A descriptive analysis and CPUE from commercial fisheries for ling (*Genypterus blacodes*) in Fishstocks LIN 2, 3, 4, 5, 6, and 7 from 1990 to 2009

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EXECUTIVE SUMMARY

Horn, P.L.; Ballara, S.L. (2012). A descriptive analysis and CPUE from commercial fisheries for ling (*Genypterus blacodes*) in Fishstocks LIN 2, 3, 4, 5, 6, and 7 from 1990 to 2009.

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Series of CPUE for commercial line fisheries targeting ling on the Chatham Rise (LIN 3&4, 1990–2009), the Sub-Antarctic (LIN 5&6, 1991–2009), the Bounty Plateau (LIN 6B, 1992–2009), the west coast of the South Island (WCSI) (LIN 7WC, 1990–2009), and Cook Strait (LIN 7CK, 1990–2009) were updated to include CELR (catch, effort, and landing return), LCER (lining catch and effort return), and LTCER (lining trip catch effort return) data to the end of the 2009 calendar year. Series of CPUE for the ling bycatch from the trawl fisheries targeting hoki in Cook Strait and WCSI since 1990 were also updated with the addition of 2009 TCEPR (trawl catch, effort, and processing return) and TCER (trawl catch effort return) data.

Data used in the CPUE analyses were groomed to remove as many errors as possible. Data for the longline analyses were selected to ensure that they related to vessels that had consistently targeted and caught significant landings of ling (and so were likely to represent experienced and competent ling fishers). For the trawl fishery analyses, only data from vessels that had consistently reported ling bycatch from the chosen years were included. The catch data were modelled using a lognormal linear analysis to produce a set of standardised indices for each stock. Coefficients of selected variables were examined to ensure that they had a plausible range. Any selected interaction variables causing implausible ranges in the coefficients of the main variables were removed from the final models.

Since the early 1990s the standardised indices for line fisheries has declined by about 55% on the Chatham Rise and Bounty Plateau, but remained relatively constant in the Sub-Antarctic. The series for the WCSI line fishery exhibited a relatively flat but variable trend. The Cook Strait index declined slightly throughout the early 1990s, increased from 1995 to 2002, and has declined steadily since then.

The standardised indices derived from the trawl fishery in Cook Strait declined steadily throughout the early 1990s, exhibited some recovery up to about 2002, but are again declining. However, the 1990–93 part of this series is probably unreliable; it is likely that some change in reporting or fishing behaviour by fishers biased the derived indices. Two indices from the trawl fishery off WCSI are presented, one using TCEPR data and one using data collected by MFish observers. The series are quite variable and have conflicting trends.

The line and trawl CPUE series derived for each of the Cook Strait and WCSI stocks are compared. The series from the two Cook Strait fisheries exhibit some similar trends, particularly since 1994 (the trawl series is believed to be most reliable). For WCSI, the line fishery series is relatively flat, while the trawl series declined from 1992 (TCEPR data) or increased in the late 1990s followed by a subsequent decline (observer data). The line series may be hyperstable, but the two trawl series show different patterns. Consequently, a reliable relative abundance series for the LIN 7WC stock has not been identified.

A descriptive analysis of ling fisheries showed that the 2008–09 line fishery catch was about 15% less than in the previous year. Although much lower than in the most productive line fishery years (i.e., 1992–2002), the 2008–09 landings were still relatively consistent with the pattern of landings since 2003. There was also a marked reduction in landings from the deepwater trawl fisheries; they were 35% less than in 2007–08, and lower than in any year since 1989–90. The largest percentage reductions occurred in the Chatham and Sub-Antarctic areas. The setnet fishery increased from its lowest recorded landings in the previous year (although it is still a very minor fishery).

1. INTRODUCTION

This document reports the results of Project LIN2009/01, Objectives 1 and 2, i.e.,

- To carry out a descriptive analysis of the commercial catch and effort data for ling from LIN 2, 3 & 4, 5 & 6, 6B (Bounties) and 7,
- To update the standardised catch and effort analyses from the ling longline and trawl bycatch fisheries in LIN 3 & 4, 5 & 6 and 7 with the addition of data up to the end of the 2008/09 fishing year.

A descriptive analysis of commercial catch and effort data for all New Zealand's ling fisheries from fishing years 1989–90 to 1998–99 was completed by Horn (2001), and this analysis was recently updated to include data to 2004–05 from Fishstocks LIN 2–7 (Horn 2007). Because a comprehensive analysis has recently been completed, the work reported here simply updates Tables 2 and 4 of Horn (2007), i.e., catch by area, by method. This will indicate whether any marked changes have occurred in the fisheries since 2004–05 and particularly in the last year. The descriptive analysis is presented in Appendix A.

The updated commercial line fishery CPUE series are for ling on the Chatham Rise, the west coast South Island (WCSI), and in Cook Strait from 1990 to 2009, the Sub-Antarctic from 1991 to 2009, and the Bounty Plateau from 1992 to 2009. These five fisheries account for over 95% of the line-caught ling (Horn 2007). The principal lining method in all areas is bottom longline, although dahn lining is also used. CPUE analyses of these fisheries were most recently reported by Horn (2010). Two additional series from the Sub-Antarctic line fishery were produced by Horn (2009a) (i.e., the Puysegur and non-Puysegur fisheries) and these are updated below incorporating 2009 data.

Series of ling CPUE indices derived from trawl fisheries targeting species other than ling were also reported by Horn (2010). The series from the trawl fishery targeting hoki in Cook Strait was believed to be a reliable index of abundance of ling vulnerable to that fishery from 1994 to 2008, but its reliability as an index from 1990 to 1993 was dubious. There was a major change in fleet composition in 1994, and the accuracy of estimated ling catch per tow before 1994 is questionable (Horn 2008a). For the trawl fishery targeting spawning hoki off WCSI, a CPUE series using TCEPR data reported by vessels believed to have recorded their ling bycatch relatively accurately was developed in 2005 (Horn 2006) and has been updated annually since then (Horn 2010). This series was believed by the Middle Depth Species Fisheries Assessment Working Group to be more likely to index ling abundance than an unmodified TCEPR series or a series based on the relatively data-poor observer database. The current analysis has updated the Cook Strait TCEPR and WCSI 'accurate' TCEPR series, using 2009 data, as well as producing series for both areas using data from observed tows only.

Dunn et al. (2000) proposed four points that should be considered as part of the process to determine whether a CPUE series accurately mirrored fish abundance.

- Is there a good likelihood that CPUE provides an index of abundance (for that part of the population targeted by the fishery)?
- Are the data used in the analyses comprehensive and accurate?
- Was the modelling method valid for the available data?
- Do fishery-independent data support the CPUE trends?

Horn (2002) showed that the CPUE series from the Chatham Rise and Sub-Antarctic longline fisheries met all these criteria, and that the Bounty Plateau and WCSI series met the first three. The Cook Strait longline series probably did not index ling abundance well (Horn 2008a). The series derived from the Cook Strait trawl bycatch fishery probably met the first three criteria from 1994 onward (Horn 2008a). There was still considerable doubt about the reliability of any of the WCSI trawl series (Horn 2009a).

Series of longline CPUE indices have been used as inputs into population models for ling since 1996. A trawl CPUE series was incorporated into the Cook Strait assessment in 2007 (Horn 2008b), and into the WCSI assessment in 2008 (Horn 2009b). However, the WCSI assessment was inconclusive because the trawl and longline CPUE series exhibited opposing trends over much of their ranges, and no other relative abundance series were available for that stock.

The updated longline and trawl series will be incorporated into future ling assessments. The stock units used in the stock modelling (and hence, in the CPUE analyses) are denoted as follows:

- Chatham Rise: QMAs 3 & 4 (LIN 3&4)
- Sub-Antarctic: QMA 5, and QMA 6 west of 176° E (LIN 5&6)
- Bounty Plateau: QMA 6 east of 176° E (LIN 6B)
- WCSI: QMA 7 west of Cape Farewell (LIN 7WC)
- Cook Strait: Statistical Areas 16 and 17 (LIN 7CK)

2. METHODS

2.1 Data grooming

Catch and effort data, extracted from the fishery statistics database managed by the Ministry of Fisheries (MFish), were used in the analyses. All catch-effort-and-landing-return (CELR), lining-catch-effort-return (LCER), net-catch-effort-and-landing-return (NCELR), trawl-catch-effort-return (TCER), lining-trip-catch-effort-return (LTCER), and trawl-catch-effort-and-processing-return (TCEPR) records where ling were targeted or caught from anywhere in the New Zealand EEZ were extracted and groomed to rectify as many errors as possible. The kinds of errors included:

- missing values (which could be completed based on values from the preceding and following records);
- data entry errors owing to unclear writing (e.g., several consecutive days of fishing in Statistical Area 33 were punctuated by a single set recorded from Area 23, target species recorded as “LIM”);
- incorrect positions, due either to incorrect recording of east or west for longitudes, or to errors of 1° in latitude or longitude (correct values were often obvious based on preceding and following records);
- transposition of some data (e.g., transposition of number of hooks and number of sets);
- recording QMA number as statistical area.

The groomed data (from the 1989–90 fishing year to the end of the 2009 calendar year) are stored in two relational database tables (t_lin_celr, and t_lin_tcepr) administered by NIWA for MFish. Data from the 2009 calendar year were obtained from MFish in May 2010 as extract 7841.

For the trawl fishery analyses, catch and effort data were requested from the Ministry of Fisheries catch-effort database “warehou” as extract 7727. The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of hake, hoki, or ling between 1 October 1989 and 30 September 2009. Catch and effort data included the total estimated catch from CELR, LCER, NCELR, TCER, LTCER, and TCEPR forms.

Data were checked for errors, using simple checking and imputation algorithms similar to those used by Horn (2010) and Devine (2010). Individual tow locations were investigated and errors were corrected using median imputation for start/finish latitude or longitude, tow speed, net depth, bottom depth, 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, or the record was removed from the data set.

The daily processed part of the TCEPR form contains information regarding the catch (of all quota species) that was caught and processed that day. The processed fish are weighed and a conversion factor (depending on processing type) allows the weight of the fish before processing (i.e., green weight) to be estimated. The same approach as used for hake by Devine (2010) was used to update the CPUE indices for the WCSI ling trawl data where tow-by-tow data were combined into vessel day summary records.

2.2 Variables

Variables used in the analysis are described in Table 1 and are generally similar to those used in previous analyses (e.g., Horn 2010). Longline CPUE was defined as catch per day (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. Hook number per day was offered both as an untransformed number and as log-transformed data. Trawl CPUE was defined as catch per tow, with tow *duration* offered as an explanatory variable. *Year* was a categorical variable and was defined as June–September for the WCSI, and either June–September or the fishing year (October–September) for Cook Strait. Season variables of both *month* and *day of year* were offered. The Southern Oscillation Index (SOI) was included as a 3-monthly running mean (using the SOI from the month in which fishing occurred, and the two preceding months).

Hoki trawling uses both bottom and midwater gear, so *method* was offered as an explanatory variable in the trawl analyses, although midwater gear was further defined as midwater trawl, or midwater trawl fished on the bottom. Midwater gear was classified as fishing on the bottom if recorded net depth was within 5 meters of recorded bottom depth. *Gear width* was not used as an explanatory variable as this field in the TCEPR variously contained wingspread and doorspread measurements. Consequently, *headline height* was the only trawl gear dimension variable offered to the trawl model.

Individual vessel details were checked for consistency each year as it is apparent that more than one vessel can have the same vessel identification number. Tow records with no vessel identification data were excluded from further analyses. *Vessel* was incorporated into the CPUE standardisation to allow for differences in fishing power between vessels.

2.3 Data selection

Data from various groups of statistical areas (Figure 1) were selected as follows:

Chatham Rise (LIN 3&4) — 018–024, 049–052, 301, 401–412
Sub-Antarctic (LIN 5&6) — 025–031, 302, 303, 501–504, 601–606, 610–612, 616–620, 623–625
Bounty Plateau (LIN 6B) — 607–609, 613–615, 621, 622
West coast South Island (LIN 7WC) — 032–036, 701–706
Cook Strait (LIN 7CK) — 016–017

Note that these analyses were conducted on the basis of presumed biological stocks, rather than administrative (QMA) stocks. Consequently, the grouping of some statistical areas may not seem logical, but has been done in a way which 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.

2.3.1 Line fisheries

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

Some line vessels had been recording individual set data on CELR forms (whereas for most vessels, a single record constitutes a day's fishing). If uncorrected, this would cause bias in CPUE analyses as those vessels would contribute about four times as many records per day fishing as other vessels. Consequently, all longline data were condensed (catches and hooks summed over vessel, day, and statistical area) to ensure that each record represented total catch and effort per statistical area per day.

To ensure that the longline data to be analysed were within plausible ranges and related to vessels that had consistently targeted and caught significant landings of ling (and so were likely to represent experienced and competent ling fishers), data were accepted if all the following constraints were met:

- catch was by line (i.e., bottom longline, trot line, dahn line),
- catch was between 1 and 35 000 kg per day,
- number of hooks was between 50 and 50 000 per day,
- number of records in five years for a vessel was more than 100 (LIN 3&4), more than 50 (LIN 5&6), or more than 30 (LIN 6B and LIN 7CK),
- vessels had fished in more than one year,
- target species was reported as ling.

Examination of the zero catch records indicated that most represented either duplicated records (two records for a particular day, one with and one without catches) or obvious mistakes (two or three days fishing with no ling catch). Exceptions to this were data recorded by two vessels fishing around the Chatham Islands (in Statistical Areas 049–052), and consistently recording ling as their target species but recording zero or small landings of that species. It is suspected that these vessels were actually targeting species other than ling, so their data were removed from the Chatham Rise analysis. After this removal, zero catches made up less than 0.3% of the data. Because of the relatively high number of hooks fished in any set, a zero catch of ling in any set that is genuinely targeting ling is likely to result either from some gear malfunction or from exploratory fishing. The removal of such data points from the analysis will not bias the index of relative abundance of ling on known fishing grounds. Consequently, as in previous analyses, all zero observations were removed.

Line fishery CPUE series were again derived for two subareas within the Sub-Antarctic stock using all the data records that were accepted into the 'whole stock' analysis (described above in Section 2.3). The data were split into Puysegur (Statistical Area 30) and non-Puysegur (all other statistical areas) sets. This is consistent with the assessment model structure for this stock which incorporates a spawing fishery at Puysegur and a non-spawning fishery in other areas (Horn 2008b).

2.3.2 WCSI trawl

Ling trawl data on the WCSI can be recorded on TCEPR, TCER, or CELR forms (Figure 2). TCEPR and TCER returns contain tow-by-tow data. CELR returns often amalgamate a day's fishing into a single line of data, so some of the data on individual tows may be lost (e.g., duration, towing speed, bottom depth, gear dimensions). Vessels recording on CELR forms changed to TCER forms from 2007–08 (Figure 2). TCEPR data was about 78–92% of the total WCSI ling trawl catch in each year up until 2006–07, but was lower at 72% and 69% of the total catch in 2007–08 and 2008–09. The WCSI ling trawl fishery is mainly bycatch in the hoki target fishery (Figure 2), although the ling caught in hake or ling target tows has been increasing since 2005. The timing of the catch on the

WCSI has varied slightly between years, but most catch has been taken from May to October, often with a peak from June to September (Figure 2). Most of the catch was taken in statistical areas 033–036.

For the WCSI fishery the ‘accurate’ TCEPR series developed by Horn (2006) was updated (with the inclusion of TCER data since late 2007). That series assumes that the percentage of hoki target tows reporting a ling bycatch provides some indication of reporting accuracy. From the observer database, 90% of trips using the bottom trawl method had at least 72% of tows reporting a ling bycatch, and 90% of trips using midwater trawl had at least 50% of tows reporting a ling bycatch. These values were used as thresholds to identify vessels that were likely to have comprehensively reported their ling bycatch, i.e., if a vessel in a particular year had reported some ling bycatch in 72% or more of their bottom trawl tows, then all the data from that vessel in that year were included in the ‘accurate’ TCEPR data set.

To ensure that trawl data to be analysed were within plausible ranges and related to vessels that had consistently caught and recorded ling landings, data were selected as follows:

- TCEPR,
- 1990–2009 with year defined as June–September (inclusive),
- statistical areas 033–036,
- target species was hoki,
- ling catch was less than 15 000 kg per tow,
- tow duration 0.2–12 hours,
- number of tows for a vessel was more than 80 in 5 years,
- vessels had fished in more than one year,
- ‘accurate’ tows.

2.3.3 Cook Strait trawl

The Cook Strait ling trawl fishery is mainly bycatch in the hoki target fishery (Figure 2). TCEPR data generally accounted for 70–86% of total ling trawled catch, although in 2008–09 it dropped to 53%. The ling trawl catch on TCERs has effectively replaced the catch on CELR forms since 2007–08. Before 1995 almost all catch had been taken from June to September (hoki spawning season), but since then the catch is recorded all year around, although most is still taken between June and September (Figure 2).

For the Cook Strait CPUE analysis, data were selected as follows:

- TCEPR,
- 1990–2009, with year defined as June–September,
- statistical areas 016–017,
- target species was hoki,
- ling catch was less than 15 000 kg per tow,
- tow duration 0.2–7 hours,
- number of tows for a vessel was more than 100 in 5 years,
- vessels had fished in more than one year.

2.3.4 Observer data

A CPUE series was also calculated using data from the WCSI or Cook Strait trawl fisheries collected by observers. Data were accepted if all the following constraints were met:

- June–September in years 1987–2009 (WCSI), or 1998–2009 (Cook Strait),
- target species was hoki,

- ling catch was less than 15 000 kg per tow,
- tow duration was 0.2– 12 hours (WCSI), or 0.2–7 hours (Cook Strait),
- number of tows for a vessel was more than 35,
- vessel had fished in more than one year.

2.4 The models

2.4.1 Line fishery analyses

The lognormal linear model was used for all analyses. A forward stepwise Generalised Linear Model (Chambers & Hastie 1991) implemented in R code (R Development Core Team 2010) was used to select variables in the model. *Year* was forced into the model as the first term, and the algorithm added variables based on changes in residual deviance. The explanatory power of a particular model is described by the reduction in residual deviance relative to the null deviance defined by a simple intercept model. Variables were added to the model until an improvement of less than 1% of residual deviance explained was seen following inclusion of an additional variable. Interaction terms between all principal variables (excluding *year*) were allowed. Variables are either categorical or continuous, with model fits to continuous variables being made as third-order polynomials. The standardised indices were calculated using GLM, with associated standard errors. Indices are presented using the canonical form (Francis 1999) so that the year effects for a particular stock were standardised to have a geometric mean of 1. The c.v.s represent the ratio of the standard error to the index. The 95% confidence intervals are also calculated for each index.

For the longline CPUE series estimated for subareas within the Sub-Antarctic stock a *year:subarea* interaction effect was forced into the model. This produced a CPUE series for each of the two subareas within the stock, but with all other expected variable effects being the same over subareas.

Unstandardised CPUE was also derived for each year and area from the available data sets. The annual indices were calculated as the mean of the individual daily catch (kg) for longline or catch per tow (kg) for trawl.

Interaction terms allow for the relationship between CPUE and a particular explanatory variable to vary with another explanatory variable (e.g., an interaction between *month* and *statarea* indicates that the relationship between CPUE and *month* differs with *statarea*). Since the primary interest is in relative year effects, possible interactions with *year* were not considered, but interactions between all other principal variables were initially allowed.

Horn (2002) discussed the problems that the inclusion of interaction effects can have on standardisation analyses, i.e., the amount of data available is insufficient to justify the number of parameters fitted, coefficients for a particular variable can have an implausible range or pattern, they can ruin estimates of main effects, and selected interaction variables may be meaningless. In an attempt to overcome these problems and produce the most valid model possible, the following analyses were conducted for each stock.

a) The lognormal linear model was run using all data, but allowing no interaction effects. If *statarea* was selected into the model, then the number of records derived from each statistical area was calculated. Data from areas contributing very few records were removed from future analyses. Although there was no set threshold below which data would be removed, the amount of data deleted was generally negligible and was never more than 3% of the total available.
b) The model was re-run, this time allowing interactions between all variables. The variable coefficient ranges were then examined, and if a range was considered implausible, the model was re-run with one or more of the least significant variables deleted until the resulting coefficient ranges of the more significant variables were considered plausible.

Model predictions for all variables selected into the final model are plotted against a vertical axis representing the expected (non-zero) catch. To calculate the *y*-values for a particular variable, all other model predictors must be fixed. These fixed values were chosen to be ‘typical’ values (see Francis (2001) for further discussion of this method). Note that if different fixed values were chosen, the values on the *y*-axis would change but the appearance of the plots would be unchanged.

2.4.2 Trawl fishery analyses

Estimates of relative year effects were obtained from a stepwise multiple regression method, where the data were fitted using lognormal and binomial models. The lognormal component of the model was used to fit log transformed non-zero catches and the binomial component was used to fit the proportion of zero tows. Combined CPUE indices were calculated by combining the lognormal and binomial indices (Vignaux 1994). A forward stepwise multiple-regression fitting algorithm (Chambers & Hastie 1991) implemented in the R statistical programming language (R Development Core Team 2010) was used to fit all models. The algorithm generated a final regression model iteratively. The reduction in residual deviance 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. Interaction terms were ignored, although nested effects between method and headline height, duration, speed, depth of net, or depth above bottom were investigated. Model fits to continuous variables were modelled as third-order polynomials, although a fourth-order polynomial was also offered to the models for duration. For models using estimated catch, all variables were included. For the models using processed catch, the variables longitude or latitude could not be used, but location was represented by statistical area.

Model fits to the lognormal component of the combined model were investigated using standard residual diagnostics. 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.

Year was treated as a categorical value so that the regression coefficients of each year could vary independently within the model, and was forced into the model as the first term. The relative year effects calculated from the regression coefficients represent the change in CPUE through time, all other effects having been taken into account. It therefore represents a possible index of abundance. Indices are presented using the canonical form (Francis 1999) so that the year effects for a particular stock were standardised to have a geometric mean of 1. The c.v.s represent the ratio of the standard error to the index. The 95% confidence intervals are also calculated for each index.

Unstandardised CPUE was also derived for each year and area from the available data sets. The annual indices were calculated as the mean of the catch per tow (t).

For the WCSI, lognormal/binomial CPUE models were run for three datasets of ling catch: tow-by-tow estimated data, processed catch by vessel-day data, and observer data. Data from the estimated and processed datasets included data from the TCEPR form only for accurate vessels for targeting hoki for the years 1990 to 2009, with year defined as June–September. For the tow-by-tow estimated data, other CPUE models were investigated: TCEPR and TCER; TCEPR 1999–2009; TCEPR target species as hoki, hake, or ling; TCEPR all tows; and TCEPR trips with an observer on board.

For Cook Strait, lognormal/binomial CPUE models were run for two datasets of ling catch: tow-by-tow estimated data, and observer data. Data from the TCEPR form included tows targeting hoki for the years 1990 to 2009, with year defined as June–September. For the tow-by-tow data, other CPUE models were investigated: TCEPR and TCER; TCEPR ice boats; TCEPR restricted area (Cook Strait Canyon and Nicholson Canyon only); TCEPR top performing boats; TCEPR 1995–2009; and TCEPR with year as October–September.

3. RESULTS

3.1 Ling target longline fishery series

For each of the five stocks, the number of records of days fished in each statistical area included in the final analysis is listed in Table 2. Total numbers of days fished, the estimated catch of ling from those fishing operations, and the number of vessels involved, by year, for data used in the final standardised analysis are given in Table 3.

3.1.1 Chatham Rise (LIN 3&4)

The Chatham Rise final analysis comprises over 16 000 records of days fished throughout the 20 years analysed (Table 3). The estimated landings from this effort represent more than 90% of the total estimated landings by line fishing for this stock. Line fishing accounted for about 55% of the LIN 3&4 landings throughout the 1990s (Horn 2001), but line-caught landings have declined since about 1996 (see Appendix A, Table A3b). Data from bottom longline, trot line, and dahn line operations were included in this analysis, and fishing method was offered as an explanatory variable. None of the 35 vessels included in this analysis had fished in every year, but 18 vessels had fished in six or more years (Figure 3).

The model run without interactions indicated that *statarea* explained an insignificant amount of the variance. Consequently, data from all but four of the statistical areas were retained in the final analysis. The areas that were deleted (301, 406, 411, 412) contributed less than 0.2% of the observations over the 20 years of the analysis, and these are probably attributable to reporting errors or exploratory fishing. In the model run with full interactions, two interactions (*vessel:log(hookno)* and *vessel:month*) entered the model. However, their inclusion resulted in some implausible *vessel* coefficients, so they were excluded. This exclusion changed the final standardised series only slightly.

Of the variables entering the model in the final analysis, *log(hookno)* was very dominant as it explained about 65% of the total variance (Table 4). The accepted variables explained 80% of the total variance. The model assumptions are mainly satisfied, and there are no marked patterns in the residuals (Figure 4). The poorly estimated points (i.e., those with residuals less than –3) make up a very small fraction of the total data set.

The effects of the selected variables are shown in Figure 5. Catch per hook increased over the entire range, but at a decreasing rate with increasing hook number. Data from 35 vessels are incorporated in the model; the difference between the best and worst of all but one of these vessels is less than a factor of 5. This level of between-vessel difference is not great given the inclusion in the analysis of auto-longliners and smaller hand-baiting inshore vessels. Highest catch rates tend to occur from August to December (the probable spawning season), but the best monthly catch rate is less than double the worst.

The standardised year effects (Table 5, Figure 5) show a steady decline from 1990 to 1997, followed by a relatively constant signal since then.

3.1.2 Sub-Antarctic (LIN 5&6)

Line fishing has accounted for 12–40% annually of the LIN 5&6 (excluding the Bounty Plateau) landings since the auto-longline fishery developed in 1991 (Horn 2007). In recent years the line-caught fraction has been at the lower end of this range (see Appendix A).

The Sub-Antarctic final analysis includes almost 6000 days of data from fishing operations responsible for about 90% of the line landings from 1991 to 2009. This fishery is almost exclusively bottom longline (99.5% of sets), so only data from this method were included in the analysis. Data from 14 vessels were included in the final analysis (see Figure 3). No vessel had fished the entire series, but seven had fished in six or more years.

The model run without interactions indicated that *statarea* was a variable with considerable explanatory power (it explained about 8% of the variance). However, 13 statistical areas each had records of 35 or fewer days fished throughout the 19-year series. Their removal involved less than 2.5% of the data, but reduced the number of included statistical areas to 11 (each with over 40 days fished). It is believed that the remaining subset of data would provide a more accurate representation of any *statarea* effect.

In the model run with full interactions, five interaction variables were selected, *vessel:month, vessel:statarea*, *vessel:log(hookno), month:statarea*, and *month:log(hookno)*. However, the inclusion of these resulted in ranges of more than two magnitudes in the coefficients of the *vessel* and *month* variables. The model was re-run restricting *vessel*, or *month*, or *statarea*, or *log(hookno)* from entering any interaction. It was apparent from these runs that all the interacting variables were causing implausible coefficient ranges. Consequently, the final model was derived from a run allowing no interactions between these variables. This reduced the total explained variance by about 8%, but the final series of year effects obtained with and without interactions were virtually identical.

The variables entering the final model were *vessel*, *log(hookno)*, and *statarea*. About 51% of the variance was explained by the *log(hookno)* variable, and total explained variance was 64% (see Table 4). The model assumptions were mainly satisfied, there being only limited deviations from normality (Figure 6).

The effects of the selected variables are shown in Figure 7. Catch per hook increased over the entire range, but at a decreasing rate with increasing hook number. Overall catch by *statarea* varied by a factor of less than 2, with the highest catch rate occurring in Statistical Area 30. Daily catch rate by vessel varied by a factor of less than 3. The standardised year effects (Table 5, Figure 7) indicate a variable series with no clear trend.

CPUE series were also produced for two subareas within the Sub-Antarctic stock; the Puysegur analysis including the Puysegur Bank and Solander Corridor (comprising Statistical Area 30), and the non-Puysegur analysis including all other areas normally included in the Sub-Antarctic analysis. The volumes of data included in each analysis are shown in Table 6. The Puysegur analysis has more than 100 days fished in most years. The non-Puysegur analysis included more data, particularly through the middle part of the series. The model assumptions were mainly satisfied, there being only limited deviations from normality (Figure 8).

The variables selected into the subarea model were the same as for the single area model, except that *statarea* was not selected. The variable *log(hookno)* explained most of the variance (46%), and with *vessel* included, 64% of total variance was explained (Table 4). For the Puysegur region, the standardised year effects (Table 6, Figure 9) exhibit a relatively constant, but jittery, trend over time. For the non-Puysegur region of the Sub-Antarctic stock, the standardised year effects (Table 6, Figure 9) show a relatively constant trend. The highest indices in each series (2007 for non-Puysegur and 2009 for Puysegur) are in the years with the lowest numbers of days fishing and both have very wide confidence bounds.

A comparison of the CPUE series from the two subareas (see Figure 9) shows some similar trends between series, but both are best interpreted as being variable but with no overall trend. CPUE at Puysegur is markedly higher than in the non-Puysegur area.

3.1.3 Bounty Plateau (LIN 6B)

Line fishing accounts for virtually all the Bounty Plateau ling landings since 1992 (see Appendix A, Table A3b), and the final analysis presented here includes data from fishing operations responsible for over 98% of those line-caught ling. However, no data from 2005 were able to be incorporated in the analysis. Only one vessel fished the Bounty Plateau in 2005 (for 12 days), and although this vessel had also fished here in 2004 (for 4 days) it did not meet the necessary threshold of 30 records. From 2007 to 2009 only one vessel fished the Bounty Plateau and it had not fished there in earlier years (although it had targeted ling in other stocks in previous years). Consequently, two independent CPUE series are presented for the Bounty Plateau line fishery, i.e., 1992–2006 and 2007–09.

