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A descriptive analysis of all ling (*Genypterus blacodes*) fisheries, and CPUE for ling fisheries in LIN 5&6, from 1990 to 2017

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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 2016–17 fishing year. The overall 2016–17 ling catch increased to 15 000 t, compared to levels of around 13 000 t from 2012–13 to 2015–16. However recent catches remain lower than the landings from the 1991–92 to 2007–08 fishing years. The Southland fishery had the largest overall catch of any fishery in 2016–17. The distribution and size of trawl fishery landings showed little change, but catches increased in all areas. Overall trawl landings were higher than those taken in 2015–16, but lower than those taken during the early to mid-2000s. The line fishery catch distribution was quite similar to previous years, although line catches in 2016–17 increased overall, with most of the increase occurring at Bounty, East NI, East SI, and Sub-Antarctic, but with a notable decrease for Chatham. The line fishery catch was markedly lower than in the most productive years (1992–2002), but relatively consistent with the pattern of landings since 2003.

Series of CPUE for commercial line and trawl fisheries targeting ling on the Sub-Antarctic (LIN 5&6, 1991–2017) were updated. Important variables in the autolongline model included *total hooks*, *statistical area*, and *vessel*, and important trawl variables included location and *target species*. Since the early 1990s the standardised indices for line fisheries have varied but show an overall decreasing trend. The line spawning CPUE was marginally higher than the CPUE in the non-spawning area. The overall line fishery trends for all indices are similar to previous analyses, and do not match the bottom trawl CPUE trend or trawl survey indices.

1. INTRODUCTION

This document reports on Specific Objective 1 of Project LIN201701, which has an overall objective "To carry out a stock assessment of ling (*Genypterus blacodes*) in the sub-Antarctic (LIN 5/6) including estimating biomass and stock status". It includes a descriptive analysis of the commercial catch and effort data for ling from LIN 2, 3&4, 5&6, 6B (Bounty Plateau) and 7, and an update of the standardised catch-per-unit-effort (CPUE) analyses from the ling longline fisheries for LIN 5&6 (Sub-Antarctic) with the addition of data up to the end of the 2016–17 fishing year. Specific Objective 1 was "To carry out a descriptive analysis of the commercial catch and effort data for ling (LIN 5&6) in the sub-Antarctic, and update the standardised catch and effort analyses." This objective requires that LIN 5&6 CPUE be updated only for the series used in the most recent previous stock assessments of the Sub-Antarctic 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) and 1989–90 to 2004–05 (Horn 2007b). 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 by Dunn & Ballara (2019) which included data up to the fishing year 2015–16 (fishing years run 1 October – 30 September); i.e., catch by area by method, to indicate whether any marked changes had 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 Sub-Antarctic (LIN 5&6) is also presented here. CPUE analyses of these fisheries were most recently reported by Ballara & Horn (2015). These fisheries, along with the Chatham Rise, 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 11384 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 2016–17. This included all fishing recorded 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 Return (LTCERs); Netting Catch Effort Landing Returns (NCELRs); and included high seas versions of these forms. Catch and effort data for ling from the Fisheries New Zealand Observer Sampling Programme (hosted by NIWA in the *cod* database) were also extracted.

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 tows 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 year to 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).

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 was not based on depth or position, but rather on the form type that the catch was reported on. TCEPR records were classified as deepwater; CELR and TCER records were 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 A2). Data for the Chatham Rise and Sub-Antarctic were grouped by statistical area as follows: Chatham Rise (LIN 3&4): 018–024, 049–052, 301, 401–412, and Sub-Antarctic (LIN 5&6): 025–031, 302, 303, 501–504, 601–606, 610–612, 616–620, 623–625. 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 2016–17, landings from Fishstocks LIN 3, LIN 4 and LIN 6 were significantly under-caught relative to their TACCs, and the LIN 1, 2, 5 and 7 TACCs were slightly over-caught. The estimated catch totals for each year ranged between 85 and 101% 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, Chatham, Southland, Sub-Antarctic, and West SI. This pattern of catches was consistent with ling distributions derived from research trawls (Anderson et al. 1998). There were some changes to the proportions of catch contributed by some areas before and after 2000. Catches from the Sub-Antarctic increased in the latter period (although have been lower from 2008–09 to 2015–16), while those from Chatham declined. By catch weight, the largest overall fishery in 2016–17 was the Southland fishery. Most ling catches since 1989–90 were reported on TCEPR or CELR forms, and were caught by bottom trawling or bottom longlining, mainly when the target species was hoki or hake (Table A3, Figure A3).

Overall, trawl-caught ling were taken mainly by bottom trawlers targeting ling or hoki, although the proportion of ling caught in hoki target tows has decreased since the mid 2000s (Figure A4). Ling are caught all year around, but more commonly between June and January (Figure A4). They are generally caught by mid-sized vessels. Compared to the previous fishing year, the 2016–17 trawl fishery catches in all areas increased (Table A4, 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 A4). 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 1900 t in 2016–17. Southland catches ranged from 1900 to 3300 t, with 3200 t 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. Chatham and East SI catches increased slightly in 2016–17. Total landings from the deepwater midwater trawl fishery have been relatively low since 2006–07, ranging between 125 and 630 t, and decreased slightly to 590 t in 2016–17 (Table A4).

For the inshore bottom trawl fishery, there were low levels of catches (i.e., generally less than 100 t annually) in all areas except for Sub-Antarctic, and Bounty, where catches were negligible or zero (Table A4). There were increased catches in Southland and West SI by inshore trawl from about 2008–09. Catches from the inshore midwater trawl fishery were negligible in all areas except West SI and Cook Strait; catches in 2016–17 in both of those areas were low (Table A4).

The catch from the ling longline fishery is taken mainly by bottom longliners targeting ling; landings occur all year around, but more commonly between June and December (Figure A5). Smaller vessels dominate this fishery. Relative to 2015–16, the line catches in 2016–17 increased overall, with most of the increase taking place in the Bounty, East NI, East SI, and Sub-Antarctic areas, although with a notable decrease for the Chatham area (Table A4, Figure A5). The line fishery catches by area varied markedly between years (Table A4). The Chatham area was still the most productive, but recent catches were only 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 (Table A4). The 2016–17 catches in East SI remained low.

Catches from fish pots were generally recorded only from East SI, where annual landings were generally between 10 and 50 t, until 2015–16 but have since been over 100 t (Table A4). Interestingly, the last two years have also seen increases in catches by this method in North NI, East NI, West SI, and Cook Strait.

Total catches from the EEZ increased to 15 000 t, compared to levels of around 13 000 t from 2012–13 to 2015–16. Catches from 2008–09 to 2015–16 were all below those from the historically high catch period of 1991–92 to 2007–08 (Table A4).

2.1.1 East SI and Chatham (LIN 3&4) catch data

On the Chatham Rise (LIN 3&4), ling trawl catch was taken mainly by bottom trawlers targeting hoki (Table B1, Figure B1). The proportion of ling caught in hake target tows has decreased since 2009 (Figure B1). In general, most catch was taken between September and June, often with a peak from September to November (Table B2, Figure B1). Most of the trawl catch was spread out across ECSI (Statistical Areas 021–023) and the Chatham Rise (Statistical Areas 401–404, and 407–410) (Figures B1–B3). More than 98% of the Chatham Rise trawl catch is reported on the TCEPR form, and 95% taken by bottom trawling (Figure B1). The trawl catch since 2010 has been lower than 1200 t; 752 t in 2014 was the lowest of all years since 1990, and in 2016–17 at 1171 t the catch was still relatively low (Table B2). Mean duration, distance, speed, and depth per tow have remained relatively unchanged (Figure B4), although mean hoki catch per tow has increased since 2004. Overall catches and number of tows by year were higher for larger vessels, although overall tow duration by year was sometimes higher for smaller inshore vessels in recent years (Table B3).

Chatham Rise (LIN 3&4) line fisheries caught ling throughout the year, but most catch is taken from July to November (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). Over 99% of the catch was taken by the bottom longline method, and 99% of the catch was from lines targeting ling (Figure B5), and by larger vessels using fewer than 5000 hooks/day (Table B3, Figure B8).

2.1.3 Southland and Sub-Antarctic (LIN 5&6) catch data

In Southland and the Sub-Antarctic (LIN 5&6), ling trawl catch was taken mainly by bottom trawlers targeting hoki or ling (Table C1, Figure C1). In general, catch was taken all year around, although higher catches were taken between September and December (Table C2, Figure C1). Most of the trawl catch was caught in Statistical Areas 027, 028, 030, 602 and 603 (Figures C1–C3). In general, trawl-caught ling were taken mainly along the edge of the Stewart-Snares shelf, in the Norwegian Hole, at Puysegur Bank, and, in smaller amounts, on the northern Campbell Plateau, and southern Auckland Islands shelf. More than 98% of the trawl ling catch in the Sub-Antarctic is reported on the TCEPR form, 96% taken by bottom trawling, and 50% of catch by target ling trawling (Figure C1). For vessels targeting hoki, hake or ling, bottom tows showed a decrease in mean distance, speed, and depth of net and bottom since 2002 (Figure C4), which can be attributed in part to the increased bottom trawl catches by smaller Korean vessels. Mean duration increased marginally. Overall catches, number of tows, and duration by year were higher for vessels larger than 28 m (Table C3).

Sub-Antarctic (LIN 5&6) line fisheries caught ling throughout the year, although very little catch is taken in July–August and December–January (Table C2, Figure C5). Most of the line catch is taken in Statistical Areas 030, 602–605, 610–611, 618, and 619 (Figures C5, C6, and C7). Most Puysegur (Statistical Area 030) catch was taken from October to December, and most non-Puysegur catch from December to July (Figure C5b). Over 99% of the catch was taken by the bottom longline method targeting ling (Figure C5), and by vessels greater than 28 m using fewer than 5000 hooks per day (Table C3, Figure C8).

2.1.4 West SI (LIN 7 WC) catch data

The LIN 7 WC trawl catch was mainly bycatch in the much larger hoki target fishery, although the ling caught in hake or ling target tows increased from 2005 (Table D1, Figure D1). In general, most catch was taken between May and October, often with a peak from June to September (Table D2, Figure D1). Most of the trawl catch was taken in Statistical Areas 033–036, in the North shallow and Deep subareas (Figures D1–D3).

About 84% of the trawl catch was recorded on TCEPR forms, and 58% of the catch taken by bottom trawling, although with only 5% of ling trawl catch targeted (Figure D1). Mean duration, distance, speed, and depth per tow decreased after about 2003–04 (Figure D4), which can be attributed in part to the increased bottom trawl catches since 2002 by smaller Korean vessels targeting hake, and changes in midwater and bottom trawl vessels. Overall catches by year were higher for larger vessels, although overall number of tows and tow duration by year were higher for smaller inshore vessels less than 28 m in length (Table D3).

LIN 7 WC line fisheries caught ling throughout the year, but most catch was taken from July to November (Table D2, Figure D5). Over 98% of the catch was taken by the bottom longline method, with 96% of the line catch targeted (Figure D5). Most of the line catch was taken in Statistical Areas 032–034 (Figures D5, D6, and D7), and by smaller inshore vessels less than 28 m using fewer than 5000 hooks per day (Table D3, Figure D8).

2.1.4 Descriptive analysis summary

The overall 2016–17 ling catch increased to 15 000 t, compared to levels of around 13 000 t from 2012–13 to 2015–16. However recent catches remained lower than landings from the 1991–92 to 2007–08 fishing years. The Southland fishery had the largest overall catches of any fishery in 2016–17. The distribution of trawl fishery landings showed little change, but catches increased in all areas. Overall trawl landings were higher than those taken in 2015–16, but lower than those taken during the early to mid-2000s.

The line fishery catch distribution was also quite similar to previous years, although line catches in 2016–17 increased overall, with most of the increase taking place in the Bounty, East NI, East SI, and Sub-Antarctic areas, but with a notable decrease for Chatham. The line fishery catch was markedly lower than in the most productive years (1992–2002), but relatively consistent with the pattern of landings since 2003.

3. CPUE ANALYSIS

3.1 Methods

CPUE variables

Variables used in the CPUE analysis are described in Tables E1 and F1 and are generally similar to those used in previous analyses (e.g., Dunn & Ballara 2019). CPUE indices were calculated using catch per tow (in kilograms) for TCEPR tow-by-tow data, with tow *duration* offered as an explanatory variable. Longline CPUE was defined as 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.

In previous analyses, data were analysed by calendar year rather than fishing year, because of a seasonal trend of higher catch rates in most ling fisheries running across the fishing year (1 October to 30 September) boundary, from about June to December (see Horn 2007a). This created a problem for stock assessment models, where the year definition for CPUE was different. The catch history used in the LIN 5&6 model is calculated using a September to August year, so that the September trawl catch is included with the similarly high catches immediately after it in October to December, rather than 'on its own' at the end of an October to September year (Masi 2019). Also, the trawl catch-at-age samples are taken from a 5-month period of September to January. Therefore for the current analysis CPUE year was aligned with the model year and shifted to be analysed using a September to August year. The Puysegur line fishery is almost exclusively October to December, and the non-Puysegur line fishery is mainly December to July (see Figure C5b). The trawl fishery occurs all year around, although most heavily in September to December, and least in March to May (see Figure C1). Observer data on female gonad stage clearly show that spawning in both the Puysegur, and Southland and Sub-Antarctic areas is at a peak around September to November (Table F2, Figure F1). Therefore the definitions 'spawning' and 'non-spawning' fisheries were changed to September to December, and January to August respectively. The previous analysis (Ballara & Horn 2015) used the 'spawning' fishery as Puysegur only September to December, and the 'non-spawning' fishery as Southland and Sub-Antarctic January to December and Puysegur January to August.

Hence, *year* was a categorical variable and was defined as a September to August 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 tows or vessel-days in a year (criteria varied by gear, see below). 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.

For line data, *total hooks* per day and *number of sets* per day were offered as an untransformed number and as log-transformed data. For trawl data, *gear width* was not used as an explanatory variable as this

field in the TCEPR form variously contained *wingspread* and *doorspread* measurements, and hence, *headline height* was the only trawl gear dimension variable offered to the model. *Grid number*, defined as the 0.5° latitude/longitude square where the catch was taken (V. McGregor, NIWA, pers. comm.) was included all trawl models.

CPUE data selection

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. As a result of this correction, there were 25 vessel-day-statistical area aggregate records removed from the dataset.

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 catchrates 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 cutoff 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 potentially previously converted from handbait to autolongline. Hence there were three types of autolongliners identified: "always autolongline" (vessel has always been an autolongliner); "autolongline now" (currently an autolongline vessel, but no information as to whether it converted from handbait to autolongline in the past); and "handbait" (handbait longliner). Overall the "always autolongline" vessels accounted for 89.5% of the catch, 82% of vessel-days, but only 24% of longline vessels, while the "handbait" category made up 56% of longline vessels (Table E2).

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 E3 and F3). Core vessel analyses were run for trawl fisheries using TCEPR tow-by-tow data, and for line fisheries using vessel-day data.

For line fishery analyses, data were accepted from the CELR and LTCER forms for target ling and line method BLL (bottom longline) for calendar years 1991–2017 for vessels that had always been an autolongline vessel, and for statistical areas with at least 50 vessel-day-statistical area combined sets (Table E3). 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. There were 73 records having zero ling catch, making up 0.9% of the records.

Data for bottom trawling were accepted for the September to August years 1991–2017, for target fisheries hoki, hake and ling, and statistical areas with at least 100 tows (Table F3). Records were

excluded if catch weight was greater than 50 t (assumed to be an error), bottom depths were not within 150–1000 m (known depth range of ling), and duration of trawling was not within 0.2–15 hours (assumed to be an error).

The data were also analysed as two fisheries within the Southland and Sub-Antarctic stock using all the data records that were accepted into the 'whole stock' analysis. The two fisheries were: "spawning" as September to December, and non-spawning as January to August.

The CPUE model

Annual unstandardised (raw) CPUE indices were calculated as the mean of the individual daily catch (kg) for a longline or as catch per tow (kg) for TCEPR tow-by-tow data. All series used the lognormal distribution for the positive catch model. For the trawl series, a binomial model based on the presence/absence of ling in each data set was also calculated, with the two models combined using the delta-lognormal method to provide the final series (Vignaux 1994). 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 and were presented in canonical form (Francis 1999). Variables were either categorical or continuous. Potential continuous variables were modelled as third-order polynomials, although a fourth-order polynomial was also offered for duration (see Tables E1 and F1). *Vessel* was incorporated into the CPUE standardisation to allow for differences in fishing ability between vessels. *Grid number* was also incorporated to allow for differences in fishing area in trawl models (Table F1). Model runs with *grid number* included all cells, top cell (cell with the highest overall catch), the top 5 cells (cells with the highest catches), and complement of the top cells (all cells not in top cells model run) (Figure F2). 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), although a *year:fishery* interaction was used in the Sub-Antarctic model (see below) .

Model fits to the lognormal component of the combined 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). For the binomial component, model fits were investigated visually using randomised quantile residuals (Dunn & Smyth 1996). Randomised quantile residuals are based on the idea of inverting the estimated distribution function for each observation to obtain exactly standard normal residuals. For discrete distributions, such as the binomial, some randomisation was introduced to produce continuous 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, or catch per tow (kg) for tow-by-tow 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 tows (trawl) or vessel-days (line) per vessel-year (Tables E3 and F3). As there were only ten "always autolongline" vessels, nine of these vessels which had fished in at least two years were chosen, making up 89% of the Sub-Antarctic longline catch.

The primary Southland and Sub-Antarctic line fishery analysis used data from 1992–2017, and the trawl fishery analysis used data from 1991–2017. Core vessel analyses were run both as a single fishery and as separate spawning and non-spawning fisheries, although there were no data for 2008 and 2013 for the non-spawning line fishery. For the CPUE series estimated for separate fisheries within the Southland and Sub-Antarctic stock, a *year:fishery* interaction effect was forced into the model. This produced a CPUE series for each of the two fisheries within the stock, but with all other expected variable effects being the same over the fisheries. The autolongline fishery indices were compared to the previous results (all longline vessels using calendar year) from Ballara & Horn (2015), and single fishery and two fishery results were compared for the spawning and non-spawning data. Autolongline and trawl CPUE indices were also compared with each other, and to Southland and Sub-Antarctic *Tangaroa* trawl survey biomass indices.

3.2 CPUE results

CPUE series for line and trawl-caught ling for Southland and the Sub-Antarctic (LIN 5&6) are presented here, with tables and figures in Appendix E (line results) and Appendix F (tow-by-tow results).

3.2.1 Longline fishery

Sub-Antarctic 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 analysis (Table E3, see Figure C5). Statistical areas that had few days fished (i.e., less than 50) throughout the 26 years (overall 1.6% of vessel-days) were probably attributable to reporting errors or exploratory fishing, so were removed from the final analysis. Further Southland and Sub-Antarctic data constraints included vessels that had always been autolongliners (see section 2.2), 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 two years (Figure E1). The core analysis included 6307 records of days fished throughout the 26 years analysed (2430 from the spawning fishery, and 3877 from the non-spawning fishery).The spawning fishery had 14–193 days fished in each year; the non-spawning fishery had 7–451 days per year. Spawning data were more abundant through the first part of the series, with the non-spawning data more abundant in later years. From 1993 to 2002 when the auto-longline fishery was at its peak, line fishing accounted for about 17–37% of the LIN 5&6 landings (excluding the Bounty Plateau) (see Tables A4

and C2). The percentage of line catch was lower from 2003 to 2009 (8–14% of the landings), but was again relatively high (21%) in 2012, and has fluctuated between 5% and 17% since then (Tables A4 and C2). The estimated catch from this CPUE data set was 89.5% of the total estimated catch by line fishing in this area (Table E3). The core analysis included data from nine vessels; six of these had fished in six or more years of the series, and one had fished in 19 years (Figure E1).

For line single fishery CPUE, four variables were selected for the lognormal model, resulting in a total r^2 of 61%, with *log(total hooks)* explaining 54% of the residual deviance (Table E4). The variables selected into the two-fishery model were similar to the single fishery model, although vessel did not enter that model. In the two-fishery model, *log(total hooks)* explained most of the variance (60%), and with *vessel* included, 62% of total variance was explained.

The standardised year effects for the single and two fisheries models show variable series with a slightly declining trend (Table E5, Figure E2). The trends in the standardised indices do not closely follow the trends in the unstandardised indices. The variable of number of hooks has the largest impact on the standarised indices (Figure E3). There were similar trends between the three series although the indices in the spawning fishery were generally higher than those in the single fishery, and the non-spawning fishery was generally the lowest (Figure E4). In the spawning series, the high 2010 index and the low 2011 index are based on low numbers of days fishing. There were very wide confidence bounds in 2010 but small confidence bounds in 2011. The trends in the indices changed somewhat from previous analyses (Figure E4b), however this is to be expected due to the changed year definition, vessel definition, vessel selection, and spawning definition, with the apparent 1-year lag seen in the spawning fishery due to the changed year definition. The trends in the CPUE indices also had a poor match to the trend shown by the trawl survey biomass indices (Figure E4c).

Influence plots (Figure E5) showed that total hooks per day had a positive influence from 1998 (except for 2004) when there was less effort with lower total hook numbers; higher catch rates are expected with higher total hook numbers. The vessel influence on CPUE was negative in most years from 1999, although was positive in 2005–2006, and in 2015. For vessel, changes are related to the movement of vessels out of the fishery, and to differing levels of effort by individual vessels. Most vessels had similar expected catch rates, which is not surprising since they are all autolongliners. For statistical area the highest expected catch rates occurred in Statistical Area 030, but rates varied by a factor of less than 2 over all areas. There was a large positive influence in 2007, 2008, and 2013 when the effort in Statistical Area 030 was the higher. 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 E6).

3.2.2 Bottom trawl fishery

TCEPR tow-by-tow commercial data from vessels targeting hoki, hake or ling were analysed to produce a CPUE series, using the combined model. Overall a total of 122 unique vessels caught 130 813 t from 91 568 tows, and from these, 36 core vessels were selected (range 5–26 per year). and the core vessels caught an estimated 111 561 t of ling from 73 533 tows (Table F4, Figures F3). The spawning fishery included 32 101 core tows with 218–2337 tows each year; the non-spawning fishery included 41 432 tows with 508–4726 tows per year. The least active core vessel had participated in the fishery for only 5 years, but there were 28 vessels in the fishery for 8 or more years (with the maximum being 21 years). The proportion of zero catch tows (i.e., tows where either hoki, hake, or ling was targeted, but no ling was caught) for core vessels ranged between 0.05 and 0.36 per year, and showed an decreasing trend for both core and all vessels, although the trend flattened off from 2002 (0.05–0.12%) (Table F4). Overall, 10 372 (14.1%) tows reported no ling catch.

Seven variables were selected into the lognormal model, resulting in a total r^2 of 55%, with *grid number* explaining 35% of the residual deviance; for the binomial model, *grid number* explained 15.2% of the variance, with the final model explaining 22% (Table F5). The variables selected into the two-fishery lognormal and binomial models were similar to those for the single fishery model.The standardised year effects from the single, spawning and non-spawning fishery lognormal models showed a flat undulating trend (Table F5, Figure F4). Unstandardised indices for the lognormal models did not follow the same

trend as the standardised indices; they were generally lower in earlier and later years and higher in middle years, with the differences attributable mainly to the influence of the variables *grid number* and *vessel* (Figure F5). The binomial series showed a flat trend, so the combined indices are similar to the lognormal model (Figure F6). A lognormal model run using data from daytime hours in November–December on the Snares Shelf showed similar trends, as did lognormal analyses using top cell, top cells or complement of top cells, although much higher values were seen for earlier years for top cell. None of the trawl CPUE series matched the line CPUE series for any of the fisheries, or the trawl survey biomass series (Figure F7).

Influence plots (Figure F8) show that fleet dynamics and behaviour have changed: most variables had a negative effect in early years. *Grid number* had a large positive influence on CPUE from from 2004. Expected catch varied between *grid number*; it was highest around the Norwegian Hole and along the Snares Shelf (Statistical Areas 028, 030, 602, and 603) with the influence of *Statistical areas* on CPUE more positive in the north, and from September to December (see Figure C1 and F2). *Vessel* had a negative trend in influence until 1999, a positive trend from 1999 to 2011, and then little influence subsequently, suggesting a change in fleet dynamics. Vessels with more overall catch tended to have higher expected catches and lower variability. Influence of *target species* showed that there is a positive influence on CPUE when ling are targeted (as would be expected), and a negative influence when hoki are targeted, especially from 2006 to 2008. The probability of a zero ling catch varied markedly with *grid number* and *vessel*, and was higher for tows that were outside the 400–800 m depth range, and for tows targeting hoki or ling (Figure F9). *Duration* has a relatively weak effect on the probability of a zero ling catch, unless the tow was very short or long. The diagnostics for both lognormal and binomial models were considered acceptable, with substantial deviation from model assumptions only occurring outside two standard deviations (Figure F10).

3.2.3 CPUE summary

In recent assessments of ling stocks around the South Island, 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 test in conjunction with indices from trawl survey series.

The Southland and Sub-Antarctic line CPUE series were variable with a declining trend for the single, spawning, and non-spawning fisheries. 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, *total hooks* or *log(total hooks)* and *statistical area* were selected into the model. *Vessel* was accepted into the single fishery 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. Clearly, catch rates vary throughout the year, probably in relation to the spawning season for ling, although no time of year variables entered the model.

One clearly apparent change in recent line fishing seasons is the reduction in effort on the Campbell Plateau, and in particular for the spawning fishery since 2008. This reduction is attributable in part to the diversion of autoline vessels to the Ross Sea toothfish fishery, but also to the permanent removal from the New Zealand fleet of some large line vessels, and to a recent reduction in overseas demand for New Zealand ling (Ballara & Horn 2015).

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 autolongline analysis further standardises the longline dataset by excluding handbait vessels with higher catch rates and more efficient hook types and baiting practices. Most longline vessels, however, were able to be identified as exclusively autolongline or handbait vessels, but due to lack of information there were a set of vessels that were current autolongliners but it was not clear whether they had previously converted from handbait to autolongline. Classification of these vessels into years when they fished as either handbait or as autolongline vessels would expand the dataset.

A combined TCEPR tow-by-tow model using QMS data from the Southland and Sub-Antarctic hoki, hake and ling target trawl fishery was updated. The r^2 values for the CPUE models were relatively high (55%), and the retained variables exhibited many similarities between models, with most of the explanatory power from the first two or three variables. Locational variable *grid number* and *target species* were the most important variables in all analyses. There is a large volume of data used in the analysis, and all the tow-by-tow estimated catch CPUE series exhibit no trend. Unstandardised indices in all three datasets did not follow the same trend as the standardised indices; they were generally lower in earlier years and higher in later years, and the differences can be attributed mainly to the influence of the variables *grid number* and *target species*. The trends in the combined and lognormal indices were similar, implying that little was gained by adding data from zero catches into that analysis. There was no agreement between the Southland and Sub-Antarctic trawl survey biomass series and the CPUE series, although the biomass trend appeared closer to the single fishery model. CPUE series from both the trawl and line fisheries are available, and there are some differences in the trends from the two fishing methods. However, indices from a different data source in an individual stock would not necessarily be expected to exhibit similar trends, owing to different fishing selectivities in the different fisheries. There is no way of establishing whether this analysis is likely to produce a reliable index series.

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 behaviour 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 autolongline analysis rolls up data to vessel-day-statistical area, and for LCER and LTCER only uses data if ling is in the top five species (see Section 3.1). Since 2004, individual set data have been captured on LCER and LTCER forms (see Figure C5). 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 both line and trawl 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. The diagnostics for the trawl binomial models were good and the quantile-quantile plots indicated very little deviation from the normal distribution of the residuals at both the lower and upper ends, i.e., very small and very large catch rates were well modelled.

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6. APPENDIX A: DESCRIPTIVE OVERALL

Table A1: Definitions of geographical areas used in the fisheries 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 & 7	LIN 7CK

Table A2: 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 2016–17. 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 catch											
Year	**LIN1**	**LIN2**	**LIN3**	**LIN4**	**LIN5**	**LIN6**	**LIN6B**	**LIN7WC**	**LIN7CK**	**Total**	**MHR**	**% of MHR**
1989–90	83	268	1 221	512	2 116	1 216	12	2 323	414	8 167	9 026	90.5
1990–91	139	437	1 935	2 156	2 093	2 683	33	1 947	527	11 950	13 675	87.4
1991–92	185	450	1 806	4 358	3 832	2 398	908	1 859	314	16 119	17 796	90.6
1992–93	155	526	1 622	3 657	2 685	5 252	969	1 874	323	17 065	19 069	89.5
1993–94	185	508	1 573	3 756	3 248	2 282	1 149	1 766	251	14 722	15 959	92.3
1994–95	219	530	2 139	5 737	3 765	3 683	396	2 875	321	20 027	19 817	101.1
1995–96	165	553	2 430	4 174	4 764	4 112	381	2 625	366	19 575	21 471	91.2
1996–97	254	525	2 069	3 849	4 294	5 035	340	2 498	366	19 285	22 535	85.6
1997–98	220	607	2 086	4 285	4 132	5 359	395	2 766	287	20 150	23 083	87.3
1998–99	178	545	1 981	3 924	3 510	4 336	563	2 927	345	18 334	21 019	87.2
1999–00	297	485	2 150	3 969	3 150	5 072	991	2 697	331	19 146	21 594	88.7
2000–01	236	597	1 743	3 445	3 394	4 641	1 064	3 070	391	18 584	20 551	90.4
2001–02	280	583	1 583	3 217	3 255	5 406	629	2 642	289	17 885	19 563	91.4
2002–03	227	471	1 845	2 719	3 061	5 137	922	2 338	353	17 075	18 908	90.3
2003–04	207	507	1 473	2 385	3 119	5 899	853	2 402	360	17 204	18 758	91.7
2004–05	241	399	1 267	2 927	4 126	5 389	49	2 057	372	16 827	17 186	97.9
2005–06	291	415	1 218	1 729	3 917	3 737	43	2 053	297	13 700	14 178	96.6
2006–07	232	512	1 601	1 943	3 998	4 112	236	1 797	239	14 670	16 099	91.1
2007–08	361	503	1 505	2 307	4 251	3 818	503	1 909	186	15 344	16 263	94.3
2008–09	307	452	1 394	1 815	3 201	2 264	232	1 851	124	11 640	13 137	88.6
2009–10	379	451	1 373	1 844	3 240	2 272	1	1 957	75	11 593	12 609	91.9
2010–11	440	482	1 173	1 398	4 013	1 129	53	2 288	129	11 105	12 337	90.0
2011–12	377	346	815	2 017	3 828	1 885	2	2 142	110	11 523	12 955	88.9
2012–13	386	369	1 032	1 918	3 691	3 396	3	2 460	176	13 431	14 339	93.7
2013–14	395	425	1 047	2 041	3 889	2 832	277	2 661	147	13 715	15 225	90.1
2014–15	400	453	876	1 877	3 817	2 993	23	2 745	146	13 330	15 002	88.9
2015–16	412	468	1 091	2 267	3 633	1 931	220	2 890	170	13 083	14 666	89.2
2016–17	442	669	1 381	2 216	3 826	2 501	739	3 016	230	15 019	16 596	90.5
Total	7 694	13 537	43 428	78 439	99 850	100 771	11 986	66 438	7 641	430 268	473 415	-
Percent	1.8	3.1	10.1	18.2	23.2	23.4	2.8	15.4	1.8	-	-	-

Table A2: continued.

Reported catch (MHR)

Year	LIN1	LIN2	LIN3	LIN4	LIN5	LIN6	LIN7	LIN10	Total
1989–90	121	736	1 876	587	2 277	935	2 496	-	9 026
1990–91	207	967	2 410	2 420	2 291	2 845	2 534	-	13 675
1991–92	241	831	2 423	4 710	3 867	3 461	2 262	-	17 796
1992–93	253	944	2 247	4 100	2 546	6 504	2 475	-	19 069
1993–94	234	779	2 167	3 917	2 459	4 248	2 155	-	15 959
1994–95	261	850	2 654	5 072	2 558	5 477	2 946	-	19 817
1995–96	245	1 051	2 962	4 632	3 137	6 341	3 103	-	21 471
1996–97	313	1 187	2 976	4 087	3 438	7 510	3 024	-	22 535
1997–98	326	992	2 943	5 215	3 321	7 331	2 955	-	23 083
1998–99	208	1 070	2 706	4 642	2 937	6 112	3 345	-	21 019
1999–00	313	983	2 779	4 402	3 136	6 707	3 274	-	21 594
2000–01	296	1 105	2 330	3 861	3 430	6 177	3 352	-	20 551
2001–02	303	1 034	2 164	3 602	3 295	5 945	3 219	-	19 563
2002–03	246	996	2 529	2 997	2 939	6 283	2 918	-	18 908
2003–04	249	1 044	1 990	2 618	2 899	7 032	2 926	-	18 758
2004–05	283	936	1 597	2 758	3 584	5 506	2 522	-	17 186
2005–06	364	780	1 711	1 769	3 522	3 553	2 479	-	14 178
2006–07	301	874	2 089	2 113	3 731	4 696	2 295	-	16 099
2007–08	381	792	1 778	2 383	4 401	4 246	2 282	-	16 263
2008–09	320	634	1 751	2 000	3 232	2 977	2 223	-	13 137
2009–10	386	584	1 718	2 026	3 034	2 414	2 446	-	12 609
2010–11	438	670	1 665	1 572	3 856	1 335	2 800	-	12 337
2011–12	384	506	1 292	2 305	3 649	2 047	2 771	-	12 955
2012–13	383	579	1 475	2 181	3 610	3 102	3 010	-	14 339
2013–14	380	674	1 442	2 373	3 935	3 221	3 200	-	15 225
2014–15	374	673	1 325	2 246	3 924	3 115	3 344	-	15 002
2015–16	422	702	1 440	2 659	3 868	2 222	3 351	-	14 666
2016–17	404	1 022	1 808	2 562	4 050	3 323	3 428	-	16 596

TACC

Year	LIN1	LIN2	LIN3	LIN4	LIN5	LIN6	LIN7	LIN10	Total
1989–90	265	977	2 137	4 401	2 706	7 000	2 176	10	19 672
1990–91	265	977	2 160	4 401	2 706	7 000	2 192	10	19 711
1991–92	265	977	2 160	4 401	2 706	7 000	2 192	10	19 711
1992–93	265	980	2 162	4 401	2 706	7 000	2 212	10	19 736
1993–94	265	980	2 167	4 401	2 706	7 000	2 213	10	19 742
1994–95	265	980	2 810	5 720	3 001	7 100	2 225	10	22 111
1995–96	265	980	2 810	5 720	3 001	7 100	2 225	10	22 111
1996–97	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
1997–98	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
1998–99	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
1999–00	265	982	2 810	5 720	3 001	7 100	2 225	10	22 113
2000–01	265	982	2 060	4 200	3 001	7 100	2 225	10	19 843
2001–02	265	982	2 060	4 200	3 001	7 100	2 225	10	19 843
2002–03	400	982	2 060	4 200	3 001	7 100	2 225	10	19 978
2003–04	400	982	2 060	4 200	3 001	7 100	2 225	10	19 978
2004–05	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2005–06	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2006–07	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2007–08	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2008–09	400	982	2 060	4 200	3 595	8 505	2 225	10	21 977
2009–10	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2010–11	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2011–12	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2012–13	400	982	2 060	4 200	3 595	8 505	2 474	10	22 226
2013–14	400	982	2 060	4 200	3 955	8 505	3 080	10	23 192
2014–15	400	982	2 060	4 200	3 595	8 505	3 080	10	22 832
2015–16	400	982	2 060	4 200	3 955	8 505	3 080	10	23 192
2016–17	400	982	2 060	4 200	3 955	8 505	3 080	10	23 192

Table A3: Estimated ling catches (t) by form type and fishing year.

