# Data for the 2011 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 4


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## EXECUTIVE SUMMARY

**Starr, P.J.; Breen, P.A.; Haist, V.; Pomarede, M. (2012). Data for the 2011 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 4.**

***New Zealand Fisheries Assessment Report 2012/08*. 48 p.**

This document presents the collation of data used in the 2011 stock assessment of rock lobsters in CRA 4. Data sets described include catch estimates, a catch and effort series from 1963–73, standardised Catch Per Unit Effort (CPUE), size data (LFs) from observer catch sampling and voluntary commercial fishery logbooks, tag-recapture da ta and puerulus settlement data.

Catch estimates included estimates from commercial, recreational, customary and illegal fisheries. The estimates were collated by year through to 1978 and then by season (spring-summer, SS, and autumn-winter, AW) and by size-limited and non-size-limited fisheries. Recreational catch was based on commercial CPUE and scaled to recreational survey estimates from 1994 and 1996, using an algorithm agreed by the Rock Lobster Fishery Assessment Working Group (RLFAWG). Catches were divided into seasons and into catch limited by size restrictions and the protection of ovigerous females, and non-restricted catch.

CPUE was standardised using previously described methodology, producing separate indices for the SS and AW seasons.

Length frequency data were collated by sex category (males, immature and mature females), season and source (observers or logbooks). Each record was weighted by the number of days' sampling, fish measured and representativeness of the sampling with respect to the commercial catch pattern in time and space. Exploratory analyses are reported.

Tag-recapture data were screened to remove records with insufficient information. Exploratory analyses are reported.

Standardised puerulus settlement indices were provided by NIWA.

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# 1. INTRODUCTION

This document describes work conducted under Objectives 3 and 4 of the Ministry of Fisheries[1](MFish) contract CRA2009-01B. This contract, a three-year contract that began in April 2010, was awarded to the New Zealand Rock Lobster Industry Council Ltd. (NZ RLIC Ltd.), who sub-contracted Objectives 3 and 4 to the authors of this report. The authors collaborated on all aspects of Objective 4 to produce a jointly authored stock assessment. This document describes the data used in the stock assessment, and a companion document (Breen et al. 2012) describes the stock assessment and development of management procedures.

Breen et al. (2012) also present a comprehensive glossary of terms used in the rock lobster stock assessment: if there are undefined terms in this document, that glossary should be consulted.

*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.*

Specific objectives confirmed by the National Rock Lobster Management Group (NRLMG) and MFish under Objective 4 were: 1) a stock assessment for red rock lobsters (*Jasus edwardsii*) in stock CRA 4, followed immediately by 2) CRA 4 management procedure review.

The CRA 4 fishery extends from the Wairoa River on the east coast, southwards along the Hawkes Bay, Wairarapa and Wellington coasts, through Cook Strait and north to the Manawatu River. Statistical areas within CRA 4, 912–915 and 934, are shown in Figure 1.

**Figure 1: Statistical areas in CRA 4. The neighbouring areas are CRA 3 to the north on the east coast of the North Island, CRA 9 to the north on the west coast and CRA 5 on the South Island.**

[1] now part of the Ministry of Agriculture and Forestry

## 2. DATA

Since the 2006 stock assessment, we have compiled catch data through to 1978[2] by year, and then by season for 1979 onwards. The stock assessment model MSLM (Haist et al. 2009) allows a mixture of annual and seasonal time steps as appropriate. The two seasons modelled are spring-summer (SS, October to March) and autumn-winter (AW, April through September).

### 2.1 Catch data

#### 2.1.1 Commercial catch

The fishing year and calendar year were the same before 1979. From 1979 onwards, the fishing year changed to an April to March year (Breen et al. 2001). Reported annual commercial catches from 1945 through 1978, summarised by calendar year, were obtained from Annala (unpublished data). From 1 January 1979 through 31 March 1986, catches were taken from monthly data summarised by fishing year from data collected by the Fisheries Statistics Unit (FSU) and now held by MFish. The three months of catch from January through March 1979 were added to the 1978 annual total to ensure that no catch was lost when switching from calendar year to fishing year collation.

From 1 April 1986 through 30 March 1988, monthly reported catch totals from all of New Zealand were obtained from Quota Management Returns (QMRs) maintained by MFish. Because QMR returns by individual QMAs were not available for this period, these total NZ 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 new forms.

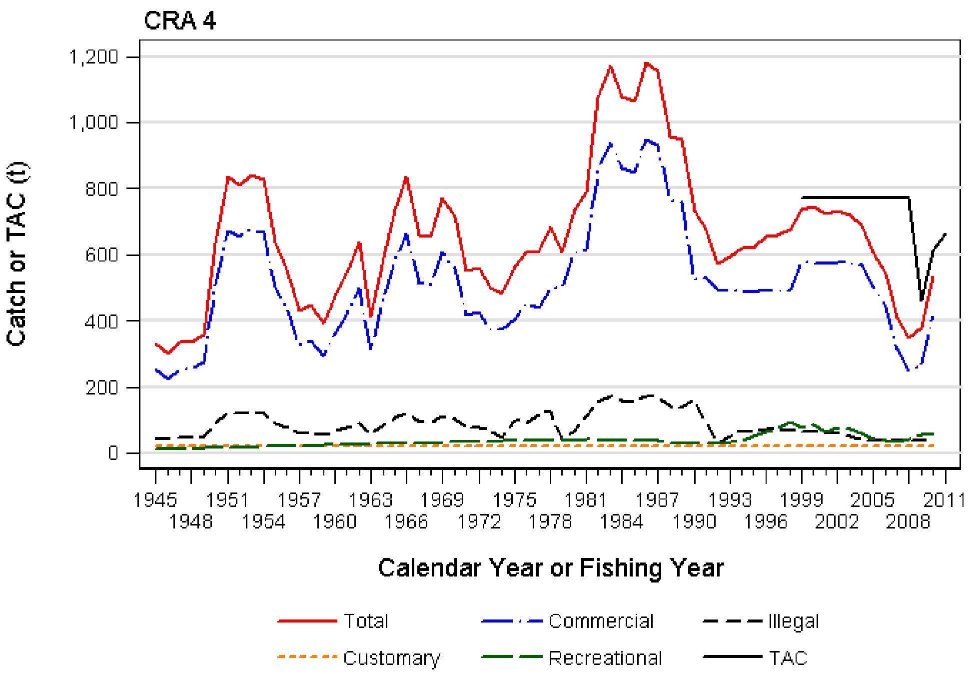


**Figure 2: CRA 4 TAC and annual catches (t) by fishery.**

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[2] the fishing year runs from 1 April to 31 March; the convention used here is to label the fishing year by the first calendar year, *viz*. the 2009–10 fishing year is labelled 2009.

Commercial catches averaged 450 t/year before 1979, with a maximum of 679 t in 1953 (Figure 2). From 1979, catches rose sharply to a peak of 950 t in 1986. Commercial catches averaged about 500 t/year between 1990 and 1998, but in 1999 the Total Annual Commercial Catch (TACC) was increased to 575 t: catches increased to this level, then began to fall in 2004, with a low of 250 t (determined by voluntary quota shelving) in 2008. The stock has since recovered as a result of a voluntary, then a regulated, management procedure first applied in 2007 (Figure 3).

There is some 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 we have confidence in the quality of these catch estimates. Catch estimates generated from the current FSU database are consistent with published historical catch estimates from the FSU system.

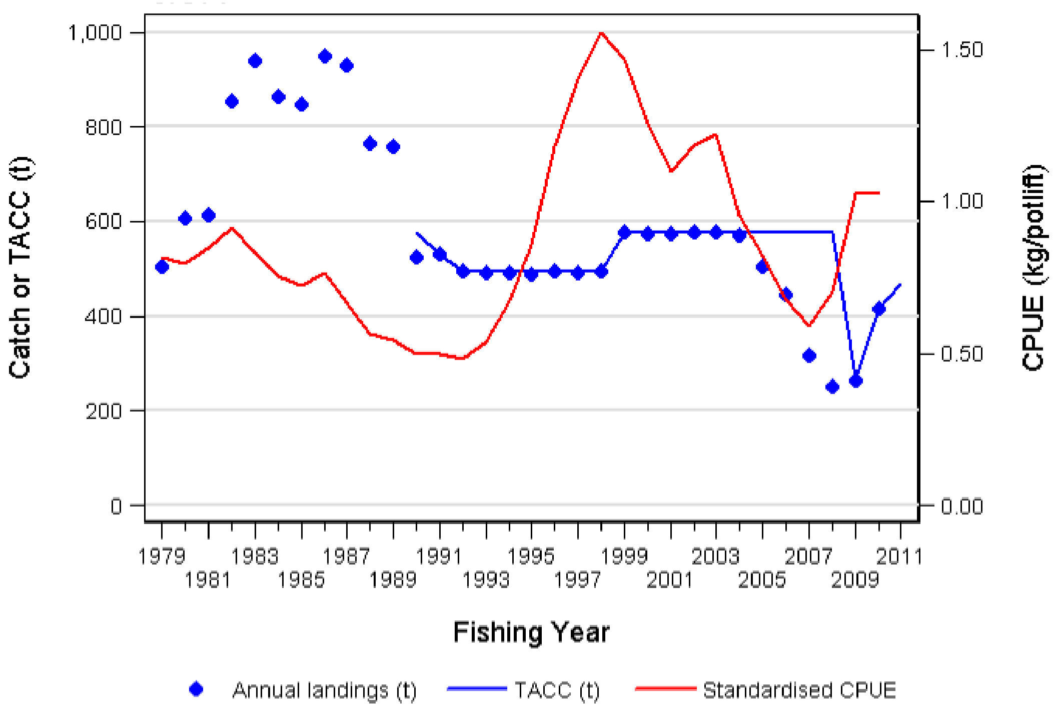



**Figure 3: Plot of annual CRA 4 commercial landings (t), the TACC (t) through to 2011 and the annual standardised CPUE index (kg/potlift) (see 0), 1979–2010.**

### 2.1.2 Recreational catch

Four annual recreational catch estimates are available for CRA 4 (Table 1). The two earlier surveys, (conducted by researchers at the University of Otago) were assessed in 2004 in a review of available recreational surveys (unpublished minutes, Recreational Technical Working Group, Auckland, 10–11 June 2004) as containing bias. The estimates from the 2000 and 2001 surveys (Boyd et al. 2004a; Boyd et al. 2004b) were not accepted by the Rock Lobster Fishery Assessment Working Group (RLFAWG) for the 2005 CRA 4 assessment (Breen et al. 2006).

MFish were asked to provide estimates of current and historical recreational catches and an appreciation of their uncertainty (see Appendix A). MFish did not provide estimates and responded by saying that "the best available information of current and historical catches are those (sic) derived from regional and national telephone and diary surveys" (Alicia McKinnon, MFish, *pers. comm.*). In the past, the RLFAWG has considered the 1994 and 1996 surveys (Bradford 1997; 1998) to be the best available information.

**Table 1: Information used to estimate recreational catch for CRA 4. All information is from the surveys (see text) except for mean weight, which is based on mean lengths from the observer catch sampling data.**

| Quantity | Value |
|---|---|
| Catch estimate 1994 | 65 000 kg |
| Catch estimate 1996 | 118 000 kg |
| Catch estimate 2000 | 371 000 kg |
| Catch estimate 2001 | 289 000 kg |
| 1994/1996 average numbers | 91 500 |
| 1994/96 SS mean weight | 0.510 kg |
| 1994/1996 average catch | 46 709 kg |
| 20% of 1994/1996 average catch | 9 342 kg |

The RLFAWG discussed whether the recreational catch should be assumed constant or proportional to abundance; they chose the latter approach and the vector was based on abundance as reflected by commercial CPUE. The recreational catch vector was scaled to the mean recreational catch estimated for 1994 and 1996 (Table 1). Catches in other years, 1979–2010, were based on SS CPUE and the relation between the mean CPUE and the mean recreational catch estimated for 1994 and 1996. This algorithm was similar to that used for CRA 5 in 2010 (Starr et al. 2011). Recreational catch in 1945 was assumed to be 20% of that estimated for 1979 and was then increased proportionately to the 1979 catch.

To the results of the procedure just described were added the maximum annual reported recreational landings reported by commercial vessels under Section 111 of the Fisheries Act (this procedure was agreed by the RLFAWG in 2006). The recreational catch trajectory is shown in Figure 4. Recreational catch was split between seasons: 90% was assumed taken in SS and 10% in AW.

### 2.1.3 Customary catch

MFish were asked to provide estimates of current and historical customary catches, and an appreciation of their uncertainty (see Appendix A). MFish did not provide estimates; instead, they stated that the information was incomplete and they provided recent information on numbers of lobsters "harvested under the Kaimoana regulations" from 2003–2010 (Table 2) (Alicia McKinnon, MFish, *pers. comm.*). These suggested a maximum annual reported catch of 12 000 lobsters, or roughly 6 t using the mean weight of about 0.5 kg/lobster in Table 1. Because of the incomplete data set, the true catch may be greater.

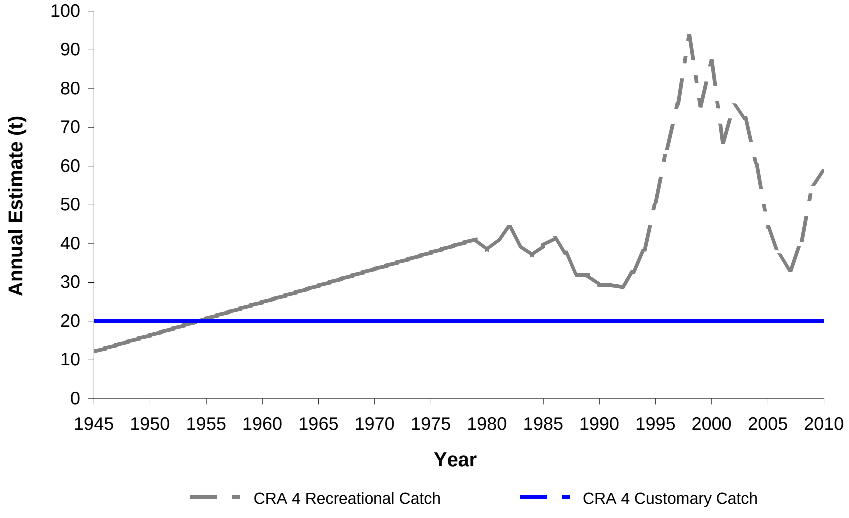



**Figure 4: CRA 4 assumed recreational (grey) and customary (blue) catch trajectories (kg). Section 111 catches of 4.84 t have been added to each year of the recreational catch.**

The RLFAWG agreed to use a constant annual estimate of 20 t for customary catch (Figure 4). This was split between seasons using the same proportions as for the recreational catch: with 90% in SS and 10% in AW.

**Table 2: “Actual quantity [numbers] of CRA 4 rock lobsters harvested under the Kaimoana Regulations” (Alicia McKinnon, MFish, *pers. comm.*) by quarter and calendar year.**

| | Quarter | | | | |
|---|---|---|---|---|---|
| Year | Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | Total |
| 2003 | 2 238 | 900 | 590 | 2 673 | 6 401 |
| 2004 | 1 181 | 951 | 1 161 | 2 300 | 5 593 |
| 2005 | 1 688 | 1 349 | 457 | 1 595 | 5 089 |
| 2006 | 1 963 | 384 | 360 | 1 870 | 4 577 |
| 2007 | 1 535 | 450 | 990 | 3 184 | 6 159 |
| 2008 | 4 421 | 671 | 850 | 3 914 | 9 856 |
| 2009 | 5 612 | 2 451 | 1 641 | 2 525 | 12 229 |
| 2010 | 944 | 1 334 | 70 | 923 | 3 271 |

### 2.1.4 Illegal catch

MFish were asked to provide estimates of current and historical illegal catches, an appreciation of their uncertainty and an estimate of the proportion of illegal catch that was reported as legal catch (see Appendix A). MFish declined to provide estimates and pointed to estimates given in the past (Table 3); they reported anecdotal evidence of a recent downward trend but gave no supporting information.

**Table 3: Available estimates of illegal catches (t) by QMA from 1990 as provided by MFish Compliance. R (reported): illegal catch processed though the legal catch system; NR: not reported.**

| 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 | | | | | | | | | | | | | | | | | | |

MFish estimates for illegal catch were usually provided in two categories per QMA per year, with many missing values (Table 3), which were treated as zeroes. The category of “commercial illegal reported” or “reported” was assumed to represent illegal commercial catch that was eventually reported to the QMS as legitimate catch; this catch was subtracted from the reported commercial catch to avoid double-counting.

The following procedure has been followed to estimate illegal catch in stock assessments since the 2004 assessment of CRA 3:

- Starting with the estimates of export discrepancies for all of NZ for the period 1974 to 1980 (John McKoy, unpublished data), the CRA 4 illegal catches for each of these seven years were estimated from the ratio of the reported commercial catch in CRA 4 to the total New Zealand reported commercial catch for the same years. The average ratio in CRA 4 of the export discrepancy catch to reported commercial catch was calculated for the period 1974–80. This ratio was used to generate an illegal catch estimate for all years with no data (1945 through 1973 and 1981 through 1989) by multiplying the reported catch by the average ratio. This approach was consistent with a decision reached by the RLFAWG on 15 Aug 2002.

- Beginning with 1990, the first year that estimates were provided by QMA, illegal catch was based on MFish Compliance estimates (Table 3). For years without Compliance estimates, the level of illegal catch was interpolated (Figure 2). Estimates for “commercial illegal reported” (R in Table 3) were used to split the illegal catch into the “SL illegal” and “NSL illegal” categories (see the next section).

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

### 2.1.5 Size-limited and non-size-limited catch

The size-limited (SL) catch is catch taken under the minimum legal size (MLS) regulations and the restriction on landing berried females; it is the sum of the commercial and recreational catches minus the reported illegal catches (Figure 5). The non-size-limited (NSL) catch is taken without regard to those restrictions; it is the sum of reported and unreported illegal catches and the customary catches.

