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Standardised CPUE analysis exploration: using the rock lobster voluntary logbook and observer catch sampling programmes

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EXECUTIVE SUMMARY

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Standardised CPUE indices derived from catch and effort data from the commercial potting fishery are routinely used to represent rock lobster abundance in stock assessments. However, the amount of detailed data available to undertake these standardisations is limited by the design of the compulsory CELR data collection system, which does not collect data by individual potlift. Instead, the data are collected on a daily basis, summarised over a large number of potlifts (often in excess of 100). Two programmes that collect data at the level of individual potlifts are available: the rock lobster voluntary logbook programme (started in 1993) and the rock lobster observer catch sampling programme (started in 1987). Data from these programmes, using the higher level of resolution accompanied by a larger number of available explanatory variables, were tested using models equivalent to those used to analyse the commercial catch/effort data.

The explanatory power of the available variables was examined for each QMA with a sufficiently long time series of data. The resulting time series of annual abundance indices were compared by QMA with alternative formulations of the data and with the equivalent time series obtained from the commercial catch/effort data. The primary conclusion of these analyses was that the underlying signal in these data is similar regardless of the level of data stratification or the suite of available explanatory variables. Trajectories of abundance indices may differ if the input data are altered (for instance, if the dependent variable changes from legal catch to total catch) or if there are sampling effects. But representative data analysed in a consistent manner result in similar trajectories. Another outcome of this work is the conclusion that more detailed data collection from these fisheries may not result in a corresponding improvement in the quality of the abundance indices obtained from these data.

1. INTRODUCTION

CPUE indices derived from catch and effort data from the commercial potting fishery have been used to track rock lobster abundance since the 1980s (Breen 1988). Standardisation procedures using general linear models have been applied to commercial catch/effort data collected by MFish since the early 1990s (Maunder & Starr 1995). However, the amount of detailed data available to undertake these standardisations is limited by the design of the compulsory MFish data collection systems, which do not collect data by individual potlift. Instead, these data are collected on a daily or monthly basis, consequently summarised over a large number of potlifts and obscuring much of the detail and variability.

Maunder & Starr (1995) examined standardising data from FSU and CELR records to obtain indices of abundance. They found that vessel effects were small and suggested that a standardisation based on year, month, and area was adequate. This conclusion was based on the observation that the standardised models differed little from the unstandardised models, with most of the available factors having little explanatory power. One problem with their analysis was that it was dominated by data from the FSU system, which had a relatively large amount of missing vessel information. Their analysis was also limited by the small set of available explanatory variables and only covered the period 1979–80 to 1992–93.

The level of detail required to be reported by each operator to the existing FSU and CELR catch and effort data collection systems creates an important limitation to what can be done with these data. The FSU data were collected on a monthly basis, with each fisherman asked to report his total daily catch and effort within the month. However, examination of the FSU data revealed that many fishermen often provided their daily effort, while reporting a monthly catch total. This resulted in many false zero observations and necessitated amalgamating the data to the level of a month to avoid losing significant amounts of data. The CELR data appear to be consistently reported on a daily basis, with each fisherman reporting his total daily catch and effort within a statistical area. However, this still represents a loss of detail relative to the true level of effort, which is at the level of an individual potlift. The level of amalgamation represented in the FSU and CELR data collection requirements has meant that detailed information, such as the depth of each pot, the location of the pot, the type of pot and the bait used, is lost, as well as the information from the catch in each pot.

Objective 6 ("*To review future CPUE data requirements*") of the Ministry of Fisheries (MFish) contract CRA2009-01A was commissioned to look in detail at the available information from rock lobster sampling programmes with the intent of making recommendations for future directions of analysis and data capture. This objective contemplated using existing fine-scale sampling programmes to investigate the effect of using a range of alternative explanatory variables and different levels of record level stratification to "*..improve the explanatory power of the models used and improve the use of CPUE as indices of abundance..*". It was envisioned that "*...if any additional factors are found to strongly influence CPUE data, these should be incorporated into the forms used to capture catch and effort data by the fleet so that these effects can be standardised in the global analysis..*".

The sub-objectives of this study are:

1. *Investigate factors available in current fine-scale rock lobster sampling programmes for their relative explanatory effect in CPUE analyses.*
2. *Investigate the effect of record level stratification, looking at the impact on the CPUE indices resulting from amalgamating potlift information to a daily or monthly level.*
3. *Make recommendations for future CPUE analysis, including possible changes to existing data collection requirements, based on these investigations.*

Two programmes, which collect data at the level of individual potlifts, have been in operation in New Zealand since the mid-1980s. One of these programme uses dedicated observers placed on lobster fishing boats to measure and record every lobster that comes on board. This programme has been in place since the mid-1980s and is characterised by a large amount of data from a relatively small number of vessels. The other programme is a voluntary logbook project where individual fishermen measure every lobster from four designated pots, a subset of their daily effort. This project has been in place since June 1993 and is characterised by a smaller number of measurements per vessel but from a larger group of fishermen.

The Rock Lobster Observer Catch Sampling Programme (RLCS) was begun in early 1987 by scientists working for the then Ministry of Agriculture and Fisheries (MAF) to provide biological samples from the rock lobster potting fisheries. Before that , there were sporadic sampling events, but this programme instituted a systematic, design-based system. The extent of this programme has varied between years, but currently it is the primary source of biological information for CRA 1, CRA 3, CRA 4, and CRA 7 (with the RLLB providing samples for most of the remaining QMAs). From 1987 through 2010–11, the RLCS has operated in eight of the nine of the rock lobster QMAs (only one sample was taken from CRA 9 in 2001), sampled from 355 vessels, logged over 310,000 potlifts and measured about 1.45 million lobsters.

In 1993, the New Zealand Fishing Industry Board (NZFIB) established a voluntary logbook programme for the rock lobster fishery. That programme was taken over by the Rock Lobster Industry Council (NZ RLIC Ltd.) and the relevant local QMA stakeholder groups in the mid-1990s, once these groups became established. This programme is the primary source for biological information for CRA 2, CRA 5 and CRA 8, with incipient programmes in CRA 4, CRA 6 and CRA 9. From 1993 through 2010–11, the RLLB has operated in all nine of the rock lobster QMAs (although participation in CRA 1 and CRA 7 has been minimal) and has involved 259 participants, logged over 230,000 potlifts and measured over 1.1 million lobsters.

The analyses in this report will investigate the use of additional explanatory variables in standardised CPUE analyses, using detailed data collected at the level of an individual potlift by the RLLB and the RLCS. It will then look at the effect on the standardised indices of combining potlifts to a daily or monthly level of amalgamation. This report uses data from the RLLB from 25 June 1993 (the first date in the *rllb*) and from the RLCS from 22 January 1987 (the first date in the *rlcs*), through to 31 March 2011. These data are used to estimate standardised and unstandardised CPUE, based on a data set distinct from the primary MFish compulsory catch/effort data collection system, to investigate the behaviour of models using a wider range of explanatory variables than are available in the MPI CELR catch/effort data and at different levels of data amalgamation.

Appendix A provides definitions of common acronyms and abbreviations used in this document.

2. DESCRIPTION OF THE DESIGN OF THE DATA COLLECTION PROGRAMMES

2.1 Design of the voluntary logbook programme (RLLB)

This voluntary scheme selects its participants non-randomly. In areas where the programme operates, all fishermen, regardless of the scale or type of their fishing activities, are encouraged to participate in the programme, with the intent of gaining the participation of as many operators as possible. Each participant is asked to sample the entire catch from four selected pots, every time that they are hauled. These four pots, selected from the hundred or so pots that each fisherman uses, are meant to be representative of the remaining pots.

Each time a designated pot is lifted, the depth, soak time, the number of octopus and other predators and the number of dead lobsters are recorded as well as the tail width, sex and maturity (of female lobsters) of each lobster . Using specially modified callipers, tail width is measured across segment two of the abdomen, rounded down to the nearest millimetre.

The design caps the number of lobsters that are measured in any single potlift. Initially this number was 31 (regardless of the size or maturity status of the measured lobster) because of the configuration of the form and the number of rows which could be easily fit on a single page (Table 1). Later, when the form was redesigned in 1998, this number was reduced to 25. Additional lobsters beyond the cap limit are recorded in two categories, those above the size limit (MLS) and those below. This categorisation is meant to be independent of the legal status of the individual. For example, a female that is above the female size limit for the area but which can not be landed because it is carrying eggs (berried) is to be included in the 'excess above' category.

2.2 Data available from the RLLB

The following data fields are available from the RLLB (Walker & Mackay 2002):

Field Name	Available	Comments
TripNumber	Every record	designated [*trip*] in this report
FisherID	Every record	designated [*skipper*] in this report
VesselRegistrationNumber	Every record	coded [*vessel*] in this report
Date	Every record	
StatArea	Every record	designated [*statistical area*] in this report
subarea	1993–94 to 1999–00	Stopped after 1999–2000
PotLiftNumber	Every record	
Latitude	Started in 2003–04	Incomplete in all years except 2010–11
Longitude	Started in 2003–04	Incomplete in all years except 2010–11
Zone	Started in 2000–01	Incomplete in all years except 2000–01 to 2002–03
SoakHours	Every record	designated [*soak_time*] in this report (only a few records missing)
DepthMetres	Every record	designated [*depth*] in this report (only a few records missing)
LiveAbove		Assume filled out correctly
LiveBelow		Assume filled out correctly
DeadAbove	Started in 2000–01	
DeadBelow	Started in 2000–01	
Sex	Every record	Assume filled out correctly
Length (tail width)	Every record	Assume filled out correctly
Kept	Started in 2000–01	Assume filled out inconsistently
Legal	Every record	Assume filled out correctly (berried and spent females not legal)

This programme collected some data on the configuration of the pots used for sampling. However, these data are known to be incomplete and were not available in the *rllb* database. These data were collected only once, under the assumption that the pot configuration would remain consistent over time.

2.3 Design of the observer catch sampling programme (RLCS)

The RLCS design is based on placing independent observers on a vessel to record information from a full day of fishing, measuring and recording the entire lobster catch from every potlift. The median number of pots observed in one day by QMA has ranged from 70 (CRA 7) to 89 (CRA 3) (Table 2). There is relatively little variation in the daily effort, with the upper 95th quantiles exceeding the median by only a small margin in all QMAs (Table 2).

For each day of fishing, samplers recorded statistical area, weather information, skipper and vessel, and for each potlift they recorded depth, presence/absence of escape gaps, predators, soak time and the total lobsters caught . Two additional potlift fields have potential as explanatory factors for CPUE: the type of bait used and a code describing the configuration of the pot. The range of factors that are recorded by observers for these fields are presented for [*bait*] in Appendix B and for [*pot type*] in Appendix C. The count of legal lobsters and their estimated weight is recorded for the entire day of fishing, but this information was not used because these data were not recorded consistently for every potlift.

Observers measure every lobster in a pot to avoid any selection process. They are allowed to skip entire pots when measuring another pot and in danger of slowing down the operation of the vessel. Data recorded for each pot included [*depth*], [*bait*] and [po*t type*], as well as the total count of lobsters captured (without regard to legal status) in a field called [*caught*] for the skipped pots. For the pots with measurements, there was a tail width taken for every lobster (rounded down to 0.1 mm bins), with the sex and the maturity status (if female) recorded. A count of the number of damaged limbs was also made for each measured lobster.

Only data from the catch sampling (coded CS or CT) programme were used in this analysis, taken from commercial pots using the appropriate escape gaps at the time of fishing (escape gap code=1). Data collected with wired-up escape gaps (escape gap code=0) were not used.

2.4 Data available from the RLCS

The following data fields are available from the RLCS (Mackay & George 2002):

Field Name	Comments
sample_no	unique sample number: not used (same as [*trip*] in *rllb*)
skipper	skipper's name: designated [*skipper*] in this report
vessel	vessel registration number: coded [*vessel*] in this report
date_s	date of fishing
area	rock lobster statistical area: designated [*statistical area*] in this report
effort_no	sequential number for effort within a sample
bait	descriptor code for bait used (see Appendix B for codes)
pot_type	descriptor code for pot design (see Appendix C for codes)
latitude	not populated
longitude	not populated
soak	designated [*soak_time*] in this report (only a few records missing)
depth	designated [*depth*] in this report (only a few records missing)
caught	count of captured lobster, without regard to legal status
no_legal	count of legal lobster taken (missing in >80% of potlifts)
legal_wt	estimate of weight of legal lobster taken (missing in >80% of potlifts)
sex	assume accurate
tail_width	in mm (assume accurate)

3. ANALYTICAL METHODS

3.1 Estimation of annual indices of CPUE

Arithmetic, unstandardised, and standardised indices of annual CPUE (Maunder & Starr 1995, Bentley et al. 2005, Starr 2011) were calculated using data available in the *rllb* and *rlcs*, based on several definitions for what constitutes a single record *i*. Arithmetic CPUE $\left(\hat{A}_y\right)$ by QMA in year *y* was calculated as the total catch for the year divided by the total effort (number of potlifts or hours) in the year:

Eq. 1 $$\hat{A}_y = \frac{\sum_{i=1}^{n_y} C_{i,y}}{\sum_{i=1}^{n_y} E_{i,y}}$$

where $C_{i,y}$ is the [*catch*] and $E_{i,y} = P_{i,y}$ ([*potlifts*]) or $E_{i,y} = S_{i,y}$ ([*soak_time*] in hours) for record *i* in year *y*, and n_y is the number of records in year *y*.

Unstandardised CPUE $\left(\hat{G}_y\right)$ for a QMA in year *y* is the geometric mean of the ratio of catch to effort for each record *i* in year *y*:

Eq. 2 $$\hat{G}_y = \exp\left[\frac{\sum_{i=1}^{n_y} \ln\left(C_{i,y} \big/ E_{i,y}\right)}{n_y}\right]$$

where C_i, $E_{i,y}$ and n_y are as defined for Eq. 1. Unstandardised CPUE has the same log-normal distributional assumption as the standardised CPUE, but does not take into account changes in the seasonal and spatial distribution of fishing effort. This index is the same as the "year index" calculated by the standardisation procedure when not using additional explanatory variables. Presenting the arithmetic and unstandardised CPUE indices in this report provides measures of how much the standardisation procedure has modified the series from these two sets of indices.

Standardised CPUE (Eq. 3) is calculated from a generalised linear model (GLM) (Maunder & Starr 1995) by QMA using a range of explanatory variables including [*fishing year*], [*month*], and [*statistical area*] by assuming a lognormal error distribution:

Eq. 3 $$\ln(I_i) = B + Y_{y_i} + \alpha_{a_i} + \beta_{b_i} + ... + f(\chi_i) + f(\delta_i) .... + \varepsilon_i$$

where $I_i = C_i / E_i$ (where $E_i = P_i$ [*potlifts*] or $E_i = S_i$ [*soak_time*]) for the i^{th} record, Y_{y_i} is the year coefficient for the year corresponding to the i^{th} record, α_{a_i} and β_{b_i} are the coefficients for factorial variables *a* and *b* corresponding to the i^{th} record, and $f(\chi_i)$ and $f(\delta_i)$ are polynomial functions (to the 3rd order) of the continuous variables χ_i and δ_i corresponding to the i^{th} record, *B* is the intercept and ε_i is an error term. The actual number of factorial and continuous explanatory variables in each model depends on the model selection criteria.

The definition of record level *i* varies with the data being analysed at one of three levels of stratification:

- potlift stratification: *i* represents data by [*potlift*], which is the base level of effort data collection in the *rllb* or *rlcs*;
- trip stratification: *i* represents data summarised by [*trip*], which is the daily effort by a vessel within a statistical area;
- month stratification: *i* represents data summarised to the level of [*vessel*], [*month*], and [*statistical area*], which is the level of amalgamation used in the CPUE analyses based on the MFish catch/effort data (Starr 2011).

Canonical coefficients and standard errors were calculated for each categorical variable (Francis 1999). Standardised analyses typically set one of the coefficients to 1.0 without an error term and estimate the remaining coefficients and the associated error relative to the fixed coefficient. This is required because of parameter confounding. The Francis (1999) procedure rescales all coefficients so that the geometric mean of the coefficients is equal to 1.0 and calculates a standard error for each coefficient, including the fixed coefficient. For comparability, the normalised unstandardised CPUE and the canonical standardised coefficients are multiplied by the geometric mean of the arithmetic CPUE index (Eq. 1) so that all three sets of indices are scaled to the same mean in terms of kg/potlift.

The procedure described by Eq. 3 is necessarily confined to the positive catch observations in the data set because the logarithm of zero is undefined. Observations with zero catch can be handled in a number of ways:

A. Zero catch records are frequently dropped, but this would not be appropriate with the data from either the RLCS or the RLLB because they constitute valid observations. The amalgamated data described above (month and trip stratification) implicitly include effort with zero catch because all effort data will be included in the summarisation. Consequently, the analyses which use individual potlifts as data records must also include these observations or else the comparisons between analyses will be biased.

B. A small increment can be added to the zero catch records so that the logarithm can be calculated. This is not a satisfactory solution because model parameter estimates are sensitive to the value selected for the increment. However, this approach was used to explore the relative explanatory power of each of the descriptive variables.

C. A linear regression model based on a binomial distribution and using the presence/absence of lobster as the dependent variable (where 1 is substituted for $\ln(I_i)$ in Eq. 3 if it is a successful catch record and 0 if it is not successful) can be estimated using the same data set. Explanatory factors are estimated in the model in the same manner as described in Eq. 3. Such a model provides another series of standardised coefficients of relative annual changes that is analogous to the equivalent series estimated from the lognormal regression.

D. A combined model which integrates the two series of relative annual changes estimated by the lognormal and binomial models can be estimated using the delta distribution, which allows zero and positive observations (Vignaux 1994). This approach uses the following equation to calculate an index based on the two contributing indices:

Eq. 4
$$ {}^{C}Y_y = \frac{{}^{L}Y_y}{\left(1 - P_0\left[1 - 1\big/{}^{B}Y_y\right]\right)} $$

where ${}^{C}Y_y$ = combined index for year y

${}^{L}Y_y$ = lognormal index for year i

${}^{B}Y_y$ = binomial index for year i

P_0 = proportion zero for base year 0

Francis (2001) suggests that a bootstrap procedure is the appropriate way to estimate the variability of the combined index, but this was not done for this study. Consequently, error bars are not reported for the combined series.

3.2 Calculation of CPUE from the RLLB data

Bentley (unpublished) recommended that, for using the RLLB data in a CPUE analysis comparable to MPI CELR series, the reported catch needed to be converted to catch weight. He suggested that a) the tail width measurements be converted to weight and summed using appropriate length-weight parameters by sex and QMA; and b) the resulting sum be adjusted upward by the ratio of total lobster divided by the measured lobster for the potlift. This latter requirement was needed to adjust for the fact that the design of the programme did not require the participants to measure every captured lobster. The method for calculating the weight of catch in the potlift can be expressed as:

Eq. 5
$$ W_i = \sum_{j=1}^{{}^{w}n_i} \sum_{s=1}^{2} {}^{q}a_s \left(l_{j,s,i} + 0.5\right)^{{}^{q}b_s} \left({}^{c}n_i \big/ {}^{w}n_i\right) $$

where:

W_i = weight of catch (kg) caught in potlift i;

${}^{w}n_i$ = number of lobsters measured in potlift i;

${}^{c}n_i$ = total number of lobsters captured in potlift i;

${}^{q}a_s$ and ${}^{q}b_s$: QMA- and sex-specific length-weight parameters (Table 3);

$l_{j,s,i}$ = tail width of the j^{th} lobster of sex s in potlift i (0.5 mm is added to adjust for rounding down when measuring);

Only legal lobsters were used in the analyses based on Eq. 5. These were lobsters above the size limit as determined by the sex, season and QMA in which the lobsters were captured, based on the integer value for the logbook tail width measurement. Berried and spent female lobsters were also excluded. All legal lobsters were used in Eq. 5 to be consistent with the CPUE analyses performed on the commercial catch and effort data collected by MPI. No attempt was made to adjust for discarding of legal lobsters, a practice that has developed in recent years. The RLLB includes a [*kept*] field to designate those lobsters which were discarded or kept, this field was not used in these analyses because earlier analyses (V. Haist, unpublished) have shown that this field has been filled out inconsistently within and among participants.

3.3 Calculation of CPUE from the RLCS data

The procedure described in Eq. 5 was also followed to estimate legal catch weight by potlift for the RLCS data, with two differences. One was that the tail width, because it was measured with an accuracy of 0.1 mm, did not require the addition of 0.5 mm. The other difference was the omission of the ratio $\left({}^{c}n_i / {}^{w}n_i\right)$ because potlifts with measurements rarely had unmeasured lobsters. However, as described below, about 13% of potlifts within this programme had no measurements at all. Potlifts with measurements tended to have lower catch rates than potlifts without measurements, leading to the conclusion that the potlifts with measurements represented a biased sample for the purposes of CPUE standardisations. Because of this bias, most of the CPUE standardisations using the *rlcs* data were based on the number (rather than the weight) of lobsters captured in each lift, a value that was reported even for potlifts where no measurements were available. Unfortunately, this total included both legal and non-legal lobsters, which meant that analyses using these data were not comparable to the analyses performed using the MFish CELR data and the *rllb* data.

3.4 Analyses undertaken in this project

A. An initial analysis fitted models, based on Eq. 3 and using all available explanatory variables (both factorial and continuous: see Section 4.3 below for a list of these variables), to the potlift data from either the *rllb* or the *rlcs* data. A small increment (0.01) was added to the zero records so that all data could be considered in a single analysis. Two models, differing in terms of the dependent variable (one model using legal catch weight and the other model using catch in numbers), were fitted to each explanatory variable, without including any of the other variables. The resulting Akaike Information Criterion (AIC) (Akaike 1974) from each dependent variable model by the contributing data set (*rllb* or the *rlcs*) was then calculated for each explanatory variable, sorted in ascending order. The purpose of this analysis was to determine the relative explanatory power held by each variable, given the data, without the influence of the other variables.

B. Lognormal and binomial models (Eq. 3) were fitted to the potlift data obtained from either the *rllb* and *rlcs*, initially fitting the model against the [*fishing year*] categorical variable. A succession of iterations were then performed, where each of the remaining variables was successively fitted by regressing each variable with the dependent variable and including all previously fitted variables. At each iteration, the variable giving the model with the lowest AIC was selected as the next variable in the model, and the procedure was repeated, accumulating variables, until all the variables were exhausted. The AIC was used for model selection to account for variables which may have same explanatory power in terms of residual deviance but require fewer degrees of freedom (Francis 2001). Once the final lognormal and binomial models had been fitted using this procedure, the model combining the lognormal and binomial Y_{y_i} coefficients (Eq. 4) was calculated. The purpose of this analysis was to explore the range of explanatory variables that could influence the standardisation of the Y_{y_i} coefficients, which are the coefficients of interest deriving from these analyses. It is a common practice, when doing stepwise model selection as described in this paragraph, to stop the selection procedure once the improvement in model deviance falls below a specified threshold (common practice often uses a 1% threshold). This part of the procedure was not followed here because the goal was to determine the relative order and explanatory power of every variable, not just those that had the greatest impact on the series of annual coefficients.

C. Standardised analyses, using Eq. 3, were performed on the *rllb* and *rlcs* data based on monthly data stratification (with data summarised to the level of [*vessel*], [*month*], and [*statistical area*]), as described in Section 3.1. This was done to emulate the annual analyses based on the MPI statutory CELR data (Starr 2011). The CELR standardised analyses described by Starr (2011) use [*fishing year*], [*month*], and [*statistical area*] as explanatory variables, based on the lognormal version of Eq. 3. The analyses reported here used the sums of the estimated catch weight (Eq. 5) for the *rllb* data and the sum of the counts of lobster for the *rlcs* data as the respective dependent variables. The *rllb* and some of the *rlcs* analyses[1] were repeated with [*vessel*] as an additional explanatory variable. The purpose of these analyses was to explore the correspondence between the analyses used to inform the stock assessments using a parallel data set with the same suite of explanatory variables and equivalently summarised. Furthermore, inferences about the effect of additional explanatory variables that are available in the *rllb* and *rlcs* data, but not in the wider CELR data, can be made by comparing these analyses with those performed in B (above).

D. The analyses described in C (using Eq. 3) were repeated using the *rllb* data based on a [*trip*] level of stratification (as described in Section 3.1 and represent the summarisation of effort at a daily level for each operator). Again, only [*fishing year*], [*month*], and [*statistical area*] were used as explanatory variables to test the sensitivity of the resulting Y_{y_i} coefficients to a level of data summarisation that was intermediate between the high level of summarisation represented in the monthly data and the greatest level of disaggregation represented by the potlift data. This level of amalgamation also represents the finest level of stratification currently available in the CELR catch/effort data collection system.

The analyses described in C and D only used the lognormal version of Eq. 3 because there were no zero records either at the monthly or trip level of stratification.

4. SUMMARY ANALYSES FOR BOTH DATA SETS

4.1 Voluntary logbook programme (RLLB)

4.1.1 RLLB: distribution of potlifts among QMAs and fishing years

Only three QMAs had a sufficiently long history of contributing to this programme, both in terms of number of years of participation as well as number of potlifts (Table 4), to be used in a long-term standardised CPUE analysis. When the number of participating vessels by fishing year and QMA was examined (Table 5), the same conclusion was reached: that only CRA 2, CRA 5 and CRA 8 were available for the analyses described in Section 3.4.

4.1.2 RLLB: frequency of measured and unmeasured lobsters by QMA

Participants measured only a portion of the catch from each potlift when catch exceeded a specified limit (see Section 2.1). Only 171,791 (Table 6) of the total 230,257 potlifts (Table 4) had measured lobsters. A further 1,293 potlifts recorded lobsters with no measurements (these 1,293 potlifts have been excluded from the totals in Table 6 to Table 10 because they represent less than 1% of the potlifts with lobsters). The remaining 57,173 potlifts had no lobsters.

The mean percentage of unmeasured lobsters by QMA and fishing year was low but variable, ranging from zero (or near zero) to as high as 16% in CRA 8 in the 2009–10 fishing year (Table 7). The percentage of unmeasured lobster tended to be higher when abundance was high, peaking in CRA 5 in the late 1990s and early 2000s and showing a large increase in CRA 8 during the most recent 5–6 years. Values for the percentage of unmeasured lobsters, averaged over the entire dataset, were below 1% for CRA 2 and between 5 and 10% in CRA 5 and CRA 8 (Table 7).

Total measured rock lobster exceeded 1,100,000 for the entire dataset, with most of these lobster measurements taken in CRA 2 (with just below 200,000 total measurements), CRA 5 and CRA 8 (both of which have just over 400,000 measurements) (Table 8). The total number of unmeasured lobsters

[1] Only CRA 3, CRA 4 and possibly CRA 7 had sufficient [*month*]/[*vessel*] observations to justify extending the analysis to include [vessel] as an explanatory factor.

was comparatively small, with about 75,000 (less than 1% of the overall total) over the full programme and less than 2,000 in CRA 2, about 30,000 in CRA 5 and 40,000 in CRA 8 (Table 9). A small number of these unmeasured lobsters were recorded as being dead (Table 10).

The ratio of total lobsters relative to measured lobsters $\left({}^{c}n_i / {}^{w}n_i \right)$ (see Eq. 5) was used to adjust the estimated weight of lobster in each potlift. The overall mean of this ratio was less than 1.05 for all QMAs except CRA 7, and the mean ratio for all potlifts was 1.026. However, there were outliers in these data (with the maximum value for this ratio ranging up to 46) and potlifts with large ratios were excluded from the CPUE analyses. This was done for two reasons: a high ratio may represent a potlift with a data error (for instance, the total captured may have been recorded instead of the excess above/below the size limit), and, because a high ratio implies that a selection was made when choosing fish for measurement, may introduce a potential bias in the measurements. The 99th quantile for this ratio (1.72; see Table 11) was used to screen out potlifts with large expansion ratios. A sensitivity analysis was done to gauge the effect of changing this ratio threshold on the results, which was negligible in all QMAs (this analysis has not been reported).

4.1.3 RLLB: reporting catch information using a more detailed zone designation

The variable [*zone*] is available in the *rllb* as an alternative area explanatory variable, beginning in 2000–01 (Table 12). This variable was collected at the level of each potlift in the *rllb* database, not by [*trip*] as was done for the statistical area information. Examination of Table 12 showed that this field had been consistently populated over time only in CRA 5, with the other QMAs showing an initial high level of participation followed by diminishing observations until they disappeared entirely. This was true for both CRA 2 and CRA 8, both of which had thousands of observations per year initially, then with CRA 8 going to nil observations in the mid-2000s and CRA 2 by the end of the 2000s. The [*zone*] data coming from CRA 5 initially seemed more promising, with reasonably high reporting in terms of total potlifts to the 2010–11 fishing year (Table 12). However, when the available data were examined in more detail, there was a disturbing trend, with participation levels dropping to around 50% in the most recent two fishing years after being over 99% in the first three years of the programme (Table 13). Preliminary analyses (not reported) indicated that the Y_{y_i} coefficients based on these data were inconsistent with the series which used [*statistical area*] as the area-based explanatory variable. Given the trend identified in Table 13 and advice that this field was not considered important by the logbook participants in CRA 5 (D. Sykes, pers. comm.), further analyses based on this data field have not been pursued or reported.

4.2 Observer catch sampling programme (RLCS)

4.2.1 RLCS: distribution of potlifts among QMAs and fishing years

There have been five QMAs (CRA 1 to CRA 4 and CRA 7) which have had consistent reporting in this programme up to 2010–11 (Table 14). The remaining QMAs have had only intermittent reporting or, in the case of CRA 8, very little recent reporting. The RLCS and RLLB programmes have reported a similar number of potlifts (around 250,000 for the *rlcs* and 230,000 for the *rllb*) from 1993–94 onwards. The number of participating vessels is only slightly lower for the RLCS compared to the RLLB, but the vessel effort is spread out over more QMAs for the RLCS (Table 15). Only data from CRA 1, CRA 2, CRA 3, CRA 4 and CRA 7 have been used in preparing the standardised CPUE series described in Section 3.4.

4.2.2 RLCS: frequency of measured and unmeasured lobsters by QMA

The design of the RLCS included the provision for observers to skip measuring pots if they cannot process the total amount caught without adversely affected the operation of the sampled vessel. The design expectation was for all lobsters within a single pot to be completely recorded to avoid selection bias. The missed pots will always be pots with lobsters, and will therefore affect the calculations in Eq. 4 as well as potentially affecting the mean CPUE if the skipped pots are drawn from a different distribution than the measured pots. Table 16 classifies all potlifts into three categories: lifts with no catch, lifts which captured lobsters but with no measurements and finally lifts with measurements. These catch status designations were determined from the [*caught*] field, which recorded the total count of lobsters in the pot, regardless of legal status. Table 17 shows that the prevalence of skipped pots with unmeasured lobsters varies among QMAs, nearing 20% in CRA 3, 13% in CRA 4 and below 5% in CRA 1 and CRA 2. The prevalence of skipped pots was very high for recent sampling in CRA 8 (e.g., over 40% in 2010–11), representing over 800 potlifts of the 2,100 lifts examined. The overall prevalence of unmeasured pots was 13%.

Table 18 demonstrates that the prevalence of unmeasured lobsters in pots that have been measured is less than 1% in all QMAs except for CRA 2, which is slightly above 2%. Mean numbers of lobsters in pots with skipped measurements ranged from near double to more than triple the equivalent mean catch rate for measured pots in CRA 3, CRA 4, CRA 7 and CRA 8 (Table 19). Only in CRA 1 and CRA 2 were the catch rates for the measured and skipped pots similar. Because of these disparate catch rates and the difficulty of interpreting Eq. 4 correctly when using only the measured lobster pots, all standardisations using Eq. 3 for the *rlcs* were based on the reported total count of lobsters in the pot, including legal and non-legal lobsters.

There are [*no_legal*] and [*legal_wt*] fields in the *rlcs* database, but over 80% of potlift records are missing data in both fields and these fields were always “null” (missing) for potlifts that had been skipped. Consequently they could not be used to interpret data from pots which had not been measured.

4.2.3 RLCS: summary information about [*bait*] and [*pot type*] fields

One of the reasons for including analyses from the RLCS was the existence of additional fields that could be included as explanatory variables which were not available in either the RLLB or the MFish CELR data. In particular, the [*bait*] and [*pot type*] fields were candidates for consideration for this type of use. These fields were well populated in this database, with most potlifts having observations (compare totals in Table 20 and Table 21 with those in Table 14). Potlift distribution tables for [*bait*] (Table 20) and [*pot type*] (Table 21) indicate that the QMAs differ in the prevalence of bait and pot configuration types. The [*bait*] and [*pot type*] fields used in each analysis were specified for each QMA independently by selecting the top nine categories for the QMA in terms of potlift frequency and using a 10th category as a “plus” group for the remaining lifts.