	Catches (tonnes)						
Year	**CELR**	**LCER**	**LTCER**	**NCELR**	**TCER**	**TCEPR**	**Total**
1989–90	1 710	-	-	-	-	6 457	8 167
1990–91	3 717	-	-	-	-	8 233	11 950
1991–92	7 076	-	-	-	-	9 043	16 119
1992–93	7 555	-	-	-	-	9 510	17 065
1993–94	8 315	-	-	-	-	6 407	14 722
1994–95	10 791	-	-	-	-	9 236	20 027
1995–96	8 715	-	-	-	-	10 860	19 575
1996–97	9 351	-	-	-	-	9 934	19 285
1997–98	8 531	-	-	-	-	11 619	20 150
1998–99	8 048	-	-	-	-	10 286	18 334
1999–00	7 982	-	-	-	-	11 164	19 146
2000–01	7 345	-	-	-	-	11 239	18 584
2001–02	6 413	-	-	-	-	11 472	17 885
2002–03	5 731	-	-	-	-	11 344	17 075
2003–04	3 556	2 075	-	-	-	11 574	17 204
2004–05	2 040	3 658	-	-	-	11 129	16 827
2005–06	1 701	2 550	-	-	-	9 449	13 700
2006–07	1 818	2 566	-	133	-	10 153	14 670
2007–08	206	2 857	2 045	99	515	9 622	15 344
2008–09	188	2 591	1 462	108	563	6 727	11 640
2009–10	131	2 857	1 744	109	698	6 055	11 593
2010–11	75	1 887	2 089	82	926	6 047	11 105
2011–12	49	2 356	1 975	54	828	6 260	11 523
2012–13	128	1 346	2 596	25	843	8 493	13 431
2013–14	165	2 397	2 912	32	985	7 224	13 715
2014–15	99	1 694	2 596	28	868	8 045	13 330
2015–16	194	2 263	2 616	83	1 025	6 903	13 083
2016–17	271	3 029	2 693	35	1 030	7 960	15 019

Table A4: Catch of ling (t) by area, by fishing year, for various fishing methods. 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		
Fishing year	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Cook Strait	Total
1989–90	10	25	148	4	47	–	–	148	4	386
1990–91	18	36	198	5	63	–	–	150	9	480
1991–92	30	21	145	2	53	–	0	192	4	448
1992–93	35	17	110	0	91	0	–	220	14	486
1993–94	29	22	64	1	78	–	–	111	22	326
1994–95	20	18	66	2	83	0	–	106	78	374
1995–96	9	24	50	3	50	0	0	188	82	406
1996–97	19	17	62	0	56	–	–	168	72	394
1997–98	9	7	45	0	30	–	–	104	24	220
1998–99	8	5	51	0	66	0	–	158	26	314
1999–00	57	7	80	0	48	–	–	129	20	340
2000–01	22	6	75	0	99	–	–	55	15	271
2001–02	11	4	99	1	89	–	–	55	17	275
2002–03	9	8	91	1	166	–	–	69	8	352
2003–04	3	3	88	0	137	–	–	54	4	290
2004–05	1	2	99	1	136	–	–	130	7	376
2005–06	6	2	46	10	106	–	–	127	3	299
2006–07	8	15	49	1	98	–	–	101	4	276
2007–08	52	18	72	0	109	–	–	240	6	496
2008–09	62	11	39	–	122	0	–	252	31	517
2009–10	86	14	66	0	180	0	–	277	26	649
2010–11	39	21	62	0	368	–	0	315	68	873
2011–12	25	51	64	13	288	0	0	275	36	753
2012–13	86	36	45	39	249	–	–	270	39	764
2013–14	78	71	53	25	399	0	–	254	19	899
2014–15	52	58	36	42	394	–	–	177	15	774
2015–16	54	65	53	25	460	–	0	234	13	904
2016–17	22	88	67	6	406	–	0	271	6	865

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

								Area		
Fishing year	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Cook Strait	Total
1989–90	1	1	3	–	–	–	–	2	42	49
1990–91	0	0	9	–	–	–	–	–	125	134
1991–92	0	1	6	–	–	–	–	2	36	44
1992–93	0	2	0	–	–	–	–	1	26	30
1993–94	0	0	1	–	–	–	–	3	11	14
1994–95	1	0	0	1	–	–	–	9	6	17
1995–96	1	0	2	–	–	–	–	24	16	43
1996–97	4	0	7	–	–	–	–	21	8	45
1997–98	9	0	4	–	–	–	–	45	13	74
1998–99	1	0	20	–	–	–	–	83	9	113
1999–00	0	0	7	–	–	–	–	206	18	232
2000–01	6	1	7	–	–	–	–	175	29	218
2001–02	0	0	9	–	–	–	–	83	14	106
2002–03	0	0	30	–	0	–	–	113	36	178
2003–04	0	0	13	0	–	–	–	67	29	110
2004–05	0	0	1	0	0	–	–	70	22	93
2005–06	0	0	2	–	–	–	–	63	21	86
2006–07	0	0	0	–	–	–	–	34	18	52
2007–08	–	–	0	–	0	–	–	2	4	6
2008–09	–	–	0	–	–	–	–	20	4	24
2009–10	–	0	0	–	–	–	–	19	2	21
2010–11	–	–	0	0	0	–	–	33	2	35
2011–12	–	–	0	–	0	–	–	43	1	45
2012–13	–	–	0	–	–	–	–	39	1	40
2013–14	–	0	0	–	–	–	–	48	2	49
2014–15	–	0	0	–	–	–	–	58	3	62
2015–16	–	–	0	–	–	–	–	89	4	93
2016–17	0	–	0	–	–	–	–	95	9	104

Table A4: continued.

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

Fishing year	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Area Cook Strait	Total
1989–90	31	59	599	500	1 953	1 174	4	370	7	4 698
1990–91	70	117	817	1 235	1 996	2 457	7	260	13	6 972
1991–92	55	87	933	1 348	3 368	2 053	35	306	4	8 189
1992–93	30	75	807	1 028	1 985	4 308	0	491	4	8 730
1993–94	45	74	727	451	2 038	1 818	4	389	47	5 595
1994–95	44	77	1 016	968	2 557	2 102	0	505	57	7 327
1995–96	73	125	1 081	697	3 945	2 807	1	385	97	9 213
1996–97	141	151	1 017	764	3 254	2 772	0	516	119	8 757
1997–98	136	130	1 174	2 262	2 933	2 970	0	498	78	10 182
1998–99	104	159	973	1 836	2 609	2 389	3	875	111	9 063
1999–00	188	156	871	1 897	2 121	3 850	0	759	90	9 932
2000–01	170	205	971	1 480	1 958	3 684	0	1 019	39	9 527
2001–02	169	207	860	1 216	2 064	4 517	1	1 133	72	10 240
2002–03	121	113	1 131	1 313	1 896	4 707	1	836	35	10 153
2003–04	108	74	811	1 061	2 269	4 936	1	815	38	10 114
2004–05	75	55	641	814	3 042	4 875	8	764	29	10 302
2005–06	124	40	610	595	2 982	3 095	4	994	21	8 465
2006–07	63	71	945	854	3 108	3 920	0	701	19	9 681
2007–08	74	19	828	1 182	3 264	3 469	0	525	41	9 402
2008–09	67	37	699	498	2 674	2 042	8	556	21	6 603
2009–10	39	23	548	539	2 607	1 475	0	603	7	5 842
2010–11	52	28	390	400	3 333	749	0	854	5	5 811
2011–12	86	6	256	731	2 914	1 158	0	761	4	5 916
2012–13	83	7	260	486	3 063	3 390	–	811	9	8 109
2013–14	39	16	242	427	3 156	2 135	3	665	21	6 705
2014–15	73	9	286	687	3 090	2 387	–	859	15	7 406
2015–16	75	4	320	549	2 919	1 541	0	779	2	6 188
2016–17	107	19	418	660	3 190	1 935	0	980	3	7 311

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

Fishing year	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Area Cook Strait	Total
1989–90	0	1	72	0	116	42	8	1 261	260	1 759
1990–91	0	13	57	69	29	9	20	740	325	1 261
1991–92	0	1	61	11	121	19	38	402	201	854
1992–93	0	4	34	24	155	58	4	324	172	775
1993–94	0	1	35	33	268	14	3	348	107	809
1994–95	0	0	38	58	417	14	3	1 260	119	1 909
1995–96	0	2	92	60	463	46	2	863	117	1 645
1996–97	0	1	106	59	133	5	0	722	145	1 174
1997–98	1	13	195	44	79	8	7	985	102	1 435
1998–99	3	11	218	47	62	6	11	772	90	1 221
1999–00	0	4	227	29	114	16	7	726	109	1 231
2000–01	0	5	81	44	351	229	0	855	147	1 712
2001–02	0	1	103	38	131	233	1	651	74	1 233
2002–03	5	4	87	19	135	217	0	585	138	1 190
2003–04	0	4	80	60	130	306	2	759	119	1 460
2004–05	0	1	70	15	98	204	6	335	97	826
2005–06	0	3	25	2	149	470	1	269	65	985
2006–07	0	1	6	1	101	191	2	125	45	472
2007–08	0	2	10	0	84	3	1	87	33	220
2008–09	0	2	4	0	6	6	2	80	25	125
2009–10	0	1	18	0	36	8	0	127	22	213
2010–11	0	3	3	0	50	20	2	141	19	237
2011–12	0	0	6	1	138	3	0	165	31	344
2012–13	0	1	16	2	5	6	3	317	34	384
2013–14	0	0	9	1	1	16	8	455	29	520
2014–15	0	1	13	0	75	39	0	467	35	630
2015–16	0	1	10	0	28	11	0	567	34	651
2016–17	0	0	22	0	16	22	0	502	26	587

Table A4: continued.

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

Fishing year	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Area Cook Strait	Total
1989–90	39	134	185	8	0	–	–	197	66	630
1990–91	50	186	613	846	2	217	7	428	55	2 406
1991–92	98	300	478	2 997	288	326	835	691	70	6 090
1992–93	83	401	491	2 605	453	886	965	708	100	6 694
1993–94	108	406	552	3 272	863	449	1 142	761	63	7 619
1994–95	128	432	811	4 707	704	1 567	385	891	59	10 047
1995–96	81	397	1 021	3 414	301	1 259	378	994	53	7 900
1996–97	67	328	635	3 026	847	2 258	340	963	20	8 506
1997–98	60	446	427	1 979	1 084	2 381	388	1 008	67	7 848
1998–99	39	370	528	2 040	770	1 940	549	972	107	7 339
1999–00	50	317	779	2 043	857	1 206	984	784	94	7 115
2000–01	36	380	473	1 921	961	728	1 063	917	160	6 640
2001–02	100	370	385	1 962	955	657	627	659	111	5 826
2002–03	91	346	401	1 386	850	214	921	686	137	5 032
2003–04	95	425	356	1 264	581	656	850	682	169	5 078
2004–05	166	340	369	2 097	848	310	34	728	215	5 107
2005–06	161	365	434	1 123	676	172	38	562	187	3 718
2006–07	161	425	498	1 087	685	–	234	745	153	3 988
2007–08	235	461	521	1 125	789	345	502	1 010	93	5 081
2008–09	177	397	583	1 314	382	216	222	887	33	4 211
2009–10	252	412	638	1 303	404	789	1	864	11	4 674
2010–11	349	431	629	995	252	360	51	902	33	4 002
2011–12	266	289	446	1 272	483	723	1	848	34	4 362
2012–13	217	325	655	1 391	367	0	–	957	88	4 000
2013–14	275	337	661	1 587	328	681	265	1 190	71	5 396
2014–15	275	385	461	1 148	249	566	23	1 157	63	4 328
2015–16	276	386	519	1 679	220	378	220	1 149	81	4 909
2016–17	274	522	694	1 545	209	544	739	1 121	122	5 770

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

Fishing year	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Area Cook Strait	Total
1989–90	2	48	210	0	0	–	–	346	36	642
1990–91	1	85	227	–	2	–	–	368	0	682
1991–92	3	40	144	0	1	–	–	264	1	453
1992–93	6	25	164	–	1	–	–	129	3	327
1993–94	3	4	179	0	0	–	–	154	1	342
1994–95	27	1	199	–	1	–	–	103	1	332
1995–96	1	5	179	–	0	0	–	170	1	357
1996–97	23	28	203	0	2	0	–	108	1	365
1997–98	4	12	201	–	2	–	–	127	0	346
1998–99	23	1	147	–	0	0	–	65	0	237
1999–00	1	1	165	–	0	–	–	94	0	262
2000–01	0	1	131	–	0	–	–	49	2	184
2001–02	1	0	123	–	1	0	–	62	0	187
2002–03	1	0	104	0	0	–	–	50	0	156
2003–04	1	1	120	–	1	–	–	24	0	148
2004–05	0	1	78	0	1	–	–	31	1	112
2005–06	0	5	51	–	1	–	–	39	0	96
2006–07	0	0	47	–	2	0	–	91	0	141
2007–08	1	2	55	0	3	0	0	43	0	104
2008–09	0	5	58	2	6	0	–	43	0	115
2009–10	0	0	62	2	5	0	–	47	0	116
2010–11	0	0	55	2	5	0	–	28	0	90
2011–12	0	0	34	–	4	0	–	22	1	62
2012–13	0	0	27	0	4	0	–	34	0	66
2013–14	1	0	26	0	2	0	–	18	0	48
2014–15	1	1	32	–	2	0	–	0	0	36
2015–16	1	1	46	0	4	0	–	40	0	92
2016–17	2	3	34	–	3	–	–	0	0	43

Table A4: continued.

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

Fishing year	Area									
	North NI	East NI	East SI	Chatham	Southland	Sub-Antarctic	Bounty	West SI	Cook Strait	Total
1989–90	0	0	2	0	1	–	–	0	0	3
1990–91	0	0	15	0	1	0	–	–	0	16
1991–92	0	–	39	0	1	–	–	0	0	40
1992–93	0	0	15	0	1	–	–	–	0	16
1993–94	0	0	11	0	1	–	–	0	0	13
1994–95	0	0	8	0	2	–	–	–	0	10
1995–96	0	0	4	0	4	–	–	0	0	8
1996–97	0	0	38	0	2	–	–	0	0	40
1997–98	0	0	40	0	3	–	–	–	0	43
1998–99	–	0	41	0	0	0	–	–	0	42
1999–00	0	0	21	–	10	–	–	–	0	32
2000–01	2	0	4	0	25	–	–	1	0	31
2001–02	0	0	3	–	16	–	–	–	0	19
2002–03	0	–	1	0	13	–	–	0	0	14
2003–04	0	0	4	0	0	–	–	0	1	5
2004–05	0	0	10	0	0	–	–	0	0	10
2005–06	0	0	49	–	3	0	–	0	0	52
2006–07	0	0	56	0	3	–	–	0	0	60
2007–08	0	0	19	0	2	–	–	–	0	21
2008–09	0	0	10	0	11	–	–	0	0	21
2009–10	0	0	41	–	8	–	–	0	0	49
2010–11	0	0	33	–	5	–	–	–	0	39
2011–12	0	0	8	0	1	–	–	0	0	10
2012–13	0	0	26	–	3	–	–	0	0	29
2013–14	0	0	56	1	3	–	–	0	0	60
2014–15	0	0	45	–	7	0	–	0	–	52
2015–16	1	9	126	0	2	–	–	16	0	154
2016–17	15	33	143	2	1	–	–	2	18	214

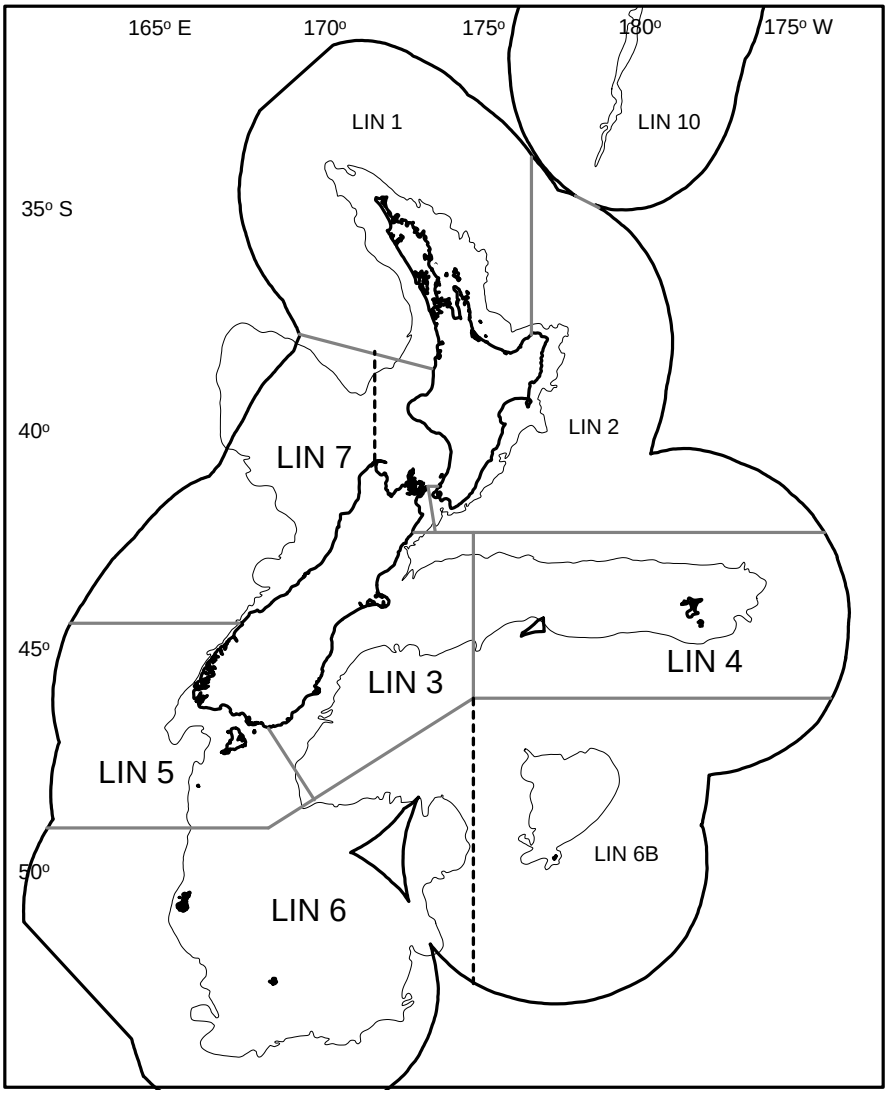


Figure A1: Ling fishstocks, and the 1000 m isobath. The boundaries used to separate biological stock LIN 6B from the rest of LIN 6, and the west coast South Island section of LIN 7 from the rest of LIN 7, are shown as broken lines.

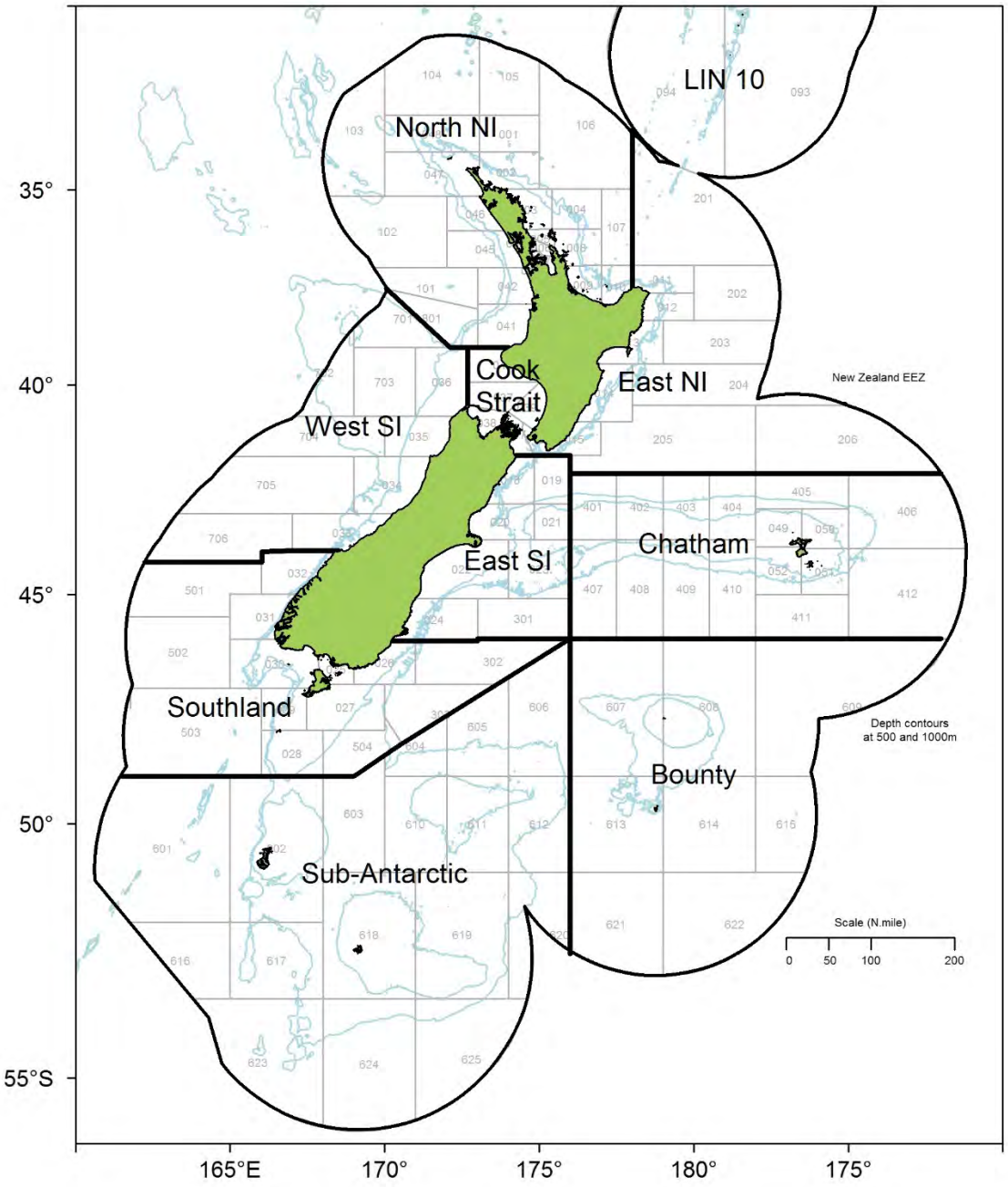


Figure A2: Definitions of geographical areas used in the analyses (based on statistical areas). See Table A1 for the administrative ling stocks they approximate.

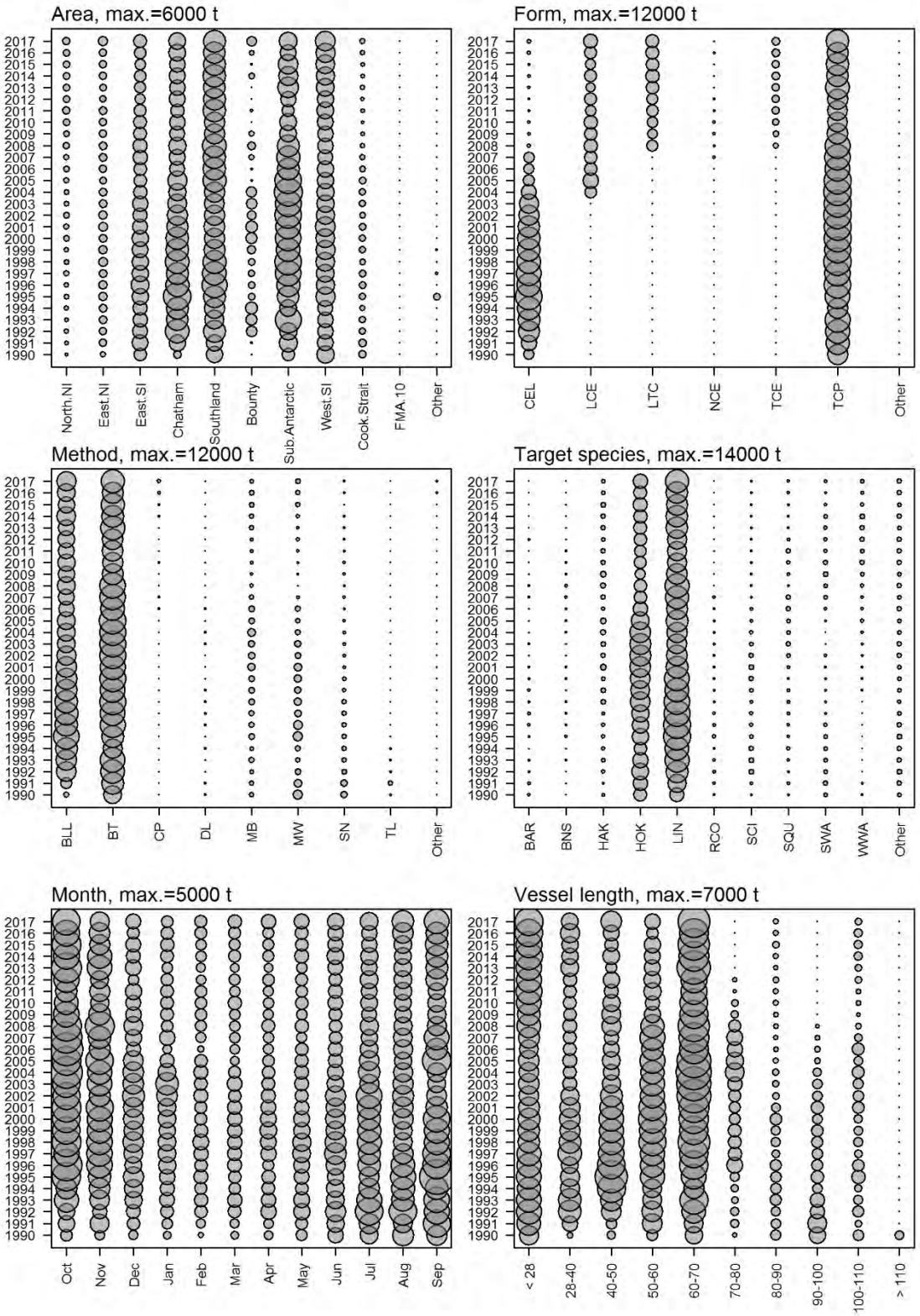


Figure A3: Distribution of annual catch by area, form type, fishing method, target species, month, and vessel length for all ling catches by all methods. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Form types: CEL is Catch, Effort, Landing Return; LCE is Lining Catch Effort return; LTC is Lining Trip Catch, Effort return; NCE is Netting 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.

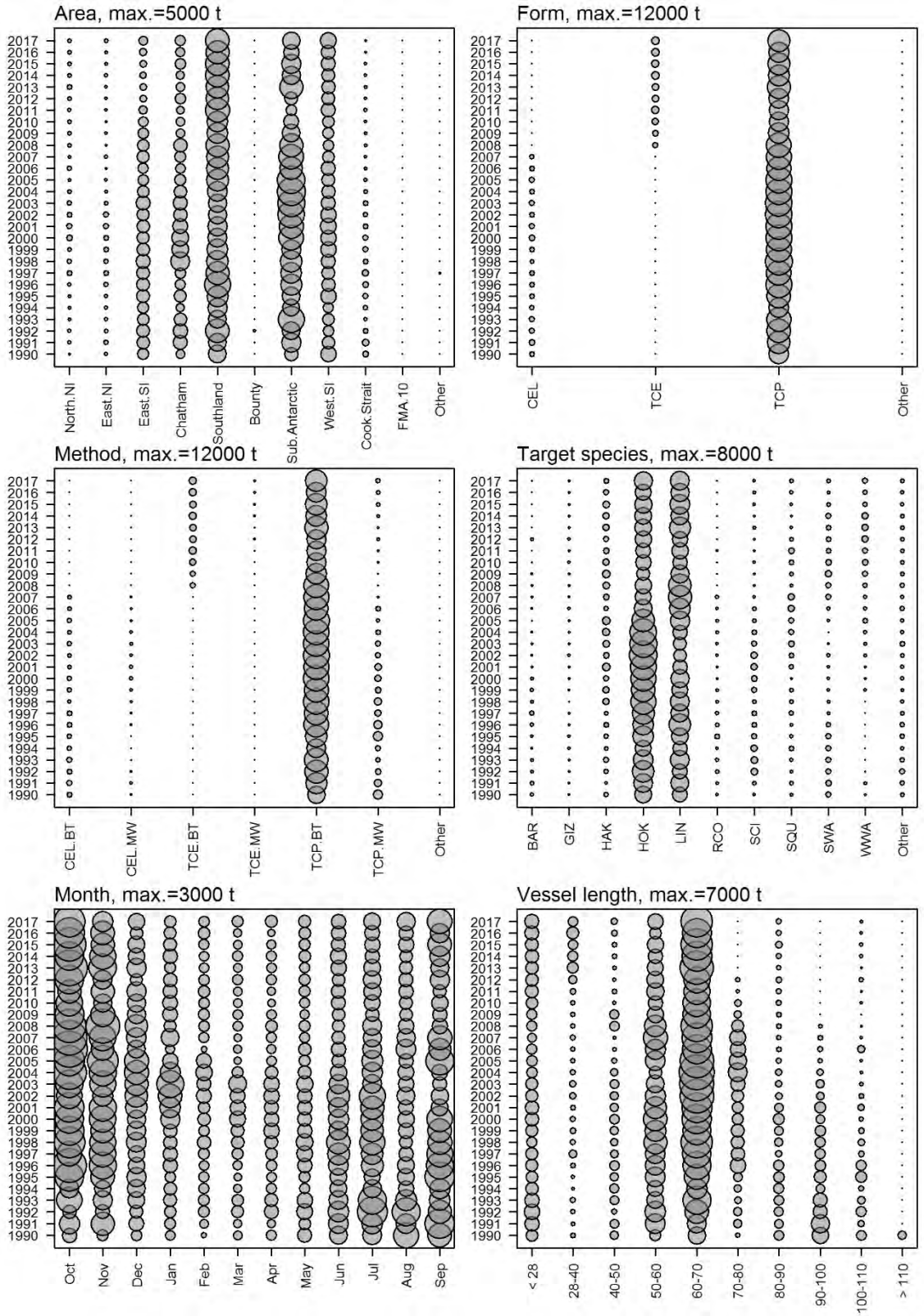


Figure A4: Distribution of annual catch by area, form type, fishing method (by form type), target species, month, and vessel length for all ling catches by trawl methods. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Form types and method types are 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.

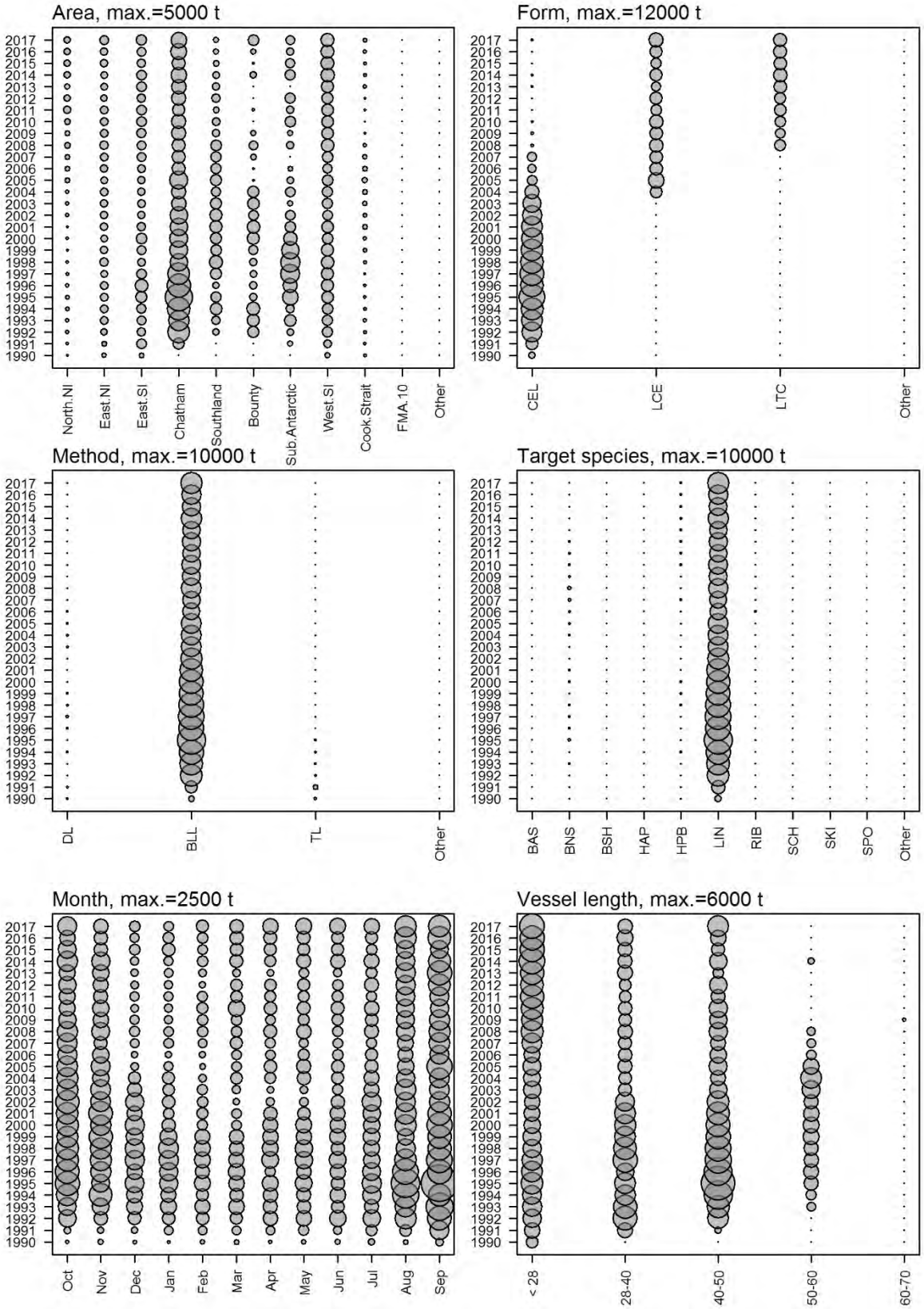


Figure A5: Distribution of annual catch by area, form type, fishing method (by form type), target species, month, and vessel length for all ling catches by line methods. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Form types and method types are defined in Figure A3. 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 2016–17. Values have been rounded to the nearest tonne, so '0' denotes catches from 1 to 499 kg and '–' denotes zero catch.

	Trawl fishery				Line fishery	
Fishing	**Hake**	**Hoki**	**Ling**	**Other**	**Ling**	**Other**
1989–90	22	574	313	264	190	3
1990–91	10	1 215	508	451	1 454	5
1991–92	65	1 444	330	516	3 467	8
1992–93	240	946	122	584	3 085	11
1993–94	110	716	27	388	3 812	12
1994–95	153	1 418	61	436	5 502	16
1995–96	154	1 436	45	262	4 420	15
1996–97	179	1 487	48	190	3 631	30
1997–98	310	2 436	710	193	2 390	16
1998–99	320	2 305	246	182	2 555	14
1999–00	287	1 934	652	124	2 817	5
2000–01	270	1 912	197	188	2 388	6
2001–02	109	1 614	339	152	2 346	1
2002–03	119	2 038	104	283	1 783	4
2003–04	256	1 554	1	174	1 596	24
2004–05	229	1 034	106	166	2 429	37
2005–06	52	806	146	230	1 505	52
2006–07	158	718	741	184	1 494	92
2007–08	134	724	920	296	1 577	69
2008–09	195	666	176	196	1 871	26
2009–10	13	672	192	290	1 912	29
2010–11	3	640	44	161	1 597	26
2011–12	1	686	98	280	1 676	42
2012–13	0	732	23	91	2 009	37
2013–14	1	574	100	78	2 222	26
2014–15	8	824	130	99	1 577	32
2015–16	1	714	98	140	2 166	31
2016–17	0	945	131	94	2 215	24

Table B2: East SI and Chatham (LIN 3&4) ling catch (t) by fishing method and month from 1989–90 to 2016–17. Values have been rounded to the nearest tonne, so '0' denotes catches from 1 to 499 kg and '–' denotes zero catch.