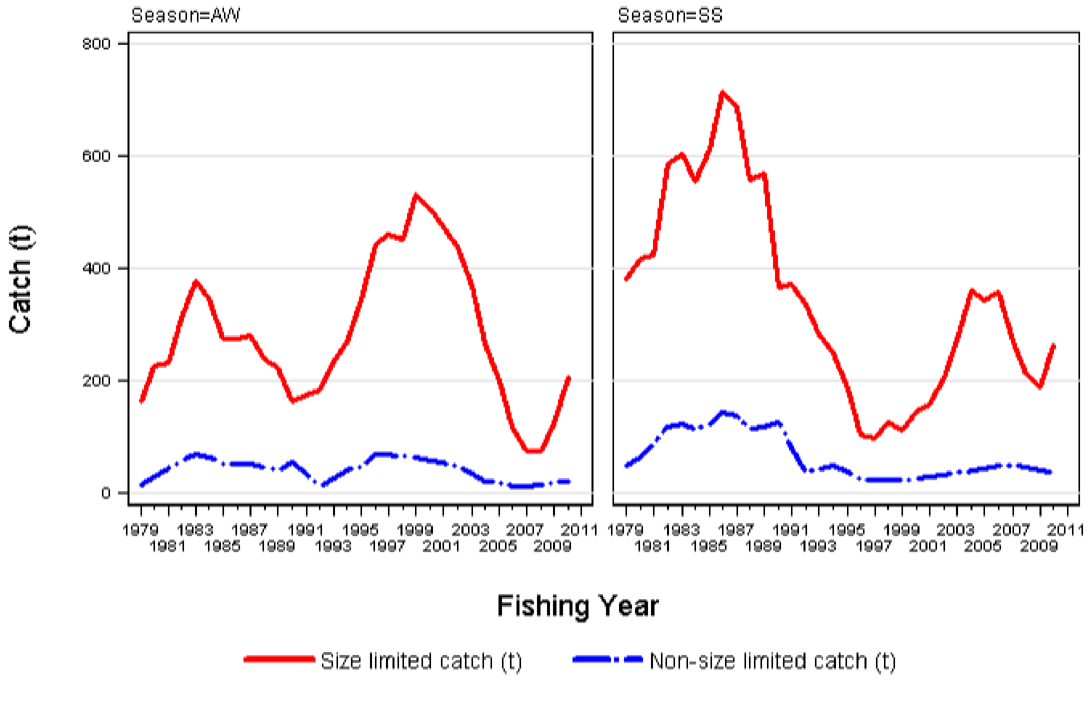



**Figure 5: CRA 4 seasonal SL and NSL catches (t) by fishing year.**

### 2.1.6 Seasonal proportion of catch

Annual commercial catches were divided into seasons (Figure 6), beginning in 1979, based on catches reported seasonally to the FSU or QMR/MHR data systems. Illegal catches were divided into the same proportions. It was assumed that 90% of the customary and recreational catches were taken in SS.

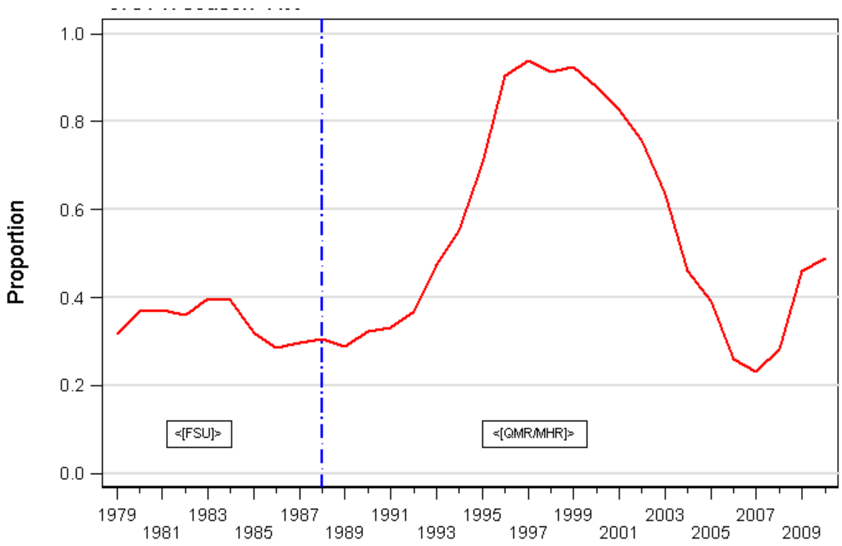



**Figure 6: CRA 4: Proportion of the commercial catch taken in AW, by fishing year.**

## 2.2 Catch rate Information

### 2.2.1 Standardised CPUE Indices

Catch and effort data from 1 April 1979–31 March 2011 in the Fisheries Statistics Unit (FSU) and Catch Effort Landing Return (CELR) systems were obtained from MFish in August 2011 (Replog 8227), loaded into the CRACE database (see Bentley et al. 2005) and processed using standard error checks (Bentley et al. 2005). Numbers of records are shown in Table 4. Data preparation alternatives were discussed by the RLFAWG: a new procedure was not accepted and the previous "B4" procedure described here was agreed. The "B4" algorithm procedure, used in all assessments since 2003, corrects the monthly estimated catch from the top part of the CELR form using the monthly landing data (Appendix A; Bentley et al. 2005). The B4 algorithm was scaled to the "L" (Licensed Fish Receiver) landings and did not account for other landing destinations such as "X" (discarded to sea) and "F" (Section 111 recreational catch). These landings are minor in CRA 4.

The CPUE standardisation procedure (see Eq. 4, Starr 2011) used a six-month "period" as the time-dependent explanatory variable. The only other explanatory variables offered to the model were month and statistical area, because in previous analyses other variables had little power to explain model deviance (Maunder & Starr 1995). Separate relative month effect series were estimated for each season by using the month in each period with the lowest standard error as the reference month. Diagnostics are shown in Figure 7; the area and month effects are shown in Figure 8.

**Table 4: Number of vessel/statistical area/month records used to calculate the CRA 4 seasonal CPUE time series.**

| Year | AW | 912 | 913 | 914 | 915 | 934 | Total | SS | 912 | 913 | 914 | 915 | 934 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | AW | 89 | 80 | 92 | 50 | 1 | 312 | SS | 136 | 113 | 136 | 96 | 1 | 482 |
| 1980 | AW | 101 | 80 | 102 | 61 | 1 | 345 | SS | 149 | 90 | 135 | 110 | 7 | 491 |
| 1981 | AW | 109 | 72 | 103 | 55 | 0 | 339 | SS | 146 | 76 | 122 | 97 | 1 | 442 |
| 1982 | AW | 122 | 66 | 117 | 64 | 1 | 370 | SS | 147 | 98 | 157 | 108 | 3 | 513 |
| 1983 | AW | 109 | 84 | 121 | 74 | 2 | 390 | SS | 137 | 111 | 157 | 101 | 5 | 511 |
| 1984 | AW | 99 | 91 | 137 | 73 | 3 | 403 | SS | 118 | 96 | 149 | 91 | 5 | 459 |
| 1985 | AW | 112 | 77 | 134 | 71 | 1 | 395 | SS | 133 | 79 | 158 | 97 | 8 | 475 |
| 1986 | AW | 102 | 85 | 131 | 67 | 0 | 385 | SS | 127 | 103 | 152 | 85 | 6 | 473 |
| 1987 | AW | 98 | 80 | 125 | 53 | 0 | 356 | SS | 121 | 94 | 160 | 79 | 3 | 457 |
| 1988 | AW | 94 | 71 | 127 | 54 | 2 | 348 | SS | 105 | 92 | 149 | 66 | 0 | 412 |
| 1989 | AW | 99 | 93 | 126 | 47 | 2 | 367 | SS | 125 | 112 | 168 | 67 | 6 | 478 |
| 1990 | AW | 93 | 85 | 115 | 58 | 2 | 353 | SS | 114 | 98 | 147 | 76 | 3 | 438 |
| 1991 | AW | 118 | 103 | 150 | 50 | 3 | 424 | SS | 127 | 105 | 146 | 62 | 5 | 445 |
| 1992 | AW | 140 | 111 | 124 | 51 | 2 | 428 | SS | 145 | 119 | 120 | 59 | 7 | 450 |
| 1993 | AW | 137 | 102 | 138 | 60 | 7 | 444 | SS | 99 | 98 | 85 | 48 | 4 | 334 |
| 1994 | AW | 96 | 107 | 165 | 63 | 17 | 448 | SS | 54 | 81 | 58 | 39 | 12 | 244 |
| 1995 | AW | 81 | 89 | 166 | 46 | 12 | 394 | SS | 42 | 55 | 45 | 17 | 1 | 160 |
| 1996 | AW | 89 | 65 | 147 | 67 | 4 | 372 | SS | 29 | 12 | 19 | 11 | 0 | 71 |
| 1997 | AW | 85 | 55 | 146 | 43 | 0 | 329 | SS | 16 | 5 | 19 | 9 | 0 | 49 |
| 1998 | AW | 94 | 44 | 138 | 47 | 0 | 323 | SS | 22 | 9 | 17 | 13 | 0 | 61 |
| 1999 | AW | 90 | 58 | 140 | 53 | 4 | 345 | SS | 23 | 2 | 20 | 9 | 4 | 58 |
| 2000 | AW | 106 | 46 | 102 | 47 | 9 | 310 | SS | 31 | 9 | 19 | 14 | 2 | 75 |
| 2001 | AW | 92 | 67 | 112 | 57 | 13 | 341 | SS | 38 | 26 | 26 | 10 | 0 | 100 |
| 2002 | AW | 81 | 80 | 114 | 52 | 4 | 331 | SS | 41 | 27 | 48 | 21 | 0 | 137 |
| 2003 | AW | 61 | 80 | 110 | 44 | 0 | 295 | SS | 42 | 42 | 46 | 28 | 0 | 158 |
| 2004 | AW | 65 | 62 | 115 | 44 | 5 | 291 | SS | 64 | 51 | 73 | 30 | 4 | 222 |
| 2005 | AW | 49 | 49 | 88 | 35 | 5 | 226 | SS | 52 | 46 | 105 | 39 | 6 | 248 |
| 2006 | AW | 34 | 51 | 84 | 46 | 7 | 222 | SS | 67 | 67 | 131 | 63 | 17 | 345 |
| 2007 | AW | 26 | 28 | 65 | 33 | 10 | 162 | SS | 54 | 55 | 104 | 49 | 15 | 277 |
| 2008 | AW | 31 | 26 | 47 | 26 | 2 | 132 | SS | 44 | 46 | 63 | 26 | 2 | 181 |
| 2009 | AW | 32 | 31 | 44 | 25 | 3 | 135 | SS | 43 | 30 | 33 | 33 | 1 | 140 |
| 2010 | AW | 51 | 39 | 78 | 46 | 4 | 218 | SS | 52 | 27 | 69 | 44 | 2 | 194 |

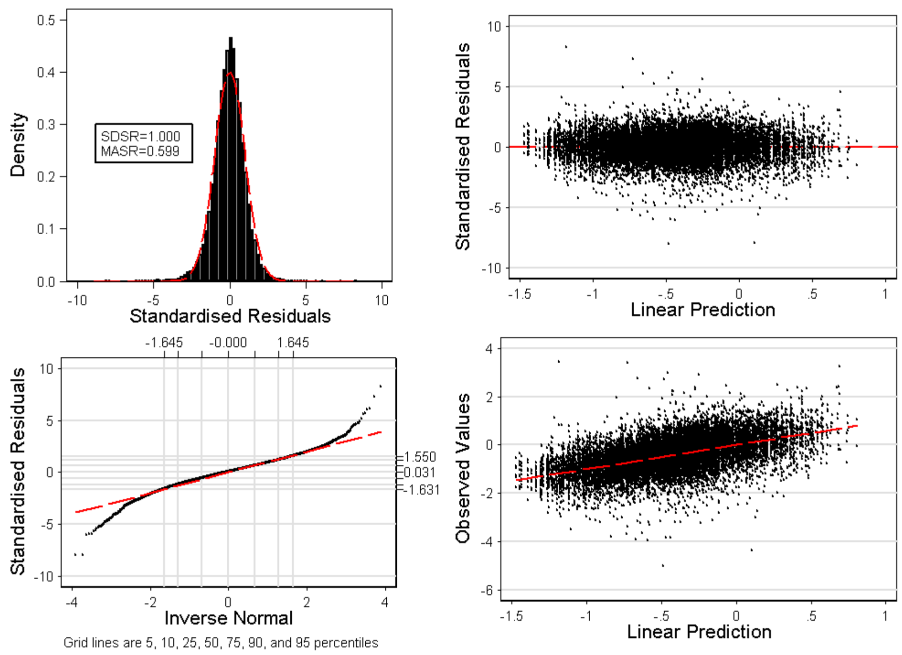



**Figure 7: Standardised residuals for the CRA 4 standardised seasonal CPUE analysis.**

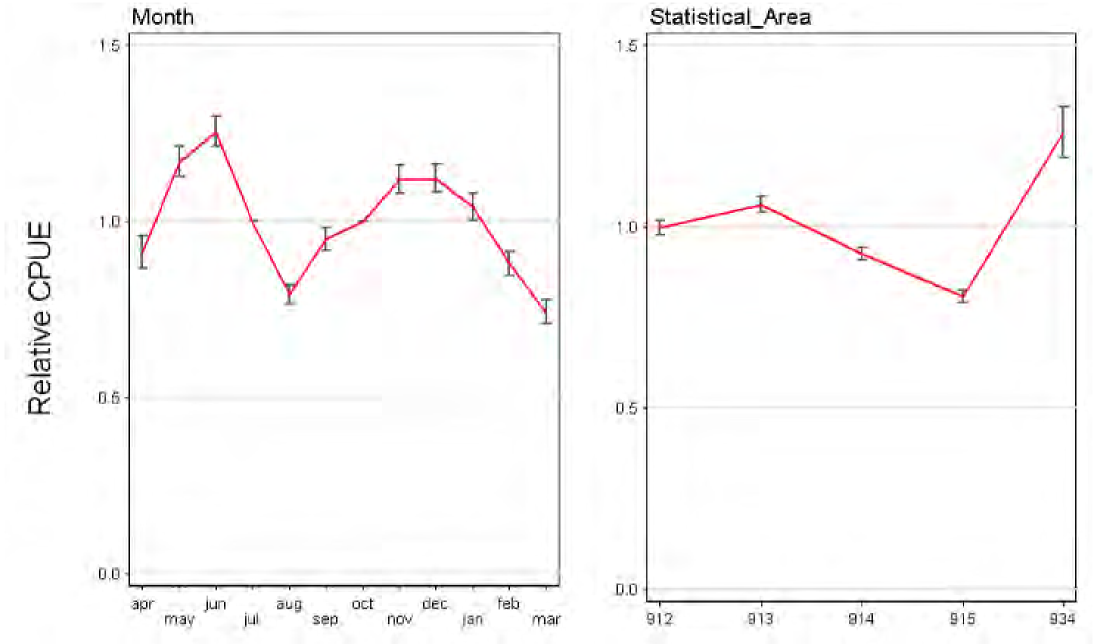



**Figure 8: Coefficients for month and statistical area from the CRA 4 seasonal CPUE standardisation. Month coefficients are not in canonical form, with each of the two reference months (July and October) set to 1.0 and the associated SE set to zero.**

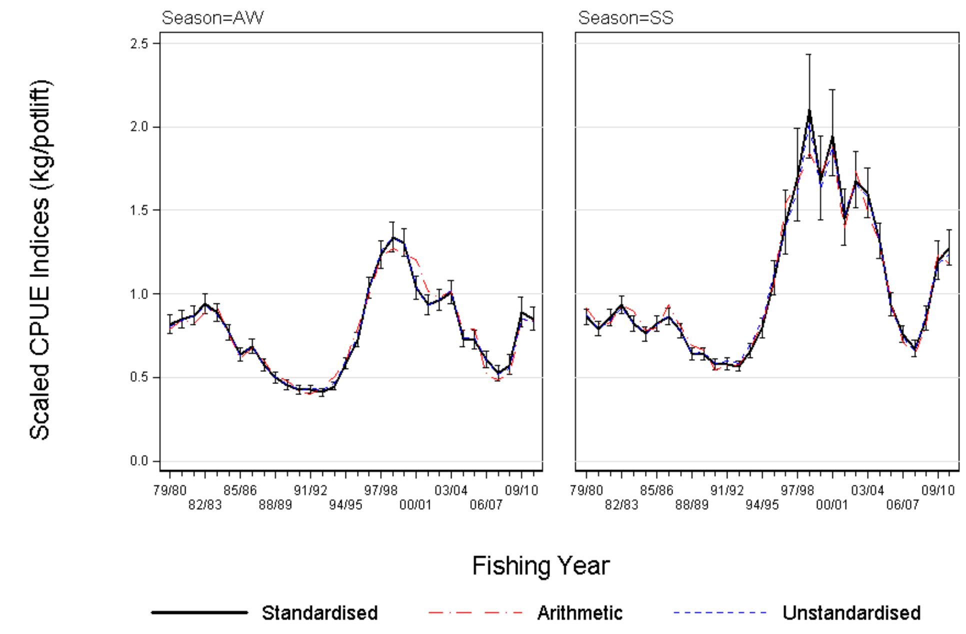



**Figure 9: CRA 4: standardised (see Eq. 4, Starr 2011), unstandardised (see Eq. 2, Starr 2011), and arithmetic (see Eq. 1, Starr 2011) CPUE indices (kg/potlift) by season and fishing year, 1979–2010; vertical bars are 95% confidence intervals. The geometric mean for the AW series (left panel) was 0.73 kg/potlift and for the SS series (right panel) was 0.97 kg/potlift.**

The total deviance explained by the CRA 4 standardised model was 29% (Table 5). Model period had the greatest explanatory power, followed by month and statistical area. These results were consistent with other rock lobster standardisation analyses. Residual patterns showed some deviation from the lognormal assumption at both tails of the residual distribution (Figure 7).

Statistical area 934 had the highest expected catch rate, but this was based on relatively few records (Table 4; Figure 8). The remaining statistical areas had limited contrast in expected catch rates. There was greater contrast in the month categorical variable, with peaks in May and June during the AW season and in November and December in the SS season (Figure 8).

CPUE showed a peak in the late 1990s in both seasons, dropping to a nadir in 2007 before rising in two years to about half the peak (Figure 9). The 2010 index value changed little from the 2009 value, with an increase in SS and a decrease in AW (the most recent period).

