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# Catch per unit effort of red rock lobsters (*Jasus edwardsii*) in CRA 2 (1990–2021)

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## EXECUTIVE SUMMARY

Webber, D.N.<sup>1</sup>; Starr, P.J.<sup>2</sup> (2022). Catch per unit effort of red rock lobsters (*Jasus edwardsii*) in CRA 2 (1990–2021).

*New Zealand Fisheries Assessment Report 2022/47. 118 p.*

This document describes the development of standardised catch per unit effort (CPUE) index series for CRA 2 using data collected by the mandatory Catch Effort Landing Return (CELR) forms and data collected voluntarily by commercial fishers in the logbook (LB) programme and the electronic fine scale / harvest pot programme.

The 2019 fishing year marked the transition of the collection of rock lobster catch and effort data from the paper-based (CELR) system to an electronic reporting system (ERS). Analyses of the 2019 and 2020 ERS data indicated that the estimated catches returned using the new ERS differed from the equivalent estimates generated by the previous CELR forms. Therefore, the Rock Lobster Working Group agreed to temporarily suspend updating CELR CPUE indices beginning with the 2019 spring/summer season. This meant that the CELR CPUE series for CRA 2 ended in 2019 autumn/winter (AW). Therefore, a new CPUE index series for CRA 2 was desired.

Bayesian generalised linear mixed models were used to model CPUE in all three data sets. The LB CPUE index series overlaps with the CELR series from 1993 AW to 2019 AW and represents all lobsters above the minimum legal size (MLS) as opposed to the CELR series which represents legal state lobsters only. The fine scale / harvest pot CPUE index series overlaps with the CELR series from 2009 AW to 2019 AW and it represents all selected lobsters, as opposed to legal state lobsters for the CELR series, or lobsters above the MLS for the LB series. Both of these series provide a potential index of abundance for use in stock assessment beyond 2019 AW. However, the LB series is preferable over the fine scale series because it is a longer time series and in the fine scale data set it is not possible to factor out lobsters below the MLS for which the pots are specifically designed not to capture. Consequently, these pots may not be capturing a consistent component of this part of the population over time.

Finally, several issues with the logbook and fine scale data sources were identified during this analysis. These issues are listed in the discussion.

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## 1. INTRODUCTION

This document describes the development of standardised catch per unit effort (CPUE) index series for CRA 2 using data collected by the mandatory Catch Effort Landing Return (CELR) forms and data collected voluntarily by commercial fishers in the logbook (LB) programme and the electronic fine scale / harvest pot programme. The CRA 2 Quota Management Area (QMA) extends from Te Arai Point, south of Whangarei, to East Cape at the easternmost end of the Bay of Plenty (Figure 1).

The 2019 fishing year marked the transition of the collection of rock lobster catch and effort data from the paper-based (CELR) system to an electronic reporting system (ERS) dependent on a user interface for data entry operated from tablets or smart phones. There are currently three different ERS reporting 'platforms' in use for rock lobster data, each with a different user interface and underlying software. Analyses of the 2019 and 2020 ERS data indicated that the estimated catches returned using the ERS system differed from the equivalent estimates generated by the previous CELR forms (see appendix B of Starr 2021 which analysed the 2019 data, but there was little improvement in the 2020 or the 2021 data). Therefore, the Rock Lobster Working Group (RLWG) agreed in 2020 to temporarily suspend updating the CELR CPUE series beginning with the 2019 spring/summer (SS) season. The RLWG concluded that, with the exception of CRA 7, there remained sufficient CELR data in the QMAs that there was comparability with previous indices for the 2019 autumn/winter (AW) data (see appendix I in Webber & Starr 2020). This meant that the CELR CPUE series for CRA 2 ended in 2019 AW.

The LB programme was initially implemented in 1993 in CRA 2, CRA 5, and CRA 8. The LB programme used paper forms for data entry, but in 2009 CRA 2 switched to an electronic reporting platform called Allegro. In addition, many of the LB participating fishers enrolled in an additional programme that recorded catch data for every pot lifted. Therefore, CRA 2 fishers fall into one of four categories:

1. those that sample LB pots only;
2. those that record data from all pots (i.e., the fine scale / harvest pots) but do not sample LB pots;
3. those that record data for both LB pots and fine scale / harvest pots; and
4. those that don't participate in either programme (Table 1).

Data entry and data storage for both CRA 2 programmes is currently done by Simon Anderson (Lat37). The transfer of the LB data from the fine scale / harvest pot database to the rock lobster logbook *rllb* database is also done by Simon Anderson. In an attempt to fully understand the CRA 2 data and its collection, interviews were conducted with S. Anderson and two commercial CRA 2 fishers, but these have not been reported here.

### 1.1 Design of the voluntary logbook programme

The voluntary LB programme began in 1993. In rock lobster QMAs where the programme operates, fishers participate on a voluntary basis and consequently their inclusion is non-random. All fishers have been encouraged to participate in the programme, with the intent of gaining the participation of as many operators as possible and covering a wide range of operator types. Each participant is asked to sample the entire catch from four selected pots, every time that they are hauled. These sampled pots, selected from the hundred or so pots that each fisherman uses and marked with a tag on the pot, are meant to be representative of their remaining pots<sup>3</sup>.

Each time a designated pot is lifted, the depth, soak time, number of octopus, and the number of dead lobsters<sup>4</sup> are recorded as well as the tail width (TW), sex, and maturity (of female lobsters) of each

<sup>3</sup> Ideally LB pots would be selected randomly from all of the pots that a LB participant lifts within a day, but this would have been too difficult to implement reliably. Consequently, LB participants were asked to select four pots that represented their average fishing effort. They were instructed to fish these pots in exactly the same manner as the remainder of their pots.

<sup>4</sup> These lobsters are not included in the capture total used for CPUE (see Section 2.2 for details).

live lobster. Using specially modified callipers, the TW of each measured lobster is measured across segment two of the abdomen, rounded down to the nearest millimetre.

The original design capped the number of lobsters to be 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 paper form and the number of rows which could be easily fit on a single A4 page (Figure A.1 in Appendix A). When the paper form was redesigned in 1998, this number was reduced to 25 (Figure A.2). Additional lobsters beyond the cap limit were recorded in two categories: those above the minimum legal size (MLS) labelled 'LiveAbove'; and those below the MLS labelled 'LiveBelow'. This categorisation was meant to be independent of the legal status of the individual. For example, a female that was alive when the pot was lifted and above the female MLS for the area, but which could not be landed because it was carrying eggs (berried), was to be included in the 'LiveAbove' category. These instructions were not followed in CRA 2 when that programme moved in 2009 from a paper form to electronic data entry using the Allegro unit (see Appendix B). Although, the electronic form did not warn fishers to stop measuring at 25 lobsters and allowed them to continue measuring if they wished, there was no provision in the data entry platform to record additional lobsters beyond 25 if the fisher chose to stop recording measurements but there remained unmeasured lobsters. It is not known how this change affected the collection of these data.

CRA 2 has always shown a high acceptance level in the LB programme, ranging from 36% (in 2001) to 79% (in 2020) participation (relative to the total number of vessels reporting in the mandatory Fisheries New Zealand catch and effort monitoring system) and with a 1993–2020 average of 52% (Table 1).

The instructions given to fishers who participated in the logbook programme are supplied in Appendix C and the SQL code used to transfer the LB data to FishServe is supplied in Appendix D.

## 1.2 Design of the fine scale / harvest pot programme

The fine scale / harvest pot programme began in 2009<sup>5</sup> with the introduction of electronic data entry for the LB programme. This more intensive reporting of catch and effort has only been implemented in CRA 2, with most of the logbook programme participants also participating in this fine scale / harvest pot programme (with the exception of 2009, Table 1). Participants are asked to count the entire catch from every pot that they lift. Most of these fishers also participate in the LB programme, with the software platform recording the appropriate logbook data when a tagged pot is encountered. Non-logbook pots are referred to as harvest pots.

When a harvest pot is lifted, fishers are asked to count the number of lobsters captured without measuring them or recording the sex and maturity status for each lobster. The position of the lifted pot (latitude and longitude), depth, temperature, date, and time are captured automatically by the Allegro unit. Fishers record the number of live lobsters caught in the pot, the number of lobsters kept, the number of dead lobsters above the MLS ('DeadAbove'), the number of dead lobsters below the MLS ('DeadBelow'), the number of packhorse rock lobsters (PHC) caught, the number of PHC kept, and any other species caught. Although the number of dead lobsters above and below the MLS is reported, the number of live lobsters is not reported in these categories (i.e., no 'LiveAbove' and 'LiveBelow').

Although it is possible to consider the number of lobsters kept as being the legal status lobsters (i.e., above the MLS and not a berried female), this ignores possible high grading. A destination 'X'<sup>6</sup> field has been added to some of the Allegro units in recent years, but it is not clear how long these data have been collected and not all units include this field (from talking with commercial fishers; and see the views of the unit in Appendix B).

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<sup>5</sup> The fine scale data were also recorded using the Allegro unit (also called Ernie, Appendix B).

<sup>6</sup> Destination 'X' is the code for legal lobsters that are returned to the water.

There are no written instructions for how the fine scale / harvest pot data should be collected by fishers and, apart from the initial training given when the fishers received their Allegro units, fishers have not had additional (refresher) training on how to collect these data.

## 2. METHODS

Data sets from three different sources were used to develop standardised CPUE series including:

1. the mandatory Catch Effort Landing Return (CELR) data;
2. data collected by individual fishers as part of the voluntary logbook (LB) programme; and
3. data collected by individual fishers as part of the fine scale / harvest pot programme.

These three data sources are respectively referred to in this report as the **CELR**, **LB**, and **fine scale** data sources. All CPUE series were ordered by period, which is the sequential combination of a fishing year and season (e.g., 2019 AW). These CPUE analyses include many different model runs using a range of different data sets, with the characteristics of the data sets used for groups of runs provided in Table 2.

Generalised linear mixed models (GLMMs) were used to model CPUE or catch. All models were implemented using *brms* (Bürkner 2017) which makes use of the Stan (Stan Development Team 2016 2017) Hamiltonian Monte Carlo (HMC) Markov chain Monte Carlo (MCMC) algorithm for Bayesian inference. The *brms* package makes these complex models more accessible to a wider range of users by allowing the user to benefit from the advantages of Stan by using extended *lme4*-like formula syntax (Bates et al. 2015).

MCMC mixing for all model runs was checked visually using trace plots (Appendix E) and by monitoring the full suite of standard Stan checks that are available after running a *brms* model including: the number of divergent transitions; the R-hat statistic; and the bulk and tail effective sample size (ESS) (Stan Development Team 2016, 2017). Model selection was done using the leave-one-out information criterion (LOO IC) (Vehtari et al. 2017) and Bayesian  $R^2$  statistics. The number of divergent transitions during all model runs and the time taken for each run was reported. Posterior predictive checks were done to ensure that each model simulates data from the posterior predictive distribution that looks similar to the observed data (i.e., the distributional assumptions are met). Coefficient distribution influence (CDI) plots, originally developed by Bentley et al. (2012) and updated for use with Bayesian GLMMs done in *brms* by Webber (unpublished), were used to visually inspect the coverage of the data, estimated covariates, and the influence of each of the model covariates (Appendix E).

### 2.1 CELR

The CELR data were held in the warehouse database until April 2020, but are now held in the Enterprise Data Warehouse (EDW). These data were obtained from Fisheries New Zealand in September 2021 (replug 13890) and processed using standard error checks (Bentley et al. 2005). The CELR data were prepared using the 'F2 LFX' algorithm (see appendix D of Starr 2021). This algorithm aggregated the weight (kg) of legal lobsters and number of pots lifted in each period ( $t$ ), month ( $m$ ), vessel ( $v$ ), and statistical area ( $a$ ). Only vessels that had been fishing in CRA 2 for at least five years were used in the analysis, retaining 46% of the vessels and 86% of the records<sup>7</sup>.

The dependent variable ( $y_{t,m,v,a}$ ) in the models run was either: the CPUE defined as the weight (kg) divided by the number of pots lifted; or the weight caught (kg). When the latter was used as the dependent variable, the number of pots lifted was used as an explanatory variable in the models. When

<sup>7</sup> The F2 LFX algorithm (Starr 2021) drops vessels that lie outside the range 0.8 to 1.2 for the estimated to landed catch ratio. This procedure dropped between 24% (2020) and 1% (2009) of the annual catch, with an average of 11% dropped between 1990 and 2020.

the number of pots lifted was used as an explanatory variable, it was offered as either a linear effect (in log-space), as the logarithm, or as a spline where the basis dimension was set to  $k = 3$  (Wood 2011)<sup>8</sup>.

The lognormal distribution was assumed in most model runs, but the Gamma and Fréchet distributions were also trailed for some model runs. When the lognormal distribution was assumed, the model was

**Equation 1:**

$$\begin{aligned} y_{t,m,v,a} &\sim \log N(\mu_{t,m,v,a}, \sigma^2) \\ \sigma^2 &\sim \text{Student}(3, 0, 2.5) \end{aligned}$$

where the predictor term ( $\mu$ ) for each period ( $t$ ), month ( $m$ ), vessel ( $v$ ), and statistical area ( $a$ ) was defined generally as

**Equation 2:**

$$\mu_{t,m,v,a} = \mathbf{X}\beta + \mathbf{Z}\gamma + \sum_{k=1}^K s_k(x_k)$$

where  $\beta$  represents the coefficients at the population level (analogous to fixed effects) and  $\mathbf{X}$  is the corresponding design matrix,  $\gamma$  represents the coefficients at the group level (analogous to random effects),  $\mathbf{Z}$  is the corresponding design matrix, and the terms  $s_k(x_k)$  represent smooth functions of unspecified form based on covariates  $x_k$  fitted via splines with basis dimension  $K$  (Wood 2011). The full list of explanatory variables offered included:

- pots, log(pots), or s(pots, k = 3)
- period
- (1 | month)
- area
- (1 | vessel)
- (1 | period × area)

The explanatory variables ‘period’ and ‘area’ were offered to the model as population-level effects. The explanatory variables ‘month’ and ‘vessel’ were offered to the model as group-level effects, hence the (1 | month) and (1 | vessel) notation. A ‘period × area’ interaction term was offered to some models as a group-level effect. The ‘varsel’ function in the R package *projpred* (Piironen et al. 2020) was used to establish the order of importance of the explanatory variables. The order of importance of the explanatory variables was found to be:

1. period
2. (1 | vessel)
3. (1 | month)
4. log(pots) – if included as an explanatory variable
5. area
6. (1 | period × area)

The explanatory variable ‘period’ was always forced as the first term, and the population-level effect for ‘area’ was always offered if the ‘period × area’ interaction term was offered. Therefore, the full suite of models was either:

- kg/pots ~ period
- kg/pots ~ period + (1 | vessel)

---

<sup>8</sup> The basis dimension ( $K$ ) of a spline is a discrete parameter. Estimating the basis dimension of a spline is not possible in *brms*/Stan because the HMC algorithm relies on gradients and discrete parameters do not have gradients. Therefore, the basis dimension must either be fixed at a sensible value, or model runs must be done across a range of basis dimensions and model comparison done (e.g., using LOO IC) to select the best value for  $K$ .

- $\text{kg/pots} \sim \text{period} + (1 \mid \text{vessel}) + (1 \mid \text{month})$
- $\text{kg/pots} \sim \text{period} + (1 \mid \text{vessel}) + (1 \mid \text{month}) + \text{area}$
- $\text{kg/pots} \sim \text{period} + (1 \mid \text{vessel}) + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$

or

- $\text{kg} \sim \log(\text{pots}) + \text{period} + (1 \mid \text{vessel}) + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $\text{kg} \sim \text{pots} + \text{period} + (1 \mid \text{vessel}) + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $\text{kg} \sim s(\text{pots}, k = 3) + \text{period} + (1 \mid \text{vessel}) + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$

## 2.2 Logbook

Data collected by individual fishers as part of the LB programme were obtained from FishServe in September 2021. The LB data are stored in the rllb database which contains data arranged into several tables (Walker & Mackay 2002). The tables relevant to this analysis include:

- trips
- potlifts
- lobsters

The fields within each of these tables are described in Table 3 (trips), Table 4 (potlifts), and Table 5 (lobsters). Figure 2 (trips), Figure 3 (potlifts), and Figure 4 (lobsters) map the extent by fishing year for each table field. It was discovered that some fields in the database were filled out incorrectly, for example: the ‘DeadAbove’, ‘DeadAboveKept’, and ‘DeadBelow’ fields in the ‘potlifts’ table all began in 2000–01 but it appears that these fields may have been padded with zeros rather than NULL prior to this (Figure 3); and the ‘Kept’ field in the ‘lobsters’ table also began in 2000–01 but it appears that this field may have been padded with zeros rather than NULL prior to this (Figure 4). Also, the ‘Depth’ field in the ‘potlifts’ table appears to be not NULL for all years, yet many of the depth records are actually zero metres deep.

Three different levels of aggregation were used for the LB data: by pot (the unaggregated form of the data), by trip, and by month. When aggregating the data by trip or by month, the number of lobsters caught and the number of pots lifted were summed separately and the number of pots lifted was used as an explanatory variable in the model.

The dependent variable was either: the number of lobsters above the MLS per pot; or the number of lobsters above the MLS within a variable number of pots when aggregated by trip or month. The number of lobsters above the MLS was calculated as the sum of the number of lobsters above the MLS that are measured within a pot (from the ‘Lobsters’ table) and the number of lobsters above the MLS that are not measured (i.e., the ‘LiveAbove’ field within the ‘PotLifts’ table). This differs from the CELR CPUE series which measures the weight in kilograms (kg) of legal lobsters (i.e., above the MLS and not a berried female) per pot. The logbook data required a different definition of the dependent variable because the ‘LiveAbove’ field does not separate berried and non-berried females so it is not possible to produce a CPUE series from the logbook data that is equivalent to the CELR series. However, there were few lobsters recorded in the ‘LiveAbove’ field (Table 6). Furthermore, in recent years this field has been set to zero when the data are transferred from the fine scale database to the rllb database (Appendix D). An alternative approach would be to ignore the ‘LiveAbove’ counts so that a logbook series based on the number of legal lobsters (i.e., above the MLS and not a berried female) could be derived. This was not done in this analysis.

Several different subsets of the LB data were generated including:

1. All lobsters above the MLS including berried females and the ‘LiveAbove’ count. Three different levels of data aggregation were applied to this data subset:

- a. A data set aggregated to period, month, statistical area, and vessel. This data set is referred to as by month.
  - b. A data set aggregated to the trip level. This data set is referred to as by trip.
  - c. An unaggregated data set. This data set is referred to as by pot.
2. As for 1c but limited to a core vessel subset where core vessels were defined as those vessels that had been in the LB programme for at least three years. This data set is referred to as core vessel by pot.
3. As for 1c but limited to a depth / soak time subset including only those records with a reported depth and soak time. This data set is referred to as depth / soak time by pot.
4. As for 1c but limited to a spatial subset including only those records where both a latitude and longitude were reported. This data set is referred to as spatial by pot.
5. As for 1c but converted from numbers to kilogram per pot lift. This data set is referred to as kg by pot.
6. As for 1c but converted from numbers to the average kilogram per pot lift each period, month, statistical area, and vessel. This data set is referred to as kg by month.
7. Three data sets were generated from all measured lobsters per potlift. These included those above and below the MLS and berried females but not the 'LiveAbove' count:
  - a. The total data set is referred to as all by pot.
  - b. A data set where the count was truncated to a maximum of 25 lobsters per potlift is referred to as max 25 by pot.
  - c. A data set where the count was truncated to a maximum of 15 lobsters per potlift is referred to as max 15 by pot.
8. One data set was generated from all measured lobsters per potlift aggregated by trip. These included those above and below the MLS and berried females but not the 'LiveAbove' count: this data set is referred to as all by trip.

Models applied to each of these data sets are described further below. Depending on the data set being fitted to, the explanatory variables offered included:

- pots, or log(pots), or s(pots, k = 3)
- period
- (1 | month)
- (1 | vessel)
- (1 | skipper)
- area
- (1 | period × area)
- octopus
- phc
- s(x, y, k = 10) (i.e., latitude/longitude)
- s(depth, k = 4) or depth\_bin
- s(soak, k = 3)

The explanatory variables 'period' and 'area' were always offered to the model as population-level effects. The explanatory variables 'month', 'vessel', and 'skipper' were always offered to the model as group-level effects. A 'period × area' interaction term was offered to some models as a group-level effect. When the explanatory variables 'pot' or 'soak' were used they were offered as either linear effects or as splines. The terms 'octopus' and 'phc' were offered as binary (i.e., presence/absence) variables. The term 'depth' was offered as either a spline or a categorical variable. The 'varsel' function in the R package *projpred* (Piironen et al. 2020) could not be used to establish the order of importance of the explanatory variables because, to date, the 'varsel' function does not work for models specified with a negative binomial distribution.

### Models applied to the by month data set

Models of the by month data set assumed a negative binomial distribution and included the following models, using the number of lobsters (n) in a month as the dependent variable:

- $n \sim \log(\text{pots}) + \text{period}$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area}$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim \text{pots} + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim s(\text{pots}, k = 3) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$

### Models applied to the by trip data set

Models of the by trip data set assumed a negative binomial distribution and included the following models, using the number of lobsters (n) in a trip as the dependent variable:

- $n \sim \log(\text{pots}) + \text{period}$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area}$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{skipper}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim s(\text{pots}, k = 3) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$

### Models applied to the by pot data set

Models of the by pot data set assumed a negative binomial distribution (except for the Poisson model) and included the following models, using the number of lobsters (n) in a potlift as the dependent variable:

- $n \sim \text{period} \text{ [Poisson]}$
- $n \sim \text{period}$
- $n \sim \text{period} + (1 \mid \text{month})$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel})$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area}$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area}) \text{ [Poisson]}$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{skipper}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area}) + \text{octopus}$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area}) + \text{phc}$

### Models applied to the core vessels by pot data set

A model of the core vessels by pot data set assumed a negative binomial distribution and included the model run, using the number of lobsters (n) in a potlift as the dependent variable:

- $n \sim \text{period}$

This model does not appear in the tables because it is a different data set and therefore cannot be compared with other models using LOO IC.



### Models applied to the depth / soak time by pot data set

Models of the depth / soak time by pot data set included depth and soak time terms. A control model run was also fitted to the depth / soak time by pot data set without any depth or soak time term. These models, using the number of lobsters (n) in a potlift as the dependent variable and assuming a negative binomial distribution, included:

- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + s(\text{depth}, k = 4)$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + \text{depth\_bin}$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + (1 \mid \text{period} \times \text{area}) + s(\text{depth}, k = 4)$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area}) + \text{depth\_bin}$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area}) + s(\text{soak}, k = 3)$

### Models applied to the spatial by pot data set

Three model runs were fitted to the spatial by pot data set using either 2D splines or a conditionally autoregressive (CAR) prior (Besag et al. 1991). A control model run was also fitted to the spatial by pot data set without any spatial spline or CAR prior. These models, using the number of lobsters (n) in a potlift as the dependent variable and assuming a negative binomial distribution, included:

- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + s(x, y, k = 10)$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + s(x, y, \text{by} = \text{season}, k = 10)$
- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{CAR}$

### Models applied to the all by pot, max 25 by pot, and max 15 by pot data sets

Logbook pots are pots marked with a tag and when these pots are lifted fishers determine the sex and measure every individual up to a maximum of 25 individuals. They are then supposed to report the number of any individuals that are not measured as ‘LiveAbove’ or ‘LiveBelow’. It is unclear how well this was done in the past; however, this is no longer done in CRA 2. This means that the counts of lobsters per potlift may be truncated at 25 and such truncation can bias the CPUE downward. The truncation issue was tested by generating the three data sets all by pot, max 25 by pot, and max 15 by pot. The truncation models were slow so only a basic model, using the number of lobsters (n) in a potlift as the dependent variable, was done:

- $n \sim \text{period}$

These models do not appear in the tables because they are different data sets and therefore cannot be compared with other models using LOO IC.

### Model applied to the all by trip data set

The all by trip data set was constructed to be as closely aligned to the fine scale data as possible by including all lobsters above and below the MLS. Only one model run, using the number of lobsters (n) in a potlift as the dependent variable, was done:

- $n \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$

This model run does not appear in the tables because it was a different data set and therefore cannot be compared with other models using LOO IC.

## Models applied to the kg by pot data set

To develop models that fit the kilogram of lobsters per pot, rather than the number of lobsters per pot, the numbers can be converted to the weight (kg) of lobsters per pot ( $i$ ) using

**Equation 3:**

$$W_i = \sum_{s,j} \alpha_s (TW_{s,i,j} + 0.5)^{\beta_s} \left( \frac{n_i^c}{n_i^m} \right)$$

where  $W_i$  is the weight of catch (kg) caught in potlift  $i$ ,  $n_i^m$  is the number of lobsters measured in potlift  $i$  (the number measured is the count per pot from the ‘Lobsters’ table),  $n_i^c$  is the number of lobsters captured in potlift  $i$  (the number captured is the number measured + ‘LiveAbove’),  $\alpha_{q,s}$  and  $\beta_{q,s}$  are the length-weight parameters for each sex ( $s$ ) in CRA 2, and  $TW_{s,i,j}$  is the TW (mm) of the  $j$ th lobsters of sex  $s$  in potlift  $i$  (0.5 mm is added to adjust for rounding down when measuring). This uses the same procedure as documented by Starr (2012).

Data for the models by weight were done at the pot level and a hurdle lognormal distribution was assumed where both the binomial and lognormal components had the same model structure. The scaled weight of lobsters per potlift was used as the dependent variable. A model run was also done using data aggregated to the month level and strata where the CPUE was zero were dropped (1.8% of records). The average weight of lobsters by potlift for the month was used as the dependent variable. The model applied to both of these data sets was:

- $\text{kg/pots} \sim \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$

These models do not appear in the tables because they use different data sets and therefore cannot be compared using LOO IC.

## 2.3 Fine scale

Data collected by individual fishers as part of the fine scale / harvest pot programme were obtained from Simon Anderson of Lat37 on 23 February 2022. There is no documentation for the fine scale data or database. There are three tables where these data are stored, which are analogous to the three tables used in the LB programme:

- trips
- traps
- measurements

The fields within each of these tables are described in Table 7 (trips), Table 8 (traps), and Table 9 (measurements). The key fields that are reported in the fine scale programme and stored in the database include:

- crays\_caught
- crays\_kept
- crays\_dead

The ‘crays\_caught’ field reports the number of all live lobsters that are caught within a pot, the ‘crays\_kept’ field reports the number of lobsters that are kept from a pot, and the ‘crays\_dead’ field reports the total number of dead lobsters within a pot and is split into dead lobsters below and above the MLS (Appendix B). The ‘crays\_caught’ field includes all live lobsters above and below the MLS and berried females. The ‘crays\_kept’ field does not record high-grading. Therefore, it is not possible to develop an index of abundance for the vulnerable biomass, or the biomass above the MLS from the fine scale data unless it is assumed that there is no discarding of legal lobsters.

The fine-scale data were modelled by trip or by month. Modelling was not done at the pot level because there were so many records that these models took too long to run, and the series by trip and by month were very similar to the analogous LB series. A negative binomial distribution was assumed with the number of lobsters in the ‘crays caught’ field ( $n$ ) as the dependent variable:

- $n \sim \log(\text{pots}) + \text{period}$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel})$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area}$
- $n \sim \log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$

### 3. RESULTS

#### 3.1 CELR

There were only four vessels in the final CELR data set during SS of the first fishing year (i.e., 1989 SS), compared with over 20 in most other periods (Table 10); therefore, this year was dropped from the analysis. Due to a substantial cut in the TACC in 2018, the number of vessels, pots lifted, and catch declined in 2018 and 2019 (Table 10). There were no pots lifted in the groomed data set during April 1990 and January 1997 (Table 11). Note that this series ends with the 2019 AW period for the reasons discussed in Section 1.

MCMC mixing was good for all model runs (see Figure E.1 in Appendix E for MCMC trace plots for the best fitting lognormal model; MCMC trace plots for the other model runs are not shown).

According to the LOO IC, the lognormal distribution was better than the Gamma, but the Fréchet was better than the lognormal (Table 12). However, the Fréchet series had a strange diversion in 1995 SS (Figure 5) and the differences in the posterior predictive densities were almost imperceptible (Figure E.2). Therefore, the lognormal was chosen as the best model run and used as the distribution of choice for all other model runs. The LOO IC and Bayesian  $R^2$  both selected the most complex model which included all of the available explanatory variables offered (Table 12).

When including the number of pots lifted as an explanatory variable, the LOO IC and Bayesian  $R^2$  both selected the model run that included the logarithm of pots, i.e.,  $\log(\text{pots})$ , which implies that CPUE increases linearly as the number of pots lifted increases (i.e., after applying the log-link function in the lognormal GLMM, Table 12). The model runs that included *pots* or attempted to model pots using a spline both resulted in conditional effects that were nonsense (Figure 6). For instance, the model run that just included *pots* suggested that CPUE increased exponentially with more pots; and the model run that included a spline suggested that CPUE increased to a maximum CPUE at about 3500 potlifts, then decreased. This second example is worrying as fishers are likely to use more pots when the CPUE is low, but this model run would correct for this and maintain a higher standardised CPUE than in reality. As expected, including  $\log(\text{pots})$  as an explanatory variable made little difference to the series when compared with the model run where the dependent variable was kilogram per potlift (Figure 7).

The CDI plot for the explanatory variable month indicated lower CPUE from February to June, but this variable had little influence in the model (Figure E.3, Figure 8). The explanatory variable vessel had the most influence in the model and there was a clear trend of low to high influence through time (Figure E.4). The explanatory variable statistical area had greatest influence in the early model years, but otherwise had relatively little influence on the series (Figure E.5). The CELR model suggested CPUE was highest in statistical area 907 (Figure 9).

The final CELR CPUE series did not update the unstandardised series much (Figure 10). The greatest differences were seen from 1990 AW to 1998 SS where the standardised CPUE was higher, and in 2019 AW, which is the final model period, the standardised CPUE was lower than the unstandardised index (Figure 10).

### 3.2 Logbook

There has been excellent participation in the logbook programme by CRA 2 fishers with many vessels reporting to the programme since its inception in 1993 (Table 13). As indicated above, the participation rate in the LB programme is high in all years (Table 1). Although the number of vessels and pots lifted has declined in recent years, the proportion of vessels in the programme has remained high, with considerable amounts of data being reported from what should be considered a representative group of operators (Table 13). The number of records (i.e., pots lifted) in the data set available for use are presented by statistical area (Figure 11), month (Figure 12), vessel (Figure 13), and skipper (Figure 14).

The logbook programme asked that fishers measure up to 31 lobsters prior to 1998 (Figure A.1), and up to 25 lobsters from 1998 onwards (Figure A.2). Prior to 1998, there were pots where up to 31 lobsters were measured (Table 14) although these percentages were low (Table 15). In 1998 and 1999, the frequency of more than 25 lobsters being measured declined, and then dropped to zero from 2000 onwards, except for 2010 to 2013 (Table 14). These data are likely spurious, generated through the operation of the Allegro units.

Any lobsters remaining in the pot that are not measured (i.e., greater than 31 or 25 individuals, depending on the year) were supposed to be reported as either 'LiveAbove', 'LiveBelow', 'DeadAbove', or 'DeadBelow' (see Table 4 and Appendix A). There are lobsters recorded in the 'LiveAbove' field in most years up to about 2008, but this field appears to have been filled out intermittently or incorrectly after the implementation of electronic reporting using the Allegro units in 2009. There were a few entries from 2009 to 2013 (possibly because the software allowed for entries greater than 25). However, after 2013, no lobsters have been recorded in the 'LiveAbove' field (Table 6). This field was derived from the fine scale database and in recent years it seems that this field was always set to zero (Appendix B). The 'LiveAbove' and 'LiveBelow' fields are not recorded by the fine scale system and therefore were not included in the rllb database (Simon Anderson pers. comm.). These results indicate that these issues began about the time that the fine scale data collection system moved to electronic reporting in 2009.

The proportion of mature females that were in berry was generally higher during the AW months when compared with the SS months; however, the proportion in berry was variable among the months (Table 16). The proportion of females in berry did vary among fishing years, but to a lesser extent compared with the variability by month (Table 16).

Models by pot took a long time to run (Table 17). One way to speed up model exploration was to aggregate data, in this case either by month or by trip. When data were aggregated in this way, the count of the number of pots lifted per stratum must be included in the model. Three different approaches were tested for including the number of potlifts as a term within negative binomial models:

- 'log(pots)' (i.e., linear in natural space);
- 's(pots)'; or
- 'pots'.

The LOO IC indicated that it was always better to use 'log(pots)' (i.e., linear in natural space) rather than 's(pots)' or just 'pots' (Table 17). This seemed like a much more intuitive option (i.e., for the number of lobsters caught to increase linearly with the number of pots) compared with the number of lobsters caught to increase exponentially with the number of pots as is assumed by using the 'pots'

term. Despite the relationship between the number of potlifts and the number of lobsters caught looking different in these three runs (Figure 15), the CPUE series produced by these models were similar (Figure 16). This is because the relationship between the number of pots and number of lobsters caught was similar across the range of pots that is most common, and the relationship only begins to diverge for higher numbers of pots for which there are few data (Figure 15).

MCMC mixing was good for all model runs (see Figure E.6, Figure E.7, and Figure E.8 for MCMC trace plots for the best fitting models fitted to the by month, by trip, and by pot data sets, respectively; MCMC trace plots for the other model runs are not shown).

When using the negative binomial distribution, the posterior predictive distribution did not match the distribution of the by month data well (Figure E.9), but did better with the by trip data (Figure E.10), and best with the by pot data (Figure E.11). The negative binomial distribution was a clear choice over the Poisson distribution (Figure E.12). Consequently, Poisson models were not explored any further.

As for the CELR model, the CDI plot for the explanatory variable month indicated lower CPUE from February to June, but, again, this variable had little influence in the model (Figure E.13, Figure 8). The explanatory variable vessel had the most influence in the model (Figure E.14). The explanatory variable statistical area had relatively little influence on the series (Figure E.15). The LB models all suggested CPUE was highest in statistical area 907 (Figure 9).

The LOO IC and Bayesian  $R^2$  always selected the most complex model when the data were by month, by trip, or by pot (Table 17).

The CPUE series from models fitted to data by month (Figure 17), by trip (Figure 18), and by pot (Figure 19) indicated little standardisation effect at each aggregation level. Furthermore, the level of data aggregation (by pot, trip, or month) had little bearing on the standardised series (Figure 20). When aggregated by month, there was a drop in CPUE in 1997 SS which looked unusual when compared with most of the other model runs (Figure 17), but all three levels of aggregation returned to similar high levels in 1998 SS and 1999 SS (Figure 20). The other run that had this sharp decline in 1997 SS was the model where number of lobsters caught increased exponentially with the number of pots which was considered an unrealistic model run (Figure 16). Declines from the mid to late 1990s can be seen in three of the four component statistical area CPUE series, except for 908 which maintained a relatively consistent CPUE throughout the late 1990s and early 2000s (Figure 21).

From the discussion above, it is apparent that the ‘LiveAbove’ and ‘LiveBelow’ fields have been reported inconsistently in the CRA 2 logbook programme. Therefore, adding the number measured per potlift to the ‘LiveAbove’ and ‘LiveBelow’ counts would result in an underestimate of the total number of lobsters caught in that pot and models based on these data could be biased low. The impact of this bias would be greater in years when the population biomass is high. An alternative model could use the total number of lobsters measured per potlift, but truncated to a maximum of 25 (i.e., any count over 25 is set to 25), and then use a truncated distribution (i.e., a negative binomial distribution truncated at 25) to model these counts. When doing this, a subset of the data (e.g., legal lobsters only) cannot be used as the counts of the subset of data cannot then be truncated. Therefore, the CPUE series that arises is an index of the entire selected population. Three different models were run: a model that included all measured lobsters (above and below the MLS and berried females); the same data set but with the counts truncated to 25 and modelled using a truncated negative binomial distribution; and the same data set but with the counts truncated to 15 and modelled using a truncated negative binomial distribution (this last model run was to see how sensitive the model was to more extreme truncation). However, truncation at 25 or 15 lobsters did not make an appreciable difference to the series (Figure 22), suggesting that it may be reasonable to ignore these issues.

Selecting the subset of core vessels (i.e., the core vessel by pot data set) did not make a difference to the series (Figure 23).

The presence of octopus or packhorse rock lobster in pots negatively influenced CPUE (Figure 24). Although both of these models were better according to the LOO IC (Table 17), they were not selected as the final model because they had very little impact on the standardised CPUE series (Figure 25).

Including depth as a categorical explanatory variable produced a better model according to the LOO IC, but including depth as a spline was worse (Table 18). For the categorical depth model, standardised CPUE decreased in the 10–20 m depth band and then increased (Figure 26). When depth was modelled using a spline, CPUE increased to a peak at about 75 m, then declined (Figure 26). However, depth had little influence on the standardised CPUE series and the series treating depth as categorical or using a spline looked about the same (Figure 27).

Including soak time as a spline also produced a better model according to the LOO IC (Table 18) and suggested that CPUE declines with longer soak times (Figure 28). However, soak time barely changed the standardised series (Figure 29).

Spatial models that included space as a spline also improved the model fit according to LOO IC (Table 18); however, these models did little to change the standardised CPUE series (Figure 30) and took a very long time to run.

The model fitted to logbook data that were limited to the year range of the fine scale data (i.e., using the by trip data set from 2009 AW to 2020 SS) was almost indistinguishable from the model fitted to all years of logbook data (Figure 31), indicating no substantive change in the collection of the logbook data over the years.

Finally, the logbook model where the numbers of lobsters per pot were converted to the weight of lobsters caught per pot (Equation 3), or aggregated to the average weight of lobsters caught per pot each month, was very similar to the CELR CPUE series (Figure 32).

### 3.3 Fine scale

Although there are fewer vessels in the fine scale database each year than the rllb database (Table 1), there are many more pots and lobsters measured in the fine scale data set (Table 19).

The fine scale data set suggests that it is common to catch no lobsters within a pot in CRA 2 (Table 20), with more than half of the pots lifted having zero catch during some years (Table 21). The logbook programme generally reports fewer pots containing no lobsters when compared with the fine scale programme suggesting that fishers may not be reporting all of their logbook pots with zero catch or, more likely, the logbook pots are not representative of the full range of fished pots (compare Table 15 and Table 21 and see Figure 33).

When the extent of the fine scale data is plotted by fishing year and by statistical area (Figure 34), by month (Figure 35), and by vessel (Figure 36), it can be seen that the participation in this programme started to wane beginning with 2018 AW. Coverage in statistical area 905 dropped noticeably from that year (Figure 34) and there are months without any coverage beginning with 2019 (Figure 35). The fine scale programme is largely based on the contribution of 8 to 10 vessels that have participated since its inception, and only 10 vessels have participated after 2018 (Figure 36).

There are examples in the fine scale data set of pots with 25 or more lobsters caught in all years, and with 31 or more lobsters caught in some years (Table 20, Table 21) which lends support to the argument that the CRA 2 logbook programme should be reporting the ‘LiveAbove’ field.

MCMC mixing was good for all model runs (see Figure E.16 and Figure E.17 for MCMC trace plots for the best fitting models fitted to trip level and pot level data, respectively; MCMC trace plots for the other model runs are not shown).

When using the negative binomial distribution, the posterior predictive distribution did not match the distribution of the monthly data well (Figure E.18). It did better at the level of trip, but there were some issues with this, particularly with fitting the zeros, suggesting that a zero inflated negative binomial distribution may do better (Figure E.19).

As for the CELR and LB models, the CDI plot for the explanatory variable month indicated lower CPUE from February to June, but, again, this variable had little (but highly variable) influence in the model (Figure E.20, Figure 8). The explanatory variable vessel had the most influence in the model with some high influence in the most recent years (Figure E.21). Unlike the CELR and LB models, the fine scale model suggested CPUE was highest in statistical area 906 rather than in 907 (Figure E.22, Figure 9).

The full suite of model runs was done for the fine scale data by month (Figure 37) and by trip (Figure 38). However, model runs by pot were too slow and so only the most basic model was done and this model run was compared with the analogous logbook model run (Figure 39). The best models, according to LOO IC (Table 22), from the CELR, logbook, and fine scale models by month were compared and all three series were similar for the overlapping years (Figure 40). Logbook CPUE increased a little faster than the CELR and fine scale CPUE series in recent years for the model runs fitted to data aggregated by month (Figure 40). Similarly, the best logbook and fine scale models by trip were similar for the overlapping years and the logbook CPUE increased a little faster than the fine scale CPUE in recent years (Figure 41). These differences are not surprising, given that the CPUE produced by each of the three data sets index different components of the population (Table 2). Finally, the model fitted to logbook data for all lobsters for the same year range (i.e., using the ‘all by trip’ data set from 2009 AW to 2020 SS) sat between the logbook and fine scale series (Figure 41).

## 4. DISCUSSION

A key challenge involved with fitting Bayesian GLMM models to the logbook and fine scale data was the sheer amount of data (1 731 355 fine scale records/pots and 118 986 logbook records/pots). This made model fitting slow (see Table 17, Table 18, and Table 22 for the time each model took to run) unless data were aggregated to the level of a trip or monthly. Fitting models to fine scale / harvest pot data by pot was impractically slow, so these models were not pursued any further. However, aggregation of the data should be done with caution because it can decrease the capacity of the models to replicate the density of the data as shown by posterior predictive checks (e.g., compare the posterior predictive check plots for the LB data in Figure E.9 and Figure E.12). Despite this, the standardised CPUE series for the different levels of data aggregation were all similar using the LB data in CRA 2 (Figure 20), but it should not be assumed that this will always be true.

These results corroborate the results from Starr (2012), who reached similar conclusions from standardised CPUE analyses based on LB data from CRA 2, CRA 5, and CRA 8. For instance, Starr (2012) demonstrated that the level of aggregation had little impact on the CPUE signal as well as showing that standardised CPUE, based on LB data which had been converted from numbers to weight, resembled the CPUE series generated from the compulsory CELR data. Furthermore, Starr (2012) showed that covariates such as depth and soak time had little impact on the estimated series while vessel had a considerable effect.

The models that require converting numbers caught to weight are not recommended for use because: the parameters of the conversion from length to weight (Equation 3) require updating; scaling by the ratio of the numbers measured per pot to the number captured per pot is not guaranteed to be unbiased (Equation 3) if the unmeasured lobsters have a different size frequency to the measured lobsters; and models by weight require the use of more complex hurdle lognormal models rather than the much simpler negative binomial models. Models fitted using the negative binomial distribution have superior numerical properties to distributions like the lognormal or hurdle lognormal.

The dependent variable in most LB model runs was the number of lobsters above the MLS which included lobsters measured within pots (from the ‘Lobsters’ table) and the number of lobsters above the MLS that are not measured (i.e., the ‘LiveAbove’ field within the ‘PotLifts’ table). This differs from the CELR CPUE series which measures the weight in kilograms of legal lobsters (i.e., above the MLS and not a berried female) per pot. Thus, an alternative approach when modelling the logbook data would be to ignore the ‘LiveAbove’ counts so that a logbook series can be based on the number of legal lobsters (i.e., above the MLS and not a berried female). However, not all females are in berry during the AW. But a key assumption made within the stock assessment model is that all females are in berry during the AW and therefore not vulnerable during this season. Including legal state lobsters in the CPUE during the AW, which will include some females that are not in berry, could result in the units within the CPUE and the stock assessment not aligning. Modelling the number of lobsters above the MLS avoids a simplifying assumption related to the AW berried females. The LB programme estimated that 68–91% of all females were berried or spent (overall mean of 83%) during the AW season between 1993 and 2021 (Table 16). As well, overall 18% of females were berried or spent in the SS season, a season for which the stock assessment model assumes has no catch in this category.

All models based on the CELR and LB data estimated similar statistical area coefficients, with the highest CPUE predicted for statistical area 907 (Figure 9). However, models based on the fine scale data suggested that statistical area 906 had the highest CPUE and that statistical areas 907 and 908 had the lowest CPUE among the four statistical areas. This result is curious, especially considering that all models returned similar monthly coefficients (Figure 8), regardless of the data source. This difference in the relative CPUE by statistical area could be because the different data sets index different parts of the population (see Table 2) or may point to fundamental differences in the reporting of catch among the three data sources. Reinforcing this difference among the data sources is the result from the all by trip LB model, which also included captured lobsters below the MLS and therefore should be the most similar to the fine scale models. However, the all by trip LB model was approximately half way between the by trip LB models and the fine scale models. The reasons for this difference are unknown but may indicate that the logbook and/or fine scale data have been collected in a manner that was not representative of the fishery.

#### 4.1 Recommendations for the stock assessment

The standardised CELR CPUE series should continue to be used in future CRA 2 stock assessments because it provides a longer time series (from 1990 AW onwards) than the LB (from 1993 AW onwards) or fine scale (from 2009 AW onwards) CPUE series. The best standardised CPUE series for the CELR data included explanatory variables for period, month, vessel, and statistical area. It didn’t matter if the number of pots lifted was included as an explanatory variable (Figure 7), so either series could be used for stock assessment.

The standardised CPUE series produced from a model fitted to the LB data by pot should be considered for use in future CRA 2 stock assessments. The best standardised CPUE series for the LB data included explanatory variables for period, month, vessel, and statistical area. Other explanatory variables such as the presence of octopus, the presence of PHC, depth, and soak time and spatial models did improve model fits according to LOO IC, but had little influence on the CPUE series so these more complex models can be ignored. It should be noted that the LB series represents all lobsters above the MLS as opposed to the CELR series which represents legal state lobsters only<sup>9</sup>. However, this may result in a better series because it avoids assuming that all mature females are in berry during the AW which is not the case (Table 16). This analysis will be repeated just before the CRA 2 stock assessment and reported in the data FAR for that assessment.

The standardised CPUE series produced from a model fitted to the fine scale data is not recommended for use in future CRA 2 stock assessments because it is a shorter time series, and it represents all selected lobsters, as opposed to legal state lobsters for the CELR series, or lobsters above the MLS for

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<sup>9</sup> The stock assessment model will need to be able to accommodate this difference.



the LB series. The main difficulty in using these data being that it is not possible to factor out lobsters below the MLS for which the pots are specifically designed not to capture. Consequently, these pots may not be capturing a consistent component of this part of the population over time.

## 4.2 Issues identified

Several issues with the logbook and fine scale data sources were identified during this analysis. These issues included:

- There is no way of telling if a measured lobster (in the fine scale ‘measurements’ table or the logbook ‘lobsters’ table) is CRA or PHC. A PHC field should be added to the lobsters table in the rllb and this field should be added to all data collection software/hardware.
- The logbook programme generally reports fewer pots containing no lobsters when compared with the fine scale programme suggesting that fishers may not be reporting all of their logbook pots with zero catch or their logbook pots may not be representative of all of a fishers pots (compare Table 15 and Table 21).
- When the fine scale data are transferred to the rllb database the ‘DeadAbove’, ‘DeadAboveKept’, and ‘DeadBelow’ fields are being set to zero whether they are NULL or contain data. These fields are being collected using the Allegro units (Appendix B) and contain potentially useful data. The data transfer script (Appendix D) should be amended to reliably provide these data to the rllb database and this issue should also be retrospectively fixed in the rllb database.
- When the LB data are transferred from the fine scale / harvest pot database to the rllb database, the ‘LiveAbove’ and ‘LiveBelow’ fields are being set to zero. Leaving these fields unpopulated does not conform to the design of the logbook programme and data for these fields should be collected. This cannot be fixed retrospectively in the rllb database, but these fields should be set to NULL retrospectively. Alternatively, the logbook programme in CRA 2 should ensure that every lobster in logbook pots is measured (i.e., even if there are more than 25 lobsters within a logbook pot).
- The fine scale programme should consider aligning with the LB programme by recording the number of lobsters in ‘LiveAbove’ and ‘LiveBelow’ fields for each potlift.
- The rllb database should contain a field that identifies how the data were collected (i.e., old paper form, new paper form, Allegro unit, Ernie). It is currently unknown which records are associated with the different data collection systems, and the years at which the data collection systems changed are unclear.
- The dates that fields started/stopped being collected should be incorporated into the *rllb* database documentation.
- In the future, the rock lobster stock assessment team should be consulted in advance of any changes to data collection procedures.
- There are no written instructions for how the fine scale (harvest pot) data should be collected by fishers and fishers have not had any refreshers on how to collect data. Both of these issues should be addressed.
- There is no documentation for the fine scale database.

## 4.3 Future research

Future research considerations include:

- There are observer catch sampling (CS) data collected in CRA 2 which could be used to develop an alternative standardised CPUE series.
- Spatial models are slow to run because they must be fitted to pot level data. However, as computer hardware and software improve these types of models will become more accessible and should be further explored.

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## 7. TABLES

Depending on what is being presented, the caption for each table begins with either ‘CELR’, ‘Logbook’, ‘Fine scale’, or nothing to help the reader distinguish among the data sets being presented.

**Table 1: Number of CRA 2 vessels participating in the logbook programme (Section 1.1), in the fine scale monitoring programme (Section 1.2), and in both programmes. For reference, the total number of vessels reporting in the mandatory catch and effort programme operated by Fisheries New Zealand (Section 2.1) is also provided. An en dash (–) indicates no participating vessels during that year.**

| Fishing year | N vessels reporting to CELR/ERS <sup>1</sup> | N vessels in logbook programme | N vessels in fine scale programme | N vessels in both programmes |
|--------------|----------------------------------------------|--------------------------------|-----------------------------------|------------------------------|
| 1989–90      | 17                                           | –                              | –                                 | –                            |
| 1990–91      | 57                                           | –                              | –                                 | –                            |
| 1991–92      | 51                                           | –                              | –                                 | –                            |
| 1992–93      | 47                                           | –                              | –                                 | –                            |
| 1993–94      | 47                                           | 26                             | –                                 | –                            |
| 1994–95      | 47                                           | 30                             | –                                 | –                            |
| 1995–96      | 44                                           | 26                             | –                                 | –                            |
| 1996–97      | 40                                           | 21                             | –                                 | –                            |
| 1997–98      | 42                                           | 19                             | –                                 | –                            |
| 1998–99      | 35                                           | 21                             | –                                 | –                            |
| 1999–00      | 34                                           | 20                             | –                                 | –                            |
| 2000–01      | 39                                           | 16                             | –                                 | –                            |
| 2001–02      | 36                                           | 13                             | –                                 | –                            |
| 2002–03      | 37                                           | 18                             | –                                 | –                            |
| 2003–04      | 34                                           | 13                             | –                                 | –                            |
| 2004–05      | 31                                           | 14                             | –                                 | –                            |
| 2005–06      | 36                                           | 18                             | –                                 | –                            |
| 2006–07      | 35                                           | 17                             | –                                 | –                            |
| 2007–08      | 32                                           | 14                             | –                                 | –                            |
| 2008–09      | 32                                           | 15                             | –                                 | –                            |
| 2009–10      | 32                                           | 15                             | 5                                 | 5                            |
| 2010–11      | 34                                           | 16                             | 14                                | 13                           |
| 2011–12      | 35                                           | 18                             | 15                                | 14                           |
| 2012–13      | 40                                           | 17                             | 14                                | 13                           |
| 2013–14      | 36                                           | 19                             | 15                                | 14                           |
| 2014–15      | 33                                           | 16                             | 16                                | 12                           |
| 2015–16      | 33                                           | 16                             | 15                                | 14                           |
| 2016–17      | 29                                           | 15                             | 15                                | 12                           |
| 2017–18      | 29                                           | 14                             | 15                                | 12                           |
| 2018–19      | 18                                           | 12                             | 10                                | 9                            |
| 2019–20      | 17                                           | 13                             | 10                                | 9                            |
| 2020–21      | 19                                           | 15                             | 13                                | 11                           |

<sup>1</sup> from table 11 of Starr (2021).

