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Data for the 2019 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 3

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EXECUTIVE SUMMARY

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This document describes the data used in the 2019 CRA 3 stock assessment. Data sets described in this report include catch estimates for all sectors of the CRA 3 fisheries, seasonal standardised CPUE indices, length frequency distributions, and tag-recapture data.

Catch estimates are provided for the commercial, recreational, customary, and illegal fisheries, collated by year to 1978 and then by six-month season (spring-summer [SS] and autumn-winter [AW]), and by size-limited and non-size-limited fisheries. Recreational catch estimates were available from older telephone/diary surveys and from two recent large-scale multi-species surveys conducted using a population-based survey methodology. The survey catch estimates were fitted, assuming a lognormal distribution, to the SS CPUE for 1994, 1996, 2011, and 2017 estimates. The estimated scaling coefficient was then used to estimate a recreational catch series from 1979 based on the standardised CRA 3 SS CPUE. Recreational catches before 1979 were interpolated from a low value in 1945 to the 1979 value.

CPUE was standardised for the SS and AW seasons. The F2 algorithm, which uses a truncated distribution of "vessel correction factors" to adjust estimated catches to final catch, was used to prepare the catch and effort data. The destination codes 'X' (discarded at sea) and 'F' (Section 111 recreational catches) were added to the destination code 'L' (landed to a Licensed Fish Receiver [LFR]) to obtain the final catch total for scaling the estimated catches. The standardisation procedure was done in two parts: from 1989, Bayesian inference was used to estimate the seasonal abundance indices and obtain better estimates of uncertainty. A vessel explanatory variable, using vessels with at least five years of data in the fishery, was included in the analysis, as has been done since 2017. Seasonal indices for the period 1979–1988 were estimated using frequentist inference without a vessel explanatory variable.

Length frequency data were available from both observer catch sampling and voluntary logbook programmes. These were collated by data source and by season, and the document describes how the individual records were weighted. Tag-recapture data provide information on growth rates for each sex and the document characterises the data set.

1. INTRODUCTION

This work addressed parts of Objectives 3 and 4 of the Fisheries New Zealand contract CRA2018-01. This one-year contract, which began in April 2019, was awarded to New Zealand Rock Lobster Industry Council Ltd. (NZ RLIC Ltd.), who sub-contract Objectives 3 and 4 to the authors of this report.

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

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

The National Rock Lobster Management Group (NRLMG) decided that both CRA 1 and CRA 3 should be assessed in 2019. Data were compiled for both stocks by a team comprising Paul Starr, D'Arcy Webber, Merrill Rudd, Kath Large, and Jim Roberts. CRA 1 was then assessed by Merrill Rudd and Kath Large, and CRA 3 was assessed by D'Arcy Webber and Jim Roberts, with Paul Starr supporting both teams. This document is limited to the data for CRA 3 and describes catches (including commercial, recreational, customary, and illegal), CPUE, length frequencies, and tag-recapture data. Puerulus settlement data were available but were not used to estimate recruitment variability, primarily because the previous CRA 3 stock assessment (Haist et al. 2015) determined that these data did not inform the 2013 stock assessment. Appendix A documents the formal data requests to Fisheries New Zealand for non-commercial catch information and the associated FNZ response is provided in Appendix B. Webber et al. (2020) present the stock assessment based on the data in this report.

The previous stock assessment of CRA 3, including the development of operational management procedures (MPs), was done in 2014 (Haist et al. 2015). The data used in that stock assessment were described by Starr et al. (2015).

Decisions on data and modelling choices were discussed and approved by the Rock Lobster Fishery Assessment Working Group (RLFAWG).

The CRA 3 fishery extends from East Cape south to the Wairoa River (see Figure 1). The current 351.9 t TAC comprises allowances of 20 t for recreational catch, 20 t for customary harvest, 89 t for illegal removals, and a total allowable commercial catch (TACC) of 222.9 t distributed among 51 quota share owners (in 2019–20) (D. Sykes, NZ RLIC, pers. comm.). In 2017–18, 25 vessels reported CRA 3 landings (Starr 2019). There is significant iwi involvement in quota share ownership and fishing and rock lobsters have great cultural significance to local Maori. The commercial harvest has an approximate landed value of $18.7 million based on an average port price of $84,500/tonne (D. Sykes, NZ RLIC, pers. comm.). There are two processing plants in Gisborne and product is also shipped to Wellington, Tauranga, and Auckland for processing. CRA 3 rock lobsters are packed for live export from three locations in Auckland.

2. CRA 3 CATCH DATA

2.1 Commercial catch

For commercial catches, the fishing year and calendar year were the same before 1979. From 1979 onwards, the fishing year has been April to March. Reported annual commercial catches from 1945 to 1978, summarised by calendar year, were obtained from sources described by Bentley et al. (2005). From 1 January 1979 to 31 March 1986, catches were taken from monthly data summarised by fishing year from the Fisheries Statistics Unit (FSU), a version of which is now held by Fisheries New Zealand. 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.

For 1 April 1986 through 30 March 1988, monthly reported catch totals from all of New Zealand were obtained from Quota Management Returns (QMRs), maintained by Fisheries New Zealand. Because catch estimates for individual QMAs were not available for this period, these total New Zealand catches 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 monthly QMRs from 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 has been increased use of destination codes that report intermediate holding of catch in many of the CRA QMAs (see Appendix C), a practice which allows operators to wait for favourable market conditions before selling their catch. However, this practice has also affected the analysis of commercial catch and effort data by breaking the link between the effort used to take the lobsters and the validated landing information (see Fisheries New Zealand 2019 for a discussion of this problem). The landing information was examined to see the extent of this practice in CRA 3, which appears to use intermediate holding pots (destination code "P", see Figure C.1). However, little use is made of Destination "X" (discarding of legal lobsters) in CRA 3 (Figure C.1). It is not known if this indicates that there is very little discarding of legal lobsters or whether discarded legal lobsters are not being recorded.

Although there is confidence in the quality of the commercial catch estimates from the FSU system, there is some uncertainty in the quality of the catch estimates in the years before the FSU system began in 1979. 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 3 averaged 119 t/year before 1979, with a short period in the late 1960s when catches exceeded 250 t/year (Figure 2). CRA 3 commercial catches were higher in the period leading up to the introduction of rock lobster into the QMS (1979–1987), with catches peaking at 763 t in 1983–84 and averaging 575 t/fishing year during that decade. Commercial catches in CRA 3 were less than the TACC until 1993 (Figure 3), when a suite of new management measures was introduced, including a greatly reduced TACC. Catches were also less than the TACC in the early to mid-2000s, partly because of shelving by fishers before the TACC was reduced in 2005. Catches have closely matched the TACC from 2008, including successive increases in TACC in 2012, 2013, and 2014 followed by a TACC decrease in 2017, all through the operation of the CRA 3 MP. A further decrease in the CRA 3 TACC was set by the MP for 2019–20.

2.2 Recreational catch

Six annual recreational survey catch estimates are available for CRA 3 (Table 1). Estimates from the two Kingett Mitchell National Surveys (Boyd et al. 2004, Boyd & Reilly 2002) were not accepted by the RLFAWG for the 2014 CRA 3 stock assessment (Starr et al. 2015) because these survey estimates were considered implausibly high for CRA 3. The 1994 and 1996 surveys, conducted by researchers at the University of Otago, were considered biased in a review of the available recreational surveys (unpublished minutes: Recreational Technical Working Group [Auckland NIWA, 10–11 June 2004]) because the interview questions possibly underestimated fisher participation rates by allowing for an easy exit from the interview ("soft refusal" bias). These two earlier surveys nevertheless continue to be used by the RLFAWG because the estimates are plausible and no other recreational information is available for these years. Both the Boyd and the Otago surveys were potentially biased high because recreational logbook participants were not closely supervised and may not have accurately recorded their fishing activity. The much higher harvest estimates in the Boyd surveys were a result of higher claimed participation in saltwater fishing over the previous 12 months in the initial screening survey.

Two large-scale population-based diary/interview surveys (National Panel Survey or NPS) have been conducted under contract for Fisheries New Zealand 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 FMA- and QMA-specific annual catches for all major finfish and non-finfish species (Heinemann et al. 2015). This survey was based on a design that resembled the New

Zealand national census, making use of the census population strata ("mesh blocks") of dwellings as the basis for identifying recreational fishers. A door-to-door survey of households in randomly selected strata was used to select participants who would report their catch for an entire year. A structured and carefully-designed Computer Assisted Telephone Interview method was used to record harvest in detail from those who had fished. The survey results were thought to be plausible for CRA 3, with 26 (2011–12) and 30 (2017–18) fishers providing 47 and 90 interviews for each survey year (see table 60 of Wynne-Jones et al. 2014 and table 51 of Wynne-Jones et al. 2019). These estimates have relatively high coefficients of variation (CVs) (0.33 in 2011–12 and 0.26 in 2017–18; Table 2). The 2011 survey provided estimates of the distribution of fishing platforms used to take lobsters in CRA 3, with large and small motor boats accounting for just over three-quarters of the catch and 22% coming from land (Table 2). The primary capture method used to take amateur rock lobster in CRA 3 was diving (55%) followed by potting (44%) (Table 2). NPS survey results from logbook participants were in terms of number of fish. Mean recreational catch weight for the most important finfish and non-finfish species QMAs was estimated in a parallel project (Hartill & Davey 2015).

A recreational catch vector was developed by assuming that recreational catch has been proportional to the CRA 3 spring-summer (SS) abundance, as reflected by the standardised SS CPUE for all of CRA 3. The standardised SS CPUE vector was calculated using data prepared with the F2-LFX algorithm (see Starr 2019). By agreement in the RLFAWG, the recreational catch vector was based on four of the six survey estimates (in tonnes – see Table 1) from the 1994 (Otago), 1996 (Otago), the 2011–12 and 2017–18 NPS surveys. The two NPS surveys were assumed to be less biased, so the estimated survey CVs were used. The CVs for the two Otago surveys were assumed to be 50% higher than that of the mean of the two NPS surveys. A scalar quantity q (Eq. 1) was estimated by obtaining the best fit to these survey estimates when minimising a lognormal distribution using the CVs indicated in Table 1:

Eq. 1

$$\boldsymbol{W_t = w_t N_t}$$
$$\boldsymbol{\widehat{W}_t = \hat{q} CPUE_t}$$
$$\mathbf{LL} = \sum_{t=1}^{5} \left(\frac{\left(\boldsymbol{LN(W_t) - LN(\widehat{W}_t)} \right)^2}{\boldsymbol{2\sigma_t^2}} \right)$$

where t subscripts the four recreational survey estimates (Table 1; 1=1994 Otago, 2=1996 Otago, 3=2011–12 NPS, 4=2017–18 NPS), w_t is the mean SS weight ≥ the MLS for lobsters sampled in year/survey t for CRA 3, N_t is the mean number of estimated lobsters captured in year/survey t for CRA 3, $CPUE_t$ is the CRA 3 SS standardised CPUE in year t, and $\widehat{W}_t$ is the CRA 3 estimated recreational catch (tonnes) for year t.

The estimated recreational catch trajectory (Eq. 2) based on the q estimated in Eq. 1 is a reasonable fit to all four survey estimates in Table 1 (Figure 4). The q parameter is estimated to be 6.0 tonnes/CPUE-unit and the recreational catch vector accounts for 262 tonnes of historical catch from 1979 to 2018.

Eq. 2

$$\boldsymbol{\widehat{W}_y = \hat{q} CPUE_y \text{ if } y \geq 1979}$$
$$\boldsymbol{\widehat{W}_{1945} = 0.2 \widehat{W}_{1979}}$$
$$\boldsymbol{\widehat{W}_y = \widehat{W}_{y-1} + \frac{\widehat{W}_{1979} - \widehat{W}_{1945}}{1979 - 1945} \text{ if } 1945 < y < 1979}$$

For assessments since 2006, the RLFAWG has included recreational landings made by commercial vessels under Section 111 of the Fisheries Act. Greenweight landings with destination code "F" were extracted from the CRACE database (Bentley et al. 2005), which showed a maximum annual value of 3047 kg for CRA 3, occurring in 2016–17. The RLFAWG has agreed to add the maximum catch

estimate to the estimated recreational catch every year since 1979 (Figure 4), increasing the total 1979 to 2018 recreational catch in the model to 384 tonnes.

2.3 Customary catch

Fisheries New Zealand were asked to provide estimates of current and historical customary catches, and an estimate of their uncertainty (see Appendix A). Fisheries New Zealand advised that a constant customary catch of 20 tonnes should be assumed (see Appendix B). This was split between seasons, with 90% assumed taken in the SS period.

2.4 Illegal catch

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

The RLFAWG rejected using the Fisheries New Zealand Compliance estimates of illegal catch (Table 3) to generate a time series of illegal catches for CRA 3. This decision was made because members felt that many of the estimates, particularly in the early 1990s, represented a substantial proportion of the legal catch, and consequently were not credible. Instead, the RLFAWG agreed to use a fixed percentage of the summed total commercial catch from 1981 to 2018, with both 10% and 20% selected by the WG. The RLFAWG did not agree to scale the resulting 38 year catch total proportionately to the annual standardised CPUE index because this approach led to very large catches in the years with high CPUE. Instead, a constant average level of illegal catch was assumed (Figure 5). This series was started in 1981 because the McKoy "export discrepancy" procedure ended in 1980 (see following discussion).

The following procedure was used to estimate illegal catch up to 1980:

- Starting with the estimates of export discrepancies for all of New Zealand for 1974–80 (McKoy, unpublished data), the CRA 3 illegal catches for each of these seven years were estimated from the ratio of the reported commercial catch in CRA 3 relative to the total New Zealand reported commercial catch for the same years.
- The average ratio of the export discrepancy catch to the reported commercial catch was calculated for the period 1974–80. This ratio was used to generate an illegal catch estimate for all years with no data (1945 to 1973 and 1981 to 1989) by multiplying the reported catch by the average ratio. This approach was agreed by the RLFAWG on 15 August 2002.

In the past, estimates for illegal catch from MPI Compliance Services have frequently been provided in two categories ("reported" or "R" and "not reported" or "NR"). The category of "commercial illegal reported" or "reported" (equals "R" in Table 3) was assumed to represent illegal commercial catch that was eventually reported to the QMS as legitimate catch. Therefore, this catch was subtracted from the reported commercial catch to avoid double-counting. Missing categories were treated as zeroes and the available values were used to estimate the overall proportion of R/NR for each QMA, which was then applied to all years (including interpolated years). MPI Compliance Services has stated that it no longer includes the "R" category in its estimates because it takes into account the possibility of eventual reporting to the MHR, so the step of moving the estimated "R" catches from "commercial" to "illegal" has now been discontinued for all CRA QMAs, beginning in 2012. The CRA 3 estimate of 4.5% of the illegal catch was applied to the illegal catch trajectories from 1981 to 2018.

We assumed that annual illegal catches were distributed between seasons in the same proportion as the commercial catch for each year. The illegal catch estimates are shown in Figure 5.

2.5 Time series of CRA 3 annual and seasonal catches

Annual catches for CRA 3 from 1945 to 1978, followed by seasonal catches from 1979 to 2018, are presented for commercial, recreational, customary, and illegal categories in Table 4.

3. CATCH INFORMATION FOR CRA 3 REGIONAL MODEL

The RLFAWG agreed that CRA 3 was best evaluated by separating the QMA into two regions defined by component statistical areas (Figure D.1 and Table D.1 of Appendix D). This decision was based on an analysis of length frequency data specific to each region which showed a consistent difference between the two regions, with region 911 having larger length distributions than in region 909+910 for most of the available year/season/sex comparisons (see Appendix D: Figure D.2 to Figure D.5). Additionally, the standardised CPUE trends for the two regions diverged after 2012, with region 911 remaining flat or increasing slightly whereas region 909+910 decreased (Figure D.6, Figure D.7).

3.1 Preparation of the catch information

The preparation of catch data for the two CRA 3 regions was hampered by inconsistent data availability, depending on the period (Table 5). Reporting from the modern rock lobster statistical areas was not available until 1979, but the fishery was well-developed by then, with significant catches taken since at least 1945. Historical catches were available by sub-area from 1963 to 1973, but the sub-area definitions used by Annala & King (1983) (Figure 6) differed substantially 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 5).

3.1.1 Method used to estimate catches in the two CRA 3 regions beginning in 1979

Beginning with 1 January 1979, data were allocated to each region (Table D.1) on the basis of the declared statistical area. This applied to all data: catch, observer and logbook catch sampling, and tagging data.

3.1.2 Algorithm used to estimate catches in the two CRA 3 regions before 1979

Assigning catch to a region before 1979 was difficult because spatial catch data were only available from 1963 to 1973 and used area definitions that differed from those used in the post-1978 data (Figure 6, 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 Table D.1 definitions by noting that a) A & K Area 5 almost perfectly overlapped with the combined Statistical Areas 909+910; and b) A & K Area 6 encompassed post-1978 Statistical Areas 911 and 912. Catches were assigned to region 911 by applying a constant proportion of 0.543 to that A & K Area 6 annual catches, where $0.543 = \sum_{1979}^{1983} \text{Statistical Area 911} / \sum_{1979}^{1983} (\text{Statistical Area 911} + \text{Statistical Area 912})$. Catches by region over the period 1974 to 1978 were filled by interpolation. Pre-1963 catches were assigned using the mean regional proportions from 1963 to 1967 (Table 9).

The following algorithm was used to apportion catches to the defined CRA 3 regions, based on distributions available when reporting was more accurate:

1. Starting from the FSU (in place for rock lobster from January 1979 to June 1989) data set, sum reported catches by statistical area from 1979–80 to year Y (initially set at 1983–84):

   $C^a = \sum_{y=1979}^{Y} c_y^a$ where a is one of the rock lobster statistical areas in Table 6.

2. Calculate the relative proportion of each contributing rock lobster statistical areas among the three Annala/King groupings identified in Table 6:

   $P^a = C^a / \sum_{a=1}^{N^A} C_a$ where N^A is the number of rock lobster statistical areas in Annala/King area A. See Table 7 for these calculations.

3. By year, calculate the contribution of the three CRA 3 statistical areas based on the proportions estimated in step 2:

   $k_y^a = P^a K_y^A$ where K_y^A is the Annala/King catch in area A in year y (y=1963–1973). Note: only used method codes 8 or 19 in the Annala/King data (these are the potting method).

4. Sum the three contributing CRA 3 statistical areas to get a total CRA 3 estimated catch in each year and divide to get the relative proportion of each CRA 3 statistical area in year y:

   $pk_y^a = k_y^a / \sum_{a=1}^{3} k_y^a$ where a is 909, 910, or 911 in year y (y=1963–1973). See columns 2 to 5 in Table 8 for these proportions. Column 6 in Table 8 is the sum of catches from the 5 rock lobster statistical areas calculated in this manner.

5. Multiply the resulting proportions by the historical CRA 3 catch in year y to get the scaled statistical area catch from 1963 to 1973:

   $c_y^a = pk_y^a C_y^{\mathrm{CRA3}}$ where C_y^{CRA3} is the catch value used in the combined CRA 3 stock assessment.

   This step is required because the summed k_y^a is greater than the values stored in CRACE (Bentley et al. 2005) for CRA 3 (which have been used by default in every rock lobster stock assessment; compare columns 6 and 7 in Table 8).

6. Values for pk_y^a from 1974 to 1978 were obtained by interpolating between pk_{1973}^a and pk_{1979}^a (Table 9) and then applying the equation in step 5 to the appropriate value of C_y^{CRA3}.

7. Values for pk_y^a before 1963 were obtained by averaging $\sum_{y=1963}^{y=1967} pk_y^a/5$ (see final row in Table 8) and then applying the equation in step 5 to the appropriate value of C_y^{CRA3}.

8. The pk_y^a proportions derived in Steps 4, 6, and 7 were used to allocate the CRA 3 non-commercial catches by statistical area and year in the years before 1979. Proportions based on the reported commercial catches by fishing year from the FSU and CELR systems were used to allocate the non-commercial catches to statistical areas from 1979 onward. The commercial catch distributions were based on the F0_LFX algorithm (see Starr 2019).

The time series of estimated catches by category of capture are presented by CRA 3 region in Figure 7, in Table 11 (region 909+910), and Table 12 (region 911).

The two regions show a similar distribution of autumn-winter (AW) commercial catch (Figure 8), and these seasonal distributions are used to allocate the commercial and illegal catches to the AW and SS seasons for each region. Arbitrary seasonal splits of 0.10 (AW) and 0.90 (SS), consistent with the assumptions used in all rock lobster stock assessments, allocate recreational and customary catches to a season. These seasonal proportions are then used to allocate catches into two categories: SL (size limited: the sum of commercial and recreational catches) and NSL (not size limited: the sum of illegal and customary catches) (Figure 9, Table 11, and Table 12). These are the catch distributions that were used to model the two CRA 3 regions.

4. CATCH RATE INFORMATION

4.1 Seasonal standardised CPUE indices

4.1.1 Introduction and methods

Catch and effort data from the CELR systems were obtained from Fisheries New Zealand in September 2019 (Replog 12557) and processed using the standard error checks (Bentley et al. 2005). Data spanned the period from 1 July 1989 through to 31 March 2019. Data for the period 1 April 1979 to 30 June 1989 came from the FSU database, a static copy of which is held by the rock lobster stock assessment team.

Preparation of the CELR data used the F2_LFX procedure (Starr 2019). 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 (Starr 2019). Vessels with a *vcf* less than 0.8 or greater than 1.2 are discarded from the analysis. The F2_LFX procedure scales the estimated catches to the combined "L" (LFR), "X" (discarded to sea), and "F" (Section 111 recreational catch) destination codes (destination codes defined in Table C.1; the number of records in the CPUE data set is provided in Table 13 for region 909+910 and in Table 14 for region 911).

The 2019 stock assessment included two standardised CPUE series calculated from generalised linear models (GLMs) that used sequential six-month periods as forced explanatory variables (see section 2.5 of Starr (2019) for a description of this procedure). One CPUE series was based on the early FSU data and the second series used the more recent CELR data. Three explanatory variables were available for both analyses in addition to the sequential [`period`] variable: [`month`] of capture, statistical [`area`] of capture, and an identification code for each fishing [`vessel`]. There is a discontinuity between the two series, with the FSU series ending with the 1 October 1988–31 March 1989 sequential period, whereas the 1 April 1989–30 September 1989 series can only start on 1 October 1989 which is the first full season for the CELR data (Bentley et al. 2005).

The variable [`vessel`] is not used in the FSU GLM. However, an analysis that included a vessel effect was done and this made no difference, so was dropped (the FSU indices extracted from this analysis for use in the 2019 stock assessment are provided in Table E.3 [region 909+910] and Table E.6 [region 911]). The FSU GLM estimated separate [`month`] effects in each half-year period, using the [`month`] in each period with the lowest standard error as the reference [`month`].

The CELR model used a [`vessel`] explanatory variable, filtered for vessels with at least five years of data in the database. The CELR GLM estimated [`month`], [`vessel`], and a [`period:area`] interaction as a group-level effects and [`period`] as a population-level effect. Bayesian inference was used to estimate parameter uncertainty in the CELR GLM. This was done using the R package *brms*, which is a wrapper for doing GLMs coded using the Stan language. Stan uses gradient-based Markov chain Monte Carlo (MCMC), specifically the Hamiltonian Monte Carlo (HMC) algorithm, for Bayesian inference. A total of 4000 samples from the posterior distribution were obtained by combining samples across four chains. Each chain consisted of a warm-up period of 2000 discarded iterations followed by sampling the following 1000 iterations.

The null model, which only includes coefficients for the sequential period (*t*), and is roughly equivalent to the unstandardised series, is defined as:

Eq. 3 $$\log\left(\frac{C_i}{E_i}\right) = \mathrm{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon_i} = \boldsymbol{\beta_0} + \boldsymbol{T\beta_t} + \boldsymbol{\varepsilon_i}$$

where

$$\varepsilon_i \sim N(0, \sigma^2)$$
$$\sigma \sim student(3,1,10)$$
$$\beta_0 \sim N(0,100)$$
$$\beta_t \sim N(0,10)$$

where C_i is the catch (tonnes) for record *i* and E_i is the effort (number of pot lifts) for record *i*. There are two time periods (*t*) each fishing year. The periods are referred to as spring-summer (SS) and autumn-winter (AW) when two (seasonal) time periods are specified. For $\boldsymbol{t}$ = (1, 2, 3, …, n), then $\boldsymbol{t}$ = (AW, SS, AW, …, SS), where SS = October to March.

The status quo model is similar to the model used in previous CPUE analyses for New Zealand rock lobster fisheries (Starr 2019) and included population-level effects for time period (*t*), and group-level effects for month (*m*), statistical area (*a*), and vessel (*v*):

Eq. 4 $$\log\left(\frac{C_i}{E_i}\right) = \mathrm{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon_i} = \boldsymbol{\beta_0} + \boldsymbol{T\beta_t} + \boldsymbol{M\beta_m} + \boldsymbol{A\beta_a} + \boldsymbol{V\beta_v} + \boldsymbol{\varepsilon_i}$$

where

$$\varepsilon_i \sim N(0, \sigma^2)$$
$$\sigma \sim student(3,1,10)$$
$$\beta_0 \sim N(0,100)$$
$$\beta_t \sim N(0,10)$$
$$\beta_m \sim N(0,10)$$
$$\beta_a \sim N(0,10)$$
$$\beta_v \sim N(0,10)$$

The interaction model includes population-level effects for time period (*t*), and group-level effects for month (*m*), and vessel (*v*), and a time period+statistical area interaction term (*a*):

Eq. 5 $$\log\left(\frac{C_i}{E_i}\right) = \mathrm{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon_i} = \boldsymbol{\beta_0} + \mathbf{T\beta_t} + \mathbf{AT\beta_{a,t}} + \mathbf{M\beta_m} + \mathbf{V\beta_v} + \boldsymbol{\varepsilon_i}$$

where

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

4.1.2 CRA 3 CELR seasonal standardised series

Pareto-smoothed-importance-sampling, leave-one-out cross-validation (PSIS-LOO) was used for model checking and model comparison (Vehtari et al. 2017). This method compares a matrix of log-likelihood values for each data point for each MCMC sample between models. The calculated leave-one-out information criterion (LOOIC) indicates the best-fit (lowest LOOIC value) for the interaction model at 902 compared with 2236 for the status quo model and 4396 for the null model (Table 15). PSIS-LOO diagnostics (for model checking) also indicate reliability of the PSIS-LOO analysis with tail shape (Pareto shape parameter *k*) estimates for each point's contribution to the model comparison below the preferred threshold of $k < 0.7$, with the majority of estimates at $k < 0.5$, which is considered ideal (Figure 10).

Trace plots of the MCMC marginal posterior samples from the interaction model appear well-mixed with no indication of lack of convergence (Figure 11). Vessel coefficients (Figure 12) show a wide range of values and many vessels with non-overlapping posterior distributions. The AW month coefficients in May and June are very different to the other coefficients (Figure 13).

There is a gradual but variable overall increasing trend from the mid-1990s in both the AW and SS series (Table 16, Figure 15). Catch rates are generally higher in the SS series compared with those in the AW, an observation made in all CRA QMAs because ovigerous females cannot be taken legally during the AW months.

4.2 Historical catch rate (CR) data

Although catch data from 1963 to 1973 from the Annala & King (1983) data set were allocated to rock lobster statistical areas using the procedure described above in Section 3.1.2, it would be incorrect to apply the same procedure to the effort (days) data. That is because following this procedure will result in exactly the same CPUE series as was estimated for the entire Annala & King area. Consequently, the unstandardised catch per day for each calendar year from 1963 to 1973 for the two defined stocks are derived from the original Annala & King areas, rather than applying specifically to the defined CRA 3 regions (Table 17). When these series are plotted after being normalised to the same geometric mean, it can be seen that the CRA 3 series in CRACE is the same as the Area 5 series (Figure 16). The Area 6 series plotted in Figure 16 was rejected by the stock assessment team because the catches come from both Statistical Areas 911 (CRA 3) and 912 (CRA 4) in nearly equal quantities (see Table 7), so it would not correctly represent region 911.

5. LENGTH FREQUENCY DISTRIBUTIONS (LFs)

CRA 3 biological sampling data were extracted in August/September 2019, comprising both observer and voluntary logbook catch sampling from the 1977–78 to the 2018–19 fishing years. The pre-1980 length measurements used carapace length (CL), which was converted to tail width (TW) using a published relationship for CRA 3 (Breen & Kendrick 1995)[1]. Each data record used for input to the model represented a weighted sum of the length measurements for a season and sampling source for each year of sampling. The 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. Initial participation in the voluntary logbook programme was reasonable from 1993 to 1996 in the 909+910 region (Table 18) and the 911 region (Table 19). After 1996, participation in the logbook programme declined until 2011 in the 909+910 region (Table 18) and did not resume in the 911 region until 2014 (Table 19). However, the primary method for biological sampling in both regions has been the observer catch sampling, which was initiated in the late 1980s (Table 18 and Table 19). This programme places dedicated observers on vessels, assigned according to availability and distributed on the basis of the previous year fishery catches. Observer sampling in region 909+910 has averaged 20 sampling days/year from 1986 (range: 10 to 38 days), and in region 911 has averaged 10 sampling days/year from 1993 (range: 4 to 18 days). This latter sampling procedure measures and sexes all lobsters from as many pots as is feasible during a day's fishing for the vessel being observed.

Record fields from both programmes include the following information:

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

[1] $TW = a + bCL$

where

$a = 5.72; b = 0.47058$ (males)

$a = -4.24; b = 0.67554$ (females)

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

Eq. 6 $$p_{g,m,a,s} = \frac{N_{g,m,a,s}}{\sum_s N_{g,m,a,s}}$$

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

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

Eq. 7 $$P_{g,s} = \frac{\sum_m \sum_a (C_{m,a} p_{g,m,a,s})}{\sum_m \sum_a \sum_s (C_{m,a} p_{g,m,a,s})}$$

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

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

Eq. 8 $$w_s = \sum_m \sum_a \frac{C_{m,a} \sqrt[3]{N_{m,a,s}} \sqrt[3]{D_{m,a}}}{\sum_m \sum_a C_{m,a}}$$

This approach of applying the relative weight by sex represented a change from past stock assessments which used a single weight for the total record, after applying a truncation rule to the weights so that single records did not have exceptional influence (see Starr et al. 2014, for instance). This former rule truncated weights to a maximum value of 10, while raising weights less than 1.0 to 1.0. Because of the change to using weights by sex category, the stock assessment team decided to use the length frequency records without applying the truncation rule. Applying relative weights by sex in this way is more practical if there are few (or no) immature female individuals measured but there are male and mature female records. Using the previous methodology, these records would have received the same weight (across all three sex categories) and the size class with few or no measured individuals would have been inappropriately up-weighted, given the small amount of data.

The region 909+910 LF data comprised 78 records from 1986 to 2018, with 19 being logbook samples and the remaining 59 being observer samples (with separate records for each season). The logbook records ranged from 477 to 6199 lobsters measured across both seasons whereas the observer samples ranged from 191 to 22 399 lobsters measured, across both seasons (Table 20). None of the logbook or observer samples were dropped. The logbook sampling relative weights by sex (Eq. 8) ranged from 0.000001 to 58.1 for the accepted samples whereas the observer catch sampling record weights ranged from 0.000001 to 30.0 (Table 21). All the very low weights corresponded to samples with few observed immature females or to mature females in the AW, giving an appropriate low weight to these poorly represented sex categories.

The region 911 LF data comprised 73 records from 1986 to 2018, with 27 being logbook samples and the remaining 46 being observer samples (with separate records for each season). Four logbook samples were dropped because fewer than 100 lobsters were measured. Three additional logbook samples (1999 AW, 2000 AW, and 2001 AW) were also dropped for unknown reasons, leaving a total of 20 logbook samples and a total 66 records for use in the stock assessment model. The logbook records ranged from 159 to 3023 lobsters measured across both seasons whereas the observer samples ranged from 292 to 5113 lobsters measured, across both seasons (Table 22). The logbook sampling

relative weights by sex (Eq. 8) ranged from 0.000001 to 9.8 for the accepted samples and the observer catch sampling record weights ranged from 0.000001 to 9.7 (Table 23). Again, all the very low weights corresponded to samples with few observed immature females or to mature females in the AW, giving an appropriate low weight to these poorly represented sex categories.

Sex proportions were calculated from normalised data records for both CRA 3 regions, with estimates that appear reasonable (Table 24). There were very few immature females (AW means equal 0.003 and 0.005 in region 909+910 and region 911, respectively, and SS means equal 0.013 and 0.010 in region 909+910 and region 911, respectively). This is because females in this QMA usually reach maturity well below the MLS of 60 mm TW. The sex ratios of males and mature females showed little systematic pattern over time in either the logbook data or the catch sampling data (Figure 17, Figure 18), with the sex proportions estimated by both sampling programmes showing the same general trends.

Mean tail width was also calculated from the data records, with absolute mean tail width being much smaller in region 909+910 than in region 911 for all three sex categories (Table 25). There was no trend in male or mature female mean length in either the AW or SS for either sampling programme, with both sampling programmes providing very similar estimates (Figure 19, Figure 20).

Although the model contains size bins in the range 30–90+ mm TW, few fish as small as 30 mm were measured and very few large fish were measured, especially for immature females, leading to many cells with zero observations (Figure 21). For sex/size bins with few observations, the model would be comparing many zero observations with zero or very small predictions, resulting in a large number of very small residuals that would distort the diagnostics and waste computing time. Bins at both ends of the range for each sex were therefore combined into accumulator "plus" and "minus" bins. Table 26 shows the number of year, season, sampling category records for each 2 mm TW bin by sex category. This table also shows the number of these records where the year, season, sampling category proportion within a sex category is less than 0.001 (an arbitrary threshold) and the calculated proportion of records is greater than 0.001 in the bin (Table 26). This information is useful to select appropriate accumulator bins for each sex category. Past experience has shown that model results were not very sensitive to the chosen threshold value.

The distributions of the LF data by sex are shown for each data record included in the stock assessment by CRA 3 region (Appendix F, CRA 3 region 909+910; Appendix G, CRA 3 region 911), 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). Length frequency distributions by year are shown for AW logbook sampling (region 909+910, Figure F.1; region 911, Figure G.1), SS logbook sampling (region 909+910, Figure F.2; region 911, Figure G.2), AW observer catch sampling (region 909+910, Figure F.3; region 911, Figure G.3), and SS observer catch sampling (region 909+910, Figure F.4; region 911, Figure G.4).

6. TAG DATA

This section describes tag-recapture data that are used to inform growth in the stock assessment of rock lobster stocks (Haist et al. 2009). These data will also be useful for informing decisions about stock structure and movement. Tag data for all CRA areas were extracted in August 2019.

6.1 Data processing

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

The tag processing software implements the following rules:

- remove duplicate records
- remove records with no date
- remove records that are missing both tail width and carapace length
- remove releases with no corresponding recapture
- iteratively match captures with recaptures
- if sex is missing at capture but not recapture, then infer sex and vice versa
- remove matched records that change sex
- remove matched records that do not have a sex code of 1 or 2
- if Statistical Area is not 901 to 943 then set to NA
- 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 is 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
- 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)
- if there is no recorded tail width, then calculate this from the carapace length using the relationships given by Breen et al. (1988)
- remove records where tail width is less than 20 mm
- remove records where tail width is greater than 150 mm
- calculate the time at liberty in days
- remove those records that are at liberty for less than 1 day
- remove those records that are at liberty for greater than 10 years
- calculate the growth increment as the difference in tail widths
- remove records with a growth increment less than -40 mm or greater than 40 mm

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

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

6.2 Tag data summaries: all QMAs

6.2.1 Comparison with previous extract

A comparison is done to ensure that new data extracts are not missing records that were available in previous years and to see how many new data records are available (Table 27 and Table 28). There was an increase in the number of release-recovery pairs in CRA 3 (in anticipation of this CRA 3 stock assessment) and increases in CRA 1, CRA 4, and CRA 5 (Table 27). As would be expected, almost all the increases in tag recaptures occurred during the years 2015 to 2018 (Table 28).

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 5 (0.208) and the lowest rate in CRA 9 (0.020) (Table 29). There are a total of 34 691 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 30). The CRA QMA with the majority of recovered tags has been CRA 8, whereas the fewest recaptured tags have come from CRA 6 and CRA 9 (Table 30).

Tagged lobsters are generally recaptured in the QMA or statistical area of release, but there are a number of cases where it appears that tagged individuals have moved much greater distances (Table 31). 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 31) may be due to data errors, which should be investigated in the future.

6.2.3 Summary for QMAs: growth patterns

The observed growth increment in tail width (mm) at release was generally greater in smaller individuals, but this relationship is very messy (Figure 22 and Figure 23). Growth rates differ among QMAs, with CRA 6 and CRA 9 showing fewer smaller individuals compared to most of the other QMAs (Figure 23). The relationship between observed growth increment (mm) and time at liberty (years) appears to be less variable (Figure 24 and Figure 25). This observation holds true for all QMAs with an adequate amount of data (Figure 25).

6.3 Tag data summaries by CRA 3 sub-stock

Tags have been assigned to a CRA 3 region on the basis of the statistical area of release, regardless of where the tag was recovered. This definition excludes all CRA 3 tags which lack a valid release statistical area.

The screened data extract for CRA 3 comprised 4209 records for region 909+910 (3483 males and 907 females) and 1258 records for region 911 (567 males and 137 females) (Table 32). If we confine the data to tags which had been at liberty for at least 365 days (see Appendix 1 of Webber et al. 2020 for a discussion of the reasons for this option), the number of tag recoveries drops considerably: to 704 and 385 recoveries for both sexes in region 909+910 and region 911, respectively (Table 32). The distributions of sizes at release and recapture by sex are shown in Figure 26, with most of the males being tagged just below the 54 mm TW and the females showing a broader distribution of tagged individuals.

Over 60% of the tag recoveries in region 909+910 were from releases made before 1985 (Table 32). The equivalent statistic for the region 911 is 66%. The prevalence of recoveries occurring before the mid-1980s is repeated for the recapture years (Table 33). These high rates of recovered tags from this period reflect the strong early research emphasis on the Gisborne lobster population. Table 32 and Table 33 show that there have been very few female tag recoveries after 2000, which means it would be difficult to estimate changes in female growth over time. All the pre-1985 releases used western rock lobster tags, with size recorded in carapace length, and all the post-1996 releases used Hallprint tags, with size recorded in tail width.

Statistical Area 910 was the most prevalent statistical area of release and recovery, followed by Statistical Area 911 and Statistical Area 909, with very few of the recaptures taking place in a statistical area other than the statistical area of release (Table 34). There are some indications of large movement to CRA 8 (Stewart Island, Statistical Area 924), but these recoveries are likely to be data errors.

6.3.1 CRA 3: times at liberty

Times at liberty in the CRA 3 tag data set varied from 1 day to 2053 days (5.6 years) for males and from 1 day to 3099 days (8.5 years) for females in region 909+910 (Table 35). The equivalent

statistics for region 911 are 1 to 1285 days (3.5 years) for males and 1 to 1831 days (5.0 years) for females. The medians were 184 days for males and 193 days for females in region 909+910 and 177 days for males and 196 days for females in region 911 (Table 35). The percentages of recaptures at liberty for less than one year in the 909+910 region are 84% and 83% for males and females, respectively. Recaptures are at liberty a bit longer in region 911, with 76% (males) and 61% (females) at liberty for less than one year. The number of times an individual is re-released is also monitored with one male re-released 8 times in region 909+910 (Table 36). Re-releases were not important in CRA 3, with 84% of males and 91% of females not re-released in region 909+910. The equivalent statistics for region 911 are 90% (males) and 92% (females) stopping at the first recapture. Condition codes were nearly all zero or missing.

6.3.2 CRA 3: growth increments

Growth increments ranged from -18.5 to 20.4 mm (males) and -27.4 to 29.0 mm (females) for region 909+910 (Table 37) and from -20.0 to 22.5 mm (males) and -11.9 to 17.0 mm (females) for region 911 (Table 37). As with the overall QMA summaries, the observed growth increment (mm) in CRA 3 by tail width (mm) at release is generally greater in smaller individuals, even when viewed by statistical area (Figure 27). Similarly, the relationship between observed growth increment (mm) and time at liberty (years) is somewhat tighter, even when viewed by statistical area (Figure 28).

6.3.3 CRA 3: tag recoveries from the Te Tapuwae o Rongokako marine reserve

Tagging was done between 2003 and 2011 by the Department of Conservation to monitor movements of rock lobster in and out of the Te Tapuwae o Rongokako marine reserve located approximately 15 km north of Gisborne within Statistical Area 910 (Freeman 2008). Tag recaptures from this tagging project were provided for the CRA 3 stock assessment, with all recaptures assigned to region 909+910. Releases which were subsequently recaptured were made from 2003 to 2011 (Table 38), with the recapture period ranging from 2004 to 2012 (only one recapture was made in 2003) (Table 38). Nearly ten times the number of males were recovered compared with females over the course of this experiment (Table 39). The actual release numbers by sex were not made available. Times at liberty ranged from 33 to 2840 days (7.8 years) for males and from 78 to 1264 days (3.5 years) for females (Table 39). Growth increments ranged from -7.7 mm to 15.5 mm for males (median=0 mm) for males and -2.9 mm to 2.0 mm (median=0 mm) for females (Table 39). A plot of the distribution of tail widths for recaptured lobsters shows a broad distribution spanning 50 mm to 70 mm for both males and females (Figure 29).

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Table 1: Information used to estimate recreational catch for CRA 3.

Survey	Numbers	Mean weight (kg)	Catch weight (t)	Assumed CV
1994 (Otago: Bradford 1997)	8 000	0.534[1]	4.27	1.5*(0.33+0.26)/2
1996 (Otago: Bradford 1998)	27 000	0.534[1]	14.42	1.5*(0.33+0.26)/2
2000 (Boyd & Reilly 2002)	270 000[2]	–	146.61	not used
2001 (Boyd et al. 2004)	215 000[2]	–	116.75	not used
2011 (NPS: Wynne-Jones 2014)	13 912[3]	0.58	8.07	0.33
2017 (NPS: Wynne-Jones 2019)	22 515[4]	0.54	12.21	0.26
Section 111 reported landings				
Maximum reported landings (t) (in 2016–17)			3.047	

[1] SS mean weight (kg) calculated from commercial sampling data from 1994 to 1996 assuming recreational minimum legal sizes (Starr et al. 2015)
[2] as reported by Boyd & Reilly (2002) and Boyd et al. (2004)
[3] estimate provided by Wynne-Jones et al. (2014)
[4] estimate provided by Wynne-Jones et al. (2019)

Table 2: Fishing platform and capture method categories for CRA 3 during 2011–12 estimated by the national NPS recreational survey (Wynne-Jones et al. 2014). The final line shows the 2011–12 CRA 3 total estimates. CV=standard error of the estimate, which does not include error associated with the estimate of mean weight.

Category	Numbers	CV	Catch (t)[1]	CV	% of Total Catch Weight
Platform (Appendix table 27.1 of Wynne-Jones et al. 2014)					
Trailer motor boat	27 070	0.43	21.21	0.39	77
Larger motor boat or launch	315	0.69	0.28	0.70	1
Trailer yacht	0		0.00		0
Larger yacht or keeler	0		0.00		0
Kayak canoe or rowboat	0		0.00		0
Off land including beach rocks or jetty	6 468	0.80	6.04	0.80	22
Something else	0		0.00		0
Capture method (Appendix table 27.2 of Wynne-Jones et al. 2014)					
Rod or line (not long line)	0		0.00		0
Long-line including set line kontiki or kite	0		0.00		0
Net (not including landing net used if caught by line)	0		0.00		0
Pot (e.g., for crayfish)	17 193	0.39	12.01	0.39	44
Dredge grapple or rake	0		0.00		0
Hand gather or floundering from shore	397	0.76	0.37	0.76	1
Hand gather by diving	16 263	0.72	15.15	0.72	55
Spearfishing	0		0.00		0
Some other method	0		0.00		0
Total	33 854	0.26	27.53	0.26	100

[1] uses mean weight estimate of 580 grams (Hartill & Davey 2015)

Table 3: Available estimates of illegal catches (tonnes) by CRA QMA from 1990, as provided by MPI Compliance Services over a number of years. R (reported): illegal catch that will eventually be processed though the legal catch/effort system; NR (not reported): illegal catch outside of the catch/effort system. Cells without data or missing rows have been deliberately left blank or filled with dashes. Years without any compliance estimates in any QMA have been suppressed in this table.

Fishing	CRA 1		CRA 2		CRA 3		CRA 4		CRA 5		CRA 6		CRA 7		CRA 8		CRA 9	
Year	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR
1990	–	38	–	70	–	288.3	–	160.1	–	178	–	85	34	9.6	25	5	–	12.8
1992	–	11	–	37	–	250	–	30	–	180	–	70	34	5	60	5	–	31
1994	–	15	–	70	5	37	–	70	–	70	–	70	–	25	–	65	–	18
1995	–	15	–	60	0	63	–	64	–	70	–	70	–	15	–	45	–	12
1996	0	72	5	83	20	71	0	75	0	37	70	–	15	5	30	28	0	12
1997	–	–	–	–	4	60	–	–	–	–	–	–	–	–	–	–	–	–
1998	–	–	–	–	4	86.5	–	–	–	–	–	–	–	–	–	–	–	–
1999	–	–	–	–	0	136	–	–	–	–	–	–	–	23.5	–	54.5	–	–
2000	–	–	–	–	3	75	–	64	–	40	–	–	–	–	–	–	–	–
2001	–	72	–	88[1]	0	75	–	–	–	–	–	10	–	–	–	–	–	1
2002	–	–	–	–	0	75	9	51	5	47	–	–	–	1	–	18	–	–
2003	–	–	–	–	0	89.5	–	–	–	–	–	–	–	–	–	–	–	–
2004	–	–	–	–	–	–	10	30	–	–	–	–	–	–	–	–	–	–
2011	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	3	–	–
2014	–	–	–	–	–	–	–	–	–	30	–	–	–	–	–	–	–	–
2015	–	–	–	–	–	–	–	40	–	–	–	–	–	–	–	–	–	–
2016	–	–	–	40[2]	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2018	–	40	–	–	–	50	–	–	–	–	–	–	–	–	–	–	–	–

[1] this value discarded by RLFAWG agreement; [2] this value is not an estimate: it is assumed by agreement by the RLFAWG.