**Table 5: Total deviance ($R^2$) explained by each variable in the CRA 4 standardised seasonal CPUE analysis.**

| Variable | 1 | 2 | 3 |
|---|---|---|---|
| Period | 0.223 | | |
| Month | 0.055 | 0.271 | |
| Statistical Area | 0.016 | 0.243 | 0.290 |
| Additional deviance explained | 0.000 | 0.047 | 0.019 |

### 2.2.2 Historical catch rate (CR) data

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 (Figure 10).

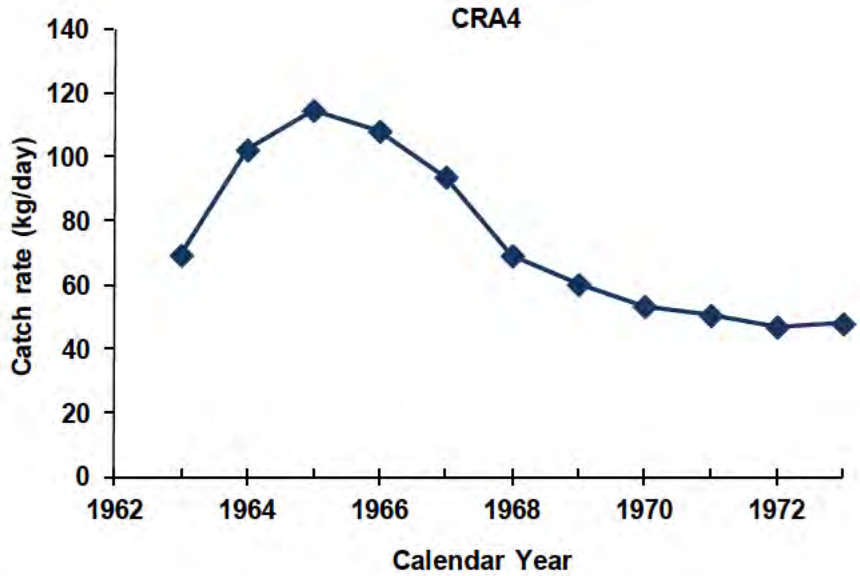



**Figure 10: CRA 4 catch rate (kg/day) (Annala & King 1983).**

### 2.3 Length frequency data

The two sources of length frequency data are voluntary logbooks and observer catch sampling. Data were summarised by year and season over three sex categories: male, immature female and mature female. The logbook data covered 1997 through 2010, intermittently, with one to three participants (five in 2010) (Table 6). The observer catch sampling data covered every year from 1986 through 2010 (Table 7). In CRA 4, the observer catch sampling has dominated in numbers of lobsters measured.

**Table 6: CRA 4 logbook participation.**

| Fishing Year | Fishers | Vessels | Trips | Potlifts | Lobsters |
|---|---|---|---|---|---|
| 1997 | 1 | 1 | 60 | 213 | 1 844 |
| 1998 | 3 | 3 | 50 | 174 | 1 397 |
| 1999 | 1 | 1 | 33 | 119 | 297 |
| 2000 | 1 | 1 | 7 | 23 | 331 |
| 2002 | 1 | 1 | 51 | 200 | 592 |
| 2003 | 1 | 1 | 95 | 374 | 1 501 |
| 2004 | 1 | 1 | 73 | 278 | 1 024 |
| 2005 | 2 | 2 | 126 | 498 | 2 462 |
| 2006 | 2 | 2 | 118 | 452 | 1 406 |
| 2007 | 1 | 1 | 71 | 278 | 1 400 |
| 2008 | 1 | 1 | 39 | 146 | 522 |
| 2009 | 2 | 2 | 37 | 143 | 945 |
| 2010 | 5 | 5 | 185 | 674 | 3 128 |

**Table 7: Number of days sampled and number of fish measured in CRA 4.**

| | Days | | | | Lobsters | | | |
|---|---|---|---|---|---|---|---|---|
| | Logbook | | Observer | | Logbook | | Observer | |
| Year | AW | SS | AW | SS | AW | SS | AW | SS |
| 1986 | | | | 2 | | | | 276 |
| 1987 | | | 6 | 9 | | | 1 194 | 1 564 |
| 1988 | | | 10 | 5 | | | 1 980 | 1 857 |
| 1989 | | | 13 | 12 | | | 3 663 | 4 615 |
| 1990 | | | 17 | 22 | | | 7 853 | 17 170 |
| 1991 | | | 3 | 19 | | | 2 984 | 15 655 |
| 1992 | | | 3 | 17 | | | 1 502 | 16 546 |
| 1993 | | | 1 | 19 | | | 1 112 | 10 795 |
| 1994 | | | 2 | 10 | | | 2 540 | 5 530 |
| 1995 | | | 3 | 13 | | | 2 396 | 7 374 |
| 1996 | | | 7 | | | | 4 555 | |
| 1997 | 58 | 2 | 34 | | 1 774 | 70 | 34 033 | |
| 1998 | 28 | 22 | 27 | | 811 | 586 | 19 141 | |
| 1999 | 33 | | 39 | | 297 | | 25 115 | |
| 2000 | 7 | | 39 | | 331 | | 22 524 | |
| 2001 | | | 26 | 6 | | | 17 157 | 3 561 |
| 2002 | 45 | 6 | 30 | 5 | 494 | 98 | 18 096 | 2 881 |
| 2003 | 82 | 13 | 30 | 5 | 1 252 | 246 | 15 122 | 3 436 |
| 2004 | 65 | 8 | 22 | 14 | 935 | 88 | 13 237 | 9 849 |
| 2005 | 109 | 17 | 17 | 29 | 2 161 | 300 | 9 445 | 16 638 |
| 2006 | 101 | 17 | 19 | 27 | 1 299 | 107 | 8 635 | 13 703 |
| 2007 | 46 | 25 | 22 | 25 | 738 | 662 | 7 419 | 12 887 |
| 2008 | 39 | | 10 | 30 | 522 | | 4 323 | 15 983 |
| 2009 | 34 | 3 | 15 | 27 | 865 | 80 | 6 161 | 14 170 |
| 2010 | 124 | 61 | 22 | 21 | 1 700 | 1 425 | 8 109 | 10 231 |
| Total | 771 | 174 | 417 | 317 | 13 179 | 3 662 | 238 296 | 184 721 |

Data were summarised by period and sex into 2-mm size classes from 30–90 mm. The voluntary logbook program measures lobsters with a precision of 1 mm while the observer catch sampling precision is 0.1 mm. The measuring convention for logbook participants is to round down all measured lengths, so 0.5 mm was added to each voluntary logbook measurement before binning to avoid introducing bias to the calculated proportions-at-size.

Each data record used in model fitting represented a single period for a single data source, either logbook or catch sampling. This record may comprise data from several months and more than one statistical area. Observations from multiple statistical areas and months within a period were weighted within the record by the proportion of catch taken in each month/area cell, the cube root of the number of sample days and the cube root of the number of fish measured. The weights assigned to samples from this procedure are shown in Table 8.

Logbook samples used in the stock assessment are shown in grey in Table 8. We tended to avoid single-participant samples, and one sample (SS 1997) was rejected based on its appearance.

**Table 8: CRA 4: total sample weight (before truncation) by fishing year, season, and sample type. LB: logbook; CS: observer catch sampling. Year/season combinations from the logbook data used in the stock assessment are highlighted in grey.**

| Fishing | AW | | SS | |
|---|---|---|---|---|
| Year | LB | CS | LB | CS |
| 1986 | | | | 0.11 |
| 1987 | | 1.02 | | 1.21 |
| 1988 | | 1.32 | | 0.79 |
| 1989 | | 2.83 | | 3.13 |
| 1990 | | 5.52 | | 8.63 |
| 1991 | | 1.38 | | 8.88 |
| 1992 | | 0.67 | | 7.42 |
| 1993 | | 0.08 | | 8.05 |
| 1994 | | 0.41 | | 5.80 |
| 1995 | | 1.22 | | 6.37 |
| 1996 | | 2.22 | | |
| 1997 | 6.94 | 17.31 | 1.83 | |
| 1998 | 2.31 | 11.50 | 4.58 | |
| 1999 | 2.80 | 12.50 | | |
| 2000 | 0.27 | 12.28 | | |
| 2001 | | 8.14 | | 1.97 |
| 2002 | 1.03 | 9.90 | 0.22 | 2.51 |
| 2003 | 1.15 | 11.49 | 0.53 | 2.80 |
| 2004 | 0.84 | 12.02 | 0.13 | 8.81 |
| 2005 | 3.11 | 7.43 | 0.56 | 9.64 |
| 2006 | 3.66 | 7.02 | 0.38 | 8.87 |
| 2007 | 3.91 | 7.10 | 1.46 | 8.65 |
| 2008 | 2.20 | 4.30 | | 9.24 |
| 2009 | 2.61 | 5.35 | 0.38 | 11.71 |
| 2010 | 4.73 | 5.01 | 4.00 | 6.84 |
| 2011 | | 2.96 | | |

Length frequency data used for the 2005 CRA 4 assessment (Breen et al. 2006) were in agreement with the data used for this assessment where there was overlap.

Preliminary analyses were performed on the length frequency data from each data source. The proportion of males for the logbook data (Figure 11) showed an increasing trend from 2003 in both seasons, while in the observer data there was little pattern. Mean lengths showed little trend in the observer catch sampling (Figure 12) but showed some decline in AW 1997 and recovery in the logbook data (Figure 13).

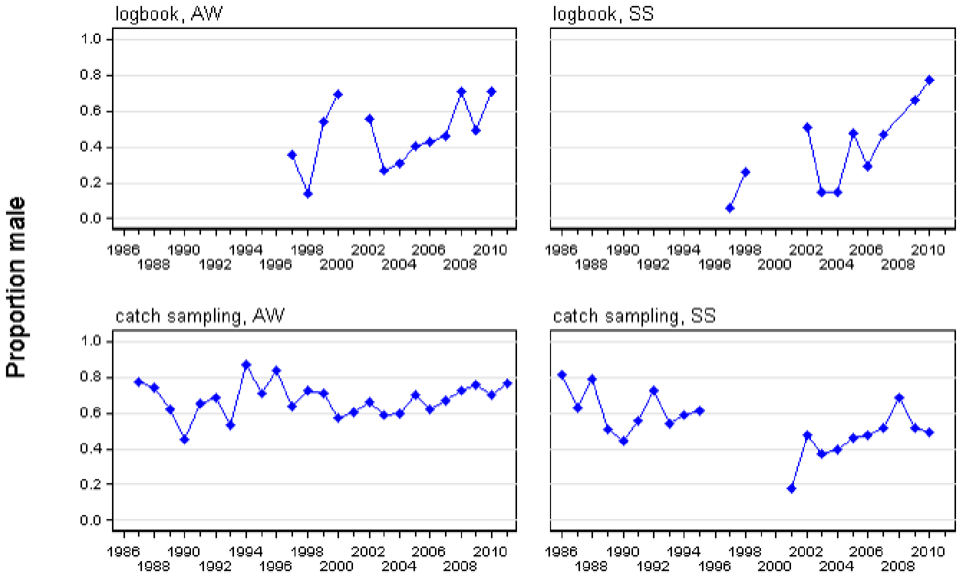



**Figure 11: CRA 4: proportion of males by data source, season and fishing year.**

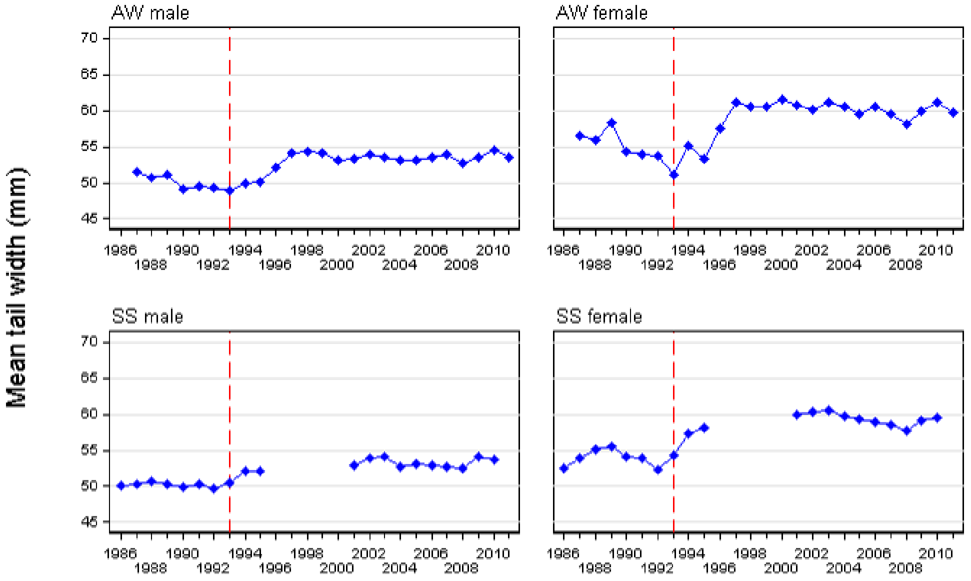



**Figure 12: CRA 4: mean length of measured lobsters from the observer catch sampling; the vertical line indicates the fishing year when escape gap regulations were changed.**

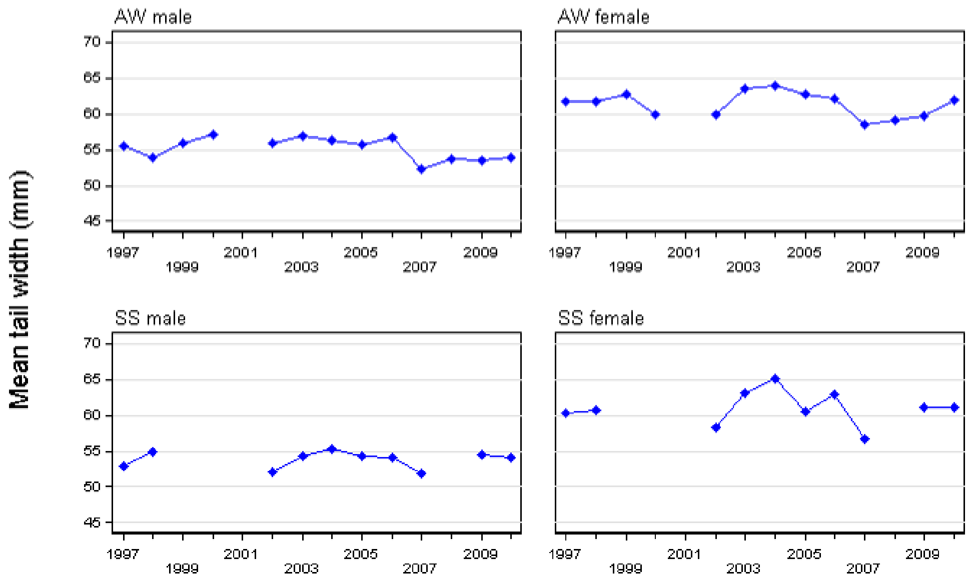



**Figure 13: Mean length of measured lobsters from the CRA 4 logbook program.**

Figure 14 shows the proportions-at-length by sex category for each year/season/data source combination for the catch sampling data and Figure 15 shows the same information for the voluntary logbook data. Proportions-at-length were normalised: they summed to 1 across all sex categories and length bins for each record. Annotations beside each figure show the year and season and the relative weight given to each proportion-at-length data set as described by Starr et al. (2003).

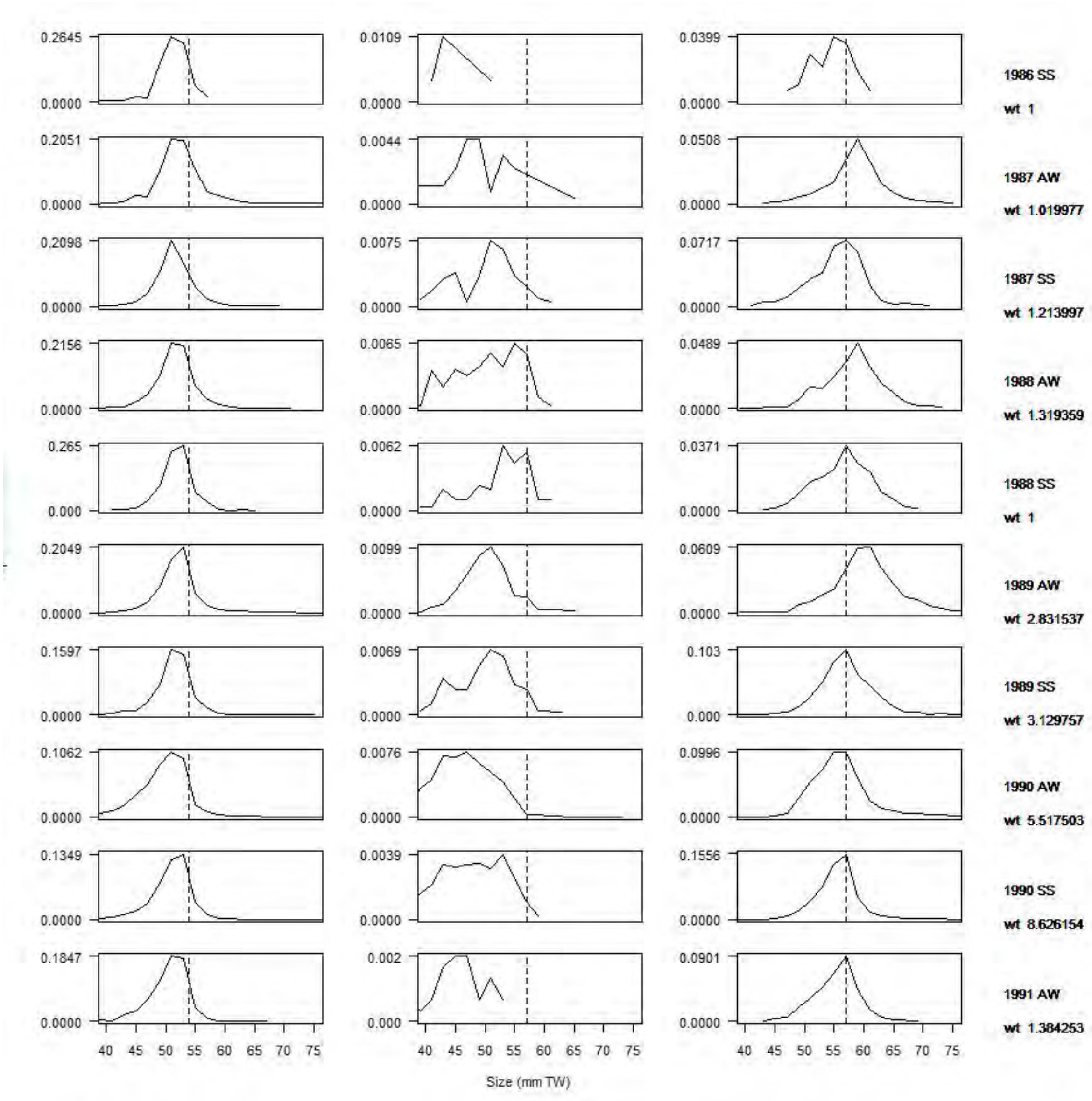



**Figure 14: CRA 4: proportions-at-length from the observer catch sampling: fishing year, season and sample weight are indicated for each sample on the right. Left: males, centre: immature females; right: mature females; note changes in scale among the sex groups.**

