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Data for the 2021 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 7&8

New Zealand Fisheries Assessment Report 2022/16

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EXECUTIVE SUMMARY

Starr, P.J.¹; Webber, D.N.²; Rudd, M.B.³; Pons, M.¹; Roberts, J.¹ (2022). Data for the 2021 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 7&8.

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This document describes the covariates and data used in the 2021 stock assessment for CRA 7&8. Covariates described in this report include catch estimates for all CRA 7&8 fishery sectors. Data sets described in this report include seasonal standardised catch-per-unit-effort (CPUE) indices, length frequency distributions, sex-ratios, tag-recapture data, and puerulus settlement indices.

An analysis of the CRA 7&8 puerulus settlement data, which were not used in the stock assessment, is described in an appendix. The retention rate of lobsters by size in CRA 8 was also analysed in another appendix to this document, which informed the inclusion of this process in the CRA 7&8 stock assessment.

An examination of tag recovery data from statistical areas within CRA 7&8 indicated that there was a high degree of movement from Otago to Southland (including the Catlins, Stewart Island, and Snares Island), and minimal movement from these places to Fiordland. There were also few mature females in either Otago or Southland. The Rock Lobster Working Group (RLWG) agreed, on the basis of an analysis presented in this report, to divide CRA 7&8 into two regions based on the amalgamation of statistical areas 920 to 925 (Otago and Southland) into region 1 and combining statistical areas 926, 927, and 928 (Fiordland) into region 2.

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 fishery catch estimates were assumed to be constant from 1979 onward at levels reasonably consistent with the low catches estimated by recent national recreational catch census surveys. Recreational catches before 1979 were interpolated from a low value in 1945 to the 1979 value. By agreement in the RLWG, post-QMS (after 1989) illegal catches were assumed to be 2% of the commercial catch and pre-QMS illegal catches were assumed to be 10% of the commercial catch. These catches were annualised and varied, using commercial CPUE after 1978. Customary catches were assumed by agreement to be low. Catches were assigned to the CRA 7&8 regions based on the statistical area of origin after 1978. Regional catch assignments before 1979 were difficult to make because spatial information was frequently missing or defined differently. The process used to accomplish this task is presented in this document.

CPUE was standardised for the AW and SS seasons from the 1979 AW season, up to the 2019 AW season. The CPUE series was terminated from that point 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 7&8 region, based on the distribution of catch and effort data by statistical area.

Length frequency and sex ratio data were available from both observer catch sampling and voluntary logbook programmes. These were collated by sex, data source, region, fishing year, and season, and this document describes how the individual records were weighted. These data were assigned to each CRA 7&8 region based on the statistical area of origin.

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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 7&8 appeared to have similar growth patterns with respect to the size at release.

1. INTRODUCTION

The National Rock Lobster Management Group (NRLMG) decided that a stock assessment(s) for CRA 7 and CRA 8 should be done in 2021. This document describes work done to address part of Objective 3 of the Fisheries New Zealand contract CRA2021-01:

To carry out full stock assessments for the CRA 7 (Otago) and CRA 8 (Southern) rock lobster stocks, including estimating biomass and sustainable yields, the status of the stock in relation to management reference points, and future projections of stock status as required to support management.

This one-year contract, which began in September 2021, was awarded to Quantifish Ltd, who sub-contracted this work to the authors of this document. This stock assessment was completed in a workshop during September and October 2021. Decisions on data and modelling choices were discussed and approved by the Rock Lobster Working Group (RLWG). The stock assessment was presented to and approved by the Fisheries New Zealand mid-year Plenary in November 2021 (Fisheries New Zealand 2021).

The CRA 7 fishery extends from the Waitaki River south along the Otago coastline to Long Point (Figure 1). The CRA 8 fishery is the largest New Zealand fishery, extending from Long Point south to Stewart Island and the Snares Islands, the islands and coastline of Foveaux Strait, and then northwards along the Fiordland coastline to Bruce Bay (Figure 1).

The previous stock assessment of CRA 7 and CRA 8 was in 2015 (Haist et al. 2016), with Starr et al. (2016) describing the data. The model was fitted to tag-recapture data, historical catch rate data for 1963–1973, standardised catch-per-unit-effort (CPUE) from 1979–2019, and length frequency / sex ratio data from voluntary logbooks and observer catch sampling. CRA 7 and CRA 8 were modelled separately but were linked by movement which was assumed to occur unidirectionally from CRA7 to CRA 8.

This document describes catches – including commercial, recreational, customary, and illegal catches – CPUE, length frequency data, tag-recapture data, and puerulus settlement indices. 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. For definitions of technical terms used here see in appendix A of Starr (2021) and the glossary of Webber et al. (2018).

From 1996 to 2019, the CRA 7 Total Allowable Commercial Catch (TACC) was set by the operation of a management procedure (MP), with the most recent MP implemented in 2013. The TACC was raised for the 2015 and 2017 fishing years, dropped for the 2018 fishing year, and raised again for the 2019 fishing year, through the operation of the CRA 7 MP (Table 1). For the 2020 fishing year, the CRA 7 Total Allowable Catch (TAC) was raised to 126 t, with allowances of 10 t for customary catch, 5 t for recreational catch, 5 t for illegal removals, and a new TACC of 106 t. The CRA 7 commercial fishery operates with a minimum legal size (MLS) of 127 mm tail length for both males and females (equivalent to 47 mm tail width (TW) for males and 48 mm TW for females). The CRA 7 fishery is open to recreational fishing with MLS 54 mm TW for males and 60 mm TW for females.

From 1996 to 2019, the CRA 8 TACC was controlled by MPs. The TACC was fully caught from 1998 onwards (Table 1, Figure 2). The 2018 TACC was raised, through the operation of the MP, from 962 t to 1071 t, which resulted in a TAC of 1162 t with the addition of allowances of 30 t for customary, 33 t for recreational, and 28 t for other mortalities. The TACC was raised again in 2019 by the MP to 1130 t, increasing the TAC to 1221 t while leaving the non-commercial allowances unchanged. The TACC was raised again in 2020 by the MP to 1192 t, increasing the TAC to 1283 t while again leaving the non-commercial allowances unchanged (Table 1).

Assessments of New Zealand red rock lobster stocks routinely attempt to include puerulus settlement indices for the stocks for which these are available. The analysis by Forman et al. (2021) provided

settlement indices for sites within CRA 7 (two sites) and CRA 8 (one site). A re-analysis of the CRA 7 and CRA 8 puerulus settlement data is described in 0. However, the indices described here were not included in the stock assessment model, due to very poor model fit to these data (Webber et al. 2022).

An analysis of the retention rate of lobsters by size in CRA 8, based on voluntary logbook data, is described in 0. Data suitable for an equivalent analysis in CRA 7 were not available. The outputs of the retention analysis were applied across both regions of the CRA 7&8 stock assessment (Webber et al. 2022).

2. CATCH

2.1 Commercial catch

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 a database maintained by the authors of this report, 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 also stored in the database maintained by the authors of this report (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. Year references in this document after 1978 apply to 1 April to 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 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.

Annual commercial catches in CRA 7 averaged 425 t before 1979, with catches exceeding 700 t/year from 1954 to 1957 (Figure 2, top panel). There is doubt about the early catches, both in terms of the magnitude of the catch and the location of the catches. Reported catches before 1979 were usually based on port of landing rather than area fished, although Annala & King (1983) reported rock lobster catches by area of capture from 1963 to 1973. Landings dropped to less than 200 t/year after the mid-1980s, but catches often exceeded 300 t/year between 1979 and 1987. Landings dropped below the TACC in 1993 and went below 100 t/year by 1995, just before the management of this fishery came under the control of a MP. After two successive lowerings of the TACC in 1999 and 2001 (Table 1), abundances in CRA 7 improved and, by 2003, landings matched the TACC (Figure 3, top panel).

Annual commercial catches in CRA 8 averaged 1840 t before 1979, with catches exceeding 3000 t/year from 1954 to 1957 (Figure 2, lower panel). As with CRA 7, there is doubt about the early catches in terms of size and location of the catch. Landings dropped to below 1000 t/year after 1990 when CRA 8 entered the QMS, but hovered around 1500 t/year between 1979 and 1987. As for CRA 7, the management of this fishery came under the control of an MP in 1997, resulting in two

successive lowerings of the TACC for 1999 and 2001 (Table 1, Figure 3, lower panel). Landings have matched the TACC in most years after CRA 8 entered the QMS, with a notable exception in 2019 when the TACC was undercaught by 112 t because of market changes associated with the COVID-19 pandemic. However, the undercatch was carried over into the next fishing year, with the TACC exceeded by 110 t in 2020 (Table 1, Figure 3, lower panel).

2.2 Recreational catch

Regional telephone and diary surveys which estimated rock lobster recreational catch were done in 1992, 1993, 1994, 1996, 2000, and 2001 (Bradford 1997, 1998, Teirney et al. 1997, Boyd & Reilly 2004). QMA-specific results from these surveys are available in the Rock Lobster Plenary introductory chapter (see table 6 of Fisheries New Zealand 2021). These surveys were considered unreliable by the RLWG for estimating recreational catch in either CRA 7 or CRA 8.

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-fish 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 Computer Assisted Telephone Interview method was used to record harvest from those who had fished. Unfortunately, the 2011–12 and 2017–18 NPS results for CRA 7 were not usable because only one diary participant provided rock lobster recreational catch information in these surveys, Table 2). While the number of CRA 8 participants in the 2011–12 was much better (62 fishers), only 19 fishers participated in the 2017–18 survey for CRA 8 (Table 2). Given the large size of the CRA 8 QMA and the remoteness of the areas with the highest lobster productivity in CRA 8, the RLWG did not have much confidence in the utility of these estimates.

Consequently, the RLWG agreed to assume, as was done for the 2015 assessment, that the recreational catches in CRA 7 and CRA 8 were constant at 5 t/year and 20 t/year, respectively, beginning with 1979. Each recreational catch was proportionately scaled from 1945 to 1979, beginning with 20% of the 1979 value in 1945. The maximum section 111 catch in each QMA (1.69 t for CRA 7 and 16.62 t for CRA 8 – Table 3) was added to each year as per RLWG agreement.

The recreational catch estimates are shown in Table 4 (CRA 7) and Table 5 (CRA 8).

2.3 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).

Customary catch was set in the same manner as was done for the 2015 assessment, with customary catch in CRA 7 assumed to be 1 t/year from 1945 to 2020 while the CRA 8 customary catch was assumed to be 6 t/year up to 2012, then ramped up to 15 t in 2014 where it remained to 2020.

The customary catch estimates are shown in Table 4 (CRA 7) and Table 5 (CRA 8).

2.4 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 the 2021 stock assessment were initially discussed in the RLWG, the meeting agreed to remain consistent with decisions made in 2019 for CRA 1 and CRA 3 (to reject the Fisheries New Zealand compliance estimates of illegal catch because these had not been adequately documented – see Starr et al. 2020a, 2020b) and in 2020 for CRA 4 and CRA 5 (to reject using the early estimates generated using the ‘export-discrepancy’ methodology – see Starr et al. 2021a, 2021b). The RLWG agreed to use 10% of the total commercial catch summed over the period 1945–1989, followed by 2% 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. This percentage was even lower than that used for CRA 4 and CRA 5 for the 2020 assessment in recognition of the remoteness of the areas of higher productivity in CRA 8 and the consequent difficulty of mounting a poaching operation in this area. These fixed catches were scaled by the annual standardised CRA 7 and CRA 8 CPUE, beginning in 1979. The final two years were set at the 2018 level because CPUE were not available from the new ERS data. 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 this 2021 stock assessment, the RLWG agreed to discontinue this practice (as done in the 2020 assessment for CRA 4 and CRA 5), 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 4 (CRA 7), Table 5 (CRA 8), and Figure 4.

3. Catch information for CRA 7&8 regional model

Appendix E summarises the available data from CRA 7 and CRA 8 in support of separating the component statistical areas into two regions, each with similar characteristics. There appears to be justification in the length frequency and tagging data for combining the two CRA 7 statistical areas with the CRA 8 Southland statistical areas and for treating the resulting combined area as a single region. Female lobsters in the Otago/Southland statistical areas are primarily immature while mature females predominate in the Fiordland CRA 8 statistical areas. CPUE trends are similar among the nine CRA 7&8 statistical areas, so it is more difficult to use this information as a basis for regional separation. All areas show an early period of low or declining CPUE, followed by an increase to a higher level which has continued to the end of the series.

3.1 Preparation of the regional catch information

The preparation of catch data for the two CRA 7&8 regions (Figure 1) was hampered by inconsistent data availability, depending on the period (Table 6). 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 from at least 1945. Historical catches were available by sub-area from 1963–1973, but the sub-area definitions used by Annala & King (1983) (Figure 1) 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 6).

3.1.1 Method used to estimate catches in the two CRA 7&8 regions beginning in 1979

Beginning with 1 January 1979, data were allocated to each region (Table 7) on the basis of the declared statistical area. This applied to catches and the length frequencies / sex ratios from the 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 7&8 regions before 1979

Assigning catch to a region before 1979 was difficult because spatial catch data were only available from 1963 to 1973 and the available information was based on area definitions that differed from those used in the post-1978 data (Figure 1, Annala & King 1983). Only annual estimates by 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 Figure 1 definitions by noting that:

- a) A & K Areas 16 and 17 map reasonably closely to statistical areas 920 and 921;
- b) A & K Area 18 appears to cover combined statistical areas 922, 923, 924, and 925 (see Figure 1; statistical area 925 seems to be included in this group as well);
- c) A & K Area 19 seems smaller than statistical area 926, but that appears to be the best match;
- d) A & K Areas 20 and 21 appear to cover all of the remainder of Fiordland and up the coast into CRA 9. However, the catch from the CRA 9 part of A & K Area 21 was negligible.

Catches were assigned to region 1 (combined 920+921+922+923+924+925) by summing A & K areas 16 to 18 (see Table 8). Similarly, catches were assigned to region 2 by summing A & K area 19 with A & K areas 20 and 21 after subtracting 0.01 of the total A & K area 20+21 catches to account for the CRA 9 contribution in the early FSU data (Table 8). Table 9 shows how these catches were distributed among the two regions from 1963 to 1973. Catches by region over the period 1974 to 1978 were interpolated (Table 10). Pre-1963 catches were assigned using the mean regional proportions from 1963–1967 (Table 11).

The time series of catches by category of capture are presented by CRA 7&8 region in Figure 5, in Table 12 (region 1: 920+921+922+923+924+925), and in Table 13 (region 2: 926+927+928).

The two regions show similar distributions of the proportion of commercial catch taken in the AW season (Figure 6), being relatively low (between 0.4 and 0.6) during the 1980s, but gradually increasing to levels above 0.6 by the early 1990s and exceeding 0.8 in the early 2000s. These seasonal distributions were 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 previous rock lobster stock assessments, were used to allocate recreational and customary catches to seasons. These seasonal catches were then summed 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 7, Table 12, and Table 13). These are the catch distributions that were used to model the two CRA 7&8 regions.

4. Catch rate information

4.1 Seasonal standardised CPUE indices

4.1.1 Introduction and methods

Catch and effort data from Catch Effort Landing Return (CELR) forms were obtained from Fisheries New Zealand in September 2021 (replog 13890) and processed using standard error checks (Bentley et al. 2005). Data for this CPUE analysis 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.

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 in a QMA (equation D.6 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 appendix B.1 of Starr 2021). The number of records in each CPUE data set is provided in Table 14 (CRA 7&8 region 1 (920–925)) and Table 15 (CRA 7&8 region 2 (926+927+928)).

The 2019 fishing year marked the transition of the collection of rock lobster catch and effort data from a paper-based (CELR) system to an electronic reporting (ER) system dependent on a user interface operated from tablets or smart phones. There are three different ER reporting “platforms”, each with different user interfaces and different underlying software. Analyses of the 2019 and 2020 ER 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 which analysed the 2019 data, but there was little improvement in the 2020 data). Therefore, the RLWG agreed to temporarily suspend updating CPUE indices beginning with the 2019 SS season (the RLWG concluded that, with the exception of CRA 7, there remained sufficient CELR data in the other QMAs to provide comparability with previous indices for the AW 2019–20 data). This meant that the 2021 combined CRA 7&8 as well as the 2020 CRA 4 and CRA 5 stock assessments were fitted to a CELR CPUE series that ended in 2019 AW, the final period with sufficient CELR data to ensure comparability in the series.

The 2021 CRA 7&8 stock assessment included four standardised CPUE series calculated from four generalised linear models (GLMs) that used sequential six-month periods as explanatory time-series variables (Table 16). Two CPUE series (one for each CRA 7&8 region) were based on the early FSU data and the second two series (one for each CRA 7&8 region) used the 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].

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 data⁴. Bayesian inference was used to estimate parameter uncertainty. This was done using the R package *brms*, which was developed 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.

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*):

⁴ Note that the five-year participation requirement was calculated for combined CRA 7 and CRA 8, not by region.

$$\text{Eq. 1} \quad \log\left(\frac{C_i}{E_i}\right) = X\beta + \varepsilon = \beta_0 + T\beta_t + AT\beta_{a,t} + M\beta_m + V\beta_v + \varepsilon$$

with priors and hyperpriors

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

and distribution

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

where C_i is the catch (t) 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 $\times$ 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 $t = (1, 2, 3, \dots, n)$, then $t = (\text{AW}, \text{SS}, \text{AW}, \dots, \text{SS})$, where AW = April to September and SS = October to March.

The monthly data from CRA 7 (statistical areas 920 and 921) require special handling because of MLS regulation changes over time. Before 1993, there were two periods within a year when different MLS regulations applied: 1) June–November, when a “concession” male/female MLS of 47/48 mm TW operated and 2) December–May when male/female MLS of 54/60 mm TW were applicable. From 1993 to 2013, the December–May fishery was closed. Fishing in these months resumed in December 2013 but the smaller “concession” MLS was permitted. This meant that catches in the months beginning with December 2013 were not comparable to the catches in the same months before 1993 (Starr 2021). This lack of comparability was handled in the region 1 CELR model by estimating separate parameters for December–May beginning in 1993 for statistical areas 920 and 921.

4.1.2 Regional seasonal standardised series

Trace plots of samples from the posterior distribution for both FSU GLM analyses appear to be well-mixed with no indication of lack of convergence (Figure 8 [region 1], Figure 9 [region 2]). Vessel coefficients from the FSU analysis show a trend whereby the lower catch rate vessels leave the fishery in region 1 (Figure 10) while there is no corresponding trend in region 2 (Figure 11). Both sets of month coefficients from the FSU analysis show low catch rates from August to October, with lower catch rates extending to November for region 1 (Figure 12 [region 1], Figure 13 [region 2]).

Trace plots of samples from the posterior distribution for both CELR GLM analyses also appear well-mixed with no indication of lack of convergence (Figure 14 [region 1], Figure 15 [region 2]). Vessel coefficients in both CELR analyses show a wide range of values, with each analysis showing a tendency for vessels with lower catch rates to drop out of the fishery in the final decade of the analysis (Figure 16 [region 1], Figure 17 [region 2]). The month coefficients show relatively little contrast, although there is a suggestion that the primary AW months (June to September) have below average catch rates in region 1 (Figure 18) while these same months (except September) have above average catch rates in region 2 (Figure 19).

There was a gradual declining trend in the standardised FSU series from 1979 in both regions extending to the 1989 AW index (Figure 20). The region 1 FSU series did not show the within-year variation between the AW and SS seasons that is apparent in region 2.

The standardised CELR CPUE series in both regions started from low levels (less than 1.0) in the early 1990s, which persists until the early 2000s when the relative index in both regions finally exceeds 1.0 (Figure 21). The region 1 CELR series declined to below 1.0 in the early 2010s after exceeding 2.0 in the mid-2000s. However, the region 1 CPUE index then increased sharply, nearly reaching 4.0 by the end of the series in 2019 AW. The region 1 CELR series does not show a strong pattern of alternating high SS and low AW indices, except for a period from 2007 to 2013 (Figure 21), as was seen in the region 1 FSU series. On the other hand, the region 2 CELR CPUE series showed a strong pattern of alternating strong SS indices which were always greater than the AW indices in the same fishing year, with little trend after a good increase from 2002 to 2007. This period of little trend was followed by an overall increasing trend starting from 2016 to the end of the series in 2019 AW (Figure 21). The credible intervals for the region 2 CPUE series were much tighter than for the equivalent series in region 1.

4.2 Historical catch rate (CR) data

Because the Annala & King (1983) catches can be assigned reasonably unambiguously to each CRA 7&8 region, a CR series for each region is available (Table 17, Figure 22).

5. Length frequency distributions (LFs)

CRA 7&8 biological sampling data were obtained in September 2021 from Fisheries New Zealand (catch sampling data: replot 13862) and Fishserve (logbook data), comprising both observer and voluntary logbook catch sampling from the 1987 to 2020 fishing years. Each 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 design of the logbook catch sampling 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. On the other hand, the observer catch sampling programme measures and sexes all lobsters in as many pots as feasible to measure during a day's fishing. CRA 7 has relied on the observer catch sampling programme to collect biological sampling data while CRA 8 embraced the logbook programme from the beginning in the early 1990s. The sampling quantities presented in Table 18 (region 1: 920+921+922+923+924+925) and Table 19 (region 2: 926+927+928) provide the regional distribution of the available biological data collected by each sampling programme over years and seasons.

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
- 36 fields, representing the relative proportion (see below) of males measured by sex class within the sizes classes $\{[30, 32), [32, 34), \dots, 98, 100), [100, \infty)\}$ mm TW
- 36 fields for immature female numbers measured
- 36 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 stratum, the numbers-at-length were summed for each sex, and the proportion-at-sex was calculated as:

$$\text{Eq. 2} \quad p_{g,m,a,s} = \frac{N_{g,m,a,s}}{\sum_s N_{g,m,a,s}}$$

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:

$$\text{Eq. 3} \quad P_{g,s} = \frac{\sum_m \sum_a (C_{m,a} p_{g,m,a,s})}{\sum_m \sum_a \sum_s (C_{m,a} p_{g,m,a,s})}$$

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

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 ($D_{m,a}$):

$$\text{Eq. 4} \quad w_s = \sum_m \sum_a \frac{C_{m,a} \sqrt[3]{N_{m,a,s}} \sqrt[3]{D_{m,a}}}{\sum_m \sum_a C_{m,a}}$$

This approach of applying the relative weight by sex represented a change from stock assessments before 2018, 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) measured lobsters in one sex category while the remaining sex categories in the same season/year/source have appreciable numbers. 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 LF data comprised 116 records for 1987–2020, with 49 being logbook samples and the remaining 67 being observer catch sampling (with separate records for each season). Unfortunately the 2019 and 2020 data for both seasons were inadvertently omitted during the preparation of the length frequency input file due to a data processing error; consequently these data were not used in the stock assessment. Eight logbook records were dropped because there were less than 100 lobsters measured or there was only one participating fisher (these were arbitrary limits agreed by the stock assessment team) (Table 20). Only one catch sampling record was dropped for having less than 100 lengths (a ‘one vessel’ rule was not applied to the catch sampling data, given the nature of the sampling). The remaining logbook records ranged from 281 to 8455 lobsters measured across both seasons, while the observer samples ranged from 121 to 7475 lobsters measured across both seasons (Table 20). The logbook sampling relative weights by sex (Eq. 4) ranged from 0.08 to 39.3 for the

accepted samples, while the observer catch sampling record weights ranged from 0.87 to 8.3 (Table 21). The samples with low weights had few sampled lobsters in all three sex categories.

The region 2 LF data comprised 79 records for 1989–2020, with 56 being logbook samples and the remaining 23 being observer samples (with separate records for each season). No samples were dropped from either sampling programme for this region. The logbook records ranged from 431 to 26 161 lobsters measured across both seasons, while the observer samples ranged from 1542 to 17 918 lobsters measured across both seasons (Table 22). The logbook sampling relative weights by sex (Eq. 4) ranged from 2.17 to 118.9, while the observer catch sampling record weights ranged from 2.0 to 31.9 (Table 23). Again, the samples with lower weights had fewer sampled lobsters in all three sex categories.

Sex proportions were calculated from normalised data records for both CRA 7&8 regions. The sex ratios of males and mature females showed little systematic pattern over time in region 1, with the males consistently around 40% of the sample in both seasons and the mature females at low levels in both seasons. There may be a slight declining trend in the proportion of immature females, which is much higher than in other CRA QMAs (also near 40% of the samples) (Figure 23). The region 2 sex ratios for males appeared to be variable but without trend, while the proportion of immature females appeared to be trending downward and the mature females may be increasing (Figure 23).

Mean TW by sex category and season in the two CRA 7&8 regions was also calculated from the data records, showing no trend in region 1 for all three sex categories in both seasons (Figure 24). The region 1 plots show a consistent difference in the AW between the observer catch sampling and the logbook records in all three sex categories. This is because the catch sampling data predominantly originate from CRA 7 while the CRA 8 samples were based on logbook samples. These data clearly show that the CRA 7 lobsters were smaller which is unsurprising given the smaller MLS in operation in the AW for CRA 7. This difference disappeared in the region 1 SS; however, the difference in the MLS between CRA 7 and CRA 8 represents an unmodelled process in this stock assessment (Figure 24). The region 2 mean TW for males and mature females appear to increase slowly in both seasons from the late-1980s to around 2010 (and may have decreased a little since), while there was no year trend in the mean TW of immature females (Figure 24).

Although the model contains size bins in the range 30–100+ mm TW, few individuals as small as 30 mm were measured and measured lobsters in the large size bins are rare, especially for immature females, leading to many cells with zero observations in both CRA 7&8 regions (Figure 25). 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 small residuals that could distort the diagnostics and waste computing time. Bins at both ends of the range for each sex were combined into accumulator “plus” and “minus” bins. Table 24 shows the lower and upper bin limits by sex category and region, in terms of the numeric bin number and the associated TW. The bin limits were determined from the distributions plotted in Figure 25, selecting the TW interval for each sex where the proportion of records with length observations drops to low levels. 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 G.1 to Figure G.18 in Appendix G). Figure 26 plots the weighted LFs for both CRA 7&8 regions, showing the progression of size distributions over the period of sampling for males, immature females, and mature females.

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 were also useful for informing decisions about stock

structure and movement. Tag data for all CRA areas were obtained in September 2021 from Fisheries New Zealand (replog 13863).

6.1 Data processing

Before the tag data were used to inform growth in stock assessments, they were processed (i.e., obvious errors were corrected and records that cannot be used were removed). This required every release-recapture event for a tag to be linked to form a single record while all tags with no recaptures were discarded. Processing, linking, and formatting were done using purpose-built software written in the R statistical computing language.

The tag processing code implemented the following:

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 and month of release, extracted from release date
- year and month 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 25 and Table 26). This comparison showed an overall increase in the number of usable recoveries of over 700 tags compared with the same total from last year (Table 25), with over half of the new usable recaptures coming from releases made in 2017 and 2019 (Table 26).

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 (0.298) and the lowest rate in CRA 6 (0.025) (Table 27). There was a total of 35 418 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 28). 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 220 recoveries (Table 28).

Tagged lobsters were 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 29). 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 29) 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 (millimetre) by TW (mm) at release was generally greater in smaller individuals, but this relationship was highly variable by QMA (Figure 27, Figure 28). Growth rates from these data differed by QMA, with CRA 3 and CRA 4 showing fewer large individuals compared with most of the other QMAs (Figure 28). The relationship between observed growth increment and time at liberty (years) appears to be less variable than for growth increment and TW, with both relationships highly variable (Figure 29, Figure 30). This observation holds true for all QMAs with an adequate amount of data (Figure 30).

6.3 CRA 7&8: tag data summaries

Tagging data were not sub-divided into the component CRA 7&8 regions because model exploration indicated that growth appeared to be the same throughout these QMAs.

The CRA 7&8 stock contains the earliest New Zealand tagging information, with just over 70 recoveries in statistical area 920 (Otago) from releases made in the 1960s (Table 30). The 1970s were characterised by a considerable amount of tagging activity around Stewart Island (statistical area 924) and Fiordland (statistical area 927) (Table 30 and Table 31). The early tagging ended by the mid-1980s, but tagging was resumed in earnest from the mid-1990s onwards, with tagging undertaken in the Fiordland statistical areas up to the late 2000s and early 2010s. There was also tagging around Stewart Island in the latter half of the 1990s. Tagging in the CRA 7 statistical areas was minimal in this period but was resumed beginning in 2007 when the 2006 stock assessment identified that CRA 7 was lacking in tag information. The total number of CRA 7&8 tag recoveries consisted of 11 661 events (6315 males and 5346 females), with 3639 recoveries occurring from releases before 1996 and the remainder occurring from releases beginning in 1996 (Table 30). Recoveries were well distributed among the sexes, with the split being 54:46% in favour of males. Releases were reasonably well distributed across the entire year with every month showing hundreds of release/recovery pairs, except for March and April (and May for females) (Table 32); however, these are months when there is little or no fishing.

Most recaptures were made in the statistical area of release, indicating that there is not much evidence for large-scale movement (Table 33). However, the recoveries summarised in Table 33 include all recoveries without considering how long the tags were at liberty. Section E.3 in Appendix E examines the evidence for movement from recoveries that had been at liberty for at least two years, to allow for adequate opportunity for movement. This analysis reduced the number of recoveries to just under 1000 (Table E.2 in Appendix E) but showed that about one-third of the 41 remaining CRA 7 (statistical areas 920 and 921) tags had moved from Otago to Southland. However, there was minimal evidence of movement between Southland and Fiordland.

The distributions of sizes at release and recapture by sex are shown in Figure 31, with most of the tagged males just below 54 mm TW, but with a broad right-hand distribution extending to nearly 70 mm TW. The female distribution is less broad than for males, with the mode around 55 mm TW (the female MLS in CRA 8 is 57 mm) and relatively fewer tagged individuals greater than 65 mm TW (Figure 31). The size distribution at recapture for males and females is shifted right, relative to the size distribution at release (Figure 31).

Times at liberty varied from 1 day to 3644 days (10.0 years) for males and from 1 day to 3652 days (10.0 years) for females (Table 34). Note that data processing step 17 (above) dropped recoveries that were at liberty for more than 10 years. Median time at liberty was 275 days for males and 335 days for females (Table 34). The number of times an individual was re-released is also monitored with a few males re-released seven to ten times and five to thirteen times for females (Table 35). Thirty percent of the male recoveries came from re-releases while the equivalent percentage for females was 25%.

Growth increments (mm) ranged from -25 to 35 mm TW (males) and -37 to 38 mm TW (females) (Table 36). The observed growth increment in CRA 7&8 was generally greater in smaller individuals (Figure 32, Figure 33). Similarly, the relationship between observed growth increment and time at liberty (years) is somewhat tighter (Figure 34, Figure 35). However, both relationships are highly variable.

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9. TABLES

Table 1: Reported commercial catch (t) from QMRs or MHRs (after 1 October 2001), commercial TACC (t), and total TAC (t) (where this quantity has been set) for rock lobster (*Jasus edwardsii*) in CRA 7 and CRA 8 for each fishing year since the species was included in the QMS on 1 April 1990. –, TAC not set for QMA or catch not available (current fishing year).

Fishing year	CRA 7			CRA 8		
	Catch	TACC	TAC	Catch	TACC	TAC
1990–91	133.4	179.4	–	834.5	1 152.4	–
1991–92	177.7	166.8	–	962.7	1 077.0	–
1992–93	131.6	154.5	–	876.5	993.7	–
1993–94	138.1	138.9	–	896.1	888.1	–
1994–95	120.3	138.9	–	855.6	888.1	–
1995–96	81.3	138.9	–	825.6	888.1	–
1996–97	62.9	138.7	–	862.4	888.1	–
1997–98	36.0	138.7	–	785.6	888.1	–
1998–99	58.6	138.7	–	808.1	888.1	–
1999–00	56.5	111.0	131.0	709.8	711.0	798.0
2000–01	87.2	111.0	131.0	703.4	711.0	798.0
2001–02	76.9	89.0	109.0	572.1	568.0	655.0
2002–03	88.6	89.0	109.0	567.1	568.0	655.0
2003–04	81.4	89.0	109.0	567.6	568.0	655.0
2004–05	94.2	94.9	114.9	603.0	603.4	690.4
2005–06	95.0	94.9	114.9	603.2	603.4	690.4
2006–07	120.2	120.2	140.2	754.9	755.2	842.2
2007–08	120.1	120.2	140.2	752.4	755.2	842.2
2008–09	120.3	123.9	143.9	966.0	966.0	1 053.0
2009–10	136.5	189.0	209.0	1 018.3	1 019.0	1 110.0
2010–11	74.8	84.5	104.5	1 018.3	1 019.0	1 110.0
2011–12	45.7	75.7	95.7	961.2	962.0	1 053.0
2012–13	53.8	63.9	83.9	960.8	962.0	1 053.0
2013–14	44.0	44.0	64.0	964.6	962.0	1 053.0
2014–15	66.0	66.0	86.0	962.0	962.0	1 053.0
2015–16	97.6	97.7	117.7	961.8	962.0	1 053.0
2016–17	97.6	97.7	117.7	961.9	962.0	1 053.0
2017–18	112.7	112.5	132.5	961.9	962.0	1 053.0
2018–19	97.0	97.0	117.0	1 070.6	1 070.7	1 161.7
2019–20	94.5	97.0	117.0	1 017.5	1 129.6	1 220.6
2020–21	107.8	106.2	126.2	1 301.8	1 191.7	1 282.7
2021–22	–	106.2	126.2	–	1 191.7	1 282.7

Table 2: Recreational catch information for CRA 7 and CRA 8 collected by the 2011–12 and 2017–18 National Panel survey.

Survey year	Fishers (n)	Events (n)	Harvest (n)	CV	Mean Wgt (kg)	Harvest (t)
CRA 7						
2011 ¹	1	1	357	1.03	0.64	0.23
2017 ²	1	1	82	1.00	1.12	0.09
CRA 8						
2011 ¹	7	19	5 153	0.60	1.34	6.93
2017 ²	25	62	24 732	0.36	0.65	16.17

¹ from Wynne-Jones et al. (2014), table 60.

² from Wynne-Jones et al. (2019), table 57.

Table 3: Section 111 catches used in the CRA 7&8 stock assessment, based on Destination “F” landing data provided by Fisheries New Zealand (replug 13890).

	Maximum section 111 (kg)	Year of maximum
CRA 7	1 688	2009
CRA 8	16 621	2020

Table 4: CRA 7 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 before 1979.

Calendar Year	Com- mercial Annual	Recre- ational Annual	Illegal Annual	Cus- tomary Annual	Fishing Year	Commercial		Recreational		Illegal		Customary	
						AW	SS	AW	SS	AW	SS	AW	SS
1945	38.4	2.7	39.5	1.0	1979	301.9	101.5	0.7	6.0	39.9	13.4	0.1	0.9
1946	32.6	2.8	39.5	1.0	1980	231.1	66.6	0.7	6.0	35.8	10.3	0.1	0.9
1947	32.2	2.9	39.5	1.0	1981	216.2	50.8	0.7	6.0	31.2	7.3	0.1	0.9
1948	36.7	3.0	39.5	1.0	1982	92.2	37.3	0.7	6.0	19.2	7.8	0.1	0.9
1949	99.7	3.2	39.5	1.0	1983	76.0	33.2	0.7	6.0	15.6	6.8	0.1	0.9
1950	141.0	3.3	39.5	1.0	1984	144.7	47.0	0.7	6.0	21.4	6.9	0.1	0.9
1951	179.6	3.4	39.5	1.0	1985	247.8	72.1	0.7	6.0	28.2	8.2	0.1	0.9
1952	243.7	3.5	39.5	1.0	1986	222.1	105.0	0.7	6.0	27.4	12.9	0.1	0.9
1953	432.6	3.6	39.5	1.0	1987	222.3	73.5	0.7	6.0	25.0	8.3	0.1	0.9
1954	711.1	3.7	39.5	1.0	1988	129.6	84.2	0.7	6.0	13.5	8.7	0.1	0.9
1955	813.5	3.9	39.5	1.0	1989	56.2	45.2	0.7	6.0	11.9	9.6	0.1	0.9
1956	904.9	4.0	39.5	1.0	1990	97.2	36.1	0.7	6.0	0.6	0.2	0.1	0.9
1957	717.5	4.1	39.5	1.0	1991	175.7	2.0	0.7	6.0	2.1	0.0	0.1	0.9
1958	615.0	4.2	39.5	1.0	1992	91.0	40.6	0.7	6.0	0.5	0.2	0.1	0.9
1959	529.4	4.3	39.5	1.0	1993	126.9	11.2	0.7	6.0	0.7	0.1	0.1	0.9
1960	481.1	4.5	39.5	1.0	1994	110.0	10.3	0.7	6.0	0.6	0.1	0.1	0.9
1961	482.9	4.6	39.5	1.0	1995	73.6	7.7	0.7	6.0	0.4	0.0	0.1	0.9
1962	536.0	4.7	39.5	1.0	1996	47.4	15.5	0.7	6.0	0.4	0.1	0.1	0.9
1963	557.1	4.8	39.5	1.0	1997	23.9	12.1	0.7	6.0	0.3	0.1	0.1	0.9
1964	520.6	4.9	39.5	1.0	1998	39.6	19.0	0.7	6.0	0.3	0.2	0.1	0.9
1965	493.7	5.0	39.5	1.0	1999	37.3	19.1	0.7	6.0	0.3	0.1	0.1	0.9
1966	677.0	5.2	39.5	1.0	2000	62.9	24.4	0.7	6.0	0.4	0.2	0.1	0.9
1967	515.8	5.3	39.5	1.0	2001	61.8	15.1	0.7	6.0	0.6	0.1	0.1	0.9
1968	672.7	5.4	39.5	1.0	2002	73.5	15.0	0.7	6.0	0.9	0.2	0.1	0.9
1969	644.6	5.5	39.5	1.0	2003	62.2	19.2	0.7	6.0	0.8	0.3	0.1	0.9
1970	597.5	5.6	39.5	1.0	2004	84.1	10.1	0.7	6.0	1.3	0.2	0.1	0.9
1971	384.4	5.7	39.5	1.0	2005	93.6	1.3	0.7	6.0	2.5	0.0	0.1	0.9
1972	195.5	5.9	39.5	1.0	2006	114.5	5.7	0.7	6.0	3.0	0.1	0.1	0.9
1973	518.0	6.0	39.5	1.0	2007	106.5	13.6	0.7	6.0	2.4	0.3	0.1	0.9
1974	391.0	6.1	39.5	1.0	2008	98.5	21.7	0.7	6.0	2.7	0.6	0.1	0.9
1975	288.0	6.2	39.5	1.0	2009	76.2	60.3	0.7	6.0	0.9	0.7	0.1	0.9
1976	262.0	6.3	39.5	1.0	2010	45.0	29.8	0.7	6.0	0.7	0.5	0.1	0.9
1977	275.0	6.5	39.5	1.0	2011	37.0	8.6	0.7	6.0	0.8	0.2	0.1	0.9
1978 ¹	435.8	6.6	39.5	1.0	2012	36.9	16.9	0.7	6.0	0.8	0.4	0.1	0.9
					2013	42.7	1.3	0.7	6.0	3.5	0.1	0.1	0.9
					2014	47.1	18.9	0.7	6.0	2.2	0.9	0.1	0.9
					2015	65.8	31.8	0.7	6.0	2.2	1.0	0.1	0.9
					2016	62.8	34.8	0.7	6.0	2.4	1.3	0.1	0.9
					2017	57.2	55.5	0.7	6.0	1.5	1.5	0.1	0.9
					2018	55.1	41.9	0.7	6.0	2.7	2.1	0.1	0.9
					2019	58.7	35.8	0.7	6.0	2.4	1.4	0.1	0.9
					2020	59.2	48.6	0.7	6.0	2.1	1.7	0.1	0.9

¹ includes January-March 1979 catches

Table 5: CRA 8 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 before 1979.

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	163.9	20.6	181.2	6.0	1979	545.7	1 179.9	3.7	33.0	82.0	177.3	0.6	5.4
1946	139.2	21.1	181.2	6.0	1980	433.7	1 029.7	3.7	33.0	65.8	156.2	0.6	5.4
1947	137.5	21.6	181.2	6.0	1981	528.8	866.9	3.7	33.0	83.5	136.8	0.6	5.4
1948	156.7	22.0	181.2	6.0	1982	523.3	979.1	3.7	33.0	64.6	120.9	0.6	5.4
1949	426.0	22.5	181.2	6.0	1983	371.8	1 153.0	3.7	33.0	32.0	99.3	0.6	5.4
1950	602.7	23.0	181.2	6.0	1984	598.6	950.7	3.7	33.0	48.9	77.7	0.6	5.4
1951	767.5	23.4	181.2	6.0	1985	883.1	982.5	3.7	33.0	72.2	80.3	0.6	5.4
1952	1 041.8	23.9	181.2	6.0	1986	531.2	1 068.8	3.7	33.0	43.3	87.2	0.6	5.4
1953	1 849.1	24.4	181.2	6.0	1987	535.2	1 130.1	3.7	33.0	45.1	95.2	0.6	5.4
1954	3 039.2	24.9	181.2	6.0	1988	242.0	805.7	3.7	33.0	22.8	76.0	0.6	5.4
1955	3 476.9	25.3	181.2	6.0	1989	429.7	820.4	3.7	33.0	30.1	57.5	0.6	5.4
1956	3 867.9	25.8	181.2	6.0	1990	241.7	592.8	3.7	33.0	1.9	4.6	0.6	5.4
1957	3 066.9	26.3	181.2	6.0	1991	265.5	697.2	3.7	33.0	1.7	4.5	0.6	5.4
1958	2 628.6	26.7	181.2	6.0	1992	283.3	593.2	3.7	33.0	1.7	3.6	0.6	5.4
1959	2 262.7	27.2	181.2	6.0	1993	472.1	424.0	3.7	33.0	4.3	3.9	0.6	5.4
1960	2 056.1	27.7	181.2	6.0	1994	394.7	461.0	3.7	33.0	3.1	3.6	0.6	5.4
1961	2 064.2	28.2	181.2	6.0	1995	337.2	488.5	3.7	33.0	2.9	4.2	0.6	5.4
1962	2 291.0	28.6	181.2	6.0	1996	324.6	537.8	3.7	33.0	2.4	3.9	0.6	5.4
1963	2 778.8	29.1	181.2	6.0	1997	293.8	491.8	3.7	33.0	2.0	3.4	0.6	5.4
1964	2 330.4	29.6	181.2	6.0	1998	244.1	564.0	3.7	33.0	1.5	3.5	0.6	5.4
1965	2 483.9	30.0	181.2	6.0	1999	326.4	383.4	3.7	33.0	2.6	3.1	0.6	5.4
1966	2 637.3	30.5	181.2	6.0	2000	392.1	311.3	3.7	33.0	3.9	3.1	0.6	5.4
1967	2 046.0	31.0	181.2	6.0	2001	311.8	260.2	3.7	33.0	4.2	3.5	0.6	5.4
1968	1 938.0	31.4	181.2	6.0	2002	315.7	251.4	3.7	33.0	5.3	4.2	0.6	5.4
1969	1 862.1	31.9	181.2	6.0	2003	451.5	116.1	3.7	33.0	10.2	2.6	0.6	5.4
1970	2 276.7	32.4	181.2	6.0	2004	463.8	139.2	3.7	33.0	12.0	3.6	0.6	5.4
1971	2 411.8	32.9	181.2	6.0	2005	514.3	88.9	3.7	33.0	15.0	2.6	0.6	5.4
1972	1 777.9	33.3	181.2	6.0	2006	657.5	97.4	3.7	33.0	18.6	2.8	0.6	5.4
1973	2 003.9	33.8	181.2	6.0	2007	606.2	146.2	3.7	33.0	18.0	4.3	0.6	5.4
1974	1 533.0	34.3	181.2	6.0	2008	859.9	106.0	3.7	33.0	23.3	2.9	0.6	5.4
1975	1 453.0	34.7	181.2	6.0	2009	710.3	308.0	3.7	33.0	17.5	7.6	0.6	5.4
1976	1 680.0	35.2	181.2	6.0	2010	758.4	259.9	3.7	33.0	17.4	5.9	0.6	5.4
1977	1 463.0	35.7	181.2	6.0	2011	637.1	324.1	3.7	33.0	15.5	7.9	0.6	5.4
1978 ¹	1 852.6	36.2	181.2	6.0	2012	582.2	378.6	3.7	33.0	14.9	9.7	0.9	8.1
					2013	635.1	329.5	3.7	33.0	16.8	8.7	1.2	10.8
					2014	498.8	463.2	3.7	33.0	13.3	12.4	1.5	13.5
					2015	417.4	544.4	3.7	33.0	10.3	13.5	1.5	13.5
					2016	471.1	490.9	3.7	33.0	13.4	14.0	1.5	13.5
					2017	618.1	343.8	3.7	33.0	21.4	11.9	1.5	13.5
					2018	634.3	436.3	3.7	33.0	20.7	14.2	1.5	13.5
					2019	704.6	312.9	3.7	33.0	22.1	9.8	1.5	13.5
					2020	713.0	588.8	3.7	33.0	17.5	14.4	1.5	13.5

¹ includes January-March 1979 catches

Table 6: Data availability by time period for CRA 7&8 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 7&8 (QMA) data availability	CRA 7&8 (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 area definitions
1986–1988	QMR estimates	FSU area definitions
1989–2000	QMR estimates	CELR (=FSU) area definitions
2001–2020	MHR estimates	CELR (=FSU) area definitions

Table 7: Mapping of Annala & King (1983) statistical areas into the New Zealand rock lobster statistical areas. CRA 7&8 statistical areas are marked with *.

FSU/CELR rock lobster statistical area	Annala/King statistical area				
	Area 16	Area 17	Area 18	Area 19	Area 20 + 21
920*	x				
921*		x			
922*			x		
923*			x		
924*			x		
925*			x		
926*				x	
927*					x
928*					x
929					x

Table 8: Percent distribution between adjacent rock lobster statistical areas in the Annala & King (1983) area groupings identified in Table 7.

Fishing year	Area 16	Area 17	Area 18				Area 19	Area 20 + 21		
	920	921	922	923	924	925	926	927	928	929
1979	1	1	0.046	0.312	0.631	0.010	1	0.515	0.465	0.020
1980	1	1	0.027	0.256	0.689	0.029	1	0.537	0.456	0.007
1981	1	1	0.035	0.278	0.643	0.044	1	0.551	0.440	0.009
1982	1	1	0.038	0.266	0.670	0.026	1	0.631	0.360	0.009
1983	1	1	0.030	0.290	0.637	0.042	1	0.589	0.408	0.003
Mean	1	1	0.035	0.281	0.654	0.030	1	0.565	0.426	0.010

Table 9: Proportions by CRA 7&8 region as calculated using the regional definitions based on Annala & King (1983) areas defined in Section 3.1.2. The final two columns are the sums of annual catch based on the Annala & King (1983) regional definitions.

Calendar year	region 1	region 2	$\sum_{a=1}^4 k_y^a$	C_y^{CRA8}
1963	0.407	0.593	3 319	3 336
1964	0.521	0.479	2 840	2 851
1965	0.499	0.501	2 967	2 978
1966	0.544	0.456	3 304	3 314
1967	0.521	0.479	2 553	2 562
1968	0.574	0.426	2 603	2 611
1969	0.546	0.454	2 498	2 507
1970	0.651	0.349	2 866	2 874
1971	0.503	0.497	2 786	2 796
1972	0.385	0.615	1 964	1 973
1973	0.503	0.497	2 512	2 522
Mean	0.514	0.486	—	—

Table 10: Interpolated proportions by CRA 7&8 region linking the Annala & King (1983) proportions (Table 8) to the FSU data which began in 1979–80.

Calendar year	region 1	region 2
1973	0.503	0.497
1974	0.506	0.494
1975	0.508	0.492
1976	0.511	0.489
1977	0.513	0.487
1978	0.516	0.484
1979	0.519	0.481

Table 11: Back calculated (based on mean distribution from 1963–1967–Table 8) proportions by CRA 7&8 region .

Calendar year	region 1	region 2
1945–1962	0.498	0.502

Table 12: Catches (tonnes) (commercial, recreational including section 111, illegal, and customary) for the CRA 7&8 region 1 (statistical areas 920+921+922+923+924+925), provided annually before 1979 (January–March 1979 added to 1978) and seasonally (AW and SS) from 1979 to 2020.

Calendar Year	Com- mercial Annual	Recre- ational Annual	Illegal Annual	Cus- tomary Annual	Year	Commercial		Recreational		Illegal		Customary	
						AW	SS	AW	SS	AW	SS	AW	SS
1945	100.8	11.6	110.0	3.5	1979	558.7	545.3	2.3	20.2	82.0	80.0	0.4	3.3
1946	85.6	11.9	110.0	3.5	1980	456.4	489.2	2.3	20.9	69.5	74.5	0.4	3.4
1947	84.5	12.2	110.0	3.5	1981	488.8	375.1	2.3	20.3	76.1	58.4	0.4	3.3
1948	96.3	12.5	110.0	3.5	1982	314.9	373.4	1.8	16.4	41.0	48.6	0.3	2.7
1949	261.9	12.8	110.0	3.5	1983	216.1	426.3	1.7	15.3	20.3	40.1	0.3	2.5
1950	370.6	13.1	110.0	3.5	1984	373.5	337.0	1.8	15.9	33.2	30.0	0.3	2.6
1951	471.9	13.4	110.0	3.5	1985	595.8	348.3	1.9	16.8	51.5	30.1	0.3	2.7
1952	640.5	13.7	110.0	3.5	1986	443.4	511.7	2.2	19.3	39.3	45.4	0.4	3.1
1953	1 136.8	14.0	110.0	3.5	1987	495.1	494.9	2.2	19.7	43.8	43.8	0.4	3.2
1954	1 868.5	14.3	110.0	3.5	1988	244.7	417.7	2.3	20.5	23.5	40.1	0.4	3.3
1955	2 137.6	14.5	110.0	3.5	1989	198.9	292.2	1.6	14.2	16.1	23.6	0.3	2.3
1956	2 378.0	14.8	110.0	3.5	1990	180.4	209.9	1.8	15.7	1.4	1.6	0.3	2.5
1957	1 885.6	15.1	110.0	3.5	1991	245.1	192.4	1.7	15.0	1.8	1.4	0.3	2.4
1958	1 616.1	15.4	110.0	3.5	1992	164.6	197.7	1.6	14.0	1.0	1.2	0.3	2.3
1959	1 391.2	15.7	110.0	3.5	1993	304.0	117.0	1.8	15.9	2.7	1.0	0.3	2.6
1960	1 264.1	16.0	110.0	3.5	1994	252.4	145.9	1.8	15.9	1.9	1.1	0.3	2.6
1961	1 269.1	16.3	110.0	3.5	1995	179.4	115.2	1.4	12.7	1.5	1.0	0.2	2.1
1962	1 408.6	16.6	110.0	3.5	1996	151.2	130.2	1.3	11.9	1.1	1.0	0.2	1.9
1963	1 356.5	13.8	89.7	2.9	1997	106.3	97.9	1.1	9.7	0.8	0.7	0.2	1.6
1964	1 484.6	18.0	114.9	3.7	1998	95.9	116.2	1.1	9.5	0.6	0.8	0.2	1.5
1965	1 485.7	17.5	110.1	3.5	1999	118.0	93.4	1.2	10.8	0.9	0.8	0.2	1.7
1966	1 802.4	19.4	120.0	3.8	2000	149.7	84.1	1.3	11.5	1.5	0.8	0.2	1.9
1967	1 334.9	18.9	115.0	3.7	2001	112.7	70.4	1.2	11.0	1.5	0.9	0.2	1.8
1968	1 498.6	21.2	126.7	4.0	2002	110.4	80.7	1.3	11.4	1.8	1.3	0.2	1.8
1969	1 368.1	20.4	120.4	3.8	2003	135.1	52.6	1.3	11.3	2.9	1.1	0.2	1.8
1970	1 871.8	24.8	143.7	4.6	2004	154.7	60.1	1.3	12.0	3.8	1.5	0.2	1.9
1971	1 406.3	19.4	111.0	3.5	2005	177.4	23.3	1.2	11.2	5.1	0.7	0.2	1.8
1972	760.6	15.1	85.1	2.7	2006	221.4	34.3	1.3	11.4	6.2	1.0	0.2	1.8
1973	1 268.5	20.0	111.0	3.5	2007	202.4	59.8	1.3	11.7	5.8	1.7	0.2	1.9
1974	972.7	20.4	111.6	3.5	2008	232.6	50.7	1.1	10.2	6.3	1.4	0.2	1.6
1975	884.7	20.8	112.1	3.6	2009	172.0	125.9	1.1	10.1	4.0	2.9	0.2	1.6
1976	991.9	21.2	112.7	3.6	2010	135.9	80.9	0.9	7.7	3.1	1.8	0.1	1.3
1977	892.2	21.6	113.3	3.6	2011	104.4	60.5	0.7	6.4	2.5	1.5	0.1	1.0
1978	1 180.7	22.0	113.9	3.6	2012	113.6	71.4	0.8	7.1	2.9	1.8	0.2	1.4
					2013	110.4	39.2	0.6	5.8	3.2	1.1	0.1	1.3
					2014	117.5	65.8	0.8	7.0	3.3	1.8	0.2	1.8
					2015	106.2	117.4	0.9	8.2	2.7	3.0	0.2	2.1
					2016	163.5	90.0	1.0	9.3	4.8	2.6	0.3	2.4
					2017	155.2	98.9	1.0	9.2	5.2	3.3	0.3	2.3
					2018	148.3	101.2	0.9	8.3	5.0	3.4	0.2	2.1
					2019	181.8	95.1	1.1	9.7	5.8	3.1	0.3	2.5
					2020	196.0	136.4	1.0	9.2	5.0	3.5	0.3	2.3

Table 13: Catches (tonnes) (commercial, recreational including section 111, illegal, and customary) for the CRA 7&8 region 2 (statistical areas 926+927+928), provided annually before 1979 (January–March 1979 added to 1978) and seasonally (AW and SS) from 1979 to 2020.

Calendar Year	Commercial Annual	Recreational Annual	Illegal Annual	Customary Annual	Year	Commercial		Recreational		Illegal		Customary	
						AW	SS	AW	SS	AW	SS	AW	SS
1945	101.5	11.7	110.7	3.5	1979	288.3	736.7	2.1	18.8	42.3	108.2	0.3	3.0
1946	86.2	12.0	110.7	3.5	1980	208.4	607.2	2.0	18.1	31.7	92.4	0.3	2.9
1947	85.1	12.3	110.7	3.5	1981	256.2	542.6	2.1	18.7	39.9	84.5	0.3	3.0
1948	97.0	12.6	110.7	3.5	1982	300.5	643.0	2.5	22.5	39.1	83.7	0.4	3.6
1949	263.7	12.9	110.7	3.5	1983	231.7	759.9	2.6	23.7	21.8	71.5	0.4	3.8
1950	373.2	13.2	110.7	3.5	1984	369.8	660.7	2.6	23.1	32.9	58.8	0.4	3.7
1951	475.2	13.5	110.7	3.5	1985	535.9	705.5	2.5	22.1	46.3	61.0	0.4	3.6
1952	645.1	13.8	110.7	3.5	1986	311.4	660.6	2.2	19.7	27.6	58.6	0.4	3.2
1953	1 144.9	14.1	110.7	3.5	1987	263.5	707.6	2.1	19.3	23.3	62.6	0.4	3.1
1954	1 881.7	14.4	110.7	3.5	1988	152.4	446.8	2.1	18.5	14.6	42.9	0.3	3.0
1955	2 152.7	14.7	110.7	3.5	1989	333.6	526.9	2.8	24.8	26.9	42.6	0.5	4.0
1956	2 394.8	14.9	110.7	3.5	1990	187.1	390.4	2.6	23.3	1.4	3.0	0.4	3.8
1957	1 898.9	15.2	110.7	3.5	1991	217.3	485.7	2.7	24.0	1.6	3.5	0.4	3.9
1958	1 627.5	15.5	110.7	3.5	1992	242.8	403.0	2.8	25.0	1.5	2.5	0.5	4.0
1959	1 401.0	15.8	110.7	3.5	1993	314.8	298.4	2.6	23.1	2.8	2.6	0.4	3.7
1960	1 273.0	16.1	110.7	3.5	1994	274.8	302.8	2.6	23.1	2.0	2.3	0.4	3.7
1961	1 278.0	16.4	110.7	3.5	1995	254.1	358.3	2.9	26.3	2.1	3.0	0.5	4.3
1962	1 418.5	16.7	110.7	3.5	1996	215.6	428.4	3.0	27.1	1.6	3.1	0.5	4.4
1963	1 979.5	20.1	130.9	4.2	1997	223.3	394.2	3.3	29.3	1.6	2.8	0.5	4.7
1964	1 366.3	16.5	105.8	3.4	1998	202.0	452.6	3.3	29.4	1.3	2.9	0.5	4.8
1965	1 491.9	17.6	110.6	3.5	1999	253.6	301.3	3.1	28.2	2.0	2.4	0.5	4.6
1966	1 511.9	16.3	100.7	3.2	2000	318.6	238.1	3.1	27.5	3.1	2.3	0.5	4.4
1967	1 227.0	17.4	105.7	3.4	2001	278.6	187.4	3.1	28.0	3.6	2.4	0.5	4.5
1968	1 112.1	15.7	94.0	3.0	2002	283.1	181.5	3.1	27.6	4.6	2.9	0.5	4.5
1969	1 138.7	17.0	100.2	3.2	2003	361.7	99.7	3.1	27.7	7.7	2.1	0.5	4.5
1970	1 002.4	13.3	77.0	2.4	2004	388.2	94.1	3.0	27.0	9.5	2.3	0.5	4.4
1971	1 389.9	19.2	109.7	3.5	2005	395.0	102.5	3.1	27.8	11.4	3.0	0.5	4.5
1972	1 212.8	24.1	135.6	4.3	2006	502.9	116.5	3.1	27.6	14.1	3.3	0.5	4.5
1973	1 253.4	19.8	109.7	3.5	2007	472.2	138.1	3.0	27.3	13.5	4.0	0.5	4.4
1974	951.3	20.0	109.1	3.5	2008	686.4	116.6	3.2	28.8	18.7	3.2	0.5	4.7
1975	856.3	20.1	108.5	3.4	2009	606.9	250.1	3.2	28.9	14.1	5.8	0.5	4.7
1976	950.1	20.3	108.0	3.4	2010	654.0	222.3	3.5	31.3	14.7	5.0	0.6	5.1
1977	845.8	20.5	107.4	3.4	2011	555.9	286.1	3.6	32.6	13.5	6.9	0.6	5.3
1978	1 107.7	20.7	106.8	3.4	2012	497.4	332.2	3.5	31.9	12.6	8.4	0.7	6.1
					2013	529.1	329.9	3.7	33.2	15.3	9.5	0.8	7.4
					2014	422.0	422.6	3.6	32.0	11.8	11.8	0.9	8.1
					2015	363.4	472.3	3.4	30.8	9.3	12.1	0.9	7.8
					2016	414.4	391.7	3.3	29.7	12.1	11.5	0.8	7.5
					2017	506.4	314.1	3.3	29.8	17.1	10.6	0.8	7.6
					2018	509.9	408.2	3.4	30.7	17.4	13.9	0.9	7.8
					2019	562.5	272.6	3.3	29.3	18.1	8.8	0.8	7.4
					2020	610.8	466.5	3.3	29.8	15.5	11.8	0.8	7.6

Table 14: Number of vessel / statistical area / month records in the dataset used to calculate the CRA 7&8 region 1 seasonal CPUE time series for both the FSU and CELR data sets. Data are provided by statistical area, fishing year (designated by the first year of the pair), and 6-month season.

