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Data for the 2015 stock assessments of red rock lobsters (*Jasus edwardsii*) in CRA 5, CRA 7 and CRA 8

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Starr, P.J.; Breen, P.A.; Webber, D.N. (2016). Data for the 2015 stock assessments of red rock lobsters (*Jasus edwardsii*) in CRA 5, CRA 7 and CRA 8.

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This document presents data for use in the 2015 stock assessments and management procedure evaluations for rock lobsters in CRA 5, CRA 7 and CRA 8. Data sets described in this report include catch estimates for all sectors of these fisheries, seasonal standardised CPUE indices, length frequency distributions, tag-recapture data and puerulus settlement 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 a recent large scale multi-species survey conducted using a population-based survey methodology. For CRA 5, a new method of scaling the survey catch estimates, beginning in 1979 relative to the SS Area 917 CPUE, was developed. Constant recreational catches were assumed from 1979 for both CRA 7 and CRA 8. 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 an LFR) to obtain the final catch total for scaling the estimated catches.

Length frequency data were available from both observer catch sampling and voluntary logbook programs (only the former were used for CRA 7). These were collated by data source and by season, and the document describes how the individual records were weighted. Tag-recapture data provide good information on growth rates for each sex and the document describes the data set. The time series of puerulus settlement data were standardised for exploration by the stock assessment model. These data were used in the CRA 5 stock assessment but were not used for either CRA 7 or CRA 8.

This work was conducted by a stock assessment team contracted by the New Zealand Rock Lobster Industry Council Ltd.

1. INTRODUCTION

This work addressed parts of Objectives 3 and 4 of the Ministry for Primary Industries (MPI) contract CRA2012-01C. This three-year contract began in April 2013 and was awarded to New Zealand Rock Lobster Industry Council Ltd. (NZ RLIC Ltd.), who sub-contracted Objective 4 to the authors of this report and other contractors. The report deals with red rock lobsters (*Jasus edwardsii*).

Specific objectives addressed by 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) determined that CRA 5, CRA 7 and CRA 8 should be assessed in 2015. Data were compiled for both stocks by a team comprising Paul Starr, D'Arcy Webber and Paul Breen. CRA 5 was then assessed by Paul Starr and D'Arcy Webber, and CRA 7 and CRA 8 were assessed together by Vivian Haist, Paul Breen and Charles Edwards, with close communication and discussion between the two teams. New graphic routines were developed by D'Arcy Webber and Charles Edwards. This document describes catches – including commercial, recreational, customary and illegal – CPUE, length frequencies, retention patterns, tag-recapture data and puerulus settlement data for CRA 5, CRA 7 and CRA 8.

Decisions on data and modelling choices were discussed and approved by the Rock Lobster Fishery Assessment Working Group (RLFAWG). For definitions of technical terms used here see the Glossary in the CRA 7 and CRA 8 stock assessment report (Haist et al. 2016).

1.1 CRA 5

The CRA 5 (Figure 1) fishery includes all of Tasman and Golden Bays as well as the Marlborough Sounds. It then extends down the northern part of the east coast of the South Island, past Kaikoura and the Banks Peninsula as far down as the Waitaki River. The previous stock assessment of CRA 5 was in 2010: Starr et al. (2011) described the data and Haist et al. (2011) described the stock assessment and management procedure evaluations, which used the Bayesian multi-stock length-based model (MSLM). The model was fit to puerulus settlement data, tag-recapture data, standardised CPUE from 1979–2014, historical catch rate data from 1963–1973 and length frequency data from voluntary logbooks and observer catch sampling. Changes in MLS and selectivity caused by escape gap regulations were taken into account.

The CRA 5 TAC and TACC were last changed in April 1999 but have been subject to review each year on the basis of the evaluation of the current management procedure. The current CRA 5 TACC for commercial catch is 350 t. Allowances set by the Minister of Fisheries in 1999 were 40 t for customary catch, 40 t for recreational catch, 37 t for illegal unreported removals for a total TAC of 467 t. The fishery is open to recreational fishing all year with MLS 54 mm TW for males and 60 mm TW for females.

1.2 CRA 7

The CRA 7 (Figure 1) fishery extends from the Waitaki River south along the Otago coastline to Long Point. The previous stock assessment of CRA 7 and CRA 8 was in 2012: Starr et al. (2013) described the data and Haist et al. (2013) described the stock assessment and management procedure evaluations, which used MSLM. This was fitted to CRA 7 and CRA 8 simultaneously and estimated movements between CRA 7 and CRA 8. The model was fitted to tag-recapture data, standardised CPUE from 1979–2006, historical catch rate data from 1963–1973 and length frequency data from

voluntary logbooks and observer catch sampling. Changes in MLS and selectivity caused by escape gap regulations were taken into account.

The CRA 7 TAC for 2014–15 was 117.72 t. Allowances set by the Minister for Primary Industries were 10 t for customary catch, 5 t for recreational catch, 5 t for illegal unreported removals and 97.72 t for the commercial catch (TACC). Before the 1993–94 fishing year, the CRA 7 commercial season was split into two parts: between 20 June and 19 November inclusive, an MLS of 127 mm tail length (TL) applied to both male and female lobsters; outside this period, it was 54 mm tail width (TW) for males and 60 mm TW for females. From 1993–94 until 01 October 2013, the period when the 54/60 mm TW MLS applied was closed (the start date for the 127 mm TL period was shifted back to 01 June in 2010). From 01 October 2013, the fishery was opened all year with the 127 mm TL MLS in force. The fishery is open to recreational fishing all year with MLS 54 mm TW for males and 60 mm TW for females.

The CRA 7 catch is exported or sold to the domestic market by several Dunedin and Christchurch fishing companies. Stock monitoring coverage in CRA 7 comprises 15 observer sampling days across both statistical areas, and has included periodic tagging, with over 2200 tagged lobsters released in 2012[1] and 1000 in 2013.

1.3 CRA 8

The CRA 8 (Figure 1) fishery extends from Long Point south to Stewart Island and the Snares Islands, through the islands and coastline of Foveaux Strait, then north along the Fiordland coastline to Bruce Bay. The previous stock assessment of CRA 7 and CRA 8 was in 2012: Starr et al. (2013) described the data and Haist et al. (2013) described the stock assessment and management procedure evaluations, which used MSLM. This was fitted to CRA 7 and CRA 8 simultaneously and estimated movements between CRA 7 and CRA 8.

The CRA 8 TAC for 2012–13 was 1053 t. Allowances set by the Minister of Fisheries were 30 t for customary catch, 33 t for recreational catch, 28 t for illegal unreported removals and 962 t for the commercial catch (TACC).

The industry supplies processing and export operations in Te Anau, Riverton, Stewart Island, Invercargill, Bluff, Christchurch, and Wellington. The CRA 8 Management Committee Inc. has developed and implemented codes of practice in relation to use and disposal of fishing gear and refuse, and was a founding member of the Guardians of Fiordland Fisheries.

2. CATCH ESTIMATES

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 from April to the end of March (Breen et al. 2001). Reported annual commercial catches between 1945 and 1978 inclusive, summarised by calendar year, were obtained from sources described in 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 MPI. 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.

From 1 April 1986 to 30 March 1988, monthly reported catch totals from all of New Zealand were obtained from Quota Management Returns (QMRs), maintained by MPI. Because catch estimates for

[1] The fishing year runs from April through March; the convention is to name fishing years by the first of the two calendar years, *viz.* 2012–13 is termed 2012.

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

High levels of commercial catches (up to 900 t/year) were recorded in CRA 5 for a few years in the late 1940s and early 1950s (Figure 2). After that period, commercial catches dropped below 400 t/year and then rose to over 700 t/year by the mid-1980s. Catches dropped when this QMA entered the QMS in 1990 to levels below 300 t/year in the mid-1990s. The TACC dropped in each year from an initial value of 465 t in 1990 to 303 t by 1993 (Figure 3). The TACC was raised to 350 t in 1999 and catches immediately rose to that level where they have remained (Figure 3). Annual CPUE peaked in 2009–10 near to 2.1 kg/potlift, but then declined about 15% to 1.8 kg/potlift in 2014–15.

Annual commercial catches in CRA 7 averaged 425 t before 1979, with a few years in the mid-1950s when catches exceeded 700 t/year (Figure 4). There is some doubt about the early catches, when the reported catches were based on port of landing rather than area fished. The stock assessment used only catches from 1963 (Haist et al. 2016). The 1963–78 CRA 7 catches averaged 464 t/year, and 1979-2014 catches averaged 138 t/year, with the higher catches in earlier years. From 2000, catches have averaged only 87 t/year. In 1994–99, 2008 and 2011, the TACC was not caught (Figure 5).

Annual commercial catches in CRA 8 averaged 1840 t before 1979, with a few years in the mid-1950s when catches exceeded 3000 t/year (Figure 6). There is some doubt about the early catches, when the reported catches were based on port of landing rather than area fished. The stock assessment used only catches from 1963 (Haist et al. 2016). The 1963–78 CRA 8 catches averaged 2033 t/year, and 1979–2014 catches averaged 1027 t/year, with the higher catches in earlier years. From 2000, catches have averaged 798 t/year. The TACC has usually been fully caught since 1992 (Figure 7).

2.2 Recreational catch

Five annual recreational catch estimates were available for CRA 5, CRA 7 and CRA 8 (Table 1). Estimates from the two Kingett Mitchell National Surveys (Boyd et al. 2004a; Boyd & Reilly 2004) were accepted by the RLFAWG for the 2012 CRA 7 and CRA 8 stock assessments (Starr et al. 2013), even though the Kingett Mitchell survey estimates were discarded by the RLFAWG for the more northerly rock lobster QMAs, including CRA 5. This was because estimated catches from the CRA 7 and CRA 8 Kingett-Mitchell surveys were low as were the earlier Otago surveys, with the estimates conforming to the expectation that recreational catches of rock lobster in the lower part of the South Island were low. The Kingett-Michell recreational catch estimates were considered implausibly high across a range of finfish and invertebrate species in the more northerly parts of New Zealand, including CRA 5. The earlier two 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]). These surveys continue to be used by the RLFAWG in spite of this advice because the estimates are plausible and no other recreational information is available for these years.

The most recent survey (large-scale multi-species or LSMS, Wynne-Jones et al. 2014), done in 2011–12, was based on residence interviews and covered all of New Zealand. The results were thought likely to be biased low for CRA 5 because there were no sampling units from Kaikoura, the section of coast considered to have the highest numbers of recreational fishers for lobsters. Similarly, the LSMS survey is thought to be biased low for CRA 7 and CRA 8, given the low number of participating

fishers involved in CRA 7 and CRA 8 (one and seven respectively) and the low number of fishing events observed (one and 19 respectively).

2.2.1 CRA 5

MPI, in its response to the Rock Lobster Stock Assessment team, recommended the following for the CRA 5 recreational fishery:

> *MPI recommends that the rock lobster stock assessment team model an 80 tonne recreational harvest (which includes amateur charter take) for the 2011–12 fishing year in the base case of this year's CRA 5 assessment and scaling this harvest relative to the CRA 5 spring-summer commercial CPUE in 2011–12. It is also suggested that a sensitivity trial of 140 tonnes is carried out.*
>
> *These recommendations are based on recent MAFWG discussions noting that the 80 tonne harvest estimate for modelling purposes takes into account:*
>
> - *The 43.47 tonne 2011–12 NPS recreational harvest estimate, while acknowledging it, is assumed to be an underestimate (the degree to which it is an underestimate is unknown).*
> - *The latest Kaikoura and Motunau boat ramp survey in 2012–13 that estimated 54.56 tonnes of rock lobster were harvested by recreational fishers and charter operators in these areas.*
> - *Anecdotal reports from recreational fishers and MPI compliance that rock lobster harvest is perceived to be high at times (particularly in Kaikoura).*
>
> *The MAFWG did consider combining the NPS and Kaikoura/Motunau survey results; however, due to interannual variability in potential harvest and the unknown proportion of resident vs. non-resident anglers between and within the two survey years, it is not practical or plausible to combine harvest estimates from different years.*

Recreational catches of rock lobster are poorly known throughout New Zealand, but reports of increased recreational activity in CRA 5 coupled with an increasing trend in abundance makes it unlikely that recreational catches have remained constant in CRA 5. The RLFAWG agreed for the 2003 (Kim et al. 2004) and 2010 CRA 5 stock assessments (Haist et al. 2011) to use a catch trajectory that reflected the increasing abundance of lobster in this QMA, based on SS CPUE. These stock assessments calculated the ratios of the CPUE relative to the recreational survey catch weight, took the mean of these ratios and applied it to the observed SS CPUE: in 2003 using CRA 5 standardised SS CPUE and in 2010 using unstandardised CPUE for Area 917 (Kaikoura). When this method was repeated for the 2015 CRA 5 stock assessment (using the survey estimates in Table 1), the estimated recreational catches were much higher than were considered credible. Consequently, the stock assessment team recommended a revised model based on a power function (Eq. 1), with the parameters estimated by fitting to the 1994 and 1996 recreational survey estimates (Table 1) and to the 80 t estimate for 2011–12 specified by MPI.

$$W_i = \alpha CPUE_i^{\beta} \quad \text{if } i >= 1979$$
$$W_{1945} = 0.2 * W_{1979}$$
$$W_i = W_{i-1} + \frac{(W_{1979} - W_{1945})}{(1979 - 1945)} \text{ if } i > 1945 \,\&\, i < 1979$$

Eq. 1

where

$CPUE_i$ = Area 917 SS CPUE from 1979 to 2014

W_i = recreational survey catch by weight for year i

α, β = parameters of a power function estimated through least squares

$\beta = 0.55$ when Eq.1 was fitted to the survey estimates in Table 1 and the estimated recreational catch trajectory is plotted in Figure 8. The maximum Section 111 catches (recreational take by commercial fishers for personal use: 7215 kg) was added to this trajectory (Figure 8). Recreational catch is split between seasons, with 90% assumed taken in the SS and the remainder in AW.

2.2.2 CRA 7 and CRA 8

MPI, in its response (Appendix B) to the NZ RLIC Ltd. request for guidance on non-commercial catch estimates (Appendix A), recommended as follows for CRA 7 and CRA 8 recreational catches:

> *CRA 7:*
> *MPI recommends that a 5 tonne recreational harvest for the 2014/15 year is used in the CRA 7 stock assessment and scaling this harvest to CRA 7 spring-summer commercial CPUE. It is also suggested that a sensitivity trial of 15 tonnes is carried out.*
>
> *CRA 8:*
> *MPI recommends that a 20 recreational harvest estimate for the 2014/15 year is used in the CRA 8 stock assessment and scaling this estimate to CRA 8 spring-summer commercial CPUE. It is also suggested that a sensitivity trial of 50 tonnes is carried out.*

The stock assessment used the suggested catches of 5 t/year and 20 t/year respectively as a constant catch spanning the full model period of 1945 to 2014 and added to these values the maximum reported Section 111 catches (Table 1; these are recreational catches taken aboard commercial fishing vessels). The constant catches were 6.7 t for CRA 7 (Figure 9) and 35.8 t for CRA 8 (Figure 9). Recreational catch is split between seasons, with 90% assumed taken in the SS and the remainder in AW.

2.3 Customary catch

MPI was asked to provide estimates of current and historical customary catches, and an appreciation of their uncertainty. MPI concluded for CRA 5, CRA 7 and CRA 8:

> *Based on the information available on CRA 5, CRA 7 and CRA 8 customary harvest, noting its incompleteness and uncertainty, MPI considers it appropriate to continue to use a 10 tonne constant customary catch estimate for CRA 5, a 1 tonne constant estimate for CRA 7 and to consider increasing the CRA 8 customary estimate from 6 to 15 tonnes. MPI also suggests that the RLFAWG considers carrying out sensitivity analyses for higher levels of customary catch for CRA 5 and CRA 8 (i.e. double the estimate).*

The recommended value of a constant 10 t for customary catch in CRA 5 is the same value used for the 2003 (Kim et al. 2004) and 2010 CRA 5 stock assessments (Haist et al. 2011). MPI clarified the instruction regarding CRA 8 and asking that the customary catch estimate be raised from 6 t in 2011 to

15 t in 2014 (Figure 9). Customary catch was split between seasons using the same proportions as for the recreational catch, with 90% assumed taken in SS.

2.4 Illegal catch

MPI were asked, before undertaking the 2015 CRA 5, CRA 7 and CRA 8 stock assessments, to provide estimates of current and historical illegal catches, along with an appreciation of their uncertainty. MPI were also asked to provide an estimate of the proportion of illegal catch that was eventually reported as legal catch. MPI pointed to estimates given in the past (Table 2) and suggested the following:

> *Taking into account the uncertainty in the available information on illegal take, MPI suggests that a 30 tonne illegal catch estimate is used in the upcoming CRA 5 stock assessment, 1 tonne continues to be used for CRA 7 and 3 tonnes continues to be used for CRA 8. It is also suggested that the RLFAWG considers carrying out sensitivity analyses with higher levels of illegal take for CRA 5 and CRA 8 (i.e. double the estimate).*

Given this advice from MPI, 30 t was used as the illegal estimate for CRA 5 in 2014 and the missing years from 2004 to 2013 were filled in by scaling the illegal catch down proportionately from the 52 t estimated for 2003 to 30 t in 2014. For CRA 7, a constant illegal catch of 1 t/year was used to fill in all years from 2003 (Table 2). For CRA 8, an estimate of 3 t was used as the estimate for 2011 (the final year of the previous CRA 8 stock assessment) and the missing years from 2003 to 2010 were filled in by scaling the illegal catch down proportionately from the 18 t estimated for 2002. The series was continued with 3 t to 2014.

In the past, MPI Compliance estimates for illegal catch 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 2) is assumed to represent illegal commercial catch that is eventually reported to the QMS as legitimate catch. Therefore this catch is subtracted from the reported commercial catch to avoid double-counting. Missing categories are treated as zeroes and the available values are used to estimate the overall proportion of R/NR for each QMA, which is then applied to all years (including interpolated years). MPI Compliance has stated that it no longer includes the "R" category in its estimates, 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 following procedure has been followed to estimate illegal catch in stock assessments since the 2004 assessment of CRA 3:

1. Starting with the estimates of export discrepancies for all of NZ for the period 1974 to 1980 (McKoy, unpub. data), the CRA 5, CRA 7 and CRA 8 illegal catches for each of these seven years were estimated from the ratio of the reported commercial catch in CRA 5, CRA 7 or CRA 8 relative to the total New Zealand reported commercial catch for the same years.
2. The average ratio in the CRA 5, CRA 7 or CRA 8 of the export discrepancy catch relative to the reported commercial catch was calculated for the period 1974–80. These ratios were used to generate an illegal catch estimate for all years with no data (from 1945 through 1973 and from 1981 through 1989) by multiplying the reported catch by the average ratio. This approach is consistent with a decision reached by the RLFAWG on 15 Aug 2002.
3. Beginning with 1990, which is the first year that estimates were provided by QMA, illegal catch was based on MPI Compliance estimates (Table 2). For years without Compliance estimates, the level of illegal catch was interpolated between estimates (Table 2).
4. Estimates for "commercial illegal reported" (equals "reported" in Table 2) are used to split the illegal catch into the "illegal reported" and "illegal unreported" categories from 1990 onwards. The estimates for the proportion of catch which eventually finds its way into the legal (SL) catch for CRA 7 and CRA 8 are relatively high compared with the other QMAs, while the

equivalent proportion is low for CRA 5 (see Table 2). The proportion of the illegal catch allocated to "illegal reported" was 6% for CRA 5, 80% for CRA 7 and 76% for CRA 8.

5. We assumed that both the reported and unreported annual illegal catch were distributed between seasons in the same proportion as the commercial catch for each year.

Illegal catch estimates are shown in Figure 2 (CRA 5), Figure 4 (CRA 7) and Figure 6 (CRA 8).

2.5 Size-limited and non-size-limited catch by season

The size-limited (SL) catch is the catch taken under the MLS regulations and the restriction on landing berried females; it is the sum of the commercial and recreational catches minus the reported illegal catches. The non-size-limited (NSL) catch is the catch taken without regard to those restrictions; it is the sum of reported and unreported illegal catches and the customary catches. Annual commercial catches were divided into seasons from 1979 onwards based on the seasonal proportions in the FSU and QMR/MHR data (Figure 10 for CRA 5 and Figure 11 for CRA 7 and CRA 8). Illegal catches were divided in the same seasonal proportions as commercial. It was assumed that 90% of the customary and recreational catches were taken in SS.

Catches by season for CRA 5, CRA 7 and CRA 8 from all four sources are shown in Table 3 and as SL/NSL catches in Figure 12 for CRA 5, Figure 13 for CRA 7 and Figure 14 for CRA 8.

3. CATCH RATES

Catch and effort data from the FSU and CELR systems were obtained from MPI in September 2015 (Replog 10163), loaded into the CRACE database and processed using standard error checks (Bentley et al. 2005). Data spanned the period from 1 April 1979 through 31 March 2015.

Data preparation used the F2-LFX procedure (Starr 2015). The F2 algorithm corrects the monthly estimated catch taken by a vessel in a statistical area using a "vessel correction factor" (*vcf*: the ratio of landed catch to estimated catch for one vessel in one year) (Starr 2012; Starr et al. 2012), and discards from the analysis those vessels with *vcf* less than 0.8 or greater than 1.2. 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.

The CPUE standardisation procedure used sequential six-month periods as a forced explanatory variable. Two other explanatory variables were available for this analysis: [`month`] of capture and [`statistical_area`] of capture. These analyses estimate 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 variable [`vessel`] was not used, although Starr (2012) showed that it was potentially important. Vessel codes are not consistent between the FSU and CELR data systems, so using [`vessel`] would require fitting to separate CPUE series unless the vessel codes could be reconciled.

3.1 CRA 5 standardised seasonal CPUE

Although the CRA 5 data set shows a diminishing number of records, there remain a reasonable number of records in the three primary statistical areas (Areas 916, 917 and 933, see Figure 1) in both the AW and SS seasons (Table 4). The total deviance explained by the CRA 5 model was 40% (Table 5), with the greatest explanatory power lying with model period, followed by statistical area. This was consistent with other rock lobster standardisation analyses. Residual patterns showed some deviation from the lognormal assumption at both tails of the residual distribution (Figure 15).

Statistical areas 916 and 918 had the highest expected catch rates, with the other statistical areas having near or below average catch rates (Figure 16). There was only minor contrast in the month categorical variable for the CRA 5 analysis, with peaks in May and from November through January (Figure 16). The CRA 5 AW CPUE series by model period showed a peak in the early 2000s, a decline to 2006, followed by a rise to the highest point in the series in 2009 (Figure 17). The SS series showed a definite peak in 2003, a drop to 2007, followed by a rise to a level equivalent to 2003 in 2009 (Figure 17; Table 6). The SS series had a larger associated error than the AW series, reflecting the relatively smaller amount of data in the SS series in recent years (Table 4).

3.2 CRA 7 standardised seasonal CPUE

CRA 7 shows a diminishing number of records over time, with some recent years having fewer than 10 [vessel], [month], [statistical_area] observations in the SS season (Table 7). The total deviance explained by the CRA 7 seasonal standardised model was 35% (Table 8). The greatest explanatory power in the model is the time step variable [period] variable, followed by [statistical_area]. The variable [month] had little explanatory power. Residual patterns showed some deviation from the lognormal assumption at both tails of the residual distribution (Figure 18). The [statistical_area] and [month] effects are shown in Figure 19.

Statistical Area 921 had a higher expected catch rate than Statistical Area 920 (Figure 19). Months from June through November had similar catch rates (Figure 19), so [month] had little effect in the model. These are the months when the smaller MLS applies, and there appears to be little seasonal variation in the catch rate.

CPUE peaked in the mid-2000s at levels greater than the long-term average in both seasons and then declined below the long-term average (Figure 20, Table 6). The two most recent CPUE observations are more than twice the long-term average and represent the highest observations in the series in both seasons.

3.3 CRA 8 standardised seasonal CPUE

The CRA 8 data are also characterised by diminishing number of records over time, although the number of records is acceptable throughout the series (Table 9). The total deviance explained by the CRA 8 seasonal standardised model was 32% (Table 10). The greatest explanatory power was in the [period] variable, followed by [month] and [statistical_area]. Residual patterns showed some deviation from the lognormal assumption at both tails of the residual distribution (Figure 21). The [month] coefficients show some contrast, with the highest catch rates occurring in the spring and early summer (Figure 22). The contrast in the [statistical_area] coefficients is largely for Area 925 [Snares], an area which is rarely fished and consequently appears to have considerably higher catch rates (Figure 22).

CPUE peaked in the late-2000s at levels several times above the long-term average in both seasons and has since declined only slightly in the AW season while there has been almost no diminution in the SS season (Figure 23, Table 6).

3.4 Historical catch rate (CR)

Monthly catch and effort (days fishing) data from 1963 through 1973 were summarised by Annala & King (1983) and used to calculate unstandardised catch per day for each calendar year from 1963 to 1973 for CRA 5, CRA 7, and CRA 8 (Figure 24).

4. LENGTH FREQUENCY DISTRIBUTIONS (LFs)

4.1 Preparation of LF records and record weighting

Data were extracted for all three QMAs in September 2015; they comprised both observer and voluntary logbook catch sampling from 1986 through 2014. Each data record compiled for input to the model was from either voluntary logbook or observer catch sampling, and contained all the length measurements for one QMA from one source in either the AW or SS season in one year.

Record fields were:

- QMA (CRA 5, CRA 7 or CRA 8)
- fishing year
- season (coded 1 for AW, 2 for SS)
- source (coded 1 for logbooks, 2 for observers; there were no data from market sampling or other old codes)
- 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, where the first size class is 30–31.9 mm tail width (TW), the next is 32–33.9 mm, etc.
- 31 fields for immature female numbers measured
- 31 fields for mature female numbers measured.

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

$$p^{g}_{m,a,s} = \frac{N^{g}_{m,a,s}}{\sum_{s} N^{g}_{m,a,s}}$$

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 cell.

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

$$P^{g}_{s} = \frac{\sum_{m}\sum_{a}\left(C_{m,a}\, p^{g}_{m,a,s}\right)}{\sum_{m}\sum_{a}\sum_{s}\left(C_{m,a}\, p^{g}_{m,a,s}\right)}$$

where P^{g}_{s} is the relative proportion-at-length for each sex in the record. The model re-normalises these to sum to 1 across each sex.

As well as the relative weight assigned to the overall LF dataset, a relative weight (*w*) 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 ($N_{m,a}$) and the cube root of the number of days sampled ($D_{m,a}$):

$$w = \sum_{m}\sum_{a} \frac{C_{m,a}\sqrt[3]{N_{m,a}}\sqrt[3]{D_{m,a}}}{\sum_{m}\sum_{a} C_{m,a}}$$

4.2 LF data by QMA

4.2.1 CRA 5

The CRA 5 LF data comprised 60 records from 1989–2014 (Table 11); 42 of these were logbook samples and 18 were observer samples, distributed relatively evenly across the two seasons. The logbook records ranged from 292 to 32 191 lobsters while the observer samples ranged from 1084 to 13 443 lobsters (Table 11). The logbook record weights ranged from 2.2 to 55.8 (the base case model truncated to 10 those records that were greater than 10). The observer weights ranged from 0.9 to 8.4 (the base case model raised the weights below 1.0 to 1.0). All LF records were used in this assessment as there were no obvious problems in the proportions by length or the mean lengths.

4.2.2 CRA 7

The CRA 7 LF data comprised 56 records from 1988–2014 (Table 12). Four of these were logbook samples, one with only 7 fish measured, and in these the proportion mature seemed higher than in the observer samples. As in the 2012 assessment (Haist et al. 2013), the logbook samples were not used. The 2012 assessment had discarded eight of the SS observer records, but it was difficult to justify this on the basis of sizes or maturity proportions, and this assessment used all the observer records in the base case.

These records ranged from 71 to 7475 fish measured; record weights ranged from 1.5 through 15.9 (in the base case model those above 10 were truncated to 10).

4.2.3 CRA 8

The CRA 8 LF data comprised 75 records from 1987–2014 (Table 13). There were 31 observer records, ranging from 500 to 20 252 fish measured. Weights of these records ranged from 1.3 to 14.8. In the 44 logbook samples, fish measured ranged from 1053 to 23 059, and record weights from 5.8 to 54.4 (on average, much higher than the observer samples). Whereas the 2012 stock assessment used all the records, we removed five suspect records based on mean length or proportion mature or both.

4.3 Proportion by sex

Sex proportions were calculated (outside the model) from normalised data records. The model calculates proportions-at-sex and fits to them. For CRA 5 (Figure 25), there were very few immature females, with females in this QMA usually reaching maturity well below the MLS of 60 mm TW. The sex ratios of males and mature females showed some systematic pattern over time in both seasons, returning in each instance to the original estimates by the end of the time series. For CRA 7 (Figure 26), there were few mature females because of the small MLS and migration from CRA 7 to CRA 8. Proportions of males show a systematic increase in the AW sampling but not in SS, and immature females showed a complementary decline in AW. In CRA 8 (Figure 27), proportions show wide variations over time, consistent between seasons and sampling sources. Mature females were at their historical high, perhaps because of differential retention, and immature females were a very small proportion of the catch.

4.4 Mean length

Mean length was also calculated from the data records. For CRA 5 (Figure 28), there was a clear increasing trend in male mean length in both the AW and SS up to the end of the 1990s, after which male mean lengths remained without trend. There was a similar increasing trend for mature females in

the late 1990s, followed by an increasing trend in mean length for AW mature females. For CRA 7 (Figure 29) there were no consistent patterns over time; the mean lengths were much more variable than in CRA 8. For CRA 8 (Figure 30), mean length for males and mature females showed a steady increase until 2010 in AW, then a slight decline; the SS increase was much less striking. Observer sampling showed more variation than logbook sampling.

4.5 Binning

Although the model contains size bins over the range 30–92 mm TW, few fish as small as 30 mm are measured and very few large fish are measured, especially for immature females, leading to many cells with zero observations. 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 population of very small residuals that would distort the diagnostics as well as taking up computing time.

Bins at both ends of the range for each sex were therefore combined into "plus" and "minus" bins. The model was given the length range of bins for each sex for each QMA that contained a reasonable number of observations, determined arbitrarily by inspecting the proportion of cells in each sex/size bin that contained a minimum proportion of normalised observations. The threshold was set at 0.001, but the procedure was not very sensitive to the chosen value. Results are shown in Figure 31 for CRA 5, Figure 32 for CRA 7 and Figure 33 for CRA 8. Inspection of these was used to determine the bins fitted and the bins used as plus or minus groups for each sex and QMA.

4.6 Length frequency (LF) distributions

The distributions of the LF data by sex are shown for each data record included in the stock assessment, where a "data record" represents the normalised frequency by sex class in a sequential six-month season by data source (logbook or observer); see Figure 34 for CRA 5, Figure 35 for CRA 7 and Figure 36 for CRA 8.

4.7 CRA 8 retention patterns

Fishers can legally return a legal lobster (above MLS, not a berried female, tail bars not broken) to the sea. Returned lobsters are thought to have a high survival rate: in CRA 8 about 25% of recaptured tagged lobsters have been captured more than once and some as many as 10 times. Survival rate is unknown (the assessment model assumes 90%).

Lobsters may have low value because of recent moulting, broken antennae or missing legs. The price per kilogram varies with size such that a large lobster can be much less valuable than two smaller lobsters of the same combined weight. A fisher might choose to return a large lobster to the sea when confident that the increased return will exceed the cost of catching two smaller lobsters. This is commonly called "high-grading" without any connotation of wrongdoing.

High-grading varies with abundance: at low abundance, the cost and uncertainty of catching smaller replacements for large lobsters returned to the sea both increase. High-grading is of interest to stock assessment because the size distribution of lobsters landed will be different from the distribution of legal lobsters caught.

In this section, "caught" refers to fish that were measured by the logbook program, "retained" or "kept" refer to fish that were recorded as having been kept for landing, "not retained" or "returned to the sea" refer to fish recorded as not having been kept and "legal" fish are defined by the regulations and explained below.

4.7.1 CRA 8 logbook data

Data from the logbook program were supplied by Nokome Bentley on 5 September 2015. Fields in the dataset were fisher ID (coded to preserve confidentiality), fishing year, calendar month, statistical area, sex (1 through 5, corresponding to males, immature females, mature females, berried females and spent females respectively), mm TW, number caught and number retained. CRA 8 data were selected based on Statistical Areas 922 through 928.

A "legal" code was constructed:

- true (1) for males 54 mm TW and above
- false (0) for males 53 mm and below
- true for sex codes 2, 3 and 5 for CRA 8 females 57 mm and above
- false for CRA 8 females 56 mm and below
- false for sex code 4 (berried) females

A simplified sex field ("sex2") was constructed: 1 for males and 2 for females in sex codes 2 through 5.

No retention was reported before 2000 (Table 14). All subsequent analyses are based on data from 2000–14. About 460 records were removed because the total fish caught was zero or blank, or because the sex code was 6 or greater (thus invalid).

For each ID code, percentage retention was calculated by year for 2000 onwards. Some ID codes had data for one year only; eight of these had zero retention or very low retention (5% or 10%). It is not credible that a fisher would return 90% or more of his fish to the sea, so these eight ID codes were removed. Of the remaining ID/year cells, some cells had less than 10% retention rate (after 10% the next highest rate was 38%) and were removed. All the removed data were from 2000 or 2001.

The groomed data set contained 159 656 measurements of legal fish from 39 fishers, who retained 75% of them (Table 15). The measured fish were about 95 300 males and 64 300 females. Males ranged from 54 to 112 mm TW; females from 57 to 109 plus one unlikely fish at 117 mm TW. Ninety-five percent of males were 82 mm or less and 95% of females were 80 mm or less (Figure 37).

4.7.2 CRA 8 retention-at-size by sex and year

For each year and each sex, the proportion of fish retained at each size was calculated. For each year for each sex, an inverse logistic curve was fitted to the proportion retained in each length bin. For each sex, the model was:

$$\hat{R}_{y,l} = \frac{Rmax_y}{\left(1+\exp\left(-\ln(19)\left(\left(R50_y - l\right)/R95_y\right)\right)\right)}$$

where $\hat{R}_{y,l}$ is the predicted proportion retained at size l (mm TW) in year y, $Rmax_y$ is the estimated maximum proportion retained in year y, $R50_y$ is the estimated length at which 50% would be retained and $R95_y$ is the estimated difference in length between 50% and 95% retention. This model was fit by assuming binomial likelihood: the negative likelihood contribution is:

$$-LL_{y,l} = -\left(x_{y,l}\ln\left(\hat{R}_{y,l}\right) + \left(n_{y,l} - x_{y,l}\right)\ln\left(1-\hat{R}_{y,l}\right)\right)$$

where $x_{y,l}$ is the number kept at length l in year y and $n_{y,l}$ is the total number caught at length l in year y. The model was fit using ADMB (Fournier et al. 2012). Parameter estimates are compared in

Table 16 and the annual fitted retention-at-size curves are shown in Figure 38 and Figure 39 for males and females respectively.

Points to note are:

- the inverse logistic fit many years' data very well
- males showed more consistent trends in parameters across years (declines in the inverse logistic parameters) than females
- retention tended to decrease with time
- male curves fitted the large fish sizes generally well, but female curves did not (there are few males or females above 80 mm TW)
- many years' data for both sexes show reduced retention of fish in the first one or two size bins above MLS, possibly because of precautionary measuring

4.7.3 CRA 8 retention-at-size curves predicted from CPUE

The inverse logistic model was also fitted to all years simultaneously by using an annual CPUE measure as a predictor of the annual inverse logistic model parameters. This fit was developed for predicting future retention rates as a function of CPUE in model projections. The CPUE metric was the mean of the AW and SS standardized CPUE indices, which are fitted in the stock assessment model. When conducting stock projections, predicted values for this CPUE measure can only be calculated for the previous year. Therefore the model parameters $Rmax_y, R50_y,$ and $R95_y$ were estimated by fitting to the CPUE from the previous year:

$$Rmax_y = a^{Rmax} + b^{Rmax} I_{y-1}$$
$$R50_y = a^{R50} + b^{R50} I_{y-1}^{\delta}$$
$$R95_y = a^{R95} + b^{R95} I_{y-1}$$

where I_y is the standardised annual CPUE in year *y* (Table 16) and $a^{Rmax}, b^{Rmax}, a^{R50}, b^{R50}, a^{R95}, b^{R95}$ and δ are the parameters estimated by fitting all years simultaneously, predicting the inverse logistic parameters from the relations above and minimising the total binomial negative log-likelihood. This was done using ADMB and results are shown in Table 17.

The negative log-likelihood value increased from the negative log-likelihood obtained from fitting individual year curves: by a little over 1% for both males and females. An alternative model, fitting the $Rmax_y, R50_y,$ and $R95_y$ parameters to the CPUE in year *y* (I_y) was also fitted, but this did not improve the predictive ability of the model (Table 18).

The logistic curves predicted from CPUE for each year are shown in Figure 38 and Figure 39 for males and females respectively. Points to note are:

- for males the two sets of curves are similar, and indeed are very similar for 2007 onwards
- for females there are much greater differences between the two sets of curves
- differences between the two curves in a year are greatest in the early years and for the largest fish

The logbook data can be used to calculate the percentage of fish retained by weight. This is done in three ways: the weight of fish retained at a given size could be directly estimated from the retention reported for each fisher in the logbook data, or from the estimated annual retention curves, or from the predictive retention curves based on CPUE. These three methods give similar results (Figure 40). Retention was about 90% by weight until 2006, then declined sharply to 60% in 2006, and has remained near that level since then.

5. TAG-RECAPTURE DATA

Tag release and re-capture data for CRA 5, CRA 7 and CRA 8 were extracted in September 2015 and processed with purpose-built software developed by D'Arcy Webber (unpublished). This software does the following:

- removes duplicate records (optional; used here)
- removes white space from all columns
- formats the date and determines the period, removes records with no date
- assigns tag type a numeric code and writes the key to file TypeKey.dat
- assigns stage a numeric code
- removes records that are missing both tail width and carapace length
- matches releases with recaptures and removes non-re-captured release records
- infers sex if sex is missing at release but not recapture or vice versa
- removes records with different sex at release and recapture, or sex code not 1 or 2
- sets statistical area to NA if not 901 to 943
- if the option qma_method = "area", determines QMA from statistical area, or if statistical area is NA then sets QMA using the project ID
    - otherwise determines QMA from the project ID, or if project ID is NA then determines the QMA from statistical area
- adds 0.5 to the TW measurement if calendar year > 1992 and source = 2 (commercial recapture with measurement rounded down)
- for older records with no TW, if there is no recorded tail width, calculates TW from carapace length using relationships developed by Breen et al. (1988).
- removes records that are less than or greater than a specified TW
- calculates time at liberty in days
- removes records from fish at liberty for less than or greater than a specified time (in this study, 1 day and 10 years)
- calculates apparent growth increment
- removes records with apparent increments that are less than or greater than specified values (in this work, -30 and 30 mm)

Where a lobster was released, recaptured, re-released and re-recaptured, this was treated as two tag-recapture events.

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

- a unique 5-digit event code
- sex (1 for males and 2 for females)
- month of release, extracted from release date
- year of release, extracted from release date
- month of recovery, extracted from recovery date
- year of recovery, extracted from recovery date
- days at liberty, obtained by subtracting release from recovery dates
- TW at release and recovery
- number of re-releases
- statistical areas of release and recovery
- a condition code
- tag type code (3 for western rock lobster tag and 4 for Hallprint Floy-type tag)

For exploration only (not for use by the model), increments were "annualised" based on days at large:

$$\Delta_i = 365.25(L_i^2 - L_i^1)/\delta_i$$

Where Δ_i is the annualised increment for the ith record, L_i^1 and L_i^2 are the sizes at release and recapture and δ_i is the number of days at liberty.

5.1 CRA 5

The screened data extract for CRA 5 comprised 7035 records: 4954 males and 2081 females (Table 19). Sizes at release and recapture by sex are shown in Figure 41. Releases were made in 1976–79 with western rock lobster tags and 2000–13 with HallPrint tags. The early releases had size recorded in carapace length and the later releases used tail width. The number of tags released by area is shown in Table 20. Generally most tags were recaptured in the area of release (Table 21).

Times at liberty varied from 1 day to 3532 days (10 years), but the median was 247 days and 73% were at liberty for less than one year and 92% less than 2 years. One fish was re-released 13 times, but 74% of records were from fish that were not re-released (Table 22). Condition codes were nearly all zero or missing. Growth increments ranged from –30 mm to 37.2 mm. Annualised growth increments ranged from -5478.8 to 2690.7, and are shown for males and females in Figure 42.

5.2 CRA 7

The screened data extract for CRA 7 comprised 489 records: 230 males and 259 females (Table 19). Sizes at release and recapture by sex are shown in Figure 43. Releases were made in 1976–79 with western rock lobster tags and in 2000–13 with HallPrint tags. The number of tags released by area is shown in Table 23. Generally most tags were recaptured in the area of release (Table 24).

Times at liberty varied from 2 days to 3652 days (10 years), but the median was 164 days and 72% were at liberty for less than one year and 94% less than 2 years. One fish was re-released four times, but 91% of records were from fish that were not re-released (Table 22). Condition codes were nearly all zero or missing. Growth increments ranged from -15.7 to 25.4 mm. Annualised growth increments ranged from -243.5 to 199.2, and are shown for males and females in Figure 44.

5.3 CRA 8

The screened data extract for CRA 8 comprised 10 751 records: 5873 males and 4878 females (Table 19). Sizes at release and recapture by sex are shown in Figure 45. Releases were made in 1976–1979 with western rock lobster tags and 2000–2013 with HallPrint tags. The early releases had size recorded in carapace length and the later releases used tail width. The number of tags released by area is shown in Table 25. Generally most tags were recaptured in the area of release (Table 26)

Times at liberty varied from 1 days to 3485 days (10 years), but the median was 297 days and 66% were at liberty for less than one year and 89% less than 2 years. One fish was re-released 13 times, but 66% of records were from fish that were not re-released (Table 22). Condition codes were nearly all zero or missing. Growth increments ranged from -37.1 to 37.6 mm. Annualised growth increments ranged from -1278.4 to 1826.2, and are shown for males and females in Figure 46.

6. PUERULUS SETTLEMENT DATA

The puerulus settlement program, conducted by NIWA, is described in annual reports (e.g. Forman et al. 2013). For CRA 5, the only site available is Kaikoura. For CRA 7, the only site used is Moeraki. For CRA 8, three sites have been used: Halfmoon Bay, Chalky Inlet and Jackson Bay.

Puerulus settlement data were organised by fishing year. Based on experimental standardisations (Andy McKenzie, NIWA, unpublished data), standardisations used the negative binomial likelihood. Year, month and collector group were used as explanatory variables.

Results are shown in Figure 47 (Kaikoura, CRA 5), Figure 48 (Moeraki, CRA 7), Figure 49 (Halfmoon Bay, CRA 8), Figure 50 (Chalky Inlet, CRA 8) and Figure 51 (Jackson Bay, CRA 8). Only the CRA 5 stock assessment incorporated these data into the base case assessment.

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Table 1: Recreational catch information for CRA 5, CRA 7 and CRA 8.