The 1992–2006 analysis incorporated over 1600 vessel days from the 15 years of data, although there were no usable data from 2005, four years were represented by just over 60 days each, and 2006 contributed only 14 days (see Table 3). Bottom longline is the only method used in this fishery (Horn 2007). Data from eight vessels were incorporated in the final analysis; one of these vessels had fished in all years from 1992 to 2004, but only one other vessel had fished in six or more years (see Figure 3). The model run without interactions did not select *statarea*. However, as Statistical Areas 607 and 608 accounted for 99% of the records, data from other statistical areas (i.e., 613 and 614) were deleted as they were probably reporting errors or exploratory fishing. In the model run with full interactions, *month:log(hookno)* and *vessel:log(hookno)* were selected. The inclusion of the *vessel* interaction effect was found to adversely affect the vessel coefficients, so it was excluded.

The variables selected into the final model explained 52% of the total variance (see Table 4). The model assumptions were mainly satisfied, there being only slight deviations from normality (Figure 10). The effects of the selected variables are shown in Figure 11. The relationship between the number of hooks set and daily catch is approximately linear. Overall catch rates for the included vessels vary by a factor of less than 3. Catch rates tended to be higher from August to October, but the difference between the best and worst month is less than a factor of 5.

The standardised year effects from 1992 to 2006 (Table 5, Figure 11) indicate a relatively rapid decline from 1992 to 1994, followed by a slight declining trend to 2004. The 2006 index is indicative of a slight recovery, but has very wide confidence intervals owing to the small volume of data from that year.

The 2007–09 analysis incorporated 195 days fishing by one vessel (see Table 3, Figure 3). In model runs with and without interactions, *log(hookno)* and *statarea* were selected, and explained 58% of the total variance. The standardised year effects (Table 5, Figure 11) indicate a slight decline over the 3-year period.

3.1.4 West coast South Island (LIN 7WC)

About 30% of the landings of ling from the WCSI section of LIN 7 were taken by line fishing throughout the 1990s, and this level of catch has been maintained since then (Horn 2007). The final analysis below includes data from fishing operations responsible for over 95% of the line landings (see Table 3). This target fishery for ling is conducted primarily by smaller inshore vessels using the bottom longline and trot line methods. Fishing method was offered as an explanatory variable in this analysis. The final analysis included data from 22 vessels (see Figure 3). Three of these had fished in all 20 years of the series, and 16 vessels had fished in six or more years.

The model run without interactions indicated that *statarea* was a variable with some explanatory power. Consequently, data from only three statistical areas (032, 033, 034) were retained in the analysis (Areas 035, 036, and 703 contributed only 1% of the available observations). In the model run with full interactions, interactions between *month*, *log(hookno)*, and *vessel* were selected. However, the inclusion of any of these interaction effects produced implausible ranges of variable coefficients, so none were retained. The variables entering the model (*vessel*, *month*, and *log(hookno)*) explained 35% of total variance (see Table 4).

The model assumptions were mainly satisfied, but there was some evidence of non-normality in the pattern of the residuals (Figure 12). However, the poorly estimated points (i.e., those with residuals smaller than –3) are a very small fraction of the total data set.

The effects of the selected variables are shown in Figure 13. The vessel coefficients were in a relatively narrow range, with the best and worst vessels varying by a factor of about 4. Catch rates were high from August to October (the spawning season), and low from January to June. Catch per hook increased over the entire range, but at a decreasing rate with increasing hook number.

The standardised year effects (Table 5, Figure 13) indicate a variable, but relatively flat series with no clear trends.

3.1.5 Cook Strait (LIN 7CK)

The line fishery in Cook Strait took about 20% of the ling landings from this area throughout the 1990s, but this proportion increased to an average of about 45% in the 2000s (Horn 2007). The ling target line fishery had relatively few records from 1997 to 2001, and in 2006, 2008, and 2009 (see Table 3), but data from all years were included in the analysis. Over 95% of days fishing occurred in Statistical Area 016 (see Table 2). Bottom longline and dahn line are both used, with longline being dominant. Three large auto-longline vessels have fished in this area since 1998. The total number of days fished by one of these vessels met the 5-year threshold (see Section 2.3), so it was included in the model. Data from 17 vessels were incorporated in the final analysis, and one of these had fished in all but the four most recent years of the series (see Figure 3). Seven vessels had fished in six or more years.

The model run without interactions indicated that *statarea* explained none of the variance, so data from both statistical areas were retained. Interactions between *vessel*, *month*, and *log(hookno)* all entered the full interaction model. However, the interactions with *vessel* gave rise to unrealistic vessel coefficients, so they were excluded. Their exclusion caused very minor changes to the standardised series. Of the variables entering the model in the final analysis, *vessel* was dominant and explained 34% of the variance. *Vessel*, *log(hookno)* and *month* were the selected variables, explaining 71% of the total variance (see Table 4). The model assumptions were mainly satisfied, there being no marked patterns in the residuals and limited deviations from normality (Figure 14).

The effects of the selected variables are shown in Figure 15. Catch rates by all but one of the vessels in the model varied by less than a factor of 4. Catch per hook increased over the entire range, but at a decreasing rate with increasing hook number. Highest catch rates tended to occur from April to August, although the difference between the best and worst month was less than a factor of 2.

The standardised year effects are quite variable (Table 5, Figure 15) but could be interpreted as showing a slight decline throughout the early 1990s, followed by a steady increase from 1995 to 2002, and then another decline to 2009. An approximate doubling of biomass from 1998 to 2002 is indicated. However, confidence bounds around many of the indices are wide, particularly those from 1999 to 2003 (i.e., most of the higher indices).

3.2 Trawl fishery ling bycatch series

CPUE series for the ling trawl bycatch fisheries for hoki (Cook Strait and WCSI) are presented. For the analyses of TCEPR and observer data from both fisheries, the estimated catch of ling, number of tows, proportion of zero catches, the number of vessels involved, and unstandardised CPUE by year for initial dataset and final dataset used in the standardised analysis (i.e., following initial grooming and removal of seldom-fished areas) are given in Table 7. The number of tows by method are also summarised by year for the final datasets.

3.2.1 WCSI (LIN 7WC)

Available TCEPR data from vessels believed to be accurately reporting their ling bycatch in the trawl fishery targeting spawning hoki off WCSI are summarised in Table 7a. There were many more vessels and catches targeting hoki in the 1990's than the 2000's, however most of the accurate tows and catches are from 1999–2009 (Table 7a, Figures 16a and 17a,b). After data grooming and selection of accurate vessels, there were 21 297 tows, with from 163 to 3126 tows in each year, and with 1991–1998 and 2007–2009 having fewer than 400 tows annually. The unstandardised indices of non-zero catch per tow had no clear trend (Table 7a). The accurate data set is dominated by the bottom trawl method, although there are midwater trawls in each year, especially from 1998 to 2007 (see Table 7a). Just less than half the midwater tows were reportedly fished on the bottom. Data from the three method categories were included in the model, and *method* was offered as an explanatory variable. Of the 58 vessels included in the final analysis, none had fished in all years, but 25 had fished in more than 5 years (see Figure 17b).

The variables selected by the stepwise regressions for the WCSI model runs are given in Table 8. Six variables were selected for the ling TCEPR accurate lognormal model, producing a total r^2 of 26%, with 12% attributable to *vessel*. The other variables selected were *duration, mid-time, depth of net*, and *day of year*. Expected catches of ling increased with duration, and peaked at a net depth of about 400 m (Figure 18a). Catch rates decreased from about 1 July to mid August and then increased through to the end of September. Higher catches tended to occur in tows centred on midday. *Depth of net*, *month*, and *vessel* were selected for the binomial model, producing a total r^2 of 8%, with *depth of net* explaining most variance. A zero ling catch is very unlikely with a *depth of net* between 300–600 m, more likely in August and September, and is more likely for vessels with a lower overall catch of ling, although these vessels have a higher variability in catches (Figure 18b).

Including nested variables in the lognormal model produced results similar to the non-nested model (Table 8), with a total r^2 of 26.4% following the inclusion of *duration in method,* and *depth of net in method*. *Depth of net in method*, *day of year* and *vessel* were selected for the binomial model resulting in a similar total r^2 of 8.9%, with *depth of net in method* explaining most variance. The overall trend was similar to the analysis without nested variables (Table 9a,b).

The standardised year effects from the combined model (Table 9a, Figure 19) produce a series with an overall declining trend; most indices before 2000 are greater than one, and most indices after 2000 are less than one. A decline can be seen from 1992 to 2003, with a subsequent increase to 2009. The binomial series is relatively flat, while the combined indices are similar to the lognormal indices. The model assumptions were well satisfied, with very balanced residuals and no deviations from normality (Figure 20a,b).

Data collected by MFish Observers from the target trawl fishery for hoki off WCSI were also analysed to produce a CPUE series, using the combined model. Data from 76 vessels were included (Table 7b, Figure 17c). Although 30 of these vessels had been observed in only two years, 21 had been observed in 5 or more years (with the maximum being 10 years). There were 21 197 tows in the data set, of which almost 5200 (25%) reported no ling catch (Table 7b). About 45% of the midwater tows were reportedly fished on the bottom. Data from the three method categories were included in the model, and *method* was offered as an explanatory variable.

The final lognormal model explained 37% of total variance, with *day of year* and *vessel* each explaining about 7% (Table 8). Expected catches tended to be lowest around August, peaked at a net depth of 400 m, increased with tow *duration*, were greater in bottom trawls than midwater trawls, and were higher further south and further east (Figure 21a). In the binomial model, *year* explained about 6% of the variance, with the final model explaining 26% (Table 8). The probability of a non-zero ling catch was lowest at a net depth of about 400–500 m, and around August (Figure 21b). Bottom trawls were marginally less likely to get a zero catch of ling than midwater trawls. The categorical variables *latitude* and *longitude* also enter the model, indicating a slightly higher expectation of zero catches further west and north. *Duration* has a relatively weak effect on the probability of a zero ling catch.

The standardised year effects from the combined model (Table 9c, Figure 22) produce a series that is quite spiky, but appears to increase from 1992 to about 1999, then decline to 2008. The binomial series has a flattish trend, while the lognormal series is similar to the combined model. The model assumptions were well satisfied, with very balanced residuals and no significant deviations from normality (Figure 20c,d).

Model runs are compared in Figure 23. The accurate TCEPR series shows a similar trend to the accurate TCEPR plus TCER series, the TCEPR data for all vessels from 1999, and TCEPR accurate 1999–2009 series. The accurate TCEPR (target hoki) indices are similar to the accurate TCEPR (target hoki, hake, ling) indices although indices are lower in the multiple target model in the last three years. TCEPR data for vessels with an observer onboard show an overall decline from 1993. The accurate TCEPR series does not follow the observer data series.

3.2.2 Cook Strait (LIN 7CK)

In the Cook Strait target hoki trawl fishery in Cook Strait there were 36 268 tows, ranging from 568 to 4266 tows per year (Table 7c). The unstandardised indices of catch per tow show a clear declining trend from 1990 to 1995 (0.38 to 0.16 t per tow), and have since been relatively constant (0.10–0.14 t per tow), although they dropped to 0.06 t per tow in 2009 (Table 7c). Fishing occurs in Statistical Areas 016 and 017, but Area 017 (which takes in Cook Strait Canyon) is the more heavily fished. This dataset is from June to September only (the hoki spawning season) when most of the ling catch has been taken. However, since 1995 the catch has been taken all year around (see Figure 2), possibly creating changes in vessel behaviour.

The fishery is dominated by the midwater trawl method (see Table 7c); little bottom trawling for hoki was conducted in this area before 1994. Horn (2003) showed that the CPUE derived from bottom trawl data only, midwater trawl data only, and both methods combined, produced series with virtually identical trends. Consequently, both methods have been included in subsequent analyses, but with the midwater trawl category split into two, i.e., fishing on the bottom, and fishing in midwater. Of the 47 vessels included in the final analysis, two had fished in all years except 2007 and 2008, and 29 had fished in six or more years (Figure 17d). Three vessels produced about 32% of the data.

For the ling TCEPR June to September lognormal model, five selected variables explained 30% of total variance, with *vessel* explaining 14% (Table 8). The other variables selected were *duration*, *day of year*, and *statarea*. Catch rates decreased from about 1 July to mid August, and then increased through to the end of September. Expected catches of ling increased with *duration*, and were higher in *statarea* 017 (Figure 24a). Variables selected when allowing nested variables were the same as in the non-nested model but including *duration in method*, and *depth of net in method* (Table 8). The total r^2 was 31%. *Day of year*, *latitude* and *vessel* were selected for the binomial model, resulting in a total r^2 of 19%, with *vessel* explaining most residual deviance (Table 8). No nested variables entered the binomial model. A zero ling catch is more likely in August, in the north of Cook Strait, and for vessels with a lower overall catch of ling (Figure 24b).

The standardised year effects (Table 9d, Figure 25) indicate a steady decline from 1990 to 1997, followed by a slight increase to 2001, and a subsequent slight decline to 2009. The individual indices have narrow confidence bounds. The model assumptions were well satisfied, there being no marked patterns in the residuals and limited deviations from normality (Figure 20e,f).

Observed tows from the target trawl fishery for hoki in Cook Strait from June to September were analysed to produce a CPUE series. From 1998 to 2009 there were 1507 observed tows ranging from 50 to 239 per year (Table 7d). Because of the relatively low number of tows, these results should be treated with caution. The final lognormal model explained 35% of total variance, with *vessel* alone explaining 16% (Table 8). In the binomial model, *vessel* explained about 7% of the variance, and the final model explained 17% (Table 8). The standardised year effects from the combined model show a declining trend from 2000 to 2009 (Table 9e, Figure 26).

Model runs for Cook Strait are compared in Figure 26. All series show a declining trend from 1990 to 1997, a slight increase to 2001, followed by a general decline to 2009. The June to September TCEPR series are very similar whether nested variables are included or not. The trend in indices do not change if TCER data is added in, if year is changed to October–September, if only Cook Strait Canyon and Nicholson's Canyon data are used, if the years are restricted to 1995–2009, if vessels processing their catch are excluded, or if top vessels by catch are included or excluded. Observer data show a steeper declining trend from 2000 than the TCEPR series.

4. DISCUSSION

4.1 LIN 3, 4, 5, 6, and 7 target longline fishery series

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 2007, 2008b, 2009b). CPUE has been the only relative abundance series available for LIN 6B, LIN 7WC, and LIN 7CK, but is used in conjunction with indices from trawl survey series for LIN 3&4 and LIN 5&6. Horn (2002) showed that most of the ling line CPUE series appeared to perform well in relation to the 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 line fishery). The exception was the Cook Strait longline series.

As would be expected, the trends in the indices for the various stocks, and the variables selected into the models, have not changed markedly between the previous (Horn 2010) and current analyses. Because the five longline fisheries examined here target a single species using similar methods, the sets of variables selected into the model for each stock might be expected to have some similarities. In all the analyses, *log(hookno)* and *vessel* were selected into the model, and *month* was accepted into all except the Sub-Antarctic 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. This is certainly the case for LIN 3&4, LIN 5&6, and LIN 6B, where *log(hookno)* is the most influential variable, accounting for the largest proportion of the 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, although vessel catch rates seldom differed by more than a factor of 4 in each stock. Clearly, catch rates in all areas vary throughout the year, probably in relation to the spawning season for ling. Hence, *month* becomes an important explanatory variable.

In some of the plots of variable effects for the *hookno* variable there is a discontinuity at low hook numbers (e.g., Figures 5 and 15). The reason for this is not apparent, but it will be investigated in more detail in future analyses. Most of the sets with low hook numbers occurred early in the fisheries, so it is possible that some of these represent exploratory fishing sets that produced relatively small catches.

It is apparent from Figure 3 that the fleet dynamics in some of the line fisheries have changed quite considerably, with periods when several vessels ceased to operate and new ones entered the fishery. However, Horn (2004a) completed separate analyses for shorter time series of data and compared the results with the “all years” indices to show that the change in fleet dynamics has not biased the CPUE. It is also considered unlikely that CPUE series have been 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).

One clearly apparent change in recent fishing seasons is the reduction in effort, particularly on the Campbell and Bounty Plateaus and in Cook Strait (see Table 3). 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, in the most recent year, to a reduction in overseas demand for New Zealand ling. However, it was apparent that a few new line vessels had entered some of the fisheries in 2004–07, and some of these have built up sufficient history in the fisheries to meet the data thresholds and be included in the analyses reported above. It was necessary to complete two independent series for the Bounty Plateau fishery as there is no overlap in vessels between 2006 and 2007.

Horn (2009a) derived subarea CPUE series for the Chatham Rise and Sub-Antarctic stocks to see whether there were any apparent differences in relative ling abundance (as indexed by line catch rates) within what are assumed to be unit stocks. The trends (and catch rates) for three Chatham Rise subareas were very similar; those series have not been re-analysed since. The two Sub-Antarctic subarea series have been updated. The assessment of this stock incorporates catch and catch-at-age data from two fisheries (a spawning fishery at Puysegur, and a non-spawning fishery in other areas), so the production of two CPUE series is consistent with the assessment model structure (Horn 2008b). CPUE trends in the subareas are similar, although catch rates are markedly higher in the Puysegur region. This is almost certainly a function of the Puysegur fishery targeting spawning aggregations, whereas the fishery in the other subarea is targeting more disaggregated (generally non-spawning) fish.

The CPUE from the Cook Strait ling line fishery is considered to be the least reliable of all the five major line series. The reduced precision in the indices from 1997 to 2003 is reflected in the relatively high c.v.s for these points (see Figure 15). This series may be biased owing to the existence of target line fisheries for bluenose and hapuku. Ling is often taken as a bycatch in these fisheries, and the distributions of the three species overlap in depth and area. The CPUE analysis uses only data where ling was the stated target species. If it is general practice to define the reported target species as the most abundant species once the catch is onboard, then any real decline in ling abundance would be underestimated in the CPUE series (because only sets where ling was the most abundant species would be included in the analysis). However, fishing practices and areas can differ when targeting each of the three species, so the reported target is often likely to be the true target. The approximate doubling of biomass between 1998 and 2002 indicated by the CPUE series could have been achieved through growth and recruitment, but if so, it does represent an exceptional increase for a fished population. The possibility of population enhancement by migration from other areas cannot be ruled out. Hence, although the reliability of this CPUE series is questionable, there are no factors that have obviously biased this series.

The WCSI series may also be biased to some extent. The 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 enable a degree of hyperstability in the CPUE indices. Also, some interactions with the trawl fishery in the same area could also lead to biases (see Section 4.3 below).

The line fishery CPUE analyses presented here for all stocks (with the exception of Cook Strait and maybe WCSI) provide sets of indices that are probably valid as relative abundance series (for that section of the population exploited by the fisheries) in stock assessment models for ling. Since the early 1990s, ling stocks targeted by line fisheries have been relatively constant in the Sub-Antarctic, but have declined by about 55% on the Chatham Rise and Bounty Plateau. The WCSI series has fluctuated, but is indicative of a stock size in 2009 little different from that in the early 1990s.

4.2 Trawl fishery ling bycatch series

The CPUE series for ling bycatch in the target trawl fisheries for hoki in Cook Strait and off WCSI have been updated using TCEPR and TCER data, and a series using WCSI observer data (previously investigated by Horn 2006) has been reintroduced. Horn (2004a) discussed in detail the likely reliability of the catch and effort data available from these fisheries, and concluded that ling in Cook Strait hoki catches would be sufficiently abundant to be consistently reported on the TCEPR forms and that any changes in fishing practice have probably been accounted for by the variables accepted into the CPUE models. A subsequent analysis of "rolled-up" (Starr 2007) Cook Strait trawl CPUE data (Horn 2008a) supported the conclusion that the TCEPR series probably provided a reasonable abundance index, at least from 1994 to 2006. However, the "roll-up" process produced few data before 1994 (the reason for this was not apparent), giving rise to doubts about the accuracy of estimated ling catch before that date. For that reason, and because there were marked changes in fleet structure that occurred around 1994 (see Figure 17d), it was considered desirable to at least place much lower weighting on the CPUE series before then, and rely on the series starting in 1994.

Horn (2008a) also tried excluding data from vessels that had dropped out of the fishery by 1995 or had recorded more than half their fishing effort in 1993 or earlier to determine whether the high CPUE indices from 1990 to 1993 were driven by vessels that participated minimally in the fishery after 1993. The resulting series was little different from the original analysis. An analysis excluding vessels that had fished only in 1990–93 was repeated here, and resulted in a similar conclusion (Figure 27). A further analysis using a fine scale area variable was run to test whether there was a subtle change around 1994 in the areas fished for hoki, with the more recent effort occurring in areas of relatively low ling abundance (Horn 2008a). Again, the resulting series was little different from the original. Plots of the means of several variables over time (Figure 28) do exhibit some consistent trends, e.g., mean distance towed has steadily declined since 1990. However, it is also apparent that the 1990–93 data includes many of the longest duration and distance tows, the slowest and deepest tows, the lowest headline heights, the smallest vessels, and the smallest hoki catches. Although duration, headline height, speed, net depth, and bottom depth are offered to the model, only duration was selected (see Table 8). It may be that some of these variables are accounted for by the *vessel* variable (which is selected into the model), but if that was the case then the exclusion of vessels fishing only before 1994 should have removed the influence of these 'extreme' data points. Consequently it is concluded that either ling were markedly more abundant in the early 1990s, or some as yet unidentified change in reporting or fishing behaviour by fishers has biased the series.

A combined model using MFish observer data from the Cook Strait hoki target trawl fishery was produced for the first time, but only covered 1998–2009 and was relatively data poor. It was indicative of a steady decline in abundance since about 2000 (see Figure 26). The Cook Strait TCEPR series is indicative of a steady decline in abundance from 1990 to 1994, but this part of the series may be unreliable. From 1994 to 2009 the indices are relatively consistent between adjacent years and have narrow confidence bounds (see Figure 25), so may be reasonably reliable. They indicate that biomass declined initially, then increased to a peak about 2001, and subsequently declined again. The 2009 index is the lowest of the entire series.

Horn (2006) noted that since about 2000 in the WCSI fishery there probably had been more active avoidance of ling, but that there are still incentives to dump or under-report ling (as is strongly believed to have occurred regularly before 1994). This situation has not changed. Consequently, the ‘accurate’ TCEPR series was developed by using observer data to identify years when particular vessels were likely to have comprehensively reported their ling bycatch (Horn 2006). This exercise confirmed that ling bycatch had been frequently not reported on the ‘estimated catch’ section of the TCEPRs from 1990 until at least 1997, and that there are still vessels appearing to consistently under-report ling.

The ‘accurate’ TCEPR combined model was updated here. The incorporation of the reported zero tows in the combined model has little effect on the lognormal series (see Figure 19). It is pleasing that the series calculated using the ling processed catch on the TCEPR had a trend similar to the series using estimated tow-by-tow catch (see Figure 23). Both series exhibited a slight overall decline from 1992 to 2008.

A combined model using MFish observer data from the WCSI hoki target trawl fishery (first developed by Horn (2006)) was also updated. While a large volume of data was used in the analysis, it is unfortunate that many of the vessels (30 out of 76) contributed to the series in only two years. The resulting series was quite spiky. Some of the explanatory variables selected into the observer model were the same as those selected into the TCEPR models; where this happened, the variable effects were generally similar (e.g. the *day of year* effect indicated high catch rates in late June and low catch rates in mid August for both models). However, the overall year effects were quite different between series (see Figure 23). In contrast to the overall decline in the TCEPR series from 1992 to 2008, the observer series increased from 1992 to peak in 1999 and then steadily declined. There is no way of establishing which of the two data sources is likely to produce the more reliable index series. Consequently, we can still not be confident that a reliable index of ling abundance is available from the trawl fishery.

4.3 Comparison of relative abundance series

CPUE series from both the line and trawl fisheries are available for the Cook Strait and WCSI stocks; in both areas there are some marked differences in the trends from the two fishing methods. However, pairs of indices from an individual stock would not necessarily be expected to exhibit similar trends, owing to different fishing selectivities in the trawl and longline fisheries.

Both Cook Strait CPUE series exhibit some similar trends, i.e., a decline followed by a recovery, and then another decline in the last 6–7 years (Figure 29). However, an overall decline is apparent in the trawl series, while a strong recovery followed by an equally strong decline dominates the line series. However, the first four points of the trawl series (i.e., 1990–93) may not be reliable or comparable to the latter part of the series. The line series is disadvantaged by having few participants, low data volumes in some years, and the potential for some bias as a result of being able to determine the target species after the catch is landed. However, the trend in the line series is similar to the trend estimated from data produced by the one vessel that had fished with the same skipper and gear in all years from 1990 to 2005 (Horn 2008a). The trawl series is based on extensive data, but relies on consistent and relatively accurate estimation of ling bycatch per tow — a comparison of series using estimated and “rolled up” data suggests that the estimation is accurate from 1994 (Horn 2008a). If only the 1994 to 2009 parts of the two series are compared, similarities are apparent, i.e., a general increase from the mid-late 1990s to a peak about 2001–02, followed by another decline. There are no fishery-independent data available to validate either of the Cook Strait CPUE series.

The WCSI line CPUE series exhibits a relatively spiky but overall flat trend (Figure 30). The two trawl CPUE series are also spiky, and exhibit greater variation that the line series. The trawl series exhibit different overall trends; the only consistency is that both indicate a decline in biomass from 1999 to 2008 (although the observer series indicates a much steeper decline). There has always been, and still is, some incentive for the trawl bycatch of ling to be actively avoided or under-reported; the use of the ‘accurate’ TCEPR data hopefully removed much of the bias that misreporting would introduce. The observer series should be devoid of any reporting bias. For the line fishery, it is suggested that the hoki trawlers sometimes direct the line vessels to areas with apparently high ling abundance, as indicated by the trawl bycatch, thereby increasing fishing pressure on a species the trawlers are trying to avoid. This behaviour would enable line fishers to reduce their search time and/or fish in areas that are likely to produce relatively high ling catch rates, hence biasing the recent line CPUE upwards. There are also 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. However, catch-at-age data from the trawl fishery are not consistent with a fishing down of the larger older fish; fish aged 15 and over are still as abundant in the catch now as they were in the early 1990s (Horn 2009b). Also, there is no perception by the line fishers that WCSI ling are more difficult to catch now than they were in the early 1990s, a view supported by the generally flat line series.

Catch-at-age data from the WCSI trawl fishery indicate some relatively strong recent recruitment (Horn & Sutton 2010). The observer data series should be relatively free of biases, and is also indicative of an overall decline in ling biomass during the 2000s. However, there are no fishery-independent data available to validate any of the WCSI CPUE series, and while it seems likely that the biomass has declined in recent years there is still no relative abundance index series that can confidently be used in stock assessments of LIN 7WC.

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Table 1: Summary of the variables offered in the CPUE models for the trawl and line fisheries. All continuous variables were offered as third order polynomials except for duration which was offered as both third and fourth order polynomials.

Variable	Type	Description
Line fisheries		
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
Subarea	Categorical	Subareas within a biological stock
Method	Categorical	Fishing method (bottom longline, trot line, dahn line)
Hookno	Continuous	Number of hooks set per day in a statistical area
Log(hookno)	Continuous	Logarithm of variable Hookno
CPUE	Continuous	Ling catch (kg) per day in a statistical area
Trawl fisheries		
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
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

Table 2: Summary of records of days fished (Days) by statistical area (Statarea) used in the analyses of the target ling longline fisheries in each ling stock. Note that there are two analyses for the Bounty Plateau (1992–2006, and 2007–09).

Chatham		Sub-Antarctic		Bounty		WCSI		Cook Strait	
1990–2009		1991–2009		1992–2006		1990–2009		1990–2009	
Statarea	Days	Statarea	Days	Statarea	Days	Statarea	Days	Statarea	Days
018	2 685	030	1 906	607	657	032	1 327	016	1 683
019	80	602	384	608	1 007	033	4 524	017	57
020	2 878	603	333			034	4 557		
021	696	604	496	2007–2009					
022	77	605	298	Statarea	Days				
023	341	610	860	607	85				
024	326	611	166	608	110				
401	1 453	612	40						
402	1 218	618	841						
403	658	619	606						
404	1 596	625	45						
405	97								
407	437								
408	400								
409	236								
410	1 592								
049	628								
050	106								
051	170								
052	684								

Table 3: Summary of data (by calendar year) used in the final standardised longline CPUE analysis for each stock. Days, number of individual records of days fished; Catch, estimated catch (t) from the accepted records; Vessels, number of vessels contributing to the accepted records. The total in the "Vessels" column indicates the number of unique vessels contributing to the accepted records throughout the time series. Note that there are two analyses for the Bounty Plateau; 1992–2006 (plain text), and 2007–09 (italic text). #, catch not reported here due to it being from fewer than 3 vessels.