Fishing year	Autumn–Winter							Spring–Summer						
	920	921	922	923	924	925	Total	920	921	922	923	924	925	Total
FSU data														
1979	252	162	15	104	177	2	712	184	85	24	151	272	5	721
1980	221	128	9	103	170	1	632	171	63	22	132	260	9	657
1981	231	133	20	90	162	–	636	146	48	11	116	220	12	553
1982	184	109	24	63	159	4	543	107	50	24	89	208	9	487
1983	169	95	16	81	130	6	497	113	46	23	121	233	13	549
1984	186	96	21	73	142	3	521	113	41	13	90	194	16	467
1985	191	91	6	85	140	6	519	129	56	7	95	173	10	470
1986	170	75	12	65	119	10	451	117	57	12	115	182	4	487
1987	146	55	18	58	125	1	403	118	52	15	97	182	2	466
1988	111	60	11	65	80	2	329	74	32	16	94	136	9	361
1989	35	10	1	18	18	–	82	–	–	–	–	–	–	–
Total	1 896	1 014	153	805	1 422	35	5 325	1 272	530	167	1 100	2 060	89	5 218
CELR data														
1989	–	–	–	–	–	–	–	61	11	1	27	74	2	176
1990	93	18	5	10	43	3	172	72	20	7	36	95	13	243
1991	87	18	6	23	43	6	183	14	1	8	36	81	11	151
1992	87	12	3	20	49	4	175	70	9	4	31	96	7	217
1993	98	12	3	21	56	11	201	16	3	3	15	48	10	95
1994	99	7	3	13	57	16	195	38	2	3	21	61	28	153
1995	81	16	2	16	31	16	162	32	3	2	23	46	20	126
1996	73	9	2	11	35	13	143	29	5	3	21	44	13	115
1997	66	20	2	21	27	9	145	19	9	3	27	38	11	107
1998	54	20	–	17	24	5	120	22	6	–	26	39	8	101
1999	51	11	–	28	26	9	125	20	6	1	29	28	11	95
2000	54	18	–	12	26	2	112	23	12	–	17	29	4	85
2001	60	24	–	4	24	4	116	25	13	1	7	23	–	69
2002	71	14	3	4	23	5	120	18	6	1	5	19	1	50
2003	57	6	3	7	19	3	95	22	4	–	6	15	–	47
2004	39	9	3	8	17	1	77	7	5	1	16	16	2	47
2005	27	7	2	10	14	2	62	3	2	1	7	5	–	18
2006	31	12	5	5	21	–	74	9	2	1	5	10	–	27
2007	37	7	6	5	27	2	84	9	4	1	10	23	3	50
2008	25	5	5	2	33	2	72	5	5	2	6	13	–	31
2009	35	13	3	4	31	–	86	20	11	1	5	30	1	68
2010	27	15	3	1	32	1	79	15	6	1	1	24	–	47
2011	30	17	–	–	36	1	84	12	8	–	–	21	2	43
2012	23	11	–	–	48	4	86	8	5	–	1	27	3	44
2013	16	9	–	–	24	1	50	4	5	–	3	15	–	27
2014	23	9	–	2	24	2	60	12	7	–	5	21	1	46
2015	20	5	–	1	19	1	46	10	1	–	2	36	4	53
2016	21	8	–	3	20	–	52	14	3	–	–	24	–	41
2017	13	8	–	–	16	–	37	13	7	–	–	23	1	44
2018	19	6	–	1	32	1	59	10	1	–	1	17	–	29
2019	6	3	–	–	13	–	22	–	–	–	–	–	–	–
Total	1 423	349	59	249	890	124	3 094	632	182	45	389	1 041	156	2 445

Table 15: Number of vessel / statistical area / month records in the dataset used to calculate the CRA 7&8 region 2 seasonal CPUE time series for both the FSU and CELR data sets. Data are provided by statistical area, fishing year (designated by the first year of the pair), and 6-month season.

Fishing year	Autumn–Winter				Spring–Summer			
	926	927	928	Total	926	927	928	Total
FSU data								
1979	107	129	123	359	182	216	223	621
1980	109	101	72	282	185	162	201	548
1981	108	72	46	226	190	100	155	445
1982	153	96	64	313	230	166	164	560
1983	151	115	53	319	266	162	175	603
1984	153	109	53	315	237	202	180	619
1985	168	145	69	382	187	198	164	549
1986	131	133	66	330	221	167	168	556
1987	108	95	47	250	217	151	142	510
1988	91	50	30	171	137	73	92	302
1989	20	21	14	55	—	—	—	—
Total	1 299	1 066	637	3 002	2 052	1 597	1 664	5 313
CELR data								
1989	—	—	—	—	122	92	40	254
1990	62	53	25	140	136	94	70	300
1991	85	74	57	216	130	94	112	336
1992	84	61	68	213	130	95	119	344
1993	95	73	64	232	106	89	106	301
1994	95	77	72	244	98	93	85	276
1995	68	78	69	215	93	90	82	265
1996	76	63	74	213	95	82	100	277
1997	89	74	90	253	122	81	127	330
1998	57	51	77	185	95	69	134	298
1999	69	56	46	171	81	69	79	229
2000	85	50	34	169	79	72	48	199
2001	82	37	39	158	53	31	31	115
2002	92	50	45	187	60	28	34	122
2003	96	38	38	172	42	14	29	85
2004	99	40	45	184	42	11	15	68
2005	93	33	42	168	30	8	12	50
2006	85	52	41	178	34	13	7	54
2007	84	43	43	170	41	17	7	65
2008	65	49	51	165	22	16	10	48
2009	61	39	69	169	40	24	32	96
2010	81	44	69	194	47	14	18	79
2011	95	41	62	198	62	22	23	107
2012	104	30	62	196	66	17	39	122
2013	80	44	49	173	59	30	20	109
2014	66	34	40	140	64	23	31	118
2015	71	32	34	137	69	40	32	141
2016	69	41	32	142	64	23	23	110
2017	58	20	28	106	45	19	17	81
2018	56	25	34	115	45	19	27	91
2019	42	13	27	82	—	—	—	—
Total	2 344	1 415	1 526	5 285	2 172	1 389	1 509	5 070

Table 16: Seasonal standardised CPUE index series used in the CRA 7&8 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.

Fishing year	region 1 (920–925)				region 2 (926+927+928)			
	Autumn-Winter		Spring-Summer		Autumn-Winter		Spring-Summer	
	Standardised Index	Standard Error	Standardised Index	Standard Error	Standardised Index	Standard Error	Standardised Index	Standard Error
FSU data								
1979–80	1.712	0.142	1.587	0.137	1.431	0.110	1.882	0.108
1980–81	1.754	0.138	1.244	0.138	1.280	0.113	1.503	0.110
1981–82	1.491	0.142	1.298	0.139	1.261	0.116	1.463	0.110
1982–83	0.986	0.139	1.142	0.138	1.022	0.111	1.311	0.109
1983–84	0.677	0.140	0.840	0.137	0.719	0.115	1.137	0.109
1984–85	0.834	0.145	0.728	0.137	0.795	0.113	0.975	0.106
1985–86	1.238	0.141	0.947	0.140	0.932	0.111	1.002	0.109
1986–87	0.974	0.139	1.098	0.139	0.652	0.114	0.977	0.108
1987–88	1.012	0.146	1.072	0.135	0.687	0.115	1.020	0.111
1988–89	0.563	0.145	0.747	0.138	0.583	0.119	0.775	0.111
1989–90	0.392	0.164	–	–	0.654	0.132	–	–
CELR data								
1989–90	–	–	0.828	0.177	–	–	0.573	0.142
1990–91	0.530	0.175	0.634	0.162	0.416	0.153	0.521	0.146
1991–92	0.559	0.168	0.810	0.173	0.397	0.148	0.582	0.146
1992–93	0.401	0.174	0.606	0.168	0.346	0.149	0.428	0.146
1993–94	0.908	0.169	0.632	0.174	0.434	0.152	0.541	0.148
1994–95	0.562	0.169	0.526	0.173	0.400	0.150	0.540	0.149
1995–96	0.552	0.174	0.485	0.172	0.407	0.152	0.598	0.147
1996–97	0.434	0.175	0.476	0.168	0.346	0.149	0.628	0.149
1997–98	0.307	0.176	0.490	0.170	0.301	0.151	0.509	0.146
1998–99	0.298	0.175	0.457	0.176	0.295	0.148	0.535	0.148
1999–00	0.388	0.176	0.384	0.177	0.353	0.150	0.488	0.146
2000–01	0.469	0.183	0.585	0.183	0.433	0.151	0.550	0.148
2001–02	0.553	0.185	0.736	0.191	0.395	0.153	0.649	0.150
2002–03	0.591	0.174	1.110	0.185	0.471	0.153	0.859	0.151
2003–04	0.789	0.180	1.106	0.199	0.729	0.148	1.146	0.158
2004–05	1.011	0.184	1.672	0.190	0.776	0.153	1.394	0.158
2005–06	1.571	0.183	1.650	0.218	0.842	0.150	1.798	0.160
2006–07	1.695	0.181	1.746	0.205	1.106	0.154	2.809	0.163
2007–08	1.246	0.174	2.037	0.186	1.368	0.150	3.250	0.161
2008–09	1.333	0.188	2.166	0.196	1.941	0.152	3.257	0.162
2009–10	0.943	0.186	1.888	0.188	1.671	0.148	3.204	0.152
2010–11	0.980	0.193	1.304	0.202	1.352	0.152	2.872	0.154
2011–12	0.872	0.206	1.103	0.205	1.246	0.149	2.682	0.152
2012–13	0.863	0.199	1.447	0.198	1.325	0.149	3.118	0.152
2013–14	1.685	0.209	2.464	0.212	1.308	0.148	3.145	0.153
2014–15	2.026	0.192	2.135	0.195	1.240	0.153	2.935	0.155
2015–16	1.907	0.207	2.350	0.204	1.225	0.152	2.585	0.150
2016–17	2.569	0.205	2.245	0.228	1.350	0.154	3.028	0.153
2017–18	2.125	0.225	2.286	0.211	1.947	0.154	3.780	0.151
2018–19	2.631	0.205	3.061	0.232	1.960	0.151	3.884	0.154
2019–20	3.785	0.240	–	–	2.286	0.157	–	–

Table 17: Catch rate (kg/day) from the potlift and days fishing data in Annala & King (1983) calculated for region 1 (920+921+922+923+924+925) and for region 2 (926+927+928) calculated from the combined data for Annala & King (1983) areas 16–18 and 19–21 (see mapping of statistical areas in Table 7).

Calendar year	region 1	region 2
1963	114.5	324.8
1964	100.7	215.1
1965	106.7	179.9
1966	128.5	151.0
1967	108.5	149.7
1968	108.4	120.6
1969	90.9	104.0
1970	106.4	107.3
1971	79.4	112.0
1972	50.3	87.2
1973	67.2	97.0

Table 18: Sampling intensity by fishing year and season in CRA 7&8 region 1 (920+921+922+923+924+925) by the logbook and observer catch sampling programme from 1987 to 2020. “Lobsters” are the number of samples measured. Samples marked in grey were dropped from the stock assessment ‘–’: no data. [Continued on next page]

Fishing year	Logbooks				Observer catch sampling			
	N fishers	Days	Potlifts	Lobsters	N vessels	Days	Potlifts	Lobsters
Season=AW								
1987	–	–	–	–	4	8	698	3 204
1988	–	–	–	–	3	8	706	2 014
1989	–	–	–	–	5	9	701	1 128
1990	–	–	–	–	4	8	744	2 825
1991	–	–	–	–	5	9	907	4 289
1992	–	–	–	–	3	9	803	4 091
1993	11	335	971	8 469	6	8	539	2 605
1994	14	290	873	5 998	7	12	1 474	4 980
1995	16	332	972	6 504	7	15	1 657	3 801
1996	10	283	885	6 377	10	18	1 867	2 156
1997	8	136	376	2 775	8	21	1 960	3 891
1998	6	96	260	1 639	3	9	902	2 113
1999	4	30	62	639	10	19	1 985	6 429
2000	5	70	198	2 047	8	16	1 648	7 231
2001 ¹	11	276	708	4 085	9	17	1 659	7 202
2002 ¹	7	151	414	3 174	8	13	1 426	4 169
2003 ¹	5	123	261	2 645	5	10	1 310	4 672
2004	3	49	114	1 341	7	10	1 088	5 420
2005	5	108	219	3 032	6	15	1 551	7 475
2006	3	75	176	2 530	7	14	1 249	7 056
2007	4	103	238	2 716	6	14	1 150	6 682
2008	5	91	287	2 871	6	9	734	3 873
2009	4	30	269	2 035	6	7	630	2 408
2010	2	22	76	441	5	10	705	2 949
2011	2	35	101	918	4	6	708	1 820
2012	–	–	–	–	6	9	978	2 565
2013	1	10	23	349	6	14	879	4 255
2014	2	21	72	944	5	9	575	2 854
2015	1	5	18	259	3	6	468	2 715
2016	–	–	–	–	7	7	744	2 036
2017	5	73	184	2 450	3	3	243	953
2018	5	109	321	3 987	5	10	1 059	5 781
2019 ²	5	82	255	3 762	4	7	835	3 691
2020 ²	3	53	168	2 629	5	8	753	3 982
Total	–	2 988	8 501	74 616	196	367	35 335	133 315

Fishing year	Logbooks				Observer catch sampling			
	N fishers	Days	Potlifts	Lobsters	N vessels	Days	Potlifts	Lobsters
Season=SS								
1987	—	—	—	—	3	6	498	1 372
1988	—	—	—	—	6	12	804	1 849
1989	—	—	—	—	6	8	541	1 478
1990	—	—	—	—	4	9	743	3 108
1991	—	—	—	—	2	6	490	2 373
1992	—	—	—	—	6	7	650	1 350
1993	11	93	261	3 725	2	2	139	865
1994	13	285	809	4 473	7	8	540	1 753
1995	15	345	943	5 649	8	10	727	534
1996	10	213	632	3 946	11	22	2 097	3 258
1997	6	73	170	1 252	5	9	594	2 526
1998	6	70	178	1 534	5	15	1 343	4 484
1999	1	1	1	2	2	8	699	487
2000	4	101	242	2 951	5	10	831	2 197
2001	4	78	206	1 953	6	10	571	2 211
2002	4	62	142	1 854	2	2	169	845
2003	2	14	21	285	3	5	369	1 732
2004	2	28	65	1 076	2	5	589	1 723
2005	1	1	4	41	—	—	—	—
2006	2	19	70	281	1	1	58	354
2007	2	13	36	333	1	1	49	121
2008	2	1	8	80	5	6	601	2 824
2009	4	16	76	901	7	8	655	2 640
2010	—	—	—	—	5	7	510	733
2011	1	11	35	206	5	9	578	914
2012	—	—	—	—	3	6	542	1 103
2013	—	—	—	—	1	1	73	71
2014	1	4	15	331	4	6	457	1 260
2015	—	—	—	—	5	9	566	2 008
2016	—	—	—	—	3	8	670	1 864
2017	1	1	4	35	6	12	1 309	4 791
2018	2	8	24	326	3	6	653	2 718
2019 ²	2	21	56	748	3	8	749	3 413
2020 ²	2	17	40	706	4	7	597	3 123
Total	—	1 475	4 038	32 688	141	249	20 461	62 082

¹ CRA 7 logbook AW data for 2001, 2002, and 2003 removed because of inconsistency with other CRA 7 data (see 0). These data consisted of 301 days fishing, 802 potlifts, and 3989 lobsters measured, collected over three years by up to six fishers.

² The region 1 2019 and 2020 data for both seasons were inadvertently omitted during the preparation of the length frequency input file due to a data processing error; consequently these data were not used in the stock assessment.

Table 19: Sampling intensity by fishing year and season in CRA 7&8 region 2 (926+927+928) by the logbook and observer catch sampling programme from 1989 to 2020. “Lobsters” are the number of samples measured. ‘-’: no data. [Continued on next page]

Fishing year	Logbooks				Observer catch sampling			
	N fishers	Days	Potlifts	Lobsters	N vessels	Days	Potlifts	Lobsters
Season=AW								
1989	—	—	—	—	3	8	879	4 421
1990	—	—	—	—	3	24	2 974	12 980
1991	—	—	—	—	3	24	2 659	15 183
1992	—	—	—	—	3	21	2 491	12 043
1993	25	672	2 424	15 115	4	25	2 578	10 547
1994	24	606	2 047	11 685	5	22	2 727	16 629
1995	44	1 026	3 326	15 610	3	22	2 121	8 735
1996	30	716	2 347	7 774	8	37	4 269	14 923
1997	29	910	3 114	9 223	4	12	1 279	5 809
1998	24	577	1 934	9 185	—	—	—	—
1999	16	422	1 487	6 672	—	—	—	—
2000	22	691	2 256	12 159	6	10	1 395	3 691
2001	14	360	1 388	5 672	—	—	—	—
2002	12	574	2 067	10 466	4	9	1 090	5 411
2003	15	575	2 012	13 981	—	—	—	—
2004	14	607	2 130	12 471	—	—	—	—
2005	12	517	2 004	12 895	—	—	—	—
2006	13	613	2 315	17 341	—	—	—	—
2007	12	393	1 667	14 973	—	—	—	—
2008	13	429	1 639	17 535	—	—	—	—
2009	11	390	1 487	15 689	—	—	—	—
2010	15	712	2 936	25 213	10	16	1 661	8 784
2011	12	621	2 517	22 692	—	—	—	—
2012	15	621	2 378	22 619	—	—	—	—
2013	11	476	1 877	18 225	—	—	—	—
2014	14	560	2 174	20 433	—	—	—	—
2015	10	413	1 576	16 238	—	—	—	—
2016	13	604	1 836	17 171	—	—	—	—
2017	15	659	2 031	26 193	—	—	—	—
2018	16	759	2 215	25 899	—	—	—	—
2019	14	352	1 156	16 699	—	—	—	—
2020	12	541	1 439	20 780	—	—	—	—
Total	—	16 396	57 779	440 608	56	230	26 123	119 156

Fishing year	Logbooks				Observer catch sampling			
	N fishers	Days	Potlifts	Lobsters	N vessels	Days	Potlifts	Lobsters
Season=SS								
1989	—	—	—	—	5	29	3 032	12 937
1990	—	—	—	—	3	33	3 636	14 915
1991	—	—	—	—	4	30	3 415	18 062
1992	—	—	—	—	3	31	3 834	15 712
1993	18	493	1 608	10 344	4	25	2 467	9 975
1994	30	705	2 258	11 023	3	27	2 850	9 264
1995	38	1 211	3 884	17 160	3	32	3 594	9 855
1996	29	921	2 983	10 353	10	30	3 711	17 052
1997	26	896	2 918	8 171	4	22	1 875	6 677
1998	23	949	3 115	9 422	—	—	—	—
1999	12	336	1 120	4 159	—	—	—	—
2000	17	435	1 480	3 884	—	—	—	—
2001	12	247	958	2 470	—	—	—	—
2002	10	160	690	3 318	—	—	—	—
2003	7	69	247	1 285	—	—	—	—
2004	4	20	141	878	—	—	—	—
2005	6	42	158	1 162	—	—	—	—
2006	6	58	227	2 280	—	—	—	—
2007	8	66	294	3 212	—	—	—	—
2008	6	34	181	2 185	—	—	—	—
2009	8	68	282	4 147	—	—	—	—
2010	7	54	193	1 780	2	3	306	1 547
2011	9	92	448	4 530	—	—	—	—
2012	12	139	542	8 360	—	—	—	—
2013	10	173	670	9 631	—	—	—	—
2014	12	218	842	12 256	—	—	—	—
2015	14	428	1 356	14 694	—	—	—	—
2016	11	224	671	10 565	—	—	—	—
2017	15	262	773	11 749	—	—	—	—
2018	15	222	745	13 007	—	—	—	—
2019	8	66	161	2 975	—	—	—	—
2020	13	267	757	12 911	—	—	—	—
Total	—	8 855	29 702	197 911	42	267	29 134	120 193

Table 20: Number of lobsters measured by fishing year, sex, and season for CRA 7&8 region 1 (920+921+922+923+924+925) by the logbook and observer catch sampling programmes from 1987–2020. Samples marked in grey were dropped from the stock assessment. ‘–’: no data. [Continued on next page]

Fishing year	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1987	–	–	–	–	238	252	10	500
1988	–	–	–	–	902	1 090	5	1 997
1989	–	–	–	–	450	628	36	1 114
1990	–	–	–	–	1 383	1 387	27	2 797
1991	–	–	–	–	2 033	2 081	106	4 220
1992	–	–	–	–	2 321	1 703	41	4 065
1993	4 099	3 959	397	8 455	1 209	1 365	20	2 594
1994	3 182	2 013	803	5 998	2 523	2 365	43	4 931
1995	3 467	2 453	580	6 500	1 869	1 851	52	3 772
1996	3 439	2 564	374	6 377	1 132	978	29	2 139
1997	1 212	1 294	269	2 775	1 924	1 897	64	3 885
1998	881	739	19	1 639	1 107	1 005	1	2 113
1999	314	251	74	639	2 971	3 103	352	6 426
2000	707	1 026	130	1 863	3 310	3 827	86	7 223
2001	1 038	1 096	142	2 276	3 556	3 402	235	7 193
2002	959	1 003	144	2 106	2 264	1 891	12	4 167
2003	606	864	69	1 539	2 566	2 091	13	4 670
2004	510	449	182	1 141	2 977	2 428	14	5 419
2005	1 266	1 306	406	2 978	4 114	3 348	13	7 475
2006	1 091	1 270	169	2 530	3 919	3 078	49	7 046
2007	1 112	1 175	378	2 665	3 601	3 044	36	6 681
2008	1 215	939	170	2 324	2 200	1 642	29	3 871
2009	468	517	160	1 145	1 520	806	80	2 406
2010	200	181	13	394	1 308	1 014	626	2 948
2011	438	439	41	918	980	782	26	1 788
2012	–	–	–	–	1 311	1 196	58	2 565
2013	197	148	4	349	2 360	1 873	21	4 254
2014	497	261	186	944	1 605	1 208	41	2 854
2015	120	1	138	259	1 513	1 190	10	2 713
2016	–	–	–	–	1 009	991	35	2 035
2017	1 416	603	431	2 450	508	411	34	953
2018	2 285	849	852	3 986	3 090	2 580	111	5 781
2019	2 474	524	762	3 760	2 281	1 322	87	3 690
2020	1 608	500	518	2 626	2 321	1 523	138	3 982
Total	34 801	26 424	7 411	68 636	68 375	59 352	2 540	130 267

Fishing year	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=SS								
1987	—	—	—	—	484	568	304	1 356
1988	—	—	—	—	789	985	58	1 832
1989	—	—	—	—	589	797	64	1 450
1990	—	—	—	—	1 125	1 442	463	3 030
1991	—	—	—	—	1 129	1 130	75	2 334
1992	—	—	—	—	607	662	65	1 334
1993	1 655	1 590	471	3 716	372	484	1	857
1994	2 181	1 486	804	4 471	755	931	54	1 740
1995	2 564	2 064	1 019	5 647	239	261	31	531
1996	1 881	1 677	388	3 946	1 413	1 315	514	3 242
1997	514	638	99	1 251	1 070	1 128	310	2 508
1998	771	727	36	1 534	1 731	2 251	463	4 445
1999	—	1	1	2	139	90	258	487
2000	1 259	1 530	162	2 951	823	826	545	2 194
2001	844	927	175	1 946	1 032	1 116	63	2 211
2002	711	1 047	95	1 853	406	418	21	845
2003	116	160	9	285	811	879	42	1 732
2004	451	603	22	1 076	794	865	64	1 723
2005	18	17	6	41	—	—	—	—
2006	147	42	92	281	161	191	2	354
2007	156	128	49	333	74	46	1	121
2008	29	18	3	50	1 413	1 306	105	2 824
2009	298	323	109	730	1 173	912	555	2 640
2010	—	—	—	—	203	190	340	733
2011	96	102	8	206	374	288	252	914
2012	—	—	—	—	361	346	396	1 103
2013	—	—	—	—	35	31	5	71
2014	159	109	63	331	606	510	144	1 260
2015	—	—	—	—	1 046	685	277	2 008
2016	—	—	—	—	839	700	325	1 864
2017	18	16	1	35	2 132	1 869	789	4 790
2018	136	17	173	326	1 409	1 037	272	2 718
2019	408	132	206	746	1 763	1 105	545	3 413
2020	414	241	51	706	1 732	986	404	3 122
Total	14 826	13 595	4 042	32 463	27 629	26 350	7 807	61 786

Table 21: Sample weights calculated for each LF sampling record described for CRA 7&8 region 1 (920+921+922+923+924+925) in Table 20. Samples marked in grey were dropped from the stock assessment. ‘-’: no data. [Continued on next page]

Fishing year Season=AW	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
1987	—	—	—	—	0.890	0.942	0.037	1.869
1988	—	—	—	—	2.193	2.443	0.011	4.647
1989	—	—	—	—	1.536	2.123	0.158	3.816
1990	—	—	—	—	2.245	2.205	0.059	4.509
1991	—	—	—	—	2.272	2.443	0.079	4.794
1992	—	—	—	—	3.088	2.618	0.096	5.802
1993	19.607	18.157	1.038	38.802	2.680	3.472	0.059	6.211
1994	19.883	12.556	6.832	39.272	2.815	3.174	0.090	6.079
1995	18.059	15.616	1.470	35.145	3.092	3.033	0.080	6.206
1996	13.227	11.071	1.147	25.445	2.314	2.203	0.078	4.596
1997	9.942	10.725	1.862	22.529	3.040	3.440	0.099	6.578
1998	3.808	3.629	0.078	7.515	0.966	0.843	0.001	1.809
1999	1.078	0.863	0.256	2.197	4.190	4.138	0.288	8.615
2000	1.697	2.538	0.291	4.527	5.339	5.391	0.186	10.916
2001	2.023	2.136	0.238	4.397	4.536	4.328	0.201	9.065
2002	2.469	2.046	0.860	5.375	1.632	1.350	0.011	2.993
2003	3.279	2.834	0.356	6.469	0.811	0.663	0.006	1.480
2004	1.891	1.794	0.204	3.888	1.169	0.894	0.004	2.067
2005	3.084	2.790	0.308	6.181	1.679	1.391	0.007	3.077
2006	1.481	1.713	0.185	3.379	1.957	1.604	0.030	3.592
2007	1.819	2.090	0.392	4.301	2.430	2.102	0.025	4.558
2008	2.204	1.693	0.289	4.186	1.021	0.816	0.019	1.855
2009	0.798	0.891	0.251	1.940	0.677	0.409	0.029	1.115
2010	0.631	0.568	0.041	1.241	0.793	0.659	0.661	2.112
2011	0.731	0.772	0.058	1.562	0.143	0.112	0.004	0.259
2012	—	—	—	—	0.287	0.268	0.014	0.569
2013	0.495	0.368	0.010	0.872	0.718	0.585	0.005	1.308
2014	1.329	0.587	0.527	2.443	0.734	0.558	0.020	1.311
2015	0.050	0.000	0.058	0.109	0.575	0.455	0.004	1.033
2016	—	—	—	—	0.924	0.949	0.032	1.904
2017	1.564	0.928	0.358	2.849	0.209	0.169	0.014	0.392
2018	1.713	0.703	0.673	3.090	1.684	1.352	0.064	3.100
2019	1.511	0.286	0.557	2.354	0.553	0.318	0.022	0.893
2020	1.095	0.438	0.194	1.727	0.912	0.532	0.057	1.502
Total	115.469	97.793	18.535	231.797	60.102	57.983	2.547	120.633

Fishing year	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=SS								
1987	—	—	—	—	0.745	0.875	0.465	2.085
1988	—	—	—	—	2.427	2.728	0.066	5.221
1989	—	—	—	—	1.244	1.700	0.168	3.112
1990	—	—	—	—	1.496	1.742	0.415	3.653
1991	—	—	—	—	0.860	0.863	0.056	1.779
1992	—	—	—	—	0.928	1.111	0.059	2.098
1993	12.165	11.514	1.301	24.980	0.123	0.160	0.000	0.284
1994	18.016	12.436	6.238	36.691	1.570	2.128	0.111	3.808
1995	10.343	10.628	2.486	23.457	1.237	1.361	0.147	2.745
1996	5.083	4.733	0.901	10.717	2.268	2.150	0.795	5.212
1997	1.909	3.791	0.195	5.895	0.852	1.047	0.307	2.206
1998	1.551	1.536	0.417	3.504	1.598	2.326	0.575	4.498
1999	—	0.038	0.038	0.076	0.113	0.071	0.212	0.396
2000	1.962	2.387	0.263	4.612	2.157	1.384	1.542	5.082
2001	2.033	2.232	0.430	4.694	2.193	2.168	0.193	4.554
2002	4.252	5.222	1.198	10.673	0.373	0.419	0.030	0.822
2003	0.950	1.524	0.244	2.718	0.925	0.962	0.077	1.963
2004	2.554	3.707	0.341	6.602	0.338	0.398	0.025	0.761
2005	0.123	0.116	0.041	0.281	—	—	—	—
2006	0.042	0.029	0.011	0.082	0.057	0.068	0.001	0.126
2007	0.575	0.508	0.140	1.222	0.065	0.040	0.001	0.105
2008	0.183	0.114	0.019	0.316	2.315	2.147	0.161	4.623
2009	0.881	0.953	0.327	2.161	1.394	1.084	0.719	3.197
2010	—	—	—	—	0.246	0.240	0.538	1.024
2011	0.404	0.429	0.034	0.867	0.092	0.059	0.131	0.283
2012	—	—	—	—	0.142	0.132	0.226	0.499
2013	—	—	—	—	0.003	0.003	0.000	0.006
2014	0.225	0.154	0.089	0.468	0.179	0.149	0.056	0.384
2015	—	—	—	—	0.327	0.224	0.060	0.610
2016	—	—	—	—	0.120	0.095	0.044	0.259
2017	0.106	0.094	0.006	0.206	1.030	0.934	0.253	2.217
2018	0.120	0.008	0.187	0.315	0.304	0.240	0.063	0.607
2019	0.506	0.043	0.371	0.920	0.751	0.469	0.250	1.471
2020	0.815	0.472	0.120	1.407	0.606	0.340	0.158	1.105
Total	64.799	62.667	15.399	142.865	29.079	29.817	7.901	66.797

Table 22: Number of lobsters measured by fishing year, sex, and season for CRA 7&8 region 2 (926+927+928) by the logbook and observer catch sampling programmes from 1989–2020. ‘–’: no data. [Continued on next page]

Fishing year Season=AW	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
1989	–	–	–	–	1 464	1 256	1 660	4 380
1990	–	–	–	–	6 097	4 684	2 080	12 861
1991	–	–	–	–	6 870	4 139	4 069	15 078
1992	–	–	–	–	5 580	2 326	4 036	11 942
1993	7 358	3 419	3 959	14 736	4 736	3 050	2 665	10 451
1994	5 187	2 920	3 152	11 259	7 512	4 698	4 267	16 477
1995	6 481	3 664	5 043	15 188	3 003	1 711	3 973	8 687
1996	3 338	1 952	2 221	7 511	5 755	5 193	3 850	14 798
1997	2 820	1 782	4 272	8 874	1 400	1 426	2 950	5 776
1998	3 766	2 688	2 731	9 185	–	–	–	–
1999	2 803	2 150	1 528	6 481	–	–	–	–
2000	5 378	4 486	2 198	12 062	1 919	1 200	558	3 677
2001	2 213	1 626	1 389	5 228	–	–	–	–
2002	4 453	2 719	2 862	10 034	2 782	1 583	1 034	5 399
2003	6 067	3 822	3 280	13 169	–	–	–	–
2004	5 791	2 816	2 955	11 562	–	–	–	–
2005	5 597	2 375	3 274	11 246	–	–	–	–
2006	6 793	1 770	6 115	14 678	–	–	–	–
2007	6 279	943	4 125	11 347	–	–	–	–
2008	7 575	1 056	6 877	15 508	–	–	–	–
2009	6 529	739	7 269	14 537	–	–	–	–
2010	8 934	810	12 183	21 927	3 480	131	5 163	8 774
2011	6 965	1 008	12 424	20 397	–	–	–	–
2012	6 303	968	13 645	20 916	–	–	–	–
2013	5 251	1 221	10 170	16 642	–	–	–	–
2014	7 212	1 565	10 757	19 534	–	–	–	–
2015	6 476	1 730	7 008	15 214	–	–	–	–
2016	7 557	1 311	8 167	17 035	–	–	–	–
2017	12 608	1 836	11 717	26 161	–	–	–	–
2018	11 023	1 203	11 880	24 106	–	–	–	–
2019	8 509	1 235	6 777	16 521	–	–	–	–
2020	10 057	868	9 766	20 691	–	–	–	–
Total	179 323	54 682	177 744	411 749	50 598	31 397	36 305	118 300

Fishing year	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=SS								
1989	—	—	—	—	5 093	5 099	2 575	12 767
1990	—	—	—	—	6 513	4 922	3 340	14 775
1991	—	—	—	—	7 012	4 776	6 130	17 918
1992	—	—	—	—	7 265	4 015	4 253	15 533
1993	4 419	3 139	2 526	10 084	4 096	2 366	3 383	9 845
1994	4 476	3 058	3 189	10 723	3 829	2 133	3 177	9 139
1995	6 435	4 125	6 366	16 926	3 585	1 958	4 243	9 786
1996	3 419	2 189	4 455	10 063	5 380	5 950	5 586	16 916
1997	2 202	1 219	4 640	8 061	1 915	2 219	2 504	6 638
1998	3 189	2 108	4 059	9 356	—	—	—	—
1999	1 572	1 196	1 357	4 125	—	—	—	—
2000	1 578	957	1 263	3 798	—	—	—	—
2001	903	390	1 044	2 337	—	—	—	—
2002	1 023	783	961	2 767	1 356	1 928	902	4 186
2003	480	355	315	1 150	—	—	—	—
2004	215	94	122	431	—	—	—	—
2005	496	194	322	1 012	—	—	—	—
2006	968	271	715	1 954	—	—	—	—
2007	1 117	342	1 236	2 695	—	—	—	—
2008	679	175	933	1 787	—	—	—	—
2009	1 115	313	2 313	3 741	—	—	—	—
2010	742	95	943	1 780	623	275	644	1 542
2011	1 348	338	1 857	3 543	—	—	—	—
2012	2 326	695	4 751	7 772	—	—	—	—
2013	2 599	664	5 901	9 164	—	—	—	—
2014	4 230	1 134	6 349	11 713	—	—	—	—
2015	5 692	1 190	7 222	14 104	—	—	—	—
2016	5 146	1 809	3 276	10 231	—	—	—	—
2017	5 704	1 121	4 662	11 487	—	—	—	—
2018	5 263	1 042	6 351	12 656	—	—	—	—
2019	1 399	229	1 289	2 917	—	—	—	—
2020	5 630	528	6 253	12 411	—	—	—	—
Total	74 365	29 753	84 670	188 788	46 667	35 641	36 737	119 045

Table 23: Sample weights calculated for each LF sampling record described for CRA 7&8 region 2 (926+927+928) in Table 22. ‘-’: no data. [Continued on next page]

Fishing year	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1989	—	—	—	—	1.752	1.380	2.588	5.719
1990	—	—	—	—	12.809	10.311	5.125	28.244
1991	—	—	—	—	9.381	5.892	5.426	20.699
1992	—	—	—	—	11.400	4.725	7.886	24.011
1993	38.186	18.109	22.374	78.668	10.643	6.696	5.467	22.806
1994	27.893	15.141	23.075	66.109	10.198	5.986	7.342	23.526
1995	41.301	22.222	35.710	99.233	7.739	4.494	8.492	20.724
1996	28.329	17.074	28.571	73.974	10.674	8.047	13.198	31.919
1997	28.297	20.362	41.101	89.759	4.060	3.909	11.325	19.294
1998	36.239	25.682	29.995	91.917	—	—	—	—
1999	30.588	20.833	25.723	77.144	—	—	—	—
2000	50.388	40.737	21.667	112.793	3.497	2.412	1.271	7.180
2001	24.369	17.985	16.638	58.992	—	—	—	—
2002	35.072	21.416	24.707	81.196	4.003	2.343	1.369	7.714
2003	46.226	30.009	29.327	105.562	—	—	—	—
2004	43.052	22.679	25.116	90.847	—	—	—	—
2005	28.200	12.597	19.312	60.109	—	—	—	—
2006	29.403	8.230	28.749	66.382	—	—	—	—
2007	24.429	4.535	16.075	45.039	—	—	—	—
2008	31.660	4.044	25.022	60.725	—	—	—	—
2009	26.210	3.959	27.688	57.857	—	—	—	—
2010	37.802	3.114	46.778	87.694	2.914	0.081	3.876	6.872
2011	27.851	4.699	45.100	77.649	—	—	—	—
2012	26.143	4.019	52.910	83.072	—	—	—	—
2013	20.188	5.803	41.194	67.185	—	—	—	—
2014	26.343	6.723	40.607	73.673	—	—	—	—
2015	31.153	8.497	32.470	72.120	—	—	—	—
2016	33.052	5.754	37.600	76.406	—	—	—	—
2017	45.447	6.614	42.472	94.533	—	—	—	—
2018	43.934	5.207	46.120	95.261	—	—	—	—
2019	34.747	4.921	21.693	61.362	—	—	—	—
2020	36.941	2.802	37.084	76.828	—	—	—	—
Total	933.443	363.770	884.879	2182.092	89.069	56.276	73.363	218.708

Fishing year	Logbooks				Observer catch sampling			
	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=SS								
1989	—	—	—	—	4.234	3.466	2.612	10.311
1990	—	—	—	—	9.599	6.587	6.047	22.233
1991	—	—	—	—	9.880	6.135	7.473	23.488
1992	—	—	—	—	9.758	5.133	6.154	21.045
1993	24.211	15.465	18.338	58.015	7.961	3.815	8.430	20.206
1994	26.336	15.222	26.909	68.468	6.174	3.178	5.761	15.113
1995	43.779	23.092	52.071	118.942	8.845	3.968	15.236	28.049
1996	29.064	15.941	47.324	92.330	7.760	6.704	16.437	30.901
1997	22.540	13.202	45.420	81.161	5.176	4.467	12.848	22.491
1998	25.311	13.141	39.509	77.961	—	—	—	—
1999	15.382	9.463	17.410	42.255	—	—	—	—
2000	18.708	10.216	15.865	44.788	—	—	—	—
2001	12.743	5.638	13.938	32.319	—	—	—	—
2002	8.289	6.206	7.534	22.029	1.830	2.602	1.217	5.649
2003	6.377	6.461	4.427	17.264	—	—	—	—
2004	1.131	0.822	0.217	2.170	—	—	—	—
2005	2.999	1.556	0.863	5.418	—	—	—	—
2006	5.644	1.390	3.981	11.014	—	—	—	—
2007	7.321	2.200	6.793	16.314	—	—	—	—
2008	6.930	1.885	8.446	17.261	—	—	—	—
2009	5.857	1.484	12.646	19.987	—	—	—	—
2010	3.850	0.612	6.666	11.128	0.813	0.359	0.840	2.012
2011	7.447	1.851	13.103	22.402	—	—	—	—
2012	8.696	2.388	25.451	36.535	—	—	—	—
2013	17.802	4.325	36.663	58.789	—	—	—	—
2014	24.901	7.140	20.722	52.763	—	—	—	—
2015	31.786	6.558	37.562	75.906	—	—	—	—
2016	27.167	9.937	17.306	54.410	—	—	—	—
2017	27.031	5.209	21.593	53.834	—	—	—	—
2018	21.891	4.521	24.718	51.131	—	—	—	—
2019	9.899	1.372	8.298	19.570	—	—	—	—
2020	21.422	1.670	27.183	50.276	—	—	—	—
Total	464.516	188.968	560.956	1214.439	72.029	46.414	83.054	201.497

Table 24: Bin limits by sex category and CRA 7&8 region used when fitting the length frequency data in the stock assessment model. The bin limits are determined from the distributions plotted for in Figure 25, selecting the tail width interval where the proportion of records with length observations drops to low levels.

	Bin number				TW (mm)			
	region 1		region 2		region 1		region 2	
	lower	upper	lower	upper	lower	upper	lower	upper
males	2	34	4	34	32	96	36	96
immature females	2	22	5	19	32	72	38	66
mature females	7	36	9	32	42	100	46	92

Table 25: 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 2020 CRA 4 assessment (Starr et al. 2021a).

Project ID	Previous	Current	Difference
CRA_Akaroa	227	227	–
CRA_CCampb	44	44	–
CRA_Gis70s	2 240	2 240	–
CRA_Gisb	48	48	–
CRA_ReefPt	573	573	–
CRA_StewIs	1 614	1 614	–
CRA01Gisb	1 179	1 179	–
CRA1_TAG	1 591	1 622	31
CRA2_EBOP	5	5	–
CRA2_TAG	4 359	4 694	335
CRA2_WBOP	268	268	–
CRA3_TAG	2 058	2 110	52
CRA4_TAG	3 115	3 132	17
CRA4_Wair	10	10	–
CRA5_Kaik	1 176	1 176	–
CRA5_TAG	5 911	6 082	171
CRA6_TAG	181	219	38
CRA7_TAG	646	678	32
CRA7rs	200	200	–
CRA8_Fiord	1 714	1 714	–
CRA8_TAG	7 189	7 223	34
CRA8rs	233	233	–
CRA9_TAG	126	127	1
Total	34 707	35 418	711

Table 26: 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 2020 CRA 4 stock assessment (Starr et al. 2021a).

Year	Previous	Current	Difference	Year	Previous	Current	Difference
1966	53	53	–	1997	2 565	2 562	- 3
1967	28	28	–	1998	2 945	2 945	–
1968	7	7	–	1999	2 486	2 486	–
1969	2	2	–	2000	1 587	1 585	- 2
1971	1	1	–	2001	1 377	1 377	–
1975	115	115	–	2002	1 572	1 572	–
1976	1 268	1 268	–	2003	1 121	1 121	–
1977	2 091	2 091	–	2004	2 079	2 079	–
1978	886	886	–	2005	2 389	2 389	–
1979	1 081	1 081	–	2006	978	975	- 3
1980	1 112	1 112	–	2007	488	481	- 7
1981	593	593	–	2008	366	366	–
1982	332	332	–	2009	304	304	–
1983	273	273	–	2010	237	237	–
1984	1 071	1 071	–	2011	548	548	–
1985	394	394	–	2012	333	425	92
1986	76	76	–	2013	484	510	26
1987	18	18	–	2014	764	777	13
1988	4	4	–	2015	855	875	20
1989	2	2	–	2016	514	524	10
1991	1	1	–	2017	372	565	193
1992	1	1	–	2018	306	362	56
1994	39	39	–	2019	94	145	51
1995	72	72	–	2020	–	239	239
1996	423	423	–	2021	–	26	26
				Total	34 707	35 418	711

Table 27: Number of tags released, including tags that were never recaptured, compared with the number and proportion recaptured by QMA.

QMA	Number released	Number recaptured	Number not recaptured	Proportion recaptured
CRA 1	19 073	2 210	16 863	0.116
CRA 2	28 932	5 478	23 454	0.189
CRA 3	41 969	5 000	36 969	0.119
CRA 4	42 673	3 088	39 585	0.072
CRA 5	43 799	7 584	36 215	0.173
CRA 6	8 809	219	8 590	0.025
CRA 7	11 408	868	10 540	0.076
CRA 8	36 164	10 793	25 371	0.298
CRA 9	6 630	178	6 452	0.027

Table 28: 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	958	1 252	2 210
CRA 2	3 106	2 372	5 478
CRA 3	3 665	1 335	5 000
CRA 4	2 414	674	3 088
CRA 5	5 240	2 344	7 584
CRA 6	43	176	219
CRA 7	412	456	868
CRA 8	5 903	4 890	10 793
CRA 9	36	142	178
Total	21 777	13 641	35 418

Table 29: 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									Total
QMA	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	
CRA 1	2 180	—	30	—	—	—	—	—	—	2 210
CRA 2	1	5 473	4	—	—	—	—	—	—	5 478
CRA 3	—	8	4 929	10	1	—	—	52	—	5 000
CRA 4	—	—	1	3 085	2	—	—	—	—	3 088
CRA 5	—	—	—	15	7 563	—	6	—	—	7 584
CRA 6	—	—	—	—	—	219	—	—	—	219
CRA 7	—	—	6	—	—	—	833	29	—	868
CRA 8	—	1	121	—	—	—	—	10 668	3	10 793
CRA 9	—	3	—	—	—	—	—	—	175	178
Total	2 181	5 485	5 091	3 110	7 566	219	839	10 749	178	35 418

Table 30: Number of tag recaptures by calendar year of release and sex for each CRA 7&8 statistical areas Unknown and 920–924. 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. [Continued on next page]

Release year	Release statistical area																	
	Unknown			920			921			922			923			924		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1965	–	–	–	34	25	59	–	–	–	–	–	–	–	–	–	–	–	–
1966	–	–	–	7	5	12	–	–	–	–	–	–	19	13	32	–	–	–
1967	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–	–	–	–
1968	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	1	6
1975	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	29	52	81
1976	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	545	397	942
1977	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	309	273	582
1978	3	3	6	–	–	–	–	–	–	–	–	–	5	6	11	2	1	3
1979	56	82	138	25	31	56	–	–	–	–	–	–	8	5	13	–	–	–
1980	54	104	158	29	19	48	–	–	–	–	–	–	2	3	5	–	–	–
1981	13	80	93	3	7	10	–	–	–	–	–	–	–	–	–	–	–	–
1982	32	94	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1983	1	6	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1984	1	30	31	–	–	–	–	–	–	3	2	5	–	–	–	–	–	–
1985	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1986	–	6	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1993	–	–	–	–	4	4	–	–	–	7	14	21	–	–	–	2	9	11
1994	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
1995	56	44	100	–	–	–	–	–	–	–	–	–	–	–	–	2	3	5
1996	79	63	142	–	–	–	–	–	–	3	1	4	–	–	–	–	–	–
1997	2	2	4	–	–	–	–	–	–	–	–	–	29	84	113	255	346	601
1998	–	1	1	–	–	–	–	–	–	–	–	–	15	22	37	57	75	132
1999	–	–	–	–	–	–	–	–	–	–	–	–	10	9	19	41	64	105
2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	11	27
2001	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	15	25
2002	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	4	9
2003	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
2004	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2005	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2006	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2007	–	–	–	87	129	216	1	–	1	–	–	–	–	–	–	–	–	–
2008	–	–	–	10	7	17	–	–	–	–	–	–	–	–	–	–	–	–
2009	–	–	–	3	–	3	1	–	1	–	–	–	–	–	–	–	–	–
2010	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2011	–	–	–	24	52	76	–	–	–	–	–	–	–	–	–	–	–	–
2012	–	–	–	98	107	205	6	15	21	–	–	–	–	–	–	–	–	–
2013	–	–	–	13	17	30	8	14	22	–	–	–	–	–	–	–	–	–
2014	–	–	–	–	–	–	2	–	2	–	–	–	–	–	–	–	–	–
2016	–	–	–	7	3	10	–	–	–	–	–	–	–	–	–	–	–	–
2017	–	–	–	28	6	34	–	–	–	–	–	–	–	–	–	–	–	–
2018	–	–	–	10	4	14	–	–	–	–	–	–	–	–	–	–	–	–
2019	–	–	–	14	10	24	–	–	–	–	–	–	15	8	23	–	–	–
2020	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2021	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	297	518	815	394	427	821	18	29	47	13	17	30	103	150	253	1 279	1 253	2 532

Table 30 (cont.): Number of tag recaptures by calendar year of release and sex for each CRA 7&8 statistical area and for combined CRA 7&8. 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 year	Release statistical area												CRA 7&8		
	925			926			927			928					
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1965	—	—	—	—	—	—	—	—	—	—	—	—	34	25	59
1966	—	—	—	—	—	—	—	—	—	—	—	—	26	18	44
1967	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2
1968	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
1974	—	—	—	—	—	—	—	—	—	—	—	—	5	1	6
1975	—	—	—	—	—	—	—	—	—	—	—	—	29	52	81
1976	—	—	—	—	—	—	—	—	—	—	—	—	545	397	942
1977	—	—	—	—	—	—	—	—	—	—	—	—	309	273	582
1978	—	—	—	—	—	—	130	169	299	—	—	—	140	179	319
1979	—	—	—	—	—	—	223	416	639	—	—	—	312	534	846
1980	—	—	—	—	—	—	—	1	1	—	—	—	85	127	212
1981	—	—	—	—	—	—	96	111	207	—	—	—	112	198	310
1982	—	—	—	—	—	—	—	—	—	—	—	—	32	94	126
1983	—	—	—	—	—	—	—	—	—	—	—	—	1	6	7
1984	—	—	—	27	26	53	—	—	—	—	—	—	31	58	89
1985	4	—	4	—	—	—	—	—	—	—	—	—	4	3	7
1986	—	—	—	—	—	—	—	—	—	—	—	—	—	6	6
1993	—	—	—	31	23	54	—	—	—	—	—	—	40	50	90
1994	—	—	—	4	2	6	1	2	3	—	—	—	5	6	11
1995	—	—	—	2	4	6	81	78	159	19	32	51	160	161	321
1996	—	—	—	1	1	2	—	—	—	5	8	13	88	73	161
1997	—	—	—	73	140	213	241	733	974	9	131	140	609	1 436	2 045
1998	6	8	14	226	134	360	370	352	722	44	33	77	718	625	1 343
1999	—	—	—	59	39	98	182	205	387	16	6	22	308	323	631
2000	—	—	—	6	1	7	106	129	235	3	2	5	131	143	274
2001	—	—	—	—	1	1	18	37	55	—	—	—	28	53	81
2002	—	—	—	3	1	4	19	38	57	—	1	1	27	44	71
2003	—	—	—	487	2	489	646	20	666	91	1	92	1 225	23	1 248
2004	—	2	2	117	1	118	374	17	391	48	—	48	539	20	559
2005	—	—	—	11	—	11	209	12	221	10	—	10	230	12	242
2006	—	—	—	—	—	—	125	10	135	5	1	6	130	11	141
2007	—	—	—	1	—	1	32	3	35	—	—	—	121	132	253
2008	—	—	—	—	—	—	23	4	27	1	—	1	34	11	45
2009	—	—	—	—	—	—	7	2	9	—	—	—	11	2	13
2010	—	—	—	—	1	1	3	1	4	—	—	—	3	2	5
2011	—	—	—	—	—	—	1	7	8	—	—	—	25	59	84
2012	—	—	—	—	—	—	—	1	1	—	—	—	104	123	227
2013	—	—	—	—	—	—	—	—	—	—	—	—	21	31	52
2014	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
2016	—	—	—	—	—	—	—	—	—	—	—	—	7	3	10
2017	—	—	—	—	—	—	—	—	—	—	—	—	28	6	34
2018	—	—	—	—	—	—	—	—	—	—	—	—	10	4	14
2019	—	—	—	7	1	8	—	—	—	—	—	—	36	19	55
2020	—	—	—	7	2	9	—	—	—	—	—	—	7	2	9
2021	—	—	—	1	—	1	—	—	—	—	—	—	1	—	1
Total	10	10	20	1 063	379	1 442	2 887	2 348	5 235	251	215	466	6 315	5 346	11 661

Table 31: Number of tag recaptures by calendar year of recovery and sex for each CRA 7&8 statistical areas Unknown and 920–924. 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. [Continued on next page]

Recovery year	Release statistical area																	
	Unknown			920			921			922			923			924		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1966	—	—	—	30	23	53	—	—	—	—	—	—	—	—	—	—	—	—
1967	—	—	—	3	2	5	—	—	—	—	—	—	15	11	26	—	—	—
1968	—	—	—	1	—	1	—	—	—	—	—	—	3	—	3	—	—	—
1969	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2	—	—	—
1970	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
1975	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	11	19
1976	—	—	—	9	6	15	—	—	—	—	—	—	—	—	—	282	147	429
1977	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	422	374	796
1978	1	—	1	—	—	—	—	—	—	—	—	—	—	1	1	158	163	321
1979	30	31	61	21	15	36	—	—	—	—	—	—	9	9	18	16	18	34
1980	55	71	126	18	26	44	—	—	—	—	—	—	4	1	5	3	6	9
1981	27	86	113	18	16	34	—	—	—	—	—	—	2	3	5	1	1	2
1982	36	107	143	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
1983	4	30	34	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
1984	6	51	57	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
1985	1	11	12	—	—	—	—	—	—	3	2	5	—	—	—	—	—	—
1986	—	15	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1987	—	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1988	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1989	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1991	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1992	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1993	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1994	—	—	—	—	2	2	—	—	—	5	6	11	—	—	—	—	4	4
1995	13	13	26	—	—	—	—	—	—	2	5	7	—	—	—	3	6	9
1996	96	69	165	—	2	2	—	—	—	—	2	2	—	—	—	1	—	1
1997	13	9	22	—	—	—	—	—	—	3	2	5	5	18	23	61	97	158
1998	10	16	26	—	—	—	—	—	—	—	—	—	29	63	92	195	249	444
1999	5	—	5	—	—	—	—	—	—	—	—	—	10	26	36	65	76	141
2000	—	2	2	—	—	—	—	—	—	—	—	—	7	1	8	33	49	82
2001	—	—	—	—	—	—	—	—	—	—	—	—	2	5	7	19	35	54
2002	—	1	1	—	—	—	—	—	—	—	—	—	1	—	1	8	10	18
2003	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	3
2004	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	2	1	3
2006	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
2007	—	—	—	53	97	150	—	—	—	—	—	—	—	—	—	—	—	—
2008	—	—	—	35	31	66	1	—	1	—	—	—	—	—	—	—	—	—
2009	—	—	—	9	8	17	1	—	1	—	—	—	—	—	—	—	—	—
2010	—	—	—	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—
2011	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2012	—	—	—	42	75	117	6	12	18	—	—	—	—	—	—	—	—	—
2013	—	—	—	68	76	144	7	16	23	—	—	—	—	—	—	—	—	—
2014	—	—	—	23	20	43	3	1	4	—	—	—	—	—	—	—	—	—
2016	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2017	—	—	—	9	3	12	—	—	—	—	—	—	—	—	—	—	—	—
2018	—	—	—	24	13	37	—	—	—	—	—	—	—	—	—	—	—	—
2019	—	—	—	26	12	38	—	—	—	—	—	—	—	—	—	—	—	—
2020	—	—	—	2	—	2	—	—	—	—	—	—	15	8	23	—	—	—
2021	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	297	518	815	394	427	821	18	29	47	13	17	30	103	150	253	1 279	1 253	2 532

Table 31 (cont.): Number of tag recaptures by calendar year of recovery and sex for each CRA 7&8 statistical area and for combined CRA 7&8. 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 year	Release statistical area												CRA 7&8		
	925			926			927			928					
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1966	—	—	—	—	—	—	—	—	—	—	—	—	30	23	53
1967	—	—	—	—	—	—	—	—	—	—	—	—	18	13	31
1968	—	—	—	—	—	—	—	—	—	—	—	—	4	—	4
1969	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2
1970	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
1975	—	—	—	—	—	—	—	—	—	—	—	—	8	11	19
1976	—	—	—	—	—	—	—	—	—	—	—	—	291	153	444
1977	—	—	—	—	—	—	—	—	—	—	—	—	422	374	796
1978	—	—	—	—	—	—	5	3	8	—	—	—	164	167	331
1979	—	—	—	—	—	—	146	187	333	—	—	—	222	260	482
1980	—	—	—	—	—	—	165	208	373	—	—	—	245	312	557
1981	—	—	—	—	—	—	37	102	139	—	—	—	85	208	293
1982	—	—	—	—	—	—	82	144	226	—	—	—	118	253	371
1983	—	—	—	—	—	—	7	20	27	—	—	—	11	51	62
1984	—	—	—	1	1	2	5	17	22	—	—	—	12	70	82
1985	—	—	—	26	22	48	1	9	10	—	—	—	31	44	75
1986	1	—	1	—	1	1	1	5	6	—	—	—	2	21	23
1987	—	—	—	—	—	—	—	1	1	—	—	—	—	7	7
1988	2	—	2	—	—	—	—	—	—	—	—	—	2	—	2
1989	—	—	—	—	1	1	—	1	1	—	—	—	—	2	2
1991	—	—	—	—	1	1	—	—	—	—	—	—	—	1	1
1992	1	—	1	—	—	—	—	—	—	—	—	—	1	—	1
1993	—	—	—	1	—	1	—	—	—	—	—	—	1	—	1
1994	—	—	—	15	8	23	—	1	1	—	—	—	20	21	41
1995	—	—	—	16	14	30	37	42	79	4	2	6	75	82	157
1996	—	—	—	5	3	8	38	30	68	11	20	31	151	126	277
1997	—	—	—	22	21	43	38	196	234	10	77	87	152	420	572
1998	—	—	—	65	93	158	336	490	826	23	77	100	658	988	1 646
1999	—	—	—	195	114	309	301	363	664	26	16	42	602	595	1 197
2000	2	—	2	52	36	88	183	223	406	18	7	25	295	318	613
2001	—	—	—	8	14	22	45	92	137	3	7	10	77	153	230
2002	—	—	—	9	7	16	28	62	90	1	3	4	47	83	130
2003	—	—	—	6	10	16	11	27	38	—	2	2	19	40	59
2004	2	5	7	449	15	464	664	28	692	110	—	110	1 225	48	1 273
2005	2	2	4	122	9	131	356	31	387	32	1	33	514	46	560
2006	—	—	—	37	3	40	241	21	262	10	3	13	288	28	316
2007	—	3	3	6	2	8	70	13	83	2	—	2	131	115	246
2008	—	—	—	8	—	8	51	6	57	—	—	—	95	37	132
2009	—	—	—	3	—	3	22	7	29	—	—	—	35	15	50
2010	—	—	—	2	1	3	11	2	13	1	—	1	17	3	20
2011	—	—	—	—	—	—	4	12	16	—	—	—	4	12	16
2012	—	—	—	—	—	—	1	4	5	—	—	—	49	91	140
2013	—	—	—	—	—	—	1	—	1	—	—	—	76	92	168
2014	—	—	—	—	—	—	—	—	—	—	—	—	26	21	47
2016	—	—	—	—	—	—	—	1	1	—	—	—	—	1	1
2017	—	—	—	—	—	—	—	—	—	—	—	—	9	3	12
2018	—	—	—	—	—	—	—	—	—	—	—	—	24	13	37
2019	—	—	—	1	—	1	—	—	—	—	—	—	27	12	39
2020	—	—	—	3	1	4	—	—	—	—	—	—	20	9	29
2021	—	—	—	11	2	13	—	—	—	—	—	—	11	2	13
Total	10	10	20	1 063	379	1 442	2 887	2 348	5 235	251	215	466	6 315	5 346	11 661

Table 32: Number of tag releases by sex and release month for CRA 7&8 by release statistical area and for all of CRA 7&8.

