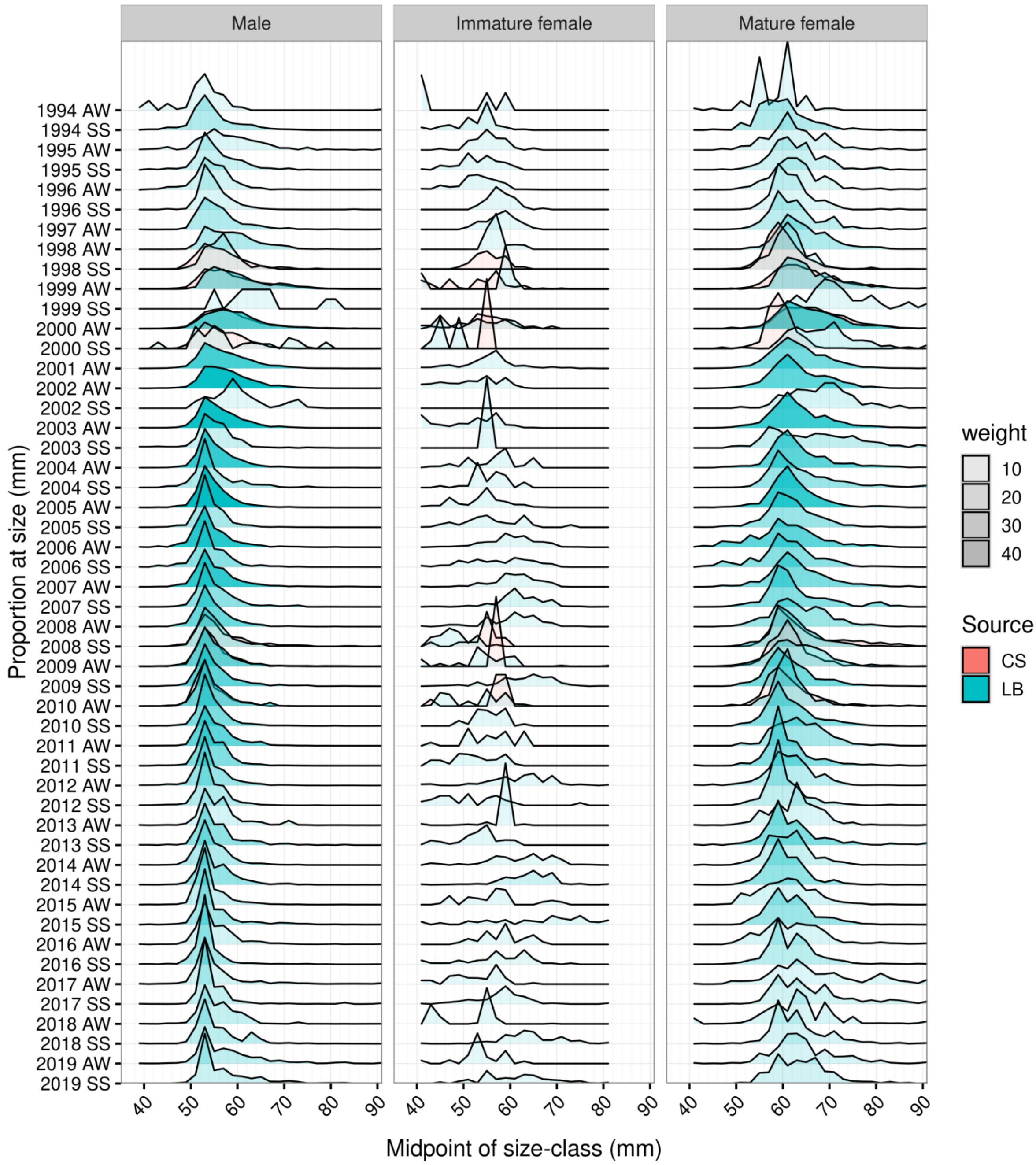

Figure 25: All observed CRA 5 region 2 (916+932+933) length frequency distributions, by sex category, fishing year, and sample source.

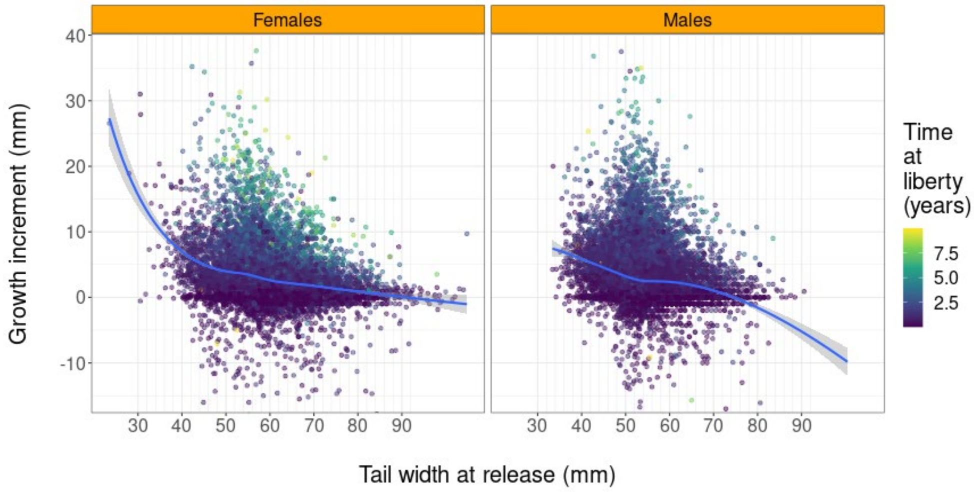

Figure 26: Growth increments (mm) by size at release (mm) and sex for all combined tag recoveries. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

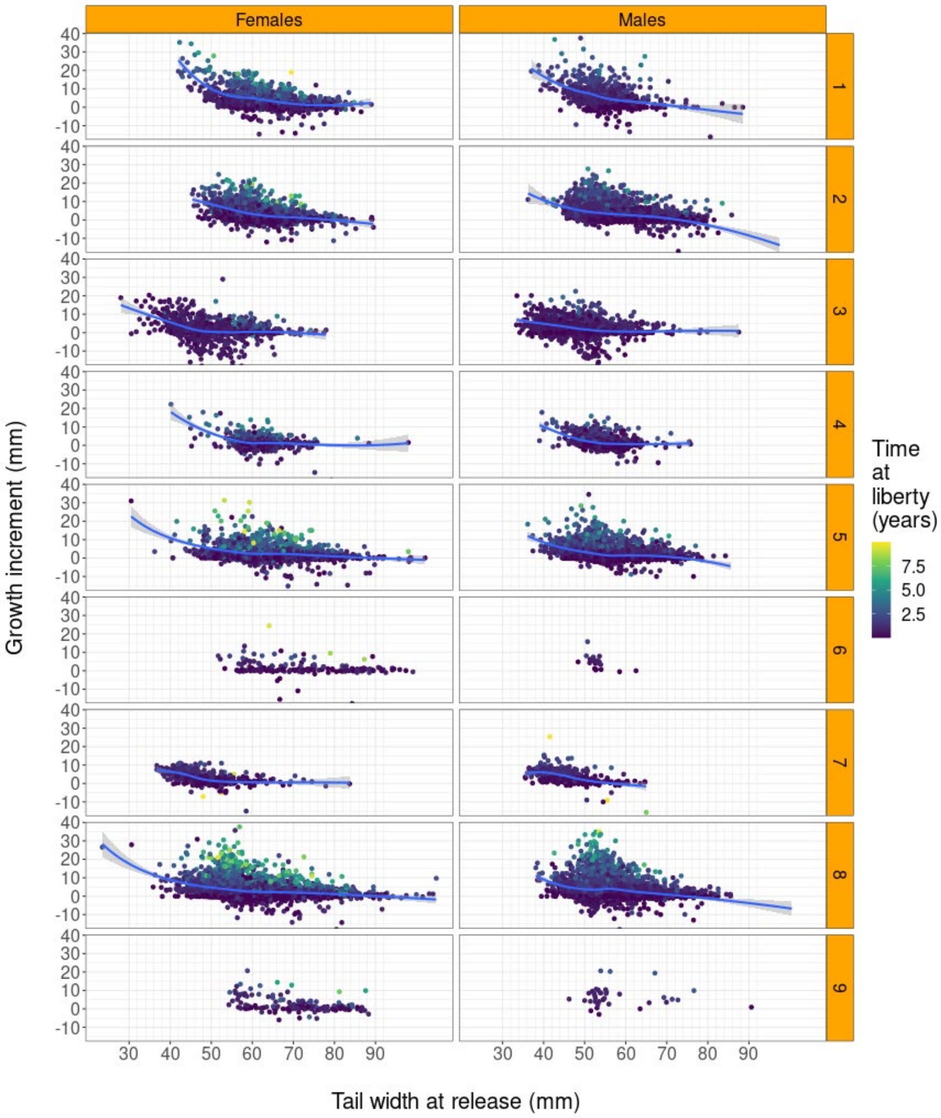

Figure 27: Growth increments (mm) by size at release (mm), sex, and QMA. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

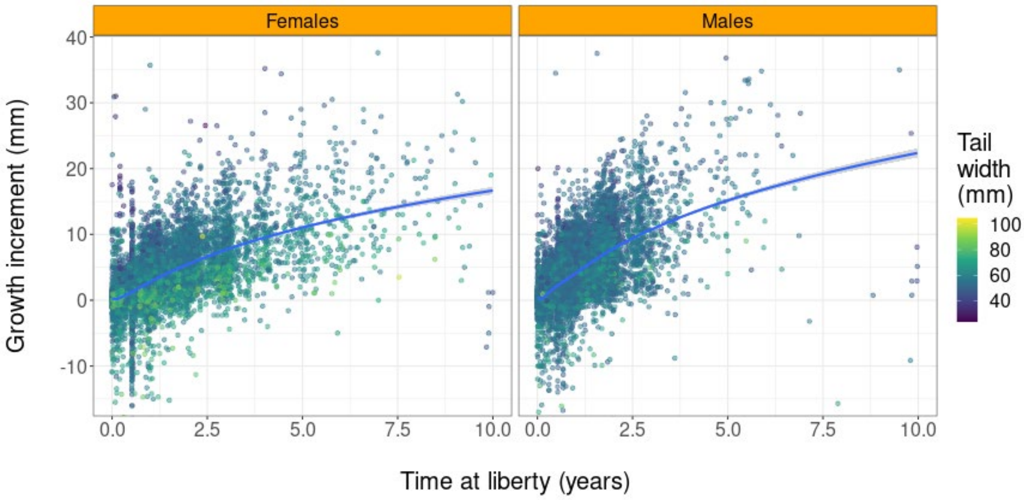

Figure 28: Growth increments (mm) by time at liberty (years) and sex for all combined tag recoveries. The colour of each point represents the size at release (mm). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

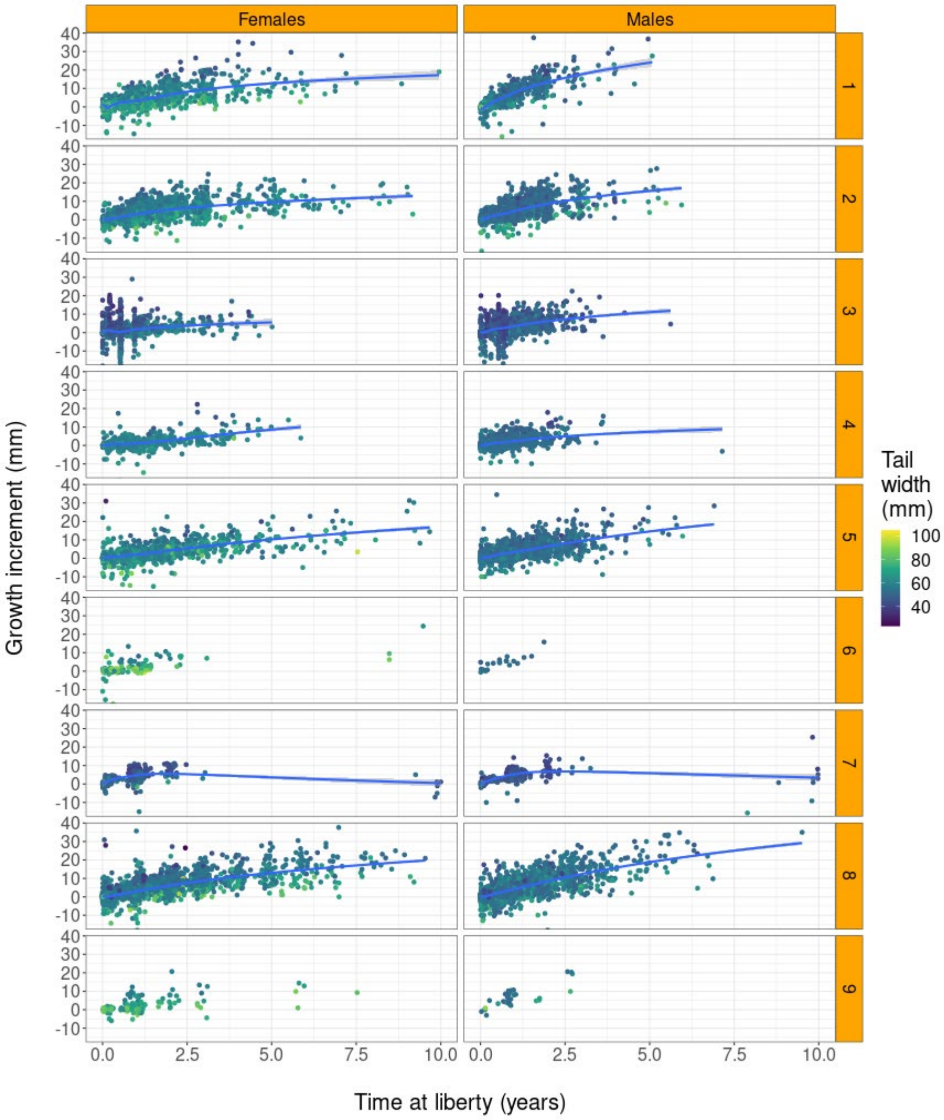

Figure 29: Growth increments (mm) by time at liberty (years), sex, and QMA. The colour of each point represents the size at release (mm). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

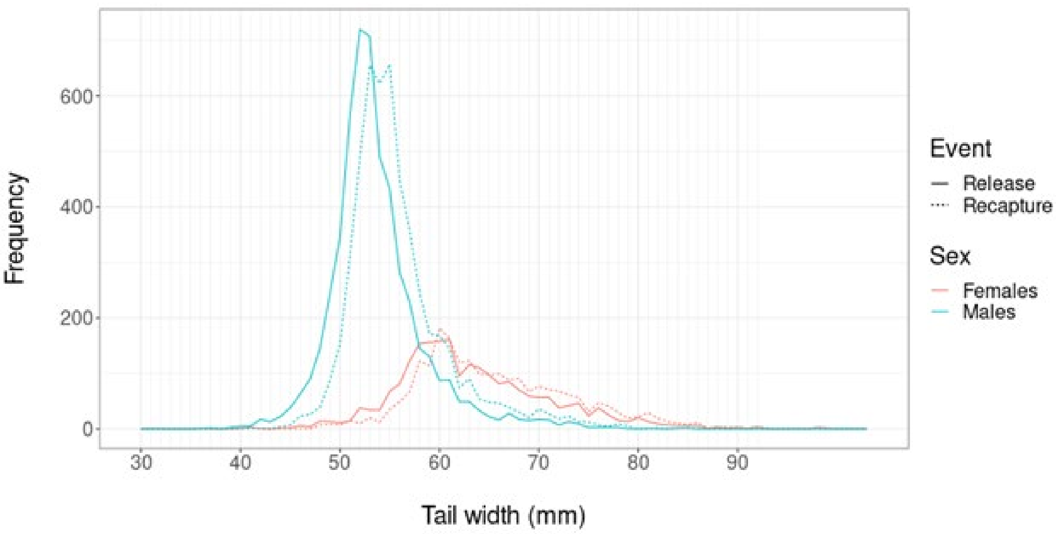

Figure 30: CRA 5 frequency polygons of size at release (solid lines) and recapture (dashed lines) by sex. A bin width of 1 mm was used.