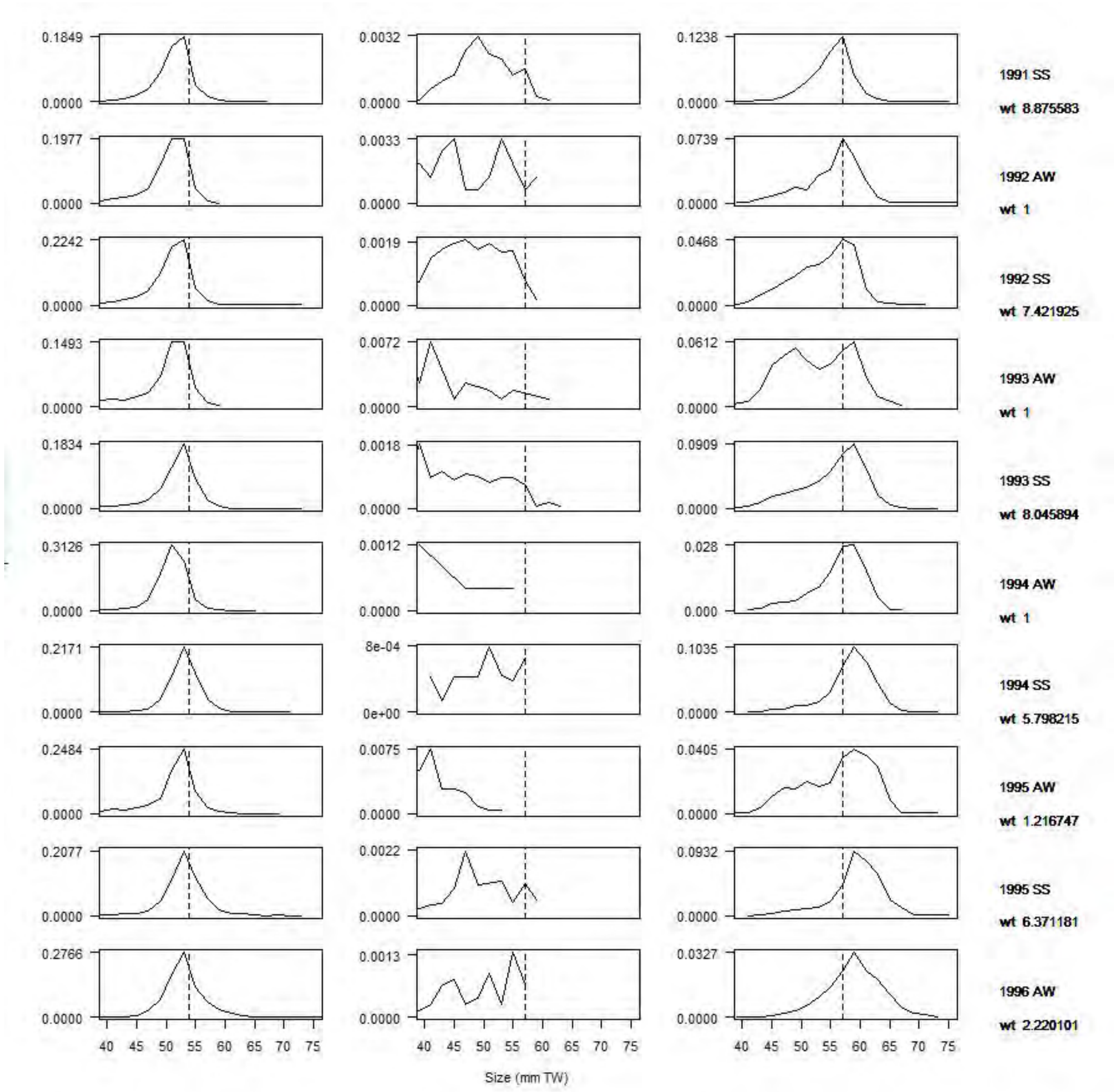



**Figure 14 continued: CRA 4: proportions-at-length from the observer catch sampling.**

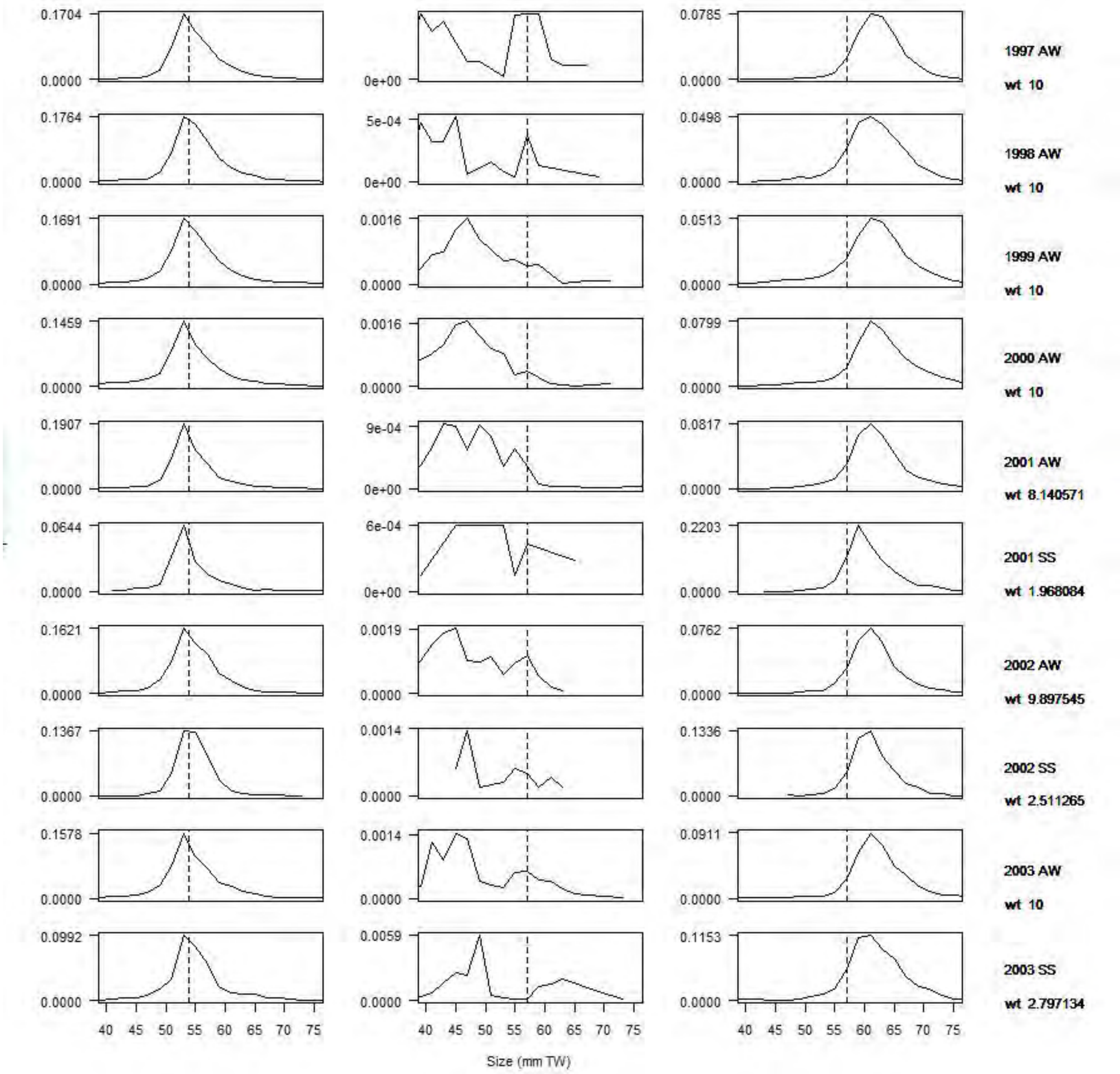



**Figure 14 continued: CRA 4: proportions-at-length from the observer catch sampling.**

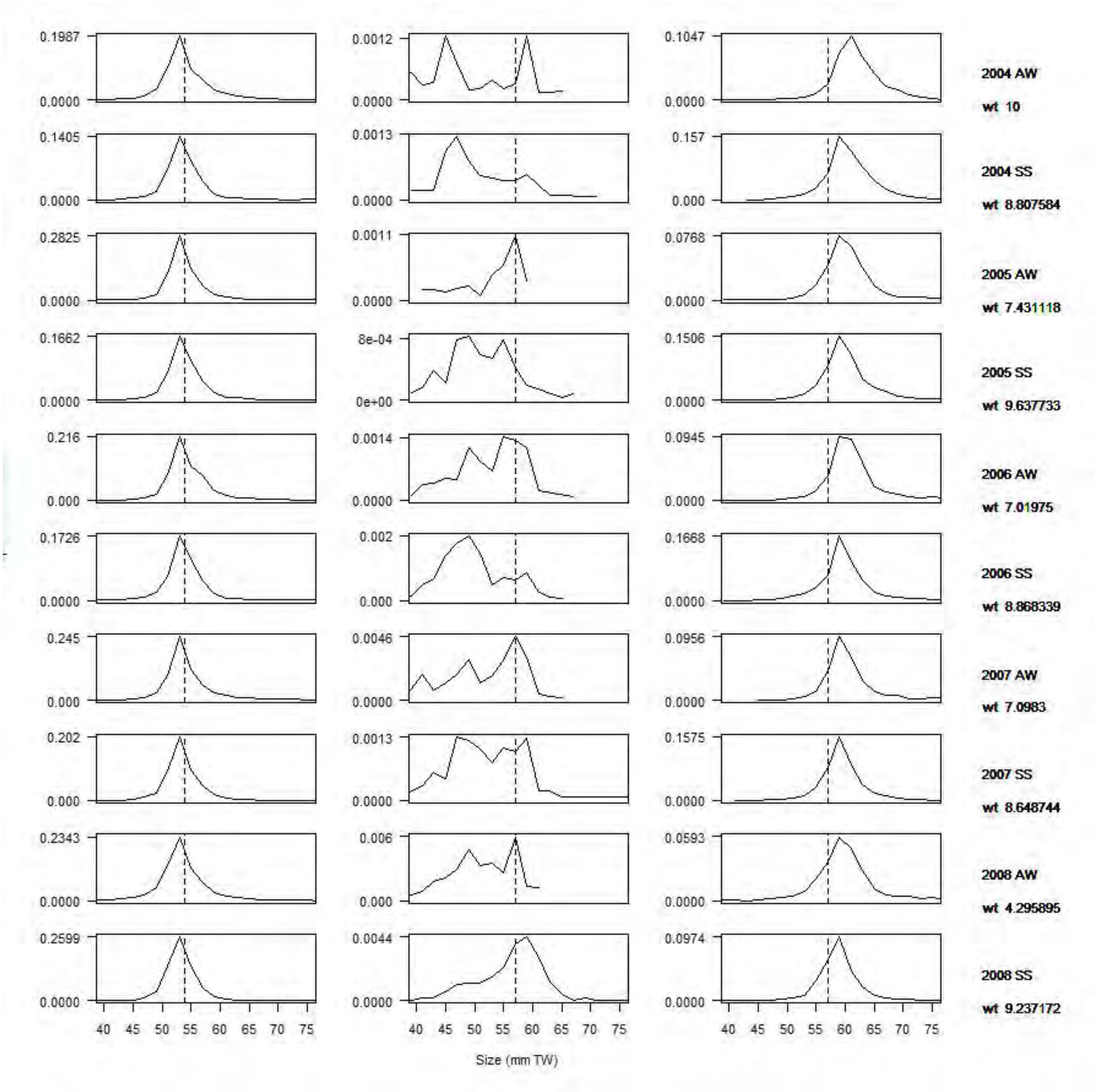



**Figure 14 continued: CRA 4: proportions-at-length from the observer catch sampling.**

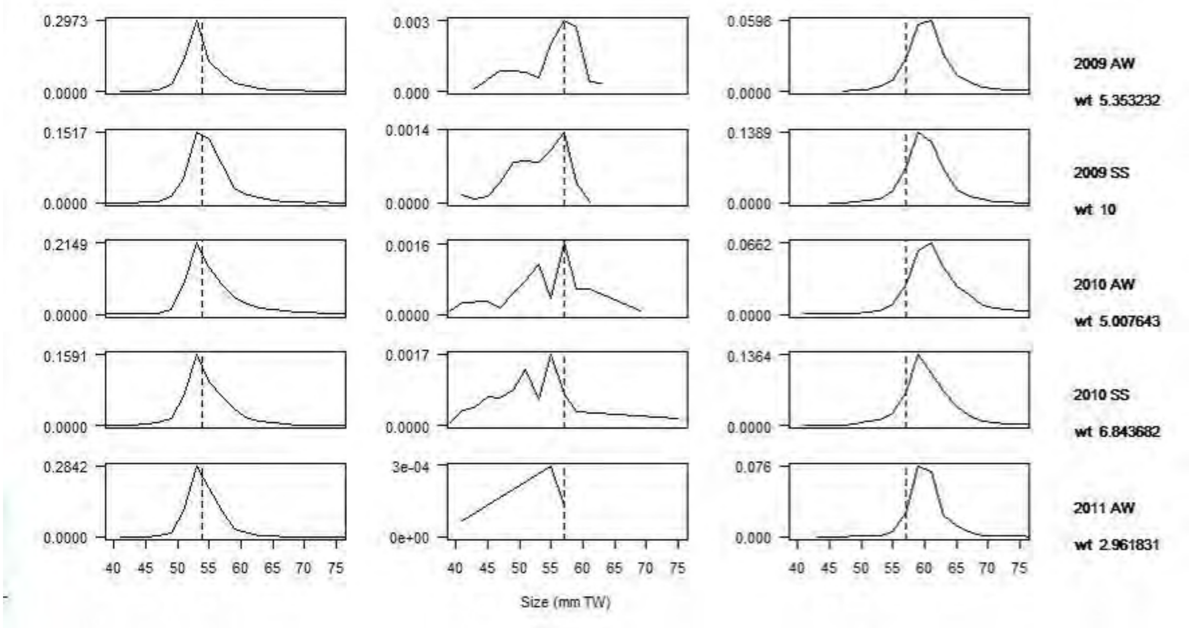



**Figure 14 continued: CRA 4: proportions-at-length from the observer catch sampling.**

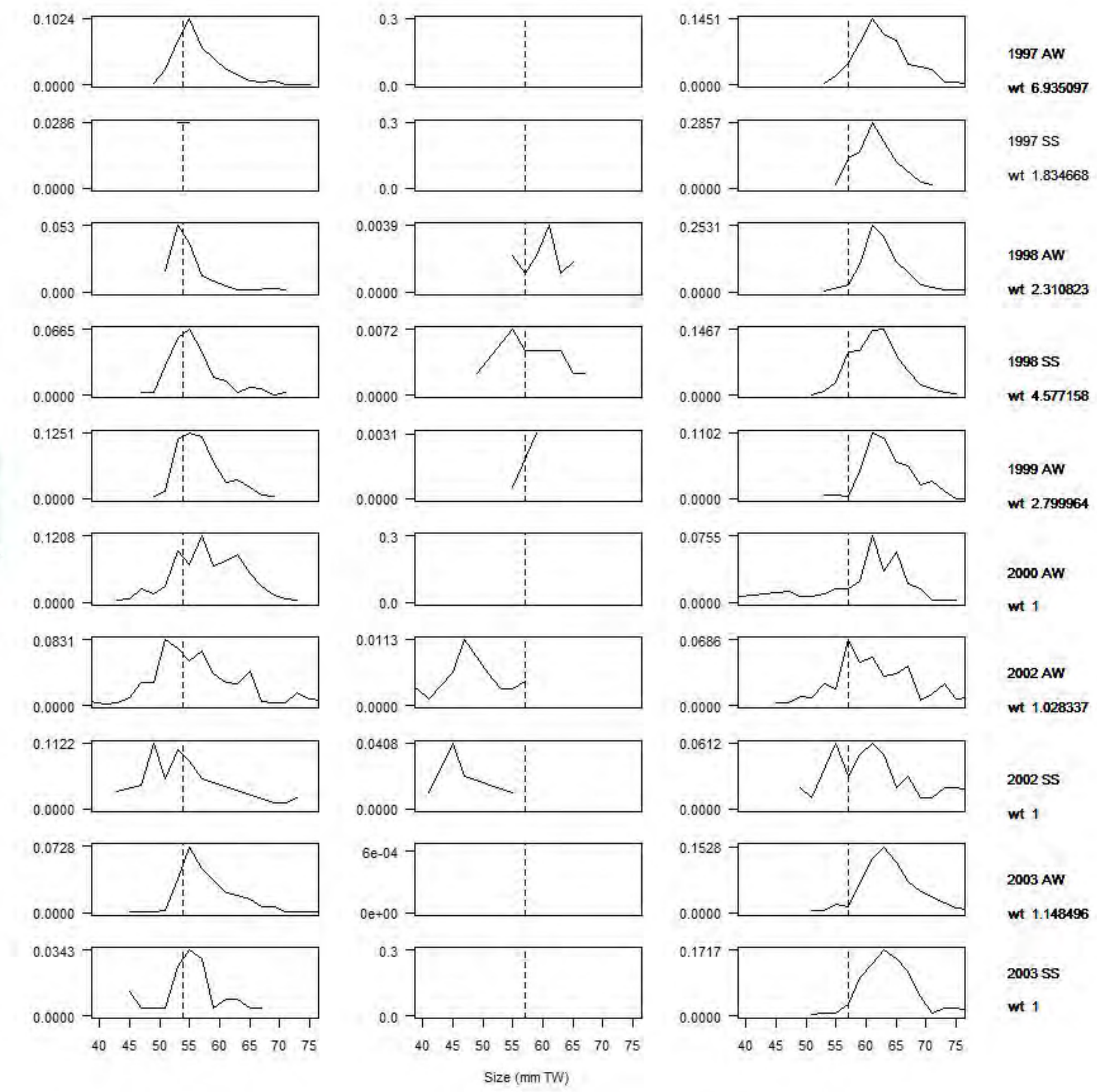



**Figure 15: CRA 4: proportions-at-length from the voluntary logbook catch sampling: fishing year, season and sample weight are indicated for each sample on the right. Left: males, centre: immature females; right: mature females; note changes in scale among the sex groups.**