	Chatham Rise (LIN 3&4)			Sub-Antarctic (LIN 5&6)			Bounty Plateau (LIN 6B)			WCSI (LIN 7WC)			Cook Strait (LIN 7CK)		
Year	Days	Catch	Vessels	Days	Catch	Vessels	Days	Catch	Vessels	Days	Catch	Vessels	Days	Catch	Vessels
1990	186	196	3	–	–	–	–	–	–	293	240	9	97	40	7
1991	682	1 731	10	116	#	2	–	–	–	438	450	12	91	36	9
1992	691	2 932	11	245	1 077	3	171	1 035	4	655	769	13	125	53	9
1993	810	3 250	13	280	1 162	5	221	1 231	5	446	616	10	168	71	10
1994	1 010	3 853	13	344	1 418	5	137	661	4	534	799	11	165	34	9
1995	991	4 493	10	349	1 853	5	62	343	3	550	786	11	94	28	7
1996	916	3 915	12	372	1 922	6	91	#	2	667	871	12	70	28	5
1997	1 140	3 275	11	654	3 208	6	62	256	3	679	991	11	32	12	4
1998	742	2 409	11	695	3 021	7	68	#	1	616	997	9	55	#	2
1999	920	2 379	13	674	2 754	6	99	669	3	529	780	10	32	89	3
2000	766	2 318	12	469	2 211	4	171	1 131	3	514	693	10	30	61	3
2001	685	2 416	9	326	1 764	6	192	975	3	529	781	11	31	90	3
2002	929	2 098	11	227	1 288	6	156	799	3	454	608	10	96	107	4
2003	684	1 837	10	162	638	5	157	858	4	525	694	10	152	119	6
2004	798	1 576	10	426	1 635	4	63	#	2	402	528	11	177	187	8
2005	1 083	2 012	13	180	#	2	0	0	0	599	635	10	124	158	6
2006	878	1 412	13	142	817	3	14	#	1	425	500	8	49	180	4
2007	863	1 370	12	111	812	3	*43*	#	*1*	570	877	10	105	159	6
2008	705	1 539	12	116	#	2	*92*	#	*1*	479	767	10	35	74	3
2009	877	1 769	9	86	#	2	*60*	#	*1*	504	726	10	12	22	3
Total	16 358	46 863	35	5 974	26 392	14	1 664	9 280	8	10 408	14 110	22	1 711	#	17
							195	#	*1*						

Table 4: Standardised CPUE models for the target ling line fisheries from the five stocks, showing the percentages of residual deviance explained as each new variable was added. Note that there are two analyses each for the Sub-Antarctic (single fishery, and two subarea fisheries) and for the Bounty Plateau (1992–2006, and 2007–09).

Step	Variable	% deviance	Step	Variable	% deviance
Chatham Rise (LIN 3&4)					
	Year	8.9			
1	log(hookno)	74.4			
2	Vessel	78.3			
3	Month	79.9			
Sub-Antarctic (LIN 5&6)					
Single fishery			Two subarea fisheries		
	Year	4.1		Year	17.0
1	log(hookno)	54.9	1	log(hookno)	62.7
2	Statarea	61.9	2	Vessel	64.3
3	Vessel	63.9			
Bounty Plateau (LIN 6B)					
1992–2006			2007–09		
	Year	3.9		Year	2.8
1	log(hookno)	36.8	1	log(hookno)	54.9
2	Vessel	44.4	2	Statarea	57.6
3	Month	48.4			
4	log(hookno):Month	52.3			
West Coast South Island (LIN 7WC)					
	Year	2.9			
1	Vessel	17.7			
2	Month	29.1			
3	log(hookno)	34.7			
Cook Strait (LIN 7CK)					
	Year	30.6			
1	Vessel	64.4			
2	log(hookno)	68.7			
3	Month	69.8			
4	log(hookno):Month	71.0			

Table 5: Unstandardised (Unstd) and standardised (Std, with 95% confidence intervals and c.v.s) year effects for the target ling line fisheries in five areas. Note that there are two separate series for the Bounty Plateau; 1992–2006 (plain text), and 2007–09 (italic text).

Year	Unstd	Std	95% CI	c.v.	Unstd	Std	95% CI	c.v.	Unstd	Std	95% CI	c.v.
	Chatham Rise (LIN 3&4)				Sub-Antarctic (LIN 5&6)				Cook Strait (LIN 7CK)			
1990	0.53	2.07	1.77–2.43	0.08	–	–	–	–	0.63	0.73	0.53–0.99	0.16
1991	0.70	1.66	1.51–1.83	0.05	0.82	0.89	0.72–1.09	0.10	0.43	1.10	0.85–1.43	0.13
1992	1.72	2.09	1.90–2.30	0.05	0.86	1.21	1.04–1.42	0.08	0.50	1.10	0.87–1.38	0.11
1993	1.51	1.54	1.42–1.68	0.04	0.77	1.24	1.07–1.44	0.08	0.39	0.80	0.64–1.00	0.11
1994	1.43	1.48	1.37–1.60	0.04	0.74	0.96	0.84–1.09	0.07	0.26	0.71	0.57–0.88	0.11
1995	2.15	1.47	1.35–1.59	0.04	1.14	1.26	1.10–1.45	0.07	0.31	0.66	0.52–0.84	0.12
1996	1.83	1.23	1.14–1.33	0.04	1.07	1.02	0.89–1.16	0.07	0.45	0.79	0.60–1.03	0.13
1997	1.07	0.85	0.80–0.91	0.03	1.07	1.16	1.04–1.29	0.05	0.55	1.05	0.72–1.52	0.19
1998	1.12	0.81	0.75–0.88	0.04	0.92	0.96	0.87–1.06	0.05	0.44	0.73	0.54–0.99	0.15
1999	0.81	0.71	0.66–0.76	0.04	0.86	0.82	0.75–0.90	0.05	3.12	1.28	0.89–1.86	0.19
2000	1.13	0.82	0.76–0.89	0.04	1.03	0.98	0.87–1.09	0.06	1.59	1.45	1.00–2.10	0.19
2001	1.74	0.81	0.75–0.89	0.04	1.20	1.11	0.97–1.26	0.06	2.47	1.30	0.87–1.92	0.20
2002	1.05	0.72	0.67–0.78	0.04	1.22	1.08	0.94–1.24	0.07	1.54	1.91	1.52–2.40	0.11
2003	1.18	0.87	0.80–0.95	0.04	0.79	0.81	0.69–0.96	0.08	1.21	1.68	1.35–2.09	0.11
2004	1.03	0.73	0.67–0.79	0.04	0.78	0.74	0.64–0.85	0.07	1.26	1.42	1.16–1.74	0.10
2005	0.60	0.81	0.75–0.87	0.04	1.10	0.84	0.69–1.02	0.10	1.29	1.17	0.94–1.46	0.11
2006	0.56	0.69	0.64–0.74	0.04	1.26	0.88	0.74–1.06	0.09	5.09	0.94	0.68–1.29	0.16
2007	0.53	0.74	0.68–0.80	0.04	1.72	1.13	0.92–1.39	0.10	2.06	0.72	0.56–0.92	0.13
2008	0.63	0.83	0.76–0.90	0.04	0.92	0.99	0.82–1.19	0.09	3.07	0.90	0.59–1.39	0.22
2009	0.68	0.66	0.61–0.72	0.04	1.21	1.16	0.93–1.44	0.11	1.81	0.65	0.36–1.16	0.30

Year	Unstd	Std	95% CI	c.v.	Unstd	Std	95% CI	c.v.
	Bounty Plateau (LIN 6B)				WCSI (LIN 7WC)			
1990	–	–	–	–	0.62	0.92	0.81–1.04	0.06
1991	–	–	–	–	0.78	1.18	1.06–1.31	0.05
1992	1.05	1.80	1.40–2.32	0.13	0.89	1.16	1.06–1.27	0.04
1993	0.97	1.58	1.28–1.96	0.11	1.01	0.92	0.84–1.02	0.05
1994	0.85	1.07	0.82–1.41	0.13	1.04	0.93	0.85–1.01	0.04
1995	1.11	1.13	0.87–1.47	0.13	1.04	0.95	0.87–1.03	0.04
1996	0.90	1.05	0.83–1.33	0.12	0.91	0.78	0.72–0.84	0.04
1997	0.81	0.85	0.66–1.11	0.13	1.02	0.85	0.78–0.92	0.04
1998	1.42	1.03	0.80–1.32	0.12	1.27	0.93	0.86–1.01	0.04
1999	1.33	1.04	0.84–1.30	0.11	1.13	1.02	0.93–1.11	0.04
2000	1.23	0.95	0.79–1.16	0.10	1.09	0.98	0.89–1.07	0.04
2001	0.96	0.81	0.67–0.99	0.10	1.17	1.12	1.03–1.22	0.04
2002	0.94	0.72	0.60–0.88	0.10	0.98	1.06	0.96–1.16	0.05
2003	1.05	0.78	0.66–0.94	0.09	0.99	1.12	1.02–1.22	0.04
2004	1.05	0.71	0.54–0.94	0.14	1.00	1.10	1.00–1.22	0.05
2005	–	–	–	–	0.87	0.85	0.78–0.93	0.04
2006	0.61	0.97	0.48–1.94	0.36	0.87	0.86	0.77–0.94	0.05
2007	*1.18*	*1.12*	*0.88–1.42*	*0.12*	1.20	1.15	1.06–1.26	0.04
2008	*1.04*	*1.12*	*0.92–1.36*	*0.10*	1.24	1.14	1.04–1.25	0.05
2009	*0.81*	*0.80*	*0.64–0.99*	*0.11*	1.13	1.15	1.05–1.26	0.05

Table 6: Summary of data used in the final standardised longline CPUE analysis for the two Sub-Antarctic subareas, and the unstandardised (Unstd) and standardised (Std, with 95% confidence intervals and c.v.s) year effects for those fisheries. Days, number of individual records of days fished; Catch, estimated catch (t) from the records; Vessels, number of vessels contributing to the records. #, catch not reported here due to it being from fewer than 3 vessels.

Year	Days	Catch (t)	Vessels	CPUE indices Unstd	Std	95% CI	c.v.
Puysegur							
1991	35	#	2	1.20	1.27	0.91–1.79	0.17
1992	89	462	3	0.90	1.35	1.07–1.71	0.12
1993	142	715	3	0.74	1.70	1.38–2.09	0.10
1994	130	717	4	0.81	1.18	0.97–1.45	0.10
1995	41	248	3	0.92	1.21	0.88–1.66	0.16
1996	101	748	3	1.58	1.28	1.03–1.60	0.11
1997	154	946	3	1.17	1.29	1.06–1.57	0.10
1998	154	846	3	0.95	0.96	0.79–1.16	0.10
1999	112	848	3	1.74	1.22	1.00–1.50	0.10
2000	117	913	3	1.88	1.32	1.08–1.60	0.10
2001	133	988	4	1.82	1.34	1.10–1.62	0.10
2002	106	858	4	1.88	1.56	1.27–1.92	0.10
2003	75	444	3	1.39	1.13	0.88–1.44	0.12
2004	165	978	3	1.30	0.94	0.79–1.13	0.09
2005	80	#	2	2.03	1.42	1.11–1.82	0.12
2006	88	665	3	1.65	1.25	0.99–1.58	0.12
2007	103	773	3	1.65	1.42	1.14–1.77	0.11
2008	54	#	1	1.39	1.05	0.79–1.39	0.14
2009	27	#	1	2.85	2.08	1.41–3.07	0.20
Non-Puysegur							
1991	81	#	1	0.63	0.65	0.51–0.83	0.12
1992	156	#	2	0.75	1.04	0.87–1.25	0.09
1993	138	447	3	0.69	0.84	0.69–1.03	0.10
1994	214	701	3	0.63	0.75	0.64–0.89	0.08
1995	308	1 605	4	1.09	1.02	0.88–1.19	0.08
1996	271	1 175	5	0.84	0.80	0.69–0.94	0.08
1997	500	2 261	5	0.95	0.90	0.80–1.02	0.06
1998	541	2 176	6	0.85	0.78	0.70–0.87	0.06
1999	562	1 905	6	0.70	0.65	0.59–0.72	0.05
2000	352	1 298	4	0.77	0.74	0.65–0.85	0.06
2001	193	775	5	0.85	0.90	0.76–1.06	0.08
2002	121	431	6	0.77	0.77	0.64–0.94	0.10
2003	87	194	4	0.42	0.62	0.49–0.77	0.11
2004	261	657	3	0.50	0.56	0.46–0.67	0.10
2005	100	#	1	0.60	0.51	0.39–0.66	0.13
2006	54	#	1	0.68	0.60	0.45–0.79	0.14
2007	8	#	1	1.14	1.10	0.55–2.21	0.36
2008	62	#	1	0.56	0.99	0.75–1.30	0.14
2009	59	#	2	0.74	0.81	0.62–1.06	0.13

Table 7: CPUE estimated and observed datasets for all vessels and for final datasets for each year. Data includes number of unique vessels fishing, number of tow records overall all by method for non-zero and zero ling catches, proportion of tows that caught zero catch, estimated catch, and un-standardised CPUE from non-zero catches from the tow-by-tow data.

(a) WCSI TCEPR estimated data targeting hoki for June–September.

	All vessels					Accurate vessels										
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	BT non-zero tows	MB non-zero tows	MW non-zero tows	Zeros	BT zero tows	MB zero tows	MW zero tows	Catch (t)	CPUE
1990	74	7 910	0.57	1421.0	0.42	8	682	272	136	174	0.15	78	9	13	183.3	0.31
1991	73	8 309	0.75	967.8	0.46	8	259	161	0	59	0.15	23	0	16	128.2	0.58
1992	66	6 171	0.76	623.3	0.42	5	163	135	0	0	0.17	28	0	0	109.4	0.81
1993	60	7 042	0.80	639.6	0.45	8	370	316	0	0	0.15	54	0	0	173.9	0.55
1994	67	8 864	0.82	630.9	0.39	9	234	166	3	35	0.13	18	0	12	125.4	0.61
1995	63	8 405	0.73	1374.5	0.60	8	403	296	7	56	0.11	31	0	13	205.3	0.57
1996	59	7 105	0.64	1195.5	0.47	9	268	208	9	1	0.19	49	1	0	102.9	0.47
1997	75	8 371	0.70	1161.6	0.46	8	166	134	0	0	0.19	32	0	0	113.3	0.85
1998	65	8 078	0.64	1419.4	0.48	14	627	235	129	159	0.17	40	32	32	180.7	0.35
1999	56	7 025	0.53	1528.5	0.46	22	1 408	740	223	189	0.18	152	62	42	765.4	0.66
2000	51	7 063	0.54	1396.9	0.43	23	1 644	792	93	449	0.19	161	30	119	592.6	0.44
2001	63	8 193	0.45	1816.2	0.40	28	2 420	1 291	268	416	0.18	237	82	126	956.7	0.48
2002	56	7 574	0.44	1746.8	0.41	17	2 074	1 116	91	539	0.16	213	29	86	685.1	0.39
2003	51	7 092	0.46	1356.7	0.36	27	3 126	1 546	496	505	0.19	321	146	112	929.9	0.37
2004	51	6 098	0.38	1490.9	0.39	29	2 956	1 047	964	457	0.17	184	187	117	1 108.7	0.45
2005	37	3 567	0.40	971.2	0.46	26	1 796	980	193	277	0.19	210	46	90	786.7	0.54
2006	36	3 180	0.36	1072.2	0.52	23	1 414	977	93	146	0.14	145	19	34	750.5	0.62
2007	32	1 884	0.47	496.0	0.49	16	532	373	2	80	0.14	59	1	17	302.9	0.67
2008	22	1 301	0.38	302.1	0.37	11	430	385	1	13	0.07	29	0	2	185.6	0.47
2009	20	1 033	0.43	302.5	0.51	12	325	310	0	1	0.04	14	0	0	209.0	0.67
Total	235	124 265		21 913.6		58	21 297	11 480	2 708	3 556		2 078	644	831	8 595.4	

Table 7 continued.

(b) WCSI observer data targeting hoki for June–September.

	All vessels					Final dataset										
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	BT non-zero tows	MB non-zero tows	MW non-zero tows	Zeros	BT zero tows	MB zero tows	MW zero tows	Catch (t)	CPUE
1987	26	2 498	0.44	246.7	0.18	13	1 395	111	44	645	0.43	4	61	530	153.4	0.19
1988	22	2 496	0.30	689.2	0.39	16	2 103	26	167	1312	0.28	6	124	468	597.7	0.40
1989	13	1 473	0.33	471.8	0.48	10	1 098	112	225	409	0.32	6	96	250	303.2	0.41
1990	14	1 556	0.15	651.1	0.49	8	1 003	167	284	443	0.11	6	28	75	370.7	0.41
1991	14	1 271	0.32	240.9	0.28	7	655	38	123	287	0.32	46	70	91	141.3	0.32
1992	10	786	0.37	140.5	0.28	7	419	53	137	116	0.27	0	65	48	112.2	0.37
1993	15	1 041	0.49	137.8	0.26	13	767	235	68	123	0.44	69	123	149	114.0	0.27
1994	15	1 595	0.52	166.7	0.22	11	1 042	59	285	226	0.45	0	225	247	111.6	0.20
1995	9	811	0.16	220.8	0.32	8	595	54	262	184	0.16	0	48	47	168.0	0.34
1996	15	1 060	0.21	278.6	0.33	10	813	127	129	406	0.19	4	40	107	220.6	0.33
1997	12	692	0.34	131.3	0.29	12	674	0	205	237	0.34	1	139	92	126.2	0.29
1998	16	912	0.22	326.6	0.46	13	806	104	273	247	0.23	17	101	64	280.3	0.45
1999	14	1 097	0.21	289.5	0.33	14	1 088	316	259	289	0.21	39	107	78	286.0	0.33
2000	17	1 169	0.28	291.0	0.34	16	1 153	235	267	334	0.27	20	125	172	282.9	0.34
2001	21	1 082	0.19	261.7	0.30	20	1 038	134	418	289	0.19	4	123	70	254.2	0.30
2002	17	1 333	0.16	512.7	0.46	15	1 302	539	345	205	0.16	85	74	54	488.3	0.45
2003	15	929	0.25	191.7	0.27	14	913	362	199	129	0.24	15	101	107	188.4	0.27
2004	16	1 306	0.10	503.3	0.43	14	1 181	323	477	263	0.10	11	45	62	446.6	0.42
2005	13	978	0.08	280.7	0.31	12	963	159	574	157	0.08	8	51	14	278.3	0.31
2006	13	782	0.12	232.4	0.34	13	781	236	277	177	0.12	23	20	48	230.5	0.33
2007	16	516	0.29	79.0	0.21	15	487	102	164	83	0.28	8	70	60	66.1	0.19
2008	11	447	0.29	71.1	0.22	10	441	106	113	94	0.29	2	69	57	69.9	0.22
2009	12	492	0.25	85.9	0.23	10	454	5	237	90	0.27	0	61	61	77.6	0.23
Total	135	26 322		6 500.8		76	21 197	3 603	5 532	6 745		374	1 966	2 951	5 368.1	

Table 7 continued.

(c) Cook Strait TCEPR estimated data targeting hoki for June–September .

	All vessels					Final dataset										
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	BT non-zero tows	MB non-zero tows	MW non-zero tows	Zeros	BT zero tows	MB zero tows	MW zero tows	Catch (t)	CPUE
1990	17	1 074	0.36	260.5	0.38	17	1 066	8	124	548	0.36	11	62	313	259.4	0.38
1991	21	2 054	0.44	325.8	0.28	19	1 968	12	324	738	0.45	5	287	602	299.8	0.28
1992	22	1 686	0.54	183.6	0.24	20	1 509	8	242	470	0.52	5	337	447	176.2	0.24
1993	18	1 550	0.61	131.9	0.22	14	1 426	5	302	265	0.60	9	473	372	124.1	0.22
1994	29	1 959	0.69	113.3	0.18	24	1 742	74	210	286	0.67	64	516	592	108.0	0.19
1995	24	2 205	0.68	108.1	0.15	23	2 128	93	217	366	0.68	155	473	824	105.4	0.16
1996	40	4 197	0.80	110.5	0.13	36	3 879	194	224	357	0.80	863	823	1418	104.0	0.13
1997	36	4 628	0.74	156.2	0.13	34	4 266	200	346	538	0.75	919	926	1337	142.4	0.13
1998	30	2 874	0.61	121.3	0.11	28	2 752	201	335	509	0.62	366	575	766	110.0	0.11
1999	21	2 458	0.50	119.5	0.10	20	2 379	283	274	613	0.51	213	264	732	115.9	0.10
2000	22	2 198	0.53	109.7	0.11	22	2 134	138	260	591	0.54	141	346	658	106.9	0.11
2001	25	1 947	0.47	129.4	0.13	21	1 784	55	274	621	0.47	37	264	533	120.9	0.13
2002	16	1 072	0.46	72.4	0.13	16	1 039	42	149	373	0.46	30	137	308	71.7	0.13
2003	20	1 870	0.51	121.2	0.13	17	1 776	20	318	538	0.51	20	331	549	119.0	0.14
2004	19	1 804	0.54	108.6	0.13	19	1 783	31	385	413	0.54	19	366	569	107.1	0.13
2005	14	1 373	0.50	95.2	0.14	14	1 354	44	376	251	0.50	7	251	425	94.5	0.14
2006	11	1 016	0.49	61.4	0.12	11	1 009	22	244	252	0.49	9	172	310	61.2	0.12
2007	7	913	0.58	38.3	0.10	7	893	10	157	202	0.59	5	152	367	37.5	0.10
2008	5	590	0.48	43.4	0.14	5	568	105	79	113	0.48	100	37	134	42.0	0.14
2009	7	827	0.64	17.8	0.06	7	813	28	72	186	0.65	68	104	355	17.3	0.06
Total	66	38 295		2428.2		47	36 268	1 573	4 912	8 230		3 046	6 896	11 611	2 323.2	

Table 7 continued.

(d) Cook Strait observer data targeting hoki for June–September.

	All vessels					Final vessels										
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	BT non-zero tows	MB non-zero tows	MW non-zero tows	Zeros	BT zero tows	MB zero tows	MW zero tows	Catch (t)	CPUE
1998	11	211	0.30	6.7	0.05	9	165	0	37	82	0.28	0	13	33	5.2	0.04
1999	10	294	0.38	19.0	0.10	9	239	32	38	89	0.33	33	10	37	17.1	0.11
2000	7	165	0.22	10.0	0.08	6	120	7	15	81	0.14	3	4	10	9.2	0.09
2001	9	264	0.30	16.4	0.09	8	185	12	45	83	0.24	9	10	26	14.7	0.10
2002	9	145	0.37	6.3	0.07	6	98	3	18	51	0.27	0	7	19	5.5	0.08
2003	5	134	0.36	5.6	0.07	5	99	1	6	58	0.34	0	1	33	4.4	0.07
2004	7	131	0.29	4.0	0.04	5	75	0	7	51	0.23	0	5	12	2.5	0.04
2005	9	122	0.39	3.7	0.05	4	66	0	6	40	0.30	0	1	19	2.1	0.05
2006	5	65	0.49	1.9	0.06	4	50	0	11	16	0.46	0	8	15	1.6	0.06
2007	7	176	0.38	10.6	0.10	6	144	4	21	72	0.33	0	5	42	9.3	0.10
2008	6	201	0.60	6.6	0.08	5	155	0	8	59	0.57	0	2	86	6.4	0.10
2009	6	170	0.45	2.6	0.03	4	111	0	5	59	0.42	0	5	42	1.7	0.03
Total	31	2078		93.4		17	1507	59	217	741		45	71	374	79.8	

Table 8: Variables retained in order of decreasing explanatory value by each model for each area and the corresponding total r^2 value.

	Lognormal		Binomial
Variable	r^2	Variable	r^2
WCSI TCEPR estimated data targeting hoki for June–September			
Year	4.9	Year	0.6
Vessel	17.0	Depth of net	6.3
Duration	19.6	Month	7.4
Time mid	22.2	Vessel	8.3
Depth of net	24.1		
Day of year	25.9		
WCSI TCEPR estimated data targeting hoki for June–September (including nested variables)			
Year	4.9	Year	0.6
Vessel	17.0	Day of year	1.1
Time mid	18.6	Vessel	2.1
Day of year	19.9	Depth of net in method	8.9
Duration in method	23.1		
Depth of net in method	26.5		
WCSI observer data targeting hoki for June–September			
Year	4.9	Year	6.2
Day of year	12.0	Day of year	11.0
Vessel	18.6	Vessel	14.5
Headline	23.2	Method	16.9
Latitude	27.5	Duration	19.1
Longitude	32.6	Latitude	21.9
Duration	35.8	Longitude	25.0
Depth of net	37.3	Depth of net	26.1
Cook Strait TCEPR estimated data targeting hoki for June–September			
Year	7.1	Year	5.8
Vessel	21.0	Vessel	13.2
Day of year	26.6	Day of year	17.6
Duration	28.3	Latitude	18.8
Statarea	29.9		
Cook Strait TCEPR estimated data targeting hoki for June–September (including nested variables)			
Year	7.1	Year	5.8
Vessel	21.0	Vessel	13.2
Day of year	26.6	Day of year	17.6
Statarea	27.9	Latitude	18.8
Duration in method	30.1		
Headline height in method	31.1		
Cook Strait observer data targeting hoki for June–September			
Year	7.4	Year	5.4
Vessel	23.0	Vessel	12.2
Duration	28.3	Duration	15.4
Longitude	31.2	Vessel experience	17.4
Latitude	32.8		
Month	34.7		

Table 9: Lognormal, binomial, and combined CPUE indices.

(a) WCSI TCEPR estimated data targeting hoki for June–September

	Lognormal			Binomial			Combined
Year	Index	95% CI	c.v.	Index	95% CI	c.v.	Index
1990	0.86	0.73–1.01	0.08	1.05	0.90–1.21	0.07	0.84
1991	0.95	0.81–1.10	0.08	0.99	0.86–1.14	0.07	0.92
1992	1.64	1.38–1.95	0.09	1.06	0.91–1.24	0.08	1.59
1993	1.24	1.06–1.45	0.08	1.05	0.91–1.20	0.07	1.21
1994	1.25	1.07–1.46	0.08	0.99	0.85–1.14	0.07	1.22
1995	1.00	0.88–1.13	0.06	0.97	0.87–1.09	0.06	0.98
1996	0.99	0.86–1.15	0.08	1.06	0.92–1.21	0.07	0.96
1997	1.31	1.09–1.57	0.09	1.04	0.88–1.24	0.08	1.26
1998	0.77	0.69–0.87	0.06	1.00	0.90–1.11	0.05	0.76
1999	1.17	1.08–1.26	0.04	1.00	0.94–1.07	0.03	1.18
2000	0.99	0.92–1.06	0.03	1.01	0.95–1.07	0.03	0.96
2001	0.97	0.92–1.03	0.03	1.00	0.95–1.06	0.03	0.96
2002	0.82	0.77–0.88	0.03	0.96	0.91–1.02	0.03	0.81
2003	0.78	0.73–0.82	0.03	1.02	0.97–1.07	0.02	0.76
2004	0.90	0.85–0.96	0.03	0.98	0.93–1.03	0.03	0.89
2005	0.87	0.81–0.93	0.03	1.02	0.96–1.08	0.03	0.86
2006	0.83	0.78–0.89	0.03	0.98	0.92–1.04	0.03	0.83
2007	0.94	0.85–1.04	0.05	0.98	0.89–1.07	0.05	0.93
2008	0.87	0.78–0.97	0.05	0.94	0.85–1.04	0.05	0.86
2009	1.25	1.11–1.41	0.06	0.92	0.82–1.03	0.06	1.24

(b) WCSI TCEPR estimated data targeting hoki for June–September including nested variables

	Lognormal			Binomial			Combined
Year	Index	CI	c.v.	Index	CI	c.v.	Index
1990	0.86	0.73–1.01	0.08	1.04	0.90–1.21	0.07	0.84
1991	0.95	0.81–1.10	0.08	0.99	0.86–1.14	0.07	0.93
1992	1.64	1.38–1.95	0.09	1.06	0.91–1.24	0.08	1.59
1993	1.24	1.06–1.45	0.08	1.05	0.91–1.20	0.07	1.21
1994	1.25	1.07–1.46	0.08	0.99	0.86–1.15	0.07	1.23
1995	1.00	0.88–1.13	0.06	0.98	0.87–1.10	0.06	0.99
1996	0.99	0.86–1.15	0.08	1.05	0.92–1.20	0.07	0.97
1997	1.31	1.09–1.57	0.09	1.04	0.88–1.23	0.08	1.27
1998	0.77	0.69–0.87	0.06	0.99	0.89–1.10	0.05	0.76
1999	1.17	1.08–1.26	0.04	1.01	0.94–1.08	0.03	1.14
2000	0.99	0.92–1.06	0.03	1.00	0.95–1.07	0.03	0.97
2001	0.97	0.92–1.03	0.03	1.00	0.95–1.06	0.03	0.95
2002	0.82	0.77–0.88	0.03	0.96	0.91–1.02	0.03	0.81
2003	0.78	0.73–0.82	0.03	1.01	0.96–1.06	0.03	0.76
2004	0.90	0.85–0.96	0.03	0.98	0.92–1.03	0.03	0.89
2005	0.87	0.81–0.93	0.03	1.03	0.97–1.09	0.03	0.85
2006	0.83	0.78–0.89	0.03	0.98	0.92–1.05	0.03	0.82
2007	0.94	0.85–1.04	0.05	0.98	0.89–1.07	0.05	0.93
2008	0.87	0.78–0.97	0.05	0.94	0.85–1.04	0.05	0.86
2009	1.25	1.11–1.41	0.06	0.93	0.83–1.04	0.06	1.24

Table 9 continued.