	CRA 5			CRA 7			CRA 8		
Survey	Estimate (numbers)	Mean weight (kg)	Weight (kg)	Estimate (numbers)	Mean weight (kg)	Weight (kg)	Estimate (numbers)	Mean weight (kg)	Weight (kg)
1994 (Bradford 1997)	67 000	0.563[1]	37 721	8 000	0.569[1]	4554	29 000	0.663[1]	19 234
1996 (Bradford 1998)	41 000	0.563[1]	23 083	3 000	0.569[1]	1708	22,000	0.663[1]	14 591
2000 (Boyd et al. 2004a)	151 000	0.565[2]	85 315	1 000	0.806[2]	806	13 000	0.676[2]	8 782
2001 (Boyd & Reilly 2004)	162 000	0.565[2]	91 530	10 000	0.806[2]	8062	29 000	0.676[2]	19 590
2011 (LSMS)	49 274	0.88[3]	43 470	357	0.640[3]	230	5 153	1.34[3]	6 930
Maximum S. 111 landings (kg)			7215			1688			15 824

[1] SS mean weight (kg) calculated from commercial sampling data from 1994 to 1996 assuming recreational minimum legal sizes
[2] SS mean weight (kg) calculated from commercial sampling data from 2000 and 2001 assuming recreational minimum legal sizes
[3] as reported by the LSMS

Table 2: MPI Compliance estimates of reported (R) and non-reported (NR) illegal catches (t) by QMA from 1990; blanks indicate no estimates provided.

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		288.2		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	0	15	5	30	28	0	12
1997					4	60												
1998					4	86.5												
1999					0	136								23.5		54.5		
2000					3	75		64										
2001		72		88	0	75												
2002					0	75	9	51		40		10		1		18		1
2003					0	89.5			5	47								
2004							10	30										
2005																		
2006																		
2007																		
2008																		
2009																		
2010																		
2011														1		3		
2012																		
2013																		
2014										30								

Table 3: Estimated CRA 5, CRA 7 and CRA 8 catches (t) (commercial, recreational including S.111, illegal and customary), provided annually before 1979 and seasonally (AW and SS) from 1979 to 2014. Pre-1979 annual catches are shown in the "AW" column. The CRA 7 and CRA 8 models started in 1963 while the CRA 5 model started in 1945. '–': no catch.

	CRA 5								CRA 7								CRA 8							
Fishing	Commercial		Recreational		Illegal		Customary		Commercial		Recreational		Illegal		Customary		Commercial		Recreational		Illegal		Customary	
year	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS
1945	138.6	–	14.6	–	25.3	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1946	203.4	–	15.5	–	37.1	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1947	253.1	–	16.4	–	46.2	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1948	533.2	–	17.2	–	97.3	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1949	689.7	–	18.1	–	125.9	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1950	901.5	–	19.0	–	164.5	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1951	580.8	–	19.8	–	106.0	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1952	579.0	–	20.7	–	105.7	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1953	381.2	–	21.6	–	69.6	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1954	339.6	–	22.5	–	62.0	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1955	356.7	–	23.3	–	65.1	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1956	350.9	–	24.2	–	64.0	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1957	258.9	–	25.1	–	47.3	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1958	336.8	–	25.9	–	61.5	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1959	429.8	–	26.8	–	78.4	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1960	391.6	–	27.7	–	71.5	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1961	365.8	–	28.6	–	66.8	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1962	435.8	–	29.4	–	79.5	–	10.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1963	375.9	–	30.3	–	68.6	–	10.0	–	557.1	–	4.8	–	99.9	–	1.0	–	2778.8	–	28.3	–	507.9	–	6.0	–
1964	461.5	–	31.2	–	84.2	–	10.0	–	520.6	–	4.9	–	93.4	–	1.0	–	2330.4	–	28.8	–	425.9	–	6.0	–
1965	472.3	–	32.0	–	86.2	–	10.0	–	493.7	–	5.0	–	88.5	–	1.0	–	2483.9	–	29.2	–	454.0	–	6.0	–
1966	602.7	–	32.9	–	110.0	–	10.0	–	677.0	–	5.2	–	121.4	–	1.0	–	2637.3	–	29.7	–	482.1	–	6.0	–
1967	483.4	–	33.8	–	88.2	–	10.0	–	515.8	–	5.3	–	92.5	–	1.0	–	2046.0	–	30.2	–	374.0	–	6.0	–
1968	395.6	–	34.7	–	72.2	–	10.0	–	672.7	–	5.4	–	120.7	–	1.0	–	1938.0	–	30.6	–	354.2	–	6.0	–
1969	439.7	–	35.5	–	80.2	–	10.0	–	644.6	–	5.5	–	115.6	–	1.0	–	1862.1	–	31.1	–	340.4	–	6.0	–
1970	394.5	–	36.4	–	72.0	–	10.0	–	597.5	–	5.6	–	107.2	–	1.0	–	2276.7	–	31.6	–	416.1	–	6.0	–
1971	397.8	–	37.3	–	72.6	–	10.0	–	384.4	–	5.7	–	68.9	–	1.0	–	2411.8	–	32.1	–	440.8	–	6.0	–
1972	417.7	–	38.1	–	76.2	–	10.0	–	195.5	–	5.9	–	35.1	–	1.0	–	1777.9	–	32.5	–	325.0	–	6.0	–
1973	376.8	–	39.0	–	68.8	–	10.0	–	518.0	–	6.0	–	92.9	–	1.0	–	2003.9	–	33.0	–	366.3	–	6.0	–
1974	316.0	–	39.9	–	40.5	–	10.0	–	391.0	–	6.1	–	50.1	–	1.0	–	1533.0	–	33.5	–	196.2	–	6.0	–
1975	417.0	–	40.8	–	100.9	–	10.0	–	288.0	–	6.2	–	69.7	–	1.0	–	1453.0	–	33.9	–	351.6	–	6.0	–
1976	382.0	–	41.6	–	74.2	–	10.0	–	262.0	–	6.3	–	50.9	–	1.0	–	1680.0	–	34.4	–	326.3	–	6.0	–
1977	375.0	–	42.5	–	96.3	–	10.0	–	275.0	–	6.5	–	70.6	–	1.0	–	1463.0	–	34.9	–	375.7	–	6.0	–
1978	447.4	–	43.4	–	114.8	–	10.0	–	435.8	–	6.6	–	111.8	–	1.0	–	1852.6	–	35.4	–	475.3	–	6.0	–
1979	129.9	272.1	4.4	39.8	11.3	23.6	1.0	9.0	301.9	101.5	0.7	6.0	26.2	8.8	0.1	0.9	545.7	1179.9	3.6	32.2	47.4	102.4	0.6	5.4
1980	136.8	368.3	5.1	45.8	15.6	42.0	1.0	9.0	231.1	66.6	0.7	6.0	26.4	7.6	0.1	0.9	433.7	1029.7	3.6	32.2	49.5	117.4	0.6	5.4
1981	96.6	379.4	4.9	44.1	17.6	69.2	1.0	9.0	216.2	50.8	0.7	6.0	38.8	9.1	0.1	0.9	528.8	866.9	3.6	32.2	96.7	158.4	0.6	5.4
1982	146.0	479.5	5.2	46.8	26.6	87.5	1.0	9.0	92.2	37.3	0.7	6.0	16.5	6.7	0.1	0.9	523.3	979.1	3.6	32.2	95.7	179.0	0.6	5.4
1983	157.3	441.8	4.7	42.4	28.7	80.6	1.0	9.0	76.0	33.2	0.7	6.0	13.6	5.9	0.1	0.9	371.8	1153.0	3.6	32.2	68.0	210.8	0.6	5.4
1984	194.7	527.2	4.7	42.7	35.5	96.2	1.0	9.0	144.7	47.0	0.7	6.0	26.0	8.4	0.1	0.9	598.6	950.7	3.6	32.2	109.4	173.8	0.6	5.4
1985	146.9	577.7	4.6	41.0	26.8	105.4	1.0	9.0	247.8	72.1	0.7	6.0	44.4	12.9	0.1	0.9	883.1	982.5	3.6	32.2	161.4	179.6	0.6	5.4
1986	146.5	479.6	4.5	40.6	26.7	87.5	1.0	9.0	222.1	105.0	0.7	6.0	39.8	18.8	0.1	0.9	531.2	1068.8	3.6	32.2	97.1	195.4	0.6	5.4
1987	116.9	379.7	3.7	33.4	21.3	69.3	1.0	9.0	222.3	73.5	0.7	6.0	39.9	13.2	0.1	0.9	535.2	1130.1	3.6	32.2	97.8	206.6	0.6	5.4

Table 3: (cont.)

	CRA 5								CRA 7								CRA 8							
Fishing	Commercial		Recreational		Illegal		Customary		Commercial		Recreational		Illegal		Customary		Commercial		Recreational		Illegal		Customary	
year	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS	AW	SS
1988	67.8	283.9	3.4	31.0	12.4	51.8	1.0	9.0	129.6	84.2	0.7	6.0	23.3	15.1	0.1	0.9	242.0	805.7	3.6	32.2	44.2	147.3	0.6	5.4
1989	64.7	247.6	3.4	30.7	11.8	45.2	1.0	9.0	56.2	45.2	0.7	6.0	10.1	8.1	0.1	0.9	429.7	820.4	3.6	32.2	78.5	150.0	0.6	5.4
1990	56.3	252.4	3.6	32.3	32.4	145.6	1.0	9.0	97.2	36.1	0.7	6.0	31.8	11.8	0.1	0.9	241.7	592.8	3.6	32.2	8.7	21.3	0.6	5.4
1991	52.1	235.3	3.2	28.7	32.4	146.6	1.0	9.0	175.7	2.0	0.7	6.0	40.8	0.5	0.1	0.9	265.5	697.2	3.6	32.2	13.1	34.4	0.6	5.4
1992	48.0	210.7	3.4	30.3	33.4	146.6	1.0	9.0	91.0	40.6	0.7	6.0	27.0	12.0	0.1	0.9	283.3	593.2	3.6	32.2	21.0	44.0	0.6	5.4
1993	97.2	213.8	3.4	30.8	39.1	85.9	1.0	9.0	126.9	11.2	0.7	6.0	29.4	2.6	0.1	0.9	472.1	424.0	3.6	32.2	34.2	30.8	0.6	5.4
1994	95.9	198.0	3.4	30.4	22.8	47.2	1.0	9.0	110.0	10.3	0.7	6.0	22.9	2.1	0.1	0.9	394.7	461.0	3.6	32.2	30.0	35.0	0.6	5.4
1995	104.1	193.5	3.6	32.2	24.5	45.5	1.0	9.0	73.6	7.7	0.7	6.0	13.6	1.4	0.1	0.9	337.2	488.5	3.6	32.2	18.4	26.6	0.6	5.4
1996	182.6	117.7	4.2	37.4	22.5	14.5	1.0	9.0	47.4	15.5	0.7	6.0	15.1	4.9	0.1	0.9	324.6	537.8	3.6	32.2	21.8	36.2	0.6	5.4
1997	218.5	81.1	5.0	44.8	27.5	10.2	1.0	9.0	23.9	12.1	0.7	6.0	14.0	7.1	0.1	0.9	293.8	491.8	3.6	32.2	21.3	35.6	0.6	5.4
1998	233.4	64.8	5.5	49.2	30.1	8.4	1.0	9.0	39.6	19.0	0.7	6.0	15.1	7.2	0.1	0.9	244.1	564.0	3.6	32.2	16.8	38.9	0.6	5.4
1999	282.0	67.5	5.6	50.6	31.7	7.6	1.0	9.0	37.3	19.1	0.7	6.0	15.5	7.9	0.1	0.9	326.4	383.4	3.6	32.2	25.1	29.5	0.6	5.4
2000	293.2	54.2	5.6	50.8	33.8	6.2	1.0	9.0	62.9	24.4	0.7	6.0	11.5	4.5	0.1	0.9	392.1	311.3	3.6	32.2	23.6	18.7	0.6	5.4
2001	320.1	29.0	5.4	48.5	42.2	3.8	1.0	9.0	61.8	15.1	0.7	6.0	6.8	1.7	0.1	0.9	311.8	260.2	3.6	32.2	16.5	13.7	0.6	5.4
2002	297.1	51.6	5.3	48.1	44.3	7.7	1.0	9.0	73.5	15.0	0.7	6.0	0.8	0.2	0.1	0.9	315.7	251.4	3.6	32.2	10.0	8.0	0.6	5.4
2003	276.4	73.5	6.1	55.1	39.6	10.5	1.0	9.0	62.2	19.2	0.7	6.0	0.8	0.2	0.1	0.9	451.5	116.1	3.6	32.2	13.0	3.3	0.6	5.4
2004	236.0	109.1	6.0	54.2	33.1	15.3	1.0	9.0	84.1	10.1	0.7	6.0	0.9	0.1	0.1	0.9	463.8	139.2	3.6	32.2	11.3	3.4	0.6	5.4
2005	239.3	110.3	6.9	62.5	31.8	14.7	1.0	9.0	93.6	1.3	0.7	6.0	1.0	0.0	0.1	0.9	514.3	88.9	3.6	32.2	11.1	1.9	0.6	5.4
2006	214.5	135.4	6.7	60.1	27.4	17.3	1.0	9.0	114.5	5.7	0.7	6.0	1.0	0.0	0.1	0.9	657.5	97.4	3.6	32.2	9.9	1.5	0.6	5.4
2007	216.0	133.8	7.0	62.6	26.4	16.4	1.0	9.0	106.5	13.6	0.7	6.0	0.9	0.1	0.1	0.9	606.2	146.2	3.6	32.2	7.8	1.9	0.6	5.4
2008	237.2	112.5	6.7	60.2	27.8	13.2	1.0	9.0	98.5	21.7	0.7	6.0	0.8	0.2	0.1	0.9	859.9	106.0	3.6	32.2	7.1	0.9	0.6	5.4
2009	246.9	103.0	8.1	72.8	27.6	11.5	1.0	9.0	76.2	60.3	0.7	6.0	0.6	0.4	0.1	0.9	710.3	308.0	3.6	32.2	4.4	1.9	0.6	5.4
2010	256.8	93.2	7.6	68.0	27.4	9.9	1.0	9.0	45.0	29.8	0.7	6.0	0.6	0.4	0.1	0.9	758.4	259.9	3.6	32.2	3.5	1.2	0.6	5.4
2011	245.6	104.4	8.6	77.4	24.9	10.6	1.0	9.0	37.0	8.6	0.7	6.0	0.8	0.2	0.1	0.9	637.1	324.1	3.6	32.2	2.0	1.0	0.6	5.4
2012	244.5	105.5	9.1	82.0	23.5	10.1	1.0	9.0	36.9	16.9	0.7	6.0	0.7	0.3	0.1	0.9	582.2	378.6	3.6	32.2	1.8	1.2	0.7	6.6
2013	244.5	105.4	8.0	71.7	22.2	9.6	1.0	9.0	42.7	1.3	0.7	6.0	1.0	0.0	0.1	0.9	635.1	329.4	3.6	32.2	2.0	1.0	0.9	7.8
2014	229.3	120.1	8.3	74.5	19.7	10.3	1.0	9.0	47.1	18.9	0.7	6.0	0.7	0.3	0.1	0.9	498.8	461.4	3.6	32.2	1.6	1.4	1.0	9.0

Table 4: Number of vessel/statistical area/month records in the dataset used to calculate the CRA 5 CPUE.

	AW							SS						
Fishing	Statistical Area							Statistical Area						
year	916	917	918	919	932	933	Total	916	917	918	919	932	933	Total
1979	50	211	65	13	7	35	381	88	373	43	7	5	57	573
1980	43	205	50	4	4	26	332	67	273	43	–	1	53	437
1981	48	149	32	2	2	36	269	63	296	51	–	8	48	466
1982	45	206	32	9	5	49	346	60	299	50	9	4	67	489
1983	39	207	33	12	–	55	346	56	300	59	–	–	69	484
1984	37	201	30	14	4	60	346	58	285	49	4	6	66	468
1985	40	185	29	11	5	57	327	56	308	51	8	7	64	494
1986	35	194	30	14	6	44	323	50	272	49	5	10	55	441
1987	46	185	25	11	7	40	314	45	288	43	5	6	51	438
1988	28	165	21	10	3	30	257	32	250	38	6	5	42	373
1989	17	110	23	3	–	17	170	43	181	41	–	–	21	286
1990	44	96	22	--	3	20	185	42	224	45	1	3	33	348
1991	32	86	40	–	6	41	205	35	157	68	–	3	46	309
1992	17	72	34	–	–	24	147	20	138	44	–	–	37	239
1993	16	84	28	–	1	44	173	10	107	45	–	1	28	191
1994	8	78	36	–	2	40	164	9	102	35	–	1	21	168
1995	10	58	15	–	–	32	115	6	83	22	1	1	18	131
1996	10	89	23	1	–	40	163	4	66	22	1	–	10	103
1997	11	77	19	1	–	44	152	7	59	24	–	–	11	101
1998	12	74	15	–	–	25	126	4	52	18	–	–	4	78
1999	11	84	21	–	1	26	143	7	57	19	1	–	2	86
2000	16	66	12	–	–	26	120	3	33	7	–	–	5	48
2001	26	52	4	–	–	25	107	2	19	2	–	–	2	25
2002	17	49	6	–	–	18	90	11	34	1	–	–	7	53
2003	28	49	6	–	–	37	120	14	19	1	–	–	20	54
2004	24	53	4	–	1	28	110	11	48	3	–	1	20	83
2005	22	65	5	–	–	30	122	14	50	8	–	–	21	93
2006	32	75	5	–	–	25	137	21	52	6	–	–	17	96
2007	29	72	5	–	–	26	132	20	58	9	–	–	23	110
2008	21	69	12	1	–	29	132	17	56	9	–	–	15	97
2009	22	59	–	–	–	31	112	17	48	–	1	–	25	91
2010	21	63	–	–	–	29	113	15	52	3	1	–	22	93
2011	20	54	2	–	–	23	99	14	46	5	–	–	24	89
2012	20	42	1	–	–	27	90	15	42	–	–	–	19	76
2013	13	54	1	–	–	28	96	10	44	2	–	–	23	79
2014	17	52	3	–	–	24	96	10	46	–	–	–	19	75

Table 5: Total deviance (R^2) explained by each variable in the CRA 5 standardised seasonal CPUE model.

Variable	1	2	3
Period	0.3600		
Statistical Area	0.0188	0.3825	
Month	0.0285	0.3822	0.4046
Additional deviance explained	0.0000	0.0225	0.0221

Table 6: Standardised seasonal CPUE and standard errors for CRA 5, CRA 7 and CRA 8.

Fishing	CRA 5				CRA 7				CRA 8			
year	AW	s.e.	SS	s.e.	AW	s.e.	SS	s.e.	AW	s.e.	SS	s.e.
1979	0.624	0.038	0.595	0.032	1.013	0.040	0.892	0.049	1.925	0.031	2.185	0.025
1980	0.706	0.041	0.756	0.036	0.993	0.043	0.671	0.052	1.828	0.033	1.807	0.026
1981	0.573	0.045	0.719	0.035	0.807	0.042	0.588	0.056	1.781	0.035	1.718	0.028
1982	0.702	0.040	0.740	0.034	0.424	0.046	0.556	0.062	1.370	0.033	1.569	0.027
1983	0.663	0.040	0.637	0.035	0.367	0.048	0.469	0.061	0.892	0.033	1.288	0.026
1984	0.693	0.040	0.627	0.035	0.561	0.047	0.503	0.062	1.080	0.033	1.094	0.026
1985	0.509	0.041	0.560	0.034	0.823	0.047	0.584	0.058	1.388	0.031	1.192	0.028
1986	0.448	0.041	0.492	0.036	0.830	0.050	0.807	0.060	0.942	0.033	1.287	0.027
1987	0.378	0.042	0.410	0.036	0.812	0.055	0.574	0.060	1.043	0.036	1.313	0.028
1988	0.334	0.045	0.355	0.039	0.374	0.059	0.468	0.074	0.743	0.042	1.014	0.033
1989	0.338	0.055	0.369	0.043	0.243	0.064	0.453	0.068	0.803	0.043	0.942	0.033
1990	0.345	0.053	0.367	0.040	0.440	0.058	0.401	0.063	0.776	0.047	0.923	0.032
1991	0.265	0.051	0.321	0.042	0.959	0.059	1.222	0.154	0.685	0.039	0.956	0.031
1992	0.262	0.059	0.308	0.047	0.363	0.064	0.438	0.074	0.642	0.040	0.763	0.031
1993	0.322	0.055	0.332	0.052	0.696	0.064	0.341	0.135	0.880	0.039	0.979	0.036
1994	0.327	0.056	0.383	0.055	0.537	0.065	0.303	0.104	0.743	0.039	0.910	0.036
1995	0.373	0.066	0.421	0.062	0.313	0.065	0.239	0.108	0.813	0.044	0.971	0.040
1996	0.488	0.056	0.543	0.070	0.219	0.078	0.331	0.119	0.675	0.044	0.997	0.039
1997	0.667	0.058	0.777	0.071	0.148	0.075	0.309	0.125	0.570	0.041	0.857	0.036
1998	0.729	0.063	1.052	0.080	0.227	0.076	0.368	0.123	0.542	0.049	0.906	0.039
1999	0.868	0.060	0.999	0.076	0.215	0.085	0.254	0.129	0.734	0.048	0.829	0.043
2000	1.046	0.065	1.468	0.101	0.319	0.076	0.416	0.112	0.900	0.051	1.000	0.047
2001	1.272	0.069	1.533	0.140	0.526	0.080	0.450	0.117	0.816	0.055	1.311	0.062
2002	1.388	0.075	1.802	0.096	0.565	0.078	0.801	0.147	0.890	0.050	1.715	0.061
2003	1.408	0.065	2.467	0.096	0.580	0.090	0.640	0.137	1.499	0.052	2.197	0.072
2004	1.071	0.068	1.739	0.078	0.858	0.104	1.065	0.212	1.504	0.052	2.899	0.073
2005	1.017	0.065	1.904	0.073	1.208	0.117	2.364	0.328	1.865	0.053	3.830	0.091
2006	1.093	0.061	1.883	0.072	1.748	0.101	2.032	0.212	2.303	0.053	4.327	0.090
2007	1.101	0.062	1.916	0.068	1.488	0.097	1.769	0.165	2.548	0.052	4.217	0.073
2008	1.274	0.062	2.271	0.072	1.815	0.119	1.478	0.204	3.558	0.052	5.434	0.089
2009	1.726	0.067	2.544	0.074	0.918	0.096	1.401	0.116	3.245	0.053	5.271	0.064
2010	1.672	0.067	2.497	0.073	0.754	0.104	0.920	0.140	2.669	0.050	4.567	0.073
2011	1.643	0.071	2.160	0.075	0.708	0.096	0.671	0.147	2.554	0.049	4.567	0.064
2012	1.397	0.075	2.243	0.081	0.619	0.111	0.885	0.169	2.550	0.048	4.982	0.060
2013	1.432	0.072	1.851	0.079	2.000	0.137	3.048	0.246	2.561	0.053	5.315	0.066
2014	1.468	0.072	2.209	0.081	2.212	0.133	2.285	0.170	2.489	0.056	4.592	0.061

Table 7: CRA 7: Numbers of vessel/statistical area/month records in the dataset used to estimate seasonal CPUE. Highlighted cells are those with very low numbers of records

Fishing		Statistical Area				Statistical Area		
year	Season	920	921	Total	Season	920	921	Total
1979	AW	252	162	414	SS	184	85	269
1980	AW	221	128	349	SS	171	63	234
1981	AW	231	133	364	SS	146	48	194
1982	AW	184	109	293	SS	107	50	157
1983	AW	169	95	264	SS	113	46	159
1984	AW	186	96	282	SS	113	41	154
1985	AW	191	91	282	SS	129	56	185
1986	AW	170	75	245	SS	117	57	174
1987	AW	146	55	201	SS	118	52	170
1988	AW	111	60	171	SS	74	32	106
1989	AW	110	30	140	SS	105	23	128
1990	AW	148	30	178	SS	111	44	155
1991	AW	131	38	169	SS	17	6	23
1992	AW	119	22	141	SS	89	17	106
1993	AW	116	24	140	SS	21	9	30
1994	AW	114	25	139	SS	43	8	51
1995	AW	102	37	139	SS	38	9	47
1996	AW	79	14	93	SS	33	6	39
1997	AW	77	25	102	SS	24	11	35
1998	AW	68	30	98	SS	28	8	36
1999	AW	61	16	77	SS	25	8	33
2000	AW	72	25	97	SS	28	16	44
2001	AW	60	28	88	SS	25	15	40
2002	AW	80	14	94	SS	19	6	25
2003	AW	61	8	69	SS	25	4	29
2004	AW	39	12	51	SS	7	5	12
2005	AW	27	13	40	SS	3	2	5
2006	AW	31	23	54	SS	9	3	12
2007	AW	42	17	59	SS	9	11	20
2008	AW	25	14	39	SS	5	8	13
2009	AW	39	21	60	SS	22	19	41
2010	AW	35	16	51	SS	18	10	28
2011	AW	35	25	60	SS	13	12	25
2012	AW	30	15	45	SS	12	7	19
2013	AW	20	9	29	SS	4	5	9
2014	AW	23	9	32	SS	12	7	19

Table 8: CRA 7: Total deviance (R^2) explained by each variable in the standardised seasonal CPUE model.

Variable	1	2	3
Period	0.3085		
Statistical Area	0.0615	0.3501	
Month	0.0042	0.3129	0.3542
Additional deviance explained	0.0000	0.0417	0.0041

Table 9: CRA 8: Numbers of vessel/statistical area/month records in the dataset used to calculate the seasonal CPUE.

	Autumn-Winter								Spring-Summer							
Fishing	Statistical Area								Statistical Area							
Year	922	923	924	925	926	927	928	Total	922	923	924	925	926	927	928	Total
1979	15	104	177	2	107	129	123	657	24	151	272	5	182	216	223	1073
1980	9	103	170	1	109	101	72	565	22	132	260	9	185	162	201	971
1981	20	90	162	–	108	72	46	498	11	116	220	12	190	100	155	804
1982	24	63	159	4	153	96	64	563	24	89	208	9	230	166	164	890
1983	16	81	130	6	151	115	53	552	23	121	233	13	266	162	175	993
1984	21	73	142	3	153	109	53	554	13	90	194	16	237	202	180	932
1985	6	85	140	6	168	145	69	619	7	95	173	10	187	198	164	834
1986	12	65	119	10	131	133	66	536	12	115	182	4	221	167	168	869
1987	18	58	125	1	108	95	47	452	15	97	182	2	217	151	142	806
1988	11	65	80	2	91	50	30	329	16	94	136	9	137	73	92	557
1989	4	40	73	5	94	69	27	312	5	59	121	10	185	135	52	567
1990	8	21	57	7	83	63	26	265	13	54	131	15	187	108	80	588
1991	16	31	58	6	114	90	70	385	24	46	105	12	188	132	132	639
1992	7	23	57	5	126	74	78	370	8	44	106	9	192	130	146	635
1993	7	29	57	12	122	81	74	382	10	23	52	11	129	97	127	449
1994	9	17	62	20	117	82	84	391	7	29	68	32	121	107	105	469
1995	2	21	31	16	78	78	72	298	2	29	48	20	102	90	82	373
1996	2	15	37	14	87	63	79	297	3	29	48	13	105	83	105	386
1997	2	23	31	9	99	77	102	343	3	34	46	11	130	88	148	460
1998	–	17	28	5	55	51	82	238	–	26	49	8	97	69	139	388
1999	–	28	29	9	72	58	49	245	1	29	29	11	83	72	83	308
2000	–	12	28	2	87	57	36	222	–	17	31	4	83	78	54	267
2001	–	4	24	4	82	37	39	190	1	7	23	–	53	31	31	146
2002	3	4	23	5	92	50	53	230	1	5	19	1	60	28	40	154
2003	3	7	22	3	99	38	38	210	–	6	16	–	42	14	29	107
2004	3	8	17	1	99	40	48	216	1	16	16	2	42	11	17	105
2005	2	10	14	2	93	36	46	203	1	7	5	–	30	12	12	67
2006	5	5	21	–	85	52	41	209	1	5	10	–	34	13	7	70
2007	6	5	27	2	84	43	45	212	1	10	23	3	41	17	10	105
2008	5	2	35	2	65	49	57	215	2	6	13	–	22	16	12	71
2009	3	4	31	–	61	40	69	208	1	5	30	1	40	28	32	137
2010	3	1	32	1	81	44	71	233	1	1	24	–	47	14	18	105
2011	–	–	36	1	101	41	64	243	–	–	21	2	67	22	24	136
2012	–	–	48	4	105	36	66	259	–	1	29	3	66	21	39	159
2013	–	1	26	1	80	44	51	203	–	3	15	–	59	30	24	131
2014	1	4	24	3	66	38	47	183	–	7	21	1	64	26	33	152

Table 10: CRA 8: Total deviance (R^2) explained by each variable in the standardised seasonal CPUE model.

Variable	1	2	3
Period	0.2669		
Month	0.0370	0.3012	
Statistical Area	0.0284	0.2933	0.3239
Additional deviance explained	0.0000	0.0343	0.0226

Table 11: CRA 5 catch sampling: numbers of days sampled and number of fish sampled for length by fishing year, season and data source.

	Number days sampling				Number lobster sampled			
Fishing	Logbook		Observer		Logbook		Observer	
Year	AW	SS	AW	SS	AW	SS	AW	SS
1989				10				3 312
1990				11				5 308
1991				10				4 963
1992				12				3 017
1993				12				6 408
1994	53	934		12	871	14 635		4 987
1995	160	363		12	2 611	6 360		4 934
1996	394	227		9	8 155	5 931		5 661
1997	401	64	3	7	9 275	1 754	1 327	3 278
1998	279	10	3	5	8 080	292	1 084	3 155
1999	485	66	21		11 145	1 579	13 443	
2000	880	125	9	3	22 646	3 378	8 146	1 790
2001	1 082	49			28 931	1 205		
2002	1 141	121			32 191	3 899		
2003	938	70			29 746	1 698		
2004	734	230			22 805	5 707		
2005	820	246			24 785	7 936		
2006	827	300			23 430	10 796		
2007	838	311			22 308	12 404		
2008	581	233		6	15 305	7 263		2 080
2009	764	287	4		22 050	11 263	1 924	
2010	643	196	6		22 587	6 719	3 435	
2011	546	230			19 789	8 621		
2012	616	162			19 070	7 001		
2013	436	305			9 859	4 777		
2014	498	344			12 932	7 131		
Total	**13 116**	**4 873**	**46**	**109**	**368 571**	**130 349**	**29 359**	**48 893**

Table 12: CRA 7 catch sampling: numbers of days sampled and fish measured by fishing year, season and data source.

	Days sampled				Number fish sampled			
Fishing	Logbook		Observer		Logbook		Observer	
Year	AW	SS	AW	SS	AW	SS	AW	SS
1988			8	6			1 997	526
1989			6	3			693	544
1990			6	3			1 979	432
1991			6				1 836	
1992			6	3			1 847	256
1993			5	2			1 121	857
1994			9	3			4 055	479
1995			12	3			2 672	243
1996			15	13			1 645	1 272
1997			18	2			2 836	264
1998			9	5			2 113	321
1999			10	8			2 196	487
2000			10	5			2 833	453
2001	185	2	10	2	1 800	7	3 536	404
2002	71		13	2	1 062		4 167	845
2003	43		10	5	1 105		4 670	1 732
2004			10	5			5 419	1 723
2005			15				7 475	
2006			14	1			7 049	354
2007			14	1			6 681	121
2008			9	6			3 872	2 824
2009			7	8			2 408	2 640
2010			8	7			2 078	733
2011			6	9			1 788	914
2012			9	6			2 565	1 103
2013			14	1			4 254	71
2014			9	6			2 854	1 260
Total	**299**	**2**	**268**	**115**	**3 967**	**7**	**86 639**	**20 858**

Table 13. CRA 8 catch sampling: numbers of days sampled and fish measured by fishing year, season and data source.

	Days sampled				Number fish sampled			
Fishing	Logbook		Observer		Logbook		Observer	
Year	AW	SS	AW	SS	AW	SS	AW	SS
1987			2	6			500	1 359
1988				6				1 309
1989			11	34			4 811	13 683
1990			26	39			13 679	17 374
1991			27	36			17 462	20 253
1992			24	35			14 160	16 612
1993	1 007	586	28	25	23 059	13 604	11 924	9 848
1994	896	990	23	32	16 851	14 769	16 540	10 402
1995	1 358	1 556	25	39	21 452	22 114	9 791	10 075
1996	999	1 134	38	39	13 888	14 009	14 955	18 887
1997	1 046	969	15	29	11 649	9 312	6 825	8 882
1998	673	1 019		10	10 824	10 890		4 125
1999	452	337	9		7 120	4 127	4 232	
2000	759	536	16	5	13 925	6 749	8 067	1 741
2001	451	323	7	8	7 504	4 283	3 657	1 807
2002	654	222	9	5	12 140	4 620	5 399	4 186
2003	655	83			14 708	1 435		
2004	644	47			12 466	1 507		
2005	614	43			13 923	1 053		
2006	688	77			17 208	2 235		
2007	488	79			13 787	3 028		
2008	520	35			17 832	1 837		
2009	420	84			15 682	4 471		
2010	734	54	18	3	22 321	1 780	9 644	1 542
2011	656	103			21 315	3 749		
2012	621	139			20 916	7 772		
2013	486	173			16 991	9 164		
2014	576	165			20 298	9 205		
Total	**15 397**	**8 754**	**276**	**345**	**345 859**	**151 713**	**141 146**	**140 726**

Table 14: CRA 8 logbook data: numbers of legal fish caught and retained and the percentage retained for all sex codes combined.

Year	Caught	Retained	%retained
1993	12 661	0	0.0%
1994	12 359	0	0.0%
1995	18 520	0	0.0%
1996	12 793	0	0.0%
1997	10 700	0	0.0%
1998	9 690	0	0.0%
1999	5 195	2	0.0%
2000	7 799	3 420	43.9%
2001	4 735	2 759	58.3%
2002	6 052	5 546	91.6%
2003	6 639	6 016	90.6%
2004	6 422	5 876	91.5%
2005	7 437	6 591	88.6%
2006	11 054	9 653	87.3%
2007	11 197	9 604	85.8%
2008	12 325	9 833	79.8%
2009	13 696	9 731	71.0%
2010	13 326	8 737	65.6%
2011	13 705	9 141	66.7%
2012	16 831	11 388	67.7%
2013	16 098	10 536	65.4%
2014	17 798	11 192	62.9%
2000–2014 total	165 114	120 023	72.7%

Table 15: CRA 8 logbook groomed data set: total numbers of legal fish caught and retained, and the percentage retained for all sex codes combined for 2000–2013 fishing years; CPUE is in kg/potlift.

Year	Caught	Kept	%kept
2000	3 838	3 278	85.4%
2001	3 238	2 733	84.4%
2002	6 052	5 546	91.6%
2003	6 639	6 016	90.6%
2004	6 422	5 876	91.5%
2005	7 437	6 591	88.6%
2006	11 054	9 653	87.3%
2007	11 197	9 604	85.8%
2008	12 325	9 833	79.8%
2009	13 696	9 731	71.0%
2010	13 326	8 737	65.6%
2011	13 705	9 141	66.7%
2012	16 831	11 388	67.7%
2013	16 098	10 536	65.4%
2014	17 798	11 192	62.9%
Total	159 656	119 855	75.1%

Table 16: CRA 8: inverse logistic model parameters from the fits to retention data by year, size and sex. The second column shows annual CRA 8 CPUE in kg/potlift (average of AW and SS F2-LFX).

		Males				Females			
Year	**CPUE**	***Rmax***	***R50***	***R95***	**-LL**	***Rmax***	***R50***	***R95***	**-LL**
1999	0.782								
2000	0.950	0.875	133.54	3.58	752.7	0.832	102.468	0.101	835.1
2001	1.064	0.848	98.58	0.21	703.7	0.840	198.283	16.259	696.1
2002	1.303	0.943	97.33	20.12	854.9	0.935	88.597	25.604	824.5
2003	1.848	0.929	106.98	1.07	1 098.0	0.890	86.988	20.239	917.7
2004	2.202	0.927	91.54	12.81	1 281.9	0.899	88.513	0.100	556.8
2005	2.848	0.914	87.74	12.77	1 634.6	0.897	103.845	38.116	911.4
2006	3.315	0.921	84.46	8.30	2 156.3	0.987	93.092	57.206	1 748.1
2007	3.383	0.919	78.73	8.06	2 722.6	0.830	148.123	0.189	1 247.3
2008	4.497	0.896	77.47	7.68	3 250.1	0.767	90.317	18.124	2 040.8
2009	4.259	0.835	77.65	6.17	3 802.3	0.824	106.333	100.000	3 568.2
2010	3.618	0.846	77.70	7.03	4 456.9	0.510	181.697	1.723	2 192.4
2011	3.566	0.885	76.84	8.31	3 364.2	1.000	75.363	75.026	3 472.7
2012	3.767	0.895	78.33	6.91	2 690.5	0.870	80.359	43.475	6 042.6
2013	3.929	0.883	77.63	6.51	2 228.7	1.000	78.173	92.770	6 665.2
2014	3.635	0.855	77.31	6.84	3 381.8	1.000	68.142	48.253	6 349.7
				total	34 379.3			total	38 068.6

Table 17: CRA 8: estimated parameters for predicting the inverse logistic retention-at-size curves from CPUE.

Sex	**Quantity**	***Rmax***	***R50***	***R95***
Males	intercept	0.9426	74.748	11.075
	slope	-0.0168	151.587	-0.956
	δ		-3.268	
	-LL		34 738.0	
Females	intercept	0.8631	73.394	-14.662
	slope	-1.43e-8	6613.33	18.7550
	δ		-5.0094	
	-LL		38 621.8	

Table 18: CRA 8: negative log-likelihood values for annual inverse logistic fits to retention-at-size data and for models that estimate the parameters of the inverse logistic retention curves from CPUE data.

Model	**Number of parameters**	**Males**	**Females**
Annual	45	34 379.3	38 068.6
CPUE in previous year	7	34 738.0	38 621.8
CPUE in year	7	34 882.4	39 167.0

Table 19: Numbers of tag recaptures by calendar release year, sex and QMA; '–': no data.

	CRA 5			CRA 7			CRA 8		
Year	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
1965	–	–	–	25	34	59	–	–	–
1966	–	–	–	5	7	12	13	19	32
1967	–	–	–	1	1	2	–	–	–
1968	–	–	–	0	1	1	–	–	–
1974	M	F	Total	–	–	–	1	5	6
1975	4	9	13	–	–	–	51	28	79
1976	84	60	144	–	–	–	398	536	934
1977	9	3	12	–	–	–	255	296	551
1978	–	–	–	–	–	–	21	25	46
1979	11	3	14	27	24	51	452	289	741
1980	10	6	16	17	25	42	305	176	481
1981	21	7	28	13	8	21	106	26	132
1982	–	–	–	–	–	–	187	128	315
1983	195	482	677	–	–	–	28	4	32
1984	23	494	517	–	–	–	52	31	83
1985	3	21	24	–	–	–	9	0	9
1986	0	2	2	–	–	–	5	4	9
1987	–	–	–	–	–	–	1	0	1
1993	–	–	–	4	0	4	46	40	86
1994	–	–	–	–	–	–	4	4	8
1995	–	–	–	–	–	–	9	5	14
1996	0	1	1	–	–	–	202	229	431
1997	507	941	1448	–	–	–	1438	614	2052
1998	41	102	143	–	–	–	608	677	1285
1999	316	109	425	–	–	–	344	329	673
2000	114	464	578	–	–	–	149	147	296
2001	223	419	642	–	–	–	65	39	104
2002	60	540	600	–	–	–	43	28	71
2003	35	120	155	–	–	–	25	1224	1249
2004	256	654	910	–	–	–	19	514	533
2005	67	340	407	–	–	–	13	225	238
2006	17	74	91	–	–	–	10	154	164
2007	7	5	12	122	85	207	3	40	43
2008	–	–	–	7	7	14	4	26	30
2009	1	0	1	11	9	20	3	7	10
2010	–	–	–	–	–	–	2	3	5
2011	–	–	–	–	–	–	5	1	6
2012	61	75	136	26	28	54	2	0	2
2013	13	16	29	1	1	2	–	–	–
2014	3	7	10	–	–	–	–	–	–
Total	2081	4954	7035	259	230	489	4878	5873	10751

Table 20: CRA 5: Numbers of tag releases by statistical area and sex; NA: unknown statistical area.

Statistical Area	Male	Female	Total
916	444	2 723	3 167
917	1 121	1 416	2 537
918	139	88	227
933	366	556	922
NA	11	171	182
Total	2 081	4 954	7 035

Table 21: CRA 5: numbers of tag release/recovery pairs by statistical area of release and recovery; NA: unknown statistical area.

Release Area	Recovery Area 915	916	917	918	919	920	921	933	NA	Total
916	3	3 012	145	0	0	0	0	7	0	3 167
917	0	0	1 542	0	0	0	0	1	994	2 537
918	0	0	0	220	1	5	1	0	0	227
933	0	2	3	0	0	0	0	917	0	922
NA	0	0	0	0	0	0	0	0	182	182
Total	3	3 014	1 690	220	1	5	1	925	1 176	7 035

Table 22: Numbers of tag re-release events by sex and QMA; re-release code zero indicates the first recapture event; '–': no data.

Re-release event #	CRA 5 Male	Female	Total	CRA 7 Male	Female	Total	CRA 8 Male	Female	Total
0	1 694	3 480	5 174	239	204	443	3 277	3 850	7 127
1	278	924	1 202	20	23	43	892	1 148	2 040
2	78	334	412	0	1	1	393	460	853
3	24	127	151	0	1	1	177	198	375
4	5	43	48	0	1	1	78	98	176
5	1	19	20	–	–	–	29	50	79
6	1	11	12	–	–	–	14	32	46
7	0	6	6	–	–	–	5	22	27
8	0	2	2	–	–	–	3	11	14
9	0	2	2	–	–	–	3	3	6
10	0	2	2	–	–	–	3	1	4
11	0	2	2	–	–	–	2	0	2
12	0	1	1	–	–	–	1	0	1
13	0	1	1	–	–	–	1	0	1
Total	2 081	4 954	7 035	259	230	489	4 878	5 873	10 751

Table 23: CRA 7: numbers of tag releases by statistical area and sex for CRA 7.

Statistical Area	Male	Female	Total
920	166	184	350
921	93	46	139
Total	259	230	489

Table 24: CRA 7: numbers of tag release/recovery pairs by statistical area of release and recovery.

Release Area	Recovery Area 910	911	920	921	922	924	927	928	Total
920	4	2	324	10	1	9	0	0	350
921	0	0	9	123	2	3	1	1	139
Total	4	2	333	133	3	12	1	1	489

Table 25: CRA 8: numbers of tag releases by statistical area and sex; NA: unknown statistical area.

Statistical Area	Male	Female	Total
922	17	13	30
923	118	70	188
924	1 281	1 302	2 583
925	10	12	22
926	383	1 105	1 488
927	2 334	2 810	5 144
928	212	262	474
NA	523	299	822
Total	4 878	5 873	10 751

Table 26: CRA 8: numbers of tag release/recovery pairs by statistical area of release and recovery; NA: unknown statistical area.