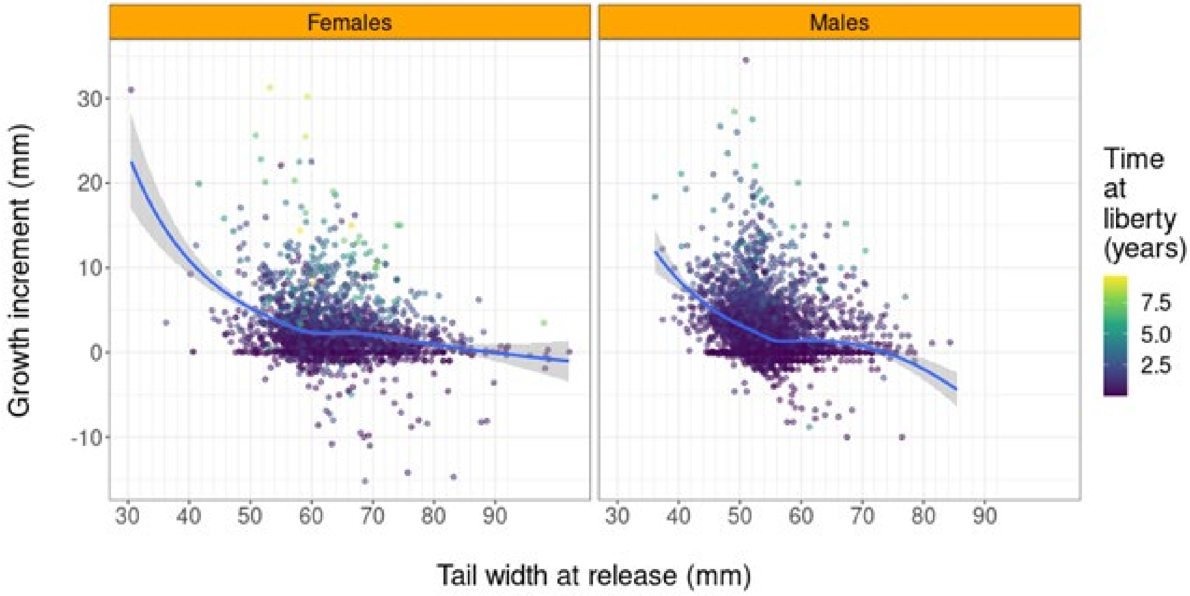

Figure 31: Growth increments (mm) by size at release (mm) and sex for all tags included in the CRA 5 stock assessment. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

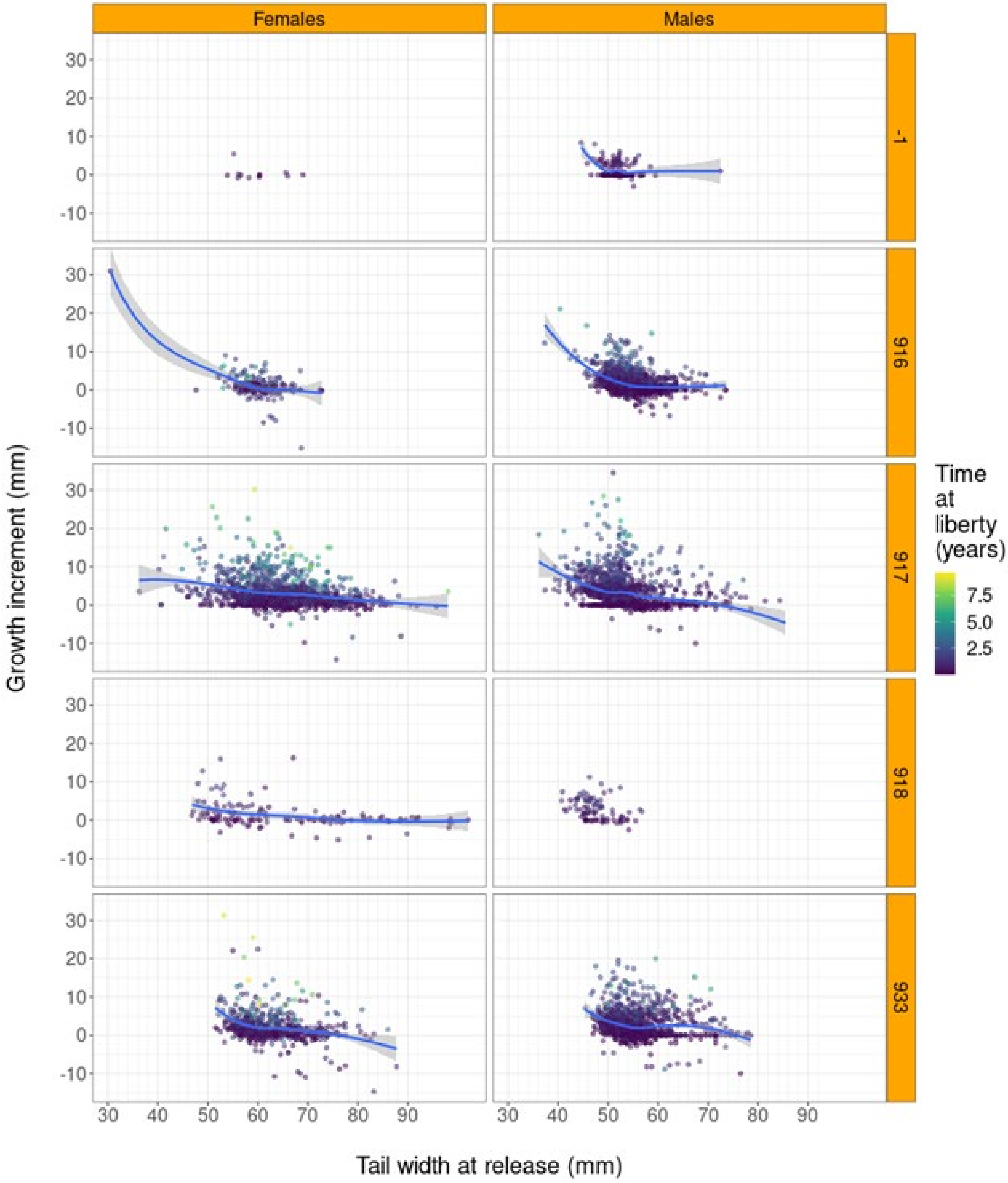

Figure 32: CRA 5 growth increments (mm) by size at release (mm) and sex in each statistical area. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval (grey shading) about this smoother is also shown.

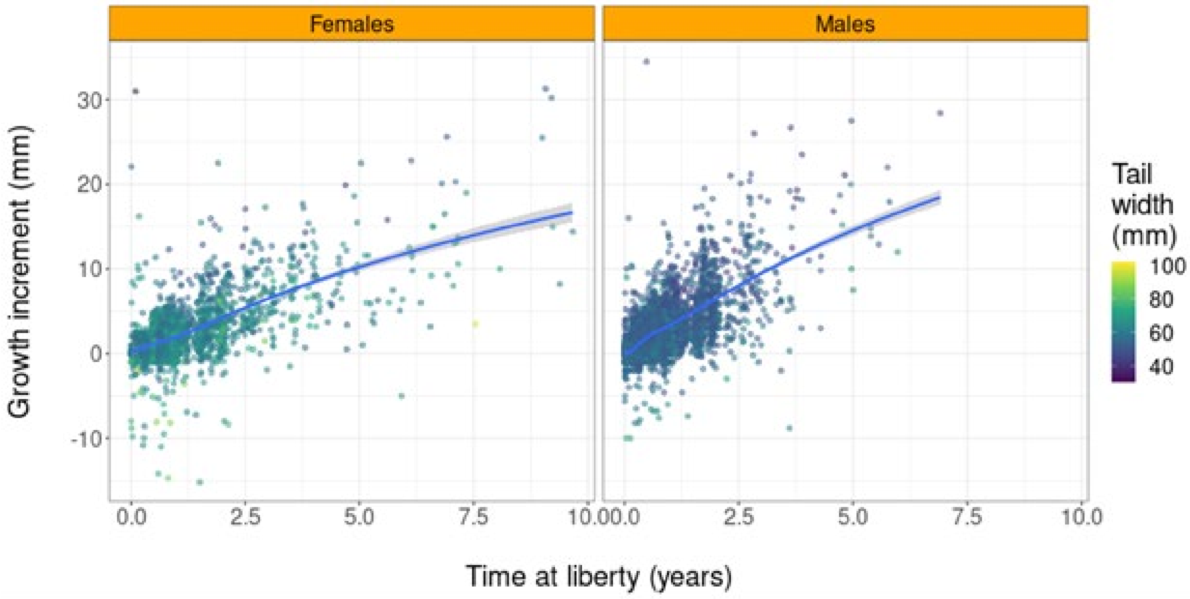

Figure 33: CRA 5 growth increments (mm) by time at liberty (years) and sex for all tags included in the stock assessment. The colour of each point represents the tail width (mm). A loess (blue line) and the 95% confidence interval (grey shading) about this smoother is also shown.

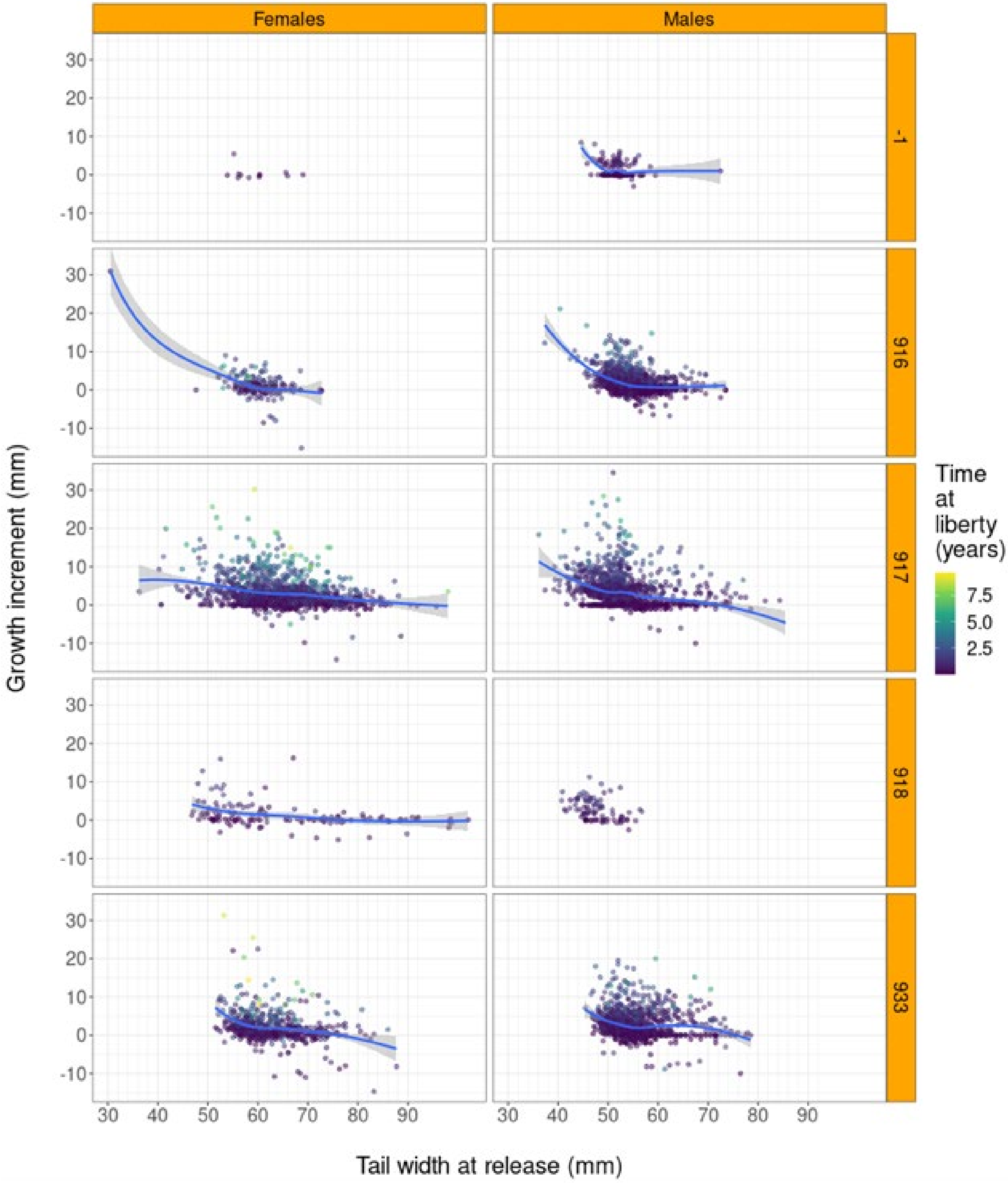

Figure 34: CRA 5 growth increments (mm) by time at liberty (years) and sex in each statistical area. The colour of each point represents the tail width (mm). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

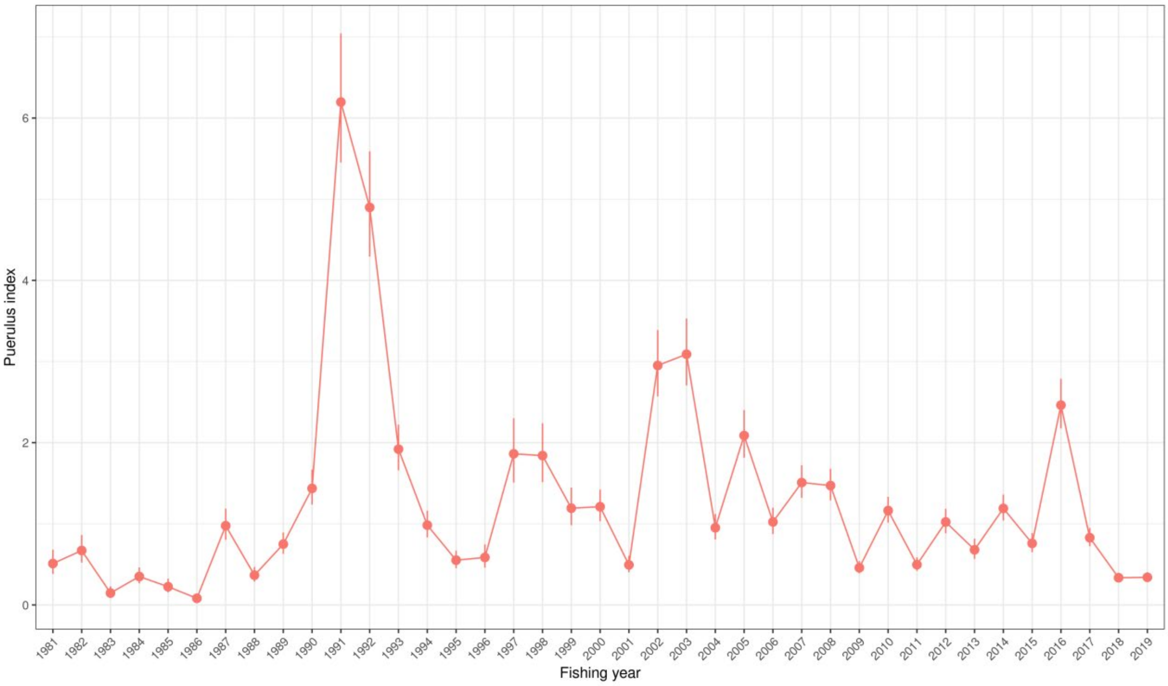

Figure 35: CRA 5: Kaikoura standardised puerulus settlement index. Error bars are 95% confidence intervals (Forman et al. 2021).

APPENDIX A: REQUEST TO FISHERIES NEW ZEALAND FOR NON-COMMERCIAL CATCH ESTIMATES

NZ ROCK LOBSTER INDUSTRY COUNCIL

Ka whakapai te kai o te moana

PRIVATE BAG 24-901 WELLINGTON 6142
64 4 385 4005 PHONE
64 4 385 2727 FAX
lobster@seafood.co.nz

20th July 2020

Alicia McKinnon, Ministry for Primary Industries

by email: *Alicia.McKinnon@mpi.govt.nz*

cc
Dr Leyla Knittweis – Chair RLFAWG
By email: *Leyla.Knittweis@mpi.govt.nz>*

Dr. Marine Pomarède, RLFAWG
by email: *Marine.Pomarede@mpi.govt.nz*

cc ECs: *jimoroberts@gmail.com*
paul@starrfish.net
darcy@quantifish.co.nz
merrillrudd@gmail.com
pons.maite@gmail.com

Dear Alicia

Under Objectives 4 and 5 of MPI contract CRA 2018/01, the stock assessment team will be conducting CRA 5 and CRA 5 stock assessments in September and October of this year.

The stock assessment team has access to data on current and historical commercial catches. However, there are limited data on the non-commercial catch components, which are customary, illegal and recreational catches. The team has limited access to customary or illegal catch information.

In the past, MPI's predecessor (MFish) provided estimates of illegal catches, but these were highly uncertain and, since 2004, only estimates in response to requests for the stock(s) being assessed in each year have been made available.

The stock assessment cannot ignore the current and historical non-commercial catches because doing so would cause stock productivity to be underestimated. In the absence of information, MPI must lead the process for choosing what to assume for these components; it is up to MPI to specify the non-commercial catch assumptions that MPI wishes to be used in the stock assessment.

It is likely that the RLFAWG will request sensitivity analyses on catch series that are alternatives to the base case non-commercial catch vectors, but the responsibility for providing the base case non-commercial mortalities lies with MPI.

For **illegal catches**, the assessment team needs to know:

- **the MPI estimates of current and recent CRA 5 and CRA 5 illegal catches and each historical trend**

To assign illegal catch to the appropriate catch components in the stock assessment model, the stock assessment team needs to know:

- **the proportions by year of the estimated illegal catches that were eventually reported to the QMS**

Otherwise, if commercial fishermen report scrubbed females or other illegal fish that are already part of the illegal catch estimate, then that catch will have been double-counted. The assessment team also request:

- **an appreciation of the uncertainty in the MPI illegal catch estimates.**

For **customary catch**, the requirement is similar: the assessment team requests that MPI provide:

- **estimates of the current customary catch in CRA 5 and CRA 5 and each historical trend**

The assessment team also request:

- **an appreciation of the uncertainty in the MPI customary catch estimates.**

For **recreational catch**, the requirements are similar: the assessment team requests that MPI provide:

- **estimates of the current recreational catch in CRA 5 and CRA 5 and each historical trend**

The assessment team also request:

- **an appreciation of the uncertainty in the MPI recreational catch estimates**

Without these estimates from MPI, it will not be possible to produce acceptable stock assessments. These MPI estimates of non-commercial catches are required by:

- **14th August 2020**

Can you please confirm your understanding of this written request? To assist the task, I will be happy to answer any questions you may have.

Sincerely,

Daryl R Sykes

Daryl Sykes

Research Programme Manager
NZ Rock Lobster Industry Council Ltd

APPENDIX B: FISHERIES NEW ZELAND RESPONSE TO NON-COMMERCIAL DATA REQUEST

Email correspondence from Fisheries New Zealand

From: Alicia McKinnon
Sent: Monday, 20 July 2020
To: Daryl Sykes
Cc: Darcy Webber, Leyla Knittweis, Marine Pomarede, Martin Cryer, Sonja Hempel
Subject: CRA4 and CRA5 non-commercial harvest estimates

Dear Daryl

This email provides guidance on the approach we propose for generating customary, illegal, and recreational take trajectories for the CRA 5 and CRA 5 stock assessments this year.

If you happen to have any questions or have ideas on alternate approaches, we're more than happy to discuss.

Customary harvest estimates
A summary of the information Fisheries New Zealand holds on CRA 5 and CRA 5 customary harvest since the 2007/08 April fishing year is provided in the attached excel file. This includes information provided under the Fisheries (Kaimoana) Regulations 1998, and the Fisheries (Amateur Fishing) Regulations 2013 (previously Regulation 27A of the Fisheries (Amateur Fishing) Regulations 1986).

Based on the customary harvest information available, noting its incompleteness and uncertainty, we consider it appropriate to continue to use a 20 tonne constant customary catch estimate for CRA 5 and a 10 tonne constant estimate for CRA 5.

Illegal take estimates
Because of the lack of robust illegal take estimates, we propose that a similar approach is taken for CRA 5 and CRA 5 this year as per CRA 1 and CRA 3 last year. This includes:

- Not using the historical estimates of illegal take, as provided by Compliance
- Using the 'export-discrepancy' methodology to generate early estimates of illegal take (i.e. up to 1980)
- Using a fixed percentage of the summed total commercial catch from 1981 to 2019 to represent illegal take, and explore scaling the catch total proportionately to annual commercial CPUE. The fixed percentages that we propose exploring for each stock are 5%, 10% and 15%.