Trawl

	Month												
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1989–90	75	16	40	7	22	46	123	224	164	6	45	405	1 173
1990–91	313	142	182	185	64	109	55	134	226	82	225	466	2 184
1991–92	214	166	137	204	188	227	260	224	234	164	143	191	2 355
1992–93	326	203	185	200	90	124	178	178	194	24	93	96	1 892
1993–94	274	164	116	101	48	35	81	98	139	51	3	130	1 240
1994–95	404	179	167	65	61	66	46	101	148	73	63	696	2 067
1995–96	246	127	139	223	77	53	99	215	240	70	51	355	1 897
1996–97	258	202	149	130	153	152	132	196	107	136	13	275	1 903
1997–98	495	366	346	196	143	186	194	219	330	388	6	781	3 649
1998–99	296	584	245	260	186	217	265	267	282	72	25	354	3 054
1999–00	203	525	432	177	129	252	244	139	221	27	1	647	2 996
2000–01	223	503	310	246	136	326	249	198	175	58	0	141	2 567
2001–02	266	96	186	368	158	154	250	226	117	38	2	354	2 214
2002–03	401	335	264	216	176	237	224	319	134	114	6	121	2 545
2003–04	270	329	276	152	86	155	126	143	141	130	84	94	1 985
2004–05	158	209	253	163	65	64	55	138	142	53	31	203	1 534
2005–06	147	211	151	99	57	51	80	102	126	63	24	124	1 235
2006–07	157	145	113	108	103	96	92	130	101	64	98	592	1 801
2007–08	290	202	226	186	139	87	103	182	99	85	270	204	2 073
2008–09	280	145	125	249	141	56	69	44	66	21	20	16	1 233
2009–10	214	118	101	107	91	82	49	72	57	42	72	162	1 168
2010–11	78	158	169	68	87	85	46	65	36	16	10	31	848
2011–12	73	97	128	151	92	65	24	58	49	19	62	247	1 064
2012–13	92	102	136	148	87	103	43	42	31	37	9	17	847
2013–14	59	67	80	133	92	66	48	41	53	3	17	92	752
2014–15	78	115	179	198	62	65	62	75	50	5	63	109	1 061
2015–16	32	106	128	150	145	96	57	84	57	6	11	81	953
2016–17	98	114	143	155	137	103	113	80	56	8	48	116	1 171

Line

	Month												
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1989–90	–	0	–	–	–	–	–	10	–	–	–	–	10
1990–91	–	7	7	89	121	104	45	3	56	0	106	435	973
1991–92	437	79	72	62	90	107	221	360	349	466	707	276	3 227
1992–93	62	22	9	280	215	71	89	218	200	136	494	956	2 752
1993–94	344	148	18	110	139	213	250	265	296	335	859	542	3 520
1994–95	478	66	87	2	294	231	76	250	85	246	1 149	1 960	4 923
1995–96	600	331	31	259	180	192	31	178	216	278	946	850	4 094
1996–97	473	71	40	102	110	85	162	136	110	199	640	882	3 010
1997–98	494	214	96	116	7	9	3	50	9	142	374	732	2 245
1998–99	446	386	112	99	–	2	55	43	4	90	321	786	2 343
1999–00	490	85	103	8	7	18	13	87	65	217	566	787	2 446
2000–01	216	92	74	4	1	24	115	38	54	104	676	870	2 267
2001–02	251	164	62	75	28	36	90	70	99	294	471	582	2 222
2002–03	64	41	41	54	58	54	7	–	2	222	512	479	1 536
2003–04	105	102	54	41	31	18	8	38	70	200	429	357	1 454
2004–05	70	144	82	105	42	79	88	47	142	216	296	886	2 197
2005–06	181	88	42	67	67	53	51	55	57	119	225	336	1 342
2006–07	130	110	60	78	52	56	82	39	76	71	268	389	1 412
2007–08	132	94	64	54	6	16	59	76	50	127	349	575	1 602
2008–09	308	186	64	51	19	38	58	30	70	89	414	543	1 870
2009–10	361	130	35	57	72	107	96	81	70	116	325	455	1 904
2010–11	199	133	68	44	79	67	48	55	56	53	329	450	1 581
2011–12	188	136	46	44	20	47	49	21	24	82	324	725	1 706
2012–13	253	113	32	14	23	21	9	14	46	159	498	844	2 024
2013–14	440	228	74	39	72	20	44	71	107	100	354	667	2 215
2014–15	388	117	23	12	13	34	48	38	68	85	387	383	1 595
2015–16	239	159	79	54	67	94	75	88	95	117	529	587	2 182
2016–17	505	140	49	57	84	96	45	89	106	204	405	430	2 209

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)	
Fishing	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**
1989–90	54	1 120	1 711	9 268	6 124	29 671
1990–91	79	2 105	1 960	9 486	7 293	35 149
1991–92	351	2 004	4 649	10 352	18 972	39 630
1992–93	350	1 543	4 292	12 479	17 596	44 163
1993–94	272	968	3 752	12 428	15 125	34 849
1994–95	185	1 882	2 733	17 580	10 875	55 890
1995–96	110	1 786	2 743	19 033	9 957	62 850
1996–97	119	1 784	2 500	18 865	9 446	63 596
1997–98	87	3 559	2 455	23 740	9 473	83 491
1998–99	95	2 958	1 955	20 897	7 791	73 111
1999–00	78	2 918	2 106	19 652	8 930	69 470
2000–01	92	2 475	1 512	18 652	6 807	70 271
2001–02	54	2 160	1 548	16 136	6 346	60 526
2002–03	44	2 500	1 398	18 071	6 140	68 465
2003–04	35	1 950	1 019	14 738	4 514	57 990
2004–05	74	1 460	2 414	12 052	12 850	45 758
2005–06	94	1 141	2 545	11 951	15 566	40 312
2006–07	37	1 764	2 872	10 993	17 782	41 263
2007–08	83	1 990	5 568	10 761	26 407	40 381
2008–09	54	1 180	5 979	9 147	26 423	35 098
2009–10	85	1 082	7 152	9 330	29 383	35 787
2010–11	69	779	5 899	8 261	25 694	31 639
2011–12	85	979	6 004	7 959	26 454	29 567
2012–13	91	756	5 805	7 601	25 993	28 503
2013–14	83	669	7 844	8 111	36 815	27 448
2014–15	82	979	7 735	8 344	37 343	30 631
2015–16	79	874	6 374	8 599	28 439	30 631
2016–17	75	1 096	7 907	8 382	32 920	30 943

Lines

	Catches (t)		Total number of days		Total number of sets	
Fishing	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**
1989–90	0	10	4	17	11	53
1990–91	18	955	40	208	77	556
1991–92	138	3 089	80	478	87	1 625
1992–93	88	2 652	57	431	100	1 660
1993–94	66	3 454	92	563	152	2 247
1994–95	168	4 755	101	608	224	2 787
1995–96	162	3 931	155	636	283	2 449
1996–97	176	2 834	186	633	405	2 381
1997–98	90	2 155	126	519	233	2 027
1998–99	–	2 339	–	553	–	2 065
1999–00	–	2 446	–	602	–	2 202
2000–01	–	2 267	–	504	–	1 689
2001–02	5	2 217	2	681	2	2 380
2002–03	–	1 536	–	380	–	1 265
2003–04	5	1 448	32	529	84	1 896
2004–05	56	2 141	221	592	845	2 253
2005–06	27	1 316	172	511	760	2 054
2006–07	344	1 068	440	428	1 508	1 655
2007–08	462	1 140	612	476	2 134	1 609
2008–09	640	1 230	598	301	1 774	1 265
2009–10	604	1 300	554	401	1 727	1 780
2010–11	586	995	623	399	1 974	1 741
2011–12	781	926	691	257	2 528	1 157
2012–13	805	1 218	775	357	1 860	1 378
2013–14	944	1 272	785	579	1 434	2 154
2014–15	664	932	754	414	1 332	1 513
2015–16	628	1 554	708	570	1 266	2 229
2016–17	543	1 666	595	612	906	2 154

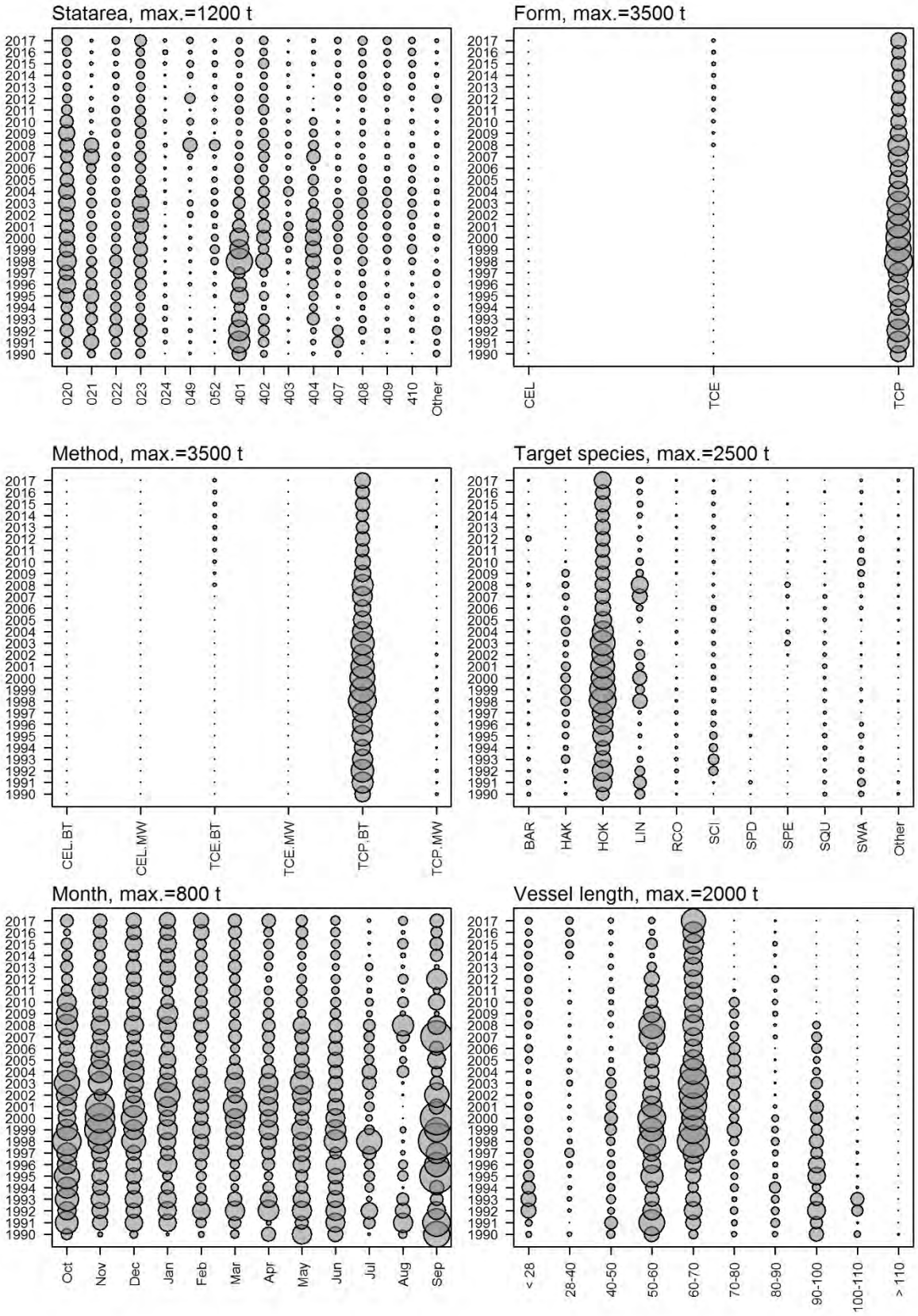


Figure B1: East SI and Chatham (LIN 3&4) trawl; distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: BAR,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

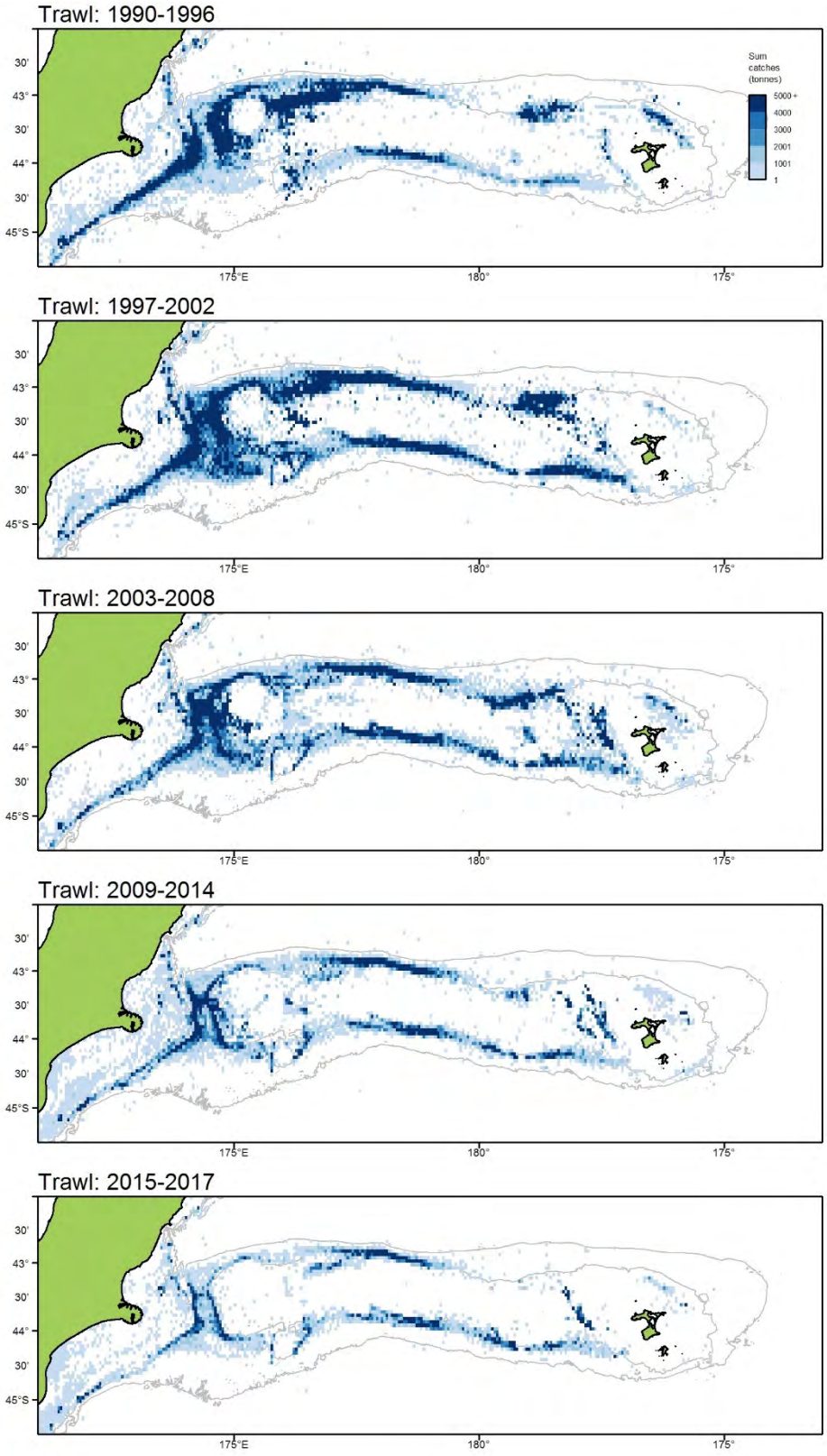


Figure B2: Density plots of East SI and Chatham (LIN 3&4) commercial ling trawl catches, for combined fishing year groups (labelled by year-ending).

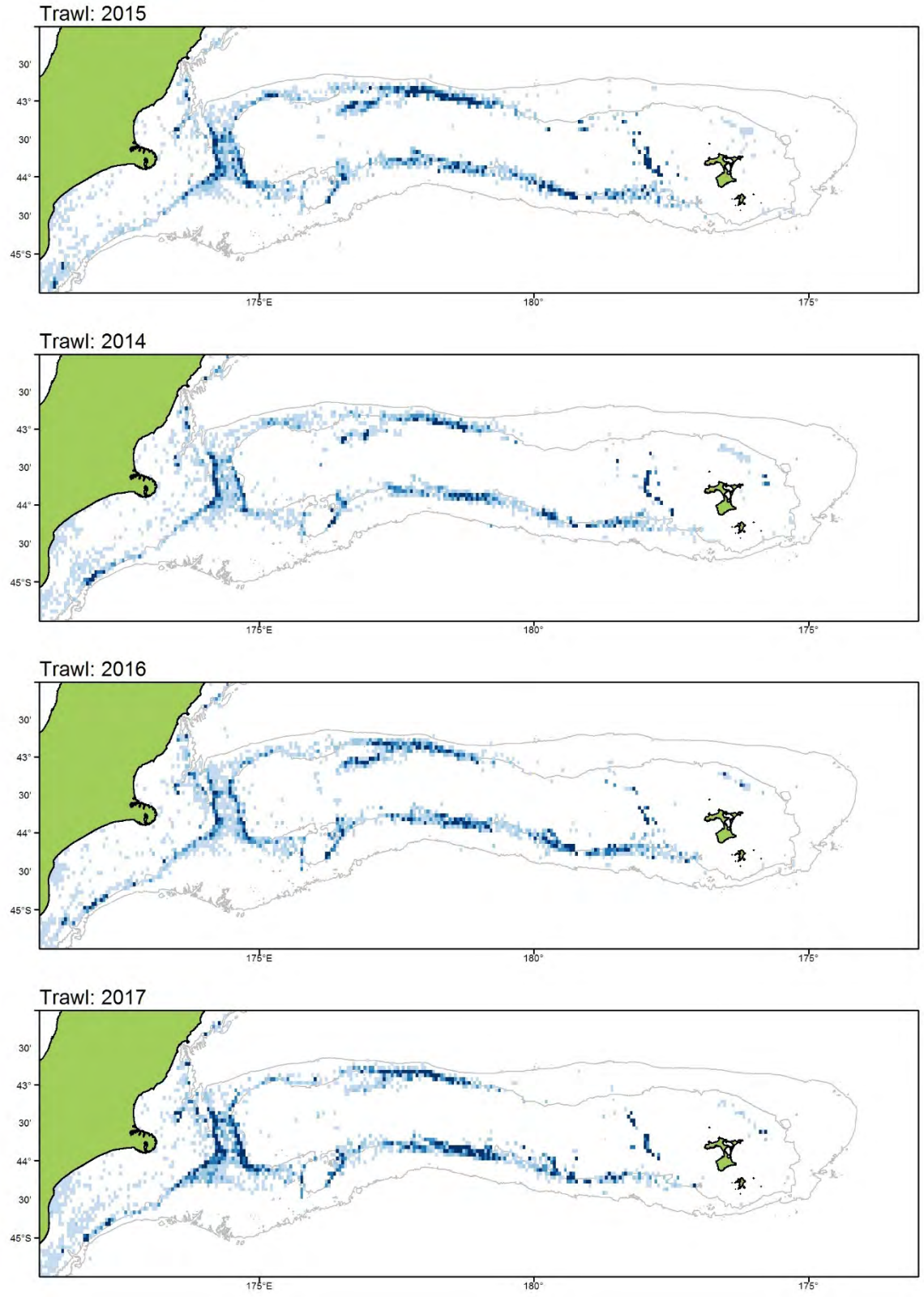


Figure B3: Density plots of East SI and Chatham (LIN 3&4) commercial ling trawl catches for the 2014–2017 fishing years (labelled by year-ending).

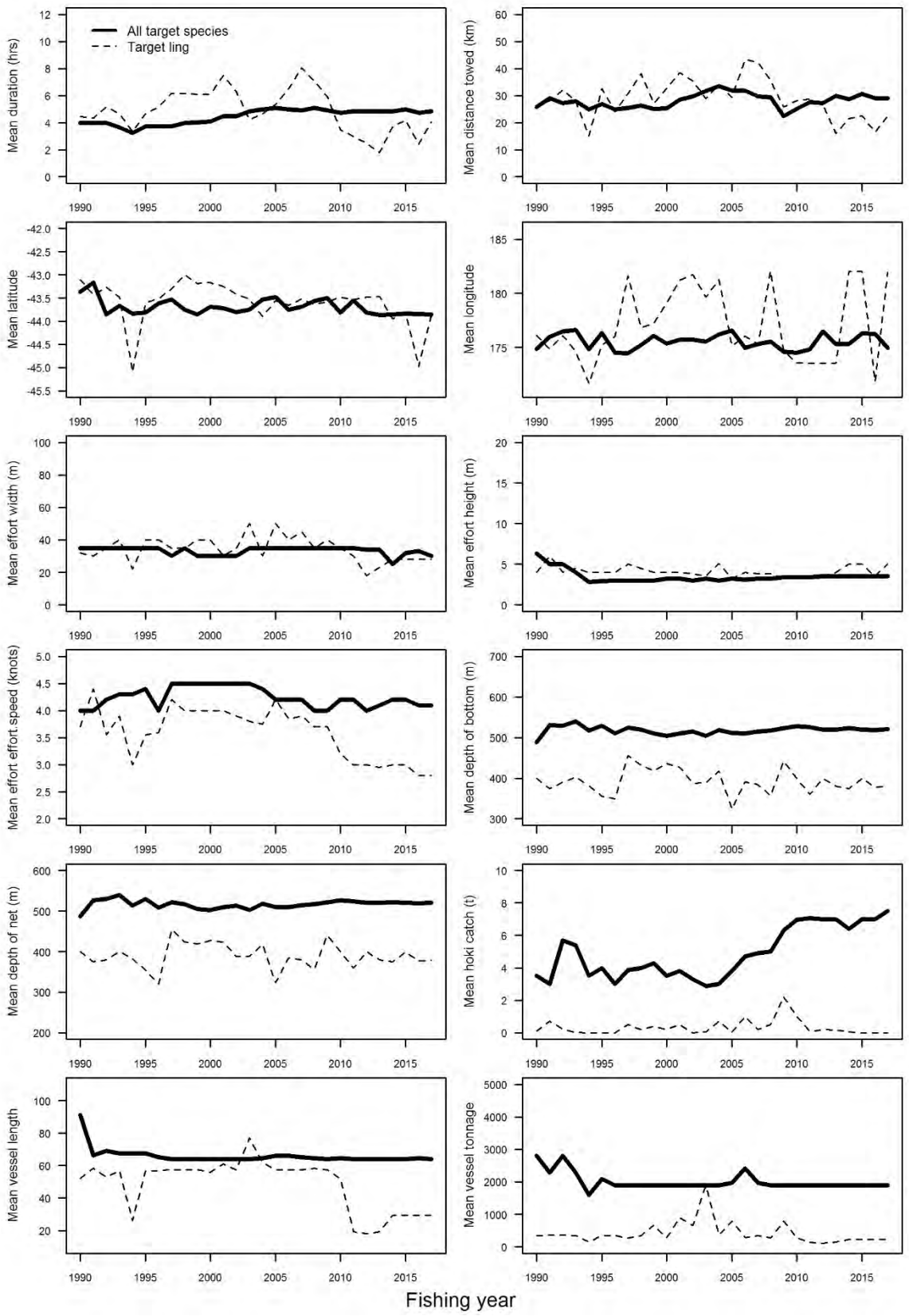


Figure B4: East SI and Chatham (LIN 3&4) bottom trawl; means of effort variables by fishing year for tows targeting ling, or targeting hake, hoki, or ling.

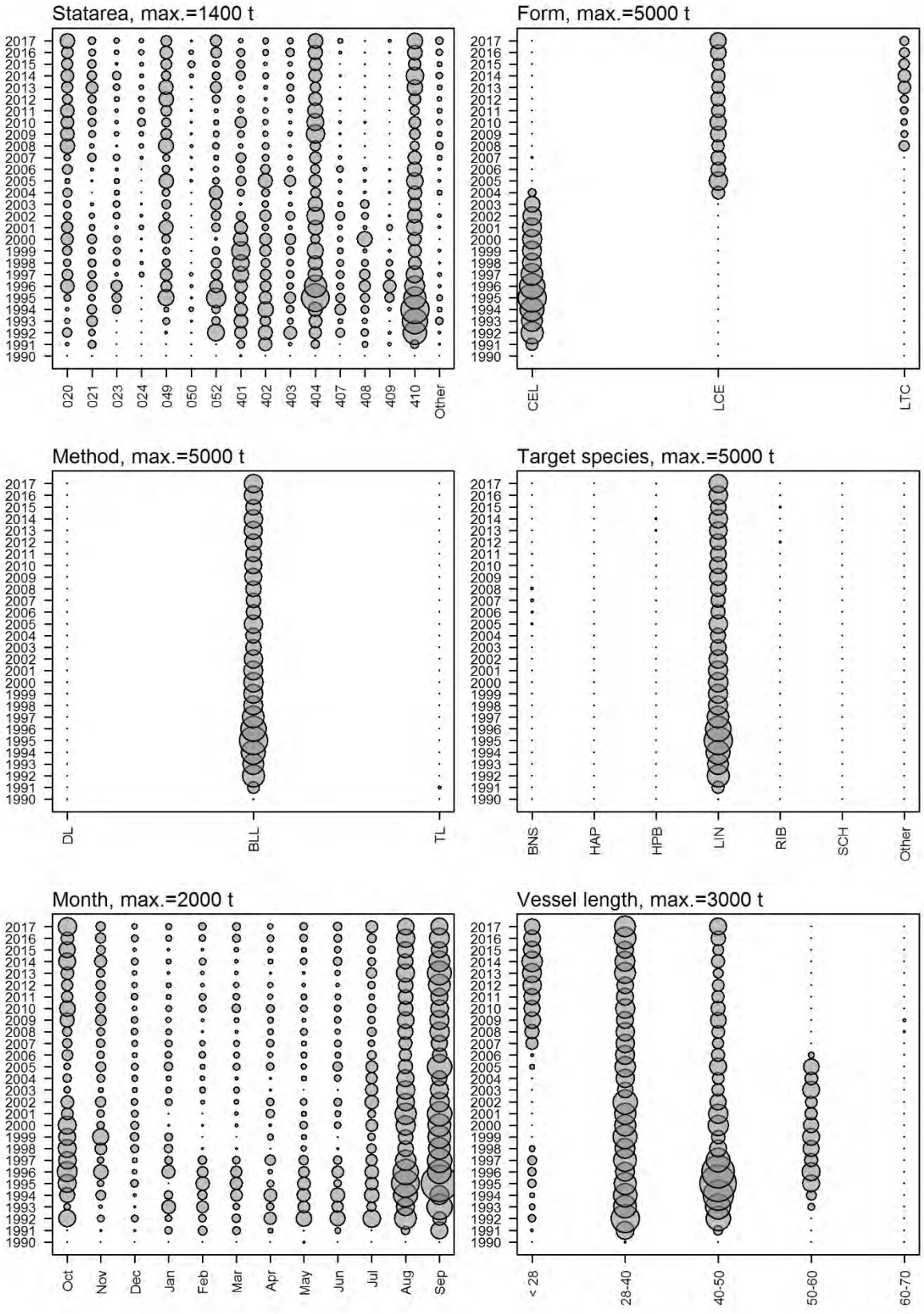


Figure B5: East SI and Chatham (LIN 3&4) line fishery distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: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

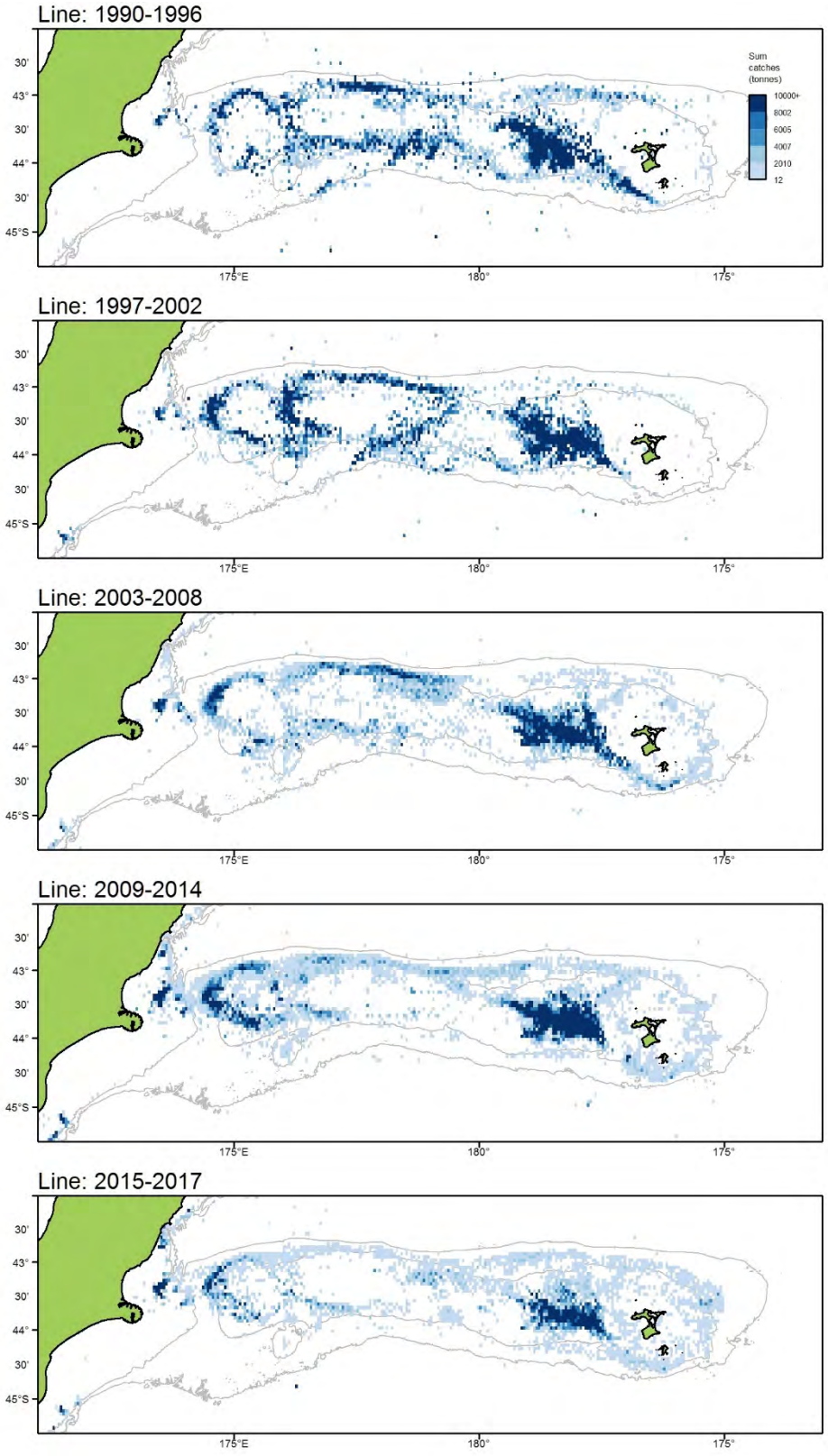


Figure B6: Density plots of East SI and Chatham (LIN 3&4) commercial ling line fishery catches for combined fishing year groups (labelled by year-ending).

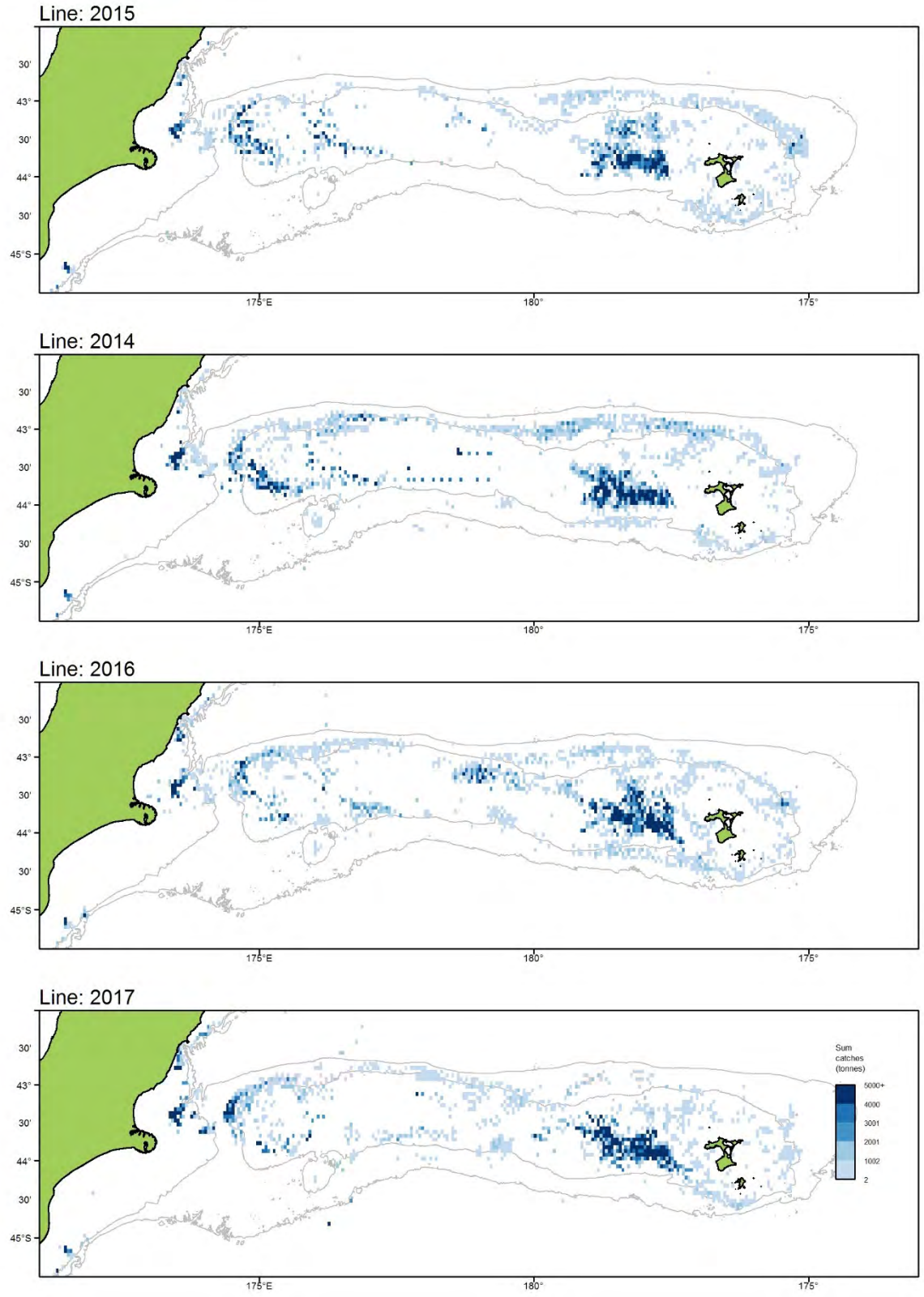


Figure B7: Density plots of East SI and Chatham (LIN 3&4) commercial ling line fishery catches for each of the 2014–2017 fishing years (labelled by year-ending).

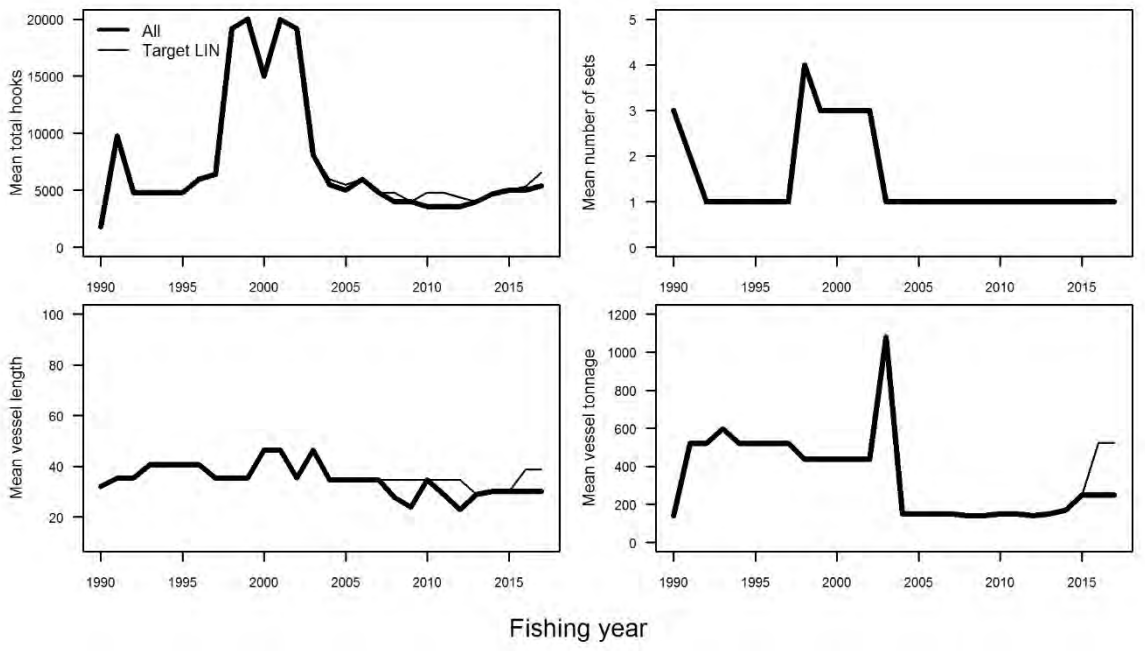


Figure B8: East SI and Chatham (LIN 3&4) bottom longline fishery; means of effort variables by fishing year for sets targeting ling (Target LIN) or targeting ling and other target species (All).

8. APPENDIX C: DESCRIPTIVE SOUTHLAND AND SUB-ANTARCTIC (LIN 5&6)

Table C1: Southland and Sub-Antarctic (LIN 5&6) trawl and line catch by target species and fishing method, 1989–90 to 2016–17 by area. Values have been rounded to the nearest tonne, so '0' denotes catches from 1 to 499 kg and '–' denotes zero catch.

	Trawl fishery				Line fishery	
Fishing	**Hake**	**Hoki**	**Ling**	**Other**	**Ling**	**Other**
1989–90	184	720	1 982	398	–	0
1990–91	77	1 227	2 654	533	219	1
1991–92	140	2 831	1 955	619	613	1
1992–93	49	2 510	3 415	521	1 332	6
1993–94	86	1 276	2 165	613	1 296	16
1994–95	56	1 572	2 900	562	2 264	7
1995–96	115	1 899	4 708	536	1 558	2
1996–97	22	2 453	3 206	481	3 102	3
1997–98	119	2 635	2 892	345	3 465	0
1998–99	117	2 146	2 376	448	2 708	2
1999–00	46	3 019	2 755	287	2 063	0
2000–01	418	3 383	1 996	455	1 685	4
2001–02	240	4 623	1 369	713	1 611	0
2002–03	331	4 217	1 755	662	1 063	1
2003–04	260	4 419	2 338	626	1 235	2
2004–05	375	3 477	3 674	693	1 158	0
2005–06	37	1 731	4 122	792	846	2
2006–07	105	1 510	4 736	903	678	8
2007–08	189	1 785	4 260	653	1 113	22
2008–09	266	788	2 940	809	590	8
2009–10	287	1 417	1 643	904	1 185	8
2010–11	162	1 022	2 379	916	608	4
2011–12	220	1 296	2 091	858	1 204	2
2012–13	270	1 283	4 310	808	366	2
2013–14	281	1 484	3 033	858	1 009	0
2014–15	290	1 364	3 738	551	815	0
2015–16	217	978	3 265	449	598	0
2016–17	236	1 223	3 307	737	748	6

Table C2: Southland and Sub-Antarctic (LIN 5&6) ling catch (t) by fishing method and month from 1989–90 to 2016–17. Values have been rounded to the nearest tonne, so '0' denotes catches from 1 to 499 kg and '–' denotes zero catch.