Release month	Release statistical area										CRA 7&8
	Unk	920	921	922	923	924	925	926	927	928	
Males											
Jan	30	1	—	—	—	8	10	3	163	2	217
Feb	62	8	—	—	—	34	—	1	356	21	482
Mar	13	1	—	—	7	1	—	1	62	5	90
Apr	—	4	—	—	6	—	—	1	82	—	93
May	—	52	—	—	—	43	—	3	114	6	218
Jun	1	60	1	—	—	—	—	9	253	24	348
Jul	1	49	13	—	—	1	—	49	202	30	345
Aug	6	41	2	3	28	609	—	114	509	41	1 353
Sep	16	154	2	—	19	150	—	130	260	8	739
Oct	74	24	—	7	16	163	—	544	63	5	896
Nov	57	—	—	3	21	250	—	46	697	94	1 168
Dec	37	—	—	—	6	20	—	162	126	15	366
Total	297	394	18	13	103	1 279	10	1 063	2 887	251	6 315
Females											
Jan	78	3	—	—	1	—	8	1	173	1	265
Feb	57	4	—	—	—	21	—	—	474	31	587
Mar	16	4	—	—	4	—	—	—	7	10	41
Apr	—	2	—	—	5	—	—	—	2	—	9
May	—	21	—	—	2	33	2	—	27	—	85
Jun	3	50	—	—	—	—	—	—	53	1	107
Jul	5	45	12	—	—	2	—	1	76	7	148
Aug	11	41	9	2	40	537	—	78	774	21	1 513
Sep	37	237	8	—	48	195	—	167	427	107	1 226
Oct	119	20	—	14	31	152	—	82	169	17	604
Nov	131	—	—	1	11	306	—	32	105	15	601
Dec	61	—	—	—	8	7	—	18	61	5	160
Total	518	427	29	17	150	1 253	10	379	2 348	215	5 346

Table 33: Number of tag recaptures by release and recovery statistical areas for CRA 7&8 releases, summed across all years. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

Release statistical area	Recovery statistical area														Total
	Unk	906	910	911	920	921	922	923	924	925	926	927	928	929	
Unknown	744	–	–	–	–	–	–	–	–	–	–	33	38	–	815
920	1	–	4	2	638	148	2	1	16	–	5	2	2	–	821
921	–	–	–	–	11	35	1	–	–	–	–	–	–	–	47
922	–	–	–	–	–	–	5	11	13	–	–	–	1	–	30
923	–	–	–	–	–	–	–	127	107	–	13	5	1	–	253
924	–	–	111	10	–	–	–	9	2 382	–	14	5	1	–	2 532
925	–	–	–	–	–	–	–	–	3	14	3	–	–	–	20
926	–	–	–	–	–	–	–	3	4	–	1 166	216	51	2	1 442
927	1 279	1	–	–	–	–	–	–	1	–	27	3 899	27	1	5 235
928	57	–	–	–	–	–	–	–	1	–	1	37	370	–	466
Total	2 081	1	115	12	649	183	8	151	2 527	14	1 229	4 197	491	3	11 661

Table 34: Days-at-liberty statistics for recaptures of CRA 7&8 releases. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

Release statistical area	Sex	N	Minimum	5%	Median	95%	Maximum
Unknown	Males	297	1	3	89	763	1 614
	Females	518	1	3	240	1 067	2 481
920	Males	394	2	10	322	861	3 644
	Females	427	1	13	305	742	3 652
921	Males	18	3	3	31	379	379
	Females	29	2	6	24	364	758
922	Males	13	304	304	365	736	736
	Females	17	334	334	419	1 506	1 506
923	Males	103	3	16	339	759	1 099
	Females	150	2	7	353	817	2 550
924	Males	1 279	1	10	284	721	2 236
	Females	1 253	1	9	333	790	3 485
925	Males	10	243	243	1 479	2 343	2 343
	Females	10	8	8	1 946	3 021	3 021
926	Males	1 063	1	9	300	990	3 473
	Females	379	1	11	396	2 148	3 260
927	Males	2 887	1	6	256	872	2 468
	Females	2 348	1	9	344	1 320	3 363
928	Males	251	1	7	250	651	1 455
	Females	215	1	4	253	1 005	2 908
CRA 7&8	Males	6 315	1	7	275	849	3 644
	Females	5 346	1	8	335	1 163	3 652

Table 35: Number of tag re-releases by sex for the CRA 7&8 release statistical areas 920, 921, 922, 923, and 924. Re-release event code = 0 means the first release-recapture event. [Continued on next page]

Re-release event	Release statistical area									
	920		921		922		923		924	
	N	Cum Prop	N	Cum Prop	N	Cum Prop	N	Cum Prop	N	Cum Prop
Males										
0	339	0.86	1	0.06	13	1.00	96	0.93	1 025	0.80
1	42	0.97	13	0.78	–	1.00	4	0.97	200	0.96
2	9	0.99	4	1.00	–	1.00	3	1.00	43	0.99
3	3	1.00	–	1.00	–	1.00	–	1.00	4	0.99
4	1	1.00	–	1.00	–	1.00	–	1.00	1	1.00
5	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
6	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
7	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
8	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
9	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
10	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
Females										
0	382	0.89	–	1.00	17	1.00	132	0.88	1 050	0.84
1	37	0.98	22	1.76	–	1.00	12	0.96	113	0.93
2	5	0.99	5	1.93	–	1.00	5	0.99	66	0.98
3	2	1.00	2	2.00	–	1.00	1	1.00	15	0.99
4	1	1.00	–	1.00	–	1.00	–	1.00	8	1.00
5	–	1.00	–	1.00	–	1.00	–	1.00	1	1.00
6	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
7	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
8	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
9	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
10	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
11	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
12	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00
13	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00

Table 35 (cont.): Number of tag re-releases by sex for the CRA 7&8 release statistical areas 925, 926, 927, and 928 plus all of CRA 7&8. Re-release event code = 0 means the first release-recapture event.

Re-release event	Release statistical area								CRA 7&8	
	925		926		927		928			
	N	Cum Prop	N	Cum Prop	N	Cum Prop	N	Cum Prop	N	Cum Prop
Males										
0	10	1.00	836	0.79	1 694	0.59	176	0.70	4 190	0.70
1	—	1.00	171	0.95	553	0.78	51	0.90	1 034	0.87
2	—	1.00	38	0.98	298	0.88	20	0.98	415	0.94
3	—	1.00	11	0.99	157	0.94	3	1.00	178	0.97
4	—	1.00	5	1.00	83	0.96	—	1.00	90	0.98
5	—	1.00	1	1.00	43	0.98	1	1.00	46	0.99
6	—	1.00	1	1.00	28	0.99	—	1.00	30	0.99
7	—	1.00	—	1.00	19	1.00	—	1.00	20	1.00
8	—	1.00	—	1.00	10	1.00	—	1.00	11	1.00
9	—	1.00	—	1.00	2	1.00	—	1.00	3	1.00
10	—	1.00	—	1.00	—	1.00	—	1.00	1	1.00
Females										
0	8	0.80	311	0.82	1 555	0.66	174	0.81	3 629	0.75
1	2	1.00	51	0.96	407	0.84	32	0.96	676	0.89
2	—	1.00	13	0.99	192	0.92	7	0.99	293	0.95
3	—	1.00	3	1.00	106	0.96	2	1.00	131	0.98
4	—	1.00	1	1.00	47	0.98	—	1.00	57	0.99
5	—	1.00	—	1.00	17	0.99	—	1.00	18	1.00
6	—	1.00	—	1.00	10	0.99	—	1.00	10	1.00
7	—	1.00	—	1.00	3	1.00	—	1.00	3	1.00
8	—	1.00	—	1.00	2	1.00	—	1.00	2	1.00
9	—	1.00	—	1.00	2	1.00	—	1.00	2	1.00
10	—	1.00	—	1.00	3	1.00	—	1.00	3	1.00
11	—	1.00	—	1.00	2	1.00	—	1.00	2	1.00
12	—	1.00	—	1.00	1	1.00	—	1.00	1	1.00
13	—	1.00	—	1.00	1	1.00	—	1.00	1	1.00

Table 36: Statistics for tail width growth increments (mm) for recaptures of CRA 7&8 releases. Recaptures were considered valid if there was a valid growth increment, regardless of the location of recapture.

Release statistical area	Sex	N	Minimum	5%	Median	95%	Maximum
Unknown	Males	297	-6.50	-1.00	0.00	9.00	16.31
	Females	518	-4.50	-0.76	0.84	7.57	18.82
920	Males	394	-15.71	0.00	3.50	9.40	28.00
	Females	427	-15.00	-1.00	2.85	9.60	26.70
921	Males	18	-10.00	-10.00	0.00	8.00	8.00
	Females	29	-5.00	-1.00	0.00	4.00	6.00
922	Males	13	-24.95	-24.95	1.93	7.24	7.24
	Females	17	-37.11	-37.11	2.60	6.85	6.85
923	Males	103	-2.80	0.00	2.90	8.60	16.00
	Females	150	-4.80	-1.20	2.52	9.40	37.60
924	Males	1 279	-18.00	-1.00	2.10	8.60	29.73
	Females	1 253	-18.00	-0.69	2.40	8.95	35.70
925	Males	10	3.62	3.62	17.20	29.10	29.10
	Females	10	0.00	0.00	10.00	23.10	23.10
926	Males	1 063	-10.00	-0.50	3.80	14.20	35.00
	Females	379	-14.20	-0.50	3.52	20.70	30.50
927	Males	2 887	-13.00	-0.20	2.80	11.30	26.70
	Females	2 348	-21.10	-0.70	2.40	12.00	29.00
928	Males	251	-10.00	-0.40	3.10	11.50	27.90
	Females	215	-9.10	-1.70	1.60	11.50	30.90
CRA7&8	Males	6 315	-25	-0.40	2.70	11.10	35.00
	Females	5 346	-37	-0.86	2.30	11.00	37.60

10. FIGURES

CRA 7 & 8

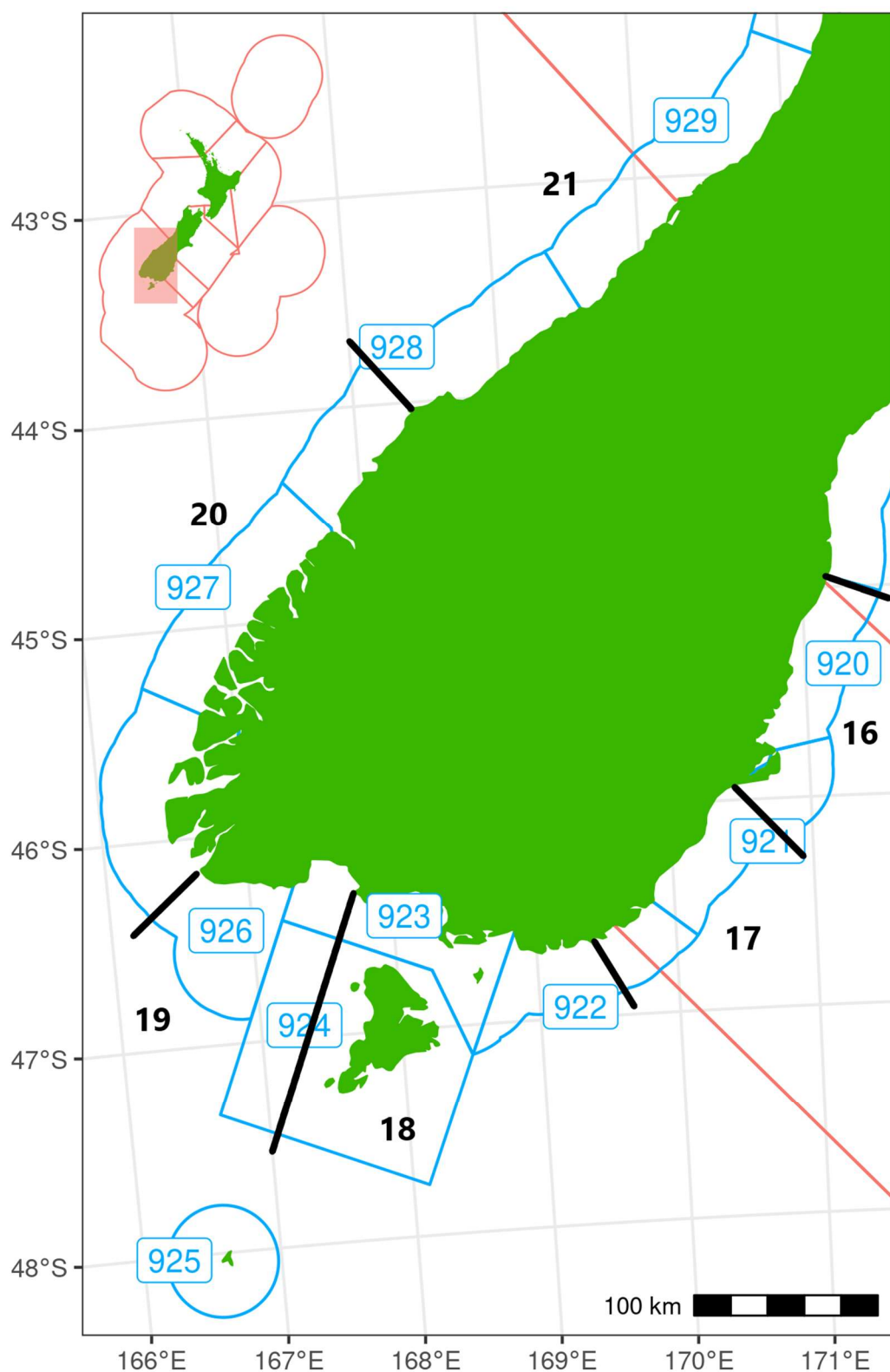


Figure 1: The CRA 7&8 Quota Management Areas (QMA) at the southern end of the South Island, along with its statistical areas (920–929). The CRA 7 and CRA 8 QMA boundaries are shown with red solid lines and the statistical area boundaries have blue lines. The solid black lines with black numbers identify the Annala & King (1983) areas.

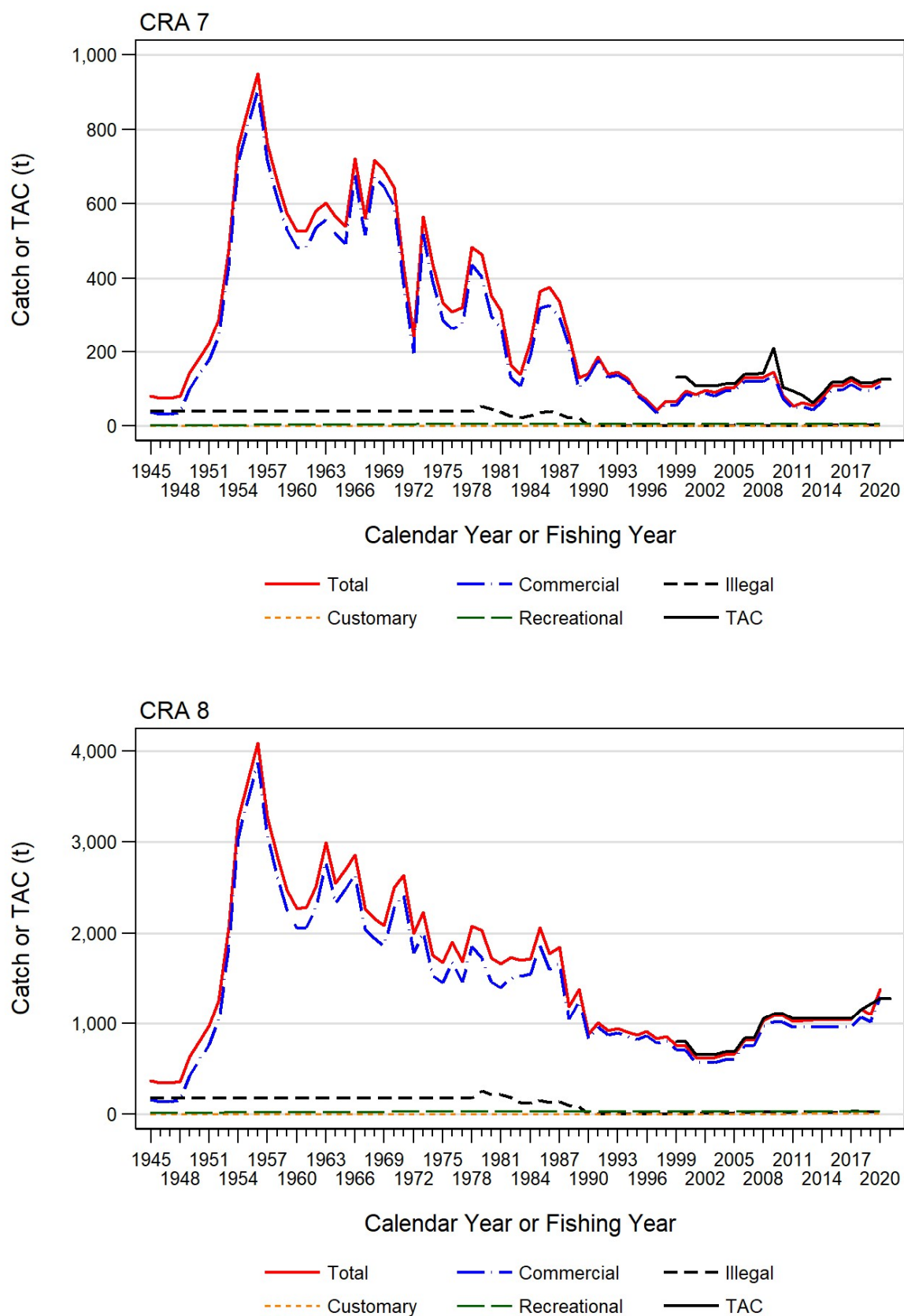


Figure 2: CRA 7 and CRA 8 catches by fishery from 1945 to 2020. Also showing the TAC from 1996 to 2021.

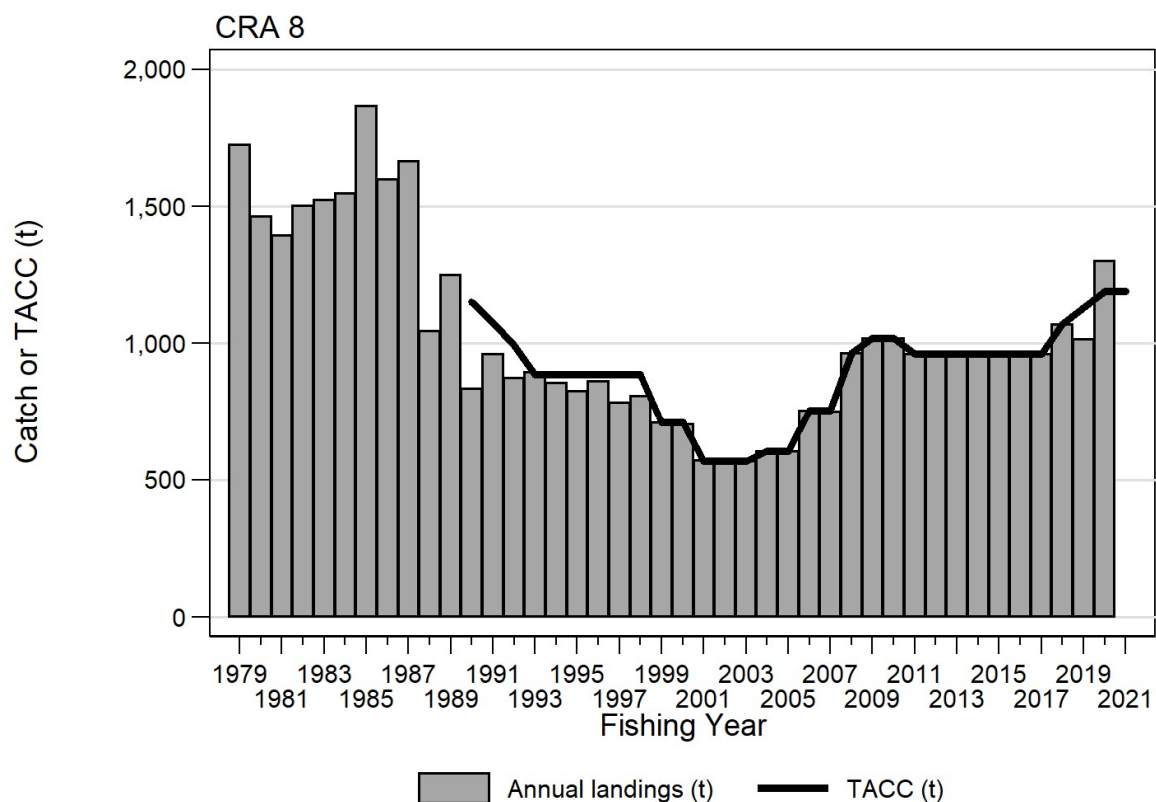
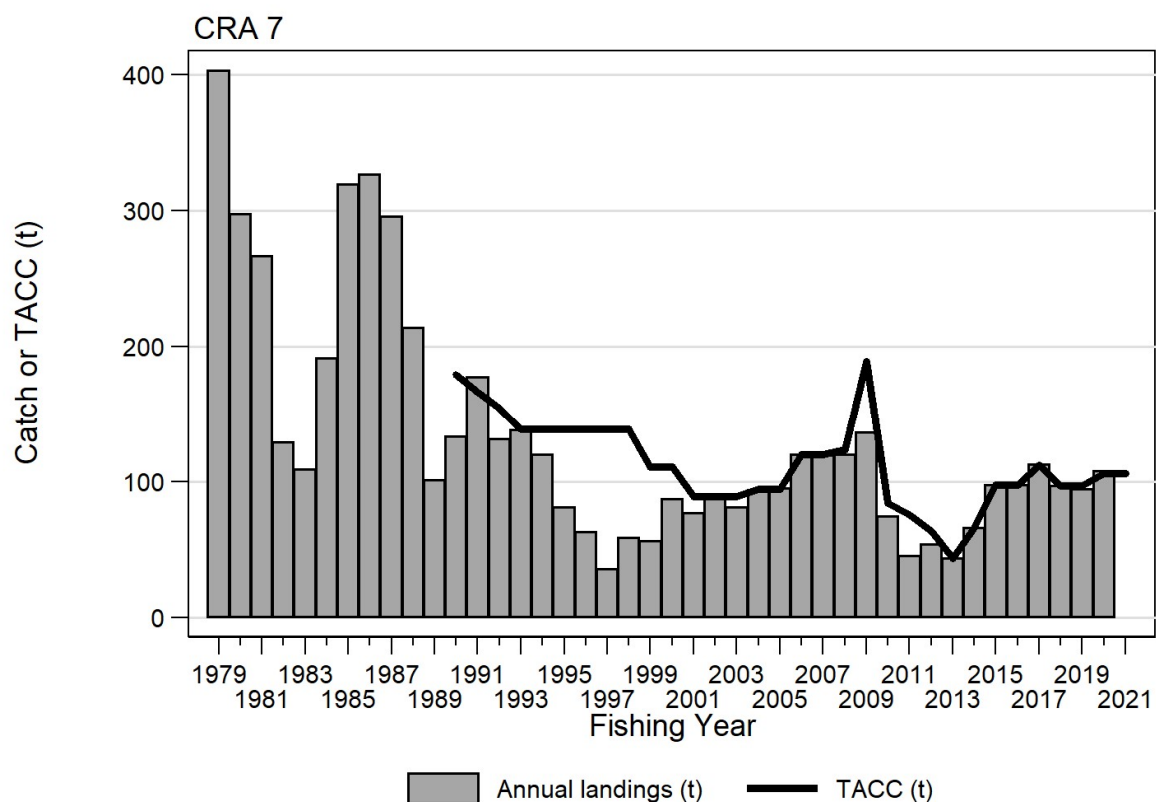


Figure 3: CRA 7 and CRA 8 annual commercial catch from 1979 to 2020, TACC from 1990 to 2021.

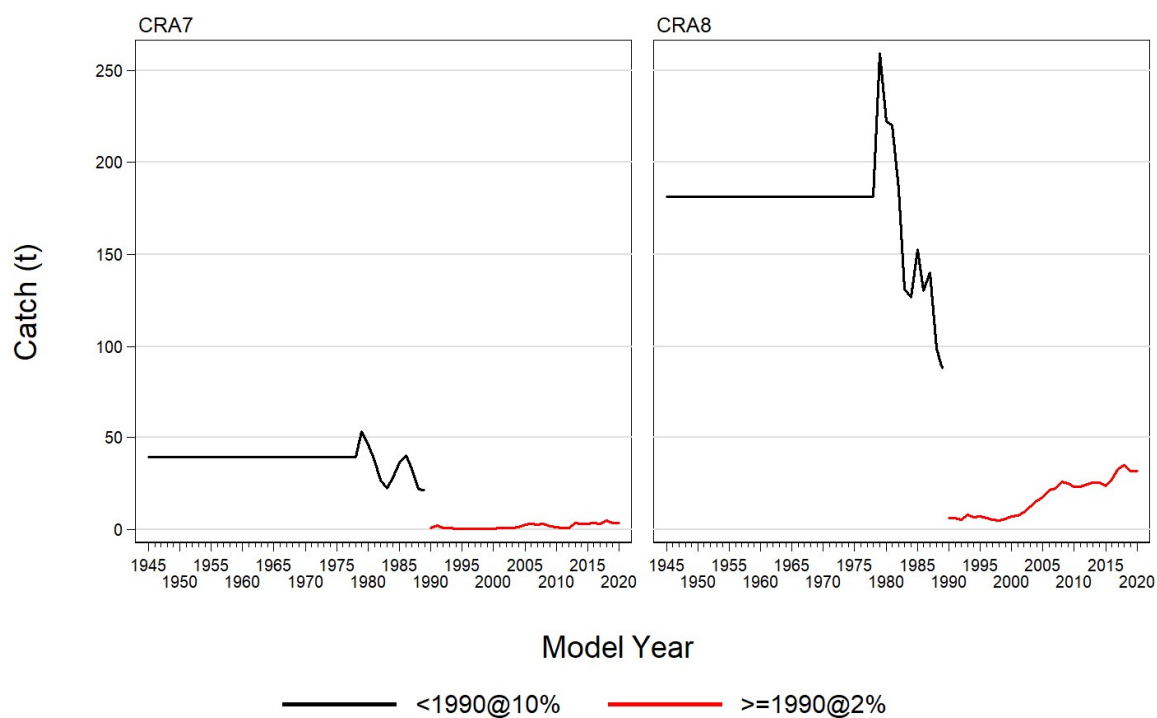
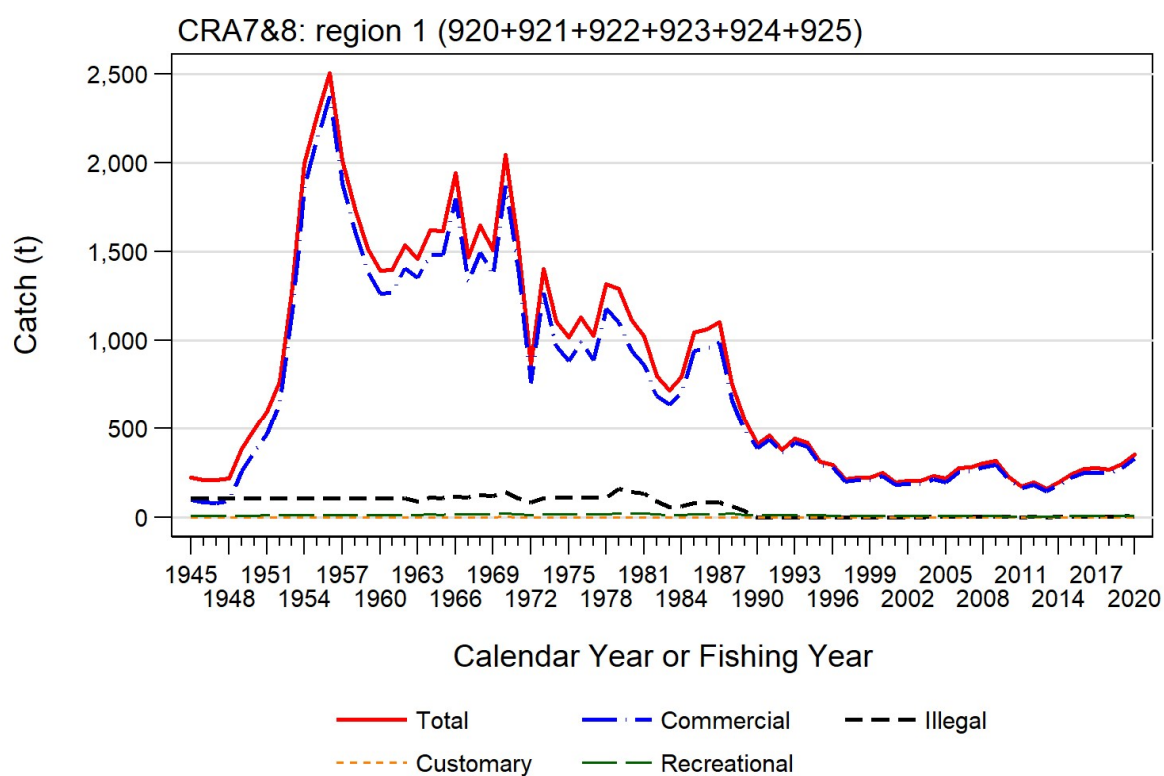
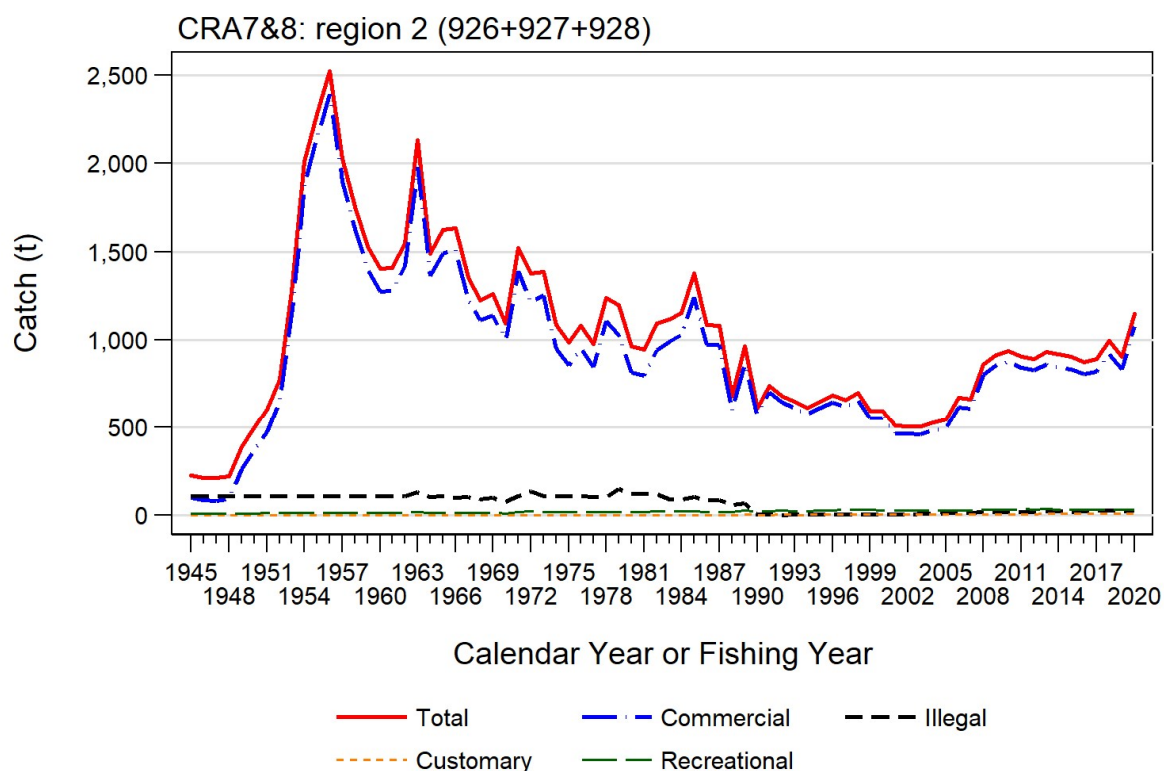


Figure 4: Illegal catch trajectories for CRA 7 and CRA 8, with catches before 1990 assumed to equal 10% of the summed commercial catch from 1945 to 1989. After 1990, illegal catches were assumed to equal 2% of the summed commercial catch from 1990 to 2020. Catches were scaled to the annual commercial CPUE from 1979 onwards.



First 1 Apr-31 Mar fishing year: 1979; Jan-Mar 1979 added to 1978



First 1 Apr-31 Mar fishing year: 1979; Jan-Mar 1979 added to 1978

Figure 5: Commercial, recreational, illegal, and customary catch trajectories for the two CRA 7&8 regions defined by rock lobster statistical areas (Table 7). Year codes are annual before 1979 and from 1979 onward refer to the first year in the statutory 1 April-31 March fishing year.

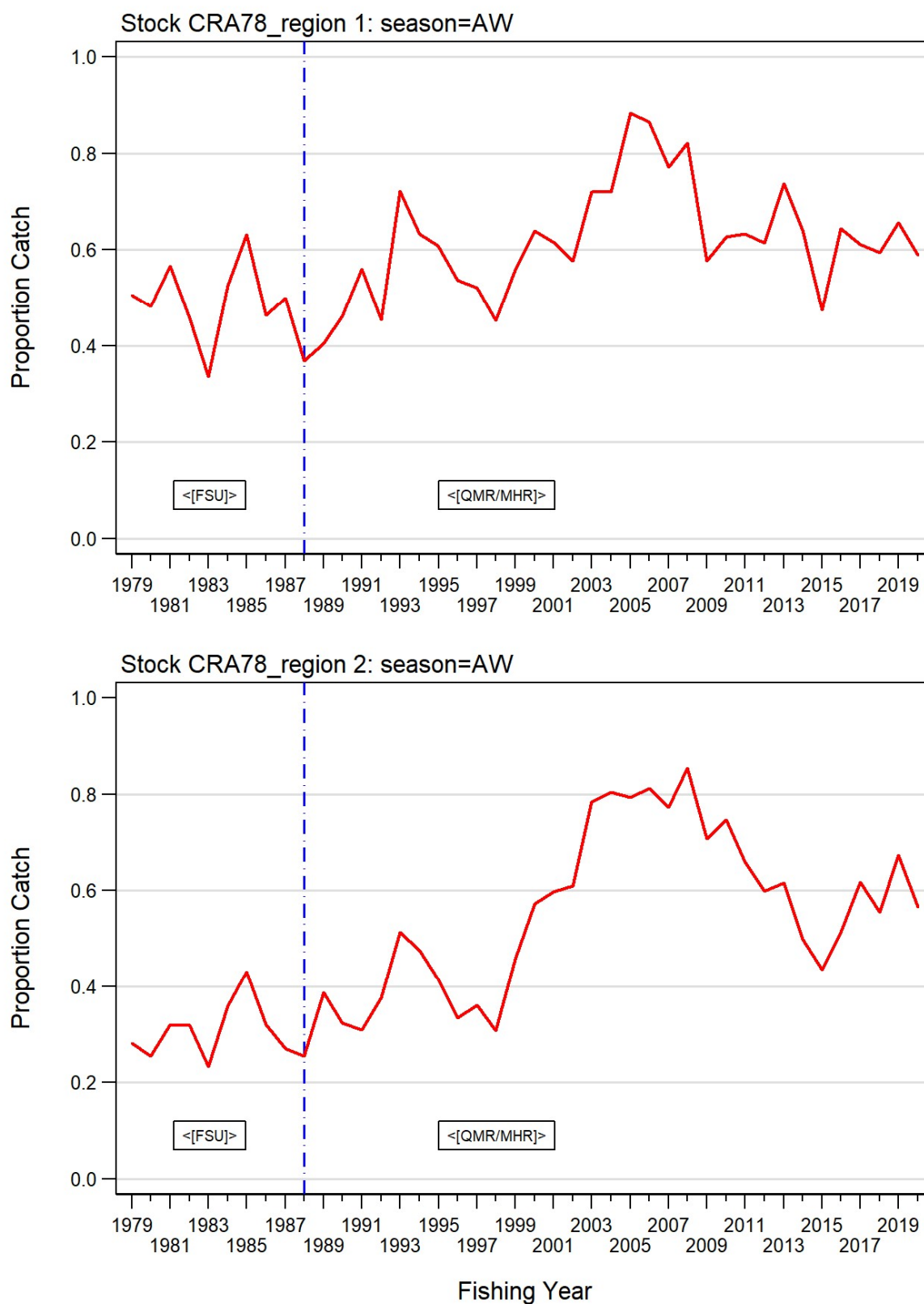


Figure 6: Seasonal proportion of the commercial AW catch by fishing year for the two CRA 8 regions defined by rock lobster statistical areas (Table 7). These proportions have been derived from reported landings by month from the FSU or CELR catch reporting systems using the F0_LFX algorithm (Starr 2021).

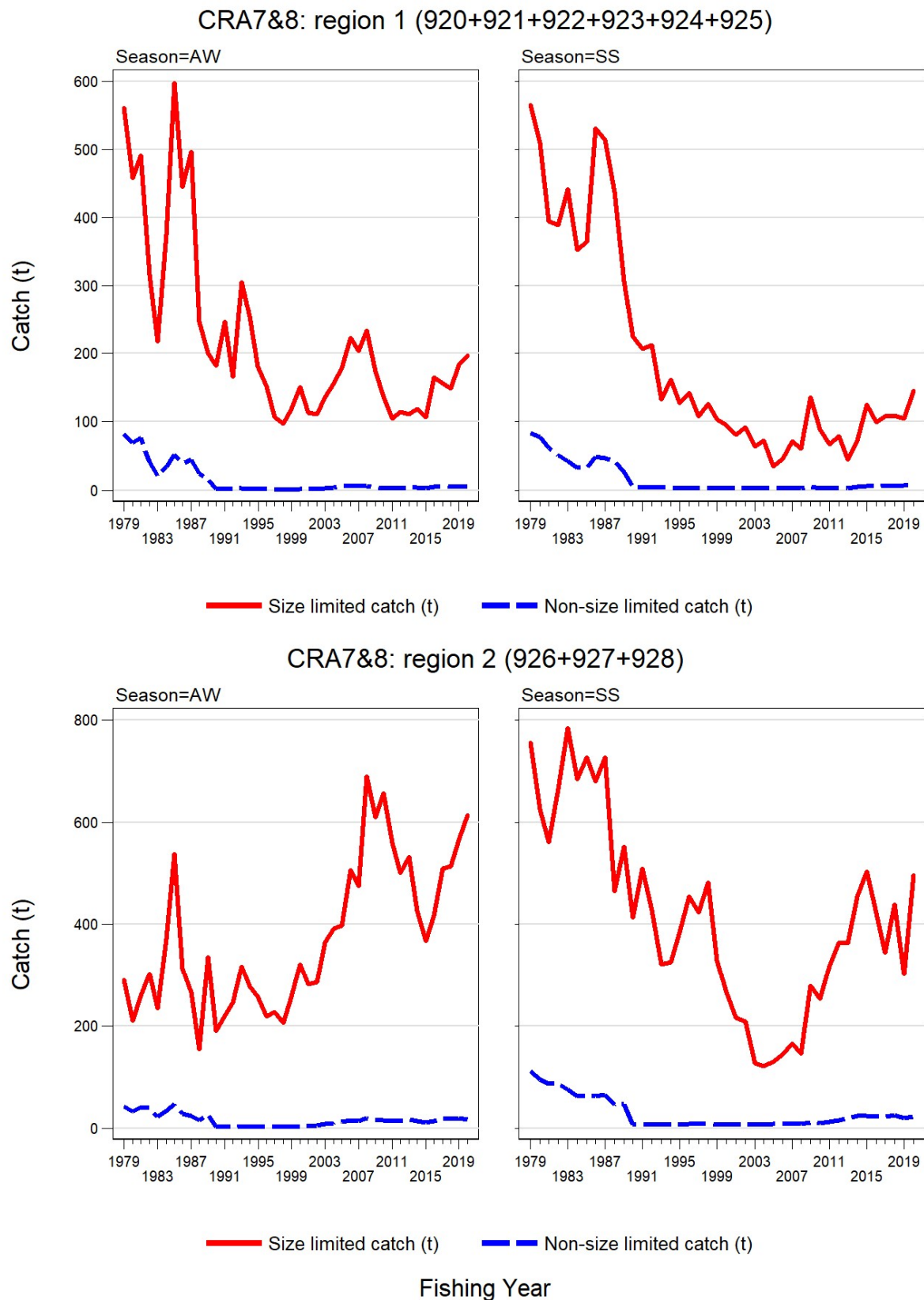


Figure 7: The seasonal size-limited (SL) and non-size-limited (NSL) catches (t) for the two CRA 7&8 regions, defined by rock lobster statistical areas (Table 7), plotted by 1 April–31 March fishing year.

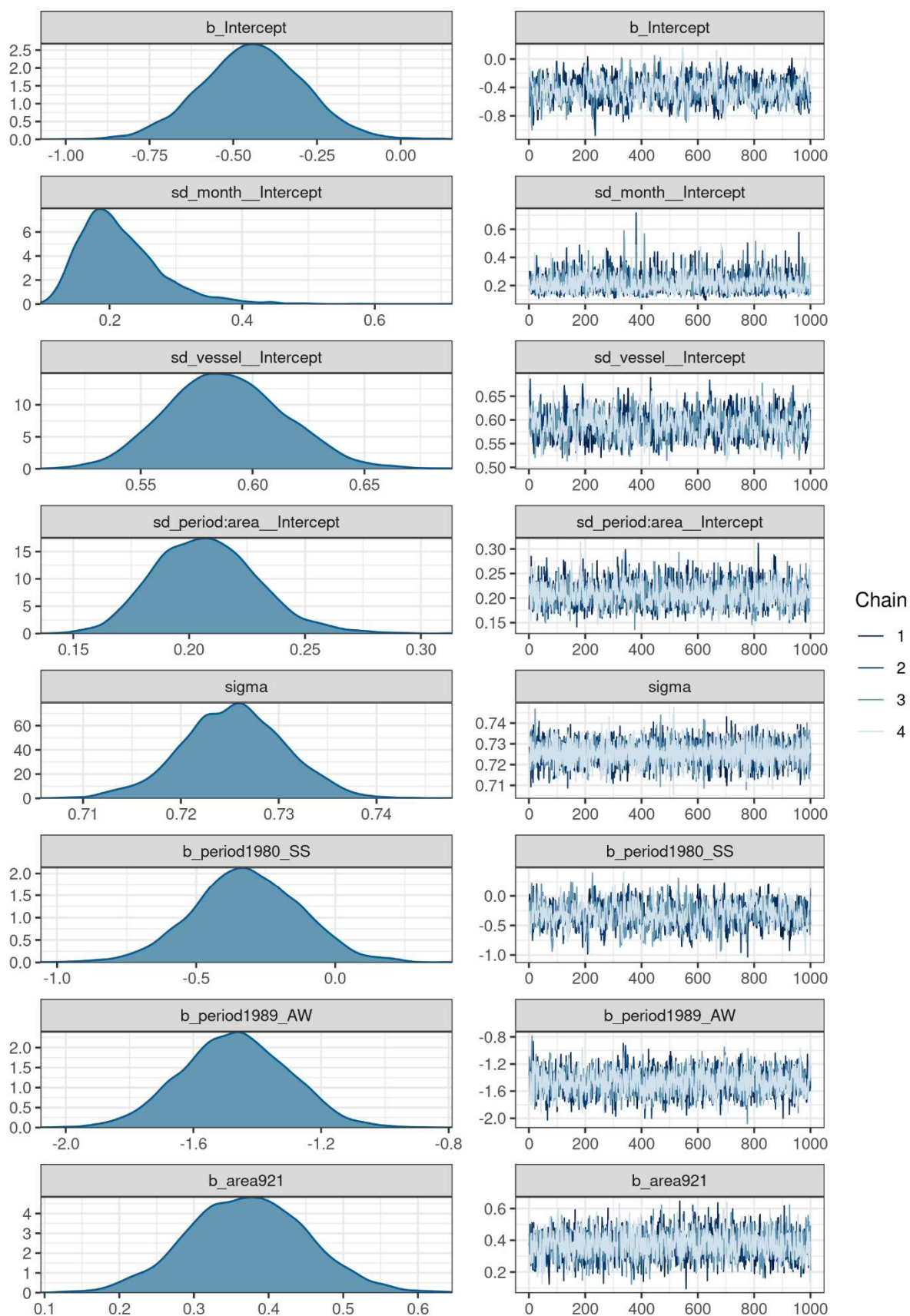


Figure 8: CRA 7&8 region 1: density [left] and trace [right] plots of samples from the posterior distribution for a subset of model parameters from the CPUE analysis based on the FSU data.

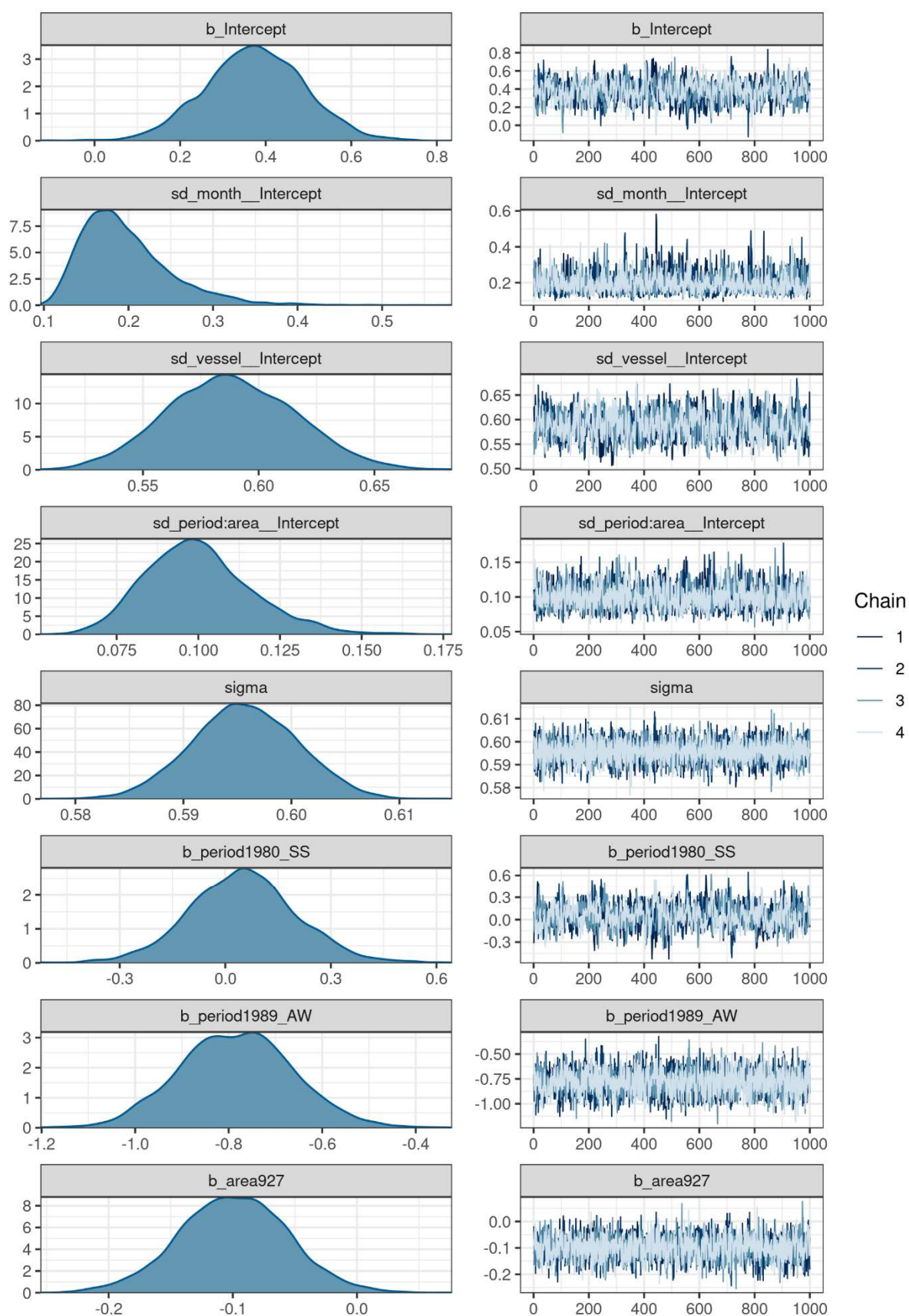


Figure 9: CRA 7&8 region 2: density [left] and trace [right] plots of samples from the posterior distribution for a subset of model parameters from the CPUE analysis based on the FSU data.

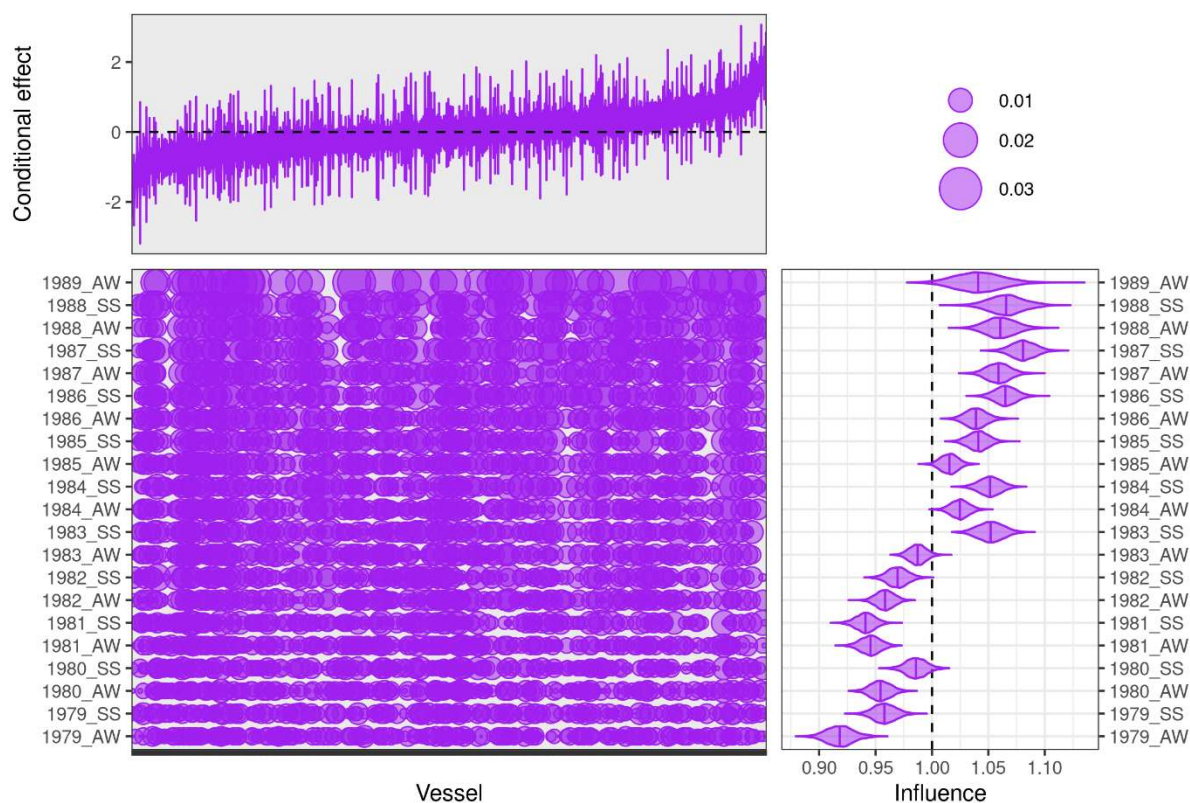


Figure 10: CRA 7&8 region 1 CDI plot (Bentley et al. 2012) showing: posterior distribution of coefficients for all vessels in the fishery from the FSU seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for core vessels in each fishing year/season [bottom right panel].