Release Area	Recovery Area												
	906	**910**	**911**	**922**	**923**	**924**	**925**	**926**	**927**	**928**	**929**	**NA**	**Total**
922	0	0	0	5	9	15	0	0	0	1	0	0	30
923	0	0	0	0	86	83	0	13	5	1	0	0	188
924	0	111	10	0	4	2 433	0	18	5	1	0	1	2 583
925	0	0	0	0	0	3	15	4	0	0	0	0	22
926	0	0	0	0	7	5	5	1 156	260	53	1	1	1 488
927	1	0	0	0	0	1	0	19	3 817	26	1	1 279	5 144
928	0	0	0	0	0	1	0	2	21	394	1	55	474
NA	0	0	0	0	0	0	0	0	34	38	0	750	822
Total	1	111	10	5	106	2 541	20	1 212	4 142	514	3	2 086	10 751

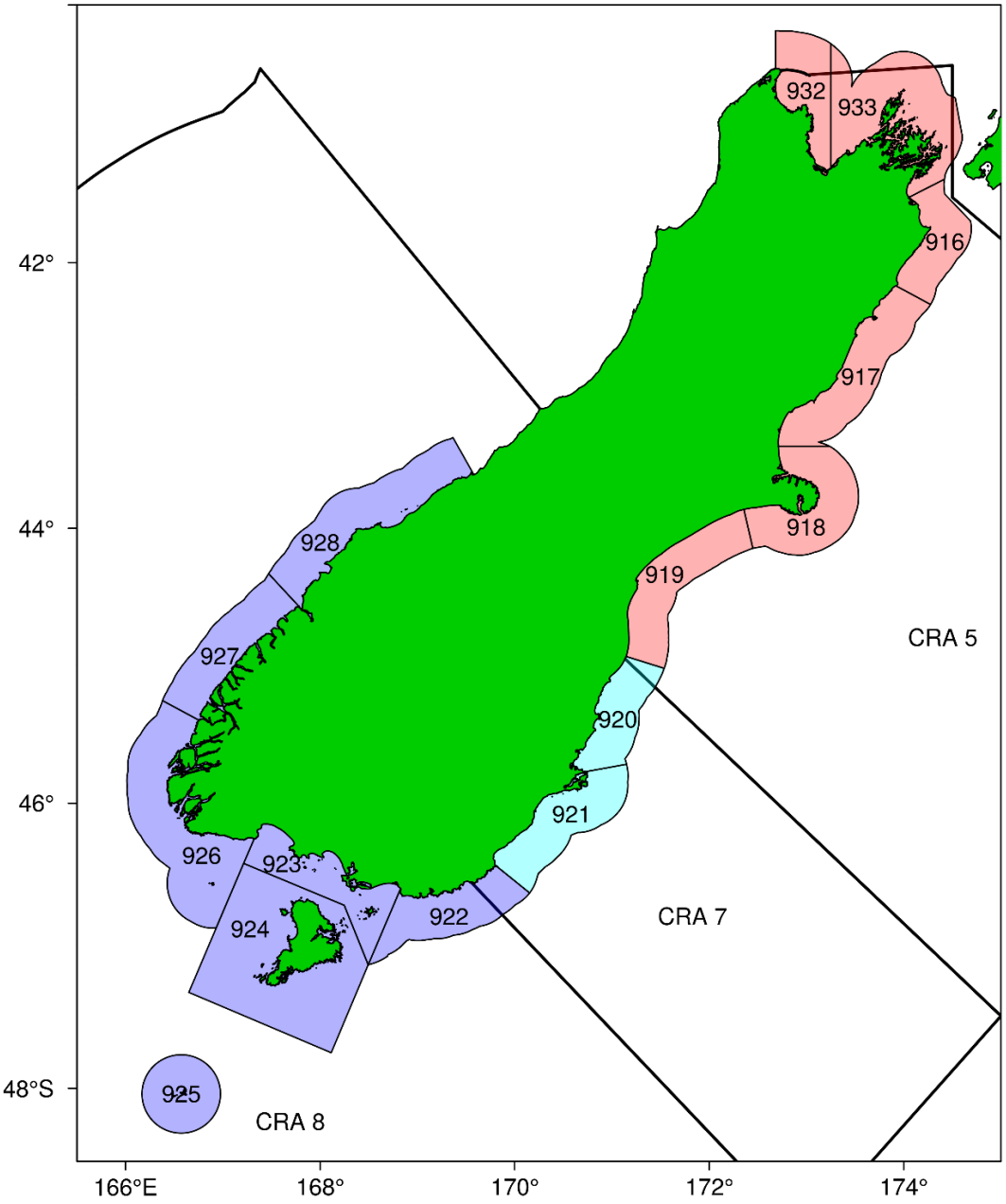


Figure 1: **CRA 5 (pink statistical areas), CRA 7 (blue statistical areas) and CRA 8 (purple statistical areas) stock areas on the South Island.**

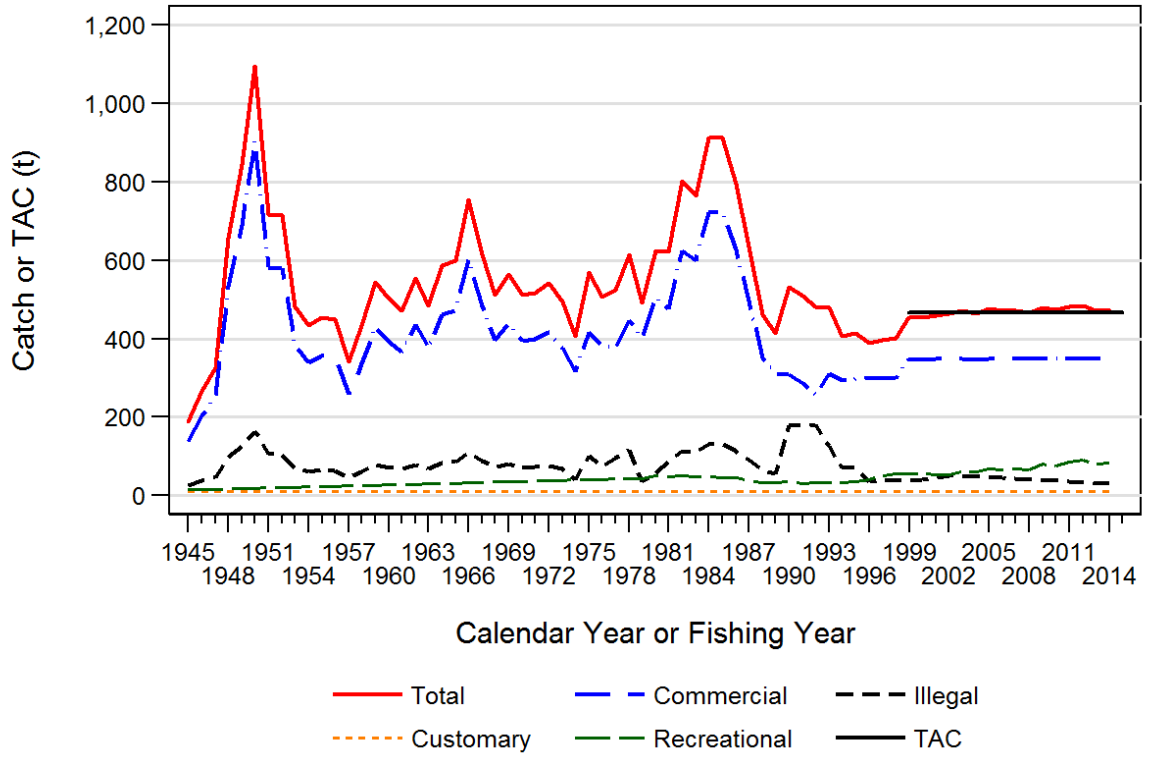


Figure 2: CRA 5: catches by source, 1945–2014.

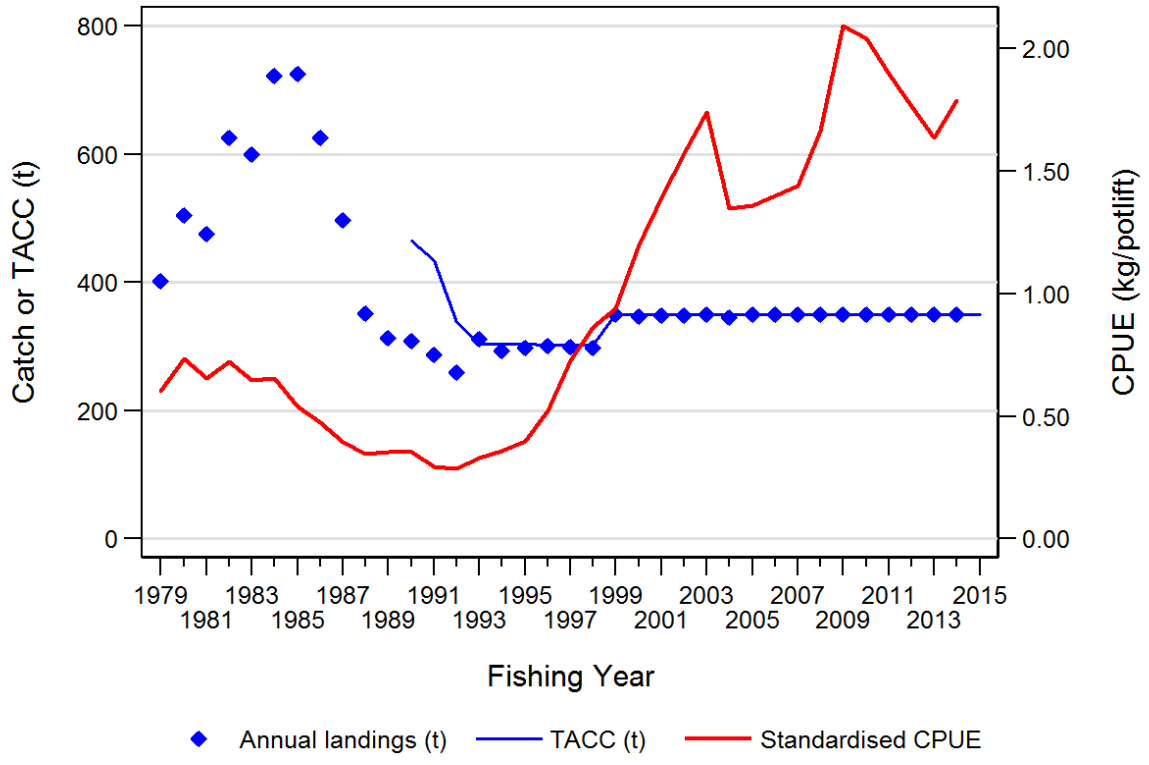


Figure 3: CRA 5: annual commercial landings (t), TACC (t) and annual standardised CPUE index, 1979–2014 plus 2015 TACC.

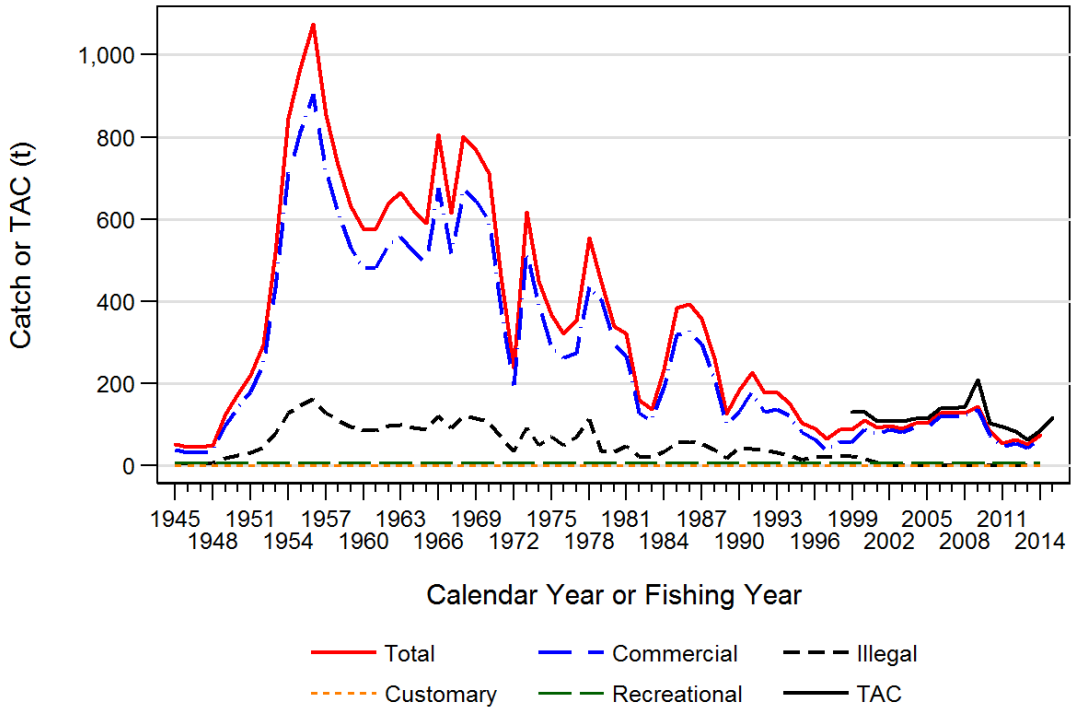


Figure 4: **CRA 7: catches by source, 1945–2014.**

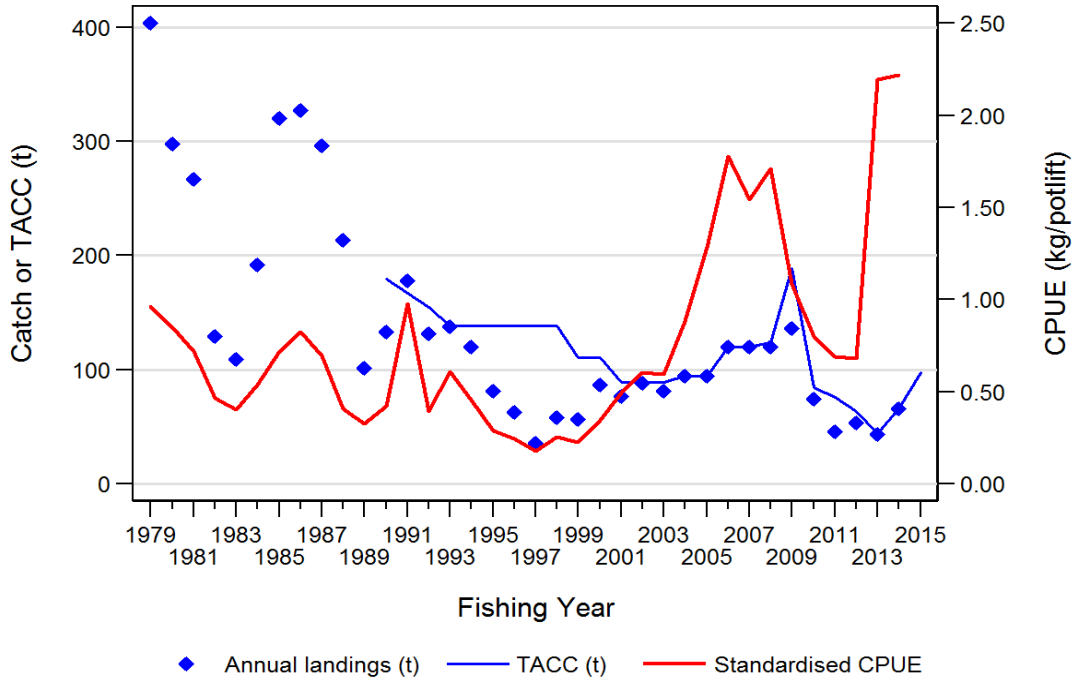


Figure 5: **CRA 7: annual commercial landings (t), TACC (t) and annual standardised CPUE index, 1979–2014, plus 2015 TACC.**

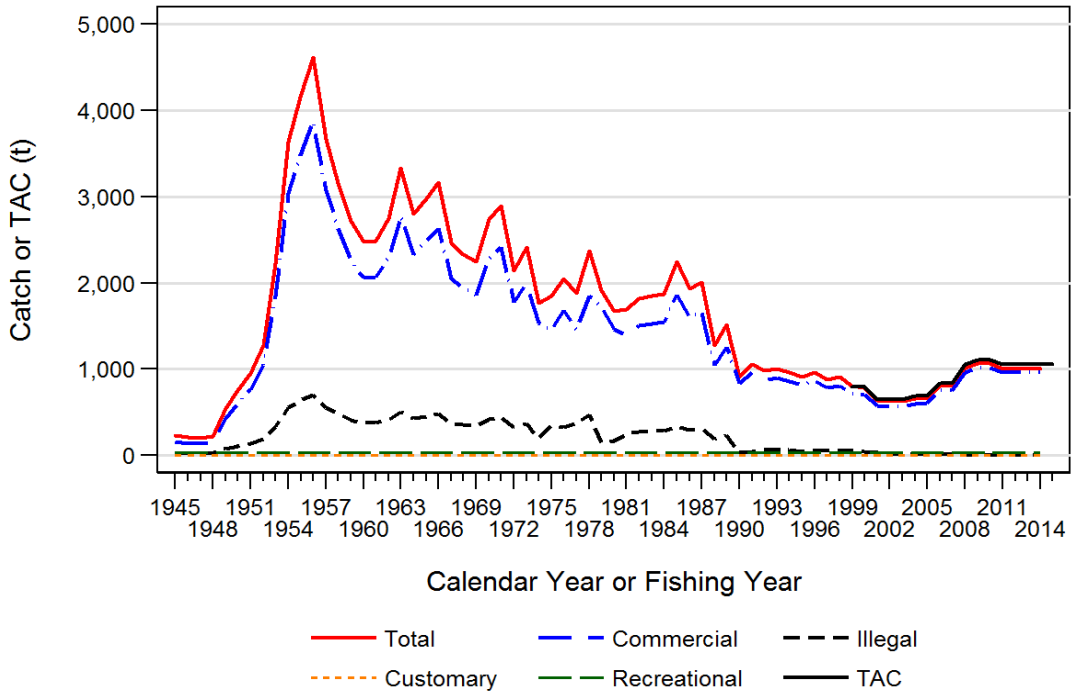


Figure 6: CRA 8: catches by source, 1945–2014.

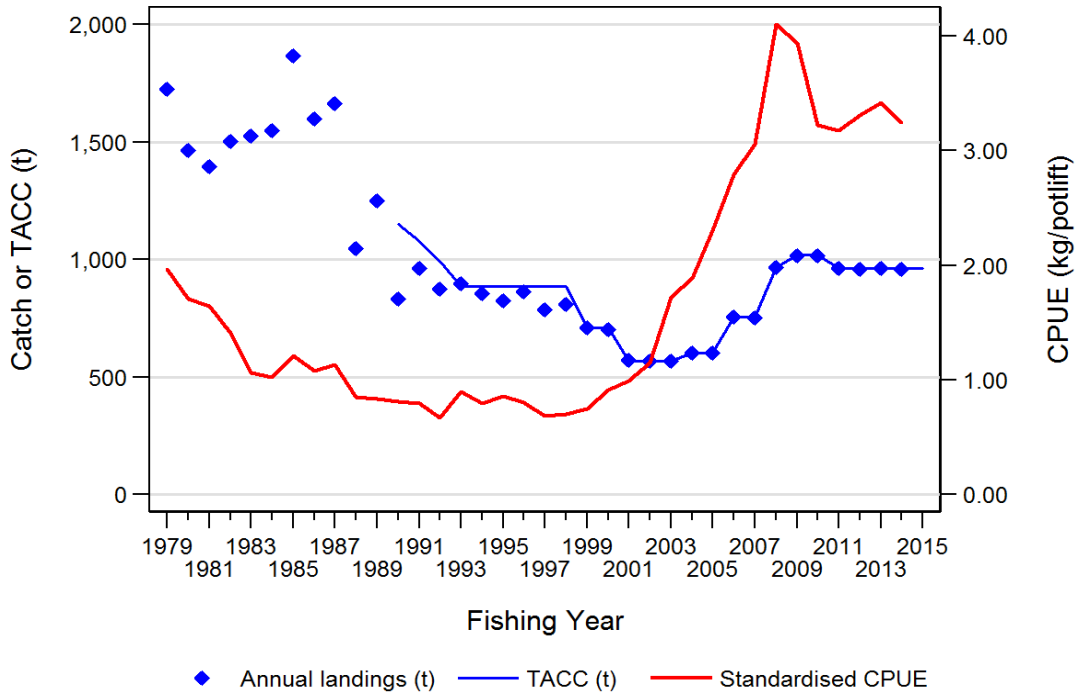


Figure 7: CRA 8: annual commercial landings (t), TACC (t) and annual standardised CPUE index for 1979–2014, plus 2015 TACC.

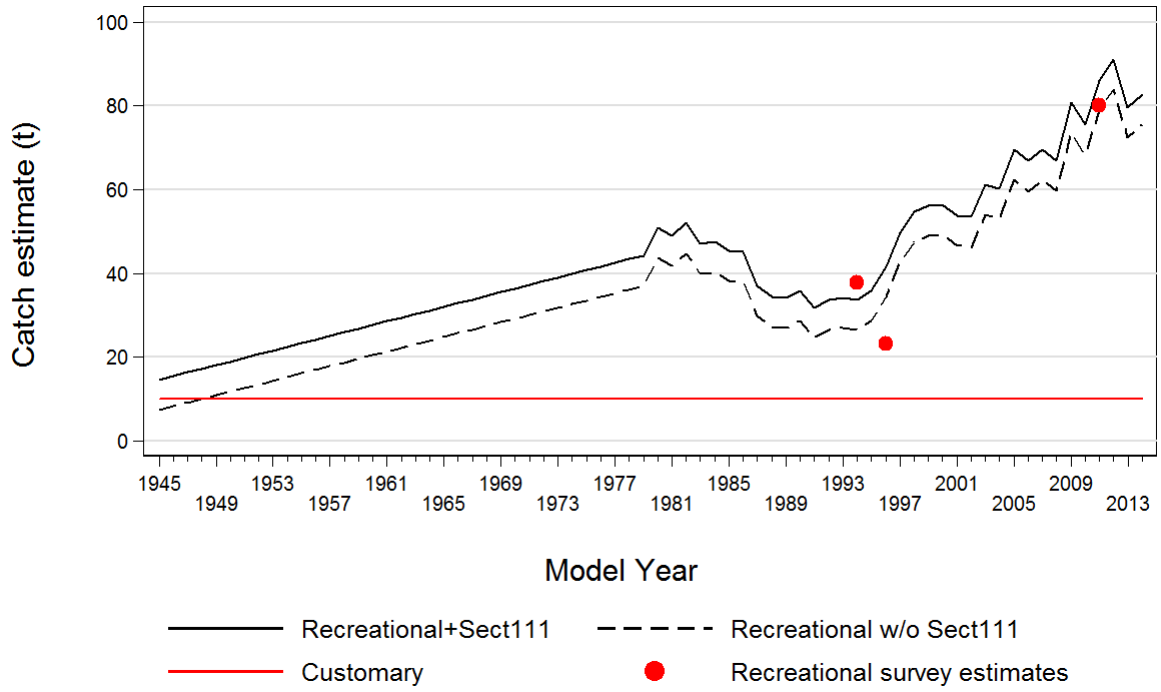


Figure 8: CRA 5: recreational (black) and customary (flat red) catch trajectories (t).

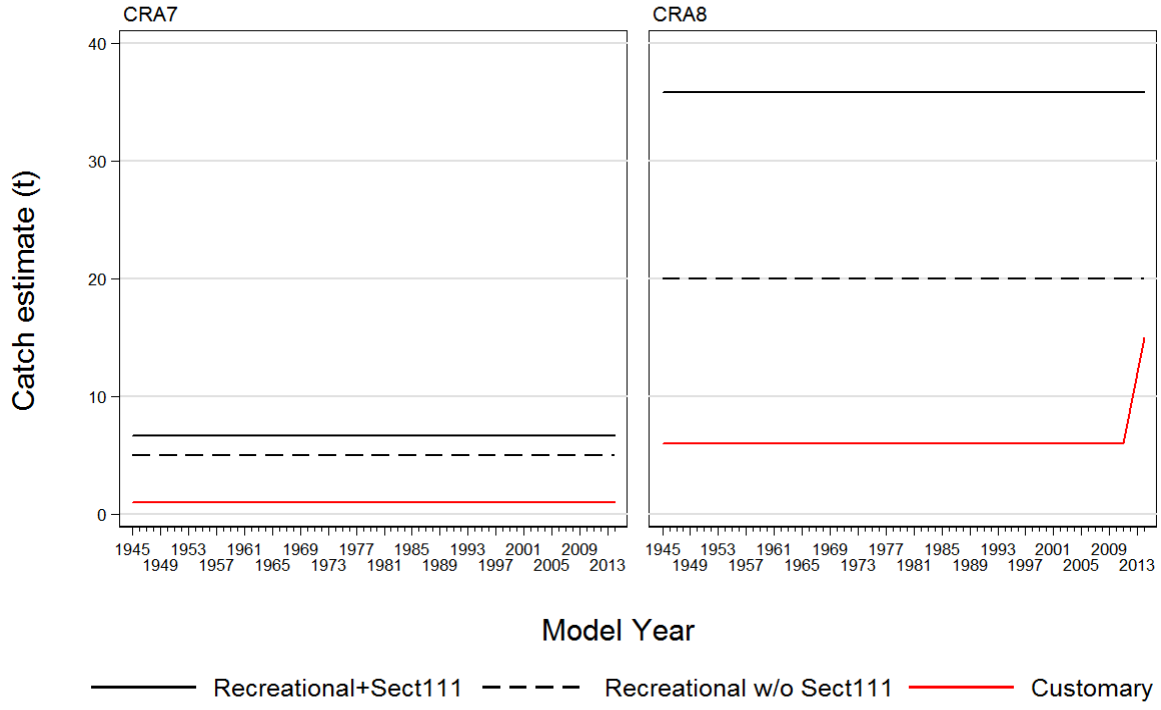


Figure 9: Recreational (black) and customary (red) catch trajectories (t) for CRA 7 (left panel) and CRA 8.

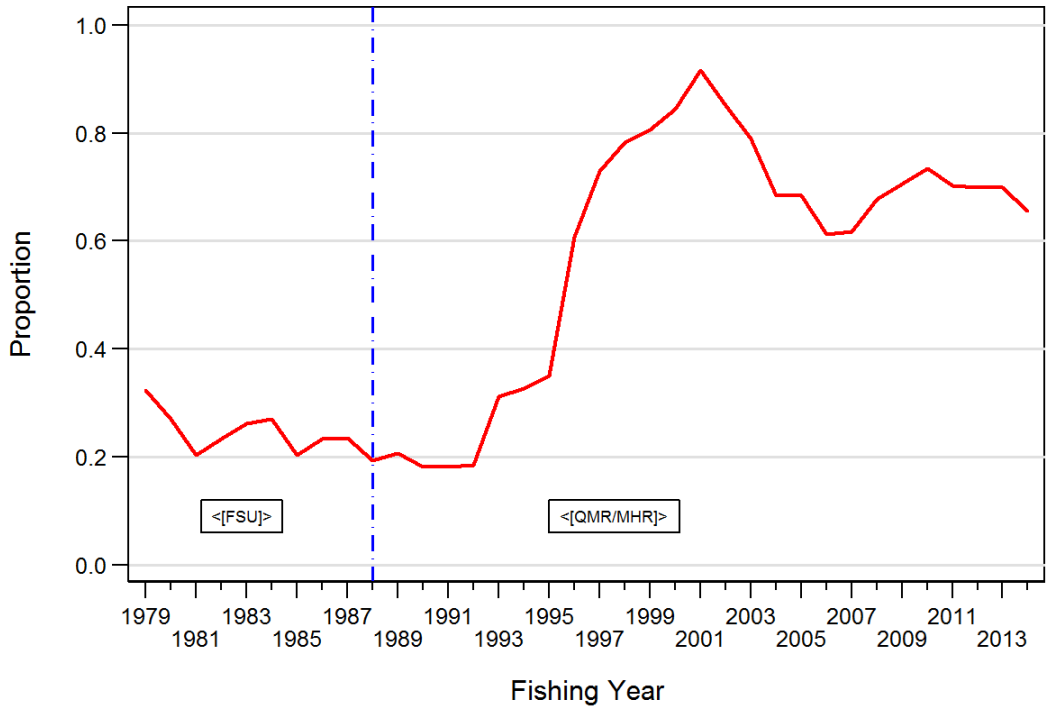


Figure 10: CRA 5: proportion of the commercial AW catch.

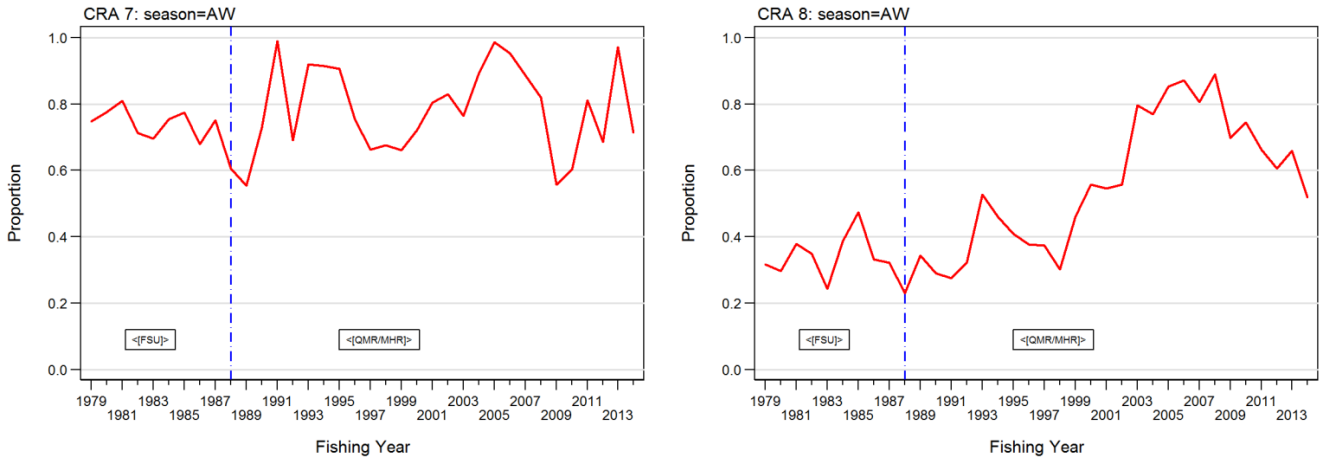


Figure 11: Proportion of the AW commercial catch for CRA 7 (left) and CRA 8.

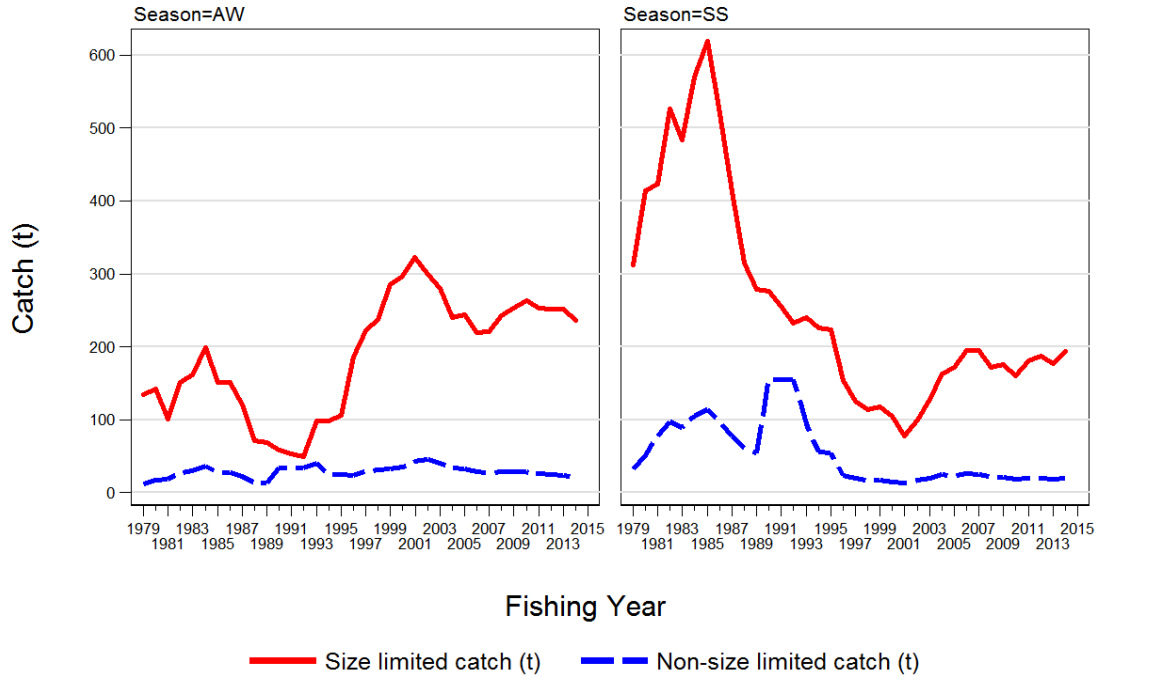


Figure 12: CRA 5: seasonal SL and NSL catches (t) from 1979.

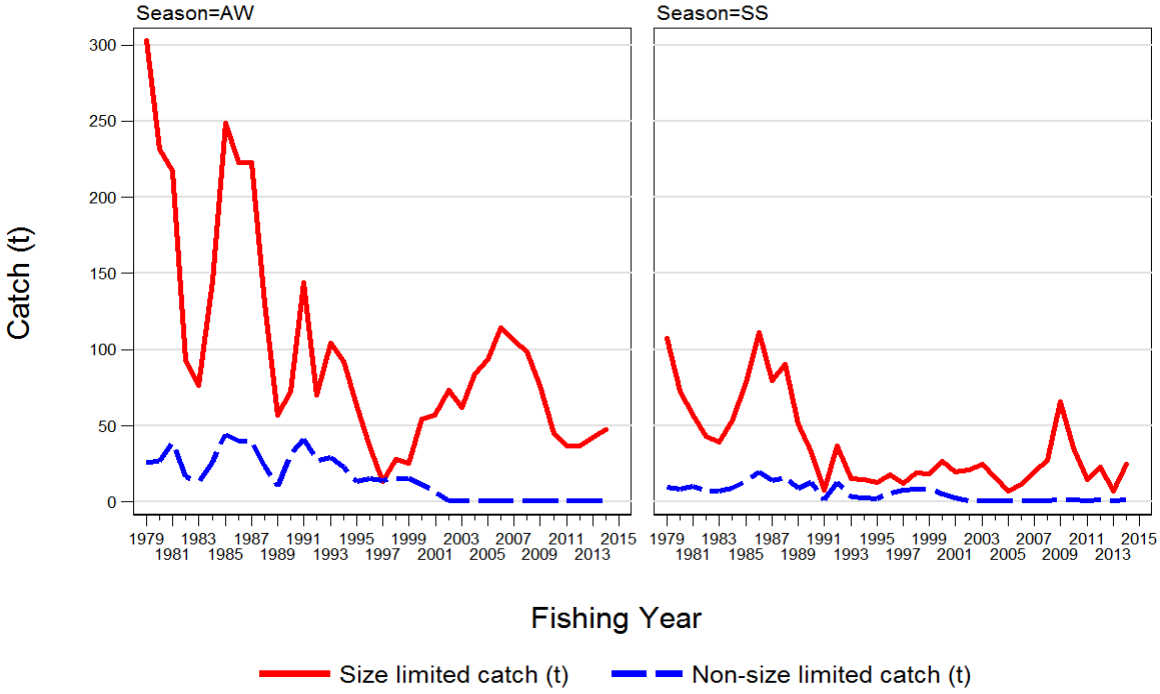


Figure 13: CRA 7: seasonal SL and NSL catches (t) from 1979.

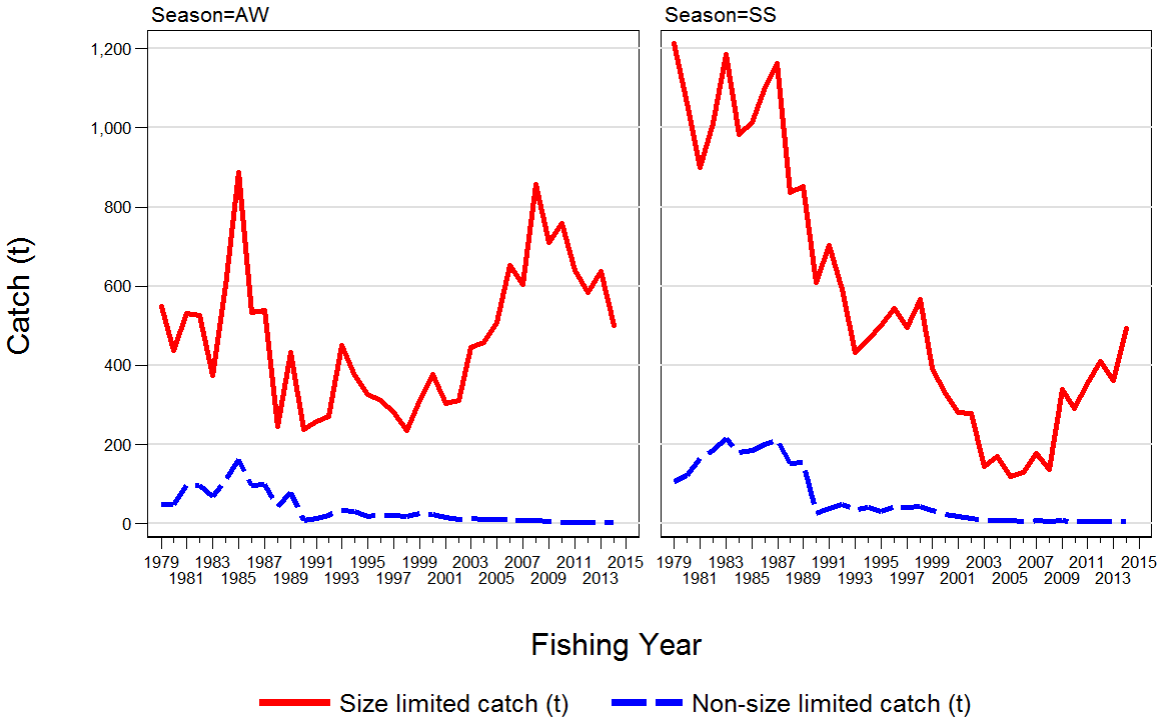


Figure 14: CRA 8: seasonal SL and NSL catches from 1979.

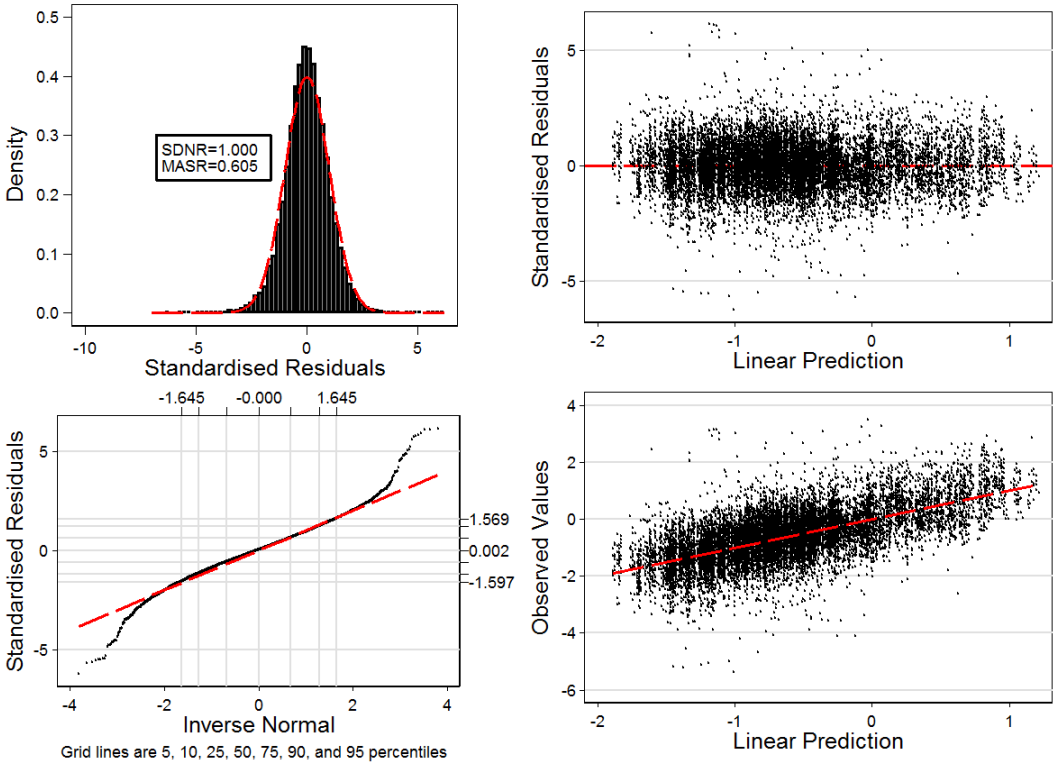


Figure 15: CRA 5: standardised residuals from the standardised seasonal CPUE analysis.

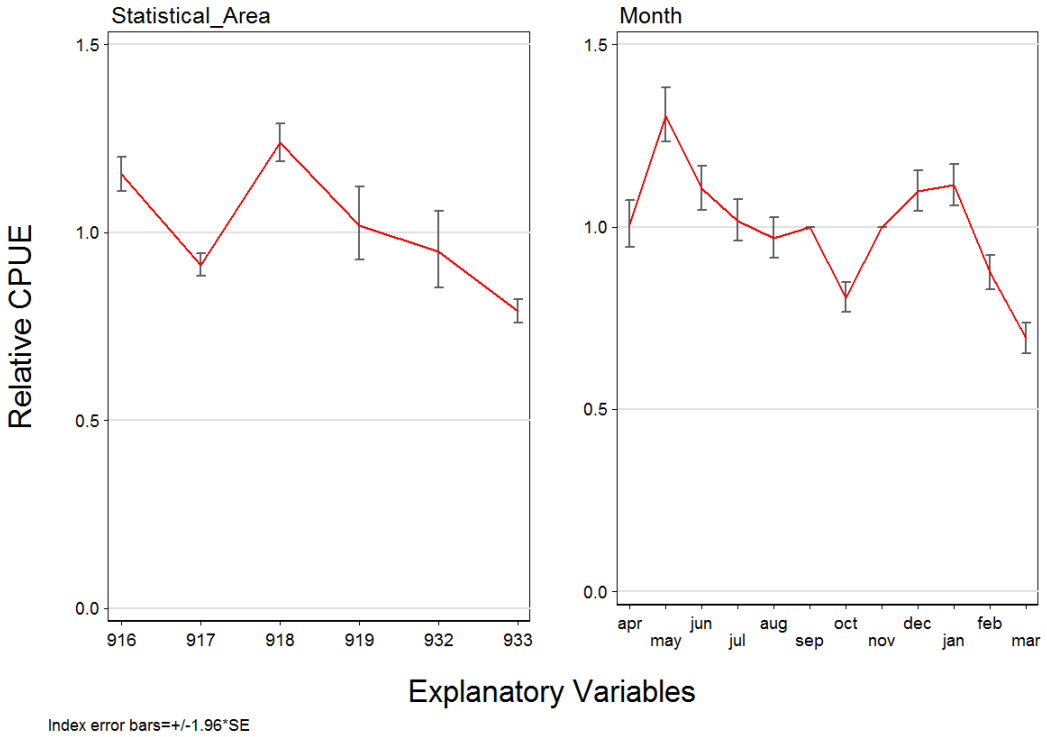


Figure 16: CRA 5: coefficients for month and statistical area from the seasonal CPUE standardisation. Month coefficients are not in canonical form, with each of the two reference months (September and October) set to 1.0 and the associated SE set to zero.

