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Tini a Tangaroa

A descriptive analysis of all ling (*Genypterus blacodes*) fisheries, and CPUE for ling longline fisheries in LIN 3&4 from 1990 to 2018

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EXECUTIVE SUMMARY

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Updated descriptive analyses for all New Zealand ling fisheries are presented incorporating data up to the 2017–18 fishing year. The overall 2017–18 ling catch from the EEZ is higher than the previous year and catches have increased from the lower levels in 2008–09 to 2011–12. However, estimated catches in the last five years were all below those reported between 1992–93 and 2003–04. The Southland fishery had the highest overall catches in 2017–18. The spatial distribution of the trawl fishery has not changed substantially since the last assessment in 2012–13. Overall trawl landings were lower than those taken in 2015–16 and 2016–17, and similar to those taken by this method during the early to mid-2000s.

The overall line fishery catch distribution has also remained relatively similar to that in the previous assessment. The 2017–18 catch is markedly lower than in the most productive years (i.e., 1992–2002), but relatively consistent with the pattern of landings since 2003.

Series of CPUE for commercial line fisheries targeting ling on the Chatham Rise (LIN 3&4, 1990–2018) was updated.

From 1990 to 1996 years, the standardised indices for line fisheries declined by about 55% on the Chatham Rise, but have remained relatively constant thereafter. Irrespective of different methods used to investigate the fishery CPUE, the overall trends for all indices are similar to previous analyses.

1. INTRODUCTION

This document reports on Specific Objective 1 of Project LIN201801, which has an overall objective "To carry out a stock assessment of ling (*Genypterus blacodes*) on the Chatham Rise (LIN 3/4) including estimating biomass and stock status". It includes a descriptive analysis of the commercial catch and effort data for ling from LIN 3&4, including analyses of the standardised catch-per-unit-effort (CPUE) with the addition of data up to the end of the 2017–18 fishing year. Specific Objective 1 was "To carry out a descriptive analysis of the commercial catch and effort data for ling (LIN 3&4) on the Chatham Rise, including analyses of the standardised catch per unit effort." This objective requires that LIN 3&4 CPUE be updated only for the series used in the most recent previous stock assessments of the Chatham Rise stock.

Earlier descriptive analyses of commercial catch and effort data for ling were completed for the fishing years 1989–90 to 1998–99 (Horn 2001); 1989–90 to 2004–05 (Horn 2007b); 1989–90 to 2012–13 (Ballara & Horn 2015) and 1989–90 to 2016–17 (Ballara 2019). These reports showed how the ling fisheries in the New Zealand EEZ had developed and operated, and defined seasonal and areal patterns of fish distribution. The work presented here updates an analysis reported in Ballara (2019) which included data up to the fishing year 2016–17 (fishing years run 1 October – 30 September); i.e. catch by area by method, to indicate whether any marked changes have occurred in the fisheries in the last year. Horn (2007b) provided a detailed description of the methods used to extract and summarise Fisheries New Zealand landings data.

An analysis updating series of CPUE indices from target line fisheries for ling on the Chatham Rise (LIN 3&4) is also presented here. CPUE analyses of these fisheries were most recently reported by Ballara (2019). These fisheries, along with the Sub-Antarctic, WCSI, Cook Strait and the Bounty Plateau line fisheries, account for over 95% of the line-caught ling. The principal lining method in all areas is bottom longline. These CPUE series are used as inputs into stock assessments.

2. CATCH DATA

2.1 Methods

Catch-effort, daily processed, and landed data were extracted from the Fisheries New Zealand catch-effort database "warehou" as extract 12063 and consist of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of hoki, hake, or ling from fishing years 1989–90 to 2017–18. This included all fishing recorded by Electronic Reporting (ERS); on Trawl Catch, Effort and Processing Returns (TCEPRs); Trawl Catch Effort Returns (TCERs); Catch, Effort and Landing Returns (CELRs); Lining Catch Effort Returns (LCERs); Lining Trip Catch Effort Returns (LTCERs); Netting Catch Effort Landing Returns (NCELRs); and high seas versions of these forms.

Data were checked for errors, using simple checking and imputation algorithms similar to those used by Ballara & O'Driscoll (2017). Data were also groomed for errors using simple checking and imputation algorithms developed in the statistical software package 'R' (R Core Team 2017). Individual tow or set locations were investigated and errors were corrected using median imputation for start/finish latitude or longitude, fishing method, target species, tow speed, net depth, bottom depth, wingspread, duration, and headline height for each fishing day for a vessel. Range checks were defined for the remaining attributes to identify outliers in the data. The outliers were checked and corrected if possible with mean imputation on larger ranges of data such as vessel, target species and fishing method for a year or month, or the record was removed from the data set. Statistical areas were calculated from positions where these were available. Transposition of some data was carried out (e.g., bottom depth and depth of net, or number of hooks and number of sets).

The fishing methods examined were: deepwater bottom trawl, deepwater midwater trawl, inshore bottom trawl, inshore midwater trawl, line, setnet, and fish pots. The distinction between deepwater and inshore trawls is not based on depth or position, but rather on the form type that the catch is reported on. TCEPR and ERS records are classified as deepwater; CELR and TCER records are classified as inshore.

New Zealand ling are managed as eight administrative Quota Management Areas (QMAs), although five of these (LIN 3, 4, 5, 6, and 7) (Figure A1) currently produce about 95% of the New Zealand landings of ling. Research has supported the assumption of at least five major biological stocks of ling in New Zealand waters (Horn 2005): Chatham Rise (LIN 3 and LIN 4), Sub-Antarctic incorporating Campbell Plateau and Stewart-Snares shelf (LIN 5, and LIN 6 west of 176º E), Bounty Plateau (LIN 6 east of 176º E), west coast South Island (LIN 7 west of Cape Farewell), and Cook Strait (those parts of LIN 2 and LIN 7 between latitudes 41° and 42° S and longitudes 174° and 175.4° E, equating approximately to Statistical Areas 016 and 017). These stocks are referred to as LIN 3&4, LIN 5&6, LIN 6B, LIN 7WC, and LIN 7CK, respectively.

The catch data from the statistical areas were combined so that the groupings generally approximated the various administrative ling stocks, with two major exceptions. The Bounty Plateau section of LIN 6 was examined separately as it is believed to contain a distinct biological stock (Horn 2005), and a Cook Strait area comprising parts of LIN 2 and LIN 7 was created. The fishery areas are labelled in this section as North North Island (North NI), East North Island (East NI), East South Island (East SI), Chatham, Southland, Sub-Antarctic, Bounty, West South Island (West SI), and Cook Strait (Table A1, Figure A1, Figure A2). Data for the Chatham Rise were grouped by statistical area as follows: Chatham Rise (LIN 3&4): 018–024, 049–052, 301, 401–412. Consequently, the grouping of some statistical areas may appear erroneous, but has been done in a way that best approximates biological stocks. For example, Statistical Areas 302, 303, and most of 026 are in LIN 3, but they have been included in the Sub-Antarctic analysis, as ling in these areas probably derive from the Sub-Antarctic stock because the Stewart-Snares shelf and Campbell Plateau are the closest submarine shelves to these statistical areas.

2.2 Catch data results

Annual estimated catches, reported landings, and TACCs by area, from all methods combined, are listed in Table A2, and shown in Figure A3. In 2017–18, landings from all Fishstocks (16 710 t) were substantially under-caught relative to their TACCs (23 192 t), except LIN 7 where the TACC (3080 t) was slightly overcaught (3291 t). The estimated catch totals for each year ranged between 85.6 and 94.3% of the Monthly Harvest Return (MHR) landings. Substantial catches were taken in all areas, but most catches were taken in five areas around the South Island: East SI (LIN 3), Chatham (LIN 4), Southland (LIN 5), Sub-Antarctic (LIN 6), and West SI (LIN 7). This pattern of catches was consistent with ling distributions derived from research trawls (Anderson et al. 1998). There were some changes in the proportions of catch contributed by some areas before and after 2000. Catches from the Sub-Antarctic increased in the latter period (although they were lower from 2008–09 to 2015–16), while those from Chatham declined. The largest ling fishery in 2017–18 was the Sub-Antarctic fishery. Most ling catches since 1989–90 were reported on the TCEPR or CELR forms, and were caught by bottom trawling or bottom longlining, mainly when the target species was hoki or ling. (Table A3, Figure A3).

Overall, trawl-caught ling were taken mainly by bottom trawlers targeting hoki (Figure A4). Trawl-caught ling are taken year around, although catches are largely outside of July-August, and taken by vessels between 50 and 70 m (Figure A4). Compared to the previous fishing year, the 2017–18 trawl fishery catches in all areas have remained relatively consistent (Table A3, Figure A4).

The deepwater bottom trawl fishery was still important in the Southland and Sub-Antarctic areas with annual catches generally greater than 2000 t (Table A3). Catches from the Sub-Antarctic increased from the late 1990s to peak at more than 4900 t in 2003–04. Only 750–1500 t was reported from 2009–10 to 2011–12, but there was a large increase to 3390 t taken in 2012–13, with a decrease to just over 1500 t in 2015–16, and a subsequent increase to just over 1900 t in 2016–17. In 2017–18, catches from the Sub-Antarctic increased to 3629 t. Southland catches ranged from 1900 to 3300 t, with 3200 t taken in

2016–17. In 2017–18, catches from Southland remained consistent with those taken in 2016–17. West SI catches have been greater than 500 t since 1996–97, and in 2016–17 increased slightly to 980 t. In 2017–18 catches were at 764 t. East SI catches increased slightly in 2016–17 from 320 t to about 420 t, but catches dropped in 2017–18 to 347 t. Chatham catches increased slightly in 2016–17 from 550 t to 660 t, and increased again in 2017–18 to 693 t. Total landings from the deepwater midwater trawl fishery have been relatively low since 2006–07, ranging between 125 and 650 t, increasing to 678 t in 2017–18 (Table A3).

There were relatively low catches (i.e., generally less than 100 t annually) in the inshore bottom trawl fishery in years pre-dating 2008–09 in all areas except for Sub-Antarctic, and Bounty, where catches have been consistently negligible or zero (Table A3). Catches increased substantially in Southland and West SI from about 2008–09, with a peak in catches at 315 t in West SI in 2010–11, and 460 t in 2015–16 in Southland. Catches have remained comparatively consistent in all areas in 2017–18 relative to previous years. Catches from the inshore midwater trawl fishery were negligible in all areas with the exception of West SI and Cook Strait; catches in 2017–18 were highest in West SI at 130 t, and at 9 t in Cook Strait (Table A3).

The catch from the ling longline fishery is taken mainly by bottom longliners targeting ling between July and August (Figure A5). The fleet is mostly composed of vessels smaller than 60 m length, ling being increasingly caught by vessels less than 28 m. Catches in 2017–18 have remained relatively consistent with those in 2016–17, with the exception of a fairly substantial decrease in Bounty from 739 t to 228 t (Table A3, Figure A5). Catches from the line fisheries by area have varied markedly between years in the past, although they have remained relatively consistent in recent years (Table A3). Chatham is considered to be the most productive area relative to others, although catches since 2002–03 have been about a third of those taken at its peak in the mid-1990s.

The setnet fishery catches have been negligible in all areas except East SI, where catches in 2017–18 were low at 31 t (Table A3).

Catches from fish pots were generally recorded only from East SI, where annual landings were generally between 10 and 50 t. However, since 2015–16, catches in all areas, bar Sub-Antarctic and Bounty, have increased with substantial increases in 2017–18 in both East SI (from 153 t to 516 t) and Cook Strait (from 18 to 85 t) (Table A3).

Total estimated catches from the EEZ increased by 1000 t in 2017–18, from 15 000 t to almost 17 000 t, a substantial increase on the 13–14 000 t levels taken from 2012–13 to 2015–16. 2017–18 catches are similar to those taken from the historically high catch period between 1991–92 and 2007–08 (Table A2).

2.2.1 Chatham (LIN 3&4) catch data

On the Chatham Rise (LIN 3&4), ling trawl catch has primarily been, and continues to be, taken by bottom trawlers targeting hoki (Table B1, Figure B1). The proportion of ling caught in hake target tows has decreased since 2009, with no catch in 2017–18 (Figure B1). Catch has consistently been taken year-round, although most has been taken largely outside of July and August (Table B2; Figure B1). Most of the trawl catch was spread out across East SI (Statistical Areas 021–023) and the Chatham Rise (Statistical Areas 401–404, and 407–410) (Figures B1–B3). Historically, more than 98% of the Chatham Rise trawl catch was reported on the TCEPR form, although most trawl catch in 2017–18 was reported on the new ERS forms (Figure B1). Trawl catches have been below 1200 t since 2010, with the lowest catches since 1990 reported in 2014 at 752 t (Table B2). In 2017–18 catches were reported at 1107 t, slightly less than those reported in 2016–17 (Table B2). When targeting hoki, hake and ling, mean duration, distance, speed, and depth per tow have remained relatively consistent over time (Figure B4). However, mean duration, distance and speed have decreased since around 2006–07 when targeting ling only (Figure B4). Vessels targeting ling trawl at a mean depth approximately 100 m shallower than when targeting hoki, hake and ling. Mean hoki catch per tow, when hoki, hake and ling are target species, has increased since 2004 (Figure B4). Overall, catches by year have been higher for larger (over 28 m) vessels, although since 2010 the number of tows reported have been similar for both large (over 28 m) and small (under 28 m) vessels (Table B3). Tow duration by year was much higher for larger vessels than those under 28 m. However, since 2010, tow duration by year has been similar for both small and large vessels (Table B3).

On the Chatham Rise (LIN 3&4), ling have consistently been taken predominantly by bottom longline fisheries targeting ling, with most catch being taken between July and October (Table B2; Figure B5). Most of the line catch is taken in Statistical Areas 020–021, 049, 052, 401–404, and 410 (Figures B5, B6, and B7). Most catch has been taken by vessels between 28 and 50 m, with vessels larger than 50 m operating between 1993 and 2006, and vessels under 28 m becoming a part of the fleet from 2007 onwards (Table B3; Figure B5).

2.2.2 Descriptive analysis summary

The overall 2017–18 estimated ling catch increased from 15 000 t in 2016–17 to almost 17 000 t. Recent estimated catches have remained below levels reported between 1992–93 and 2003–04, when catches were estimated at greater than 17 000 t. However, estimated catches have been increasing since 2016–17.

The trawl fishery targets different areas to the line fishery, particularly in recent years. The spatial extent of high-catch areas appears to have reduced over time, with the trawl fishery predominantly operating on the western Rise, and the line fishery on the eastern and central Rise (Figure B2; Figure B6). The spatial distribution of both the trawl and line fisheries has not changed substantially since the last assessment in 2012–13 (Figure B4; Figure B7).

3. CPUE ANALYSIS

3.1 Methods

CPUE variables

Variables used in the CPUE analysis are described in Tables C1 and are generally similar to those used in previous analyses (e.g., Dunn & Ballara 2019). Longline CPUE indices were calculated using catch per day per statistical area (i.e., daily estimated catch in kilograms by a vessel in a particular statistical area), and number of hooks set per day was offered as an explanatory variable. Catch per day (rather than catch per hook) was used as the unit of CPUE because it has been shown (Horn 2002) that the relationship between catch per hook and the number of hooks set per day is non-linear.

Year was a categorical variable and was defined as the calendar year. Season variables of both *month* and *day of year*, and statistical area (*statarea*) variables were offered to the model.

Vessel was incorporated into the CPUE standardisation to allow for possible differences in fishing ability between vessels. Records with no vessel identification data were excluded from analyses. Data from vessels that fished infrequently were excluded by including data only from “core” vessels, which were those that together reported at least 80% of ling estimated catches, and were all involved in the fishery for two or more years, and for a substantial number of vessel-days in a year. Vessels not involved in the fishery for at least two years were excluded as they provided little information for standardisations, which could result in model over-fitting (Francis 2001). Individual vessel details were checked for consistency each year. One vessel was excluded from the analysis, even though it fit the "core" vessel criteria due to suspected reporting issues.

For line data, *total hooks* per day and *number of sets* per day were offered as an untransformed number and as log-transformed data.

CPUE data selection

Data for the Chatham Rise were grouped by statistical area as follows: Chatham Rise (LIN 3&4): 018–024, 049–052, 301, 401–412. Note that these analyses were carried out on the basis of presumed biological stocks, rather than administrative (QMA) stocks. Consequently, the grouping of some statistical areas may appear erroneous, but has been done in a way that best approximates biological stocks. For example, although Statistical Areas 302, 303, and most of 026 are in LIN 3, they have been excluded from the Chatham Rise analysis, as ling in these areas probably derive from the Sub-Antarctic stock because the Stewart-Snares shelf and Campbell Plateau are the closest submarine shelves to these statistical areas.

Data were available from 1 October 1989, but were analysed by calendar year rather than fishing year because of a seasonal trend of higher catch rates in most ling line fisheries running from about June to December (see Horn 2007a). This ensured that all catches in a particular season peak were included in a single year, rather than being spread between two (fishing) years.

For line fisheries, some vessels recorded individual set data on CELR forms, but most vessels reported a single CELR record for a day's fishing. If uncorrected, this would bias CPUE analyses, as those vessels recording individual events would contribute about four times as many records per day. Consequently, all line data for CELR, LTCER and LCER forms were condensed (catches, hooks, and sets summed for each vessel, day, and statistical area) to ensure that each record represented total catch and effort per statistical area per day. The estimated catch of the top five species per day can be reported on the CELR form, whereas the estimated catch of the top eight species per set can be reported on the LCER and LTCER forms. If there was more than one set recorded in a day, the estimated catch of numerous (up to 20–30) species may be reported for a single day of fishing on LCER and LTCER forms, compared to five species on CELR forms. This can result in small catches being reported in LCER and LTCER records that would not have appeared had CELR forms been used. Therefore the daily aggregate estimated catch of ling was only included with the LCER or LTCER daily aggregate effort record if the catch of that species was ranked amongst the five largest species catches (by weight) for the vessel fishing day and statistical area.

It was identified by the MPI Deepwater Fisheries Assessment Working Group meeting on 8 February 2018 that handbait vessels are more likely to have higher catch rates and have more targeted effort than autoliners (owing to more hooks being comprehensively and successfully baited than by the auto-baiting process), hence identifying and excluding these vessels from a CPUE analysis is important. It was not simple to use number of hooks per day as a cut off to define autolongliners, so information was obtained from industry and MPI to identify longline vessel types as either autolongline or handbait. Some vessels were able to be identified as exclusively autolongline or handbait vessels, but there was a set of vessels that were current autolongliners but had previously converted from handbait to autolongline. Dates of vessel type conversion were provided, therefore vessels could be split into two groups: Autolongliners and handbaiters, based on which vessel type was active at each time step. Overall the autolongline vessels accounted for 80.5 % of the catch, while handbait vessels made up 19.5 % of the catch (Table C2).

To ensure that the data were in plausible ranges and related to vessels that had consistently targeted and caught significant landings of ling, data were accepted if all the constraints were met (Tables C3). Core vessel analyses were run for line fisheries using vessel-day data.

Records were excluded if catches were outside of the range 1–35 000 kg, and the total number of hooks was outside of the range 50–50 000. Examination of records reporting zero catch indicated that most represented either duplicate records (two records for a particular day, one with and one without catches) or obvious mistakes (two or three days fishing with no catch). Because of the relatively high number of hooks fished in any set, a zero catch of ling in any set that was targeting ling was likely to result either from a reporting error or, if real, some gear malfunction or unsuccessful exploratory fishing. As a result, zero catch records were removed from the data set, andtherefore no combined model was necessary.

The CPUE model

Annual unstandardised (raw) CPUE indices were calculated as the mean of the individual daily catch (kg) for longline data. All series used the lognormal distribution for the positive catch model. Estimates of relative year effects were obtained from a stepwise multiple regression method, where the data were fitted using a lognormal model using log transformed non-zero catch-effort data. The predictor variable *year* was forced into the model (as it is mandatory for a biomass index), and other variables tested for inclusion. A forward stepwise multiple-regression fitting algorithm (Chambers & Hastie 1991) implemented in the R statistical programming language (R Core Team 2017) was used to select additional predictor variables, and they were entered into the model in the order which gave the maximum decrease in the AIC. The algorithm generates a final regression model iteratively and used the *year* term as the initial or base model in all cases. The reduction in residual deviance (denoted r^2) was calculated for each single term added to the base model. The term that resulted in the greatest reduction in the residual deviance was then added to the base model, where the change was at least 1%. The algorithm was then repeated, updating the base model, until no more terms were added. A stopping rule of 1% change in residual deviance was used because this results in a relatively parsimonious model with moderate explanatory power. Alternative stopping rules or error structures were not investigated.

Predictor variables were either categorical or continuous. The variable *year* was treated as a categorical value so that the regression coefficients of each year could vary independently within the model. The relative year effects calculated from the regression coefficients represent the change in CPUE through time, all other effects having been taken into account, and represents a possible index of abundance. *Year* was standardised to the first year of the data series. Year indices were standardised to the mean and were presented in canonical form (Francis 1999). Potential continuous variables were modelled as third-order polynomials (see Tables C1). *Total hooks* were offered as a fourth-order polynomial as well as a categorical variable (where hooks were split at 10 000 hooks) in the base model. *Vessel* was incorporated into the CPUE standardisation to allow for differences in fishing ability between vessels. *Position* was included to investigate differences in the spatial distribution of fishing effort and catches. The index CVs represent the ratio of the standard error to the index. The 95% confidence intervals were also calculated for each index. Date was included in the catch runs as *year* and *month*, or *day of year*. Interaction terms were not used in the line fisheries, because in the past their inclusion resulted in some implausible vessel coefficients (Dunn et al. 2013).

Model fits to the lognormal component of the model were investigated using standard residual diagnostics. For each model, a plot of residuals against fitted values and a plot of residuals against quantiles of the standard normal distribution were produced to check for departures from the regression assumptions of homoscedasticity and normality of errors in log-space (i.e., log-normal errors). Randomised quantile residuals are based on the idea of inverting the estimated distribution function for each observation to obtain exactly standard normal residuals.

Unstandardised CPUE was also derived for each year from the available datasets. The annual indices were calculated as the mean of the individual daily catch (kg) for line data.

The model predictors for each selected variable were plotted, with all other model predictors fixed. These fixed values were chosen to be ‘typical’ values (see Francis (2001) for further discussion of this method). If different fixed values were chosen, the absolute values on the plotted *y*-axis would change but the trend would be unchanged.

The influence of each variable accepted into the lognormal models was described by coefficient–distribution–influence (CDI) plots (Bentley et al. 2012). These plots show the combined effect of (a) the expected log catch for each level of the variable (model coefficients) and (b) the distribution of the levels of the variable in each year, and therefore describe the influence that the variable has on the unstandardised CPUE and that is accounted for by the standardisation.

CPUE analyses were undertaken for "core" vessels that were determined for each area analysis using area-specific criteria based on approximately 80% of ling catch, the number of years of vessel participation, and the number of vessel-days (line) per vessel-year (Tables C3).

For the line fisheries, six CPUE analyses were conducted, where each analysis included data that were accepted from the CELR and LTCER forms for target ling and line method BLL (bottom longline) for calendar years 1991–2018. A base CPUE model was run comparative to the last analysis, using non-zero catches from all "core" vessels (Ballara & Horn 2015). The second CPUE analysis removed all vessels that operated only in the earliest years, and where there was little to no overlap with later years in the series (i.e. those that were predominantly active pre-1997). Two CPUE analyses were used to investigate spatial differences: 1. By offering positional data (latitude and longitude) to the GLM; and 2. By splitting the dataset into East and West at 180 degrees as well as based on statistical areas on either side of the 180 degree line, and comparing trends of each area. Positional data weres not available for 8 % of all catch records, of which 19 % were associated with CEL forms. The relative percentage of records where positional data were missing has changed over time, and the quality of records appears to follow the introduction of new forms (Figure C1). Two separate CPUE indices were compared for differences between autolongliners and handbait vessels, as determined using the vessel information provided by industry and MPI. A final CPUE analysis was conducted to assess the effects of different conversion factors over time on CPUE indices, by standardising greenweights using the most current conversion factors for each processed state. This final analysis was used to investigate whether the observed spike in the CPUE trend in the early 1990s could be due to one or more erroneous conversion factors (Table C4).

All CPUE indices were compared to the previous results from Ballara & Horn (2015), and single fishery and two fishery results were compared for spatial data, as well as for autolongliners versus handbaiting vessels.

No CPUE was run for trawl fishing since ling are not always a target species so trawl fishery CPUE may not index abundance well. The trawl survey abundance indices are considered a more reliable alternative.

3.2 CPUE results

CPUE series for line-caught ling for Chatham Rise (LIN 3&4) are presented here, with tables and figures in Appendix C. All CPUE indices can be found in Table C6.

Chatham Rise line fisheries catch ling throughout the year by bottom longline and ling targeting, so only data from this method and target were included in the analyses (Table C3). Statistical areas that had few days fished (i.e., fewer than 20) throughout the 27 years were probably attributable to reporting errors or exploratory fishing, so were removed from the final analysis. Further data constraints included catches of 1–35 000 kg, and number of hooks at 50–50 000 per vessel-day.

Core vessels for the bottom longline index were defined as those participating in the fishery for at least four years (Figure C2; Figure C3). The core analysis included 19 333 records of days fished throughout the 27 years analysed. The core analysis included data from 22 vessels (one vessel was removed for suspected reporting issues) (Figure C4).

3.2.1 Single Line Fishery

For single line fishery CPUE, three variables were selected for the lognormal model, resulting in a total r^2 of 64.4%, with *log(total hooks)* explaining 36% of the residual deviance (Table C5a).

The standardised year effects for the single fishery model showed a relatively steep (approximately 55%) initial decline, although the trend remained largely flat after 1997. Offering *total hooks* as a fourth-order polynomial or as a categorical variable did not produce any difference in year effect, so was not investigated in further CPUE series (Table C5a, Figure C5a). Vessel coefficients were quite variable, and there were higher catch rates during the spawning season (between August and October), and catches increased with hook number.

The number of hooks variable had the largest impact on the standardised index (Figure C6a). The trend of the single line fishery CPUE index remains similar to that in the previous analysis (Figure C7a).

Influence plots (Figure C8a) showed a shift in total hooks per day from fewer than 10 000 at the beginning of the series to more than 10 000 from the year 2000 and then back to fewer than 10 000 since 2003. Generally, vessel had little influence on CPUE (range 0.85 – 1.15 for the entire time series). However, there were three vessels (11, 12 and 15) that had notably stronger influence than other vessels. Month had relatively little influence overall, although higher coefficients were estimated during the spawning season (August – October). The diagnostics for each line model showed some departure from model assumptions, and the catch rate extremes were not well captured by the model (Figure C9a).

3.2.2 Single Line Fishery – without early vessels

When removing those vessels where there was little to no overlap with later years in the series, the single line fishery lognormal model selected four variables, resulting in a total r^2 of 64.0%, with *log(total hooks)* explaining 34.7% of the residual deviance (Table C5b).

The extent of the initial decline in observed year effects was less in this model than in the baseline single line fishery, although the trend post-1997 was similar (Table C5b, Figure C5a). Vessel coefficients remained quite variable, and the effects of month and hook number were similar to the baseline model. However, statistical area was not selected as a predictor in the baseline model.

As with the baseline model, the number of hooks variable had the largest impact on the standardised index (Figure C6b). The CPUE index with early vessels removed compared to the baseline single line fishery model was similar after around 2000 (Figure C7a). However, the spike in the CPUE observed in early years in the baseline model was reduced.

Influence plots (Figure C8b) showed a similar trend in total hooks per day, and month to the baseline model. Generally, vessel had little influence on CPUE, although a 'step change' is apparent at the beginning of the time series. Some statistical areas had substantial catches despite very little attributed effort (e.g. 406). Area 022 appeared to have a particularly strong influence in 1991, which may have affected the overall influence of statistical area on the model. The diagnostics for each line model showed some departure from model assumptions, and the catch rate extremes were not well captured by the model (Figure C9a).

3.2.3 Single Line Fishery – Conversion Factors

The spike in the single line fishery CPUE was investigated with regards to conversion factors, since these have changed over time, and some could be erroneous, potentially having an impact on historical greenweights and thus CPUE. Greenweights were adjusted using the most recent conversion factors for each processed weight. Based on the conversion factors used between 1990 and 1993, it appeared plausible that applying the most recent conversion factors to these years may have an effect on CPUE.

For the conversion factor model, four variables were selected for the lognormal model, resulting in a total r^2 of 57.0%, with *log(total hooks)* explaining 31.3% of the residual deviance (Table C5c).

The standardised year effects for the single fishery model show a relatively consistent trend, without the steep decline that had been observed in the baseline model. (Table C5c, Figure C5b). Vessel coefficients were similar for all vessels, catch rates were consistent year-round, and catches increased very gradually with hook number. Statistical area effects were similar for all areas except Statistical Area 412.

The number of hooks variable had the largest impact on the standardised index (Figure C6c). The trend of the conversion factor model was similar to the baseline single line fishery CPUE index, although the trend appears to be a little flatter when greenweight data were recalculated using standardised conversion factors (Figure C7b).

Influence plots (Figure C8c) showed a shift in total hooks per day from fewer than 10 000 at the beginning of the series to more than 10 000 around 2000 and then back to fewer than 10 000 since 2003. Generally, vessel had little influence on CPUE (range 0.85 – 1.15 for the entire time series). However, there were three vessels that had notably stronger influence than other vessels. Month had relatively little influence overall, although higher coefficients were estimated during the spawning season (August – October). The diagnostics for each line model showed some departure from model assumptions, and the catch rate extremes were not well captured by the model (Figure C9a).

3.2.4 Single Line Fishery – Spatial analysis

To investigate the spatial component on CPUE indices, positional (latitude and longitude) data were included in the model as *position*. This single line fishery lognormal CPUE model selected three variables, resulting in a total r^2 of 63.0%, with *log(total hooks)* explaining 30.0% of the residual deviance (Table C5d). *Position* was not selected for the model.

Overall, the standardised year effects and influence plots showed very similar patterns to those observed by the baseline model, with the number of hooks variable having the largest impact on the standardised index (Figure C5b, Figure C6d). The trend of the single line fishery CPUE index with positional data offered was similar to the baseline model, although the peak in the early 1990s was slightly higher when positional data were offered (Figure C7b). The diagnostics for each line model showed some departure from model assumptions, and the catch rate extremes were not well captured by the model (Figure C9a).

3.2.5 Two Line Fisheries – Western and Eastern

Further exploration of spatial effects on the line fishery CPUE was conducted by splitting the data at 180 degrees, and where positional data were not available, by statistical area split either side of the 180-degree line.

For the western line fishery, four variables were selected for the lognormal model, resulting in a total r^2 of 64.0%, with *log(total hooks)* explaining 30.4% of the residual deviance (Table C5e). For the eastern line fishery, three variables were selected for the lognormal model, resulting in a total r^2 of 64.5%, with *log(total hooks)* explaining 36.1% of the residual deviance (Table C5e).