(c) WCSI observer data targeting hoki for June–September

	Lognormal			Binomial			Combined
Year	Index	95% CI	c.v.	Index	95% CI	c.v.	Index
1987	0.53	0.47–0.60	0.06	1.34	1.21–1.48	0.05	0.46
1988	0.93	0.84–1.03	0.05	1.12	1.03–1.22	0.04	0.86
1989	1.38	1.23–1.56	0.06	1.12	1.01–1.23	0.05	1.28
1990	1.29	1.16–1.44	0.06	0.96	0.87–1.06	0.05	1.25
1991	0.80	0.71–0.91	0.06	1.14	1.03–1.26	0.05	0.74
1992	0.75	0.65–0.87	0.07	1.07	0.94–1.21	0.06	0.70
1993	1.01	0.89–1.16	0.07	1.07	0.97–1.18	0.05	0.95
1994	0.94	0.84–1.04	0.05	0.99	0.92–1.07	0.04	0.89
1995	1.23	1.09–1.39	0.06	0.90	0.81–0.99	0.05	1.20
1996	1.44	1.30–1.59	0.05	0.93	0.85–1.01	0.04	1.40
1997	1.49	1.33–1.66	0.06	1.01	0.92–1.11	0.05	1.41
1998	1.38	1.25–1.51	0.05	0.95	0.88–1.03	0.04	1.33
1999	1.59	1.45–1.74	0.05	0.96	0.88–1.04	0.04	1.53
2000	1.24	1.14–1.35	0.04	0.97	0.91–1.04	0.04	1.19
2001	0.99	0.91–1.08	0.04	0.96	0.89–1.03	0.04	0.96
2002	1.28	1.18–1.39	0.04	0.93	0.86–1.00	0.04	1.24
2003	0.73	0.67–0.81	0.05	1.01	0.93–1.09	0.04	0.70
2004	1.27	1.17–1.38	0.04	0.92	0.85–0.99	0.04	1.24
2005	0.86	0.79–0.93	0.04	0.91	0.84–0.99	0.04	0.84
2006	0.88	0.79–0.97	0.05	0.91	0.83–0.99	0.05	0.86
2007	0.70	0.62–0.78	0.06	0.96	0.87–1.06	0.05	0.67
2008	0.61	0.54–0.69	0.06	1.01	0.91–1.12	0.05	0.58
2009	0.74	0.66–0.84	0.06	0.98	0.89–1.09	0.05	0.71

(d) Cook Strait TCEPR estimated data targeting hoki for June–September

	Lognormal			Binomial			Combined
Year	Index	95% CI	c.v.	Index	95% CI	c.v.	Index
1990	2.28	2.05–2.54	0.05	0.82	0.76–0.88	0.04	2.33
1991	1.91	1.77–2.07	0.04	0.86	0.82–0.91	0.03	1.90
1992	1.67	1.53–1.84	0.05	0.91	0.86–0.97	0.03	1.61
1993	1.69	1.53–1.86	0.05	1.01	0.95–1.07	0.03	1.53
1994	1.14	1.04–1.25	0.05	1.03	0.97–1.09	0.03	1.02
1995	1.01	0.93–1.09	0.04	1.11	1.06–1.17	0.02	0.86
1996	0.99	0.91–1.06	0.04	1.19	1.15–1.24	0.02	0.80
1997	0.90	0.84–0.96	0.03	1.12	1.08–1.16	0.02	0.76
1998	0.84	0.79–0.89	0.03	1.07	1.03–1.11	0.02	0.73
1999	0.83	0.78–0.88	0.03	0.96	0.92–1.00	0.02	0.78
2000	0.98	0.92–1.05	0.03	0.98	0.94–1.02	0.02	0.91
2001	1.06	0.99–1.13	0.03	0.95	0.91–1.00	0.02	0.99
2002	1.00	0.92–1.09	0.04	0.96	0.91–1.03	0.03	0.93
2003	1.02	0.95–1.10	0.04	1.00	0.95–1.05	0.02	0.93
2004	0.85	0.79–0.91	0.04	0.99	0.95–1.04	0.02	0.77
2005	0.93	0.86–1.01	0.04	1.01	0.95–1.06	0.03	0.85
2006	0.88	0.80–0.96	0.04	0.96	0.90–1.03	0.03	0.82
2007	0.59	0.53–0.66	0.05	1.09	1.02–1.16	0.03	0.51
2008	0.70	0.62–0.78	0.06	0.97	0.90–1.06	0.04	0.65
2009	0.38	0.33–0.42	0.06	1.07	1.00–1.15	0.04	0.33

Table 9 continued.

(e) Cook Strait TCEPR estimated data targeting hoki for June–September

	Lognormal			Binomial			Combined
Year	Index	95% CI	c.v.	Index	95% CI	c.v.	Index
1990	2.28	2.05–2.54	0.05	0.82	0.76–0.88	0.04	2.17
1991	1.91	1.77–2.07	0.04	0.86	0.82–0.91	0.03	1.79
1992	1.67	1.53–1.84	0.05	0.91	0.86–0.97	0.03	1.63
1993	1.69	1.53–1.86	0.05	1.01	0.95–1.07	0.03	1.50
1994	1.14	1.04–1.25	0.05	1.03	0.97–1.09	0.03	1.03
1995	1.01	0.93–1.09	0.04	1.11	1.06–1.17	0.02	0.84
1996	0.99	0.91–1.06	0.04	1.19	1.15–1.24	0.02	0.80
1997	0.90	0.84–0.96	0.03	1.12	1.08–1.16	0.02	0.78
1998	0.84	0.79–0.89	0.03	1.07	1.03–1.11	0.02	0.77
1999	0.83	0.78–0.88	0.03	0.96	0.92–1.00	0.02	0.81
2000	0.98	0.92–1.05	0.03	0.98	0.94–1.02	0.02	0.93
2001	1.06	0.99–1.13	0.03	0.95	0.91–1.00	0.02	1.06
2002	1.00	0.92–1.09	0.04	0.96	0.91–1.03	0.03	0.98
2003	1.02	0.95–1.10	0.04	1.00	0.95–1.05	0.02	1.00
2004	0.85	0.79–0.91	0.04	0.99	0.95–1.04	0.02	0.81
2005	0.93	0.86–1.01	0.04	1.01	0.95–1.06	0.03	0.88
2006	0.88	0.80–0.96	0.04	0.96	0.90–1.03	0.03	0.85
2007	0.59	0.53–0.66	0.05	1.09	1.02–1.16	0.03	0.53
2008	0.70	0.62–0.78	0.06	0.97	0.90–1.06	0.04	0.55
2009	0.38	0.33–0.42	0.06	1.07	1.00–1.15	0.04	0.30

(f) Cook Strait Observer data targeting hoki for June–September

	Lognormal			Binomial			Combined
Year	Index	CI	c.v.	Index	CI	c.v.	Index
1998	1.24	1.00–1.54	0.11	0.96	0.57–1.61	0.26	1.16
1999	1.12	0.91–1.38	0.11	1.07	0.75–1.53	0.18	1.01
2000	1.75	1.40–2.19	0.11	0.87	0.65–1.16	0.15	1.69
2001	1.34	1.08–1.68	0.11	1.04	0.85–1.28	0.10	1.23
2002	1.35	1.02–1.77	0.14	1.00	0.80–1.24	0.11	1.25
2003	1.44	1.07–1.94	0.15	1.02	0.79–1.31	0.12	1.32
2004	1.26	0.95–1.68	0.14	0.94	0.72–1.22	0.13	1.19
2005	0.77	0.54–1.09	0.18	0.97	0.71–1.32	0.16	0.72
2006	1.10	0.74–1.63	0.20	1.15	0.82–1.61	0.17	0.97
2007	0.54	0.40–0.73	0.15	0.99	0.76–1.29	0.13	0.50
2008	0.56	0.41–0.78	0.16	1.09	0.78–1.52	0.17	0.51
2009	0.49	0.35–0.69	0.17	0.94	0.64–1.39	0.20	0.46

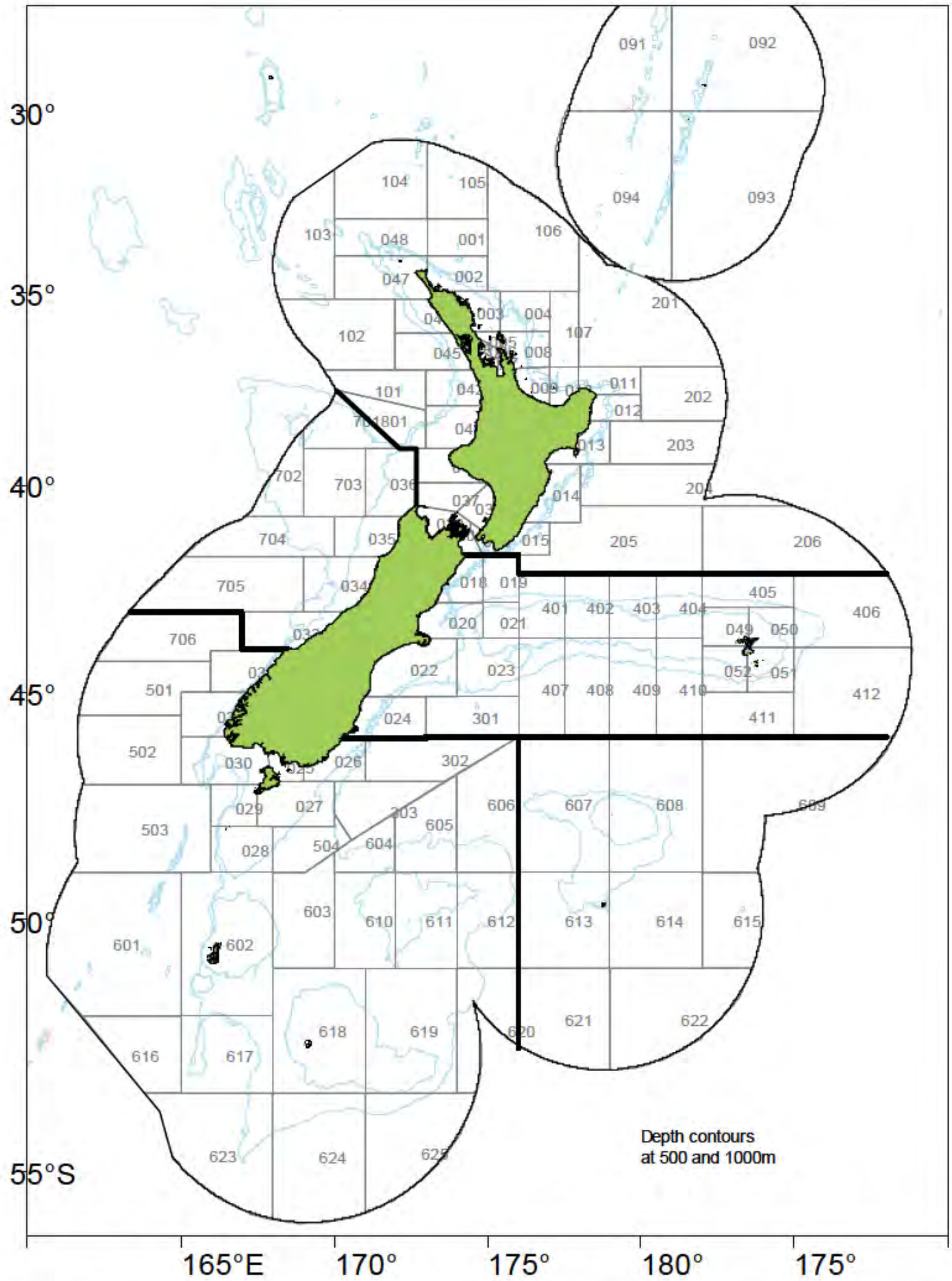
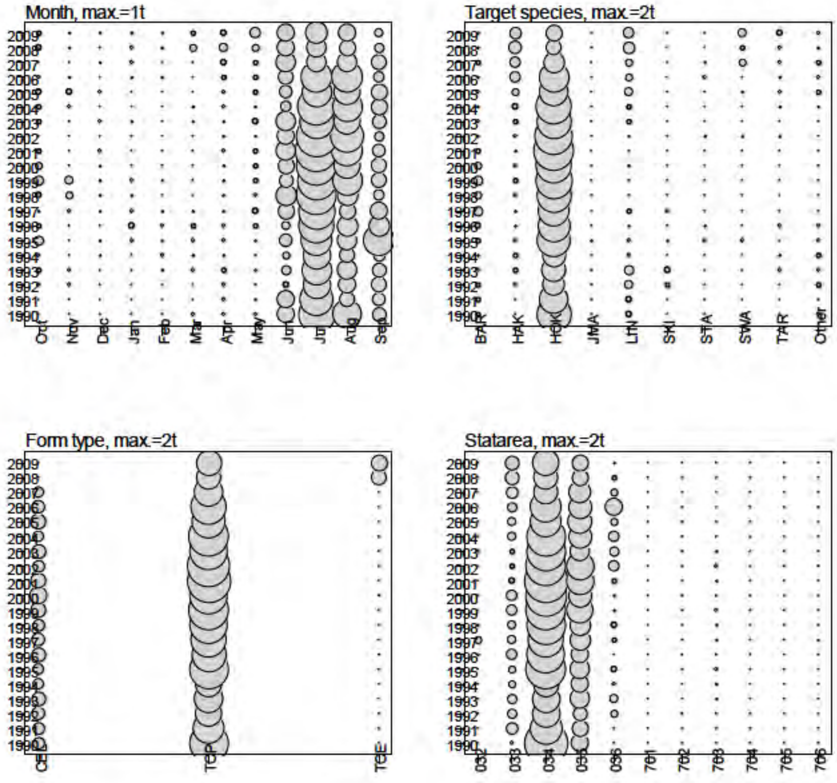


Figure 1: Map of the New Zealand EEZ with statistical areas (numbers from 001 to 801), showing how they were grouped (thick lines) to construct the stock areas used in this analysis.

(a) WCSI



(b) Cook Strait

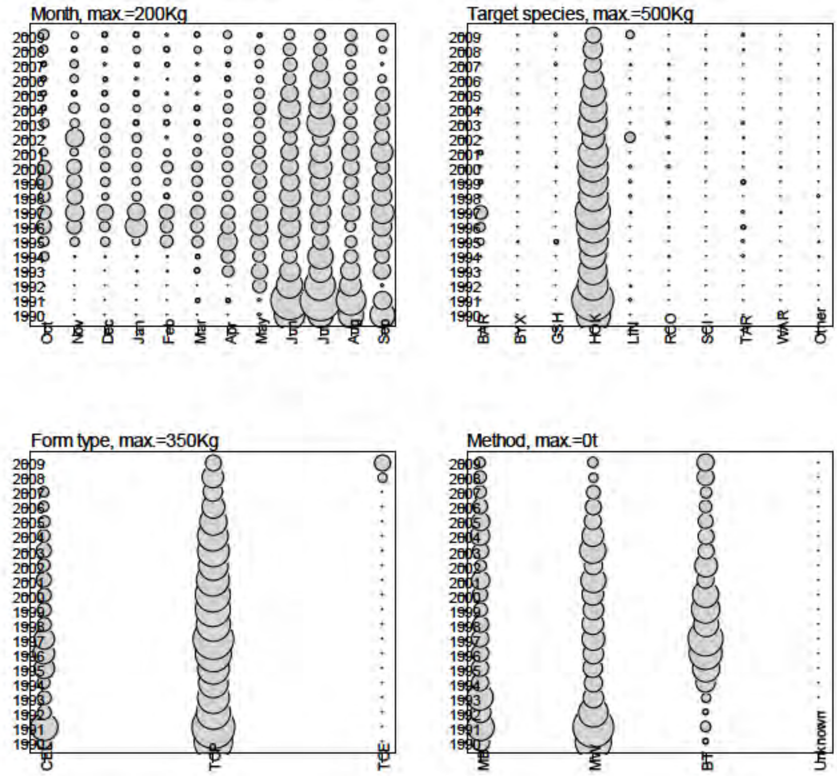


Figure 2: Distribution of WCSI and Cook Strait ling trawl catch by month, target species, form type, and statarea or method for 1989–90 (1990) to 2008–09 (2009) fishing years. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Form types: CEL (CELR), TCP (TCEPR), and TCE (TCER). Method definitions: BT, bottom tow; MB, midwater tow on the bottom, and MW, midwater tow.

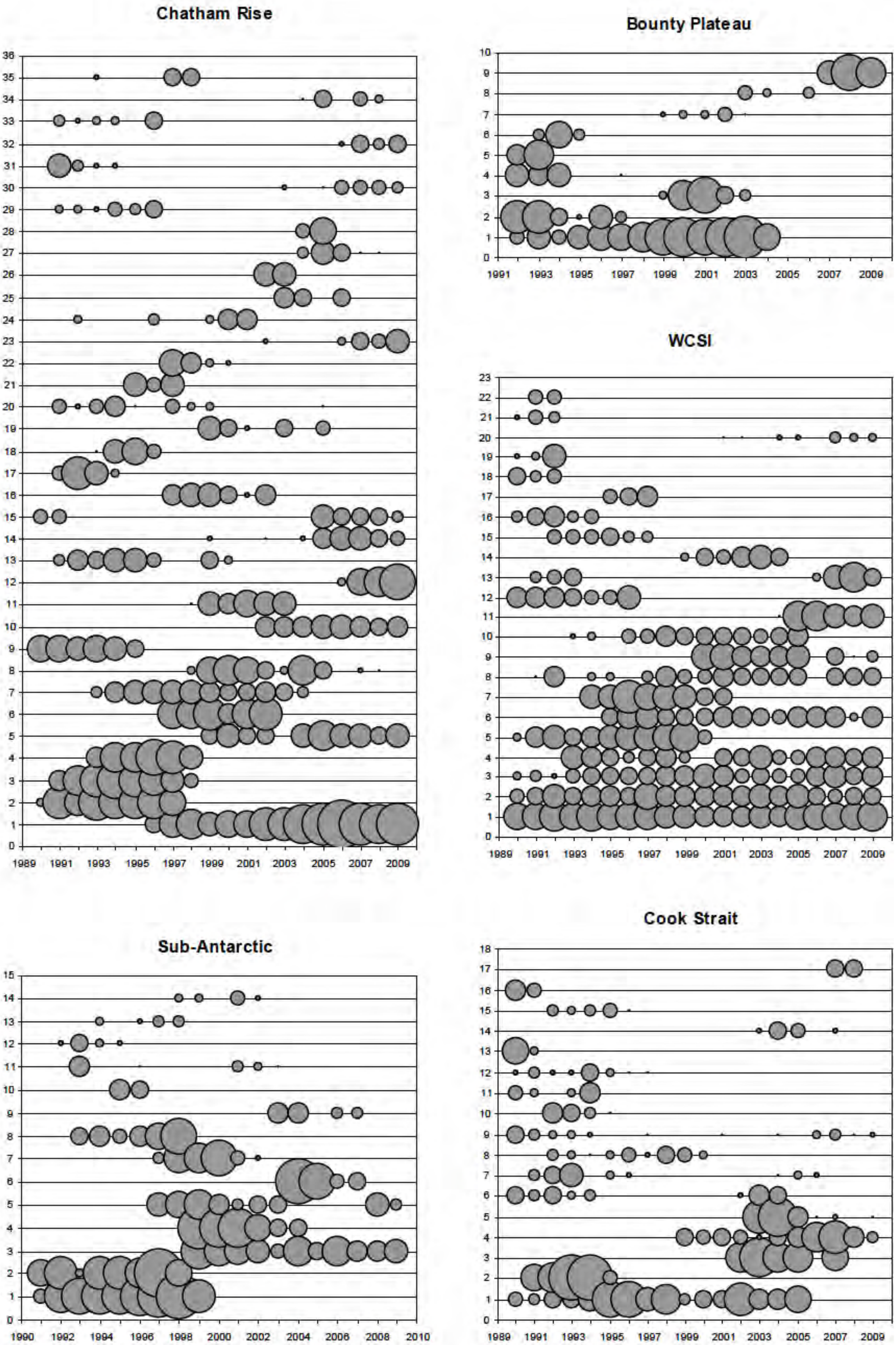


Figure 3: Line fishing effort (where circle area is proportional to number of days fished) by year for individual vessels (denoted anonymously by number on the *y*-axis) included in the final longline CPUE analyses for the five main stocks.

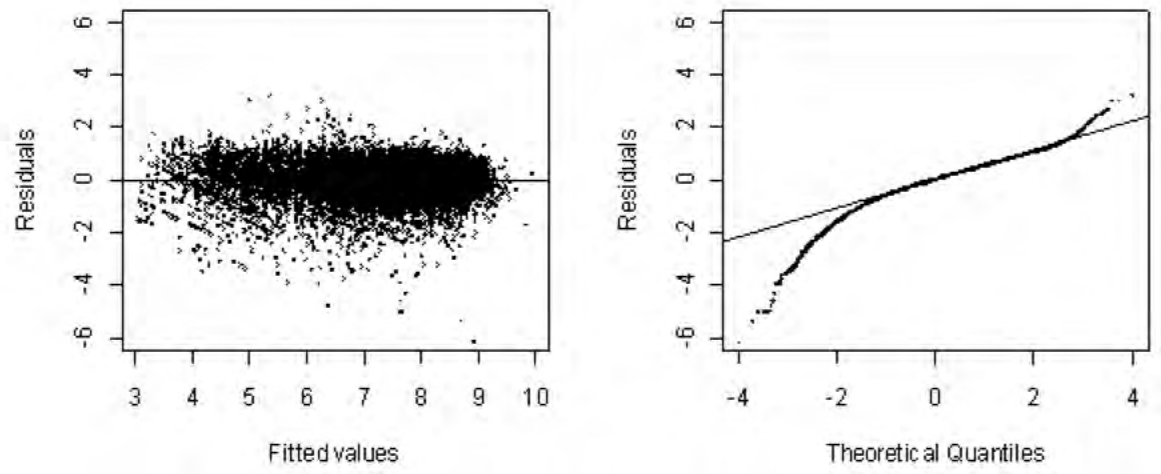


Figure 4: Diagnostic plots for the CPUE model of the Chatham Rise (LIN 3&4) ling line fishery.

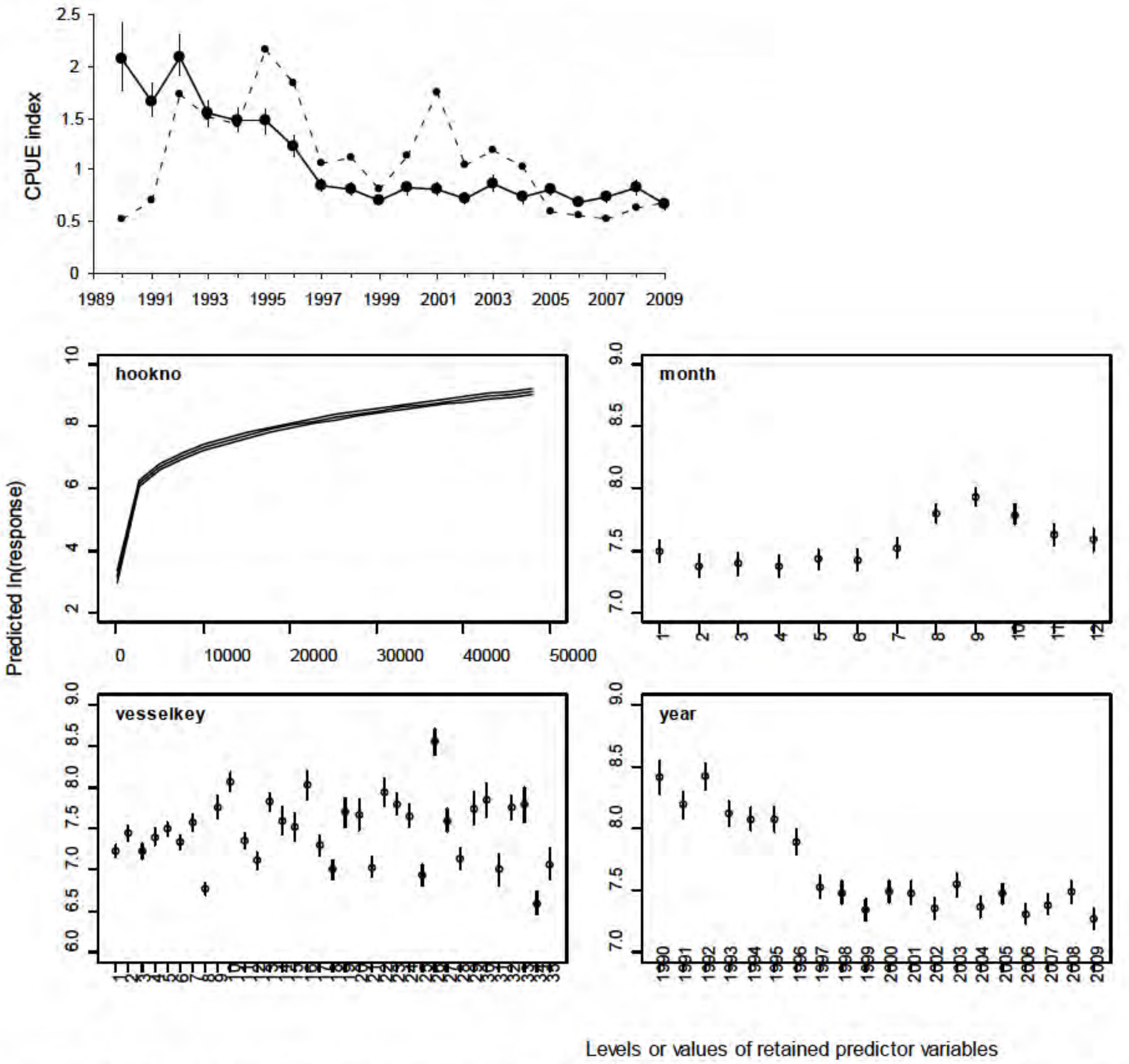


Figure 5: Predicted variable effects for variables selected into the CPUE model for the Chatham Rise (LIN 3&4) ling line fishery. Standardised year effects with 95% confidence intervals are shown by the solid line in the top plot; unstandardised data are shown as a broken line.

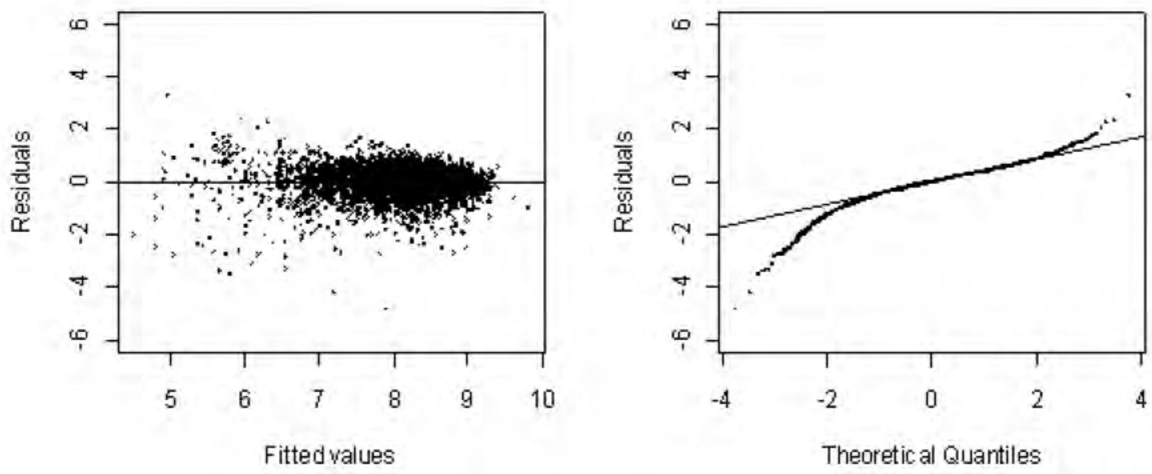


Figure 6: Diagnostic plots for the CPUE model of the Sub-Antarctic (LIN 5&6) ling line fishery.

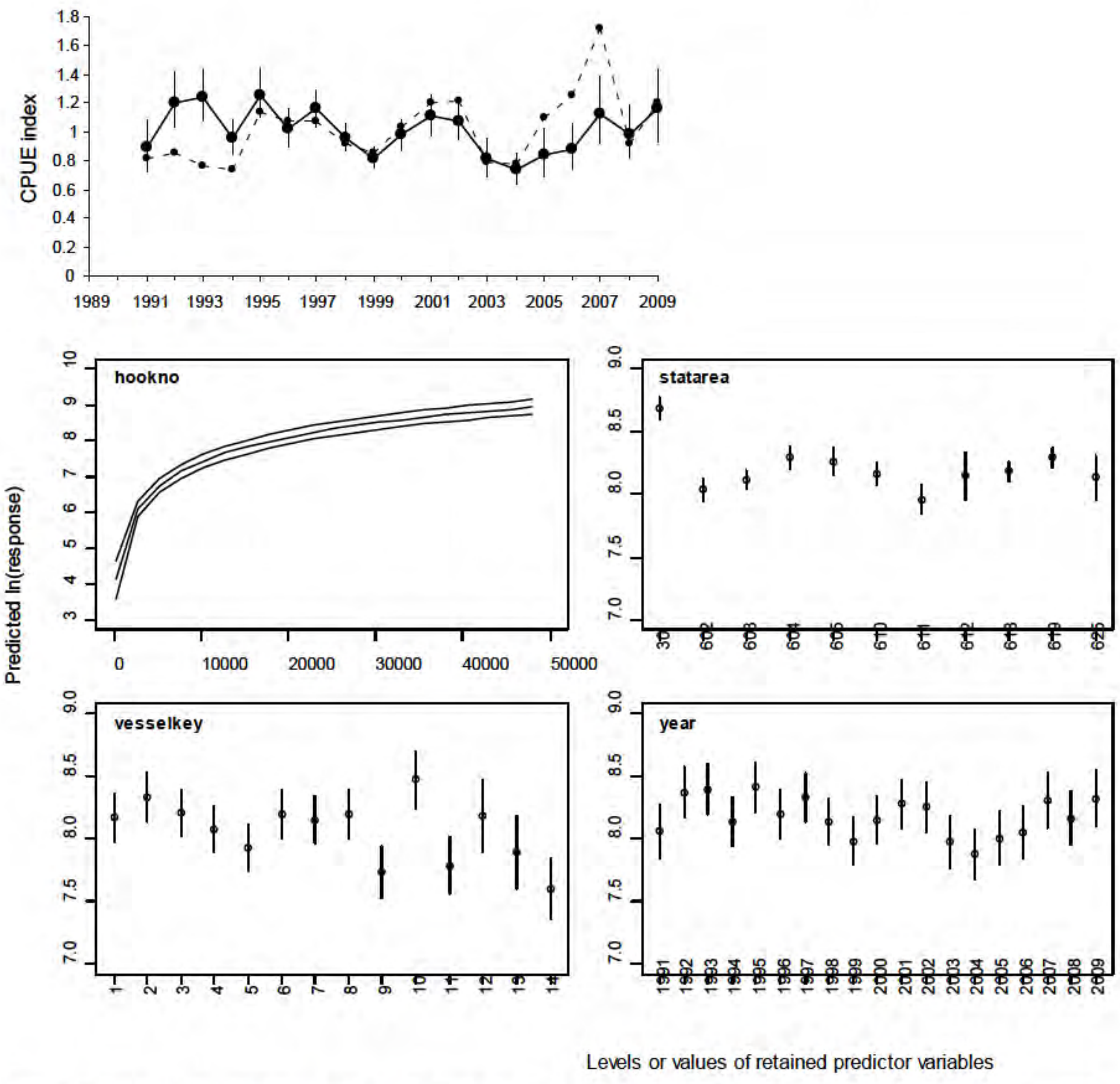


Figure 7: Predicted variable effects for variables selected into the CPUE model for the Sub-Antarctic (LIN 5&6) ling line fishery. Standardised year effects with 95% confidence intervals are shown by the solid line in the top plot; unstandardised data are shown as a broken line.