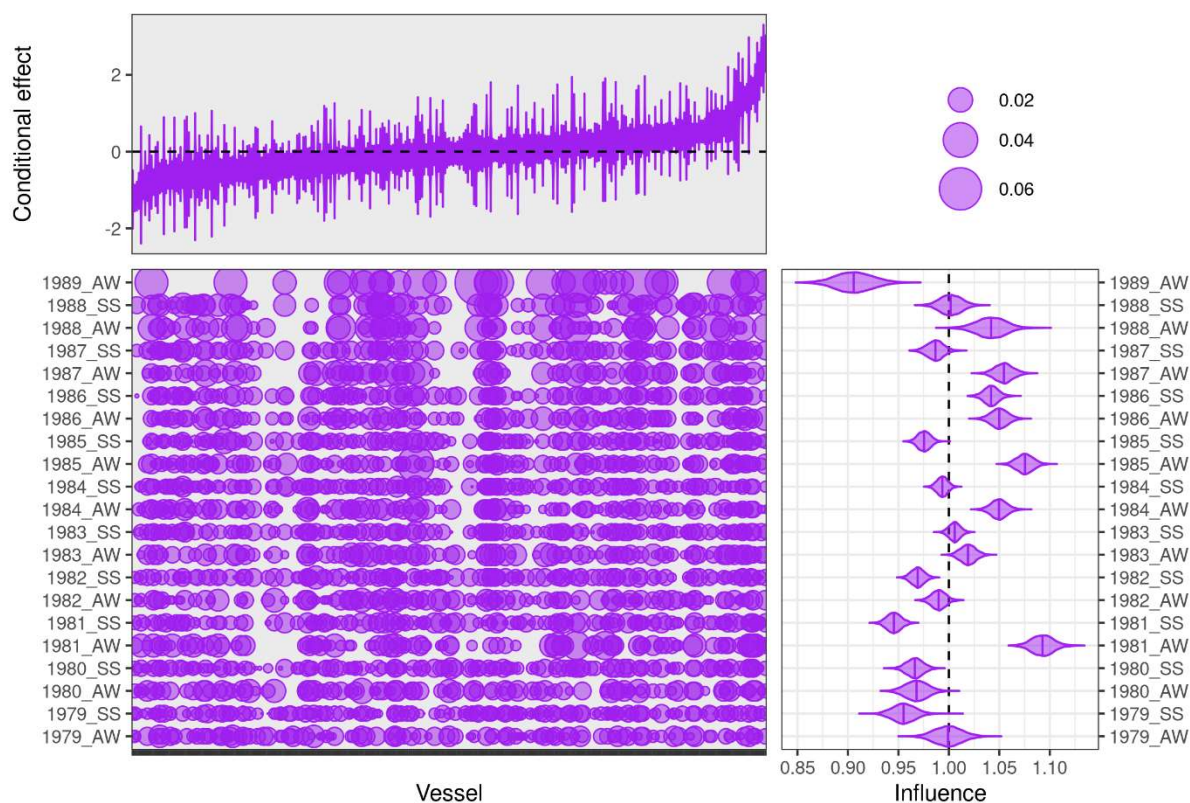


Figure 11: CRA 7&8 region 2 CDI plot (Bentley et al. 2012) showing: posterior distribution of coefficients for all vessels in the fishery from the FSU seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for core vessels in each fishing year/season [bottom right panel].

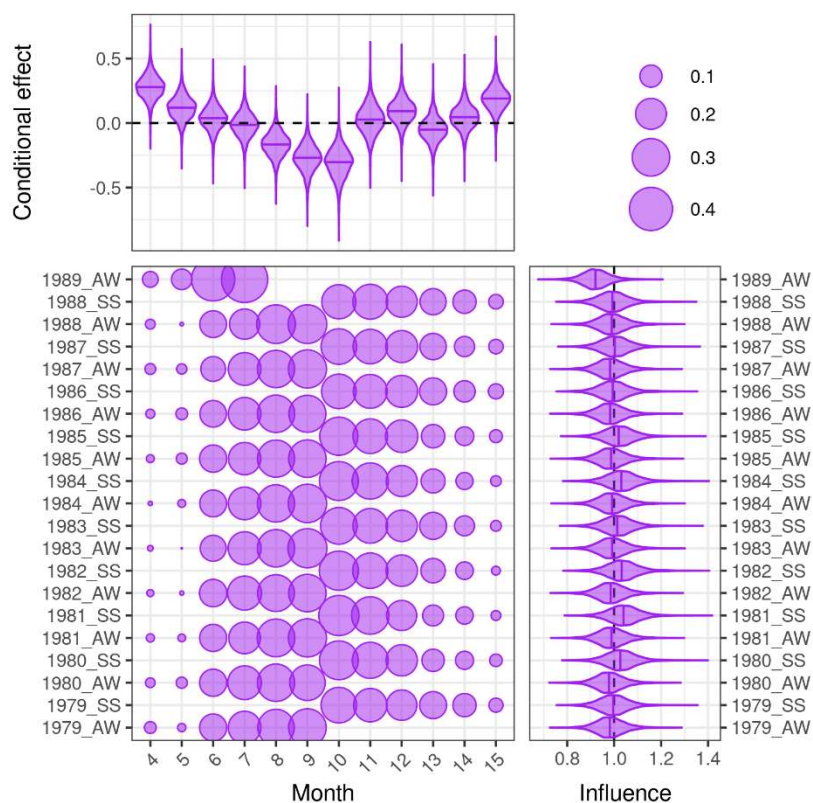


Figure 12: CRA 7&8 region 1: [top panel]: CDI plot (Bentley et al. 2012) showing: posterior distribution of month coefficients (4=April to 15=March) in the fishery from the FSU seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for the month variable for each fishing year/season [bottom right panel].

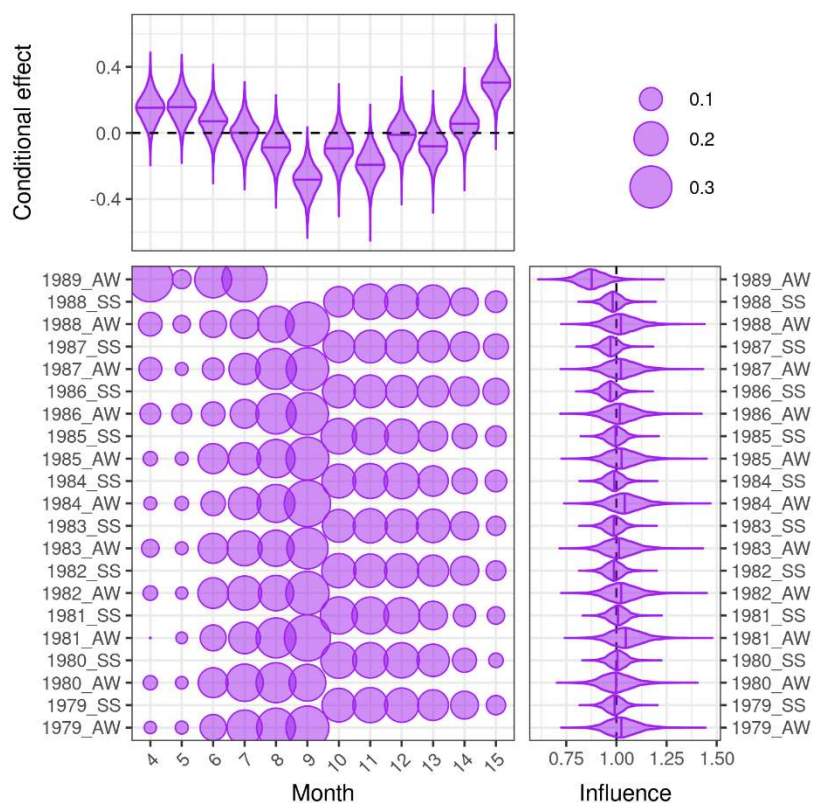


Figure 13: CRA 7&8 region 2: [top panel]: CDI plot (Bentley et al. 2012) showing: posterior distribution of month coefficients (4=April to 15=March) in the fishery from the FSU seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for the month variable for each fishing year/season [bottom right panel].

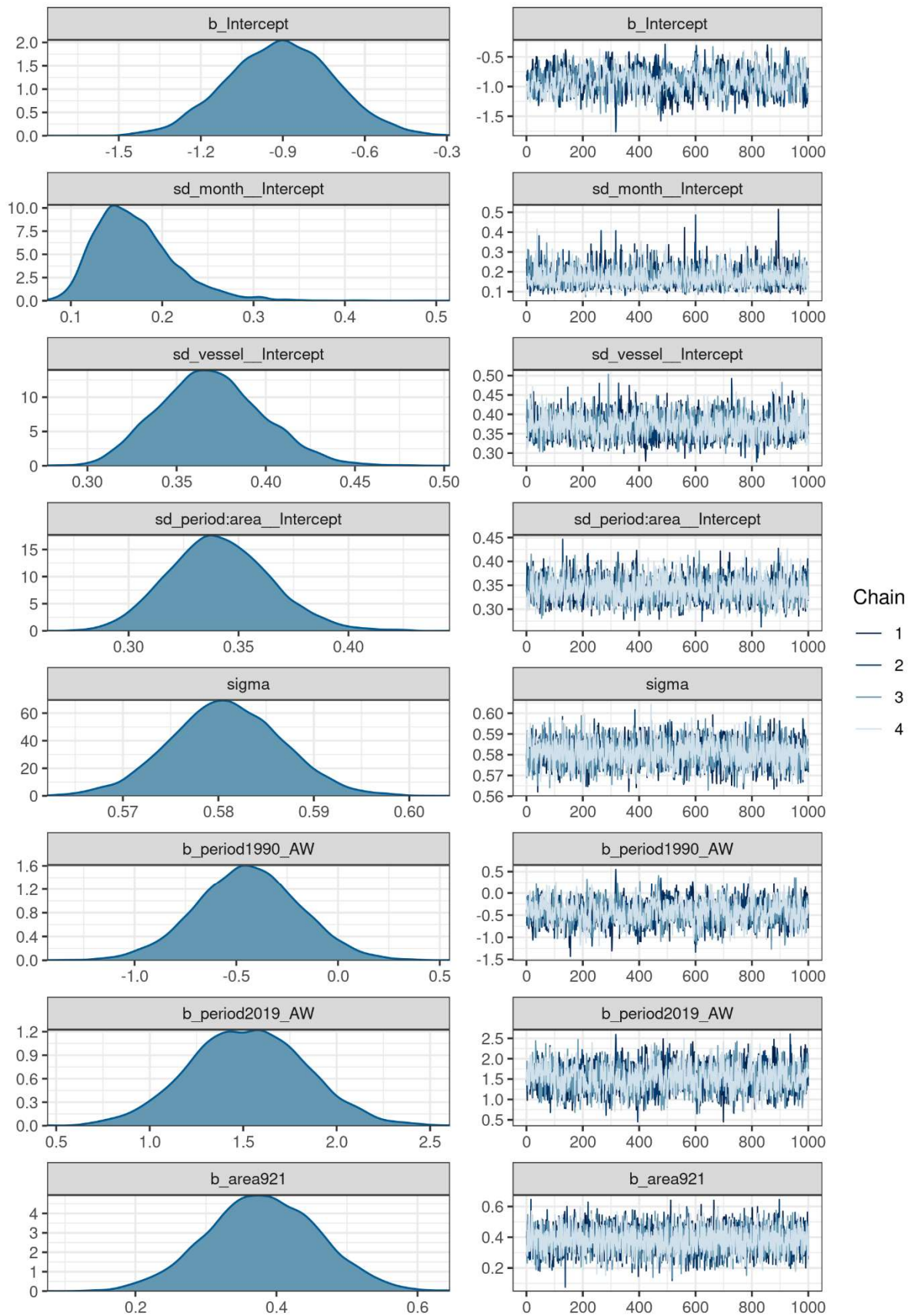


Figure 14: CRA 7&8 region 1: density [left] and trace [right] plots of samples from the posterior distribution for a subset of model parameters from the CPUE analysis based on the CELR data.

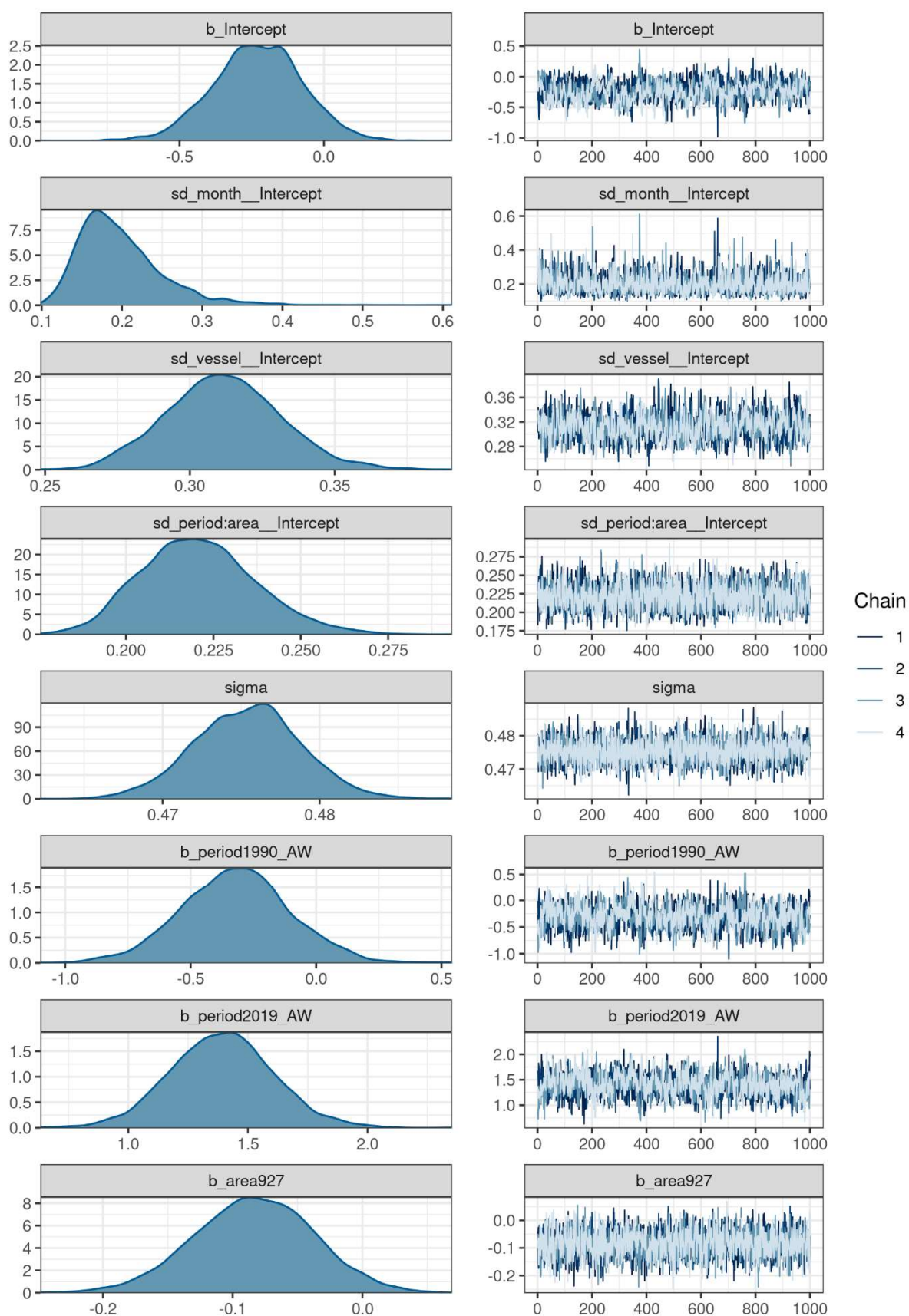


Figure 15: CRA 7&8 region 2: density [left] and trace [right] plots of samples from the posterior distribution for a subset of model parameters from the CPUE analysis based on the CELR data.

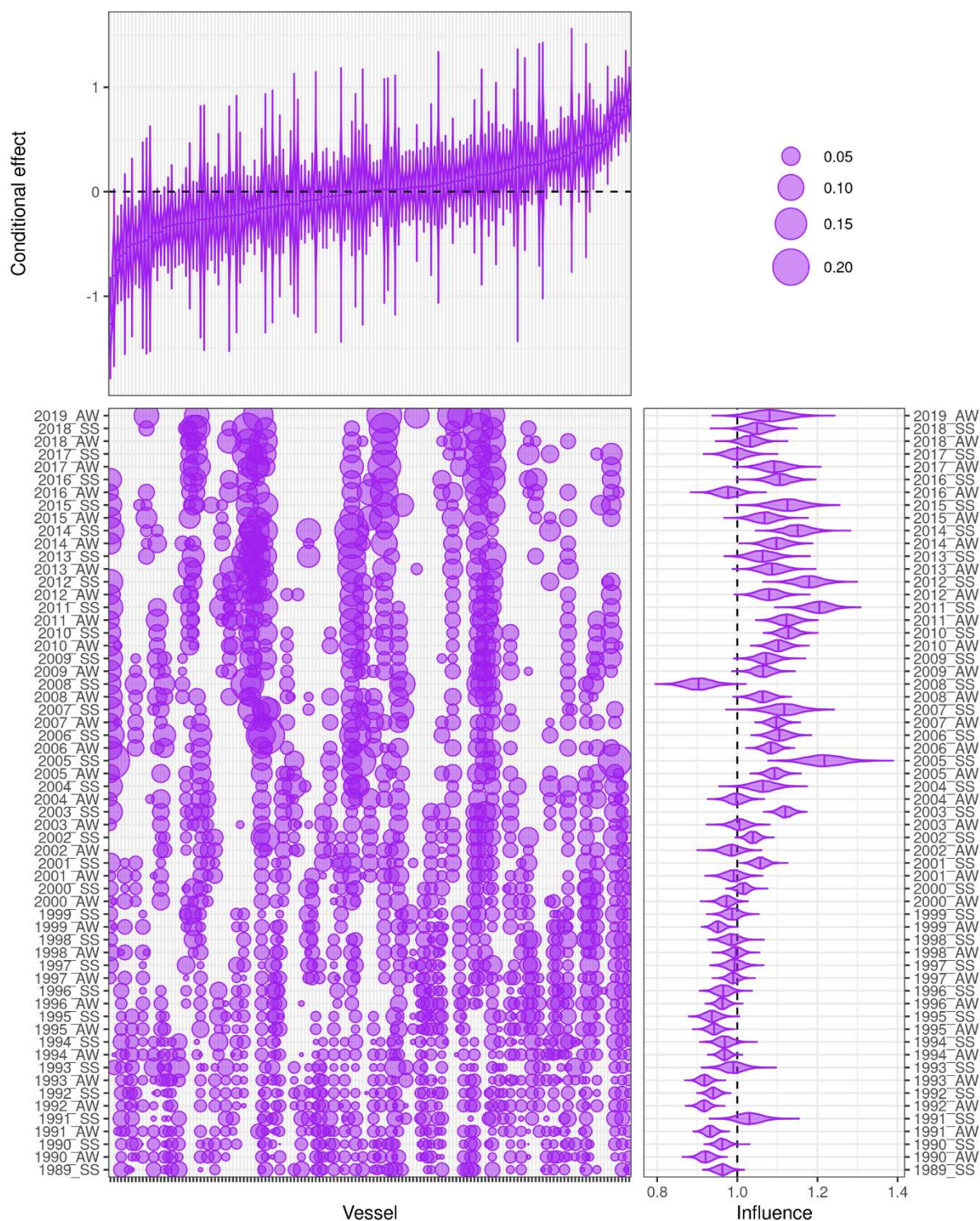


Figure 16: CRA 7&8 region 1 CDI plot (Bentley et al. 2012) showing: posterior distribution of coefficients for vessels with at least five years of data in the fishery from the CELR seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for core vessels in each fishing year/season [bottom right panel].

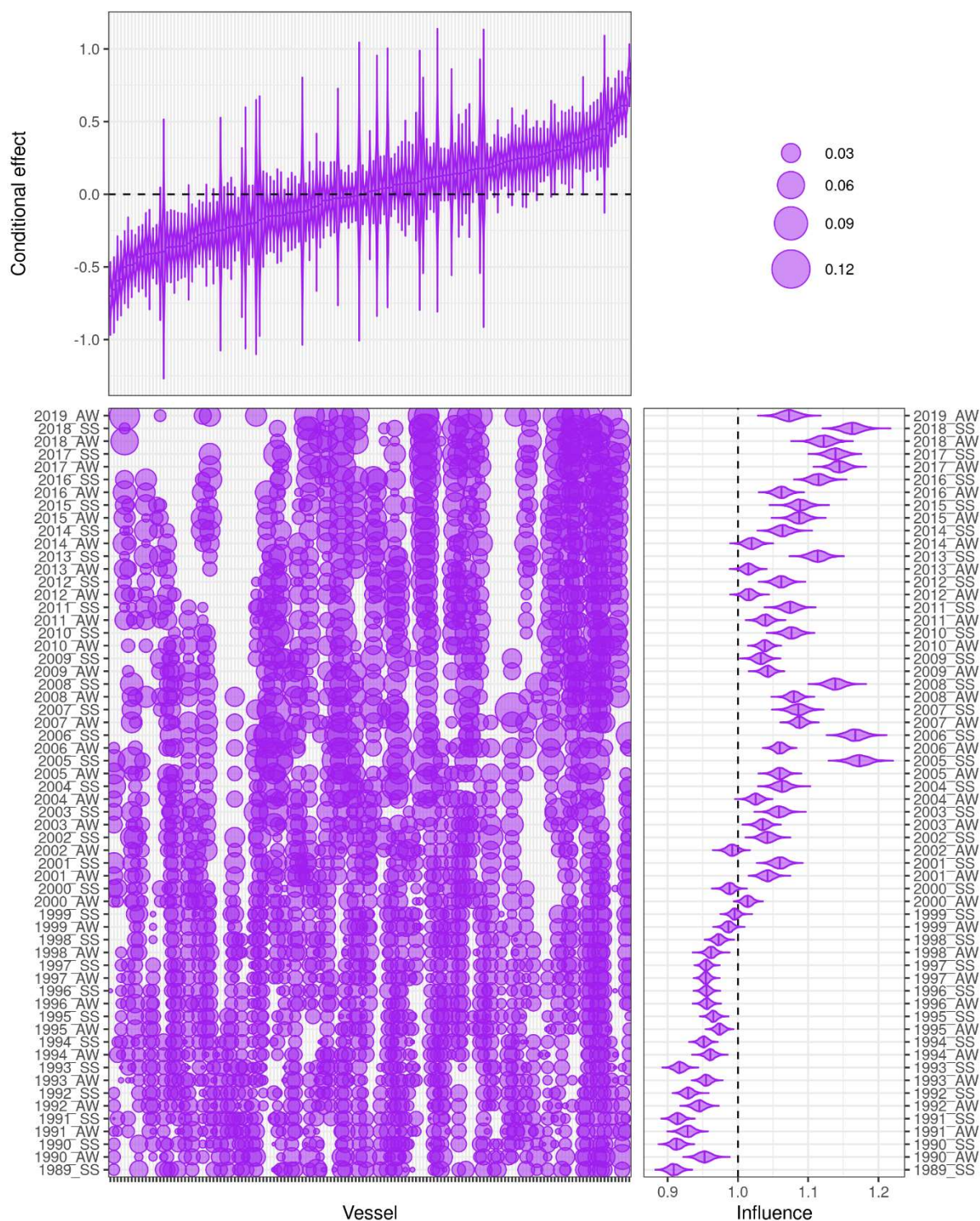


Figure 17: CRA 7&8 region 2 CDI plot (Bentley et al. 2012) showing: posterior distribution of coefficients for vessels with at least five years of data in the fishery from the CELR seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for core vessels in each fishing year/season [bottom right panel].

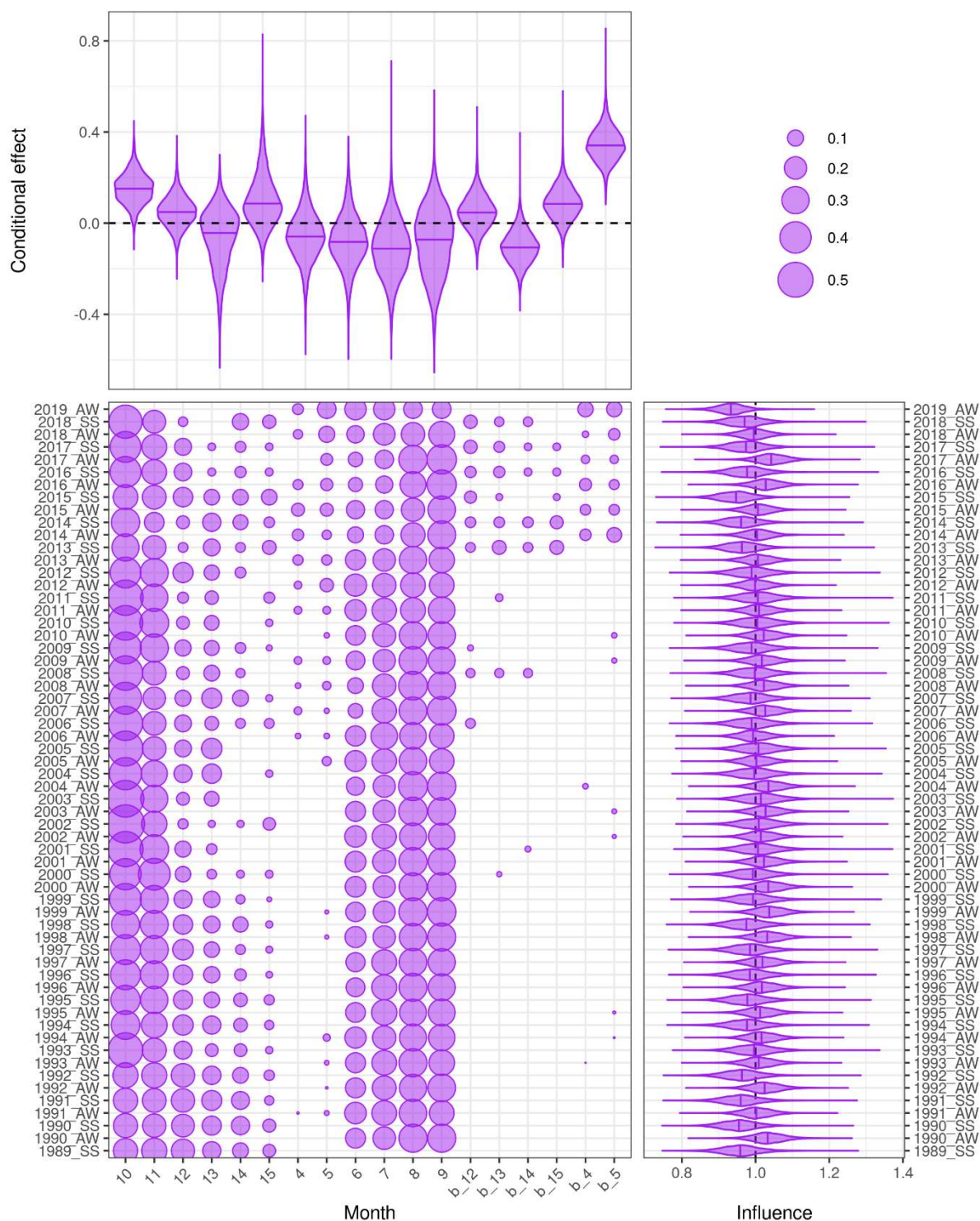


Figure 18: CRA 7&8 region 1 CDI plot (Bentley et al. 2012) showing: posterior distribution of month coefficients (4=April to 15=March) in the fishery from the CELR seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for the month variable for each fishing year/season [bottom right panel]. Note that the ‘b_x’ months index the post-1993 months in CRA 7 with a changed MLS regime (see last paragraph in Section 4.1.1).

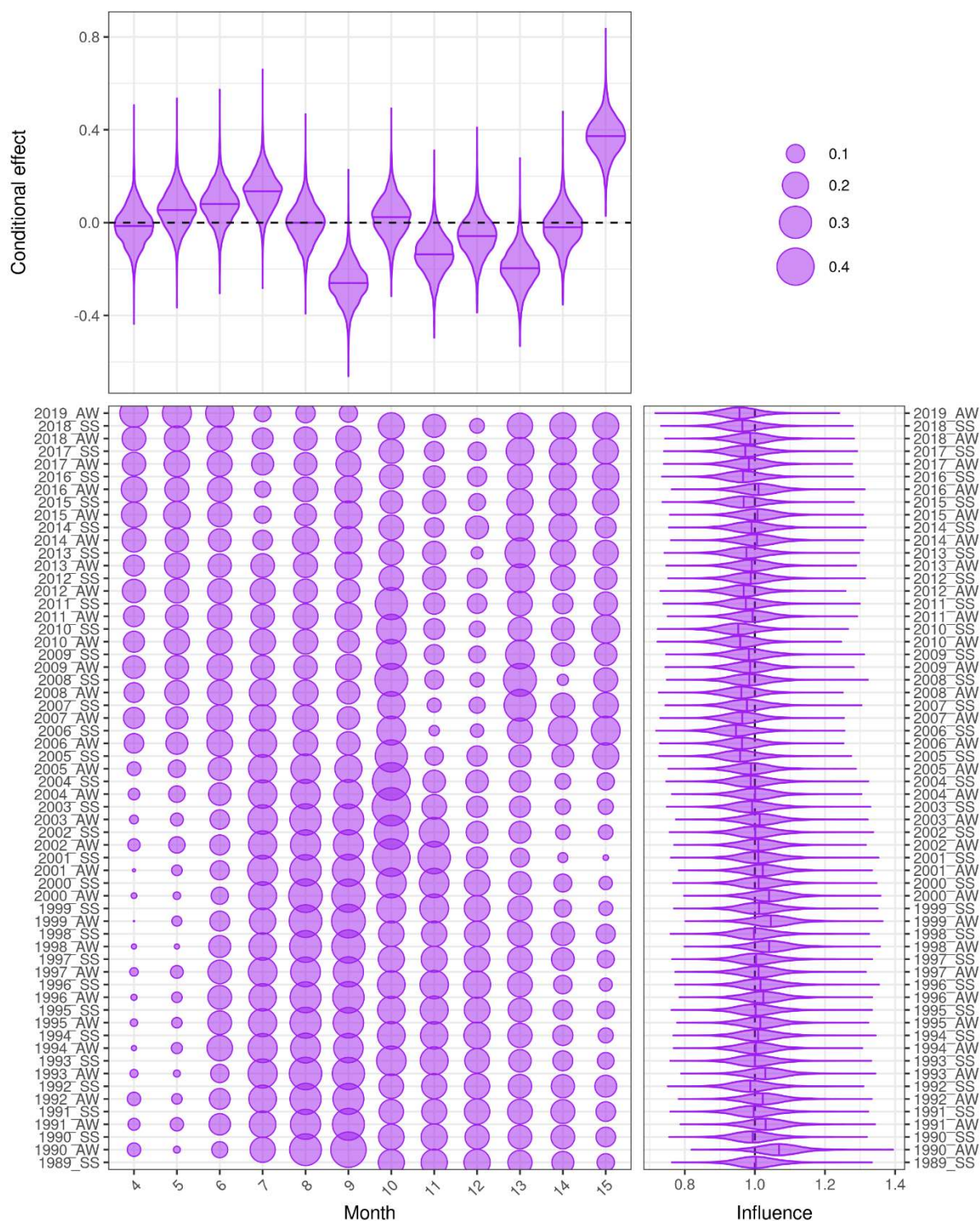
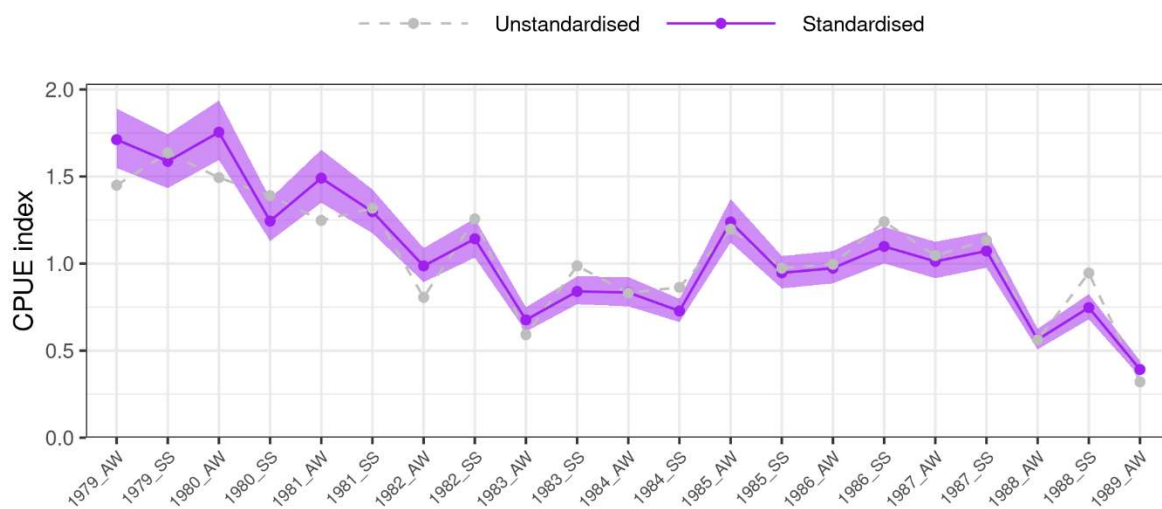


Figure 19: CRA 7&8 region 2 CDI plot (Bentley et al. 2012) showing: posterior distribution of month coefficients (4=April to 15=March) in the fishery from the CELR seasonal CPUE standardisation [top panel]; relative distribution of records by fishing year/season, with each row summing to one [bottom left panel]; posterior distribution of influence (product of coefficients weighted by the data distribution) for the month variable for each fishing year/season [bottom right panel].

920-925

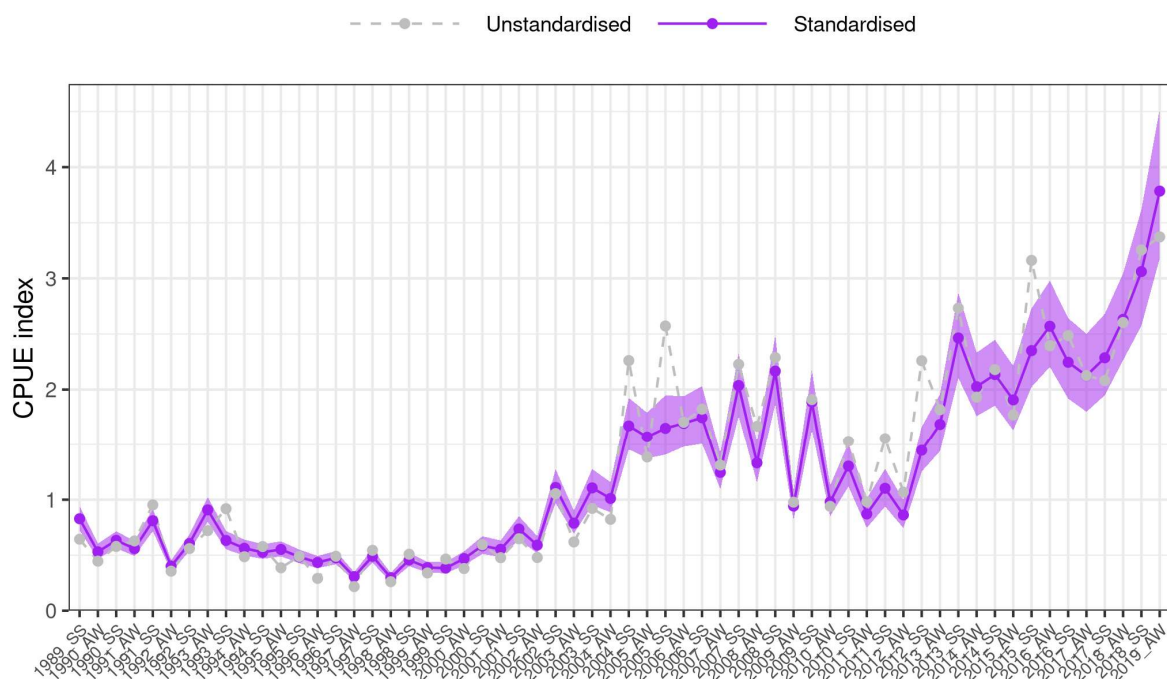


926-928



Figure 20: CRA 7&8 region 1 (920+921+922+923+924+925) and region 2 (926+927+928) standardised FSU CPUE indices by season and fishing year. Plot shows the posterior median (points connected by lines) and the 50% credible interval (shaded region).

920-925



926-928

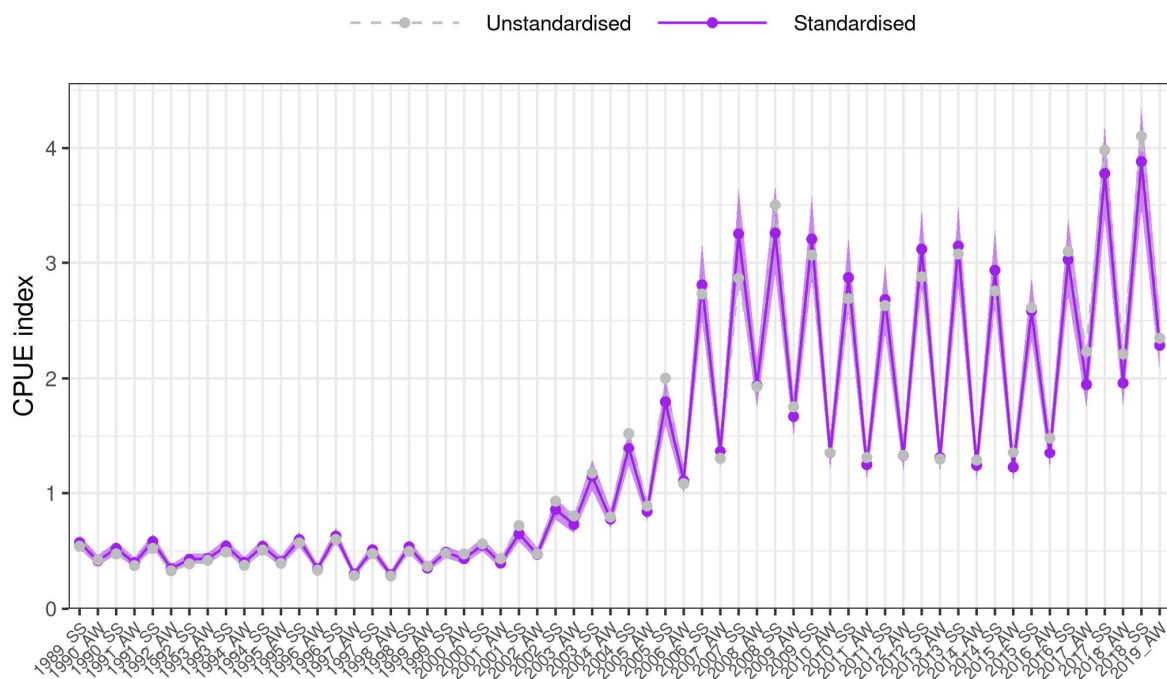


Figure 21: CRA 7&8 region 1 (920+921+922+923+924+925) and region 2 (926+927+928) standardised CELR CPUE indices by season and fishing year from SS 1989–90 to AW 2019–20. Plot shows the posterior median (points connected by lines) and the 50% credible interval (shaded region).

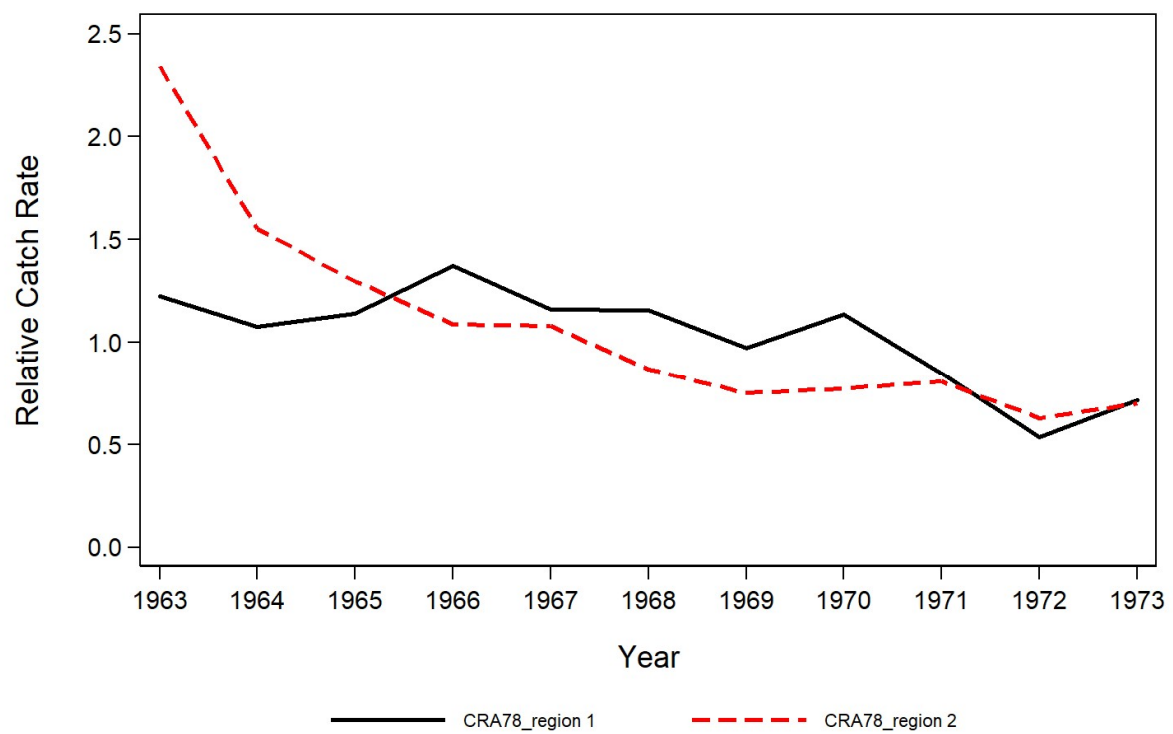
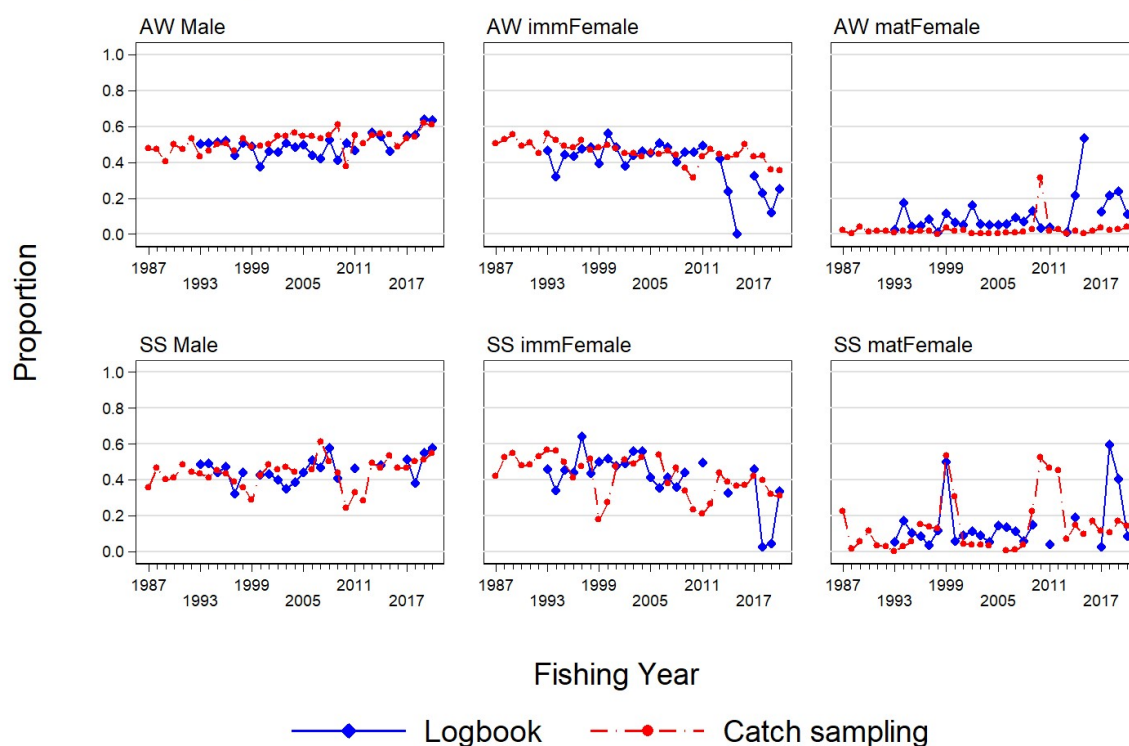


Figure 22: Catch rate (kg/day) by year for CRA 7&8 region 1 and region 2 from Annala & King (1983). Both series have been standardised to have a geometric mean of 1.0.

CRA 7&8 region 1 (920+921+922+923+924+925)



CRA 7&8 region 2 (926+927+928)

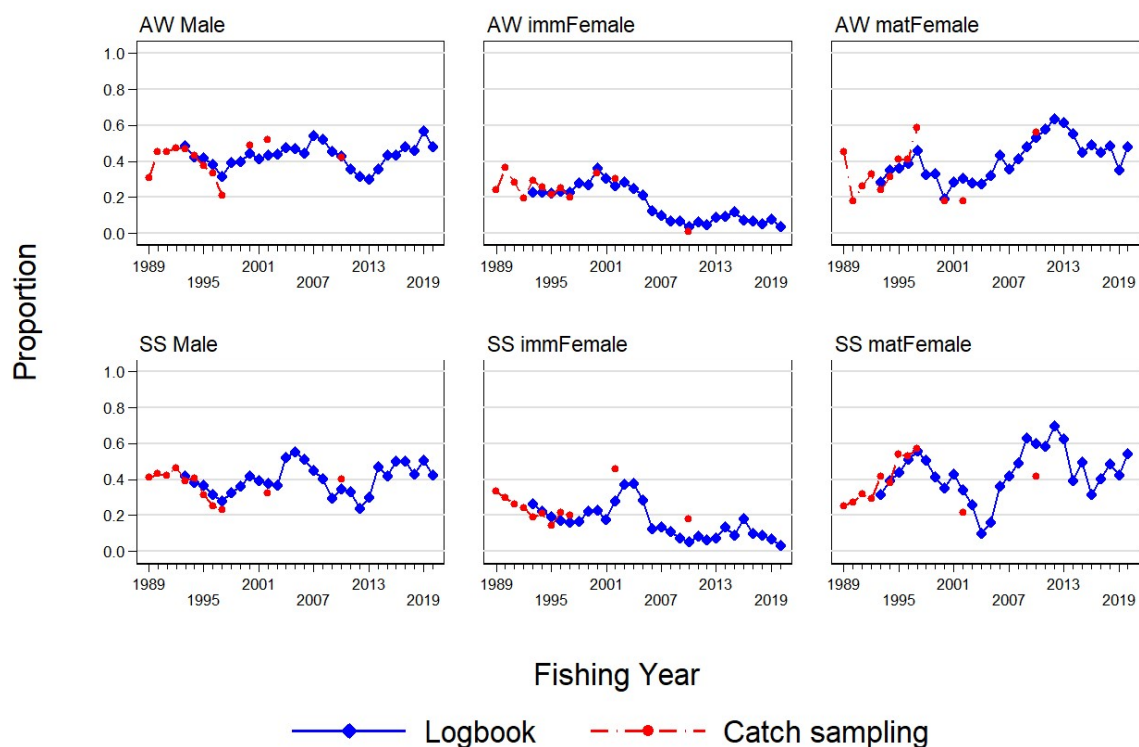
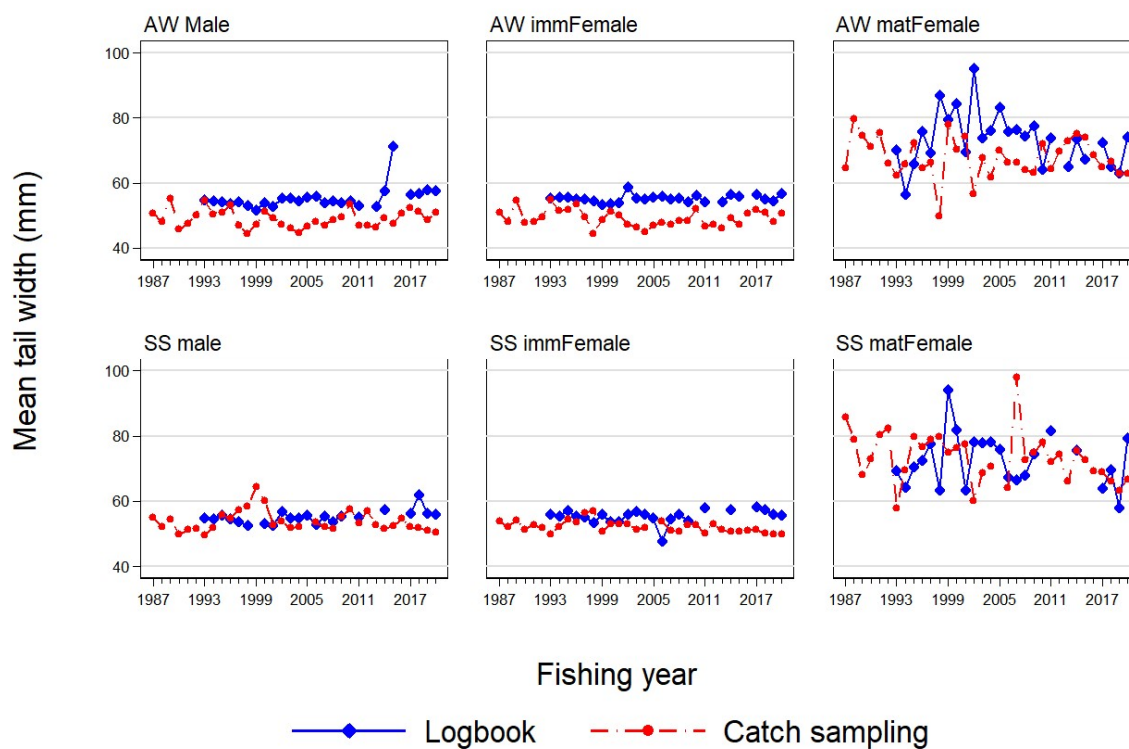


Figure 23: Proportion-at-sex by year, season, and sampling source for the two CRA 7&8 regions, defined by rock lobster statistical areas (Table 7).

CRA 7&8 region 1 (920+921+922+923+924+925)



CRA 7&8 region 2 (926+927+928)

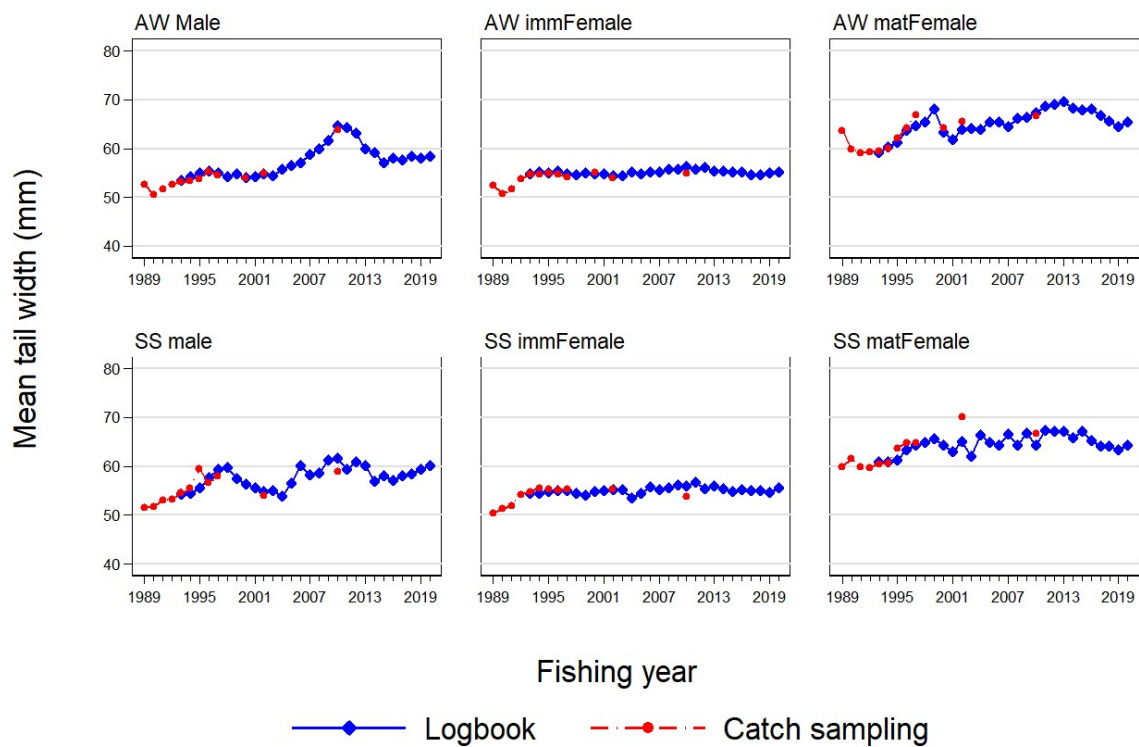


Figure 24: Mean length by year, season, sex, and sampling source for the two CRA 7&8 regions, defined by rock lobster statistical areas (Table 7).

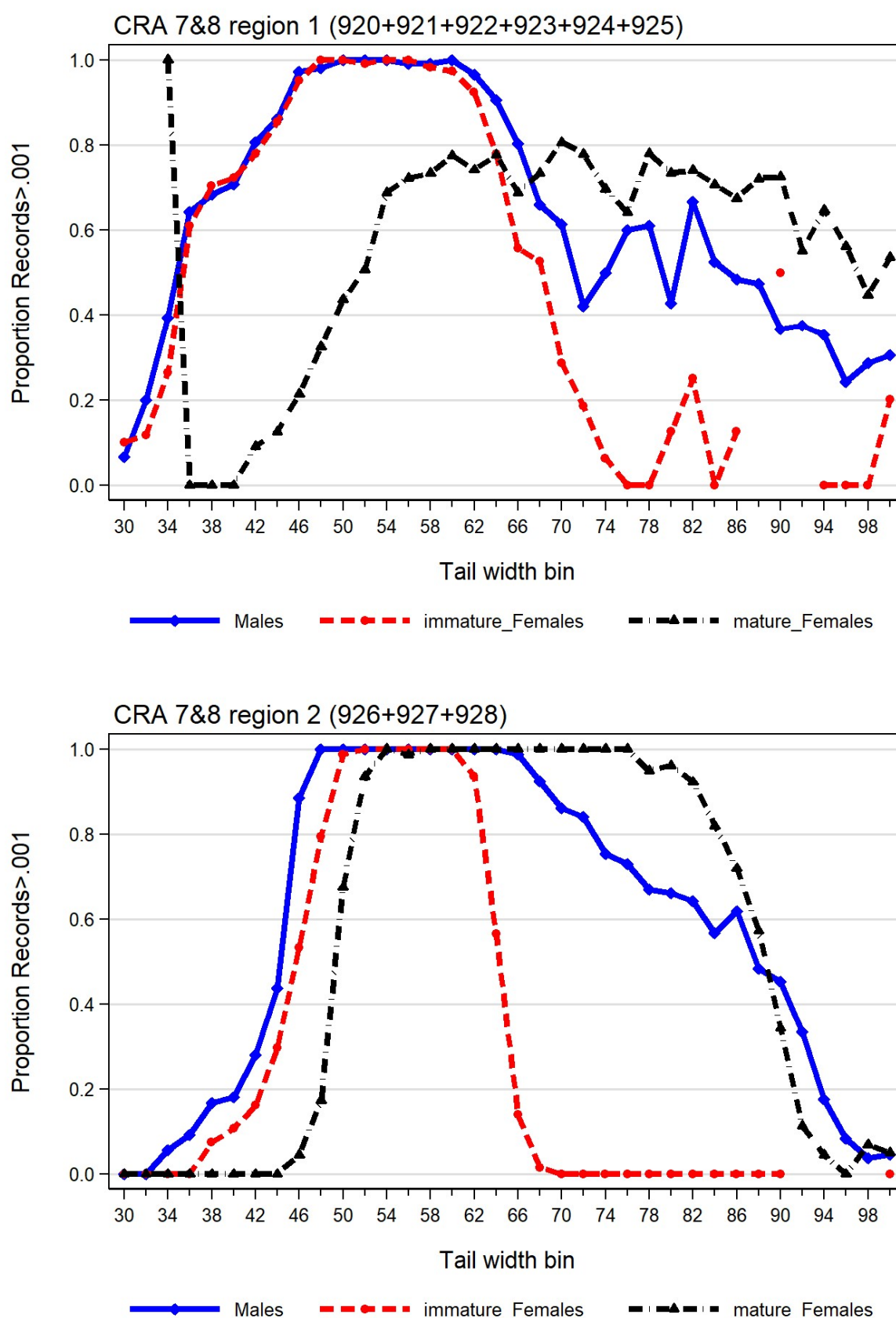


Figure 25: The proportion of size bins for the two CRA 7&8 regions, defined by rock lobster statistical areas (Table 7) that contain a proportion of 0.001 or higher when the data are normalised across the three sex categories. Length bins with little or no data will have a low proportion on this figure.