The standardised year effects for both the western and eastern fisheries models showed a relatively steep initial decline similar to that observed in the baseline model, with a moderately flat trend after 1997 (Table C5e, Figure C5c). For both western and eastern fisheries models, vessel coefficients were quite variable, and there were higher catch rates during the spawning season (between August and October), and catches increased with hook number. Statistical Area 411 had the greatest effect of all statistical areas on the western fishery model.

The number of hooks variable had the largest impact on the standardised indices of both models (Figure C6e, Figure C6f). The trend of the eastern fishery was very similar to that of the baseline single line fishery CPUE index (Figure C7c). However, the CPUE trend for the western fishery, although similar from 1995, had a higher peak in the early 1990s than either the eastern or baseline models.

Influence plots (Figure C8e, Figure C8f) for both the eastern and western models showed a shift in total hooks per day. The western model showed a shift from predominantly more than 10 000 hooks per day until around 2007, to around 5000 thereafter. In the eastern fishery, hook numbers per day began at fewer than 10 000, then shifted to more than 10 000 hooks per day around 2000 and then back to fewer than 10 000 around 2003. Generally, vessel had little influence on CPUE. Month had relatively little influence overall, although higher coefficients were estimated by both models during the spawning season (August – October). The diagnostics for each line model showed some departure from model assumptions, and the catch rate extremes were not well captured by the model (Figure C9b). The overall influence of statistical area on the western model was minimal, but consideration should perhaps be given to the removal of statistical areas where coefficient CV were high (e.g. Statistical Area 411) for future model runs.

3.2.6 Two Line Fisheries – Handbait and Autolongliner

To investigate the effects of vessel type on the line fishery CPUE, the fishery was split into two based on whether vessels were handbaiting vessels or autolongliners, as determined by industry and MPI. It must be noted that there was no catch for handbaiting vessels between 1995 and 2002.

For the autolongliner fishery CPUE, three variables were selected for the lognormal model, resulting in a total r^2 of 64.9%, with *log(total hooks)* explaining 36.9% of the residual deviance (Table C5f). For the handbaiting fishery CPUE, three variables were selected for the lognormal model, resulting in a total r^2 of 39.9%, with *log(total hooks)* explaining 21.2% of the residual deviance (Table C5f).

The standardised year effects for the autolongliner fishery model showed a similar trend to that observed in the baseline model (Table C5f, Figure C5d). Vessel coefficients were similar for all vessels, except one which was the only vessel in the series to have switched gear type within the time series. As with the baseline model, the autolongliner model showed that there were higher catch rates during the spawning season (between August and October). However, the handbaiting model showed catch rates to be consistent year-round. Both models demonstrated that catches increased with hook number.

The number of hooks variable had the largest impact on the standardised indices of both models (Figure C6g, Figure C6h). The trend of the autolongliner fishery CPUE index was very similar to that of the baseline single line fishery index (Figure C7d). The CPUE index for the handbaiting fishery differed substantially at the beginning of the time series, with no obvious peak being observed in the early 1990s. The handbaiting CPUE trend was more similar to the autolongliner and baseline indices towards the end of the series, but remained relatively flatter, rather than decreasing slightly.

Influence plots (Figure C8g, Figure C8h) for the autolongliner model showed a shift in total hooks per day from fewer than 10 000 at the beginning of the series to more than 10 000 around 2000 and then back to fewer than 10 000 after 2003; similar to that observed with the baseline model. The handbaiting fishery showed a gradual increase in total hooks per day from around 1000 in 1991 to around 6000 hooks in 2018. Generally, vessel had little influence on CPUE (range 0.85 – 1.15 for both models). However, the coefficients were particularly high for the single vessel that switched gear type within the time series. Month had relatively little influence overall, although higher coefficients were estimated by the autolongliner model, during the spawning season (August – October). The diagnostics for each line model showed some departure from model assumptions, and the catch rate extremes were not well captured by the model (Figure C9b).

3.3 CPUE summary

In recent assessments of ling stocks on Chatham Rise, series of CPUE indices derived from commercial fisheries have been used as indices of abundance (e.g., Horn et al. 2013, Roberts 2016), usually as a sensitivity run in conjunction with indices from trawl survey series.

The Chatham Rise line CPUE series were relatively consistent with a largely flat trend for at least years post-2000 for all CPUE indices investigated. As would be expected, the trends in the indices, and the variables selected into the models, have not changed markedly between the previous (Ballara & Horn 2015) and current analyses. The longline fisheries examined here target a single species using the same method, so the sets of variables selected into the model for each stock might be expected to have some similarities. In all the analyses, *log(total hooks), vessel* and *month* were selected into the model. S*tatistical area* was accepted into the single fishery model without early vessels, the western fishery model and the conversion factor model. With the CPUE unit being ‘kg per day’, it would be expected that the number of hooks set per day would be a very influential variable, and it is indeed the most influential variable in the current analyses, accounting for the largest proportion of explained variance. Skill levels and/or gear efficiency will vary between vessels so the selection of a *vessel* variable in each model would be expected. Catch rates vary throughout the year in relation to the spawning season for ling so the selection of a *month* predictor in each model would be expected.

Horn (2002) concluded that most ling line CPUE series performed well in relation to four criteria raised by Dunn et al. (2000), and so were probably reasonable indices of abundance (for that part of the population targeted by the fishery). Although the longline fleet composition has changed over time, Horn (2004a) completed parallel analyses for shorter time series of data and compared the results with the “all years” indices to show that the change in fleet dynamics did not bias the line CPUE. It is considered unlikely that line CPUE series have been seriously biased by any changes in fishing practice over the durations of the fisheries (Horn 2004b), although data on some potentially influential factors are either unavailable before 2004 (e.g., hook spacing) or would be difficult to incorporate into analyses (e.g., vessel skipper, learning by fishers). The current analysis distinguishing between autolongliners and handbaiting vessels highlights the differences in CPUE for each fleet, particularly in the beginning of the time series, although differences were marginal after around 2003. There was only one vessel identified as having converted from one method to the other, but the overall influence of this single vessel on the CPUE trend was minimal. It was difficult to explain the drop in CPUE between 1996 and 1999, and it was present in all models, although the degree of the decline was slightly reduced for the handbaiting model and the eastern model.

The line CPUE was expected to provide a relatively unbiased CPUE index. However, biases in CPUE caused by changes in fishing practice not accounted for by the available predictors may still be present. This may be particularly pronounced for the ling target line fishery. For example, the line fishery generally targets ling on clearly defined geological features using relatively short longlines that can be accurately placed. The accurate placement of fishing gear in optimal ling habitat could bring about hyperstability in the CPUE index. Also, some interactions with the trawl fishery in the same area could also lead to biases, and it has been suggested that the hoki trawlers may direct the line vessels to areas with apparently high ling abundance, as indicated by the trawl bycatch (Horn & Ballara 2012). This behavior would enable line fishers to reduce their search time and/or fish in areas that are likely to produce relatively high, and consistently high, ling catch rates. If the extent of this behavior changed over time, it would bias the line CPUE. There are also anecdotal reports of trawlers directly transferring some of their ling catch (presumably for which they have no quota) to line or setnet boats; this behaviour would bias both trawl and line CPUE.

The current analysis rolls up data to vessel-day-statistical area, and for LCER and LTCER data only uses data if ling is in the top five species (see Section 3.1). Since 2004, line individual set data have been captured on LCER and LTCER forms. There are now 14 years of individual set data, so it would be worthwhile to investigate a comparison of individual set information rather than a rolled up data set. This would also increase the number of records in a year, although would still not get around confidentiality issues where data cannot be reported if it is produced from fewer than 3 vessels in a year.

The diagnostic plots for all line lognormal models were unable to capture the extremes in catch rates and tended to underestimate the lower or higher catch rates. This suggests that the lognormal models can be improved, and there may be violations of model assumptions (i.e., the assumption of normally distributed constant variance residual errors). Other models may need investigating.

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6. APPENDIX A: DESCRIPTIVE OVERALL

Table A1: Definitions of geographical areas used in the fishery's descriptive analyses (based on statistical areas), and the administrative ling stocks they approximate. For a plot of statistical areas, see Figure A2.

Area	Statistical areas	Administrative stock	Assessment stock
North NI	041–048, 001–010, 101–110, 801	LIN 1	–
East NI	011–015, 201–206	LIN 2	–
East SI	018–024, 301	LIN 3	LIN 3&4
Chatham	049–052, 401–412	LIN 4	LIN 3&4
Southland	025–031, 302, 303, 501–504	LIN 5	LIN 5&6
Sub-Antarctic	601–606, 610–612, 616–620, 623–625	Part of LIN 6	LIN 5&6
Bounty	607–609, 613–615, 621, 622	Part of LIN 6	LIN 6B
West SI	032–036, 701–706	Part of LIN 7	LIN 7WC
Cook Strait	016, 017, 037–040	Parts of LIN 2 and 7	LIN 7CK

Table A2a: Estimated ling catch (t) as reported on TCEPR, TCER, CELR, NCER, and LCER returns, reported landings (t) from MHR records, and TACC (t) by QMA and by assessment stock area (see Figure A1) from 1989–90 to 2017–18. All catches have been rounded to the nearest tonne. Fishing year 1989–90 is denoted as "1990", etc. The percentage of total estimated landings (Total) taken from each area is also presented (Percent). The QMR total also includes small catches from FMA 10 and outside the EEZ.

	Estimated Catches (tonnes)											
Year	**LIN 1**	**LIN 2**	**LIN 3**	**LIN 4**	**LIN 5**	**LIN 6**	**LIN 6B**	**LIN 7WC**	**LIN 7CK**	**Total**	**MHR Total**	**% of MHR**
1990	83	268	1 221	512	2 116	1 216	12	2 323	414	8 167	9 026	90.5
1991	139	436	1 935	2 156	2 092	2 683	33	1 947	527	11 950	13 675	87.4
1992	185	450	1 806	4 358	3 831	2 398	908	1 858	314	16 119	17 796	90.6
1993	155	525	1 620	3 657	2 684	5 253	969	1 875	323	17 065	19 069	89.5
1994	185	508	1 572	3 756	3 248	2 278	1 149	1 767	251	14 722	15 959	92.3
1995	217	530	1 946	4 480	3 644	3 643	392	2 611	319	18 155	19 817	91.6
1996	162	552	2 384	4 145	4 489	3 587	381	2 610	364	18 748	21 471	87.3
1997	254	527	2 067	3 796	4 284	5 009	340	2 503	366	19 281	22 535	85.6
1998	220	607	2 084	4 261	3 997	5 371	395	2 766	287	20 150	23 083	87.3
1999	178	545	1 981	3 924	3 510	4 336	563	2 927	345	18 334	21 019	87.2
2000	297	485	2 148	3 970	3 150	5 072	991	2 697	331	19 146	21 594	88.7
2001	236	597	1 743	3 445	3 394	4 641	1 064	3 070	391	18 584	20 551	90.4
2002	280	584	1 582	3 217	3 255	5 406	629	2 642	289	17 886	19 563	91.4
2003	226	471	1 845	2 719	3 063	5 135	922	2 338	353	17 075	18 908	90.3
2004	207	507	1 473	2 385	3 119	5 899	853	2 402	360	17 204	18 758	91.7
2005	228	394	1 213	2 570	3 774	5 207	49	2 056	372	15 863	17 186	92.3
2006	290	415	1 207	1 663	3 634	3 195	43	2 051	297	12 819	14 178	90.4
2007	232	512	1 601	1 943	3 997	4 112	236	1 797	239	14 670	16 099	91.1
2008	361	503	1 505	2 307	4 251	3 818	503	1 910	186	15 344	16 263	94.3
2009	307	452	1 394	1 815	3 201	2 264	232	1 851	124	11 640	13 137	88.6
2010	379	451	1 373	1 844	3 240	2 272	1	1 957	75	11 593	12 609	91.9
2011	440	482	1 173	1 398	4 013	1 129	53	2 288	129	11 105	12 337	90
2012	377	346	815	2 017	3 828	1 885	2	2 142	110	11 523	12 955	88.9
2013	386	369	1 032	1 918	3 691	3 396	3	2 460	176	13 431	14 339	93.7
2014	395	425	1 046	2 041	3 889	2 832	277	2 661	147	13 713	15 225	90.1
2015	400	453	876	1 877	3 817	2 993	23	2 745	146	13 330	15 002	88.9
2016	412	468	1 091	2 267	3 633	1 931	220	2 890	170	13 083	14 666	89.2
2017	442	673	1 392	2 213	3 826	2 501	739	3 022	230	15 039	16 601	90.6
2018	386	722	1 684	2 370	3 830	4 198	228	2 990	301	16 710	18 694	89.4
Total by area	8 061	14 257	44 811	79 022	102 500	103 661	12 210	69 160	7 938	442 449	492 113	-
% total by area	1.8	3.2	10.1	17.9	23.2	23.4	2.8	15.6	1.8	-	-	-

Table A2b:

									Reported Catch (MHR)
Year	**LIN 1**	**LIN 2**	**LIN 3**	**LIN 4**	**LIN 5**	**LIN 6**	**LIN 7**	**LIN 10**	**LIN 10E**	**Total**
1990	121	736	1 876	587	2 277	935	2 496	0	0	9 028
1991	207	967	2 410	2 420	2 291	2 845	2 534	0	0	13 674
1992	241	831	2 423	4 710	3 867	3 461	2 262	0	0	17 795
1993	253	944	2 247	4 100	2 546	6 504	2 475	0	0	19 069
1994	234	779	2 167	3 917	2 459	4 248	2 155	0	0	15 959
1995	261	850	2 654	5 072	2 558	5 477	2 946	0	0	19 818
1996	245	1 051	2 962	4 632	3 137	6 341	3 103	0	0	21 471
1997	313	1 187	2 976	4 087	3 438	7 510	3 024	0	0	22 535
1998	326	992	2 943	5 215	3 321	7 331	2 955	0	0	23 083
1999	208	1 070	2 706	4 642	2 937	6 112	3 345	0	0	21 020
2000	313	983	2 779	4 402	3 136	6 707	3 274	0	0	21 594
2001	296	1 105	2 330	3 861	3 430	6 177	3 352	0	0	20 551
2002	303	1 034	2 164	3 602	3 295	5 945	3 219	0	0	19 562
2003	246	996	2 529	2 997	2 939	6 283	2 918	0	0	18 908
2004	249	1 044	1 990	2 618	2 899	7 032	2 926	0	0	18 758
2005	283	936	1 597	2 758	3 584	5 506	2 522	0	0	17 186
2006	364	780	1 711	1 769	3 522	3 553	2 479	0	0	14 178
2007	301	874	2 089	2 113	3 731	4 696	2 295	0	0	16 099
2008	381	792	1 778	2 383	4 401	4 246	2 282	0	0	16 263
2009	320	634	1 751	2 000	3 232	2 977	2 223	0	0	13 137
2010	386	584	1 718	2 026	3 034	2 414	2 446	0	0	12 608
2011	438	670	1 665	1 572	3 856	1 335	2 800	0	0	12 336
2012	384	506	1 292	2 305	3 649	2 047	2 771	0	0	12 954
2013	383	579	1 475	2 181	3 610	3 102	3 010	0	0	14 340
2014	380	674	1 442	2 373	3 935	3 221	3 200	0	0	15 225
2015	374	673	1 325	2 246	3 924	3 115	3 344	0	0	15 001
2016	422	702	1 440	2 659	3 868	2 222	3 351	0	0	14 664
2017	404	1 022	1 808	2 565	4 051	3 323	3 428	0	0	16 601
2018	415	1 106	2 171	2 636	4 034	4 846	3 487	0	0	18 695

Table A2c:

Year	LIN 1	LIN 2	LIN 3	LIN 4	LIN 5	LIN 6	LIN 7	LIN 10	TACC Total
1990	265	977	2 137	4 401	2 706	7 000	2 176	10	19 672
1991	265	977	2 160	4 401	2 706	7 000	2 192	10	19 711
1992	265	977	2 160	4 401	2 706	7 000	2 192	10	19 711
1993	265	980	2 162	4 401	2 706	7 000	2 212	10	19 736
1994	265	980	2 167	4 401	2 706	7 000	2 213	10	19 742
1995	265	980	2 810	5 720	3 001	7 100	2 225	10	22 111
1996	265	980	2 810	5 720	3 001	7 100	2 225	10	22 111
1997	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
1998	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
1999	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
2000	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
2001	265	982	2 060	4 200	3 001	7 100	2 225	10	19 843
2002	265	982	2 060	4 200	3 001	7 100	2 225	10	19 843
2003	400	982	2 060	4 200	3 001	7 100	2 225	10	19 978
2004	400	982	2 060	4 200	3 001	7 100	2 225	10	19 978
2005	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2006	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2007	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2008	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2009	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2010	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2011	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2012	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2013	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2014	400	982	2 060	4 200	3 595	8 505	3 080	10	23 192
2015	400	982	2 060	4 200	3 595	8 505	3 080	10	22 832
2016	400	982	2 060	4 200	3 595	8 505	3 080	10	23 192
2017	400	982	2 060	4 200	3 955	8 505	3 080	10	23 192
2018	400	982	2 060	4 200	3 955	8 505	3 080	10	23 192

Table A3: Catch of ling (t) by area, by fishing year, for various fishing methods, from 1989–90 to 2017–18. Fishing year 1989–90 is denoted as "1990", etc. Values were rounded to the nearest tonne, so "0" represents estimated landings of less than 0.5 t, and "–" indicates nil reported landings. Total catches also includes catches from FMA 10 and outside the EEZ.

(a) Inshore bottom trawl (method BT and BPT on CELR and TCER forms)

	Area									
Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Cook Strait	Total
1990	10	25	148	4	47	–	–	148	4	386
1991	18	36	198	5	63	–	–	150	9	480
1992	30	21	145	2	53	–	0	192	4	448
1993	35	17	110	0	91	0	–	220	14	486
1994	29	22	64	1	78	–	–	111	22	326
1995	20	18	66	2	83	0	–	106	78	374
1996	9	24	50	3	50	0	0	188	82	406
1997	19	17	62	0	56	–	–	168	72	394
1998	9	7	45	0	30	–	–	104	24	220
1999	8	5	51	0	65	0	–	158	26	314
2000	57	7	80	0	48	–	–	129	20	340
2001	22	6	75	0	99	–	–	55	15	271
2002	11	4	99	1	89	–	–	55	17	275
2003	9	8	91	1	166	–	–	69	8	352
2004	3	3	88	0	137	–	–	54	4	290
2005	1	2	99	1	136	–	–	130	7	376
2006	6	2	46	10	106	–	–	127	3	299
2007	8	15	49	1	98	–	–	101	4	276
2008	52	18	72	0	109	–	–	240	6	496
2009	62	11	39	0	122	0	–	252	31	517
2010	86	14	66	0	180	0	–	277	26	649
2011	39	21	62	0	368	–	0	315	68	873
2012	25	51	64	13	288	0	0	275	36	753
2013	86	36	45	39	249	–	–	270	39	764
2014	78	71	53	25	399	0	–	254	19	899
2015	52	58	36	42	394	–	–	177	15	774
2016	54	65	53	25	460	–	0	234	13	904
2017	22	88	67	6	406	–	0	271	6	866
2018	9	73	55	1	442	–	–	187	6	772

(b) Inshore midwater trawl (method MW and MPT on CELR and TCER forms)

	Area									
Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Cook Strait	Total
1990	1	1	3	0	0	0	0	2	42	49
1991	0	0	9	0	0	0	0	0	125	134
1992	0	1	6	0	0	0	0	2	36	44
1993	0	2	0	0	0	0	0	1	26	30
1994	0	0	1	0	0	0	0	3	11	14
1995	1	0	0	1	0	0	0	9	6	17
1996	1	0	2	0	0	0	0	24	16	43
1997	4	0	7	0	0	0	0	21	8	45
1998	9	0	4	0	0	0	0	45	13	74
1999	1	0	20	0	0	0	0	83	9	113
2000	0	0	7	0	0	0	0	206	18	232
2001	6	1	7	0	0	0	0	175	29	218
2002	0	0	9	0	0	0	0	83	14	106
2003	0	0	30	0	0	0	0	113	36	178
2004	0	0	13	0	0	0	0	67	29	110
2005	0	0	1	0	0	0	0	70	22	93
2006	0	0	2	0	0	0	0	63	21	86
2007	0	0	0	0	0	0	0	34	18	52
2008	0	0	0	0	0	0	0	2	4	6
2009	0	0	0	0	0	0	0	20	4	24
2010	0	0	0	0	0	0	0	19	2	21
2011	0	0	0	0	0	0	0	33	2	35
2012	0	0	0	0	0	0	0	43	1	45
2013	0	0	0	0	0	0	0	39	1	40
2014	0	0	0	0	0	0	0	48	2	49
2015	0	0	0	0	0	0	0	58	3	62
2016	0	0	0	0	0	0	0	89	4	93
2017	0	0	0	0	0	0	0	95	9	104
2018	2	0	0	0	0	0	0	130	9	141

(c) Deepwater bottom trawl (methods BT and BPT on TCEPR and ERS forms)

Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Area Cook Strait	Total
1990	31	59	599	500	1 953	1 174	4	370	7	4 698
1991	70	117	817	1 236	1 996	2 457	7	260	13	6 972
1992	55	87	932	1 348	3 367	2 053	35	306	4	8 189
1993	30	74	806	1 028	1 984	4 309	0	492	4	8 730
1994	45	74	726	451	2 038	1 814	4	393	47	5 595
1995	44	77	827	818	2 455	2 065	0	489	57	6 833
1996	71	125	1049	691	3 862	2 339	1	381	96	8 634
1997	141	152	1017	762	3 244	2 772	0	526	119	8 757
1998	136	129	1173	2 262	2 908	2 996	0	498	78	10 182
1999	105	159	973	1 836	2 609	2 390	3	875	111	9 063
2000	188	156	871	1 897	2 121	3 850	0	759	90	9 932
2001	170	205	971	1 480	1 958	3 684	0	1019	39	9 527
2002	169	207	860	1 216	2 064	4 517	1	1133	72	10 240
2003	121	113	1131	1 313	1 898	4 705	1	836	35	10 153
2004	108	74	811	1 061	2 269	4 936	1	815	38	10 114
2005	73	51	589	798	2 690	4 694	8	764	29	9 696
2006	123	40	600	566	2 768	2 777	4	993	21	7 915
2007	63	71	945	854	3 106	3 920	0	701	19	9 681
2008	74	19	828	1 182	3 264	3 469	0	525	40	9 402
2009	67	37	699	498	2 674	2 042	8	556	21	6 603
2010	39	23	548	539	2 607	1 475	0	603	7	5 842
2011	52	28	390	400	3 333	749	0	854	5	5 811
2012	86	6	256	731	2 914	1 158	0	761	4	5 916
2013	83	7	260	486	3 063	3 390	0	811	9	8 109
2014	39	16	242	427	3 156	2 135	3	665	21	6 705
2015	73	9	286	687	3 090	2 387	0	859	15	7 406
2016	75	4	320	549	2 919	1 541	0	779	2	6 188
2017	107	19	418	660	3 190	1 935	0	980	3	7 311
2018	98	11	347	693	3 189	3 629	0	764	1	8 731

(d) Deepwater midwater trawl (methods MW and MPT on TCEPR and ERS forms)

Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Area Cook Strait	Total
1990	0	1	57	0	116	42	8	1 261	260	1 744
1991	0	13	57	69	29	9	20	740	325	1 261
1992	0	1	62	11	121	19	38	402	200	854
1993	0	4	34	24	155	58	4	324	172	775
1994	0	1	35	33	268	14	3	348	106	809
1995	0	0	35	54	397	11	3	1 014	116	1 631
1996	0	2	88	59	272	24	2	855	117	1 419
1997	0	1	106	59	133	5	0	721	145	1 173
1998	1	13	194	44	79	8	7	985	102	1 435
1999	3	11	218	47	62	6	11	772	90	1 221
2000	0	4	227	29	114	16	7	726	109	1 232
2001	0	5	81	44	351	229	0	855	147	1 712
2002	0	1	103	38	131	233	1	651	74	1 233
2003	5	4	87	19	135	217	0	585	138	1 190
2004	0	4	80	60	130	306	2	759	119	1 460
2005	0	1	68	15	98	203	6	335	97	822
2006	0	3	24	2	80	246	1	269	65	691
2007	0	1	6	1	101	191	2	125	45	472
2008	0	2	10	0	84	3	1	87	33	220
2009	0	2	4	0	6	6	2	80	25	125
2010	0	1	18	0	36	8	0	127	22	213
2011	0	3	3	0	50	20	2	141	19	237
2012	0	0	6	1	138	3	0	165	31	344
2013	0	1	16	2	5	6	3	317	34	384
2014	0	0	9	1	1	16	8	455	29	520
2015	0	1	13	0	75	39	0	467	35	630
2016	0	1	10	0	28	11	0	567	34	651
2017	0	0	22	0	16	22	0	502	26	587
2018	0	0	17	1	11	9	0	605	35	678

(e) Line (methods BLL, TL, and DL on CELR, LCER, and LTCER forms)

Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Area Cook Strait	Total
1990	39	134	185	8	0	0	0	197	66	630
1991	50	186	613	846	2	217	7	428	55	2 406
1992	98	300	478	2 997	288	326	835	691	70	6 090
1993	83	401	491	2 605	453	886	965	708	100	6 694
1994	108	406	552	3 272	863	449	1 142	761	63	7 619
1995	126	432	811	3 604	704	1 567	381	889	59	8 946
1996	81	396	1011	3 392	301	1 224	378	991	53	7 880
1997	67	328	634	2 974	847	2 232	340	958	20	8 502
1998	60	446	427	1 955	975	2 366	388	1 008	67	7 848
1999	39	370	528	2 040	770	1 940	549	972	107	7 339
2000	50	317	776	2 043	857	1 206	984	784	94	7 115
2001	36	380	473	1 921	961	728	1 063	917	160	6 640
2002	100	371	385	1 962	955	657	627	659	111	5 827
2003	90	346	401	1 386	850	214	921	686	137	5 032
2004	95	425	356	1 264	581	656	850	682	169	5 078
2005	154	339	369	1 757	848	310	34	728	215	4 754
2006	161	365	434	1 085	676	172	38	562	187	3 680
2007	161	425	498	1 087	685	0	234	745	153	3 988
2008	235	461	521	1 125	789	345	502	1 010	93	5 081
2009	177	397	583	1 314	382	216	222	887	33	4 211
2010	252	412	638	1 303	404	789	1	864	11	4 674
2011	349	431	629	995	252	360	51	902	33	4 002
2012	266	289	446	1 272	483	723	1	848	34	4 362
2013	217	325	655	1 391	367	0	0	957	88	4 000
2014	275	337	659	1 587	328	681	265	1 190	71	5 394
2015	275	385	461	1 148	249	566	23	1 157	63	4 328
2016	276	386	519	1 679	220	378	220	1 149	81	4 909
2017	274	527	696	1 542	209	544	739	1 127	122	5 779
2018	247	598	680	1 598	158	552	228	1 154	108	5 323

(f) Setnet (method SN on CELR and NCELR forms)

Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Area Cook Strait	Total
1990	2	48	210	0	0	0	0	346	36	642
1991	1	85	226	0	2	0	0	368	0	682
1992	3	40	144	0	1	0	0	264	1	453
1993	6	25	164	0	1	0	0	129	3	327
1994	3	4	179	0	0	0	0	151	1	342
1995	27	1	199	0	1	0	0	103	1	332
1996	1	5	179	0	0	0	0	170	1	357
1997	23	28	203	0	2	0	0	108	1	365
1998	4	12	201	0	2	0	0	126	0	346
1999	23	1	147	0	0	0	0	65	0	237
2000	1	1	165	0	0	0	0	94	0	262
2001	0	1	131	0	0	0	0	49	2	184
2002	1	0	123	0	1	0	0	62	0	187
2003	1	0	104	0	0	0	0	50	0	156
2004	1	1	120	0	1	0	0	24	0	148
2005	0	1	78	0	1	0	0	31	1	112
2006	0	5	51	0	1	0	0	39	0	96
2007	0	0	47	0	2	0	0	91	0	141
2008	1	2	55	0	3	0	0	43	0	104
2009	0	5	58	2	6	0	0	43	0	115
2010	0	0	62	2	5	0	0	47	0	116
2011	0	0	55	2	5	0	0	28	0	90
2012	0	0	34	0	4	0	0	22	1	62
2013	0	0	27	0	4	0	0	34	0	66
2014	1	0	26	0	2	0	0	18	0	48
2015	1	1	32	0	2	0	0	0	0	36
2016	1	1	46	0	4	0	0	40	0	92
2017	2	3	34	0	3	0	0	0	0	43
2018	1	5	31	0	2	0	0	6	0	45

(g) Fishpots (methods RLP, CP, and FP on CELR forms)

Year	North NI	East NI	East SI	Chatham	Southland	Sub Antarctic	Bounty	West SI	Area Cook Strait	Total
1990	0	0	2	0	1	0	0	0	0	3
1991	0	0	15	0	1	0	0	0	0	16
1992	0	0	39	0	1	0	0	0	0	40
1993	0	0	15	0	1	0	0	0	0	16
1994	0	0	11	0	1	0	0	0	0	13
1995	0	0	8	0	2	0	0	0	0	10
1996	0	0	4	0	4	0	0	0	0	8
1997	0	0	38	0	2	0	0	0	0	40
1998	0	0	40	0	3	0	0	0	0	43
1999	0	0	41	0	0	0	0	0	0	42
2000	0	0	21	0	10	0	0	0	0	32
2001	2	0	4	0	25	0	0	1	0	31
2002	0	0	3	0	16	0	0	0	0	19
2003	0	0	1	0	13	0	0	0	0	14
2004	0	0	4	0	0	0	0	0	1	5
2005	0	0	10	0	0	0	0	0	0	10
2006	0	0	49	0	3	0	0	0	0	52
2007	0	0	56	0	3	0	0	0	0	60
2008	0	0	19	0	2	0	0	0	0	21
2009	0	0	10	0	11	0	0	0	0	21
2010	0	0	41	0	8	0	0	0	0	49
2011	0	0	33	0	5	0	0	0	0	39
2012	0	0	8	0	1	0	0	0	0	10
2013	0	0	26	0	3	0	0	0	0	29
2014	0	0	56	1	3	0	0	0	0	60
2015	0	0	45	0	7	0	0	0	0	52
2016	1	9	126	0	2	0	0	16	0	154
2017	15	33	153	2	1	0	0	2	18	224
2018	0	15	516	4	8	0	0	13	85	642

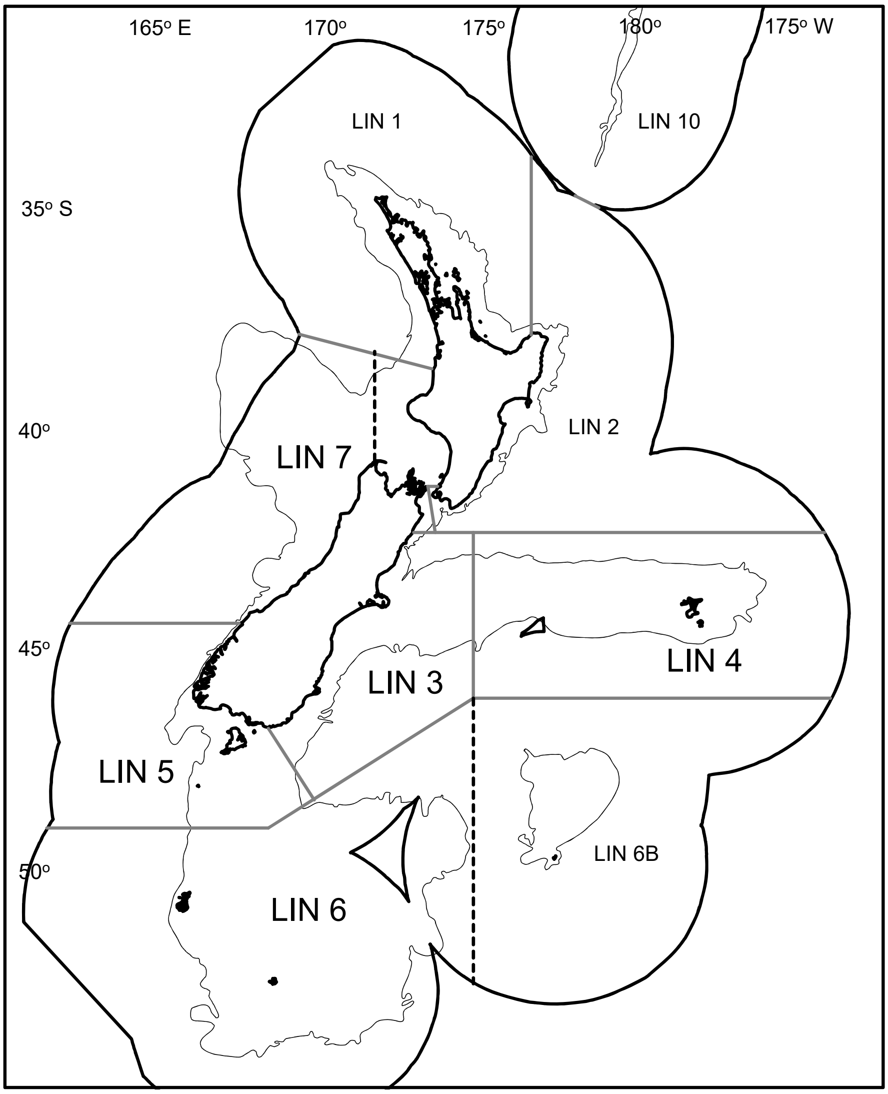


Figure A1: Ling fishstocks, and the 1000 m isobath. The boundaries used to separate biological stock LIN 6B from the rest of LIN 6, and the west coast South Island section of LIN 7 from the rest of LIN 7, are shown as broken lines.