4.3 Explanatory variables used for each data set

The following is a list of the available explanatory variables from each data set:

rllb	*rlcs*	Variable type	Comment
Fishing year	Fishing year	Categorical	used to estimate the sequential time index in all models
Month	Month	Categorical	
Statistical area	Statistical area	Categorical	
Vessel	Vessel	Categorical	restricted to vessels with at least 300 potlifts (*rllb*) or 150 potlifts (*rlcs*)
Skipper	–	Categorical	omitted for the *rlcs* analyses (not different from [*vessel*])
	Bait	Categorical	only available from the *rlcs*
	Pot type	Categorical	only available from the *rlcs*
Depth	Depth	Continuous	approximated as a 3rd order polynomial
Soak time	Soak time	Continuous	approximated as a 3rd order polynomial

5. RESULTS

5.1 Relative importance of available explanatory variables

5.1.1 RLLB (see Section 3.4A for analysis description)

Two models were compared in each of three QMAs, each based on the same potlift data set, but using different fields to specify the dependent variable (Table 22). When each variable was examined for its explanatory power in the available data, [*vessel*] and [*skipper*] ranked at or near to having the best explanatory power in each of the three QMAs (Table 22). Only in CRA 8 did [*fishing year*] have a lower AIC than either [*vessel*] or [*skipper*]. [*vessel*] had slightly lower AICs than did [*skipper*] for the three QMAs. [*soak time*] had the highest AIC for both models in all three QMAs and consequently the lowest explanatory power. The remaining variable rankings varied in terms of the order of each variable relative to the other available explanatory variables. There was no difference in the rank of variable importance between the two models based on either catch weight or numbers of lobster, with the order of relative importance being the same for each QMA, regardless of whether catch weight or number of legal lobsters was used as the dependent variable (Table 22).

5.1.2 RLCS (see Section 3.4A for analysis description)

This analysis repeated the one described for the RLLB, with two dependent catch variable choices (number of total lobsters or weight of legal lobsters) fitted to eight explanatory variables from the RLCS (Table 23). Note that the two dependent variable types are not completely comparable, with the count of lobsters including sub-legal lobsters as well. Two additional explanatory variables available in this data set were offered to the models ([*bait*] and [*pot type*]) and [*skipper*] was dropped because of the lack of contrast with [*vessel*]. The top nine [*bait*] and [*pot type*] categories in each QMA were used as the explanatory categories, with the tenth category incorporating all the remaining observations as a "plus" group. The [*bait*] and [*pot type*] categories used in each QMA analysis are specified in Table 20 and Table 21.

These results are more variable than those from the RLLB, with more contrast between the 5 available QMAs and the two dependent variable types. For instance, [*vessel*] had the lowest AIC in only 6 of 10 comparisons, with [*fishing year*] and [*month*] rounding out the remaining four comparisons as the variables with the best explanatory power (Table 23). However, [*vessel*] was the second ranked variable in the 4 comparisons when it was not first. Among the variables with the least explanatory power, [*soak time*] only accounted for three of the 10 comparisons with the greatest AIC, with [*statistical area*] (3 in the last rank order), [*depth*] (2 in the last rank order), [*bait*] (1 in the last rank order) and [pot type] (1 in the last rank order) in the remaining analyses. As well, there was switching in rank order between models based on different dependent variable types, with [*vessel*] and [*fishing year*] swapping lowest AIC in CRA 2 and [*vessel*] and [*month*] exchanging in CRA 3 with the change in dependent variable (Table 23). CRA 7 was the only analysis that selected the variables in the same order with each dependent variable types. This may be because the legal catch definition is close to the total catch, given the low MLS used in this QMA.

5.2 Standardised models fitted to potlift data with available explanatory variables

5.2.1 RLLB (see Section 3.4B for analysis description)

Standardised models using *rllb* data were fitted to seven explanatory variables (see Section 4.3) for CRA 2 (Appendix D), CRA 5 (Appendix E), and CRA 8 (Appendix F). Each appendix provides a suite of diagnostic plots for each model, plus a summary table of the supporting data and an output table for the final model showing the order the explanatory variables were accepted into the model, the final deviance explained and the improvement in R^2 with the addition of each variable. Table 24 summarises each lognormal and binomial model by QMA, showing the order each variable entered the model and the cumulative AIC associated with that variable.

Only the [*fishing year*] and [*vessel*] explanatory variables accounted for more than 1% of the total lognormal and binomial CRA 2 model deviance (Table D.2). All the remaining variables explained less than 1% of the deviance, with [*statistical area*] and [*soak_time*] accounting for less than 0.1% of the deviance of the lognormal model and [*soak_time*], [*depth*], and [*statistical area*] 0.1% or less of the deviance of the binomial model. The year coefficient trajectories were very similar for both the binomial and lognormal models, but the combined model lay well above either of the constituent trajectories (Figure 2).

The variables used in the CRA 5 lognormal model had more explanatory power than seen in CRA 2, with all variables above or near the +1% deviance threshold, except for [*soak time*] (Table E.2). [*statistical area*], [*depth*] and [*soak_time*] all were below a 1% threshold for the CRA 5 binomial model. The CRA 5 binomial model annual trajectory very closely resembled the combined trajectory, while the lognormal trajectory showed almost no contrast and diverged considerably from the other two (Figure 2).

[*fishing year*], [*vessel*] and [*month*] all exceeded a 1% deviance threshold for the CRA 8 lognormal model, while [*soak time*] and [*statistical area*] had almost no explanatory power in the lognormal model (Table F.2). The CRA 8 binomial model behaved similarly, with only [*fishing year*] and [*vessel*] exceeding a 1% threshold. The three CRA 8 models showed the most divergence between constituent models in terms of the estimated annual coefficients, with the lognormal model being nearly flat, compared to the combined model which showed a strong increasing trend over the past decade (Figure 2).

When the combined models based on the *rllb* potlift data were compared by QMA with the equivalent monthly stratified “B4_L” model using CELR data (Figure 3), the results showed good agreement in CRA 2 and CRA 8. The CRA 5 potlift-based trajectory appeared to lie below the corresponding MPI CELR-based trajectory from the mid-2000s on to the end of the series.

5.2.2 RLCS (see Section 3.4B for analysis description)

Standardised models using *rlcs* data were fitted to eight explanatory variables for CRA 1 (Appendix G), CRA 2 (Appendix H), CRA 3 (Appendix I), CRA 4 (Appendix J) and CRA 7 (Appendix K). Each Appendix provides a suite of diagnostic plots for each model, plus a summary table of the supporting data and an output table for the final model showing the order the explanatory variables were accepted into the model, the final deviance explained and the improvement in R^2 with the addition of each variable. Table 25 summarises each lognormal and binomial model by QMA, showing the order each variable entered the model and the cumulative AIC associated with that variable.

[*fishing year*], [*vessel*] and [*depth*] exceeded a 1% deviance threshold for the CRA 1 lognormal model while [*month*], [*pot type*], [*bait*] and [*soak time*] all had low explanatory power in the lognormal model (Table G.2). The CRA 1 binomial model exceeded a 1% threshold only with [*fishing year*] and [*vessel*] while [*soak time*], [*pot type*], [*depth*] and [*bait*] all had low explanatory power. There was not a great deal of difference between the lognormal, binomial and combined annual coefficient trajectories, with only the combined model showing some contrast across the years (Figure 4).

[*fishing year*], [*vessel*] and [*month*] exceeded a 1% deviance threshold for the CRA 2 lognormal model while [*depth*], [*pot type*], [*soak time*] and [*statistical area*] had very low explanatory power in the lognormal model (Table H.2). The [*bait*] variable was dropped from the lognormal model because there was no increase in AIC for this variable. The CRA 2 binomial model exceeded a 1% threshold only with [*fishing year*] and [*vessel*] with all other variables having very low explanatory power. All the CRA 2 annual trajectories show a similar declining trend, with little difference between the three models (Figure 4).

[*fishing year*], [*vessel*] and [*month*] were the only variables with explanatory power in either the lognormal or the binomial CRA 3 models (Table I.2). The [*depth*], [*bait*] and [*pot type*] variables were exceptionally uninformative in the lognormal model, as were [*pot type*] and [*statistical area*] in the binomial model. The three CRA 3 annual trajectories from these models are relatively flat, with some moderate highs and lows which were exaggerated in the combined model (Figure 4).

Several variables informed the CRA 4 lognormal model, with [*fishing year*], [*vessel*], [*soak time*], [*pot type*] and [*month*] all contributing (Table J.2), although the "stepwise" plot (Figure J.2) showed little change in the annual coefficients after the addition of the first two variables. [*bait*] and [*statistical area*] were uninformative in the lognormal model, as were [*pot type*], [*depth*], [*statistical area*] and [*bait*] in the binomial model. [*fishing year*], [*vessel*], [*soak time*] and [*month*] were the variables that informed the binomial model. The CRA 4 annual trajectory from the binomial models was flat, while the lognormal model closely resembled the combined model, although the former model shows less extreme variation (Figure 4).

[*fishing year*] had almost all the explanatory power in the CRA 7 lognormal model, while [*vessel*] and [*month*] only just exceed a cut-off threshold of 1% improvement in explained deviance (Table K.2). A similar pattern exists for the binomial model, with [*fishing year*] and [*vessel*] being the only informative variables. The CRA 7 annual trajectory estimated by the binomial models was flat, while the lognormal model has the same pattern as the combined model, the combined model trajectory is much more extreme (Figure 4).

When the combined models based on the *rlcs* potlift data were compared by QMA with the monthly stratified "B4_L" model using CELR data (Figure 5), only CRA 3 showed almost no resemblance to CELR-derived annual indices. CRA 1, CRA 2 and CRA 4 all showed similarities with the series drawn from a wider data set, while the correspondence between the CRA 7 *rlcs*-derived series and the CRA 7 CELR-derived series was very good.

5.3 Standardised models fitted to monthly stratified data with available explanatory variables

5.3.1 RLLB (see Section 3.4C for analysis description)

This analysis compared the standardised series of annual coefficients generated from the *rllb* data, prepared and analysed in the same manner as the MPI CELR data, with the equivalent analysis generated from the MPI CELR data. The resulting *rllb* series showed good overall correspondence with the CELR series for CRA 2, CRA 5, and CRA 8, although the CELR and *rllb* series diverged somewhat when examined in detail, with some of the series inflection points offset by about one year between the two series (Figure 6). The *rllb* monthly stratified analysis was repeated with the addition of [*vessel*] as an explanatory factor, resulting in no appreciable change in CRA 2. However, the effects diverged for the other two QMAs, with CRA 5 series dropping and CRA 8 series rising relative to the equivalent series without [*vessel*] (Figure 6). Note that the monthly CRA 5 series with [*vessel*] matched the "combined" series while the equivalent series for CRA 8 diverged away from both the "combined" and "B4_L" series.

The failure of the CPUE analyses based on the *rllb* data sets to better match the equivalent analyses based on the MFish CELR data should not be surprising, given that these data sets were based on subsets of operators who only sampled a small fraction (probably less than 5%) of their effort. The sensitivity of these models to the inclusion of the vessel explanatory variable is more troubling, but the inclusion of this variable is justified given its high level of explanatory power shown in the AIC tables presented in Table 22 and Table 23, as well as in Appendix A to Appendix K.

5.3.2 RLCS (see Section 3.4C for analysis description)

A similar analysis compared the standardised series of annual coefficients generated from the *rlcs* data, summarised and analysed in the same manner as the MPI CELR data (except that the dependent variable was total catch in numbers rather than legal weight), with the analysis generated from the MFish CELR data. The resulting *rlcs* series show good overall correspondence for four of the five QMAs, although the CRA 3 *rlcs* data failed to show the strong peak in late 1990s (Figure 7). This failure to match the CELR series in CRA 3 may be due to the use of total catch (legal plus non-legal) instead of just legal fish as the dependent variable, with a large component of the CRA 3 catch being undersized and showing less contrast. The series generated by the *rlcs* data in CRA 1, CRA 2 and CRA 4 all resemble the corresponding CELR series, but tended to diverge more than in the equivalent *rllb* series comparison, probably because the *rlcs* series were based on the catch of total counted lobsters, not legal catch weight. This conclusion is supported by the near perfect correspondence of the CRA 7 *rlcs* monthly series with the CRA 7 CELR series: this is the QMA where there is a low MLS resulting in catch estimates that will consist almost entirely of legal lobsters.

Figure 7 also compares, by QMA, the combined index (Eq. 4) based on potlift data with the monthly stratified index, showing good similarity between these annual indices and those generated using monthly stratification and standardised with only [*fishing year*], [*month*] and [*statistical area*], confirming the observations made when examining the model output tables in Table G.2 to Table K.2: that the majority of the additional explanatory variables were making relatively little contribution to the time series of annual coefficients.

The effect of adding the variable [*vessel*] to the *rlcs* monthly standardised analysis could not be explored for CRA 1 and CRA 2 because of insufficient records. The CRA 4 and CRA 7 analyses which included [*vessel*] did not strongly differ from the analyses without this variable (compare "Month_strat" and "Month_strat+vessel" in Figure 7 for CRA 4 and CRA 7). However, there was a large shift in the CRA 3 monthly stratified analysis with the addition of [*vessel*] as an explanatory variable, with the resulting series showing a strong peak in the late 1990s, similar to the peak observed from the "B4_L" CELR analysis. However, this result did not appear to be exclusively the effect of adding [*vessel*] as an explanatory variable, because the "Combined" model also used [*vessel*] as an explanatory variable and this latter series more closely resembled the monthly stratified series which did not use [*vessel*] (compare "Combined", "Month_strat" and "Month_strat+vessel" in Figure 7).

5.4 Standardised models fitted to daily [*trip*] stratified data with available explanatory variables

5.4.1 RLLB (see Section 3.4D for analysis description)

Figure 6 also compared a trajectory generated from daily stratified data based on data from the *rllb* data set with the equivalent trajectories based on the MFish CELR data, monthly stratified data (with and without [*vessel*] explanatory variable, and potlift-based data using all available explanatory variables (Section 4.3). The daily *rllb* data were analysed in the same manner as the CELR data, using [*fishing_year*], [*month*] and [*statistical_area*] as the explanatory variables. The [*trip*] stratified series resembled all the other CRA 2 series, while it closely resembled the "Month_strat" series in CRA 5 and the "B4_L" and "Combined" series in CRA 8.

6. DISCUSSION

6.1 Independent consideration of each explanatory variable

There is consistency in the selection of variables for the models based on the *rllb* data. The CRA 2 and CRA 5 models selected [*vessel*] and [*skipper*] (in that order), while these variables were preceded by [*fishing year*] in CRA 8. [*soak time*] was consistently the last variable selected (Table 22). The variable selection was less consistent for the *rlcs* data, with [*vessel*] less predominant as the best explanatory variable, with other variables such as [*month*] and [*fishing year*] having similar or better explanatory power (Table 23). Some of these differences may be due to the choice of the dependent variable, which in the case of ln([*number*]) included non-legal lobsters or possibly to differing fishing patterns by programme participants. The extra variables available only in the *rlcs* data behaved inconsistently, with [*bait*] having a good explanatory power in CRA 2 (for both the ln([*number*]) and ln([*weight*]) models), while having the least explanatory power in the CRA 3 ln([*number*]) model. The [*pot type*] variable showed similar behaviour, with little consistency in its rank order in terms of explanatory power. It is likely that several of these variables have similar effects in the models, with [*pot type*], [*bait*] and [*statistical area*] all substituting for some aspect of [*vessel*] behaviour.

6.2 Standardised CPUE analyses based on potlift data

The variable [*vessel*] was selected immediately after [*fishing year*] (which was forced as the first variable) in each model fitted to the *rllb* data (Table 24). The variable [*month*] was selected second after [*vessel*] in five of the six models and was selected third by the sixth model (CRA 2 lognormal, Table 24). When fitted in conjunction with other variables, [*depth*], [*statistical area*] and [*soak time*] had little additional explanatory power and had no effect on the trajectory of annual coefficients. This can be seen from the stepwise plots provided in each Appendix, showing the effect of adding each variable to annual coefficients time series (see Figure D.2, Figure E.2, and Figure F.2). As a general rule, there seemed to be relatively little effect (relative to the unstandardised model) from the standardisation procedure in the three lognormal models and the binomial model was mainly affected by the addition of the [*vessel*] variable.

As seen with the *rllb* data, the models based on the *rlcs* data all selected [*vessel*] immediately after [*fishing year*], which was again forced as the first variable (Table 25). After that selection step, there was less consistency between models and QMAs, although [*month*] was the second selection for both of the CRA 2 and CRA 3 models, the CRA 1 binomial model and the CRA 7 lognormal model. Interestingly, [*soak time*] was the second selection in both CRA 4 models but was one of the poorer variables in terms of explanatory power in most other areas. The variable [*depth*] was the second selection in the CRA 1 lognormal and CRA 7 binomial models, but showed relatively little explanatory power in the remaining QMAs. The variables [*bait*] and [*pot type*] were generally chosen in latter part of the selection procedure and had little effect on the year indices.

The underlying signal in these data was very strong and appeared to reside mainly in the unstandardised data, given the relatively small changes caused by the standardisation procedure. There is very good correspondence between the year indices based on data derived from the MPI CELR data and the equivalent QMA series generated using the *rllb* data (Figure 3) and the *rlcs* data (Figure 5). The only notable exception to this comparison result is the CRA 3 based on the *rlcs* data ([centre left] Figure 5), which is likely affected by the inclusion of non-legal lobsters in the *rlcs* dependent variable. The lack of sensitivity to the additional explanatory variables (and the stratification level) can be seen in the CRA 7 comparison, with the strong correspondence between the relatively low level standardisation in the CELR series and the high level of standardisation from the *rlcs* series ([lower left] Figure 5).

6.3 Standardised CPUE analyses based on monthly and daily stratified data

These analyses confirm the conclusion reached in Section 6.2: that the underlying signal in these data was very strong and was expressed regardless of the underlying level of stratification in the data and the number of explanatory variables in the analysis. Stratifying the data by [*month*], [*statistical area*] and [*vessel*] resulted in trajectories of annual coefficients that were very similar to the trajectories obtained when the data were analysed at the level of a potlift using a wider suite of explanatory variables. This was true for the *rllb* data (Figure 6) and the *rlcs* data (Figure 7). The conclusion was unchanged when the *rllb* data were stratified by day (same as [*trip*]; Figure 6). Each data set (either *rllb* or *rlcs*) generated a consistent set of annual coefficients for each QMA at each level of data stratification investigated as well as when a larger suite of explanatory variables were offered (see Figure 6 and Figure 7). There is some evidence that the *rllb* monthly stratified data shifted away from the MPI CELR series in recent years, particularly in CRA 5 and somewhat less in CRA 8, but this was likely a property of the data set rather than a property of the analysis, given the stability of the CRA 2 analysis and different directions of the shift in CRA 5 and CRA 8.

6.4 Summary

Maunder & Starr (1995) concluded that [*fishing year*], [*statistical area*] and [*month*] were adequate to standardise these data, given the available data and the strong underlying signal in the unstandardised data. This analysis, although more thorough and covering a much longer period with a greater amount of data available to it, has come to a similar conclusion, with the exception that it is likely that [*vessel*] is a much more important explanatory variable than had been concluded by Maunder & Starr. Most of the analyses presented in Table 24 and Table 25 selected [*fishing year*] and [*vessel*], after which the annual coefficients showed very little sensitivity to additional explanatory variables. It is likely that [*vessel*] and [*statistical area*] have similar effects in these data because rock lobster fishermen operate in highly localised areas and [*statistical area*] is probably just a coarser surrogate for [*vessel*]. Most of the analyses in Table 24 and Table 25 then selected [*month*] as the next factor, with the resulting series strongly resembling the much wider-based series based on the compulsory CELR data collected by MPI, with the differences noted in Figure 6 and Figure 7 most likely due to differences arising from sampling effects, given the limited coverage of the RLLB and RLCS. The effects shown by other variables associated with each potlift, such as [*depth*], [*soak_time*], [*pot_type*] and [*bait*] are mixed, all showing a much lower explanatory power than the main effects discussed above. There was also very little impact from the level of data amalgamation, with analyses done at all three levels of stratification showing very similar trajectories of annual coefficients.

The lack of sensitivity shown here by the annual coefficients to the level of underlying stratification and to the inclusion or exclusion of explanatory variables indicates that there may be little to be gained from trying to obtain highly detailed data from these fisheries. This study was not able to investigate the utility of obtaining fine scale positional data, given the low level of participation by the RLLB operators in using the [*zone*] field and the scarcity of detailed positional information in either data set. However, given the stability shown in these analyses, there is a reasonable likelihood that detailed positional information will also have little effect on the overall signal in these data.

The conclusions presented in this report suggest that [*vessel*] should be investigated as an additional explanatory variable for use in the CPUE analyses performed on the wider MPI CELR data. The inclusion of this explanatory variable in the wider analyses may lead to some problems because of the inconsistent reporting of [*vessel*] in the FSU data set and the likely lack of correspondence between some of the [*vessel*] codes used in FSU and CELR data systems.

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Table 1: RLLB: number of potlifts in each measurement category for potlifts where ${}^{c}n_i / {}^{w}n_i > 1.0$ (i.e., there were both measured and unmeasured lobsters in the potlift). The two maximum values determined from the RLLB form are highlighted in grey.

Number of lobsters measured in the potlift	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
1	115	–	1	139	3	12	95	36	401
2	76	2	2	114	1	12	89	26	322
3	48	–	–	101	–	13	90	28	280
4	23	–	3	73	–	8	85	11	203
5	12	1	1	73	1	6	64	12	170
6	14	–	2	80	–	11	65	8	180
7	6	1	1	56	–	15	62	5	146
8	3	–	1	61	–	9	37	3	114
9	2	–	–	61	–	16	32	3	114
10	1	–	1	51	–	7	29	2	91
11	–	–	–	41	–	6	28	4	79
12	2	–	–	30	–	5	25	1	63
13	1	–	–	35	–	4	20	–	60
14	–	–	1	43	–	5	9	1	59
15	–	–	–	35	–	2	8	–	45
16	2	–	–	23	–	5	12	–	42
17	–	–	–	18	–	4	15	–	37
18	–	–	–	22	–	3	19	–	44
19	1	–	–	21	–	1	7	–	30
20	–	–	–	21	–	3	4	–	28
21	–	–	–	21	–	2	6	–	29
22	–	–	–	18	–	1	3	–	22
23	–	–	–	19	–	2	7	–	28
24	–	–	–	44	–	5	25	–	74
25	37	–	12	2,420	6	10	1,645	14	4,144
26	–	–	–	1	–	–	–	–	1
28	–	–	–	–	–	–	4	–	4
29	1	–	–	–	–	–	–	–	1
30	4	–	–	3	–	–	5	–	12
31	62	75	18	131	–	–	600	–	886
62	–	–	–	–	–	–	1	–	1
Total	410	79	43	3,755	11	167	3,091	154	7,710

Table 2: Median (P50) and 95th quantile (P95) of the number of potlifts in a sampling day in the *rlcs* database by fishing year and QMA (CRA 9 not reported because there was only one sample in the database) '–': no observations

Fishing	CRA 1		CRA 2		CRA 3		CRA 4		CRA 5		CRA 6		CRA 7		CRA 8	
Year	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95
86/87	–	–	72	72	84	84	95	95	–	–	–	–	–	–	–	–
87/88	–	–	72	73	–	–	85	94	–	–	–	–	84	84	95	95
88/89	–	–	–	–	–	–	95	100	–	–	–	–	67	99	53	58
89/90	–	–	–	–	89	89	92	100	80	94	67	86	76	94	82	98
90/91	–	–	53	53	94	100	84	99	84	85	–	–	77	95	85	99
91/92	–	–	–	–	94	100	80	98	78	100	–	–	60	93	82	100
92/93	–	–	–	–	90	99	83	92	75	99	–	–	94	96	82	98
93/94	–	–	–	–	92	100	80	81	73	73	71	98	58	81	75	98
94/95	–	–	–	–	90	100	97	98	81	81	73	80	67	82	84	100
95/96	–	–	–	–	98	100	89	89	82	93	74	94	75	97	72	98
96/97	–	–	–	–	70	91	92	93	86	99	72	99	85	100	79	100
97/98	85	99	–	–	94	100	77	98	68	84	64	86	76	95	74	100
98/99	78	93	–	–	75	98	71	89	55	92	–	–	93	99	70	96
99/00	73	99	73	73	71	83	72	84	93	94	–	–	95	98	73	90
00/01	81	99	90	90	47	90	79	99	74	88	–	–	77	95	83	97
01/02	90	100	75	75	69	100	85	97	–	–	–	–	74	92	55	75
02/03	80	98	83	99	96	100	79	99	–	–	–	–	94	98	92	99
03/04	71	90	95	95	83	93	71	100	–	–	–	–	48	83	–	–
04/05	72	97	87	97	93	100	65	98	–	–	–	–	92	99	–	–
05/06	73	94	90	91	79	98	77	95	–	–	–	–	69	82	–	–
06/07	65	95	93	93	84	98	84	95	–	–	–	–	80	99	–	–
07/08	50	65	94	99	93	100	80	99	–	–	–	–	79	86	–	–
08/09	49	88	81	81	95	99	81	98	53	55	–	–	75	98	–	–
09/10	84	97	85	98	92	99	80	93	96	96	–	–	88	99	–	–
10/11	76	94	99	99	83	98	68	100	89	89	–	–	72	77	73	99
Average	73	98	85	99	89	100	80	99	81	99	70	96	77	98	79	98

Table 3: RLLB and RLCS: length-weight parameters by sex and QMA used to convert tail width measurements (Eq. 5) to total weight in kg.

	Males		Females	
QMA	${}^{q}a$	${}^{q}b$	${}^{q}a$	${}^{q}b$
1	4.160E-06	2.935	1.300E-05	2.545
2	4.160E-06	2.935	1.300E-05	2.545
3	4.160E-06	2.935	1.300E-05	2.545
4	4.160E-06	2.935	1.300E-05	2.545
5	4.160E-06	2.935	1.300E-05	2.545
6	3.394E-06	2.967	1.037E-05	2.632
7	3.394E-06	2.967	1.037E-05	2.632
8	3.394E-06	2.967	1.037E-05	2.632
9	3.394E-06	2.967	1.037E-05	2.632

Table 4: Distribution of potlifts in the *rllb* database by fishing year and QMA. '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	129	7,071	790	–	–	–	–	5,264	–	13,254
94/95	251	6,245	1,303	–	3,626	–	–	5,987	–	17,412
95/96	170	3,934	798	–	1,884	–	–	9,125	–	15,911
96/97	–	3,492	621	–	2,339	–	–	6,847	153	13,452
97/98	–	2,953	152	213	1,725	–	–	6,578	147	11,768
98/99	–	3,051	192	174	1,059	–	–	5,487	329	10,292
99/00	–	3,684	116	119	2,110	–	–	2,670	153	8,852
00/01	–	3,787	153	23	3,817	–	–	4,176	488	12,444
01/02	–	2,910	86	–	4,299	142	478	2,782	644	11,341
02/03	–	5,014	–	200	4,897	445	208	3,105	–	13,869
03/04	–	3,810	–	374	3,842	732	116	2,425	–	11,299
04/05	–	4,677	–	278	3,502	621	–	2,450	–	11,528
05/06	–	5,874	–	498	3,969	1,243	–	2,385	482	14,451
06/07	–	4,170	–	452	4,249	966	–	2,788	584	13,209
07/08	–	4,274	–	278	4,385	978	–	2,235	916	13,066
08/09	–	5,074	–	146	3,144	865	–	2,115	816	12,160
09/10	–	4,696	–	143	4,082	317	–	2,114	1,126	12,478
10/11	–	5,196	40	674	3,370	492	–	3,237	462	13,471
Total	550	79,912	4,251	3,572	56,299	6,801	802	71,770	6,300	230,257

Table 5: Distribution of vessels in the *rllb* database by fishing year and QMA. The 'Total' for all fishing years is the number of unique vessels that have participated in the programme for each QMA across all years. The 'Total' across QMAs within a fishing year is the sum of vessels without determining if vessels participated in more than one QMA (which is unlikely). '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	1	26	14	–	–	–	–	42	–	83
94/95	2	30	16	–	14	–	–	55	–	117
95/96	1	26	12	–	8	–	–	66	–	113
96/97	–	21	5	–	13	–	–	51	1	91
97/98	–	19	3	1	12	–	–	43	1	79
98/99	–	21	4	3	10	–	–	37	4	79
99/00	–	20	1	1	12	–	–	20	1	55
00/01	–	16	1	1	22	–	–	24	2	66
01/02	–	13	1	–	25	2	6	19	3	69
02/03	–	18	–	1	24	6	3	15	–	67
03/04	–	13	–	1	20	8	2	17	–	61
04/05	–	14	–	1	21	6	–	15	–	57
05/06	–	18	–	2	17	18	–	16	4	75
06/07	–	17	–	2	20	11	–	18	5	73
07/08	–	14	–	1	19	15	–	16	4	69
08/09	–	15	–	1	18	12	–	17	5	68
09/10	–	15	–	2	20	3	–	14	4	58
10/11	–	16	1	5	18	9	–	17	4	70
Total	3	75	25	10	64	31	6	145	14	373

Table 6: Number of potlifts in the *rllb* database with measured lobsters by QMA and fishing year. Potlifts which captured lobsters but with no measured lobsters have been excluded from this table. '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	56	4,503	705	–	–	–	–	4,306	–	9,570
94/95	142	4,307	1,125	–	2,695	–	–	4,671	–	12,940
95/96	109	2,810	678	–	1,363	–	–	6,805	–	11,765
96/97	–	2,508	558	–	1,908	–	–	4,895	78	9,947
97/98	–	2,112	141	193	1,422	–	–	4,385	91	8,344
98/99	–	2,199	170	151	921	–	–	3,873	199	7,513
99/00	–	2,642	101	85	1,632	–	–	1,872	78	6,410
00/01	–	2,568	132	23	3,043	–	–	3,099	331	9,196
01/02	–	1,788	69	–	3,557	52	301	2,020	435	8,222
02/03	–	2,740	–	138	4,174	255	144	2,485	–	9,936
03/04	–	2,444	–	275	3,311	380	107	1,982	–	8,499
04/05	–	2,734	–	181	2,938	357	–	2,106	–	8,316
05/06	–	3,563	–	442	3,419	822	–	2,045	406	10,697
06/07	–	2,771	–	342	3,752	649	–	2,462	462	10,438
07/08	–	2,682	–	208	3,996	697	–	2,060	742	10,385
08/09	–	3,304	–	116	2,777	620	–	1,992	656	9,465
09/10	–	2,867	–	124	3,714	181	–	1,968	838	9,692
10/11	–	3,259	34	511	3,029	281	–	2,979	363	10,456
Total	307	51,801	3,713	2,789	47,651	4,294	552	56,005	4,679	171,791

Table 7: Percentage of potlifts in the *rllb* database with unmeasured lobsters relative to the total number of potlifts with measured lobsters by QMA and fishing year. Potlifts which captured lobsters but with no measured lobsters have been excluded from this table; '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9
93/94	0	0.4	0.3	–	–	–	–	5.0	–
94/95	0	0.8	1.8	–	1.2	–	–	2.8	–
95/96	0	0.1	2.8	–	1.9	–	–	2.0	–
96/97	–	0.6	3.9	–	0.6	–	–	1.5	0
97/98	–	0.05	9.2	5.7	1.6	–	–	1.3	0
98/99	–	0.1	0	4.6	2.6	–	–	1.0	2.0
99/00	–	0.04	1.0	0	1.5	–	–	1.1	2.6
00/01	–	1.6	0	0	11.1	–	–	6.0	1.2
01/02	–	2.2	1.4	–	11.1	0	32.6	5.4	1.1
02/03	–	1.5	–	0	11.3	0	24.3	5.7	–
03/04	–	0.7	–	1.1	11.3	0.8	31.8	8.8	–
04/05	–	1.5	–	0	12.8	0.0	–	7.6	–
05/06	–	1.6	–	0.7	10.8	0.4	–	9.9	4.2
06/07	–	0.6	–	0	7.8	0.5	–	11.1	5.8
07/08	–	1.1	–	1.9	6.8	0.1	–	13.7	2.3
08/09	–	1.1	–	0	6.7	0	–	14.2	5.3
09/10	–	0.6	–	1.6	7.1	0	–	16.1	3.3
10/11	–	0	2.9	2.5	9.1	0.4	–	10.0	4.1
Average	0	0.8	2.1	1.5	7.9	0.3	30.3	5.5	3.3