**Table 2: Summary of the models fitted. An en dash (–) indicates no data aggregation was done.**

| Data source | Data set                                                            | Dependent variable                                 | Strata                                     | Terms offered                                                                           | What the series is indexing                                                                                         |
|-------------|---------------------------------------------------------------------|----------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| CELR        | <u>CPUE (catch/pots) as dependent variable</u>                      | Sum of catch (kg) divided by number of pots lifted | period, month, area, vessel                | period, (1   month), area, (1   vessel)                                                 | Legal lobsters only (i.e., above the MLS and no berried females)                                                    |
| CELR        | <u>Catch as dependent variable and pots as explanatory variable</u> | Sum of catch (kg)                                  | period, month, area, vessel                | log(pots), pots, s(pots, k = 3), period, (1   month), area, (1   vessel)                | Legal lobsters only (i.e., above the MLS and no berried females)                                                    |
| Logbook     | <u>by month</u>                                                     | Number of lobsters                                 | period, month, area, vessel                | log(pots), pots, s(pots, k = 3), period, (1   month), area, (1   vessel)                | Lobsters above the MLS (including berried females)                                                                  |
| Logbook     | <u>by trip</u>                                                      | Number of lobsters                                 | period, month, area, vessel, skipper, trip | log(pots), pots, s(pots, k = 3), period, (1   month), area, (1   vessel), (1   skipper) | Lobsters above the MLS (including berried females)                                                                  |
| Logbook     | <u>by pot</u>                                                       | Number of lobsters                                 | –                                          | period, (1   month), area, (1   vessel)                                                 | Lobsters above the MLS (including berried females)                                                                  |
| Logbook     | <u>core vessel by pot</u>                                           | Number of lobsters                                 | –                                          | period                                                                                  | Lobsters above the MLS (including berried females)                                                                  |
| Logbook     | <u>depth / soak time by pot</u>                                     | Number of lobsters                                 | –                                          | period, month, area, vessel, s(depth, k = 4), depth_bin                                 | Lobsters above the MLS (including berried females)                                                                  |
| Logbook     | <u>spatial by pot</u>                                               | Number of lobsters                                 | –                                          | period, month, area, vessel, CAR, s(x, y, k = 10), s(x, y, k = 10, by = season)         | Lobsters above the MLS (including berried females)<br>Subset of data for which latitude and longitude were recorded |
| Logbook     | <u>all by trip</u>                                                  | Number of lobsters                                 | period, month, area, vessel, trip          | period, (1   month), area, (1   vessel)                                                 | All lobsters (above and below the MLS and berried females)                                                          |
| Logbook     | <u>all by pot</u>                                                   | Number of lobsters                                 | –                                          | period                                                                                  | All lobsters (above and below the MLS and berried females)                                                          |
| Logbook     | <u>max 25 by pot</u>                                                | Number of lobsters                                 | –                                          | period                                                                                  | All lobsters (above and below the MLS and berried females)                                                          |
| Logbook     | <u>max 15 by pot</u>                                                | Number of lobsters                                 | –                                          | period                                                                                  | All lobsters (above and below the MLS and berried females)                                                          |
| Logbook     | <u>kg by month</u>                                                  | Average catch (kg) per pot                         | period, month, area, vessel                | period, (1   month), area, (1   vessel)                                                 | Converted from numbers to weight (kg) using Equation 3                                                              |
| Logbook     | <u>kg by pot</u>                                                    | Catch (kg) per pot                                 | –                                          | period, (1   month), area, (1   vessel)                                                 | Converted from numbers to weight (kg) using Equation 3                                                              |
| Fine scale  | <u>by month</u>                                                     | Number of lobsters                                 | period, month, area, vessel                | pots, period, (1   month), area, (1   vessel)                                           | All lobsters (above and below the MLS)                                                                              |
| Fine scale  | <u>by trip</u>                                                      | Number of lobsters                                 | period, month, area, vessel, trip          | pots, period, (1   month), area, (1   vessel)                                           | All lobsters (above and below the MLS)                                                                              |
| Fine scale  | <u>by pot</u>                                                       | Number of lobsters                                 | –                                          | period                                                                                  | All lobsters (above and below the MLS)                                                                              |

**Table 3: Logbook: fields in the ‘trips’ table from the rllb database and how some of the fields are derived from the ‘trips’ table in the fine scale database.**

| Field name        | Availability       | Fine scale field | Comments                                                                  |
|-------------------|--------------------|------------------|---------------------------------------------------------------------------|
| <u>TripNumber</u> | Every record       | trip_id          | Links with the <u>potlifts</u> table. Designated ‘trip’ in this analysis. |
| FisherID          | Every record       | skipper_name     | Designated ‘skipper’ in this analysis.                                    |
| subarea           | 1993–94 to 1990–00 | Set to ‘NULL’    | –                                                                         |
| Date              | Every record       | tripdate         | Used to derive ‘period’ and ‘month’ in this analysis.                     |
| FishingYear       | Every record       | fishing_year     | –                                                                         |
| VesselNumber      | Every record       | vessel           | Designated ‘vessel’ in this analysis.                                     |
| StatArea          | Every record       | statarea         | Designated ‘area’ in this analysis.                                       |
| SwellDirection    | Started in 2000–01 | swell_dir        | –                                                                         |
| SwellHeight       | Started in 2000–01 | swell_ht         | –                                                                         |
| WindDirection     | Started in 2000–01 | wind_dir         | –                                                                         |
| WindSpeed         | Started in 2000–01 | wind_ht          | –                                                                         |
| SoakUnits         | –                  | Set to ‘DAY’     | –                                                                         |
| DepthUnits        | –                  | Set to ‘MET’     | –                                                                         |

**Table 4: Logbook: fields in the ‘potlifts’ table from the rllb database and how some of the fields are derived from the ‘traps’ table in the fine scale database.**

| Field name           | Availability       | Fine scale field | Comments                                                                        |
|----------------------|--------------------|------------------|---------------------------------------------------------------------------------|
| <u>PotLiftNumber</u> | Every record       | trap_id          | Links with the <u>lobsters</u> table                                            |
| <u>TripNumber</u>    | Every record       | trip_id          | Designated [trip] in this analysis, links with the trips table                  |
| Pot                  | –                  | Set to zero      | –                                                                               |
| Lat                  | Started in 2003–04 | lat              | –                                                                               |
| Long                 | Started in 2003–04 | lon              | –                                                                               |
| SoakHours            | –                  | soak_time        | Designated [soak] in this analysis.                                             |
| DepthMetres          | –                  | depth            | Designated [depth] in this analysis.                                            |
| LiveAbove            | –                  | Set to zero      | –                                                                               |
| LiveAboveKept        | –                  | Set to zero      | –                                                                               |
| LiveBelow            | –                  | Set to zero      | –                                                                               |
| TotDead              | –                  | crays_dead       | –                                                                               |
| DeadAbove            | Started in 2000–01 | Set to zero      | May be padded with zeros prior to 2000–01 and appears to have ended in 2014–15. |
| DeadAboveKept        | Started in 2000–01 | Set to zero      | –                                                                               |
| DeadBelow            | Started in 2000–01 | Set to zero      | May be padded with zeros prior to 2000–01 and appears to have ended in 2014–15. |
| Octopus              | –                  | octopus          | Designated ‘octopus’ in this analysis.                                          |
| PHC                  | –                  | phc_caught       | Designated ‘phc’ in this analysis.                                              |
| PHCKept              | –                  | phc_kept         | –                                                                               |
| OtherName            | –                  | othername        | –                                                                               |
| Other                | –                  | otherkept        | –                                                                               |
| MeaSex               | –                  | Set to zero      | –                                                                               |
| Zone                 | –                  | –                | Not relevant since the reporting of latitude and longitude began in 2003–04     |

**Table 5: Logbook: fields in the ‘lobsters’ table from the rllb database and how some of the fields are derived from the ‘measurements’ table in the fine scale database.**

| Field name      | Availability       | Fine scale field | Comments                                                                                |
|-----------------|--------------------|------------------|-----------------------------------------------------------------------------------------|
| LobsterIDNumber | Every record       | –                | –                                                                                       |
| PotliftNumber   | Every record       | –                | Links with the <u>potlifts</u> table.                                                   |
| LobsterNumber   | –                  | –                | –                                                                                       |
| Sex             | Every record       | sex              | Assume filled out correctly.                                                            |
| TailWidth       | Every record       | tail_width       | Assume filled out correctly, however, larger measurements could be PHC rather than CRA. |
| Kept            | Started in 2000–01 | kept             | Starr (2012) suggested assume filled out inconsistently.                                |
| Legal           | Every record       | –                | Assume filled out correctly, berried and spent females not legal.                       |

**Table 6: Logbook: frequency of ‘LiveAbove’ counts per pot recorded in the ‘potlifts’ table for CRA 2. An en dash (–) indicates a frequency of zero. Grey shading marks the introduction of the Allegro unit.**

| Fishing year | Frequency of LiveAbove |    |   |   |   |   |    |
|--------------|------------------------|----|---|---|---|---|----|
|              | 0                      | 1  | 2 | 3 | 4 | 5 | 6+ |
| 1993–94      | 7 059                  | 3  | 4 | – | – | – | 5  |
| 1994–95      | 6 236                  | 3  | 4 | 1 | – | – | 1  |
| 1995–96      | 3 931                  | 1  | 1 | 1 | – | – | –  |
| 1996–97      | 3 480                  | 1  | 2 | 1 | – | 3 | 5  |
| 1997–98      | 2 952                  | –  | – | 1 | – | – | –  |
| 1998–99      | 3 048                  | 1  | 1 | – | 1 | – | –  |
| 1999–00      | 3 684                  | –  | – | – | – | – | –  |
| 2000–01      | 3 783                  | 2  | 1 | – | – | – | 1  |
| 2001–02      | 2 907                  | 2  | 1 | – | – | – | –  |
| 2002–03      | 5 011                  | 2  | 1 | – | – | – | –  |
| 2003–04      | 3 810                  | –  | – | – | – | – | –  |
| 2004–05      | 4 671                  | 2  | – | – | 2 | 1 | 1  |
| 2005–06      | 5 855                  | 7  | 6 | 1 | 1 | 1 | 3  |
| 2006–07      | 4 167                  | 1  | 1 | – | – | – | 1  |
| 2007–08      | 4 268                  | 5  | 1 | – | – | – | –  |
| 2008–09      | 5 065                  | 4  | 1 | 1 | – | – | 3  |
| 2009–10      | 4 686                  | 10 | – | – | – | – | –  |
| 2010–11      | 5 204                  | –  | – | – | – | – | –  |
| 2011–12      | 5 087                  | –  | – | 1 | – | – | –  |
| 2012–13      | 5 761                  | –  | – | – | – | – | –  |
| 2013–14      | 5 982                  | 4  | – | – | 1 | – | –  |
| 2014–15      | 4 991                  | –  | – | – | – | – | –  |
| 2015–16      | 5 288                  | –  | – | – | – | – | –  |
| 2016–17      | 3 319                  | –  | – | – | – | – | –  |
| 2017–18      | 3 302                  | –  | – | – | – | – | –  |
| 2018–19      | 1 706                  | –  | – | – | – | – | –  |
| 2019–20      | 1 720                  | –  | – | – | – | – | –  |
| 2020–21      | 1 904                  | –  | – | – | – | – | –  |

**Table 7: Fine scale: fields in the ‘trips’ table from the fine scale database.**

| Field name     | Type   | Logbook field  | Description                                                                                                    |
|----------------|--------|----------------|----------------------------------------------------------------------------------------------------------------|
| tripno         | int    | –              | –                                                                                                              |
| tripdate       | date   | Date           | Date of the trip                                                                                               |
| vessel         | char   | VesselNumber   | Name of the vessel                                                                                             |
| skipper_name   | char   | FisherID       | First and last name of the skipper                                                                             |
| statarea       | char   | StatArea       | Statistical Area of the trip – it seems to me like pots within a trip can have different stat areas though     |
| swell_dir      | char   | SwellDirection | Direction of the swell during the trip                                                                         |
| swell_ht       | double | SwellHeight    | Swell height (m) during the trip                                                                               |
| wind_dir       | char   | WindDirection  | Wind direction during the trip                                                                                 |
| wind_ht        | double | WindSpeed      | Wind speed during the trip (knots)                                                                             |
| soaktime_units | char   | –              | Units for the soak time (days or unknown)                                                                      |
| depth_units    | char   | –              | Units for the depth (m = meters, fms = fathoms)                                                                |
| fishing_year   | int    | FishingYear    | Fishing year (1 April to 31 March)                                                                             |
| trip_id        | int    | –              | –                                                                                                              |
| fishing_season | char   | –              | Fishing season: autumn (Apr, May Jun), winter (Jul, Aug, Sept), spring (Oct, Nov, Dec), summer (Jan, Feb, Mar) |

**Table 8: Fine scale: fields in the ‘traps’ table from the fine scale database.**

| Field name   | Type   | Logbook field | Description                                                                                                      |
|--------------|--------|---------------|------------------------------------------------------------------------------------------------------------------|
| vessel       | char   | –             | Name of the vessel                                                                                               |
| skipper_name | char   | –             | First and last name of the skipper                                                                               |
| tripno       | int    | –             | –                                                                                                                |
| trapno       | int    | –             | –                                                                                                                |
| pulldate     | date   | –             | Date that the pot was pulled                                                                                     |
| pulltime     | char   | –             | Time that the pot was pulled                                                                                     |
| lat          | double | Lat           | Latitude in decimal degrees                                                                                      |
| lon          | double | Lon           | Longitude in decimal degrees                                                                                     |
| latstr       | char   | –             | Latitude                                                                                                         |
| lonstr       | char   | –             | Longitude                                                                                                        |
| soak_time    | int    | –             | Soak time of the pot                                                                                             |
| depth        | double | –             | Depth of the pot (m)                                                                                             |
| temperature  | double | –             | Bottom temperature (°C)                                                                                          |
| crays_caught | int    | –             | Total number of lobsters dead or alive and above or below the MLS in the pot                                     |
| crays_kept   | int    | –             | Number of lobsters above the MLS that were retained – is this the same as LiveAboveKept in the logbook database? |
| crays_dead   | int    | TotDead       | Number of dead lobsters above or below the MLS in the pot. This is ‘TotDead’ in the rllb database.               |
| phc_caught   | int    | PHC           | Total number of packhorse lobsters dead or alive and above or below the MLS in the pot                           |
| phc_kept     | int    | PHCKept       | Number of packhorse lobsters above the MLS that were retained                                                    |
| octopus      | int    | Octopus       | Number of octopus in the pot                                                                                     |
| othername    | char   | OtherName     | Other species caught in the pot                                                                                  |
| otherkept    | int    | Other         | Number of other species retained                                                                                 |
| measured     | char   | –             | If the pot is a harvest pot (N) or a logbook pot (Y)                                                             |
| pos_good     | bool   | –             | A check to see if the coordinates provided were within the vessels statistical area                              |
| trap_id      | int    | –             | –                                                                                                                |
| trap_posn    | char   | –             | –                                                                                                                |
| statarea     | char   | –             | Statistical area of the pot                                                                                      |
| dupl_posn    | bool   | –             | Duplicate position (GPS lockups etc)                                                                             |
| ok2recalc    | bool   | –             | –                                                                                                                |

**Table 9: Fine scale: fields in the ‘measurements’ table from the fine scale database.**

| Field name   | Type   | Logbook field | Description                                                                                                                      |
|--------------|--------|---------------|----------------------------------------------------------------------------------------------------------------------------------|
| vessel       | char   | —             | Name of the vessel                                                                                                               |
| skipper_name | char   | —             | First and last name of the skipper                                                                                               |
| tripno       | int    | —             | —                                                                                                                                |
| trapno       | int    | —             | —                                                                                                                                |
| measure_no   | int    | —             | —                                                                                                                                |
| sex          | char   | Sex           | Sex of the measured lobster (MM = mature male, IF = immature female, MF = mature female, BF = berried female, SF = spent female) |
| tail_width   | double | TailWidth     | Tail width (mm) of the measured lobster                                                                                          |
| kept         | bool   | Kept          | If the lobster is kept (Y) or not (N)                                                                                            |
| measure_id   | int    | —             | —                                                                                                                                |
| status       | char   | —             | —                                                                                                                                |



**Table 10: CELR: summary of the number of vessels, number of pots lifted, estimated catch (tonnes), and scaled catch (tonnes) by fishing year and season. This is the data set that was used (i.e., vessels within the fishery for at least five years, records with error codes removed, etc.).**

| Fishing year | Number of vessels |    |       | Number of pots lifted |         |         | Estimated catch |       |       | Scaled catch |       |       |
|--------------|-------------------|----|-------|-----------------------|---------|---------|-----------------|-------|-------|--------------|-------|-------|
|              | AW                | SS | Total | AW                    | SS      | Total   | AW              | SS    | Total | AW           | SS    | Total |
| 1989–90      | –                 | 4  | 4     | –                     | 7 973   | 7 973   | –               | 3.7   | 3.7   | –            | 4.1   | 4.1   |
| 1990–91      | 22                | 23 | 23    | 89 906                | 93 527  | 183 433 | 41.6            | 54.0  | 95.6  | 42.2         | 54.8  | 97.0  |
| 1991–92      | 25                | 26 | 26    | 115 094               | 130 059 | 245 153 | 43.5            | 62.4  | 105.8 | 44.4         | 63.8  | 108.2 |
| 1992–93      | 30                | 31 | 32    | 123 514               | 172 195 | 295 709 | 43.5            | 66.8  | 110.3 | 44.4         | 68.0  | 112.4 |
| 1993–94      | 34                | 35 | 37    | 173 592               | 146 773 | 320 365 | 67.7            | 64.5  | 132.2 | 69.6         | 66.5  | 136.1 |
| 1994–95      | 38                | 34 | 40    | 198 418               | 95 029  | 293 447 | 85.0            | 59.6  | 144.6 | 88.5         | 61.8  | 150.3 |
| 1995–96      | 38                | 26 | 39    | 178 162               | 38 376  | 216 538 | 107.6           | 31.3  | 138.9 | 109.9        | 32.0  | 141.9 |
| 1996–97      | 30                | 12 | 30    | 159 386               | 12 347  | 171 733 | 117.1           | 13.3  | 130.4 | 120.3        | 13.5  | 133.8 |
| 1997–98      | 36                | 21 | 37    | 192 541               | 16 946  | 209 487 | 160.4           | 19.2  | 179.7 | 161.7        | 19.6  | 181.2 |
| 1998–99      | 33                | 18 | 33    | 182 223               | 23 938  | 206 161 | 160.6           | 22.1  | 182.7 | 164.1        | 23.0  | 187.1 |
| 1999–00      | 27                | 25 | 27    | 197 245               | 40 119  | 237 364 | 123.1           | 41.1  | 164.2 | 126.0        | 41.9  | 167.8 |
| 2000–01      | 31                | 29 | 33    | 173 087               | 90 582  | 263 669 | 100.5           | 75.3  | 175.8 | 103.9        | 77.3  | 181.2 |
| 2001–02      | 32                | 30 | 32    | 198 055               | 146 058 | 344 113 | 92.8            | 87.0  | 179.8 | 99.0         | 90.9  | 189.9 |
| 2002–03      | 30                | 31 | 31    | 166 390               | 212 562 | 378 952 | 56.8            | 99.5  | 156.3 | 60.4         | 104.6 | 165.0 |
| 2003–04      | 30                | 31 | 32    | 167 397               | 217 632 | 385 029 | 58.8            | 97.1  | 155.9 | 61.6         | 101.4 | 163.0 |
| 2004–05      | 25                | 25 | 26    | 122 846               | 181 014 | 303 860 | 46.5            | 82.4  | 128.9 | 47.8         | 85.6  | 133.5 |
| 2005–06      | 30                | 31 | 31    | 160 627               | 211 568 | 372 195 | 62.9            | 106.7 | 169.6 | 63.7         | 109.3 | 173.0 |
| 2006–07      | 30                | 32 | 32    | 160 208               | 200 145 | 360 353 | 72.3            | 113.3 | 185.6 | 74.4         | 118.2 | 192.7 |
| 2007–08      | 29                | 31 | 31    | 159 268               | 213 780 | 373 048 | 71.5            | 116.5 | 188.0 | 74.1         | 121.1 | 195.2 |
| 2008–09      | 28                | 28 | 28    | 150 245               | 209 090 | 359 335 | 73.9            | 114.2 | 188.1 | 77.0         | 119.2 | 196.2 |
| 2009–10      | 31                | 32 | 32    | 180 636               | 250 521 | 431 157 | 76.6            | 128.5 | 205.1 | 79.3         | 132.8 | 212.1 |
| 2010–11      | 31                | 32 | 32    | 162 114               | 271 921 | 434 035 | 63.3            | 125.4 | 188.7 | 65.8         | 129.7 | 195.5 |
| 2011–12      | 31                | 31 | 31    | 165 199               | 289 884 | 455 083 | 56.2            | 138.7 | 195.0 | 58.1         | 141.2 | 199.3 |
| 2012–13      | 32                | 32 | 34    | 187 931               | 277 297 | 465 228 | 74.8            | 118.5 | 193.3 | 76.9         | 120.6 | 197.5 |
| 2013–14      | 31                | 31 | 31    | 214 383               | 309 292 | 523 675 | 70.1            | 125.5 | 195.6 | 72.2         | 129.1 | 201.3 |
| 2014–15      | 28                | 28 | 28    | 181 155               | 285 191 | 466 346 | 52.8            | 109.2 | 162.0 | 54.5         | 112.3 | 166.7 |
| 2015–16      | 27                | 29 | 29    | 177 597               | 307 950 | 485 547 | 41.1            | 101.1 | 142.2 | 43.4         | 106.8 | 150.2 |
| 2016–17      | 28                | 27 | 28    | 140 059               | 263 408 | 403 467 | 33.4            | 86.7  | 120.1 | 35.1         | 90.4  | 125.5 |
| 2017–18      | 26                | 27 | 27    | 142 227               | 231 335 | 373 562 | 37.4            | 77.8  | 115.1 | 39.4         | 81.2  | 120.6 |
| 2018–19      | 16                | 16 | 18    | 56 911                | 64 554  | 121 465 | 27.3            | 35.5  | 62.8  | 28.3         | 36.7  | 65.0  |
| 2019–20      | 14                | –  | 14    | 58 892                | –       | 58 892  | 34.3            | –     | 34.3  | 36.4         | –     | 36.4  |

**Table 11: CELR: number of pots by year and month. An en dash (–) indicates zero pots, a middle dot (·) indicates no data, and grey shading is not included in the CPUE models.**

| Fishing year | AW     |        |        |        |        |        | SS     |        |        |        |        |        | Total   |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
|              | Apr    | May    | Jun    | Jul    | Aug    | Sep    | Oct    | Nov    | Dec    | Jan    | Feb    | Mar    |         |
| 1989–90      | ·      | ·      | ·      | ·      | ·      | ·      | 2 575  | 2 904  | 1 368  | 447    | 255    | 424    | 7 973   |
| 1990–91      | –      | 60     | 3 634  | 19 586 | 32 990 | 33 636 | 27 014 | 17 198 | 19 095 | 14 612 | 11 658 | 3 950  | 183 433 |
| 1991–92      | 1 100  | 3 792  | 8 572  | 33 733 | 34 643 | 33 254 | 39 011 | 30 721 | 24 540 | 13 146 | 14 856 | 7 785  | 245 153 |
| 1992–93      | 1 874  | 2 340  | 10 928 | 28 390 | 37 653 | 42 329 | 42 849 | 35 468 | 34 905 | 28 313 | 18 126 | 12 534 | 295 709 |
| 1993–94      | 1 562  | 630    | 12 123 | 55 495 | 56 085 | 47 697 | 50 646 | 35 925 | 28 148 | 21 997 | 6 593  | 3 464  | 320 365 |
| 1994–95      | 1 506  | 1 586  | 22 805 | 55 894 | 65 069 | 51 558 | 42 609 | 24 700 | 12 927 | 6 611  | 6 017  | 2 165  | 293 447 |
| 1995–96      | 1 361  | 4 516  | 27 790 | 51 624 | 54 338 | 38 533 | 27 021 | 5 618  | 2 299  | 770    | 1 494  | 1 174  | 216 538 |
| 1996–97      | 4 337  | 19 322 | 24 475 | 49 762 | 34 966 | 26 524 | 6 683  | 1 266  | 1 440  | 1 010  | 1 170  | 778    | 171 733 |
| 1997–98      | 10 107 | 11 602 | 29 637 | 60 039 | 47 869 | 33 287 | 13 830 | 1 179  | 596    | –      | 286    | 1 055  | 209 487 |
| 1998–99      | 4 173  | 15 770 | 24 104 | 41 282 | 51 850 | 45 044 | 11 526 | 4 488  | 727    | 82     | 3 177  | 3 938  | 206 161 |
| 1999–00      | 5 022  | 17 528 | 24 098 | 49 010 | 50 583 | 51 004 | 31 078 | 3 054  | 968    | 1 408  | 1 367  | 2 244  | 237 364 |
| 2000–01      | 11 124 | 7 883  | 8 275  | 36 599 | 56 919 | 52 287 | 46 330 | 16 473 | 6 644  | 1 479  | 7 211  | 12 445 | 263 669 |
| 2001–02      | 18 002 | 11 467 | 9 419  | 43 171 | 54 265 | 61 731 | 56 992 | 31 728 | 13 065 | 7 645  | 15 852 | 20 776 | 344 113 |
| 2002–03      | 17 470 | 7 894  | 7 898  | 44 985 | 46 050 | 42 093 | 65 188 | 45 215 | 27 566 | 22 949 | 24 908 | 26 736 | 378 952 |
| 2003–04      | 14 650 | 5 796  | 8 298  | 42 860 | 49 821 | 45 972 | 53 801 | 43 836 | 33 869 | 39 094 | 25 626 | 21 406 | 385 029 |
| 2004–05      | 8 868  | 6 752  | 4 605  | 34 872 | 35 042 | 32 707 | 42 658 | 37 763 | 24 183 | 27 396 | 25 017 | 23 997 | 303 860 |
| 2005–06      | 9 930  | 5 669  | 5 040  | 38 684 | 52 942 | 48 362 | 50 056 | 42 380 | 35 124 | 30 616 | 32 683 | 20 709 | 372 195 |
| 2006–07      | 10 387 | 2 520  | 5 859  | 39 353 | 45 386 | 56 703 | 51 105 | 36 607 | 35 213 | 28 695 | 24 721 | 23 804 | 360 353 |
| 2007–08      | 7 102  | 4 462  | 8 063  | 39 555 | 49 272 | 50 814 | 45 254 | 48 291 | 31 443 | 35 386 | 31 037 | 22 369 | 373 048 |
| 2008–09      | 10 850 | 3 472  | 5 034  | 35 157 | 46 142 | 49 590 | 57 600 | 49 072 | 31 008 | 28 781 | 21 853 | 20 776 | 359 335 |
| 2009–10      | 6 572  | 3 819  | 9 890  | 49 761 | 50 182 | 60 412 | 67 242 | 52 689 | 45 967 | 39 010 | 30 608 | 15 005 | 431 157 |
| 2010–11      | 2 930  | 1 974  | 11 256 | 47 019 | 53 789 | 45 146 | 64 758 | 60 907 | 43 597 | 39 913 | 38 541 | 24 205 | 434 035 |
| 2011–12      | 565    | 878    | 6 189  | 39 828 | 58 343 | 59 396 | 63 644 | 60 824 | 55 221 | 54 453 | 35 868 | 19 874 | 455 083 |
| 2012–13      | 1 649  | 1 776  | 13 372 | 50 997 | 62 319 | 57 818 | 70 057 | 72 816 | 56 795 | 41 578 | 25 315 | 10 736 | 465 228 |
| 2013–14      | 4 049  | 5 939  | 16 436 | 68 610 | 57 797 | 61 552 | 80 616 | 73 429 | 52 036 | 51 620 | 30 171 | 21 420 | 523 675 |
| 2014–15      | 1 107  | 2 522  | 11 633 | 55 105 | 51 903 | 58 885 | 70 076 | 65 332 | 60 777 | 47 125 | 26 373 | 15 508 | 466 346 |
| 2015–16      | 1 539  | 2 726  | 15 269 | 51 000 | 57 093 | 49 970 | 66 620 | 66 699 | 64 306 | 53 034 | 36 074 | 21 217 | 485 547 |
| 2016–17      | 1 411  | 1 581  | 4 349  | 29 616 | 49 732 | 53 370 | 69 163 | 58 973 | 54 722 | 44 456 | 26 395 | 9 699  | 403 467 |
| 2017–18      | 3 067  | 2 483  | 6 711  | 36 721 | 41 989 | 51 256 | 62 054 | 56 347 | 49 019 | 35 805 | 20 371 | 7 739  | 373 562 |
| 2018–19      | 394    | 1 016  | 1 772  | 16 285 | 16 409 | 21 035 | 30 191 | 15 117 | 6 709  | 4 687  | 4 140  | 3 710  | 121 465 |
| 2019–20      | 7 299  | 3 376  | 166    | 9 863  | 19 851 | 18 337 | ·      | ·      | ·      | ·      | ·      | ·      | 58 892  |

**Table 12: CELR: model comparison statistics for models fitted to the CELR data including: the  $\Delta$ ELPD (higher is better), LOO IC (lower is better), P LOO (the effective number of parameters), Bayesian  $R^2$  (higher is better), number of divergent transitions, and time taken for each model run. The values in the  $\Delta$ ELPD column were computed by making pairwise comparisons between each model and the model with the largest ELPD. For this reason, the  $\Delta$ ELPD column will always have the value zero in the first row (i.e., the difference between the preferred model and itself) and negative values in subsequent rows for the remaining models. All distributions were assumed to be lognormal unless specified using square brackets. Only vessels with five years experience were included in each data set.**

| Model                                                                                    | $\Delta$ ELPD |     | LOO IC |     | P LOO |      | Bayesian R <sup>2</sup> |       | Divergent | Time     |
|------------------------------------------------------------------------------------------|---------------|-----|--------|-----|-------|------|-------------------------|-------|-----------|----------|
|                                                                                          | Mean          | SD  | Mean   | SD  | Mean  | SD   | Mean                    | SD    |           |          |
| <b>CPUE (catch/pots) as dependent variable</b>                                           |               |     |        |     |       |      |                         |       |           |          |
| period + (1   vessel) + (1   month) + area + (1   period $\times$ area) [Fréchet]        | 0             | 0   | -2 443 | 301 | 495.0 | 53.3 | 0.023                   | 0.001 | 0         | 01:24:43 |
| period + (1   vessel) + (1   month) + area + (1   period $\times$ area)                  | -162          | 101 | -2 119 | 333 | 285.4 | 11.0 | 0.031                   | 0.002 | 0         | 00:24:33 |
| period + (1   vessel) + (1   month) + area + (1   period $\times$ area) [Gamma]          | -254          | 126 | -1 936 | 267 | 295.1 | 14.6 | 0.264                   | 0.015 | 0         | 00:34:57 |
| period + (1   vessel) + (1   month) + area                                               | -361          | 105 | -1 722 | 338 | 158.8 | 6.4  | 0.028                   | 0.001 | 0         | 00:13:36 |
| period + (1   vessel) + (1   month)                                                      | -365          | 105 | -1 713 | 338 | 155.9 | 6.3  | 0.027                   | 0.001 | 0         | 00:35:23 |
| period + (1   vessel)                                                                    | -828          | 100 | -787   | 306 | 142.8 | 5.3  | 0.025                   | 0.001 | 0         | 00:04:13 |
| period                                                                                   | -1 793        | 125 | 1 142  | 373 | 66.4  | 3.4  | 0.010                   | 0.001 | 0         | 00:02:54 |
| <b>Catch as dependent variable and pots as an explanatory variable</b>                   |               |     |        |     |       |      |                         |       |           |          |
| log(pots) + period + (1   vessel) + (1   month) + area + (1   period $\times$ area)      | 0             | 0   | 93 124 | 248 | 292.7 | 10.4 | 0.813                   | 0.004 | 0         | 00:48:47 |
| s(pots, k = 3) + period + (1   vessel) + (1   month) + area + (1   period $\times$ area) | -1 075        | 122 | 95 275 | 239 | 300.4 | 11.6 | 0.782                   | 0.003 | 6         | 03:43:11 |
| pots + period + (1   vessel) + (1   month) + area + (1   period $\times$ area)           | -2 333        | 124 | 97 790 | 230 | 288.6 | 10.4 | 0.557                   | 0.007 | 0         | 06:57:00 |

**Table 13: Logbook: summary of the number of vessels, number of potlifts, and number of lobsters (above and below the MLS and any legal status) counted by fishing year and season. These data include all vessels.**

| Fishing year | Number of vessels |    |       | Number of potlifts |       |       | Number of lobsters |       |        |
|--------------|-------------------|----|-------|--------------------|-------|-------|--------------------|-------|--------|
|              | AW                | SS | Total | AW                 | SS    | Total | AW                 | SS    | Total  |
| 1993–94      | 23                | 21 | 26    | 3 743              | 3 328 | 7 071 | 10 562             | 7 610 | 18 172 |
| 1994–95      | 27                | 20 | 30    | 4 657              | 1 588 | 6 245 | 12 861             | 5 273 | 18 134 |
| 1995–96      | 26                | 10 | 26    | 3 460              | 474   | 3 934 | 9 901              | 1 757 | 11 658 |
| 1996–97      | 21                | 4  | 21    | 3 315              | 177   | 3 492 | 11 824             | 698   | 12 522 |
| 1997–98      | 19                | 3  | 19    | 2 887              | 66    | 2 953 | 9 025              | 200   | 9 225  |
| 1998–99      | 21                | 2  | 21    | 2 880              | 171   | 3 051 | 8 719              | 453   | 9 172  |
| 1999–00      | 19                | 13 | 20    | 3 202              | 482   | 3 684 | 8 664              | 1 660 | 10 324 |
| 2000–01      | 16                | 12 | 16    | 2 912              | 875   | 3 787 | 6 601              | 2 585 | 9 186  |
| 2001–02      | 10                | 11 | 13    | 1 264              | 1 646 | 2 910 | 3 005              | 2 890 | 5 895  |
| 2002–03      | 18                | 16 | 18    | 2 818              | 2 196 | 5 014 | 4 714              | 3 558 | 8 272  |
| 2003–04      | 11                | 13 | 13    | 1 412              | 2 398 | 3 810 | 2 513              | 4 941 | 7 454  |
| 2004–05      | 13                | 12 | 14    | 2 248              | 2 429 | 4 677 | 3 983              | 4 561 | 8 544  |
| 2005–06      | 16                | 16 | 18    | 2 292              | 3 582 | 5 874 | 4 048              | 6 710 | 10 758 |
| 2006–07      | 15                | 14 | 17    | 2 305              | 1 865 | 4 170 | 4 884              | 3 961 | 8 845  |
| 2007–08      | 12                | 14 | 14    | 1 725              | 2 549 | 4 274 | 3 289              | 5 727 | 9 016  |
| 2008–09      | 15                | 13 | 15    | 2 039              | 3 035 | 5 074 | 4 663              | 5 756 | 10 419 |
| 2009–10      | 12                | 15 | 15    | 1 719              | 2 977 | 4 696 | 2 769              | 5 910 | 8 679  |
| 2010–11      | 14                | 16 | 16    | 1 637              | 3 567 | 5 204 | 3 275              | 8 735 | 12 010 |
| 2011–12      | 13                | 18 | 18    | 1 761              | 3 327 | 5 088 | 3 071              | 5 761 | 8 832  |
| 2012–13      | 17                | 15 | 17    | 2 128              | 3 633 | 5 761 | 4 319              | 7 317 | 11 636 |
| 2013–14      | 18                | 17 | 19    | 2 496              | 3 491 | 5 987 | 4 710              | 7 267 | 11 977 |
| 2014–15      | 16                | 15 | 16    | 2 074              | 2 917 | 4 991 | 3 064              | 4 956 | 8 020  |
| 2015–16      | 15                | 16 | 16    | 2 131              | 3 157 | 5 288 | 2 793              | 3 527 | 6 320  |
| 2016–17      | 14                | 15 | 15    | 1 132              | 2 187 | 3 319 | 1 021              | 2 637 | 3 658  |
| 2017–18      | 13                | 13 | 14    | 1 487              | 1 815 | 3 302 | 1 673              | 2 561 | 4 234  |
| 2018–19      | 10                | 11 | 12    | 910                | 796   | 1 706 | 2 153              | 2 221 | 4 374  |
| 2019–20      | 12                | 11 | 13    | 1 277              | 443   | 1 720 | 2 919              | 1 358 | 4 277  |
| 2020–21      | 11                | 14 | 15    | 1 004              | 900   | 1 904 | 2 135              | 2 938 | 5 073  |

**Table 14: Logbook: frequency of the number of lobsters (above and below the MLS and any legal status) measured per logbook pot each fishing year. In the logbook programme, the number of lobsters that are measured in any single potlift was capped, initially to 31, but when the form was redesigned in 1998, this number was reduced to 25. These caps, 1998, and 2009 (the year that the fine scale programme came online) are highlighted in grey. An en dash (–) indicates a frequency of zero. The ‘Total’ column is the total number of lobsters measured each fishing year.**

| Fishing year | Frequency of the number of lobsters measured per pot |       |     |     |     |     |     |     |     |    |       |       |       |    |       |    |       | Total |
|--------------|------------------------------------------------------|-------|-----|-----|-----|-----|-----|-----|-----|----|-------|-------|-------|----|-------|----|-------|-------|
|              | 0                                                    | 1     | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9  | 10–14 | 15–19 | 20–24 | 25 | 26–30 | 31 | 32–43 |       |
| 1993–94      | 2 568                                                | 1 067 | 906 | 733 | 478 | 361 | 263 | 183 | 111 | 76 | 205   | 62    | 23    | 3  | 17    | 15 | —     | 7 071 |
| 1994–95      | 1 938                                                | 1 091 | 870 | 648 | 434 | 303 | 253 | 151 | 118 | 94 | 191   | 63    | 29    | 3  | 21    | 38 | —     | 6 245 |
| 1995–96      | 1 124                                                | 612   | 575 | 402 | 312 | 239 | 156 | 123 | 85  | 78 | 168   | 40    | 10    | —  | 7     | 3  | —     | 3 934 |
| 1996–97      | 984                                                  | 471   | 441 | 355 | 273 | 216 | 165 | 117 | 87  | 72 | 188   | 66    | 21    | 4  | 18    | 14 | —     | 3 492 |
| 1997–98      | 841                                                  | 440   | 398 | 317 | 211 | 187 | 142 | 87  | 82  | 55 | 139   | 32    | 16    | 1  | 4     | 1  | —     | 2 953 |
| 1998–99      | 852                                                  | 519   | 426 | 319 | 231 | 156 | 133 | 92  | 71  | 62 | 134   | 37    | 16    | 1  | 2     | —  | —     | 3 051 |
| 1999–00      | 1 042                                                | 630   | 520 | 421 | 278 | 211 | 134 | 118 | 104 | 49 | 137   | 26    | 11    | —  | 3     | —  | —     | 3 684 |
| 2000–01      | 1 219                                                | 672   | 532 | 406 | 290 | 188 | 126 | 99  | 86  | 47 | 96    | 20    | 4     | 2  | —     | —  | —     | 3 787 |
| 2001–02      | 1 124                                                | 529   | 390 | 279 | 188 | 104 | 110 | 61  | 26  | 22 | 60    | 17    | 0     | 1  | —     | —  | —     | 2 911 |
| 2002–03      | 2 277                                                | 932   | 660 | 400 | 255 | 147 | 97  | 82  | 41  | 28 | 65    | 20    | 10    | 1  | —     | —  | —     | 5 015 |
| 2003–04      | 1 375                                                | 774   | 610 | 350 | 211 | 170 | 106 | 78  | 46  | 27 | 47    | 14    | 7     | —  | —     | —  | —     | 3 815 |
| 2004–05      | 1 954                                                | 878   | 620 | 441 | 258 | 148 | 136 | 74  | 46  | 34 | 67    | 16    | 6     | 6  | —     | —  | —     | 4 684 |
| 2005–06      | 2 320                                                | 1 191 | 821 | 611 | 339 | 187 | 128 | 88  | 47  | 32 | 78    | 18    | 5     | 18 | —     | —  | —     | 5 883 |
| 2006–07      | 1 407                                                | 789   | 635 | 472 | 286 | 202 | 119 | 82  | 65  | 32 | 65    | 10    | 7     | 2  | —     | —  | —     | 4 173 |
| 2007–08      | 1 600                                                | 704   | 622 | 460 | 267 | 198 | 142 | 85  | 48  | 52 | 76    | 17    | 5     | 2  | —     | —  | —     | 4 278 |
| 2008–09      | 1 774                                                | 1 055 | 797 | 484 | 298 | 217 | 124 | 84  | 65  | 48 | 93    | 28    | 3     | 6  | —     | —  | —     | 5 076 |
| 2009–10      | 1 843                                                | 949   | 698 | 402 | 264 | 169 | 114 | 97  | 55  | 24 | 61    | 20    | 7     | 1  | —     | —  | —     | 4 704 |
| 2010–11      | 1 692                                                | 1 106 | 761 | 525 | 328 | 225 | 152 | 101 | 70  | 60 | 135   | 35    | 10    | 2  | 5     | —  | 3     | 5 210 |
| 2011–12      | 1 911                                                | 1 146 | 748 | 486 | 312 | 183 | 107 | 57  | 37  | 25 | 55    | 16    | 2     | 1  | 2     | —  | 0     | 5 088 |
| 2012–13      | 2 065                                                | 1 116 | 871 | 617 | 391 | 236 | 151 | 94  | 50  | 38 | 78    | 36    | 15    | —  | 2     | —  | 1     | 5 761 |
| 2013–14      | 2 134                                                | 1 261 | 841 | 584 | 391 | 280 | 149 | 111 | 57  | 47 | 92    | 27    | 12    | —  | 1     | —  | —     | 5 987 |
| 2014–15      | 2 204                                                | 1 301 | 833 | 518 | 307 | 152 | 103 | 67  | 50  | 15 | 43    | 11    | 1     | —  | —     | —  | —     | 5 605 |
| 2015–16      | 2 366                                                | 1 373 | 751 | 349 | 201 | 109 | 62  | 34  | 14  | 12 | 12    | 5     | —     | —  | —     | —  | —     | 5 288 |
| 2016–17      | 1 490                                                | 932   | 455 | 242 | 88  | 57  | 25  | 11  | 6   | 1  | 8     | 2     | 2     | —  | —     | —  | —     | 3 319 |
| 2017–18      | 1 331                                                | 893   | 539 | 258 | 132 | 62  | 38  | 21  | 13  | 4  | 9     | 2     | —     | —  | —     | —  | —     | 3 302 |
| 2018–19      | 476                                                  | 351   | 271 | 194 | 114 | 77  | 52  | 43  | 38  | 23 | 42    | 16    | 8     | 1  | —     | —  | —     | 1 706 |
| 2019–20      | 402                                                  | 378   | 311 | 222 | 127 | 75  | 63  | 43  | 28  | 21 | 43    | 5     | 2     | —  | —     | —  | —     | 1 720 |
| 2020–21      | 414                                                  | 394   | 351 | 241 | 162 | 118 | 48  | 56  | 22  | 26 | 56    | 13    | 3     | —  | —     | —  | —     | 1 904 |

**Table 15: Logbook: percentage of the number of lobsters (above and below the MLS and any legal status) measured per logbook pot each fishing year. In the logbook programme, the number of lobsters that are measured in any single potlift was capped, initially to 31, but when the form was redesigned in 1998, this number was reduced to 25. These caps, 1998, and 2009 (the year that the fine scale programme came online) are highlighted in grey. The ‘Total’ column is the total number of lobsters measured each fishing year.**

| Fishing year | Frequency of the number of lobsters measured per pot |       |       |       |      |      |      |      |      |      |       |       |       |      |       |      |       | Total  |
|--------------|------------------------------------------------------|-------|-------|-------|------|------|------|------|------|------|-------|-------|-------|------|-------|------|-------|--------|
|              | 0                                                    | 1     | 2     | 3     | 4    | 5    | 6    | 7    | 8    | 9    | 10–14 | 15–19 | 20–24 | 25   | 26–30 | 31   | 32–43 |        |
| 1993–94      | 36.32                                                | 15.09 | 12.81 | 10.37 | 6.76 | 5.11 | 3.72 | 2.59 | 1.57 | 1.07 | 2.90  | 0.88  | 0.33  | 0.04 | 0.24  | 0.21 | 0.00  | 100.00 |
| 1994–95      | 31.03                                                | 17.47 | 13.93 | 10.38 | 6.95 | 4.85 | 4.05 | 2.42 | 1.89 | 1.51 | 3.06  | 1.01  | 0.46  | 0.05 | 0.34  | 0.61 | 0.00  | 100.00 |
| 1995–96      | 28.57                                                | 15.56 | 14.62 | 10.22 | 7.93 | 6.08 | 3.97 | 3.13 | 2.16 | 1.98 | 4.27  | 1.02  | 0.25  | 0.00 | 0.18  | 0.08 | 0.00  | 100.00 |
| 1996–97      | 28.18                                                | 13.49 | 12.63 | 10.17 | 7.82 | 6.19 | 4.73 | 3.35 | 2.49 | 2.06 | 5.38  | 1.89  | 0.60  | 0.11 | 0.52  | 0.40 | 0.00  | 100.00 |
| 1997–98      | 28.48                                                | 14.90 | 13.48 | 10.73 | 7.15 | 6.33 | 4.81 | 2.95 | 2.78 | 1.86 | 4.71  | 1.08  | 0.54  | 0.03 | 0.14  | 0.03 | 0.00  | 100.00 |
| 1998–99      | 27.93                                                | 17.01 | 13.96 | 10.46 | 7.57 | 5.11 | 4.36 | 3.02 | 2.33 | 2.03 | 4.39  | 1.21  | 0.52  | 0.03 | 0.07  | 0.00 | 0.00  | 100.00 |
| 1999–00      | 28.28                                                | 17.10 | 14.12 | 11.43 | 7.55 | 5.73 | 3.64 | 3.20 | 2.82 | 1.33 | 3.72  | 0.71  | 0.30  | 0.00 | 0.08  | 0.00 | 0.00  | 100.00 |
| 2000–01      | 32.19                                                | 17.74 | 14.05 | 10.72 | 7.66 | 4.96 | 3.33 | 2.61 | 2.27 | 1.24 | 2.53  | 0.53  | 0.11  | 0.05 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2001–02      | 38.61                                                | 18.17 | 13.40 | 9.58  | 6.46 | 3.57 | 3.78 | 2.10 | 0.89 | 0.76 | 2.06  | 0.58  | 0.00  | 0.03 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2002–03      | 45.40                                                | 18.58 | 13.16 | 7.98  | 5.08 | 2.93 | 1.93 | 1.64 | 0.82 | 0.56 | 1.30  | 0.40  | 0.20  | 0.02 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2003–04      | 36.04                                                | 20.29 | 15.99 | 9.17  | 5.53 | 4.46 | 2.78 | 2.04 | 1.21 | 0.71 | 1.23  | 0.37  | 0.18  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2004–05      | 41.72                                                | 18.74 | 13.24 | 9.42  | 5.51 | 3.16 | 2.90 | 1.58 | 0.98 | 0.73 | 1.43  | 0.34  | 0.13  | 0.13 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2005–06      | 39.44                                                | 20.24 | 13.96 | 10.39 | 5.76 | 3.18 | 2.18 | 1.50 | 0.80 | 0.54 | 1.33  | 0.31  | 0.08  | 0.31 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2006–07      | 33.72                                                | 18.91 | 15.22 | 11.31 | 6.85 | 4.84 | 2.85 | 1.97 | 1.56 | 0.77 | 1.56  | 0.24  | 0.17  | 0.05 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2007–08      | 37.40                                                | 16.46 | 14.54 | 10.75 | 6.24 | 4.63 | 3.32 | 1.99 | 1.12 | 1.22 | 1.78  | 0.40  | 0.12  | 0.05 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2008–09      | 34.95                                                | 20.78 | 15.70 | 9.54  | 5.87 | 4.28 | 2.44 | 1.65 | 1.28 | 0.95 | 1.83  | 0.55  | 0.06  | 0.12 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2009–10      | 39.18                                                | 20.17 | 14.84 | 8.55  | 5.61 | 3.59 | 2.42 | 2.06 | 1.17 | 0.51 | 1.30  | 0.43  | 0.15  | 0.02 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2010–11      | 32.48                                                | 21.23 | 14.61 | 10.08 | 6.30 | 4.32 | 2.92 | 1.94 | 1.34 | 1.15 | 2.59  | 0.67  | 0.19  | 0.04 | 0.10  | 0.00 | 0.06  | 100.00 |
| 2011–12      | 37.56                                                | 22.52 | 14.70 | 9.55  | 6.13 | 3.60 | 2.10 | 1.12 | 0.73 | 0.49 | 1.08  | 0.31  | 0.04  | 0.02 | 0.04  | 0.00 | 0.00  | 100.00 |
| 2012–13      | 35.84                                                | 19.37 | 15.12 | 10.71 | 6.79 | 4.10 | 2.62 | 1.63 | 0.87 | 0.66 | 1.35  | 0.62  | 0.26  | 0.00 | 0.03  | 0.00 | 0.02  | 100.00 |
| 2013–14      | 35.64                                                | 21.06 | 14.05 | 9.75  | 6.53 | 4.68 | 2.49 | 1.85 | 0.95 | 0.79 | 1.54  | 0.45  | 0.20  | 0.00 | 0.02  | 0.00 | 0.00  | 100.00 |
| 2014–15      | 39.32                                                | 23.21 | 14.86 | 9.24  | 5.48 | 2.71 | 1.84 | 1.20 | 0.89 | 0.27 | 0.77  | 0.20  | 0.02  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2015–16      | 44.74                                                | 25.96 | 14.20 | 6.60  | 3.80 | 2.06 | 1.17 | 0.64 | 0.26 | 0.23 | 0.23  | 0.09  | 0.00  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2016–17      | 44.89                                                | 28.08 | 13.71 | 7.29  | 2.65 | 1.72 | 0.75 | 0.33 | 0.18 | 0.03 | 0.24  | 0.06  | 0.06  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2017–18      | 40.31                                                | 27.04 | 16.32 | 7.81  | 4.00 | 1.88 | 1.15 | 0.64 | 0.39 | 0.12 | 0.27  | 0.06  | 0.00  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2018–19      | 27.90                                                | 20.57 | 15.89 | 11.37 | 6.68 | 4.51 | 3.05 | 2.52 | 2.23 | 1.35 | 2.46  | 0.94  | 0.47  | 0.06 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2019–20      | 23.37                                                | 21.98 | 18.08 | 12.91 | 7.38 | 4.36 | 3.66 | 2.50 | 1.63 | 1.22 | 2.50  | 0.29  | 0.12  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |
| 2020–21      | 21.74                                                | 20.69 | 18.43 | 12.66 | 8.51 | 6.20 | 2.52 | 2.94 | 1.16 | 1.37 | 2.94  | 0.68  | 0.16  | 0.00 | 0.00  | 0.00 | 0.00  | 100.00 |