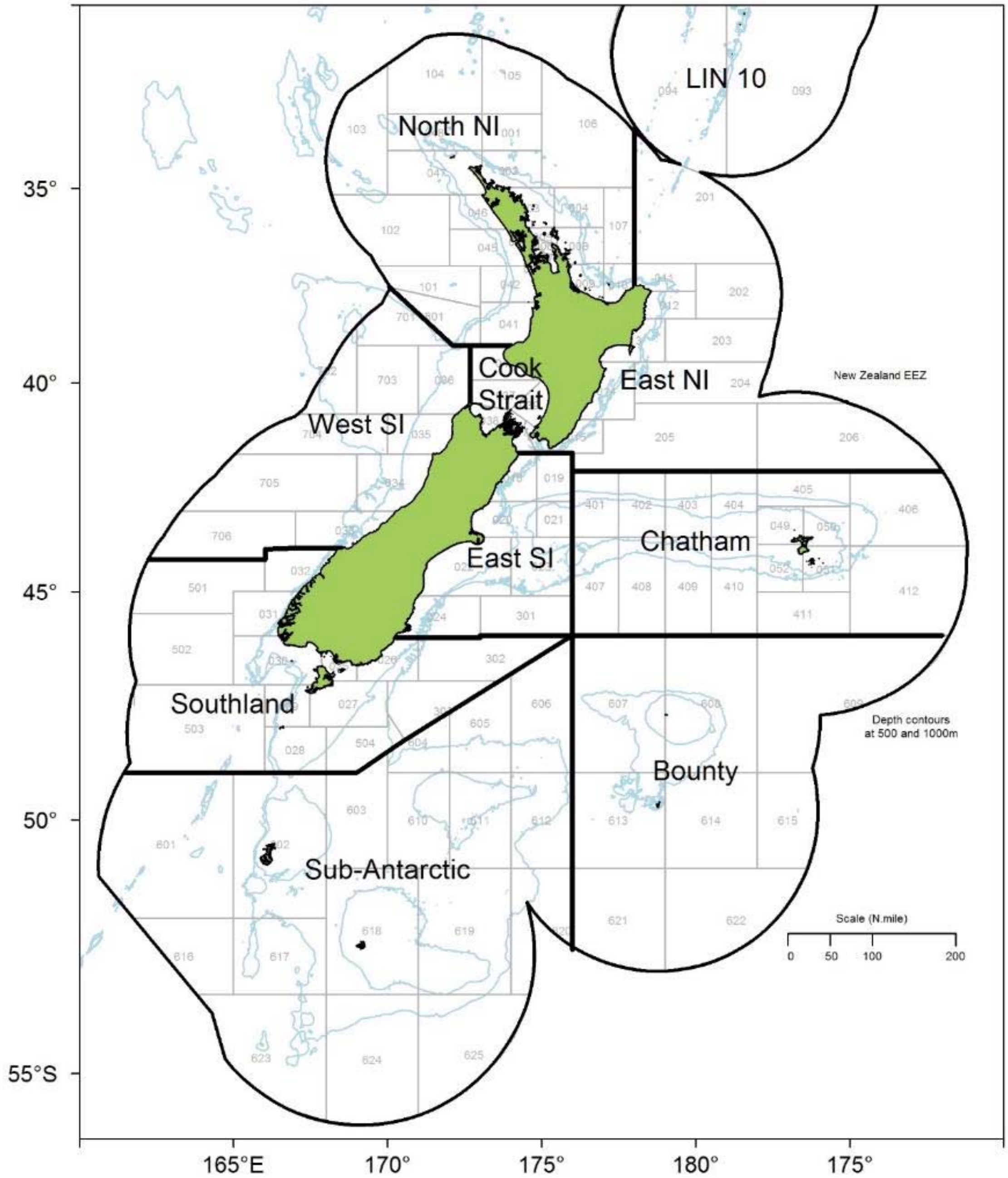


Figure A2: Definitions of geographical areas used in the analyses (based on statistical areas). See Table A1 for the administrative ling stocks they approximate.

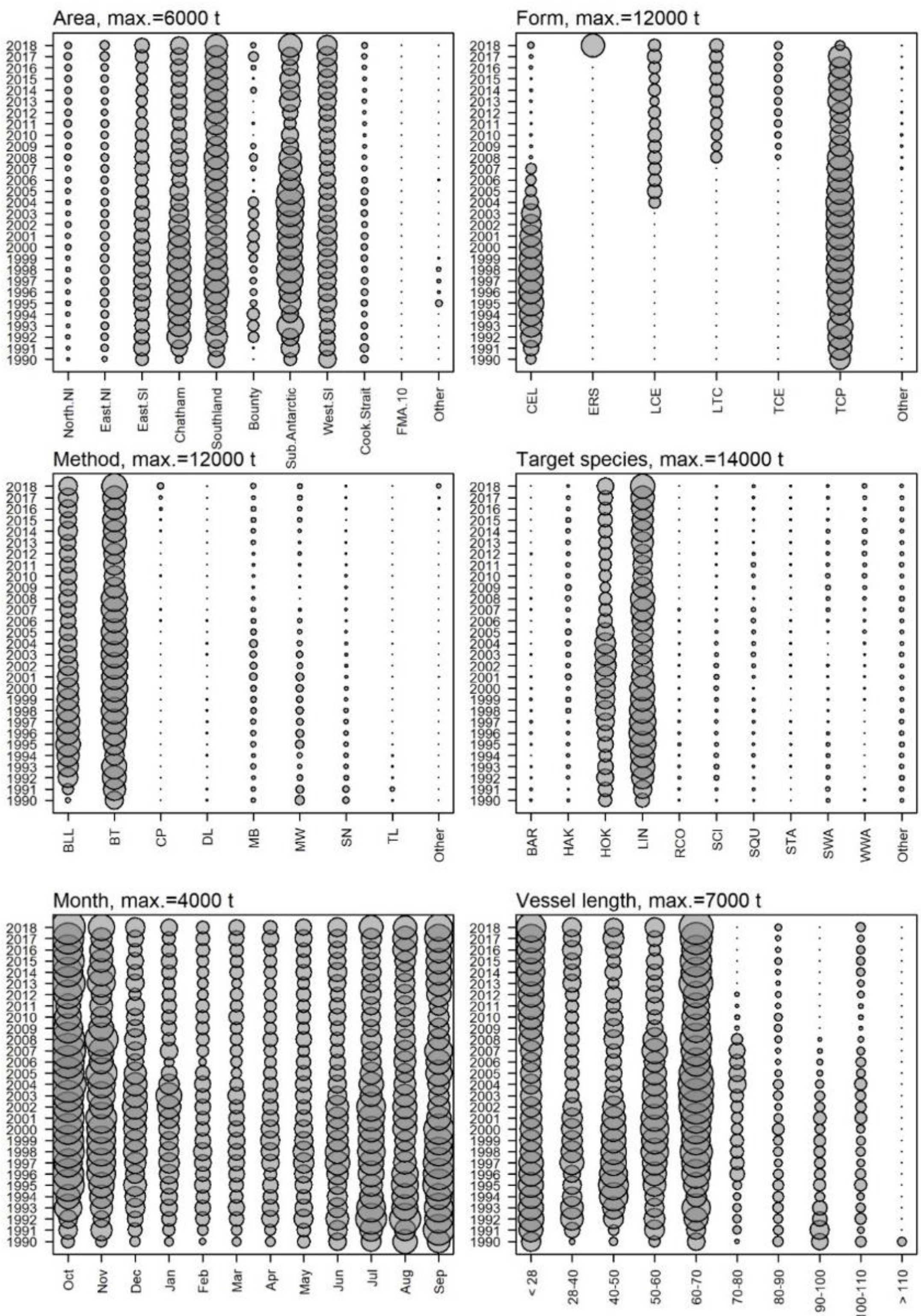


Figure A3: Distribution of annual catch by area, form type, fishing method, target species, month, and vessel length for all ling catches by all methods. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Form types: CEL is Catch, Effort, Landing Return; LCE is Line Catch Effort Return; LTC is Lining Trip Catch, Effort Return; NCE is Net Catch Effort Return; TCE is Trawl, Catch, Effort Return; TCP is Trawl, Catch, Effort, and Processing Return. Method definitions: BLL, bottom longlining; BT, bottom trawl; CP, cod potting; DL, dahn lines; MB, midwater trawl on the bottom; MW, midwater trawl; SN, set net; TL, trot line. Species codes: BAR, barracouta; BNS, bluenose; HAK, hake; HOK, hoki; LIN, ling; RCO, red cod; SCI, scampi; SQU, arrow squid; SWA, silver warehou; WWA, white warehou.

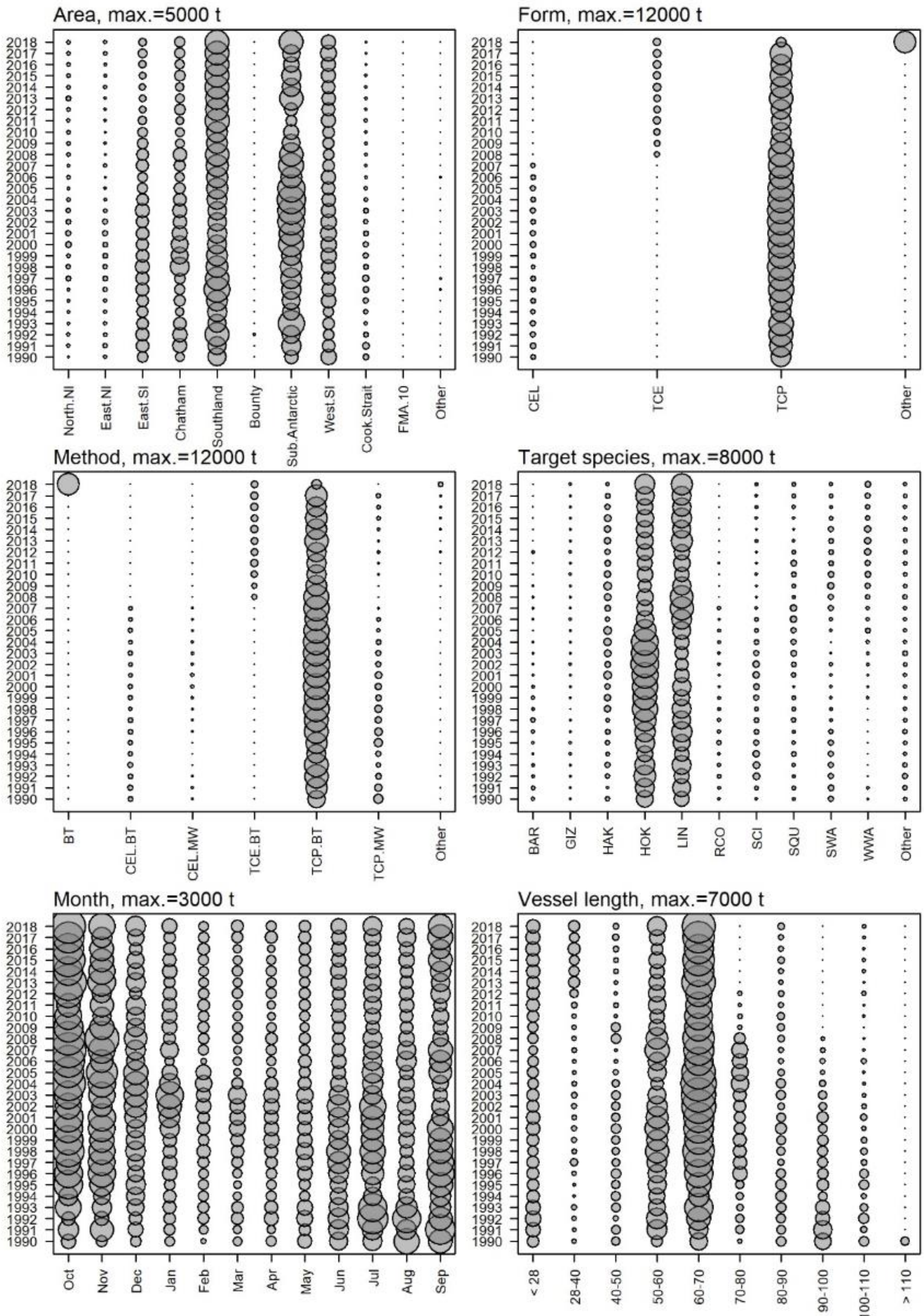


Figure A4: Distribution of annual catch by area, form type, fishing method (by form type), target species, month, and vessel length for all ling catches by trawl methods. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Form types and method types are defined in Figure A3. Species codes: BAR, barracouta; GIZ, giant stargazer; HAK, hake; HOK, hoki; LIN, ling; RCO, red cod; SCI, scampi; SQU, arrow squid; SWA, silver warehou; WWA, white warehou.

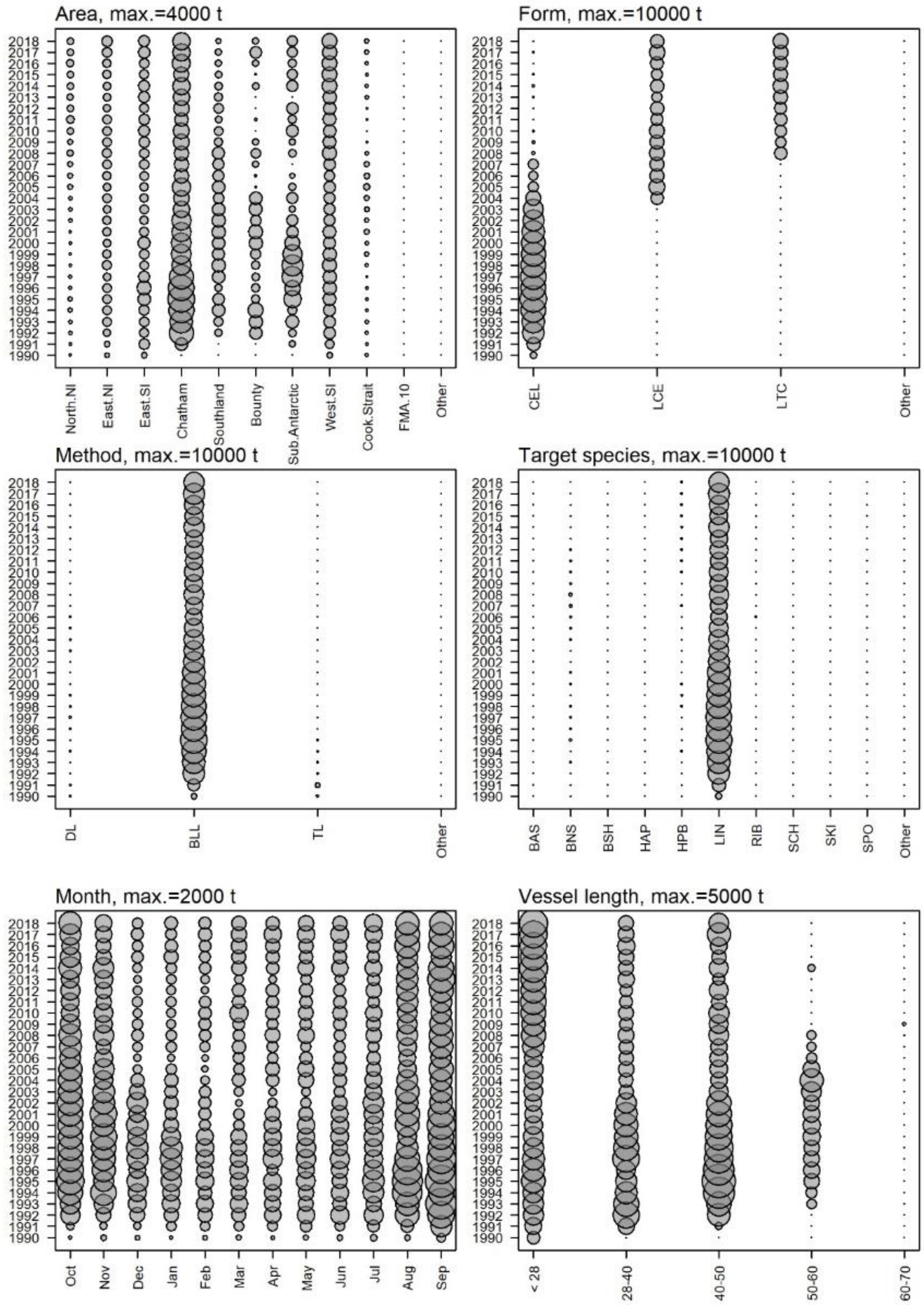


Figure A5: Distribution of annual catch by area, form type, fishing method (by form type), target species, month, and vessel length for all ling catches by line methods. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Form types and method types are defined in Figure A1. BAS, bass; BNS, bluenose; BSH, seal shark; HAP, hapuku; HPB, hapuku and bass; LIN, ling; RIB, ribaldo; SCH, school shark; SKI, gemfish; SPO, rig.

7. APPENDIX B: DESCRIPTIVE EAST SI AND CHATHAM (LIN 3&4)

Table B1: East SI and Chatham (LIN 3&4) trawl and line catch by target species and fishing method, 1989–90 to 2017–18. Values have been rounded to the nearest tonne, so '0' denotes catches < 0.5 kg and '–' denotes zero catch.

	Trawl Fishery				Line Fishery	
Year	**Hake**	**Hoki**	**Ling**	**Other**	**Ling**	**Other**
1990	22	559	313	264	10	0
1991	10	1 215	508	451	973	0
1992	65	1 444	330	516	3 227	0
1993	240	945	122	584	2 750	2
1994	110	716	27	388	3 519	1
1995	153	1 147	44	379	3 829	0
1996	154	1 417	42	242	4 074	0
1997	179	1 487	48	190	3 009	0
1998	310	2 436	710	193	2 239	6
1999	320	2 305	246	182	2 397	0
2000	287	1 934	652	123	2 502	-
2001	270	1 912	197	188	2 304	-
2002	109	1 613	339	152	2 233	-
2003	119	2 038	104	283	1 536	0
2004	256	1 554	1	174	1 452	19
2005	217	1 027	56	163	1 878	26
2006	45	785	145	220	1 291	42
2007	158	718	741	184	1 352	86
2008	134	724	920	296	1 556	68
2009	195	666	176	196	1 851	25
2010	13	672	192	290	1 882	28
2011	3	640	44	161	1 582	26
2012	1	686	98	280	1 666	42
2013	0	732	23	91	1 987	37
2014	1	574	99	78	2 191	26
2015	9	824	130	99	1 564	32
2016	1	714	98	140	2 152	31
2017	0	945	131	95	2 215	23
2018	-	862	104	141	2 260	14

Table B2: East SI and Chatham (LIN 3&4) ling catch (t) by fishing method and month from 1989–90 to 2017–18. Values have been rounded to the nearest tonne, so '0' denotes catches < 0.5 kg and '–' denotes zero catch.

Trawl

											Month	
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1990	75	16	40	7	22	46	123	225	149	6	45	405	1 158
1991	313	142	182	185	64	109	55	134	226	82	225	466	2 185
1992	214	166	137	205	188	227	260	224	234	165	143	191	2 355
1993	326	203	185	200	90	124	178	178	194	24	93	96	1 891
1994	274	164	116	101	48	35	81	98	139	51	3	130	1 240
1995	404	179	167	65	61	66	46	100	146	73	50	366	1 723
1996	209	123	139	223	77	53	99	215	240	71	51	355	1 855
1997	258	202	149	130	153	152	132	196	107	136	13	275	1 903
1998	495	365	346	197	143	186	194	219	330	388	6	781	3 649
1999	296	584	245	260	186	217	265	267	282	72	25	354	3 053
2000	203	525	432	177	129	251	243	139	221	27	1	647	2 996
2001	223	503	310	246	136	326	249	198	175	58	0	141	2 567
2002	267	96	186	368	158	154	250	226	117	37	2	353	2 214
2003	401	335	264	216	176	237	224	319	134	114	6	121	2 545
2004	270	329	276	152	86	155	126	143	141	130	84	94	1 985
2005	158	209	253	163	65	64	55	138	142	53	31	132	1 464
2006	108	210	151	99	57	51	80	103	126	63	24	124	1 195
2007	157	145	113	108	103	96	92	130	101	64	98	593	1 801
2008	290	202	226	187	139	87	103	182	99	85	270	204	2 073
2009	280	145	125	249	141	56	69	44	66	21	20	16	1 233
2010	214	118	101	107	91	82	49	73	57	42	72	162	1 168
2011	78	158	169	68	87	85	46	65	37	16	10	31	848
2012	73	97	128	151	92	65	23	58	49	19	62	247	1 064
2013	92	102	136	148	87	103	43	42	31	37	9	17	847
2014	59	67	80	133	92	66	48	41	53	3	17	93	752
2015	78	115	179	198	62	65	62	75	50	5	63	109	1 061
2016	31	106	128	150	145	96	57	84	57	6	11	81	953
2017	98	113	143	155	137	103	113	80	56	8	48	116	1 171
2018	188	154	187	134	67	82	108	97	39	5	3	45	1107

Line

											Month	
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1990	-	0	-	-	-	-	-	10	-	-	-	-	10
1991	-	7	7	89	121	104	45	3	56	0	106	435	973
1992	437	79	72	62	90	107	221	360	349	466	707	276	3 227
1993	62	21	9	280	215	71	89	218	200	136	494	956	2 752
1994	344	148	18	110	139	213	250	265	296	335	859	542	3 520
1995	478	66	87	2	294	231	76	250	85	246	933	1082	3 830
1996	580	331	31	259	180	192	31	178	216	278	946	850	4 074
1997	473	71	40	102	110	85	162	136	110	199	640	882	3 010
1998	494	214	96	115	7	9	3	50	9	141	374	733	2 245
1999	446	386	112	99	-	2	55	43	3	89	321	786	2 343
2000	490	85	103	8	7	18	13	87	65	217	566	787	2 446
2001	216	92	74	4	1	24	115	38	54	104	676	870	2 267
2002	251	164	62	75	29	36	90	70	99	294	471	582	2 222
2003	64	41	41	54	58	54	7	-	2	222	512	479	1 536
2004	105	102	54	41	31	18	8	39	70	200	429	357	1 454
2005	71	144	81	105	42	79	88	47	142	216	263	579	1 857
2006	144	88	42	67	67	53	51	55	57	119	225	336	1 305
2007	130	110	60	78	52	56	82	39	76	71	268	389	1 412
2008	132	94	64	54	6	16	59	76	50	127	349	575	1 602
2009	308	186	64	51	19	38	58	29	70	89	414	543	1 870
2010	361	130	35	57	72	107	96	81	70	116	325	455	1 904
2011	199	133	68	44	79	67	48	55	56	53	329	450	1 581
2012	188	136	46	44	20	47	49	21	24	82	324	725	1 706
2013	253	113	32	13	23	21	9	14	46	159	498	844	2 024
2014	440	228	74	39	72	20	44	71	107	100	354	666	2 214
2015	388	117	23	12	13	34	48	38	68	85	387	383	1 595
2016	239	159	79	54	67	94	75	88	95	117	529	587	2 182
2017	505	140	49	57	83	96	45	89	106	204	405	429	2 208
2018	305	65	61	29	37	98	64	51	48	371	562	576	2 266

Table B3: East SI and Chatham (LIN 3&4) catches and effort for vessels < 28 m and ≥28 m overall length, by year.

Trawls

	Catches (t)		Total number of tows		Total duration (hrs)	
Year	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**
1990	54	1 104	1 721	9 309	6 162	29 779
1991	79	2 106	1 978	9 492	7 434	35 094
1992	351	2 003	4 690	10 356	19 376	39 476
1993	349	1 542	4 321	12 484	17 685	44 215
1994	272	968	3 779	12 436	15 220	34 908
1995	186	1 537	2 744	16 794	10 900	52 584
1996	113	1 739	2 774	18 096	10 082	59 141
1997	129	1 774	2 530	18 871	9 502	63 746
1998	87	3 559	2 485	23 719	9 567	83 478
1999	95	2 958	1 971	20 889	7 836	73 153
2000	78	2 918	2 155	19 609	9 024	69 446
2001	98	2 469	1 768	18 398	7 661	69 485
2002	62	2 152	1 766	15 933	7 022	59 931
2003	60	2 485	1 674	17 795	7 049	67 599
2004	48	1 937	1 169	14 588	5 027	57 510
2005	74	1 390	2 430	11 822	12 826	44 938
2006	94	1 102	2 548	11 611	15 580	38 511
2007	38	1 763	2 914	10 951	17 915	41 166
2008	83	1 990	5 585	10 761	26 461	40 406
2009	54	1 180	5 999	9 153	26 498	35 144
2010	85	1 082	7 187	9 330	29 506	35 809
2011	69	779	5 925	8 261	25 794	31 660
2012	85	979	6 014	7 962	26 496	29 617
2013	91	756	5 817	7 601	26 044	28 524
2014	83	669	7 861	8 111	36 884	27 470
2015	82	979	7 763	8 344	37 455	30 653
2016	79	874	6 399	8 599	28 518	30 654
2017	75	1 096	7 932	8 439	33 031	31 053
2018	56	1 051	7 331	7 953	30 343	29 209

Lines

Year	Catches (t)		Total number of days		Total number of sets		Number of sets per day		Total number of hooks		Number of hooks per day	
	< 28 m	≥ 28 m	< 28 m	≥ 28 m	< 28 m	≥ 28 m	< 28 m	≥ 28 m	< 28 m	≥ 28 m	< 28 m	≥ 28 m
1990	0	10	4	17	11	53	3	3	1 200	32 485	300	1 911
1991	18	955	40	208	77	556	2	3	23 313	2 575 908	583	12 384
1992	138	3 089	80	478	87	1 625	1	3	174 574	7 036 541	2 182	14 721
1993	88	2 652	57	431	100	1 660	2	4	298 700	7 270 336	5 240	16 869
1994	66	3 454	91	564	150	2 252	2	4	88 926	10 175 766	977	18 042
1995	155	3 662	98	608	219	2 354	2	4	197 290	10 822 366	2 013	17 800
1996	162	3 912	155	636	283	2 438	2	4	112 205	13 309 794	724	20 927
1997	176	2 834	186	633	404	2 380	2	4	411 362	13 712 961	2 212	21 663
1998	90	2 155	126	519	233	2 027	2	4	783 700	11 374 408	6 220	21 916
1999	-	2 339	-	553	-	2 065	-	4	-	12 394 506	-	22 413
2000	-	2 446	-	602	-	2 202	-	4	-	13 813 887	-	22 947
2001	-	2 267	-	504	-	1 689	-	3	-	12 307 887	-	24 420
2002	5	2 217	2	681	2	2 380	1	3	4 000	14 504 052	2 000	21 298
2003	-	1 536	-	380	-	1 265	-	3	-	8 654 507	-	22 775
2004	5	1 448	32	529	84	1 896	3	4	38 900	10 156 770	1 216	19 200
2005	56	1 801	221	592	845	2 111	4	4	1 816 450	11 701 950	8 219	19 767
2006	27	1 278	172	511	760	2 023	4	4	1 380 600	9 960 507	8 027	19 492
2007	344	1 068	440	428	1 537	1 655	3	4	4 305 358	7 334 286	9 785	17 136
2008	462	1 140	612	476	2 134	1 609	3	3	5 208 843	6 863 310	8 511	14 419
2009	640	1 230	598	301	1 774	1 265	3	4	4 569 503	6 515 448	7 641	21 646
2010	604	1 300	554	401	1 727	1 780	3	4	4 163 040	8 410 709	7 515	20 974
2011	586	995	623	399	1 976	1 741	3	4	4 547 260	8 016 090	7 299	20 090
2012	781	926	692	257	2 540	1 157	4	5	5 780 470	5 417 825	8 353	21 081
2013	805	1 218	775	357	1 860	1 378	2	4	5 538 376	6 152 410	7 146	17 234
2014	942	1 272	786	579	1 435	2 154	2	4	4 182 230	10 420 722	5 321	17 998
2015	664	932	754	414	1 332	1 513	2	4	3 947 966	8 700 659	5 236	21 016
2016	628	1 554	712	570	1 272	2 229	2	4	4 257 721	12 751 817	5 980	22 372
2017	542	1 666	597	612	909	2 154	2	4	3 462 566	13 189 742	5 800	21 552
2018	679	1 588	676	491	1 182	1 588	2	3	4 188 631	11 230 822	6 196	22 873

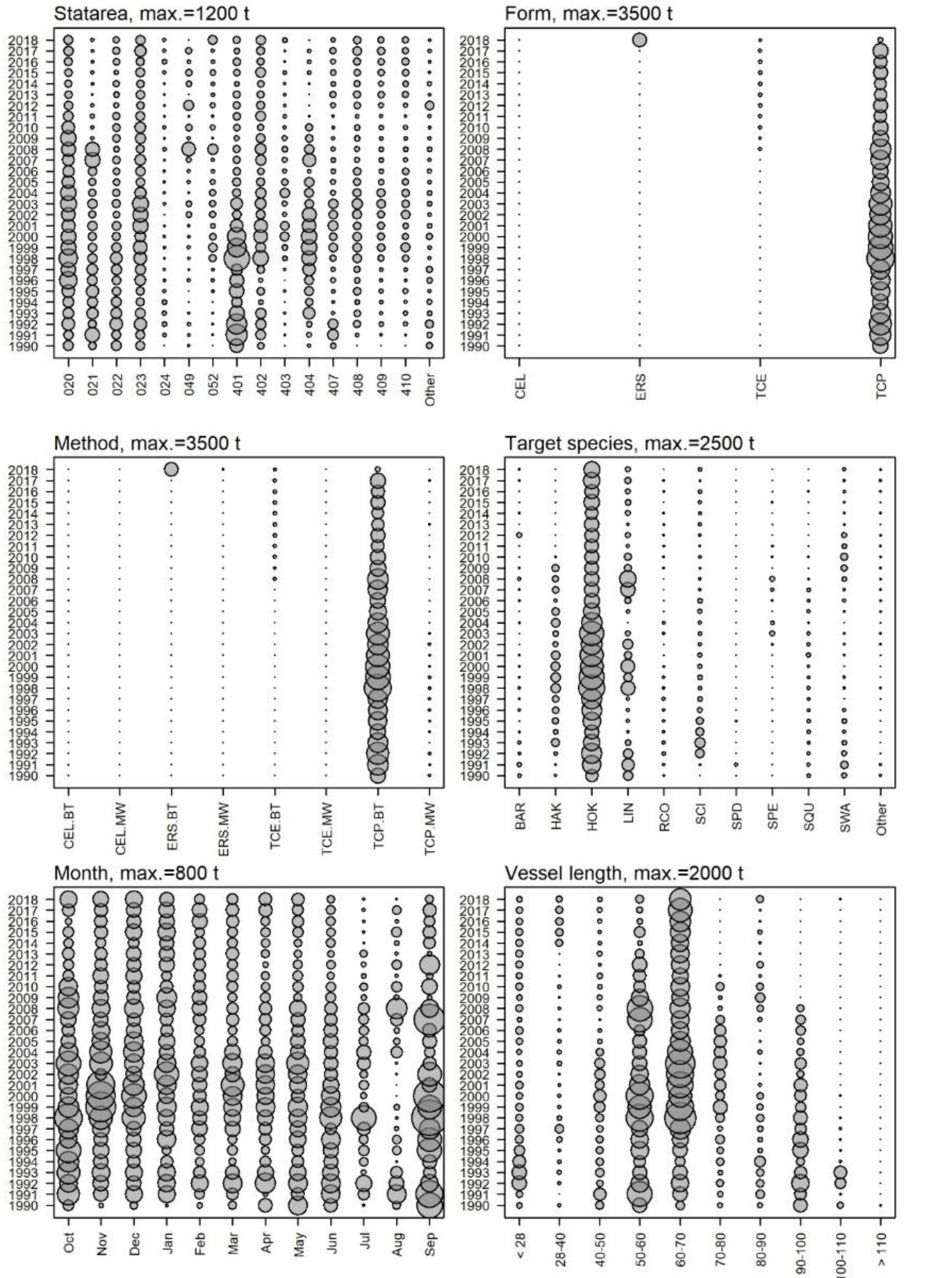


Figure B1: East SI and Chatham (LIN 3&4) trawl; distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: BAR, barracouta; HAK, hake; HOK, hoki; LIN, ling; RCO, red cod; SCI, scampi; SPD, spiny dogfish; SPE, sea perch; SQU, arrow squid; SWA, silver warehou.