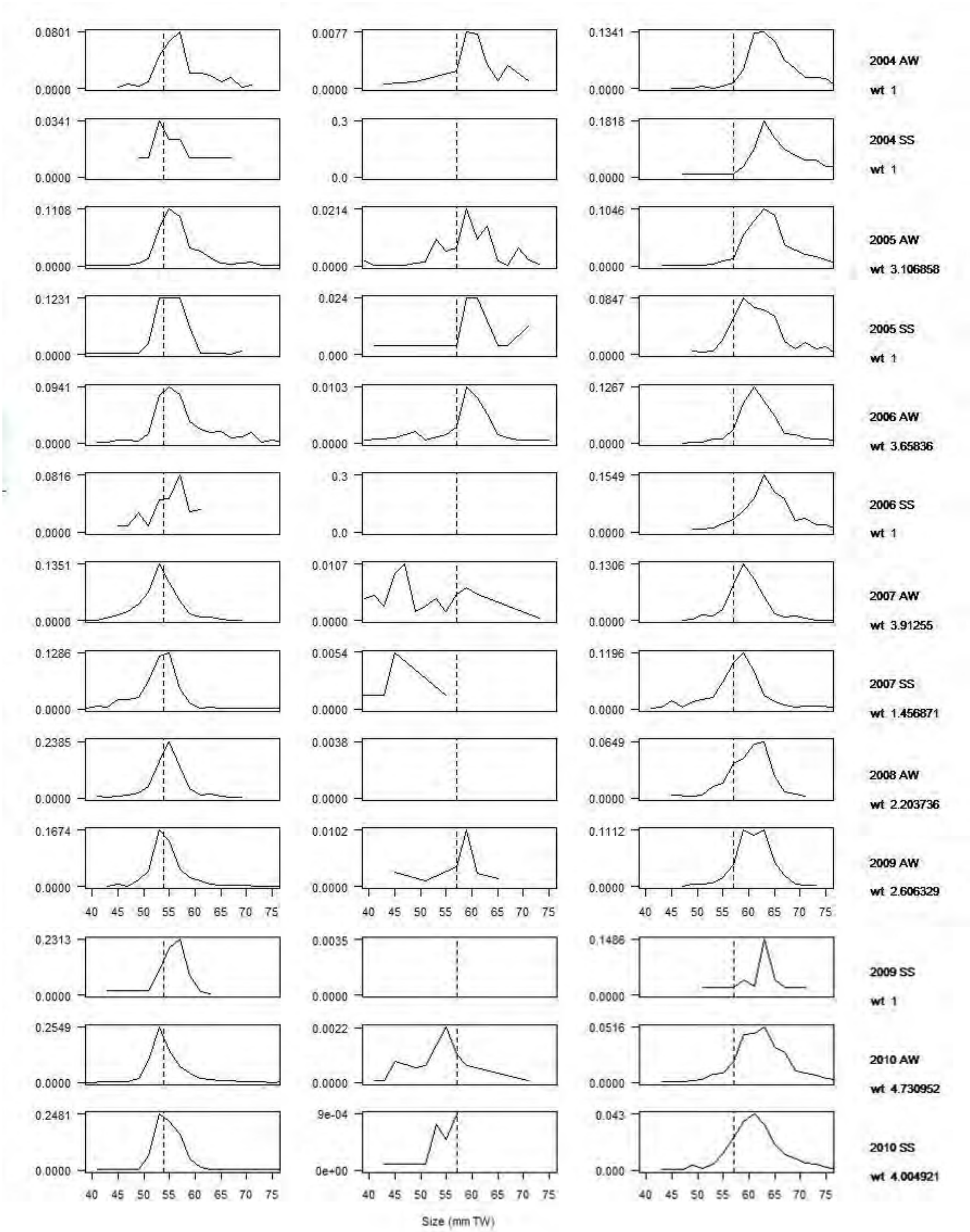


**Figure 15 continued: CRA 4: proportions-at-length from the voluntary logbook catch sampling.**

## 2.4 Puerulus settlement data

Standardised puerulus settlement data were provided to the assessment team by Andy McKenzie of NIWA with MFish permission (*pers. comm.*) (Table 9). Puerulus settlement has been measured since 1979 at sites in Castlepoint and Napier. Each site had at least one group of five collectors that were checked monthly when possible, resulting in a monthly mean catch per group of collectors, which was used to generate a standardised index of settlement (Figure 16, Table 9) by fishing year (Bentley et al. 2004). Groups of collectors used for the CRA 4 standardisation were Napier (001,002,003,004) and Castlepoint (001,002,003). A Wellington site was excluded by NIWA.

Explanatory variables used were fishing year, month, and collector. The "unstandardised" index was the geometric mean of the data for the fishing year. Unstandardised and standardised indices were scaled so that both had geometric means of 1.0.

Recent settlement (Figure 16, Table 9) has been rising, but settlement after 1996 appeared lower than previous settlement: the average from 1979–1996 was 1.26 compared with 0.86 after 1996.

**Table 9: Puerulus settlement indices for CRA 4 by fishing year (Andy McKenzie, NIWA, *pers. comm.*)**

| Year | Unstandardised | Standardised | Upper 97.5% | Lower 2.5% | S.E. |
|---|---|---|---|---|---|
| 1979 | 0.492 | 0.694 | 1.110 | 0.434 | 0.237 |
| 1980 | 0.924 | 1.337 | 1.864 | 0.959 | 0.168 |
| 1981 | 1.271 | 1.922 | 2.574 | 1.435 | 0.148 |
| 1982 | 1.421 | 1.731 | 2.260 | 1.325 | 0.135 |
| 1983 | 1.294 | 1.305 | 1.677 | 1.015 | 0.127 |
| 1984 | 0.612 | 0.656 | 0.897 | 0.480 | 0.158 |
| 1985 | 0.540 | 0.505 | 0.744 | 0.343 | 0.196 |
| 1986 | 0.935 | 0.839 | 1.167 | 0.603 | 0.167 |
| 1987 | 1.937 | 1.583 | 2.056 | 1.219 | 0.132 |
| 1988 | 1.028 | 1.021 | 1.382 | 0.755 | 0.153 |
| 1989 | 1.268 | 1.195 | 1.551 | 0.921 | 0.132 |
| 1990 | 1.201 | 1.132 | 1.467 | 0.873 | 0.131 |
| 1991 | 3.034 | 2.239 | 2.718 | 1.844 | 0.098 |
| 1992 | 2.458 | 2.003 | 2.429 | 1.652 | 0.097 |
| 1993 | 1.355 | 1.205 | 1.479 | 0.982 | 0.104 |
| 1994 | 1.285 | 1.023 | 1.253 | 0.835 | 0.103 |
| 1995 | 1.248 | 0.975 | 1.197 | 0.794 | 0.104 |
| 1996 | 1.741 | 1.363 | 1.655 | 1.123 | 0.098 |
| 1997 | 1.581 | 1.260 | 1.531 | 1.037 | 0.099 |
| 1998 | 1.183 | 0.976 | 1.201 | 0.793 | 0.105 |
| 1999 | 0.324 | 0.349 | 0.459 | 0.266 | 0.138 |
| 2000 | 0.530 | 0.574 | 0.732 | 0.450 | 0.123 |
| 2001 | 0.856 | 0.930 | 1.157 | 0.747 | 0.110 |
| 2002 | 0.861 | 0.914 | 1.138 | 0.734 | 0.111 |
| 2003 | 0.737 | 0.842 | 1.052 | 0.674 | 0.112 |
| 2004 | 0.497 | 0.571 | 0.729 | 0.447 | 0.124 |
| 2005 | 1.067 | 1.177 | 1.451 | 0.955 | 0.106 |
| 2006 | 0.445 | 0.496 | 0.638 | 0.385 | 0.128 |
| 2007 | 0.982 | 1.002 | 1.254 | 0.800 | 0.113 |
| 2008 | 0.797 | 0.814 | 1.023 | 0.648 | 0.115 |
| 2009 | 1.003 | 1.030 | 1.282 | 0.828 | 0.110 |
| 2010 | 1.100 | 1.127 | 1.397 | 0.909 | 0.109 |

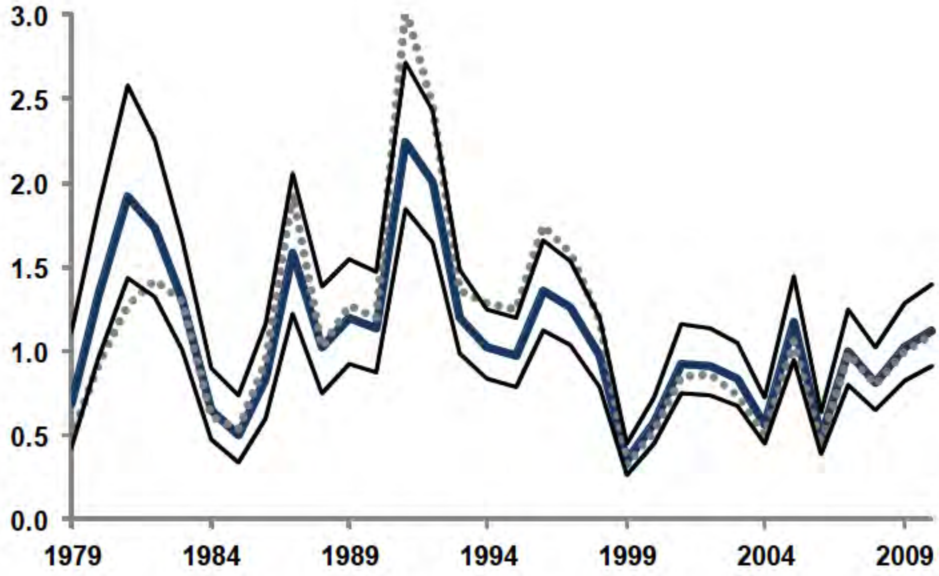



**Figure 16: Standardised CRA 4 puerulus settlement index (heavy central solid line), its 95% confidence bounds (light solid lines), and the unstandardised index (dashed line) (Andy McKenzie, NIWA, *pers. comm.*).**

## 2.5 Tag-recapture data

Data were obtained from the MFish *tag* database, maintained under contract by NIWA (Mackay & Wood 2008). This database was revised and rebuilt in 2007, adding the capacity to track multiple tags on the same fish. Data are grouped into "Projects", categorising releases and recoveries that were associated through a common objective in a single QMA. Every rock lobster release and recapture event was extracted from this database, excluding only "duplicates", which were recoveries of multiple lobsters released from the same "project" on the same day with the same tag type and tag number.

The tagging data were processed by linking identifiable release and recovery "pairs". Multiple recoveries of the same tag number were linked sequentially through an incremented "release" field, where the size of the recovered lobster in the first event became the release size in the following event. Where multiple tags were recovered from the same lobster, the tag with the lowest tag ID number was selected for analysis. Older records had release and recapture lengths in carapace length, which were converted to tail width using the morphometric relation of Breen et al. (1988).

The stock assessment used only those release-recovery pairs that satisfied the following criteria: sex was the same at release and recovery (this excludes recoveries for which the sex is missing), time at liberty was more than 30 days and the apparent change in size (raw increment) was greater than negative 10 mm and less than 40 mm.

The tag release program measures lobsters with a precision of 0.1 mm while industry are instructed to measure recaptures to the nearest 1 mm, rounded down. To correct the bias in the apparent increment, we added 0.5 mm to each return after 1992, on the assumption that it was measured at the lower precision. For CRA 4, the extract delivered 1746 records after the screening described above, 63% more than the 1072 used in 2005 (Breen et al. 2006). There were a number of reasons for this increase. Improved data extraction routines gave more tag recaptures than earlier extracts, additional recaptures were added to the database since 2005, changes to the stock assessment model (Haist et al. 2009) meant that animals released and recaptured in the same season were not automatically excluded, as they had been in 2005, and using robust normal likelihood (Breen et al. 2009) greatly reduced the need for outlier removal.

Table 10 shows the number of records by sex, year and tag type. WRL is the Western Rock Lobster tag, and the HallPrint tag is a much smaller tag similar to the Floy T-bar tag. Two-thirds of the records came from 1998–2000 tagging and about 70% were males. Only 8% of tags were re-captured more than once, with 116 captured twice, 18 three times, four captured four times and two five times. Some summary information is shown in Table 11.

The frequencies of size at release for recaptured lobsters are shown in Figure 17. Few animals were released at less than 50 or more than 70 mm TW. Most females (65%) were released at or above the MLS of 60 mm, but most males (62%) were below the MLS of 54 mm TW. Annualised increments, plotted only for information (the model did not fit these), are shown in Figure 18.

**Table 10: Numbers of CRA 4 tag-recapture records after screening. See text for explanation of tag type codes.**

| Year of release | Male WRL | Male HallPrint | Female WRL | Female HallPrint | Total |
|---|---|---|---|---|---|
| 1982 | 7 | 0 | 2 | 0 | 9 |
| 1998 | 0 | 288 | 0 | 86 | 374 |
| 1999 | 0 | 446 | 0 | 210 | 656 |
| 2000 | 0 | 58 | 0 | 84 | 142 |
| 2001 | 0 | 2 | 0 | 1 | 3 |
| 2002 | 0 | 0 | 0 | 4 | 4 |
| 2003 | 0 | 0 | 0 | 3 | 3 |
| 2004 | 0 | 0 | 0 | 1 | 1 |
| 2005 | 0 | 87 | 0 | 68 | 155 |
| 2006 | 0 | 39 | 0 | 4 | 43 |
| 2007 | 0 | 137 | 0 | 59 | 196 |
| 2008 | 0 | 6 | 0 | 1 | 7 |
| 2009 | 0 | 34 | 0 | 5 | 39 |
| 2010 | 0 | 106 | 0 | 5 | 111 |
| 2011 | 0 | 3 | 0 | 0 | 3 |
| Total | 7 | 1 206 | 2 | 531 | 1 746 |

**Table 11: Summary of the CRA 4 tag-recapture records.**

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | Min | Mean | Max | Min | Mean | Max |
| Year of release | 1982 | 2001.6 | 2011 | 1982 | 2000.9 | 2010 |
| Year of recovery | 1984 | 2002.5 | 2011 | 1984 | 2002.0 | 2011 |
| Days at large | 31 | 249.9 | 1325 | 35 | 398.0 | 2141 |
| TW at release | 39.0 | 53.8 | 75.8 | 40.2 | 62.1 | 98.0 |
| TW at recovery | 41.5 | 55.8 | 77.5 | 44.8 | 64.1 | 99.5 |
| # re-recaptures | 0 | 0.1 | 4 | 0 | 0.1 | 4 |
| Area of release | 912 | 913.4 | 916 | 912 | 914.1 | 916 |
| Area of recapture | 912 | 913.4 | 916 | 912 | 914.2 | 934 |

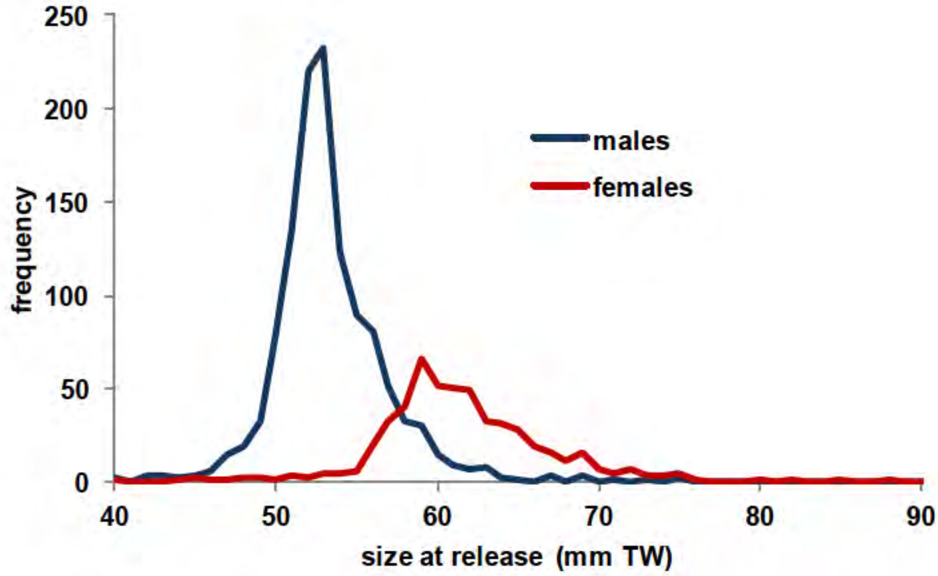
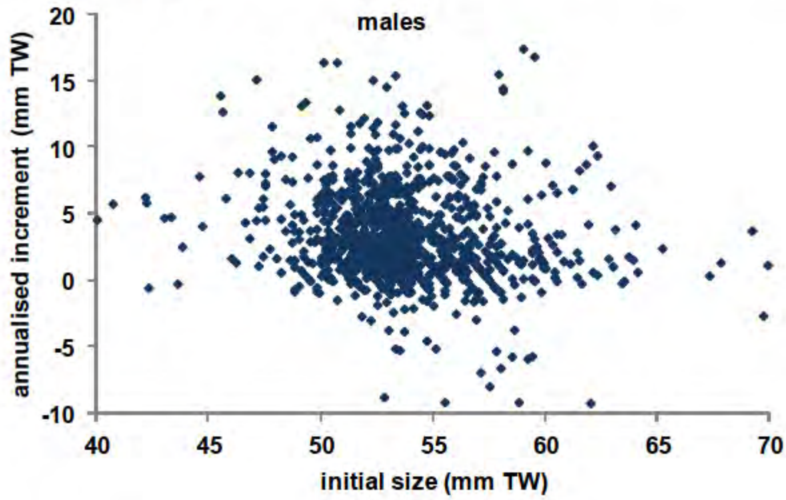



**Figure 17: Tail width frequencies (size at release) from the tag recaptures of males and females from CRA 4.**



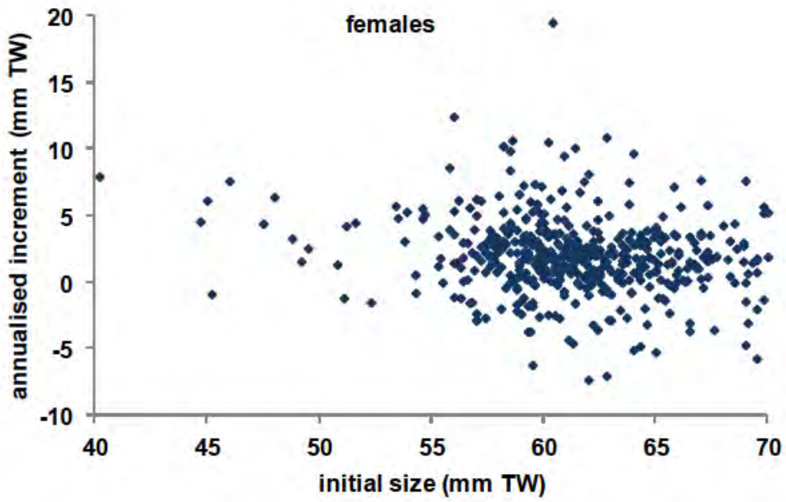




**Figure 18: Annualised CRA 4 tag-recapture increments vs. initial size; the y-axis is truncated at 20 mm.**

Preliminary fits were made using only the tag data in the model likelihood and estimating only the growth parameters. In these, the c.v. parameter and the minimum standard deviation were estimated in some runs and fixed near estimated values in others – the assessment used fixed values for these parameters. Results are shown in Table 12 and growth curves from a plausible pdH fit are shown in Figure 19. Residuals are shown in Figure 20. Residuals are shown plotted against year (using the date at the mid-point between date of release and date of recovery) in Figure 21 to explore the possibility of a recent trend in growth rate over time: there appeared to be no trend. The minimum standard deviation estimate was used for the assessment.