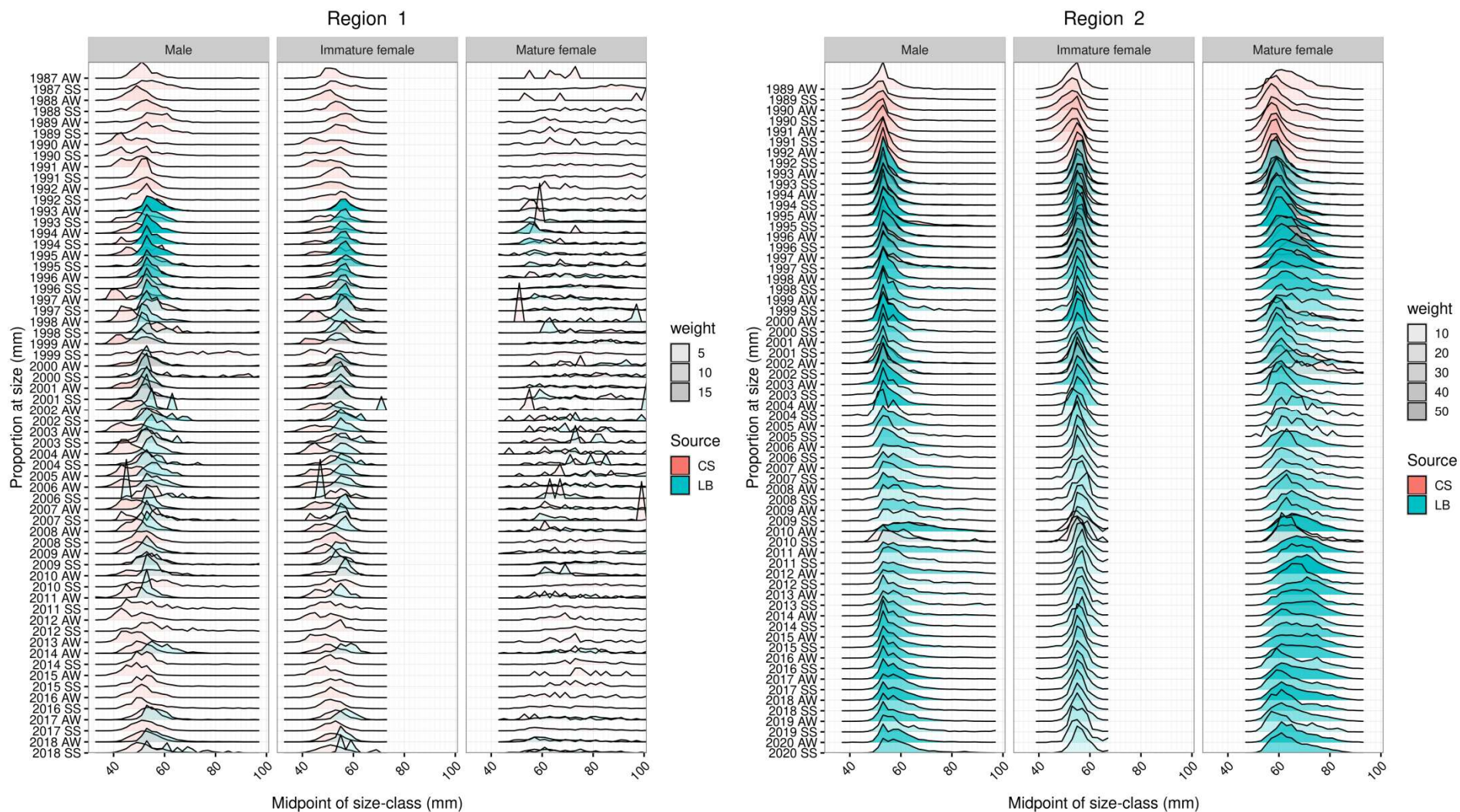


Figure 26: All observed CRA 7&8 length frequency distributions for region 1 [920+921+922+923+924+925: left] and region 2 [926+927+928: right], by sex category, fishing year, and sample source (CS is observer catch sampling and LB is logbook catch sampling).

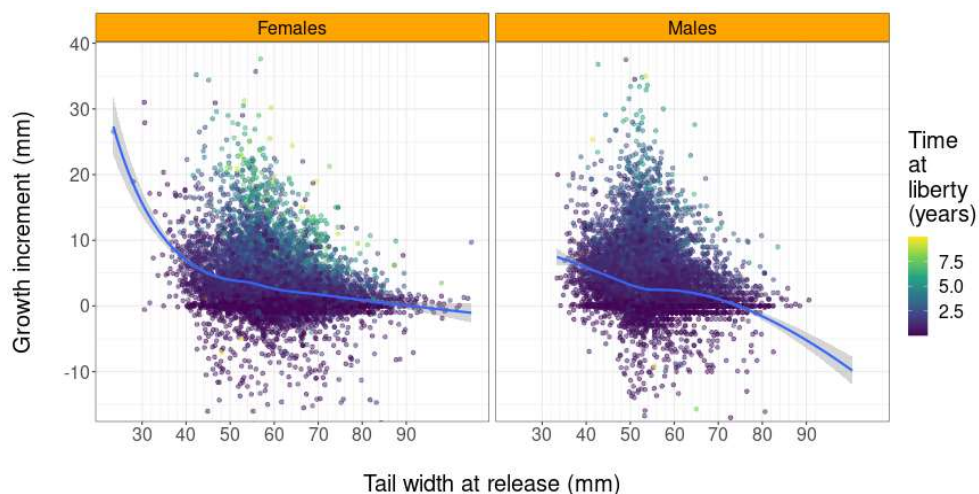


Figure 27: Growth increments (mm) by size at release (mm) and sex for all combined tag recoveries. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

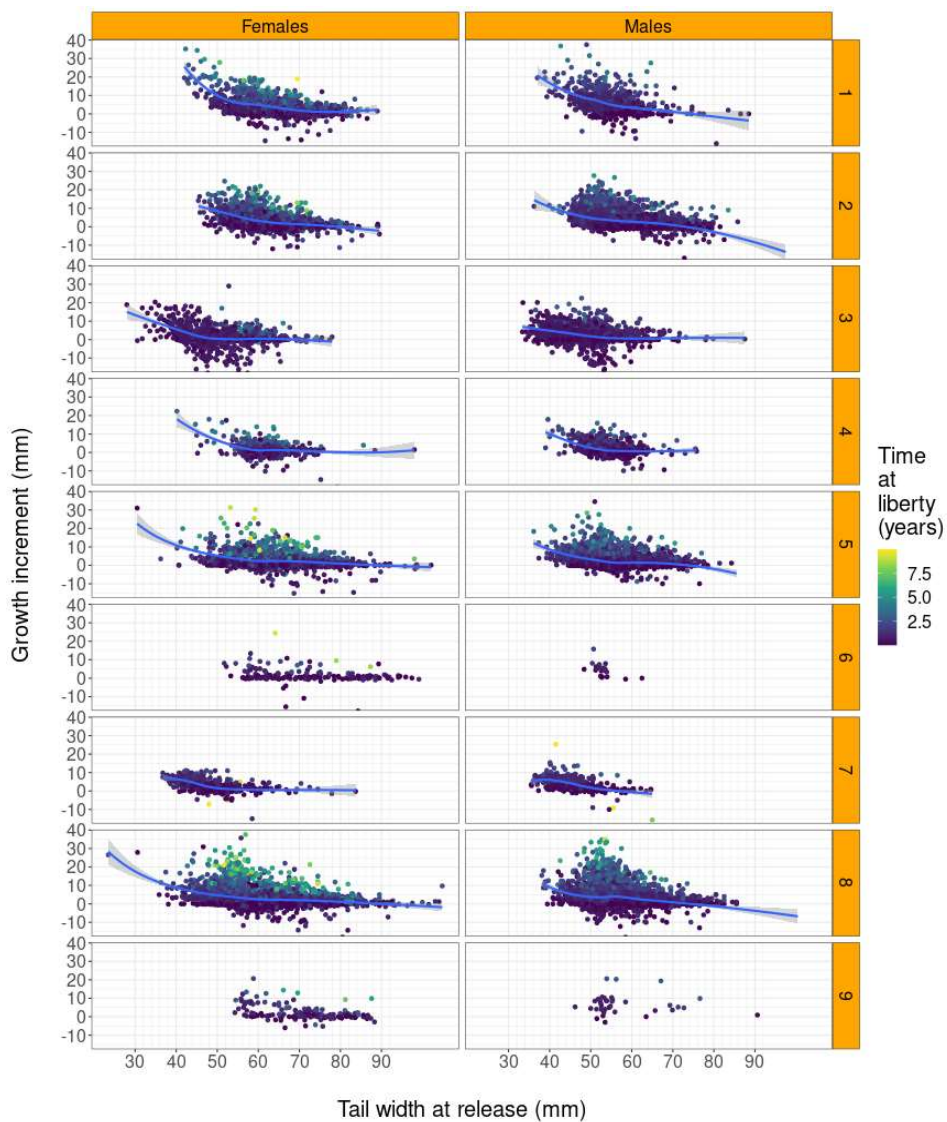


Figure 28: Growth increments (mm) by size at release (mm), sex, and QMA. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

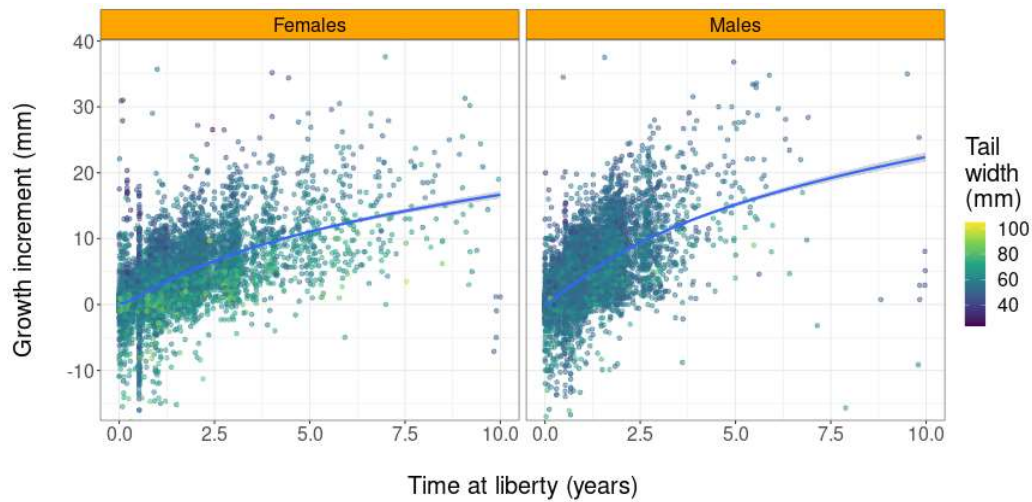


Figure 29: Growth increments (mm) by time at liberty (years) and sex for all combined tag recoveries. The colour of each point represents the size at release (mm). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

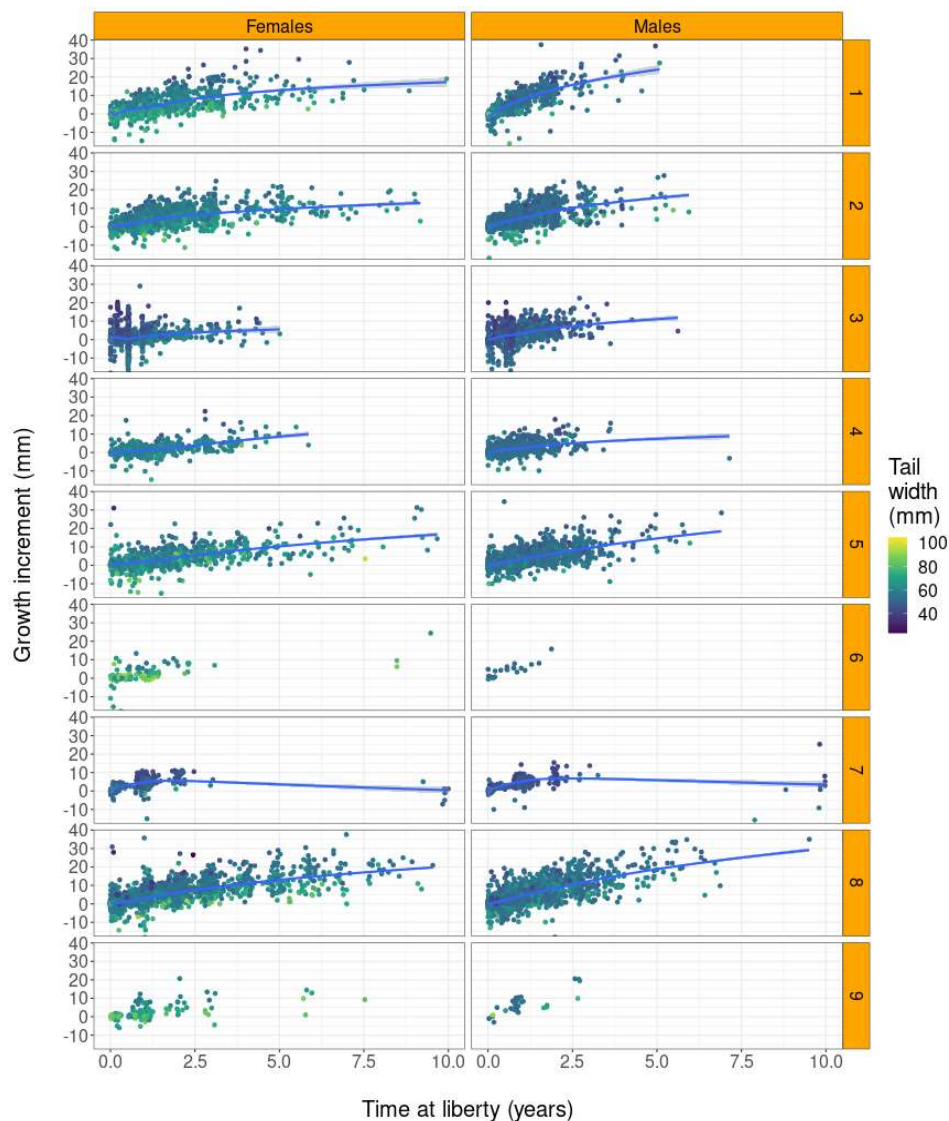


Figure 30: Growth increments (mm) by time at liberty (years), sex, and QMA. The colour of each point represents the size at release (mm). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

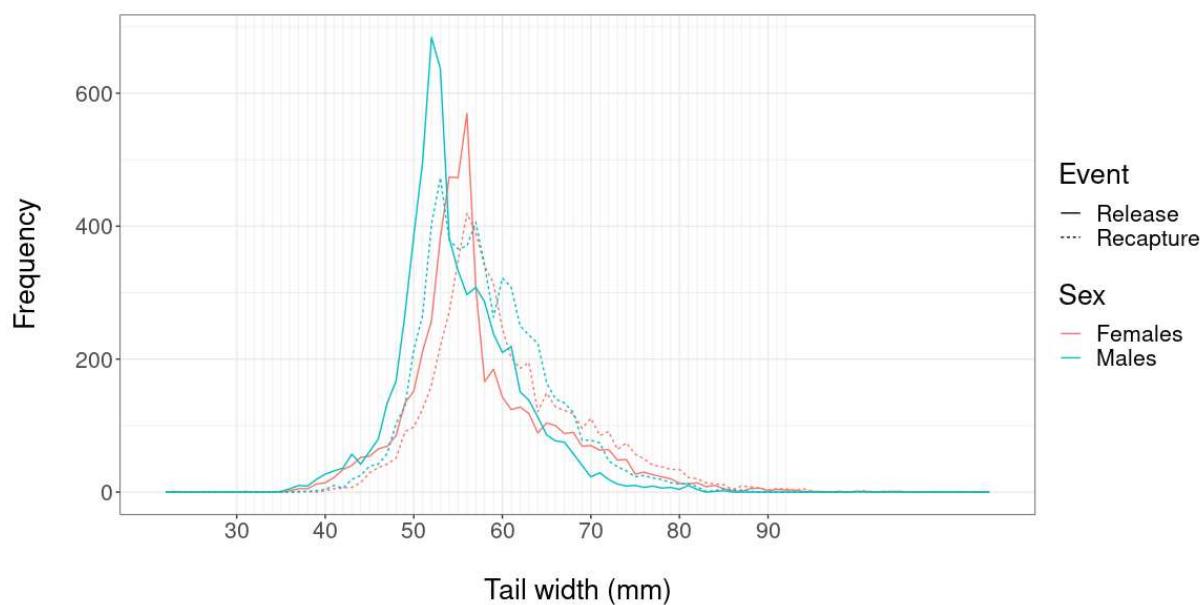


Figure 31: CRA 7&8 distribution of size at release (solid lines) and recapture (dashed lines) by sex. A bin width of 1 mm was used.

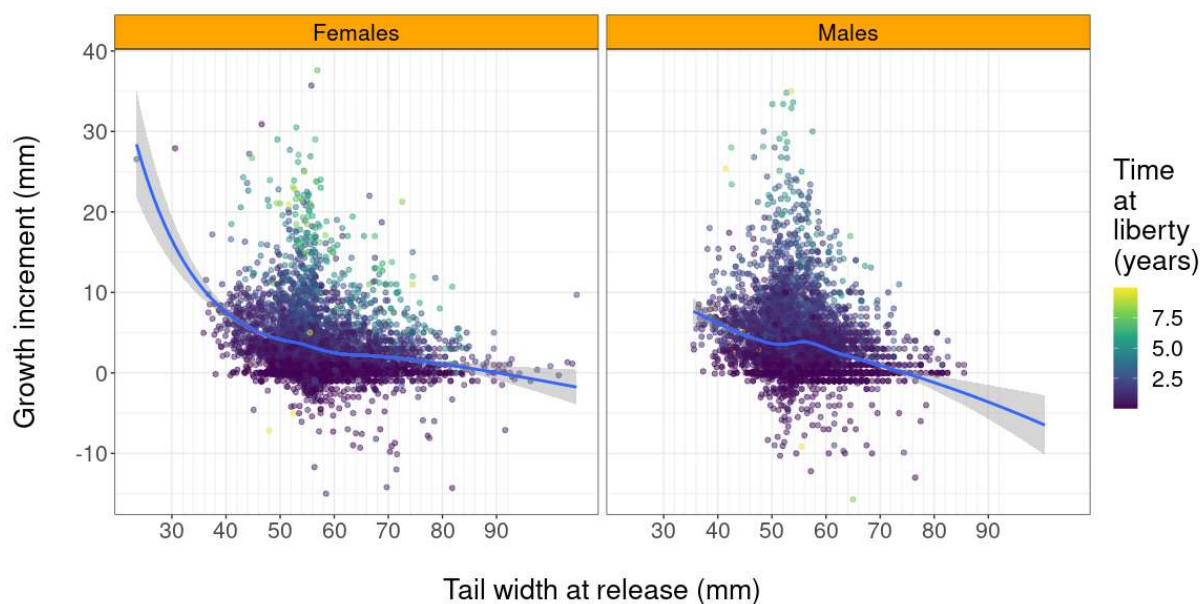


Figure 32: Growth increments (mm) by size at release (mm) and sex for all tags included in the CRA 7&8 stock assessment. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown.

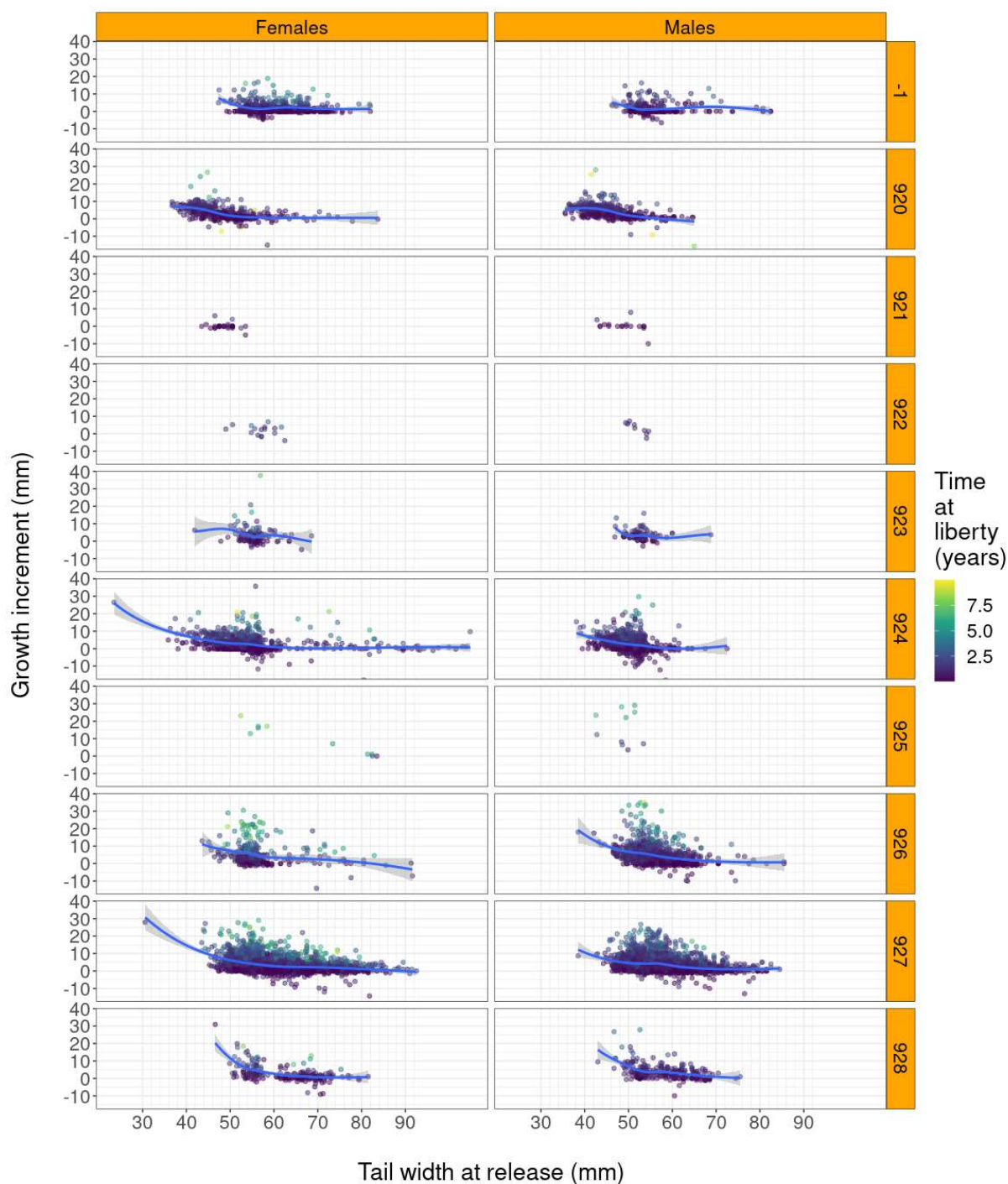


Figure 33: CRA 7&8 growth increments (mm) by size at release (mm) and sex in each release statistical area. The colour of each point represents the time at liberty (years). A loess smoother (blue line) and the 95% confidence interval (grey shading) about this smoother is also shown. -1: unknown statistical area.

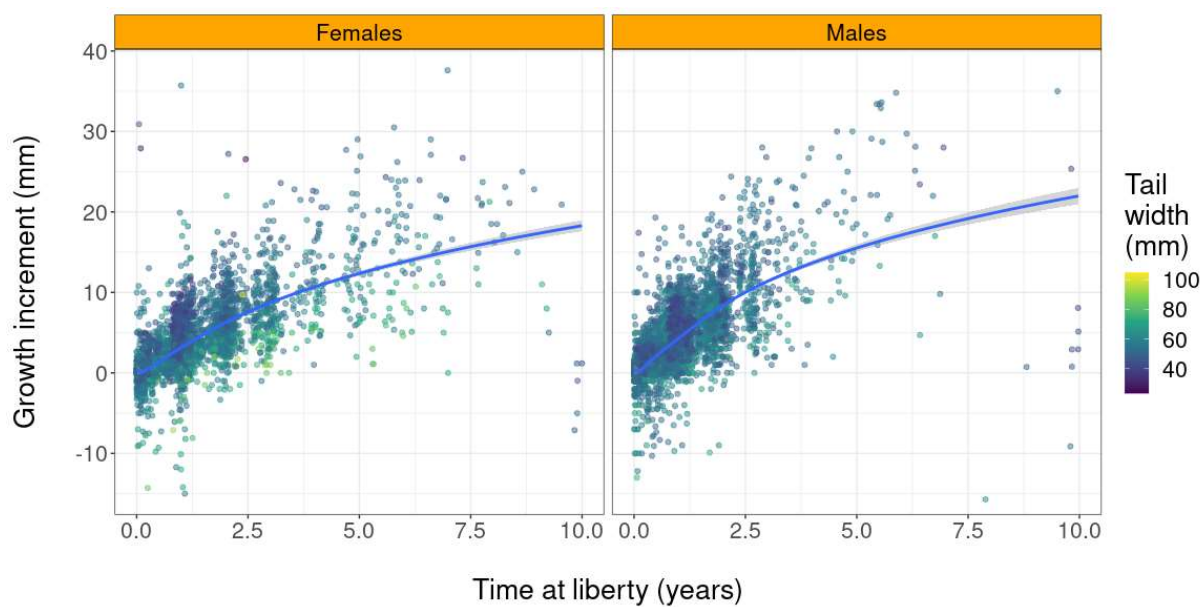


Figure 34: CRA 7&8 growth increments (mm) by time at liberty (years) and sex for all tags included in the stock assessment. The colour of each point represents the tail width (mm). A loess (blue line) and the 95% confidence interval (grey shading) about this smoother is also shown.

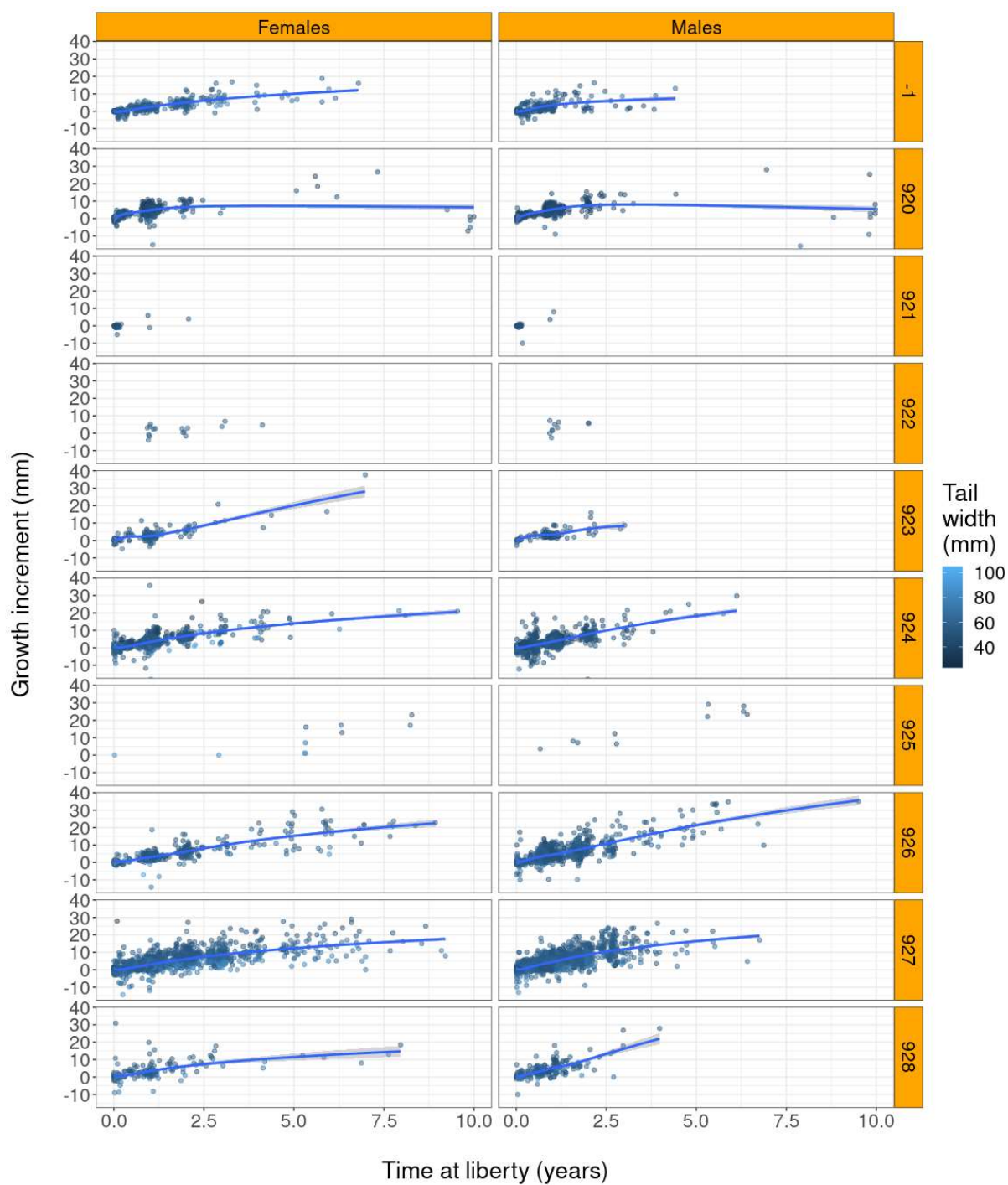


Figure 35: CRA 7&8 growth increments (mm) by time at liberty (years) and sex in each release statistical area. The colour of each point represents the tail width (mm). A loess smoother (blue line) and the 95% confidence interval about this smoother (grey shading) is also shown. -1: unknown statistical area.

Appendix A: Request to Fisheries New Zealand for non-commercial catch estimates



✉ darcy@quantifish.co.nz

🌐 www.quantifish.co.nz

72 Haukore Street
Hairini
Tauranga 3112
New Zealand

☎ 021 0233 0163

28 August 2021

RE: non-commercial data request for New Zealand red rock lobster stock assessments in 2021

By email: Sonja.Hempel@mpi.govt.nz
Carbon copy: Leyla.Knittweis@mpi.govt.nz
merrillrudd@gmail.com
paul@starrfish.co.nz
pons.maite@gmail.com
jimroberts@gmail.com

Dear Sonja,

Specific Objectives 3 in Fisheries New Zealand CRA2021-01 include:

To carry out full stock assessments for the CRA 7 (Otago) and CRA 8 (Southern) rock lobster stocks, including estimating biomass and sustainable yields, the status of the stock in relation to management reference points, and future projections of stock status as required to support management.

During September and October of this year, the rock lobster stock assessment team will be working on the CRA 7 and CRA 8 stock assessments. To complete these objectives, the stock assessment team will require estimates of non-commercial catch components for lobsters, including customary, illegal, and recreational catches. The team has no access to customary or illegal catch information. In the past, Fisheries New Zealand 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. This year, we will require these estimates for:

1. CRA 7
2. CRA 8

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, Fisheries New Zealand must lead the process for choosing what to assume for these components; it is up to Fisheries New Zealand to specify the non-commercial catch assumptions that Fisheries New Zealand 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 Fisheries New Zealand.

The assessment team needs to know the following information for all of the stocks listed above:

1. the Fisheries New Zealand estimates of current and recent **illegal** catches, historical catch trends, and an appreciation of the uncertainty;
2. the Fisheries New Zealand estimates of current and recent **customary** catches, historical catch trends, and an appreciation of the uncertainty; and
3. the Fisheries New Zealand estimates of current and recent **recreational** catches, historical catch trends, and an appreciation of the uncertainty.

Without these estimates from Fisheries New Zealand, it will not be possible to produce acceptable stock assessments. These Fisheries New Zealand estimates of non-commercial catches are required by COB **6 September 2021**. 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,



D'Arcy Webber

Fisheries Scientist
Quantifish Limited

Appendix B: Fisheries New Zealand response to non-commercial data request

Leyla Knittweis

From: Sonja Hempel
Sent: Monday, 6 September 2021 3:38 PM
To: Darcy Webber
Cc: Leyla Knittweis; Ian Tuck
Subject: CRA 7 and CRA 8 non-commercial harvest estimates
Attachments: Summary CRA7 CRA8 customary catch as at July2021.xlsx

Mōrena Darcy,

This email provides guidance on the approach I propose for generating customary, illegal, and recreational take trajectories for the CRA 7 and CRA 8 stock assessments this year.

If you have any questions or have ideas on alternate approaches, I'm more than happy to discuss.

Customary harvest estimates

A summary of the information Fisheries New Zealand holds on CRA 7 and CRA 8 customary harvest since the 2007/08 April fishing year is provided in the attached excel file. This information is provided under the South Island Customary Fishing Regulations 1999.

Based on the customary harvest information available, noting its incompleteness and uncertainty, we consider it appropriate to continue to use a 1 tonne constant customary catch estimate for CRA 7, and for CRA 8, the following is proposed: a constant estimate of 6 tonnes from 1963 to 2012, increased proportionately to 15 tonnes in 2014, and a constant estimate of 15 tonnes from 2014.

Illegal take estimates

Because of the lack of robust illegal take estimates, we propose that a similar approach is taken for CRA 7 and CRA 8 this year as per CRA 4 and CRA 5 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 1%, 5%, 10% and 15%.

I would like Fisheries Compliance in the regions to be able to consider the illegal take trajectories once they have been created. Would this be possible following the upcoming Rock Lobster Fisheries Assessment Working Groups (i.e. provide feedback by end of September on a preferred approach)?

If this is not possible, then noting the incompleteness and uncertainty of the information, I would consider it appropriate to use the following illegal take estimates:

- 1 tonne per year from 2002 for CRA 7, and
- 3 tonnes per year from 2011-14, scaled to 18 tonnes for 2002, and then 18 tonnes per year from 2002.

Handling mortality

I assume that handling mortality estimates will be generated as part of the stock assessment, and assumed to be 10% of returned lobsters until 1990, and then 5% thereafter.

Could we please consider exploring a sensitivity with higher handling mortality? I note there is anecdotal Compliance information of comparatively high catching and holding pot mortalities, particularly in CRA 8, associated with high

loading of holding pots, remote locations with access difficulties, and stringent LFR requirements potentially leading to more fish being discarded. I would suggest considering exploring the following sensitivities for handling mortality:

- 10% of returned lobsters until 1990, and 5% hereafter (status quo),
- 10% of commercial catch after 1990 added to the status quo, and
- 20% of commercial catch after 1990 added to the status quo.

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 CRA 7 and CRA 8, I 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 CRA 4 and CRA 5.

If this is not possible, then noting the incompleteness and uncertainty of the information, I would consider it appropriate to use constant recreational take estimates of 5 tonnes for CRA 7, and 20 tonnes for CRA 8.

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 may also be recreational length frequency data available for CRA 7 and CRA 8 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)
1	34	65	19 350	0.47	0.82	15.91
2	33	79	19 123	0.35	0.74	14.21
3	30	90	22 515	0.26	0.54	12.21
4	72	195	52 145	0.21	0.79	41.38
5	61	265	51 464	0.21	0.80	40.96
7	1	1	82	1.00	1.12	0.09
8	25	62	24 732	0.36	0.65	16.17
9	22	62	20 034	0.34	0.85	17.07
TOTAL	261	819	209 446	0.11	0.75	158.00

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

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

based on commercial observer and logbook data - see Appendix 1

data from 2016–17 and 2017–18 combined

Kind regards,
Sonja

Ngā mihi,

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Appendix C: CRA 7&8 puerulus settlement index analysis

C.1 Background

Stock assessments for New Zealand red rock lobster routinely trial the inclusion of puerulus settlement indices to inform annual recruitment strength. It was hypothesised that relative counts of puerulus from collectors near to where a fishery operates may be correlated with annual recruitment patterns once an appropriate time lag between settlement and recruitment is assumed. Puerulus settlement information is currently used with success to predict the catch rate of Western rock lobster (*Panulirus cygnus*) (e.g., Caputi et al. 2012). This approach makes the underlying assumption that the monitoring sites used to generate the puerulus indices are representative of the settlement across the stock.

Puerulus settlement has been monitored at various **sites** in New Zealand since the early 1980s (see main plot of Figure C.1), using monthly puerulus counts at individual **collectors**, organised into **groups** (see inset plots of Figure C.1). The puerulus count data have been analysed using a generalised linear model (GLM) to estimate standardised annual settlement indices for each site (noting that, with the exception of CRA 4 and CRA 8, there is not more than one site per QMA). The relevant puerulus settlement index time series was then supplied to the assessment team, which conducted a set of ‘randomisation trials’ to determine whether the puerulus settlement index should be used in the stock assessment. These trials determined the statistical likelihood of all the data when the puerulus settlement index was fitted and compared this with the equivalent likelihood when the puerulus index was randomly resampled (see Haist et al. 2013 for a fuller description of this process). Currently, none of the base case models for any of the New Zealand red rock lobster stock assessments (i.e., for CRA 1–8) includes a puerulus settlement index.

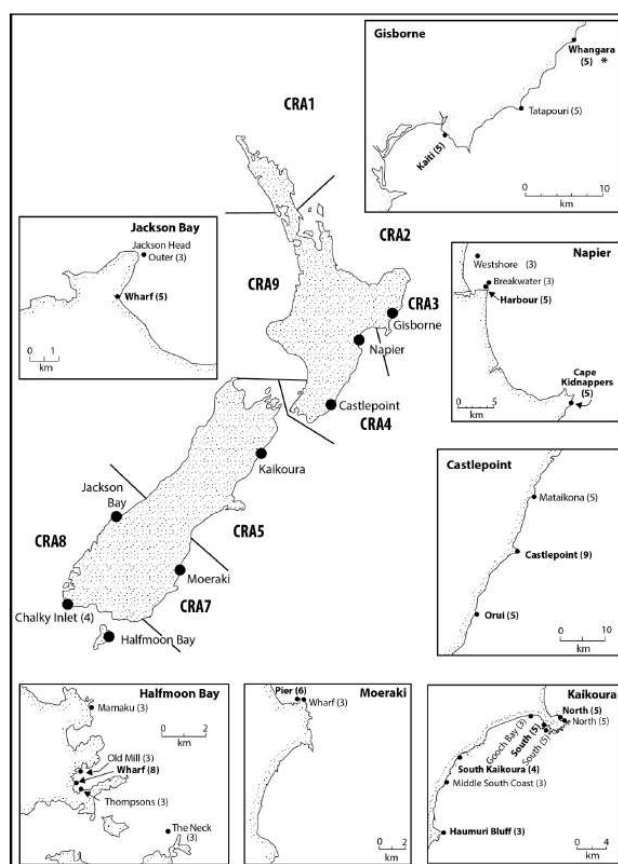


Figure C.1: Locations of red rock lobster puerulus collector sites around New Zealand (main plot) and groups at each site (inset plots). Figure reproduced from Forman et al. (2021).

For CRA 7 and CRA 8, the puerulus monitoring sites with an adequate time series of observations are situated at Moeraki (CRA 7), and Halfmoon Bay, Chalky Inlet, and Jackson Bay (all CRA 8) (Figure C.1). Note that monitoring at Chalky Inlet was continuous from 1985–86 to 2004–05 but has been sampled intermittently since then (Forman et al. 2021).

The puerulus indices were not used by the 2015 assessment for CRA 7&8 (Haist et al. 2016) due to the very poor fit to this index obtained during the 2012 assessment (Haist et al. 2013), and also due to the contrasting temporal patterns in settlement at the three historical collector sites in CRA 8.

Furthermore, while the 2015 CRA 7 and CRA 8 stock assessments were conducted for each QMA separately, the 2021 stock assessment (Webber et al. 2022) combined statistical areas 920–925 (all of CRA 7 and the eastern part of CRA 8, including Stewart Island as well as Snares Island) into the ‘Southland’ model region, and areas 926–928 into the ‘Fiordland’ model region (see Appendix E for the rationale underlying this choice). This spatial configuration linked the Halfmoon Bay collector site (in CRA 8) with the Moeraki site, and both were assumed to be relevant to recruitment patterns in the Southland region, while the Chalky Inlet and Jackson Bay sites were assumed to be representative of the Fiordland region.

Because of this, a reanalysis of the puerulus count data was required, with the objective of producing settlement indices that would be consistent with the model structure being used for the 2021 stock assessment of CRA 7 and CRA 8. The main difference from the approach of Forman et al. (2021) being that settlement indices were developed for each region within the combined CRA 7&8, i.e., the Southland and Fiordland regions (see 0) rather than for single monitoring sites. This appendix describes that analysis.

C.2 Puerulus count data

Monthly counts of puerulii are made at active collectors. The spatial organisation of collectors is summarised by Forman et al. (2021). Briefly, monitoring sites are located 140–400 km apart (Figure C.1). Each monitoring site consists of groups of collector traps that are separated by 10 to 30 km, with 3–20 individual collectors in each group.

The monthly puerulus count data from all collectors within CRA 7 and CRA 8 were supplied by NIWA on 1 October 2021 (see Forman et al. 2021 for a summary of these data and methods used to collect them). These data had a row for each monthly count at each individual collector. Fields in the dataset included: a joint identifier of monitoring site and the associated group (e.g., ‘HMB001’, which would be collector group 1 at the Halfmoon Bay monitoring site at Stewart Island); the date of each count; the individual collector ID (within a group), and the number of puerulii counted at each respective collector.

Following the approach of Forman et al. (2021), some of the counts were dropped from this analysis:

- Collector group labels with suffix “J”, which denotes juvenile counts.
- Individual collectors with < 36 monthly sampling events.
- Sampling events outside of relatively high-count months (varies by site; see Forman et al. (2021); note all months were used for Chalky Inlet).

In addition, this analysis excluded counts from:

- Collectors with < 30 puerulii counted across all years, which would have minimal relevance to settlement across a site or region.
- Years with zero puerulii counted within a region (defined below), which can cause issues for inclusion within the stock assessment model (see Haist et al. 2013).

C.3 Standardisation approach

Annual puerulus settlement indices (by fishing year) were produced for each of the two assessment model regions of (see Appendix E):

- Southland, which included puerulus settlement information from the Halfmoon Bay and Moeraki monitoring sites (consistent with a recommendation by Cockcroft 2011); and
- Fiordland, which included Chalky Inlet and Jackson Bay.

The settlement indices were predicted using GLMs fitted to monthly counts at collectors, using *brms* (Bürkner 2017) in *R* (R Core Team 2021). All models assumed a negative binomial error distribution, which Forman et al. (2021) found to be appropriate for the puerulus count data.

The candidate model terms were: fishing year (forced), day of the year (i.e., from 1–365), monitoring site, group, and individual collector ID. Fishing year and day were specified as population-level effects, with the latter specified as a cyclical spline that was allowed to vary by monitoring site. Collector ID was either specified as a group-level effect on its own or was nested within group within monitoring site. Thus, the most complex model had the structure:

$$\text{count} \sim \text{year} + \text{s}(\text{day}, \text{by} = \text{monitoring site}) + (1 \mid \text{monitoring site} / \text{group} / \text{collector_id})$$

The day cyclical spline used a basis dimension (k) value of 4, which was found to give adequate flexibility.

The Hamiltonian Markov chain Monte Carlo (MCMC) algorithm employed by *brms* was used to obtain samples from the posterior distribution. The default *brms* prior was used for all parameters. Model performance was evaluated by visual inspection of MCMC trace plots to assess for non-convergence issues, posterior predictive plots to determine agreement with distributional assumptions, and plots to check the shape of the smoothing terms. Model comparison was done using the leave-one-out information criterion (LOO IC) (Vehtari et al. 2017).

C.4 Results

The sum of monthly sampling events at collectors by monitoring site and fishing year is shown in Figure C.2 (note that this figure excludes counts dropped from this analysis). In both regions, there has been a shift in the intensity of sampling by monitoring site. Prior to fishing year 1990, all sampling in Southland was at Halfmoon Bay, and the relative amount of sampling at Moeraki has varied since then, although it was less than at Halfmoon Bay in most years. In Fiordland, all sampling was at Chalky Inlet before fishing year 1999, but after that year, sampling at Jackson Bay increased, while sampling at Chalky Inlet has been intermittent. The raw counts are summarised by fishing year and group within each monitoring site (Figure C.3) and by month and group (Figure C.4).

MCMC trace plots are shown for the final models for each region (Figure C.5 and Figure C.6), along with posterior predictive plots (Figure C.7 and Figure C.8), and plots to check the shape of the smoothing terms (Figure C.9 and Figure C.10).

For the **Southland** region, the best model in terms of LOO IC was the model with the most complex structure (fits0), including: fishing year, a spline for day of the year by monitoring site, and group as a nested group-level effect, with collector ID nested within group, nested within site (Table C.1). The trace plots for this model run suggest that convergence was achieved (Figure C.5) and posterior predictive plots indicate that the assumed negative binomial error distribution was appropriate given the data and model (Figure C.7). The splines for the day of the year effect had a slightly different shape for each monitoring site, with the winter peak in counts occurring approximately a month later at Halfmoon Bay, compared with Moeraki (Figure C.9). The model predictions by fishing year were

highly uncertain and were possibly consistent with elevated puerulus settlement in the early 1980s and from 2000–01 to 2003–04, and possibly after 2015–16 (Figure C.11). The shape of the model predictions by year were primarily influenced by sampling at the ‘HMB001’ group (compare Figure C.11 with Figure C.3), which had more collectors than the other groups in this region (8 collectors, compared with ≤ 6 for the other groups) and the longest time series of sampling. Figure C.3 also shows that there is minimal temporal overlap comparing the three Moeraki groups (‘MOE002’, ‘MOE007’, and ‘MOE008’), indicating that there may be some confounding between the year effect and the group effect in the model estimates, although this should have been prevented to some extent by also including the ‘HMB001’ group in this model, which has a long and unbroken time period of sampling.

For **Fiordland**, the model run with the best LOO IC was again the most complex model (fitf0) (Table C.2), although the diagnostics for this model indicated non-convergence (not shown). The next best model in terms of LOO IC (fitf2) was consequently selected. Model fitf2 had acceptable mixing (Figure C.6). The posterior predictive plots indicated that the assumed negative binomial error distribution was appropriate given the data and model, although the data were slightly more dispersed relative to the model assumption (Figure C.8). The shapes of the seasonal splines for Jackson Bay (almost flat) and Chalky Inlet (strongly peaked) were very different, justifying the decision to allow this covariate to vary by site (Figure C.10). The model predictions by fishing year were also highly uncertain for Fiordland and were consistent with an extended period of relatively low puerulus settlement from 1985–86 to 2009–10, followed by consecutive years of much higher settlement rate (Figure C.11). This pattern was strongly influenced by sampling at ‘JKB001’, which had more intensive sampling than the other collector groups at Jackson Bay or Chalky Inlet.

The model parameter estimates are shown in Table C.3 and Table C.4. The model predicted puerulus settlement indices for both regions are also tabulated in Table C.5 and were used in the stock assessment (Webber et al. 2022).

C.5 Conclusions and future research

For the purposes of this analysis, all observations were given the same statistical weighting, which meant that the group with the most individual counts had the most weight in the model. Consequently, the model predicted settlement indices were most influenced by the observations from only two groups (‘HMB001’ and ‘JKB001’). It is not known how representative these two groups are of temporal patterns in each of the two regions.

An attempt was made to include these puerulus settlement indices in the 2021 CRA 7&8 stock assessment model to inform annual recruitment deviations (Webber et al. 2022). However, the inconsistencies between the index series (Table C.5) and the other data used in the stock assessment were so large that the puerulus randomisation trials were not done and the puerulus settlement indices were not included in the stock assessment.

Recommendations for future research include:

1. Explore potential environmental drivers of recruitment variability for the CRA 7&8 stock, such as sea temperature, given the southerly location of this stock within the New Zealand range of this species.
2. Collect/review information relevant to the processes occurring between puerulus settlement and the size/age at full recruitment to stock assessment models, e.g., including density dependent effects and climate processes.

C.6 Tables

Table C.1: Comparison of model runs for the Southland region. Final model used for predicting the settlement index is highlighted with * symbol.

Model label	Model structure	LOO IC	SE LOO IC	Convergence status
fits0*	count ~ fyear + s(day, by = site) + (1 site/group/collector_id)	3734.3	104.3	yes
fits1	count ~ fyear + s(day) + (1 site/group/collector_id)	3756.7	104.3	yes
fits2	count ~ fyear + s(day, by = site) + (1 collector_id)	3766.8	104.5	yes

Table C.2: Comparison of model runs for the Fiordland region. Final model used for predicting the settlement index is highlighted with * symbol.

Model label	Model structure	LOO IC	SE LOO IC	Convergence status
fitf0	count ~ fyear + s(day, by = site) + (1 site/group/collector_id)	7071.0	134.9	no
fitf2*	count ~ fyear + s(day, by = site) + (1 collector_id)	7074.6	134.8	yes
fitf1	count ~ fyear + s(day) + (1 site/group/collector_id)	7169.6	136.4	yes

Table C.3: Summary of parameter estimates for the final model used to predict to puerulus settlement indices for the Southland region (fits0). Parameters “sds(sdaysiteHMB_1)” and “sds(sdaysiteMOE_1)” are the variance parameters for the seasonal smooths for Halfmoon Bay and Moeraki sites, respectively, and the other smooth terms are the fixed effect part of each respective spline; “shape” is the overdispersion parameter for the negative binomial distribution. The group-level effects are the variance parameters for the locational group-level effects.

Parameter	Median	SD	2.5%	97.5%
Population-level effects (fishing year):				
Intercept	-0.332	1.043	-2.771	1.799
1981	1.923	0.734	0.604	3.600
1982	-1.229	0.882	-2.961	0.644
1983	1.204	0.759	-0.135	2.885
1984	-1.745	1.070	-4.137	0.332
1986	-2.768	1.372	-6.354	-0.366
1987	0.071	0.760	-1.296	1.756
1988	-2.580	1.064	-4.832	-0.510
1989	-0.739	0.794	-2.174	0.995
1990	-1.206	0.782	-2.712	0.543
1991	-1.291	0.772	-2.724	0.423
1992	-0.898	0.762	-2.294	0.810
1994	-0.656	0.739	-2.030	1.030
1995	-1.205	0.754	-2.617	0.476
1996	-0.972	0.740	-2.358	0.716
1997	-0.963	0.762	-2.335	0.745
1998	-1.294	0.764	-2.722	0.436
1999	-1.945	0.871	-3.682	-0.080
2000	0.632	0.700	-0.656	2.274
2001	0.294	0.701	-0.975	1.942
2002	-0.477	0.723	-1.794	1.193
2003	1.260	0.696	0.013	2.896
2004	-2.402	0.838	-4.032	-0.596
2005	-4.599	1.316	-8.059	-2.230
2006	-2.972	0.873	-4.669	-1.122
2007	-1.081	0.750	-2.465	0.601
2008	-3.025	0.931	-4.934	-1.132
2009	-0.500	0.727	-1.800	1.176
2010	-0.056	0.713	-1.316	1.577
2011	-1.533	0.755	-2.903	0.154
2012	-1.279	0.714	-2.594	0.387
2013	-0.729	0.704	-1.997	0.911
2014	-1.032	0.729	-2.347	0.614
2015	0.491	0.695	-0.751	2.122
2016	0.022	0.698	-1.241	1.653
2017	0.577	0.700	-0.664	2.201
2018	-0.183	0.723	-1.481	1.461
2019	-0.615	0.713	-1.914	1.041
2020	0.230	0.703	-1.037	1.864
Smooth terms (day):				
sds(sdaysiteHMB_1)	1.960	0.916	0.888	5.733
sds(sdaysiteMOE_1)	2.281	1.010	1.051	6.306
Group-level effect (collector ID):				
sd(Intercept) ~collector ID	0.834	0.774	0.041	3.572
sd(Intercept) ~site:group	0.782	0.344	0.358	2.297
sd(Intercept) ~site:group:collector_id	0.148	0.076	0.015	0.309
s_sjuliansiteHMB_1[1]	-2.034	0.195	-2.429	-1.653
s_sjuliansiteHMB_1[2]	-1.119	0.196	-1.503	-0.740
s_sjuliansiteMOE_1[1]	-2.812	0.340	-3.485	-2.148
s_sjuliansiteMOE_1[2]	-0.335	0.203	-0.737	0.062
Family-specific parameters:				
shape	1.641	0.196	1.306	2.111

Table C.4: Summary of parameter estimates for the final model used to predict to puerulus settlement indices for the Fiordland region (fitf2). Parameters “sds(sdaysiteCHI_1)” and “sds(sdaysiteJKB_1)” are the variance parameters for the seasonal smooths for Chalky Inlet and Jackson Bay sites, respectively, and the other smooth terms are the fixed effect part of each respective spline; “shape” is the overdispersion parameter for the negative binomial distribution. The group-level effects are the variance parameters for the locational group-level effects.

Parameter	Median	SD	2.5%	97.5%
Population-level effects (fishing year):				
Intercept	-0.778	0.542	-1.907	0.259
1986	-0.527	0.599	-1.661	0.690
1987	0.907	0.571	-0.171	2.080
1988	1.061	0.590	-0.056	2.285
1989	1.196	0.572	0.114	2.379
1990	1.415	0.559	0.366	2.575
1991	1.012	0.587	-0.107	2.238
1992	0.037	0.582	-1.070	1.240
1993	-0.961	0.662	-2.238	0.383
1994	1.490	0.566	0.433	2.657
1995	0.046	0.614	-1.129	1.308
1996	1.453	0.549	0.414	2.597
1997	1.334	0.549	0.326	2.460
1998	0.161	0.556	-0.883	1.316
1999	0.914	0.539	-0.106	2.044
2000	1.211	0.534	0.225	2.328
2001	0.341	0.545	-0.666	1.467
2002	1.840	0.536	0.832	2.949
2003	1.242	0.539	0.238	2.357
2004	0.316	0.558	-0.730	1.488
2005	1.659	0.558	0.611	2.818
2006	0.281	0.652	-0.978	1.602
2007	0.009	0.603	-1.126	1.246
2008	-0.907	0.724	-2.375	0.529
2009	1.351	0.578	0.252	2.532
2010	2.409	0.547	1.383	3.545
2011	2.453	0.542	1.435	3.588
2012	3.365	0.545	2.357	4.500
2013	4.115	0.547	3.088	5.257
2014	4.499	0.543	3.477	5.630
2015	3.262	0.559	2.221	4.429
2016	4.159	0.549	3.130	5.296
2017	1.413	0.564	0.359	2.572
2018	2.494	0.544	1.481	3.631
2019	1.082	0.555	0.044	2.240
2020	1.895	0.566	0.837	3.070
Smooth terms (day):				
sds(sdaysiteCHI_1)	1.716	0.913	0.690	5.174
sds(sdaysiteJKB_1)	0.125	0.131	0.005	1.596
s_sjuliansiteCHI_1[1]	-1.694	0.143	-1.974	-1.416
s_sjuliansiteCHI_1[2]	0.037	0.144	-0.243	0.321
s_sjuliansiteJKB_1[1]	0.008	0.061	-0.139	0.184
s_sjuliansiteJKB_1[2]	0.034	0.072	-0.095	0.258
Group-level effect:				
sd(intercept) – collector ID	0.610	0.139	0.402	1.000
Family-specific parameters:				
shape	0.921	0.053	0.822	1.036

Table C.5: Model predicted puerulus settlement indices by fishing year and region (median estimates, with 95% credibility interval shown in brackets).