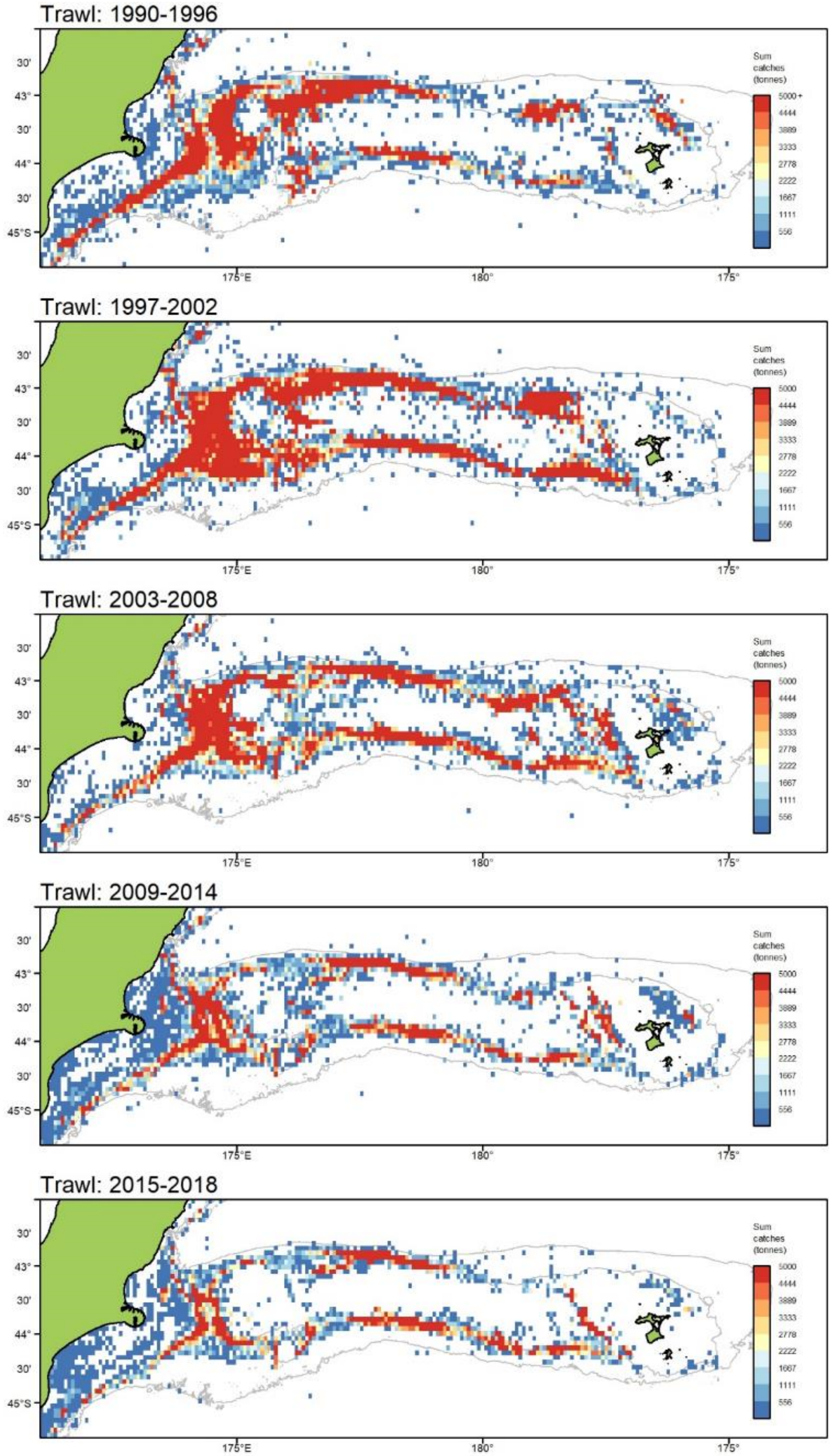


Figure B2: Density plots of East SI and Chatham (LIN 3&4) commercial ling trawl catches, for combined fishing year groups (labelled by year-ending).

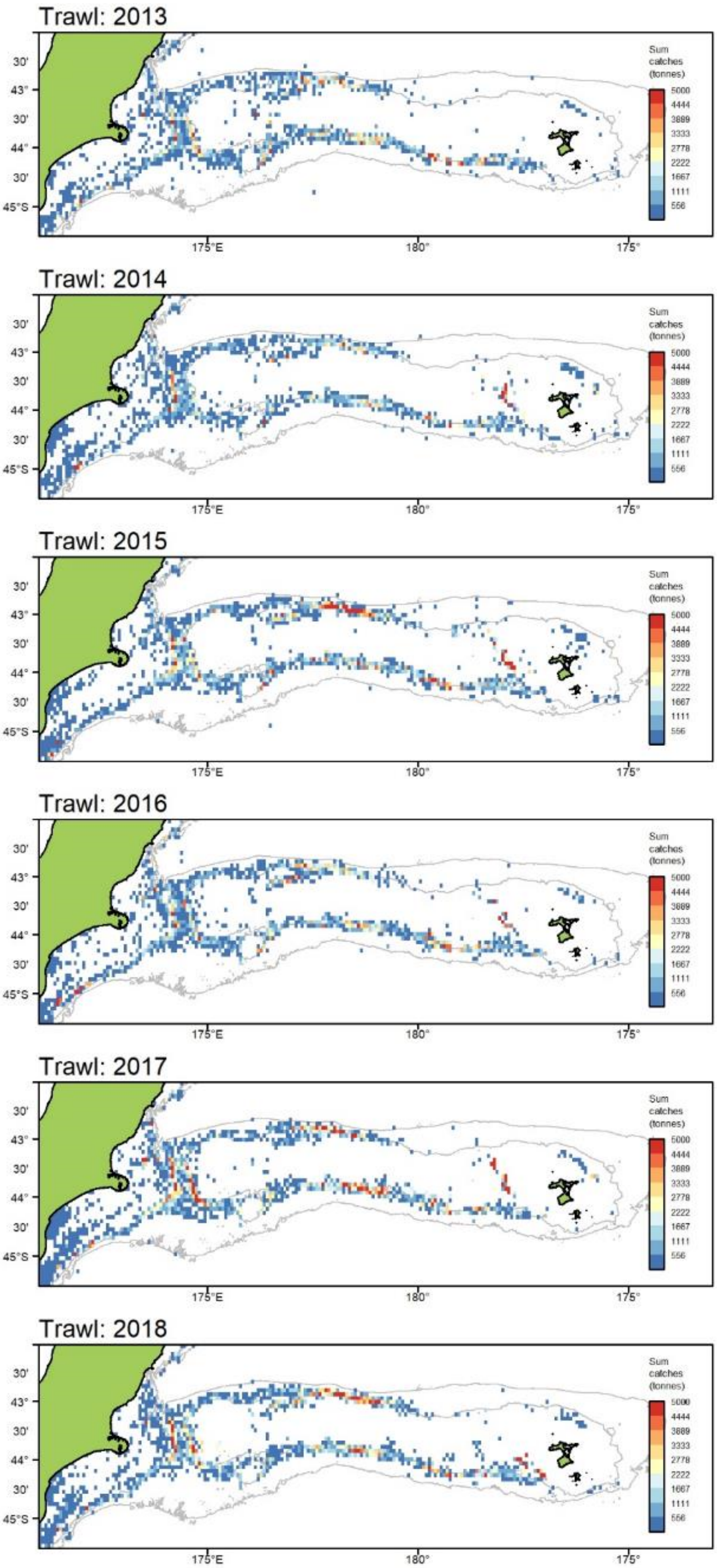


Figure B3: Density plots of East SI and Chatham (LIN 3&4) commercial ling trawl fishery catches for each of the 2013–2018 fishing years (labelled by year-ending).

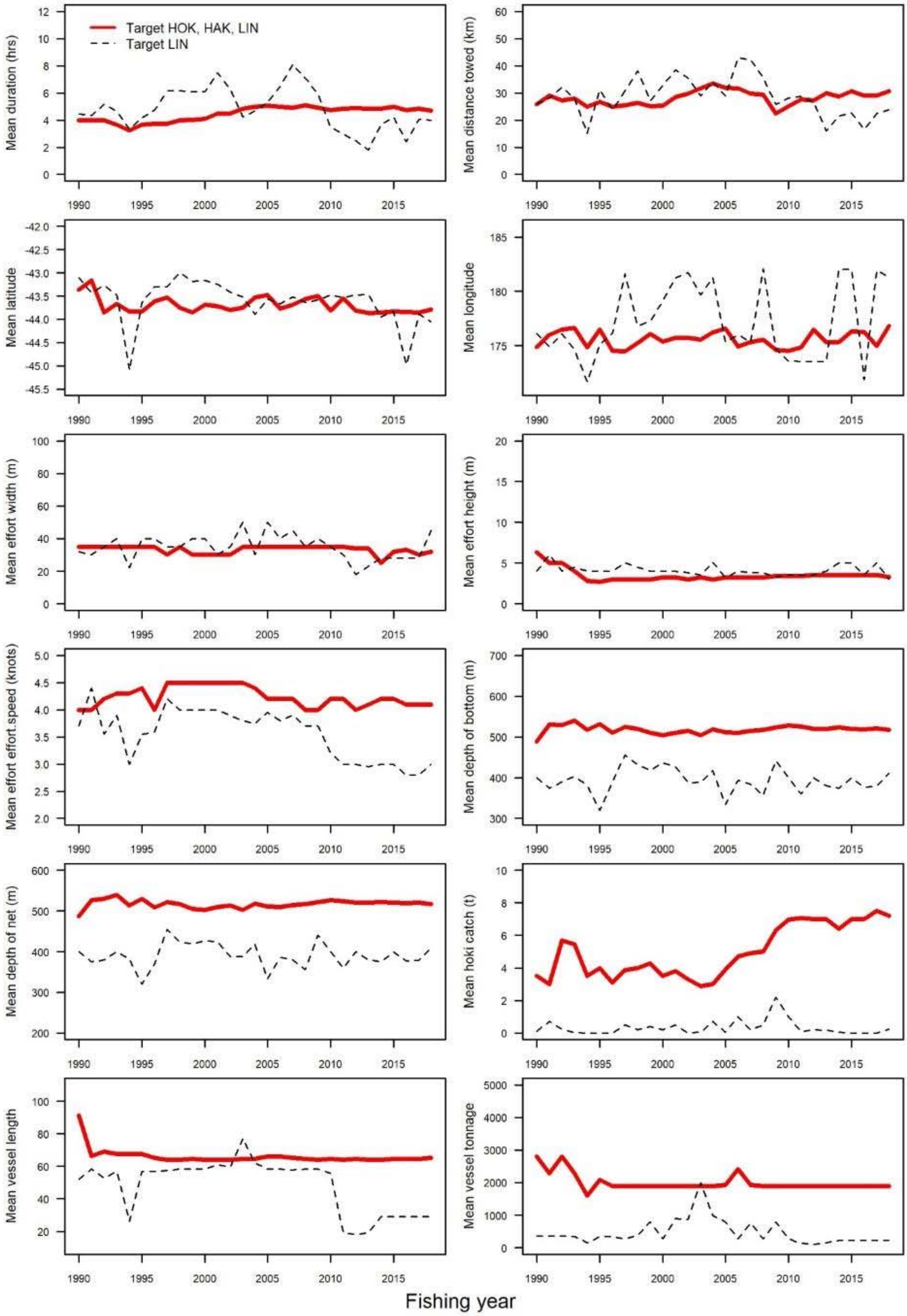


Figure B4: East SI and Chatham (LIN 3&4) bottom trawl; means of effort variables by fishing year for tows targeting ling, or targeting hake, hoki, or ling.

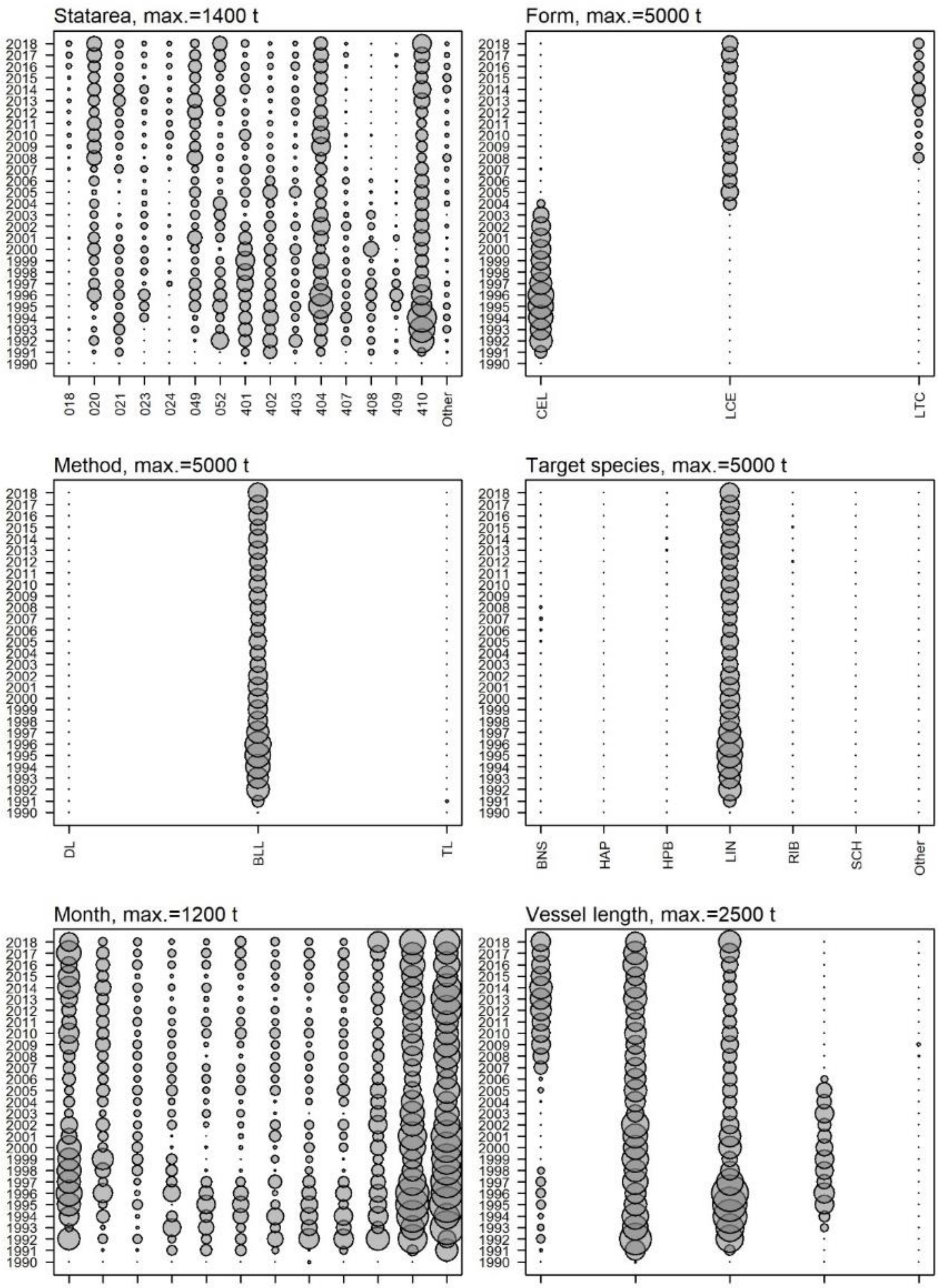


Figure B5: East SI and Chatham (LIN 3&4) line fishery distribution of annual catch by statistical area, form type, fishing method, target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: BNS, bluenose; HAP, hapuku; HPB, hapuku and bass; LIN, ling; RIB, ribaldo; SCH, school shark.

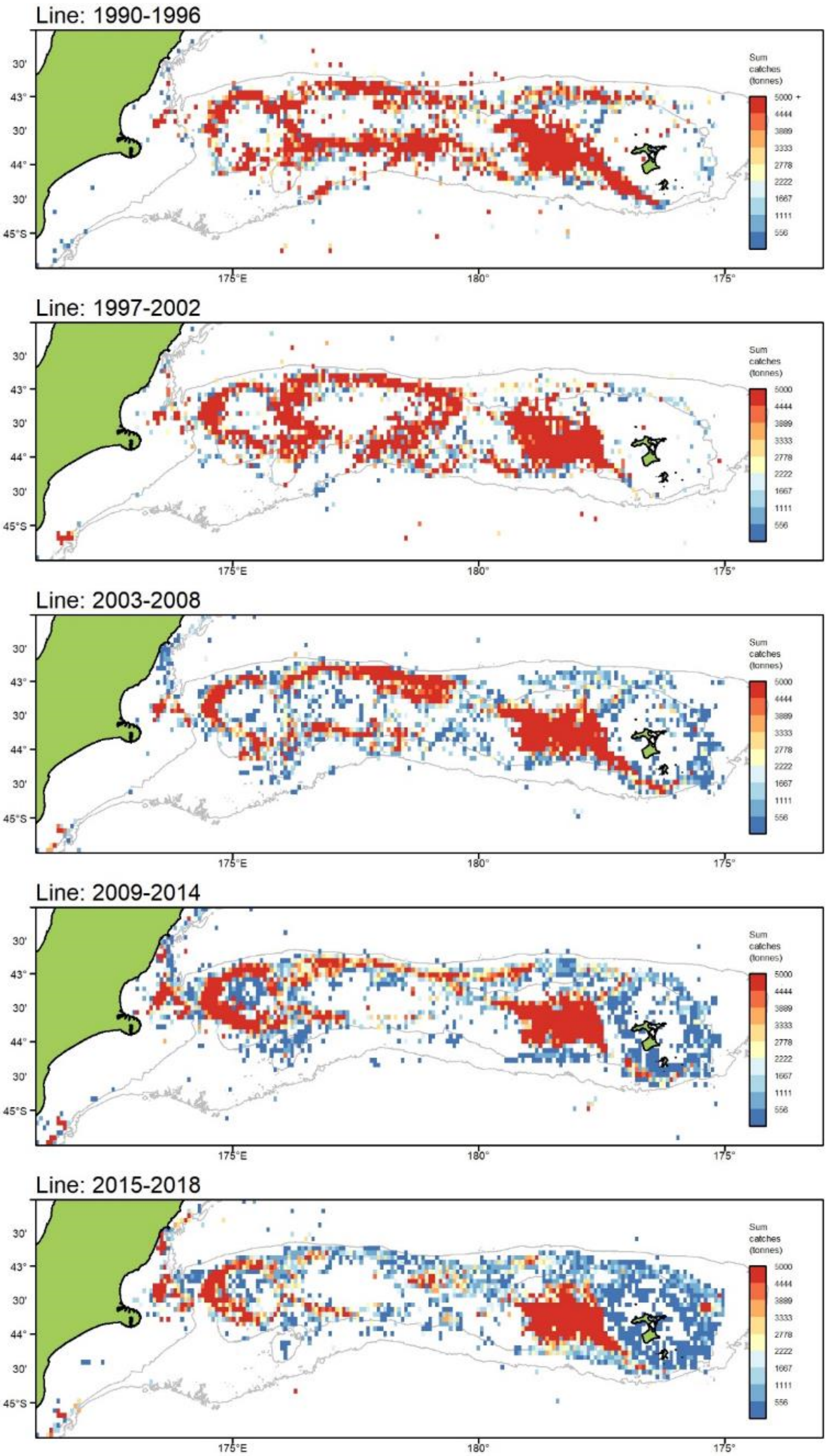


Figure B6: Density plots of East SI and Chatham (LIN 3&4) commercial ling line fishery catches for combined fishing year groups (labelled by year-ending).

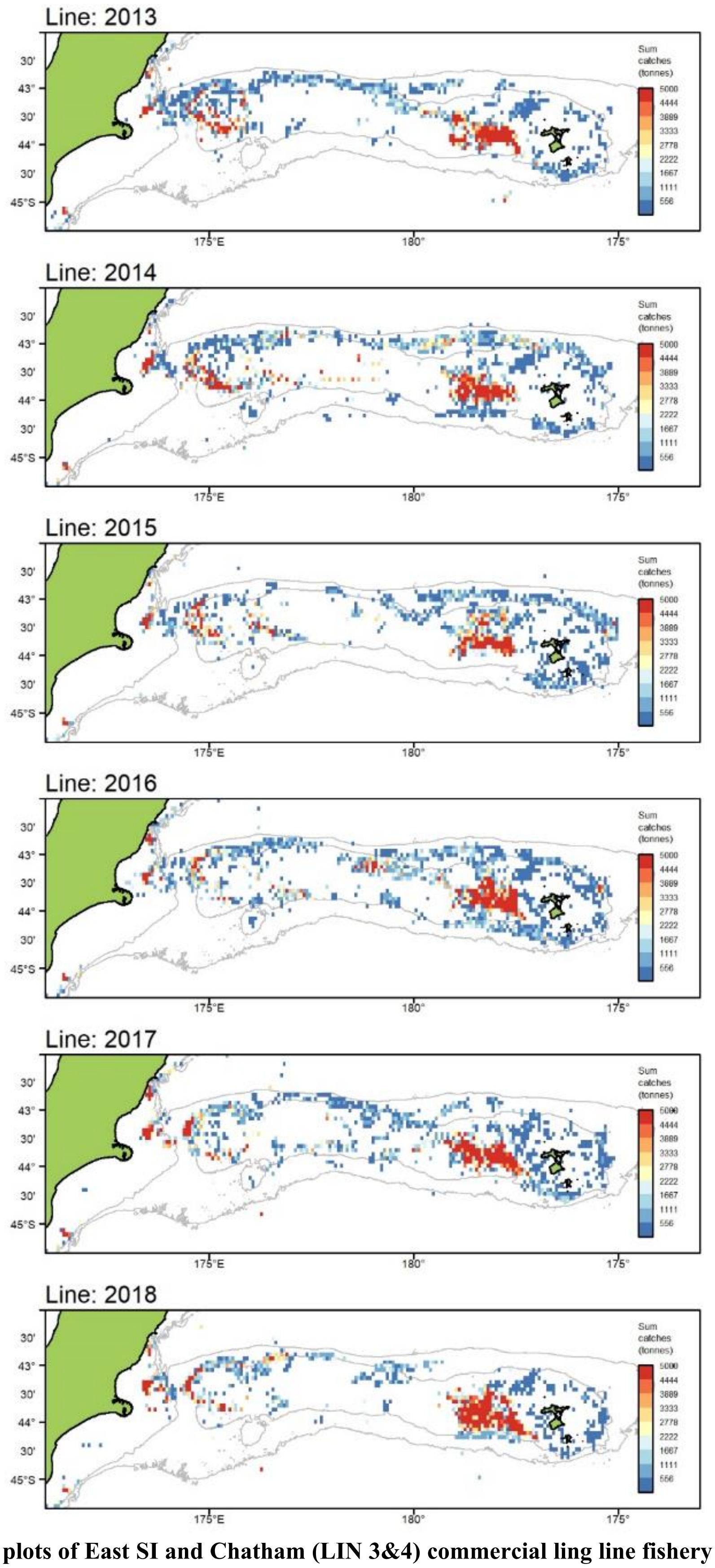


Figure B7: Density plots of East SI and Chatham (LIN 3&4) commercial ling line fishery catches for each of the 2013–2018 fishing years (labelled by year-ending).

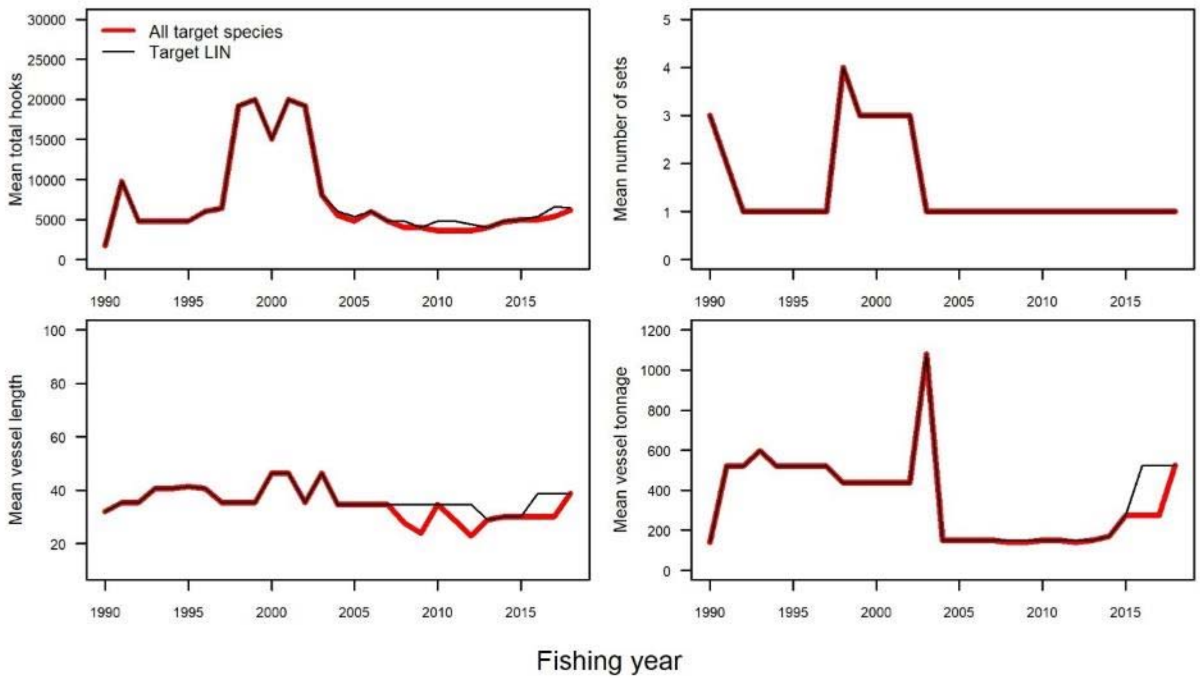


Figure B8: East SI and Chatham (LIN 3&4) bottom longline fishery; means of effort variables by fishing year for sets targeting ling (Target LIN) or targeting ling and other target species (All).

8. APPENDIX C: EAST SI AND CHATHAM RISE LINE CPUE (LIN 3&4)

Table C1: Summary of predictors offered in the East SI and Chatham Rise (LIN 3&4) CPUE models for the line fisheries.

Variable	Type	Description
Year	Categorical	Calendar year
Month	Categorical	Month of year
Statistical area	Categorical	Statistical area for the set or tow
Vessel	Categorical	Unique vessel identifier
Day of year	Continuous	Julian day, starting at 1 on 1 January
Method	Categorical	Fishing method (bottom longline, trot line, dahn line)
Total hooks	Continuous	Number of hooks set per day in a statistical area offered as a third-order polynomial
Log(Total hooks)	Continuous	Logarithm of variable Total hooks
Number of sets	Continuous	Number of set per day in a statistical area
Log(Number of sets)	Continuous	Logarithm of variable Number of sets
CPUE	Continuous	Ling catch (kg) per day in a statistical area

Table C2: Catches (t) and percent of total catches by vessel type (autolongline or handbaiting) and year in the East SI and Chatham Rise (LIN 3&4) line fishery.