**Table 16: Logbook: proportion of mature females that were in berry (i.e., carrying eggs or spent) measured by fishing year, season, and month. An en dash (–) indicates no logbook sampling during that fishing year / month.**

| Fishing year | AW           |              |              |              |              |              |              | SS           |              |              |              |              |              |              |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|              | Apr          | May          | Jun          | Jul          | Aug          | Sep          | Apr-Sep      | Oct          | Nov          | Dec          | Jan          | Feb          | Mar          | Oct-Mar      |
| 1993–94      | 0.000        | 0.038        | 0.932        | 0.971        | 0.955        | 0.780        | <b>0.910</b> | 0.386        | 0.193        | 0.437        | 0.102        | 0.000        | –            | <b>0.341</b> |
| 1994–95      | 0.000        | 0.143        | 0.827        | 0.970        | 0.977        | 0.828        | <b>0.907</b> | 0.508        | 0.938        | –            | –            | –            | –            | <b>0.516</b> |
| 1995–96      | 0.000        | 0.172        | 0.876        | 0.992        | 0.980        | 0.868        | <b>0.909</b> | 0.768        | 0.064        | –            | –            | –            | –            | <b>0.662</b> |
| 1996–97      | 0.000        | 0.093        | 0.908        | 0.996        | 0.961        | 0.584        | <b>0.852</b> | 0.229        | –            | –            | –            | –            | –            | <b>0.229</b> |
| 1997–98      | 0.000        | 0.093        | 0.807        | 0.987        | 0.896        | 0.492        | <b>0.758</b> | 0.010        | 0.000        | 0.000        | –            | –            | –            | <b>0.005</b> |
| 1998–99      | 0.006        | 0.029        | 0.623        | 0.975        | 0.978        | 0.660        | <b>0.765</b> | 0.403        | 0.376        | –            | –            | 0.000        | –            | <b>0.398</b> |
| 1999–00      | 0.000        | 0.158        | 0.865        | 0.964        | 0.942        | 0.641        | <b>0.722</b> | 0.093        | 0.004        | 0.000        | 0.000        | 0.050        | 0.006        | <b>0.045</b> |
| 2000–01      | 0.000        | 0.071        | 0.859        | 0.957        | 0.926        | 0.772        | <b>0.822</b> | 0.371        | 0.187        | 0.006        | 0.000        | 0.000        | 0.023        | <b>0.273</b> |
| 2001–02      | 0.000        | 0.000        | 0.500        | 0.885        | 0.870        | 0.520        | <b>0.668</b> | 0.222        | 0.079        | 0.007        | 0.002        | 0.000        | 0.000        | <b>0.097</b> |
| 2002–03      | 0.000        | 0.000        | 0.896        | 0.961        | 0.958        | 0.726        | <b>0.822</b> | 0.266        | 0.057        | 0.000        | 0.000        | 0.000        | 0.000        | <b>0.114</b> |
| 2003–04      | 0.000        | 0.195        | 1.000        | 0.954        | 0.906        | 0.550        | <b>0.705</b> | 0.162        | 0.017        | 0.004        | 0.000        | 0.000        | 0.000        | <b>0.064</b> |
| 2004–05      | 0.000        | –            | 1.000        | 0.961        | 0.950        | 0.614        | <b>0.846</b> | 0.220        | 0.023        | 0.000        | 0.000        | 0.000        | 0.000        | <b>0.111</b> |
| 2005–06      | 0.000        | –            | –            | 0.948        | 0.945        | 0.633        | <b>0.817</b> | 0.174        | 0.099        | 0.003        | 0.000        | 0.000        | 0.000        | <b>0.087</b> |
| 2006–07      | 0.000        | –            | –            | 0.901        | 0.904        | 0.727        | <b>0.822</b> | 0.262        | 0.059        | 0.003        | 0.000        | 0.000        | 0.000        | <b>0.116</b> |
| 2007–08      | 0.000        | –            | 0.600        | 0.934        | 0.955        | 0.527        | <b>0.785</b> | 0.258        | 0.098        | 0.035        | 0.005        | 0.062        | 0.286        | <b>0.132</b> |
| 2008–09      | 0.000        | 0.000        | 0.746        | 0.960        | 0.923        | 0.605        | <b>0.788</b> | 0.243        | 0.034        | 0.015        | 0.000        | 0.000        | 0.000        | <b>0.101</b> |
| 2009–10      | 0.000        | –            | 0.750        | 0.928        | 0.908        | 0.519        | <b>0.759</b> | 0.179        | 0.055        | 0.011        | 0.005        | 0.000        | 0.000        | <b>0.088</b> |
| 2010–11      | 0.000        | 0.000        | 0.905        | 0.947        | 0.924        | 0.878        | <b>0.909</b> | 0.386        | 0.185        | 0.134        | 0.278        | 0.070        | 0.200        | <b>0.241</b> |
| 2011–12      | 0.000        | –            | 1.000        | 0.986        | 0.952        | 0.601        | <b>0.797</b> | 0.240        | 0.111        | 0.195        | 0.238        | 0.343        | 0.000        | <b>0.207</b> |
| 2012–13      | 0.000        | 0.000        | –            | 0.966        | 0.882        | 0.838        | <b>0.833</b> | 0.574        | 0.379        | 0.011        | 0.268        | –            | 0.000        | <b>0.458</b> |
| 2013–14      | 0.000        | 0.000        | 0.875        | 0.955        | 0.938        | 0.851        | <b>0.761</b> | 0.543        | 0.254        | 0.000        | 0.459        | –            | –            | <b>0.419</b> |
| 2014–15      | 0.000        | 0.000        | –            | 1.000        | 0.987        | 0.585        | <b>0.680</b> | 0.212        | 0.147        | 0.000        | 0.000        | –            | –            | <b>0.172</b> |
| 2015–16      | –            | 0.000        | 0.804        | 0.976        | 0.951        | 0.668        | <b>0.844</b> | 0.278        | 0.000        | –            | –            | –            | –            | <b>0.275</b> |
| 2016–17      | –            | –            | 0.970        | 0.938        | 0.904        | 0.793        | <b>0.877</b> | 0.465        | 0.372        | 0.135        | 0.241        | 0.465        | 0.000        | <b>0.363</b> |
| 2017–18      | –            | –            | 1.000        | 0.974        | 0.943        | 0.794        | <b>0.874</b> | 0.321        | 0.039        | 0.004        | 0.000        | 0.000        | 0.000        | <b>0.141</b> |
| 2018–19      | –            | –            | 1.000        | 0.946        | 0.929        | 0.513        | <b>0.720</b> | 0.289        | 0.098        | 0.002        | 0.005        | 0.000        | 0.000        | <b>0.112</b> |
| 2019–20      | –            | –            | 0.833        | 0.980        | 0.958        | 0.472        | <b>0.753</b> | 0.128        | 0.034        | 0.007        | 0.003        | 0.000        | 0.000        | <b>0.055</b> |
| 2020–21      | –            | –            | 1.000        | 0.900        | 0.876        | 0.511        | <b>0.677</b> | 0.155        | 0.214        | 0.148        | 0.173        | 0.145        | 0.000        | <b>0.167</b> |
| Overall      | <b>0.001</b> | <b>0.102</b> | <b>0.852</b> | <b>0.969</b> | <b>0.940</b> | <b>0.666</b> | <b>0.825</b> | <b>0.299</b> | <b>0.114</b> | <b>0.045</b> | <b>0.060</b> | <b>0.045</b> | <b>0.055</b> | <b>0.178</b> |

**Table 17: Logbook: model comparison statistics for models fitted to the by month and by trip logbook data sets including: the  $\Delta$ ELPD (higher is better), LOO IC (lower is better), P LOO (the effective number of parameters), Bayesian  $R^2$  (higher is better), number of divergent transitions, and time taken for each model run. The values in the  $\Delta$ ELPD column were computed by making pairwise comparisons between each model and the model with the largest ELPD. For this reason, the  $\Delta$ ELPD column will always have the value zero in the first row (i.e., the difference between the preferred model and itself) and negative values in subsequent rows for the remaining models. All distributions were assumed to be negative binomial.**

| Model                                                                                | $\Delta$ ELPD |    | LOO IC  |     | P LOO |     | Bayesian R <sup>2</sup> |       | Divergent | Time     |
|--------------------------------------------------------------------------------------|---------------|----|---------|-----|-------|-----|-------------------------|-------|-----------|----------|
|                                                                                      | Mean          | SD | Mean    | SD  | Mean  | SD  | Mean                    | SD    |           |          |
| <b>by month</b>                                                                      |               |    |         |     |       |     |                         |       |           |          |
| log(pots) + period + (1   month) + (1   vessel) + area + (1   period $\times$ area)  | 0             | 0  | 22 551  | 125 | 228.5 | 9.3 | 0.745                   | 0.009 | 0         | 00:03:35 |
| log(pots) + period + (1   month) + (1   vessel) + area                               | -88           | 14 | 22 727  | 126 | 139.3 | 6.7 | 0.704                   | 0.009 | 0         | 00:02:57 |
| log(pots) + period + (1   month) + (1   vessel)                                      | -94           | 15 | 22 738  | 126 | 138.6 | 6.6 | 0.703                   | 0.009 | 0         | 00:02:25 |
| s(pots) + period + (1   month) + (1   vessel) + area + (1   period $\times$ area)    | -281          | 26 | 23 113  | 117 | 230.9 | 9.9 | 0.738                   | 0.009 | 1         | 00:53:30 |
| log(pots) + period + (1   month)                                                     | -491          | 31 | 23 533  | 125 | 74.1  | 3.6 | 0.605                   | 0.010 | 1         | 00:02:18 |
| log(pots) + period                                                                   | -555          | 33 | 23 661  | 124 | 62.2  | 3.1 | 0.576                   | 0.010 | 0         | 00:00:20 |
| pots + period + (1   month) + (1   vessel) + area + (1   period $\times$ area)       | -566          | 38 | 23 683  | 108 | 212.3 | 7.9 | 0.736                   | 0.006 | 0         | 00:03:52 |
| <b>by trip</b>                                                                       |               |    |         |     |       |     |                         |       |           |          |
| log(pots) + period + (1   month) + (1   vessel) + area + (1   period $\times$ area)  | 0             | 0  | 164 812 | 359 | 288.1 | 6.8 | 0.340                   | 0.006 | 0         | 02:25:14 |
| log(pots) + period + (1   month) + (1   skipper) + area + (1   period $\times$ area) | -23           | 31 | 164 858 | 360 | 273.4 | 6.4 | 0.337                   | 0.006 | 0         | 02:40:42 |
| s(pots) + period + (1   month) + (1   vessel) + area + (1   period $\times$ area)    | -26           | 7  | 164 864 | 359 | 288.6 | 6.8 | 0.341                   | 0.006 | 1         | 16:17:10 |
| log(pots) + period + (1   month) + (1   vessel) + area                               | -633          | 37 | 166 077 | 361 | 148.2 | 4.9 | 0.293                   | 0.005 | 0         | 01:38:02 |
| log(pots) + period + (1   month) + (1   vessel)                                      | -648          | 38 | 166 108 | 361 | 146.5 | 5.2 | 0.292                   | 0.005 | 0         | 01:02:40 |
| log(pots) + period + (1   month)                                                     | -2 593        | 73 | 169 997 | 367 | 73.9  | 1.7 | 0.214                   | 0.005 | 0         | 01:06:40 |
| log(pots) + period                                                                   | -2 961        | 77 | 170 734 | 364 | 62.6  | 1.5 | 0.195                   | 0.004 | 0         | 00:04:10 |



**Table 18: Logbook: model comparison statistics for models fitted to the by pot, depth / soak time by pot, and spatial by pot logbook data sets including: the  $\Delta$ ELPD (higher is better), LOO IC (lower is better), P LOO (the effective number of parameters), Bayesian  $R^2$  (higher is better) statistics for models fitted to the logbook data, the number of divergent transitions, and time taken for the model run. The values in the  $\Delta$ ELPD column were computed by making pairwise comparisons between each model and the model with the largest ELPD. For this reason, the  $\Delta$ ELPD column will always have the value zero in the first row (i.e., the difference between the preferred model and itself) and negative values in subsequent rows for the remaining models. All distributions were assumed to be negative binomial unless specified using square brackets.**

| Model                                                                                     | $\Delta$ ELPD |     | LOO IC  |       | P LOO  |       | Bayesian R <sup>2</sup> |       | Divergent | Time     |
|-------------------------------------------------------------------------------------------|---------------|-----|---------|-------|--------|-------|-------------------------|-------|-----------|----------|
|                                                                                           | Mean          | SD  | Mean    | SD    | Mean   | SD    | Mean                    | SD    |           |          |
| <b><u>by pot</u></b>                                                                      |               |     |         |       |        |       |                         |       |           |          |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area) + octopus         | 0             | 0   | 373 993 | 718   | 295.0  | 5.6   | 0.123                   | 0.003 | 0         | 11:00:60 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area) + phc             | -55           | 13  | 374 103 | 718   | 295.2  | 5.6   | 0.122                   | 0.003 | 0         | 09:45:44 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area)                   | -65           | 12  | 374 122 | 718   | 293.8  | 5.6   | 0.122                   | 0.003 | 0         | 09:26:05 |
| period + (1   month) + (1   skipper) + area + (1   period $\times$ area)                  | -106          | 36  | 374 204 | 720   | 278.1  | 5.1   | 0.120                   | 0.003 | 0         | 09:52:15 |
| period + (1   month) + (1   vessel) + area                                                | -936          | 46  | 375 865 | 719   | 147.3  | 3.9   | 0.100                   | 0.002 | 0         | 05:03:20 |
| period + (1   month) + (1   vessel)                                                       | -957          | 46  | 375 907 | 719   | 145.2  | 4.0   | 0.100                   | 0.002 | 0         | 04:29:09 |
| period + (1   month)                                                                      | -3 541        | 87  | 381 074 | 732   | 70.5   | 1.1   | 0.065                   | 0.002 | 1         | 03:56:46 |
| period                                                                                    | -4 066        | 93  | 382 125 | 732   | 59.4   | 1.0   | 0.057                   | 0.002 | 0         | 00:13:08 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area) [Poisson]         | -22 862       | 452 | 419 717 | 1 396 | 736.8  | 15.4  | 0.125                   | 0.001 | 0         | 13:44:05 |
| period [Poisson]                                                                          | -32 845       | 574 | 439 683 | 1 585 | 147.4  | 2.6   | 0.056                   | 0.001 | 0         | 00:10:39 |
| <b><u>depth / soak time by pot</u></b>                                                    |               |     |         |       |        |       |                         |       |           |          |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area) + depth_bin       | 0             | 0   | 360 729 | 702   | 295.0  | 5.6   | 0.129                   | 0.003 | 0         | 10:07:25 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area) + s(depth, k = 4) | -126          | 17  | 360 981 | 702   | 291.9  | 5.6   | 0.27                    | 0.003 | 9         | 14:51:07 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area) + s(soak, k = 3)  | -273          | 30  | 361 274 | 706   | 293.3  | 5.6   | 0.124                   | 0.003 | 7         | 14:46:26 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area)                   | -338          | 28  | 361 406 | 705   | 291.5  | 5.6   | 0.124                   | 0.003 | 1         | 09:56:09 |
| period + (1   month) + (1   vessel) + area + depth_bin                                    | -885          | 45  | 362 498 | 703   | 150.0  | 3.9   | 0.108                   | 0.002 | 0         | 05:15:59 |
| period + (1   month) + (1   vessel) + s(depth, k = 4)                                     | -1 000        | 49  | 362 729 | 704   | 149.4  | 3.9   | 0.106                   | 0.002 | 108       | 17:35:00 |
| <b><u>spatial by pot</u></b>                                                              |               |     |         |       |        |       |                         |       |           |          |
| period + (1   month) + (1   vessel) + s(x, y, k = 10)                                     | 0             | 0   | 186 775 | 499   | 110.2  | 2.0   | 0.093                   | 0.003 | 0         | 18:17:24 |
| period + (1   month) + (1   vessel) + area + (1   period $\times$ area)                   | -157          | 40  | 187 089 | 504   | 177.2  | 3.3   | 0.088                   | 0.003 | 0         | 05:37:22 |
| period + (1   month) + (1   vessel) + CAR                                                 | -421          | 31  | 187 617 | 503   | 98.5   | 2.1   | 0.080                   | 0.003 | 0         | 23:03:37 |
| period + (1   month) + (1   vessel) + s(x, y, by = season, k = 10)                        | -15 981       | 324 | 218 736 | 918   | 6486.6 | 191.6 | 0.280                   | 0.035 | 0         | 12:41:29 |

**Table 19: Fine scale: summary of the number of vessels, number of potlifts, and number of lobsters counted by fishing year and season.**

| Fishing year | Number of vessels |    |       | Number of potlifts |         |         | Number of lobsters |         |         |
|--------------|-------------------|----|-------|--------------------|---------|---------|--------------------|---------|---------|
|              | AW                | SS | Total | AW                 | SS      | Total   | AW                 | SS      | Total   |
| 2009–10      | 4                 | 5  | 5     | 13 037             | 34 513  | 47 550  | 17 286             | 45 469  | 62 755  |
| 2010–11      | 13                | 14 | 14    | 63 101             | 110 900 | 174 001 | 76 197             | 156 160 | 232 357 |
| 2011–12      | 13                | 15 | 15    | 65 114             | 121 495 | 186 609 | 77 461             | 168 880 | 246 341 |
| 2012–13      | 14                | 13 | 14    | 74 070             | 116 915 | 190 985 | 109 587            | 175 505 | 285 092 |
| 2013–14      | 15                | 15 | 15    | 86 042             | 117 855 | 203 897 | 126 192            | 176 507 | 302 699 |
| 2014–15      | 15                | 16 | 16    | 73 260             | 133 470 | 206 730 | 85 236             | 179 753 | 264 989 |
| 2015–16      | 14                | 15 | 15    | 94 451             | 125 371 | 219 822 | 105 178            | 143 643 | 248 821 |
| 2016–17      | 15                | 15 | 15    | 63 061             | 110 131 | 173 192 | 61 305             | 119 360 | 180 665 |
| 2017–18      | 15                | 13 | 15    | 66 688             | 80 928  | 147 616 | 74 632             | 95 389  | 170 021 |
| 2018–19      | 8                 | 10 | 10    | 24 241             | 29 043  | 53 284  | 41 654             | 56 101  | 97 755  |
| 2019–20      | 10                | 9  | 10    | 33 674             | 13 766  | 47 440  | 51 184             | 28 318  | 79 502  |
| 2020–21      | 9                 | 12 | 13    | 27 520             | 25 800  | 53 320  | 50 895             | 58 185  | 109 080 |
| 2021–22      | 8                 | 5  | 8     | 25 763             | 1 146   | 26 909  | 45 680             | 2 300   | 47 980  |

**Table 20: Fine scale: frequency of the number of lobsters caught (crays\_caught) per harvest pot each fishing year. In the logbook programme, the number of lobsters that are measured in any single potlift was capped, initially to 31, but when the form was redesigned in 1998, this number was reduced to 25. These caps are highlighted in grey. An en dash (–) indicates a frequency of zero. The ‘Total’ column is the total number of lobsters measured each fishing year.**

| Fishing year | Frequency of the number of lobsters caught per pot |        |        |        |       |       |       |       |       |       |       |       |       |    |       |    |        | Total   |
|--------------|----------------------------------------------------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|-------|----|--------|---------|
|              | 0                                                  | 1      | 2      | 3      | 4     | 5     | 6     | 7     | 8     | 9     | 10–14 | 15–19 | 20–24 | 25 | 26–30 | 31 | 32–155 |         |
| 2009–10      | 22 457                                             | 10 547 | 6 028  | 3 491  | 1 956 | 1 074 | 730   | 403   | 253   | 173   | 335   | 73    | 19    | 4  | 6     | –  | 1      | 47 550  |
| 2010–11      | 79 916                                             | 39 200 | 22 832 | 13 277 | 7 379 | 4 427 | 2 542 | 1 479 | 986   | 588   | 1 115 | 197   | 45    | 6  | 8     | –  | 4      | 174 001 |
| 2011–12      | 86 586                                             | 42 195 | 24 663 | 13 771 | 7 577 | 4 534 | 2 641 | 1 455 | 957   | 630   | 1 203 | 276   | 74    | 9  | 27    | –  | 11     | 186 609 |
| 2012–13      | 86 420                                             | 42 191 | 24 234 | 14 245 | 8 255 | 5 153 | 3 241 | 2 004 | 1 428 | 890   | 2 092 | 538   | 195   | 19 | 50    | 5  | 25     | 190 985 |
| 2013–14      | 93 627                                             | 44 034 | 25 663 | 14 950 | 8 758 | 5 456 | 3 607 | 2 117 | 1 556 | 1 067 | 2 195 | 581   | 176   | 19 | 56    | 7  | 28     | 203 897 |
| 2014–15      | 98 511                                             | 45 909 | 26 264 | 15 034 | 8 237 | 4 879 | 2 863 | 1 652 | 1 144 | 659   | 1 254 | 223   | 72    | 5  | 17    | 2  | 5      | 206 730 |
| 2015–16      | 111 196                                            | 49 742 | 26 499 | 14 105 | 7 405 | 4 310 | 2 539 | 1 411 | 902   | 488   | 939   | 203   | 59    | 1  | 12    | 1  | 10     | 219 822 |
| 2016–17      | 89 912                                             | 39 746 | 20 630 | 10 542 | 5 341 | 2 873 | 1 689 | 915   | 550   | 314   | 553   | 93    | 25    | –  | 7     | 1  | 1      | 173 192 |
| 2017–18      | 76 060                                             | 33 167 | 17 024 | 8 971  | 4 667 | 2 742 | 1 642 | 969   | 698   | 430   | 889   | 221   | 79    | 9  | 17    | 5  | 26     | 147 616 |
| 2018–19      | 21 698                                             | 11 539 | 7 067  | 4 500  | 2 620 | 1 759 | 1 128 | 678   | 635   | 373   | 839   | 238   | 116   | 15 | 34    | 3  | 42     | 53 284  |
| 2019–20      | 18 653                                             | 10 888 | 6 837  | 4 192  | 2 467 | 1 556 | 1 000 | 575   | 396   | 257   | 425   | 100   | 45    | 3  | 16    | 3  | 27     | 47 440  |
| 2020–21      | 17 044                                             | 12 269 | 8 403  | 5 576  | 3 440 | 2 041 | 1 396 | 884   | 659   | 446   | 881   | 201   | 50    | 7  | 8     | 2  | 13     | 53 320  |
| 2021–22      | 10 416                                             | 6 180  | 3 811  | 2 436  | 1 359 | 832   | 596   | 335   | 256   | 164   | 333   | 104   | 50    | 5  | 15    | 2  | 15     | 26 909  |

**Table 21: Fine scale: percentage of the number of lobsters caught (crays\_caught) per harvest pot each fishing year. In the logbook programme, the number of lobsters that are measured in any single potlift was capped, initially to 31, but when the form was redesigned in 1998, this number was reduced to 25. These caps are highlighted in grey. The ‘Total’ column is the total number of lobsters measured each fishing year.**

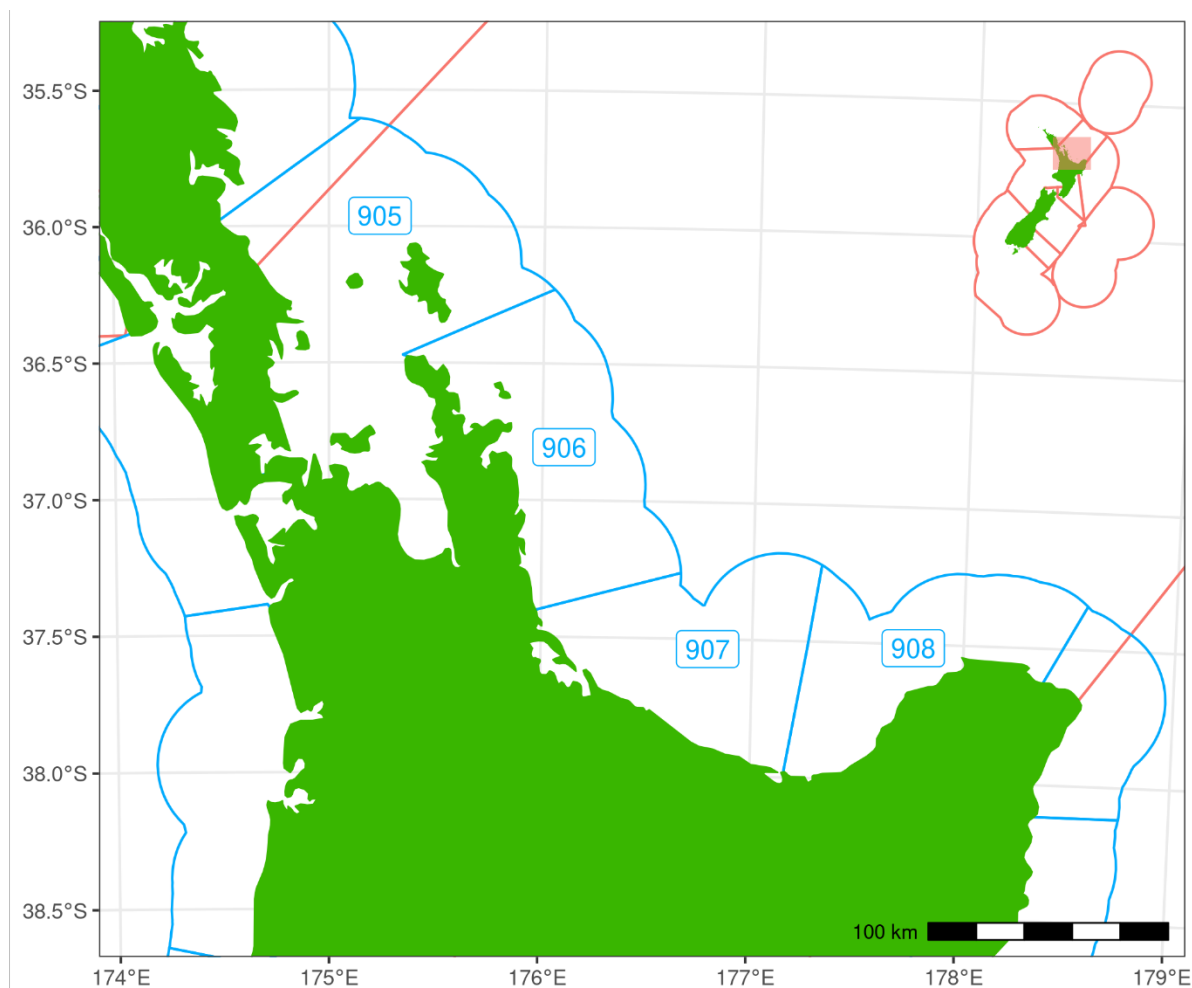
| Fishing year | Frequency of the number of lobsters caught per pot |       |       |       |      |      |      |      |      |      |       |       |       |      |       |      |        | Total  |
|--------------|----------------------------------------------------|-------|-------|-------|------|------|------|------|------|------|-------|-------|-------|------|-------|------|--------|--------|
|              | 0                                                  | 1     | 2     | 3     | 4    | 5    | 6    | 7    | 8    | 9    | 10–14 | 15–19 | 20–24 | 25   | 26–30 | 31   | 32–155 |        |
| 2009–10      | 47.23                                              | 22.18 | 12.68 | 7.34  | 4.11 | 2.26 | 1.54 | 0.85 | 0.53 | 0.36 | 0.70  | 0.15  | 0.04  | 0.01 | 0.01  | 0.00 | 0.00   | 100.00 |
| 2010–11      | 45.93                                              | 22.53 | 13.12 | 7.63  | 4.24 | 2.54 | 1.46 | 0.85 | 0.57 | 0.34 | 0.64  | 0.11  | 0.03  | 0.00 | 0.00  | 0.00 | 0.00   | 100.00 |
| 2011–12      | 46.40                                              | 22.61 | 13.22 | 7.38  | 4.06 | 2.43 | 1.42 | 0.78 | 0.51 | 0.34 | 0.64  | 0.15  | 0.04  | 0.00 | 0.01  | 0.00 | 0.01   | 100.00 |
| 2012–13      | 45.25                                              | 22.09 | 12.69 | 7.46  | 4.32 | 2.70 | 1.70 | 1.05 | 0.75 | 0.47 | 1.10  | 0.28  | 0.10  | 0.01 | 0.03  | 0.00 | 0.01   | 100.00 |
| 2013–14      | 45.92                                              | 21.60 | 12.59 | 7.33  | 4.30 | 2.68 | 1.77 | 1.04 | 0.76 | 0.52 | 1.08  | 0.28  | 0.09  | 0.01 | 0.03  | 0.00 | 0.01   | 100.00 |
| 2014–15      | 47.65                                              | 22.21 | 12.70 | 7.27  | 3.98 | 2.36 | 1.38 | 0.80 | 0.55 | 0.32 | 0.61  | 0.11  | 0.03  | 0.00 | 0.01  | 0.00 | 0.00   | 100.00 |
| 2015–16      | 50.58                                              | 22.63 | 12.05 | 6.42  | 3.37 | 1.96 | 1.16 | 0.64 | 0.41 | 0.22 | 0.43  | 0.09  | 0.03  | 0.00 | 0.01  | 0.00 | 0.00   | 100.00 |
| 2016–17      | 51.91                                              | 22.95 | 11.91 | 6.09  | 3.08 | 1.66 | 0.98 | 0.53 | 0.32 | 0.18 | 0.32  | 0.05  | 0.01  | 0.00 | 0.00  | 0.00 | 0.00   | 100.00 |
| 2017–18      | 51.53                                              | 22.47 | 11.53 | 6.08  | 3.16 | 1.86 | 1.11 | 0.66 | 0.47 | 0.29 | 0.60  | 0.15  | 0.05  | 0.01 | 0.01  | 0.00 | 0.02   | 100.00 |
| 2018–19      | 40.72                                              | 21.66 | 13.26 | 8.45  | 4.92 | 3.30 | 2.12 | 1.27 | 1.19 | 0.70 | 1.57  | 0.45  | 0.22  | 0.03 | 0.06  | 0.01 | 0.08   | 100.00 |
| 2019–20      | 39.32                                              | 22.95 | 14.41 | 8.84  | 5.20 | 3.28 | 2.11 | 1.21 | 0.83 | 0.54 | 0.90  | 0.21  | 0.09  | 0.01 | 0.03  | 0.01 | 0.06   | 100.00 |
| 2020–21      | 31.97                                              | 23.01 | 15.76 | 10.46 | 6.45 | 3.83 | 2.62 | 1.66 | 1.24 | 0.84 | 1.65  | 0.38  | 0.09  | 0.01 | 0.02  | 0.00 | 0.02   | 100.00 |
| 2021–22      | 38.71                                              | 22.97 | 14.16 | 9.05  | 5.05 | 3.09 | 2.21 | 1.24 | 0.95 | 0.61 | 1.24  | 0.39  | 0.19  | 0.02 | 0.06  | 0.01 | 0.06   | 100.00 |

**Table 22: Fine scale: model comparison statistics for models fitted to the by month and by trip fine scale / harvest pot data sets including: the  $\Delta$ ELPD (higher is better), LOO IC (lower is better), P LOO (the effective number of parameters), Bayesian  $R^2$  (higher is better) statistics for models fitted to the fine scale data, the number of divergent transitions, and time taken for the model run. The values in the  $\Delta$ ELPD column were computed by making pairwise comparisons between each model and the model with the largest ELPD. For this reason, the  $\Delta$ ELPD column will always have the value zero in the first row (i.e., the difference between the preferred model and itself) and negative values in subsequent rows for the remaining models. All distributions were assumed to be negative binomial.**

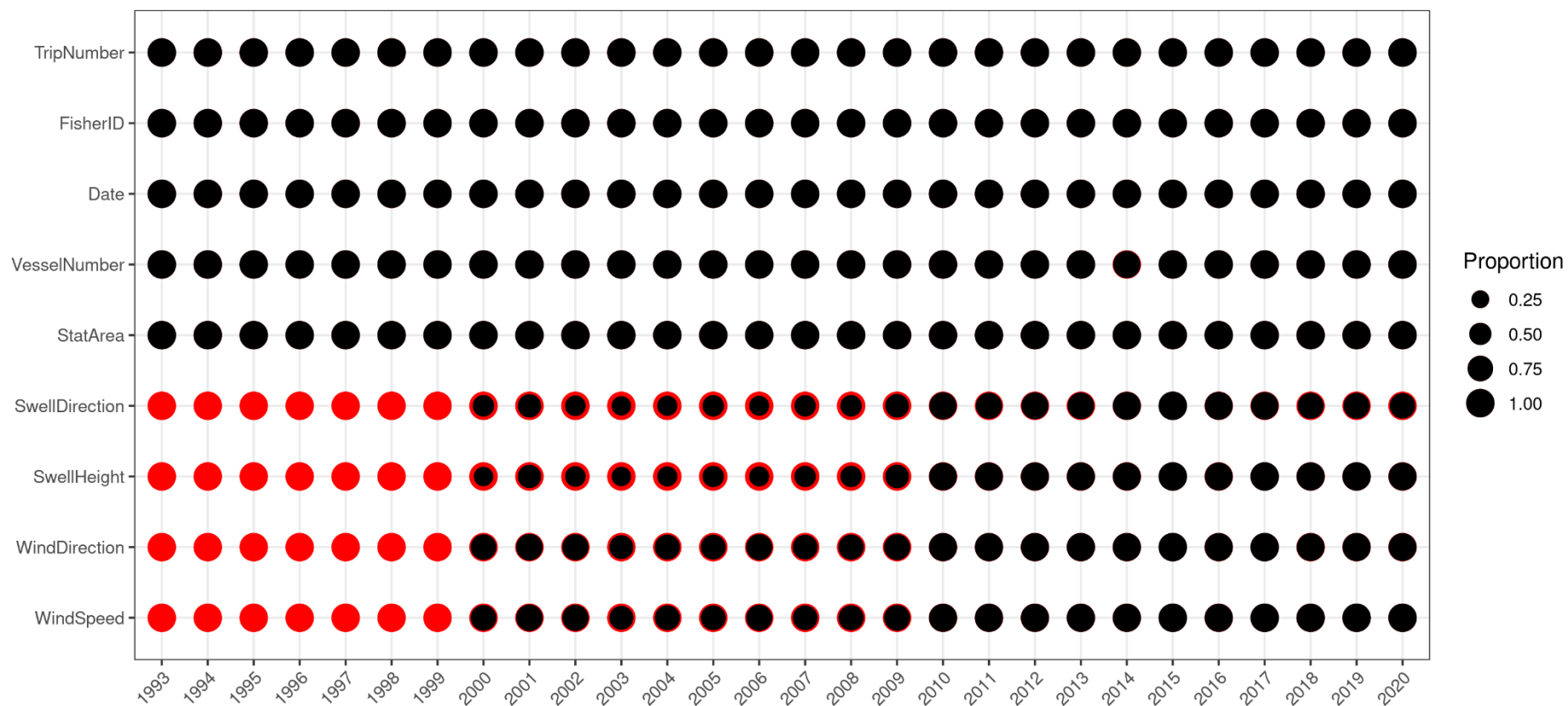
| Model                                                                               | $\Delta$ ELPD |    | LOO IC  |     | P LOO |     | Bayesian R <sup>2</sup> |       | Divergent | Time     |
|-------------------------------------------------------------------------------------|---------------|----|---------|-----|-------|-----|-------------------------|-------|-----------|----------|
|                                                                                     | Mean          | SD | Mean    | SD  | Mean  | SD  | Mean                    | SD    |           |          |
| by month                                                                            |               |    |         |     |       |     |                         |       |           |          |
| log(pots) + period + month + vessel + area + (1   period $\times$ area)             | 0             | 0  | 18 036  | 123 | 124.7 | 9.6 | 0.865                   | 0.005 | 0         | 00:02:04 |
| log(pots) + period + (1   month) + (1   vessel) + area                              | -43           | 11 | 18 121  | 122 | 73.6  | 6.5 | 0.848                   | 0.005 | 1         | 00:02:10 |
| log(pots) + period + (1   month) + (1   vessel)                                     | -75           | 15 | 18 186  | 127 | 67.6  | 6.5 | 0.846                   | 0.005 | 2         | 00:01:45 |
| log(pots) + period + (1   month)                                                    | -315          | 25 | 18 666  | 131 | 47.6  | 5.2 | 0.748                   | 0.004 | 1         | 00:01:03 |
| log(pots) + period                                                                  | -414          | 27 | 18 864  | 131 | 35.9  | 4.7 | 0.724                   | 0.004 | 0         | 00:00:10 |
| by trip                                                                             |               |    |         |     |       |     |                         |       |           |          |
| log(pots) + period + (1   month) + (1   vessel) + area + (1   period $\times$ area) | 0             | 0  | 176 182 | 316 | 160.8 | 4.1 | 0.620                   | 0.004 | 0         | 02:06:06 |
| log(pots) + period + (1   month) + (1   vessel) + area                              | -617          | 40 | 177 415 | 317 | 77.5  | 2.1 | 0.591                   | 0.003 | 231       | 01:33:01 |
| log(pots) + period + (1   month) + (1   vessel)                                     | -813          | 48 | 177 808 | 323 | 71.9  | 1.9 | 0.590                   | 0.003 | 1         | 01:18:30 |
| log(pots) + period + (1   month)                                                    | -3 009        | 78 | 182 199 | 320 | 46.6  | 1.3 | 0.498                   | 0.003 | 5         | 00:38:46 |
| log(pots) + period                                                                  | -3 602        | 84 | 183 386 | 318 | 34.6  | 1.0 | 0.469                   | 0.004 | 0         | 00:02:58 |

## 8. FIGURES

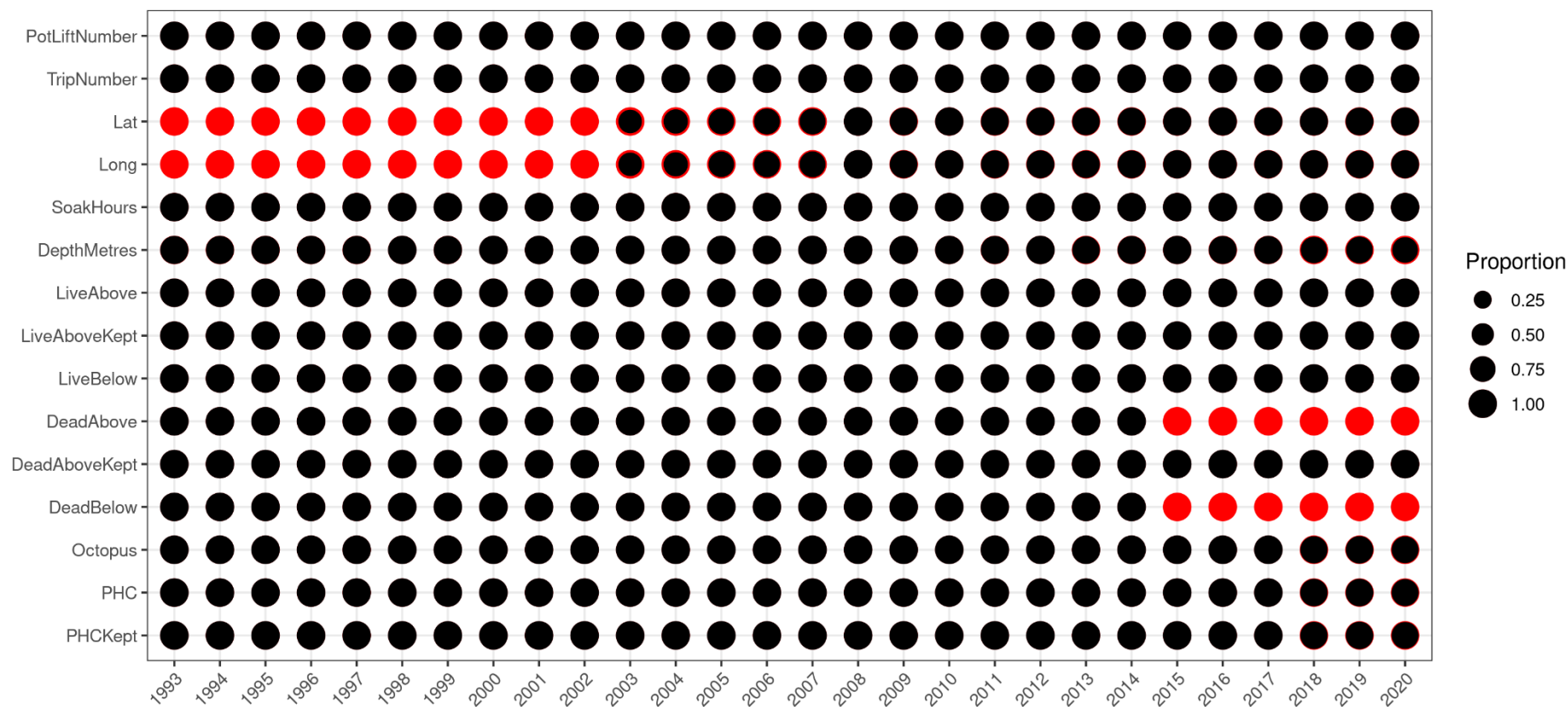
Depending on what is being presented, the caption for each figure begins with either ‘CELR’, ‘Logbook’, ‘Fine scale’, or nothing to help the reader distinguish among the data sets being presented.



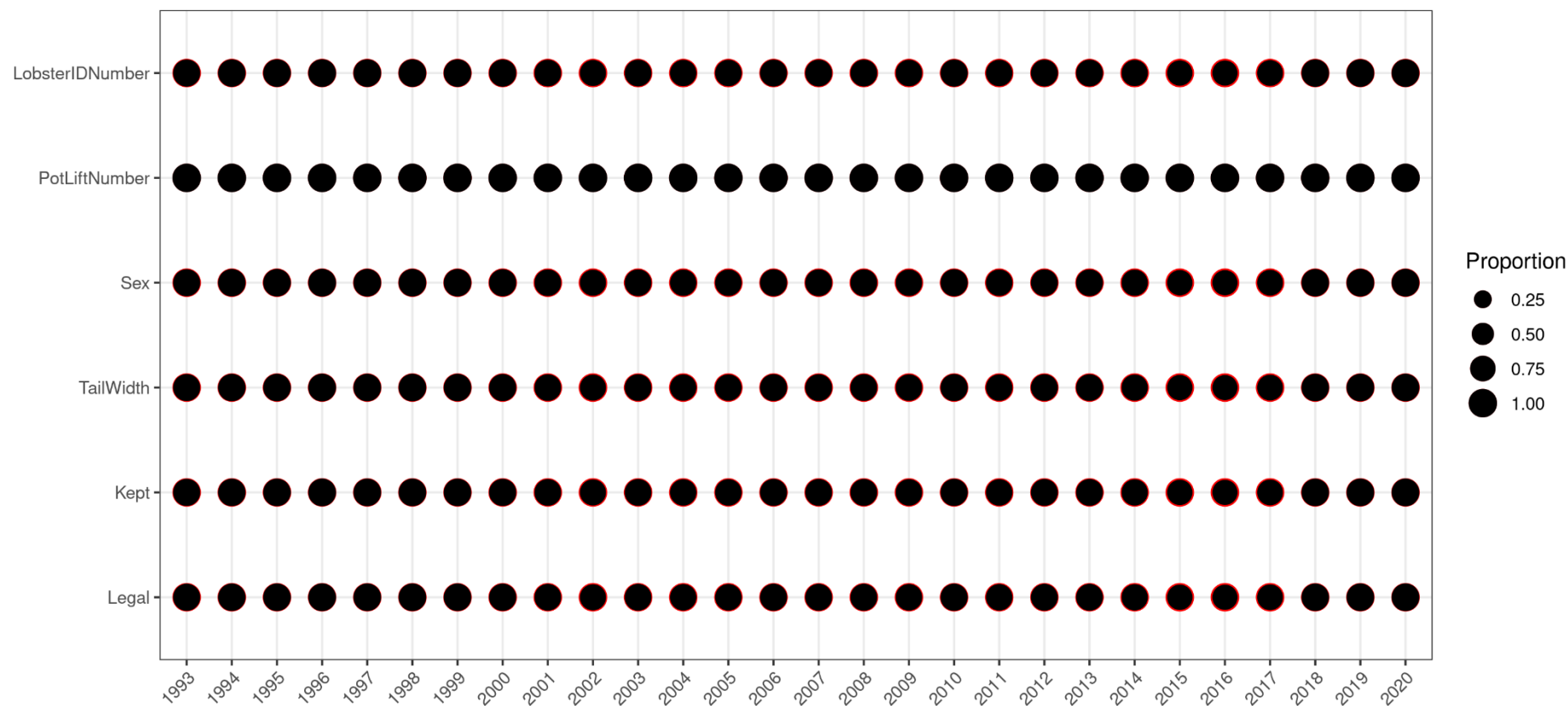
**Figure 1:** The CRA 2 Quota Management Area (QMA) boundaries (red lines) and statistical area boundaries (blue lines).



**Figure 2: Logbook: the proportion of records that are not missing (i.e., not NULL) for each field by fishing year in the 'Trips' table from the rllb database for CRA 2. For each fishing year / field red is the proportion of records that are missing data and black is the proportion records that are not missing.**

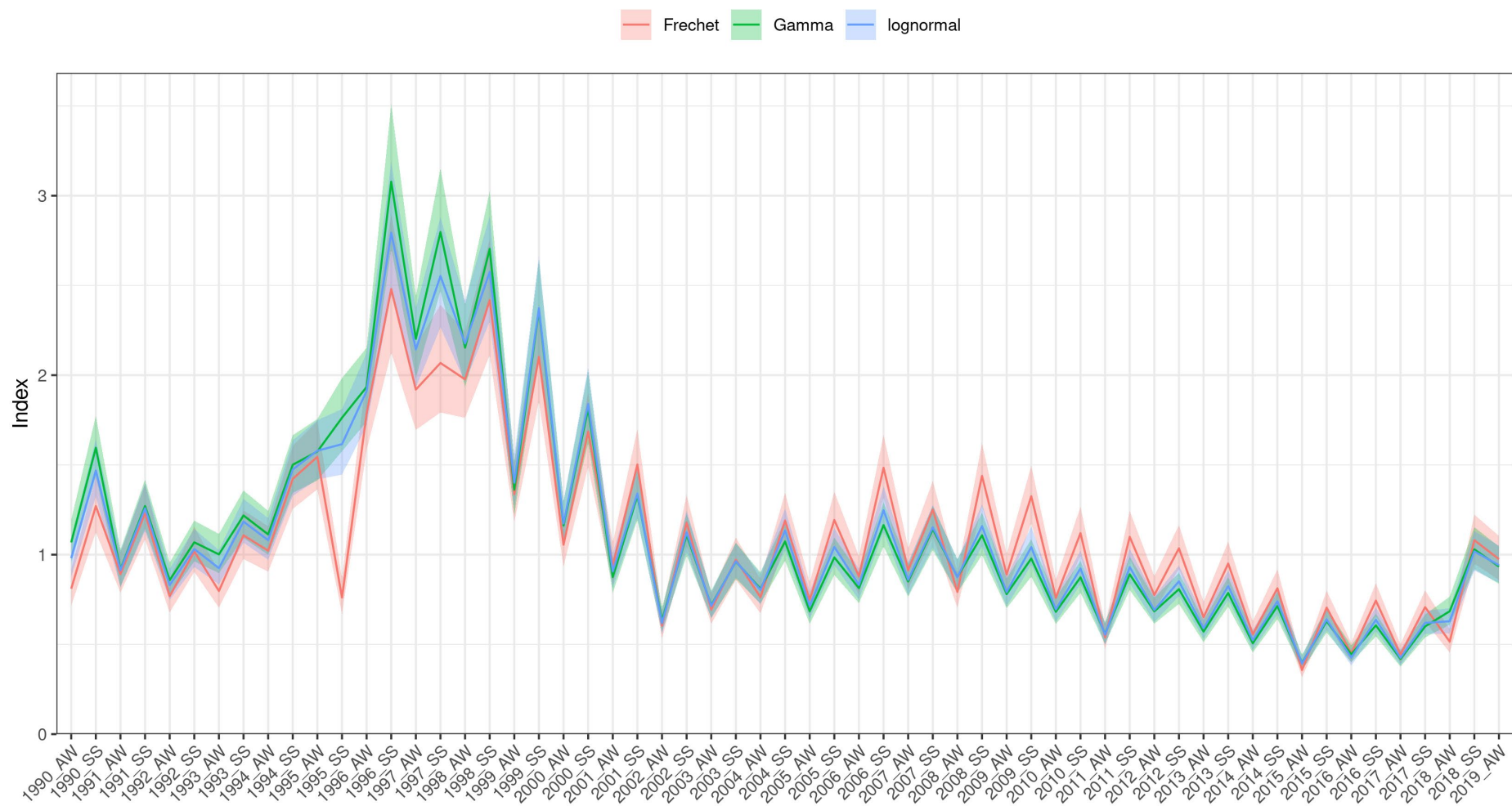


**Figure 3: Logbook: the proportion of records that are not missing (i.e., not NULL) for each field in the ‘PotLifts’ table from the rllb database for CRA 2. Note that this figure suggests that the fields for all QMAS ‘DeadAbove’, ‘DeadAboveKept’, and ‘DeadBelow’ are not NULL for all years despite the collection of these fields beginning in 2000–01. Also note, that while the ‘Depth’ field appears to be not NULL for all years, many of the depth records are actually zero metres deep. For each fishing year / field red is the proportion of records that are missing data and black is the proportion records that are not missing.**

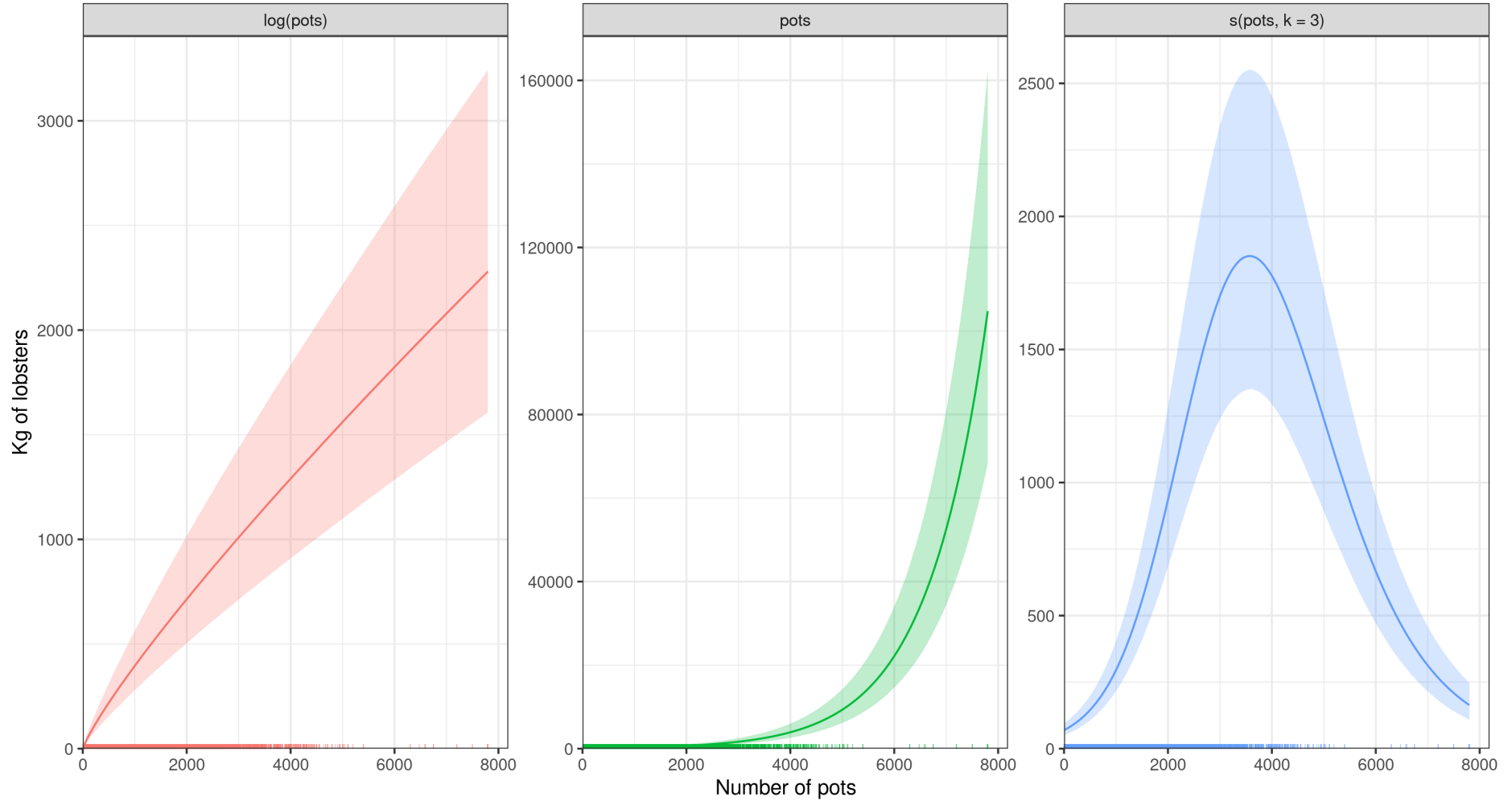


**Figure 4: Logbook: the proportion of records that are not missing (i.e., not NULL) for each field in the ‘Lobsters’ table from the rllb database for CRA 2. Note that this figure suggests that the field ‘Kept’ is not NULL for all years despite the collection of this field beginning in 2000–01 for all QMAs. For each fishing year / field red is the proportion of records that are missing data and black is the proportion records that are not missing.**