Fishing year	Southland	Fiordland	Fishing year	Southland	Fiordland
1980–81	0.783 (0.097–5.979)	–	2000–01	1.372 (0.342–7.357)	1.510 (0.539–4.134)
1981–82	5.148 (1.231–28.206)	–	2001–02	0.989 (0.251–5.179)	0.632 (0.222–1.758)
1982–83	0.228 (0.035–1.539)	–	2002–03	0.459 (0.113–2.502)	2.805 (1.012–7.744)
1983–84	2.502 (0.572–14.21)	–	2003–04	2.593 (0.668–13.33)	1.544 (0.545–4.255)
1984–85	0.138 (0.011–1.138)	–	2004–05	0.069 (0.012–0.440)	0.616 (0.207–1.796)
1985–86	–	0.454 (0.100–1.870)	2005–06	0.008 (0.000–0.088)	2.360 (0.796–6.944)
1986–87	0.050 (0.001–0.599)	0.270 (0.078–0.855)	2006–07	0.040 (0.006–0.262)	0.603 (0.164–2.152)
1987–88	0.810 (0.182–4.592)	1.124 (0.351–3.379)	2007–08	0.258 (0.058–1.445)	0.456 (0.140–1.470)
1988–89	0.060 (0.006–0.501)	1.322 (0.389–4.198)	2008–09	0.037 (0.005–0.264)	0.183 (0.040–0.739)
1989–90	0.364 (0.080–2.159)	1.502 (0.462–4.545)	2009–10	0.454 (0.112–2.409)	1.755 (0.539–5.430)
1990–91	0.227 (0.047–1.340)	1.869 (0.590–5.576)	2010–11	0.703 (0.174–3.624)	5.002 (1.686–14.171)
1991–92	0.206 (0.045–1.195)	1.256 (0.372–3.927)	2011–12	0.164 (0.038–0.909)	5.167 (1.803–14.670)
1992–93	0.308 (0.069–1.759)	0.474 (0.143–1.469)	2012–13	0.209 (0.050–1.118)	12.836 (4.548–36.527)
1993–94	–	0.175 (0.044–0.637)	2013–14	0.360 (0.089–1.874)	27.251 (9.502–78.713)
1994–95	0.386 (0.092–2.159)	2.027 (0.638–5.968)	2014–15	0.267 (0.065–1.442)	39.792 (13.938–113.437)
1995–96	0.226 (0.050–1.281)	0.479 (0.135–1.593)	2015–16	1.211 (0.311–6.112)	11.635 (3.934–34.578)
1996–97	0.283 (0.066–1.619)	1.951 (0.642–5.469)	2016–17	0.759 (0.191–3.855)	28.431 (9.960–81.748)
1997–98	0.287 (0.067–1.639)	1.720 (0.579–4.752)	2017–18	1.316 (0.332–6.390)	1.828 (0.614–5.420)
1998–99	0.209 (0.047–1.241)	0.538 (0.170–1.549)	2018–19	0.614 (0.152–3.001)	5.388 (1.872–15.219)
1999–00	0.111 (0.018–0.732)	1.129 (0.388–3.153)	2019–20	0.401 (0.098–1.971)	1.319 (0.450–3.853)
			2020–21	0.925 (0.233–4.443)	2.984 (0.986–8.982)

C.7 Figures

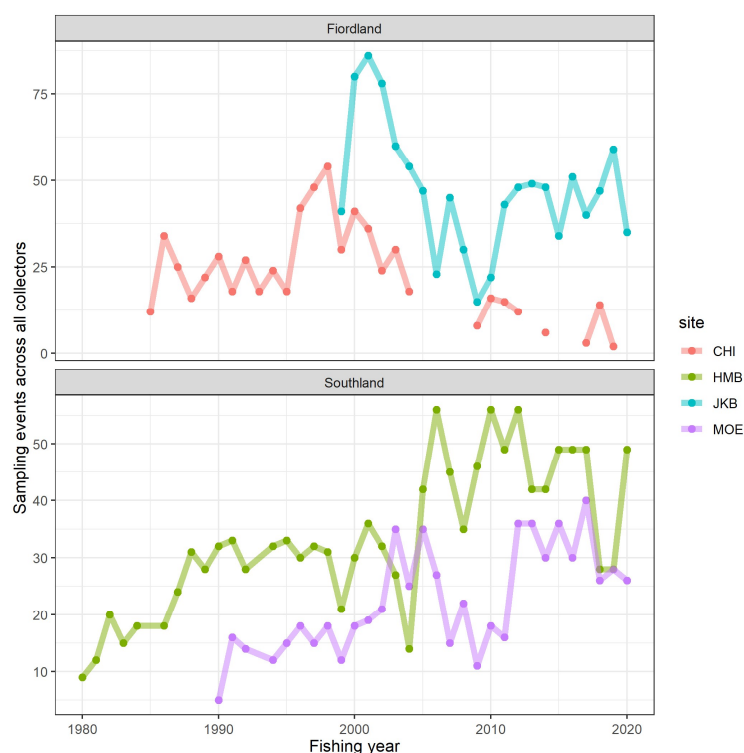


Figure C.2: Sum of puerulus sampling events by monitoring site and fishing year. Note that these values are pooled across all individual collectors within a monitoring site and the maximum number of sampling events for each collector in a fishing year is 12 (once in each month). Fishing years are labelled with the start year, e.g., “1980” = the fishing year 1980–81.

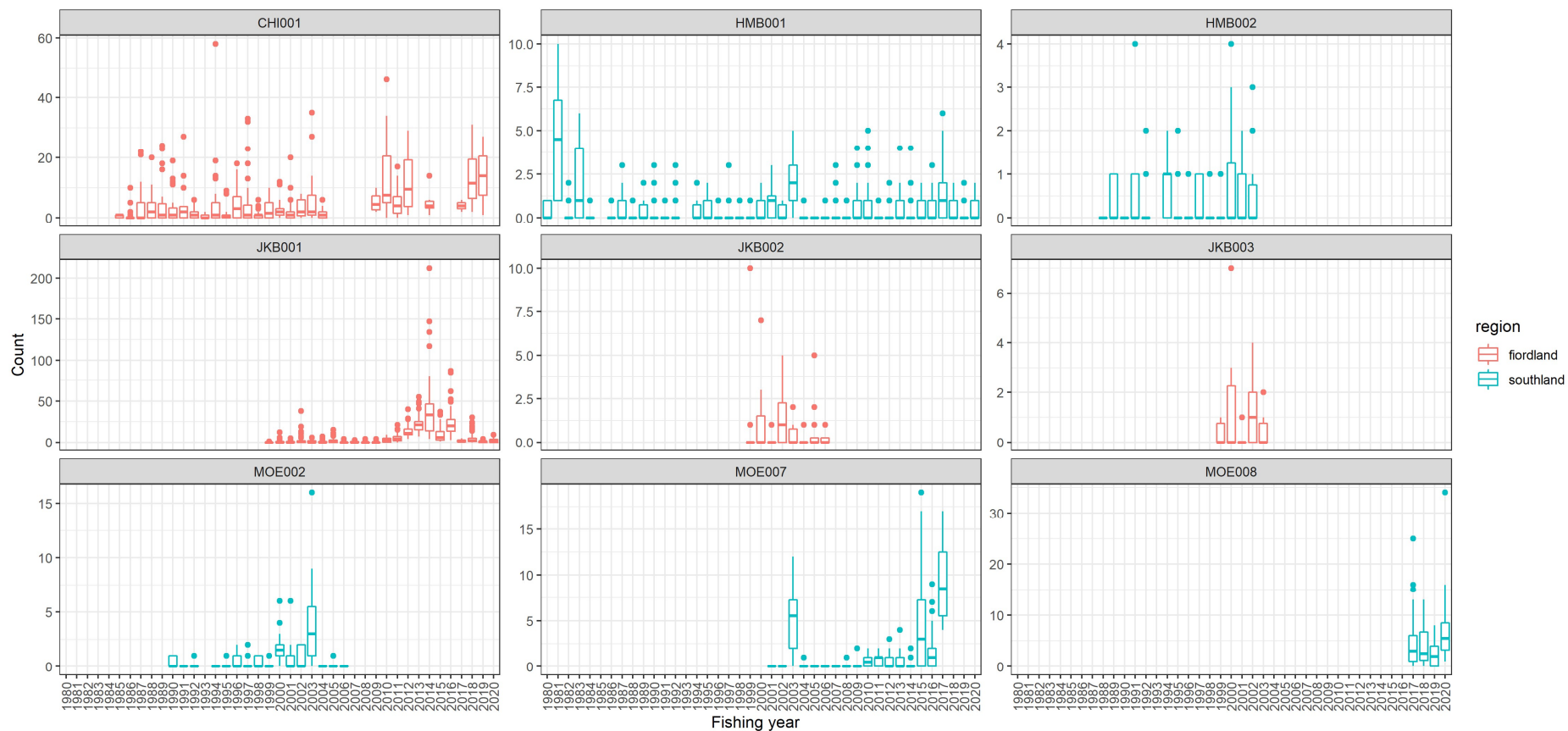


Figure C.3: Raw puerulus collector counts by group and fishing year, with separate colours used for the Southland and Fiordland regions. These data exclude counts removed by the data subsetting procedure. Fishing years are labelled with the start year, e.g., “1980” = the fishing year 1980–81.

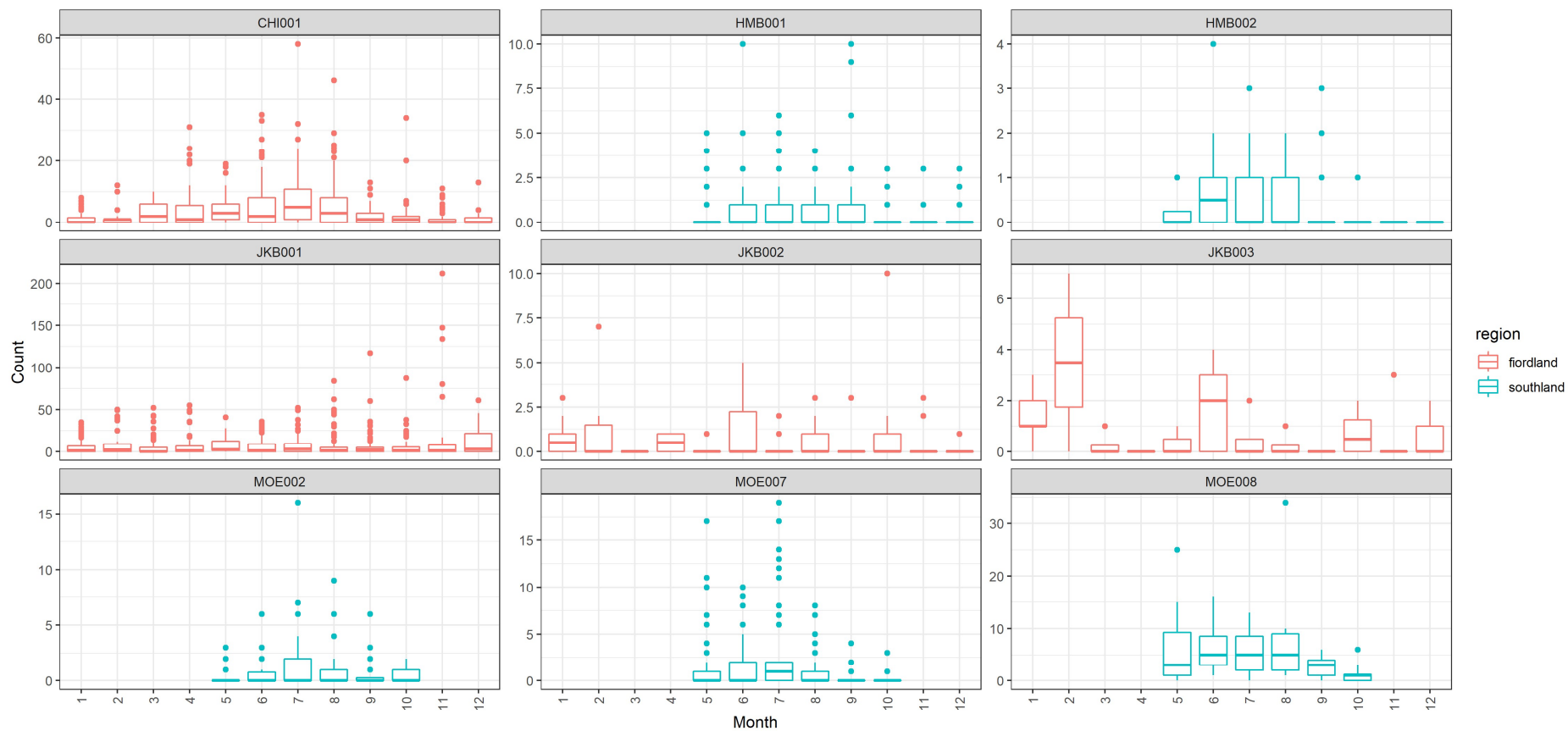


Figure C.4: Raw puerulus collector counts by group and month (i.e., "1" = January and "2" = February), with separate colours used for the Southland and Fiordland regions. These data exclude counts removed by the data subsetting procedure.

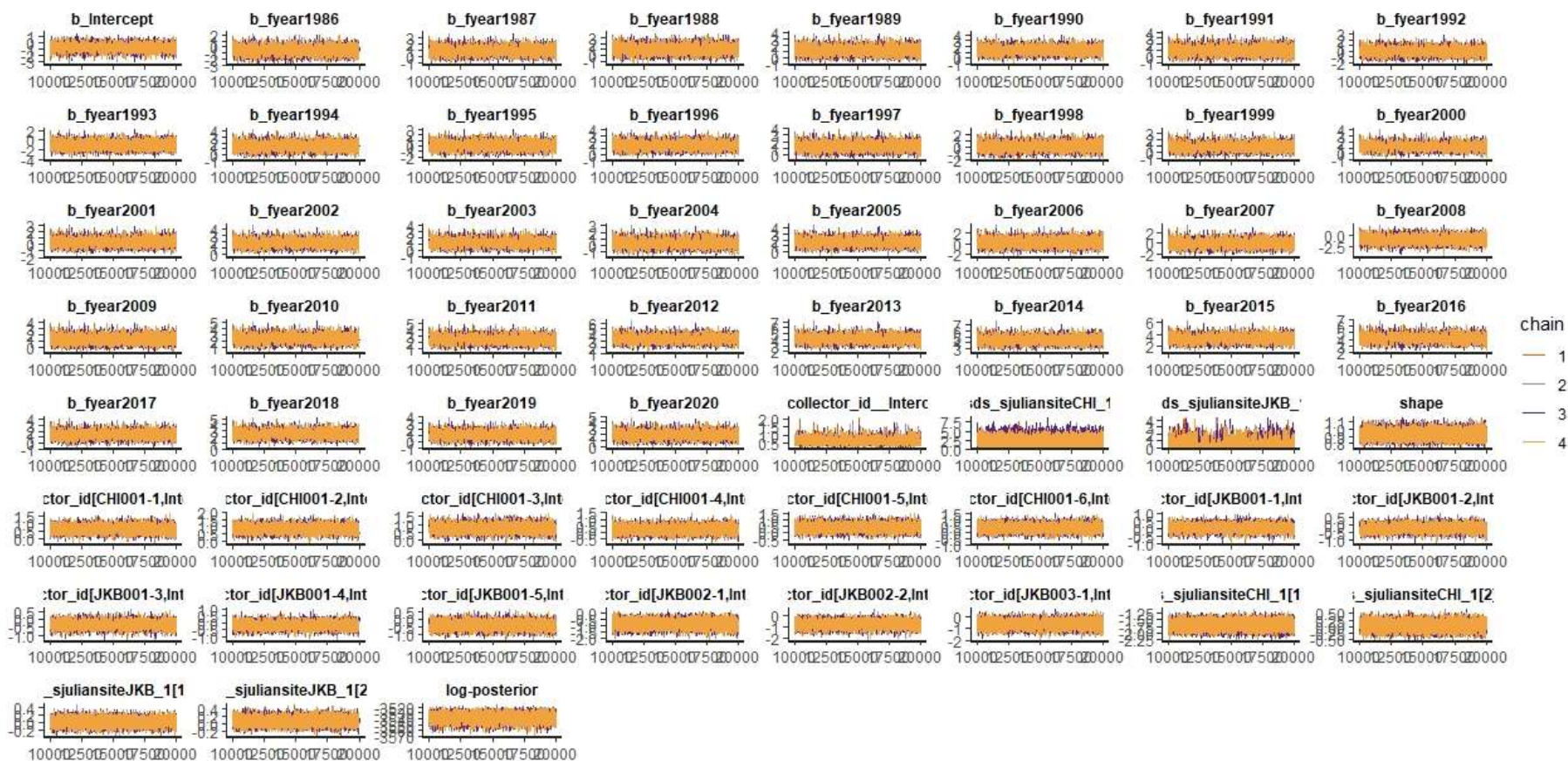


Figure C.6: Model trace plots for all model parameters and the likelihood function for model fit2 (Table C.2), the selected model for the Fiordland region.

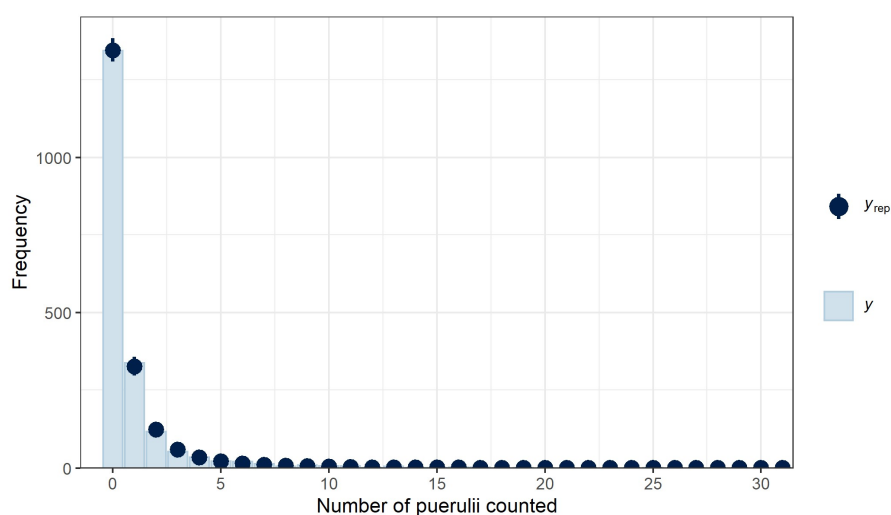


Figure C.7: Posterior predictive plots comparing the true distribution of the frequency of collector counts (bars) with 1000 simulations from the selected model for the Southland region (fits0) (points, with 95% credible intervals represented by whiskers).

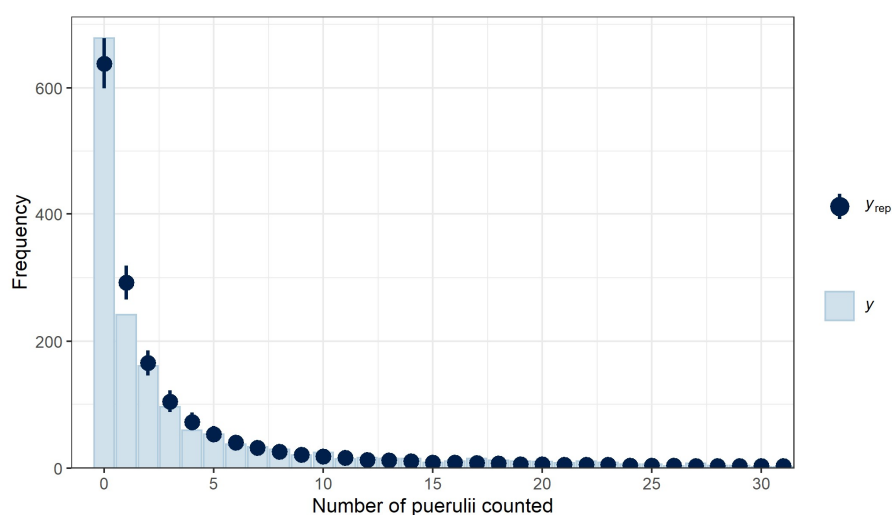


Figure C.8: Posterior predictive plots comparing the true distribution of the frequency of collector counts (bars) with 1000 simulations from the selected model for the Fiordland region (fitf2) (points, with 95% credible intervals represented by whiskers).

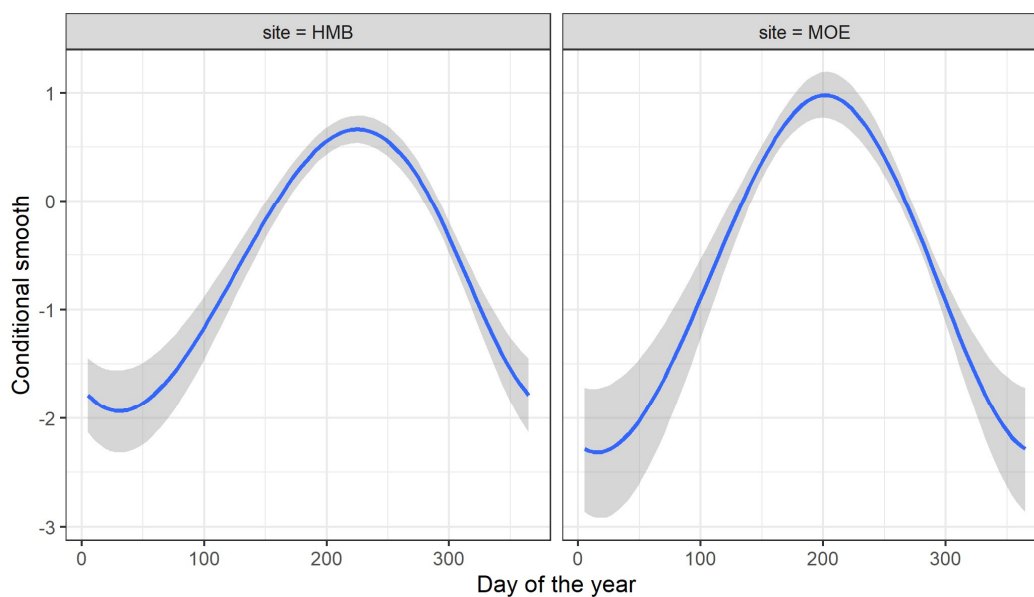


Figure C.9: Seasonal smooths by collector site from the Southland region model. “HMB” = Halfmoon Bay, “MOE” = Moeraki.

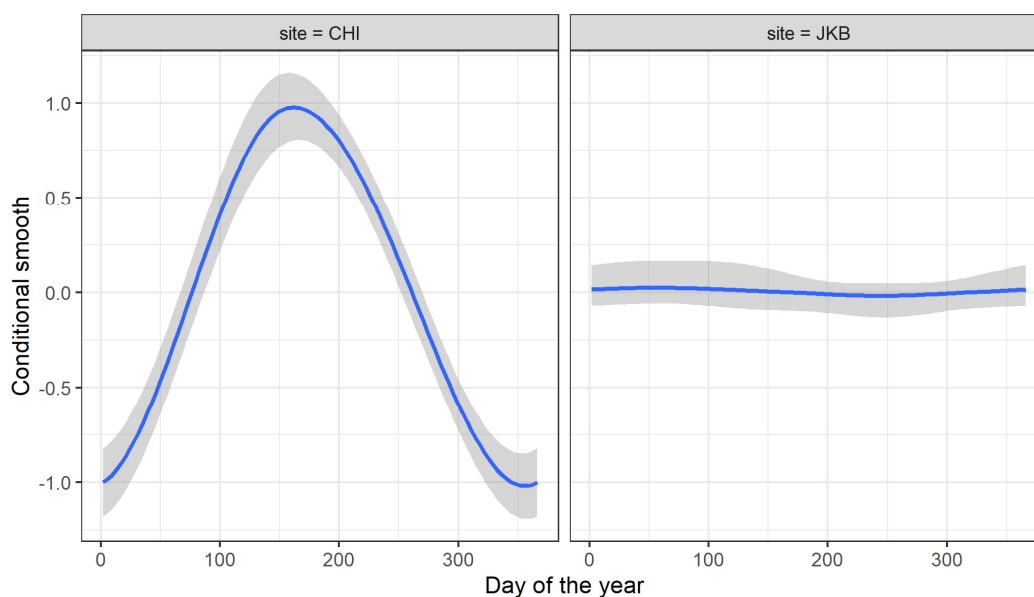


Figure C.10: Seasonal smooths by collector site from the Southland region model. “CHI” = Chalky Inlet, “JKB” = Jackson Bay.

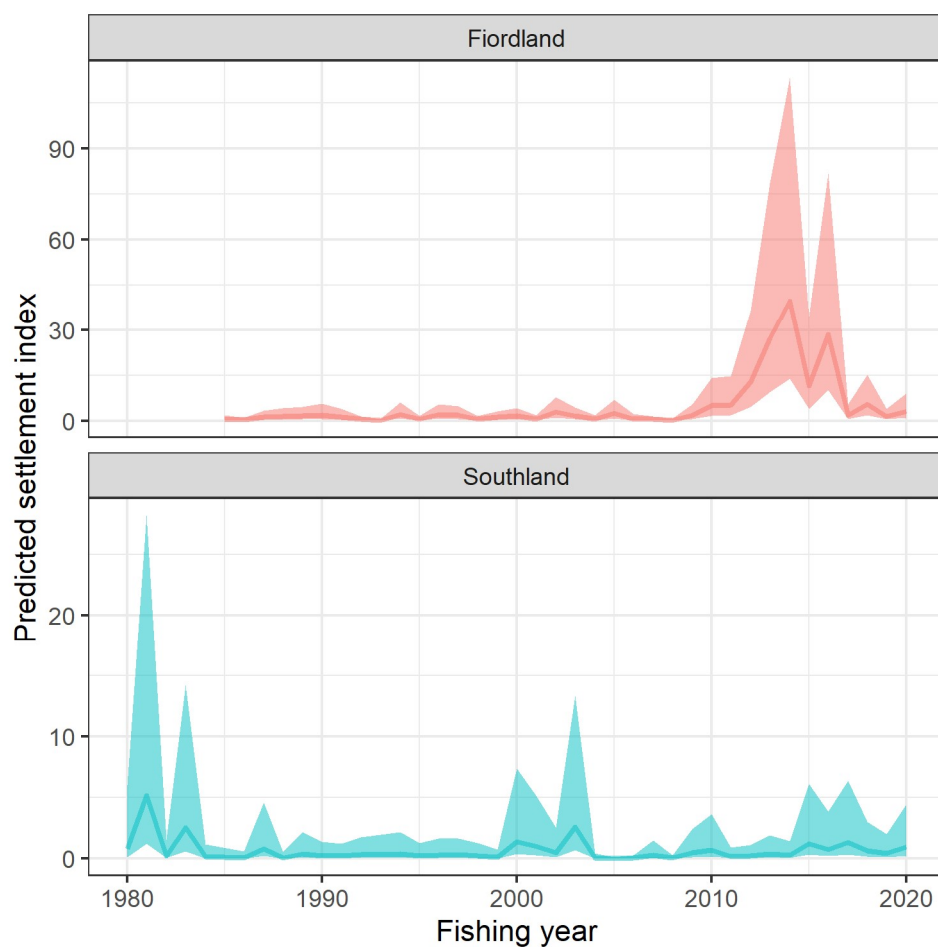


Figure C.11: Model predicted puerulus settlement indices for the Southland and Fiordland regions, showing the median (lines) and respective 95% credible intervals (shaded areas). Note the different y-axis scale used for each region. Fishing years are labelled with the start year, e.g., “1980” = the fishing year 1980–81.

Appendix D: CRA 8 retention patterns analysis

D.1 Background

Fishers are permitted to return legal lobsters (i.e., above the minimum legal size (MLS), not a berried female, and tail bars not broken) to the sea. Returned lobsters are thought to have a high survival rate: in CRA 8, about 25% of recaptured tagged lobsters have been captured more than once and some as many as 10 times. The actual survival rate for red rock lobsters is unknown, although recent stock assessments (e.g., Webber et al. 2018) assumed 95% of lobsters survive being handled and returned to the sea (90% before 1990), based on a literature review and by agreement within the RLWG.

Some lobsters may have relatively low value because of recent moulting, broken antennae, or missing legs. The price per kilogram varies with size and generally larger lobsters are less valuable per kilogram than smaller lobsters. A fisher might choose to return a large lobster to the sea when confident that the increased return will exceed the cost of catching two smaller lobsters. This practice is known as “high-grading” and its prevalence varies among the nine CRA QMAs. High-grading varies with abundance: at low abundance, the cost and uncertainty of catching smaller replacements for large lobsters returned to the sea increase. High-grading is of interest to stock assessment because the size distribution of lobsters removed from the stock will differ from the distribution of caught legal lobsters, particularly if the majority of the discarded legal lobsters tend to be large.

Retention was included in the 2012 and 2015 assessments for CRA 7 and 8, and was determined to be around 90% by weight prior to 2006, declining sharply to 60% thereafter (Starr et al. 2016). This was applied to catches in CRA 8 only (because CRA 7 lacks the logbook data required for this analysis), specifying the proportion returned by tail-width (TW) for each sex and year. This appendix describes the analysis that informed the retention function used by the latest assessment for CRA 7&8 (Webber et al. 2022).

In this appendix, “caught” refers to fish that were measured by the logbook programme (which measures all captured lobsters), “retained” or “kept” refer to fish that were recorded as having been kept for landing, “not retained” or “returned to the sea” refer to fish recorded as not having been kept, and “legal” fish are defined by the regulations and explained below.

D.2 Logbook data

Observations from the voluntary fisher logbook programme were supplied by FishServe on 2 September 2021. The dataset is structured to include a record for each lobster in the pot sample. Data fields included trip number, fisher ID, vessel number, event date, statistical area, pot lift number, sex (1 through 5, corresponding to males, immature females, mature females, berried females, and spent females respectively), mm TW (rounded to the nearest mm), and a binary ‘kept’ flag (indicating whether a lobster was retained or returned to the sea).

CRA 8 data were selected by taking a subset of records for statistical areas 922–928. Lobsters with a sex code of 6 were also omitted from the analysis (approximately 0.2% of the total sample), along with lobsters with a recorded TW of less than 30 mm. Legal males were defined as being 54 mm TW or above and legal females were defined as being 57 mm or above and not in berry.

Retention was not reported in the logbooks before 2000. Consequently, these analyses are based on data from 2000 to 2020. For each fisher ID code, the percentage retention was calculated by year. Some fisher ID codes had data for one year only; eight of these (all from 2000–01 or 2001–02) had zero or very low retention rates (not more than 10%), which was not credible (the next lowest rate was 28%). Consequently these eight fisher ID codes were removed.

The final, groomed data set contained 289 145 measurements of legal lobsters from 49 fishers, who retained 70% of them (Table D.1). Of the measured lobsters, 167 416 were males and 121 729 were females. Plots of the raw data indicated a high degree of variability in shape of retention by tail width comparing fishing years (Figure D.1) and fishers (Figure D.2).

D.3 CRA 8 retention-at-size by sex and year

For each year and each sex, the proportion of fish retained at each size was calculated. For each sex, Bernoulli models were fitted to the proportion retained at each length bin, using *brms* (Bürkner 2017) in *R* (R Core Team 2021). Six alternative models were run for each sex, forcing TW as the first model term, and offering fishing year and fisher ID as candidate model terms. Fishing year was offered either as a group-level effect or a population-level effect, whereas fisher ID was only offered as a group-level effect (Table D.2).

Bayesian inference was done using the Hamiltonian Markov chain Monte Carlo (MCMC) algorithm. The default *brms* priors were used. Model performance was assessed by the visual inspection of trace plots to evaluate convergence issues (Figure D.3 and Figure D.4) and posterior predictive plots to determine the degree of model fit to the observations (Figure D.5). Due to the large number of observations in the fitted dataset, model comparison by LOO IC (Vehtari et al. 2017) and other standard methods were not practical. As such, model selection was based on the requirements of the stock assessment (e.g., tail width and fishing year were likely to be influential for retention and can easily be included in the stock assessment model).

For both sexes, model fitting was problematic for models 5 and 6, which had poor mixing (not shown) and long run times. Of the remaining models with good mixing, model 3 was chosen as the final model for both sexes, which included tail width and fishing year (Table D.2). The posterior predictive plots indicated good model fits to the data for both sexes (Figure D.5).

The estimates from model 3 are summarised in Table D.3. Two sets of predictions were produced from the models for each sex:

1. proportion retained by TW for each sex (Table D.4 and Figure D.6); and
2. proportion retained by TW for each sex and year (Figure D.7).

These predictions are consistent with:

- a decline in retention rate with increasing TW for both males and females, although much lower retention of larger males than larger females;
- greater uncertainty with respect to the retention rate of females; and
- a decrease in the retention rate of both males and females beginning in fishing year 2000, with the lowest retention in the most recent years.

D.4 Summary

Retention is an important process in CRA 8, with fishers tending to return the larger male lobsters (most males over ~80 mm TW were returned to the sea). The retention rates estimated by this analysis were included as a process in the most recent stock assessment model for CRA 7&8 (specifying the proportion lobsters caught that were returned by TW for each sex/year) (Webber et al. 2022).

Retention cannot be estimated in CRA 7 because there are no logbook data in this QMA and the catch sampling programme does not record retention information. However, very few males captured in CRA 7 were greater than 60 mm TW (see main text of this report) and, if the predicted curves for CRA 8 are representative (Figure D.6), then retention rates in CRA 7 should be relatively high across the total catch.

The data indicate that some fishers are returning the smaller legal lobsters back to the sea (see Figure D.2). Future retention analyses could consider alternative functional forms for fitting to these data.

D.5 Tables

Table D.1: CRA 8 logbook data: numbers of legal fish caught and retained, and the proportion retained for all ‘legal’ lobsters of sex codes 1–5 and tail width of at least 30 mm.

Fishing year	Caught	Kept	Proportion retained	Fishing year	Caught	Kept	Proportion retained
1993–94	13 588	0	0.000	2007–08	11 197	9 604	0.858
1994–95	12 715	0	0.000	2008–09	12 325	9 833	0.798
1995–96	19 237	0	0.000	2009–10	13 696	9 731	0.710
1996–97	13 397	0	0.000	2010–11	13 326	8 737	0.656
1997–98	10 809	0	0.000	2011–12	13 705	9 141	0.667
1998–99	9 690	0	0.000	2012–13	16 831	11 388	0.677
1999–00	5 195	2	0.000	2013–14	16 098	10 536	0.654
2000–01	3 838	3 278	0.854	2014–15	20 086	12 521	0.623
2001–02	3 238	2 733	0.844	2015–16	17 034	11 315	0.664
2002–03	6 052	5 546	0.916	2016–17	15 230	10 327	0.678
2003–04	6 639	6 016	0.906	2017–18	23 228	15 867	0.683
2004–05	6 422	5 876	0.915	2018–19	25 543	15 300	0.599
2005–06	7 437	6 591	0.886	2019–20	22 224	13 691	0.616
2006–07	11 054	9 653	0.873	2020–21	23 942	15 602	0.652
				2000–2020 total	289 145	203 286	0.703

Table D.2: Alternative model structures used to predict the retention rate of each sex by size. “retained” is the proportion of lobsters retained, “TW” = tail width (mm), “year” = fishing year, and “fisher” = fisher ID.

Model run	Model structure	Convergence
1	retained ~ TW	Yes
2	retained ~ TW + year	Yes
3	retained ~ TW + (1 year)	Yes
4	retained ~ TW + (1 fisher)	Yes
5	retained ~ TW + year + (1 fisher)	No
6	retained ~ TW + (1 year) + (1 fisher)	No

Table D.3: Summary table of estimates for all estimated model parameters (model 3) for the male and female models.

Parameter	Male model					Female model				
	Mean	SD	2.5%	Mean	97.5%	Mean	SD	2.5%	Mean	97.5%
Intercept	7.16	0.11	6.95	7.16	7.38	2.74	0.20	2.33	2.74	3.13
TW	-0.09	0.00	-0.09	-0.09	-0.09	-0.03	0.00	-0.03	-0.03	-0.03
sd_year	0.46	0.08	0.34	0.45	0.65	0.84	0.15	0.61	0.82	1.17
2000	0.04	0.12	-0.19	0.04	0.28	0.79	0.20	0.40	0.79	1.21
2001	-0.24	0.12	-0.47	-0.23	-0.01	0.81	0.20	0.41	0.80	1.21
2002	0.82	0.12	0.60	0.82	1.06	1.15	0.20	0.75	1.15	1.56
2003	0.62	0.11	0.40	0.62	0.85	0.93	0.20	0.55	0.93	1.35
2004	0.75	0.11	0.54	0.75	0.97	1.24	0.21	0.83	1.24	1.66
2005	0.54	0.11	0.33	0.54	0.76	0.94	0.20	0.55	0.94	1.35
2006	0.65	0.10	0.45	0.65	0.86	0.59	0.20	0.20	0.59	0.98
2007	0.36	0.10	0.16	0.36	0.57	0.78	0.20	0.39	0.77	1.18
2008	0.07	0.10	-0.13	0.07	0.27	0.28	0.20	-0.10	0.28	0.68
2009	-0.21	0.10	-0.41	-0.21	-0.01	-0.22	0.19	-0.60	-0.22	0.18
2010	-0.28	0.10	-0.48	-0.28	-0.08	-0.73	0.19	-1.10	-0.73	-0.33
2011	-0.22	0.10	-0.42	-0.22	-0.02	-0.39	0.19	-0.77	-0.39	0.01
2012	-0.08	0.10	-0.29	-0.08	0.12	-0.26	0.19	-0.64	-0.27	0.13
2013	-0.15	0.10	-0.35	-0.15	0.05	-0.37	0.19	-0.75	-0.37	0.03
2014	-0.34	0.10	-0.54	-0.34	-0.14	-0.68	0.19	-1.06	-0.68	-0.29
2015	-0.28	0.10	-0.48	-0.28	-0.08	-0.54	0.19	-0.91	-0.54	-0.14
2016	-0.38	0.10	-0.58	-0.38	-0.18	-0.54	0.19	-0.91	-0.54	-0.14
2017	-0.45	0.10	-0.64	-0.45	-0.25	-0.56	0.19	-0.94	-0.56	-0.17
2018	-0.30	0.10	-0.50	-0.30	-0.10	-1.23	0.19	-1.61	-1.23	-0.83
2019	-0.31	0.10	-0.51	-0.31	-0.11	-1.14	0.19	-1.51	-1.14	-0.74
2020	-0.44	0.10	-0.64	-0.44	-0.25	-0.68	0.19	-1.05	-0.68	-0.28

Table D.4: Predicted (model 3) retention rate by tail width for males and females.

Tail width bin (mm)	Males		Females	
	Mean predicted retention rate (95% credible interval)	Standard deviation	Mean predicted retention rate (95% credible interval)	Standard deviation
53	0.919 (0.883–0.965)	0.027	0.738 (0.479–0.916)	0.479
55	0.905 (0.864–0.958)	0.031	0.727 (0.464–0.912)	0.464
57	0.889 (0.841–0.95)	0.036	0.716 (0.449–0.907)	0.449
59	0.870 (0.816–0.941)	0.041	0.705 (0.435–0.902)	0.435
61	0.849 (0.789–0.931)	0.047	0.694 (0.420–0.896)	0.420
63	0.826 (0.758–0.919)	0.053	0.682 (0.405–0.890)	0.405
65	0.799 (0.724–0.904)	0.060	0.671 (0.391–0.884)	0.391
67	0.770 (0.687–0.888)	0.067	0.659 (0.376–0.878)	0.376
69	0.738 (0.648–0.869)	0.073	0.647 (0.362–0.871)	0.362
71	0.704 (0.607–0.848)	0.080	0.634 (0.348–0.865)	0.348
73	0.667 (0.564–0.823)	0.086	0.622 (0.335–0.858)	0.335
75	0.628 (0.520–0.796)	0.092	0.609 (0.321–0.850)	0.321
77	0.588 (0.475–0.766)	0.097	0.597 (0.309–0.842)	0.309
79	0.546 (0.432–0.733)	0.100	0.584 (0.296–0.834)	0.296
81	0.504 (0.389–0.697)	0.102	0.571 (0.283–0.826)	0.283
83	0.462 (0.347–0.659)	0.103	0.558 (0.271–0.817)	0.271
85	0.420 (0.308–0.618)	0.102	0.545 (0.260–0.808)	0.260
87	0.379 (0.272–0.576)	0.100	0.532 (0.248–0.798)	0.248
89	0.341 (0.238–0.532)	0.097	0.519 (0.237–0.789)	0.237
91	0.304 (0.208–0.487)	0.092	0.506 (0.227–0.779)	0.227
93	0.269 (0.180–0.444)	0.087	0.493 (0.217–0.768)	0.217
95	0.237 (0.155–0.401)	0.080	0.480 (0.206–0.758)	0.206
97	0.207 (0.133–0.359)	0.074	0.467 (0.197–0.747)	0.197
99	0.181 (0.114–0.320)	0.067	0.454 (0.188–0.735)	0.188
101	0.157 (0.283–0.283)	0.097	0.441 (0.178–0.723)	0.178

D.5 Figures

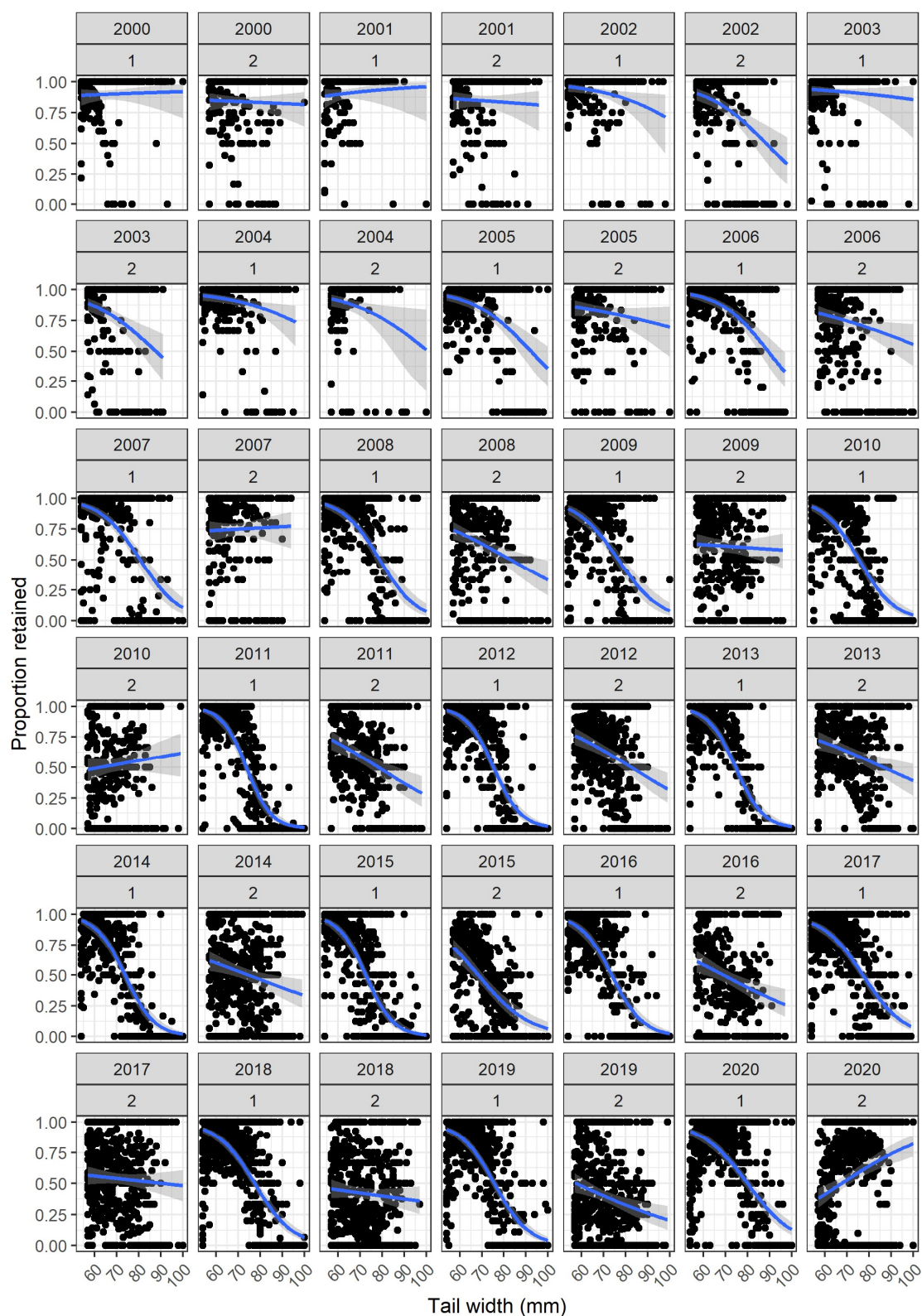


Figure D.1: Plot of proportion of captured lobsters that were retained by tail width (mm), fishing year (labelled with first year of respective fishing year) and sex (“1” = male and “2” = female). Black points represent the data, the blue lines represent the mean estimates of the proportion retained from binomial GLMs fitted to these data, and the shaded areas are the corresponding standard errors of the GLM model predictions.

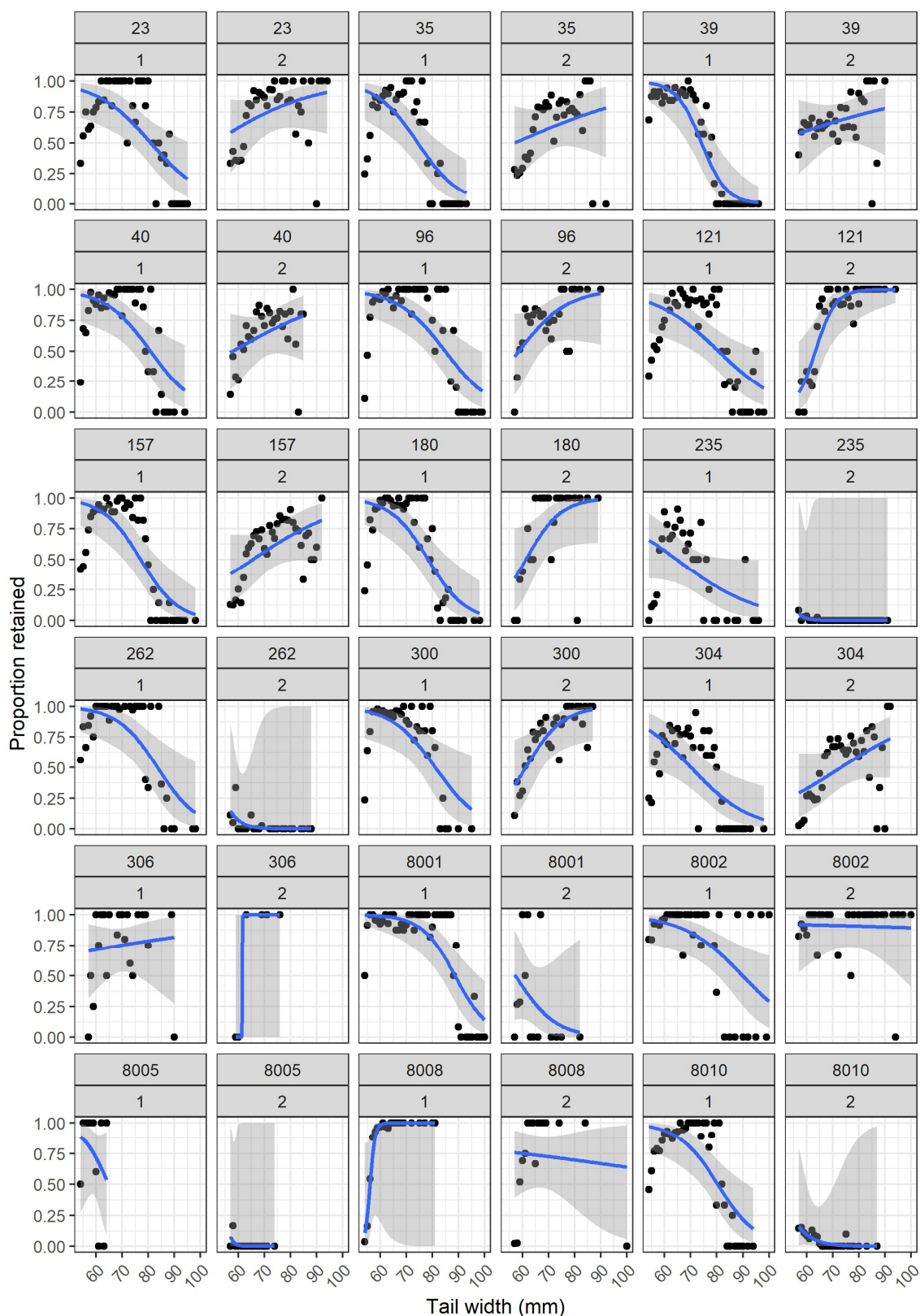


Figure D.2: Plot of proportion of captured lobsters that were retained by tail width (mm), fisher ID, and sex (“1” = male and “2” = female). Black points represent the data, the blue lines represent the mean estimates of the proportion retained from binomial GLMs fitted to these data, and the shaded areas are the corresponding standard errors of the GLM model predictions.

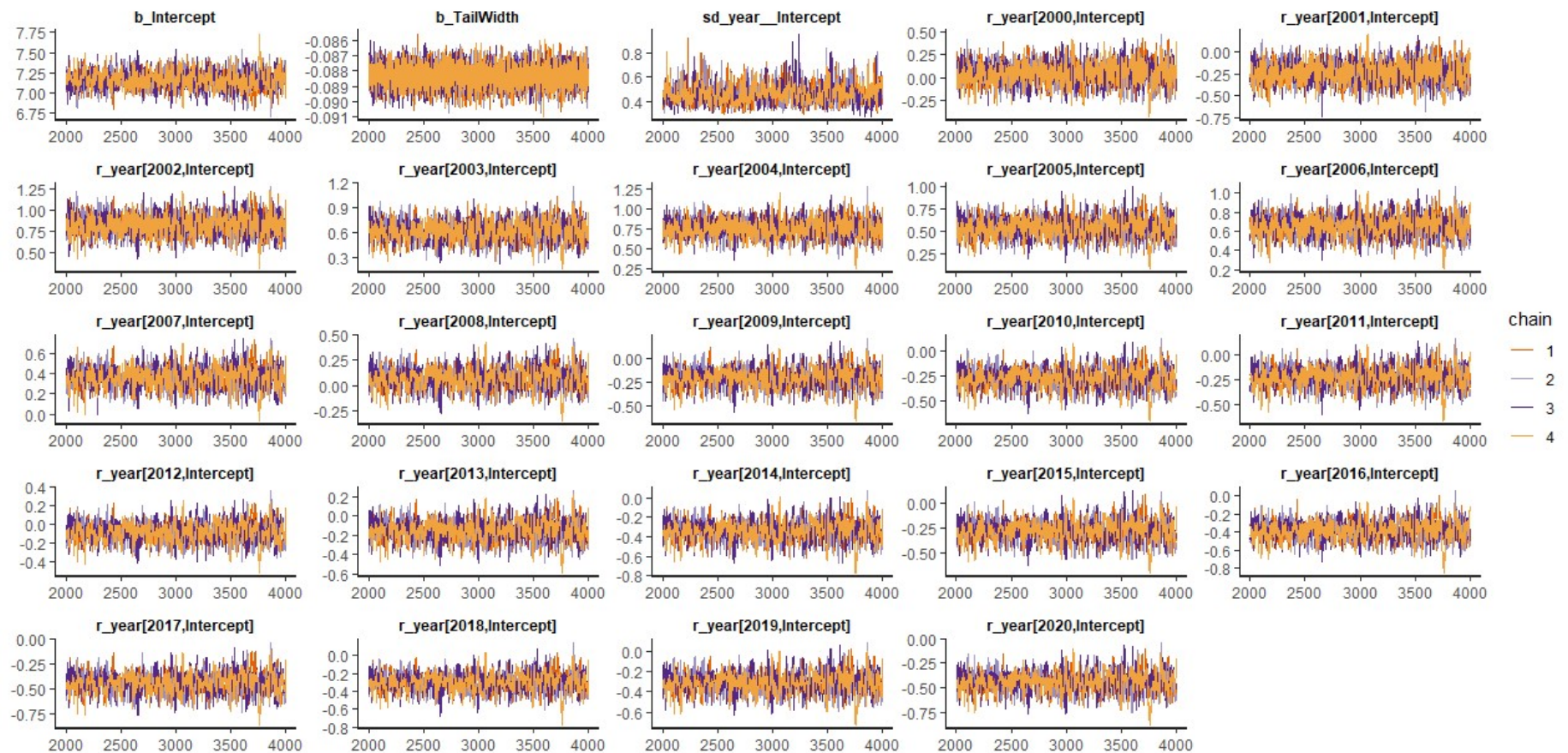


Figure D.3: MCMC trace plots for estimated parameters for model run 3 (males).

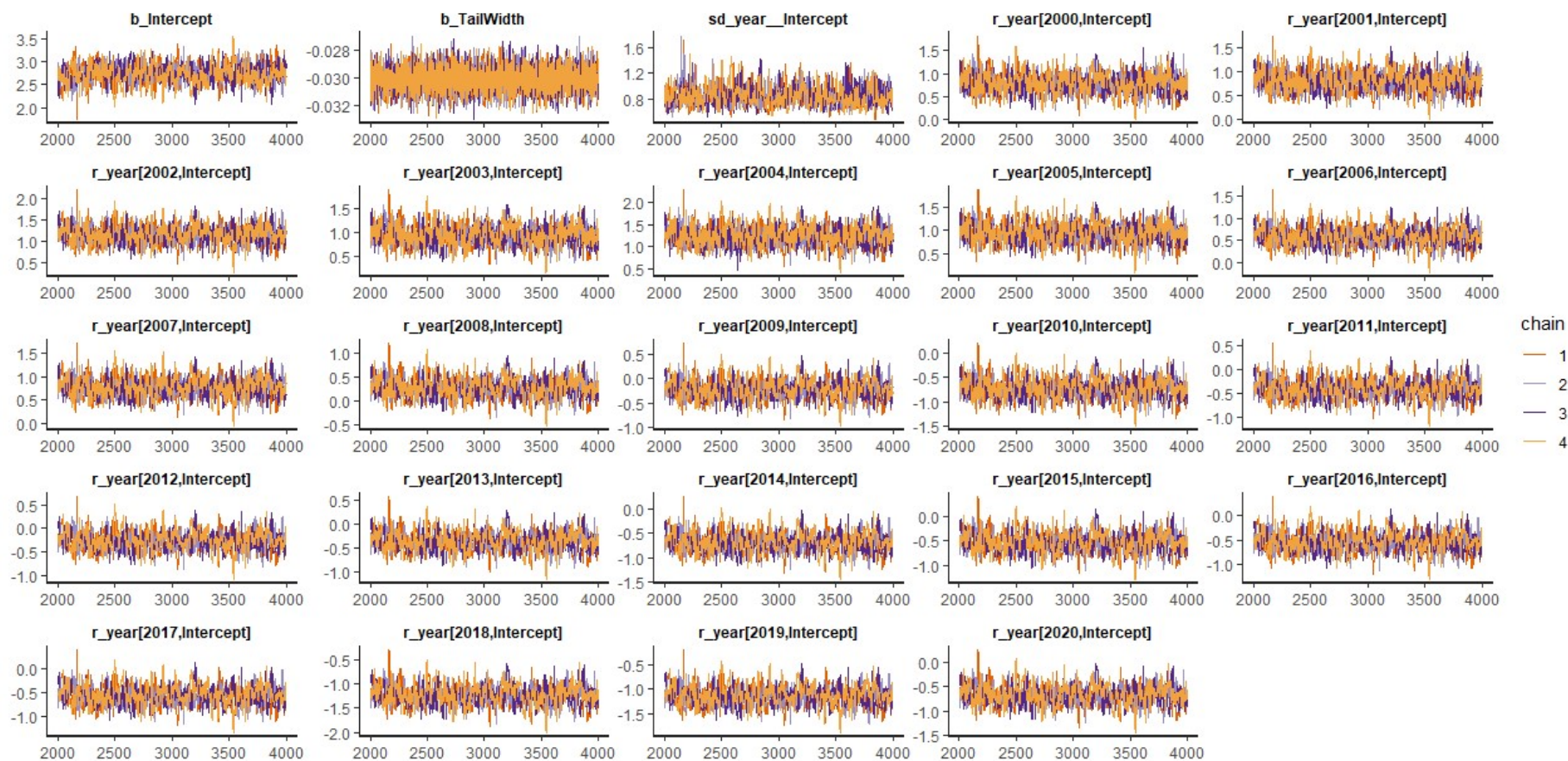


Figure D.4: MCMC trace plots for estimated parameters for model run 3 (females).