	Catches (t)			Percent of total catches (%)	
Year	**Autolongline**	**Handbaiting**	**Total**	**Autolongline**	**Handbaiting**
1991	293	121	414	70.8	29.2
1992	371	108	479	77.5	22.5
1993	530	110	640	82.8	17.2
1994	686	95	781	87.8	12.2
1995	652	61	713	91.4	8.6
1996	660	0	660	100.0	0.0
1997	744	0	744	100.0	0.0
1998	486	0	486	100.0	0.0
1999	656	0	656	100.0	0.0
2000	558	0	558	100.0	0.0
2001	602	0	602	100.0	0.0
2002	646	79	725	89.1	10.9
2003	350	75	425	82.4	17.6
2004	511	76	587	87.1	12.9
2005	490	152	642	76.3	23.7
2006	449	96	545	82.4	17.6
2007	487	245	732	66.5	33.5
2008	439	156	595	73.8	26.2
2009	542	234	776	69.8	30.2
2010	538	274	812	66.3	33.7
2011	533	272	805	66.2	33.8
2012	496	244	740	67.0	33.0
2013	533	255	788	67.6	32.4
2014	649	272	921	70.5	29.5
2015	617	218	835	73.9	26.1
2016	863	224	1087	79.4	20.6
2017	663	227	890	74.5	25.5
2018	528	167	695	76.0	24.0
Total	15 572	3 761	19 333	80.5	19.5

Table C3: CPUE data constraints for East SI and Chatham Rise (LIN 3&4) ling fishery.

	Bottom longline data
Data source	CELR (all catch), LTCER and LCER (ling catch included only if ling is one of the top 5 species by weight caught in a day's fishing for a vessel/stat area)
Year range	1991–2018
Year definition	Calendar year
Statistical areas	All
Method	BLL
Target	LIN
Vessel type	All vessels
Catch	1–35 000 kg
Total number of hooks	50–50 000
Core vessel selection	At least 80% of catch, ≥ 4 years vessel participation

Table C4: Conversion factor regulations for different processed states, with date of implementation and regulation end date for ling in the East SI and Chatham Rise (LIN 3&4) line fishery.

State Code	Definition	Conversion Factor	Regulation start	Regulation end
ACC	Accidental loss	1	1986	2999
CHK	Cheeks	0	1994	2999
DIS	Discarded	1	1990	2999
DRE	Dressed	1.8	1990	1997
DRE	Dressed	1.85	1997	2002
DRE	Dressed	1.8	2002	2999
EAT	Eaten	1	1990	2999
FIL	Fillets: skin on	2.1	1986	2001
FIT	Fish tails	0	2001	2999
FLP	Flaps	0	1994	2999
GBP	Gut by-product	0	2001	2999
GGU	Gilled and gutted	1.1	1986	1990
GRE	Green	1	1986	2999
GUT	Gutted	1.1	1986	1991
GUT	Gutted	1.25	1991	1993
GUT	Gutted	1.15	1993	2999
HDS	Heads	0	1994	2999
HGT	Headed, gutted, tailed	1.7	1986	1990
HGT	Headed, gutted, tailed	1.55	1995	2005
HGT	Headed, gutted, tailed	1.6	2005	2008
HGT	Headed, gutted, tailed	1.65	2008	2999
HGU	Headed and gutted	1.5	1986	1993
HGU	Headed and gutted	1.45	1993	2999
LIB	Livers by-product	0	2001	2999
LUG	Lugs or collars	0	1994	2999
MEA	Fish meal	5.556	1986	1990
MEA	Fish meal	5.6	1990	2999
MEB	Fish meal by-product	0	2001	2999
MKF	Minced, skin off fillets	3.1	2009	2011
MKF	Minced, skin off fillets	3.05	2011	2999
OAD	Observer authorised discard	1	2013	2999

State Code	Definition	Conversion Factor	Regulation start	Regulation end
OIL	Oil	0	1986	2999
ROE	Roe	0	1986	2999
TSK	Fillets: skin off trimmed	3.7	1993	1996
TSK	Fillets: skin off trimmed	3	1996	2004
TSK	Fillets: skin off trimmed	2.95	2004	2999
USK	Fillets: skin off untrimmed	2.65	1993	1995
USK	Fillets: skin off untrimmed	2.8	1995	2001
USK	Fillets: skin off untrimmed	2.85	1998	2999
UTF	Fillets: skin on untrimmed	2.2	1993	1996
UTF	Fillets: skin on untrimmed	2.35	1996	2005
UTF	Fillets: skin on untrimmed	2.25	2005	2011
UTF	Fillets: skin on untrimmed	2.4	2011	2999
XMU	Skin on untrimmed hoki fillets process to mince	2.25	1999	2004
XSK	Skins	0	2001	2003
SKF	Fillets: skin off	2.75	1992	2001
SUR	Surimi	4.3	1986	2999
SWB	Sounds or swim bladders	0	1994	2999
TRF	Fillets: skin on trimmed	2.8	1993	2999
TRU	Trunked	1.7	1986	1990

Table C5: Variables retained in the East SI and Chatham Rise (LIN 3&4) line GLMs order of decreasing explanatory value, for each model lognormal and fishery, with the corresponding deviance explained (R-squared, %).

(a) Single line fishery

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	56 138	12.5	12.5
poly(daily.hooks, 3)	3	45 889	48.5	36.0
vessel	21	41 117	59.9	11.4
month	11	38 806	64.4	4.6

(b) Single line fishery – without early vessels

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	44 815	10.1	10.1
poly(daily.hooks, 3)	3	37 251	44.9	34.7
vessel	16	32 911	58.4	13.6
month	11	31 251	62.7	4.3
statarea	22	30 752	64.0	1.3

(c) Single line fishery – Conversion Factors

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	58 566	10.9	10.9
poly(daily.hooks, 3)	3	50 125	42.2	31.3
vessel	21	46 665	50.2	9.8
month	11	45 067	55.9	3.9
statarea	23	44 598	57.0	1.2

(d) Single Line Fishery – Spatial analysis

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	49 632	16.0	16.0
poly(daily.hooks, 3)	3	41 827	46.0	30.0
vessel	19	37 605	57.5	11.6
month	11	35 192	63.0	5.5

(e) Two line fisheries – East and West

West

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	50 067	15.5	15.5
poly(daily.hooks, 3)	3	42 139	45.9	30.4
vessel	19	37 837	57.6	11.7
month	11	35 425	63.0	5.4
statarea	23	34 988	64.0	1.0

East

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	53 695	12.6	12.6
poly(daily.hooks, 3)	3	43 879	48.7	36.1
vessel	21	39 411	59.9	11.1
month	11	37 190	64.5	4.6

(f) Tow line fisheries – Handbait and Autolongline

Autolongline

Step	Df	AIC	% deviance explained	% additional deviance explained
	26	44 293	11.7	11.7
poly(daily.hooks, 3)	3	35 874	48.6	36.9
month	11	32 582	58.5	9.9
vessel	15	29 973	64.9	6.5

Handbait

Step	Df	AIC	% deviance explained	% additional deviance explained
	20	8 988	13.7	13.7
poly(lhooks, 3)	3	7 946	35.0	21.2
vessel	4	7 747	38.5	3.5
month	11	7 686	39.9	1.4

Table C6: CPUE standardised year lognormal indices for East SI and Chatham Rise (LIN 3&4) line fisheries for vessels that have always been autolongline vessels (with CVs). Year defined as calendar year.

Year	Single Line Fishery			Single Line Fishery – Without early vessels			Single Line Fishery – Conversion Factors		
	Index	CI	CV	Index	CI	CV	Index	CI	CV
1991	1.84	1.5–2.13	0.07	1.84	1.59–2.13	0.07	1.65	1.43–1.91	0.07
1992	2.33	2.08–2.62	0.06	2.33	2.08–2.62	0.06	2.06	1.83–2.31	0.06
1993	1.88	1.68–2.11	0.06	1.88	1.68–2.11	0.06	1.72	1.54–1.93	0.06
1994	1.70	1.53–1.89	0.05	1.70	1.53–1.89	0.05	1.58	1.42–1.75	0.05
1995	1.80	1.62–1.99	0.05	1.80	1.62–1.99	0.05	1.59	1.44–1.76	0.05
1996	1.38	1.25–1.53	0.05	1.38	1.25–1.53	0.05	1.28	1.16–1.42	0.05
1997	0.95	0.87–1.04	0.04	0.95	0.87–1.04	0.04	0.91	0.84–1.00	0.04
1998	0.86	0.78–0.94	0.05	0.86	0.78–0.94	0.05	0.83	0.75–0.91	0.05
1999	0.87	0.79–0.94	0.04	0.87	0.79–0.94	0.04	0.87	0.79–0.94	0.04
2000	0.96	0.89–1.04	0.04	0.96	0.89–1.04	0.04	0.54	0.50–0.59	0.04
2001	0.99	0.90–1.08	0.05	0.99	0.90–1.08	0.05	1.06	0.97–1.16	0.05
2002	0.86	0.80–0.93	0.04	0.86	0.80–0.93	0.04	0.87	0.80–0.94	0.04
2003	0.91	0.82–1.00	0.05	0.91	0.82–1.00	0.05	0.97	0.88–1.07	0.05
2004	0.86	0.79–0.95	0.05	0.86	0.79–0.95	0.05	0.88	0.80–0.96	0.05
2005	0.94	0.86–1.02	0.04	0.94	0.86–1.02	0.04	0.95	0.87–1.03	0.04
2006	0.77	0.71–0.85	0.05	0.77	0.71–0.85	0.05	0.80	0.73–0.88	0.05
2007	0.83	0.77–0.90	0.04	0.83	0.77–0.90	0.04	0.87	0.81–0.95	0.04
2008	0.92	0.84–1.01	0.05	0.92	0.84–1.01	0.05	0.96	0.88–1.05	0.05
2009	0.86	0.79–0.93	0.04	0.86	0.79–0.93	0.04	0.91	0.84–0.98	0.04
2010	0.83	0.77–0.90	0.04	0.83	0.77–0.90	0.04	0.88	0.81–0.95	0.04
2011	0.68	0.63–0.74	0.04	0.68	0.63–0.74	0.04	0.73	0.68–0.79	0.04
2012	0.83	0.77–0.91	0.04	0.83	0.77–0.91	0.04	0.89	0.82–0.97	0.04
2013	0.83	0.76–0.90	0.04	0.83	0.76–0.90	0.04	0.90	0.83–0.98	0.04
2014	0.87	0.81–0.94	0.04	0.87	0.81–0.94	0.04	0.96	0.89–1.04	0.04
2015	0.71	0.65–0.77	0.04	0.71	0.65–0.77	0.04	0.80	0.74–0.87	0.04
2016	0.82	0.76–0.89	0.04	0.82	0.76–0.89	0.04	0.94	0.86–1.01	0.04
2017	0.81	0.75–0.88	0.04	0.81	0.75–0.88	0.04	0.93	0.86–1.01	0.04
2018	0.83	0.76–0.90	0.04	0.83	0.76–0.90	0.04	0.95	0.88–1.04	0.04

Year	Single Line Fishery – Spatial analysis			Two Line Fishery - West			Two Line Fishery - East		
	Index	CI	CV	Index	CI	CV	Index	CI	CV
1991	1.84	1.54–2.19	0.09	1.83	1.54–2.18	0.09	1.93	1.66–2.25	0.08
1992	2.75	2.41–3.13	0.06	2.75	2.41–3.12	0.06	2.35	2.08–2.64	0.06
1993	2.08	1.84–2.36	0.06	2.08	1.84–2.36	0.06	1.90	1.69–2.13	0.06
1994	1.93	1.73–2.16	0.06	1.93	1.72–2.15	0.06	1.70	1.53–1.89	0.05
1995	1.74	1.56–1.95	0.06	1.74	1.56–1.94	0.06	1.83	1.65–2.03	0.05
1996	1.47	1.33–1.64	0.05	1.47	1.32–1.64	0.05	1.39	1.25–1.54	0.05
1997	0.98	0.90–1.08	0.05	0.98	0.90–1.08	0.05	0.97	0.89–1.07	0.05
1998	0.87	0.79–0.95	0.05	0.87	0.79–0.95	0.05	0.86	0.78–0.95	0.05
1999	0.82	0.75–0.90	0.05	0.82	0.75–0.90	0.05	0.85	0.78–0.93	0.04
2000	0.93	0.85–1.02	0.04	0.94	0.86–1.02	0.04	0.96	0.88–1.05	0.04
2001	0.96	0.88–1.05	0.05	0.97	0.88–1.06	0.05	1.00	0.91–1.09	0.05
2002	0.85	0.78–0.92	0.04	0.84	0.77–0.91	0.04	0.86	0.80–0.94	0.04
2003	0.93	0.83–1.04	0.06	0.91	0.81–1.01	0.05	0.91	0.83–1.01	0.05
2004	0.84	0.76–0.92	0.05	0.85	0.77–0.93	0.05	0.86	0.78–0.94	0.05
2005	0.97	0.88–1.07	0.05	0.98	0.89–1.08	0.05	0.90	0.83–0.99	0.04
2006	0.81	0.73–0.90	0.05	0.81	0.73–0.90	0.05	0.77	0.70–0.84	0.05
2007	0.93	0.85–1.03	0.05	0.93	0.85–1.03	0.05	0.83	0.76–0.90	0.04
2008	0.89	0.81–0.97	0.05	0.89	0.81–0.97	0.05	0.92	0.84–1.01	0.05
2009	0.81	0.74–0.88	0.04	0.81	0.74–0.88	0.04	0.85	0.78–0.93	0.04
2010	0.81	0.74–0.87	0.04	0.81	0.75–0.88	0.04	0.82	0.76–0.89	0.04
2011	0.66	0.61–0.71	0.04	0.66	0.61–0.71	0.04	0.68	0.63–0.73	0.04
2012	0.80	0.74–0.87	0.04	0.81	0.74–0.87	0.04	0.83	0.77–0.91	0.04
2013	0.79	0.73–0.86	0.04	0.79	0.73–0.86	0.04	0.83	0.76–0.91	0.04
2014	0.82	0.75–0.89	0.04	0.82	0.75–0.89	0.04	0.87	0.80–0.94	0.04
2015	0.67	0.62–0.73	0.04	0.67	0.62–0.74	0.04	0.71	0.65–0.77	0.04
2016	0.78	0.72–0.85	0.04	0.78	0.72–0.85	0.04	0.81	0.74–0.88	0.04
2017	0.77	0.71–0.84	0.04	0.78	0.71–0.84	0.04	0.81	0.75–0.89	0.04
2018	0.79	0.72–0.86	0.04	0.79	0.72–0.86	0.04	0.82	0.76–0.89	0.04

Year	Two Line Fishery - Autolongline			Two Line Fishery - Handbaiting		
	Index	CI	CV	Index	CI	CV
1991	1.72	1.45–2.03	0.08	1.78	1.36–2.32	0.13
1992	2.50	2.21–2.82	0.06	1.49	1.19–1.87	0.11
1993	1.94	1.72–2.19	0.06	1.35	1.08–1.68	0.11
1994	1.80	1.62–2.01	0.05	1.22	0.96–1.54	0.12
1995	1.81	1.63–2.01	0.05	1.52	1.20–1.93	0.12
1996	1.41	1.27–1.56	0.05	1.27	0.93–1.75	0.16
1997	0.96	0.88–1.05	0.04	0.82	0.65–1.04	0.12
1998	0.86	0.78–0.94	0.05	0.86	0.67–1.10	0.12
1999	0.86	0.79–0.94	0.04	0.70	0.58–0.85	0.10
2000	0.97	0.89–1.05	0.04	0.56	0.46–0.70	0.10
2001	0.98	0.89–1.07	0.05	0.64	0.55–0.74	0.07
2002	0.86	0.79–0.93	0.04	0.92	0.76–1.11	0.09
2003	0.92	0.82–1.03	0.05	0.96	0.83–1.10	0.07
2004	0.87	0.79–0.96	0.05	1.01	0.88–1.16	0.07
2005	1.02	0.93–1.12	0.05	0.95	0.83–1.09	0.07
2006	0.85	0.77–0.94	0.05	0.94	0.81–1.10	0.08
2007	1.00	0.91–1.10	0.05	0.91	0.78–1.05	0.07
2008	0.96	0.86–1.06	0.05	0.98	0.84–1.13	0.07
2009	0.89	0.81–0.98	0.05	0.84	0.73–0.98	0.07
2010	0.83	0.76–0.91	0.05	1.02	0.88–1.18	0.07
2011	0.68	0.62–0.75	0.05	1.01	0.86–1.18	0.08
2012	0.88	0.80–0.97	0.05	1.07	0.91–1.26	0.08
2013	0.85	0.77–0.93	0.05	1.78	1.36–2.32	0.13
2014	0.79	0.72–0.87	0.05	1.49	1.19–1.87	0.11
2015	0.64	0.58–0.71	0.05	1.35	1.08–1.68	0.11
2016	0.71	0.64–0.78	0.05	1.22	0.96–1.54	0.12
2017	0.70	0.64–0.78	0.05	1.52	1.20–1.93	0.12
2018	0.72	0.65–0.79	0.05	1.27	0.93–1.75	0.16

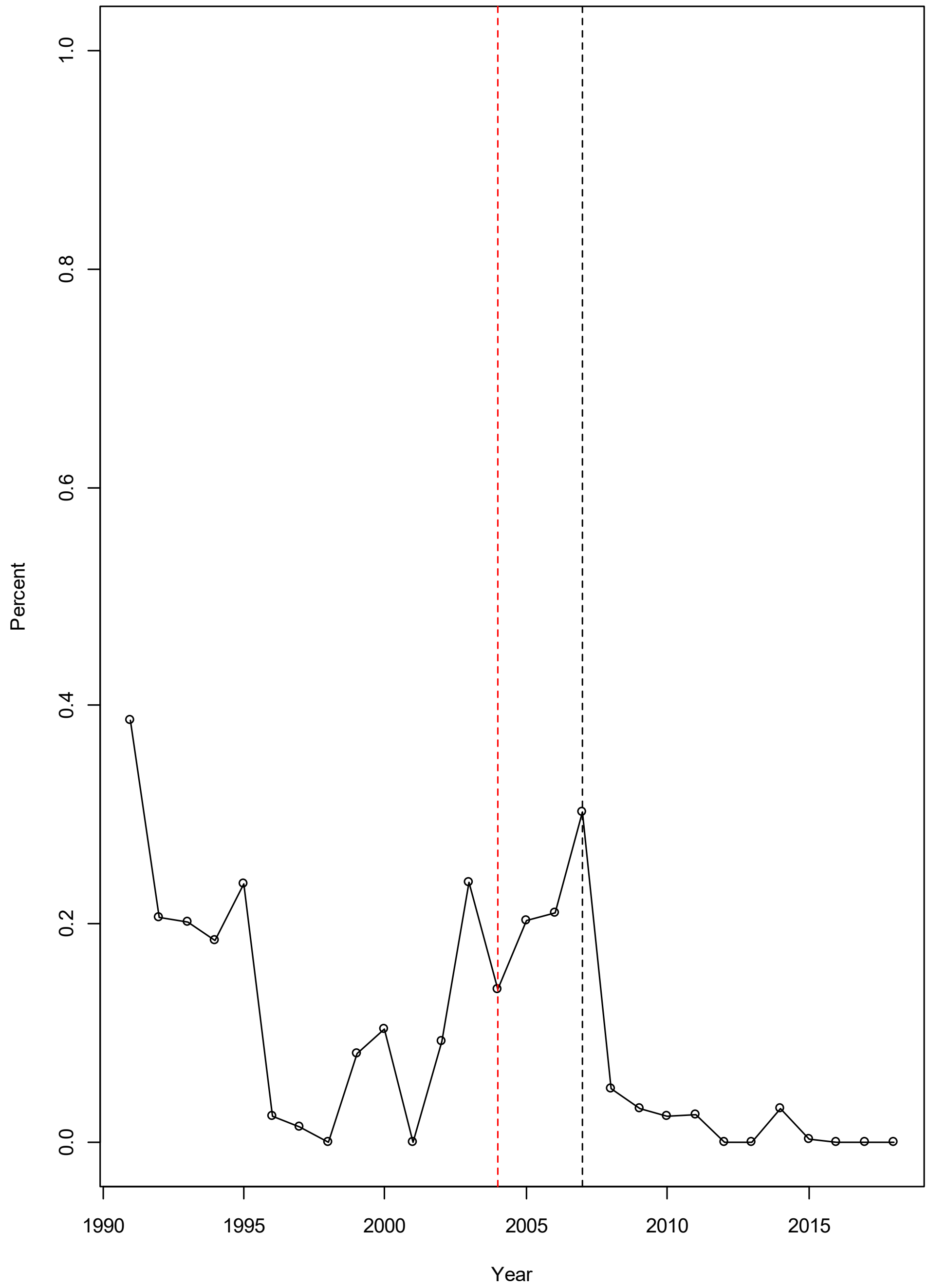


Figure C1: Percentage of records where positional latitude and longitude data were recorded for each year between 1991 and 2018, for the East SI and Chatham Rise single line fishery. The red verticle line denotes the year when LCER forms were introduced. The black verticle line denotes the year when LTCER forms were introduced.

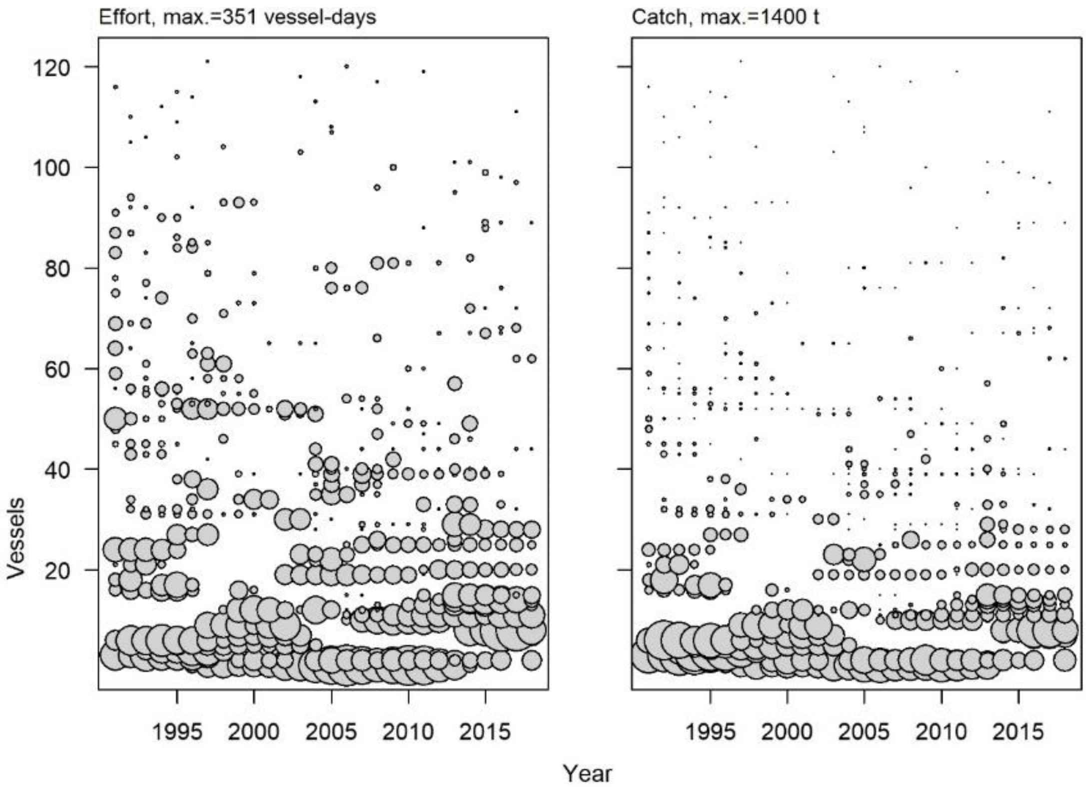


Figure C2: East SI and Chatham Rise single line fishery fishing effort and catches by year for all individual vessels (denoted anonymously by number on the y-axis) in the line fishery. Circle area is proportional to the effort or catch.

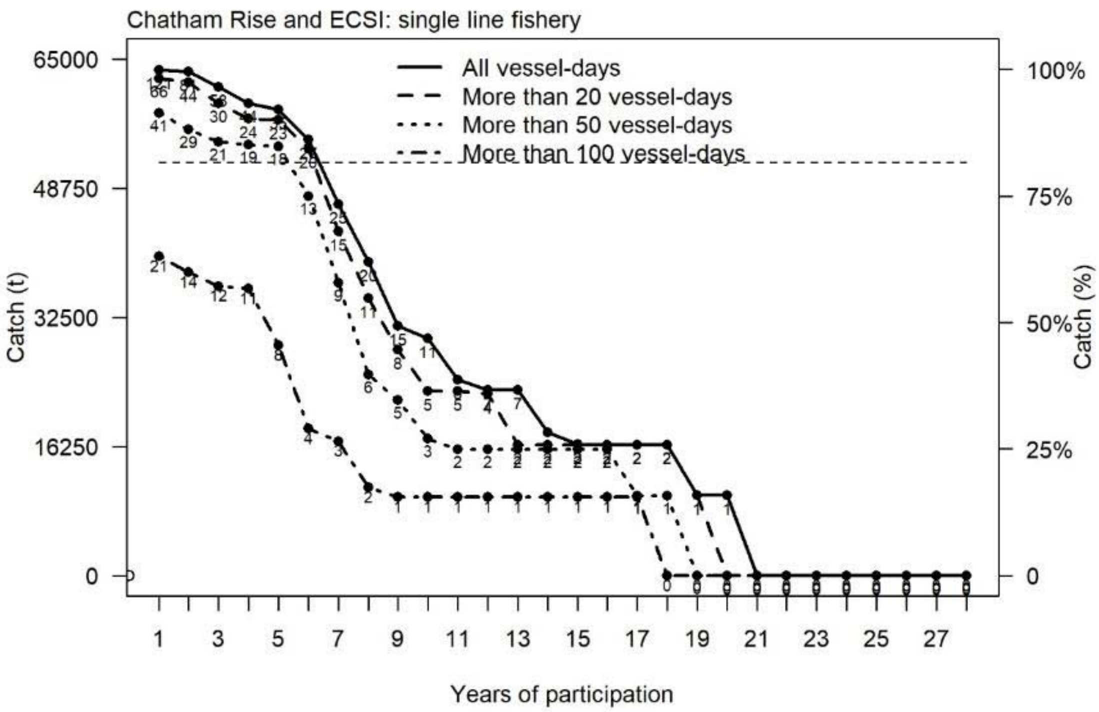


Figure C3: Chatham Rise and East SI single line fishery catches by years of participation in the fishery for all individual vessels, where yearly participation was defined as all days, more than 20 days, more than 50 days or more than 100 days. Horizontal dotted line denoted where 80 % of the yearly catch was taken. Year defined as September–August.

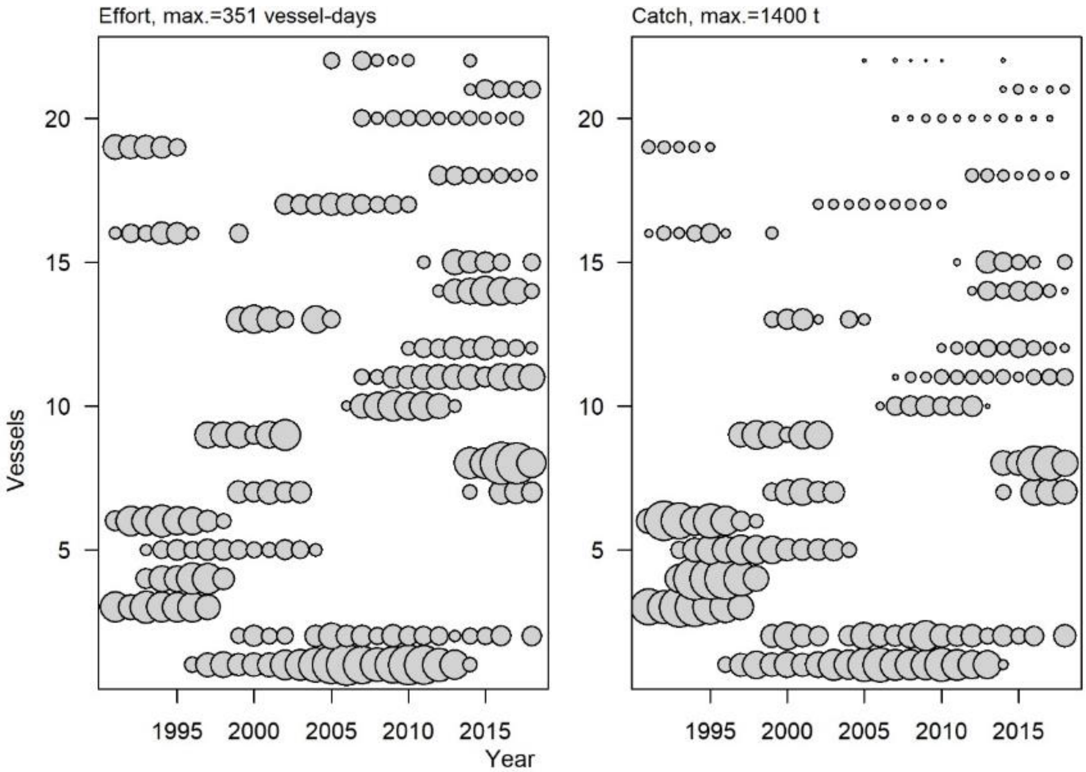


Figure C4: East SI and Chatham Rise (LIN 3&4) single line fishery fishing effort and catches by year for individual vessels (denoted anonymously by number on the y-axis) in core CPUE analyses. Circle area is proportional to the effort or catch.