Recreational harvest estimates
Available estimates of recreational rock lobster harvest for each stock are presented in the November Fisheries Assessment Plenary. All estimates are presented there, but the harvest estimates provided by the 2000 and 2001 telephone-diary surveys are no longer considered reliable by the MPI Marine Amateur Fisheries Working Group and should not be used (they are implausibly high for many species). The most recent harvest estimates are from the 2017/18 National Panel Survey (NPS) – Table 57 from FAR2019-24 is duplicated below. Harvest is given in numbers of lobsters and tonnes.

For CRA4 and CRA5, we propose that a scaling parameter between the available survey estimates and commercial CPUE is explored to create a recreational catch vector, like has been done recently for CRA1 and CRA3.

For CRA5 this includes the use of the 80 tonne 2011/12 estimate previously specified by Fisheries NZ. We also suggest considering whether it is feasible to use the results from Kaikoura/Motunau ramp-based surveys to index harvest in years between National Panel Surveys.

We also encourage the Rock Lobster Fisheries Assessment Working Group to consider different sensitivities, including double or half recreational catch.

Estimates of the mean weights of lobsters taken by recreational fishers are available – see Table 7 below from FAR2019-25 (noting some of this information for pot-caught lobsters comes from commercial catches). There will also be recreational length frequency data available for CRA 5 and CRA 5 from the mean weights programme. This may be useful for estimating selectivity of recreational divers (which seems different from pots) if the stock assessment team can/decide to separate this out in the models.

Table 57: Lobster/crayfish harvest by fishstock.

QMA.CRA	Fishers (n)	Events (n)	Harvest (n)	CV	Mean Weight (kg)	Harvest (tonnes)	CV
1	34	65	19 350	0.47	0.82	15.91	0.47
2	33	79	19 123	0.35	0.74	14.21	0.36
3	30	90	22 515	0.26	0.54	12.21	0.26
4	72	195	52 145	0.21	0.79	41.38	0.23
5	61	265	51 464	0.21	0.80	40.96	0.21
7	1	1	82	1.00	1.12	0.09	1.00
8	25	62	24 732	0.36	0.65	16.17	0.36
9	22	62	20 034	0.34	0.85	17.07	0.34
TOTAL	261	819	209 446	0.11	0.75	158.00	0.11

Table 7: Mean weight estimates (g) for rock lobster by QMA, by diver and by pot caught fish. Best estimates are boxed.

	Summer			Winter			All year			Seasonal	Best
	Estimate (g)	SE	n	Estimate (g)	SE	n	Estimate (g)	SE	n	difference	estimate
CRA 1 (diver)	851	34.0	162	755	36.2	70	822	26.3	232	–	Annual
CRA 2 (diver)	747	20.3	229	795	35.9	44	754	18.0	273	–	Annual
CRA 3 (diver)	563	13.6	50	597	29.8	12	570	97.5	62	–	Annual ##
CRA 4 (diver)	961	71.9	70	1 169	354.0	6	977	71.3	76	–	Annual
CRA 5 (diver)	945	24.1	344	1 203	66.1	39	971.0	23.0	383	***	Seasonal
CRA 7 (diver)	1125	107.9	25	–	–	–	1 125	107.9	25	–	Annual
CRA 8 (diver)	No creel data available						654	–	6 921	–	Annual #
CRA 9 (diver)	791	55.9	29	1 478	251.1	9	852	–	268	*	Annual #
CRA 1 (pot)	–	–	–	871	–	1	817	–	2 091	–	Annual #
CRA 2 (pot)	704	49.4	18	662	59.8	6	588	–	2 285	–	Annual #
CRA 3 (pot)	553	33.4	18	–	–	–	531	–	2 716	–	Annual #
CRA 4 (pot)	614	34.6	34	1 116	427.7	2	502	–	8 858	–	Annual #
CRA 5 (pot)	595	10.6	241	678	24.8	83	616	10.3	324	**	Seasonal
CRA 7 (pot)	No creel data available			–	–	–	657	–	1 471	–	Annual #
CRA 8 (pot)	No creel data available						654	–	6 921	–	Annual #
CRA 9 (pot)	758	65.8	13	951	34.0	6	852	–	268	*	Annual #

\# based on commercial observer and logbook data - see Appendix 1

\## data from 2016–17 and 2017–18 combined

Kind regards
Alicia

Alicia McKinnon | Senior Fisheries Analyst
Fisheries Management | Fisheries New Zealand – Tini a Tangaroa
Ministry for Primary Industries | 21 Domett Street, Ahuriri | P O Box 12034 | Napier

APPENDIX C: EVIDENCE FOR REGIONAL SEPARATION IN CRA 5

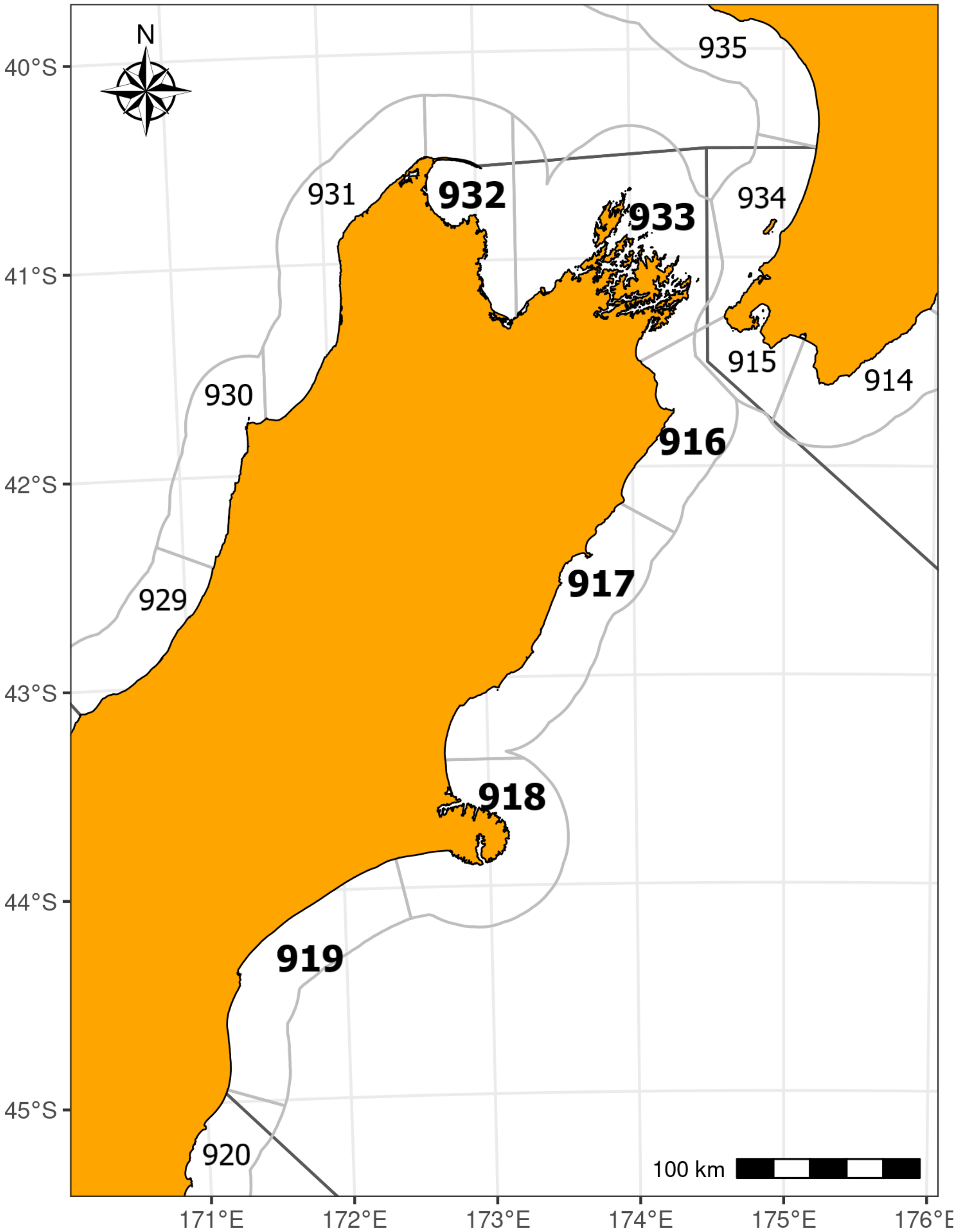

Figure C.1: Locations of the post-1978 rock lobster statistical areas inside CRA 5 and contiguous with CRA 5. QMA boundaries are shown with heavy black lines and the statistical area boundaries have thinner grey lines. CRA 5 statistical areas are shown in large bold fonts and non-CRA 5 statistical areas are shown in smaller fonts.

C.1 COMPARISON OF STANDARDISED CPUE SERIES

The standardisation procedure described in section 4 can be applied to individual statistical areas or to combinations of statistical areas. Plots showing the posterior median and 90% credibility intervals for each region defined for Model 1 in Table C.1 are difficult to compare. Consequently, the posterior median for each region in Model 1 has been overlaid (after transforming to mean=1.0) in Figure C.3, showing that the Marlborough Sounds region (primarily 933) has been declining in both seasons after peaking in the early 2000s. There is also a suggestion of a slight increasing trend in 933 since 2017–18. Region 917+918+919 has shown a gradual increasing trend up to the late 2000s, after which it plateaued. There is a suggestion for this series that the AW indices have been recently decreasing. Statistical area 916 is intermediate between the other two regions, while it more closely resembles region 932+933, but without the upturn in the most recent three to four years (Figure C.3). When statistical area 916 is combined with region 1 (917+918+919), the resulting series changes little with the previous plot (compare red series in Figure C.4 with green series in Figure C.3). Adding statistical area 916 to region 932+933 results in a series that is similar to the series without 916, except it loses the final uptick (Figure C.5.). The catch trajectories for statistical area 916 resemble its CPUE series, particularly in the AW season (Figure C.6).

Model statistics provided in Table C.1 show that while Model 3 had the lowest LOO IC, the differences between the three models are small. This indicates that any one of the three models could be used in the stock assessment model.

Table C.1: Comparison of diagnostic statistics for three standardised CPUE models incorporating different CRA 5 statistical area combinations (Figure C.1).

	Model	Bayesian R^2	LOOIC	SE
1.	{917, 918, 919}, {916}, {932, 933}	0.442	5481.8	236.5
2.	{916, 917, 918, 919}, {932, 933}	0.413	5783.2	236.0
3.	{917, 918, 919}, {916, 932, 933}	0.429	5778.9	235.1

C.2 COMPARISON OF LENGTH FREQUENCY (LF) DISTRIBUTIONS

Comparison of the empirical cumulative length frequency distributions for each sex category across the four main CRA 5 statistical areas and averaged over the period 1999–2019, indicated that statistical area 918 (Banks Peninsula) had much larger males and mature females in both the AW (Figure C.7) and SS (Figure C.8). On the other hand, statistical area 916 consistently had the smallest males and mature females. Statistical areas 933 and 917 were intermediate between these extremes, with 917 larger than 933 in each comparison except AW males, where the two areas were the same.

C.3 COMPARISON OF PROPORTIONS OF MATURE FEMALES

There appears to be a declining trend in the proportion of mature females in the catches in both seasons for statistical area 916, while the mature females in statistical area 917 have been increasing since the late 2000s (Figure C.9). The proportion of mature females in statistical area 933 may also be slightly declining.

C.4 CONCLUSION

The RLFAWG reviewed this information and concluded that the evidence for separating CRA 5 into component regions based on apparent differences between statistical areas is reasonably strong. Statistical areas 916 and 933 show declining trends in CPUE since the early 2000s and both show declines in the proportion of mature females though this is not apparent in 917. There are clear differences in size distributions, with statistical areas 917 and 918 having larger males and mature females than in 916 and 933. The RLFAWG agreed to model CRA 5 using the region definitions presented in Table C.2. It was considered impractical to model three separate regions, given the very small amount of data available for 918.

Table C.2: Region definitions for CRA 5 regions, showing the rock lobster statistical area definitions used (Figure C.1).

Region label	Statistical area definition	Region name
917+918+919	Areas 917 + 918 + 919	Kaikōura/Motunau/Banks Peninsula
916+932+933	Areas 916 + 932 + 933	Cape Campbell/Marlborough Sounds

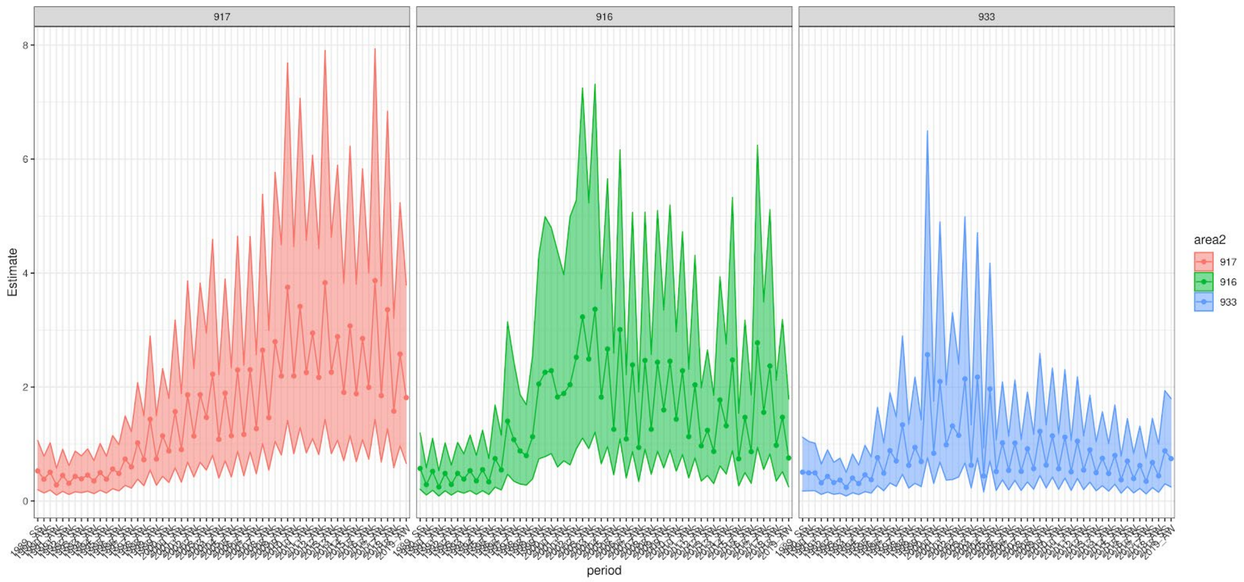

Figure C.2: Seasonal standardised CPUE for Model 1 ({917, 918, 919}, {916}, {932, 933}) in Table C.1. Median posterior estimates connected with solid lines are shown, along with the associated 90% credibility intervals.

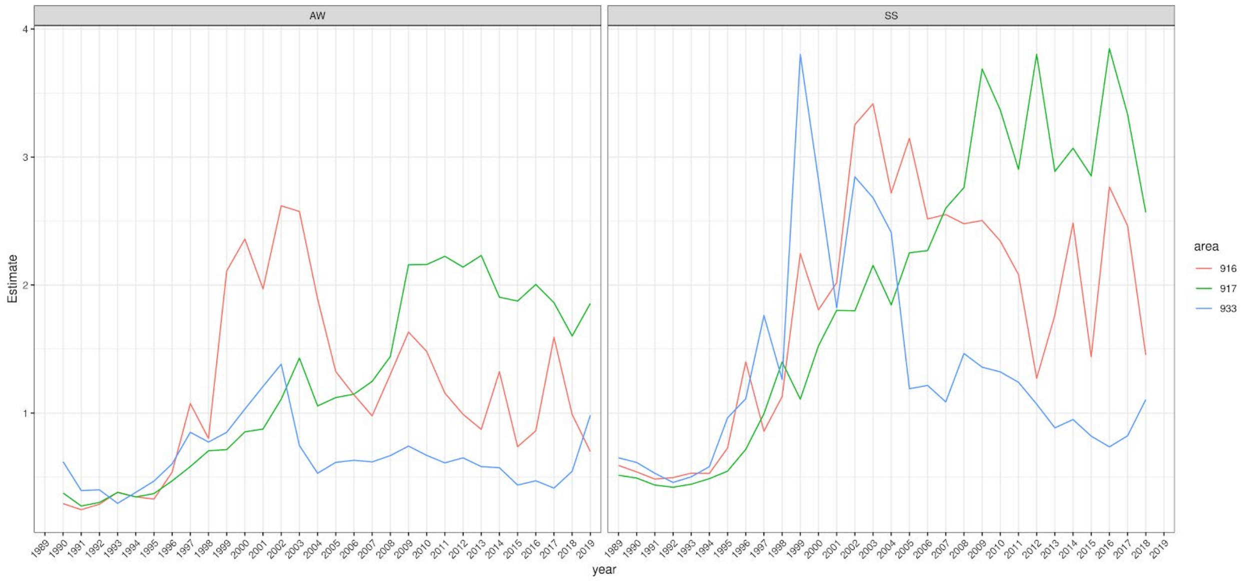

Figure C.3: Median posterior standardised CPUE by season for Model 1 ({917, 918, 919}, {916}, {932, 933}) in Table C.1. Each series has been standardised to a geometric mean = 1.0.

Figure C.4: Median posterior standardised CPUE by season for Model 2 ({916, 917, 918, 919}, {932, 933}) in Table C.1. Each series has been standardised to a geometric mean = 1.0.