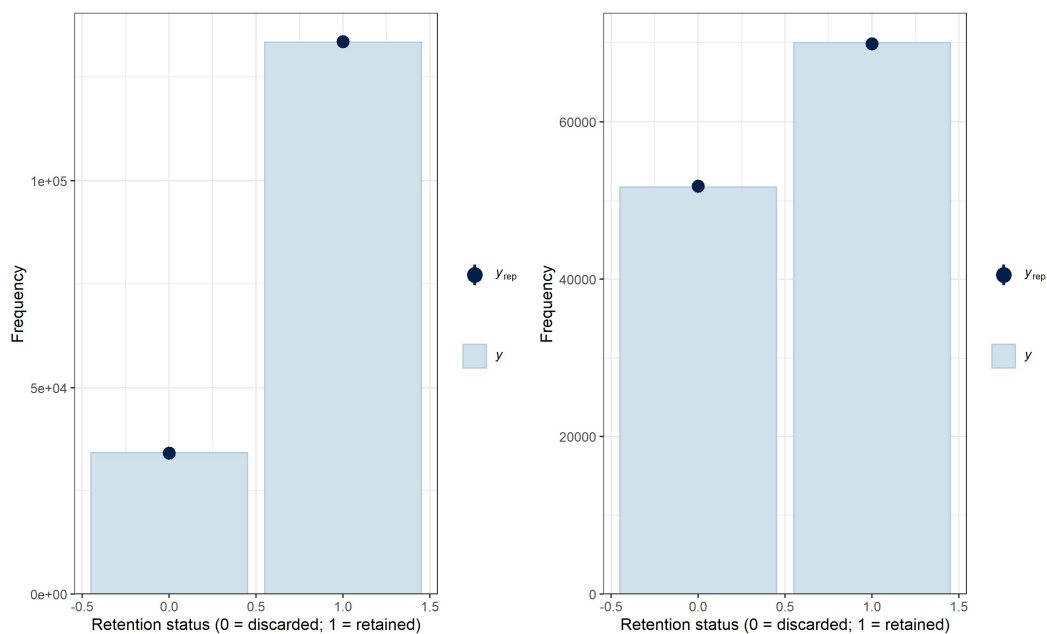


Figure D.5: Posterior predictive check plot of observed (blue bars) and predicted (dark blue points) numbers of lobsters retained and discarded for model run 3 for males (left) and females (right).

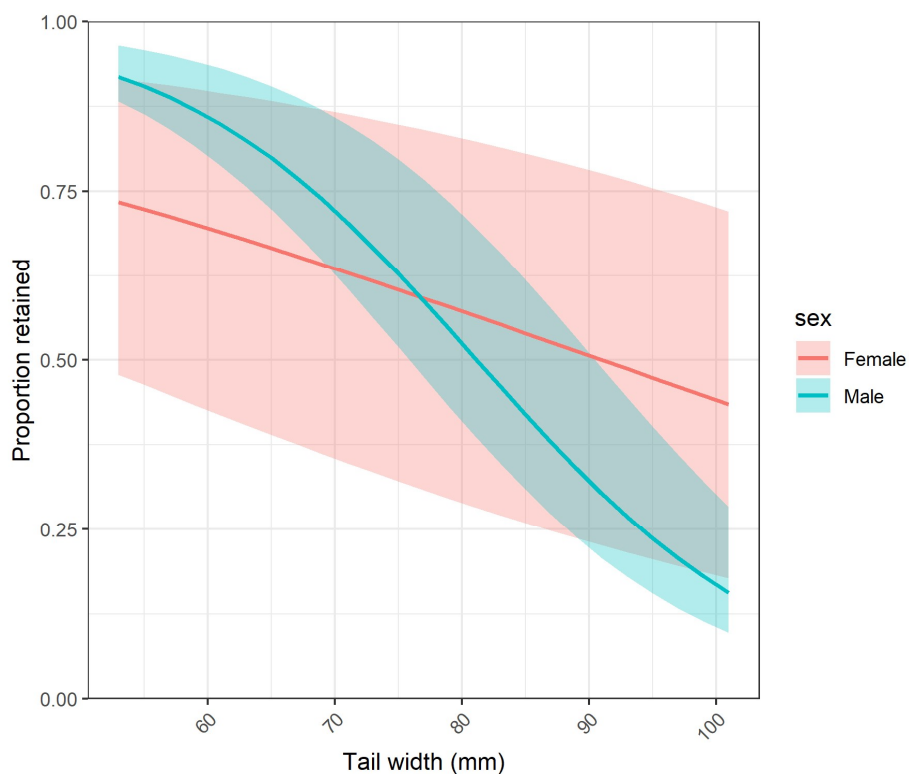


Figure D.6: The predicted retention rate of legal male (left) and female lobsters (right) by tail width across all fishing year, as predicted by model run 3 (lines are the mean predictions by sex, and ribbons are 95% credible intervals).

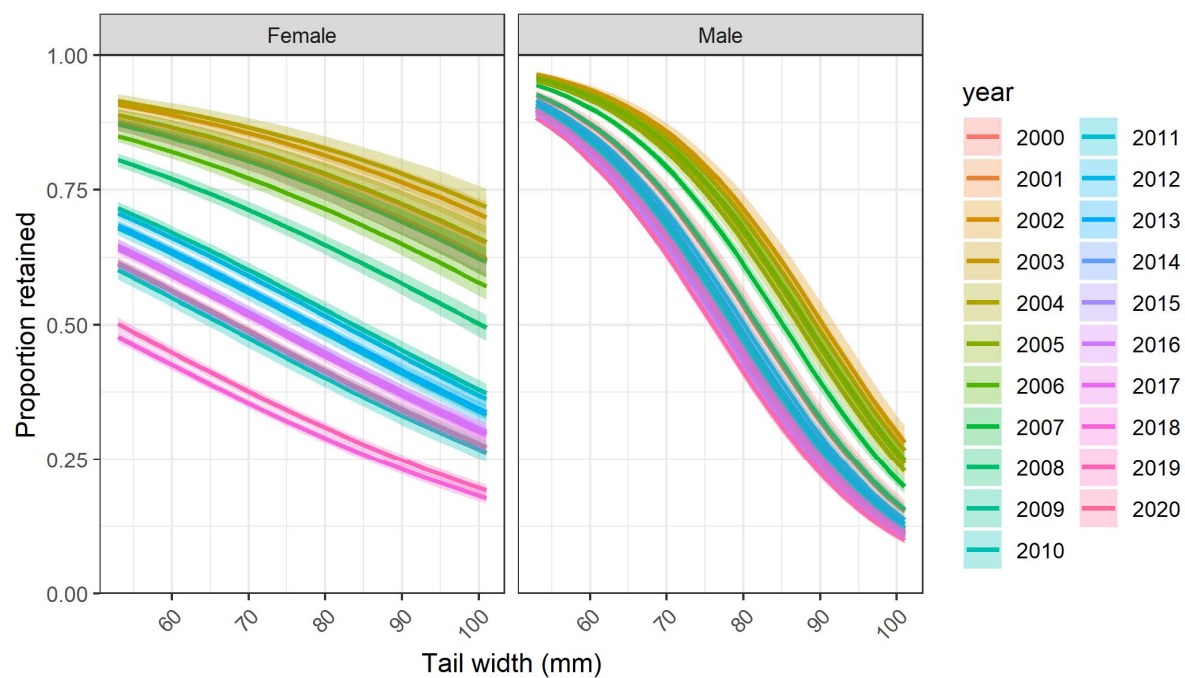


Figure D.7: The prediction retention rate of legal male (left) and female lobsters (right) by tail width and fishing year, as predicted by model run 3 (lines are the mean predictions by fishing year and ribbons are 95% credible intervals).

Appendix E: Evidence for regional separation in CRA 7&8

This appendix summarises data in support of separating CRA 7 and CRA 8 into two regions, one combining Otago (CRA 7) with four Southland (CRA 8) statistical areas and the other comprising the remaining three CRA 8 Fiordland statistical areas (Table 7).

E.1 Comparison of length frequency (LF) distributions

Figure E.1 and Figure E.2 compare the summarised LF distributions by season and sex category for the two regions. These figures show that the main difference between the two regions lies in the mature females, with the two regions showing very similar distributions for both males and immature females in both seasons. On the other hand, region 1 has overall smaller mature females than region 2 but there is a much longer tail in region 1. This difference likely reflects the effect of amalgamating CRA 7 with the Southland data, with the long tail of large mature females associated with the Stewart Island samples. The consistency within each region and the differences across regions can be seen clearly in Figure E.3 (AW) and Figure E.4 (SS) which compare the annual LF distributions for each region by season.

E.2 Comparison of standardised CPUE series

There seems to be agreement among the component statistical areas with the summarised regional CPUE series by season, with both region 1 (Figure E.5) and region 2 (Figure E.6) showing similar trends across the component statistical areas. The region 1 overall trend appears to be influenced by the CRA 7 statistical areas, with these two areas showing a drop between 2009 and 2013 which is not shared by the Southland CRA 8 statistical areas (Figure E.5). The region 2 summary CPUE series shows somewhat more variation among the statistical areas than does region 1, with statistical area 926 generally lying below the more northerly areas of 927 and 928 (Figure E.6). These differences disappear in the final years of the series. The overall comparison between regions shows general agreement between the two regions, although region 1 ends more strongly in the AW while the end points of the relative regional CPUE trends are reversed in the SS (Figure E.7).

E.3 Tag-based movement

There is evidence from the tagging data to link CRA 7 lobsters with the Southland statistical areas. Previous CRA 7&8 stock assessments estimated annual movement from CRA 7 to CRA 8, given anecdotal evidence of long-range movements of individual lobsters in some years (e.g., Haist et al. 2016). Unfortunately, there are only a relatively small number of tag-recapture observations for lobsters which have spent a reasonable period of time at liberty and thus would have sufficient opportunity to move. Table E.2 shows the available data for CRA 7&8 lobsters which have been at liberty for two years (an arbitrary cut-off). This table shows that about one-third of the recaptured lobsters from CRA 7 (statistical areas 920 and 921) underwent counter-current movement to CRA 8. Of these, the majority (14 of 16) were recaptured in Southland (statistical areas 922–924), while the other two were recaptured in region 2. This set of limited tagging information supports the regional separation of CRA 7&8.

E.4 Conclusion

There appears to be justification in the length frequency and tagging data for combining the two CRA 7 statistical areas with the CRA 8 Southland statistical areas and for treating the resulting combined area as a single region. The females in the Otago/Southland statistical areas are primarily immature while mature females predominate in the Fiordland CRA 8 statistical areas. CPUE trends are reasonably similar among the nine CRA 7&8 statistical areas, so it is more difficult to use this information as a basis for regional separation. All areas show an early period of low or declining CPUE, followed by an increase to a higher level which has continued to the end of the series.

E.5 Tables

Table E.1: Definitions for CRA 7&8 regions, showing the rock lobster statistical area definitions used (Figure 1).

Region label	Statistical areas	Region name
region 1	920, 921, 922, 923, 924, 925	Otago/Southland
region 2	926, 927, 928	Fiordland

Table E.2: Tag-based movement information for CRA 7&8. This table shows the statistical areas of release and recovery for all lobsters released and recaptured in CRA 7&8 that were at liberty for a period of at least two years. This period was selected arbitrarily and was based on a trade-off between maximising the number of recaptures while allowing the lobsters adequate time for movement.

Statistical area of release	Statistical area of recovery									Total
	920	921	922	923	924	925	926	927	928	
920	17	9	1	1	10	0	0	1	1	40
921	0	1	0	0	0	0	0	0	0	1
922	0	0	0	1	5	0	0	0	1	7
923	0	0	0	6	14	0	5	2	0	27
924	0	0	0	1	153	0	3	2	1	160
925	0	0	0	0	1	13	2	0	0	16
926	0	0	0	0	0	0	117	71	21	209
927	0	0	0	0	0	0	0	463	5	468
928	0	0	0	0	0	0	1	2	22	25
Total	17	10	1	9	183	13	128	541	51	953

E.6 Figures

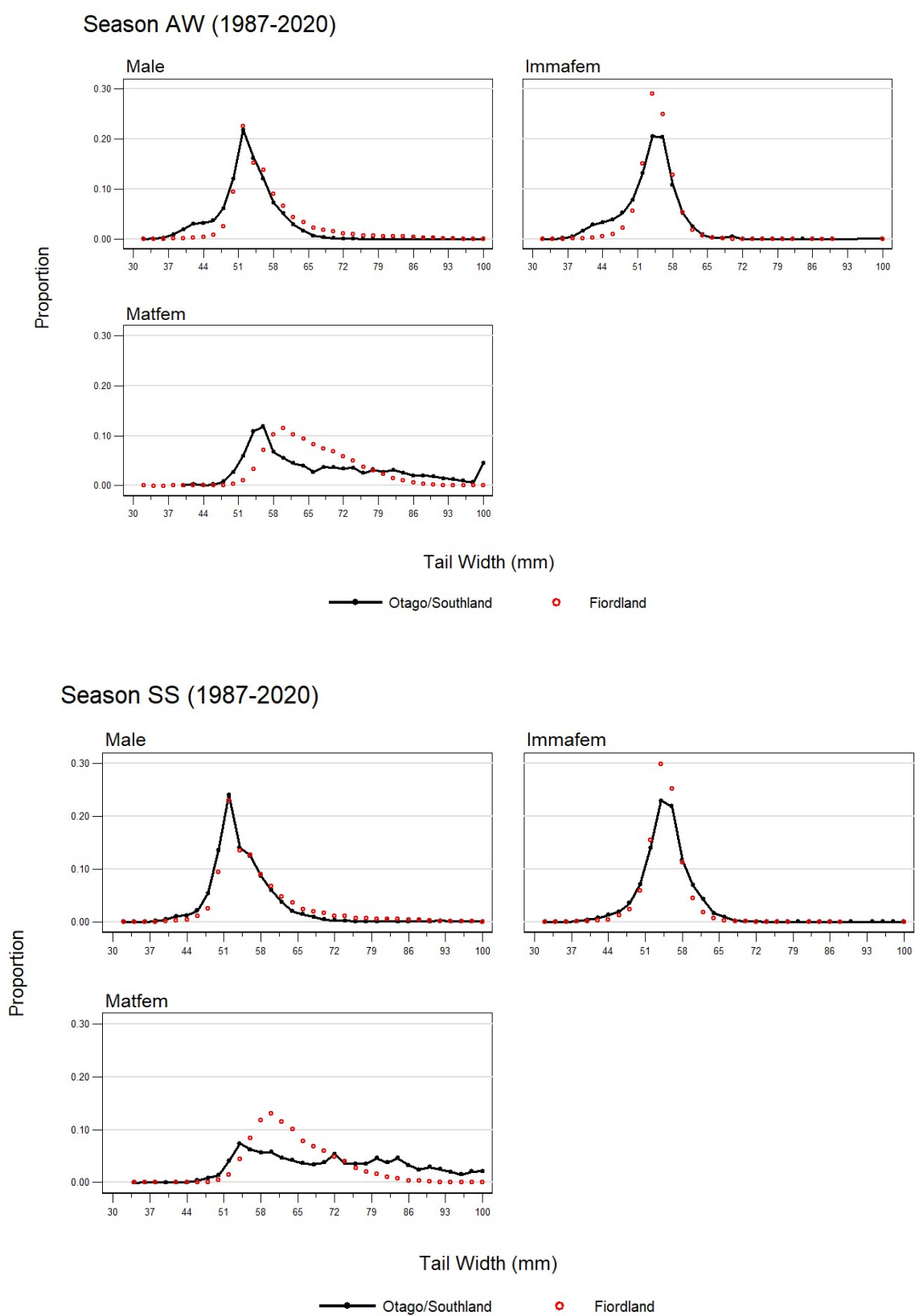
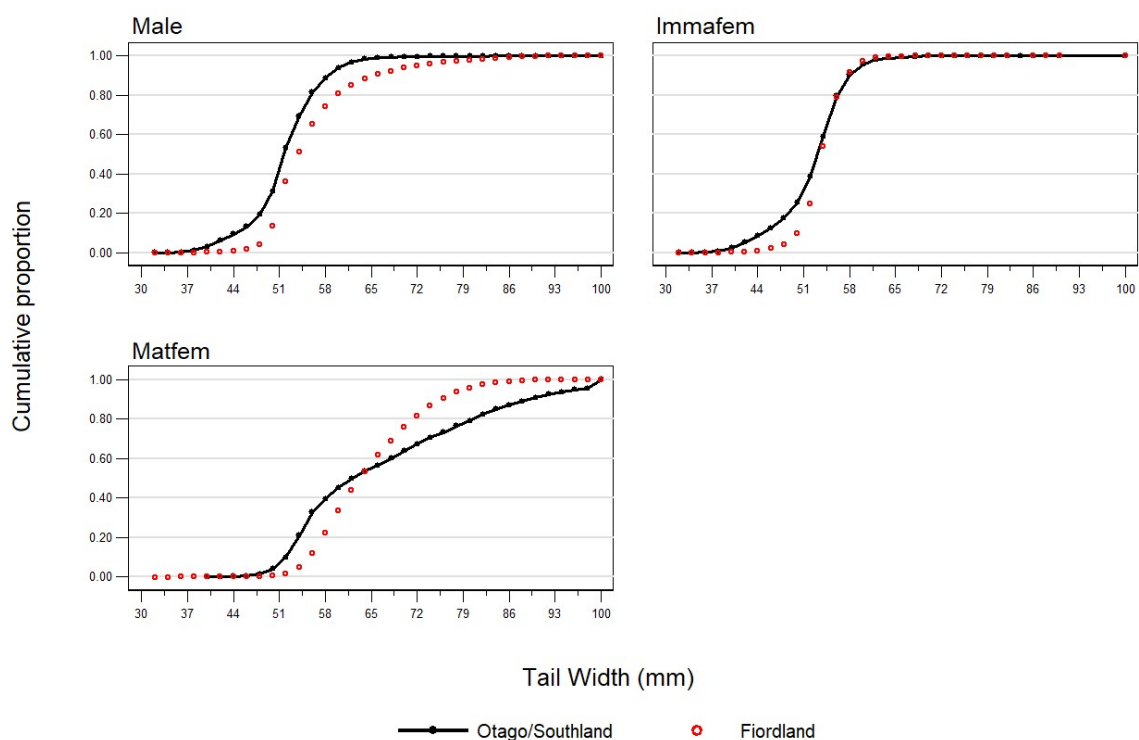


Figure E.1: Comparison of length frequency distributions, summarised across all years, for each CRA 7&8 region by season.

Season AW (1987-2020)



Season SS (1987-2020)

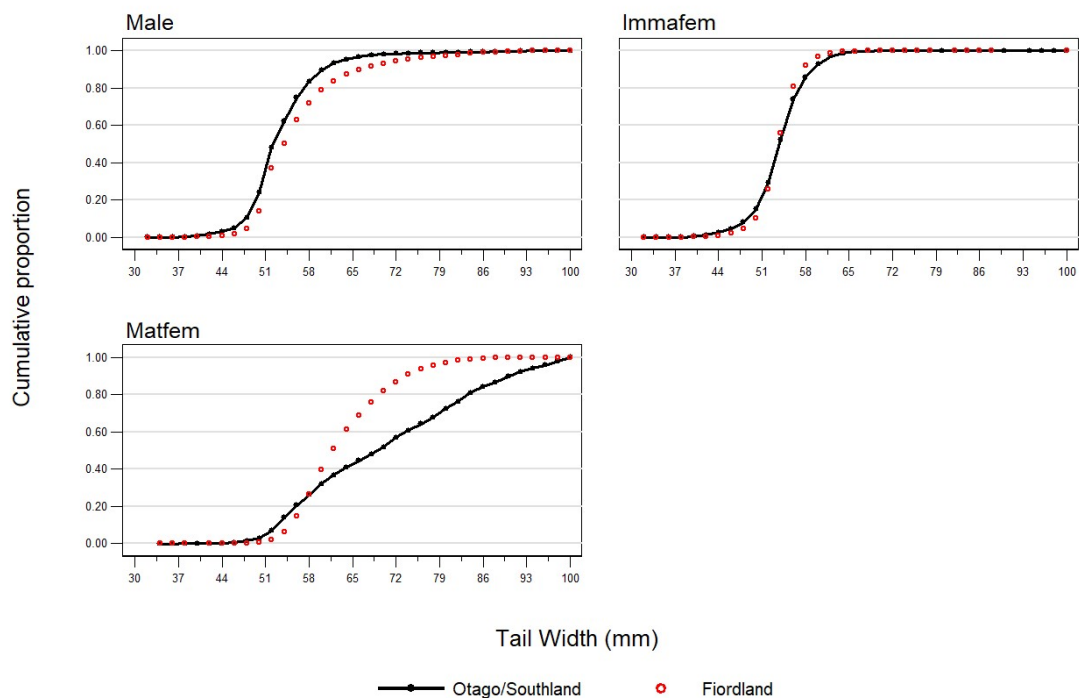


Figure E.2: Comparison of cumulative length frequencies, summarised across all years, for each CRA 7&8 region by season.

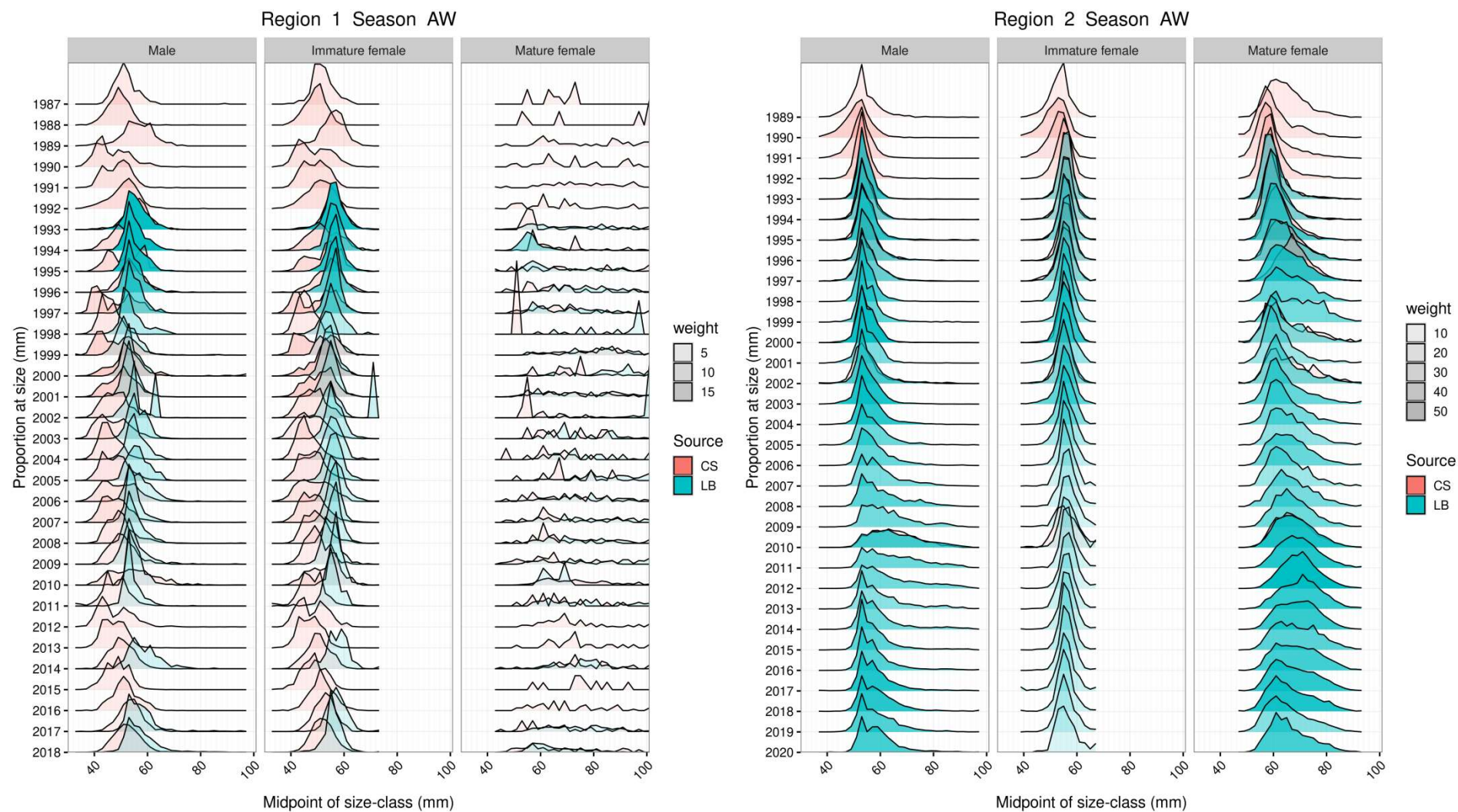


Figure E.3: Plots comparing the region 1 and region 2 AW LF distributions by sex category and fishing year. CS is observer catch sampling and LB is logbook catch sampling.

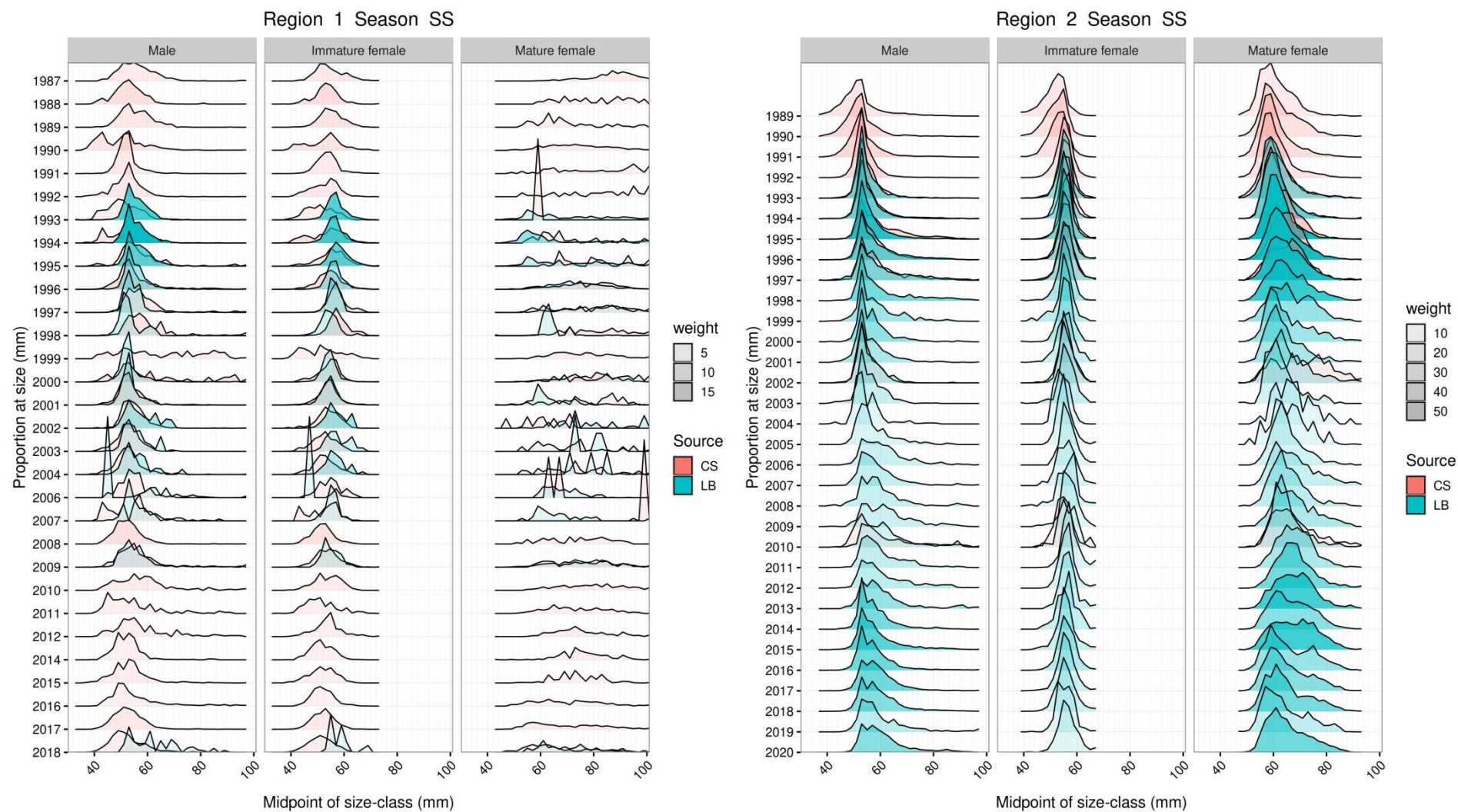


Figure E.4: Plots comparing the region 1 and region 2 SS LF distributions by sex category and fishing year. CS is observer catch sampling and LB is logbook catch sampling.

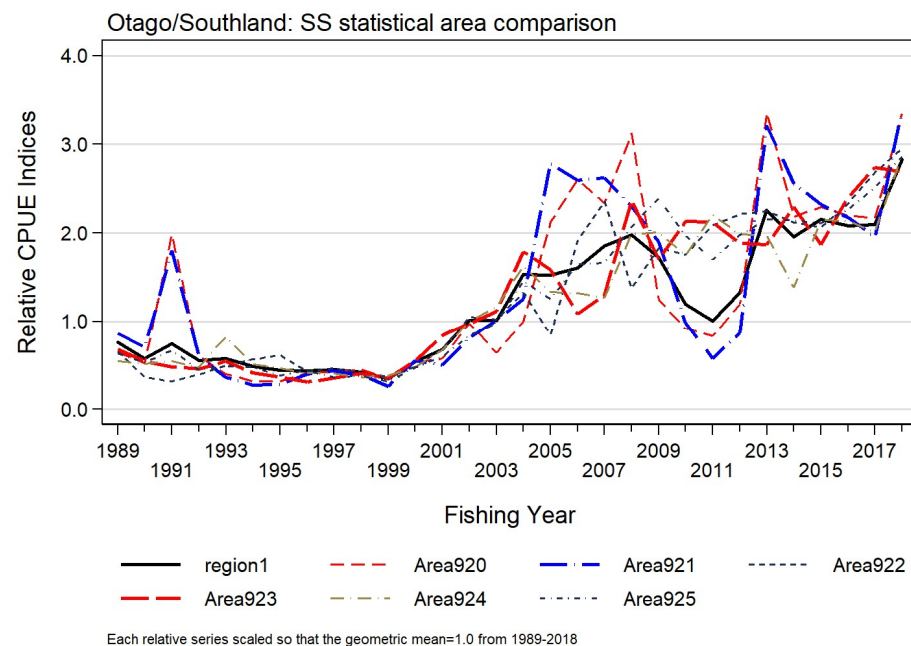
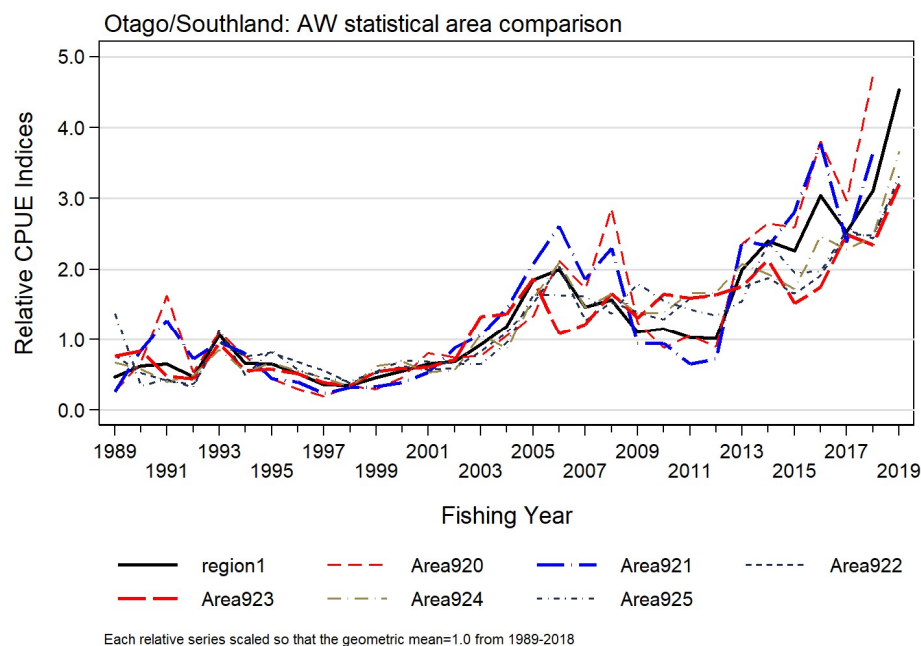


Figure E.5: Plots of the mean seasonal CRA 7&8 region 1 standardised CPUE compared to the mean standardised CPUE for each regional component statistical area.

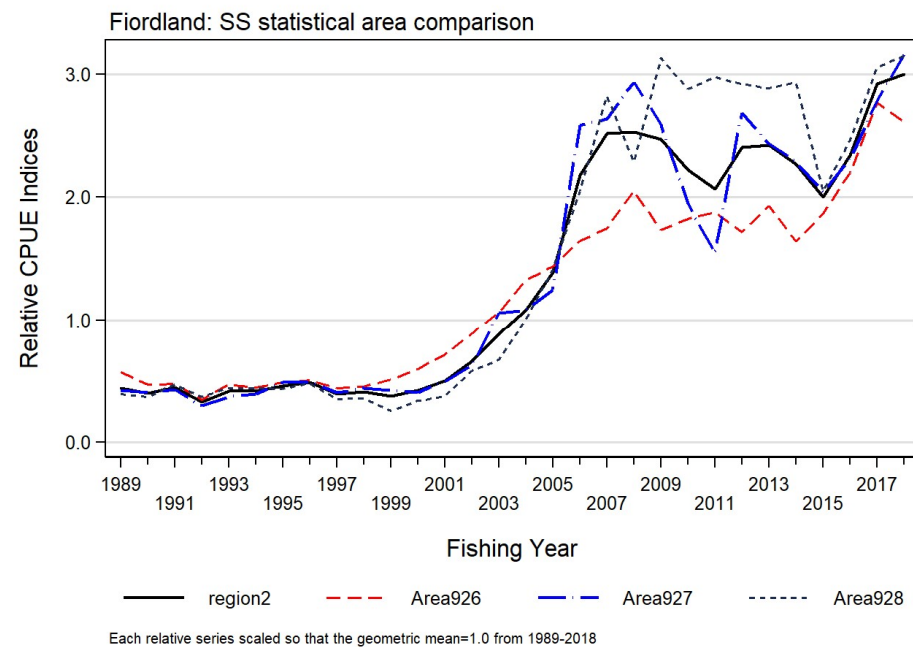
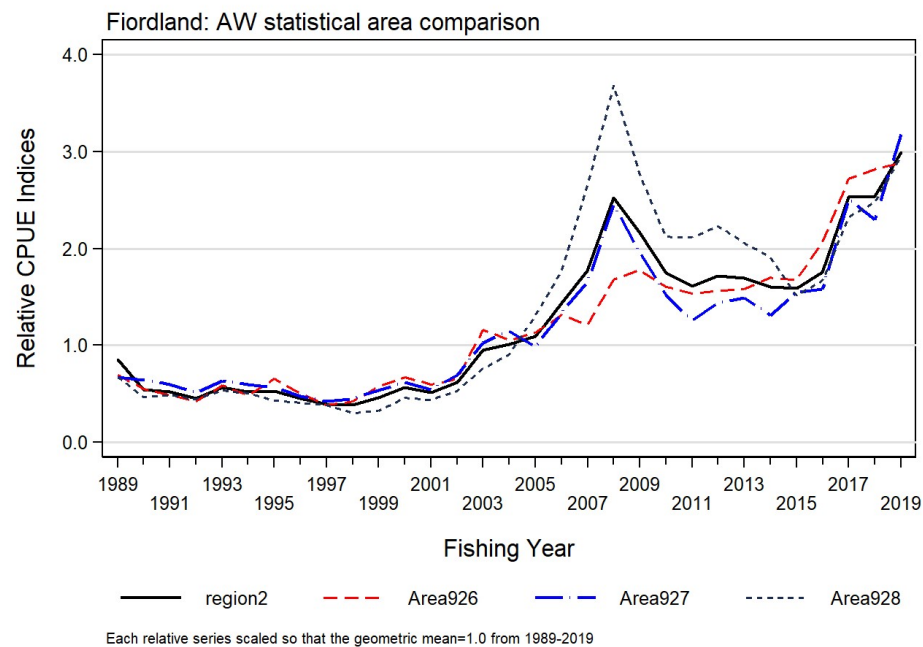


Figure E.6: Plots of the mean seasonal CRA 7&8 region 2 standardised CPUE compared to the mean standardised CPUE for each regional component statistical area.

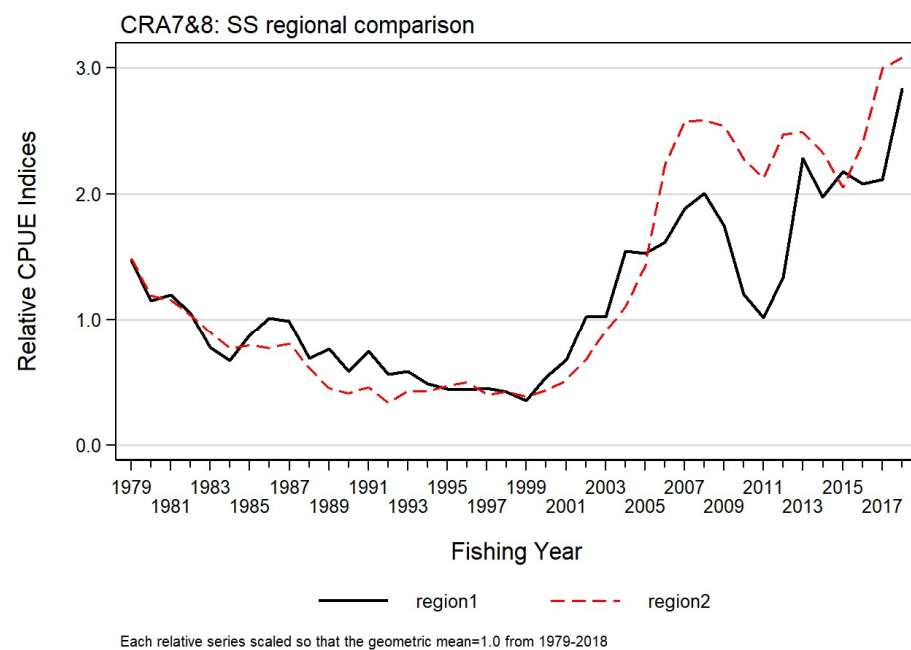
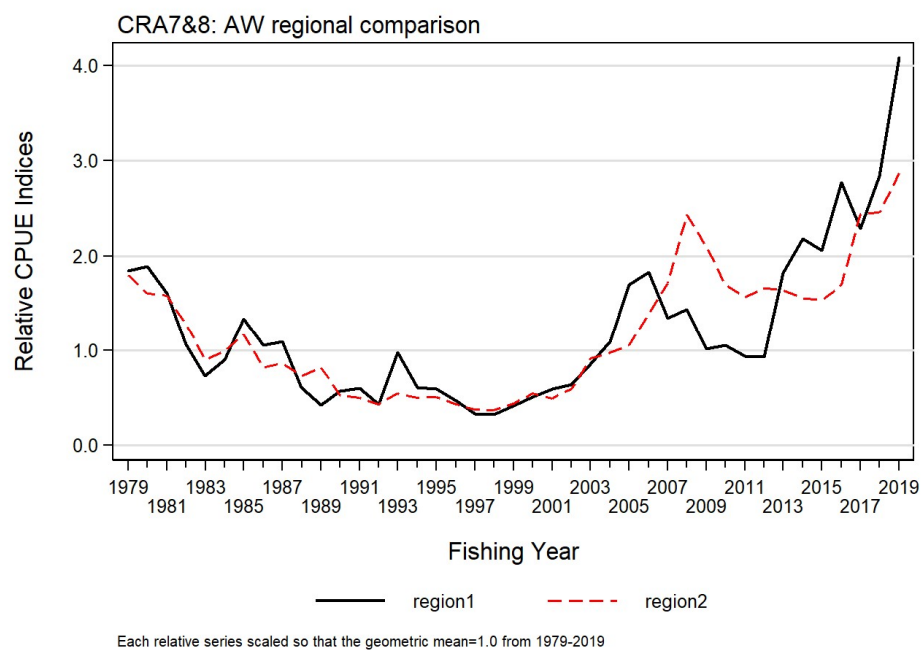


Figure E.7: Comparison plots of the seasonal median CRA 7&8 standardised CPUE among each component region.

Appendix F: Removal of inconsistent length frequency data in CRA 7

Just under 4000 logbook programme length measurements, collected over three years (2001, 2002, 2003) in the AW season, were removed from the CRA 7 biological data set because of considerable inconsistency with other CRA 7 data as well as an apparent poor classification of immature and mature females (see footnote in Table 18). The level of inconsistency is apparent in Figure F.1, with the LF distributions for the three years of logbook data being shifted right relative to the equivalent data collected by the catch sampling programme in the same and adjacent years. This inconsistency extends to the female LF distributions, with the immature females apparently larger than the mature females in 2002 and 2003, as well as having very large immature females in 2001.

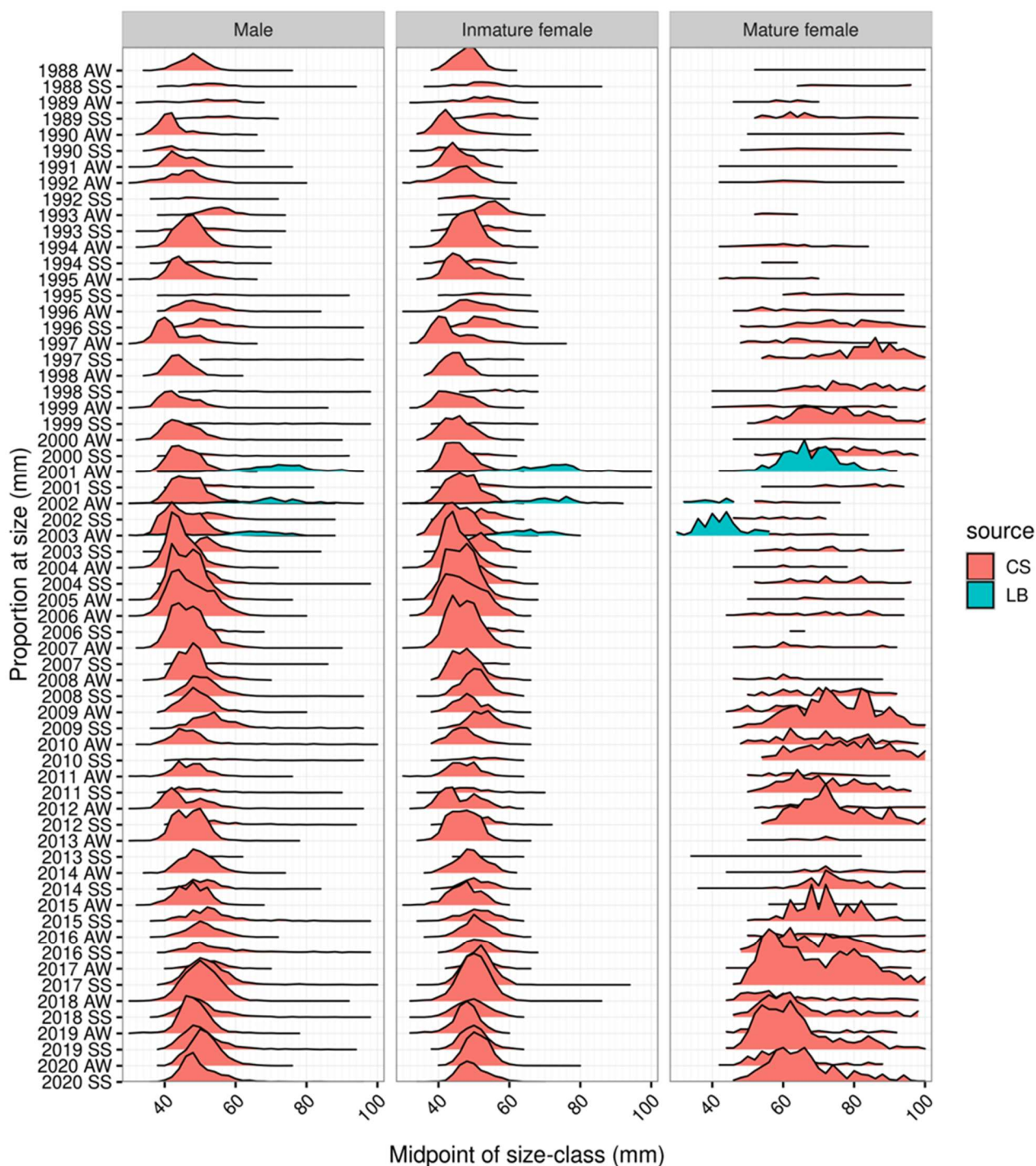


Figure F.1: Plot showing CRA 7 LF distributions by sex category, year, season, and sampling source (CS is observer catch sampling and LB is logbook catch sampling).

Appendix G: Logbook and catch sampling length frequency distributions: CRA 7&8

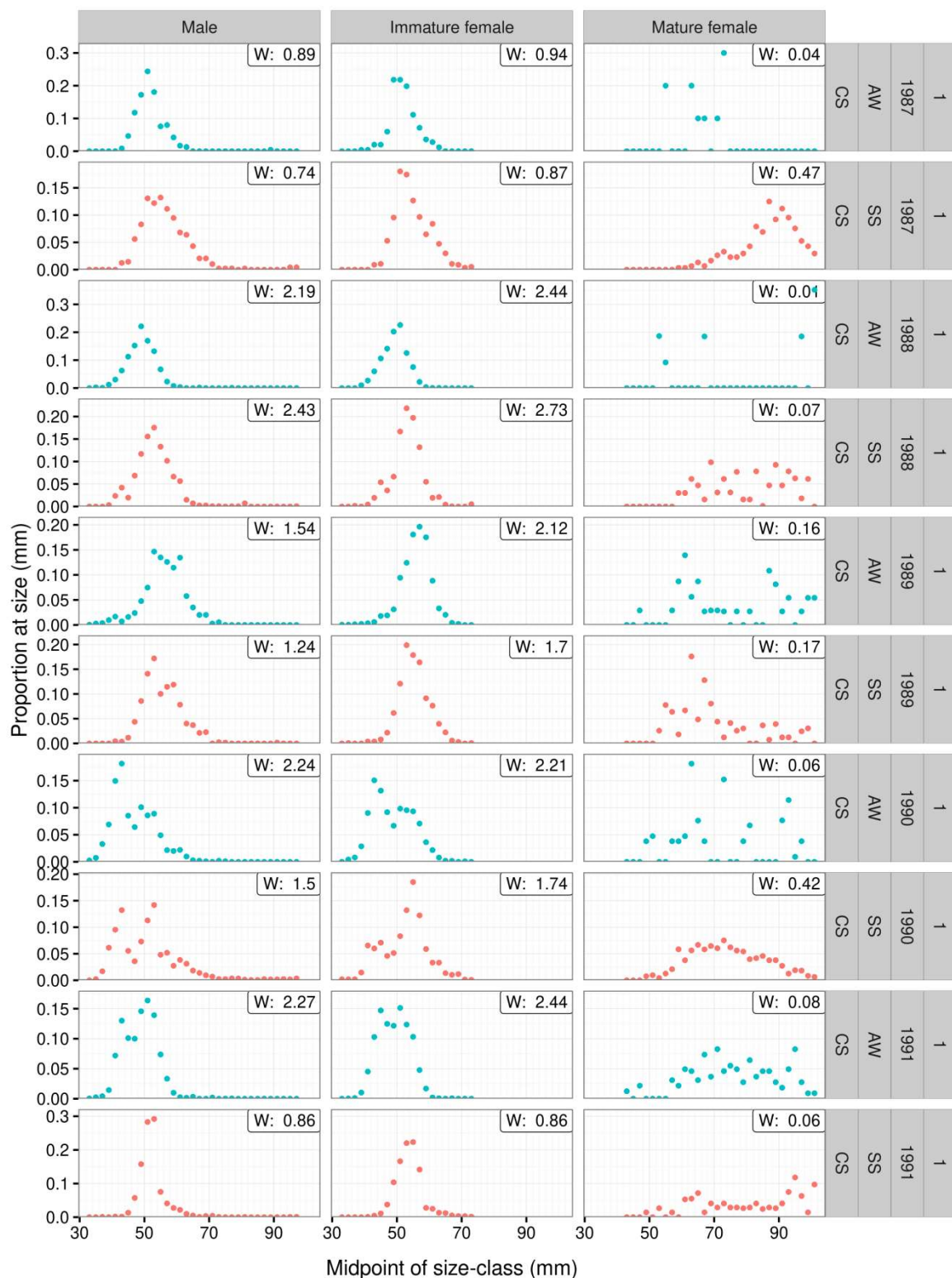


Figure G.1: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 1987 AW to 1991 SS. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

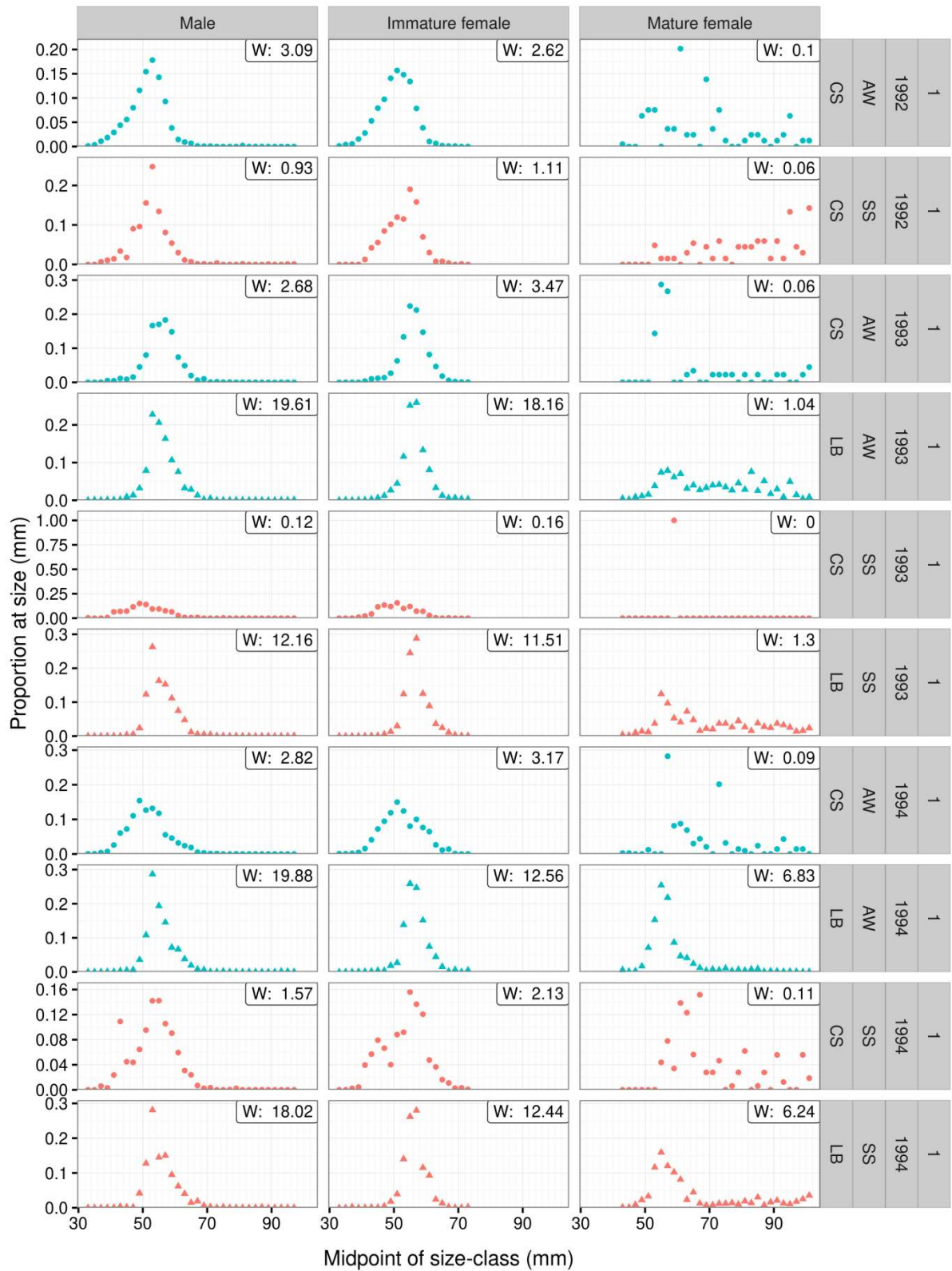


Figure G.2: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 1992 AW to 1994 SS. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

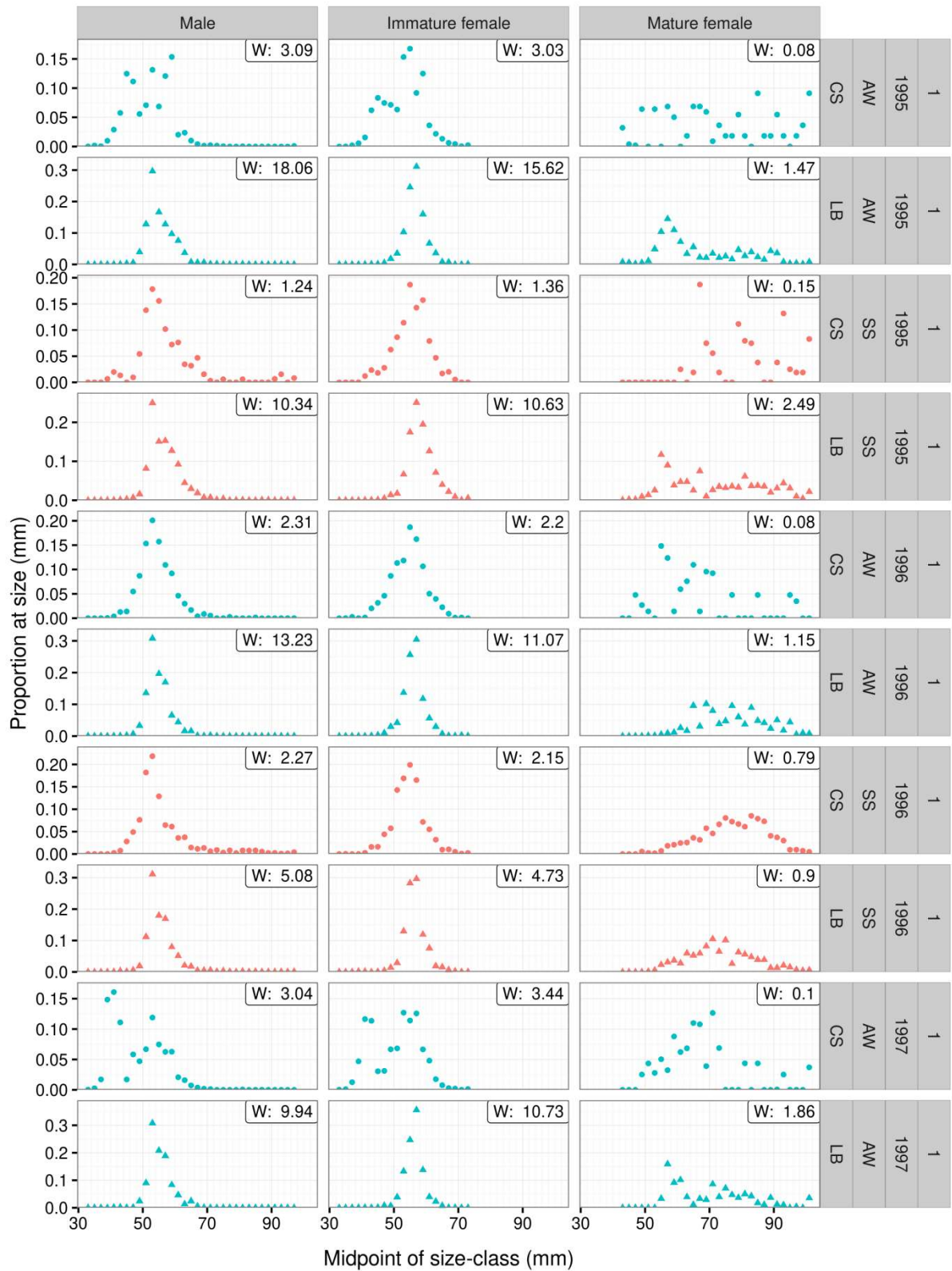


Figure G.3: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 1995 AW to 1997 AW. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