Table 4: Estimated CRA 3 catches (commercial, recreational including section 111, illegal, and customary) by season. Note that the model does not use two seasons until 1979. Annual estimates are provided in the AW column before 1979. (Continued on next page)

	Commercial		Recreational		Illegal		Customary		Total	
Year	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS
1945	43.1	–	4.0	–	6.9	–	20	–	74.0	–
1946	38.8	–	4.1	–	6.2	–	20	–	69.1	–
1947	55.1	–	4.2	–	8.9	–	20	–	88.1	–
1948	57.0	–	4.3	–	9.2	–	20	–	90.4	–
1949	32.1	–	4.4	–	5.2	–	20	–	61.6	–
1950	41.5	–	4.5	–	6.7	–	20	–	72.7	–
1951	54.3	–	4.6	–	8.7	–	20	–	87.7	–
1952	36.5	–	4.7	–	5.9	–	20	–	67.1	–
1953	35.2	–	4.8	–	5.7	–	20	–	65.7	–
1954	20.8	–	5.0	–	3.4	–	20	–	49.1	–
1955	15.8	–	5.1	–	2.5	–	20	–	43.4	–
1956	13.4	–	5.2	–	2.2	–	20	–	40.7	–
1957	22.5	–	5.3	–	3.6	–	20	–	51.4	–
1958	27.1	–	5.4	–	4.4	–	20	–	56.8	–
1959	29.1	–	5.5	–	4.7	–	20	–	59.3	–
1960	34.8	–	5.6	–	5.6	–	20	–	66.0	–
1961	57.2	–	5.7	–	9.2	–	20	–	92.1	–
1962	64.0	–	5.8	–	10.3	–	20	–	100.1	–
1963	117.1	–	5.9	–	18.8	–	20	–	161.8	–
1964	212.2	–	6.1	–	34.1	–	20	–	272.4	–
1965	186.7	–	6.2	–	30.0	–	20	–	242.9	–
1966	236.8	–	6.3	–	38.1	–	20	–	301.2	–
1967	349.4	–	6.4	–	56.2	–	20	–	432.0	–
1968	363.0	–	6.5	–	58.4	–	20	–	448.0	–
1969	260.8	–	6.6	–	42.0	–	20	–	329.4	–
1970	206.1	–	6.7	–	33.2	–	20	–	266.0	–
1971	146.9	–	6.8	–	23.6	–	20	–	197.3	–
1972	131.7	–	6.9	–	21.2	–	20	–	179.9	–
1973	103.0	–	7.0	–	16.6	–	20	–	146.6	–
1974	183.0	–	7.1	–	23.4	–	20	–	233.6	–
1975	162.0	–	7.3	–	39.2	–	20	–	228.5	–
1976	198.0	–	7.4	–	38.5	–	20	–	263.8	–
1977	220.0	–	7.5	–	56.5	–	20	–	304.0	–
1978	305.4	–	7.6	–	78.3	–	20	–	411.3	–
1979	106.2	374.0	0.8	6.9	9.2	32.5	2	18	118.2	431.4
1980	155.6	450.8	0.8	7.2	17.7	51.4	2	18	176.1	527.4
1981	153.9	420.2	0.8	7.3	24.8	67.6	2	18	181.4	513.1
1982	184.8	549.1	0.8	7.4	29.7	88.4	2	18	217.4	662.9
1983	246.9	516.8	0.8	7.1	39.7	83.2	2	18	289.4	625.1
1984	194.6	514.3	0.7	6.4	31.3	82.8	2	18	228.6	621.5
1985	152.7	501.4	0.7	6.4	24.6	80.7	2	18	180.0	606.5
1986	100.6	469.4	0.7	6.0	16.2	75.5	2	18	119.5	568.8
1987	85.2	270.2	0.5	4.9	13.7	43.5	2	18	101.5	336.6
1988	54.1	227.7	0.6	5.1	8.7	36.6	2	18	65.3	287.4
1989	81.0	304.9	0.6	5.4	13.0	49.1	2	18	96.6	377.3
1990	78.3	232.9	0.6	5.1	72.5	215.7	2	18	153.4	471.8
1991	60.5	196.3	0.5	4.4	63.4	205.7	2	18	126.3	424.4
1992	39.1	141.2	0.5	4.2	54.2	195.8	2	18	95.8	359.2
1993	116.1	56.8	0.8	7.1	98.0	48.0	2	18	216.9	129.9
1994	144.5	14.3	1.1	9.7	38.2	3.8	2	18	185.7	45.8
1995	147.7	6.3	1.6	14.3	60.4	2.6	2	18	211.7	41.2
1996	197.0	2.5	1.9	16.7	89.9	1.1	2	18	290.7	38.4
1997	219.3	1.3	1.4	12.3	63.6	0.4	2	18	286.3	31.9
1998	288.6	33.0	2.0	17.6	81.2	9.3	2	18	373.8	77.9
1999	281.5	38.4	1.5	13.5	119.7	16.3	2	18	404.7	86.2
2000	255.8	68.8	1.2	10.7	61.5	16.5	2	18	320.5	114.1
2001	180.1	106.4	1.0	8.8	47.1	27.9	2	18	230.2	161.1
2002	162.1	125.8	0.7	6.2	42.2	32.8	2	18	207.0	182.7
2003	118.4	93.5	0.6	5.4	50.0	39.5	2	18	171.0	156.4
2004	84.8	73.3	0.6	5.1	46.6	40.3	2	18	134.0	136.7
2005	89.2	77.2	0.6	5.5	45.1	39.1	2	18	136.9	139.8
2006	85.9	89.1	0.6	5.5	40.1	41.5	2	18	128.6	154.2
2007	89.3	79.6	0.6	5.6	41.8	37.2	2	18	133.7	140.4
2008	110.4	76.0	0.7	6.2	45.2	31.1	2	18	158.3	131.3
2009	104.6	56.2	0.8	7.1	47.9	25.8	2	18	155.3	107.0
2010	134.6	25.9	1.0	9.3	59.6	11.5	2	18	197.2	64.7
2011	145.9	15.0	1.3	11.5	62.1	6.4	2	18	211.2	50.8
2012	143.9	49.4	1.5	13.9	49.0	16.8	2	18	196.4	98.1
2013	176.2	49.2	1.5	13.8	49.4	13.8	2	18	229.2	94.8
2014	175.2	85.3	1.4	12.4	40.7	19.8	2	18	219.3	135.4
2015	193.5	67.4	1.3	11.7	42.9	15.0	2	18	239.7	112.0

	Commercial		Recreational		Illegal		Customary		Total	
Year	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS
2016	185.8	75.1	1.3	11.8	39.4	15.9	2	18	228.5	120.8
2017	167.3	70.4	1.2	10.4	37.0	15.6	2	18	207.5	114.5
2018	168.7	87.5	1.1	9.6	32.9	17.1	2	18	204.7	132.2

Table 5: Data availability by time period for CRA 3 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 3 (QMA) data availability	CRA 3 (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
2001–2015	MHR estimates	CELR (=FSU) area definitions

Table 6: Selected mapping of Annala & King (1983) statistical areas into the NZ rock lobster statistical areas. CRA 3 statistical areas are marked with *.

Rock lobster	Annala/King statistical area	
statistical area	Area 5	Area 6
909*	x	
910*	x	
911*		x
912		x

Table 7: Percent distribution between adjacent rock lobster statistical areas in the Annala & King (1983) area groupings identified in Table 6.

Fishing	Area 5		Area 6	
year	909	910	911	912
1979	0.189	0.811	0.607	0.393
1980	0.264	0.736	0.546	0.454
1981	0.284	0.716	0.460	0.540
1982	0.245	0.755	0.511	0.489
1983	0.181	0.819	0.592	0.408
Mean	0.233	0.767	0.543	0.457

Table 8: Proportions by CRA 3 sub-stock as calculated in Step 4 (above). The final two columns are the sums of annual catch defined in Steps 4 and 5 of Section 3.1.2.

Calendar	Stock/statistical area		$\sum_{a=1}^{3} k_y^a$	C_y^{CRA3}
year	909+910	911		
1963	0.629	0.371	410.1	117.1
1964	0.675	0.325	692.9	212.2
1965	0.563	0.437	731.0	186.7
1966	0.667	0.333	782.5	236.8
1967	0.792	0.208	972.2	349.4
1968	0.801	0.199	999.3	363.0
1969	0.645	0.355	891.4	260.8
1970	0.667	0.333	681.6	206.1
1971	0.701	0.299	461.7	146.9
1972	0.663	0.337	437.8	131.7
1973	0.616	0.384	368.5	103.0
Mean	0.675	0.325	–	–

Table 9: Interpolated proportions by CRA 3 sub-stock as described in Step 6 of Section 3.1.2.

Calendar year	Stock/statistical area 909+910	911
1973	0.616	0.384
1974	0.622	0.378
1975	0.628	0.372
1976	0.635	0.365
1977	0.641	0.359
1978	0.647	0.353

Table 10: Back calculated (based on mean distribution from 1963 to 1967) proportions by CRA 3 sub-stock as described in Step 7 of Section 3.1.2.

Calendar year range	Stock/statistical area 909+910	911
1945–1962	0.665	0.335

Table 11: Estimated catches (t) (commercial, recreational including section 111, illegal, and customary) for the Area 909+910 CRA 3 sub-stock, provided annually before 1979 (January-March 1979 added to 1978) and seasonally (AW and SS) from 1979 to 2018.

Calendar year	Comm-ercial Annual	Recrea-tional Annual	Cus-tomary Annual	Illegal Annual	Fishing year	Commercial AW	Commercial SS	Recreational AW	Recreational SS	Customary AW	Customary SS	Illegal AW	Illegal SS
1945	28.8	2.7	13.3	4.6	1979	70.6	243.2	0.5	4.5	1.3	11.8	6.1	21.1
1946	25.9	2.7	13.3	4.2	1980	101.7	267.5	0.5	4.4	1.2	11.0	11.6	30.5
1947	36.7	2.8	13.3	5.9	1981	98.9	285.0	0.6	4.9	1.4	12.2	10.6	30.5
1948	38.0	2.9	13.3	6.1	1982	127.0	373.5	0.6	5.1	1.4	12.4	10.6	31.2
1949	21.4	2.9	13.3	3.4	1983	159.4	330.5	0.5	4.6	1.3	11.6	12.8	26.6
1950	27.7	3.0	13.3	4.5	1984	112.2	298.2	0.4	3.7	1.2	10.5	9.7	25.8
1951	36.2	3.1	13.3	5.8	1985	84.3	286.6	0.4	3.7	1.1	10.3	7.9	26.9
1952	24.4	3.2	13.3	3.9	1986	65.5	297.4	0.4	3.8	1.3	11.6	7.1	32.1
1953	23.4	3.2	13.3	3.8	1987	60.2	175.8	0.4	3.3	1.4	12.1	10.5	30.6
1954	13.9	3.3	13.3	2.2	1988	30.5	126.8	0.3	2.9	1.1	10.3	6.7	28.0
1955	10.5	3.4	13.3	1.7	1989	51.8	195.5	0.4	3.5	1.3	11.7	8.3	31.3
1956	8.9	3.5	13.3	1.4	1990	48.5	141.4	0.3	3.0	1.2	10.7	9.3	27.0
1957	15.0	3.5	13.3	2.4	1991	36.1	102.7	0.3	2.3	1.1	9.5	8.4	23.8
1958	18.1	3.6	13.3	2.9	1992	20.4	76.5	0.3	2.2	1.0	9.4	6.7	25.0
1959	19.4	3.7	13.3	3.1	1993	72.8	37.1	0.5	4.5	1.3	11.4	25.5	13.0
1960	23.2	3.7	13.3	3.7	1994	95.8	4.4	0.7	6.2	1.3	11.6	37.6	1.7
1961	38.1	3.8	13.3	6.1	1995	101.4	0.5	1.1	9.6	1.4	12.1	40.8	0.2
1962	42.7	3.9	13.3	6.9	1996	141.5	0.4	1.3	12.0	1.4	12.9	43.5	0.1
1963	73.9	3.8	12.6	11.9	1997	156.2	0.5	1.0	8.8	1.4	12.9	43.7	0.1
1964	143.5	4.1	13.5	23.1	1998	215.8	28.5	1.5	13.4	1.5	13.7	41.0	5.4
1965	105.4	3.5	11.3	17.0	1999	195.8	30.4	1.1	9.5	1.4	12.7	37.2	5.8
1966	158.3	4.2	13.4	25.5	2000	147.9	45.3	0.7	6.4	1.2	10.8	27.9	8.5
1967	277.3	5.1	15.9	44.6	2001	99.2	42.5	0.5	4.4	1.0	9.0	21.2	9.1
1968	291.2	5.2	16.0	46.9	2002	96.3	42.3	0.3	3.0	1.0	8.7	20.5	9.0
1969	168.7	4.3	12.9	27.1	2003	74.2	29.0	0.3	2.7	1.0	8.8	21.5	8.4
1970	137.8	4.5	13.4	22.2	2004	64.3	23.6	0.3	2.9	1.1	10.1	25.0	9.2
1971	103.2	4.8	14.1	16.6	2005	63.8	28.1	0.3	3.1	1.1	10.1	23.6	10.4
1972	87.6	4.6	13.3	14.1	2006	61.0	35.8	0.3	3.1	1.1	10.1	21.4	12.6
1973	63.6	4.3	12.4	10.2	2007	67.4	35.9	0.4	3.5	1.2	11.1	24.6	13.1
1974	114.1	4.5	12.5	14.6	2008	84.2	34.8	0.4	4.0	1.3	11.6	27.8	11.5
1975	102.0	4.6	12.6	24.7	2009	78.6	22.8	0.5	4.5	1.3	11.5	30.2	8.8
1976	125.8	4.7	12.7	24.4	2010	90.9	11.6	0.7	6.0	1.3	11.7	35.0	4.5
1977	141.1	4.8	12.8	36.2	2011	105.0	6.8	0.9	8.1	1.4	12.7	40.4	2.6
1978	197.7	4.9	13.0	50.7	2012	106.2	26.4	1.1	9.5	1.4	12.3	33.5	8.3
					2013	122.9	34.0	1.1	9.6	1.4	12.5	33.2	9.2
					2014	122.9	45.7	0.9	8.0	1.3	11.7	28.8	10.7
					2015	132.5	37.7	0.8	7.6	1.3	11.7	30.9	8.8
					2016	112.3	46.8	0.8	7.2	1.2	11.0	26.2	10.9
					2017	100.6	48.7	0.7	6.6	1.3	11.3	25.8	12.5
					2018	104.9	40.1	0.6	5.5	1.1	10.2	24.9	9.5

Table 12: Estimated catches (t) (commercial, recreational including section 111, illegal, and customary) for the Area 911 CRA 3 sub-stock, provided annually before 1979 (January–March 1979 added to 1978) and seasonally (AW and SS) from 1979 to 2018.

Calendar year	Comm-ercial Annual	Recrea-tional Annual	Cus-tomary Annual	Illegal Annual	Fishing year	Commercial		Recreational		Customary		Illegal	
						AW	SS	AW	SS	AW	SS	AW	SS
1945	14.4	1.3	6.7	2.3	1979	35.6	130.9	0.3	2.4	0.7	6.2	3.1	11.4
1946	12.9	1.4	6.7	2.1	1980	53.9	183.3	0.3	2.8	0.8	7.0	6.2	20.9
1947	18.4	1.4	6.7	3.0	1981	53.5	131.2	0.3	2.4	0.7	5.9	5.7	14.1
1948	19.0	1.4	6.7	3.1	1982	56.5	171.5	0.3	2.3	0.6	5.6	4.7	14.3
1949	10.7	1.5	6.7	1.7	1983	85.7	182.7	0.3	2.5	0.7	6.4	6.9	14.7
1950	13.8	1.5	6.7	2.2	1984	80.9	212.2	0.3	2.7	0.8	7.5	7.0	18.4
1951	18.1	1.5	6.7	2.9	1985	69.0	208.8	0.3	2.8	0.9	7.7	6.5	19.6
1952	12.2	1.6	6.7	2.0	1986	37.1	164.4	0.2	2.1	0.7	6.4	4.0	17.7
1953	11.7	1.6	6.7	1.9	1987	24.6	89.4	0.2	1.6	0.7	5.9	4.3	15.6
1954	6.9	1.7	6.7	1.1	1988	26.6	92.4	0.2	2.2	0.9	7.8	5.9	20.4
1955	5.3	1.7	6.7	0.9	1989	20.7	112.5	0.2	1.9	0.7	6.3	3.3	18.0
1956	4.5	1.7	6.7	0.7	1990	28.4	100.4	0.2	2.1	0.8	7.3	5.4	19.2
1957	7.5	1.8	6.7	1.2	1991	26.7	97.9	0.2	2.1	1.0	8.5	6.2	22.6
1958	9.0	1.8	6.7	1.5	1992	19.8	69.3	0.2	2.0	1.0	8.6	6.5	22.7
1959	9.7	1.8	6.7	1.6	1993	42.2	22.0	0.3	2.6	0.7	6.6	14.8	7.7
1960	11.6	1.9	6.7	1.9	1994	45.7	9.4	0.4	3.4	0.7	6.4	17.9	3.7
1961	19.0	1.9	6.7	3.1	1995	43.5	6.1	0.5	4.7	0.7	5.9	17.5	2.4
1962	21.3	1.9	6.7	3.4	1996	54.6	1.6	0.5	4.7	0.6	5.1	16.8	0.5
1963	43.2	2.2	7.4	7.0	1997	60.7	0.5	0.4	3.5	0.6	5.1	17.0	0.2
1964	68.6	2.0	6.5	11.0	1998	75.3	0.7	0.5	4.2	0.5	4.3	14.3	0.1
1965	81.3	2.7	8.7	13.1	1999	84.9	9.5	0.4	4.0	0.6	5.3	16.1	1.8
1966	78.5	2.1	6.6	12.6	2000	101.9	27.6	0.5	4.3	0.8	7.2	19.2	5.2
1967	72.2	1.3	4.1	11.6	2001	79.9	62.9	0.5	4.4	1.0	9.0	17.1	13.5
1968	71.9	1.3	4.0	11.6	2002	66.5	80.7	0.4	3.2	1.0	9.3	14.2	17.2
1969	92.2	2.3	7.1	14.8	2003	44.2	63.0	0.3	2.8	1.0	9.2	12.8	18.2
1970	68.4	2.2	6.6	11.0	2004	24.1	44.6	0.3	2.2	0.9	7.9	9.4	17.4
1971	43.7	2.0	6.0	7.0	2005	24.4	48.4	0.3	2.4	0.9	8.0	9.0	17.9
1972	44.2	2.3	6.7	7.1	2006	24.1	52.4	0.3	2.4	0.9	7.9	8.5	18.4
1973	39.4	2.7	7.7	6.3	2007	21.0	42.7	0.2	2.1	0.8	6.9	7.7	15.6
1974	68.9	2.7	7.5	8.8	2008	22.0	43.4	0.2	2.2	0.7	6.4	7.3	14.3
1975	60.0	2.7	7.4	14.5	2009	21.3	35.8	0.3	2.6	0.7	6.5	8.2	13.8
1976	72.2	2.7	7.3	14.0	2010	40.3	15.5	0.4	3.3	0.7	6.3	15.5	6.0
1977	78.9	2.7	7.2	20.3	2011	37.3	9.4	0.4	3.4	0.6	5.3	14.4	3.6
1978	107.7	2.7	7.1	27.6	2012	33.7	27.0	0.5	4.4	0.6	5.7	10.6	8.5
					2013	49.2	19.4	0.5	4.2	0.6	5.5	13.3	5.2
					2014	51.1	40.7	0.5	4.4	0.7	6.3	12.0	9.5
					2015	61.5	29.3	0.5	4.1	0.7	6.3	14.4	6.8
					2016	69.7	32.1	0.5	4.6	0.8	7.0	16.3	7.5
					2017	66.6	21.9	0.4	3.9	0.7	6.7	17.1	5.6
					2018	75.5	35.8	0.5	4.2	0.9	7.8	17.9	8.5

Table 13: Number of vessel/month records in the dataset used to calculate the Area 909+910 CRA 3 sub-stock CPUE time series (based on the F2_LFX algorithm). The FSU data were processed without a vessel filter while the CELR data applied a 5-vessel filter to the data. '–': no data

Fishing							AW							SS
year	Apr	May	Jun	Jul	Aug	Sep	Total	Oct	Nov	Dec	Jan	Feb	Mar	Total
1989	–	–	–	–	13	15	28	18	22	21	20	18	16	115
1990	9	12	13	15	16	13	78	17	17	18	18	18	15	103
1991	16	11	20	19	19	15	100	21	22	22	20	17	18	120
1992	11	6	20	22	20	9	88	19	21	20	20	17	18	115
1993	13	11	21	25	24	–	94	–	–	–	–	19	12	31
1994	9	–	21	20	15	–	65	–	–	–	–	3	4	7
1995	6	–	19	19	13	–	57	–	–	–	–	–	1	1
1996	7	–	16	15	14	–	52	–	–	–	–	–	2	2
1997	6	–	16	19	13	–	54	–	–	–	–	–	1	1
1998	13	–	17	18	16	1	65	–	–	–	–	8	1	9
1999	7	–	16	17	15	–	55	–	–	–	–	9	8	17
2000	10	–	16	15	14	13	68	–	–	–	1	12	12	25
2001	11	–	17	17	17	–	62	–	–	1	1	14	15	31
2002	10	–	17	17	18	11	73	7	11	11	13	13	15	70
2003	5	–	19	19	16	6	65	6	8	7	7	9	6	43
2004	4	–	19	17	15	3	58	2	5	7	8	7	7	36
2005	1	–	18	16	15	6	56	7	11	10	8	7	8	51
2006	5	–	18	17	17	5	62	9	13	9	11	11	11	64
2007	5	–	15	16	16	4	56	9	9	8	6	8	8	48
2008	5	–	14	13	12	2	46	–	–	–	9	10	2	21
2009	–	–	13	13	15	1	42	–	–	–	11	10	–	21
2010	–	–	16	17	17	1	51	–	–	–	8	6	–	14
2011	2	–	17	17	18	2	56	–	–	–	8	–	3	11
2012	3	1	12	14	15	2	47	1	–	–	9	4	7	21
2013	13	–	8	13	12	1	47	–	–	–	9	6	11	26
2014	14	6	7	12	15	1	55	1	–	1	12	10	10	34
2015	13	10	11	14	15	1	64	–	–	1	11	12	6	30
2016	12	8	13	11	11	–	55	–	1	–	13	11	8	33
2017	10	6	12	12	11	–	51	–	–	–	14	12	10	36
2018	11	4	12	12	12	1	52	–	1	–	12	12	7	32

Table 14: Number of vessel/month records in the dataset used to calculate the CRA 3 region 911 CPUE time series (based on the F2_LFX algorithm). '–': no data

Fishing							AW							SS
year	Apr	May	Jun	Jul	Aug	Sep	Total	Oct	Nov	Dec	Jan	Feb	Mar	Total
1989	–	–	–	–	9	10	19	11	10	10	10	9	5	55
1990	3	5	7	9	9	12	45	12	12	12	12	12	8	68
1991	8	5	6	10	11	12	52	12	12	12	12	12	9	69
1992	6	5	10	12	13	13	59	13	13	13	13	13	12	77
1993	8	13	13	12	12	–	58	–	–	–	–	12	4	16
1994	7	–	9	10	11	–	37	–	–	–	–	6	2	8
1995	6	–	10	10	9	–	35	–	–	–	–	4	5	9
1996	5	–	10	9	9	–	33	–	1	–	–	1	2	4
1997	6	–	8	8	8	–	30	–	–	–	–	–	4	4
1998	6	–	6	7	6	–	25	–	–	–	–	–	2	2
1999	6	1	8	8	8	–	31	–	–	–	–	2	3	5
2000	7	–	8	8	8	7	38	–	–	–	–	2	3	5
2001	7	–	7	7	7	–	28	–	–	–	–	6	7	13
2002	5	–	6	6	6	6	29	6	3	2	5	6	6	28
2003	3	–	7	7	8	7	32	9	9	7	9	9	9	52
2004	6	–	8	8	7	8	37	8	8	8	7	8	8	47
2005	5	–	8	8	8	9	38	10	9	9	7	8	8	51
2006	4	–	8	9	10	10	41	10	10	10	8	9	9	56
2007	3	–	7	7	7	7	31	7	7	7	6	6	6	39
2008	3	–	7	8	8	8	34	9	9	9	8	8	6	49
2009	–	–	6	7	8	8	29	8	8	9	8	6	2	41
2010	1	–	7	9	9	8	34	7	2	3	6	6	5	29
2011	5	–	8	8	8	8	37	4	–	2	4	4	1	15
2012	2	–	4	4	1	5	16	4	2	3	4	2	4	19
2013	4	–	2	4	4	5	19	3	2	–	5	4	3	17
2014	7	6	4	6	7	6	36	2	2	5	5	6	4	24
2015	7	6	4	6	5	5	33	3	2	3	5	6	3	22
2016	6	5	2	5	5	5	28	3	2	1	6	2	3	17
2017	5	4	4	3	4	5	25	3	2	2	3	2	2	14
2018	5	3	3	4	5	5	25	3	2	2	4	2	2	15

Table 15: CRA 3 standardised seasonal CPUE models: the number of model parameters (p), the Bayesian LOO estimate of the expected log pointwise predictive density (elpd_loo), estimated effective number of parameters (p_loo), and the leave-one-out information criterion (LOOIC). The standard error (SE) for each value is provided in parenthesis. Lower LOOIC indicates a better fit, and, in a well specified model, the estimated effective number of parameters (p_loo) should be smaller than or similar to the total number of parameters in the model.

Model	p	elpd_loo (SE)	p_loo (SE)	LOOIC (SE)
interaction	412	-451.1 (109.6)	297.8 (10.6)	902.1 (219.2)
status-quo	140	-1118.1 (94.3)	139.6 (6.4)	2236.3 (188.7)
null	60	-2197.8 (85.7)	61.0 (2.1)	4395.6 (171.3)

Table 16: Seasonal CPUE indices calculated from the analysis of CRA 3 catch and potlift data including a vessel explanatory variable based on vessels with at least five years of data in the database. Standardised index for the interaction model.

	Autumn-Winter				Spring-Summer			
	909+910		911		909+910		911	
Fishing Year	Standard-ised Index	Standard Error	Standard-ised Index	Standard Error	Standard-ised Index	Standard Error	Standard-ised Index	Standard Error
89/90	-	-	-	-	0.4758	0.2189	0.6454	0.2842
90/91	0.2555	0.1101	0.3882	0.1652	0.4142	0.1834	0.4579	0.2015
91/92	0.1897	0.0819	0.2227	0.0951	0.2912	0.1296	0.3675	0.1619
92/93	0.1686	0.0865	0.1672	0.0710	0.3023	0.1400	0.2995	0.1322
93/94	0.3320	0.1531	0.3224	0.1371	0.7784	0.3686	1.0416	0.4679
94/95	0.7544	0.4055	0.6911	0.2954	1.2046	0.6609	1.3257	0.6086
95/96	1.2925	0.5870	0.7814	0.3359	2.3182	1.3305	2.3471	1.0922
96/97	1.4400	0.6289	1.0939	0.4717	2.8257	1.5853	2.2705	1.0989
97/98	1.8701	0.8924	1.6120	0.6937	1.5432	0.8819	1.5065	0.7445
98/99	1.3684	0.6024	1.3266	0.5721	2.3678	1.1605	2.3150	1.2157
99/00	1.4703	0.7014	1.1737	0.5064	1.8412	1.1103	3.0798	1.4733
00/01	1.0185	0.5246	1.1150	0.4758	1.3384	0.6757	2.6259	1.2249
01/02	0.6401	0.2835	0.7946	0.3428	0.9771	0.4937	1.9018	0.8506
02/03	0.4793	0.2148	0.6372	0.2725	0.6132	0.3358	0.9063	0.4017
03/04	0.4470	0.2053	0.4570	0.1960	0.4089	0.1816	0.4723	0.2072
04/05	0.3825	0.1671	0.2327	0.0988	0.5314	0.2417	0.3631	0.1603
05/06	0.4991	0.2237	0.3517	0.1504	0.4538	0.2102	0.5440	0.2415
06/07	0.5481	0.2993	0.3962	0.1688	0.5662	0.3112	0.5460	0.2413
07/08	0.5877	0.2900	0.3382	0.1455	0.6897	0.3572	0.4681	0.2066
08/09	0.6626	0.3206	0.3542	0.1513	0.7779	0.3533	0.5298	0.2347
09/10	0.7803	0.3416	0.4490	0.1922	0.9008	0.4158	0.6858	0.3045
10/11	0.8760	0.3932	0.7253	0.3109	1.0953	0.5232	1.2235	0.5420
11/12	1.1813	0.5182	1.1361	0.4905	1.5792	0.8508	1.7152	0.7822
12/13	1.7759	0.7911	1.7900	0.7757	2.0648	1.0441	2.0999	0.9437
13/14	1.6523	0.7435	1.9509	0.8481	1.7657	0.8331	1.7454	0.7911
14/15	1.5050	0.6558	1.7193	0.7369	1.5058	0.6859	1.8872	0.8366
15/16	1.2273	0.5352	1.4906	0.6422	1.3648	0.6650	1.8365	0.8114
16/17	1.1853	0.5253	1.6269	0.7000	1.4575	0.6971	1.8483	0.8220
17/18	1.1479	0.5036	1.4411	0.6187	1.1148	0.5216	1.7025	0.7741
18/19	0.9725	0.5032	1.7393	0.7487	0.9231	0.4861	2.4482	1.0988

Table 17: Catch rate (kg/day) from the potlift data in Annala & King (1983) calculated for the two Annala & King areas that overlap CRA 3 (see Figure 1). The total CRA 3 catch rate values are those that are stored in CRACE.

Calendar	Annala & King area		
year	Area 5	Area 6	CRA 3
1963	200.8	145.7	91.1
1964	242.1	211.8	109.8
1965	172.0	285.4	78.0
1966	138.2	245.3	62.7
1967	159.5	238.2	72.4
1968	109.8	162.4	49.8
1969	92.2	157.6	41.8
1970	84.4	115.9	38.3
1971	70.1	95.6	31.8
1972	70.1	77.9	31.8
1973	77.9	103.9	35.3

Table 18: Sampling intensity by fishing year in CRA 3 region 909+910 by the logbook and observer catch sampling programme from 1977. "Lobsters" are the number of individuals measured. Number of active vessels is included to show the level of participation in the logbook programme. '–': no data.

Fishing			Logbooks			Observer catch sampling		
year	N vessels[1]	Fishermen	Potlifts	Lobsters	Vessels	Days	Potlifts	Lobsters
1977	–	–	–	–	0	3	–	1 532
1986	48	–	–	–	2	2	73	199
1989	54	–	–	–	7	10	1 165	5 368
1990	35	–	–	–	4	17	2 045	14 088
1991	36	–	–	–	5	21	2 195	14 811
1992	27	–	–	–	6	23	2 163	13 553
1993	28	8	460	4 702	11	38	4 116	23 860
1994	28	8	794	6 599	10	33	3 988	36 423
1995	23	7	495	6 154	9	29	2 934	28 804
1996	23	6	425	6205	8	24	2 423	27 755
1997	22	1	65	1 190	6	24	2 041	29 581
1998	21	1	80	478	6	24	2 240	19 908
1999	22	–	–	–	4	17	1 763	14 203
2000	22	–	–	–	4	16	1 538	17 473
2001	20	–	–	–	8	25	2 766	20 738
2002	24	–	–	–	7	19	2 441	13 376
2003	23	–	–	–	6	13	1 803	7 375
2004	18	–	–	–	6	14	1 725	9 570
2005	18	–	–	–	7	16	1 902	8 914
2006	16	–	–	–	7	15	2 049	9 722
2007	16	–	–	–	9	14	1 582	8 345
2008	17	–	–	–	9	14	1 828	11 031
2009	15	–	–	–	9	19	2 271	15 082
2010	17	–	–	–	7	20	2 208	12 234
2011	16	3	297	1 985	6	20	1 950	11 950
2012	16	1	103	1 222	5	19	1 449	9 543
2013	17	4	311	3 303	8	20	2 008	15 014
2014	17	4	1 040	6 079	7	18	1 848	14 845
2015	17	4	583	5 632	5	11	1 153	8 658
2016	16	5	488	4 974	6	15	1 419	9 853
2017	15	7	859	8 485	6	18	1 634	10 511
2018	16	4	667	6 244	7	21	1 957	13 086
Total	–	–	6 667	63 252	–	592	62 677	457 405

[1] from Starr (2019)

Table 19: Sampling intensity by fishing year in CRA 3 region 911 by the logbook and observer catch sampling programme from 1986. "Lobsters" are the number of individuals measured. Number of active vessels is included to show the level of participation in the logbook programme. Samples marked in grey were dropped from the stock assessment. '–': no data.

Fishing	Logbooks				Observer catch sampling			
year	N vessels[1]	Fishermen	Potlifts	Lobsters	Vessels	Days	Potlifts	Lobsters
1986	29	–	–	–	1	1	84	329
1993	20	5	266	979	6	18	1 773	5 615
1994	14	6	556	2 425	8	18	1 763	8 700
1995	12	4	320	738	5	8	851	4 385
1996	10	2	196	518	4	8	859	5 222
1997	9	1	87	281	2	5	673	2 296
1998	9	1	112	417	4	8	731	3 271
1999	10	1	109	440	4	4	360	1 199
2000	11	1	160	846	3	4	435	2 781
2001	13	1	86	348	1	4	551	2 953
2002	14	–	–	–	5	10	983	5 623
2003	16	–	–	–	4	15	1 463	6 330
2004	16	–	–	–	5	15	1 419	3 960
2005	11	–	–	–	4	13	1 265	4 336
2006	12	–	–	–	3	13	1 232	3 620
2007	12	–	–	–	3	14	1 414	3 309
2008	9	–	–	–	3	14	1 474	3 481
2009	9	–	–	–	3	10	1 129	3 400
2010	9	1	40	126	2	7	764	2 668
2011	9	2	143	630	2	9	840	3 610
2012	7	1	47	178	2	9	652	4 217
2013	9	–	–	–	3	8	537	3 722
2014	10	3	359	2 386	2	7	461	3 816
2015	11	2	422	3 449	2	12	821	6 198
2016	9	2	370	2 909	3	7	548	3 793
2017	10	3	373	4 004	2	6	355	2 372
2018	9	2	298	2 557	3	8	507	3 356
Total	–	–	3 944	23 231	–	255	23 944	104 562

[1] from Starr (2019)

Table 20: Number of lobsters measured by the observer and logbook catch sampling programmes by fishing year, sex, and season for CRA 3 region 909+910. '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1989	–	–	–	–	655	20	588	1 263
1991	–	–	–	–	626	8	452	1 086
1992	–	–	–	–	1 278	56	415	1 749
1993	–	–	–	–	8 860	177	1 549	10 586
1994	5 565	16	494	6 075	20 056	165	2 178	22 399
1995	5 770	2	381	6 153	17 980	58	1 063	19 101
1996	5 758	3	438	6 199	17 808	89	1 198	19 095
1997	1 170	1	19	1 190	17 920	83	1 313	19 316
1998	410	–	67	477	7 611	42	893	8 546
1999	–	–	–	–	5 007	15	311	5 333
2000	–	–	–	–	5 830	18	457	6 305
2001	–	–	–	–	3 915	27	476	4 418
2002	–	–	–	–	7 109	20	406	7 535
2003	–	–	–	–	5 566	19	452	6 037
2004	–	–	–	–	5 037	20	472	5 529
2005	–	–	–	–	5 814	40	675	6 529
2006	–	–	–	–	6 723	98	769	7 590
2007	–	–	–	–	4 556	17	398	4 971
2008	–	–	–	–	3 897	16	201	4 114
2009	–	–	–	–	9 325	62	638	10 025
2010	–	–	–	–	8 026	26	742	8 794
2011	1 897	2	86	1 985	9 279	11	232	9 522
2012	1 213	–	9	1 222	9 171	33	329	9 533
2013	3 199	–	98	3 297	12 151	36	345	12 532
2014	3 868	21	309	4 198	6 181	24	184	6 389
2015	3 731	18	254	4 003	7 528	4	243	7 775
2016	2 959	8	67	3 034	6 814	19	250	7 083
2017	5 481	17	207	5 705	4 783	5	118	4 906
2018	4 303	2	228	4 533	6 206	6	151	6 363
Total	45 324	90	2 657	48 071	225 712	1 214	17 498	244 424
Season=SS								
1986	–	–	–	–	123	23	45	191
1989	–	–	–	–	2 826	57	1 030	3 913
1990	–	–	–	–	8 478	218	4 797	13 493
1991	–	–	–	–	8 842	245	4 213	13 300
1992	–	–	–	–	7 562	235	3 611	11 408
1993	4 418	22	751	5 191	9 735	115	2 666	12 516
1994	–	–	–	–	10 786	67	1 719	12 572
1995	–	–	–	–	7 471	59	1 407	8 937
1996	–	–	–	–	5 929	53	1 667	7 649
1997	–	–	–	–	6 810	43	2 568	9 421
1998	–	–	–	–	8 378	35	2 590	11 003
1999	–	–	–	–	6 615	28	1 847	8 490
2000	–	–	–	–	8 135	102	2 748	10 985
2001	–	–	–	–	12 905	714	2 466	16 085
2002	–	–	–	–	4 914	23	712	5 649
2003	–	–	–	–	733	6	547	1 286
2004	–	–	–	–	3 473	30	445	3 948
2005	–	–	–	–	1 803	6	522	2 331
2006	–	–	–	–	1 615	52	406	2 073
2007	–	–	–	–	2 833	56	401	3 290
2008	–	–	–	–	5 097	321	1 489	6 907
2009	–	–	–	–	4 301	122	596	5 019
2010	–	–	–	–	2 991	60	357	3 408
2011	–	–	–	–	2 145	2	214	2 361
2013	–	–	–	–	2 302	8	171	2 481
2014	1 414	31	557	2 002	7 708	51	695	8 454
2015	1 128	3	383	1 514	792	–	90	882
2016	1 727	7	326	2 060	2 515	88	160	2 763
2017	2 160	10	506	2 676	4 515	479	598	5 592
2018	1 480	5	194	1 679	5 091	102	1 527	6 720
Total	12 327	78	2 717	15 122	157 423	3 400	42 304	203 127

Table 21: Sample weight calculated for each LF sampling record described for CRA 3 region 909+910 in Table 20. '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1989	–	–	–	–	2.353	0.061	1.786	4.201
1991	–	–	–	–	0.250	0.003	0.180	0.433
1992	–	–	–	–	0.186	0.008	0.061	0.255
1993	–	–	–	–	11.257	0.174	1.763	13.193
1994	45.514	0.172	2.715	48.402	19.013	0.133	2.051	21.198
1995	48.064	0.012	2.373	50.450	29.958	0.087	1.686	31.732
1996	44.168	0.011	2.309	46.488	21.079	0.102	1.341	22.522
1997	2.111	0.002	0.033	2.146	28.429	0.121	1.615	30.165
1998	3.931	–	0.540	4.471	14.751	0.085	1.894	16.729
1999	–	–	–	–	4.911	0.017	0.352	5.279
2000	–	–	–	–	9.713	0.028	0.745	10.486
2001	–	–	–	–	5.650	0.037	0.695	6.382
2002	–	–	–	–	18.279	0.046	0.923	19.247
2003	–	–	–	–	19.479	0.047	1.095	20.621
2004	–	–	–	–	15.446	0.036	0.957	16.439
2005	–	–	–	–	13.630	0.074	1.377	15.080
2006	–	–	–	–	16.824	0.196	1.405	18.424
2007	–	–	–	–	14.776	0.064	1.002	15.842
2008	–	–	–	–	11.252	0.036	0.465	11.754
2009	–	–	–	–	13.100	0.094	0.884	14.079
2010	–	–	–	–	17.474	0.058	1.534	19.066
2011	16.070	0.014	0.677	16.761	25.287	0.024	0.533	25.843
2012	3.006	–	0.021	3.027	18.854	0.069	0.621	19.543
2013	25.209	–	0.745	25.954	23.344	0.045	0.623	24.012
2014	13.292	0.052	0.878	14.222	15.037	0.042	0.385	15.465
2015	12.248	0.058	0.786	13.092	11.764	0.002	0.207	11.973
2016	8.443	0.023	0.245	8.712	7.211	0.016	0.196	7.423
2017	27.281	0.064	1.416	28.761	6.860	0.005	0.161	7.026
2018	21.966	0.008	1.452	23.426	9.731	0.009	0.227	9.966
Total	271.303	0.417	14.191	285.911	405.898	1.718	26.763	434.379
Season=SS								
1986	–	–	–	–	0.104	0.020	0.038	0.162
1989	–	–	–	–	4.883	0.095	1.398	6.376
1990	–	–	–	–	11.948	0.403	6.953	19.303
1991	–	–	–	–	10.624	0.418	4.818	15.860
1992	–	–	–	–	10.859	0.439	4.386	15.684
1993	58.135	0.438	7.863	66.436	25.258	0.317	4.866	30.440
1994	–	–	–	–	8.434	0.048	1.021	9.502
1995	–	–	–	–	4.639	0.037	0.874	5.549
1996	–	–	–	–	3.906	0.035	1.098	5.039
1997	–	–	–	–	4.082	0.026	1.539	5.647
1998	–	–	–	–	4.528	0.019	1.400	5.947
1999	–	–	–	–	4.250	0.018	1.187	5.455
2000	–	–	–	–	4.402	0.055	1.487	5.944
2001	–	–	–	–	8.902	0.570	1.655	11.127
2002	–	–	–	–	2.501	0.011	0.360	2.872
2003	–	–	–	–	0.557	0.003	0.663	1.223
2004	–	–	–	–	2.107	0.019	0.376	2.501
2005	–	–	–	–	1.155	0.006	0.579	1.740
2006	–	–	–	–	1.890	0.045	0.361	2.296
2007	–	–	–	–	1.312	0.024	0.184	1.519
2008	–	–	–	–	9.682	0.624	2.928	13.234
2009	–	–	–	–	5.016	0.120	0.573	5.709
2010	–	–	–	–	9.820	0.129	0.829	10.778
2011	–	–	–	–	8.832	0.008	0.880	9.721
2013	–	–	–	–	4.381	0.013	0.286	4.680
2014	7.125	0.100	2.680	9.906	5.128	0.033	0.540	5.701
2015	12.269	0.042	4.671	16.983	2.642	–	0.300	2.942
2016	15.866	0.052	2.720	18.639	0.927	0.048	0.000	0.975
2017	21.382	0.088	4.997	26.468	5.591	0.457	0.747	6.794
2018	8.964	0.027	0.712	9.703	5.050	0.073	1.959	7.082
Total	123.742	0.748	23.644	148.134	173.407	4.113	44.284	221.804

Table 22: Number of lobsters measured by the observer and logbook catch sampling programmes by fishing year, sex, and season for CRA 3 region 911. Samples marked in grey were dropped from the stock assessment. '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1993	–	–	–	–	1 358	105	543	2 006
1994	1 281	10	731	2 022	3 311	31	983	4 325
1995	562	9	84	655	3 267	39	967	4 273
1996	426	–	85	511	3 663	45	1 405	5 113
1997	255	–	26	281	1 793	3	480	2 276
1998	353	–	64	417	2 462	26	714	3 202
1999	400	–	40	440	887	9	282	1 178
2000	571	6	192	769	1 597	5	1 159	2 761
2001	223	2	123	348	1 438	4	1 496	2 938
2002	–	–	–	–	1 522	8	528	2 058
2003	–	–	–	–	1 417	22	1 693	3 132
2004	–	–	–	–	792	15	661	1 468
2005	–	–	–	–	1 003	5	404	1 412
2006	–	–	–	–	917	4	229	1 150
2007	–	–	–	–	1 286	20	475	1 781
2008	–	–	–	–	776	16	356	1 148
2009	–	–	–	–	760	3	147	910
2010	31	–	20	51	1 283	4	698	1 985
2011	389	3	79	471	1 817	3	241	2 061
2012	177	–	1	178	396	1	31	428
2013	–	–	–	–	975	2	303	1 280
2014	237	1	88	326	1 002	–	96	1 098
2015	1 179	1	680	1 860	2 677	6	518	3 201
2016	1 581	1	435	2 017	2 380	6	438	2 824
2017	2 499	2	522	3 023	1 467	11	301	1 779
2018	1 817	2	383	2 202	1 131	8	156	1 295
Total	11 981	37	3 553	15 571	41 377	401	15 304	57 082
Season=SS								
1986	–	–	–	–	129	11	152	292
1993	651	21	311	983	2 467	66	1 003	3 536
1994	309	5	146	460	2 375	61	1 738	4 174
1999	28	–	49	77	–	–	–	–
2002	–	–	–	–	1 287	17	2 120	3 424
2003	–	–	–	–	973	50	2 133	3 156
2004	–	–	–	–	1 040	45	1 357	2 442
2005	–	–	–	–	1 229	24	1 652	2 905
2006	–	–	–	–	1 191	21	1 234	2 446
2007	–	–	–	–	639	21	834	1 494
2008	–	–	–	–	1 278	27	1 016	2 321
2009	–	–	–	–	1 458	28	999	2 485
2010	37	1	37	75	381	10	284	675
2011	98	–	61	159	712	–	825	1 537
2012	–	–	–	–	1 716	17	2 056	3 789
2013	2	–	–	2	1 272	9	1 161	2 442
2014	722	1	688	1 411	1 458	4	1 256	2 718
2015	980	5	727	1 712	1 368	1	1 627	2 996
2016	509	–	347	856	336	3	630	969
2017	374	–	479	853	298	–	295	593
2018	197	1	143	341	1 312	6	742	2 060
Total	3 907	34	2 988	6 929	22 919	421	23 114	46 454

Table 23: Sample weight calculated for each LF sampling record described for CRA 3 region 911 in Table 22. Samples marked in grey were dropped from the stock assessment. '–': no data.