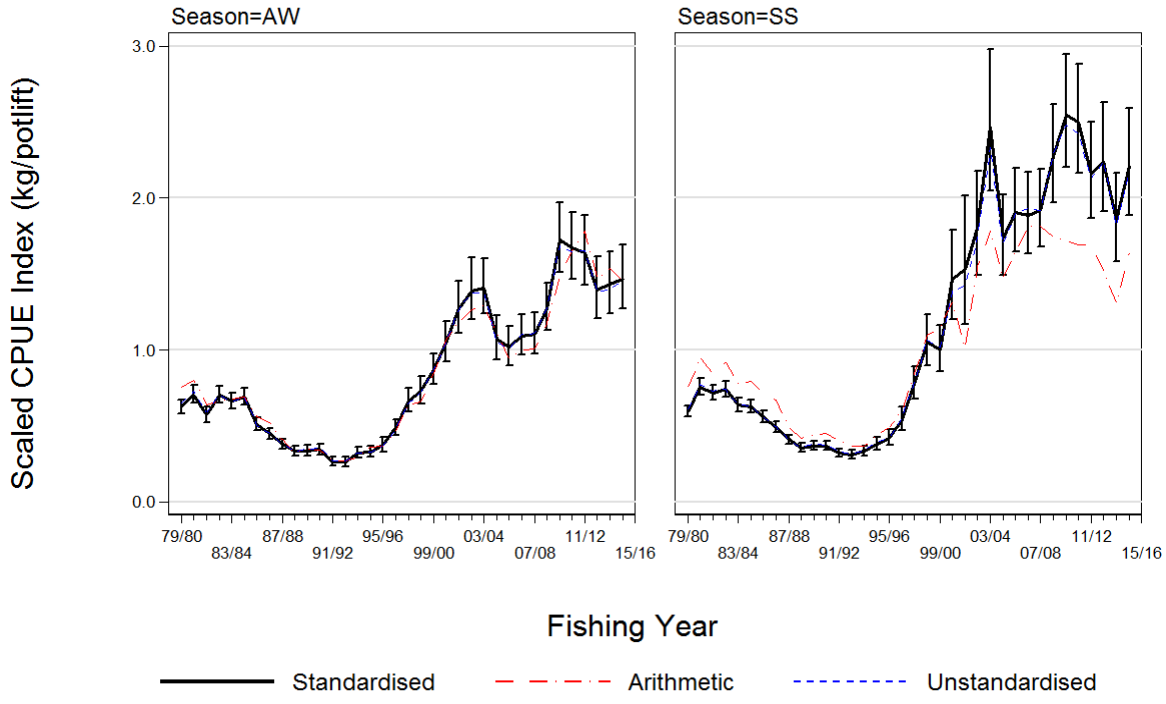


Figure 17: CRA 5: standardised, unstandardised, and arithmetic CPUE indices (kg/potlift) by season and fishing year; geometric mean for AW = 0.72 kg/potlift; geometric mean for SS = 0.92 kg/potlift.; error bars show plus and minus 1.96 standard errors.

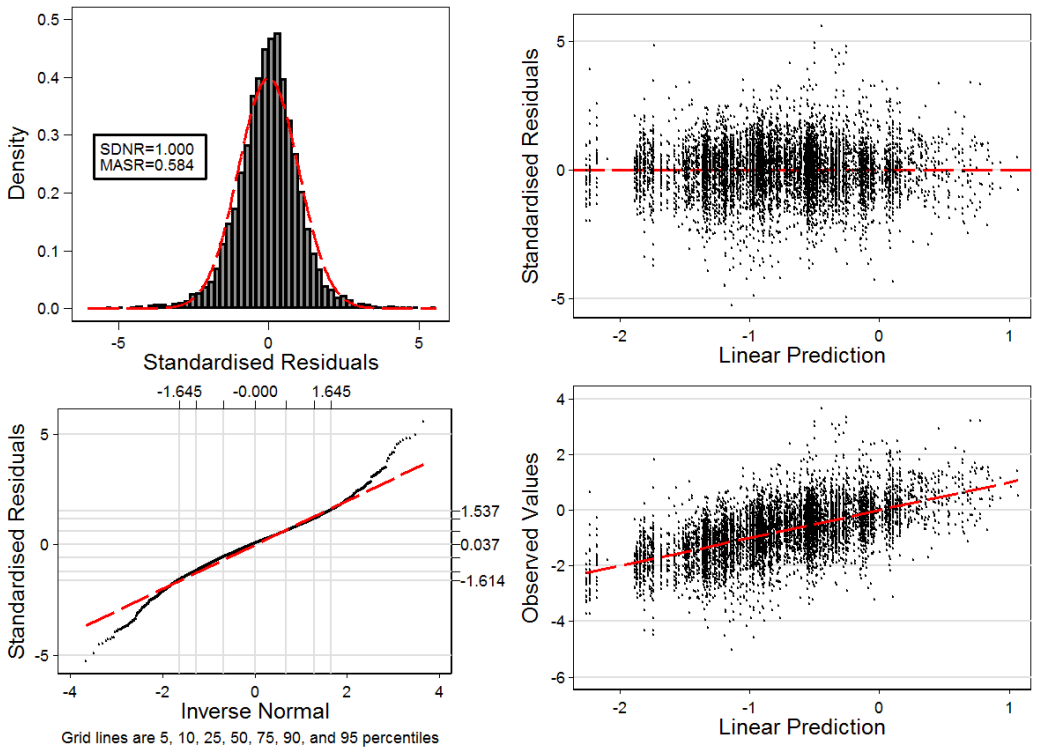


Figure 18: CRA 7: standardised residuals from the standardised seasonal CPUE model.

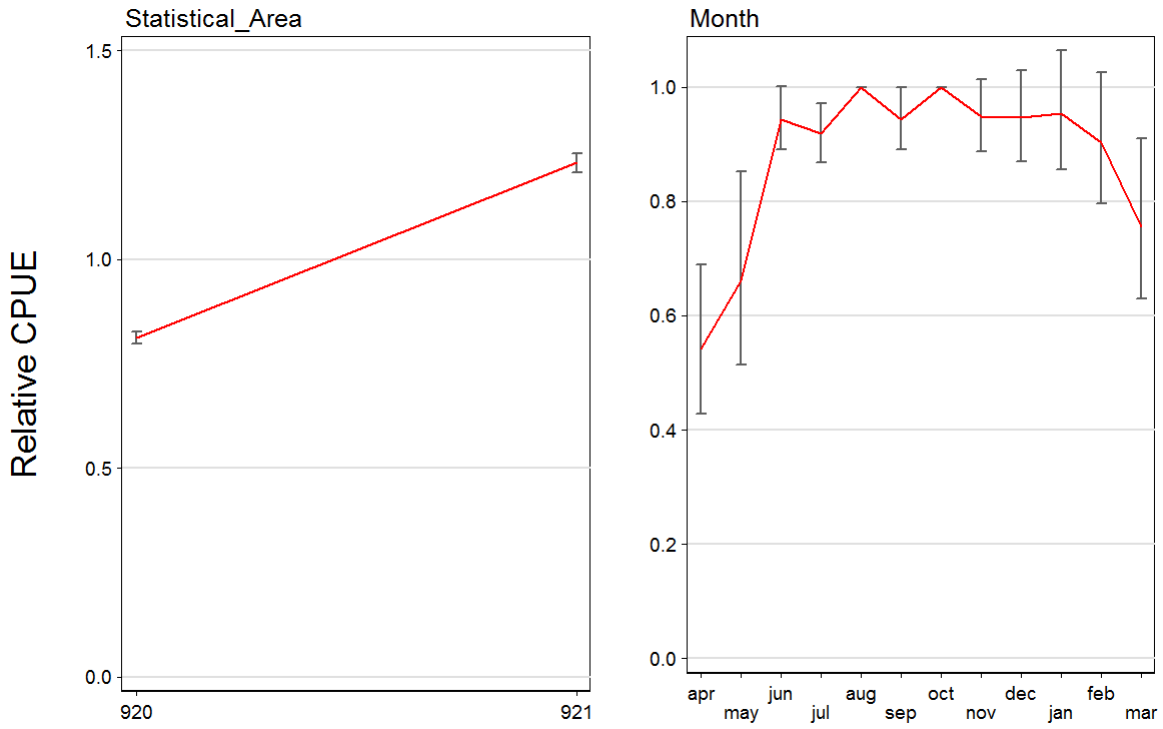


Figure 19: CRA 7: coefficients for month and statistical area from the standardised seasonal CPUE model. Month coefficients are not in canonical form, with each of the two reference months (August and October) set to 1.0 and the associated SE set to zero; error bars show plus and minus 1.96 standard errors.

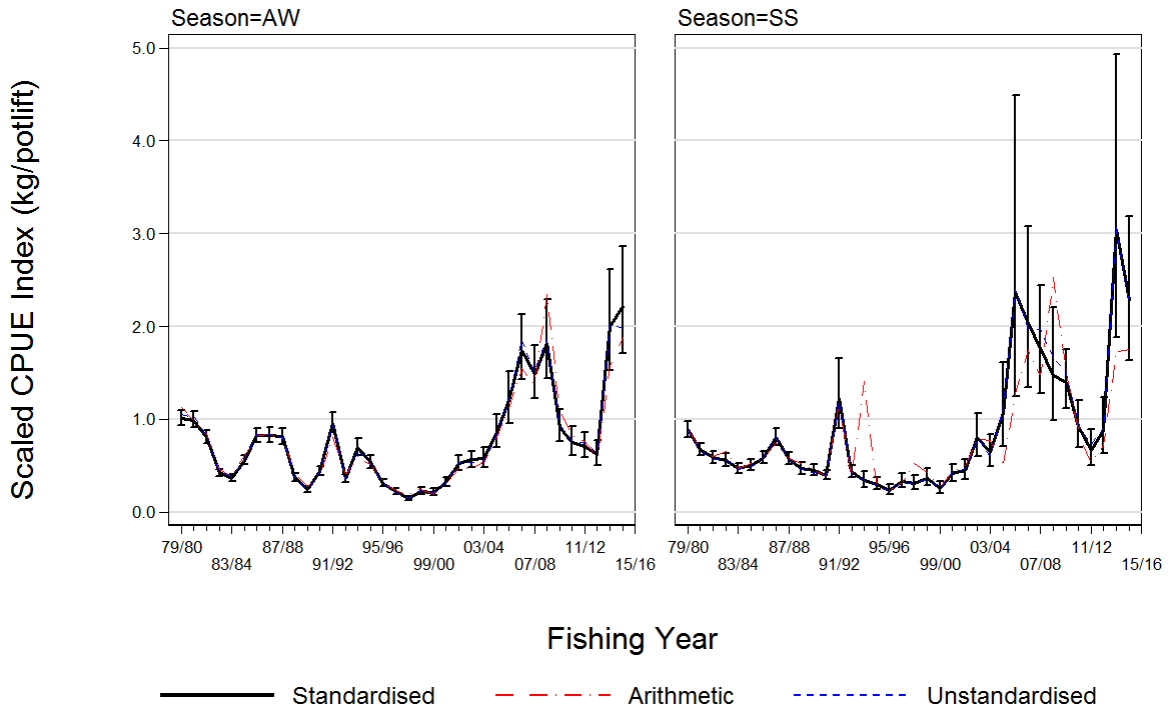


Figure 20: CRA 7: standardised, unstandardised, and arithmetic CPUE indices (kg/potlift) by season and fishing year; AW geometric mean = 0.62 kg/potlift and SS geometric mean = 0.68 kg/potlift; error bars show plus and minus 1.96 standard errors.

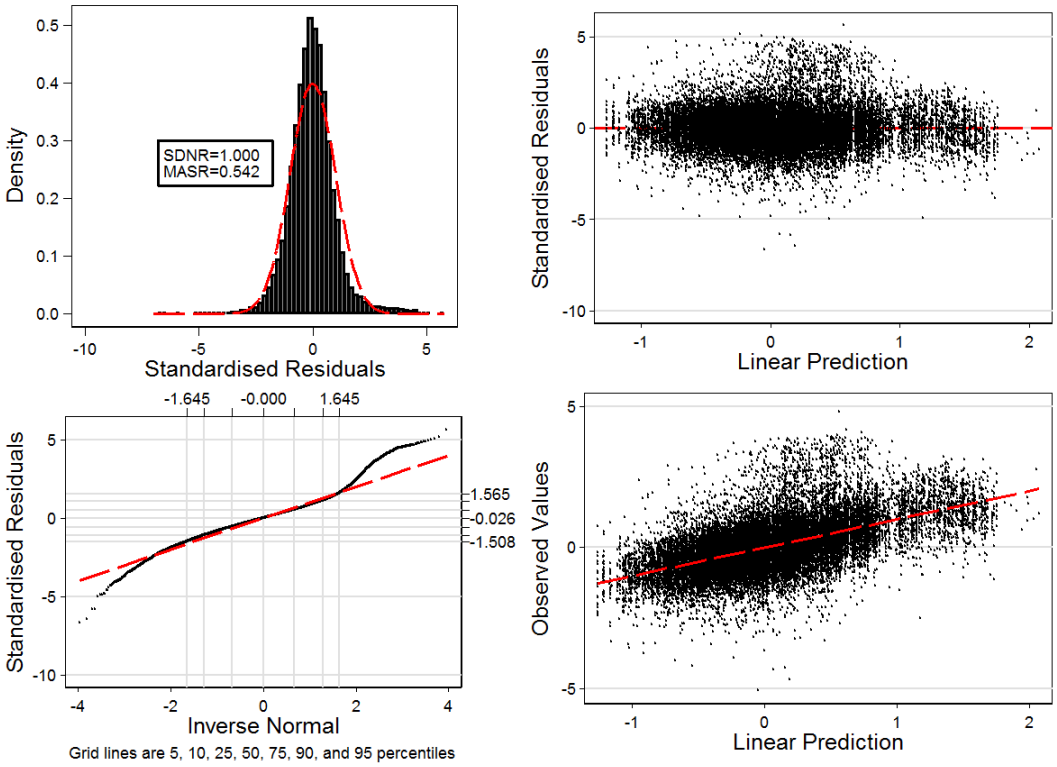


Figure 21: CRA 8: standardised residuals from the standardised seasonal CPUE model.

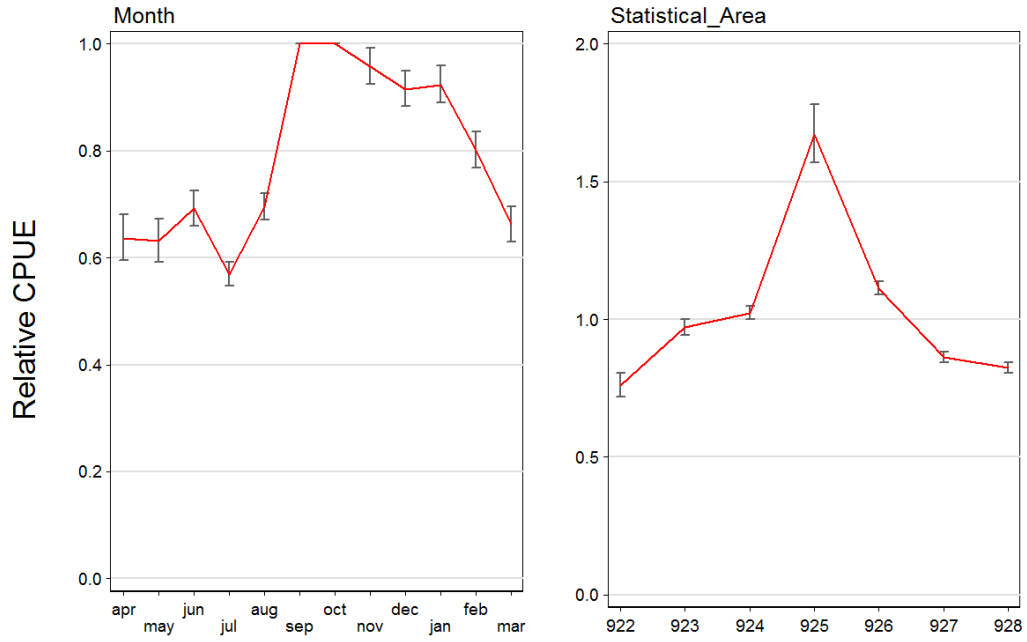


Figure 22: CRA 8: coefficients for month and statistical area from the standardised seasonal CPUE model. Month coefficients are not in canonical form, with each of the two reference months (August and October) set to 1.0 and the associated SE set to zero; standard error bars show plus and minus 1.96 standard errors.

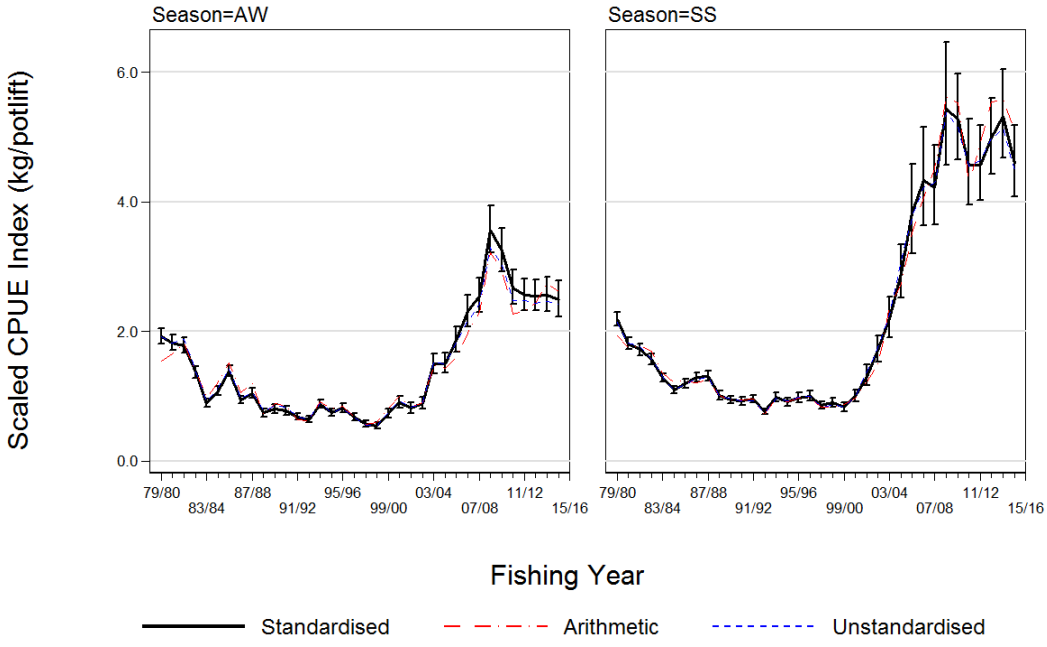


Figure 23: CRA 8: standardised, unstandardised, and arithmetic CPUE indices (kg/potlift) by season and fishing year; AW geometric mean = 1.26 kg/potlift) and SS geometric mean = 1.77 kg/potlift); standard error bars show plus and minus 1.96 standard errors.

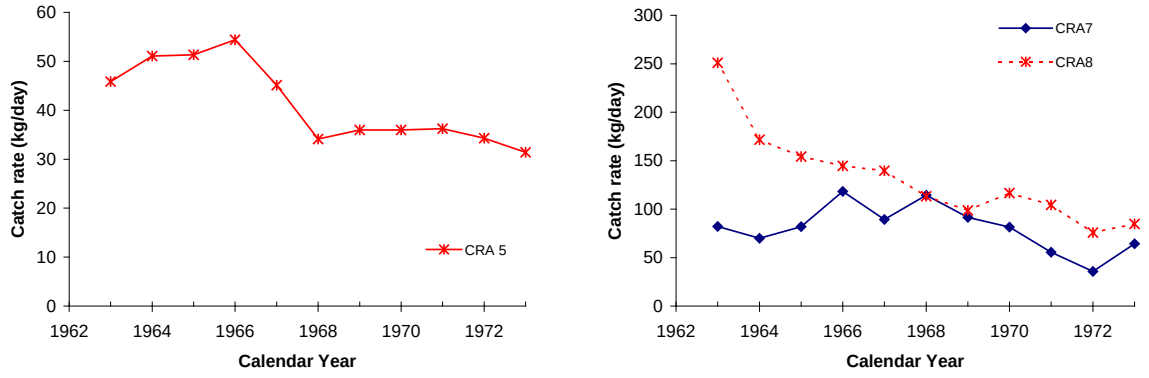


Figure 24: Catch rate (kg/day) by calendar year for CRA 5, CRA 7 and CRA 8, from Annala & King (1983).

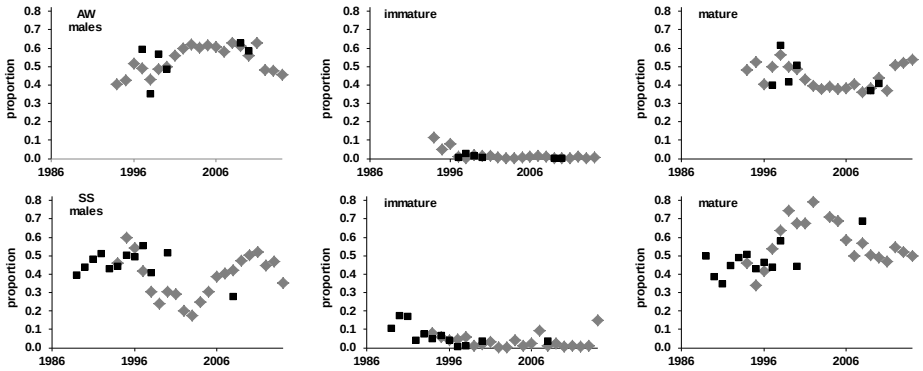


Figure 25: CRA 5: proportions by sex, season and source: grey diamonds are logbooks, black squares are observer samples.

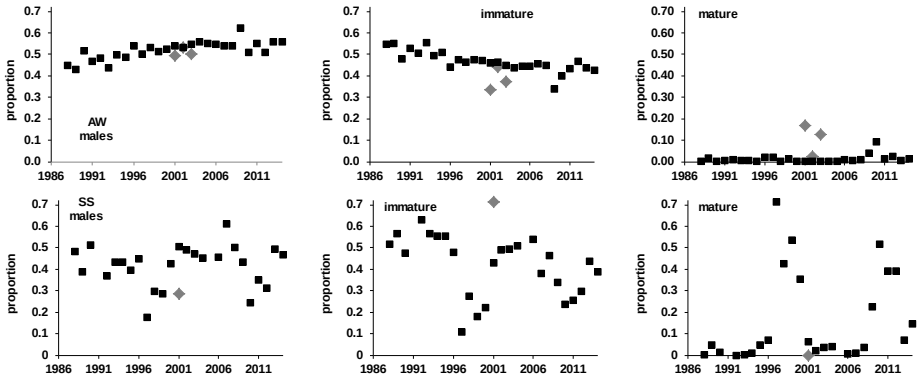


Figure 26: CRA 7: proportions by sex, season and source: grey diamonds are logbooks, black squares are observer samples.

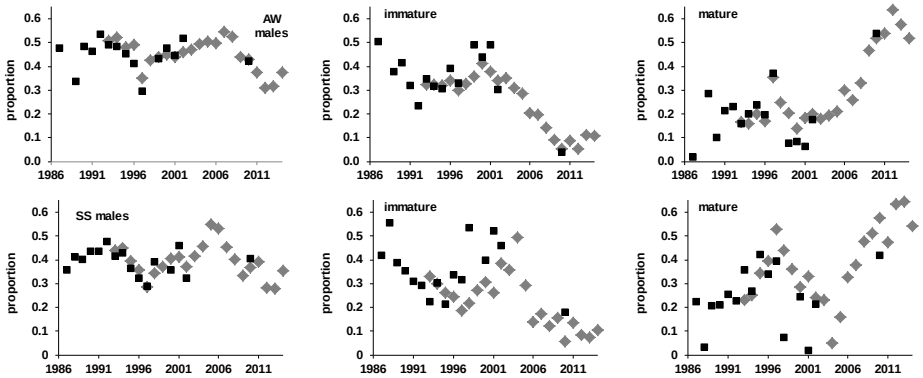


Figure 27: CRA 8: proportions by sex, season and source: grey diamonds are logbooks, black squares are observer samples.

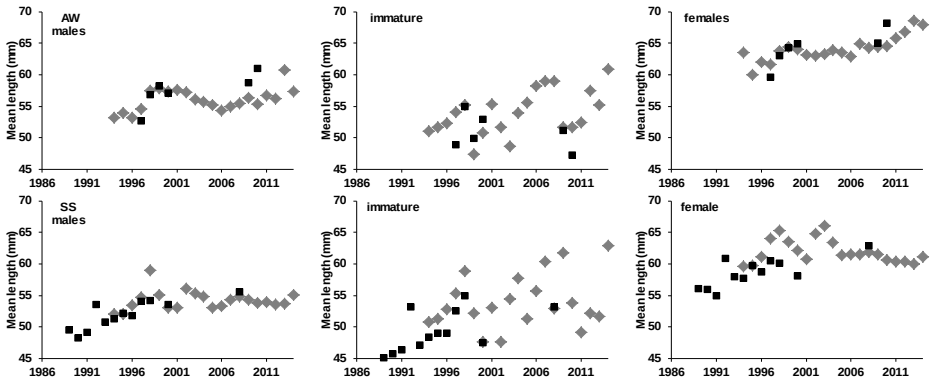


Figure 28: CRA 5: mean length by sex, season and source: grey diamonds are logbooks, black squares are observer samples.

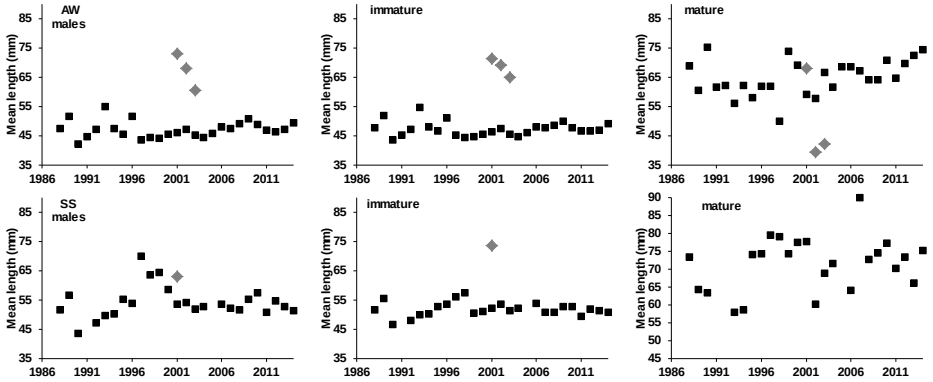


Figure 29: CRA 7: mean size by sex, season and source: grey diamonds are logbooks, black squares are observer samples.

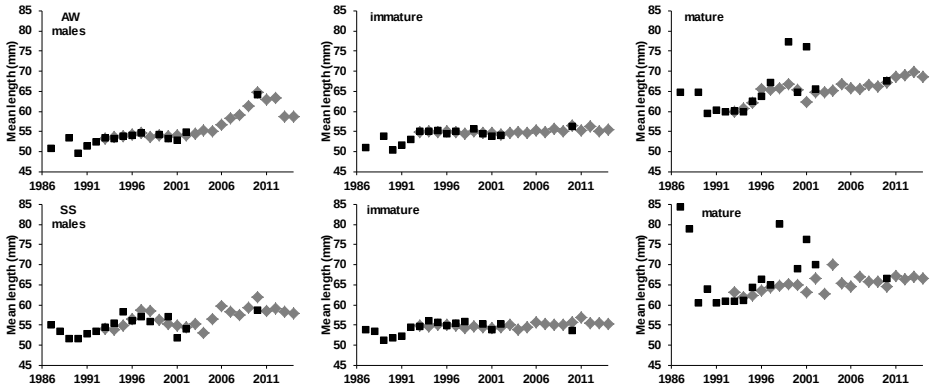


Figure 30: CRA 8: mean length by sex, season and source: grey diamonds are logbooks, black squares are observer samples.

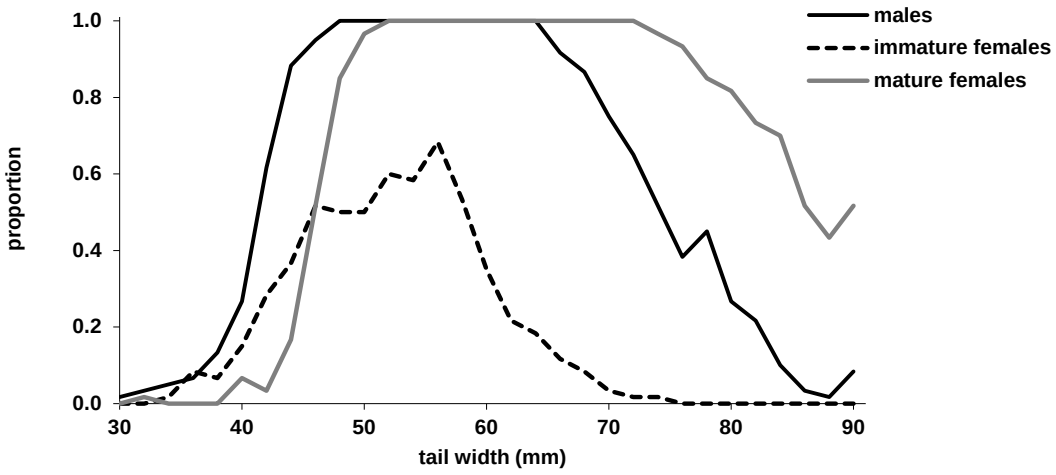


Figure 31: CRA 5: for each sex and each size bin, the proportion of records with a proportion-at-size at least 0.001.

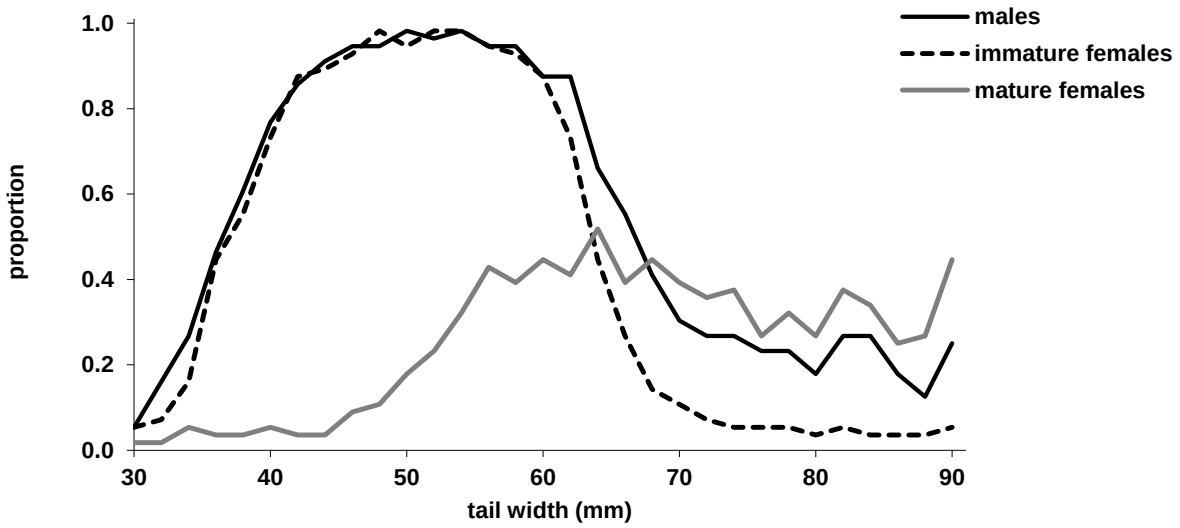


Figure 32: CRA 7: for each sex and each size bin, the proportion of records with a proportion-at-size at least 0.001.

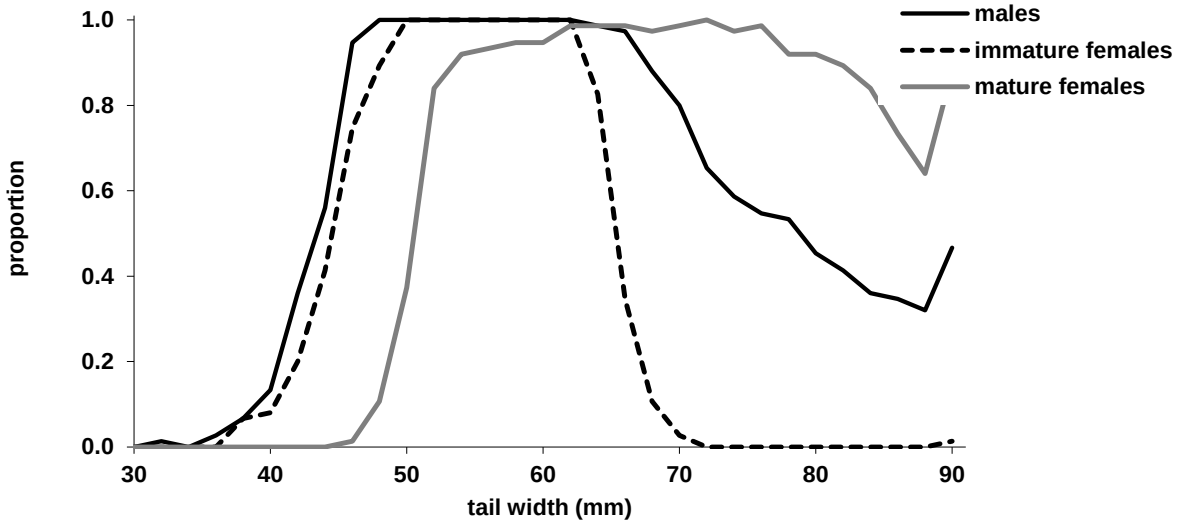


Figure 33: CRA 8: for each sex and each size bin, the proportion of records with a proportion-at-size at least 0.001.

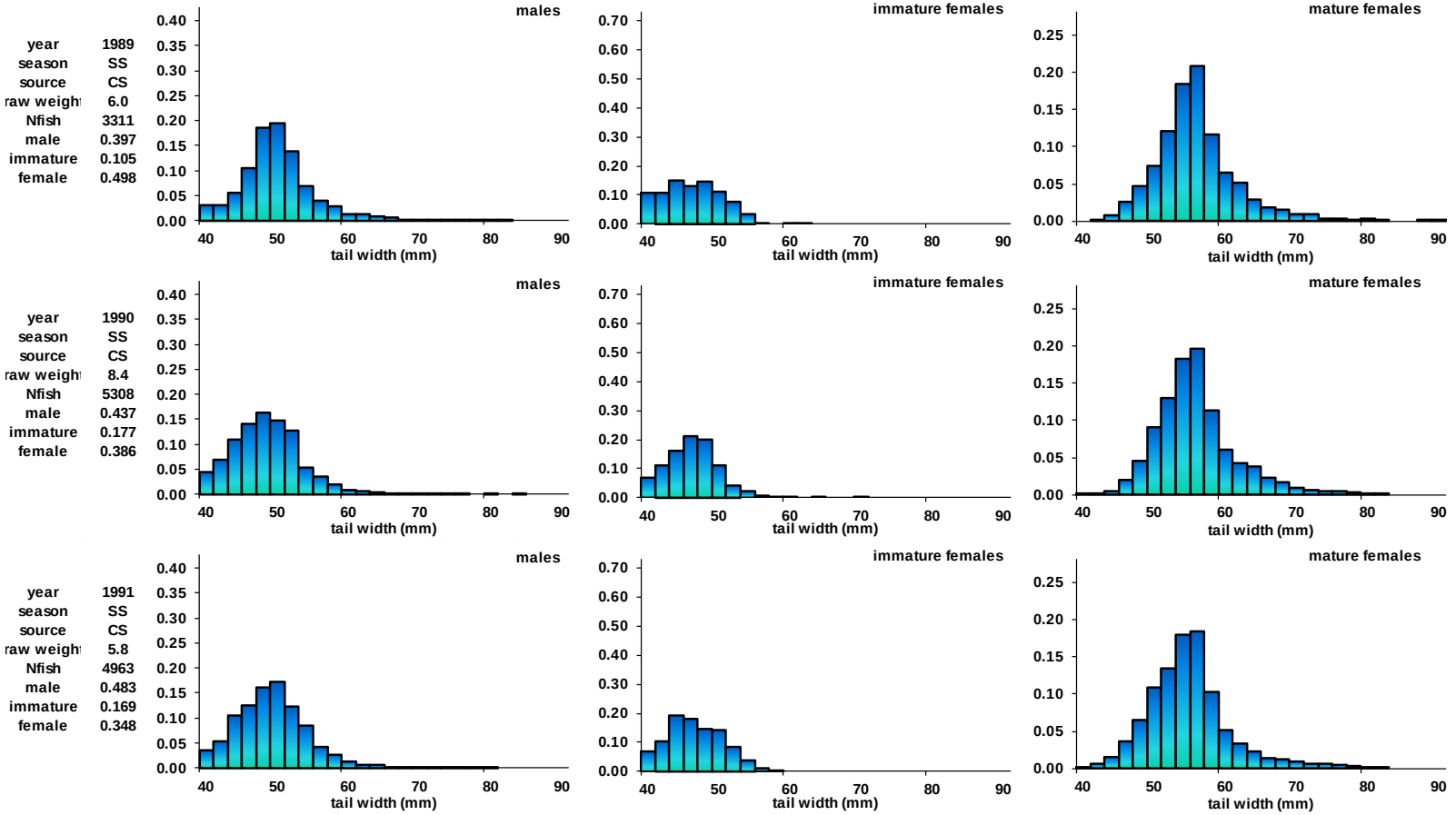


Figure 34: CRA 5: Length frequency records; left: males, centre: immature females; right: mature females; note that scales differ among sex classes but not between records; information on left is year, season, source (CS indicates observer catch sampling), record weight, number of fish measured and proportion by sex class.

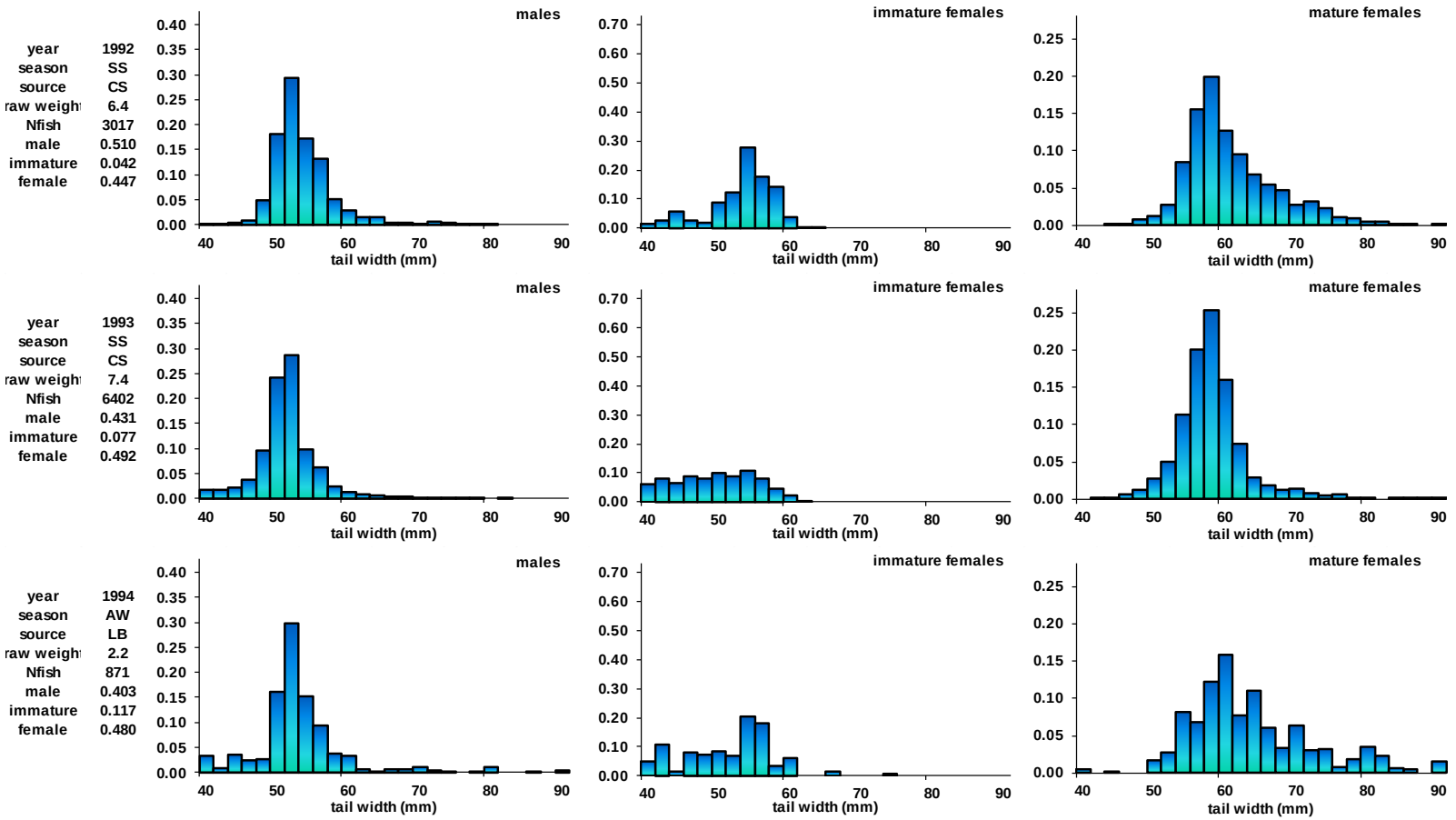


Figure 34 continued.

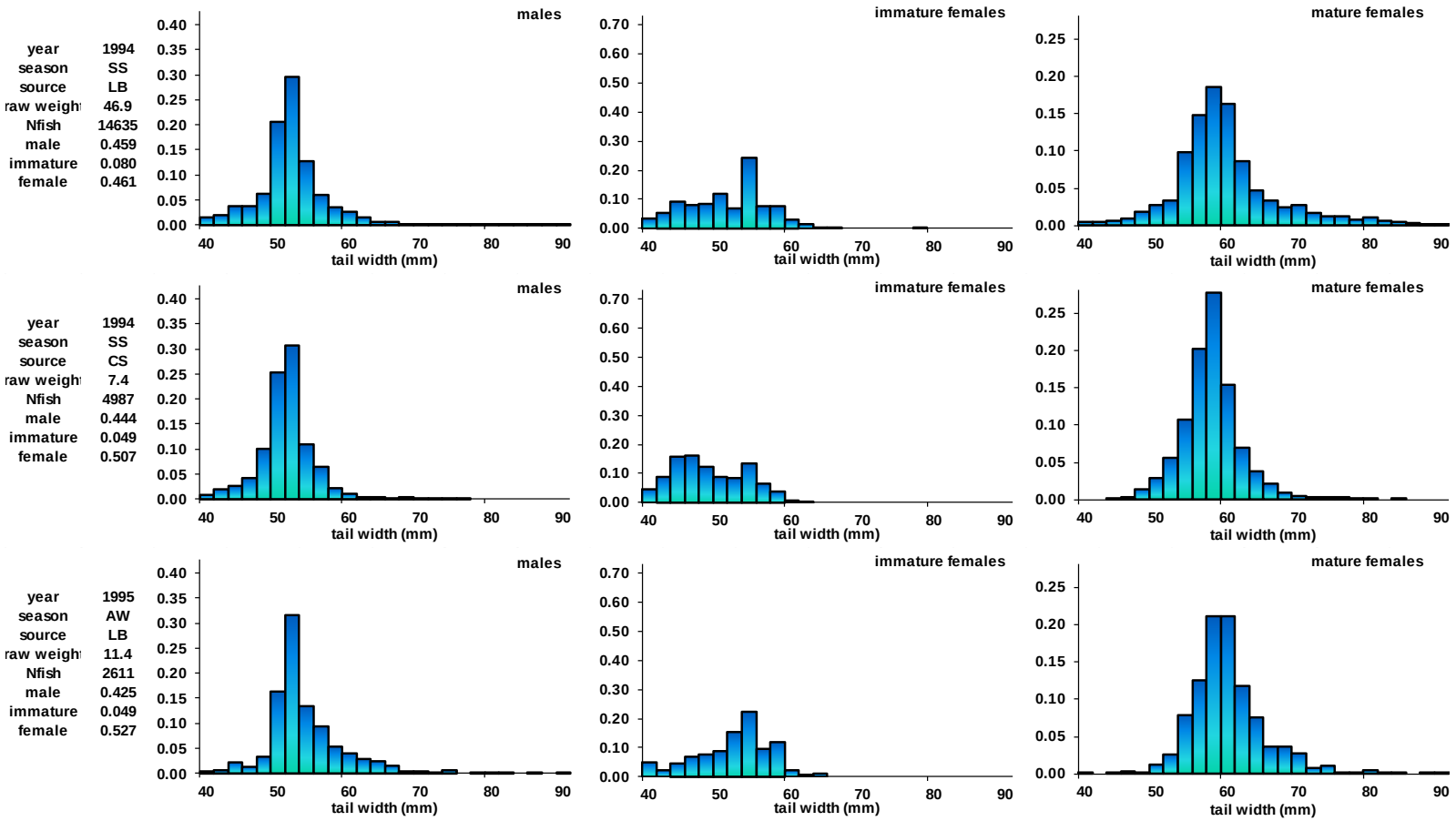


Figure 34 continued.