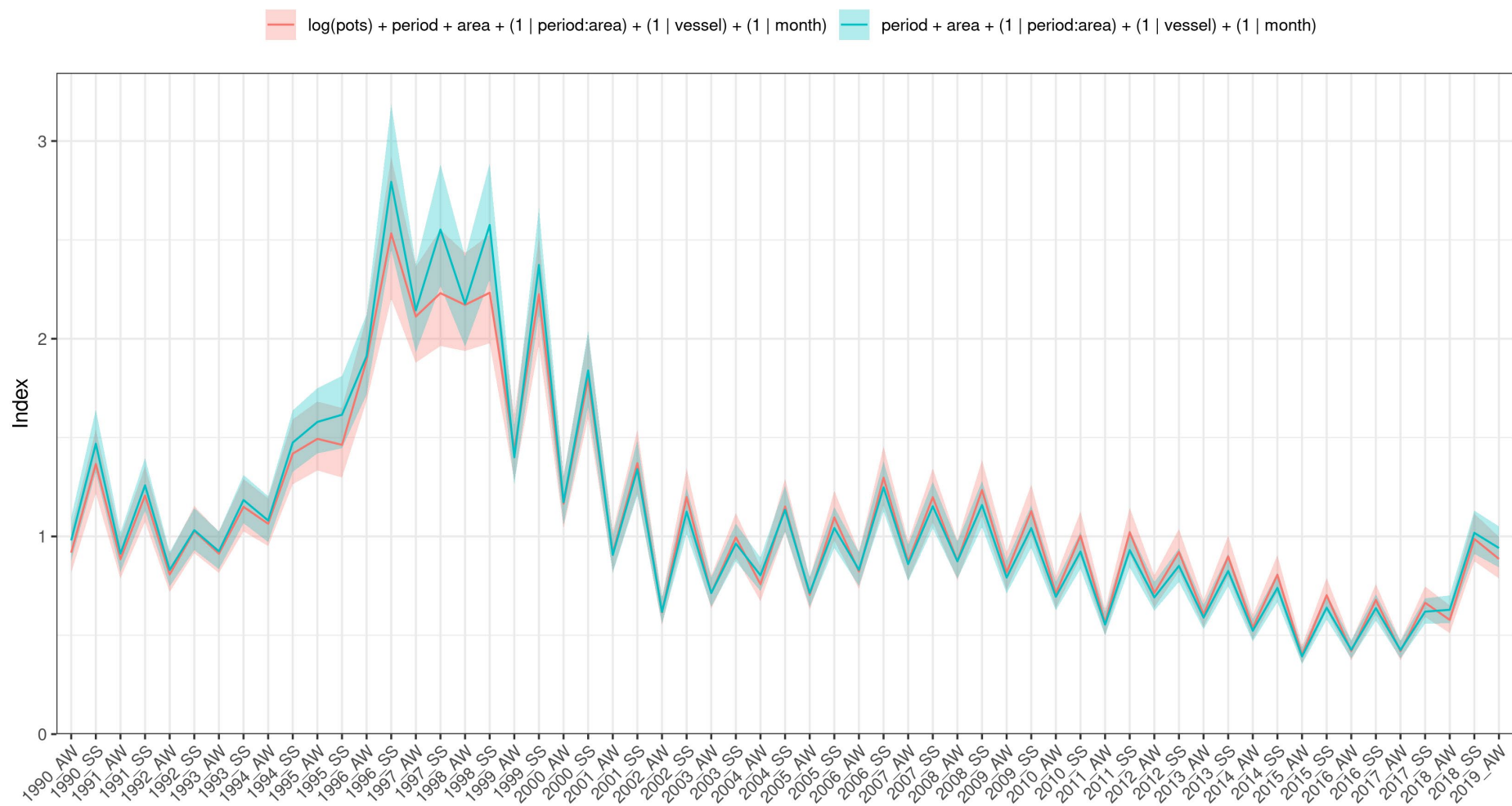




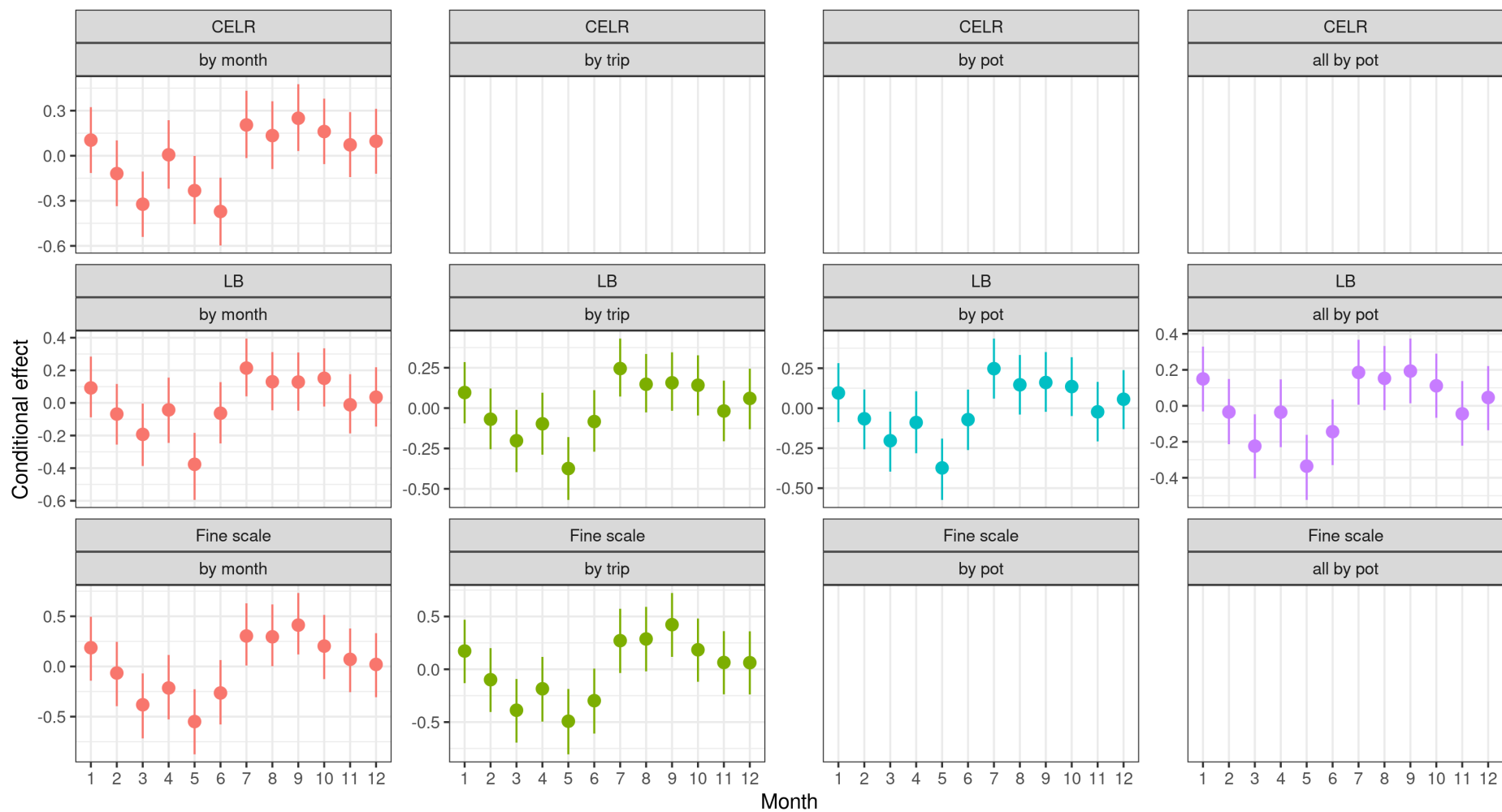
**Figure 5: CELR: median standardised CPUE and 50% credible interval by period for models assuming a lognormal, Fréchet, or Gamma distribution. The models all had the form which was  $period + area + (1 | vessel \times area) + (1 | vessel) + (1 | month)$ . The LOO IC for each of these models is provided in Table 12.**



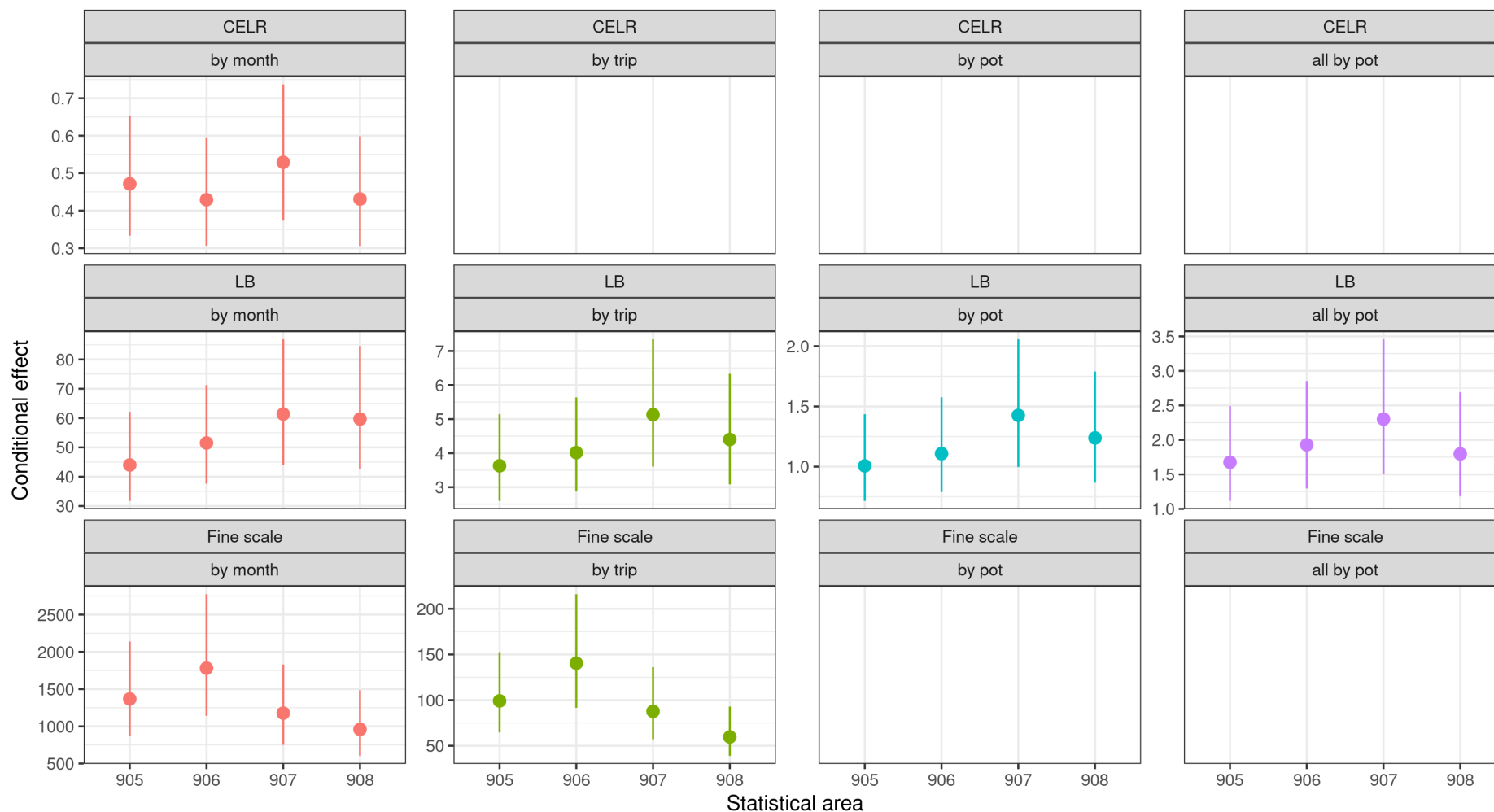
**Figure 6: CELR: conditional effect of the number of pots lifted on the weight (kg) of lobsters caught using the data aggregated by month for the models  $f(pots) + period + area + (1 | period \times area) + (1 | vessel) + (1 | month)$  where  $f(pots)$  is either  $pots$ ,  $\log(pots)$ , or  $s(pots, k = 3)$ . The best model according to LOO IC was the model that used the term  $\log(pots)$  (Table 12).**



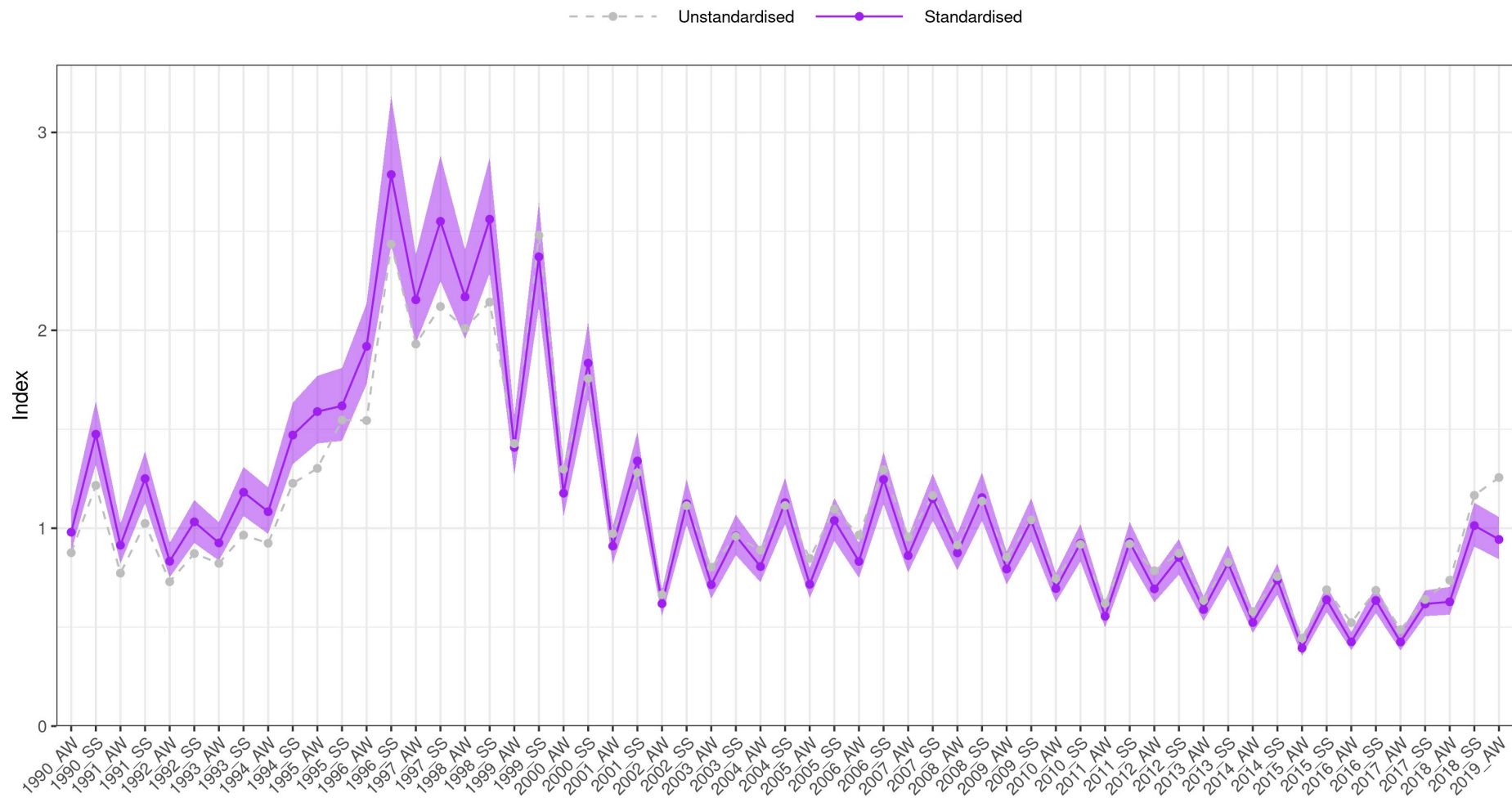
**Figure 7: CELR: median standardised CPUE and 50% credible interval by period for models where the dependent variable is CPUE (i.e., kilogram of lobsters caught / number of pots) or the dependent variable is kilogram of lobsters caught and pot is included as an explanatory variable. The LOO IC for each of these models is provided in Table 12.**



**Figure 8:** conditional effect of month on the number of lobsters caught using the by month, by trip, by pot, and all by pot data sets for the model  $\log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$  or  $\text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$ . Month 1 is January.

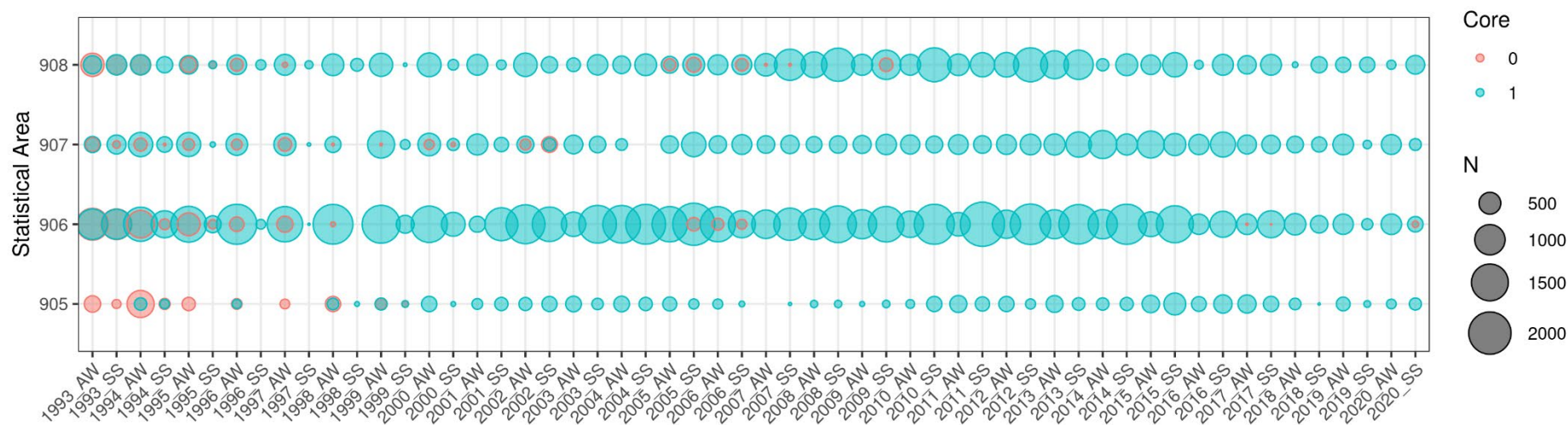


**Figure 9:** conditional effect of statistical area on the number of lobsters caught using the by month, by trip, by pot, and all by pot data sets for the model  $\log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$  or  $\text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$ .



**Figure 10: CELR: unstandardised and standardised (with 50% credible interval) CPUE for the best model according to LOO IC (Table 12). The model was fitted to data assuming a lognormal distribution and had the form  $period + area + (1 | vessel \times area) + (1 | vessel) + (1 | month)$ .**

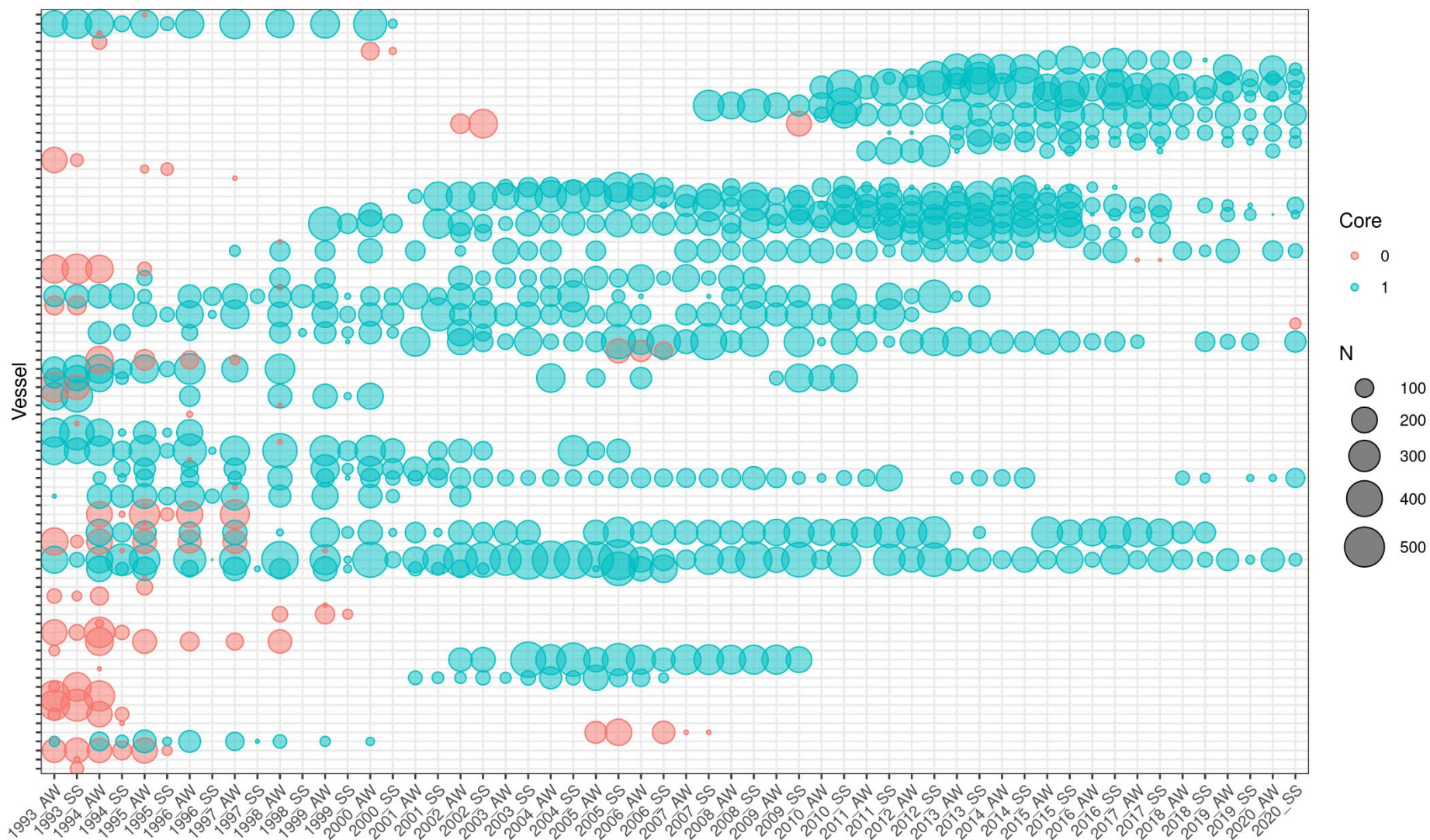




**Figure 11: Logbook: the number of records/potlifts by period and statistical area in the logbook data set. See Figure 1 for the locations of these statistical areas. Core vessels were defined as those vessels that had been in the logbook programme for at least three years.**

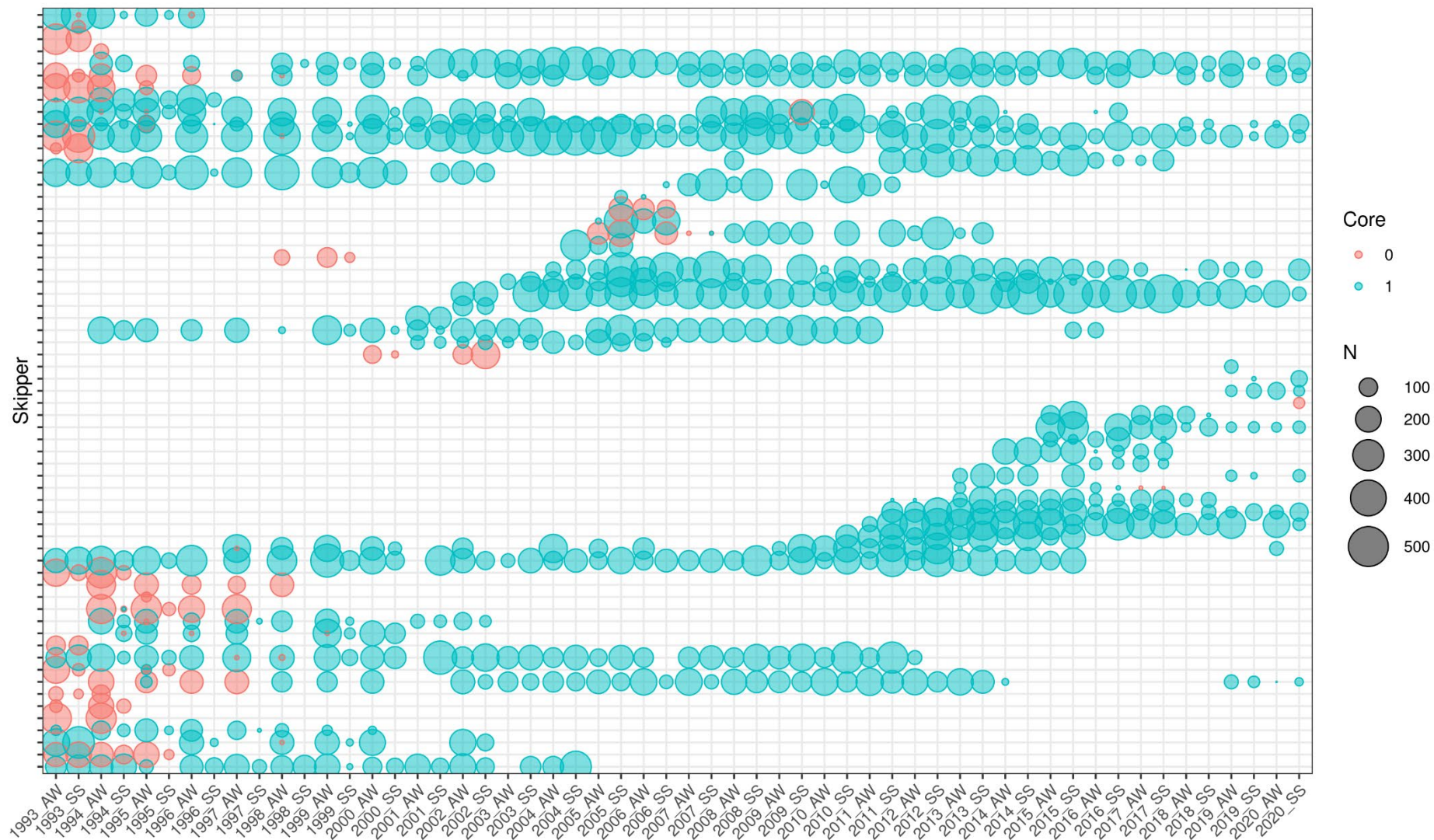


**Figure 12: Logbook: the number of records/potlifts by fishing year and month in the logbook data set. Core vessels were defined as those vessels that had been in the logbook programme for at least three years.**

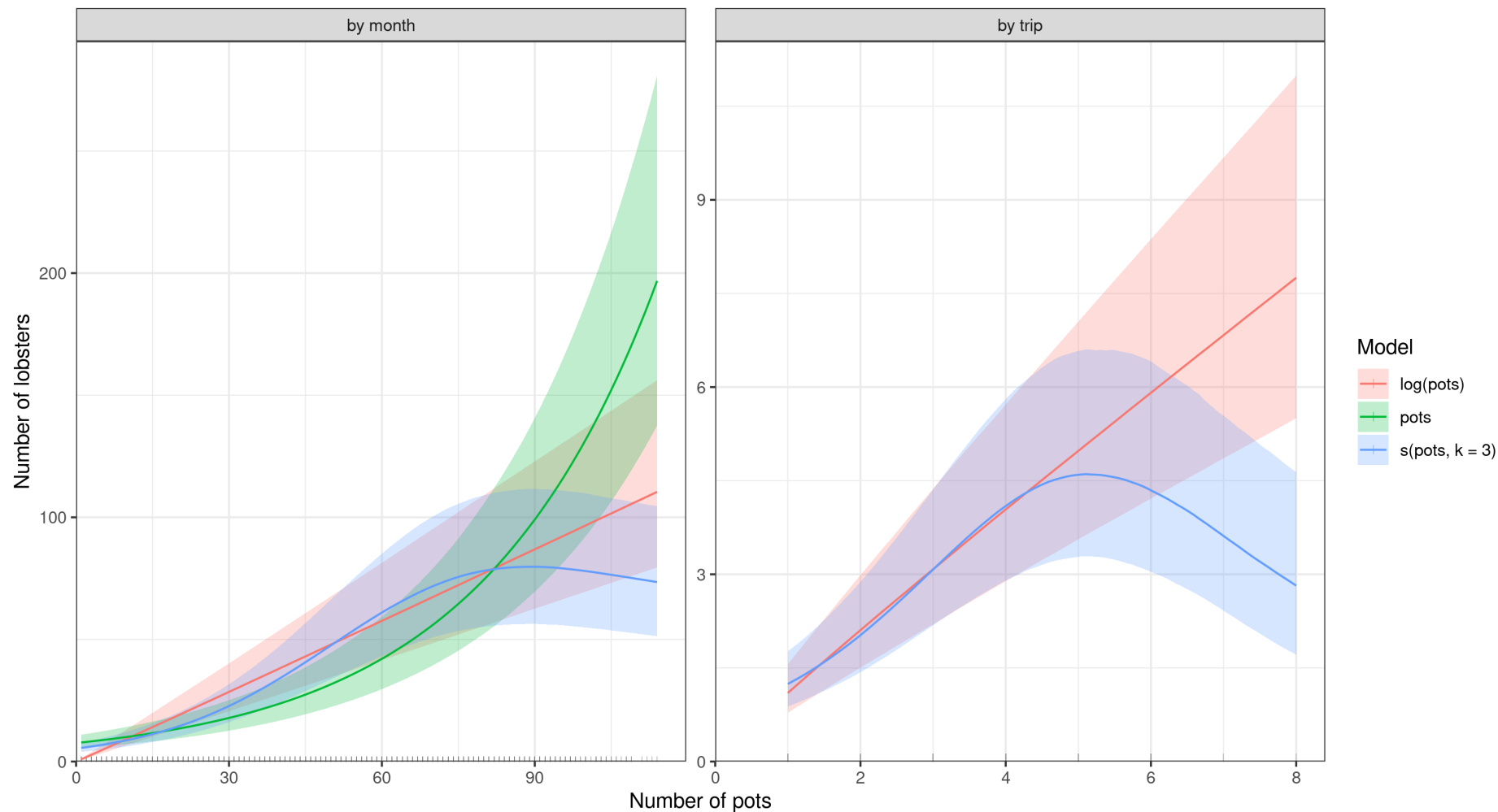


**Figure 13: Logbook: the number of records/potlifts by period and vessel for the 84 vessels in the logbook data set. Core vessels were defined as those vessels that had been in the logbook programme for at least three years.**

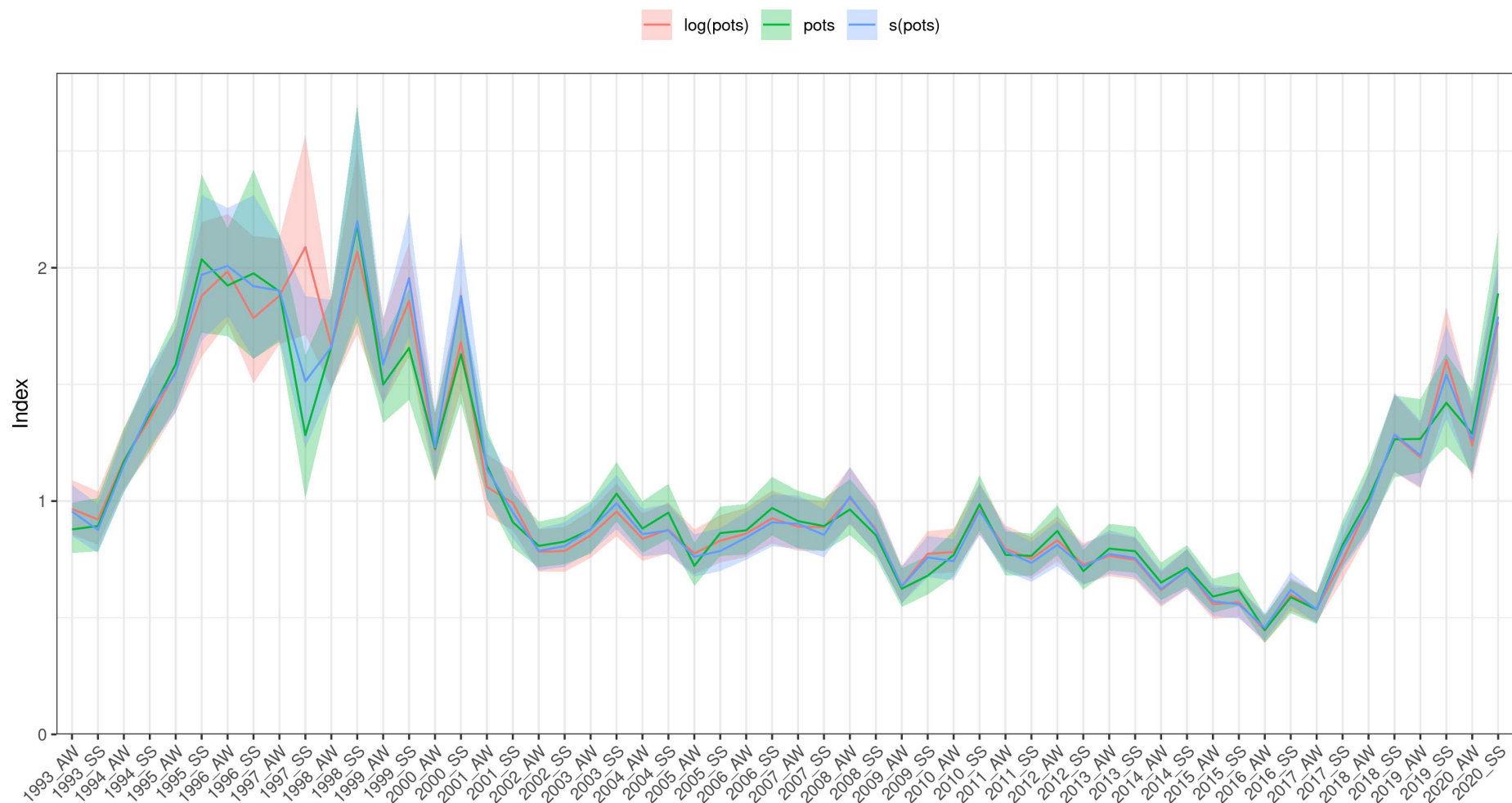




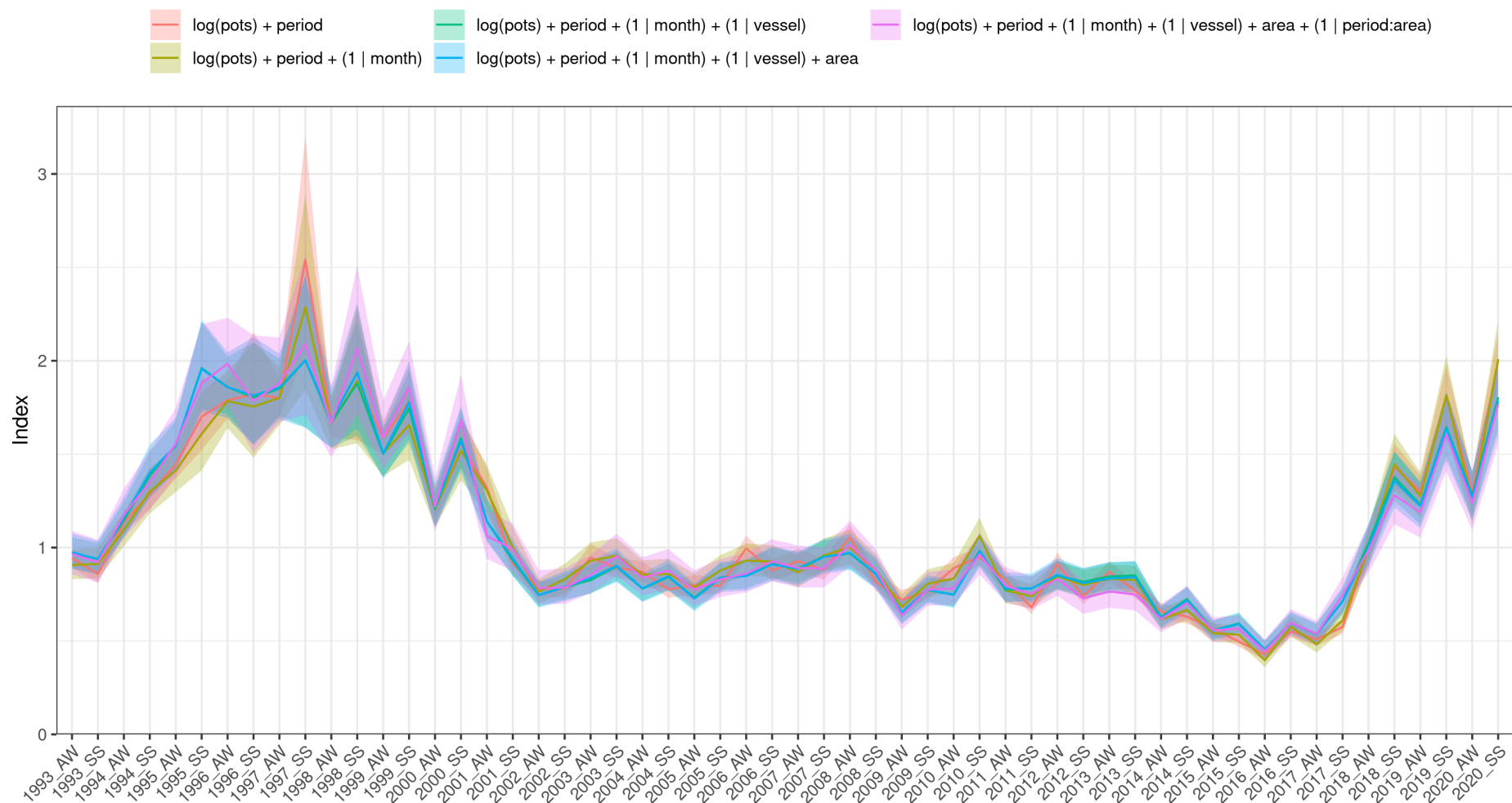
**Figure 14: Logbook: the number of records/potlifts by period and skipper for the 63 skippers in the logbook data set. Core vessels were defined as those vessels that had been in the logbook programme for at least three years.**



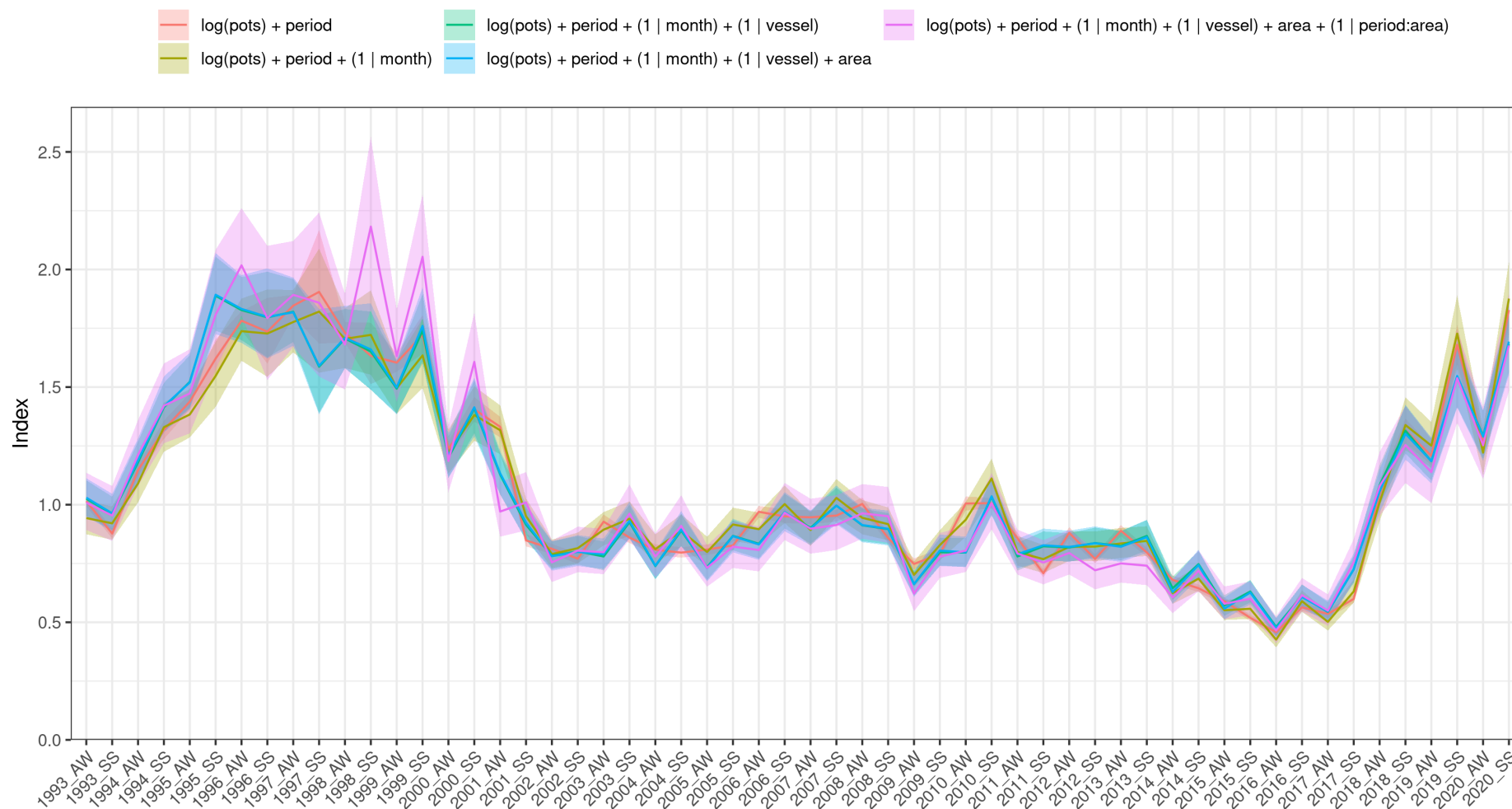
**Figure 15: Logbook: conditional effect of the number of logbook pots lifted on the number of lobsters caught using the by month and by trip data sets for the models  $f(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$  where  $f(\text{pots})$  is either  $\text{pots}$ ,  $\log(\text{pots})$ , or  $s(\text{pots}, k = 3)$ . Note that these effects are conditioned on the reference category for all factors which is always the first factor level (i.e., the 1993 AW period, month 4, the first vessel, and statistical area 905). The LOO IC for each of these models is provided in Table 17.**



**Figure 16: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by month data set for the models:  $\text{pots} + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period:area})$ ;  $\log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period:area})$ ; and  $s(\text{pots}, k = 3) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period:area})$ . The LOO IC for each of these models is provided in Table 17.**

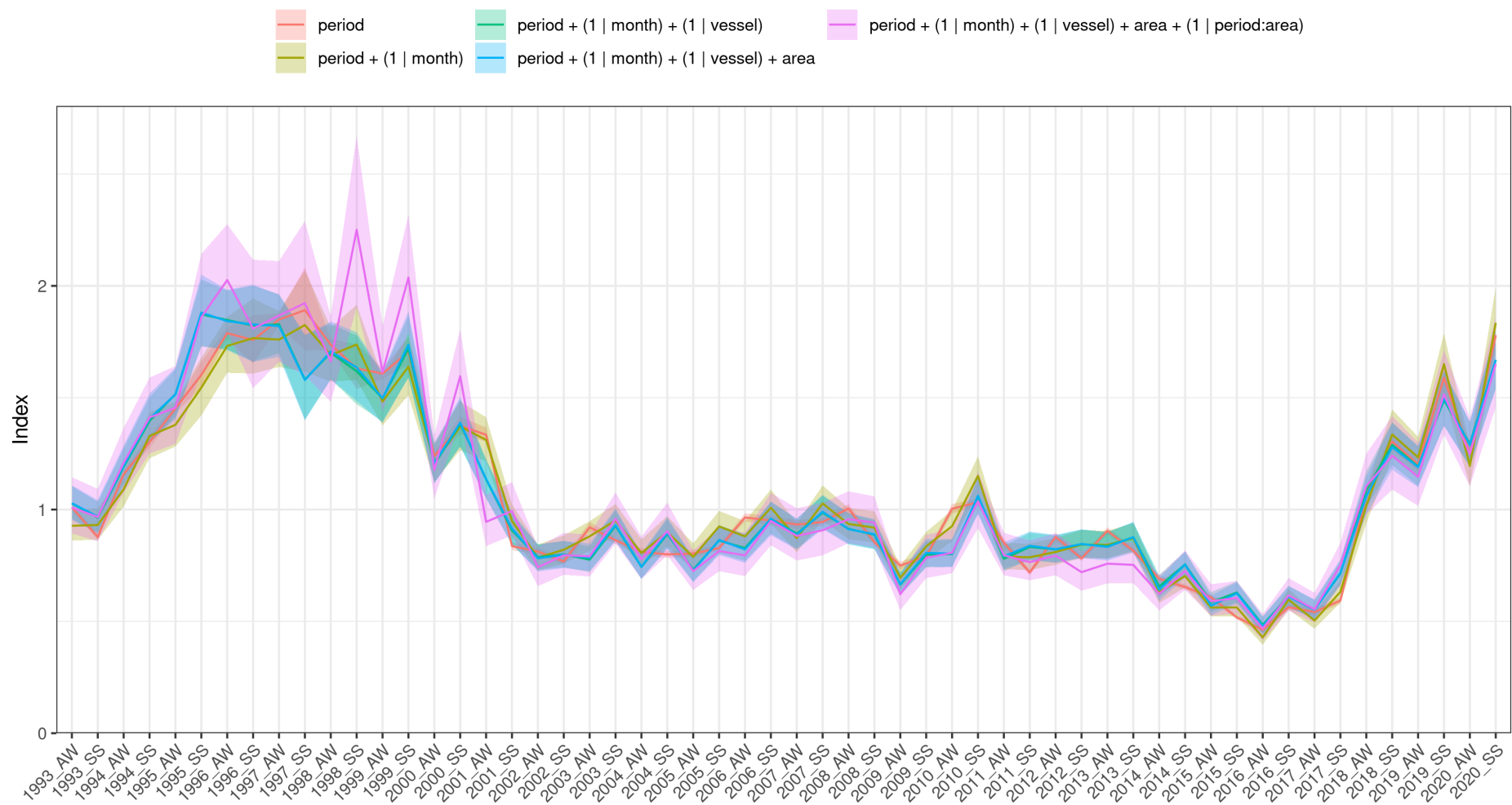


**Figure 17: Logbook: median standardised CPUE and 50% credible interval by period for the suite of main models fitted to the by month data set. The LOO IC for each of these models is provided in Table 17.**

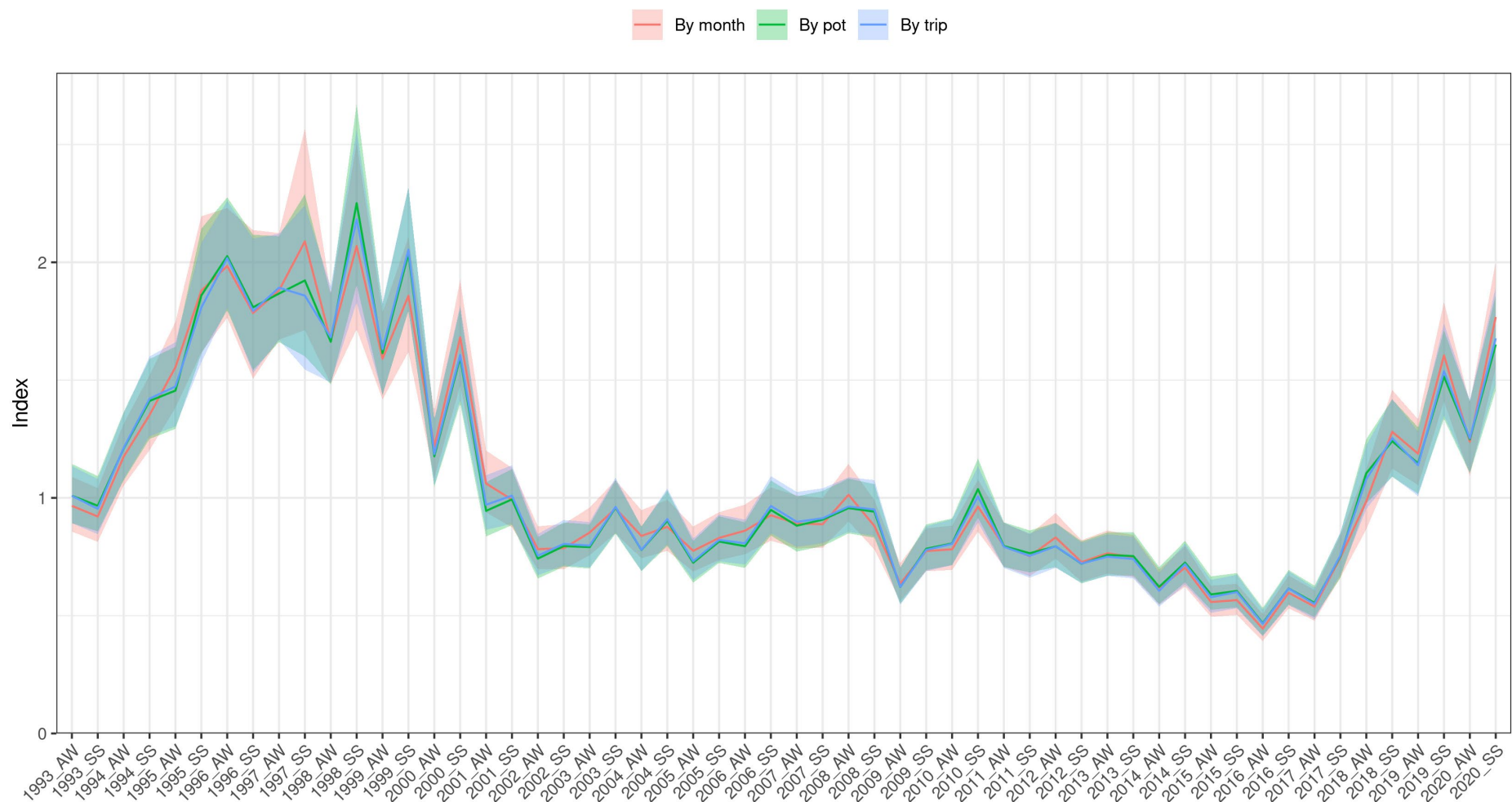


**Figure 18: Logbook: median standardised CPUE and 50% credible interval by period for the suite of main models fitted to the by trip data set. The LOO IC for each of these models is provided in Table 17.**