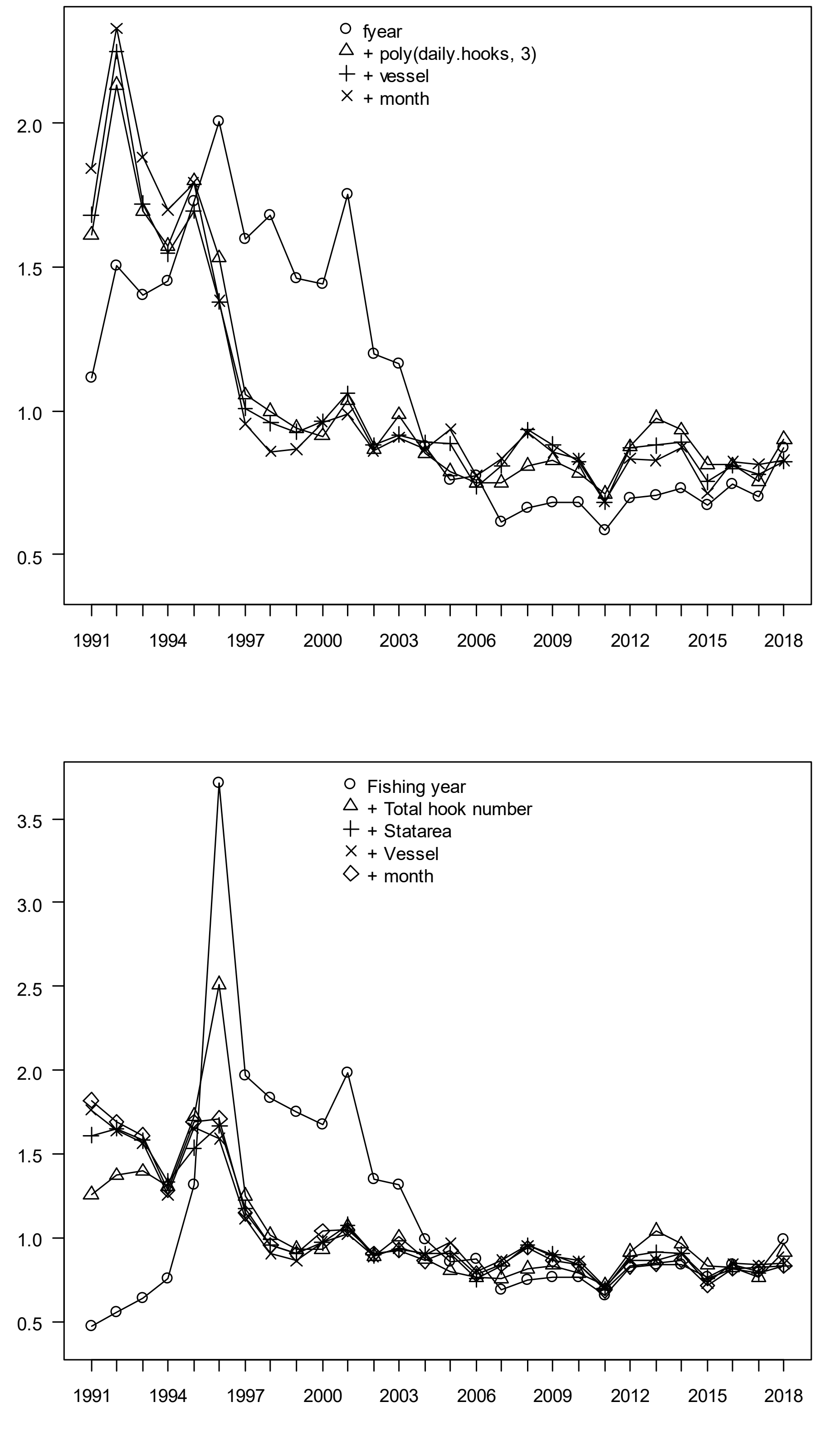


Figure C5a: Addition of variables into the lognormal CPUE model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Single line fishery; Single line fishery – without early vessels.

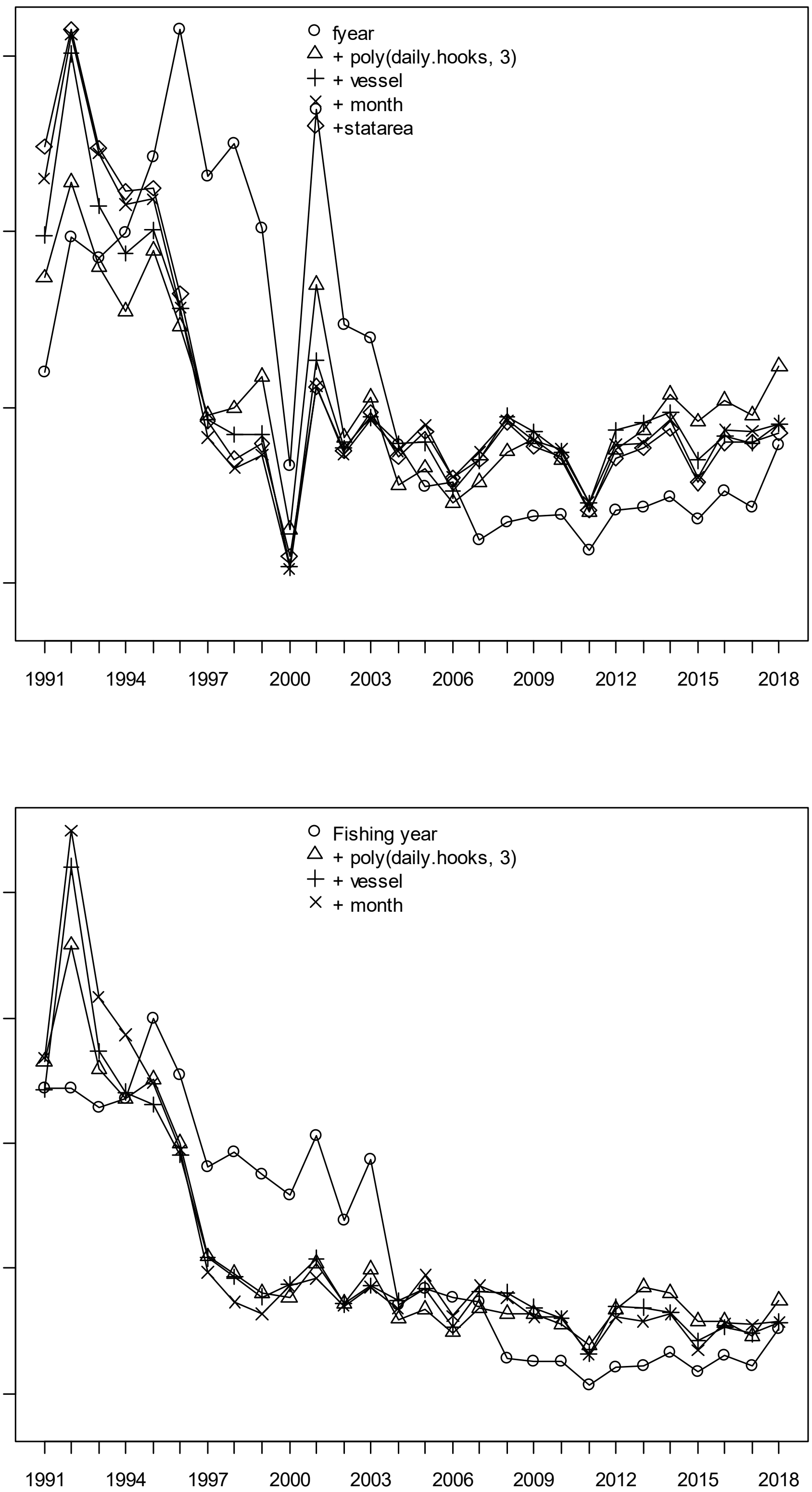
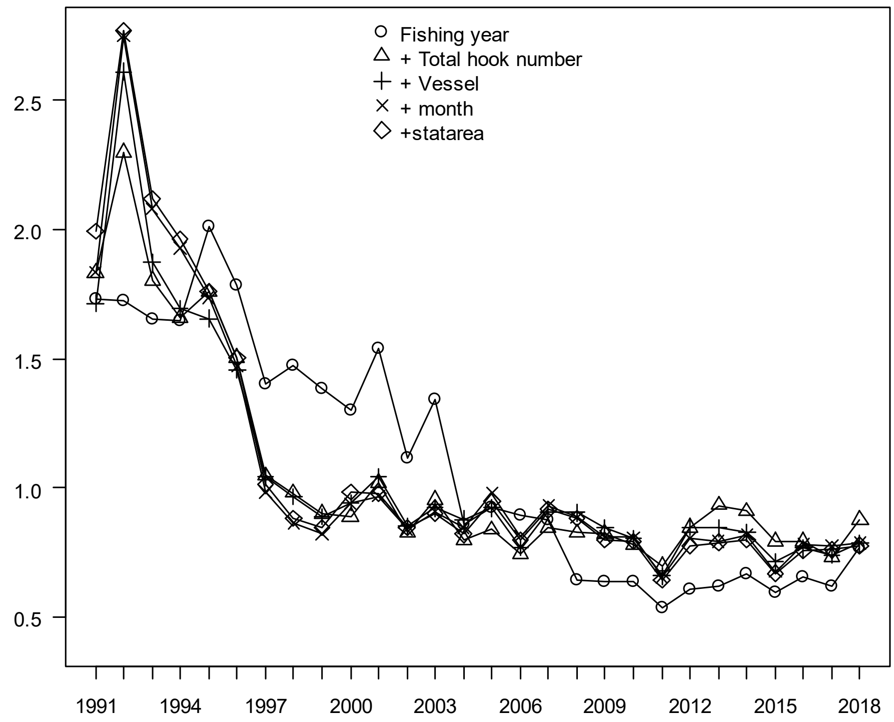


Figure C5b: Addition of variables into the lognormal CPUE model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Single line fishery – Conversion factors; Single line fishery – spatial analysis.



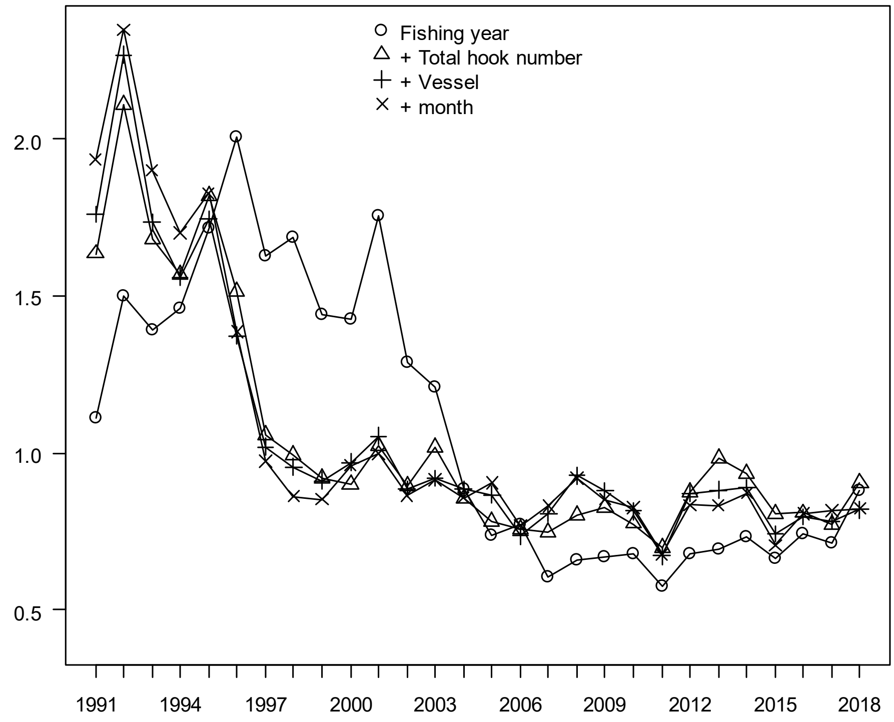
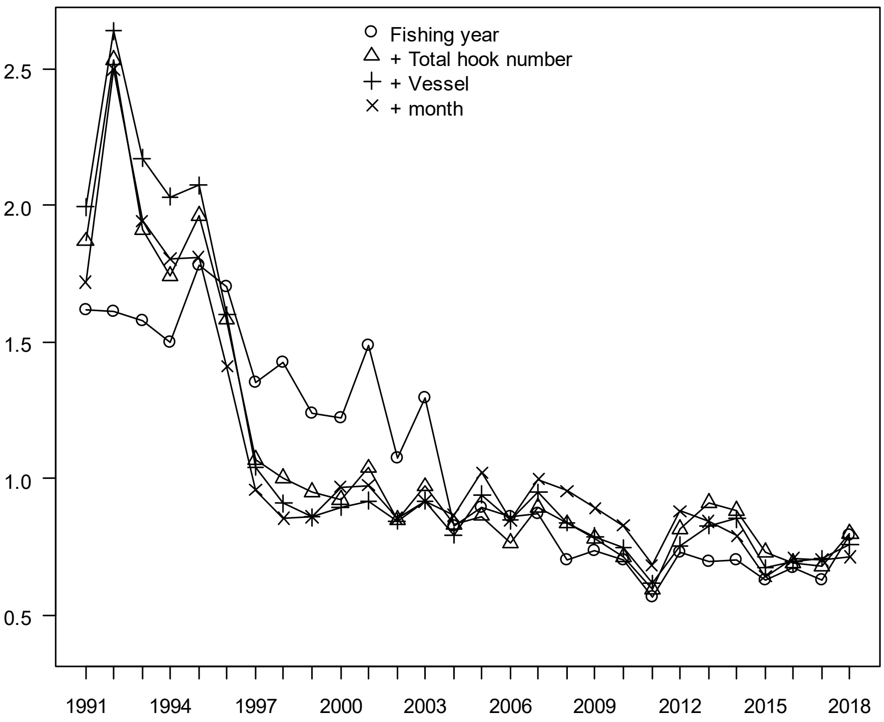


Figure C5c: Addition of variables into the lognormal CPUE model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Two line fisheries – West; Two line fisheries – East.



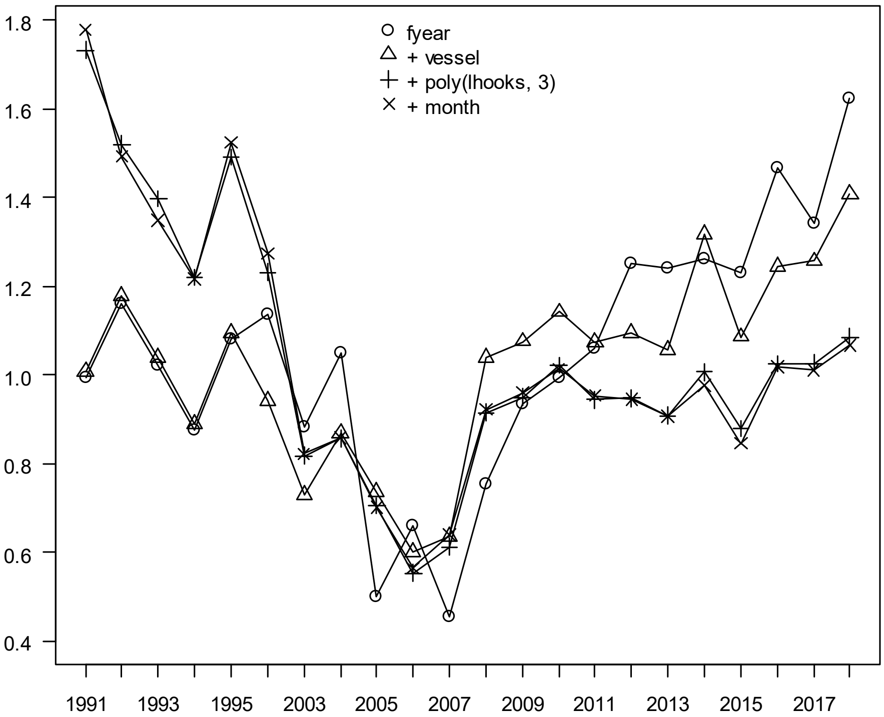


Figure C5d: Addition of variables into the lognormal CPUE model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Two line fisheries – Autolongline; Two line fisheries – Handbaiting.

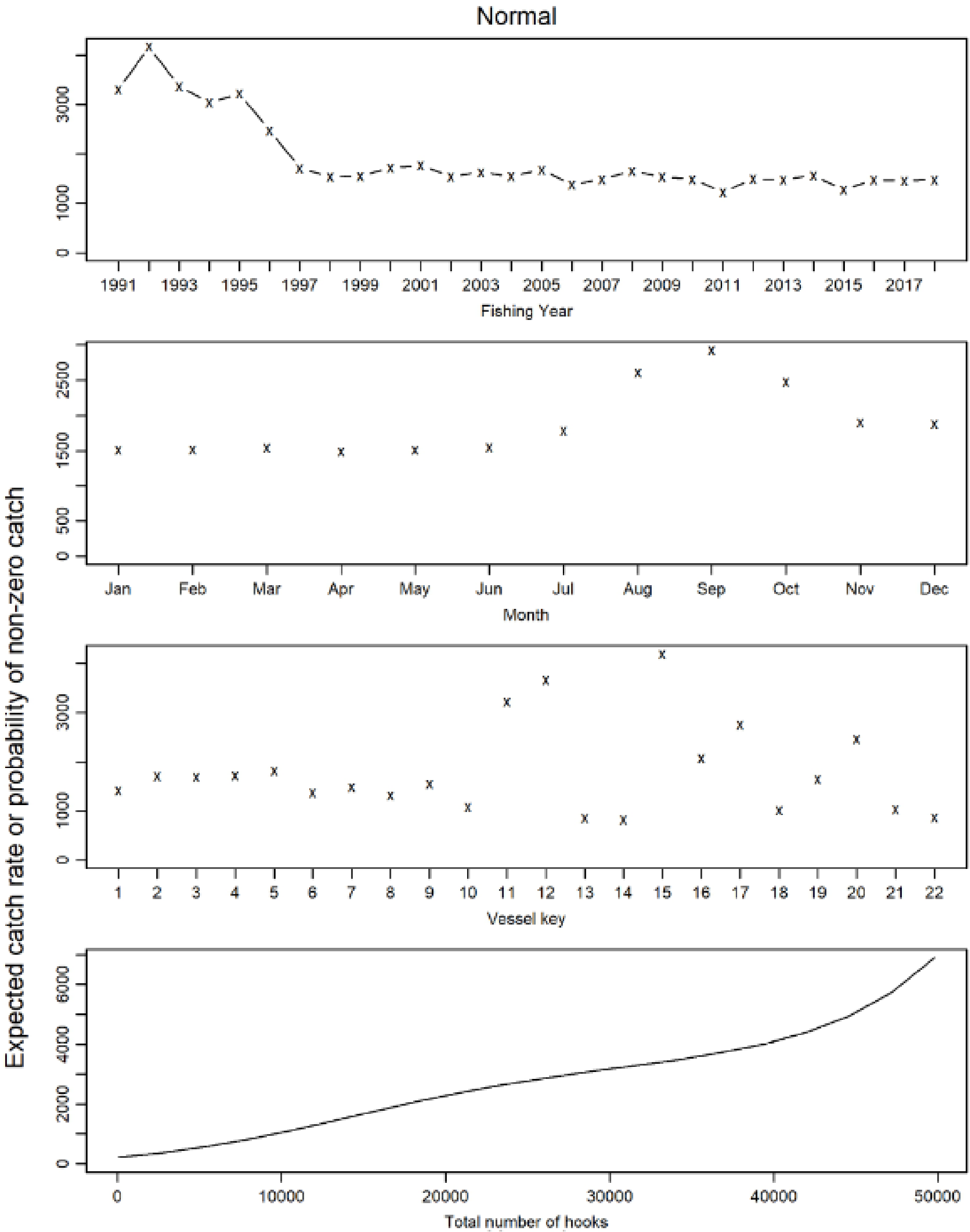


Figure C6a: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal single line fishery model.

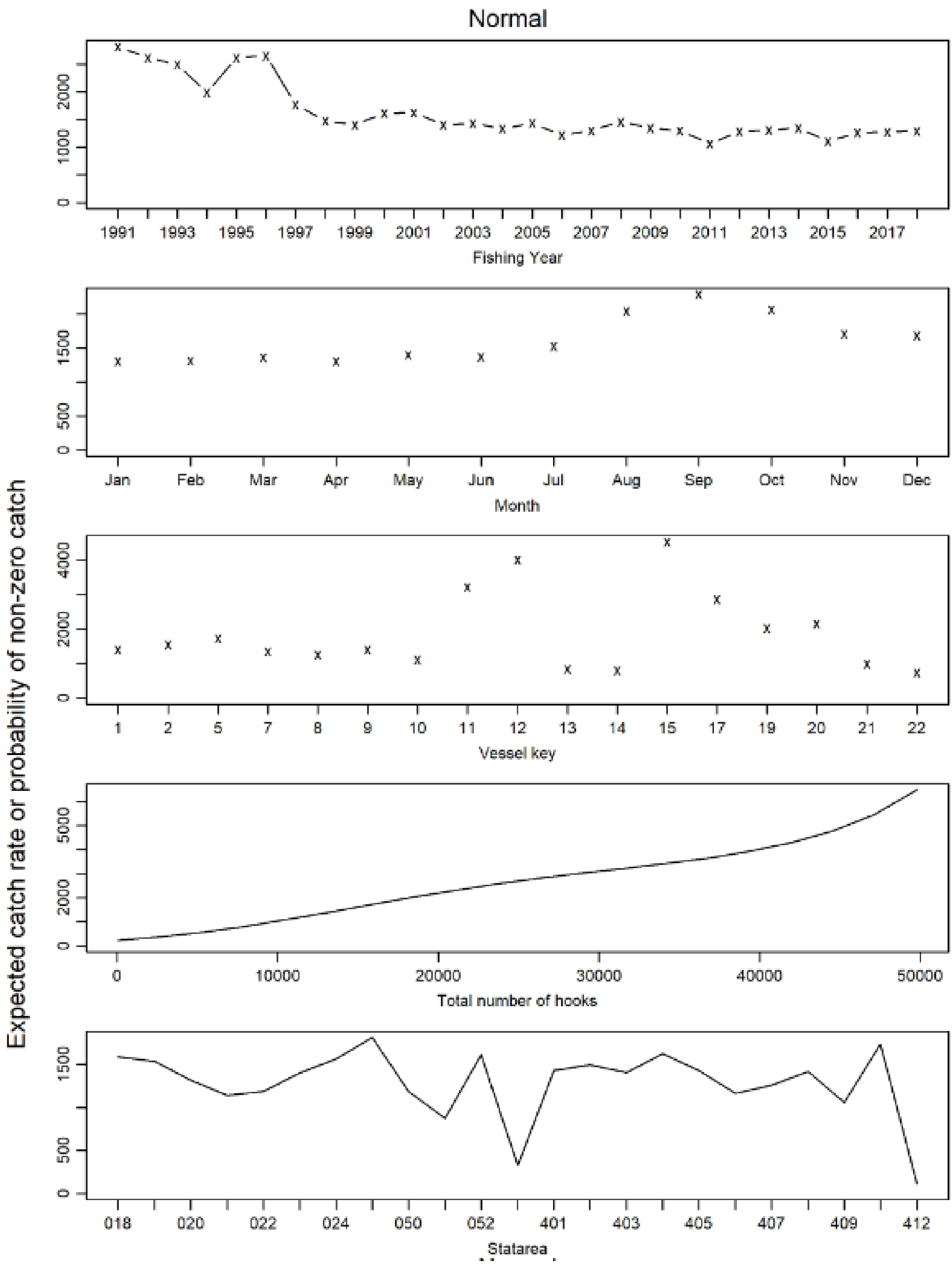


Figure C6b: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal single line fishery model, without early vessels.

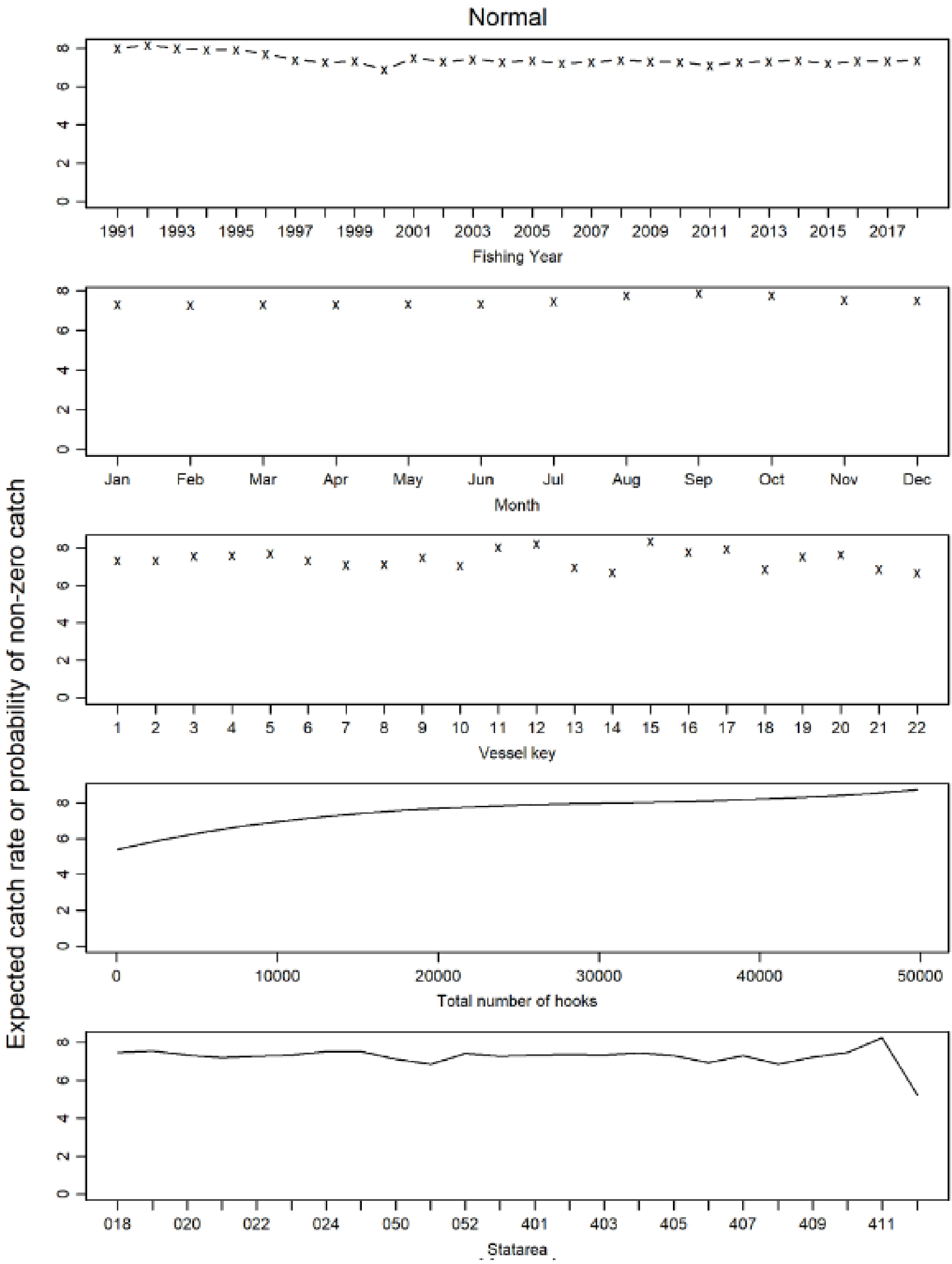


Figure C6c: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal single line fishery model – conversion factors.

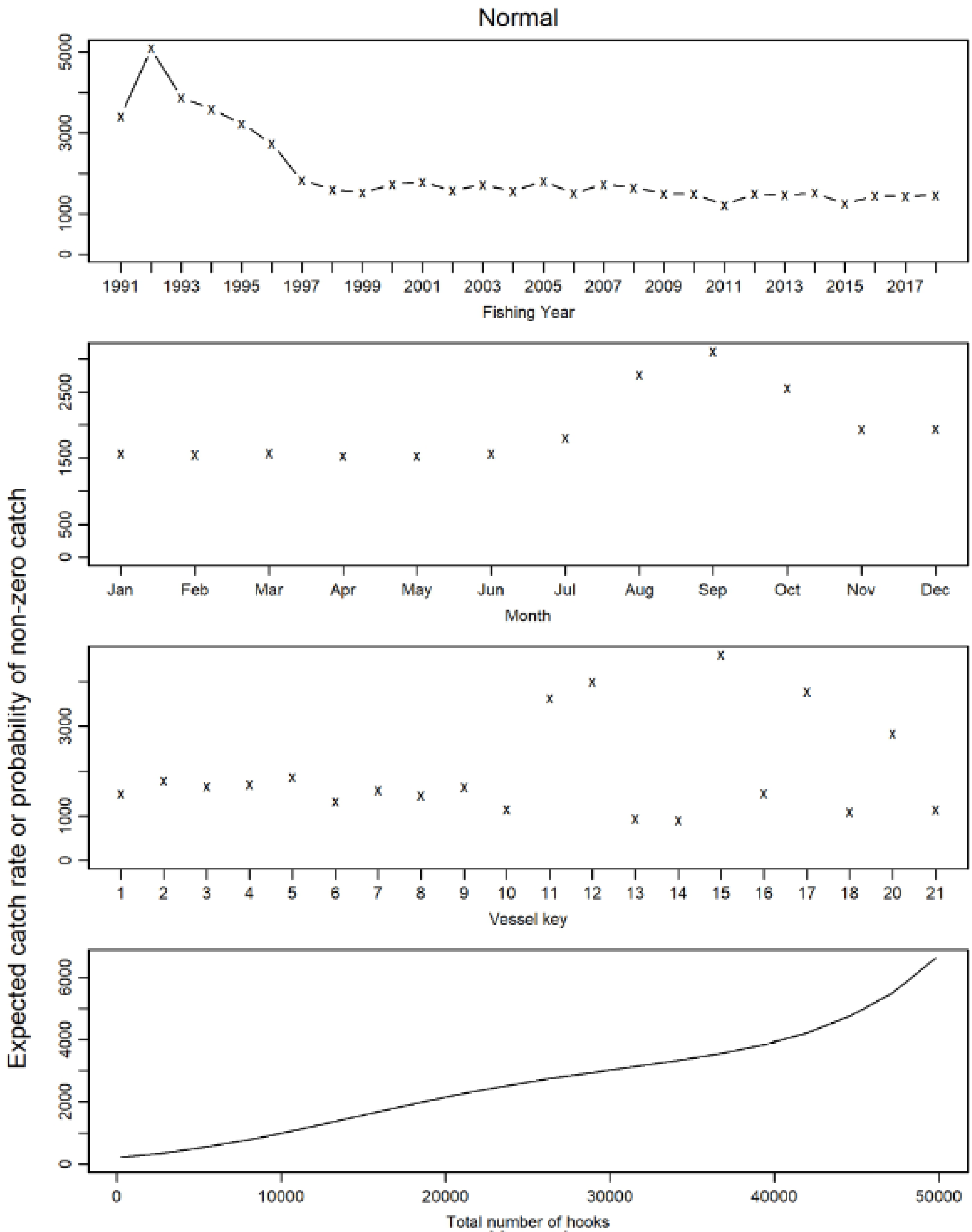


Figure C6d: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal single line fishery model – spatial analysis.