	Logbooks				Observer catch sampling			
Fishing year	Male	Immature female	Mature female	Total	Male	Immature female	Mature female	Total
Season=AW								
1993	–	–	–	–	0.994	0.077	0.397	1.468
1994	5.486	0.042	3.224	8.751	3.655	0.032	1.028	4.715
1995	4.253	0.066	0.641	4.960	3.140	0.038	0.931	4.109
1996	2.976	–	0.555	3.531	2.364	0.028	0.899	3.291
1997	1.661	–	0.201	1.862	1.151	0.002	0.315	1.468
1998	1.897	–	0.325	2.222	1.913	0.019	0.567	2.499
1999	2.484	–	0.314	2.798	1.310	0.013	0.416	1.739
2000	3.256	0.023	1.126	4.405	1.323	0.004	0.960	2.287
2001	2.198	0.021	1.212	3.431	1.868	0.005	1.983	3.856
2002	–	–	–	–	2.290	0.014	0.848	3.152
2003	–	–	–	–	1.948	0.027	2.335	4.310
2004	–	–	–	–	1.297	0.020	1.058	2.375
2005	–	–	–	–	1.434	0.006	0.544	1.984
2006	–	–	–	–	1.122	0.007	0.269	1.398
2007	–	–	–	–	1.773	0.030	0.659	2.462
2008	–	–	–	–	0.730	0.013	0.261	1.003
2009	–	–	–	–	1.073	0.004	0.206	1.283
2010	0.182	–	0.117	0.300	1.442	0.002	0.413	1.856
2011	1.705	0.036	0.372	2.113	1.637	0.002	0.227	1.867
2012	0.477	–	0.003	0.480	0.335	0.001	0.026	0.362
2013	–	–	–	–	0.900	0.002	0.269	1.171
2014	1.622	0.009	0.608	2.239	0.804	–	0.077	0.881
2015	3.488	0.002	1.804	5.294	1.377	0.005	0.413	1.796
2016	5.721	0.006	1.443	7.170	2.611	0.010	0.374	2.995
2017	7.635	0.008	1.720	9.363	1.494	0.017	0.432	1.942
2018	6.734	0.007	1.078	7.819	1.274	0.011	0.169	1.454
Total	51.774	0.220	14.740	66.735	41.259	0.388	16.077	57.724
Season=SS								
1986	–	–	–	–	0.201	0.017	0.237	0.455
1993	9.848	0.319	4.726	14.894	7.732	0.199	3.068	10.999
1994	8.021	0.139	3.748	11.908	9.677	0.249	7.082	17.007
1999	0.116	–	0.204	0.320	–	–	–	–
2002	–	–	–	–	1.588	0.020	2.444	4.051
2003	–	–	–	–	1.555	0.078	4.194	5.827
2004	–	–	–	–	2.162	0.097	2.948	5.208
2005	–	–	–	–	1.614	0.032	2.860	4.505
2006	–	–	–	–	1.605	0.033	1.984	3.623
2007	–	–	–	–	1.234	0.047	1.486	2.767
2008	–	–	–	–	2.525	0.054	1.992	4.571
2009	–	–	–	–	2.131	0.051	1.633	3.815
2010	0.929	0.025	0.929	1.883	0.992	0.030	0.744	1.765
2011	0.960	–	0.597	1.557	2.838	–	3.289	6.127
2012	–	–	–	–	3.256	0.032	3.901	7.188
2013	0.066	–	–	0.066	1.616	0.007	1.476	3.098
2014	4.177	0.005	4.009	8.191	1.646	0.005	1.418	3.069
2015	4.028	0.017	3.074	7.119	1.276	0.002	1.866	3.144
2016	2.640	–	1.862	4.502	0.212	0.002	0.398	0.613
2017	1.286	–	1.663	2.949	0.552	–	0.546	1.099
2018	0.580	0.003	0.419	1.002	2.814	0.009	1.520	4.343
Total	32.652	0.508	21.230	54.390	47.228	0.963	45.085	93.275

Table 24: Statistics for the proportion-at-sex for each season, summarised across all records for a season using the weights in Table 23.

		Autumn-Winter			Spring-Summer		
Region	Statistic	Male	Immature Female	Mature Female	Male	Immature Female	Mature Female
909+910	Maximum	0.972	0.032	0.425	0.936	0.120	0.542
	Minimum	0.560	0.001	0.027	0.455	0.001	0.061
	Mean	0.940	0.003	0.057	0.803	0.013	0.184
911	Maximum	0.965	0.052	0.542	0.679	0.038	0.720
	Minimum	0.452	0.001	0.034	0.267	0.000	0.301
	Mean	0.747	0.005	0.248	0.541	0.010	0.449

Table 25: Statistics for mean tail width (mm) by sex for each season, summarised across all records for a season using the weights in Table 23.

		Autumn-Winter			Spring-Summer		
			Immature	Mature		Immature	Mature
Region	Statistic	Male	Female	Female	Male	Female	Female
909+910	Maximum	52.0	51.4	58.1	53.0	54.7	62.8
	Minimum	49.0	36.0	48.3	49.7	42.3	49.6
	Mean	50.9	46.1	55.1	51.2	49.7	55.2
911	Maximum	58.6	62.0	61.7	57.8	60.0	61.3
	Minimum	50.9	47.5	55.2	50.2	49.5	55.7
	Mean	55.7	52.5	59.0	54.3	51.7	58.4

Table 26: Number of year, season, sampling category records by 2 mm tail width bin for each sex category for all of CRA 3. Also shown are the number of records where the year, season, sampling category proportion within a sex category is less than 0.001 and the calculated proportion of records is greater than 0.001. Bold grey cells indicate accumulator bins used in the model.

	Males			Immature Females			Mature Females		
Bin	N records	N records <0.001	Prop >0.001	N records	N records <0.001	Prop >0.001	N records	N records <0.001	Prop >0.001
[30,32)	14	14	0.00	6	6	0.00	1	1	0.00
[32,34)	32	29	0.09	14	14	0.00	2	1	0.50
[34,36)	43	40	0.07	23	23	0.00	6	5	0.17
[36,38)	**64**	**47**	**0.27**	**43**	**41**	**0.05**	**13**	**11**	**0.15**
[38,40)	72	29	0.60	43	41	0.05	37	34	0.08
[40,42)	77	13	0.83	60	57	0.05	62	48	0.23
[42,44)	80	3	0.96	57	45	0.21	70	35	0.50
[44,46)	81	0	1.00	64	43	0.33	74	26	0.65
[46,48)	83	0	1.00	69	46	0.33	77	12	0.84
[48,50)	84	0	1.00	62	37	0.40	81	7	0.91
[50,52)	86	0	1.00	62	38	0.39	81	1	0.99
[52,54)	87	0	1.00	66	41	0.38	83	4	0.95
[54,56)	87	0	1.00	67	45	0.33	83	1	0.99
[56,58)	87	0	1.00	58	42	0.28	84	0	1.00
[58,60)	87	3	0.97	50	40	0.20	87	0	1.00
[60,62)	85	4	0.95	35	34	0.03	86	0	1.00
[62,64)	84	5	0.94	**18**	**17**	**0.06**	86	3	0.97
[64,66)	82	12	0.85	4	4	0.00	83	11	0.87
[66,68)	78	21	0.73	5	5	0.00	81	24	0.70
[68,70)	74	30	0.59	3	3	0.00	76	29	0.62
[70,72)	72	30	0.58	1	1	0.00	66	32	0.52
[72,74)	60	26	0.57	3	3	0.00	52	33	0.37
[74,76)	**53**	**30**	**0.43**	1	1	0.00	44	37	0.16
[76,78)	40	26	0.35	1	1	0.00	**28**	**24**	**0.14**
[78,80)	35	28	0.20	0			19	17	0.11
[80,∞)	39	33	0.15	0			23	20	0.13

Table 27: 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 2018 CRA 6 stock assessment (Starr et al. 2019).

Project_ID	Previous	Current	Difference
CRA_Akaroa	227	227	–
CRA_CCampb	44	44	–
CRA_Gis70s	2243	2244	1
CRA_Gisb	48	48	–
CRA_ReefPt	573	573	–
CRA_StewIs	1615	1622	7
CRA01Gisb	1191	1179	-12
CRA1_TAG	1486	1592	106
CRA2_EBOP	5	5	–
CRA2_TAG	4309	4364	55
CRA2_WBOP	268	268	–
CRA3_TAG	1777	2070	293
CRA4_TAG	2616	3128	512
CRA4_Wair	10	10	–
CRA5_Kaik	1176	1176	–
CRA5_TAG	5629	5946	317
CRA6_TAG	183	183	–
CRA7_TAG	589	632	43
CRA7rs	199	199	–
CRA8_Fiord	1714	1714	–
CRA8_TAG	7295	7295	–
CRA8rs	236	236	–
CRA9_TAG	73	126	53

Table 28: Comparison of the number of recapture records by calendar year in the new tag data extract with the number of records in the extract made for the 2018 CRA 6 stock assessment (Starr et al. 2019).

Year	Previous	Current	Difference
1966	53	53	–
1967	29	29	–
1968	7	7	–
1969	2	2	–
1971	1	1	–
1975	115	115	–
1976	1 268	1 275	7
1977	2 094	2 096	2
1978	887	886	-1
1979	1 093	1 081	-12
1980	1 112	1 112	–
1981	593	593	–
1982	332	332	–
1983	273	273	–
1984	1 071	1 071	–
1985	395	395	–
1986	76	76	–
1987	18	18	–
1988	4	4	–
1989	2	2	–
1991	1	1	–
1992	1	1	–
1994	40	40	–
1995	73	73	–
1996	515	515	–
1997	2 579	2 579	–
1998	2 949	2 950	1
1999	2 494	2 494	–
2000	1 593	1 593	–
2001	1 378	1 378	–
2002	1 576	1 576	–
2003	1 122	1 122	–
2004	2 083	2 083	–
2005	2 410	2 410	–
2006	978	978	–
2007	490	489	-1
2008	367	367	–
2009	306	306	–
2010	237	237	–
2011	550	550	–
2012	333	333	–
2013	485	485	–
2014	727	768	41
2015	508	856	348
2016	159	516	357
2017	127	375	248
2018	–	306	306
2019	–	79	79

Table 29: Number of tags released, including tags that were never recaptured, compared with the number and proportion recaptured by QMA.

QMA	Number released	Number recaptured	Proportion recaptured
CRA 1	16 454	2 163	0.131
CRA 2	23 509	4 522	0.192
CRA 3	36 241	5 637	0.156
CRA 4	38 194	3 121	0.082
CRA 5	35 438	7 354	0.208
CRA 6	4 724	181	0.038
CRA 7	9 793	823	0.084
CRA 8	21 378	10 764	0.504
CRA 9	6 452	126	0.020

Table 30: Number of complete tagging release/recovery records by sex and QMA. Note that the row totals are not always consistent with other tables as some records could not be assigned to a sex.

QMA	Male	Female	Total
CRA 1	947	1216	2 163
CRA 2	2 358	2 164	4 522
CRA 3	4 273	1 364	5 637
CRA 4	2 411	710	3 121
CRA 5	5 163	2 191	7 354
CRA 6	21	160	181
CRA 7	383	440	823
CRA 8	5 884	4 880	10 764
CRA 9	32	94	126
Total	21 472	13 219	34 691

Table 31: 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 as some records could not be assigned to a QMA.

QMA	CRA1	CRA2	CRA3	CRA4	CRA5	CRA6	CRA7	CRA8	CRA9
CRA1	1 841	9	30	–	-	–	–	–	–
CRA2	–	3 759	2	–	-	–	–	–	–
CRA3	–	16	5 136	–	3	–	–	56	–
CRA4	–	–	–	2 580	32	–	-	–	–
CRA5	–	–	–	3	5 854	–	6	–	–
CRA6	–	–	–	–	–	177	-	–	–
CRA7	–	–	6	–	–	–	800	17	–
CRA8	–	1	127	–	–	–	–	8 475	3
CRA9	–	–	–	–	–	–	–	–	73

Table 32: Number of tag recaptures by year of release and sex for the two CRA 3 regions. Tags classified to region on the basis of release statistical area.

	All tag recaptures						Tags at liberty for >365 days					
Release	Region 909+910			Region 911			Region 909+910			Region 911		
year	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1975	337	49	386	16	11	27	25	12	37	4	6	10
1976	555	35	590	164	226	390	42	11	53	46	105	151
1977	425	54	479	72	100	172	35	20	55	6	34	40
1978	0	0	0	161	81	242	0	0	0	35	14	49
1979	406	425	831	0	0	0	14	27	41	0	0	0
1980	204	144	348	2	0	2	20	21	41	0	0	0
1984	4	0	4	0	0	0	0	0	0	0	0	0
1995	86	6	92	0	0	0	19	4	23	0	0	0
1996	131	23	154	0	0	0	14	10	24	0	0	0
1997	55	18	73	0	0	0	24	9	33	0	0	0
1998	1	1	2	0	0	0	0	0	0	0	0	0
1999	4	1	5	0	0	0	2	1	3	0	0	0
2001	195	9	204	26	27	53	54	3	57	15	15	30
2002	10	0	10	6	1	7	2	0	2	0	0	0
2003	2	0	2	0	1	1	0	0	0	0	0	0
2004	262	4	266	105	50	155	107	0	107	30	23	53
2005	26	0	26	31	5	36	2	0	2	1	0	1
2006	0	0	0	2	0	2	0	0	0	0	0	0
2007	1	0	1	0	1	1	0	0	0	0	0	0
2008	75	0	75	15	19	34	26	0	26	1	9	10
2009	63	0	63	47	6	53	50	0	50	12	0	12
2010	49	1	50	12	6	18	11	0	11	0	1	1
2011	77	0	77	4	0	4	29	0	29	0	0	0
2012	102	7	109	0	0	0	20	2	22	0	0	0
2013	93	25	118	0	0	0	30	17	47	0	0	0
2014	129	4	133	17	8	25	16	0	16	6	7	13
2015	26	0	26	0	0	0	3	0	3	0	0	0
2016	88	0	88	5	0	5	23	0	23	1	0	1
2017	32	2	34	32	2	34	0	0	0	14	0	14
2018	48	0	48	1	0	1	0	0	0	0	0	0
Total	3 486	808	4 294	718	544	1 262	568	137	705	171	214	385

Table 33: Number of tag recaptures by year of recovery and sex for the two CRA 3 regions. Tags classified to region on the basis of release statistical area.

	All tag recaptures						Tags at liberty for >365 days					
Recovery	Region 909+910			Region 911			Region 909+910			Region 911		
year	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1975	161	18	179	1	2	3	0	0	0	0	0	0
1976	418	45	463	101	113	214	13	7	20	2	3	5
1977	653	47	700	134	151	285	28	9	37	40	71	111
1978	80	20	100	130	128	258	56	19	75	12	62	74
1979	317	294	611	24	19	43	4	3	7	14	18	32
1980	250	243	493	22	2	24	6	23	29	20	2	22
1981	46	37	83	3	3	6	27	27	54	3	3	6
1982	2	2	4	0	0	0	2	2	4	0	0	0
1983	0	1	1	0	0	0	0	1	1	0	0	0
1984	3	0	3	0	0	0	0	0	0	0	0	0
1985	1	0	1	0	0	0	0	0	0	0	0	0
1995	32	1	33	0	0	0	0	0	0	0	0	0
1996	53	6	59	0	0	0	4	2	6	0	0	0
1997	128	19	147	0	0	0	15	2	17	0	0	0
1998	42	12	54	0	0	0	21	9	30	0	0	0
1999	16	6	22	0	0	0	13	6	19	0	0	0
2000	1	0	1	0	0	0	1	0	1	0	0	0
2001	64	7	71	6	9	15	5	1	6	0	0	0
2002	107	3	110	21	13	34	21	3	24	12	10	22
2003	31	1	32	5	7	12	25	1	26	3	5	8
2004	76	6	82	2	3	5	6	2	8	0	0	0
2005	189	1	190	120	34	154	84	1	85	20	7	27
2006	24	0	24	14	9	23	20	0	20	9	7	16
2007	6	0	6	2	5	7	6	0	6	2	4	6
2008	29	0	29	8	14	22	3	0	3	0	4	4
2009	52	0	52	32	9	41	21	0	21	1	5	6
2010	23	1	24	22	9	31	11	0	11	7	3	10
2011	94	0	94	12	4	16	43	0	43	5	3	8
2012	77	0	77	4	0	4	30	0	30	0	0	0
2013	111	9	120	0	0	0	25	0	25	0	0	0
2014	144	15	159	5	0	5	23	7	30	0	0	0
2015	70	5	75	11	5	16	19	5	24	5	4	9
2016	61	6	67	4	3	7	10	6	16	1	3	4
2017	46	1	47	5	1	6	22	1	23	1	0	1
2018	79	2	81	30	1	31	4	0	4	14	0	14
Total	3 486	808	4 294	718	544	1 262	568	137	705	171	214	385

Table 34: Number of tag recaptures by recovery statistical area for the two CRA 3 regions. Tags classified to region on the basis of release statistical area.

Recovery	All tag recaptures			Tags at liberty for >365 days		
stat_area	909+910	911	Total	909+910	911	Total
908	16	0	16	8	0	8
909	775	1	776	234	1	235
910	3 163	5	3 168	364	2	366
911	2	1 190	1 192	0	354	354
916	3	0	3	1	0	1
924	51	1	52	0	0	0
Unknown	284	65	349	98	28	126
Total	4 294	1 262	5 556	705	385	1 090

Table 35: Statistics for days-at-liberty for recaptures from the two CRA 3 regions. Tags classified to region on the basis of release statistical area.

Sub-stock	Sex	N	Min(days)	p5%(days)	Median(days)	p95%(days)	Max(days)
909+910	Males	3 486	1	5	184	582	2 053
	Females	718	1	4	193	639	3 099
911	Males	808	1	14	177	619	1 285
	Females	544	1	15	196	837	1 831

Table 36: Number of tag re-releases by sex and CRA 3 region. Re-release event code=0 means the first release-recapture event.

	region 909+910				Region 911			
Re-release event	Male	Female	Proportion male	Proportion female	Male	Female	Proportion male	Proportion female
0	2 932	736	0.841	0.911	642	498	0.894	0.915
1	349	66	0.941	0.993	42	18	0.953	0.949
2	165	6	0.989	1.000	31	28	0.996	1.000
3	24	0	0.995	1.000	3	0	1.000	1.000
4	9	0	0.998	1.000	0	0	1.000	1.000
5	3	0	0.999	1.000	0	0	1.000	1.000
6	2	0	0.999	1.000	0	0	1.000	1.000
7	1	0	1.000	1.000	0	0	1.000	1.000
8	1	0	1.000	1.000	0	0	1.000	1.000
Total	3 486	808			718	544		

Table 37: Statistics for tail width growth increments (mm) for recaptures from the two CRA 3 regions. Tags classified to region on the basis of release statistical area.

Sub-stock	Sex	N	Min(incr)	p5%(incr)	Median(incr)	p95%(incr)	Max(incr)
909+910	Males	3 486	-18.5	-0.5	1.3	7.0	20.4
	Females	718	-27.4	-9.1	0.5	10.9	29.0
911	Males	808	-20.0	-0.1	2.7	9.4	22.5
	Females	544	-11.9	-0.6	0.3	6.5	17.0

Table 38: Number of tag recaptures by year of release and of recovery by sex in the Te Tapuwae o Rongokako marine reserve.

Release	All tags			>365 days at liberty			Recovery	All tags			>365 days at liberty		
year	Male	Female	Total	Male	Female	Total	year	Male	Female	Total	Male	Female	Total
2003	490	54	544	128	13	141	2003	1	0	1			
2004	99	25	124	15	5	20	2004	431	59	490	18	1	19
2005	172	5	177	20	1	21	2005	138	13	151	100	10	110
2006	120	10	130	20	3	23	2006	228	14	242	23	7	30
2007	27	2	29	19	2	21	2007	80	6	86	32	2	34
2008	23	2	25	9	0	9	2008	17	1	18	12	1	13
2009	26	0	26	5	0	5	2009	25	3	28	7	1	8
2010	6	0	6	2	0	2	2010	34	2	36	17	2	19
2011	2	0	2	2	0	2	2011	8	0	8	8	0	8
Total	965	98	1 063	220	24	244	2012	3	0	3	3	0	3
							Total	965	98	1 063	220	24	244

Table 39: Statistics for days-at-liberty and tail width growth increments (mm) for recaptures by sex in the Te Tapuwae o Rongokako marine reserve.

	Days at liberty		Growth increment	
	Males	Females	Males	Females
N	965	98	965	98
Minimum	33	71	-7.7	-2.9
p5%	74	75	-0.2	-1.7
Median	260	271	0	0
p95%	753	1 079	5.2	0.8
Maximum	2 840	1 264	15.5	2.0

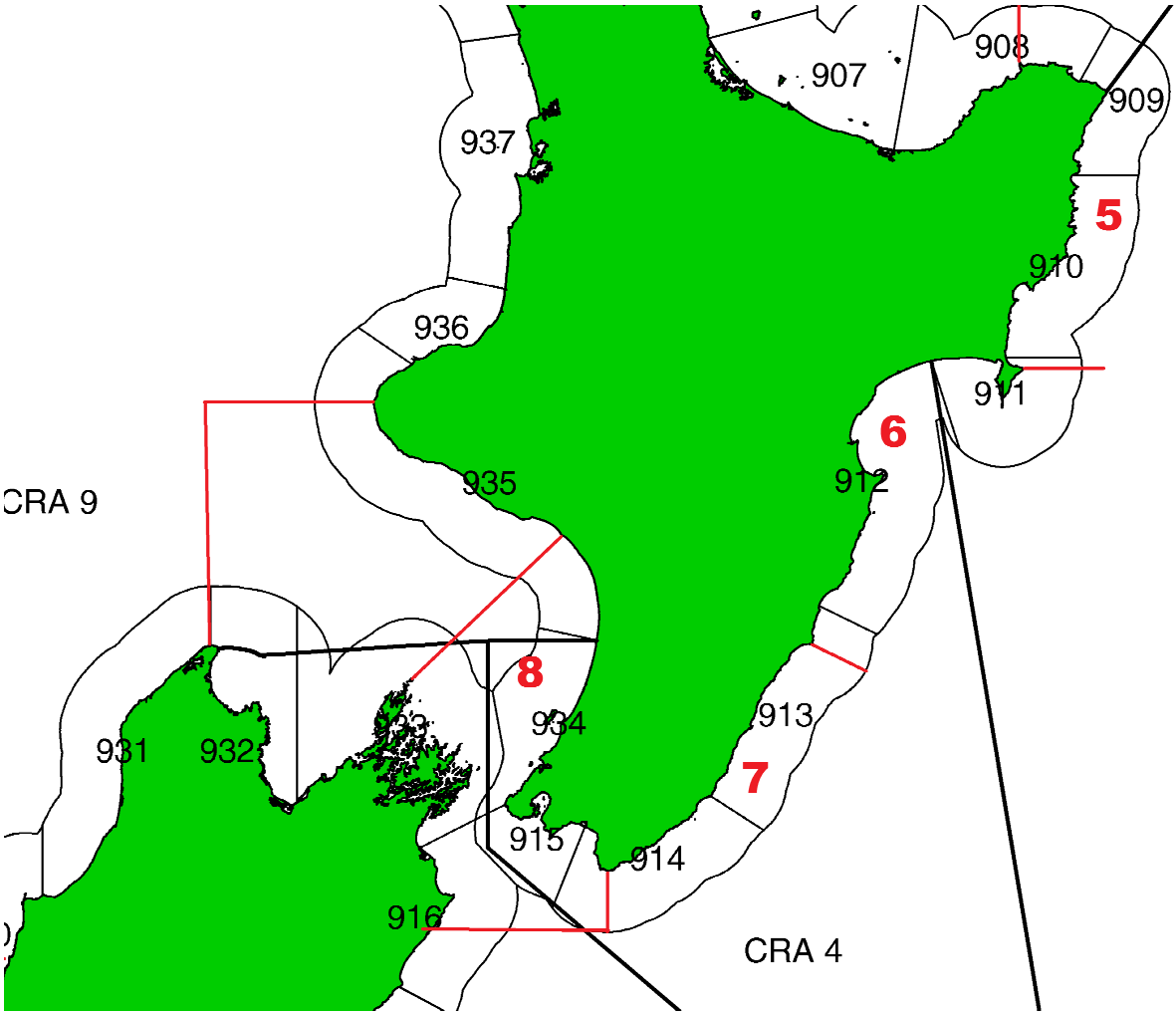


Figure 1: **The CRA 3 Quota Management Area (QMA) on the northern coast of the North Island, and its statistical areas. The QMA boundaries are shown with heavy black lines and the statistical area boundaries have thinner black lines. The approximate location of the Annala/King (1983) statistical areas are labelled in red with red boundary lines.**

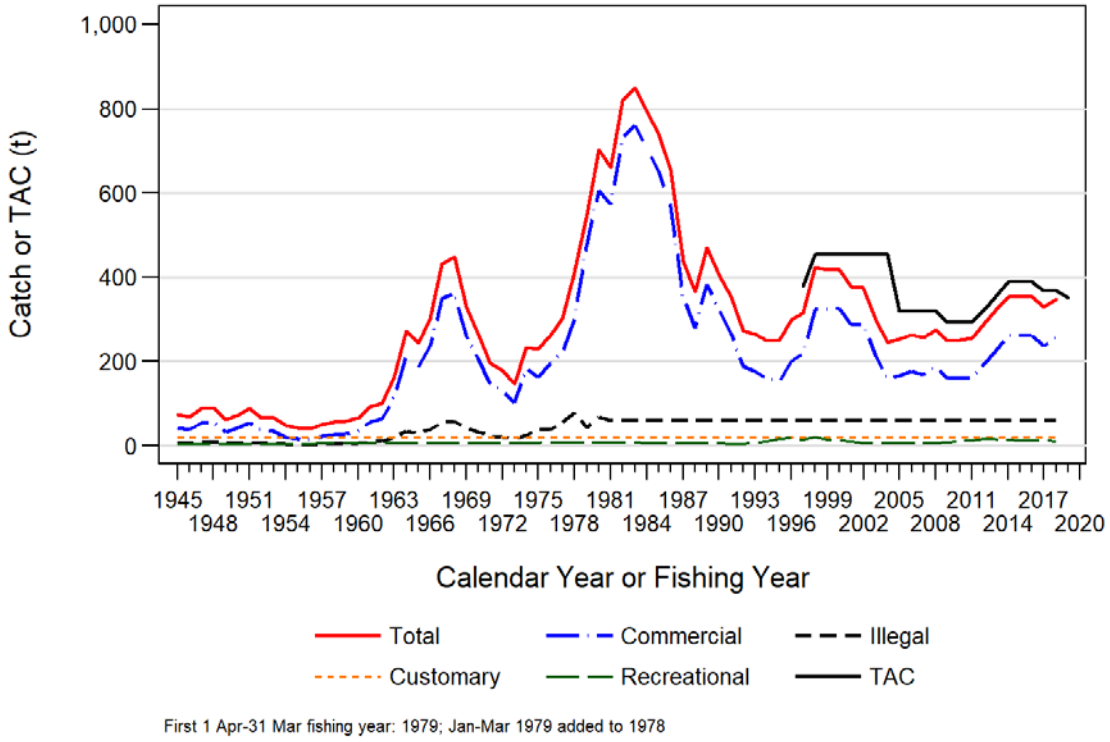


Figure 2: **Annual catches (tonnes) by fishery (commercial, illegal, recreational, and customary), using the three RLFAWG agreed non-commercial catch series (see Sections 2.2, 2.3, and 2.4).**

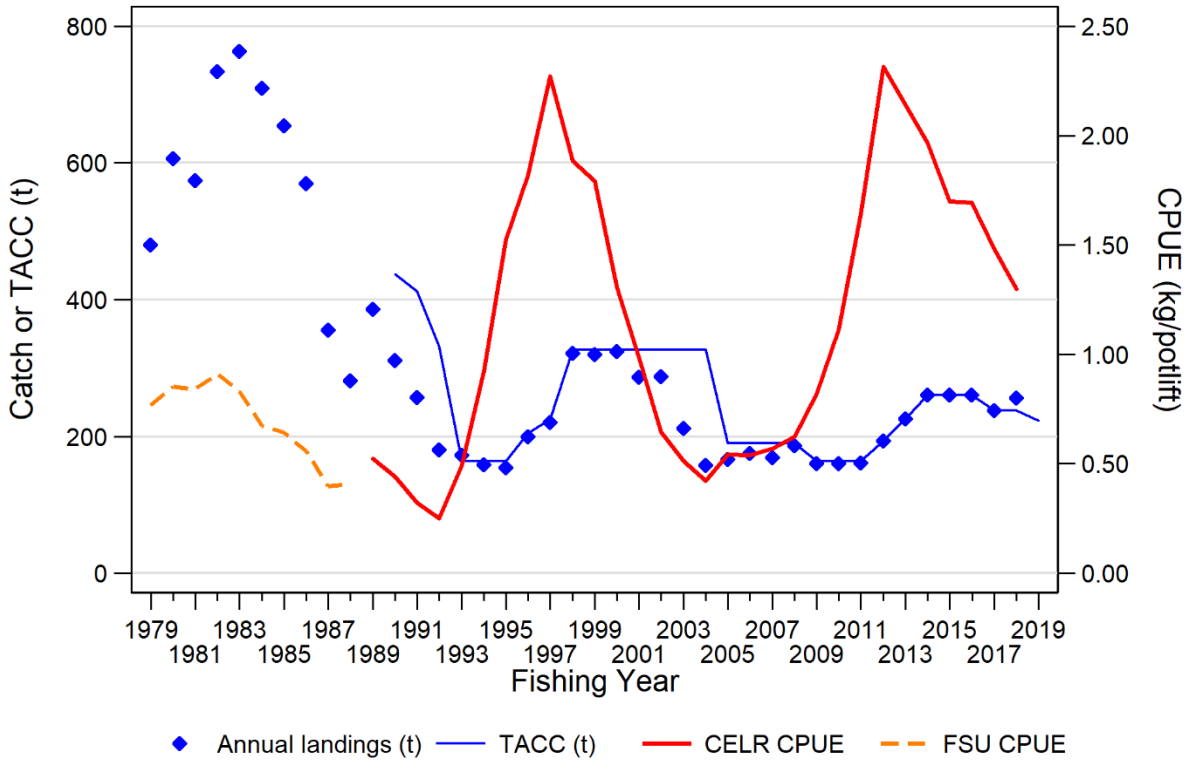


Figure 3: **Plot of annual commercial landings (tonnes), the TACC (tonnes), and the annual standardised CPUE index by fishing year, 1979–2018.**

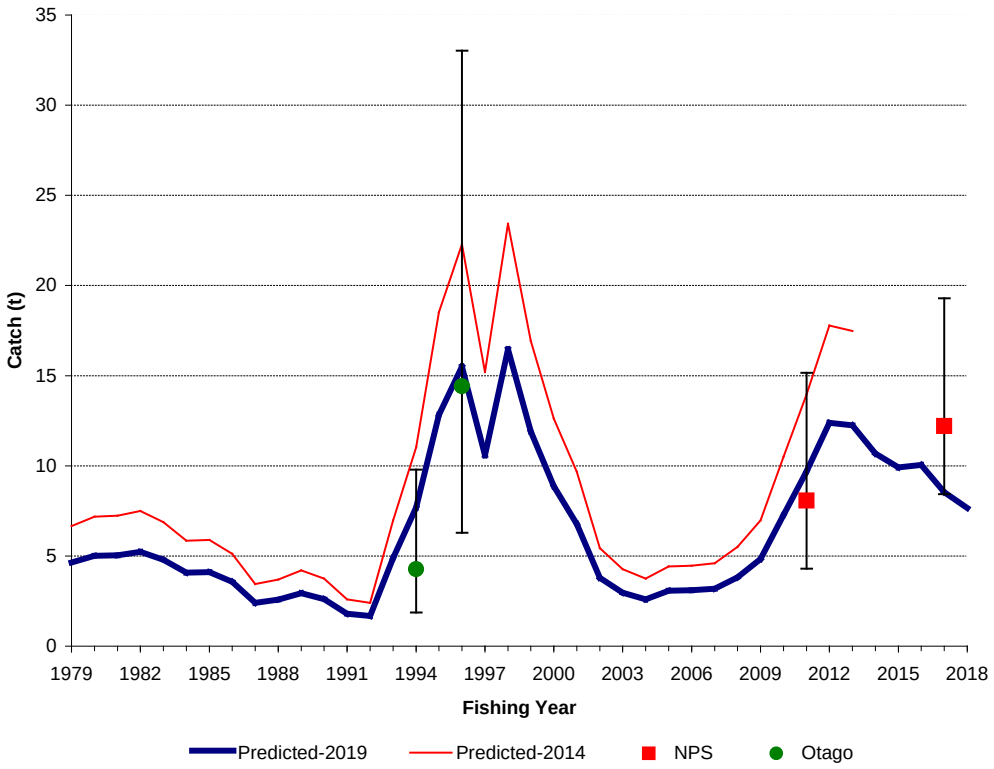


Figure 4: **CRA 3 recreational catch trajectory (tonnes) (Eq. 2) based on the unstandardised (geometric mean) SS seasonal CPUE series fitted to four recreational catch surveys (Eq. 1 and Table 1). Error bars are ±2 SE, assuming a lognormal distribution, with the upper error bars for the two Otago estimates suppressed. Also shown is the equivalent recreational catch series used in the 2014 CRA 3 stock assessment.**

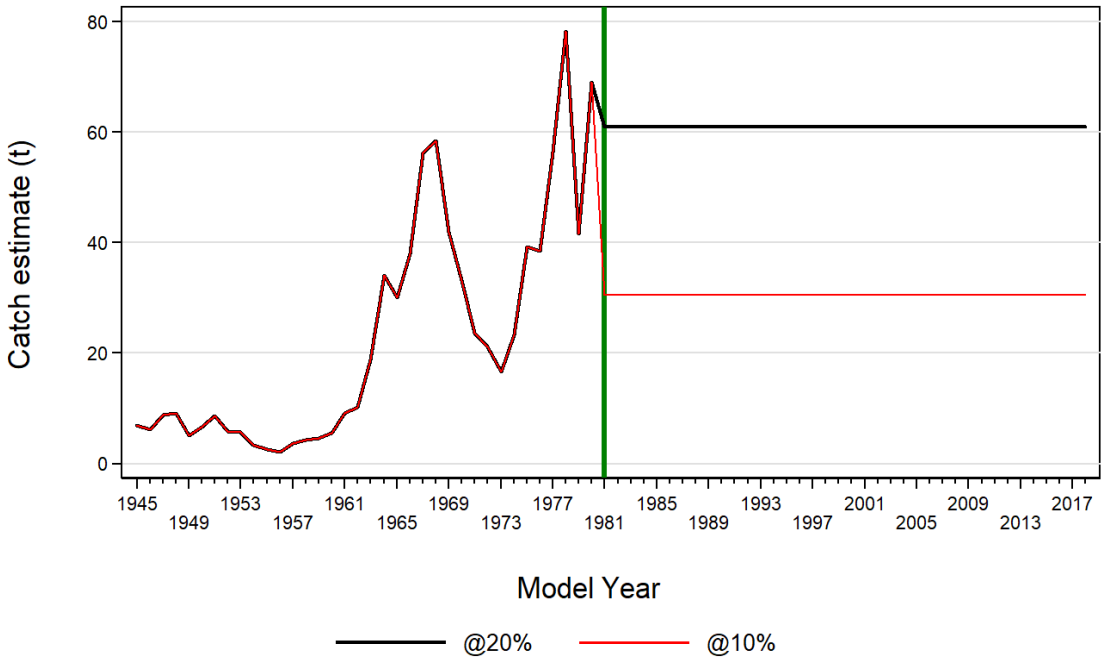


Figure 5: **CRA 3 illegal catch trajectories under two assumptions discussed at the RLFAWG meeting held 19 September 2019: post-1980 illegal catches sum to 10% or 20% of the total 1981–2018 CRA 3 commercial catch. Each of these post-1980 trajectories assume an equal catch in every year, starting in 1981. Both trajectories use the McKoy 'export discrepancy' procedure to set illegal catches from 1945 to 1980. There were no `illegal reported' estimates for CRA 3. Compliance reports at 4.5% of the total illegal catch which was applied to the above illegal catches from 1981 to 2011 (not plotted).**

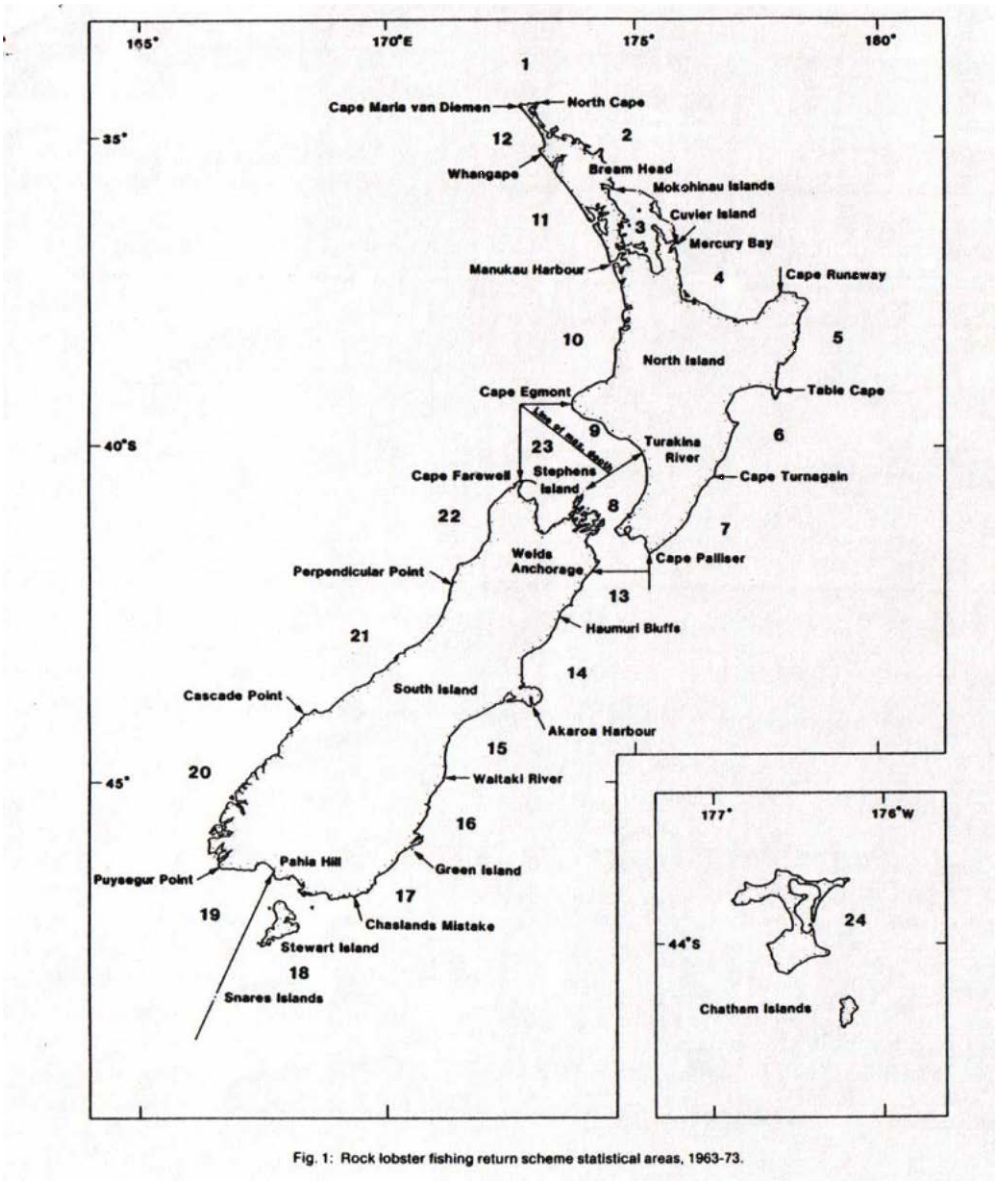
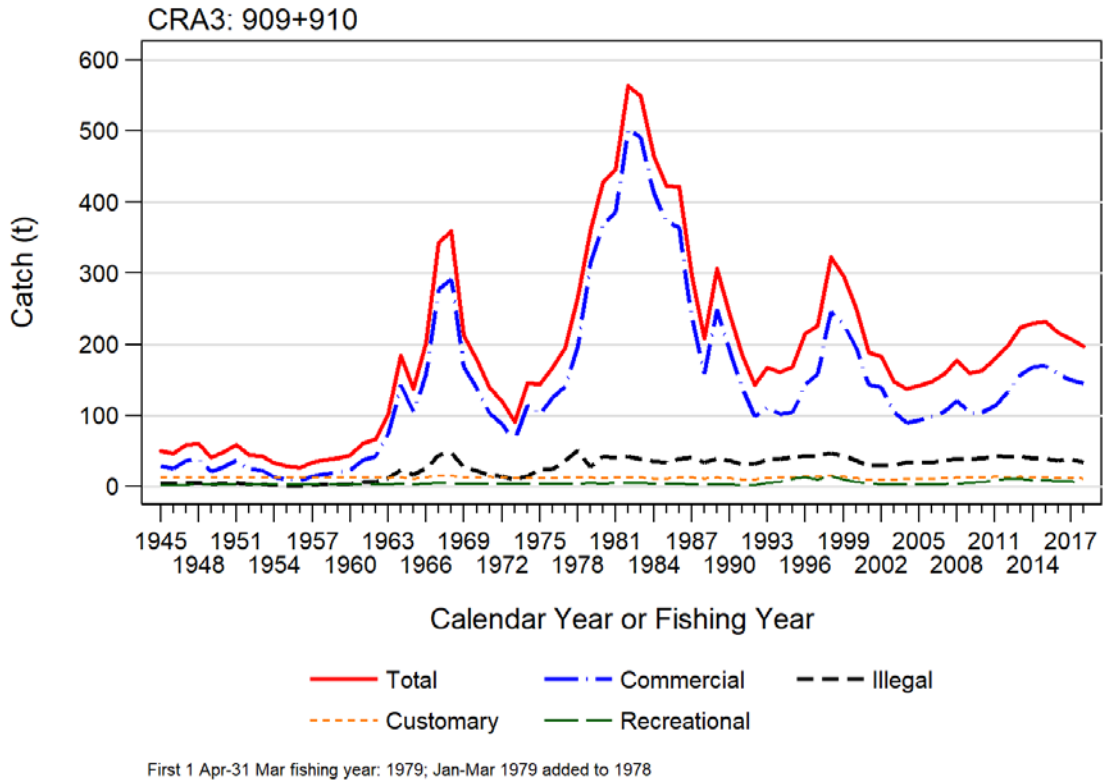


Fig. 1: Rock lobster fishing return scheme statistical areas, 1963-73.

Figure 6: Map showing Annala & King statistical areas (from Annala & King 1983).