Table 8: Number of measured lobsters in the *rllb* database by QMA and fishing year; '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	179	18,172	6,208	–	–	–	–	37,653	–	62,212
94/95	484	18,134	8,559	–	17,007	–	–	33,179	–	77,363
95/96	486	11,658	6,830	–	9,547	–	–	44,923	–	73,444
96/97	–	12,522	6,723	–	14,087	–	–	28,450	209	61,991
97/98	–	9,225	1,471	1,844	11,029	–	–	21,421	266	45,256
98/99	–	9,172	895	1,397	8,372	–	–	21,780	606	42,222
99/00	–	10,324	517	297	12,725	–	–	11,472	220	35,555
00/01	–	9,186	769	331	26,030	–	–	21,041	1,211	58,568
01/02	–	5,895	348	–	30,214	122	1,816	12,364	1,779	52,538
02/03	–	8,272	–	592	36,095	599	1,067	17,745	–	64,370
03/04	–	7,454	–	1,501	31,461	1,171	1,106	17,090	–	59,783
04/05	–	8,544	–	1,024	28,525	941	–	15,766	–	54,800
05/06	–	10,758	–	2,462	32,763	3,256	–	17,130	1,930	68,299
06/07	–	8,845	–	1,406	34,238	2,271	–	22,432	2,631	71,823
07/08	–	9,016	–	1,400	34,717	2,797	–	21,234	3,483	72,647
08/09	–	10,419	–	522	23,758	2,347	–	22,671	3,344	63,061
09/10	–	8,679	–	945	35,348	543	–	22,772	3,775	72,062
10/11	–	9,898	126	3,128	31,857	995	–	27,653	1,276	74,933
Total	1,149	186,173	32,446	16,849	417,773	15,042	3,989	416,776	20,730	1,110,927

Table 9: Number of unmeasured lobsters in the *rllb* database by QMA and fishing year. Potlifts which captured lobsters but with no measured lobsters (there are 1,293 such potlifts) have been excluded from this table; '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	0	286	9	–	–	–	–	6,364	–	6,659
94/95	0	466	164	–	247	–	–	1,755	–	2,632
95/96	0	14	198	–	300	–	–	4,706	–	5,218
96/97	–	143	129	–	89	–	–	1,375	0	1,736
97/98	–	3	92	123	200	–	–	752	0	1,170
98/99	–	7	0	153	228	–	–	789	6	1,183
99/00	–	3	1	0	148	–	–	361	2	515
00/01	–	99	0	0	1,956	–	–	2,047	4	4,106
01/02	–	66	2	–	3,553	0	242	849	10	4,722
02/03	–	59	–	0	3,726	0	72	1,233	–	5,090
03/04	–	22	–	24	3,251	39	75	1,480	–	4,891
04/05	–	91	–	0	3,503	0	–	1,751	–	5,345
05/06	–	228	–	4	3,877	7	–	2,260	35	6,411
06/07	–	28	–	0	2,258	9	–	2,484	193	4,972
07/08	–	39	–	22	2,073	5	–	3,367	78	5,584
08/09	–	93	–	0	1,497	0	–	3,542	73	5,205
09/10	–	20	–	6	2,020	0	–	3,711	61	5,818
10/11	–	0	2	22	1,918	1	–	1,568	29	3,540
Total	0	1,667	597	354	30,844	61	389	40,394	491	74,797

Table 10: Number of dead lobsters in the *rllb* database by QMA and fishing year. These lobsters are included in the unmeasured totals reported in Table 9. Dead lobsters were not reported consistently in the form used prior to 2000–01. Potlifts which captured lobsters but with no measured lobsters have been excluded from this table; '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	0	0	0	–	–	–	–	0	–	0
94/95	0	0	0	–	0	–	–	0	–	0
95/96	0	0	0	–	0	–	–	0	–	0
96/97	–	0	0	–	0	–	–	0	0	0
97/98	–	0	0	0	0	–	–	0	0	0
98/99	–	0	0	0	0	–	–	0	6	6
99/00	–	0	1	0	3	–	–	1	2	7
00/01	–	71	0	0	208	–	–	66	4	349
01/02	–	62	2	–	155	0	1	61	2	283
02/03	–	55	–	0	229	0	0	48	–	332
03/04	–	22	–	1	169	1	23	85	–	301
04/05	–	45	–	0	176	0	–	60	–	281
05/06	–	42	–	0	164	2	–	80	25	313
06/07	–	20	–	0	179	2	–	173	28	402
07/08	–	29	–	0	140	0	–	188	19	376
08/09	–	36	–	0	93	0	–	123	67	319
09/10	–	13	–	0	136	0	–	139	61	349
10/11	–	0	2	20	224	1	–	218	29	494
Total	0	395	5	21	1,876	6	24	1,242	243	3,812

Table 11: RLLB: 99th quantile for the potlift ratio of total lobsters relative to measured lobsters $\left({}^{c}n_i / {}^{w}n_i\right)$ by QMA and fishing year. '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
93/94	1.000	1.000	1.000	–	–	–	–	2.839	–	1.613
94/95	1.000	1.000	1.226	–	1.065	–	–	1.387	–	1.226
95/96	1.000	1.000	1.484	–	1.355	–	–	1.387	–	1.226
96/97	–	1.000	1.290	–	1.000	–	–	1.400	1.000	1.100
97/98	–	1.000	1.355	1.742	1.194	–	–	1.129	1.000	1.097
98/99	–	1.000	1.000	2.065	1.323	–	–	1.000	1.500	1.000
99/00	–	1.000	1.000	1.000	1.097	–	–	1.129	2.000	1.000
00/01	–	1.500	1.000	1.000	1.760	–	–	2.000	1.111	1.760
01/02	–	2.000	1.286	–	1.960	1.000	3.000	1.920	1.040	2.000
02/03	–	1.500	–	1.000	2.000	1.000	2.500	1.840	–	1.880
03/04	–	1.000	–	1.040	2.040	1.000	2.000	1.920	–	1.920
04/05	–	1.500	–	1.000	2.280	1.000	–	2.000	–	2.000
05/06	–	1.400	–	1.000	2.240	1.000	–	2.200	2.000	2.000
06/07	–	1.000	–	1.000	2.000	1.000	–	2.160	3.000	2.000
07/08	–	1.250	–	1.160	1.800	1.000	–	2.720	1.800	2.000
08/09	–	1.143	–	1.000	1.880	1.000	–	2.520	2.000	2.000
09/10	–	1.000	–	1.120	1.720	1.000	–	2.400	2.000	2.000
10/11	–	1.000	1.400	1.250	1.960	1.000	–	2.000	3.000	1.720
Average	1.000	1.000	1.258	1.167	1.880	1.000	3.000	2.000	2.000	1.720

Table 12. Number of valid observations ([*potlifts*]) for the field "*zone*" in the *rllb* database by QMA and fishing year; '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
98/99	–	–	–	–	–	–	–	–	32	32
99/00	–	–	–	–	60	–	–	6	–	66
00/01	–	3,785	–	23	3,802	–	–	4,176	190	11,976
01/02	–	2,910	–	–	4,298	142	–	2,782	502	10,634
02/03	–	5,014	–	180	4,896	351	–	3,105	–	13,546
03/04	–	1,580	–	280	3,641	575	–	223	–	6,299
04/05	–	1,690	–	–	2,959	611	–	103	–	5,363
05/06	–	1,551	–	–	3,377	1,062	–	–	224	6,214
06/07	–	966	–	–	3,523	531	–	–	238	5,258
07/08	–	947	–	–	3,556	248	–	–	649	5,400
08/09	–	–	–	–	2,223	120	–	–	206	2,549
09/10	–	312	–	–	2,316	–	–	–	488	3,116
10/11	–	–	–	–	1,728	–	–	–	144	1,872
Total	–	18,755	–	483	36,379	3,640	–	10,395	2,673	72,325

Table 13. RLLB (CRA 5): number of observations ([*potlifts*]) in the field [*zone*] by the name designator for the declared [*zone*] and by fishing year. Only potlifts with legal catch are included. The final 2 rows show the number and percentage of potlifts without a [*zone*] designation; '–': no observations

	Fishing Year											
Zone	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	Total
G01	267	732	798	482	455	739	1,109	1,027	552	517	418	7,096
G02	226	–	102	541	307	347	3	–	–	–	–	1,526
G03	58	18	–	62	114	51	91	53	21	69	105	642
G04	–	49	136	–	–	–	–	199	–	15	–	399
G05	372	296	337	275	111	–	23	71	57	3	8	1,553
G06	52	225	265	56	82	55	59	126	98	77	57	1,152
G07	41	173	203	55	69	68	106	121	85	95	71	1,087
G08	204	227	283	198	117	271	243	135	–	–	–	1,678
G09	97	111	107	26	141	171	194	–	–	–	–	847
G10	–	9	–	76	–	–	–	311	301	243	216	1,156
G13	155	77	69	–	–	–	–	–	–	–	–	301
M10	–	–	–	–	–	–	–	–	1	–	–	1
M12	427	249	335	252	165	193	258	347	245	328	203	3,002
M13	76	129	109	9	66	167	–	203	–	–	–	759
M14	–	–	38	–	–	–	–	–	–	–	–	38
M15	210	460	603	503	339	348	493	193	255	355	202	3,961
Total	2,185	2,755	3,385	2,535	1,966	2,410	2,579	2,786	1,615	1,702	1,280	25,198
no "*zone*"	8	–	–	152	331	386	571	648	818	1,599	1,364	5,877
% no "*zone*"	0.4%	0.0%	0.0%	5.7%	14.4%	13.8%	18.1%	18.9%	33.6%	48.4%	51.6%	18.9%

Table 14: Distribution of potlifts in the *rlcs* database by fishing year and QMA. '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
86/87	–	267	157	177	–	–	–	–	–	601
87/88	–	167	–	1,280	–	–	589	607	–	2,643
88/89	–	–	–	1,280	–	–	1,125	385	–	2,790
89/90	–	–	1,165	2,734	1,006	1,144	708	4,445	–	11,202
90/91	–	196	2,045	4,312	1,284	–	794	7,303	–	15,934
91/92	–	230	2,195	2,394	1,080	–	626	6,845	–	13,370
92/93	–	–	2,163	2,295	1,850	–	874	6,904	–	14,086
93/94	–	–	5,889	2,300	1,652	918	485	5,238	–	16,482
94/95	–	–	5,751	1,379	1,511	900	1,479	6,112	–	17,132
95/96	–	–	3,785	1,634	1,576	3,446	1,757	6,342	–	18,540
96/97	–	–	3,282	711	716	3,964	2,976	8,968	–	20,617
97/98	1,252	–	2,714	4,220	566	2,372	1,827	3,881	–	16,832
98/99	668	–	2,886	3,123	885	–	1,406	839	–	9,807
99/00	1,722	1,387	2,123	4,639	2,669	–	1,991	693	–	15,224
00/01	1,256	1,517	1,973	4,217	1,129	–	1,619	2,255	–	13,966
01/02	1,110	1,337	3,317	3,980	–	–	1,065	1,059	151	12,019
02/03	1,245	1,338	3,424	4,533	–	–	1,595	1,504	–	13,639
03/04	1,321	1,414	3,266	4,429	–	–	1,679	–	–	12,109
04/05	1,013	1,170	3,144	4,397	–	–	1,677	–	–	11,401
05/06	1,132	1,320	3,167	5,410	–	–	1,551	–	–	12,580
06/07	1,315	1,365	3,281	5,665	–	–	1,307	–	–	12,933
07/08	780	1,335	2,996	5,235	–	–	1,199	–	–	11,545
08/09	994	1,430	3,302	3,991	535	–	1,335	–	–	11,587
09/10	1,177	1,445	3,400	4,318	551	–	1,285	–	–	12,176
10/11	1,237	1,451	2,972	3,968	727	–	1,087	2,095	–	13,537
Total	16,222	17,369	68,397	82,621	17,737	12,744	32,036	65,475	151	312,752

Table 15: Distribution of vessels in the *rlcs* database by fishing year and QMA. The 'Total' for all fishing years is the number of unique vessels that have participated in the programme for each QMA across all years. The 'Total' across QMAs within a fishing year is the sum of vessels without determining if vessels participated in more than one QMA (which is unlikely). '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	CRA 9	Total
86/87	–	2	3	2	–	–	–	–	–	7
87/88	–	1	–	2	–	–	3	4	–	10
88/89	–	–	–	4	–	–	3	3	–	10
89/90	–	–	7	5	4	9	4	8	–	37
90/91	–	2	4	5	4	–	3	6	–	24
91/92	–	1	5	3	4	–	3	6	–	22
92/93	–	–	6	3	2	–	4	6	–	21
93/94	–	–	17	2	4	9	4	8	–	44
94/95	–	–	18	4	4	11	5	10	–	52
95/96	–	–	14	4	3	22	6	8	–	57
96/97	–	–	12	5	3	27	11	21	–	79
97/98	5	–	8	12	3	18	7	11	–	64
98/99	3	–	11	11	5	–	5	2	–	37
99/00	11	12	8	14	11	–	7	4	–	67
00/01	9	13	7	15	6	–	7	10	–	67
01/02	8	10	9	13	–	–	7	5	1	53
02/03	6	12	12	17	–	–	8	5	–	60
03/04	8	12	10	19	–	–	5	–	–	54
04/05	6	12	11	17	–	–	8	–	–	54
05/06	4	10	11	16	–	–	6	–	–	47
06/07	6	9	10	15	–	–	7	–	–	47
07/08	4	11	12	17	–	–	6	–	–	50
08/09	6	7	12	17	5	–	8	–	–	55
09/10	7	8	12	15	4	–	10	–	–	56
10/11	9	12	9	15	5	–	6	12	–	68
Total	24	32	58	66	26	51	36	61	1	355

Table 16: Number of potlifts in the *rlcs* database summarised for three measurement categories by QMA and fishing year. [A]: no lobsters captured in the potlift; [B]: lobsters captured but not measured; [C]: lobsters captured and measured. '–': no observations

Fishing		CRA 1			CRA 2			CRA 3			CRA 4	
Year	[A]	[B]	[C]	[A]	[B]	[C]	[A]	[B]	[C]	[A]	[B]	[C]
86/87	–	–	–	93	13	161	22	48	87	16	80	81
87/88	–	–	–	87	1	79	–	–	–	263	220	797
88/89	–	–	–	–	–	–	–	–	–	268	160	852
89/90	–	–	–	–	–	–	102	434	629	636	376	1,722
90/91	–	–	–	68	1	127	125	620	1,300	731	778	2,803
91/92	–	–	–	38	77	115	205	586	1,404	171	361	1,862
92/93	–	–	–	–	–	–	365	274	1,524	342	191	1,762
93/94	–	–	–	–	–	–	914	1,428	3,547	523	156	1,621
94/95	–	–	–	–	–	–	590	513	4,648	387	4	988
95/96	–	–	–	–	–	–	295	572	2,918	342	35	1,257
96/97	–	–	–	–	–	–	249	412	2,621	81	27	603
97/98	530	8	714	–	–	–	189	141	2,384	278	683	3,259
98/99	160	3	505	–	–	–	237	681	1,968	361	796	1,966
99/00	484	5	1,233	465	5	917	233	497	1,393	699	923	3,017
00/01	357	2	897	505	8	1,004	136	374	1,463	636	776	2,805
01/02	373	6	731	455	22	860	584	337	2,396	612	494	2,874
02/03	342	6	897	587	27	724	314	945	2,165	919	337	3,277
03/04	386	25	910	658	19	737	707	578	1,981	793	511	3,125
04/05	255	10	748	618	22	530	662	458	2,024	543	669	3,185
05/06	300	4	828	551	16	753	728	142	2,297	724	519	4,167
06/07	354	292	669	568	23	774	539	427	2,315	1,099	256	4,310
07/08	248	35	497	475	29	831	725	385	1,886	1,070	195	3,970
08/09	271	19	704	513	43	874	601	479	2,222	690	172	3,129
09/10	240	79	858	551	13	881	400	495	2,505	607	331	3,380
10/11	329	61	847	657	11	783	451	428	2,093	826	201	2,941
Total	4,629	555	11,038	6,889	330	10,150	9,373	11,254	47,770	13,617	9,251	59,753

Table 16 (cont):

Fishing		CRA 5			CRA 6			CRA 7			CRA 8	
Year	[A]	[B]	[C]	[A]	[B]	[C]	[A]	[B]	[C]	[A]	[B]	[C]
86/87	–	–	–	–	–	–	–	–	–	–	–	–
87/88	–	–	–	–	–	–	95	83	411	146	116	345
88/89	–	–	–	–	–	–	432	27	666	113	6	266
89/90	316	45	645	583	2	559	363	9	336	1,337	381	2,727
90/91	275	81	928	–	–	–	220	60	514	1,725	1,251	4,327
91/92	234	96	750	–	–	–	131	81	414	1,153	1,332	4,360
92/93	801	2	1,047	–	–	–	352	26	496	1,526	331	5,047
93/94	442	47	1,163	571	2	345	121	136	228	1,435	282	3,521
94/95	434	9	1,068	554	1	345	491	9	979	1,600	73	4,439
95/96	577	9	990	2,204	4	1,238	908	2	847	2,253	72	4,017
96/97	120	–	596	1,767	336	1,861	1,922	4	1,050	2,779	200	5,989
97/98	104	10	452	1,310	16	1,046	1,018	4	805	1,127	15	2,739
98/99	167	105	613	–	–	–	700	–	706	184	26	629
99/00	678	–	1,991	–	–	–	1,046	–	945	150	115	428
00/01	183	–	946	–	–	–	752	–	867	681	112	1,462
01/02	–	–	–	–	–	–	361	16	688	159	456	444
02/03	–	–	–	–	–	–	554	12	1,029	239	107	1,158
03/04	–	–	–	–	–	–	495	18	1,166	–	–	–
04/05	–	–	–	–	–	–	412	40	1,225	–	–	–
05/06	–	–	–	–	–	–	367	70	1,114	–	–	–
06/07	–	–	–	–	–	–	132	388	787	–	–	–
07/08	–	–	–	–	–	–	219	218	762	–	–	–
08/09	89	57	389	–	–	–	119	495	721	–	–	–
09/10	75	111	365	–	–	–	288	139	858	–	–	–
10/11	42	191	494	–	–	–	379	7	701	198	809	1,088
Total	4,543	763	12,431	6,989	361	5,394	11,881	1,844	18,311	16,810	5,684	42,981

Table 17: Percentage of potlifts in the *rlcs* database which captured rock lobsters but for which none were measured expressed as a percentage of the total number of potlifts which captured lobsters (i.e., [B]/([B] + [C]) – using the column notation in Table 16) by fishing year and QMA. '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8
86/87	–	7.5	35.6	50.6	–	–	–	–
87/88	–	1.3	–	21.6	–	–	16.9	25.2
88/89	–	–	–	15.9	–	–	3.9	2.2
89/90	–	–	40.8	17.9	6.5	0.4	2.6	12.3
90/91	–	0.8	32.3	21.7	8.0	–	10.5	22.4
91/92	–	40.1	29.5	16.2	11.4	–	16.4	23.4
92/93	–	–	15.2	9.8	0.2	–	5.0	6.2
93/94	–	–	28.7	8.8	3.9	0.6	37.4	7.4
94/95	–	–	9.9	0.4	0.8	0.3	0.9	1.6
95/96	–	–	16.4	2.7	0.9	0.3	0.2	1.8
96/97	–	–	13.6	4.3	–	15.3	0.4	3.2
97/98	1.1	–	5.6	17.3	2.2	1.5	0.5	0.5
98/99	0.6	–	25.8	28.8	14.6	–	–	4.0
99/00	0.4	0.5	26.3	23.4	–	–	–	21.2
00/01	0.2	0.8	20.4	21.7	–	–	–	7.1
01/02	0.8	2.5	12.3	14.7	–	–	2.3	50.8
02/03	0.7	3.6	30.4	9.3	–	–	1.2	8.5
03/04	2.7	2.5	22.6	14.1	–	–	1.5	–
04/05	1.3	4.0	18.5	17.4	–	–	3.2	–
05/06	0.5	2.1	5.8	11.1	–	–	5.9	–
06/07	30.4	2.9	15.6	5.6	–	–	33.0	–
07/08	6.6	3.4	17.0	4.7	–	–	22.2	–
08/09	2.6	4.7	17.7	5.2	12.8	–	40.7	–
09/10	8.4	1.5	16.5	9.0	23.3	–	13.9	–
10/11	6.7	1.4	17.0	6.4	28.1	–	1.0	42.7
Average	4.8	3.2	19.1	13.4	5.8	6.3	9.2	11.7

Table 18: Percentage of unmeasured lobsters in the *rlcs* database by fishing year and QMA for all pots where lobsters were measured (i.e., column [C] in Table 16) . '–': no observations

Fishing Year	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8
86/87	–	32.45	12.44	3.67	–	–	–	–
87/88	–	1.27	–	0.62	–	–	1.89	0.48
88/89	–	–	–	0.27	–	–	0.00	0.15
89/90	–	–	0.06	0.00	0.03	0.00	0.00	0.00
90/91	–	1.35	0.07	0.00	0.00	–	0.00	0.00
91/92	–	0.21	0.09	0.01	0.00	–	0.00	0.01
92/93	–	–	0.14	0.01	0.00	–	0.00	0.00
93/94	–	–	0.06	0.03	0.03	0.00	0.05	0.01
94/95	–	–	0.20	0.00	0.00	0.00	0.00	0.00
95/96	–	–	0.17	0.00	0.00	0.00	0.00	0.00
96/97	–	–	0.02	0.00	0.00	0.01	0.00	0.00
97/98	0.49	–	0.98	0.00	0.00	0.00	0.00	0.00
98/99	0.04	–	0.06	0.01	0.00	–	0.00	0.00
99/00	0.26	0.42	0.02	0.00	0.00	–	0.00	0.00
00/01	0.17	1.08	0.22	0.00	0.00	–	0.00	0.00
01/02	0.18	1.37	0.10	0.01	–	–	0.00	0.00
02/03	0.43	0.74	0.08	0.01	–	–	0.00	0.00
03/04	0.31	1.71	0.26	0.01	–	–	0.00	–
04/05	1.08	1.24	0.60	0.01	–	–	0.00	–
05/06	0.38	1.58	0.36	0.00	–	–	0.00	–
06/07	0.18	3.19	0.49	0.00	–	–	0.00	–
07/08	4.01	1.40	0.94	0.01	–	–	0.00	–
08/09	3.36	1.64	0.31	0.01	0.00	–	0.03	–
09/10	0.97	1.77	0.42	0.02	0.00	–	0.00	–
10/11	0.56	1.13	0.27	0.01	0.00	–	0.00	0.01
Average	0.81	2.23	0.28	0.02	0.00	0.01	0.06	0.01

Table 19: Mean catch rate (numbers of legal + non-legal lobsters) per potlift in the *rlcs* database by fishing year and QMA for each category which captured lobsters ([B]: lobsters captured but not measured; [C]: lobsters captured and measured) '–': no observations

Fishing	CRA 1		CRA 2		CRA 3		CRA 4		CRA 5		CRA 6		CRA 7		CRA 8	
Year	[B]	[C]	[B]	[C]	[B]	[C]	[B]	[C]	[B]	[C]	[B]	[C]	[B]	[C]	[B]	[C]
86/87	–	–	9.1	5.4	7.2	6.9	9.8	7.3	–	–	–	–	–	–	–	–
87/88	–	–	1.0	3.0	–	–	6.6	5.0	–	–	–	–	13.6	6.7	9.4	5.5
88/89	–	–	–	–	–	–	6.9	5.6	–	–	–	–	9.1	3.8	2.8	5.0
89/90	–	–	–	–	14.4	8.5	10.6	4.9	13.9	5.2	2.5	2.6	12.1	3.7	22.8	6.9
90/91	–	–	1.0	2.9	18.5	10.8	15.0	9.1	13.1	5.8	–	–	8.6	4.8	20.3	7.3
91/92	–	–	9.2	8.2	19.1	10.6	20.0	10.3	16.3	6.6	–	–	10.2	4.5	18.3	8.7
92/93	–	–	–	–	17.1	8.9	17.5	10.4	1.5	2.9	–	–	10.5	4.3	19.0	6.2
93/94	–	–	–	–	15.1	8.3	20.7	7.5	11.6	5.6	1.0	1.9	35.4	8.7	28.6	6.2
94/95	–	–	–	–	19.8	9.7	11.3	8.4	13.3	4.7	1.0	1.9	8.0	4.7	14.3	6.3
95/96	–	–	–	–	18.0	11.4	17.1	7.9	13.2	5.0	5.5	2.1	2.0	3.5	15.8	5.0
96/97	–	–	–	–	22.0	12.1	22.0	7.7	–	9.1	5.1	4.1	2.5	2.8	15.0	5.8
97/98	1.0	3.5	–	–	22.0	13.5	16.2	10.6	17.0	10.2	4.1	2.6	4.5	3.9	11.0	5.8
98/99	1.0	5.2	–	–	13.7	11.7	15.3	9.9	14.3	6.9	–	–	–	3.4	27.0	6.6
99/00	1.2	5.6	1.0	3.4	11.2	11.1	14.7	8.4	–	6.8	–	–	–	2.8	22.4	9.9
00/01	1.0	5.2	1.6	3.1	13.1	9.4	16.6	8.2	–	10.6	–	–	–	3.8	26.0	6.7
01/02	2.0	3.8	1.5	3.6	14.1	9.2	16.0	7.3	–	–	–	–	18.6	5.6	17.1	11.9
02/03	1.2	5.2	7.9	3.2	13.7	8.8	10.0	6.5	–	–	–	–	16.3	4.9	21.6	8.3
03/04	2.0	5.3	1.5	2.6	15.2	6.9	12.2	6.0	–	–	–	–	16.4	5.5	–	–
04/05	4.1	5.5	1.4	2.6	12.9	6.7	14.0	7.3	–	–	–	–	16.8	5.8	–	–
05/06	1.5	6.0	2.1	3.1	10.9	5.8	13.4	6.3	–	–	–	–	17.9	6.7	–	–
06/07	4.9	6.0	1.8	2.6	14.3	5.8	15.0	5.2	–	–	–	–	17.9	9.4	–	–
07/08	6.1	6.1	2.5	2.8	15.0	6.2	11.2	5.2	–	–	–	–	21.2	8.9	–	–
08/09	2.0	5.4	2.8	3.0	14.8	6.6	17.2	6.6	19.6	5.4	–	–	16.6	9.3	–	–
09/10	7.3	5.7	1.6	3.2	14.5	7.4	12.7	6.1	7.8	5.3	–	–	16.4	5.9	–	–
10/11	7.3	4.9	1.5	2.5	16.3	7.1	13.0	6.3	12.7	7.1	–	–	16.0	4.0	16.4	10.3
Average	5.1	5.2	4.4	3.1	15.5	9.0	14.4	7.2	13.3	6.3	5.0	2.9	17.9	5.2	19.1	6.7

Table 20. Distribution of potlifts for the top 23 bait codes in the *rlcs* database, summed over all fishing years from 1989–90 to 2010–11, by QMA. Codes marked in grey were used as factors in the standardised analysis (the remainder are summed into a "plus" group). See Appendix B for a description of these codes. '–': no observations

[*bait*] code	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	Total
500	7,929	8,281	20,723	17,005	6,862	3,939	5,076	9,495	79,310
300	2,398	209	7,980	15,991	6,334	3,544	10,798	29,914	77,168
100	1,617	1,460	17,014	20,115	1,725	1,078	2,006	7,260	52,275
303	107	496	4,932	10,238	1,398	365	3,009	1,216	21,761
103	1,641	2,119	1,632	6,294	418	275	1,184	3,097	16,660
306	3	587	940	1,374	3	350	190	6,197	9,644
121	–	111	3,074	787	84	622	2	22	4,702
108	1,053	733	1,260	356	148	114	192	4	3,860
317	2	–	–	–	115	81	3,157	–	3,355
309	617	735	1,294	165	322	58	1	62	3,254
336	–	–	357	673	–	–	–	1,461	2,491
118	438	90	1,632	272	1	–	–	–	2,433
116	–	–	–	–	–	1,105	1,030	113	2,248
102	52	975	687	259	–	10	–	–	1,983
302	–	16	229	945	–	530	–	–	1,720
106	–	–	248	–	–	–	66	1,378	1,692
506	–	–	–	–	–	–	–	1,643	1,643
503	–	185	173	205	–	51	–	694	1,308
111	–	–	525	435	–	–	334	–	1,294
333	–	–	–	–	–	–	1,232	–	1,232
318	–	86	433	686	–	–	–	–	1,205
136	–	–	–	605	34	–	–	382	1,021
119	–	–	1,015	–	–	–	–	–	1,015
Total	15,857	16,083	64,148	76,405	17,444	12,122	28,277	62,938	293,274
Total	16,222	16,935	68,239	79,665	17,737	12,744	30,191	64,479	306,212

[1] Table total (sum of top 23 [*bait*] codes)
[2] Total all potlifts with valid [*bait*] codes

Table 21. Distribution of potlifts for the top 30 [*pot type*] codes in the *rlcs* database, summed over all fishing years from 1989–90 to 2010–11, by QMA. Codes marked in grey were used as factors in the standardised analysis (the remainder are summed into a "plus" group). See Appendix C for a description of these codes '–': no observations.

[*pot type code*]	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 6	CRA 7	CRA 8	Total
L5	2,121	10,180	54,714	48,080	2,845	6	–	24	117,970
B1	89	–	–	75	246	381	715	12,376	13,882
B3	736	78	156	588	1,125	2,205	311	5,914	11,113
B2	27	3	–	715	920	1,627	281	7,444	11,017
L4	–	457	6,067	4,013	126	–	–	–	10,663
B4	1,134	124	–	224	1,114	10	5,185	2,675	10,466
B9	–	–	–	–	14	30	5,864	3,557	9,465
A9	–	8	–	–	35	6	7,060	825	7,934
C4	701	7	3	137	303	92	151	6,039	7,433
I3	–	–	–	–	4	–	–	6,433	6,437
A1	2	1	22	17	1,863	23	863	3,486	6,277
A3	3	33	6	613	2,623	297	387	2,185	6,147
A5	2,062	1,071	91	1,608	562	166	4	–	5,564
L2	–	–	4,226	1,107	–	2	–	–	5,335
A4	31	95	202	127	77	4	4,492	103	5,131
A2	–	33	203	374	2,576	576	129	788	4,679
C3	180	17	–	174	–	2,340	34	1,794	4,539
C2	200	–	–	136	29	3,287	25	751	4,428
B5	1,629	819	37	1,404	77	198	2	10	4,176
B7	–	–	–	10	–	88	596	3,290	3,984
H3	11	4	–	106	291	–	–	3,471	3,883
A7	–	–	–	–	9	11	2,391	569	2,980
32	14	–	166	2,674	–	12	–	–	2,866
33	20	–	–	2,792	–	–	–	12	2,824
L3	–	40	715	1,738	–	1	–	5	2,499
C5	974	68	137	1,034	160	38	3	–	2,414
35	124	58	292	1,858	–	–	–	–	2,332
S5	1,607	636	–	–	–	–	–	–	2,243
39	–	–	745	1,447	–	1	18	–	2,211
M5	678	327	27	1,006	65	101	–	1	2,205
Total	12,343	14,059	67,809	72,057	15,064	11,502	28,511	61,752	283,097
Total	16,222	16,935	68,240	79,884	17,737	12,744	30,321	64,482	306,565

[1] Table total (top 30 [*pot type*] codes)
[2] Total all bait codes with valid [*pot type*] codes

Table 22: AIC for seven explanatory variables from the *rllb* offered to two models in three QMAs, sorted in ascending order of AIC for each model and QMA. The models were run only for the first iteration, fitting each variable singly to the dependent variable. Data used were by potlift, with the dependent variable being ln([*catch*]), where [*catch*] was either weight in kg or the number of lobster of legal lobsters. A small increment (0.01) added to [*catch*] for lifts with no lobster catch.