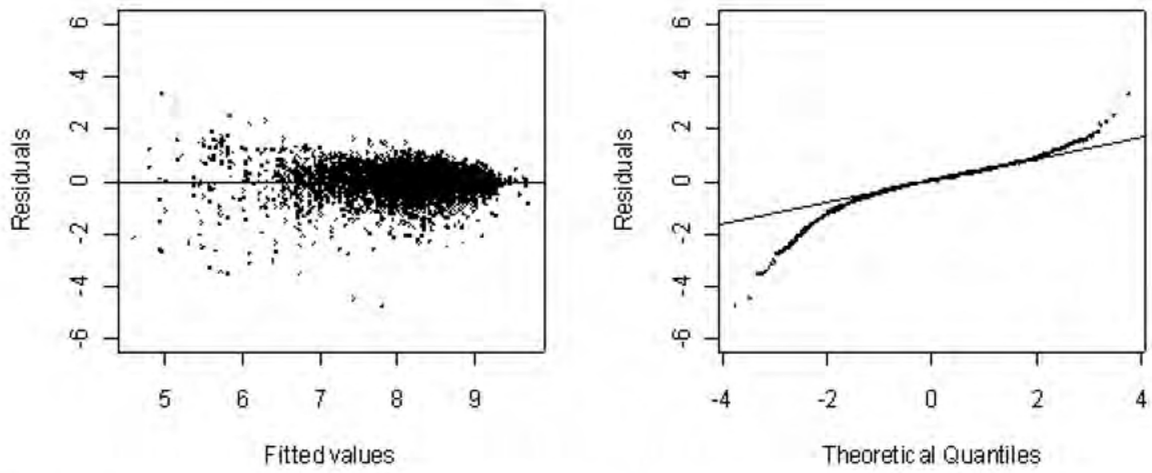


Figure 8: Diagnostic plots for the CPUE model of the two subarea fisheries in the Sub-Antarctic (LIN 5&6) ling line fishery.

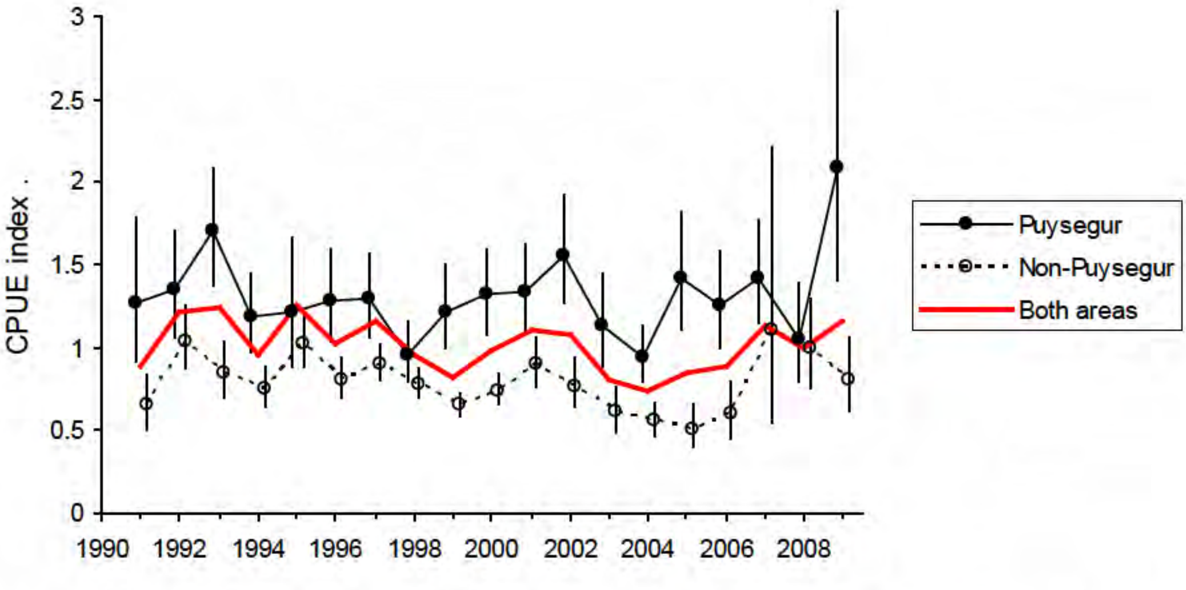


Figure 9: CPUE indices (with 95% confidence intervals) for the line fisheries in the two subareas of the Sub-Antarctic stock, and for both areas combined.

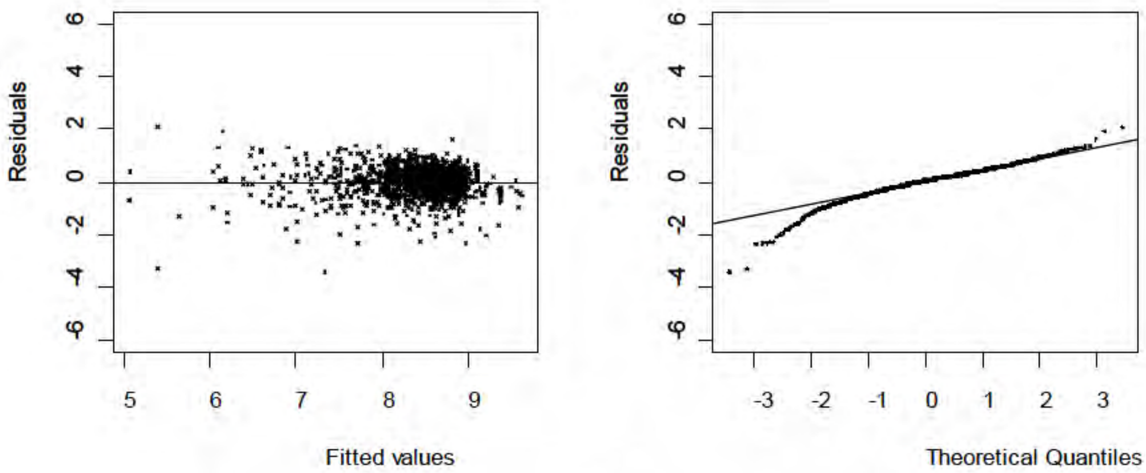


Figure 10: Diagnostic plots for the CPUE model of the Bounty Plateau (LIN 6B) ling line fishery from 1992 to 2006.

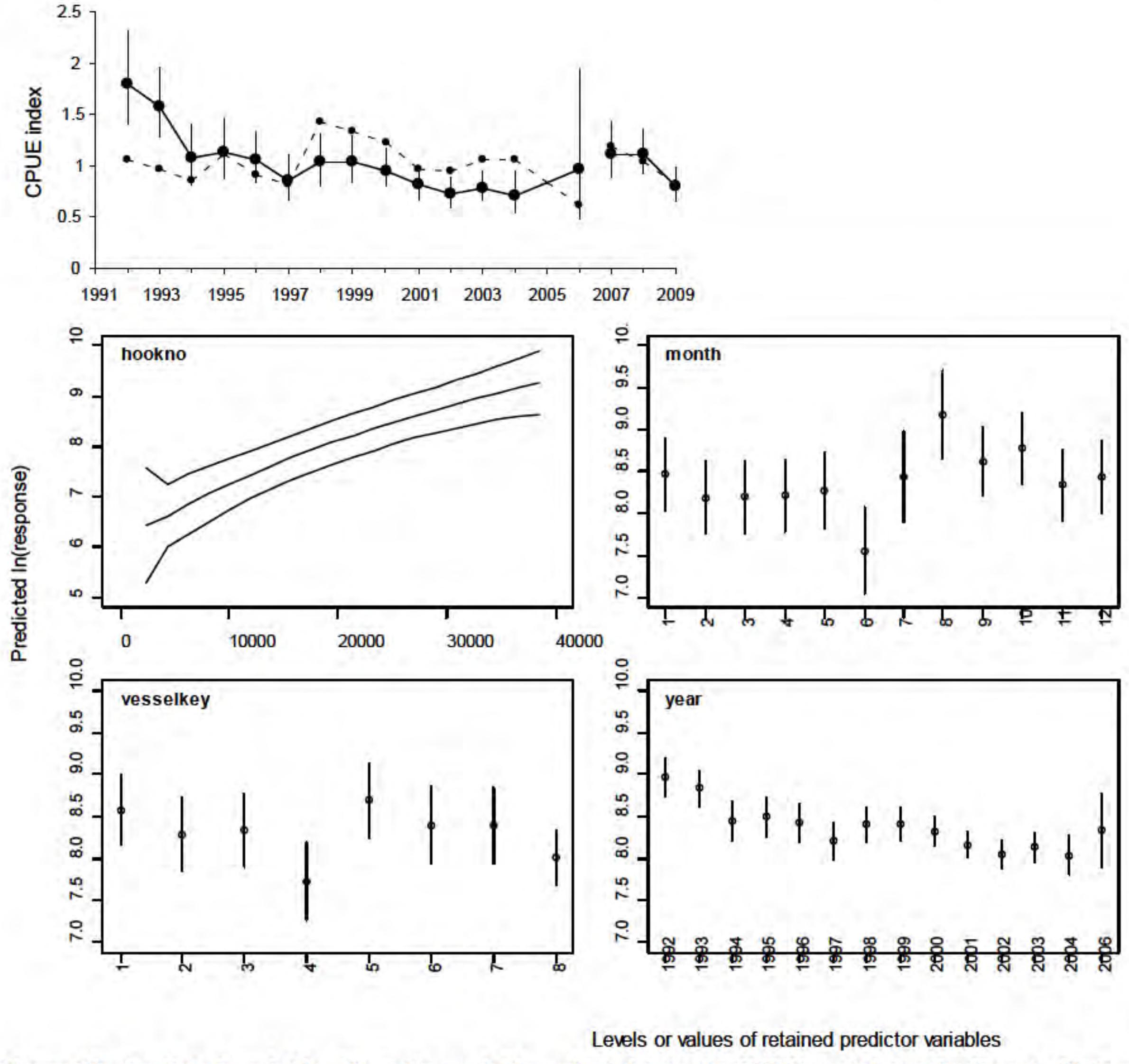


Figure 11: Predicted variable effects for variables selected into the CPUE model for the Bounty Plateau (LIN 6B) ling line fishery, 1992–2006. Standardised year effects for both Bounty CPUE series (with 95% confidence intervals) are shown by the solid lines in the top plot; unstandardised data are shown as a broken lines. Note that there are no data from 2005.

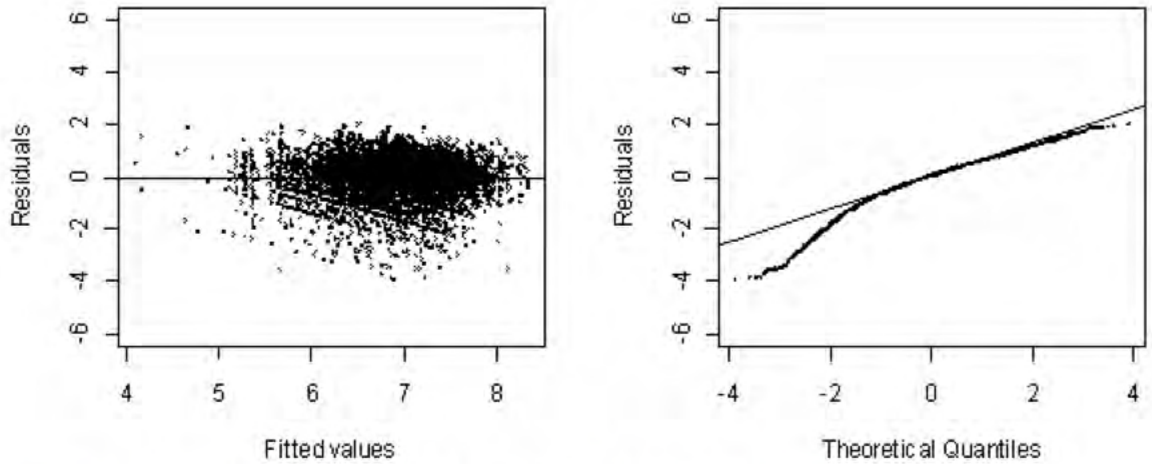


Figure 12: Diagnostic plots for the CPUE model of the WCSI (LIN 7WC) ling line fishery.

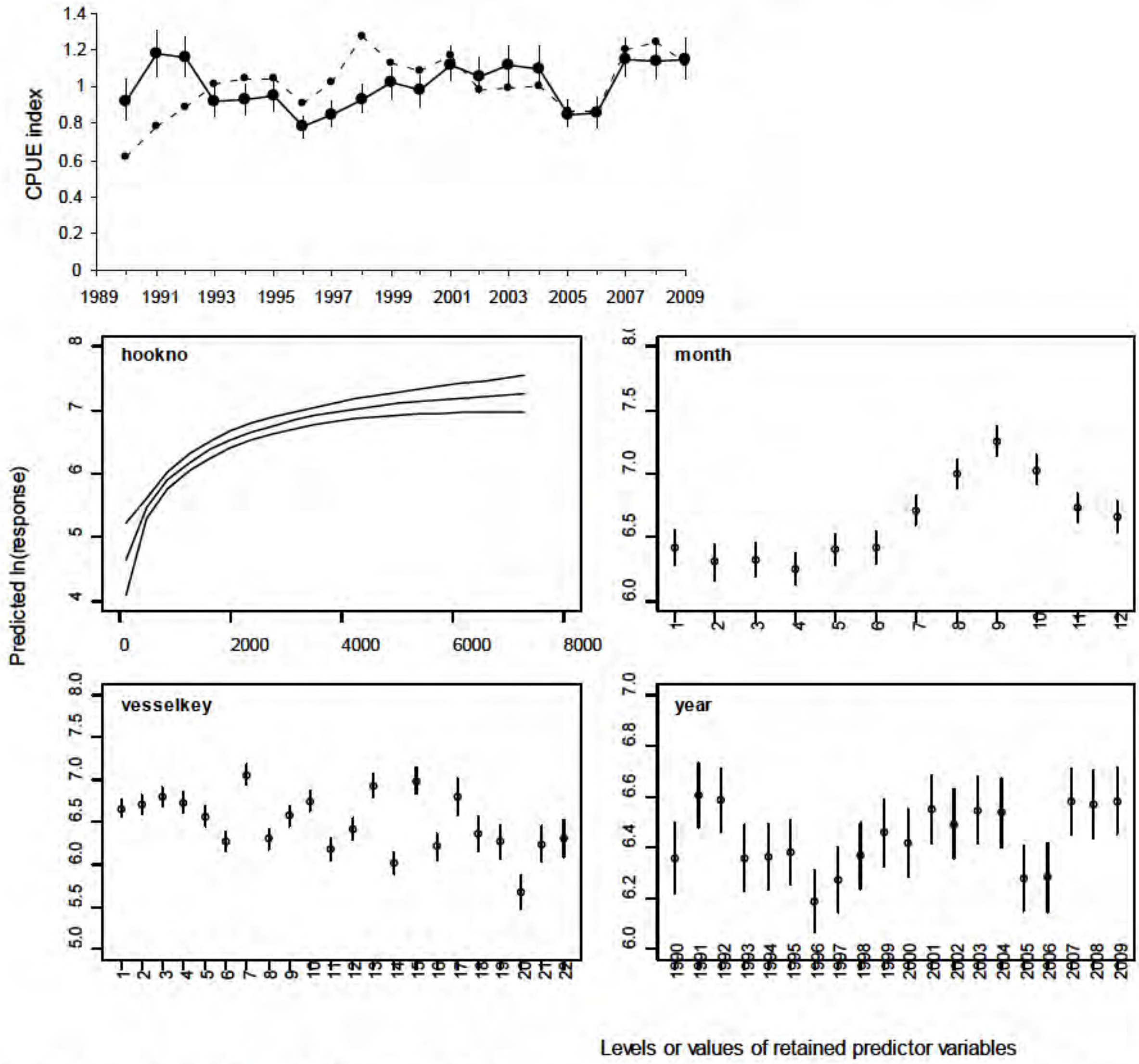


Figure 13: Predicted variable effects for variables selected into the CPUE model for the WCSI (LIN 7WC) ling line fishery. Standardised year effects with 95% confidence intervals are shown by the solid line in the top plot; unstandardised data are shown as a broken line.

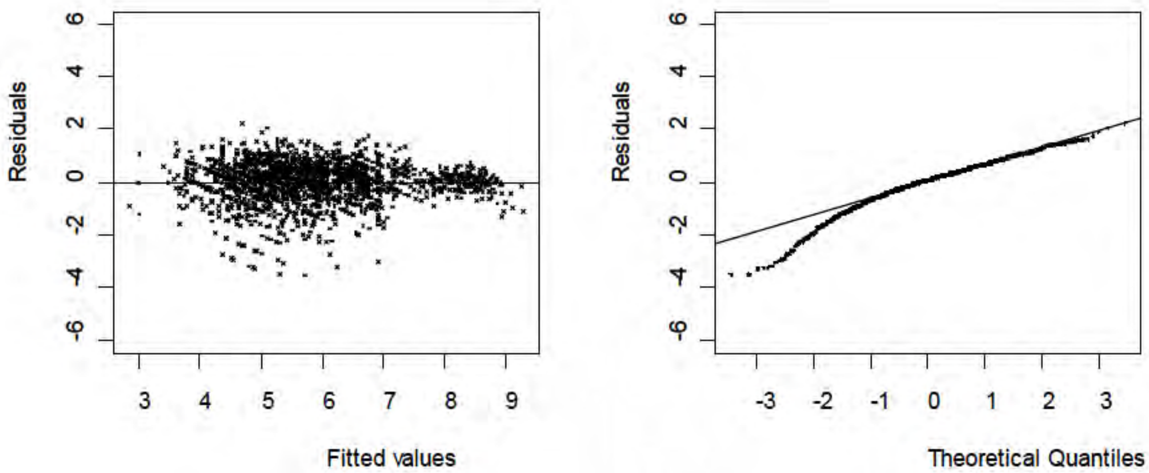


Figure 14: Diagnostic plots for the CPUE model of the Cook Strait (LIN 7CK) ling line fishery.

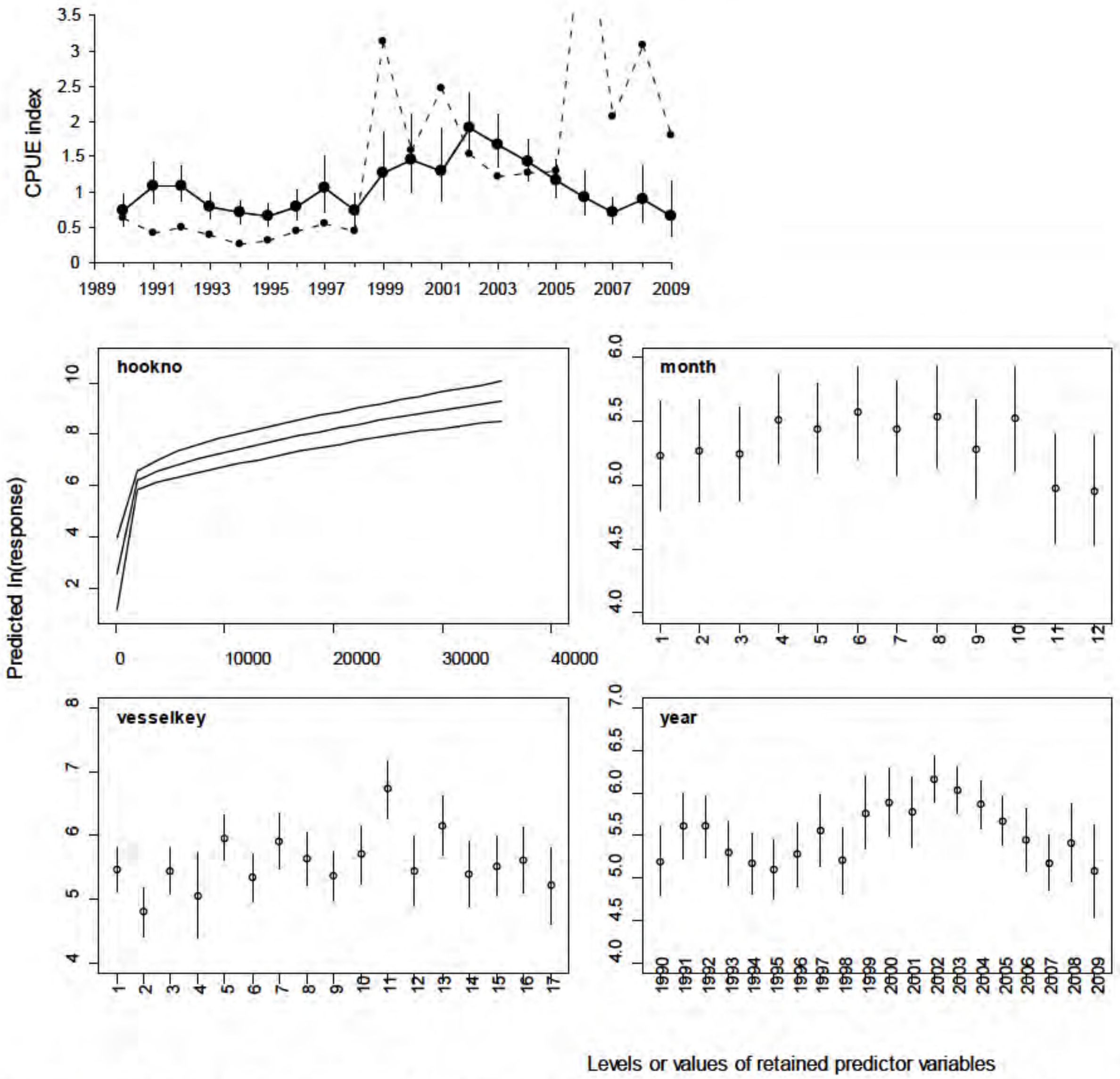
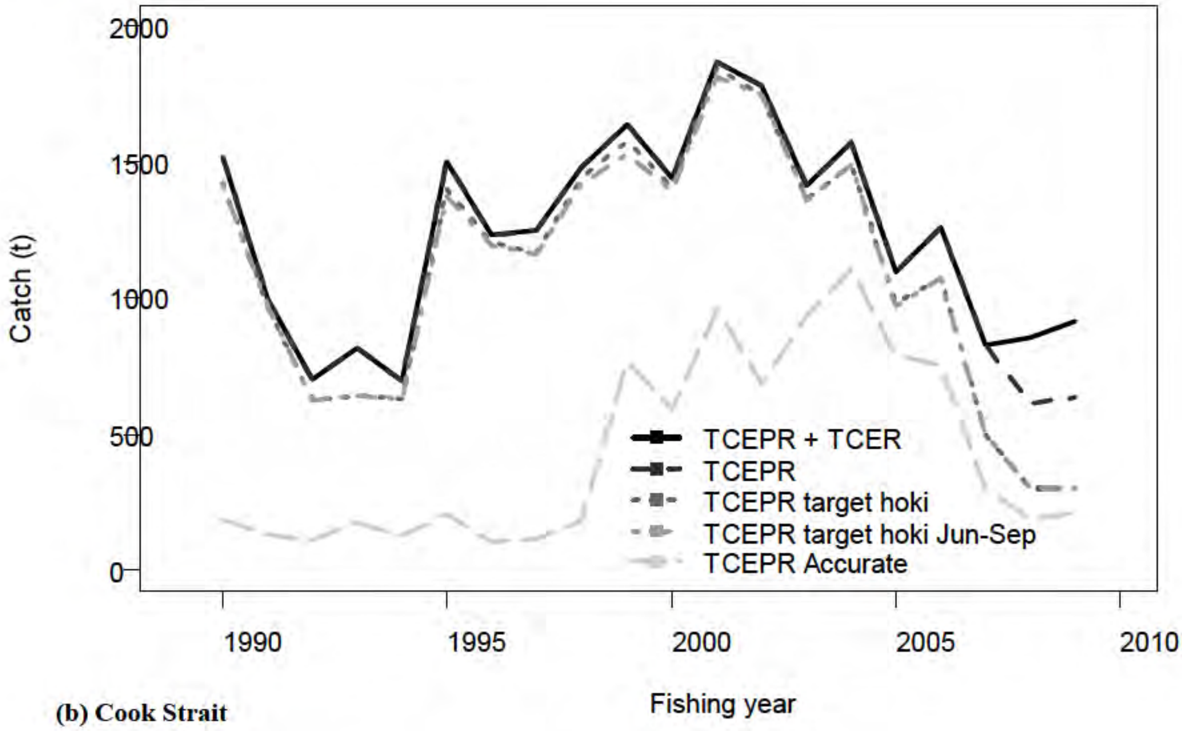


Figure 15: Predicted variable effects for variables selected into the CPUE model for the Cook Strait (LIN 7CK) ling line fishery. Standardised year effects with 95% confidence intervals are shown by the solid line in the top plot; unstandardised data are shown as a broken line.

(a) WCSI



(b) Cook Strait

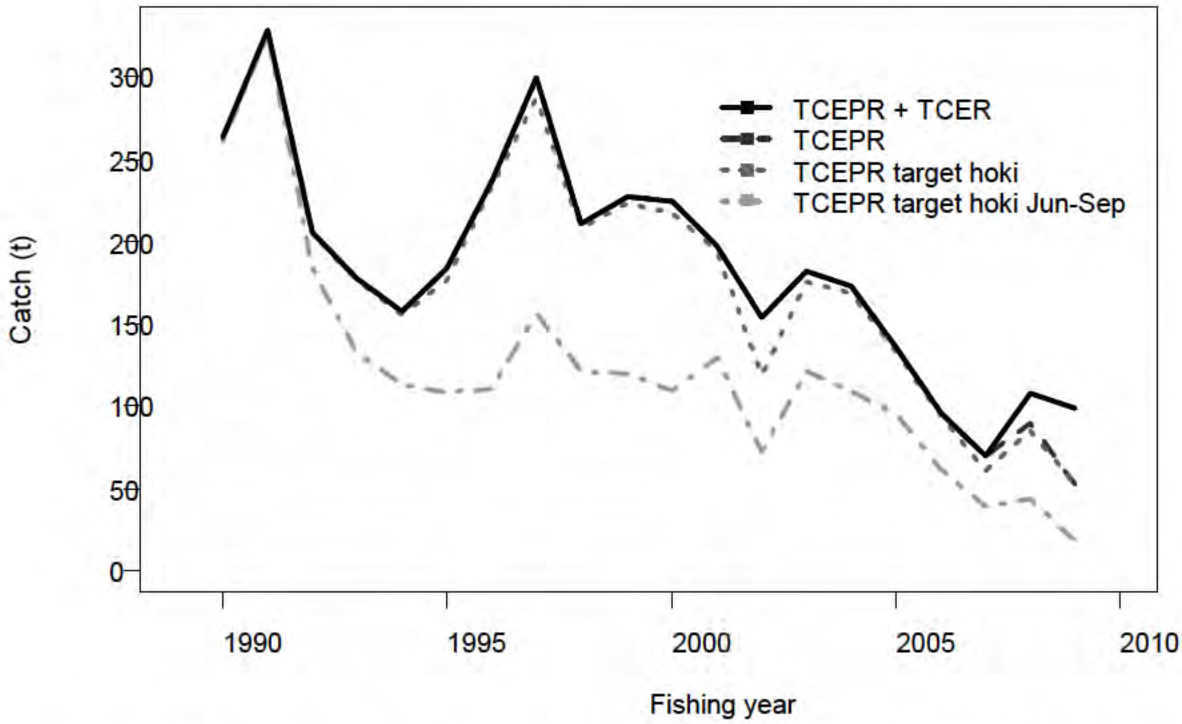
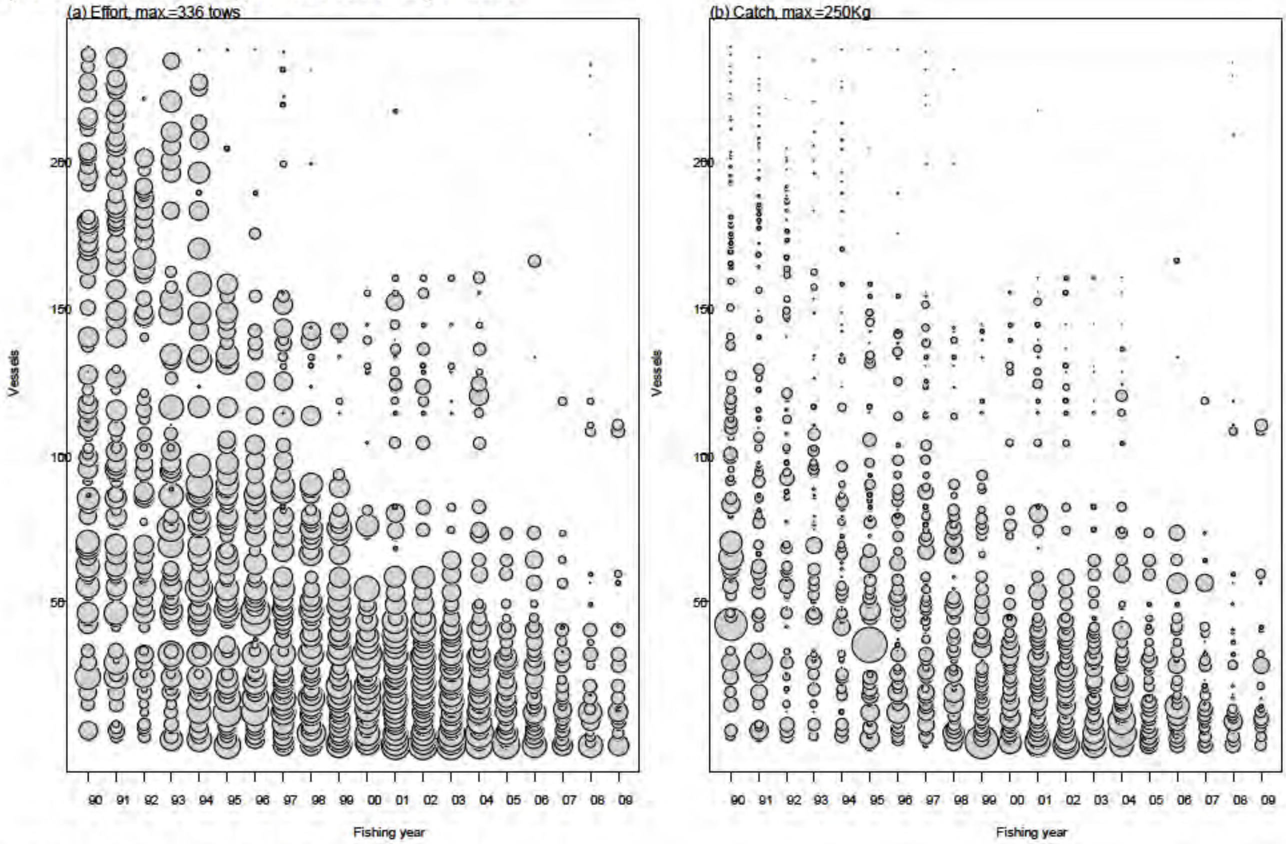


Figure 16: Estimated ling trawl catch (t) by datasets for the (a) WCSI and (b) Cook Strait fisheries.