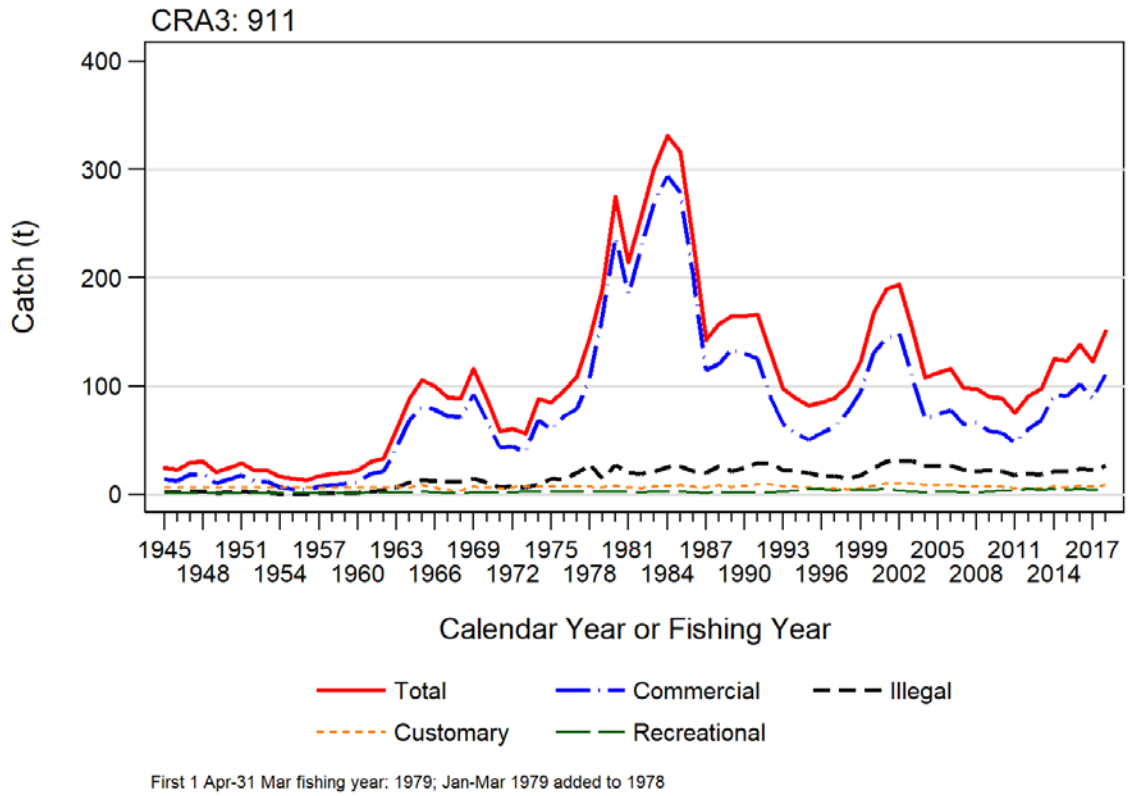


Figure 7: **Commercial, recreational, illegal, and customary catch trajectories for the two CRA 3 regions defined by rock lobster statistical areas (Table D.1). Year codes are annual before 1979 and from 1979 onward refer to the first year in the statutory 1 April-31 March fishing year. Catches from January-March 1979 have been added to 1978.**

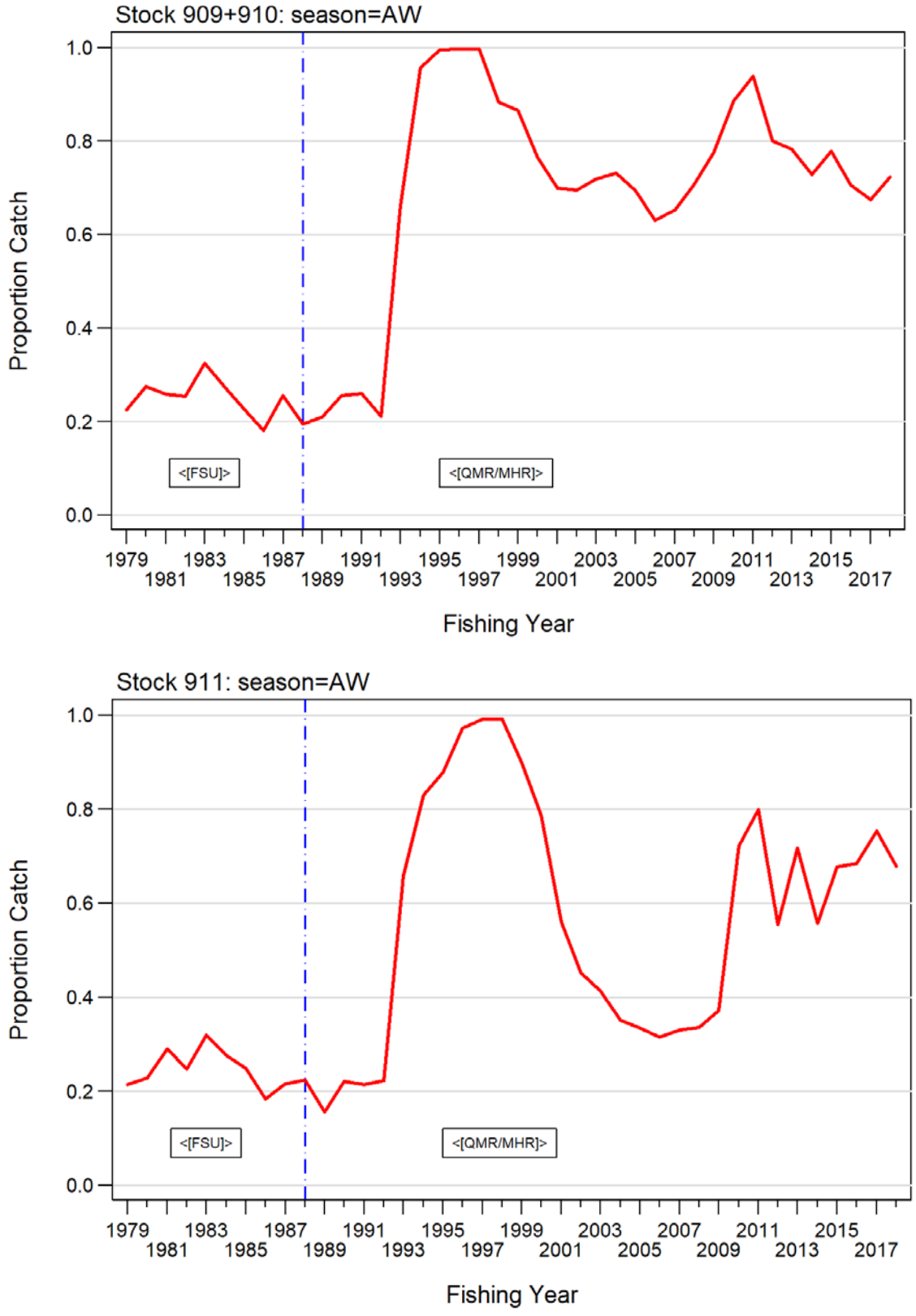


Figure 8: **Seasonal proportion of the commercial AW catch by fishing year for the two CRA 3 regions defined by rock lobster statistical areas (Table D.1). These proportions have been derived from reported landings by month from the FSU or CELR catch reporting systems using the F0_LFX algorithm (Starr 2019).**

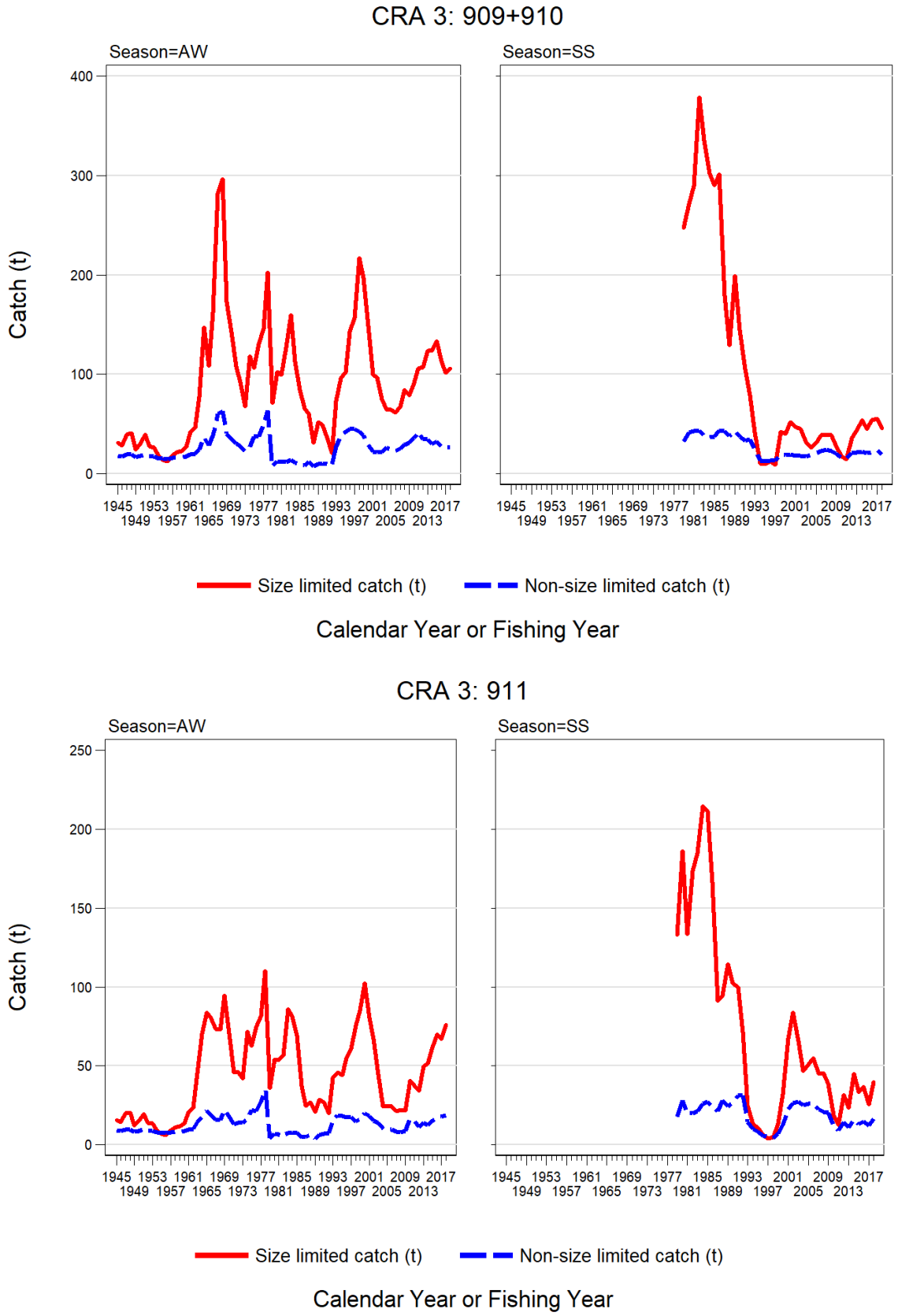


Figure 9: **The seasonal SL (size-limited) and NSL (non-size-limited) catches (t) for the two CRA 3 regions, defined by rock lobster statistical areas (Table D.1), plotted by calendar year from 1945 to 1978 (January-March 1979 added to 1978) and by 1 April-31 March fishing year from 1979 onwards.**

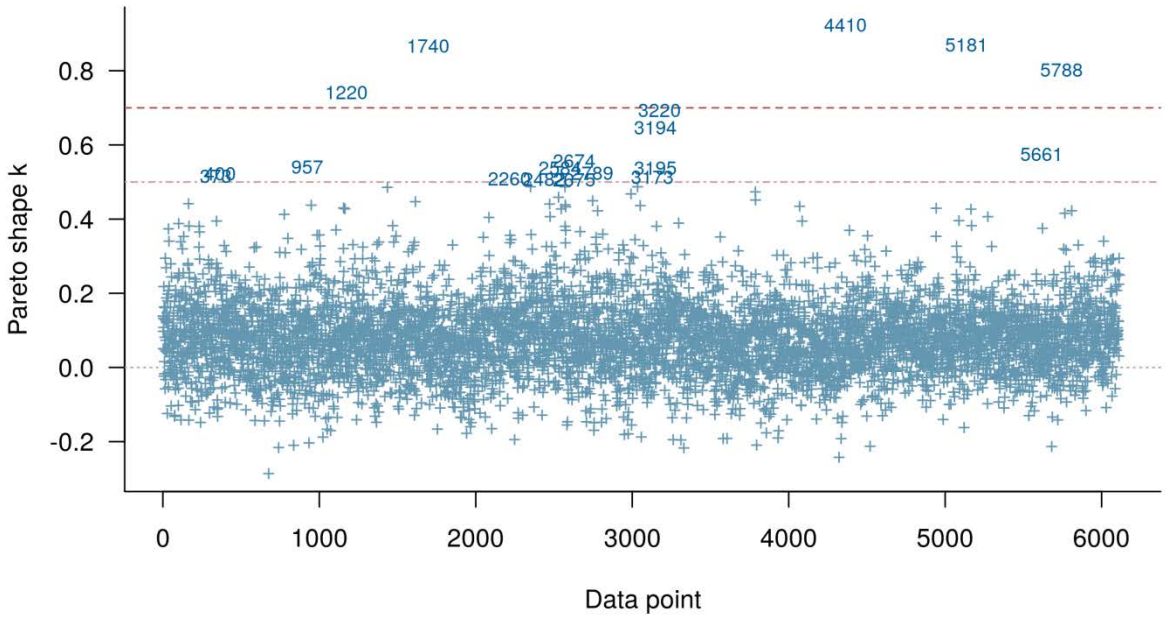


Figure 10: Interaction model: tail shape (Pareto shape parameter *k*) estimates for each point's contribution to the leave-one-out information criteria (LOOIC). Almost all points fall below the preferred threshold k < 0.7, with the majority of estimates below k < 0.5 (where the distribution of raw importance ratios has a finite variance and the central limit theorem holds) which is considered ideal (Vehtari et al. 2017).

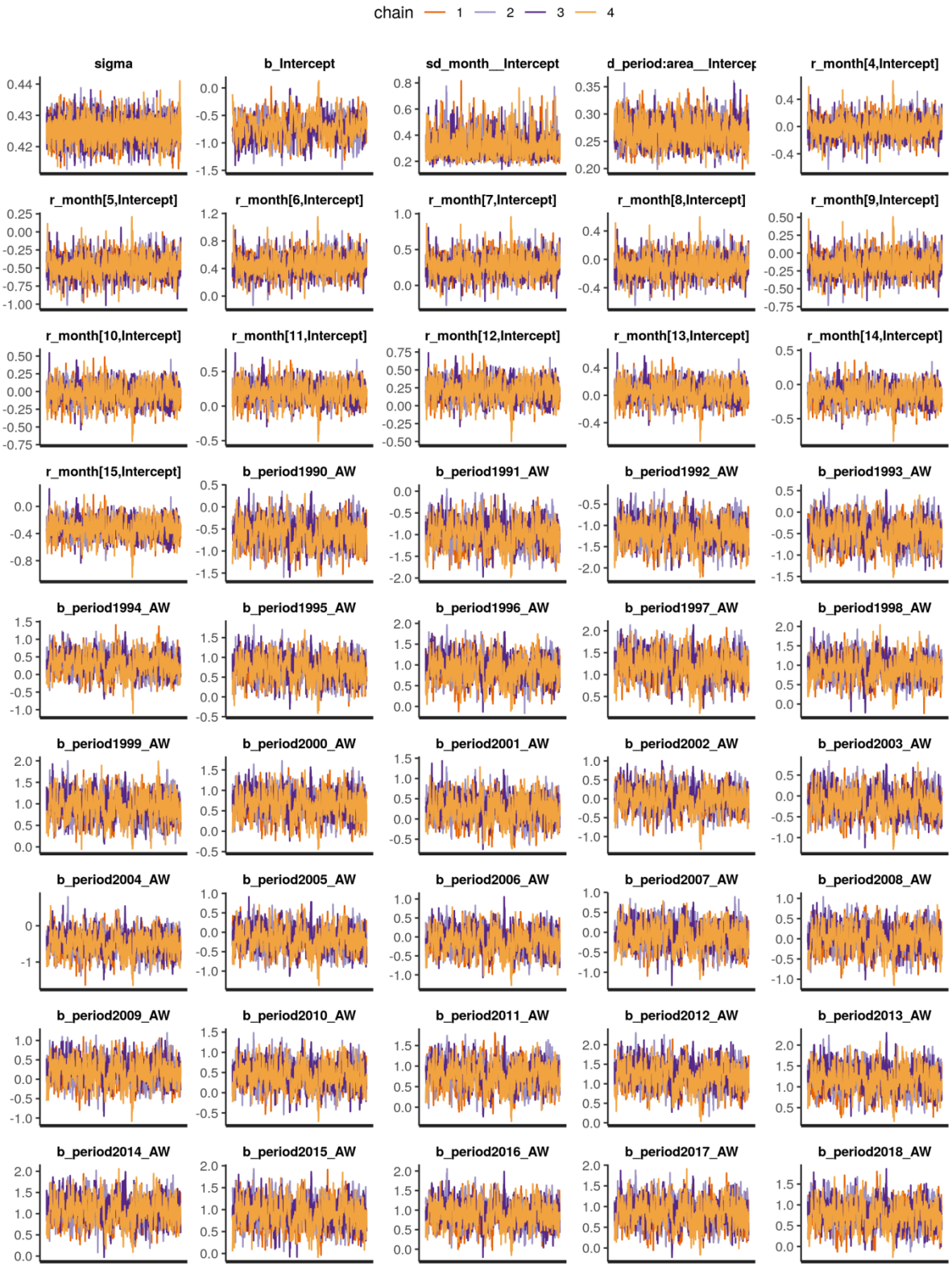


Figure 11: Trace plots of the MCMC posterior samples for parameters and coefficients of the interaction model.

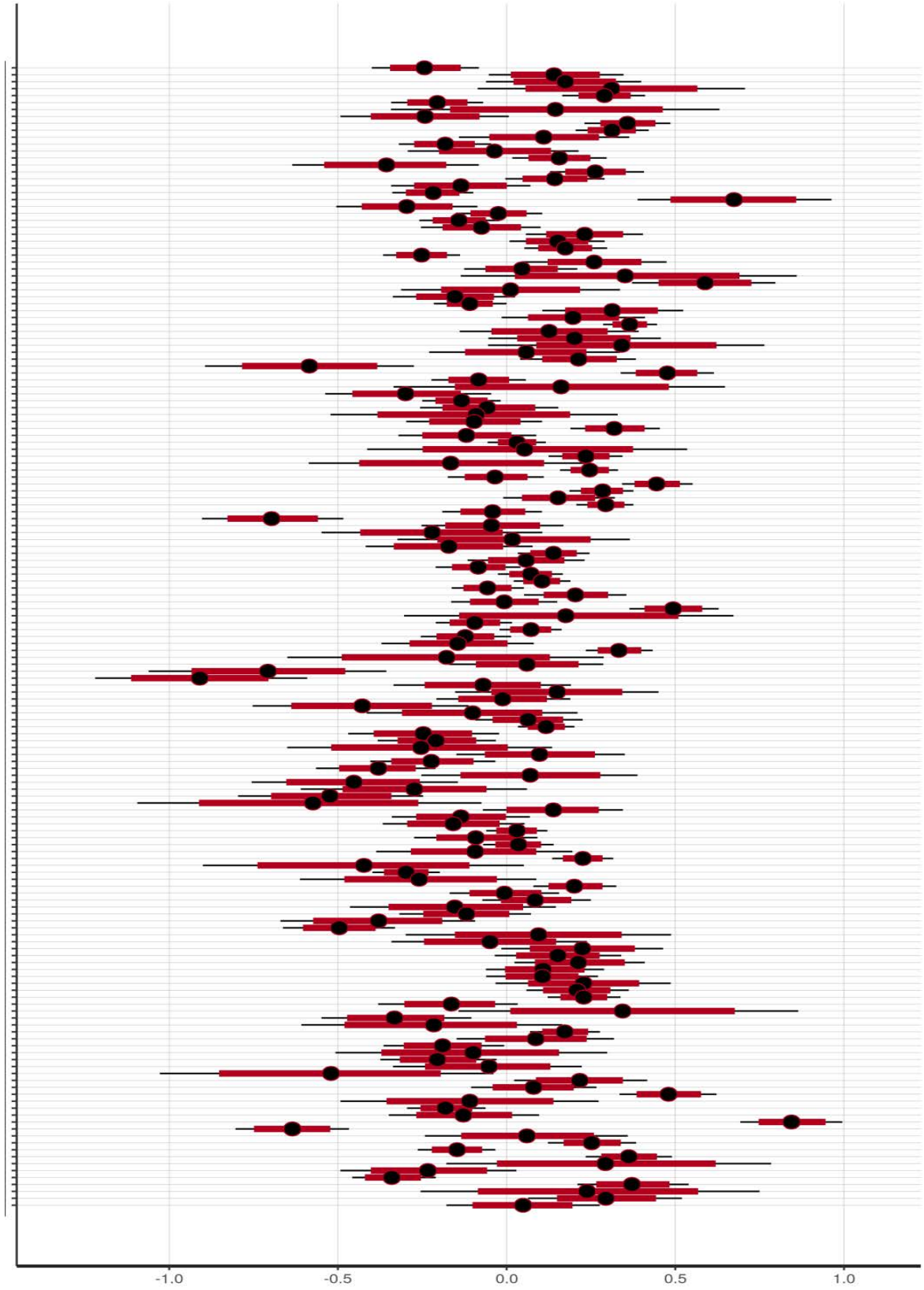


Figure 12: Coefficients for vessels with at least five years of data from the CRA 3 seasonal CPUE standardisation (interaction model). Vessel coefficients are estimated as group-level effects. MCMC median (black dots), MCMC 95% credible interval (red bars), MCMC marginal posterior distribution range (black bars).

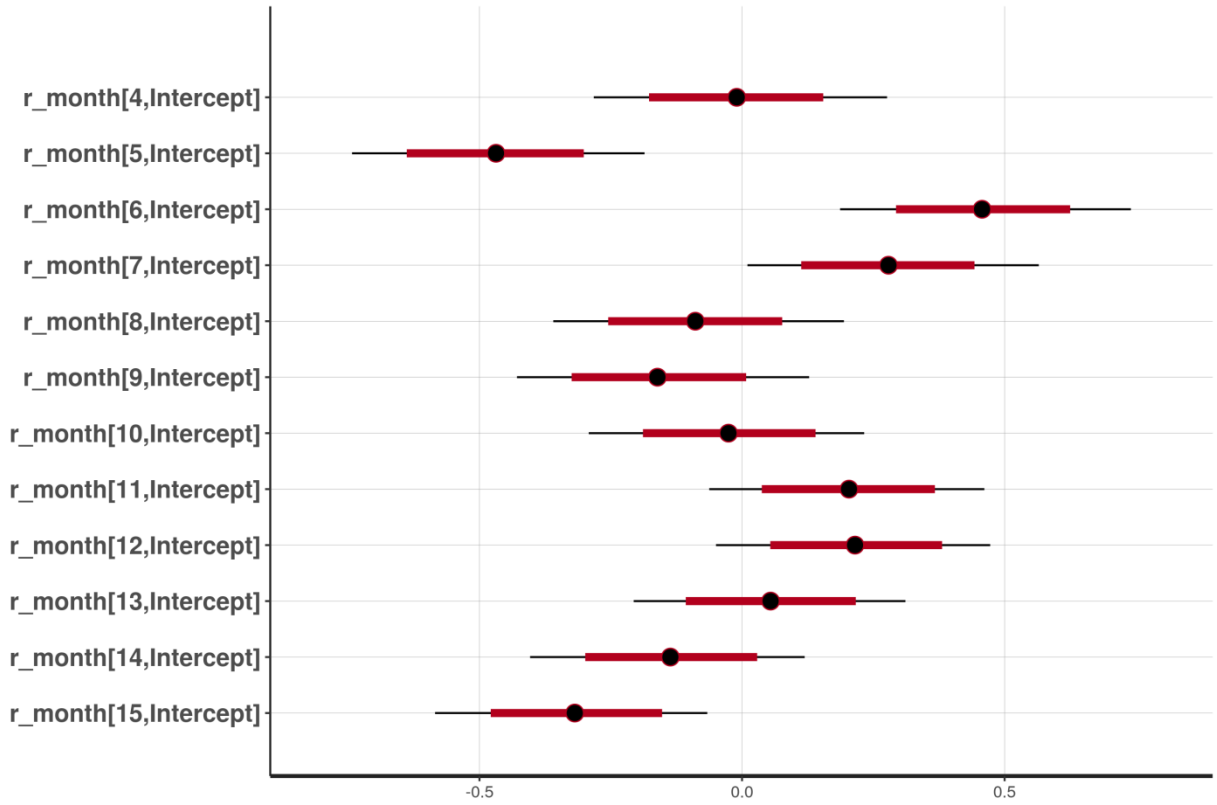


Figure 13: **Coefficients for month from the CRA 3 seasonal CPUE standardisation (interaction model). Month coefficients are estimated as group-level effects. MCMC median (black dots), MCMC 95% credible interval (red bars), MCMC marginal posterior distribution range (black bars).**

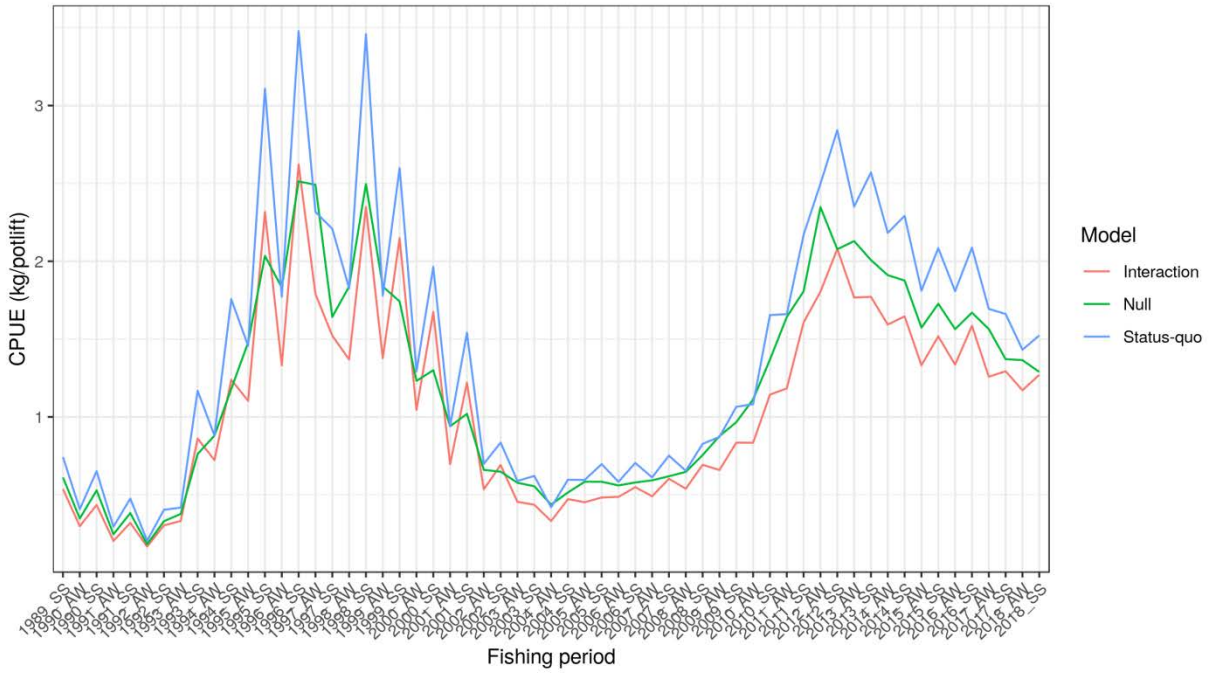


Figure 14: **Median CPUE indices (kg/potlift) by season and fishing year from 1989–90 to 2017–18 for the three CRA 3 seasonal CPUE models presented.**

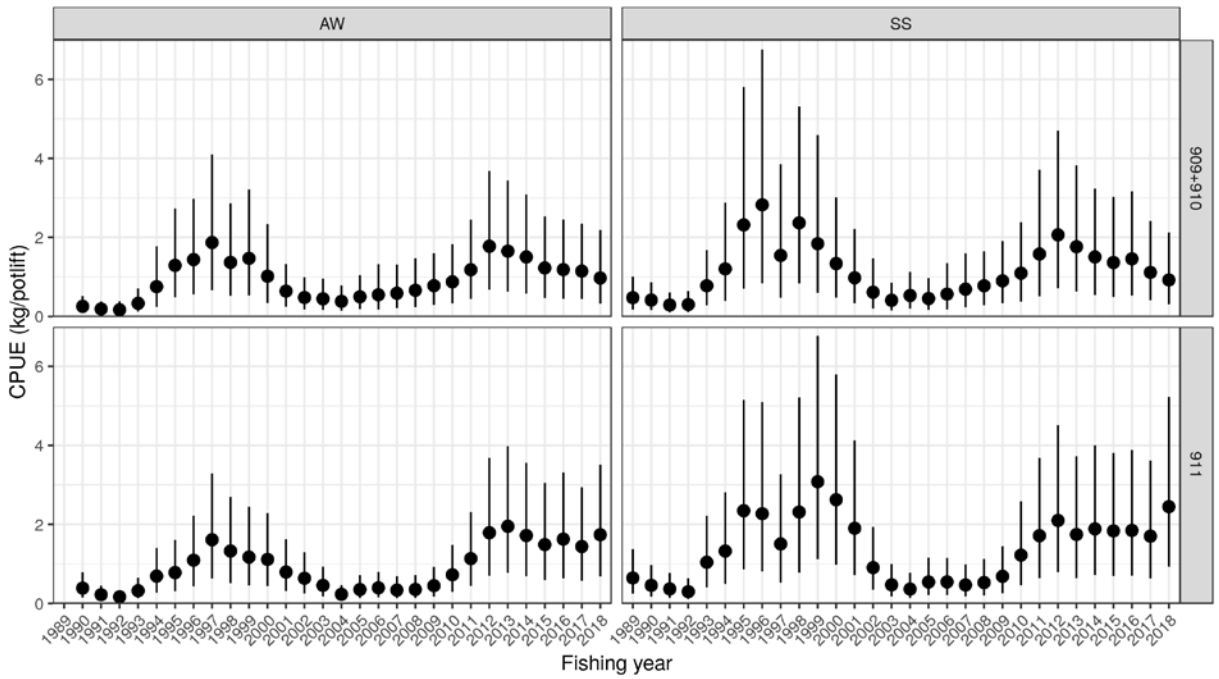


Figure 15: **CPUE indices (kg/potlift) by season and fishing year for the CRA 3 seasonal CPUE GLM analysis which included a vessel variable filtered for vessels with at least five years of data using the F2 algorithm scaled to "LFX" landings from 1989–90 to 2017–18: AW and SS. MCMC sample median (points) and 95% credible interval (lines) for the interaction model.**

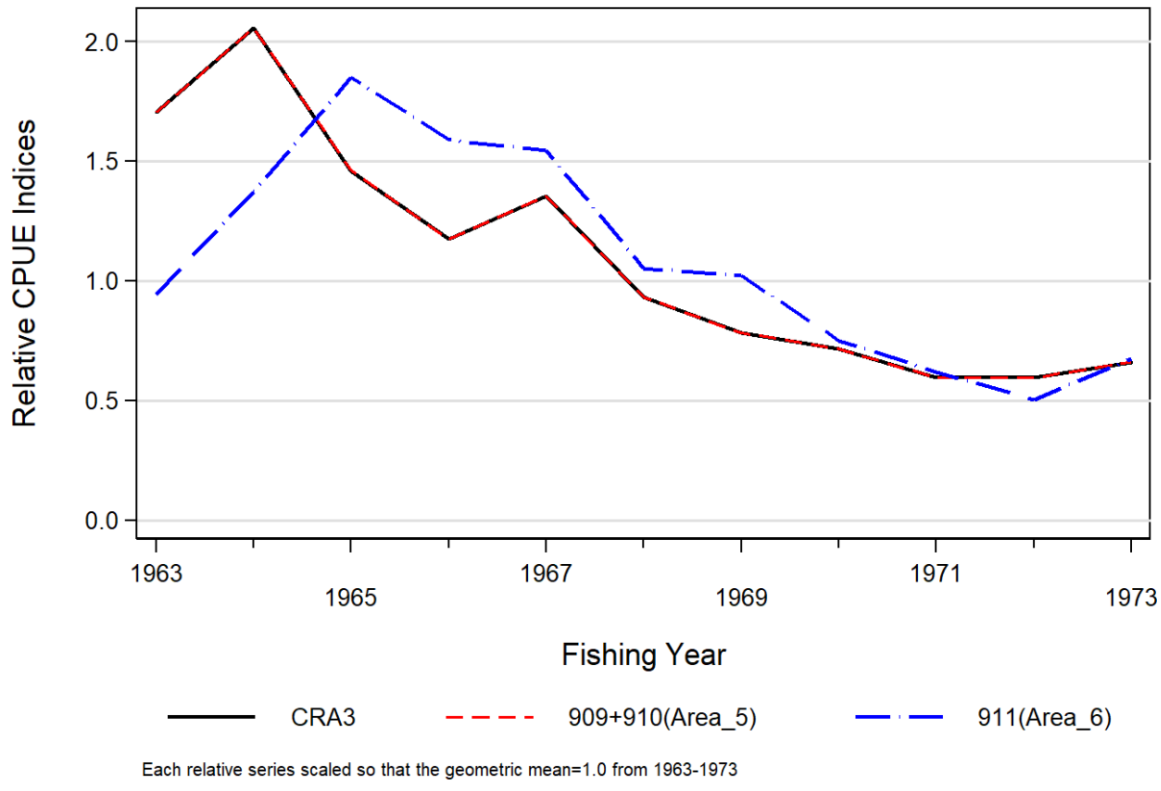


Figure 16: **Annala & King catch rates (Table 17), normalised to the geometric mean, plotted for the two CRA 3 regions and the overall CRA 3 (which is the same as the Areas 909+910 series).**

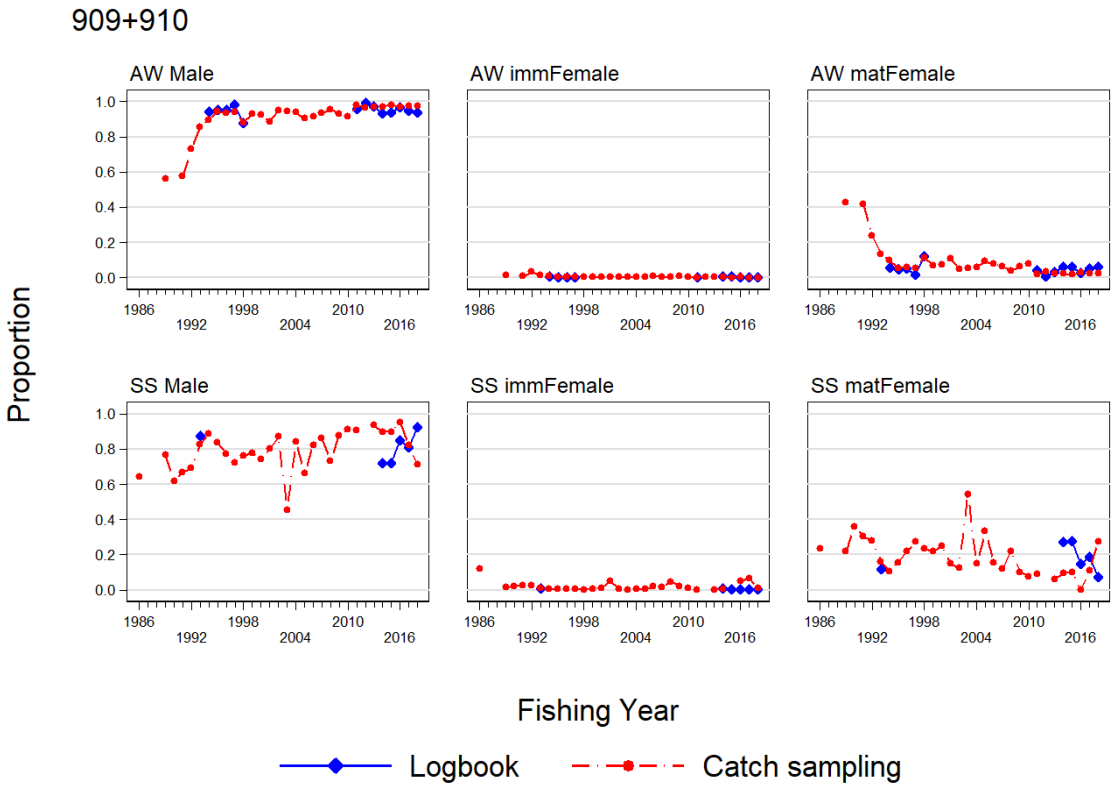


Figure 17: Proportion-at-sex by year, season, maturity stage, and sampling source for 909+910.

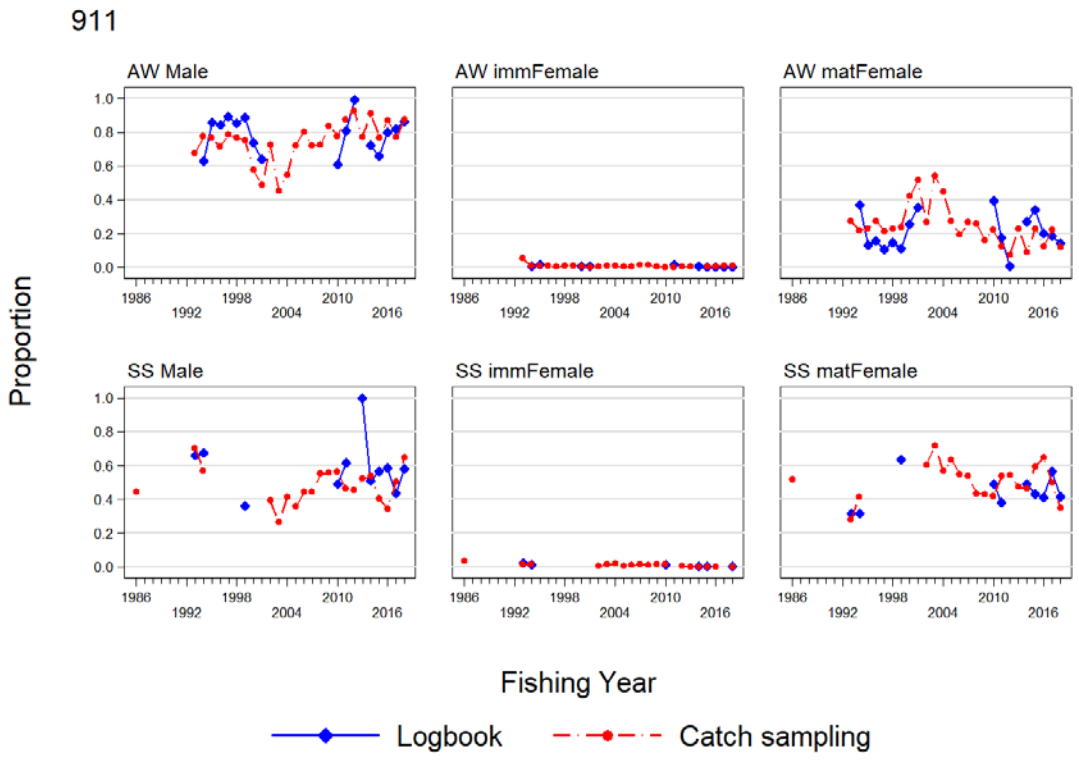


Figure 18: Proportion-at-sex by year, season, maturity stage, and sampling source for 911.

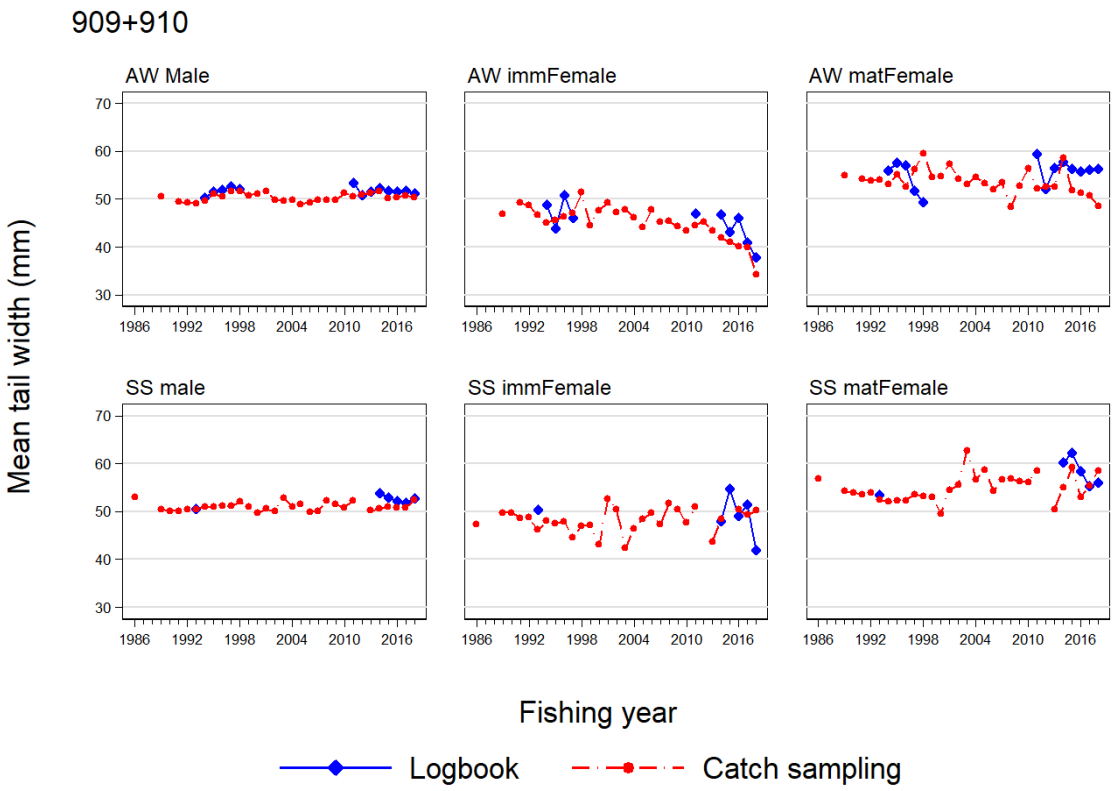


Figure 19: Mean length by year, season, sex, and sampling source for 909+910.

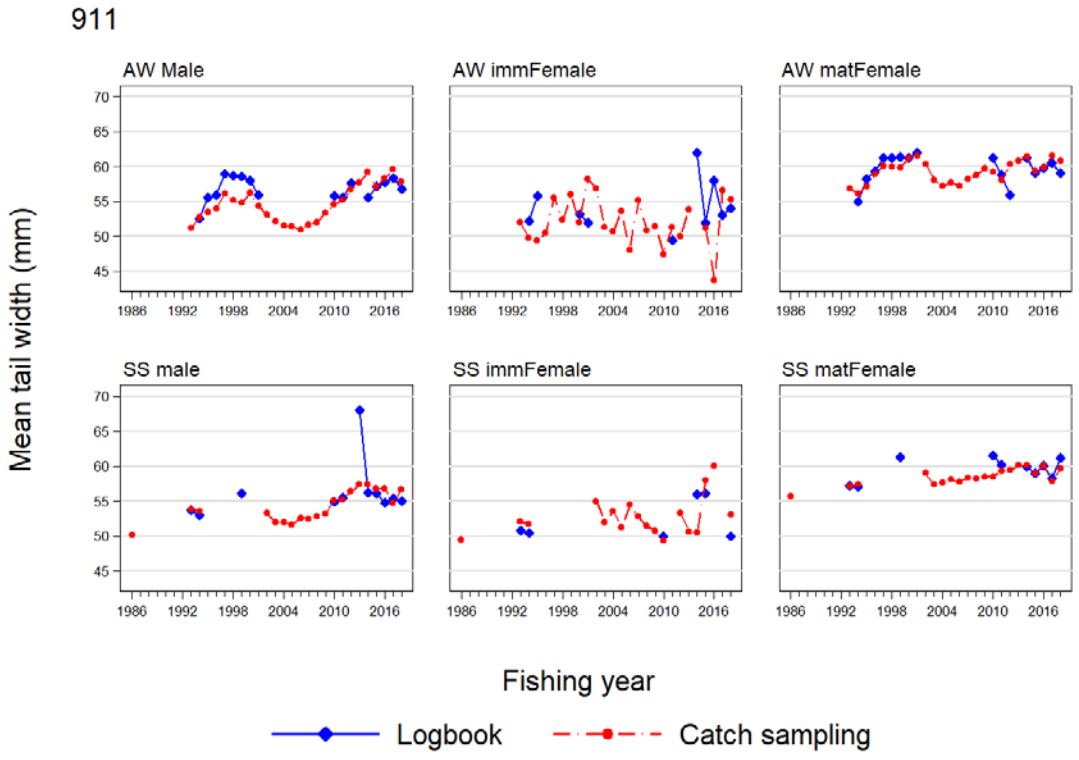


Figure 20: Mean length by year, season, sex, and sampling source for 911.