Model: catch weight from measured lobsters and scaled (Eq. 5) to total catch		Model: count of legal lobsters scaled (Eq. 5) to total numbers	
CRA 2		CRA 2	
Variable	AIC	Variable	AIC
Vessel	352,442	Vessel	363,078
Skipper	352,516	Skipper	363,146
Fishing year	353,835	Fishing year	364,630
Month	354,899	Month	365,452
Depth	355,147	Depth	365,694
Statistical area	355,170	Statistical area	365,744
Soak time	355,306	Soak time	365,803
CRA 5		CRA 5	
Variable	AIC	Variable	AIC
Vessel	232,267	Vessel	239,258
Skipper	233,586	Skipper	240,491
Statistical area	236,995	Statistical area	244,073
Fishing year	242,710	Fishing year	250,285
Month	243,026	Month	250,380
Depth	244,101	Depth	251,512
Soak time	244,686	Soak time	252,134
CRA 8		CRA 8	
Variable	AIC	Variable	AIC
Fishing year	290,113	Fishing year	300,759
Vessel	291,055	Vessel	300,789
Skipper	291,791	Skipper	301,430
Month	295,612	Statistical area	305,011
Statistical area	295,720	Month	305,264
Depth	296,711	Depth	305,960
Soak time	296,962	Soak time	306,446

Table 23: AIC for eight explanatory variables from the *rlcs* offered to two models in five QMAs, sorted in ascending order of AIC for each model and QMA. The models were run only for the first iteration, fitting each variable singly to the dependent variable. Model "Total Number Captured" uses the count of all lobsters captured in every potlift as the dependent variable, without consideration of legal status; model "Total Weight Measured" uses the converted length to weight calculation (Eq. 5) for the pots with legal measured lobster as the dependent variable. Both models are based on potlift data, with a small increment (0.01) added to lifts with no lobster catch

							Model
Total Number Captured		Total Weight Measured		Total Number Captured		Total Weight Measured	
CRA 1		CRA 1		CRA 2		CRA 2	
Variable	AIC	Variable	AIC	Variable	AIC	Variable	AIC
Vessel	75,525	Vessel	65,208	Vessel	74,308	Fishing year	59,827
Statistical area	76,013	Statistical area	65,602	Bait type	74,574	Vessel	59,832
Pot type	76,243	Pot type	65,918	Fishing year	74,618	Bait type	59,931
Depth	76,276	Depth	66,128	Month	74,688	Month	59,956
Month	76,643	Bait type	66,356	Pot type	74,700	Pot type	59,983
Bait type	76,645	Month	66,385	Depth	74,716	Depth	60,025
Fishing year	76,785	Fishing year	66,508	Statistical area	74,803	Soak time	60,090
Soak time	76,919	Soak time	66,583	Soak time	74,834	Statistical area	60,093
CRA 3		CRA 3		CRA 4		CRA 4	
Variable	AIC	Variable	AIC	Variable	AIC	Variable	AIC
Vessel	294,248	Month	141,137	Vessel	353,635	Vessel	232,456
Statistical area	303,382	Vessel	145,528	Statistical area	361,363	Fishing year	235,989
Fishing year	304,655	Fishing year	145,531	Fishing year	362,664	Month	237,557
Month	304,973	Bait type	151,639	Soak time	363,629	Bait type	237,784
Soak time	305,526	Statistical area	151,647	Bait type	363,746	Soak time	237,837
Depth	306,541	Depth	151,697	Pot type	364,164	Statistical area	237,855
Pot type	307,210	Soak time	151,753	Month	364,246	Pot type	237,928
Bait type	307,336	Pot type	151,908	Depth	365,269	Depth	238,728
CRA 7		CRA 7					
Variable	AIC	Variable	AIC				
Fishing year	126,937	Fishing year	98,859				
Vessel	129,488	Vessel	100,928				
Bait type	130,421	Bait type	101,723				
Pot type	131,162	Pot type	101,742				
Month	131,529	Month	102,472				
Soak time	131,799	Soak time	102,519				
Depth	131,868	Depth	102,601				
Statistical area	131,955	Statistical area	102,632				

Table 24: Final lognormal and binomial models (Eq. 3) by QMA fitted to the *rllb* potlift data, showing the order that each variable entered the model and the cumulative AIC for the model up to and including each variable. (Fyear: Fishing year)

CRA 2				CRA 5				CRA 8			
Lognormal		Binomial		Lognormal		Binomial		Lognormal		Binomial	
Term	AIC	Term	AIC	Term	AIC	Term	AIC	Term	AIC	Term	AIC
Null	80,264	Null	106,189	Null	90,040	Null	60,719	Null	99,507	Null	75,871
Fyear	77,973	Fyear	105,166	Fyear	88,257	Fyear	59,336	Fyear	92,743	Fyear	72,139
Vessel	75,950	Vessel	102,817	Vessel	78,517	Vessel	52,362	Vessel	90,854	Vessel	69,653
Depth	75,608	Month	102,265	Month	76,689	Month	51,496	Month	90,053	Month	69,149
Month	75,311	Soak	102,150	Depth	76,213	Statarea	51,156	Depth	89,773	Depth	68,974
Statarea	75,305	Depth	102,118	Statarea	75,679	Depth	51,077	Soak	89,738	Soak	68,927
Soak	75,300	Statarea	102,096	Soak	75,625	Soak	51,002	Statarea	89,714	Statarea	68,918

Table 25: Final lognormal and binomial models (Eq. 3) by QMA fitted to the *rlcs* potlift data, showing the order that each variable entered the model and the cumulative AIC for the model up to and including each variable. (Fyear: Fishing year)

CRA 1				CRA 2				CRA 3			
Lognormal		Binomial		Lognormal		Binomial		Lognormal		Binomial	
Term	AIC	Term	AIC	Term	AIC	Term	AIC	Term	AIC	Term	AIC
Null	30,296	Null	18,849	Null	20,891	Null	20,833	Null	164,979	Null	53,529
Fyear	30,121	Fyear	18,709	Fyear	20,777	Fyear	20,654	Fyear	162,037	Fyear	51,821
Vessel	28,282	Vessel	17,981	Vessel	20,175	Vessel	20,325	Vessel	145,630	Vessel	47,657
Depth	27,769	Month	17,834	Month	20,071	Month	20,212	Month	143,230	Month	46,755
Statarea	27,640	Soak	17,775	Depth	20,041	Pot type	20,140	Soak	142,409	Depth	46,420
Month	27,565	Pot type	17,740	Pot type	20,023	Bait type	20,071	Statarea	141,832	Soak	46,190
Pot type	27,516	Depth	17,709	Soak	20,020	Statarea	20,043	Depth	141,642	Bait type	46,017
Bait type	27,497	Bait type	17,684	Statarea	20,019	Depth	20,014	Bait type	141,476	Pot type	45,970
Soak	27,476					Soak	19,986	Pot type	141,343	Statarea	45,941

Table 25 (cont.):

CRA 4				CRA 7			
Lognormal		Binomial		Lognormal		Binomial	
Term	AIC	Term	AIC	Term	AIC	Term	AIC
Null	185,853	Null	70,034	Null	47,323	Null	34,864
Fyear	182,029	Fyear	68,811	Fyear	43,978	Fyear	31,592
Vessel	167,394	Vessel	64,953	Vessel	43,522	Vessel	31,145
Soak	165,875	Soak	63,942	Month	43,316	Depth	30,911
Pot type	164,638	Month	63,275	Bait type	43,229	Bait type	30,826
Month	163,604	Pot type	63,172	Pot type	43,190	Pot type	30,777
Depth	162,987	Depth	63,078	Depth	43,151	Soak	30,748
Bait type	162,834	Statarea	63,009	Statarea	43,118	Month	30,746
Statarea	162,750	Bait type	62,966	Soak	43,108	Statarea	30,746

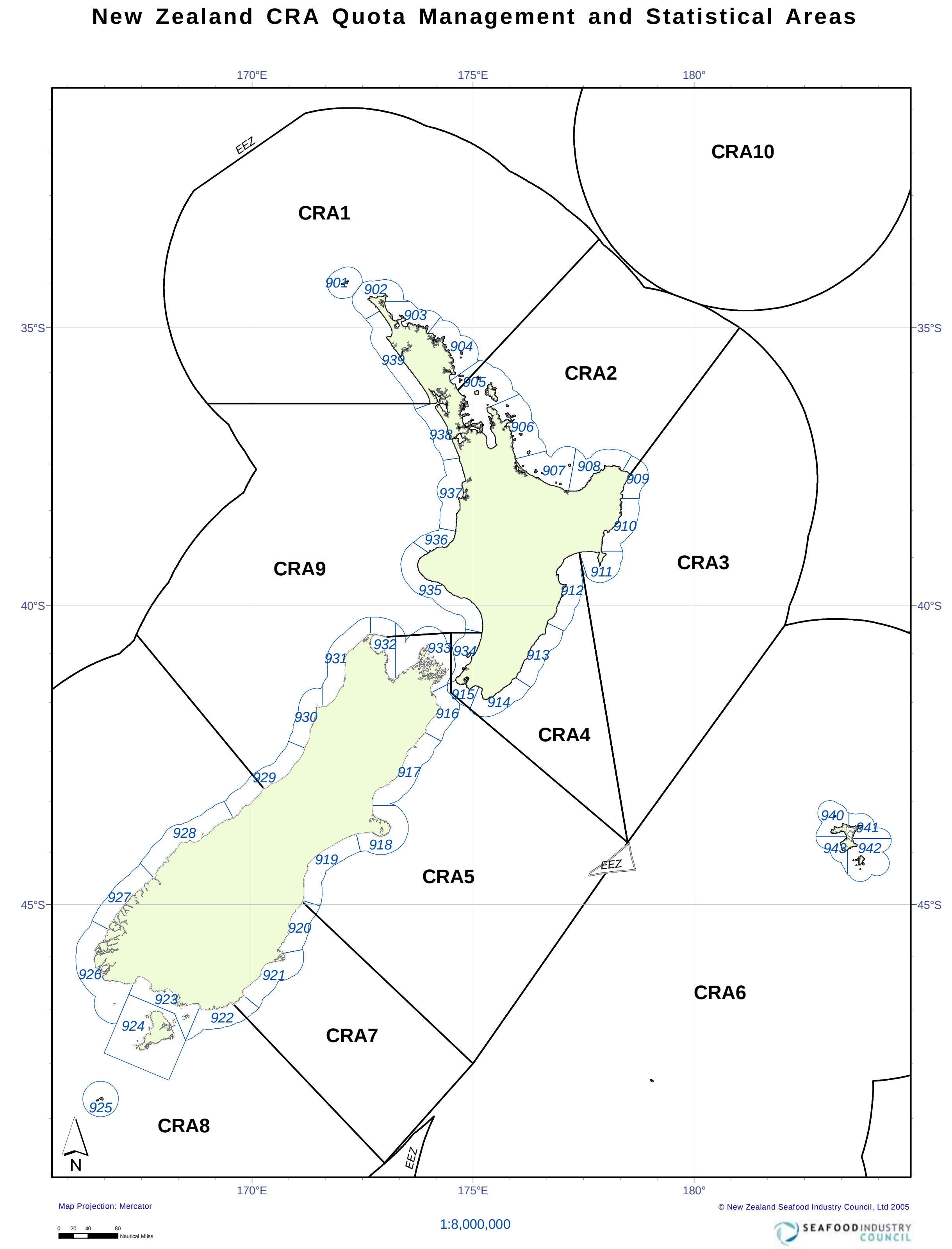

Figure 1: Map of rock lobster statistical areas and Quota Management Areas.

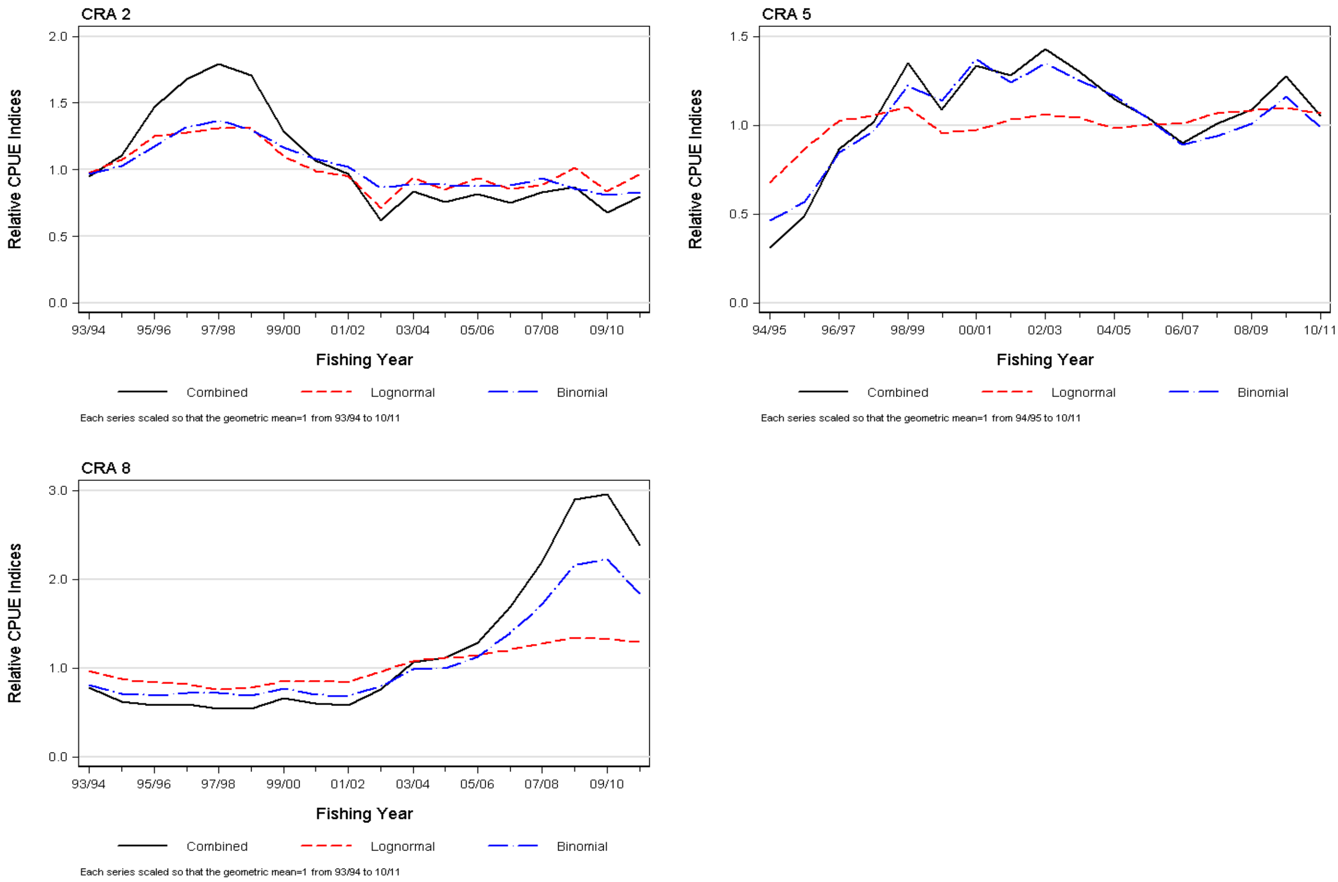

Figure 2. RLLB: three standardised potlift-based CPUE analyses (lognormal [Eq. 3], binomial [Eq. 3, modified as described in Section 3.1C], and combined [Eq. 4], plotted for CRA 2, CRA 5 and CRA 8, using all available explanatory variables listed in Table D.2 (CRA 2), Table E.2 (CRA 5), and Table F.2 (CRA 8).

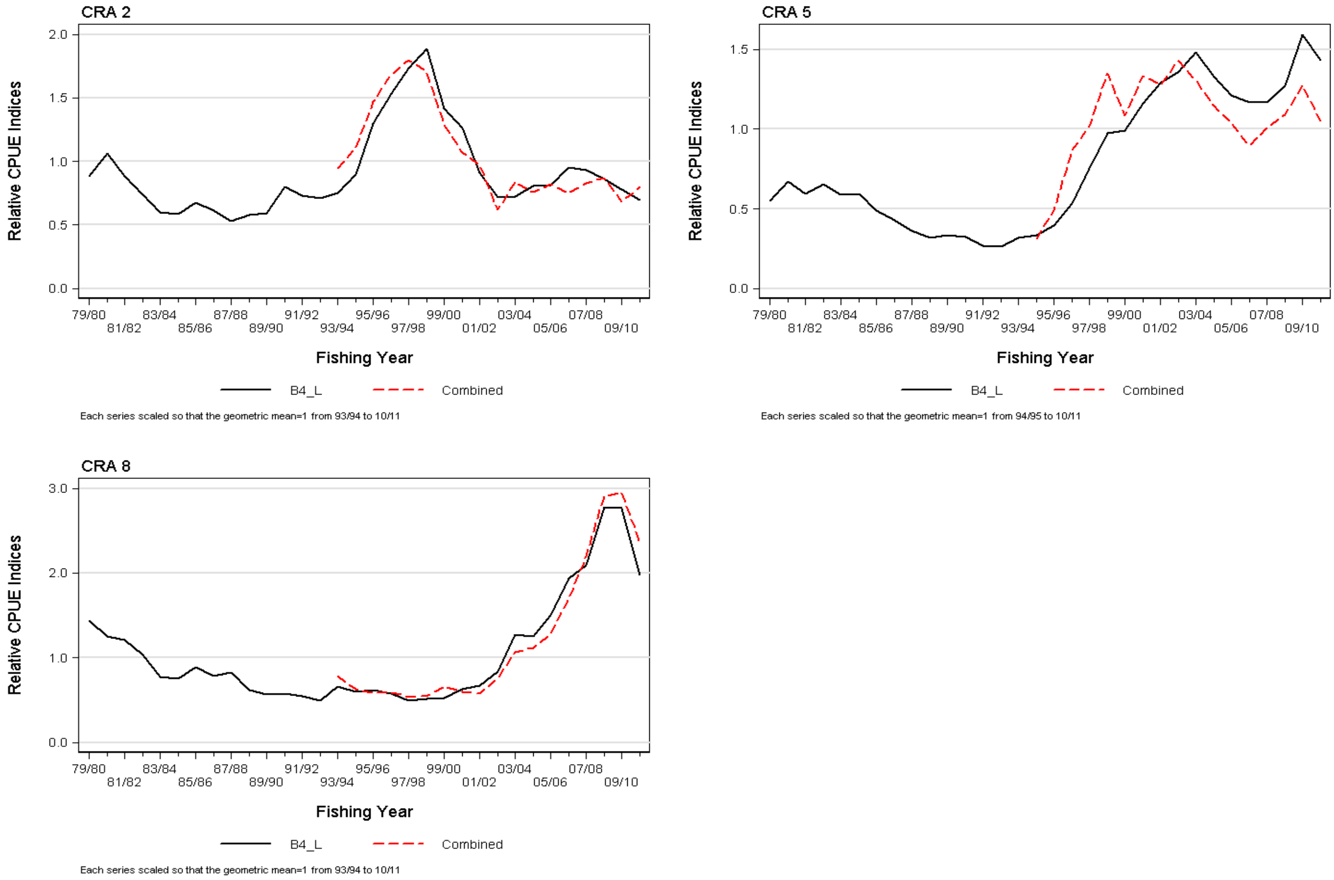

Figure 3. RLLB: comparison of the annual "B4_L" CPUE analyses (based on MFish CELR data) for CRA 2, CRA 5 and CRA 8 with the combined standardised CPUE analyses (Eq. 4) for the same three QMAs (CRA 2:Appendix A; CRA 5: Appendix E; CRA 8:Appendix F), based on potlift data using all available explanatory variables.

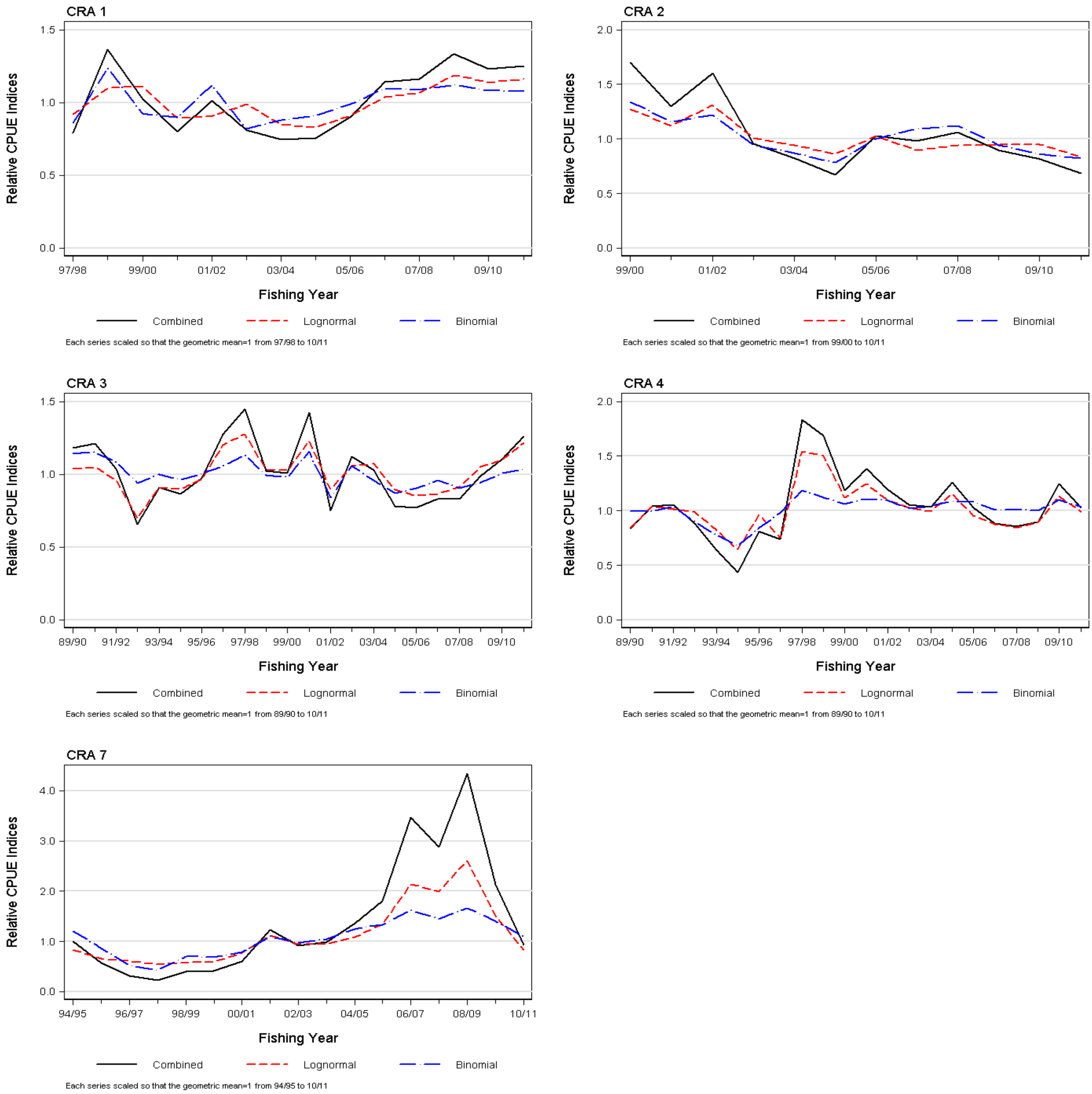

Figure 4. RLCS: three standardised potlift-based CPUE analyses (lognormal [Eq. 3], binomial [Eq. 3, modified as described in Section 3.1C], and combined [Eq. 4], plotted for CRA 1, CRA 2, CRA 3, CRA 4 and CRA 7, using all available explanatory variables listed in Table G.2 (CRA 1), Table H.2 (CRA 2), Table I.2 (CRA 3), Table J.2 (CRA 4) and Table K.2 (CRA 7).

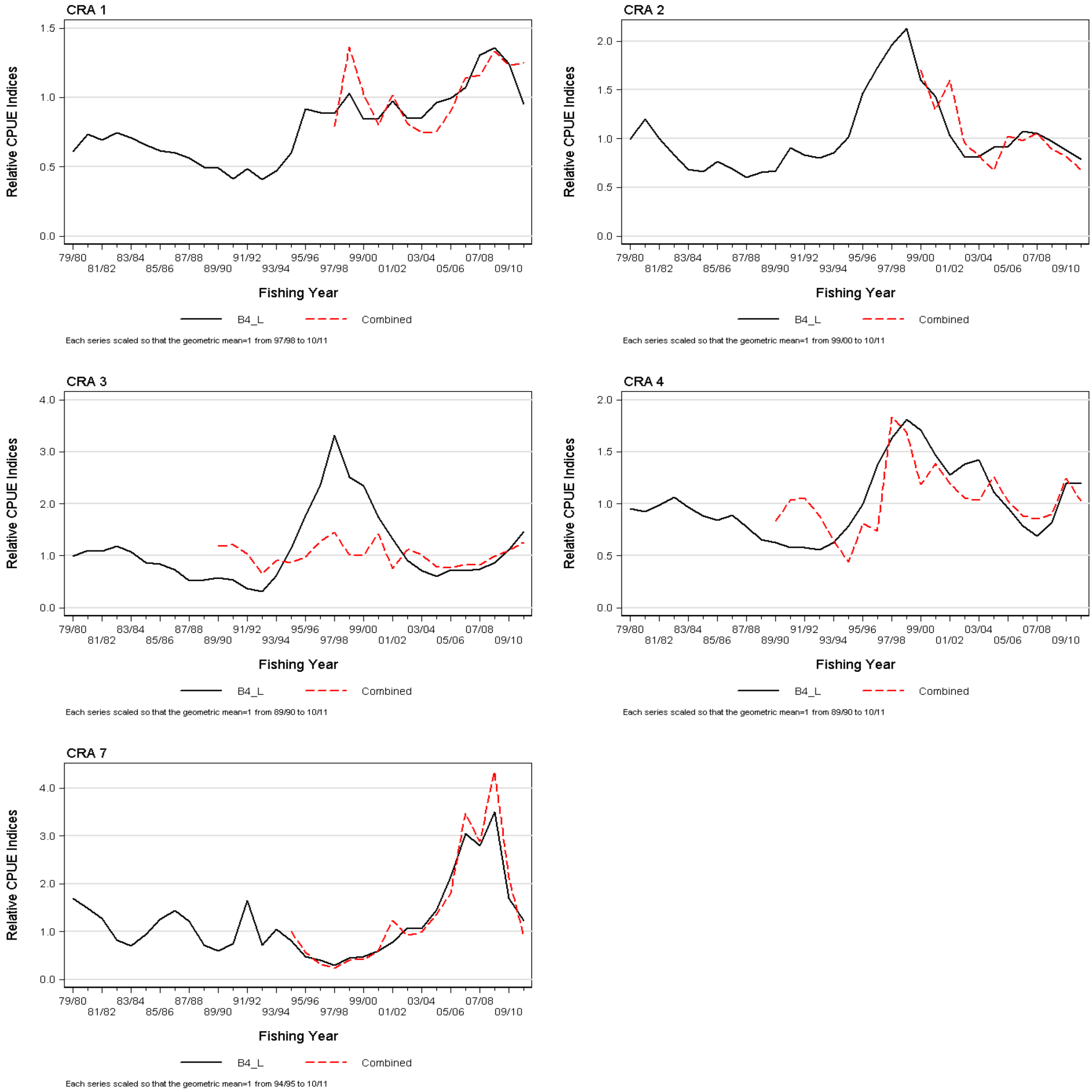

Figure 5. RLCS: comparison of the annual "B4_L" CPUE analyses (based on MFish CELR data) for CRA 1, CRA 2, CRA 3, CRA 4 and CRA 8 with the combined standardised CPUE analyses (Eq. 4) for the same five QMAs (CRA 1:Appendix G, CRA 2:Appendix H, CRA 3:Appendix I, CRA 4:Appendix J and CRA 7:Appendix K).

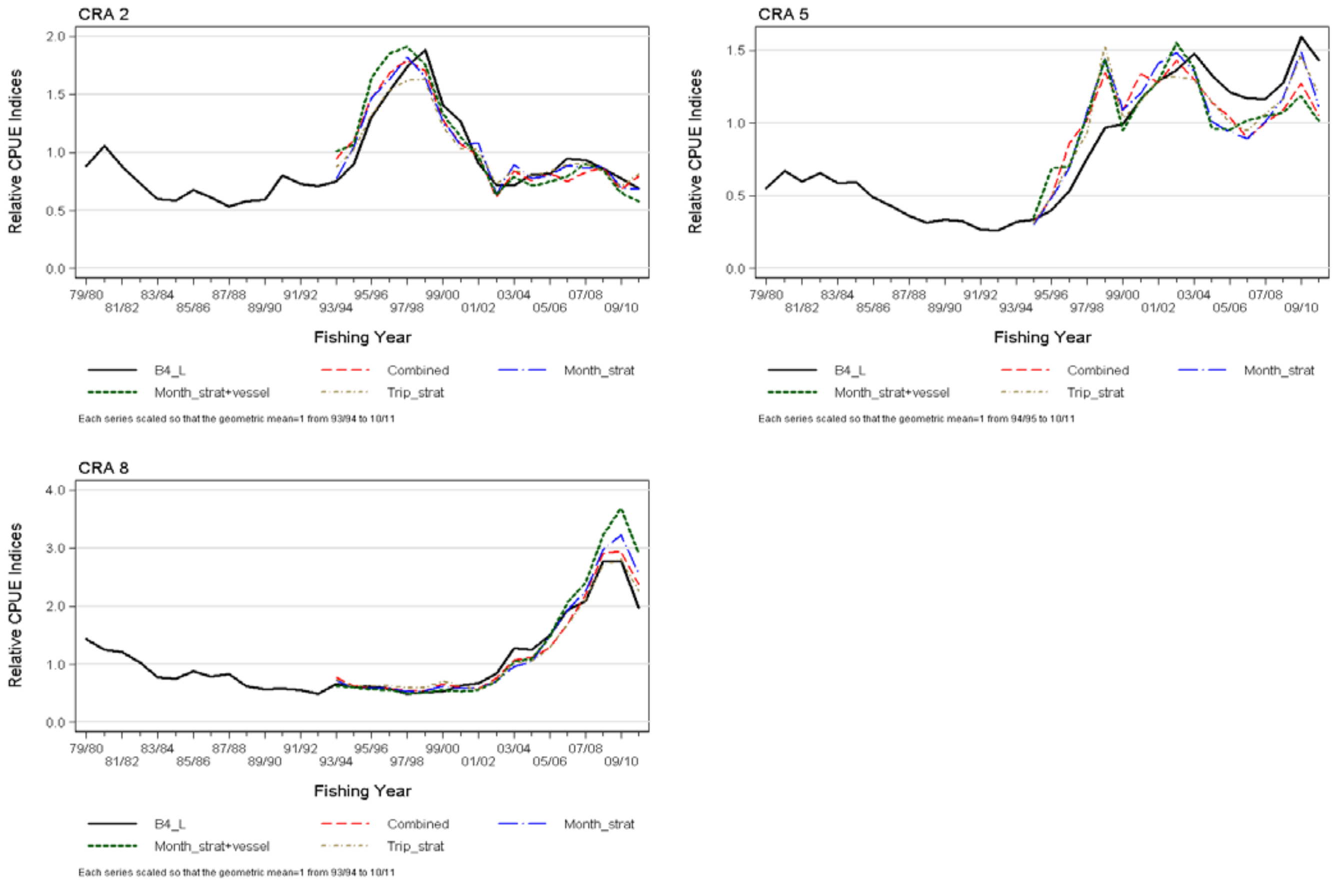

Figure 6: RLLB: comparison for CRA 2, CRA 5 and CRA 8 of (a) the annual "B4_L" CPUE analyses (based on MFish CELR data) with (b) the "Combined" series: Eq. 4 and Figure 5, (c) "Month_strat": prepared and analysed in the same manner as the CELR data, (d) Month_strat+vessel": same as (c) with added vessel explanatory variable and (e) "Trip_strat", a daily series based on the [*trip*] field using [*year*], [*month*], and [*statistical area*] as explanatory variables.