(a) WCSI TCEPR target hoki June-September



(b) WCSI TCEPR target hoki June-September accurate

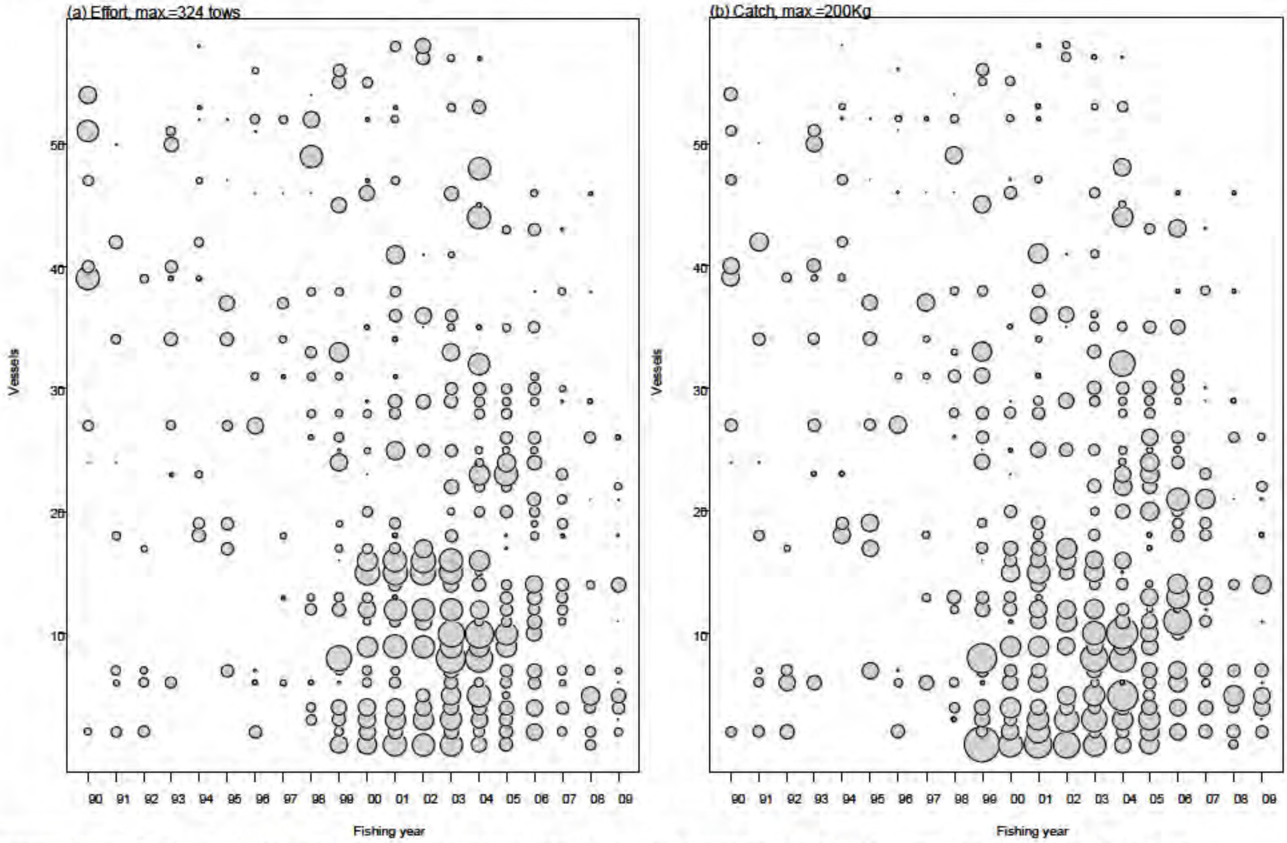
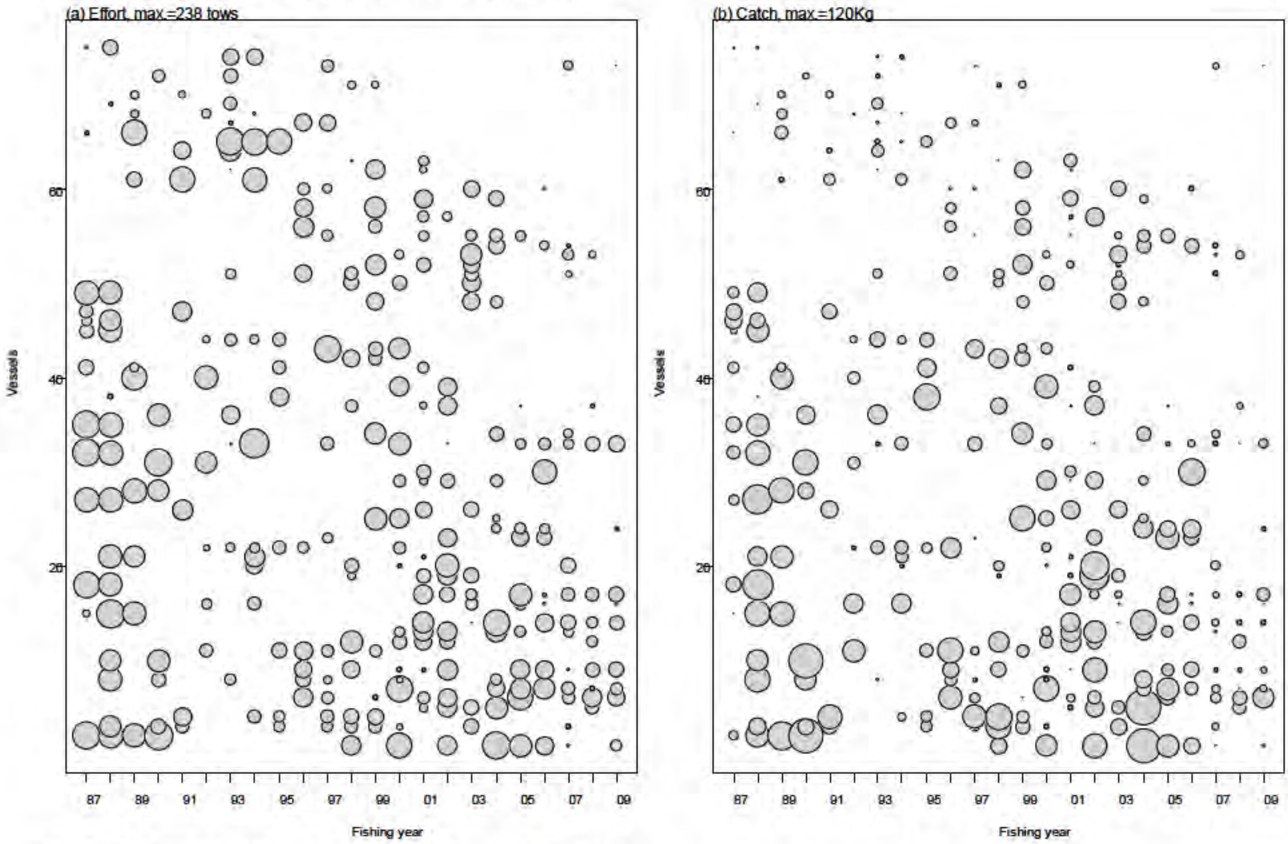


Figure 17a: Fishing effort and catches (where circle area is proportional to number of days fished or catches) by year for individual vessels included in the final trawl CPUE analyses.

(c) WCSI Observer target hoki June-September



(d) Cook Strait TCEPR target hoki June-September

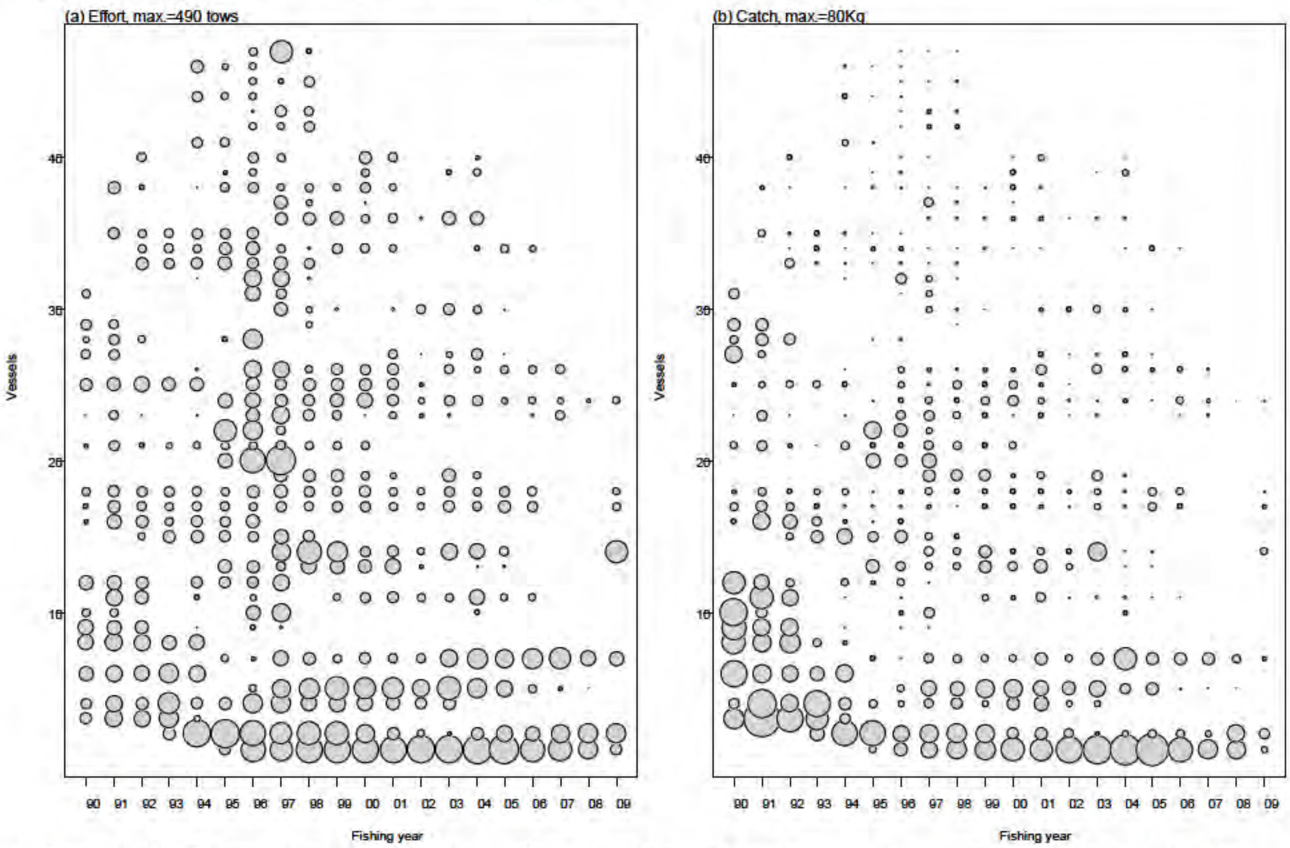


Figure 17b: Fishing effort and catches (where circle area is proportional to number of days fished or catches) by year for individual vessels included in the final trawl CPUE analyses.

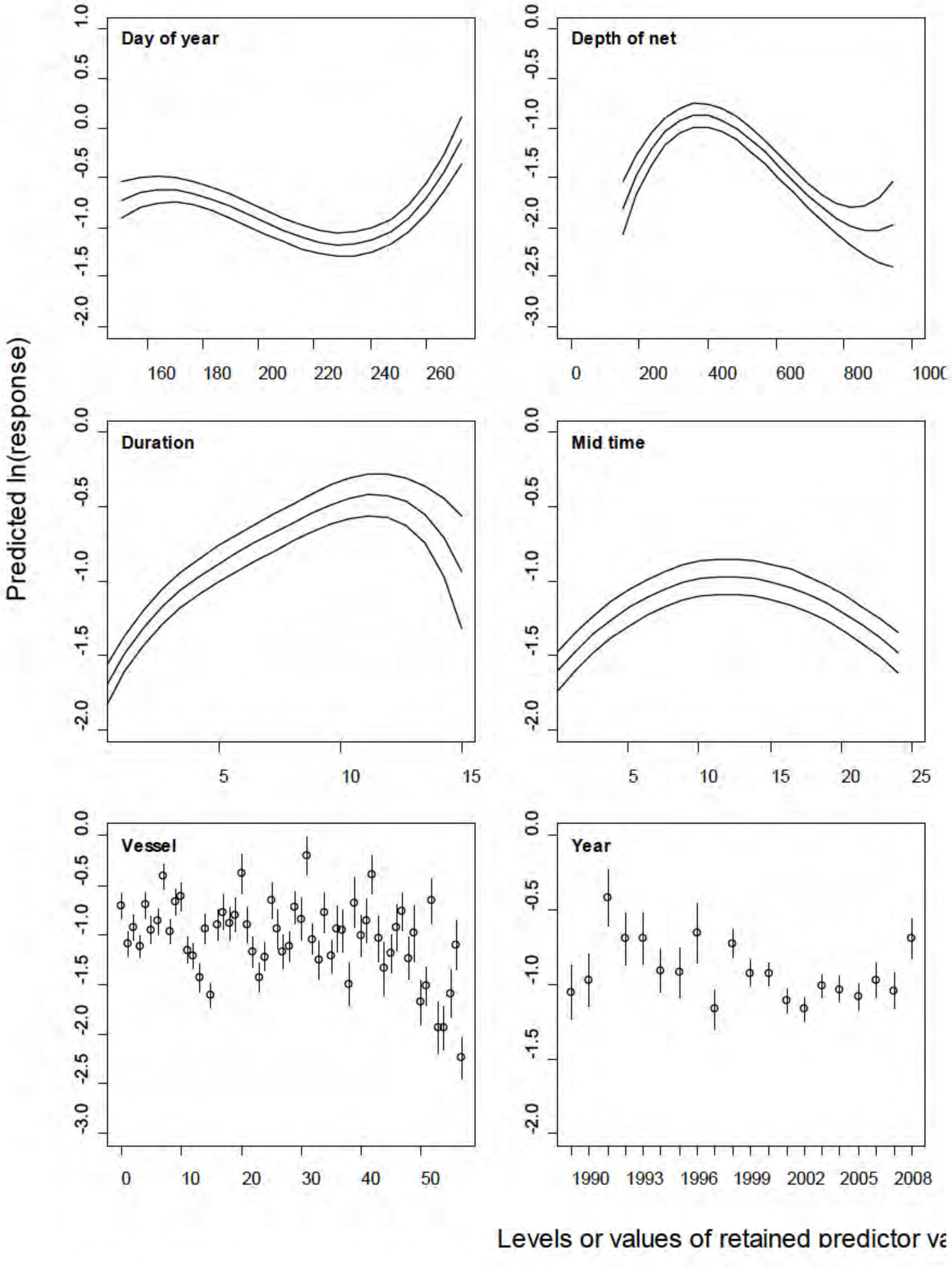


Figure 18a: Expected variable effects for variables selected into the 'accurate' TCEPR CPUE lognormal model for the WCSI hoki trawl fishery, 1990–2009. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables.

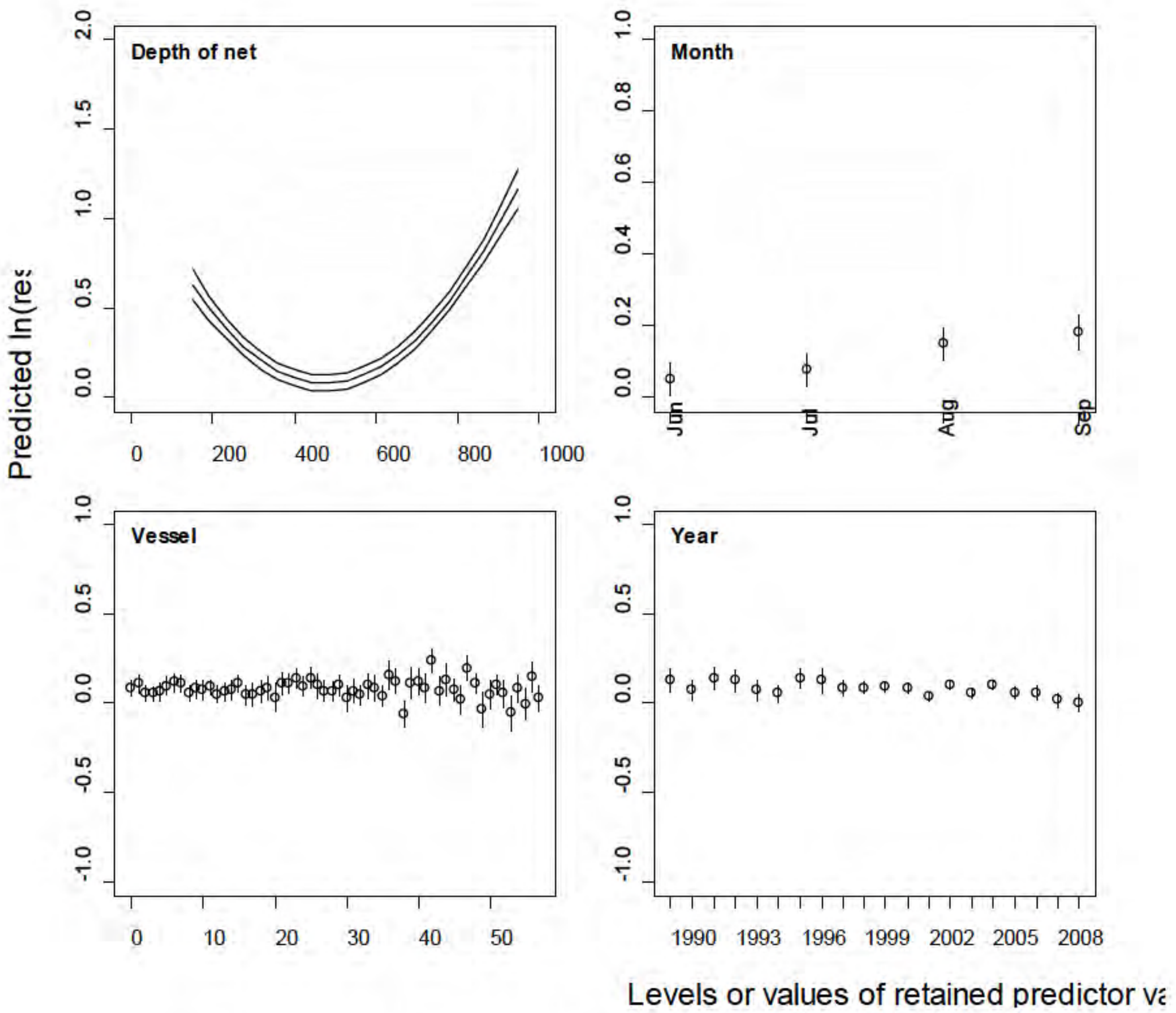


Figure 18b: Expected variable effects for variables selected into the binomial part of the combined CPUE model for the WCSI TCEPR accurate hoki trawl fishery, 1990–2009. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables.

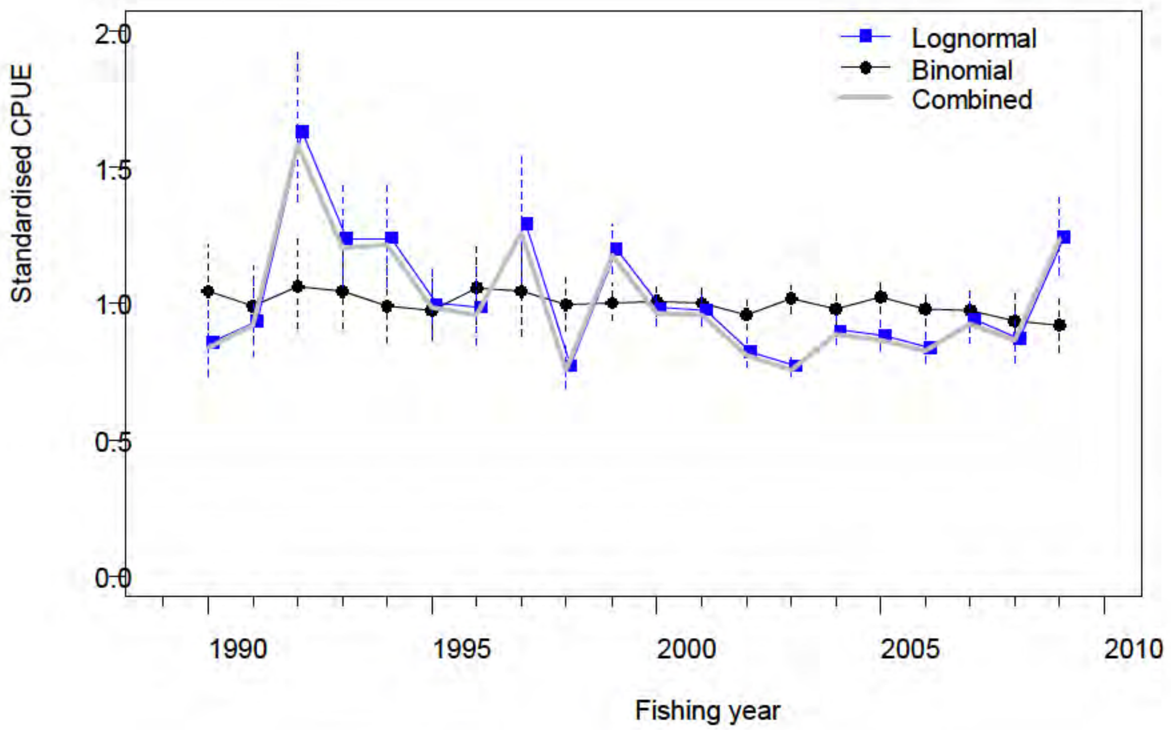
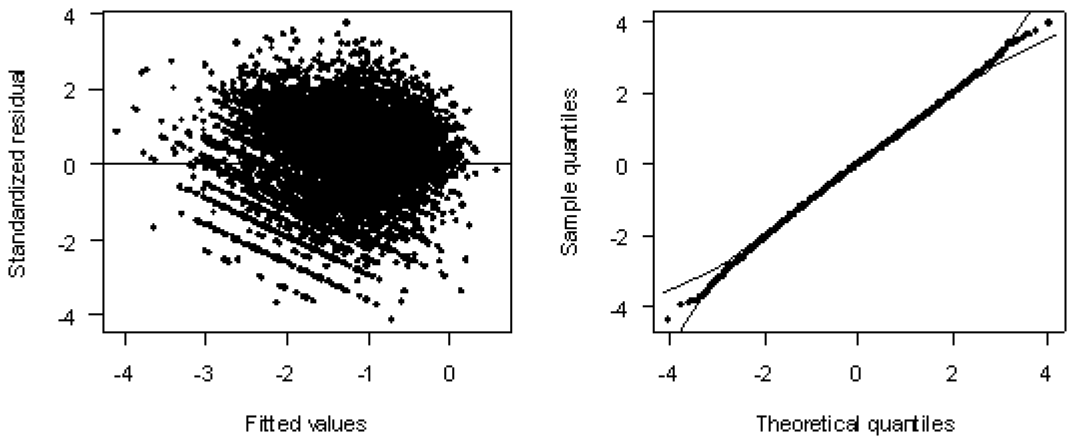
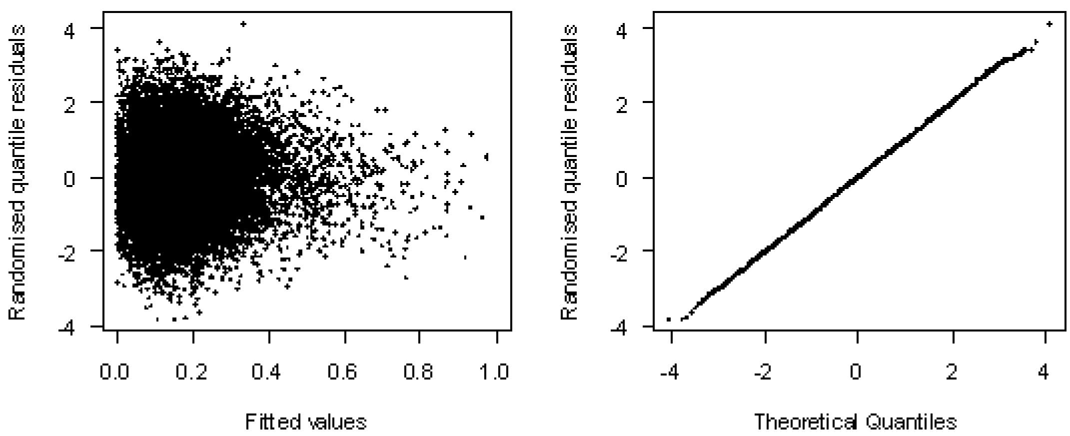


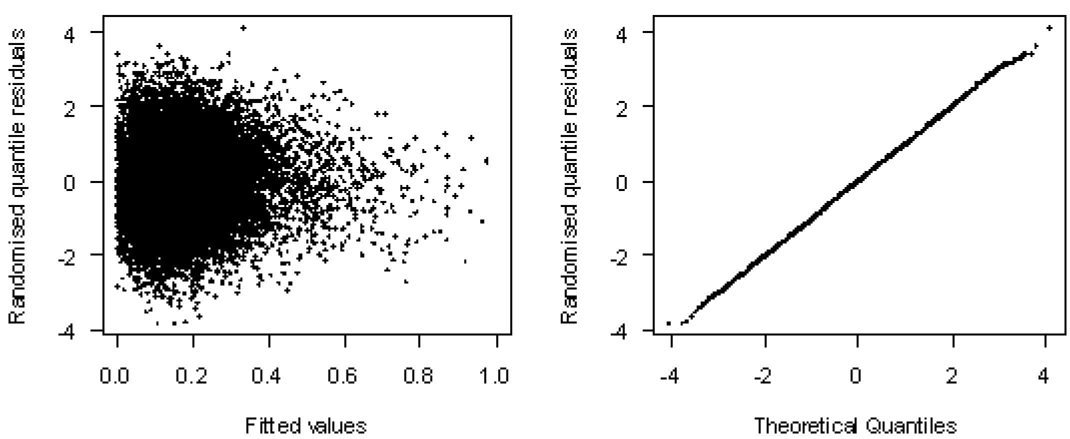
Figure 19: CPUE from the lognormal, binomial, and combined models for the WCSI TCEPR hoki trawl accurate dataset, 1990–2009. Bars indicate 95% confidence intervals.



(a) Diagnostic plots for the WCSI TCEPR target hoki June-September accurate CPUE lognormal models.

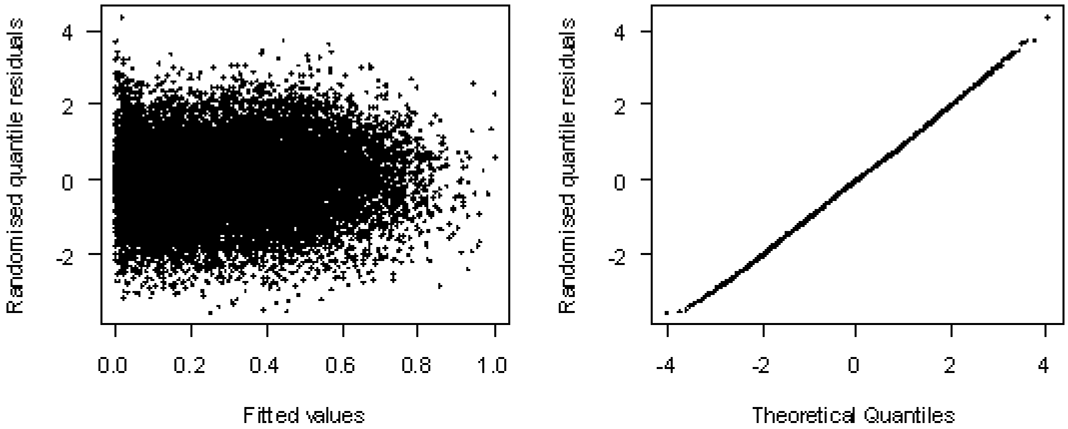


(b) Diagnostic plots for the WCSI TCEPR target hoki June-September accurate CPUE binomial models.