Trawl

	Month												
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1989–90	414	276	223	173	21	90	90	177	263	23	856	675	3 281
1990–91	578	1 053	310	60	84	31	86	142	356	86	396	1 307	4 490
1991–92	175	240	235	92	79	88	167	327	636	1 344	1 370	806	5 559
1992–93	1 218	684	446	179	171	160	177	332	532	1 233	662	747	6 540
1993–94	522	444	612	252	180	116	115	74	448	268	381	723	4 136
1994–95	1 493	1 093	684	168	143	30	90	126	345	2	353	554	5 082
1995–96	2 291	1 478	469	175	100	98	118	237	517	389	367	992	7 230
1996–97	1 065	1 329	453	293	82	63	128	337	774	241	308	1 062	6 135
1997–98	1 594	1 071	515	212	267	166	200	423	640	240	178	450	5 956
1998–99	1 546	693	564	142	40	140	265	200	376	318	41	738	5 064
1999–00	1 567	1 003	357	640	224	300	264	247	474	224	166	636	6 100
2000–01	1 900	1 126	689	697	164	182	198	262	440	195	32	292	6 176
2001–02	1 371	744	937	891	324	319	288	208	789	624	164	274	6 934
2002–03	1 530	1 104	913	1 407	224	431	318	244	410	10	171	192	6 955
2003–04	2 482	1 302	992	747	523	89	188	213	393	186	28	381	7 525
2004–05	2 161	1 894	1 063	329	426	31	128	97	153	455	84	1 388	8 209
2005–06	3 130	956	544	77	6	94	97	206	224	187	273	860	6 654
2006–07	2 731	1 445	740	558	125	35	100	64	35	456	405	606	7 300
2007–08	2 216	2 352	916	146	121	92	137	72	50	496	67	245	6 909
2008–09	1 595	1 185	628	258	130	141	117	83	126	148	87	351	4 848
2009–10	1 375	603	629	386	125	50	68	122	296	162	95	396	4 306
2010–11	1 081	1 023	649	375	178	57	70	140	274	277	100	266	4 490
2011–12	1 741	702	176	262	162	153	172	161	196	210	77	488	4 501
2012–13	2 764	1 597	663	140	109	47	120	125	312	244	14	562	6 696
2013–14	1 707	1 427	505	322	110	152	156	160	296	77	115	669	5 694
2014–15	2 399	1 078	469	184	155	112	101	125	149	185	82	946	5 986
2015–16	2 065	1 171	233	184	138	31	32	129	167	141	94	575	4 959
2016–17	2 043	829	451	134	58	135	201	196	104	158	155	1 102	5 566

Line

	Month												
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1990–91	–	–	–	–	–	–	64	82	15	58	–	–	219
1991–92	–	36	211	211	108	–	–	–	40	–	2	2	611
1992–93	186	331	203	8	46	328	150	14	–	–	–	–	1 265
1993–94	97	378	224	112	30	20	124	29	69	68	–	85	1 237
1994–95	164	365	368	386	68	147	342	153	121	103	–	–	2 216
1995–96	121	227	244	165	130	262	46	134	102	104	–	–	1 534
1996–97	131	405	441	413	318	284	323	282	307	135	–	–	3 039
1997–98	227	458	484	389	395	329	414	296	170	206	73	–	3 440
1998–99	258	335	251	153	206	209	320	326	293	195	0	–	2 547
1999–00	236	368	346	26	65	13	206	158	187	171	65	141	1 984
2000–01	354	579	178	2	48	30	116	94	153	127	–	–	1 681
2001–02	361	340	500	91	94	28	–	–	88	109	–	–	1 611
2002–03	274	443	172	–	7	26	–	35	93	13	–	–	1 063
2003–04	370	94	–	–	8	214	148	136	91	64	2	109	1 236
2004–05	478	406	–	–	–	78	79	81	35	–	–	–	1 158
2005–06	318	350	0	–	–	121	51	–	–	–	–	–	840
2006–07	498	147	–	–	–	–	–	7	17	2	–	7	678
2007–08	511	295	1	41	152	77	37	–	2	4	5	2	1 127
2008–09	123	180	61	0	41	28	2	147	1	1	1	1	585
2009–10	6	297	15	–	64	288	139	149	169	61	2	1	1 190
2010–11	68	68	0	0	40	64	125	91	65	49	19	–	587
2011–12	188	164	0	–	–	129	143	158	138	145	124	–	1 189
2012–13	117	214	–	0	0	8	3	7	6	–	3	–	358
2013–14	77	165	0	–	14	143	71	125	90	194	84	3	964
2014–15	82	97	44	83	66	146	85	80	132	–	–	–	814
2015–16	110	68	–	81	30	108	76	54	–	2	–	38	566
2016–17	43	98	–	11	79	73	148	84	137	18	4	23	717

Table C3: Southland and Sub-Antarctic (LIN 5&6) 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**
1989–90	148	3 133	127	11 410	520	39 795
1990–91	205	4 285	128	13 962	616	51 928
1991–92	267	5 292	1 175	13 301	5 341	53 770
1992–93	151	6 389	1 203	14 227	5 776	52 054
1993–94	102	4 034	1 015	11 552	5 391	41 548
1994–95	61	5 021	1 396	11 416	8 864	45 316
1995–96	80	7 139	1 584	13 841	9 886	52 785
1996–97	70	6 065	1 163	15 469	7 707	59 636
1997–98	51	5 905	1 094	15 742	7 861	59 959
1998–99	65	4 999	1 418	13 915	10 195	52 388
1999–00	98	6 002	1 383	14 706	10 023	52 536
2000–01	102	6 075	1 399	14 637	10 036	54 001
2001–02	74	6 860	1 298	16 527	9 349	66 030
2002–03	64	6 891	878	15 300	7 089	65 307
2003–04	41	7 484	588	14 894	5 134	64 976
2004–05	9	8 201	763	14 981	5 252	68 503
2005–06	10	6 644	903	12 487	6 325	63 893
2006–07	4	7 296	705	10 601	4 934	53 697
2007–08	114	6 794	6 452	9 717	20 419	43 863
2008–09	133	4 715	6 530	9 112	22 811	42 335
2009–10	198	4 108	6 812	8 772	21 183	43 894
2010–11	360	4 130	6 087	8 808	20 965	44 139
2011–12	310	4 191	6 627	7 935	23 038	39 376
2012–13	275	6 420	6 802	6 812	23 584	34 398
2013–14	408	5 285	7 300	6 413	25 527	31 828
2014–15	400	5 586	5 751	6 013	19 886	30 845
2015–16	473	4 487	6 948	5 583	26 447	25 870
2016–17	431	5 135	7 039	6 290	27 955	32 803

Lines

	Catches (t)		Total number of days		Total number of sets	
Year	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**
1990–91	–	219	–	56	–	141
1991–92	2	608	1	148	1	569
1992–93	–	1 265	–	267	–	1 007
1993–94	–	1 236	–	249	–	1 011
1994–95	1	2 215	1	397	1	1 614
1995–96	–	1 534	–	346	–	1 396
1996–97	–	3 039	–	552	–	2 224
1997–98	0	3 440	1	711	1	2 719
1998–99	0	2 547	1	653	1	2 424
1999–00	–	1 984	–	395	–	1 346
2000–01	–	1 681	–	289	–	1 082
2001–02	2	1 609	1	274	1	869
2002–03	–	1 063	–	178	–	576
2003–04	1	1 235	1	327	1	965
2004–05	–	1 158	–	204	–	570
2005–06	–	840	–	123	–	460
2006–07	5	673	11	97	29	339
2007–08	134	993	67	153	233	505
2008–09	5	580	42	113	100	383
2009–10	130	1 059	86	145	212	411
2010–11	83	504	92	141	150	445
2011–12	114	1 074	74	188	75	504
2012–13	28	331	34	50	36	147
2013–14	41	923	19	172	20	491
2014–15	57	757	11	181	12	552
2015–16	79	487	34	156	36	468
2016–17	115	602	65	146	75	391

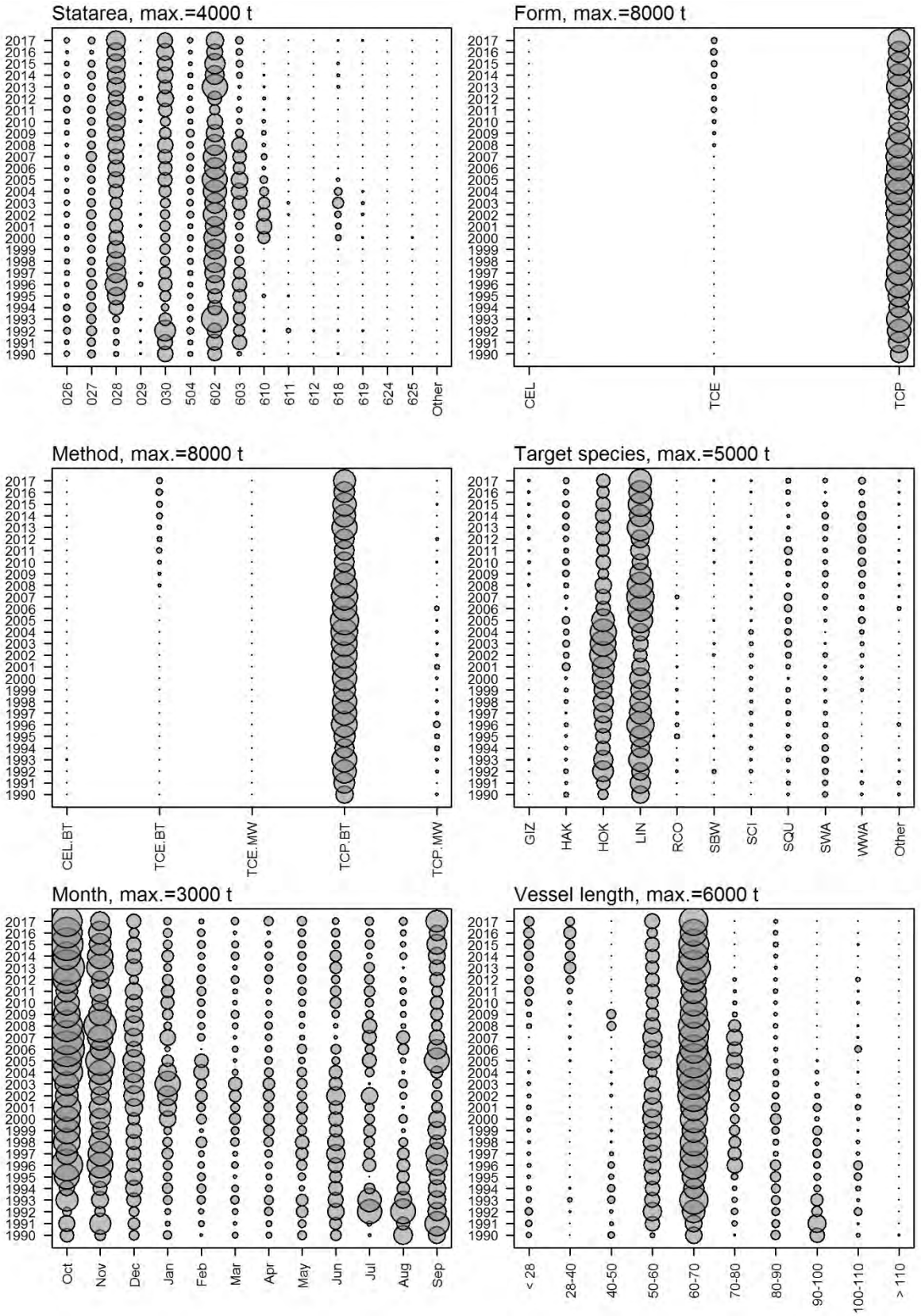


Figure C1: Southland and Sub-Antarctic (LIN 5&6) trawl fishery; distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: GIZ, giant stargazer; HAK, hake; HOK, hoki; LIN, ling; RCO, red cod; SBW, southern blue whiting; SCI, scampi; SQU, arrow squid; SWA, silver warehou; WWA, white warehou.

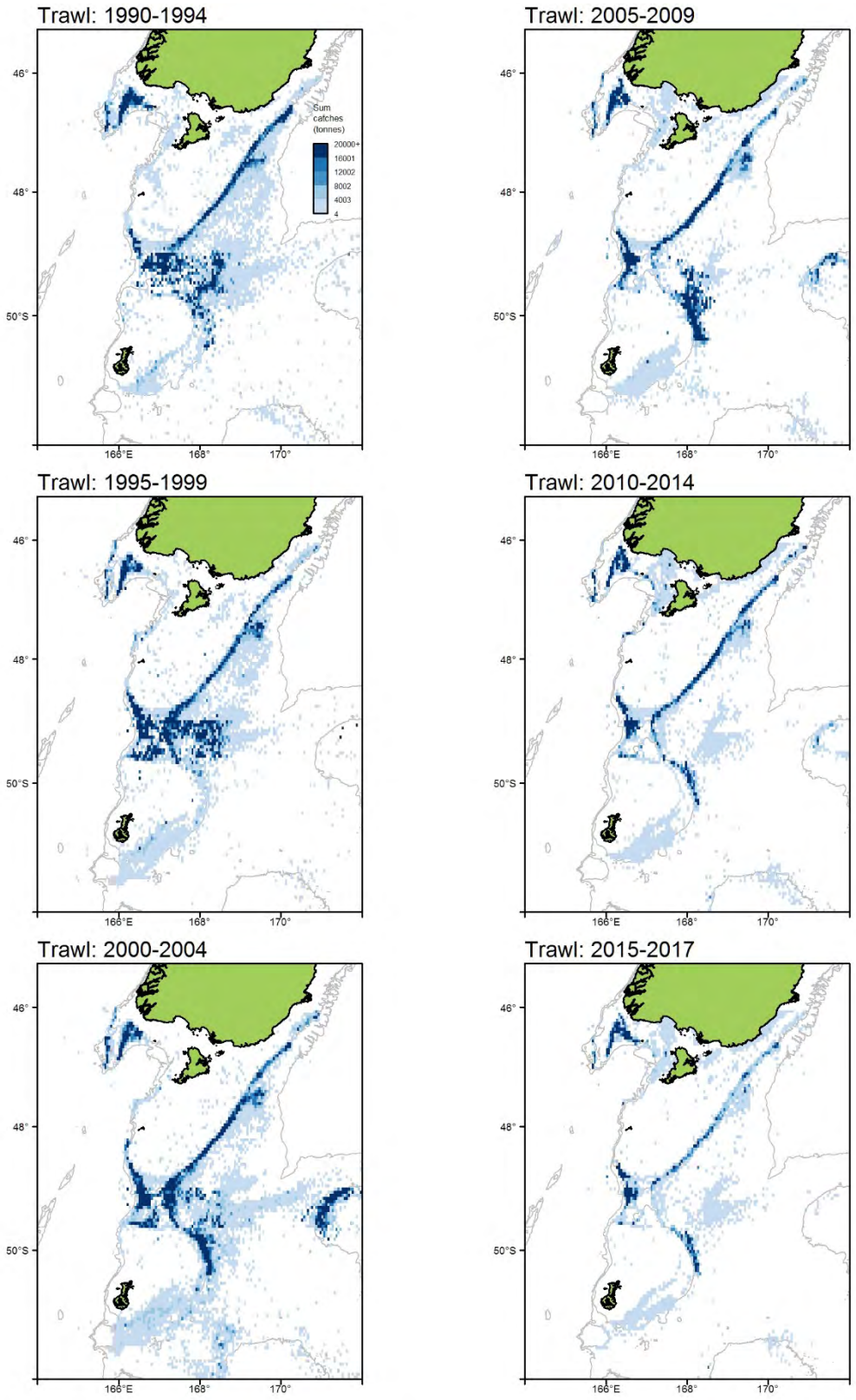


Figure C2: Density plots of Southland and Sub-Antarctic (LIN 5&6) commercial ling trawl catches for combined fishing year groups (labelled by year-ending).

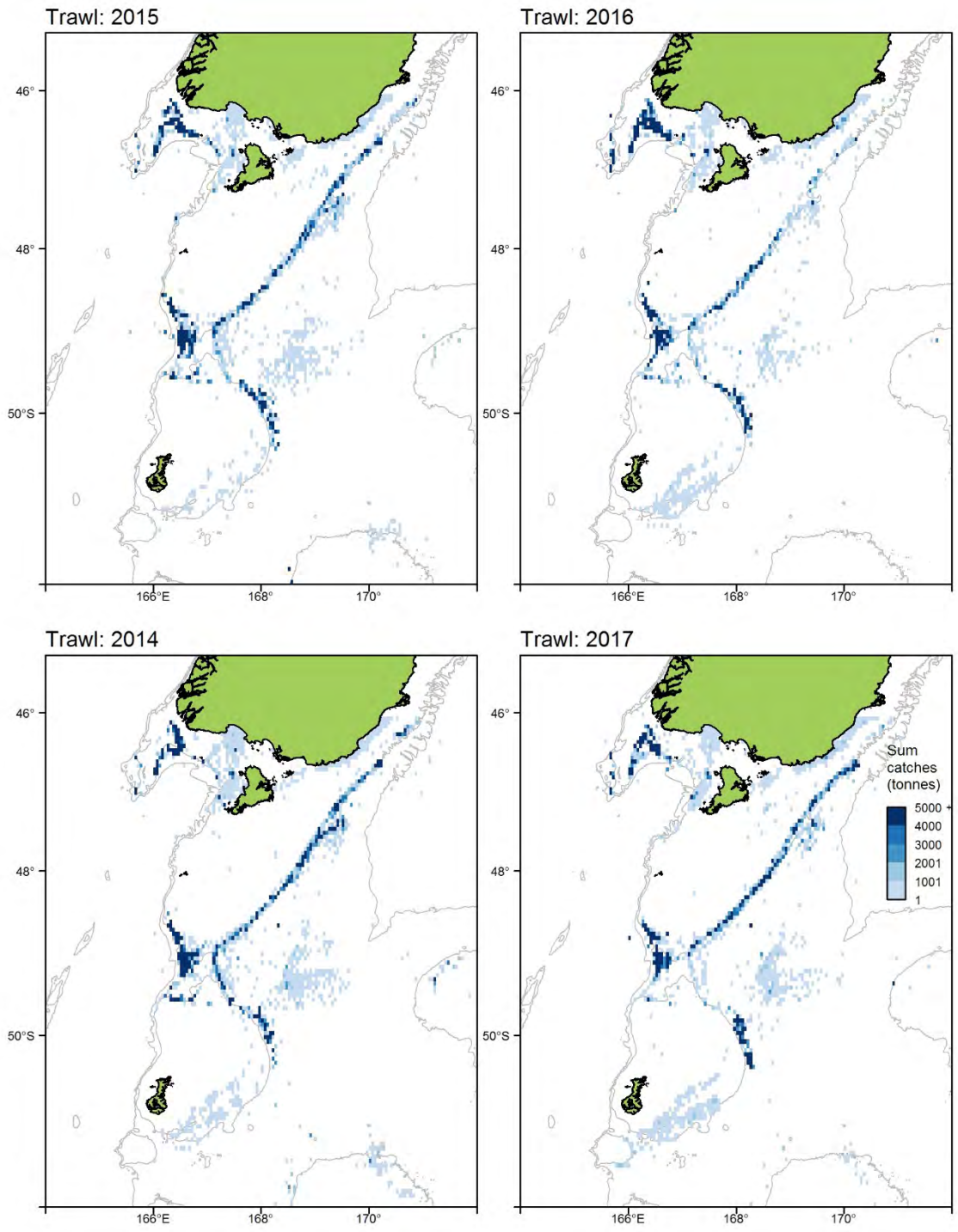


Figure C3: Density plots of Southland and Sub-Antarctic (LIN 5&6) commercial ling trawl catches for each of the 2014–2017 fishing years (labelled by year-ending).

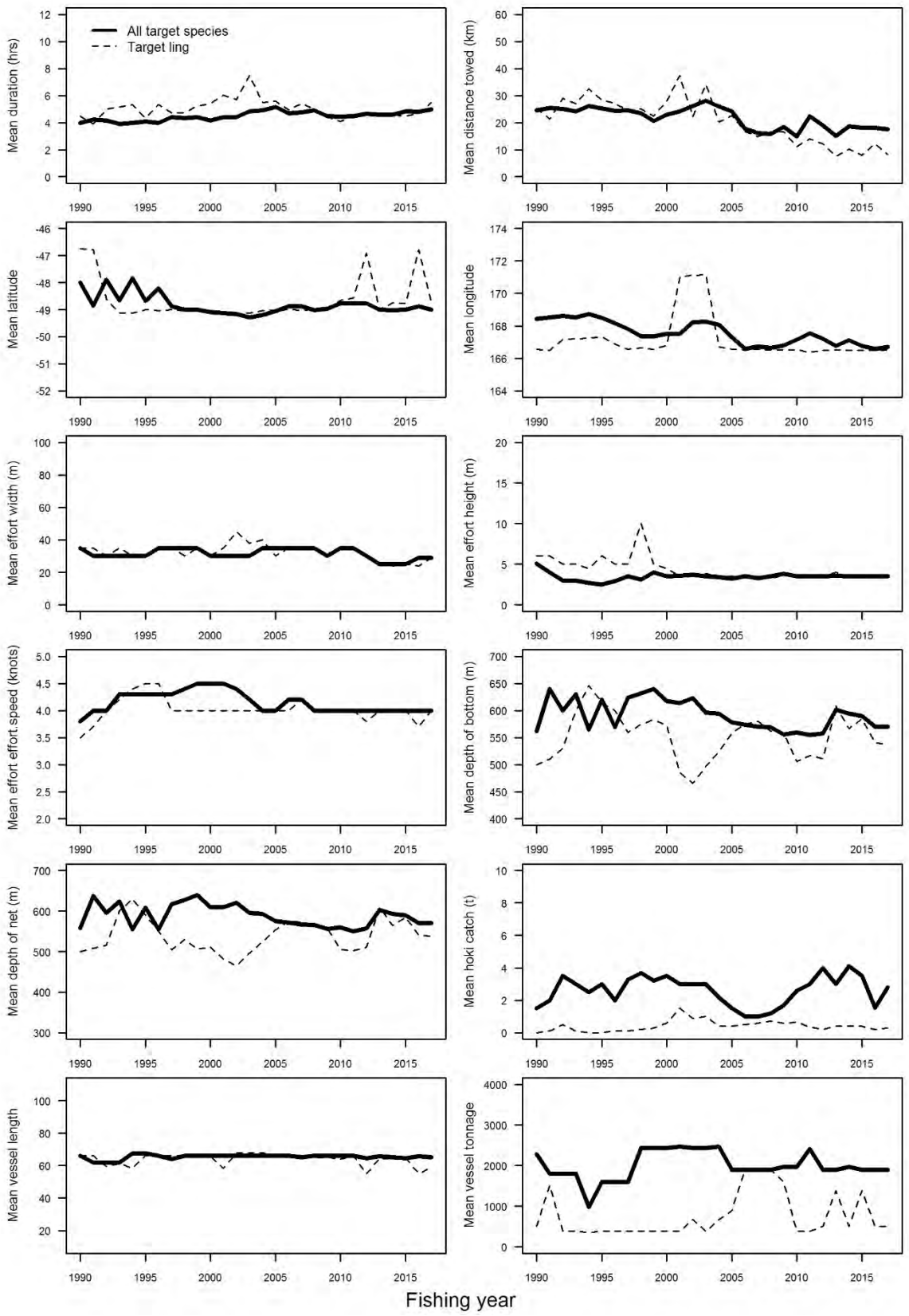


Figure C4: Southland and Sub-Antarctic (LIN 5&6) bottom trawl fishery; means of effort variables by fishing year for tows targeting ling, or targeting hake, hoki, or ling.

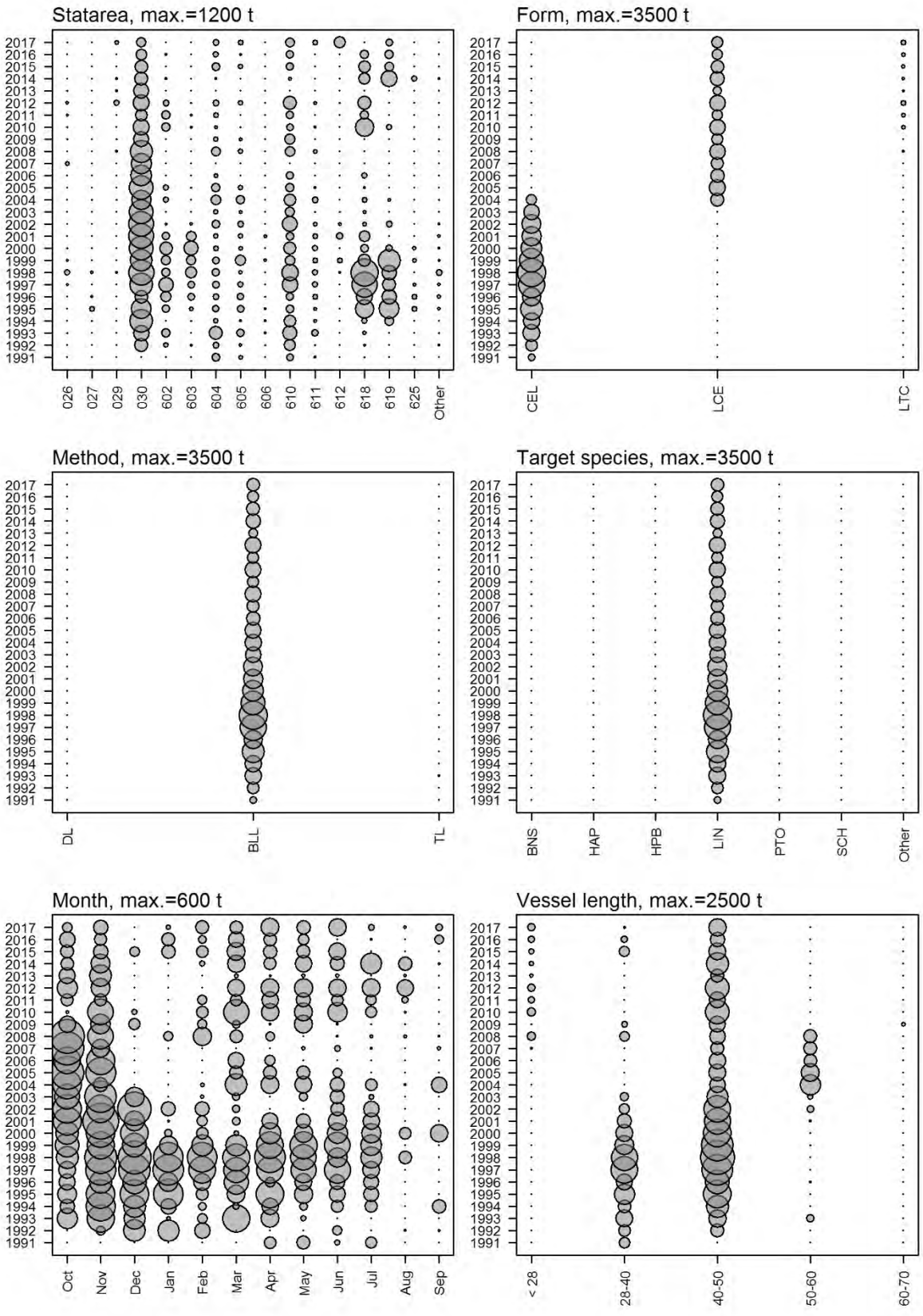


Figure C5a: Southland and Sub-Antarctic (LIN 5&6) line fishery distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: BNS, bluenose; HAP: hapuku; HPB, hapuku and bass; LIN, ling; PTO, Patagonian toothfish; SCH, school shark.

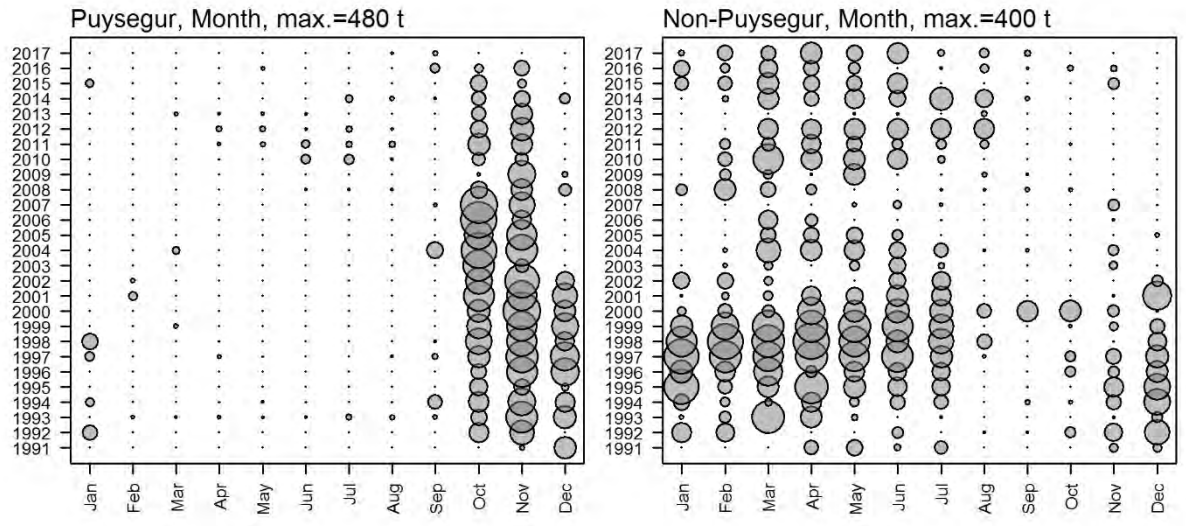


Figure C5b: Southland and Sub-Antarctic (LIN 5&6) continued. Distribution of Southland and Sub-Antarctic ling line fishery catch by month for Puysegur (Statistical Area 030) and non-Puysegur for the 1990 to 2017 calendar years. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

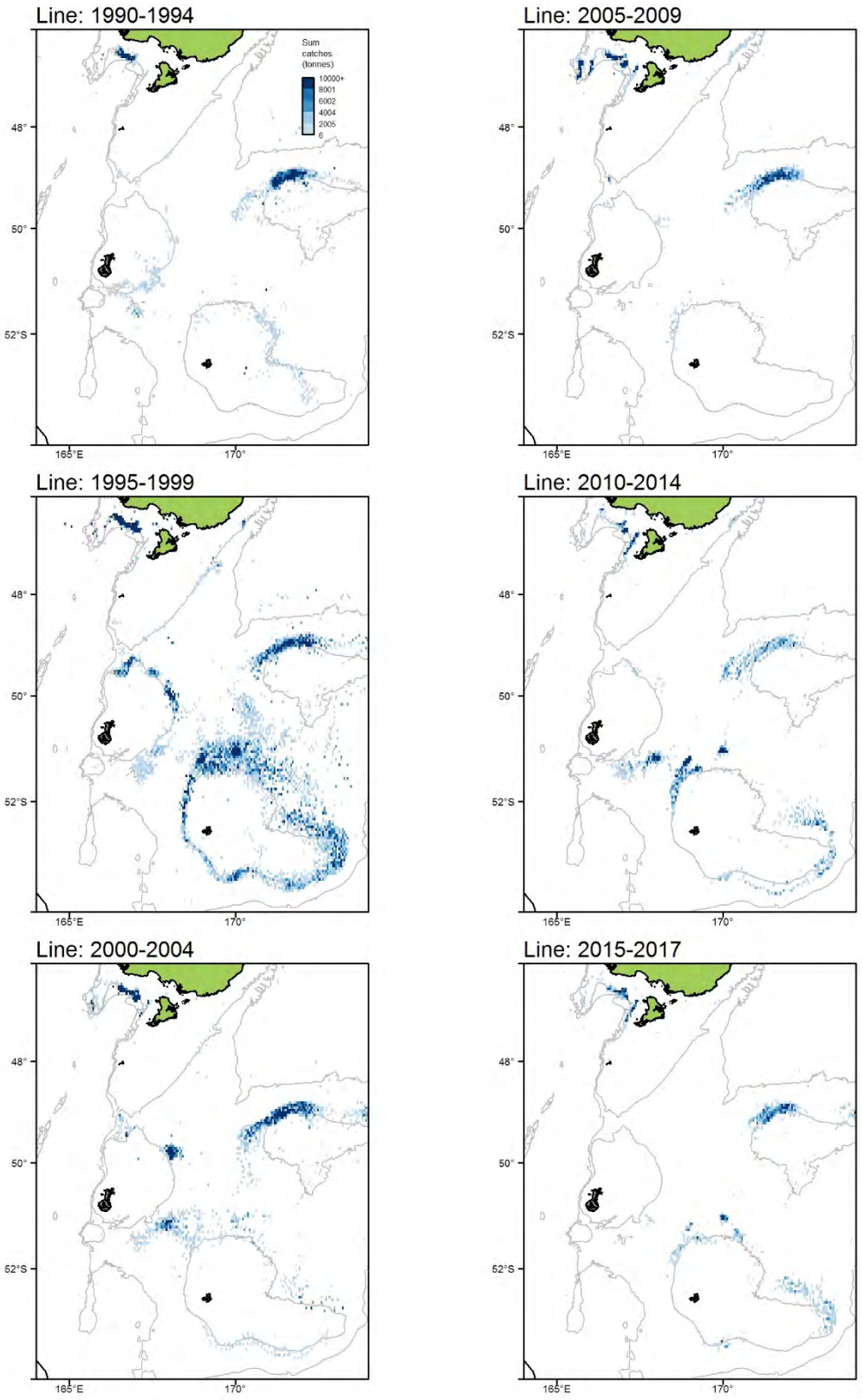


Figure C6: Density plots of Southland and Sub-Antarctic (LIN 5&6) commercial ling line catches for combined fishing year groups (labelled by year-ending).

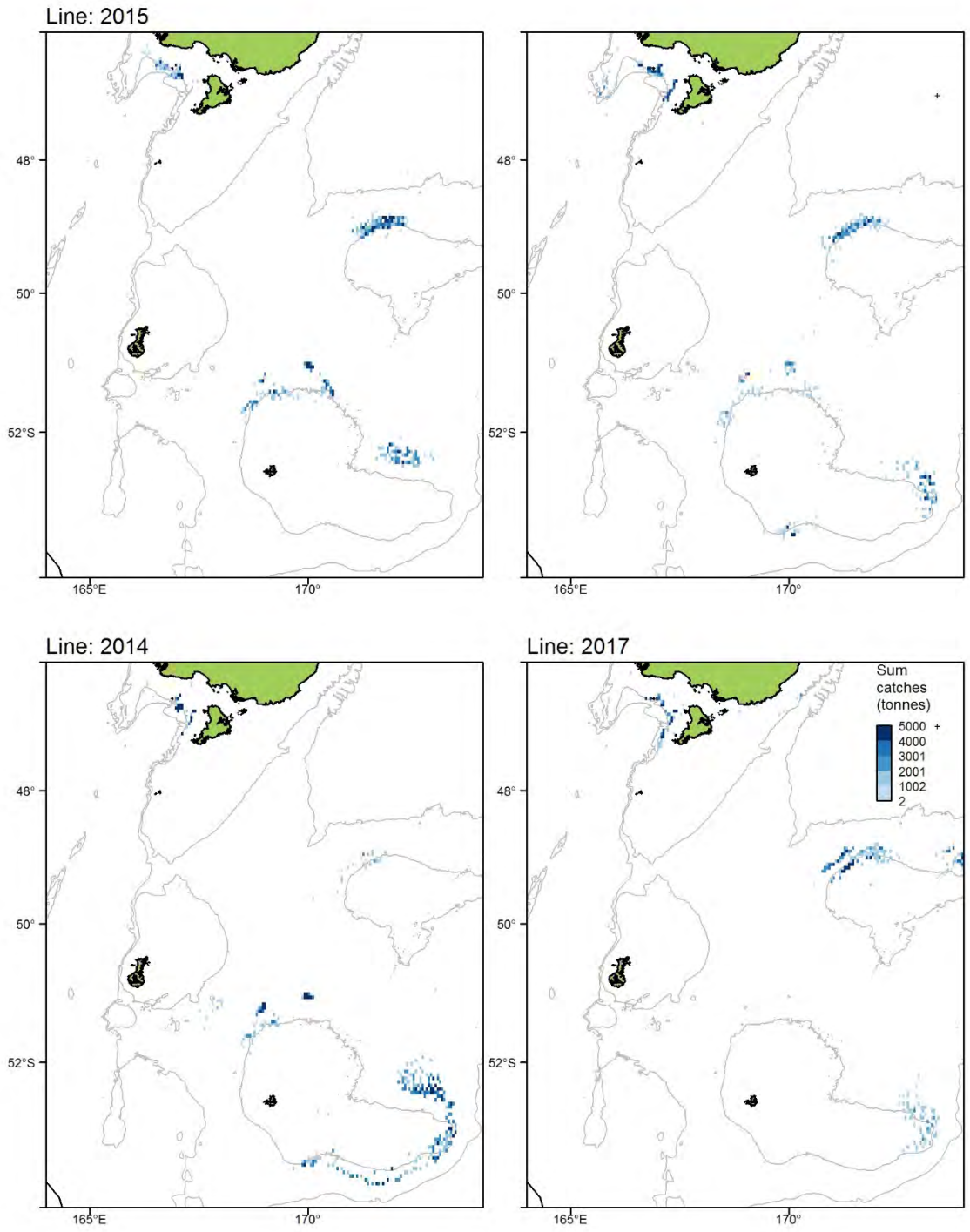


Figure C7: Density plots of Southland and Sub-Antarctic (LIN 5&6) commercial ling line catches for each of the 2014–2017 fishing years (labelled by year-ending).