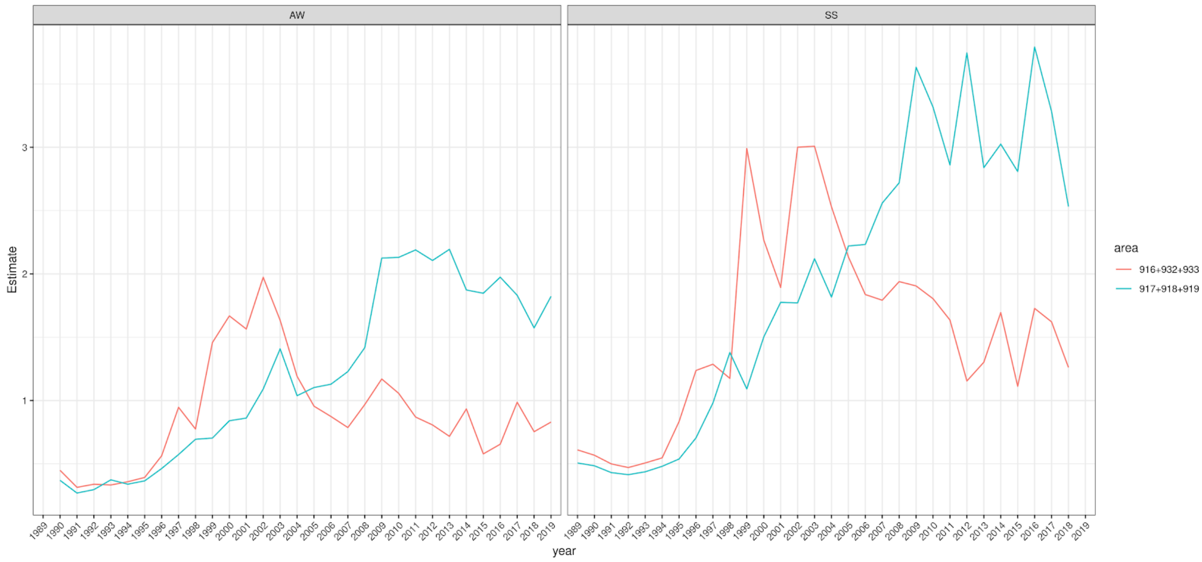

Figure C.5: Median posterior standardised CPUE by season for Model 3 ({917, 918, 919}, {916, 932, 933}) in Table C.1. Each series has been standardised to a geometric mean = 1.0.

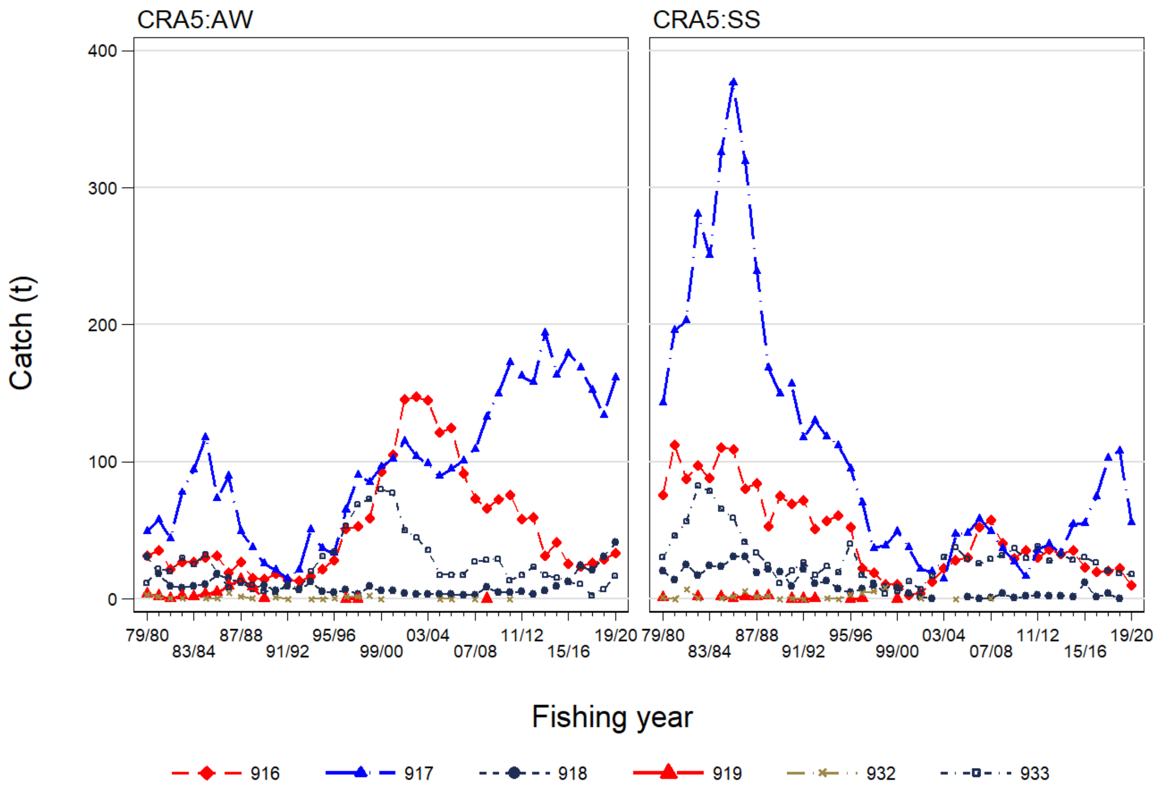

Figure C.6: Seasonal catch trajectories from 1979 to 2019 for each of the six CRA 5 statistical areas.

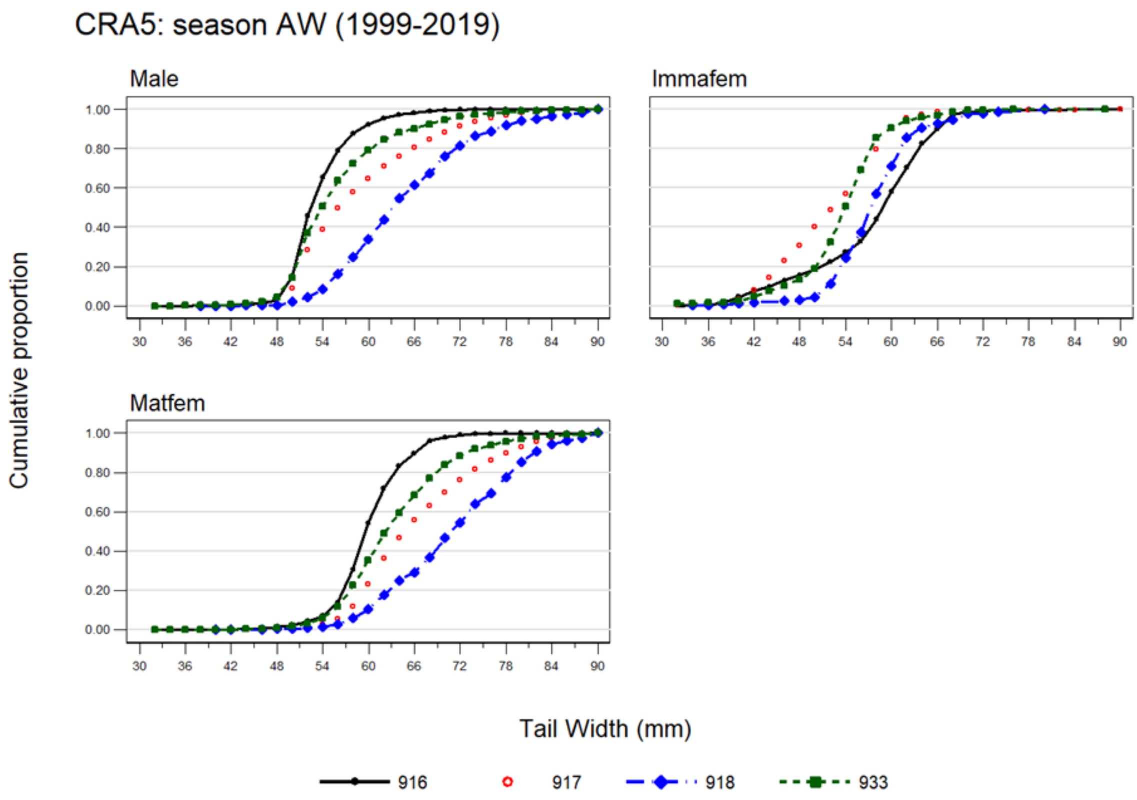

Figure C.7: Mean (1999-2019) empirical cumulative LF distribution by sex category for the four main CRA 5 statistical areas in the AW season.

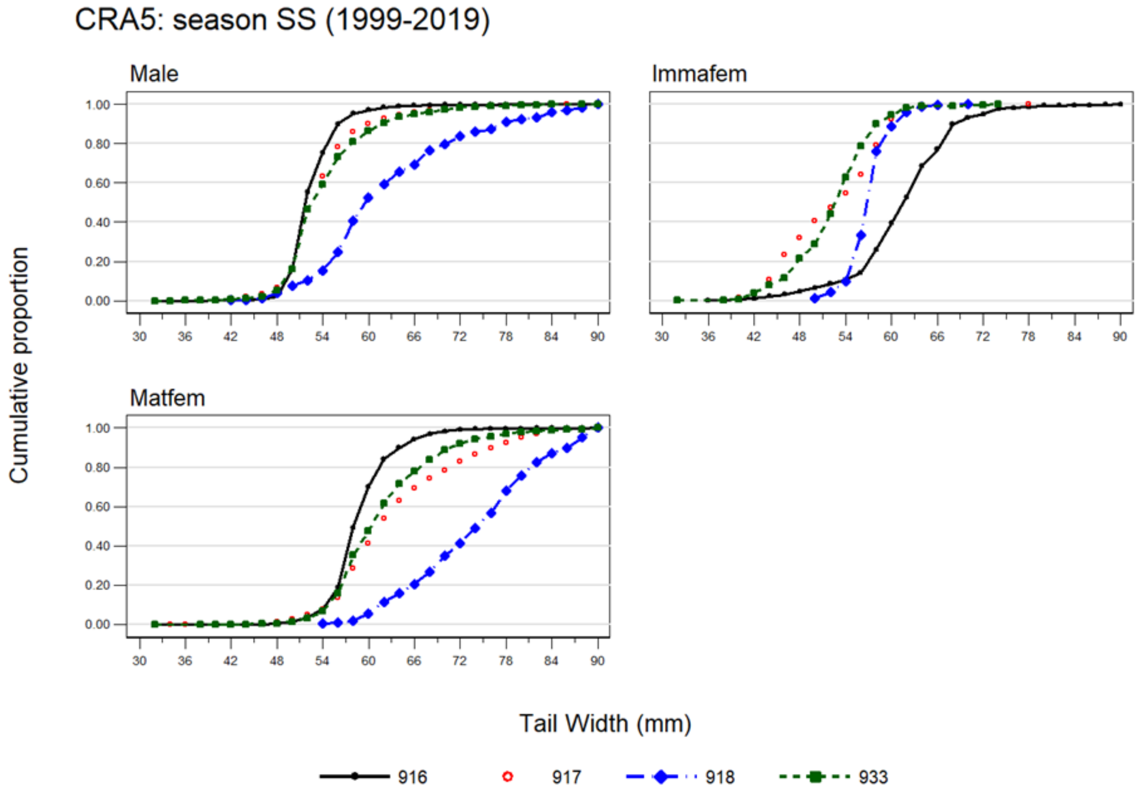

Figure C.8: Mean (1999-2019) empirical cumulative LF distribution by sex category for the four main CRA 5 statistical areas in the SS season.

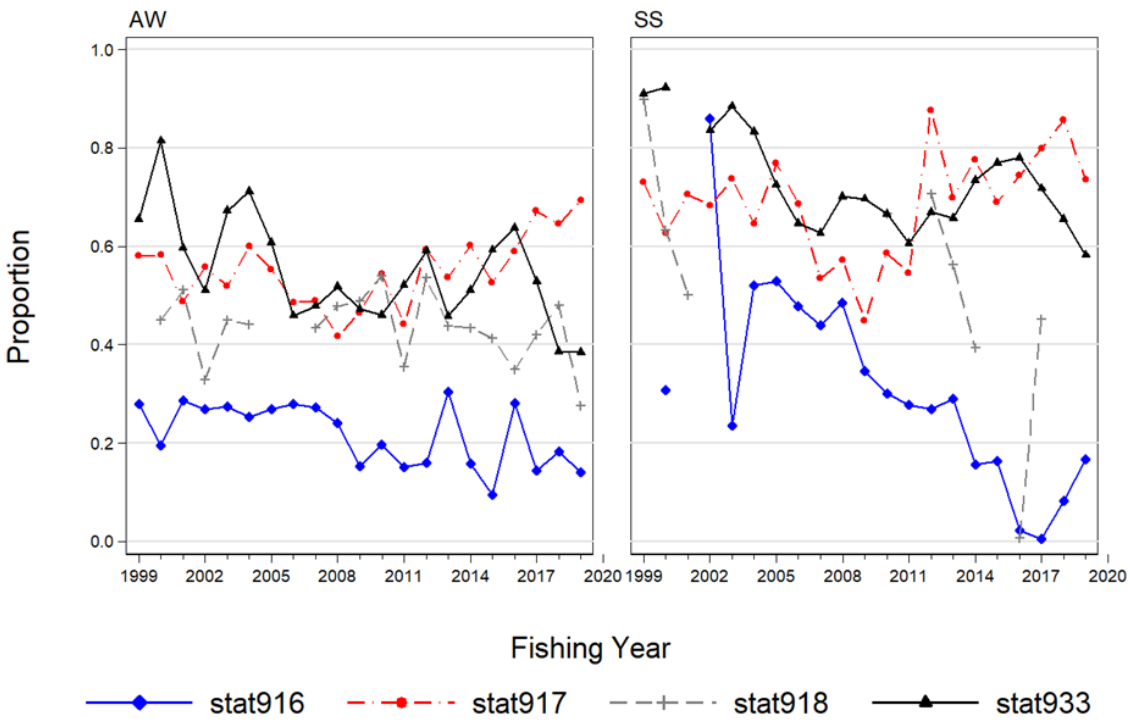

Figure C.9: Plot of proportion mature females in the catch for each of the four main CRA 5 statistical areas from 1997–2019.

APPENDIX D: COMPARISON OF LENGTH FREQUENCY DISTRIBUTIONS USING F0_LFX AND F2_LFX CATCH WEIGHTING

The preparation of the length frequency (LF) data requires weighting by catch between statistical areas and months (see Eq. 4 in section 5). The RLFAWG agreed in 2013 to use catch data based on the F0_LFX catch expansion algorithm (see appendix D of Starr 2021). This decision was based on an unpublished comparison of LFs prepared using three different algorithms, the F0_LFX, F2_LFX, and B4_LFX, which found no appreciable differences among the resulting distributions. The F0_LFX distribution was chosen because, unlike the other two algorithms, no catch data are dropped.

Given the problems described in section 1 with the transition from paper forms to electronic reporting (also see appendix B of Starr 2021), the 2013 comparison was repeated for the 2019–20 fishing year using the F0_LFX and the F2_LFX algorithms. Note that the F0_LFX algorithm retains all data, regardless of the *vcf* value while the F2_LFX algorithm only accepts catch associated with a vessel having a *vcf* between 0.8 and 1.2. As defined in appendix E of Starr (2021), *vcf* is the ratio of the total annual estimated catch divided by the annual landings for that vessel. Because the *vcf* is defined annually, this quantity combined all CELR and ER returns in 2019–20 for a vessel.

Plots comparing the empirical cumulative LF distributions prepared using catch weights derived from the two catch correction algorithms were prepared by QMA, sex category, season, and catch sampling programme:

Sex category	Sampling programme	Figure number
male	logbook	Figure D.1
immature female	logbook	Figure D.2
mature female	logbook	Figure D.3
male	observer catch sampling	Figure D.4
immature female	observer catch sampling	Figure D.5
mature female	observer catch sampling	Figure D.6

These plots show that there is no difference between the resulting LF distributions in the majority of comparisons (61 of the 71 available pairs). There are some exceptions, particularly in the immature females for which there tend to be less data. Only in CRA 3/immature females (Figure D.5) there is a strong difference between the distributions generated by the two catch algorithms while the remaining nine divergent plots are reasonably close. The RLFAWG agreed to proceed with LFs prepared using catch data from the F0_LFX algorithm for this stock assessment.

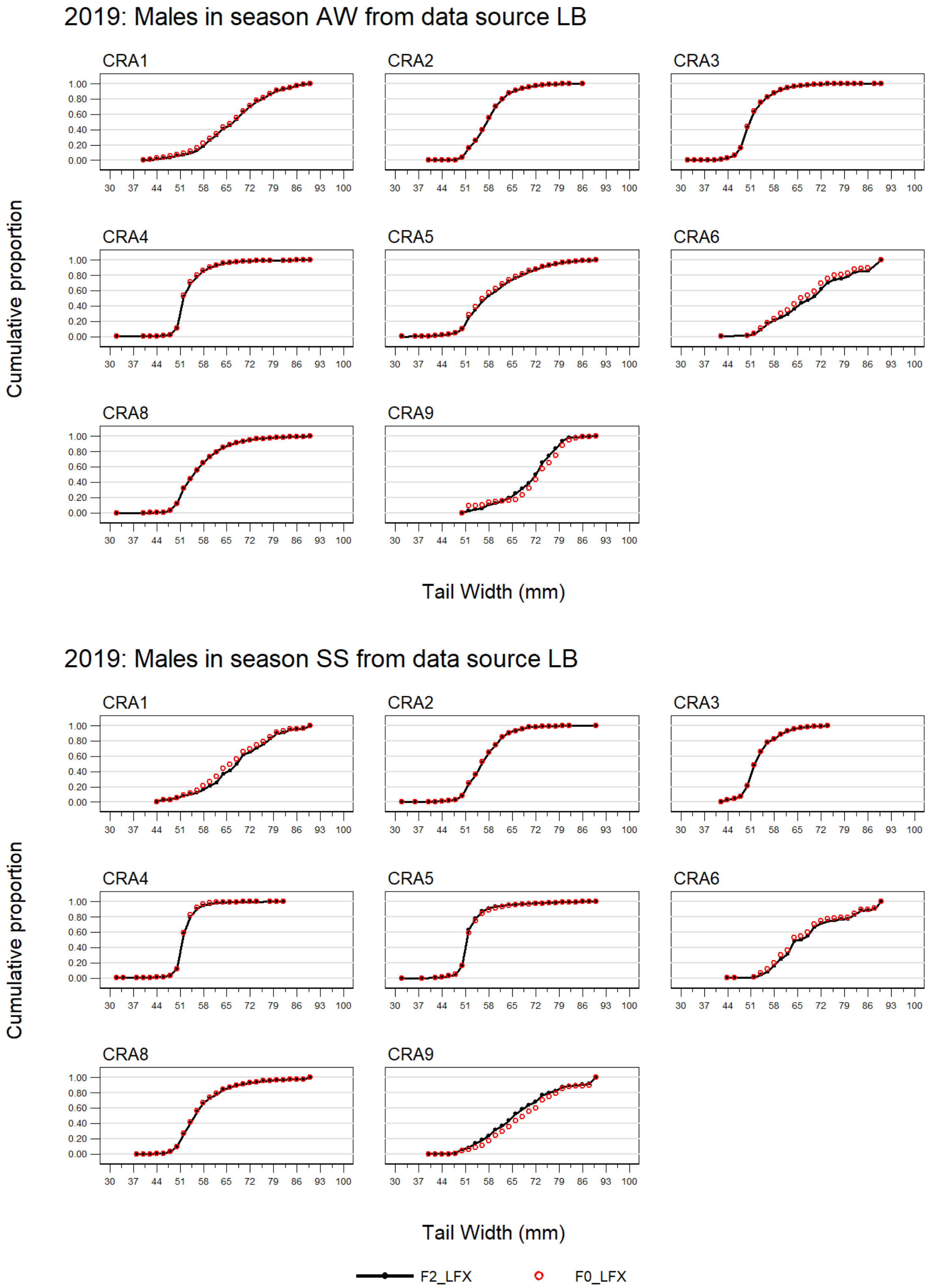

Figure D.1: Comparison of two 2019–20 empirical cumulative length frequency distributions by QMA for males sampled by the respective logbook programmes in the AW (top) and SS (bottom) seasons. The catches used to weight these distributions (Eq. 4) were generated using either F0_LFX or the F2_LFX catch correction algorithms.