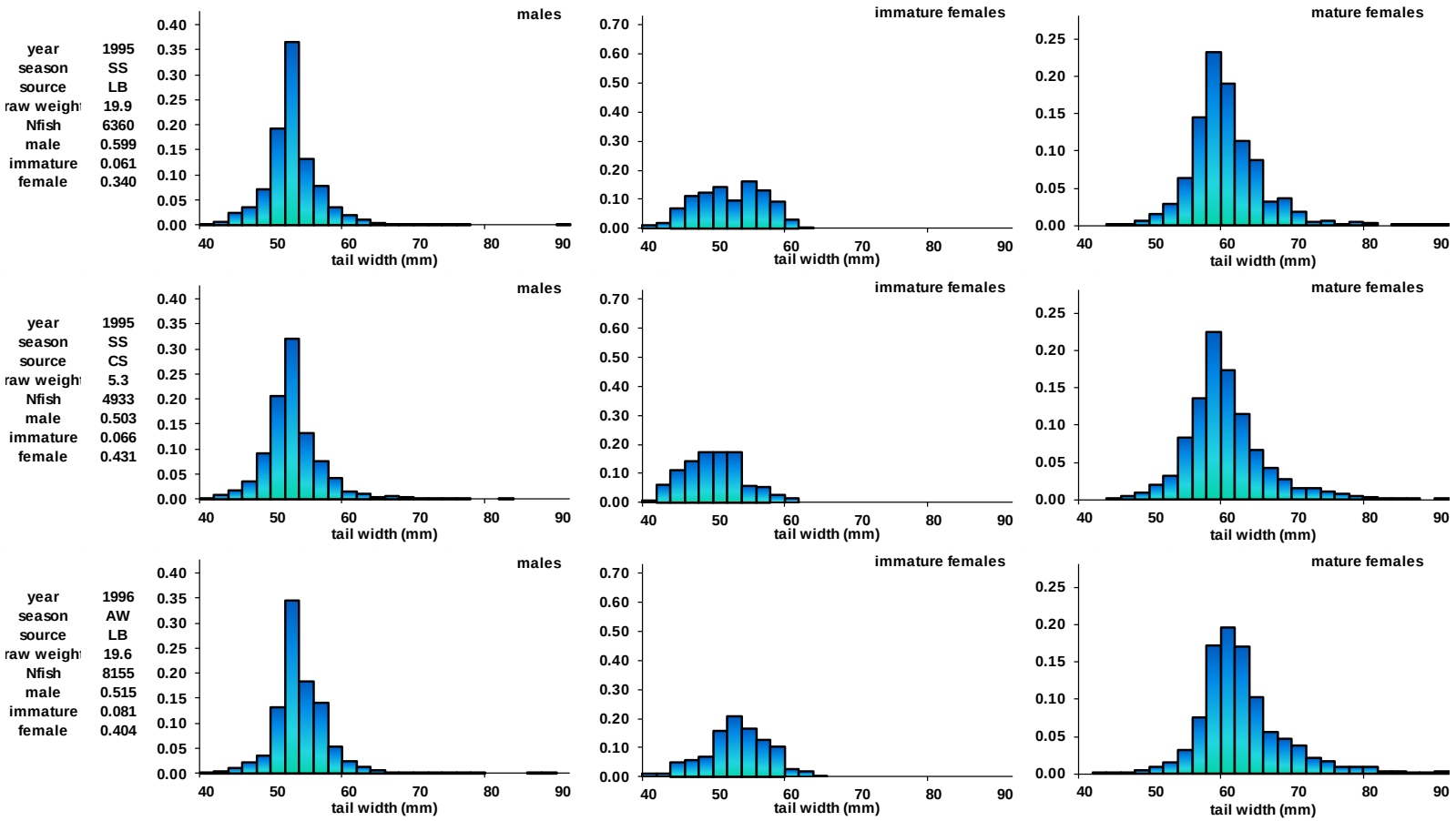


Figure 34 continued.

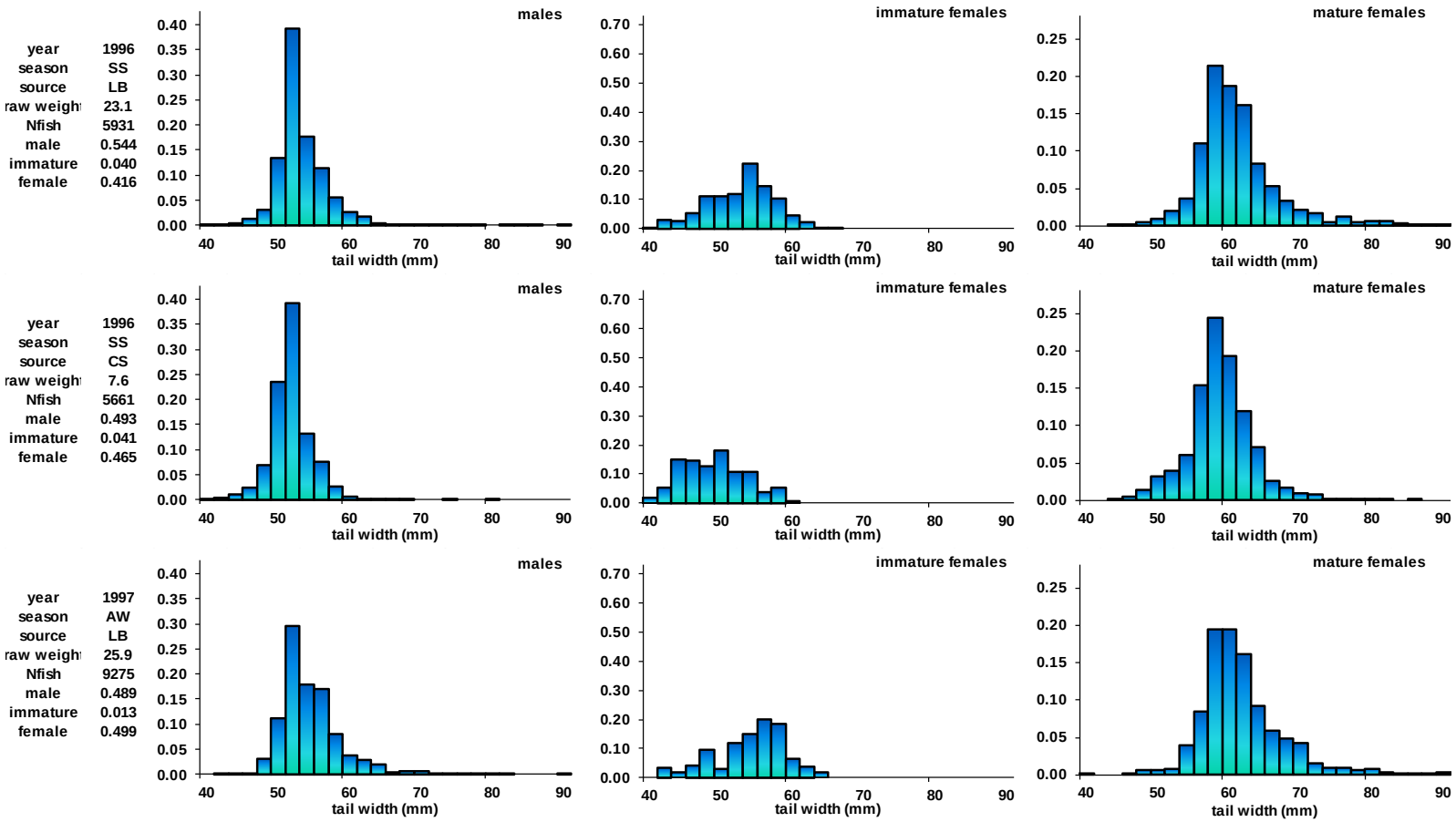


Figure 34 continued.

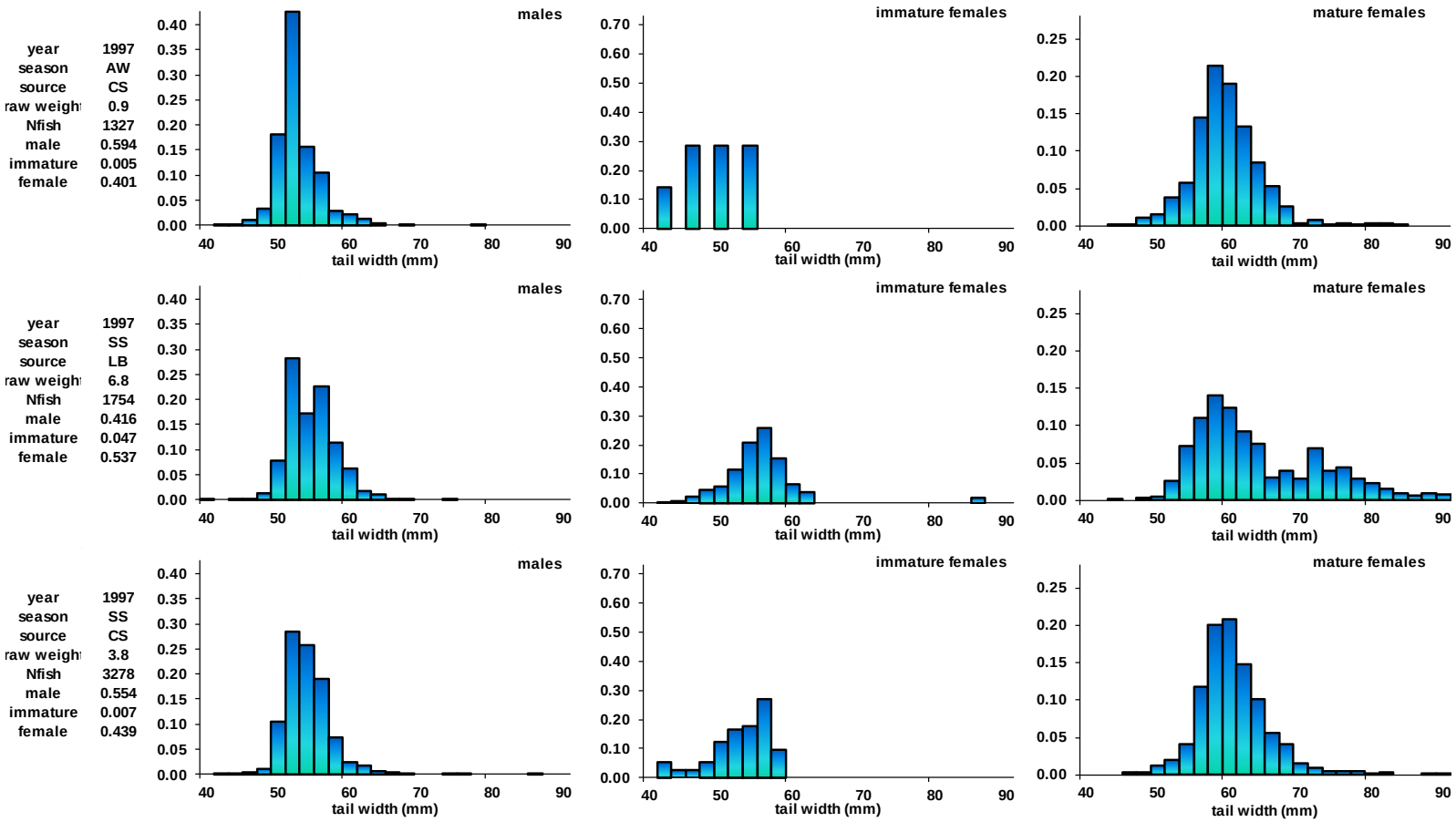


Figure 34 continued.

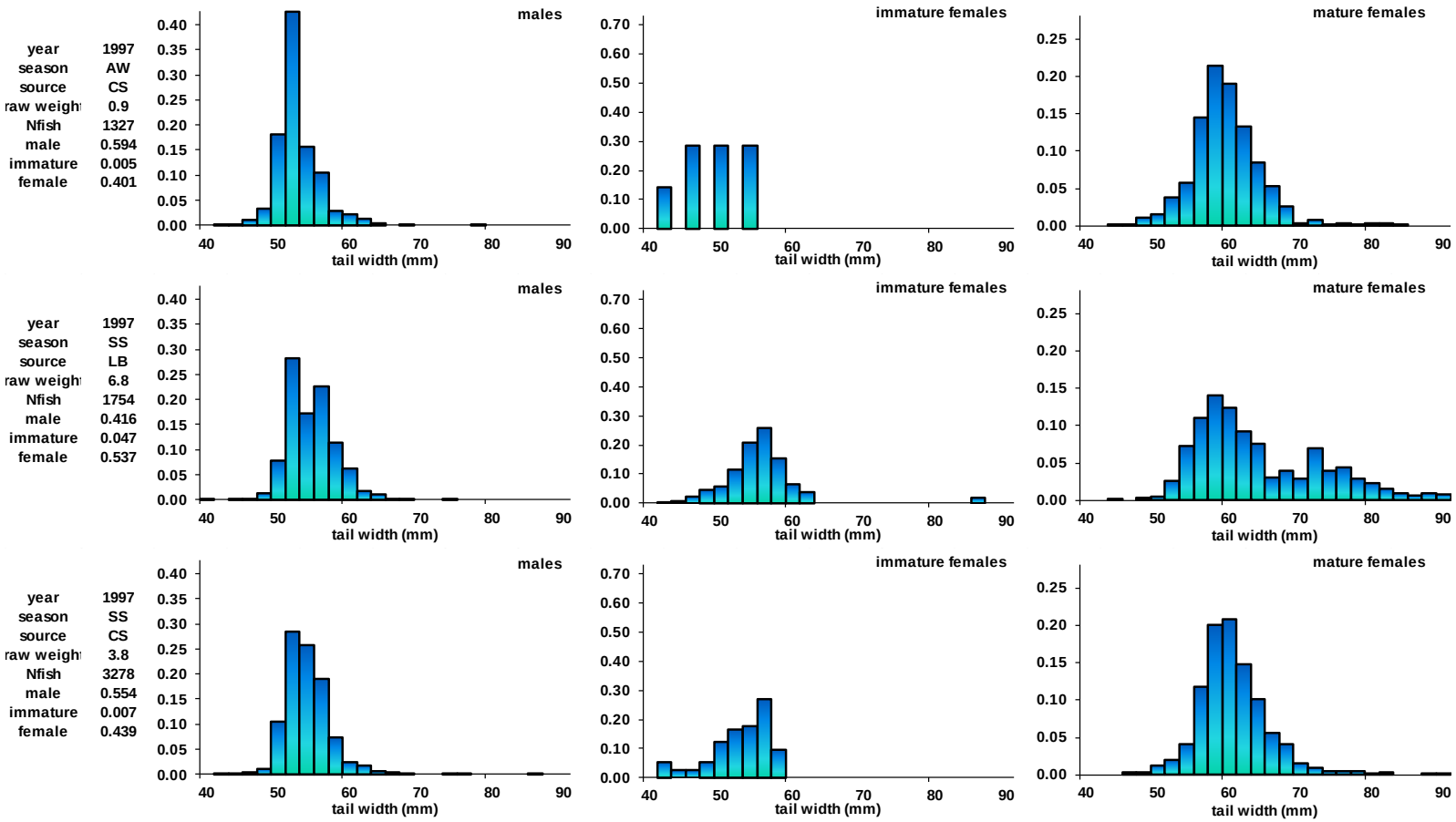


Figure 34 continued.

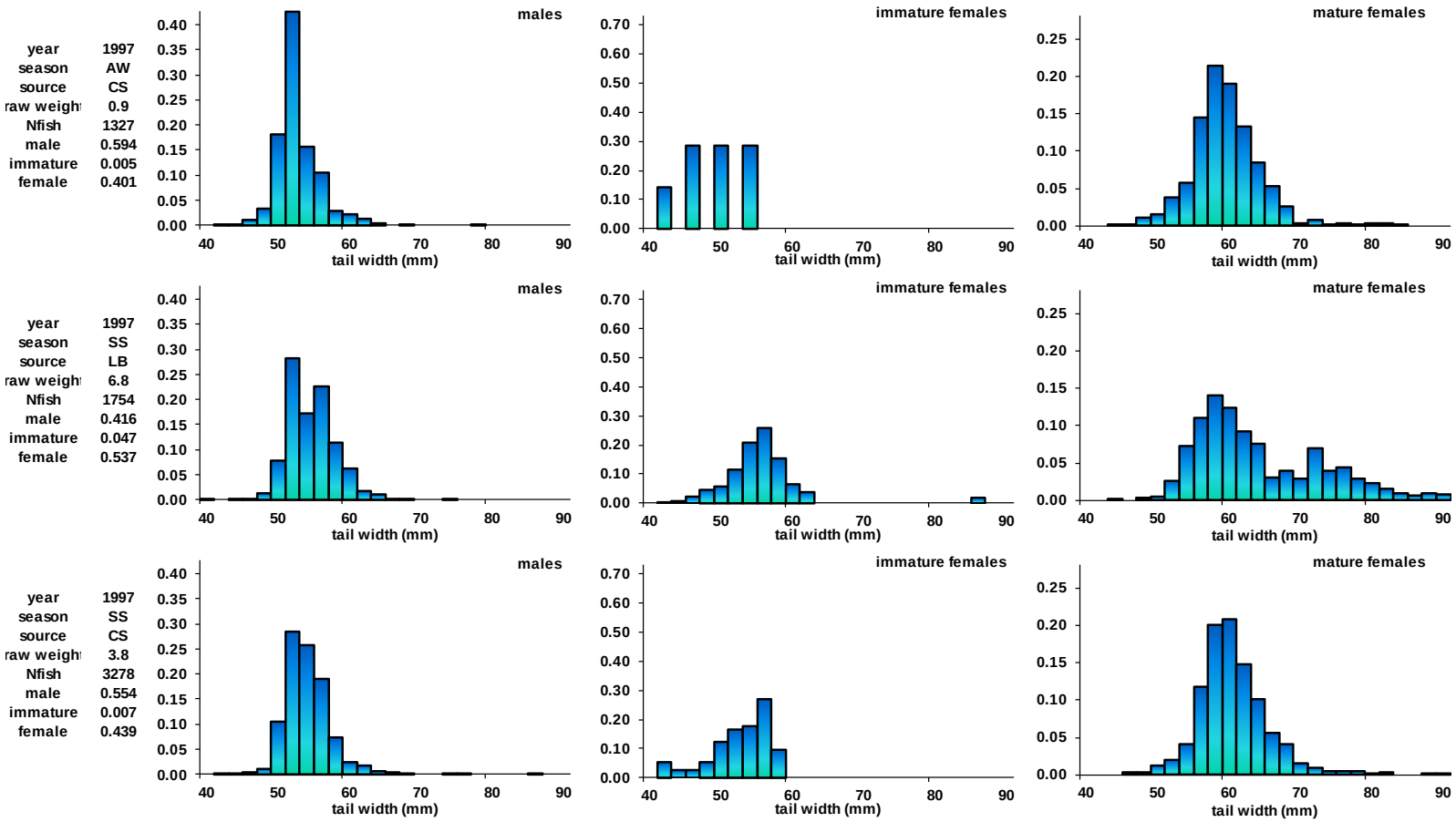


Figure 34 continued.

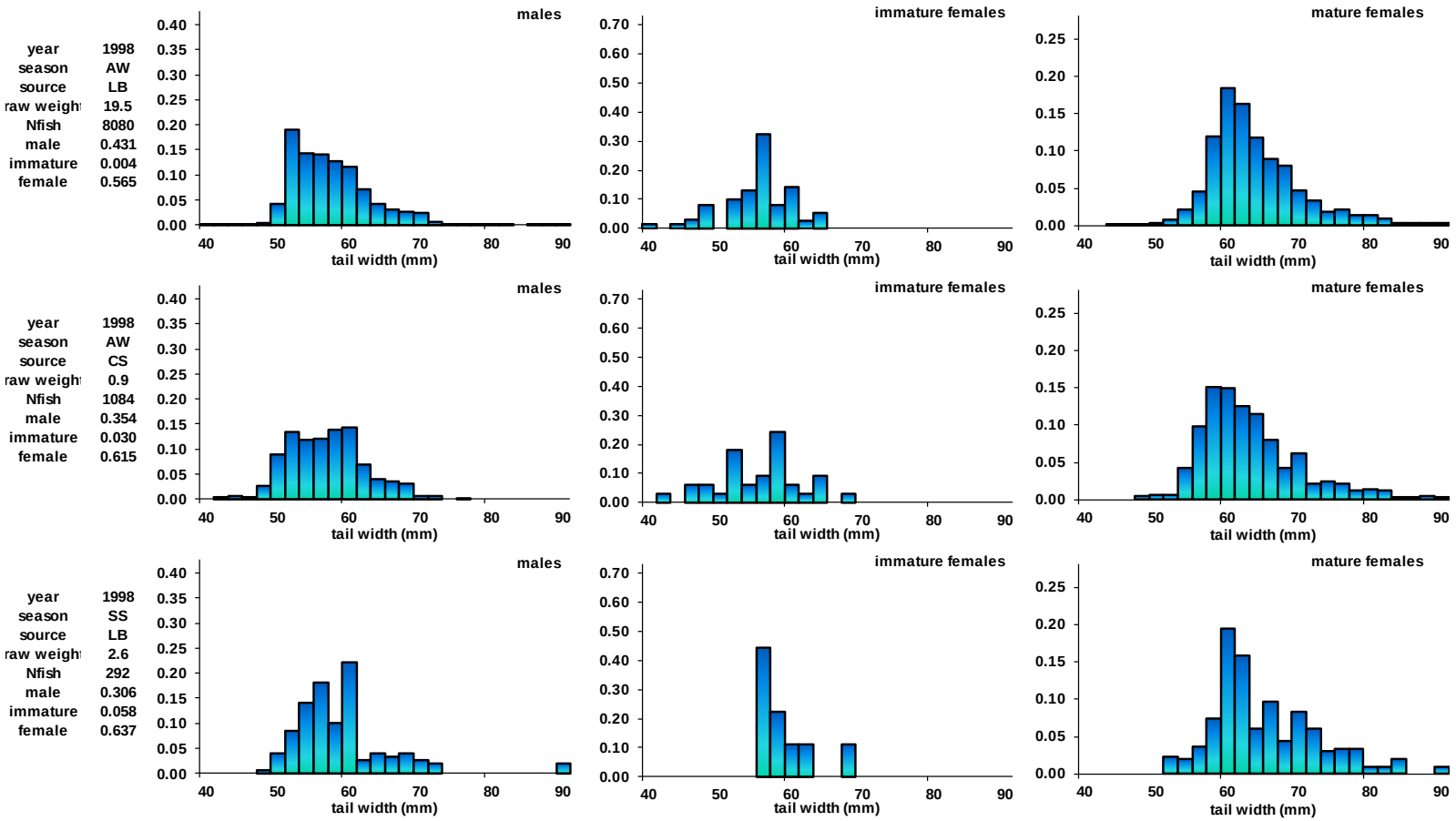


Figure 34 continued.

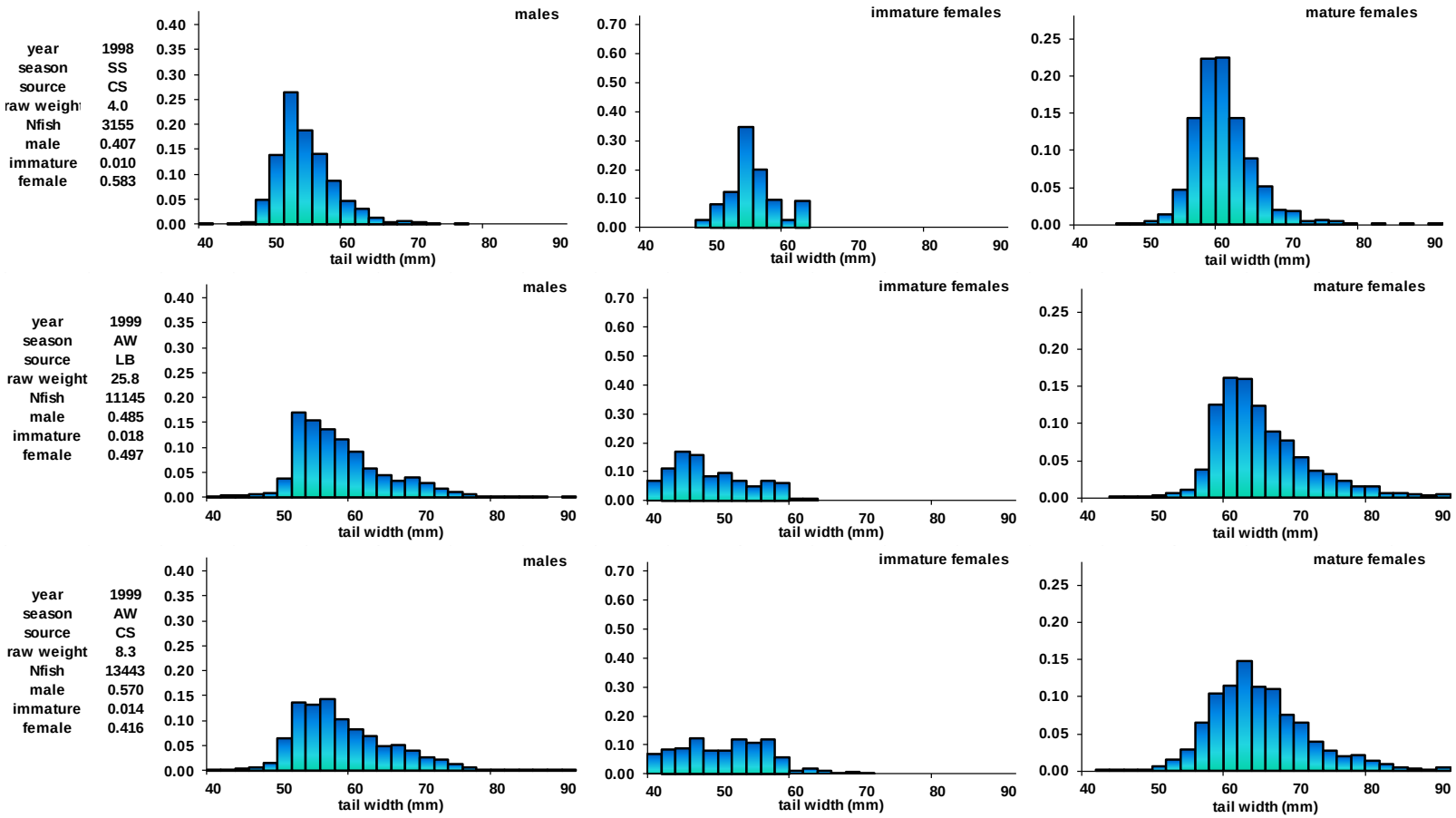


Figure 34 continued.

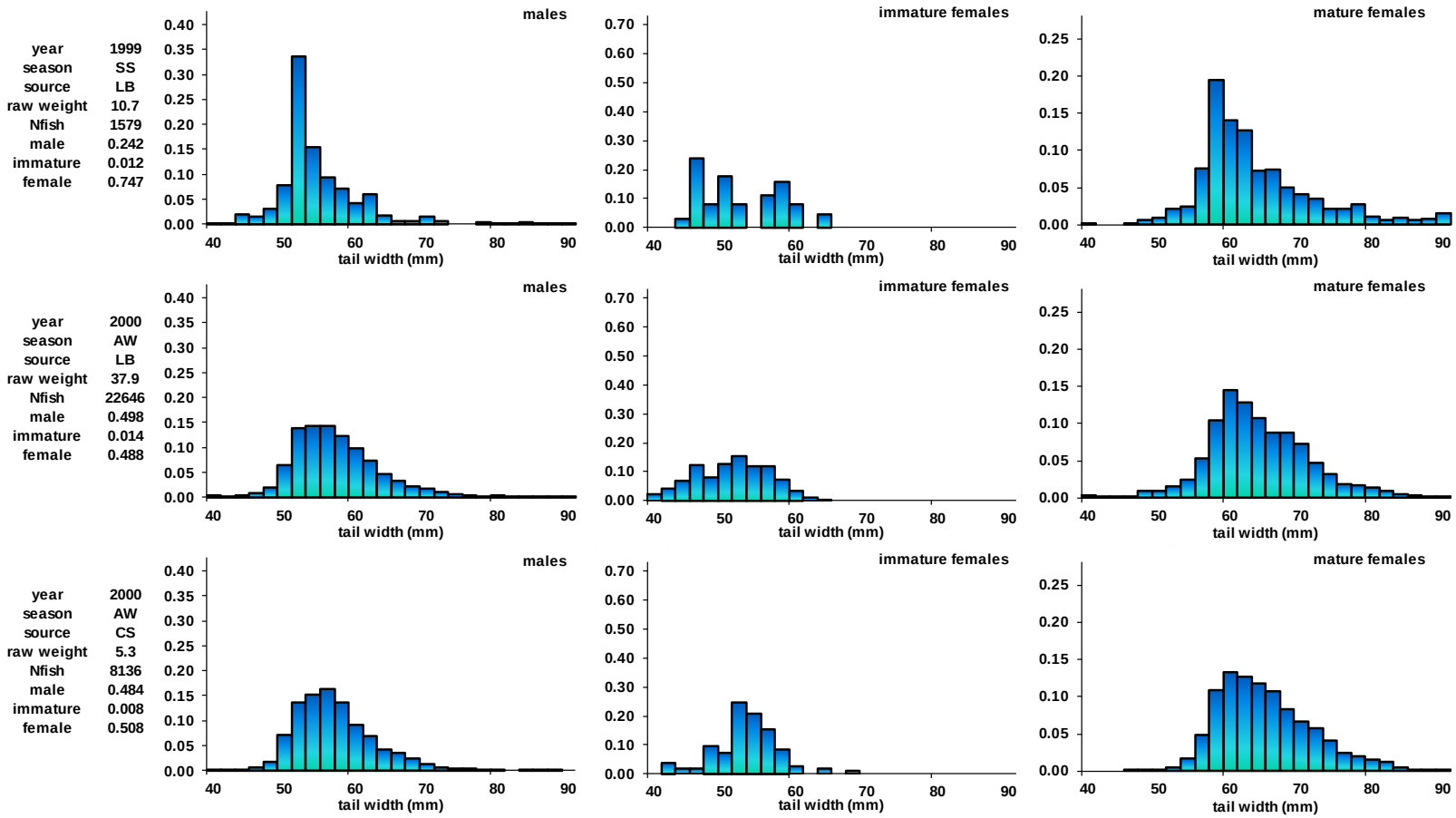


Figure 34 continued.

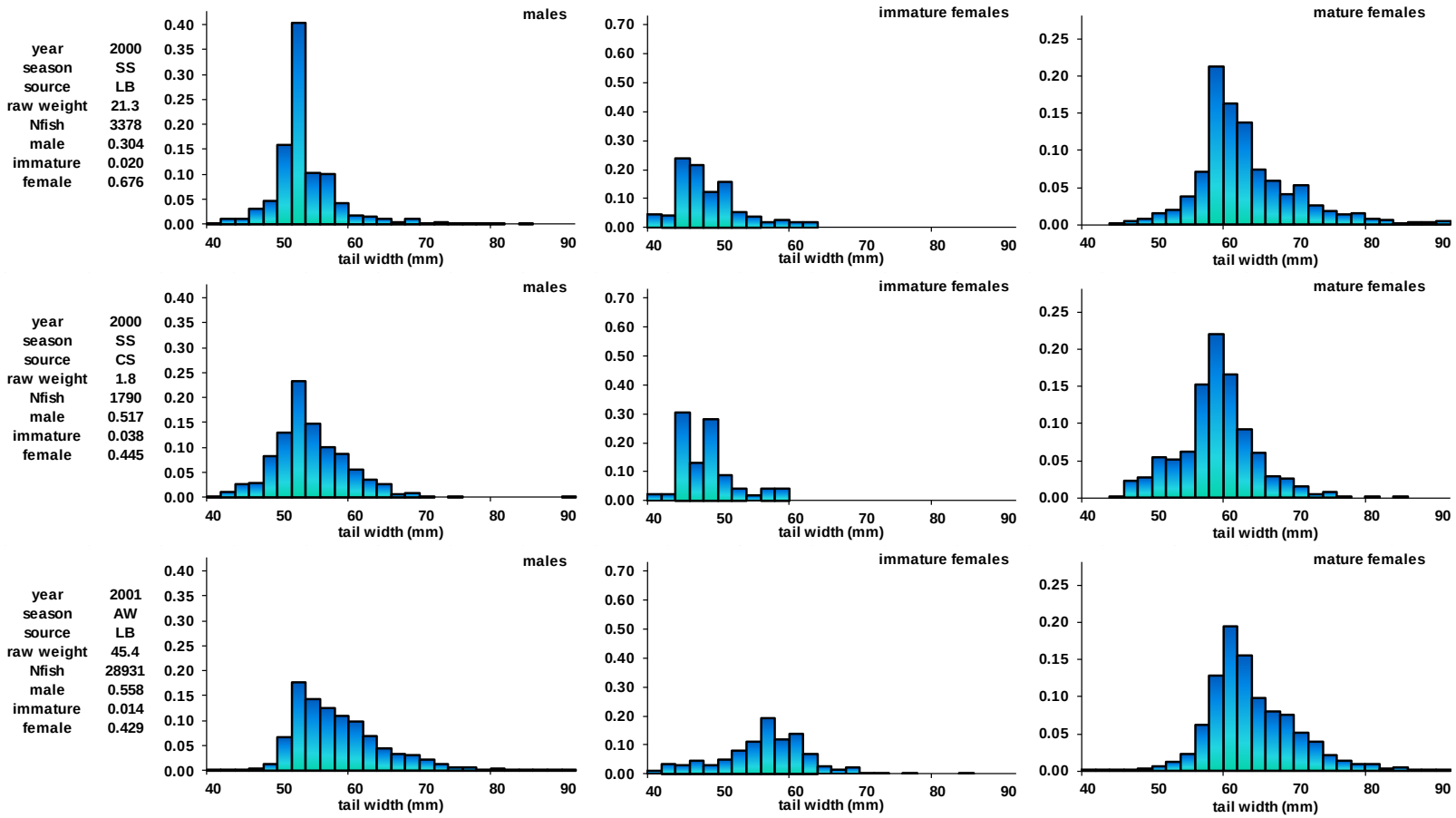


Figure 34 continued.

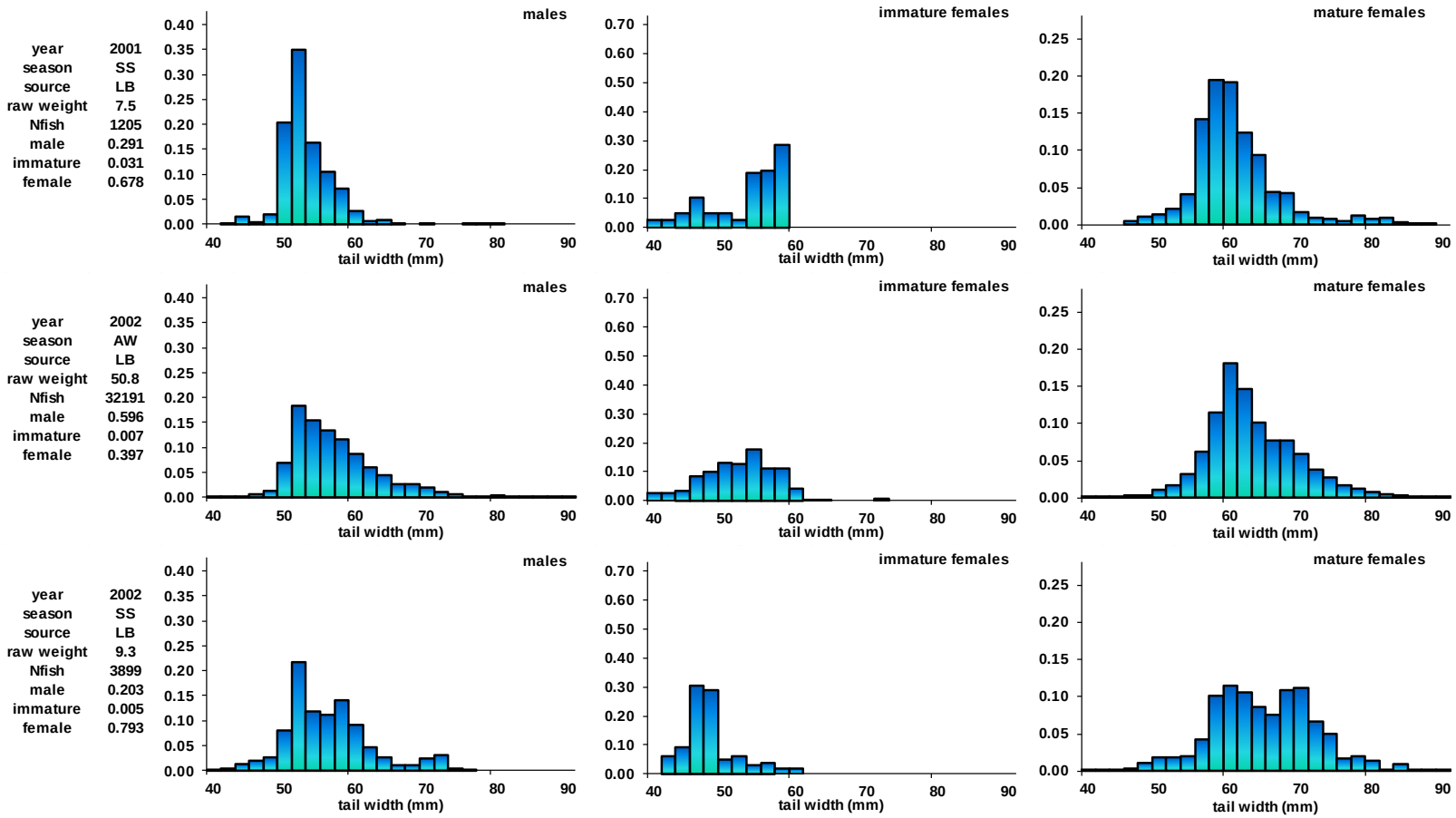


Figure 34 continued.

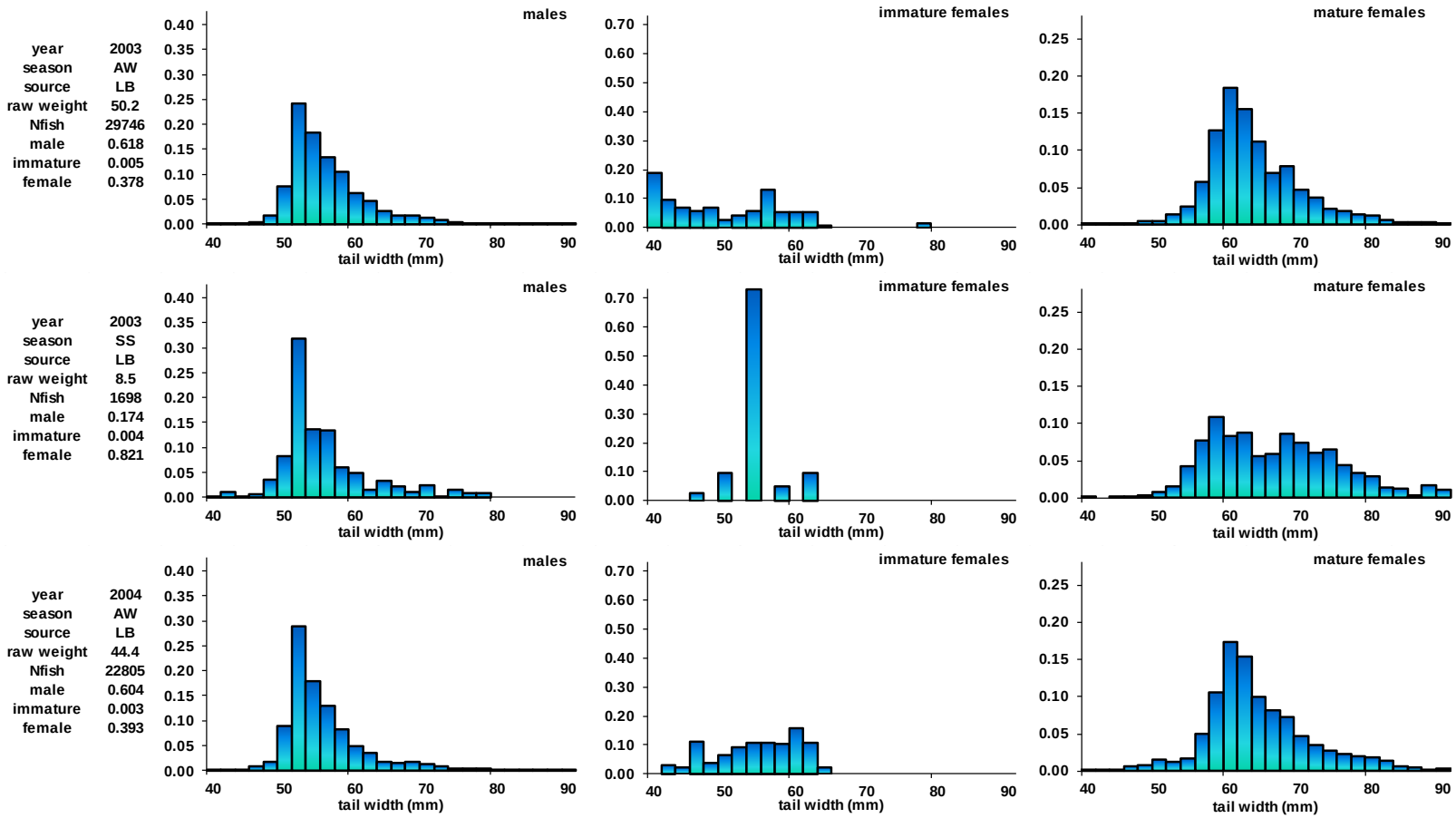


Figure 34 continued.