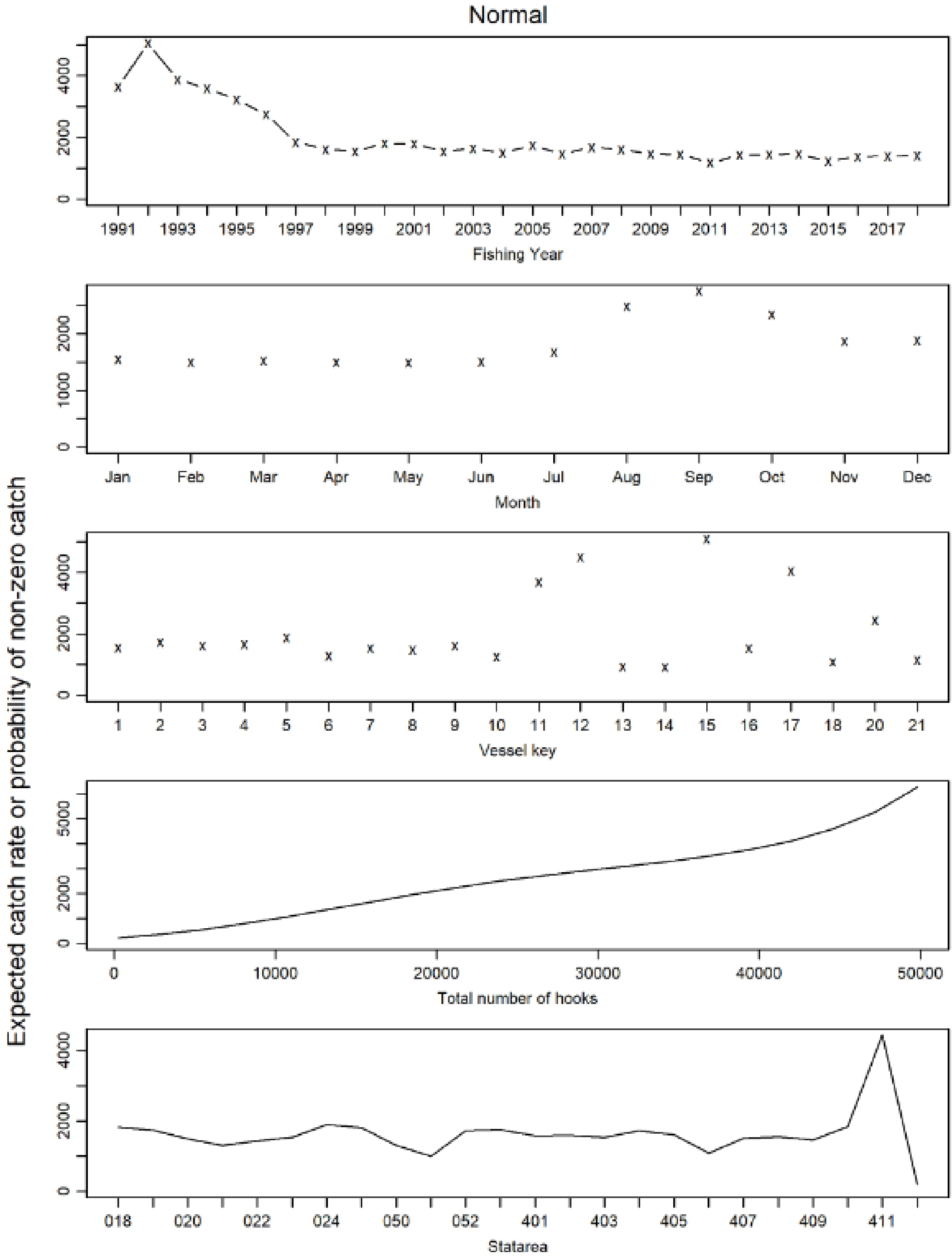


Figure C6e: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal two line fishery model for the western fishery.

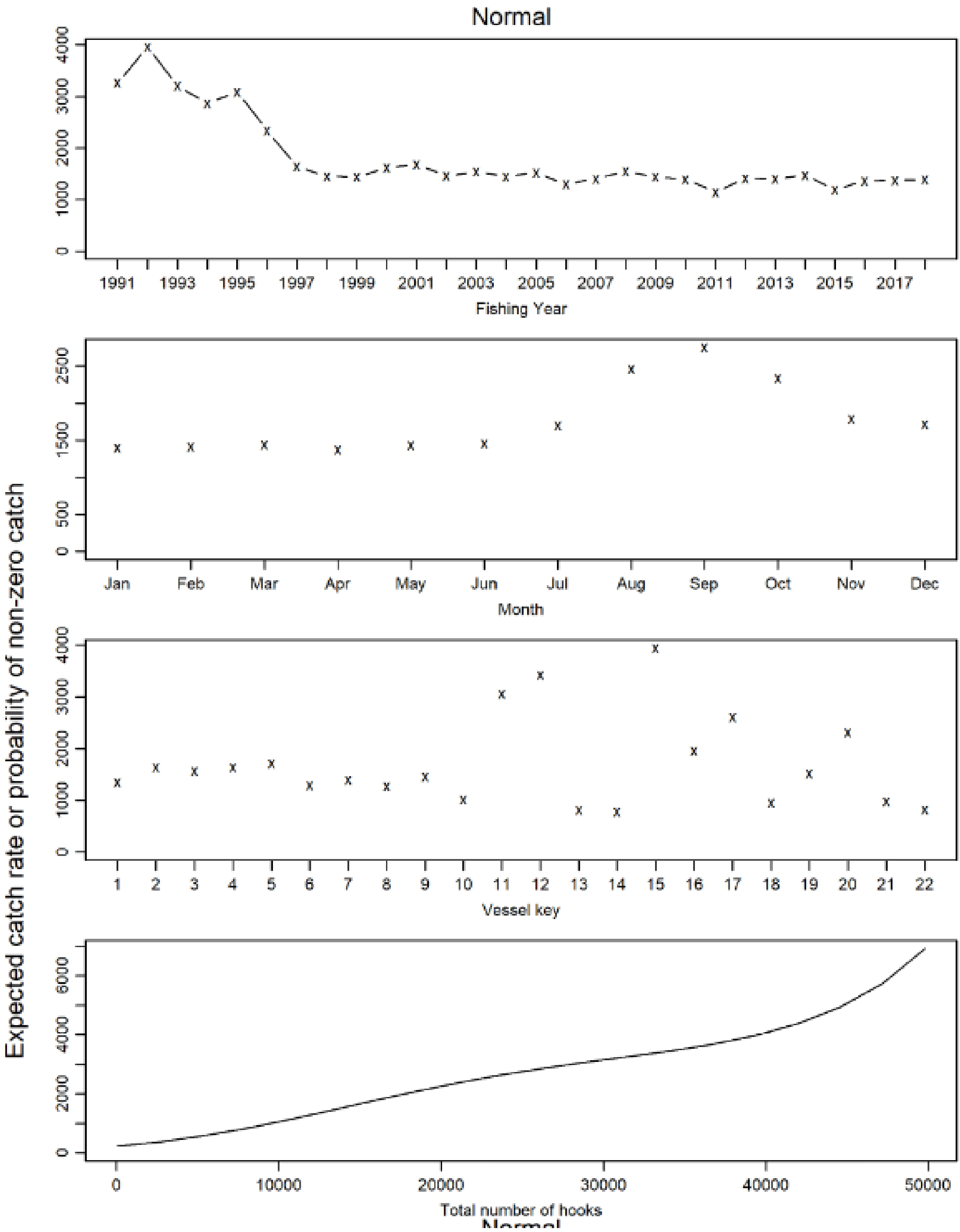


Figure C6f: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal two line fishery model for the eastern fishery.

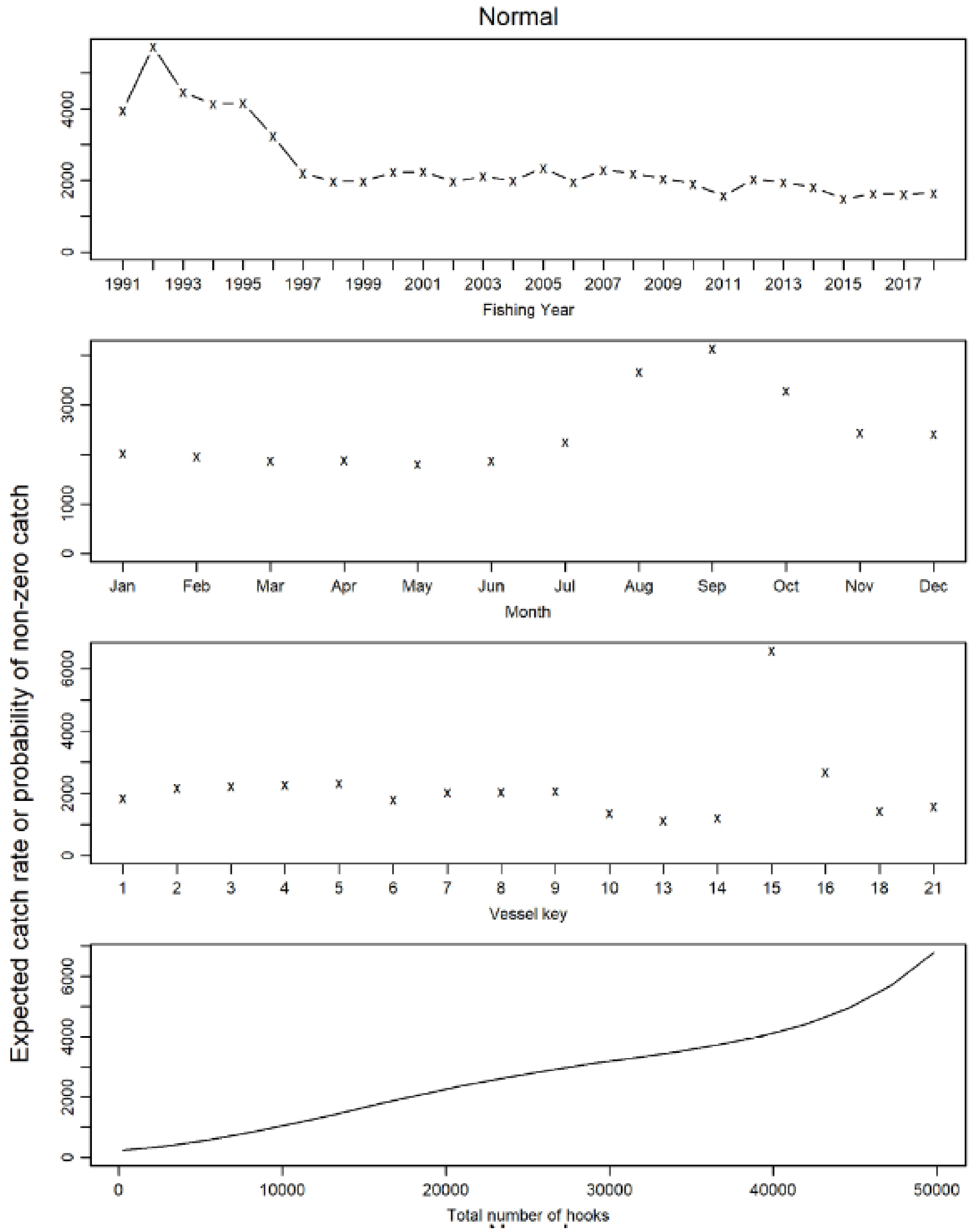


Figure C6g: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal two line fishery model for the autolongline fishery.

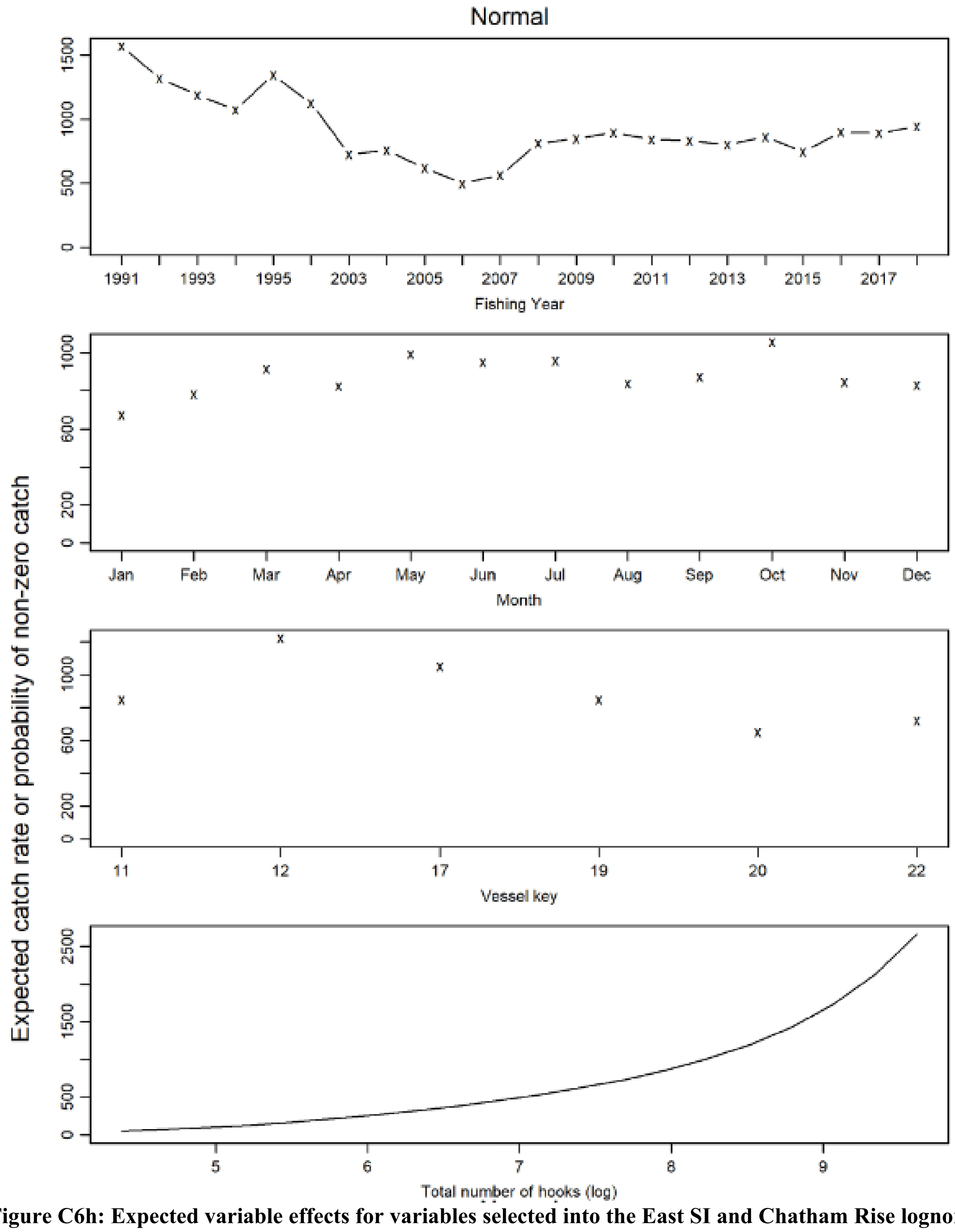
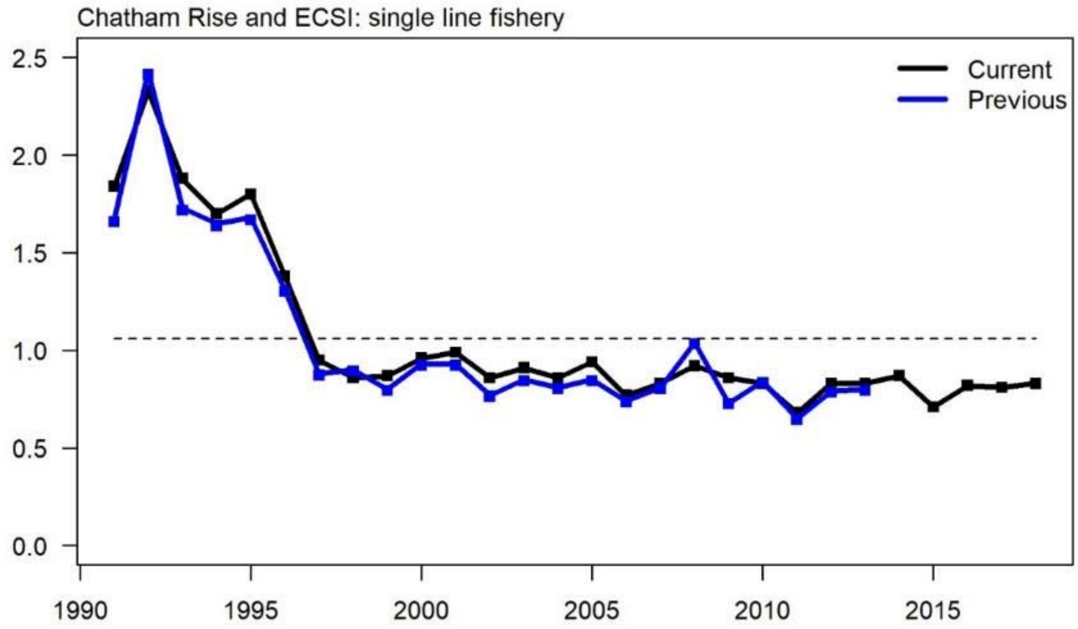


Figure C6h: Expected variable effects for variables selected into the East SI and Chatham Rise lognormal two line fishery model for the handbaiting fishery.



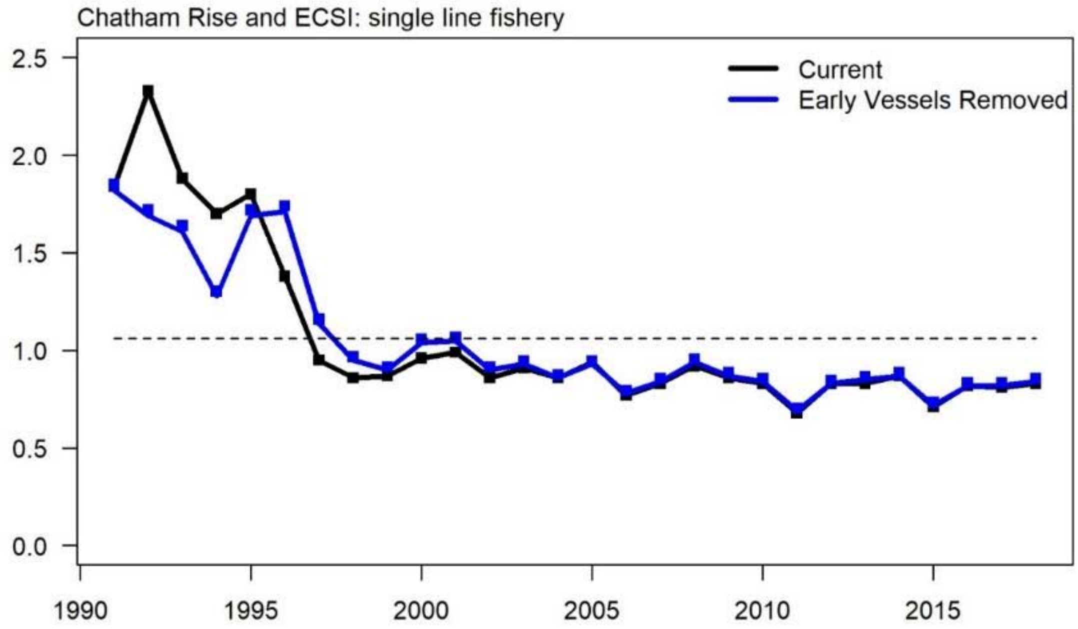
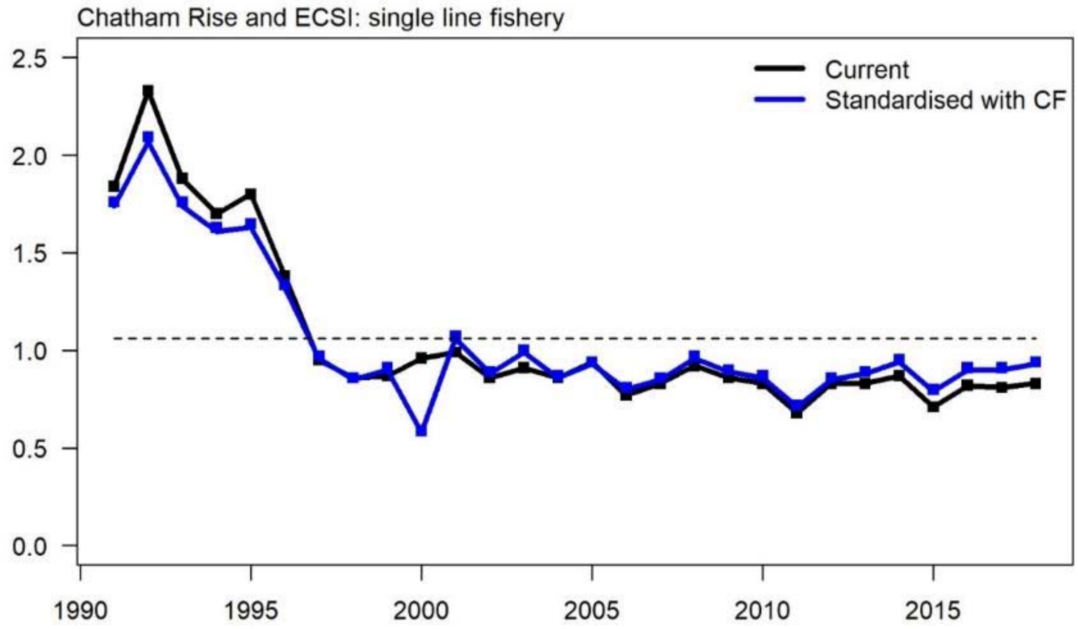


Figure C7a: CPUE indices for the lognormal model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Single line fishery in current analysis compared to the previous CPUE index; Single line fishery – without early vessels, compared to current single line fishery model CPUE.



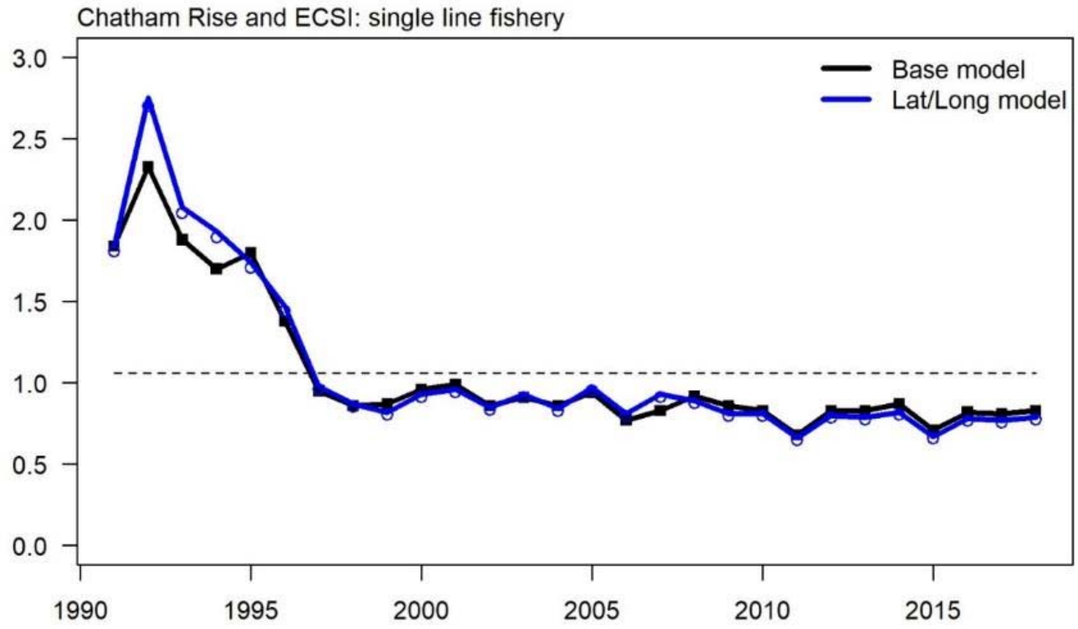


Figure C7b: CPUE indices for the lognormal model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Single line fishery – Conversion factors ; Single line fishery – spatial analysis. Both CPUE indices are compared to current single line fishery model CPUE.

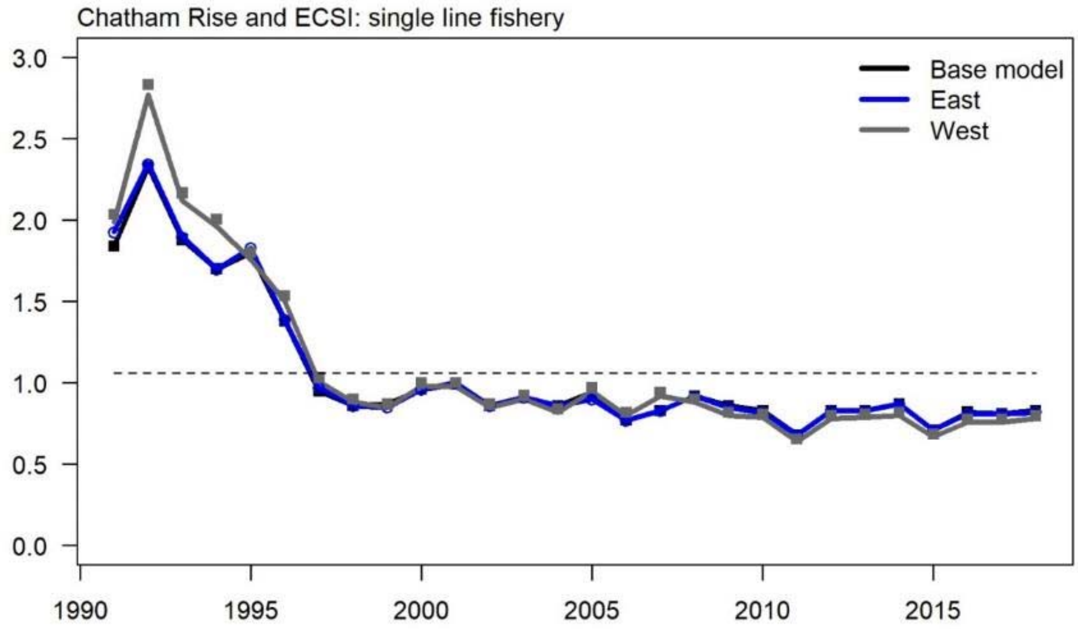


Figure C7c: CPUE indices for the lognormal model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Two line fisheries – West; Two line fisheries – East. Both CPUE indices are compared to current single line fishery model CPUE.

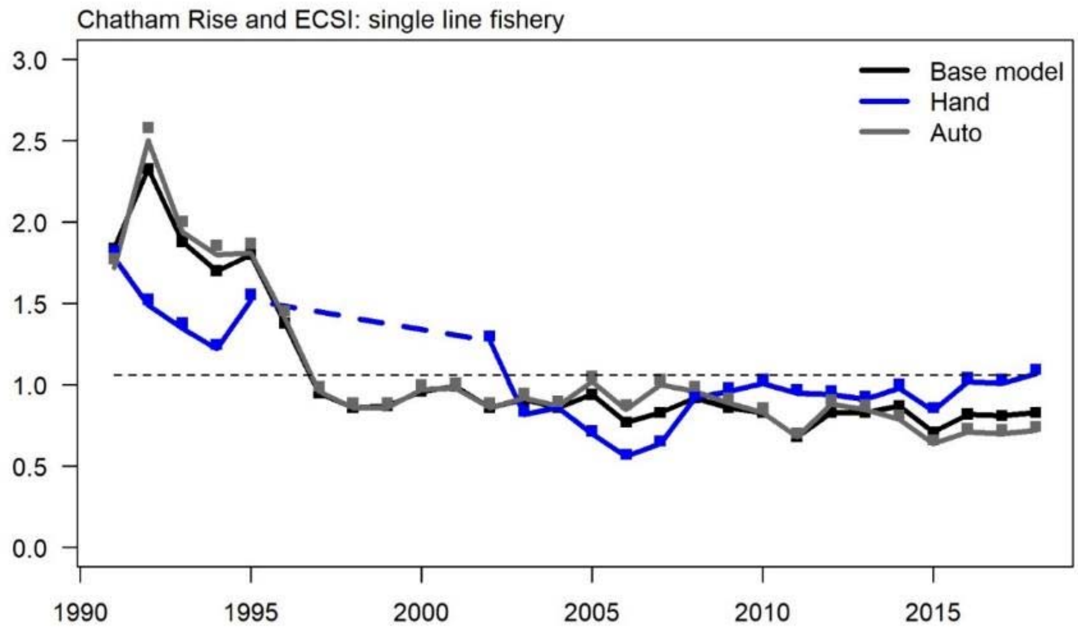


Figure C7d: CPUE indices for the lognormal model for each East SI and Chatham Rise line fishery models. From top to bottom panels: Two line fisheries – Autolongline; Two line fisheries – Handbaiting. Both CPUE indices are compared to current single line fishery model CPUE.