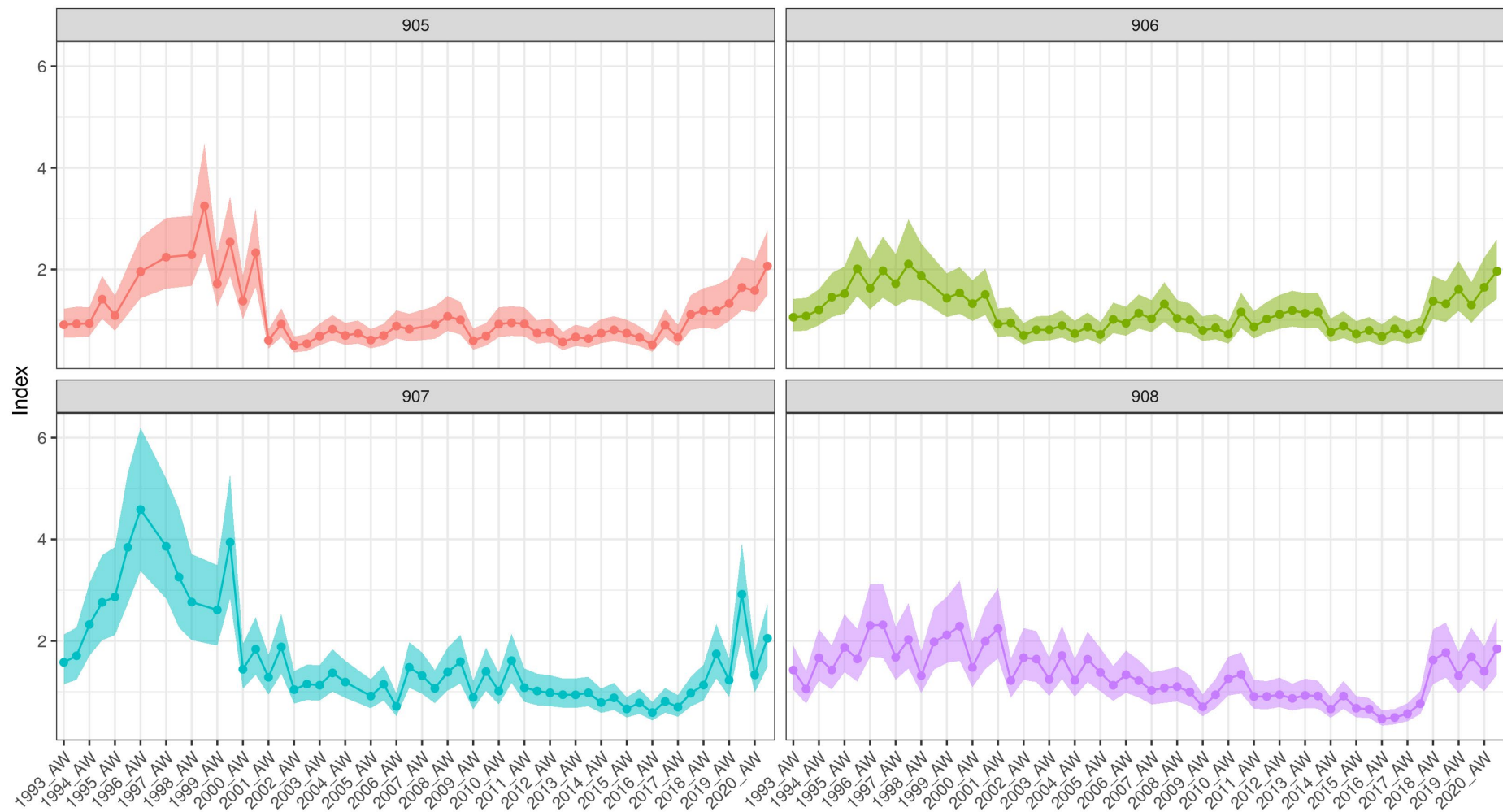




**Figure 19: Logbook: median standardised CPUE and 50% credible interval by period for the suite of main models fitted to the by pot data set. The LOO IC for each of these models is provided in Table 17.**

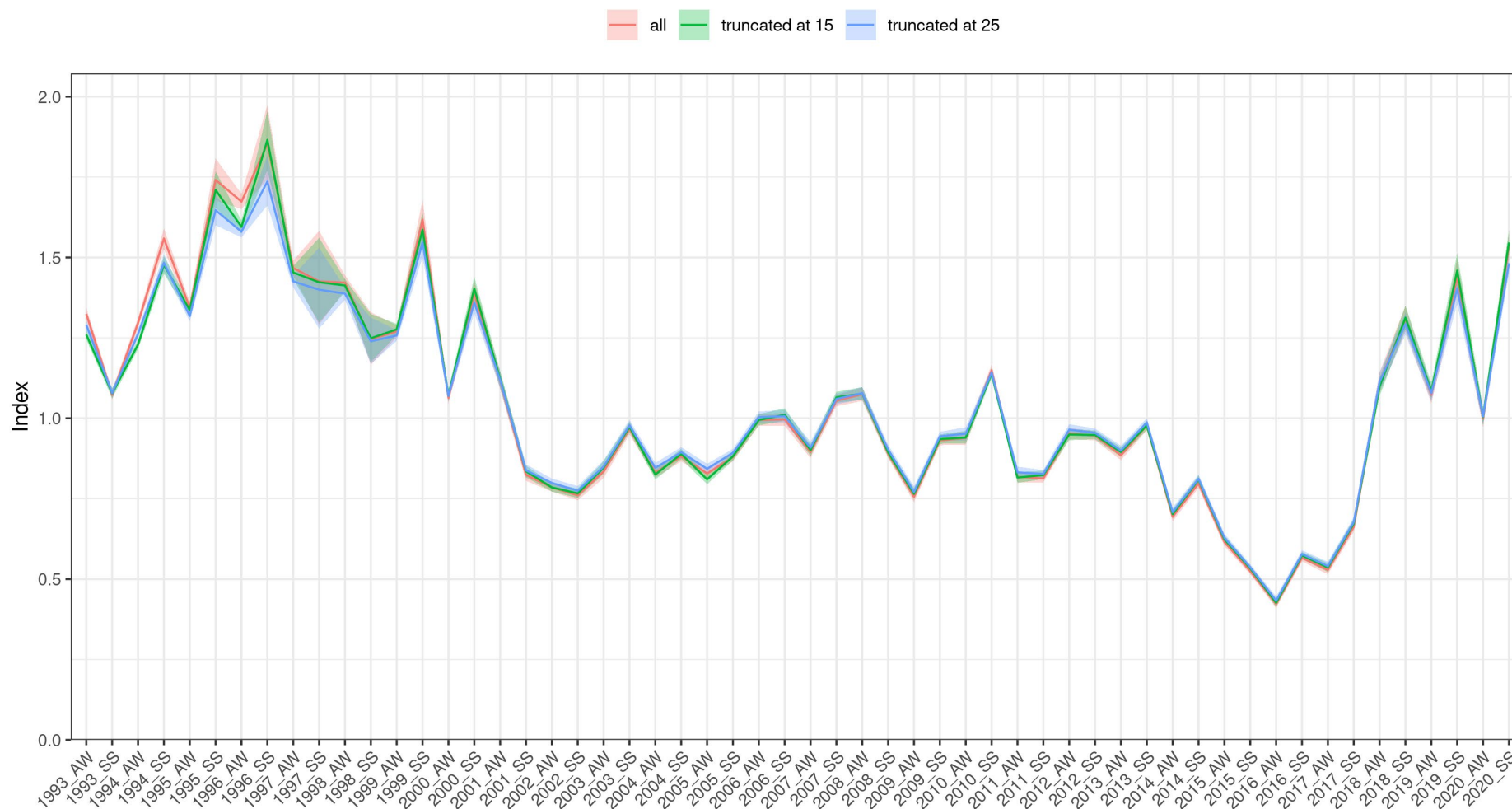


**Figure 20: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by month, by trip, and by pot data sets for the model  $\log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period:area})$ . The LOO IC for each of these models is provided in Table 17.**

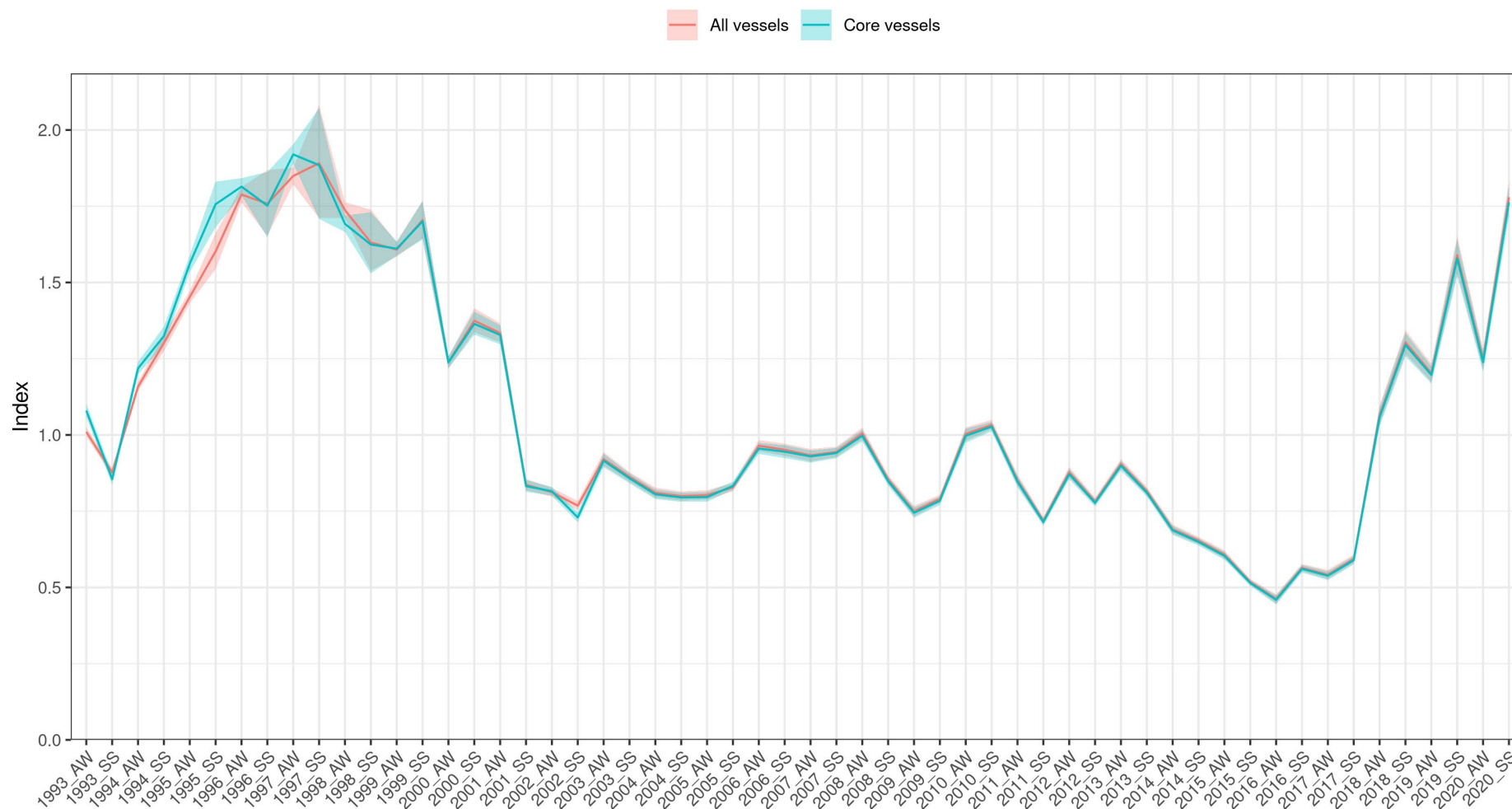


**Figure 21: Logbook: median standardised CPUE and 50% credible interval by period and statistical area for the model fitted to the *by\_pot* data set for the model  $\log(\text{pots}) + \text{period} + (1 | \text{month}) + (1 | \text{vessel}) + \text{area} + (1 | \text{period:area})$ . The LOO IC for this model is provided in Table 17.**

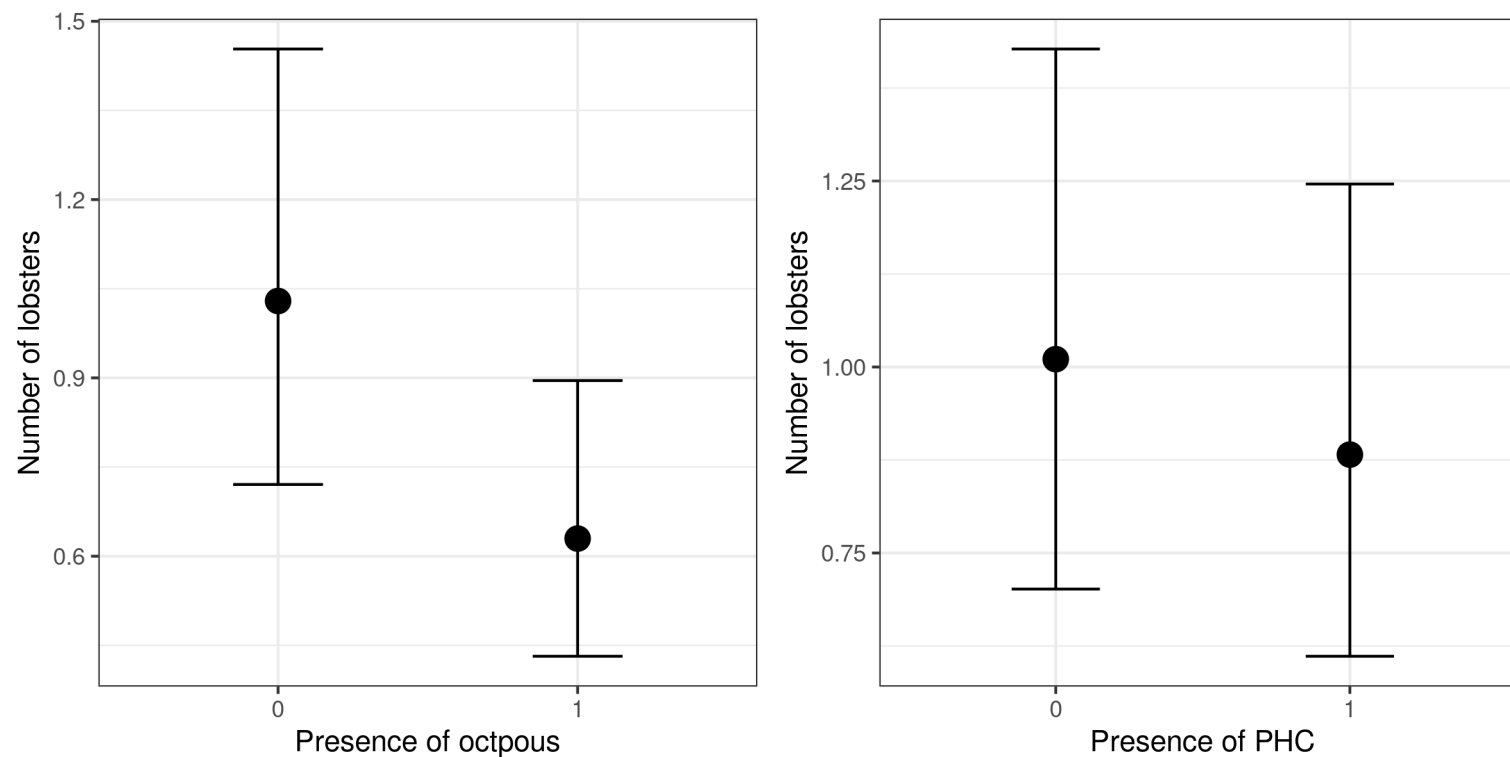




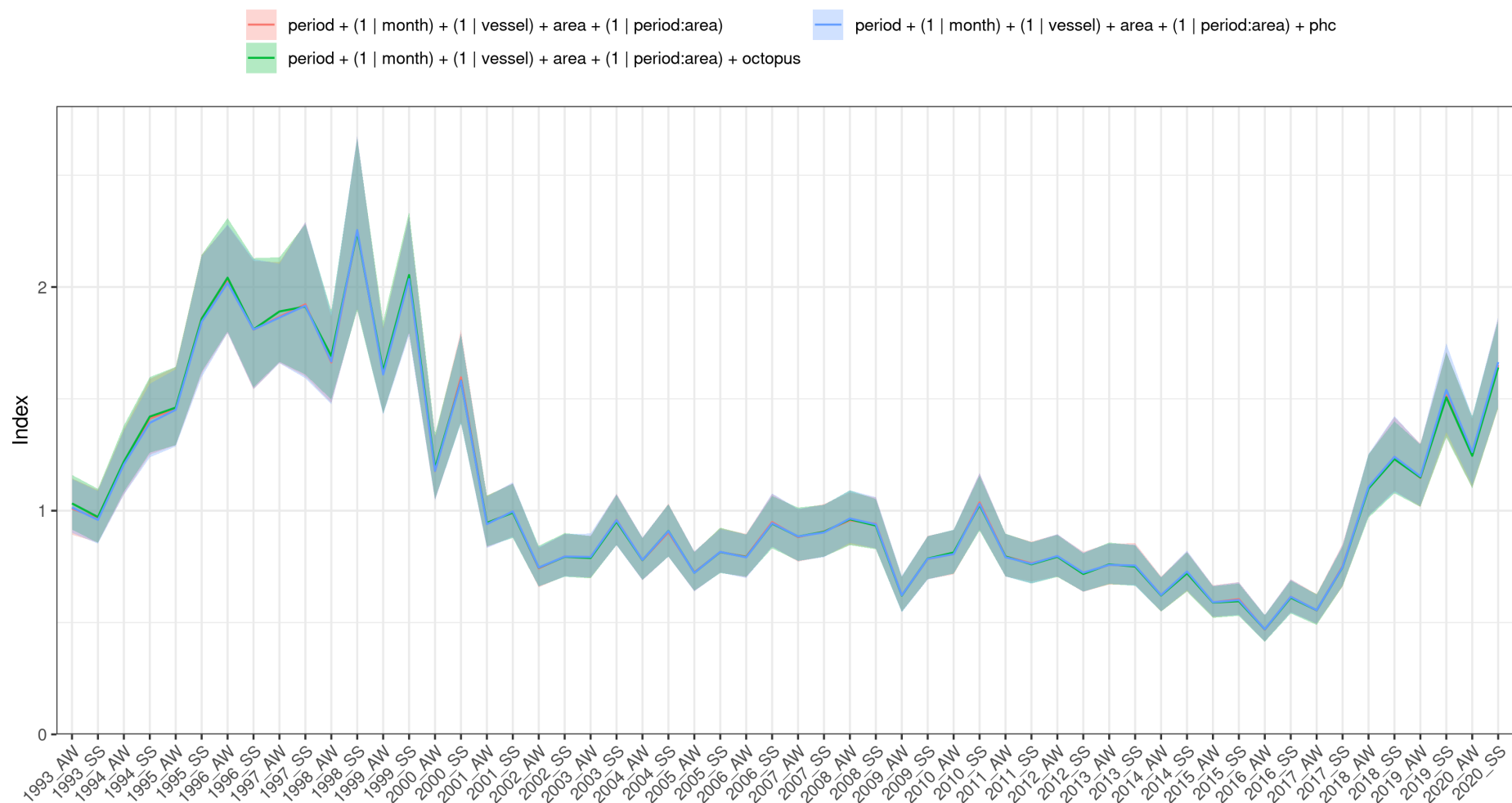
**Figure 22: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the all by pot, max 25 by pot, and max 15 by pot data sets. This was a simple model with the form *period*.**



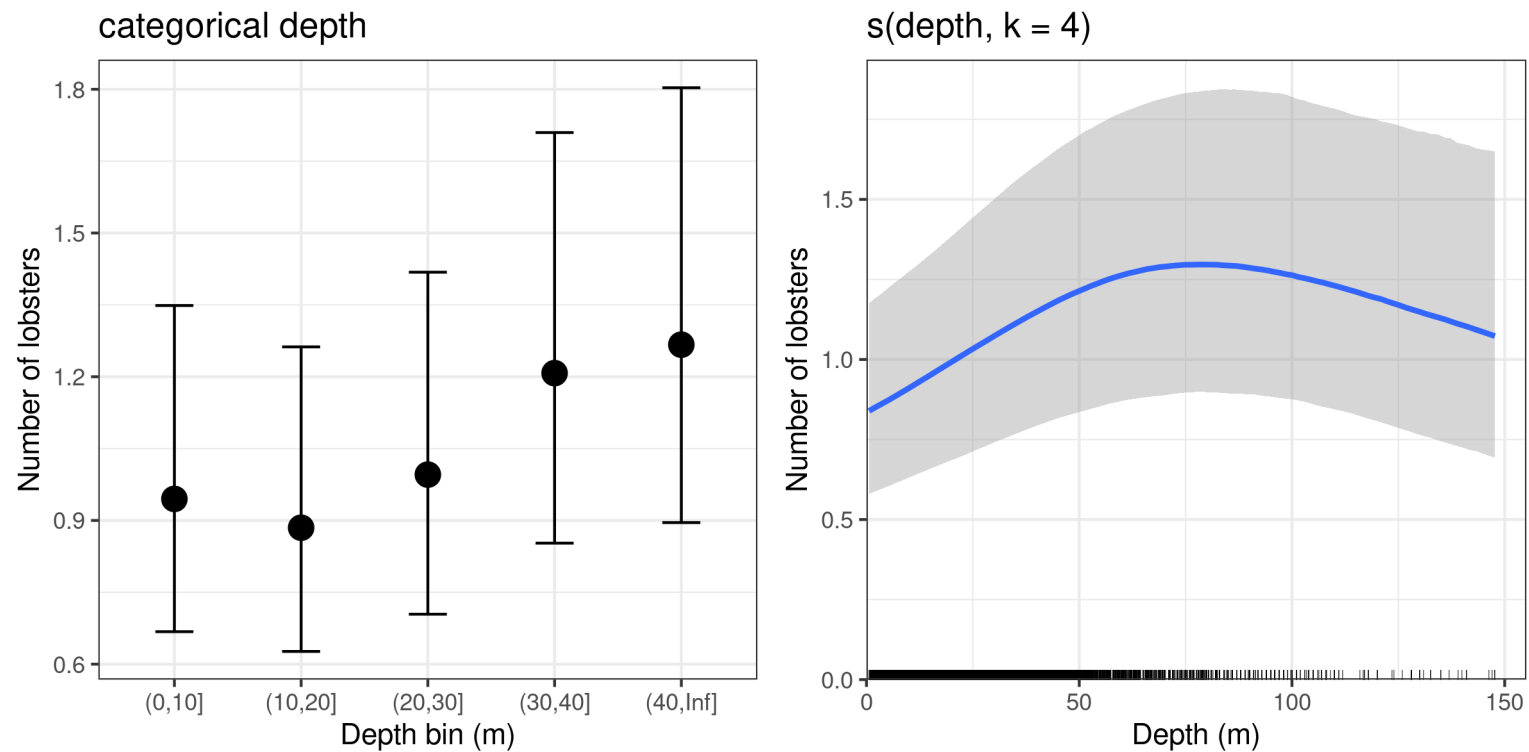
**Figure 23: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by pot and core vessels by pot data sets. Core vessels were defined as those vessels that had been in the logbook programme for at least three years. This was a simple model with the form *period*.**



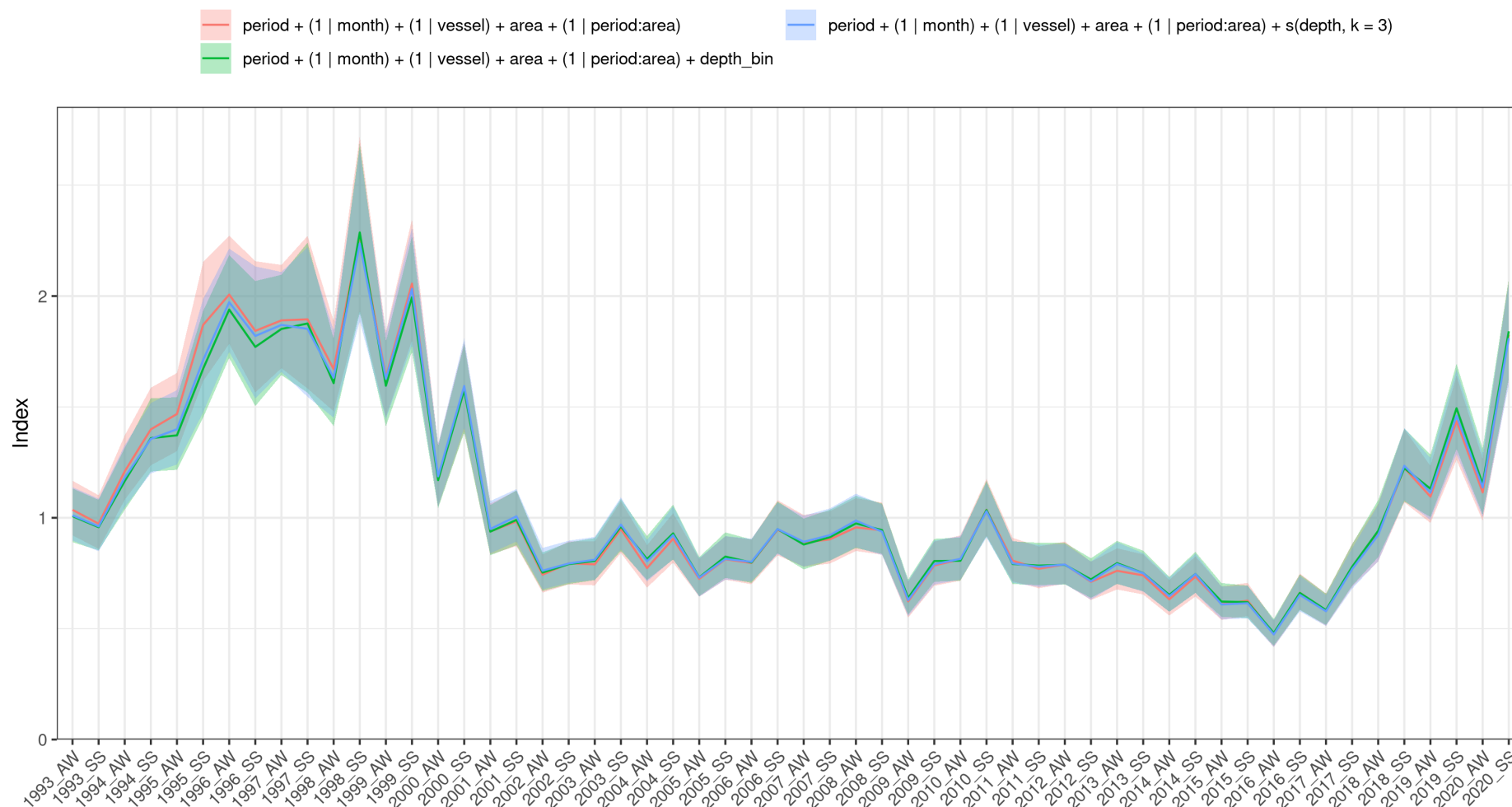
**Figure 24: Logbook: conditional effect of the presence of octopus [left] (for the model  $\log(pots) + period + (1 | month) + (1 | vessel) + area + (1 | period:area) + octopus$ ) or presence of packhorse rock lobster [right] (for the model  $\log(pots) + period + (1 | month) + (1 | vessel) + area + (1 | period:area) + phc$ ) on the number of lobsters caught using the by\_pot data sets. The LOO IC for each of these models is provided in Table 17.**



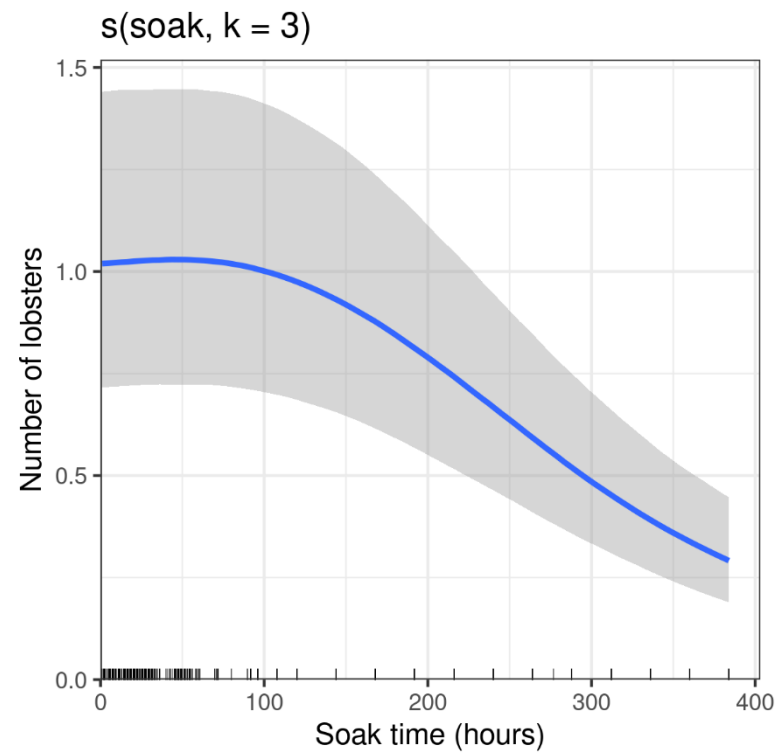
**Figure 25: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by\_pot data set for the models that include octopus (*octopus*) and packhorse rock lobster (*phc*) terms. The LOO IC for each of these models is provided in Table 17.**



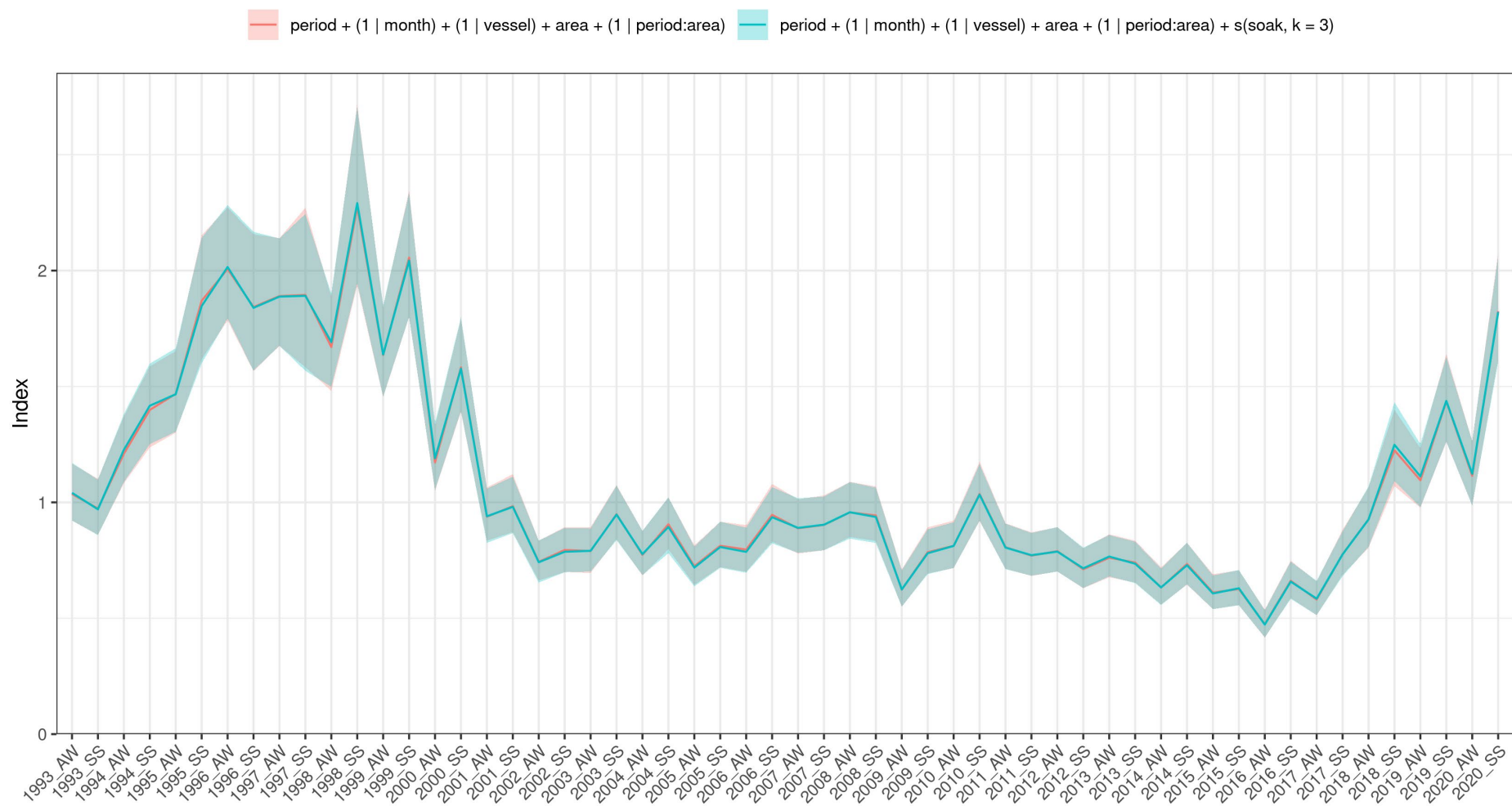
**Figure 26:** Logbook: conditional effect of depth (m) on the number of lobsters caught using the by\_pot data set when depth is treated as a categorical variable (for the model  $period + (1 | month) + (1 | vessel) + area + (1 | period \times area) + depth\_bin$ ) [left] or a spline (for the model  $period + (1 | month) + (1 | vessel) + area + (1 | period \times area) + s(depth, k = 4)$ ) [right]. The black tick marks at the bottom of the right plot indicate the depth for each data point. The LOO IC for each of these models is provided in Table 17.



**Figure 27: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by pot data set that included depth terms. The LOO IC for each of these models is provided in Table 18.**

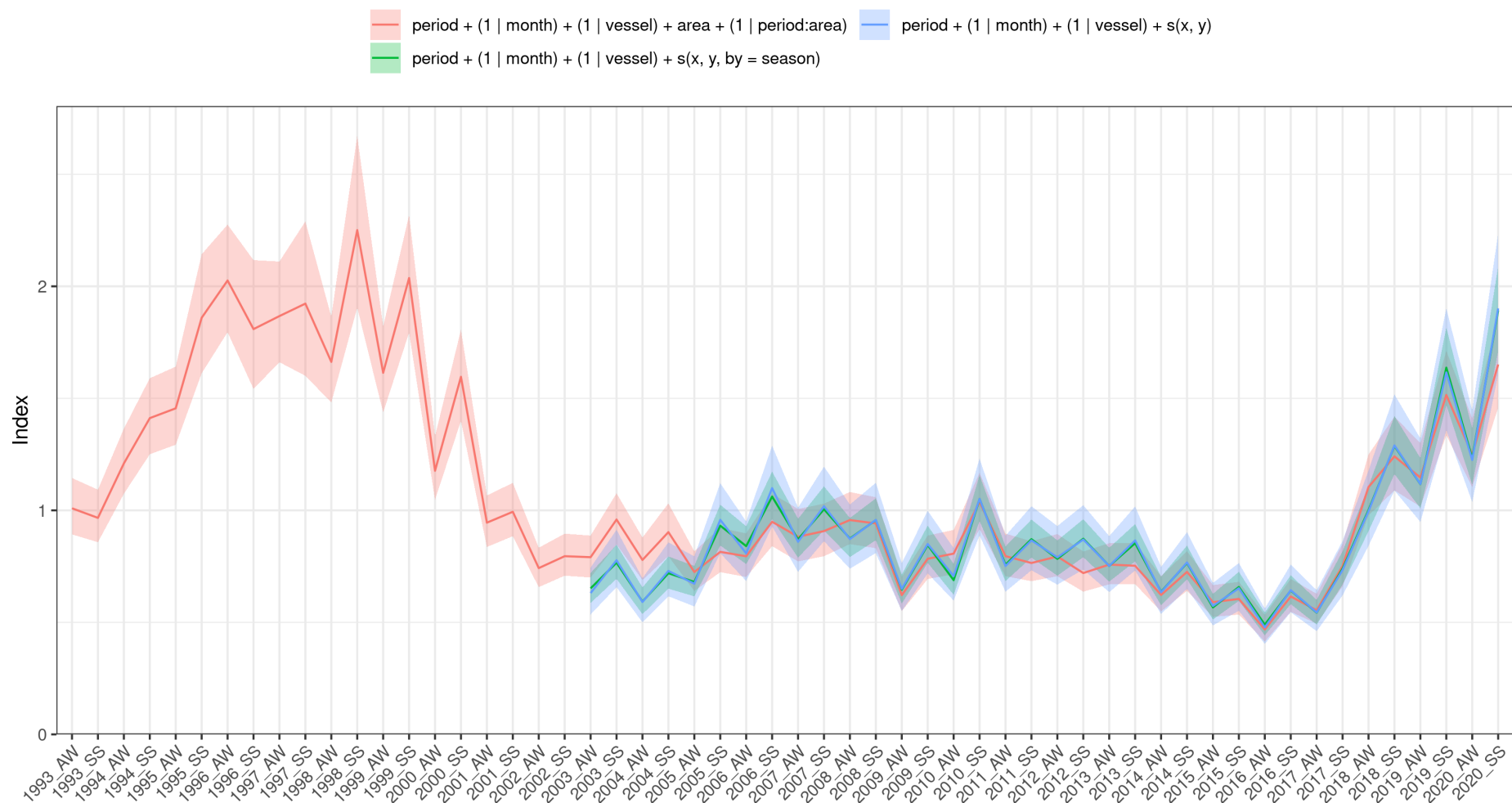


**Figure 28: Logbook: conditional effect of soak time (hours) on the number of lobsters caught using the by pot data set when depth is treated as a spline. The black tick marks at the bottom of the plot indicate the soak time for each data point. The LOO IC for this model is provided in Table 17.**

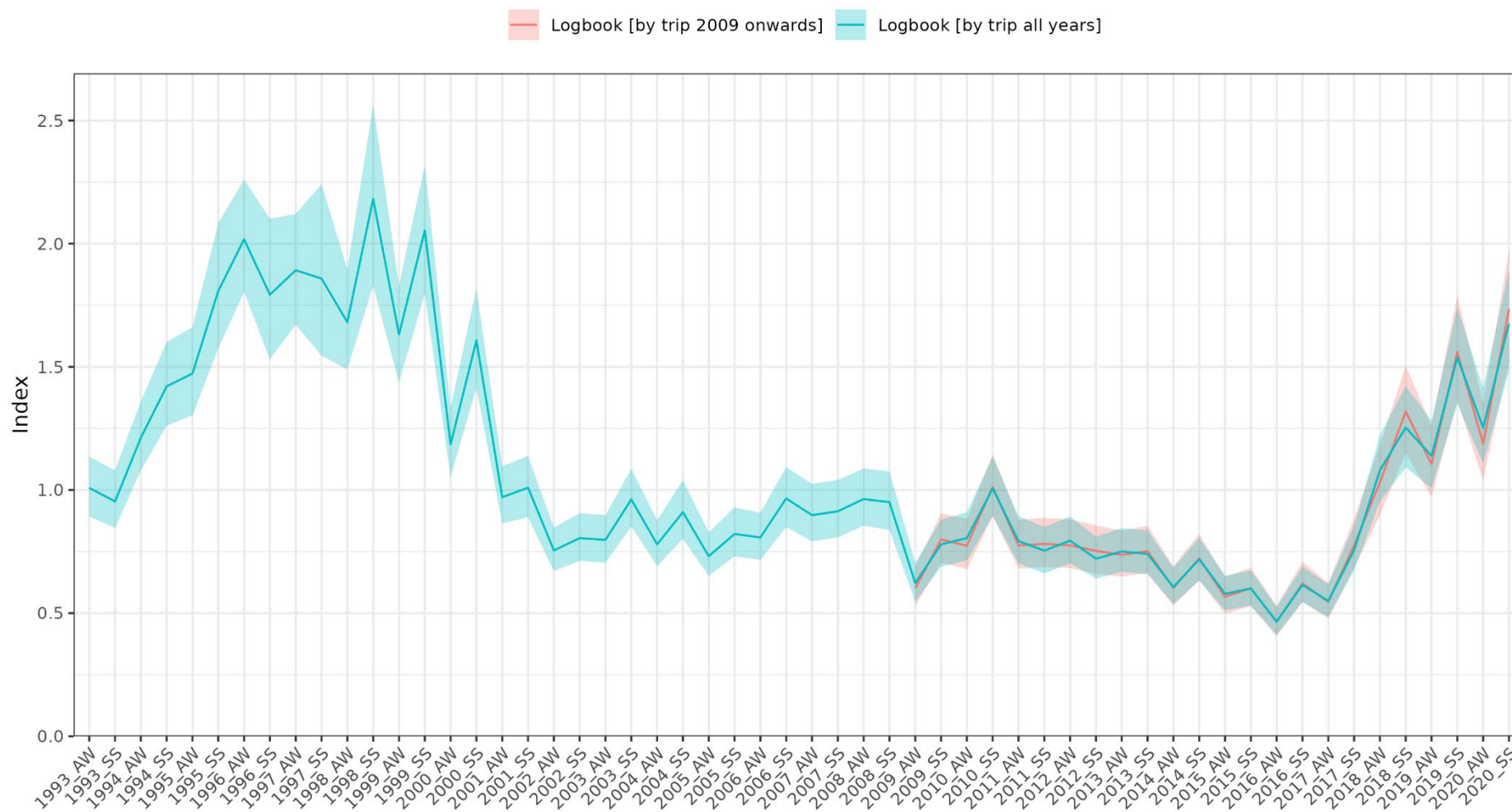


**Figure 29: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by\_pot data set for the model that includes a soak time term. The LOO IC for each of these models is provided in Table 18.**

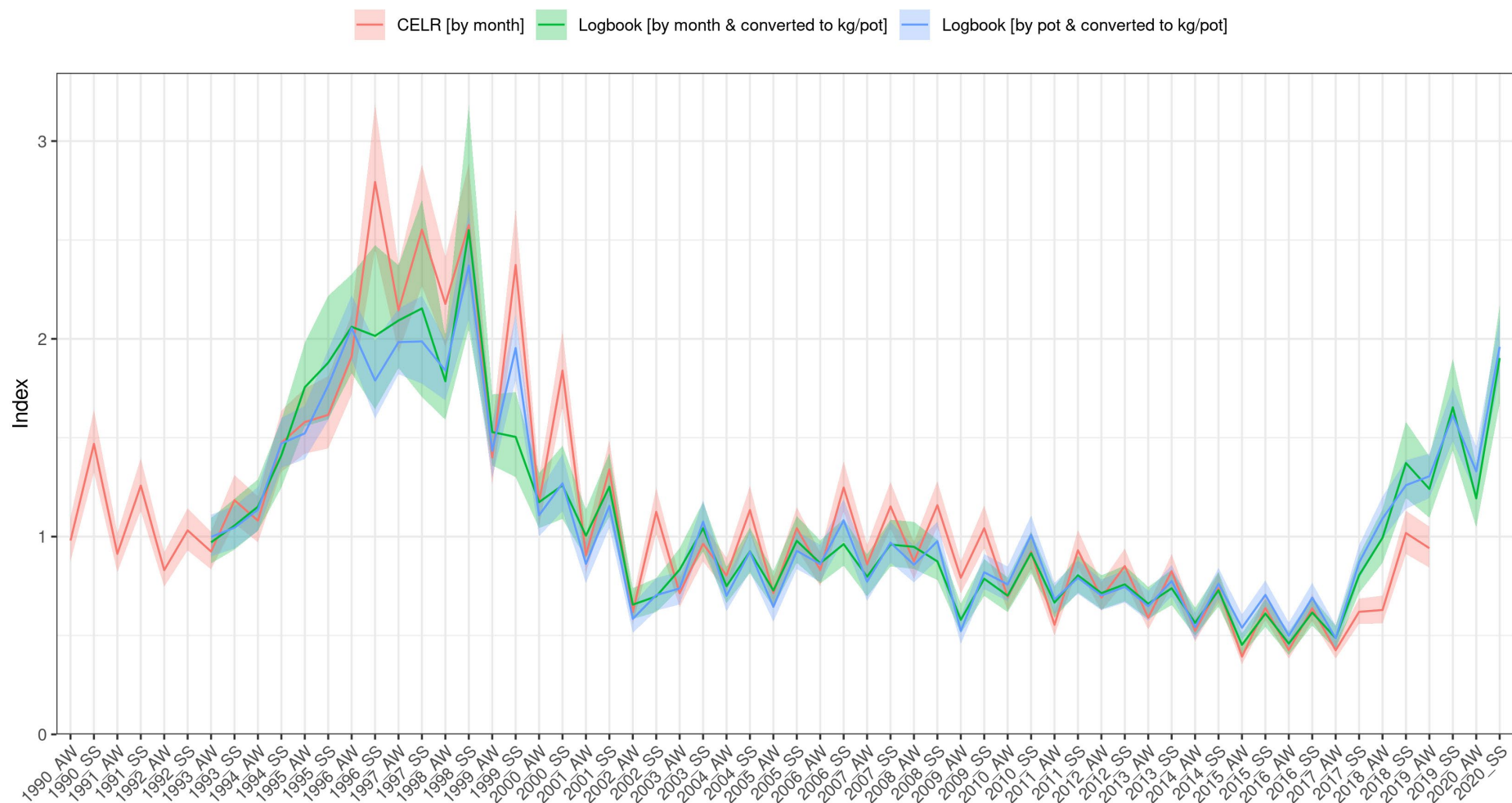




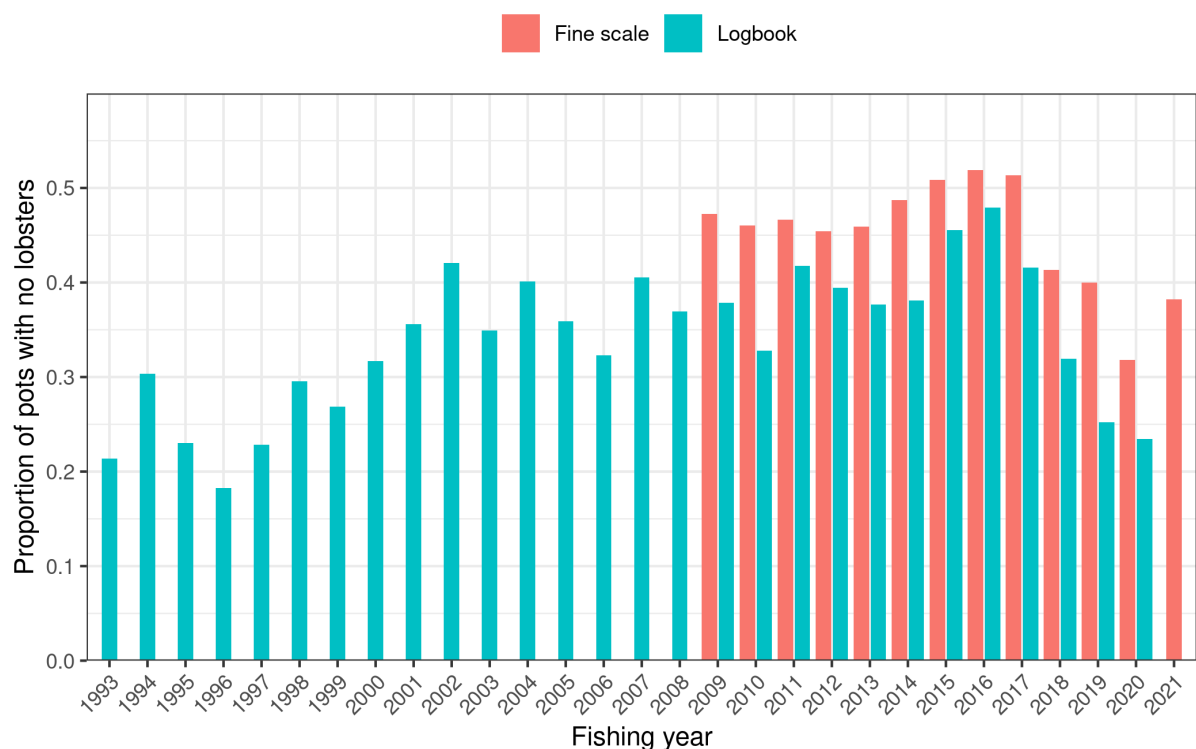
**Figure 30: Logbook: median standardised CPUE and 50% credible interval by period for models fitted to the by\_pot data set for the models that include spatial terms. The LOO IC for each of these models is provided in Table 18.**



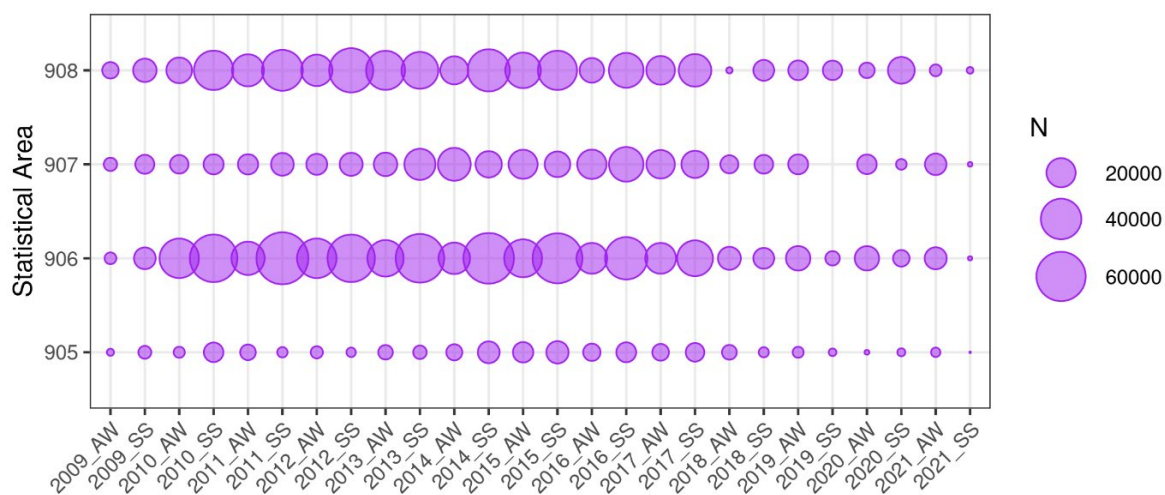
**Figure 31: Comparison of the logbook CPUE series fitted to data aggregated by trip, for all years and from 2009 AW onwards, with the model structure  $\log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$ .**



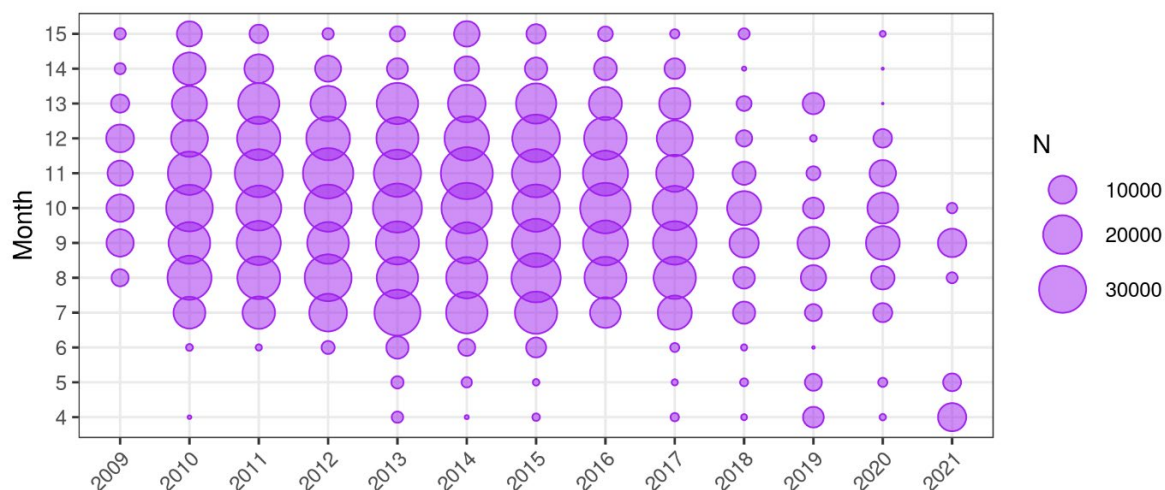
**Figure 32: Comparison of the CELR and logbook CPUE series. The data for the CELR series was aggregated by month with units kg/pot and a lognormal distribution was assumed. The data for the logbook series were either not aggregated (using the kg by pot data set) with units kg/pot and a hurdle-lognormal distribution was assumed or aggregated by month (using the kg by month data set) with units kg/pot and a lognormal distribution was assumed. In all cases, the model structure was  $period + (1 | month) + (1 | vessel) + area + (1 | period \times area)$ .**