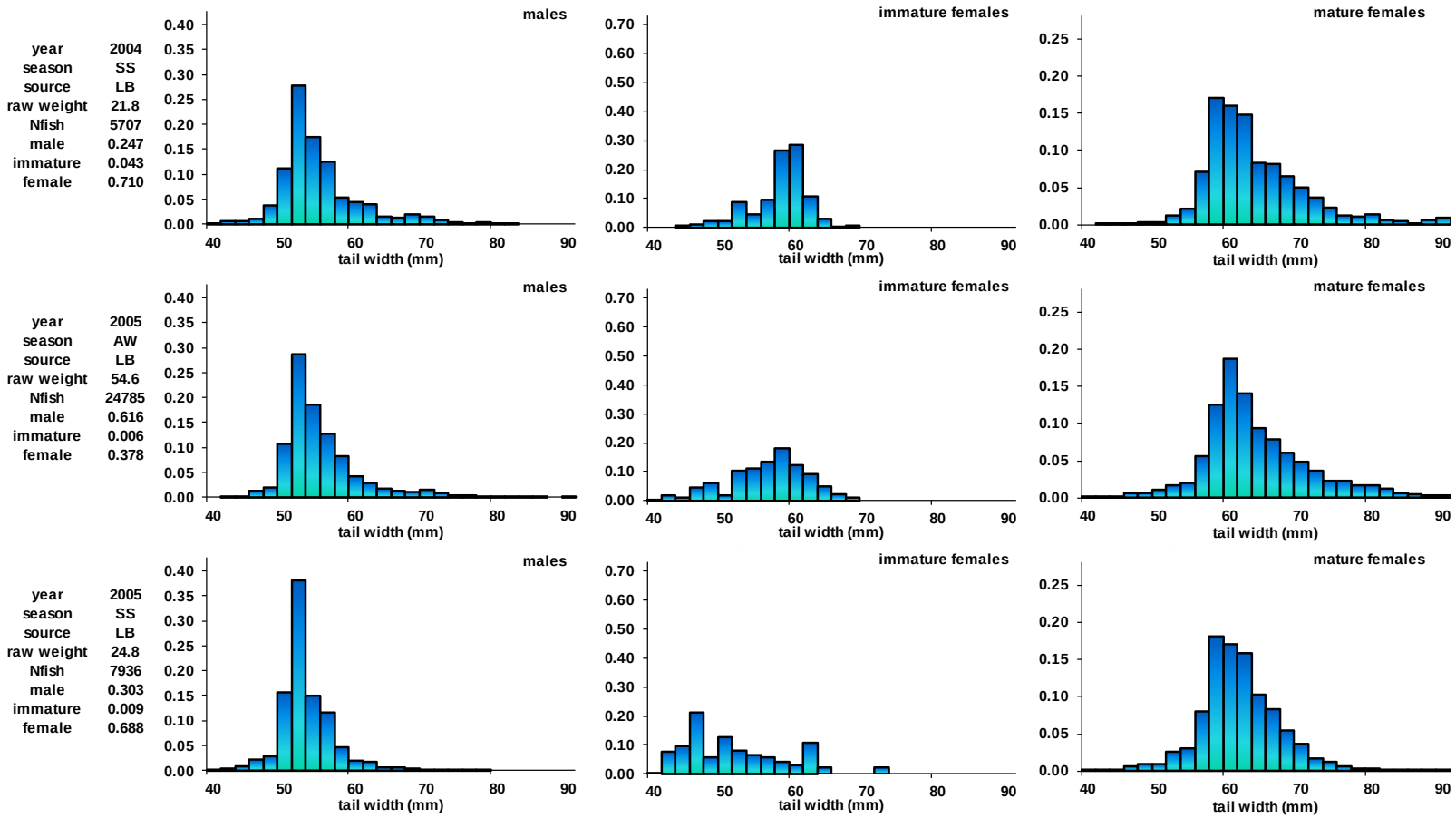
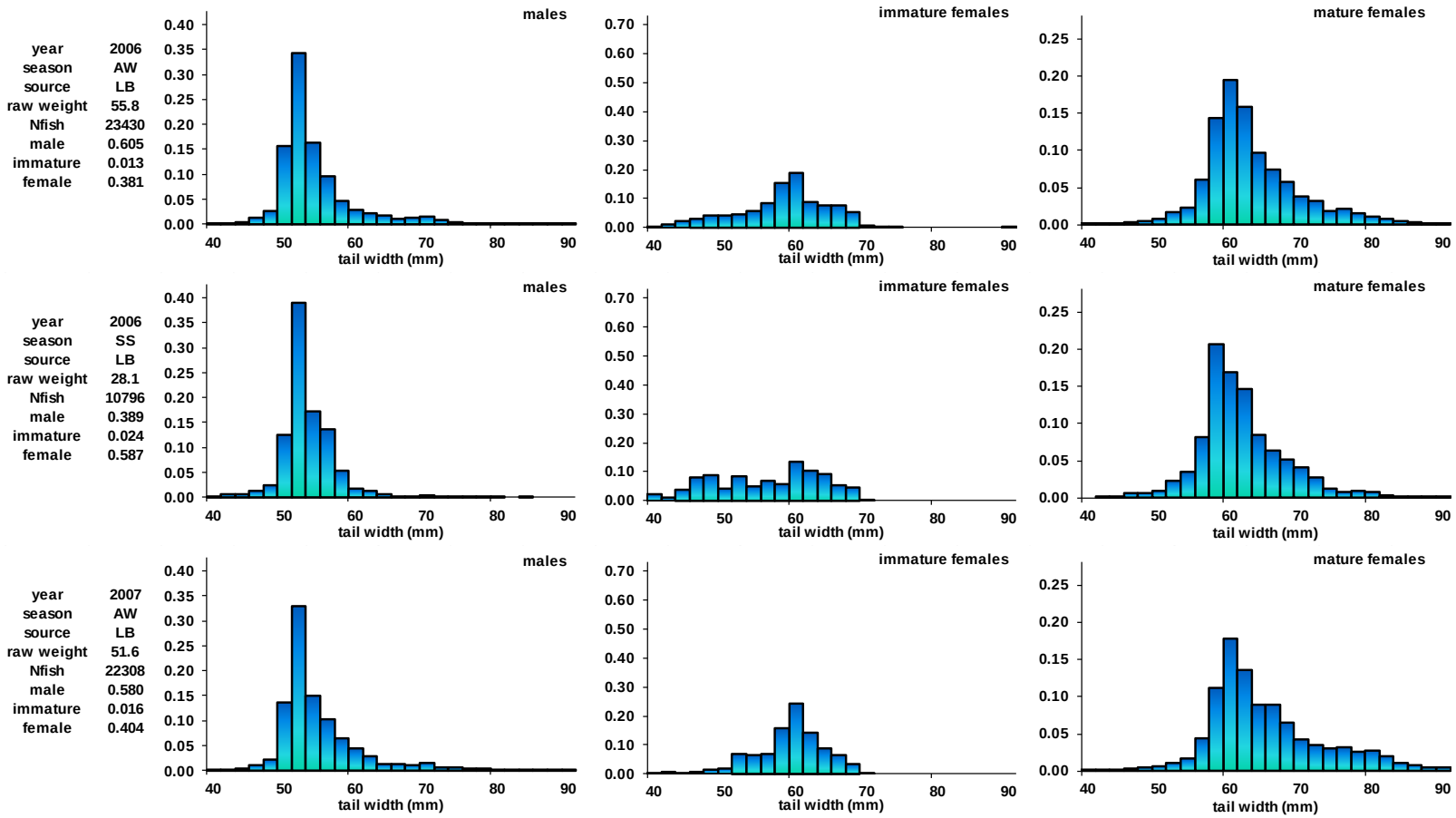


Figure 34 continued.



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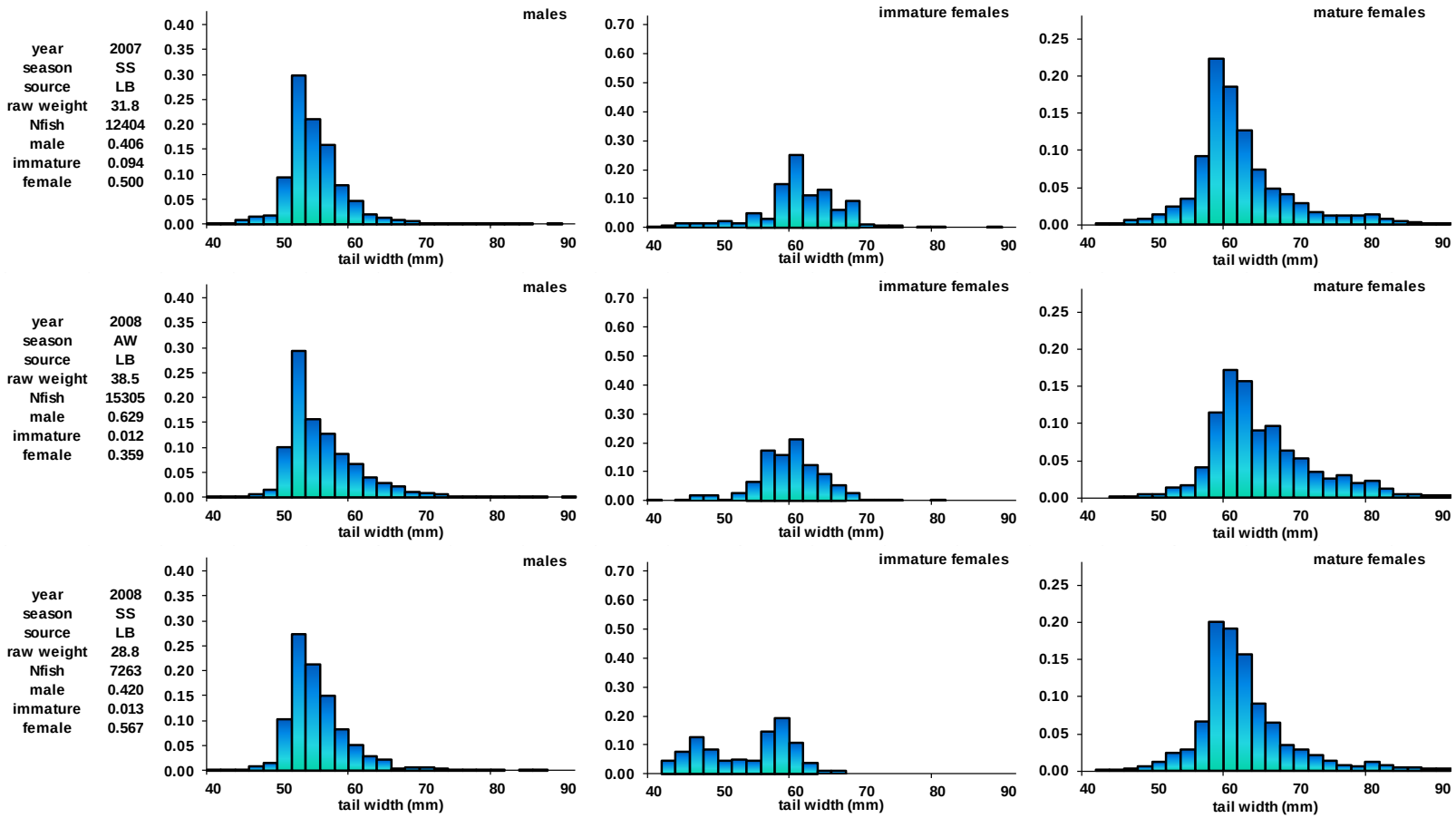

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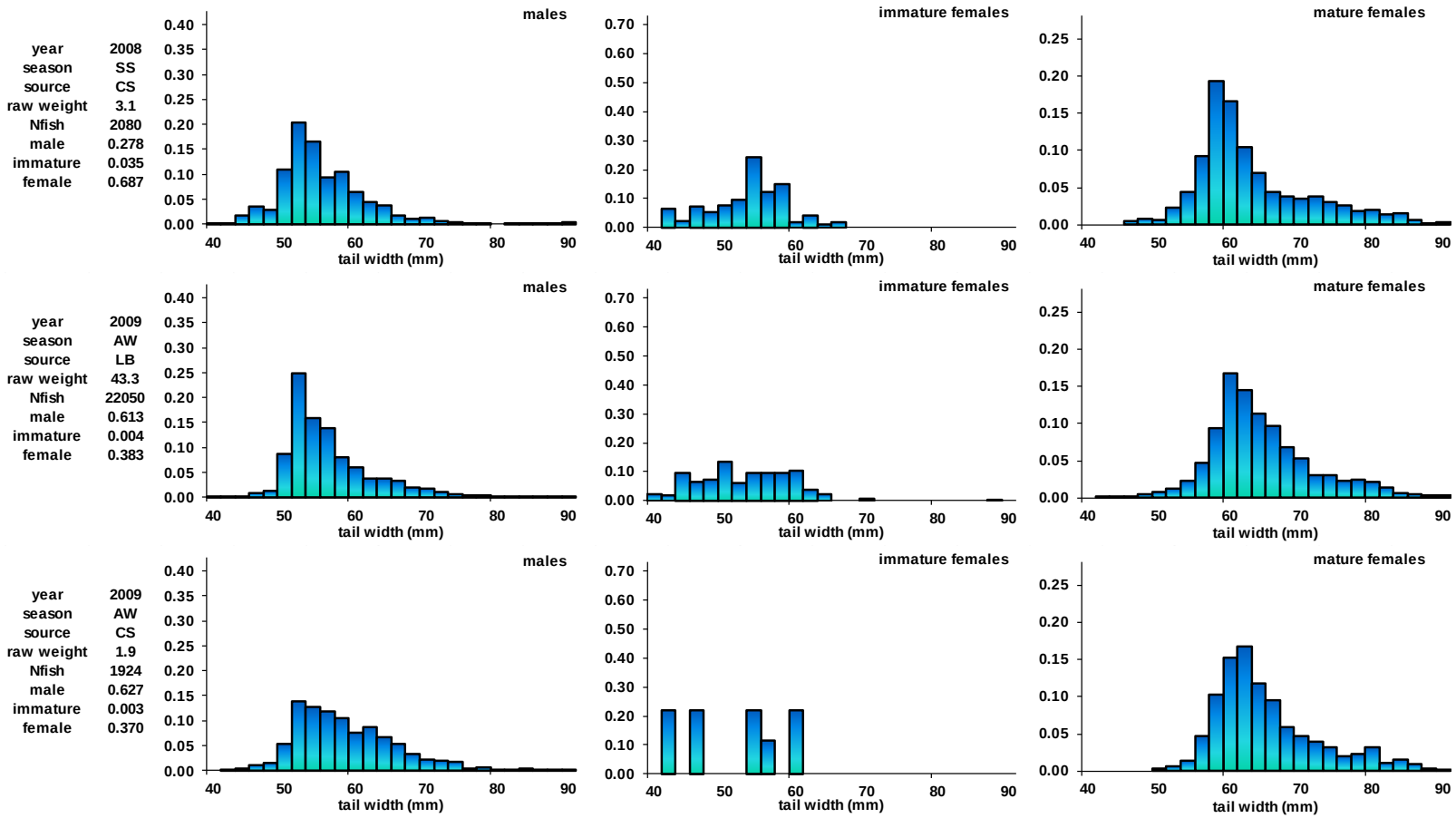

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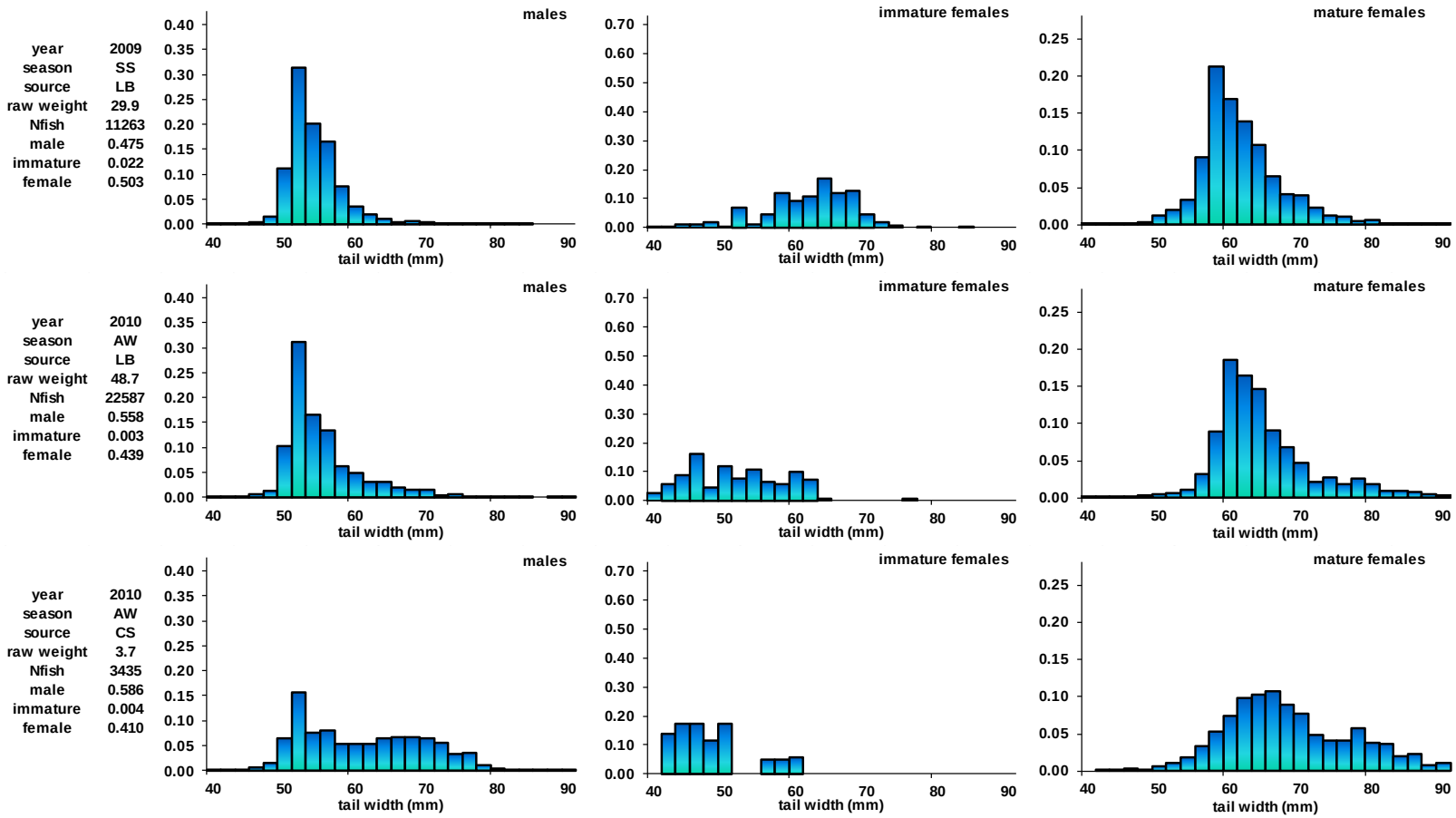

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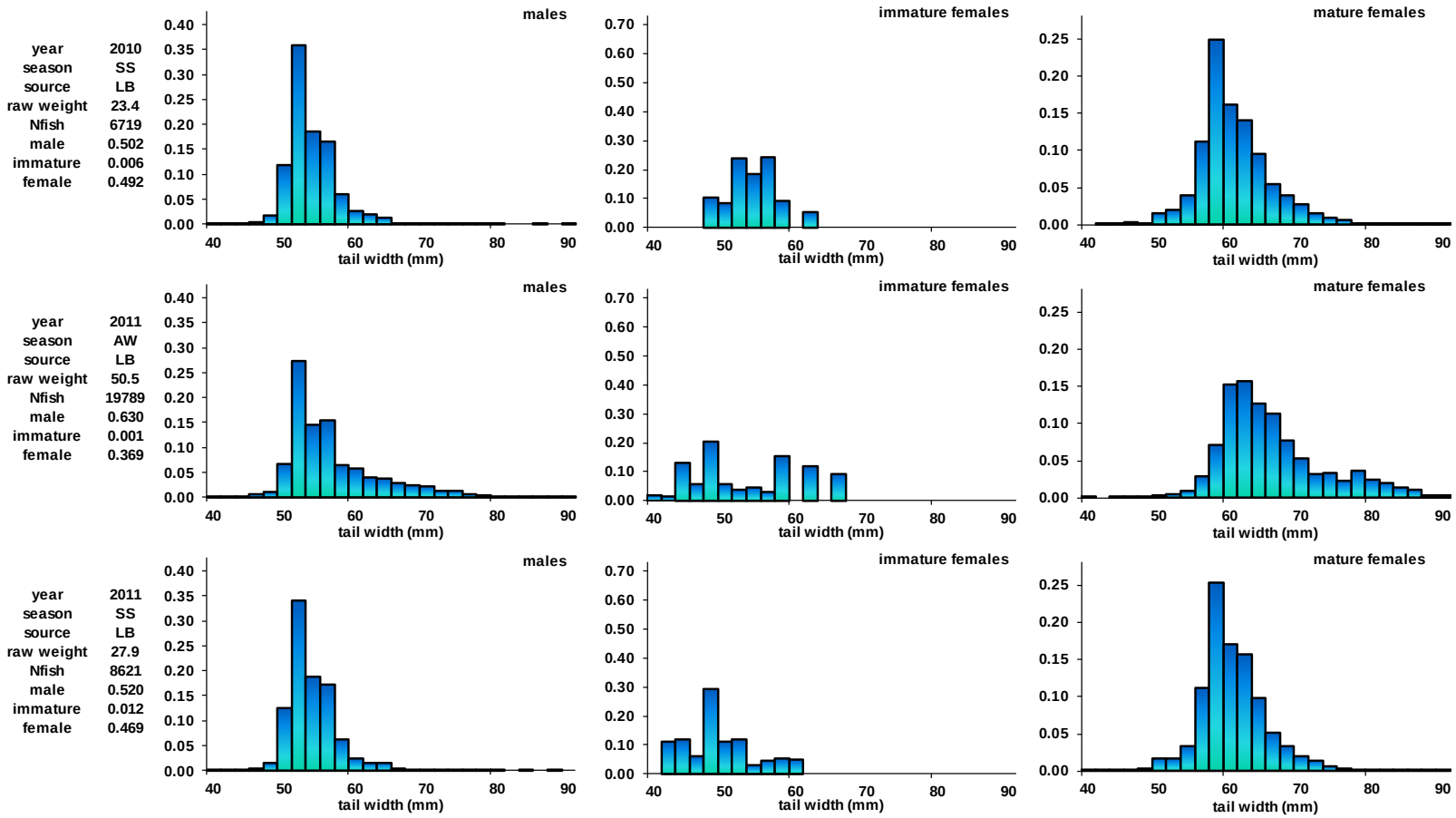

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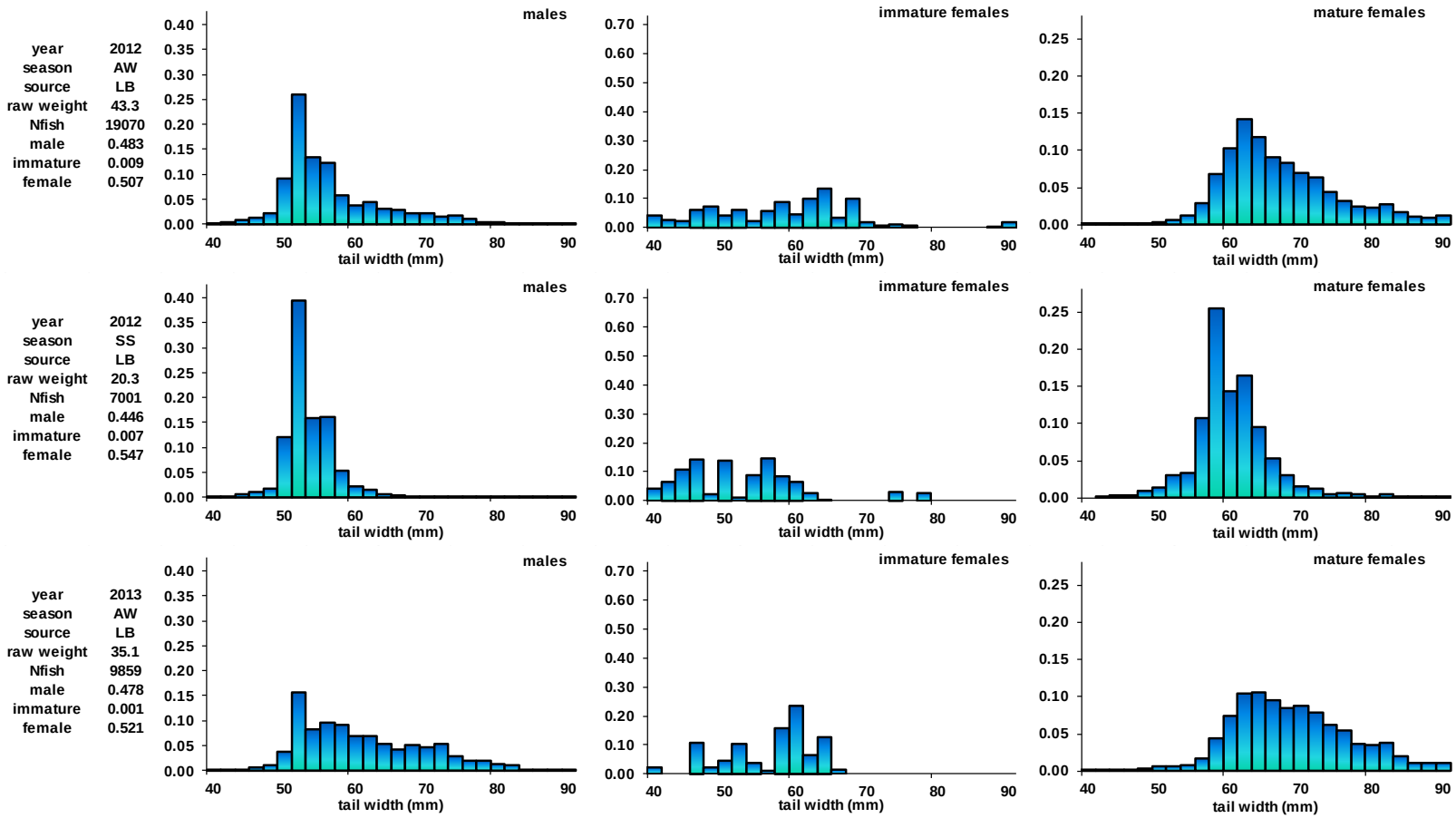

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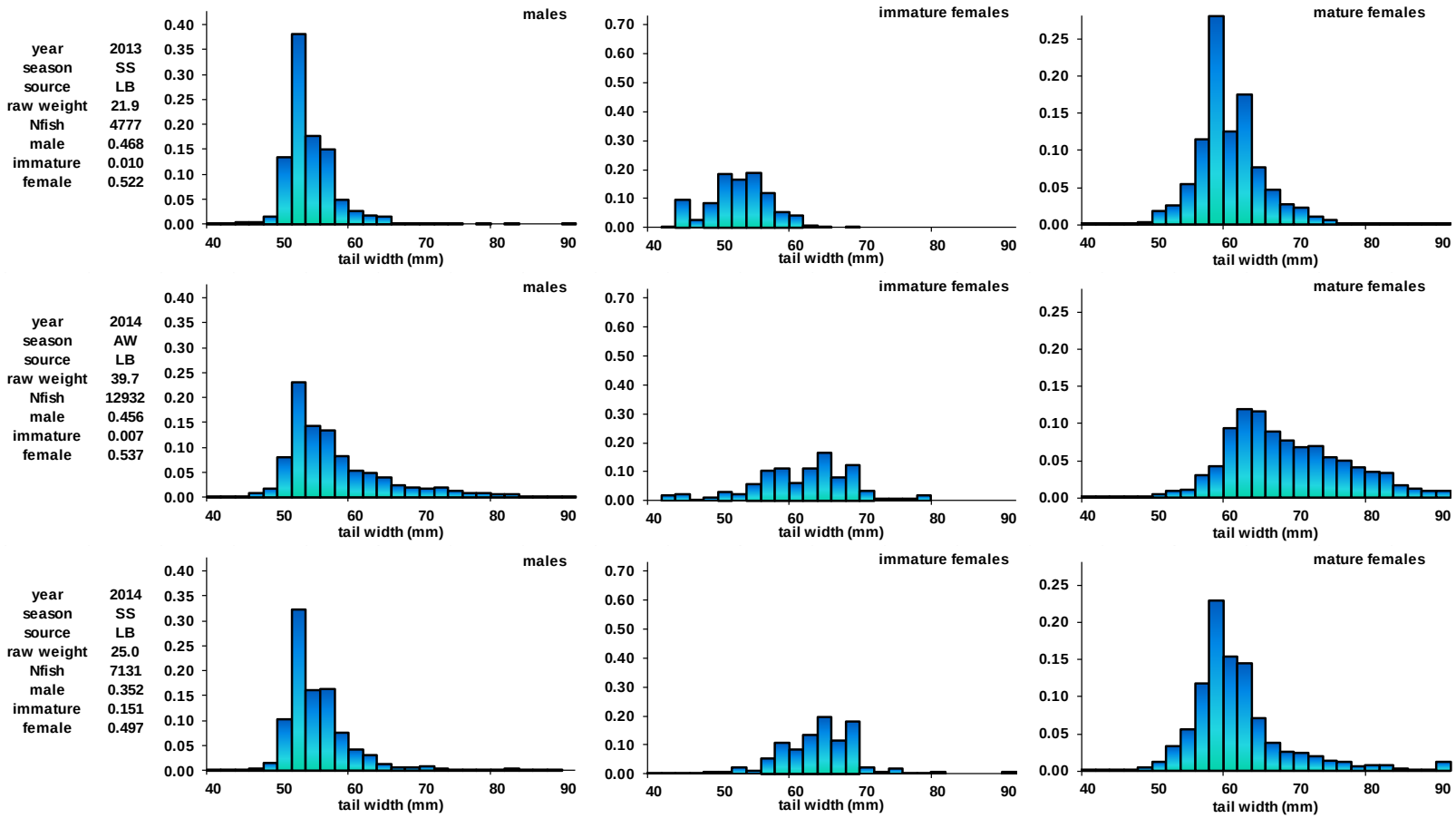

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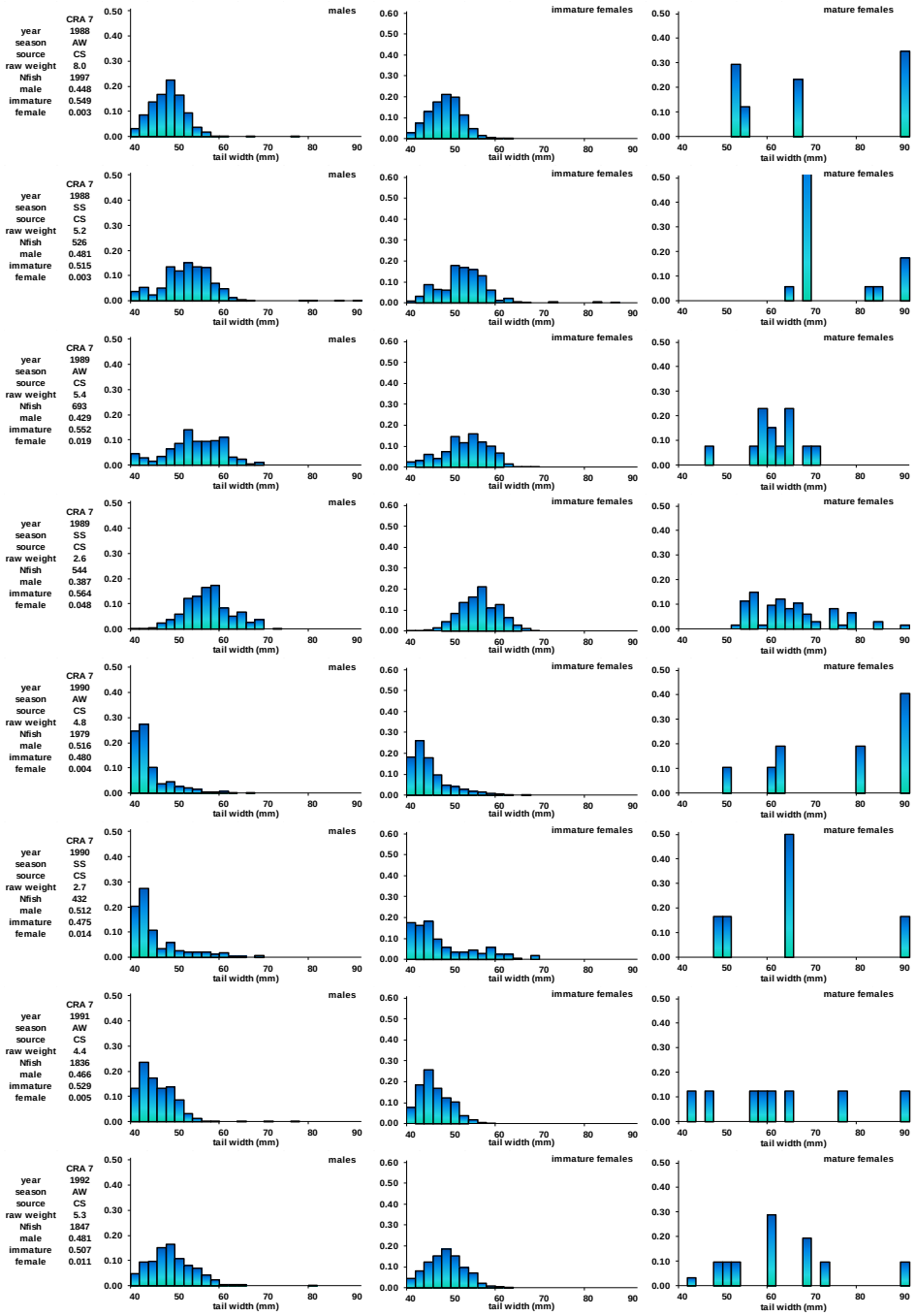
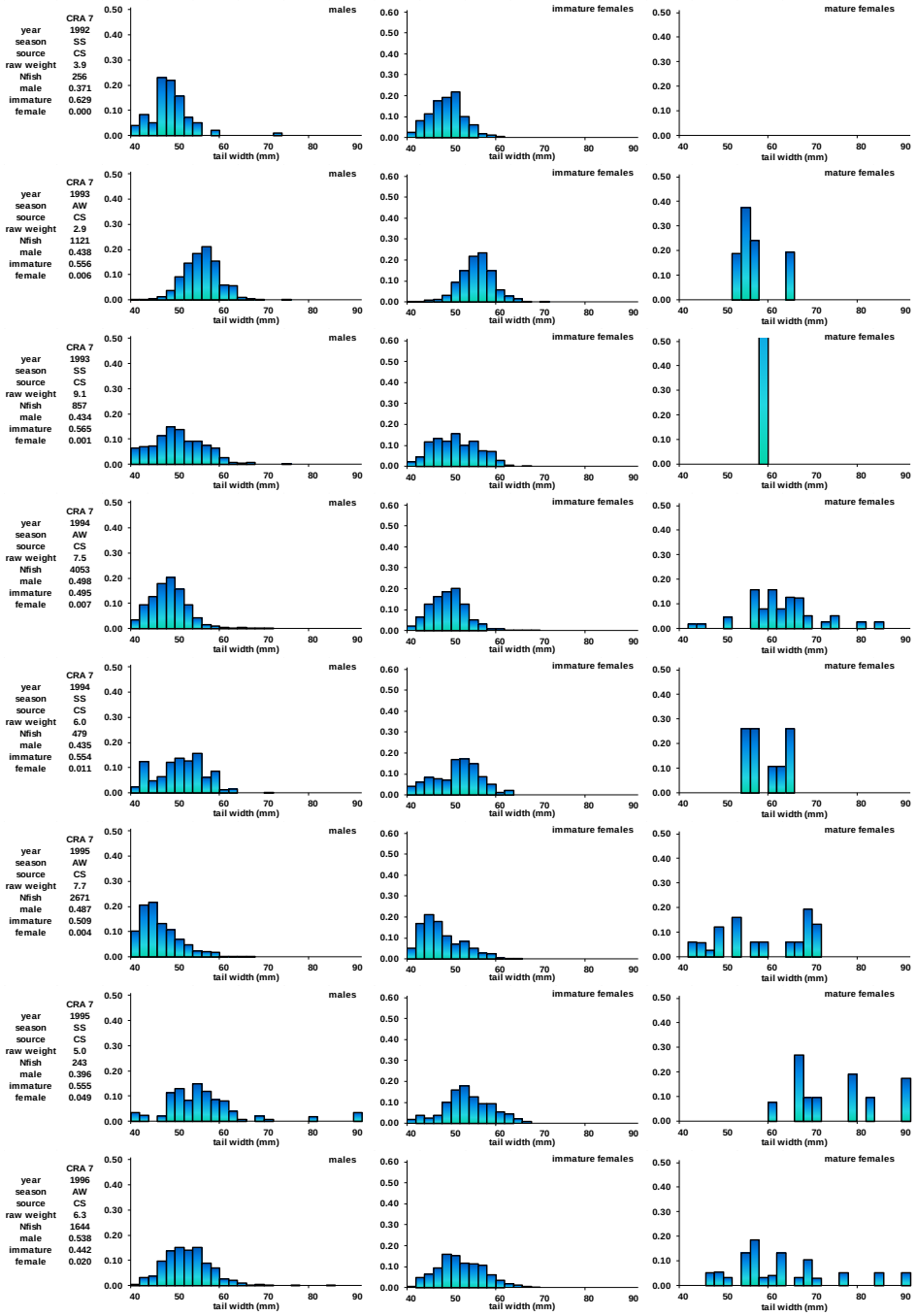


Figure 35: CRA 7: Length frequency records; left: males, centre: immature females; right: mature females; note that scales differ among sex classes but not between records; information on left is year, season, source (CS indicates observer catch sampling), record weight, number of fish measured and proportion by sex class.