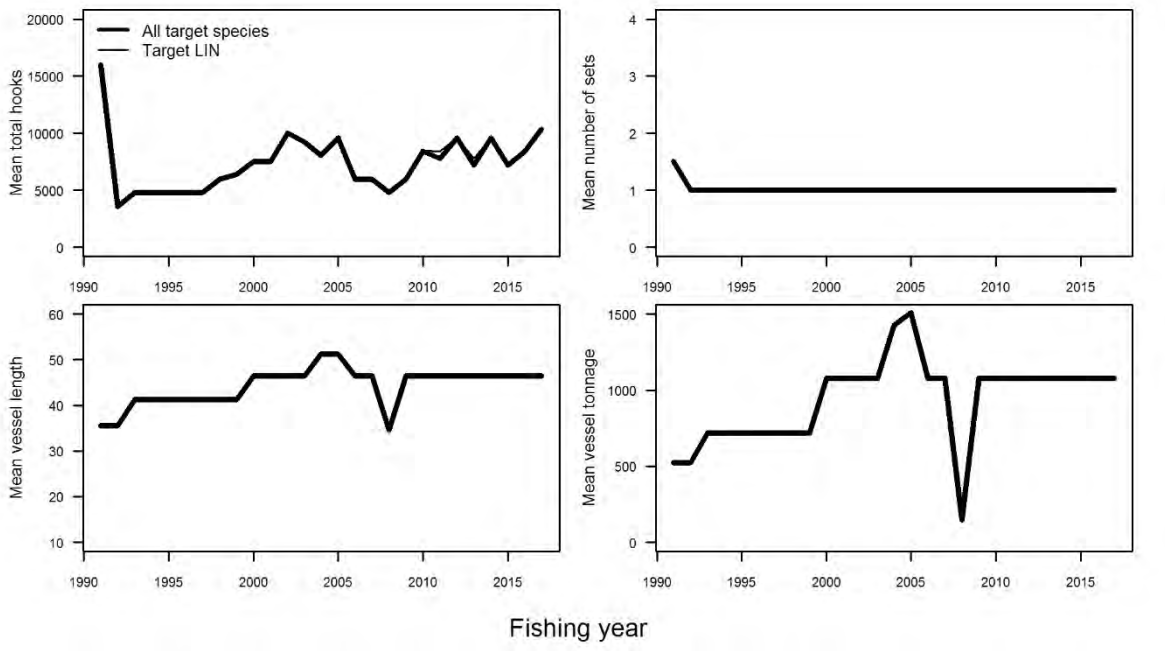


Figure C8: Southland and Sub-Antarctic (LIN 5&6) bottom longline fishery; means of effort variables by fishing year for sets targeting ling (Target LIN), or or targeting ling and other target species ling (All).

9. APPENDIX D: DESCRIPTIVE WEST SI (LIN 7WC)

Table D1: West SI (LIN 7 WC) trawl and line catch by target species and fishing method, 1989–90 to 2016–17. Values have been rounded to the nearest tonne, so '0' denotes catches from 1 to 499 kg and '–' denotes zero catch.

	Trawl fishery				Line fishery	
Year	**Hake**	**Hoki**	**Ling**	**Other**	**Ling**	**Other**
1989–90	1	1 627	59	92	195	2
1990–91	0	1 030	58	62	422	6
1991–92	24	659	94	126	666	26
1992–93	43	729	123	142	662	46
1993–94	35	714	16	86	721	40
1994–95	22	1 683	21	155	824	68
1995–96	11	1 305	16	129	981	13
1996–97	16	1 210	31	169	935	28
1997–98	23	1 517	7	85	973	35
1998–99	41	1 684	4	160	910	62
1999–00	26	1 681	13	100	716	68
2000–01	13	2 034	–	56	869	48
2001–02	22	1 847	8	45	649	10
2002–03	41	1 496	21	45	655	31
2003–04	52	1 566	31	46	662	21
2004–05	69	1 058	79	92	702	26
2005–06	159	1 147	70	76	547	15
2006–07	153	544	76	187	711	34
2007–08	226	322	197	112	940	70
2008–09	204	347	164	205	850	37
2009–10	125	554	213	154	838	27
2010–11	209	742	251	155	846	56
2011–12	124	847	173	127	809	39
2012–13	154	1 073	110	132	922	35
2013–14	145	1 085	107	116	1 146	44
2014–15	205	1 225	86	72	1 133	25
2015–16	99	1 335	105	146	1 114	35
2016–17	61	1 552	159	101	1 102	18

Table D2: West SI (LIN 7 WC) ling catch (t) by fishing method and month from 1989–90 to 2016–17. Values have been rounded to the nearest tonne, so '0' denotes catches from 1 to 499 kg and '–' denotes zero catch.

Trawl

	Month												
Fishing	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1989–90	1	0	0	3	3	13	11	12	269	810	527	131	1 780
1990–91	4	2	0	2	1	1	9	5	190	684	150	103	1 151
1991–92	12	11	1	1	0	2	13	3	29	490	193	148	903
1992–93	17	11	2	1	5	13	21	7	64	546	231	119	1 037
1993–94	10	4	1	3	12	5	8	4	45	509	165	85	851
1994–95	66	2	9	11	4	13	15	5	103	617	245	792	1 881
1995–96	28	2	0	26	10	15	11	17	53	754	261	282	1 461
1996–97	8	15	7	9	7	8	7	29	173	809	159	196	1 426
1997–98	25	32	6	6	0	0	9	11	264	944	263	72	1 631
1998–99	56	43	8	12	10	4	10	21	136	900	539	150	1 889
1999–00	33	2	6	2	1	3	6	17	165	999	446	140	1 820
2000–01	19	4	11	2	2	3	12	18	248	1 098	578	109	2 104
2001–02	1	3	0	2	1	1	8	6	204	1 004	640	53	1 922
2002–03	20	4	5	6	3	7	6	25	251	717	426	133	1 603
2003–04	16	11	0	3	5	8	11	8	72	846	556	161	1 695
2004–05	26	20	7	1	1	4	9	18	108	539	405	161	1 298
2005–06	12	8	4	5	9	3	21	17	139	584	576	75	1 453
2006–07	4	4	6	14	2	1	25	22	243	254	246	140	960
2007–08	31	9	1	14	8	41	48	38	193	245	171	58	857
2008–09	22	7	5	9	8	22	28	70	185	314	202	48	921
2009–10	24	30	7	10	39	41	20	62	138	395	217	61	1 046
2010–11	59	15	35	14	28	31	40	43	188	466	349	92	1 358
2011–12	10	24	24	10	10	12	31	60	156	574	259	101	1 272
2012–13	15	16	21	7	14	12	26	77	381	406	362	133	1 469
2013–14	7	21	7	9	4	7	26	106	287	600	214	165	1 453
2014–15	3	4	2	14	13	8	16	95	348	451	435	199	1 588
2015–16	5	6	3	6	26	24	21	85	311	444	566	187	1 685
2016–17	1	6	6	13	34	45	19	75	369	560	617	128	1 874

Line

	Month												
Fishing	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1989–90	5	22	20	4	16	20	4	0	12	25	28	41	197
1990–91	54	32	11	22	6	8	12	48	35	63	34	102	428
1991–92	40	89	41	18	0	7	48	44	74	61	37	234	691
1992–93	207	87	6	0	11	10	13	4	7	98	137	128	708
1993–94	161	106	29	3	11	8	6	26	64	133	50	165	761
1994–95	218	79	85	41	6	14	11	41	63	72	89	172	891
1995–96	183	99	72	40	11	47	27	45	81	137	122	128	994
1996–97	140	61	53	37	34	57	34	70	76	59	96	247	963
1997–98	144	110	55	3	8	36	62	125	76	95	136	157	1 008
1998–99	129	213	28	64	58	56	65	66	61	71	93	68	972
1999–00	114	68	55	11	13	19	48	59	28	72	144	151	784
2000–01	92	163	67	23	46	24	25	58	72	151	94	101	917
2001–02	144	70	38	0	1	11	26	37	18	123	128	62	659
2002–03	112	69	28	37	28	12	31	54	34	110	130	40	686
2003–04	130	109	37	15	1	22	31	21	26	98	113	78	682
2004–05	172	50	17	41	14	10	10	31	41	65	102	173	728
2005–06	118	39	23	4	4	6	38	44	52	39	93	101	562
2006–07	74	43	67	78	40	47	33	30	14	38	72	208	745
2007–08	84	165	120	45	11	36	36	132	28	82	158	113	1 010
2008–09	102	81	34	55	75	35	51	43	83	100	89	139	887
2009–10	79	54	25	52	75	93	36	88	67	133	126	35	864
2010–11	113	96	36	74	52	42	35	69	82	82	152	68	902
2011–12	79	72	46	56	50	69	63	90	44	108	128	43	848
2012–13	62	122	44	100	98	89	63	128	58	47	92	57	957
2013–14	45	124	29	120	109	143	88	131	110	96	89	105	1 190
2014–15	66	87	92	182	96	102	105	119	38	91	92	86	1 157
2015–16	26	73	64	99	85	120	139	125	62	68	130	157	1 149
2016–17	14	101	119	96	80	138	155	107	56	26	122	106	1 121

Table D3: West SI (LIN 7 WC) catches and effort for vessels < 28 m and ≥28 m overall length, by year.

Trawls

	Catches (t)		Total number of tows		Total duration (hrs)	
Fishing	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**
1989–90	154	1 625	1 072	9 834	10 310	43 067
1990–91	151	999	1 237	9 788	10 453	41 315
1991–92	195	708	1 901	7 991	19 178	31 673
1992–93	237	800	3 234	9 105	31 653	33 364
1993–94	114	737	2 228	11 494	20 657	41 242
1994–95	118	1 763	1 961	12 078	19 091	48 477
1995–96	216	1 244	2 131	8 916	20 663	37 362
1996–97	201	1 225	2 770	10 517	27 163	46 422
1997–98	157	1 474	1 740	10 142	16 012	44 013
1998–99	253	1 636	2 436	9 739	24 382	39 580
1999–00	348	1 471	2 161	8 929	21 432	33 650
2000–01	250	1 854	2 296	9 780	22 679	37 127
2001–02	155	1 767	1 738	8 617	15 388	32 893
2002–03	185	1 418	1 920	8 460	19 086	38 605
2003–04	123	1 572	2 032	7 000	19 998	33 350
2004–05	200	1 098	2 105	5 432	22 376	26 917
2005–06	190	1 263	2 249	4 977	23 559	28 329
2006–07	135	825	2 360	3 975	25 756	23 410
2007–08	246	610	5 979	3 218	27 125	18 351
2008–09	286	636	6 318	2 757	28 097	17 682
2009–10	317	730	6 823	2 754	27 707	12 801
2010–11	364	994	5 602	3 594	22 170	15 990
2011–12	346	925	5 815	3 726	24 204	15 489
2012–13	341	1 128	5 773	3 768	24 088	15 550
2013–14	333	1 120	6 231	4 553	26 421	19 346
2014–15	262	1 325	6 122	5 610	25 522	23 338
2015–16	351	1 334	6 409	5 204	25 914	17 852
2016–17	408	1 466	6 596	5 521	27 277	23 112

Lines

	Catches (t)		Total number of days		Total number of sets	
Fishing	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**	**< 28 m**	**≥ 28 m**
1989–90	197	–	317	–	452	–
1990–91	428	–	509	–	598	–
1991–92	690	2	742	2	845	2
1992–93	708	0	656	1	826	1
1993–94	760	1	709	1	962	1
1994–95	887	4	751	3	921	6
1995–96	974	20	917	7	1 063	25
1996–97	953	9	987	8	1 207	8
1997–98	924	84	792	62	984	173
1998–99	921	51	930	20	1 225	57
1999–00	784	0	826	2	1 172	2
2000–01	916	1	868	1	1 107	1
2001–02	641	17	629	3	860	5
2002–03	686	–	718	–	977	–
2003–04	680	2	735	2	950	2
2004–05	728	–	867	–	1 272	–
2005–06	559	2	744	1	917	1
2006–07	745	–	732	–	1 005	–
2007–08	1 010	–	820	–	1 221	–
2008–09	887	–	763	–	1 176	–
2009–10	864	–	663	–	838	–
2010–11	902	–	768	–	1 494	–
2011–12	848	–	737	–	1 301	–
2012–13	954	2	673	37	1 029	149
2013–14	1 190	1	788	17	1 231	48
2014–15	1 157	0	729	19	990	61
2015–16	1 147	2	759	11	1 020	31
2016–17	1 121	0	669	3	969	18

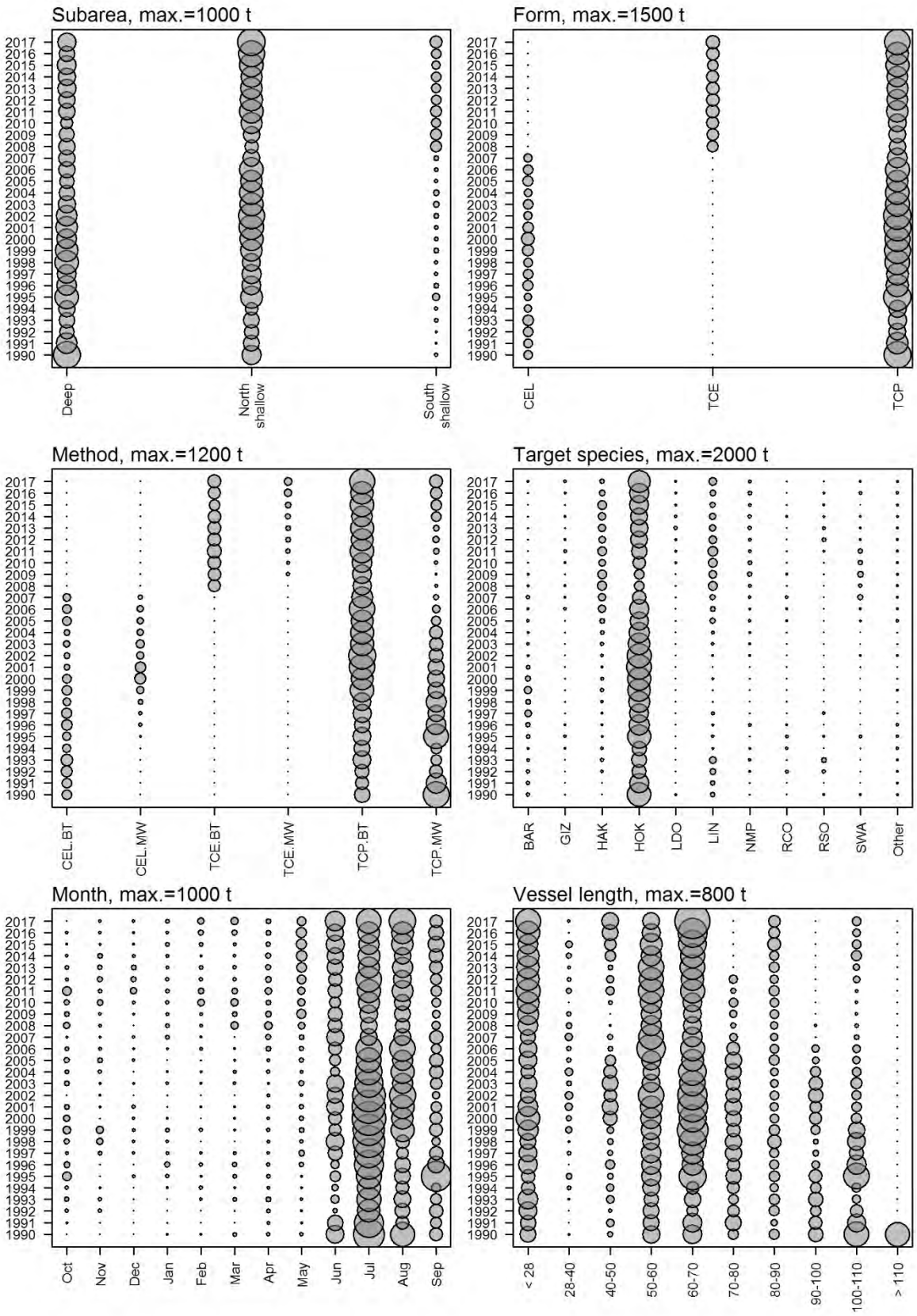


Figure D1: West SI (LIN 7 WC) trawl fishery; distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: BAR, barracouta; GIZ, giant stargazer; HAK, hake; HOK, hoki; LDO, lookdown dory; LIN, ling; NMP, tarakihi; RCO, red cod; RSO, gemfish; SWA, silver warehou.

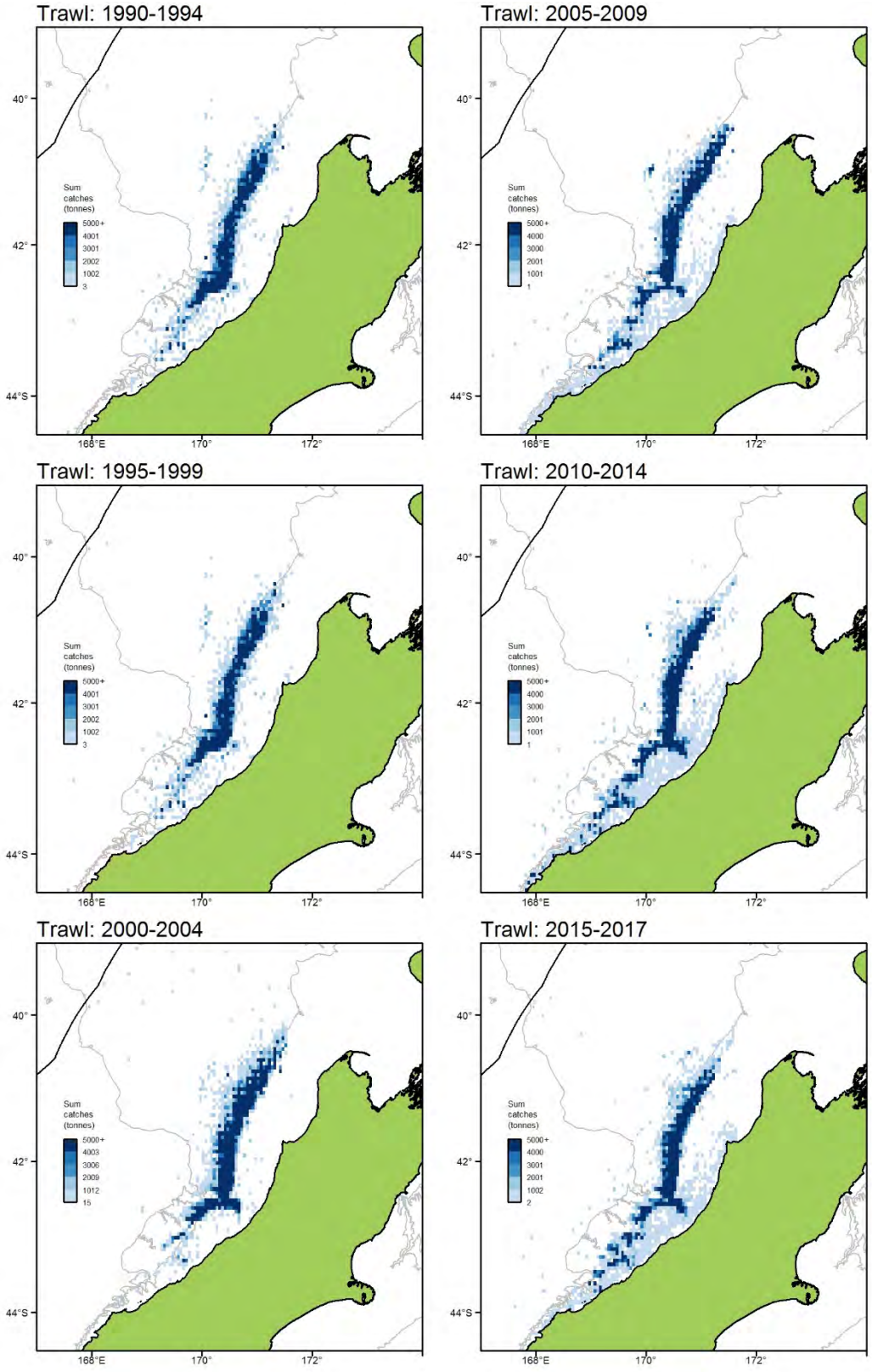


Figure D2: Density plots of West SI (LIN 7 WC) commercial ling trawl catches for combined fishing year groups (labelled by year-ending).

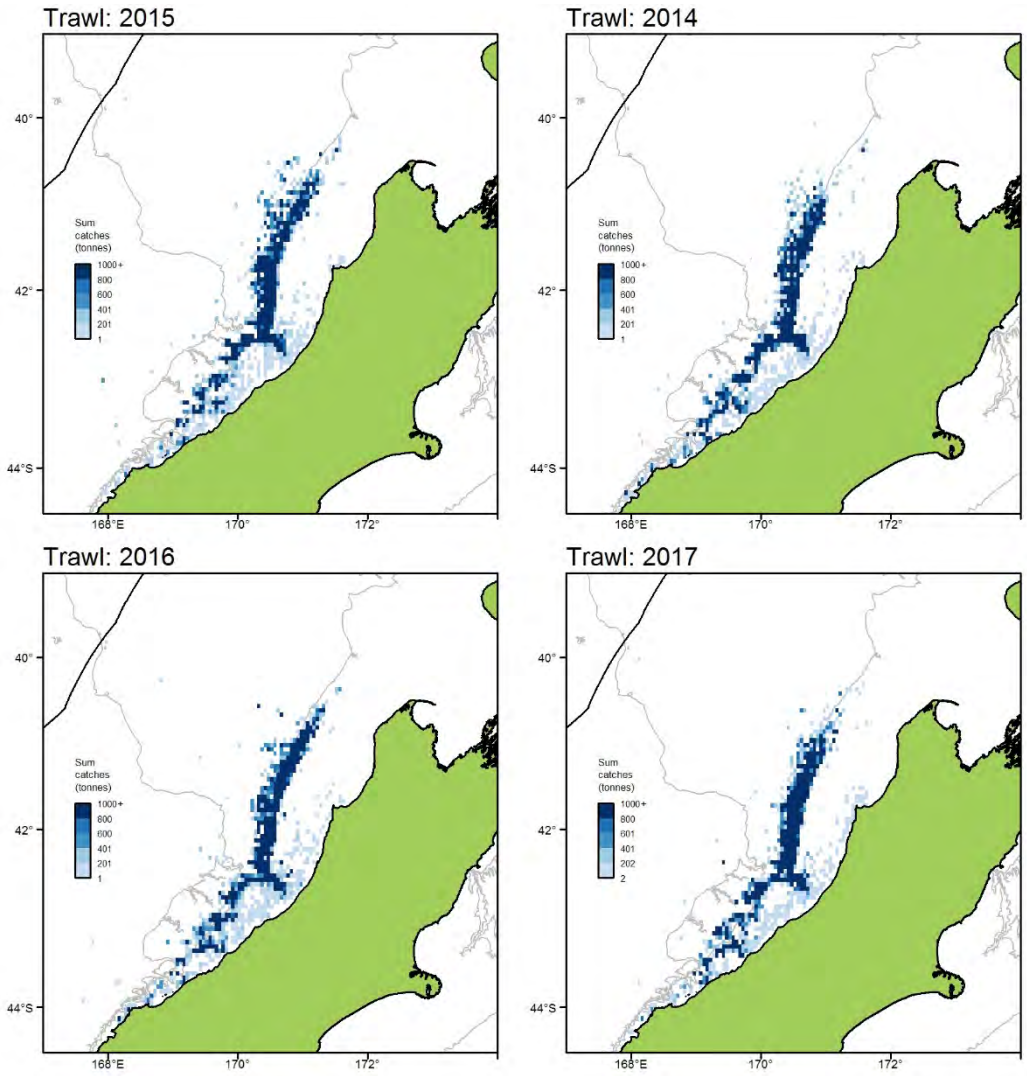


Figure D3: Density plots of West SI (LIN 7 WC) commercial ling trawl catches for each of the 2014–2017 fishing years (labelled by year-ending).

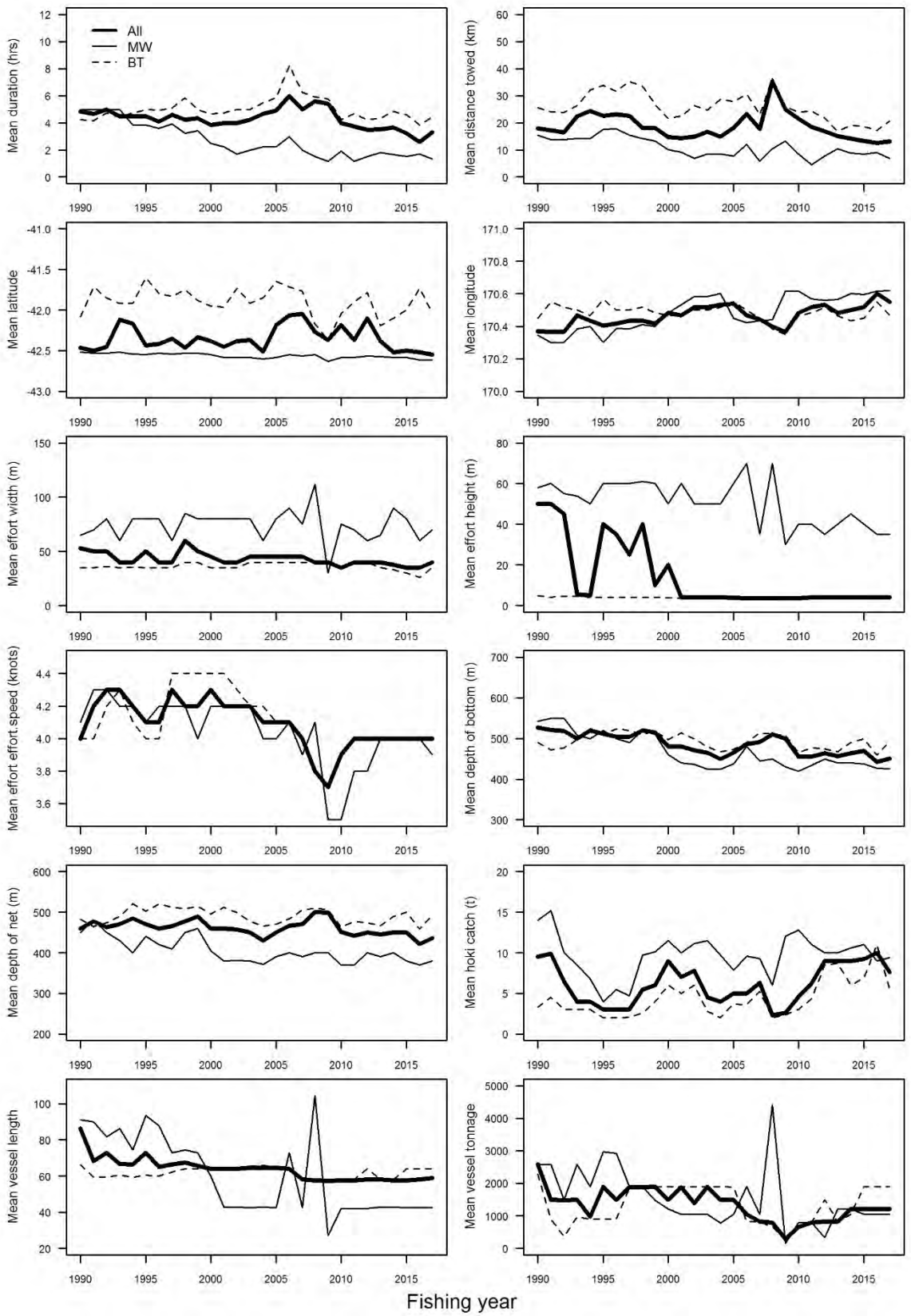


Figure D4: West SI (LIN 7WC) trawl fishery; means of effort variables by fishing year for tows targeting hake, hoki, or ling, for all tows (All), bottom tows (BT), and midwater tows (MW).

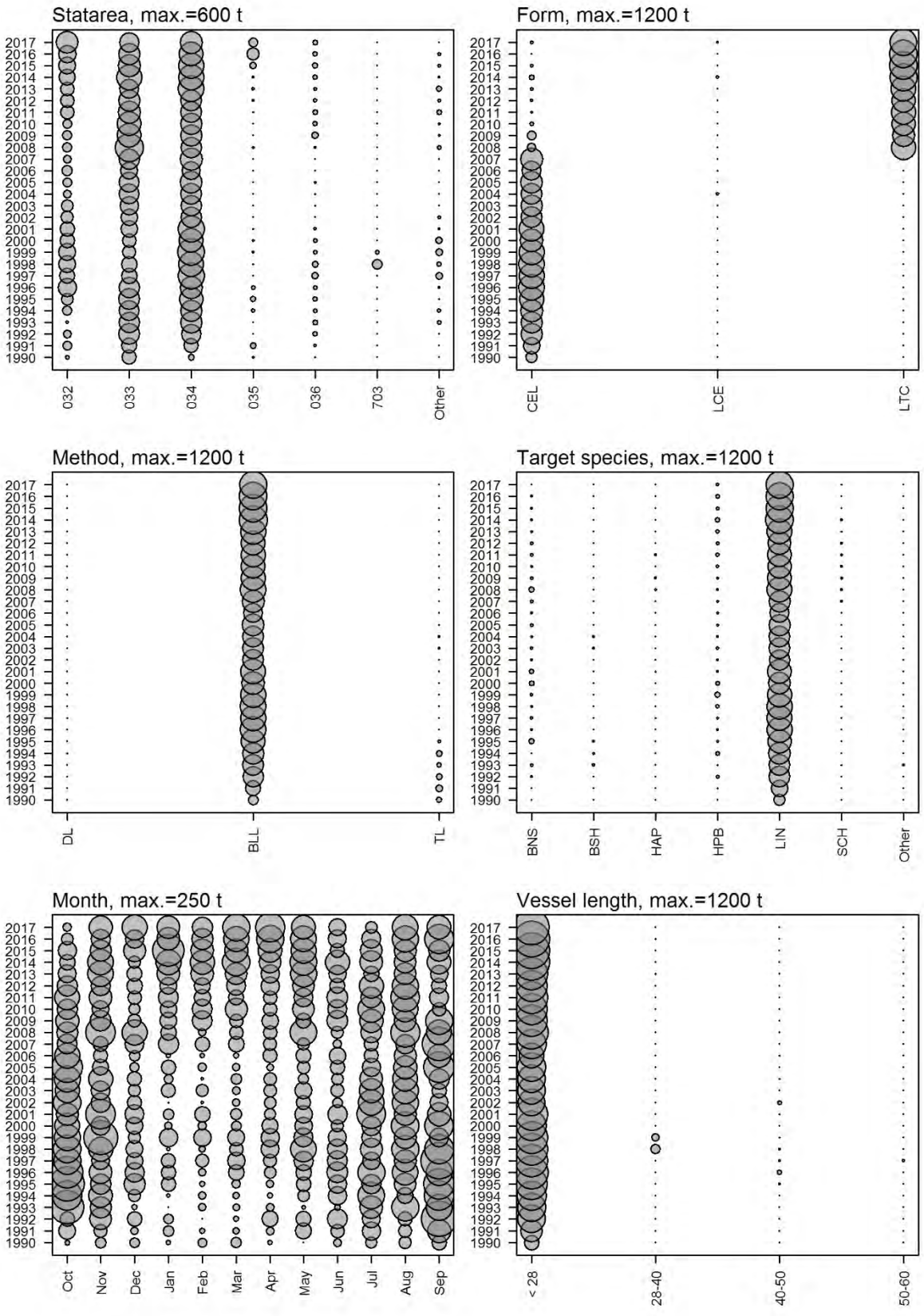


Figure D5: West SI (LIN 7 WC) line fishery distribution of annual catch by statistical area, form type, fishing method (by form type), target species, month, and vessel length. Circle size is proportional to catch; maximum circle size is indicated in the heading of each plot. Species codes: BNS, bluenose; BSH, seal shark; HAP, hapuku; HPB, hapuku and bass; LIN, ling; SCH, school shark.

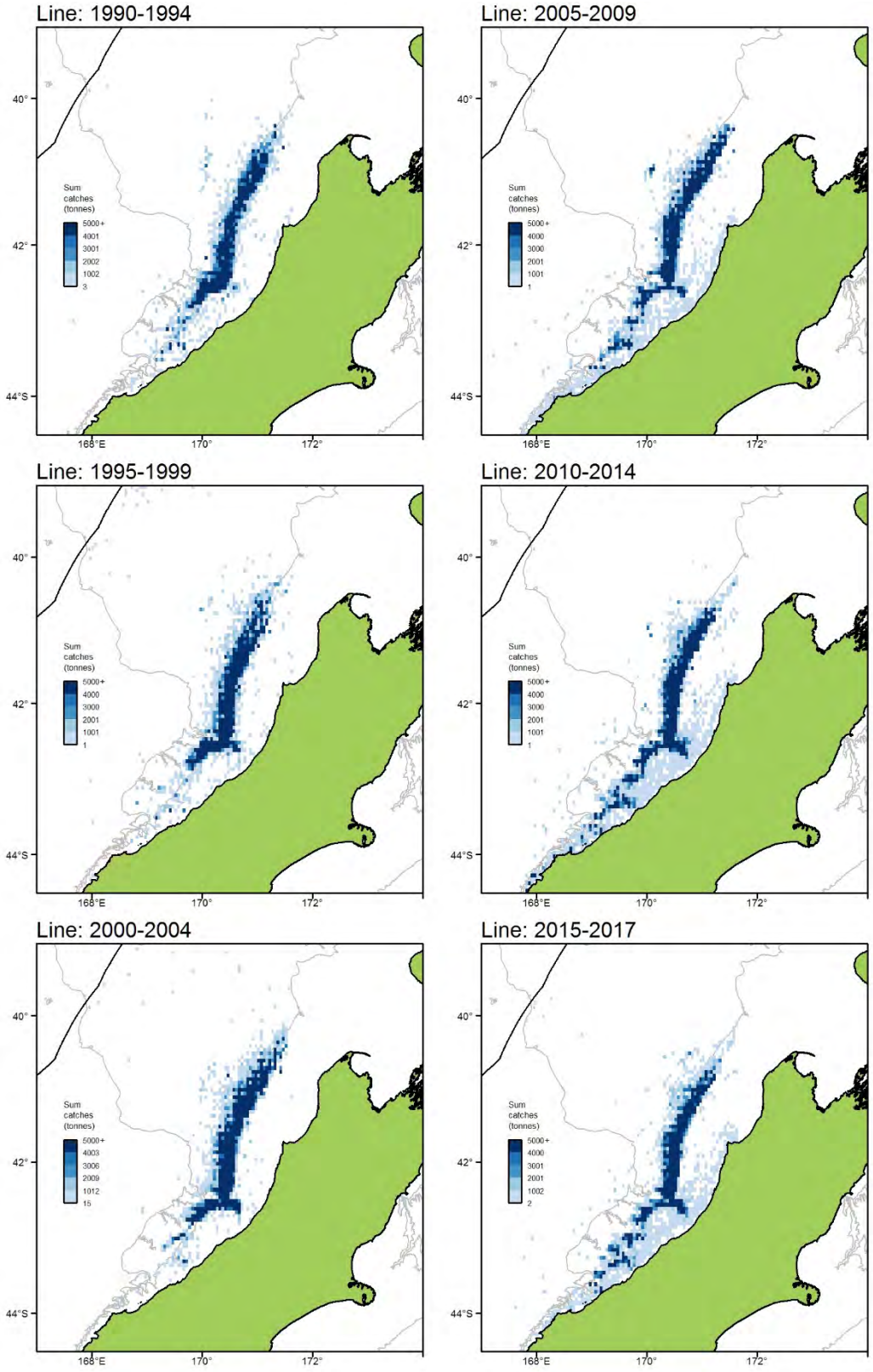


Figure D6: Density plots of West SI (LIN 7 WC) commercial ling line fishery catches for combined fishing year groups (labelled by year-ending).

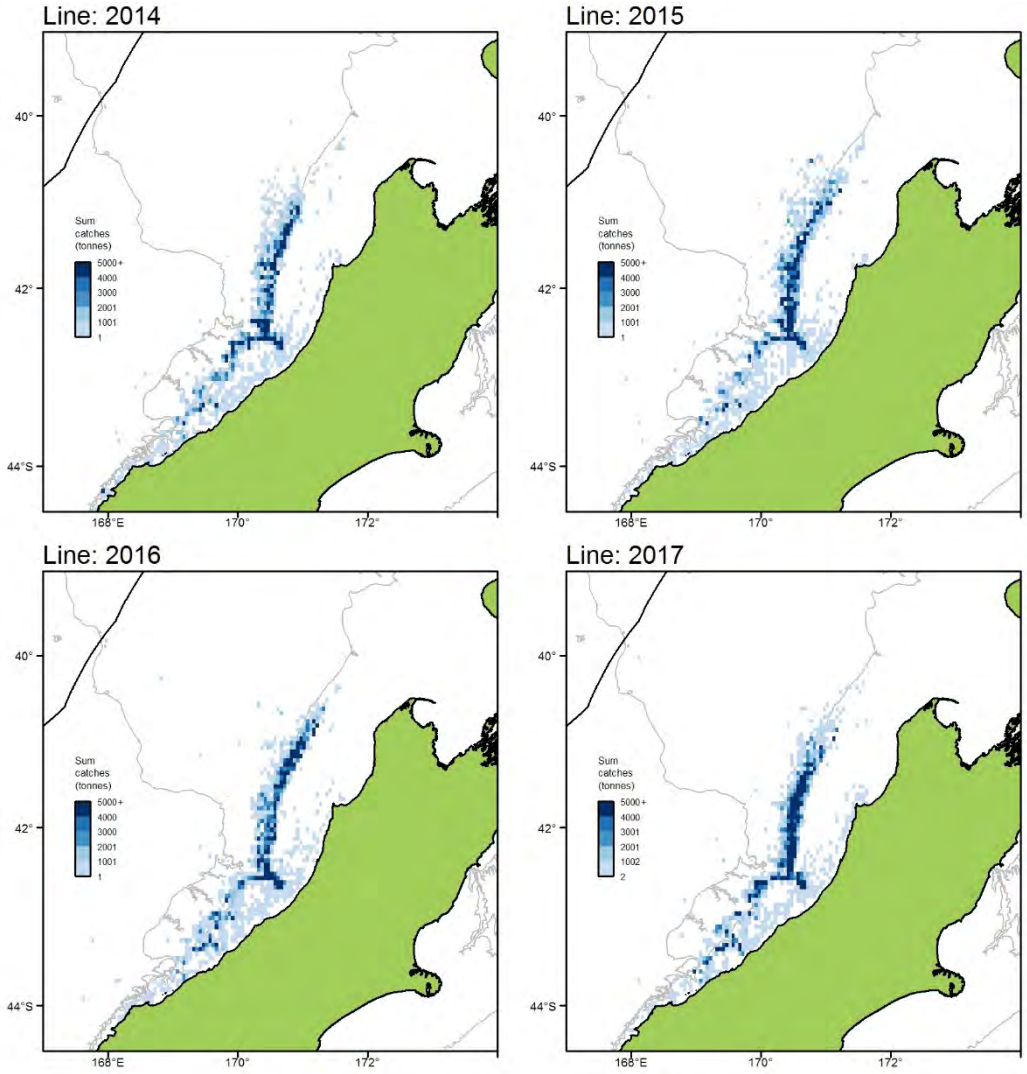


Figure D7: Density plots of West SI (LIN 7 WC) commercial ling line fishery catches for each of the 2014–2017 fishing years (labelled by year-ending).