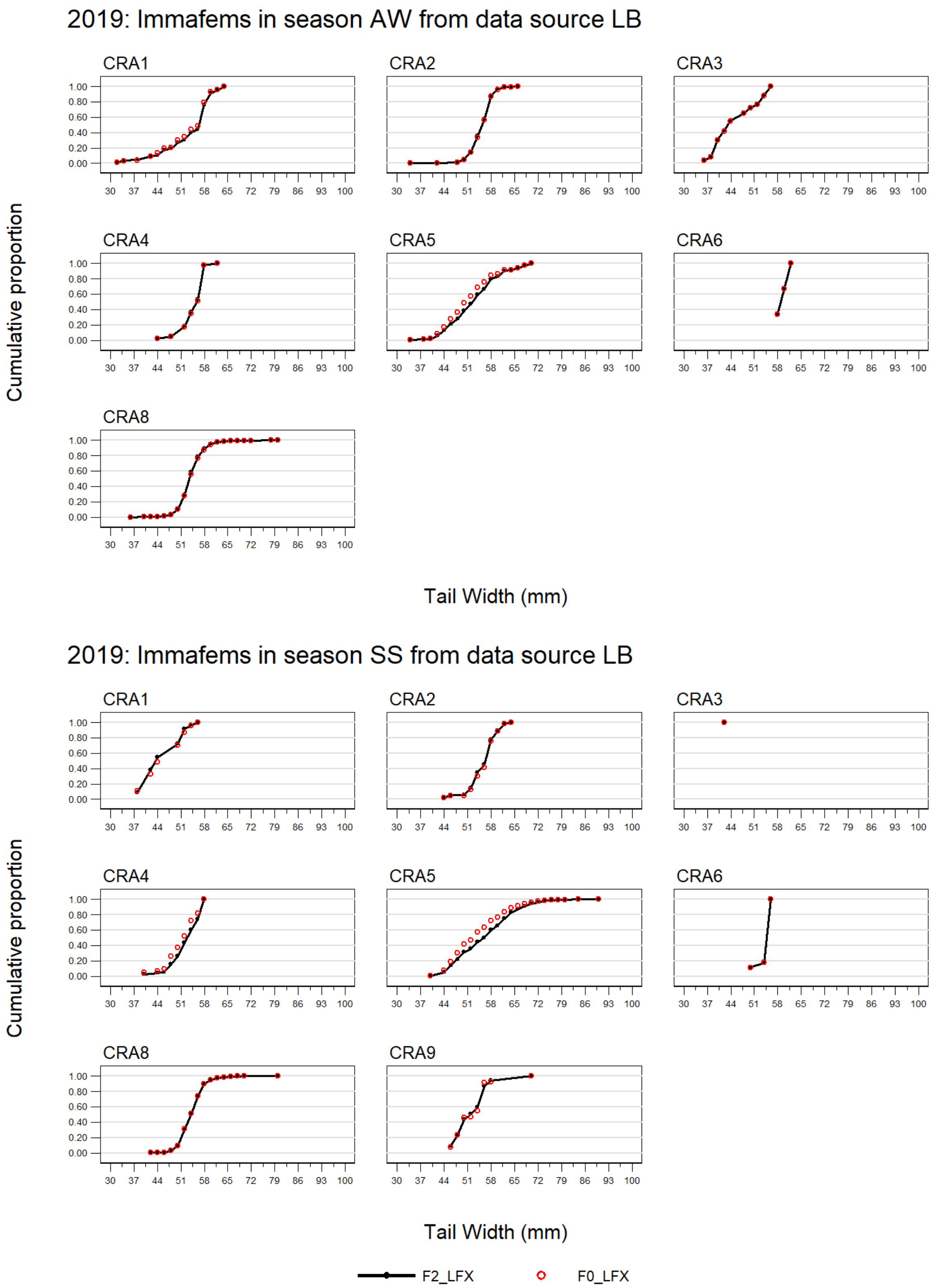

Figure D.2: Comparison of two 2019–20 empirical cumulative length frequency distributions by QMA for immature females sampled by the respective logbook programmes in the AW (top) and SS (bottom) seasons. The catches used to weight these distributions (Eq. 4) were generated using either F0_LFX or the F2_LFX catch correction algorithms.

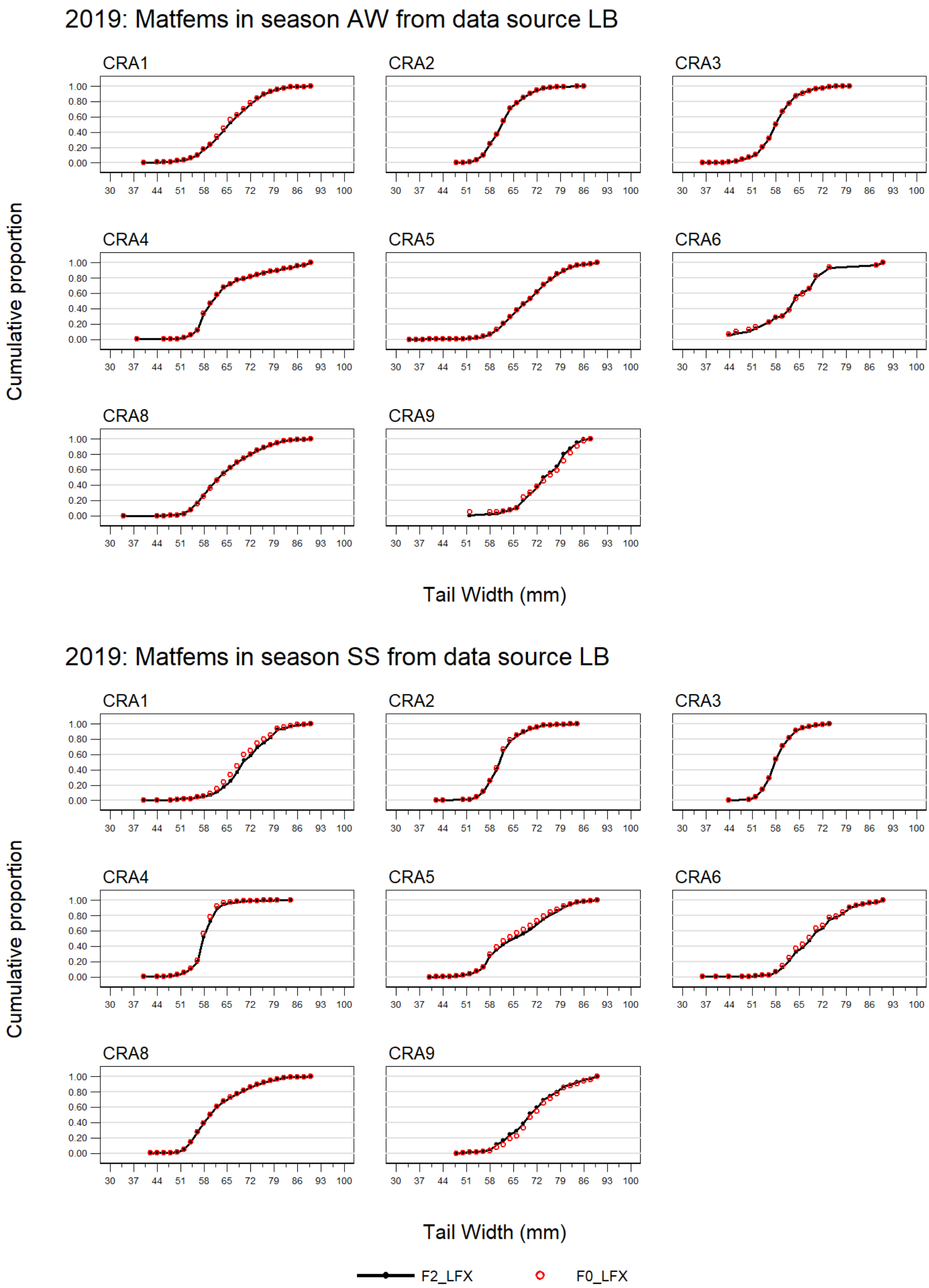

Figure D.3: Comparison of two 2019–20 empirical cumulative length frequency distributions by QMA for mature females sampled by the respective logbook programmes in the AW (top) and SS (bottom) seasons. The catches used to weight these distributions (Eq. 4) were generated using either F0_LFX or the F2_LFX catch correction algorithms.

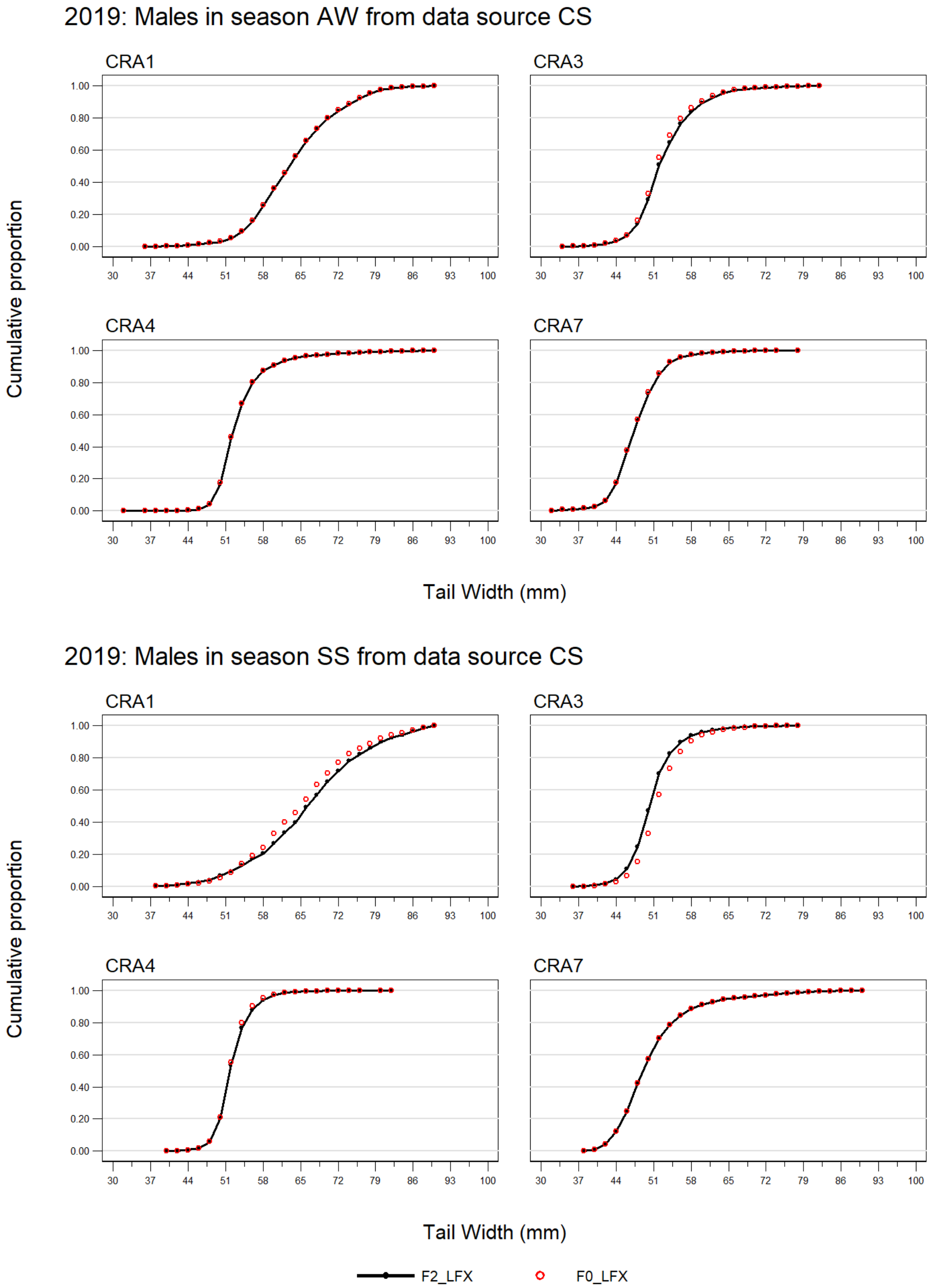

Figure D.4: Comparison of two 2019–20 empirical cumulative length frequency distributions by QMA for males sampled by the respective observer catch sampling programmes in the AW (top) and SS (bottom) seasons. The catches used to weight these distributions (Eq. 4) were generated using either F0_LFX or the F2_LFX catch correction algorithms.

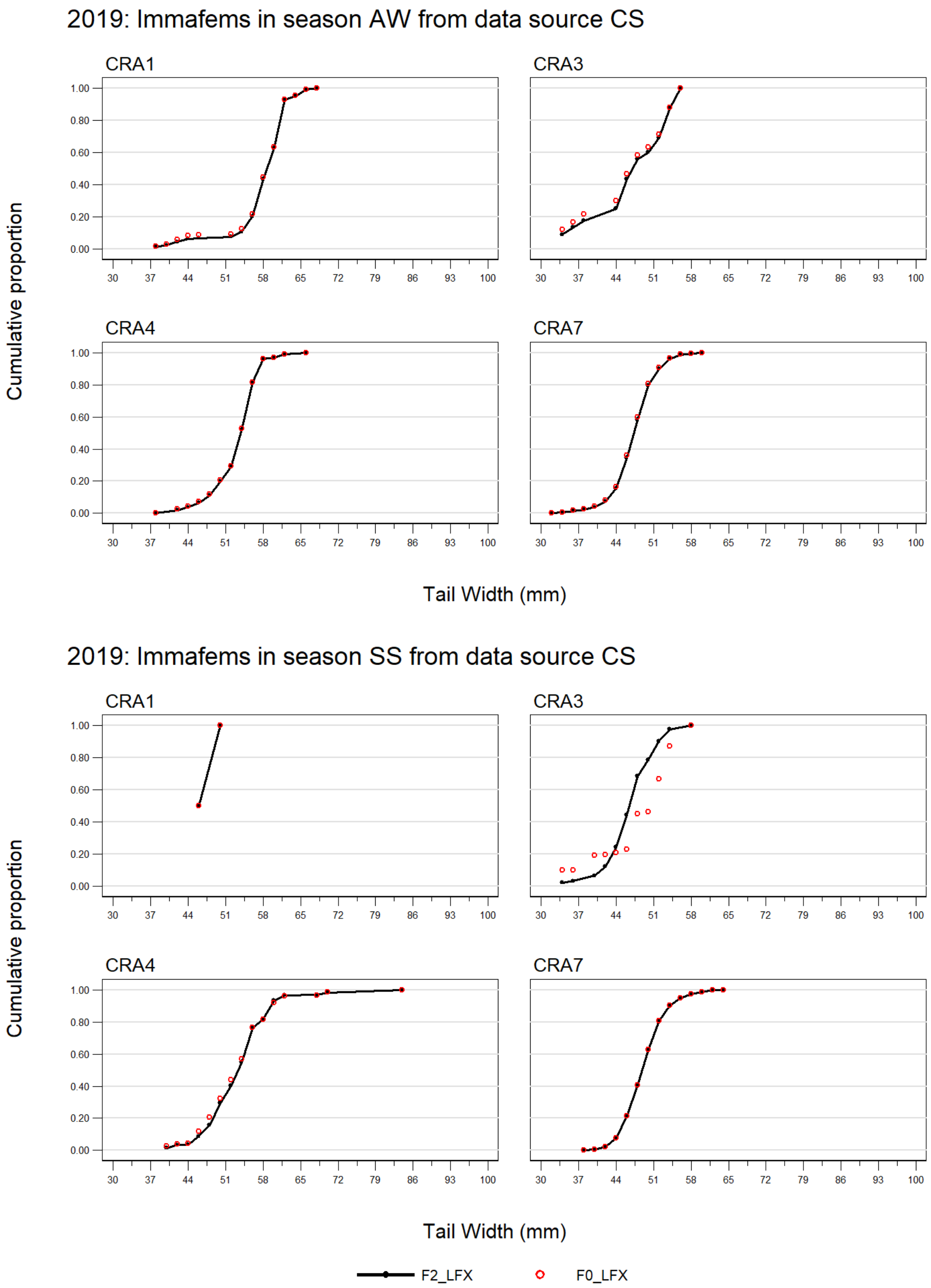

Figure D.5: Comparison of two 2019–20 empirical cumulative length frequency distributions by QMA for immature females sampled by the respective observer catch sampling programmes in the AW (top) and SS (bottom) seasons. The catches used to weight these distributions (Eq. 4) were generated using either F0_LFX or the F2_LFX catch correction algorithms.