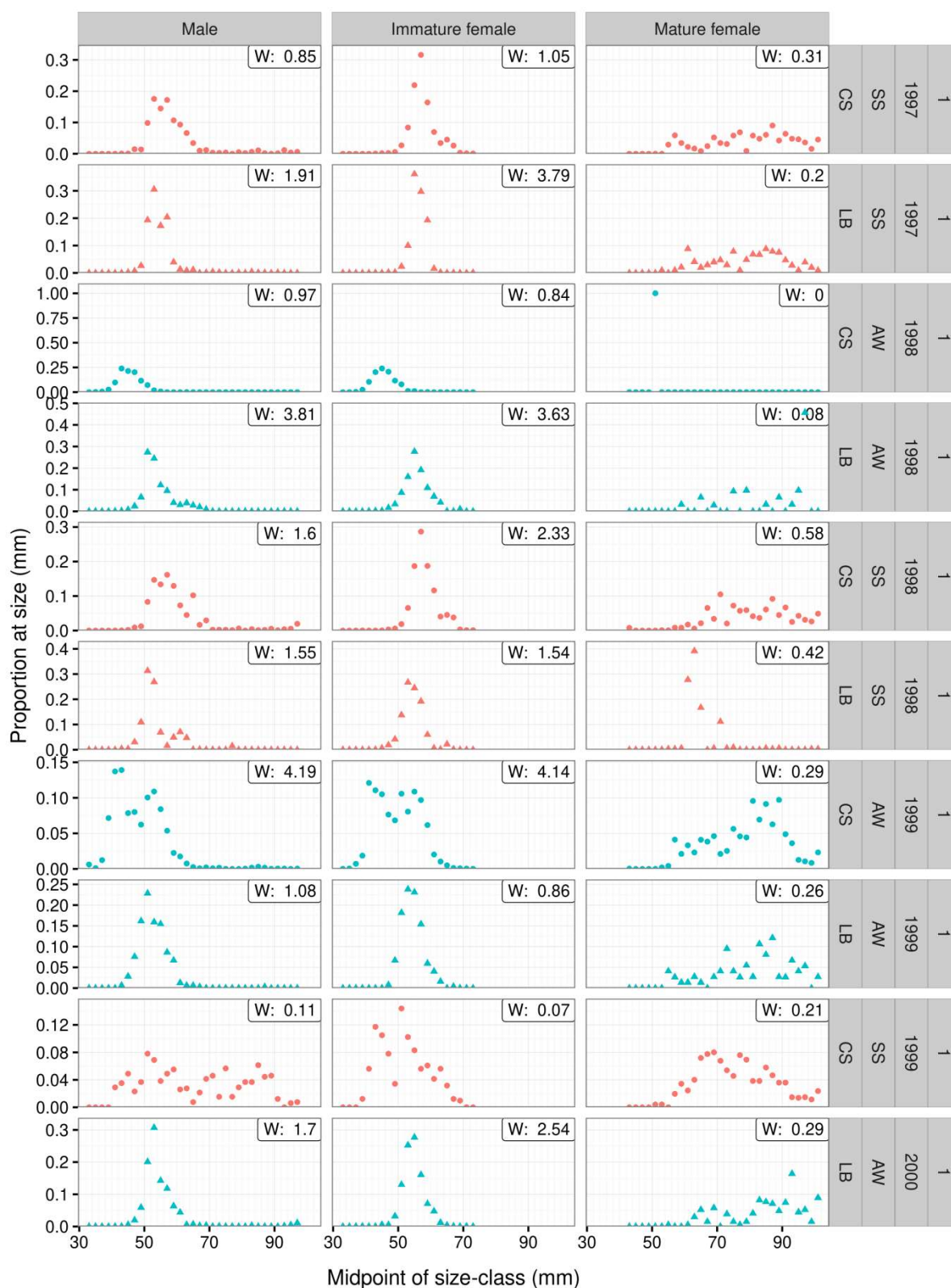


Figure G.4: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 1997 SS to 2000 AW. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

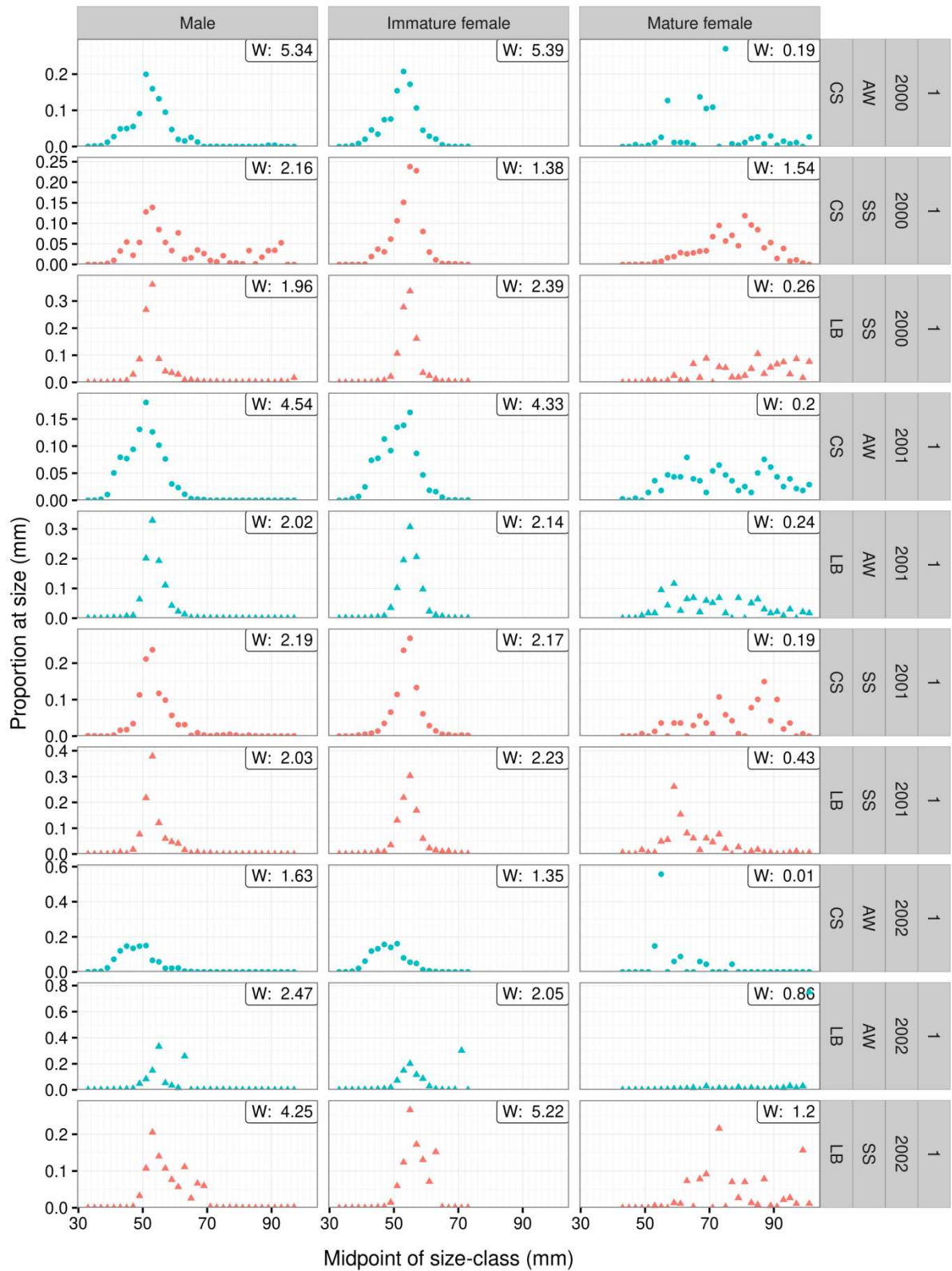


Figure G.5: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 2000 AW to 2002 SS. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

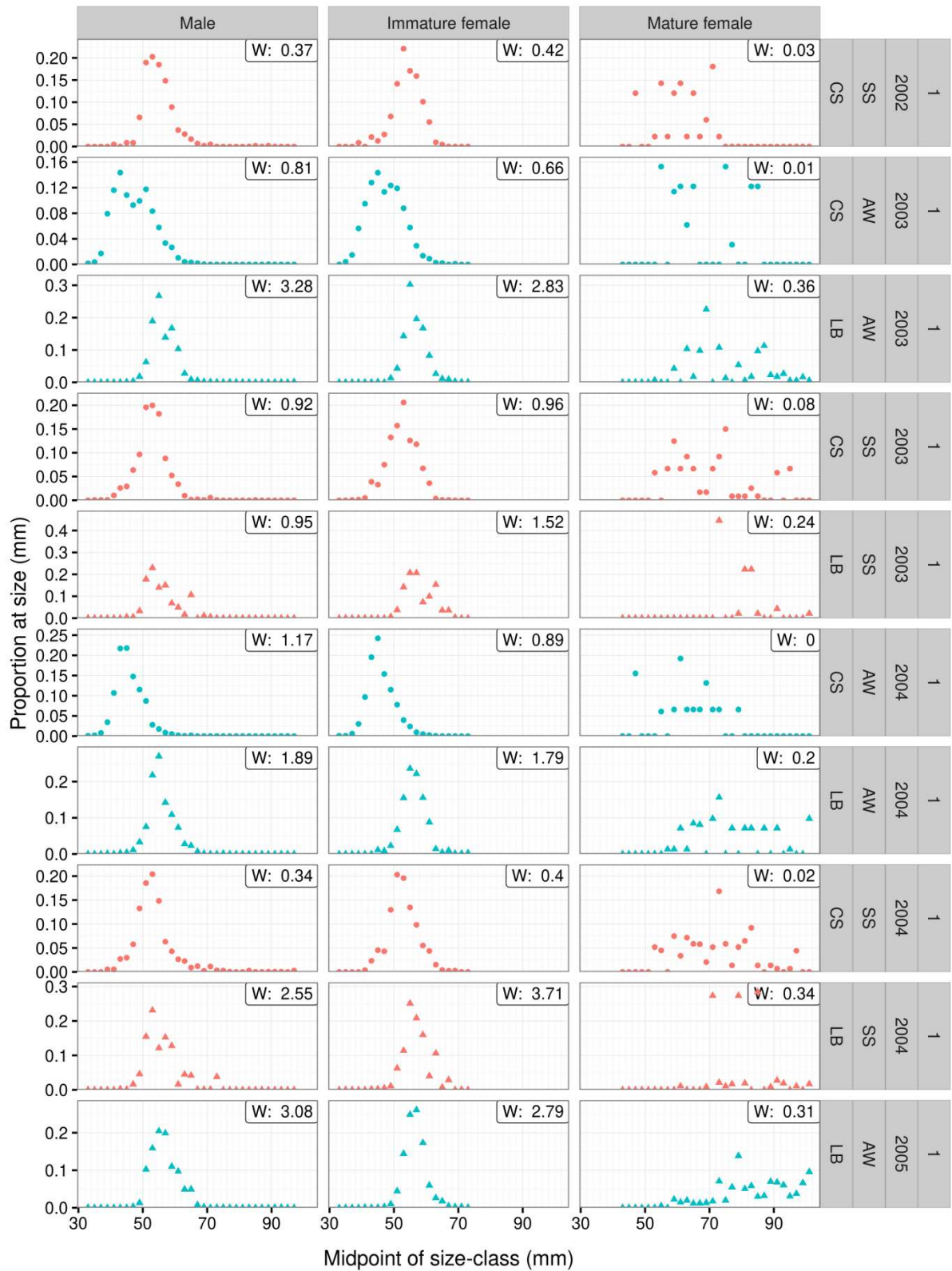


Figure G.6: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 2002 SS to 2005 AW. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

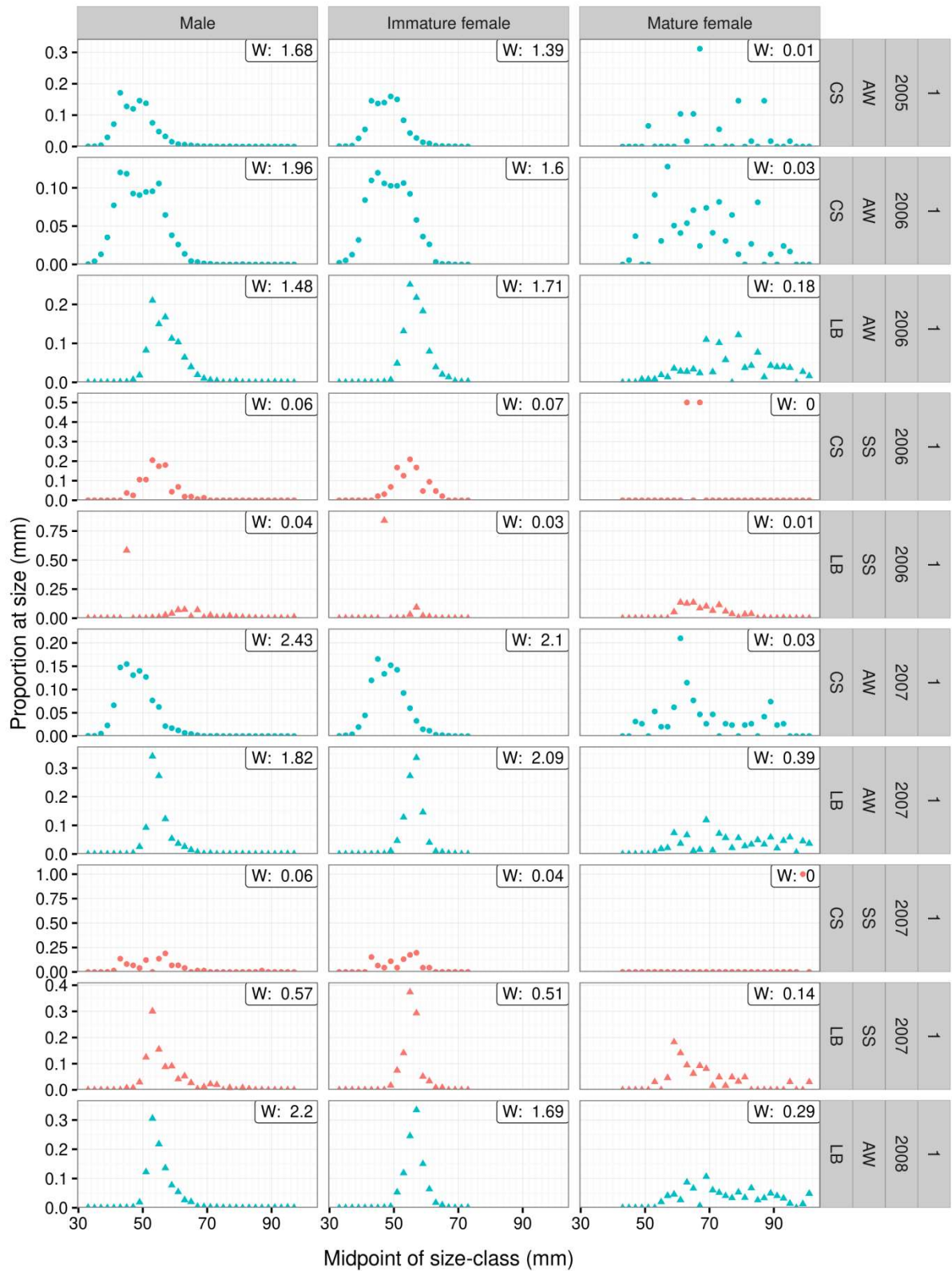


Figure G.7: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 2005 AW to 2008 AW. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

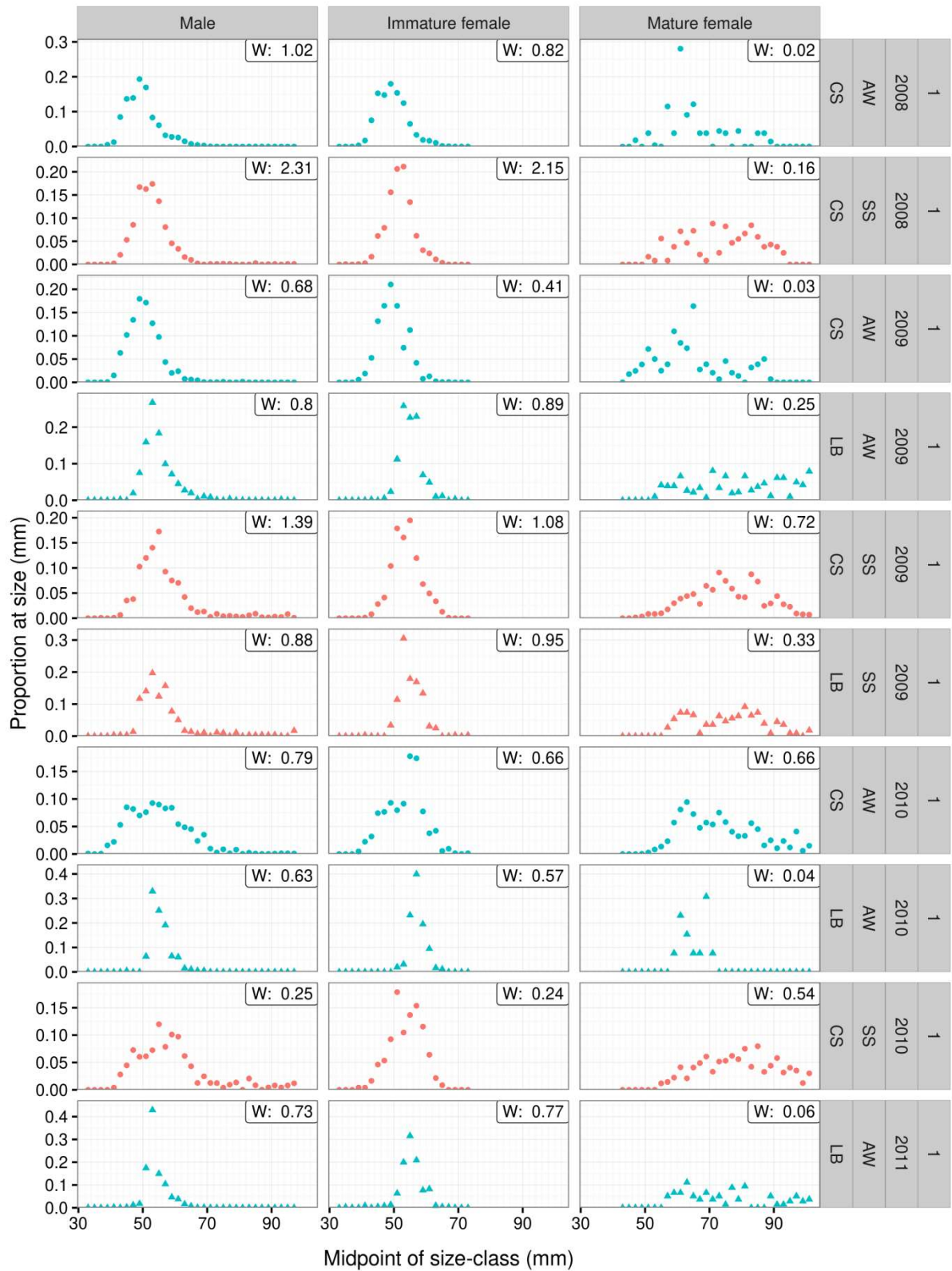


Figure G.8: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 2008 AW to 2011 AW. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

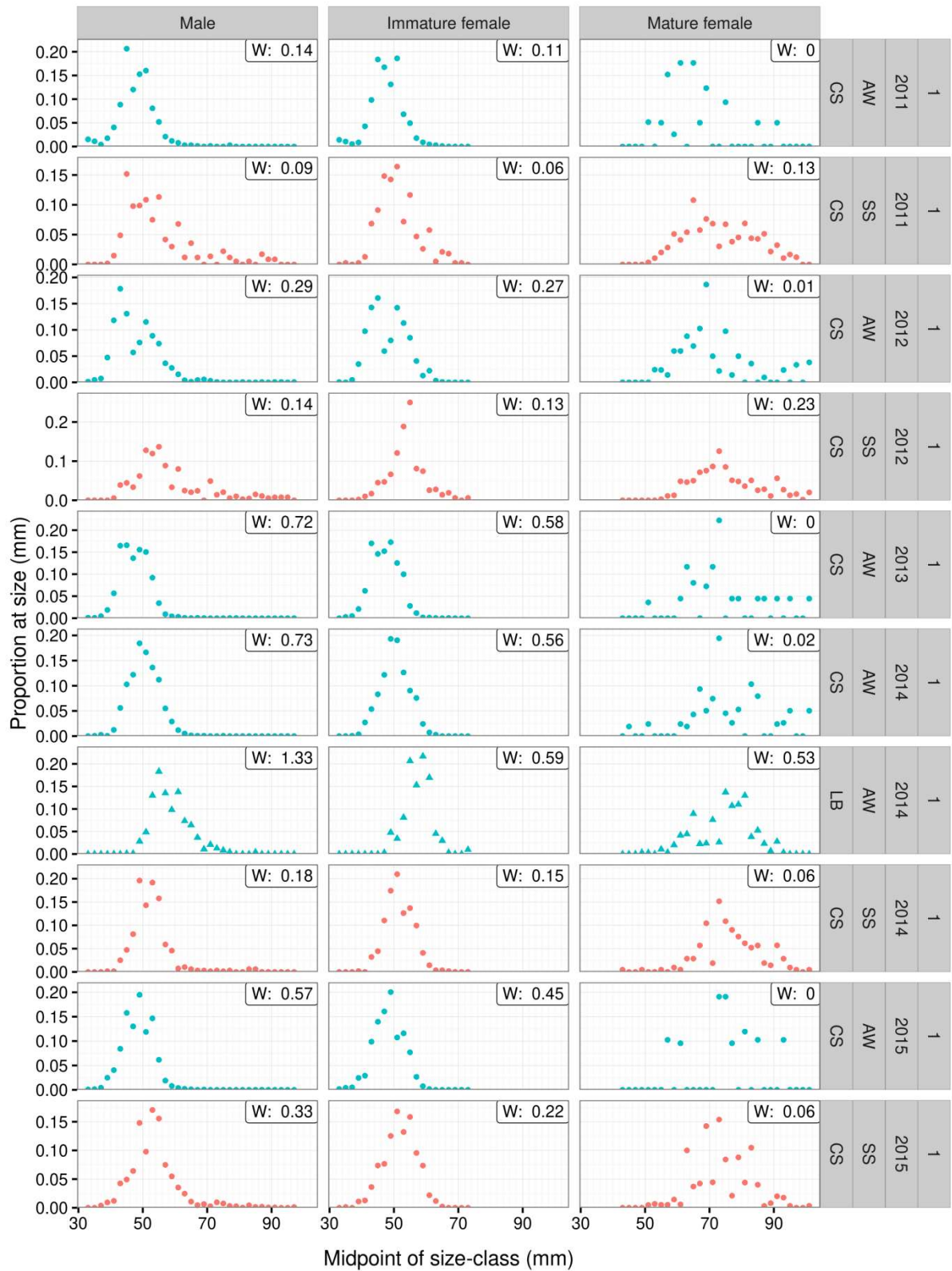


Figure G.9: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 2011 AW to 2015 SS. Each cell shows the associated weight from Table 21; CS=observer catch sampling; LB=logbook catch sampling.

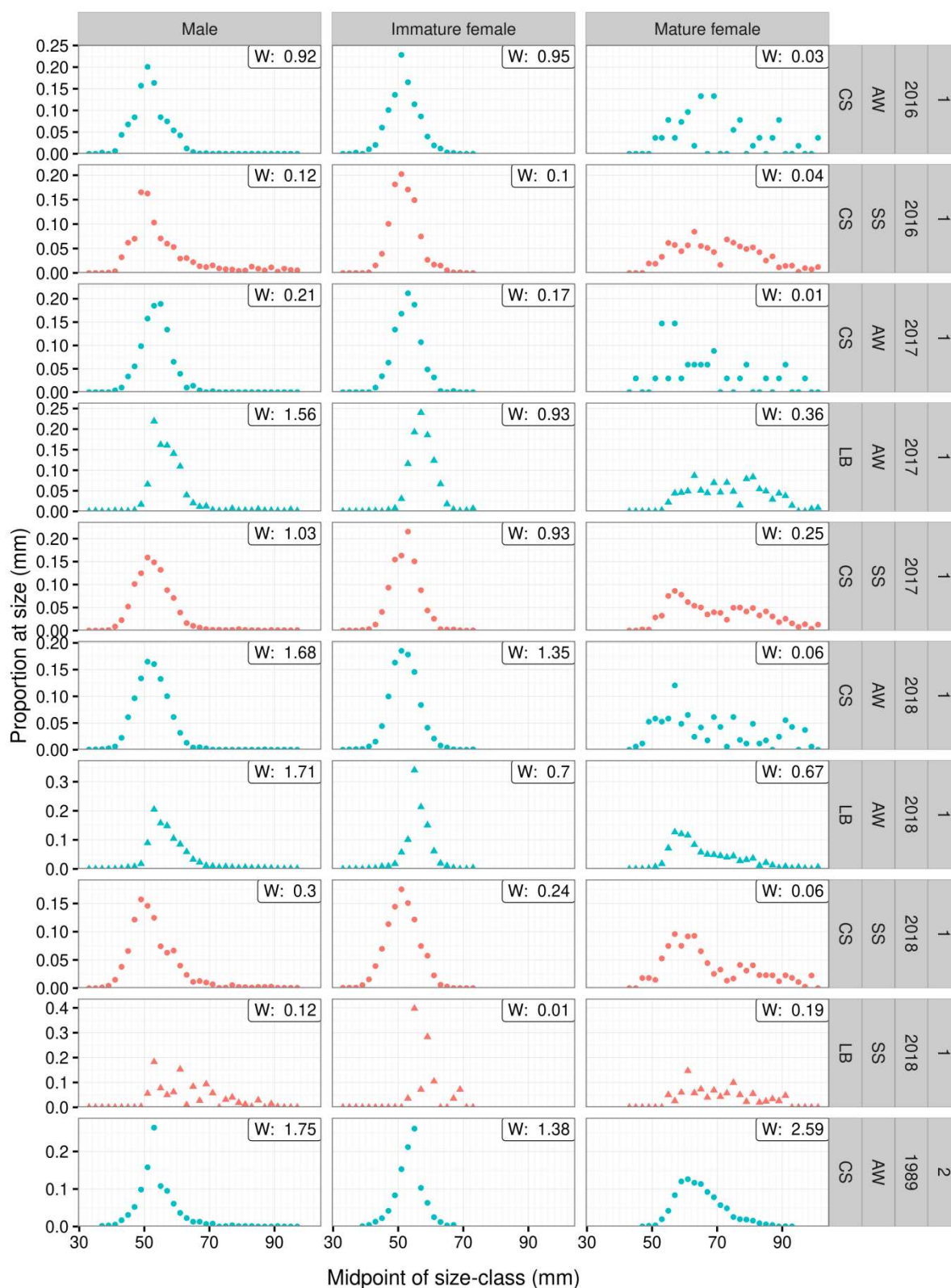


Figure G.10: CRA 7&8 region 1 (920–925) observed length frequency distributions by sex category from 2016 AW to 2018 SS and the region 2 (926+927+928) 1989 AW. Each cell shows the associated weight from Table 21 (region 1) and Table 23 (region 2); CS=observer catch sampling; LB=logbook catch sampling.

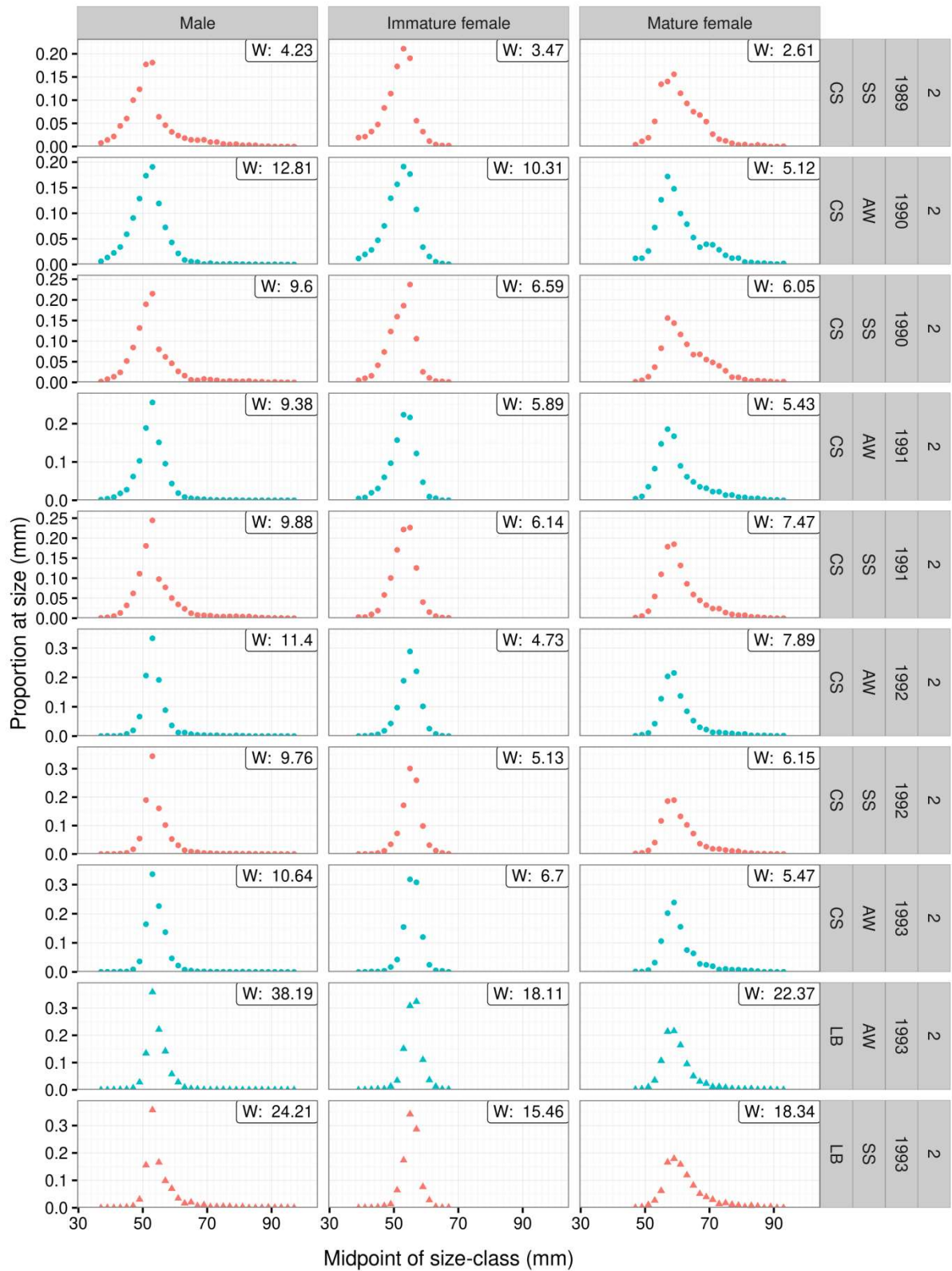


Figure G.11: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 1989 SS to 1993 SS. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

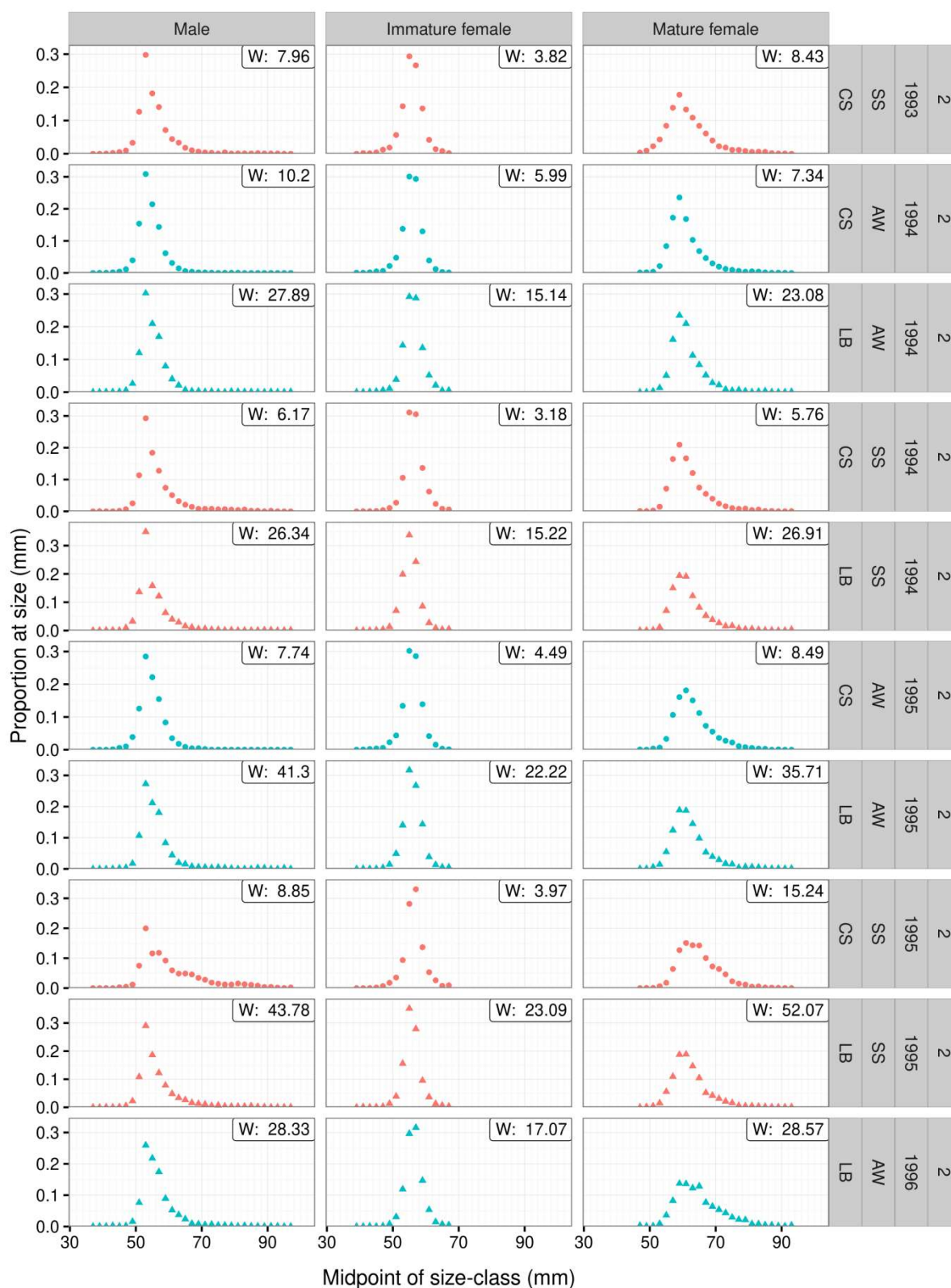


Figure G.12: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 1993 SS to 1996 AW. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

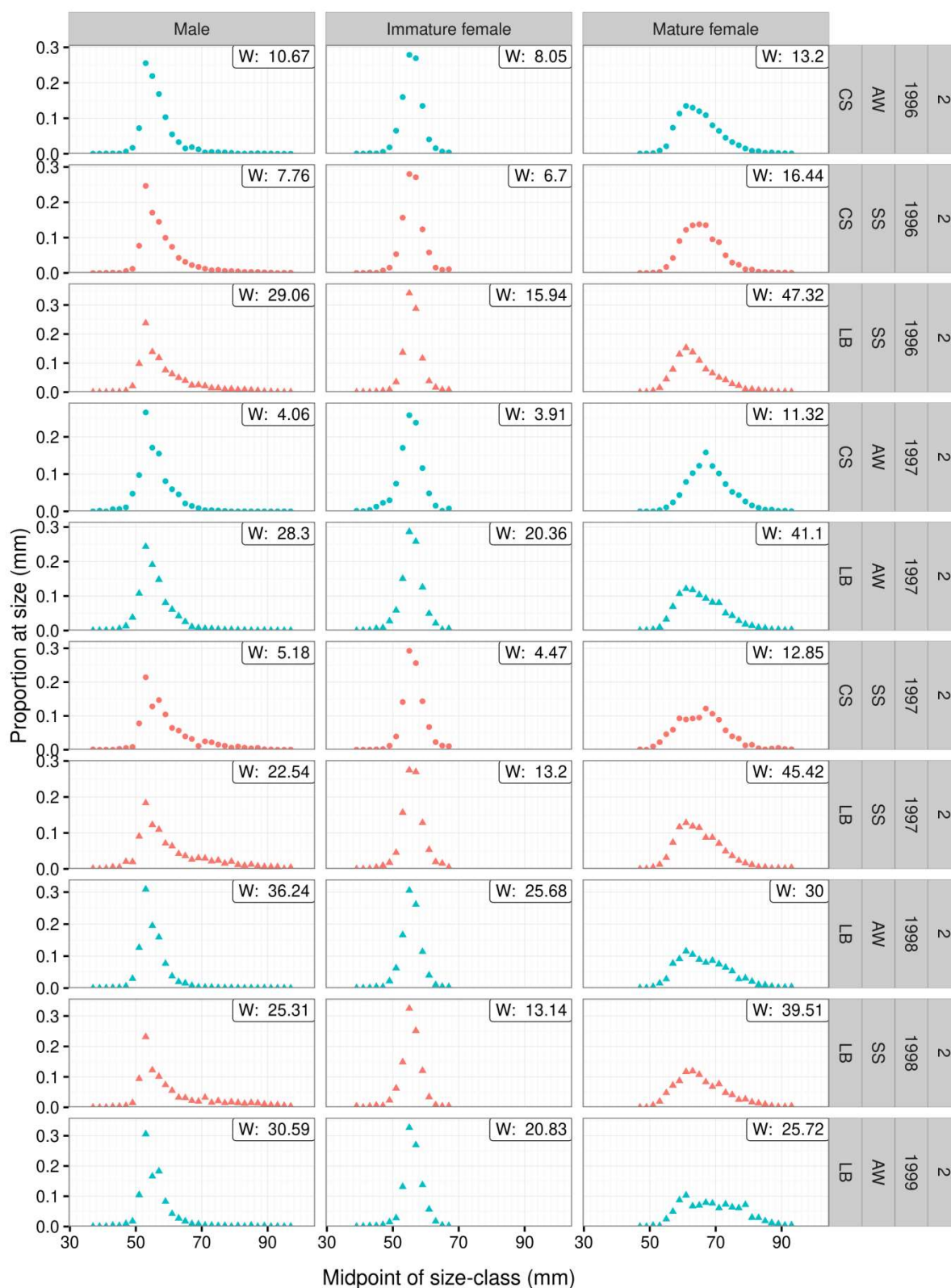


Figure G.13: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 1996 AW to 1999 AW. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

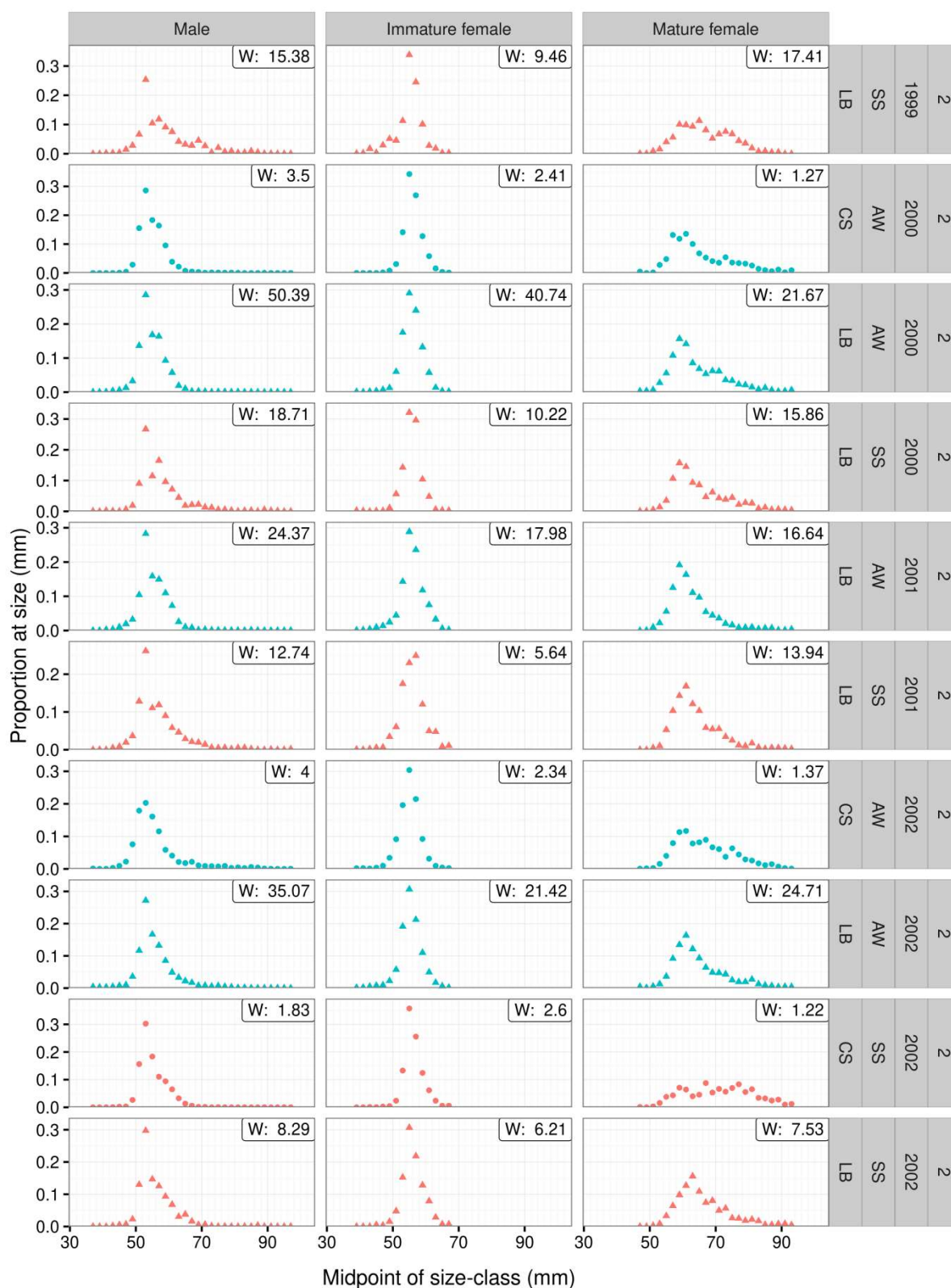


Figure G.14: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 1999 SS to 2002 SS. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

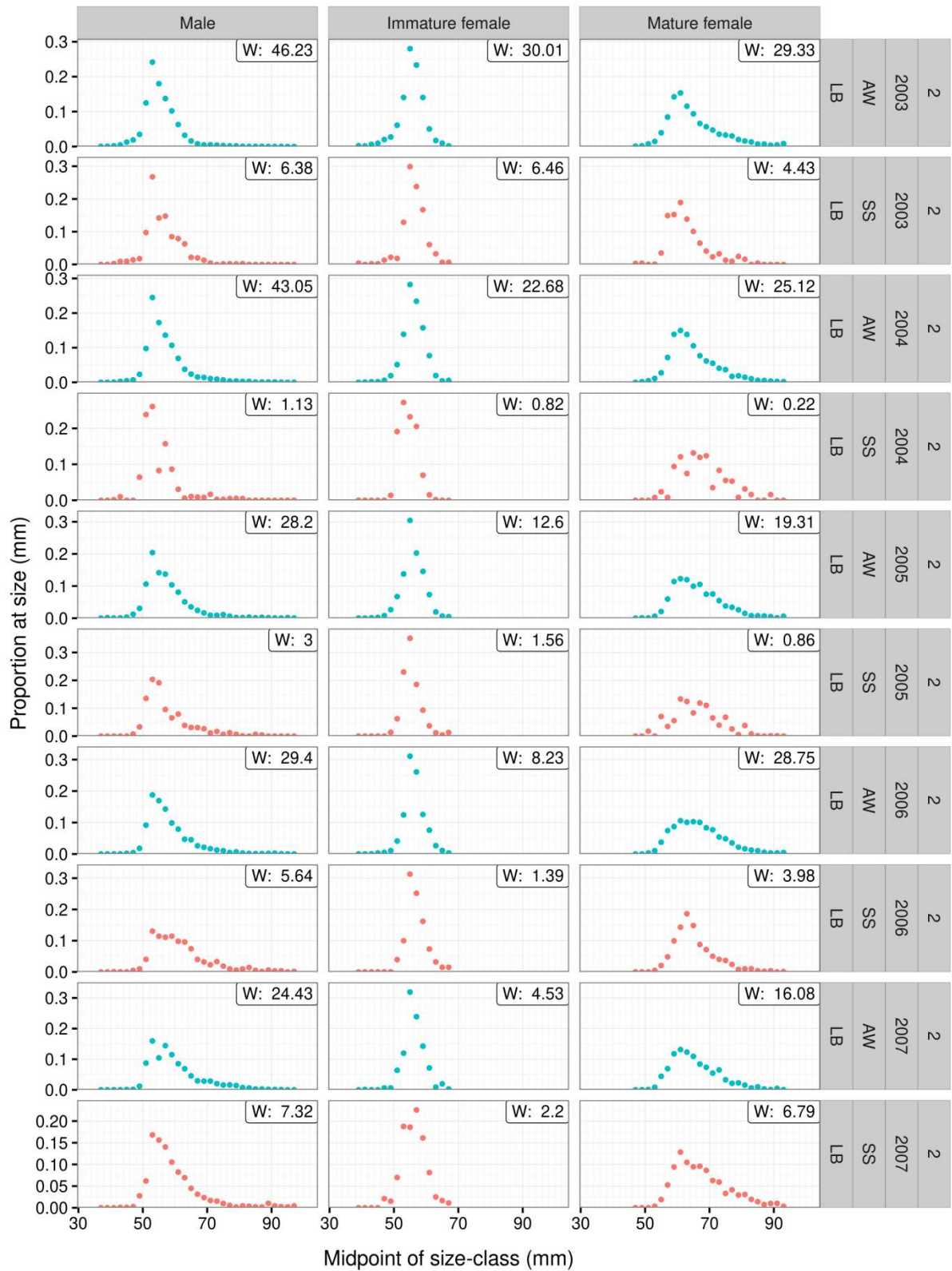


Figure G.15: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 2003 AW to 2007 SS. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

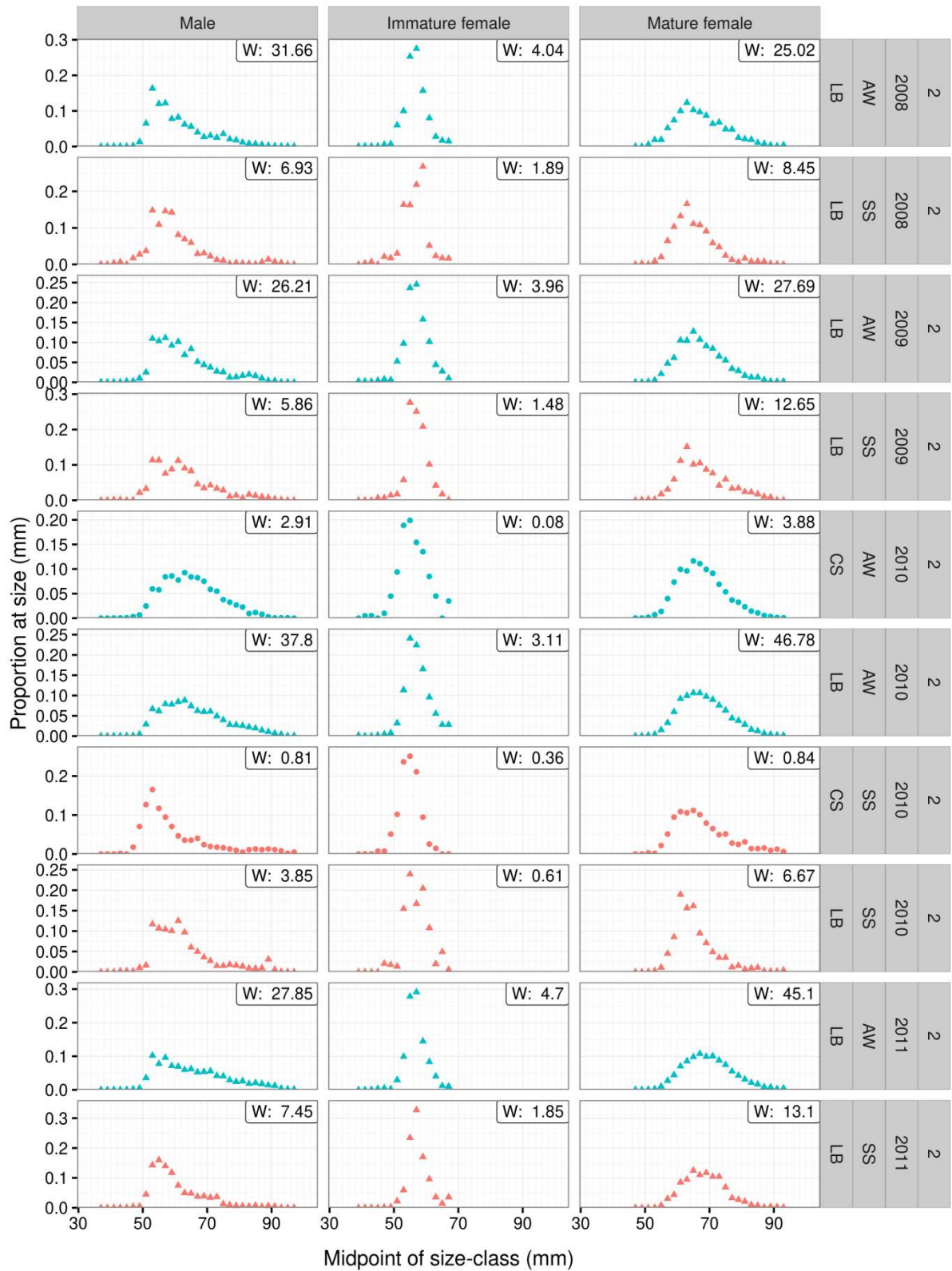


Figure G.16: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 2008 AW to 2011 SS. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

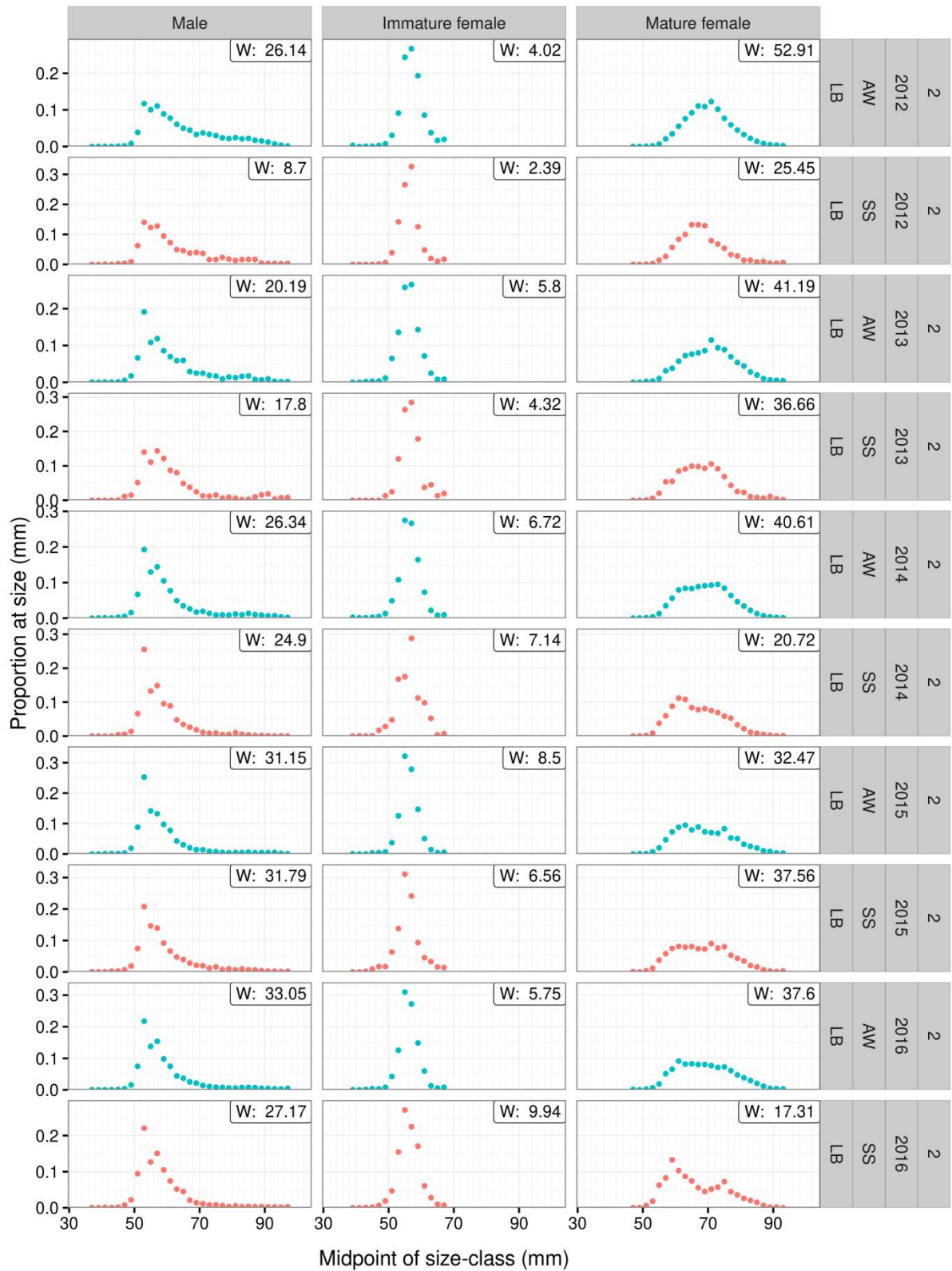


Figure G.17: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 2012 AW to 2016 SS. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.

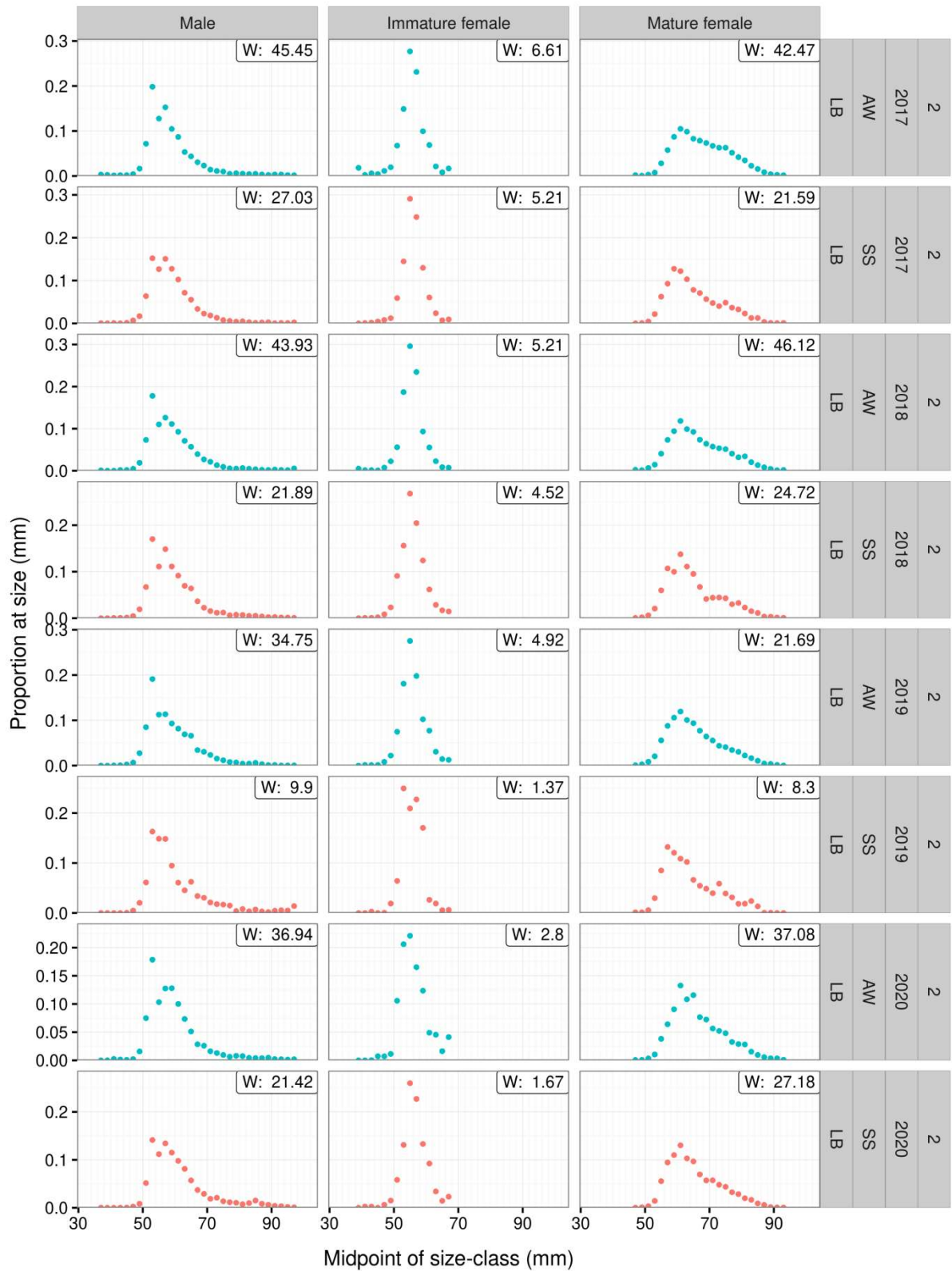


Figure G.18: CRA 7&8 region 2 (926+927+928) observed length frequency distributions by sex category from 2017 AW to 2020 SS. Each cell shows the associated weight from Table 23; CS=observer catch sampling; LB=logbook catch sampling.