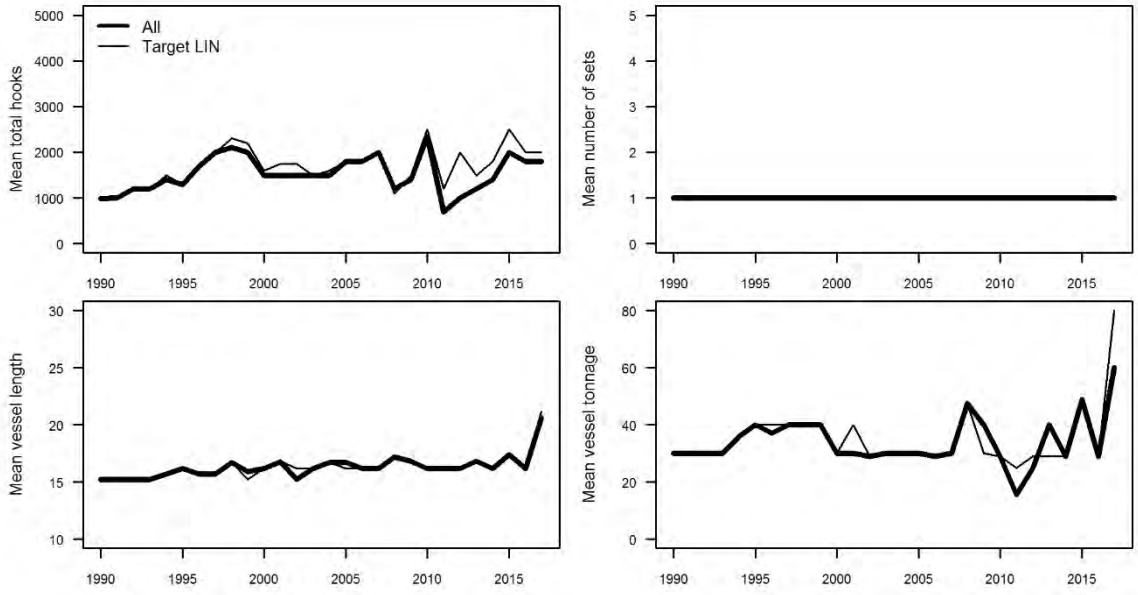


Figure D8: West SI (LIN 7WC) bottom longline fishery; means of effort variables by fishing year for sets targeting ling (Target LIN), or or targeting ling and other target species (All).

10. APPENDIX E: SOUTHLAND AND SUB-ANTARCTIC LINE CPUE (LIN 5&6)

Table E1: Summary of predictors offered in the Southland and Sub-Antarctic 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
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 E2: Percentage of catches, vessel-days, and vessels by vessel type and year groups in the Southland and Sub-Antarctic fishery (LIN 5&6) line fishery. Vessel type: Always auto, vessel has always been an autolongliner; Auto now, currently an autolongline vessel but no information as to whether it converted from Handbait to autolongline in the past; and Handbait, Handbait longliner. Year defined as September–August.

Year	Catches (t)			Number of vessel-days		
	Always auto	Auto now	Handbait	Always auto	Auto now	Handbait
1992–1995	92.8	6.0	1.1	84.6	7.7	7.6
1996–1999	88.4	11.2	0.5	83.2	13.9	3.0
2000–2003	87.7	12.3	-	81.1	18.6	0.3
2004–2007	99.9	0.1	-	98.7	1.3	-
2008–2011	82.5	11.9	5.6	61.8	23.1	15.1
2012–2015	90.9	0.0	9.1	81.5	-	18.5
2016–2017	78.6	3.6	17.8	74.2	5.7	20.0
Total	89.5	8.0	2.5	81.8	11.4	6.9

Year	Number of vessels		
	Always auto	Auto now	Handbait
1992–1995	25.0	25.0	50.0
1996–1999	35.3	23.5	41.2
2000–2003	50.0	37.5	12.5
2004–2007	80.0	20.0	-
2008–2011	36.4	18.2	45.5
2012–2015	25.0	-	75.0
2016–2017	33.3	11.1	55.6
Total	24.4	19.5	56.1

Table E3: CPUE data constraints by area for Southland and Sub-Antarctic line vessels.

	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	1991–2017
Year definition	September–August
Statistical areas	At least 50 sets: 026, 029, 030, 031, 602–605, 610, 611, 612, 618, 619, 625
Method	BLL
Target	LIN
Vessel type	Always autolongline
Catch	1–35 000 kg
Total number of hooks	50–50 000
Core vessel selection	Approx. 89% of catch, ≥ 2 years vessel participation

Table E4: Variables retained in the Southland and Sub-Antarctic (LIN 5&6) line GLMs order of decreasing explanatory value, for each model lognormal and fishery, with the corresponding deviance explained (R-squared, %).

(a) Single line fishery – vessels that have always been autolongline

Variable	R-squared
Year	8.99
Number of hooks	54.27
Statistical area	60.33
Vessel	61.50

(b)Two fishery model – vessels that have always been autolongline

Variable	R-squared
Year	20.21
Number of hooks	60.20
Statistical area	62.12

Table E5: CPUE standardised year lognormal indices for Southland and Sub-Antarctic line fisheries for vessels that have always been autolongline vessels (with CVs). Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

	Single line fishery			Spawning fishery			Non-spawning fishery		
Year	Index	CI	CV	Index	CI	CV	Index	CI	CV
1992	1.00	0.82–1.21	0.10	1.03	0.80–1.33	0.13	1.15	0.94–1.40	0.10
1993	1.39	1.16–1.66	0.09	1.76	1.47–2.10	0.09	1.16	0.93–1.44	0.11
1994	1.10	0.93–1.31	0.09	1.59	1.29–1.95	0.10	1.02	0.86–1.22	0.09
1995	1.25	1.07–1.46	0.08	1.26	1.08–1.47	0.08	1.44	1.24–1.68	0.08
1996	1.06	0.89–1.26	0.09	1.33	1.06–1.66	0.11	1.05	0.89–1.24	0.08
1997	1.18	1.02–1.37	0.07	1.27	1.07–1.50	0.08	1.30	1.15–1.47	0.06
1998	1.05	0.92–1.20	0.07	1.15	0.99–1.34	0.07	1.10	0.98–1.23	0.06
1999	0.82	0.74–0.91	0.05	1.03	0.87–1.22	0.09	0.74	0.66–0.83	0.06
2000	0.96	0.85–1.08	0.06	1.07	0.89–1.30	0.10	0.86	0.74–0.99	0.07
2001	1.21	1.06–1.38	0.07	1.29	1.10–1.52	0.08	1.03	0.85–1.24	0.09
2002	1.25	1.08–1.45	0.07	1.36	1.15–1.61	0.09	0.99	0.77–1.27	0.13
2003	1.31	1.09–1.57	0.09	1.49	1.21–1.82	0.10	0.64	0.46–0.90	0.17
2004	0.82	0.71–0.94	0.07	0.78	0.63–0.96	0.11	0.71	0.62–0.81	0.07
2005	0.83	0.71–0.97	0.08	1.02	0.86–1.20	0.08	0.71	0.58–0.88	0.11
2006	1.08	0.90–1.29	0.09	1.46	1.16–1.84	0.11	0.78	0.59–1.04	0.14
2007	1.13	0.91–1.41	0.11	1.19	0.96–1.49	0.11	0.76	0.32–1.78	0.45
2008	1.23	1.00–1.51	0.10	1.27	1.05–1.55	0.10	-	-	-
2009	0.95	0.77–1.17	0.11	1.03	0.79–1.36	0.14	0.92	0.66–1.28	0.17
2010	1.30	1.10–1.54	0.09	2.05	1.40–3.00	0.19	1.18	0.98–1.42	0.09
2011	0.75	0.62–0.89	0.09	0.69	0.48–0.99	0.18	0.76	0.62–0.92	0.10
2012	1.01	0.88–1.18	0.07	1.04	0.78–1.37	0.14	0.99	0.84–1.16	0.08
2013	0.99	0.73–1.34	0.15	1.10	0.81–1.49	0.15	-	-	-
2014	0.85	0.73–1.00	0.08	0.87	0.63–1.21	0.16	0.84	0.70–1.00	0.09
2015	0.75	0.63–0.90	0.09	0.65	0.47–0.90	0.16	0.84	0.71–0.99	0.08
2016	0.54	0.46–0.64	0.09	0.58	0.43–0.80	0.16	0.52	0.43–0.64	0.10
2017	0.78	0.66–0.92	0.08	0.64	0.38–1.09	0.27	0.72	0.60–0.86	0.09

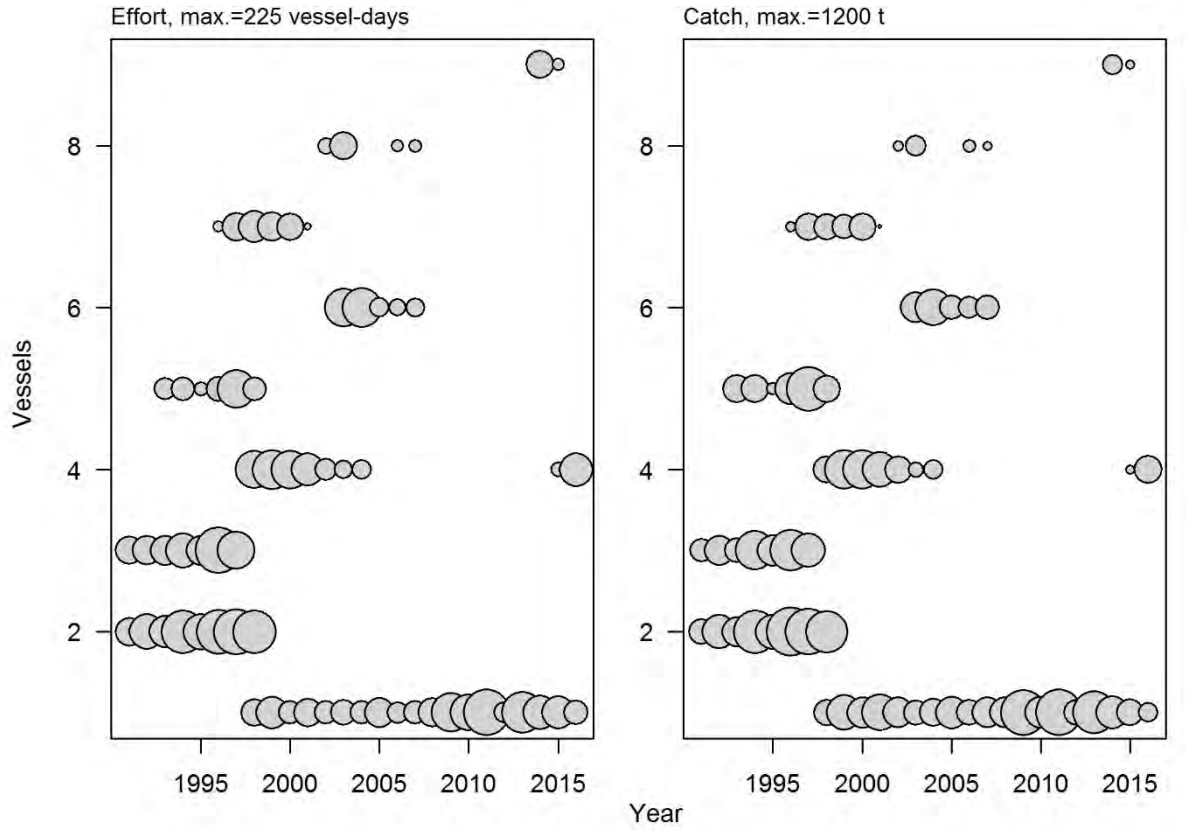


Figure E1: Southland and Sub-Antarctic autolongline single fishery fishing effort and catches by year for individual vessels (denoted anonymously by number on the y-axis) in core CPUE analyses. Circle area is proportional to the effort or catch. Year defined as September–August.

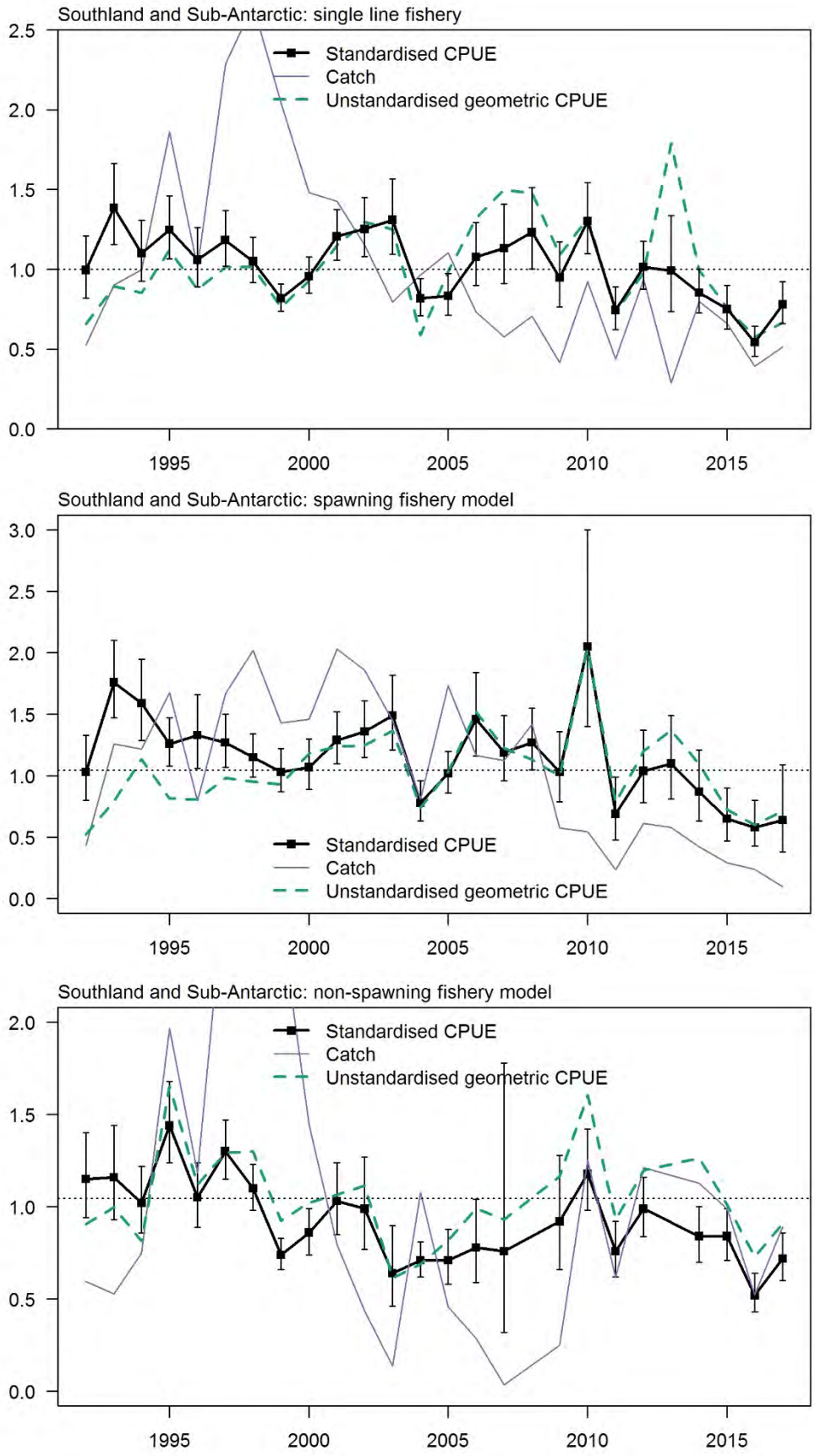


Figure E2: Year index from the lognormal model for each Southland and Sub-Antarctic autolongline fishery. Bars indicate 95% confidence intervals. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

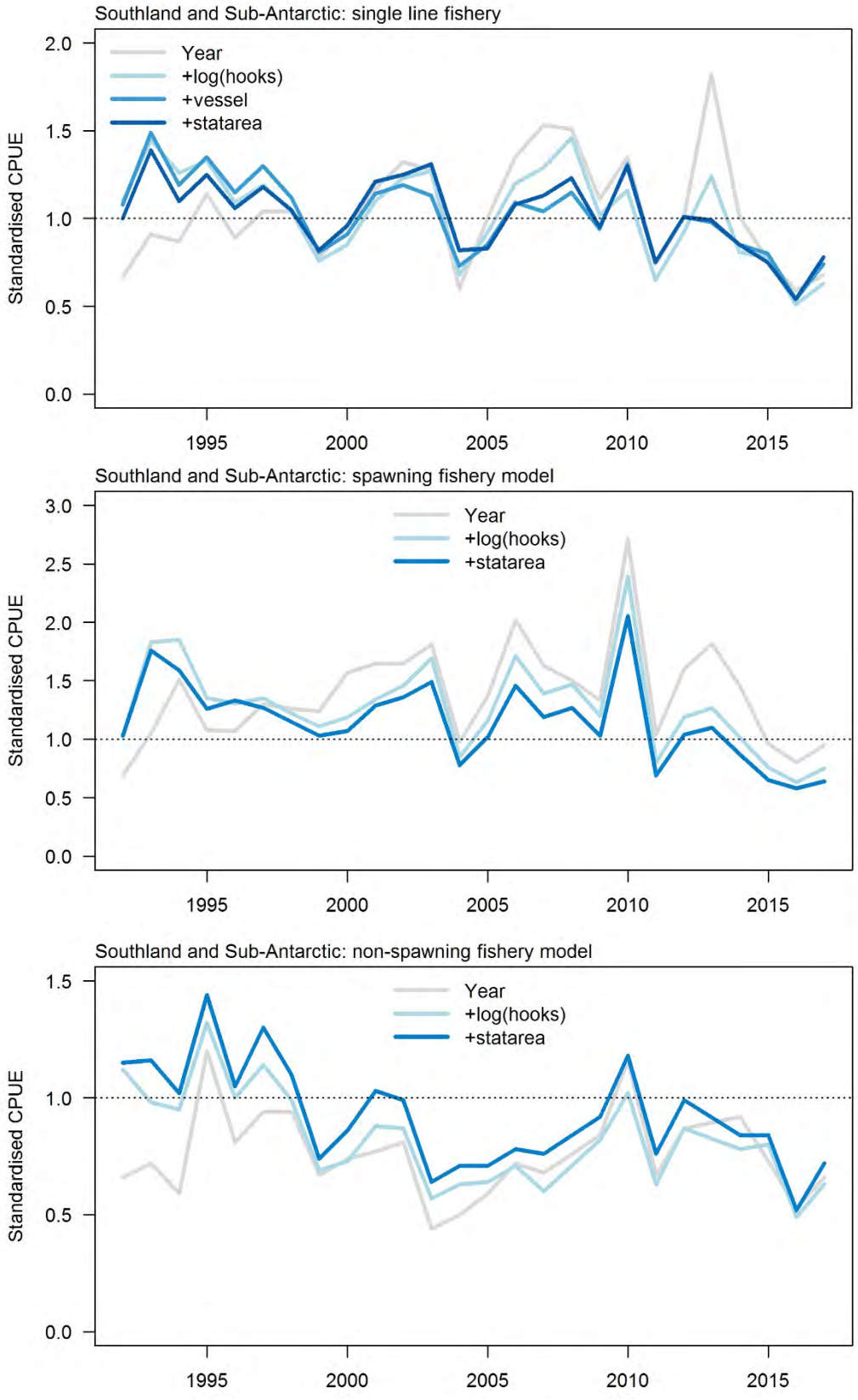


Figure E3: Addition of variables into the lognormal CPUE model for each Southland and Sub-Antarctic autolongline fishery. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

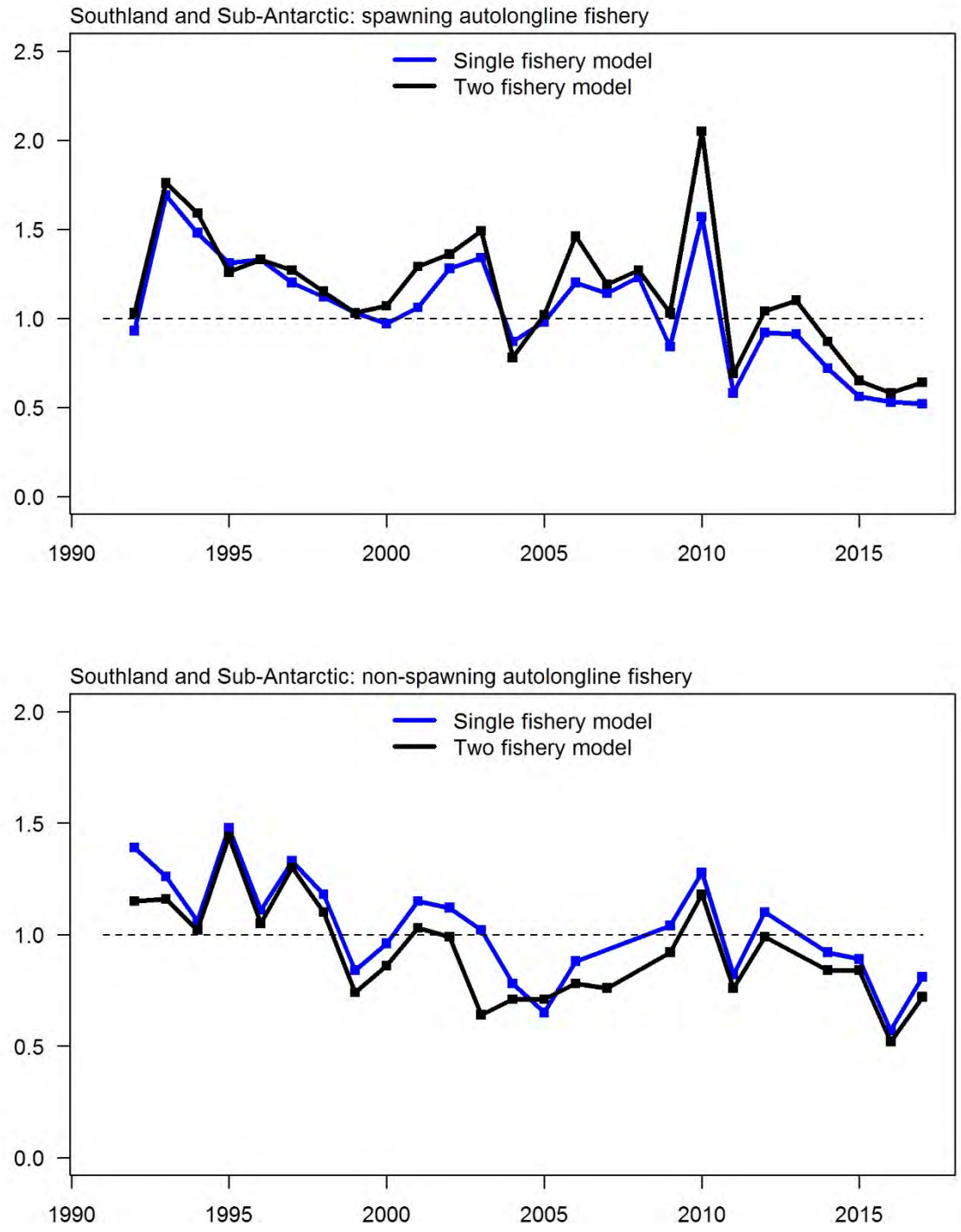


Figure E4a: CPUE indices for the lognormal model for the Southland and Sub-Antarctic autolongline single and two fishery (spawning and non-spawning fisheries). Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

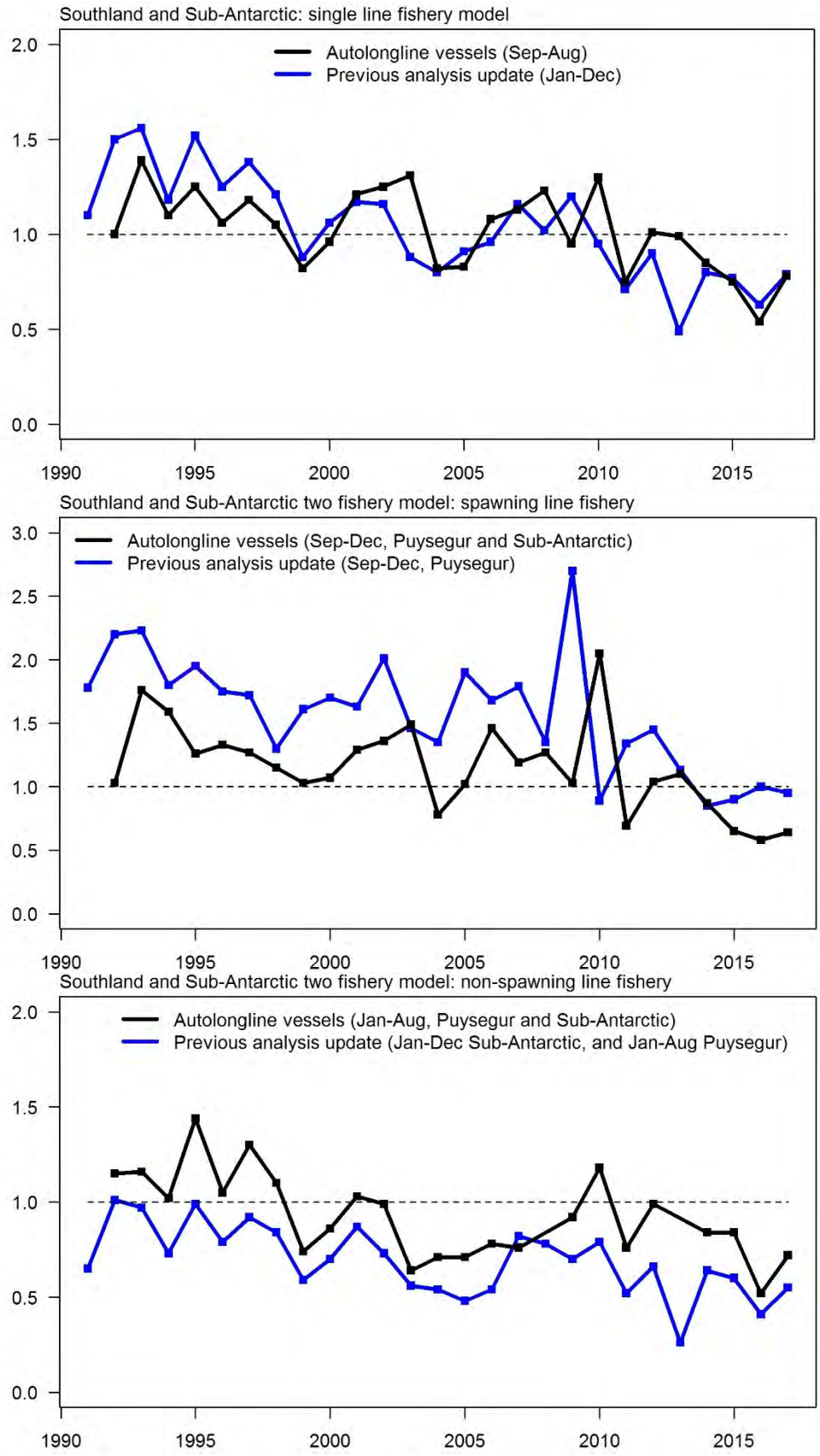


Figure E4b: CPUE indices for the lognormal model for the Southland and Sub-Antarctic single fishery (spawning and nonspawning) and two fishery (spawning and non-spawning) models, comparing the current core vessel analysis with the previous analysis. For the current analysis year is defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

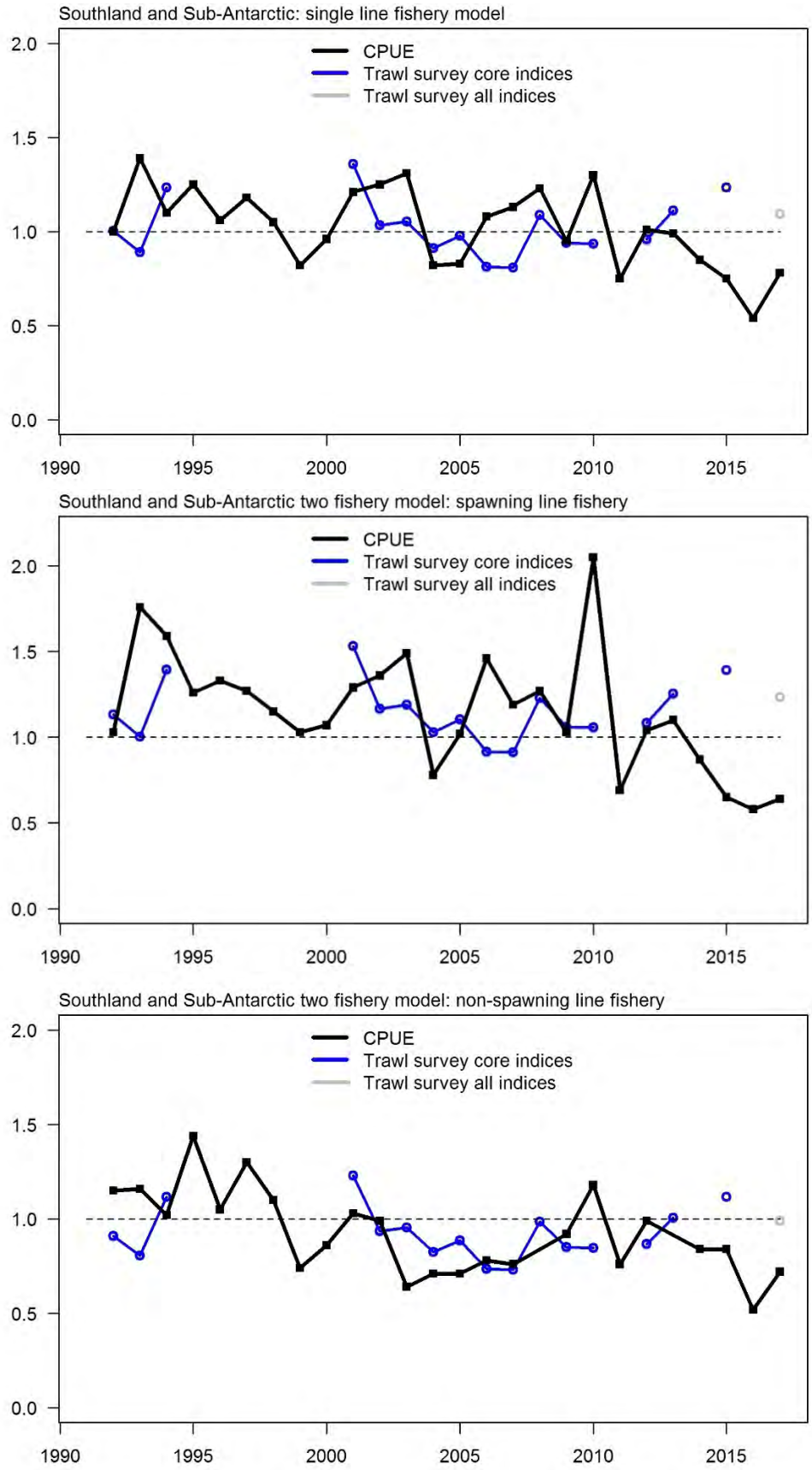


Figure E4c: Comparison of the Southland and Sub-Antarctic CPUE autolongline models to Southland and Sub-Antarctic *Tangaroa* ling trawl survey biomass indices. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

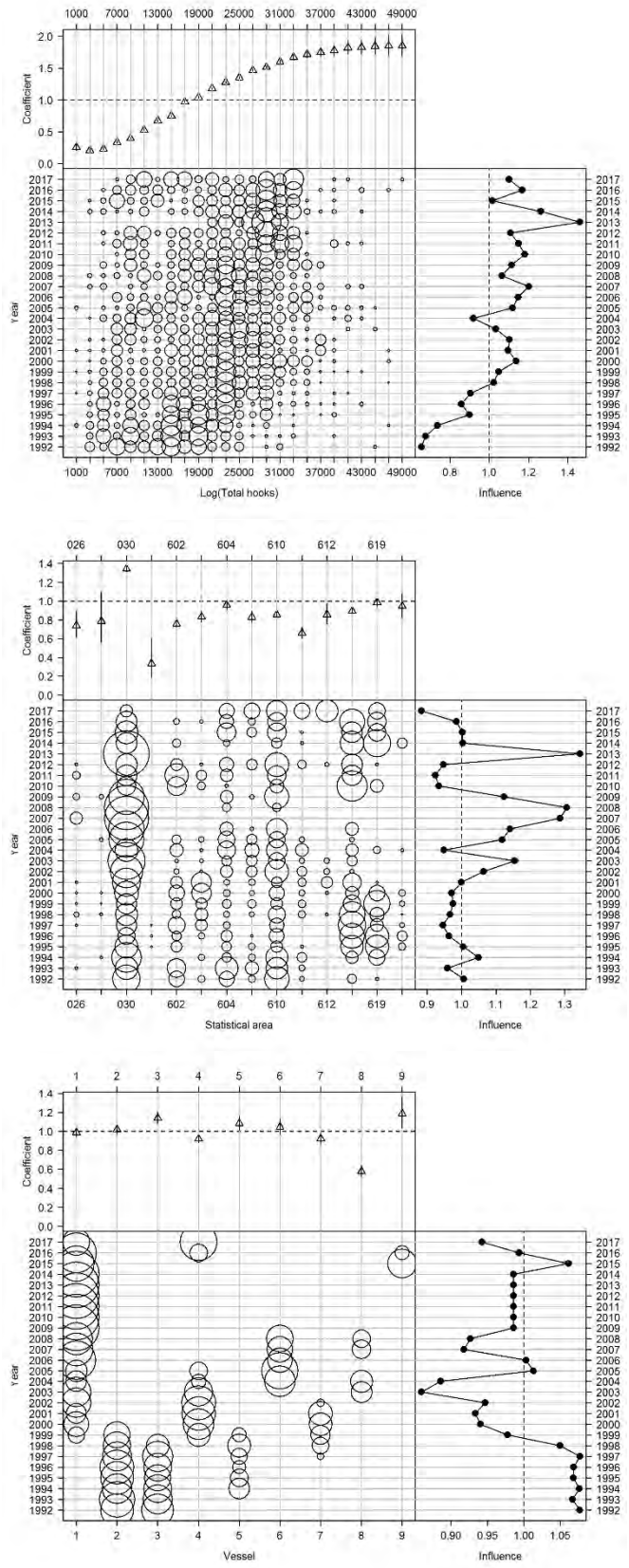
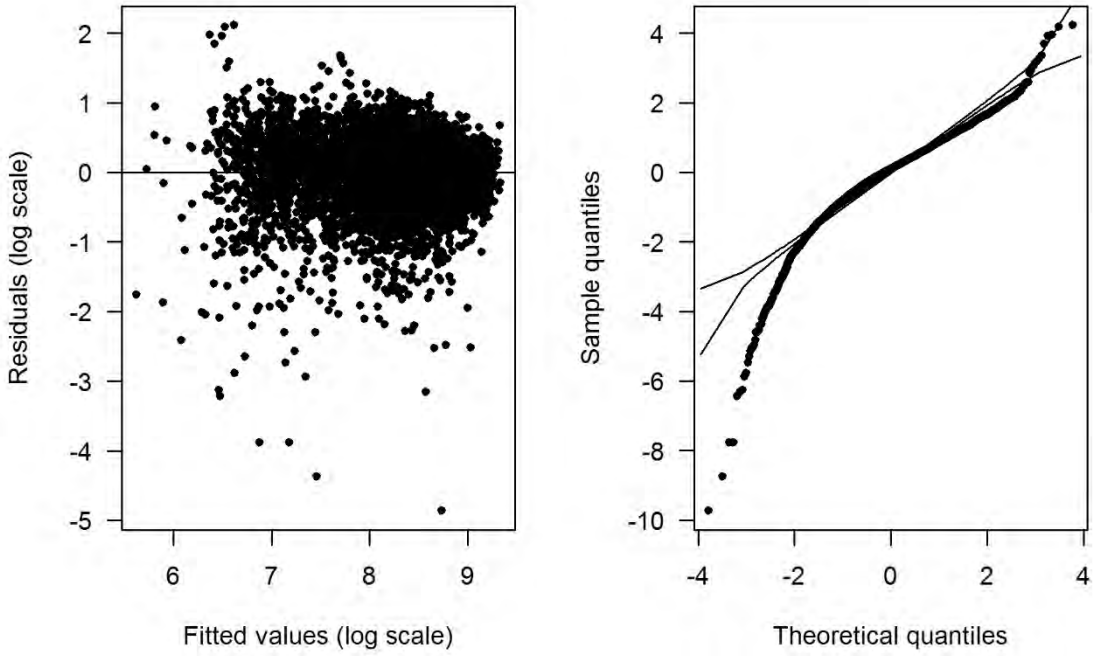


Figure E5: Effect and influence of non-interaction term variables in the Southland and Sub-Antarctic single autolongline lognormal model. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by year. Year defined as September–August.