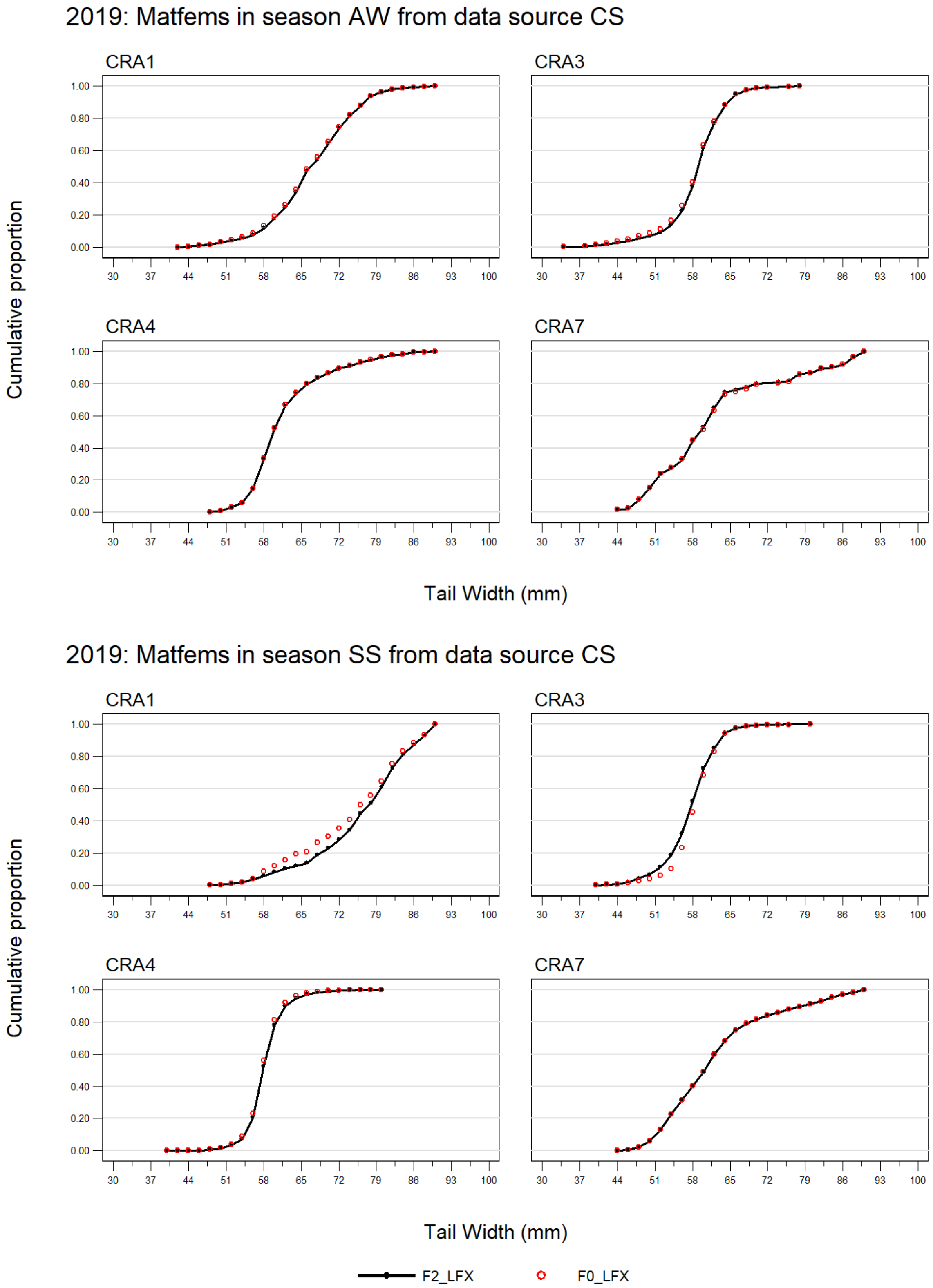

Figure D.6: Comparison of two 2019–20 empirical cumulative length frequency distributions by QMA for mature females sampled by the respective observer catch sampling programmes in the AW (top) and SS (bottom) seasons. The catches used to weight these distributions (Eq. 4) were generated using either F0_LFX or the F2_LFX catch correction algorithms.

APPENDIX E: LENGTH FREQUENCY DISTRIBUTIONS FROM LOGBOOK AND CATCH SAMPLING

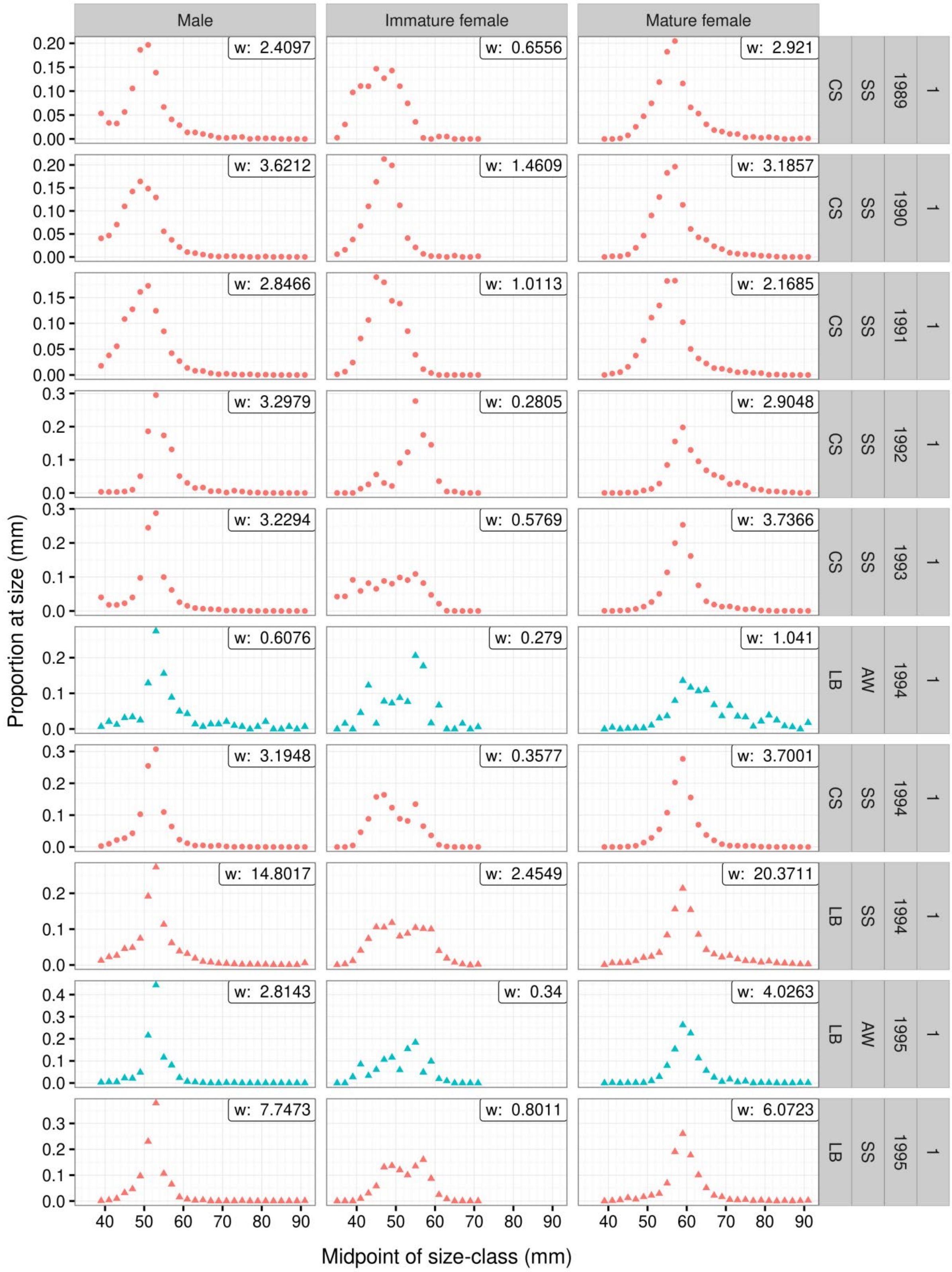

Figure E.1: CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 1989 SS CS to 1995.SS.LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling

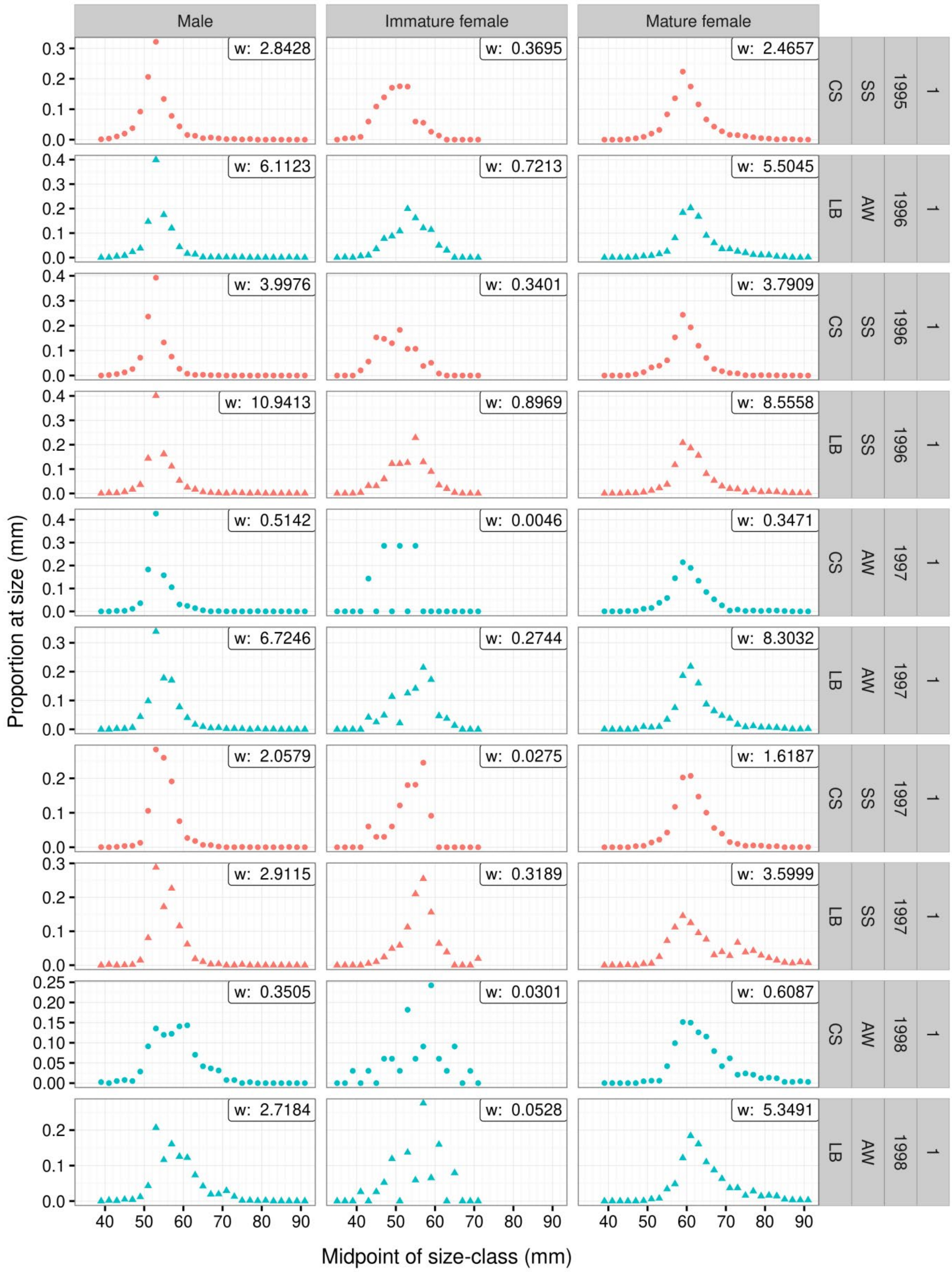

Figure E.2: CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 1995.SS.CS to 1998.AW.LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling.

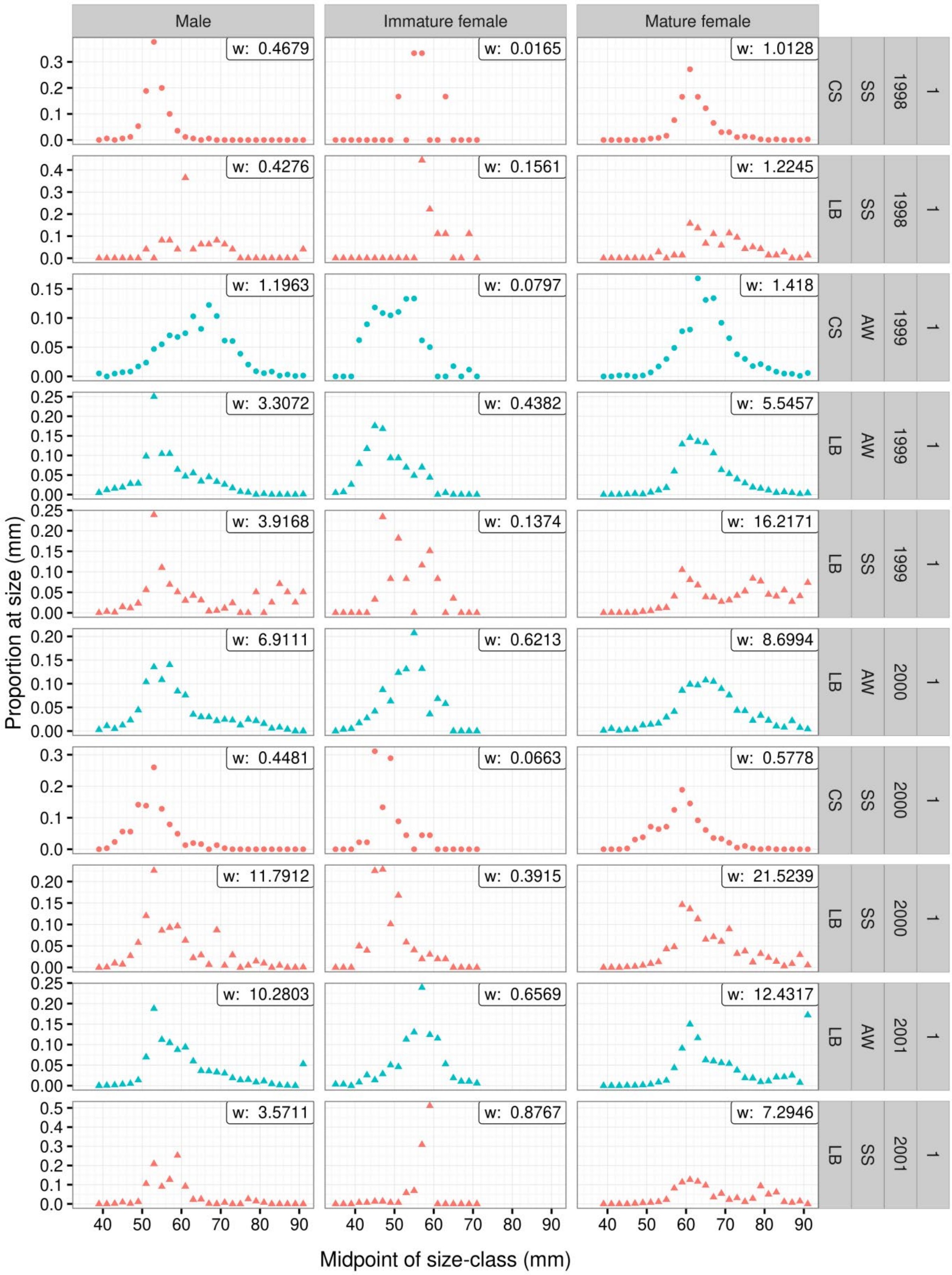

Figure E.3: **CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 1998.SS.CS to 2001.SS.LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling.**

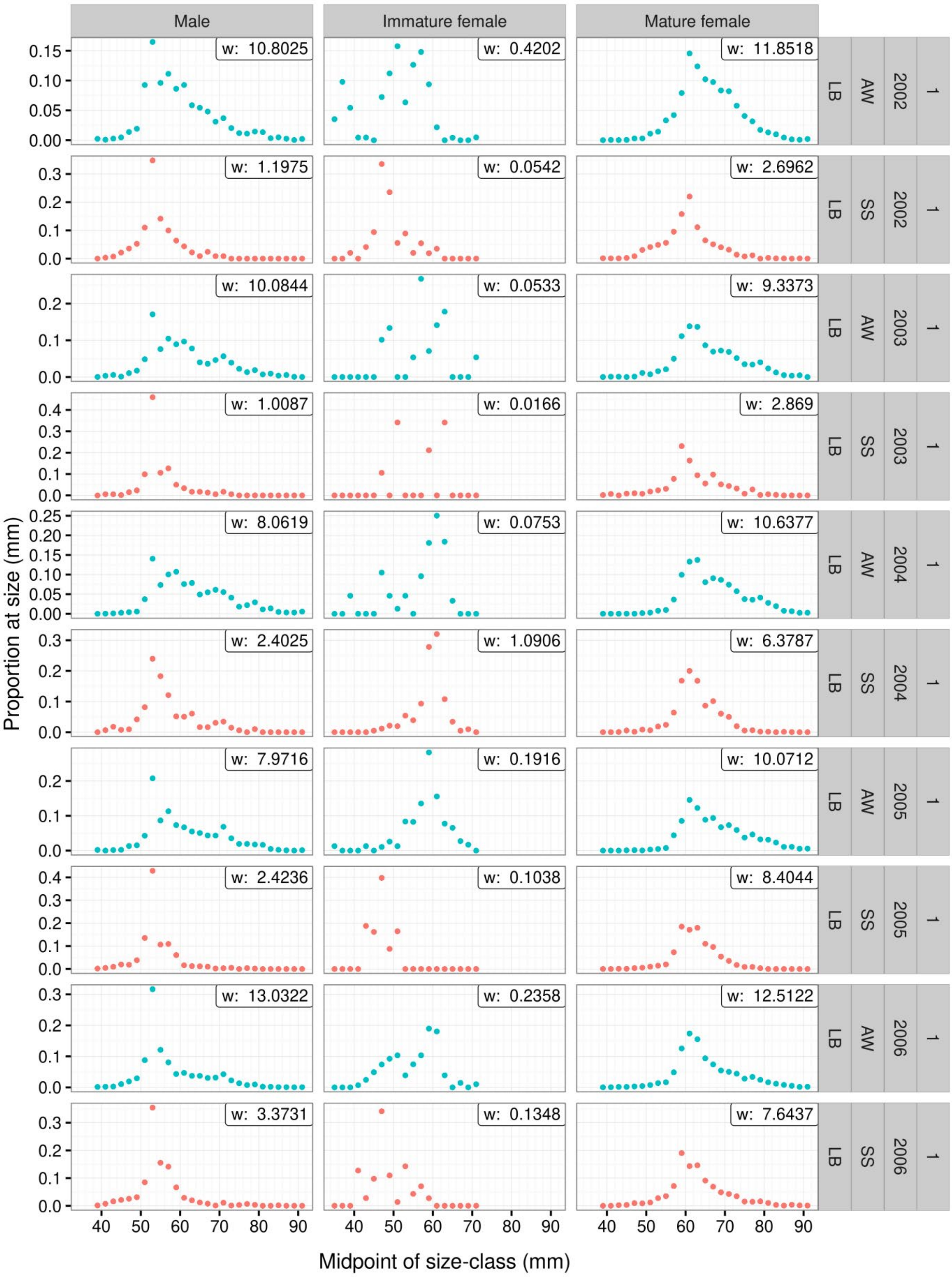

Figure E.4: CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 2002.AW.LB to 2006.SS.LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling.