For comparison with CRA 5, a similar process was followed using the CRA 5 data from the 2010 assessment; results are shown in Table 12 and Figure 22. Male growth was slightly slower in CRA 4 than in CRA 5 but female growth was similar.

**Table 12: Exploratory tag-only fits with the CRA 4 tag-recapture data. Little grey cells indicate fixed quantities; boxed cells show explorations with the c.v. and minimum standard deviation parameters. The final column shows comparable estimates from the 2010 CRA 5 data. The first column refers to model parameters and outputs described in Breen et al. (in prep).**

| | | | | | | | CRA 4 | CRA 5 |
|---|---|---|---|---|---|---|---|---|
| Tags-weight | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Tags-sdnr | 1.07 | 1.23 | 1.25 | 1.21 | 1.25 | 1.23 | 1.23 | 1.15 |
| Tags-MAR | 0.57 | 0.64 | 0.66 | 0.63 | 0.65 | 0.65 | 0.64 | 0.65 |
| function value | 3520.3 | 3490.6 | 3482.0 | 3491.7 | 3486.1 | 3482.4 | 3490.6 | 11881.9 |
| *GalphaM* | 3.390 | 3.047 | 3.307 | 3.057 | 3.268 | 3.314 | 3.043 | 3.653 |
| *GbetaM* | 1.059 | 1.592 | 1.126 | 1.493 | 1.154 | 1.123 | 1.630 | 1.849 |
| *GdiffM* | 0.312 | 0.522 | 0.340 | 0.489 | 0.353 | 0.339 | 0.536 | 0.506 |
| *GshapeM* | 5.364 | 5.505 | 5.552 | 5.482 | 5.534 | 5.529 | 5.515 | 6.437 |
| *GrowthCVM* | 0.448 | 0.5* | 0.378 | 0.5* | 0.4* | 0.385 | 0.5* | 0.249 |
| *GalphaF* | 3.277 | 3.549 | 3.356 | 3.609 | 3.619 | 3.365 | 3.533 | 3.509 |
| *GbetaF* | 0.806 | 0.717 | 0.771 | 0.691 | 0.681 | 0.767 | 0.717 | 1.443 |
| *GdiffF* | 0.246 | 0.202 | 0.230 | 0.192 | 0.188 | 0.228 | 0.203 | 0.411 |
| *GshapeF* | 5.162 | 5.397 | 5.311 | 5.358 | 5.407 | 5.299 | 5.406 | 4.620 |
| *GrowthCVF* | 0.729 | 0.5* | 0.594 | 0.5* | 0.4* | 0.597 | 0.5* | 0.447 |
| *StdMin* | 1.5* | 0.911 | 1.055 | 1.05* | 1.092 | 1.1* | 0.9* | 1.2* |
| *StdObs* | 1* | 1* | 1* | 1* | 1* | 1* | 1* | 1* |

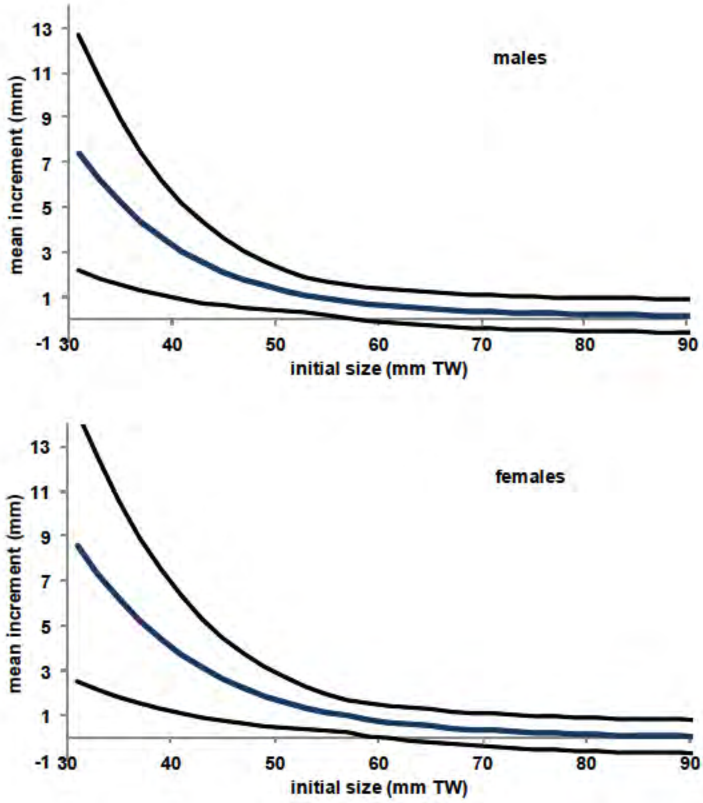



**Figure 19: CRA 4: tag-only growth estimates: the central blue line shows the mean predicted increment-at-length for one time step and the outer black lines show one standard deviation; based on the parameter estimates in Table 12.**

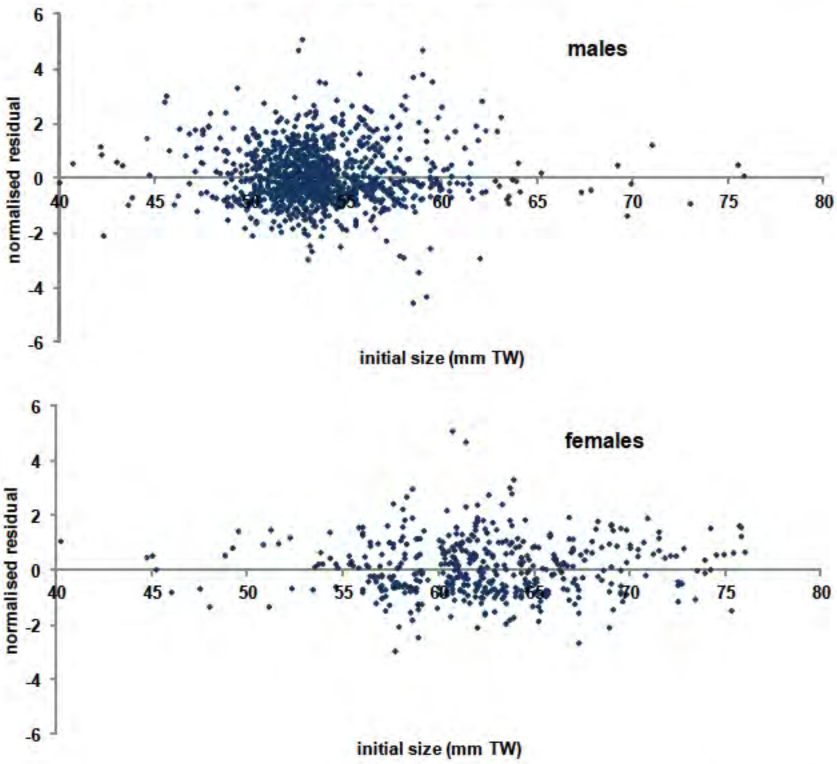



**Figure 20: Residuals from the fit shown in Figure 19; the y-axis was truncated from -6 to 6, which eliminated a few outlying values from the plots.**

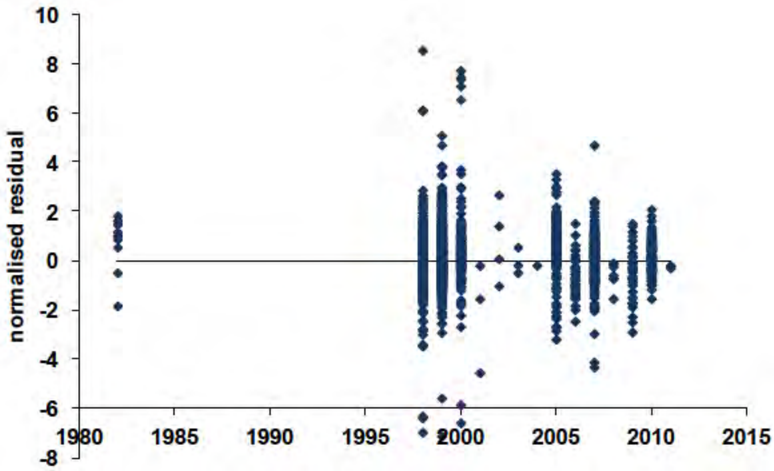



**Figure 21: Normalised residuals from the fit shown in Figure 19 plotted against the year at midpoint of liberty. The horizontal line is zero.**

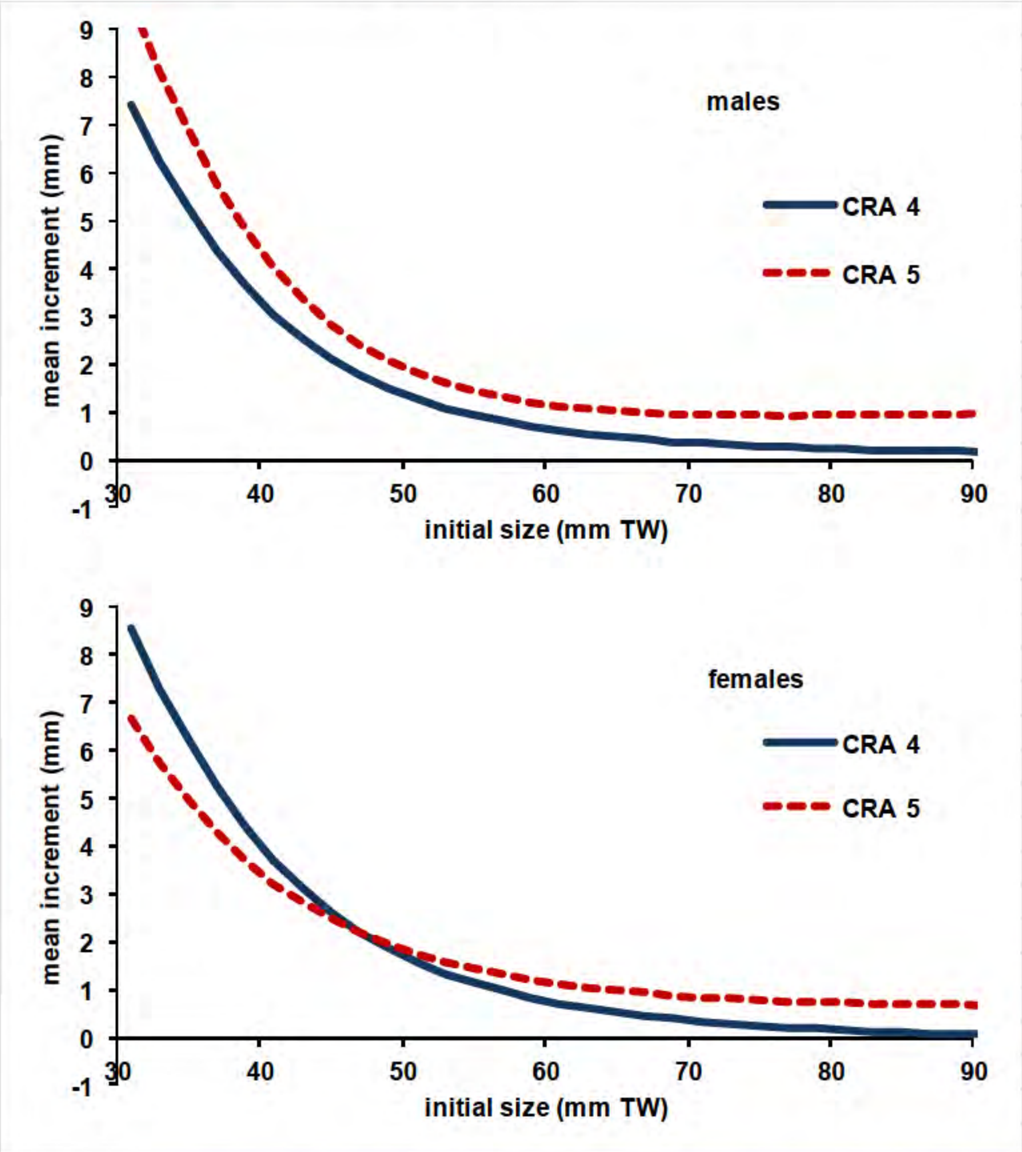



**Figure 22: A comparison of tag-only growth estimates based on data used in 2010 for CRA 5 (red) and 2011 data from CRA 4 (blue): MPD growth parameter estimates are shown in Table 12.**

## 3. ACKNOWLEDGEMENTS

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## APPENDIX A. DOCUMENTATION FOR ANNUAL (1 APRIL–31 MARCH) CPUE ANALYSIS FOR CRA 4

Annual CPUE was used only in the fishery summary for CRA 4 (see Figure 3). This was calculated using data prepared by the B4 algorithm (see Appendix A) as described above for the seasonal CPUE analysis. Index values and associated standard errors are provided in Table A.1. The amount of deviance explained by each model variable is given in Table A.2. Model residuals are shown in Figure A.1. "Influence" plots for the month explanatory variable are provided in Figure A.2 and for the statistical area variable in Figure A.3. A "stepwise" graph, showing the effect on the year variable with the addition of each model explanatory variable, is given in Figure A.4 and the standardised model is shown in Figure A.5.

**Table A.1: Annual CPUE indices calculated from the analysis of CRA 4 catch and potlift data. Arithmetic index: sum(annual catch)/sum(potlifts); unstandardised index: geometric mean of the CPUE observations by year; standardised index: annual index after removal of month and statistical area effects.**

| Fishing year | Arithmetic Index | Unstandardised Index | Standardised Index | Lower Bound | Upper Bound | Standard Error |
|---|---|---|---|---|---|---|
| 1979 | 0.87 | 0.86 | 0.82 | 0.79 | 0.85 | 0.021 |
| 1980 | 0.83 | 0.82 | 0.79 | 0.76 | 0.83 | 0.021 |
| 1981 | 0.83 | 0.86 | 0.85 | 0.81 | 0.88 | 0.021 |
| 1982 | 0.92 | 0.94 | 0.91 | 0.88 | 0.95 | 0.020 |
| 1983 | 0.90 | 0.85 | 0.83 | 0.80 | 0.86 | 0.020 |
| 1984 | 0.77 | 0.77 | 0.76 | 0.73 | 0.79 | 0.020 |
| 1985 | 0.73 | 0.74 | 0.72 | 0.69 | 0.75 | 0.020 |
| 1986 | 0.84 | 0.79 | 0.77 | 0.74 | 0.80 | 0.020 |
| 1987 | 0.73 | 0.69 | 0.67 | 0.64 | 0.70 | 0.021 |
| 1988 | 0.62 | 0.58 | 0.56 | 0.54 | 0.59 | 0.021 |
| 1989 | 0.59 | 0.56 | 0.54 | 0.52 | 0.56 | 0.020 |
| 1990 | 0.50 | 0.51 | 0.50 | 0.48 | 0.52 | 0.021 |
| 1991 | 0.50 | 0.52 | 0.50 | 0.48 | 0.52 | 0.020 |
| 1992 | 0.52 | 0.50 | 0.48 | 0.46 | 0.50 | 0.020 |
| 1993 | 0.58 | 0.56 | 0.54 | 0.51 | 0.56 | 0.021 |
| 1994 | 0.69 | 0.68 | 0.67 | 0.64 | 0.70 | 0.022 |
| 1995 | 0.86 | 0.84 | 0.86 | 0.82 | 0.90 | 0.025 |
| 1996 | 1.03 | 1.08 | 1.18 | 1.12 | 1.25 | 0.028 |
| 1997 | 1.24 | 1.29 | 1.40 | 1.32 | 1.49 | 0.030 |
| 1998 | 1.31 | 1.42 | 1.56 | 1.47 | 1.65 | 0.030 |
| 1999 | 1.27 | 1.34 | 1.47 | 1.39 | 1.55 | 0.029 |
| 2000 | 1.26 | 1.17 | 1.26 | 1.19 | 1.33 | 0.030 |
| 2001 | 1.06 | 1.04 | 1.10 | 1.04 | 1.16 | 0.028 |
| 2002 | 1.09 | 1.13 | 1.19 | 1.13 | 1.25 | 0.027 |
| 2003 | 1.14 | 1.19 | 1.22 | 1.16 | 1.29 | 0.028 |
| 2004 | 1.00 | 0.96 | 0.95 | 0.91 | 1.00 | 0.026 |
| 2005 | 0.88 | 0.83 | 0.82 | 0.78 | 0.87 | 0.027 |
| 2006 | 0.65 | 0.69 | 0.68 | 0.64 | 0.71 | 0.025 |
| 2007 | 0.60 | 0.61 | 0.59 | 0.56 | 0.63 | 0.028 |
| 2008 | 0.71 | 0.74 | 0.71 | 0.66 | 0.75 | 0.033 |
| 2009 | 1.02 | 1.02 | 1.03 | 0.96 | 1.10 | 0.035 |
| 2010 | 0.98 | 1.01 | 1.03 | 0.98 | 1.09 | 0.029 |