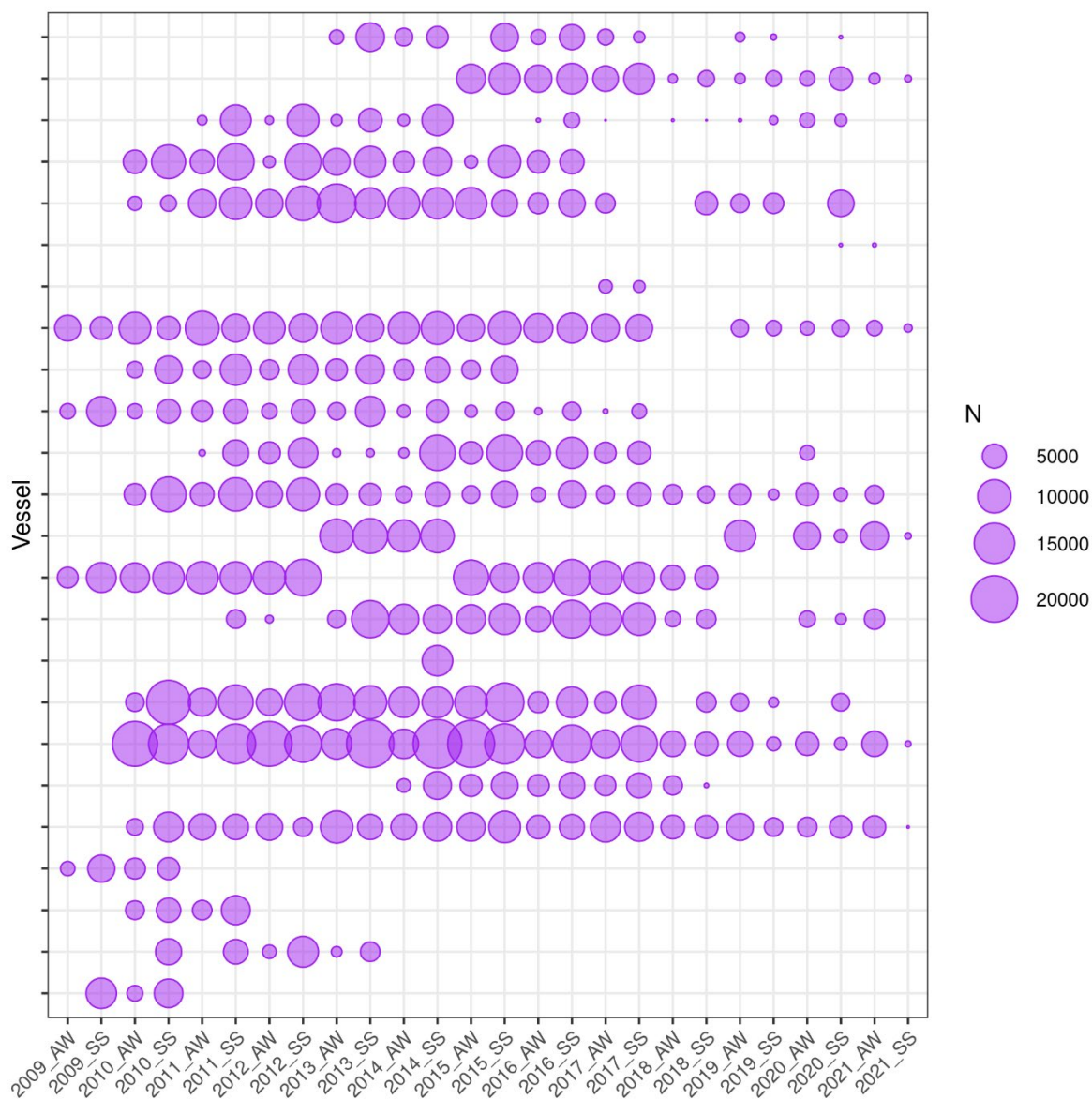
**Figure 33: Proportion of pots lifted containing no lobsters by fishing year in the logbook and fine scale programmes. Note that these proportions were derived from all lobsters (i.e., above and below the MLS and any legal status). This comparison is based on the subset of fishers who participated in both the logbook and fine scale programmes in the same fishing year.**



**Figure 34: Fine scale: the number of records/potlifts by period and statistical area in the fine scale data set. See Figure 1 for the locations of these statistical areas.**

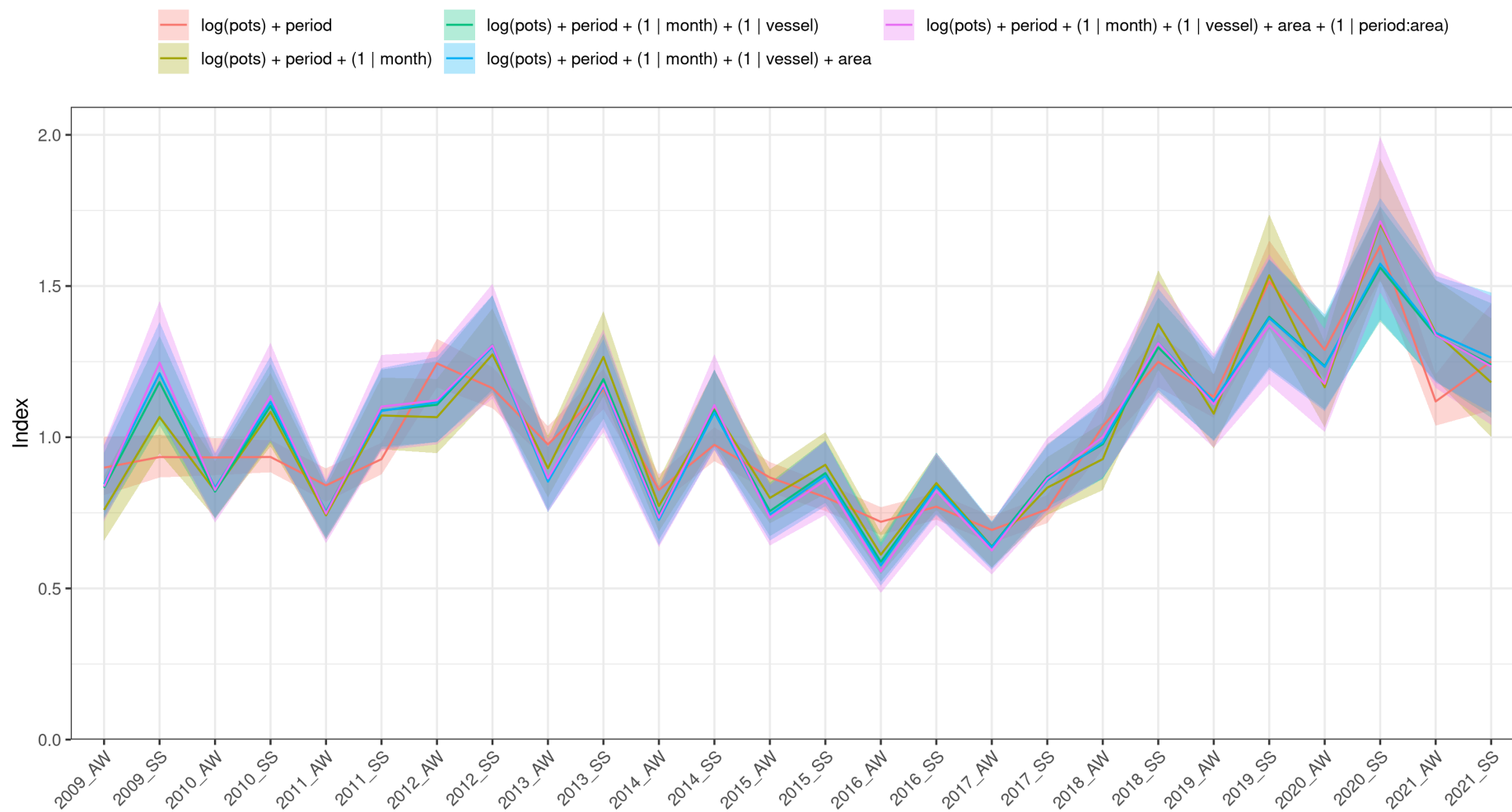


**Figure 35: Fine scale: the number of records/potlifts by fishing year and month in the fine scale data set.**

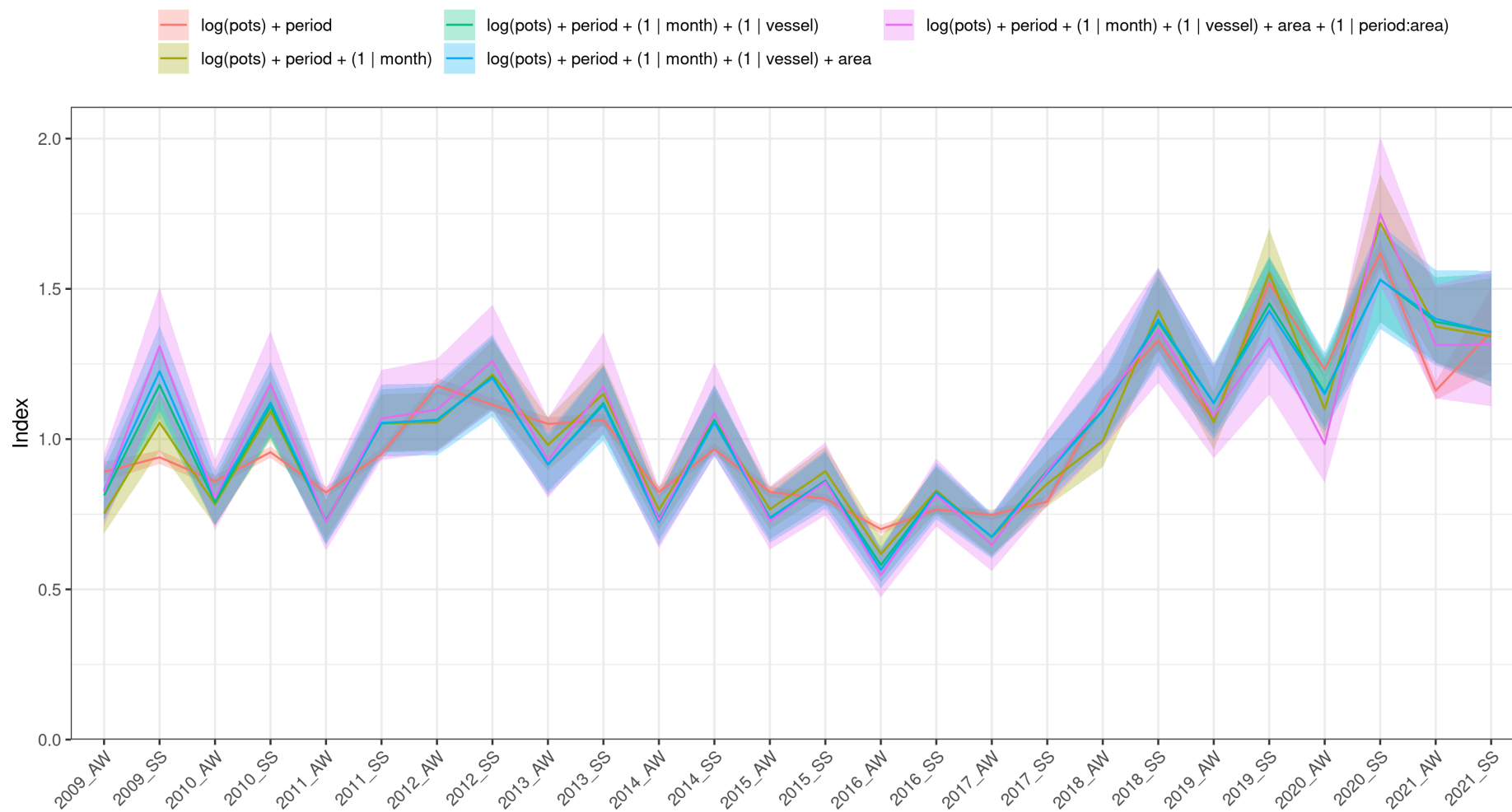


**Figure 36: Fine scale: the number of records/potlifts by period and vessel for the 24 vessels in the fine scale data set. Note that the vessel keys have been removed from the y-axis of this plot.**

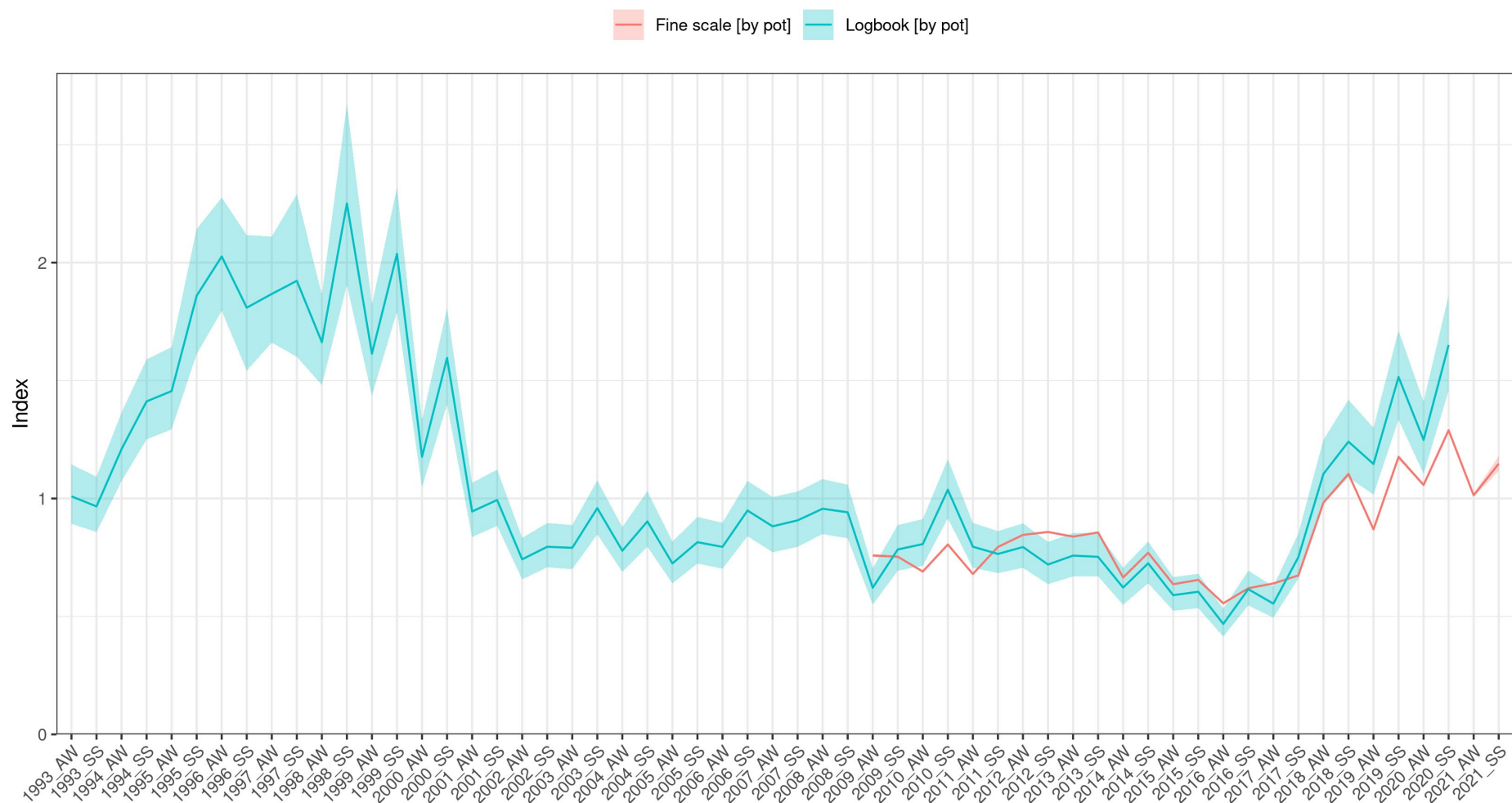




**Figure 37: Fine scale: median standardised CPUE and 50% credible interval by period for the suite of models fitted to monthly data. The LOO IC for each of these models is provided in Table 22.**

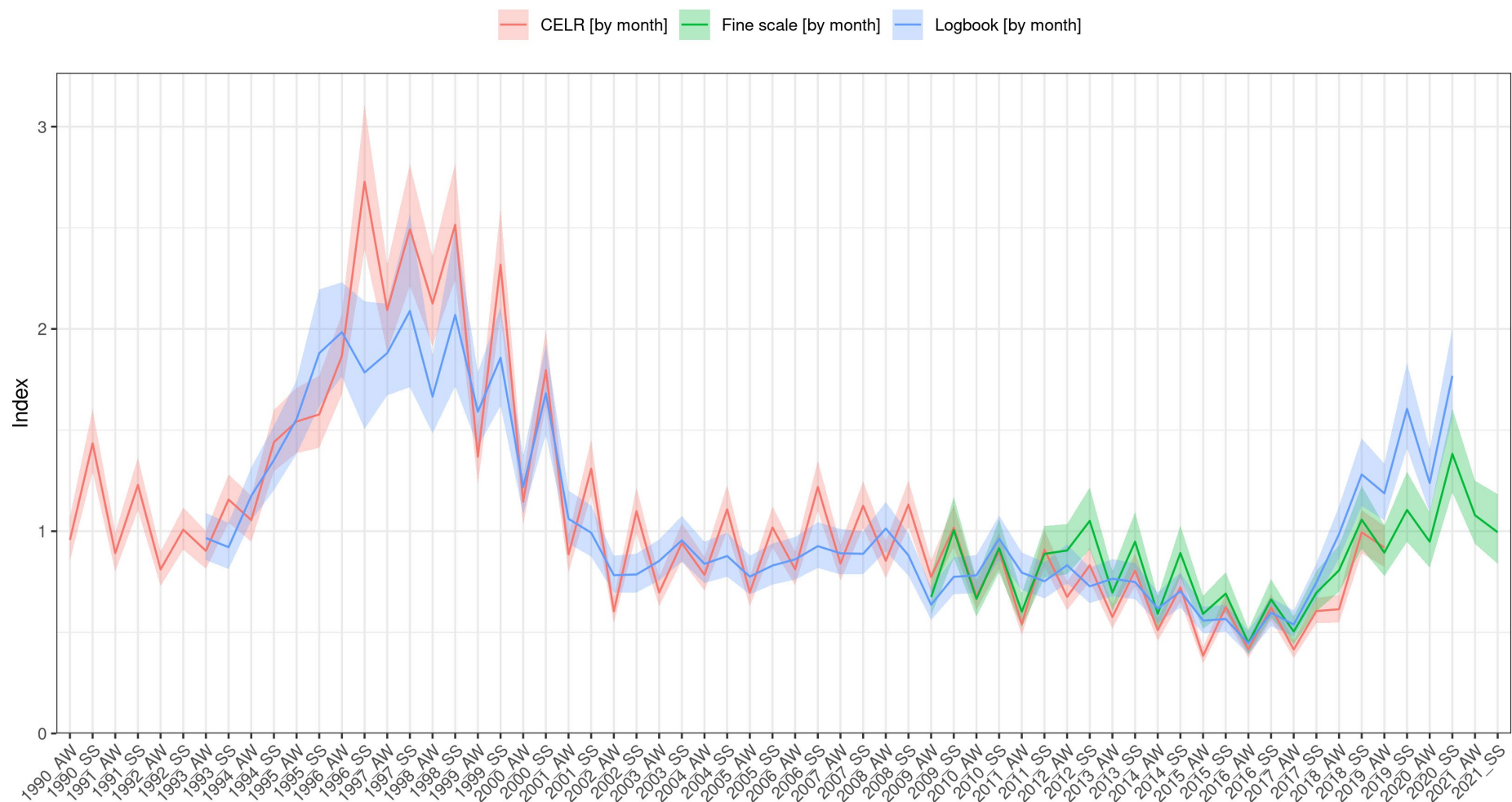


**Figure 38: Fine scale: median standardised CPUE and 50% credible interval by period for the suite of models fitted to trip level data. The LOO IC for each of these models is provided in Table 22.**

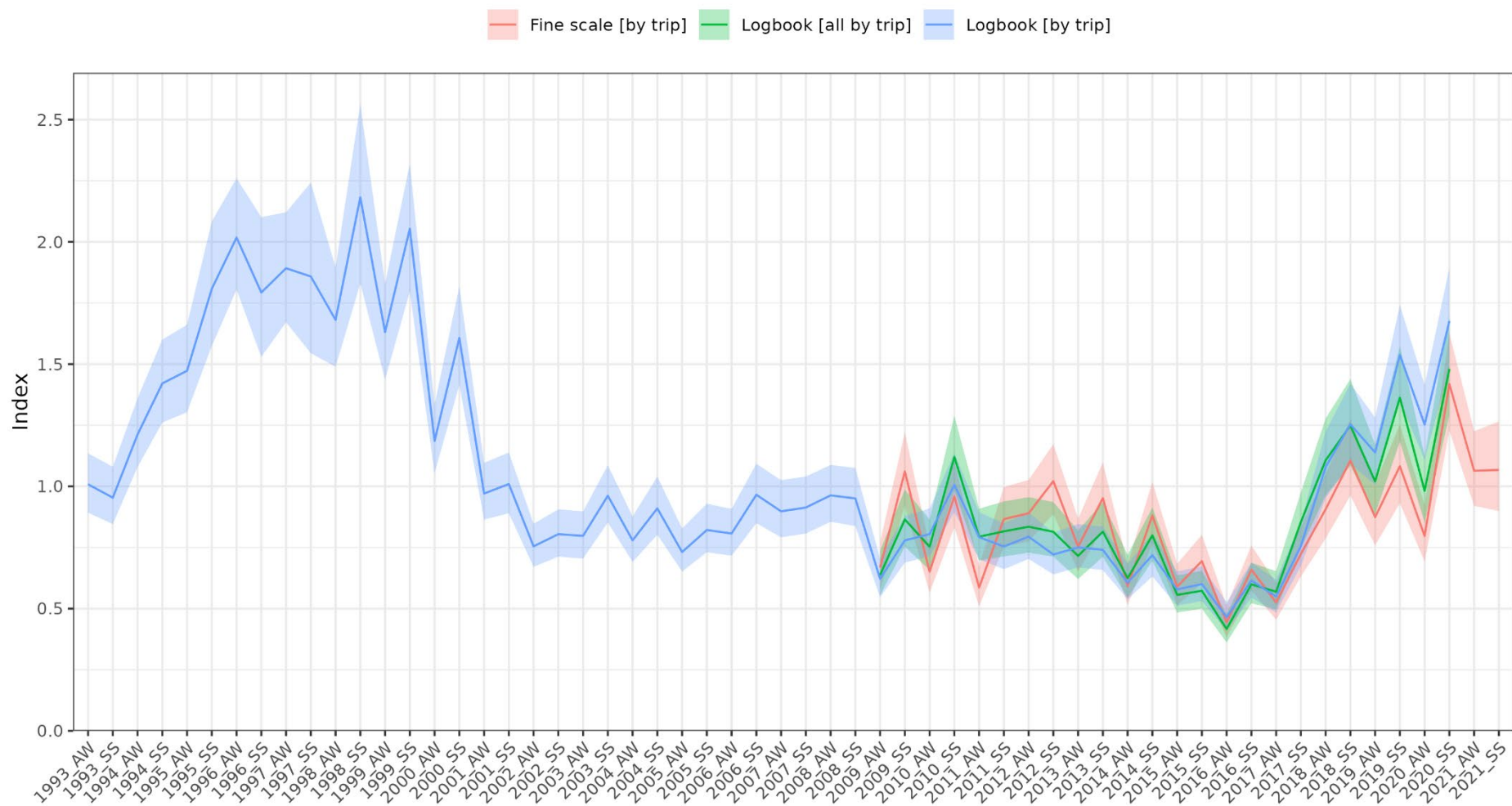


**Figure 39: Comparison of the logbook (using the kg by pot data set) and fine scale CPUE series fitted to data by pot with the model structure *period*. More complex models for the fine scale analysis by pot were too slow.**





**Figure 40: Comparison of the CELR, logbook (using the kg by pot data set), and fine scale CPUE series fitted to data aggregated by month showing the median standardised CPUE and 50% credible interval by period with the model structure  $\log(pots) + period + (1 | month) + (1 | vessel) + area + (1 | period \times area)$ .**



**Figure 41: Comparison of the logbook (the by trip and all by trip data sets) and fine scale CPUE series fitted to data aggregated by trip with the model structure  $\log(\text{pots}) + \text{period} + (1 \mid \text{month}) + (1 \mid \text{vessel}) + \text{area} + (1 \mid \text{period} \times \text{area})$ .**

# APPENDIX A LOGBOOK PAPER FORMS

Date: 06/05/96 Vessel: 84034 Stat. area: 927 Sub area: 07 Page 1 of 3

Skipper: Joe Bloggs. SAMPLE FORM

Pot #1 Pot #2 Pot #3 Pot #4

Soak Time: (Day/Hours) 0.3 (Day/Hours) 0.1 (Day/Hours) 2.7 (Day/Hours)

Depth: (feet, fathoms, metres) 1.8 (feet, fathoms, metres) 3.0 (feet, fathoms, metres) 4.5 (feet, fathoms, metres)

\* Actual width = 107

Sex Tail width

\* This pot was not lifted

Sex Tail width

\* This pot was lifted but was empty

Sex Tail width

\* When the column is full count the remaining fish above and below the size limit (regardless of their legal status) and record each total in the appropriate box

Excess catch (Numbers):

Above size limit

Below size limit

Dead

Predators:

Octopus

Other

Excess catch (Numbers):

Above size limit

Below size limit

Dead

Predators:

Octopus

Other

Excess catch (Numbers):

Above size limit

Below size limit

Dead

Predators:

Octopus

Other

Excess catch (Numbers):

Above size limit

Below size limit

Dead

Predators:

Octopus

Other

Write comments on back of form

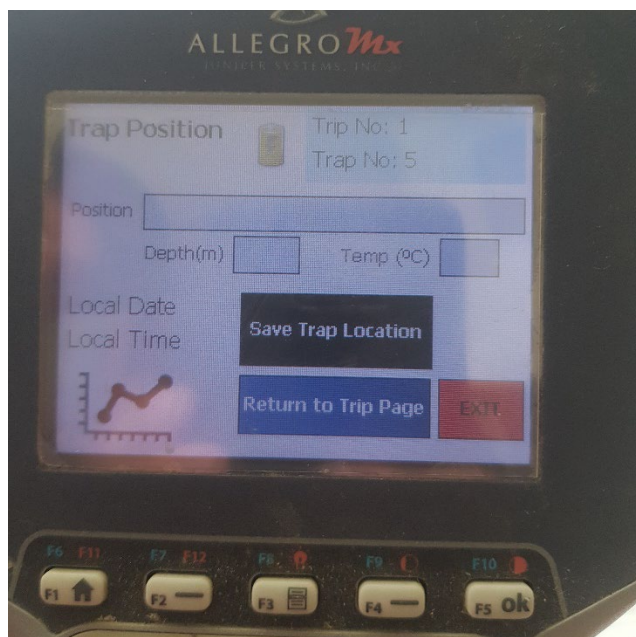
Figure A.1: An example of a completed paper logbook form. This version of the form allows for 31 lobsters to be measured and was used up until 1998.



**Figure A.2:** The paper logbook form. This version of the form allows for 25 lobsters to be measured, allows latitude and longitude to be reported, and was used from 1998.

## APPENDIX B ALLEGRO SOFTWARE

Since 2009, all logbook and fine scale data in CRA 2 have been collected using the Allegro unit.



After entering information about the trip on the 'Trip Page', the fisher is asked to record pot location, depth, and temperature on the 'Trap Position' page. Once this is done, the fisher can then select 'Save Trap Location' to begin entering information about the catch in that pot.

**Trap Position**

 Trip No: 1  
Trap No: 2

Position

Depth(m)  Temp (°C)

Local Date  
Local Time



**Save Trap Location**

**Return to Trip Page** **EXIT**

Once the pot information above is saved, the page changes to entering the 'Catch Data'. For the pot, enter the number of 'Crays caught', 'Crays kept', 'Crays dead', 'PHC Caught', 'PHC Kept', 'Octopus' caught, and 'Other' species caught. The fisher is forced to complete the 'Crays caught' field and then the 'Crays kept' field (the fields default to Nil). Once 'Crays kept' is entered, the cursor moves to 'SAVE' (typically traps only contain CRA). The fisher can also choose to 'Measure' if at a logbook pot.

**Catch Data**

Trip No: 1      Logbook  
 Trap No: 2      1

Crays Caught **Nil**

Crays Kept **Nil**

Crays Dead **Nil**

PHC Caught **Nil**

PHC Kept **Nil**

Octopus **Nil**

Other **Nil**

Soak Time **1**

**SAVE** **CANCEL**

**Measure** **Tags**

If the fisher enters the number of fish caught and then attempts to open the 'Measure' tab, they get the following warning

**Catch Data**

Trip No: 1      Logbook  
 Trap No: 1      0

Crays Caught **5**

Crays Kept **2**

Crays Dead **Nil**

PHC Caught **Nil**

PHC Kept **Nil**

Octopus **Nil**

Other **Nil**

**Measure** **Tags**

**Counts not allowed yet** **ok**

Do not enter counts when you intend to measure.

If the pot is a logbook pot and 'Measure' is selected, then the fisher is asked to enter the 'Sex', 'TailWidth', and if the lobster was 'Kept' or not. A validation check is done.

**Measurements - Trap No. 2**

| CrayNo | Sex | TailWidth | Kept  |
|--------|-----|-----------|-------|
| 1      | MF  | 63        | False |

**Cray Too Small** **ok**

Undersize Male Crayfish. Animal below size limit is marked KEPT

No. **2** Sex **MM** Tail Width (mm) **45** ☒ **Kept**

**Done** **CANCEL**

**Measurements - Trap No. 1**

| CrayNo | Sex | TailWidth | Kept |
|--------|-----|-----------|------|
| 1      | MM  | 54        | True |

No. **2** Sex **MM** Tail Width (mm) **63** ☒ **Kept**

**SAVE** **Done** **CANCEL**

After the fisher is finished measuring and they select 'Done', they are returned to the 'Catch Data' page and asked if there is anything else in the pot to enter.

**Catch Data**

|            |         |
|------------|---------|
| Trip No: 1 | Logbook |
| Trap No: 2 | 2       |

Crays Caught

Crays Kept

Crays Dead

PHC Caught

PHC Kept

Octopus

Other

**Is there more data?**

Do you have more data to enter: ie. PHC or OCT?

When returned to the 'Catch Data' page, the software auto populates the 'Crays Caught' and 'Crays kept' fields from the data entered on the 'Measurements' page. In the example below, the Allegro is showing that 25 fish were measured with 16 kept, but fishers do have the ability to add more fish to the overall caught and kept totals.

**Catch Data**

|            |         |
|------------|---------|
| Trip No: 1 | Logbook |
| Trap No: 3 | 2       |

Crays Caught

Crays Kept

Crays Dead

PHC Caught

PHC Kept

Octopus

Soak Time

If the fisher enters the number of 'Crays Caught' and this number is less than the number measured a warning is issued. Warnings are also issued if the 'Crays Caught' field is large.

**Catch Data**

|            |         |
|------------|---------|
| Trip No: 1 | Logbook |
| Trap No: 3 | 2       |

Crays Caught

Crays Kept

Crays Dead

PHC Caught

PHC Kept

Octopus

**Check Data**

The number caught must not be less than the number measured.

**Check Data**

You have entered a large number. Is this correct?

It is at this point that 'Crays dead' can be entered. If the fisher selects 'Crays dead' then it asks for further information. Dead crays are not counted against the number of crays in the pot.

### Catch Data

|              |                                                                                                                                              |                                                                                                                                             |         |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------|
| Crays Caught | 1                                                                                                                                            | Trip No: 1                                                                                                                                  | Logbook |
| Crays Kept   | 0                                                                                                                                            | Trap No: 2                                                                                                                                  | 2       |
| Crays Dead   | 5                                                                                                                                            | Soak Time                                                                                                                                   |         |
| PHC Caught   | Nil                                                                                                                                          | 1                                                                                                                                           |         |
| PHC Kept     | Nil                                                                                                                                          | <div style="border: 1px solid black; padding: 5px;">SAVE</div> <div style="background-color: red; color: white; padding: 5px;">CANCEL</div> |         |
| Octopus      | Nil                                                                                                                                          | <div style="background-color: cyan; padding: 5px;">Measure</div> <div style="background-color: yellow; padding: 5px;">Tags</div>            |         |
| Other        | <div style="border: 1px solid black; padding: 2px;">▼</div> <div style="border: 1px solid black; padding: 2px; margin-left: 10px;">Nil</div> |                                                                                                                                             |         |

DeadCrays
🔊 1:39

Save

Cancel

Below MLS: 5

Above MLS: 0 ☐ Kept

Finally, a small summary is provided to fishers which provides a running summary of the current trip and information about all of their trips.

| Analysis                               |      | GRAPH |  |
|----------------------------------------|------|-------|-----------------------------------------------------------------------------------|
| Current Trip - 0 traps                 |      |       |                                                                                   |
| Number of Crays Caught                 | 0    |       |                                                                                   |
| Number of Crays Kept                   | 0    |       |                                                                                   |
| CPUE* for today                        | 0    |       |                                                                                   |
| All Data - 40 trips. 3790 traps.       |      |       |                                                                                   |
| Total number of Crays Caught           | 7319 |       |                                                                                   |
| Total number of Crays Kept             | 5524 |       |                                                                                   |
| Total CPUE*                            | 1.46 |       |                                                                                   |
| Total Destination X Crays              | 0    |       |                                                                                   |
| * CPUE = Num Kept per Trap (kept/trap) |      |       |                                                                                   |



## APPENDIX C LOGBOOK INSTRUCTIONS

### INSTRUCTIONS FOR FILLING IN THE ROCK LOBSTER LOGBOOK

Thank you for participating in this industry funded and organised data collection project. The data collected as part of this programme will be used in the stock assessment process, which assists in characterising your fishery, so that conclusions about the population being fished can be drawn. The data collected by this programme will be under full control of your regional representative group, and will remain **confidential**, with only authorised stock assessment specialists accessing the raw data. Data summaries will be provided when the data is given to your commercial stakeholder organisation, or used in the stock assessment process.

#### SELECTION OF POTS:

Choose **FOUR** pots at random. Try to pick four average pots (not your best or worst pots) and fish them as you would fish all your pots. Tags have been provided to identify the four individual pots. Please ensure that these tags are attached securely with the cable ties provided. Loop the ties through twice if possible. The tags may be placed either on the pots or the floats. Once chosen, these four pots are to be sampled every time they are pulled whether or not they contain lobsters. The four chosen pots should be sampled on every normal fishing day.

If possible, do not change pots within a season unless there are overriding reasons (such as pot loss, etc.). If you do lose a pot, please replace it with a similar pot and see your technician for another tag. Selected pots can be moved, especially if this is the way you usually manage your pots. Remember that these pots are to be representative of your average fishing success, not your best or worst.

Once a year (or if the sampled pots change significantly), you will be asked to complete a datasheet describing the pots you are sampling from and outlining a summary of your fishing patterns.

#### MEASUREMENT METHOD:

A set of plastic vernier callipers has been provided for the measurement of the tail width of each sampled rock lobster. The plastic callipers have been modified to standardise the position from where the measurement is taken.

The number of millimetres should be read at the 0 mark on the slide. Round down to the nearest millimetre, i.e. a tail width of 53.9 mm should be recorded as '53'.

**Note:** *These callipers have been provided to be used with the Rock Lobster logbook programme only and should not be used in place of the official MFish measuring gauge used in MFISH projects.*

**MEASURE ONLY LIVE ROCK LOBSTERS!**

**MEASURE ONLY RED ROCK LOBSTERS!**

**FILLING IN THE DATASHEETS:**

The datasheets are printed on waterproof paper and can be rinsed with fresh water to prevent them sticking together. Use the pencils provided to fill in the datasheet (otherwise use a medium or soft pencil i.e. 'H' or 'HB'). Remember that pens don't like salt water! Take care not to smudge the pencil and write as clearly as possible (capitals are best). The data is of no use if it can't be read.

Please try to fill in every record where possible but DO NOT EVER make up information. If you are not sure, leave the box blank and make a note in the comment section. It is easier for someone to check with you later than to try to fix 'wrong' data.

- DATE:** Record the day, month and year. The 2nd of April 2000, for example, would be recorded as '020400'. It is important that the correct date is recorded.
- VESSEL:** Record the Vessel Registration Number.
- SKIPPER:** Record the name of the skipper of the vessel on the day.
- STAT. AREA:** The map provided at the rear of this document shows the rock lobster statistical areas. Record in this box the number that best represents the area that the sampled pots were lifted from.
- SWELL:** Record the direction and height of the sea swell that best describes the conditions during your trip to lift pots for this day. Record the direction as a compass heading (e.g. NE for North East). Record the swell height in metres.
- WIND:** Record the direction and speed of the wind that best describes the conditions during your trip to lift pots for this day. Record the direction as a compass heading (e.g. SW for South West). Record the wind speed in knots.
- SOAK TIME UNITS:** Record the units you use for ALL Soak time entries on this datasheet. Cross out the inappropriate unit leaving only the suitable unit (either days or hours).  
ALWAYS INDICATE THE UNITS YOU USE.
- DEPTH UNITS:** Record the units you use for ALL the Depth entries on this datasheet. Cross out the inappropriate units leaving only the suitable unit (feet, fathoms or metres).  
ALWAYS INDICATE THE UNITS YOU USE.
- ZONE:** The list provided in the Logbook Kit details the zones developed for this logbook programme. Record the code for the zone that represents the area, where each sampled pot was lifted.

**SOAK TIME:** Record either the number of whole hours or whole days that each individual sampled pot was soaked. Even if the sampled pot is empty, this box must be filled in.  
ALWAYS RECORD THE SOAK TIME UNITS AT THE TOP OF THE SHEET.

**DEPTH:** Record the depth at the position each sampled pot was lifted. Again, even if the sampled pot is empty, this box must be filled in.  
ALWAYS RECORD THE DEPTH UNITS AT THE TOP OF THE SHEET.

**NOTE:** *If a pot is empty, the soak time and the depth boxes still need to be filled in. If the pot was not lifted, then the soak time and depth boxes will be left blank and a line is to be drawn through the 31 biological boxes (see sample datasheet).*

**SEX:** Record the sex as a code. If the sampled pot is empty, leave this column blank.

Two features make it easy to determine the sex of the rock lobster.

1. The female has small pincers on the rear pair of legs, these are absent in the male.
2. The red rock lobster has appendages (pleopods) attached to each side of four segments under the tail. In the female, these appendages are branched. On the male, the appendages are unbranched.

Setae are hairs that carry eggs on the narrow branch, which lies under the wide branch of the pleopod. The lengths of these setae are used to determine the maturity of the female. Look at the pleopods in the mid-section of the tail. Ignore the tuft of setae on the end of the narrow branch.

Record the appropriate code (in bold print below) in the sex box from the following list, this list is also provided on the laminated sample datasheet.

Male: **MM** - All males.

Female: **IF** - Immature female - the setae are less than 6mm ( $\frac{1}{4}$  inch) long, and often much less.

**MF** - Mature female - the setae are longer than 6mm ( $\frac{1}{4}$  inch).

**BF** - Berried female - eggs are attached to the setae.

**SF** - Spent female - some empty egg cases can be seen, and there may be unhatched or infertile eggs among them. The setae are often 'ratty' in appearance.

**CONTINUATIONS:** *If the sex of a rock lobster is repeated more than once, you can draw a line instead of writing the same code all the way*

down the column. The continuation line must go through at least two rows so it does not get mistaken for a “1”, and the repeated code must appear at the bottom of the continuation line. It also helps to draw an arrow head at the end of the continuation line (↓).

**TAIL WIDTH:**

Record the tail width of up to 25 LIVE rock lobster in the sampled pot. Round down to the nearest millimetre. If the sampled pot is empty, leave this column blank, but fill in the depth and soak time in the pot header section.

Please record ALL digits of the tail width measurement.

**NOTE:** *There is only space on the datasheet for 25 lobsters to be measured from each sampled pot. If the number of lobsters in the sampled pot is more than 25, the remainder is to be counted and the number recorded in the appropriate box under additional catch.*

**ADDITIONAL CATCH:**

When there are more than 25 **LIVE** rock lobsters in the sampled pot measure only 25 lobsters. Pick the 25 lobsters at random, not just the largest or the smallest fish. The remainder is to be counted and the number recorded in the appropriate box: the number above the Minimum Legal Size (MLS) and the number below the Minimum Legal Size. Berried females should be treated as if they are legal (if they are above the female size limit).

Any **DEAD** rock lobsters should be counted and the number recorded in the appropriate box: the number above the Minimum Legal Size and the number below the Minimum Legal Size.

For any **OTHER** species found in the pot record the name and the number of each species found in the pot in the appropriate boxes. A box is allocated to “Octopus” and “PHC” (Packhorse Lobster) and one other box has adjacent space where you can record the species name.

For the LIVE and DEAD rock lobsters that are “Above MLS” and the “PHC”, please indicate whether these were retained (kept).

**COMMENTS:**

If you have left any categories on the datasheet blank, then make notes for the reason on the bottom of the datasheet. Make sure the pot number is clearly associated with the appropriate notes.

If there are further species caught in the pot record the details (name and numbers of each species) in the comment box or on the back of the datasheet. If there are any other factors that you think may have affected the catch in an individual sampled pot in any way (e.g. current, time of day, increasing roll, bad set, weather...), record them here also.

**SENDING IN THE DATASHEETS:**

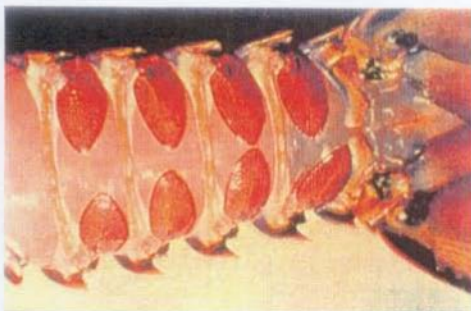
Send the datasheets in to your area technician or to NZ RLIC every two to four weeks in the envelopes provided, or when it best suits you to do so. Try not to accumulate too many datasheets at a time.

If you have any questions, contact your technician or NZ RLIC.

## CRA 2 Zones

| Zone | Name or Boundary                                    | Boundary                  | Features                                        |
|------|-----------------------------------------------------|---------------------------|-------------------------------------------------|
| B01  | Marotere Islands                                    |                           |                                                 |
| B02  | The Pinnacles                                       |                           |                                                 |
| B03  | Waipu River                                         | Pakiri River              |                                                 |
| B04  | Pakiri River                                        | Whangateau Harbour        |                                                 |
| B05  | Whangateau Harbour                                  | Mahurangi Harbour         |                                                 |
| B06  | Mahurangi Harbour                                   | Weiti River               | Includes Motoura, Kaitukala and Kawau Islands   |
| B07  | Weiti River                                         | Waitemata Harbour         |                                                 |
| B08  | Waitemata Harbour                                   | Waimangu Point            | Includes Brown and Pakihi Islands               |
| B09  | Rangitoto, Motutapu, Rakino, and The Noises Islands |                           |                                                 |
| B10  | Waiheke, Ponui, Rotoroa and Pakatoa Islands         |                           |                                                 |
| B11  | Waimangu Point                                      |                           |                                                 |
| B12  | Ngarimu Bay                                         |                           |                                                 |
| B13  | Deadmans Point                                      | Colville Bay              |                                                 |
| B14  | Mokohinau Islands                                   |                           | Includes Simpson Rock                           |
| B15  | Little Barrier Island                               |                           | Includes Horn Rock                              |
| B16  | East Great Barrier Island                           |                           | From Cape Barrier to Needles Point              |
| B17  | West Great Barrier Island                           |                           | From Needles Rock to Cape Barrier               |
| B18  | Colville Bay                                        | Cape Colville             |                                                 |
| C01  | Cape Colville                                       | Waikawau Bay              |                                                 |
| C02  | Cuvier Island                                       |                           |                                                 |
| C03  | Great Mercury, Kuripuki, Green and Middle Islands   |                           |                                                 |
| C04  | Stanley, Double and Red Mercury Islands             |                           |                                                 |
| C05  | Ohinau Island (East of 'Hole In The Wall')          |                           | Includes Cobra, Whale, Danger and Old Man Rocks |
| C06  | Waikawau Bay                                        | Whangapoua Harbour        |                                                 |
| C07  | Whangapoua Harbour                                  | Whitianga                 |                                                 |
| C08  | Whitianga                                           | Hot Water Beach           |                                                 |
| C09  | Hot Water Beach                                     | Tairua harbour            | Includes Shoe Island                            |
| C10  | Alderman Islands                                    |                           |                                                 |
| C11  | Tairua Harbour                                      | Whangamata Harbour        | Includes Slipper Island                         |
| C12  | Whangamata Harbour                                  | Waihi Beach               |                                                 |
| C13  | Waihi Beach                                         | Tauranga Harbour Entrance |                                                 |
| C14  | Major Island                                        |                           |                                                 |
| D01  | Tauranga Harbour Entrance                           | Waihi Estuary             | Includes Motiti and Motunau Islands             |
| D02  | Waihi Estuary                                       | Tarawera River            |                                                 |
| D03  | Tarawera River                                      | Ohiwa Harbour             | Includes Rurima Islands and Whale Island        |
| D04  | White Island                                        |                           |                                                 |
| D05  | Ohiwa Harbour                                       | Motu River                |                                                 |
| D06  | Motu River                                          | Kereu River               |                                                 |
| D07  | Kereu River                                         | Cape Runaway              |                                                 |
| D08  | Cape Runaway                                        | Te Arorua                 |                                                 |
| D09  | Te Arorua                                           | East Cape                 |                                                 |

## NZ RLIC LTD ROCK LOBSTER LOGBOOK PROGRAMME



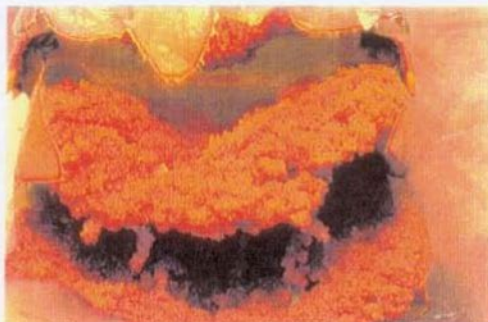
MM UNBRANCHED PLEOPODS



IF BRANCHED PLEOPODS AND SHORT SETAE



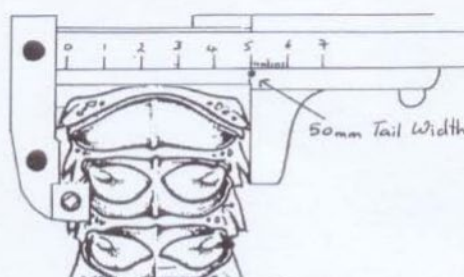
MF SETAE LONGER THAN 6MM



BF EGGS ATTACHED TO THE SETAE



SF SOME EGGS REMAINING, SETAE RATTY LOOKING



USE OF CALIPERS

THE SPINE OF THE SECOND TAIL SEGMENT IS FITTED INTO THE CORNER OF THE ADDED PIECE OF PLASTIC

### SEX CODES

|    |                 |                                          |
|----|-----------------|------------------------------------------|
| MM | MATURE MALE     | (ALL MALES)                              |
| IF | IMMATURE FEMALE | (SHORT SETAE-LESS THAN 6MM)              |
| MF | MATURE FEMALE   | (LONG SETAE-LONGER THAN 6MM)             |
| BF | BERRIED FEMALE  | (EGGS ATTACHED TO PLEOPODS)              |
| SF | SPENT FEMALE    | (SOME EGGS PRESENT, SETAE RATTY LOOKING) |

YOUR STATISTICAL AREA:

YOUR SUB AREA:

## VOLUNTARY ROCK LOBSTER LOGBOOK

### ANNUAL SURVEY

Thank you for participating in this industry organised data collection project. To give us an overall picture of how you fish we need you to provide details of your fishing operation. You only need to do this once a year. This information will remain confidential. Please fill out the Annual Survey form and pot description form as fully and as accurately as possible.

#### FILLING IN THE FORM:

- NAME OF FISHERMAN:** Record your name.
- ADDRESS/PHONE:** Record your address and phone numbers so we can contact you.
- NAME OF VESSEL:** Record your vessel name.
- VESSEL REGISTRATION:** Record your vessel registration number.
- SIZE OF VESSEL:** Record the length of the vessel here. Cross out whichever of 'meters/feet' does NOT apply.
- WORKING SPEED:** Record the working speeds of the vessel.
- HORSE POWER OF VESSEL:** Record the horsepower of the vessel.
- TOTAL NUMBER OF POTS:** Record the total number of pots that you fish with your vessel.
- QUOTA HELD:** Record the amount of quota held or fished against.
- EXPERIENCE:** Record your Rock Lobster fishing experience here. For example, the number of years fishing lobsters and the areas in which you have fished, etc.
- COMMENTS:** Record here any other information that you think would help us to get an over all picture of your fishing patterns. Also if the sample pots that you fish are identical, record that here and you only have to describe one pot.

## **FILLING IN THE FORM:**

### **POT DETAILS:**

completed.

For each of the four sample pots there is a table to be completed. If all your sample pots are identical then you only need to describe pot 1 in detail. Record in the comments section that the other 3 sample pots are identical. You can draw a picture of your pots on the back of the form if it will help in the

description.

### **POT DIMENSIONS:**

Record the dimensions as either the square/rectangular or the beehive/circular type of pot. If square/rectangular record as Length x Width x Height. If beehive/circular record as Top diameter x Bottom diameter x Height. Please indicate measurement units clearly e.g. metres, feet etc. This is where a picture might help.

### **FRAME MATERIAL:**

Record the type of material used for the frame e.g. steel, wood, supplejack, wire, etc.

### **MESH MATERIAL:**

Describe the type of material used for the mesh. This can often be a combination of materials e.g. 15% trawl mesh and 85% chicken wire.

### **MESH DIMENSIONS:**

Record the shape of the mesh e.g. rectangular, diamond etc. The measurement should be taken across the longest dimension. If you have more than one mesh material please clearly state the size of each material.

### **NUMBER OF NECKS:**

Record the number of necks on the pot.

### **NECK TYPE:**

Describe the neck of the pot e.g. bucket, wire mesh etc.

### **NECK MATERIAL:**

Again, describe the material used for the neck.

### **NUMBER OF ESCAPE GAPS:**

Record the number of escape gaps in your pot.

### **ESCAPE GAP DIMENSIONS:**

Record the dimensions of the escape gaps as length x width. Clearly indicate measurement units used.

### **ESCAPE GAP LOCATION AND ORIENTATION:**

Describe the location as best possible e.g. Vertical/Centre, Horizontal/Bottom, etc.

### **COMMENTS:**

If you do not fill in any of the boxes on the pot description form please explain why here. Also if you have any other comments to help us understand your pot descriptions include them here to.

### **SIGNATURE/DATE:**

Please sign and date the form when completed and return to your area technician or to the NZ RLIC office.