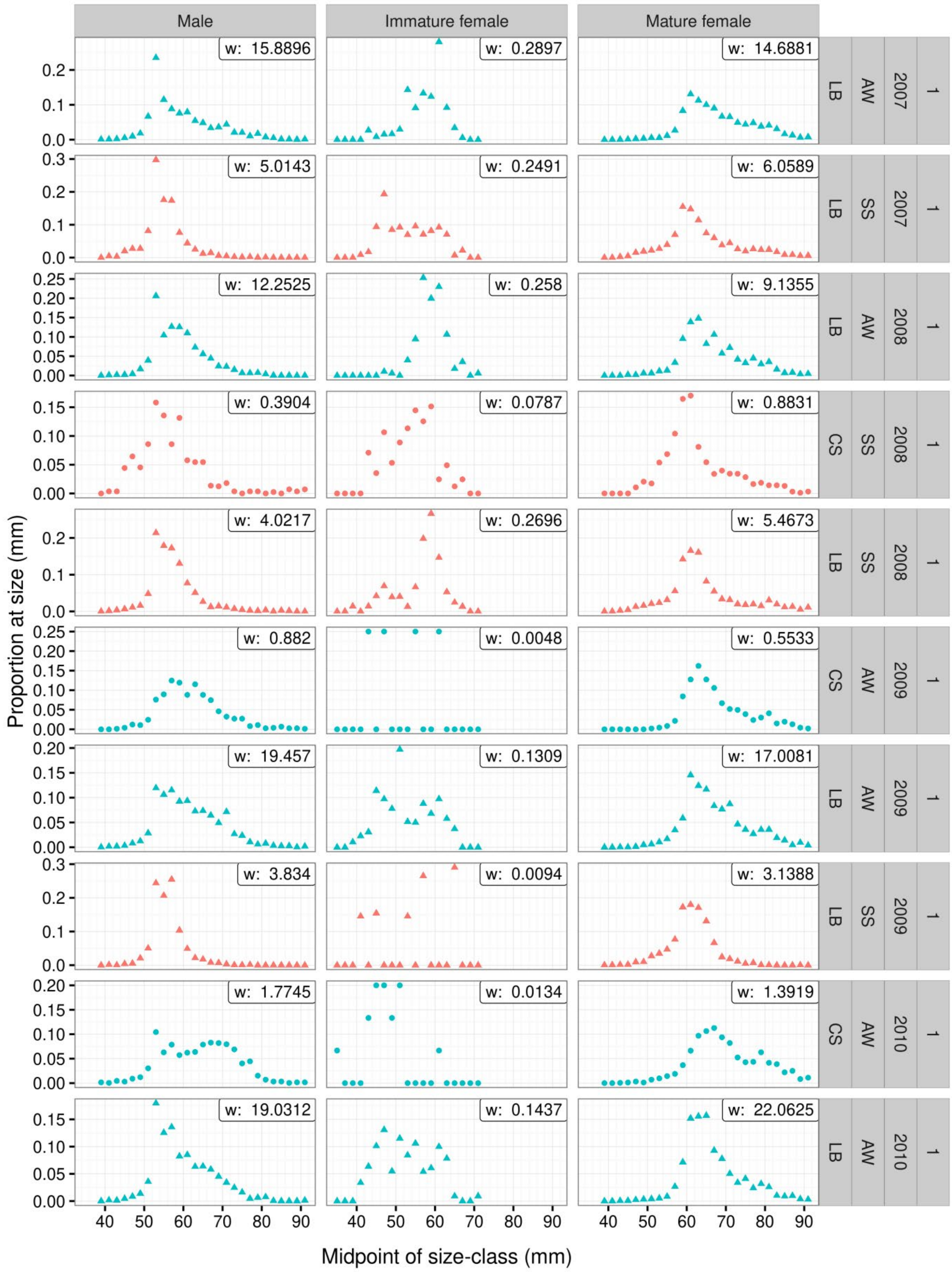

Figure E.5: CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 2007 AW LB to 2010 AW LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling.

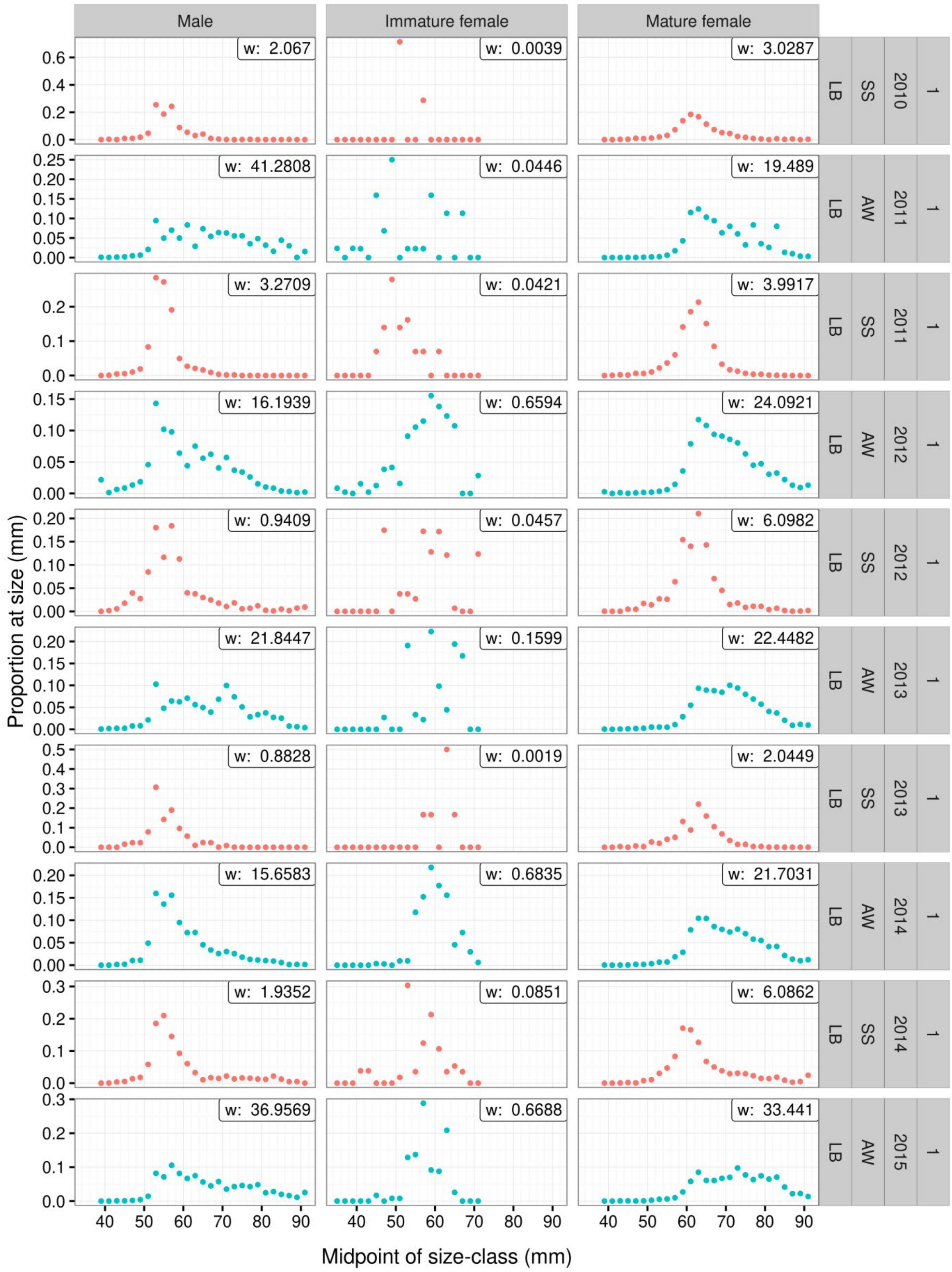

Figure E.6: CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 2010 SS LB to 2015 AW LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling.

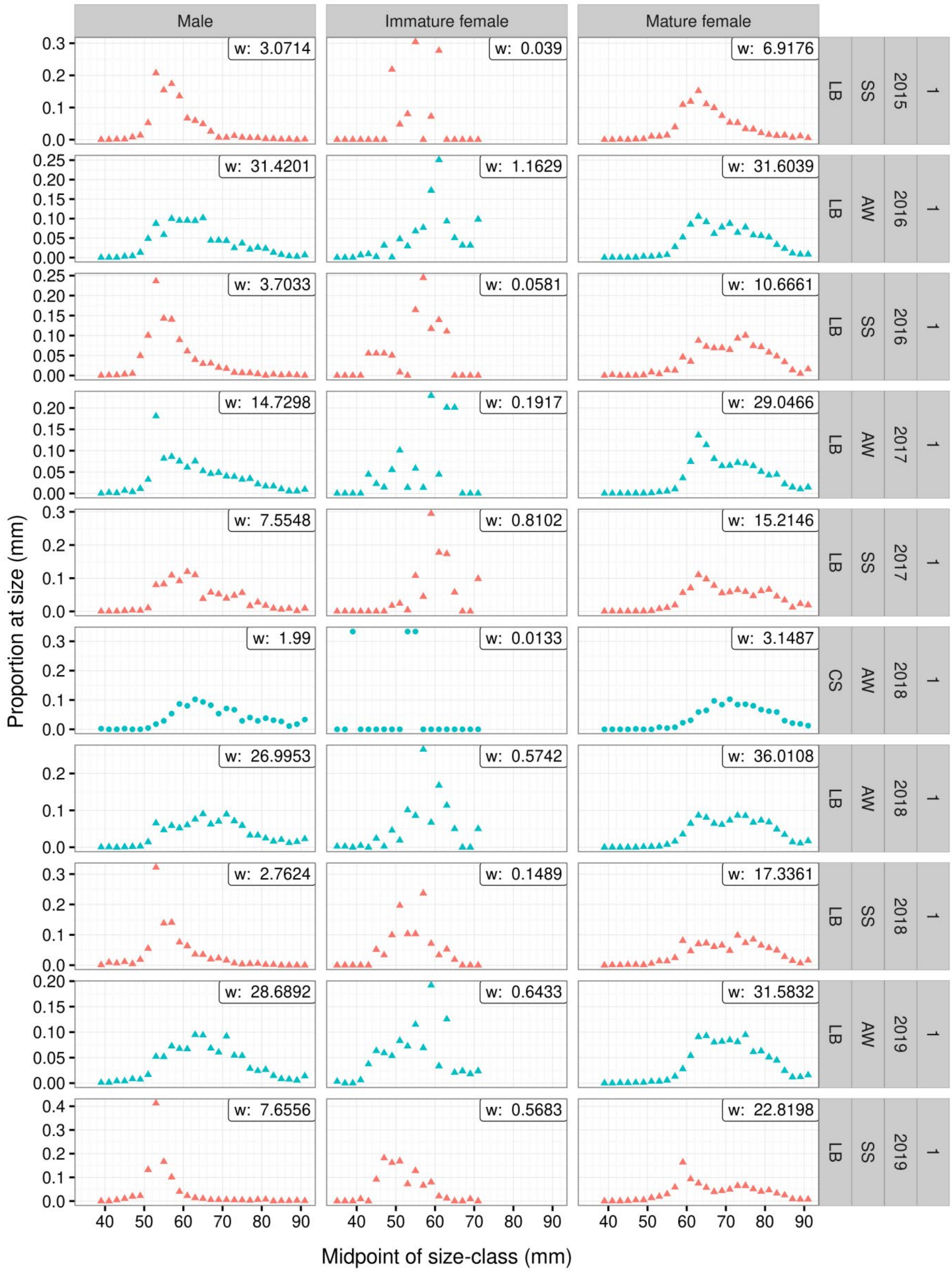

Figure E.7: CRA 5: region 1 (917+918+919) observed length frequency distributions by sex category from 2015 SS LB to 2019 SS LB. Each cell shows the associated weight from Table 17. CS=observer catch sampling; LB=logbook catch sampling.

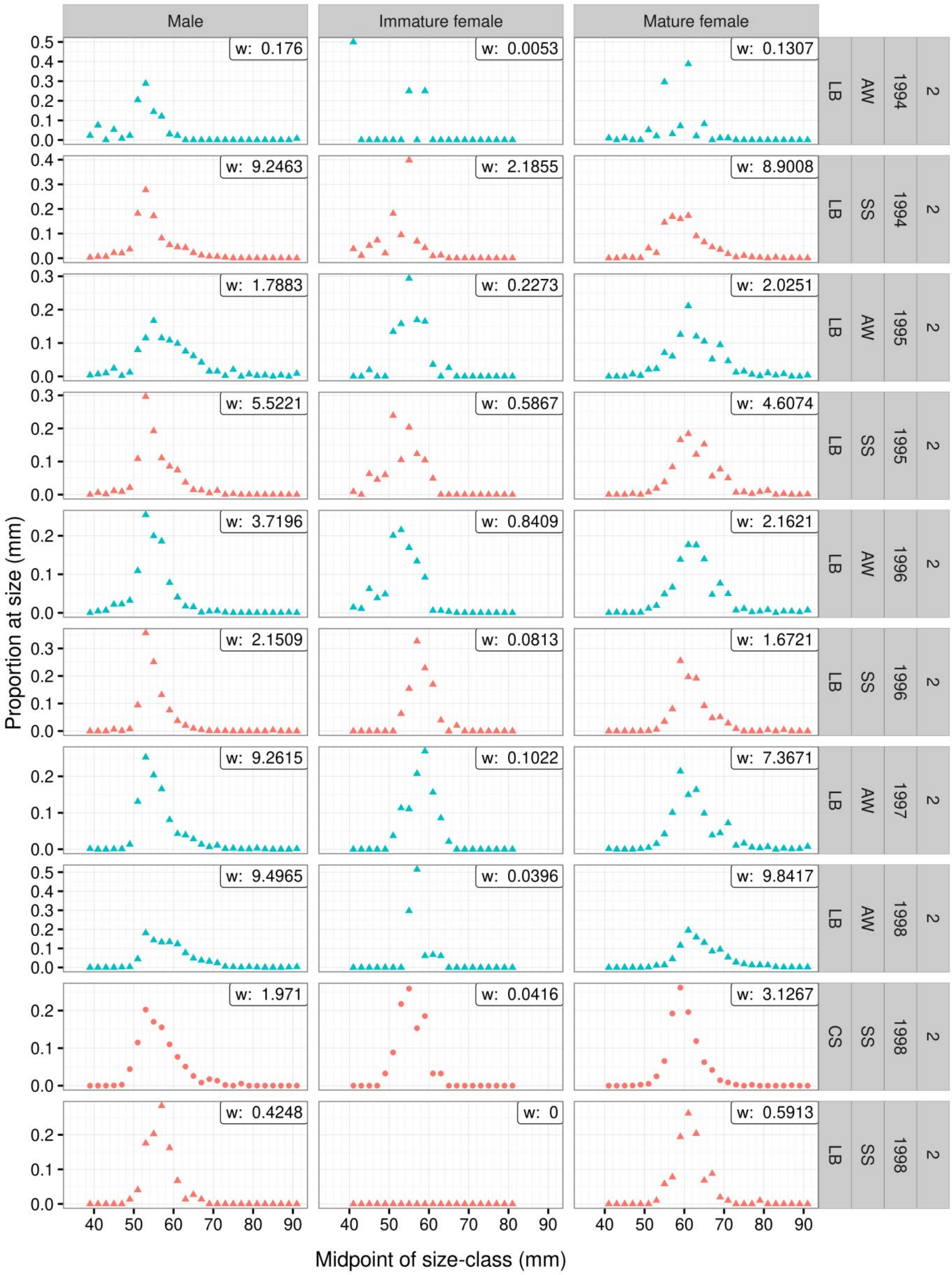

Figure E.8: CRA 5: region 2 (916+932+933) observed length frequency distributions by sex category from 1994 AW LB to 1998 SS LB. Each cell shows the associated weight from Table 19. CS=observer catch sampling; LB=logbook catch sampling.