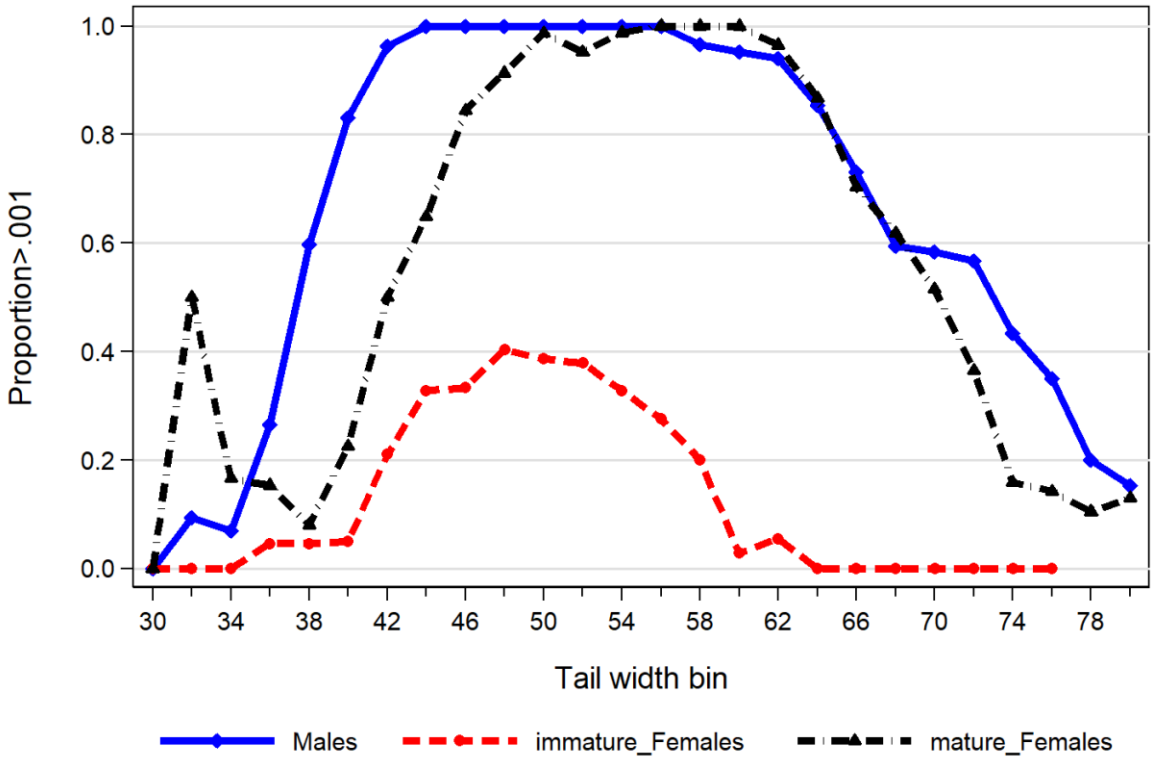


Figure 21: **The proportion of size bins (across 86 year/season/sampling source strata) that contain a proportion of 0.001 or higher when the data are normalised by sex. Length bins with little or no data will have a low proportion on this figure.**

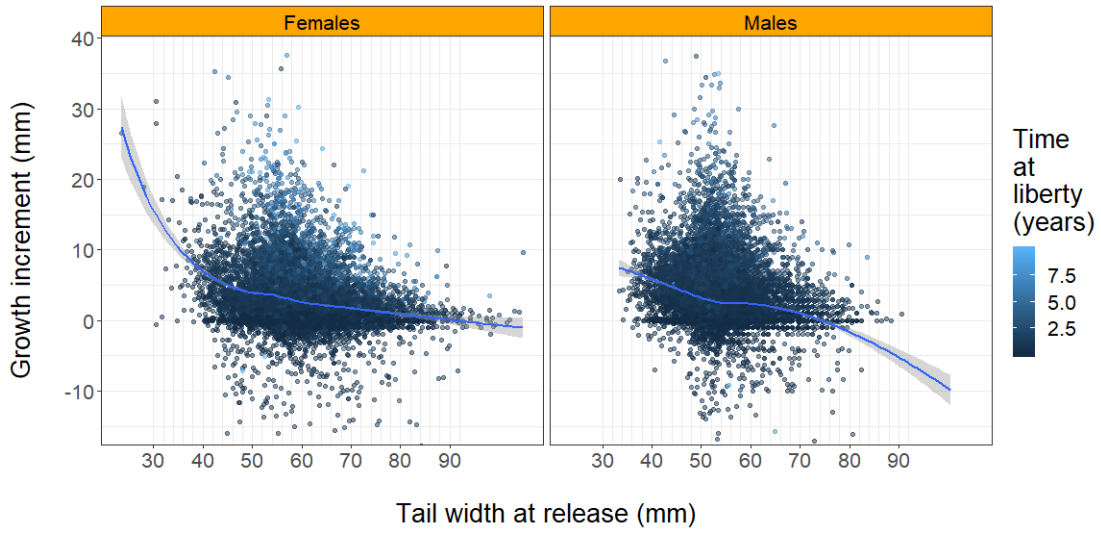


Figure 22: **Growth increments (mm) by size at release (mm) and sex for all NZ tag recapture events. The colour of each point represents the time at liberty (years). A loess smoother and the 95% confidence interval about this smoother is also shown.**

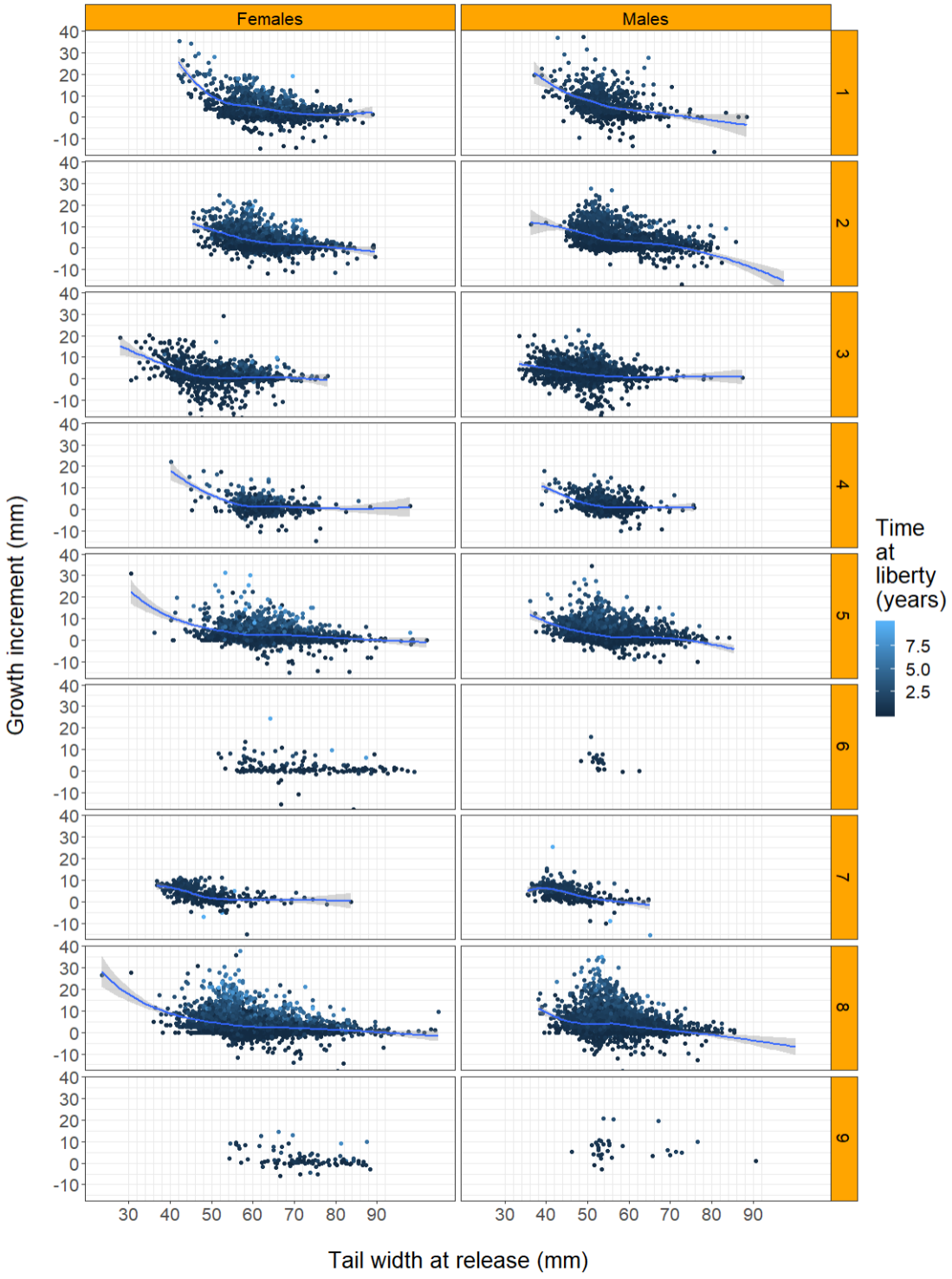


Figure 23: **Growth increments (mm) by size at release (mm), sex, and QMA, summed across all recovery years. The colour of each point represents the time at liberty (years). A loess smoother and the 95% confidence interval about this smoother is also shown.**

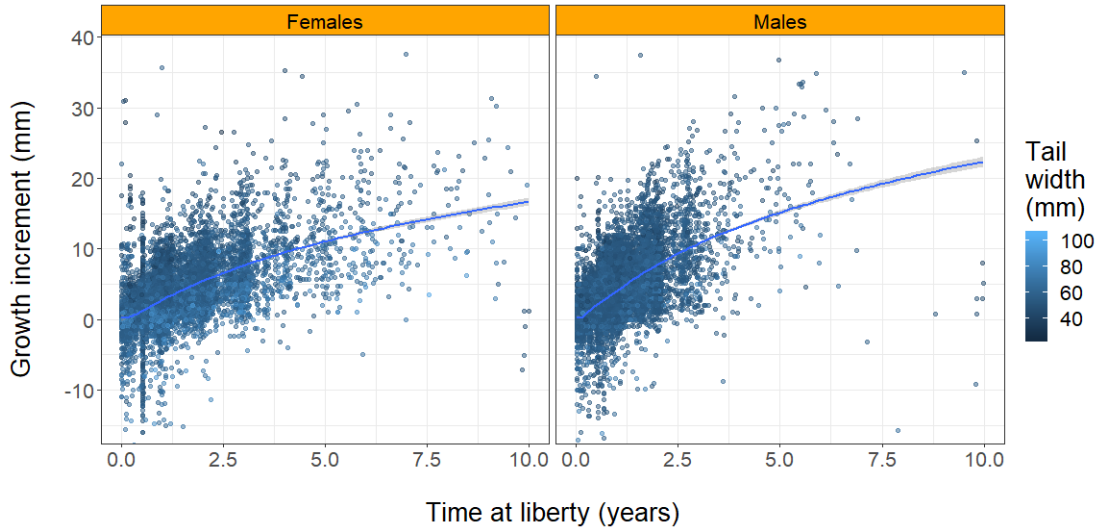


Figure 24: **Growth increments (mm) by time at liberty (years) and sex for all NZ tag recapture events. The colour of each point represents the size at release (mm). A loess smoother and the 95% confidence interval about this smoother is also shown.**

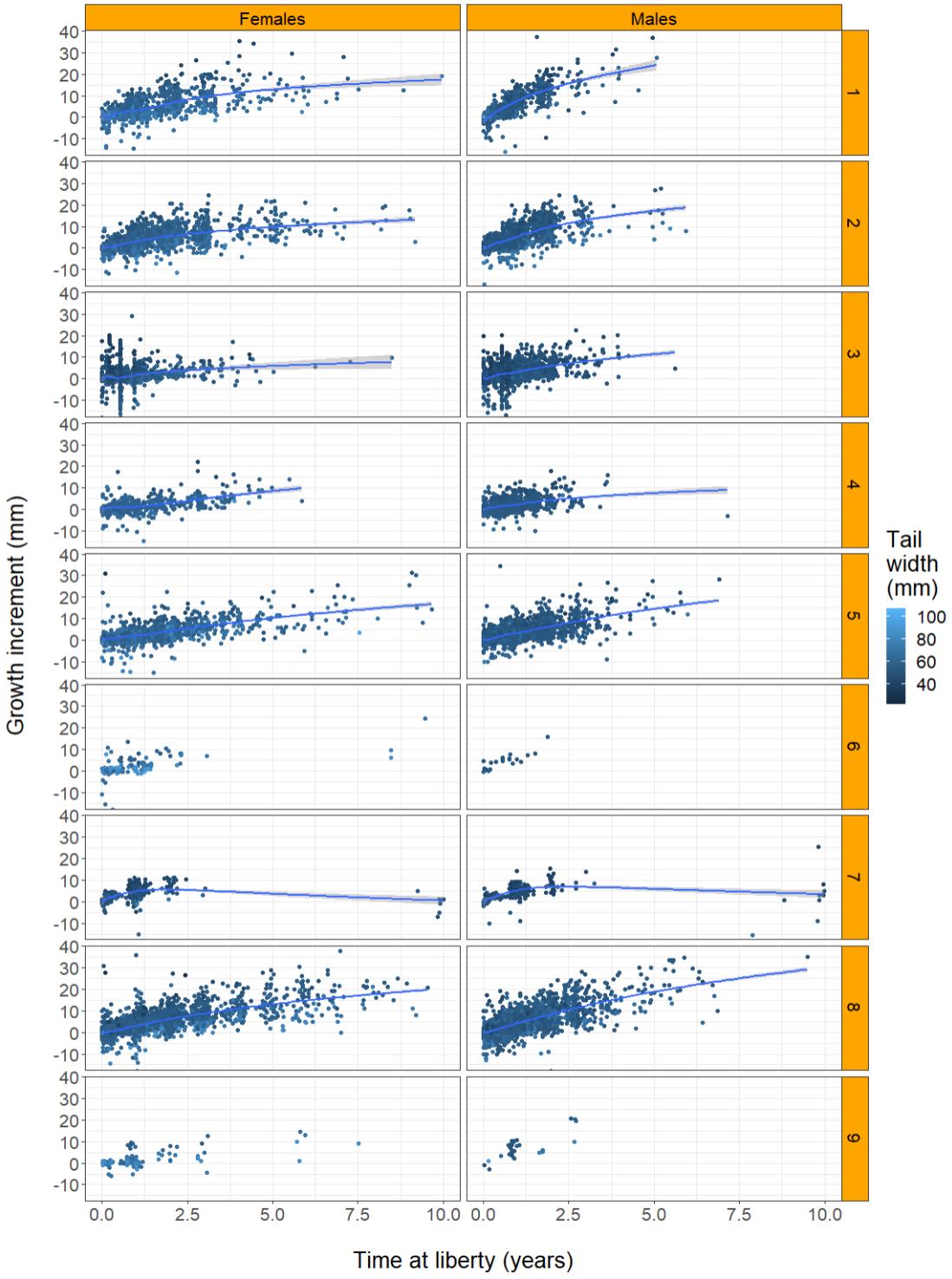


Figure 25: **Growth increments (mm) by time at liberty (years), sex, and QMA summed across all tag recapture years. The colour of each point represents the size at release (mm). A loess smoother and the 95% confidence interval about this smoother is also shown.**

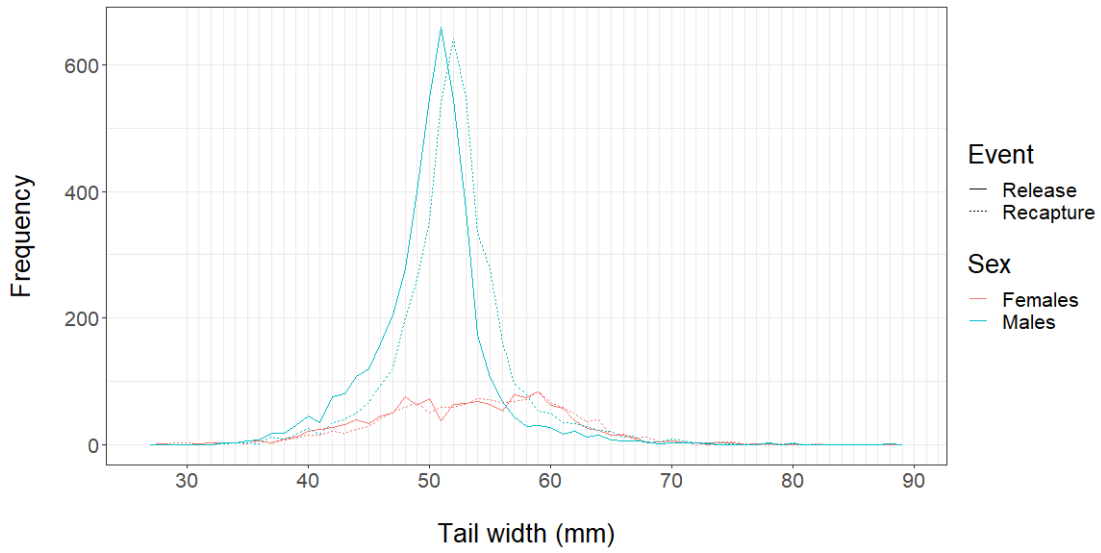


Figure 26: CRA 3 frequency polygons of size at release (solid lines) and recapture (dashed lines) by sex. A bin width of 1 mm was used.

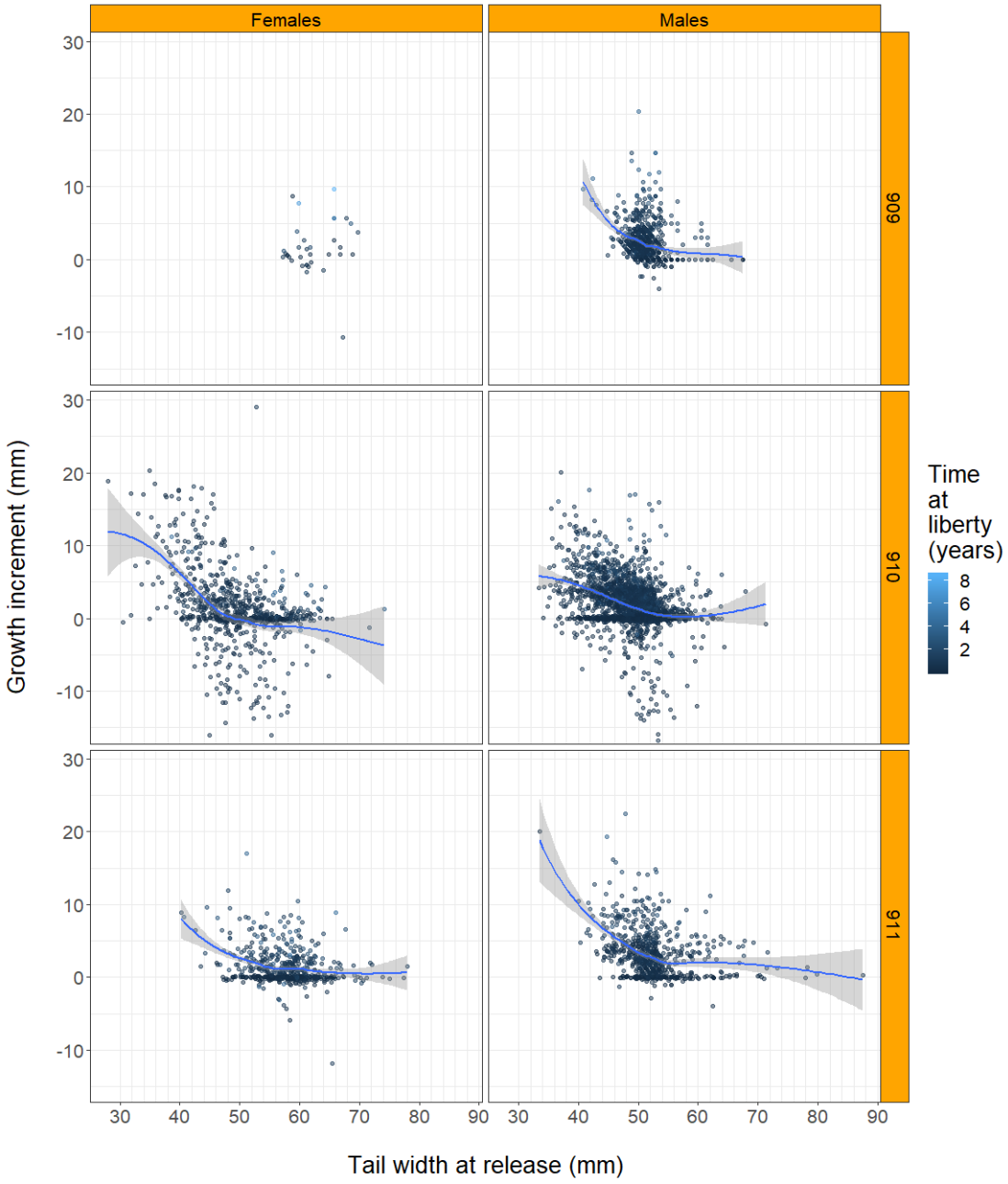


Figure 27: **CRA 3 growth increments (mm) by size at release (mm) and sex in each statistical area, showing all recapture events. The colour of each point represents the time at liberty (years). A loess smoother and the 95% confidence interval about this smoother is also shown for each panel.**

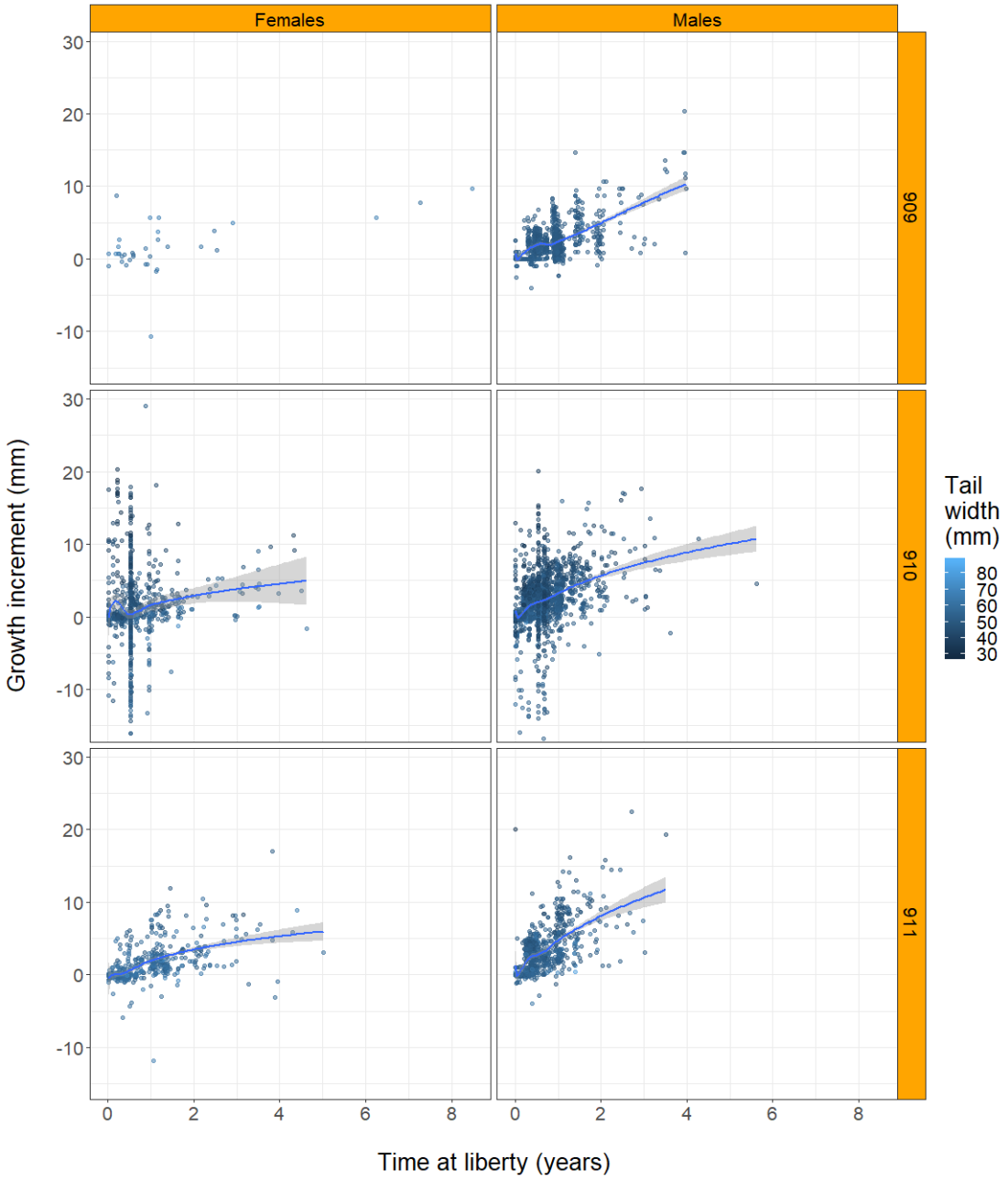


Figure 28: **CRA 3 growth increments (mm) by time at liberty (years) and sex in each statistical area, showing all recapture events. The colour of each point represents the tail width (mm). A loess smoother and the 95% confidence interval about this smoother is also shown for each panel.**

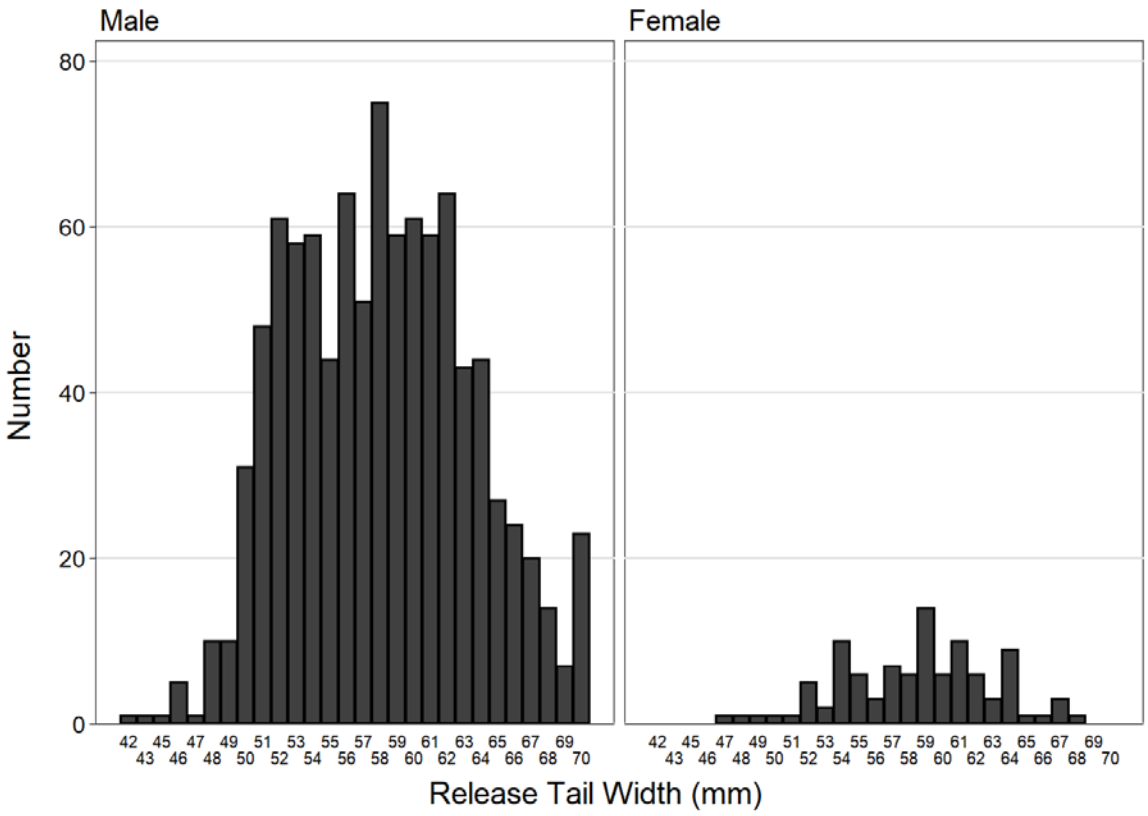


Figure 29: Frequency distribution of tail widths for all recaptures by sex from the Te Tapuwae o Rongokako marine reserve.

APPENDIX A. LETTER TO FISHERIES NEW ZEALAND REQUESTING NON-COMMERCIAL CATCH INFORMATION

NZ ROCK LOBSTER INDUSTRY COUNCIL

Ka whakapai te kai o te moana

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64 4 385 2727 FAX
lobster@seafood.co.nz

June 2019

Alicia McKinnon, Ministry for Primary Industries – Fisheries New Zealand

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

cc Marine Pomarede, Chair, RLFAWG
by email: *Marine.Pomarede@fish.govt.nz cc ECs:*
darcy@quantifish.co.nz
merrillrudd@gmail.com paul@starrfish.net

Dear Alicia

Under the objectives set out in MPI contract CRA 2018/01, in September and October of this year, the stock assessment team will be conducting a CRA 1 stock assessment and a CRA 3 stock assessment and developing the management procedure options.

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

The team has no access to customary or illegal catch information.

The stock assessment cannot ignore the current and historical non-commercial catches: that would cause stock productivity to be greatly underestimated. In the absence of information, only MPI can solve the problem of what to assume for these components; it is up to MPI to specify the non-commercial catch assumptions that MPI wishes to be used in the stock assessment.

It is likely that the RLFAWG will request sensitivity analyses on catch series that are alternatives to the base case non-commercial catch vectors, but the base case non-commercial mortalities must be provided by MPI.

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

- **the MPI estimates of current and recent CRA 1 illegal catch and its historical trend**
- **the MPI estimates of current and recent CRA 3 illegal catch and its historical trend**

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

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

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

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

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

- **estimates of the current customary catch in CRA 1 and its historical trend**
- **estimates of the current customary catch in CRA 3 and its historical trend**

The assessment team also request:

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

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

- **estimates of the current recreational catch in CRA 1 and its historical trend**
- **estimates of the current recreational catch in CRA 3 and its historical trend**

The assessment team also request:

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

Without these estimates from MPI, it will not be possible to produce acceptable stock assessments. The assessment input data, including these estimates, are scheduled to be discussed at a RLFAWG meeting on
19th September 2019. These MPI estimates of non-commercial catches are thus required by:

- **12th September 2019**

Can you please confirm your understanding of this written request and advise likely delivery dates for these catch estimates? To assist the task, I will be happy to answer any questions you may have.

Sincerely,

Daryl Sykes

Research Programme Manager
NZ Rock Lobster Industry Council Ltd

APPENDIX B. FISHERIES NEW ZEALAND RESPONSE TO NON-COMMERCIAL DATA REQUEST

To: Daryl Sykes <lobster@nzrocklobster.co.nz>, Marine Pomarede <Marine.Pomarede@mpi.govt.nz>
CC: Sonja Hempel <Sonja.Hempel@mpi.govt.nz>, Mark Edwards <Mark.Edwards@nzrocklobster.co.nz>, Darcy Webber <darcy@quantifish.co.nz>, "paul@starrfish.net" <paul@starrfish.net>
Subject: Non-commercial harvest estimates for CRA1 and CRA3

Hi Daryl

Non-commercial catch estimates for the CRA1 and CRA3 stock assessments

Thank you for your request for information to support the upcoming stock assessments in CRA1 and CRA3. We do not have the information to accurately answer a number of the questions you pose as part of your data request.The following response provides guidance on what information should be considered for recreational, customary and illegal take within the stock assessment models.

Recreational harvest estimates

Available estimates of recreational rock lobster harvest for each stock are presented in the November Fisheries Assessment Plenary. This is while acknowledging that 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 (they are implausibly high for many species).

Missing from the November 2018 Plenary is the recently released 17/18 National Panel Survey harvest estimates for rock lobster. These estimates can be found in the Fisheries Assessment Report here: https://fs.fish.govt.nz/Page.aspx?pk3D113&dk3D24728. These estimates should be considered as part of the new CRA1 and CRA3 stock assessments.

Customary harvest estimates

A summary of the information Fisheries New Zealand holds on CRA1 and CRA3customary harvest since the 07/08 April fishing year is provided in the attached excel file.This includes information provided under the Fisheries (Kaimoana) Regulations 1998, and the Fisheries (Amateur Fishing) Regulations 13 (previously Regulation 27A of the Fisheries (Amateur Fishing) Regulations 1986).

Based on the customary harvest information available, noting its incompleteness and uncertainty, we consider it appropriate to continue to use a 10 tonne constant customary catch estimate for CRA1 and a 20 tonne constant estimate for CRA3.

Illegal take estimates

Estimating illegal removals is inherently difficult, as by its nature it is hard to detect. We acknowledge that historical illegal take estimates are highly uncertain and that we do not currently have a robust and defensible methodology to accurately estimate illegal take from any New Zealand fishery (be it rock lobster or another species). We are currently working on solutions to this issue, including looking at the metrics compliance collect (i.e. compliance breach rates) and how we can make improvements to the FOCUS system compliance use to record inspection and enforcement information (i.e. based off the recommendations provided in the 12 MRAG report). Having better quality compliance information, will hopefully allow us to better estimate illegal take in time (a challenge in itself).

Based on our experience and knowledge of the CRA1 and CRA3 fisheries, and compliance monitoring, knowledge and intelligence, we propose that the illegal take estimates for CRA1 and CRA3 are reduced to 40 and 50 tonnes respectively. This recognises that illegal take is unlikely to be at 72 tonnes for CRA1 and 89.5 tonnes for CRA3, but acknowledges that illegal take is still at reasonable levels in these fisheries. We propose that theCRA1 illegal take is ramped down from 72 tonnes in 01 to 40 tonnes in 19, and the CRA3 illegal take estimate is ramped down from 89.5 tonnes in 03 to 50 tonnes in 19.As you suggest in your request, we recommend that sensitivity trials are carried out to test for robustness to uncertainty in the illegal take assumptions.

Happy to discuss ahead of the RLFAWG next week.

See you then.

Cheers

Alicia

Alicia McKinnon | Senior Fisheries AnalystFisheries Management | Fisheries New Zealand - Tini a TangaroaMinistry for Primary Industries | 21 Domett Street, Ahuriri | P O Box 134 | Napier

APPENDIX C. DISTRIBUTION OF DESTINATION CODES IN CRA 3 LANDING DATA

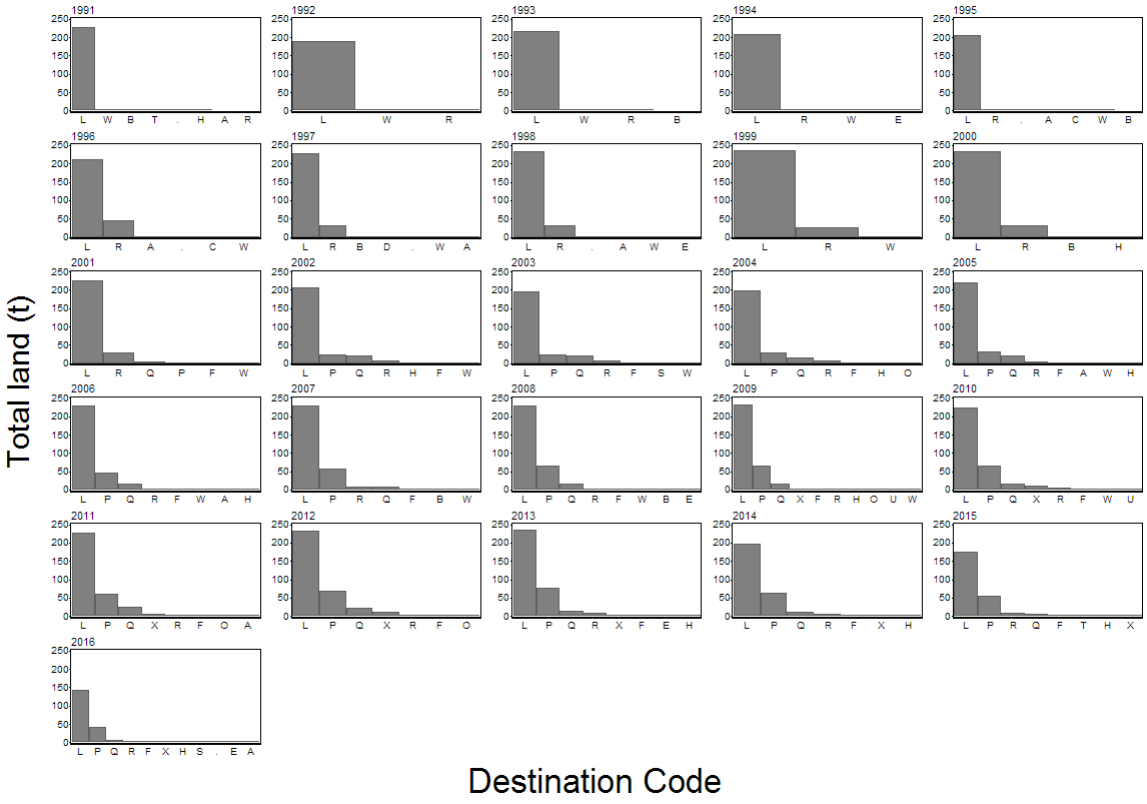

Figure C.1: Plot showing destination codes reported by fishing year in CRA 3. Only the destination codes reported in each year are shown in descending order of total annual landings. Full stop on the x-axis indicates no destination code specified.

Table C.1: Destination codes used by MPI.

Destination code	Description	How used in procedure
A	Accidental loss	Keep
C	Disposed to Crown	Keep
E	Eaten	Keep
F	Section 111 Recreational Catch	Keep
H	Loss from holding pot	Keep
L	Landed in NZ (to LFR)	Keep
M	QMS returned to sea (Part 6A)	Keep
O	Conveyed outside NZ	Keep
S	Seized by Crown	Keep
U	Bait used on board	Keep
W	Sold at wharf	Keep
X	QMS returned to sea, except 6A	Keep
B	Bait stored for later use	Drop
D	Discarded (non-ITQ)	Drop
P	Holding receptacle in water	Drop
Q	Holding receptacle on land	Drop
R	Retained on board	Drop
T	Transferred to another vessel	Drop
NULL	Nothing	Drop

APPENDIX D. EVIDENCE FOR REGIONAL SEPARATION IN CRA 3

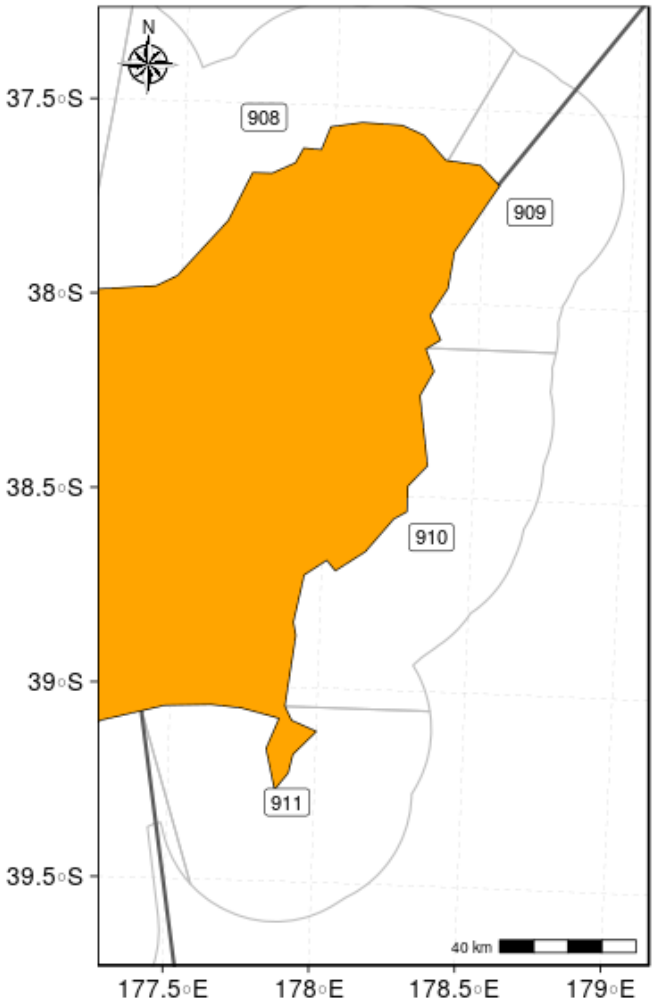

Figure D.1: Map showing location of CRA 3 statistical areas.

The stock assessment team has evaluated the evidence for separating CRA 3 into two regions based on observed differences in recent unstandardised catch rates (Table D.1).

Table D.1: Sub-stock definitions for CRA 3 regions, showing the rock lobster statistical area definitions used (Figure D.1).

Region label	Statistical area definition	Region name
909+910	Area 909 + Area 910	East Cape and Gisborne
911	Area 911	Mahia Peninsula

D.1 COMPARISON OF LENGTH FREQUENCY (LF) DISTRIBUTIONS

Length frequency data for CRA 3 organised into the above regions were plotted by fishing year, season, and sex as empirical cumulative frequency distributions, using the summed weights for each tail width (TW) measurement after combining the two sources of length frequency data (logbook and catch sampling). The underlying statistics to these plots are provided in Table D.2.

The LF comparison plots are, including evaluation:

AW males	Figure D.2	most (22) of the comparisons show region 909+910 larger than region 911 and the remaining (4) have region 909+910 the same as region 911
SS males	Figure D.3	(14) of the comparisons have region 909+910 larger than Sub-stock 1, (6) are the same, and (2) have region 911 larger than region 909+910
AW mature females	Figure D.4	most (24) of the comparisons have region 909+910 larger than region 911, and only (2) of the comparisons are the same
SS mature females	Figure D.5	(11) of the comparisons have region 909+910 larger than region 911, (7) of the comparisons are the same, and (2) of the comparisons have region 911 larger than region 909+910

The stock assessment team considers this evaluation to be reasonably definitive, with most of the comparisons resulting in region 911 being larger than region 909+910 in all four of the sex/season categories. There were adequate number of lobsters measured in most year/season/sex strata (Table D.2). This relative consistency in the size difference between these two regions can be interpreted as evidence to assess these regions separately.

D.2 COMPARISON OF STANDARDISED CPUE SERIES

The catch and effort data for each of the defined regions were standardised in the usual way and compared in Figure D.6. The two regions show very similar trajectories up to 2012–13, when they both peak, after which they diverge, with the sub-stock 2 series continuing to increase while the region 911 series declines (Figure D.6). There is very little difference in the scaling between the two series, with both regions showing similar levels of relative abundance in terms of kg/potlift (Figure D.7).

D.3 CONCLUSION

The stock assessment team has reviewed this information, reaching the conclusion that the evidence for separating CRA 3 into these two regions is strong. There are consistent differences in the size distributions between the two regions across year, season, and sex categories. Although the CPUE series appear to be synchronous up to the early 2010s, they have since diverged in the most recent 5–6 years, with one series increasing and the other decreasing. Given these differences, the stock assessment team recommends assessing these two populations in a joint model, with separate data and unique parameters for each sub-stock. Some parameters, such as M, can be estimated jointly. The stock assessment team will determine the extent of parameter overlap in the final model.

Table D.2: Statistics for CRA 3 sub-regional analysis by sub-stock, sex, season, and fishing year.

	Number lobsters measured				Total weight			
Fishing	**AW**		**SS**		**AW**		**SS**	
year	**909,910**	**911**	**909,910**	**911**	**909,910**	**911**	**909,910**	**911**
Male								
1986	–	–	246	258	–	–	0.21	0.40
1989	1 310	–	5 652	–	4.71	–	9.77	–
1990	–	–	16 956	–	–	–	23.90	–
1991	1 252	–	17 684	–	0.50	–	21.25	–
1992	2 556	–	15 124	–	0.37	–	21.72	–
1993	17 720	2 716	28 306	6 236	22.51	1.99	166.78	35.16
1994	51 242	9 184	21 572	5 368	129.06	18.28	16.87	35.40
1995	47 500	7 658	14 942	–	156.05	14.79	9.28	–
1996	47 132	8 178	11 858	–	130.50	10.68	7.81	–
1997	38 180	4 096	13 620	–	61.08	5.62	8.16	–
1998	16 042	5 630	16 756	–	37.36	7.62	9.06	–
1999	10 014	2 574	13 230	56	9.82	7.59	8.50	0.23
2000	11 660	4 336	16 270	–	19.43	9.16	8.80	–

	Number lobsters measured				Total weight			
Fishing		**AW**		**SS**		**AW**		**SS**
year	**909,910**	**911**	**909,910**	**911**	**909,910**	**911**	**909,910**	**911**
2001	7 830	3 322	25 810	–	11.30	8.13	17.80	–
2002	14 218	3 044	9 828	2 574	36.56	4.58	5.00	3.18
2003	11 132	2 834	1 466	1 946	38.96	3.90	1.11	3.11
2004	10 074	1 584	6 946	2 080	30.89	2.59	4.21	4.32
2005	11 628	2 006	3 606	2 458	27.26	2.87	2.31	3.23
2006	13 446	1 834	3 230	2 382	33.65	2.24	3.78	3.21
2007	9 112	2 572	5 666	1 278	29.55	3.55	2.62	2.47
2008	7 794	1 552	10 194	2 556	22.50	1.46	19.36	5.05
2009	18 650	1 520	8 602	2 916	26.20	2.15	10.03	4.26
2010	16 052	2 628	5 982	836	34.95	3.25	19.64	3.84
2011	22 352	4 412	4 290	1 620	82.71	6.69	17.66	7.60
2012	20 768	1 146	–	3 432	43.72	1.62	–	6.51
2013	30 700	1 950	4 604	2 548	97.11	1.80	8.76	3.36
2014	20 098	2 478	18 244	4 360	56.66	4.85	24.51	11.65
2015	22 518	7 712	3 840	4 696	48.02	9.73	29.82	10.61
2016	19 546	7 922	8 484	1 690	31.31	16.66	33.59	5.70
2017	20 528	7 932	13 350	1 344	68.28	18.26	53.95	3.68
2018	21 018	5 896	13 142	3 018	63.39	16.02	28.03	6.79
Mature females								
1986	–	–	90	304	–	–	0.08	0.47
1989	1 176	–	2 060	–	3.57	–	2.80	–
1990	–	–	9 594	–	–	–	13.91	–
1991	904	–	8 426	–	0.36	–	9.64	–
1992	830	–	7 222	–	0.12	–	8.77	–
1993	3 098	1 086	6 834	2 628	3.53	0.79	25.46	15.59
1994	5 344	3 428	3 438	3 768	9.53	8.50	2.04	21.66
1995	2 888	2 102	2 814	–	8.12	3.14	1.75	–
1996	3 272	2 980	3 334	–	7.30	2.91	2.20	–
1997	2 664	1 012	5 136	–	3.30	1.03	3.08	–
1998	1 920	1 556	5 180	–	4.87	1.78	2.80	–
1999	622	644	3 694	98	0.70	1.46	2.37	0.41
2000	914	2 702	5 496	–	1.49	4.17	2.97	–
2001	952	3 238	4 932	–	1.39	6.39	3.31	–
2002	812	1 056	1 424	4 240	1.85	1.70	0.72	4.89
2003	904	3 386	1 094	4 266	2.19	4.67	1.33	8.39
2004	944	1 322	890	2 714	1.91	2.12	0.75	5.90
2005	1 350	808	1 044	3 304	2.75	1.09	1.16	5.72
2006	1 538	458	812	2 468	2.81	0.54	0.72	3.97
2007	796	950	802	1668	2	1.32	0.37	2.97
2008	402	712	2978	2032	0.93	0.52	5.86	3.98
2009	1276	294	1192	1998	1.77	0.41	1.15	3.27
2010	1484	1436	714	642	3.07	1.06	1.66	3.35
2011	636	640	428	1772	2.42	1.2	1.76	7.77
2012	676	64	–	4112	1.28	0.06	–	7.8
2013	886	606	342	2322	2.74	0.54	0.57	2.95
2014	986	368	2504	3888	2.53	1.37	6.44	10.85
2015	994	2396	946	4708	1.99	4.43	9.94	9.88
2016	634	1746	972	1954	0.88	3.63	5.44	4.52
2017	650	1646	2208	1548	3.15	4.3	11.49	4.42
2018	758	1078	3442	1770	3.36	2.49	5.34	3.88

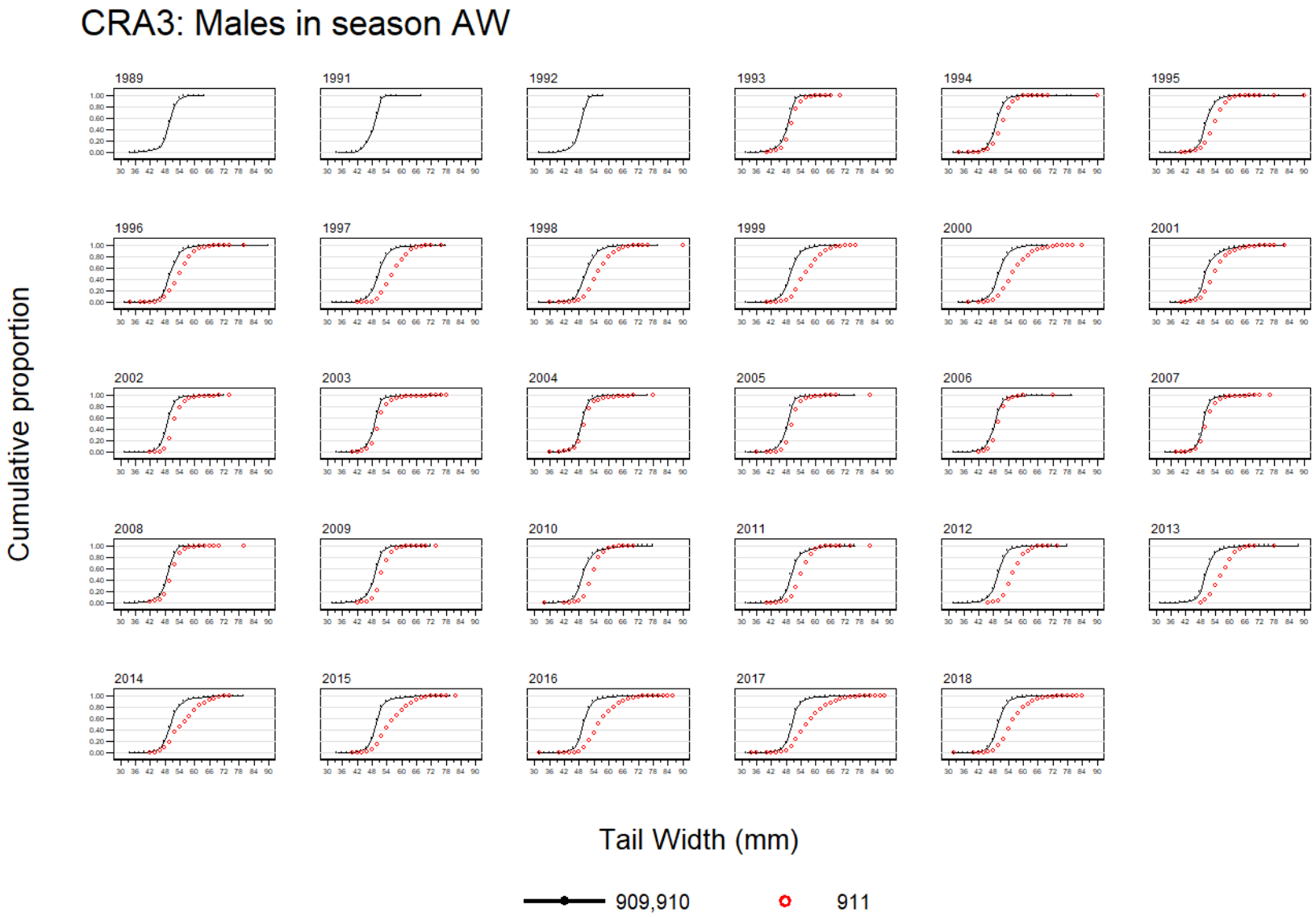

Figure D.2: Plot of cumulative male LFs by AW fishing year for two CRA 3 regions: 1) region 909+910 (black solid line) and 2) region 911 (hollow red markers).