**Table A.2: Total deviance ($R^2$) for each variable in the CRA 4 standardised annual CPUE model.**

| Variable | 1 | 2 | 3 |
|---|---|---|---|
| Fishing Year | 0.161 | | |
| Month | 0.050 | 0.236 | |
| Statistical Area | 0.016 | 0.181 | 0.256 |
| Additional deviance explained | 0.000 | 0.075 | 0.020 |

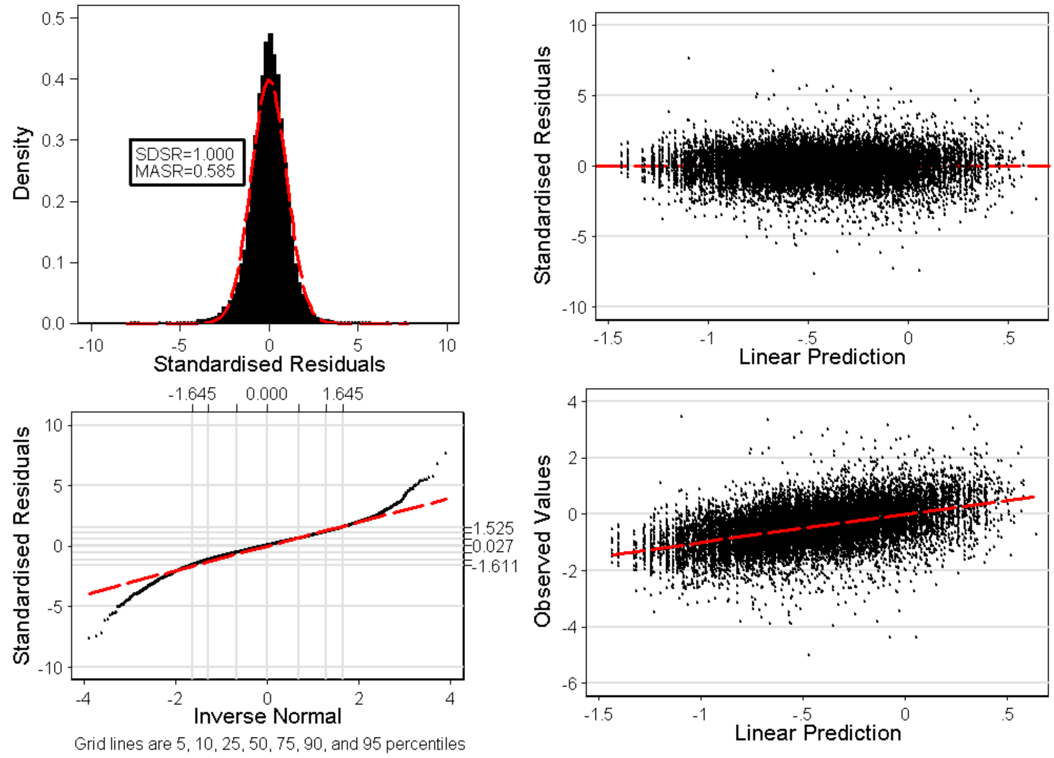


**Figure A.1:** **Standardised residual plots for the CRA 4 standardised annual CPUE analysis.**

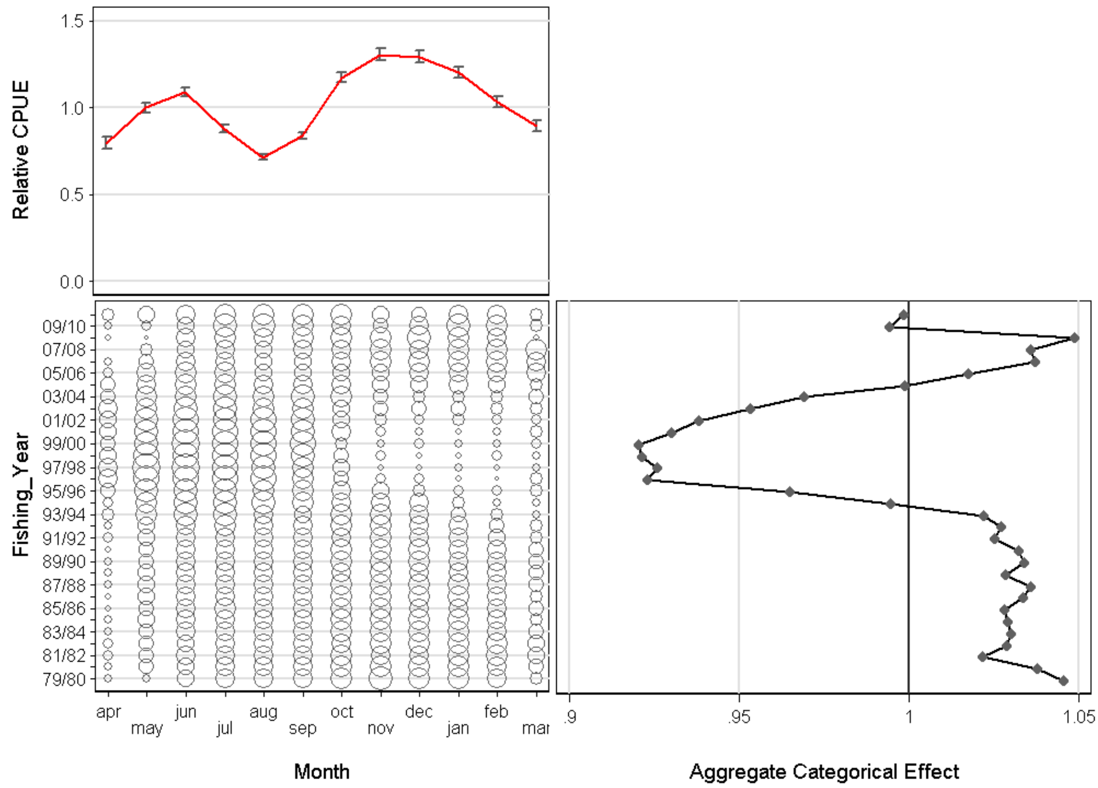


**Figure A.2:** **Effect of the month categorical variable in the annual CRA 4 standardisation: top left: effect by level of variable; bottom left: distribution of variable by year; bottom right: cumulative effect of variable by year.**

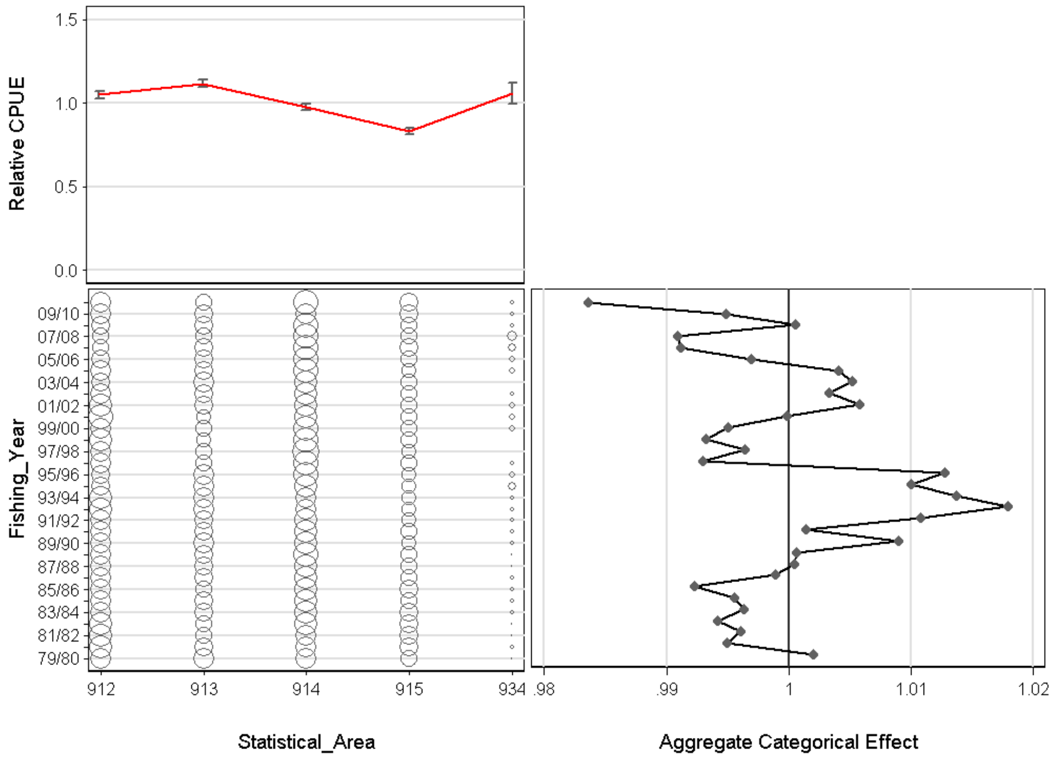


**Figure A.3:** **Effect of the statistical area categorical variable in the annual CRA 4 standardisation: top left: effect by level of variable; bottom left: distribution of variable by year; bottom right: cumulative effect of variable by year.**

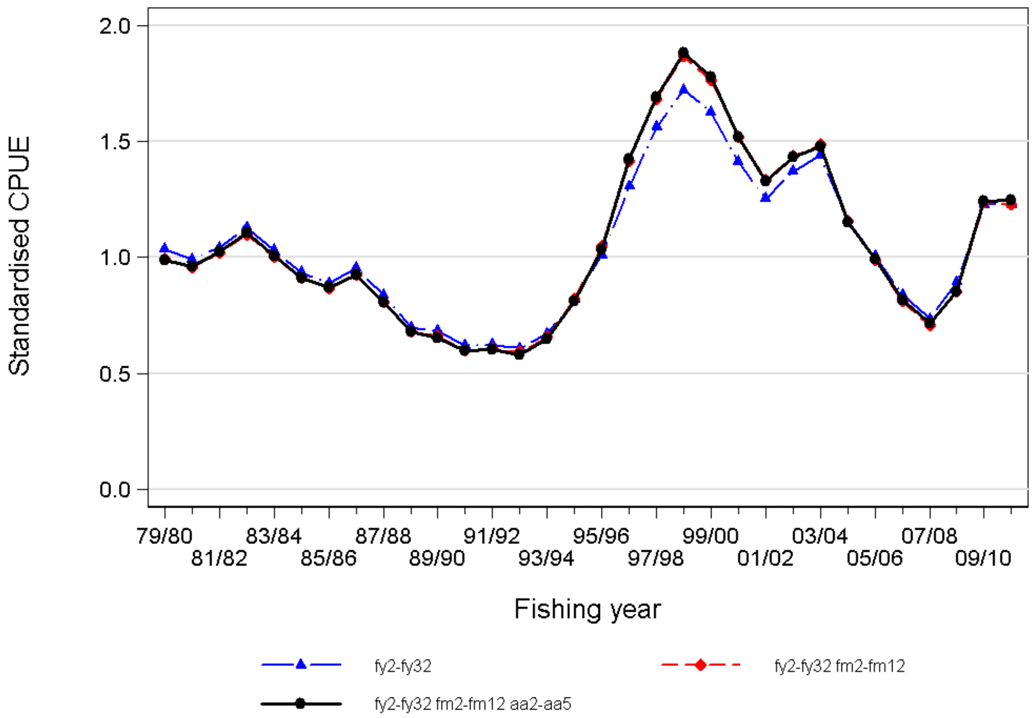


**Figure A.4:** **Stepwise graph showing the effect on the year coefficients from the successive addition of each categorical variable to the annual CRA 4 standardisation. The final model is shown by a thick heavy line.**

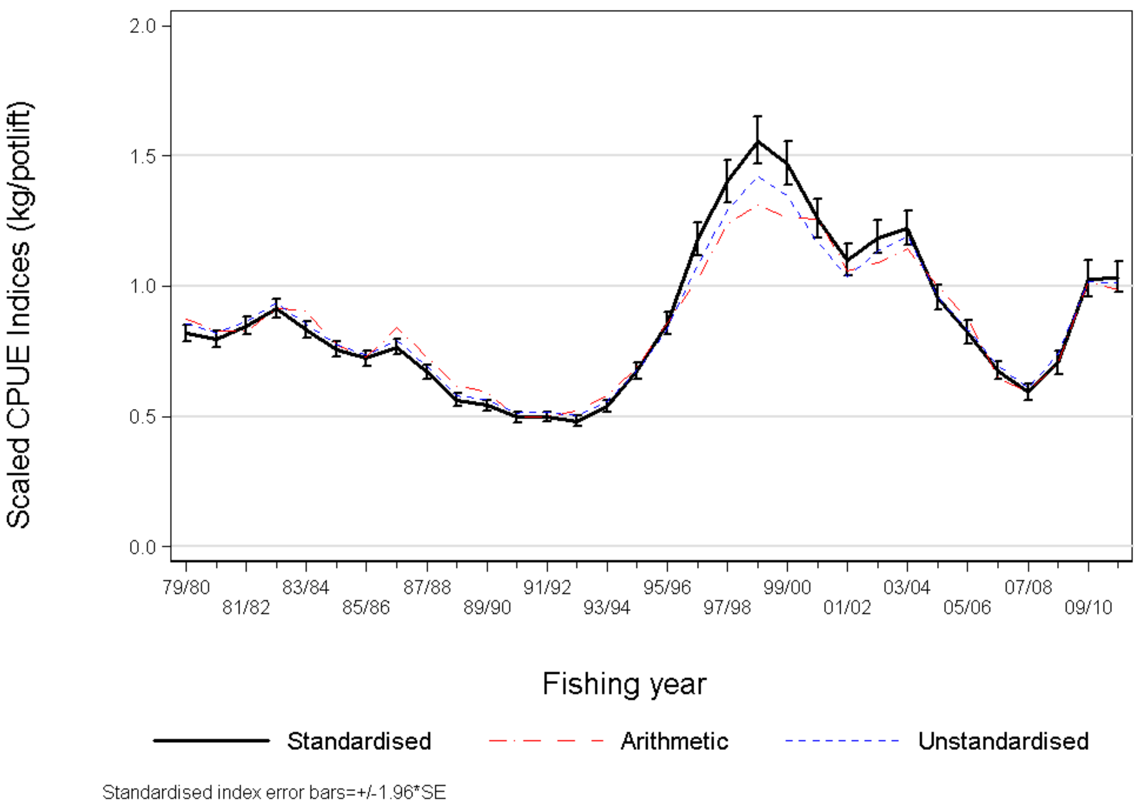


**Figure A.5: Annual CPUE indices for CRA 4: arithmetic (dashed line), unstandardised (dotted line), and standardised (bold line) ± 2 s.e. from 1979–80 to 2010–11. The geometric mean for each series is 0.83 kg/potlift.**

# APPENDIX B. CORRESPONDENCE WITH RESPECT TO NON-COMMERCIAL CATCHES

**NZ ROCK LOBSTER INDUSTRY COUNCIL LTD**

PRIVATE BAG 24-901
WELLINGTON 6142
New Zealand

**Alicia McKinnon**

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

**cc Kevin Sullivan, Chair, RLFAWG**
by email: *Kevin.Sullivan@fish.govt.nz*

April 19th 2011

**Dear Alicia**

As you know, under Objective 4 of the principal research contract CRA2009/01, the stock assessment team will be conducting a CRA 4 stock assessment and management procedure evaluation later this year.

The stock assessment team has access to good data on current and historical commercial catches. However, there are limited data, or almost no data, on the non-commercial catch components, which may be very important in CRA 4. Although some customary permit catches are reported, most are not. In addition, MFish in the past provided estimates of illegal catches, these were highly uncertain and there have been no estimates since 2004. Recreational catches were estimated in 1994-96 and again in 2000-01, but these estimates are neither current, nor wholly credible.

The stock assessment team cannot invent data to use in the stock assessment model; neither can the RLFAWG. The NZ RLIC considers that there is almost no useable information on these non-commercial catches – what is available is outdated and unreliable.

At the same time, the stock assessment cannot ignore the current and historical non-commercial catches: that would cause stock productivity to be greatly underestimated.

**Therefore, in the absence of information, only MFish can solve the problem of how to proceed with a stock assessment. It is up to MFish to specify the non-commercial catches that MFish wishes to be used in the stock assessment. (It is, of course, likely that the RLFAWG will request sensitivity analyses that should be done on alternatives to the base case non-commercial catch vectors, but the base case <u>must</u> be provided by MFish.)**

- For **illegal catch**, the assessment team needs to know the MFish estimates of current CRA 4 catch and the historical trend. Illegal catch includes reliable estimates of all unreported removals as well as catch landed illegally (for example, berried, unmeasureable, under-sized, in excess of bag limits etc). To assign illegal catch to the appropriate catch components in the stock assessment model, the assessment team needs to know the proportion of the estimated illegal catch that is reported to the QMS. Otherwise, if commercial fishermen report scrubbed females or other illegal fish to an LFR, the catch is double-counted. The assessment team would also like an appreciation of the uncertainty in the MFish illegal catch estimates.

- For **customary catch**, the requirements are similar: the assessment team requires the MFish estimate of the current customary catch in CRA 4 and their historical trends. The assessment team would also like an appreciation of the uncertainty in the MFish customary catch estimates.

- For **recreational catches**, the assessment team requires the MFish estimates of current and historical recreational catches and an appreciation of the uncertainty in the MFish recreational catch estimates.

Without these estimates from MFish it will not be possible to produce a credible CRA 4 stock assessment. For the stock assessment to proceed on schedule, the MFish estimates are required by 15 August 2011.

Can you please confirm your understanding of this written request and also advise likely delivery dates for the catch estimates as required for the CRA 4 assessment. To assist the task I will be happy to answer any queries you may have.