## VOLUNTARY ROCK LOBSTER LOGBOOK PROGRAMME

### ANNUAL SURVEY FORM

NAME OF FISHERMAN: \_\_\_\_\_

ADDRESS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

PHONE NUMBERS: Home: \_\_\_\_\_

Vessel: \_\_\_\_\_

Mobile: \_\_\_\_\_

VESSEL NAME: \_\_\_\_\_

VESSEL REGISTRATION: \_\_\_\_\_

VESSEL SIZE: \_\_\_\_\_ (Metres/Feet)

WORKING SPEED: \_\_\_\_\_

HORSE POWER: \_\_\_\_\_

NUMBER OF POTS: \_\_\_\_\_

QUOTA HELD: \_\_\_\_\_

EXPERIENCE: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

COMMENTS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_

*Voluntary Rock Lobster Annual Survey*

## POT NUMBER 1 DESCRIPTION FORM

**POT DIMENSIONS:** Fill out one of the following pot types.

### SQUARE/RECTANGULAR

Length\_\_\_\_\_ (m/ft) Width\_\_\_\_\_ (m/ft) Height\_\_\_\_\_ (m/ft)

### BEEHIVE/CIRCULAR

Top Diameter\_\_\_\_\_ (m/ft) Bottom Diameter\_\_\_\_\_ (m/ft) Height\_\_\_\_\_ (m/ft)

### FRAME MATERIAL

- |                                                   |                                     |
|---------------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel                    | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> <b>Steel Welded Mesh</b> | <input type="checkbox"/> Timber     |
| <input type="checkbox"/> Supplejack               | <input type="checkbox"/> Other_____ |

### MESH MATERIALS

- |                                           |                                       |
|-------------------------------------------|---------------------------------------|
| <input type="checkbox"/> Trawl Mesh       | <input type="checkbox"/> Steel        |
| <input type="checkbox"/> Nylon            | <input type="checkbox"/> Chicken Mesh |
| <input type="checkbox"/> Wire/Chainlink   | <input type="checkbox"/> Other_____   |
| <input type="checkbox"/> Combination_____ |                                       |

### MESH DIMENSIONS

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| <input type="checkbox"/> Rectangular | <input type="checkbox"/> Diamond    |
| <input type="checkbox"/> Octagonal   | <input type="checkbox"/> Other_____ |
- Measurement at widest gap\_\_\_\_\_ (mm/in)

**NUMBER OF NECKS**\_\_\_\_\_

### NECK TYPE

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| <input type="checkbox"/> Prongs/Tines | <input type="checkbox"/> Fingers    |
| <input type="checkbox"/> Bucket       | <input type="checkbox"/> Forks      |
| <input type="checkbox"/> Square Mesh  | <input type="checkbox"/> Other_____ |
| <input type="checkbox"/> Round Mesh   |                                     |

### NECK MATERIAL

- |                                          |                                     |
|------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel           | <input type="checkbox"/> Plastic    |
| <input type="checkbox"/> Cane/Supplejack | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> Wood            | <input type="checkbox"/> Other_____ |

**NUMBER OF ESCAPE GAPS**\_\_\_\_\_

### ESCAPE GAP DIMENSIONS

Length\_\_\_\_\_ (mm/in) Width\_\_\_\_\_ (mm/in)

### ESCAPE GAP LOCATION AND ORIENTATION

- |                                            |                                                        |
|--------------------------------------------|--------------------------------------------------------|
| <input type="checkbox"/> Vertical/Centre   | <input type="checkbox"/> Vertical/Corners              |
| <input type="checkbox"/> Horizontal/Top    | <input type="checkbox"/> Horizontal/Bottom             |
| <input type="checkbox"/> Horizontal/Middle | <input type="checkbox"/> Horizontal - 1 Top & 1 Bottom |
| <input type="checkbox"/> Other_____        |                                                        |

**BAIT CONTAINER** ☐ Yes ☐ No

**TIED BAIT** ☐ Yes ☐ No

**COMMENTS:**\_\_\_\_\_

## POT NUMBER 2 DESCRIPTION FORM

**POT DIMENSIONS:** Fill out one of the following pot types.

### SQUARE/RECTANGULAR

Length\_\_\_\_\_ (m/ft) Width\_\_\_\_\_ (m/ft) Height\_\_\_\_\_ (m/ft)

### BEEHIVE/CIRCULAR

Top Diameter\_\_\_\_\_ (m/ft) Bottom Diameter\_\_\_\_\_ (m/ft) Height\_\_\_\_\_ (m/ft)

### FRAME MATERIAL

- |                                                   |                                     |
|---------------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel                    | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> <b>Steel Welded Mesh</b> | <input type="checkbox"/> Timber     |
| <input type="checkbox"/> Supplejack               | <input type="checkbox"/> Other_____ |

### MESH MATERIALS

- |                                           |                                       |
|-------------------------------------------|---------------------------------------|
| <input type="checkbox"/> Trawl Mesh       | <input type="checkbox"/> Steel        |
| <input type="checkbox"/> Nylon            | <input type="checkbox"/> Chicken Mesh |
| <input type="checkbox"/> Wire/Chainlink   | <input type="checkbox"/> Other_____   |
| <input type="checkbox"/> Combination_____ |                                       |

### MESH DIMENSIONS

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| <input type="checkbox"/> Rectangular | <input type="checkbox"/> Diamond    |
| <input type="checkbox"/> Octagonal   | <input type="checkbox"/> Other_____ |
- Measurement at widest gap\_\_\_\_\_ (mm/in)

**NUMBER OF NECKS**\_\_\_\_\_

### NECK TYPE

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| <input type="checkbox"/> Prongs/Tines | <input type="checkbox"/> Fingers    |
| <input type="checkbox"/> Bucket       | <input type="checkbox"/> Forks      |
| <input type="checkbox"/> Square Mesh  | <input type="checkbox"/> Other_____ |
| <input type="checkbox"/> Round Mesh   |                                     |

### NECK MATERIAL

- |                                          |                                     |
|------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel           | <input type="checkbox"/> Plastic    |
| <input type="checkbox"/> Cane/Supplejack | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> Wood            | <input type="checkbox"/> Other_____ |

**NUMBER OF ESCAPE GAPS**\_\_\_\_\_

### ESCAPE GAP DIMENSIONS

Length\_\_\_\_\_ (mm/in) Width\_\_\_\_\_ (mm/in)

### ESCAPE GAP LOCATION AND ORIENTATION

- |                                            |                                                        |
|--------------------------------------------|--------------------------------------------------------|
| <input type="checkbox"/> Vertical/Centre   | <input type="checkbox"/> Vertical/Corners              |
| <input type="checkbox"/> Horizontal/Top    | <input type="checkbox"/> Horizontal/Bottom             |
| <input type="checkbox"/> Horizontal/Middle | <input type="checkbox"/> Horizontal - 1 Top & 1 Bottom |
| <input type="checkbox"/> Other_____        |                                                        |

**BAIT CONTAINER** ☐ Yes ☐ No

**TIED BAIT** ☐ Yes ☐ No

**COMMENTS:**\_\_\_\_\_

### POT NUMBER 3 DESCRIPTION FORM

**POT DIMENSIONS:** Fill out one of the following pot types.

**SQUARE/RECTANGULAR**

Length\_\_\_\_\_ (m/ft)      Width\_\_\_\_\_ (m/ft)      Height\_\_\_\_\_ (m/ft)

**BEEHIVE/CIRCULAR**

Top Diameter\_\_\_\_\_ (m/ft)      Bottom Diameter\_\_\_\_\_ (m/ft)      Height\_\_\_\_\_ (m/ft)

**FRAME MATERIAL**

- |                                                   |                                     |
|---------------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel                    | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> <b>Steel Welded Mesh</b> | <input type="checkbox"/> Timber     |
| <input type="checkbox"/> Supplejack               | <input type="checkbox"/> Other_____ |

**MESH MATERIALS**

- |                                           |                                       |
|-------------------------------------------|---------------------------------------|
| <input type="checkbox"/> Trawl Mesh       | <input type="checkbox"/> Steel        |
| <input type="checkbox"/> Nylon            | <input type="checkbox"/> Chicken Mesh |
| <input type="checkbox"/> Wire/Chainlink   | <input type="checkbox"/> Other_____   |
| <input type="checkbox"/> Combination_____ |                                       |

**MESH DIMENSIONS**

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| <input type="checkbox"/> Rectangular | <input type="checkbox"/> Diamond    |
| <input type="checkbox"/> Octagonal   | <input type="checkbox"/> Other_____ |
- Measurement at widest gap\_\_\_\_\_ (mm/in)

**NUMBER OF NECKS** \_\_\_\_\_

**NECK TYPE**

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| <input type="checkbox"/> Prongs/Tines | <input type="checkbox"/> Fingers    |
| <input type="checkbox"/> Bucket       | <input type="checkbox"/> Forks      |
| <input type="checkbox"/> Square Mesh  | <input type="checkbox"/> Other_____ |
| <input type="checkbox"/> Round Mesh   |                                     |

**NECK MATERIAL**

- |                                          |                                     |
|------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel           | <input type="checkbox"/> Plastic    |
| <input type="checkbox"/> Cane/Supplejack | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> Wood            | <input type="checkbox"/> Other_____ |

**NUMBER OF ESCAPE GAPS** \_\_\_\_\_

**ESCAPE GAP DIMENSIONS**

Length\_\_\_\_\_ (mm/in)      Width\_\_\_\_\_ (mm/in)

**ESCAPE GAP LOCATION AND ORIENTATION**

- |                                            |                                                        |
|--------------------------------------------|--------------------------------------------------------|
| <input type="checkbox"/> Vertical/Centre   | <input type="checkbox"/> Vertical/Corners              |
| <input type="checkbox"/> Horizontal/Top    | <input type="checkbox"/> Horizontal/Bottom             |
| <input type="checkbox"/> Horizontal/Middle | <input type="checkbox"/> Horizontal - 1 Top & 1 Bottom |
| <input type="checkbox"/> Other_____        |                                                        |

**BAIT CONTAINER**    ☐ Yes    ☐ No

**TIED BAIT**    ☐ Yes    ☐ No

**COMMENTS:** \_\_\_\_\_

## POT NUMBER 4 DESCRIPTION FORM

**POT DIMENSIONS:** Fill out one of the following pot types.

### SQUARE/RECTANGULAR

Length\_\_\_\_\_ (m/ft)      Width\_\_\_\_\_ (m/ft)      Height\_\_\_\_\_ (m/ft)

### BEEHIVE/CIRCULAR

Top Diameter\_\_\_\_\_ (m/ft)      Bottom Diameter\_\_\_\_\_ (m/ft)      Height\_\_\_\_\_ (m/ft)

### FRAME MATERIAL

- |                                                   |                                     |
|---------------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel                    | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> <b>Steel Welded Mesh</b> | <input type="checkbox"/> Timber     |
| <input type="checkbox"/> Supplejack               | <input type="checkbox"/> Other_____ |

### MESH MATERIALS

- |                                           |                                       |
|-------------------------------------------|---------------------------------------|
| <input type="checkbox"/> Trawl Mesh       | <input type="checkbox"/> Steel        |
| <input type="checkbox"/> Nylon            | <input type="checkbox"/> Chicken Mesh |
| <input type="checkbox"/> Wire/Chainlink   | <input type="checkbox"/> Other_____   |
| <input type="checkbox"/> Combination_____ |                                       |

### MESH DIMENSIONS

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| <input type="checkbox"/> Rectangular | <input type="checkbox"/> Diamond    |
| <input type="checkbox"/> Octagonal   | <input type="checkbox"/> Other_____ |
- Measurement at widest gap\_\_\_\_\_ (mm/in)

**NUMBER OF NECKS** \_\_\_\_\_

### NECK TYPE

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| <input type="checkbox"/> Prongs/Tines | <input type="checkbox"/> Fingers    |
| <input type="checkbox"/> Bucket       | <input type="checkbox"/> Forks      |
| <input type="checkbox"/> Square Mesh  | <input type="checkbox"/> Other_____ |
| <input type="checkbox"/> Round Mesh   |                                     |

### NECK MATERIAL

- |                                          |                                     |
|------------------------------------------|-------------------------------------|
| <input type="checkbox"/> Steel           | <input type="checkbox"/> Plastic    |
| <input type="checkbox"/> Cane/Supplejack | <input type="checkbox"/> Wire       |
| <input type="checkbox"/> Wood            | <input type="checkbox"/> Other_____ |

**NUMBER OF ESCAPE GAPS** \_\_\_\_\_

### ESCAPE GAP DIMENSIONS

Length\_\_\_\_\_ (mm/in)      Width\_\_\_\_\_ (mm/in)

### ESCAPE GAP LOCATION AND ORIENTATION

- |                                            |                                                        |
|--------------------------------------------|--------------------------------------------------------|
| <input type="checkbox"/> Vertical/Centre   | <input type="checkbox"/> Vertical/Corners              |
| <input type="checkbox"/> Horizontal/Top    | <input type="checkbox"/> Horizontal/Bottom             |
| <input type="checkbox"/> Horizontal/Middle | <input type="checkbox"/> Horizontal - 1 Top & 1 Bottom |
| <input type="checkbox"/> Other_____        |                                                        |

**BAIT CONTAINER**    ☐ Yes    ☐ No

**TIED BAIT**    ☐ Yes    ☐ No

**COMMENTS:** \_\_\_\_\_

## APPENDIX D SQL FOR DATABASE TRANSFER

Below is the SQL for the transfer from the fine scale database to the *rllb* database (Mackay & George 2015). Issues with these scripts are highlighted in yellow.

### D.1 TRIPS

File LB2021trips.txt

```
CREATE OR REPLACE VIEW "public"."LB2021trips" AS
SELECT nextval('"logbook_TripNumber"'::regclass) AS nextval,
       trips.skipper_name,
       trips.tripno,
       ( SELECT skippers.skipper_id
         FROM skippers
        WHERE ((skippers.skipper_name)::text =
(trips.skipper_name)::text)) AS fisherid,
       NULL::unknown AS subarea,
       trips.tripdate AS date,
       trips.fishing_year AS fishingyear,
       ( SELECT v.imo_nr_num
         FROM vessels v
        WHERE ((trips.vessel)::text = (v.vessel)::text)) AS vesselnumber,
       trips.statarea,
       trips.swell_dir AS swelldirection,
       trips.swell_ht AS swellheight,
       trips.wind_dir AS winddirection,
       trips.wind_ht AS windspeed,
       'DAY' AS soakunits,
       'MET' AS depthunits
FROM trips
WHERE ((trips.fishing_year = 2021) AND (EXISTS ( SELECT traps.tripno
        FROM traps
       WHERE ((trips.skipper_name)::text = (traps.skipper_name)::text)
AND (trips.tripno = traps.tripno) AND (traps.measured = 'Y'::bpchar)))));
```

### D.2 POTLIFTS

File LB2011potlifts.txt

```
CREATE OR REPLACE VIEW "public"."LB2011potlifts" AS
SELECT nextval('"logbook_PotliftNumber"'::regclass) AS nextval,
       traps.skipper_name,
       traps.tripno,
       traps.trapno,
       ( SELECT skippers.skipper_id
         FROM skippers
        WHERE ((skippers.skipper_name)::text =
(traps.skipper_name)::text)) AS fisherid,
       0 AS pot,
       traps.soak_time AS soakraw,
       traps.depth AS depthraw,
       traps.soak_time AS soakhours,
       traps.depth AS depthmeters,
       ( SELECT count(*) AS count
         FROM measurements_original m
        WHERE ((traps.vessel)::text = (m.vessel)::text) AND
(traps.tripno = m.tripno) AND (traps.trapno = m.trapno) AND (m.sex = ANY
(ARRAY['MM'::bpchar, 'MF'::bpchar]))) AS liveabove,
```

```

        ( SELECT count(*) AS count
          FROM measurements_original m
          WHERE      (((traps.vessel)::text      =      (m.vessel)::text)      AND
(traps.tripno = m.tripno) AND (traps.trapno = m.trapno) AND (m.sex = ANY
(ARRAY['MM'::bpchar, 'MF'::bpchar]))) AND (m.kept = 'Y'::bpchar))) AS
liveabovekept,
        ( SELECT count(*) AS count
          FROM measurements_original m
          WHERE      (((traps.vessel)::text      =      (m.vessel)::text)      AND
(traps.tripno = m.tripno) AND (traps.trapno = m.trapno) AND (m.sex <> ALL
(ARRAY['MM'::bpchar, 'MF'::bpchar])))) AS livebelow,
        traps.crays_dead AS totdead,
        '0' AS deadabove,
        '0' AS deadabovekept,
        '0' AS deadbelow,
        traps.octopus,
        traps.phc_caught AS phc,
        traps.phc_kept AS phckept,
        traps.othername,
        traps.otherkept AS other,
        0 AS mealsex,
        'X' AS zone
    FROM traps
    WHERE ((traps.measured = 'Y'::bpchar) AND (fishing_year(traps.pulldate) =
2011))
    ORDER      BY      (nextval('"logbook_PotliftNumber"'::regclass)),
traps.skipper_name, traps.tripno, traps.trapno;

```

#### File LB2021potlifts.txt

```

CREATE OR REPLACE VIEW "public"."LB2021potlifts" AS
SELECT nextval('"logbook_PotliftNumber"'::regclass) AS nextval,
        traps.skipper_name,
        traps.tripno,
        traps.trapno,
        ( SELECT skippers.skipper_id
          FROM skippers
          WHERE      ((skippers.skipper_name)::text      =
(traps.skipper_name)::text)) AS fisherid,
        0 AS pot,
        traps.soak_time AS soakraw,
        traps.depth AS depthraw,
        traps.soak_time AS soakhours,
        traps.depth AS depthmeters,
        0 AS liveabove,
        0 AS liveabovekept,
        0 AS livebelow,
        traps.crays_dead AS totdead,
        '0' AS deadabove,
        '0' AS deadabovekept,
        '0' AS deadbelow,
        traps.octopus,
        traps.phc_caught AS phc,
        traps.phc_kept AS phckept,
        traps.othername,
        traps.otherkept AS other,
        0 AS mealsex,
        'X' AS zone
    FROM traps
    WHERE ((traps.measured = 'Y'::bpchar) AND (fishing_year(traps.pulldate) =
2021))

```

```
ORDER BY (nextval('"logbook_PotliftNumber"'::regclass)),
traps.skipper_name, traps.tripno, traps.trapno;
```

### D.3 LOBSTERS

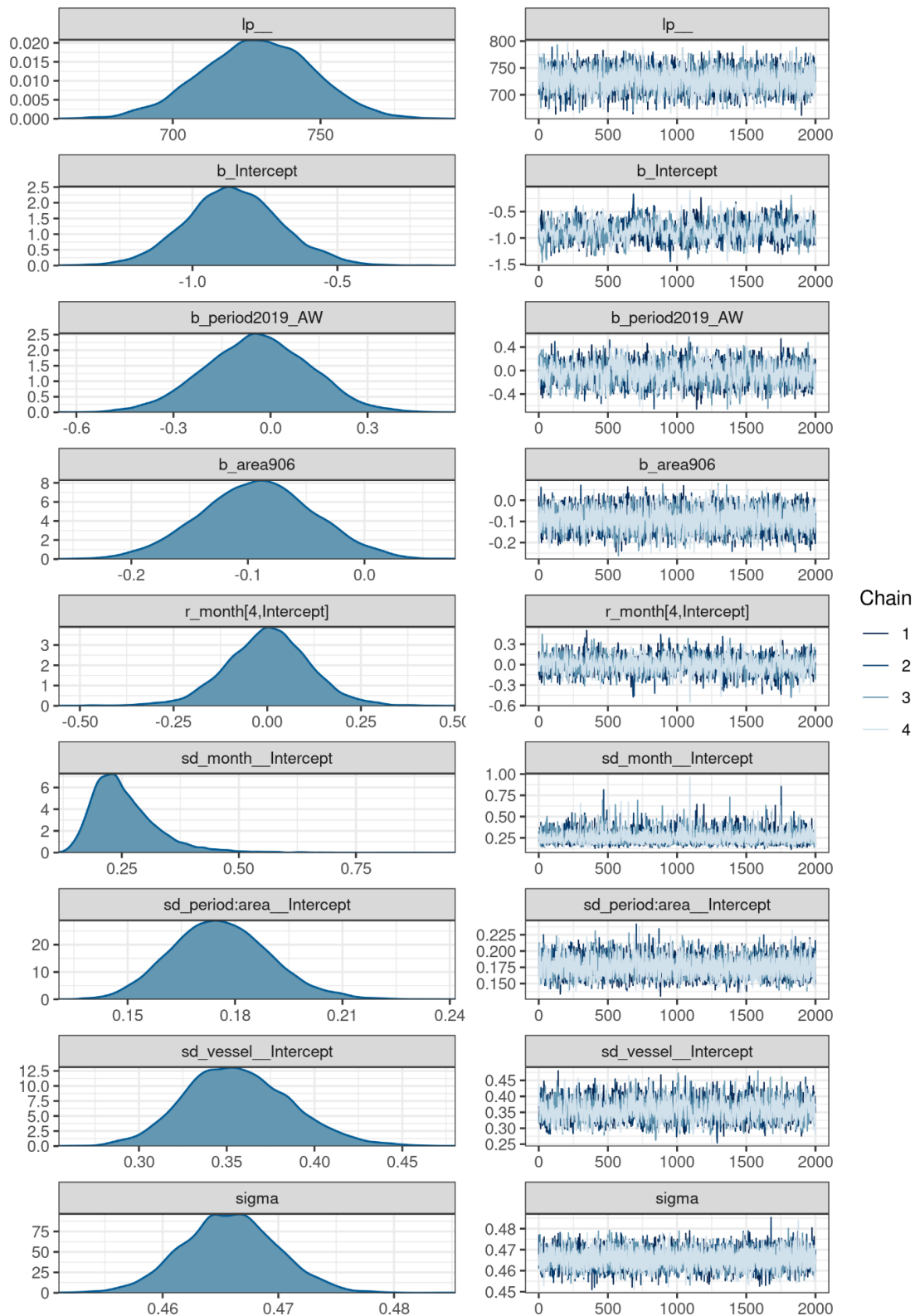
File LB2021lobsters.txt

```
select  a.vessel,
        (select  imo_nr_num  from  vessels  v  where  a.vessel=v.vessel)  as
vessel_no,
        round(a.depth) as depth, a.statarea, b.*
from traps a, cray_tags b
where a.vessel=b.vessel
      and a.tripno=b.tripno
      and a.trapno=b.trapno
```

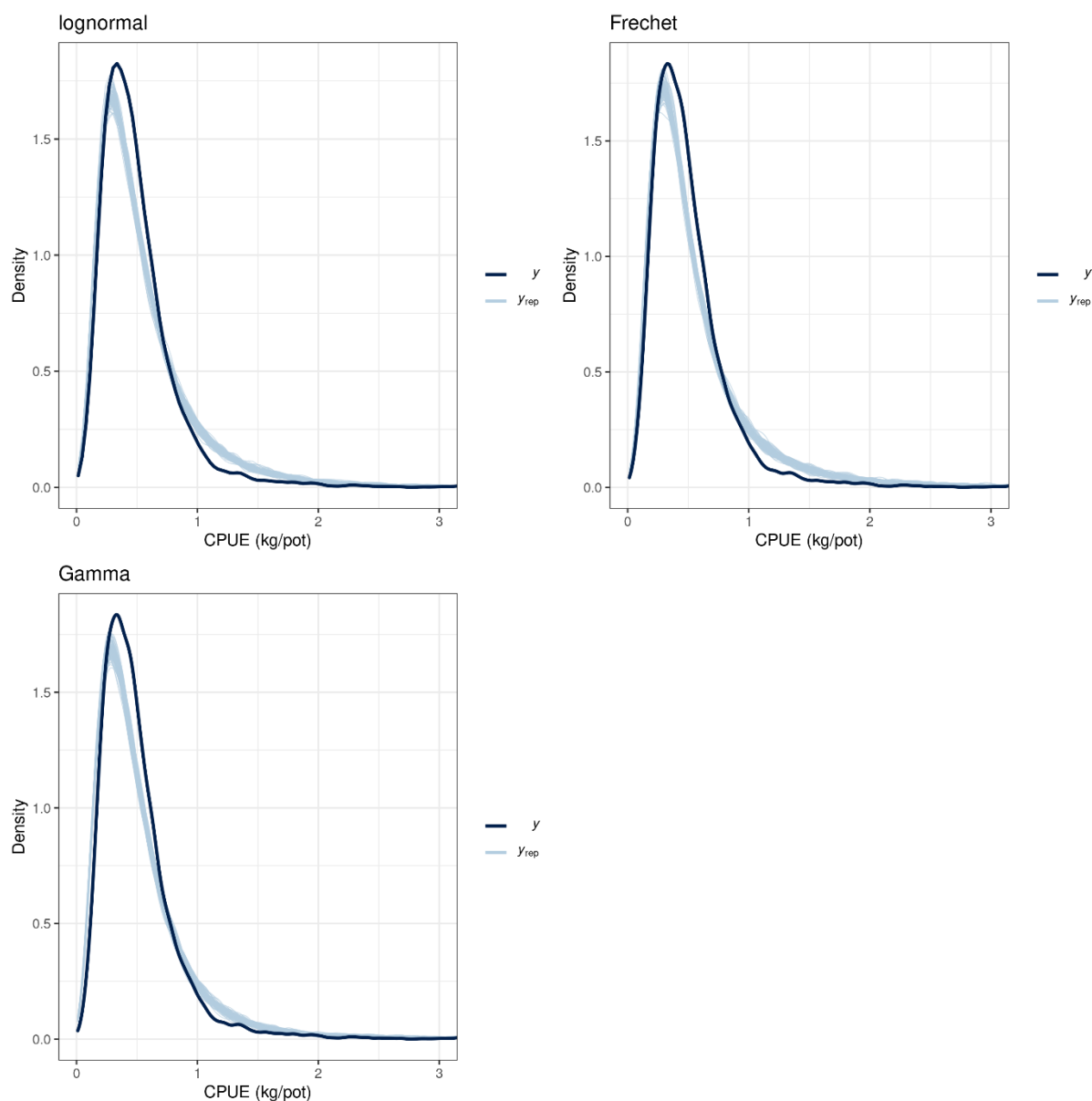


## APPENDIX E DIAGNOSTIC PLOTS

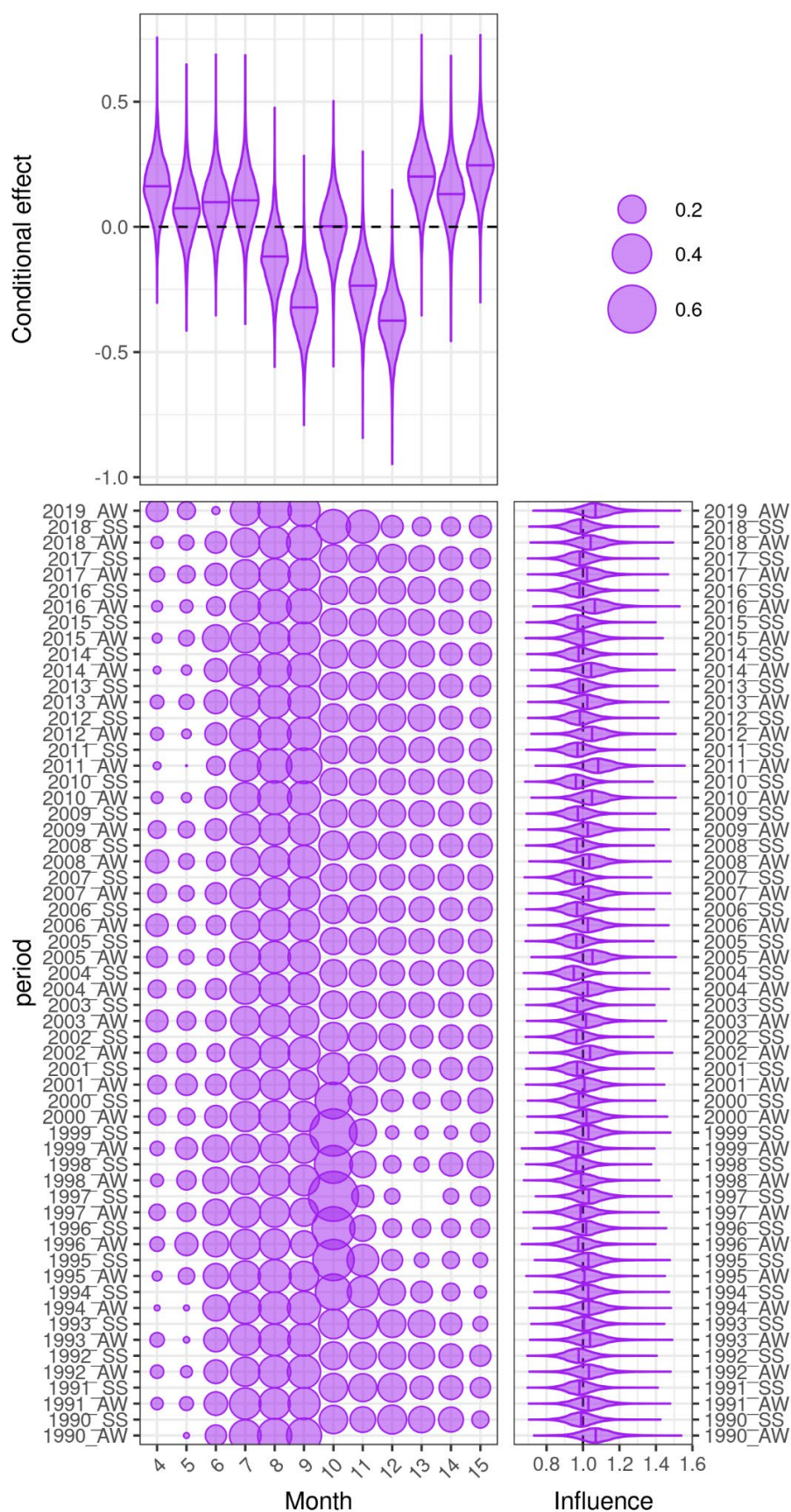
### E.1 CELR CPUE MODELS



**Figure E.1:** CELR: MCMC trace plots for a selection of parameters for the best fitting lognormal CELR model, i.e., ' $period + (1 | vessel) + (1 | month) + area + (1 | period \times area)$ ', according to LOO IC (Table 12).

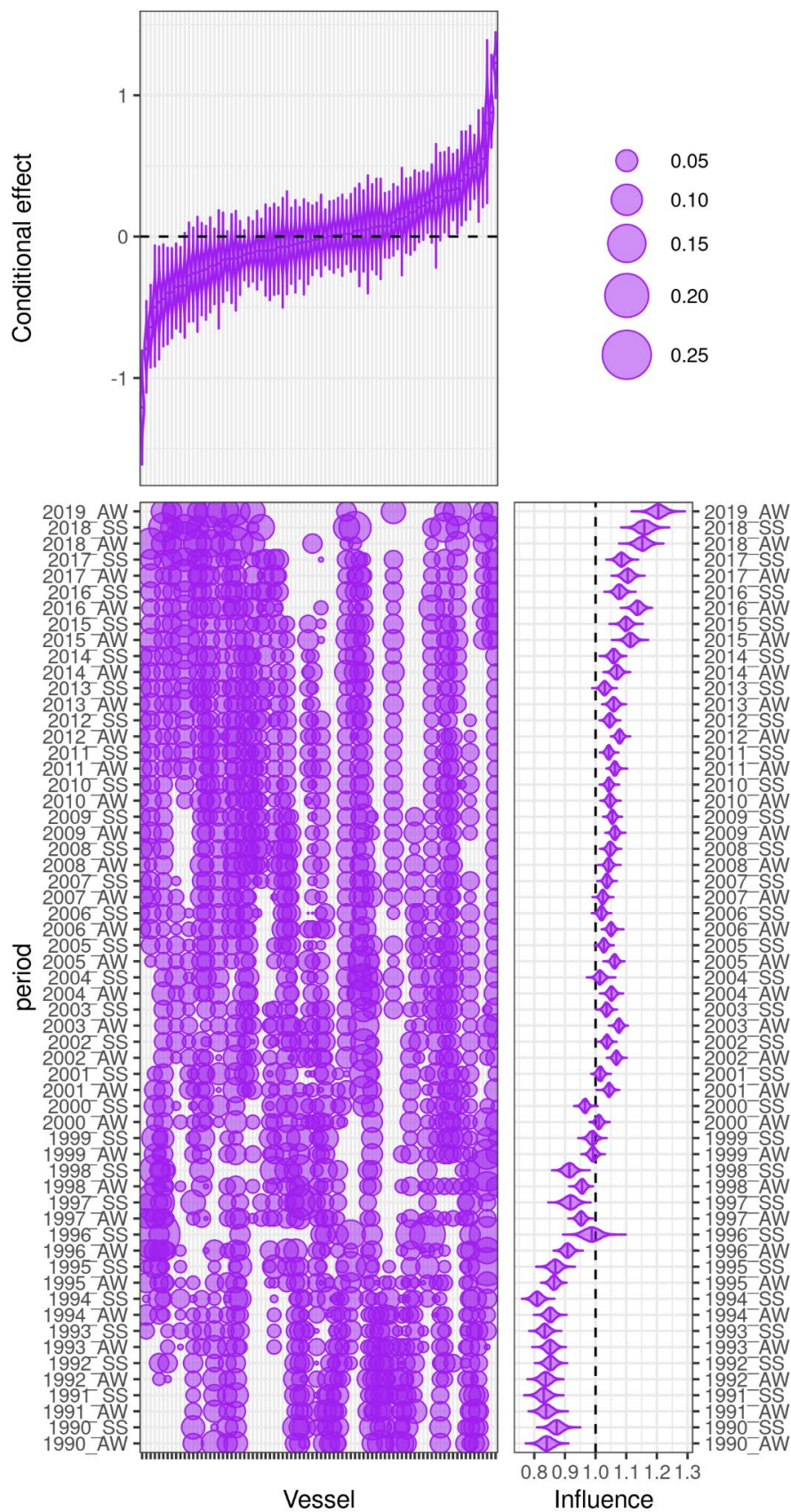


**Figure E.2:** CELR: posterior predictive density plots for the models assuming the lognormal, Frechet, or Gamma distribution with the form ' $period + (I \mid vessel) + (I \mid month) + area + (I \mid period \times area)$ '. In each plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution.

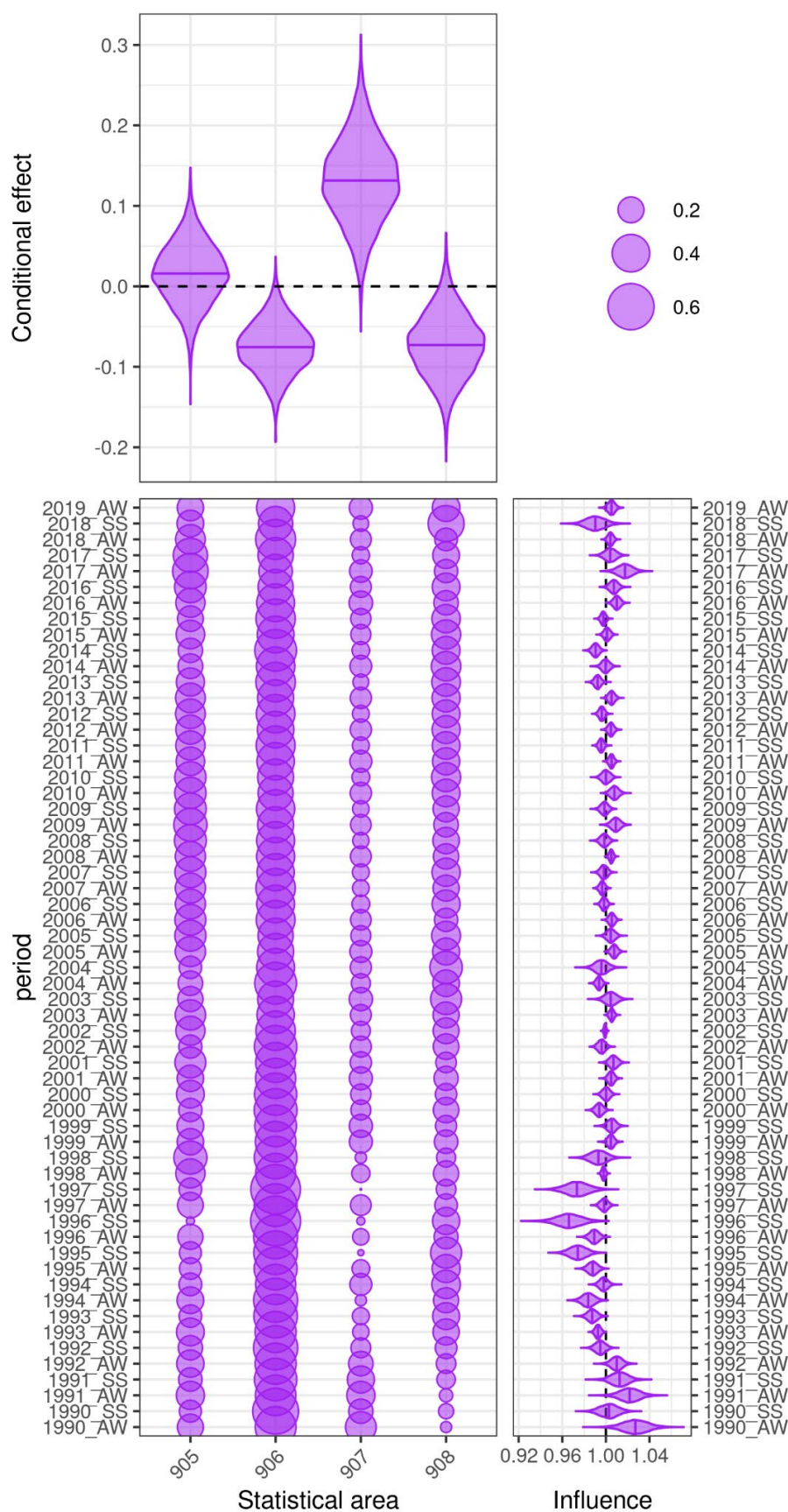


**Figure E.3:** CELR: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable month for the model *'period + (1 | vessel) + (1 | month) + area + (1 | period × area)'*.



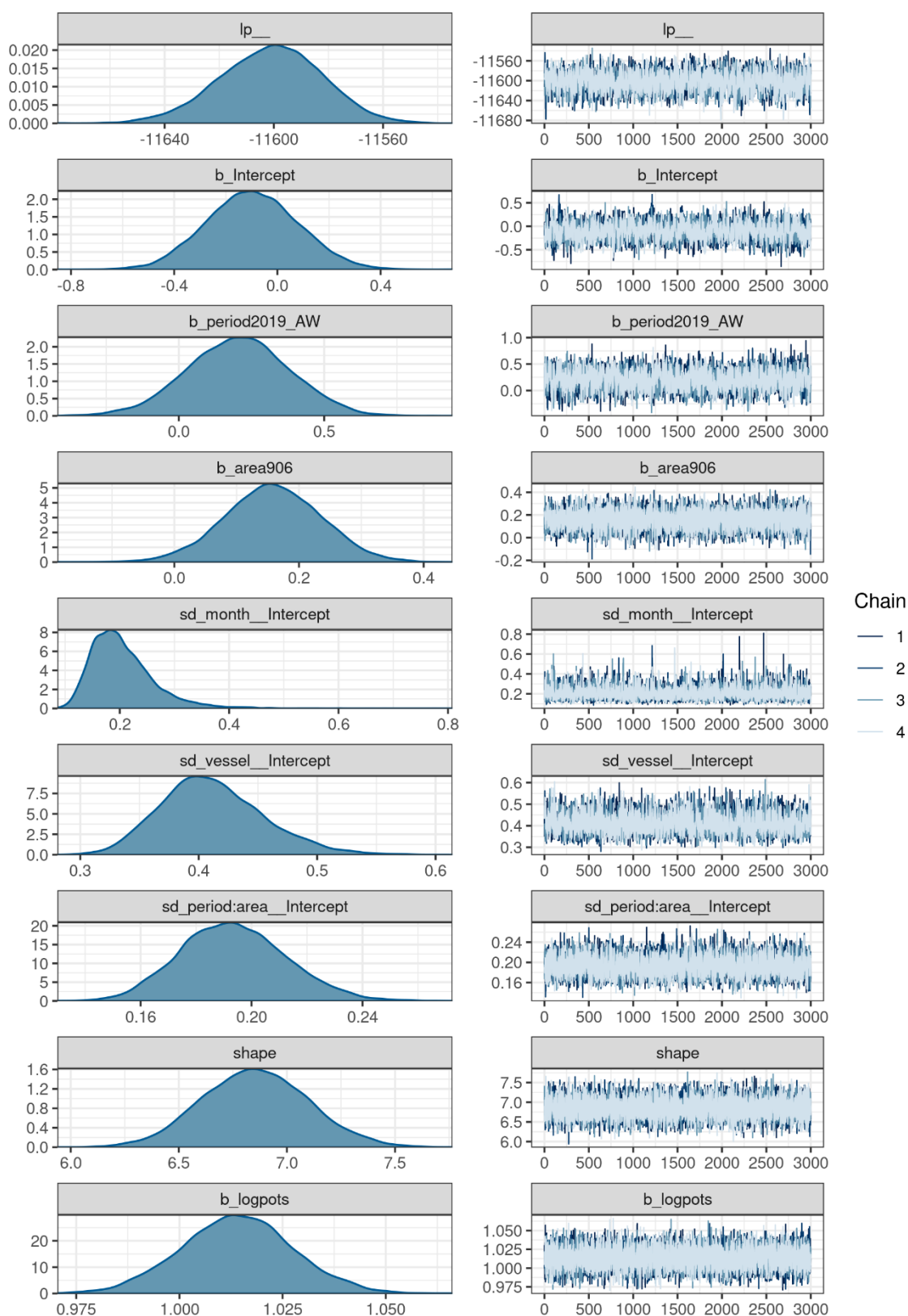


**Figure E.4:** CELR: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable vessel for the model ' $period + (I | vessel) + (I | month) + area + (I | period \times area)$ '.



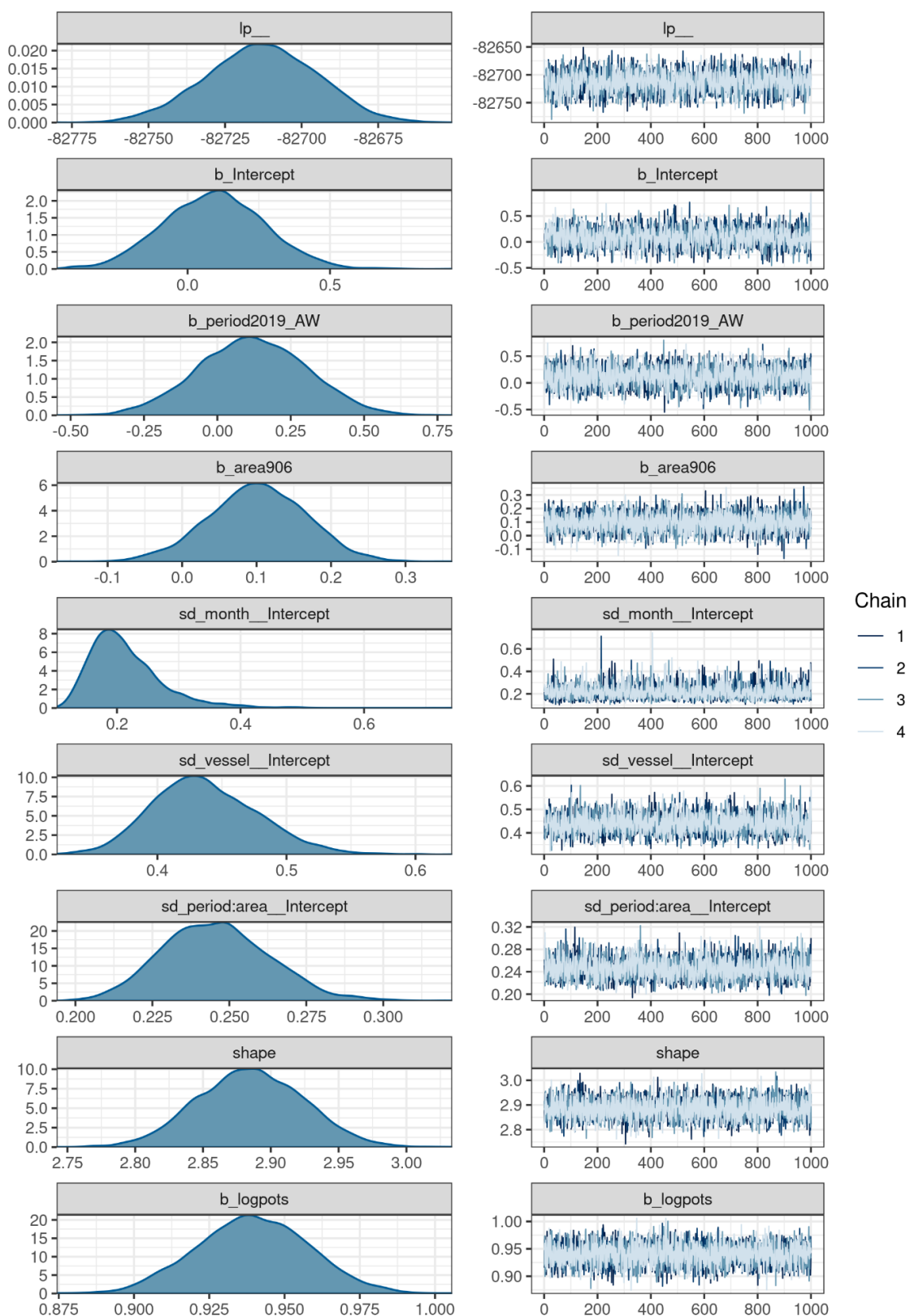
**Figure E.5:** CELR: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable statistical area for the model ' $period + (1 | vessel) + (1 | month) + area + (1 | period \times area)$ '.

## E.2 LOGBOOK CPUE MODELS

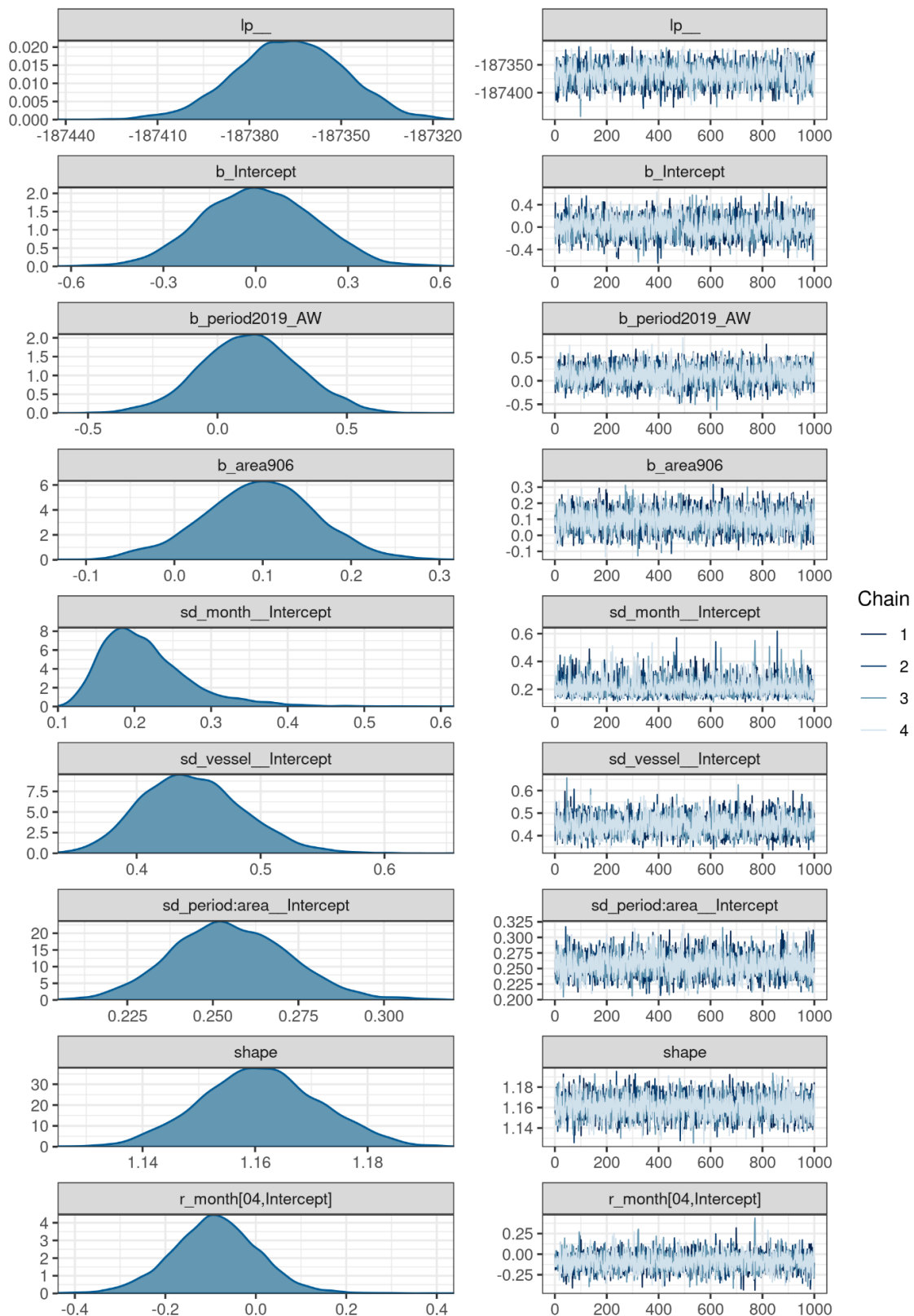


**Figure E.6:** Logbook: MCMC trace plots for the best fitting logbook model fitted to the by month data set, i.e.,  $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ , according to LOO IC (Table 17).



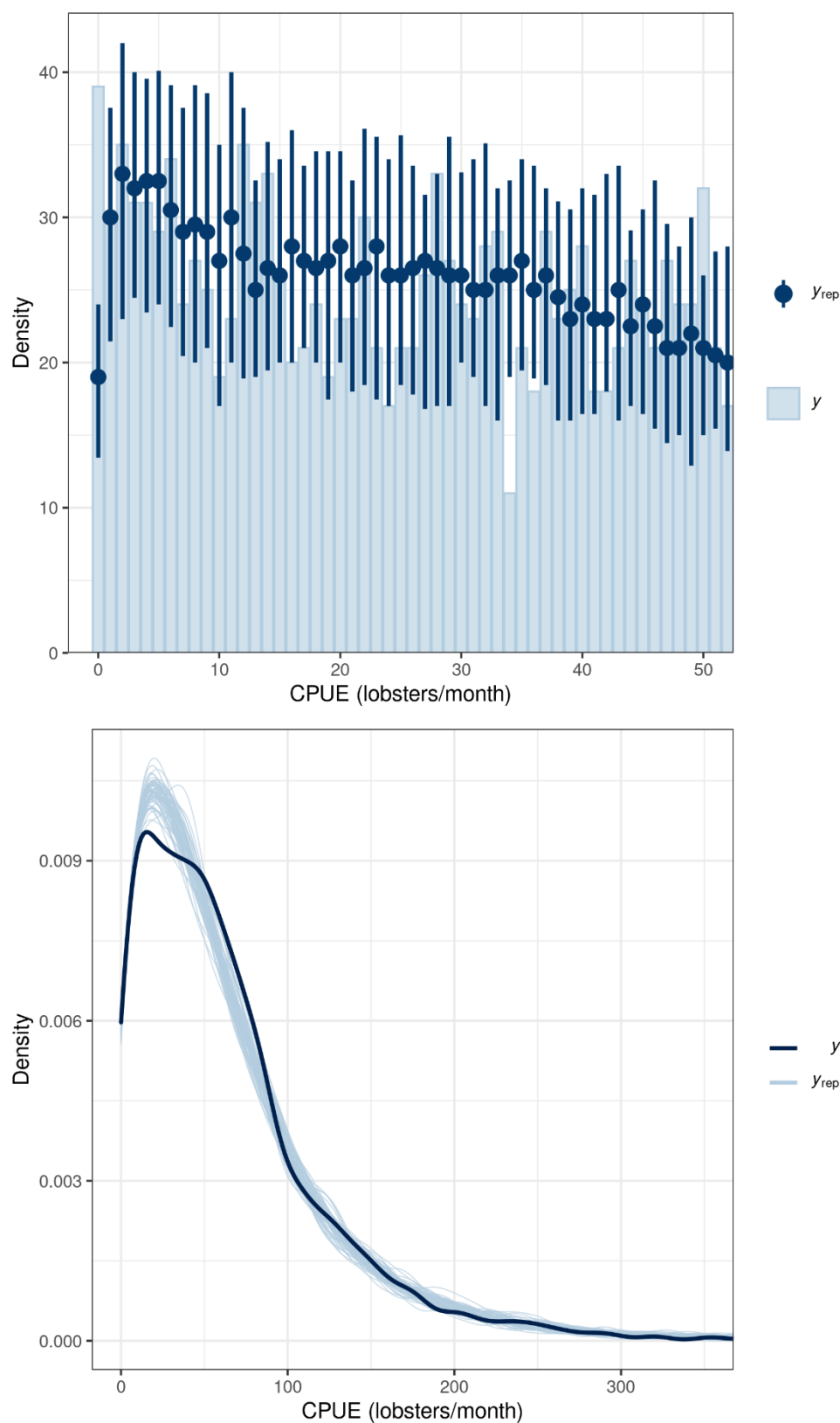


**Figure E.7:** Logbook: MCMC trace plots for the main logbook model fitted to the by trip data set, i.e., ‘ $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ’, according to LOO IC (Table 17).