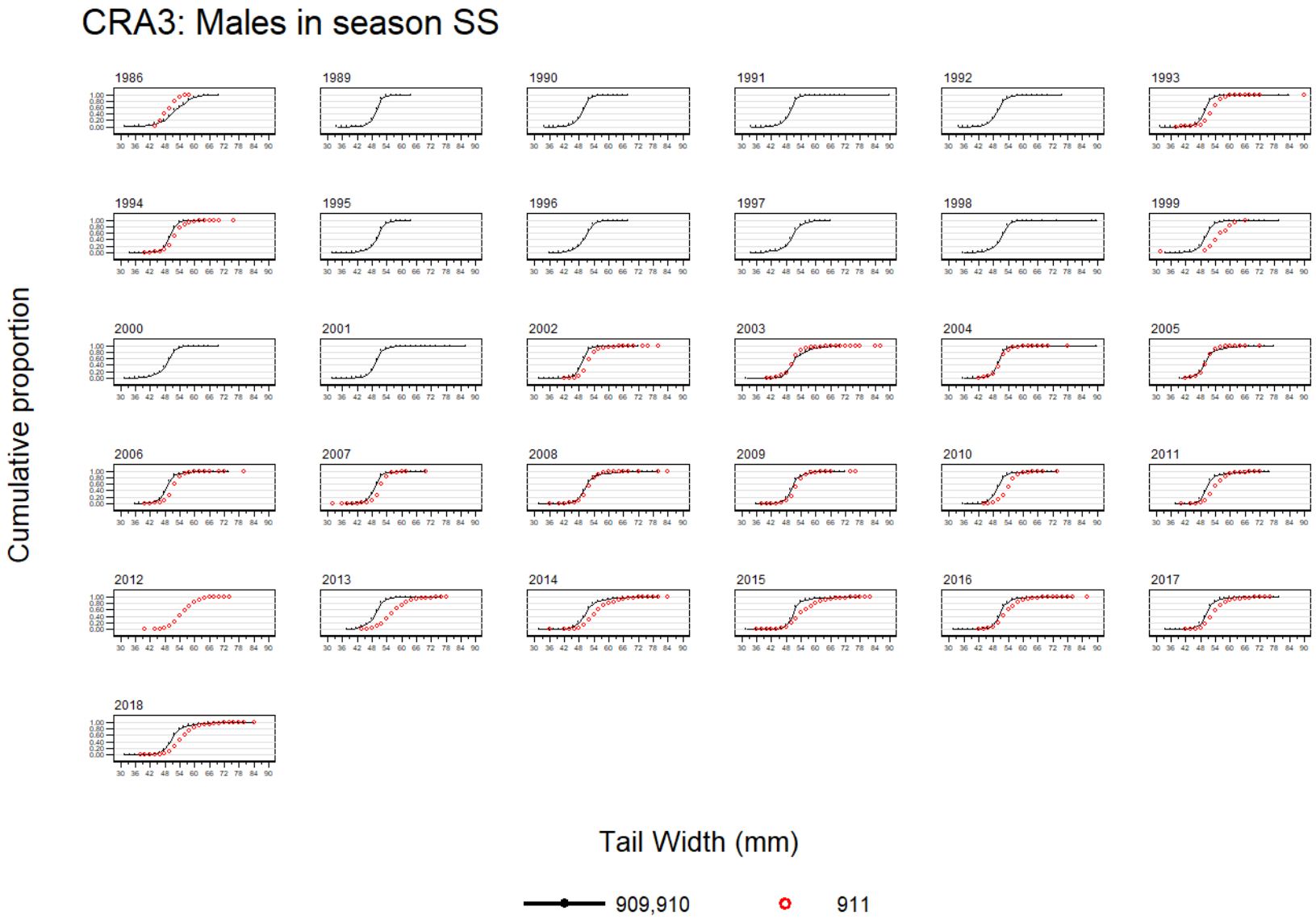

Figure D.3: Plot of cumulative male LFs by SS fishing year for two CRA 3 regions: 1) region 909+910 (black solid line) and 2) region 911 (hollow red markers).

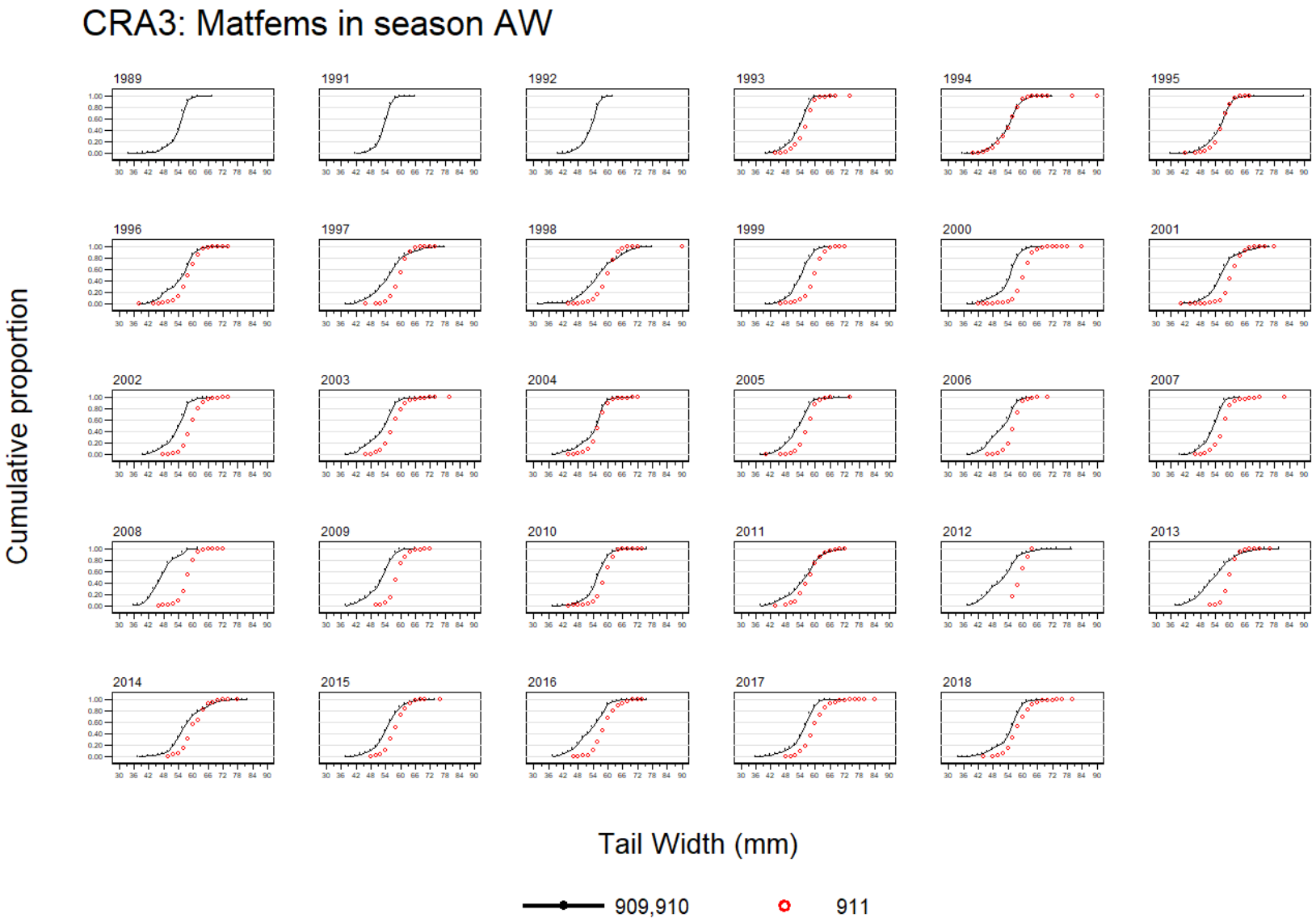

Figure D.4: Plot of cumulative mature female LFs by AW fishing year for two CRA 3 regions: 1) region 909+910 (black solid line) and 2) region 911 (hollow red markers).

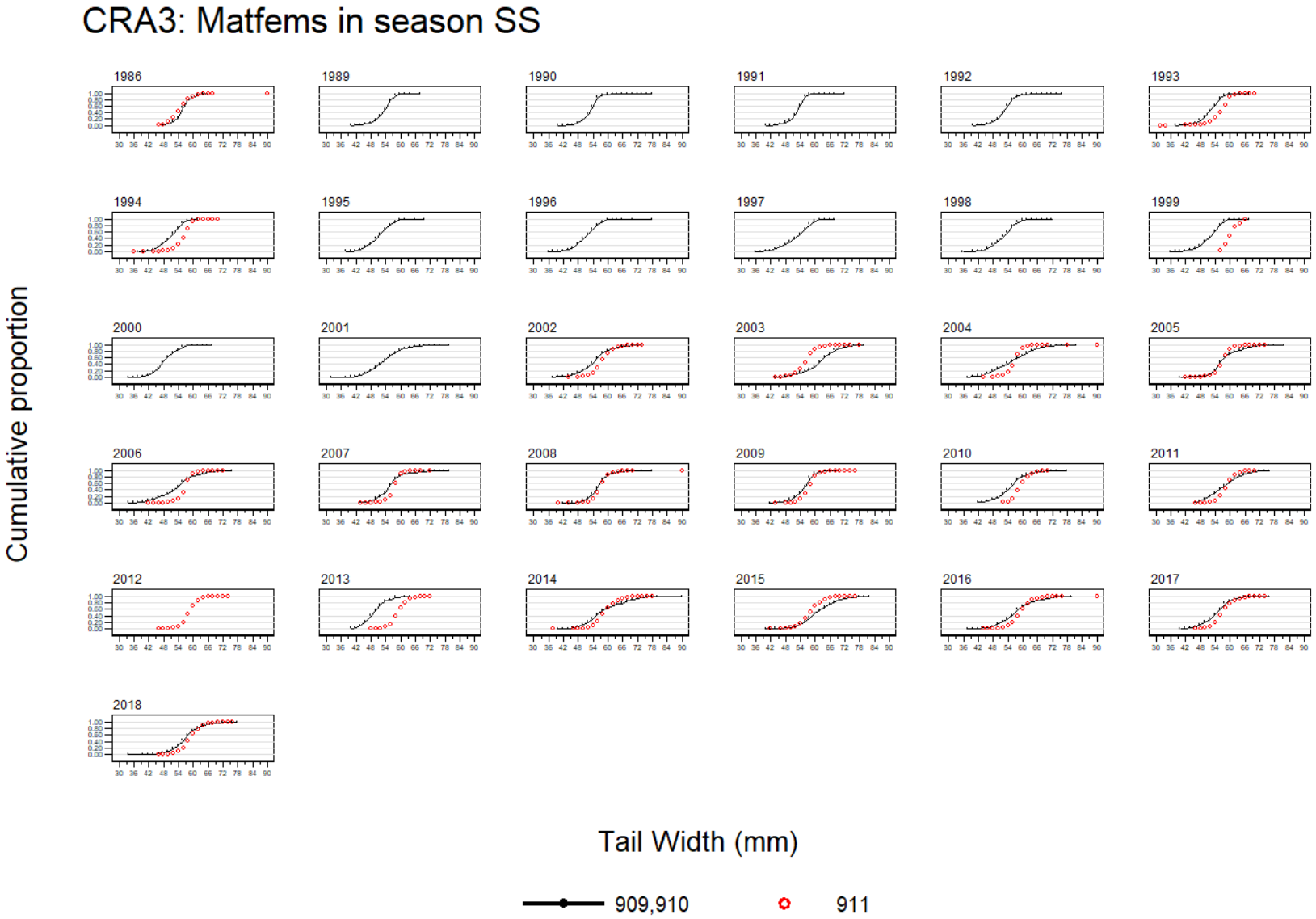

Figure D.5: Plot of cumulative mature female LFs by SS fishing year for two CRA 3 regions: 1) region 909+910 (black solid line) and 2) region 911 (hollow red markers).

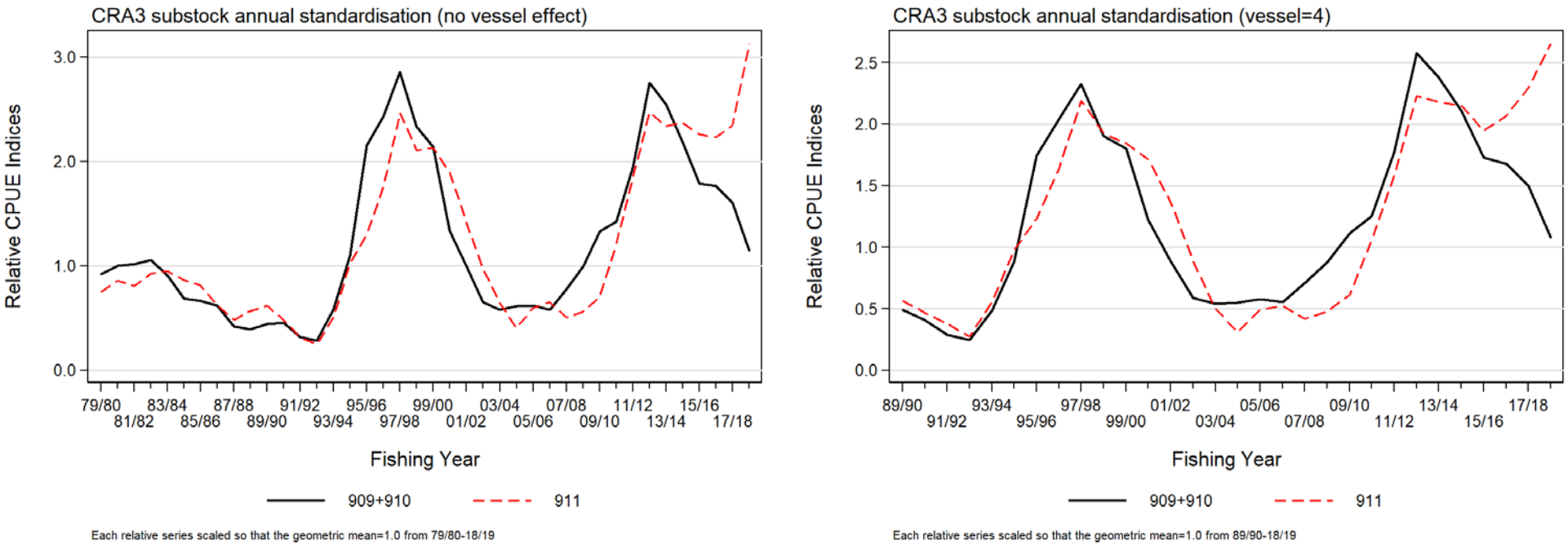

Figure D.6: Comparison of standardised CPUE trends for the two CRA 3 regions (1. region 909+910 (black solid line) and 2. region 911 (red dashed line)) showing [left panel] standardised without a vessel effect; [right panel] standardised with a vessel effect using vessels with at least 4 years of data.

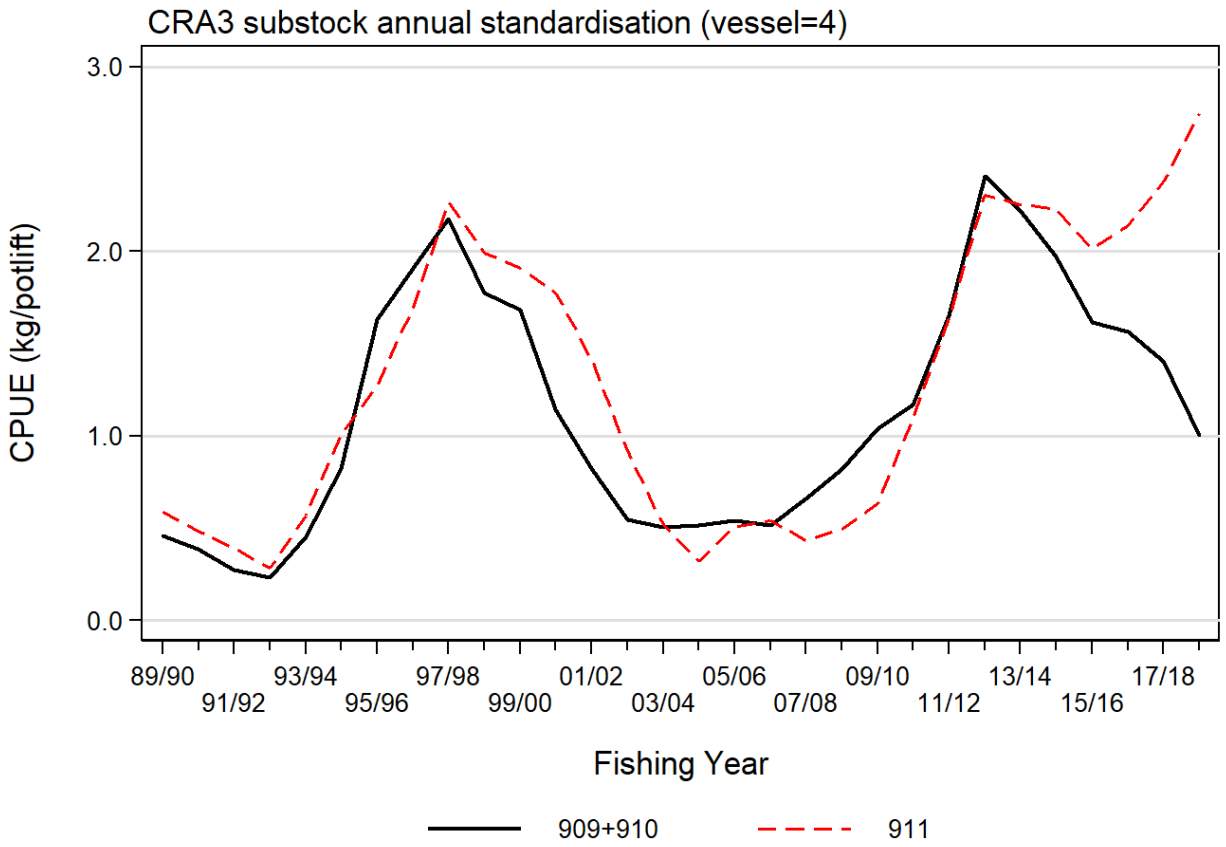

Figure D.7: Same comparison plot as in Figure D.6 (right panel), plotted without standardising to the same geometric mean.

APPENDIX E. DOCUMENTATION FOR CRA 3 REGIONAL SEASONAL CPUE ANALYSES WITHOUT VESSEL EFFECT

The data used in this analysis are described in the first two paragraphs in Section 4.1.1 and the methods followed are documented by Starr (2019). A [vessel] explanatory variable was not used in this model; the purpose of the analysis was to provide a set of FSU seasonal indices. The FSU data had been excluded from the analysis presented in Section 4.1 with the inclusion of the [vessel] explanatory variable. Two models are described in this Appendix: one for statistical areas 909 + 910 and the second for statistical area 911.

E.1 CRA 3 REGION 909+910

Two explanatory variables were available for this analysis in addition to the sequential [period] variable: [month] of capture and [statistical_area] of capture as an explanatory variable. This seasonal analysis estimated separate relative [month] effects in each half-year period by using, as the reference [month], the [month] in each period with the lowest standard error. The number of vessel/statistical area/month records available to each analysis is documented in Table E.1.

Table E.1: Number of vessel/month records in the dataset used to calculate region 909+910 CPUE time series (based on the F2_LFX algorithm). The FSU data were processed without a vessel filter while the CELR data applied a 4-vessel filter to the data. '–': no data

Fishing year	Apr	May	Jun	Jul	Aug	Sep	AW Total	Oct	Nov	Dec	Jan	Feb	Mar	SS Total
1979	21	9	31	34	28	19	142	39	54	59	53	35	29	269
1980	25	11	31	41	34	25	167	34	54	56	56	40	38	278
1981	28	13	35	39	31	18	164	38	46	48	52	41	38	263
1982	26	14	38	46	45	28	197	47	55	54	55	47	39	297
1983	28	21	45	47	45	30	216	47	52	54	52	41	39	285
1984	25	20	54	50	37	31	217	52	54	53	50	49	34	292
1985	32	16	48	51	31	26	204	51	53	50	46	40	27	267
1986	14	4	31	39	26	38	152	45	47	48	49	41	23	253
1987	15	18	47	46	34	35	195	49	48	49	45	32	24	247
1988	12	7	27	23	23	22	114	36	35	38	29	22	28	188
1989	21	16	29	33	28	33	160	40	43	44	45	36	32	240
1990	19	21	23	27	25	21	136	27	28	29	28	28	21	161
1991	20	13	26	28	27	21	135	30	32	35	32	28	26	183
1992	16	9	25	29	27	13	119	24	27	26	24	21	22	144
1993	14	12	24	29	28	–	107	–	–	–	–	23	15	38
1994	9	–	23	21	16	–	69	–	–	–	–	3	4	7
1995	6	–	20	20	14	–	60	–	–	–	–	–	1	1
1996	8	–	17	16	14	–	55	–	–	–	–	–	2	2
1997	7	–	16	20	14	–	57	–	–	–	–	–	2	2
1998	16	–	19	20	19	1	75	–	–	–	–	9	1	10
1999	7	–	18	19	17	–	61	–	–	–	–	10	9	19
2000	11	–	19	19	17	15	81	–	–	–	1	14	14	29
2001	12	–	18	18	18	–	66	–	–	1	1	16	17	35
2002	11	–	20	20	21	13	85	9	12	12	13	14	16	76
2003	5	–	19	20	17	7	68	7	9	8	8	10	7	49
2004	5	1	21	19	16	3	65	2	5	7	8	7	7	36
2005	1	–	19	17	16	6	59	8	12	11	8	7	8	54
2006	5	–	18	17	17	5	62	9	13	9	11	11	11	64
2007	5	–	15	16	16	4	56	9	9	8	6	8	8	48
2008	5	–	14	13	12	2	46	–	–	–	10	11	3	24
2009	--	–	14	14	16	1	45	–	–	–	12	11	1	24
2010	–	–	16	17	17	1	51	–	–	–	8	6	–	14
2011	2	–	17	17	18	2	56	–	–	–	8	–	3	11
2012	3	1	12	14	15	2	47	1	–	2	9	4	7	23
2013	13	–	8	13	12	1	47	–	–	–	9	6	11	26
2014	14	6	8	13	16	1	58	1	–	1	12	10	10	34
2015	13	10	12	15	16	1	67	–	–	1	12	13	7	33
2016	13	8	14	12	12	–	59	–	1	1	15	11	8	36
2017	11	6	13	13	11	–	54	–	–	–	15	12	10	37
2018	12	4	13	13	13	1	56	–	1	–	13	13	7	34

Table E.2: Total deviance (R^2) explained by each variable in region 909+910 standardised seasonal CPUE model without including a vessel explanatory variable. The number of categories in each explanatory variable is given in parentheses.

Variable	1	2	3
Period (80)	0.482		
Month (12)	0.071	0.541	
Statistical Area (2)	0.015	0.498	0.556
Additional deviance explained	0.000	0.059	0.015

Table E.3: Seasonal CPUE indices calculated from the analysis of region 909+910 catch and potlift data without including a vessel explanatory variable. Arithmetic index: sum(annual catch)/sum(potlifts). Unstandardised index: geometric mean of the CPUE observations by year. Standardised index: annual index. Coloured cells show the FSU indices used in the 2019 region 909+910 sub-stock assessment.

	Autumn-Winter				Spring-Summer			
Fishing Year	Arithmetic Index	Unstandardised Index	Standardised Index	Standard Error	Arithmetic Index	Unstandardised Index	Standardised Index	Standard Error
1979	0.796	0.701	0.712	0.0461	1.025	0.881	0.782	0.0355
1980	0.867	0.837	0.861	0.0430	0.931	0.888	0.798	0.0350
1981	0.853	0.762	0.768	0.0434	1.036	0.975	0.880	0.0357
1982	0.892	0.934	0.949	0.0402	0.955	0.923	0.814	0.0342
1983	0.754	0.757	0.784	0.0388	0.848	0.798	0.717	0.0347
1984	0.592	0.556	0.559	0.0387	0.706	0.637	0.565	0.0345
1985	0.515	0.506	0.504	0.0396	0.692	0.658	0.575	0.0358
1986	0.480	0.471	0.467	0.0449	0.715	0.598	0.532	0.0364
1987	0.350	0.345	0.347	0.0404	0.441	0.391	0.341	0.0368
1988	0.290	0.297	0.298	0.0510	0.407	0.386	0.339	0.0412
1989	0.314	0.288	0.307	0.0441	0.498	0.449	0.408	0.0371
1990	0.285	0.305	0.334	0.0473	0.517	0.446	0.411	0.0438
1991	0.222	0.232	0.243	0.0473	0.327	0.306	0.274	0.0415
1992	0.180	0.179	0.185	0.0498	0.327	0.315	0.284	0.0460
1993	0.461	0.404	0.416	0.0523	0.578	0.622	0.690	0.0858
1994	0.950	0.918	0.868	0.0638	1.001	1.045	1.258	0.1948
1995	1.646	1.854	1.754	0.0681	1.149	1.289	1.773	0.5128
1996	1.925	2.043	1.941	0.0710	2.930	2.700	3.478	0.3631
1997	2.135	2.474	2.348	0.0697	1.644	1.475	1.900	0.3631
1998	1.645	1.873	1.826	0.0615	2.028	2.281	2.605	0.1637
1999	1.758	1.911	1.852	0.0676	1.118	1.236	1.464	0.1194
2000	1.060	1.063	1.071	0.0594	0.894	0.989	1.143	0.0973
2001	0.807	0.854	0.841	0.0652	0.658	0.708	0.779	0.0890
2002	0.680	0.596	0.595	0.0581	0.456	0.501	0.478	0.0611
2003	0.792	0.555	0.532	0.0642	0.427	0.442	0.401	0.0751
2004	0.683	0.532	0.508	0.0656	0.476	0.537	0.495	0.0869
2005	0.732	0.657	0.625	0.0687	0.444	0.447	0.402	0.0718
2006	0.612	0.561	0.552	0.0671	0.453	0.437	0.410	0.0662
2007	0.721	0.706	0.690	0.0704	0.619	0.631	0.580	0.0760
2008	0.886	0.837	0.803	0.0773	0.778	0.817	0.829	0.1058
2009	0.987	1.182	1.133	0.0782	0.976	0.991	1.009	0.1058
2010	1.169	1.219	1.159	0.0736	1.157	1.181	1.189	0.1378
2011	1.547	1.703	1.640	0.0704	1.396	1.372	1.351	0.1552
2012	2.070	2.429	2.439	0.0765	1.588	1.833	1.921	0.1079
2013	1.922	2.123	2.153	0.0766	1.512	1.783	1.955	0.1018
2014	1.624	1.795	1.941	0.0694	1.337	1.474	1.537	0.0892
2015	1.358	1.416	1.532	0.0649	1.117	1.226	1.316	0.0906
2016	1.232	1.405	1.466	0.0689	1.245	1.350	1.397	0.0867
2017	1.421	1.447	1.489	0.0717	1.087	1.028	1.084	0.0856
2018	1.045	1.047	1.065	0.0705	0.758	0.718	0.757	0.0892

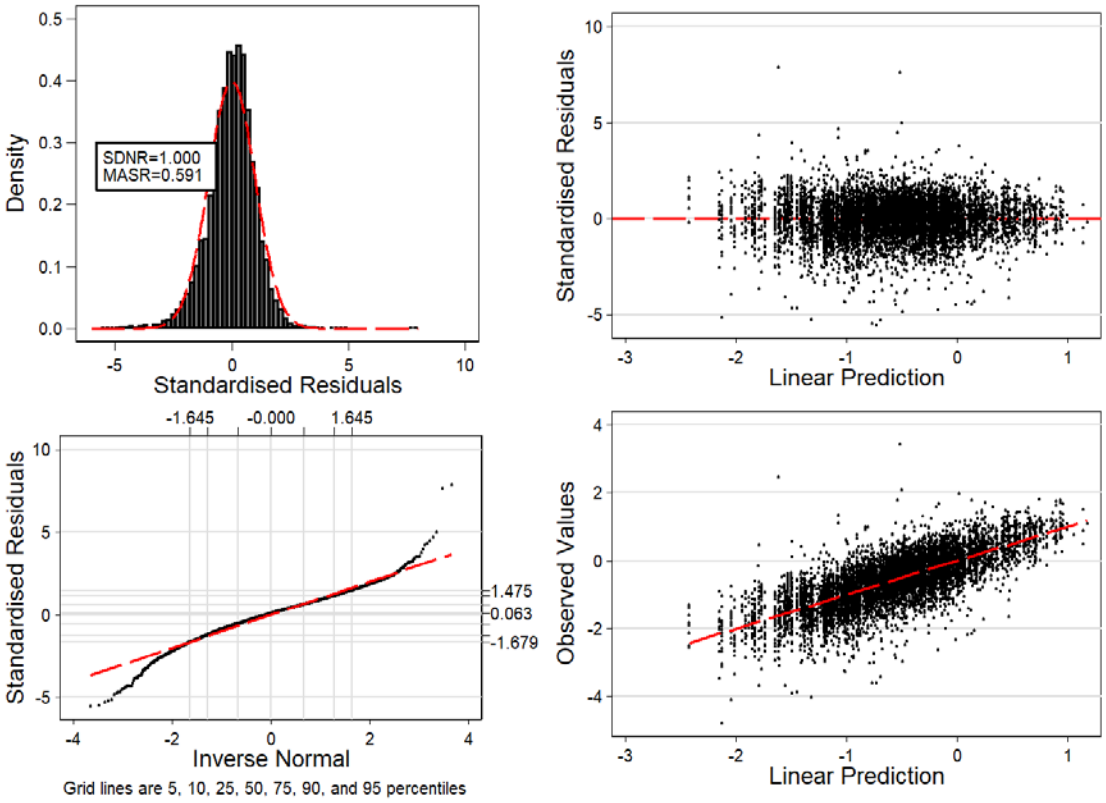

Figure E.1: Standardised residuals for region 909+910 standardised seasonal CPUE model without including a vessel explanatory variable.

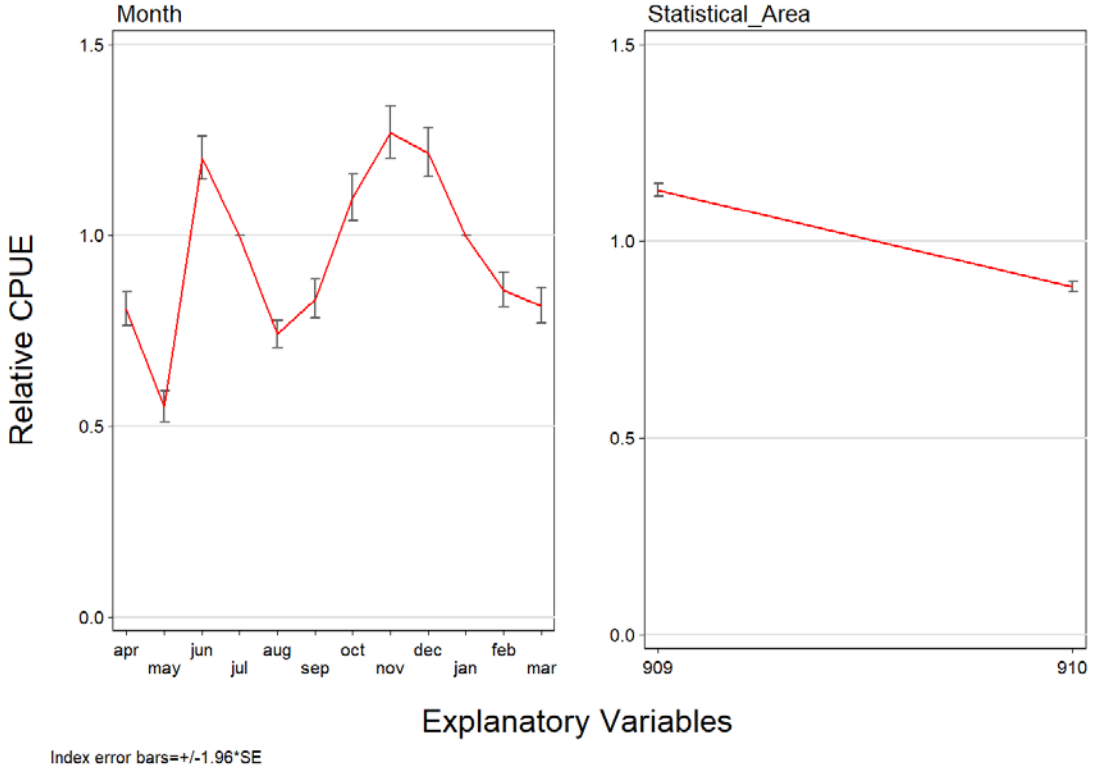

Figure E.2: Coefficients for month and statistical area from region 909+910 standardised seasonal CPUE model without including a vessel explanatory variable. Month coefficients are not in canonical form, with each of the two reference months (July and January) set to 1.0 and the associated SE set to zero.

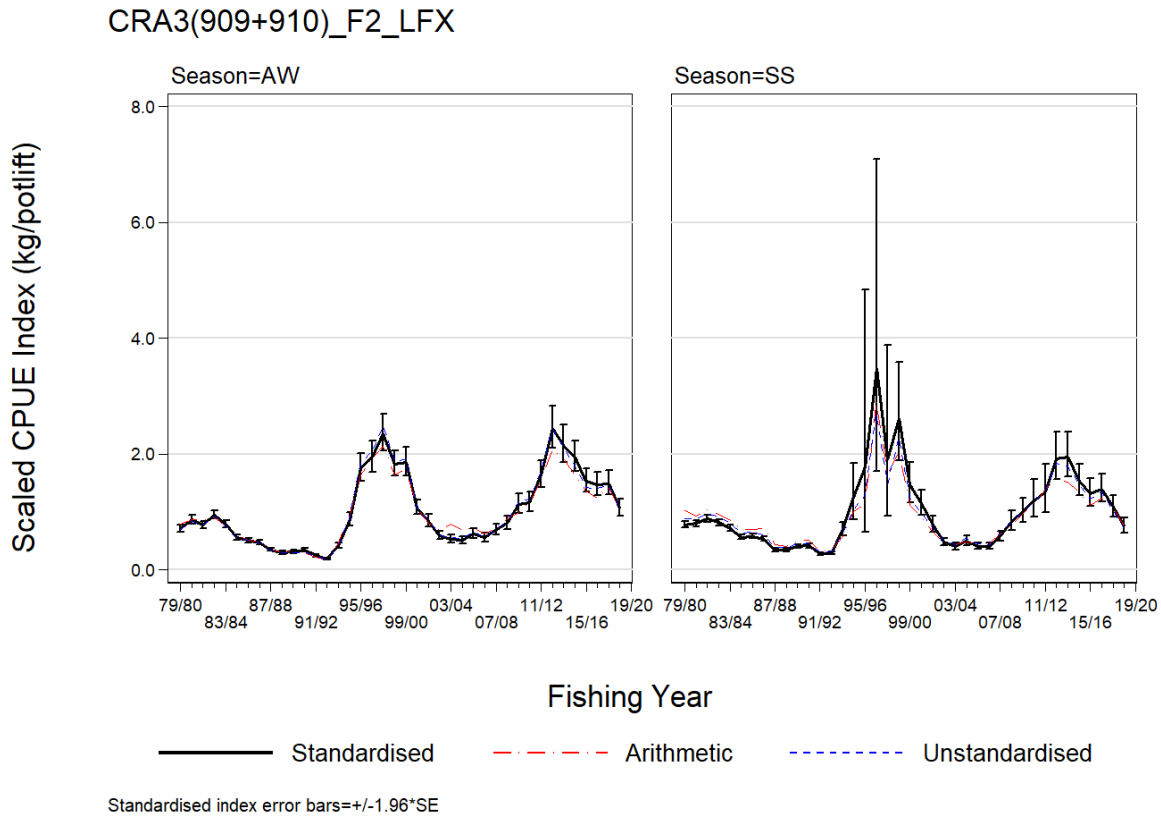

Figure E.3: Standardised, unstandardised (geometric mean), and arithmetic mean CPUE indices (kg/potlift) by season and fishing year for region 909+910 standardised seasonal CPUE model without including a vessel explanatory variable and using the F2 algorithm scaled to "LFX" landings from 1979–80 to 2018–19: AW ($^{g}\overline{\mu}$ =0.825 kg/potlift) and SS ($^{g}\overline{\mu}$ =0.817 kg/potlift).

E.2 CRA 3 REGION 911

Only one explanatory variable was available for this analysis in addition to the sequential [`period`] variable: [`month`] of capture. This seasonal analysis estimated separate relative [`month`] effects in each half-year period by using, as the reference [`month`], the [`month`] in each period with the lowest standard error. The number of vessel/ month records available in this analysis is documented in Table E.4.

Table E.4: Number of vessel/month records in the dataset used to calculate region 911 CPUE time series (based on the F2_LFX algorithm). The FSU data were processed without a vessel filter while the CELR data applied a 4-vessel filter to the data. '–': no data

Fishing							AW							SS
year	Apr	May	Jun	Jul	Aug	Sep	Total	Oct	Nov	Dec	Jan	Feb	Mar	Total
1979	7	3	12	20	19	22	83	29	31	31	29	21	10	151
1980	10	4	14	23	25	18	94	29	33	32	32	26	17	169
1981	9	5	14	23	24	23	98	27	27	28	27	26	15	150
1982	9	7	16	21	24	25	102	24	26	25	23	22	18	138
1983	10	7	17	25	24	24	107	25	27	28	30	28	24	162
1984	12	8	20	30	28	31	129	30	31	31	29	28	17	166
1985	14	6	20	27	28	26	121	24	26	27	28	24	20	149
1986	9	2	15	22	23	23	94	23	25	25	27	28	19	147
1987	11	8	19	21	21	17	97	23	22	24	24	18	14	125
1988	6	5	13	13	15	19	71	20	20	21	21	16	16	114
1989	9	5	7	11	14	19	65	22	22	21	21	19	10	115
1990	6	6	10	18	17	23	80	22	22	23	24	23	17	131
1991	15	8	12	21	25	25	106	27	30	28	27	25	17	154
1992	16	16	23	23	25	25	128	29	26	26	25	25	20	151
1993	13	20	20	19	19	–	91	–	–	1	–	16	4	21
1994	8	–	12	13	15	–	48	–	–	–	–	6	3	9
1995	7	1	12	12	11	–	43	–	–	–	–	4	6	10
1996	5	–	10	9	10	–	34	–	1	–	–	1	2	4
1997	6	–	9	9	9	–	33	–	–	–	–	–	4	4
1998	6	–	6	7	6	–	25	–	–	–	–	–	2	2
1999	6	1	8	8	8	–	31	–	–	–	–	2	3	5
2000	7	–	8	8	9	8	40	–	–	–	–	2	4	6
2001	9	–	10	10	10	–	39	–	–	–	–	9	9	18
2002	6	–	8	8	8	8	38	8	5	4	8	9	9	43
2003	4	–	11	11	11	10	47	13	12	9	12	12	12	70
2004	10	–	11	11	11	11	54	11	11	10	10	11	11	64
2005	7	–	9	10	10	11	47	11	10	10	8	9	9	57
2006	5	–	10	10	11	12	48	12	12	12	10	11	11	68
2007	3	–	8	8	8	9	36	10	10	10	8	8	8	54
2008	3	–	7	8	8	8	34	9	9	9	8	8	6	49
2009	–	–	6	7	8	8	29	8	8	9	8	6	2	41
2010	1	–	7	9	9	8	34	7	2	3	6	6	5	29
2011	5	–	8	8	8	8	37	4	–	2	4	4	1	15
2012	3	–	5	5	1	5	19	4	2	3	4	2	5	20
2013	4	–	2	5	5	5	21	3	2	–	5	4	3	17
2014	9	7	5	7	9	7	44	2	3	6	7	9	6	33
2015	9	8	6	8	6	7	44	5	2	4	7	9	6	33
2016	9	8	5	8	7	7	44	5	3	3	8	6	7	32
2017	7	6	6	6	6	6	37	4	3	3	4	3	3	20
2018	6	4	5	6	6	6	33	3	2	2	4	3	3	17

Table E.5: Total deviance (R^2) explained by each variable in region 911 standardised seasonal CPUE model without including a vessel explanatory variable. The number of categories in each explanatory variable is given in parentheses.

Variable	**1**	**2**
Period (80)	0.535	
Month (12)	0.056	0.589
Additional deviance explained	0.000	0.054

Table E.6: Seasonal CPUE indices calculated from the analysis of region 911 catch and potlift data without including a vessel explanatory variable. Arithmetic index: sum(annual catch)/sum(potlifts). Unstandardised index: geometric mean of the CPUE observations by year. Standardised index: annual index. Coloured cells show the FSU indices used in the 2019 region 911 stock assessment.