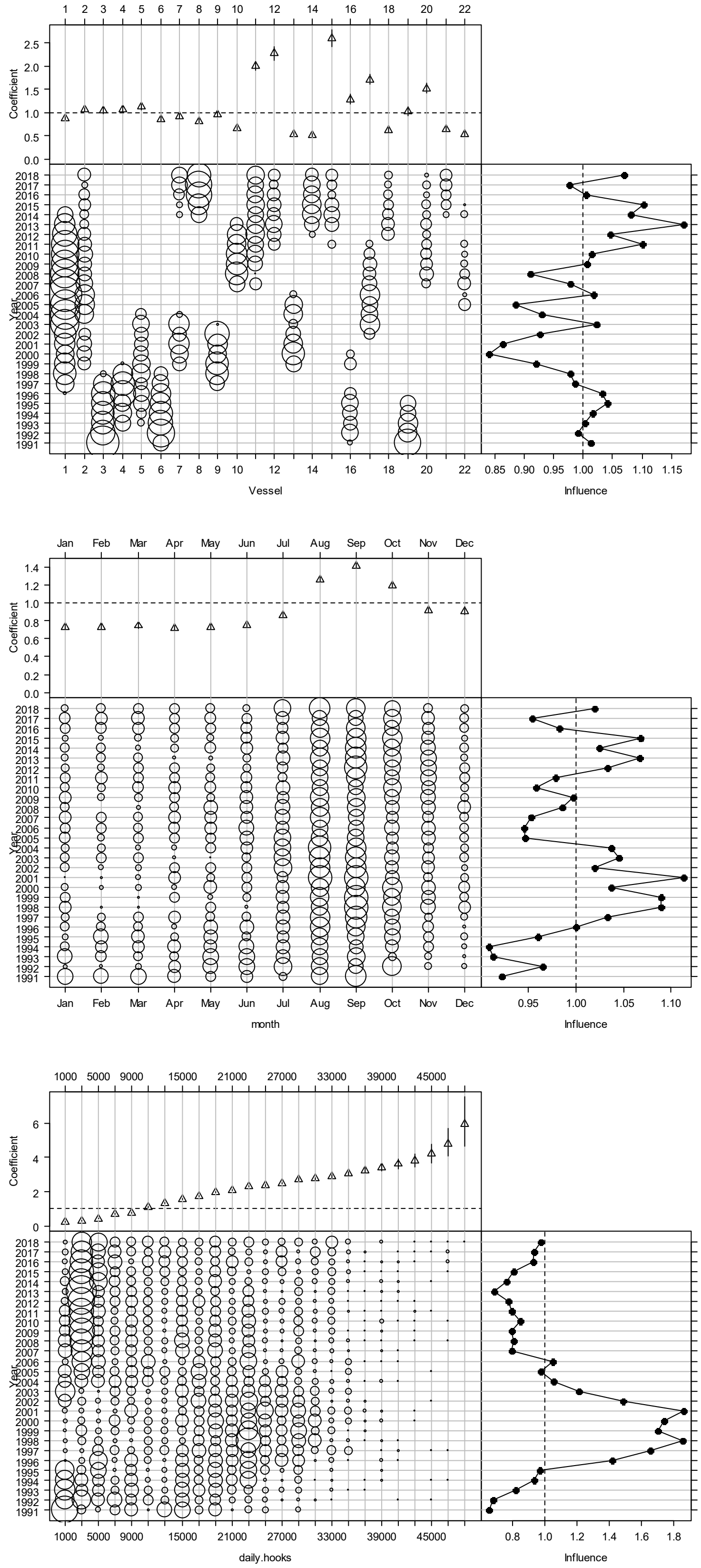


Figure C8a: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal single line fishery model. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

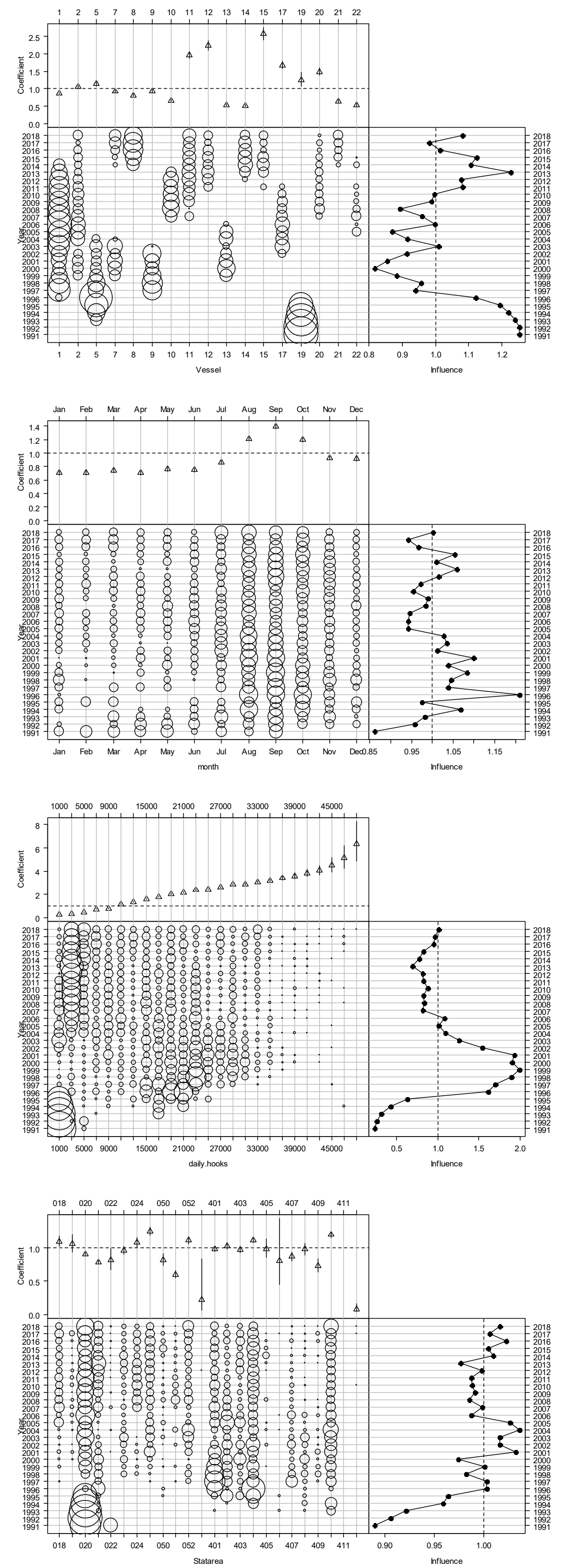


Figure C8b: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal single line fishery model without early vessels. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

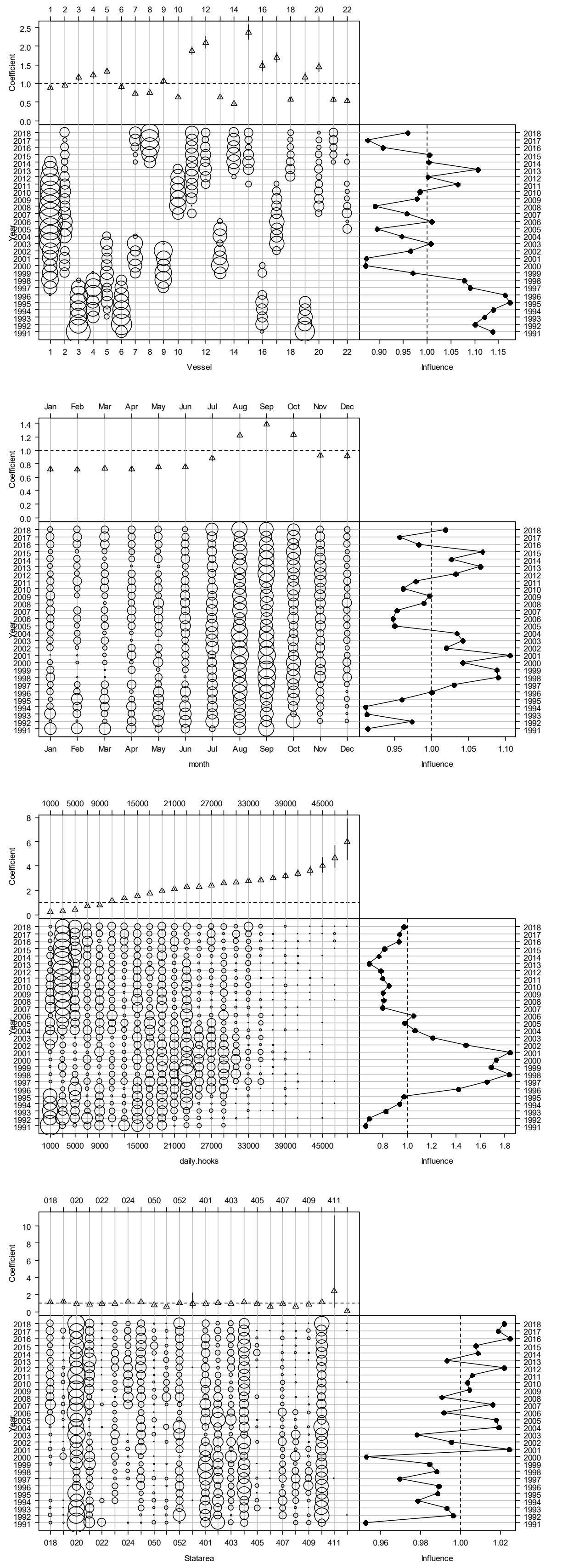


Figure C8c: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal single line fishery model – conversion factors. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

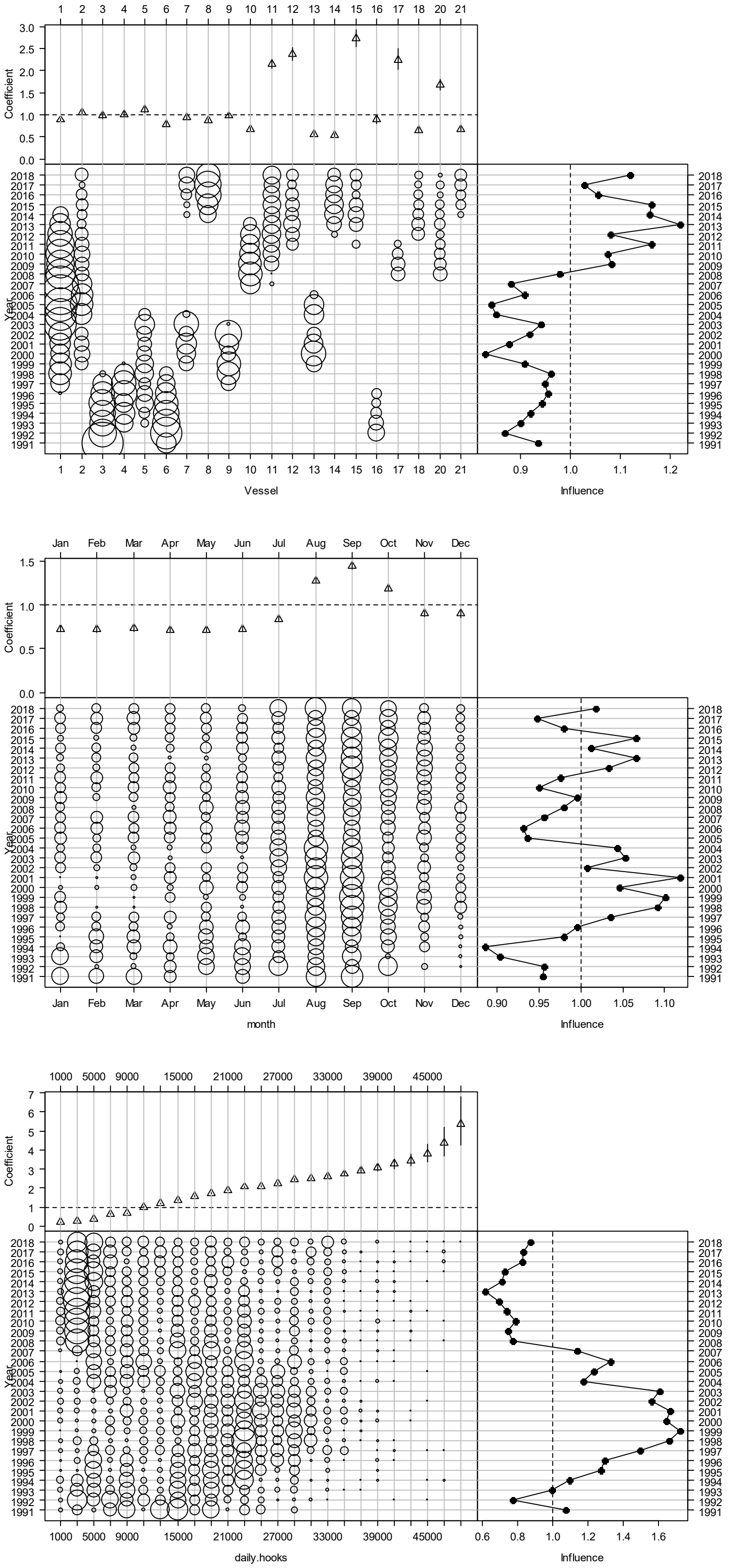


Figure C8d: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal single line fishery model – spatial analysis. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

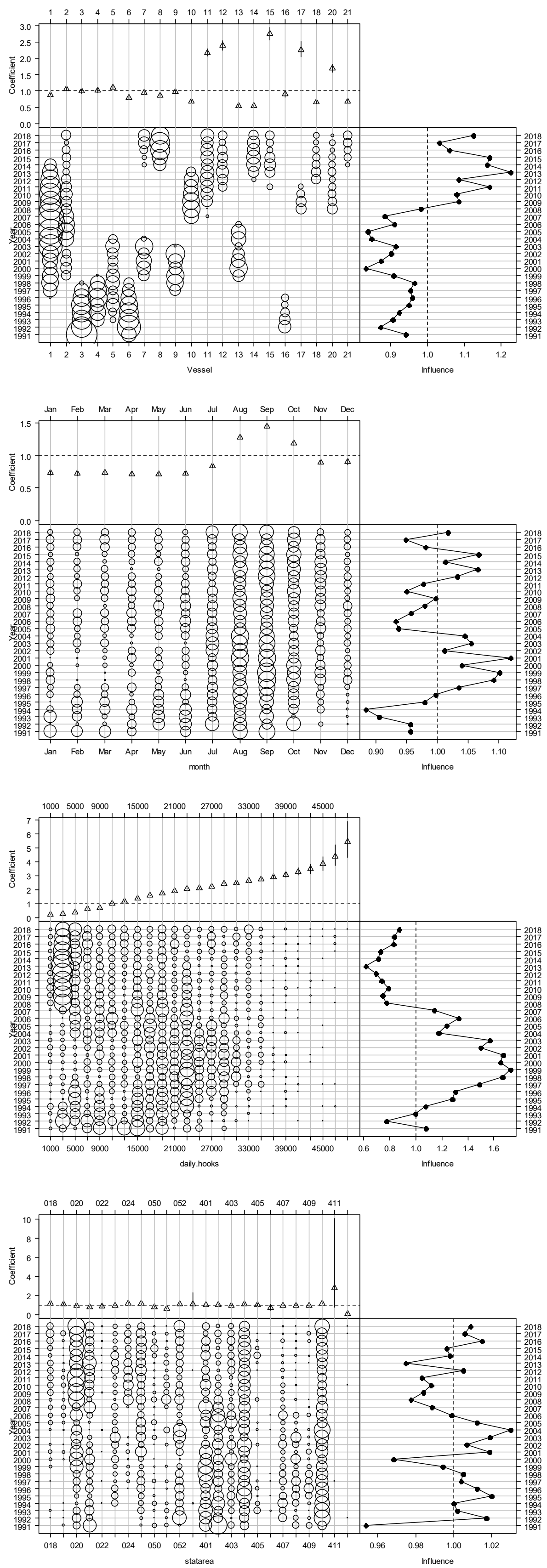


Figure C8e: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal two line fishery model for the western fishery. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

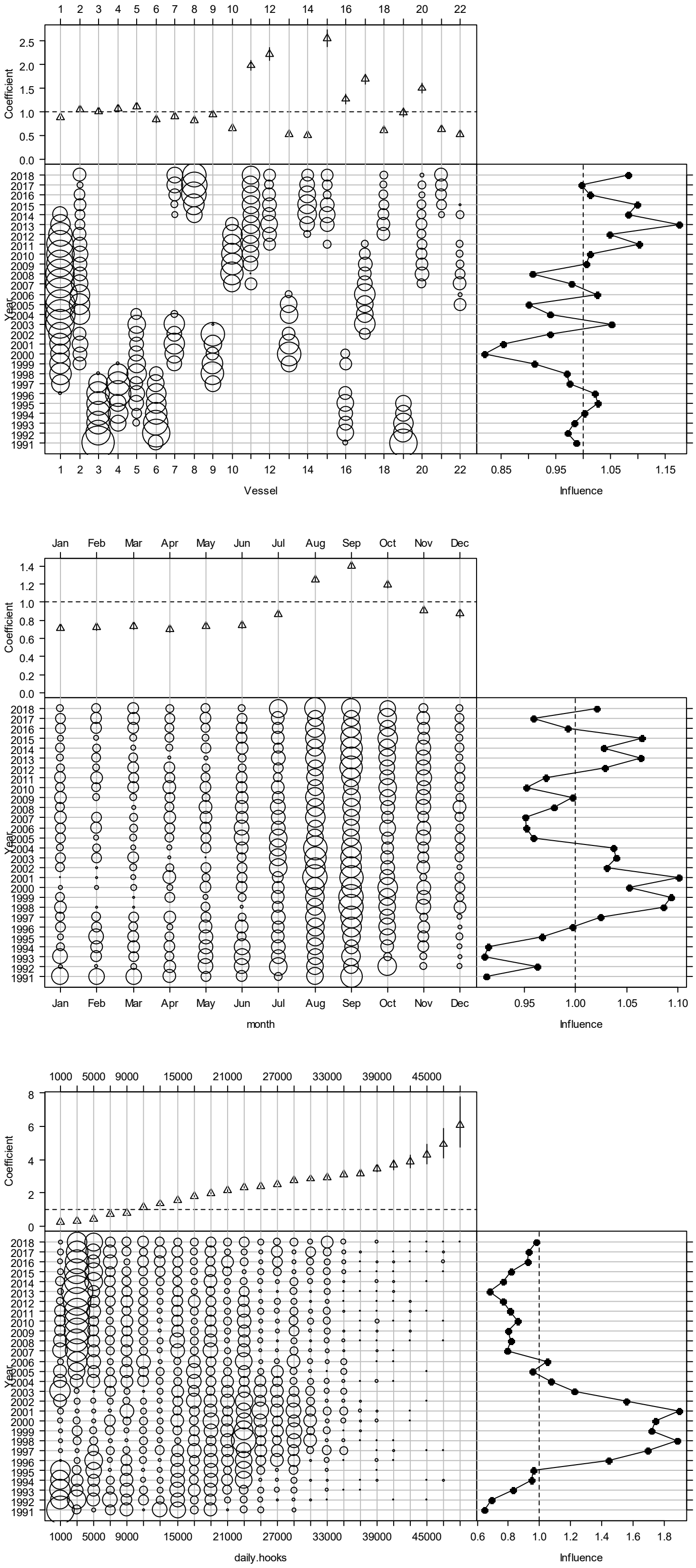


Figure C8f: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal two line fishery model for the eastern fishery. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

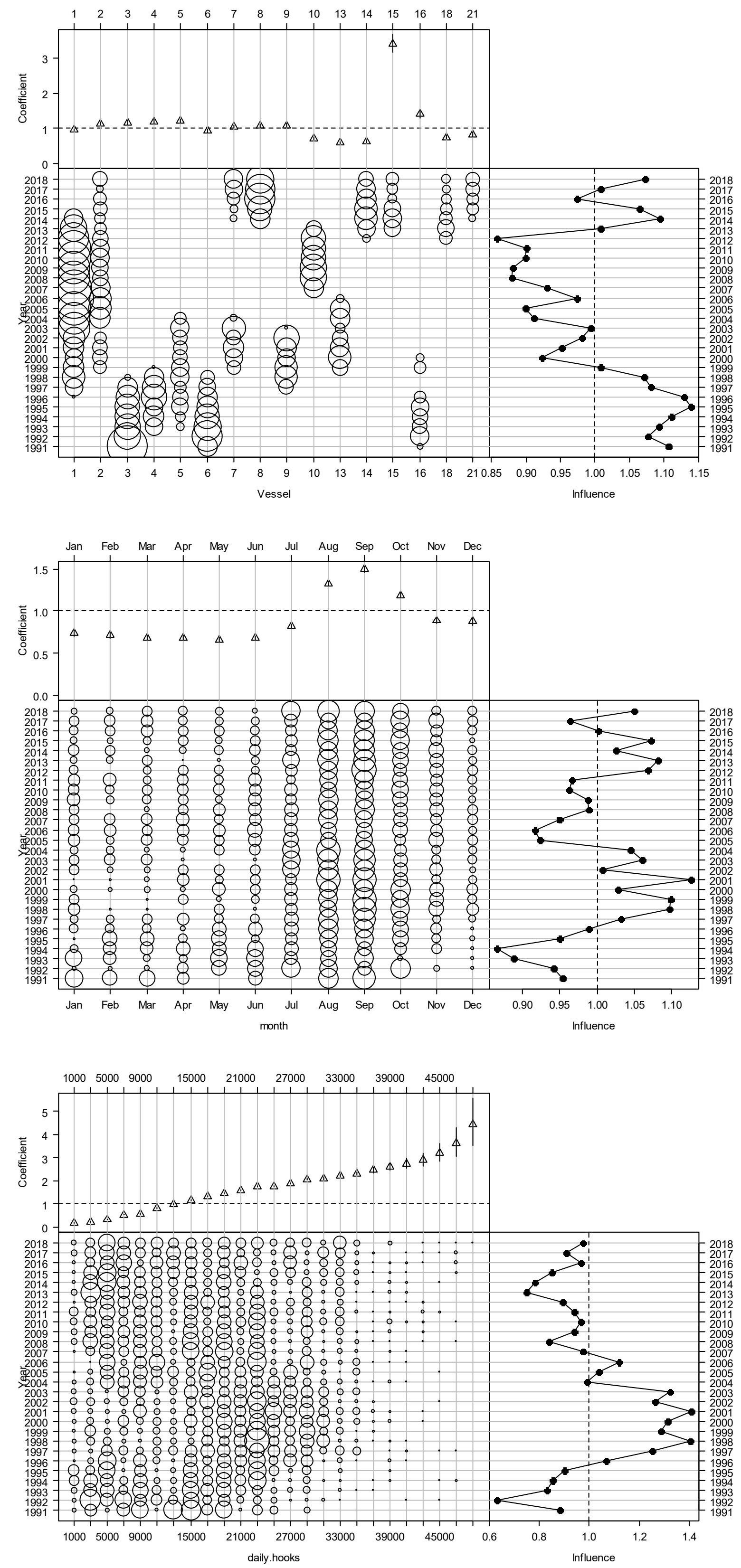


Figure C8g: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal two line fishery model for the autolongline fishery. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

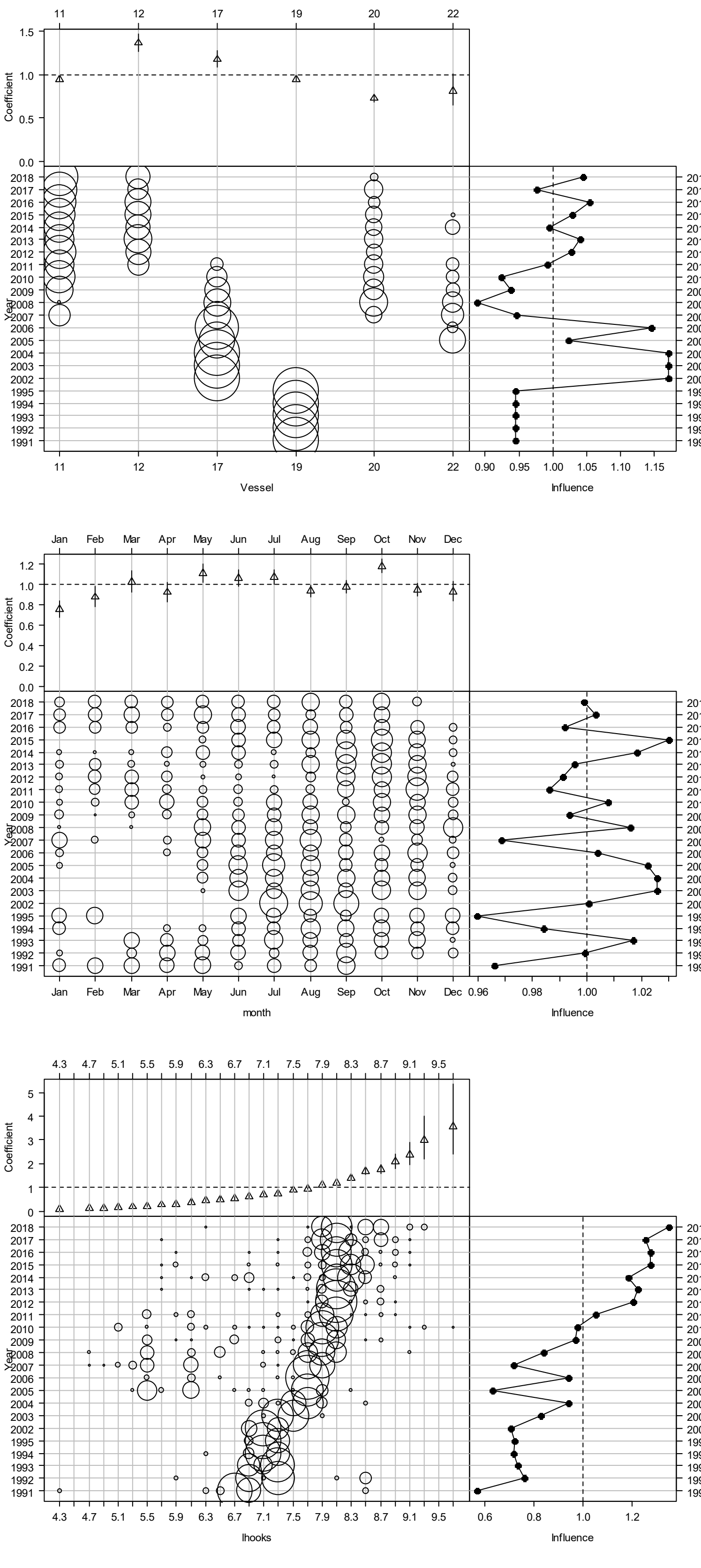


Figure C8h: Effect and influence of non-interaction term variables in the East SI and Chatham Rise lognormal two line fishery model for the handbaiting fishery. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year.

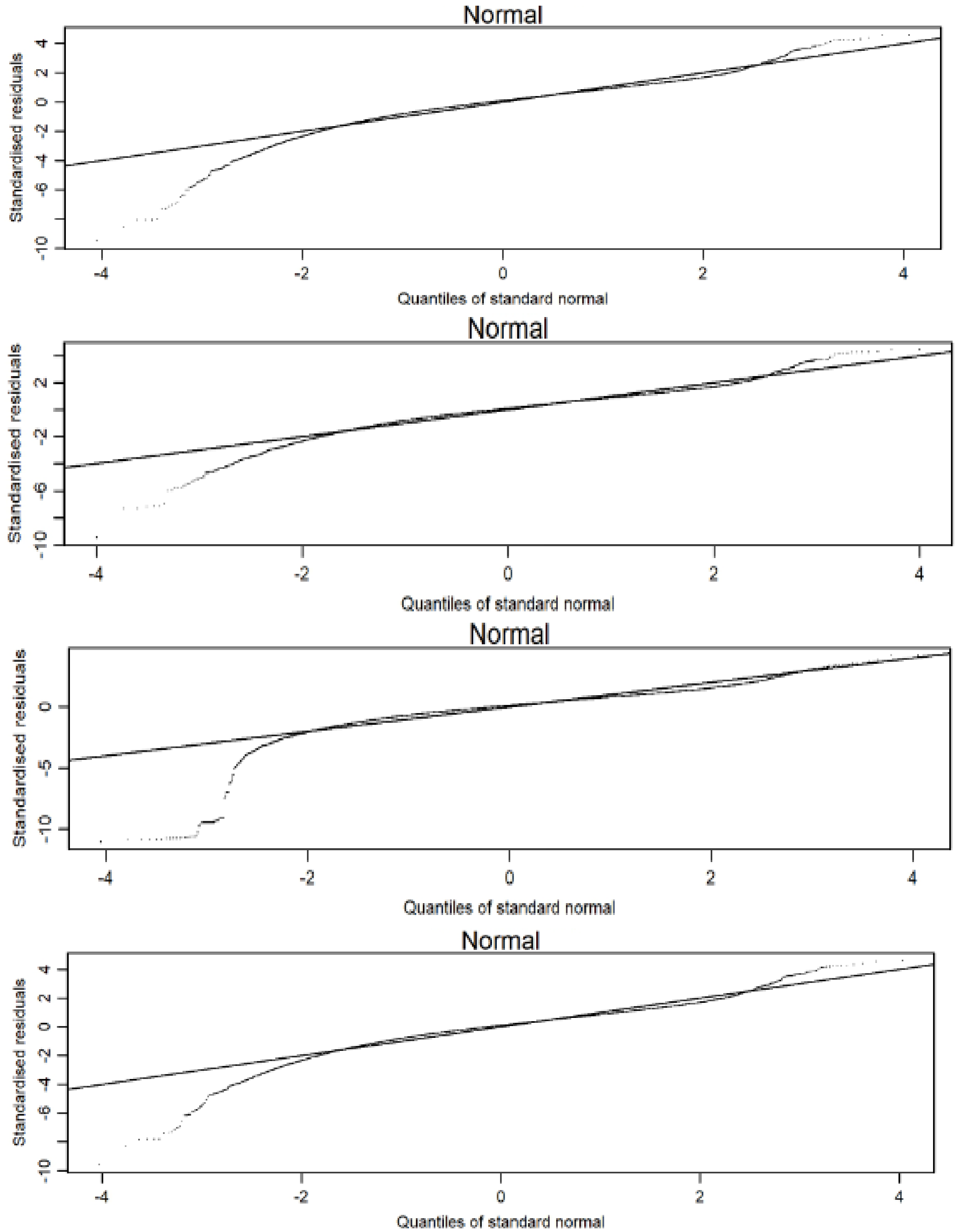


Figure C9a: Diagnostic plots for the East SI and Chatham Rise (LIN 3&4) single and two fishery lognormal CPUE models. Top to bottom panels: Single line fishery; Single line fishery – without early vessels; Single line fishery – Conversion factors; Single line fishery – Spatial analysis.

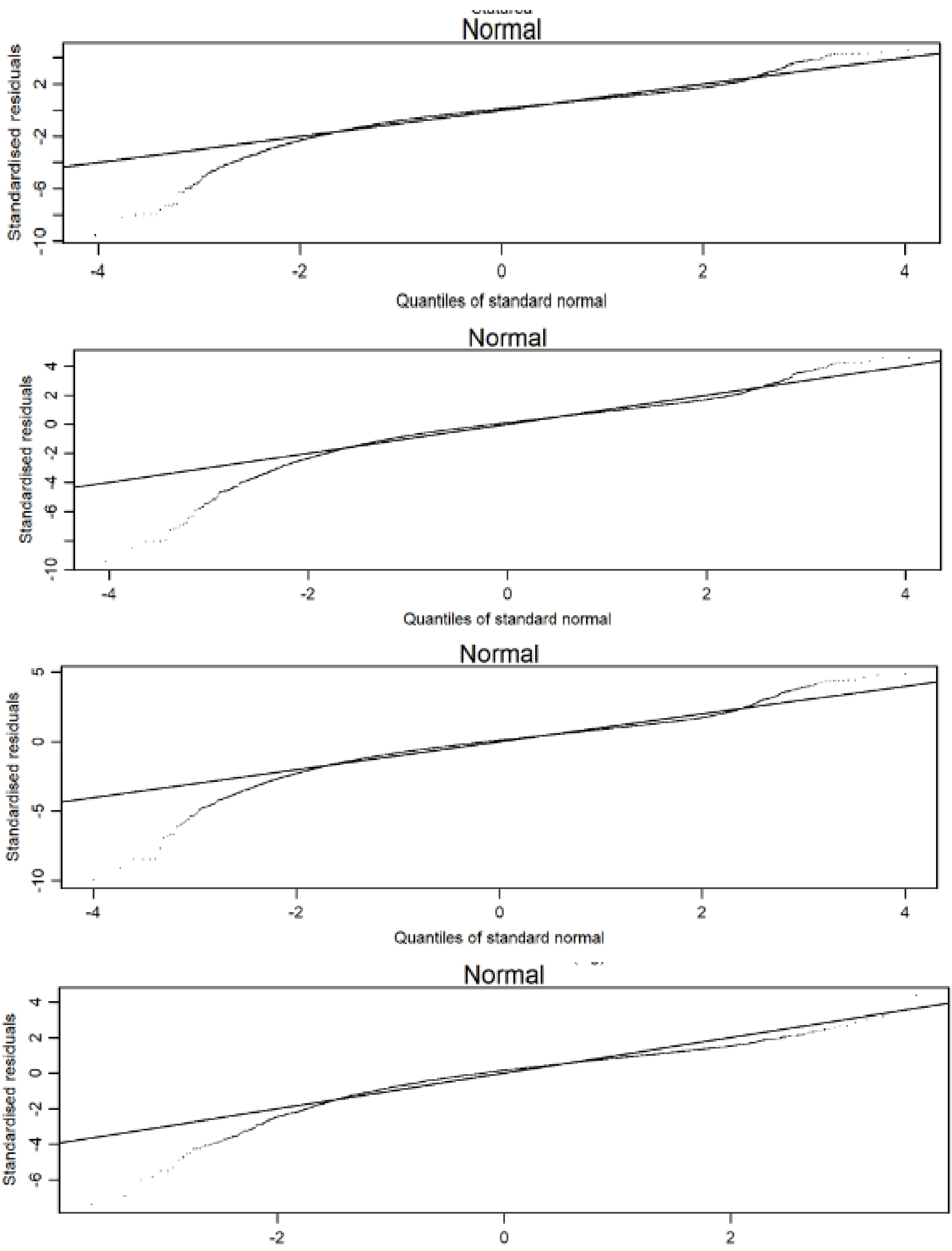


Figure C9b: Diagnostic plots for the East SI and Chatham Rise (LIN 3&4) single and two fishery lognormal CPUE models. Top to bottom panels: Two line fishery – West; Two line fishery – East; Two line fishery – Autolongline; Two line fishery – Handbaiting.