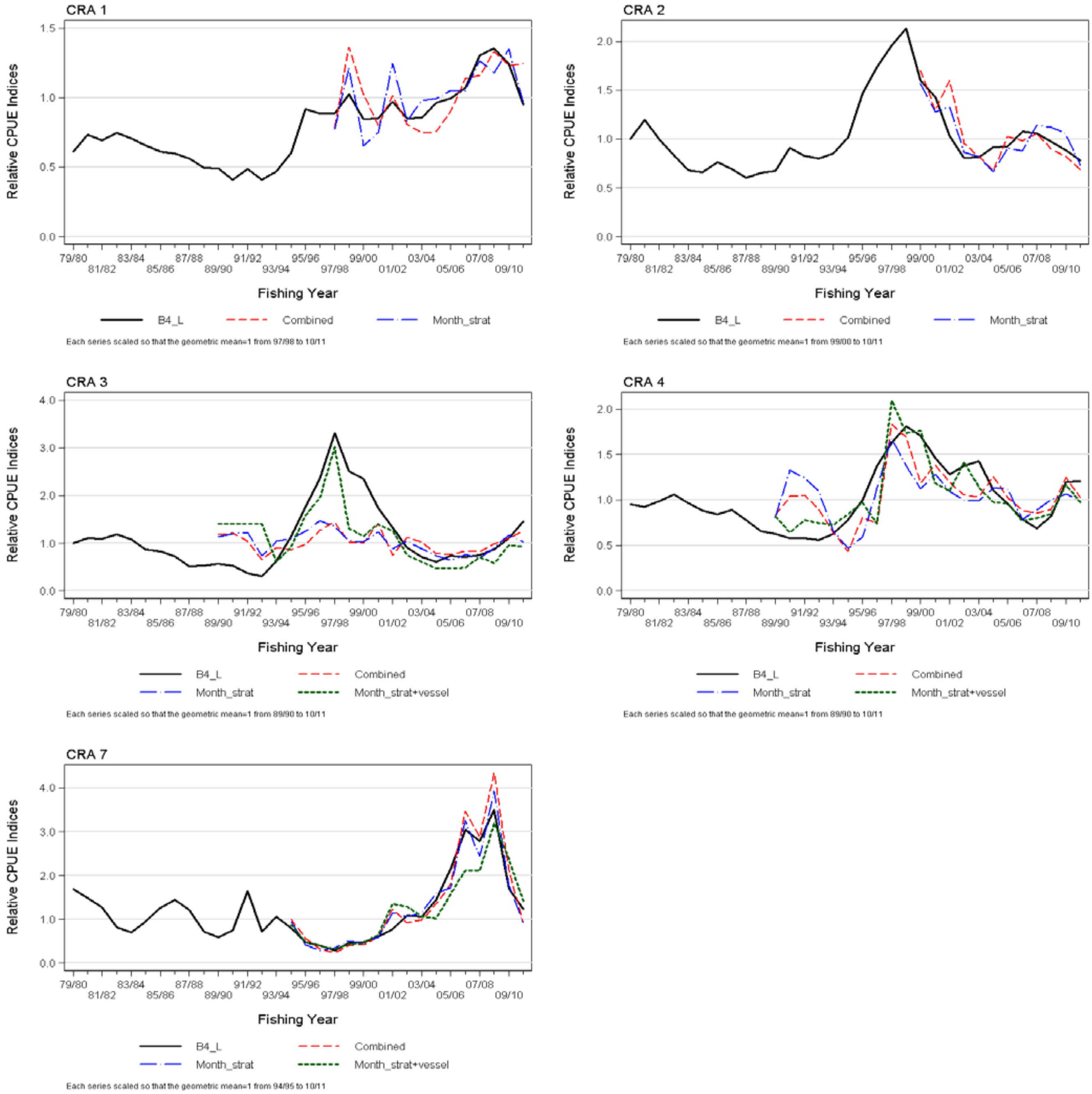

Figure 7: RLCS: comparison for CRA 1, CRA 2, CRA 3, CRA 4 and CRA 8 of (a) the annual "B4_L" CPUE analyses (based on MFish CELR data) with (b) the "Combined" series: Eq. 4 and Figure 5, (c) "Month_strat": prepared and analysed in the same manner as the CELR data, (d) Month_strat+vessel": same as (c) with added vessel explanatory variable (CRA 3, CRA 4 and CRA 7 only)

Appendix A. TABLE OF ABBREVIATIONS AND DEFINITIONS OF TERMS

Term/Abbreviation	Definition
arithmetic CPUE	Eq. 1
B4_L	standardised CPUE analysis based on MFish CELR data using monthly stratification and [*fishing year*], [*month*], and [*statistical area*] as the explanatory variables. The data have been corrected to "L" landings using the "B4" algorithm (Bentley et al. 2005)
CELR	Catch Effort Landing Return: MFish reporting form for rock lobster fishermen since July 1989 (all statutory catch/effort data for rock lobster are currently reported on this form). This form reports the total daily effort (potlifts) and catch (all rock lobster that could legally be retained) from a single operator within one statistical area. When the vessel off-loads retained catch to an LFR, the entire landing (one day or multiple days) is recorded in the landing part of the form by QMA
CPUE	Catch Per Unit Effort
fishing year	1 April – 31 March period
FSU	Fisheries Statistics Unit: format used to report rock lobster catch and effort, January 1979 to June 1989
legal catch	catch taken in accordance with the lobster regulations at the time of capture, including provisions regarding the minimum legal size by sex allowed to be retained and the egg-bearing status of females (females bearing eggs must be released)
LFR and "L" landings	Licensed Fish Receiver: processors legally allowed to receive commercially caught rock lobster. Landings to a LFR are designated with the destination code "L"
MFish	New Zealand Ministry of Fisheries, which has recently (1 July 2011) been amalgamated with the Ministry of Agriculture and Forestry
MLS	Minimum Legal Size: tail width measurement below which rock lobster are required by law to be released. These size limits vary between sexes and among QMAs
monthly stratified data	underlying level of data summarisation used in current CELR-based CPUE analyses: all catch and effort data combined to the level of [*vessel*], [*month*] and [*statistical area*]
[*name*]	designates a data [*field*] in the *rllb* or *rlcs*
non-legal catch	catch required to be released in accordance with the lobster regulations at the time of capture
potlift	unit of effort in rock lobster potting fishery: one lift for a single trap (usually daily)
potlift stratified data	lowest level of effort stratification available: all information available from the lifting of a single pot
QMA	Quota Management Area: legally defined unit area used for rock lobster management (see Figure 1)
rlcs	rock lobster catch sampling observer database: relational database which holds all the available data from the rock lobster on-board observer programme
RLCS	Rock Lobster observer Catch Sampling programme
rllb	rock lobster voluntary logbook database: relational database which holds all the available data from the rock lobster voluntary logbook programme
RLLB	Rock Lobster voluntary LogBook programme
standardised CPUE	Eq. 3
statistical area	sub-areas contained within a rock lobster QMA which are identified in catch/effort returns (see Figure 1). These statistical areas differ from those used for finfish.
trip stratified data	a level of data summarisation for use in the RLLB CPUE analysis: summarised to [*trip*], which is the daily activity of the logbook participant within a single statistical area, lifting from one to four pots and measuring all the captured lobsters
unstandardised CPUE	Eq. 2

Appendix B. RLCS: BAIT TYPE CODING SHEET

Table B.1. Codes used by observers to describe bait type on *rlcs* forms. Table transcribed from Mackay & George (2002) (page 46). Codes highlighted with bold font in grey cells were the top 20 pot types when summarised over all QMAs between 1989–90 to 2010–11 (Table 20).

[*bait*] code	Description	[*bait*] code	Description	[*bait*] code	Description
0	Bait Type Unknown				
100	**Mixed species (Processed/frames/etc)**	**300**	**Mixed species (Whole or pieces)**	**500**	**Mixed species (Mixed states/processed whole)**
101	Ling (Processed)	301	Ling (Whole)	501	Ling (Mixed states)
102	**Bluenose Grouper (Processed)**	**302**	**Bluenose Grouper (whole)**	502	Bluenose grouper (Mixed states)
103	**Barracouta (Processed)**	**303**	**Barracouta (Whole)**	**503**	**Barracouta (Mixed states)**
104	Hapuku (Processed)	304	Hapuku (Whole)	504	Hapuku (Mixed states)
105	Trevally (Processed)	305	Trevally (Whole)	505	Trevally (Mixed states)
106	**Jack Mackerel (Processed)**	**306**	**Jack Mackerel (Whole)**	**506**	**Jack mackerel (Mixed states)**
107	Stargazers (Processed)	307	Stargazers (Whole)	507	Stargazers (Mixed states)
108	**Red gurnard (Processed)**	308	Gurnards (Whole)	508	Red gurnard (Mixed states)
109	Kahawai (Processed)	**309**	**Kahawai (Whole)**	509	Kahawai (Mixed states)
110	Marble Fish (Processed)	310	Marble Fish (Whole)	510	Marble fish (Mixed states)
111	**Hoki (Processed)**	311	Hoki (Whole)	511	Hoki (Mixed states)
112	Frost Fish (Processed)	312	Frost Fish (Whole)	512	Frost fish (Mixed states)
113	Copper Moki (Processed)	313	Copper Moki (Whole)	513	Copper moki (Mixed states)
115	Blue Moki (Processed)	315	Blue Moki (Whole)	515	Blue moki
116	**Blue Cod (Processed)**	316	Blue Cod (Whole)	516	Blue cod (Mixed states)
117	Red Cod (Processed)	**317**	**Red Cod (Whole)**	517	Red cod (Mixed states)
118	**Gemfish (Processed)**	318	Gemfish (Whole)	518	Gemfish (Mixed states)
119	Deepwater Cardinalfish (Processed)	319	Deepwater Cardinalfish (Whole)	519	Deepwater cardinalfish (Mixed states)
120	White Warehou (Processed)	320	White Warehou (Whole)	520	White warehou
121	**Tarakihi (Processed)**	321	Tarakihi (Whole)	521	Tarakihi (Mixed states)
122	Greenbone/Butterfish (Processed)	322	Greenbone/Butterfish (Whole)	522	Greenbone/Butterfish (Mixed states)
123	Trumpeter (Processed)	323	Trumpeter (Whole)	523	Trumpeter (Mixed states)
124	Silver Warehou (Processed)	324	Silver Warehou (Whole)	524	Silver warehou (Mixed states)
125	Common Warehou (Processed)	325	Common Warehou (Whole)	525	Common warehou (Mixed states)
126	Wrasse/Parrot Fish (Processed)	326	Wrasse/Parrot Fish (Whole)	526	Wrasse/Parrot fish (Mixed states)
127	Kingfish (Processed)	327	Kingfish (Whole)	527	Kingfish (Mixed states)
128	Leatherfish (Processed)	328	Leatherfish (Whole)	528	Leatherjacket (Mixed states)
129	Sea Perch/Jock Stewart (Processed)	329	Sea Perch/Jock Stewart (Whole)	529	Sea Perch (Mixed states)
130	Snapper (Processed)	330	Snapper (Whole)	530	Snapper (Mixed states)
131	Porae (Processed)	331	Porae (Whole)	531	Porae (Mixed states)
132	Orange Roughy (Processed)	332	Orange Roughy (Whole)	532	Orange roughy (Mixed states)
133	Sole (Processed)	**333**	**Sole (Whole)**	533	Sole (Mixed states)
134	Flounder (Processed)	334	Flounder (Whole)	534	Flounder (Mixed states)
135	Rock Cod (Processed)	335	Rock Cod (Whole)	535	Rock cod (Mixed states)
136	Alfonsino (Processed)	**336**	**Alfonsino (Whole)**	536	Alfonsino (Mixed states)
137	Rattail (Processed)	337	Rattail (Whole)	537	Rattail (Mixed states)
138	Squid (Processed)	338	Squid (Whole)	538	Squid (Nixed states)
139	Ribaldo (Processed)	339	Ribaldo (Whole)	539	Ribaldo (Mixed states)
140	Moonfish (Processed)	340	Moonfish (Whole)	540	Moonfish (Mixed states)
141	Spotted gurnard (Processed)	341	Spotted gurnard (Whole)	541	Spotted gurnard (Mixed states)
142	Ruby Fish (Processed)	342	Ruby Fish (Whole)	542	Ruby Fish (Mixed states)
143	Hake (Processed)	343	Hake (Whole)	543	Hake (Mixed states)
144	Parore (Processed)	344	Parore (Whole)	544	Parore (Mixed states)
145	Carpet Shark (Processed)	345	Carpet Shark (Whole)	545	Carpet Shark (Mixed states)
146	Witch (Processed)	346	Witch (Whole)	546	Witch (Mixed states)
147	Koheru (processed)	347	Koheru (Whole)	547	Koheru (Mixed states)
148	English mackerel (Processed)	348	English mackerel (Whole)	548	English mackerel (Mixed states)

Appendix C. RLCS: POT TYPE CODING SHEET

Table C.1. Codes used by observers to describe pot type on *rlcs* forms. Table transcribed from Mackay & George (2002) (page 47). Codes highlighted with bold font in grey cells were the top 30 pot types when summarised over all QMAs between 1989–90 to 2010–11 (Table 21).

Shape/frame/mesh	Largest Dimension (m)	Mesh size range (mm) 10–19	20–29	30–34	35–39	40–44	45–49	50–54	55–59	60–69
Rectangular/steel frame/net fibre	<1.2	A7	**A9**	**A1**	**A2**	**A3**	**A4**	**A5**	A6	A8
	1.2–1.5	**B7**	**B9**	**B1**	**B2**	**B3**	**B4**	**B5**	B6	B8
	>1.5	C7	C9	C1	**C2**	**C3**	**C4**	C5	C6	C8
Rectangular/steel frame/plastic	<1.2	D7	D9	D1	D2	D3	D4	D5	D6	D8
	1.2–1.5	E7	E9	E1	E2	E3	E4	E5	E6	E8
	>1.5	G7	G9	G1	G2	G3	G4	G5	G6	G8
Rectangular/steel frame/steel	<1.2	H7	H9	H1	H2	H3	H4	H5	H6	H8
	1.2–1.5	I7	I9	I1	I2	**I3**	I4	I5	I6	I8
	>1.5	K7	K9	K1	K2	K3	K4	K5	K6	K8
Rectangular/HRC/folded frame	<1.2	L7	L9	L1	**L2**	L3	**L4**	**L5**	L6	L8
	1.2–1.5	M7	M9	M1	M2	M3	M4	M5	M6	M8
	>1.5	O7	O9	O1	O2	O3	O4	O5	O6	O8
Rectangular/wood frame/plastic	<1.2	R7	R9	R1	R2	R3	R4	R5	R6	R8
Rectangular/wood frame/net fibre	<1.2	S7	S9	S1	S2	S3	S4	S5	S6	S8
Beehive/cane or supplejack	<1.2	T7	T9	T1	T2	T3	T4	T5	T6	T8
	>4	V7	V9	V1	V2	V3	V4	V5	V6	V8
Beehive/wire	<1.2	W7	W9	W1	W2	W3	W4	W5	W6	W8
	>4	X7	X9	X1	X2	X3	X4	X5	X6	X8
Cylinder/steel/plastic	1.2–1.5	Z7	Z9	Z1	Z2	Z3	Z4	Z5	Z6	Z8
	>1.5	57	59	51	52	53	54	55	56	58
	<1.2	47	49	41	42	43	44	45	46	48
Round/steel/plastic	<1.2	67	69	61	62	63	64	65	66	68
Truncated pyramid/steel|plastic/wood|fibre	<1.2	37	39	31	32	33	34	35	36	38
	>1.2	97	99	91	92	93	94	95	96	98
Cod pot/steel/net fibre	>1.5	77	79	71	72	73	74	75	76	78
	<1.5	27	29	21	22	23	24	25	26	28
Circular/HRC/folded frame	<1.2	87	89	81	82	83	84	85	86	88
Round/plastic/plastic	<1.2	P7	P9	P1	P2	P3	P4	P5	P6	P8

Appendix D. CRA 2 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLLB* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*WEIGHT*) (LEGAL ONLY)

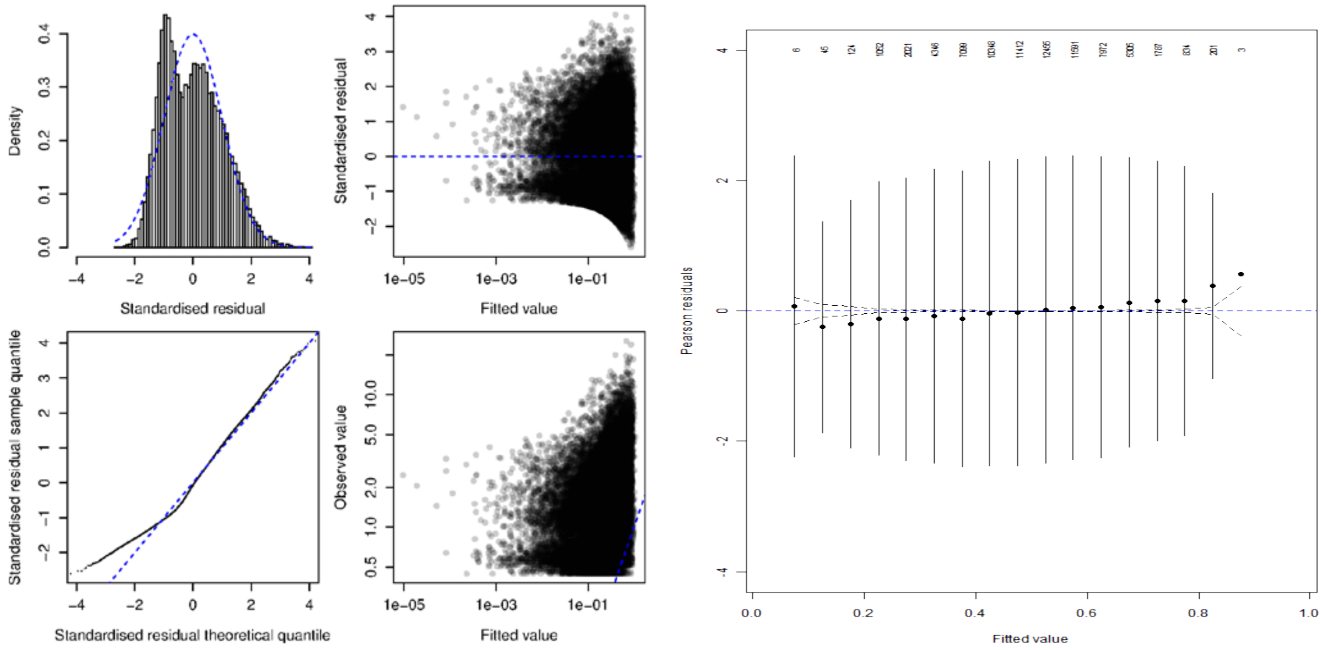

Figure D.1. Residual plots for CRA 2 CPUE regression analyses using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables on potlift data from the *rllb* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

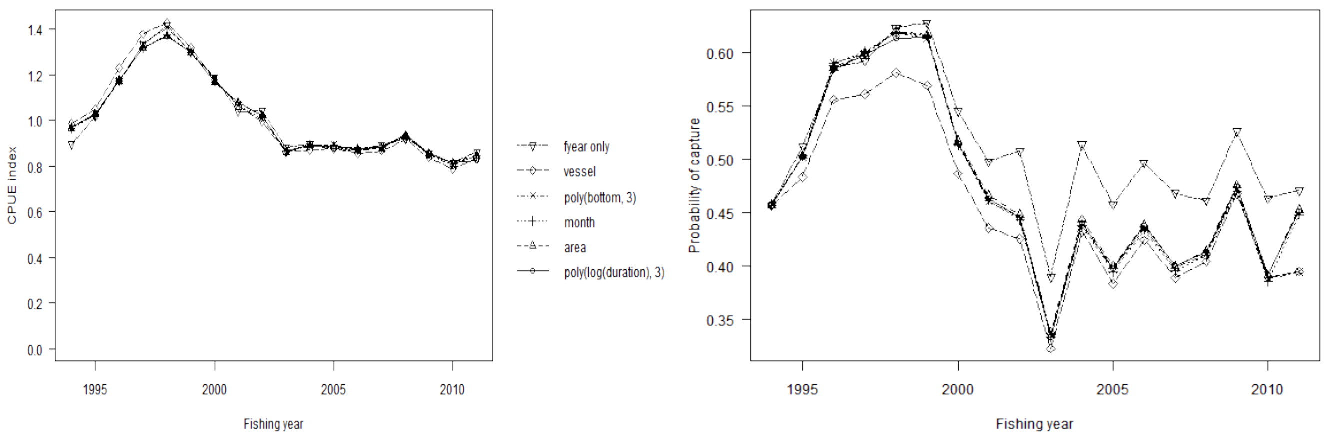

Figure D.2. Year index coefficients for the standardised CPUE analysis based on CRA 2 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

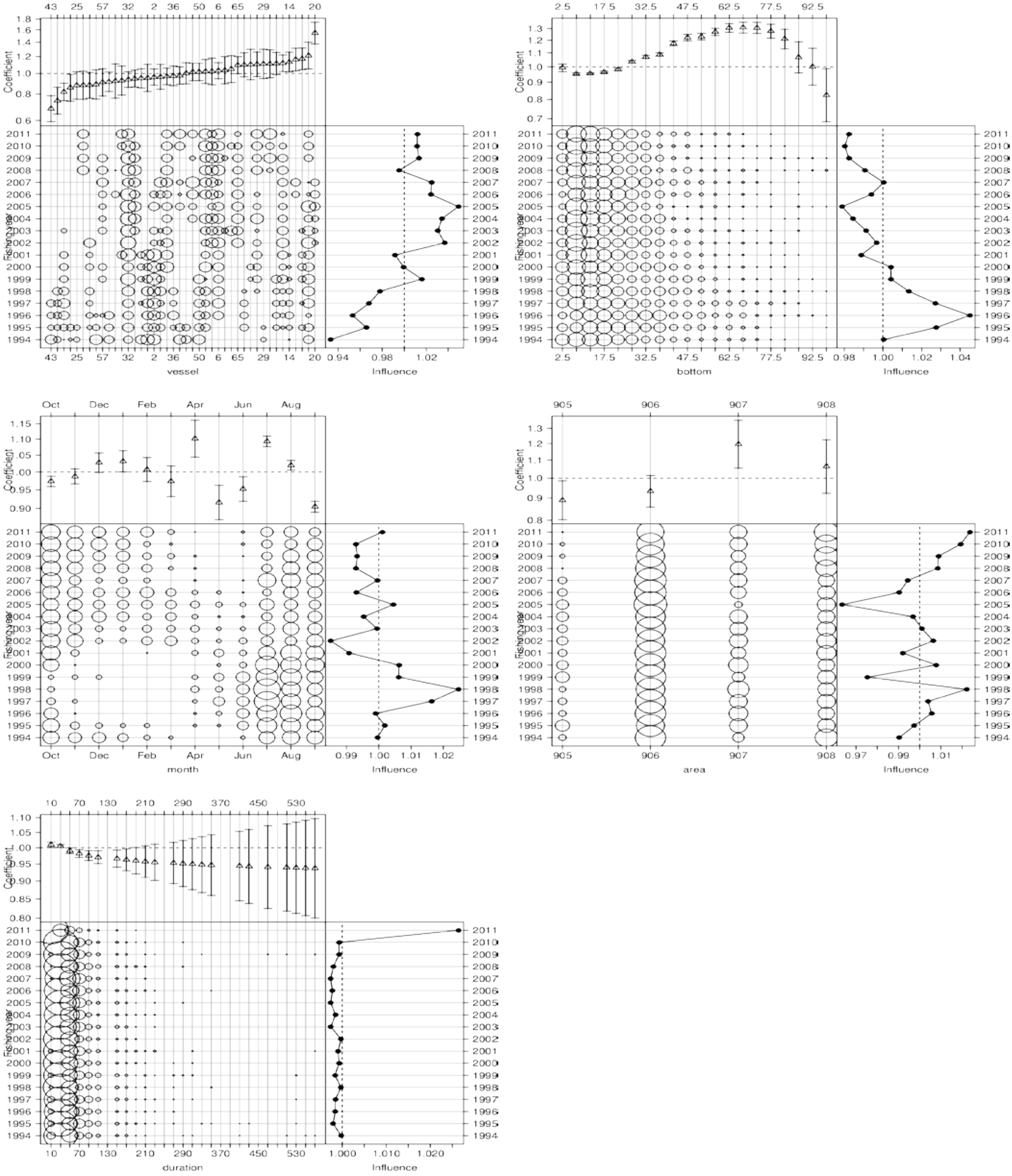

Figure D.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 2 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *depth* continuous variable; [centre left panel] *month* categorical variable; [centre right panel] *statistical area* categorical variable; [lower left panel] *soak_time* continuous variable;

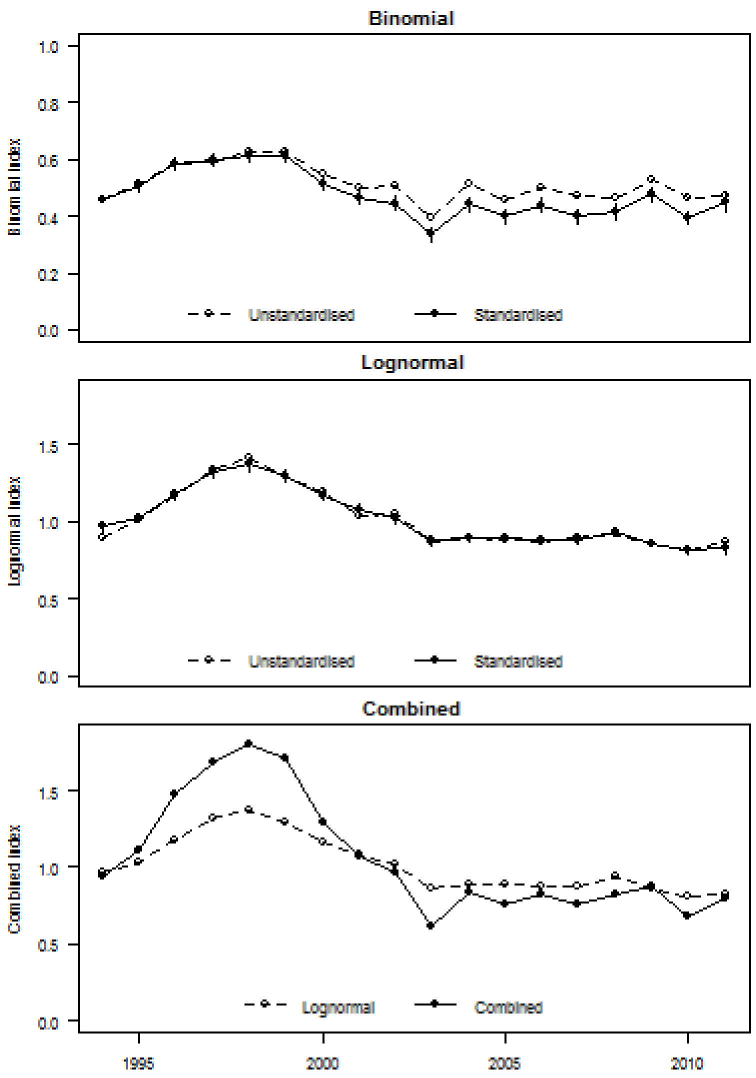

Figure D.4. Standardised annual CPUE indices for the model based on CRA 2 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table D.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 2 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables.

Fishing year	Potlifts	Vessels	Trips	Weight (kg)	Soak time (h)	% zero
93/94	7,057	26	2,083	4,696	269,010	53.9
94/95	6,238	30	1,678	5,210	260,766	48.9
95/96	3,919	26	1,072	4,360	154,900	41.3
96/97	3,488	21	930	4,622	143,507	40.7
97/98	2,951	19	779	4,359	108,531	37.6
98/99	3,048	21	796	3,988	126,869	37.3
99/00	3,683	20	973	3,835	138,409	45.5
00/01	3,771	16	986	3,029	148,595	50.4
01/02	2,884	13	782	2,502	105,660	49.2
02/03	4,991	18	1,330	2,688	210,613	61.0
03/04	3,797	13	1,012	2,736	141,804	48.6
04/05	4,661	14	1,226	2,883	189,021	54.2
05/06	5,846	18	1,536	3,890	242,776	50.3
06/07	4,162	17	1,100	2,688	168,906	53.1
07/08	4,261	14	1,144	2,743	166,459	53.8
08/09	5,061	15	1,342	3,487	186,685	47.3
09/10	4,688	15	1,274	2,678	170,252	53.6
10/11	5,192	16	1,600	3,216	41,503	53.7

Table D.2. Summary table for two standardised CPUE models based on CRA 2 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	18,085	80,264	–	–
Fishing year	18	17,028	77,973	0.058	0.058
Vessel	59	16,123	75,950	0.108	0.050
Depth	62	15,979	75,608	0.116	0.008
Month	73	15,847	75,311	0.124	0.007
Statistical area	76	15,842	75,305	0.124	0.000
Soak time	79	15,838	75,300	0.124	0.000
Binomial Model					
Null	0	106,187	106,189	–	–
Fishing year	18	105,130	105,166	0.010	0.010
Vessel	59	102,699	102,817	0.033	0.023
Month	70	102,125	102,265	0.038	0.005
Soak time	73	102,004	102,150	0.039	0.001
Depth	76	101,966	102,118	0.040	0.000
Statistical area	79	101,938	102,096	0.040	0.000

Appendix E. CRA 5 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLLB* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*WEIGHT*) (LEGAL ONLY)

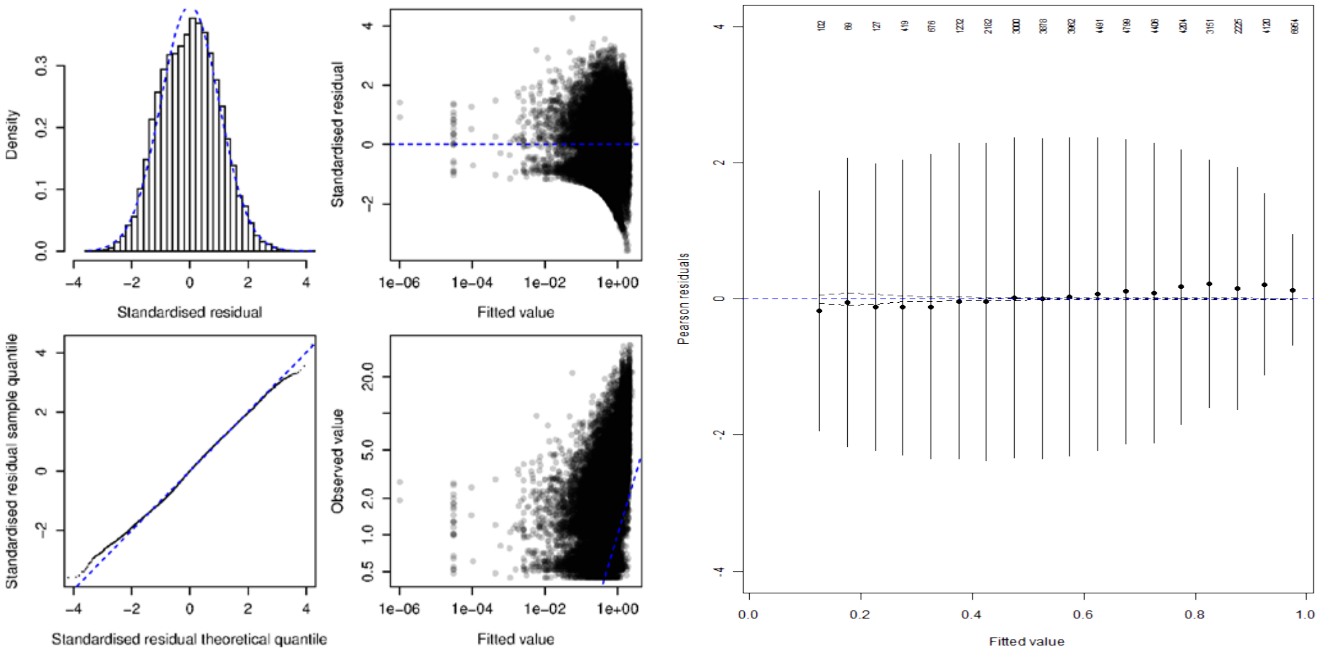

Figure E.1. Residual plots for CRA 5 CPUE regression analyses using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables on potlift data from the *rllb* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

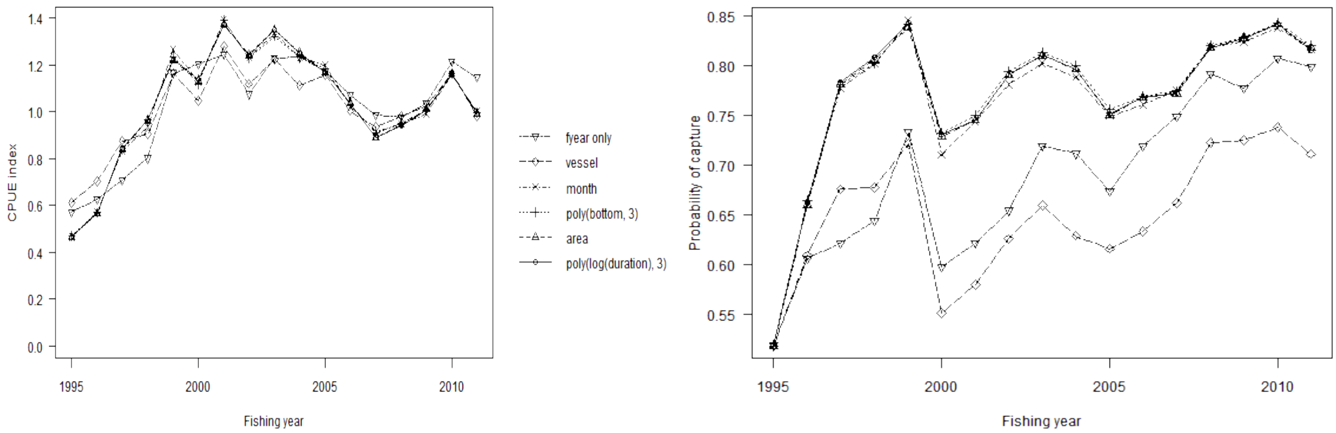

Figure E.2. Year index coefficients for the standardised CPUE analysis based on CRA 5 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