Southland and Sub-Antarctic: single fishery model



Southland and Sub-Antarctic: two fishery model

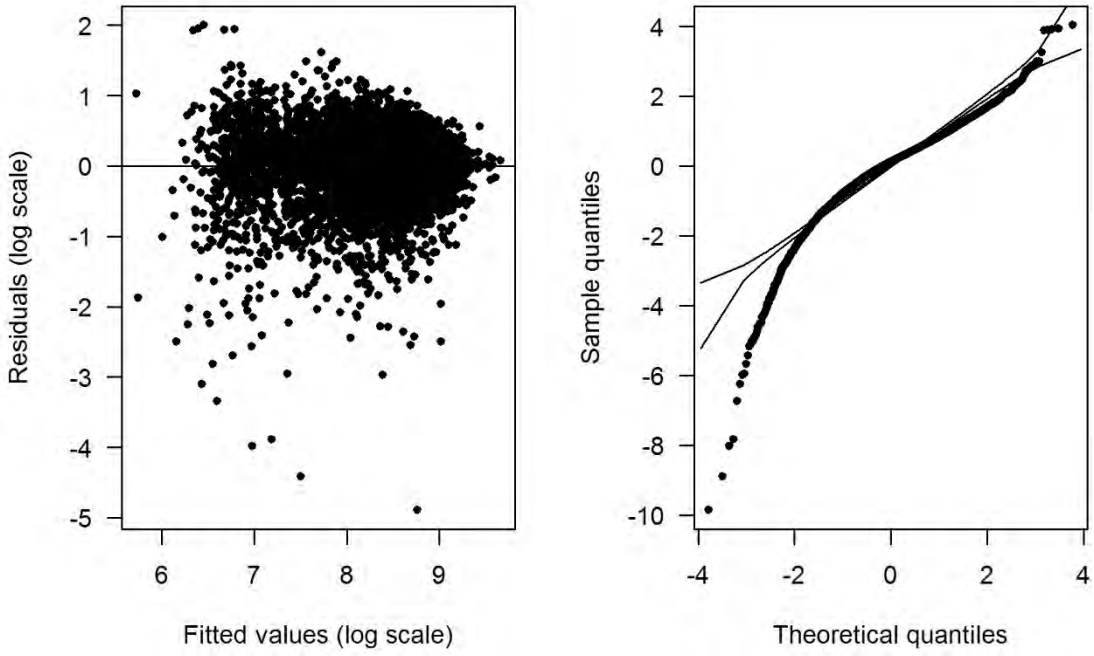


Figure E6: Diagnostic plots for the Southland and Sub-Antarctic single and two fishery lognormal autolongline CPUE models.

11. APPENDIX F: SOUTHLAND AND SUB-ANTARCTIC TRAWL CPUE (LIN 5&6)

Table F1: Summary of predictors offered in the Southland and Sub-Antarctic CPUE models for the trawl fisheries.

Variable	Type	Description
Year	Categorical	Fishing year, or June–September
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	Trawl method (bottom trawl, midwater trawl on bottom, midwater trawl)
Twin trawl	Categorical	Vessel did or did not use a twin trawl
Number of nets	Categorial	Number of nets used in a trawl
Headline height	Continuous	Distance between trawl headline and groundrope (m)
Duration	Continuous	Tow duration, in hours
Start time	Continuous	Start time of tow, 24-hour clock
Mid time	Continuous	Time at the midpoint of the tow, 24-hour clock
Depth bottom	Continuous	Bottom depth (m)
Depth net	Continuous	Depth of groundrope (m)
Speed	Continuous	Towing speed (kts)
Latitude	Continuous	Start latitude of tow
Longitude	Continuous	Start longitude of tow
CPUE	Continuous	Ling catch (kg) per tow
Grid number	Categorical	0.5 degree square based on start latitude and longitude of tow

Table F2: Number of female ling gonads staged by observers from commercial trawl catches by month sampled from each area by the observer programme for fishing years 1990–91 to 2016–17 where data exist. Areas defined in Figure A1. Stages are: 1, resting or immature; 2, ripening; 3, ripe; 4, running ripe and partially spent; 5, spent.

(a) Southland and Sub-Antarctic (excluding Puysegur)

	Month											
Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2 611	2 647	2 647	3 486	2 842	1 816	1 411	1 733	8 370	8 817	5 347	4 246
2	592	357	357	392	392	459	544	930	3 369	4 256	1 709	1 342
3	110	14	14	67	16	129	166	138	368	950	457	197
4	17	0	0	9	3	6	21	14	30	125	168	16
5	18	22	22	23	49	11	0	32	259	471	444	106

(b) Puysegur

	Month											
Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	16	17	14	40	59	106	140	121	321	399	466	81
2	7	4	13	0	7	25	77	127	481	883	201	62
3	5	0	0	0	0	1	34	122	420	786	313	73
4	0	0	0	0	0	0	15	19	36	66	55	2
5	0	0	0	0	1	1	4	10	11	45	34	3

Table F3: CPUE data constraints by area for Southland and Sub-Antarctic trawl vessels.

Data source	TCEPR
Year range	1991–2017
Year definition	September–August
Statistical areas	At least 100 tows: 026–028, 030, 504, 602–604, 610, 618
Method	BT, headline height < 18m
Target	HOK, HAK, LIN
Catch	< 50 t
Bottom depth	150–1000 m
Trawl duration	0.2–15 hours
Core vessel selection	Approx. 80% of catch, ≥ 5 years vessel participation, at least 20 tows per vessel-year

Table F4: Summary of data for all vessels and for vessels included in the core Southland and Sub-Antarctic (LIN 5&6) CPUE standardisation datasets. Data include: number of unique vessels fishing (Vessels), number of tow records for non-zero and zero ling catches for trawl data (Effort), proportion of tows that caught zero catch (Zeros), estimated catch, and unstandardised CPUE from non-zero catches from the tow-by-tow data. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

(a) Single trawl fishery

	All vessels					Core vessels				
Year	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**
1991	38	3 283.4	3 255	0.31	1.01	5	549.4	466	0.36	1.18
1992	45	5 169.8	4 284	0.37	1.21	11	2 086.4	1 755	0.29	1.19
1993	40	5 728.6	4 292	0.26	1.33	11	2 680.2	2 142	0.18	1.25
1994	28	3 203.2	2 143	0.14	1.49	7	1 769.8	1 301	0.13	1.36
1995	26	3 840.7	2 434	0.21	1.58	12	3 059.0	1 774	0.21	1.72
1996	31	5 239.9	2 414	0.25	2.17	14	3 871.7	1 731	0.22	2.24
1997	40	4 862.2	3 050	0.24	1.59	22	3 978.6	2 562	0.26	1.55
1998	43	5 840.5	4 132	0.17	1.41	24	4 964.7	3 912	0.17	1.27
1999	35	4 058.7	3 150	0.16	1.29	22	3 713.0	2 891	0.13	1.28
2000	31	5 596.2	5 302	0.16	1.06	24	5 579.5	5 261	0.16	1.06
2001	34	5 558.4	4 830	0.17	1.15	25	5 390.1	4 616	0.17	1.17
2002	35	5 852.5	5 538	0.11	1.06	25	5 632.4	5 272	0.11	1.07
2003	37	5 919.2	4 514	0.11	1.31	26	5 744.1	4 353	0.11	1.32
2004	27	6 289.9	3 101	0.11	2.03	17	6 044.9	2 959	0.11	2.04
2005	27	6 187.3	2 014	0.07	3.07	16	5 958.4	1 889	0.07	3.15
2006	24	5 384.4	1 671	0.12	3.22	16	5 077.2	1 605	0.12	3.16
2007	22	6 316.5	2 113	0.07	2.99	17	6 188.2	2 060	0.07	3
2008	23	6 227.4	2 086	0.10	2.99	15	5 647.6	1 923	0.10	2.94
2009	19	3 843.7	1 674	0.10	2.30	11	3 343.2	1 518	0.10	2.20
2010	19	3 155.2	1 559	0.11	2.02	10	3 017.4	1 474	0.11	2.05
2011	20	3 328.6	1 606	0.10	2.07	12	3 139.5	1 534	0.10	2.05
2012	21	3 026.2	1 519	0.08	1.99	14	2 743.4	1 442	0.09	1.90
2013	21	5 587.8	1 923	0.05	2.91	12	5 240.3	1 853	0.05	2.83
2014	17	4 503.2	2 248	0.10	2	12	4 234.8	2 125	0.10	1.99
2015	19	4 621.9	2 005	0.09	2.31	15	4 410.4	1 853	0.09	2.38
2016	18	4 313.2	1 473	0.07	2.93	13	3 910.6	1 368	0.07	2.86
2017	19	3 874.6	1 622	0.10	2.39	9	3 586.3	1 522	0.10	2.36

Table F4: continued.

(b) Spawning trawl fishery

	All vessels					Core vessels				
Year	**Vessels**	**Catch**	**Effort**	**Zeros**	**CPUE**	**Vessels**	**Catch**	**Effort**	**Zeros**	**CPUE**
1991	4	310.5	160	0.27	1.94	4	310.5	160	0.27	1.94
1992	6	683.5	370	0.46	1.85	6	683.5	370	0.46	1.85
1993	9	1 082.5	915	0.17	1.18	9	1 082.5	915	0.17	1.18
1994	6	886.9	678	0.13	1.31	6	886.9	678	0.13	1.31
1995	12	2 373.1	830	0.19	2.86	12	2 373.1	830	0.19	2.86
1996	13	2 755.9	924	0.18	2.98	13	2 755.9	924	0.18	2.98
1997	15	2 516.9	1 058	0.23	2.38	15	2 516.9	1 058	0.23	2.38
1998	19	3 242.6	1 033	0.25	3.14	19	3 242.6	1 033	0.25	3.14
1999	17	2 550.1	902	0.14	2.83	17	2 550.1	902	0.14	2.83
2000	21	3 282.8	1 294	0.14	2.54	21	3 282.8	1 294	0.14	2.54
2001	24	3 572.1	1 712	0.12	2.09	24	3 572.1	1 712	0.12	2.09
2002	25	2 602.5	2 043	0.13	1.27	25	2 602.5	2 043	0.13	1.27
2003	22	3 082.5	1 726	0.13	1.79	22	3 082.5	1 726	0.13	1.79
2004	15	4 065.3	1 432	0.12	2.84	15	4 065.3	1 432	0.12	2.84
2005	14	4 632.9	1 223	0.06	3.79	14	4 632.9	1 223	0.06	3.79
2006	15	4 285.7	1 068	0.09	4.01	15	4 285.7	1 068	0.09	4.01
2007	17	4 868.0	1 396	0.07	3.49	17	4 868.0	1 396	0.07	3.49
2008	15	4 961.0	1 577	0.08	3.15	15	4 961.0	1 577	0.08	3.15
2009	10	2 792.0	895	0.10	3.12	10	2 792.0	895	0.10	3.12
2010	8	2 351.3	732	0.11	3.21	8	2 351.3	732	0.11	3.21
2011	12	2 449.8	883	0.10	2.77	12	2 449.8	883	0.10	2.77
2012	13	2 031.5	559	0.11	3.63	13	2 031.5	559	0.11	3.63
2013	11	4 531.4	1 011	0.05	4.48	11	4 531.4	1 011	0.05	4.48
2014	11	3 268.0	1 011	0.07	3.23	11	3 268.0	1 011	0.07	3.23
2015	13	3 692.6	920	0.06	4.01	13	3 692.6	920	0.06	4.01
2016	12	3 447.3	898	0.07	3.84	12	3 447.3	898	0.07	3.84
2017	8	3 052.8	731	0.04	4.18	8	3 052.8	731	0.04	4.18

(c) Non-spawning trawl fishery

	All vessels					Core vessels				
Year	**Vessels**	**Catch**	**Effort**	**Zeros**	**CPUE**	**Vessels**	**Catch**	**Effort**	**Zeros**	**CPUE**
1991	3	238.9	306	0.40	0.78	3	238.9	306	0.40	0.78
1992	11	1 403.0	1 385	0.22	1.01	11	1 403.0	1 385	0.22	1.01
1993	11	1 597.8	1 227	0.18	1.30	11	1 597.8	1 227	0.18	1.30
1994	6	882.9	623	0.13	1.42	6	882.9	623	0.13	1.42
1995	10	685.9	944	0.23	0.73	10	685.9	944	0.23	0.73
1996	12	1 115.8	807	0.25	1.38	12	1 115.8	807	0.25	1.38
1997	22	1 461.7	1 504	0.28	0.97	22	1 461.7	1 504	0.28	0.97
1998	22	1 722.1	2 879	0.14	0.60	22	1 722.1	2 879	0.14	0.60
1999	22	1 162.8	1 989	0.13	0.58	22	1 162.8	1 989	0.13	0.58
2000	24	2 296.6	3 967	0.16	0.58	24	2 296.6	3 967	0.16	0.58
2001	23	1 818.0	2 904	0.20	0.63	23	1 818.0	2 904	0.20	0.63
2002	25	3 029.9	3 229	0.10	0.94	25	3 029.9	3 229	0.10	0.94
2003	24	2 661.6	2 627	0.09	1.01	24	2 661.6	2 627	0.09	1.01
2004	17	1 979.6	1 527	0.11	1.30	17	1 979.6	1 527	0.11	1.30
2005	11	1 325.5	666	0.09	1.99	11	1 325.5	666	0.09	1.99
2006	9	791.5	537	0.16	1.47	9	791.5	537	0.16	1.47
2007	14	1 320.2	664	0.06	1.99	14	1 320.2	664	0.06	1.99
2008	10	686.7	346	0.20	1.98	10	686.7	346	0.20	1.98
2009	10	551.2	623	0.10	0.88	10	551.2	623	0.10	0.88
2010	10	666.0	742	0.12	0.90	10	666.0	742	0.12	0.90
2011	10	689.7	651	0.10	1.06	10	689.7	651	0.10	1.06
2012	10	711.9	883	0.07	0.81	10	711.9	883	0.07	0.81
2013	7	708.9	842	0.06	0.84	7	708.9	842	0.06	0.84
2014	9	966.8	1 114	0.13	0.87	9	966.8	1 114	0.13	0.87
2015	11	717.8	933	0.12	0.77	11	717.8	933	0.12	0.77
2016	8	463.3	470	0.07	0.99	8	463.3	470	0.07	0.99
2017	8	533.5	791	0.14	0.67	8	533.5	791	0.14	0.67

Table F5: Variables retained in the GLMs order of decreasing explanatory value, for each Southland and Sub-Antarctic (LIN 5&6) trawl model (lognormal, binomial), with the corresponding deviance explained (R-squared, %).

(a) Single trawl fishery

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	10.73	Year	3.32
Grid number	34.77	Grid number	15.22
Target species	44.71	Vessel	18.03
Mid time of tow	48.34	Depth of bottom	19.79
Vessel	51.12	Target species	21.39
Month	53.44	Duration	22.43
Duration	55.31		

(b) Two trawl fishery model

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	19.69	Year	4.23
Grid number	38.32	Grid number	15.87
Target species	46.00	Vessel	18.65
Vessel	49.74	Depth of bottom	20.43
Mid time of tow	52.01	Target species	22.04
Month	53.95	Duration	23.09
Duration	55.80		

Table F6: CPUE standardised indices for Southland and Sub-Antarctic trawl fisheries (LIN 5&6), and binomial, and combined CPUE indices for trawl indices (with CVs). Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

(a) Single trawl fishery

	Lognormal		Binomial		Delta lognormal	
Year	**Index**	**CV**	**Index**	**CV**	**Index**	**CV**
1991	0.68	0.05	0.84	0.00	0.60	0.05
1992	0.82	0.03	0.92	0.00	0.79	0.03
1993	1.11	0.03	0.98	0.00	1.13	0.03
1994	1.14	0.03	0.98	0.00	1.16	0.03
1995	1.05	0.03	0.93	0.00	1.02	0.03
1996	0.93	0.03	0.87	0.00	0.85	0.03
1997	1.08	0.02	0.87	0.00	0.97	0.02
1998	0.97	0.02	0.92	0.00	0.93	0.02
1999	0.83	0.02	0.93	0.00	0.80	0.02
2000	0.79	0.02	0.91	0.00	0.75	0.02
2001	0.87	0.02	0.88	0.00	0.80	0.02
2002	1.16	0.02	0.99	0.00	1.19	0.02
2003	1.16	0.02	0.95	0.00	1.15	0.02
2004	1.27	0.02	0.96	0.00	1.27	0.02
2005	1.40	0.02	0.98	0.00	1.43	0.02
2006	0.98	0.03	0.87	0.00	0.89	0.03
2007	0.92	0.02	0.95	0.00	0.91	0.02
2008	0.99	0.02	0.91	0.00	0.94	0.02
2009	0.91	0.03	0.95	0.00	0.90	0.03
2010	0.95	0.03	0.96	0.00	0.95	0.03
2011	0.88	0.03	0.97	0.00	0.89	0.03
2012	1.03	0.03	0.98	0.00	1.05	0.03
2013	1.11	0.02	1.00	0.00	1.15	0.02
2014	1.07	0.02	0.99	0.00	1.11	0.02
2015	0.95	0.02	0.98	0.00	0.97	0.02
2016	1.12	0.03	1.00	0.00	1.17	0.03
2017	1.17	0.03	0.99	0.00	1.21	0.03

Table F6: continued.

(b) Spawning trawl fishery

	Lognormal		Binomial		Delta lognormal	
Year	**Index**	**CV**	**Index**	**CV**	**Index**	**CV**
1991	0.63	0.08	0.98	0.00	0.66	0.08
1992	0.60	0.06	0.73	0.00	0.46	0.06
1993	1.25	0.04	0.97	0.00	1.29	0.04
1994	0.94	0.05	0.97	0.00	0.97	0.05
1995	0.99	0.04	0.90	0.00	0.95	0.04
1996	0.72	0.04	0.89	0.00	0.68	0.04
1997	0.99	0.04	0.89	0.00	0.94	0.04
1998	0.83	0.04	0.87	0.00	0.76	0.04
1999	0.96	0.04	0.92	0.00	0.94	0.04
2000	0.84	0.03	0.91	0.00	0.81	0.03
2001	0.90	0.03	0.91	0.00	0.87	0.03
2002	0.99	0.03	0.97	0.00	1.02	0.03
2003	1.03	0.03	0.92	0.00	1.01	0.03
2004	1.18	0.03	0.93	0.00	1.16	0.03
2005	1.32	0.04	0.97	0.00	1.36	0.04
2006	0.94	0.04	0.84	0.00	0.84	0.04
2007	1.00	0.03	0.92	0.00	0.97	0.03
2008	0.96	0.03	0.91	0.00	0.93	0.03
2009	1.04	0.04	0.92	0.00	1.02	0.04
2010	1.00	0.04	0.93	0.00	0.98	0.04
2011	0.90	0.04	0.95	0.00	0.91	0.04
2012	0.95	0.05	0.88	0.00	0.89	0.05
2013	1.32	0.04	0.97	0.00	1.36	0.04
2014	1.04	0.04	0.95	0.00	1.05	0.04
2015	1.13	0.04	0.97	0.00	1.16	0.04
2016	1.16	0.04	0.97	0.00	1.20	0.04
2017	1.11	0.04	0.98	0.00	1.16	0.04

(c) Non-spawning trawl fishery

	Lognormal		Binomial		Delta lognormal	
Year	**Index**	**CV**	**Index**	**CV**	**Index**	**CV**
1991	0.75	0.06	0.74	0.00	0.59	0.06
1992	0.92	0.03	0.95	0.00	0.93	0.03
1993	1.06	0.04	0.95	0.00	1.07	0.04
1994	1.48	0.05	0.92	0.00	1.45	0.05
1995	1.12	0.04	0.91	0.00	1.09	0.04
1996	1.28	0.04	0.79	0.00	1.08	0.04
1997	1.17	0.03	0.80	0.00	0.99	0.03
1998	1.05	0.03	0.91	0.00	1.02	0.03
1999	0.79	0.03	0.90	0.00	0.76	0.03
2000	0.79	0.03	0.87	0.00	0.73	0.03
2001	0.86	0.03	0.83	0.00	0.76	0.03
2002	1.29	0.03	0.97	0.00	1.32	0.03
2003	1.25	0.03	0.93	0.00	1.24	0.03
2004	1.34	0.03	0.95	0.00	1.35	0.03
2005	1.54	0.04	0.95	0.00	1.55	0.04
2006	1.09	0.05	0.85	0.00	0.98	0.05
2007	0.78	0.04	0.95	0.00	0.79	0.04
2008	1.08	0.06	0.81	0.00	0.93	0.06
2009	0.75	0.04	0.94	0.00	0.75	0.04
2010	0.90	0.04	0.95	0.00	0.91	0.04
2011	0.84	0.04	0.96	0.00	0.85	0.04
2012	1.10	0.04	0.99	0.00	1.15	0.04
2013	0.91	0.04	0.98	0.00	0.95	0.04
2014	1.12	0.04	0.98	0.00	1.17	0.04
2015	0.82	0.04	0.96	0.00	0.84	0.04
2016	1.05	0.05	1.00	0.00	1.12	0.05
2017	1.24	0.04	0.97	0.00	1.28	0.04

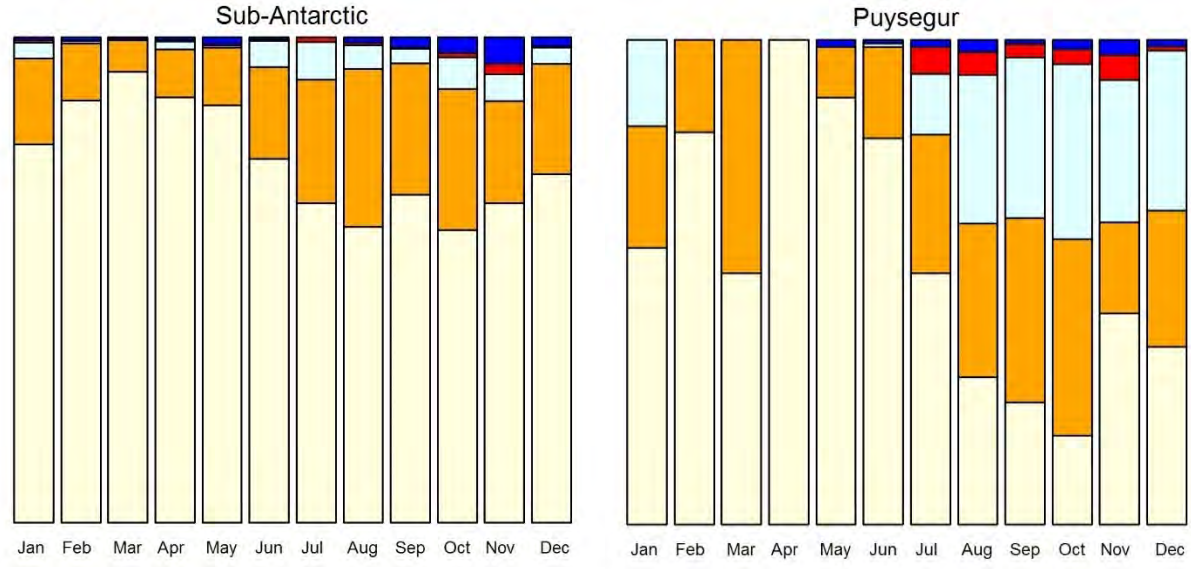


Figure F1: Gonad stages of female ling sampled by observers from commercial trawl catches, by month and area. Areas defined in Figure A1. Sub-Antarctic gonad stages include "Southland and "Sub-Antarctic" areas (see Figure A2) but excludes "Puysegur". Stages are: 1, resting or immature (yellow); 2, ripening (orange); 3, ripe (light blue); 4, running ripe and partially spent (red); 5, spent (blue).

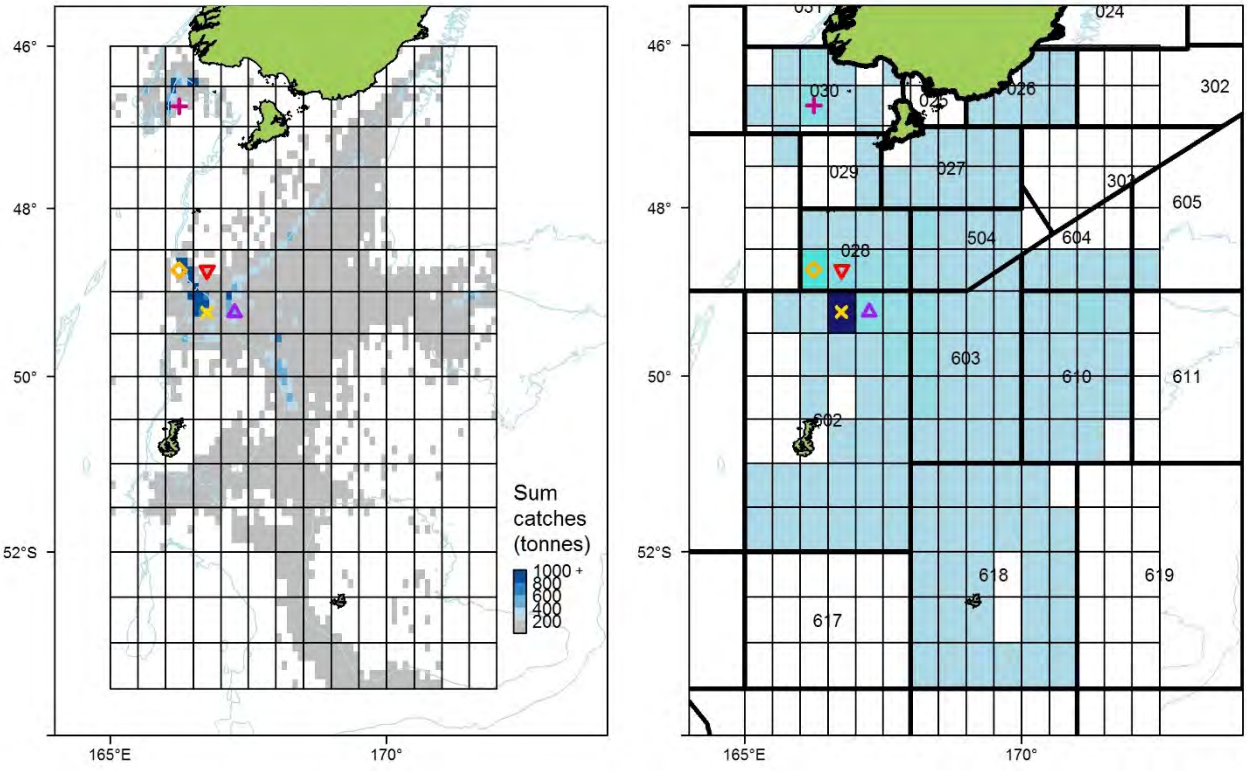


Figure F2: Density plots (latitude and longitude, and 0.5° grid cells) of commercial ling catches from TCEPR tow-by-tow datasets for target hake, hoki, and ling tows, for all years combined, with the grid cells producing the top five catch totals marked (1: gold cross; 2: orange diamond; 3: red triangle; 4: red cross; 5: purple triangle).

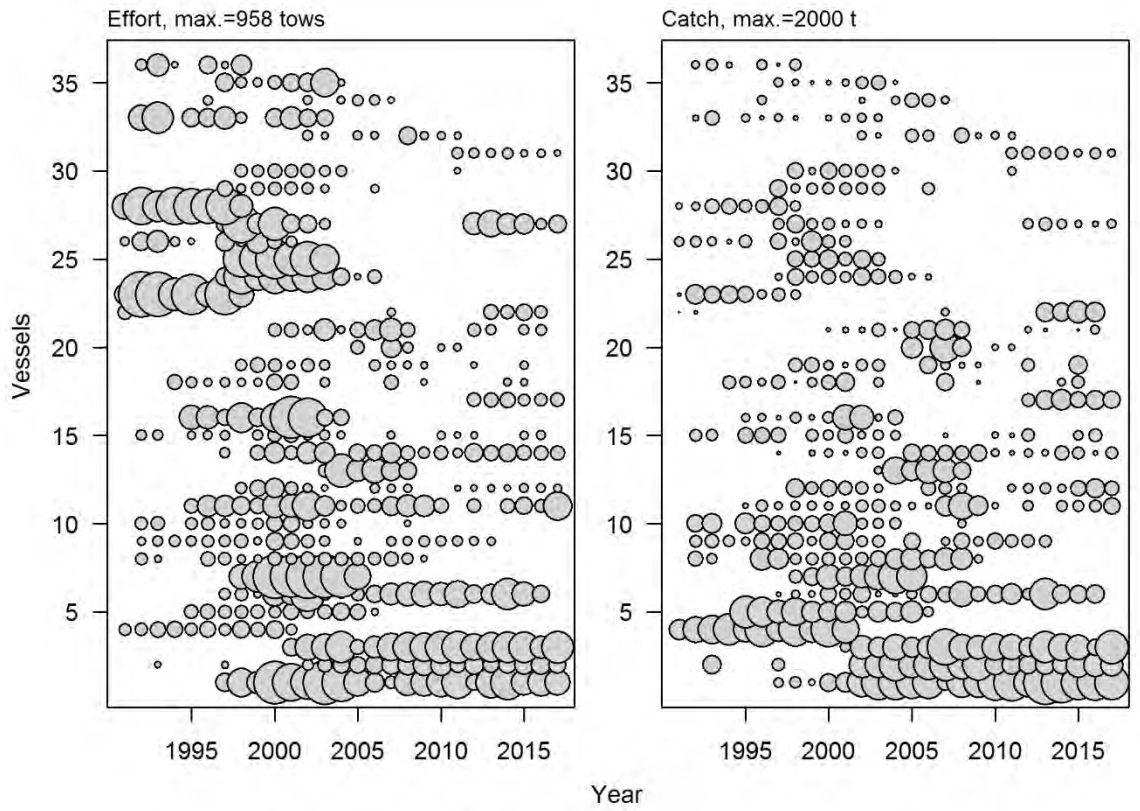


Figure F3: Southland and Sub-Antarctic single trawl fishing effort and catches by year for individual vessels (denoted anonymously by number on the y-axis) in core CPUE analyses in the single trawl fishery. Circle area is proportional to the effort or catch. Year defined as September–August.

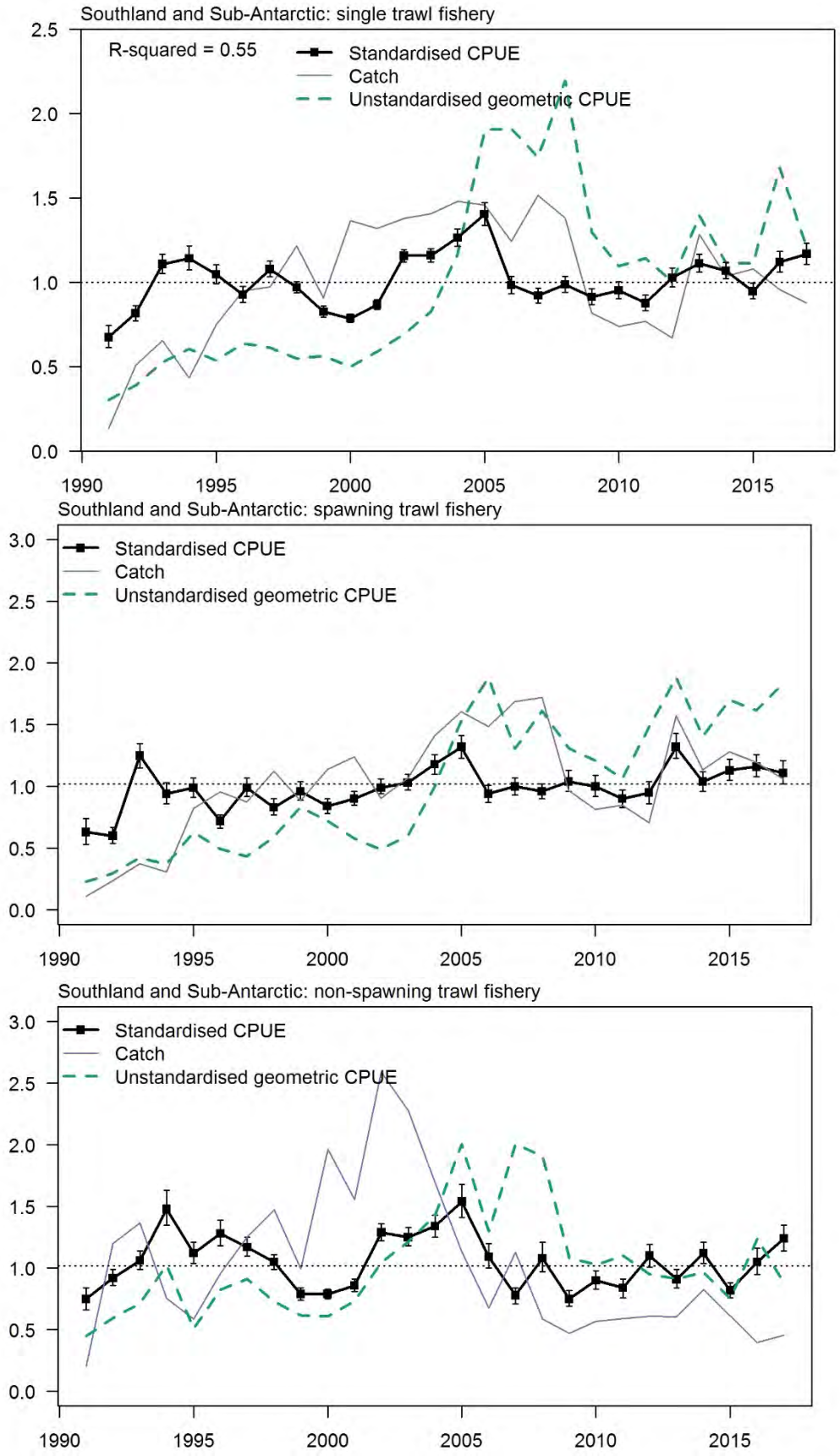


Figure F4: Year index from the lognormal model for each Southland and Sub-Antarctic trawl fishery. Bars indicate 95% confidence intervals. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

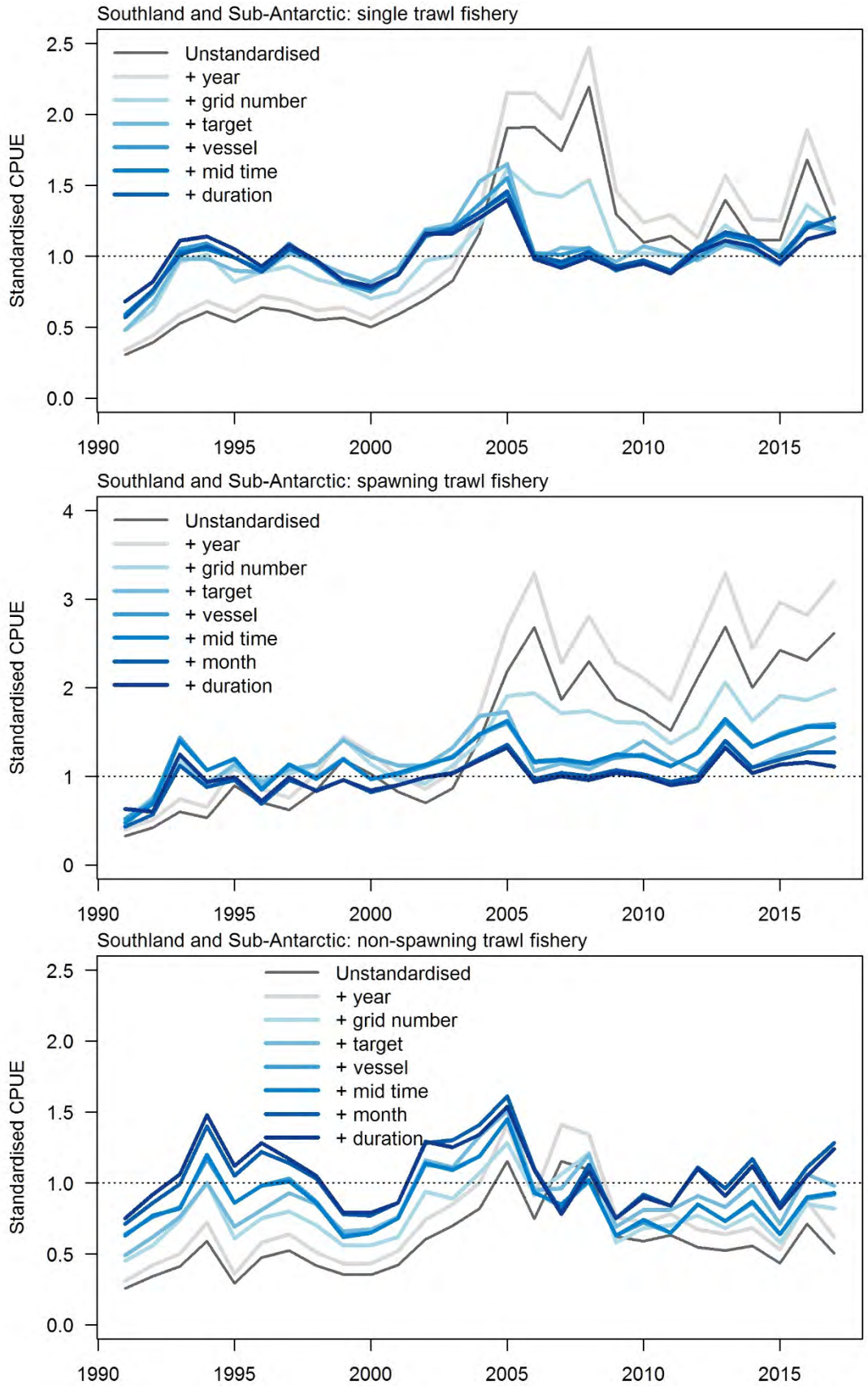


Figure F5: Effects of the addition of variables into the lognormal CPUE model for each Southland and Sub-Antarctic trawl fishery. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

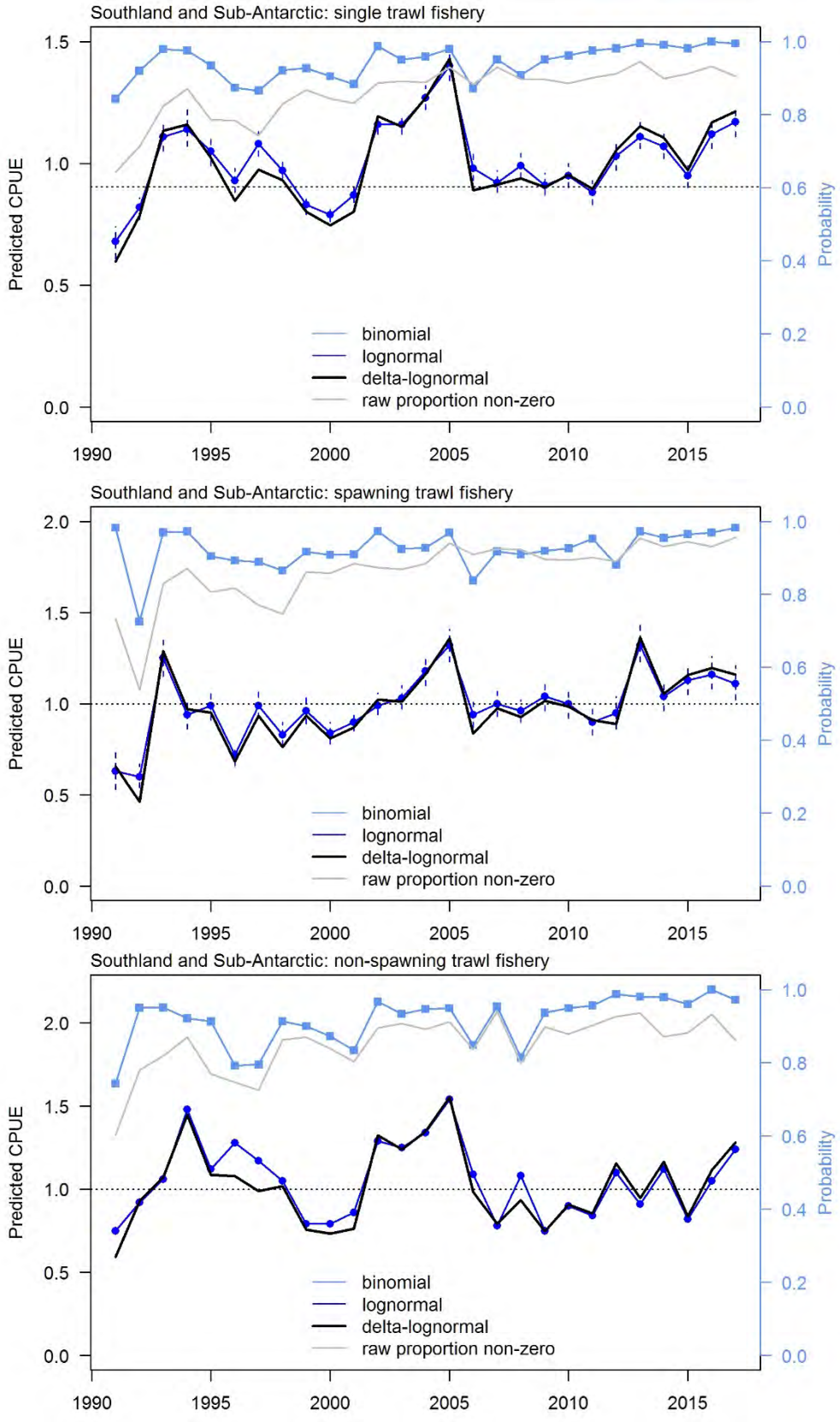


Figure F6: Southland and Sub-Antarctic indices from the lognormal, binomial and combined model for each fishery. Bars indicate 95% confidence intervals. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model. The horizontal dotted line shows the mean of the combined series. The probability scale relates to the binomial and raw proportion non-zero series.