Yours sincerely,

NZ Rock Lobster Industry Council Ltd

*Daryl Sykes*

Executive Officer.

Ministry of
**Fisheries**
Te Tautiaki i nga tini a Tangaroa

New Zealand Government

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12 August 2011

Daryl Sykes
NZ Rock Lobster Industry Council Ltd
By email: lobster@seafood.co.nz

Dear Daryl

Thank you for your letter dated 19 April 2011 regarding rock lobster non-commercial harvest information for the upcoming CRA 4 stock assessment and management procedure evaluations.

The Ministry of Fisheries (the Ministry) considers that accurate and reliable rock lobster harvest information from all sectors is essential to stock assessment, management procedure development and fishery management decision-making processes. However, unlike commercial catch information, information on non-commercial harvest is currently incomplete and generally highly uncertain.

Outlined below is a summary of what the Ministry considers the best available information on non-commercial harvest information for the CRA 4 fishery.

**CRA 4 Illegal Catch Estimates**

*Current Estimate*

The most recent estimate of illegal catch for CRA 4 was produced for the 2004-05 fishing year. This estimate is equal to 40 tonnes and consists of 10 tonnes for "reported" catch and 30 tonnes for "non-reported" catch. The es timate cannot be verified and is subject to high levels of uncertainty.

The Ministry does not have the ability to update the CRA 4 illegal catch estimate at this time. The methodology that was used to produce the 40 tonne illegal catch estimate was rudimentary in nature and needs to be revised. To address this issue, the Ministry has recently contracted a research provider to undertake a project to explore the development of a reliable, robust and defensible methodology to estimate illegal take in selected New Zealand fisheries. The CRA 3 (Gisborne) rock lobster fishery is being used as a case study. It is hoped in future that the methodology developed under this project can be applied to other rock lobster fisheries.

*Historical Estimates*

Historical estimates of CRA 4 illegal catches have been supplied to the Rock Lobster Fisheries Assessment Working Group on several occasions from 1990-91 to 2004-05. These estimates are outlined in the November 2010 Rock Lobster Fishery Assessment Plenary Report. There has been no additional information which would give the Ministry's Field Operations Business Group a reason to amend the values supplied previously, but as noted above, these figures cannot be verified and are therefore considered highly uncertain.

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Anecdotal evidence from the Ministry's Field Operations staff suggests there may have been a downward trend in CRA 4 illegal extractions, from people within all sectors, in recent years. Information that provides an indication of this downward trend includes prosecutions, observed activities, intelligence and intangible anecdotal knowledge.

**CRA 4 Customary Catch Estimates**

Information on the quantity of rock lobsters harvested under customary fishing permits or authorisations is currently incomplete. Although reporting requirements exist under the customary fishing regulations, the framework for collecting and storing this information is still being implemented in some areas.

A substantial proportion of the CRA 4 fishery is covered by the Fisheries (Kaimoana) Regulations 1998 (refer Attachment 1). The Kaimoana Regulations require the appointment of tangata kaitiaki (guardians) who then authorise and manage customary harvest. Tangata kaitiaki are responsible for providing quarterly reports to the Ministry.

The following table provides a summary of information the Ministry holds on the quantity of CRA 4 rock lobster harvested under the Kaimoana Regulations:

| | Actual quantity of CRA 4 rock lobsters harvested under the Kaimoana Regulations (expressed in numbers) | | | | |
|---|---|---|---|---|---|
| **Calendar Year** | **Jan-Mar** | **Apr-Jun** | **Jul-Sep** | **Oct-Dec** | **Total** |
| **2003** | 2238 | 900 | 590 | 2673 | 6401 |
| **2004** | 1181 | 951 | 1161 | 2300 | 5593 |
| **2005** | 1688 | 1349 | 457 | 1595 | 5089 |
| **2006** | 1963 | 384 | 360 | 1870 | 4577 |
| **2007** | 1535 | 450 | 990 | 3184 | 6159 |
| **2008** | 4421 | 671 | 850 | 3914 | 9856 |
| **2009** | 5612 | 2451 | 1641 | 2525 | 12229 |
| **2010** | 944 | 1334 | 70 | 923 | 3271 |

Where tangata kaitaiki have not been appointed, harvest of shellfish species for the purpose of hui or tangi can be undertaken in accordance with regulation 27A of the Fisheries (Amateur Fishing) Regulations 1986. There is no requirement for regulation 27A permit issuers to provide the Ministry with details of customary fishing authorisations.

The Ministry has very little regulation 27A information available for the CRA 4 fishery. Information from the east coast area of the CRA 4 fishery shows 510 rock lobsters were gathered under the amateur regulations in 2009 and 1520 were gathered in 2010. No regulation 27A information is currently available for the southern and western areas of CRA 4.

**CRA 4 Recreational Catch Estimates**

The Ministry considers the best available information of current and historical recreational harvest estimates from CRA 4 are those derived from regional and national telephone and diary surveys. However, these estimates are highly uncertain given challenges with the sampling methodology.

The Ministry notes a number of research initiatives are underway to improve information on recreational harvest for rock lobster fisheries. This research includes the large-scale multi-species survey of recreational harvest that will commence in October 2011. Also, specific onsite surveys, like the one underway in the CRA 2 fishery, may be applied to other rock lobster stocks in the future (subject to Ministry prioritisation).

**Additional Matters**

*CRA 4 Stock Assessment and Management Procedure Performance Indicators*

The performance indicators that the Ministry proposes are used in the 2011 CRA 4 stock assessment and management procedure development are outlined in Attachment 2. The indicators listed are those that were used in the last year's CRA 5 stock assessment/management procedure development with the addition of spawning stock biomass indicators (as requested at last years' Plenary meeting).

*The form of the revised CRA 4 Management Procedure*

The Ministry requests that a TAC rule is developed for the CRA 4 fishery this year, instead of a TACC rule. A TAC rule will ensure an appropriate TAC is set for the CRA 4 fishery in accordance with the Minister's statutory obligations under the Fisheries Act 1996.

If you should any questions on the information supplied, please do not hesitate to contact me: alicia.mckinnon@fish.govt.nz or 06 831 0279.

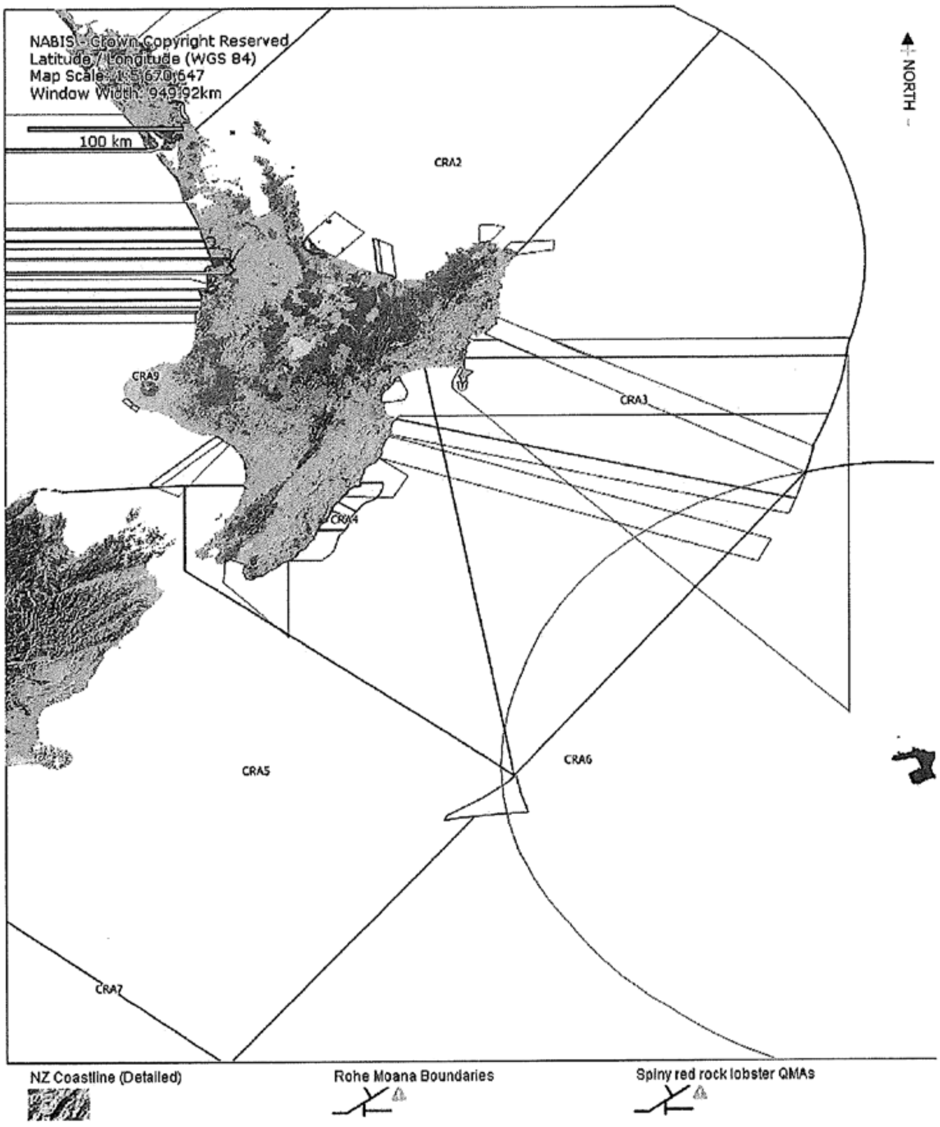
Kind regards

AMcKinnon

Alicia McKinnon
**Ministry of Fisheries**

**Attachment 1:**

**Customary Areas (Rohe Moana) gazetted under the Fisheries (Kaimoana) Regulations 1998**




This map is intended to be used as a guide only, in conjunction with other data sources and methods, and should only be used for the purpose for which it was developed. Although the information on this map has been prepared with care and in good faith, no guarantee is given that the information is complete, accurate or up-to-date.

Ministry of Fisheries

Date: 1 August 2011

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**Attachment 2:**

**A) Proposed reference points, performance indicators and probabilities for the 2011 CRA 4 Stock Assessment**

| | |
|---|---|
| **Reference Points** | |
| *Bmin* | The lowest beginning AW vulnerable biomass in the series |
| *Bcurrent* | Beginning of season AW vulnerable biomass for the year the stock assessment is performed |
| *Bref* | Beginning of season mean vulnerable biomass for an agreed historical reference period |
| *Bproj* | Projected beginning of season AW vulnerable biomass (ie, the year of stock assessment plus 4 years) |
| *Bmsy* | Beginning of season AW vulnerable biomass associated with *MSY*, calculated by doing deterministic forward projections with recruitment *R0* and current fishing patterns |
| *MSY* | Maximum sustainable yield (sum of AW and SS SL catches) found by searching a across a range of multipliers on F |
| *Fmult* | The multiplier that produced *MSY* |
| **CPUE Indicators** | |
| *CPUEcurrent* | CPUE at *Bcurrent* |
| *CPUEproj* | CPUE at *Bproj* |
| *CPUEmsy* | CPUE at *Bmsy* |
| **Performance Indicators** | |
| *Bcurrent / Bmin* | Ratio of *Bcurrent* to *Bmin* |
| *Bcurrent / Bref* | Ratio of *Bcurrent* to *Bref* |
| *Bcurrent / Bmsy* | Ratio of *Bcurrent* to *Bmsy* |
| *Bproj / Bcurrent* | Ratio of *Bproj* to *Bcurrent* |
| *Bproj / Bref* | Ratio of *Bproj* to *Bref* |
| *Bproj /Bmsy* | Ratio of *Bproj* to *Bmsy* |
| *USLcurrent* | The current exploitation rate for SL catch in AW |
| *USLproj* | Projected exploitation rate for SL catch in AW |
| *USLproj / USLcurrent* | Ration of SL projected exploitation rate to current SL exploitation rate |
| **Probabilities** | |
| P(*Bcurrent>Bmin*) | Probability *Bcurrent>Bmin* |
| P(*Bcurrent>Bref*) | Probability *Bcurrent>Bref* |
| P(*Bcurrent>Bmsy*) | Probability *Bcurrent>Bmsy* |
| P(*Bproj>Bmin*) | Probability *Bproj>Bmin* |
| P(*Bproj>Bref*) | Probability *Bproj>Bref* |
| P(*Bproj>Bmsy*) | Probability *Bproj>Bmsy* |
| P(*Bproj>Bcurrent*) | Probability *Bproj>Bcurrent* |
| P(USLproj>USLcurrent) | Probability SL exploitation rate *proj* > SL exploitation rate *current* |
| P(*SSBcurrent<0.2 SSBO*) | Soft limit: probability *SSBcurrent* < 20% *SSB0* |
| P(*SSBproj<0.2 SSBO*) | Soft limit: probability *SSBproj* < 20% *SSB0* |
| P(*SSBcurrent<0.1 SSBO*) | Hard limit: probability *SSBcurrent* < 10% *SSB0* |
| P(*SSBproj<0.1 SSBO*) | Hard limit: probability *SSBproj* < 10% *SSB0* |

## B) Proposed indicators for the 2011 CRA 4 Management Procedure Evaluations

- mean biomass during the 20-year run, scaled as a proportion of *Bref*
- the difference between minimum and maximum biomass during the run
- terminal biomass, scaled as a proportion of *Bref*
- minimum commercial catch during the run
- mean commercial catch during the run
- mean total catch during the run
- the mean commercial catch during the first five years of the run
- minimum recreational catch during the run
- mean recreational catch during the run
- minimum observed offset-year CPUE during the run
- mean observed offset-year CPUE during the run
- average annual variation in TACC during the run
- projected biomass as a proportion of *Bmsy*
- CPUE in AW of the last projected year
- the proportion of years in which observed offset-year CPUE exceeded 2.4 kg/pot
- the proportion of years in which biomass was less than *Bref*
- the proportion of years in which biomass was less than *Bmin*
- the proportion of years in which biomass was less than *Bmsy*
- the proportion of years in which TACC changed
- the proportion of years in which SSB was less than 20% *SSB0*
- the proportion of years in which SSB was less than 10% *SSB0*
- the proportion of years in which biomass was less than *Bref* in year 5
- the proportion of years in which biomass was less than *Bref* in year 10
- the proportion of years in which biomass was less than *Bref* in year 20
- predicted AW CPUE in year 5
- predicted AW CPUE in year 10
- predicted AW CPUE in year 20

## APPENDIX C. THE "B4" ALGORITHM

Bentley et al. (2005) briefly described the "B4" algorithm, but did not provide a detailed description of the method. Steps 1 to 6 describe this algorithm, using Eq.1 to Eq.5 as required. This algorithm is performed on records where the error code is one or less (Bentley et al. 2005). There are seven active error fields in CRACE: three in the [*landings*] table and two each in the [*fishing_event*] and [*estimated_subcatch*] tables.

**Step 1**: aggregate all landings by vessel (*i*) and month (*m*) within a year (*y*):

**Eq. 1**
$$L_{imy} = \sum_{g=1}^{n_{imy}^{l}} L_{giy}$$

where $L_{giy}$ = landed weight in record *g* for vessel *i* in month *m* and year *y*; there are $n_{imy}^{l}$ such records;

$L_{giy}$ can be composed of "L" or "L+F+X" destination codes.

**Step 2**:

A. Create a list of vessels $V_{my}$ that are active in month (*m*) within a year, based on the [*fishing event*] table.

B. if $L_{V_{my}my} = 0$ then $L_{V_{(m+1)y}(m+1)y} = 0$

note that the pointer array $V_{my}$ evaluates to a vessel subscript *i*.

**Step 3**: aggregate all estimated catch weight by vessel (*i*) and month (*m*) within a year (*y*):

**Eq. 2**
$$C_{imy} = \sum_{h=1}^{n_{imy}^{c}} C_{hiy}$$

where $C_{hiy}$ = estimated catch weight in record *h* for vessel *i* in month *m* and year *y*; there are $n_{imy}^{c}$ such records;

**Step 4**: aggregate all estimated catch weight and potlifts by vessel (*i*), month (*m*) and statistical area (*a*) within a year (*y*):

**Eq. 3**
$$C_{iamy} = \sum_{j=1}^{n_{iamy}^{c}} C_{jiy}$$

where $C_{jiy}$ = estimated catch weight in record *j* for vessel *i* in month *m*, statistical area (*a*) and year *y*; there are $n_{iamy}^{c}$ such records;

**Eq. 4**
$$P_{iamy} = \sum_{j=1}^{n_{iamy}^{c}} P_{jiy}$$

where $P_{jiy}$ = number potlifts in record *j* for vessel *i* in month *m*, statistical area (*a*) and year *y*; there are $n_{iamy}^{c}$ such records;

**Step 5**: estimate landed catch weight by vessel (*i*), month (*m*) and statistical area (*a*) within a fishing year (*y*):

**Eq. 5**
$$\hat{L}_{iamy} = \frac{C_{iamy}}{C_{imy}} L_{imy}$$

where $\hat{L}_{imay}$ = estimated landed weight in area *a* for vessel *i* in month *m* and year *y*;

note that $\hat{L}_{imay} = 0$ for the month/vessel strata identified in Step 2

**Step 6**: obtain the QMA $\left(Q^{c}_{iamy}\right)$ based on the statistical area in stratum *iamy* (use associations in Table C.1).

**Table C.1: Assignment table for QMAs derived from rock lobster statistical areas.**

| QMA | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| CRA 1 | 901 | 902 | 903 | 904 | 939 | | |
| CRA 2 | 905[1] | 906 | 907 | 908 | | | |
| CRA 3 | 909[1] | 910 | 911 | | | | |
| CRA 4 | 912 | 913 | 914 | 915 | 934 | | |
| CRA 5 | 916 | 917 | 918 | 919 | 932 | 933 | |
| CRA 6 | 940 | 941 | 942 | 943 | | | |
| CRA 7 | 920 | 921 | | | | | |
| CRA 8 | 922[1] | 923 | 924 | 925 | 926 | 927 | 928 |
| CRA 9 | 929[1] | 930 | 931 | 935 | 936 | 937 | 938 |

[1] straddling statistical area: the assignment rules in this table ignore this status

Note: nominal arithmetic CPUE $\left(I_{iamy}\right)$ in stratum *iamy* is (this is not part of the B4 algorithm):

Eq. 6 $$I_{iamy} = \frac{\hat{L}_{iamy}}{P_{iamy}}$$