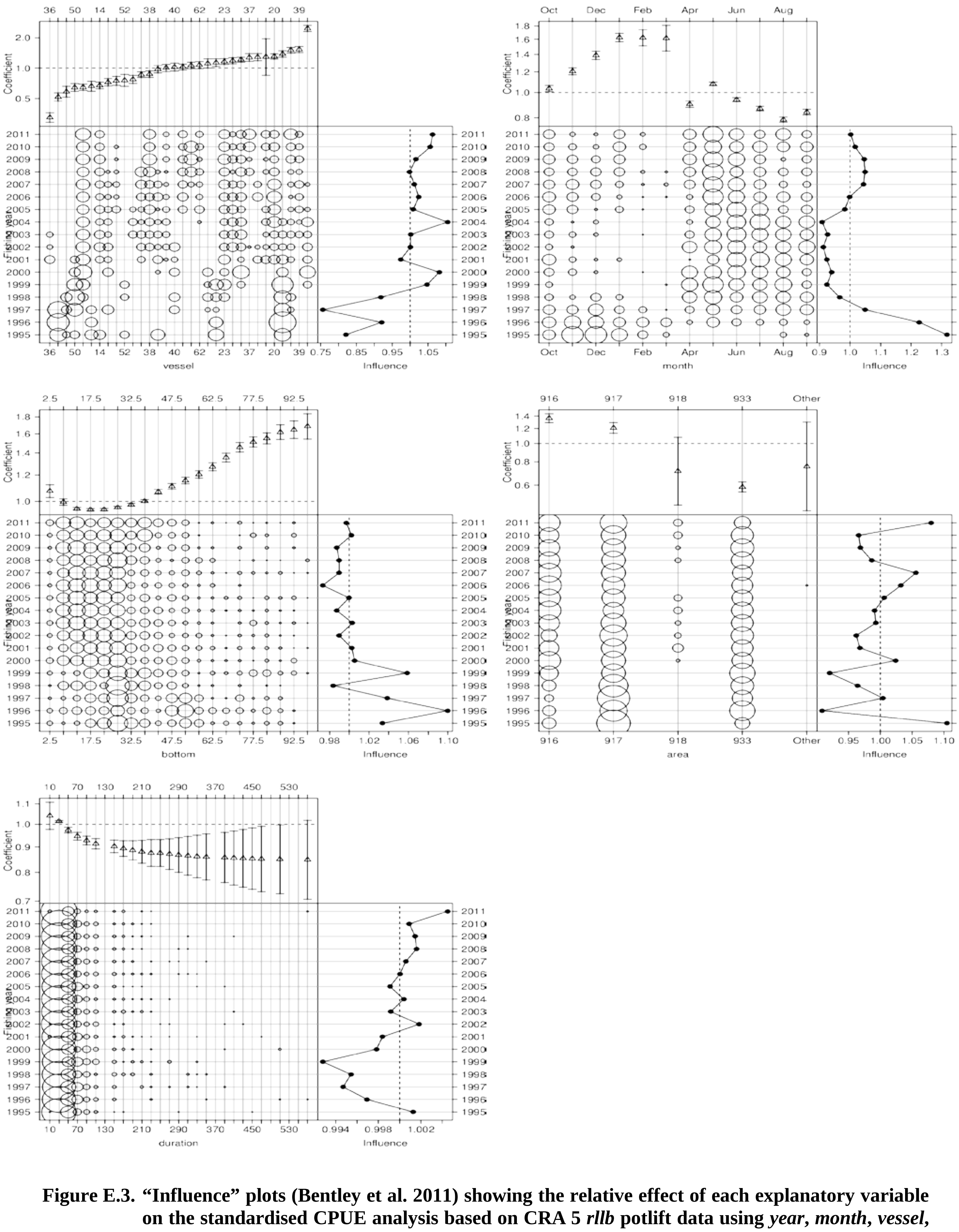

Figure E.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 5 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *month* categorical variable; [centre left panel] *depth* continuous variable; [centre right panel] *statistical area* categorical variable; [lower left panel] *soak_time* continuous variable;

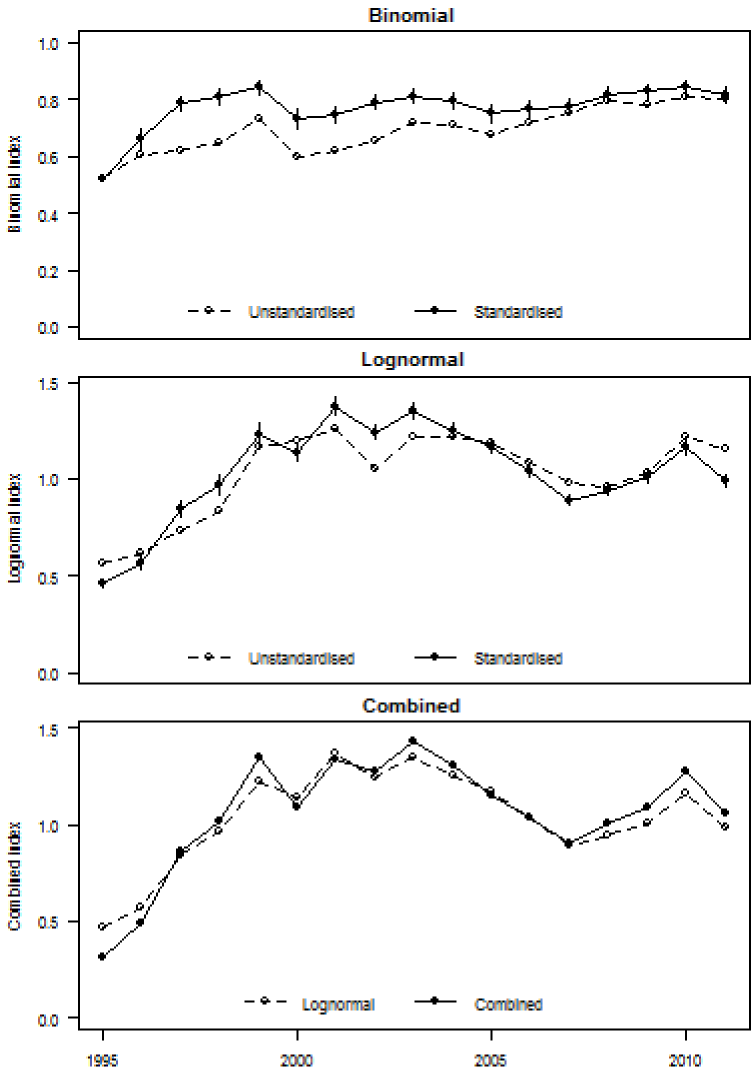

Figure E.4. Standardised annual CPUE indices for the model based on CRA 5 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table E.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 5 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables.

Fishing year	Potlifts	Vessels	Trips	Weight (kg)	Soak time (h)	% zero
94/95	3,613	14	970	2,471	121,002	48.7
95/96	1,874	8	523	1,470	70,875	46.4
96/97	2,338	13	621	2,488	97,752	38.2
97/98	1,722	12	465	2,257	70,128	33.7
98/99	1,054	10	289	2,311	48,720	26.8
99/00	2,092	12	551	4,181	86,664	40.3
00/01	3,718	22	1,004	8,482	140,849	41.0
01/02	4,234	25	1,130	10,243	158,256	34.9
02/03	4,806	24	1,262	11,636	180,203	29.6
03/04	3,771	20	1,006	9,024	134,330	28.7
04/05	3,405	21	962	7,156	128,763	32.5
05/06	3,888	17	1,065	7,701	144,288	28.1
06/07	4,187	20	1,126	7,484	150,110	24.8
07/08	4,339	19	1,149	8,636	150,746	20.9
08/09	3,104	18	838	6,372	110,001	21.6
09/10	4,038	20	1,094	10,361	142,390	18.3
10/11	3,313	18	894	7,337	109,962	20.2

Table E.2. Summary table for two standardised CPUE models based on CRA 5 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	26,589	90,040	–	–
Fishing year	17	25,254	88,257	0.050	0.050
Vessel	48	19,117	78,517	0.281	0.231
Month	59	18,139	76,689	0.318	0.037
Depth	62	17,892	76,213	0.327	0.009
Statistical area	66	17,619	75,679	0.337	0.010
Soak time	69	17,589	75,625	0.338	0.001
Binomial Model					
Null	0	60,717	60,719	–	–
Fishing year	17	59,302	59,336	0.023	0.023
Vessel	48	52,266	52,362	0.139	0.116
Month	59	51,378	51,496	0.154	0.015
Statistical area	63	51,030	51,156	0.160	0.006
Depth	66	50,945	51,077	0.161	0.001
Soak time	69	50,864	51,002	0.162	0.001

Appendix F. CRA 8 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLLB* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*WEIGHT*) (LEGAL ONLY)

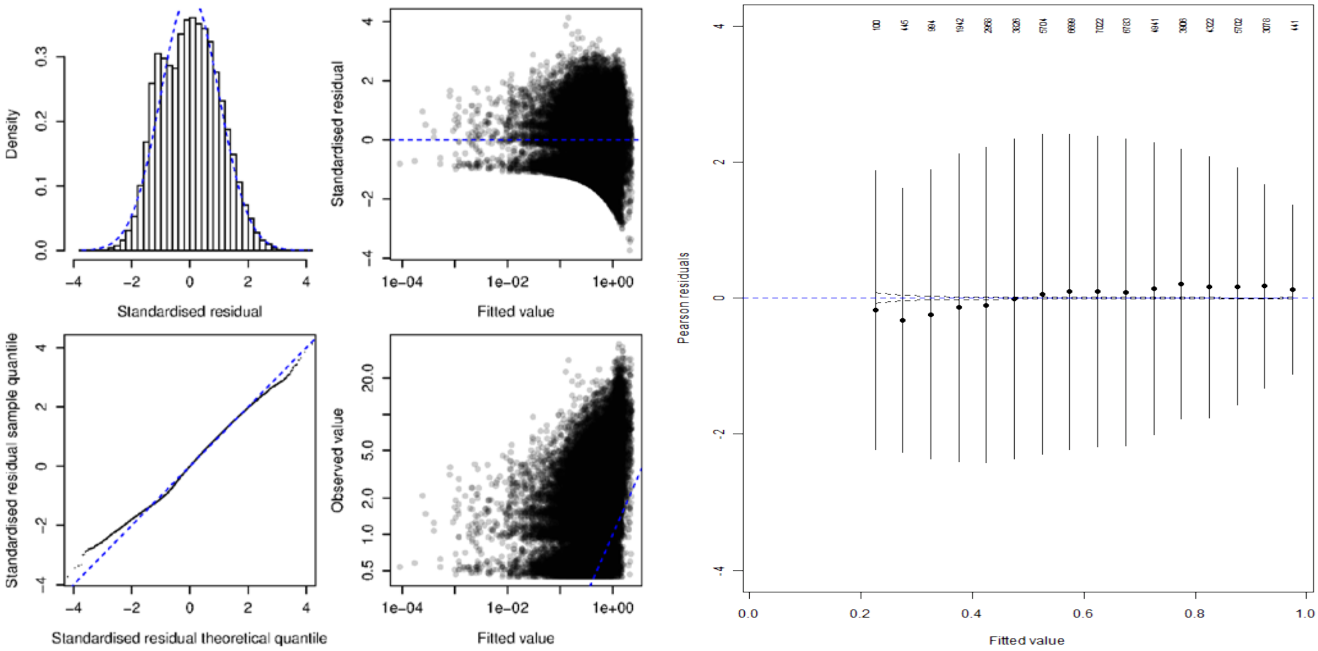

Figure F.1. Residual plots for CRA 8 CPUE regression analyses using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables on potlift data from the *rllb* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

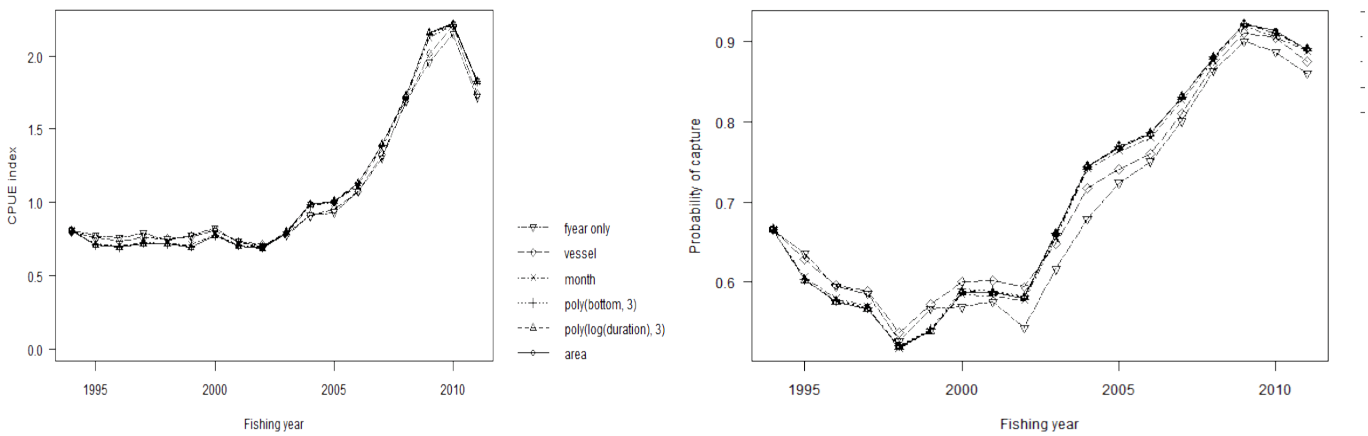

Figure F.2. Year index coefficients for the standardised CPUE analysis based on CRA 8 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

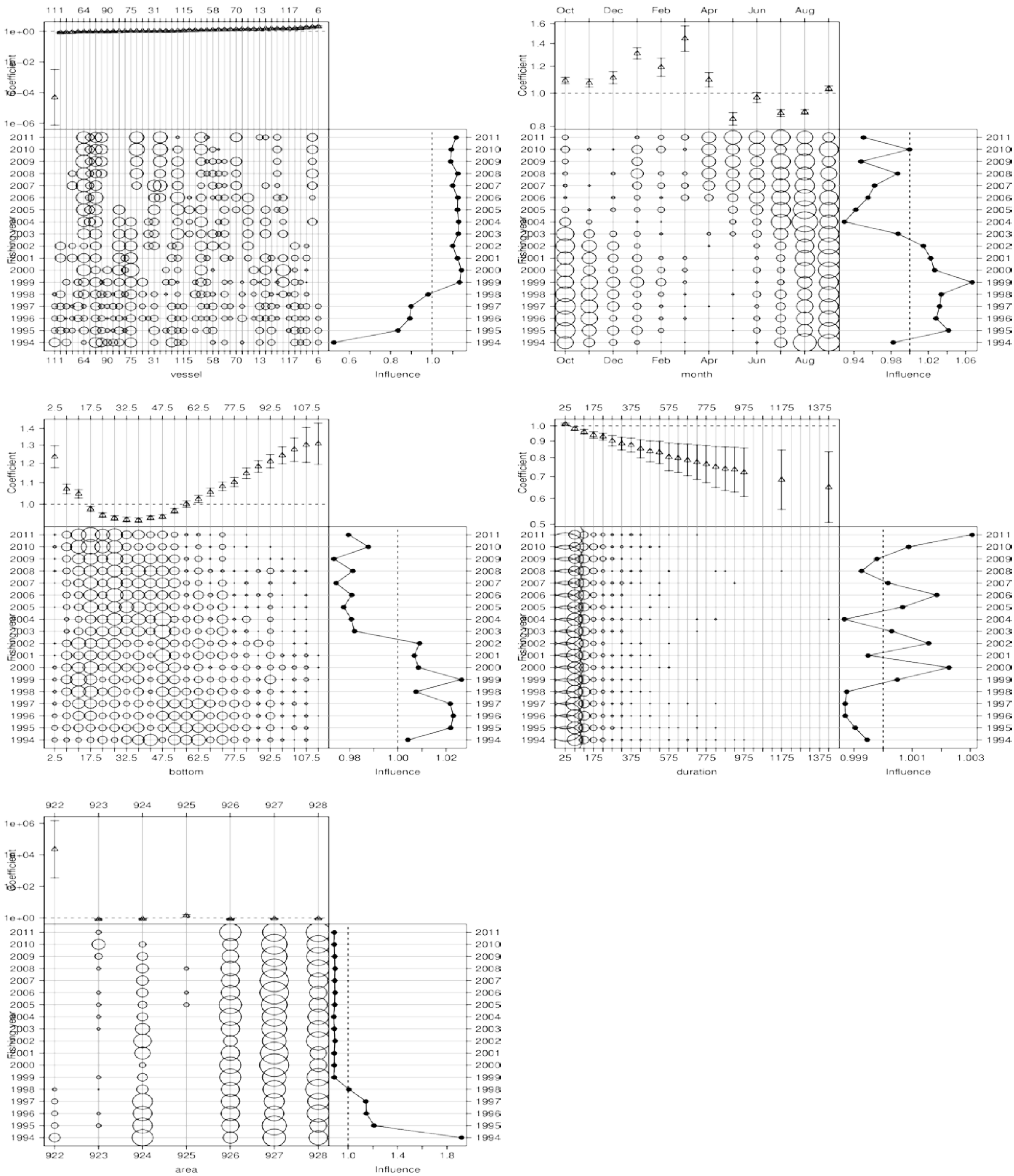

Figure F.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 8 *rllb* potlift data using *year, month, vessel, statistical area, depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *month* categorical variable; [centre left panel] *depth* continuous variable; [centre right panel] *soak_time* continuous variable; [lower left panel] *statistical area* categorical variable

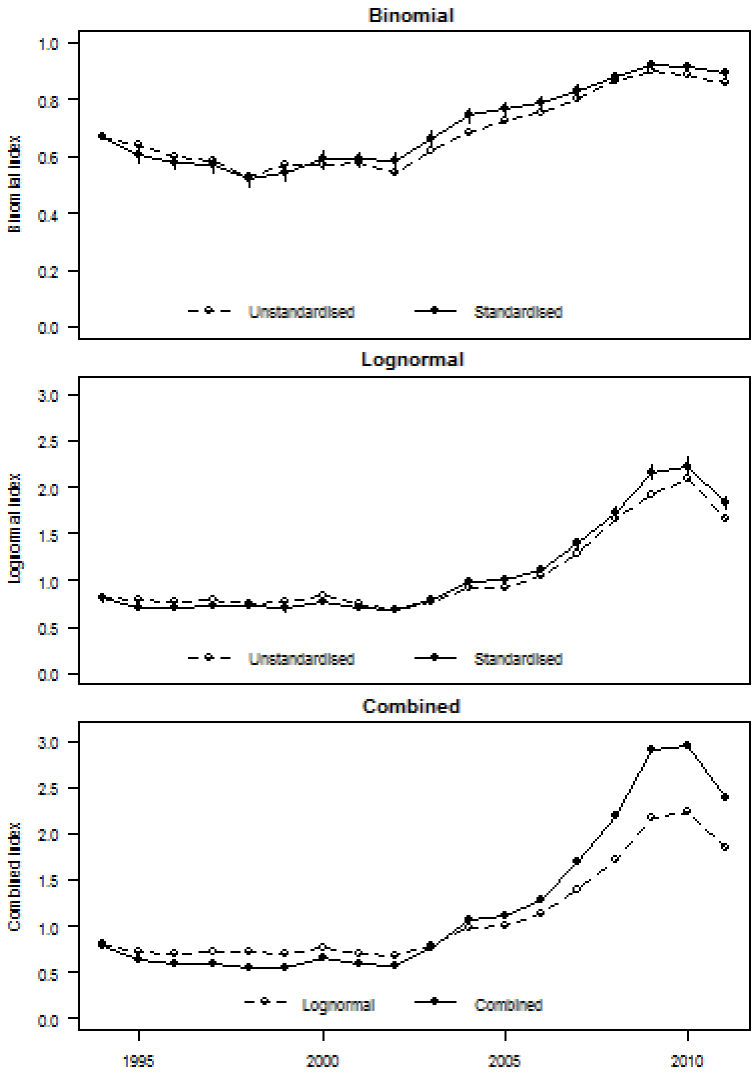

Figure F.4. Standardised annual CPUE indices for the model based on CRA 8 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table F.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 8 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables.

Fishing year	Potlifts	Vessels	Trips	Weight (kg)	Soak time (h)	% zero
94/95	3,613	14	970	2,471	121,002	48.7
95/96	1,874	8	523	1,470	70,875	46.4
96/97	2,338	13	621	2,488	97,752	38.2
97/98	1,722	12	465	2,257	70,128	33.7
98/99	1,054	10	289	2,311	48,720	26.8
99/00	2,092	12	551	4,181	86,664	40.3
00/01	3,718	22	1,004	8,482	140,849	41.0
01/02	4,234	25	1,130	10,243	158,256	34.9
02/03	4,806	24	1,262	11,636	180,203	29.6
03/04	3,771	20	1,006	9,024	134,330	28.7
04/05	3,405	21	962	7,156	128,763	32.5
05/06	3,888	17	1,065	7,701	144,288	28.1
06/07	4,187	20	1,126	7,484	150,110	24.8
07/08	4,339	19	1,149	8,636	150,746	20.9
08/09	3,104	18	838	6,372	110,001	21.6
09/10	4,038	20	1,094	10,361	142,390	18.3
10/11	3,313	18	894	7,337	109,962	20.2

Table F.2. Summary table for two standardised CPUE models based on CRA 8 *rllb* potlift data using *year*, *month*, *vessel*, *statistical area*, *depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	29,832	99,507	–	–
Fishing year	18	25,008	92,743	0.162	0.162
Vessel	63	23,757	90,854	0.204	0.042
Month	74	23,255	90,053	0.220	0.017
Depth	77	23,083	89,773	0.226	0.006
Soak time	80	23,058	89,738	0.227	0.001
Statistical area	85	23,038	89,714	0.228	0.001
Binomial Model					
Null	0	75,869	75,871	–	–
Fishing year	18	72,103	72,139	0.050	0.050
Vessel	63	69,527	69,653	0.084	0.034
Month	74	69,001	69,149	0.091	0.007
Depth	77	68,820	68,974	0.093	0.002
Soak time	80	68,767	68,927	0.094	0.001
Statistical area	85	68,748	68,918	0.094	0.000

Appendix G. CRA 1 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLCS* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *POT TYPE*, *BAIT TYPE*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*NUMBERS*) (LEGAL + NON-LEGAL)

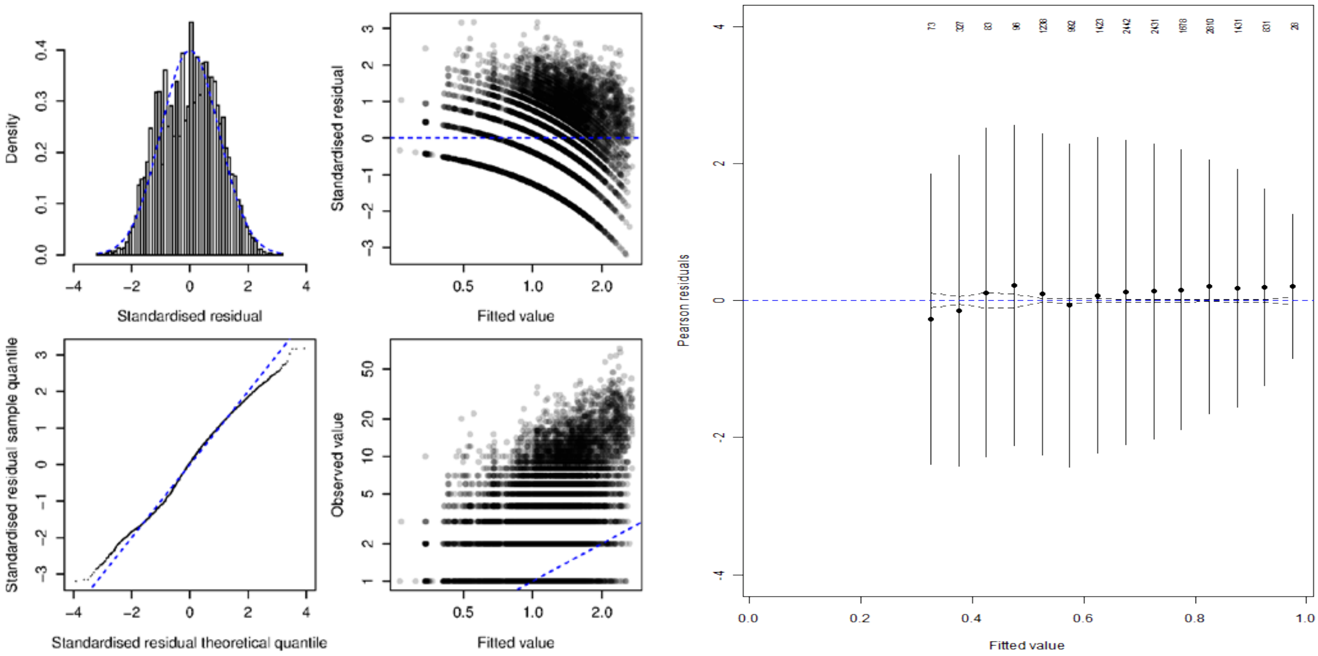

Figure G.1. Residual plots for CRA 1 CPUE regression analyses using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables on potlift data from the *rlcs* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

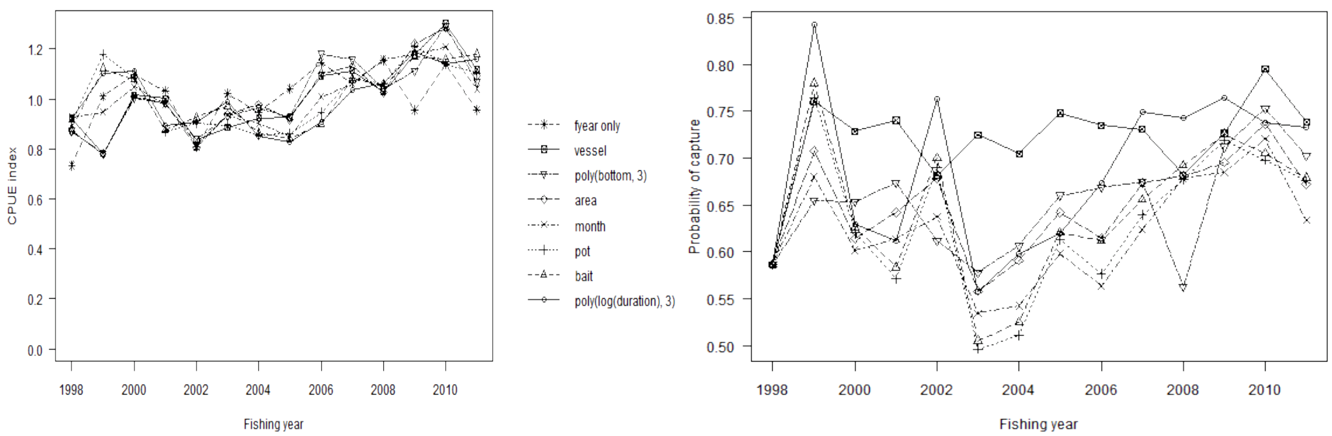

Figure G.2. Year index coefficients for the standardised CPUE analysis based on CRA 1 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

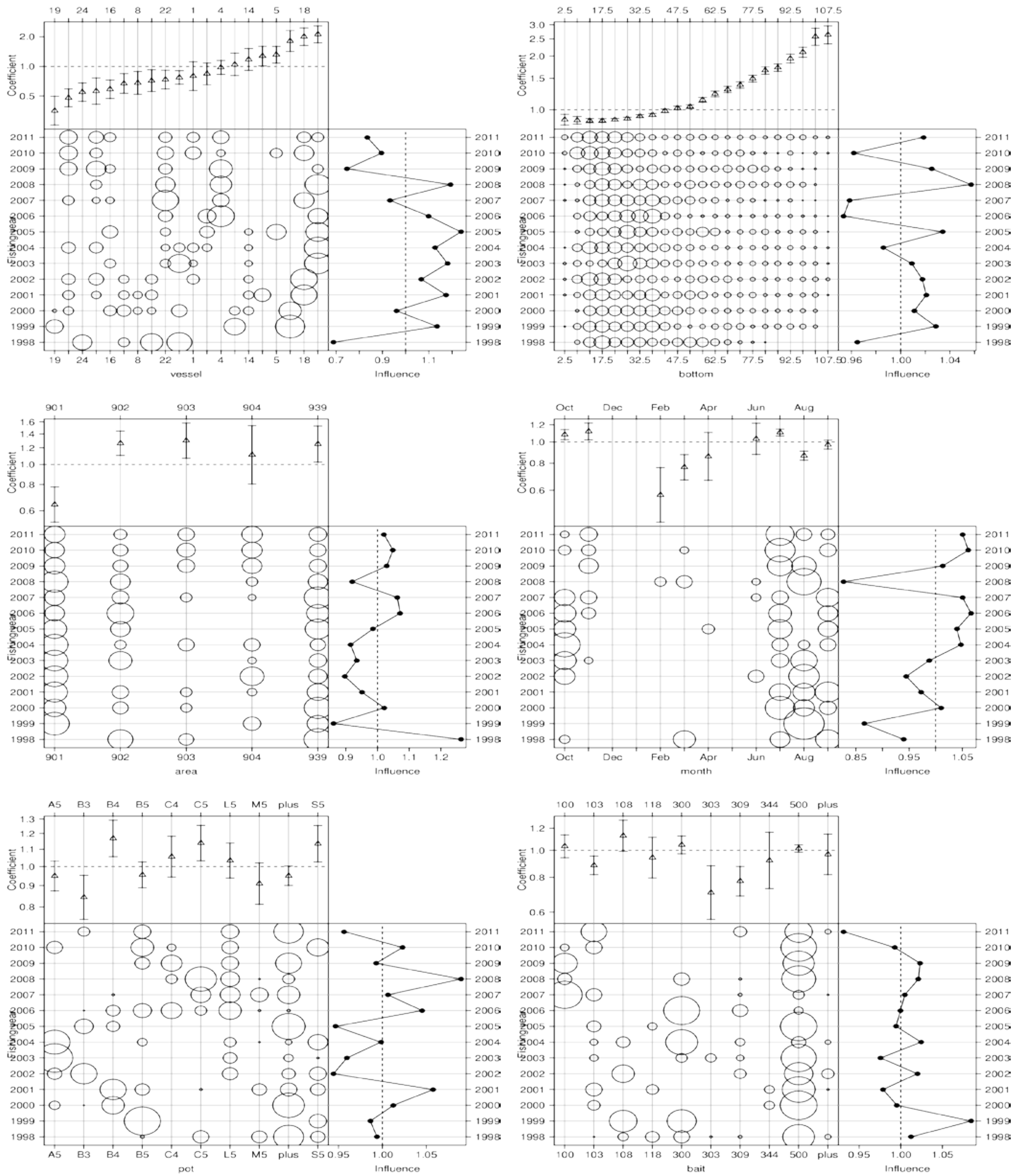

Figure G.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 1 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *depth* continuous variable; [centre left panel] *statistical area* categorical variable; [centre right panel] *month* categorical variable; [lower left panel] *pot type* categorical variable; [lower right panel] *bait type* categorical variable;

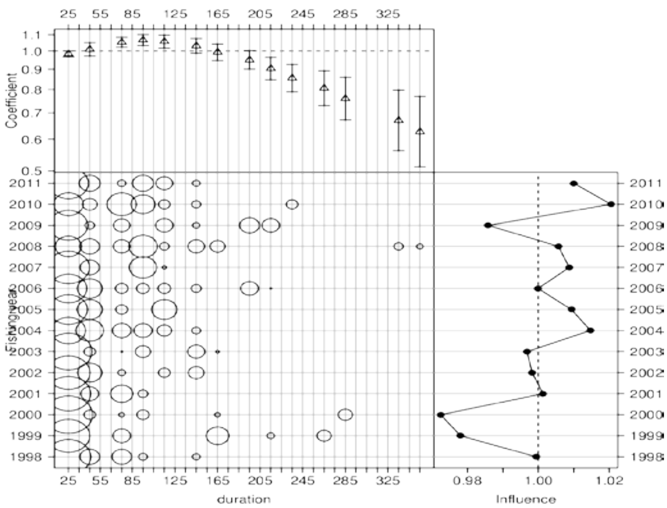

Figure G.3. (cont.): *soak_time* continuous variable

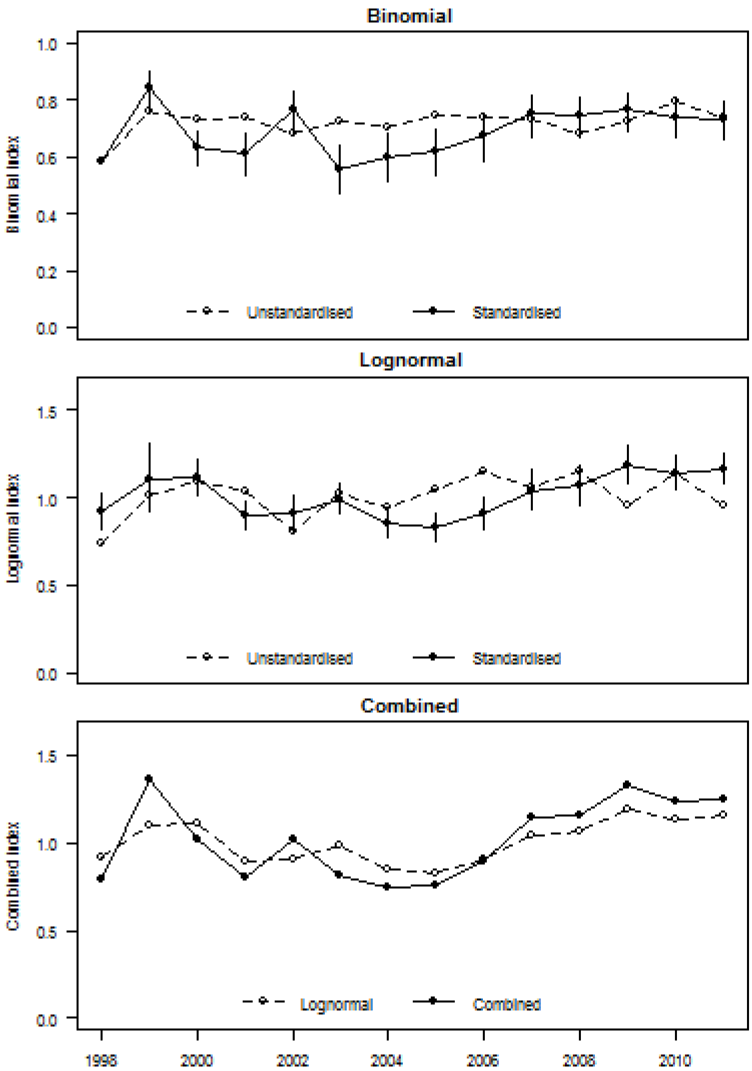

Figure G.4. Standardised annual CPUE indices for the model based on CRA 1 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index

representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table G.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 1 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables.