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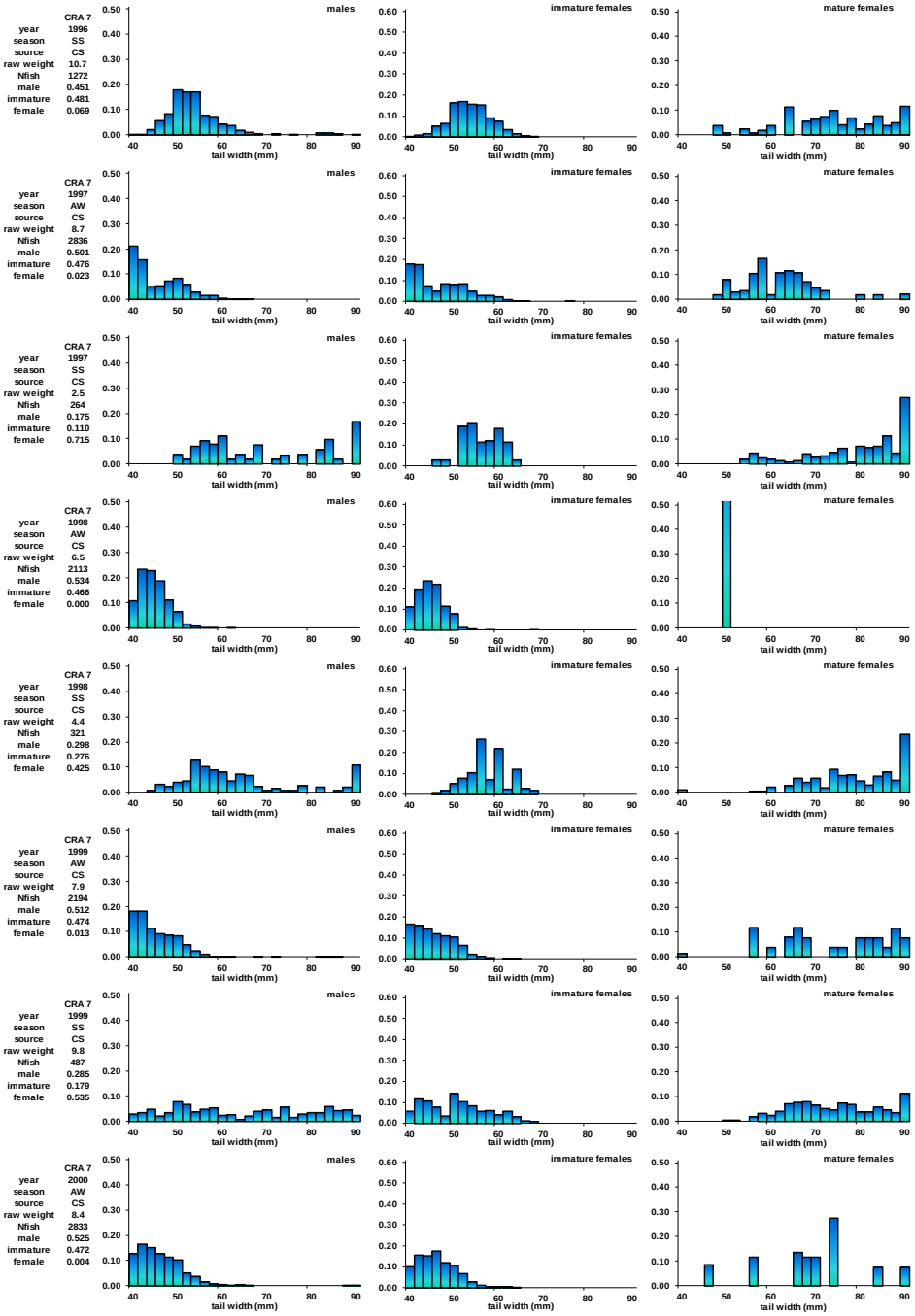

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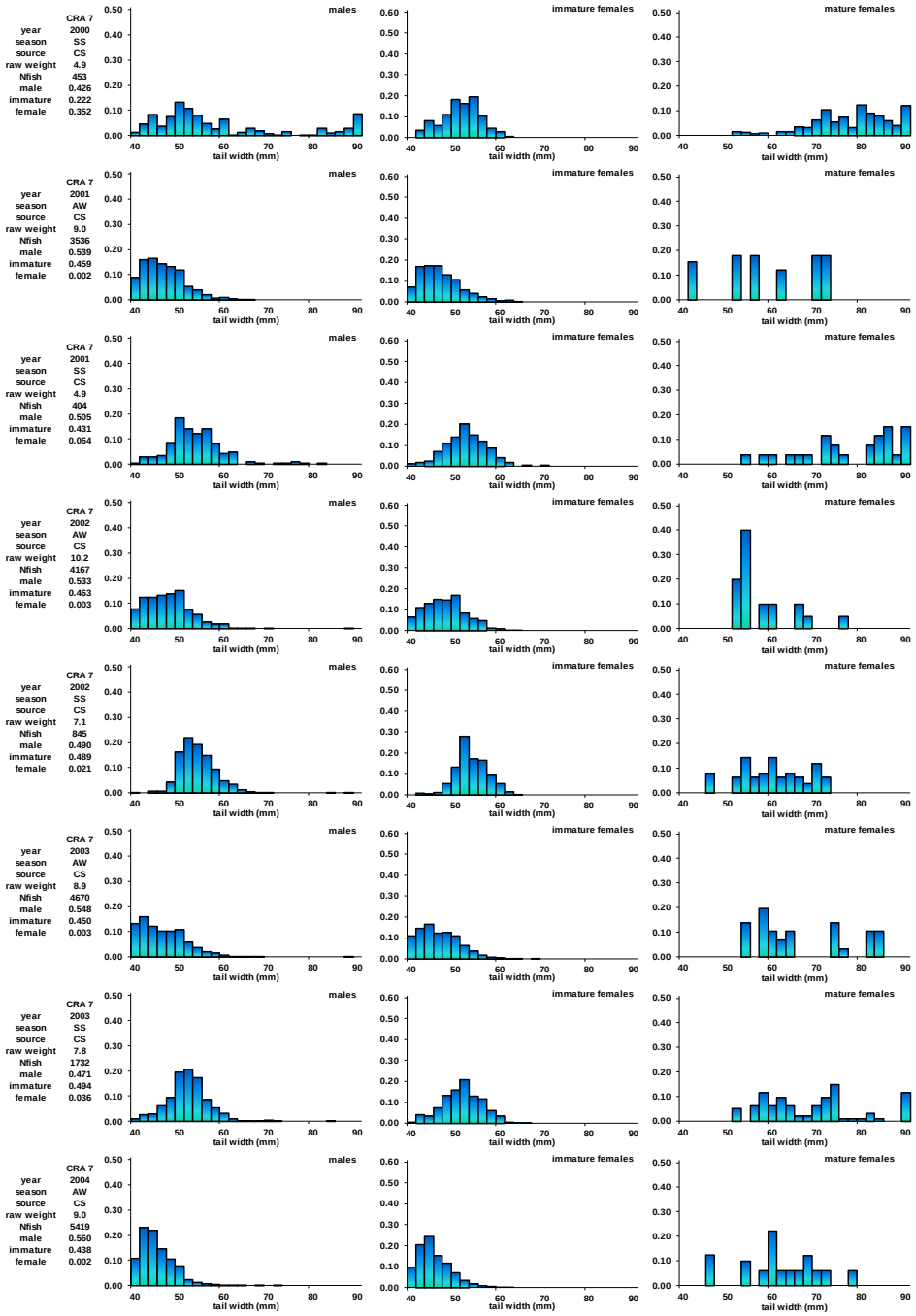

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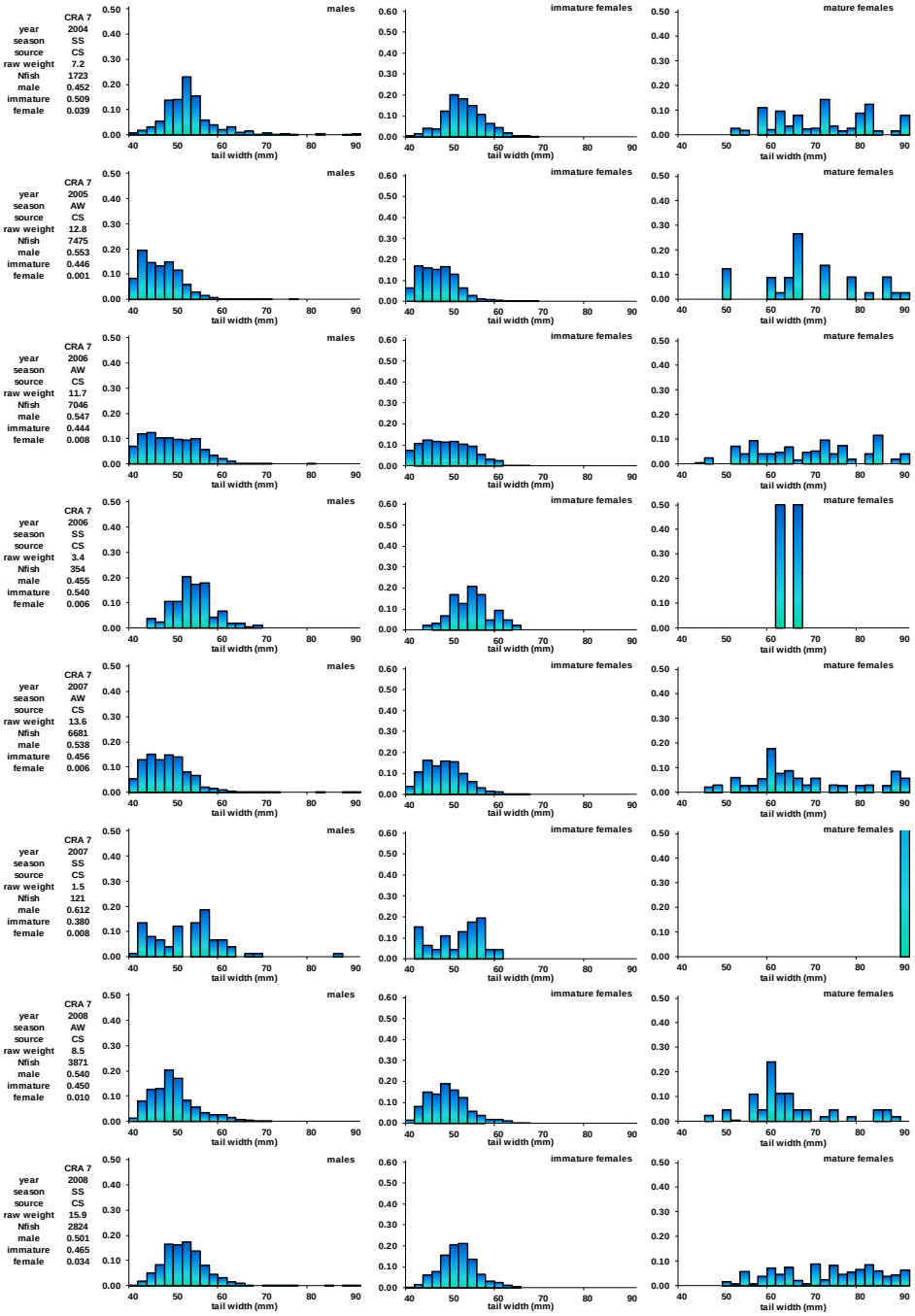

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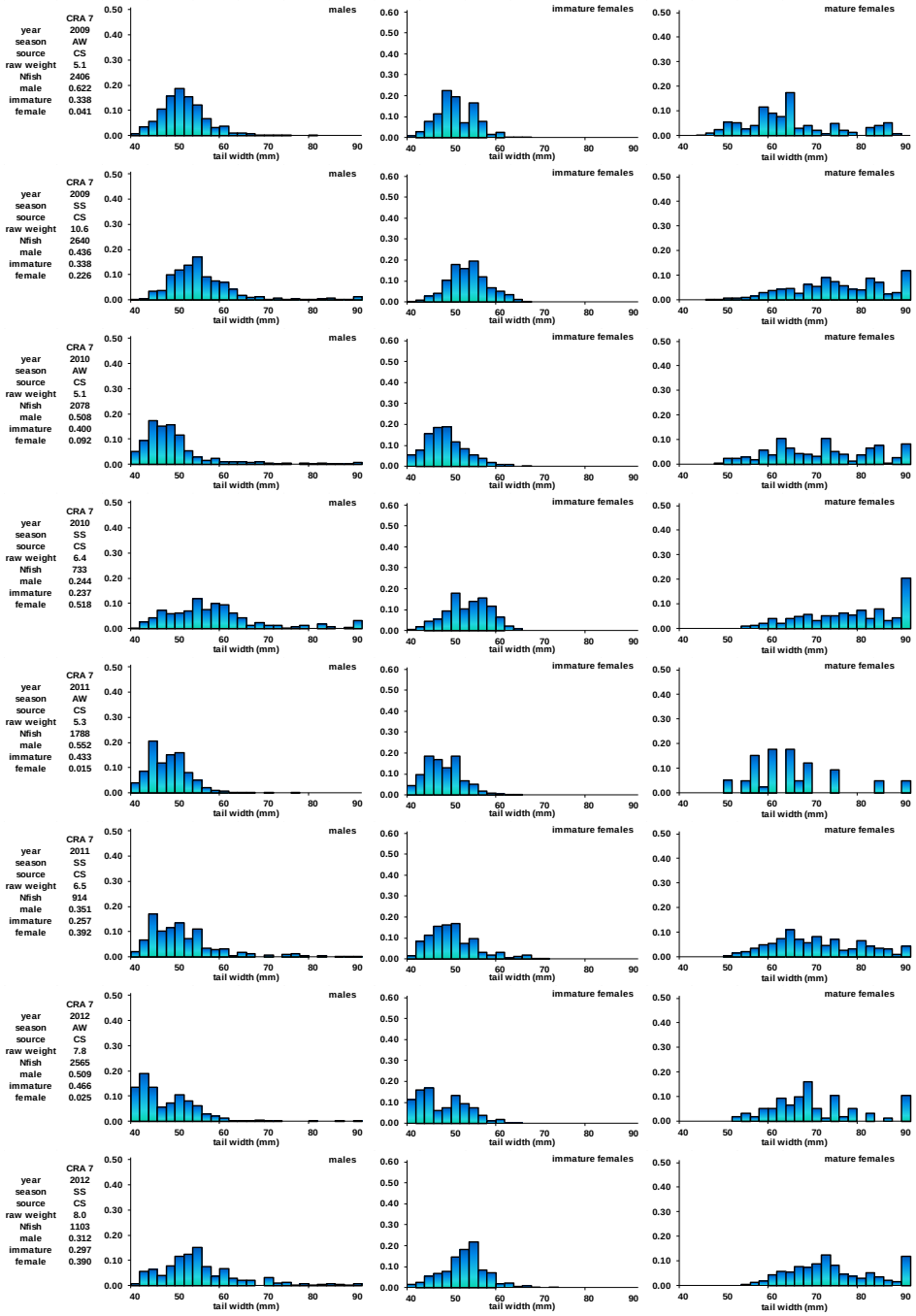

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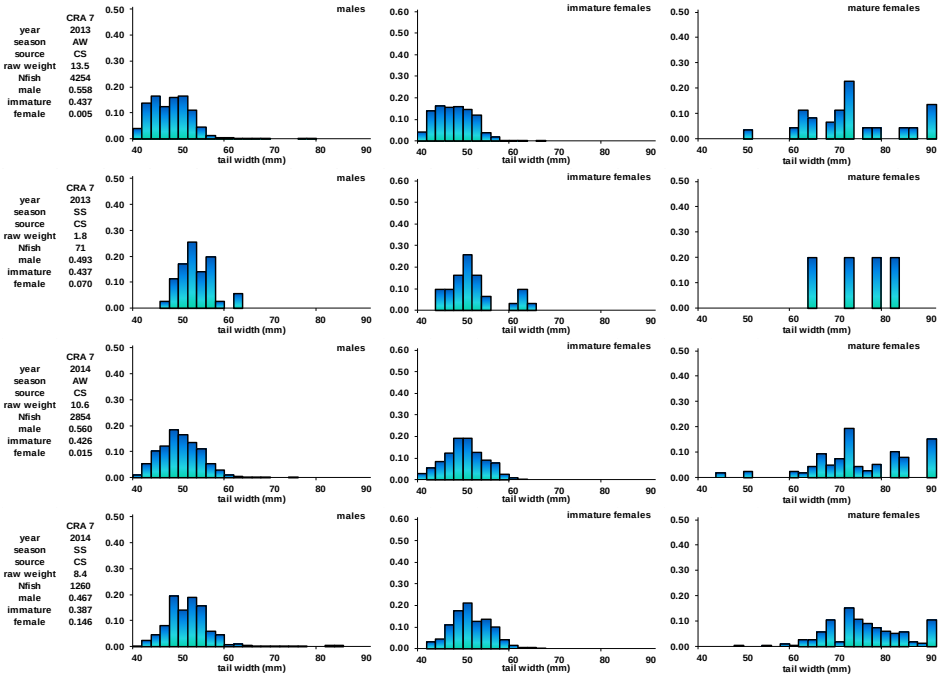

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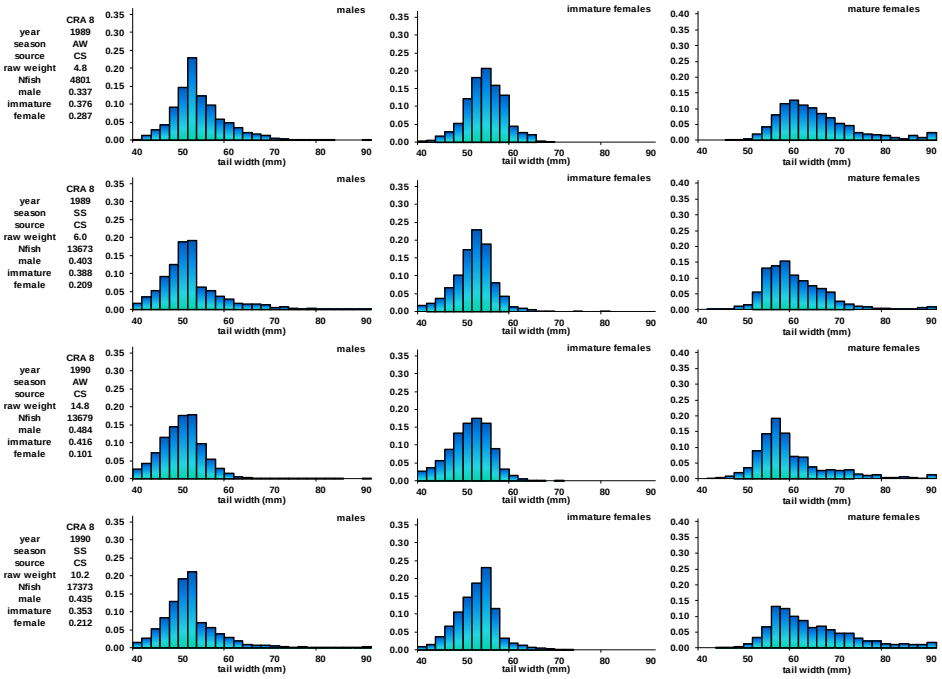
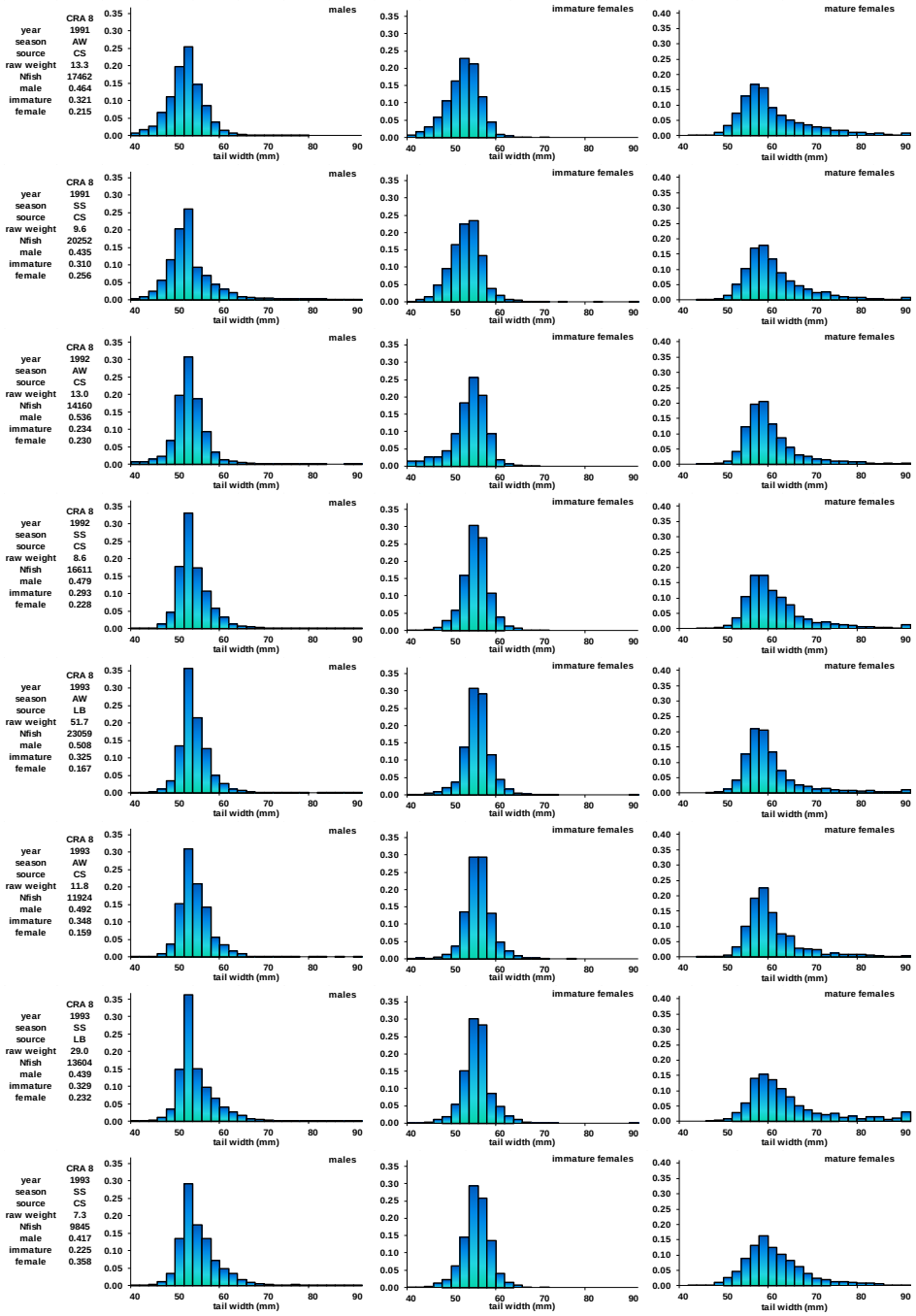


Figure 36: CRA 8: Length frequency records; left: males, centre: immature females; right: mature females; note that scales differ among sex classes but not between records; information on left is year, season, source (CS indicates observer catch sampling), record weight, number of fish measured and proportion by sex class.



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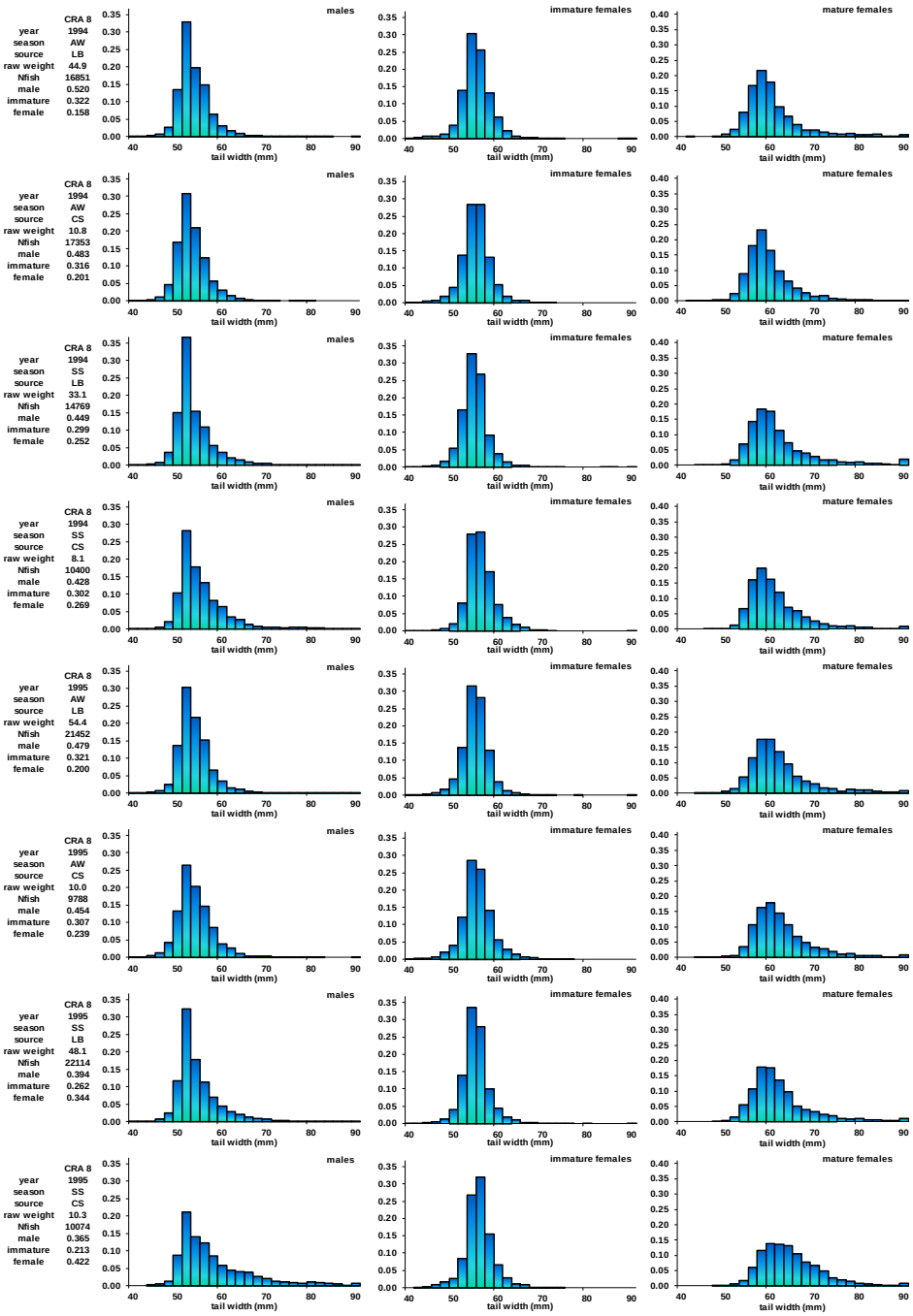

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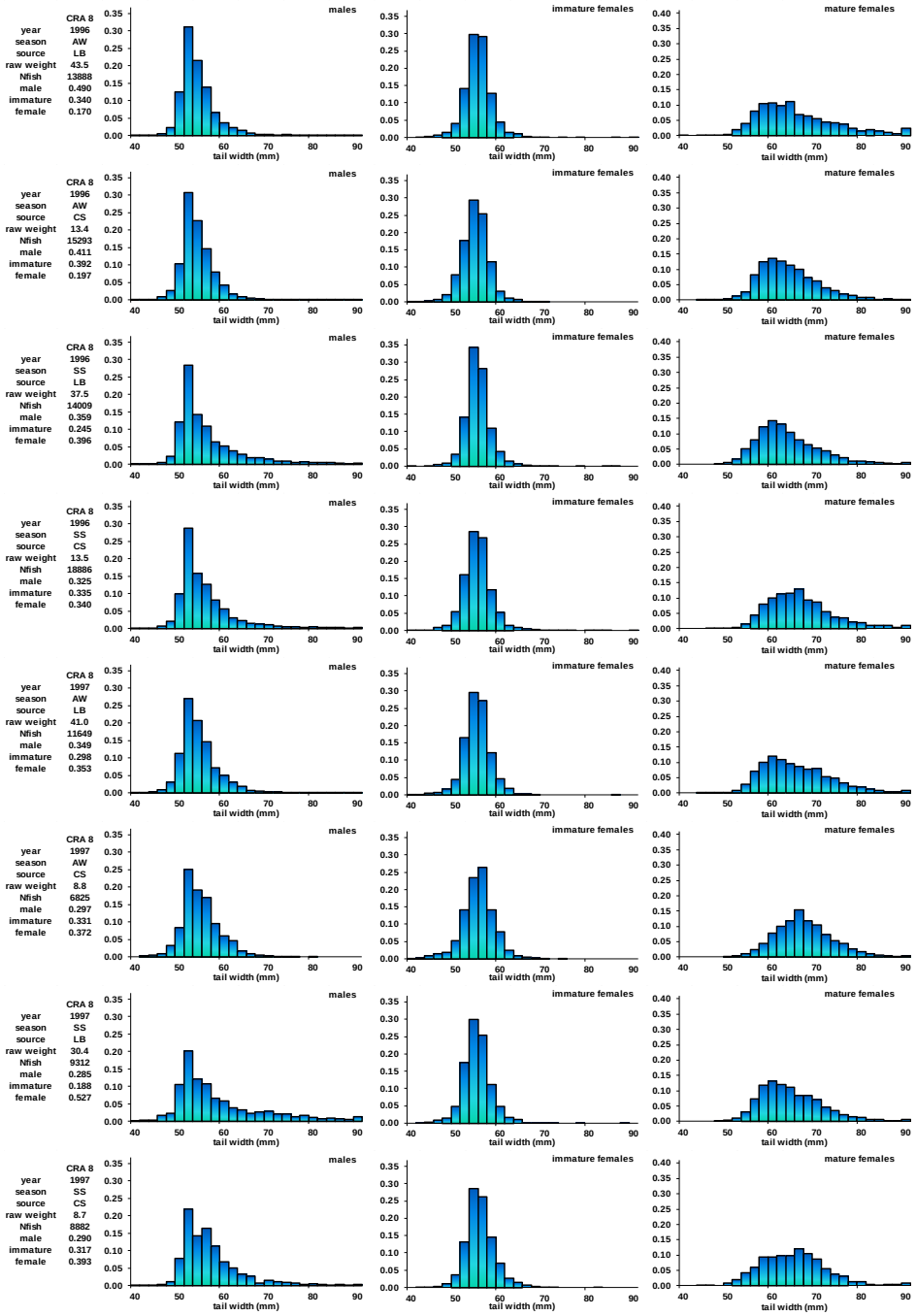

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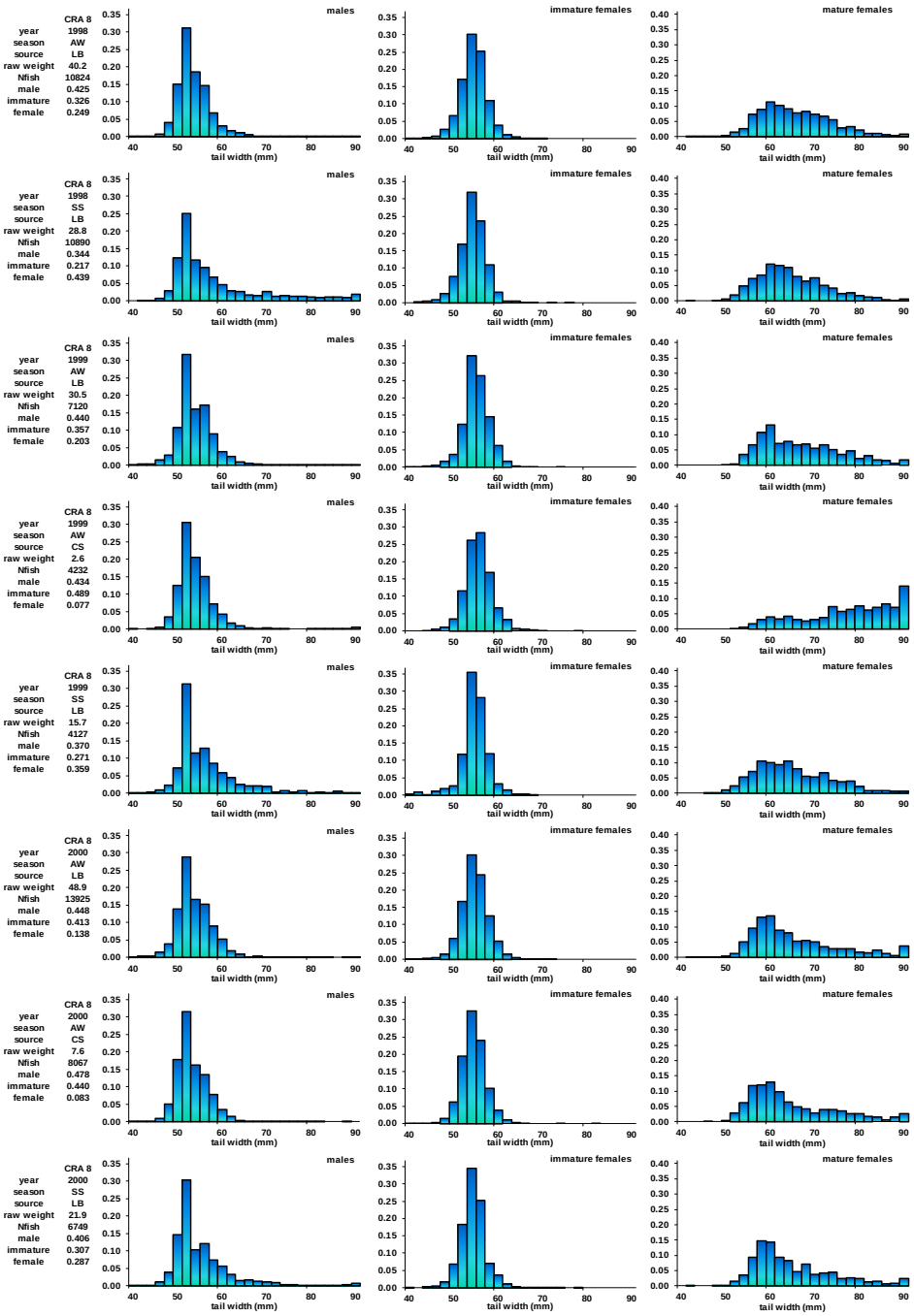

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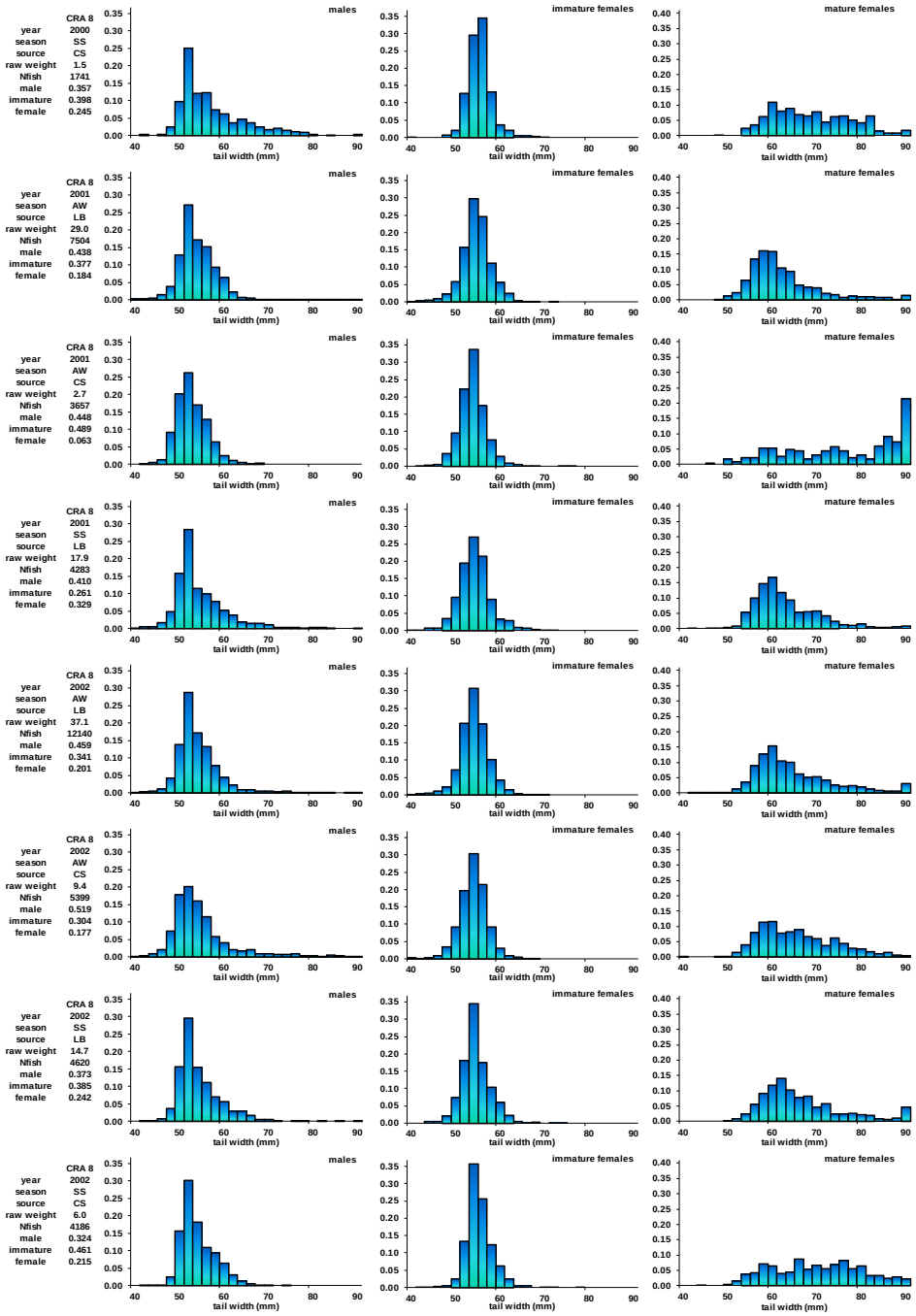

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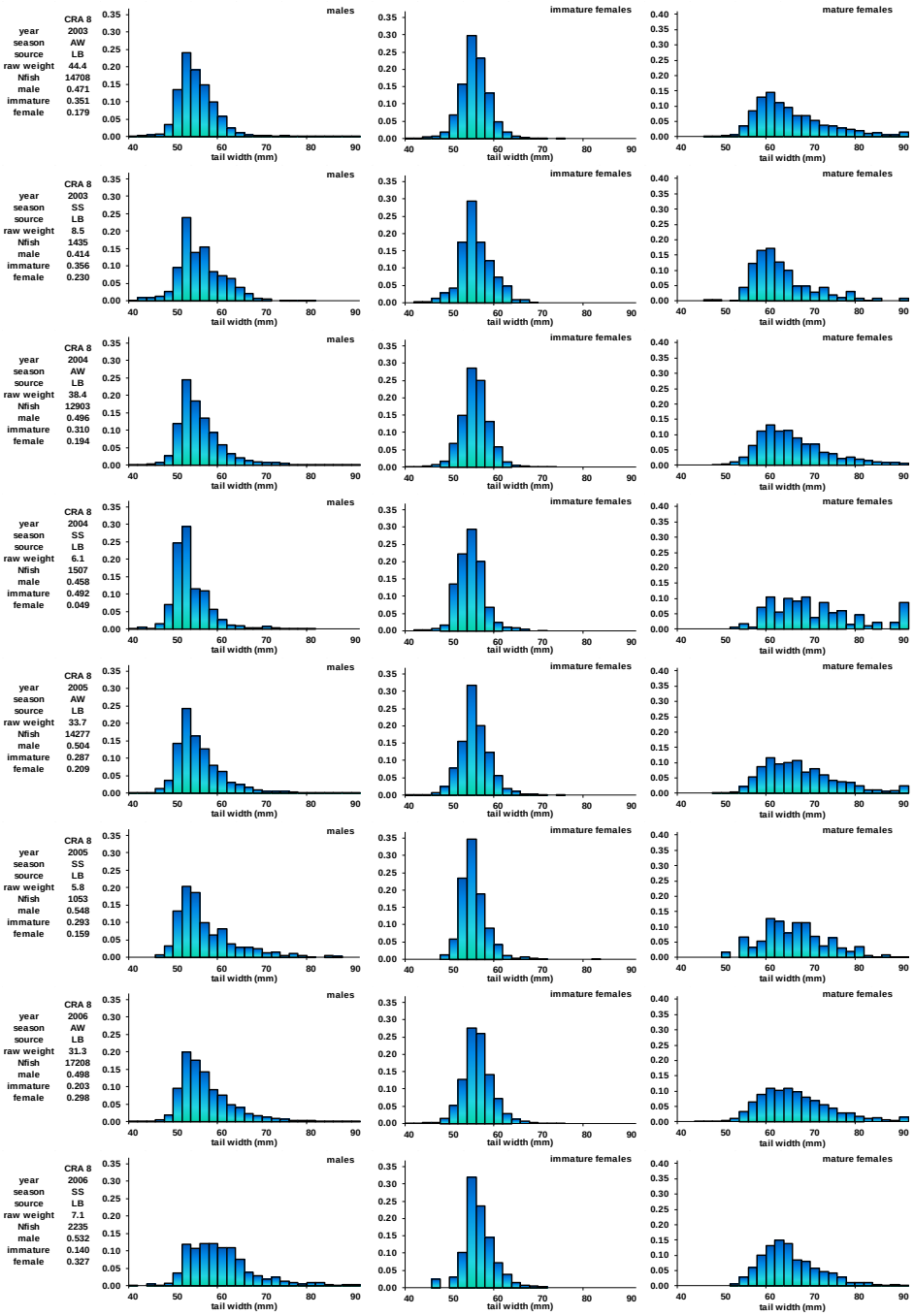

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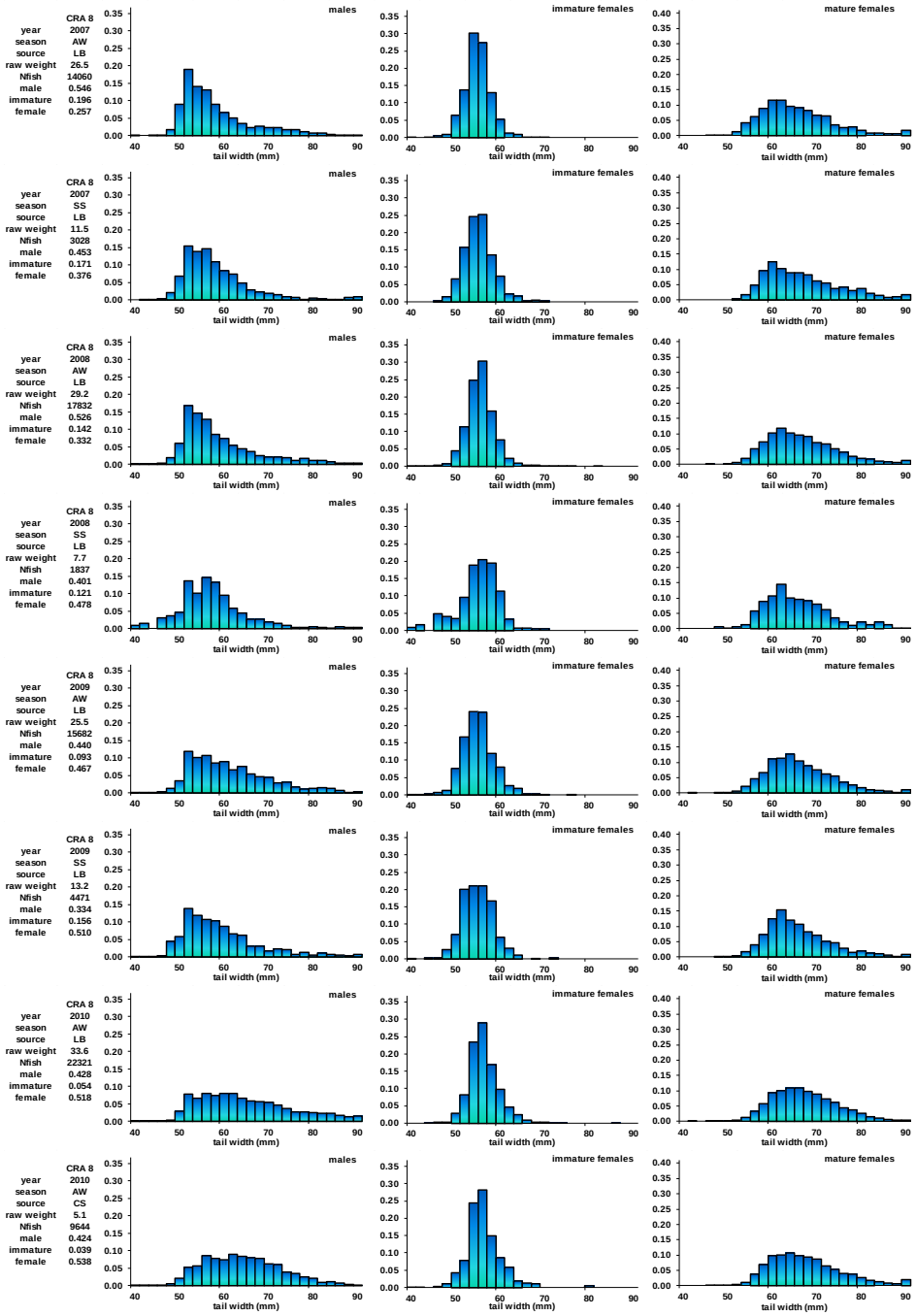

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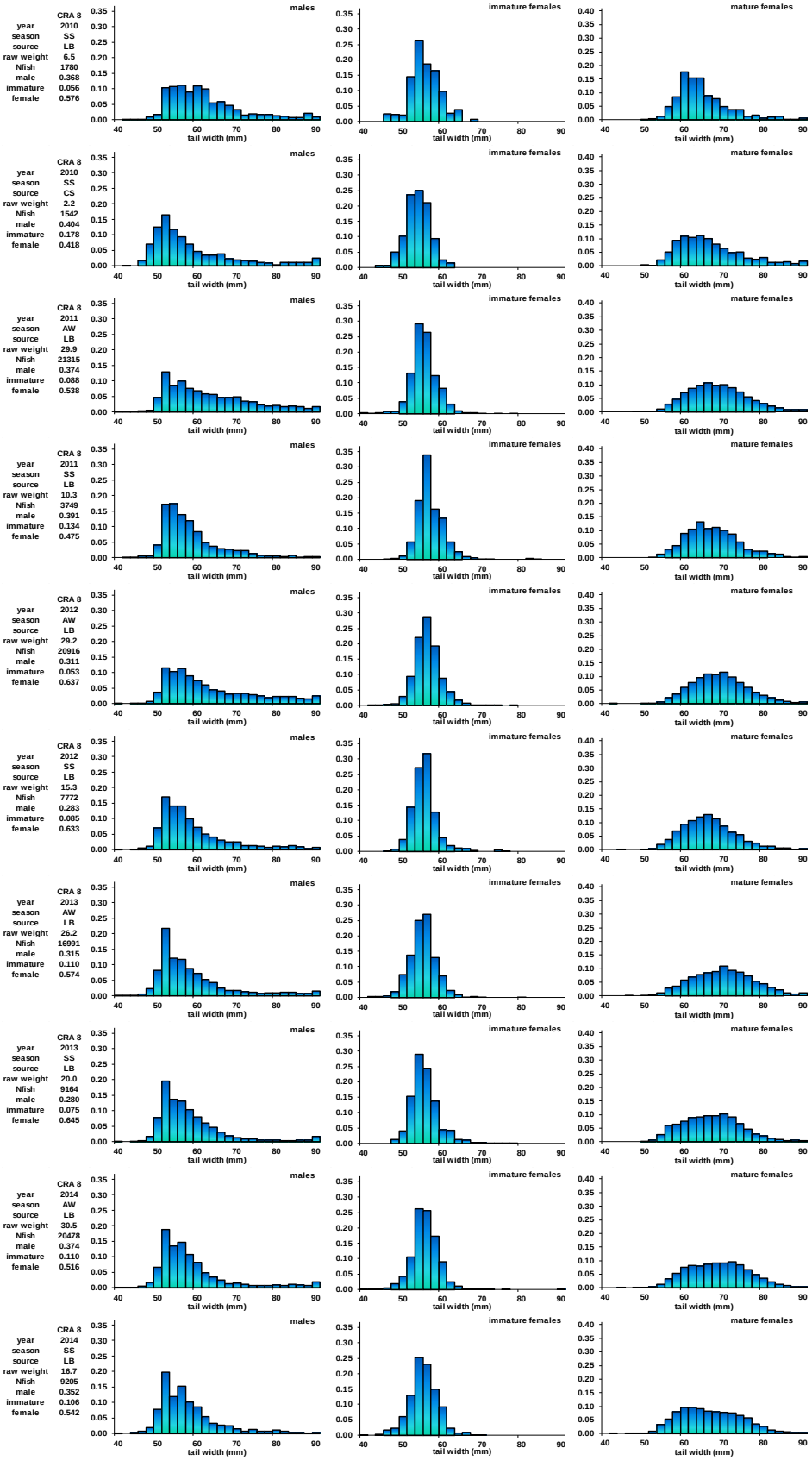

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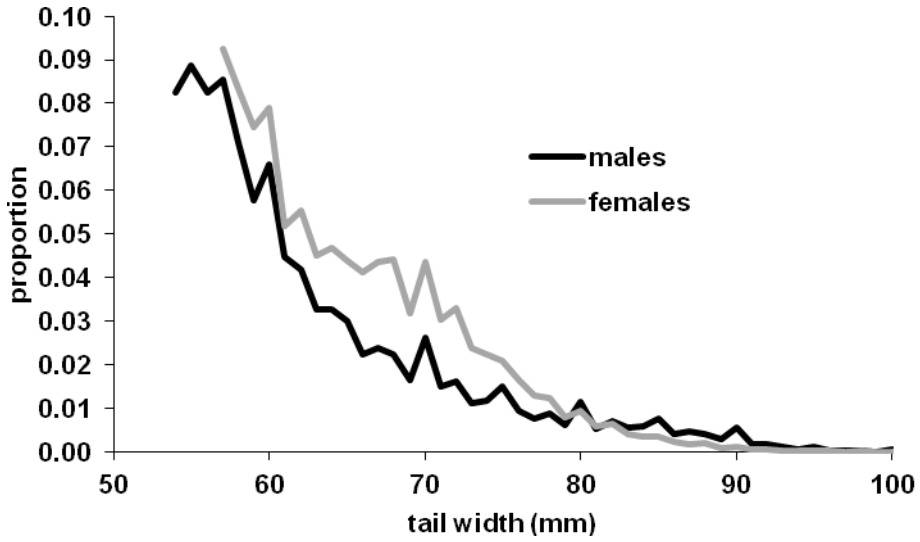

Figure 37: CRA 8: proportion-at-size of the legal fish from the groomed logbook data set collated across all years.