	Autumn-Winter				Spring-Summer			
Fishing Year	Arithmetic Index	Unstandardised Index	Standardised Index	Standard Error	Arithmetic Index	Unstandardised Index	Standardised Index	Standard Error
1979	0.682	0.707	0.712	0.0574	0.889	0.820	0.725	0.0448
1980	0.813	0.762	0.766	0.0540	1.004	0.959	0.866	0.0427
1981	0.805	0.818	0.830	0.0531	0.849	0.813	0.740	0.0446
1982	0.820	0.801	0.820	0.0523	1.100	1.013	0.930	0.0462
1983	0.883	0.873	0.886	0.0512	1.014	0.991	0.923	0.0432
1984	0.755	0.722	0.733	0.0473	0.996	0.986	0.896	0.0429
1985	0.690	0.635	0.639	0.0485	0.990	0.969	0.893	0.0448
1986	0.454	0.474	0.473	0.0542	0.807	0.749	0.694	0.0448
1987	0.374	0.390	0.395	0.0535	0.547	0.568	0.516	0.0483
1988	0.434	0.448	0.457	0.0616	0.669	0.664	0.611	0.0502
1989	0.441	0.467	0.488	0.0642	0.786	0.737	0.665	0.0500
1990	0.423	0.447	0.462	0.0584	0.536	0.504	0.466	0.0472
1991	0.257	0.235	0.244	0.0514	0.436	0.371	0.337	0.0442
1992	0.184	0.182	0.190	0.0476	0.314	0.305	0.282	0.0445
1993	0.369	0.351	0.373	0.0557	0.922	0.925	1.030	0.1094
1994	0.805	0.863	0.822	0.0737	1.099	1.165	1.375	0.1662
1995	0.931	0.998	0.949	0.0778	3.398	2.039	2.560	0.1582
1996	1.487	1.507	1.421	0.0870	2.272	2.183	2.501	0.2489
1997	2.142	2.264	2.139	0.0883	1.033	1.432	2.015	0.2500
1998	1.806	1.816	1.724	0.1010	1.731	2.140	3.105	0.3522
1999	1.542	1.631	1.571	0.0909	4.602	3.975	5.054	0.2228
2000	1.413	1.487	1.457	0.0805	2.858	2.876	3.700	0.2037
2001	1.020	1.051	0.997	0.0816	1.733	1.801	2.197	0.1184
2002	0.881	0.841	0.821	0.0825	0.966	1.012	0.999	0.0778
2003	0.630	0.666	0.645	0.0746	0.618	0.638	0.605	0.0621
2004	0.385	0.338	0.330	0.0700	0.421	0.457	0.432	0.0647
2005	0.475	0.470	0.461	0.0746	0.664	0.713	0.666	0.0684
2006	0.529	0.583	0.571	0.0738	0.672	0.713	0.667	0.0630
2007	0.469	0.455	0.444	0.0847	0.494	0.553	0.511	0.0701
2008	0.526	0.464	0.453	0.0870	0.614	0.660	0.606	0.0733
2009	0.580	0.565	0.555	0.0939	0.870	0.858	0.756	0.0799
2010	0.946	0.990	0.966	0.0869	1.128	1.373	1.345	0.0939
2011	1.497	1.581	1.541	0.0836	1.987	2.033	1.945	0.1294
2012	2.259	2.466	2.344	0.1157	2.414	2.359	2.312	0.1127
2013	2.110	2.206	2.217	0.1098	2.186	2.129	2.124	0.1217
2014	2.171	2.087	2.249	0.0772	2.224	2.176	2.117	0.0881
2015	1.954	1.901	2.040	0.0774	1.784	2.172	2.152	0.0881
2016	1.907	1.867	2.019	0.0774	2.170	2.139	2.117	0.0896
2017	2.220	1.929	2.052	0.0838	2.564	2.412	2.269	0.1125
2018	2.550	2.435	2.548	0.0884	3.649	3.607	3.486	0.1218

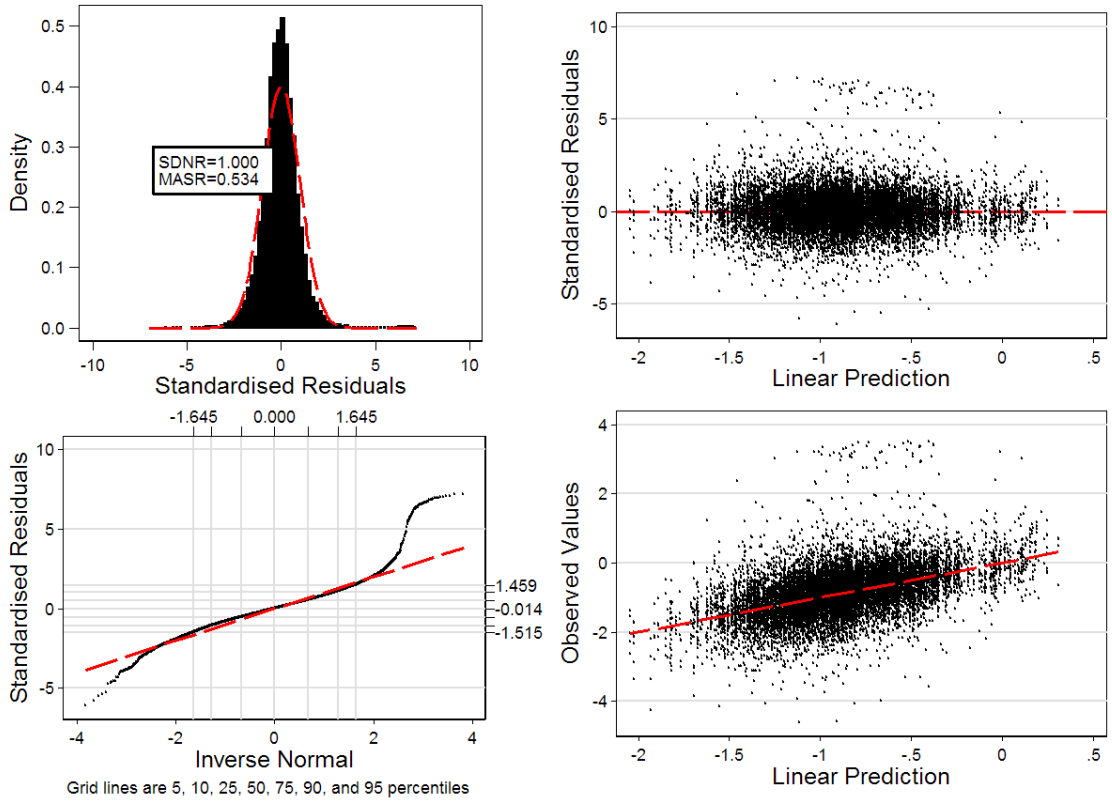

Figure E.4: Standardised residuals for region 911 standardised seasonal CPUE model without including a vessel explanatory variable.

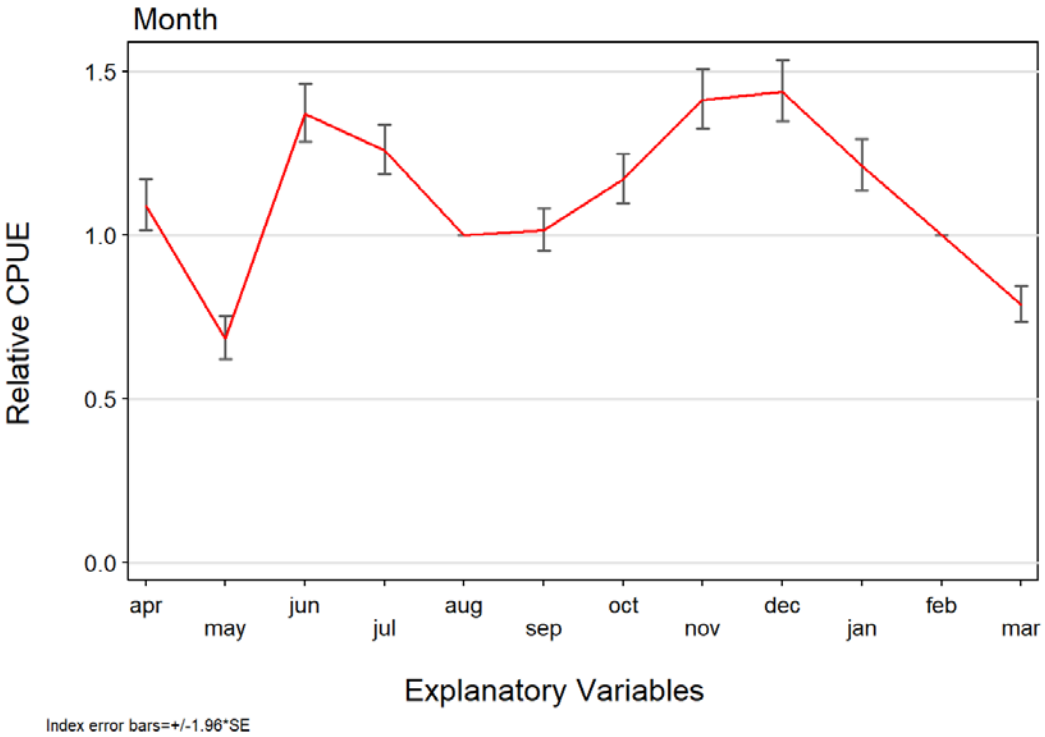

Figure E.5: Coefficients for month from region 911 standardised seasonal CPUE model without including a vessel explanatory variable. Month coefficients are not in canonical form, with each of the two reference months (August and February) set to 1.0 and the associated SE set to zero.

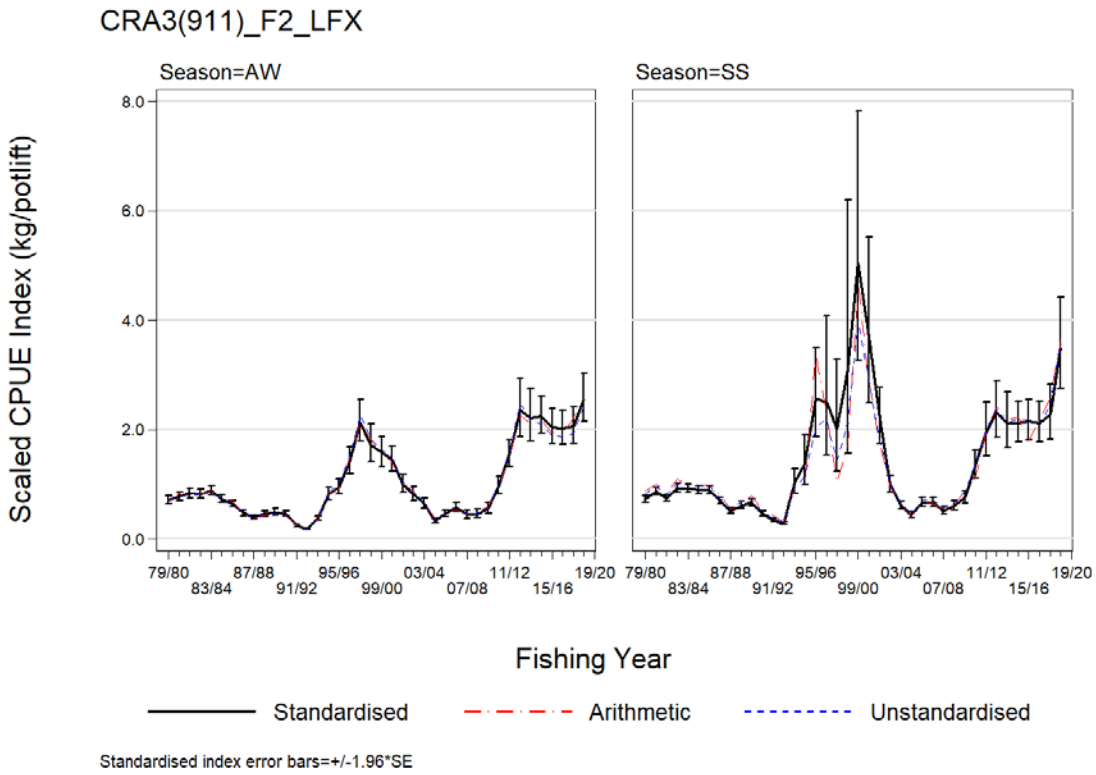

Figure E.6: Standardised, unstandardised (geometric mean), and arithmetic mean CPUE indices (kg/potlift) by season and fishing year for region 911 standardised seasonal CPUE model without including a vessel explanatory variable and using the F2 algorithm scaled to "LFX" landings from 1979–80 to 2018–19: AW ($^{g}\overline{\mu}$ =0.84 kg/potlift) and SS ($^{g}\overline{\mu}$ =1.13 kg/potlift).

APPENDIX F. LOGBOOK AND OBSERVER LENGTH FREQUENCY DISTRIBUTIONS FOR CRA 3 REGION 909+910

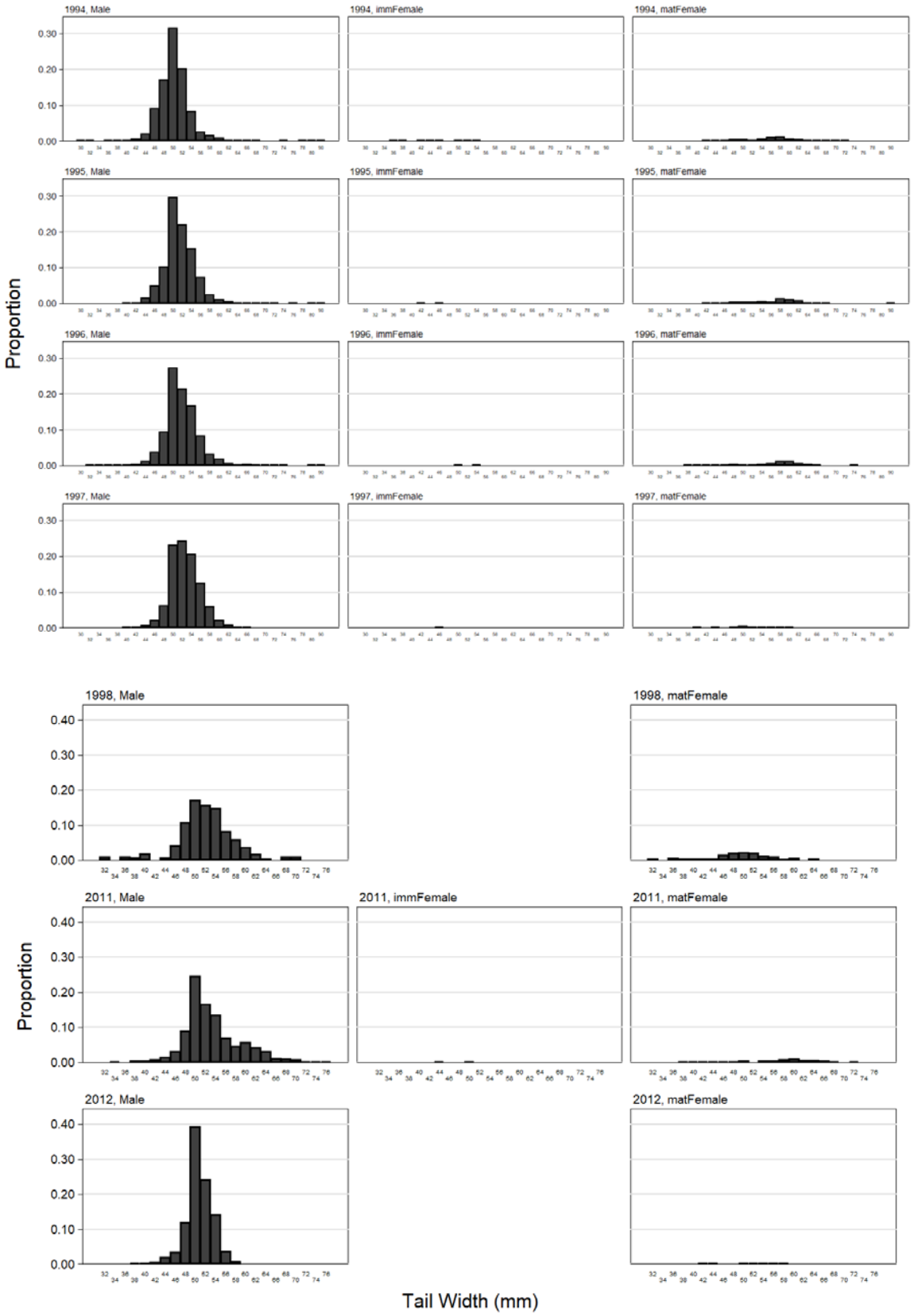

Figure F.1A: Length frequency histograms by sex category for AW logbook sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

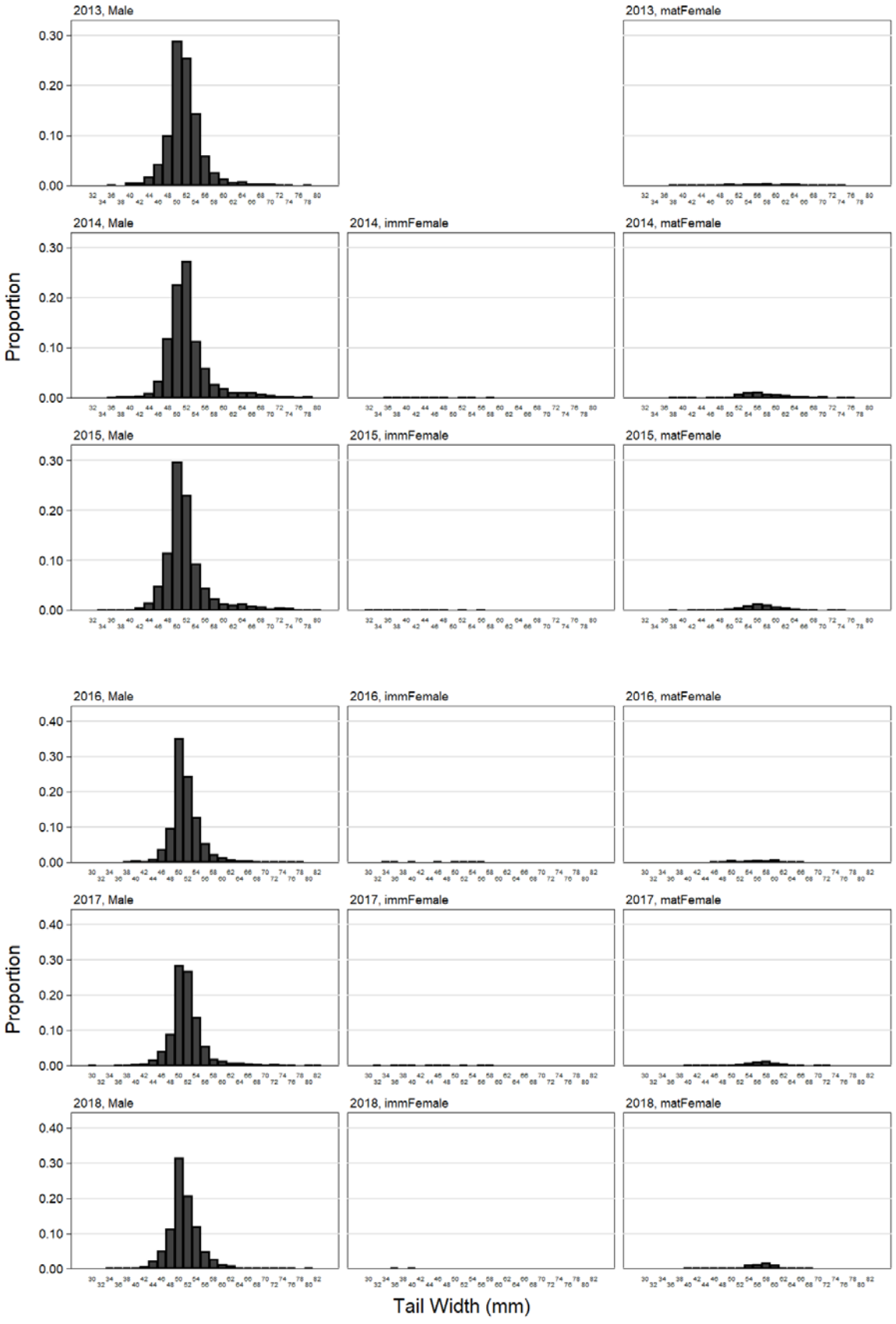

Figure F.1B: Length frequency histograms by sex category for AW logbook sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

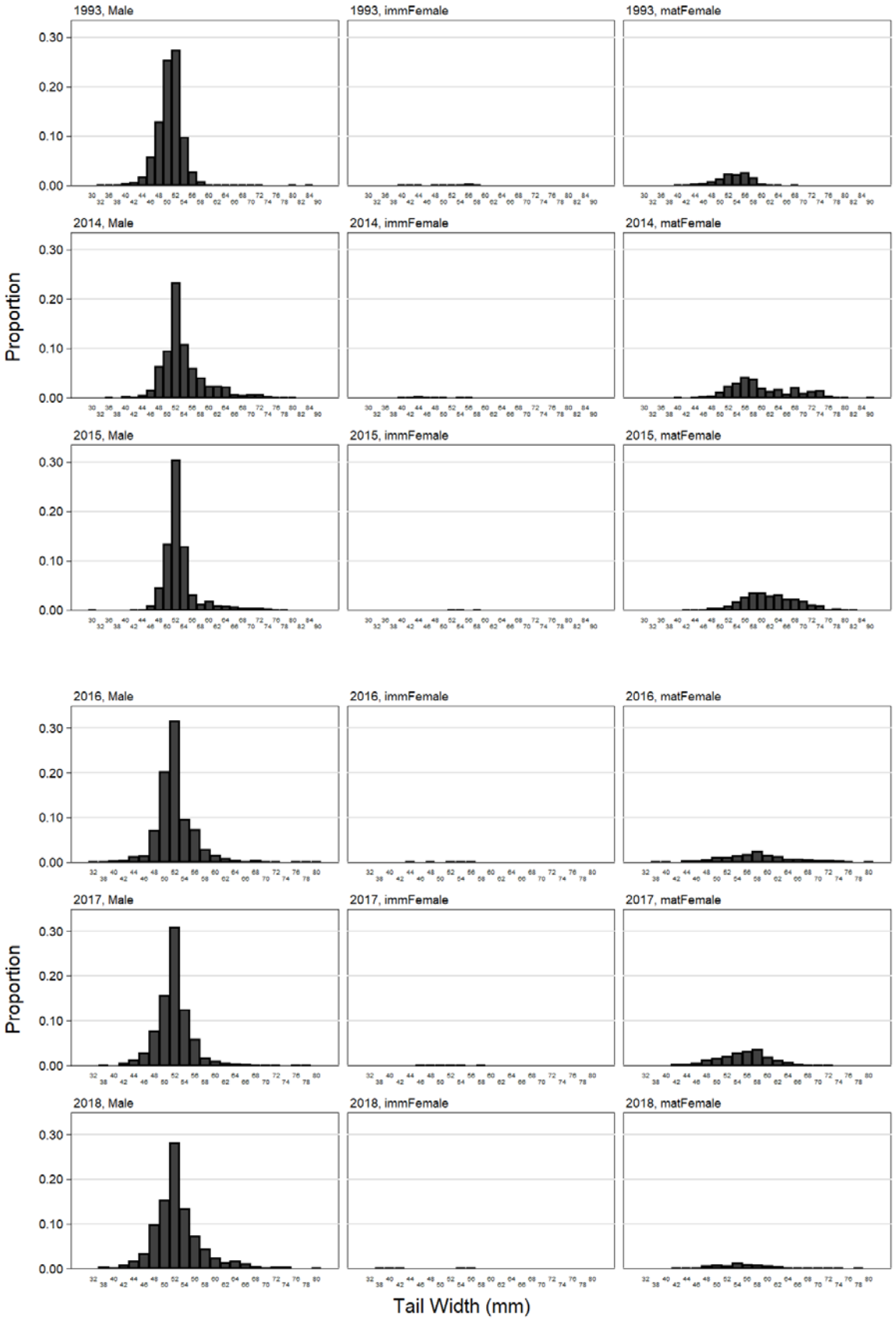

Figure F.2A: Length frequency histograms by sex category for SS logbook sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

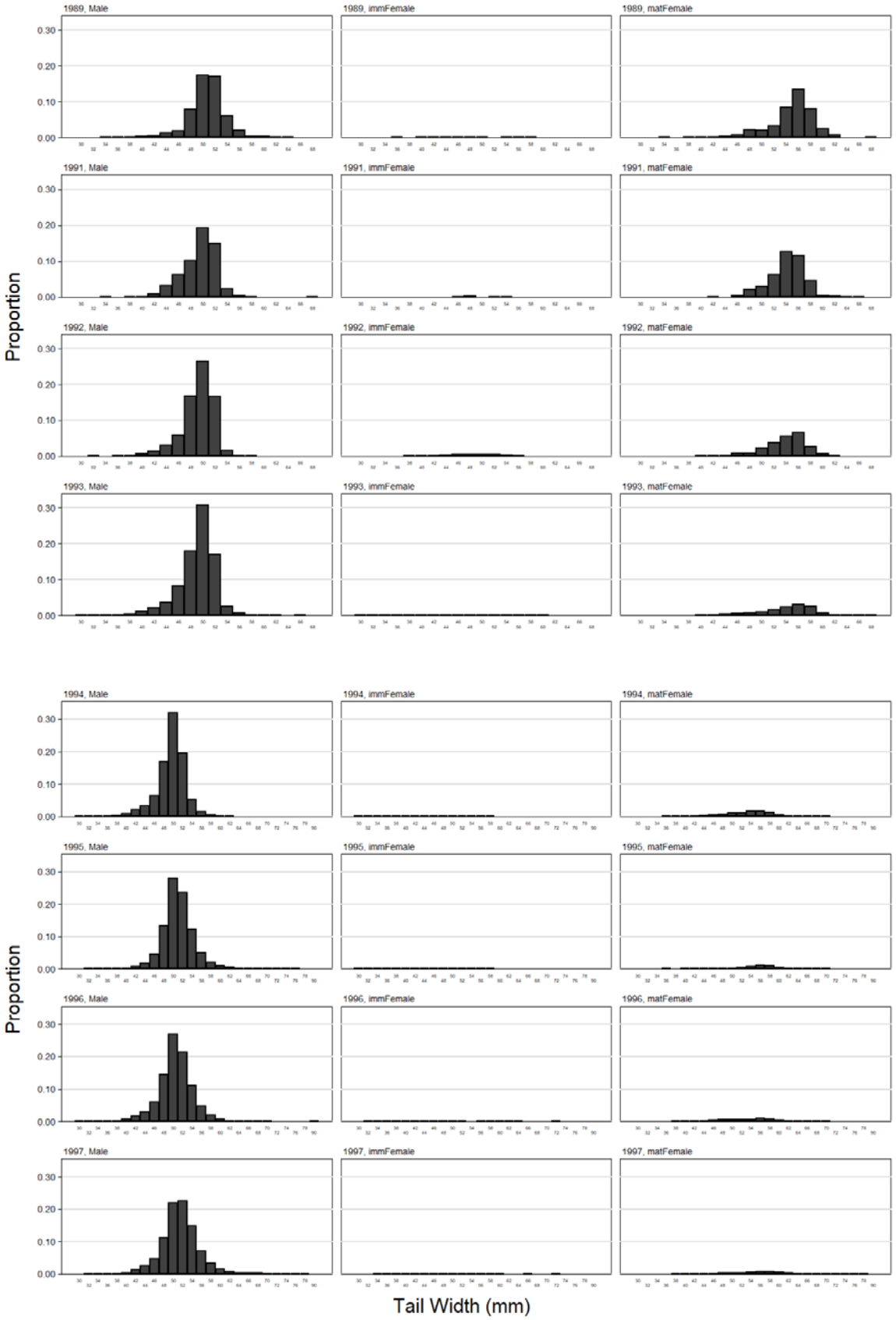

Figure F.3A: Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

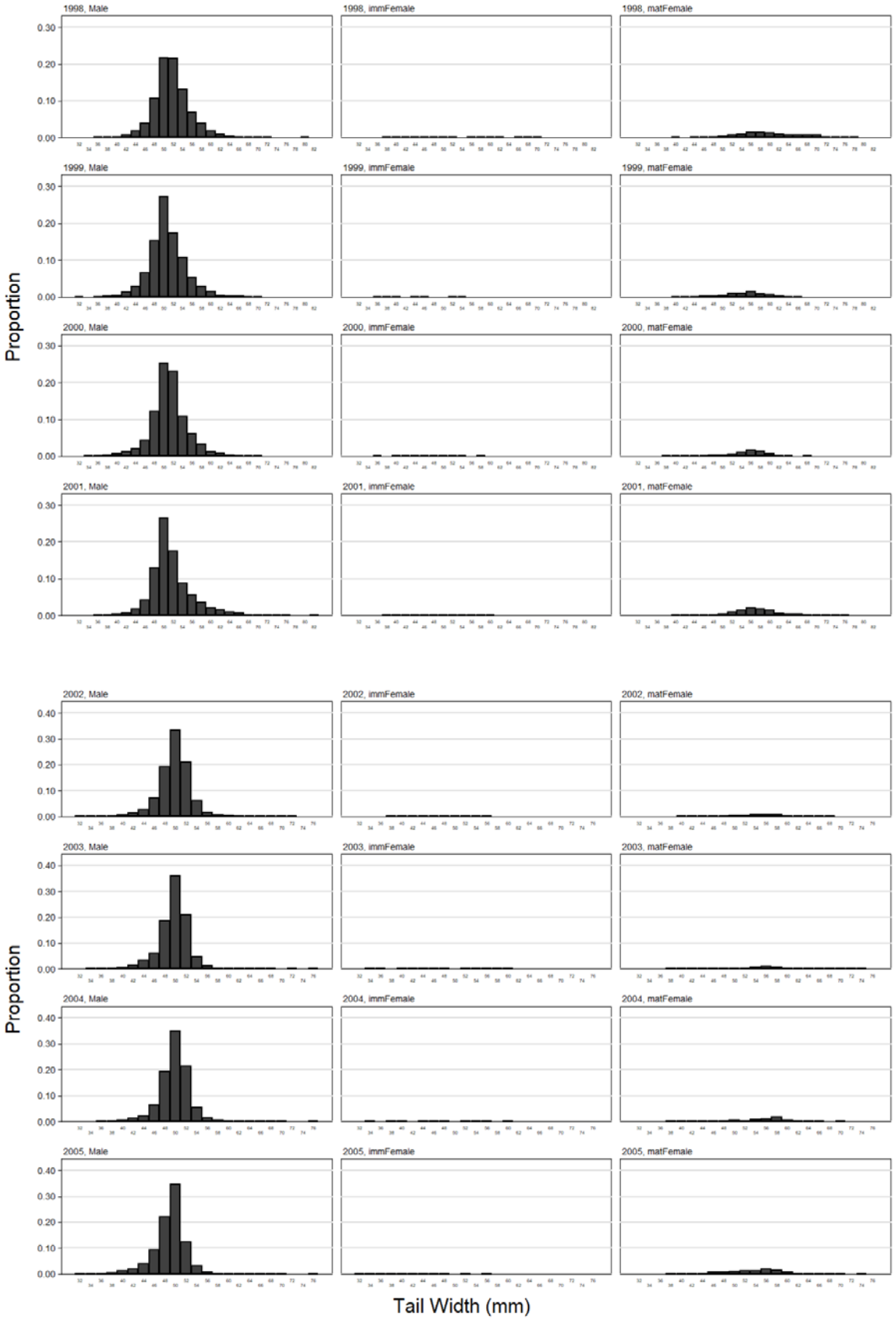

Figure F.3B: Length frequency histograms by sex category for AW observer catch sampling, for indicated years. Proportions by sex in each year (row) sum to 1.0.