Fishing year	Potlifts	Vessels	Trips	Numbers	Weight (kg)	Soak time (h)	% zero
97/98	1,216	4	16	2,442	1,621	50,808	41.4
98/99	668	3	9	2,639	1,416	51,360	24.0
99/00	1,687	10	23	6,862	3,542	83,664	27.1
00/01	1,194	8	14	4,579	2,841	44,184	26.0
01/02	1,030	7	11	2,692	1,205	44,952	31.8
02/03	1,243	6	15	4,670	2,515	53,328	27.5
03/04	1,310	8	16	4,630	2,334	72,576	29.5
04/05	1,011	6	15	4,120	2,278	50,904	25.2
05/06	1,131	4	20	4,975	3,044	68,760	26.5
06/07	1,315	6	15	5,432	2,126	62,712	26.9
07/08	780	4	16	3,261	1,815	80,208	31.8
08/09	988	6	15	3,823	2,180	73,056	27.3
09/10	1,165	7	16	5,290	2,523	94,464	20.5
10/11	1,145	8	15	4,219	1,960	58,632	26.1

Table G.2. Summary table for two standardised CPUE models based on CRA 1 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	9,474	30,296	–	–
Fishing year	14	9,309	30,121	0.017	0.017
Vessel	33	7,899	28,282	0.166	0.149
Depth	36	7,548	27,769	0.203	0.037
Statistical area	39	7,460	27,640	0.213	0.009
Month	47	7,401	27,565	0.219	0.006
Pot type	56	7,358	27,516	0.223	0.005
Bait type	65	7,334	27,497	0.226	0.003
Soak time	68	7,316	27,476	0.228	0.002
Binomial Model					
Null	0	18,847	18,849	–	–
Fishing year	14	18,681	18,709	0.009	0.009
Vessel	33	17,915	17,981	0.049	0.041
Month	41	17,752	17,834	0.058	0.009
Soak time	44	17,687	17,775	0.062	0.003
Pot type	53	17,634	17,740	0.064	0.003
Depth	56	17,597	17,709	0.066	0.002
Bait type	65	17,554	17,684	0.069	0.002

Appendix H. CRA 2 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLCS* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *POT TYPE*, *BAIT TYPE*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*NUMBERS*) (LEGAL + NON-LEGAL)

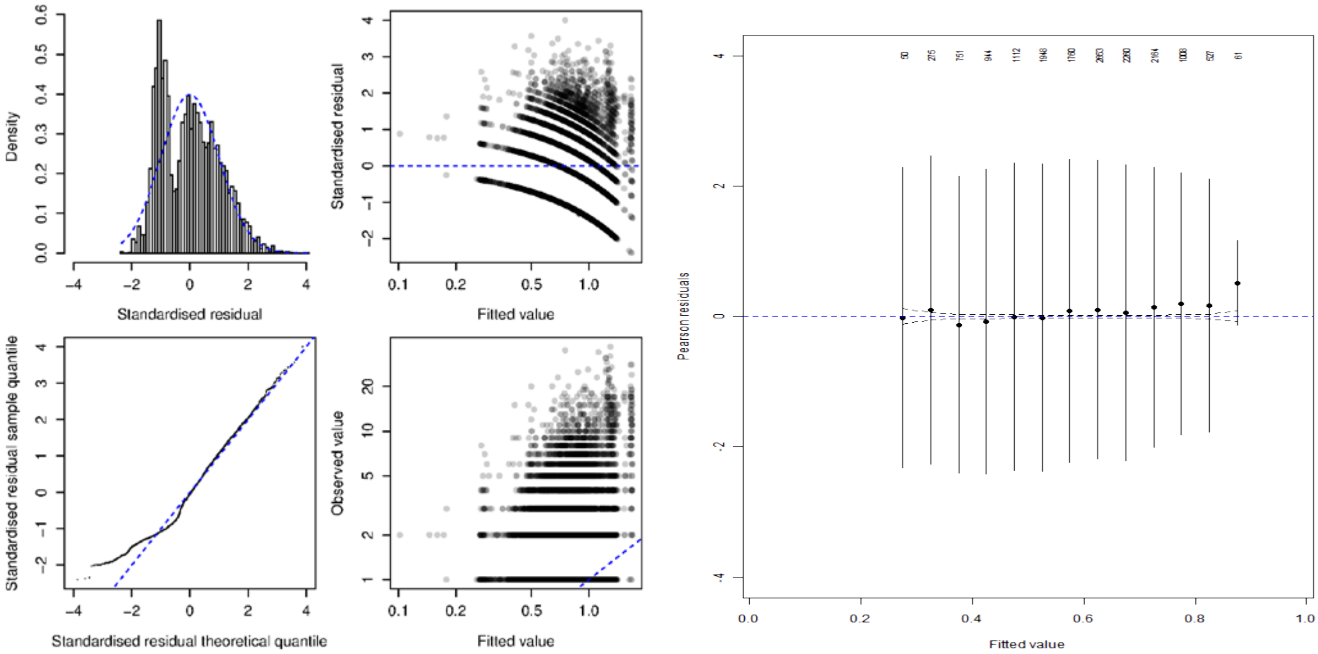

Figure H.1. Residual plots for CRA 2 CPUE regression analyses using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables on potlift data from the *rlcs* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

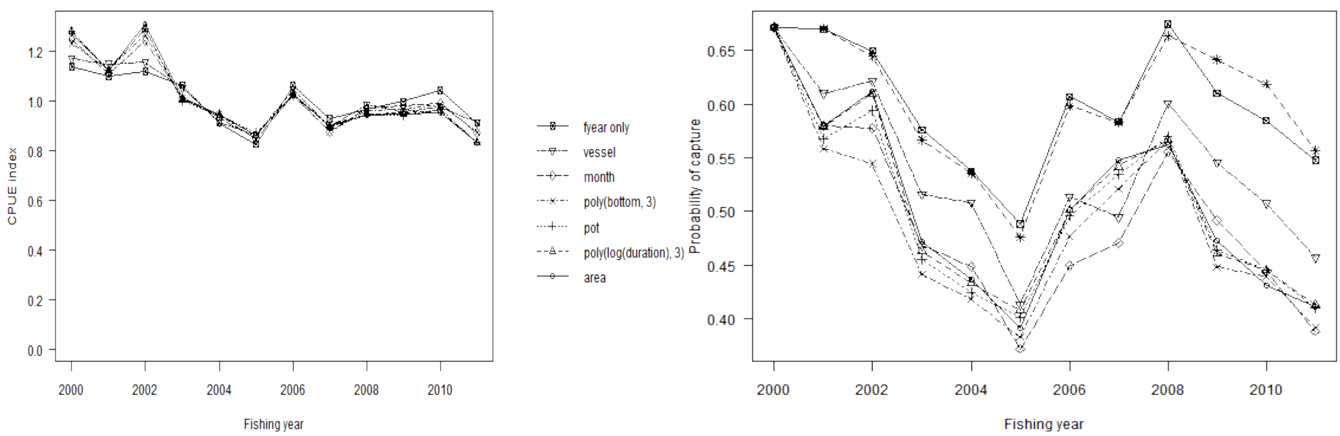

Figure H.2. Year index coefficients for the standardised CPUE analysis based on CRA 2 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

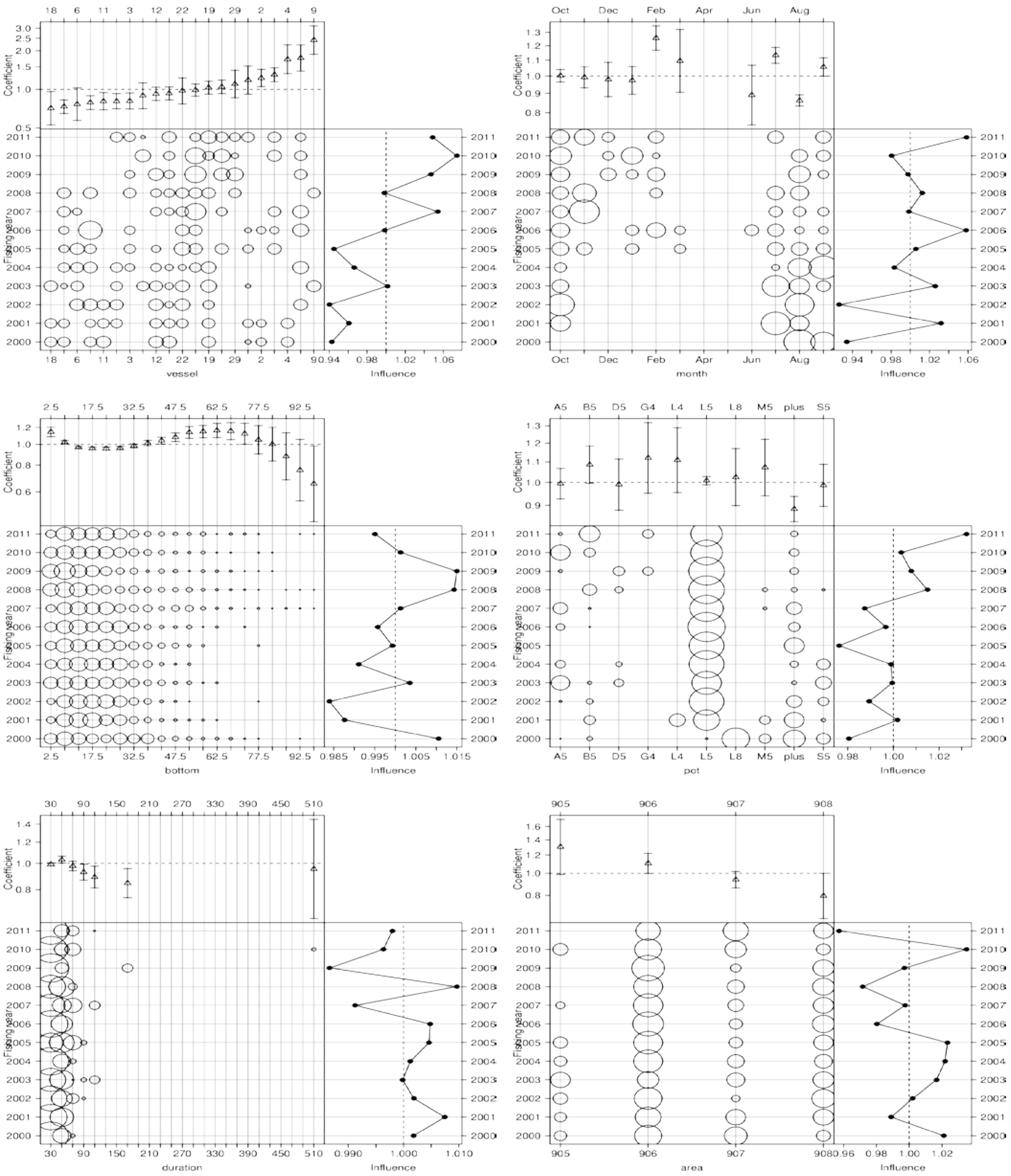

Figure H.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 2 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *month* categorical variable; [centre left panel] *depth* continuous variable; [centre right panel] *pot type* categorical variable; [lower left panel] *soak_time* continuous variable; [lower right panel] *statistical area* categorical variable;

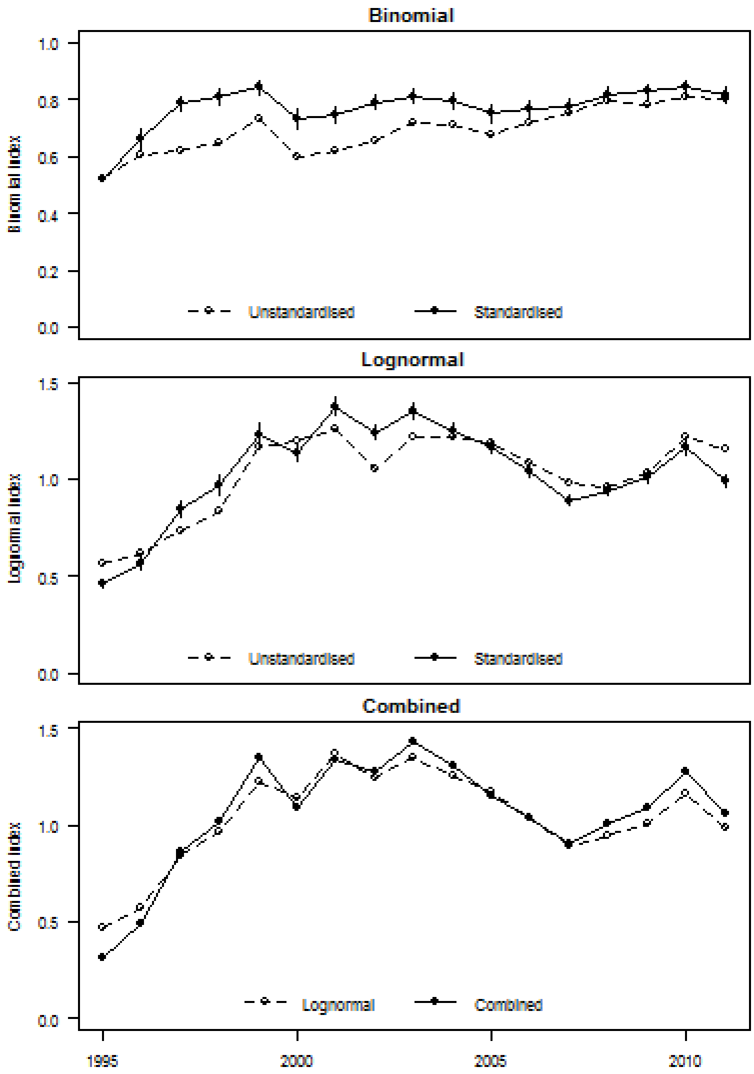

Figure H.4. Standardised annual CPUE indices for the model based on CRA 2 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table H.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 2 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables.

Fishing year	Potlifts	Vessels	Trips	Numbers	Weight (kg)	Soak time (h)	% zero
99/00	1,153	10	10	2,726	1,109	33,864	32.9
00/01	1,407	12	12	2,916	1,152	44,784	33.0
01/02	1,225	9	10	2,829	947	43,224	35.6
02/03	1,264	11	13	2,423	776	57,312	43.4
03/04	1,364	11	11	1,909	601	41,808	46.4
04/05	994	10	10	1,093	348	45,288	52.4
05/06	1,229	9	11	2,317	639	39,120	40.2
06/07	1,361	9	12	2,062	734	61,392	41.7
07/08	1,249	10	11	2,259	812	44,856	33.7
08/09	1,430	7	12	2,740	698	53,400	35.9
09/10	1,445	8	14	2,845	783	58,248	38.1
10/11	1,392	11	12	1,936	784	45,096	44.3

Table H.2. Summary table for two standardised CPUE models based on CRA 2 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	5,099	20,891	–	–
Fishing year	12	5,025	20,777	0.014	0.014
Vessel	32	4,693	20,175	0.080	0.065
Month	41	4,632	20,071	0.092	0.012
Depth	44	4,614	20,041	0.095	0.003
Pot type	53	4,596	20,023	0.099	0.004
Soak time	56	4,592	20,020	0.099	0.001
Statistical area	58	4,590	20,019	0.100	0.000
Binomial Model					
Null	0	20,831	20,833	–	–
Fishing year	12	20,630	20,654	0.010	0.010
Vessel	32	20,261	20,325	0.027	0.018
Month	41	20,130	20,212	0.034	0.006
Pot type	50	20,040	20,140	0.038	0.004
Bait type	59	19,953	20,071	0.042	0.004
Statistical area	61	19,921	20,043	0.044	0.002
Depth	64	19,886	20,014	0.045	0.002
Soak time	67	19,852	19,986	0.047	0.002

Appendix I. CRA 3 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLCS* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *POT TYPE*, *BAIT TYPE*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*NUMBERS*) (LEGAL + NON-LEGAL)

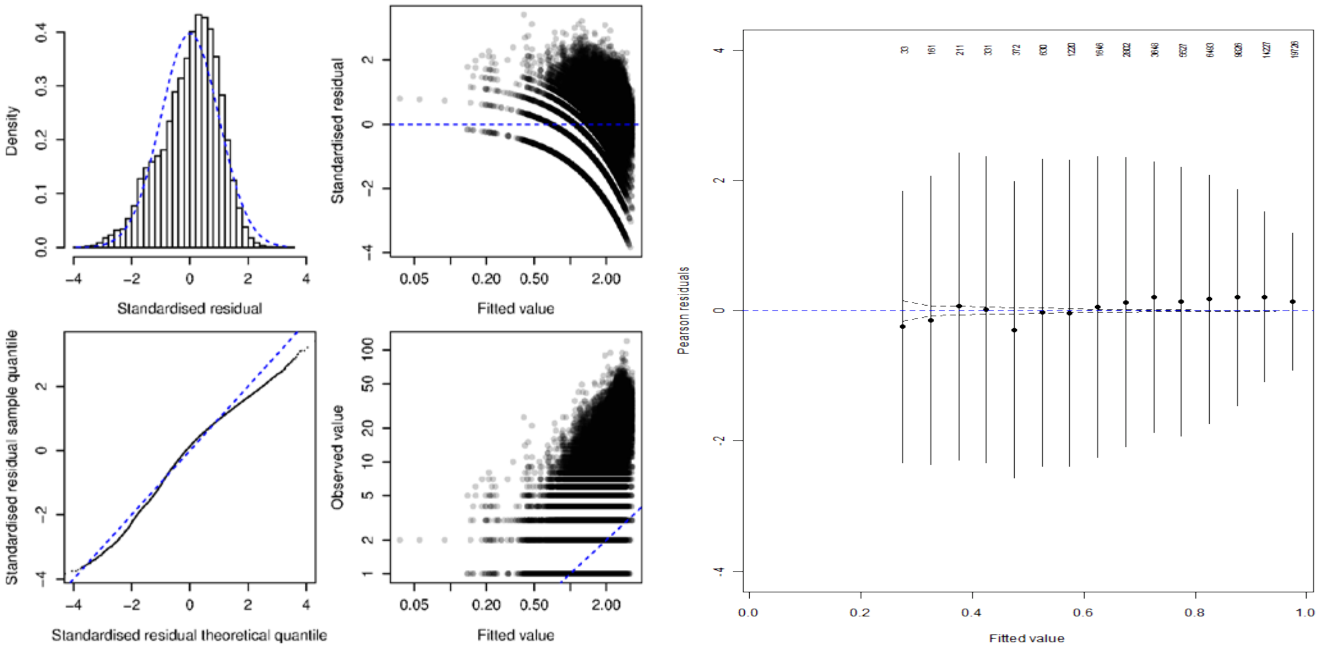

Figure I.1. Residual plots for CRA 3 CPUE regression analyses using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables on potlift data from the *rlcs* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

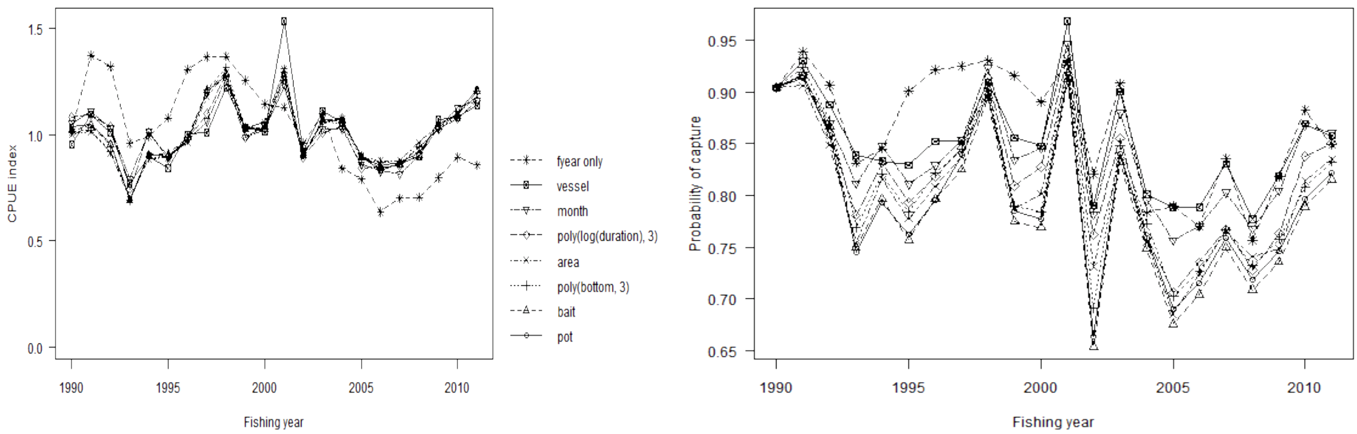

Figure I.2. Year index coefficients for the standardised CPUE analysis based on CRA 3 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

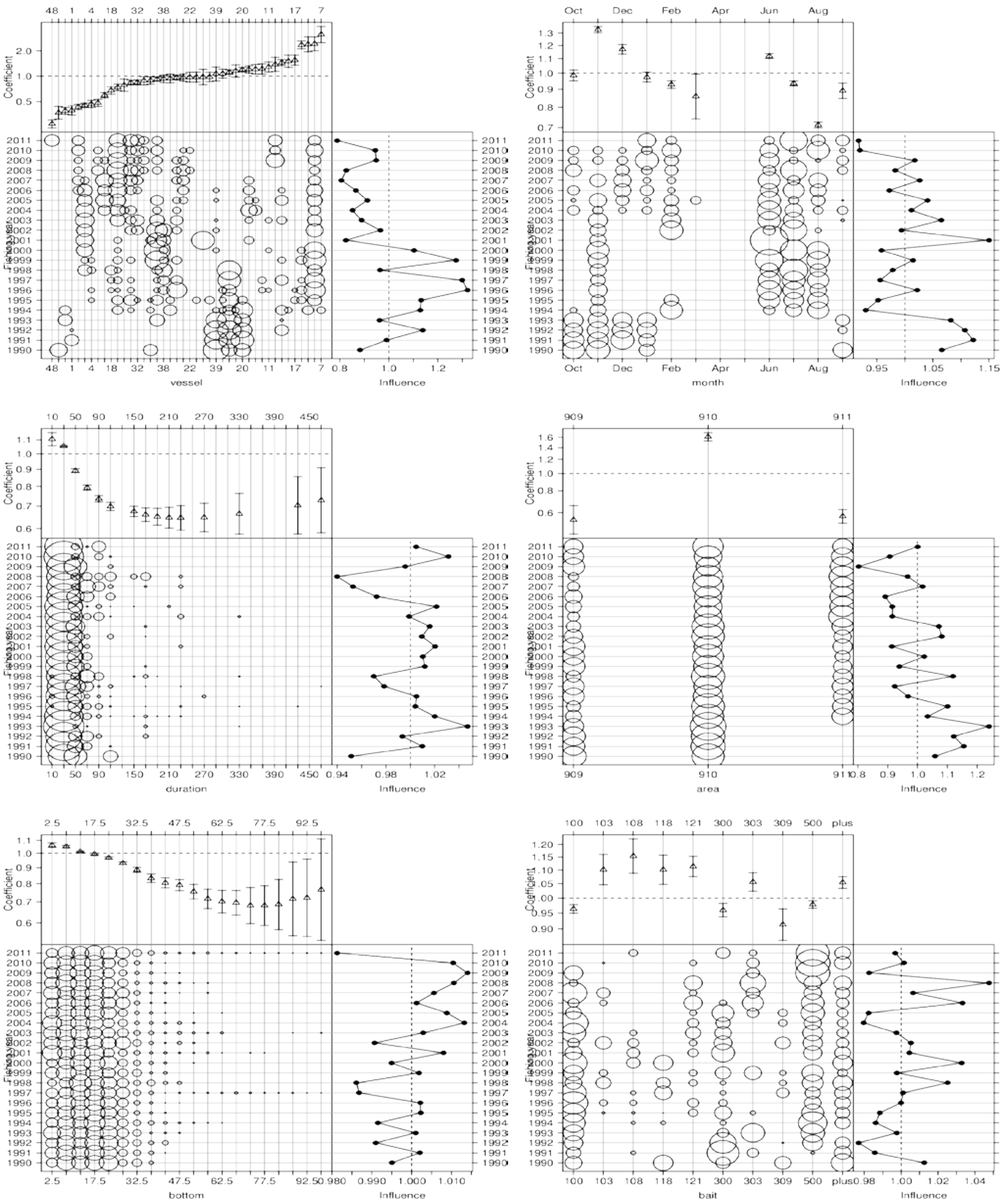

Figure I.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 3 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *month* categorical variable; [centre left panel] *soak_time* continuous variable; [centre right panel] *statistical area* categorical variable; [lower left panel] *depth* continuous variable; [lower right panel] *bait type* categorical variable;

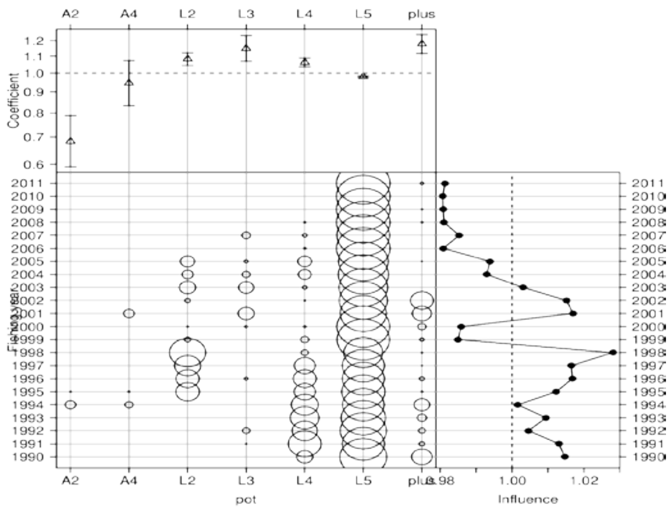

Figure I.3. (cont.): ***pot type*** **categorical variable**

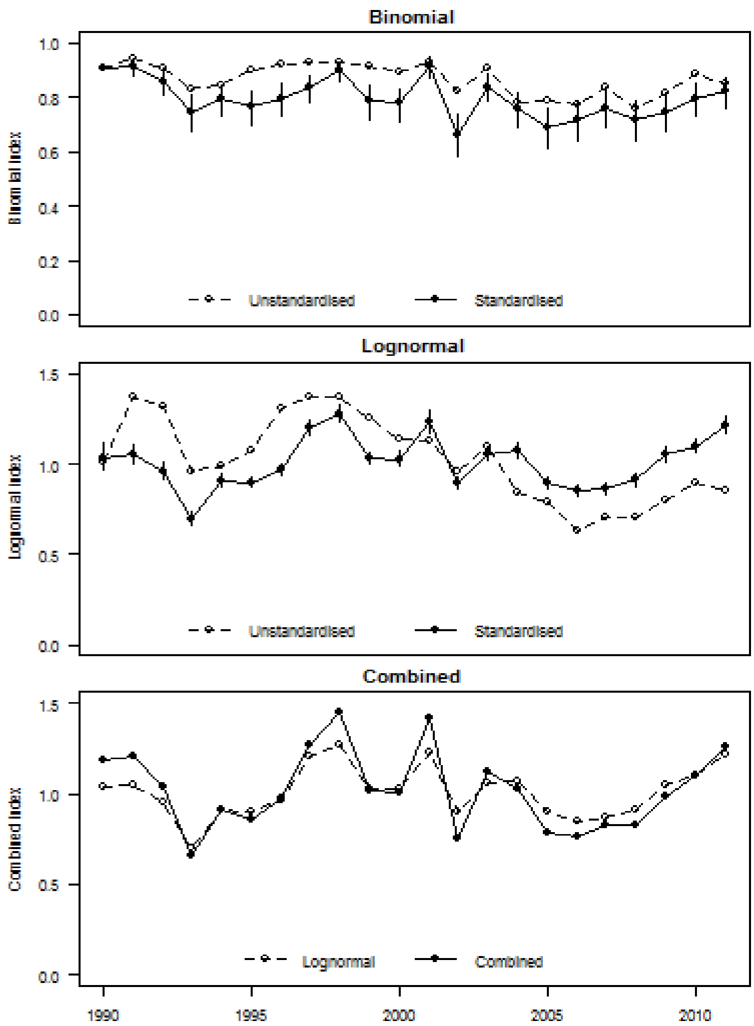

Figure I.4. Standardised annual CPUE indices for the model based on CRA 3 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table I.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 3 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables. '–': not available

Fishing year	Potlifts	Vessels	Trips	Numbers	Weight (kg)	Soak time (h)	% zero
89/90	895	5	8	8,363	–	40,320	9.6
90/91	2,045	4	17	25,539	–	63,624	6.1
91/92	2,195	5	21	26,014	–	77,976	9.3
92/93	2,163	6	23	18,267	–	62,808	16.9
93/94	5,533	14	53	48,562	2,493	176,034	15.5
94/95	5,444	15	47	53,806	5,177	183,242	9.9
95/96	3,785	14	37	43,554	5,899	123,238	7.8
96/97	3,199	11	31	39,210	6,011	116,510	7.5
97/98	2,714	8	29	35,290	6,401	107,922	7.0
98/99	2,811	10	30	31,302	3,277	85,560	8.3
99/00	2,123	8	21	20,960	1,590	65,880	11.0
00/01	1,973	7	20	18,706	2,390	60,216	6.9
01/02	3,195	8	28	26,177	2,624	100,776	18.0
02/03	3,371	11	28	31,480	2,147	101,568	9.2
03/04	3,266	10	28	22,510	1,296	135,696	21.7
04/05	3,143	11	29	19,509	1,151	100,704	21.1
05/06	3,167	11	29	14,852	862	130,320	23.0
06/07	3,281	10	28	19,534	1,020	151,008	16.4
07/08	2,976	11	27	17,291	1,063	176,304	24.4
08/09	3,302	12	28	21,627	971	114,336	18.2
09/10	3,317	11	28	25,132	2,330	92,640	11.8
10/11	2,955	9	27	21,861	2,356	97,104	15.1