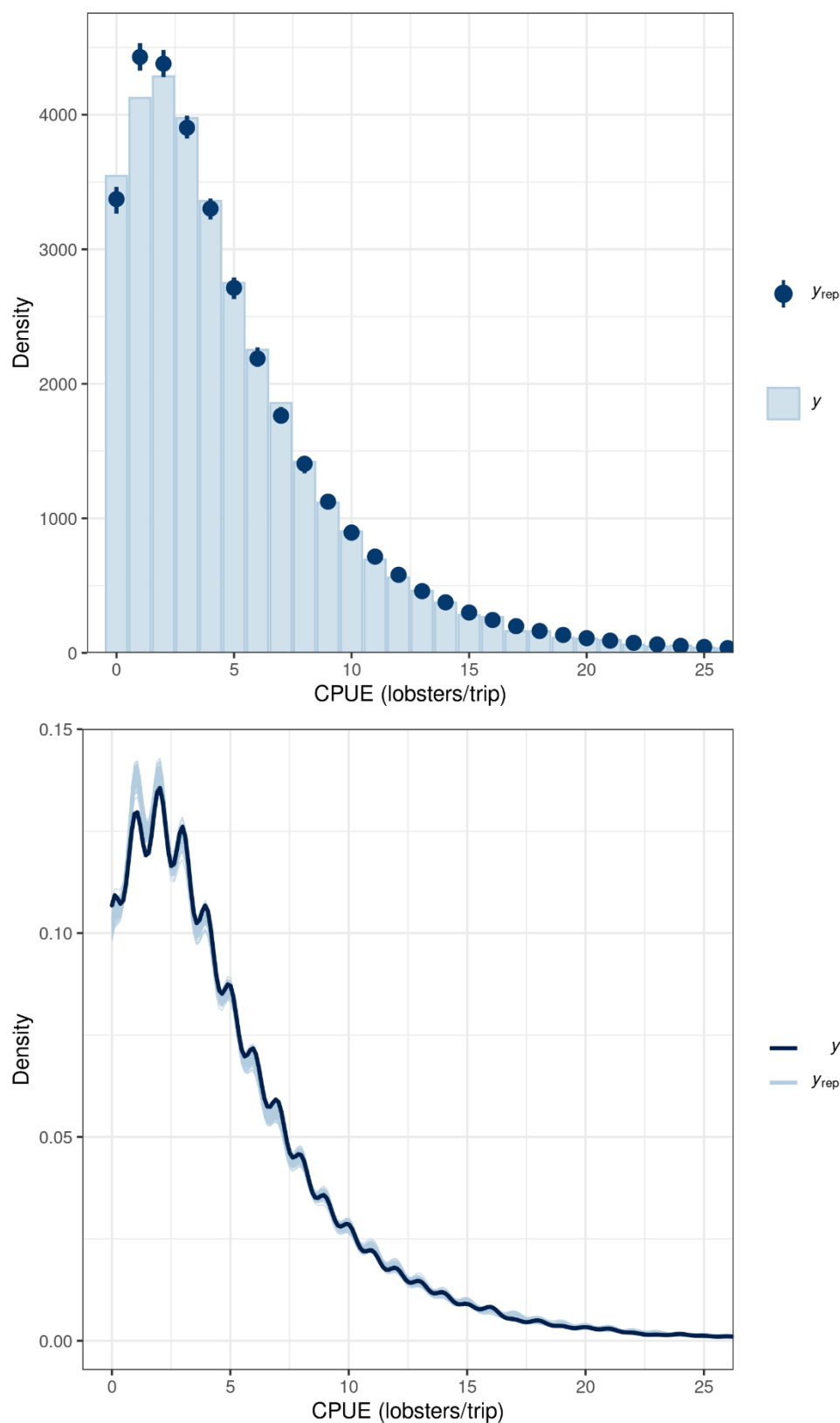


**Figure E.8:** Logbook: MCMC trace plots for the main logbook model fitted to the by pot data set, i.e., ‘ $period + (1 \mid month) + area + (1 \mid period \times area)$ ’, according to LOO IC (Table 17).

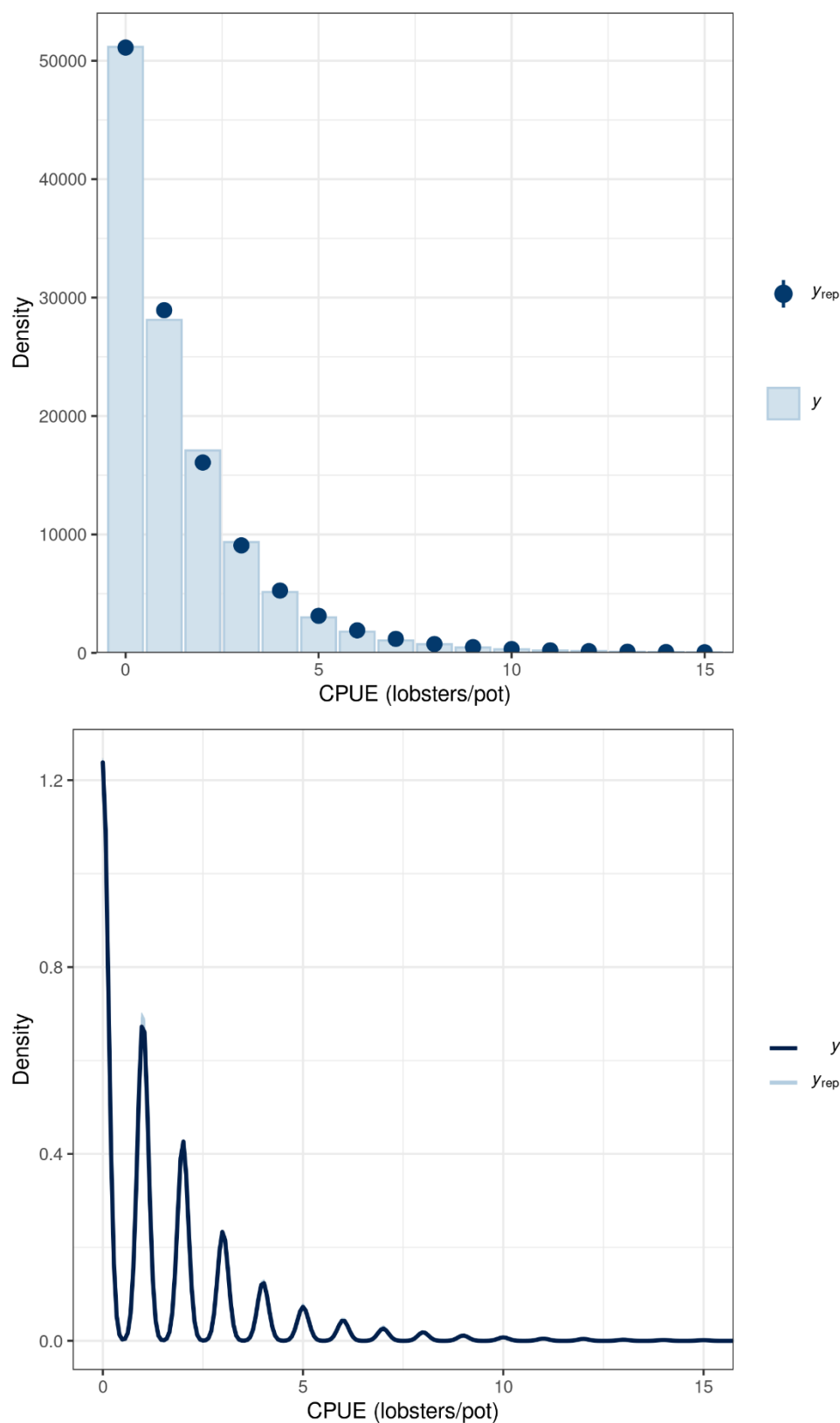




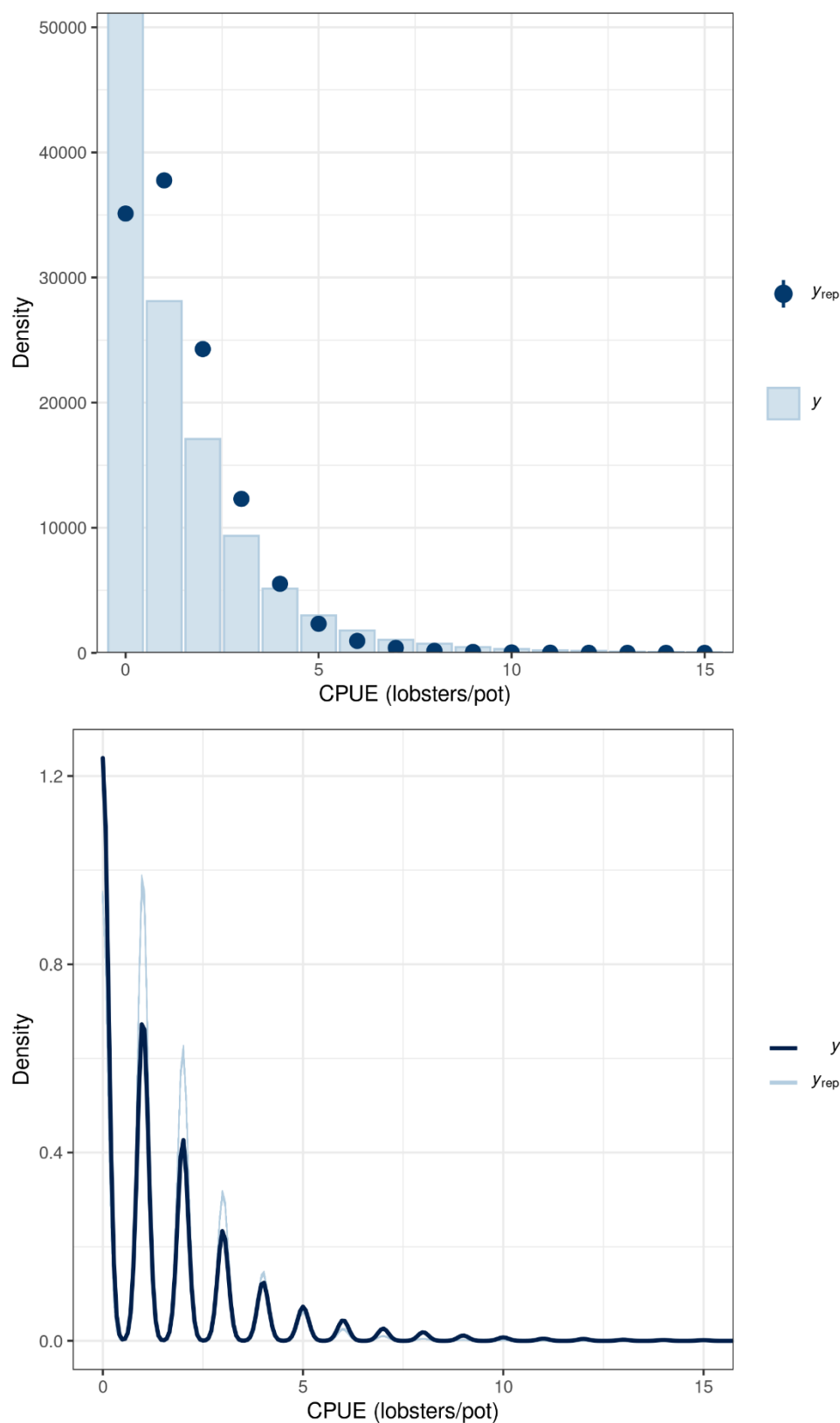
**Figure E.9:** Logbook: posterior predictive density plots as bars [top] and density lines [bottom] for the model ' $\log(pot) + period + (1 | month) + area + (1 | period \times area)$ ' assuming a negative binomial distribution fitted to the by month data set. In each plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution. Note that the x-axis has been limited to a CPUE of 50 lobsters/month in the top plot and 350 lobsters/month in the bottom plot.



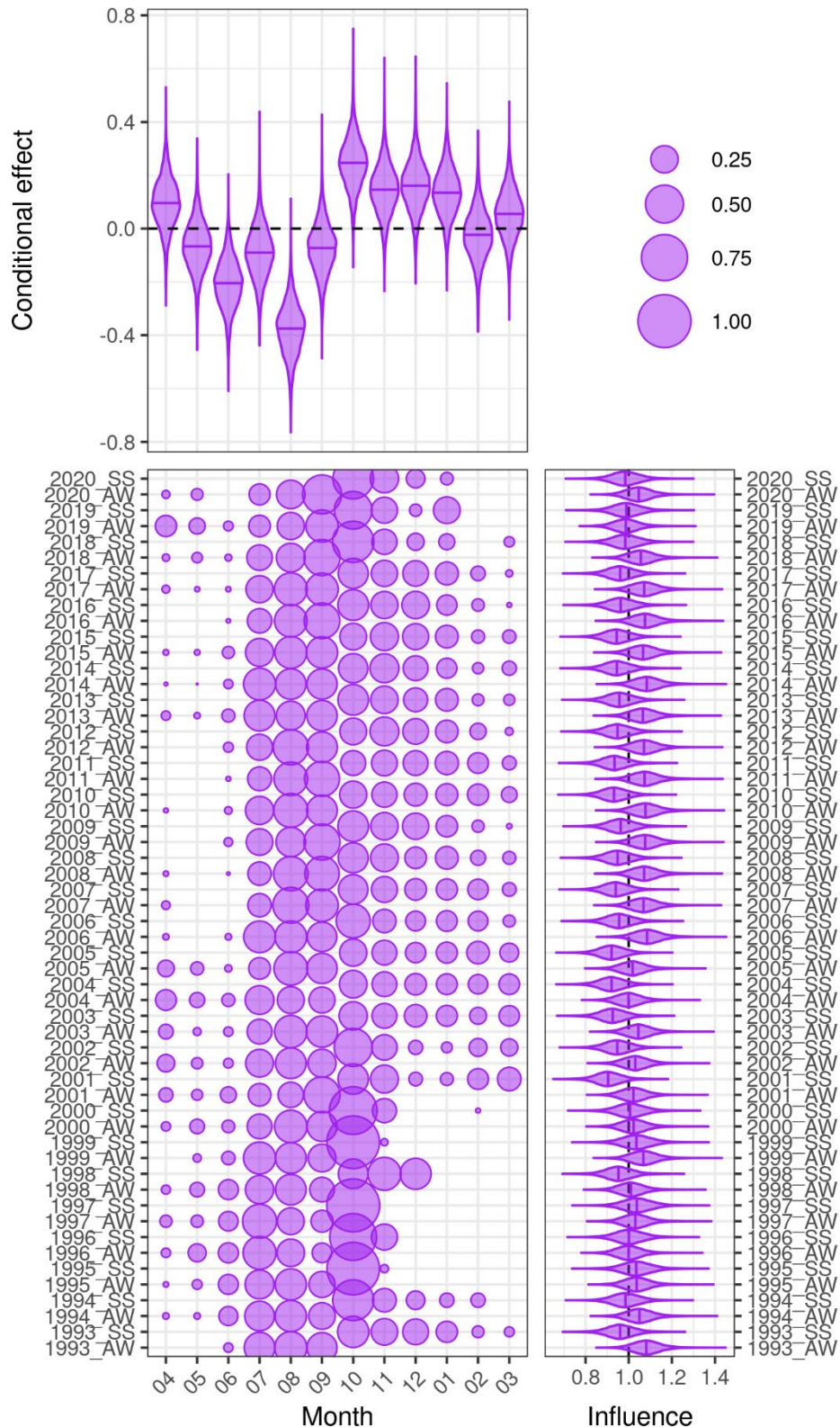
**Figure E.10:** Logbook: posterior predictive density plots as bars [top] and density lines [bottom] for the model ' $\log(pot) + period + (1 | month) + area + (1 | period \times area)$ ' assuming a negative binomial distribution fitted to the by trip data set. In each plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution. Note that the x-axis has been limited to a CPUE of 25 lobsters/trip in both plots.



**Figure E.11:** Logbook: posterior predictive density plots as bars [top] and density lines [bottom] for the model ' $period + (I \mid month) + area + (I \mid period \times area)$ ' assuming a negative binomial distribution fitted to the by pot data set. In each plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution. Note that the x-axis has been limited to a CPUE of 15 lobsters/pot in both plots.

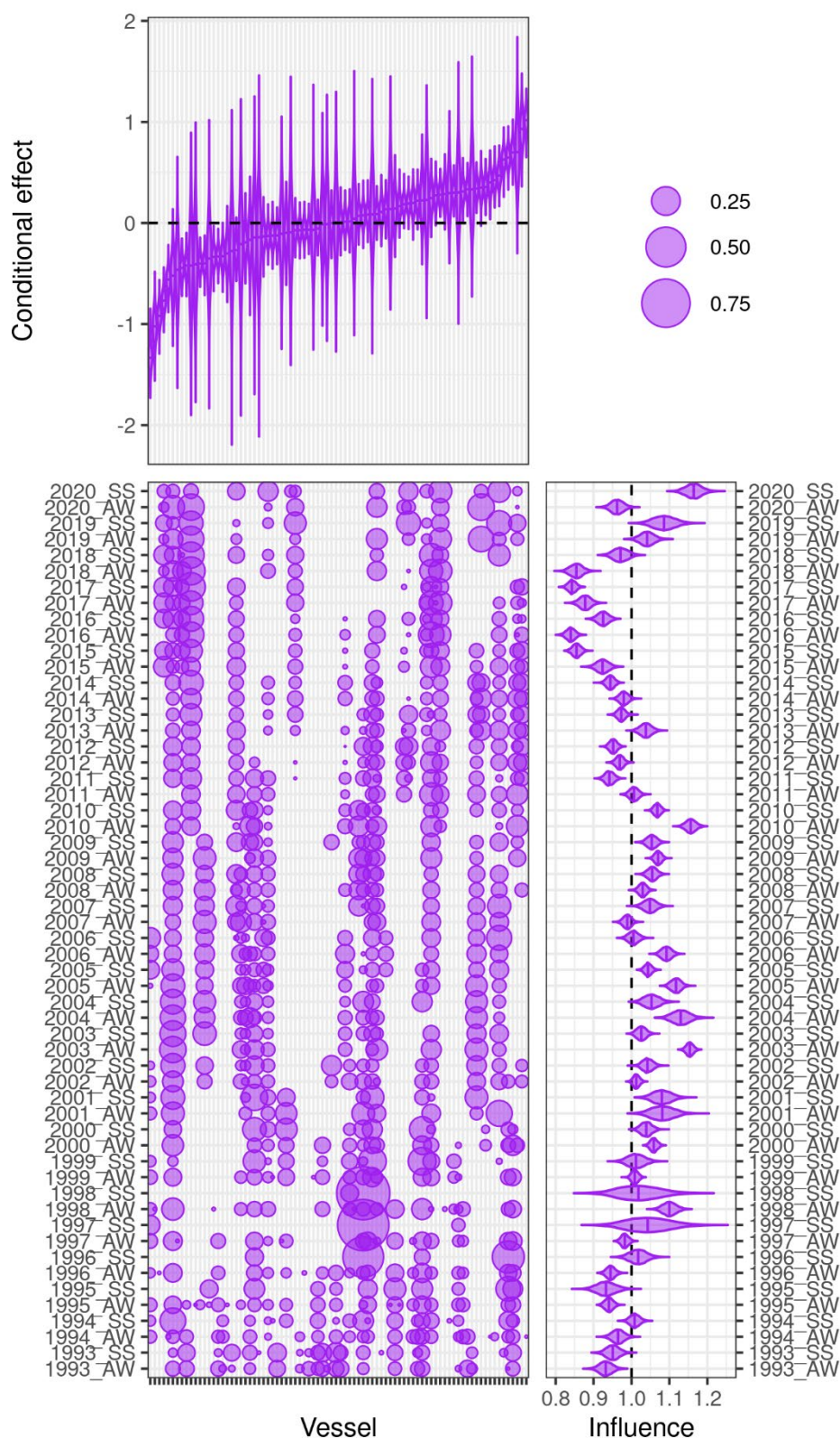


**Figure E.12:** Logbook: posterior predictive density plots as bars [top] and density lines [bottom] for the model ' $period + (I | month) + area + (I | period \times area)$ ' fitted to the by\_pot data set assuming the Poisson distribution. In this plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution. Note that the x-axis has been limited to a CPUE of 15 lobsters/month in both plots.

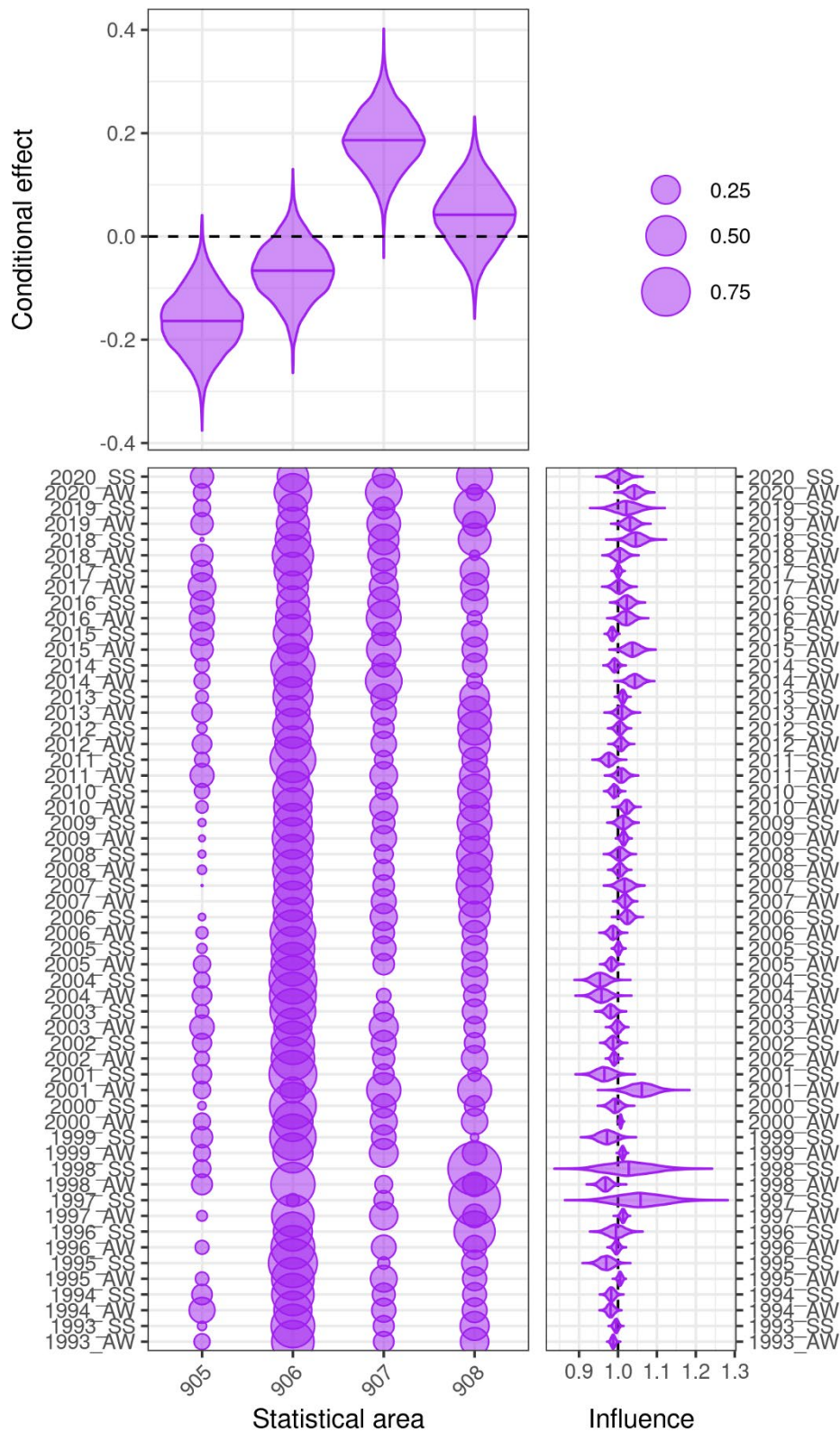


**Figure E.13:** Logbook: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable month ('04' is April) for the main logbook model fitted to the by pot data set, i.e., ' $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ', according to LOO IC (Table 17).



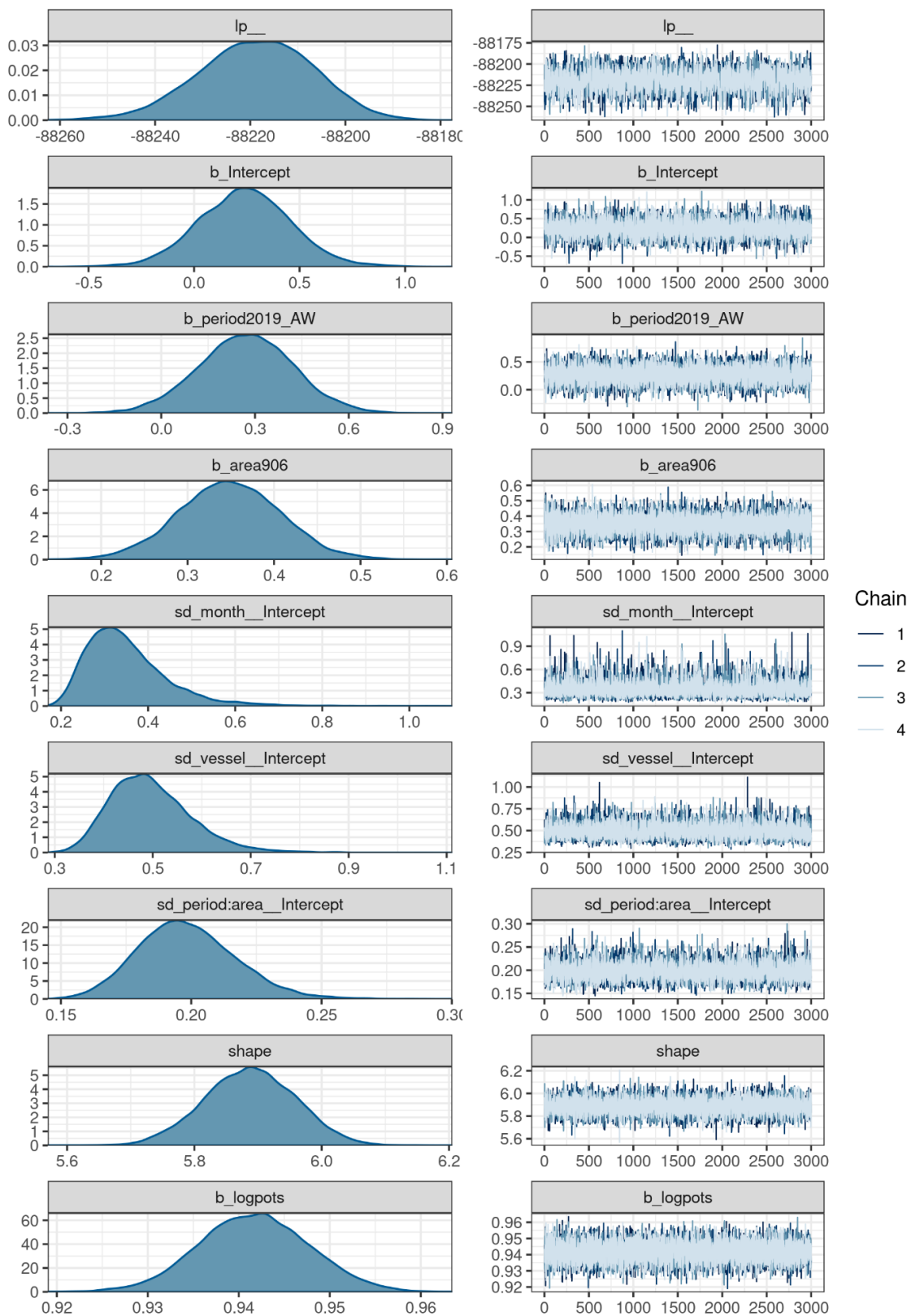


**Figure E.14:** Logbook: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable vessel for the main logbook model fitted to the by pot data set, i.e., ' $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ', according to LOO IC (Table 17). Note that the vessel keys have been removed from the x-axis of this plot.



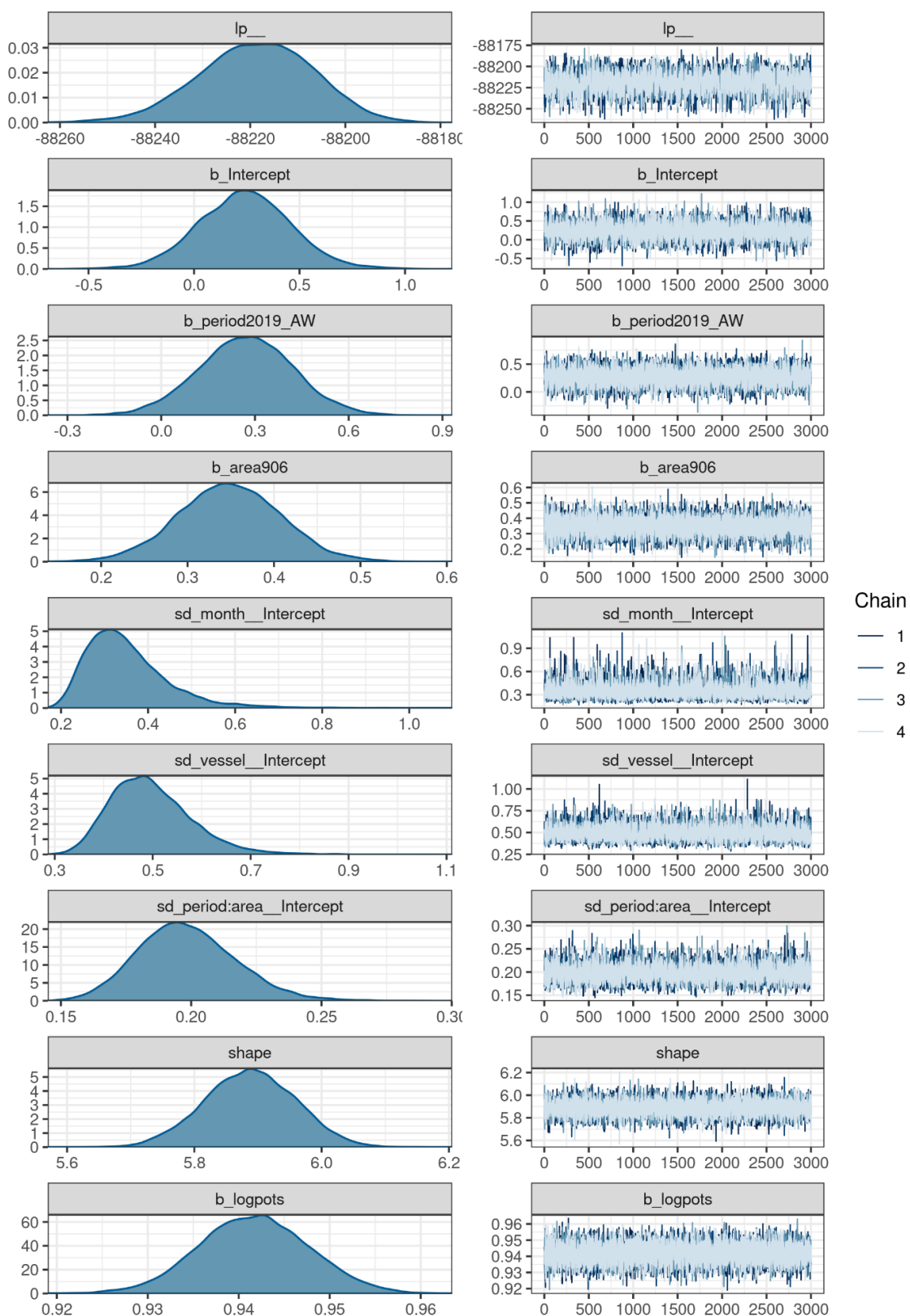
**Figure E.15:** Logbook: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable statistical area for the main logbook model fitted to the by pot data set, i.e., ' $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ', according to LOO IC (Table 17).

### E.3 FINE SCALE CPUE MODELS

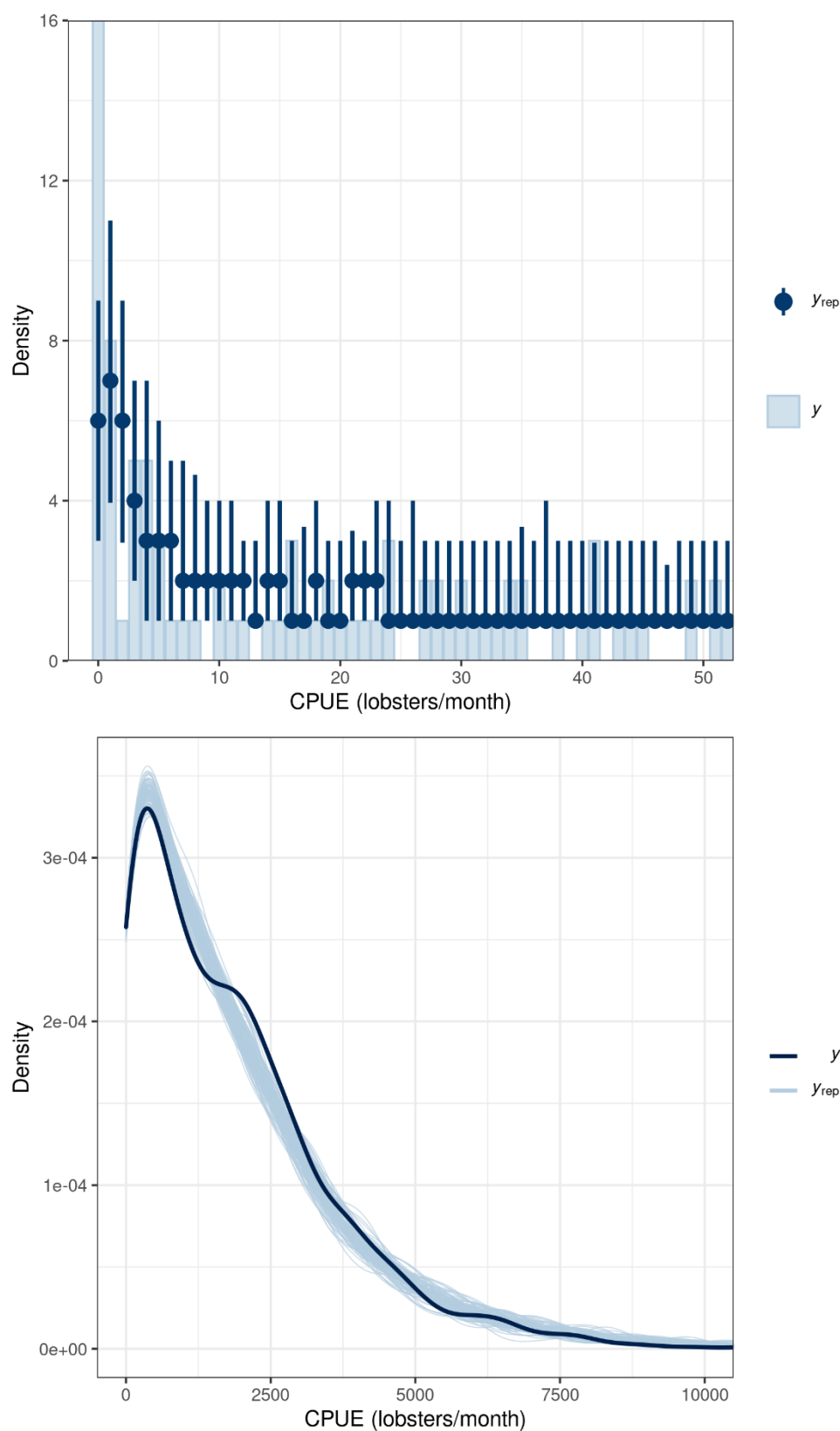


**Figure E.16:** Fine scale: MCMC trace plots for the best fitting fine scale model fitted to month level data, i.e., ' $\log(pot) + period + (1 | month) + area + (1 | period \times area)$ ', according to LOO IC (Table 22).

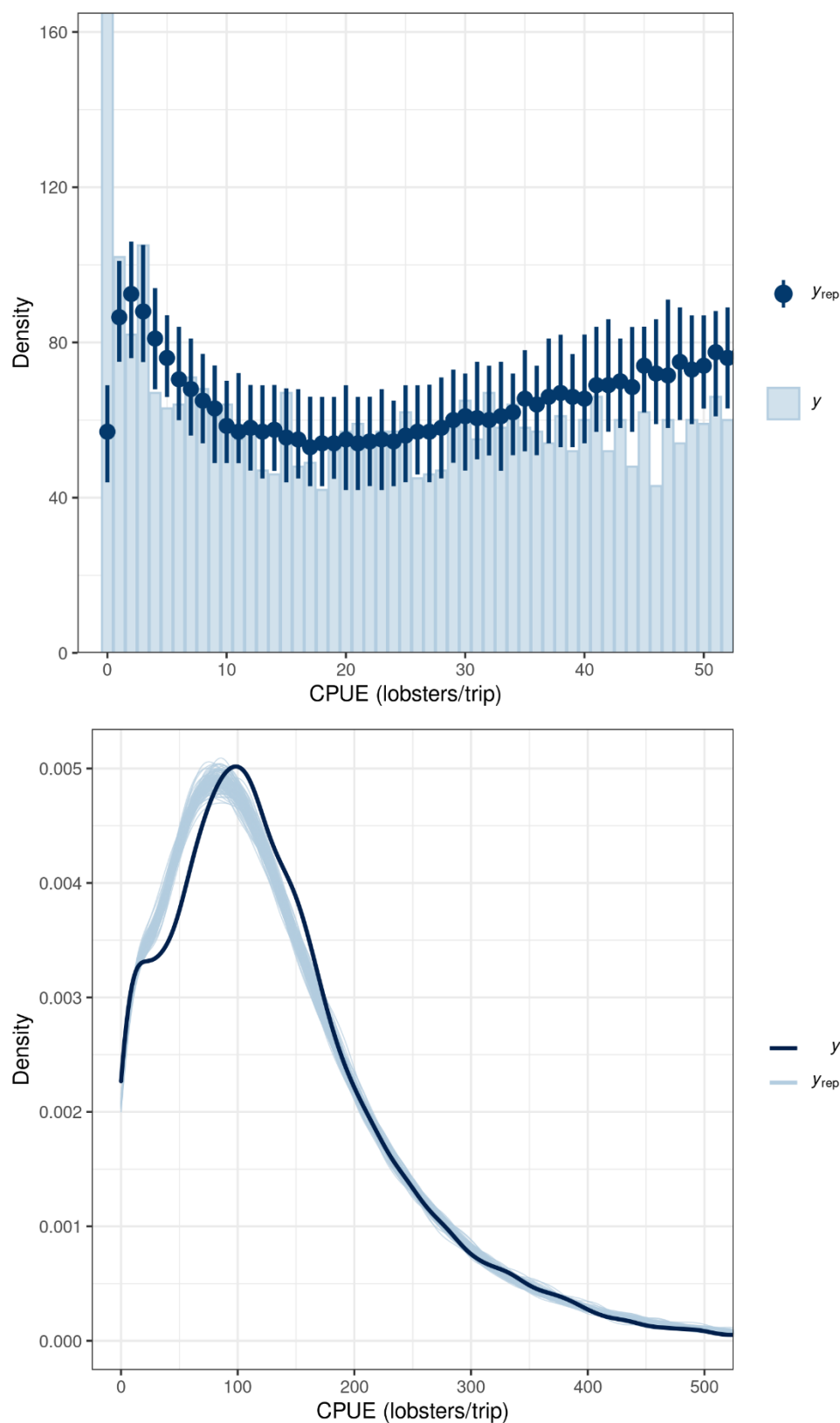




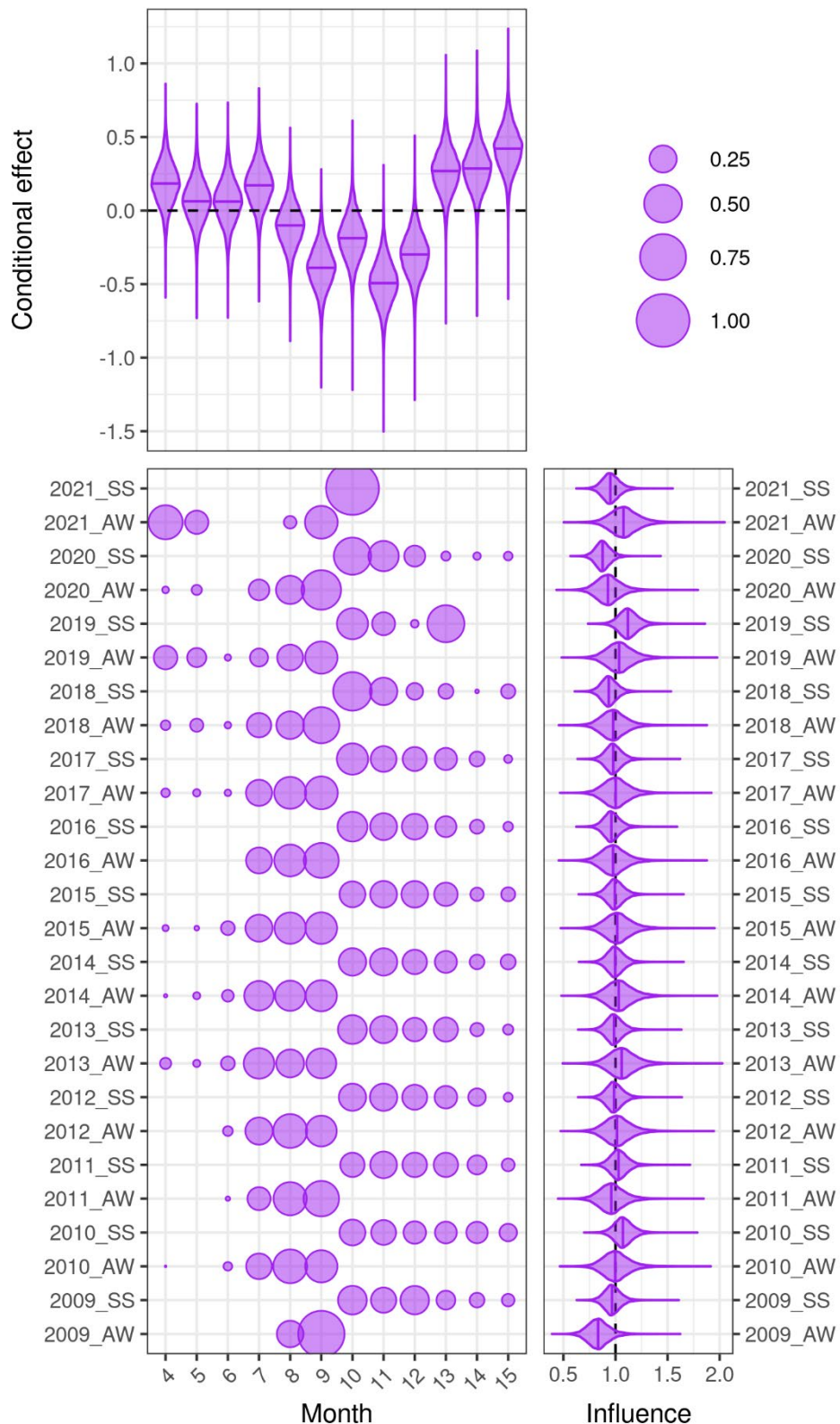
**Figure E.17:** Fine scale: MCMC trace plots for the best fitting fine scale model fitted to trip level data, i.e., ' $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ', according to LOO IC (Table 22).



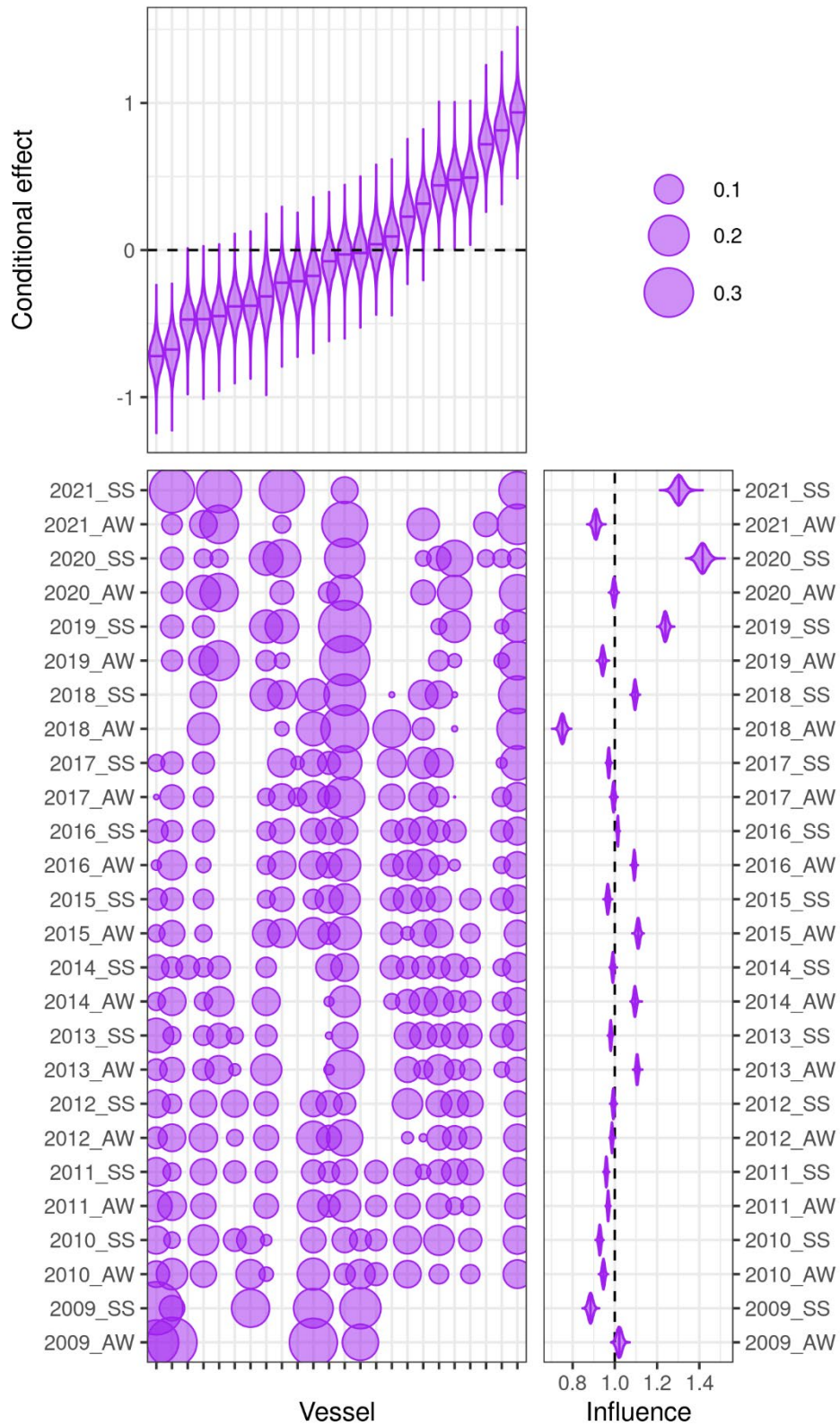
**Figure E.18:** Fine scale: posterior predictive density plots as bars [top] and density lines [bottom] for the model '*period + (I | month) + area + (I | period × area)*' fitted to the fine scale data at the month level assuming the negative binomial distribution. In this plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution. Note that the x-axis has been limited to a CPUE of 50 lobsters/month in the top plot and 10 000 lobsters/month in the bottom plot.



**Figure E.19:** Fine scale: posterior predictive density plots as bars [top] and density lines [bottom] for the model ' $period + (I | month) + area + (I | period \times area)$ ' fitted to the fine scale data at the trip level assuming the negative binomial distribution. In this plot,  $y$  is the density of the data (solid blue line) and  $y_{rep}$  is the density of 100 draws of data from the posterior predictive distribution. Note that the x-axis has been limited to a CPUE of 50 lobsters/trip in the top plot and 500 lobsters/trip in the bottom plot.

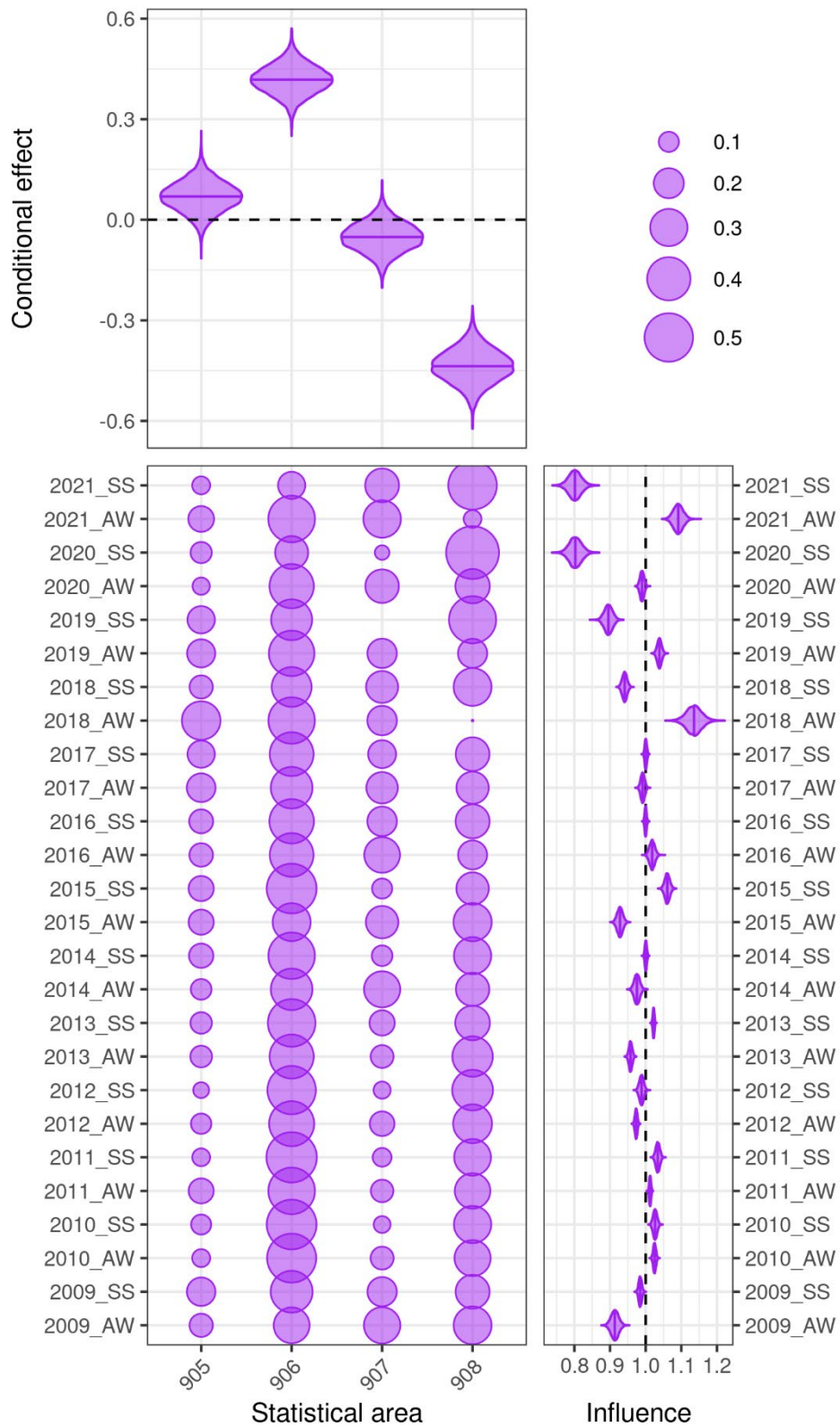


**Figure E.20:** Fine scale: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable month ('4' is April) for the best fitting fine scale model fitted to trip level data, i.e., ' $\log(\text{pot}) + \text{period} + (1 | \text{month}) + \text{area} + (1 | \text{period} \times \text{area})$ ', according to LOO IC (Table 22).



**Figure E.21:** Fine scale: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable vessel for the best fitting fine scale model fitted to trip level data, i.e., ' $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ', according to LOO IC (Table 22).





**Figure E.22:** Fine scale: coefficient distribution influence (CDI) plots (Bentley et al. 2012) for the explanatory variable statistical area for the best fitting fine scale model fitted to trip level data, i.e., ' $\log(\text{pot}) + \text{period} + (1 \mid \text{month}) + \text{area} + (1 \mid \text{period} \times \text{area})$ ', according to LOO IC (Table 22).