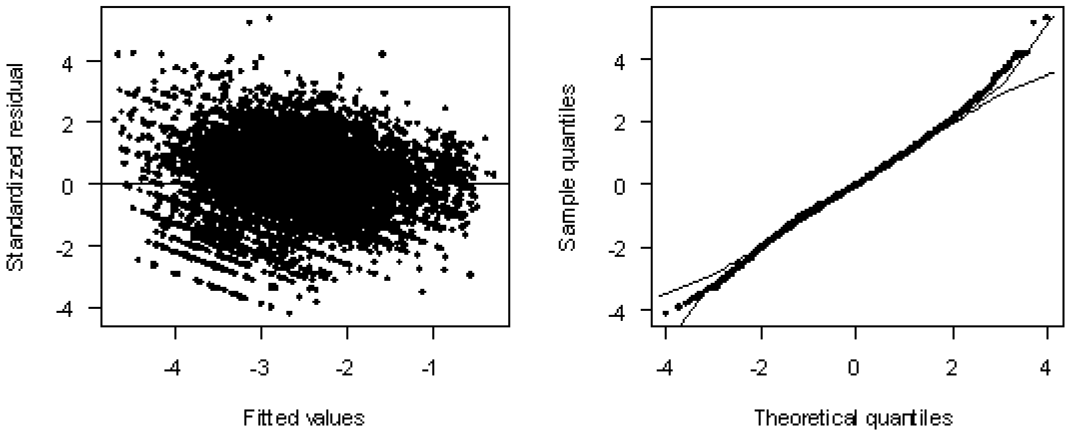


(c) Diagnostic plots for the WCSI Observer target hoki June-September CPUE lognormal models.

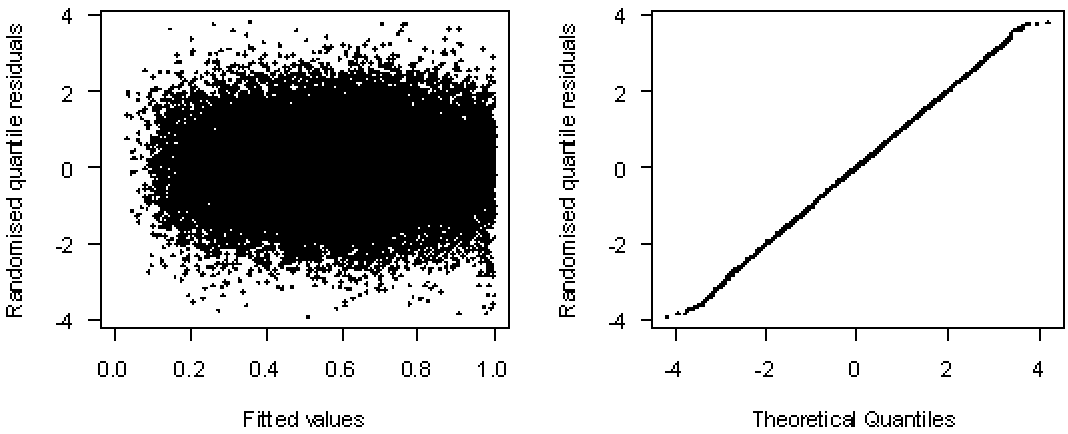
Figure 20: Diagnostic plots for the CPUE models.



(d) Diagnostic plots for the WCSI Observer target hoki June-September CPUE binomial models.



(e) Diagnostic plots for the Cook Strait TCEPR target hoki June-September CPUE lognormal models.



(f) Diagnostic plots for the Cook Strait TCEPR target hoki June-September CPUE binomial models.

Figure 20 continued.

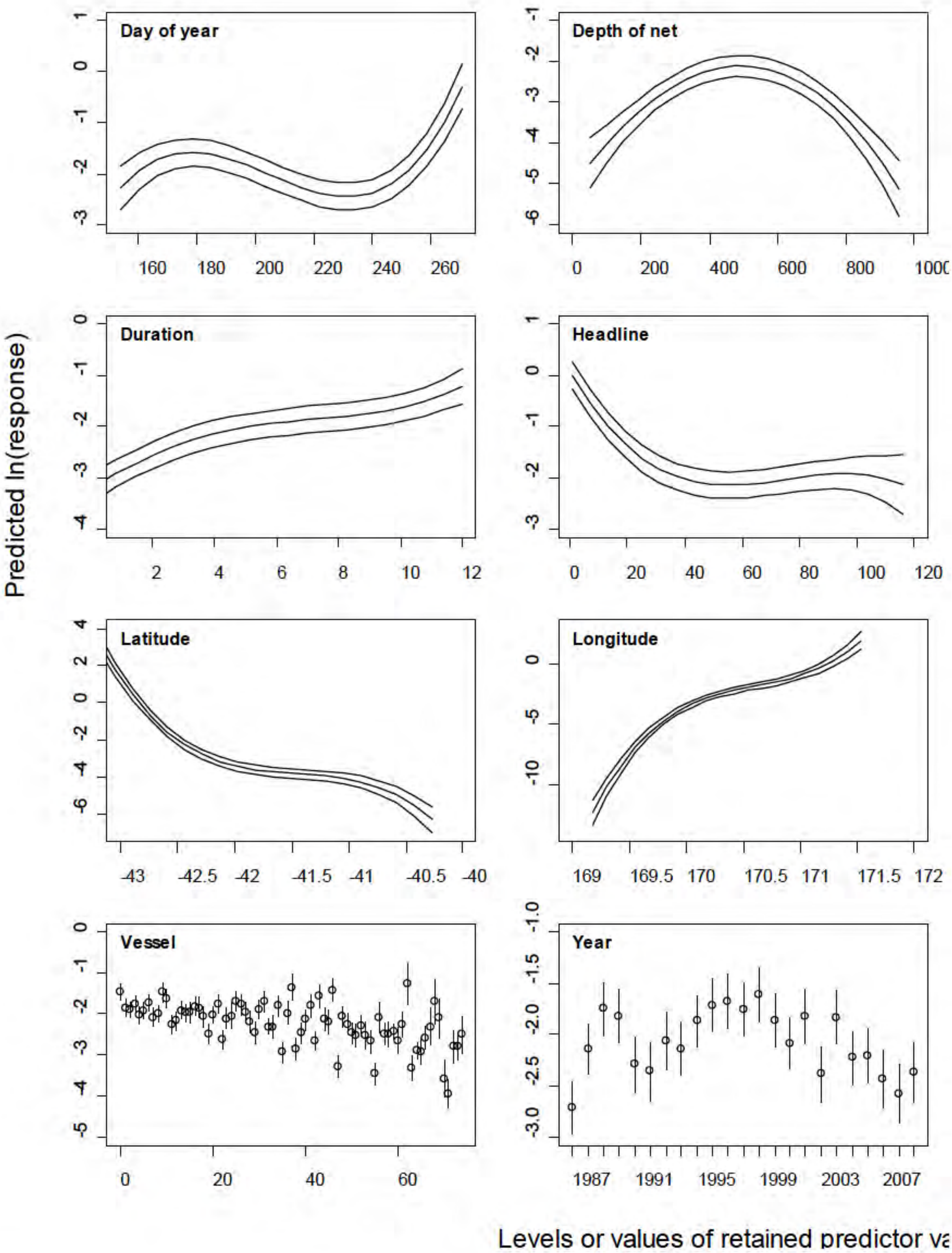


Figure 21a: Expected variable effects for variables selected into the CPUE lognormal model for the observed hoki trawl fishery, 1987–2009. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables.

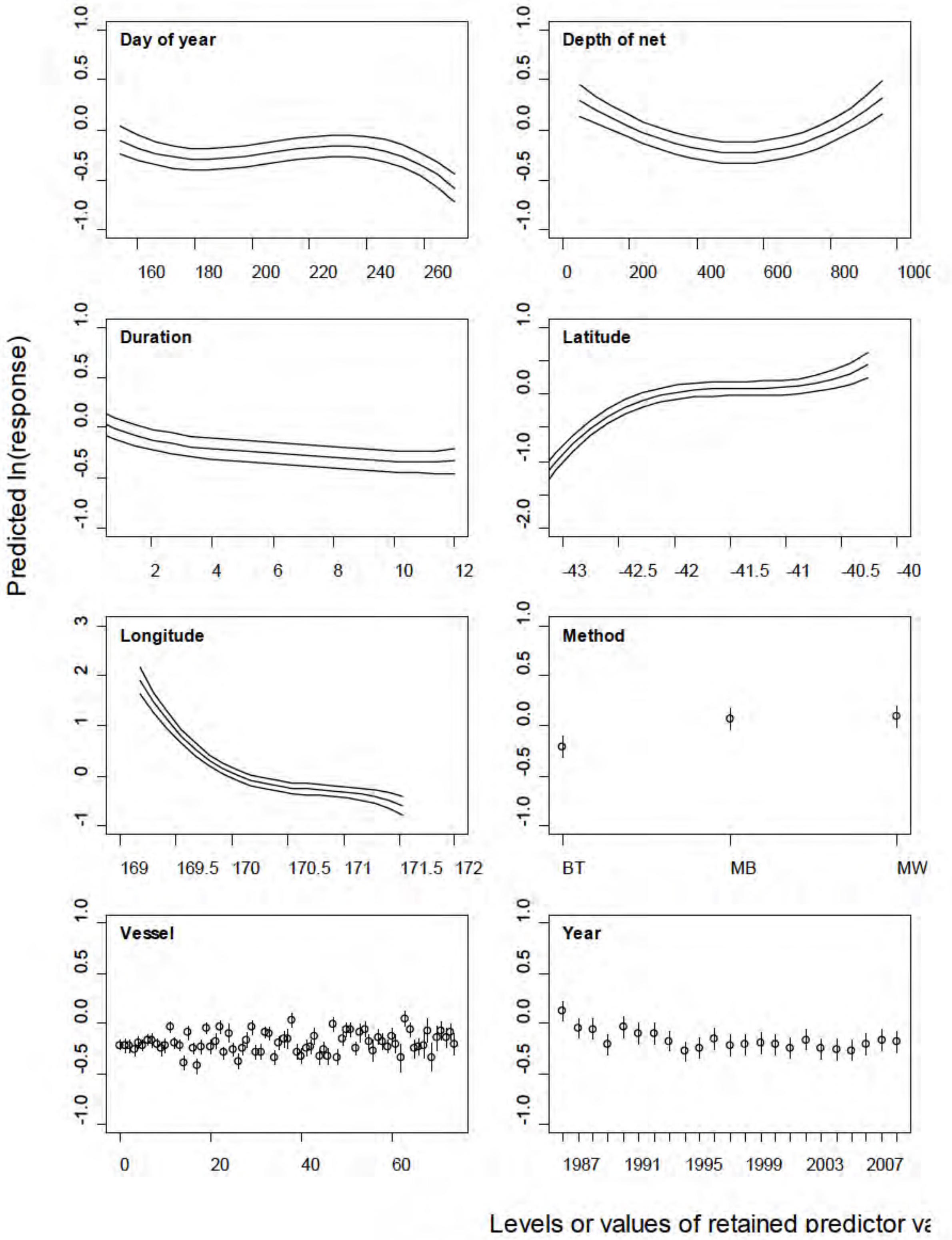


Figure 21b: Expected variable effects for variables selected into the binomial part of the combined CPUE model for the WCSI observed hoki trawl fishery, 1987–2009. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables.

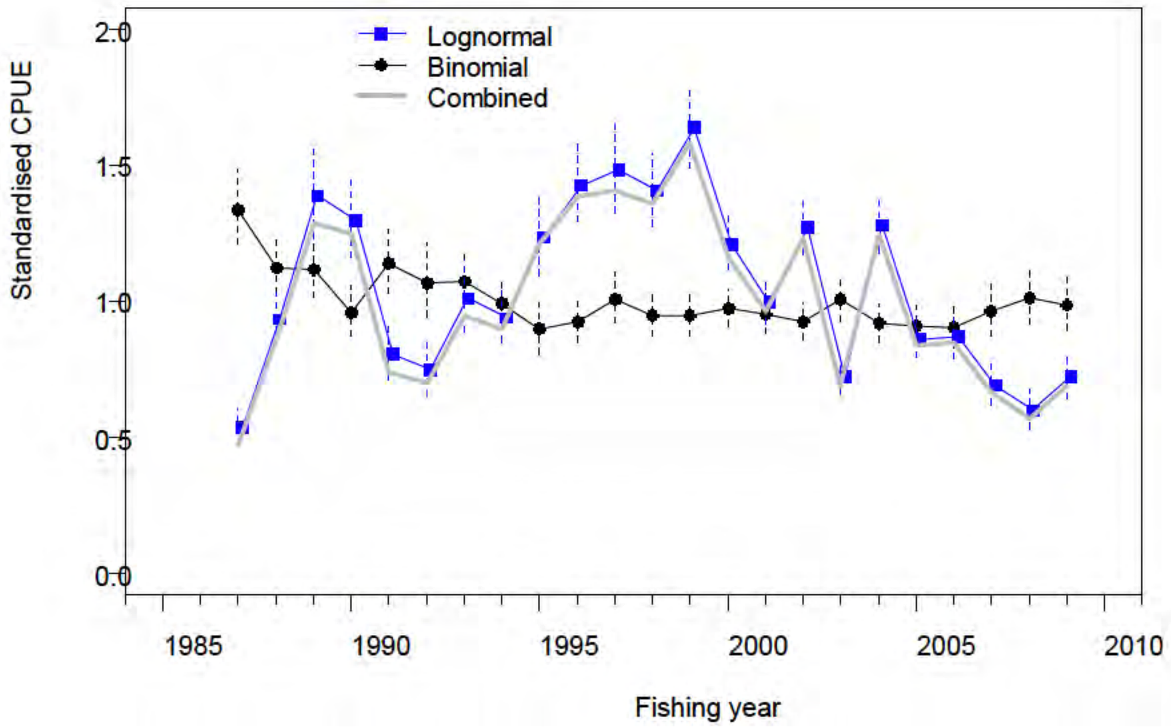


Figure 22: CPUE from the lognormal, binomial, and combined models for the WCSI observed hoki trawl fishery, 1990–2009. Bars indicate 95% confidence intervals.

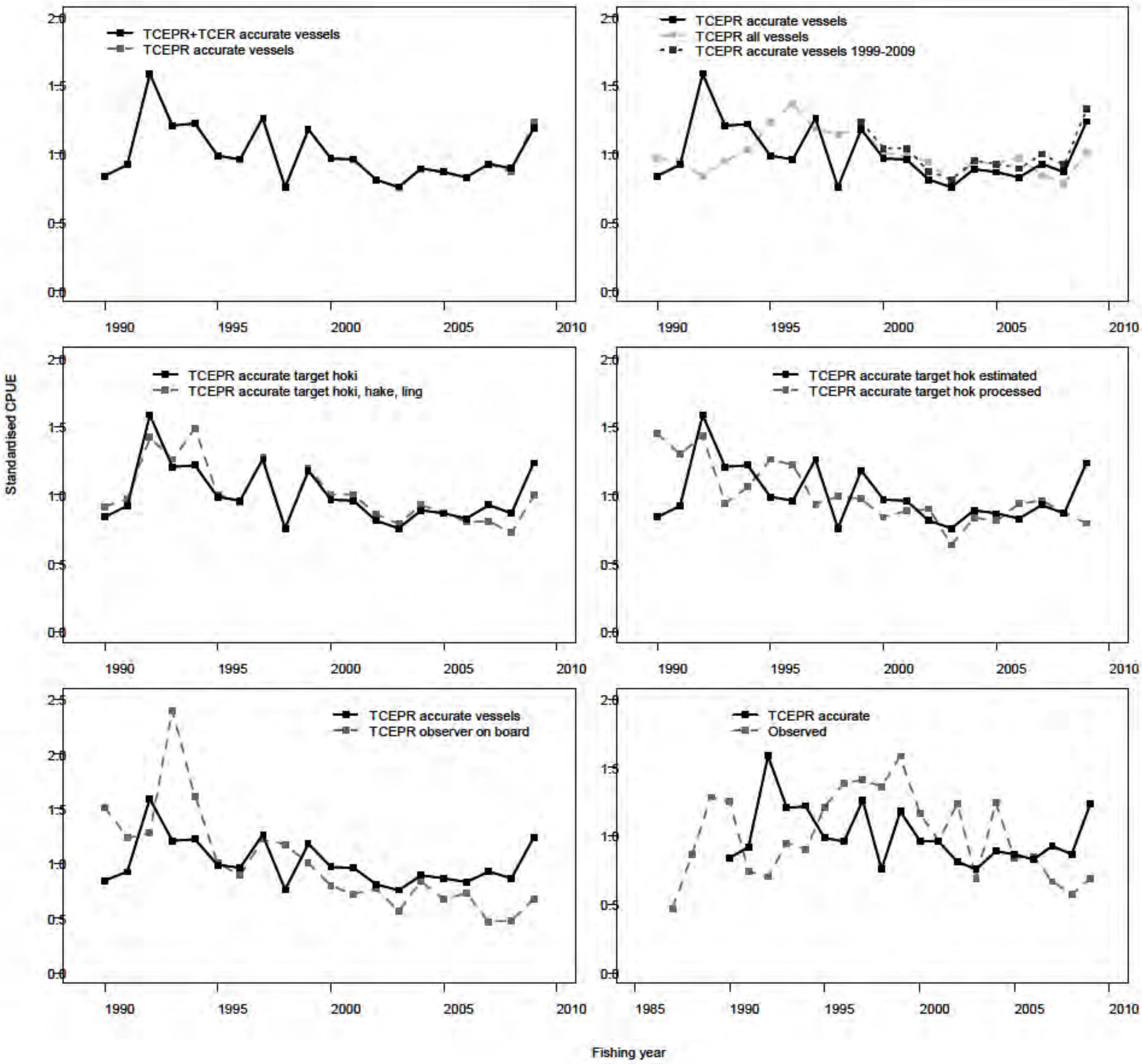


Figure 23: Comparison of WCSI combined CPUE indices for each model run.

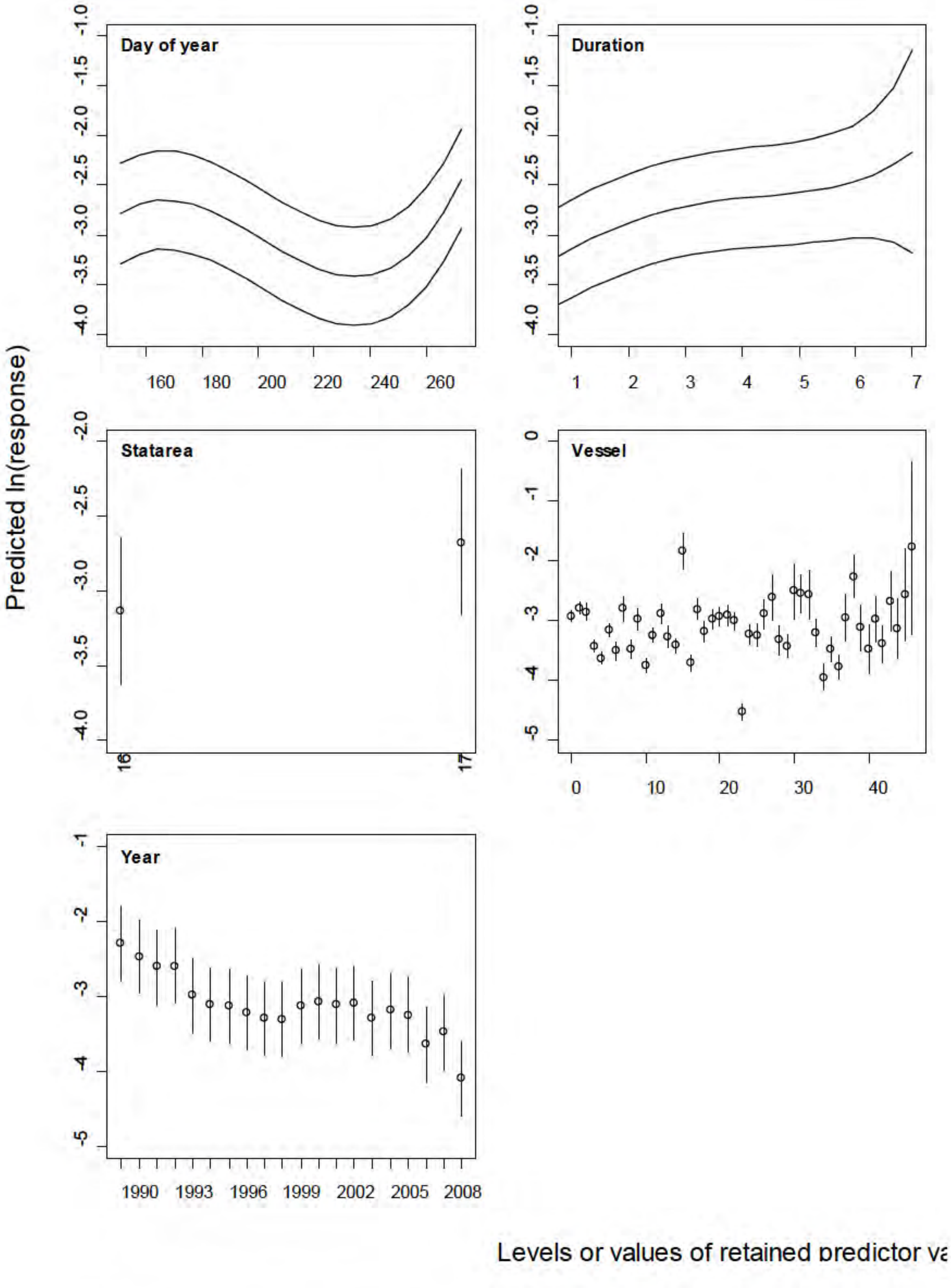


Figure 24a: Expected variable effects for variables selected into the CPUE lognormal model for the Cook Strait TCEPR hoki trawl fishery, 1990–2009. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables.

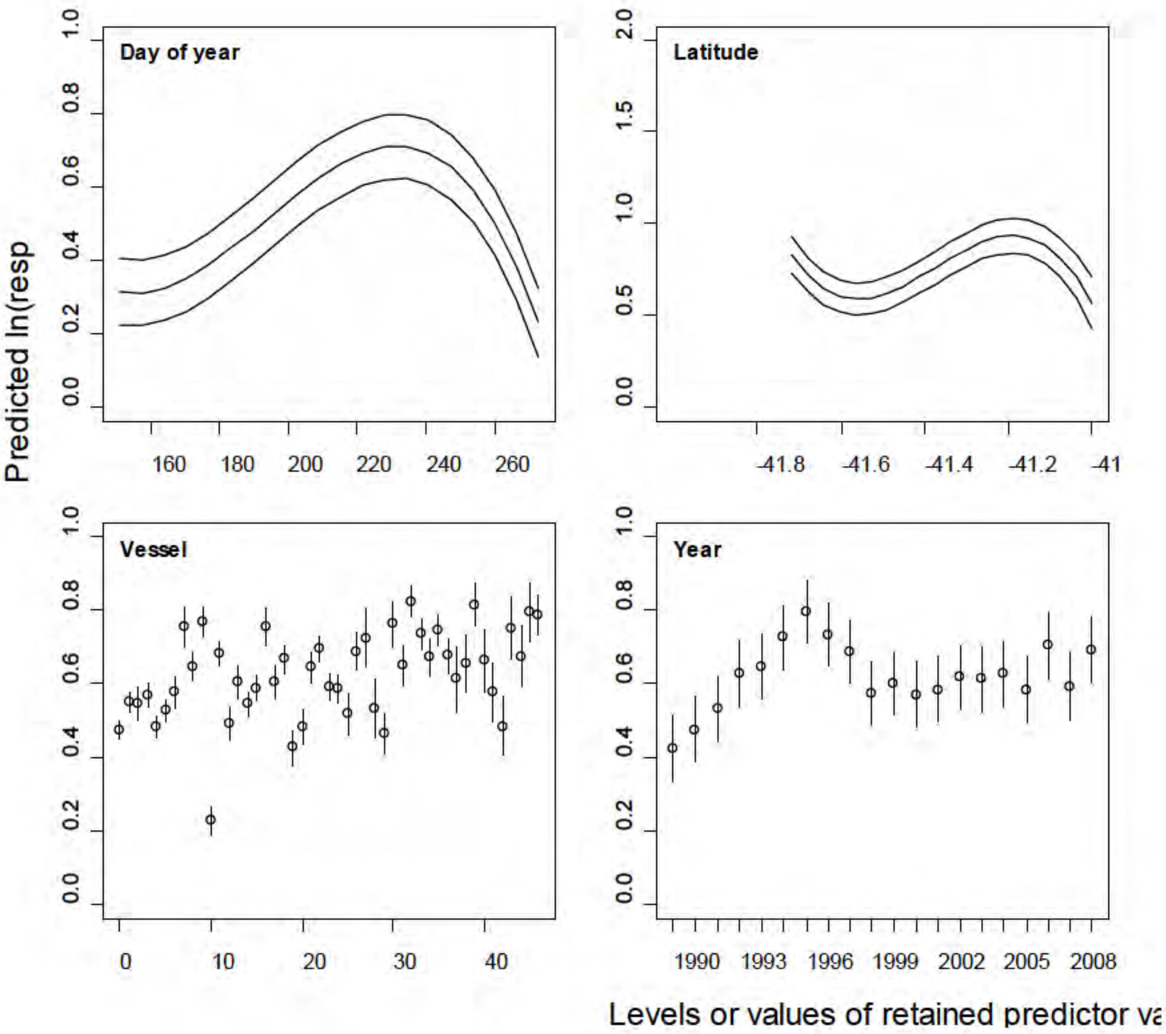


Figure 24b: Expected variable effects for variables selected into the binomial part of the combined CPUE model for the for the Cook Strait hoki trawl fishery, 1990–2009. The 95% confidence intervals are shown as bars for categorical variables and as upper and lower lines for continuous variables.

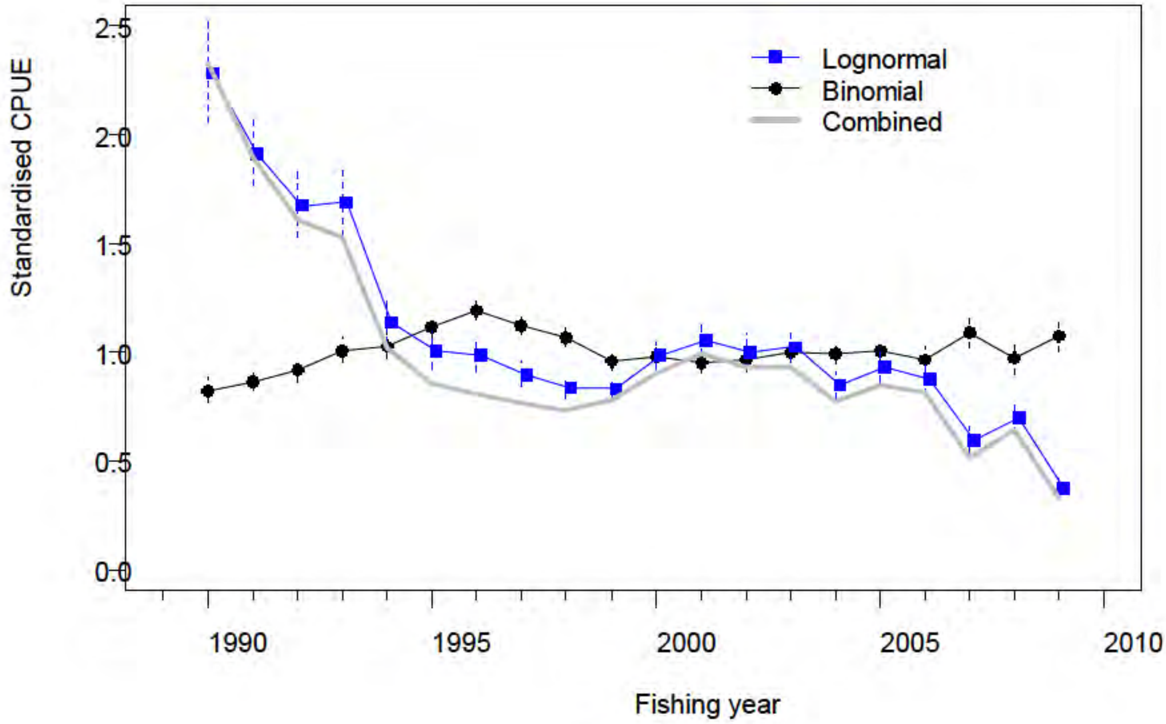


Figure 25: CPUE from the lognormal, binomial, and combined models for the Cook Strait TCEPR hoki trawl fishery, 1990–2009. Bars indicate 95% confidence intervals.