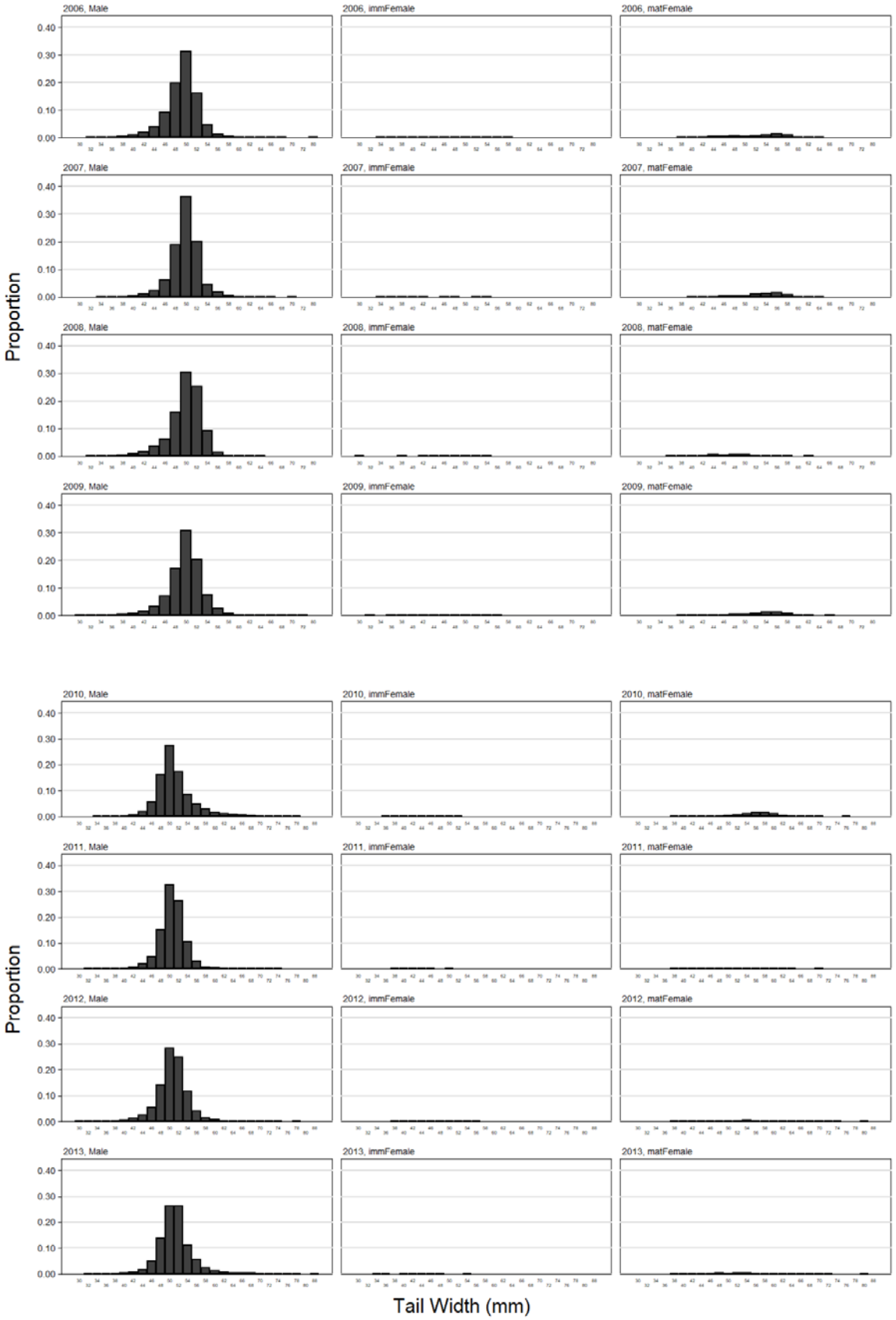

Figure F.3C: Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

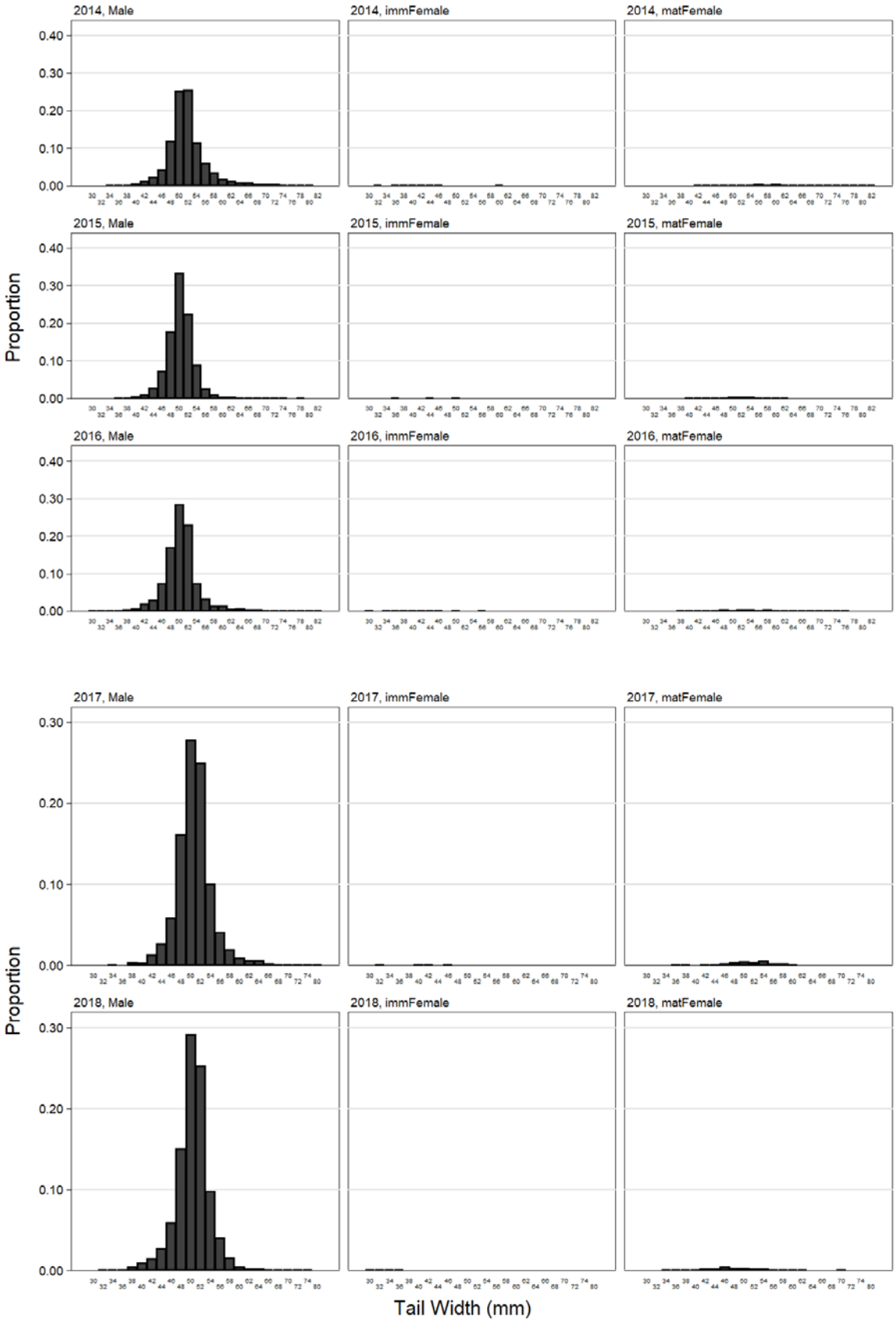

Figure F.3D: Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

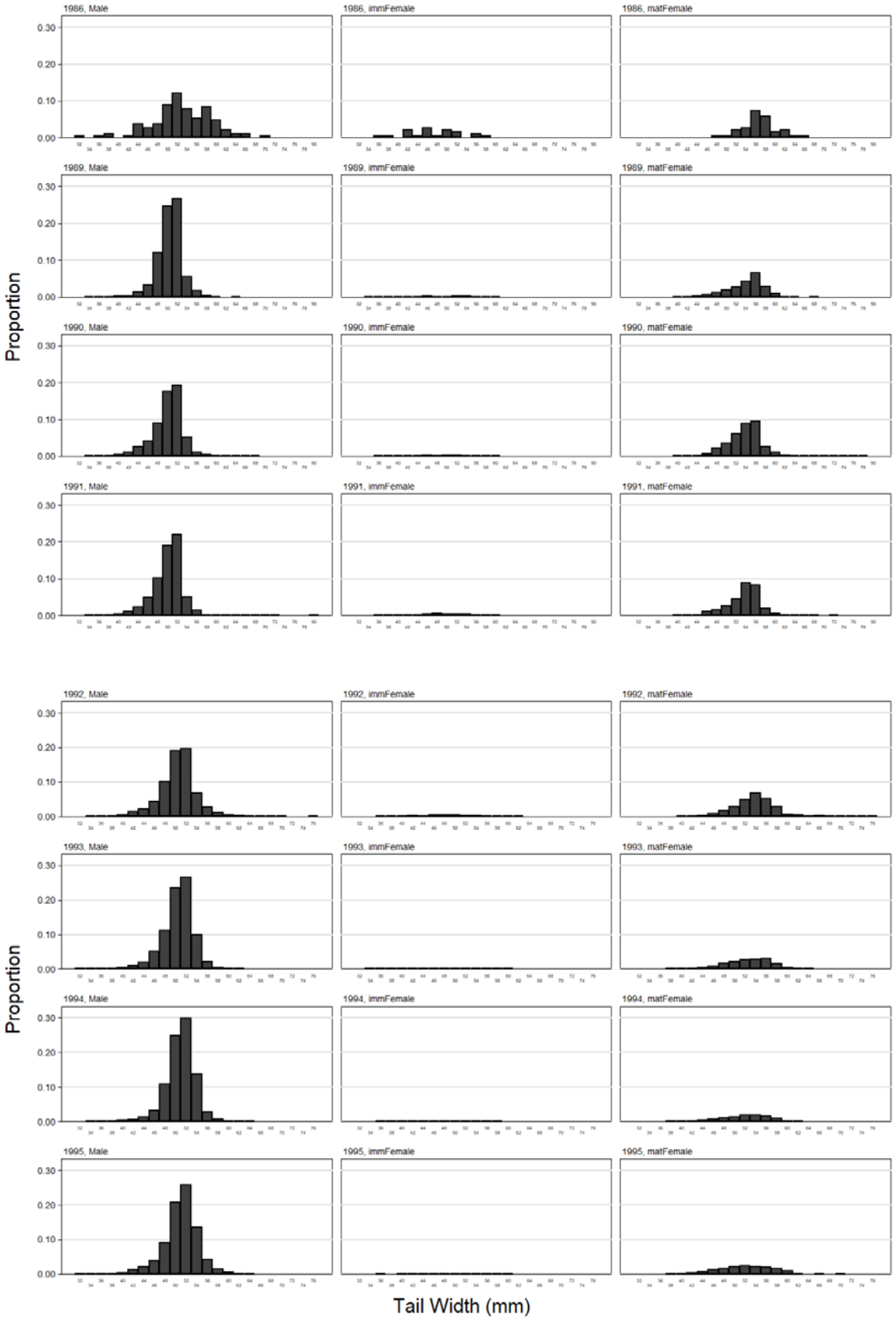

Figure F.4A: Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

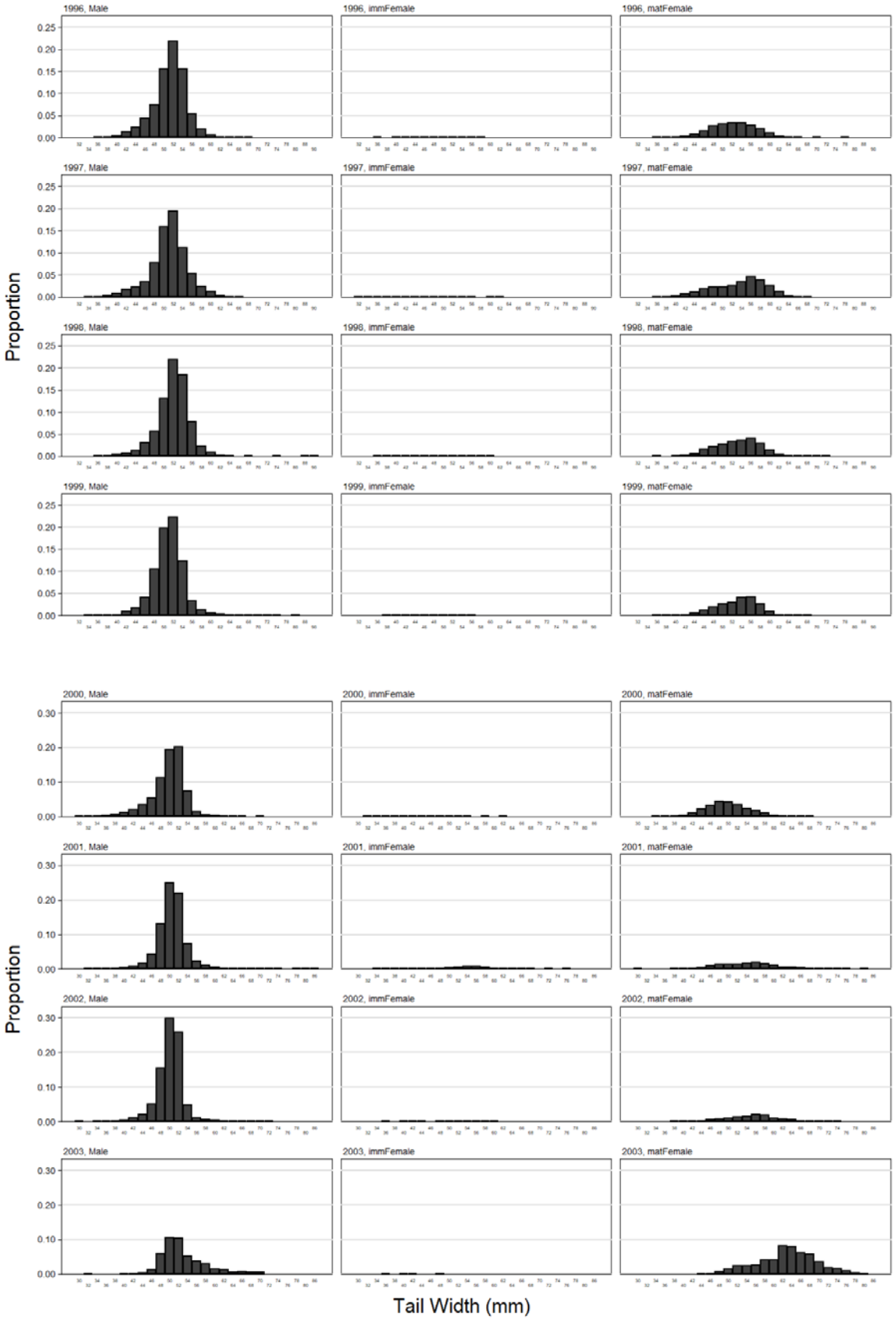

Figure F.4B: Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

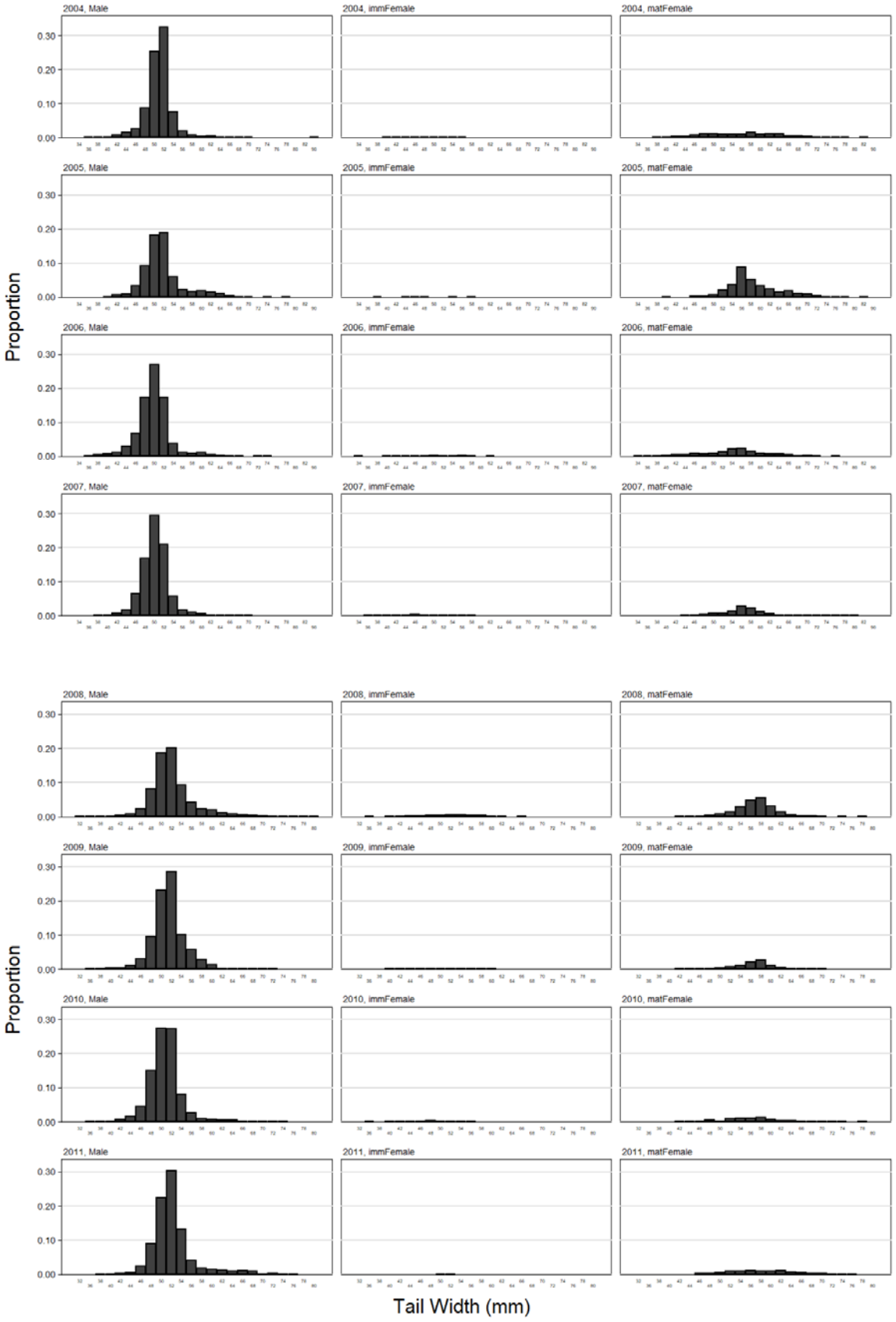

Figure F.4C: Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

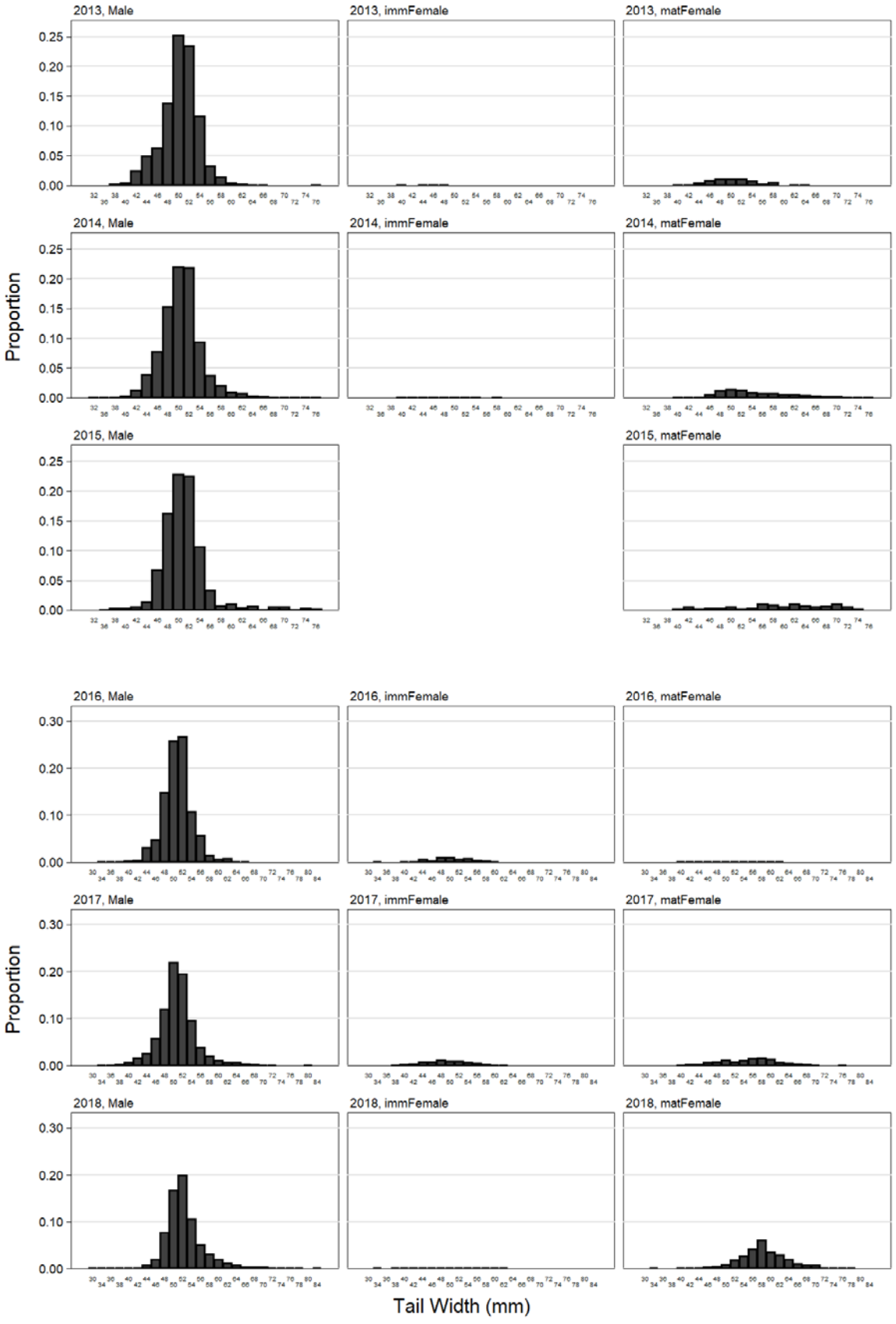

Figure F.4D: Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

APPENDIX G. LOGBOOK AND OBSERVER LENGTH FREQUENCY DISTRIBUTIONS FOR CRA 3 REGION 911

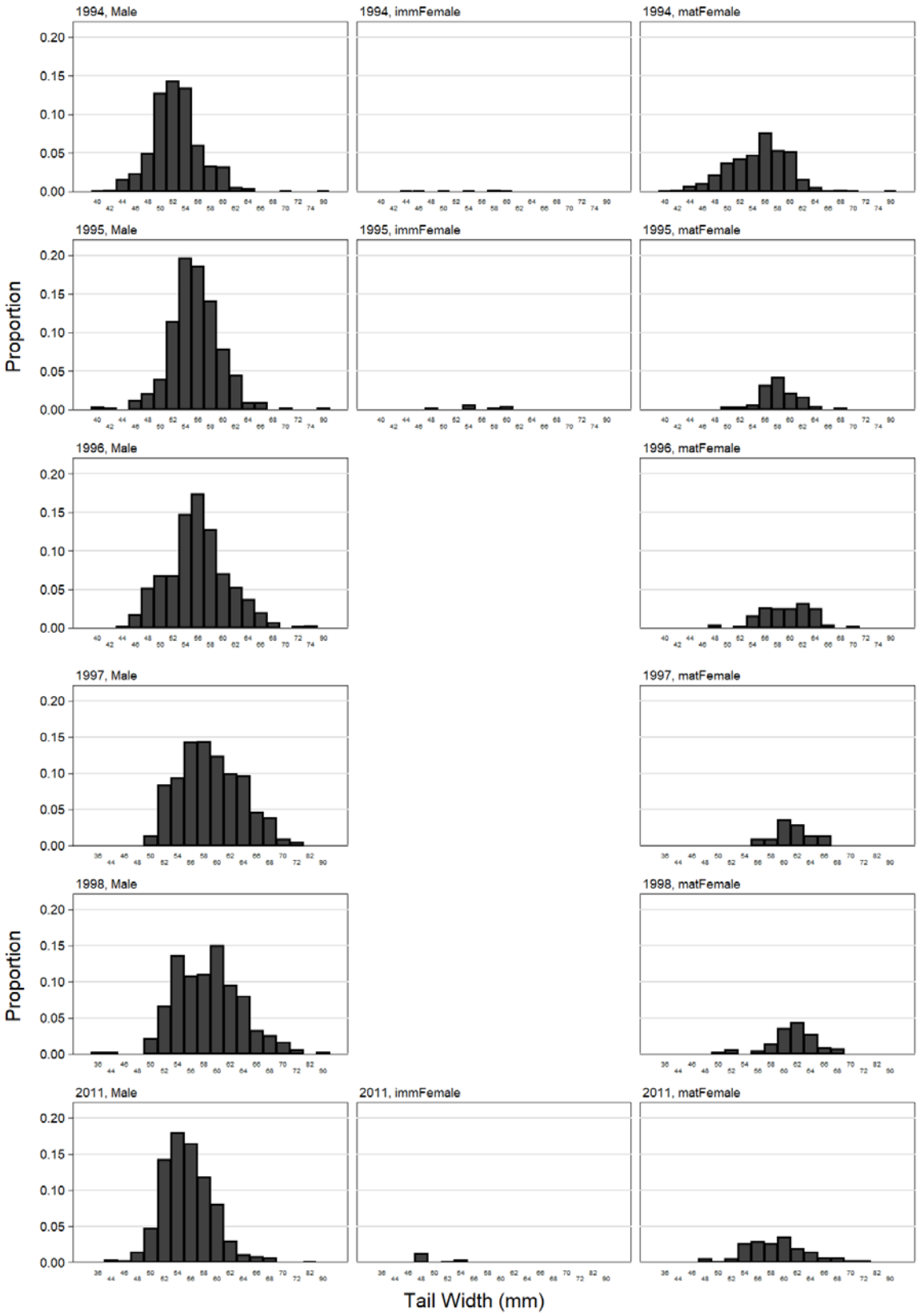

Figure G.1A:Length frequency histograms by sex category for AW logbook sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

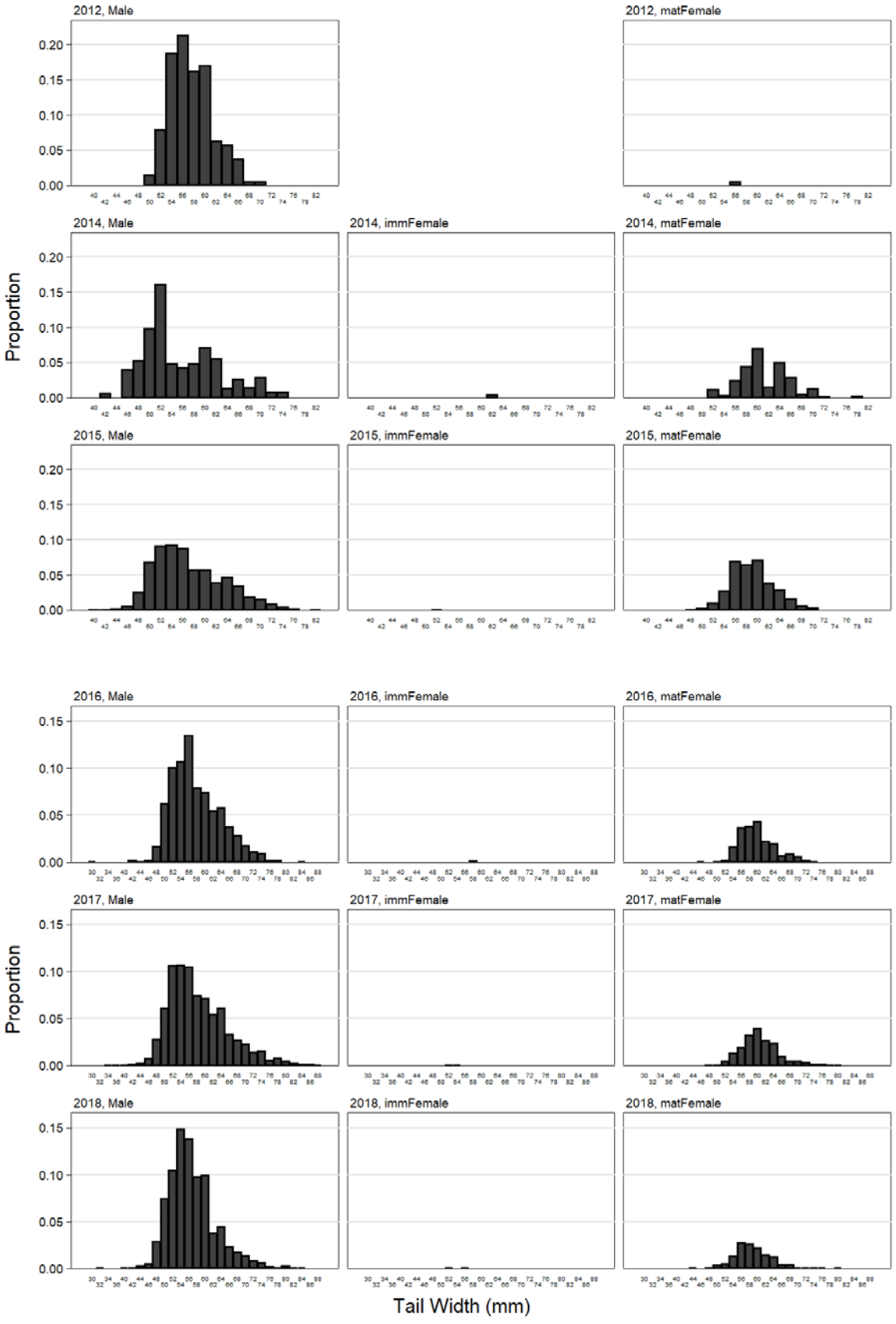

Figure G.1B: Length frequency histograms by sex category for AW logbook sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

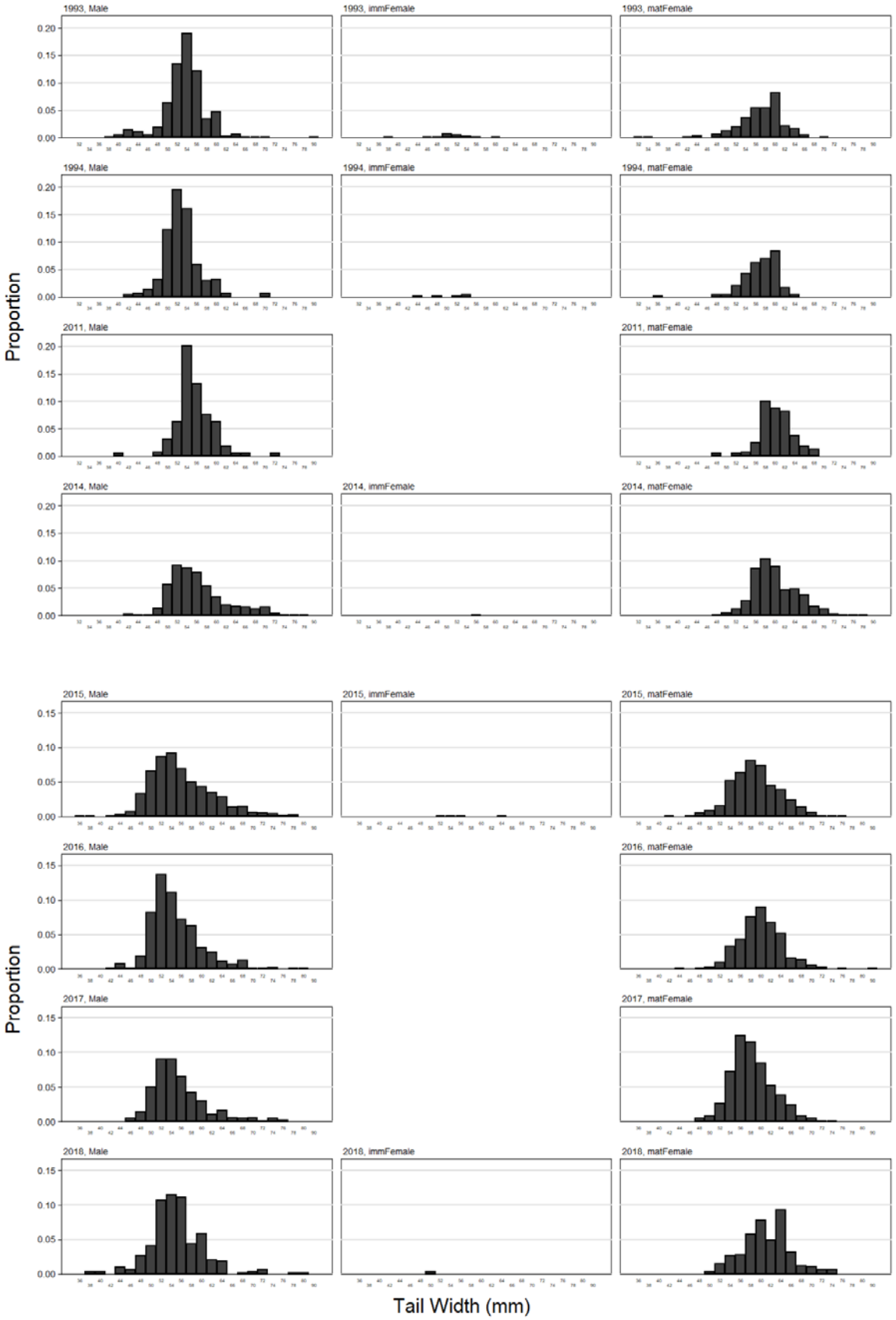

Figure G.2A:Length frequency histograms by sex category for SS logbook sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

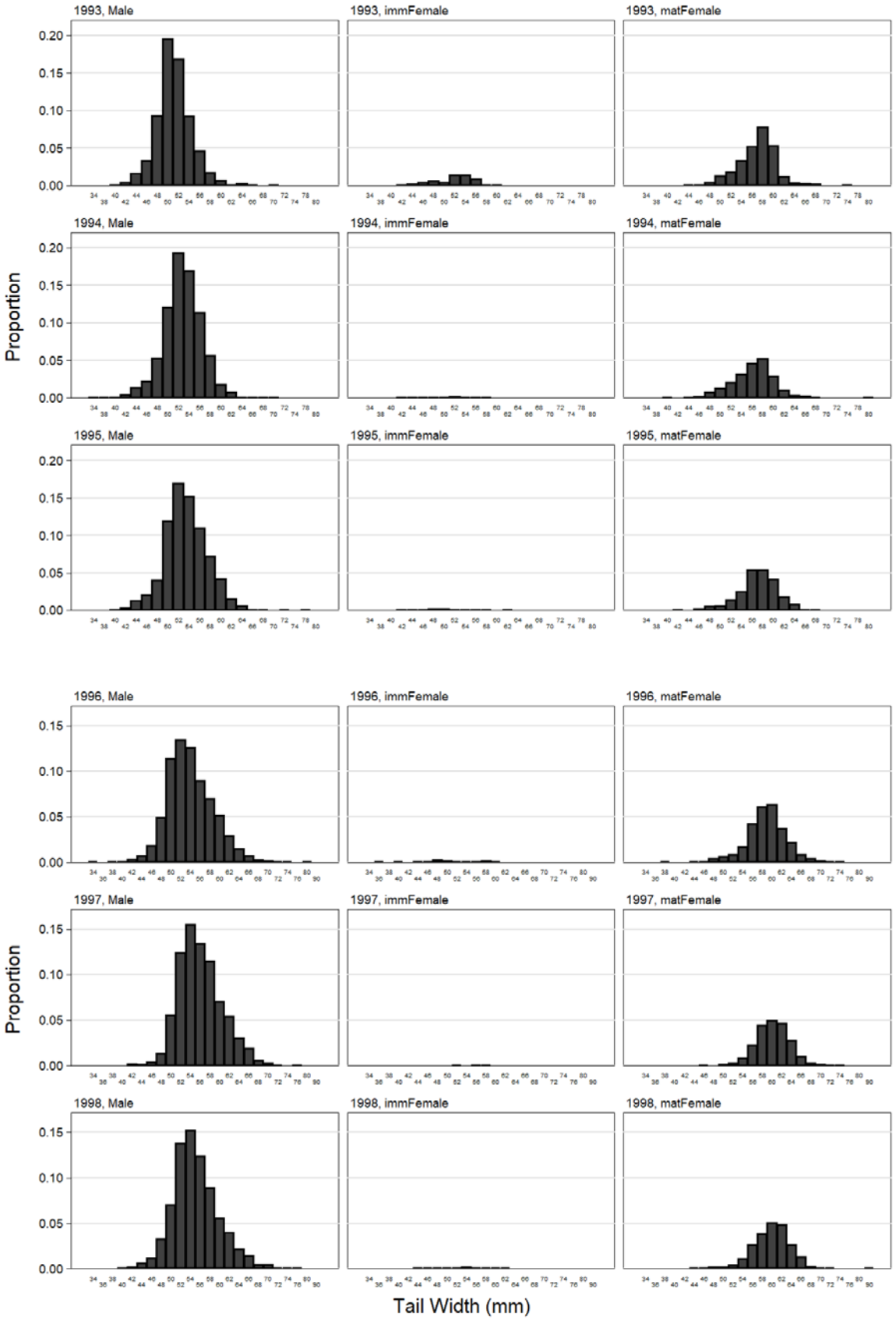

Figure G.3A:Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

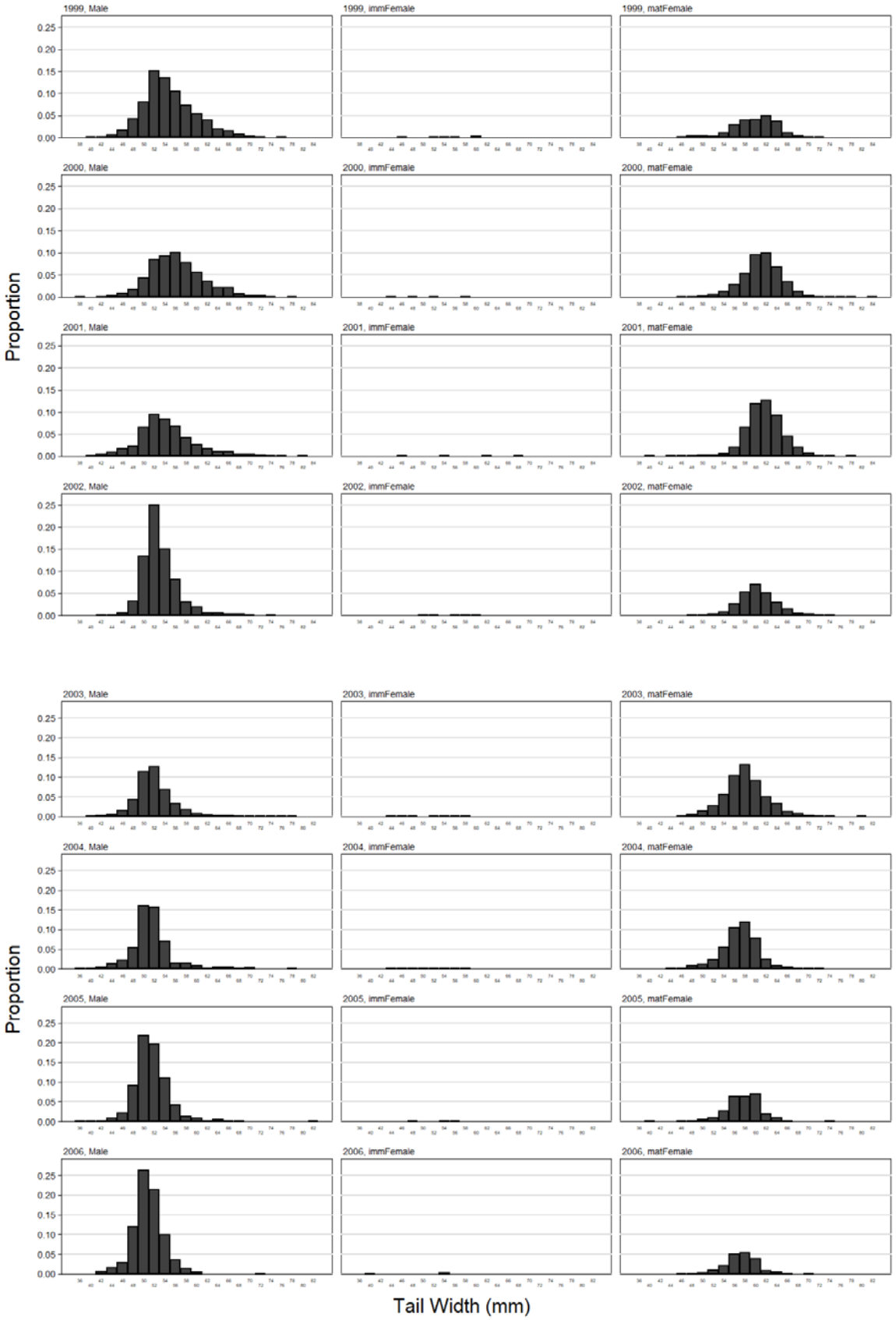

Figure G.3B: Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

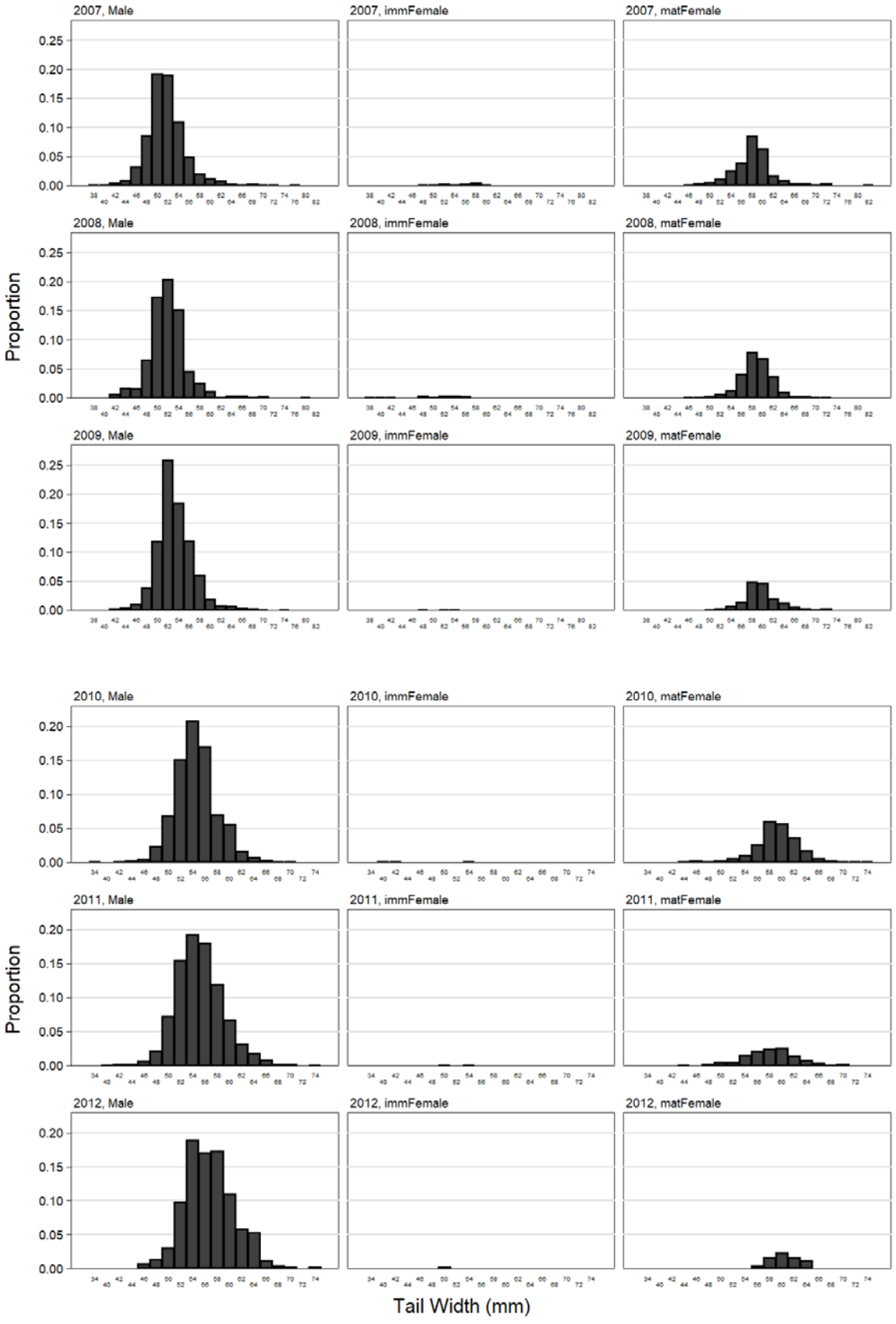

Figure G.3C:Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

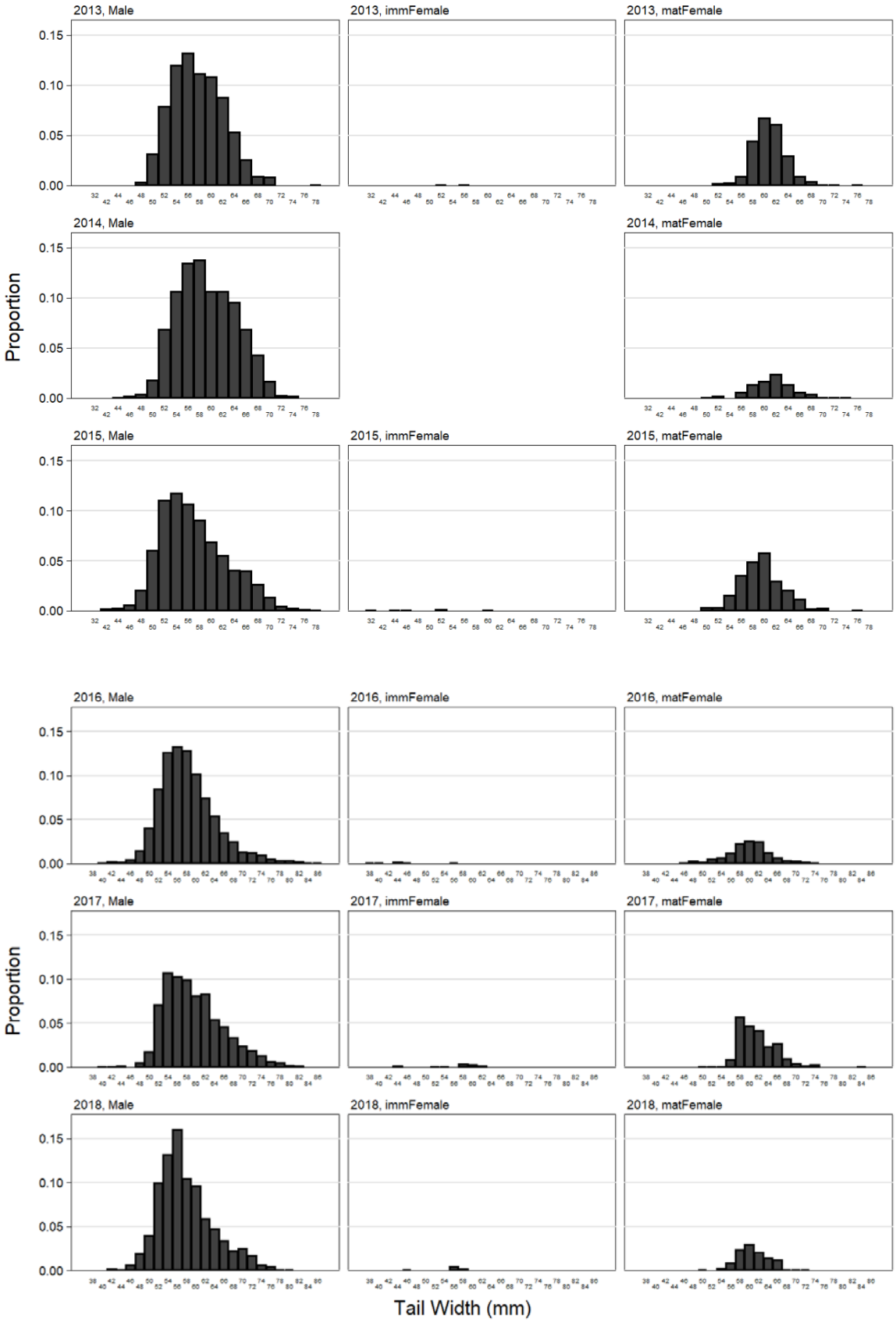

Figure G.3D:Length frequency histograms by sex category for AW observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

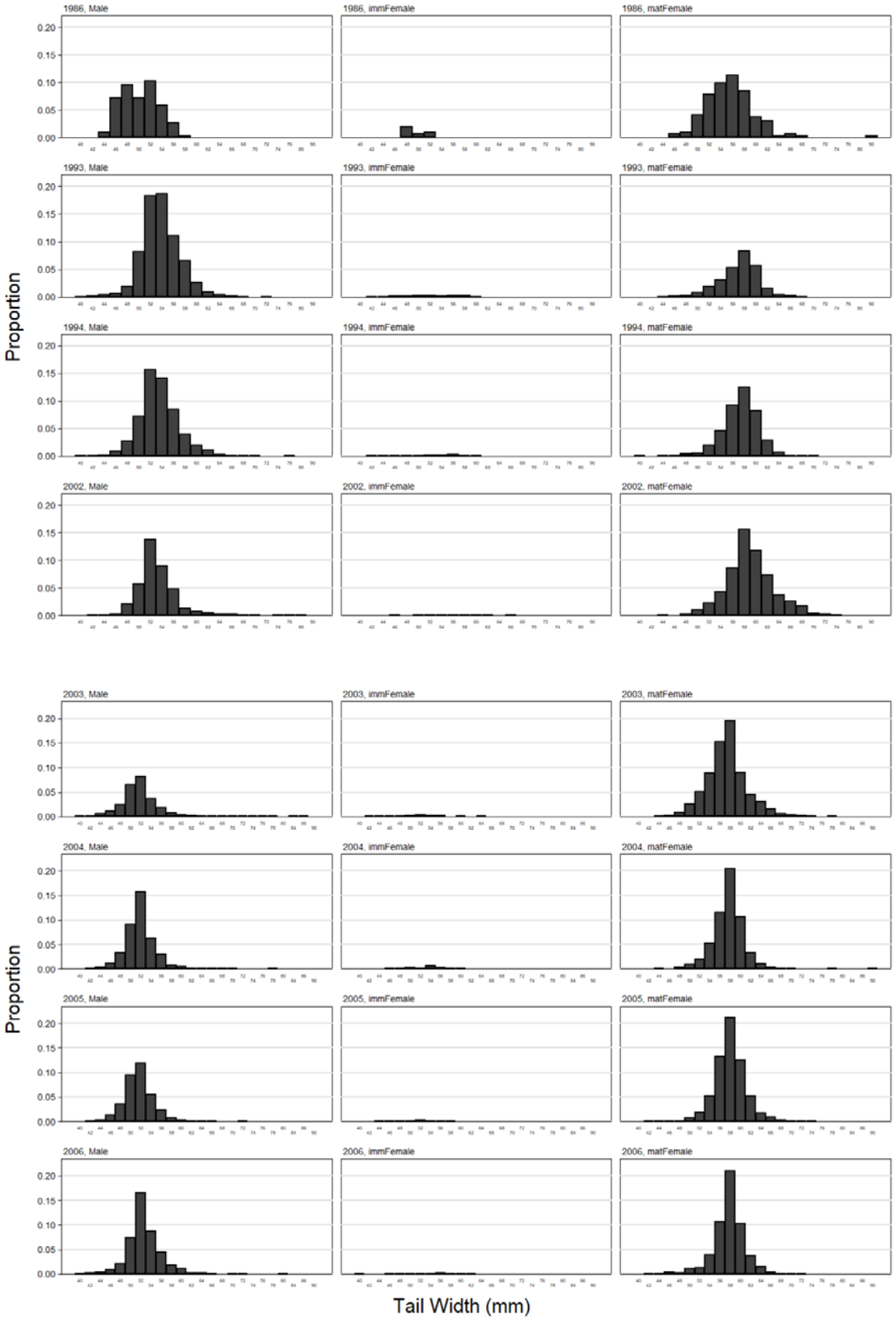

Figure G.4A:Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

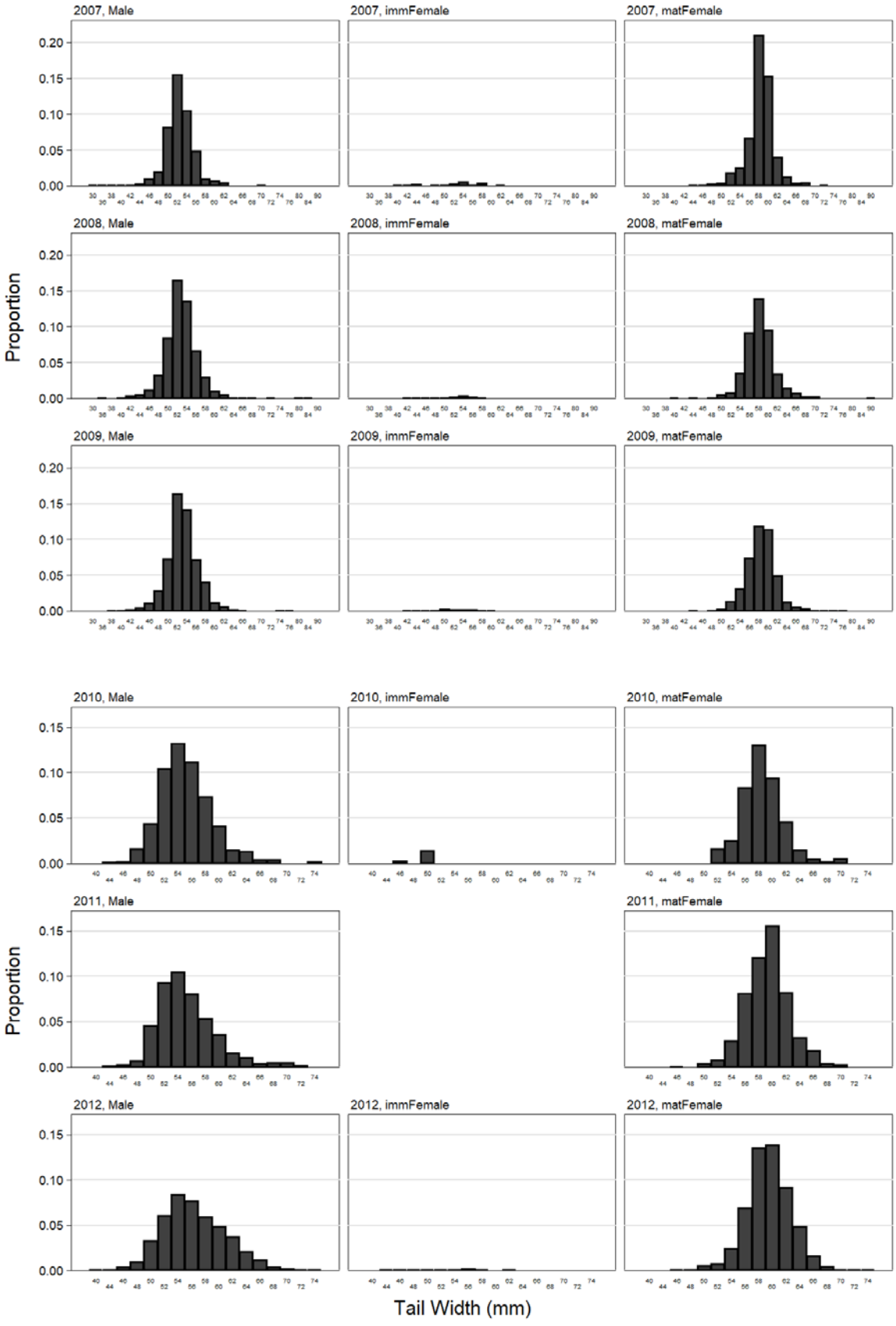

Figure G.4B: Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.

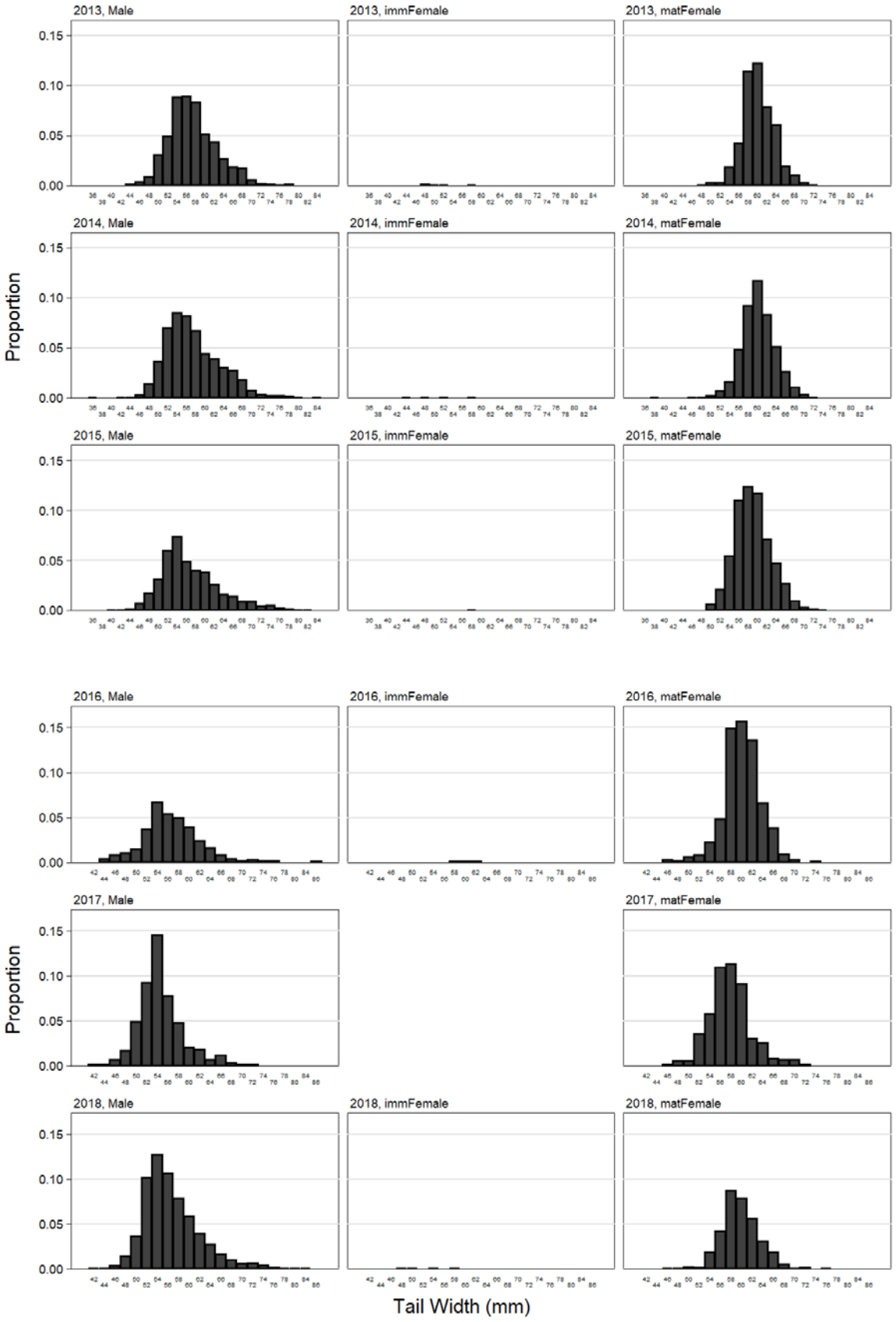

Figure G.4C:Length frequency histograms by sex category for SS observer catch sampling for indicated years. Proportions by sex in each year (row) sum to 1.0.