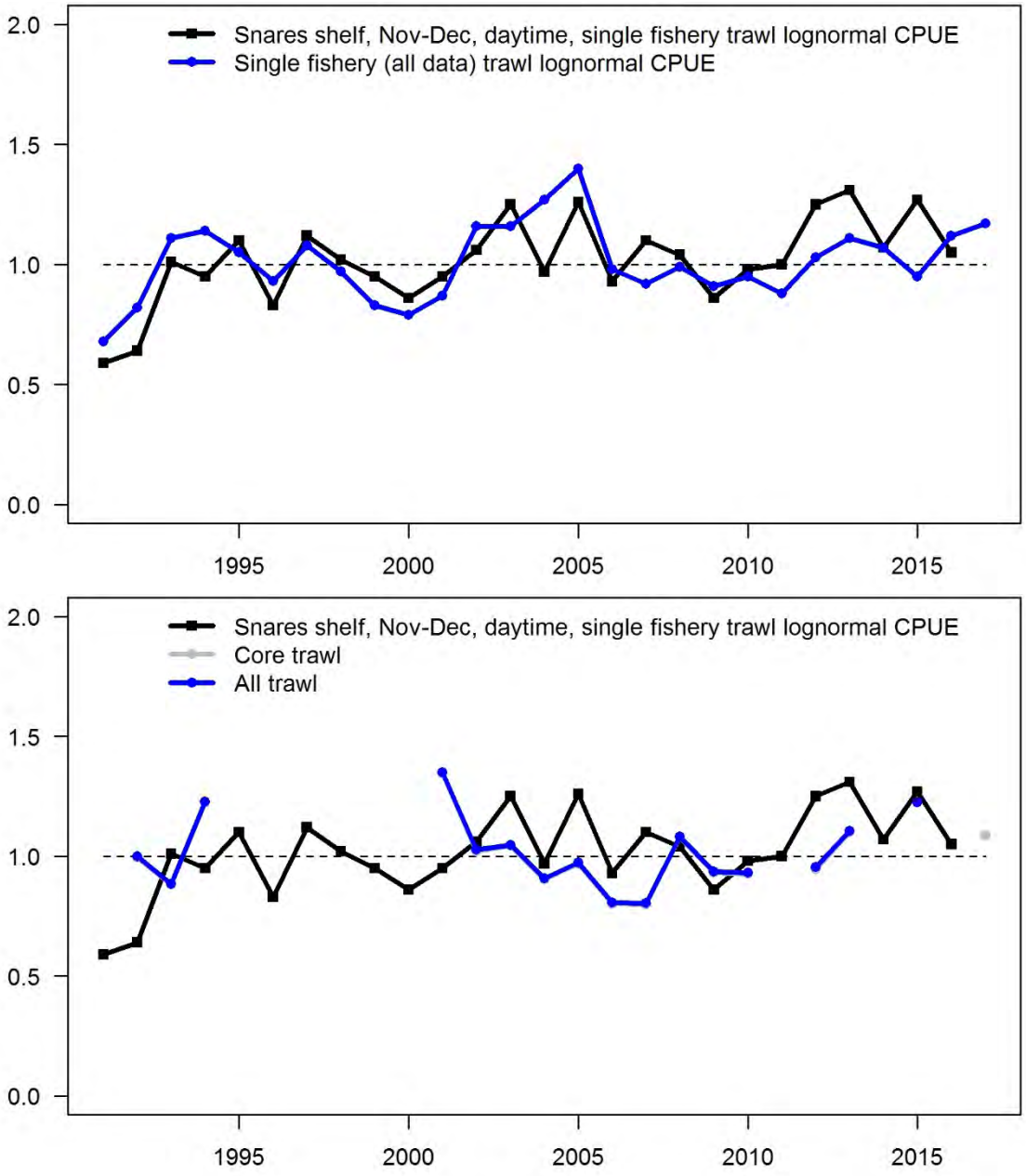


Figure F7a: Comparison of CPUE indices for the lognormal model for the Southland and Sub-Antarctic single September–August fishery with the Snares Shelf November–December daytime single fishery model (top), and the Snares Shelf November–December daytime single fishery model with the Southland and Sub-Antarctic *Tangaroa* ling trawl survey biomass indices.

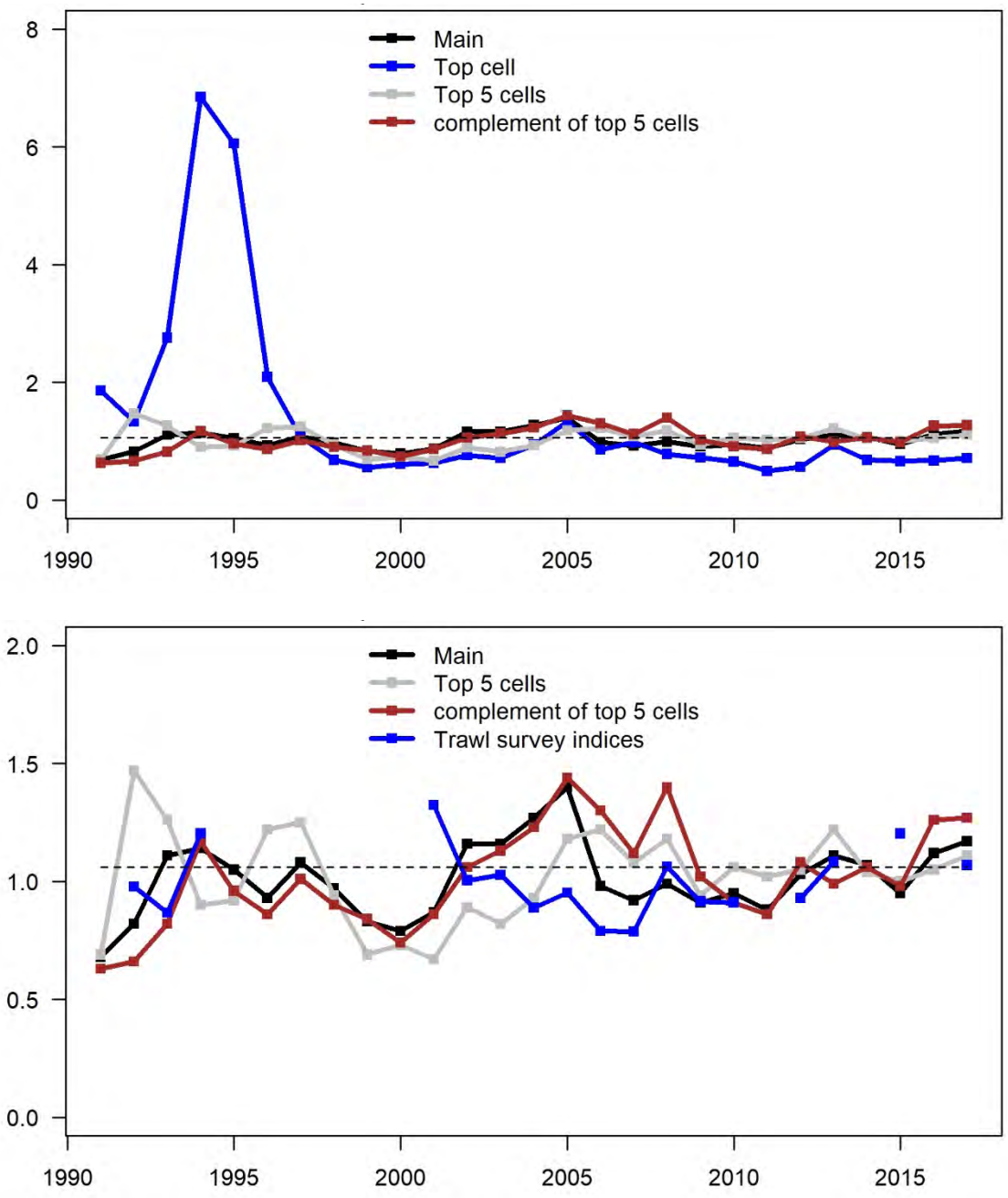


Figure F7b: CPUE indices for the combined model for the Southland and Sub-Antarctic single fishery (both spawning and non-spawning) comparing the current core vessel analysis with other cell models. The bottom plot is on a smaller y-axis scale, so trends can be seen, and excludes the top cell indices, but includes the Southland and Sub-Antarctic *Tangaroa* November–December ling trawl survey biomass indices. Year defined as September–August.

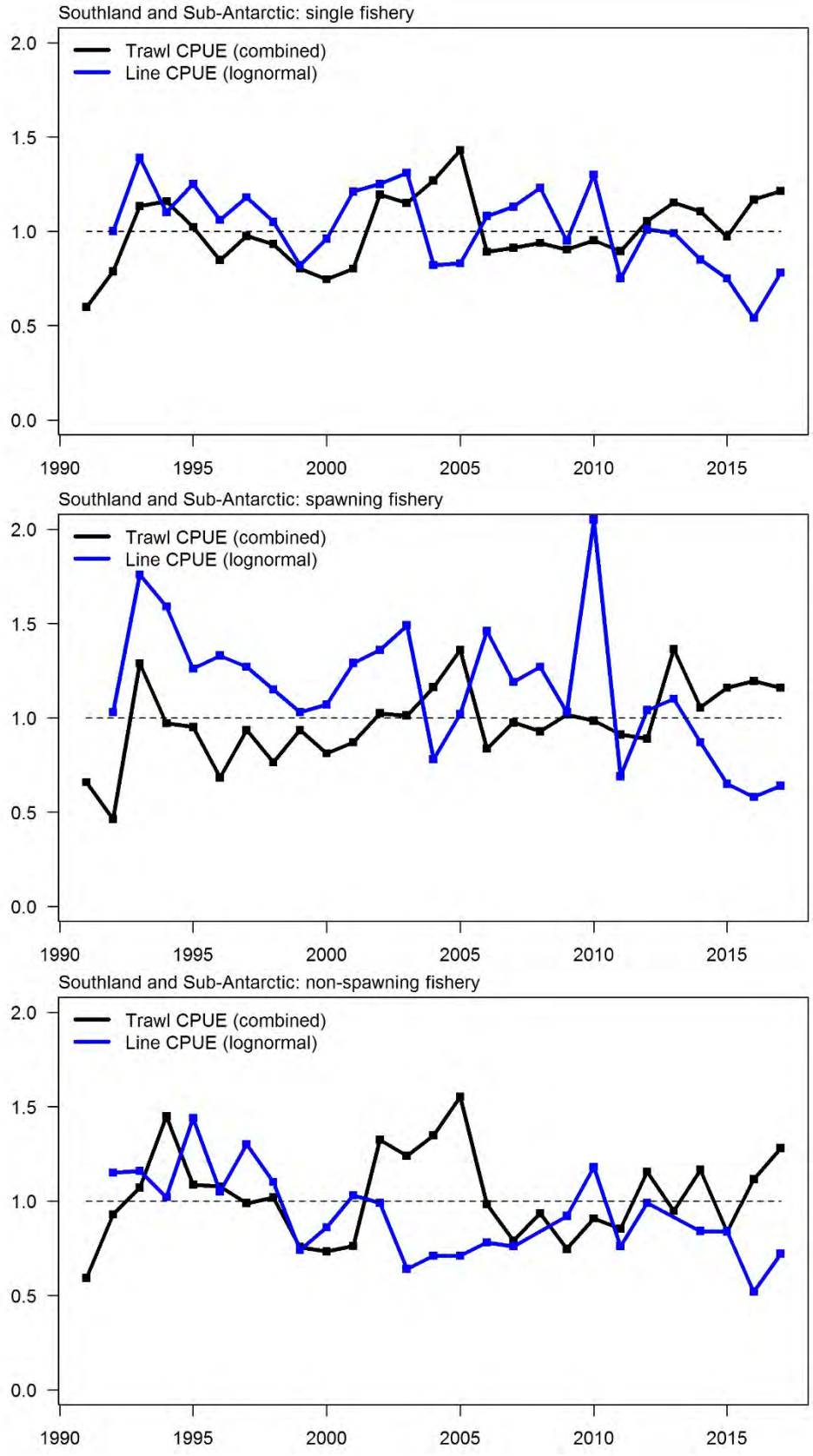


Figure F7c: CPUE indices for the combined model for the Southland and Sub-Antarctic single (two fisheries) and two fishery (spawning and non-spawning) models, comparing the current core vessel analysis with the longline CPUE indices. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

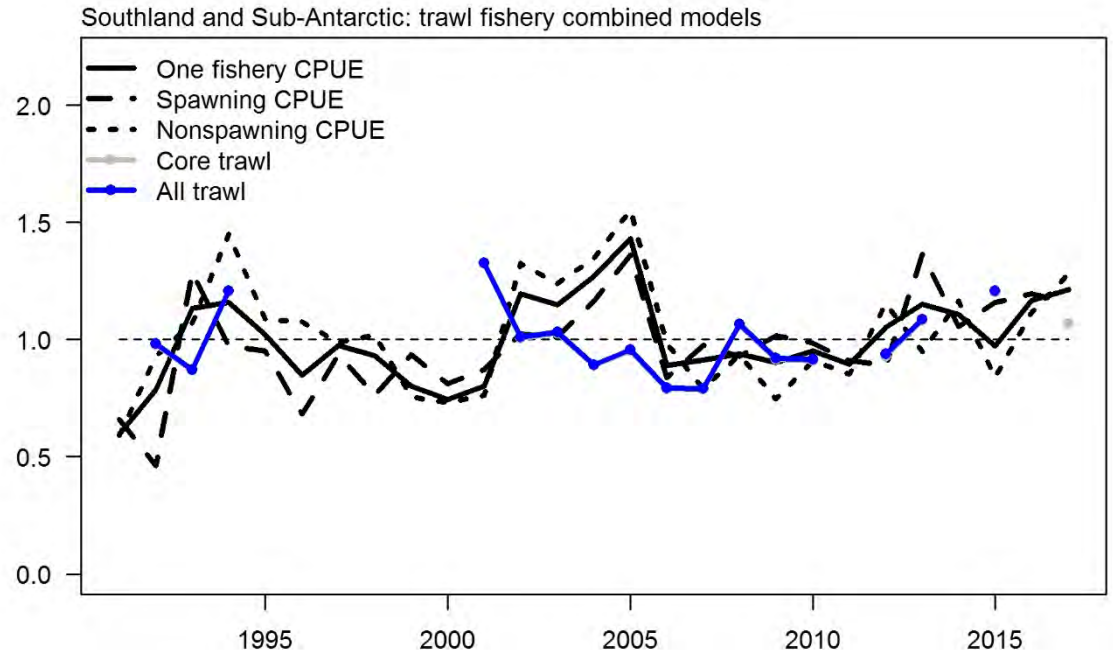


Figure F7d: CPUE indices for the combined model for the Southland and Sub-Antarctic single fisheries and two fishery (spawning and non-spawning) models, comparing the current core vessel analysis with the Southland and Sub-Antarctic *Tangaroa* ling trawl survey abundance indices. Year defined as September–August for the single model, September–December for the spawning model, and January–August for the non-spawning model.

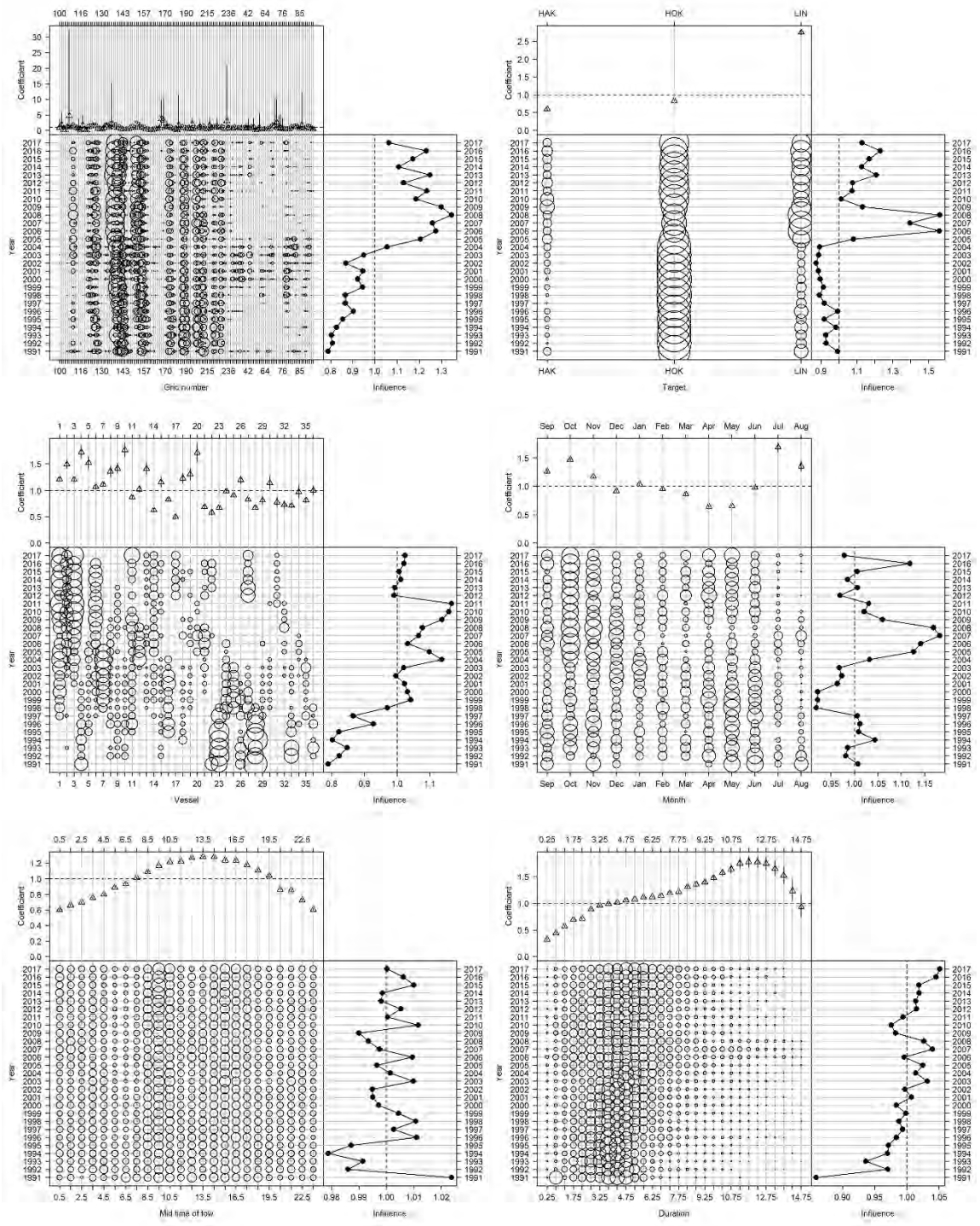


Figure F8: Effect and influence of non-interaction term variables in the Southland and Sub-Antarctic trawl core vessel lognormal model. Top: relative effect by level of each variable. Bottom left: relative distribution of each variable by year. Year defined as September–August. Bottom right: influence of variable on unstandardised CPUE by fishing year.

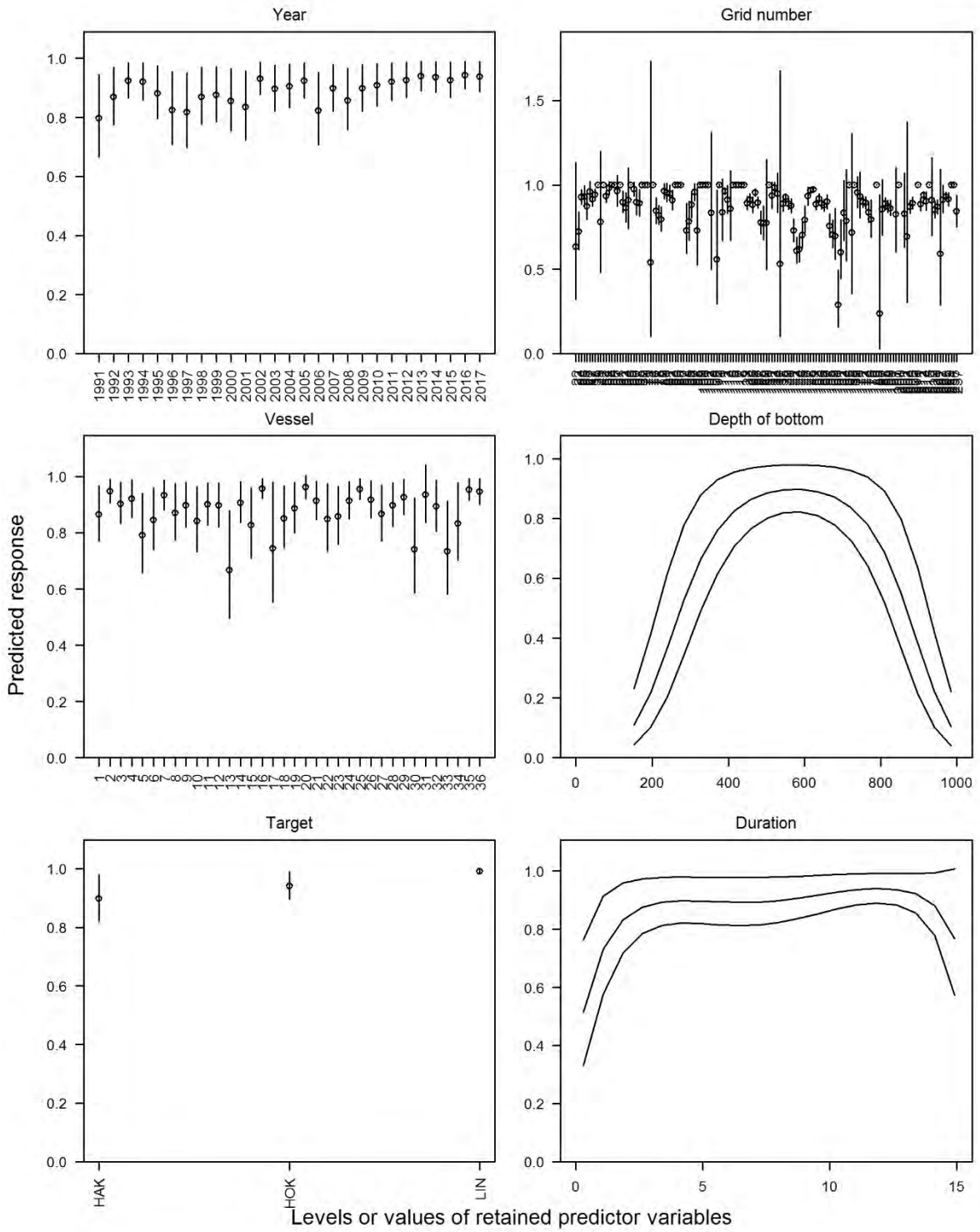
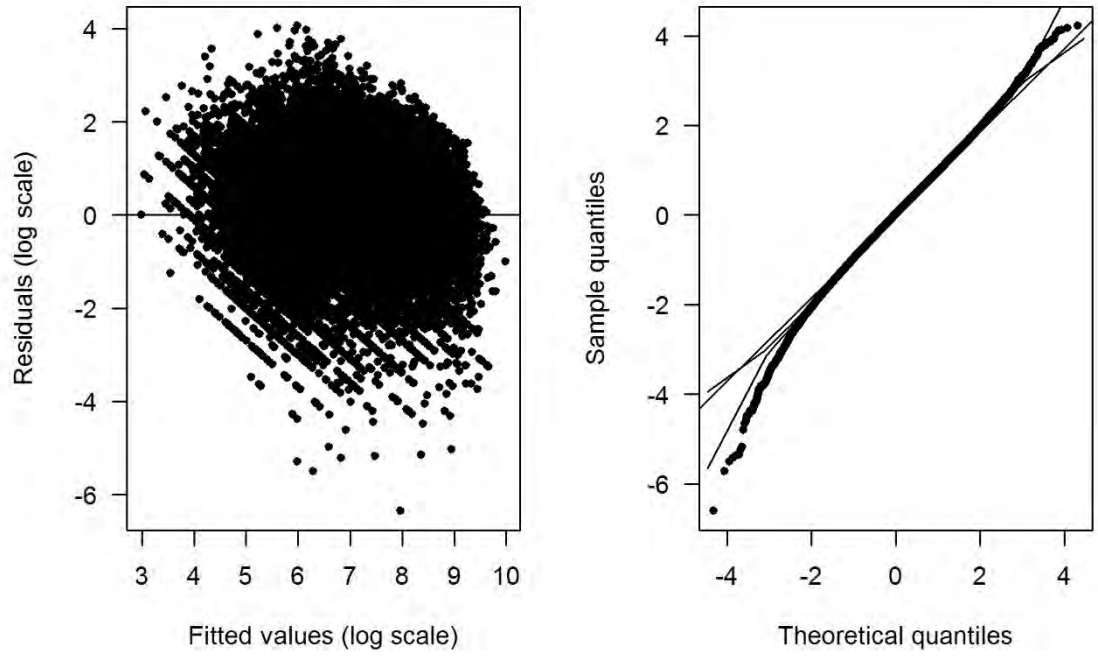


Figure F9: Expected variable effects for variables selected into the CPUE binomial model for the Sub-Antarctic TCEPR tow-by-tow core vessel single fishery, 1991–2017. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables. Year defined as September–August.

Southland and Sub-Antarctic: single trawl fishery model



Southland and Sub-Antarctic: two trawl fishery model

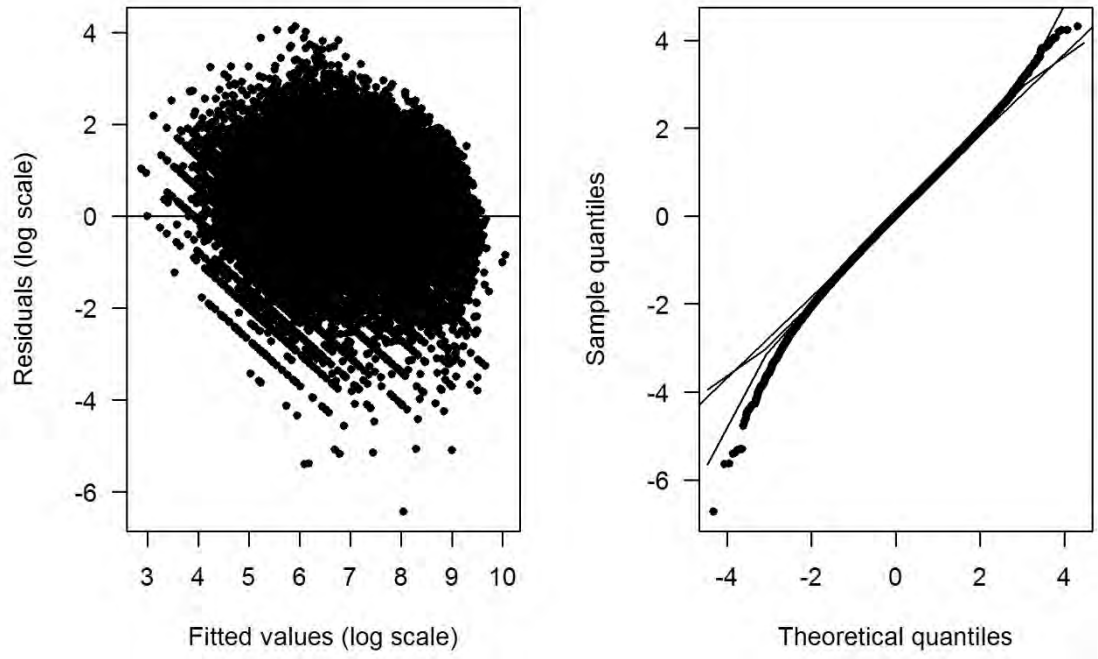
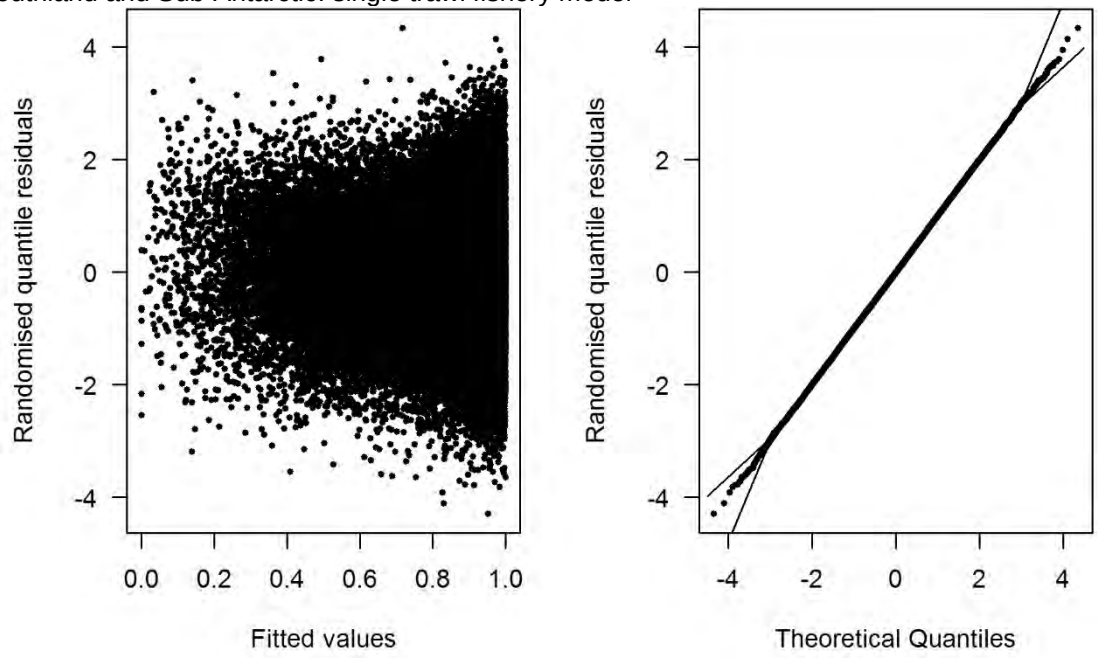


Figure F10a: Diagnostic plots for the Southland and Sub-Antarctic single and two fishery lognormal trawl CPUE models.

Southland and Sub-Antarctic: single trawl fishery model



Southland and Sub-Antarctic: two trawl fishery model

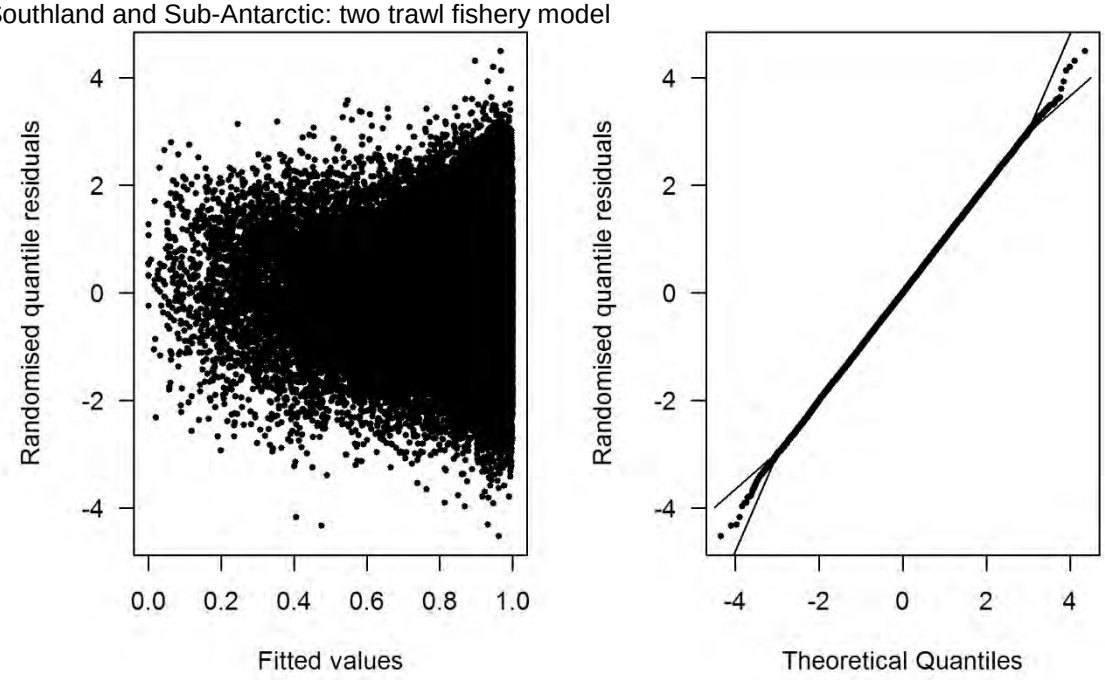


Figure F10b: Diagnostic (residual and q-q) plots for the Southland and Sub-Antarctic single and two fishery binomial trawl CPUE models.