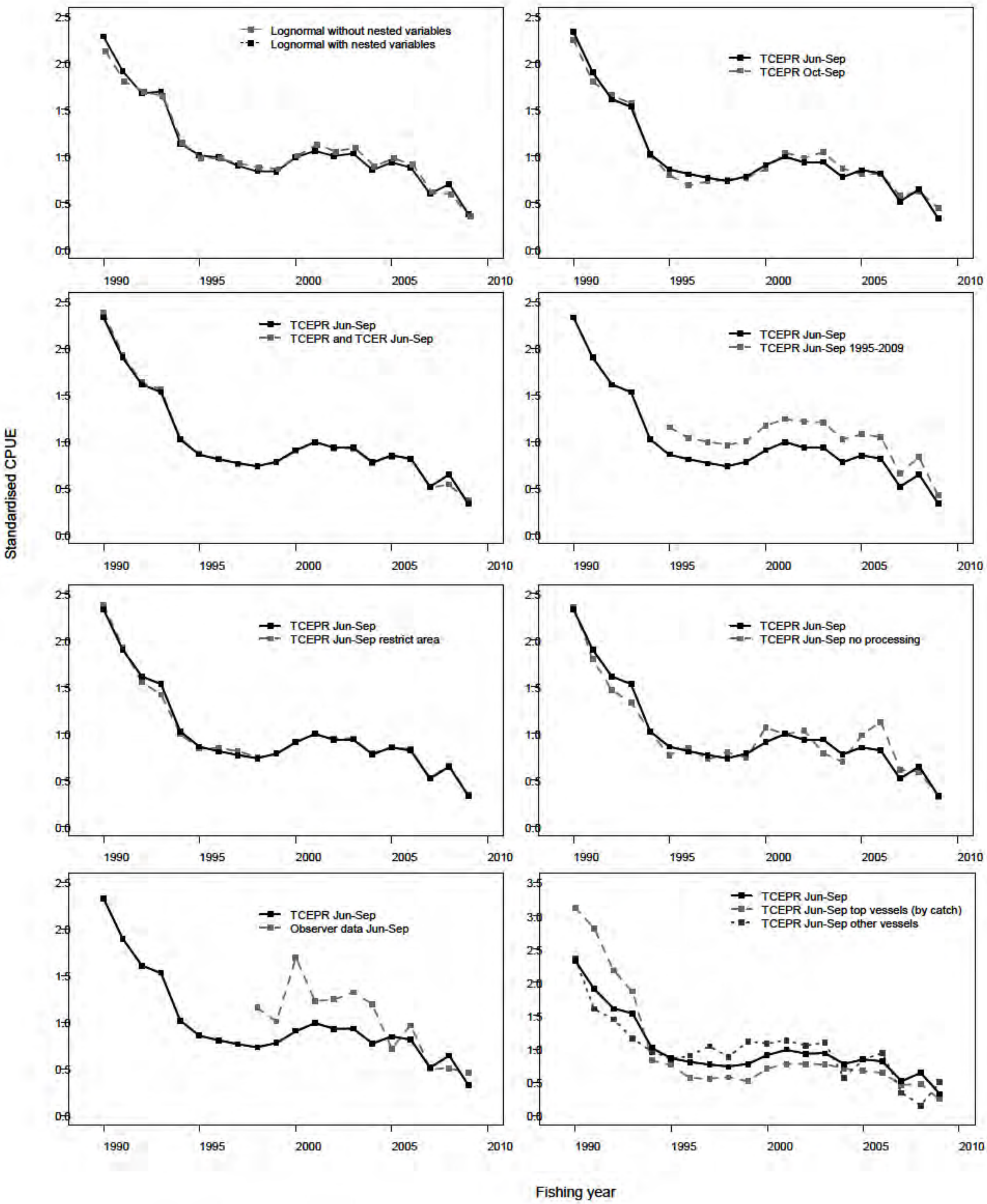


Figure 26: Comparison of Cook Strait trawl CPUE indices for each model run. All are combined model indices except where they are labelled 'lognormal'.

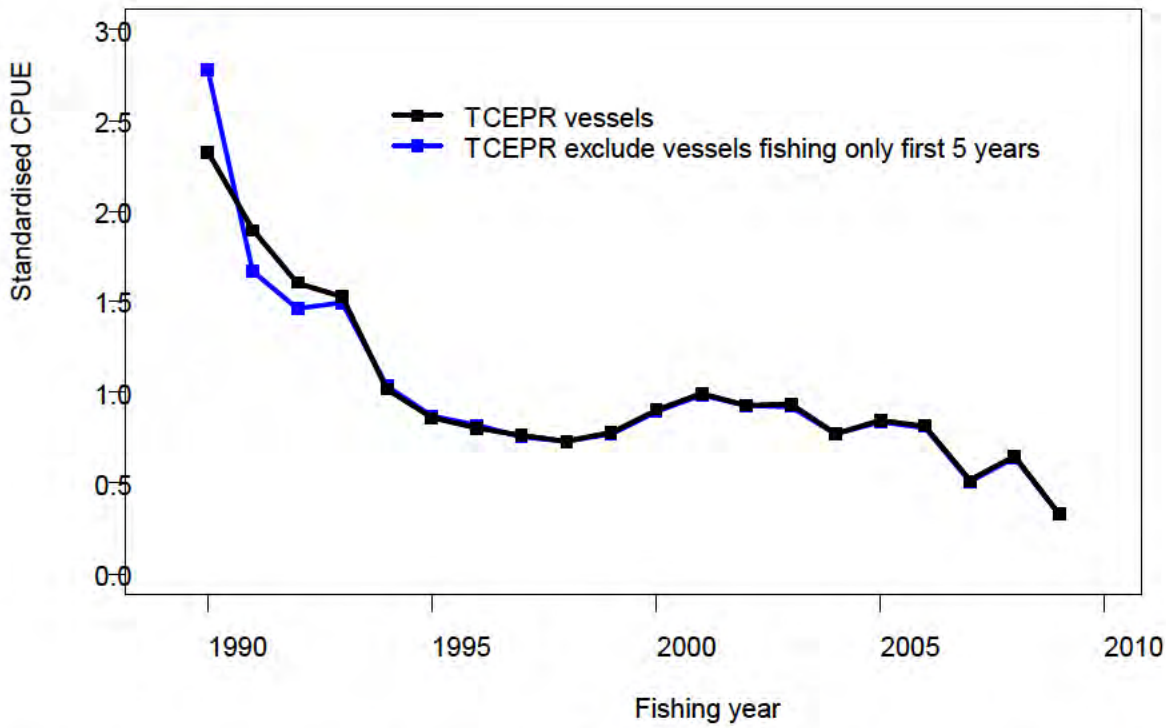


Figure 27: CPUE from the combined models for the Cook Strait TCEPR hoki trawl fishery, 1990–2009, including and excluding vessels that had fished in only the first five years of the series.

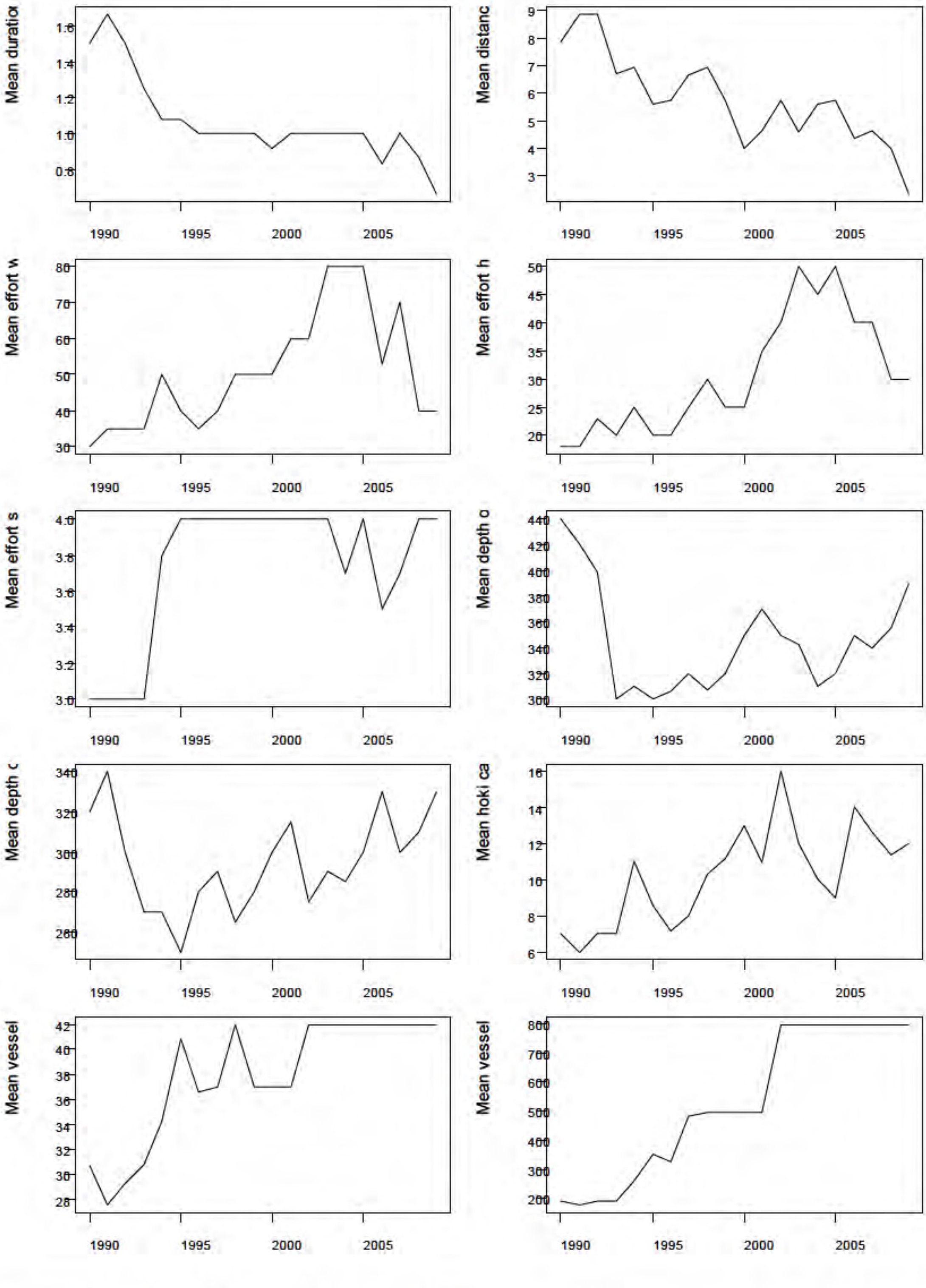


Figure 28: Mean values, by year, for a selection of variables relating to vessels and tows in the Cook Strait TCEPR June–September dataset.

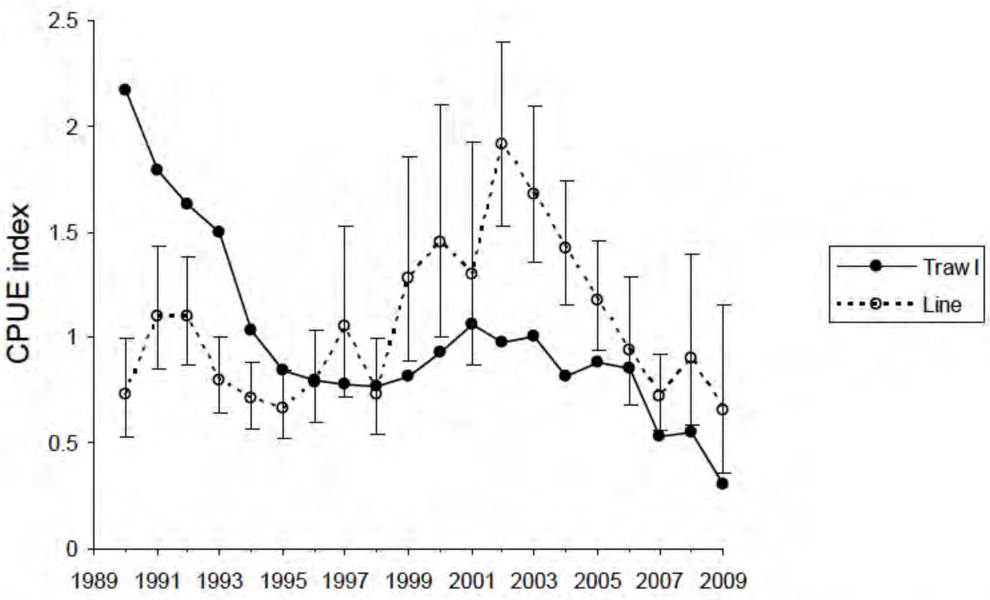


Figure 29: CPUE indices for the Cook Strait line and trawl fisheries. The values in each series are scaled to average 1. Where presented, error bars are 95% confidence intervals.

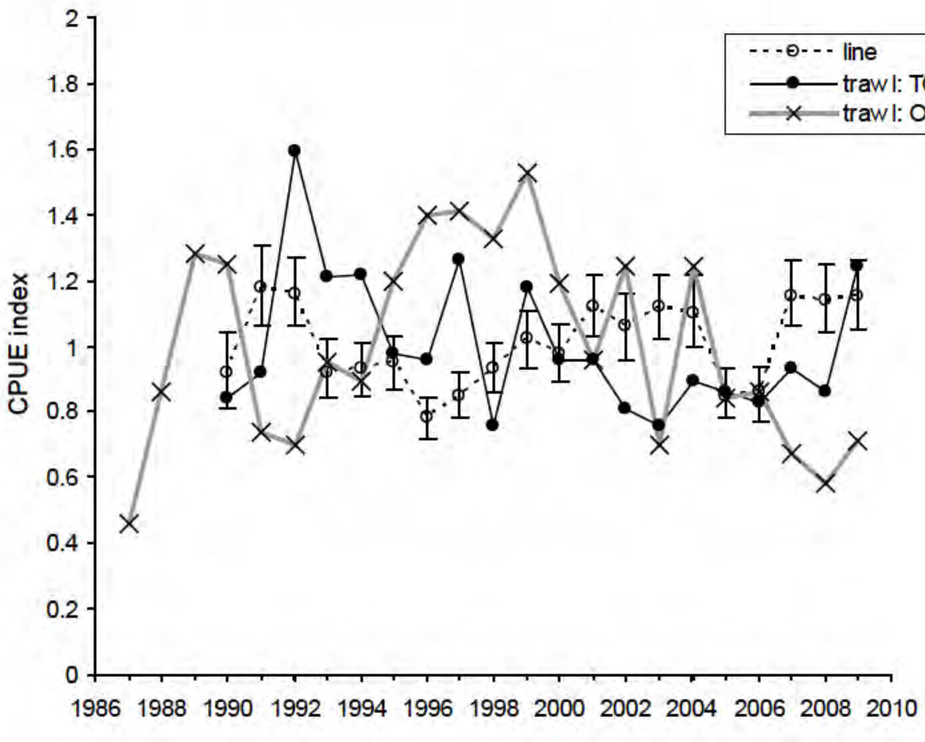


Figure 30: CPUE series calculated for WCSI line and trawl fisheries. The values in each series are scaled to average 1. Where presented, error bars are 95% confidence intervals.

APPENDIX A. Updated descriptive analysis

Previous 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 2007). These were both comprehensive reports showing how the ling fisheries in the New Zealand EEZ had evolved and operated. They also aimed to define seasonal and areal patterns of fish distribution. The work presented here simply updates tables A2 and A3 of Horn (2010), i.e., catch by area, by method, to indicate whether any marked changes have occurred in the fisheries in the last year.

For a detailed description of the methods used to extract and summarise the landings data, see Horn (2007). Commercial catch and effort data for all landings of ling from fishing years 1989–90 to 2008–09 had previously been extracted from the MFish catch and effort database, and groomed. The data extracted were reported by fishers on CELR (Catch, Effort, and Landing Return), LCER (Lining Catch Effort Return), LTCER (Lining Trip Catch Effort Return), NCELR (Netting Catch Effort Landing Return), TCER (Trawl Catch Effort Return), or TCEPR (Trawl, Catch, Effort, and Processing Return) forms. The fishing methods examined were: deepwater bottom trawl, deepwater midwater trawl, inshore bottom trawl, inshore midwater trawl, line, setnet, and fish pots. The distinction between deepwater and inshore trawls is not based on depth or position, but rather on the form type that the catch is reported on. TCEPR records are classified as deepwater; CELR and TCER records are classified as inshore.

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 areas are: 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).

All landings data

Annual estimated landings by area, from all methods combined, are listed in Table A2. The estimated totals for each year amount to between 85 and 93% of the actual reported landings. Significant landings have been taken in all areas. Most landings are taken in five areas around the South Island: East SI, Chatham, Southland, Sub-Antarctic, and West SI. This pattern of landings is consistent with ling distributions derived from research trawls (Anderson et al. 1998). There are some changes in the proportions of landings contributed by some areas before and after 2000. Landings from the Sub-Antarctic increased in the latter period, while those from East SI and Chatham declined. There are also some changes between the 2007–08 and 2008–09 fishing years. Line-caught landings from Cook Strait, Southland, and the Bounty Plateau approximately halved, and Sub-Antarctic landings also declined markedly (Table A3b). Deepwater bottom trawl catch from Southland, Chatham Rise, and Sub-Antarctic were also much lower than in the previous year; catch in the latter two areas were the second lowest since 1990 (Table A3a). Total landings from the EEZ were lower than in any year since 1990 (Table A2).

Landings summaries by fishing method and area

Ling are taken by a variety of fishing methods in each of the areas. Summaries of catch by fishing method, by area and fishing year, are presented in Tables A3a–c.

The inshore bottom trawl fishery (Table A3a) produces low levels of landings (i.e., generally less than 100 t annually) in all areas except Sub-Antarctic, Chatham, and Bounty, where catches are negligible or zero. However, there is some indication of an increasing West SI catch by this method. The deepwater bottom trawl fishery (Table A3a) is still important in the Southland and Sub-Antarctic areas (despite the reductions relative to 2007–08), with annual landings generally in excess of 2000 t. Landings in the Sub-Antarctic increased from the late 1990s to peak at more than 4700 t in 2003–04, but only 1300 t was reported in 2008–09.

Landings from the inshore midwater trawl fishery (Table A3a) are negligible in all areas except West SI and Cook Strait; catches from 2008–09 in both those areas are low relative to recent previous years. Total landings from the deepwater midwater trawl fishery (Table A3b) in 2008–09 are less than in any year since 1989–90. Landings declined in most areas, but particularly in Southland.

The line fishery (Table A3b) is significant in all areas. The total catch was lower than last year, with marked declines apparent in Southland, Sub-Antarctic, and Bounty. Relative to 2007–08, only East SI and Chatham produced higher landings. The Chatham area is still the most productive, but its recent landings are only about a third of those taken at its peak in the mid 1990s.

Setnet fishery landings (Table A3b) have long been negligible in all areas except East SI and West SI. The 2008–09 landings in these two areas rebounded from the extreme lows of the previous year. Landings from fish pots (Table A3c) are generally recorded only from East SI and Southland, but they average about 20 t annually. The 2008–09 landings are typical.

Conclusions

In summary, the overall 2008–09 ling catch from the EEZ is markedly lower than in any year since 1990–91. The overall line fishery catches were about 15% lower than in the previous year. This is markedly lower than in the most productive years (i.e., 1992–2002), but relatively consistent with the pattern of landings since 2003. A marked reduction in landings was recorded in the deepwater trawl fisheries; they were 35% less than in 2007–08, and lower than in any year since 1989–90. The largest percentage reductions occurred in the Chatham and Sub-Antarctic areas. The setnet fishery increased from its lowest recorded landings in the previous year (although it is still a very minor fishery).

Table A1: Definitions of geographical areas used in the analysis (based on statistical areas), and the administrative ling stocks they approximate. For a plot of statistical areas, see Figure 1.

Area	Statistical areas	Approximate ling stock
East NI	11–15, 201–206	LIN 2
East SI	18–24, 301	LIN 3
Chatham	49–52, 401–412	LIN 4
Southland	25–31, 302, 303, 501–504	LIN 5
Sub-Antarctic	601–606, 610–612, 616–620, 623–625	Part of LIN 6
Bounty	607–609, 613–615, 621, 622	Part of LIN 6
West SI	32–36, 701–706	Part of LIN 7
Cook Strait	16, 17, 37–40	Parts of LIN 2 and 7

Table A2: Total estimated ling landings (t) as reported on TCEPR, CELR, NCER, and LCER returns, by fishing year, by area. Fishing year 1989–90 is denoted as "1990", etc. The percentage of total landings taken over two distinct periods (1990–1999 and 2000–2009) from each area is also presented (Percentage). Total estimated landings by year (Total) can be compared with actual reported landings from Fishstocks LIN 2–7 (Landings).

Area										Fishing year	Percentage
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	1990–99
East NI	268	425	451	512	501	508	509	478	562	423	2.9
East SI	1 220	1 934	1 808	1 612	1 571	1 948	2 320	2 034	2 031	1 939	11.5
Chatham	513	2 157	4 360	3 649	3 755	4 839	4 151	3 814	4 343	3 926	22.2
Southland	2 143	2 105	3 841	2 890	3 259	3 646	4 537	4 445	4 123	3 549	21.6
Sub-Antarctic	1 189	2 673	2 390	5 038	2 270	3 653	3 591	4 951	5 382	4 284	22.1
Bounty	12	32	907	969	1 149	382	387	351	394	563	3.2
West SI	2 322	1 946	1 854	1 864	1 765	2 399	2 595	2 536	2 745	2 975	14.4
Cook Strait	415	527	314	324	252	319	369	381	276	344	2.2
Total	8 083	11 800	15 925	16 859	14 524	17 695	18 459	18 990	19 855	18 004	
Landings	8 907	13 296	17 537	18 812	15 720	19 580	21 183	22 209	22 841	20 811	
% of landings	90.7	88.8	90.8	89.6	92.4	90.4	87.1	85.5	86.9	86.5	

Area										Fishing year	Percentage
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000–09
East NI	461	557	582	481	507	393	416	512	492	474	3.1
East SI	2 098	1 681	1 571	1 842	1 475	1 213	1 202	1 592	1 421	1 389	9.9
Chatham	3 969	3 412	3 214	2 723	2 379	2 570	1 667	1 947	2 308	1 817	16.6
Southland	3 423	3 557	3 349	3 143	3 350	4 294	3 918	4 492	4 562	3 478	24.0
Sub-Antarctic	4 716	4 469	5 326	5 052	5 658	4 678	2 935	3 613	3 503	1 526	26.5
Bounty	990	1 064	629	922	853	49	43	236	503	232	3.5
West SI	2 685	3 068	2 630	2 344	2 406	2 057	2 051	1 797	1 791	1 845	14.5
Cook Strait	332	395	289	346	360	373	299	241	182	127	1.9
Total	18 674	18 203	17 591	16 852	16 990	15 628	12 531	14 430	14 760	10 887	
Landings	21 300	20 255	19 255	18 654	18 506	16 894	13 814	15 798	15 881	12 792	
% of landings	87.7	89.9	91.4	90.3	91.8	92.5	90.7	91.3	92.9	85.1	

Table A3a: Catch of ling (t) by area, by fishing year, for various fishing methods: inshore bottom trawl, deepwater bottom trawl, inshore midwater trawl. Fishing year 1989–90 is denoted as "1990", etc. Values have been rounded to the nearest tonne, so "0" represents reported landings of less than 0.5 t, and "–" indicates nil reported landings.

Method and																				Fishing year
Area	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inshore bottom trawl																				
East NI	25	25	21	17	22	18	24	17	7	5	7	6	4	8	3	2	2	15	11	11
East SI	148	197	145	109	64	66	50	62	46	51	80	75	106	91	88	99	46	49	71	39
Chatham	4	5	2	–	1	2	3	0	0	0	–	0	1	1	0	1	10	1	–	–
Southland	47	63	54	94	78	83	50	56	28	66	67	99	89	166	137	136	106	100	10	121
West SI	148	150	192	218	111	107	190	166	105	157	129	51	54	69	55	130	127	101	239	252
Cook Strait	4	9	3	10	22	78	83	72	25	25	20	15	17	8	4	7	3	4	6	31
Total	376	450	418	447	297	354	400	373	211	304	303	245	270	342	287	375	294	269	437	455
Deepwater bottom trawl																				
East NI	59	117	88	75	74	79	126	153	131	163	157	206	207	113	74	51	40	71	19	37
East SI	599	817	936	802	726	824	1 084	1 019	1 158	972	857	956	855	1 127	810	589	599	944	827	700
Chatham	500	1 236	1 344	1 010	443	818	729	771	2 254	1 841	1 889	1 461	1 217	1 317	1 062	798	567	854	1 183	498
Southland	1 980	2 008	3 376	2 182	2 096	2 507	3 929	3 407	2 921	2 650	2 396	2 095	2 133	1 944	2 431	3 157	2 971	3 534	3 571	2 951
Sub-Antarctic	1 148	2 445	2 045	4 104	1 758	2 013	2 297	2 661	2 990	2 344	3 496	3 540	4 447	4 655	4 764	4 223	2 598	3 495	3 154	1 304
Bounty	4	7	35	–	4	0	1	–	–	3	1	0	1	1	1	9	4	–	–	8
West SI	370	260	306	476	385	486	370	518	496	876	761	1 018	1 133	838	823	763	993	703	525	556
Cook Strait	7	13	4	2	48	58	96	126	77	111	88	39	72	35	38	30	21	19	40	21
Total	4 666	6 901	8 133	8 650	5 534	6 786	8 632	8 655	10 026	8 961	9 645	9 315	10 063	10 029	10 004	9 620	7 794	9 620	9 321	6 076
Inshore midwater trawl																				
East NI	1	0	1	2	0	0	0	–	0	–	0	1	–	–	0	0	–	–	–	–
East SI	3	9	6	0	1	0	2	7	4	8	7	7	2	30	13	1	2	0	1	–
West SI	2	–	2	4	3	10	24	25	57	83	206	180	82	113	67	70	63	34	6	33
Cook Strait	42	125	37	30	11	6	16	22	13	9	18	30	14	36	29	23	21	18	14	14
Total	48	134	45	35	14	17	43	54	74	100	231	218	98	178	110	93	86	52	20	48

Table A3b: Catch of ling (t) by area, by fishing year, for various fishing methods: deepwater midwater trawl, line, setnet. Fishing year 1989–90 is denoted as “1990”, etc. Values have been rounded to the nearest tonne, so “0” represents reported landings of less than 0.5 t, and “–” indicates nil reported landings.

Method and																				Fishing year
Area	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Deepwater midwater trawl																				
East NI	0	12	1	4	1	0	2	2	12	7	4	5	1	4	4	1	3	1	2	2
East SI	72	57	62	35	39	34	87	111	198	213	213	81	103	88	79	65	24	6	10	3
Chatham	–	69	11	44	39	54	59	52	44	45	30	44	38	20	60	15	2	1	0	–
Southland	116	29	121	173	271	398	274	133	79	57	100	380	139	169	197	139	161	175	84	6
Sub-Antarctic	42	11	19	48	11	11	22	5	5	6	15	200	225	183	239	157	165	118	3	6
Bounty	8	19	38	4	3	3	2	–	7	11	7	0	1	–	2	6	1	2	1	2
West SI	1 261	740	402	340	353	803	857	725	997	768	713	855	651	587	759	335	268	123	87	80
Cook Strait	260	326	200	179	107	117	119	141	105	91	107	147	74	137	119	96	65	45	33	25
Total	1 759	1 261	854	828	824	1 421	1 421	1 168	1 446	1 197	1 189	1 713	1 233	1 188	1 460	815	690	471	220	124
Line																				
East NI	135	186	300	389	401	409	353	278	401	248	292	339	370	356	425	339	365	425	459	419
East SI	185	613	475	488	550	816	913	593	382	512	748	426	379	400	360	370	430	492	502	579
Chatham	8	846	3 003	2 595	3 272	3 966	3 360	2 991	2 045	2 039	2 050	1 907	1 958	1 386	1 257	1 757	1 088	1 092	1 124	1 316
Southland	0	2	288	439	813	653	280	845	1 090	775	850	960	972	850	583	860	676	678	796	382
Sub-Antarctic	–	217	326	886	501	1 630	1 273	2 285	2 388	1 934	1 204	728	655	214	655	298	172	–	345	216
Bounty	–	7	834	965	1 142	378	384	351	386	549	982	1 063	627	921	850	34	38	234	502	222
West SI	197	428	686	698	761	891	983	975	963	990	782	913	648	688	678	729	562	745	934	887
Cook Strait	66	56	70	100	63	59	53	20	56	107	98	163	112	130	169	216	189	155	89	34
Total	591	2 357	5 982	6 560	7 503	8 801	7 598	8 337	7 710	7 154	7 007	6 499	5 721	4 945	4 976	4 602	3 520	3 820	4 751	4 055
Setnet																				
East NI	48	85	40	25	4	1	4	27	12	1	1	1	–	0	1	0	5	0	–	5
East SI	210	227	145	164	180	199	180	205	201	147	171	132	124	104	120	79	51	47	6	58
Chatham	0	–	0	–	–	–	–	–	–	–	–	–	–	0	–	0	–	–	–	2
Southland	0	2	1	1	0	1	0	2	2	0	0	0	1	0	1	1	1	2	1	6
West SI	345	368	266	129	154	103	170	126	129	103	94	49	62	50	24	31	39	91	0	36
Cook Strait	36	0	1	3	1	1	1	1	0	0	0	2	0	0	0	1	0	0	0	0
Total	639	681	452	322	339	305	356	361	343	251	266	184	186	155	147	112	96	140	7	108

Table A3c: Catch of ling (t) by area, by fishing year, for various fishing methods: fish pots. Fishing year 1989–90 is denoted as "1990", etc. Values have been rounded to the nearest tonne, so "0" represents reported landings of less than 0.5 t, and "–" indicates nil reported landings.

Method and Area		Fishing year																		
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fish pots																				
East NI	–	–	–	–	–	0	–	0	–	–	–	–	–	–	–	–	0	–	–	–
East SI	2	14	39	15	12	8	4	38	41	36	21	4	3	1	4	10	49	53	4	10
Chatham	0	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Southland	1	1	1	1	1	2	4	2	3	0	10	24	16	13	0	0	3	3	1	11
West SI	–	–	0	–	–	–	0	0	0	–	–	1	–	–	0	–	–	–	–	0
Cook Strait	–	0	0	0	–	–	–	–	–	–	0	–	–	–	1	–	–	–	–	–
Total	3	16	40	16	13	10	8	40	44	36	31	29	19	14	5	10	52	57	5	21