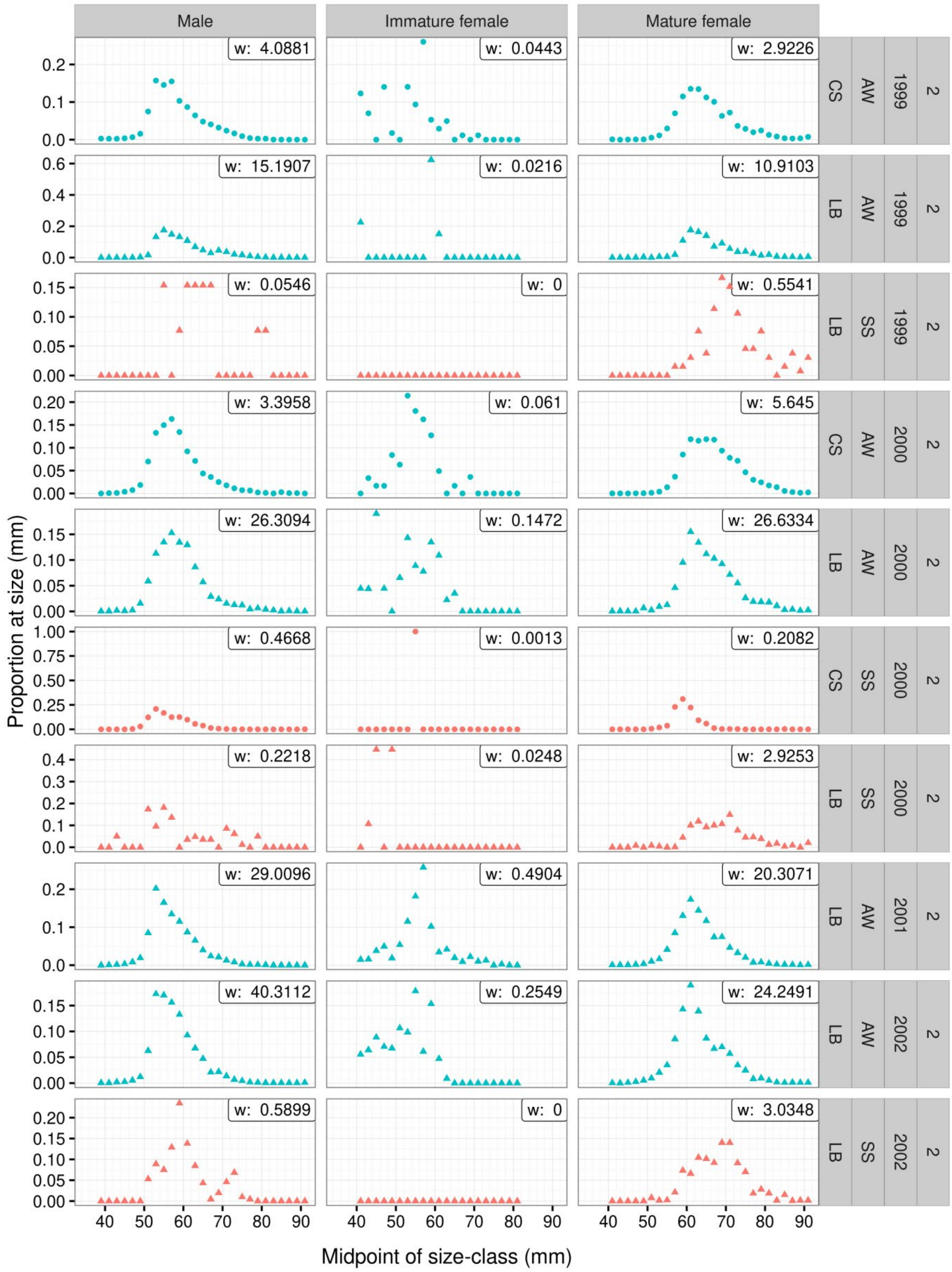

Figure E.9: CRA 5: region 2 (916+932+933) observed length frequency distributions by sex category from 1999 AW CS to 2002 SS LB. Each cell shows the associated weight from Table 19. CS=observer catch sampling; LB=logbook catch sampling.

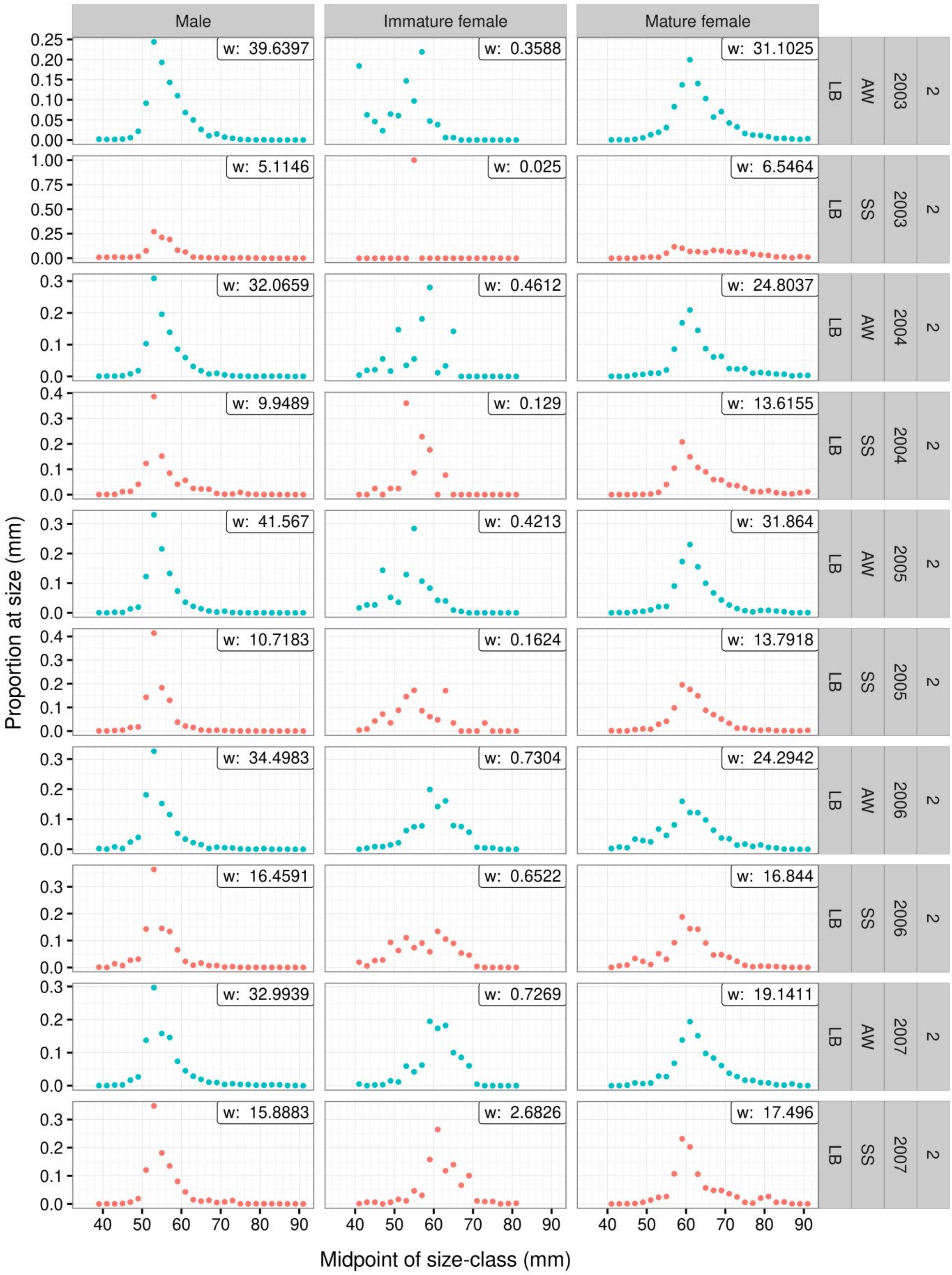

Figure E.10: CRA 5: region 2 (916+932+933) observed length frequency distributions by sex category from 2003 AW LB to 2007 SS LB. Each cell shows the associated weight from Table 19. CS=observer catch sampling; LB=logbook catch sampling.

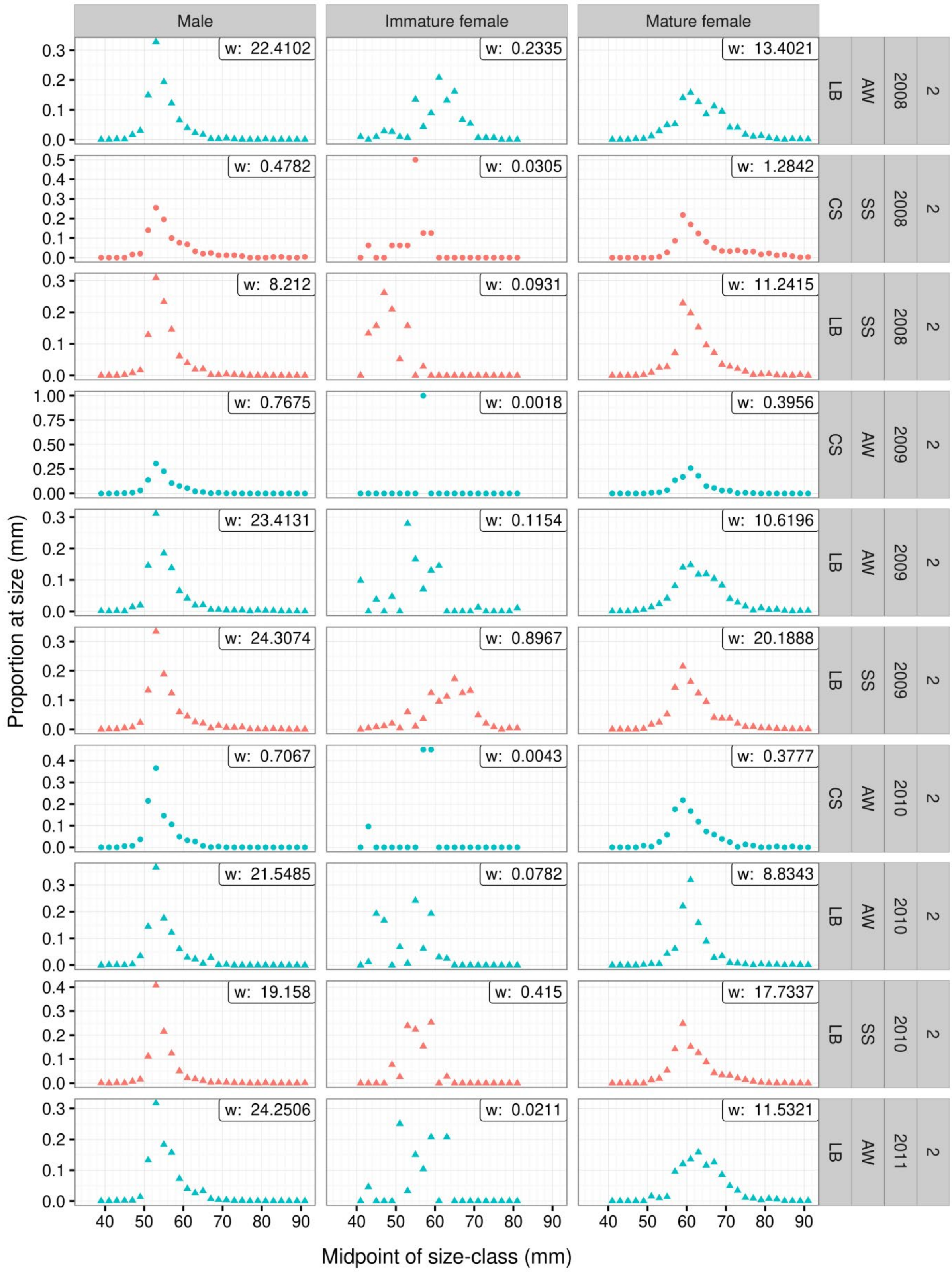

Figure E.11: CRA 5: region 2 (916+932+933) observed length frequency distributions by sex category from 2008 AW LB to 2011 AW LB. Each cell shows the associated weight from Table 19. CS=observer catch sampling; LB=logbook catch sampling.

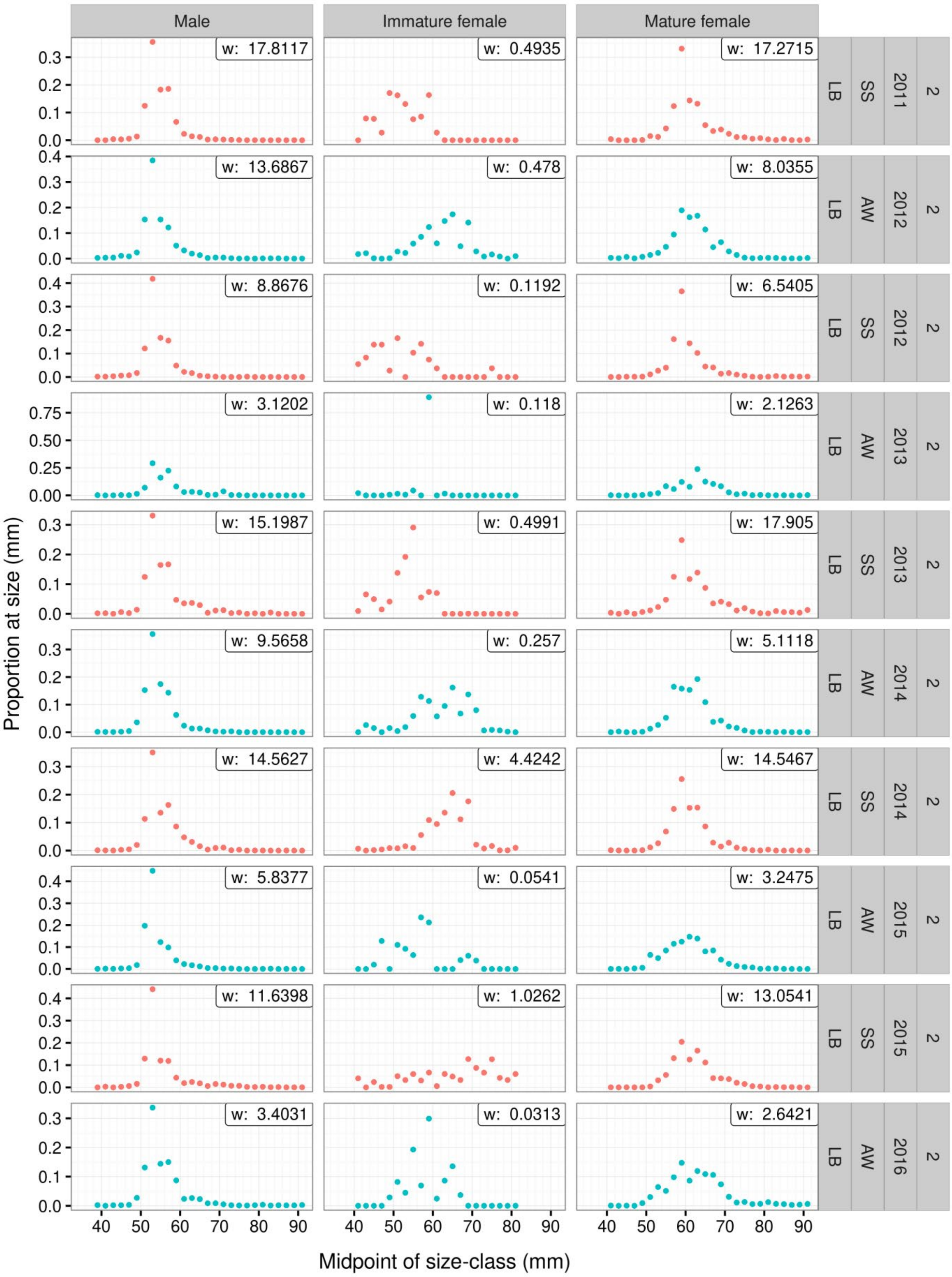

Figure E.12: CRA 5: region 2 (916+932+933) observed length frequency distributions by sex category from 2011 SS LB to 2016 AW LB. Each cell shows the associated weight from Table 19. CS=observer catch sampling; LB=logbook catch sampling.

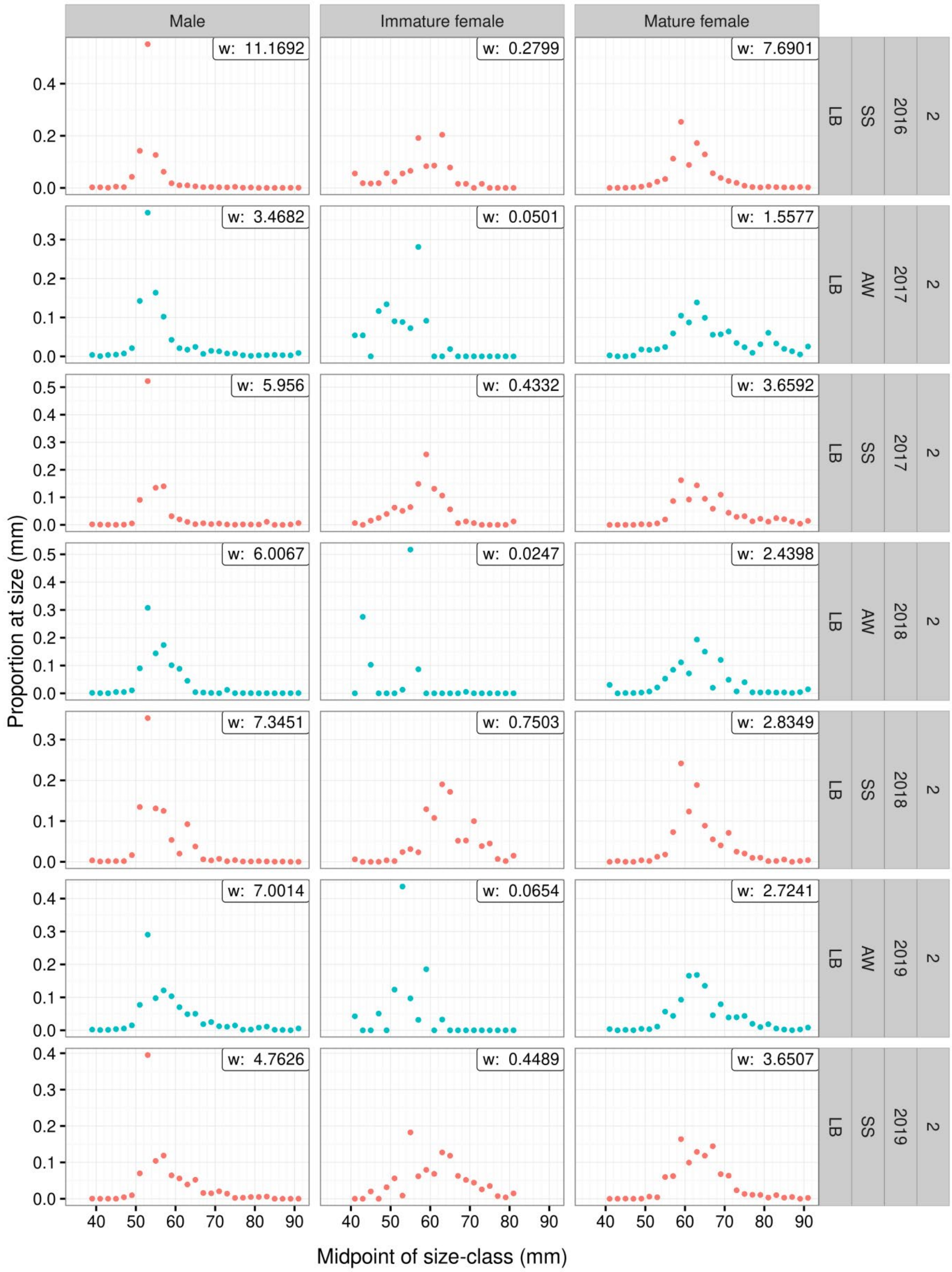

Figure E.13: CRA 5: region 2 (916+932+933) observed length frequency distributions by sex category from 2016 SS LB to 2019 SS LB. Each cell shows the associated weight from Table 19. CS=observer catch sampling; LB=logbook catch sampling.