Table I.2. Summary table for two standardised CPUE models based on CRA 3 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	59,013	164,979	–	–
Fishing year	22	56,037	162,037	0.050	0.050
Vessel	63	42,100	145,630	0.287	0.236
Month	72	40,372	143,230	0.316	0.029
Soak time	75	39,797	142,409	0.326	0.010
Statistical area	77	39,397	141,832	0.332	0.007
Depth	80	39,264	141,642	0.335	0.002
Bait type	89	39,138	141,476	0.337	0.002
Pot type	95	39,041	141,343	0.338	0.002
Binomial Model					
Null	0	53,527	53,529	–	–
Fishing year	22	51,777	51,821	0.033	0.033
Vessel	63	47,531	47,657	0.112	0.079
Month	72	46,611	46,755	0.129	0.017
Depth	75	46,270	46,420	0.136	0.006
Soak time	78	46,034	46,190	0.140	0.004
Bait type	87	45,843	46,017	0.144	0.004
Pot type	93	45,784	45,970	0.145	0.001
Statistical area	95	45,751	45,941	0.145	0.001

Appendix J. CRA 4 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLCS* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *POT TYPE*, *BAIT TYPE*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*NUMBERS*) (LEGAL + NON-LEGAL)

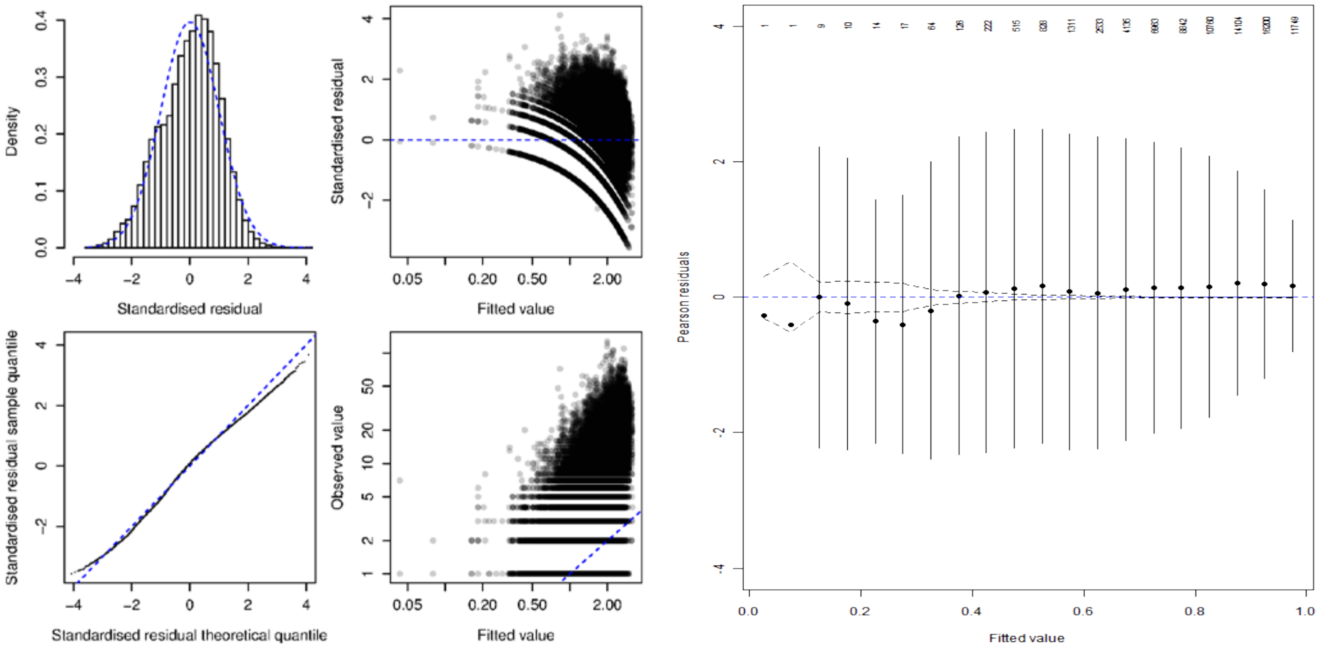

Figure J.1. Residual plots for CRA 4 CPUE regression analyses using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables on potlift data from the *rlcs* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

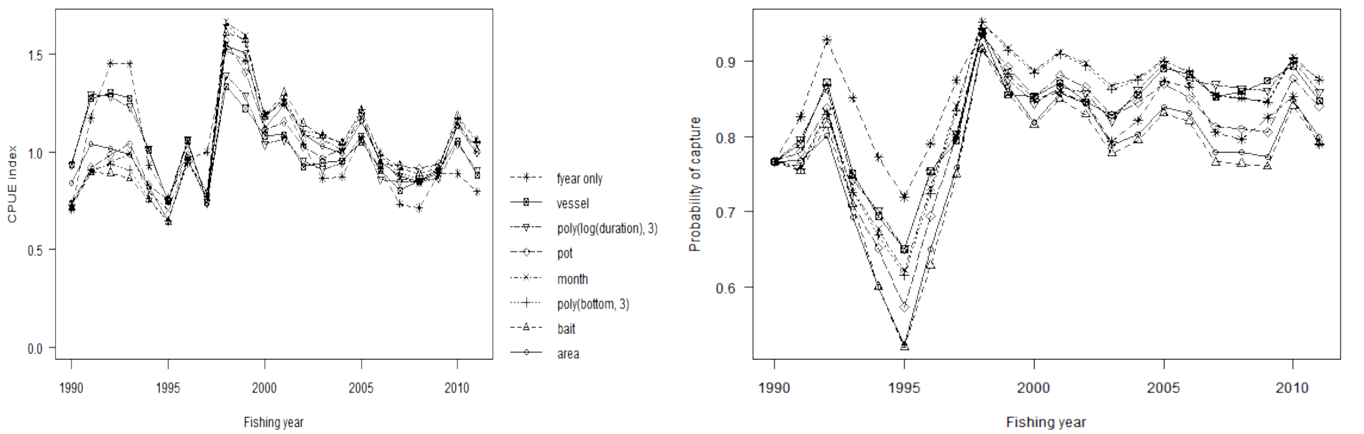

Figure J.2. Year index coefficients for the standardised CPUE analysis based on CRA 4 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

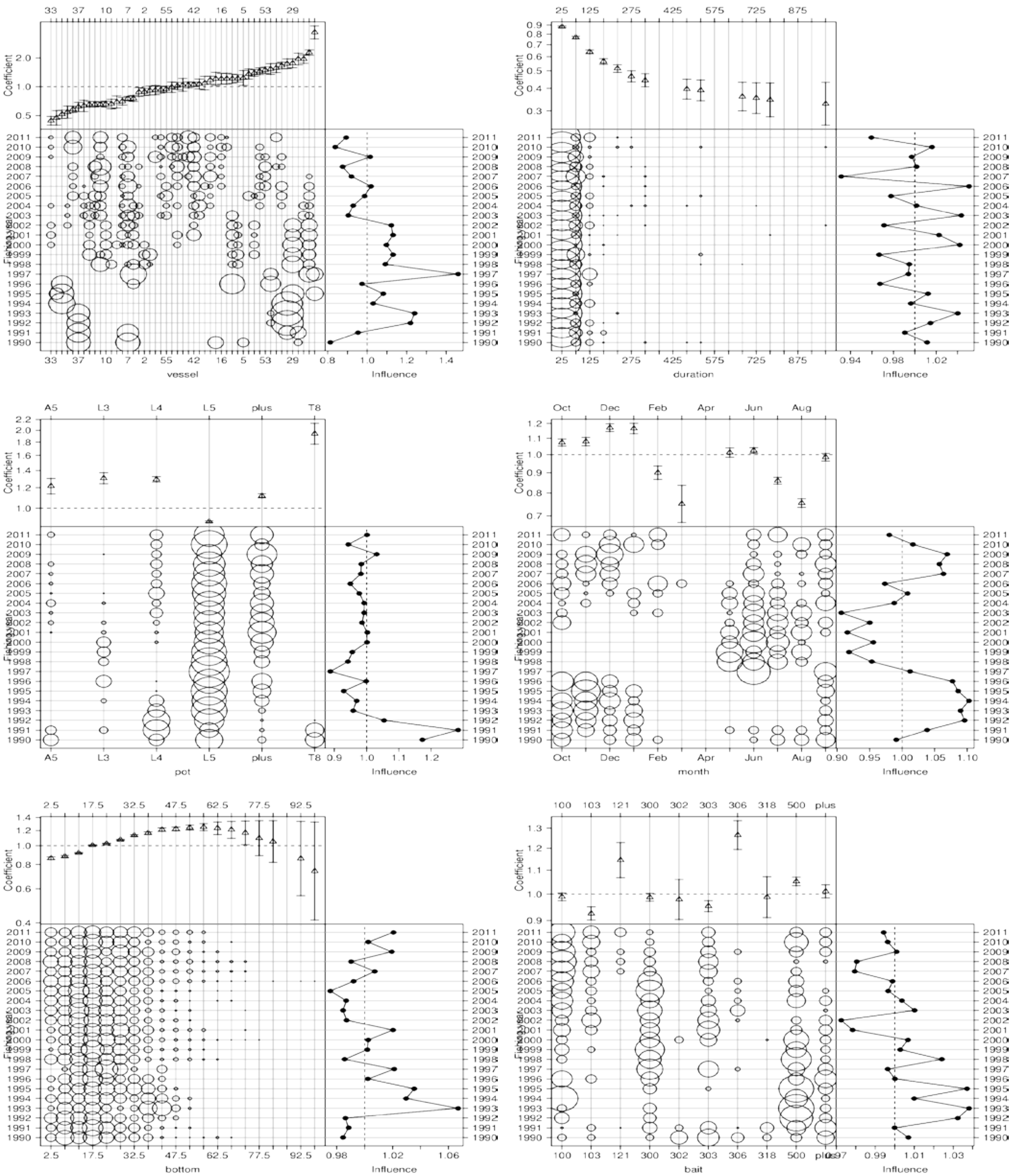

Figure J.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 4 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *soak_time* continuous variable;[centre left panel] *pot type* categorical variable; [centre right panel] *month* categorical variable; [lower left panel] *depth* continuous variable; [lower right panel] *bait type* categorical variable;

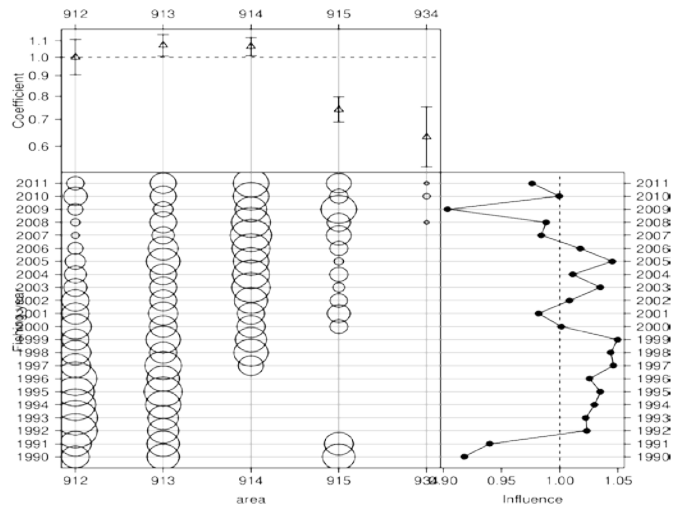

Figure J.3. (cont.): *statistical area* categorical variable

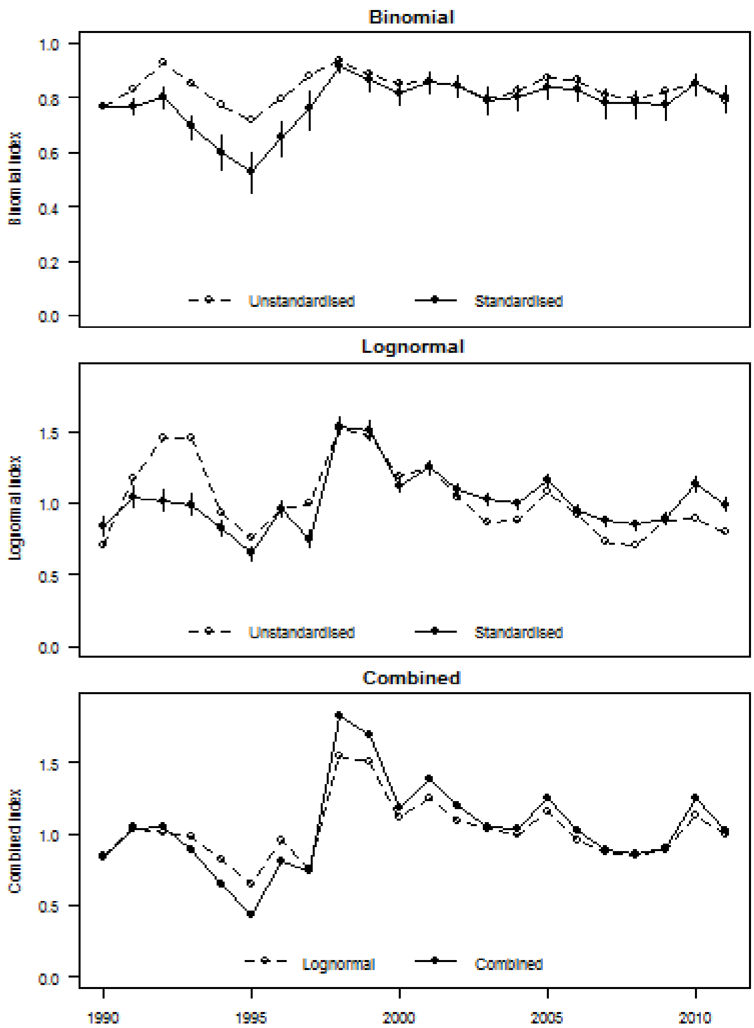

Figure J.4. Standardised annual CPUE indices for the model based on CRA 4 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch

Table J.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 4 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables

Fishing year	Potlifts	Vessels	Trips	Numbers	Weight (kg)	Soak time (h)	% zero
89/90	2,734	5	25	12,463	800	103,704	23.3
90/91	4,178	4	38	35,649	1,067	168,792	17.4
91/92	2,394	3	22	26,344	796	82,704	7.1
92/93	2,295	3	20	21,741	772	71,319	14.9
93/94	2,300	2	20	15,415	887	88,464	22.7
94/95	1,379	4	12	8,331	877	45,831	28.1
95/96	1,634	4	16	10,511	1,521	64,032	20.9
96/97	600	4	6	4,239	594	25,440	12.5
97/98	4,152	10	32	45,365	6,844	148,488	6.2
98/99	3,061	10	26	31,230	5,315	136,752	11.7
99/00	4,639	14	39	39,084	6,251	136,143	15.1
00/01	3,994	13	37	35,119	4,100	132,363	14.1
01/02	3,980	13	32	28,886	3,670	180,018	15.4
02/03	4,387	16	33	23,272	4,444	125,784	20.7
03/04	4,429	19	35	25,016	4,145	177,462	17.9
04/05	4,288	16	35	31,088	3,668	168,457	12.6
05/06	5,410	16	46	33,375	5,001	156,672	13.4
06/07	5,607	14	45	26,168	4,595	268,296	19.5
07/08	5,038	15	45	22,039	3,872	184,393	20.4
08/09	3,910	16	39	22,548	3,837	144,288	17.5
09/10	4,152	13	40	23,299	4,768	181,584	14.7
10/11	3,843	14	42	20,383	4,177	164,784	21.0

Table J.2. Summary table for two standardised CPUE models based on CRA 4 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	65,416	185,853	0.000	.
Fishing year	22	61,669	182,029	0.057	0.057
Vessel	70	49,253	167,394	0.247	0.190
Soak time	73	48,120	165,875	0.264	0.017
Pot type	78	47,213	164,638	0.278	0.014
Month	88	46,460	163,604	0.290	0.012
Depth	91	46,020	162,987	0.297	0.007
Bait type	100	45,900	162,834	0.298	0.002
Statistical area	104	45,836	162,750	0.299	0.001
Binomial Model					
Null	0	70,032	70,034	0.000	.
Fishing year	22	68,767	68,811	0.018	0.018
Vessel	70	64,813	64,953	0.075	0.056
Soak time	73	63,796	63,942	0.089	0.015
Month	83	63,109	63,275	0.099	0.010
Pot type	88	62,996	63,172	0.100	0.002
Depth	91	62,896	63,078	0.102	0.001
Statistical area	95	62,819	63,009	0.103	0.001
Bait type	104	62,758	62,966	0.104	0.001

Appendix K. CRA 7 STANDARDISED ANALYSIS: DIAGNOSTIC PLOTS FOR MODEL FITTED TO *RLCS* POTLIFT DATA USING *YEAR*, *MONTH*, *VESSEL*, *STATISTICAL AREA*, *POT TYPE*, *BAIT TYPE*, *DEPTH* AND *SOAK TIME* AS EXPLANATORY VARIABLES FITTED TO LN(*NUMBERS*) (LEGAL + NON-LEGAL)

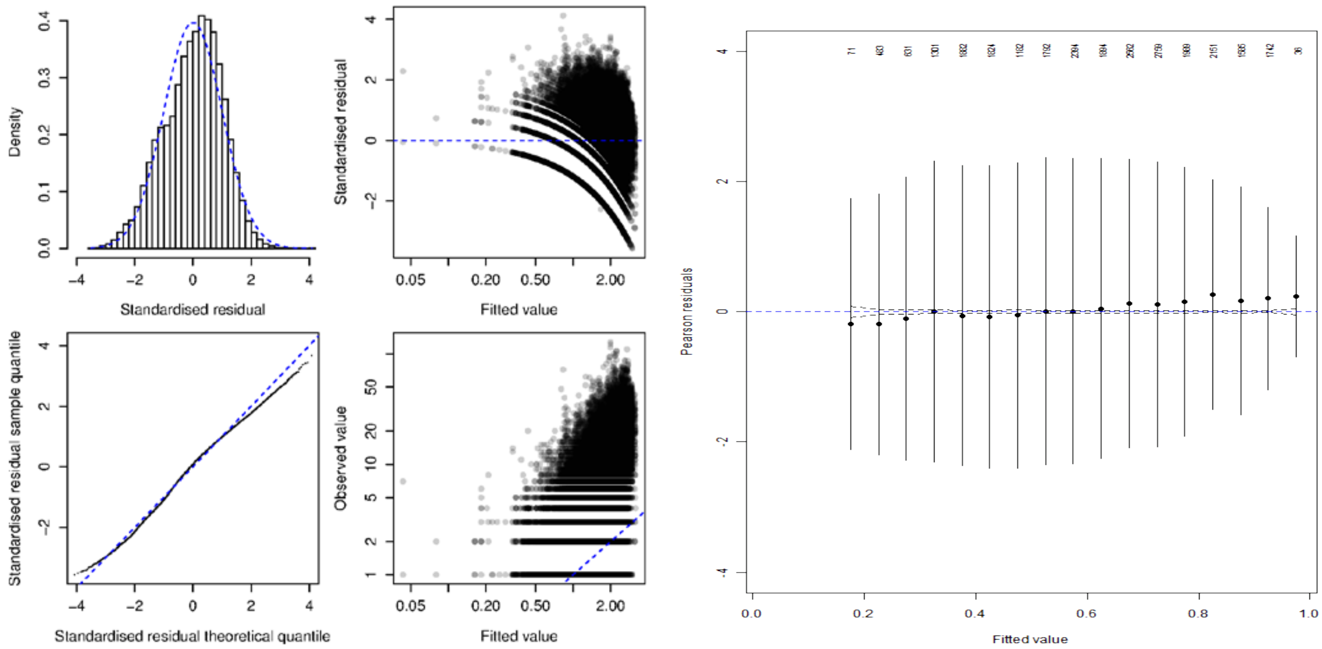

Figure K.1. Residual plots for CRA 7 CPUE regression analyses using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables on potlift data from the *rlcs* database. [left panel] residuals from the lognormal model using positive catch records [right panel] residuals from the binomial logit model of the probability of a successful lift.

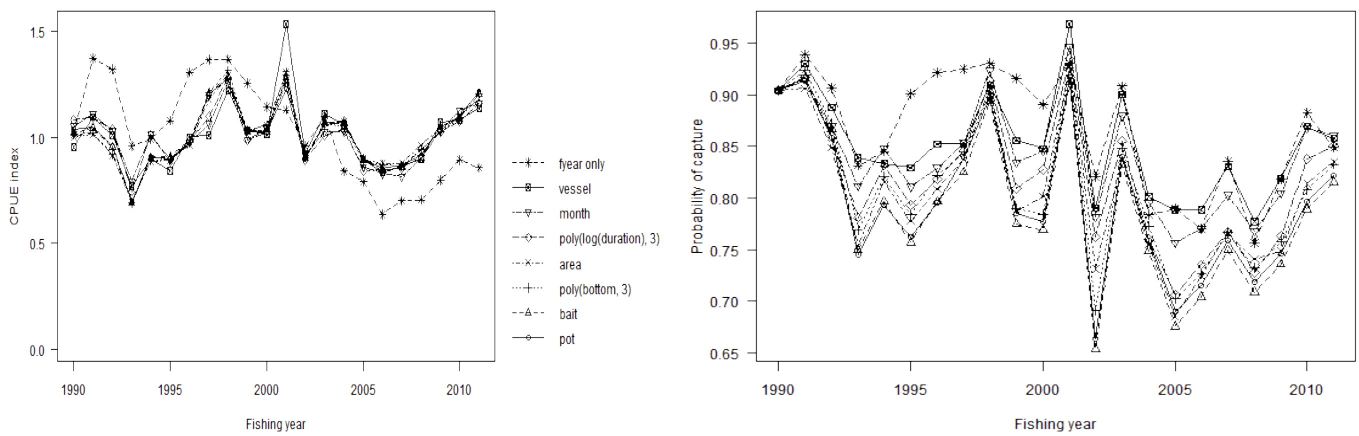

Figure K.2. Year index coefficients for the standardised CPUE analysis based on CRA 7 *rlcs* potlift data using *year*, *month*, *vessel*, *statistical area*, *pot type*, *bait type*, *depth* and *soak time* as explanatory variables: effect of adding successive variables to the trajectory of Y_{y_i} indices; [left panel] lognormal model using positive catch records [right panel] binomial logit model of the probability of a successful lift

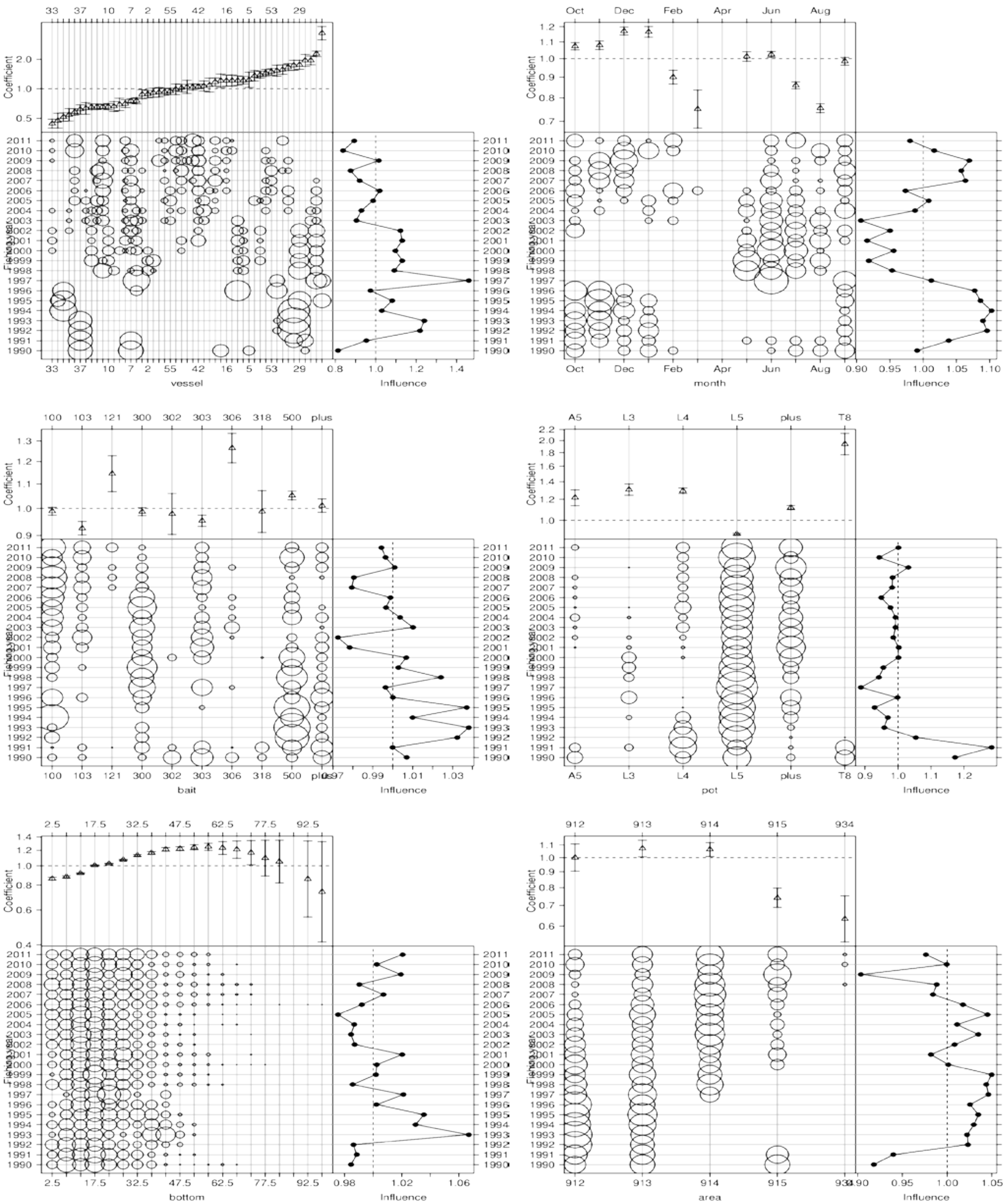

Figure K.3. "Influence" plots (Bentley et al. 2011) showing the relative effect of each explanatory variable on the standardised CPUE analysis based on CRA 7 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables: [upper left panel] *vessel* categorical variable; [upper right panel] *month* categorical variable; [centre left panel] *bait type* categorical variable; [centre right panel] *pot type* categorical variable; [lower left panel] *depth* continuous variable; [lower right panel] *statistical area* categorical variable;

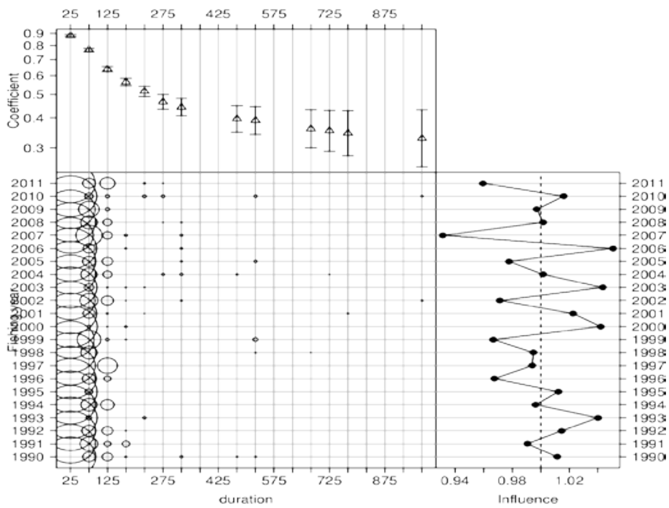

Figure K.3. (cont.): ***soak_time*** **continuous variable**

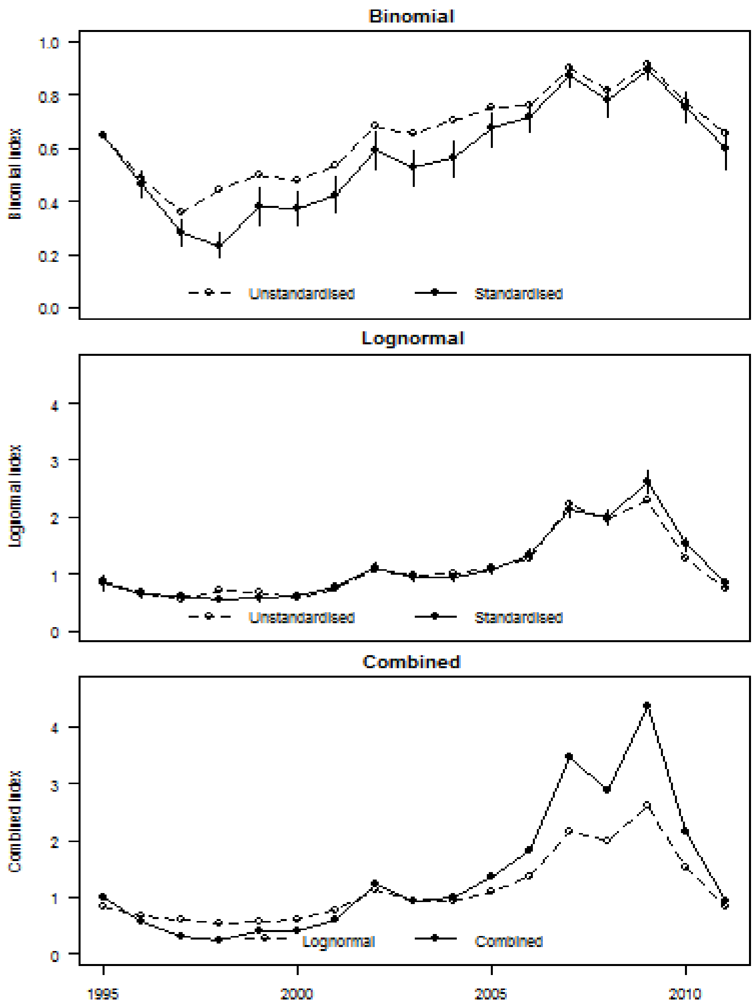

Figure K.4. Standardised annual CPUE indices for the model based on CRA 7 ***rlcs*** **potlift data using** ***year, month, vessel, statistical area, pot type, bait type, depth*** **and** ***soak time*** **as explanatory variables. [top panel] binomial index representing probability of capture; [centre panel] lognormal index representing magnitude of positive catch records; [bottom panel] combined index using delta method representing expected catch**

Table K.1. Summary of data used in the standardised annual CPUE indices for the model based on CRA 7 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables

Fishing year	Potlifts	Vessels	Trips	Numbers	Weight (kg)	Soak time (h)	% zero
94/95	1,335	4	11	4,043	949	48,432	35.4
95/96	1,757	6	15	2,935	574	69,864	51.7
96/97	2,857	9	26	2,879	1,004	90,222	64.4
97/98	1,780	6	19	3,077	475	73,776	55.8
98/99	1,406	5	14	2,434	471	49,872	49.8
99/00	1,991	7	18	2,683	667	66,528	52.5
00/01	1,619	7	15	3,286	648	41,664	46.5
01/02	864	5	8	3,662	681	25,296	31.6
02/03	1,595	8	15	5,210	1,272	54,288	34.7
03/04	1,679	5	15	6,699	1,428	70,824	29.5
04/05	1,677	8	15	7,815	1,376	53,568	24.6
05/06	1,505	5	14	8,464	1,538	45,264	24.3
06/07	1,307	7	15	14,365	1,729	33,792	10.1
07/08	1,199	6	15	11,421	1,541	38,952	18.3
08/09	1,335	8	15	14,922	1,996	49,896	8.9
09/10	1,285	10	15	7,324	1,909	36,672	22.4
10/11	1,087	6	15	2,923	863	33,384	34.9

Table K.2. Summary table for two standardised CPUE models based on CRA 7 *rlcs* potlift data using *year, month, vessel, statistical area, pot type, bait type, depth* and *soak time* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: proportion of deviance explained; Improvement: increase in explained deviance with the addition of the indicated variable. All available variables were fitted to the model except those which resulted in no improvement in AIC. '–': not applicable

Variable	DF	Deviance	AIC	R^2	Improvement
Lognormal Model					
Null	0	17,334	47,323	–	–
Fishing year	17	14,096	43,978	0.187	0.187
Vessel	42	13,666	43,522	0.212	0.025
Month	47	13,487	43,316	0.222	0.010
Bait type	56	13,400	43,229	0.227	0.005
Pot type	65	13,353	43,190	0.230	0.003
Depth	68	13,317	43,151	0.232	0.002
Statistical area	69	13,288	43,118	0.233	0.002
Soak time	72	13,275	43,108	0.234	0.001
Binomial Model					
Null	0	34,862	34,864	–	–
Fishing year	17	31,558	31,592	0.095	0.095
Vessel	42	31,061	31,145	0.109	0.014
Depth	45	30,821	30,911	0.116	0.007
Bait type	54	30,718	30,826	0.119	0.003
Pot type	63	30,651	30,777	0.121	0.002
Soak time	66	30,616	30,748	0.122	0.001
Month	71	30,604	30,746	0.122	0.000
Statistical area	72	30,602	30,746	0.122	0.000