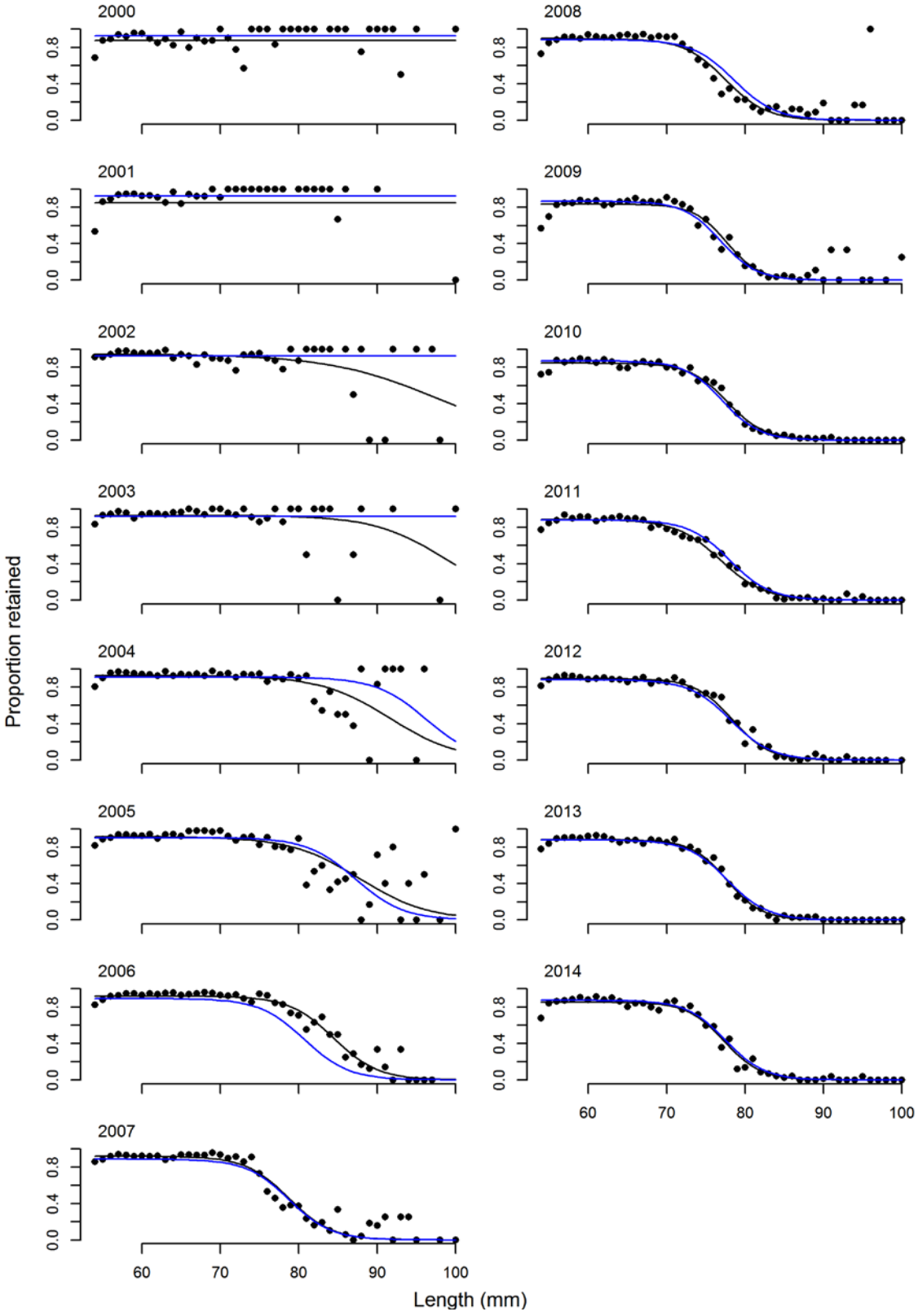

Figure 38: CRA 8: inverse logistic model fits to individual years for males (black solid line) and the curves predicted from CPUE (blue line: see the following section). Black points show the observed proportions retained.

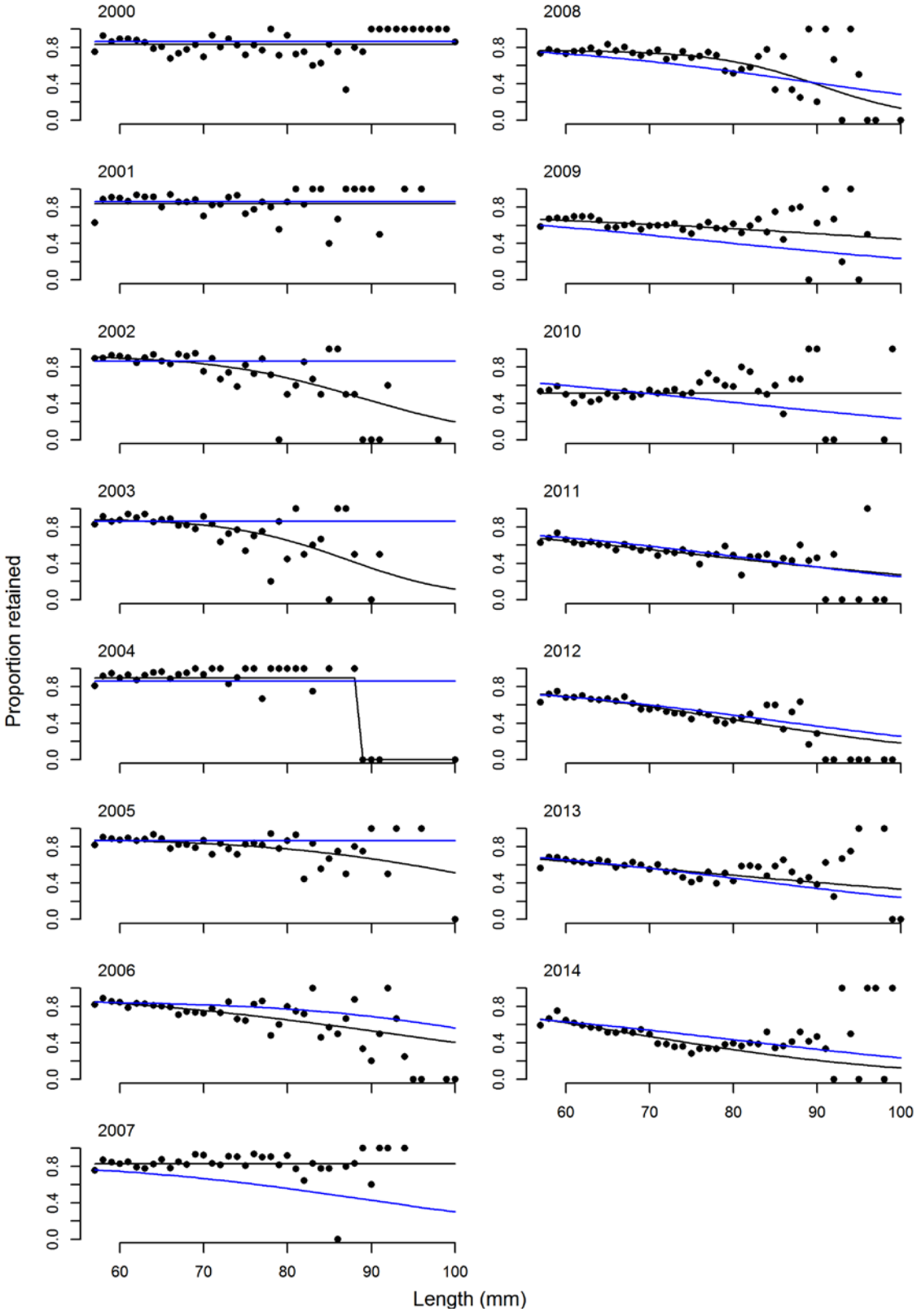

Figure 39: CRA 8: inverse logistic model fits to individual years for females (black solid line) and the curves predicted from CPUE (blue line: see the following section). Black points show the observed proportions retained.

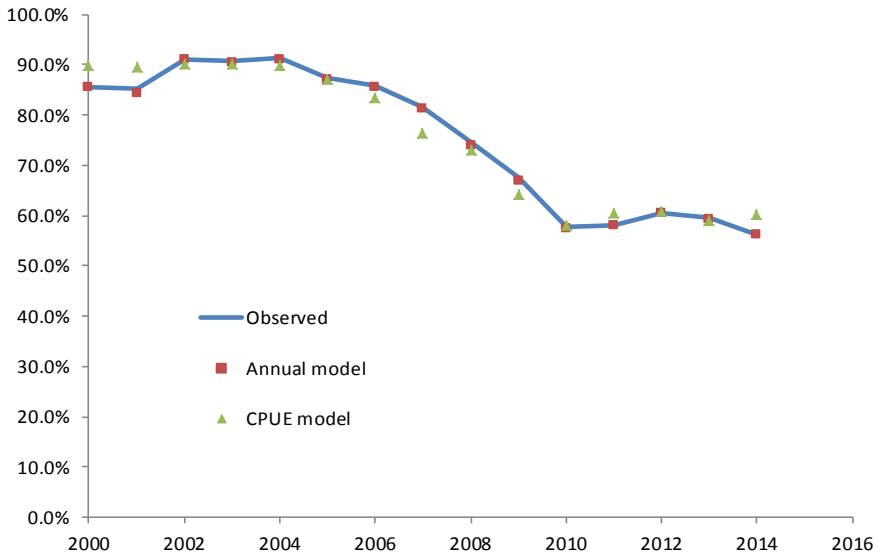

Figure 40: CRA 8: annual percentage by weight of legal fish retained, observed from the groomed logbook data, compared with the percentage predicted from the annual and predictive models of retention.

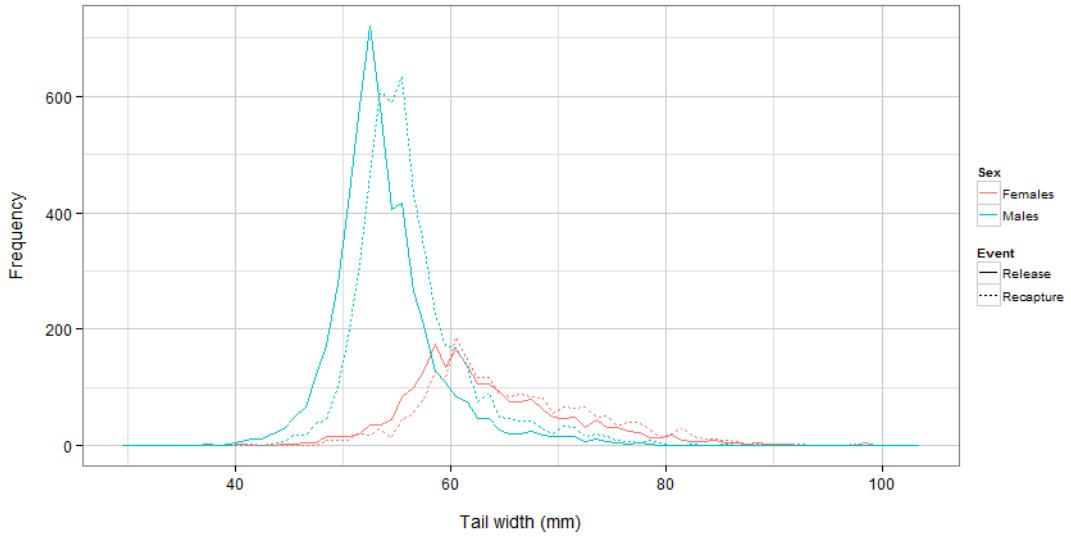

Figure 41: CRA 5: frequency polygons of size at release (solid lines) and recapture (dashed lines) by sex. A bin width of 1 mm was used.

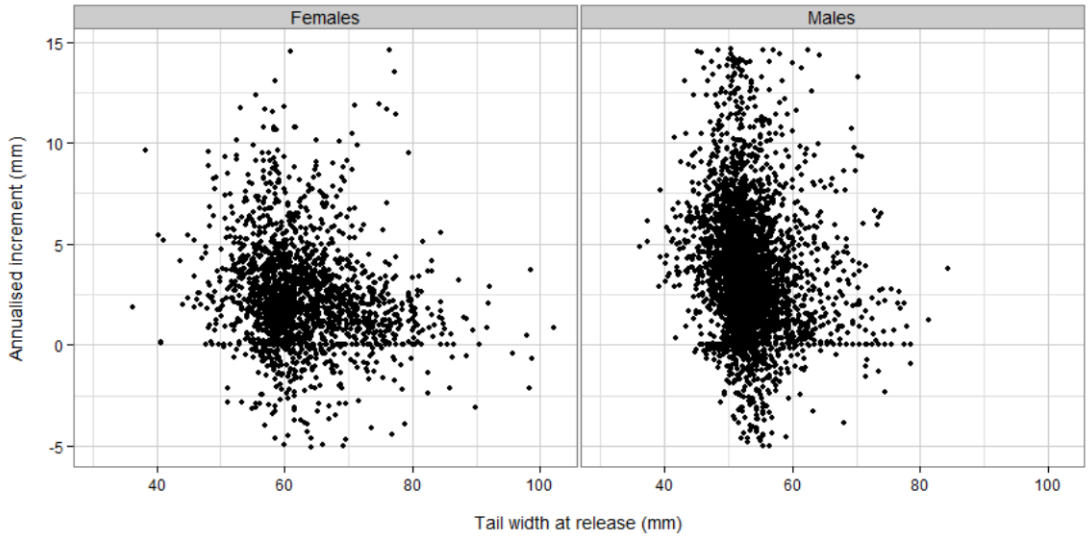

Figure 42: CRA 5: annualised increments versus size at release by sex. The y-axes have been truncated to the 4% and 96% quantiles to exclude the extreme outliers.

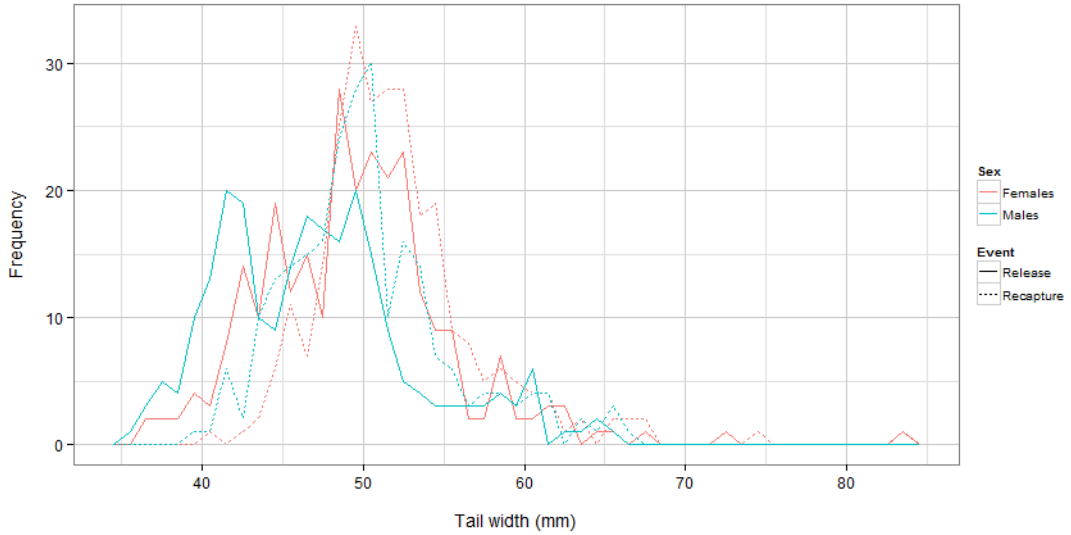

Figure 43: CRA 7: frequency polygons of size at release (solid lines) and recapture (dashed lines) by sex. A bin width of 1 mm was used.

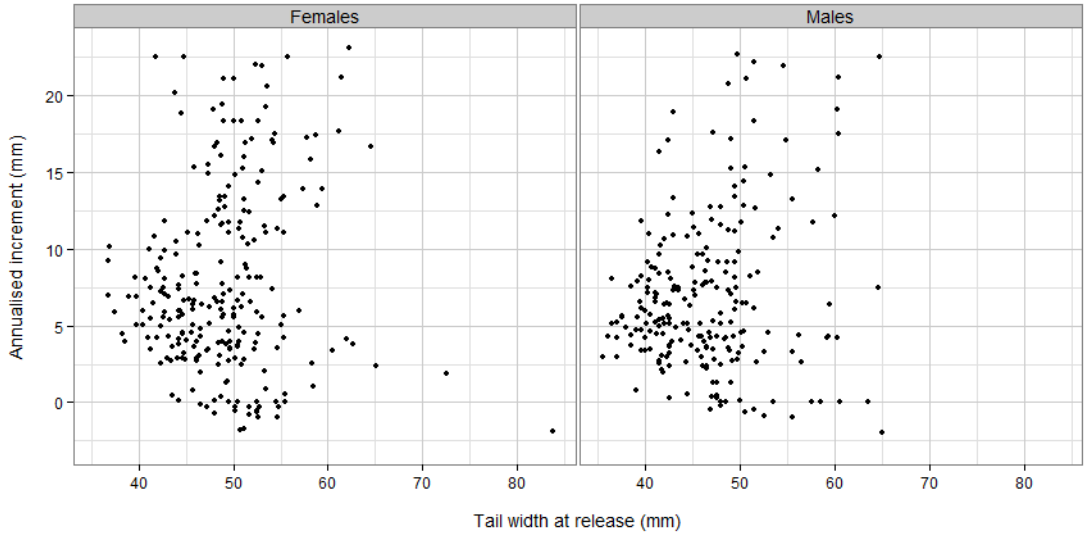

Figure 44: CRA 7: annualised increments versus size at release by sex. The y-axes have been truncated to the 4% and 96% quantiles to exclude the extreme outliers.

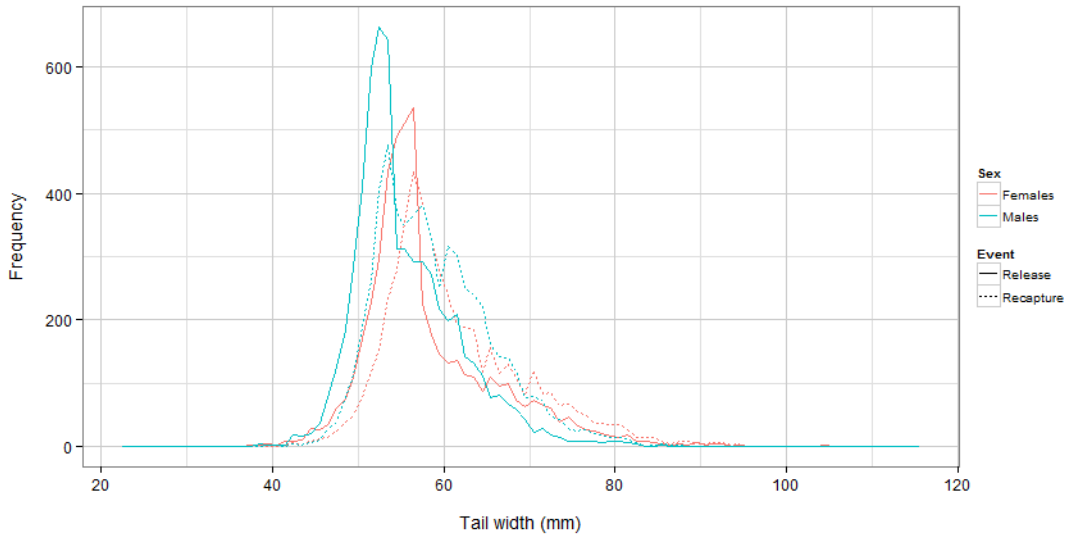

Figure 45: CRA 8: frequency polygons of size at release (solid lines) and recapture (dashed lines) by sex. A bin width of 1 mm was used.

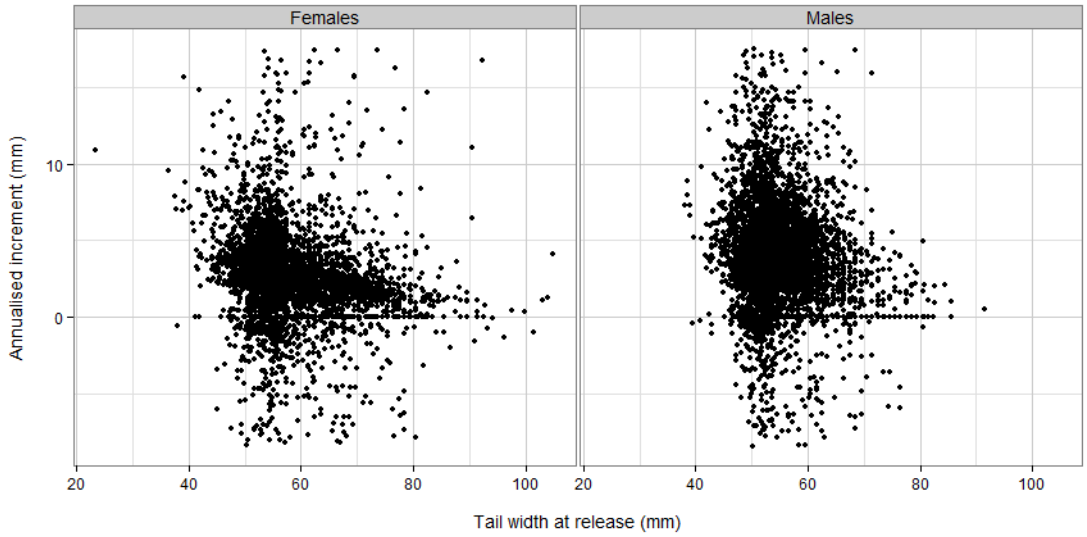

Figure 46: CRA 8: annualised increments versus size at release by sex. The y-axes have been truncated to the 4% and 96% quantiles to exclude the extreme outliers.

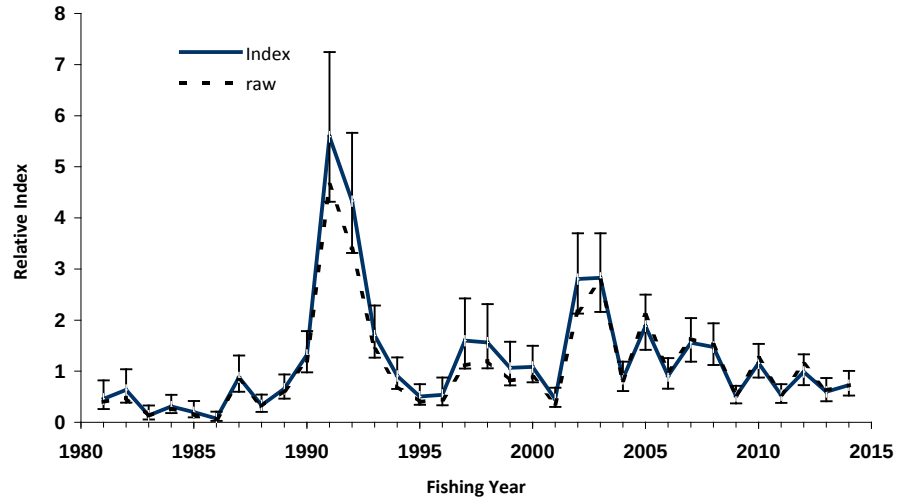

Figure 47: CRA 5: Kaikoura standardised puerulus settlement index (MPI, unpublished).

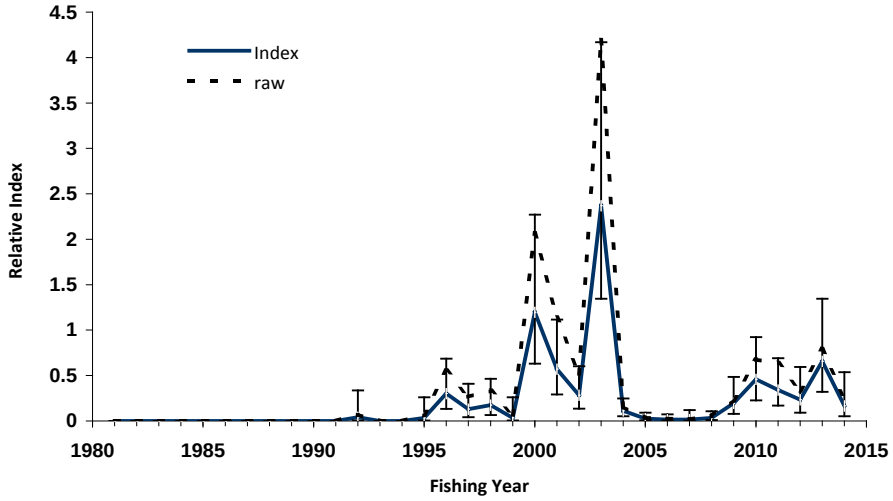

Figure 48: CRA 7: Moeraki standardised puerulus settlement index (MPI, unpublished).

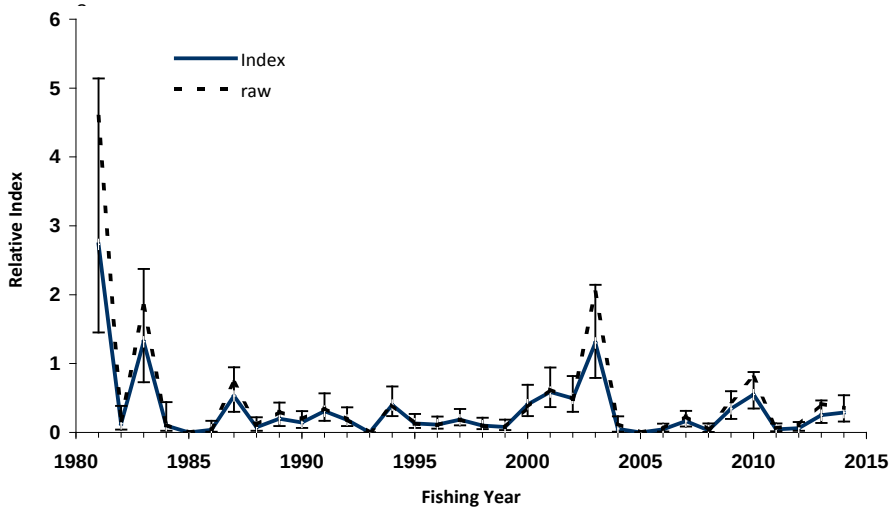

Figure 49: CRA 8: Halfmoon Bay standardised puerulus settlement index (MPI, unpublished).

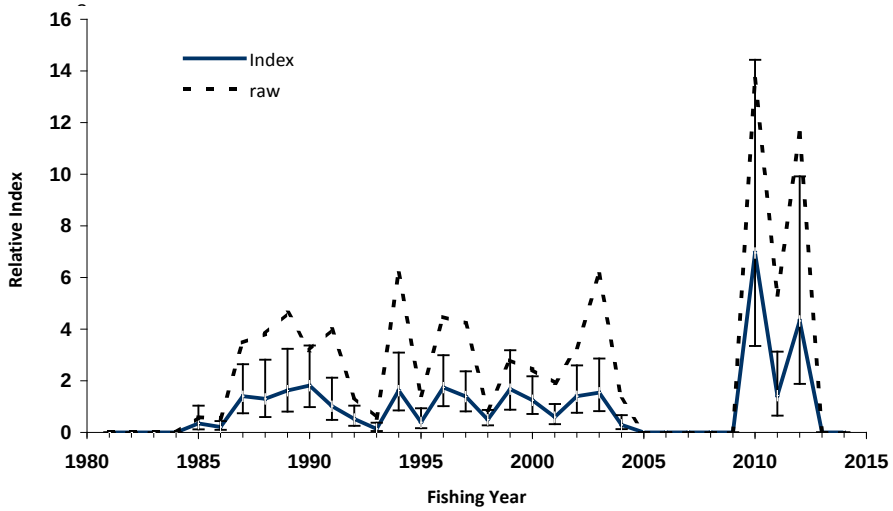

Figure 50: CRA 8: Chalky Inlet standardised puerulus settlement index (MPI, unpublished).

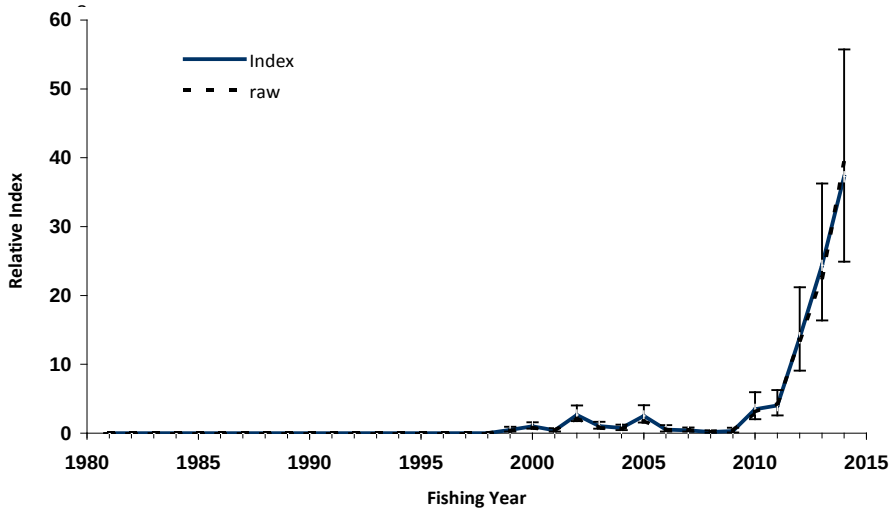

Figure 51: CRA 8: Jackson Bay standardised puerulus settlement index (MPI, unpublished).

APPENDIX A: REQUEST TO MPI FOR NON-COMMERCIAL CATCH ESTIMATES

NZ ROCK LOBSTER INDUSTRY COUNCIL

Ka whakapai te kai o te moana

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

May 5th 2015

Alicia McKinnon, Ministry of Fisheries
by email: *Alicia.McKinnon@mpi.govt.nz*

cc Kevin Sullivan, Chair, RLFAWG
by email: *Kevin.Sullivan@fish.govt.nz*
cc ECs:
bb26@inspire.net.nz
charles.edwards@niwa.co.nz
haistv@shaw.ca
paul@starrfish.net
darcy@quantifish.co.nz

Dear Alicia:

Under Objectives 4 and 5 of MPI contract CRA 2012/01C, in September and October of this year the stock assessment team will be conducting a CRA 5 stock assessment, reviewing the CRA 5 management procedure, conducting a joint CRA 7 and CRA 8 stock assessment and reviewing the CRA 7 and CRA 8 management procedures.

The stock assessment team has access to good 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 catch information.

In the past, MFish provided estimates of illegal catches, but these were highly uncertain and since 2004 there have been no estimates except for advice in response to requests about the stock(s) being assessed each year.

Recreational catch has been estimated by the large-scale multi-species national survey (LSMS), which ended in September 2012. Previous estimates of recreational catch are available from various old surveys.

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 CRA 5, CRA 7 and CRA 8 illegal catches and their 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 reported to the QMS. Otherwise, if commercial fishermen report to an MHR 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 requests an appreciation of the uncertainty in the MPI illegal catch estimates.

For customary catch, the requirements are similar: the assessment team requests that MPI provide estimates of the current customary catches in CRA 5, CRA 7 and CRA 8 and their historical trends. 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 catches in CRA 5, CRA 7 and CRA 8 and their historical trends. 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 credible stock assessments.

The input data, including these estimates, are scheduled to be discussed at a RLFAWG meeting on 22 September 2015. These MPI estimates of non-commercial catches are thus required by 1 September 2015.

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

Sincerely,

Daryl Sykes
Research Programme Manager
NZ Rock Lobster Industry Council

APPENDIX B: MPI RESPONSE TO NON-COMMERCIAL DATA REQUEST
[MPI letterhead]

2 September 2015

Dear the Rock Lobster Stock Assessment Team

NON-COMMERCIAL CATCH ESTIMATES FOR THE CRA 5, CRA 7 AND CRA 8 STOCK ASSESSMENTS

This is a response to your request of 5 May 2015 for MPI advice on customary, recreational and illegal take estimates to use in the upcoming CRA 5, CRA 7 and CRA 8 stock assessments.

Customary catch estimates

Summaries of the information MPI holds on CRA 5, CRA 7 and CRA 8 customary harvest since the 2009/10 April fishing year is provided at the end of this letter (Tables A to D).

CRA 5 customary harvest information is collected under two types of regulations: the Fisheries (South Island Customary Fishing) Regulations 1999, and Regulation 50 of the Fisheries (Amateur Fishing) Regulations 2013 (previously Regulation 27A of the Fisheries (Amateur Fishing) Regulations 1986). CRA 7 and CRA 8 customary harvest information is collected under the South Island Customary Regulations only.

Under the South Island Customary Regulations, Tangata Kaitiaki/Tiaki are responsible for providing quarterly reports of their harvest authorisations to MPI. Therefore, the information provided for CRA 7 and CRA 8 is considered more complete. In areas not covered by South Island Regulations, customary harvest can be authorised for the purpose of hui or tangi under the Amateur Regulations. There is no mandatory requirement for permit issuers under the Amateur Regulations to provide MPI with details of customary fishing authorisations. The majority of the top of the South Island (i.e. Marlborough Sounds) is covered by the Amateur Regulations; therefore, customary harvest information for CRA 5 is considered to be incomplete and uncertain.

Based on the information available on CRA 5, CRA 7 and CRA 8 customary harvest, noting its incompleteness and uncertainty, MPI considers it appropriate to continue to use a 10 tonne constant customary catch estimate for CRA 5, a 1 tonne constant estimate for CRA 7 and to consider increasing the CRA 8 customary estimate from 6 to 15 tonnes. MPI also suggests that the RLFAWG considers carrying out sensitivity analyses for higher levels of customary catch for CRA 5 and CRA 8 (i.e. double the estimate).

Recreational harvest estimates

All available estimates of recreational rock lobster harvest by Quota Management Area are presented in the November 2014 Fisheries Assessment Plenary. The harvest estimates provided by the historical telephone diary surveys (1992, 1993, 1994, 1996, 2000 and 2001) are no longer considered reliable by the MPI Marine Amateur Fisheries Working Group (MAFWG).

For CRA 5, CRA 7 and CRA 8, recreational harvest estimates are available from the 2011-12 National Panel Survey (NPS), which include charter fishing activity (Table 1). For CRA 5, given that no "meshblock" was randomly selected for the Kaikoura area in the NPS and that a locally resident fisher population is assumed to account for a substantial proportion of the harvest in this area, it is likely that the survey has underestimated the recreational harvest in CRA 5. For CRA 7 and CRA 8, given the low number of fishers and events covered in the NPS and the high CVs, it is highly likely the survey has also underestimated the recreational harvest in CRA 7 and CRA 8.

Table 1: Total estimated harvest for CRA 5, CRA 7 and CRA 8 for the 2011-12 fishing year from the National Panel Survey:

Stock	Fishers (n)	Events (n)	Harvest (n)	CV	Mean Weight (kg)	Harvest (t)	CV
CRA 5	44	143	49,274	0.23	0.88	43.47	0.24
CRA 7	1	1	357	1.03	0.64	0.23	1.03
CRA 8	7	19	5,153	0.60	1.34	6.93	0.60

CRA5:
MPI recommends that the rock lobster stock assessment team model an 80 tonne recreational harvest (which includes amateur charter take) for the 2011/12 fishing year in the base case of this year's CRA 5 assessment and scaling this harvest relative to the CRA 5 spring-summer commercial CPUE in 2011/12. It is also suggested that a sensitivity trial of 140 tonnes is carried out.

These recommendations are based on recent MAFWG discussions noting that the 80 tonne harvest estimate for modelling purposes takes into account:

- The 43.47 tonne 2011-12 NPS recreational harvest estimate while acknowledging it is assumed to be an underestimate (the degree to which it is an underestimate is unknown).
- The latest Kaikoura and Motunau boat ramp survey in 2012/13 that estimated 54.56 tonnes of rock lobster were harvested by recreational fishers and charter operators in these areas.
- Ancedotal reports from recreational fishers and MPI compliance that rock lobster harvest is perceived to be high at times (particularly in Kaikoura).

The MAFWG did consider combining the NPS and Kaikoura/Motunau survey results; however, due to interannual variability in potential harvest and the unknown proportion of resident vs. non-resident anglers between and within the two survey years, it is not practical or plausible to combine harvest estimates from different years.

CRA 7:
MPI recommends that a 5 tonne recreational harvest for the 2014/15 year is used in the CRA 7 stock assessment and scaling this harvest to CRA 7 spring-summer commercial CPUE. It is also suggested that a sensitivity trial of 15 tonnes is carried out.

CRA 8:
MPI recommends that a 20 recreational harvest estimate for the 2014/15 year is used in the CRA 8 stock assessment and scaling this estimate to CRA 8 spring-summer commercial CPUE. It is also suggested that a sensitivity trial of 50 tonnes is carried out.

The MAFWG noted there are emerging problems with scaling recreational harvest estimates from years with estimates to years without estimates using commercial CPUE information. Considerable caution should be applied when doing so. Based on recent data in other fisheries (i.e. SNA 1) recreational harvest can vary dramatically between years independent of stock abundance. This is thought to reflect changes in availability of the stock to recreational fishers. If commercial CPUE is thought to reflect stock abundance, scaling recreational harvest by commercial CPUE assumes a direct relationship between stock abundance and recreational harvest. At least for some stocks, this assumption is not valid.

Illegal take estimates

MPI acknowledges that there is currently no robust and defensible methodology that can be used to accurately estimate illegal catches from any rock lobster fishery.

From MPI's perspective, 'true' illegal take relates to offending when rock lobsters are harvested from the water. This includes offences like non-commercial excess and undersize catch, use of unlawful gear, taking from restricted or prohibited areas, and any unreported catch (where there is a legal requirement to report). This definition of illegal take does not necessarily include i.e. poaching and blackmarket sale activities where rock lobsters have been sourced legally. It is likely that fish that have been sourced legally and then illegally sold a distance from the point of harvest may have been captured in other reporting and estimating schemes (e.g. recreational boat ramp surveys, reported s111 catch, or customary authorisations). To avoid double counting, MPI considers it appropriate to restrict the definition of illegal take to 'true' offending.

Despite there being no robust methodology for estimating illegal take, MPI Compliance have revisited the last illegal take estimates that were supplied for CRA 5, CRA 7 and CRA 8 (52 tonnes, 1 tonne and 3 tonnes respectively). Information that was considered in the assessment consisted of detected illegal removals based on prosecutions, observed activities, intelligence and intangible anecdotal knowledge, and other information provided by Fishery Officers. This method for estimating illegal take is rudimentary and therefore, the estimates are not able to be verified and are subject to high levels of uncertainty.

Taking into account the uncertainty in the available information on illegal take, MPI suggests that a 30 tonne illegal catch estimate is used in the upcoming CRA 5 stock assessment, 1 tonne continues to be used for CRA 7 and 3 tonnes continues to be used for CRA 8. It is also suggested that the RLFAWG considers carrying out sensitivity analyses with higher levels of illegal take for CRA 5 and CRA 8 (i.e. double the estimate).

Handling mortality

On a slightly separate note, it is understood that a 10% handling mortality amount is used in each rock lobster stock assessment. MPI Compliance are curious to know exactly how this handling mortality is factored into the model and what type of handling mortality it specifically covers.

Management Procedure form

MPI proposes that future management procedures for CRA 5, CRA 7 and CRA 8 are TACC rules. MPI is also open to considering, along with the standard management procedures, "money fish" management procedures and rules that suggest i.e. bag limit changes at various levels of commercial CPUE.

MPI are available to discuss any of this details of this letter, before or at the upcoming Rock Lobster Fisheries Assessment Working Group meetings.

Yours sincerely

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Table A: Summary of CRA 5 customary harvest information MPI holds that was collected under the Amateur Regulations from the 2009/10 April fishing year

April fishing year	Quantity Approved		Actual Quantity Harvested	
	Unit Type	Total	Unit Type (2)	Total
2009/10	NO. (blank)	2537 850	NO. (blank)	1142 502
2010/11	NO. (blank)	827 2430	NO. (blank)	20 1020
2011/12	NO. (blank)	501 478	(blank)	0
2012/13	NO. (blank)	80 630	(blank)	80
2013/14	NO. (blank)	40 170	(blank)	32
2014/15	(blank)	462	(blank)	52

Table B: Summary of CRA 5 customary harvest information MPI holds that was collected under the South Island Regulations from the 2009/10 April fishing year

April fishing year	Quantity Approved		Actual Quantity Harvested	
	Unit Type	Total	Unit Type (2)	Total
2009/10	NO.	2199	NO.	1341
2010/11	NO.	4575	NO.	3687
2011/12	NO.	4427	NO.	3847
2012/13	NO.	8685	NO.	6489
2013/14	NO.	3804	NO.	3113
2014/15	NO.	3847	NO.	3146

Table C: Summary of CRA 7 customary harvest information MPI holds that was collected under the South Island Customary Regulations from the 2009/10 April fishing year

April fishing year	Quantity Approved		Actual Quantity Harvested	
	Unit Type	Total	Unit Type (2)	Total
2005/06	(blank)	60	(blank)	60
2007/08	NO.	40	NO.	22
2008/09	KG NO.	30 160	KG NO.	30 160
2009/10	NO.	406	NO.	370
2010/11	NO.	2660	NO.	2542
2011/12	NO.	790	NO.	790
2013/14	NO.	541	NO.	408

Table D: Summary of CRA 8 customary harvest information MPI holds that was collected under the South Island Customary Regulations from the 2009/10 April fishing year

April fishing year	Quantity Approved		Actual Quantity Harvested	
	Unit Type	Total	Unit Type (2)	Total
2009/10	KG NO.	6150 9146	KG NO.	6150 8777
2010/11	KG NO.	180 19140	KG NO.	87 18880
2011/12	KG NO.	80 10940	KG NO.	42 10860
2012/13	KG NO.	80 8858	KG NO.	80 8560
2013/14	NO.	9950	NO.	9769
2014/15	NO.	7086	NO.	7086